National Aeronautics and Space Administration

Headquarters
Washington, DC 20546-0001

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Reply to Attn of: OLIA/2010-00422:MDC:eel

The Honorable Edward J. Markey
Chairman
Select Committee on Energy Independence
and Global Warming
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Enclosed are responses to written questions submitted by Members of the Select Committee resulting from the March 16, 2010, hearing at which Dr. Shindell testified regarding "Clearing the Smoke: Understanding the Impacts of Black Carbon Pollution."

This material completes the information requested during that hearing.

Sincerely,

L. Seth Statler
Associate Administrator
for Legislative and Intergovernmental Affairs

Enclosure

Response to questions from the Select Committee on Energy Independence and Global Warming

Dr. Drew Shindell

NASA Goddard Institute for Space Studies

These responses reflect my own opinions and are not meant to represent an official position of NASA.

1) Would eliminating or reducing black carbon emissions merely "buy us time" while we figure out how best to deal with GHG emissions, or do we need to include it as a critical component of a balanced portfolio of climate change actions?

There are two distinct issues at play – short-term and long-term climate change. They are distinct not only in the time frame over which they occur, but more importantly in this case because they are driven by different agents. Dealing with climate change over the long-term (several decades to centuries) requires sharp reductions in emissions of long-lived greenhouse gases, especially carbon dioxide. The annual reduction rate needed is relatively small if reductions begin quite soon, but becomes larger if the start date for reductions is delayed assuming a fixed target for maximum allowable warming (e.g. avoiding dangerous climate change, as the US agreed to at the Earth Summit in 1992 or as in the 2 C warming target in the Copenhagen Accord). The long-lived greenhouse gases are the dominant drivers of long-term climate change due to human activity because they accumulate in the atmosphere. Conversely, relatively short-lived climate warming agents including black carbon, carbon monoxide, volatile organic compounds (VOCs) and methane, play a lesser role in long-term climate change as they do not remain in the atmosphere nearly as long. This means, however, that they offer strong leverage over climate change in the near-term (years to a few decades) since they respond rapidly to emissions changes. Hence reductions in black carbon and other short-lived warming agents along with reductions in emissions of long-lived greenhouse gases are both necessary to accomplish the largely independent goals of mitigating near-term and longer-term climate change.

2) Why did the Kyoto Protocol fail to address black soot and other tropospheric ozone as methods of addressing global warming?

There are three primary reasons that I believe the Kyoto Protocol did not address black carbon or tropospheric ozone precursors (other than methane) as methods to address global warming. The first is that there is much less data available that shows how these pollutants have changed since the Industrial Revolution than there is for long-lived greenhouse gases. The abundance of the greenhouse gases can be determined from air bubbles trapped in ice cores, but measurements of black carbon or tropospheric ozone are minimal a century or more ago. As the concentration of those short-lived pollutants varies greatly from place to place, vastly more data than is available would be needed to accurately quantify their preindustrial distributions. The second reason is that the global impact of these pollutants on climate is less certain. A commonly used metric to evaluate climate impact is global mean

annual average radiative forcing (a change in the balance between incoming solar radiation and outgoing terrestrial radiation). For long-lived greenhouse gases, this forcing is known to within about 10%. The Kyoto Protocol drew on the prior IPCC Second Assessment Report (SAR) from 1995, which estimated the radiative forcing from soot to have "an uncertainty of at least a factor of 3". Forcing from tropospheric ozone also had substantially greater uncertainty than long-lived greenhouse gas forcing. Furthermore tropospheric ozone is not directly emitted but results from multiple atmospheric chemical interactions, so that the link to emissions of a particular precursor pollutant that might be included in an international treaty is much more complex. Finally, the third reason is that unlike the case for the long-lived greenhouse gases, the climate impact of emissions of black carbon or tropospheric ozone precursors depends upon both the location and time of emission. This makes their inclusion in any policy that requires evaluating the relative impact of emissions changes in different nations much more complicated than is the case for the long-lived greenhouse gases included in the Kyoto Protocol.

3) It seems that most GHG and black carbon emissions are coming from India, China and developing nations. Shouldn't efforts to address global warming be focused mainly on them?

Annual average carbon dioxide emissions from China recently exceeded those from the US, but the sum from all developed countries (US, EU, Japan, former Soviet Union, Canada, Australia, Korea, Taiwan, etc) is still greater than the total emissions from developing nations. Growth in emissions in China and other developing countries is very high, however, so that their share of emissions may in fact soon exceed that of developed nations. However, given the long residence time of carbon dioxide in the atmosphere and large historical emissions, the contribution to climate change from the emissions by the developed nations will continue to outweigh that of the developing world for many decades. Hence it is important that both developed nations, which bear the brunt of the responsibility for changing climate thus far, and the developing nations, whose emissions are increasing so rapidly, reduce GHG emissions in order to mitigate long-term climate change.

Emissions of black carbon are indeed greatest in the developing world at present. However, substantial emissions still do take place in developed nations as well. Given the well-documented adverse impacts of these emissions on human health, it is clearly in the interest of every country to reduce their own emissions for the sake of their own population's well-being. In addition to the local health benefits, the climate benefits from reducing black carbon extend more broadly, so that it is everyone's interest for global emissions to decrease. While it certainly makes sense to encourage efforts to mitigate global warming by reducing black carbon emissions in the developing world where they are greatest, it also makes sense to reduce them elsewhere. Differing local conditions both in the atmosphere and in socio-political systems mean that there will be different costs and benefits associated with emissions reductions from region to region and even from source to source. A logical strategy would be to target those emissions for which the benefit/cost ratio is greatest regardless of where they are located.

4) Why is the Antarctic spared from the effects of black carbon?

There is minimal transport of black carbon to the Antarctic primarily because it is so far from most of the black carbon emissions. This means that little black carbon reaches the ice sheet or surrounding sea ice in comparison with the Arctic or lower latitude snow and glaciers. Climate change in response to black carbon can nonetheless extend well beyond the locations with substantial black carbon amounts as the atmosphere and ocean efficiently transport heat to even remote areas. Hence while Antarctica may receive very little black carbon from lower latitudes, it most likely experiences a temperature change due to black carbon that is only slightly lower than the global mean value - perhaps a few tenths of a degree warming since the preindustrial. This is much smaller than the probable effect of black carbon on the Arctic or Northern Hemisphere mid-latitude areas, however.

5) As scientists, do you consider the work done by the IPCC to be the "gold standard" of scientific research?
    - Would you use the information and conclusions from IPCC reports, especially the most recent one in 2007, without any reservation?
    - Would you incorporate IPCC data into your body of work without hesitation?

It is important to be aware that the IPCC does not perform any original scientific research but simply assesses work done by the scientific community. Their assessments can provide substantial added value in interpreting the results of the large body of studies that have been published, but it is the studies themselves that are the 'gold standard' of research. In my opinion, the conclusions of the IPCC reports, including the 2007 report, are extremely reasonable and reliable with the exception of a very small number of well-known and acknowledged errors. I have, and will continue to, use the IPCC assessments as a guide to both our current state of knowledge and to the best available underlying scientific work that I attempt to build on in my own studies.

6) If you were in the position to do so, how would you structure a comprehensive climate change bill?

Taking into consideration that I am not a policy expert and that the specifics of such a bill are well beyond my expertise, and reiterating that I am not speaking on behalf of NASA and the Executive Branch, in my opinion the overarching aims of such a bill should be to simultaneously reduce emissions to mitigate long-term climate change and to target short-lived black carbon, methane, carbon monoxide and VOCs to mitigate near-term change. As part of the effort to mitigate emissions of short-lived pollutants, I would also attempt to correct the current situation where the damages from highly polluting activities are largely not included in the costs associated with those activities, distorting the marketplace to artificially encourage emissions that have serious adverse health and climate impacts (the cost of emissions permits for the Clean Air Act's criteria pollutants accounts for only a small fraction of their impact). While putting a price on carbon dioxide emissions has been widely discussed, emissions of particulate can cause substantial health impacts while emissions of tropospheric ozone precursors lead to both adverse health impacts and reduced agricultural and forestry yields. So-called 'green accounting' includes these environmental impacts.

These impacts could be included using any of the mechanisms discussed for putting a price on carbon dioxide emissions that would bring the power of the market and of policy tools to bear on emissions reductions. In my opinion, the critical need is to rectify the current situation where a clean power source such as wind is very expensive compared to a coal-fired power plant because the comparison includes only the cost paid by power generators and ignores the environmental damages resulting from the coal burning (solid waste, atmospheric emissions, etc). In contrast, a full accounting is likely to find the opposite results, namely that the overall impact on society including valuation of human health impacts and crop yield and forestry losses shows coal-fired power plants being more expensive than many renewable energies. Associating an economic cost proportional to the damages resulting from emissions would remove the present implicit favoring of highly polluting activities and would be a fairer approach than the current system.

7) Given the extent of the impact of black carbon on the Arctic and Himalayan glaciers, and the potential consequences for various water supplies, shouldn't this be a number one priority issue for those Asian countries that would be directly affected? Why is this not the case?

While there is an impact of black carbon on Asian glaciers, it is not yet clear exactly how large this impact is. Glaciers are melting around the world, so observation of glacier retreat in the Himalayas is by itself not enough to implicate black carbon in that retreat. More work is needed to better clarify the relative importance of local black carbon versus global greenhouse gas increases in the melting of glaciers in Asia. A strong regional effect of black carbon on the Arctic is more clearly established, and the Arctic Council nations have indeed begun making this a priority issue, at least in discussions.

In Asia, emissions of black carbon also likely alter monsoon rainfall, which may have profound consequences on human well-being. Again, these effects are difficult to demonstrate from observations alone, as changes in rainfall will arise from other factors such as increasing greenhouse gases as well. Hence the role of black carbon in altering Asian water supplies is difficult to quantify and to demonstrate clearly, and in my opinion this has delayed appreciation of its importance. The physical principles that underlie black carbon's ability to change the water cycle are well understood however, and the impacts from changes in the monsoon are potentially so large that the current range of results carries substantial risk and should be given higher priority by Asian countries. As in the US, efforts to deal with black carbon (whose adverse health impacts are extremely clear and arguably should by themselves be enough to motivate action) must compete with other national priorities, and often short-term economic or political interests trump the long-term problem of climate change. While there are ongoing efforts to reduce emissions, for example by improving the efficiency of rural cookstoves, these could benefit from increased national and international funding, which can be a large barrier to implementation in developing nations even if the will to reduce emissions is there.