

What is the contribution of black carbon and methane to Arctic climate change?

Can reductions in black carbon and ozone be a shortcut in the greenhouse?

Gunnar Myhre

EDITORIALS

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Time for early action

Carbon dioxide is not the only warming agent worth tackling now in the bid to cool the planet. A good place to start is with black carbon.

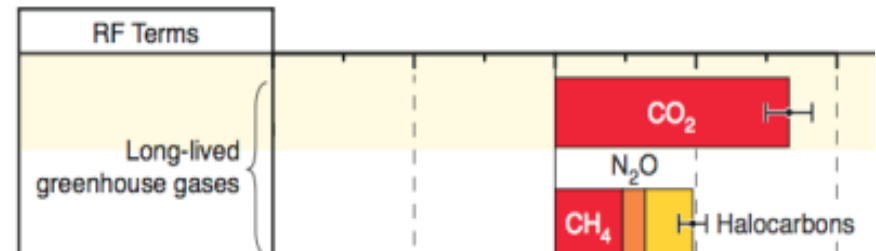
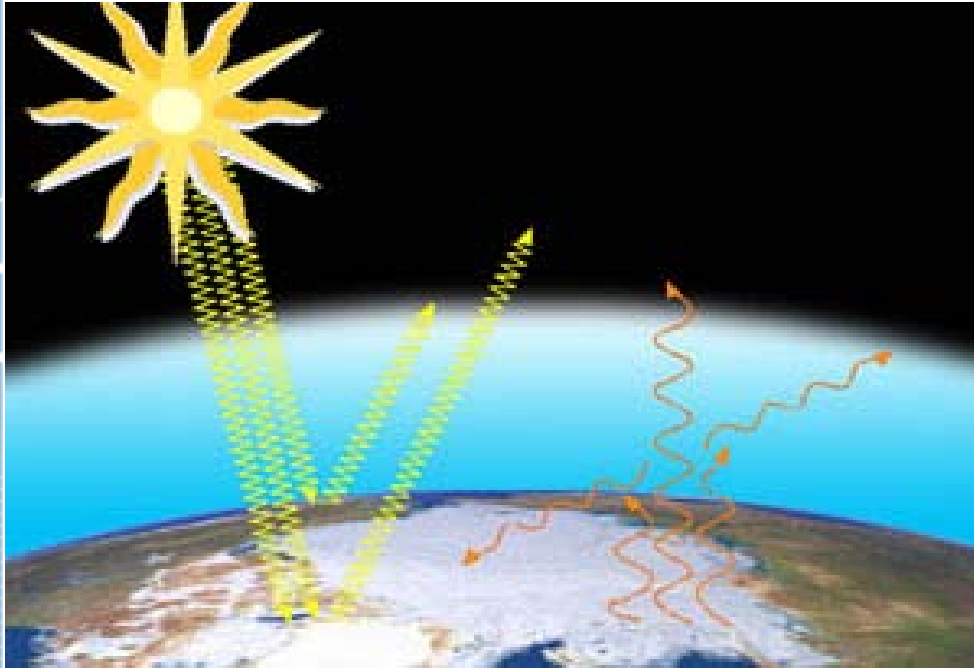
V. (Ram) **Ramanathan** of the UC-San Diego La Jolla, said that reducing black carbon could play an important role in reducing global climate change.

According to Dr. Mark Jacobson of Stanford University, control of BC, “particularly from fossil-fuel sources, is very likely to be the fastest method of slowing global warming” in the immediate future.¹⁵

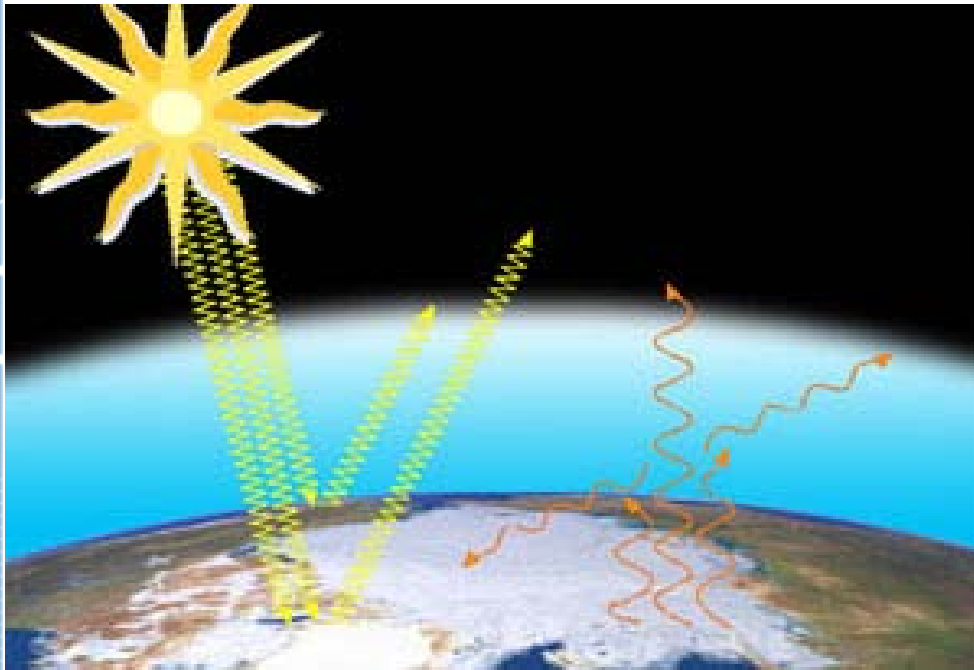
Outline

- Short description of black carbon (BC) and other aerosols and their impact on climate
- What do we know of the current climate effect of black carbon?
- Global temperature changes from BC reductions
- Discuss the consequences of BC reductions and the awareness that must be taken into account in such an approach
- Development of the emissions of the main driver of climate change

Black carbon impacts climate in several ways



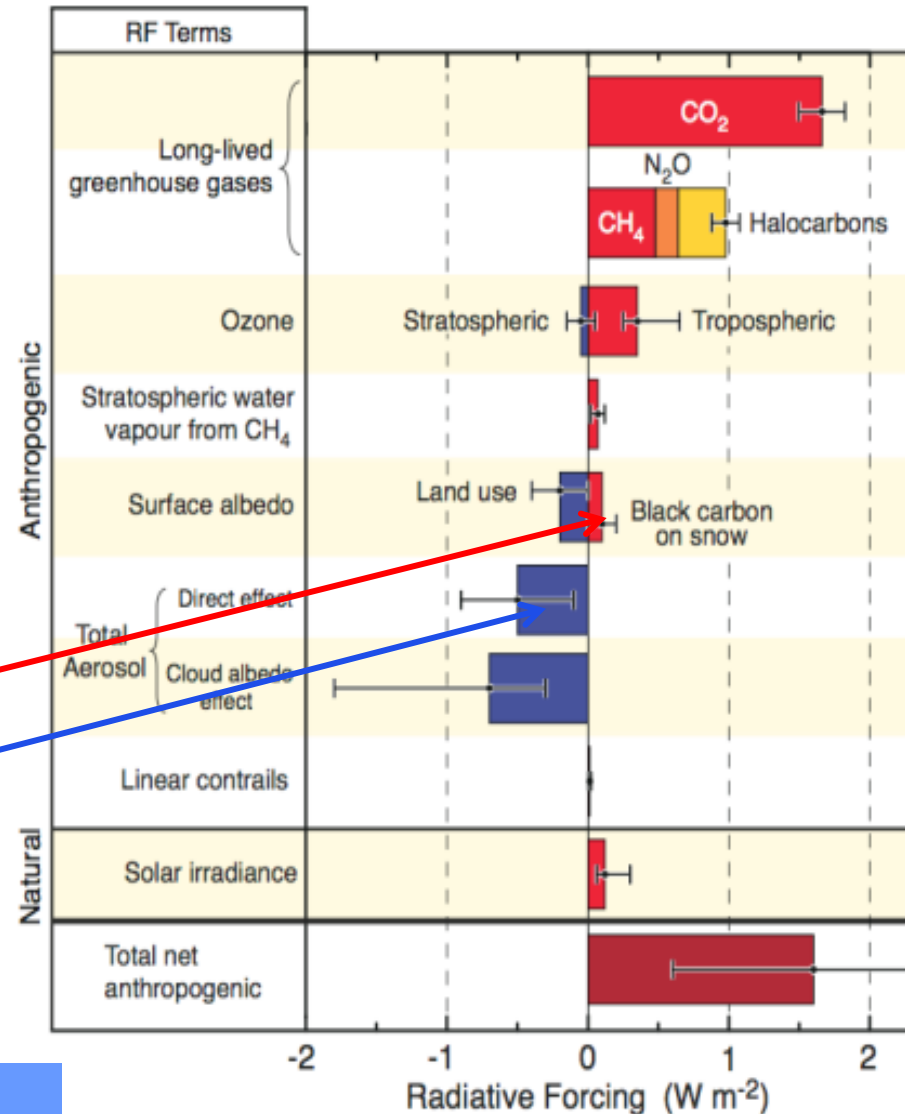
Black carbon impacts climate in several ways

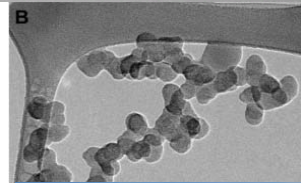
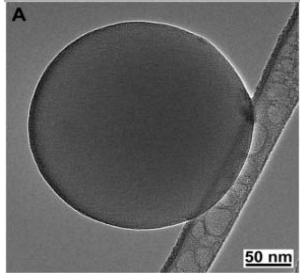
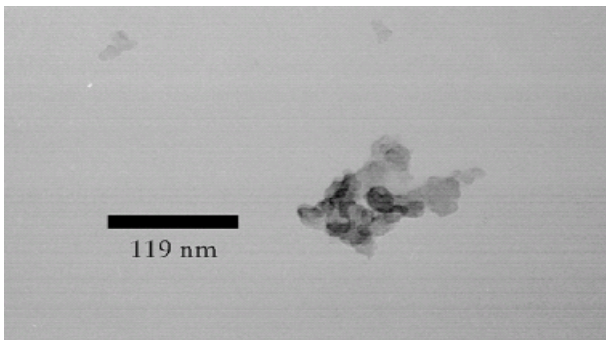


Black carbon

- Impact on snow
- Direct aerosol effect
- Effect on clouds

Aerosols mask the warming





Photos; Ann-Christine Engvall, NILU.

“Dirty ice” reports by Nansen and Nordenskiöld

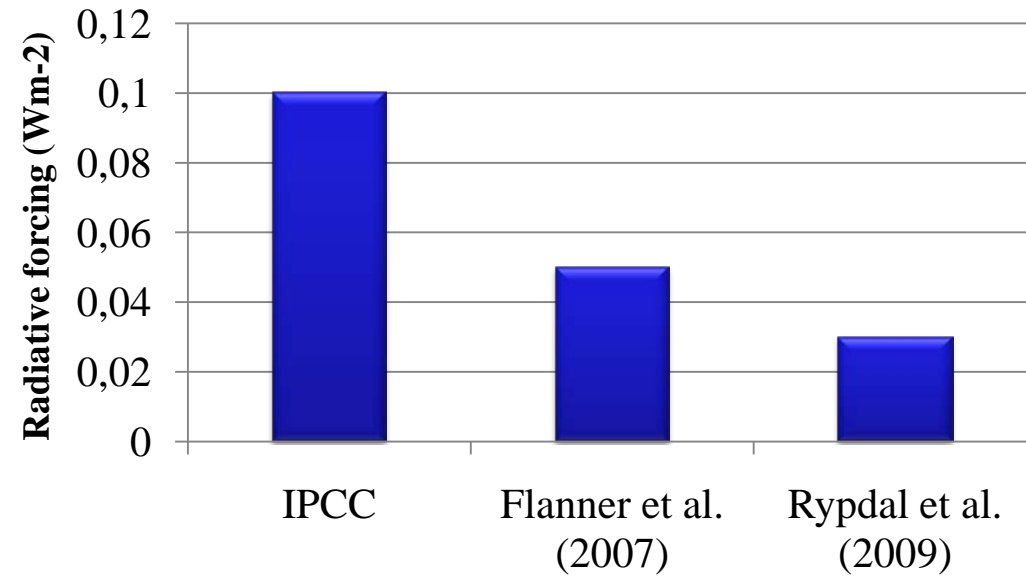
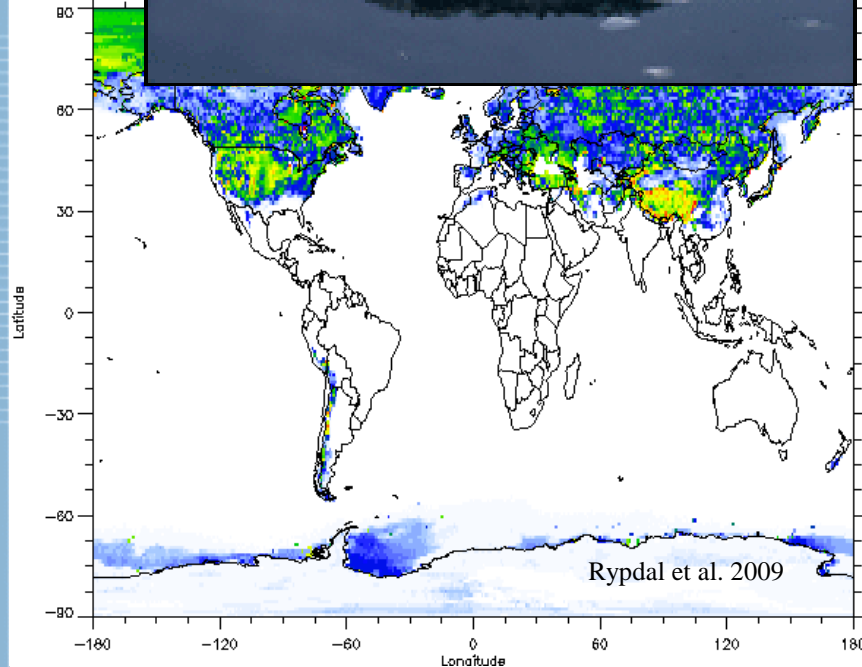


“Everywhere where the snow from last winter has melted away, a fine dust, gray in color, and, when wet, black or dark brown, is distributed over the inland ice in a layer which I should estimate at from 0.1 to 1 millimetre.”

Nordenskiöld, A. E., Science, December 1883

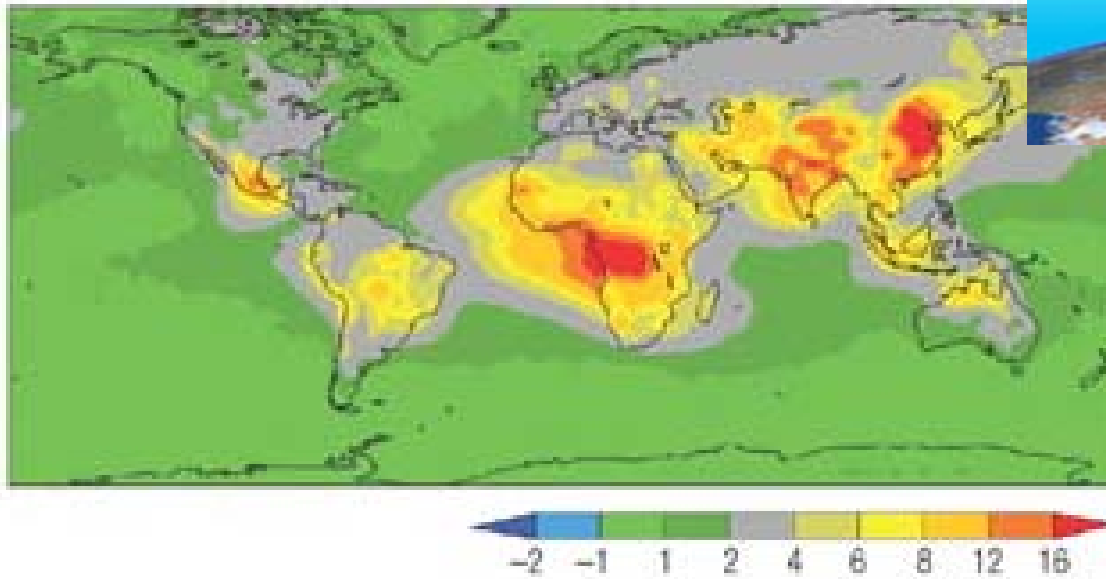
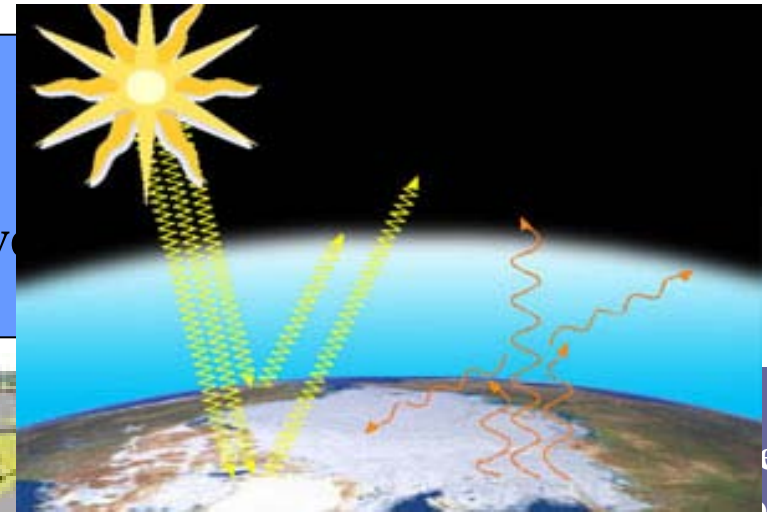


Radiative forcing from BC impact on snow and ice



Radiative forcing of direct aerosol effect of BC

- Best estimate in IPCC AR4 is 0.2 Wm^{-2} with a range from 0.05 to 0.35 Wm^{-2}
- Newer studies indicate stronger radiative forcing from BC



Ramanathan and Carmichael, Nature Geoscience, 2008

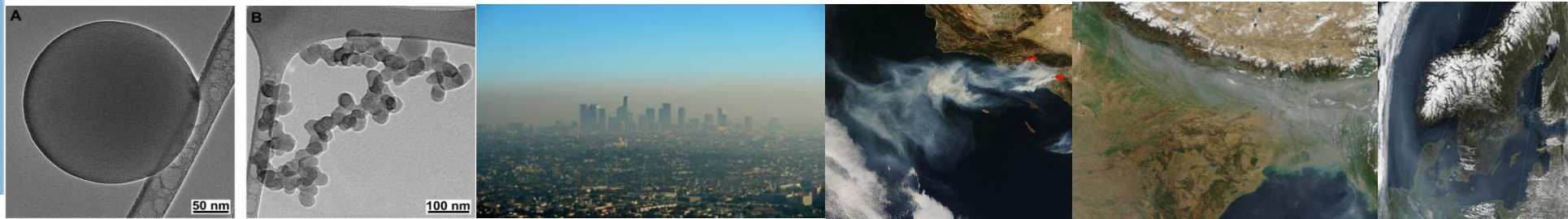
With consistency between two methods

Consistency Between Satellite-Derived and Modeled Estimates of the Direct Aerosol Effect

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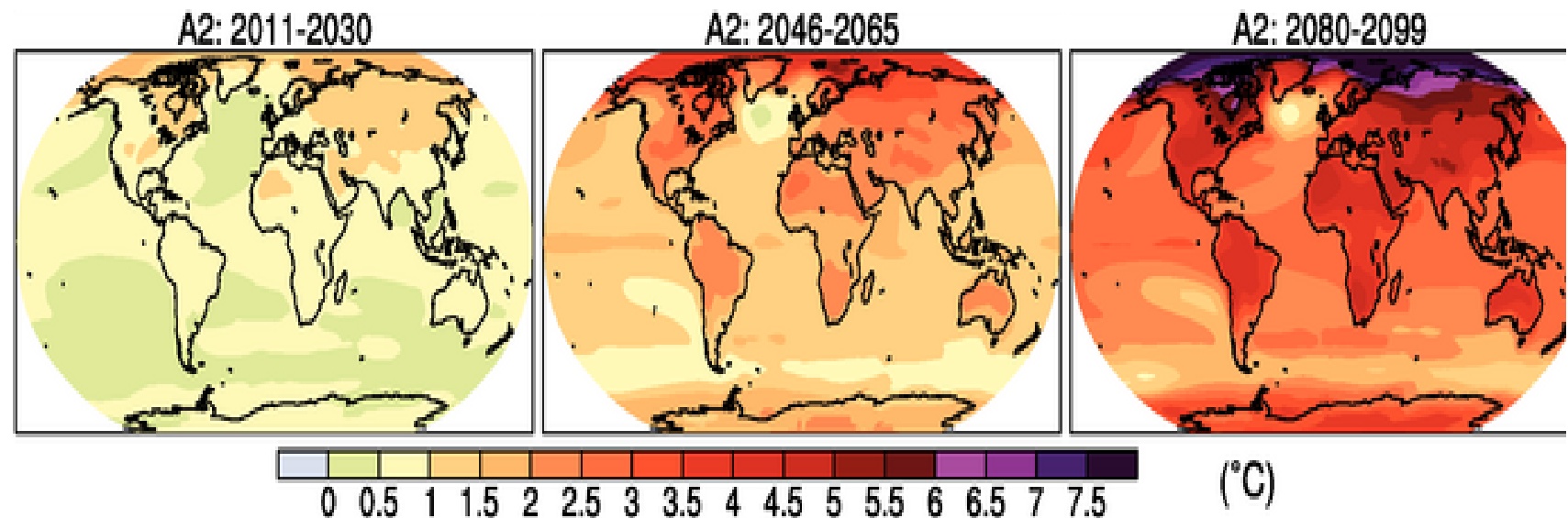
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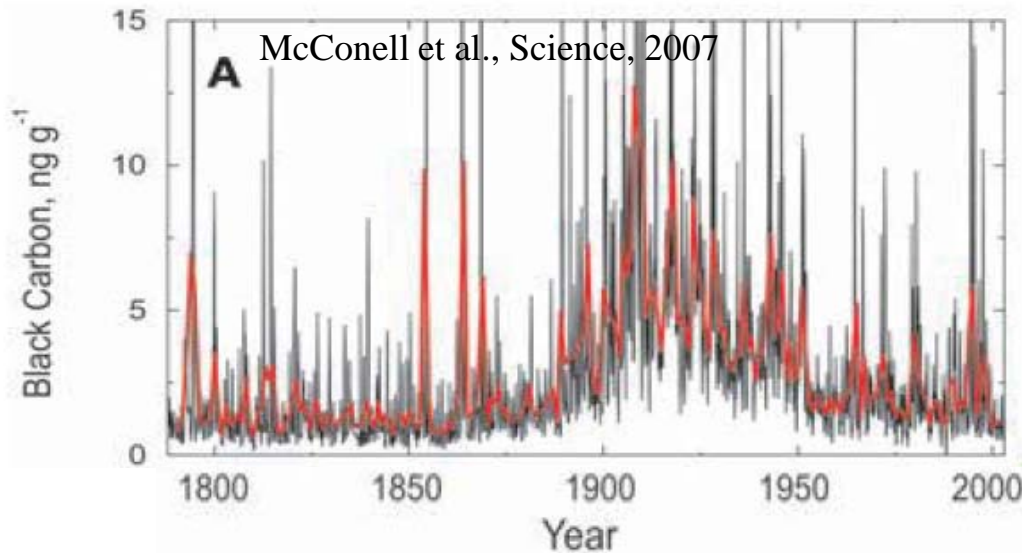


Do BC and ozone contribute strongly to Arctic warming?

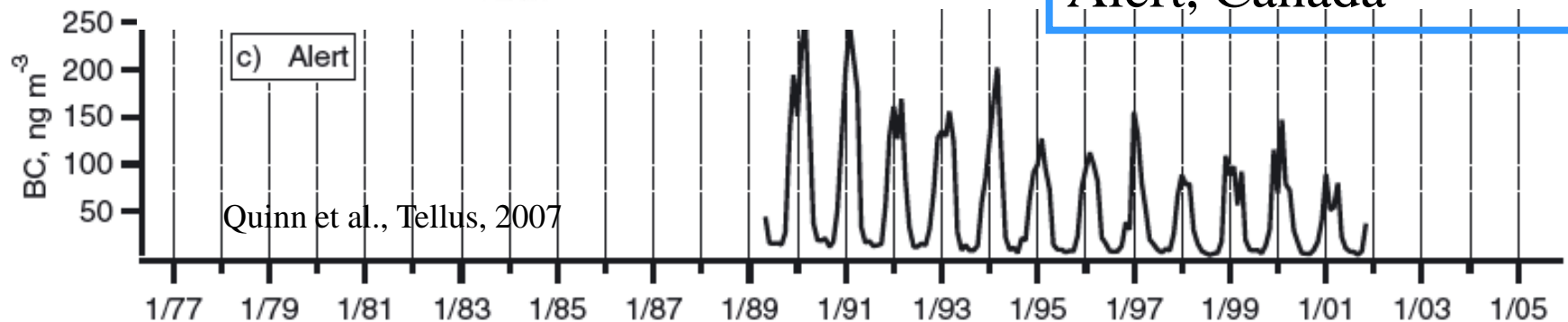
- Models predict an Arctic warming twice as large as for the rest of the world due to CO₂ changes
- It is quite uncertain how BC contribute to the Arctic warming



Trends in BC show no indications of a strong contribution to current warming



BC from ice core measurements at Greenland

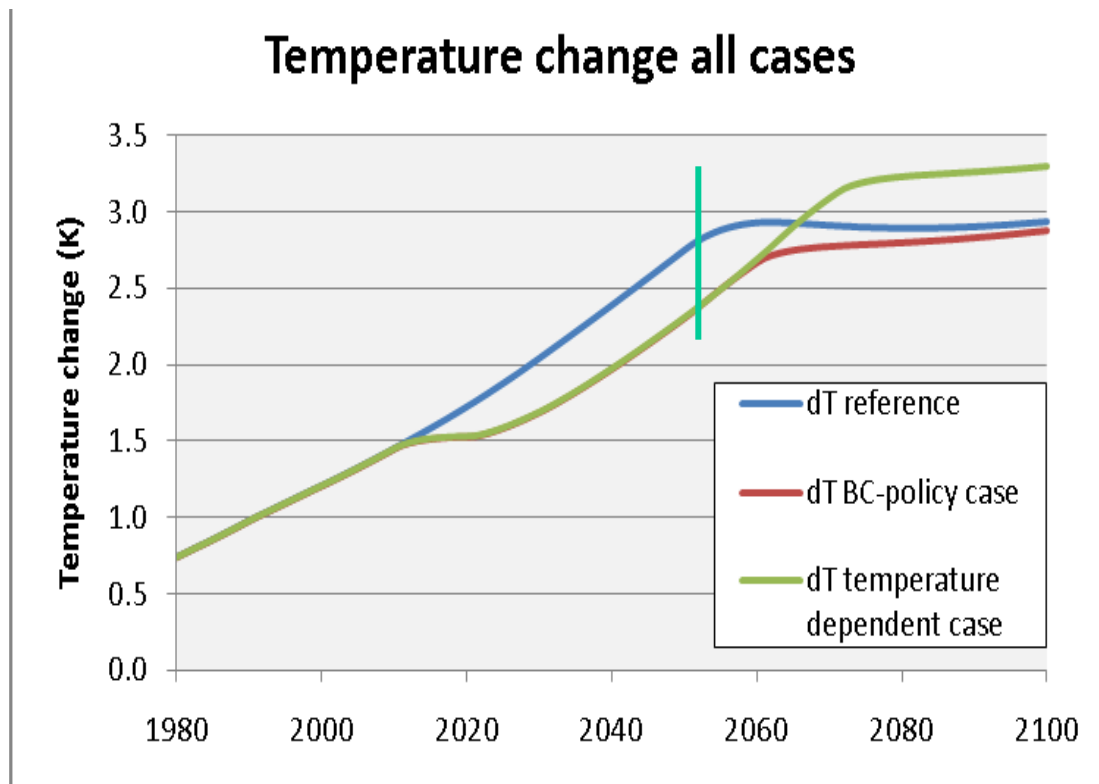


BC from air samples at Alert, Canada

Effect of mitigation strategy on black carbon

Mitigation of greenhouse gas emissions
What is the driver?

Greenhouse gases – long lifetimes
Aerosols – short lifetimes

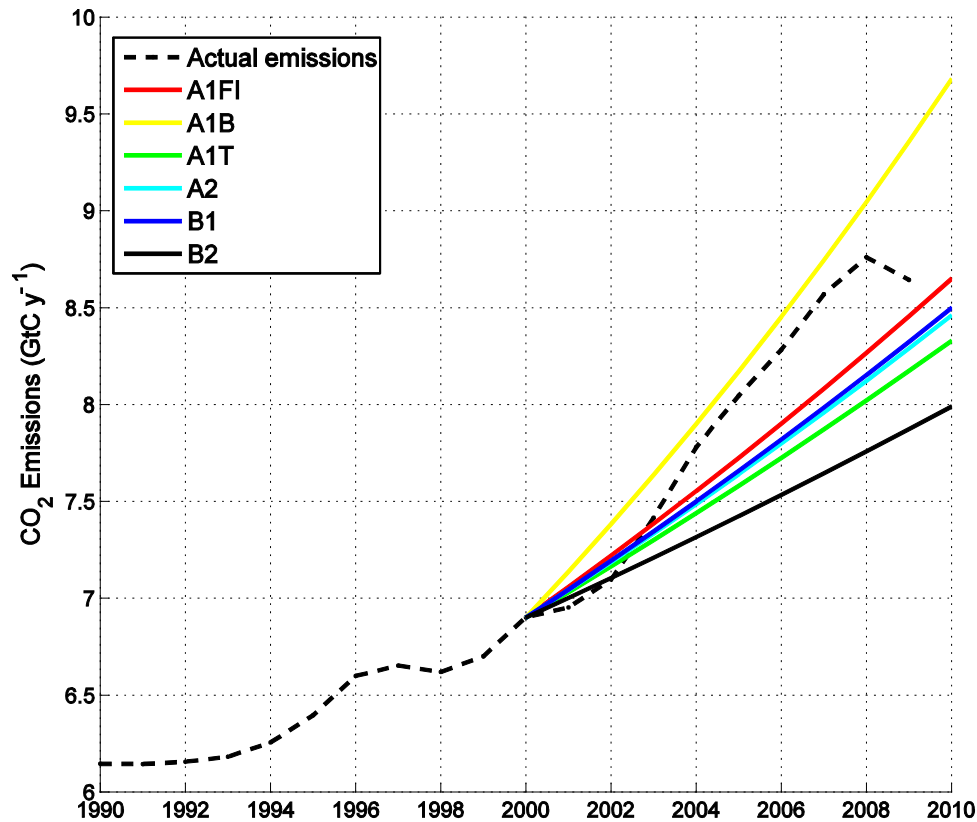


- Radiative forcing BC of 0.8 Wm^{-2}
- Climate sensitivity of $0.8 \text{ K} / \text{Wm}^{-2}$

- Reference – standard IPCC A2 scenario. 70% reduction after 2050 of all emissions
- BC-policy – reduce BC from 2010-2020 otherwise as reference
- Temperature dependent- same as policy focused, except wait with the 70% reduction in all the anthropogenic emissions until same temperature change as in 2050 for the 'Reference'.

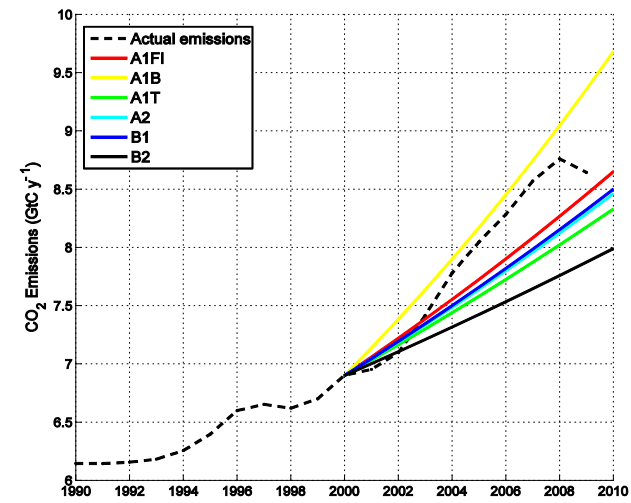
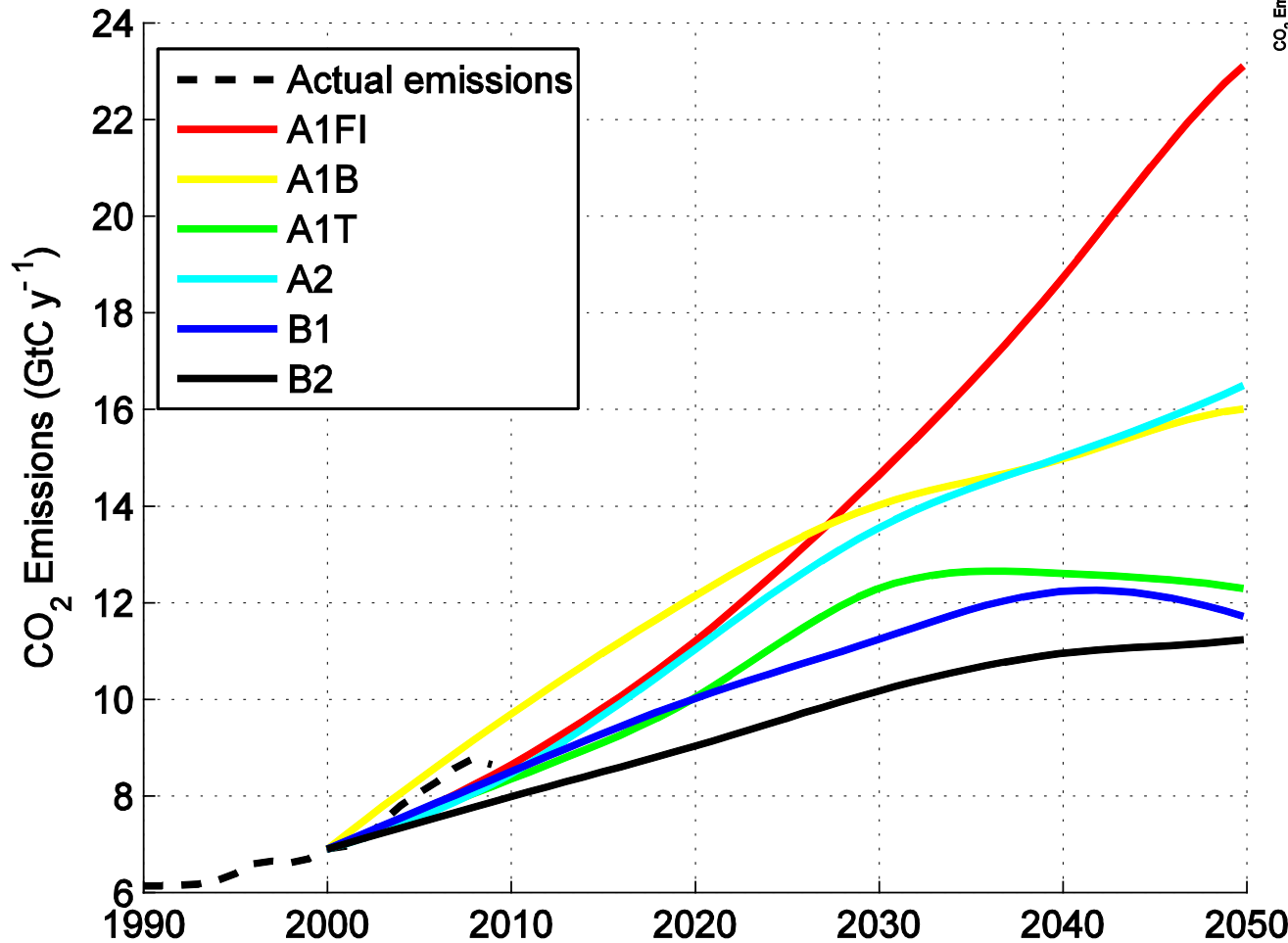
Results shown for strong forcing of BC
For best estimate small impact of BC

Fossil fuel CO₂ emissions



- A drop in the 2009 fossil fuel CO₂ emissions
- Almost 40% increase in the fossil fuel CO₂ emissions since 1990
- Above almost all IPCC scenarios

Fossil fuel CO₂ emissions



IOP PUBLISHING
 Environ. Res. Lett. 4 (2009) 034012 (4pp)
 ENVIRONMENTAL RESEARCH LETTERS
 doi:10.1088/1748-9326/4/3/034012

A fast method for updating global fossil fuel carbon dioxide emissions

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CICERO

Center for International Climate and Environmental Research – Oslo

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Summary

- The main driver of climate change is CO₂ and without strong mitigation strategies the emissions will increase substantially
- Total radiative forcing of BC is uncertain and this is partly also the case for tropospheric ozone
- Important to understand better the climate effect of aerosols for future predictions
- A mitigation strategy focusing on BC is complex and knowledge about goals and implications are important otherwise it may lead to unwanted consequences
- Mitigation strategies must focus on CO₂ and other greenhouse gases and thereafter short-lived compounds may be considered



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