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HEARING ON EPA BLACK CARBON

AND GLOBAL WARMING

Thursday, October 18, 2007

House of Representatives,

Committee on Oversight

and Government Reform,

Washington, D.C.

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Committee Hearings

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The committee met, pursuant to call, at 10:06 a.m. in room 2154, Rayburn House Office Building, the Honorable Henry A. Waxman [chairman of the committee] presiding.

Present: Representatives Waxman, Maloney, Cummings, Kucinich, Tierney, Norton, McCollum, Hodes, Davis of Virginia, Shays, Mica, Duncan, Issa, and Bilbray.

Staff Present: Phil Schiliro, Chief of Staff; Phil Barnett, Staff Director and Chief Counsel; Greg Dotson, Chief Environmental Counsel; Earley Green, Chief Clerk; Teresa Coufal, Deputy Clerk; Caren Auchman, Press Assistant; Ella Hoffman, Press Assistant; Leneal Scott, Information Systems Manager; David Marin, Minority Staff Director; Kristina Husar, Minority Counsel; Larry Brady, Minority Senior Investigator and Policy Advisor; Patrick Lyden, Minority Parliamentarian & Member Services Coordinator; Brian McNicoll, Minority Communications Director; Benjamin Chance, Minority Clerk; Ali Ahmad, Minority Deputy Press Secretary.

*Chairman Waxman. The meeting of the Committee will please come to order.

Today's hearing will focus on the issue of black carbon and global warming. Black carbon is commonly known as soot. It is emitted from our diesel trucks, our trains, planes, ships, and even our fireplaces. Over the years, Congress and the Environmental Protection Agency have focused on tiny particles like black carbon because it cut short the lives of our seniors and sickened our children; however, black carbon is also important because of the ongoing role it plays in the warming of the earth.

Today we will hear that black carbon may be responsible for almost 20 percent of the warming the planet is currently experiencing. Experts will tell us that black carbon may be the second most significant global warming pollutant after carbon dioxide; yet controlling black carbon has not been seriously examined at the Federal level as a way of possibly mitigating global warming.

At today's hearing we will explore what may seem to be an overwhelmingly complex issue involving atmospheric chemistry, global climate modeling, and literally millions of sources of air pollution.

It may seem complex, and indeed there are complexities and unanswered questions, but it is manageable. Here is what we know:

Global warming is happening and carbon dioxide is the principal pollutant of concern. Other pollutants, like black carbon, also contribute to the problem. Because black carbon doesn't stay in the earth's atmosphere as long as carbon dioxide, controlling it may achieve major benefits in the short term.

We may need short-term benefits in order to prevent irreversible impacts from occurring. Reducing particulate air pollution, like black carbon, could also achieve major public health benefits.

This is not a theoretical issue. We can now see the impacts of global warming with our own eyes. To illustrate this last point, I have several slides of glaciers that I would like to put up on the screen.

This first is of Carroll Glacier in Alaska. As you can see, this glacier has basically disappeared in the 97 years between when these photographs were taken. As you can seek it is a straight glacier untouched by any warming, complete ice, no deterioration. We will soon see a photograph that shows a very different picture.

We also have photographs which we will exhibit in the near term, and these photographs are of McCall Glacier, which has receded dramatically over the last 45 years, and then there is also Toboggan Glacier that has vanished over the course of 90 years.

The glaciers of the world are receding. These receding glaciers are one measure of the warming that we now know to be occurring, but it isn't the only one. What is happening in the Arctic is alarming.

We have a time-lapsed animation of Arctic sea ice. This animation shows the last 30 years of summer sea ice, based upon data compiled by the National Snow and Ice Data Center. It begins in 1978 and runs through 2007. While Arctic sea ice has been consistently declining over the years, this past summer was truly stunning.

If you look on the right, you can see the area that has now been lost, which has opened up perhaps sea lanes that we never expected, but problems that we should definitely be concerned about.

Global warming is happening, and the planet's natural systems are giving us every reason to pay attention to this problem.

Today we have a very distinguished panel and I thank you all for being here and for paying attention to this problem. I am very pleased that they have agreed to appear, and we look forward to your testimony.

We want to bring in part of the debate on global warming that has not been the focus of attention yet on the Hill, and we think this hearing will give us the opportunity to do that.

[Prepared statement of Chairman Waxman follows:]

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*Chairman Waxman. Mr. Davis?

*Mr. Davis of Virginia. Thank you, Mr. Chairman, and thank you for holding today's hearing to consider the relationship between black carbon emissions and climate change.

Climate change is a critically important issue, and as policy-makers it is our job to consider all sensible options to reduce the emission of climate-warming pollutants. My head is not in the sand on this issue. I am not one who denies the reality of climate change, and I am motivated to learn more about what we can do to advance the debate and come up with some potential solutions. Therefore, I think this hearing can serve as an example of how we as a Committee can work together to rationally investigate the facts surrounding climate change, and at the same time seek agreement on the best way forward.

While the United States and the world have focused attention on reducing carbon dioxide emissions, it appears that not enough attention has been focused on controlling black carbon and its effects on the climate.

According to the witnesses scheduled to testify, there is a significant scientific evidence that black carbon is the second leading cause of climate change after carbon dioxide. In layman's terms, black carbon is soot. It is emitted into the air during fossil fuel and biofuel combustion and biomass burning. Developing nations like China and India are the leading source of black carbon emissions, while the United States is only responsible for about 6.1 percent.

Unlike some ways of controlling CO2 emissions, technology already is available to reduce emissions in black carbon. That technology has reduced by a factor of five the soot emissions in this Country since the 1950s. We need to find ways to ensure the developing world has access to this technology.

One witness will tell us that reductions in black carbon emissions could buy us significant time to reduce CO2 emissions. That would be a welcome respite to allow the world to develop consensus solutions that don't stall growth or give some nations competitive advantages over others.

Because the developing world is the major source of black carbon emissions, this hearing serves as a reminder that any future international treaties on climate change must include China and India. Failure to do so would forfeit a prime opportunity to bring about meaningful changes in behavior that both include quality of life and reduce the immediate impact of climate change on the planet.

Moreover, as we look for ways to mitigate harmful greenhouse gases, we must do so while acknowledging that energy is essential to the economic activity that sustains and improves our quality of life.

Renewable energy shows great promise, and biofuels have provided some relief from our dependence on traditional energy sources that contribute to climate change. However, the only fuels that have a realistic growth potential -- solar, wind, biomass -- only make up about 3.5 percent of the Nation's energy supply. Even with healthy growth, these energy sources will not cure our dependence on coal and oil. Accordingly, policy-makers must look to technologies that decrease the externalities associated with the use of energy so that we can limit emissions that contribute to climate change.

There is no question that we live in a challenging world and we only have real-world options available to us to address the twin challenges of climate change and energy independence.

This Committee and this Congress should devote more time and attention to exploring these options so that we can craft effective, real-world solutions. Reducing black carbon emissions around the world may be an overlooked, cost-effective solution that will provide enormous benefits.

Finally, I want to thank our distinguished panel who will be testifying today for their dedication to the science of climate change and for taking the time to share their knowledge with us and their expertise.

Thank you.

[Prepared statement of Mr. Davis of Virginia follows:]

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*Chairman Waxman. Thank you.

We have a very distinguished panel.

Mr. Issa, did you want to say anything? If not, we will proceed to the panel.

*Mr. Issa. That would be fine just to proceed.

*Chairman Waxman. Okay.

We have Dr. Mark Jacobson, who is the Co-founder and Director of the Atmospheric Energy Program at Stanford University's Department of Civil and Environmental Engineering, where he has been a faculty member since 2004. His research is dedicated to addressing atmospheric problems such as climate change and urban air pollution. Since 1994, he has published two textbooks and more than 70 peer-reviewed journal articles on related topics. We are pleased that you are here.

Dr. Tami Bond leads a research group at the University of Illinois at Urbana-Champaign focused on aerosols and the global environment. She is well known for her work identifying black carbon emission sources. We are pleased that you are here.

Dr. V. Ramanathan has been researching climate and atmospheric science for more than 30 years. Among other positions, he currently serves as a member of the World Clean Air Congress Advisory Board as Co-Chief Scientist for the Atmospheric Brown Cloud Project and is Chair to the National Academy of Science's Committee on Strategic Advice on the U.S. Climate Change Science Program. He is a distinguished Professor of Atmospheric and Climate Sciences at the Scripps Institute of Oceanography at the University of California, San Diego.

Dr. Charles Zender is the Director of the Earth System Modeling Facility and leads the Climate Health, Aerosols, Radiation, and Micro-Physics Group at the University of California, Irvine. His recent research focuses on the impact of aerosol deposits on snow and ice in the Arctic, and he holds a Ph.D. in astrophysics, planetary, and atmospheric science from the University of Colorado at Boulder. We are pleased you are here.

And Dr. Joel Schwartz is a Professor of Environmental Epidemiology at the Harvard University School of Public Health. He has conduced research on the adverse health impacts of air pollution all over the world, including studies in the United States, the European Union, Canada, Israel, and Turkey, among others. Dr. Schwartz, it is good to see you, as well.

It is the practice of this Committee to ask all witnesses that appear before us, because we are an investigative Committee, to testify under oath. It seems a bit awkward with scientists, because you are going to give us theories and ideas that may change. In fact, you may change your minds as you look at some of these matters further. But we will keep with our practice and ask you to please stand and raise your right hands.

[Witnesses sworn.]

*Chairman Waxman. The record will reflect that each of the witnesses answered in the affirmative.

Dr. Jacobson, let's hear from you first.

STATEMENTS OF MARK Z. JACOBSON, PROFESSOR OF CIVIL AND ENVIRONMENTAL ENGINEERING, ATMOSPHERE/ENERGY PROGRAM, STANFORD UNIVERSITY; TAMI C. BOND, ASSISTANT PROFESSOR OF CIVIL ENGINEERING, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN; V. RAMANATHAN, PROFESSOR OF CLIMATE AND ATMOSPHERIC SCIENCES, SCRIPPS INSTITUTE OF OCEANOGRAPHY, UNIVERSITY OF SAN DIEGO; CHARLES ZENDER, ASSOCIATE PROFESSOR OF EARTH SYSTEM SCIENCE, UNIVERSITY OF CALIFORNIA AT IRVINE; JOEL SCHWARTZ, PROFESSOR OF ENVIRONMENTAL EPIDEMIOLOGY, HARVARD UNIVERSITY

STATEMENT OF MARK Z. JACOBSON

*Mr. Jacobson. Thank you, Chairman Waxman, Ranking Member Davis, and the Committee for inviting me to testify today. I will speak on the role of black carbon in global climate change and methods of reducing black carbon emissions.

Fossil fuel and biofuel burning soot particles containing black carbon have a strong probability of being the second leading cause of global warming after carbon dioxide and ahead of methane. Because of the short lifetime of soot relative to greenhouse gases, control of soot, particularly from fossil fuels, is very likely to be the fastest method of slowing global warming. Because soot particles are generally small, and small aerosol particles are the leading cause of air pollution mortality, controlling soot emissions will not only slow global warming but also improve human health.

The United States soot contributions to global warming may exceed each of its methane and its nitrous oxide contributions to global warming. Despite soot regulations to date based on health grounds, the United States has significant room to reduce soot emissions further, thereby reducing health and climate problems further.

Soot is an aerosol particle emitted during fossil fuel, biofuel, and biomass combustion. Soot particles contain black carbon, organic carbon, and smaller amounts of sulfur and other chemicals. Soot particles warm the air by converting sunlight into infrared or heat radiation and emitting the heat radiation to the air around them. This differs from greenhouse gases, which heat the air by absorbing the earth's infrared radiation but not sunlight.

When soot particles age in the atmosphere, they become coated by other chemicals, increasing their size and their ability to heat the air, but also their ability to form clouds. Soot particles that end up on snow or sea ice surfaces also darken those surfaces, contributing to their warming and melting.

The figure now on the screen shows the relative contributions of greenhouse gases, soot, the urban heat island effect, and cooling particles to global warming, as determined by recent detailed computer model simulations. About half of actual global warming today is being marked by cooling particles which contain sulfate, nitrate, ammonia, certain organic carbon, and water primarily. Thus, as cooling particles are removed by the cleanup of air pollution, much global warming will be unmasked; nevertheless, the removal of such particles is still desirable for improving human health.

The figure also shows that fossil fuel plus biofuel soot may contribute to about 16 percent of gross global warming, which is the warming before cooling is subtracted out, but its control and isolation could reduce 40 percent of net global warming.

Soot particles also differ from greenhouse gases in that soot particles have relatively short lifetimes of around one to four weeks. This compares with thirty to forty-three years for carbon dioxide and eight to twelve years for methane. The lifetime of a chemical is the time required for its concentration in the air to decay to about 37 percent its original value.

Because of soot's short lifetime and strong climate impacts, reduction in its emissions can result in rapid climate benefits. This is illustrated by the figure now on the screen, which shows that controlling soot could reduce

temperatures faster than controlling carbon dioxide for up to ten years, but controlling carbon dioxide has a larger overall climate benefit over 100 years.

Whereas the U.S. emits about 21 percent of global anthropogenic carbon dioxide, it emits about a little over 6 percent of global fossil fuel plus biofuel soot. Nevertheless, the warming due to U.S. soot appears to exceed the warming due to U.S. methane and nitrous oxide.

Proposed methods of controlling fossil fuel soot have included improving engines, changing fuels, adding particle traps, and changing vehicle types. Recent emission regulations in the United States have begun to address reducing particle emissions, but more needs to be done.

It is thought that because diesel vehicles contain better gas mileage than gasoline vehicles, using more diesel will slow global warming; however, this concept ignores the larger emissions of fossil fuel soot from diesel and the resulting climate effects. Further, the addition of a particle trap to diesel vehicles, while decreasing particles significantly, increases carbon dioxide, and the ratio of NO2 to NO in exhaust, thereby increasing ozone in most of the U.S.

Improvements in neither gasoline nor diesel vehicles can contribute significantly to reducing carbon dioxide emissions by 80 percent, the level needed to stabilize atmospheric carbon dioxide, while accounting for future economic growth. A more certain method is to convert from fossil fuel to electric, plug-in hybrid, or hydrogen fuel cell vehicles, where the electricity or hydrogen is produced by a renewable source such as wind, solar, geothermal, hydroelectric wave, or tidal power. Such a conversion would reduce global warming and improve human health simultaneously.

The figure on the screen shows results for the first wind mapping study of North America at 80 meters above the ground. This is all from data. The Great Plains has long been known as the Saudi Arabia of wind, but the figure identifies other ares, particularly coastal, of intense winds that were previously unknown. The data indicate that the U.S. has twice as much wind energy than total energy consumed from all sources, and ten times as much wind energy as electricity consumed in locations where wind is economical.

The U.S. could replace all its on-road vehicles with battery electric vehicles powered by 71,000 to 122,000 five-megawatt wind turbines, which is less than the 300,000 airplanes produced during World War II by the United States.

The land area needed for such wind turbines is 0.5 percent of the U.S., much less than the 15 percent of the U.S. that has fast wind. The wind area required is also 1/30th of that required for corn ethanol and 1/20th of that required for cellulosic ethanol to replace the same vehicles. The land area required for solar energy is also very low.

In sum, an effective method of reducing the combined effects of carbon dioxide and soot on climate and health is to convert as many combustion devices as possible to those powered by renewable energy.

Thank you again for considering my testimony.

[Prepared statement of Mr. Jacobson follows:]

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*Chairman Waxman. Thank you. We appreciate that testimony.

Dr. Bond, we would like to hear from you.

STATEMENT OF TAMI C. BOND

*Ms. Bond. Chairman Waxman, Ranking Member Davis, and members of the Committee, I have spent the last 12 years modeling and measuring sources of black carbon, and I am pleased to share my expertise about the role of black carbon in climate change.

I commend your Committee for continuing this discussion at a national level, and I am honored to participate. Thank you very much for your invitation.

I will speak to you on sources of black carbon, its role in the climate system, and the potential for mitigation. These are the major points of my presentation, which are supported further in my written testimony:

First, the major sources of black carbon are known.

Second, historically clean alternatives reduce black carbon emissions. This transition occurs naturally during economic development, but it can be accelerated.

Third, black carbon and other products of incomplete combustion should be considered together with greenhouse gases.

Fourth, mitigation options that address black carbon, particularly in developed countries, are not always cost effective compared to greenhouse gases when climate benefits alone are considered.

Fifth, some options can economically reduce warming. These offer major co-benefits in terms of human health and local environmental protection.

The first slide there is showing that black carbon emissions in 2000 came from four categories: diesel engines for transportation or industrial use; solid fuels, such as wood and coal, for cooking and heating; open forest and savannah burning, both natural and for land clearing; and solid fuel use in industrial combustion.

The comparative magnitude of each contribution will change as these estimates improve, but the major sources will neither vanish nor grow to dominate the whole picture.

Fuel use in the United States has grown phenomenally since World War II, but black carbon emissions have decreased due to cleaner technology and fuels. Estimates of the North American emission trend are broadly consistent with the Arctic record.

History suggests a consistent trajectory during a nation's economic development. Initially, emissions come from solid fuels for heating and cooking. These fade as incomes increase and clean household energy is introduced.

Next, emissions from the industrial sector increase and are reduced by regulation. In the meantime, internal combustion engines for transportation and other mobile power proliferate and eventually dominate.

It is rarely possible to reduce greenhouse gases alone, aerosols alone, or black carbon alone. Evaluating all emissions from a single source is more comprehensive and more accurate than looking at the effects of individual chemical species such as carbon dioxide only.

No current efforts on climate mitigation are evaluated in this way; however, rapid changes such as those occurring in the Arctic suggest that no opportunity should be missed.

Particles from diesel engines and cook stoves are strongly light absorbing and therefore warming, despite the presence of non-absorbing cooling particles from these sources. Particles from open biomass burning, however, are on the border between cooling and warming.

This figure shows a very preliminary evaluation of cost-effectiveness in terms of CO2 equivalent reductions. Here I discuss only methods of eliminating existing black carbon emissions.

Mitigation options for solid fuel combustion include improving wood cook stoves and promoting cleaner fuels, including distillate fossil fuels. This would also reduce exposure to indoor smoke, a major health hazard.

Reducing vehicle emissions is possible through accelerated retirement, retrofits, and targeting of high emitters.

The figure I show supports some optimism, because some costs are close to worthwhile, even from a climate protection perspective. Some reductions appear affordable, while some appear costly; however, consideration of immediate benefits, health and environmental protection, and Arctic snow forcing will decrease the costs, as well. However, caution is also necessary.

First, many of the least-expensive mitigation actions can be found in developing countries. Industrialized countries have already enacted many of the least-expensive aerosol reductions, and the remaining black carbon is expensive to mitigate. Thus, acknowledging the role of black carbon in the climate system is unlikely to detract developed countries from reducing greenhouse gases.

Second, reductions may be challenging, despite strong justification for climate protection. The two measures that appear most promising -- reducing diesel emissions and improving cooking fuels -- involve millions of small sources and operators, whose ability to afford the relatively low-cost investments is limited.

In conclusion, black carbon reductions can contribute to climate protection, and exploration of this possibility should proceed rapidly, although cautiously. Reducing emissions can eliminate warming quickly, and in some cases economically. These measures also result in major health and environmental benefits; however, they are not always cost effective for climate purposes, alone, especially in industrialized countries, and they reduce warming only in the short term.

Thank you.

[Prepared statement of Ms. Bond follows:]

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*Chairman Waxman. Thank you very much, Dr. Bond.
Dr. Ramanathan?

STATEMENT OF V. RAMANATHAN

*Mr. Ramanathan. Honorable Chairman and members of the Committee, I am really honored to be here. I am going to talk about more the global and regional effects of these black carbon particles.

They basically start off as soot as an urban or rural haze, and then fast atmospheric transport spreads this haze far and wide in a matter of a week over an entire subcontinent or an ocean basin. My basic work is to use satellite measurements to track these plumes and then launch aircraft to make detailed measurements of their effects on climate.

In atmosphere, black carbon is mixed with other particles such as sulfates, nitrates, and together the mix of manmade particles are sometimes referred to as atmospheric brown clouds, or ABCs.

First, touching on the global warming issue, BC is one of the strongest absorbers as far as particles are concerned of solar radiation in the atmosphere. My own estimates of BC heating from observations such as that the current solar warming effect of BC is maybe as much as 60 percent of that current CO2 greenhouse warming effect.

I want to point out that the estimates of the BC warming effect are uncertain by a factor of three or more, as well as our understanding of the emissions.

Now, digressing to the whole mix of particles, I want to comment on the global water budget. These brown clouds lead to large reductions in the amount of sunlight in the surface, and we call it dimming, and the corresponding increase in the solar heating. They both are two sides of the same coin. Together, the ABC dimming leads to a weaker hydrological cycle and drying of the planet, which connects ABCs, or atmospheric brown clouds, directly to availability of fresh water.

Moving on to the regional climate impacts, the regional effects of brown clouds are estimated to be particularly large over Asia, Africa, and the Arctic. Since the dimming and atmospheric heating are non-uniform in space and time, modern studies have linked the black carbon effects on climate to the Saharan drought, the decrease in monsoon rainfall over India, and drying of modern China. These are all recent model studies.

A more recent study by my group employing unmanned aerial vehicles, or UAVs, show from direct observations black carbon enhances atmospheric solar heating by about 50 percent. This heating may have contributed as much as greenhouse warming to the glacier retreat, which is a major, major issue for the Asian region.

I want to comment next to last on the black carbon reductions and its effect on global warming. I basically consider this not as a mitigation in complete, more as buying time, because the BC warming effect may offer an opportunity to reduce the projected warming trends in the short term.

The lifetime of BC is about a few weeks, so its effect would manifest almost immediately. The reduction of BC emissions is also important to public health, and I defer to my colleague, Dr. Schwartz, for that.

Let me proceed to understand, because of the uncertainty, by a careful and well-documented, scientific study of the impact of black carbon reduction. Towards this goal we have teamed up with a team of NGOs and public health experts and proposed a project in the [foreign word] region in India where we are going to adopt a large rural area with 20,000 population and provide alternate cooking and biogas plans and measure the impact of this on the atmosphere.

Lastly, I want to comment on the black carbon reduction is not proposed as an alternative to CO2 reduction; at best, it is a short-term measure to probably buy a decade or two, time for implementing CO2 emission reduction strategies.

The problem is highly uncertain, so I wanted to summarize with what is it we have reasonable consensus on. First, the lifetime of black carbon is about a few days to a few weeks is generally agreed upon, and globally black carbon has a net warming effect on the climate system, that is also generally agreed. However, the magnitude of the current warming effect is subject to a large uncertainty ranging from 15 percent to as much as 60 percent of the warming effect of CO2.

Next also there is a consensus BC adds solar heating to the atmosphere but causes dimming of the surface.

The fifth point -- again, reasonable consensus -- is atmospheric brown clouds' -- this is BC -- own particles lead to dimming of the surface, and the global average effect of this is to decrease rainfall.

And the last point, which will be addressed by my colleague -- we have reasonable consensus on that -- deposition of BC on sea ice and snow darken the surface and leads to more solar absorption and melting of sea ice and snow.

Prior confirmation is the regional effects of BC on shifts in the rainfall patterns and the retreat of the Himalayan glaciers. These need additional studies.

Thank you, Mr. Chairman.

[Prepared statement of Mr. Ramanathan follows:]

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*Chairman Waxman. Thank you very much for your testimony.
Dr. Zender?

STATEMENT OF CHARLES ZENDER

*Mr. Zender. Thank you Chairman Waxman, Mr. Davis, and members and staff of the Committee for hearing my testimony regarding the effects of black carbon on Arctic climate.

The Arctic is warming about twice as rapidly as the rest of earth. Although long-lived, manmade greenhouse gases are the dominant cause of earth's recent warming, short-lived black carbon particles explain a significant fraction of the observed Arctic warming.

My colleagues have described what BC is, where it comes from, and how effectively BC reductions could slow near-term global warming. The four points most relevant to black carbon in the Arctic are:

First, that most Arctic black carbon comes from fossil fuel combustion, not from open fires;

Second, black carbon appears to warm the Arctic more than any other agent except CO2;

Third, Arctic climate is very sensitive to the surface warming of the type that black carbon causes;

Fourth, reducing Arctic black carbon now will cool the plant more than will a delayed reduction.

We know that economic and technological factors affect Arctic black carbon concentrations. From 1880 to 1950, industrial emissions increased black carbon concentrations in Greenland's snow seven-fold relative to pre-industrial levels. Black carbon concentrations in Greenland have been lower since about 1950, likely due to North American shifts in combustion fuels and technology, combined with wildfire suppression.

Black carbon decreased in some Arctic regions from the late 1980s and early 1990s during the decline of industrial activity in the former Soviet Union. Late 20th century increases in Greenland black carbon may be linked to increased coal combustion in the rapidly expanding Asian economies.

There are three reasons why black carbon warms the Arctic more than any agent except CO2. First, black carbon absorbs sunlight and warms the Arctic atmosphere by approximately the same amount as human injected CO2. This happens in spring and summer when snow and ice are most vulnerable to melting.

Second, black carbon also warms the Arctic, including in winter, by thickening low-level clouds that then trap more of earth's emitted heat.

Finally, black carbon warms the Arctic after it lands on the surface. Uniquely, surface black carbon is an impurity that darkens the otherwise bright Arctic snow and ice, causing them to absorb more sunlight. This dirty snow, seen in the picture, warms and melts the Arctic's surface very efficiently, because the heat is trapped at the surface by the strong Arctic temperature inversions and by the insulating properties of the snow, itself.

Over the course of the Arctic spring, black-carbon-contaminated snow absorbs enough extra sunlight to melt earlier, weeks earlier in some places, than clean snow.

Melting Arctic surfaces uncover the darker, underlying surfaces such as tundra and ocean. These dark surfaces then absorb even more sunlight, triggering a powerful climate warming mechanism known as the ice-albedo feedback.

In the pre-industrial climate, black carbon was less effective than wind-blown dust at triggering alce-albedo warming, but, as shown in this slide, manmade greenhouse gases have not only warmed the Arctic; they have exacerbated its vulnerability to warming by other pollutants such as black carbon.

The diagram shows that darkening of snow and ice by human-injected black carbon has warmed the Arctic by about half a degree centigrade since the pre-industrial era. Warm snow is darker than cold snow, so the ability of a cleaner Arctic surface to cool the planet will diminish as the Arctic warms. Snow and ice retreat also weaken black carbon's leverage over Arctic climate; hence, the diagram shows that reducing the concentration of black carbon now will cool the Arctic significantly more than a delayed reduction.

Nothing in climate is more aptly described as a tipping point than the zero-degree centigrade boundary that separates frozen from liquid water. The bright, reflective snow and ice from the dark, heat-absorbing ocean, arctic snow, glaciers, and sea ice are, on average, about 1.5 centigrade warmer than in the pre-industrial era. This may not sound like a lot, but each above-freezing day causes more melt, which amplifies the strong Arctic warming effects.

Greenhouse gas and black-carbon-induced warming are inexorably pushing more of the Arctic earlier in the year toward its zero-degree centigrade tipping point.

In summary, because of its short life time and strong effects, reducing Arctic black carbon concentrations sooner rather than later is the most efficient way that we know of to retard Arctic warming.

Thank you for your attention.

[Prepared statement of Mr. Zender follows:]

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*Chairman Waxman. Thank you very much, Dr. Zender.
Dr. Schwartz?

STATEMENT OF JOEL SCHWARTZ

*Mr. Schwartz. Thank you very much, Chairman Waxman, Mr. Davis, members of the Committee. I am pleased to be here to talk to you about the health effects of black carbon, if I can get my slides up.

*Chairman Waxman. I want to congratulate all of you on the successful slides that you have had available to you in your presentation. It is very helpful to be able to follow the slides and actually see them.

*Mr. Schwartz. I want to start off by showing you what we are talking about. Particulate air pollution is, in fact, the only manmade object that is visible from space, and you can see it over here over Bangladesh and the Himalayas up in the north.

You have heard a lot about what those particles do when they are up in the atmosphere in terms of absorbing heat, but I want to point out that the highest concentration of those particles is about at that altitude here where people breathe, and so I want to talk about what we know about the health effects of breathing those particles.

One of the things we know comes from the Harvard Six Cities Study, and this has now been replicated in a bunch of other cohort studies, and that is that breathing particles shortens people's life expectancy, and by non-trivial amounts. This is after controlling for hypertension, smoking, individual risk factors, the life expectancy in six U.S. cities versus the PM2.5 concentration, which is the total concentration of all combustion particles, not just the black ones. You can see more than a two-year difference in life expectancy between the most-polluted and the least-polluted of these U.S. cities.

Again, this has been seen in multiple studies.

What is most interesting is what we saw when we went back to those cities and looked at another ten years of follow-up in this cohort of individuals we had been studying. That was that, as air pollution levels declined in U.S. cities, the mortality rates -- not life expectancy, but mortality rates on the Y axis -- went down. And in the cities such as Stubenville with the "S'' where there was a large drop in particle concentrations, there was a large change in mortality rates, whereas in Topeka with the "T'' you can see a small drop in particle concentrations and a small drop in mortality rates.

So not only do we see that particles shorten life; we see that controlling particles results in a reduction in the mortality rate relatively quickly. So just as we get the global warming effects quickly, we get the mortality benefits quickly.

Now, again, this is talking about all combustion particles. What do we know about black carbon in particular? Not nearly as much, because we have only recently started to look at different kinds of combustion particles. But there was a study in the Netherlands where they estimated black carbon concentrations outside the homes of people based on models they fit using their monitoring data, and they also found that long-term exposure to black carbon was associated with a shortened life expectancy.

But what was interesting is the effect of the size that they saw. The amount of shortening was bigger per unit reduction in black carbon than what we saw per unit reduction of all combustion particles, suggesting that these particles, which in Europe and North America are predominately from diesel, are more toxic than average. Getting rid of them has more health benefits than average.

We did a study in eastern Massachusetts where we also put out 83 monitoring stations around the Boston metropolitan area measuring black carbon and developed a model to estimate the variation in black carbon concentrations over

space and time, and then we got data on all the deaths in eastern Massachusetts, and we geocoded everybody's addresses. Looking at the people who died out-of-hospital, we found that, at the 75th percentile of black carbon concentration, 2.3 percent more deaths per day occurred than at the 25th percentile of black carbon concentrations.

Again, this is larger than what we see for all combustion particles when we look at these short-term effects. And in this study everyone was their own control. We looked at the black carbon outside the address of the subject the day before they died versus a week earlier when they didn't die. On average, it was higher the day before they died. That is what drove those results.

Since black carbon is expensive to measure but since it predominately comes from traffic, there have also been studies that have looked at traffic as a surrogate marker for this exposure. So we looked at all of the confirmed cases of heart attack in Worcester County over a period of a couple of years based on a heart attack registry they have, and we did a case control study with 5,000 cases and 10,000 controls. We found that, again, going from the 25th to the 75th percentile, traffic density within 100 meters of your house, increased your risk of having a heart attack by 4 percent, and at the same time controlling for that, every kilometer closer you lived to a major highway increased your risk of a heart attack by another 5 percent.

We followed people who had been admitted to the hospital for heart failure, which is a growing disease in the United States, and looked at their survival rate. We again found that doubling the traffic within 100 meters of the home increased their risk of dying in the next five years by 5 percent, and doubling the distance to a bus route cut the risk by 3 percent, so a significant contributor to mortality risks.

Now, that is in the United States, but, as you heard, most of the black carbon emissions are actually coming from developing countries, and what can we say about them?

First of all, heart disease is an increasing cause of death in China and in India, and so increasing risks for those matter to them, too.

Secondly, we did a randomized trial of people in Guatemala in the highlands retrofitting a chimney stove into their homes where they cooked without a chimney before and reducing their exposure to all of this biomass soot. What we saw in adult women in those homes was that doing that reduced their blood pressure by about 3.5 millimeters of mercury. That is half as much as you can get from giving people drugs to treat hypertension.

So, as heart disease is a growing cause of death in the developing world, there are opportunities there for them to improve the health of their subjects and reduce mortality substantially by doing things to control black carbon.

I would like to end by saying that the conundrum with carbon dioxide control is that everyone gets to benefit, even if you are the only one who pays. So we all want the other guy to pay. But you only get the benefit of the health effects of reduced exposure to black carbon if you are the one who reduces the exposure, because these things occur locally.

So China and India are the ones that are going to reap the health benefits of controlling black carbon in the future, and I think that has great prospects for helping us to convince them that it is time to act now.

Thank you.

[Prepared statement of Mr. Schwartz follows:]

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*Chairman Waxman. Thank you very much.

I am going to start off the questions.

In 2002 the National Snow and Ice Data Center in Boulder, Colorado, reported that summertime melting in the Arctic was at a record level. If the Arctic sea ice continued to shrink at the same rate, they predicted that the Arctic could be ice-free in the summer of 2050.

In February of this year the Inter-Governmental Panel on Climate Change confirmed this view, projecting that it was possible that the Arctic could be ice free in summertime by the latter part of this century. Many around the world were shocked to think that we could see such a turn of events as soon as 2050, but then the summer of 2007 brought unexpected melting. Arctic sea ice plummeted to the lowest level ever recorded, shattering the previous record by nearly 25 percent. According to the National Snow and Ice Data Center, sea ice may have fallen by as much as 50 percent from the 1950s.

On October 1st the Center reported that the sea ice is in a downward spiral and may have passed the point of no return. As a years go by, we are losing more and more ice and summer and growing back less and less in winter.

The Center went on to say that the Arctic Ocean could be ice-free in summer as soon as 2030. According to some scientists, we may lose the Arctic sea ice even sooner than that.

Dr. Zender, you testified that the Arctic is warming about twice as rapidly as the rest of the earth. Can you tell us if we need to be concerned about what is happening in the Arctic? And also how important is black carbon in what is happening in the Arctic?

*Mr. Zender. Well, certainly the recent trends in Arctic sea ice extent are quite troubling. As you mentioned, the long-term trend until the last one or two years was about 8 percent per decade. With this year's record retreat, there is 23 percent less sea ice in the arctic than there was in 2005, the year of the previous record low.

What is troubling about these trends is that they are in agreement with model predictions that predict a steady decline followed by an abrupt tipping point, or complete disappearance of summertime Arctic sea ice.

The disappearance of summertime Arctic sea ice would be hard to imagine. It would be difficult to imagine a plausible mechanism to restore that sea ice in the future. Melting of Arctic ice surfaces is what you might call a wet process. It can occur very quickly. Ice can slide into the ocean very quickly, whereas restoration of such ice, sea ice, and glaciers is a slow, dry process that takes an order of magnitude longer to occur.

Conservative estimates which placed summertime ice-free Arctic in about the year 2040 a few years ago have reevaluated their findings. Many scientists think that an ice-free Arctic could occur much sooner, perhaps as quickly as 20 years.

I think the overall concern that is unique to the Arctic about warming is that when ice on land -- not sea ice, but ice on land -- melts, it contributes directly and immediately to sea level rise. Sea level rise is, of course, something that affects everyone worldwide who lives near the coast.

*Chairman Waxman. The ice, if it melts in the water, would not contribute to the increasing ocean levels?

*Mr. Zender. That is true; however, the ice that melts in the water does have an effect on the ocean circulation. By melting the sea ice, we then uncover the underlying ocean, which warms up. One of the critical areas in the Arctic that we are worried about is the temperature of the ocean near the Northern Hemisphere is greatest ice sheet, Greenland. Warming ice near Greenland could reduce the buttressing that the sea ice shelves have, which maintain the land glaciers that drain Greenland ice. If those buttresses disappear, then Greenland's ice balance will quickly turn more negative.

*Chairman Waxman. Let me ask Dr. Jacobson, you testified that because of black carbon's short lifetime in the atmosphere, a reduction in its emissions can result in rapid climate benefits. If we want to forestall the warming we are seeing happen in the Arctic, is reducing black carbon part of the solution? And would we be able to achieve results as quickly by focusing solely on carbon dioxide?

*Mr. Jacobson. Yes, it is part of the solution. I think, as I mentioned in my testimony, the global contribution to global warming by black carbon from fossil fuel and biofuel sources is about 16 percent or so, and on a global scale. So theoretically, if you reduce all the black carbon worldwide from those sources, you could have a fast impact on reducing maybe proportionately not quite that number in the Arctic.

In the U.S.'s case, U.S.'s contribution is about 6 percent, so there is less of an impact on average.

Of course, it depends on the effect of the Arctic countries that are responsible for the warming from black carbon, and it is not easy to tell, but the U.S. is a portion, and then there is Europe, and then there is Russia, and there is Southeast Asia and other parts of Asia that are contributing.

But we have definitely got a beneficial impact by controlling in the U.S. black carbon. It is not going to be a huge impact. You have to control the CO2 simultaneously to ensure long-term stability of the Arctic, but you can get an immediate feedback, so there is a benefit.

*Chairman Waxman. CO2 control is not going to be sufficient alone?

*Mr. Jacobson. Definitely not in the short term, because, because of the long lifetime of CO2, the warming that is occurring in the atmosphere due to CO2, even if we eliminated all emissions today of CO2, anthropogenic emissions, you are not going to see the feedback on the global climate system for many years to decades to come. We will see a little bit incrementally, but if you control all the CO2 emissions today compared to all the black carbon emissions -- and there is a lot more CO2 emitted -- it would take at least ten years before CO2 effects outpace the black carbon effects on this climate impact. So it is faster cooling if you control the black carbon compared to the CO2; however, you want to do both simultaneously.

*Chairman Waxman. Yes. Dr. Bond, you worked to understand the sources of black carbon. Can you tell us if we know which sources we need to control if we want to reduce the presence of black carbon in the Arctic?

*Ms. Bond. There have been studies done that suggest that about a third of the black carbon is from the U.S. and Europe, and about a third is from the developing world, especially in south and east Asia, and about a third is from arboreal forests. Now, these are still uncertain, but those give you the biggest contributors.

I believe that we know the sources in each of those regions. In the developed countries, as I mentioned during my testimony, a lot of it is from transportation, including both on-road and off-road mobile sources. Both the U.S. and Europe have taken action to reduce emissions from these sources, which means that they will be coming down in the near future, but it also means that there is experience in regulating those kinds of sources and in being successful at bringing the emissions down.

There are also measures to reduce emissions from solid fuel combustion in developing countries and, as well, from industrial combustion.

Those are the two major industrial type of sources that can be reduced. I don't think that we have a clear understanding of how to reduce black carbon from open biomass burning, especially remote forest burning. Some of those options have been looked at in terms of cost and they turn out to be extremely expensive, so I would say that the transportation and residential solid fuels would be the place to look first.

*Chairman Waxman. Thank you.

Mr. Davis?

*Mr. Davis of Virginia. Thank you very much, Mr. Chairman. I want to thank the panel.

Now, Europeans have really moved to diesel, haven't they, which is worse for black carbon; is that correct? And so they may be ahead of us in some ways and kind of behind. Is there any thought there of scrubbing this and moving to something else?

*Mr. Jacobson. The Europeans, about 40 to 50 percent of all the passenger vehicles sold are diesel. They emit a lot more NOX. A diesel vehicle emits a lot more oxides of nitrogen, maybe ten times more than a gasoline vehicle. Also, without a control device, a huge amount more, a factor of five to ten more particulate matter --

*Mr. Davis of Virginia. You can see it in a diesel.

*Mr. Jacobson. Yes. And so a lot of the new cars now, they put particle traps on a lot of the new cars, but even with the particle trap, the particle trap decreases the mileage of the diesel by about 3 to 8 percent, so that means more CO2 emissions, so there is a tradeoff. By reducing the particles, you increase the CO2 emissions from the vehicles, but also you also change this ratio in the exhaust of the NO2 to NO.

In the U.S., what that does is NO2 is a precursor to ozone in smog. In the U.S. that really produces smog right out of tailpipe. In Europe, where it is a little higher latitude, it is not so much. But in the U.S. we did a study looking what the effect would be, and you increase on average ozone over the U.S. by adding a trap to new diesel vehicles.

*Mr. Davis of Virginia. Let me ask, I don't know who is best able to answer this, but what happens to black carbon once it has reached its life span? Does it just disappear? Does it settle on ice and continue to trap heat? Does it settle but stop conducting heat? What happens? What is the life span?

*Mr. Jacobson. Most of it is removed by precipitation and most of it will go over the ocean. Now, the stuff that settles onto snow, that will have a longer impact if it settles onto snow or sea ice because it sits there for a while until it gets buried or it sinks or is covered up by more snow, but even that more snow will have some black carbon. So most of it is removed to the oceans eventually, and a lot of it will deposit to the surface, too, in rain or in just some deposition to the surface. That stuff, because the surface is soil or blacktop or whatever it is, it is not going to have much of an impact there except maybe if it goes over sand in the desert.

*Mr. Davis of Virginia. Dr. Ramanathan, let me ask you what percentage of the melting ice sheets in the arctic can you contribute to the black carbon? Is it hard to put a percentage on it?

*Mr. Ramanathan. I have not by myself estimated the Arctic part. I think that is what Dr. Zender was talking about. But the key thing is in the Arctic, as I think was the point, the transport comes from all directions. Some comes from east Asia. We track these. Some comes from North America and eastern Europe, so all these sources are contributing to that.

The one issue I want to point out which has not come up is that we the sea ice retreating, there are no talks about new ships traveling through the open water, and ship is a major source for black carbon. I am concerned that now there is going to be an additional source of black carbon directly depositing and facilitating more ship traffic. That is an issue that has not come up yet and we need to worry about that, too.

*Mr. Davis of Virginia. Let me ask Dr. Bond what respective roles should the developing and the under-developed nations play in mitigating the emissions of black carbon? What I am trying to say is, Was it a mistake not to include that in the Kyoto Protocol?

*Ms. Bond. Was it a mistake? No. The Kyoto Protocol was a first step. It was never meant to be the ultimate solution.

*Mr. Davis of Virginia. The end all. Yes.

*Ms. Bond. So I am not going to comment on what we should have done in the Kyoto Protocol. What matters is what we can do now and next. I don't believe that we can reduce black carbon impacts on the global atmosphere without the cooperation of developing countries, but I think that all of this is consistent with the Framework Convention on Climate Change, which refers to differentiated responsibilities between developed and developing countries.

*Mr. Davis of Virginia. Sure.

*Mr. Ramanathan. I think we have to remember that close to 80 percent of the black carbon emission comes from developing nations.

*Mr. Davis of Virginia. Right.

*Mr. Ramanathan. Asia, Africa, Latin America. Because of the impact of the black carbon on the local and regional climate and the glacier retreat, my own experience with India and China is there is tremendous interest in focusing on the air pollution issues.

*Mr. Davis of Virginia. Yes. I have been to Shihon in China where people have to wear masks over their faces. That is the health issues that you addressed earlier, in addition to the global warming. But the polar caps, how much of this stuff finds its way up there? Obviously, you are talking about the steamships and planes, but is there that much other stuff up there that is generating the black carbon at the polar caps?

*Mr. Ramanathan. I will defer to others.

*Mr. Zender. The concentrations of black carbon in the Arctic are relatively low relative to the developing world where the sources are. The problem in the Arctic is that this black carbon has essentially a double or even triple lifetime. Because the Arctic is so very bright, as you know, the sunlight that it can absorb has two chances to be absorbed by it: on its way down, and on its way back up being reflected from the ice sheets. But then that third lifetime that I mentioned is once it lands on the surface a very, very small concentration of black carbon -- we are talking parts per billion --

*Mr. Davis of Virginia. It is just more potent there, basically? Is that what you are saying?

*Mr. Zender. It is just more potent. It is the most potent warming agent we know of in the Arctic.

*Mr. Davis of Virginia. Okay. So it may not be significant in terms of its volume compared to other places, but it just has a more potent effect there?

*Mr. Zender. That is right. The exposure to inhaled black carbon is very low in the Arctic; it is the atmospheric and surface effects and their consequences on climate that are of the most immediate concern, I think.

*Mr. Davis of Virginia. Now, the sources for black carbon for the developed world are basically different from the developing world? For example, in Africa you have wood-burning stoves, we are cutting down and burning trees, and it may be diesel in Europe. Is that fair to say?

*Ms. Bond. It is fair. It is a different mix. We still have fireplaces here.

*Mr. Davis of Virginia. Right.

*Ms. Bond. So it is not completely different, but for the most part this country and Europe has the benefit of access to clean household energy, but we have a lot of transport. We have a lot more transport because we have more goods. So there is a different mix, and if you --

*Mr. Davis of Virginia. So if you fly a private plane somewhere, you are creating more black carbon, basically?

*Ms. Bond. That is true.

*Mr. Davis of Virginia. As opposed to flying coach or first class or something somewhere else, I mean, just to get into it. Yes.

If we make these technologies available to the developing world, are they available now and just not economic? I mean, what is the issue? I know in

China we talked about Shihon. In Beijing we were there and didn't see the sky for three days, the smog was so bad. I mean, you would think over there if you make these technologies available somebody would do something about it. What is the problem?

*Mr. Ramanathan. I can comment on rural regions of India.

*Mr. Davis of Virginia. Okay. India is fine.

*Mr. Ramanathan. Major source of biofuel. The government has connections to gas, natural gas, for cooking, but they can't afford it, so it is in some parts technology and others just sheer affordability of it.

*Mr. Davis of Virginia. When you said that you meant natural gas or propane. Propane in the third world is the preferable choice if available.

*Mr. Ramanathan. This is methane, not propane.

*Mr. Davis of Virginia. Thank you, Mr. Chairman.

*Chairman Waxman. Thank you, Mr. Davis.

Mr. Cummings?

*Mr. Cummings. Thank you very much, Mr. Chairman.

Each of the witnesses today have emphasized that there are opportunities for mitigating emissions of black carbon. It seems that if we could reduce emissions of black carbon we could potentially realizes significant climate benefits.

Dr. Jacobson, what is your advice to us as we begin to explore controls of black carbon emissions?

*Mr. Jacobson. Sir, there is the direct way of reducing emissions, which is adding particle traps to vehicles. In the U.S., it is the off-road vehicles that are creating the most emissions, the construction machines.

*Mr. Cummings. The adding particle traps, is that a very expensive venture?

*Mr. Jacobson. I don't know the exact cost. The number I heard per tractor was $3,000, maybe to $5,000 or $6,000 if it is a big tractor, but that was a few years ago. I don't know. Tami might now.

*Mr. Schwartz. You know, for a bus or for a typical sized piece of construction equipment it is a couple of thousand dollars to add these things, but then they last for a long time. That is a capital cost.

*Mr. Cummings. When you say cost, you mean perhaps the life of the bus or the tractor?

*Mr. Schwartz. Yes. Or at least a good fraction of the life. The thing is that the new rules the U.S. EPA put out and the new Euro Five standards for diesel engines are only for new diesel engines. There is no retrofit requirement. That is where the opportunity is. There is an opportunity to retrofit it on existing engines, because diesel engines often last for 30 years.

*Mr. Cummings. Yes.

*Mr. Schwartz. That has been done. In London they retrofitted all 6,000 London buses with particle traps in two years. In Massachusetts they are going to retrofit all the municipal and school buses in a three-year period. There are retrofit kits commercially for sale, and it is definitely a doable thing.

*Mr. Jacobson. But let me caution. That is an immediate step, but there are these unintended consequences, like the lower mileage, and therefore the higher CO2 emissions resulting from those traps, and also the change in the NO2 to NO ratio, which affects the ozone. This is particularly important for these big vehicles, the trucks especially that are replaced with traps. There you get the highest ratio of NO2 to NO, which would exacerbate the smog the most.

But I think even a better maybe -- I don't know if it is a short-or long-term -- solution is really if you want to control both the soot and the CO2 simultaneously and the other air pollutants coming from these vehicles, it is really to switch your vehicle types to electric, plug-in hybrids, hydrogen fuel cell vehicles, because these all can eliminate simultaneously your CO2, your

black carbon, your ozone precursors, and the ozone and the particulates are the ones that cause most of the health problems, particulates even more.

So you can really solve the whole problem by really focusing on these different types of vehicles rather than trying to incrementally improve just the emissions of the black carbon or reduce the black carbon.

*Mr. Cummings. Dr. Schwartz, you look like you are trying to jump out your seat. Did you want to say something?

*Mr. Schwartz. Well, I agree that in the long term that is the way to go, but I need to point out that there are retrofit kits, particle traps and particle filters, that can be put on vehicles tomorrow, and that hydrogen fuel cell-powered or all-electric garbage trucks aren't going to be here for quite a while, and so there is an opportunity to have a staged strategy where we do something for the existing fleet with the commercially available technology that can be implemented in a couple of years, while developing the new vehicles that replace those vehicles when they come to the end of their lifetime.

*Mr. Cummings. Okay.

Dr. Ramanathan, you have studied emissions in Asia. What can you tell us about the mitigation opportunities there?

*Mr. Ramanathan. It is my personal view there are huge opportunities in terms of trying to mitigate the global warming potential. When you talk about Arctic, all these discussions are germane, but when you want to reduce the global warming, potential black carbon --

*Mr. Cummings. Can you keep your voice up?

*Mr. Ramanathan. When you want to reduce the global warming potential of black carbon, your focus has to be on Asia and Africa and Latin America, because that is where the main sources are.

Although not an economist, I would venture to speculate it would be a lot cheaper to try to mitigate black carbon emission in Asia, particularly India and China in the major focus. For example, the biofuel emissions, cooking with wood and cow dung is at least 50 percent of the total emission of black carbon from south Asia. Replacing those cookers with solar cookers or biogas plans, the relative cost we have to estimate. That is what we are trying to do. But I think that is where the huge potential is there, the emission of black carbon, coal-fired appliance in China and biofuels in India and Africa.

This is a major vulnerable region. I wish I brought substance abuse. You will see huge plumes covering most of central Africa from the savannah burning. That is where I see major opportunities.

*Mr. Cummings. Thank you.

*Chairman Waxman. Thank you, Mr. Cummings.

Mr. Bilbray?

*Mr. Bilbray. Thank you, Mr. Chairman.

Dr. Schwartz, I have been sort of out of the business, the air resources business, for a while, so if you can give me a crash refresher course, when you were talking about the morbidity related to diesel emissions, referring specifically to the particulates, I didn't hear you discuss what we ran into at the Air Resources Board in California, which was that the true toxic component was the benzene, and that the particulate was tending to be the carrying agent. Is the benzene still considered the most toxic component in the diesel emission?

*Mr. Schwartz. Well, there is actually more benzene in the exhaust from gasoline vehicles than from diesel vehicles, because aromatics tend to have too much octane, and you don't want octane in a diesel engine, unlike in a gasoline engine, and so you tend in a refinery to segregate the aromatics more to the gasoline. But there is certainly benzene in diesel exhaust, and if you are talking about cancer, then that is where the action is for sure.

But these deaths that we are looking at are deaths from heart disease, and that doesn't seem to be related to the benzene. It seems to be related to something about --

*Mr. Bilbray. So yours was specifically to cardiovascular?

*Mr. Schwartz. To cardiovascular mortality, and that really seems to be the particles.

Now, that said, it may well be that it is something that is carried by these particles other than benzene, like metals or some other things.

*Mr. Bilbray. We found that. I mean, all the talking back in the 1970s was about dioxins. We found that the benzene in the diesel trucks was like a magnitude of 10 to 20 over the toxicity of certain dioxins and whatever, and so all at once we were realizing that to reduce health exposure we weren't doing waste incineration. We were sending around three trucks to recycle materials, and the health impacts were a net negative rather than a net positive.

When you did your modeling for morbidity, did you consider socio-economic numbers?

*Mr. Schwartz. Yes, we controlled for socio-economics.

*Mr. Bilbray. I mean, let's face it, the whole difference in places like Pittsburgh in 20 years going from a coal/steel industry to a high-tech industry, you do have a major jump between socio-economic, and that --

*Mr. Schwartz. And when you are talking about exposure to traffic, you have to remember the people who live on heavily trafficked streets tend to be poorer than the people who live in the nice houses.

*Mr. Bilbray. And people who are poor tend to have certain exposures.

*Mr. Schwartz. Absolutely. So, for example, in our study we had individual education for each of the people who died, and then we had census block group measures of socio-economic status we also controlled for.

*Mr. Bilbray. Yes. The scrubber issue when I was working with Mexico on Mexico City and we worked with Athens reducing their emissions, they went through the scrubber originally, but the natural gas conversion seemed to be the much cleaner quantum leap sort of between where Mr. Jacobson is and where you are with the scrubber of being able to use natural gas as the major source but only using diesel as the igniter. Is there an environmental problem with shifting off actually from being your major source of fuel for these mobile sources from diesel over to natural gas?

*Mr. Schwartz. To my knowledge there isn't an environmental problem. Running buses on natural gas produces considerably less particles than running buses on diesel with a particle trap, so the natural gas conversion certain would make sense. It makes more economic sense on fleets of vehicles that operate around the city and then come back to a terminal every day, either buses or trucks and things where they can fill up with the natural gas, than on the long-haul trucks where it is not always easy to find a source of fuel.

*Mr. Bilbray. Where infrastructure is there.

*Mr. Schwartz. Where the infrastructure is easy to put in. Exactly.

*Mr. Bilbray. I appreciate that.

Dr. Jacobson, the discussion of the transition in California, we were looking at the zero emission generators. California, we went to natural gas with our stationary sources because it was the only way to pencil out a lot of this generation within our air basins. The question is: the low-lying fruit is going to be -- correct me if I am wrong -- has always been stationary sources are always the place we can get the most bang for the buck. I mean, if there was any place historically we have been able to reduce substantially emissions with much more cost-effectiveness, stationary sources have been that, hasn't it?

*Mr. Jacobson. Well, yes. Historically in California most of the electricity is natural gas. We don't have much coal. We have a lot of hydroelectric.

*Mr. Bilbray. Let me correct you, sir. You burn coal in California air basins, you go to prison.

*Mr. Jacobson. Right. Yes. There is very little coal.

*Mr. Bilbray. Our concept is clean coal is about as logical as safe cigarettes.

*Mr. Jacobson. Right. But there is emissions from natural gas, but in California there is room for more renewable energy, of course. That may not be in the question, but we did mapping of winds offshore locations where you get really strong winds, and you can combine wind with hydroelectric, geothermal, and solar and you can power the entire State just about with the available resources.

*Mr. Bilbray. I just want to warn you, we got that issue, and transmission becomes a hot issue.

*Mr. Jacobson. That is the limiting factor, and that is actually why you kind of need maybe a national grid.

*Mr. Bilbray. But I agree with you. I think the big thing that California is going to have to confront is stop using natural gas as your stationary source because it will probably be our transition fuel between what you are talking about and what you are talking about, and we are burning it at power plants rather than using it for our off-road, which is now the big challenge, as Mr. Waxman knows, in California, cracking down on those off-road emissions.

Thank you very much, Mr. Chairman.

*Chairman Waxman. Thank you, Mr. Bilbray.

Ms. McCollum?

*Ms. McCollum. Thank you, Mr. Chair.

This is a very interesting discussion, and I want to thank Mr. Waxman for having it.

Dr. Schwartz, I was feeling pretty good about turning off the air conditioner, leaving the windows open on a main street in D.C. where I hear a lot of trucks, and I know I have a lot of soot because I have to clean here more than I have to clean in the city of St. Paul, Minnesota, so my trying to save burning fossil fuels running an air conditioner might lead to my increased of a heart attack, so thank you very much for not making me feel much better about my decision.

*Mr. Schwartz. Unfortunately, turning on the air conditioner and closing your windows cuts the particle concentrations coming into your house from outside in half.

*Ms. McCollum. And I point that out because this isn't a one-fix solution; this is going to take a lot of different scientists such as yourself sitting around the table and a lot of different people willing to look at different ways and to change their lifestyle, and businesses in the way that they operate in order to really tackle this. This is, like I said, a very interesting discussion, and I thank the Chair for having it.

In Minnesota we decided to retrofit our school buses -- we are calling it Project Green Fleet -- to do what we could to reduce the amount of carbon. Has there been any studies done, for example, if all the school districts were to retrofit, what kind of impact it could have? Would that be a model that we could look at to maybe figure out some targeted ways where we could start doing things and also get the word out?

*Mr. Schwartz. I don't know of any studies that have looked at what the impact of just targeting school bus fleets are. I think that it is such a small fraction of the diesel fuel use in a given city that you are not going to see very much if you just go after the school buses as opposed to the construction equipment and the heavy duty trucks and all the other things, as well.

*Ms. McCollum. But sometimes the way to address the problem is to get people to realize that there is a problem and to starts talking about it.

*Mr. Schwartz. That is absolutely true, and there have been retrofit programs, and EPA funds some retrofit programs to go after school buses. One thing that we can do that is a double winner is all the buses you see lined up on Independence Avenue idling for three hours while the people that they drove

to the museum are inside, if you just turn off the engines of buses when you are not actually driving some place then you save the CO2 and the carbon and all sorts of other stuff. So awareness would be useful.

*Ms. McCollum. We have done that, as well, in Minnesota, to turn the buses off.

*Mr. Schwartz. That is good.

*Ms. McCollum. The developing world discussion is very interesting. I have had a fortune of traveling both in Asia and in Africa. It seems to me that we need to look at doing something similar to what we did with ozone with the Montreal Protocol on this.

Dr. Ramanathan, you have done a fabulous amount of work on this. Can you share with this Committee -- I also serve on State and Foreign Operations Appropriations -- what we can do in working with partner countries to help them reduce their health effects and carbon?

*Mr. Ramanathan. Thank you very much for that question.

I first of all would preface it, there is one thing we have to be aware of. This outdoor haze or this pollution contains partially black carbon, other particles, sulfates, nitrates, et cetera. These are all cooling particles. The black carbon is heating. When you add all of them together, they have massed as much as 50 of the global warming from greenhouse gases. What that means is that we have to be careful when we reduce those particulates.

See, the EPA, not only in the U.S., but the EPAs of the world, they are focusing on air pollution. Traditionally when there is air pollution, it is sulfates. For example, I see in American media we complain about sulfate emissions from China. The problem is if you cut the sulfates and leave the black carbon behind, we can have at least a factor of two amplification in the warming what we will see just from air pollution regulations, because you are taking off the cooling particles.

So we have to make sure. I am not saying we should leave the sulfates behind. They have other ecosystem destruction. But we should make sure when we remove the sulfates we also remove the black carbon. That is number one point.

In fact, Dr. Schwartz and I were in a big intercontinental air pollution meeting in Australia. We tried to bring it up. We tried to educate the air pollution community. Be careful. What you do has implications for climate change.

The second point I want to make is that again I don't want to be misunderstood. We have to cut down sulfate emissions because of acid rain and others, but please let's take out the black carbon at the same time because the sulfates, if any, is shielding the planet from the global warming.

The second is the black carbon emission. I was in a meeting last week where the Prime Minister was there, the finance minister, as well as Mr. Jeb Bush, former governor of Florida. I was surprised how receptive they were when I talked about what the black carbon, haze, is doing to the regional climate and glaciers. As you know, China is now trying to reduce the emissions in Beijing just before the Olympic, and some of us are thinking this is a fantastic natural experiment to see downwind what happens.

For example, we published a study last year: 75 percent of the black carbon over the west coast of the U.S. during springtime comes from long-range transport from east Asia. So we are trying to see do we see an impact on air pollution just for this one-month period.

Although I have not moved in government circles, my assumption is that they would be very receptive to U.S. and European governments trying to approach India and China on this issue and see how collaborations and resource sharing would help them bring down the black carbon emission.

*Chairman Waxman. Dr. Bond, did you want to comment?

*Ms. Bond. I did, if you would allow me to.

*Chairman Waxman. Sure.

*Ms. Bond. I would like to point out that there is already collaboration between governments. At the Sustainable Development Meeting in Johannesburg, the United States and other countries initiated the Partnership for Clean Indoor Air. Now, this was not a climate or outdoor air protection committee; it was a group of organizations that now numbers about 150 NGOs and government organizations internationally, and they are working on the problem of household energy and solid fuels. That is something that has already been started.

Now, the climate benefits have not really been brought into that picture, but they are very receptive.

*Chairman Waxman. Thank you, Ms. McCollum.

Mr. Shays?

*Mr. Shays. Thank you. Mr. Chairman, really thank you so much for holding this hearing. It is rare when we have all doctors coming before us, so when I say "doctor'' I will now have to use a name.

I would first like to ask Dr. Bond if you would turn to page four. I am trying to understand where liquified LNG plants -- there is a real effort to bring LNG into the United States, and it is somewhat controversial, particularly on Long Island Sound, and I have taken a position against it and others have, but I begin to wonder. We are at the end of the pipeline. Am I just making a bad decision here or not?

Liquified natural gas, just explain this middle chart to me, page four. "Energy increases faster than BC due to advances in technology.''

First you describe different types -- biofuel, coal, oil, Middle East, light, distilled, aviation fuel, natural gas.

*Ms. Bond. Okay. Let me understand what you are trying to --

*Mr. Shays. First explain this chart to me.

*Ms. Bond. That chart is the global consumption of energy by fuel.

*Mr. Shays. Okay.

*Ms. Bond. In history.

*Mr. Shays. Now explain to me, in terms of black carbon, is liquified natural gas a less sooty, more sooty, indifferent?

*Ms. Bond. Much less.

*Mr. Shays. Much less.

*Ms. Bond. Certainly. And the point of that figure was that it is both improved technology and cleaner fuels that have contributed to black carbon. This slower increase in black carbon emissions, if black carbon emissions went up as quickly as energy did over the last 50 years, we would not be able to breathe.

*Mr. Shays. Okay. Let me ask you this. In my house I have gas coming in. I now have a heating system that they don't want it to exhaust up through the chimney; they put it through the side of the house. Could they do that with oil as well, or is it more likely they can do it with gas?

*Ms. Bond. Gas burns a lot cleaner than oil.

*Mr. Shays. Right.

*Ms. Bond. Especially during the transient periods where the furnace is turning on and off.

*Mr. Shays. Thank you very much.

Dr. Ramanathan, would you explain to me the charges on eight? It looks like the United States is not that bad a player compared to others in the charts, these charts up top here. I am on page eight.

*Mr. Ramanathan. Yes.

*Mr. Shays. Explain those charts to me, if you would.

*Mr. Ramanathan. Right. This is basically using most recent satellite measurements which give information about particulates, and look at the total loading of particulates in the atmosphere.

*Mr. Shays. And red would be the worst case?

*Mr. Ramanathan. Red is worse. By the time you have seen those charts green to yellow, you would already see the haze in the sky as brown clouds.

*Mr. Shays. So is that the soot blowing off our coast?

*Mr. Ramanathan. Thank you. What you see of the east coast, this is just not only soot, it is all particulates -- sulfates, nitrates. That is why we call them brown cloud.

*Mr. Shays. All particulates. But basically it is in the air blowing from the United States?

*Mr. Ramanathan. Right. And you see that stream is all the coal plants in the east coast just going across the Atlantic.

*Mr. Shays. Okay. And then in China and in India we just see a mass of red.

*Mr. Ramanathan. Exactly.

*Mr. Shays. And it is all coal?

*Mr. Ramanathan. And also I direct your attention to Africa, the savannah burning.

*Mr. Shays. Yes. Now, this is not in defense of the Administration, but it is wanting to understand something. They are doing a lot of bilateral agreements with various countries. The United States was told be part of Kyoto, in spite of the fact that China and India were not. They were told, you know, just be part of the family. If you can't meet it, at least you are part of the team.

But my understanding is the United States has done, in comparison to Europe, not as bad as people would think. That is kind of a negative way to say it, but actually we keep making some improvement. Is Europe making a lot more improvement versus the United States in global warming issues and particulates? Any of you can answer that, if that is all right.

*Mr. Ramanathan. I think as far as the particulates are concerned, Europe versus the United States, I have the expert here. I would rather let Dr. Tami Bond respond to that.

*Ms. Bond. Are you talking about all global warming emissions?

*Mr. Shays. Yes. Let's do that first.

*Ms. Bond. I am not sure I have the background to answer that, because I haven't really looked at energy intensity in Europe or the United States.

*Mr. Shays. Dr. Jacobson?

*Mr. Jacobson. I will try. I think, in terms of air pollution, the U.S. has really been in the forefront, especially California. I mean, California is really the leader in the world.

*Mr. Shays. Mr. Waxman's State?

*Mr. Jacobson. Yes.

*Mr. Shays. Okay.

*Mr. Jacobson. Yes, in terms of air pollution control.

*Chairman Waxman. As opposed to any other California.

*Mr. Jacobson. I am not biased.

*Mr. Schwartz. If I could add to that, if you look at the particle concentrations in urban areas, they are lower in the United States than they are in Europe. Part of that is because of their emphasis on diesel engines, in fact, but not entirely. We have stricter standards on particle emissions in the U.S. than Europe.

*Mr. Shays. Can I ask one last question, Mr. Chairman?

*Chairman Waxman. Sure.

*Mr. Shays. I live in an urban area. We have Indonesian ships that come out way off coast. They transport the coal on the barge and bring it in to a facility three-quarters of a mile from my house, maybe a mile from my house. Should I prefer that they burn -- I think I know the answer -- the so-called less-sulfur coal, or liquified natural gas?

*Mr. Schwartz. You are going to get less CO2 emission per unit of electricity generated and less particulate and sulfate emissions per unit of electricity generated burning liquified natural gas than burning coal, even low-sulfur coal.

*Mr. Shays. Thank you.

*Mr. Jacobson. Can I comment on that? In Long Island there was a proposed wind farm offshore, and that would obviously be better than the other two.

*Mr. Shays. Absolutely. Absolutely, but are they mutually exclusive? That is the question we have to ask.

*Mr. Jacobson. Yes.

*Mr. Shays. Yes. Thank you very much. Thank you again, Mr. Chairman.

*Chairman Waxman. Thank you, Mr. Shays.

Mr. Hodes?

*Mr. Hodes. Thank you, Mr. Chairman. Thank you for having this very important panel. I want to thank the panel for being here today.

I want to focus first on black carbon international agreements. There has been some mention here, but as I understand it black carbon is not explicitly covered by international environmental agreements. Now, black carbon doesn't deplete the ozone layer, so it isn't covered by the Montreal Protocol. And black carbon isn't technically a greenhouse gas, so it is not covered by the United Nations Framework Convention on Climate Change. And the Kyoto Protocol requires the developed world to reduce its emissions of certain greenhouse gases, but the protocol doesn't include black carbon.

Given the depth of the problem which you have now graphically outlined for us, as we engage in new negotiations aiming towards the possibility of future international agreements that will succeed the Kyoto Protocol, should we be seeking to include black carbon in the agreement or agreements that hopefully we will participate in? I can start with Dr. Jacobson, and then anybody else on the panel. I would be interested in hearing your thoughts.

*Mr. Jacobson. I definitely think we should. Even though the United States' portion of the black carbon emissions is on the order of 6 percent -- not the largest -- it is a good example to set for the rest of the world. I strongly feel we should include it, because we know it is a warming agent, and, as you mentioned, it is not being controlled internationally, so it will have dual benefits of health and climate, and I think it should be controlled.

*Mr. Hodes. Dr. Bond?

*Ms. Bond. First of all, I agree with Dr. Jacobson, not just because we want to control all the warming agents, but I think we really want to look at what we are doing when we undertake specific actions. And, as Dr. Jacobson has shown, you can decrease carbon dioxide and increase warming if you don't consider the black carbon. So I think we should at least be comprehensive.

Secondly, I don't agree that black carbon is not in the Framework Convention. I would say it is not part of the objective, which refers to stabilization of greenhouse gases. We don't really want to stabilize black carbon anyway. However, the Framework Convention does say that we should be comprehensive and that we should consider all sources, and sources include aerosols in their definition. So I don't think that what we are talking about is inconsistent, and I do think that future agreements could be conducted under that convention.

*Mr. Hodes. Could I just clarify for one moment? I appreciate the clarification, but it sounds like we need to be more specific about including black carbon as one of those sources which is of concern and not leave it perhaps to the generalized framework that you referred to. Do you agree?

*Ms. Bond. I would agree with that. At the time the Framework Convention was written, this issue was not anywhere on the radar screen.

*Mr. Hodes. Great. Thank you.

*Mr. Ramanathan. I participated in the Intergovernmental Panel on Climate Change. In addition, I run a United Nations environmental program called Atmospheric Brown Clouds focused on Asia. We have all the nations participating in this research, and I can give you a flavor of what Asians think about. We have Chinese. We have Indians. We have Koreans. We have Japanese.

I think my feeling is pushing the black carbon issue at the same level as the carbon dioxide in the international agreements may be premature for this one small reason: the first definitive study of the CO2 effects on climate was published 40 years ago. It took us hundreds if not thousands of studies before we came to the state where there was some general consensus. I don't have to remind you scientists rarely agree on anything. When you get five of us together in a room, you get conflicting opinions.

Compared to that, the black carbon issue is in its infancy. For example, the study you heard by Professor Zender, my own study, and Jacobson's study, they are all less than ten years old, and science is confirmed by repeatability, many trying to repeat our results.

There is still a wide uncertainty, so when we take the black carbon issue to the table the ones who are opposed to that could take the lowest estimate, which say it is not that important.

It has not been properly vetted through the IPCC process. My feeling is there could be more success than this by bilateral working within U.S., Europe, India, and China, and try to make progress on that because Dr. Schwartz' research shows us there are health problems and my research shows it has got regional problems, things like glacier melting and rainfall. So I think it may be easier to push it on the regional impacts issue than on the global issue.

*Mr. Hodes. I appreciate the difficulty of reaching agreement on those issues. It sounds a lot like working in Congress. We often disagree.

It sounds like you are addressing really the strategic implications of how we deal with the issue, but is it fair to say that, at least in your mind and that of the other panelists, there is no disagreement about the importance of dealing with black carbon?

*Mr. Ramanathan. Yes, I agree with you. I agree with the opinions which were raised here. I am more thinking about the scientific uncertainty being larger so it poses strategic difficulties.

*Mr. Hodes. Thank you. I appreciate that.

Mr. Chairman, may I just give the other panelists a brief opportunity to finish the question?

Dr. Zender?

*Mr. Zender. Thank you for the opportunity.

I agree with the panelists who summarized some of the conditions that led to the Framework Convention being oriented towards the mitigation of greenhouse gases, which, after all, were at the time known to be the primary cause of global warming. Since that period perhaps we have gained enough wisdom and knowledge through the scientific process to understand that not all the agents forcing the climate system cause an equal response in terms of climate, precipitation, and temperature per unit forcing.

If there were one thing that I could recommend be done differently in the next round of treaties, it would be to consider the response of the climate system, to look at the temperature effects of each forcing agent by sector and by time scale.

To reiterate, one of the conclusions I think that the panel has shared is that black carbon presents a unique opportunity because it can offset or mitigate warming on a very quick time scale, giving us an additional decade or perhaps two to struggle with the more complex emissions such as carbon dioxide that our infrastructure depends on to such a critical degree.

*Mr. Hodes. Thank you.

Dr. Schwartz?

*Mr. Schwartz. Thank you very much for the opportunity.

I agree with basically what has been said. I think that we are relatively much more uncertain about black carbon than about CO2 in terms of climate change and stuff, but I think the existence of very substantial health benefits means we can afford to make that investment. It is justified on the health, alone, and so we can live with that uncertainty and incorporate it into one of the strategies going forward.

*Mr. Hodes. I thank you all very much.

Mr. Chairman, thank you for the additional time.

*Chairman Waxman. Thank you, Mr. Hodes, for your questions.

Let me ask a few more questions, if I might.

Dr. Zender, if we look at the Arctic where we can see the dramatic level of destruction that is taking place in a time frame that no one imagined, and we try to attribute how much of that warming is due to the black carbon, can you give us any estimate? Is that possible?

*Mr. Zender. I think it is possible based on the results of our best understanding, which come from these general circulation or climate models which incorporate, as closely as they can, all processes known to contribute to the problem in the Arctic. My best guess is that up to 30 percent of the warming in the Arctic since pre-industrial can be attributed to manmade black carbon injections into the Arctic. This is an uncertain number and certainly greenhouse gases are playing the dominant role, especially CO2.

What is interesting at the Arctic and why it is changing so rapidly is that it is more susceptible, more vulnerable to a tipping point situation because you have the ice that, once it melts, uncovers these dark surfaces.

So the current data showing record sea ice retreat, showing acceleration of glacial outpouring into the oceans around southern Greenland and around the west Antarctic ice sheet, are all indicators that you would expect to see from these same models that give us these estimates; that the models are doing something right there. They have a degree of skill there.

So my best estimate would be that sitting on top of a dominant greenhouse gas contribution is the role of short-lived pollutants, not only including black carbon in the Arctic, but also ozone and methane. Some of those are clearly causing quit a bit of warming in the Arctic.

*Chairman Waxman. We hear a lot about tipping points with regard to global warming. You are talking about the tipping point in the Arctic, which is quite sobering, but we have heard from some researchers that tell us that if we don't deal with carbon emissions overall we are going to have a tipping point so that when we start dealing with it seriously the time lag before we see the benefits may be too late to stop irreversible damage.

Do any of you want to comment on that? Dr. Jacobson?

*Mr. Jacobson. Sir, I guess the three major tipping points are one, with regard to the coral reefs, like if we raise the temperatures another one degree celsius you might bleach the corals, and that would cause a lot of irreversible damage to fisheries, for example.

And then the second is the sea level rise due to, just as we are talking, if you melt all this Arctic ice, and in particular if you go down to the Antarctic and the west Antarctic ice sheet goes, then you are going to raise the sea level significantly. But in the case of the Arctic, because of the positive feedback, once you melt that ice you are warming the surface more, and make it harder to cool down.

This is a serious problem with the Arctic. Once you have melted that ice, you have all your sunlight warming the surface, so I am really concerned about that.

But I also want to point out that black carbon has a bigger effect on the Arctic than it does kind of on the rest of the world per unit meter or some kind of unit like that, but so does CO2. CO2 actually also has a larger effect on

the Arctic and over snow and sea ice compared to over land surfaces. You can see that just in numerical simulations over Russia and over the Arctic and over even in other places where there is snow. So I am concerned about the tipping point, but also I think you really need to control the CO2 and the black carbon simultaneously, because both of them have super linear effects over snowy or highly reflective surfaces.

*Chairman Waxman. So as we look at this global warming problem, if we deal with the black carbon we will get a more immediate benefit, maybe delay the tipping point that we are fearful about, and give us some additional time to avoid some of the irreversible damage to the planet that has been predicted?

*Mr. Jacobson. Yes. It would give additional time, but I guess I wouldn't want that to be translated into, okay, then we don't have to control the CO2.

*Chairman Waxman. Right.

*Mr. Jacobson. Which is the concern. It really needs to be done simultaneously I think with CO2 controls. It is not really an either/or.

*Chairman Waxman. Okay. Thank you.

Mr. Davis, did you have any other questions?

*Mr. Davis of Virginia. No. I just want to thank the panel for helping to illuminate us on this situation, and I hope that we can respond accordingly.

Thank you, Mr. Chairman.

*Chairman Waxman. Thank you.

Ms. Norton, did you want to ask some questions?

*Ms. Norton. No questions.

*Chairman Waxman. No questions. Okay.

This has been a terrific education for us and we hope to share this hearing record with the rest of our colleagues in the Congress and others who are looking at the whole question of how do we come to terms with the global warming problems. I think you make a compelling case that we need to look at controlling black carbon as part of that solution.

I want to do some housekeeping.

I want to ask unanimous consent that all members of this Committee will have an opportunity to enter an opening statement in the record if they wish to.

Secondly, I would like to be able to give the opportunity to Members to submit questions in writing to the panel and have you respond in writing to them if you would.

I thank you so much. I think you have done an excellent job, and I think this is an important hearing for the debate that we are continuing to have in the Congress of the United States. Thank you.

That concludes our business and the Committee stands adjourned.

[Whereupon, at 11:50 a.m., the committee was adjourned.]