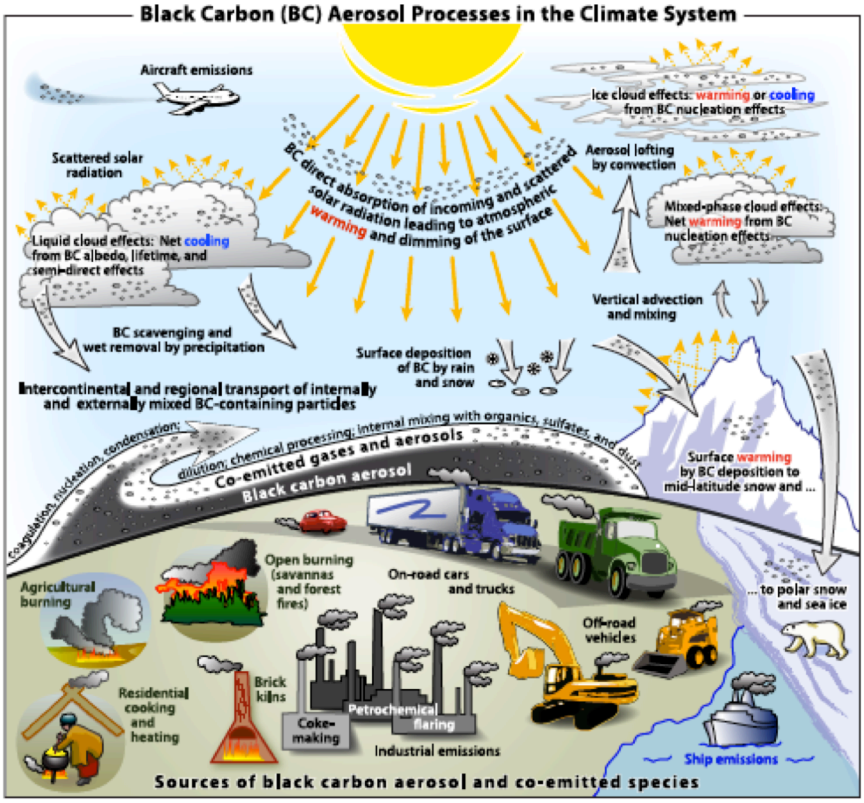
Bounding the role of black carbon in the climate system: A scientific assessment

Why should I care about black carbon?

Black carbon is a small, dark particle that warms Earth's climate. Although black carbon is a particle rather than a greenhouse gas, it is the second largest climate warmer, after carbon dioxide. Unlike carbon dioxide, black carbon is quickly washed out and can be eliminated from the atmosphere if emissions stop. Reductions would also improve human health.

How does black carbon affect climate?

Black carbon absorbs sunlight and heats the atmosphere. It can also change the brightness of water and ice clouds. Black carbon darkens snow and accelerates melting. All these changes, shown in the figure, alter the amount of sunlight reaching the Earth.



What is the "Bounding-BC" study?

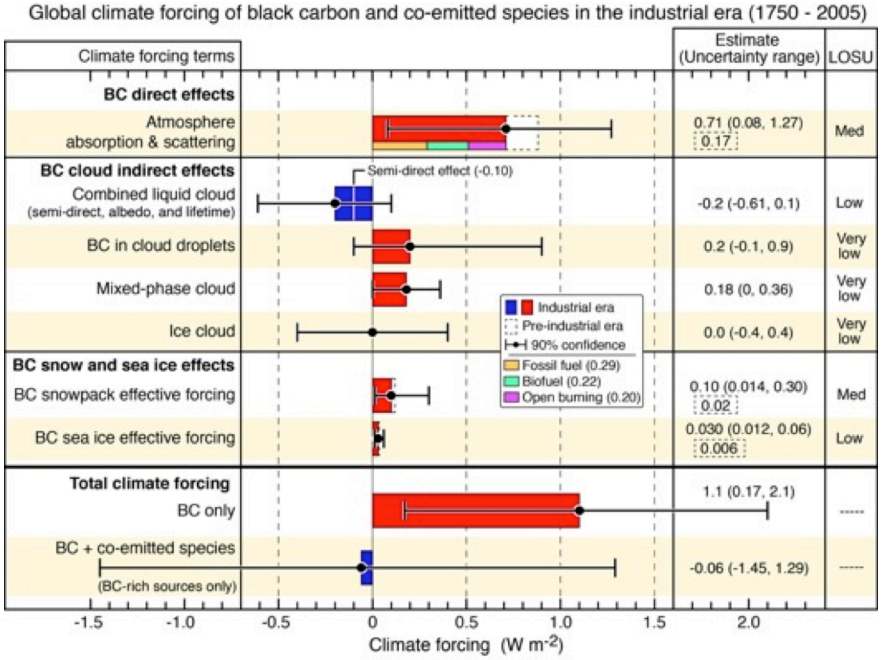
Policymakers are considering actions that slow climate warming by reducing black carbon emissions. This assessment is an effort of 31 experts around the world to provide scientific support for policy decisions, and was initiated by the International Global Atmospheric Chemistry Project. The treatment is *comprehensive*, because it includes all the known ways that black carbon affects the climate system; *quantitative*, by providing best estimates and uncertainties using global models and observations; and *diagnostic*, identifying the reasons why estimates differ.

Is the estimate of black carbon climate influence different from previous work?

The best estimate of climate impact from direct absorption is about a factor of two higher than most previous work, including the estimates in the last Intergovernmental Panel on Climate Change (IPCC). Many models simulate lower absorption than observed in the atmosphere and thus underestimate warming by black carbon. Causes of the mismatch include underestimated emissions in certain regions and the way absorption by black carbon particles is treated in some models. The higher level of absorption was suggested by a few earlier papers and is supported by the evidence reviewed in the assessment.

Does the climate impact change when the influences of clouds and snow are included?

Each component of black carbon forcing and its uncertainty was assessed (figure). Including all effects makes the best estimate of climate impact more warming. Cloud changes are not well understood, so the total effect is also quite uncertain, but there is still high confidence that black carbon leads to warming.



Quantitative estimates of black carbon influence, expressed as "climate forcing," or perturbation to Earth's energy balance. The upper red bar can be compared to the direct forcing of +0.34 W m^{-2} from the IPCC Fourth Assessment report. The addition of forcing components to give net forcing (lowest red bar) was one contribution of this work. For comparison, carbon dioxide forcing in the year 2005 was +1.66 W m^{-2}.

Will shutting off every source that emits black carbon reduce this large warming?

Not necessarily, because each source also emits other species, including other particles and ozone-forming gases, that may warm or cool the climate. The short-term climate impact of emissions from all black carbon sources is a slight cooling with large uncertainties; it could be positive or negative. However, individual sources that emit mostly black carbon can be targeted to reduce a portion of the warming.

What sources are most likely to reduce warming if their emissions are eliminated?

Diesel engines are the most promising, followed by some types of wood and coal burning in small household burners and some kinds of industrial processes. Eliminating open vegetation burning is least likely to reduce warming, although it could be beneficial near snow and ice. Both the immediate climate impact of air pollutants and the long-term climate change from greenhouse gases are important.

What is different about this assessment?

It provides a framework to estimate climatic impacts of mitigation actions, in contrast to traditional methods that focus on individual chemical species or physical effects. This framework is designed to be updated as the science of black carbon moves forward.

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