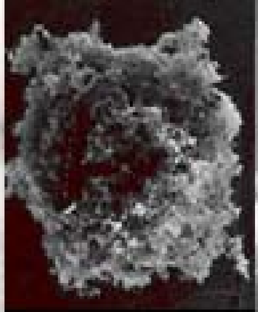
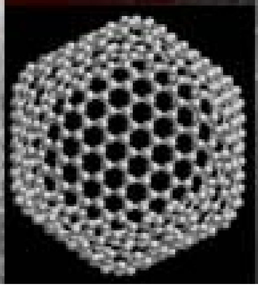


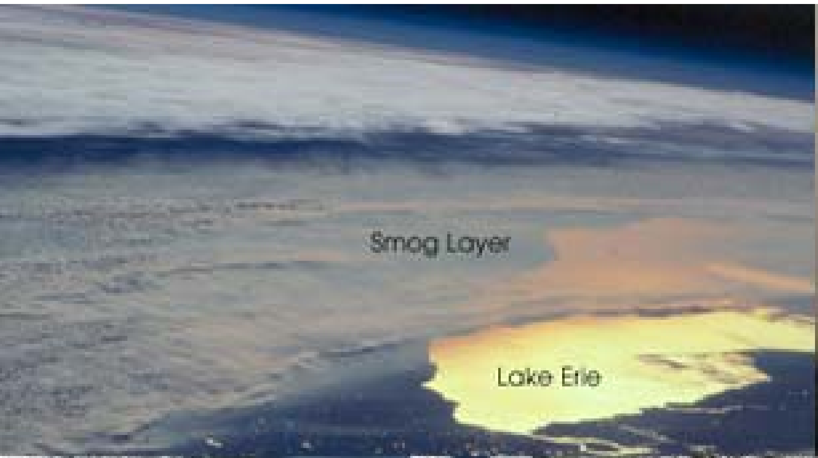


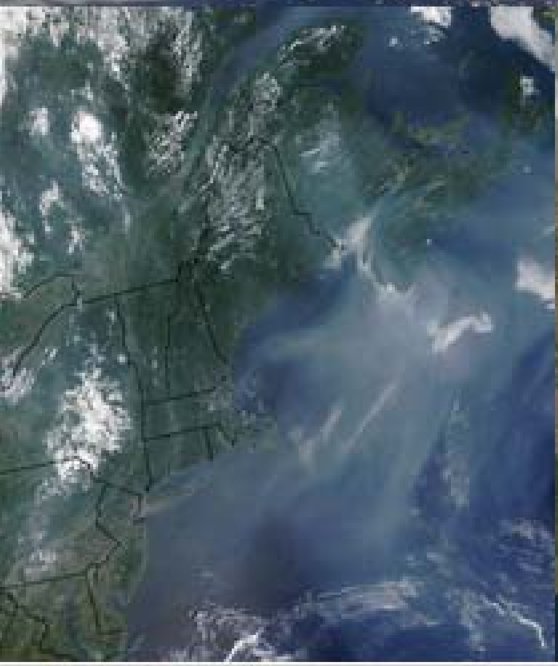
SOOT THE CRITICAL FACTOR

Dark Carbon Aerosols Causing Warming Then And Now

- **Dark Carbon Aerosols May Be Generating More Warming Than Green House Gases**
- **Implications for Future International Policy and Technology Development**
- **Simple Solutions To Warming Can Generate Unprecedented Economic Wealth**

Sam Bock / June 2008





PARAGON

Cover (permission still required)

Upper, from left to right:

- Some of Pittsburgh's Carbon aerosol soot in 1906. Widespread and primitive coal burning appears to have led to the first wave of industrial warming that struck North America and the Arctic hardest in the 20s and 30s at the peak of coal use
- Microscopic soot particle – potent climate warmer and cause of lethal lung disease
- Molecular model of carbon fullerene - Wikipedia.Org
- Donora Pennsylvania at 12:00 noon in 1948 - (© Pittsburgh Post-Gazette, all rights reserved.)

Bottom, clockwise from left:

- Smog and soot over Great Lakes region - NASA
- Coal soot in Linfen China - (Globe and Mail)
- Lady on bicycle in Linfen China - (Globe and Mail)
- Carbon aerosol soot flowing off India and covering the Indian ocean - NASA
- Air pollution flowing from eastern seaboard of North America into the North Atlantic Basin - NASA

Potential Infrastructure of the Future

http://www.massivechangeinaction.virtualmuseum.ca/stories/hydrogen/impact.html

How To Use This Research Format

Two serious & unexpected climate change developments occurred in 2007:

- New science findings explained why regional warming is happening so quickly due to excess soot pollution, indicating different solutions are needed to solve the warming problem
- Polar and glacial melting exceeded GHG theory predictions for 2070. If this current melting trend continues, the catastrophic loss of all Arctic summer ice could occur by 2012.

Simple fiscal policy measures can immediately solve the newly identified crisis.

This research is organized into 3 basic parts to very quickly provide this critical information to government policy makers, business leaders, researchers, and consumers:

- A very brief synopsis of the basic problems and solutions (3 minutes to read)

- A more in-depth Executive Summary (30 minutes)

- The complete body of detailed research and references (3-10 hours, depending on familiarity with the material)

The research assumes no prior training in climate science, but is written for scientists as well.

Future electronic and web-based versions will have a hyperlinked executive summary to allow quick access to more in-depth referencing.

Unexpected Causes and Solutions to Climate Change: A Brief Synopsis

There is little doubt the burning of carbon fuels is driving rapidly accelerating climate change.

However, much of the very rapid current warming may be primarily driven by particulate air pollution (mostly from China), and not CO_2 and the other anthropogenic Green House Gases.

2007 appears to have been a watershed year, both for the planet, and for climate science. Until now air pollution has been thought to cause cooling. However, unexpected research findings; the staggering melting trend in the Arctic; and supporting economic data all show rapidly rising soot emissions of dark carbonaceous particulate are causing rapidly increasing warming of regional atmospheres & snowpacks, and draught & flooding, by altering rain droplet formation in clouds. [1 2 3]

This paper shows that the combined effects of such particulate warming appear to explain the extreme warming of certain polar and glacial regions not predicted by Green House Gas theory.

If these particulate emissions and the current warming trend continue, they may destabilize the ecosystem & food chain within 4 - 8 years by causing catastrophic Arctic melting, global water shortages, and destruction of the northern boreal forests.

This raises two main issues:

1) ***Most particulates fall back to Earth within weeks**,* whereas ***Green House Gases remain in the atmosphere.*** As such, particulates (other than micro-fine at altitudes created by aircraft) can be quickly reduced, while removing GHGs will take decades, if not centuries. Once specific particulate emissions are reduced, research indicates temperatures will immediately fall. ***CO_2 may still need to be reduced and/or recaptured to prevent additional warming and ocean acidification.***

2) If particulate is causing the majority of current warming, then world-wide efforts focused primarily on very expensive reduction of CO2 put the planet at risk.

That most particulate aerosols don't accumulate in the atmosphere with each year, as GHGs do, is politically very important. New policy is required – the world's largest emitters need to immediately reduce particulates, regardless of past contributions to CO_2 & GHG emissions.

Paradoxically, while the current excessive level of dark carbon particulate emissions makes the warming problem multiples more serious and immediate than previously thought, it also makes the problem potentially much easier to rectify, as existing particle scrubbing technologies can dramatically and immediately reduce such particulate at little cost.

- Green House Gas Theory predicts gradual ***global*** warming due to globally distributed levels of GHGs. But new global maps showing actual temperature change show a different and unpredicted ***regional*** warming and melting is occurring. This regional melting, much of which is seen in the Arctic over the last 10 years, began to seriously accelerate in 2005, and then very dramatically in 2007. Paradoxically, despite predictions of GHG theory, most of Antarctica continues to remain stable or slightly cooling, as it has for the past 30 years (except in specific areas of the Antarctic Peninsula and Western Antarctica that are also affected by large increases in particulate pollution).

Surprisingly, this indicates that evenly distributed CO_2 and GHGs aren't driving global warming as much as previously thought. Instead the warming being measured is highly regional and worst in the world's most polluted regions, which include the Arctic.

- Moreover, GHG climate models neither predict the current Arctic warming nor its past cooling. Further, *Stott et al.* (Science September 2007) also show CO_2 did not initiate cycles of warming prior to the Industrial Revolution, although it may contribute to feedback loops.

- While Green House Gas theory and GHG reduction have been the focus of past research and policy making, the new research indicates the majority of the warming and melting in the Arctic is being caused by heavy regional air pollution drifting in from Asia, Europe and North America – mostly dark carbonaceous particulates (soots – the dark powdery residues of unburned fossil & bio fuels) and certain metal particulates. Satellite and other preliminary evidence show specific regions in Europe, South America, Australia, and Antarctica suffering similar pollution are rapidly warming too.

- Normally sunlight only warms when it strikes a surface on Earth and is absorbed and converted to heat. Because of this, the Earth's atmosphere normally warms mostly from the bottom up. GHGs further warm the atmosphere by trapping some of the Earth's escaping low-energy heat.

However, most air pollution today can cause significantly more warming than GHGs in 3 ways:

1) It actually converts incoming high-energy visible & UV light into heat – directly warming the atmosphere, heating the Earth from above. ***Now, just as in an oven, the Earth is baked by the heat coming from below, and broiled by the pollution from above.***

2) Such pollution causes a second positive feedback warming loop, as these particulates alter cloud water droplets, making them smaller, and causing them to disperse & spread over greater surface areas. Unlike an unpolluted atmosphere and clouds, polluted ones absorb and reflect more heat, causing an enhancement of the water-vapor green house effect.

3) Finally, once settled in snow, dark particulates cause accelerated melting in the presence of sunlight. Moreover, 24 hour polar sunlight can cause runaway melting to occur in polar regions with excessive surface levels of dark carbon particulates.

- As so much soot is either temporarily suspended in regional atmospheres and/or landing in the Arctic and many other regions of the world, this explains why warming in those regions is happening very much faster than predicted by GHG theory.

Every summer the Arctic's summer sea ice reaches a minimum. That minimum was about 8M sq km in 1980.[4] By 2005 only 4.1 M sq km remained [5], and then 27% of that was lost in 2007.[6] If this trend continues, potentially catastrophic melting of all Arctic summer sea ice will occur by 2012.

As peer-reviewed research herein shows, it appears the recent and rapidly accelerating increases in black and brown carbonaceous aerosols may be the primary drivers behind this unexpected and dramatically accelerated Arctic warming:

- Significantly elevated levels of atmospheric and surface Black and Brown Carbon are found in all polar and glacial regions where there is significant warming, but not in regions where it's still cool.

- Northern Hemisphere atmospheric carbon soot and other warming aerosols from industrial, transportation, and heating emissions are being carried by winds to the Arctic.

- These factors also explain the late 19th - early 20th century warming not explained by GHG theory.

Despite very low levels of accumulated anthropogenic GHGs, various regions of the world warmed significantly during the early coal boom from 1890 - 1940. By the early 1940s Arctic temperatures had become as elevated as they were in 2000. Then, despite continuously rising GHG levels, certain regions cooled as coal and diesel soot pollution fell dramatically with the switch to much cleaner burning oil and gas and the adoption of cleaner technologies that began in earnest during the 1950s & 60s. But since the 1970s, many regions began to warm once again with the tremendous surge in the use of cars, trucks & jet aircraft and the resumed use of dirty coal as a source of electricity.

New global temperature maps showing temperature changes over many decades indicate that regional warming and cooling coincide with regional increases and decreases in anthropogenic air pollution caused by the dirty burning of certain fuels.

- Annual emissions of dark carbon particulates are driven primarily by dirtier combustion methods of: heavy fuel oils – such as diesel fuel, jet kerosene, and marine bunker oils; biofuels – for cooking & heating stoves; and coal.

While Asia's surging economic output over the past 5 years has had little effect on total atmospheric CO_2 accumulations since 1850, its incremental impact on ***annually increasing*** global carbon soot generation has been enormous, as most Asian coal-fired emitters are not properly filtered with scrubbers or converters. (Neither are the world's diesel and bio-fuel emitters.) Much of Asia's and the world's unfiltered coal-fired particulate pollution is traveling to the Arctic.

Coal use in China has increased 31% from 2.06 M short tons in 2004 to 2.7M in 2007 [7] (up 108% from 1.3M in 1993) driving world coal consumption 24% higher in 10 years, and an incredible 11% higher in just 3 years. Arctic warming surged dramatically in this 3 year period as well.

Because acid-rain regulations in developed nations have required scrubbers since the 1970s, much of that coal burning is relatively clean of soot. However, because most of Asia's new coal burning is done with no particulate filtering, world soot emissions have climbed by a much greater percentage. While the data are still not available, the figures directly above indicate its possible that Asian fuel burning may have increased world soot emissions as much as 100 - 200 % in just 10 years.

In the last 8 years China has built 603 coal-fired generators - 64% of the 942 new generators installed worldwide.[8] 133 of those 942 were built in India. [9] 700 more are planned in China alone.

Since 1997 China has added 225,000 mega watts of coal-fired electricity generation, an increase of 155% from 145,000 MW in 1997 to 370,000 MW in 2007 [10], ***the equivalent of 225 medium size 1000 MW nuclear reactors***.

Policy to reverse climate change must address both rapidly increasing particulate pollution in China, India, and elsewhere, as well as previously existing levels in Europe and North America.

Simple, immediate steps by world governments can allow consumers & business to quickly invest in profitable technologies to reduce both particulate and GHG emissions to stabilize this very dangerous situation. Implementing such solutions will stimulate economic activity, not reduce it. This paper outlines such international cooperation, tax incentives, and market driven forces.

1) While nations & politicians struggle to reduce GHGs, research findings leave no doubt the World's initial focus must be on the immediate reduction of dark carbonaceous particulates.

2) Simple market-driven fiscal policy that stimulates rapid worldwide technology implementation, will make governments, businesses, and consumers wealthier, and economies more competitive, forcing laggards to catch up or become increasingly less competitive.

3) A problem with emissions taxation, caps, and trading is they put the onus on governments to regulate emissions and collect taxes. This also encourages cheating.

   However, the implementation of a combination of tax incentives for capital investment and government mortgage guarantees of bank lending for such capital investment will rapidly drive industry and consumers to qualify for profit increasing tax benefits without regulation and red tape. The motive for profit puts the onus for change on industry and consumers, creating win-win solutions.

4) Unless simple, cost-effective fiscal policy to reduce specific pollutants is put in place within 1-3 years, it appears devastating climate change will arrive 80 years early. Communicating this new science and practical economic solutions is extremely urgent.

DRAFT 4

Preface: The Precautionary Principle and Dark Carbonaceous Aerosols

In any crisis situation, when future science will require years to fully determine answers, and prior scientific consensus has failed to accurately predict effect or fully determine cause, other methods of problem solving become necessary, or catastrophic losses are possible.

The Precautionary Principle should be invoked in such crisis situations. It states that we must err on the side of caution, when we can not prove the safety of our practices or methods.

In this case, as applies to climate change, the practices in question are 1) the lengthy scientific method to determine the exact causes of climate change and 2) scientific reluctance to make clear and firm recommendations until then, especially when current data indicate significant probabilities.

Climate science and its current modeling have failed to predict the current state of the world's climate. While the scientific community warned the world of warming, the projections of when and how this might occur have failed badly.

If scientists were to completely rethink all that known about the state of our planet, GHG theory, that originated years ago, would not carry the same weight it carries today, politically or scientifically.

New research on regional warming effects due to visible & UV light-absorbing black & brown carbons and other aerosols is radically altering our understanding of climate change, and the large role they play. As importantly, such aerosols can be easily and inexpensively controlled.

Leading scientist's in this field know with certainty that reducing such aerosols will immediately reduce temperatures, buying the planet more time to find ways to remove GHG from the atmosphere.

Unfortunately, further advancement in this critically important field has been severely hampered by a lack of current data on levels of dark carbon emissions, atmospheric content, and surface deposition.

Many scientist's current use of 1990s fuel-use statistics in climate studies only serves to significantly underestimate the problem, unless they are somehow scaled up to represent the tremendous surge in the use unfiltered coal, diesel, and biofuels emissions around the world.

In just 3 years China's coal use alone has increased 31% from 2.06 million short tons to 2.7 [11], up from just 1.3 in 1993. Europe and North America's consumption of diesel and jet fuel has continued to increase steadily as well. The recent large increases of both black and brown carbon particulate making its way to the Arctic, and its potential to powerfully accelerate positive feedback loops of warming must be assessed in a more realistic manner.

We can not rely on outdated economic reporting and fuel-use data when scientifically trying to estimate the potential affects of carbon based aerosols to warm the Arctic and other parts of the planet – especially in light of the latest data showing warming in the Arctic has accelerated very dramatically in the last 3 years, while much of the Antarctic remains stable. This is not the pattern of warming projected by GHG climate models.

And because the patterns are not occurring as projected, we must also challenge accepted climate science dogma – the notion that GHGs are responsible for the vast majority of warming.

If current GHG theory is correct, the warming we are seeing now should be far less regional, with both polar ice caps warming as projected. We know they are not. While Greenland rapidly warms, most of Antarctica, except for those specific regions known to be polluted with carbon-based aerosols, is cooling or stable.

Further, GHG climate models should also predict past Arctic cooling in the 50's and 60s, as well as the extremely rapid warming we are seeing know, and they do neither.

Any pragmatically-minded problem solver has to accept this inconvenient truth, and accept that scientific consensus may be wrong, and that GHG may not be the primary cause of the most recent warming.

If we do not challenge this thinking, we potentially risk the planet. Because, if other anthropogenic factors, including Black & Brown Carbon and various metal aerosols, are causing warming that is being falsely attributed to Green House Gases, and worse, if they potentially produce far more severe warming than projected with GHG, we risk sitting idle doing nothing about an easily solved problem as it destroys our ecosystem.

As such, we need to put personal and scientific egos to the side, and use the most humble and objective mindset possible to determine the true nature of this emergency.

We need to accept that it's possible that large increases in the generation of carbon-based and metallic aerosol particles that accompanied rapid economic expansion, both in the early 20th century, and again today, may in fact be the primary warming factors affecting our planet, then and now.

Most importantly, we have to invoke the use of the Precautionary Principle when planning policy and courses of action, and base both on the most recent knowledge and our gut instincts for survival.

To effectively structure such policy, both individual scientists and the scientific community as a whole must have the courage to use the Principle to make multiple recommendations to counter both the GHG and aerosol warming threats.

The current temperature and melting data now clearly indicate dark carbon aerosols are a very substantial and immediate problem, which, if underestimated, could wreak havoc. Such carbon aerosols may ultimately explain the surface melting and melt ponds that so quickly penetrated 220m thick Larsen Ice Shelves. Similar feedback loops may destroy arctic ice and many of the world's glacial water sources within 4 - 8 years.

Because these particles can be very quickly and significantly reduced worldwide, and at little cost as compared to the world-wide investment required to reduce GHG emissions, by law/treaty they should be immediately reduced as a necessary precautionary measure.

The scientific, business, and political communities needs to stand up and say so.

Executive Summary

Overview

This paper explains why excess atmospheric carbonaceous aerosol (soot) emissions dramatically warm regional climates in three distinct and cumulative manners by:

- directly warming the atmosphere,
- affecting water droplet formation in the atmosphere, enhancing regional green house effects
- causing rapid melting once deposited in snow and ice

The regions affected are large. They begin at the source of the pollution and extend as far as the winds carry the particulate before it settles out of the atmosphere, much of it carried North into the Arctic, but also to the glaciers of the Himalayas, Alps, Andes, and Pacific coast mountains, and on to the ice sheets of the Antarctic Peninsula.

The empirical and peer-reviewed evidence presented herein shows that the warming caused by these anthropogenic particulates appears to be driving the majority of warming forcing experienced today. Moreover, this evidence further indicates that while still a potential problem, the anthropogenic Green House Gases do not appear to be playing as large a role in the current warming trend as currently thought.

Future climate change policy must quickly address particulate emissions, and then address GHGs.

Introduction – The Unexpected Effects of Certain Particulates on Climate

When the Green House Gas theory was first postulated by Swedish physical chemist Svant Arrhenius in 1896, scientists we not aware of the direct warming effects of carbonaceous aerosols (soot) on the atmosphere, or of their affects on cloud condensation nuclei (CCN) and ice nuclei, or of their effects on snowpacks exposed to sunlight. Many climate scientists today are still not aware of these effects.

However, many scientists do recognize that the largest uncertainty in the radiative forcing of climate change over the industrial era is that due to aerosols, a substantial fraction of which is the uncertainty associated with scattering and absorption of shortwave (solar) radiation by anthropogenic aerosols (IPCC, 2001).[12]

Quantifying and reducing the uncertainty in aerosol influences on climate is critical to understanding climate change over the industrial period and to improving predictions of future climate change for assumed emission scenarios.[13] Measurements of aerosol properties during major field campaigns in several regions of the globe during the past decade are contributing to an enhanced understanding of atmospheric aerosols and their effects on light absorption & scattering and climate.[14]

Rosenfeld 2000, in collaboration with NASA, shows the large concentrations of small CCN in the smoke from burning fuels and vegetation nucleate many small cloud droplets,[15] preventing rain from falling and causing many well-known effects, including droughts.

However, as this paper explains, those increased numbers of smaller droplets also appear to cause positive warming feedbacks due to increased atmospheric water vapor absorption of the Earth's heat.

This paper also shows why soot that eventually deposits on snow or ice exposed to sunshine causes very rapid melting.

The explosion in unfiltered aerosol emissions from the economic boom of the last 10 years is driving much of climate change we are seeing today.

The most significant increases in light-absorbing carbonaceous aerosol emissions are from South East Asia, due primarily to unprecedented economic development.

China alone has increased world coal consumption 24% in just 10 years, and 11% in just the last 3 years. Oil consumption in China has also exploded in just 10 years, increasing almost 100% from 3.9M B/D to 7.7M B/D in 2007. This has been accompanied with steadily continued growth of diesel use in the western economies.

Most particulate emissions from the developing world are unregulated and unfiltered. Much of this dark particulate drifts into the Arctic where it is causing very rapid melting of snow and ice.

Left: Chinese oil refinery - Reuters

Research now shows how rapidly increasing emissions of various classes of dark carbonaceous aerosols are causing atmospheric warming in many different ways that were not previously understood.

When these very significant carbonaceous aerosol forcings are added into the mathematical balance that quantify the total observed warming, it’s readily apparent that other warming factors, like GHGs, must be contributing much less to the current warming trend than previously thought. This is supported by many new bodies of scientific evidence showing that GHGs are less of factor in both the past Ice Ages and the present warming being caused by anthropogenic fuel burning.

This paper shows that for more than a decade various regions of the world’s climate, particularly in the Far North, have warmed far faster than predicted by the most advanced climate models based on GHG gas theory.

Examining The Factors Driving Climate Change – Why Current Climate Models Failed

Anthropogenic climate change is being caused by changes in the way solar radiation is reflected or absorbed by various molecules of gas, liquid, or particulate found in the atmosphere, in water, or on land, snow, and ice.

Climate modelers try to build accurate climate prediction models based on these known relationships. To do this they use well established principles regarding light and solar radiation that allow the calculation of the energies absorbed by various compounds in our ecosystem.

While these formulas are quite simple, the incredibly complex climate models built with them are not.

For more than a decade various regions of the world's climate, particularly in the Far North, have heated up far faster than predicted by the most advanced climate models.

Further, when the climate models are run in reverse they fail to predict actual climate history and the cooling that occurred in the 1950s and 60s.

This means there is something wrong in the climate models we are using to predict climate change. This isn't surprising. Because there are so many weather variables to predict, climate models are infinitely complex to design and very hard to get working properly.

That said, there is nothing wrong with the basic formulas for energy absorption being used in these models, but rather, in how the various principles may be arranged in any climate prediction programs, ***and***, whether other key relationships may have been omitted from the programs. This research shows various aerosol forcings have not been properly accounted for in these models.

Fortunately, individual climate modulators (like CO_2 or certain particulates) have distinct signatures, and these signatures can now be easily seen on new global maps that show various eras of temperature change. Because of this, we can now see which of these basic modulators are having the greatest affects.

As the relative weights of each of these basic modulators is better understood, scientists are better able to see which anthropogenic factors are having the greatest affects on climate. This in turn can help policy-makers effectively fine tune the world strategies and policies necessary to reduce anthropogenic activity driving the very rapid climate change that threatens Earth.

Most are familiar with Green House Gas warming theory. Because these gases are quite evenly spread through the atmosphere, they are thought to cause warming that is more ***global*** in nature.

But the emerging research & temperature data now show that lesser-discussed ***regional*** warming factors related to carbon soot and other aerosols, are significantly altering scientific understanding of how light's energy can be absorbed, re-emitted, and/or reflected by aerosols in our environment.

The actions & effects of regional aerosols are:

- not hard to understand
- easily observed in the environment
- related to air pollution rather than green house gases – specifically various types of particulate, or solid non-gaseous matter, found in smog.

Various types of soot, metals, and other pollution appear to be causing very significant, large-scale, regional planetary warming due to climate forcing factors not previously considered.

Why Particulate Soot Pollution Warms the Planet so Quickly as Compared to GHGs

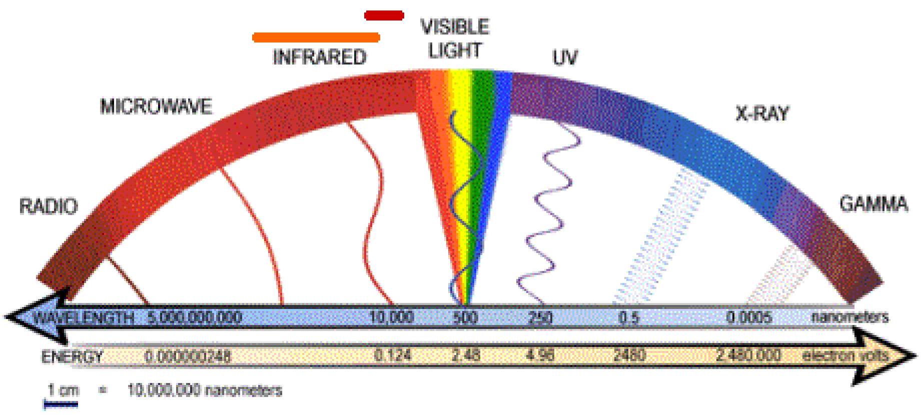
Because the Earth must give off as much energy as it receives to remain at a constant temperature, ultimately its oceans & land surfaces radiate the same amount of energy acquired from the Sun and Space back out to Space. If they didn't, we'd be quickly destroyed by the rapid build-up of heat.

More importantly, to a large degree, the Earth is normally able to maintain & regulate temperatures because of its vast waters, atmosphere, and the way both interact with electromagnetic radiation, as discussed below.

However if soot finds its way into the atmosphere, the atmosphere immediately begins to loose its ability to regulate and lower temperatures, as shown below. The well established principles used to show why this is the case are not difficult to grasp.

First we need to briefly consider the nature of ***light***, ***heat***, and other types of electromagnetic radiation, all of which comprise of ***photons*** of ***energy*** traveling at light speed.

Beams of natural sunlight comprise of large numbers & different types of photons, all individual wave/particles oscillating at particular frequencies – the shorter the wavelength, the higher the photon's energy; the longer the wavelength, the lower the energy.



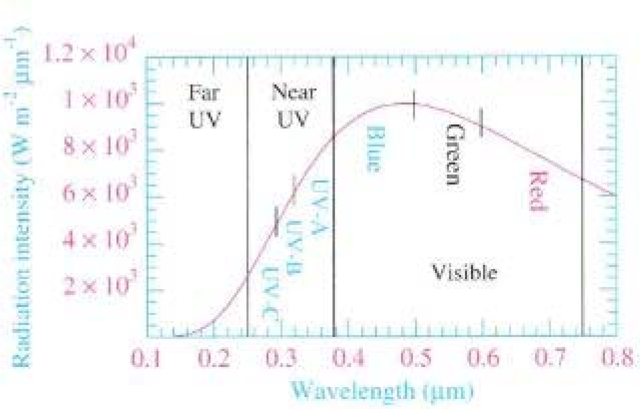
Most importantly, photons of *specific* energies, or wavelengths, are capable of being "caught" and absorbed by electrons of *specific* frequencies surrounding *specific* atoms, energizing those atoms. Hydrogen atoms in water absorb a certain set of frequencies of energy. Carbon, oxygen, and all other atoms also absorb different frequencies of energy, depending on their electron structures.

A newly energized atom may then release all, or a portion, of that energy as lower-energy infrared heat. As can be calculated from the chart above, each photon of absorbed visible sunlight ultimately generates about 20 photons of low energy heat, while each photon of absorbed UV light generates about 40 photons of heat. The importance of this will be very evident shortly.

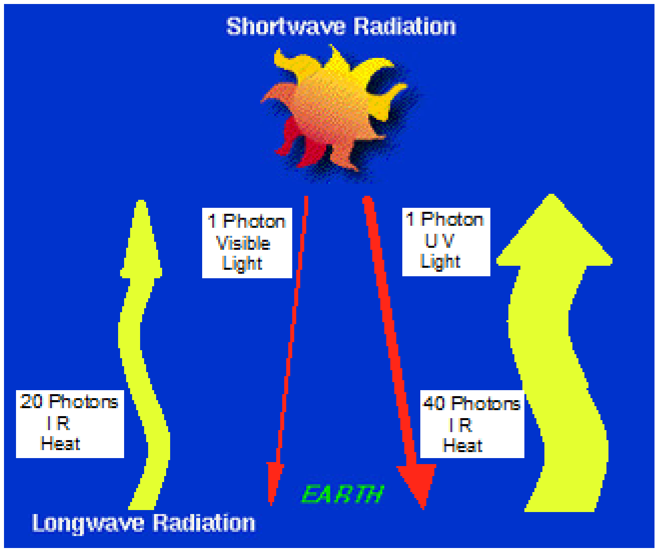
The Sun emits mostly higher-energy photons that easily penetrate the Earth's clear atmosphere, because the electrons surrounding the atoms of all its gases, including CO_2, water vapor, and the other Green House Gases, are unable to absorb these high energy photons.

Approximately 70% of the high-energy sunlight that passes through the atmosphere to reach the Earth is absorbed.[16] Upon reaching the Earth's surface, a portion of these high-energy rays are reflected back through the atmosphere to Space, while the rest are absorbed by various atoms on Earth's surfaces, and are converted to lower energy wavelengths of heat, warming the planet.

This low-energy long-wavelength heat is capable of being trapped and reflected back to Earth by water vapor and the other green house gases, further warming the planet.



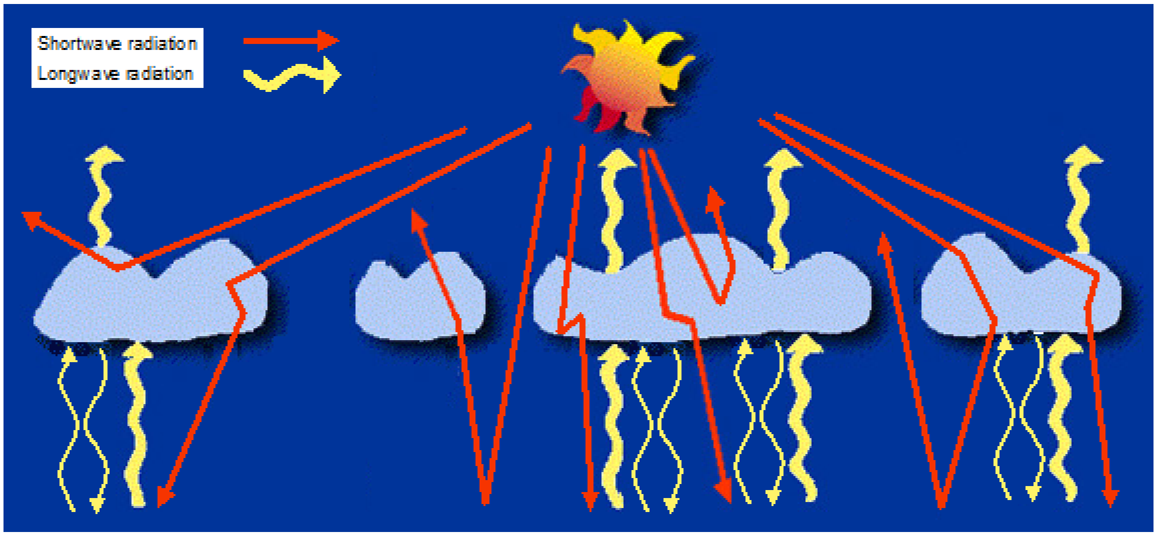
Above: UV and visible portions of the solar spectrum. This spectrum is received at the top of the atmosphere. (Jacobson 2002)



It's very important to understand that in a normal, healthy green house, heat initially emanates only from the Earth below (once light photons from above are converted to heat photons), and not from the atmosphere above. As discussed below, pollution changes that.

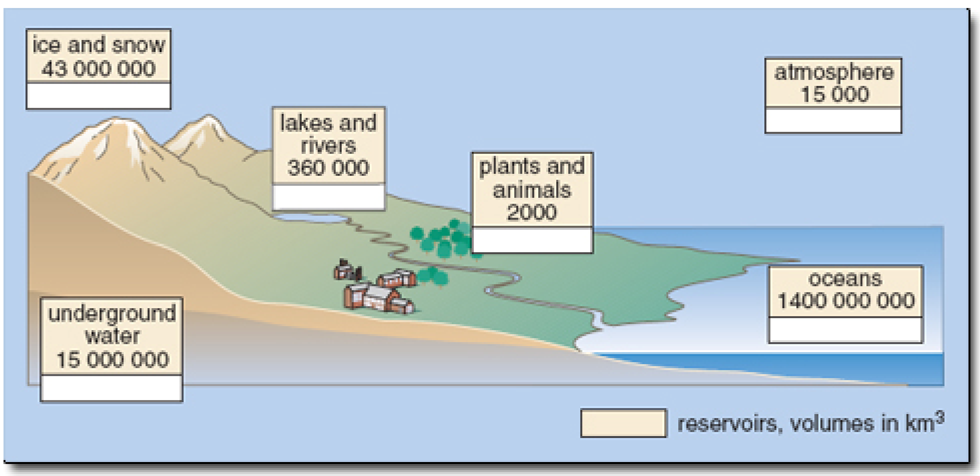
In the following images the red arrows indicate shortwave radiation coming from the Sun and elsewhere in Space. The wide yellow arrows indicate the number of heat photons generated at the Earth's surface by the absorption of individual incoming visible and UV light rays, and the net amount of low-energy longwave heat that is ultimately reflected back to Space.

The thin downward facing yellow arrows below represent that smaller portion of heat captured and reflected by greenhouse gases in clouds and in the atmosphere. The thin upward yellow arrows represent that same heat then being reabsorbed and re-reflected back to space. (This briefly explains what is going on in the atmosphere above the Earth's surface - more on this below)



Water not only allows life, it has a great capacity to absorb heat at the Earth's surface (which is also why we use it in the radiators of cars, helping to keep engine temperatures stable). As the world's oceans contain 96% of the world's water and cover 71% of the planet's surface, their deep waters provide a massive heat sink on the Earth's surface, helping to regulate its temperatures.

Reservoir	Volume/km^3	Volume/% total water
oceans	1400 000 000	96
ice and snow	43 000 000	
underground water	15 000 000	1.0
lakes and rivers	360 000	0.025
atmosphere	15 000	0.001
plants and animals	2 000	0.000 14
total	1460 000 000*	100*



http://openlearn.open.ac.uk/mod/resource/view.php?id=285835

While temperatures on land can fluctuate widely from - 80° C to 50°+ C, ocean temperatures only range from about -2°C to about 35°C due to their enormous heat storing capacity.

That said, Earth's ocean heat sinks are always in a state of flux, at times taking in vast amounts of energy, and at others releasing large amounts of trapped energy. Much of this energy exchange is driven by shorter seasonal/annual cycles and large atmospheric & ocean circulation patterns.

However, these seasonal rhythms can be shifted warmer or cooler by longer cycling regional effects, such as El Nino and la Nina for example. **So even while the planet gets warmer, and on a net basis the oceans warm as well, the oceans still have the capability to dramatically shift world temperatures one way or the other, depending on how much heat is being released or recaptured by these huge heat sinks at any given time.**

As relates to climate and temperatures, the water vapor coming off the oceans (and lakes, rivers & land masses) is the most important substance in the Earth's atmosphere, due to its two primary atmospheric effects: one of warming, and the other of cooling.

Atmospheric water vapor (some in the form of clouds) is the most important GHG, trapping by far the most outgoing heat of any of the GHGs. It, and not the other GHGs, is the primary factor raising atmospheric temperatures to levels that support life, as discussed in greater detail below.
But, uniquely, water vapor also plays the Earth's most important temperature regulation role as well, by generating cloud cover capable of reflecting incoming sunlight back to space.

It's important not to confuse the effects of translucent warm water vapor with that of cooler reflective clouds, even though they are both forms of water vapor. Translucent warm water vapor only causes atmospheric warming. However, the overall net effect of clouds remains one of cooling, even though some clouds either: a) trap heat – i.e. high cirrus, b) are temperature neutral – i.e. deep convective, or c) block sunlight – thick low cloud.[17]

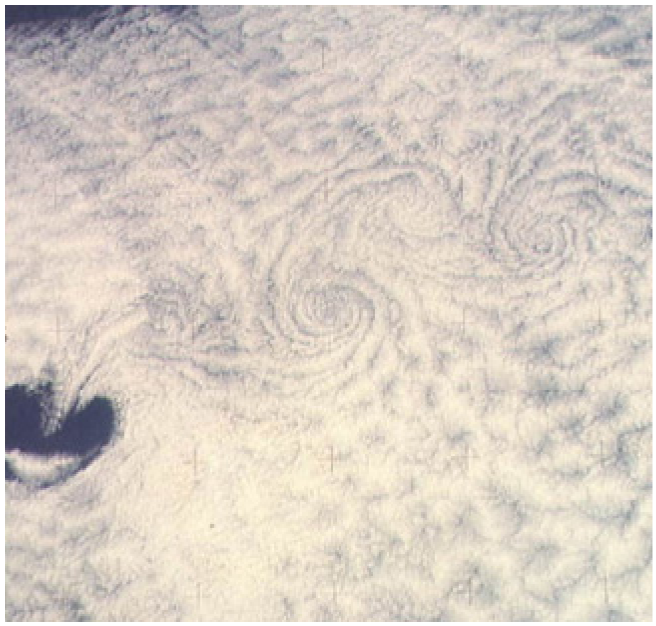
While levels of the other atmospheric GHGs are normally quite stable on a moment to moment basis, the amount of water vapor in most regions of the atmosphere is constantly fluctuating. This is because any heat coming from the Earth that is initially trapped (by either water vapor, other GHGs, or any other warming factor) further warms the water and land surfaces below, causing them to throw off more water vapor, causing even more heat to be trapped in the process. This is known as the water vapor positive feedback warming loop. Somewhat ironically, it's this water vapor positive feedback that both allows Earth to remain warm and control temperature.

Barring the influx of cool water currents or winds, from morning until late afternoon, regions that are warming will only stop warming once enough warm water vapor evaporates from the ocean and land surfaces. This warm vapor rises upwards, and cools & condenses, thereby increasing the total amount of low white cloud cover overhead.

That thickened cloud cover then reflects a greater portion of the incoming high energy sunlight back to space before it can reach the Earth below, thereby cooling the surfaces and atmosphere below.

If a cloudy atmosphere then cools the atmosphere enough, due to thicker cloud cover or other factors, moisture condenses and water drops out of the atmosphere as rain or snow. This ultimately reduces the amount of the GHG water vapor in that region of the atmosphere, allowing more heat to pass through to Space, cooling the atmosphere and surfaces below even further.

So, as the world gets too warm, increased cloud cover works to cool it down. And as it cools, less water vapor is evaporated, reducing cloud cover and allowing the planet to re-warm.



http://earthobservatory.nasa.gov/Library/Clouds/clouds4.html

As discussed earlier, the Sun's incoming high-energy shortwave rays either easily pass through the atmosphere to heat the planet below, or they are reflected directly back to space by reflective surfaces on Earth or the white clouds above it.

Because a clean atmosphere and its clouds can not absorb shortwave sunlight, they can not be directly warmed by those incoming rays. This allows the planet's reflective white cloud cover to moderate land and water surface temperature fluctuations by forming a protective barrier from the Sun's energy. Thus a normal range of temperatures and a general equilibrium are achieved in a clean environment.

However, if for any reason enough pollution gets into the atmosphere, this causes the atmosphere and its clouds to begin directly capturing Sunlight's energy. This can quickly disturb the Earth's critically important cloud-cover equilibrium, rendering this crucial thermostat ineffective, resulting in the insulation and overheating of the surfaces below by the atmosphere above. This happens for two primary reasons as discussed below.

Reason 1) If the atmosphere and its clouds begin to collect soot and metals, which contain atoms capable of directly absorbing the Sun's high energy rays, then the atmosphere's ability to cool itself becomes limited, as it is less able to use clouds to reflect incoming radiation.

Instead, those new foreign atoms within the atmosphere's gases or clouds begin to absorb high-energy sunlight from above, thereby directly and dramatically heating the atmosphere. Now the Earth's atmosphere is directly heating from incoming high energy waves from ***above***, and not just from the normal absorption of low-energy outgoing heat emanating from ***below*** *as discussed earlier*.

FIG 1

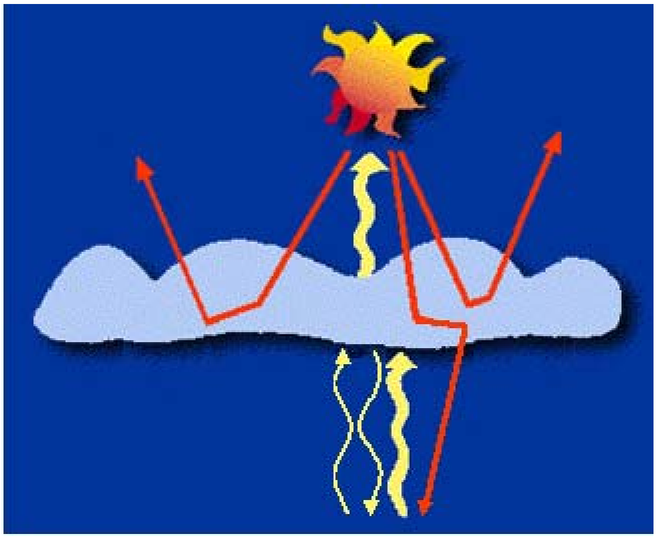
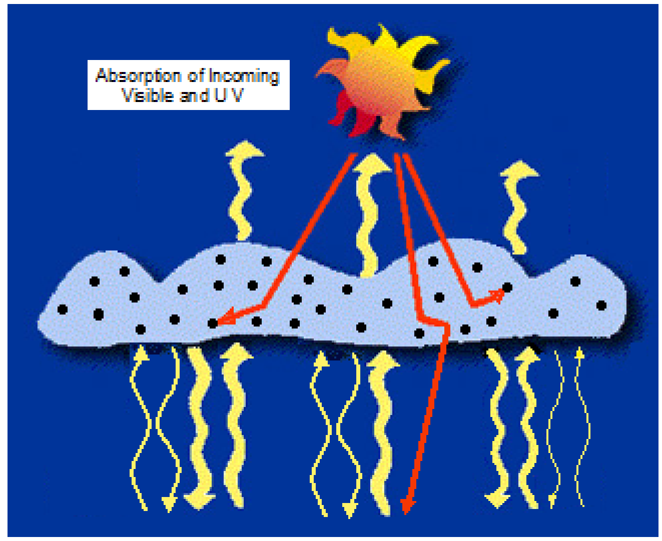


FIG 2



It's easy to track of how much additional heat is being generated by particulate soot pollution.

As discussed above, all absorbed Solar radiation is ultimately re-emitted back to Space. So the incoming energy ***entering at the top of to the atmosphere*** must equal the energy ***leaving at the top of the atmosphere***. We'll assume all incoming sunlight is visible light (to keep things simple and conservative, even though a portion of incoming light is higher energy UV), so each photon of incoming light will convert to approximately 20 photons of lower energy heat.

In Fig. 1 only one of three incoming solar photons makes it to Earth's surface to be absorbed and transformed into heat. That incoming solar photon generates 20 heat photons of equal energy and is reflected back to space as shown by the wide yellow arrow leaving the Earth's surface.

A percentage of that heat is trapped by water vapor, clouds, and the other Green House Gases in the atmosphere. This percentage is represented by the smaller downward yellow arrows.

Those greenhouse-reflected photons are then re-emitted to space, as indicated by the smaller upward yellow arrow of equal energy. Because the GHG-reflected warmth is ultimately re-emitted, it represents 2 vectors of warming heading in opposite directions. Therefore, as relates to the total amount of heat leaving the top of the atmosphere, those vectors cancel each other out and do not add to the total heat leaving the system.

The net sum of heat photons ultimately leaving the system is still equal to the one photon of sunlight initially converted to heat – or 20 photons, as represented by the 1 wide yellow arrows exiting above the top of the atmosphere.

As seen by adding up the vectors below the top surface of the atmosphere, the ***normal GHG potential for atmospheric warming*** due to surface absorption in photon-heat-units is:
(1 x 20 heat photons) + (2 x GHG heat photon absorption %)

In Fig. 2, two other incoming solar photons are absorbed by pollution rather than reflected by the clouds, as might normally occur. The photon on the left now generates 20 photons of heat directed at the Earth, as indicated by the wide downward arrow below it. This must be reflected by Earth, as indicated by the 20 photon wide upward vector beside it. This upward vector is then partially reflected by GHG in the clouds and atmosphere, further heating the atmosphere.

The total atmospheric warming below associated with this single solar photon is:
(2 x 20 heat photons) + (2 x GHG heat photon absorption %), a significant 20 photon increase in warming, as compared to a photon's normal conversion to heat once it reaches Earth's surface.

The energy emitted from the top of the atmosphere is still 20 photons of heat, or 1 solar photon.

Since the absorption of a solar photon subsequently radiates heat energy in all directions, depending on the depth of the soot particle in the cloud / atmosphere, as much as half the energy (10 Photons) could be reflected back into Space immediately. In Fig. 2, this is illustrated with the photon on the right which is striking a soot particle near the top of a cloud. Only half the generated heat is emitted towards Earth, as shown with the 50% smaller incoming downward vector and subsequent outgoing upward vector widths.

The total energy emitted from the top of the atmosphere is still 20 photons of heat – the initial 10 that escaped to Space immediately, and the subsequent 10 that were then reflected and emitted from below.

The total atmospheric warming below associated with this single solar photon is:
(2 x 10 heat photons) + (2 x the GHG heat photon absorption %).

Adding up all the vectors in Fig. 2, the sum of atmospheric warming caused by all three absorbed photons is now: (3 x 20) + (2 x 10) + (4 x GHG absorption %) + (2 x .5 GHG absorption %)

In the example above, the particulate-related solar warming dwarfs the GHG-related warming.

Moreover, soot pollution in the atmosphere doesn't just affect incoming solar radiation. The incoming high-energy sunlight that is normally reflected off Earth's surface back through the atmosphere into space is also now capable of being absorbed by this soot pollution, generating additional reflected heat back to Earth, as shown in Fig. 4 as compared to Fig. 3.

FIG 3

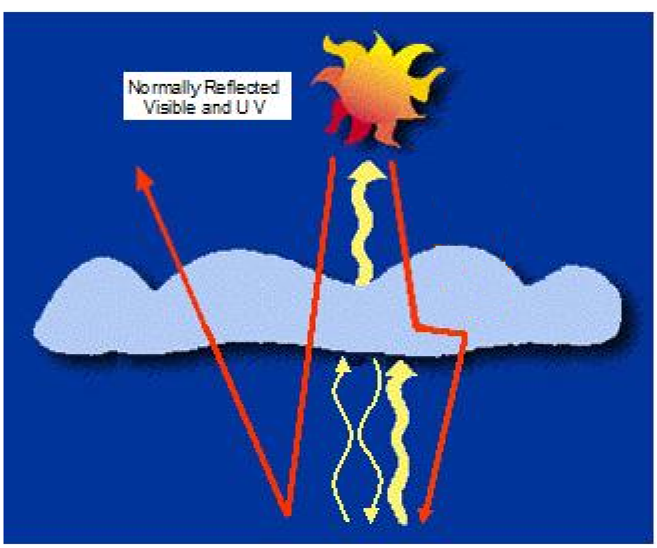
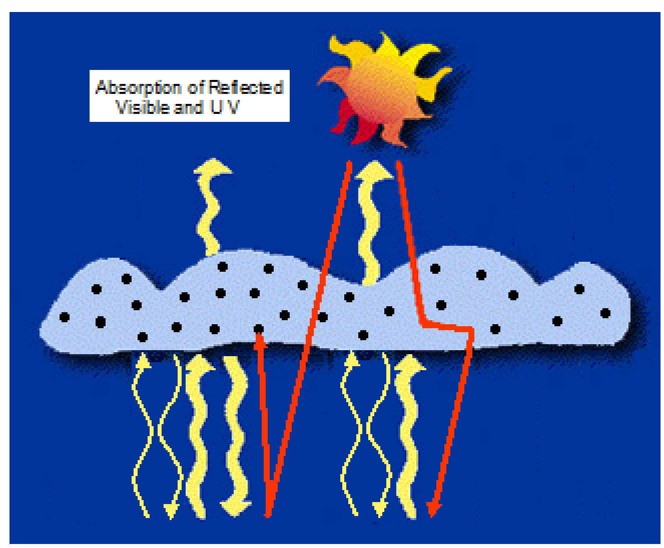


FIG 4

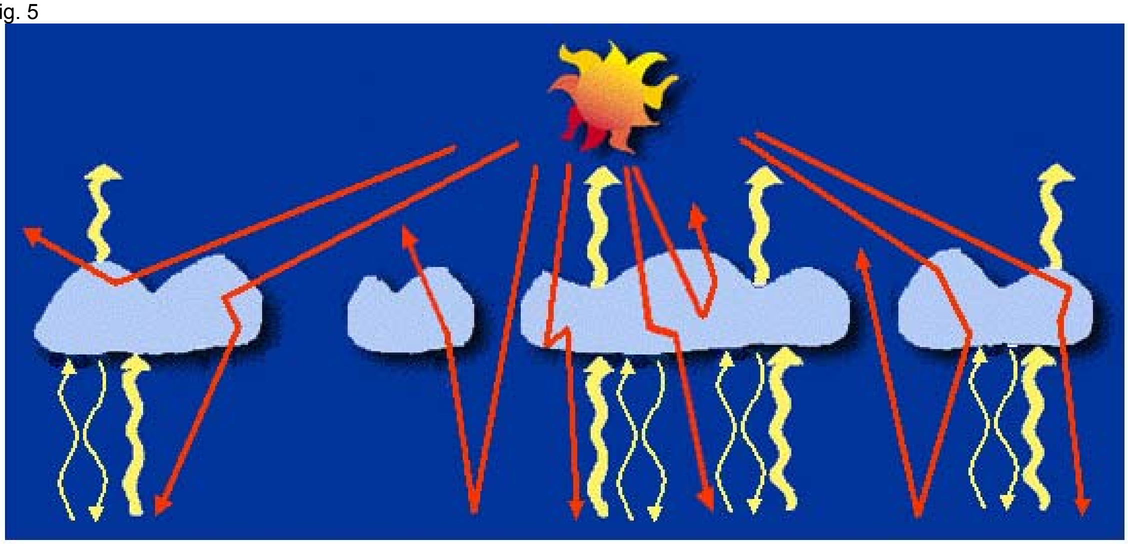


To better illustrate the affects of soot on atmospheric warming, we'll look at the hypothetical behavior of 8 photons entering a clean atmosphere vs. one polluted with soot particulate.

In Fig. 5 the atmosphere and its clouds are free of any particulate soot pollution. 8 photons of high energy sunlight (red lines) arrive at the top surface of the atmosphere. 4 photons are reflected before they can be converted to heat on Earth: the 1st is reflected back to space by a white cloud; the 2nd passes through the atmosphere, and is reflected back to space through a cloud; the 3rd is redirected twice within a cloud before returning to space; and the 4th passes through a cloud to Earth, is reflected, and then passes directly out to space through the atmosphere.

4 others pass through the atmosphere and clouds, reach Earth below, and are converted to heat, warming the Earth. Those photons are re-emitted as 80 photons of heat (represented as 4 wide yellow bands of 20 photons each).

Fig. 5

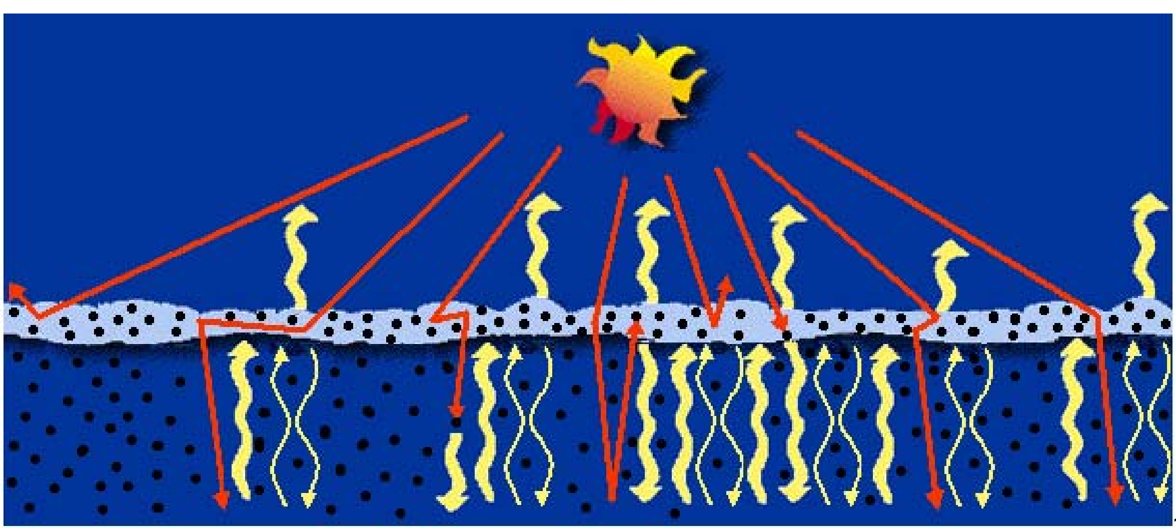


A percentage of those 80 photons are captured by GHGs and reflected back to Earth further warming the atmosphere and surfaces below (smaller yellow arrows).

Prior to exiting the top of the atmosphere, the total atmospheric warming in photon heat units is (4 x 20) + (8 x GHG absorption %), as it should be.

However once enough soot is added to the atmospheric mixture, the atmosphere begins to quickly overheat. The total number of incoming sunlight photons remains the same at 8.

Fig. 6



Only 3 make it to the Earth's surface, generating the normal amount of heat. A 4th is absorbed by soot floating in the atmosphere, generating an extra 20 photons of Earth-bound heat radiation. The 5th and 6th are absorbed by soot in the clouds generating an extra 40 photons of Earth-bound heat radiation.

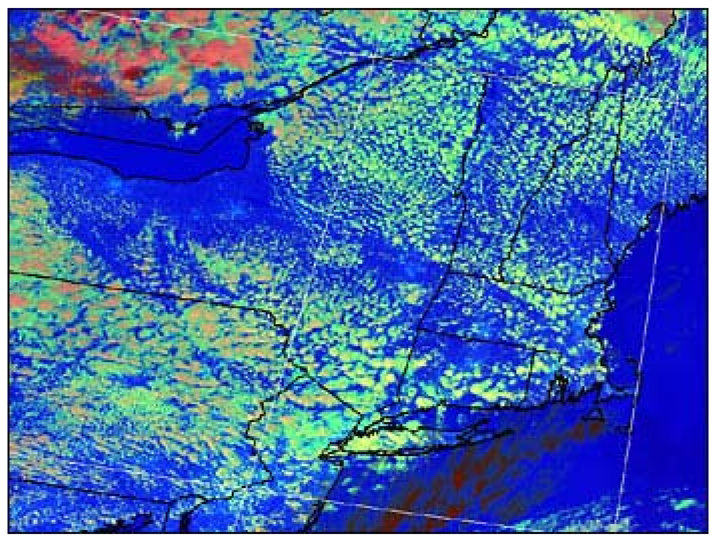
In this example, a 2 photon (50%) increase in Solar absorption, generates a 100 heat photon (125%) increase in atmospheric warming.

Each solar photon absorbed by atmospheric pollution generates almost twice as much warming as compared to a solar photon that reaches Earth through a clean atmosphere.

Reason 2) This additional warming in then further magnified by soot's affect on atmospheric GHG water vapor.

Research shows carbon soots and other air pollution alters cloud formation and water vapor behavior by dispersing moisture and preventing droplet formation[18], as documented in NASA satellite images. As shown below, this can dramatically increase the amount of water vapor exposed to thermal radiation, which can therefore increase water vapor's atmospheric green house warming potential by potentially significant orders of magnitude as explained below.

As *Rosenfeld* 2000 and its analysis of NASA Satellite images show, soot is preventing water droplets and clouds from forming naturally. Instead of normally forming large drops capable of raining, soot is causing the moisture to remain dispersed, resulting in the formation of clouds that do not initially release their moisture. As pointed out in that important paper, this is affecting rainfall, causing drought in some areas, and excess rain and/or flooding in others.



In this satellite image, taken in 2000, the yellow clouds scattered over the Northeast are polluted clouds with small water droplets. The pink clouds over Canada have larger droplets, and are relatively clean. Because the aerosols prevent cloud water droplets from growing large enough to precipitate, this type of pollution can reduce rainfall.

http://earthobservatory.nasa.gov/Study/Pollution/pollution.html

What has not been fully considered, is that this anthropogenic moisture dispersal should also dramatically increase the green house effect of clouds.

It's well established that the water molecule is capable of absorbing thermal radiation, which is what makes large amounts of ocean water vapor such a powerful green house forcing agent.

A typical water droplet is roughly 10^{20} water molecules packed together.[19] However, only a much smaller number of droplet ***surface molecules*** are directly exposed to incoming radiation, as most of those 10^{20} molecules within the interior of the droplet are sheltered by a skin of molecules on the exterior, and as such, unable to absorb radiation immediately. (This is why water boiled in a pot heats gradually from the bottom up, rather than evenly and instantly.) Therefore, the bigger the water drop, the greater the number of internal water molecules sheltered from outside radiation.

Approximately half of the heat absorbed by those surface molecules higher in the atmosphere is radiated back to space immediately (in the same manner as the heat that is generated and emitted in all directions from particulate in clouds near the top of the atmosphere in the Fig 4).

To better understand how much extra heat can be trapped, we need to consider droplet surface area. The diameter of a typical water droplet in a cloud is 0.01 mm. These tiny droplets eventually coalesce to a 2 mm raindrop, some 200 times greater in diameter, and 8,000,000 times in volume.[20]

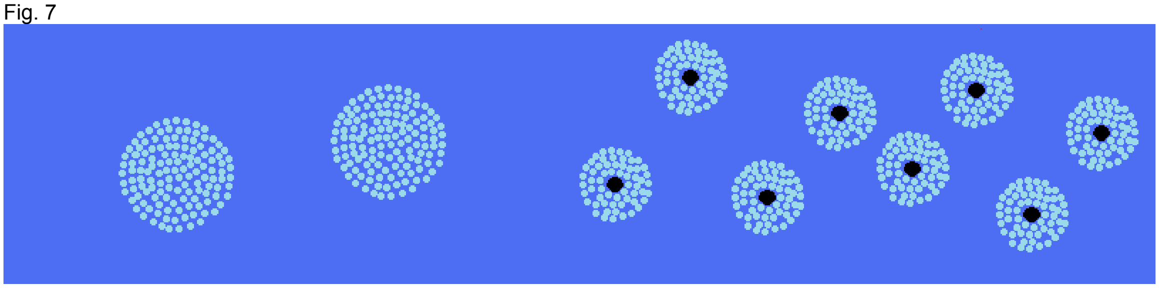
What is important to recognize when considering the amount of surface area exposed to thermal radiation, is that it takes 8,000,000 tiny water droplets to eventually form 1 rain drop. The combined surface area of those 8 million droplets is a massive 200 times greater than that of the rain drop.

Because soot keeps water dispersed into smaller droplets in affected clouds, this significantly increases the total surface area and number of cloud water droplets capable of capturing outgoing heat from the Earth below. The figures below give us a better idea of this relationship.

In Fig. 7 two larger 2mm drops containing 4.188mm³ volume of water are shown. Only reducing droplet diameter about 35% to 1.26mm now produces 8 droplets from the same volume of water.

The two larger droplets combined surface area is 25.13mm². The 8 smaller droplets have a 63% larger 39.9 mm² combined surface area exposed to the Earth's radiation. **The increased droplet surface area will prevent a proportional amount of heat from freely exiting the atmosphere.**

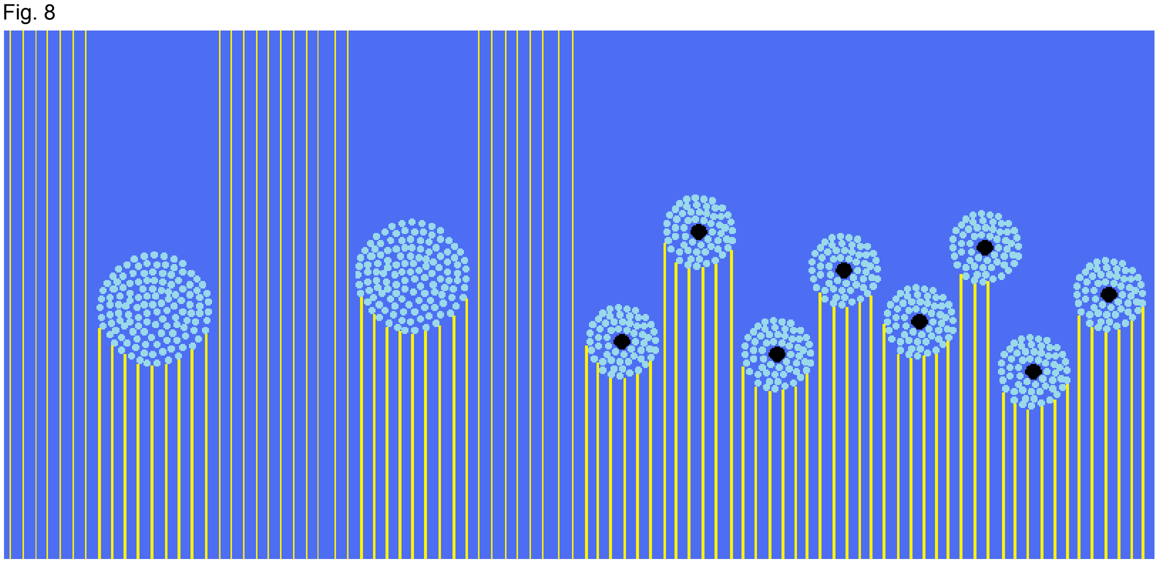
Fig. 7



As the drawings below are side views, they are not mathematically accurate. None the less they convey an idea of how much exiting radiation can be blocked & reflected by a greater number of smaller water droplets of the same water volume.

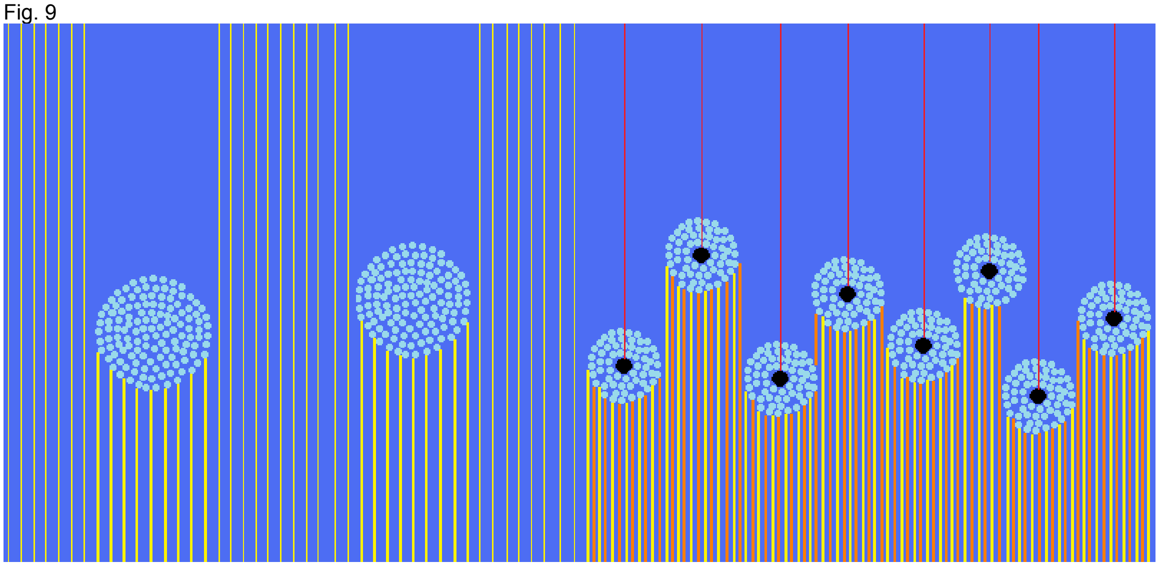
In Fig. 8 below, the thin yellow lines indicate Earth's heat escaping to space while the thicker lines indicate heat that has been reflected back to Earth, only to be reflected back to space again. Larger droplets clearly reflect less heat.

Fig. 8



In Fig 9, the added effect of solar photon absorption (from above) by the soot in the smaller dirty water droplets makes the problem much worse, as shown on the right.

Fig. 9



The above analysis of light-absorbing-particulate's effects on incoming solar radiation and outgoing thermal radiation clearly shows why diesel, coal, biomass and other soot-based pollution in the atmosphere & clouds is both absorbing large amounts of high-energy solar radiation and significantly increasing water vapor GHG warming potential at the same time.

These effects are most likely a significant cause of the intense warming in Europe, China and other regions in recent years, as pollution emissions there have grown.

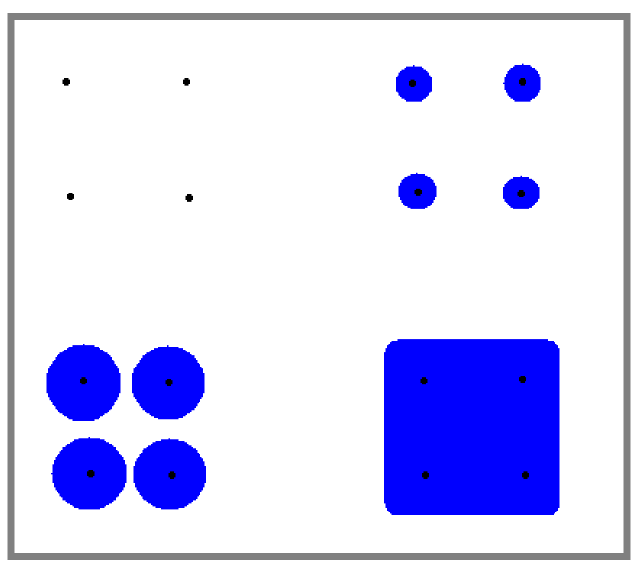
These effects are even worse in more extreme southern and northern latitude summers when the sunlight exposure there is most intense. The Artic and Antarctic Peninsula are particularly affected.

Only recently have scientists begun to realize the full potential of certain particulate pollution to capture UV & visible light on the ground. Deposited soot and metals can cause melting of light-***reflecting*** snow & ice, and in the process create light-***absorbing*** water and more melting. Such soot deposition in polar snow and ice has the added potential to cause runaway positive feed back loops of melting.

Such feed backs become most intense in the presence of 24 hour polar sunshine. Per the hypothesis advanced in this paper, the intensity of such feed backs appears most dependant on the quantities of carbon soot lying both near the surface and just below it (from years past).

Normally the highly reflective albedo of the ice and snow in the polar regions causes most of the sun's energy that reaches the surface to be reflected, thereby preventing the transfer of energy into heat, and with that, potential to cause melting.

However, if even a small sprinkling of microscopic soot is deposited on the ice or snow, and then remains exposed to sunlight, the potential for a powerful melting feedback loop can be established.



This positive feedback loop is described and illustrated in the figure above:

- the carbon soot deposited in snow (black dots) absorbs light and generates heat (IR),
- The heat melts snow next to the soot, producing a small amount of water,
- the freshly melted water, the beginnings of a surface “Melt Pond”, is blue and has a low albedo, and begins to absorb more sunlight, generating more heat,
- The warm water then begins to pool, melting the ice below, and sinking long vertical holes into the ice (see satellite shots below of Larsen B just before it “spontaneously” broke up),
- The growth of surface Melt Ponds continues as long as the sun is shining, which can be 24 hours per day for months of the year in the polar regions.

The patterns of melting now occurring in the Arctic, the Antarctic Peninsula, western Antarctica and on glaciers round the world, are indicative of carbon aerosol warming described above and show that these additional anthropogenic factors need to be fully considered if we are to develop policy to stop the very rapidly accelerating climate change.

More specifically, it shows that Humankind initially needs to make dramatic reductions in soot and other particulate emissions with existing filter & converter technologies, and then work to completely eliminate carbon fuel use.

While this pollution is immediately and entirely preventable, it is currently affecting large regions of atmosphere and snowpack around the planet, as can be clearly seen in the satellite photos herein.

Which makes the following points critically important when assessing the current weights / effects of various anthropogenic emissions on today’s climate:

- those very powerful positive feedback warming effects associated with atmospheric soot described herein are not built into current climate models,
- the sum of these radiative forcing components and their potential for warming is many times larger than that currently predicted by GHG theory, as shown and explained above,
- which means that current warming attributed to GHGs is much less than thought
- which means world leaders need to quickly focus on the real problem first, or they further risk allowing severe damage to the ecosystem in a few short years.

New Maps and Other Data Show The History of Planetary Warming in a New Light

Clearly, the rapid increase in soot and other particulate emissions over the last decades may explain the rapid warming in various regions of the world today.

Similar earlier increases in soot generation appear to explain previous warming in North America & the Arctic in the 1920s, 30s, and 40s, when there was no significant accumulations of GHGs in the atmosphere. Instead, back then there was extreme air pollution that resulted from earlier, dirtier methods of burning coal during the industrial revolution. This would also explain why, when such pollution diminished in the 1950s and 60s, significant cooling occurred in many parts of the World. However, since then, with the World’s tremendous surge in energy use (initially marked by the OPEC oil crisis of the early 70s), regional air pollution and temperatures have once again been climbing.

As discussed above, because Green House Gases are quite evenly distributed throughout the planet’s atmosphere, GHG theory predicts a warming of a distinct and somewhat global nature.

Until recently, it has been difficult to ascertain whether the world was warming as predicted by the increase of GHG. Then in 2005, NASA’s GISS world temperature data was assembled to create global temperature anomaly maps that clearly show the changes from one era to another.

The use of thousands of historical temperatures to create new global mapping tools provides the capability to actually visualize the World's climate change. They now allow anyone to see how temperatures have changed from one decade to another around the globe. (And, because economic activity requires energy, and most of its generation produces pollution & Dark Carbonaceous aerosols, shifts in the world's economic history can be seen in these maps. Shifts in biomass burning can also be seen in these maps.)

Most importantly, these illuminating new maps allow the comparison of actual historical climate change with those trends projected by the climate models (as seen and discussed below).

The discrepancies between the actual and predicted temperature trends are very surprising, and provide strong indicators as to which climate forcing factors may really be dominating the world's climate systems. These maps clearly show that currently accepted GHG theory climate is incomplete – at a minimum failing to account for the warming caused by air pollution and the dark carbon aerosols and metals within it.

While dark carbon aerosols are known to cause significant warming as compared to GHG on a unit to unit basis, it has been assumed that collectively aerosols cool the planet, partly because lighter brown carbon aerosols do not absorb visible light. However it has been more recently discovered that these brown carbons actually absorb even higher energy UV light.[21]

However, because many scientists are still not fully aware of the warming natures of black and brown carbons, they believe aerosol pollution reduces, or dims, sunlight reaching the Earth by scattering or reflecting a portion of that light back to space, thereby cooling the planet when it would otherwise be warming more quickly. This, and the potential cooling effect, are referred to as Global Dimming.

But the new maps and other research indicate that while aerosol pollution may be dimming, this net dimming actually results in a powerful warming effect – where some of the dimming is the result of that light not being reflected back to space, but instead being absorbed by carbon aerosols in the atmosphere, causing these particles to radiate trapped heat, first warming the atmosphere instead of cooling it, and then seasonally warming any ice and snow surfaces in which this particulate may eventually settle (explained further below).

Unfortunately many climate scientists have yet to see these maps, or had enough time to study them fully, as their fields of study are often focused on very specific research in other areas. As a result, many are unaware of the evidence showing the full extent of aerosol warming and continue to believe that CO_2 and GHGs must be the primary factor behind the climate change we are experiencing.

These Historical Climate Maps Indicate Why The Climate Models Are Not Working

The new maps clearly indicate the potential warming role of various aerosols and air pollution has not been calculated correctly.

To better understand why, this paper explores current climate theory regarding aerosols and green house gases, and from that, discusses sustainable government policy and highly profitable economic solutions that may not only solve the climate problems, but make our economies more competitive and improve living standards at the same time.

The Emerging Data on Dark Carbons and Observed Rates of Warming Challenge GHG Theory

Black Carbon, also known technically as "carbon soot", is the black powdery residue of partially burned fuel. It is almost pure carbon. Brown carbon, while not pure carbon aerosol, is a brown powdery residue that resembles soot. Both are particulate pollution formed by the incomplete combustion of carbon-based fuels and bio-mass. The burning of coal, diesel, heavy oil, natural gas, bio-mass, and forests generate the largest sources of these dark carbon aerosols.[22] But they are also produced when any hydrocarbon or organic matter (OM) is burned.

Dark carbon aerosols are not to be confused with CO_2, or other atmospheric Green House Gases. These carbons aerosols are not gases, but particulate – black or brown dusts, often microscopic and invisible – much of which travels suspended in the atmosphere until it falls back to Earth.

Many new bodies of climate data & research, some being those world maps showing actual, but unexpected, temperature anomalies through various decades, indicate that much of the recent warming seen in various regions of the planet may be driven by anthropogenic dark carbon particulate (aerosol), metals, and other emissions found in air pollution.

More surprisingly, this data also indicates that atmospheric CO_2 (considered the Green House Gas with the greatest potential for anthropogenic climate forcing capable of causing climate change) may be contributing less to warming than previously thought. As well, analysis of the Vostok Ice cores by *Stott et al.* (2007) indicates pre-industrial increases in atmospheric CO_2 and methane concentrations resulted from of planetary warming, and not the other way around as currently believed by many.[23]

Due in part to the measurements of very evenly distributed CO_2 about the planet, current climate change computer models predict warming of a relatively global nature – with the greatest warming occurring closest to the poles due to the altering of surface albedo that occurs with lost snow and ice, and with that, less capability to reflect warming sunlight.

However, the ***new maps showing historic temperature anomalies indicate the warming isn't happening in a generally global manner, but in a distinctly regional manner instead***. The Northern Hemisphere, and its most northern latitudes in particular, are warming far more quickly than predicted by the GHG computer models, while the southern most latitudes in the Southern Hemisphere are cooling, with the exception of certain specific regions subject to high levels of particulate air pollution.

Those temperature anomaly maps along, along with other emerging peer-reviewed evidence, much of which was published between 2000 – and June 2007, indicates that longer term fluctuations in the average annual anthropogenic generation of aerosol pollution, including carbon soot, could be the primary contributor to the fluctuating climate change seen since the Industrial Revolution, and more importantly, to the rapidly accelerating climate change of the past 35 - 40 years.

An earlier April 2007 analysis of much of the above research by this author led to the hypothesis that:

- certain aerosol pollution, much of which is soot, can cause extreme regional warming,
- the Arctic is in danger of collapse due to such climate forcings within 10 years,
- the regional warming that is affecting certain smaller regions of Antarctica, while the rest of Antarctica cools, appears driven by carbon aerosols, and not green house gases,
- Green House Gas (GHG) climate forecasting models do not account for aerosols properly, and are not working as predicted.

Since September 2007, this hypothesis has been further supported by: the unexpected, extreme melting of Arctic Summer sea ice; the record accumulation of Antarctic winter sea-ice in 2007 (since those measurements began in 1979); and several critically important peer-reviewed studies related to CO_2's and carbon soot's roles in past warming.
In September 2007 it was confirmed that the Arctic's summer sea-ice had retreated to a record low, 27% lower than the previous low of 2005, while in the South, Antarctic winter sea ice accumulated to a record high since measurements began in the late 1970s. These events are a surprising as:

1. The extreme melting seen in the North; lack of evidence for predicted global warming patterns; and increased freezing of sea ice in Antarctica show that GHG warming models do not predict the pattern of anthropogenic warming being seen.

2. CO_2 concentrations are very evenly spread about the planet, yet the warming is regional, and occurring mostly in the Northern Hemisphere and in other parts of the world with the highest levels of soot and other air pollution.

3. Current climate theory suggests that high levels of aerosol pollution are dimming the Sun and masking the true potential of GHGs to warm those polluted regions, keeping them cooler than less polluted regions. However new global temperature maps show that in many regions the opposite is occurring – the most polluted regions are warming fastest, and are not cooler than less polluted regions, indicating that something(s) in the aerosol pollution is causing warming.

These data and events indicate that if new climate policy is not adopted, and certain aerosol air pollutants (which are regional climate forcers) are not fully recognized and quickly brought under control in the Northern Hemisphere, the Arctic is in danger of imminent collapse.
This paper discusses research showing how and why excess anthropogenic emissions of carbon soot and other light absorbing aerosols can cause severe regional warming wherever the winds carry these atmospheric particles.

Much anthropogenic aerosol, that first concentrates locally at mid latitudes, then travels to the polar region of the hemisphere in which it was generated. Soot created in China, North America, and Europe warms those regions before traveling on to the Arctic.

Temperature maps and other data indicate dark carbon aerosols from South America and the Amazon are warming those regions locally, and then travel to the Antarctic Peninsula where they combine with soot generated by local scientific research activity fueled by diesel generators. Both atmospheric levels and the subsequent local deposition of these aerosols may be contributing to rapid melting of the Antarctic Peninsula as discussed below.

As well, data indicates dark carbon aerosols are causing dramatically increased regional warming where their generation is most intense: particularly in China, where 1-2 coal plants are coming on line each week[24]; in Europe and Asia, where many vehicles run on diesel fuel; in North America where there are both increased numbers of large cars and trucks on the road and increasing coal-fired power generation, and in Australia where coal burning has doubled since 1980.[25]

Dark Carbon Aerosols Have Driven Warming and Cooling Since The Industrial Revolution

During ***two*** specific periods of economic expansion since the industrial revolution (1880s - 1940s, and from about 1970 until today) increasing carbon soot emissions in the Northern Hemisphere produced growing, quasi-permanent, regional build-ups of atmospheric pollution, and with it, increasingly dense hazes over large areas during those periods. ***Now it's known from* Garrett & Zhao *(Nature, May, 2006) that such carbon-based haze causes regional warming.***

Moreover the research presented herein explains how longer term fluctuations in carbon haze may have caused the regional / global warming and cooling seen during various phases of economic expansion when primary energy sources being used changed dramatically during the past century.

Few realize that temperatures in the Arctic and North America warmed dramatically in the early 20th century,[26] [27] just as is re-occurring now. Historical data and other evidence presented herein indicates this may have been caused by excessive generation of carbon aerosols, mostly from inefficient coal burning in North American factories, which would have then traveled north polluting and heating the atmosphere in the Arctic, as is now known to be happening, as reported by *Garrett & Zhao* (2006).

This particulate collects in what is known locally as Arctic Haze, and is now considered one of the largest atmospheric pollution problems on the planet, at times spanning an area the size of Africa.

New data challenge current IPCC theory that warming is primarily the result of GHG accumulation in the atmosphere, and as importantly, that the full effect of GHG induced warming is being reduced by cooling caused by aerosol pollution. Instead the growing research on soot and aerosol pollution, in combination with an analysis of new maps of historical and current temperature data, indicates that ***any aerosol hazes containing enough dark carbon aerosol actually insulate & warm these areas of the planet they cover***. It explains how atmospheric soot is carried by wind currents to the respective poles. As the vast majority of anthropogenic aerosols are generated in the Northern Hemisphere, they travel north to the Arctic both heating and insulating the air there. This may explain why there is much less warming in the Southern Hemisphere as compared to the Northern.

In addition to warming the atmosphere, once such particulate settles in snow and ice, it causes a significant acceleration in surface melting, even if near-surface air temperatures initially remain unchanged. This is due to the drastic changes caused to the surface albedo – or reflective properties – of snow or ice, even when only small amounts of microscopic dark carbon aerosols are deposited.

Urban northerners witness this principle in action most winters. When a fresh layer of white snow falls on a road surface and fully covers the black asphalt below, it often remains dry and stable in bright sunshine. However, if a snow plow removes a portion of this dry snow from the road surface, moments later the exposed black asphalt immediately begins to warm, causing rapid melting of adjacent snow in the street.

White snow and ice normally reflect most radiation (90%) striking it. However, pure black carbon soot captures most solar radiation (96%), and converts it to long wave infrared radiation (IR), which melts the snow or ice that the soot particle is resting on. Further, this melting changes what was once a white and reflective surface to light-absorbing blue water, which then generates more heat, causing more melting, and ***starting a positive feedback loop driven mostly by exposure to sunshine***.

Further, when the poles tilt towards the Sun during their summer seasons, bathing large polar regions in 24 hours of sunlight for long periods of time, any exposed soot in those regions raises the surface temperature and causes continuously increased warming of snow & ice to take place.

While the global warming debate has focused on carbon dioxide emissions, Charlie Zender and Mark Flanner, scientists at UC Irvine, have determined that dirty snow can explain much of the Arctic warming primarily attributed to greenhouse gases (discussed below).

Zender June 2007, determined that in the past two centuries, the Arctic has warmed about 1.6 degrees, with dirty snow causing .5 to 1.5 degrees of the warming, or up to 94 percent of the observed change.[28]

Zender 2007 and many other earlier research papers discuss how and why soot that lands on snow and ice can cause ***surface*** warming. In addition to this, *Garrett & Zhao* 2006 shows how atmospheric soot also significantly warms the ***atmosphere***.

It's evident that soot may be responsible for the majority of warming in the Arctic if one considers the surface soot warming findings from Zender 2007 with the findings on atmospheric soot warming of Garrett & Zhao 2006. This conclusion is supported by several other factors presented in this paper, including analysis of recent satellite data and historical temperature records.

While certain infrared frequencies of light (heat) are absorbed by CO_2 and the Green House Gases, black carbon soots absorbs these as well as many other frequencies, including almost all visible sunlight, and are black for this reason. While certain types of Brown Carbon absorb very little visible light, they quite strongly absorb higher energy UV light, as discussed above.

The following chart shows why dark carbon soots and any other aerosols that absorb a wide range of radiation can have such a large warming effect in polar regions as compared to CO_2 and Green Houses Gases.

Known Effects	**Dark Carbons**	**CO_2/GHG**
Absorbs and reflects infrared	Yes	Yes
Absorbs visible and UV light reaching snow & ice surfaces causing heat that creates melting ponds capable of runaway melting of snow and ice in 24 hour sunlight	Yes	No
Absorbs visible and UV light and emits IR, thereby warming clouds and atmosphere containing it	Yes	No
Shown to cause regional warming	Yes	No
Has an increased affect in the Northern Hemisphere	Yes	No
Probable cause of 1920s - 40s regional warming in North America and the Arctic	Yes	No
Explains Antarctic mainland cooling / Antarctic Peninsula warming paradox (discussed below)	Yes	No
Explains Arctic 40s cooling / Peninsula warming	Yes	No

As mentioned above, the fact that soot may be driving more warming than previously thought is further supported by several critical research findings confirmed just this year.

1. Analysis of the Vostok ice cores (*Stott* 2007 September, Science) indicates that the trigger for the initial deglacial warming around Antarctica was the change in solar insolation over the Southern Ocean and that ultimately these forcings promoted enhanced ventilation of the deep sea and the subsequent rise in atmospheric CO_2. In other words the warming was not driven by increased CO_2, but that the CO_2 was caused by the warming, indicating that CO_2 may not be as potent a warming agent as first suspected, and that other anthropogenic factors like Carbon soot and metals may be causing more warming than previously suspected.

2. While ice in the Arctic and on most glaciers around the world is rapidly melting, the vast majority of the Antarctic is cooling, despite the fact the CO_2 levels around the planet are essentially even. ***Record accumulations of Antarctic sea ice were recorded by satellite in September 2007.*** Moreover, those regions in Antarctica where significant melting is known to be occurring are those known to be affected by soot and other aerosol pollution.

3. Since 1979 satellite images show the level of summer sea ice in the artic has shrunk by approximately 60%. Very much more troubling than that, ***the unexpected record melting of Arctic summer sea ice in 2007, to levels 27% lower than the previous record low in 2005, indicate most estimate of carbon soot warming may be too conservative, as green house gases have not increased enough to explain this, or other historical melting and freezing seen in the Arctic during the 1940s, 50s and 60s.*** In fact, current Green House Gas climate theory and models fail to accurately predict any of the recent or more historical climate change we have seen over the past 60 years.

4. *McConnell et al*, September 2007, Science, show that beginning about 1850, industrial emissions resulted in a sevenfold increase in certain Greenland ice-core black carbon (BC) concentrations, with most change occurring in winter. The source of these emissions at that particular drilling sight have been estimated to have come from North America. BC concentrations after about 1951 were much lower but increasing, which coincides with the reduction of coal use in the US economy at the time. At its maximum from 1906 to 1910, estimated surface climate forcing in early summer from BC in Arctic snow was 3.2 watts per square meter, eight times the typical pre industrial forcing value (this despite the relatively low levels of soot generation in North-East America in 1910, as compared to that now emanating from Asia, and to a lesser but still significant extent from Europe and North America today.)

More importantly, despite the significant warming *McConnell et al.* 2007 show soot has caused in Greenland, the continuous Katabatic winds have always protected Greenland from the levels of soot concentration found elsewhere in the Arctic, which can be 5 – 10 times higher, as measurements discussed below have shown.

This indicates that the much higher levels of carbon soot in heavily polluted parts of the Arctic might be capable of creating warming in the range of 15+ watts per square meter, which would explain the rapid loss of sea-ice witnessed in the last few years, and how 220m thick ice shelves on the Antarctica Peninsula could have melted so quickly.

To put this enormous amount of warming in perspective, the IPCC estimated that the global mean radiative forcing of the climate system for the year 2000, relative to 1750, amounted to 2.4 watts /sq meter.

When the above research is examined with additional data presented below, a new picture emerges indicating that rapidly increasing generation of anthropogenic Dark Carbon aerosols could lead to the catastrophic melting of Arctic summer sea ice, possibly within 4-8 years if the rate of melting seen from 2005 -2007 continues.

Dark carbon particulates are not evenly distributed around the globe – as such, neither are their warming effects.

Arctic snow samples (measured in ppbw, parts per billion by weight) taken in the 1980s, from sites in Alaska, Canada, Greenland, Sweden, Spitzbergen, and on sea ice in the central Arctic, yielded typical BC amounts of 10–50 ppbw and an average of 30ppbw (excluding Greenland at 2 - 6 ppbw).

Comparatively, pristine Antarctic regions were found to contain 0.1–0.3 ppbw, more than two orders of magnitude less than in the Arctic.[29] The primary reason for this is that the vast majority of human activity takes place in the Northern Hemisphere, leaving South Hemisphere skies relatively clear of particulate air pollution. (Not so for CO_2 and other gases, which are quite evenly distributed about the planet.) If soot pollution is a major driver of warming, this would explain why the Southern Hemisphere is not warming a quickly as the Northern Hemisphere.

(Note: As temperatures vary all over the globe, warming and cooling are measured in terms of relative changes in a region's average temperature from one time period to another.)

Only quite recently, since the late 1940s, have both local and long distance sources of BC pollution been affecting previously pristine parts of Antarctica. BC amounts of 3 ppbw (10- 30 x higher) were found 1 km downwind of the South Pole research station,[30] where the station's power plant and aircraft operations were a suspected source. Fuel consumption figures obtained from the research station show that approximately 0.4 million US gallons, or 1.55 million liters, of aviation kerosene (JP8) and heating oil are burned each year at the station.[31] BC of 3 ppbw was also reported at Siple Dome above the Ross Ice Shelf, an amount that appears to be related to local research pollution.[32]

Where & when atmospheric particulates ultimately lands depends on the size of the particle and the prevailing air currents that carry it. Fortunately, over much of Antarctica and Greenland, prominent and cold katabatic winds exist, blowing for most of the year. (Katabatic wind originates in a cooling of air at the top of a mountain, glacier, or hill. Since the density of air increases with lower temperature, the air will flow downwards, warming adiabatically as it descends, but still remaining relatively cold.)

The Katabatic winds affecting Greenland have probably prevented higher concentrations of adjacent nearby sources of BC soot from reaching the upper plateaus and may be the reason why earlier measurements of BC soot concentrations on Greenland (2 - 6 ppbw) were not as high as elsewhere in the Arctic (10–50 ppbw).

However, due to the very high overall levels of atmospheric soot in the Northern Hemisphere as compared to the Southern, it's reasonable to assume that background concentrations of BC in the katabatic winds over Greenland would be higher, possibly leading to the 2 - 6 ppbw of BC soot surface deposition measured in Greenland, which was 20 times higher than the 0.1–0.3 ppbw in Antarctica. This may explain why Greenland is melting while most of Antarctica in not.

In Antarctica, similar katabatic winds blow from the continent's center to the coastline driven by gravity. So far little BC soot has fallen on the higher elevations of the Antarctic continent, probably due to these powerful wind patterns which prevent adjacent BC pollution from landing there. This may be one reason most of these middle higher regions of Antarctica have not warmed.

But, while most of Antarctica appears to be cooling, one region – the Antarctic Peninsula – is considered by some to be the fastest warming place on Earth. This apparent paradox should raise the question – if warming is primarily caused by Green House Gases, which are evenly distributed around the planet, why isn't the entire southern polar region warming? Could this warming be caused by BC soot pollution which is known to produce regional warming?

Both atmospheric and surface depositions of BC soot on the Antarctic Peninsula are at much higher levels than on most of the Antarctic mainland, and along with other dark carbons may be contributing to rapid melting seen on the Peninsula while most of Antarctica remains stable, particularly when certain longer range and local factors are taken into account.

(Note: The Northern Hemisphere has heated up whenever there was an increase in soot generation due to economic activity, first in the late 19th / early 20th centuries when dirty coal was the primary fuel source, and then later in the 20th century with the explosion of fossil fuel use. During the late 40's, 50, and 60s, when there was a significantly reduced use of dirty fuels in the Northern Hemisphere, relative temperatures there dropped. This is a strong indicator that BC soot and other pollution may have a much bigger impact on anthropogenic warming than currently perceived by the IPCC.)

Even though CO_2 levels distribute evenly, when the Northern Hemisphere began to cool in the late 40's, the Antarctic Peninsula began to warm. The reason could be tied to increased use of dirty fuels in Antarctica & South America, and to biomass burning in the Amazon which began around then.

Since the late 40's, the Antarctic Peninsula has been exposed to continuous and increasingly higher levels of diesel & heavy oil soot emissions from research station power plants, ***and*** from long range dark aerosols coming from bio mass burning in the Amazon (*Pereira et al.* 2006). However, most of mainland Antarctica has not been significantly exposed to soot deposition due to the same type of katabatic winds helping to limit Greenland's exposure to soot levels seen elsewhere in the Arctic.

There are 82 research stations on the continent, with many placed about the perimeter. However a dense concentration of 35 stations are on the Peninsula, positioned just a very short distance upwind of what used to be the enormous Larsen A & B Ice Shelves. Larsen A (closest) and B (slightly further away) spectacularly broke up in 1995 and 2002 respectively. Fuel consumption records show at least 4.8 M liters, or 1.25 M US gallons of soot-generating diesel fuel are burned each year at these 35 research stations, with the vast majority of that being consumed in the summer months when research activity is greatest, and summer sunlight exposure longest.

Even though the total local research emission levels may not seem high when compared to other parts of the world, because the Larsen A & B Ice shelves were very close and downwind to these stations:

1. those emissions remain quite concentrated due to the short distance to Larsen A & B,
2. they are further compounded by long range pollution also now arriving from the Amazon, and,
3. since there were essentially no BC emissions in the region previously, any introduction of BC to the area could dramatically alter the surface albedo and atmospheric conditions that allowed the ice shelves to form in the first place.

This combination of factors may have been enough to cause the surface melting and melting ponds confirmed to have penetrated Larsen B's enormous 220 meter thickness in just a few short years.

Moreover, because cyclonic winds blow in off the ocean, causing local winds to circulate about the entire Antarctic coast in a clock-wise direction, the Peninsula is also downwind of Antarctica's largest research station, McMurdo, which houses as many as 4000 people and has 19 bulk storage fuel tanks with a capacity of 8.7 million gallons of fuel. Fuel consumption figures obtained from McMurdo show that approximately 2.5 million US gallons, or 9.4 million liters, of diesel fuel and heating oil are burned each year at the station.

This is more than 6 times the fuel levels burned at the South Pole Station that increased downwind soot deposition there 10-30 x over pre-station levels. Therefore its plausible that McMurdo has increased local soot deposition to levels 60 - 180 x higher than pre-station levels – levels of similar magnitude to those seen in the highly polluted Arctic. Those higher local concentrations would have their greatest effects on the Ross Ice Shelf and other areas closest to McMurdo in West Antarctica, now known to be warming.

In May 2007 Son Nghiem of NASA's Jet Propulsion Laboratory in Pasadena, Calif., and Konrad Steffen, director of the Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder, published research and maps (see below) showing vast regions of West Antarctica, directly downwind of McMurdo, melted in January 2005.

It was the first widespread Antarctic melting ever detected with NASA's QuikScat satellite and the most significant melt observed using satellites during the past three decades. Combined, the affected regions encompassed an area as big as California.

The observed melting was not spread about generally, but occurred in multiple ***distinct regions***, including far inland, at high latitudes and at high elevations, where melt had been considered unlikely. Evidence of melting was found up to 560 miles inland from the open ocean, farther than 85 degrees south -- about 310 miles from the South Pole -- and higher than 6,600 feet above sea level.

As the maps found herein show, the largest area of warming in the Antarctic region is on the West coast, and begins directly down wind from the massive McMurdo research installation.

BC soot from McMurdo potentially threatens the Ross Ice Shelf, which is warming quickly. The Ross Ice Shelf is the main outlet for several major glaciers draining the West Antarctic Ice Sheet, which contains the equivalent of 5 m of sea level rise in its above-sea-level ice.

Several factors make the warming scenario specific to the Antarctic Peninsula – one that was capable of rapidly melting ice 220 meters thick – somewhat unique as compared to most other polar regions.

First, as the vast majority of human activity occurs in the Northern Hemisphere, the Arctic has been subject to significantly increasing dark carbon aerosol loads for the past 150 years, and for many hundreds of years before that. As such, the initial climate changes due to increased pollution there happened prior to humankind's ability to measure this. That said, as warm as the Arctic was in 2000, we know that it was just as warm for a brief period at the height of the world's first coal burning era in the 1930s and 40s, as is discussed further below.)

However, much of South America, the Antarctic Peninsula, and the Antarctic mainland had been free of any significant man made pollution prior to post WWII development that only began 60 years ago.

Secondly, the prevailing winds over the very narrow Antarctic Peninsula are unique. Amazon and South American dark carbon aerosols in those winds arriving at the Peninsula from the north are then blown across the Peninsula from west to east by continuous and dominate winds circulating around Antarctica. As the Larsen Ice Shelves are found on the Peninsula's eastern side, the ice shelves are not only subject to particulate arriving from the north, but local regional pollution from research stations very nearby on the western side also reach the short distance traveled to the eastern side in higher concentrations. And, most of these local research emissions would arrive during the busy summer research season, at the time of maximum exposure to 24 hour polar sunlight.

The dramatic regional melting seen on the Peninsula and other specific regions of Antarctica serve as a warning of what may occur in the Arctic in the presence of prolonged 24 hour sunlight should excess atmospheric BC and BC surface deposition continue to rapidly escalate from China / India, and at more gradual rates from Europe, North America, and elsewhere.

Arctic sea-ice is a fraction of the thickness of the 220M thick Larsen Ice shelves. Comparison of Arctic sea-ice draft data acquired on submarine cruises between 1993 and 1997 with similar data acquired between 1958 and 1976 indicates that the mean ice draft at the end of the melt season has decreased by about 1.3 m (42%) in most of the deep water portion of the Arctic Ocean, from 3.1 m in 1958 -1976 to 1.8 m in the 1990s.[33] According to US Navy computer models, the thickness of the sea ice reaches its annual maximum during the month of May. It reaches its annual minimum (about one meter less) in September. [34]

In 2006 *Holland, Bitz & Tremblay* indicated that all Arctic summer sea-ice could melt as soon as 2040 – shocking enough. That estimate was based on data from 2005 going back approximately 30 years. They indicated the ice retreat will accelerate as thinning increases the open water formation efficiency for a given melt rate and the ice-albedo feedback increases shortwave absorption, and that the retreat is abrupt when ocean heat transport to the Arctic is rapidly increasing.

Author Tim Flannery gave a newly updated estimate in a February 2007 speech. While only a rough approximation, he further adjusted earlier peer-reviewed projections of retreating ice to reflect the record decline seen in 2005. He calculated that should it continue at that rate, the complete melting of Arctic summer sea-ice will happen very much sooner than the 2040 prediction. Adding the new data to previously existing curves plotting melting, Flannery extended the estimated melting curve to project where all the summer-ice has melted. The two lines intersected somewhere between 2010 and 2020. He admits this isn't the way science is normally done, but at the same time it is a potential indicator that can't be ignored.[35]

Since Flannery's remarks, ***the unexpected melting of 27% more Arctic summer sea ice in 2007 as compared to the previous record low in 2005, indicates Flannery's estimate may even be too conservative.***

This and other very urgent indicators call for the use of the Precautionary Principle when determining both immediate and future inter-governmental policy affecting Climate Change.

Spring snowmelt on tundra in Siberia, Alaska, Canada, and Scandinavia has trended earlier, by 2–5 weeks, in recent decades. The magnitude of this shift exceeds that in climate model simulations with realistic global warming,[36] suggesting that other mechanisms contribute to the early snow disappearance.

BC soot deposition levels found in snow at lower latitudes in the Northern Hemisphere are highly variable, usually in the range 5–100 ppbw. Larger amounts found in the French Alps, ~100–300 ppbw,[37] may be related to the high proportion of diesel engines in European surface transportation. *Hansen & Nazarenko* (2004) estimate that it seems likely that East Asia snow has large BC amounts, because China and India are now the largest sources of BC emissions, and photographs (see cover) reveal a thick brown haze filled with BC that butts up against the Himalayas,[38] but measurements are lacking.

Continued melting of the world's glaciers may cause fresh water shortages and draughts in any part of the world relying on glacial feeds for such, as in India, China, Europe, and North & South America. Many of the melting glaciers in the Andes are subject to unprecedented local air pollution problems in the cities below or nearby.

While black and brown carbon deposition in snow and ice is clearly a major problem, the problematic effects of those carbon aerosols in the atmosphere are also increasingly clear.

This paper provides analysis of temperature data from world climate maps developed using both historical and more recent NASA data. The warming potential of low altitude BC aerosol haze indicated in these maps may explain the ***three distinct periods*** of regional warming & cooling experienced regionally & globally in the post industrial revolution era since 1850.

The first period, one of ***warming*** seen from about the 1880s to the early 1940's, appears to have been most severe in North America and the Arctic, and could have been caused by the continually increasing use of highly inefficient, incomplete coal burning, which at its height generated massive amounts of heat-generating black carbon soot in North America. Moreover, based on known wind patterns, this soot would have drifted north to cause the severe warming in the Arctic region in the 1920s, 30s, and 40s.

Records for the period compared to year 2000 show: the Arctic and North America were as warm; while most of the world elsewhere was not as warm. This can not be explained by GHG theory, as:

1. CO_2 is very evenly distributed throughout the Earth's atmosphere (global), whereas that warming was regional.
2. CO_2 was at far lower atmospheric concentrations in the 1920s, 30s, and 40s when temperatures first soared in North America and the Arctic, and moderately elsewhere.

The second period, one of variable regional & global ***cooling*** starting in the late 1940s through to the 60s, occurred as world economies replaced significant amounts of highly inefficient coal burning with cleaner burning oil and gas, resulting in a dramatic reduction of dark carbon emissions in such regions. Again, North America and the Arctic cooled more than most regions, probably because intense coal emissions there were dramatically reduced. Interestingly China cooled dramatically as the economy collapsed during Mao's reign. (The main body of this paper also explains why sulphate aerosol pollution would not be primarily responsible for such cooling as currently thought.) As the Northern Hemisphere was cooling during this time, the Antarctic Peninsula was beginning to warm, most likely due to the beginning of bio-mass burning in the Amazon and the beginning use of diesel fired research stations on the Peninsula.

Since the beginnings of the OPEC oil crisis in the early 1970s, ***a third period*** has seen ***significant warming in many more regions***. (As discussed above, as CO_2 concentrations are dispersed very evenly around the globe, if this warming was primarily because of CO_2, then per current IPCC theory the Southern Hemisphere should be warming more than the Northern Hemisphere, as the Northern Hemisphere should see offsetting cooling due to dimming effects of heavy aerosol pollution found there. However recently available temperature anomaly maps show the opposite is occurring.)

This third phase – the most dramatic period of warming – has probably been caused by the explosion in the number and power of fossil fuel internal combustion engines and coal-fired power plants around the world since then. The introduction of cheap cars in the 60's led to an upsurge of car use in Europe and elsewhere. Moreover in the last ten years: coal burning has increased in India and the

United States, and nearly doubled in China; SUVs have become commonplace in North America; and European and world transportation has shifted heavily towards diesel from gasoline.

Despite significantly improved BC emission efficiencies over early industrial-revolution-era technologies, the sheer volumes of combustion have led to significant increases in BC and other aerosol pollution. This may be causing a re-warming of North America, more significant regional re-warming in the mid latitudes of the Northern Hemisphere in Europe and Asia, and further increases in Arctic pollution, bringing a re-warming, extensive soot deposition, and the extreme melting of snow and ice there.

To summarize the supporting peer-reviewed research:

Stott 2007 shows pre-industrial revolution changes in solar insolation over the Southern Ocean promoted enhanced ventilation of the deep sea and the subsequent rise in atmospheric CO_2.

In May 2007, *Stroeve et al.* published research which raises more questions about GHG theory by showing that:

- arctic melting is happening approximately 3 times faster than in the most recent projections, and at a rate far beyond any predictions of GHG theory and modeling,
- The arctic ice pack is on track to completely melt 30 years sooner than previously predicted
- GHG models are not correctly predicting this - hence there is something wrong with the models
- and as such, " The sensitivity of this region may well be greater than the models suggest."

And while the global warming debate has focused on carbon dioxide emissions, in June *Zender* 2007 determined that dirty snow alone may explain up to 94% of the Arctic warming primarily attributed to greenhouse gases.

McConnell et al 2007, show after 1850, North American industrial emissions at times resulted in a sevenfold increase in certain Greenland ice-core BC concentrations. Estimated surface climate forcings reached 3.2 watts per square meter, eight times the typical pre industrial forcing value.

Earlier work by Clarke, Noone [1985], Chylek et al. [1987], Warren, Hansen, Jacobson, Nazarenko, and many others discussed the emerging evidence of Black Carbon's climate forcing effects. Now, *Garrett & Zhao* 2006 have shown how soot in the atmosphere is significantly heating the Arctic climate, in agreement with the evidence presented herein. They show that mid latitude pollutants are warming the far north. "Now we are finding there is another way pollution can warm up the Arctic. Particulate pollution from factories and cars can be transported long distances to the Arctic, where it changes clouds so that they become more effective blankets, trapping more heat and further aggravating climate warming." The instrumentation used in their study showed the particulate pollution from mid-latitude cities mixes with thin clouds, making them better able to trap heat.[39]

In May 2007 Nghiem & Steffen, showed vast regions of West Antarctica melted in January 2005. The observed melting was not spread about generally, but occurred in multiple ***distinct regions***, including far inland, at high latitudes and at high elevations, where melt had been considered unlikely. The research in this paper shows all those regions are suspected of significant BC soot contamination.

As well, *Pereira et al*. (2006) provide evidence of how both locally generated BC soot from researcher's diesel generators and long distance BC from Amazon fires may be warming the Antarctic peninsula, while leaving other parts of the Antarctic still unaffected.

Research shows why such blankets of BC haze are not unique to the Arctic, or the Antarctic Peninsula, and that they are found in all industrialized areas of the world, ***but mostly*** in the Northern Hemisphere. This new evidence, when combined with other recent findings, conclusively shows that where there are significant accumulations of Black Carbon, there is significant warming.

Nobel laureate Mario Molina's recent research is further support of this. In a March 2007 study, Molina used a host of satellite measurements to analyze intense Pacific storms following wind-blown bursts of soot from the booming factories of Asia. His team found BC soot is warming the clouds that cross the Pacific Ocean, causing intense storms, like those that struck the North America's North West in December 2006, and the one that destroyed thousands of ancient trees in Vancouver's Stanley Park.

Because of all this new research, our rapidly growing understanding of microscopic dark carbon soots may soon affect currently accepted theory on Global Warming long believed to have been well understood.

Using the New Climate Data to Clarify and Generate Effective Policy

One reason so little has been done about climate change is that the subject as presented today is complex, and with many conflicting facts and opinions. As such, most business and government leaders are unsure of what to believe, and where and how to start to deal with it.

However as discussed above, simple principles and relationships often underlie complex subjects. And once identified, they can be very helpful to demonstrate the validity of various theories in a manner anyone can understand.

The problem of BC soot has become very apparent in Montreal where I live. A rapid resurgence of the economy and local air pollution there since 1995 caused noticeable changes to atmospheric factors that might affect climate – specifically the dramatic increase in the frequency of brilliant sunsets in the weeknight skies caused by the scattering of red light.

This led to my questioning whether particle pollution was also scattering and/or reflecting infrared radiation (IR) found just below the red light wavelengths, and if so, was it possibly leading to a net reflection of warming IR back to Earth instead of out to space?

Then in Northwest British Columbia, beginning in the latter 1990s, the normally pristine air there began to develop a haze that was not the usual seen with forest fire smoke. I wondered if it might possibly be pollution from China and Asia. Now we know that it was and still is.

We also now know dark carbon haze not only reflects IR back to the surface, just like a GHG would, but that dark carbon's light-absorbing nature also causes this haze to absorb sunlight, transforming it to IR, and warming these low altitude hazes themselves, thereby potentially producing more warming than possible with GHGs, which do not absorb and transform sunlight, but merely reflect IR back to Earth's surface.

As a Canadian, this gave me a deeper understanding of the "clear, cold days" of years past.

I was trained in environmental science & economics, and first worked on Wall Street in energy related finance work. About 15 years ago, after observing so many indicators that climate change was real, and occurring much too quickly to be natural, I intensified my research into both the science, and the technologies & policies necessary to ensure efficient solutions and transitions for businesses, governments, and consumers.

Initially the objective was to outline simple warming relationships that could be used to quickly explain warming science, problems, and solutions to those in positions of influence in business or government.

To be most effective, I felt those scientific relationships needed to be based in empirical evidence – not controversial climate prediction models capable of producing erroneous conclusions, which might lack the credibility demanded of evidence for such a contentious and critical world issue.

As such, this analysis relies almost entirely on empirical observation and temperature data. As discussed above, the newly created temperature anomaly maps based on historical NASA data, now offer an unprecedented view of where, when, and how much the Earth has actually warmed. These maps are not based on theories, just hard data of historical temperature changes.

What was so surprising when first seeing these new temperature anomaly maps is that they clearly show ***highly regional*** warming – these maps do not look like the hypothetical maps projecting warming based on current GHG theory. In fact they look quite the opposite in many regions.

Further analysis of this empirical data leaves little doubt that air pollution & dark carbonaceous emissions are contributing to the serious warming that is happening so much faster than predicted, and that soot deposition on snow or ice surfaces in polar regions may even be a far more powerful driver of melting than that caused by near surface air temperatures.

There is both bad and potentially good news with these findings.

The bad news is that the data & melting trends indicate that if serious changes to daily ways of doing business are not achieved within 5 years, the World is literally on the eve of an unprecedented planetary crisis. A date in history that might be analogous to today is 1933, although this problem is far bigger than that posed by WWII when it broke out 6 years later.

Collectively the evidence provided herein shows that planetary warming is at a far more critical stage than reported in the media or by the IPCC.

The data suggests:

- regional warming on a global scale is happening far faster than the IPCC acknowledges
- the Arctic ecosystem and food chain is showing significant signs of impending collapse
- the rest of the Earth's ecosystem is dependant on a cold Arctic climate
- dark carbon soot pollution may be a / the primary driver of planetary warming
- Soot may be responsible for the vast majority of warming in the Arctic if one combines the surface soot warming findings from *Zender* 2007 with the findings on atmospheric soot warming of *Garrett & Zhao* 2006
- GHGs may not be as critical, at least not in the immediate shorter term
- conventional diesel, heavier oil, and coal burning are the biggest generators of soot
- to stop more warming caused by soot and/or GHG requires new power technologies
- Kyoto is not remotely sufficient to solve the problem, and doesn't address soot
- Humankind has too quickly forgotten the plague of tuberculosis and other illnesses that stalk society in times of coal and other serious air pollution
- China, not knowing better, is building 700 more coal-fired plants: 1- 2 new plants per week. They will have to change course just because of the national health crisis that is building
- world leaders and governments are far from organized to quickly solve this problem
- they need practical tools to get up to speed
- ***to succeed, they'll need a viable and profitable economic/business plan, as recently humans have shown they won't do much unless there is profit involved.***

The good news is that, as awesome as this problem appears to be, it may not be as hard to address as we currently believe because:

- most soot particles fall back to Earth within days to weeks where Green House Gases do not
- if soot is the major climate forcer indicated, we are fortunate, as while GHGs can not be quickly reduced, fossil fuel use and soot can be reduced much sooner, and once it is, the data indicates temperatures will fall
- The technology and financing necessary to solve the problem are readily available
- Wind sources alone can provide 5 – 7 times the power the world uses now [40]
- Enough sunlight reaches the earth in an hour to power the world for a year [41]
- Solar Panel technology developed by Boeing has just reached 40.7% efficiency [42]
- The use of Hybrid cars can eliminate 70-75%[43] of driving emissions in congested cities

- Implementation of such technologies will make any economy much more competitive
- ***Tax incentives to act as an invisible hand to guide market forces can bring rapid change to make individual economies significantly more competitive than today's***
- ***Once one economy becomes more competitive, the others must soon follow out of financial necessity***
- ***Solving this problem makes the entire world economically much richer and healthier***
- ***World leaders are ready to act if a sensible plan is developed.***

90 years ago, when there was little ability to communicate as compared to today, the world none the less began rapidly converting from coal to oil & gas due to the significant economic and practical advantages.

Superior, cost-effective technologies are starting to take over once again. While most older energy producing technologies in use today cost less up front to implement, they require constant fuel & cash expenditures to keep running. New fossil-free technologies cost more up front, but little or nothing to run. Governments need to implement ***simple*** plans to stimulate rapid capital investment in these superior technologies. (Part Two of this paper, to be released shortly, outlines such a fiscal plan.)

Due to the ability to instantly communicate and share information with billions via email and on the web, a well coordinated strategy can:

- rapidly educate the world about the causes of our current climate problems,
- instantly deliver strategic & profitable policy solutions to the world's government, business, and media leaders,
- quickly reveal the obvious economic, practicality, and health advantages of the next generation of energy technologies just waiting to be used.

This will make it easier for governments to enact policy to stimulate the rapid corporate and consumer investment in technologies necessary to stabilize the climate and save the planet.

Both consumers, and the world's industrial & energy companies that will build and fuel the modified machines, will require capital financing, and the cooperation of governments to provide short-term incentives and guarantees to the financial services industry providing that capital.

As such, we are developing electronic and printed educational & planning media to allow business leaders, researchers, policy makers, and the public to grasp the problem and profitable solutions to solve it. These are designed to help clarify the science and to provide a strategic framework for national & international fiscal policy to enable rapid world wide investment in the new technology required to halt warming.

To avoid climatic disaster, much of the transition to a particulate-free, sustainably-powered economy must be completed in less than 10 years. This can be done, just as occurred 90 years ago, if billions of independent business and household decision makers around the world are led to common action by obvious economic benefit, just as has occurred more recently in the computing, information management, and telecommunications industries.

As such, our collective task is first educating, and then providing the financial and technical models to allow leaders in China, India (and their financial partners) the US, Europe, and the rest of the world to implement simple plans to sustainably and profitably generate, life-sustaining power.

The ultimate presentation formats for delivering this intellectual capital will be capable of quickly providing consumers and business & government leaders with the necessary information through:

- brief Abstracts,
- hyperlinked executive summaries, which will link to
- the full body of research evidence for scientists, the public, and policy makers.

Part One, that you are reading now, reviews new science regarding warming, and briefly discusses the new direction potential international & government fiscal policy and corporate & consumer investment must take to avoid a rapid worsening of the current crisis.

Part Two, to be released shortly, goes beyond the scope of a scientific research paper. It considers the major implications these scientific findings will have in broad terms and will:

- outline sustainable fiscal policy for national and international governing bodies to stimulate profitable corporate & consumer investment in such solutions,
- provide comprehensive infrastructure planning models for the most efficient integrations of technology to reduce BC soot in countries around the world. These models will include visual tools – including computer modeling of various technologies, plans, maps, etc. – based on existing infrastructure, natural resources available, and the political and economic scenarios affecting each of those countries or regions,
- outline complimenting corporate and consumer financial models required for rapid private and public implementation of these solutions,
- identify potential corporate & consumer partnerships to capitalize on these investment opportunities,
- provide an overview of the type of international policy and cooperation required to rapidly achieve this – much in the manner of a modern day Marshall Plan.

The Kyoto Protocol at the time of its drafting appeared to be a necessary and admirable start. But even if CO_2 turns out to be the single greatest climate forcer, Kyoto is not remotely enough to slow the current pace of warming, as if the current warming is primarily due to the 388 ppm level of CO_2 in the atmosphere (up from pre-industrial levels of 280 ppm), the planet will clearly not tolerate the IPCC's targets of 550 ppm, as even the full affects at 388 ppm won't be realized for years.

Moreover, if the research on soot continues to firm, Kyoto, or its successor, needs significant enhancing to address soot emissions, and just as importantly, a new structure that attracts governments, businesses, and consumers because they are economically better off joining the agreement.

Developing profitable models for consumer & industry financing of more efficient heating, power generation and transportation technologies that eliminate the production of Carbon soot air pollution is imperative.

Whether desirable or not, money drives most decisions – so the solution can, and must, be profitable for business, consumers, and governments if it is to succeed. This paper represents a start to such a plan.

The implementation of profit & market driven measures by world governments can rapidly accelerate both the innovation and world-wide implementation of new economically-superior infrastructure required to stabilize climate.

The implementation of fiscal policy that encourages the financing of more efficient energy technologies will make any nation's economy superior through the increased efficiencies achieved. ***This will force the other national economies to follow, or to risk becoming less competitive.***

Worldwide investment programs to reduce BC soot must start immediately. The combined effects of quickly accelerating Northern Hemisphere particulate emissions are rapidly devastating the Arctic climate.

Incentives to eliminating the worst BC soot offenders first – such as coal, marine diesel, land diesel, and jet kerosene – appear imperative to the success of any plan. Europe's temperatures are rising along with its diesel emissions. China is warming at almost twice the world average with its coal pollution.

While most BC soot particulate falls back to Earth, this may not be the case for aircraft BC emissions, which are steadily collecting at altitudes between 8 - 11km up, and which may remain there for many hundreds of years.

And, even if CO_2 proves not to be the primary climate warmer, anthropogenic emissions still need to be eliminated, and possibly recaptured, as they are turning the oceans overly acidic.

Ultimately the solutions to reducing carbonaceous aerosols and CO_2 are one in the same – the elimination of fossil fuel combustion emissions.

Future generations will remember this as the time in history that required Humankind to react and move more quickly then ever before.

Part 1

The Dark Carbonaceous Aerosol Regional Warming Model:

Appears to Explain Both Earlier Industrial Revolution Climate Data, And The Recent Dramatic Melting In The Arctic and Antarctic Not Explained by Green House Gas Models

Abstract

Aerosol hazes containing carbon soots are formed by the incomplete combustion of fossil fuels and bio-mass. Analysis of temperature anomalies indicates that low altitude carbon hazes, both in the late 19^{th} and early 20th century and again today, have been driving a significant portion of near surface warming, above and beyond that attributed to rising levels of GHG in the atmosphere.

These hazes are causing a rapid acceleration of ***regional*** planetary warming, particularly in the Northern Hemisphere, where most transport emissions, coal burning, and forest fires are occurring. The data suggests that while carbon aerosol hazes causing dimming, they are also both absorbing incoming sunlight, and by enhancing the dispersion of water droplets in the atmosphere, dramatically enhancing the reflection of IR back to the surface, thereby warming & insulating the planet.

The new data also appear to explain the significant fluctuations in global temperature seen in the 20^{th} century, and suggest that deposited soot particulate is dramatically accelerating the melting of arctic ice and snow, by altering the albedo of the surface and leading to an increase in surface melting that transfers heat along the melting surface without significantly increasing near surface temperatures.

These findings contradict mainstream warming theory which hypothesizes 1) most global warming is caused by Green House Gas (GHG), and 2) that such warming is being significantly offset by the cooling “dimming” effects of aerosol pollution reflecting sunlight back to space before it can heat the planet’s surface.

There are many potential ramifications indicated by these findings:

If carbon fuel particulate emissions are not dramatically reduced or eliminated, regional global temperatures, particularly those in the Northern Hemisphere should continue to rise more rapidly than currently predicted. As planetary warming appears highly regional and not evenly distributed, the use of global average temperatures has been, and continues to be, misleading.

The Arctic Haze, caused by dark carbonaceous, metal, and other aerosol emissions originating from the mid latitudes in the Northern Hemisphere, is very problematic, and appears to be the major contributor to extremely rapid surface-melting of ice and snow in the Arctic region due to the continuous settling of soot on the ice’s surface. Rough approximations generated using the most recent figures recording the rates of summer sea melting indicate all arctic summer sea-ice could melt within 4- 8 years. Because of this, the overall stability of the Northern Hemisphere’s ecosystem, and thus that of the world, could be in jeopardy within a decade. Water supplies, forests, animals, fish, and other species are already being significantly affected.

However because most carbon fuel particulate emissions are low-altitude particulate, and have a very limited life in the atmosphere (days - weeks), if they are dramatically reduced, most existing particulate will drop out of the atmosphere, resulting in an equally rapid cooling of affected regions. Aircraft BC emissions, which can remain trapped at higher altitudes for many hundreds of years, may be a much more serious problem in the future.

Overview

This paper explains why excess atmospheric carbonaceous aerosol (soot) emissions dramatically warm regional climates in three distinct and cumulative manners by:

- directly warming the atmosphere,
- affecting water droplet formation in the atmosphere, enhancing regional green house effects
- causing rapid melting once deposited in snow and ice

The geographic regions affected are large. They begin at the source of the pollution and extend as far as the winds carry the particulate before it settles out of the atmosphere, much of it carried North into the Arctic, but also to the glaciers of the Himalayas, Alps, Andes, and Pacific coast mountains, and on to the ice sheets of the Antarctic Peninsula.

The empirical and peer-reviewed evidence presented herein shows that the warming caused by these anthropogenic particulates appears to be driving the majority of warming forcing experienced today. Further, the evidence indicates that while still a potentially significant problem, anthropogenic Green House Gases do not appear to be playing as large a role in the current warming trend as currently thought.

Future climate change policy must quickly address particulate emissions, and then address GHGs.

Introduction – The Unexpected Effects of Certain Particulates on Climate

When the Green House Gas theory was first postulated by Swedish physical chemist Svant Arrhenius in 1896, scientists we not aware of the direct warming effects of carbonaceous aerosols (soot) on the atmosphere, or of their affects on cloud condensation nuclei (CCN) and ice nuclei, or of their effects on snowpacks exposed to sunlight. Many climate scientists today are still not aware of these effects.

However, many scientists do recognize that the largest uncertainty in the radiative forcing of climate change over the industrial era is that due to aerosols, a substantial fraction of which is the uncertainty associated with scattering and absorption of shortwave (solar) radiation by anthropogenic aerosols (IPCC, 2001).[44]

Quantifying and reducing the uncertainty in aerosol influences on climate is critical to understanding climate change over the industrial period and to improving predictions of future climate change for assumed emission scenarios.[45] Measurements of aerosol properties during major field campaigns in several regions of the globe during the past decade are contributing to an enhanced understanding of atmospheric aerosols and their effects on light absorption & scattering and climate.[46]

Rosenfeld 2000, in collaboration with NASA, shows the large concentrations of small CCN in the smoke from burning fuels and vegetation nucleate many small cloud droplets,[47] preventing rain from falling and causing many well-known effects, including droughts.

However, as this paper explains, those increased numbers of smaller droplets also appear to cause positive warming feedbacks due to increased atmospheric water vapor absorption of the Earth's heat.

This paper also shows why soot that eventually deposits on snow or ice exposed to sunshine causes very rapid melting.

The explosion in unfiltered aerosol emissions from the economic boom of the last 10 years is driving much of climate change we are seeing today.

The most significant increases in light-absorbing carbonaceous aerosol emissions are from South East Asia, due primarily to unprecedented economic development.

China alone has increased world coal consumption 24% in just 10 years, and 11% in just the last 3 years. Oil consumption in China has also exploded in just 10 years, increasing almost 100% from 3.9M B/D to 7.7M B/D in 2007. This has been accompanied with steadily continued growth of diesel use in the western economies.

As can be seen in the photos below, most particulate emissions from the developing world are unregulated and unfiltered. Much of this dark particulate drifts into the Arctic where it is causing very rapid melting of snow and ice.

Left: Chinese oil refinery - Reuters

Research now shows how rapidly increasing emissions of various classes of dark carbonaceous aerosols are causing both atmospheric and surface warming in many different ways that were not previously understood.

When these very significant carbonaceous aerosol forcings are added into the mathematical balance that quantify the total observed warming, it's readily apparent that other warming factors, like GHGs, must be contributing less to the current warming trend than previously thought. This is supported by many new bodies of scientific evidence showing that GHGs are less of factor in both the past Ice Ages and the present warming being caused by anthropogenic fuel burning.

This paper shows that for more than a decade various regions of the world's climate, particularly in the Far North, have warmed far faster than predicted by the most advanced climate models based on GHG gas theory.

Further, because various aerosol forcings have not been properly accounted for in these models, when the climate models are run in reverse they fail to predict actual climate history and the cooling that occurred in the 1950s and 60s.

This clearly indicates there is something wrong with the climate models being used to predict climate change. This isn't surprising. Because there are so many weather variables to predict, climate models are almost infinitely complex to design and very hard to get working properly.

Examining The Factors Driving Climate Change – Why Current Climate Models Failed

Anthropogenic climate change is being caused by changes in the way solar radiation is reflected or absorbed by various molecules of gas, liquid, or particulate found in the atmosphere, in water, or on land, snow, and ice.

Climate modelers try to build accurate climate prediction models based on these known relationships. To do this they use well established principles regarding light and solar radiation that allow the calculation of the energies absorbed by various compounds in our ecosystem.

While these formulas are quite simple, the incredibly complex climate models built with them are not.

For more than a decade various regions of the world's climate, particularly in the Far North, have heated up far faster than predicted by the most advanced climate models. As well, when the climate models are run in reverse, they fail to predict recent climate history.

This means there is something wrong in the climate models we are using to predict climate change. This isn't surprising. Because there are so many weather variables to predict, climate models are infinitely complex to design and very hard to get working properly.

That said, there is nothing wrong with the basic formulas for energy absorption being used in these models, but rather, in how the various principles may be arranged in any climate prediction programs, ***and***, whether other key relationships may have been omitted from the programs.

Fortunately, individual climate modulators (like Co2 or certain particulates) have distinct signatures, and these signatures can now be easily seen on new global maps that show various eras of temperature change. Because of this, we can now see which of these basic modulators are having the greatest affects.

As the relative weights of each of these basic modulators is better understood, scientists are better able to see which anthropogenic factors are having the greatest affects on climate. This in turn can help policy-makers effectively fine tune the world strategies and policies necessary to reduce anthropogenic activity driving the very rapid climate change that threatens Earth.

Most are familiar with Green House Gas warming theory. Because these gases are quite evenly spread through the atmosphere, they are thought to cause warming that is more ***global*** in nature.

But the emerging research & temperature data now show that lesser-discussed ***regional*** warming factors related to carbon soot and other aerosols, are significantly altering scientific understanding of how light's energy can be absorbed and reflected in our environment.

The actions & effects of these regional aerosols are:

- not hard to understand
- easily observed in the environment
- related to air pollution rather than green house gases – specifically various types of particulate, or solid non-gaseous matter, found in smog.

Various types of soot, metals, and other pollution appear to be causing very significant, large-scale, regional planetary warming due to climate forcing factors not previously considered.

New Maps and Other Data Show The History of Planetary Warming in a New Light

The very rapid increase in soot and other particulate emissions over the last decades may explain the rapid warming in various regions of the world today.

Similar earlier increases in soot generation appear to explain previous warming in North America & the Arctic in the 1920s, 30s, and 40s, when there was no significant accumulations of GHGs in the atmosphere. Instead, back then there was extreme air pollution that resulted from earlier, dirtier methods of burning coal during the industrial revolution. This would also explain why, when such pollution diminished in the 1950s and 60s, significant cooling occurred in many parts of the World. However, since then, with the World's tremendous surge in energy use (initially marked by the OPEC oil crisis of the early 70s), regional air pollution and temperatures have once again been climbing.

As discussed above, because Green House Gases are quite evenly distributed throughout the planet's atmosphere, GHG theory predicts a warming of a distinct and somewhat global nature.

Until recently, it has been difficult to ascertain whether the world was warming as predicted by the increase of GHG. But then in 2005, NASA's GISS world temperature data was assembled to create global temperature anomaly maps that clearly show the changes from one era to another.

The use of thousands of historical temperatures to create new global mapping tools provides the capability to actually visualize the World's climate change. They now allow anyone to see how temperatures have changed from one decade to another around the globe. (And, because economic activity requires energy, and most of its generation produces pollution & Dark Carbonaceous aerosols, shifts in the world's economic history can be seen in these maps. Shifts in biomass burning can also be seen in these maps.)

Most importantly, these illuminating new maps allow the comparison of actual historical climate change with those trends projected by the climate models (as seen and discussed below).

The discrepancies between the actual and predicted temperature trends are very surprising, and provide strong indicators as to which climate forcing factors may really be dominating the world's climate systems. These maps clearly show that currently accepted GHG theory climate is incomplete – at a minimum failing to account for the warming caused by air pollution and the dark carbon aerosols and metals within it.

While dark carbon aerosols are known to cause significant warming as compared to GHG on a unit to unit basis, it has been assumed that collectively aerosols cool the planet, partly because lighter brown carbon aerosols do not absorb visible light. However it has been more recently discovered that these brown carbons actually absorb even higher energy UV light.[48]

However, because many scientists are still not fully aware of the warming natures of black and brown carbons, they believe aerosol pollution reduces, or dims, sunlight reaching the Earth by scattering or reflecting a portion of that light back to space, thereby cooling the planet when it would otherwise be warming more quickly. This, and the potential cooling effect, are referred to as Global Dimming.

But the new maps and other research indicate that while aerosol pollution may be dimming, this net dimming actually results in a powerful warming effect – where some of the dimming is the result of that light not being reflected back to space, but instead being absorbed by carbon aerosols in the atmosphere, causing these particles to radiate trapped heat, first warming the atmosphere instead of cooling it, and then seasonally warming any ice and snow surfaces in which this particulate may eventually settle (explained further below).

Unfortunately many climate scientists have yet to see these maps, or had enough time to study them fully, as their fields of study are often focused on very specific research in other areas. As a result, many are unaware of the evidence showing the full extent of aerosol warming and continue to believe that CO_2 and GHGs must be the primary factor behind the climate change we are experiencing.

These Historical Climate Maps Indicate Why The Climate Models Are Not Working

The new maps indicate that the warming role of aerosols and air pollution has not been calculated correctly. Most climate scientists believe aerosol pollution dims sunlight reaching the Earth by reflecting it back to space, thereby cooling the planet when it would otherwise be warming more quickly. This potential cooling effect is usually referred to as Global Dimming.

However the new climate maps and other research data indicate that while aerosol pollution may be dimming, this net dimming may actually result in a powerful warming effect – where some of the dimming is the result of that light not being reflected back to space, but absorbed by metal and black & brown carbonaceous aerosols instead, causing those particles to radiate trapped heat, thereby warming the atmosphere instead of cooling it.

To better understand why this occurs, this paper will explore current climate theory regarding aerosols and green house gases, and from that, discuss sustainable government policy and highly profitable economic solutions that not only solve the climate problems, but make our economies more competitive while improving lifestyles & standards of living at the same time.

World Climate Policy Must Quickly Adapt

The patterns of melting now occurring in the Arctic, the Antarctic Peninsula, western Antarctica and on glaciers round the world, are indicative of carbon aerosol warming described above and show that these additional anthropogenic factors need to be fully considered if we are to develop policy to stop the very rapidly accelerating climate change.

More specifically, it shows that Humankind initially needs to make dramatic reductions in soot and other particulate emissions with existing filter & converter technologies, and then work to completely eliminate carbon fuel use.

While this pollution is immediately and entirely preventable, it is currently affecting large regions of atmosphere and snowpack around the planet, as can be clearly seen in the satellite photos herein.

Which makes the following points critically important when assessing the current weights / effects of various anthropogenic emissions on today's climate:

- the very powerful positive feedback warming effects associated with atmospheric soot described below are not built into current climate models,
- the sum of these radiative forcing components and their potential for warming is many times larger than that currently predicted by GHG theory, as shown and explained below,
- which means that current warming attributed to GHGs is much less than thought
- which means world leaders need to quickly focus on the real problem first, or they further risk allowing severe damage to the ecosystem in a few short years.

1. Understanding Aerosol Pollution vs. Green House Gases

The Potential Role of Aerosol Air Pollution in Regional Warming

Since the industrial revolution, and specifically during two periods of economic expansion (1880 - 1945, and from 1970 until today), increasing soot emissions in the Northern Hemisphere produced growing, quasi-permanent, and regional build-ups of atmospheric pollution, and increasingly dense haze over large areas during those periods.

The following provides important terms, definitions, data, and analysis to enable the reader to critique the conclusions of this paper, which re-examines the roles of Black Carbon soot, Brown Carbon, other aerosols, Green House Gases, and the roles they play in various types of planetary warming.

What are Aerosols

Alternatively referred to as particulates, particulate matter (PM), or fine particles, aerosols range in size from less than 10 nanometers to more than 100 micrometers in diameter. (The notation PM10 describes particles of 10 micrometers or less.) They range in size from gatherings of a few molecules to particles that can no longer be carried by the gas. Sources of particulate matter can be anthropogenic or natural.

Green House Gases, on the other hand, are gases which can fully dissolve into the atmosphere, becoming part of the gaseous make-up of the atmosphere. Those gas molecules will stay there indefinitely until a specific chemical reaction potentially removes them from the atmosphere.

But, particulates are like very small rocks which are capable of falling through the atmosphere when it is calm enough. An aerosol describes any particulate matter "floating" in air in suspension. (To differentiate suspensions from true solutions, the term “sol” evolved – originally meant to cover dispersions of sub-microscopic particles in a liquid. With studies of dispersions in air, the term “aerosol” evolved to embrace both liquid droplets, solid particles, and combinations of these.)

Most Anthropogenic Aerosol Production Is Concentrated In The Northern Hemisphere

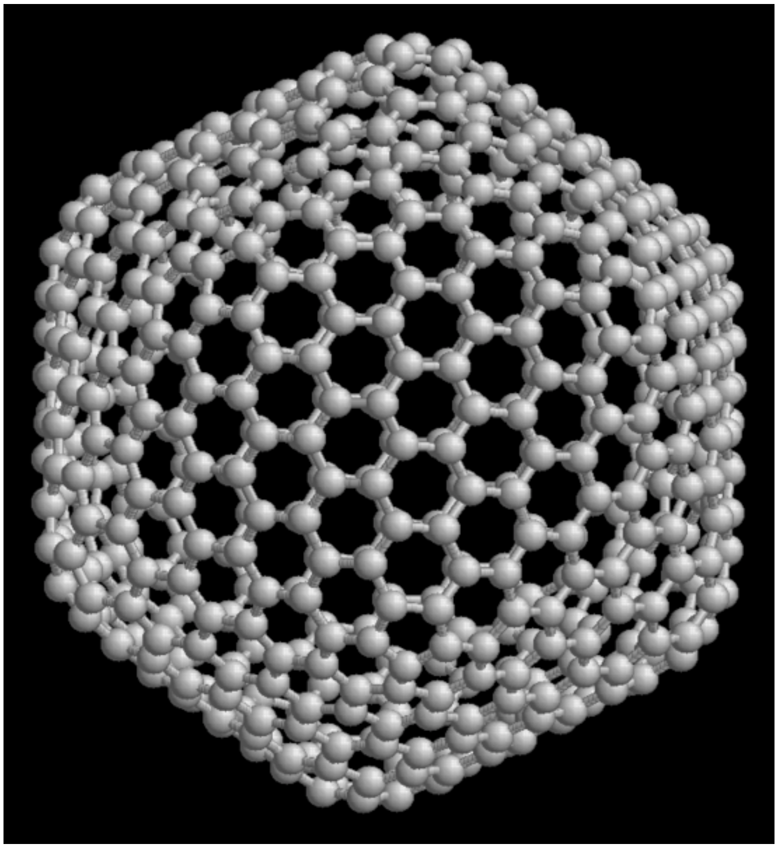
Most aerosols occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels also generate aerosols. Averaged over the globe, anthropogenic aerosols – those made by human activities – currently account for about 10 percent of the total amount of aerosols in our atmosphere.[49] Most of that 10 percent is concentrated in the Northern Hemisphere, especially downwind of industrial sites, slash-and-burn agricultural regions, and overgrazed grasslands. [50] This indicates that a figure closer to 20% rather than 10% represents a more accurate estimation of the % of anthropogenic aerosols in the Northern Hemisphere, and that regional concentrations have the potential to be much higher.

This is significant as certain aerosols are now known to trap significant amounts of the Sun’s energy and the earth’s surface heat. The most potent are known as Black and Brown Carbon.

The Properties of Carbon Soot

Soot, also called lampblack, is a dark powdery deposit of unburned fuel residues, usually composed mainly of amorphous carbon, that accumulates in chimneys, automobile mufflers insides of smoke saunas and other surfaces exposed to smoke—especially from the combustion of carbon-rich organic fuels in the lack of sufficient oxygen. The combustion is thus incomplete.

Lampblack is sometimes used only to refer to carbon deposited from incomplete burning of liquid hydrocarbons, while carbon black may be used to refer to carbon deposited from incomplete burning or pyrolysis of gaseous hydrocarbons such as natural gas.[51]

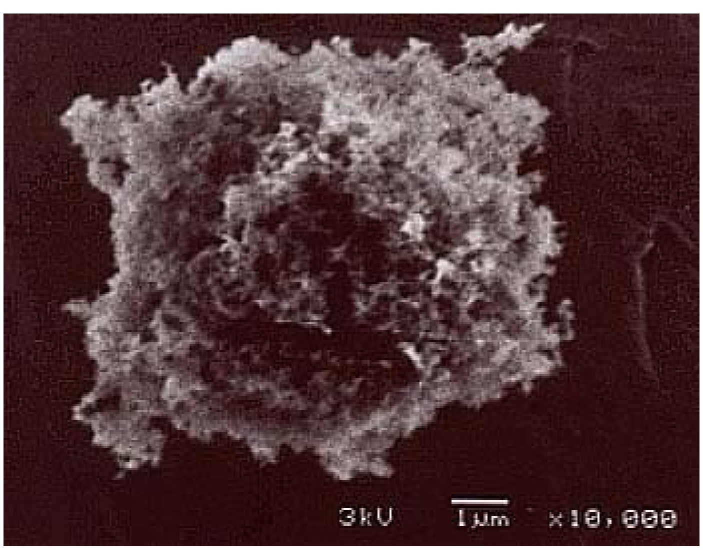


Black carbon (BC), or Carbon Black, or Elemental Carbon (EC), is composed of pure carbon clusters, skeleton balls and fullerenes, and is one of the most important absorbing aerosol species in the atmosphere.

Fullerenes (C_{540} shown at left; source Wikipedia.org) are molecules composed entirely of carbon, in the form of a hollow sphere, ellipsoid, or tube[52]. They are similar in structure to graphite, which is composed of a sheet of linked hexagonal rings, but they contain pentagonal (or sometimes heptagonal) rings that prevent the sheet from being planar. C_{60} and other fullerenes were noticed to occur outside of a laboratory environment in normal candle soot.[53]

BC from fossil fuels is estimated in the Fourth Assessment Report of the IPCC to contribute a global mean radiative forcing of +0.2 W/m² (was +0.1 W/m² in the Second Assessment Report of the IPCC, SAR), with a range +0.1 to +0.4 W/m². [54] This papers research shows this definition to be in accurate and the warming potential to be largely underestimated.

Much BC and OC Particulate Is Microscopic



Many of these particles are about the size of the wavelengths of visible light, and are not detectable by the human eye alone.[55]

Soot and aerosol particles of 0.4 µm to 10 µm (1 µm = 10^{-6} mm), which are much smaller than the diameter of a human hair in radius can move throughout the atmosphere of the Northern Hemisphere in as little as 8 to 11 days, according to the model developed by *Kim, Muskett,* and colleagues.

An electron microscope image showing a particle of Black Carbon soot. (NASA Goddard Institute for Space Studies, D. M. Smith, University of Denver).

Most Carbon Soot Settles While GHGs Remain In The Atmosphere…

Because carbon soot is particulate – not a gas - and settles, it will eventually fall out of the atmosphere and deposit on the Earth's surfaces. Once soot falls from the air, the very significant atmospheric warming it causes ceases. However, it can cause even more warming if it lands on snow or ice surfaces and is exposed to sunlight. This is a major problem in the Arctic and on the Antarctic Peninsula as discussed below.

However, Some Carbon Soot Will Remain Aloft For Centuries

Extremely small diameter carbonaceous particulate of less than .1 μm may remain aloft for hundreds of years or more, accumulating with time, and in doing so causing continual and increasing warming. **Carbon soot from aircraft is accumulating at altitudes between 8-11km and may prove to be a significant long term problem as discussed below.**

Time For Particles to fall 1 km in the atmosphere by sedimentation under near surface conditions [56]	
Particle diameter (μm)	Time to Fall 1km
0.02	228 years
0.1	36 years
1.0	328 days
10.0	3.6 days
100.0	1.1 days
1000.0	4 minutes
5000.0	1.8 minutes

2. Why Soot Warms the Atmosphere so Quickly as Compared to GHGs

Sunlight and Water Vapor Contribute to Global Temperature Regulation

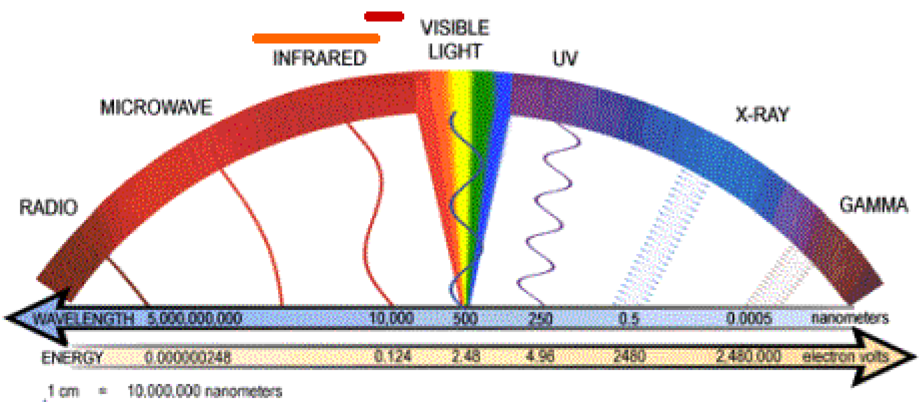
Because the Earth must give off as much energy as it receives to remain at a constant temperature, ultimately its oceans & land surfaces radiate the same amount of energy acquired from the Sun and Space back out to Space. If they didn't, we'd be quickly destroyed by the rapid build-up of heat.

More importantly, to a large degree, the Earth is normally able to maintain & regulate temperatures because of its vast waters, atmosphere, and the way both interact with electromagnetic radiation, as discussed below.

However if soot finds its way into the atmosphere, the atmosphere immediately begins to loose its ability to regulate and lower temperatures, as shown below. The well established principles used to show why this is the case are not difficult to grasp.

First we need to briefly consider the nature of ***light***, ***heat***, and other types of electromagnetic radiation, all of which comprise of ***photons*** of ***energy*** traveling at light speed.

Beams of natural sunlight comprise of large numbers & different types of photons, all individual wave/particles oscillating at particular frequencies – the shorter the wavelength, the higher the photon's energy; the longer the wavelength, the lower the energy.



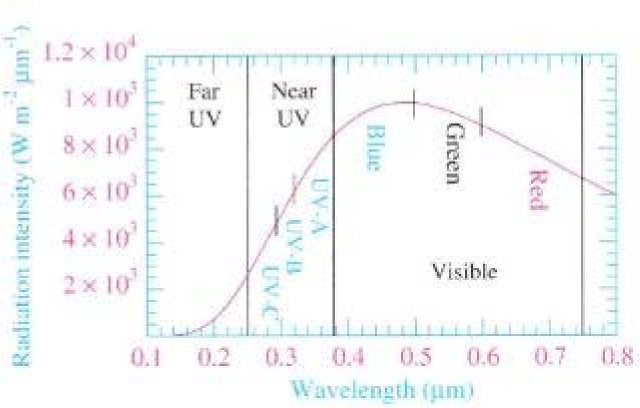
Most importantly, photons of *specific* energies, or wavelengths, are capable of being "caught" and absorbed by electrons of *specific* frequencies surrounding *specific* atoms, energizing those atoms. Hydrogen atoms in water absorb a certain set of frequencies of energy. Carbon, oxygen, and all other atoms also absorb different frequencies of energy, depending on their electron structures.

A newly energized atom may then release all, or a portion, of that energy as lower-energy infrared heat. As can be calculated from the chart above, each photon of absorbed visible sunlight ultimately generates about 20 photons of low energy heat, while each photon of absorbed UV light generates about 40 photons of heat. The importance of this will be very evident shortly.

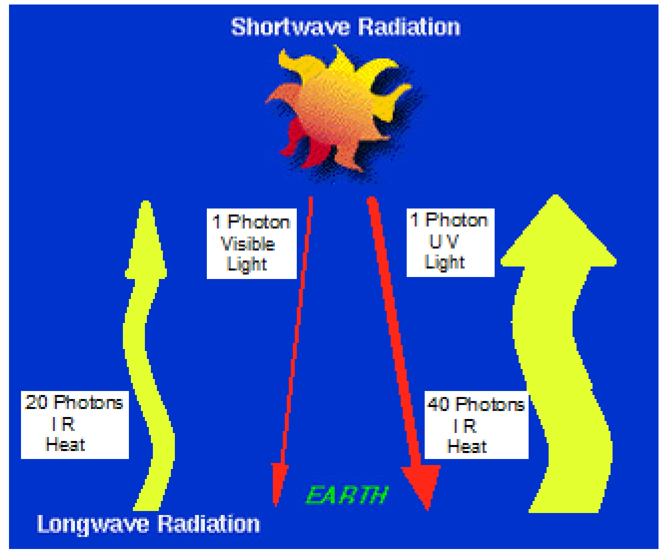
The Sun emits mostly higher-energy photons that easily penetrate the Earth's clear atmosphere, because the electrons surrounding the atoms of all its gases, including CO2, water vapor, and the other Green House Gases, are unable to absorb these high energy photons.

Approximately 70% of the high-energy sunlight that passes through the atmosphere to reach the Earth is absorbed.[57] Upon reaching the Earth's surface, a portion of these high-energy rays are reflected back through the atmosphere to Space, while the rest are absorbed by various atoms on Earth's surfaces, and are converted to lower energy wavelengths of heat, warming the planet.

This low-energy long-wavelength heat is capable of being trapped and reflected back to Earth by water vapor and the other green house gases, further warming the planet.



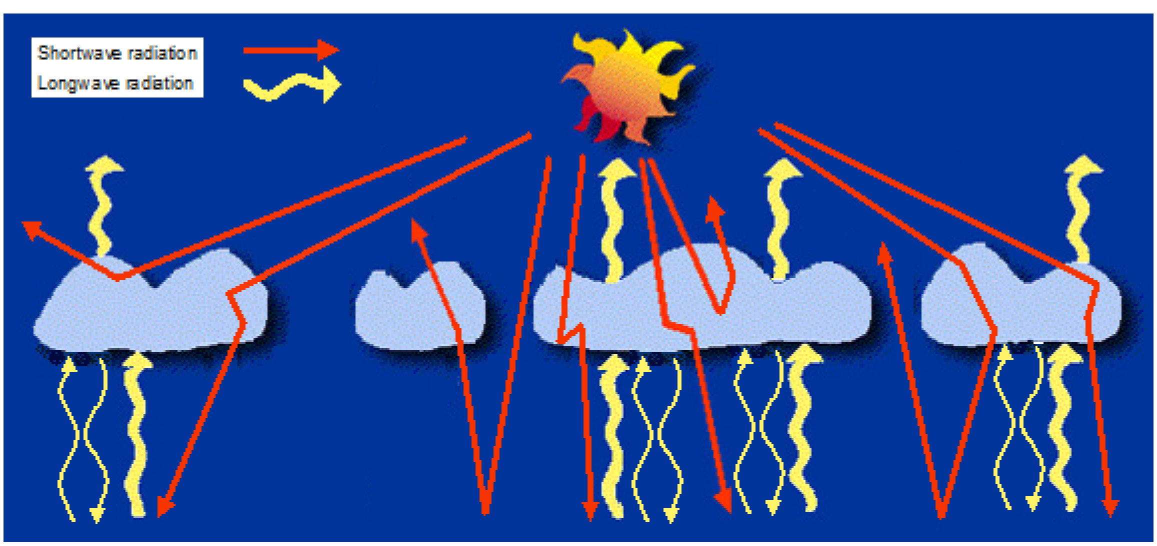
Above: UV and visible portions of the solar spectrum. This spectrum is received at the top of the atmosphere. (Jacobson 2002)



It's very important to understand that in a normal, healthy green house, heat initially emanates only from the Earth below (once light photons from above are converted to heat photons), and not from the atmosphere above. As discussed below, pollution changes that.

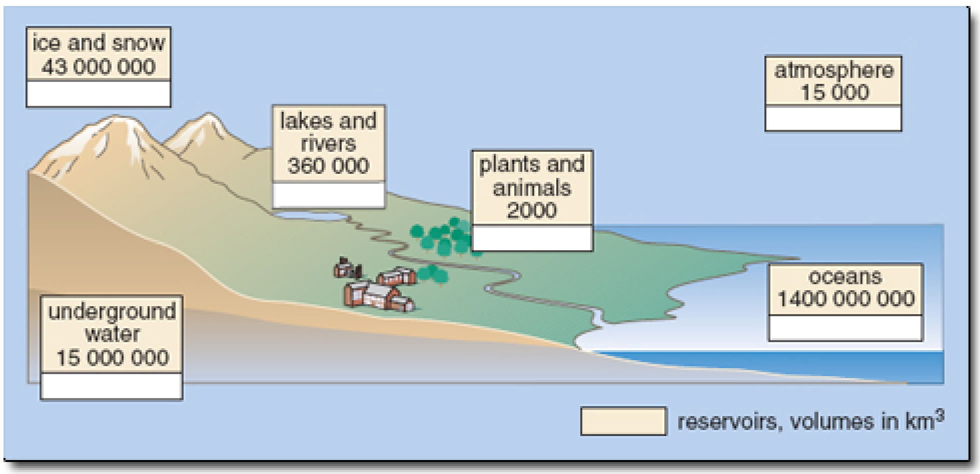
In the following images the red arrows indicate shortwave radiation coming from the Sun and elsewhere in Space. The wide yellow arrows indicate the number of heat photons generated at the Earth's surface by the absorption of individual incoming visible and UV light rays, and the net amount of low-energy longwave heat that is ultimately reflected back to Space.

The thin downward facing yellow arrows below represent that smaller portion of heat captured and reflected by greenhouse gases in clouds and in the atmosphere. The thin upward yellow arrows represent that same heat then being reabsorbed and re-reflected back to space. (This briefly explains what is going on in the atmosphere above the Earth's surface - more on this below)



Water not only allows life, it has a great capacity to absorb heat at the Earth's surface (which is also why we use it in the radiators of cars, helping to keep engine temperatures stable). As the world's oceans contain 96% of the world's water and cover 71% of the planet's surface, their deep waters provide a massive heat sink on the Earth's surface, helping to regulate its temperatures.

Reservoir	Volume/km^3	Volume/% total water
oceans	1400 000 000	96
ice and snow	43 000 000	
underground water	15 000 000	1.0
lakes and rivers	360 000	0.025
atmosphere	15 000	0.001
plants and animals	2 000	0.000 14
total	1460 000 000*	100*



http://openlearn.open.ac.uk/mod/resource/view.php?id=285835

While temperatures on land can fluctuate widely from - 80° C to 50°+ C, ocean temperatures only range from about -2°C to about 35°C due to their enormous heat storing capacity.

That said, Earth's ocean heat sinks are always in a state of flux, at times taking in vast amounts of energy, and at others releasing large amounts of trapped energy. Much of this energy exchange is driven by shorter seasonal/annual cycles and large atmospheric & ocean circulation patterns.

However, these seasonal rhythms can be shifted warmer or cooler by longer cycling regional effects, such as El Nino and la Nina for example. **So even while the planet gets warmer, and on a net basis the oceans warm as well, the oceans still have the capability to dramatically shift world temperatures one way or the other, depending on how much heat is being released or recaptured by these huge heat sinks at any given time.**

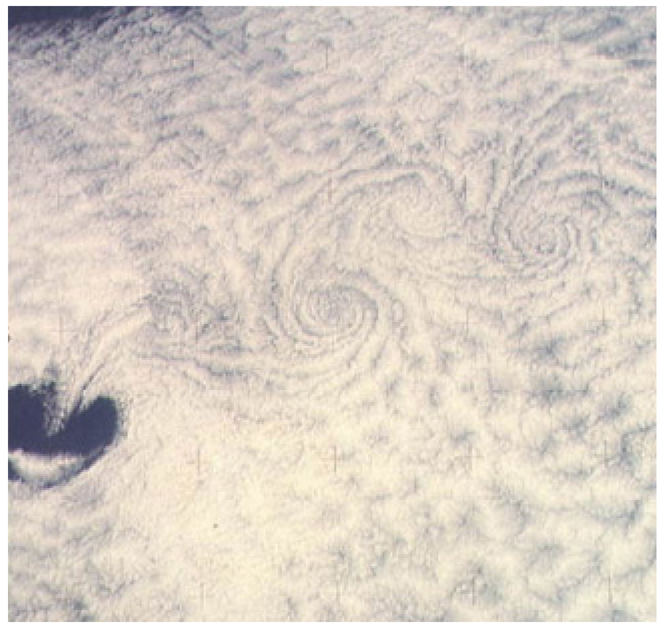
As relates to climate and temperatures, the water vapor coming off the oceans (and lakes, rivers & land masses) is the most important substance in the Earth's atmosphere, due to its two primary atmospheric effects: one of warming, and the other of cooling.

Atmospheric water vapor (some in the form of clouds) is the most important GHG, trapping by far the most outgoing heat of any of the GHGs. It, and not the other GHGs, is the primary factor raising atmospheric temperatures to levels that support life, as discussed in greater detail below. But, uniquely, water vapor also plays the Earth's most important temperature regulation role as well, by generating cloud cover capable of reflecting incoming sunlight back to space.

It's important not to confuse the effects of translucent warm water vapor with that of cooler reflective clouds, even though they are both forms of water vapor. Translucent warm water vapor only causes atmospheric warming. However, the overall net effect of clouds remains one of cooling, even though some clouds either: a) trap heat – i.e. high cirrus, b) are temperature neutral – i.e. deep convective, or c) block sunlight – thick low cloud.[58]

While levels of the other atmospheric GHGs are normally quite stable on a moment to moment basis, the amount of water vapor in most regions of the atmosphere is constantly fluctuating. This is because any heat coming from the Earth that is initially trapped (by either water vapor, other GHGs, or any other warming factor) further warms the water and land surfaces below, causing them to throw off more water vapor, causing even more heat to be trapped in the process. This is known as the water vapor positive feedback warming loop. Somewhat ironically, it's this water vapor positive feedback that both allows Earth to remain warm and control temperature.

Barring the influx of cool water currents or winds, from morning until late afternoon, regions that are warming will only stop warming once enough warm water vapor evaporates from the ocean and land surfaces. This warm vapor rises upwards, and cools & condenses, thereby increasing the total amount of low white cloud cover overhead.



http://earthobservatory.nasa.gov/Library/Clouds/clouds4.html

That thickened cloud cover then reflects a greater portion of the incoming high energy sunlight back to space before it can reach the Earth below, thereby cooling the surfaces and atmosphere below.

If a cloudy atmosphere then cools the atmosphere enough, due to thicker cloud cover or other factors, moisture condenses and water drops out of the atmosphere as rain or snow. This ultimately reduces the amount of the GHG water vapor in that region of the atmosphere, allowing more heat to pass through to Space, cooling the atmosphere and surfaces below even further.

So, as the world gets too warm, increased cloud cover works to cool it down. And as it cools, less water vapor is evaporated, reducing cloud cover and allowing the planet to re-warm.

How Soots interfere With Water Vapor and Temperature Regulation

As discussed earlier, the Sun's incoming high-energy shortwave rays either easily pass through the atmosphere to heat the planet below, or they are reflected directly back to space by reflective surfaces on Earth or the white clouds above it.

Because a clean atmosphere and its clouds can not absorb shortwave sunlight, they can not be directly warmed by those incoming rays. This allows the planet's reflective white cloud cover to moderate land and water surface temperature fluctuations by forming a protective barrier from the Sun's energy. Thus a normal range of temperatures and a general equilibrium are achieved in a clean environment.

However, if for any reason enough pollution gets into the atmosphere, this causes the atmosphere and its clouds to begin directly capturing Sunlight's energy. This can quickly disturb the Earth's critically important cloud-cover equilibrium, rendering this crucial thermostat ineffective, resulting in the insulation and overheating of the surfaces below by the atmosphere above. This happens for two primary reasons as discussed below.

Carbonaceous Soots Disturb the Balance by Converting Sunlight To Heat In The Atmosphere

Reason 1) If the atmosphere and its clouds begin to collect soot and metals, which contain atoms capable of directly absorbing the Sun's high energy rays, then the atmosphere's ability to cool itself becomes limited, as it is less able to use clouds to reflect incoming radiation.

Instead, those new foreign atoms within the atmosphere's gases or clouds begin to absorb high-energy sunlight from above, thereby directly and dramatically heating the atmosphere. Now the Earth's atmosphere is directly heating from incoming high energy waves from ***above***, and not just from the normal absorption of low-energy outgoing heat emanating from ***below*** *as discussed earlier*.

FIG 1

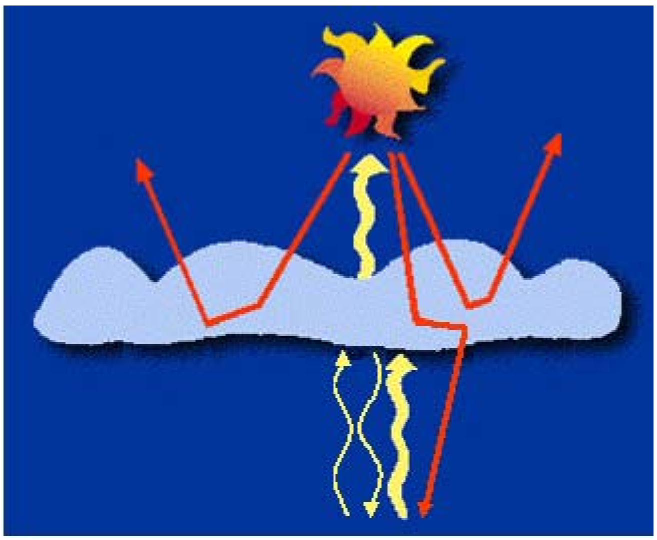
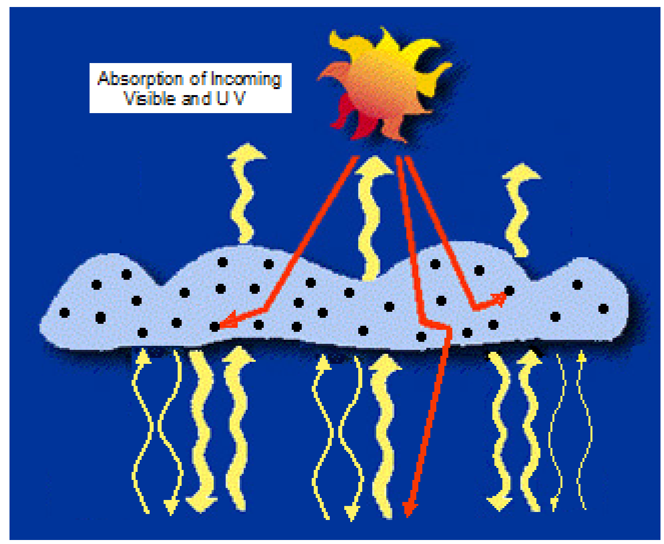


FIG 2



It's easy to track of how much additional heat is being generated by particulate soot pollution.

As discussed above, all absorbed Solar radiation is ultimately re-emitted back to Space. So the incoming energy ***entering at the top of to the atmosphere*** must equal the energy ***leaving at the top of the atmosphere***. We'll assume all incoming sunlight is visible light (to keep things simple and conservative, even though a portion of incoming light is higher energy UV), so each photon of incoming light will convert to approximately 20 photons of lower energy heat.

In Fig. 1 only one of three incoming solar photons makes it to Earth's surface to be absorbed and transformed into heat. That incoming solar photon generates 20 heat photons of equal energy and is reflected back to space as shown by the wide yellow arrow leaving the Earth's surface.

A percentage of that heat is trapped by water vapor, clouds, and the other Green House Gases in the atmosphere. This percentage is represented by the smaller downward yellow arrows.

Those greenhouse-reflected photons are then re-emitted to space, as indicated by the smaller upward yellow arrow of equal energy. Because the GHG-reflected warmth is ultimately re-emitted, it represents 2 vectors of warming heading in opposite directions. Therefore, as relates to the total amount of heat leaving the top of the atmosphere, those vectors cancel each other out and do not add to the total heat leaving the system.

The net sum of heat photons ultimately leaving the system is still equal to the one photon of sunlight initially converted to heat – or 20 photons, as represented by the 1 wide yellow arrows exiting above the top of the atmosphere.

As seen by adding up the vectors below the top surface of the atmosphere, the ***normal GHG potential for atmospheric warming*** due to surface absorption in photon-heat-units is:
(1 x 20 heat photons) + (2 x the % of GHG heat photon absorption)

In Fig. 2, two other incoming solar photons are absorbed by pollution rather than reflected by the clouds, as might normally occur. The photon on the left now generates 20 photons of heat directed at the Earth, as indicated by the wide downward arrow below it. This must be reflected by Earth, as indicated by the 20 photon wide upward vector beside it. This upward vector is then partially reflected by GHG in the clouds and atmosphere, further heating the atmosphere.

The total atmospheric warming below associated with this single solar photon is:
(2 x 20 heat photons) + (2 x the % of GHG heat photon absorption), a significant 20 photon increase in warming, as compared to a photon's normal conversion to heat once it reaches Earth's surface.

The energy emitted from the top of the atmosphere is still 20 photons of heat, or 1 solar photon.

Since the absorption of a solar photon subsequently radiates heat energy in all directions, depending on the depth of the soot particle in the cloud / atmosphere, as much as half the energy (10 Photons) could be reflected back into Space immediately. In Fig. 2, this is illustrated with the photon on the right which is striking a soot particle near the top of a cloud. Only half the generated heat is emitted towards Earth, as shown with the 50% smaller incoming downward vector and subsequent outgoing upward vector widths.

The total energy emitted from the top of the atmosphere is still 20 photons of heat – the initial 10 that escaped to Space immediately, and the subsequent 10 that were then reflected and emitted from below.

The total atmospheric warming below associated with this single solar photon is:
(2 x 10 heat photons) + (2 x the GHG heat photon absorption %).

Adding up all the vectors in Fig. 2, the sum of atmospheric warming caused by all three absorbed photons is now: (3 x 20) + (2 x 10) + (4 x GHG absorption %) + (2 x .5 GHG absorption %)

In the example above, the particulate-related solar warming dwarfs the GHG-related warming.

Moreover, soot pollution in the atmosphere doesn't just affect incoming solar radiation. The incoming high-energy sunlight that is normally reflected off Earth's surface back through the atmosphere into space is also now capable of being absorbed by this soot pollution, generating additional reflected heat back to Earth, as shown in Fig. 4 as compared to Fig. 3.

FIG 3

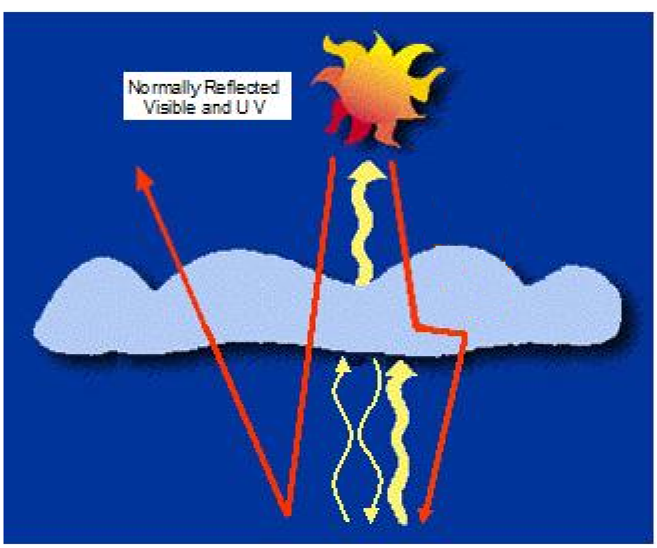
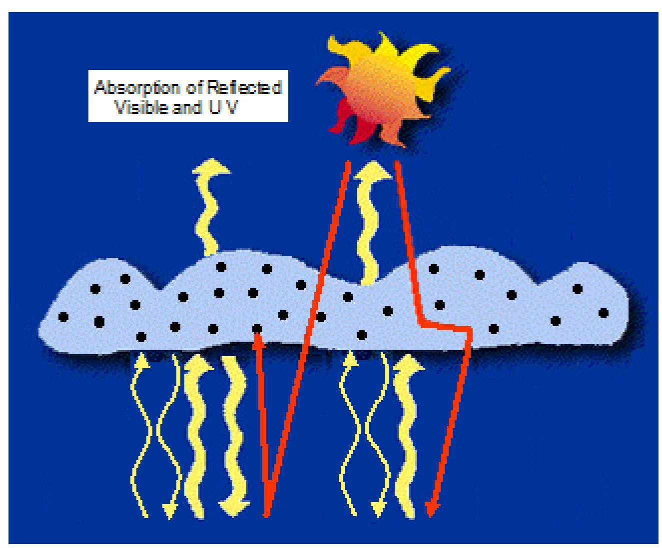


FIG 4

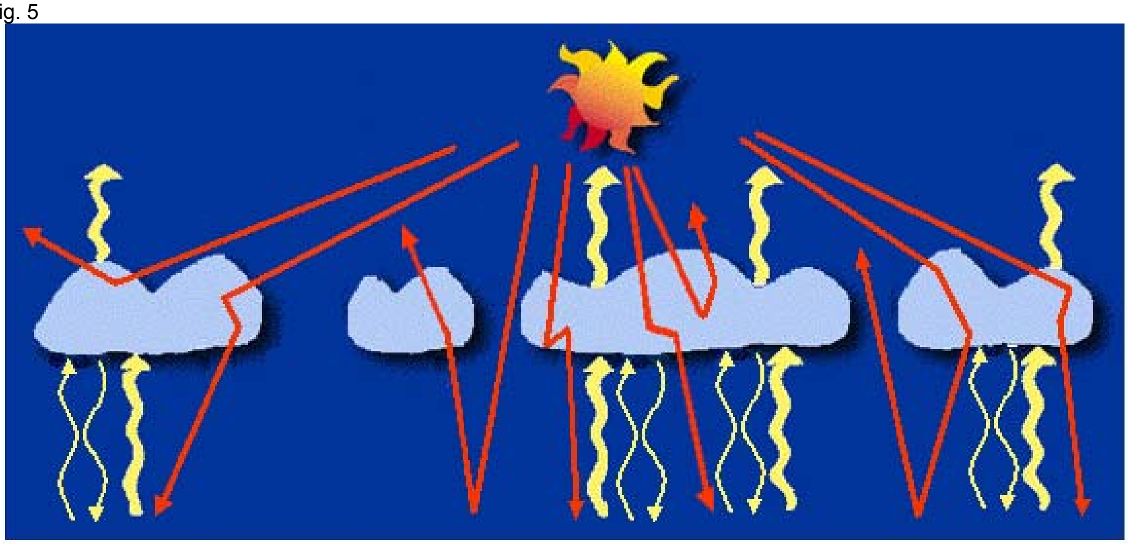


To better illustrate the affects of soot on atmospheric warming, we'll look at the hypothetical behavior of 8 photons entering a clean atmosphere vs. one polluted with soot particulate.

In Fig. 5 the atmosphere and its clouds are free of any particulate soot pollution. 8 photons of high energy sunlight (red lines) arrive at the top surface of the atmosphere. 4 photons are reflected before they can be converted to heat on Earth: the 1st is reflected back to space by a white cloud; the 2nd passes through the atmosphere, and is reflected back to space through a cloud; the 3rd is redirected twice within a cloud before returning to space; and the 4th passes through a cloud to Earth, is reflected, and then passes directly out to space through the atmosphere.

4 others pass through the atmosphere and clouds, reach Earth below, and are converted to heat, warming the Earth. Those photons are re-emitted as 80 photons of heat (represented as 4 wide yellow bands of 20 photons each).

Fig. 5

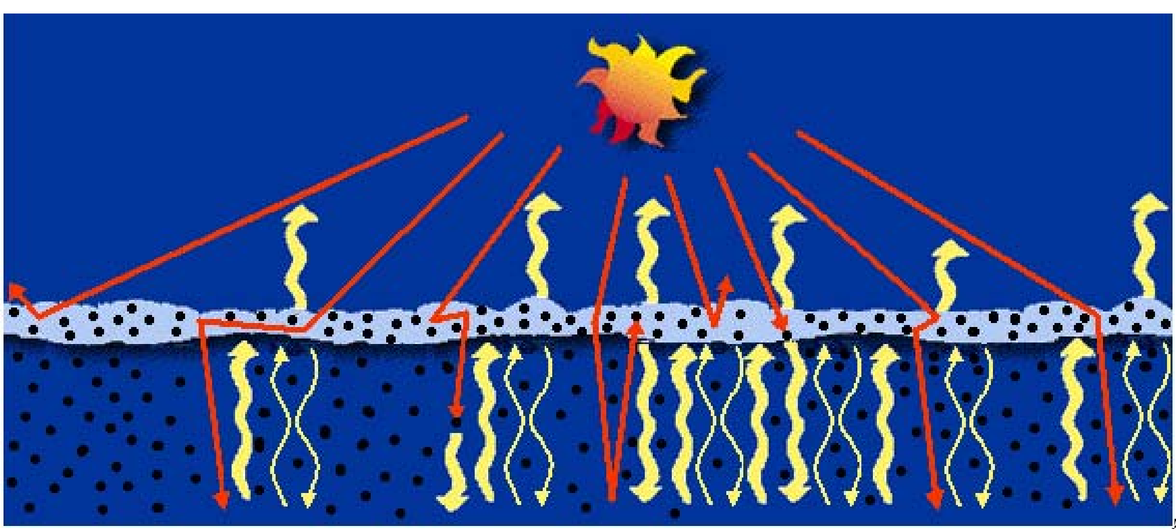


A percentage of those 80 photons are captured by GHGs and reflected back to Earth further warming the atmosphere and surfaces below (smaller yellow arrows).

Prior to exiting the top of the atmosphere, the total atmospheric warming in photon heat units is (4 x 20) + (8 x GHG absorption %), as it should be.

However once enough soot is added to the atmospheric mixture, the atmosphere begins to quickly overheat. The total number of incoming sunlight photons remains the same at 8.

Fig. 6



Only 3 make it to the Earth's surface, generating the normal amount of heat. A 4th is absorbed by soot floating in the atmosphere, generating an extra 20 photons of Earth-bound heat radiation. The 5th and 6th are absorbed by soot in the clouds generating an extra 40 photons of Earth-bound heat radiation.

In this example, a 2 photon (50%) increase in Solar absorption, generates a 100 heat photon (125%) increase in atmospheric warming.

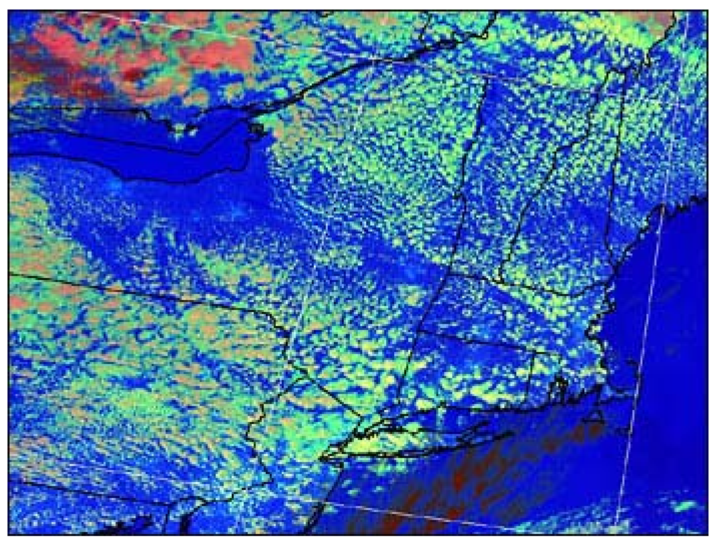
Each solar photon absorbed by atmospheric pollution generates almost twice as much warming as compared to a solar photon that reaches Earth through a clean atmosphere.

Atmospheric Soot Also Magnifies Water Vapor's Green House Effect

Reason 2)   This additional warming in then further magnified by soot's affect on atmospheric water vapor - GHG.

Rosenfeld 2000 shows carbon soots and other air pollution alters cloud formation and water vapor behavior by dispersing moisture and preventing droplet formation[59], as documented in NASA satellite images. As shown below, this can dramatically increase the amount of water vapor exposed to thermal radiation, which can therefore increase water vapor's atmospheric green house warming potential by potentially significant orders of magnitude as explained below.

As *Rosenfeld* 2000 and its analysis of NASA Satellite images show, soot is preventing water droplets and clouds from forming naturally. Instead of normally forming large drops capable of raining, soot is causing the moisture to remain dispersed, resulting in the formation of clouds that do not initially release their moisture. As pointed out in that important paper, this is affecting rainfall, causing drought in some areas, and excess rain and/or flooding in others.



In this satellite image, taken in 2000, the yellow clouds scattered over the Northeast are polluted clouds with small water droplets. The pink clouds over Canada have larger droplets, and are relatively clean. Because the aerosols prevent cloud water droplets from growing large enough to precipitate, this type of pollution can reduce rainfall.

http://earthobservatory.nasa.gov/Study/Pollution/pollution.html

What has not been fully considered, is that this anthropogenic moisture dispersal must also dramatically increase the green house effect of clouds, as described below**.**

It's well established that the water molecule is capable of absorbing thermal radiation, which is what makes large amounts of ocean water vapor such a powerful green house forcing agent.

A typical water droplet is roughly 10^{20} water molecules packed together.[60] However, only a much smaller number of droplet ***surface molecules*** are directly exposed to incoming radiation, as most of those 10^{20} molecules within the interior of the droplet are sheltered by a skin of molecules on the exterior, and as such, unable to absorb radiation immediately. (This is why water boiled in a pot heats gradually from the bottom up, rather than evenly and instantly.) Therefore, the bigger the water drop, the greater the number of internal water molecules sheltered from outside radiation.

Approximately half of the heat absorbed by those surface molecules higher in the atmosphere is radiated back to space immediately (in the same manner as the heat that is generated and emitted in all directions from particulate in clouds near the top of the atmosphere in the Fig 4).

To better understand how much extra heat can be trapped, we need to consider droplet surface area. The diameter of a typical water droplet in a cloud is 0.01 mm. These tiny droplets eventually coalesce to a 2 mm raindrop, some 200 times greater in diameter, and 8,000,000 times in volume.[61]

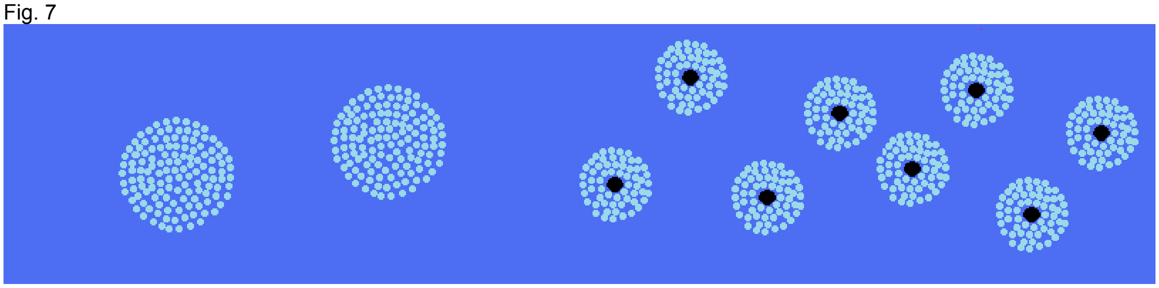
What is important to recognize when considering the amount of surface area exposed to thermal radiation, is that it takes 8,000,000 tiny water droplets to eventually form 1 rain drop. The combined surface area of those 8 million droplets is a massive 200 times greater than that of the rain drop.

Because soot keeps water dispersed into smaller droplets in affected clouds, this significantly increases the total surface area and number of cloud water droplets capable of capturing outgoing heat from the Earth below. The figures below give us a better idea of this relationship.

In Fig. 7 two larger 2mm drops containing $4.188mm^3$ volume of water are shown. Only reducing droplet diameter about 35% to 1.26mm now produces 8 droplets from the same volume of water.

The two larger droplets combined surface area is $25.13mm^2$. The 8 smaller droplets have a 63% larger 39.9 mm^2 combined surface area exposed to the Earth's radiation. **The increased droplet surface area will prevent a proportional amount of heat from freely exiting the atmosphere.**

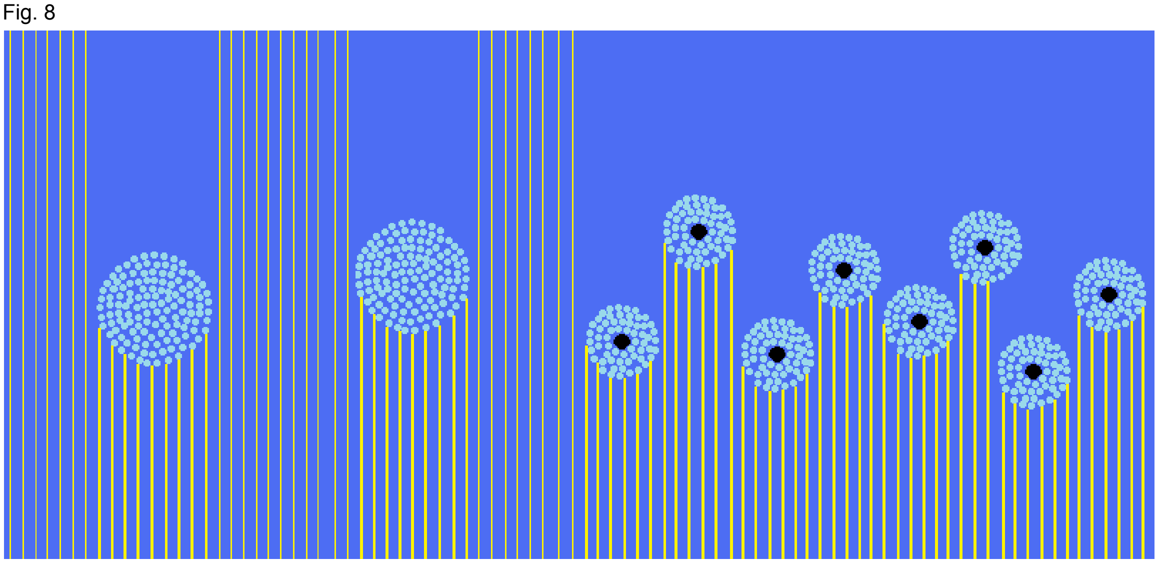
Fig. 7



As the drawings below are side views, they are not mathematically accurate. None the less they convey an idea of how much exiting radiation can be blocked & reflected by a greater number of smaller water droplets of the same water volume.

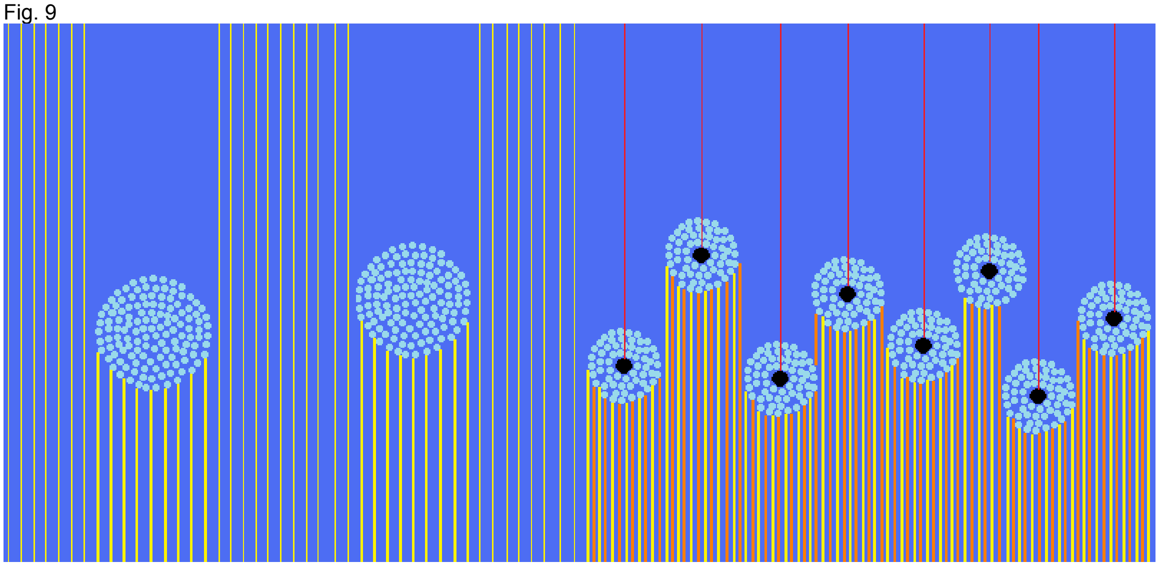
In Fig. 8 below, the thin yellow lines indicate Earth's heat escaping to space while the thicker lines indicate heat that has been reflected back to Earth, only to be reflected back to space again. Larger droplets clearly reflect less heat.

Fig. 8



In Fig 9, the added effect of solar photon absorption (from above) by the soot in the smaller dirty water droplets makes the problem much worse, as shown on the right.

Fig. 9



The above analysis of light-absorbing-particulate's effects on incoming solar radiation and outgoing thermal radiation clearly shows why diesel, coal, biomass and other soot-based pollution in the atmosphere & clouds is both absorbing large amounts of high-energy solar radiation and significantly increasing water vapor GHG warming potential at the same time.

These effects are most likely a significant cause of the intense warming in Europe, China and other regions in recent years, as pollution emissions there have grown.

These effects are even worse in more extreme southern and northern latitude summers when the sunlight exposure there is most intense. The Artic and Antarctic Peninsula are particularly affected.

Citrus Growers Have Known Soot Traps The Earth's Heat, Causing Warming – Not Cooling

Another good description of how carbon aerosol traps the earth's heat is found in Jacobson's 2002 Journal Of Geophysical Research paper, *Control Of Fossil-Fuel Particulate Black Carbon And Organic Matter, Possibly The Most Effective Method Of Slowing Global Warming*, where he describes the ''Smudge-Pot Effect''. During day and night all aerosol particles trap the Earth's thermal-IR radiation, warming the air (*Bergstrom and Viskanta*, 1973; *Zdundowski et al*., 1976). This warming is well known to citrus growers who, at night, used to burn crude oil in smudge pots to fill the air with smoke and trap thermal-IR radiation, preventing crops from freezing. The warming of air relative to a surface below increases the stability of air, reducing vertical fluxes of horizontal momentum, slowing surface winds (and increasing them aloft), reducing the wind speed-dependent emission rates of sea-spray, soil-dust, road-dust, pollens, spores and some gas-phase particle precursors. The reduction in these particles affects daytime solar and daytime/nighttime thermal- IR radiation transfer. Changes in stability and winds also affect energy and pollutant transport. The effect of thermal- IR absorption by particles on the emission of other particles and gases and on local energy and pollutant transport is referred to as the ''smudge-pot effect''.

All aerosols either absorb or scatter solar and terrestrial radiation. If a substance absorbs a significant amount of radiation, as well as scattering, it is considered absorbing. This is quantified in the *Single Scattering Albedo* (SSA), the ratio of scattering alone to scattering plus absorption (*extinction*) of radiation by a particle. The SSA tends to unity if scattering dominates, with relatively little absorption, and decreases as absorption increases, becoming zero for infinite absorption. For example, sea-salt aerosol has an SSA of 1, as a sea-salt particle only scatters, whereas BC soot (discussed below) has an SSA of 0.23, showing that it is a major atmospheric aerosol absorber.[62]

Aerosols, natural and anthropogenic, affect climate by changing the way radiation is transmitted through the atmosphere. However, direct observations of the effects of aerosols are quite limited so any attempt to estimate their global effect necessarily has involved the use of computer models.[63] Unfortunately computer models are only as good as their assumptions, so they are often full of uncertainty.

The IPCC Needs to Quickly Reconsider Its Position on Aerosol Climate Forcers

The Intergovernmental Panel on Climate Change, IPCC, 2007 Fourth Assessment Report says: "Anthropogenic contributions to aerosols (primarily sulphate, ***organic carbon, black carbon***, nitrate and dust) together produce a cooling effect, with a total direct radiative forcing of -0.5 [-0.9 to -0.1] W m-2 and an indirect cloud albedo forcing of -0.7 [-1.8 to -0.3] W m-2." 64

Regardless of the fact that aerosols have now been shown to trap outgoing radiation at the earth's surface, the IPCC's current position is still that aerosols tend to cause cooling of the Earth's surface immediately below them. The consensus is that the magnitude of this cooling effect depends on the size and composition of the aerosol particles, as well as the reflective properties of the underlying surface.

However, what is not be being considered is that lower altitude aerosol hazes could be both reflecting and absorbing incoming sunlight, causing the observed dimming, and at the same time reflecting equal or greater amounts of the Earth's IR radiation back to Earth, causing an net increase in warming. Instead the IPCC consensus is that because most aerosols reflect sunlight back into space, this reflection must be having a "direct" cooling effect because it's reducing the amount of solar radiation that reaches the surface. As such the IPCC currently feels this aerosol cooling may partially offset expected global warming that is attributed to increases in the amount of carbon dioxide from human activity. [65]

However, there is a simple proof to determine if that theory is valid or not:

If the IPCC consensus is correct, then the regions with the most aerosol pollution should be cooling, and other regions with less pollution should be seeing a relative warming, due to the increase in net warming associated with the actions of GHGs without the dimming affects of aerosols.

However, the analysis of existing temperature data found further below indicates the most polluted areas are not cooling, but heating up the fastest, and that these generalized IPCC assumptions, and computer models based on those assumptions, do not correlate with the observed data

3. Black and Brown Carbon Aerosols Cause Regional Warming

Black and Organic Brown Carbons – The Darker Carbonaceous Aerosols Defined

The incomplete burning of any carbon based fuel will produce varying quantities of carbon particulate-based smoke and soot. These soots are not to be confused with CO_2 and the Green House Gases.

Because the climate effects of the carbonaceous aerosols strongly depend on their physical and chemical properties, as well as on their residence time and distribution in the atmosphere (Jacobson, 2001), both a thorough understanding of these properties and accurate techniques for their determination in the atmosphere is essential.

Andreae & Gelencser 2006 point out that the terminology in this scientific field draws upon a variety of definitions that are based on source processes, morphological characteristics, chemical composition and optical properties. Since these definitions are usually not congruent, the terminology has evolved to be confusing, complex and contradictory. To reduce the confusion, they provided a set of definitions for referring to atmospheric carbon that will be used in this paper.

"Soot": A black, blackish or brown substance formed by combustion, present in the atmosphere as fine particles ("soot particles"), or adhering to the sides of the chimney or pipe conveying the smoke.

The initial chemical composition of combustion particles ("soot") depends strongly on its sources: some sources can produce almost pure elemental carbon, while others produce particles of which 50% by mass is organic matter (Medalia and Rivin, 1982). Graphite, the thermodynamically most stable form of pure elemental carbon, is an absolutely inert material under atmospheric conditions. It can be oxidized in air only at temperatures exceeding 600C.

Two general types of soot are capable of absorbing the Sun's energy. We will discuss both carefully.

The most common, and to which the term ***soot*** usually refers in most climate research, is known as Black Carbon soot. However this term is usually misused and requires clarification.

"Soot carbon" (Csoot) are carbon particles with the morphological and chemical properties typical of soot particles from combustion: comprising of aggregates of spherules made of graphene layers, consisting almost purely of carbon, with minor amounts of bound heteroelements, especially hydrogen and oxygen. This definition does not include the organic substances (oils, etc.) frequently present in or on combustion particles.

In summary, soot carbon has been identified as an impure form of near-elemental carbon with a graphite-like structure, which is formed in flaming combustion and in internal combustion engines (White and Germer, 1941; Grisdale, 1953; Medalia and Rivin, 1982; Bockhorn, 1994).

While Black Carbon is the most commonly used term in the climate-science community, it's usually without consideration of its unclear definition. "**Black Carbon**" ("BC") is conventionally and carelessly used in the literature, and is generally implied to have optical properties and composition similar to "soot carbon". In the literature, "black carbon" or "soot carbon" are often used synonymously for the major light-absorbing component of combustion aerosols (aka "soot").

The term Black Carbon is also commonly used for the result of a LAC (light absorbing carbon) measurements made using an optical absorption technique.

Black Carbon Absorbs Visible Light

Because soot carbon is almost pure carbon, as discussed below, it is black and absorbs almost all visible light striking it, making it a powerful warmer.

Currently many climate scientists erroneously believe that Black Carbon in the only carbon based aerosol that absorbs light causing warming, and that all other forms of organic carbon aerosols do not absorb heat, but rather reflect it back to space causing cooling.

Brown Carbon Absorbs UV Light!

However, there is another class of darker organic carbon particulates known as ***Brown Carbon*** that is also capable of absorbing light. This second type of soot has very different properties as relates to the absorption of light.

Its more recently understood that these brown carbon particles, previously suspected of causing cooling, are actually causing the absorption of more powerful UV rays. [66] ***This misunderstanding by most scientists may explain why most do not fully grasp why air pollution is a potent warming forcer.***

This fundamentally alters our understanding of the roles of Black and Brown Carbon soots and air pollution on climate change.

As *Andreae & Gelencser* 2006 state “recently, it has become clear that certain organic compounds in addition to Black Carbon may also contribute to light absorption in atmospheric aerosols. There has been mounting evidence from chemical aerosol measurements, laboratory studies, or direct measurements of the spectral dependence of light absorption (Mukai and Ambe, 1986; Havers et al.,1998b; Hoffer et al., 2005) that there is a continuum of carbonaceous substances in atmospheric aerosols.

At one end of this continuum is the thermally refractory and strongly light absorbing near-elemental “EC”, or Black Carbon, and at the other extreme are thermally reactive and colorless organic substances, such as most hydrocarbons. Although the absorption efficiency of light-absorbing organic species at the wavelength of 550 nm (visible light – see chart above) is much less than that of Black Carbon, it increases sharply towards shorter higher energy wavelengths, making their absorption in the UV potentially significant due to their observed high abundance in continental aerosol (Kirchstetter et al., 2004; Hoffer et al., 2005).

Side note: This helps explain why Europe is heating up so dramatically in the sun-rich summers.

The spectral dependence causes the material brown carbon, or its solution, to appear brown (or yellow). In analogy to soot carbon, *Andreae & Gelencser* propose to call these species collectively Cbrown, or Brown Carbon, highlighting their optical properties as well as their uncertain origin and chemical composition.

Side note: Any observer in a busy city can see the brown haze that accumulates as air pollution.

It was observed that particles from smoldering combustion (Patterson and McMahon, 1984), or from residential coal combustion (Bond, 2001) can contain substantial amounts of Brown Carbon. This particulate matter appears light brown to yellowish, and not black as would be expected for pure soot particles (Bond et al., 1998; Bond, 2001).

Carbon Soots Absorbs Large Amounts Of Sunlight And Covert It To Heat (IR)

As Black Carbon soot is black, it is one of the least reflective substances.

Albedos of typical materials in visible light range from up to 90% for fresh snow, to about 4% for charcoal, one of the darkest substances. (Exceptions are deeply shadowed cavities whose effective albedo may approach the zero of a blackbody.) [67] Black Carbon (BC) soot particles absorb visible light and convert that absorbed light into heat (infrared radiation).[68]

Brown carbon soots absorb more powerful and invisible UV light, converting it to heat.

BC Estimated to Produce 90-190 Times The Warming Of Calculated CO_2 Equivalent

BC produced by the incomplete combustion of bio-mass, coal, diesel, and other fossil fuels, has recently been estimated to cause between 90-190 times the warming of equivalent units of CO_2 (*Jacobson*, 2005).

Jacobson's research indicates the 100-year climate response per unit mass emission of fossil fuel (f.f.) BC+OM relative to that of CO_2-C was estimated as 90-190.[69]

Large emissions of BC would obviously have a significant affect on warming. Below is his example application of this function:

If 1 tonnes of f.f. BC is emitted and the emission ratio of OM:BC is 2:1 (the assumption used to derive the climate response function), then:

the low-end equivalent CO_2 emission over 100 years is 1 tonnes f.f. BC * (3 tonnes f.f. BC+OM / tonne f.f. BC) * (90 tonnes CO_2-C / tonne f.f. BC+OM) * 44 tonnes- CO_2/ 12 tonne CO_2-C = 990 tonnes- CO_2 [70]

The high end is 1 tonnes f.f. BC * (3 tonnes f.f. BC+OM / tonne f.f. BC) * (190 tonnes CO_2-C / tonne f.f. BC+OM) * 44 tonnes- CO_2/ 12 tonne CO_2-C = 2090 tonnes- CO_2

Deposited Carbon Soot Causes Rapid Melting Of Ice And Snow

Carbon soot particles are a factor in an earlier onset of spring in the Northern Hemisphere. A study on the effects of very small amounts of soot on fresh snow showed a reduced albedo of about 30% and a 50% increase in melting compared to clean fresh snow.[71] There is no place for anthropogenic carbon soot in the Arctic or Antarctic as is discussed below.

Hansen and Nazarenko (2004) estimated a climate forcing effect of 0.3 W/m2 by soot on high-latitude snow and ice albedos of the Northern Hemisphere. They calculated global warming just from soot in snow and ice for a 120-year simulation could account for 25% of the observed global warming.

However, only recently have scientists begun to realize the full potential of certain particulate pollution to capture UV & visible light on the ground. Deposited soot and metals can cause melting of light-***reflecting*** snow & ice, and in the process create light-***absorbing*** water and more melting. Such soot deposition in polar snow and ice has the added potential to cause runaway positive feed back loops of melting.

Such feed backs become most intense in the presence of 24 hour polar sunshine. Per the hypothesis advanced in this paper, the intensity of such feed backs appears most dependant on the quantities of carbon soot lying both near the surface and just below it (from years past).

Zender June 2007, determined that in the past two centuries, the Arctic has warmed about 1.6 degrees, with dirty snow causing .5 to 1.5 degrees of the warming, or up to 94 percent of the observed change.[72]

Carbon soot particles attach to snowflakes in the atmosphere and can deposit freely on ice or firn by deposition (firn is well-bonded snow older than one year). As the soot particles continuously absorb visible light, most of which was reflected previously by snow/firn or ice, they convert the absorbed light into heat (infrared radiation).

Microphotographies show carbon enriched aerosol particles (*Pereira et al*. 2006)

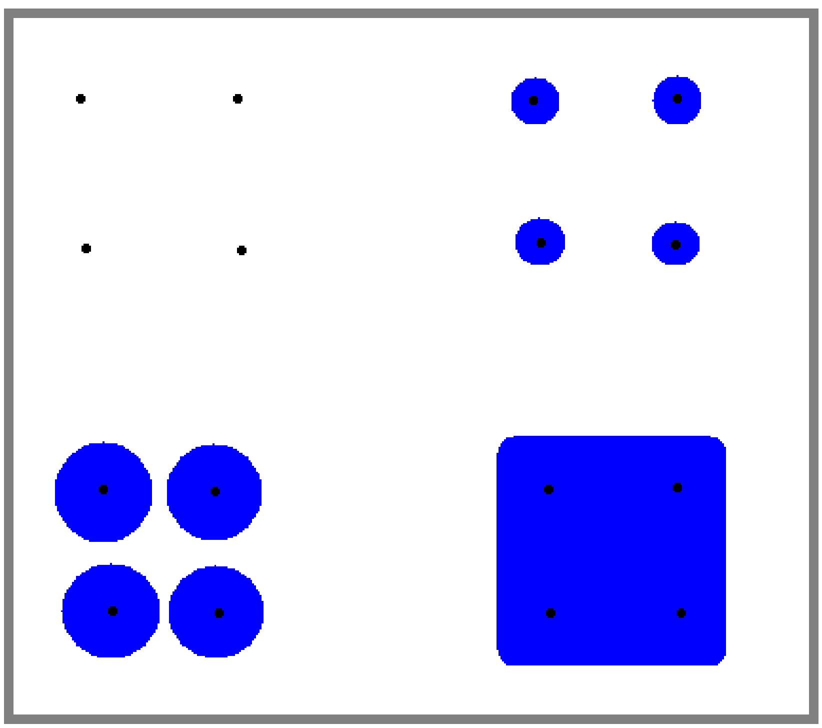
How Sunlight- Exposed Carbon Soot Depositions Might Rapidly Melt Large Ice Shelves

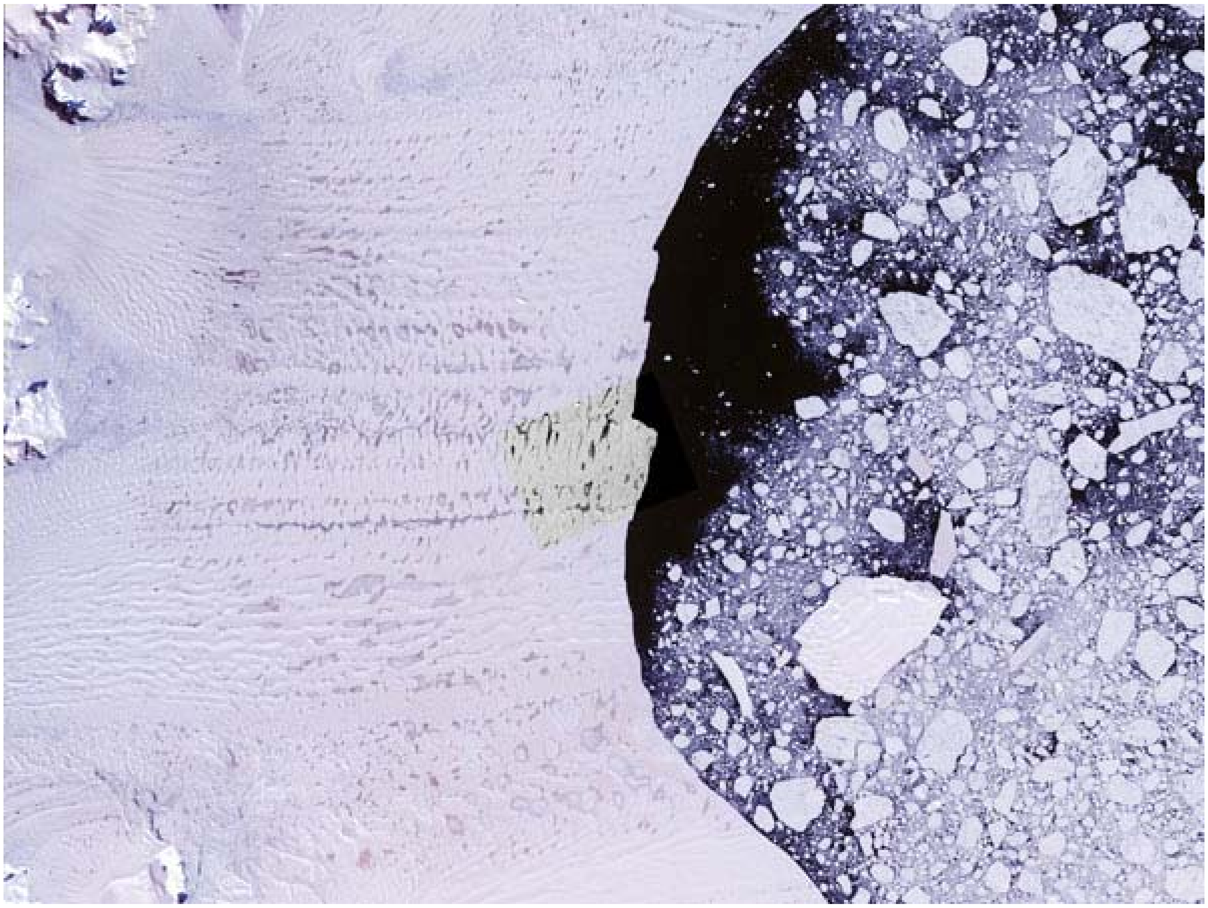
Normally the highly reflective albedo of the ice and snow in the polar regions causes most of the sun's energy that reaches the surface to be reflected, thereby preventing the transfer of heat, and with that, potential to cause melting.

However, if even a small sprinkling of microscopic soot is deposited on the ice or snow, and then remains exposed to sunlight, the potential for a powerful melting feedback loop can be established.

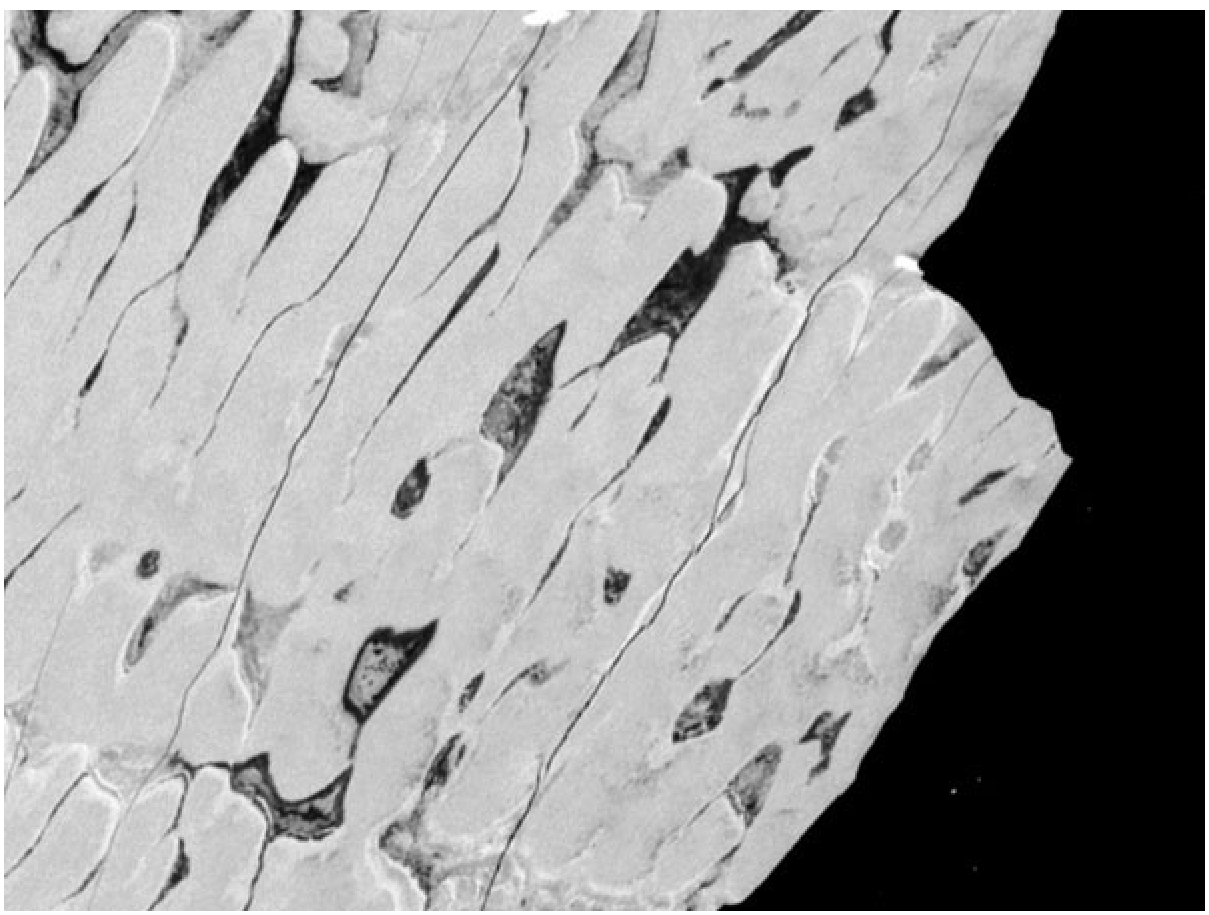
This positive feedback loop is described and illustrated below:

- The carbon soot deposited in snow (black dots) absorbs light and generates heat (IR),
- The heat melts snow next to the soot, producing a small amount of water,
- The freshly melted water, the beginnings of a surface "Melt Pond", is blue and has a low albedo, and begins to absorb more sunlight, generating more heat,
- The warm water then begins to pool, melting the ice below, and sinking long vertical holes into the ice (see satellite shots below of Larsen B just before it "spontaneously" broke up),
- The growth of surface Melt Ponds continues as long as the sun is shining, which can be 24 hours per day for months of the year in the polar regions.





Larsen B Ice Shelf just prior to complete collapse in 2002. Note Melt Ponds throughout the Ice Shelf - see exploded view below of section at the middle of leading edge of ice shelf above.
http://www.nasa.gov/centers/goddard/news/topstory/2004/0913larsen.html



Near Surface Temperature Warming May Not Be As Critical to Polar Melting As Carbon Soot Deposition

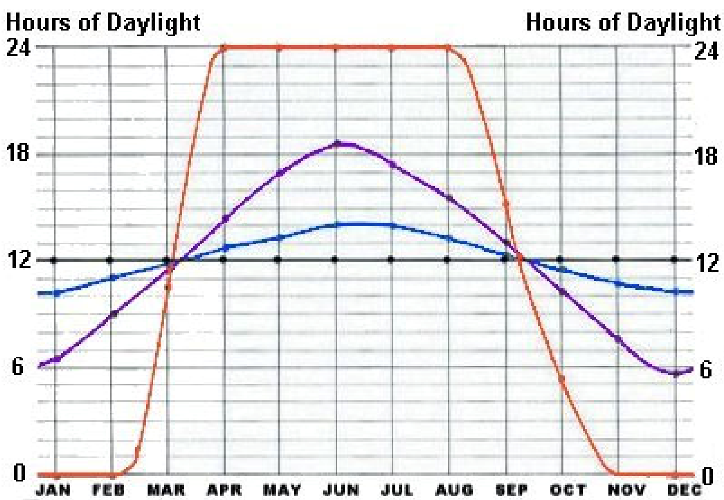
As illustrated above, when exposed to sunlight, increases in BC soot deposition can cause increased surface melting of ice & snow despite no significant increase in seasonal near surface temperatures.

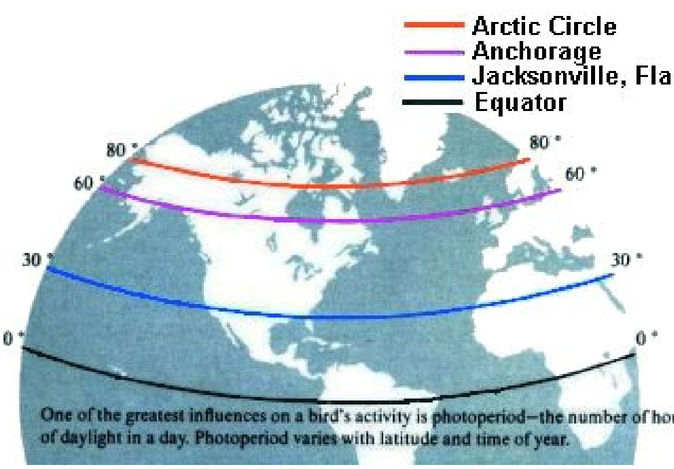
Canadians living in northern urban settings understand this principle well. When a fresh layer of white snow falls and fully covers the black asphalt below, it often remains dry and stable in bright sunshine. However, if a snowplow removes a portion of this dry snow, moments later the exposed asphalt immediately begins to warm, causing rapid melting of adjacent snow in the street.

Carbon Soot Combined With Months of 24 Hour Sunlight Could Devastate The Arctic In Years

Carbon coal soot deposition from China, India, and North America, and increasing amounts of diesel soot from Europe, Asia and North America, travel north during the winter and collect in the Arctic, as described further below. As such, Arctic sea ice is now heavily contaminated with increasing amounts of soot. And because the sun shines on the Arctic for long periods of time in the summer, approximately along the lines graphed below, this is having a disastrous affect on the rate of melting in the Arctic.

Source of graphs: (http://www.paulnoll.com/Oregon/Birds/climate-photoperiod.html)





China is adding 1- 2 coal plants on line each week and world-wide diesel emissions are climbing.

The potential for much of the Arctic sea ice to rapidly break up as the Larsen Ice shelf did in 2002 becomes a more serious threat as each new coal plant in the Northern Hemisphere comes on line.

4. Carbonaceous & Arctic Hazes

The Nature of Carbonaceous Aerosol Haze – an Atmospheric Insulator

The new research on carbon soot, as well as historical and current temperature data, indicate these hazes of pollution insulate the areas of the planet they cover. This is because both minute and larger particles of carbon soot are not only absorbing light from the sun[73], but the sulfur and other aerosols in the haze re-reflect infrared rays from the earth's surface that would normally escape into space.

Analysis of recently assembled historical and current temperature anomalies indicate that low altitude carbon based aerosols, resulting from the incomplete combustion of fossil fuels and bio-mass, are driving a significant portion of global warming, above and beyond that attributed to rising levels of GHG in the atmosphere.[74]

This appears to be causing a rapid acceleration of ***regional*** global warming, particularly in the Northern hemisphere, where most coal burning; land, air, and marine transport emissions; and forest fires are occurring.

Aerosols and Global Dimming

Global dimming is the gradual reduction in the amount of global direct irradiance at the Earth's surface (sunlight reaching the surface), observed since systematic measurements began in 1950s. The effect varies by location, but worldwide it is of the order of a 4% reduction over the three decades from 1960–1990. This trend may have reversed somewhat in some regions during the past decade as emissions controls on cars, trucks and industry have reduced pollution levels in certain countries.

Global dimming is believed to create a cooling effect that may partially mask the effect of greenhouse gases on global warming. However the opposite may be the case most often.

While there is no doubt that dimming is caused by aerosol pollution, as discussed above, there is new evidence showing that dimming pollution can cause warming due to the carbon soot content in the pollution.

The data maps below show that where the greatest dimming has occurred is also where the most warming has occurred. Russia, which at one point had the greatest measured dimming at 30%,[75] also warmed faster than most places on Earth (see global warming maps above or below).

How Carbon Haze May Cause Dimming And Warming, Not Cooling

The following is an explanation of how low altitude yellow, red, and/or gray light-absorbing carbon aerosol haze is blocking light from reaching earth's surface, causing dimming, but still causing warming and not the cooling currently thought to be associated with aerosol dimming.

- When incoming sunlight meets the haze that contains various concentrations of aerosol carbon, one of three things happens:
    1. some of the light passes through the haze to Earth's surface below.
    2. a portion of that incoming light is immediately reflected back to space (causing dimming),
    3. the rest of the light is initially scattered in the haze upon colliding with aerosols there (also causing dimming).

- The scattered (and temporarily trapped) light ricochets around within the haze (not being absorbed - this is known as elastic Rayleigh scattering), and eventually:
    1. some of this light is re-reflected back into space,
    2. some is re-reflected and continues on to Earth,
    3. some collides with the carbon aerosols in the haze and is absorbed, converted to IR, leading to a warming of the aerosol haze (and ultimately the surfaces below).

- Of the sunlight that does reach Earth:
    1. some is absorbed by plants and other life forms,
    2. some is reflected off snow, ice, water, and other reflective surfaces back to space.
    3. but much is absorbed and transformed to IR.

- A portion of the latter IR is normally reflected back towards space,
    1. but some encounters water vapor and other GHG in the atmosphere, is absorbed and then reflected back to Earth, warming it.
    2. and, in this case, some encounters the aerosol haze and is absorbed and then reflected back to Earth, further warming it.

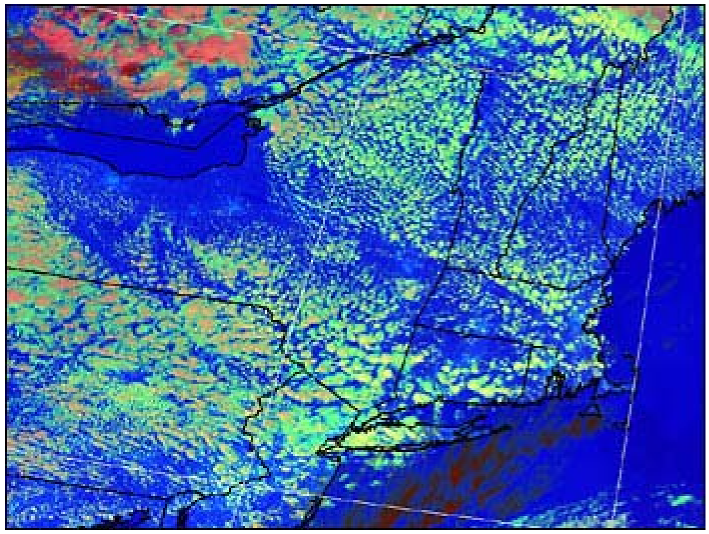
- As well, some of the sunlight that was absorbed by the Earth during the day is trapped in heat sinks which then release heat (IR) after the sun goes down.
    1. Most of the released IR exits the atmosphere, but some of this is absorbed and then reflected back to Earth by GHGs in the atmosphere, keeping the Earth warm.
    2. When this nighttime IR encounters aerosol haze a greater portion is now reflected back to earth creating a rise in evening temperatures.

A 3rd Potential Warming Effect Due to Increasing Haze Density and Overall Haze Volume

In the 1960s and 70s many urban areas had thick pollution due to growing numbers of automobiles, all without any emissions controls. But, as many such urban areas and their suburbs were much smaller, the pollution remained quite localized, and would often dissipate over cleaner surrounding country-sides, thinning the haze dramatically. These regions had room to "breathe", as the next closest urban area was often sufficiently far away to prevent any serious build-up of particulate.

However, as can be seen in this 2004 photo of Los Angeles, urban sprawl has connected many previously separated communities. http://origin.www.nature.com/ngeo/journal/v1/n1/pdf/ngeo.2007.62.pdf

Despite modern emissions controls, both increased industrial output, and the shear number of vehicles (with higher horsepower engines) has led to huge clouds of smog interconnecting and covering entire geographic regions, as seen in the image of North-East America below.



http://earthobservatory.nasa.gov/Study/Pollution/pollution.html

In this photo, the dense concentration of powerplants, factories, trucks, and automobiles on the U.S. east coast continuously emit soot and other particulate pollutants into the sky. The photo shows the extent of the pollution (yellow-green) over this huge area.

(As discussed earlier, because small particles suspended in the air often end up interacting with clouds, they form a larger number of smaller droplets than those found in an unpolluted cloud. In this satellite image, taken in 2000, the yellow-green clouds scattered over the northeast are polluted clouds with small water droplets. The pink clouds over Canada have larger droplets, and are relatively clean. Pollution levels have continued to increase since 2000 when this photo was taken. Image by Daniel Rosenfeld, Hebrew University of Israel)

Analysis of research and other data presented herein suggests that in the atmosphere of any region(s) affected by a relative increase in the:

1. density of carbonaceous particles within the haze
2. total surface area covered by such haze, and
3. volume of haze over that total surface area,

(or, in other words, as haze thickens, covers more area, and rises higher into the atmosphere)

the normally elastic Rayleigh scattering relationship that reflects a certain amount of incoming sunlight back to space, begins to break down proportionately to the amount of light-absorbing particulate in the haze (and the energy it ultimately absorbs. In an elastic collision the incident and target particles remain intact (like billiard balls). No energy is absorbed and converted.)

Not unlike a flashlight's beam that becomes increasingly lost when pointed into a thickening fog, as carbonaceous haze density and volume increase, the warming feedback accelerates because more of the solar radiation entering this thicker haze is trapped and ultimately absorbed by the carbon soots within the haze, rather than being eventually scattered & re-emitted from the haze back to space. This effect would cause increasingly intense regional warming.

And as one urban area's smog extends & connects with smog in other areas, larger tracks of land and sea can be affected, further heightening the effect.

Much of China, India, the rest of Asia, Europe, and North America are affected by this problem.

Los Angeles, pictured above, is just one of many well known examples in North America. The entire Northeast of America is another, as can be seen in the photos that follow.

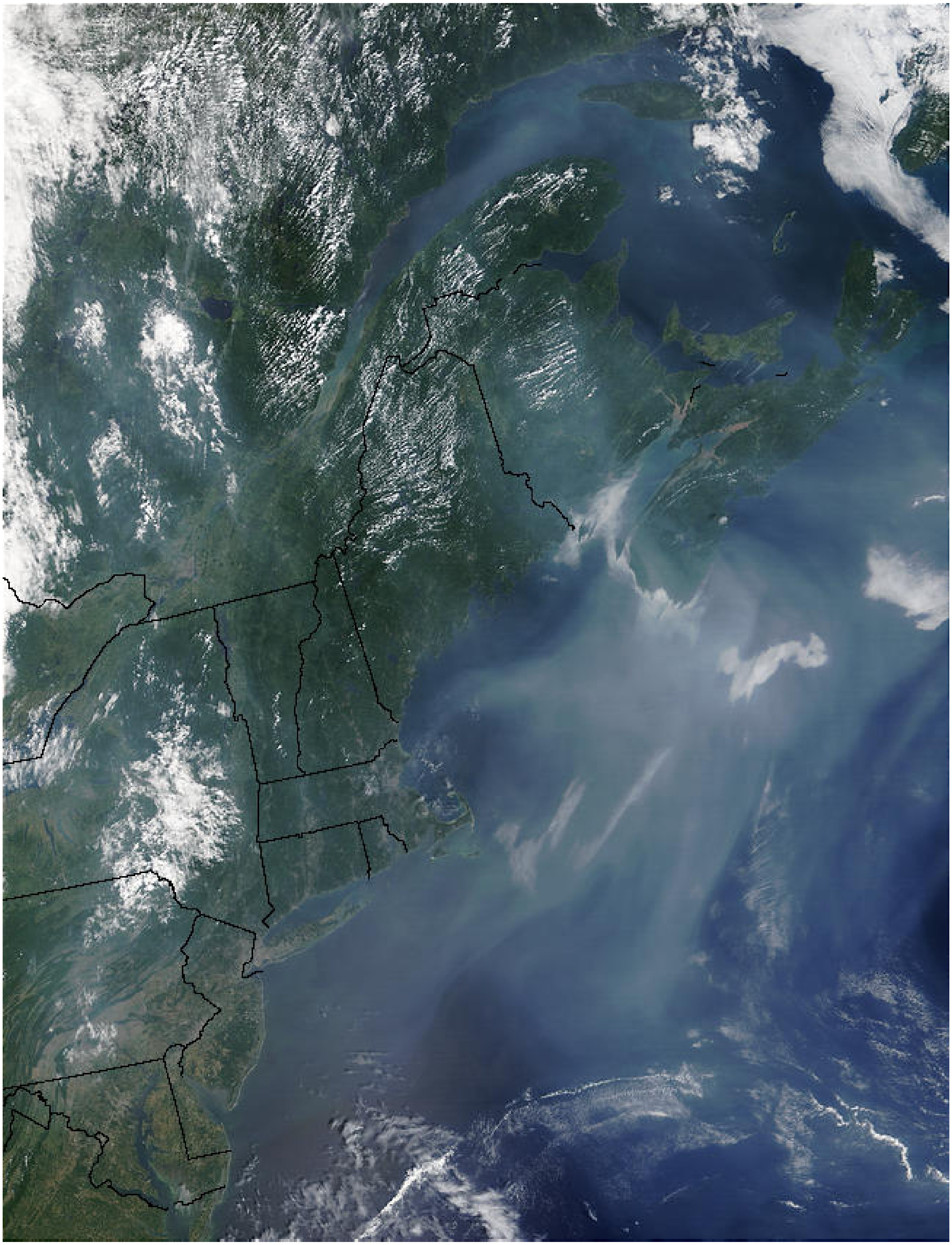
http://visibleearth.nasa.gov/view_rec.php?id=1519

Image provided by the Earth Science and Image Analysis Laboratory, Johnson Space Center

The STS-92 Space Shuttle astronauts photographed upstate New York at sunset on October 21, 2000. Water bodies (Lake Ontario, Lake Erie, the Finger Lakes, the St. Lawrence and Niagara Rivers) are highlighted by sunglint (sun reflecting off the water surface), making for a dramatic and unusual regional view.

The photograph was taken looking toward the southwest from southern Canada, and captures a regional smog layer extending across central New York, western Lake Erie and Ohio, and further west. The layer of atmospheric pollution layer is capped by an atmospheric inversion, which is marked by the layer of clouds at the top of the photograph. The astronauts were able to document this smog event from a variety of vantage points as they orbited over the northeastern U.S. and southern Canada.

Satellite Photos Show Blankets of Smog Covering Huge Areas



Pollution off the East Coast

Images & Animations

- 650 x 850 JPEG (114.4KB)
- 1300 x 1700 JPEG (404.6KB)
- 2600 x 3400 JPEG (1.3MB)
- 5200 x 6800 JPEG (3.7MB)
- Details and More Imagery

- Credit Jacques Descloitres, MODIS Land Rapid Response Team, NASA/GSFC

Great swirls of pollution cover the northeastern United States and parts of Canada in this true-color Terra MODIS image acquired August 14, 2002. While clouds in this image appear solidly white, the pollution is a murky, semi-transparent gray that makes indistinct the image's geographic and aquatic features.

The pollution is worst in the Gulf of Maine and Atlantic Ocean, partially obscuring the southern edge of Nova Scotia. It also partially obscures a phytoplankton bloom in the waters of the Gulf of St. Lawrence (top center). Had the pollution been absent or not so severe, the bloom would appear to be a bright blue-green color, caused by sunlight reflecting off of the chlorophyll in the phytoplankton.

Smoke from Russian fires across Northeast China

Images & Animations

- 2000 x 2600 JPEG (942.1KB)
- 4000 x 5200 JPEG (2.8MB)
- 8000 x 10400 JPEG (7.7MB)
- Details and More Imagery

- Credit Jacques Descloitres, MODIS Land Rapid Response Team, NASA/GSFC

Fires burning across southern Russia are choking the skies with thick smoke in this Moderate Resolution Imaging Spectroradiometer (MODIS) image from the Aqua satellite on May 9, 2003. Large numbers of fires (detected by MODIS and marked with red dots) are burning in the terrain around Lake Baikal (top left). They are spreading plumes of smoke southward hundreds of miles over China and the Korean Peninsula. At bottom left, some of the haze may be from air pollution.

Carbon Soots are Melting Glaciers

The more dense and voluminous hazes described and pictured above are very common today.

In lower and mid latitudes this would affect local atmosphere temperatures and warming. However, any local glacial snow packs at higher elevations collect soot that deposits in the snow, triggering accelerated melting in the presence of sunshine and a reduction of water supplies dependant upon them. This is made worse by deposits of brown carbon, now understood to be trapping the Sun's more powerful UV rays.

The photograph below of Santiago, Chile is typical of many South American cities at the base of the Andes Mountains. Notice that this haze has the brown tinge indicative of Brown Carbon pollution. This is very problematic for the glaciers above and downwind from the city.

http://www.britannica.com/ebi/art-73098/A-thick-layer-of-smog-hovers-over-Santiago-Chile

How Soot May Be Causing Rapid Acceleration In Both Regional And Polar Climate Change

The following chain of events indicates how the combination of: 1) atmospheric carbon aerosols, and 2) subsequent soot deposition resulting from it, may be causing the rapid acceleration in both regional and polar climate change – with those polar changes being much greater than just that attributable to a rise in near-surface polar air temperatures, because of the altered albedo of the snow and ice by deposited soot:

- Soot emissions from industry and vehicles at mid latitudes cause immediate local atmospheric warming and IR insulating, primarily in the mid latitudes, leading to increased temperatures and more violent weather there,

- higher mid-latitude temperatures lead to spread of pine beetles, dying trees, and to increased forest fires in North American and Siberian boreal forest, with that soot from fires causing additional local warming,
- industrial soot emissions from China, North America, and Europe float northward on winds causing heavy arctic carbon soot pollution know as Arctic Haze (see below),
- Forest fire smoke also travels north along with industrial emissions and contributes further to Arctic Haze, further increasing near-surface temperatures,
- Eventually soot in Arctic Haze deposits in the snow and ice, and while not increasing near-surface temperatures all that significantly, it radically alters the albedo of the snow and ice. Measured Arctic soot levels are approximately 90 times higher than at the South Pole,[76]
- The dirty snow and ice is sheltered somewhat from direct sunlight in the winter due to the tilt of the Earth's axis and very short day light hours,
- However, during the summer when the Arctic is lit up by sunlight for most of the day, the deposited soot causes an elevation of temperatures on the surface of the snow and ice itself, but not necessarily of the air above. However the air above is warming too, being further warmed by the carbon aerosol haze above,
- Snow and ice melt rapidly as running water quickly transfers energy along the surface of snow and ice, but without significantly warming the air,
- Combination of warm, soot-rich, blue surface water traps more heat right at the surface and causes more surface melting with little increase in near-surface air temperatures,
- Resulting loss of sea ice results in relative loss of albedo necessary to reflect sunlight and near-surface arctic temperatures start to rise. This leads to further warming in the north and the cycle repeating, causing more forest fires.
- Smoke from fires in South America, and Diesel generators on Antarctic Peninsula and other parts of the Antarctic region could be having same effect on the Antarctic Peninsula.

Arctic Haze

Arctic Haze describes the phenomena of a visible reddish-brown haze in the atmosphere at high latitudes in the Arctic due to air pollution. The haze aerosols are up to 90% sulphurous, mixed with carbon, which gives the haze its characteristic colour.[77] The pollutants are known to originate from coal-burning in northern mid-latitudes.

The term was coined in the 1950s when pilots traveling on weather reconnaissance flights in the Canadian high Arctic, reported seeing bands of haze in the springtime in the Arctic region. The term "Arctic haze" was first used to refer to this smog of unknown origin. When an aircraft is within a layer of Arctic haze, pilots describe an unusual reduction in visibility, where horizontal visibility can drop to one tenth that of normally clear sky.

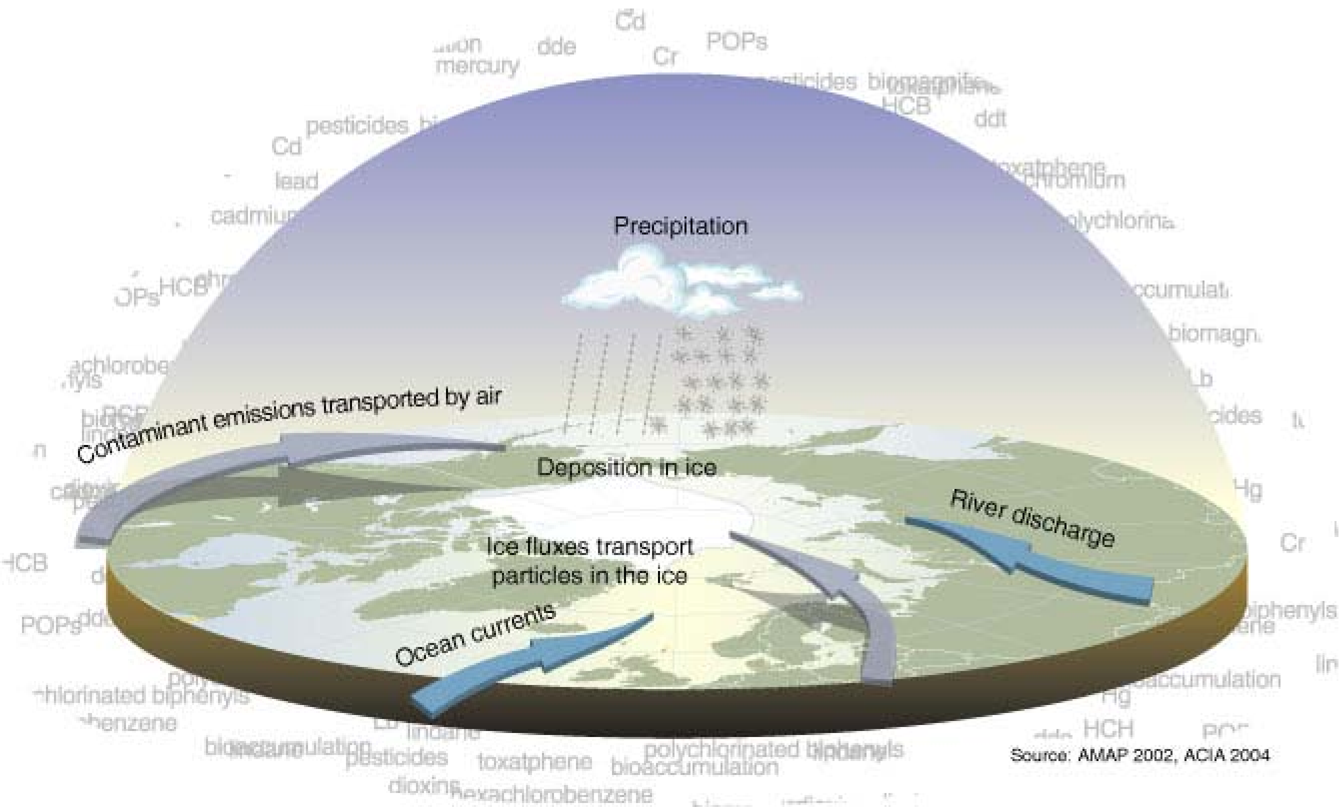
(photo: www.alumni.utah.edu/u-news/june06/ Garrett)

The haze is seasonal, reaching a peak in late Winter and Spring. In 1972 Dr. Glenn Shaw of the Geophysical Institute at the University of Alaska first put forth ideas of the nature and long-range origin of Arctic haze, attributing this smog to transboundary anthropogenic pollution, with the Arctic being the recipient of contaminants whose sources are thousands of miles away. (The idea that the source was long range was initially very difficult for many scientists to support.)

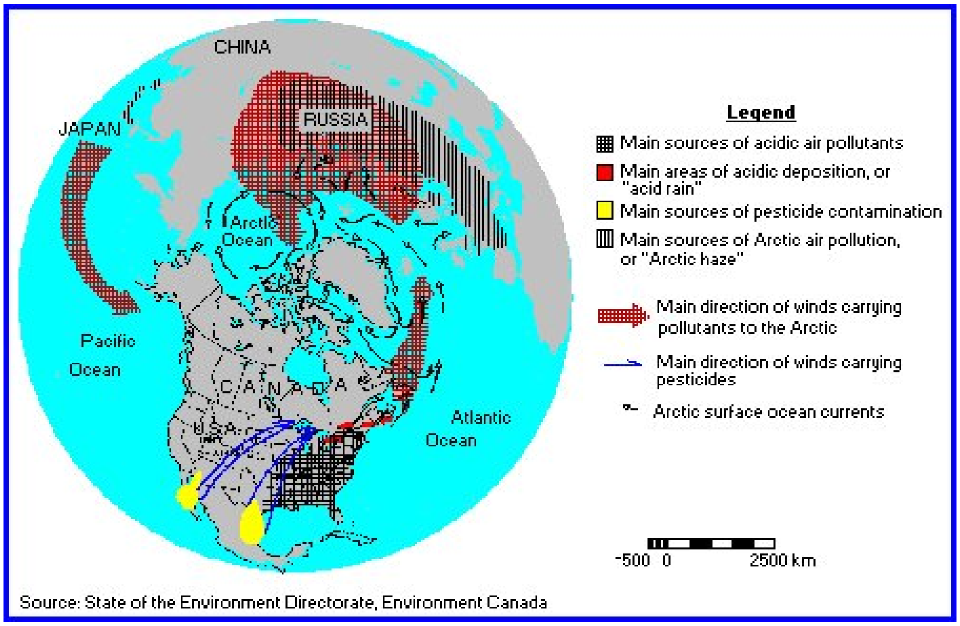
Each winter, cold dense air settles over the Arctic. In the darkness of the winter months, the Arctic becomes ever more polluted by a build-up of mid-latitude emissions from fossil fuel combustion, smelting, and other industrial processes. By late winter, the Arctic is covered by a layer of haze the size of the continent of Africa.[78] When the spring light arrives in the Arctic, the smog-like haze can resemble pollution over cities like Los Angeles.

This polluted air is a well-known and characterized feature of the late winter Arctic environment. Certain evidence from ice cores drilled from the ice sheet of Greenland indicates that these haze particles were not always present in the Arctic, but began to appear only in the last century. However, others believe Arctic haze has been seen in the Arctic since the Industrial Revolution began about 1750. Whalers and explorers noticed what looked like pollution and couldn't figure out where it was coming from. [79] The Inuit (Eskimos) called it "poo-jok."

The graphics below and on the following page demonstrate how particulates travels to the Arctic.



(Map Above, Ahlenius,H., UNEP/GRID-Arendal source: Arctic Monitoring and Assessment Programe, Arctic Climate Impact Assessment url: http://maps.grida.no/go/graphic/pathways_of_contaminants_to_the_arctic)



This map was produced by the Canadian Government in 1995 when China was not yet the economic force it is today.

In 1993 China used 1.27 billion tons of coal.

In 2004 it used 2.06 billion tons and the US used 1.1 billion tons. [80]

In 2007 China used another 31% more: 2.7 billion tons.

The Arctic haze particles are similar to smog particles observed in industrial areas farther south, consisting mostly of sulfates mixed with particles of Black Carbon soot. It is believed the particles are formed when gaseous sulfur dioxide produced by burning sulfur-bearing coal is irradiated by sunlight and oxidized to sulfate, a process catalyzed by trace elements in the air. These sulfate particles or droplets of sulfuric acid quickly capture the BC soot particles which are also floating in the air. Pure sulfate particles or droplets are colorless, so it is believed the darkness of the haze is caused by the mixed-in BC particles.

Left - Pollution from China will contribute to a big increase in warming.
Chang W. Lee/The New York Times

In the North American Arctic, episodes of brown or black snow have been traced to continental storm tracks that deliver gaseous and particulate-associated contaminants from Asian deserts and agricultural areas. As well, a National Ocean and Atmospheric Administration research station measured concentrations of particulates, mostly sulfates from coal-burning power plants & smelters and from fossil fuels burned by automobiles & other sources in cities. It is now known that some contaminants originate from North America, but most are from Europe and Asia (*Garrett and Zhao,* 2006).

Garrett's and Zhao's study, published in *Nature* in May 2006, found that mid latitude BC pollutants warm the far north. The instrumentation used in the study showed the particulate pollution from mid-latitude cities mixes with thin clouds, making them better able to trap heat.[81]

Arctic haze has been studied most extensively in Point Barrow, Alaska, across the Canadian Arctic and in Svalbard, Norway. Earlier measurements made by sampling air at those locations show that the haze contains small amounts of vanadium. The vanadium, being a natural component of crude oil, is injected into the atmosphere in areas of heavy industrial activity. [82]

Arctic haze above Svalbard. On the left (May 2nd, 2006), orange brown dust is clearly visible. On the right (May, 8.), the dust has disappeared.

What is most interesting and alarming about this photo is that the haze is now appearing in May.

Credit: Jergen Graeser, Alfred-Wegener-Institut[83]

Tim Garrett, an assistant professor of meteorology, and Chuanfeng Zhao, a doctoral student in meteorology at the University of Utah, concluded Arctic Haze makes the Arctic 2 - 3 degrees Fahrenheit warmer during polluted, cloudy episodes than when the air is clean.

They conducted their study using four years of measurements collected at two research sites near Barrow, Alaska, the northernmost town in the United States. With upward-looking instruments, they measured multispectral infrared radiation – different wavelengths of heat – emitted by clouds, and then used this with other data to determine how effective low-lying clouds are at absorbing heat emitted by the Earth's surface – in order to see "how good a blanket they were" Garrett said. (The more heat clouds absorb from the ground, the more heat they emit.)

Using a theoretical model, they also estimated how much water the clouds had, and also the sizes of droplets in the clouds when the clouds were polluted and not polluted.

They found that when clouds were present and the air polluted, the clouds "were more effective at stopping the surface from releasing its heat to outer space" Garrett says. "The reason this was true is that the pollution particles made the cloud droplets more numerous, but consequently smaller. Even if the amount of water is the same in the cloud, a larger number of small droplets corresponds to a more effective blanket."

Garrett says people living in Salt Lake City or other mid-latitude desert climates experience the same effect during winter. "When clouds are present, it doesn't get as cold at night as when they are absent".

5. How Varying Levels of Soot Deposition Affect the Poles

Understanding The Rate At Which Arctic Land & Sea Ice Is Melting

Understanding the full impact of Arctic Haze on climate change is the major issue for researchers. Over the past 2 - 3 years, both the unexpected new data discussed above, and the observations of dramatic sea-ice melting in the Arctic, have begun to challenge the theories previously believed to be causing warming in the region.

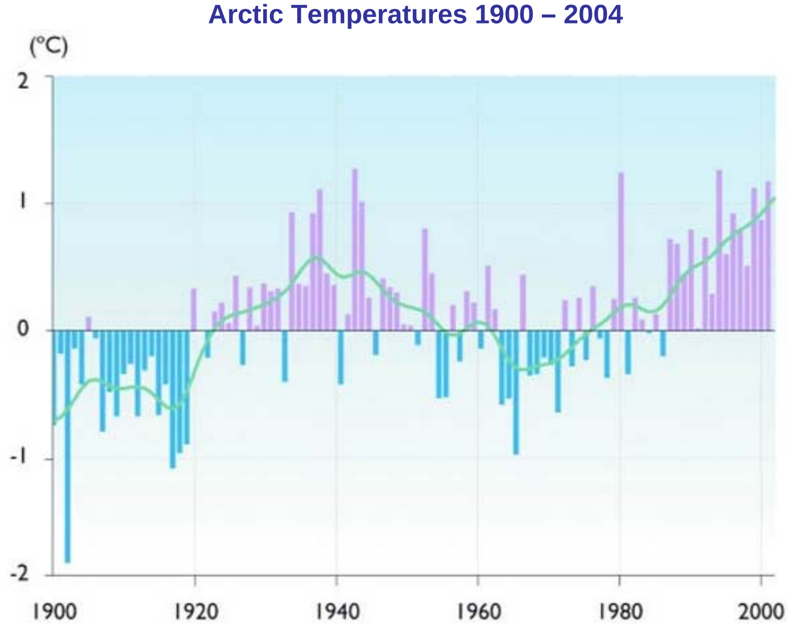
In 2006 *Holland, Bitz & Tremblay* suggested that all Arctic summer sea-ice could melt as soon as 2040 – shocking enough. That estimate was based on data from 2005 going back approximately 30 years. They indicated the ice retreat will accelerate as thinning increases the open water formation efficiency for a given melt rate and the ice-albedo feedback increases shortwave absorption, and that the potential retreat is abrupt when ocean heat transport to the Arctic is rapidly increasing.

Author Tim Flannery gave a newly updated estimate in a February 2007 speech. While only a rough approximation, he adjusted earlier peer-reviewed projections of retreating ice to reflect the record decline seen in 2005. He calculated that should it continue at that rate, the complete melting of Arctic summer sea-ice will happen very much sooner than 2040. Adding the new data to previously existing curves plotting melting, Flannery extended the estimated melting curve to project where all the summer-ice has melted. The two lines intersected somewhere between 2010 and 2020. He admits this isn't the way science is normally done, but at the same time it is a potential indicator that can't be ignored.[84]

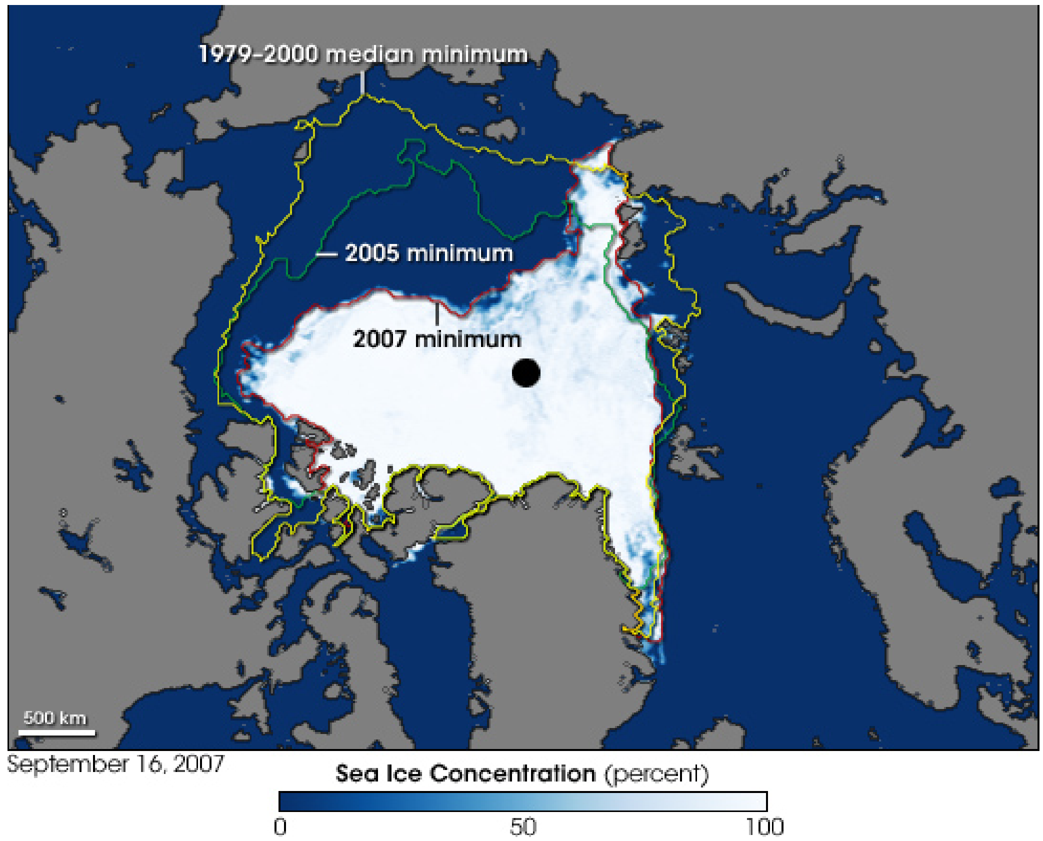
Since Flannery's remarks, ***the unexpected melting of 27% more Arctic summer sea ice in 2007 as compared to the previous record low in 2005, indicates Flannery's estimate may even be too conservative.***

As seen in the chart below, Arctic temperatures from 1900 - 2004 oscillated dramatically. However as this paper discusses, those ***arctic temperature fluctuations appear to coincide with variations in the amount of soot and other air pollution generated during specific periods of economic activity in the 20th century, and not the continuously increasing levels of CO_2.***

Arctic Temperatures 1900 – 2004

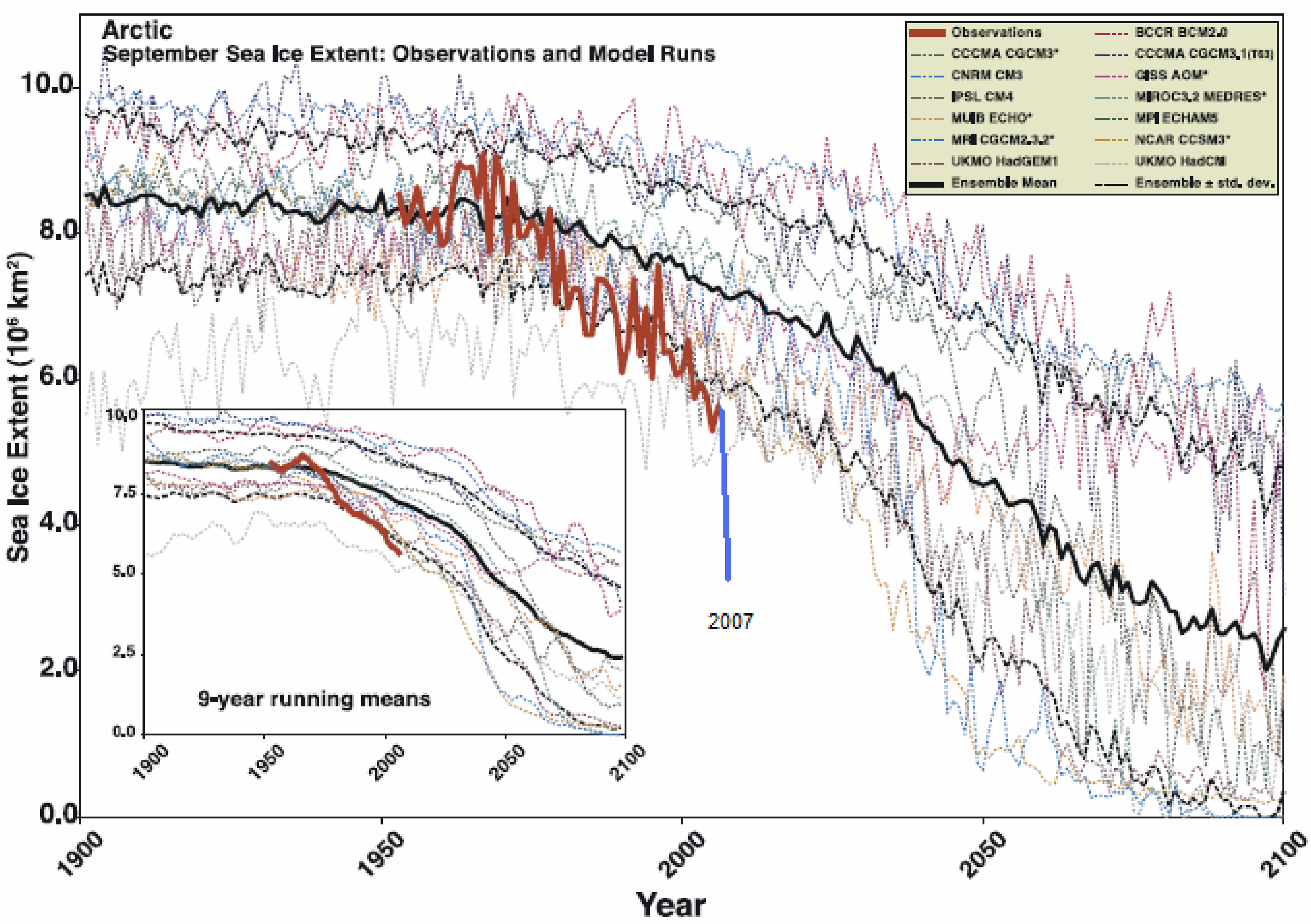


Annual average change in near surface air temperature on land relative to average for 1961-90, © ACIA 2004
http://amap.no/acia/



http://www.globalwarmingart.com/wiki/Image:2007_Arctic_Sea_Ice_jpg

STROEVE ET AL.: ARCTIC ICE LOSS—FASTER THAN FORECAST



In May 2007, *Stroeve et al.* raised more questions about GHG theory by showing that:

- Even prior to the September 2007 meltdown in the Arctic, arctic melting was happening approximately 3 times faster than in the most recent projections, and at a rate far beyond any predictions of GHG theory and modeling,
- The arctic ice pack is on track to completely melt 30 years sooner than previously predicted
- GHG models are not correctly predicting this - hence there is something wrong with the models
- and as such, " The sensitivity of this region may well be greater than the models suggest."

Furthermore, while not mentioned in the *Stroeve* paper, the models discussed do not predict the accumulation of ice as the climate cooled from the late 40s until the late 1960s. In the chart above, the actual observations to 2006 are **charted in red**. However, if that line were continued back into the late 1940's we'd see the actual and more significant ice expansion that would have actually occurred, and, that it doesn't match up with the gradual melting projected by the models, **in black**.

The **blue line** represents the record year of ice loss seen in 2007.

Had *Stroeve et al.* had this data they would have concluded melting was occurring was occurring between 6-8 times faster than the GHG modeling predicts.

This and other very urgent indicators call for the use of the Precautionary Principle when considering the potential affects of carbon aerosols and determining the immediate and future inter-governmental policy affecting Climate Change.

Most of Antarctica Is Normally Colder Than The Arctic For Two Reasons

One, much of the continent is more than 3 km above sea level, and temperature decreases with elevation. Two, the Arctic Ocean covers the north polar zone: the ocean's relative warmth is transferred through the icepack and prevents temperatures in the Arctic regions from reaching the extremes typical of the land surface of Antarctica.

Comparison Of Carbonaceous Soot Levels In The Arctic Vs Antarctic

	Measured BC in Snow/Sea Ice, ng/g
Alert	45.5 (0 – 127) a
Antarctica	2.5 b
South Pole	0.2 (0.1– 0.34) c

These figures – from: a *Clarke and Noone* (1985) b *Chylek et al.* (1987) and c *Warren and Clarke* (1990) and *Chylek et al.* (1999) – help explain why the Arctic is currently so much warmer than most of the Antarctic. Until now, most of the continent (except for the Antarctic Peninsula) has been quite stable, and some is even cooling. However, soot levels are beginning to accumulate there now too.

Why Soot Doesn't Often Reach The Eastern And Upper Elevations Of Antarctica

For a period during the summer, more solar radiation reaches the South Pole's surface during clear days than at the equator because of the 24 hours of sunlight reaching the Pole on those long days. However, most likely due to the prevailing katabatic winds, the region's albedo remains relatively unaffected by higher levels of soot like those found on the Peninsula, thereby reducing the potential for BC induced melting.

As discussed above, *Pereira* 2006 shows that winds coming from the North carry urban BC soot from South America to the Antarctic Peninsula. They also show that considerable soot is generated locally on the Peninsula by the research activity there.

However, most of this soot remains trapped on the Peninsula, as weather fronts rarely penetrate far into the continent.[85] At the edge of the continent, strong katabatic winds off the polar plateau often blow at storm force. In the interior, however, wind speeds are typically moderate.

These winds have probably protected most of the Antarctic continent from the type of BC induced warming occuring in the Arctic. As these winds also contribute to the generation of a local clockwise circulation of winds about the continent, they would also help explain the potential for BC induced warming downwind of (see map on page 35)

The Antarctic Peninsula Is Warming Very Quickly, And Probably Not Just Because of GHGs

In relative terms, the Antarctic Peninsula is warming faster than anywhere else on Earth, and its glaciers are in massive retreat.[86] However, as the Peninsula warms much of the rest of Antarctica appear to have cooled slightly (*Doran et al*, 2002; GISTEMP).

How can this be if Green House Gases are causing most warming? These two regions, which lie right beside each other, have the exact same concentration of GHGs in the local atmosphere they share, yet one place is warming faster than anywhere else on earth, and the other region just a few hundred kilometers to the south and east may be cooling. (See various maps below.)

The answer could very well be connected to anthropogenic BC Soot.

Several anthropogenic sources of BC affect the Antarctic Peninsula, in particular at King George Island (see maps below). Researchers have also shown that one source of BC is long range pollution, mostly from bio-mass burning in the Amazon and Africa (*Pereira et al.* 2006).

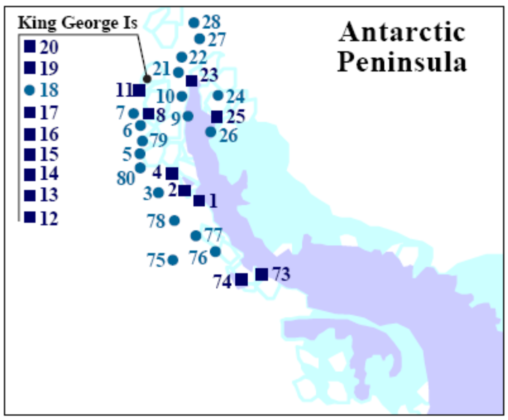
(Haze Over Fuji Station, Antarctica, source: http://www.terradaily.com/reports/Haze_Is_Heating_Up_The_Arctic.html)

Research Activity May Be Contributing To Regional Warming In Antarctica

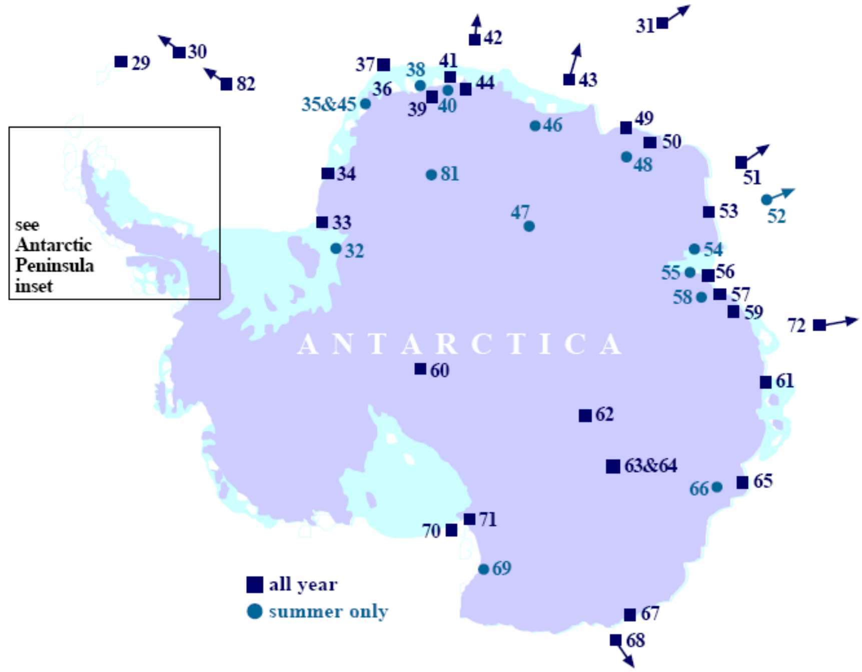
The Antarctic Peninsula is now being subjected to research and human activity on a scale never seen before. There are more than 35 research bases located on an area once remote and untouched by BC and soot. King George Island has one of the highest human population densities of the entire Antarctic continent. This is because of the large concentration of research stations and support bases and its proximity to South America, which facilitates local tourism during summer months. **The operation of several scientific stations together and all the logistics associated with them lead to an increase of atmospheric pollution and consequently an increase in black carbon concentration.**[87]

Antarctic stations and bases are like small villages located in a remote and harsh cold climate that require power for fresh water, cooking facilities, heating, lighting, sewage and wastewater disposal, transport, recreational facilities, medical support, office equipment, maintenance plant, as well as laboratory and research facilities. All these services require a mix of electric and thermal power that has traditionally been provided by Diesel-engine power generators and these remain the dominant source of domestic energy in Antarctica today.

Since the late 1940s the Antarctic Peninsula has been exposed to continuous and increasingly higher levels of diesel soot from the research station power plants, making those diesel engines the most important local source of BC.[88] They are estimated to constitute steady sources of BC to the atmosphere since the electric power plants run around the clock all year round. Garbage burning also creates BC pollution on the peninsula.[89]



(source: The Council of Managers of National Antarctic Programs - COMNAP)



http://pdf.comnap.aq/comnap/comnap.nsf/P/Pages/Operations.ENMANET/#5

There are 82 research stations on the continent, mostly placed about the perimeter, with a dense concentration of 35 stations on the Peninsula. COMNAP fuel consumption records show these 35 research stations burn at least 4.8 M liters, or 1.25 M US gallons of diesel fuel are each year, with the vast majority of that being consumed in the summer months when research activity is greatest. **Raw data for measurements of airborne BC concentrations on King George Island show several degrees of contamination by activities from local scientific stations [Pereira 2006].** As discussed further below, due to local wind patterns much of this local diesel soot combines with long range bio-mass soot from the Amazon and is then blown across the Larsen Ice Shelves, which, as discussed below, have been the most rapidly melting ice formations anywhere.

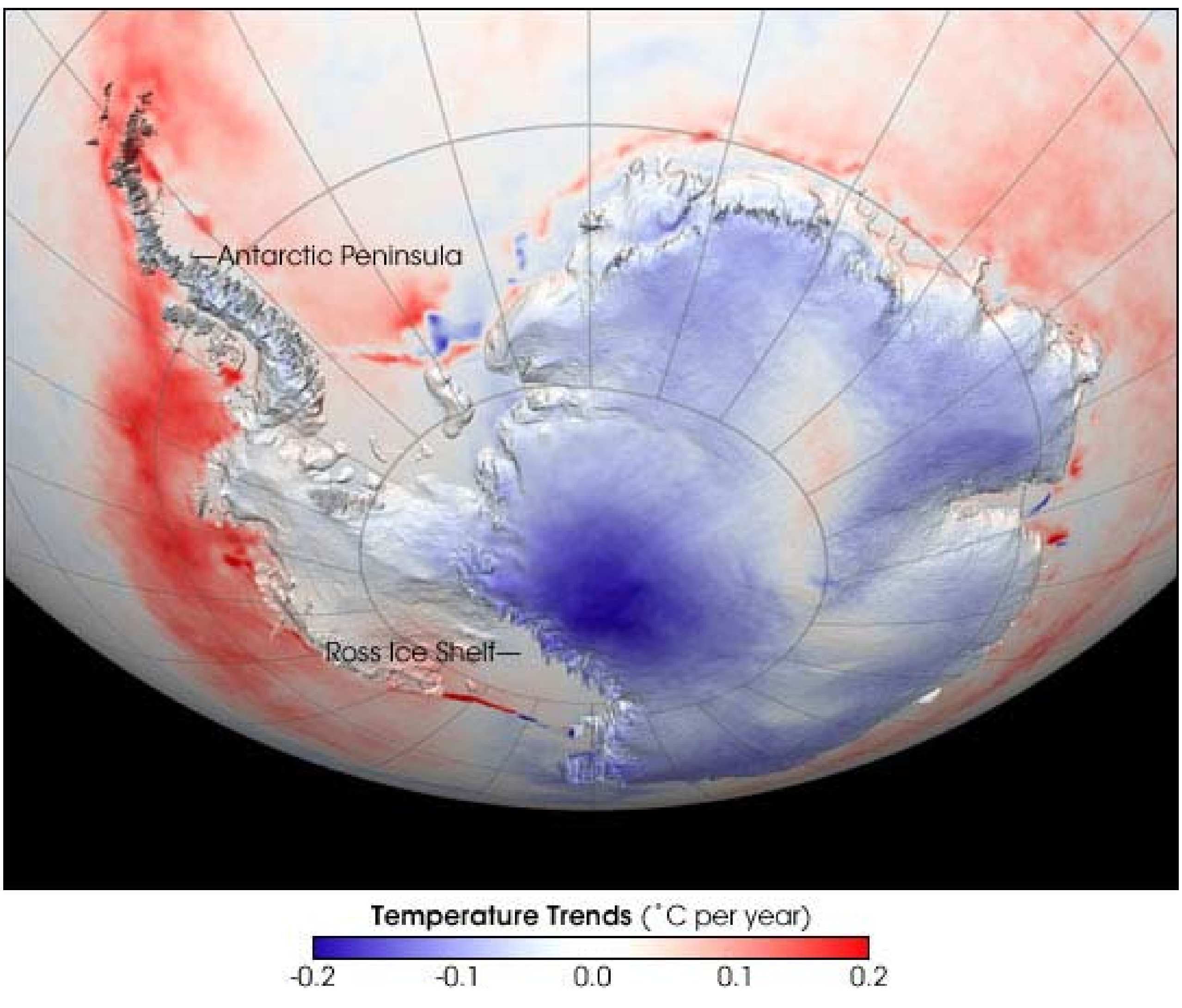
The largest research station, US McMurdo (#70 on the map above), houses as many as 4000 people. Between 1955 and 1968 17 bulk fuel storage tanks were installed at McMurdo. Two additional tanks were built in 1993. The tanks have a combined capacity of 8.7 million gallons.[90] Fuel consumption figures obtained from McMurdo show that approximately 2.5 million US gallons, or 9.4 million liters, of diesel fuel and heating oil are burned each year at the station.

Moreover, because cyclonic winds blow in off of the ocean and circle the coast in a clock-wise direction, both the West Shelf and the Peninsula, the only two sites in Antarctica that are warming are downwind of McMurdo soot emissions. As seen in various maps below, the greatest area of warming on the Antarctic coast clearly extends downwind from this massive research installation.

Click directly on the picture or link below to get an exploded view of this station and its true scale.
http://upload.wikimedia.org/wikipedia/commons/b/bb/McMurdo_Station.jpg

The image below shows trends in skin temperatures—temperatures from roughly the top millimeter of the land or sea surface—of Antarctica from 1982 to 2004. Notice the intensity of warming downwind of McMurdo and the 35 research stations on the Peninsula itself. The two smaller hotspots on East coast are the locations of research stations burning more than 1.4M liters of fuel per year.

http://upload.wikimedia.org/wikipedia/commons/a/a6/Antarctic_temps.AVH1982-2004.jpg



6. Did Amazon & Local Diesel Soot Cause The Larsen Ice Shelves Collapse?

While The Arctic Cooled in the 1940s, The Antarctic Peninsula Began to Warm

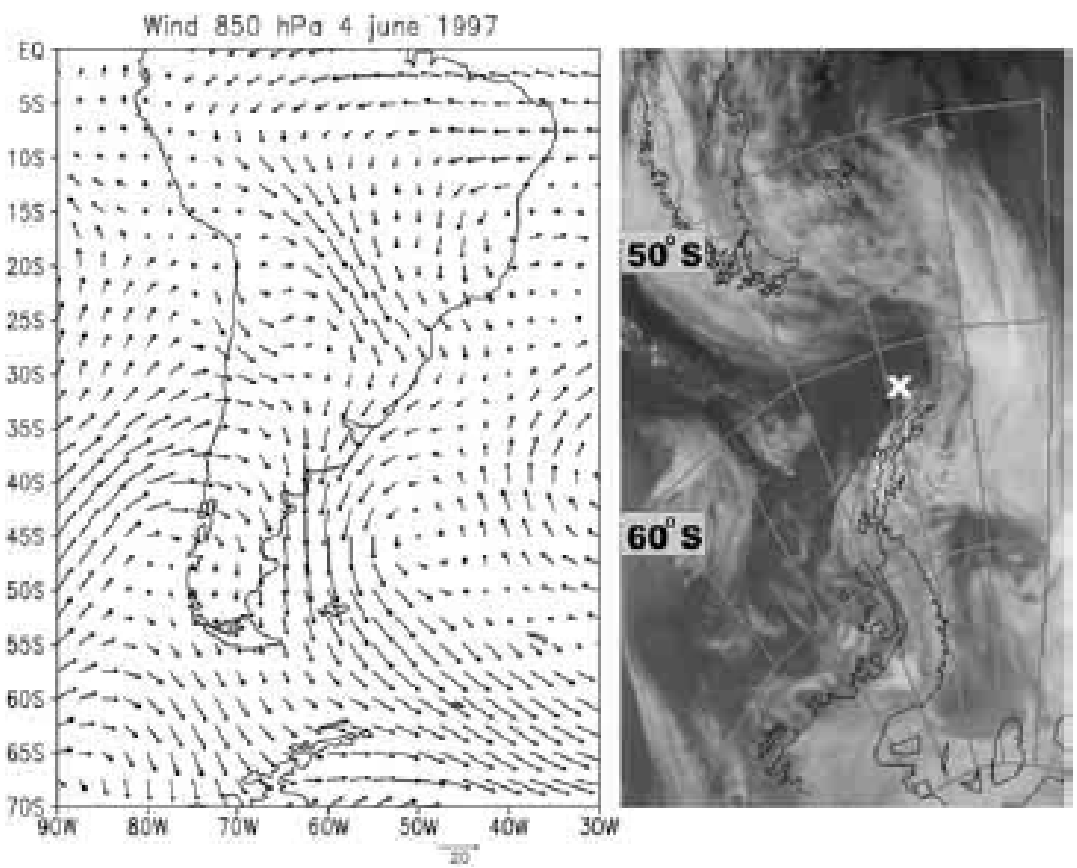
As discussed, an initial warming period in the Northern Hemisphere from the1880s – mid 1940s was followed by a cooling period in the late 40’s, 50’s and 60’s, just as earlier coal use was being replaced by cleaner burning oil and gas.

However, while the Northern Hemisphere was beginning to cool in the late 1940’s, on the Antarctic Peninsula a warming trend of approximately 0.5 degrees Celsius per decade was starting,[91] right around the same time that many diesel-powered research stations were being established, and that the Amazon deforestation and biomass burning began.

As discussed above, if microscopic concentrations of carbon soot on snow are subjected to longer term exposure to sunlight, the resulting continuous input of energy from the sun can cause a positive feedback loop of melting to occur, as the white snow or ice supporting a warming dark carbon particle melts to produce blue water which capture more sunlight, which melts more snow into water.

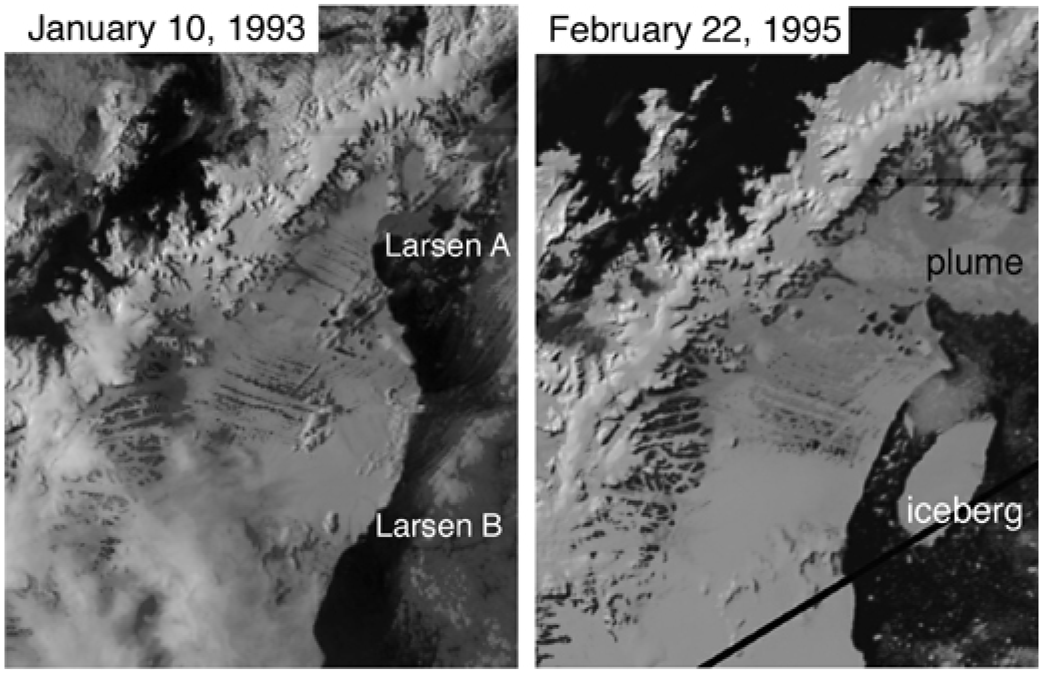
In addition to the large number of diesel power plants on the Antarctic Peninsula, flows of soot from biomass burning in the Amazon and urban activity in South America are also arriving in the winds that blow over across the peninsula (see maps below). Both factors may have been creating the potential for long-term soot deposition in the region.

(Maps below: (left) Wind vectors at 850 hPa from NCEP reanalysis during 04/06/1997 and (right) NOAA 12 satellite image for the same day. *Pereira et al*. 2006)



As the Antarctic Peninsula is both so narrow, and prevailing winds blow across it, the combined diesel soot deposition on its eastern ice shelves from the 35 local peninsula stations to the North/ West may help explain why surface melting ponds occurred on the Larsen Ice Shelf, causing the parts closest to the research emissions to break up first, while most of Antarctica directly adjacent remained stable.

The Larsen Ices Shelf was made up of 3 sections – A, B, and C. Larsen A, the smallest, was first to collapse, and, prior to that collapse, the closest in proximity to the majority of local diesel and long range Amazon soot deposition.



Furthermore, the collapse happened in a different way as compared to the normal periodic process of iceberg 'calving'. Instead of normal calving, over the last 2.5 decades, there has been an increase in surface melting, causing the formation of melt ponds and channels as discussed above, which weaken the structure and interior strength of the ice shelves with cracks and rifts. [92]

The Department of Geology at Portland State University has focused on how meltwater and ponds alter ice mechanics. Assistant professor Christina Hulbe and collaborators Ted Scambos (National Snow and Ice Data Center, Boulder, CO) and Mark Fahnestock (University of Maryland, College Park, MD) have come to the conclusion that what matters most about the warming is when it actually occurs. In short: surface melt-water, generated during summers with long melt seasons, fills the otherwise air-filled crevasses (cracks) in the ice surface, and enables them to propagate through the full ice-shelf thickness. Thus weakened, the ice shelf is vulnerable to rapid break-up.

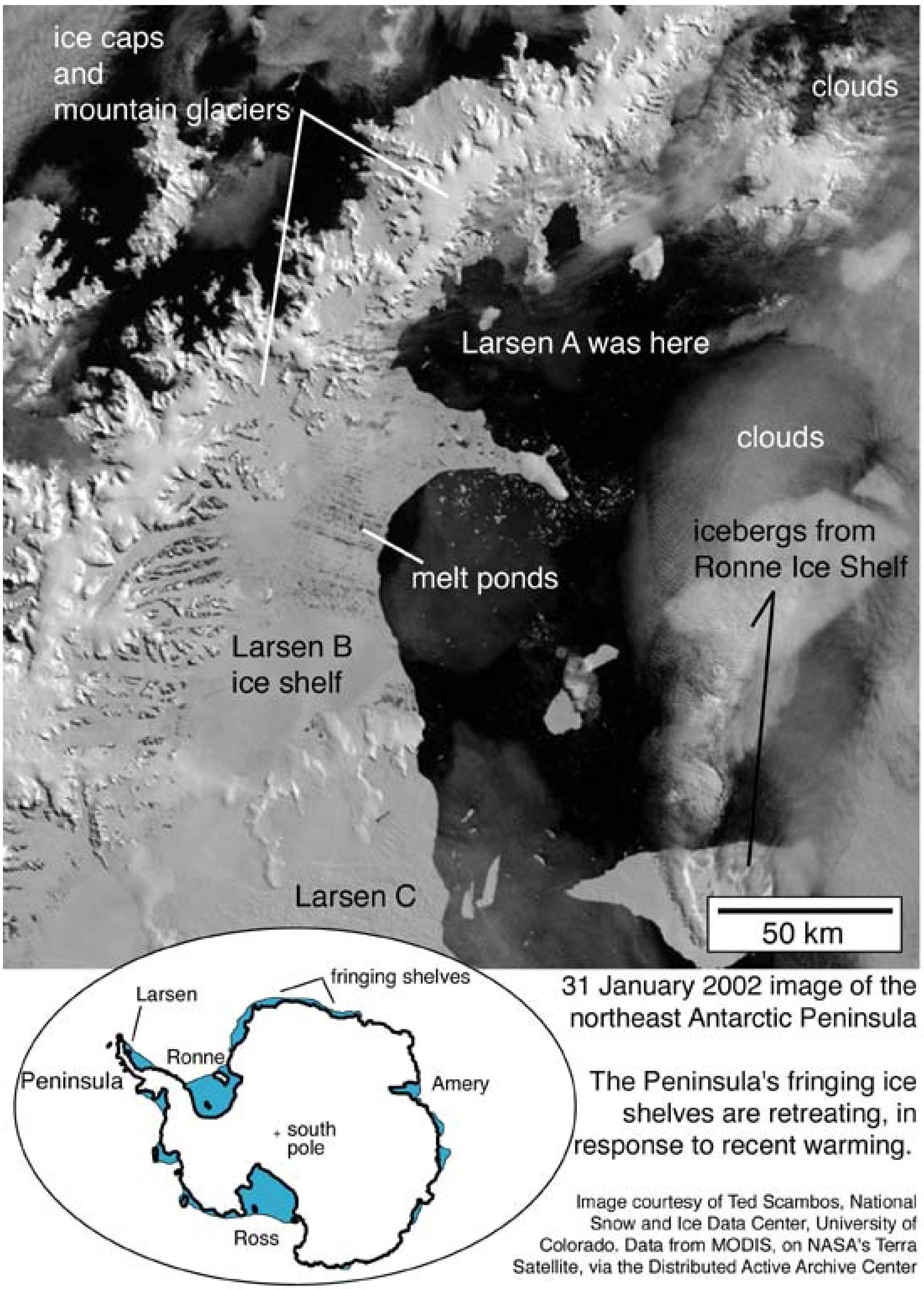
Larsen A was the first of the Larson Ice Shelves ice to disintegrate in this manner in 1995.

"The aftermath of two distinct iceberg producing events are demonstrated in this "before" and "after" pair of visible band AVHRR images. Larsen B's 1995 large ice berg is what glaciologists expect to see, but the disintegration of Larsen A into a plume of small shards is not. Meltwater ponds, visible as dark spots on the ice shelf surface link these events to ongoing warming around the Antarctic Peninsula."[93]

The northern section of the Larsen B ice shelf, a much larger, 220 meter thick floating ice mass, collapsed in the same manner in just 2 days in March 2002, after significant surface melting began to accelerate in the long days of January. (Note that the Larsen B melt ponds found in the photographs below are already significantly formed in both the 1993 and 1995 photos above.)

The shattered ice separated from the continent and formed a plume of thousands of icebergs adrift in the Weddell Sea. A total of about 3,250 km^2 of shelf area disintegrated in a 35-day period beginning on 31 January 2002. In the five years prior to 2002, the shelf lost a total of 5,700 km^2, and or about 60 percent of the size of its previous minimum stable extent. [94]

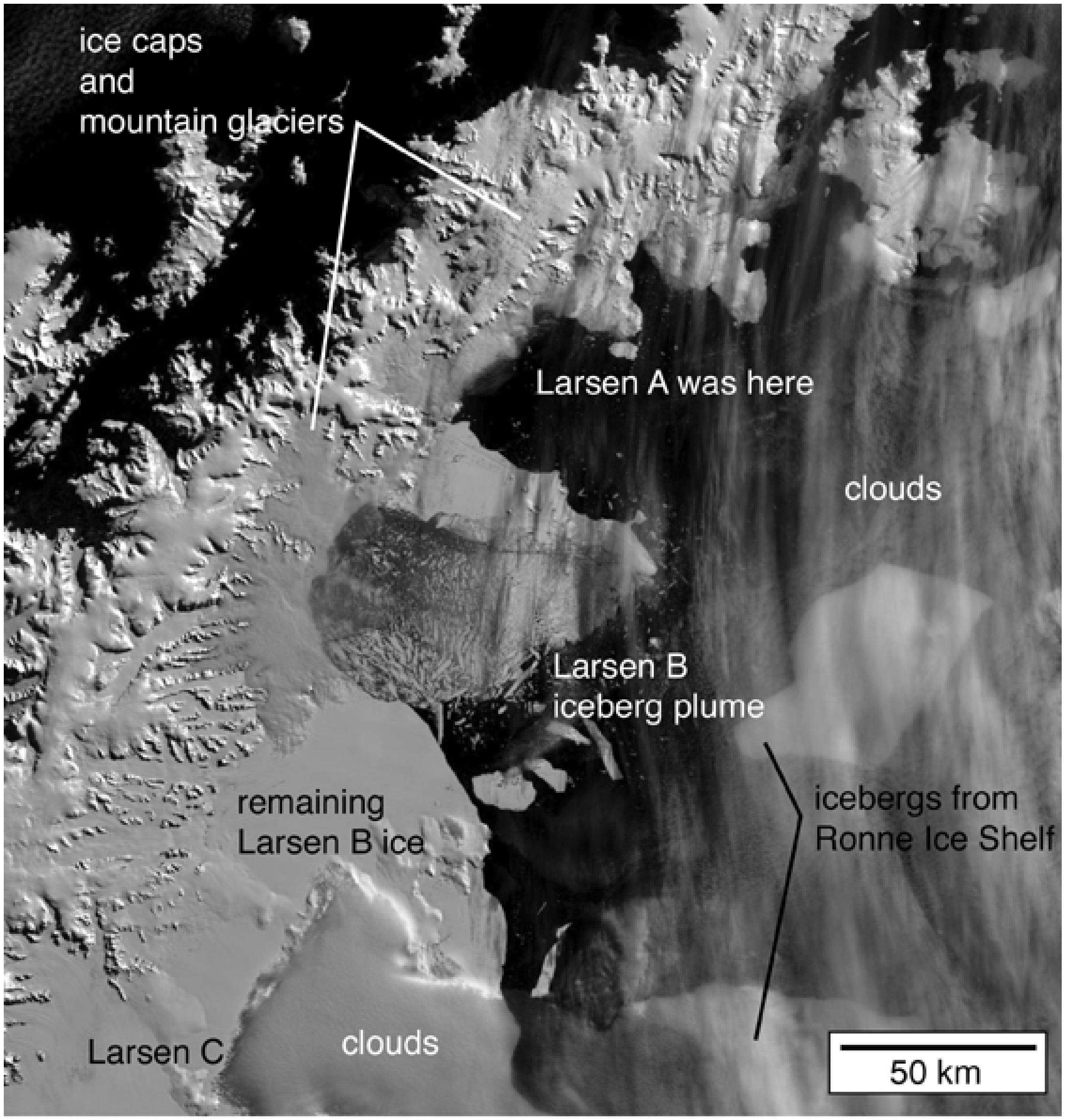
The 2002 collapse was the largest single event in a series of retreats by ice shelves on the Peninsula over the last 30 years. Overall on the Peninsula, as of 2002 the extent of seven ice shelves had declined by a total of about 13,500 km^2 since 1974. This value excludes areas that would be expected to calve under stable conditions.[95]



31 January 2002 image of the northeast Antarctic Peninsula

The Peninsula's fringing ice shelves are retreating, in response to recent warming.

Image courtesy of Ted Scambos, National Snow and Ice Data Center, University of Colorado. Data from MODIS, on NASA's Terra Satellite, via the Distributed Active Archive Center

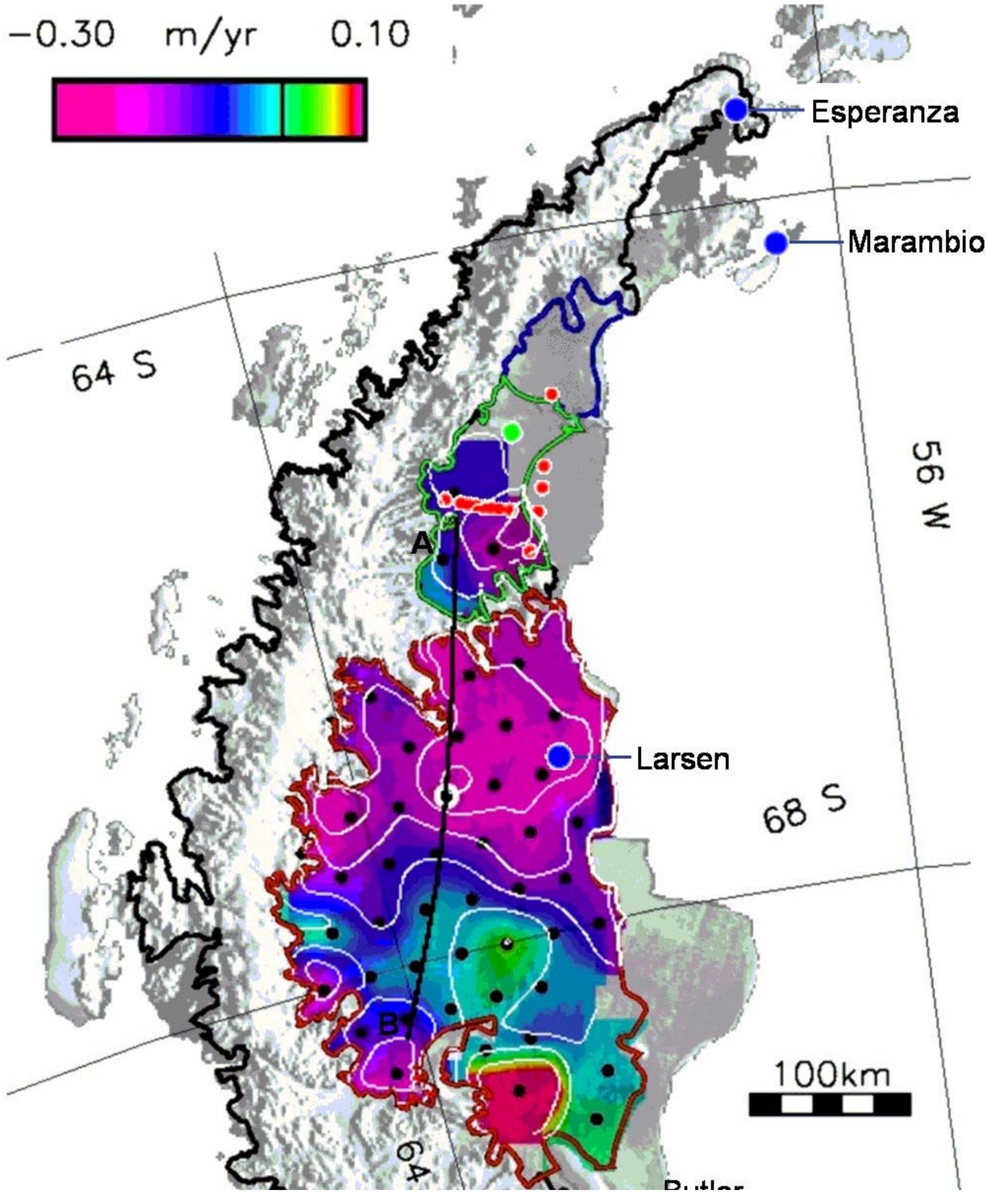


5 March 2002 image of the northeastern Antarctic Peninsula

The northern part of the Larsen B ice shelf has disintegrated, sending approximately 720 cubic kilometers of icebergs into the ocean. Because the ice was already floating, it does not affect sea level. The southern edge of the break-out tracks to the melt-pond boundary observed in the 31 January image.

Image courtesy of Ted Scambos, National Snow and Ice Data Center, University of Colorado. Data from MODIS, on NASA's Terra Satellite, via the Distributed Active Archive Center system.

(Photo: http://igloo.gsfc.nasa.gov/wais/pastmeetings/abstracts03/Shepherd.html)



An international group of scientists investigating these ice-shelf breakup events all agreed that ***regional*** climate warming was at the heart of the recent Larsen changes. [96] **This paper argues that in cases of localized regional warming, BC soot should always be considered as a potential factor.**

As discussed, speculation as to the mechanism that caused the final collapses has concentrated upon the destabilizing effects of increased surface melt-water, which may have enhanced the process of crevasse fracture. [97] That mechanism provides a link between the regional climate warming and the break-up of ice shelves at the Antarctic Peninsula. [98]

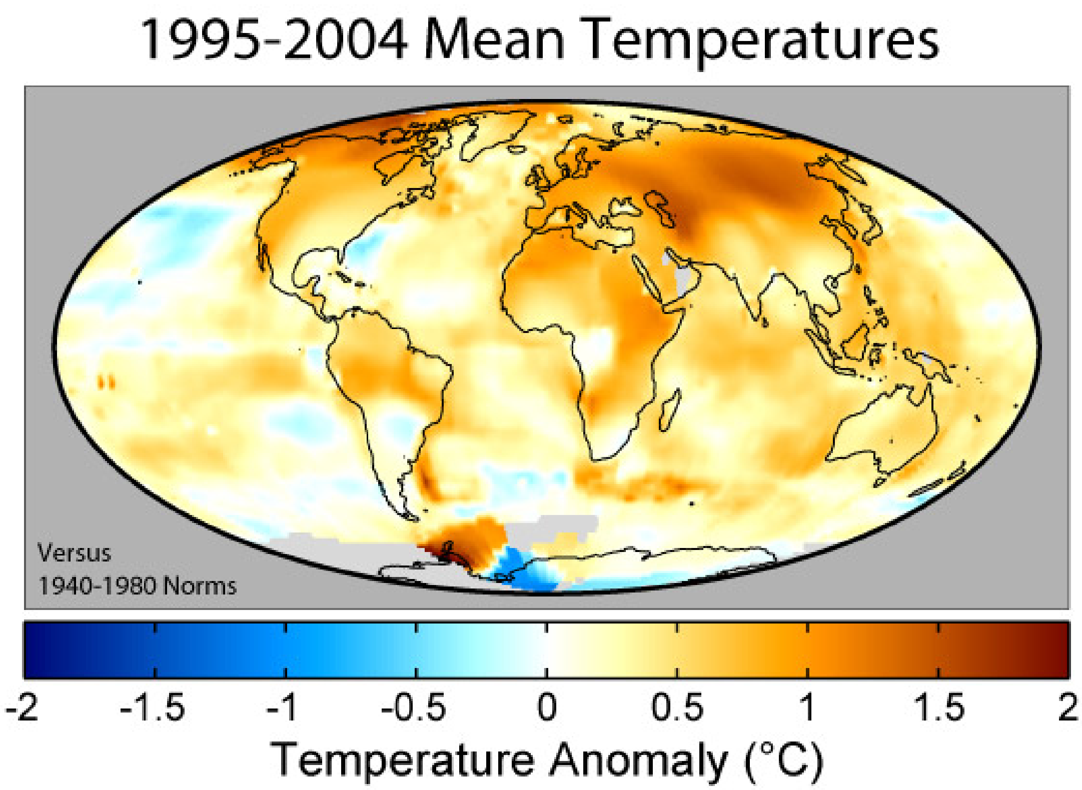
Pereira et al. **2006, clearly demonstrate the presence of local and long range BC soot sources in this Antarctic region, potentially linking BC to the collapse of the Larsen Ice Shelves.**

Raw data for measurements of airborne BC concentrations on King George Island show several degrees of contamination by activities from local scientific stations [Pereira 2006].

To ensure they could show the long range arrival of BC soot from the Amazon, the researchers developed a method to tag and remove local surges of BC from their database:

"Thus the data screening was based on a case-by-case exam of the time series and the inspection of the station logbook, a very time-demanding but necessary procedure. Our field observations at King George Island show that surges of local BC have distinct time series signatures in comparison to rises of BC due to long-range transport from central South America. Concentrations of BC associated to long range air masses displacements increase steadily in time and decrease following almost this same pattern, whereas local black carbon contributions increase rapidly often following an irregular pattern, reaching concentration values of up to two orders of magnitude higher than the annual average. These events were normally attributed to the traffic of snowmobiles, boats, and airplanes in the environs of the sampling point. The corresponding records identified as bad were simply removed from the global database."

As this data was removed from the database, it is difficult to tell what effect research activity itself may be having on the local climate. However, as can be learned from *Garrett and Zhao* (2006), significant long range pollution causes warming over very large regional areas, as can be seen in the far north in the map below. However the warming in Antarctica is very much more local, with significant adjacent cooling occurring nearby, as can also be seen in the map below.



***McConnell et al*. 2007**, ***Zender* 2007*, Hansen & Nazarenko* 2004, and other research presented in this paper link Black Carbon soot deposition to regional surface melting and warming.**

As such, its possible that a portion of the peninsula's recent warming could be due to BC emissions from diesel generators and other local pollution now being generated on the Peninsula.

Localized testing of surface concentrations would allow researchers to determine the extent of their own BC impact as compared to that of long range sources. Long range sources should spread soot quite evenly over wide areas of the Peninsula. However significant sources of local contamination would lead to larger surface concentrations extending downwind from each of the bases in question. The extent and magnitude of downwind surface concentrations could be used to determine the relative weight of each source.

Earlier 1987 measurements of BC soot deposition at a test location on the Peninsula had already shown more than a tenfold increase as compared to pristine areas inland (see table on page 34).

Ice Shelves Are Required For The Stability of Antarctica

The following is an excerpt from a report from the National Snow and Ice Data Centre. The full article can be found here:
http://nsidc.org/iceshelves/larsenb2002/

"While the breakup of the ice shelves in the Peninsula has little consequence for sea level rise, the breakup of other shelves in the Antarctic could have a major effect on the rate of ice flow off the continent.

Ice shelves act as a buttress, or braking system, for glaciers. Further, the shelves keep warmer marine air at a distance from the glaciers; therefore, they moderate the amount of melting that occurs on the glaciers' surfaces.

Once their ice shelves are removed, the glaciers increase in speed due to meltwater percolation and/or a reduction of braking forces, and they may begin to dump more ice into the ocean than they gather as snow in their catchments. Glacier ice speed increases are already observed in Peninsula areas where ice shelves disintegrated in prior years. (Author's note: Almost immediately after the 2002 Larsen B ice shelf collapse, researchers observed nearby glaciers flowing up to eight times faster than prior to the breakup. This also caused glacier elevations to drop, lowering them by as much as 38 meters (124 feet) in six months. [99])

With the Peninsula shelf breakups as a guide, we can now reassess the stability of ice shelves around the rest of the Antarctic continent. Past assessments of stability were based primarily on mean annual temperature; with this guideline, most shelves outside the Peninsula were considered well within their climate limit.

Given the success of the melt pond theory, we use the climate conditions and physical parameters of ice shelves at the point of ponding as a guide in this assessment. In particular, the next shelf to the south, the Larsen C, is very near the stability limit, and may start to recede in the coming decade if the warming trend continues. Melt ponds are occasionally observed in limited regions of the Larsen C shelf.

More importantly, the warmest part of the giant Ross Ice Shelf is in fact only a few degrees too cool in summer presently to undergo the same kind of retreat process. ***The Ross Ice Shelf is the main outlet for several major glaciers draining the West Antarctic Ice Sheet, which contains the equivalent of 5 m of sea level rise in its above-sea-level ice."***

When the above NSIDC research is considered with the other research on carbon soot deposition presented herein, it seems possible that the current operation of the McMurdo station may threaten the potential stability of the Ross Ice Shelf. The same can be said for other climate stations operating on the continent, although they are not as large as McMurdo.

New power systems based on a seasonal and combined use of solar panels and modified wind turbines, designed to handle the increased wind speeds found in the Antarctic region,

would be a prudent way to conduct research in Antarctica. They should be mandated by international treaty until more has been learned about the effects of BC soot in the region.

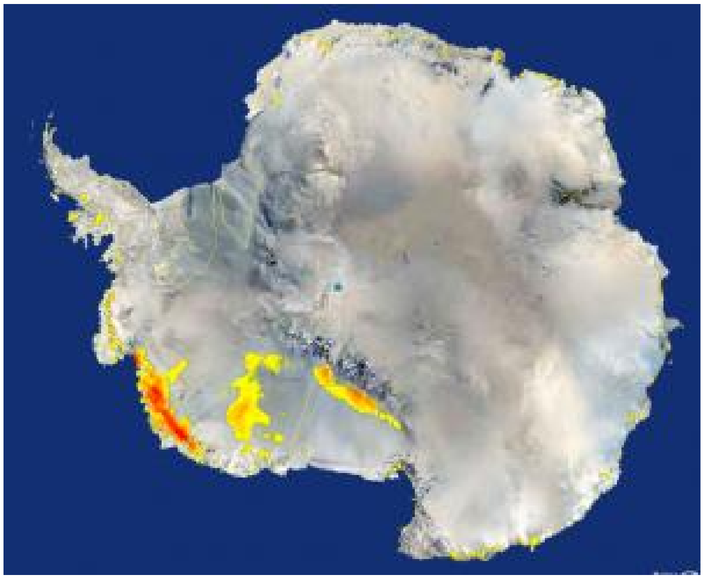
BC soot shouldn't be released in this very sensitive the region. The potential consequences could be too severe.

Regional Melting Recently Observed in Western Antarctica

In May 2007 Son Nghiem of NASA's Jet Propulsion Laboratory, and Konrad Steffen, at the University of Colorado at Boulder, published research showing vast regions of West Antarctica – directly downwind of McMurdo – melted in the recent past.

It was the first widespread Antarctic melting ever detected with NASA's QuikScat satellite and the most significant melt observed using satellites during the past three decades. Combined, the affected regions encompassed an area as big as California.

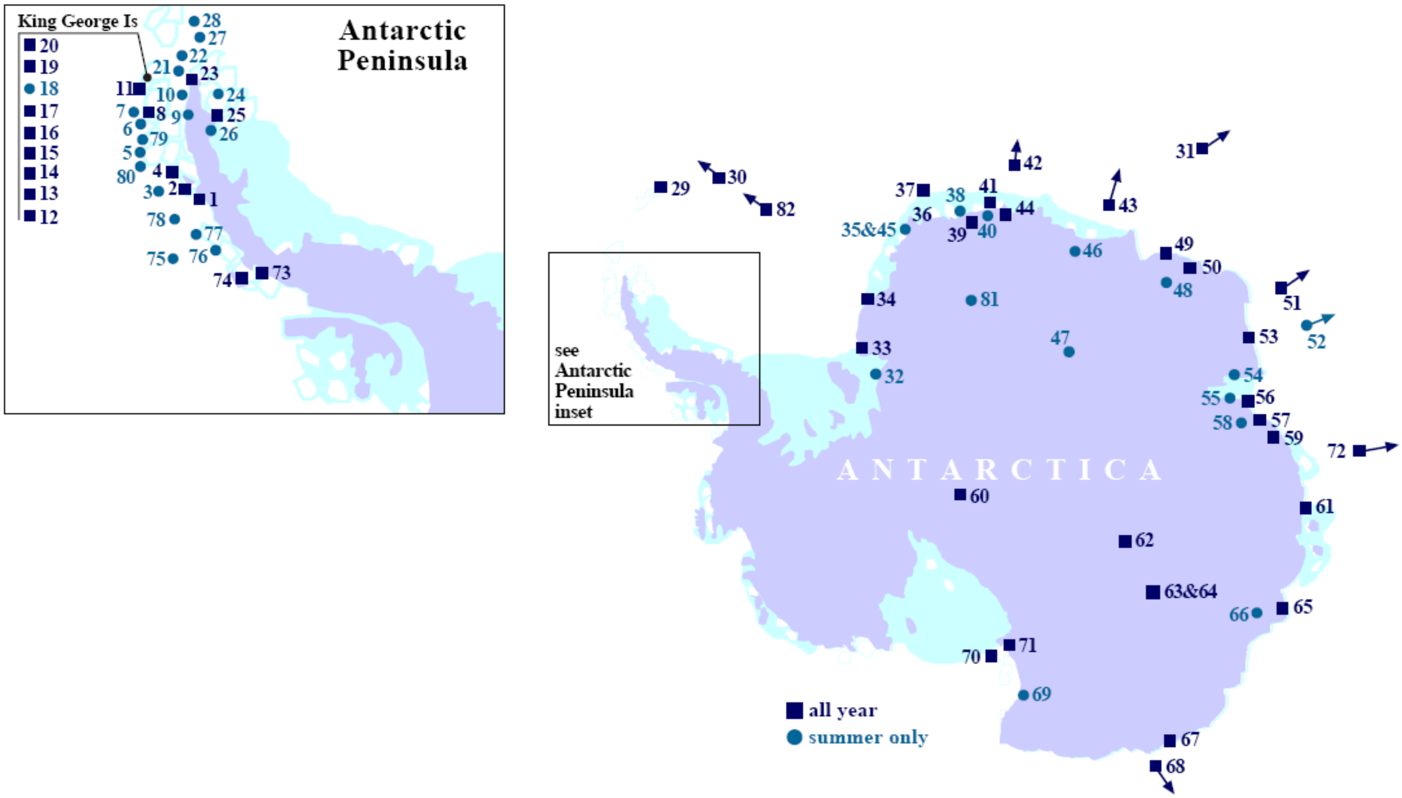
The observed melting occurred in multiple ***distinct regions***, including far inland, at high latitudes and at high elevations, where melt had been considered unlikely. Evidence of melting was found up to 560 miles inland from the open ocean, farther than 85 degrees south -- about 310 miles from the South Pole -- and higher than 6,600 feet above sea level, as shown in the map below.



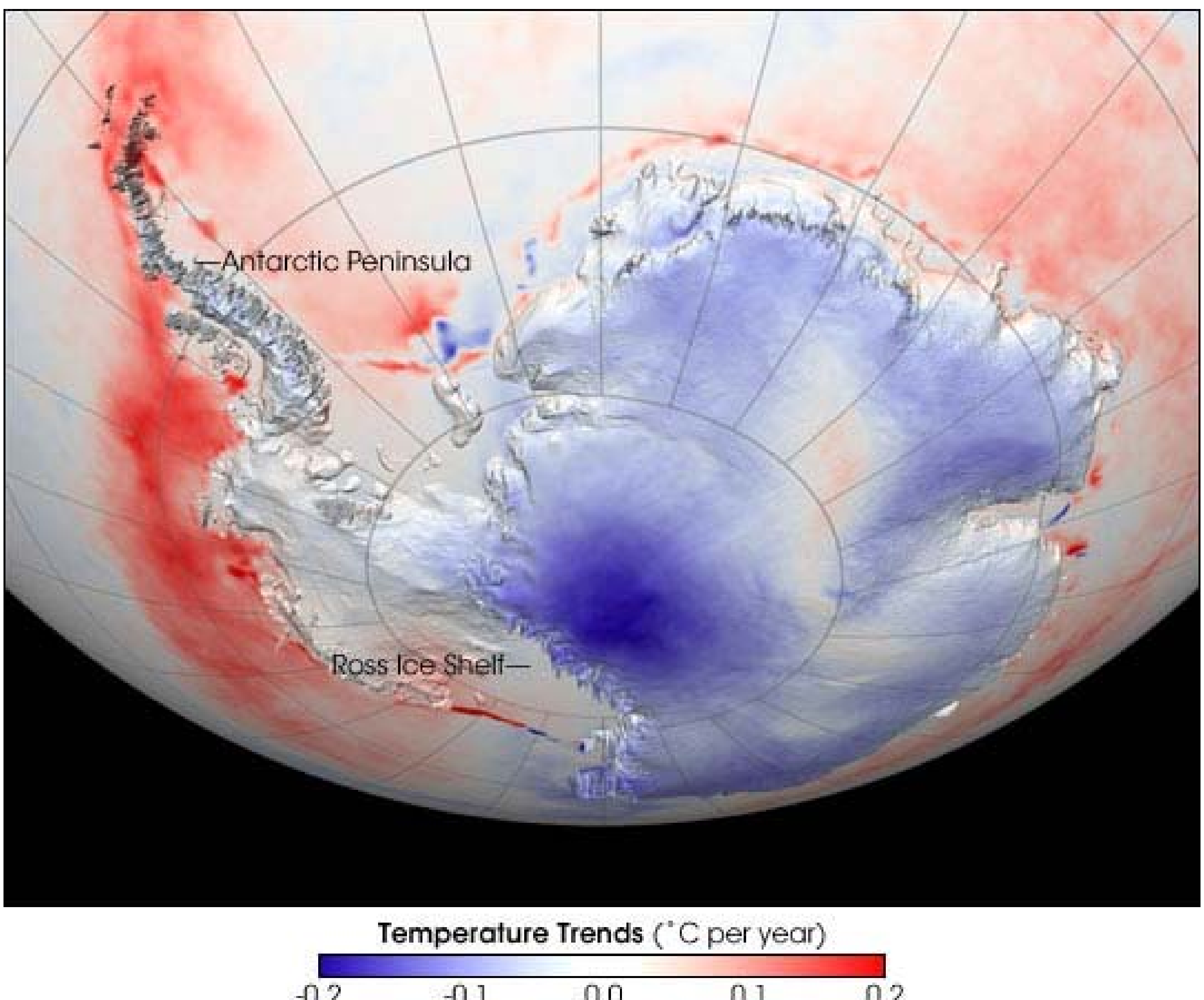
NASA's QuikScat satellite detected extensive areas of snowmelt, shown in yellow and red, in west Antarctica in January 2005. (Credit: NASA)

As the maps found in this report show, some of the greatest warming in the Antarctic is on the west coast, and begins directly downwind from the large McMurdo research (#70 on the map below), which is positioned on the edge of the Ross Ice Shelf, and upwind of the 35 stations on the Peninsula. As well, other hot spots are located directly downwind of year round research installations, in particular those numbered 53 and 56.

While research has clearly shown the link between the generation of melt-ponds and sea ice / ice shelf melting, the connection that locally generated Black Carbon diesel soot may be contributing to these melt ponds appears not to have been made in prior research. ***The potential link between regional warming and research-related BC emissions on the Peninsula, at McMurdo, and at other Antarctic bases should be promptly evaluated.***



http://en.wikipedia.org/wiki/Image:Antarctic_temps.AVH1982-2004.jpg



Could Volcanic Ash from Antarctic Volcanoes Also Be Altering Surface Albedo?

McMurdo Station is next to Mt. Erebus, the most active volcano in Antarctica. If Erebus has been sporadically ejecting large volumes of non-white albedo-altering ash, this could conceivably contribute to the generation of melt ponds. However, if the frequency of eruptions is shown to be constant & long term, then just the ash on its own can not be a primary factor, as the Ross Ice Shelf and other ice in the area has been stable for centuries.

Erebus typically has 2 to 6 small Strombolian eruptions a day. [100] Strombolian activity is characterized by short-lived, explosive outbursts of pasty lava ejected a few tens or hundreds of meters into the air. Unlike Hawaiian eruptions, Strombolian eruptions never develop a sustained eruption column. They eject relatively viscous basaltic lava from the throat of the volcano.

The picture below indicates the volcano at least sporadically ejects a darker ash. This ash if emitted in large enough quantities would appear capable of darkening snows downwind. ***However according to scientists observing Erebus, only small ash eruptions are occasionally noted from vents adjacent to the lava lake***.[101]

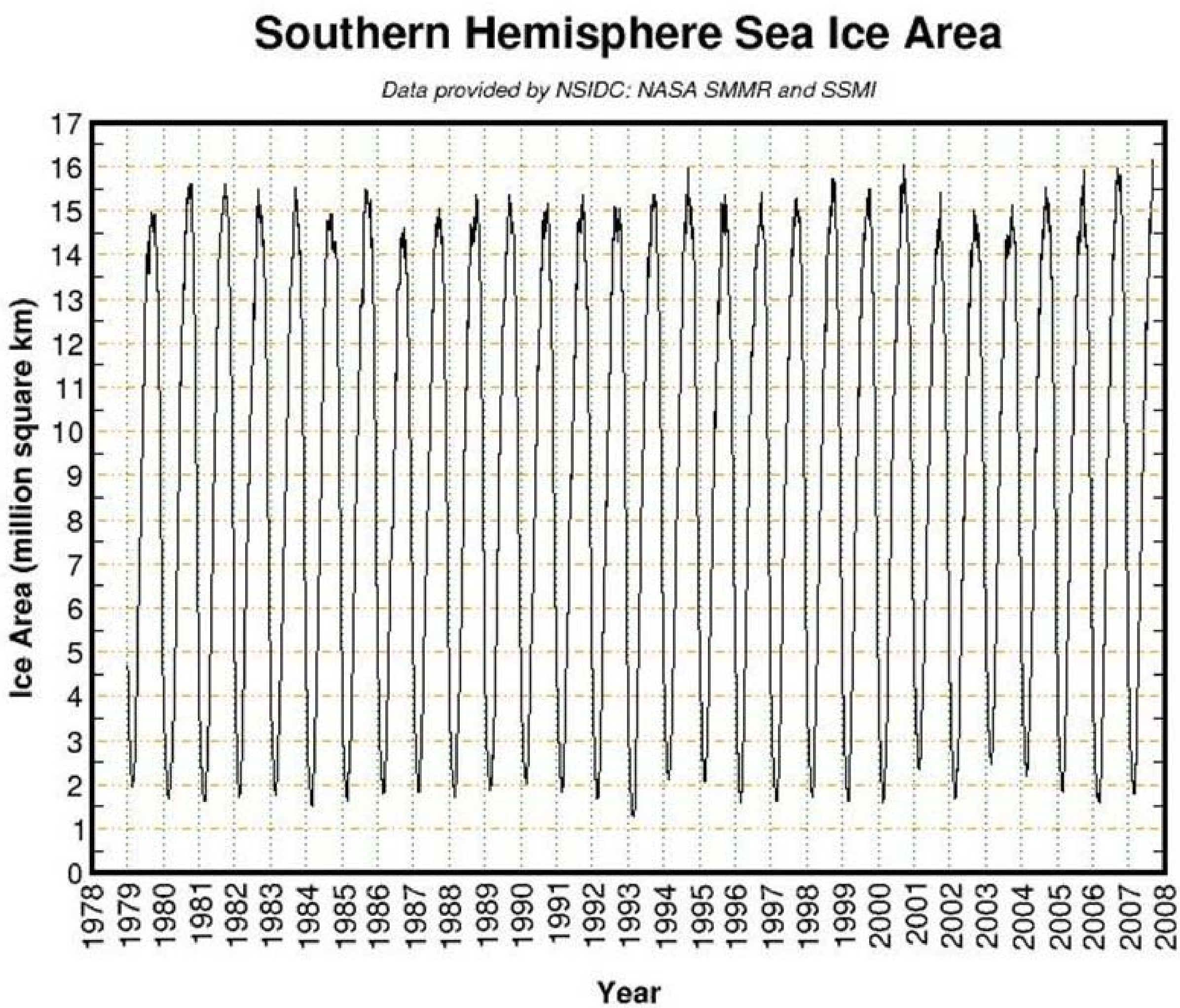
(Photo by Phil Kyle) http://www.andrill.org/iceberg/blogs/betty/images/erebus-crater.jpg

Whether McMurdo BC emissions, or potential albedo-altering ash from Mt. Erebus, and/or a combination of both could be altering surface albedo needs to be determined.

Antarctic Sea Ice Is Stable

Since satellite measurements began in 1979 sea- ice levels in Antarctica have been very stable. And while record loses of were reported in the Arctic in September, in the south a record accumulation was seen in the Antarctic winter, as seen below.

This further indicates that factors other than green house gases are influencing ice break ups in different regions of the world.



Why Changes In Polar Surface Albedo May Be The Most Important Effect On Climate

The fact that both Arctic sea ice and elevated Greenland ice mass is melting and that Antarctica's sea-ice and elevated ice mass is not, is additional evidence that BC Haze and soot deposition may be a bigger driver of polar warming than GHG effects.

Earlier measurments of BC soot levels in snow of 2 - 6 ppbw in Greenland were 20 times higher than the 0.1–0.3 ppbw found in Antarctica.[102] While the katabatic winds may still be protecting Greenland to a limited extent, it's quite likely that soot levels elsewhere in the Arctic have risen significantly in the last 10 years with the explosion of economic activity in the Northern Hemisphere.

Total accumulations of BC soot surface deposition may be a critical factor determining melting and freezing rates at the Poles, as can be seen from the well established relative warming differences between:

- the lower BC soot deposition and ice-melting levels in Greenland, and the higher soot levels and greater melting rates in the rest of the Arctic,
- the Antarctic's lower levels of soot and mainland cooling, and the Arctic's higher soot levels and ongoing warming,
- the Antarctic's lower levels of soot and mainland cooling, and the Antarctic Peninsula's higher soot levels and ongoing warming,
- past temperature cooling in the Arctic as world wide coal use dropped in the 1950's, and rising temperatures in the Antarctic Peninsula in the 50's with increased diesel fueled research and long-range Amazonian soot deposition.

This author hypothesizes that the rapid increase in atmospheric & surface-deposited BC on the Larsen Ices Shelves led to the development of melting ponds, which over a prolonged period were able to penetrate and melt ice hundreds of meters thick.

The annual concentration of BC soot would appear to be a critical factor in determining whether an ice sheet might collapse over the duration of the summer melt.

The spontaneous collapses of Larsen A & B should serve as a warning for what might happen just as quickly in the Arctic should Northern Hemisphere BC soot levels be allowed to keep rising as quickly as they are in China, North America, Europe, India, and on the high seas.

China's current increase in coal use (1-2 new plants per week) alone might be enough to destabilize the Arctic based on the most recent melting trends there.   That said Western economies are responsible for creating demand for Chinese goods, and for consuming even larger amounts of BC generating fuels for transportation, heating, and power generation.

Other Impacts Of Aerosol Contaminants On The Ecosystem

The impact of carbon haze on Arctic and global ecosystems has not been adequately researched. While the pollutants have been studied in their aerosol form over the Arctic, little is known about what eventually happens to them. It is known that the contaminants are somehow removed, and likely end up in the North Atlantic, Norwegian Sea, and possibly the Bering Sea — three important fisheries.

The uniqueness of the arctic seas lies in their special physical, chemical, and biological characteristics, and their largely limited capability for recovery. Even small-scale anthropogenic pollution may have severe consequences (*Brinken and Pyzhin*, 1993).

7. The Role of Anthropogenic Green House Gases in Warming

What are Green House Gases (GHG)

Water vapor is the most important GHG. Per current theory, prior to the polluting of the atmosphere, it was believed to trap 88.9% of the heat retained by our atmosphere. Carbon Dioxide was believed to trap another 7.5%, nitrous oxide 1.5%, ozone 1.1%, methane 0.5%, and others the remainder. [103]

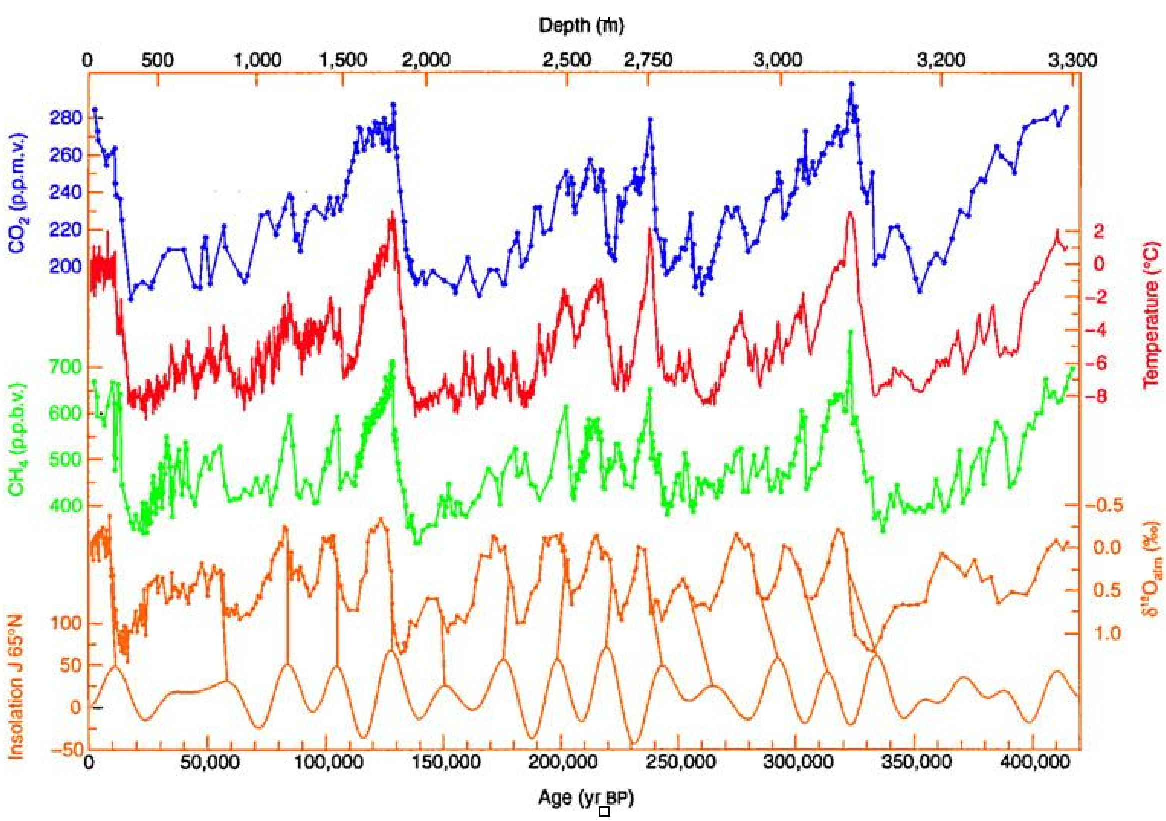
However, as explored in this paper, is it not possible that the abundance of water on planet earth is the most important Green House factor? Might fluctuations in other known warming forcers like natural black & brown carbon and other aerosols have been causing fluctuations in the amount of water being evaporated into the atmosphere prior to the Industrial revolution?

How GHGs Warm

Simply put, most higher-energy short-wavelength sunlight, which easily penetrates the natural layer of GHG, is converted to long wavelength heat on contact with the Earth's surfaces. Green house gases like water vapor then trap a percentage of that heat (which has a longer wave length that can be absorbed by green house gases) that would normally escape the earth's surface if it wasn't there.

However, the full role and extent of anthropogenic CO_2 and methane in warming is still being hotly debated. New data contradicts prior assumptions about these gases roles in warming prior to the industrial revolution.

The data in the chart below is one of several studies that raises questions about the ability of CO_2 and methane to initially raise temperatures.



- Solar variation at 65°N due to Milankovitch cycles (connected to ^{18}O).
- ^{18}O isotope of oxygen gas.
- Levels of methane (CH_4).
- Relative temperature (converted from ^{2}H isotope in ice).
- Levels of carbon dioxide (CO_2).

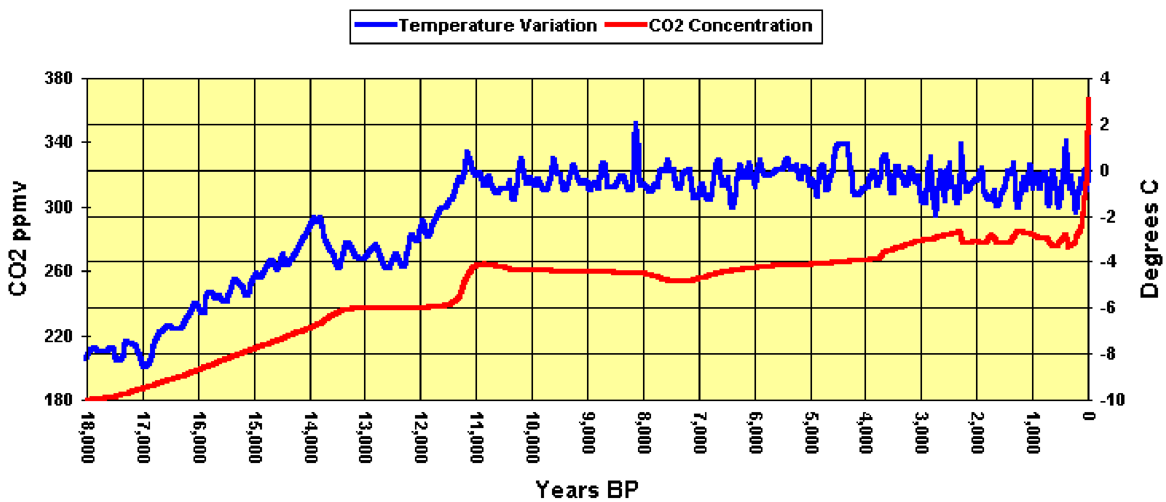
In this chart we see how, prior to the industrial revolution, that atmospheric methane (CH_4) and CO_2 levels closely follow fluctuations in temperature for 420,000 years (BP) before present. Many feel this is an indicator that the those two gases drive temperature fluctuations.

However, considering the historical pattern of CO_2, CH_4, and Temperature, probability logic suggests it is quite unlikely that two independent variables (CO_2 and CH_4) would be emitted in extremely similar ratios for 420,000 consecutive years to drive temperature.

Its much more probable that fluctuations in temperature were causing proportional changes in CO_2 and methane levels – by affecting trace levels of CO_2 evaporation from oceans, and trace levels of methane from fluctuations in the rates of organic decomposition as huge sheets of ice moved back and for the over the land masses through the cycles of the Ice Ages.

Confirmed longer term changes in sunlight levels reaching the earth also track with temperature, further reducing the probability that CO_2 and methane were the initial factors driving temperature.

Moreover a closer examination of CO_2 and temperature level after the start of the industrial revolution further indicates that CO_2 levels do not significantly drive temperature.



http://www.daviesand.com/Choices/Precautionary_Planning/Closer_Look/index.html

In this exploded view of the timescale we see CO_2 following temperature until the Industrial Revolution, when CO_2 levels accelerate dramatically with no similar rise in temperature.

Further, analysis of the Vostok ice cores (*Stott* 2007, September, Science) indicates that the trigger for initial deglacial warming around Antarctica was the change in solar insolation over the Southern Ocean and that ultimately these forcings promoted enhanced ventilation of the deep sea and the subsequent rise in atmospheric CO_2.[104] In other words the warming was not driven by increased CO_2, but that the CO_2 increase was caused by the warming.

This indicates that CO_2 may not be the potent warming agent suspected, and that other anthropogenic factors like Black Carbon may be causing more warming than previously suspected.

Why Low Altitude BC Soot May Increase Water Vapor's Green House Potential

If carbonaceous soots and other aerosols are warming both the atmosphere and near surface temperatures, this would cause increased ocean evaporation and water vapor feedback, or an increasing in atmospheric water's green house effect.

Swiss researchers examined surface radiation measurements from 1995 to 2002 over the Alps in Central Europe and showed strongly increasing total surface absorbed radiation, concurrent with rapidly increasing temperature. The authors, led by Rolf Philipona of the World Radiation Center in Davos, showed experimentally that 70 percent of the rapid temperature increase is very likely caused by water vapor feedback.[105] They indicated that the remaining 30 percent is likely due to increasing manmade greenhouse gases. However, due to the significant use of diesel in Europe, the evidence in this paper would indicate that BC soot might be a significant factor.

Soot Induced Vapor Feedback May Also Explain The Torrential Rains In India

It's well known that a thick haze of soot hangs over the Indian Ocean (as the photograph on the cover shows). It's possible that due to the droplet dispersing effects of soots on atmospheric water vapor, the soot causes warm hyper-saturated air that is more prone to collide with cold fronts descending from the Himalayas, causing such massive downpours, like the 37 inches of rain that fell on Mumbai in just 24 hours on July 26, 2005.

The Great Indian Desert (Thar Desert) and adjoining areas of the northern and central Indian Subcontinent heats up too much during the hot seasons of summer. This causes a low pressure area over the northern and central Indian subcontinent. To fill up this void, the moisture-laden winds from the Indian Ocean rush in to the subcontinent. These winds, rich in moisture, are drawn towards the Himalayas, creating winds that blow storm clouds towards the subcontinent. However the Himalayas act like a high wall and do not allow the winds to pass into Central Asia, forcing them to rise. With the gain in altitude of the clouds, the temperature drops and precipitation occurs. Some areas of the subcontinent receive up to 10,000 mm of rain.[106]

Climate change studies undertaken so far reveal that action is essential in order to prevent long term damage to India's water cycle. [107] The livelihood of a vast population in India depends on agriculture, forestry, wetlands and fisheries and land use in these areas is strongly influenced by water-based ecosystems that depend on monsoon rains.

During the 24 hours ending early Wednesday, Mumbai saw more than 37 inches (900 mm) of rain, setting a national record for the most rain in one day.

Mumbai, formerly known as Bombay, normally braves heavy rainfall during the three-month monsoon season, but this time the rain was too much for the city. In 12 hours, it recorded more than half its average annual rainfall. The water had no place to go because the high tide conditions rendered storm-water drains ineffective. The city, which is home to more than 15 million people and is the commercial and financial hub of India, came to a virtual halt.

8. The Role of Carbonaceous Soots – A Summary of The Latest Studies

Why Carbon Soots Can Cause More Warming In Comparison To GHGs And Other Aerosols

As discussed above, dark carbons have a greater warming effect in polar regions because the radiation from the sun (photons) can transfer energy to those atoms with compatible electron frequencies. The photons energize these atoms as they are absorbed by the atom.

While certain infrared frequencies of light (heat) are absorbed by CO_2 and the Green House Gases, Black Carbon not only absorbs infrared, but many other frequencies as well, including almost all visible sunlight, and, of course, is black for this reason. Brown carbon absorbs UV light.

The following chart comparing the known effects of GHG vs. dark carbons, shows why Dark Carbon can have such a large warming effect in polar regions as compared to CO_2 and Green Houses Gases.

Known Effects	**Dark Carbons**	**CO_2/GHG**
Absorbs and reflects infrared	Yes	Yes
Absorbs visible and UV light reaching snow & ice surfaces causing heat that creates melting ponds capable of runaway melting of snow and ice in 24 hour sunlight	Yes	No
Absorbs visible and UV light and emits IR, thereby warming clouds and atmosphere containing it	Yes	No
Shown to cause regional warming	Yes	No
Has an increased affect in the Northern Hemisphere	Yes	No
Probable cause of 1890s - 1940s regional warming in North America and the Arctic	Yes	No
Explains Antarctic mainland cooling / Antarctic Peninsula warming paradox (discussed below)	Yes	No
Explains late 1940s Arctic cooling / Peninsula warming	Yes	No

Summary of Physical Evidence Showing that BC Aerosols May Be A Major Factor In Warming As Compared To CO_2 & GHG

The following is a summary of points made in this paper, each of which is evidence that carbon-aceous aerosols may be a major factor in warming as compared to anthropogenic CO_2 and GHG.

Any of the following points not already discussed in greater detail above are discussed in the various sections of the paper that follow this summary.

1. *Flanner et al. (2007, Science) -* calculated the warming potential of BC from estimates of Black Carbon deposition and estimates very significant regional warming due just to soot deposition - 1.6 degrees C in the Arctic in 1998, and as much as 20 W m-2 of seasonal warming over the Tibetan Plateau and other regions!

Data suggests the anthropogenic contribution to total BC forcing is at least 80%. “Efficacy” of BC/snow forcing is more than 3 times greater than forcing by CO2.

These high estimates were generated despite the use of completely outdated 1998 data on world coal consumption. Since then China's coal use alone has more than doubled, much of which is completely unfiltered. As much of the developed world’s coal emissions are scrubbed, its very likely that that local Asian soot levels are very much higher than estimated.

While the conclusions of this paper are very important, I'm surprised there are no notes regarding the relative irrelevance of that data used, and that actual warming could be so much greater as result.

In the last 8 years China has built 603 coal-fired generators - 64% of the 942 new generators installed worldwide (133 of these in India).

Since 1997 China has added 225,000 mega watts of coal-fired electricity generation, an increase of 155% from 145,000 MW in 1997 to 370,000 MW in 2007, the equivalent of 225 medium size 1000 MW nuclear reactors.

And in just 3 years, coal use in China has increased an incredible 31% from 2.06 M short tons in 2004 to 2.7M in 2007. (From 1.3M ST in 1993)

While Asia's surging economic output over the past 5 years has had little effect on total atmospheric CO2 accumulations since 1850, its, and the rest of the world's, impact on annual BC generation has been enormous.

When these latest world wide coal consumption figures (and the increased diesel, marine fuel, and jet kerosene use) are considered, its obvious the potential warming is much greater than the 1998 estimates cited in this paper.

Further, to better understand total BC warming in the Arctic, we need to add Garrett and Zhao's estimated additional 1.1 - 1.6 C of warming due to atmospheric BC, based on measurements made on polluted days in 2004, to Flanner's 1998 surface estimates of 1.6 C. This would roughly equal:

Total Arctic BC Warming = (1998 surface warming of 1.6 C x new coal factor) + (2004 atmospheric warming of 1.1 - 1.6 C) = 3.2 C x (significant surface and atmospheric multipliers to account for subsequent increases in carbon & metallic aerosol emissions since 1998 and 2004.)

Flanner`s paper also points out the lack of up to date BC snow measurements globally and the need for research in this area. (This can't happen fast enough considering the current rate of warming. I hope there are researchers doing this now, but am not sure.)

Of course these emissions can be significantly reduced with coal / wet scrubber technology not in use in China and India, and diesel particulate burners for vehicles world wide - **but there are just a few short years** to get these simple and inexpensive technologies implemented before the sea-ice is potentially lost due to unanticipated positive BC feedback loops.

2. *McConnell et al*, September 2007, Science, show that beginning about 1850, industrial emissions resulted in a sevenfold increase in certain Greenland ice-core BC concentrations, with most change occurring in winter. The source of these emissions at this particular sight have been estimated to have come from North America. BC concentrations after about 1951 were much lower but increasing, which coincides with the reduction of coal use in the US economy at the time. At its maximum from 1906 to 1910, estimated surface climate forcing in early summer from BC in Arctic snow was a staggering 3.2 watts per square meter, which is eight times the typical pre industrial forcing value.

To put this enormous amount of warming in perspective, the IPCC estimated that the total global mean radiative forcing of the climate system for the year 2000, relative to 1750, amounted to 2.4 watts /sq meter.

AUTHOR'S NOTE: *McConnell et al.* 2007 show the incredible warming BC soot has caused in the past in Greenland.

However more importantly, Katabatic winds have always protected Greenland from the levels of BC concentration found elsewhere in the Arctic, which can be 5 – 10 times higher, as measurements discussed below have shown.

This indicates that in more heavily polluted parts of the Arctic, Black Carbon deposition might be capable of creating warming in the range of 15+ watts per square meter, which would easily explain the rapid loss of sea-ice witnessed in the last few years, and how 220m thick ice shelves on the Antarctica Peninsula could have melted so quickly.

When the Greenland research is examined with in the context of the other data presented in this paper, a new picture emerges. It indicates that the rapidly increasing generation of anthropogenic carbonaceous soots could lead to the catastrophic melting of all Arctic summer sea ice, possibly within 6-8 years.

3. CO_2 and other GHGs are evenly mixed throughout the atmosphere, as shown from measurements taken around the world.[108] Therefore if they are primarily responsible for warming, the Antarctic mainland should be warming like the Greenland mainland. But, it is not.

   Record accumulations of Antarctic sea ice were recorded by satellite in September 2007. While ice in the Arctic and on most glaciers around the world is rapidly melting, the vast majority of the Antarctic is cooling very slightly. If GHGs are primary warming drivers, the Antarctic mainland should also be warming like the Antarctic Peninsula, considered by some to be the fastest warming place on the planet, and just a few hundred kilometers away.

   All regions in Antarctica where significant melting is known to be occurring are those known to be affected by dark carbon and other aerosol pollution.

4. Because CO_2 and other GHGs are quite evenly mixed in the atmosphere, and if dimming caused by aerosols is reflecting sunlight away from the earth, thereby reducing the full potential of GHG warming and leading to regional cooling as hypothesized by the IPCC,[109] then areas with high levels of aerosol pollution should be cooling relative to the unpolluted areas. But, they are not, as seen in the Global Warming anomaly map generated using 1995-2004 NASA's historical temperature data.[110] Increasingly polluted regions are warming the fastest.

   Further, the polluted Northern Hemisphere should be cooler than the cleaner Southern Hemisphere. However, this is not seen in the NASA data maps. When the trends in the NASA data maps are compared to trends indicated in GHG model projections, opposing trends are seen in many parts of the maps.

   In fact, if one examines the maps very carefully by superimposing one image on top of the other, many entire sections on one map looks like the reverse image of the other. This indicates 1) the aerosol relationship may be backward in the models, and 2) that aerosols are causing warming due to their varying BC content, not cooling.

5. Moreover, as Greenland is also affected by greater relative levels of aerosol pollution, per current IPCC theory it should be slightly cooling in comparison with mainland Antarctica which has the least polluted atmosphere on the planet, as confirmed by the earlier soot deposition measurement taken there. It's not – Greenland is warming relative to mainland Antarctica.

6. Since 1979, satellite images show the level of summer sea ice in the artic has shrunk by approximately 60%.

   Even more troubling than that, the unexpected record melting of Arctic summer sea ice in 2007, to levels 27% lower than the previous record low in 2005, indicate most climate scientist's estimates for current Arctic BC warming may be much too conservative, as green house gases have not increased enough to explain this or other historical melting and freezing seen in the Arctic during the 1940s, 50s and 60s.

   Computer models based on current GHG climate theory fail to accurately predict any of the recent or more historical climate change we have seen over the past 60 years.

7. Because the greatest warming is seen in the most polluted areas, then BC soot or other aerosols must be having a much greater impact than currently believed.

   Garrett and Zhao 2006's Arctic data on atmospheric BC supports this hypothesis.

   Zender 2007's discussion of the effects of BC soot deposition further supports this hypothesis.

8. The *Molina* (2007) Pacific Ocean atmospheric study showing soot's potential to warm clouds and generate storm activity further supports this hypothesis.

9. Analysis of the Vostok ice cores (*Stott* September 2007, Science) indicates that the trigger for initial deglacial warming around Antarctica was the change in solar insolation over the Southern Ocean and that ultimately these forcings promoted enhanced ventilation of the deep sea and the subsequent rise in atmospheric CO_2. In other words the warming was not driven by increased CO_2, but that instead the increase in atmospheric CO_2 was caused by the warming, indicating that CO_2 may not be the potent warming agent suspected, and that other anthropogenic factors like Black Carbon may be causing more warming than previously suspected.

10. 20th century global temperatures and CO_2 records don't correlate.

    World temperatures rose dramatically from 1890 - 1945, prior to any significant increase in anthropogenic CO_2.

    Then, as CO_2 emissions continued to grow, most of the world cooled over the next two decades.

    However historical temperature fluctuations do correlate with estimations of historical carbon aerosol output, as described below in this paper's research.

11. As discussed below, despite extreme regional warming in North America in the 1920s and 30s, there were only moderate temperature increases recorded elsewhere globally, as shown by lower average global temperatures increases, which included the hotter North American temperatures within that average.

    This regional warming can not be explained by GHGs, but is well explained by the tremendous quantities of coal soot generated during the extremely dirty and massive industrial revolution and expansion going on in America and parts of Canada at the time.

12. The Global Cooling Map, generated with NASA's historical temperature data and showing relative cooling from 1965-75 as compared to the warmer period of 1937- 46, also correlate with estimated changes in historical BC output due to changing economic activity in various regions of the world at the time.

13. Satellite pictures showing certain geographical regions with significant anthropogenic BC and OM pollution, such as bio-mass fires, marine shipping activity, and oil & gas flaring correlate with the regions of warming seen on the 1995-2004 Global Warming Anomaly Maps seen below.

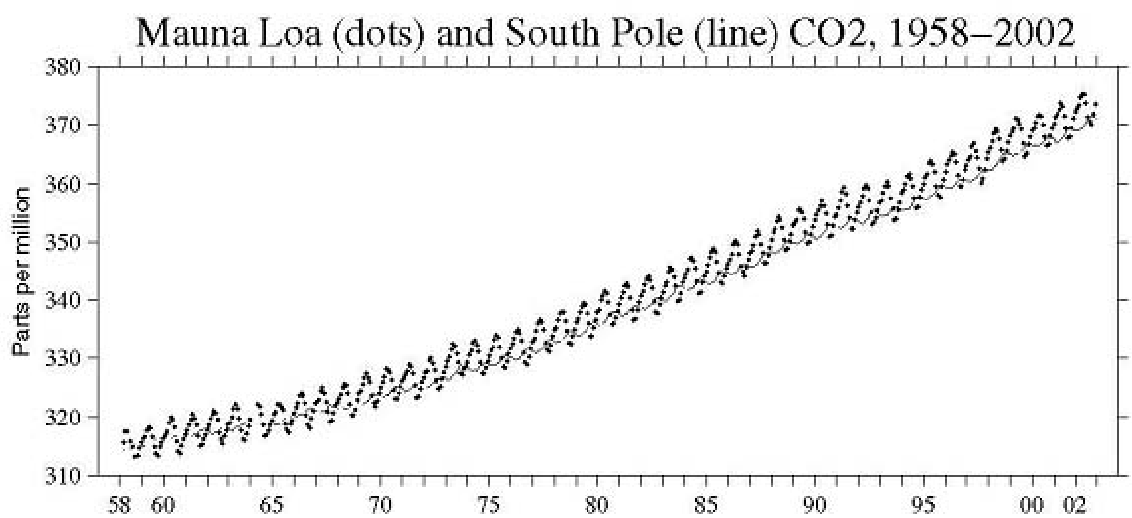
9. Analysis of Historical Temperature Anomaly Maps and Other Data

Below, an analysis of GHG concentrations, global temperature anomaly maps, and other relevant historical data discussed above is presented along with those various maps, satellite photographs, and other data. Examined together they indicate that BC soot and other air pollution may be the primary drivers of the climate change we are witnessing.

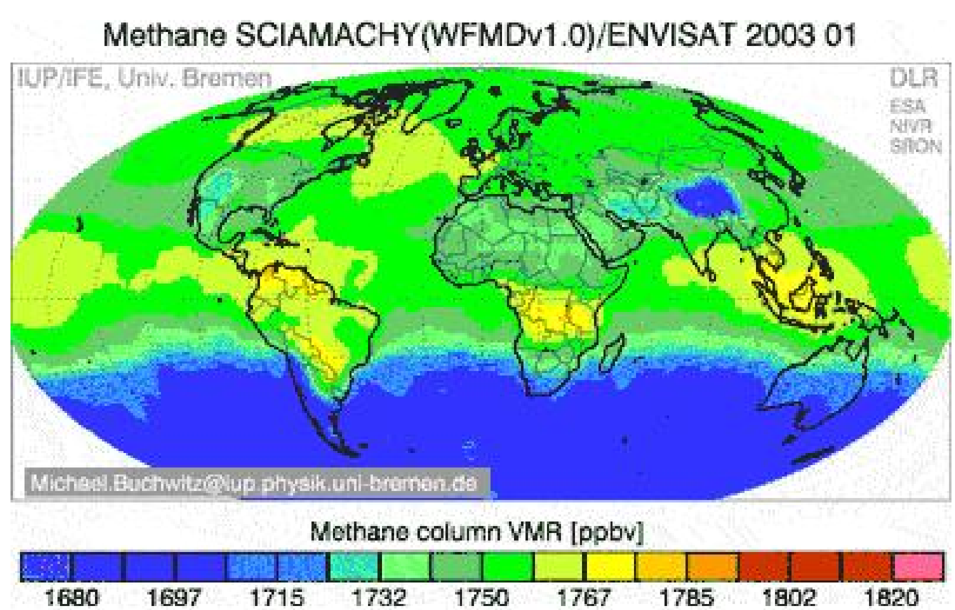
GHG Are Mixed Evenly Throughout The Atmosphere

- CO_2 and other GHG are evenly mixed throughout the atmosphere, as shown from continuous measurements of CO_2 taken at more than 60 data collection stations in almost every part of the globe.[111]

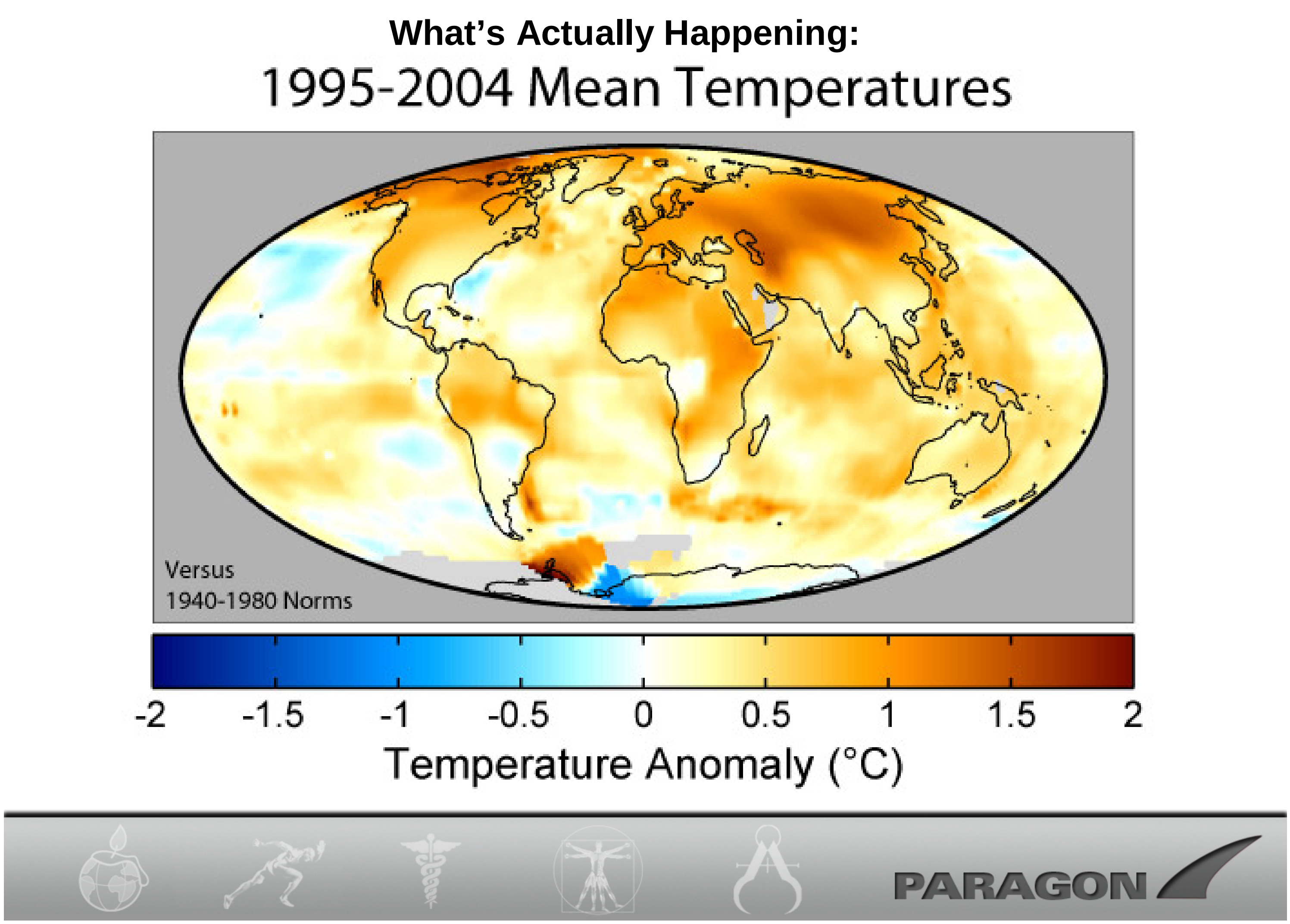
  In a recent review of the data from all stations there was no more than a 10 point, or 2.5% deviation from the highest CO_2 recording to the lowest.



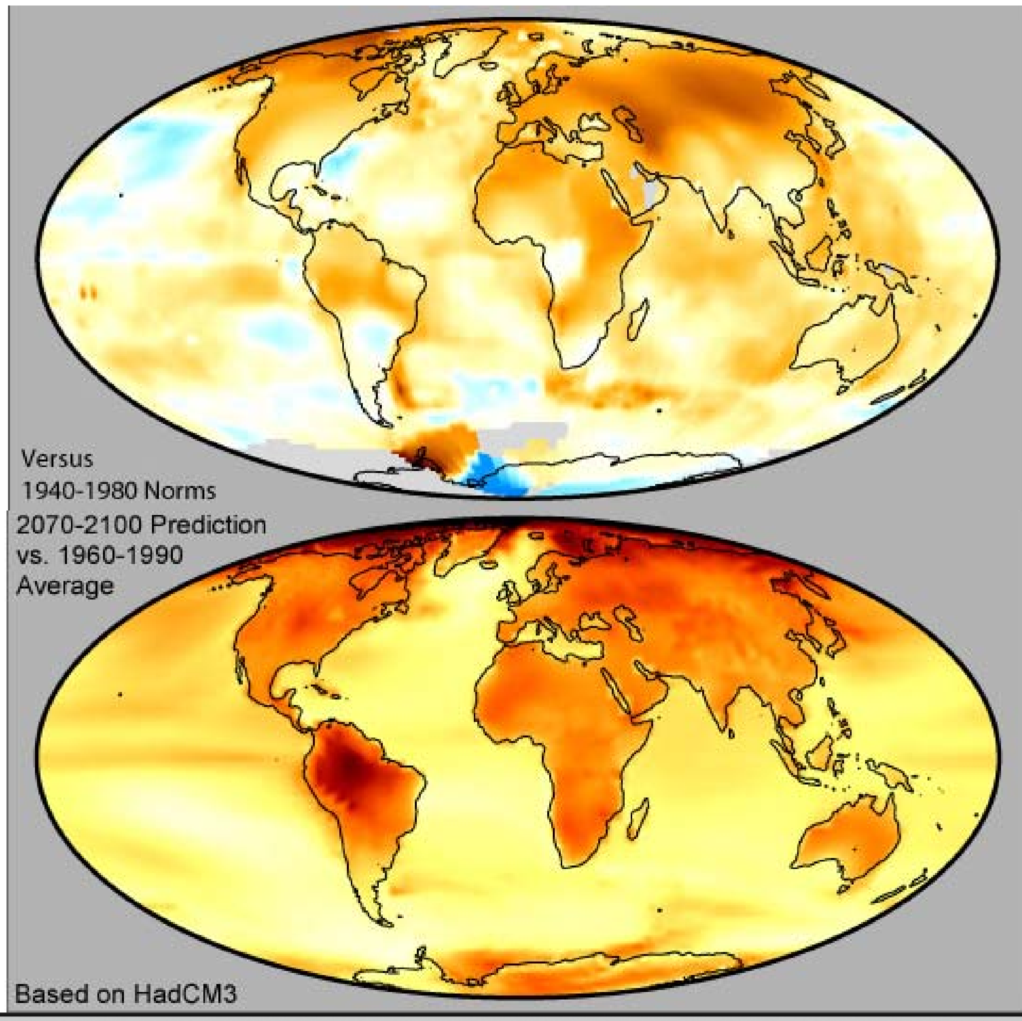
- For a view of monthly global Methane levels from 2003 – 2005 see: http://www.esa.int/esaCP/SEM1DUQ08ZE_index_1.html



- Because GHGs are evenly distributed in the atmosphere, if the dimming caused by aerosols is preventing sunlight from reaching the Earth, thereby reducing the full potential GHG warming and leading to regional cooling as hypothesized by the IPCC,[112] the areas with high levels of aerosol pollution should be cooling relative to the unpolluted areas. Clearly this isn't the case, as shown in the slides below.



- And, when comparing the computer generated warming projections made with such assumptions (bottom) against the Global Warming Map built on NASA's actual historical temperature data [113] (upper), no relative correlation is seen.



This slide discusses what should be seen on the warming map if current IPCC theory was correct.

Should see very different map below – more like that to the right.

CO2 and other GHG gases mix evenly in the atmosphere. If air pollution is cooling and GHG are warming, then there should be similar, if not more warming in the cleaner southern hemisphere, and there isn't.

Lack of dimming should be raising temperatures in more pristine areas like Pacific, instead there is cooling

Dimming should cool most polluted areas, instead it's warming many of them. Russia was dimmest - 30% - due to air pollution and smoky low intensity forest fires, however warming not cooling.

US only realized 10% increase in dimming as it was already an industrial center of the world from 1940s-60s, and then began falling back relative to Europe, and then Asia

Cooling seen off US coast may be due to reduction in industrial output

White aerosol ash (modern coal) may be causing cooling.

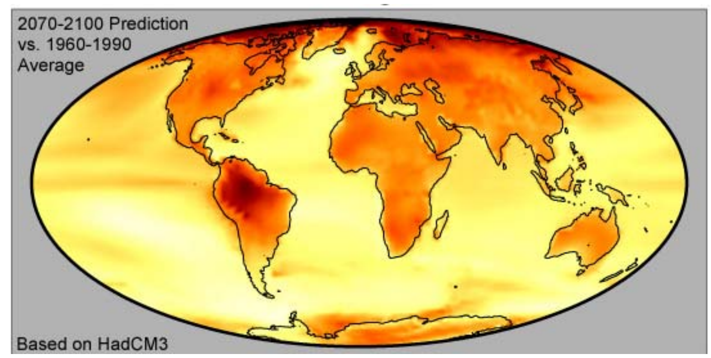
BC soot from coal, marine, aviation, & diesel emissions causing warming.

Soot and particulate settles in polar regions causing warming.

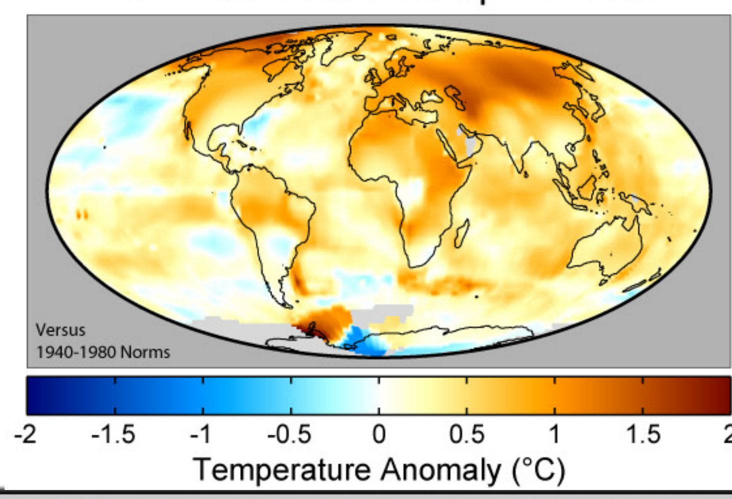
Contrails causing vapor cloud, trapping heat. Water vapor emissions may be causing more warming than thought, especially from tall stacks

More complete formula maybe: Warming = + BC + GHG – GD

Bottom Line: Air pollution appears to be accelerating warming

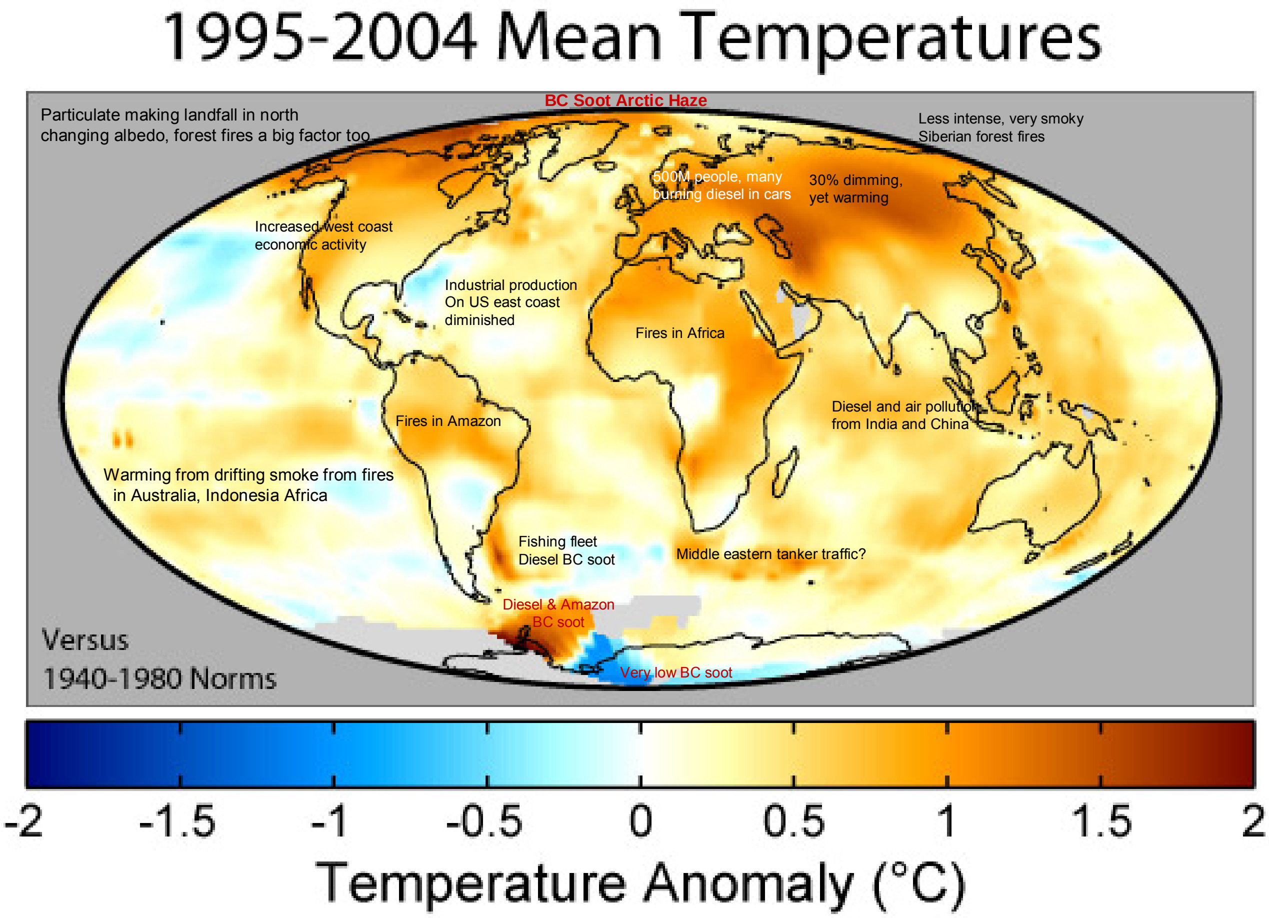


1995-2004 Mean Temperatures



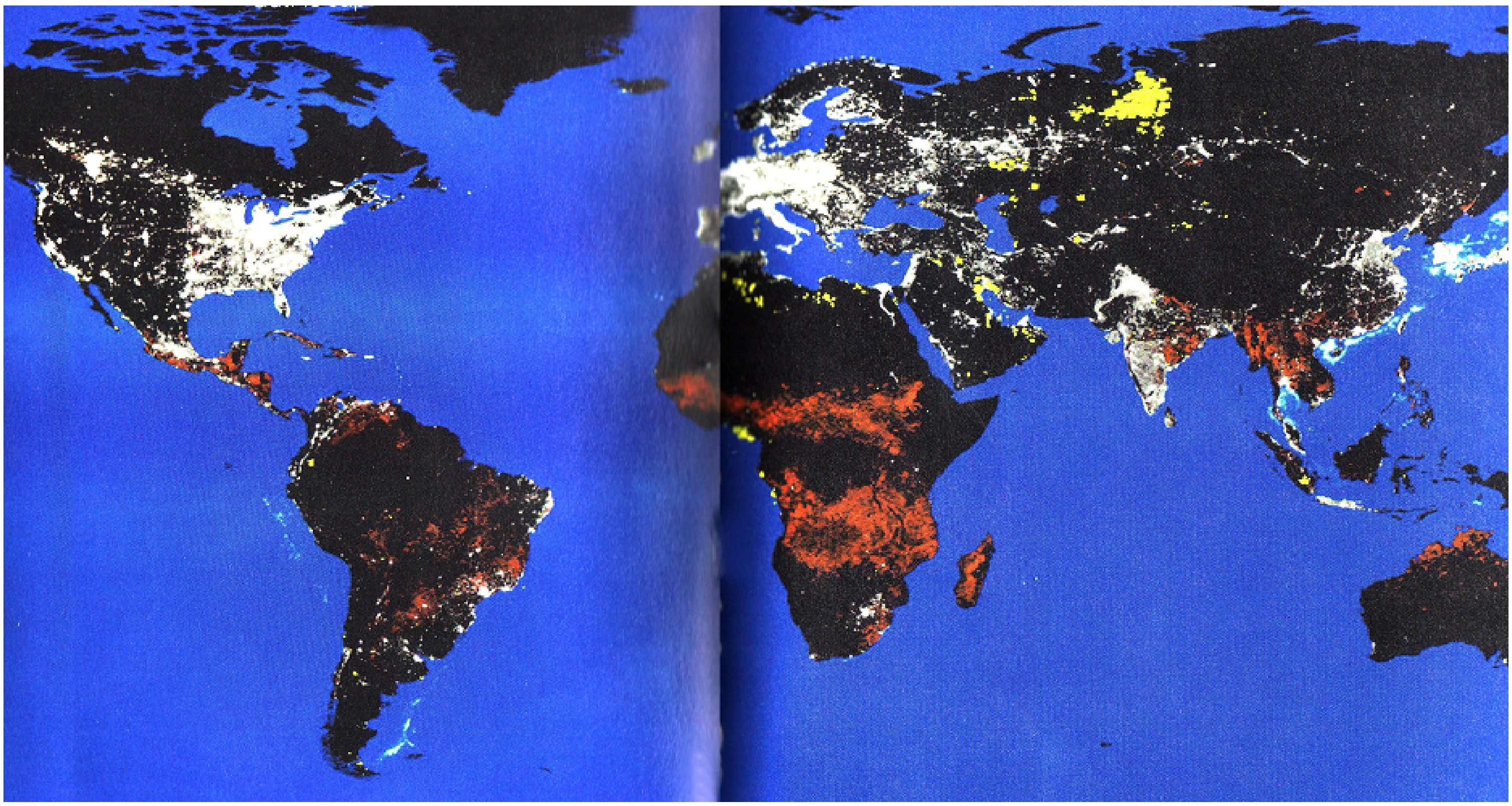
Further, because warming is seen in areas with high pollution, then BC must be having a greater impact than currently believed, just as further analysis of NASA's temperature data indicates it is.

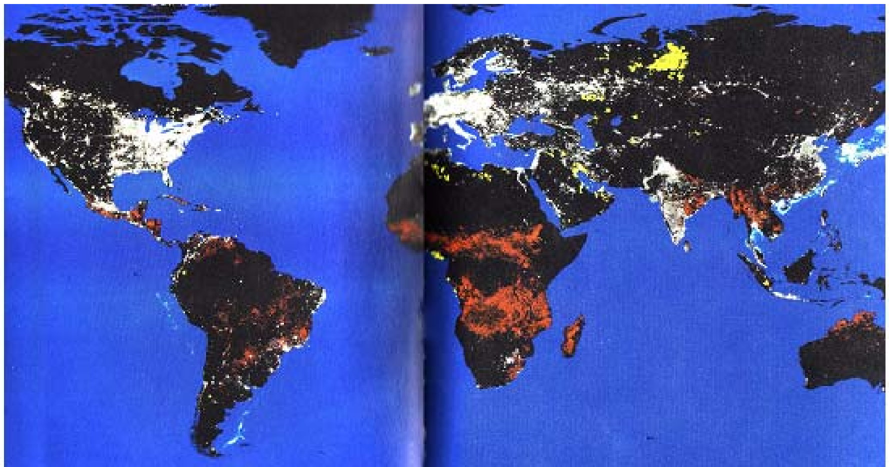
This plot is based on the NASA GISS Surface Temperature Analysis (GISTEMP), which combines the 2001 GISS land station analysis data set (Hansen et al. 2001) with the Rayner/Reynolds oceanic sea surface temperature data set (Rayner 2000, Reynolds et al. 2002). The data itself was prepared through the GISTEMP online mapping tool, and the specific dataset used is available here



- Satellite maps showing geographical regions of various human activities correlate with the regions of warming on the Global Warming Map.

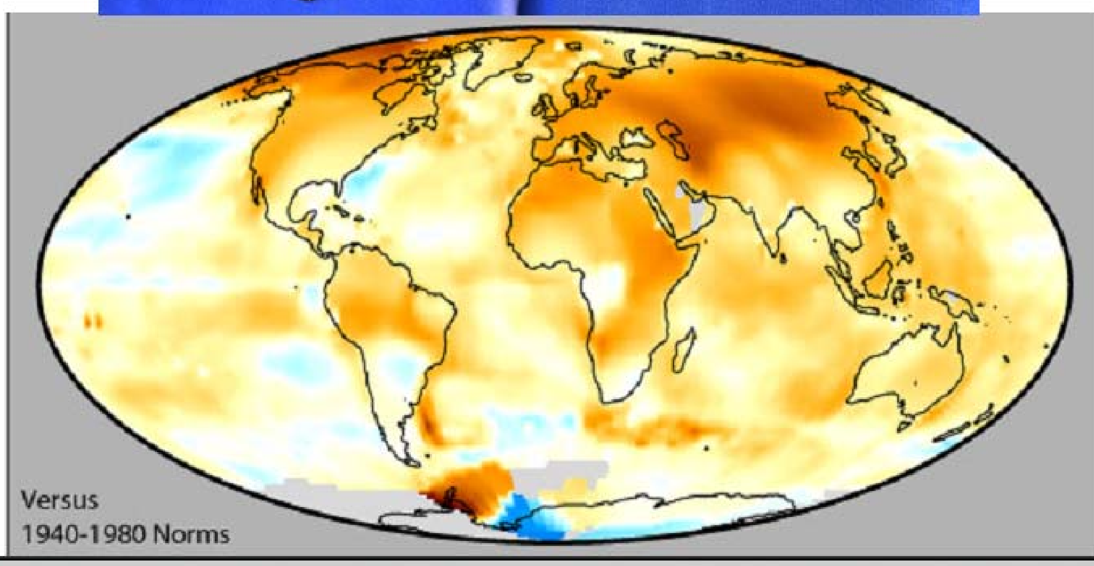
Mr. Gore's satellite map of bio-mass burning (red), oil field flaring (yellow), shipping activity (blue), combined with westerly winds, correspond with temperature rising.





Compare areas of known particulate generation on Mr. Gore's map – shipping exhaust In blue, fires in red, and oil & gas flaring in yellow – to regions on warming map below.

Coal & diesel emissions and seasonal forest fire smoke in the Northern Hemisphere are not indicated on Mr. Gore's image, and would account for much of the warming occurring in the north.



10. The First Era of Significant Anthropogenic Warming 1880-1940

Early Fuel Burning Methods Produced Huge Quantities Of Soot per BTU Generated

The world's primary fuel source evolved from wood, to that of coal, and then to oil & gas.

Rome was plagued with thousands of wood-burning fires and blackened buildings – c. AD 61. Seneca (statesman and Nero's tutor) "As soon as I had gotten out of the heavy air of Rome and from the stink of the smoky chimneys thereof, which being stirred, poured forth whatever pestilential vapors and soot that had enclosed in them, I felt an alteration of my disposition. [114]

In terms of particulate and BC soot emissions produced, wood combustion is highest, early coal burning only slightly better, cleaner burning coal technologies much better, and oil and gas significantly better yet. (Solar & wind generated electricity and hydrogen produce none.)

Each improvement in combustion technology led to large, but temporary decreases in regional, and in some cases, global particulate emissions during various eras of human history. However, eventually in most cases, total particulate levels eventually surpassed the previous era's highs as world fuel consumption rapidly and steadily grew.

150 years ago, the world relied almost exclusively on wood for heating. (Water wheels, windmills, and early coal-fired steam engines were used for other energy requirements. Another major source of energy used for agriculture included horses, mules, and other draft animals, as well as human labor.)

With the advent of newer coal-burning technology, wood rapidly decreased as a source of energy, especially in urban areas and major cities. The availability of coal offered an economic advantage as the supply of wood diminished exponentially. Steam driven cars, ploughs, and threshing machines first appeared on in the 1880s. Most steam engines designed for use in agriculture made use of straw for fuel, although some burned wood or coal.

1896 Salveson steam cart

10 Hp [115]

Photo (http://images.indianahistory.org/cdm4/item_viewer.php?CISOROOT=/P0130&CISOPTR=628&REC=4)

Industrial energy supplies were gradually converted to coal and, by the start of the 20th Century, most of the world's energy requirements were being supplied by coal (the exception being wood-burning stoves in private residences for heat and hot water).

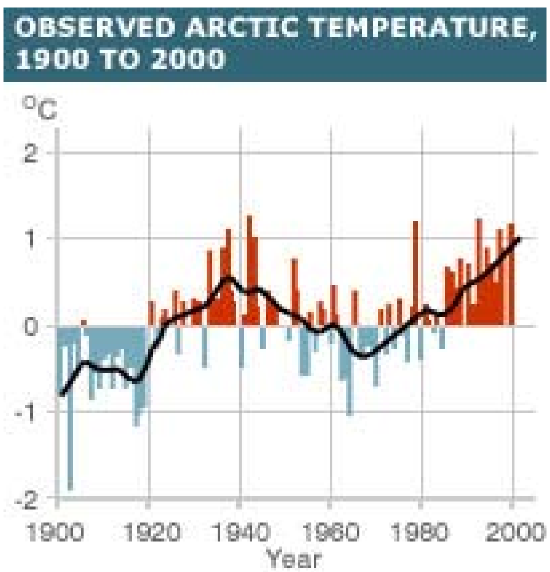
Understandably urban air quality in the industrial world declined rapidly with the increased use of coal and wood fired steam, and to a lesser extent with early use of inefficient internal combustion engines.

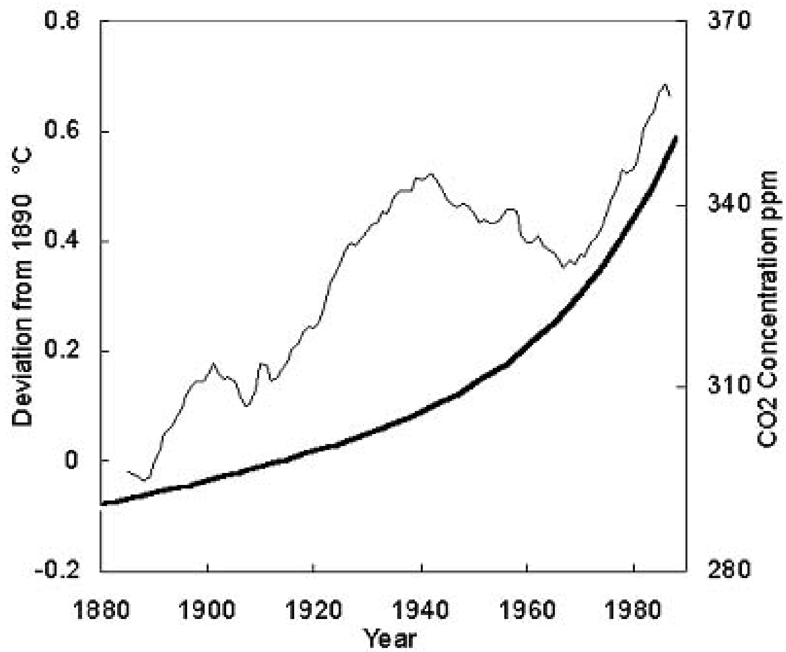
Varying Soot Emissions May Explain 20th Century Temperature Fluctuations

Over the past 150 years global CO_2 emissions have been steadily rising, but global temperatures have instead oscillated independently relative to CO_2.

In the figure on the right below, the eleven-year moving average of global surface temperature, as estimated by NASA GISS, is plotted as deviation from 1890 (left axis and light line), as compared with atmospheric CO_2 (right axis and dark line). As of 1998 (when this graphic was created), approximately 82% of the increase in CO_2 occurred after the temperature maximum in 1940.[116]

As can be seen, 20th century historical global temperatures and CO_2 records don't match up. And while actual statistics for historical particulate levels are not available, there is significant photographic evidence indicating that total global soot levels may have been oscillating in a very similar pattern to that of global temperature levels. As well, Bond researchThe reasons why historical soot outputs seem to match historical temperatures estimations of are discussed below.





(chart above left:, http://news.bbc.co.uk/2/hi/science/nature/6610125.stm)

World temperature records since 1880 show three main phases. During the first phase, temperatures steadily rose from the late 1880s until the 1940s. This was followed by a slight cooling in the 1950's and 60's, and then by a second phase of warming which began in the 1970's.

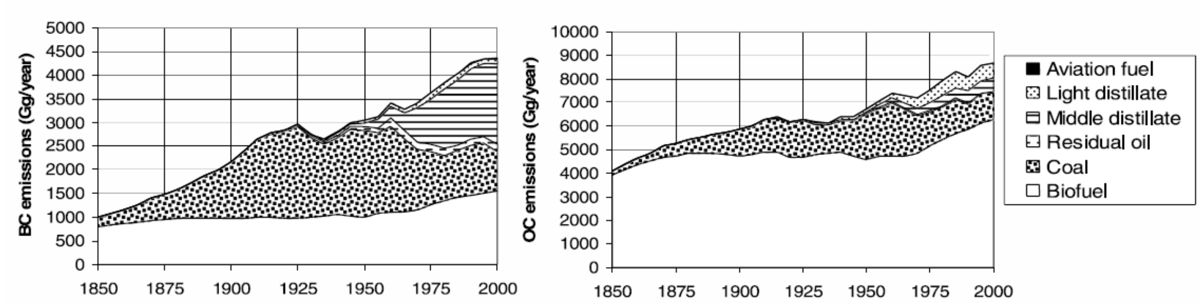
Dr. Tami Bond's latest Research on BC and OC Emissions

Earlier analyses of historical BC & OC emissions were flawed. *Novakov et al.* [2003] used the emission factors of *Cooke et al.* [1999], which assumed that emission factors in developing countries were five times higher than those in developed countries, without regard to technology. *Ito and Penner* (2005) admit that their estimates for the early 1900s could be too low because they did not consider changes in combustion except for diesels.[117]

Dr. Tami Bond, one of the world's leading experts on historical BC and OC emissions, has spent twelve years modeling and measuring sources of black carbon and other aerosols. *Bond et al* (2007) considered all manners of technology as applied to many industrial sectors in an exhaustive analysis of historical world-wide BC and OC. That paper both acknowledges:

- that regional aerosol forcings can be an order of magnitude greater than greenhouse gas forcings [e.g., Satheesh and Ramanthan, 2000], and
- that early in the industrial era, aerosols may have contributed more to average forcing owing to low levels of accumulated anthropogenic CO_2 and comparatively high aerosol pollution.

The paper presents an emission inventory of primary black carbon (BC) and primary organic carbon (OC) aerosols from fossil fuel and biofuel combustion between 1850 and 2000. It reconstructs fossil fuel consumption and represents changes in technology on a national and sectoral basis. The work supports a gradual increase of emissions between 1850 and 1925, with a reduction between 1925 and 1950, with the implementation of clean technology being the primary reason. They estimate that later on the sheer number of emissions led to another gradual increase between 1950 and 2000.



What is so important about this research is that it estimates that increased particulate levels were associated with earlier dirtier methods of combustion used. Their analysis shows an oscillating level of soot emissions, that correlates with the basic pattern of oscillating historical warming seen, as shown above. Bond et al's soot fluctuations track world warming more closely than CO2 does. Further, while *Bond et al* (2007)'s estimates considered changes in combustion, they may have falsely assumed that technological change was adopted so rapidly. It's well established that technology adoption can take years, particularly in less competitive economies, or in economies where feed stocks are plentiful and inexpensive.

An example of such a delay is cited in their paper as relates to steel making: "The major transition in coking has been capturing and using the volatile matter driven off. No volatile matter was captured in the early days of coking, when the ovens were called ''beehives'' owing to their shape. Capture of byproducts in recovery ovens, particularly in Germany, began in the late 1800s in Europe [Lunge, 1909]. The United States began recovery of byproducts around 1910 [Tarr, 1996], although new beehives were constructed until 1931 [Kiessling, 1934]."

With delayed adoption of new technologies, the planet's air would not have begun to clear for several years later, which could easily explain the 15 year deviation in Bond et al's emissions estimates and actual world temperatures.

Temperatures Began Rising In The 1890s

All earlier fuel burning methods, including those for oil and gasoline, produced much higher levels of soot and particle generation due to less efficient fuel burning systems. The percentage of unburned and partially burned molecules was very much worse due to the extremely poor combustion chamber dynamics of earlier furnaces and engines. Early furnaces and engines belched BC soot, and were used on a large scale in North America, Europe and Asia.

So as can seen from the photographs below, it's possible that previous levels of suspended BC particulate were high enough during the industrial revolution to explain the deviations in historical temperature fluctuations relative to total GHG accumulations, and more specifically the elevated Arctic and North American dust bowl temperatures of the 1930s.

Pittsburgh 1906… Click on Photo for exploded view
http://isu.indstate.edu/jspeer/conservation

London, Youngstown, Pittsburgh and many other cities were once famous for there “fogs” of coal soot particulate during the industrial revolution. Below: Youngstown, Ohio c. 1910

(Library of Congress Prints and Photographs division Washington D.C.)

Donora, Pennsylvania 1910 http://e3.uci.edu/clients/bjbecker/SpinningWeb/week9d.html

Noontime smog on a street in Donora, Pennsylvania, 1948. (© Pittsburgh Post-Gazette, all rights reserved.)

Smog filled view under Brooklyn Bridge, May, 1918. (above)
Municipal Building takes shape in the smoggy background, 1912. (below)
Eugene de Salignac/Aperture Foundation & the New York City Municipal Archives
http://news.bbc.co.uk/2/shared/spl/hi/pop_ups/07/in_pictures_new_york_rises/html/4.stm

As seen above, with the spread of the industrial revolution during the later 19th and early 20th century, soot particulate pollution from dirty, inefficient coal combustion increased dramatically.

The latest studies on effects caused by excessive atmospheric BC soot indicate this would have caused significant ***regional*** warming and increasingly intense ***regional*** weather over this period.

So despite lower levels of ***total coal consumption*** in the 30's and 40's as compared to today, the much dirtier earlier methods of burning coal (and oil and gas), and large scale land clearing/burning and deforestation going on at the time, appear to have led to ever increasingly higher levels of soot and other heat scattering particulate in the air in the late thirties and early forties.

The temperature tables and storm data below show just that.

The Unites States Warmed Faster Than Elsewhere In The World in the 1920s and 30s

As the coal-fired United States became the world's economic engine in the 20s and 30s, with the increases in BC soot emissions came rises in annual average temperatures.

The left hand chart below show the hottest years in the US[118] as compared to the rest of the world[119] (right). As seen in the US Temperature records (USHCN Version 1) below, 1934, '31, '21, remain among the hottest 6 years in US history, with '39,'38,'46,'33 and '41 all in the top 25. **Nine of the 25 hottest years in US history came at the height of the 1st coal burning era in America.**

Data in Years and Degrees Fahrenheit				
Rank	**USHCN Version 1**		**USHCN Version 2 Beta**	
1	2006	55.01	1998	55.09
2	1998	54.94	2006	54.95
3	**1934**	54.91	1999	54.61
4	1999	54.53	1934	54.54
5	**1921**	54.49	1921	54.37
6	**1931**	54.34	1990	54.37
7	1990	54.24	2001	54.35
8	2001	54.23	2005	54.28
9	1953	54.18	1931	54.20
10	1954	54.13	1953	54.10
11	2005	54.08	1986	54.08
12	1987	54.08	1987	54.07
13	1986	54.08	1991	53.98
14	1939	54.07	2002	53.95
15	1938	54.01	2003	53.94
16	1981	53.88	2000	53.92
17	1991	53.87	1939	53.89
18	2003	53.86	1954	53.88
19	2000	53.84	1938	53.86
20	1946	53.81	1981	53.79
21	1933	53.81	2004	53.78
22	2002	53.76	1994	53.66
23	2004	53.62	1933	53.64
24	1994	53.61	1946	53.63
25	1941	53.57	1995	53.51

Rank	Year
1	2005
1	1998
3	2002
4	2003
5	2004
6	2001
7	1997
8	1990
9	1995
10	1999
11	2000
12	1991
13	1987
14	1988
15	1994
16	1983
17	1996
18	1944
19	1989
20	1993

As coal-driven economic activity was less intense and already established in other parts of the "Old World", those regions warmed less, as the comparison of US and World temperatures show. World temperature averages for the 1920's & 30's would be even lower with the US component removed.

Despite the gradual conversion from coal to oil and gas that had already begun, it's no surprise that the years of increased arms manufacturing in preparation for WWII made 1938, '39, and '41 some of the warmest in the US history.

And, on the scale of average world temperatures, 1944 was the hottest of the early years, right at the peak of the WWII.

US Storm Activity Surged between 1880 and 1940 As Well

The significant warming seen in this first warming period should have generated increased Atlantic storm activity during the period. Not surprisingly, there was a significant increase in local Atlantic storm intensity affecting the US during the period.

While there was only 1 category 4 storm from 1850-1879 ('55), there were 4 from 1880-1909 ('86, '93, '98, 1900) and 6 from 1910- 40 ('15,'19,'26,'28,'32,'35) including the first ever category 5 in 1935.

Category 3 and higher storms increased in number as well.

1850-1879: 51, 52, 54, 55, 56, 60, 69, 71, 73, 75, 77, 79, 79,
1880-1909: 80, 82, 85, 86, 86, 88, 93, 93, 93, 94, 96, 98, 99, 00, 06, 09, 09, 09,
1910-1940: 15, 15, 16, 16, 17, 18, 19, 21, 26, 26, 28, 29, 32, 33, 33, 33, 34, 35, 36, 38,

Source: The Deadliest, Costliest, and Most Intense United States Tropical Cyclones From 1851 to 2005,NOAA/NWS/Tropical Prediction Center/National Hurricane Center http://www.nhc.noaa.gov/Deadliest_Costliest.shtml

And Now Molina Has Shown How Soot is Can Cause Violent Weather

In a March 2007 study, Nobel Prize-winner Mario Molina - who 30 years ago helped discover how pollution thins the ozone layer - used a host of satellite measurements to analyze intense Pacific storms following wind-blown bursts of soot from the booming factories of Asia. His team found BC soot is heating the clouds that cross the Pacific Ocean, causing intense storms, like those that struck the North West in December 2006, and the one that destroyed thousands of ancient trees in Vancouver's Stanley Park.[120]

The study blames sooty, sulphurous coal smoke from Asian industry - largely in China and India - for altering the eastbound "storm track" in the Pacific. Floating BC soot particles change the chemistry of the air making regular clouds form into towering storm clouds through convection, or rising warm air.

"The intensified Pacific storm track is climatically significant," as the scientists have been able to measure the effect of BC aerosols on climate. So far, they have studied a relatively short time-frame, by climate standards, comparing the period 1984-1994 with 1994 to 2004. ***The second 10 years averaged between 20 and 50 per cent more storm activity, and the reason is "unambiguously" pollution,*** as announced in the journal Proceedings of the National Academy of Sciences.

That said, it should be remembered that European and North American diesel and coal soot are causing similar problems in other parts of the world, and such effects must influence weather patterns around the world.

11. As Soot Levels Fell, So Did Temperatures in The 1950s & 60s

The Conversion from Early Coal Use to Oil & Gas

After World War I, oil and natural gas began replacing coal as a primary energy carrier. During the following two decades, the transition from coal to oil (caused by improvements in efficiency, not scarcity) was nearly completed.

A milestone of American energy conversion followed the railroad's, electric utilities', and U.S. Navy's switch to oil as their primary fuel.[121] The use of coal became relegated to the production of electric power and steel due to the economics of large-scale, baseload power utilities.

In the field of transportation, during the post-World War II era, more efficient oil-fired diesels replaced coal as the primary fuel. In part, this was due to the evolution from public rail to personal automobiles. This change was followed by residential and commercial customers using pipeline natural gas for home heating.

This eventual world wide conversion from coal to oil by the late 40's led to a large, but temporary, decrease in global particulate emissions.

Why Most Sulphate Aerosols May Not Provide A Net Cooling Effect As Currently Predicted

Sulphate and other aerosols are suspected by the IPCC of reflecting incoming sunlight, causing dimming, and because of that, cooling.

As such, most IPCC scientists argue that that cooling of average global temperatures during the 1950s and 60s was due to an increase in sulfur dioxide emissions from an increasing number of coal-fired electricity generation plants brought on line during the 1950s & 60s. However, this argument doesn't stand up for several reasons.

First, sulphate rich emissions didn't just begin all of a sudden in the 1940s – their sustained production had been continuously accelerating since the beginning of the industrial revolution due to the increased burning of sulfur rich coal.

But most importantly to the cooling, the dirtiest forms of coal burning highest in BC soot were phased out as discussed above, leading to a significant reduction of warming particulate during this period.

In the US industrial coal use fell from 212M short tons in 1949 to 147M by1975. And the uses that generated proportionately greater levels of soot, due to fluctuating burn rates (accelerations and decelerations) – early heating and transportation uses – all fell even further:

- Residential use fell 95% from 52.4M short tons in 1949 to 2.8M by 1975. [122]
- Commercial use fell 90% from 64.0M short tons in 1949 to 6.5M by 1975. [123]
- And the worst, that of transportation use fell almost 100% from 70.1 million short tons in 1949 to 0.02M by 1975.[124]

As well, total coal use in the United States fell significantly during the period. After total annual coal consumption peaked at 505M short tons in 1952, it fell to 385M by 1959, rising only slightly to 402M by 1962.[125] By 1970, it had climbed back to 501M.

Coal use then began to accelerate rapidly once again, to 680M by 1979 as cleaner burning electricity plants were brought on line more rapidly. However this cleaner burning coal would now generate the microscopic black carbon produced by modern engines and furnaces.

However, the most convincing proof of the potential net warming effect of sulpher-rich haze is the Artcic Haze itself. The haze's aerosols are up to 90% sulphurous, mixed with carbon, which gives the haze its characteristic colour.[126] While the sulphates may have a cooling effect on its own, the powerful warming potential of BC soot in the Arctic Haze easily overrides it. The pollutants are commonly thought to originate from coal-burning in northern mid-latitudes.

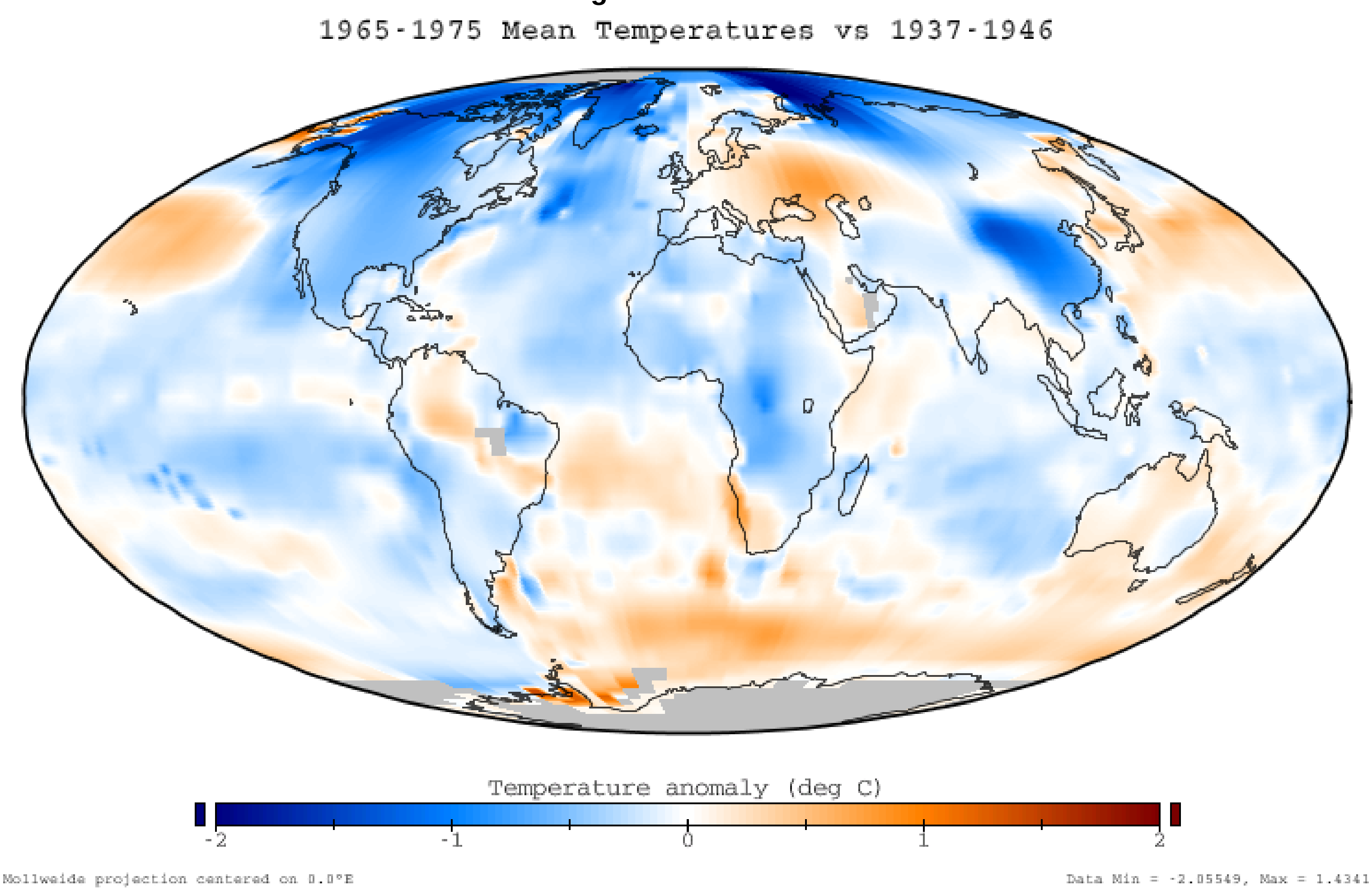
World Temperatures Cooled in the 1950s and 60s

The subsequent conversion to cleaner burning oil, gasoline, and natural gas would have resulted in less suspended particulate and cooling, as temporarily seen through the 50's and 60's.

- Global Cooling Map, built upon NASA's historical temperature data and showing relative cooling from between the eras of 1937-46 and 1965-75, which also correlate with estimations of historical BC output.

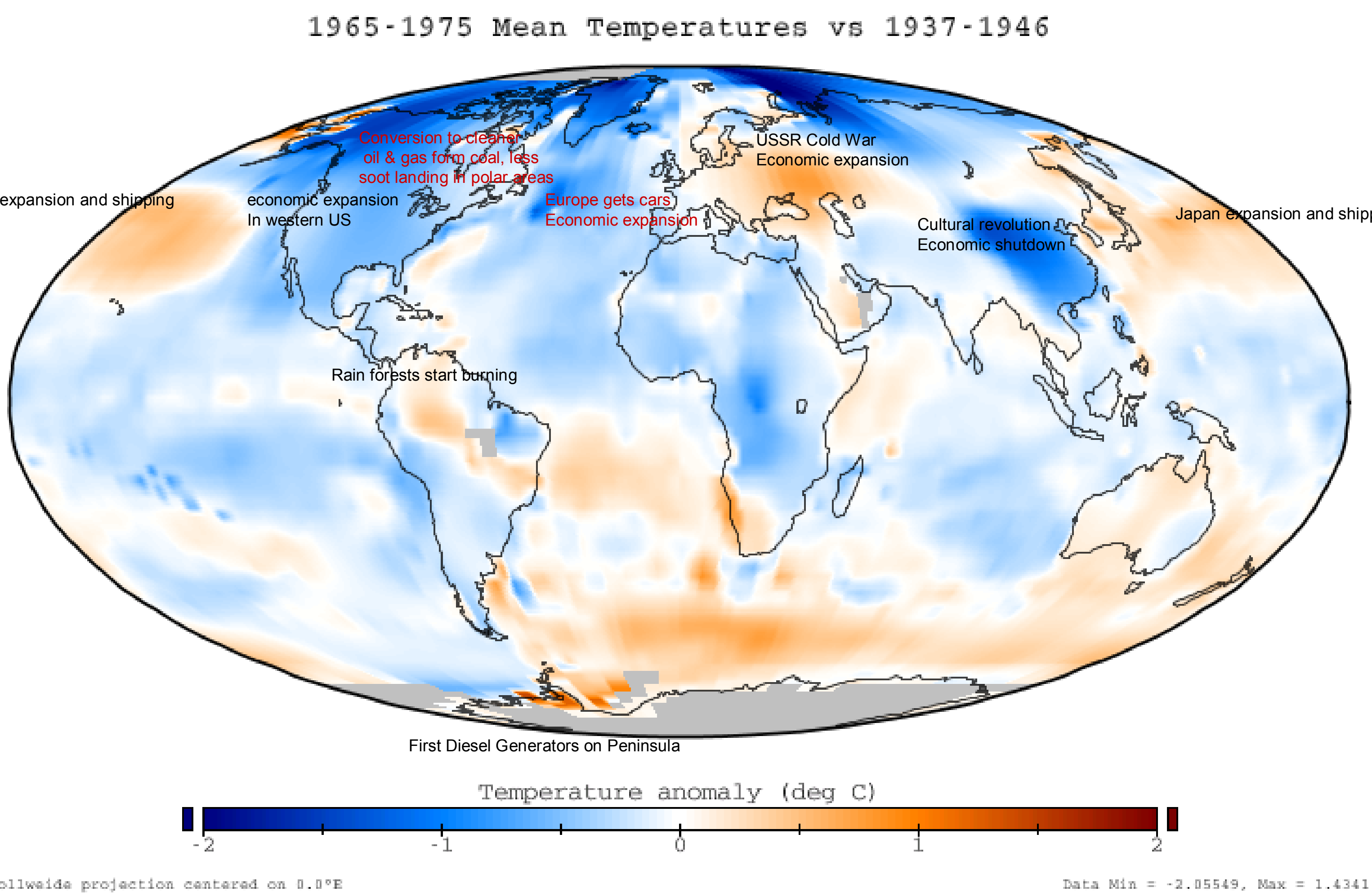
This plot is based on the NASA GISS Surface Temperature Analysis (GISTEMP), which combines the 2001 GISS land station analysis data set (Hansen et al. 2001) with the Rayner/Reynolds oceanic sea surface temperature data set (Rayner 2000, Reynolds et al. 2002). The data itself was prepared through the GISTEMP online mapping tool, and the specific dataset used is available here.

Further Evidence of Regional Aerosol-Driven Climate Affects



Particularly striking is the potential cooling off of the Chinese bicycle economy under Mao.

This figure shows the difference in instrumentally determined surface temperatures between the period January 1965 through December 1975 and "normal" temperatures at the same locations,defined to be the average over the interval January 1937 to December 1946. The average decrease on this graph is -0.11 °C, and the temperature decreases are considered to be an aspect of global cooling.



Since The 1970s The World, And Particularly The Northern Hemisphere, Has Been Warming

The current warming reaccelerated in the 1970s with the explosion in fossil fuel burning, first in North America and Europe, and then in Asia.

The gasoline era evolved in response to growing demand for automobiles. (This growth in fossil fuel use led to the establishment of an energy infrastructure network not seen in previous attempts by humankind.)

Total BC particulate levels would eventually surpassed the previous era's highs, as world fuel consumption rapidly and steadily grew from the early 70s on.

Not surprisingly, temperatures started to rise right around the same time as world demand for oil surged, causing the OPEC oil crisis. The creation of the VW bug, Fiat, and other small affordable cars accelerated the consumption of oil and gas, and the generation of CO_2 and particulate significantly. Hondas, Nissans and Toyotas quickly followed. World oil demand surged to meet Europe and the world's demand for new cheaper cars.

Temperatures have since risen far faster than earlier GHG models predicted. Based on the evidence provide so far, this is probably due to the huge surges of microscopic diesel, coal, and gasoline BC soot emissions in Asia, North America, and Europe.

In North America and Europe, the thick hazes of BC soot of the early industrial revolution have been replaced by a finer microscopic haze that is visible in LA, NY, Boston, Toronto, London and most cities today.

However, hundreds of China's city atmospheres are currently saturated in suspended particulate, like London, Youngstown, and Pittsburgh past.

Evidence That Warming Is Happening Very Much Faster Than Predicted By The IPCC

According to the 4th IPCC report, GHG gases will the Earth's surface temperatures to warm by 1.8 – 4.0 degrees by 2100 or, .018 - .04 degree change per year.

(Such minute increases would be almost impossible to notice as they are so small, yet everyday citizens are noticing changes their sensory systems are picking up.)

Assuming the worst scenario, .04 per year would amount to .4 degrees per decade, or 1.2 degrees in 30 years.

Actual warming in China, Upper North America, and Greenland is far outpacing that rate, so clearly there's a problem with the above projection.

South eastern Greenland has warmed 3 degrees in last 20 years. [127]

The average summer 2005 temperature in Fairbanks was 64.5°F/18.1°C, and according to the Alaska Climate Center, was a full 2 degrees warmer than the previous record from the summer of 1975 .[128]

China, which should be cooling per current IPCC aerosol theory, is heating faster than anywhere in the world. The China Meteorological Administration announced through the Xinhua news agency on Feb 19, 2007 that in the past 50 years China's surface temperature rose an average 0.22 degrees every 10 years, outpacing increases in global and northern hemisphere temperatures. [129]

By 2020, China is predicting average annual temperatures could rise by 1.3 to 2.1 degrees Celsius (2.3 to 3.78 Fahrenheit) over 1961-1990 averages and increase by a startling 3.9 to 6.0 degrees by 2100, Xinhua news agency . That compares with the IPCC projections of a rise by between 1.8 and 4.0 degrees this century.

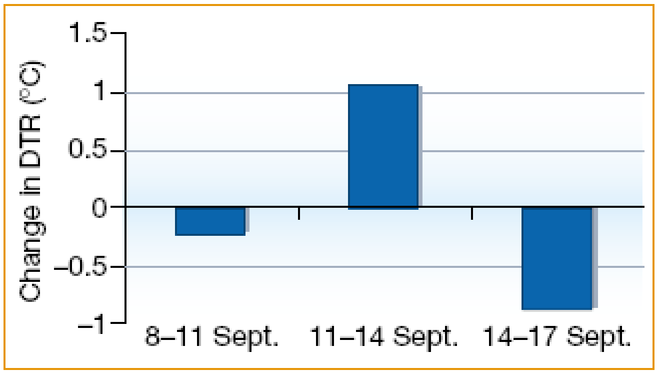
Travis Research Shows Reduced Diurnal Temperature Range (DTR)

The fact that aerosols are causing changes in climate, was further demonstrated in David Travis's research on the effects of aircraft contrails on climate. Prior to *Travis et al.'s* research, the potential of condensation trails (contrails) from jet aircraft to affect regional-scale surface temperatures had been debated for years [130] [131] [132], but had been difficult to verify until the three-day grounding of all commercial aircraft in the United States in the aftermath of September 11th 2001.

In their research, *Travis et al.* showed that there was an anomalous increase in the average diurnal temperature range (the difference between the daytime maximum and night-time minimum temperatures) for the period 11–14 September 2001. Because persisting contrails can reduce the transfer of both incoming solar and outgoing infrared radiation[133] [134] and so reduce the daily temperature range, they attributed at least a portion of this anomaly to the absence of contrails over this period.

They analyzed maximum and minimum temperature data [135] from about 4,000 weather stations throughout the conterminous United States (the 48 states not including Alaska and Hawaii) for the period 1971–2000**,** and compared these to the conditions that prevailed during the three-day aircraft grounding period. All sites were inspected for data quality and adjusted for the time of observation.

Because the grounding period commenced after the minimum temperatures had been reached on the morning of 11 September and ended before maximum temperatures were attained on 14 September (at noon, Eastern Standard Time), they staggered the calculation of the average diurnal temperature range (DTR) across adjacent days (for example, 11 September maxima minus 12 September minima). They repeated this procedure for the three-day periods immediately before and after the grounding period, and also for the same periods (8–11, 11–14 and 14–17 September) for each year from 1971 to 2000.



DTRs for 11–14 September 2001 measured at stations across the United States show an increase of about 1.1 C over mean 1971–2000 values (Fig. 1). This is in contrast to the adjacent three-day periods, when DTR values were near or below the mean (Fig. 1). DTR departures for the grounding period are, on average, 1.8 C greater than DTR departures for the two adjacent three-day periods.

Several things are indicated by these measurements:

1. This increase in DTR is larger than any during the 11–14 September period for the previous 30 years, and is the only increase greater than 2 standard deviations away from the mean DTR (s.d., 0.85 C).
2. Moreover, the 11–14 September increase in DTR was more than twice the national average for regions of the United States where contrail coverage has previously been reported to be most abundant (such as the midwest, northeast and northwest regions).
3. The DTR mean could be artificially high, as it was calculated with figures from 1970 – 2000, a period of steadily increasing BC emissions.

Reduced Diurnal Temperature Range (DTR) Indicates Warming not Cooling

Many of those interpreting Travis's research assumed that the haze created from aircraft contrails is dimming and cooling. However, evaluated on its own, it would be impossible to know whether Travis's research showed that the removal of haze showed:

- a warming of daytime temperatures
- or a decreasing of nighttime temperatures
- or a combination of both.

However when his results are combined with the other NASA anomaly data it indicates that this haze is probably raising night-time temperatures, as the haze appears to be causing warming, and not cooling as indicated by the IPCC. [136]

BC Aircraft Contrails May Be Heating Up The Troposphere

Furthermore because aircraft contrails contain microscopic BC, these may be further contributing to the warming of the troposphere. And because these particles are so tiny and emitted at such high altitudes they might stay aloft for many hundreds of years.

In one German/Swedish study, aircraft sampling of residual particles from evaporated ice crystals was performed using a Counterflow Virtual Impactor. Samples of crystals taken in both contrails and cirrus clouds were compared with interstitial aerosols found in natural cirrus. The samples were analyzed with a scanning electron microscope equipped with a windowless energy-dispersive X-ray detector (SEM/EDX).

In the contrail and cirrus cases BC particles dominated the residual size spectra for particles smaller than 1 μm. [137] As can be seen from the table below, these particles would remain aloft a very long time.

The coarse residual particle mode (D[p] ≥ 1.5 μm) in contrails consisted almost completely of mechanically generated metallic particles which contributed only about 1% to residual particle number but approximately 50% to residual particle volume. [138]

Presumably this fine metal is from the engine's working parts. These particles would fall back to earth somewhere within several years to a few weeks based on the altitude at which they are emitted, which could be as high as 11 km for much of the particulate on longer flights.

Time For Particles to fall 1 km in the atmosphere by sedimentation under near surface conditions [139]	
Particle diameter (μm)	Time to Fall 1km
0.02	228 years
0.1	36 years
1.0	328 days
10.0	3.6 days
100.0	1.1 days
1000.0	4 minutes
5000.0	1.8 minutes

However, small diameter BC particulate of less than .1 μm may remain aloft for several hundred years or more, merely accumulating with time, and in doing so causing continual and increasing potential for upper atmospheric warming.

The German/Swedish study indicated that particulate is collecting, as the fraction of BC particles (0.1 μm < D[p] < 0.8 μm) in the interstitial aerosol samples increased with altitude from < 70% at 8 km, to 95% at 11 km near the air-traffic corridors with number concentrations of ≈ 0.1 cm[-3].

Moreover, as the observed particle number concentrations and BC mass concentration of the residual particles were 0.2 cm[-3] and 16 ng m[-3] inside the contrail and 0.02 cm[-3] and < 2 ng m[-3] inside the cirrus, its reasonable to assume that a significant portion of the < 2 ng m[-3] inside the cirrus is residual BC from previous air traffic.

Furthermore, higher-altitude jet aircraft contrails are basically man-made cirrus clouds, or high-altitude ice clouds. They form when hot and humid air from jet exhaust mixes with the cold and drier air of the upper troposphere, where jets travel. If the relative humidity of the high-level air is very low, contrails dissipate quickly. If the air is moist, however, the contrails spread horizontally and form a thin layer of cirrus clouds that persists for many hours. [140]

Cirrus clouds, and therefore contrails, are climatologically important because they are considered net warmers of the atmosphere. [141] Since they are very thin and composed entirely of ice crystals, they allow most of the incoming solar radiation to pass through them. But water vapor (frozen or liquid) is the most important and abundant greenhouse gas in the atmosphere, and therefore traps the outgoing long wave radiation from the surface. As a result, cirrus clouds produce a net positive radiative forcing, or a net warming effect, on the atmosphere and the surface.

Worldwide jet air traffic is expected to grow up to 5% per year over the next 50 years, therefore careful assessment of the effect of contrails on atmospheric and surface temperatures is critical. To date, only the young, linear contrails easily distinguished from other cirrus clouds have been studied before in relation to climate change.

However, in just a few hours, contrails that start out only a few meters wide can spread to cover more than 20,000 square kilometers, Pat Minnis, a senior research scientist at NASA Langley, reported at a spring 2002 American Meteorological Society meeting. [142]

Consider the following scenario:

If BC particulate is ultimately revealed to be a more problematic anthropogenic source of radiative forcing than CO_2, then global warming might ultimately be a temporary problem as it was in the 1930s and 40s in North America and the Arctic, as BC normally settles back to earth quickly at near surface altitudes.

However aircraft traffic would be generating super fine particulate that behaves more like a gas and not like particulate, thereby unnecessarily creating a long-term warming problem. And while the BC levels accumulated so far may still be somewhat insignificant, within a few decades we may have created a serious problem.

This same rationale would apply to any fine BC mass that is propelled to higher altitudes into the atmosphere, whether from aircraft, or coal or gas fired electricity generation plants.

Intensified research of all sources of BC emissions propelled to higher altitudes is needed.

12. China Now Generates Much of The World's Warming & Mercury Pollution

Understanding China's Unusual Coal Consumption

All the scientific evidence provided in this paper indicates why soots produced from the dirty burning of coal, heavy oil, diesel, and bio fuels are the primary drivers of much of the climate change around the world, and not CO2 and GHG.

Moreover, this research shows why recent and skyrocketing soot emissions are responsible for almost all warming occurring in the Arctic, and on the other glaciers and ice sheets rapidly melting.

While the science discussed herein is critical to understanding the factors driving climate change today, **there is no bigger climate issue that the soot generated by China's coal burning system.**

It appears to be the single dominant factor in regional Northern Hemisphere warming for many differing reasons, as this analysis shows. While Eurasian, North American and Indian diesel, coal and biofuels combustion are also contributing to the problem, and require action, **no other factor is able to radically alter the planet's climate and ecosystem as China's coal burning does today.**

The reason is twofold:

1. **China's 1.3 billion, 1/5 of the world population, consume 40% of the coal used in the world**.

   In 2006 China led world coal use with 39%. The United States followed with 18%. The European Union and India accounted for 10% and 8%, respectively.[143] World coal consumption reached a record 3,090 million tons of oil equivalent (Mtoe) in 2006, an increase of 4.5% over 2005.[144] In 2006, coal accounted for 25% of world primary energy supply.[145]

   In terms of growth, China is even more dominant. China's growth in coal consumption accounted for more than 70% of global growth in 2006 and more than 60% of the past decade's. India, at just over 10% growth in the last 10 years, ranks a distant second.[146]

   According to preliminary data, five new coal-fired generators with a combined capacity of 600 megawatts came online in the US in 2006, while India added 930 megawatts of capacity.[147] In startling contrast, China brought online about as much capacity each week as the United States and India together did over the entire year, adding an unprecedented 90 gigawatts in 2006.[148]

   (Side note: In the US, 47 workers were killed in coal mine accidents in 2006, while China's State Work Safety Supervision Administration reported a staggering 4,746 deaths.[149] Since 1949 over 250,000 coal mining deaths have been recorded in China.[150] However, since 2002, the death toll gradually decreases while the coal production nearly doubles in the same period.)

2. **Most of China's coal burning emissions are not passed through scrubbers**.

Less than 15% of China's coal plants have desulphurization systems.[151] On the other hand, most coal burning in the developed world is regulated, and requires the use scrubbers to remove most soot, sulfur dioxide (SO_2), and nitrogen oxide (NO_x). As a result those plants produce between 90 - 95 % less soot compared to those without scrubbers.

The most advanced scrubbing systems, such as the Electro-Catalytic Oxidation (ECO) system developed by Powerspan http://www.powerspancorp.com/technology/eco_overview.shtml, are integrated air pollution control technologies that achieve a 95% reduction of fine particulate matter ($PM_{2.5}$) emissions. They also achieve major reductions in the other primary air pollutants of concern from coal-fired power plants, specifically 99% reduction of SO_2 emissions, 90% NO_x emissions, and 80-90% of mercury (Hg) emissions (While not even on the world's radar yet, new research shows China's mercury emissions may be the world's second largest problem as discussed below.)

These systems also provide high removal of other metals and acid gases such as sulfuric acid (SO_3/H_2SO_4), hydrochloric acid (HCl), and hydrofluoric acid (HF). The ECO system also produces a valuable, ammonium sulfate fertilizer co-product, reducing operating costs and minimizing landfill disposal of waste.

China May Produce Most Of The World's Coal Soot Emissions

China's larger "ultra-supercritical" thermal power generators, with over 1 million kilowatts generating capacity, consume roughly 290 grams of coal per kilowatt, while some smaller generators use around 1,000 grams per kilowatt.[152] According to Li Junhong, a power expert in Nanjing, generators under 50,000 kilowatts consume 200 grams more coal per kilowatt of electricity generated than those above 300,000 kilowatts.

A woman walks near power lines in Shanghai, China, on Tuesday, Jan. 15, 2008. Photographer: Kevin Lee/Bloomberg News http://www.bloomberg.com/apps/news?pid=photos&sid=adiV9Mxiqip8

China's smaller and older generators, which are also the most inefficient and polluting, comprise a large share of total installations. Currently, nearly 30% of the nation's coal-fired power installations are generators of less than 100,000 kilowatts.[153] They are so inefficient that they generate a much smaller percentage of the nations electricity, while producing most of it's particulate smog.

Chinese statistics reveal that small plants emit 20 times more particulate matter and smog-forming pollutants than larger ones (and three times the sulfur dioxide).[154]

Combining the figures above (30% x 20 units of smog = 600units, 70% x 1u = 70u; 670 total units) **indicates roughly 89% of China's coal soot emissions may have been from the 30% of smaller plants that were still in operation in 2007** (prior to the current fuel supply crisis - see below).

As less than 15% of China's coal plants have desulphurization systems and most developed nations burning coal have system-wide modern scrubbing systems that equal anything being used in China today, this also indicates Chinese particulate emissions may make up a very large percentage of the world's coal particulates.

Subcritical boilers are a first-generation technology, with thousands in use throughout the world. Supercritical plants are widely used in the United States, Europe, Russia, and Japan, with a limited number in operation in South Africa and China. Europe and Japan have also constructed ultra-supercritical plants, which demonstrate even higher efficiencies than do their supercritical counterparts. [155]

In 2006, coal burning was responsible for 70% of its emissions of particulate matter and other smog-forming pollutants and 90% of China's sulfur dioxide discharges, according to the Worldwatch Institute.[156]

China's Coal Emissions May Have Just Fallen Very Sharply Since Mid 2007

In light of the rising impacts of coal burning on China's energy supply and the environment, the government has sought to tackle the closure of smaller coal-fired power plants for several years. It began issuing notices and set a series of targets for this endeavor as early as 1999, but only in 2007—eight years later—did it begin to take action.

A 2007 NDRC list of small power generators scheduled to close by 2010 involves nearly 700 plants & 16 million kilowatts, or 3.2 percent of the national total. However, because Beijing froze power prices in 2007 to cool inflation but let market-set costs for fuel continue to rise,[157] its appears as though additional market driven economic pressure has accelerated this timetable considerably.

One year later, utility companies have let coal stocks run down and are buying less fuel to avoid losses. This has also made it impossible for smaller less-efficient plants to remain profitable, and hence they have been closing as fast as local coal prices have been rising.

Further, because there is only a limited amount of coal available for China's continually growing electricity demand (GNP grew by 10.6% in the 1st quarter of 2008 [158]), larger more efficient plants have been very rapidly replacing smaller plants as well. The shortage of coal and electricity means that only the most efficient plants get the available coal.

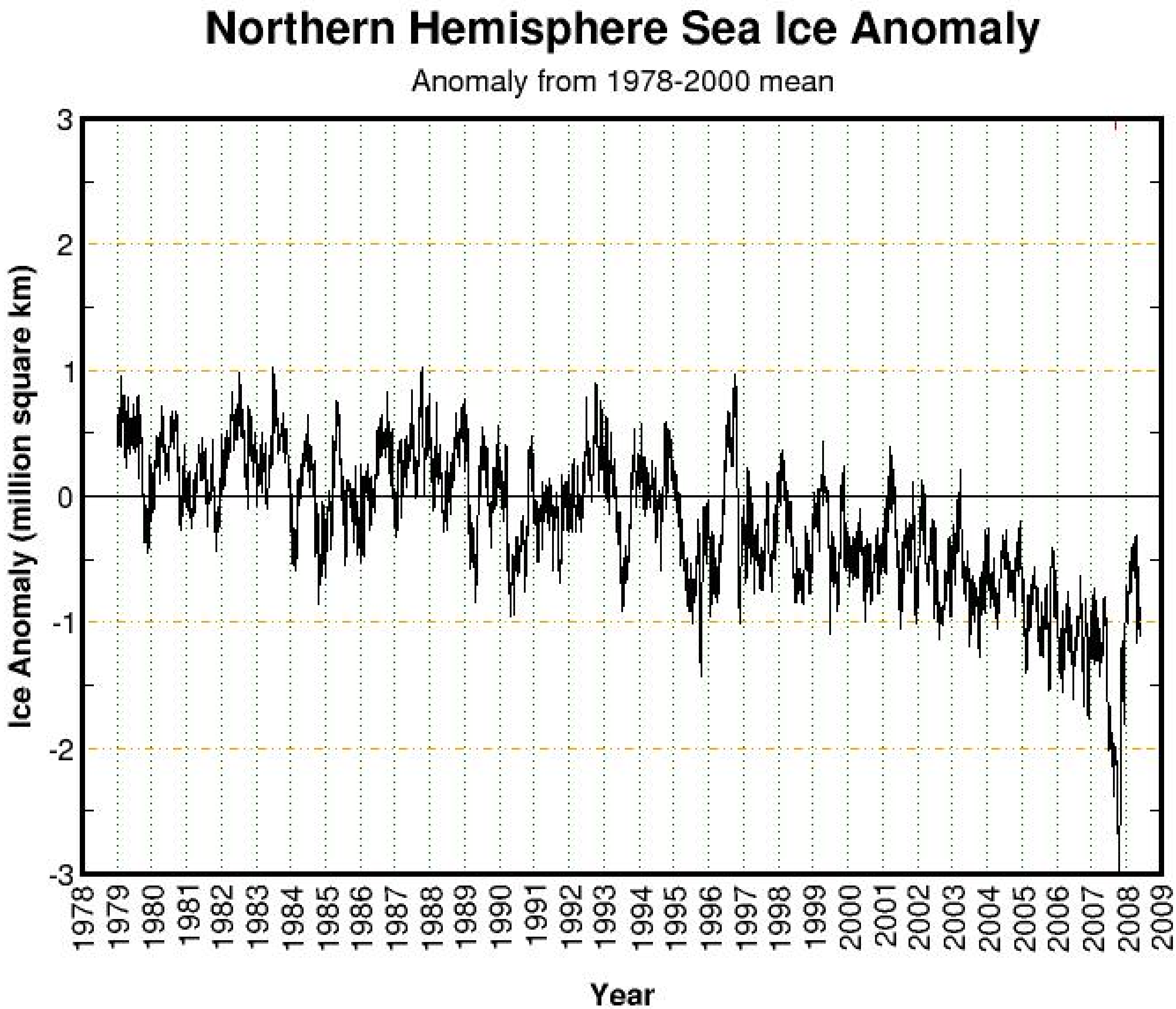
As of May 20, 2008, power plants in the eastern province of Anhui had just 2.8 days' supply of coal, while those in Beijing had 6.9 days' supply, the Chinese government electricity agency said.[159] The recommended minimum is 15 days; a week's supply is considered dangerously low.

Beijing has also frozen retail prices of gasoline and diesel at low levels.[160] Oil refiners say they are suffering heavy losses because they are barred from passing on higher crude costs to motorists. Some responded last year by cutting production, causing fuel shortages in parts of China's south.

China's Falling Emissions May Be Lowering Arctic and World Temperatures

As China's soot emissions have fallen due to economic pressures, world temperatures in 2008 have been falling as well. Whether this is due to a reduction in anthropogenic and /or natural soot (as predicted by the peer-reviewed research cited in this paper), and/or due to fluctuations in heat absorption rates by the oceans, and/or other effects, has yet to be determined.

Once thing is certain: if less soot accumulated in the Arctic in the winter of 2007 - 2008 due to lower levels of long range soot deposition originating in China, this might explain the sharp 1/2 million square km increase in the amount of sea ice that froze in the Arctic this winter, as compared to the one before. It might also explain why the amount of sea ice that melted by May 2008 was approximately 1 million square kms less than occurred by May 2007, as seen in the May 29th 2008 chart of the Northern Hemisphere Sea Ice Anomaly below.



http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/current.anom.jpg

As *Molina* 2007 shows, asian soot is heating the clouds that cross the Pacific Ocean, causing intense storms, like those that struck the North West in December 2006.[161] It can be argued that the heat from these soot-laden winds ultimately affects temperatures east and downwind from China, as any point source of warming in a regional atmosphere must have some effect (albeit potentially small if the point source is small) on the relative warmth of the adjacent atmosphere ultimately affected by the air blowing in from the west.

However, if soot levels have now been falling, the westward blowing winds would now be cooler. More importantly, the soot levels reaching the Arctic to create the Arctic Haze in the winter would fall as well, potentially slowing the rate of seasonal melting.

Coal Mine Fires

In dozens of locations around the world, there are vast underground coal fires consuming millions of tons of coal - creating enormous environmental and human health problems. Some of these fires have burned for decades - some for centuries. They are burning in thousands of underground coal seams from Pennsylvania to Mongolia, releasing toxic gases, soot, and baking the earth until vegetation shrivels and the land sinks.

One coal fire in northern China, for instance, is burning over an area more than 3,000 miles wide and almost 450 miles long. About 360 million metric tons of CO_2 is generated from coal fires in China alone. The CO_2 production of all of these fires in China is more than the total CO_2 production in The Netherlands. This amounts to 2-3% of the annual worldwide production of CO_2 from fossil fuels, or as much as emitted from all of the cars and light trucks in the United States.

"Coal fires release a variety of potentially harmful gases [and] combustion by-products, including sulfur and particulates," says Glenn Stracher, associate professor of geology at East Georgia College in Swainsboro, Georgia. "The catastrophe that we're faced with is the fact that these fires are emitting noxious gases." In fire-plagued regions such as in Centralia, Pennsylvania, he says, the ground is littered with sulfur and other pollutants that have killed off virtually all visible plant and animal life.[162]

According to Stracher's article in the "International Journal of Coal Geology," scientists have determined that coal fires in China consume up to 200 million tons of coal per year. For comparison, coal consumption in the United States during 2000 was just over one billion tons, according to the U.S. Department of Energy.[163]

Scientists and government agencies are starting to use heat-sensing satellites to map the fires and try new ways to extinguish them. But in many instances — particularly in Asia — they are so widespread and stubborn that miners simply work around the flames. Globally, thousands of inextinguishable mine fires are burning, especially in China and India, where poverty, lack of government regulations and runaway development combine to create an environmental disaster. Modern strip mining exposes smoldering coal seams to the air, revitalizing the flames.[164]

Rural Chinese in coal-bearing regions often dig coal for household use, abandoning the pits when they become unworkably deep, leaving highly combustible coal dust exposed to the air. Using satellite imagery to map China's coal fires resulted in the discovery of many previously unknown fires. The oldest coal fire in China is in Baijigou and is said to have been burning since the Qing Dynasty

Mine fires may begin as a result of an industrial accident, generally involving a gas explosion. Historically, some mine fires were started when bootleg mining was stopped by authorities, usually by blowing the mine up. Many recent mine fires have started from people burning trash in a landfill that was in proximity to abandoned coal mines, including the much publicized Centralia, Pennsylvania fire, which has been burning since 1962. Of the hundreds of mine fires in the United States burning today, most are found in the state of Pennsylvania.

Some fires along coal seams are natural occurrences. Some coals may self-ignite at temperatures as low as 40 °C (104 °F) in the right conditions of moisture and grain size. Wildfires (lightning-caused or others) can ignite the coal closer to the surface or entrance, and the smoldering fire can spread through the seam, creating subsidence that may open further seams to oxygen. Prehistoric clinker outcrops in the American West are the result of prehistoric coal fires that left a residue that resists erosion better than the matrix, leaving buttes and mesa. It is estimated that Australia's Burning Mountain, the oldest known coal fire, has burned for 6,000 years.

Mercury Pollution From Coal

The largest emissions of Hg to the global atmosphere occur from combustion of fossil fuels, mainly coal in utility, industrial, and residential boilers. As much as two-thirds of the total emission of 2190 tons of Hg emitted from all anthropogenic sources worldwide in 2000 came from combustion of fossil fuels. **Emissions of Hg from coal combustion are between one and two orders of magnitude higher than emissions from oil combustion**, depending on the country. Various industrial processes account for additional 30% of Hg emissions from anthropogenic sources worldwide in 2000.

China headed the list of the 10 countries with highest Hg emissions from anthropogenic activities in 2000. With more than 600 tons of Hg, China contributed about 28% to the global emissions of mercury back then. [165] Since its coal burning has increased another 125% in the last 7 years, a more accurate figure might be closer to 1350 tons, thereby resulting in a 35% further increasing world mercury emissions about 35% in that period. As such, China now generates about 46% of the world's mercury emissions.

Since China's mercury emissions have increased so dramatically, its likely that in 2007 anthropogenic mercury compised of 65% from stationary combustion, of which coal-fired power plants are the largest aggregate source. (in 1999 mercury compised of 65% from stationary combustion.[166]) This includes power plants fueled with gas where the mercury has not been removed. **Emissions from coal combustion are between one and two orders of magnitude higher than emissions from oil combustion**, depending on the country.[167]

Since the 1990s, methods for capturing mercury from coal-fired power plant flue gases have been the subject of considerable R&D and demonstration initiatives in the United States. Up until now, control of mercury emissions from coal-fired plants has been achieved primarily as a co-benefit of existing pollution controls. Fabric filters and ESPs, FGD systems, and SCR systems contribute to mercury capture (Srivastava et al., 2005). On average, these pollution controls are estimated to remove 36 percent of the mercury emitted from U.S. coal-fired boilers.[168]

In 2000, the total mercury content of the coal received at power plants in the United States was approximately 75 tons. [169] Because of fuel processing and other environmental control equipment, total mercury emissions from coal-fired power plants in the United States were approximately 45 tons—representing a 40 percent reduction relative to "as received" coal. Approximately 30 percent of the mercury in eastern bituminous coal is typically removed by coal washing before shipping to the plant.[170]

Complicating both coal washing and mercury emission controls is the need to dispose of mercury containing wastes generated from the removal of mercury from coal and flue gases.

Mercury is known to bioaccumulate in fish as methylmercury—its most toxic form. Human exposure to methylmercury, which occurs primarily from fish consumption, is associated with serious neurological and developmental effects. The U.S. Centers for Disease Control and Prevention estimates that roughly 6 percent of American women of child-bearing age have blood levels of mercury that are above the reference dose set by EPA to represent a safe level. Studies of the brain development of children whose mothers ate significant amounts of fish with high mercury levels during pregnancy have been carried out in New Zealand, the Faroes and the Seychelles. [171]

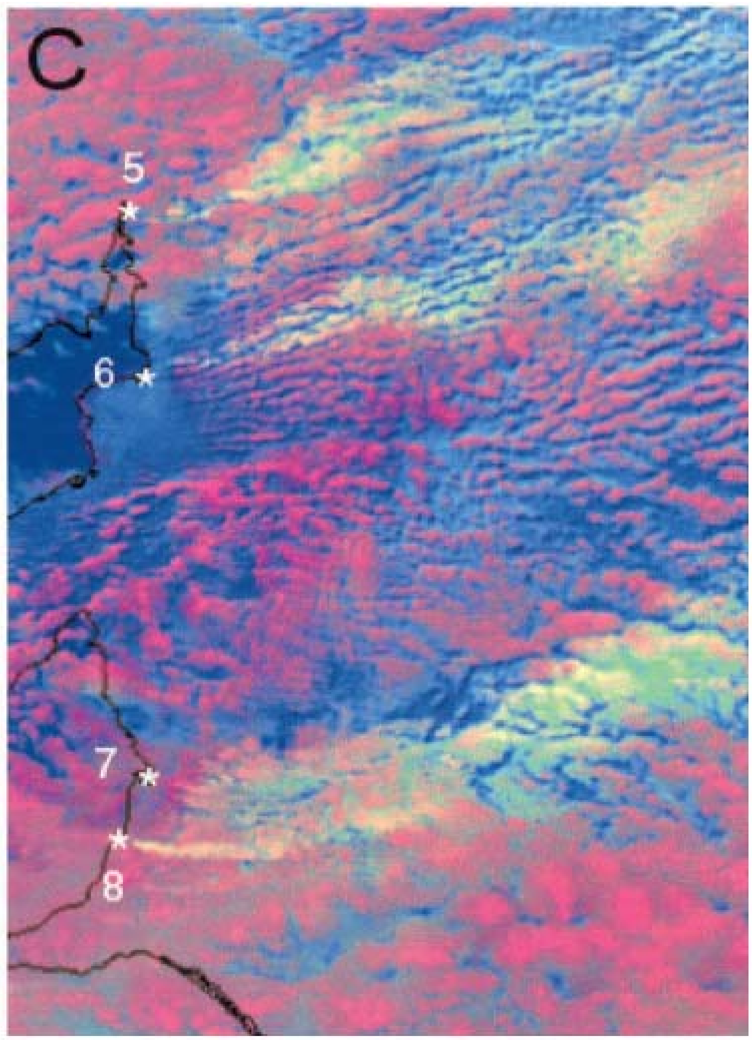
The Joint Food and Agriculture Organization (FAO) and World Health Organization (WHO) Expert Committee on Food Additives (JECFA) reviewed these studies in June 2003. These researchers recommended reducing the amount of fish known to contain mercury in the diet, particularly for pregnant women.

Australia's Increased Coal Use Causing Coastal Mercury Pollution and Sydney's Drought

The fact that Australian waters have become very polluted has been confirmed by highly toxic and abnormal levels of mercury found in the hair of Victorian residents regularly eating local fish.[172] Research shows this is primarily due to Australia's burning of brown coal.[173] Mercury laden sootfall appears to be falling in the ocean waters off the Victorian coast.

Australian research also shows that mercury levels differ from one species of fish to the next. This is due to factors such as type of fish, size, location, habitat, diet and age. Fish that are predatory (eat other fish) are large and at the top of the food chain, and so tend to contain more mercury. Mercury levels in some fish, particularly shark, could be even higher than in the areas studied. In fact, it seems that mercury levels in some shark species caught in Victorian waters are particularly high.[174]

Rosenfeld 2000 shows direct evidence demonstrating that urban and industrial air pollution can completely shut off precipitation from clouds that have temperatures at their tops of about -10°C over large areas. Satellite data reveal plumes of reduced cloud particle size and suppressed precipitation originating from major urban areas and from industrial facilities such as power plants. Measurements obtained by the Tropical Rainfall Measuring Mission satellite reveal that both cloud droplet coalescence and ice precipitation formation are inhibited in polluted clouds,[175] possibly contributing to Sydney's drought.



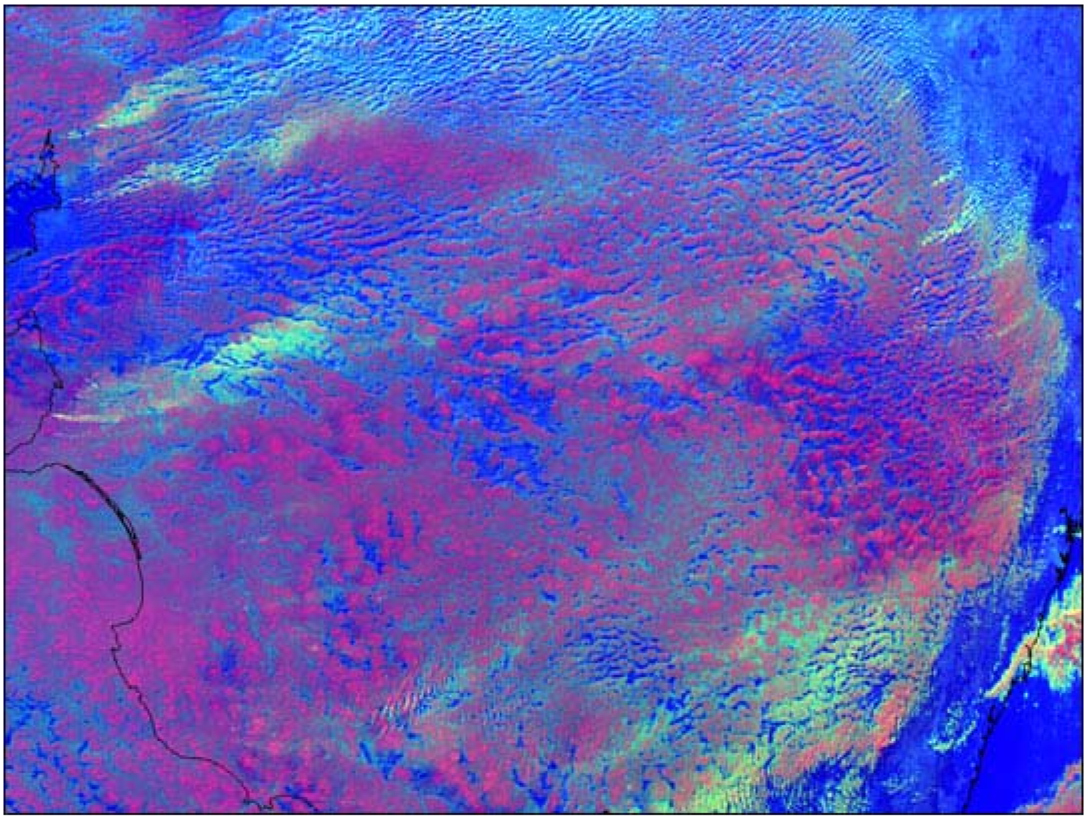
The picture to the right:

Study of the pollution tracks emanating from the region of Adelaide, South Australia, Australia, is especially interesting. They received special attention because of their intensity and frequent occurrence. These pollution tracks were identified in the clouds of all 47 AVHRR images on different days examined in which stratocumulus and cumulus clouds with tops warmer than about -12°C existed over the region.

The pollution tracks in Fig. C coincide with the following major industrial and urban areas: (i) Port Augusta has a 520-MW power plant operating on brown coal, providing electricity to the nearby mines and to the adjacent large steel industry in Whyalla. (ii) Port Pirie is the home of the world's largest lead smelter and refinery. (iii) Adelaide has industry for processing minerals mined in the vicinity. Among these are Australia's largest cement plant, located on the Port Adelaide River. A major oil refinery and a power plant are located 20 km to the south of the city near the origin of the strongest pollution track in Fig.C.

An area of about 350 km by 450 km containing pollution tracks over South Australia on 12 August 1997 at 05:26 UT originating from the Port Augusta power plant (*5), the Port Pirie lead smelter (*6), Adelaide port (*7), and the oil refineries (*8).

The image is oriented with north at the top. The image is a color composite, where the red is modulated by the visible channel; blue is modulated by the thermal infrared (IR); and green is modulated by the solar reflectance component of the 3.7-mm channel, where larger (greener) reflectance indicates smaller droplets. The composition of the channels determines the color of the clouds, where red represents clouds with large drops and yellow represents clouds with small drops. The blue background represents the ground surface below the clouds. A full description of the color palettes and their meaning is provided by Rosenfeld and Lensky.
http://earth.huji.ac.il/data/pics/Science_Smoke.pdf



http://visibleearth.nasa.gov/view_rec.php?id=674

This similar false-color image over Australia, produced using NOAA Advanced Very High Resolution Radiometer (AVHRR) data, shows where pollution from human industry reduced clouds' particle sizes. (Notice the smog over regions near Sydney and Melbourne.)

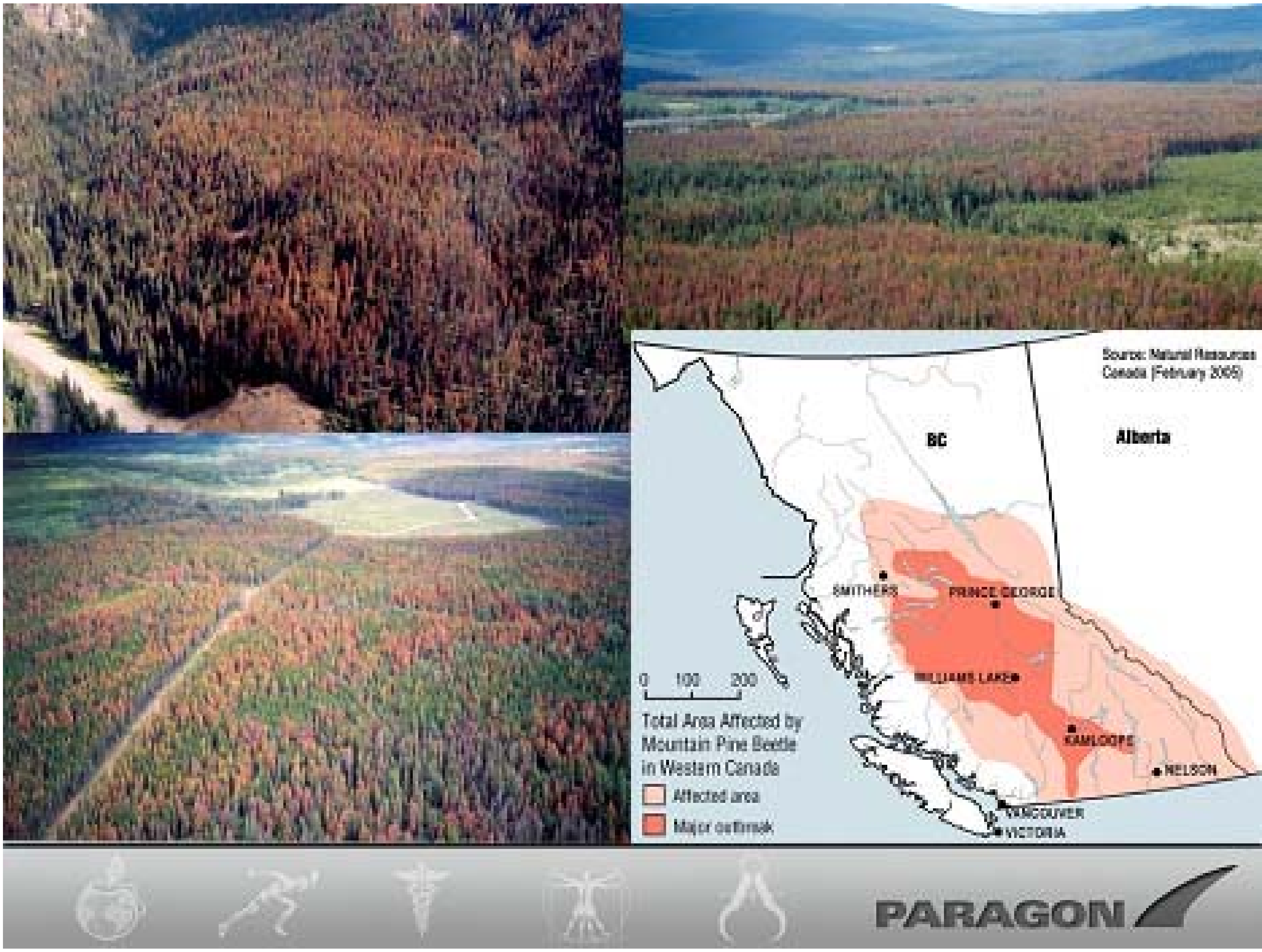
Polluted clouds may rain less frequently then unpolluted clouds because the pollutants prevent water droplets from growing large enough to precipitate. Blue areas are cloudless, while purplish-red areas are covered by thick clouds comprised of large droplets. The yellowish-green and orange streaks are clouds comprised of small droplets. These latter clouds are more polluted than the purplish-red clouds and literally pointing to their sources of pollution.

Daniel Rosenfeld, a scientist collaborating with NASA, colored the visible, midwave-infrared, and thermal infrared AVHRR data as red, green, and blue, respectively, in this image to differentiate clouds with different properties in a three-dimensional way. Red was used to indicate the reflectiveness of the cloud in visible wavelengths. Green corresponds to droplet size. The more green there is in an area (as determined by AVHRR measurements of energy reflected at the 3.7 micrometer wavelength) the smaller the droplets. Blue was used to represent the clouds' temperature. The deeper the blue, the warmer the temperature (determined by AVHRR measurements of brightness temperature at 10.8 micrometer wavelength).

13. Other Devastating Environmental Impacts of Particulate Warming

Canada's Forests Are Dying At An Alarming Rate

"The mountain pine beetle (MPB) epidemic currently affecting British Columbia forests has been described as a natural disaster in slow motion, but based on the destruction that the tiny insect has wrought on BC's pine forests in just a few years, perhaps that characterization is not entirely accurate. Ministry of Forests and Range (MOFR) projections of the annual destruction of lodge-pole pine based on aerial overviews have changed radically in just one year as the amount of beetle-killed timber has multiplied far faster than expected." [176]



Warm winters of recent years have been the primary contributor to the MPB epidemic. In order to stop the beetle epidemic a period of extremely cold weather in the range of -20°C in the fall or -40°C in the late winter is required. However, since the beetle population has become so large, it may be necessary to have this kind of extreme weather occur in consecutive years.[177] This is not expected to occur.

As such, government scientists project that, by 2013, 80% of the lodgepole pine, or 40% of the forest in BC will be killed, with over half of that amount destroyed by mid-2007. [178]

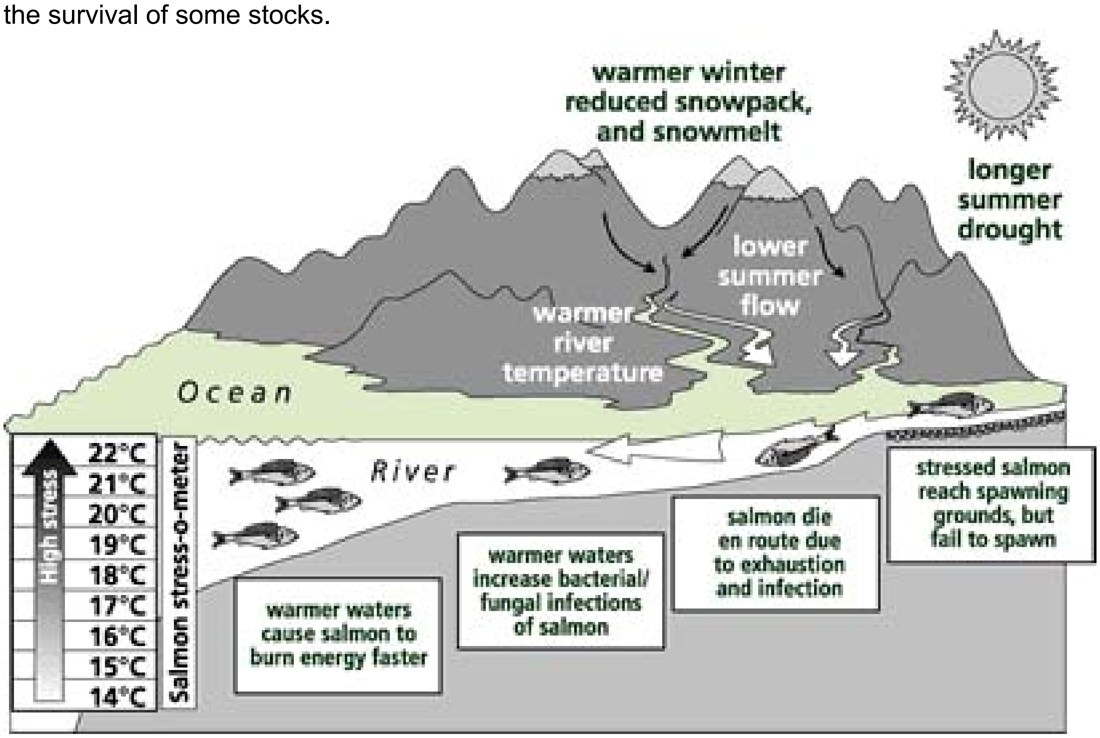
The infestation is the worst on record, 20 times larger than in the 1930s when 1.2 million acres were killed. [179] It should be noted that the last infestation of this nature occurred during the last period of North American warming.

Canada's Fish Are Dying Too

Various aspects of climate change that affect Britich Columbia's salmon throughout their lives have negatively affected their survival in most recent years. Several times over the past decade it was ocean temperatures.[180] Then there were high temperatures in the Fraser River that caused migratory stress and mortality, especially on stocks that migrate long distances. [181]

Several times within the last decade Fraser River temperatures have exceeded tolerances that migrating stocks of summer sockeye could endure. This resulted in the death of large numbers of spawners due to stress-related diseases created by the high temperatures. Half of some stocks died while migrating up the river, never to reach their spawning grounds and complete their cycle. [182]

The prevailing consensus is that the long-predicted effects of climate change are becoming a major challenge to accurately forecasting returning numbers of salmon, and in fact are seriously threatening the survival of some stocks.



Graphic courtesy B.C. Ministry of Environment

How Pine Beetle Affects Fish

The implications of the mountain pine beetle epidemic will undoubtedly add to the survival challenges facing Fraser sockeye stocks.

This added misfortune is especially sobering given that current projections have the beetle epidemic killing about 9.5 million hectares of forest. [183] This total accounts for the large-scale timber salvage operations now underway, which are expected to capture about 40 percent of the available pine in that time, in addition to a significant amount of non-pine. Presumably, wildfire losses will either make up a portion of that total or will be added on after the fact.

The majority of the spawning and rearing habitats for Fraser sockeye stocks occur in portions of the province that are or will be heavily impacted by the infestation. As the pine forests within many watersheds die or are harvested or are consumed by fire -- or a combination of the three -- the inevitable results will be reduced watershed stability, and altered snow and rain run-off rates and patterns. Spawning and rearing habitats will be impacted, but to what extent isn't fully known yet.

While these hydrological impacts accumulate, the associated defoliation of the central interior's watersheds will increase stream temperatures, leading to a cumulative effect in the larger rivers such as the Nechako, Fraser and Thompson. This combination of factors is a serious threat to Fraser salmon and to the hopes of all those who covet them.

The potential for the mountain pine beetle epidemic to compound current problems with Fraser River stocks is real and looms heavy on the horizon for people and animals who depend on them.

14. Sources of Carbon Soot

What Generates Carbon Soot

As discussed above, Carbon soots are created any time hydrocarbons or other organic carbons are burned without enough oxygen present. A good example of this is the black soot created by the yellow flame of an oxy-acetylene torch's prior to the administration of additional oxygen. Another is that of a diesel truck or car under acceleration – the big puff of black smoke is the result of the engine not being able to fully burn the initial increase in fuel being sent to the motor.

Use of traditional fuels and poor combustion technologies, especially in developing countries also results in significant carbon soot emissions. For example, the combustion of solid biofuels – such as wood, agricultural waste, and dried animal manure in cooking stoves – is the largest source of carbon soot emissions in India (*Venkataraman et al.,* 2005).

Soot Is Always Produced Together With CO_2 – However, CO_2 can be Created Without Soot

CO_2 can be created without soot, just as when we animals burn energy. But, our industrial methods are not as efficient as Nature's, and always produce some unburned fuel byproduct.

Why It's Difficult To Burn Transportation Fossil Fuels Without Creating Soot

Carbon soot is created every time a motor is accelerated under load. While increased combustion and engine efficiencies reduce soot, some will always be created by any engine requiring acceleration, because achieving perfect nano-combustion is almost impossible. Therefore, any unburned nano-carbon will still generate a carbon-based particulate haze when millions of vehicles are operated together.

Which Anthropogenic Processes Create The Most Carbonaceous Soot

The burning of coal, diesel for cars and trucks, heating and fuel oil, heavy oil for large marine diesel motors, and jet aircraft fuel are significant sources of soot. Bio mass burning is another contributor.

Prior estimations of major world-wide anthropogenic sources of carbon soot were split evenly, with coal and diesel combustion accounting for approximately 50% of emissions, while biomass burning makes up the remainder (*Cooke et al*., 1999; *Cooke and Wilson,* 1996; *Liousse et al*., 1996).

However these earlier estimates do not include China's dramatic increase in coal use for electricity generation and steel making. In 1993 China used 1.27 billion tons of coal – in 2004 it used 2.06 billion tons. [184] In 2007 China's coal used for power generation was estimated to be 2.7 billion tons.[185] China is currently building two new power stations each week.[186]

Diesel cars (emitting continuously under the most recent U.S. and E.U. particulate standards 0.08 g/mi; 0.05 g/km) may warm climate per distance driven over the next 100+ years more than equivalent gasoline cars. Toughening vehicle particulate emission standards by a factor of 8 (0.01 g/mi; 0.006 g/km) does not change this conclusion, although it shortens the period over which diesel cars warm to 13–54 years.[187]

Diesel is responsible for more than half of black carbon emissions in the U.S. (Battye et al., 2002), and about 30% globally (Bond et al., 2004).

Combustion also results in emissions of organic carbon (OC), with the ratio between black and organic emissions being primarily dependent on the combustion temperature. Since most electricity generating plants operate at very high temperatures, industry is a major source of BC, while domestic fuel use is mainly responsible for OC emissions. [188]

Cooke and Wilson [1996] found that biomass burning emissions are roughly 33% lower than that from fossil fuel combustion.

Marine Diesels Are A Large Problem

90% of the world's commerce moves on water. The world marine shipping fleet consists of 46,000 ships plying 3,000 ports. [189] Shipping emissions are largely unregulated.

Oceangoing ships burn primarily bunker fuel (residual or heavy fuel oil)— up to 5,000 times dirtier than 2006 US highway diesel fuel.[190] Thus, shipping BC emissions rates are among the highest for any source category in the world. Marine SO_2 emissions constitute 5+% of world total.[191]

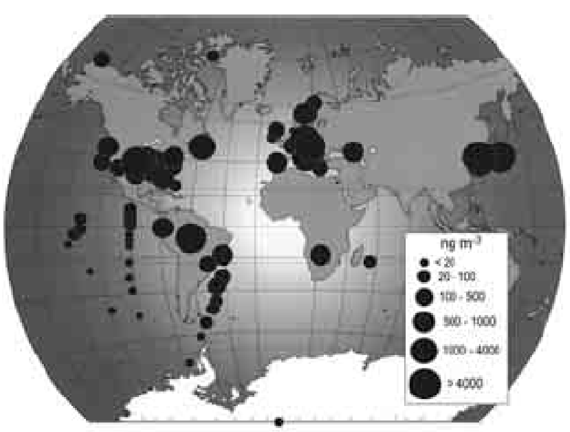
http://www.westcoastdiesel.org/files/sector-marine/Haagen-Smit%20Symposium%20Clean%20Air%20Task%20Force.pdf

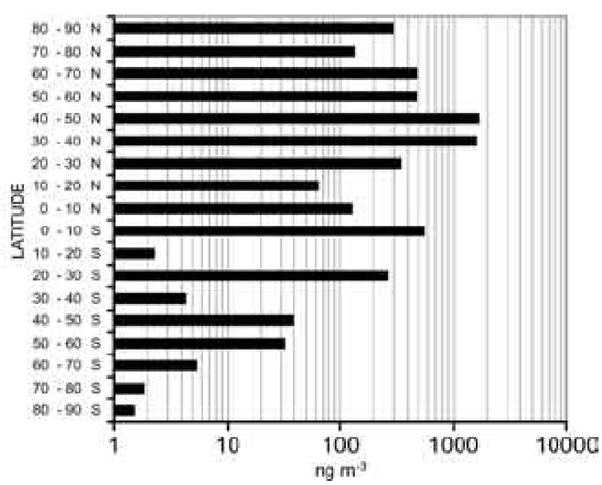
Where Most BC Is Generated

The charts below indicate where much of the world's BC is generated. However notable omissions from Maldonado's map would be BC generated in North America's and Russia's Siberian boreal forest fires.[192] This map also fails to show China's enormous contribution to soot generation.

During the summer of 2004, interior Alaska experienced its largest wildfire season on record, when approximately 6.7 million acres (27,114 km^2) burned.[193] The average temperature in Fairbanks was 64.5°F/18.1°C, and according to the Alaska Climate Center, was 2 degrees warmer than the previous record from the summer of 1975. Records for the past 50 years show an increase in both the number and size of Alaska boreal fires, and during the late 20th century, Arctic sea ice and glaciers in Alaska and western Canada have been melting at an accelerated rate.[194]

(left) Worldwide BC inventory (*Maldonado*, 2003); (right) latitudinal average BC concentration. (*Pereira, et al.,* 2006)





Further Evidence Of Diesel's Tremendous Detrimental Impact On Atmosphere

The following abstract is from the research paper *Anthropogenic Fine Aerosol Distribution over Europe with special emphasis on primary PM2.5 and Black Carbon*, *Schaap, M. et al*. (2003)

Abstract

> Primary particles are an important component of fine aerosol mass over Europe. We present a model simulation for the year 1995 in which we account for primary aerosols. For this purpose we have developed a new emission inventory for BC, based on the CEPMEIP emission inventory for PM. **For Europe and the Former Soviet Union we estimated an annual emission of 0.47 Tg and 0.26 Tg, respectively**. Transport (off and onroad) and households are the most important sources for BC in Europe.

Distributions of BC and additional primary material were calculated using the LOTOS model. Modeled BC concentrations range from 0.05 μg/m3 and lower in remote regions to more than 0.5 μg/m3 in central Europe. Peak levels above 1 μg/m3 are calculated over large urban areas. **The BC concentration is about 25% of the total primary aerosol concentration.** The primary aerosol fields were combined with previously calculated secondary aerosol concentrations to obtain an estimate of the anthropogenic fine aerosol distribution. Modeled BC levels contribute only 4-10% to the total fine aerosol mass, where sulphate and nitrate contribute 25-50% and 5-35%, respectively. Comparison with experimental data revealed that the model underestimates PM2.5 levels, caused by the underprediction of BC and additional primary material by about a factor of 2. The underestimate could be explained by (a combination) of local emissions, measurement uncertainties, representation of wet deposition. In addition, the uncertainties associated with the emission inventory play a role.

The black carbon emission inventories have evolved over the years leading to much lower emission estimates. However, using the most recent inventories the observed BC concentrations are severely underestimated. Unaccounted sources contribute at most 15 % to the total BC emission. Emission factors, most notably those for traffic, were identified as the cause of the largest uncertainty in the emission estimates.
http://igitur-archive.library.uu.nl/dissertations/2003-1209-110044/c5.pdf

15. Currently Available Technical Solutions

Particle Scrubbing Technologies for Diesel Ground Transportation Applications

The following summarizing information was found at an excellent Wikipedia website. For more information please go to: http://en.wikipedia.org/wiki/Diesel_particulate_filter

A diesel particulate filter, sometimes called a DPF, is a device designed to remove diesel particulate matter or soot from the exhaust gas of a diesel engine. Wall-flow diesel particulate filters usually remove 85% or more of the soot, and can at times (heavily loaded condition) attain soot removal efficiencies of close to 100%. A diesel-powered vehicle equipped with functioning filter will emit no visible smoke from its exhaust pipe.

In addition to collecting the particulate, a method must exist to clean the filter. Some filters are single use (disposable), while others are designed to burn off the accumulated particulate, either through the use of a catalyst (passive), or through an active technology, such as a fuel burner which heats the filter to soot combustion temperatures, through engine modifications (the engine is set to run a certain specific way when the filter load reaches a pre-determined level, either to heat the exhaust gases, or to produce high amounts of NO_2, which will oxidize the particulates at relatively low temperatures), or through other methods. This is known as "filter regeneration." Fuel sulfur interferes with many "regeneration" strategies, so almost all jurisdictions that are interested in the reduction of particulate emissions, are also passing regulations governing fuel sulfur levels.

Particulate filters have been in use on non-road machines since 1980, and in automobiles since 1996. Diesel engines during combustion of the fuel/air mix produce a variety of particles generically classified as diesel particulate matter due to incomplete combustion. The composition of the particles varies widely dependent upon engine type, age, and the emissions specification that the engine was designed to meet. Two-stroke diesel engines produce more particulate per horsepower output than do four-stroke diesel engines, as they burn the fuel-air mix less completely.

Historically diesel engine emissions were not regulated until 1987 when the first California Heavy Truck rule was introduced capping particulate emissions at 0.60 g/BHP Hour. Since then progressively tighter standards have been introduced for both On-Road and Non-Road diesel engines.

While particulate emissions from diesel engines was first regulated in the United States, similar regulations have also been adopted by the European Union, most Asian countries, and the rest of North and South America World List of Standards.

While no jurisdiction has made filters mandatory, the increasingly stringent emissions regulations that engine manufactures must meet mean that eventually all on-road diesel engines will be fitted with them. The American 2007 heavy truck engine emissions regulations cannot be met without filters. In the European Union, filters are expected to be necessary to meet Euro.VI heavy truck engine emissions regulations currently under discussion and planned for the 2012-2013 time frame. PSA Peugeot Citroën was the first company to make them standard fit on passenger cars in 2000, in anticipation of the future Euro V regulations.

It is expected that non-road diesel engines will be regulated in a similar manner.

As of July 2006 the California Air Resources Board is looking at introducing regulations that will require retrofit of all diesel engines operating in the state by the year 2013 . Other jurisdictions may also do this. A variety of retrofit programs have been done:

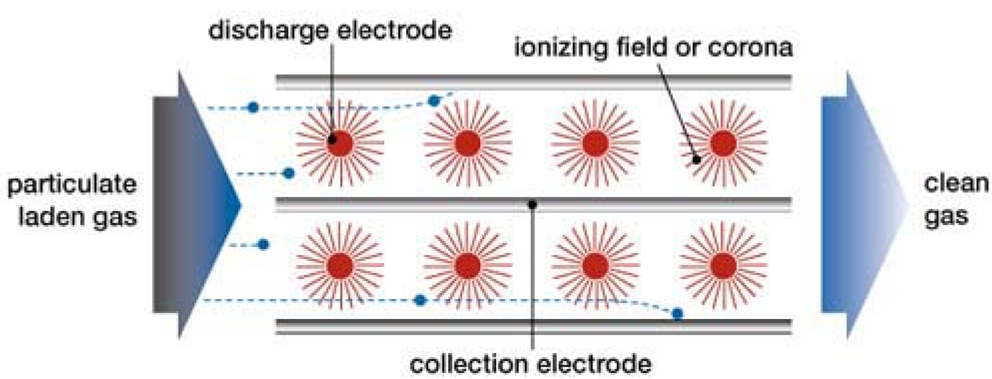
2002 - In Japan the Prefecture of Tokyo passed a law banning trucks without filters from entering the city limits.
2003 - Mexico City started a program to retrofit trucks
2001 - Hong Kong retrofit program
2004 - New York City retrofit program (non-road)
2008 - London Low Emission Zone charges charging vehicles that do not meet emission standard encourages retrofit filters

Particle Scrubbing Technologies for heavy industrial Applications

Dirty industrial coal and oil refinery operations can be quickly cleaned up with existing scrubber technologies.

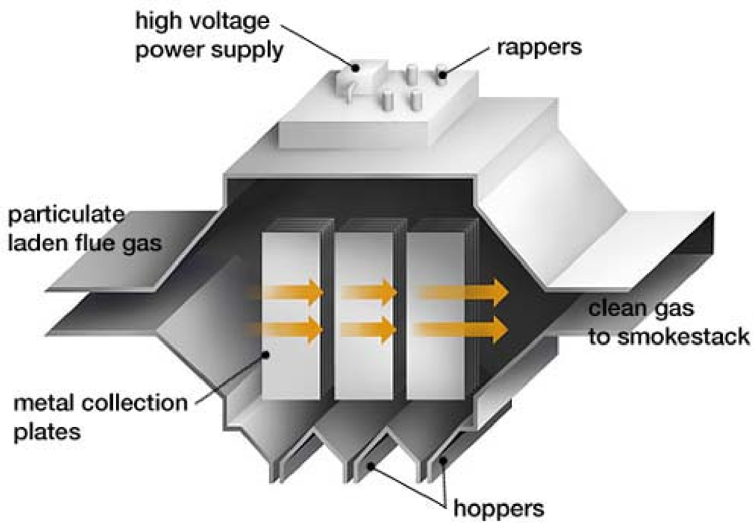
Electrostatic Precipitators:

Electrostatic precipitators (ESPs) are particulate collection devices which use an induced electrical charge to remove particles from flue gas. ESP has been the preferred technology for use at coal-fired power plants.



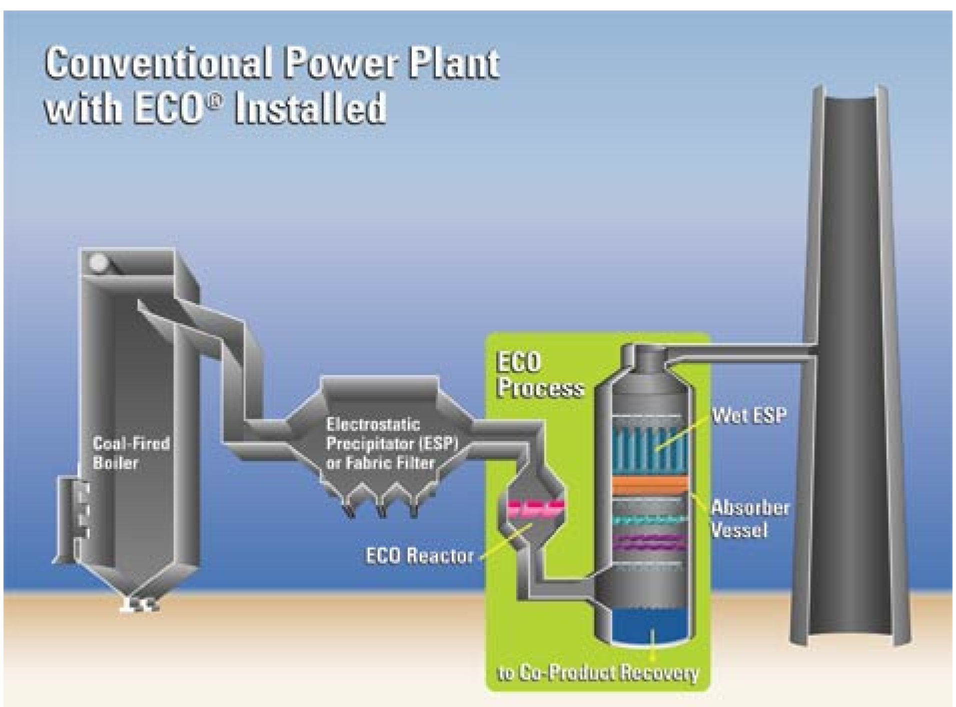
http://www.eas.asu.edu/~holbert/wise/electrostaticprecip.html

When working properly they can be highly efficient at particulate removal (typically 99.0-99.5 percent) and have minimal impact on air flow through the device. Since they do not require a large pressure drop, they have less of an impact on plant efficiency, compared to fabric filters. One primary challenge to an ESP's efficiency is electrical resistance, which can result from combustion of low-sulfur coal. Though this is typically a dry process, it is possible to spray incoming air with moisture, which can improve the capture of fine particles, as well as reduce the electrical resistance of the incoming particles.



Dry ESP waste is adsorbed onto metal plates, then rapped to remove the particulate matter for disposal or potentially reuse (e.g., fly ash used in cement). Wet ESP waste is flushed with water for treatment or disposal. At present more than 96 percent of the coal power plants in China have ESP, however clearly these are not working as intended.

http://www.powerspancorp.com/technology/eco_overview.shtml



Fabric Filters:

Fabric filters, alternately referred to as baghouses, have been employed more widely than ESP since the 1970s, largely at the industrial scale (IEA, 2006c). China has seen a similar increase in the use of baghouses, not only for industrial purposes but also for use at power plants. The choice between ESP and fabricfilters depends on coal type, plant size, and boiler type and configuration; additionally, if regulations require removal efficiency above 99.5 percent, fabric filtersmay be more cost-effective (World Bank, 2007). However, fabric filters require a decrease in pressure and thus a decrease in plant efficiency.[195]

Improved Rural Cooking Stove Technology

More on this technology to come later.

Jacobson – The Answer Is Blowing in the Wind

December 3, 2006

The answer is blowing in the wind

Bob Dylan's question, "How many deaths will it take 'till he knows that too many people have died," applies fittingly to the outdoor air pollution health epidemic that claims 800,000 lives annually worldwide and to global warming, which has already produced more intense heat waves and tropical storms. Dylan also prophetically has a solution to these problems, the power blowing in the wind. Wind primarily, but also solar, geothermal, hydroelectric, and wave power and energy efficiency would solve future energy problems as well.

Wind power is not new, but only recently have the world's winds been mapped at the height of modern wind turbines. The numbers are impressive. Enough wind exists over land worldwide to satisfy all current energy needs 5-7 times over. Wind can produce energy not only for lights, but also for electric, plug-in-hybrid, and hydrogen fuel cell vehicles.

Today's carbon dioxide emissions must be decreased by over 80 percent to stop global warming while accounting for future economic growth. Wind power displacing fossil fuels reduces carbon dioxide and other air pollutants by 98 percent.

How many wind turbines would eliminate nearly all fossil-fuel carbon dioxide emissions and the 50,000 annual U.S. air-pollution-related deaths? The answer is 420,000-580,000 current-technology large ones (5 megawatts with 415-foot blades operating in wind speeds averaging 19 miles per hour, the offshore average worldwide).

Of these, about 82,000 turbines could produce electricity for enough battery-electric vehicles to replace all U.S. gasoline and diesel onroad vehicles, eliminating 25 percent of U.S. carbon dioxide and 10,000 pollution-related deaths annually. This is less than the 120,000-plus smaller wind turbines currently installed worldwide. The new turbines would reside over an ocean and land area equivalent to 0.4 percent of U.S. land with a footprint of only 3 square miles.

Alternatively, about 242,000 turbines could produce electricity to split water into hydrogen to power all onroad vehicles converted to fuel cell vehicles, requiring an ocean or land area equivalent to 1.2 percent of U.S. land. These turbines would eliminate the same carbon and air pollution as battery vehicles.

How does wind compare with ethanol? E85 is a fuel containing 85 percent ethanol and 15 percent gasoline. If enough ethanol-E85 were produced from corn to power all U.S. onroad vehicles, 22-38 times more land (9-15 percent of the U.S.) would be needed for corn than for wind turbines powering battery vehicles. This E85 would reduce U.S. carbon emissions by only 0.5 percent, according to the latest data, and would increase air-pollution-related deaths by about 200 per year relative to current vehicles.

Similarly, 12-30 times more land (5-12 percent of the U.S.) would be needed to grow switchgrass to run all vehicles on cellulosic-ethanol-E85, which does not exist at the commercial scale today. Conversion to this E85 would reduce overall U.S. carbon emissions by up to only 11 percent yet still increase air-pollution-related deaths by 200 per year.

Wind raises important issues, such as bird loss. However, if 420,000-580,000 turbines powered all energy in the U.S., bird loss would be less than 10 percent that from U.S. communication towers and offset by an annual saving of 50,000 humans and millions of birds by eliminating fossil fuels.

Next, wind does not blow predictably. Yet, by interconnecting wind farms through the transmission grid, fast winds at one location compensate for slow winds at another, smoothing supply. Other renewables, such as hydroelectric, can also serve as a backup when wind is slow, and wind energy stored in hydrogen or batteries does not need to be predictable.

Finally, while wind turbines affect the scenery, so do all energy sources. Living near a wind farm would appear to be preferable to living near a power plant emitting chemicals.

Yes, the answer is blowing in the wind. The diversion of investment to energy sources, such as ethanol, that do not reduce air pollution and have little climate benefit, at the expense of true renewables, which have large, immediate benefits, will cause certain damage as population, energy use, and emissions rise further. Current laws legislating increased renewables are too weak to reduce emissions by 80 percent. Only a large-scale renewable and efficiency program can attain this goal.

Mark Z. Jacobson
Stanford University

And Shining in The Sun – Solar Cell Breaks the 40% Efficiency Barrier

Solar Cell Breaks the 40% Efficiency Barrier, Renewable Energy Access, December 7 2006, http://www.renewableenergyaccess.com/rea/news/story?id=46765

http://www.renewableenergyaccess.com/rea/news/story?id=46765
St. Louis, Missouri & Washington, DC [RenewableEnergyAccess.com]

A photovoltaic (PV) cell achieved a milestone earlier this week with a conversion efficiency of 40.7 percent. Produced by Spectrolab, Inc. -- a wholly owned subsidiary of Boeing -- and funded in part by the U.S. Department of Energy (DOE), the breakthrough could lead to PV systems with an installed cost of $3 per watt and produce electricity at a cost of $0.08 to $0.10 cents per kilowatt-hour.

"The excellent performance of these materials hints at still higher efficiency in future solar cells."-- Dr. Richard R. King, Spectrolab, principal investigator.

The 40.7 percent cell was developed using a structure called a multi-junction solar cell. This type of cell achieves a higher efficiency by capturing more of the solar spectrum. In a multi-junction cell, individual cells are made of layers, where each layer captures part of the sunlight passing through the cell -- allowing the cell to absorb more energy from the sun's light.

According to Spectrolab, high efficiency multijunction cells have an advantage over conventional silicon cells in concentrator systems because fewer solar cells are required to achieve the same power output.

"These results are particularly encouraging since they were achieved using a new class of metamorphic semiconductor materials, allowing much greater freedom in multijunction cell design for optimal conversion of the solar spectrum," said Dr. Richard R. King, principal investigator of the high efficiency solar cell research and development effort. "The excellent performance of these materials hints at still higher efficiency in future solar cells."

For the past two decades researchers have tried to break the "40 percent efficient" barrier on solar cell devices. In the early 1980s, DOE began researching what are known as "multi-junction gallium arsenide-based solar cell devices," multi-layered solar cells which converted about 16 percent of the sun's available energy into electricity. In 1994, DOE's National Renewable Energy laboratory broke the 30 percent barrier, which attracted interest from the space industry. Most satellites today use these multi-junction cells.

"Reaching this milestone heralds a great achievement for the Department of Energy and for solar energy engineering worldwide," Alexander Karsner, Assistant Secretary for Energy.

Efficiency and Renewable Energy at the U.S. DOE. "We are eager to see this accomplishment translate into the marketplace as soon as possible, which has the potential to help reduce our nation's reliance on imported oil and increase our energy security."

Almost all of today's solar cell modules do not concentrate sunlight but use only what the sun produces naturally, what researchers call "one sun insolation," which achieves an efficiency of 12 to 18 percent.
However, by using an optical concentrator, sunlight intensity can be increased, squeezing more electricity out of a single solar cell.

"This solar cell performance is the highest efficiency level any photovoltaic device has ever achieved," said Dr. David Lillington, president of Spectrolab. "The terrestrial cell we have developed uses the same technology base as our space-based cells. So, once qualified, they can be manufactured in very high volumes with minimal impact to production flow."

Development of the high-efficiency concentrator cell technology was funded by NREL's High Performance Photovoltaics program and Spectrolab.

For Further Information
U.S. Department of Energy (DOE)
Spectrolab

Hydrogen and Electric Vehicles

BMW chief executive Norbert Reithofer revealed that the German automaker was considering bringing a battery-powered vehicle to the U.S. market by 2012 in an effort to meet more stringent CAFE standards. A final decision will come later in the year, though company officials have disclosed that initial tests have already shown such a move to be technically feasible. In addition to its 7 Series hydrogen vehicles, BMW is planning on expanding its roster of eco-friendly cars by partnering with GM and Mercedes to build hybrid models.

The BMW Hydrogen 7 holds approximately 8 kilograms of liquid hydrogen. The car consumes about 15 miles per kilogram for a total cruising range of 120 miles, BMW says. In gas mode, the car's 74-liter (19.5-gallon) gasoline tank offers a range of about 300 miles.

At $10.30 per kilogram, hydrogen fuel is no bargain, even in Europe, where gas prices are significantly higher than in the United States. Filling up a 74-liter gas tank in Germany with high-test gas costs about $123, which for a cruising range of 300 miles is a much better deal than $82.40 you'll pay to go 120 miles on hydrogen fuel. The price of hydrogen is astronomical compared to the $2.20 or so per gallon price in the United States. However, BMW representatives on hand for the car demonstration in Berlin last week said hydrogen pump prices should be significantly lower if production increases for use as car fuel.[196]

At the fueling station, sensors will shut down fuel flow from the pumps if a leak is detected, while the car's engine and hydrogen gas flow will also stop in case of a puncture or leak, BMW says.

Hydrogen is primarily produced from natural gas, a process that generates more CO_2 than gasoline car engines. However, solar, wind and hydroelectric generation of hydrogen and its extraction from biomass represent viable long-term options that promise negligible CO_2 emission, BMW says.

The automaker concedes its Hydrogen 7 production car is just a start. The model's acceleration and mileage pale in comparison with many ethanol-fueled and gas-electric-hybrid models, such as the latest Lexus hybrid. Company engineers are working to introduce lower pressure in the fuel tank to limit how fast the liquid hydrogen boils off. And they're researching new materials for a lighter and less bulky fuel tank.

The dearth of fueling stations will hamper drivers who need to fill up in the middle of places like Kansas. For the 100 Hydrogen 7s in operation next year, BMW says hydrogen filling stations will be located in the vicinity of where the cars are loaned, albeit probably fewer than 12 worldwide in 2007. Hydrogen trucks will offer mobile fill-ups for the loaned cars, BMW says.

BMW engineers plan to develop an engine that offers acceleration and power comparable to any gasoline internal-combustion engine vehicle. To do that, BMW is developing a hydrogen-only internal-combustion engine that will produce 95 kilowatts of power per liter instead of the 32 kilowatts per liter now in the hybrid Hydrogen 7, with direct, cryogenic injection in a pure hydrogen tank. On a per-volume basis, cryogenic liquid hydrogen offers 75 percent more energy compared to hydrogen in a compressed gaseous state at 700 bars of pressure.[197]

http://www.treehugger.com/files/2008/03/bmw-electric-vehicle.php

This Research Paper Remains A Work In Progress

All the above sections will be regularly updated to reflect the latest developments.

The data indicates that excess BC soot emission is causing severe regional warming.

As such, the World needs to rapidly reduce BC emissions and work to eliminate the most problematic sources of this pollution from the burning of coal, marine diesel, and automotive & trucking diesel.

Where as most BC soot will settle out of the atmosphere, jet aircraft particulate may prove to be a most troubling problem, as it is behaving almost like a gas and collecting in the atmosphere.

The data also indicate that CO_2 may not be the primary driver of regional warming on the planet. But even if CO_2 in not the primary problem behind warming, we still have to sequester it anyway, as we can not leave the world's oceans full of CO_2 and in an acidic state. And if CO_2 is shown to be causing warming, we must begin sequestering it within a few years.

This may be achievable with massive solar and/or wind farms in the Middle East deserts that power artificial photosynthesis technology capable of converting CO_2 and water first into methane, and then into heavier oils that can be pumped back into local reservoirs.

16. Conclusion: Implications for International & National Policies

As discussed in the executive summary, this research indicates the need for a modification in our approach to climate change, and the immediate development of effective national and international policies for investment in new infrastructure to address the problems.

Part Two, to be released shortly, concerns technology and fiscal policy solutions, and goes beyond the scope of a typical scientific research paper. It considers the major implications these scientific findings will have in broader terms and outlines the need for the:

- most efficient integrations of technology and infrastructure planning to reduce BC soot;
- financing models required to rapidly implement profitable and effective solutions
- international policy and cooperation required to quickly achieve this – much in the manner of a modern day Marshall Plan.

A potential framework for such policy has been in development for the past five years at Paragon (see below) and will be ready for review shortly. It will provide a detailed summary of current economic data related to energy consumption and the world economy, and a full economic analysis of various measures for viable market driven solutions.

For any emissions reduction plan to be successful, it must preserve and ultimately transfer the wealth of the world's corporate stockholders, appeal to human nature and its insatiable desire for profit, and not dislocate world economies. Otherwise, regardless of its merit it will be resisted and fail.

Despite no real communication technologies, it was motive for profit and superior technology that allowed oil & gas to begin rapidly replacing coal some 90 years ago. The business & environment friendly policies to be proposed are designed with that in mind, and have been designed to take full advantage of human & corporate nature.

The measures being considered would not put any material financial burden on governments or economies. Instead they'd allow market-driven, highly profitable tax and capitalization structures that make it attractive for corporations and consumers to rapidly invest (and recover) their own capital in the technologies necessary to generate results far beyond Kyoto targets, and much faster.

Most importantly, these measures are designed to allow any nation or state adopting them to immediately become more economically competitive. This will force others to adopt them to remain competitive on the world stage, just as most economies followed the US lead 20-30 years ago.

For many nations, meeting Kyoto targets is based on painful restrictions. This is because their current plans are based on a managed demise of antiquated technology.

However, this plan will demonstrate to leaders of the world's nations the bounty and improved living standards possible when investments in new technology are made. It's designed to turn a crisis into an opportunity. And positive thinking always generates innovation faster than depression and fear.

Most energy related technologies in use today cost less up front, but require constant fuel, and cash expenditures to keep running. New fossil-free technologies cost more up front, but little or nothing to run later. Governments need to implement ***simple*** plans to stimulate rapid capital investment in these superior technologies. The second part of this paper will outline such a fiscal plan.

Both consumers, and the world's industrial & energy companies that will build and fuel our modified machines, will require capital financing, and the cooperation of governments to provide short-term incentives and guarantees to the financial services industry providing that capital.

To develop viable policy models to quickly bring about world wide technology implementation on the massive scale required, we've brought together some of the most dynamic energy-related business leaders to help finalize this plan.

That plan will be designed to be used as a foundation for any national strategy/policy, and will also include models for international cooperatives designed to allow joint investment in China, India, Africa, and other parts of the developing world. The structures of such partnerships reward nations & corporations investing in those requiring economic development.

Outline to Part Two: Technological and Fiscal Solutions to Climate Change

Immediate Educational, Economic & Political Solutions to Climate Problems

Current World Power Requirements

Future Infrastructure Layouts

Technology to be Used

Costs of Systems

Systems Financing

Tax Benefits to Users

Increased Economic Competitiveness Will Force Other Nations To Follow

Unprecedented Cost Benefits and Wealth Generation


Back-up Power System
Fleet Fueling
ACME ELECTRONICS
Industrial Application
Community Fueling
Home Fueling
Primary Electricity
Hydrogen
Hydrogen-Generated Electricity
H2 Generation Module
H2 Storage Module
Power Module
Fuel Dispensing Module
Personal Energy Station (PES)
PES Storage Module
Hydrogen Tank

Appendix 1: Evolution Of Melting Processes Of Sea Ice

Melting is an important process in the evolution of a sea-ice floe. It is quite relevant to the role of sea ice in climate. As the data base of sea ice ablation is fairly limited (Fetterer, 1998), more research (i.g. SHEBA) focused on this topic during recent years. Before going into the details of the melting processes, the summary chart provides an overview from the onset of melt to disappearance of the ice. Now let's see in detail each process.

Melting Processes Of The Seasonal Ice In Arctic

Melting is dominated by the contrasts in the albedos of snow and ice (albedo is from 0.1 to 0.9) and open water (albedo is below 0.1) or melt ponds (albedo is from 0.2 to 0.4) (Fetterer, 1998; Perovich, 1996). Albedo is in fact a controlling factor in sea ice melting in summer time. Snow and ice are good reflectors of solar radiant energy, while water is a quite effective absorber of solar radiant energy.

Onset of snow melt: All large scale sea ice melting is triggered by the solar radiation. For sea ice with snow cover, the first to melt is the surface snow flakes due to the absorption of solar energy and the subsequent increase of temperature over freezing point. Meanwhile, solar radiation also penetrates into the snow and causes snow melting, settling and packing, which increase the heat conductivity of the snow, and thus the heat transfer from the snow to the ice is enhanced. Once the snow starts to melt, the accumulating water content will further decrease the surface albedo, thus more solar energy will be absorbed. Owing to the penetration of solar shortwave radiation into the mass of ice, the ice surface temperature is lower than it would be without this effect (Dononin,1977). Penetration of radiation into the ice raises its temperature by the order of a fraction of one degree. With further increase in air temperature and solar radiation the surface layer of the snow is saturated with water and the albedo decreases further.

Impurity particles embedded in the ice or snow decrease the albedo of the surface and become melting centers. Micro-organisms may increase melting of ice in the same way as inorganic sedimental particles. Warm winds from nearby land masses can increase the turbulent heat flux and thus accelerate melting.

Shallow Meltwater Puddles Begin To Cover The Ice

With melting, dark patches, which consist of snow saturated with water, are the starting points for the formation of melt ponds. Since the melt rate of ice beneath ponds can be up to 2-3 times more rapid than that of bare ice (Hanson, 1965), the ponds deepen and shrink in diameter, first rapidly and then more slowly.

However, on some cases, especially on large and level first year ice floes, melt snow will form puddles. These puddles usually continue to increase steadily in size during summer after vertical depth reaches some definite value and thus vertical melting proceeds very slowly or even stops. Individual puddles gradually increase in size and join one another to form connected puddle systems.

Vertical melt holes develop and a network of surface drainage canals forms: Accumulation of impurities and organic mater in the deepest parts of the puddles intensifies the heat absorption there, resulting in formation of thaw holes or sometimes called cryoconite holes (Podgorny et al., 1996; Eicken et al., 1994), until reaching the bottom of the ice, creating a drainage system. Ablation holes are formed due to dirt deposition at the low parts of ice.

Internal melting:
Besides the absorption of solar radiation at the snow and sea ice surface, absorption of solar short wave radiation can also occur inside the ice due to penetration of the shortwave radiation. Increase of

inner temperature can result in internal melting, increasing the ice porosity and enhancing the desalination of the ice.

Disintegration of sea ice cover: The surface of the ice is extremely irregular from the run-off of over-ice water. The central parts of the ice in the water puddles break up and float up due to their structural weakness. As the more saline the ice the greater its ability to absorb solar heat, and as a general rule the ice near the thermal and dynamic cracks formed in winter has the greatest salinity, it is natural that the ice in these cracks is weakest and the first to melt. Thus they are the natural lines of cleavage of the ice in the spring. Typical small cracks will develop during this stage.

Breaking-up into section along the lines of least resistance: The warm melt water will run off along the cracks of the weakened ice, and melts further the lateral sides of the cracks, enlarging the separations. Ice can be broken apart by the wind, the currents and the waves after the ice is weakened by thawing. The outer contours of these broken parts are accidental and have sharp angles. The collisions among these parts due to their movement caused by winds, current, waves, result in the breaking away of outward projecting parts of the floes, leaving water separation in between.

Leads produced by movement of broken ice: After the sea ice breaks into parts, various forces will drive the floes further apart, leaving leads between.

Bottom ablation and lateral melting on the floe edges: As the waterís albedo is no more than 0.1, i.e. much less than that of snow and ice, solar radiation is absorbed quickly in the leads. Transfer of the heat to the lateral and bottom surfaces of ice results in bottom ablation and lateral melting, eventually leaving only small disintegrated floes and pieces of ice, or we call them mushroom ice. All ice floes will disappear soon.

Melting Of Multi-Year Ice

The physical mechanism for melting of multi-year (MY) ice is the same as the first year (FY) ice. However, due to the different thickness and morphology, ablation of MY ice shows different features.

Onset of melting of snow: Compared with FY ice melting, melt water on top of MY ice usually accumulates in the snow, drains and then re-freezes at the snow-ice interface. And thus, a rough superimposed ice layer (Onstott, 1992) or frozen melt pool (Gogineni, et al., 1992) is formed in the interface between snow and ice.

Subsurface melt pools: In the early summer to midsummer, increase in air temperature results in more melting of snow. Snow thickness decreases, wet snow and slush appear. Melting water accumulates in the low parts, subsurface melt pools appear.

Open puddles: In the midsummer to late summer, as the snow melts completely, open puddles appear. Small melt ponds separated by hummocks at first, can be connected to form large open water. Unlike the FY ice, water in the surface melt pools does not usually run off and is frozen in the following fall and winter to form the frozen melt pools.

Features In Melting Of Multi-Year Sea Ice

Underwater ice growth at the interface between sea-ice and sea-waters, while melting at the surface in early summer. The surface melts due to absorption of solar radiation while the bottom of the MY ice is still below freezing point mainly because of the thickness of the MY sea ice.

Bottom melting of MY sea ice during vigorous growth of young ice in Fall to Winter: In thick ice heat stored during the summer retards thermal conduction at the bottom, allowing most of the oceanic heat flux F_w to contribute directly into bottom ablation; in thin ice conductive fluxes in the ice are much larger than F_w and ice growth is rapid.

As surface melting and bottom growth are balanced eventually in an annual cycle, an equilibrium ice thickness is reached. The yearly-averaged equilibrium thickness is a thickness that does not vary from year to year under given climatic conditions and is subject only to internal changes (Doronin, 1977). These internal changes include microsture change and desalination, et al..

Melting from above and addition of new ice layers from below result in an vertical movements in the ice of all kinds of foreign matter, which freezes to the lower surface of the ice in one way or another will finally appear on the upper surface.

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About The Author/Editor

Sam Bock was born in Montreal in1959. He received a degree in Economics and Environmental Science from Middlebury College in Vermont in 1982. His passion in college was the independent study of particle physics and chemistry. His 1982 thesis was a technical and economic analysis of the roles oil & gas, coal, nuclear, solar, wind, and other alternatives might play in meeting North America's energy needs.

After school he worked on Wall Street and in Denver in energy project finance for 4 years, before leaving this for an R&D career that involved many different fields (Olympic sport, medicine, environment/climate). For much of the past 20 years, he has been investigating climate change and potential technologies & policy necessary to meet it.

Because of this, 14 years ago he bought a pristine property in the northwest corner of British Columbia as a refuge from future warming. While back then he didn't think the current extent of warming would arrive so soon, 4 years ago, after witnessing the devastating carnage in BC's forests he began an intensive research effort of the latest climate data, and to look for viable technology, government policy, and financing solutions based on that review.

About Paragon

Based in Canada, Paragon Technologies Ltd. is a private sport, health and environmental sciences R&D company that has developed knowledge & technologies to help advance our understanding of sport, human health, and how we interact with the natural environment.

These include:

- RD&D of advanced pharma-nutraceutical medicines & metabolic diagnostics for degenerative disease
- Climate research and the development of models for new infrastructure & sustainable government policy
- RD&D of world leading sport training & nutrition chemistry programs – including revolutionary motor-specific sport training equipment; other specialized equipment & apparel for sport training & competition; and architectural designs for state-of-the-art multi-sport training facilities

Previous technologies Paragon developed became world leaders in certain specific fields:

- Combined applications of advanced metabolic testing and custom pharma-nutraceuticals
- Advanced sports nutrition research & formulation development
- Power/Speed training for Olympic and professional sport
- Revolutionary sport training equipment for all sport; sprint shoes for Olympic competition; Bobsleds for Olympic competition
- Advanced apparel for Olympic sport training and competition

These technologies were the product of R&D efforts to improve Canadian athletic performance and to reduce and rehabilitate injury. They allowed many athletes to set world records, win Olympic gold, and excel in professional sport. This ongoing research is being successfully applied to research and development of new medicines and metabolic diagnostic technologies to reverse many types of degenerative disease now affecting our modern world.

Athletes trained under Paragon coaching have produced 25+ world records, 35+ World Cup medals, Olympic Gold, several world championship medals, as well as All-star performances in the NHL. Other top athletes using Paragon designed nutrition technologies, custom training equipment & apparel, and/or racing equipment have won dozens of Olympic & World medals and awards at professional levels, in many different sports.

The company has worked with Nike and adidas to design revolutionary sports product, including Michael Johnson's 1996 gold shoes, Donovan Bailey's ultra light adidas racing shoes, and adidas' Sydney 2000 line of track and field shoes. It provided research and marketing for Mondo, official supplier of track surfaces to the IAAF and Summer Olympics. It is currently developing various sport-related technologies and evaluating the development of new medical technologies with various leading health care companies.

Non-Profit Work

Paragon uses much of its commercial revenue to subsidize non-profit development of Canadian amateur sport and the development of various policy models for the sustainable funding and implementation of progressive social programs to enhance the health and welfare of Canadians.

Current models of taxation and economic development driving industry, agriculture, medicine and health care are detrimentally impacting the long-term health of citizens, the environment, and the economy.

As discussed further below, Paragon is working to develop viable market driven proposals for progressive federal & provincial taxation and socio-economic policy necessary to address the health care, environment, and climate-change crises affecting Canada, without disrupting the short-term economic needs of Canadians.

Paragon believes any successful long-term strategy must address both human nature and economic realities – and that when developing new ideas to address urgent social, environmental and climate change problems, the more economically effective such as strategy is, the more quickly it will be implemented.

Why the Company was Formed and What it Does Today

Paragon's founder, Sam Bock, was trained in Economics/Environmental Science at Middlebury College, and left a finance career to pursue bobsledding. Within 2 ½ years Bock was third in Canada's National Championships and was designing and building special equipment for Canada's 1988 Olympic Team.

Paragon was initially formed in 1989, with support from Canada's National Research Council, to privately develop technology for Canada's national sport programs. Paragon pioneered motor-specific weight training programs, advanced nutrition regimens superior to steroid regimens, rapid regeneration programs to treat injury, as well as state-of-the-art sports training and competition equipment that helped some of the world's best power athletes achieve the highest speeds achieved in their respective sports.

Paragon has evolved from developing sport technology and powerful Olympic champion athletes into a diversified R&D and consulting company.

Current independent and joint-research is focused primarily in three areas:

1. Paragon is working with health care companies to investigate new classes of pharma-nutraceutical drugs and advanced metabolic diagnostics for the natural treatment of degenerative disease based on successful R&D and testing of Paragon developed formulations and applied diagnostics.

2. Paragon is developing a variety of sport-related equipment designs. Paragon continues to privately develop products for its own athlete's use, and/or future licensing.

3. In non-profit work, Paragon is privately working to develop potential public policy models for:

- **The rapid implementation of an economically superior fossil-free economy**, to further enhance the wealth and competitiveness of Canada, while effectively addressing global warming. Iceland is already close to achieving this feat, based on a plan for economic self-sufficiency proposed by one of the country's university professors. While Germany, Japan, Denmark, and China are just getting started, they are not too far behind. Canada is presently regressing in this area of policy development critical to our future prosperity.

- **The development of simple educational media to inform Canada and other nations of sophisticated fossil-free technologies already developed** (by world leaders such as BP, Sharp, BMW, Magna, Ballard, GE, Opti-Solar, Hydrogenics, Sun Edison, Goldman Sachs, Dupont any many other firms) **and methods for their financing**.

- **The development of a viable government strategy and implementation plan to promote corporate and consumer investment in the new infrastructure required to sustainably power industry, heat homes and businesses, and transport Canadians** without sacrificing the independence and convenience to which we've become accustomed. Low interest government-guaranteed loans from the nation's financial institutions could provide funding for private investments in technologies with lifespans of 20-25 years, that would pay for themselves within 5-7 years, leaving the end-users with 17-20 years of free use prior to the need to reinvest.

- **The development of international assistance and foreign investment plans for the world's poorest, but hot & solar-rich, African/Asian economies to enable cheap wind & solar/hydrogen production** to power and develop their own infrastructures, and to allow them to generate significant hydrogen export revenues. (The amount of solar energy reaching the Earth in approximately 1 hour is enough to power the entire world for a year.)

- The phasing out of toxic industrial and agribusiness practices, to enable to the Earth and its inhabitants to regain potential for full health. This would be achieved in Canada, and elsewhere, through laws banning such unsustainable practice, and by providing tax-incentives to help those industries, employees, and shareholders make an smooth transition to healthy sustainable practices.

Paragon nutrition and metabolic research has affected past Canadian federal environmental policy. In 1999 Bock circulated an Internet letter asking Canadians to write the Canadian Government's Senate Committee on Energy, Environment and Natural Resources to ask for a full review of Bill C-32 prior to signing it into law. Bock later addressed the Committee regarding the problematic effects of randomly produced industrial chemical by-products on the food chain and plant and animal enzyme chemistries. As indicated in the Committee's final report, he helped persuade the Senators to recommend that the Canadian Environmental Protection Act be put into a perpetual state of review.

- **The development of simple educational tools to inform citizens of the latest, conclusive research showing how our genetic expression and health are controlled by nutrition, environmental factors, and physical activity** – not by our genetic codes themselves, and why most people who are ill in the western world are getting sick unnecessarily.

- **The development of an improved single-tier, universally available health care strategy** that improves treatment and care, reduces waiting times, and educates people on why they get sick & how they can recover & prevent future illness. It would considerably reduce costs to the nation by dramatically reducing the numbers of ill through self-funding tax rebate incentives that significantly reward families who learn to maximize health.

- **In related community work**, Paragon's metabolic testing nutritional regimens are being used by many people to heal from many serious degenerative conditions and diseases.

Paragon is also working in a joint venture to develop energy efficient low-cost world-class training facilities to cover full-length tracks and has developed state-of-the-art technologies that allow proper year round multi-sport athletic development and speed training in any climate.

Today it costs about $50-$80M Cdn. to build a traditional domed facility like those in Calgary, Lillehammer, and Nagano. Paragon's new buildings will cost as little as $1M-$6M each, will adapt to the varying weather conditions, and require very little energy or maintenance.

Contact Information

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Partial List of Research Links

http://earthobservatory.nasa.gov/Study/Pollution/pollution.html smokestacks/weather
http://www.esa.int/esaCP/SEM7ZF8LURE_index_0.html ESA 2006 Arctic melting
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