Black Carbon and Methane Effects on Climate, the Arctic, and Health

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Impacts of Fossil+Biofuel Soot and Methane

Soot (black carbon plus organic matter and other chemicals)

1. Direct health Impacts (~1.5 million deaths/yr worldwide)
2. Second-leading cause of global warming
3. Greatest climate impacts over Arctic and other snow/ice
4. Short-lived (weeks) so its control is the fastest method of reducing temperatures and Arctic ice loss expected in 20-30 y

Impacts of Fossil+Biofuel Soot and Methane

Methane

1. Third-leading cause of global warming
2. Greatest climate impacts over Arctic and other snow/ice
3. Moderate (8-12 y) lifetime so its control will slow loss of Arctic
4. Produces ozone globally; natural gas leaks a major source

Impacts of Soot on Climate

Impacts on clear sky

Soot absorbs solar radiation. Absorption increases with coating

Impacts on clouds

Soot increases number, reduces size of cloud drops (indirect effects)

Soot in clouds heats clouds (cloud absorption effects)

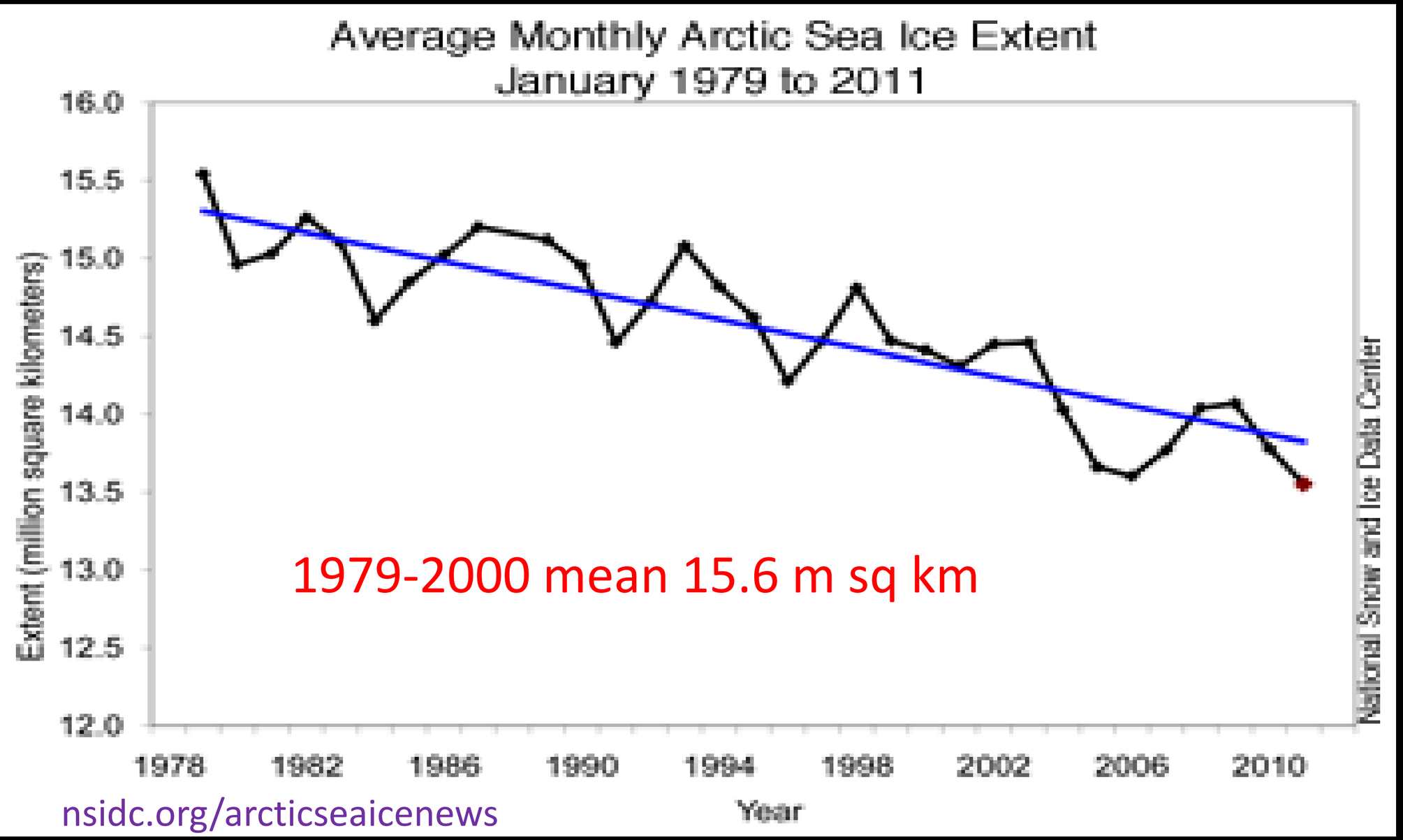
Stabilizes air, reducing water/heat transfer from ground to cloud

Impacts on surfaces

Soot deposits to snow/sea ice, reducing their albedos

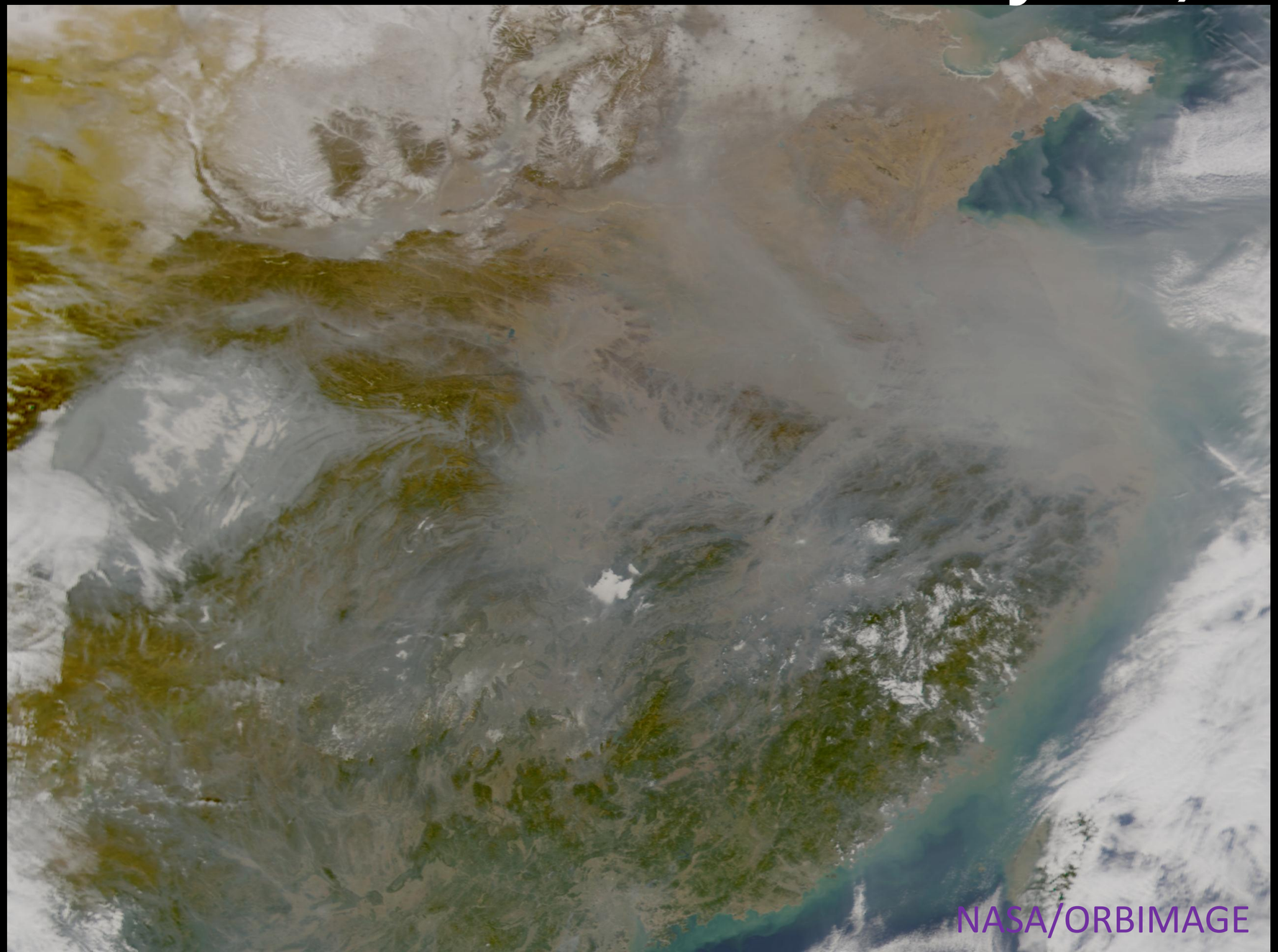
Its warming evaporates surface water, increasing warming more

Arctic Sea Ice 1979-2011



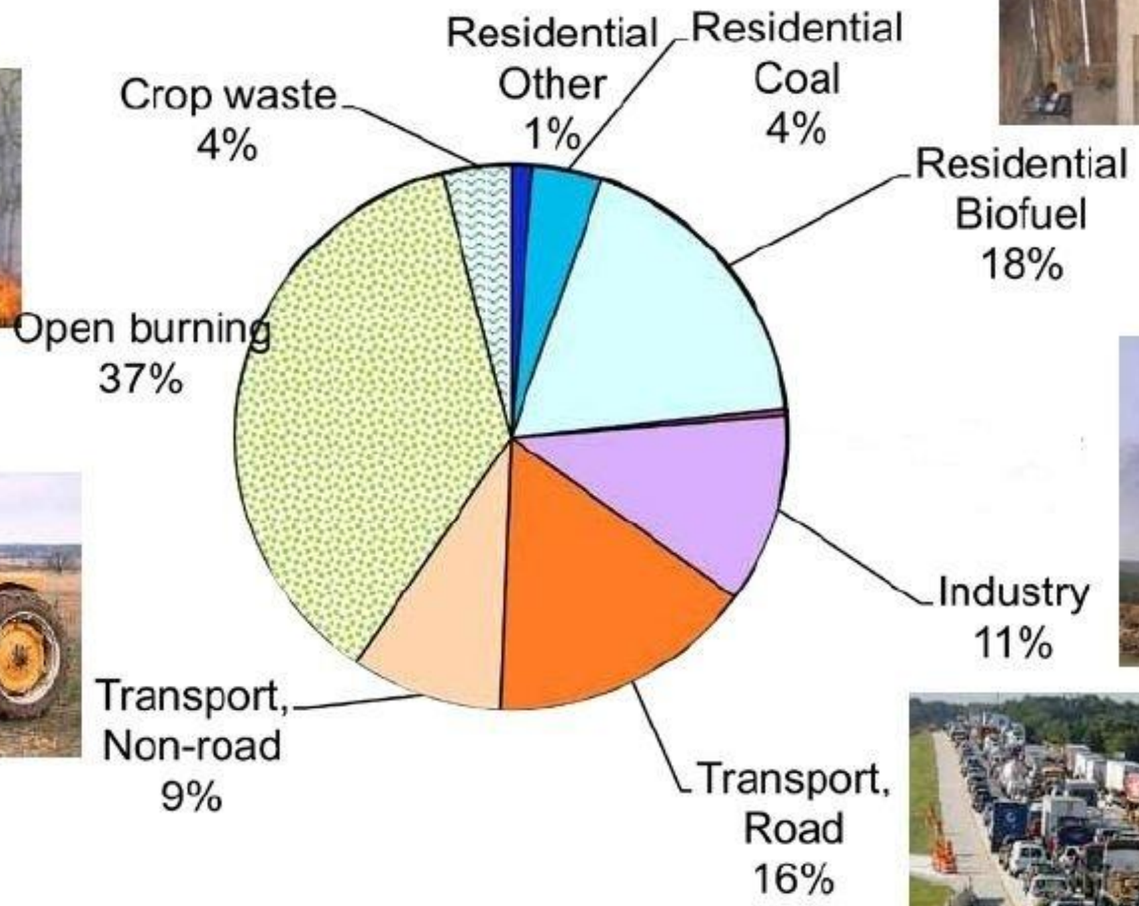
Lowest years
2011
2005
2006
2007
2009

Burnoff of Clouds Over Asia By BC, BrC



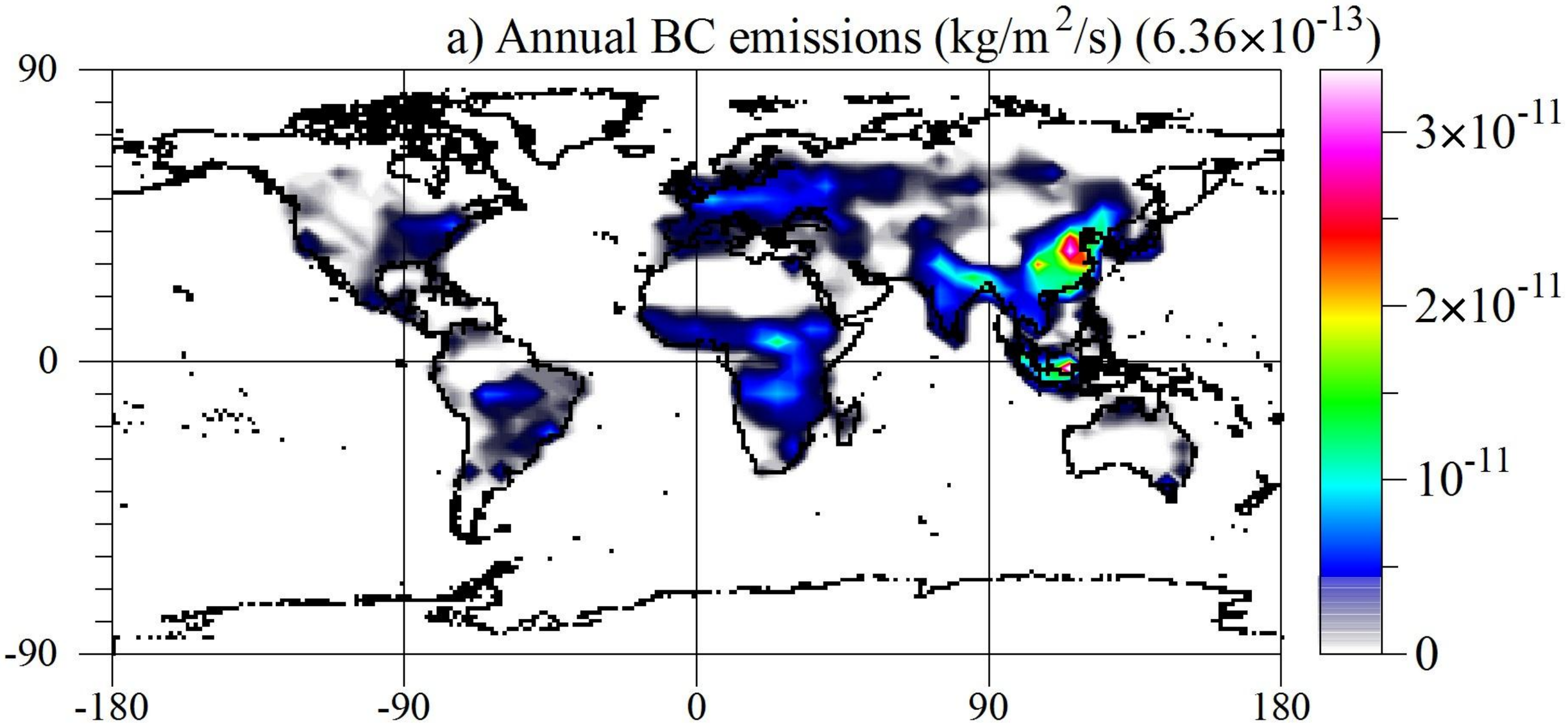
Global sources of black carbon

~8800 (short) tons/yr

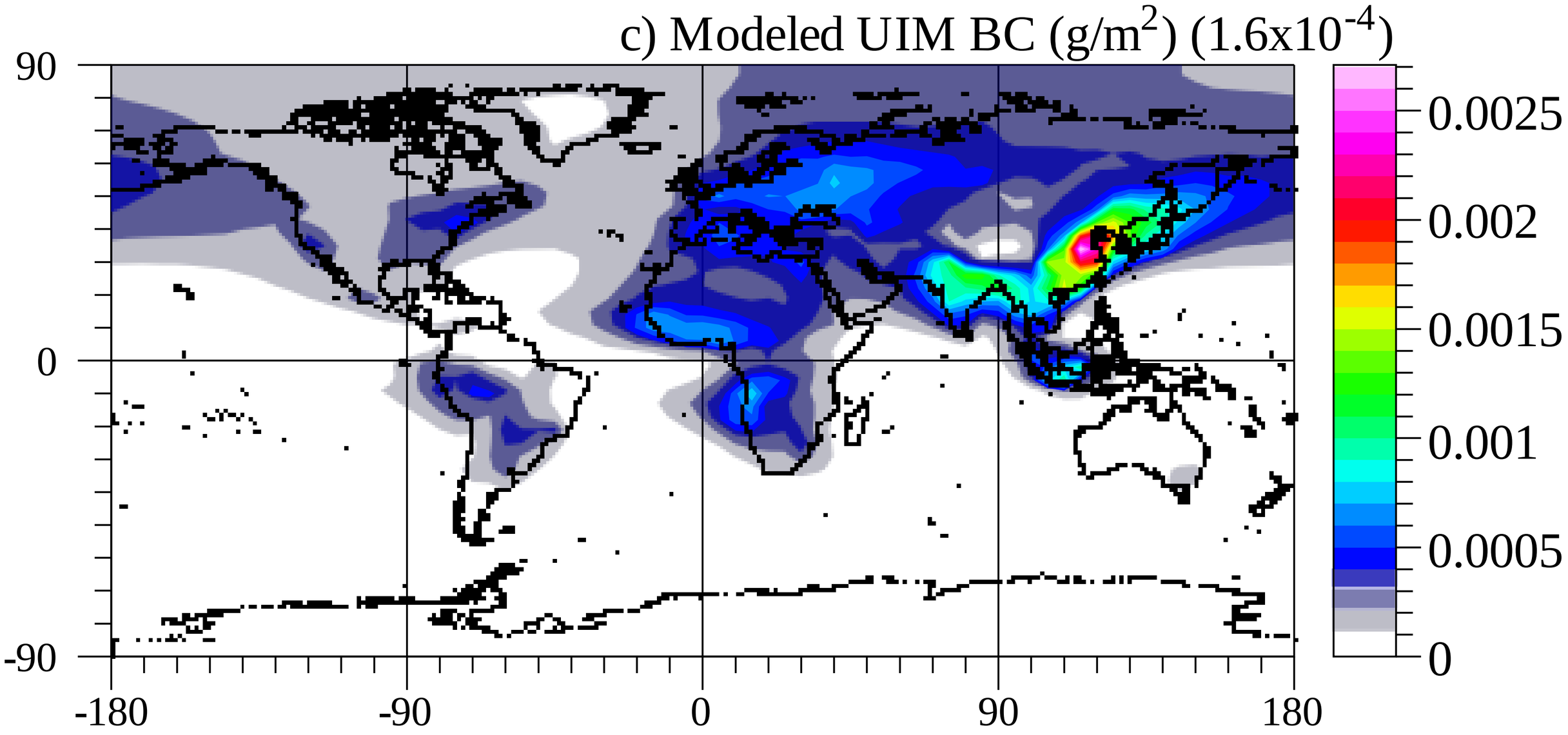


Year 2000 estimates (Bond et al., GBC 2007 + van der Werf, 2006 + updates for IPCC AR5)

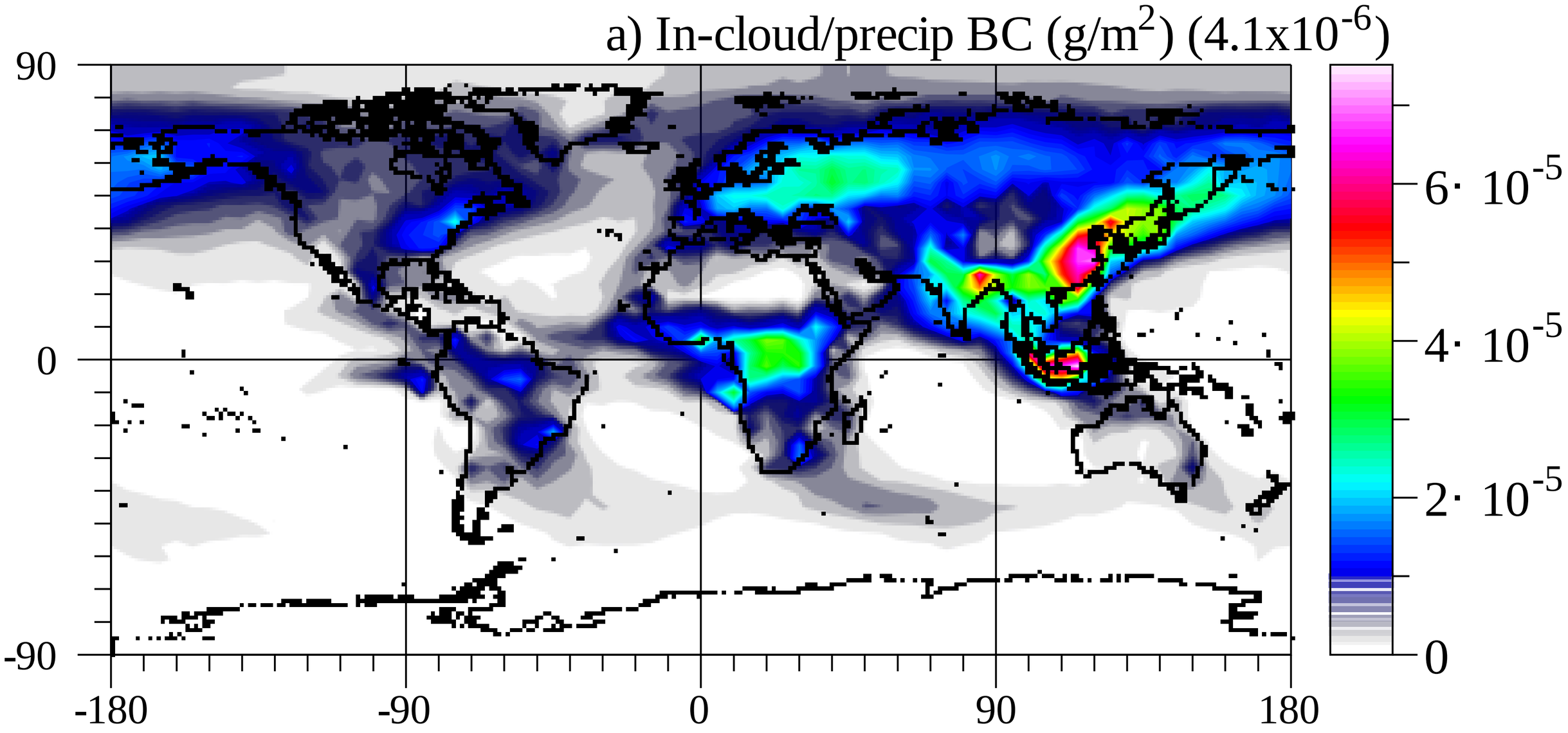
Black Carbon Emission



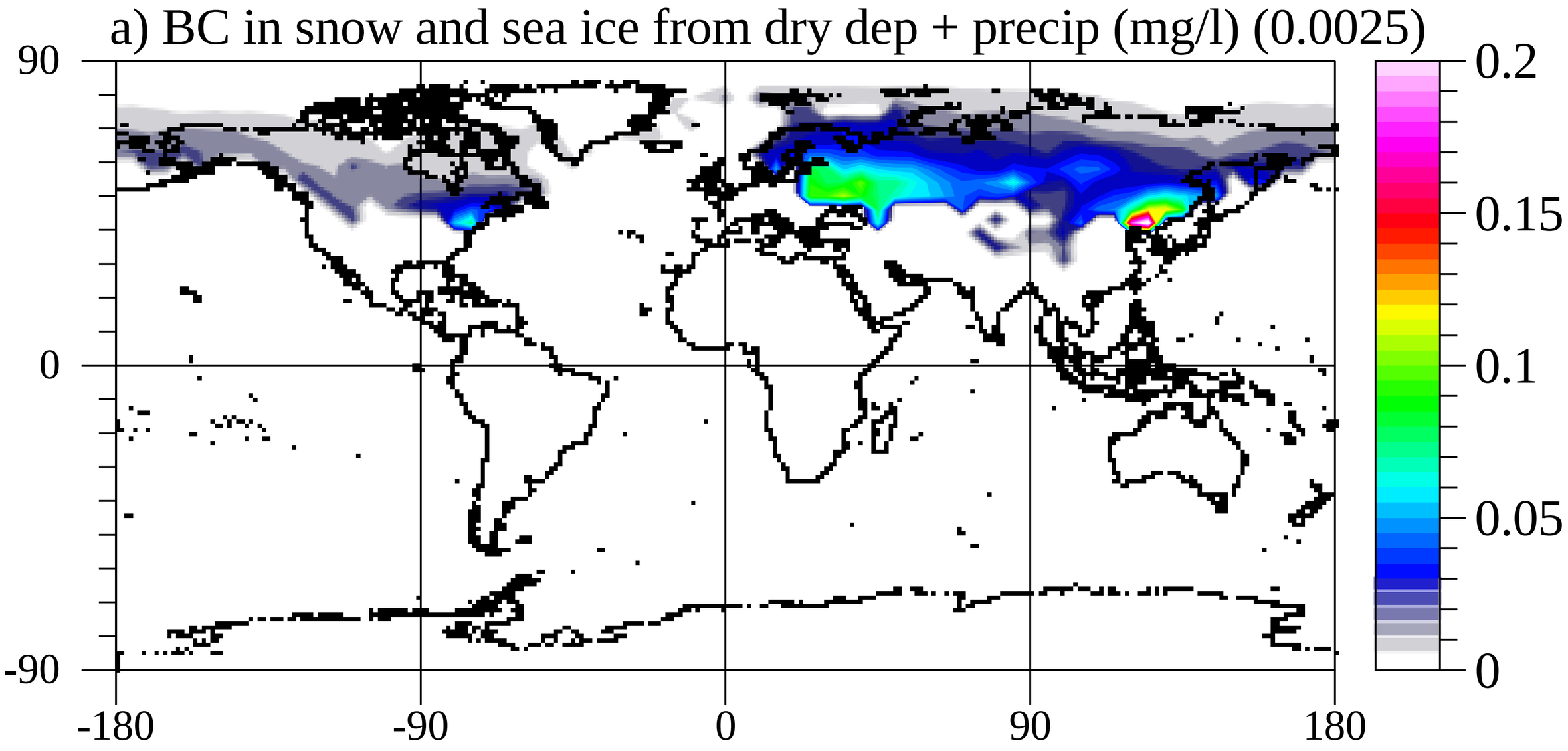
Black Carbon in the Air in the Clear Sky



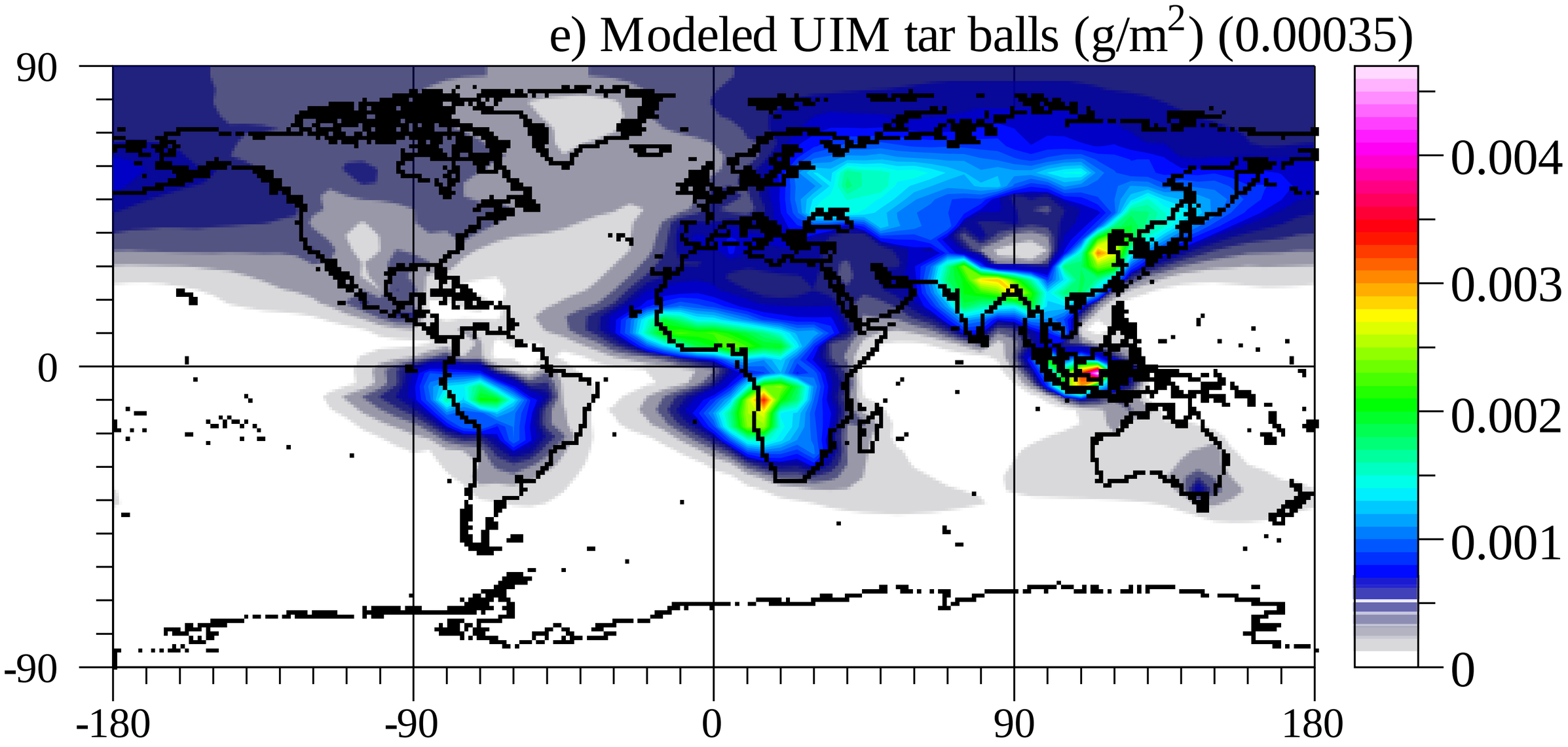
Black Carbon in Clouds



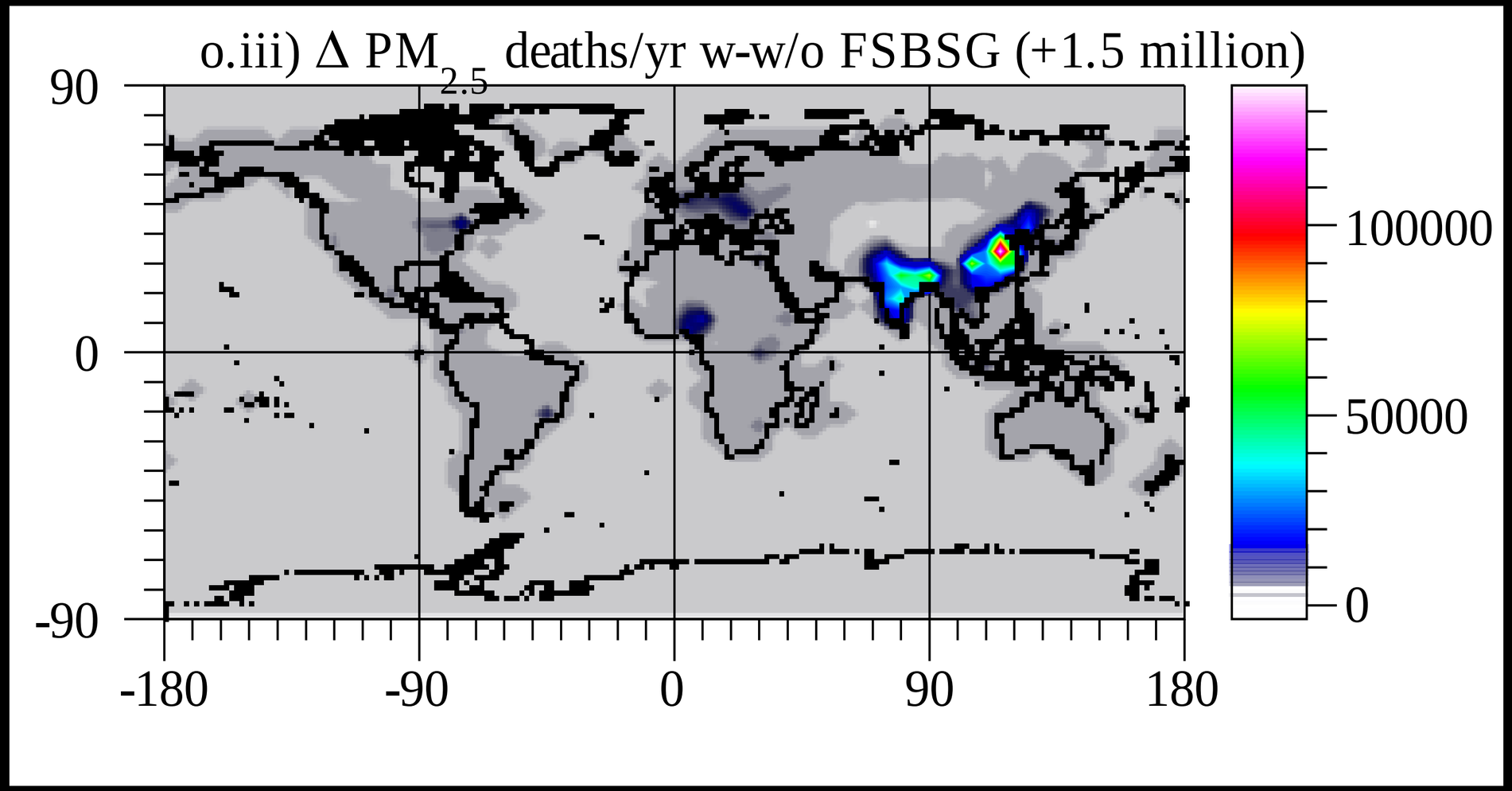
Black Carbon in Snow and Sea Ice



Brown Carbon in the Clear Sky



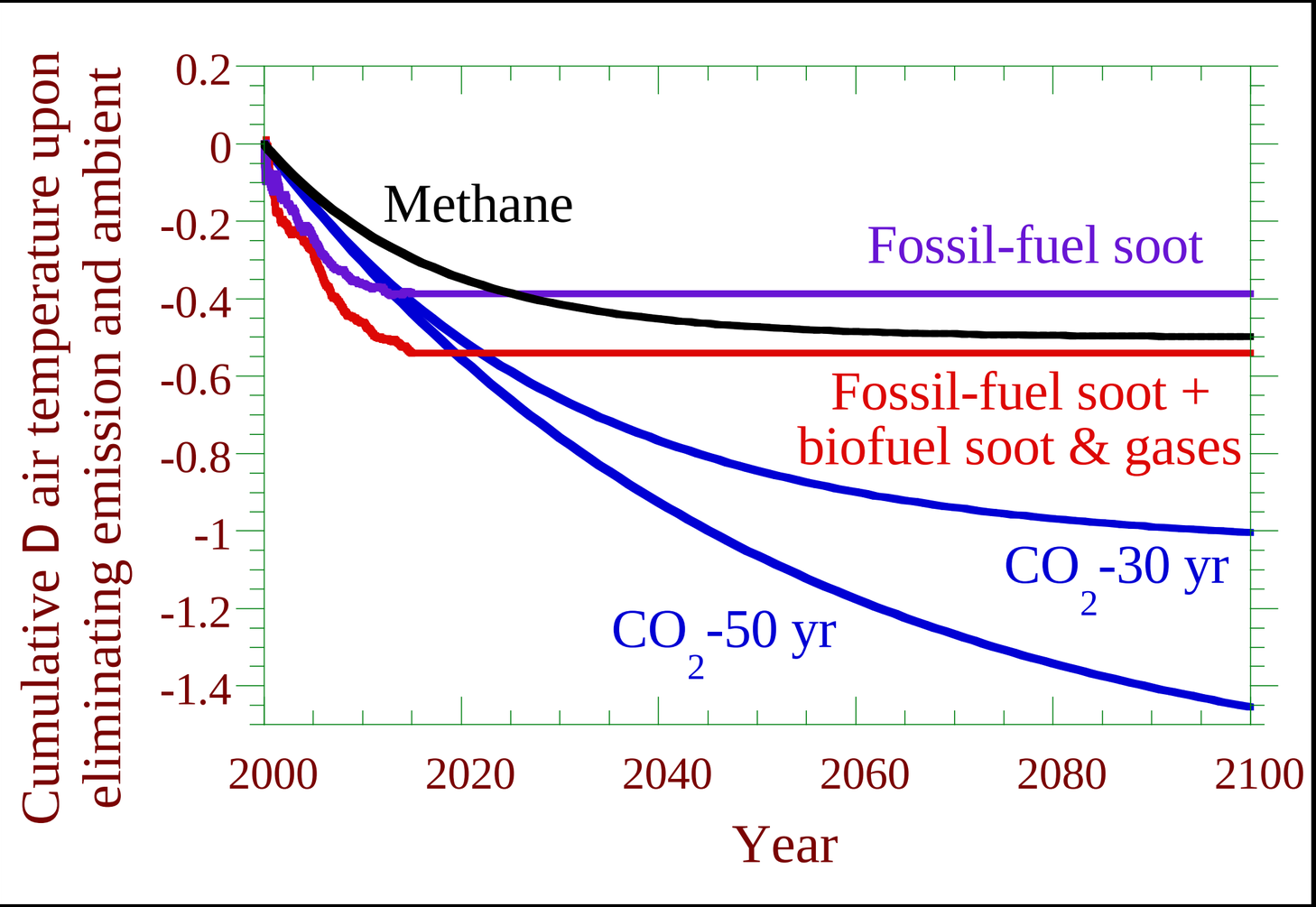
Annual Deaths Due to Fossil-Fuel plus Biofuel Soot



Annual deaths due to biofuel soot: 1.5 million/yr

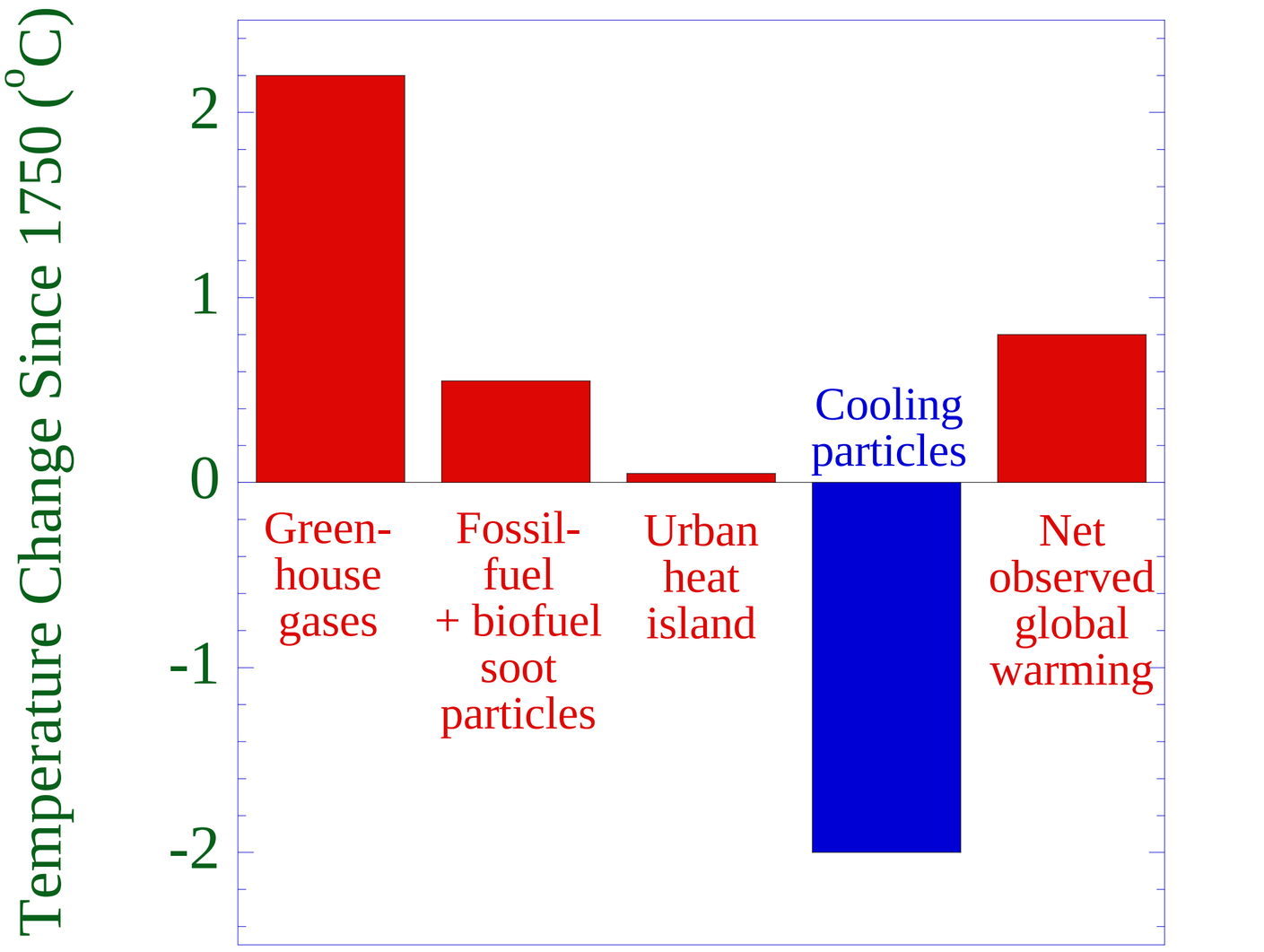
Annual deaths due to fossil-fuel soot: 200,000/yr

100-yr Temperature Changes Due to Eliminating Fossil-Fuel and Biofuel Soot, CH_4, CO_2 Emissions



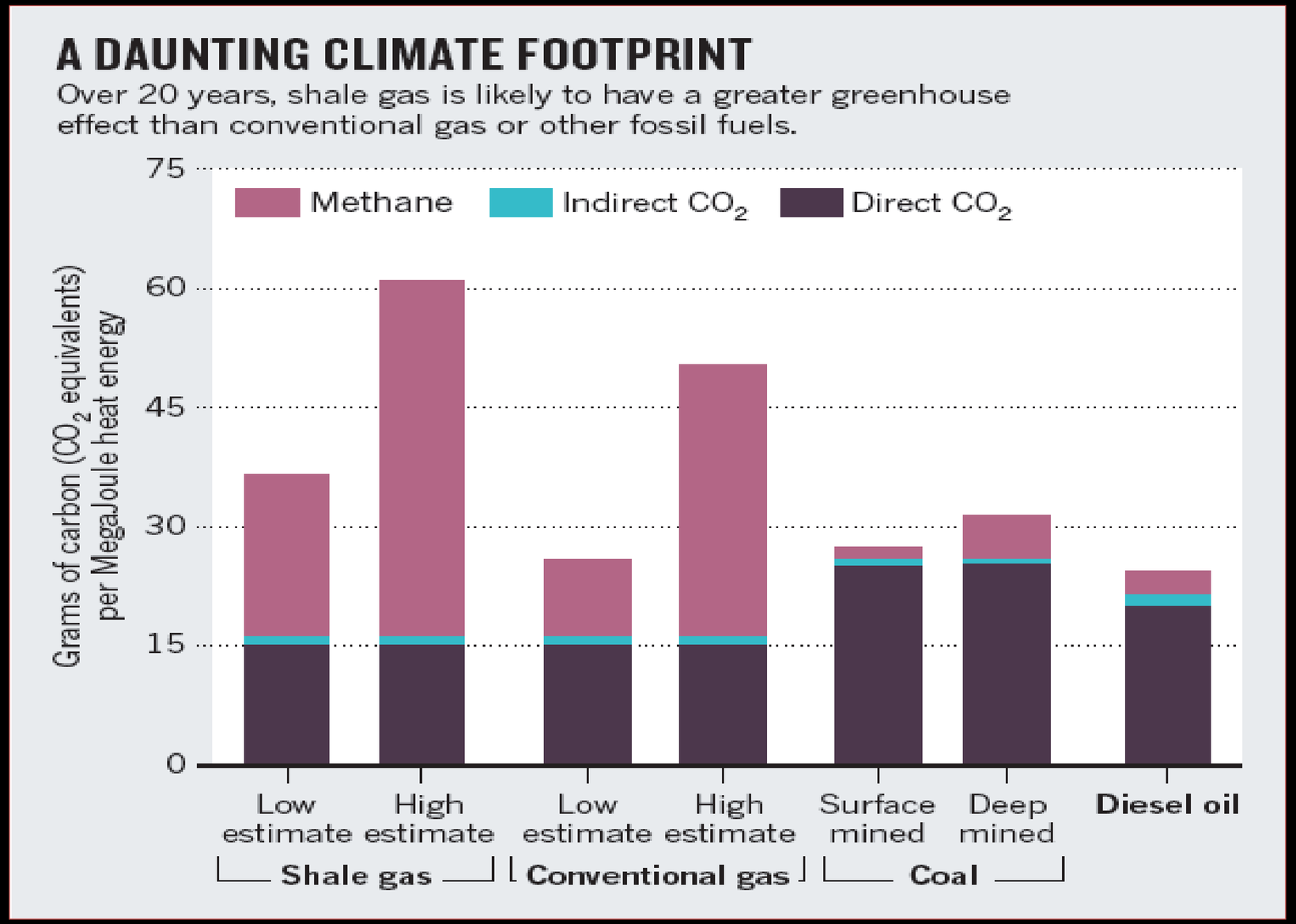
Controlling fossil-fuel plus biofuel soot and gases may be fastest method of slowing global warming and preventing loss of Arctic sea ice. www.stanford.edu/group/efmh/jacobson/controlfossilfuel.html

Contributors to Global Warming



Jacobson (2010, JGR 115, D14209)

Greenhouse gas footprint of shale gas compared with other fossil fuels (20-year integrated global warming potential for methane)



Howarth & Ingraffea, *Nature*, 15 September 2011

Summary

Soot (containing black and organic carbon) and methane are the second- and third-leading causes of global warming, respectively.

Soot kills ~1.5 million people/yr worldwide. Methane increases ozone, which has global health impacts. Temperature increases due to both also enhance air pollution.

Controlling soot and methane may be the only methods of preventing loss of the Arctic sea ice and a tipping point to more rapid global warming.

www.stanford.edu/group/efmh/jacobson/Articles/VIII/controlfossilfuel.html
www.stanford.edu/group/efmh/jacobson/Articles/VII/CloudAbsorption.html