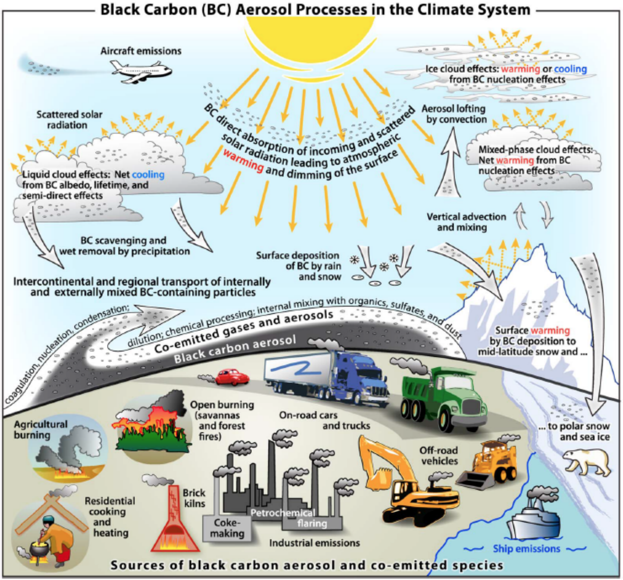
Climate Effects of Black Carbon Aerosols

Ulrike Lohmann

ETH Zurich
Institute for Atmospheric
and Climate Science

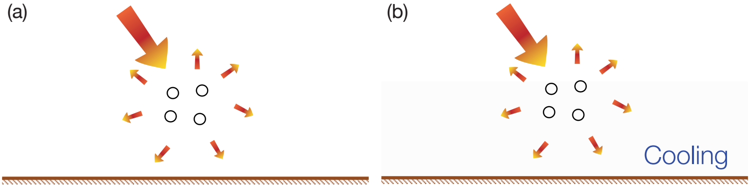
Acknowledgements:
Zamin Kanji and André Welti



Bond et al., JGR (2013)

Aerosol-radiation interactions

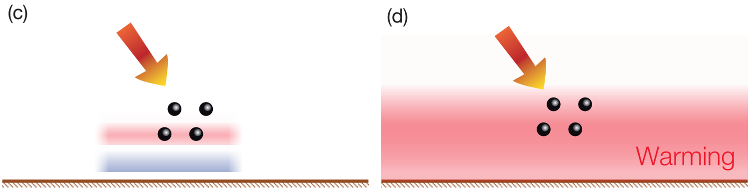
Scattering aerosols



Aerosols scatter solar radiation. Less solar radiation reaches the surface, which leads to a localised cooling.

The atmospheric circulation and mixing processes spread the cooling regionally and in the vertical.

Absorbing aerosols



Aerosols absorb solar radiation. This heats the aerosol layer but the surface, which receives less solar radiation, can cool locally.

At the larger scale there is a net warming of the surface and atmosphere because the atmospheric circulation and mixing processes redistribute the thermal energy.

IPCC, Fig. FAQ 7.2, (2013)

Vertical profiles of BC

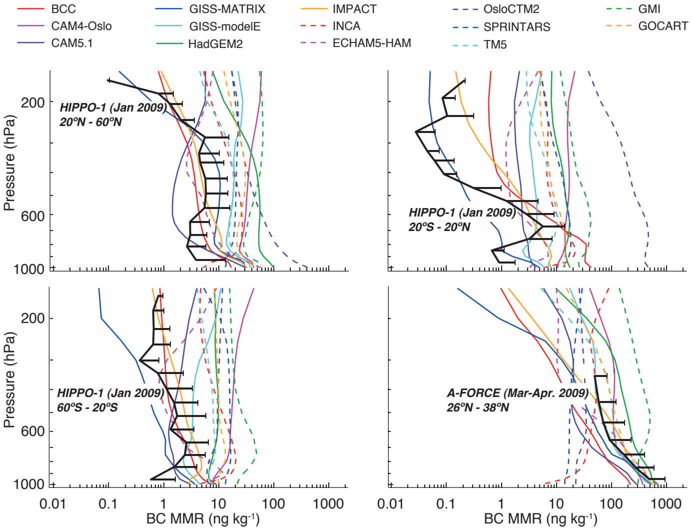
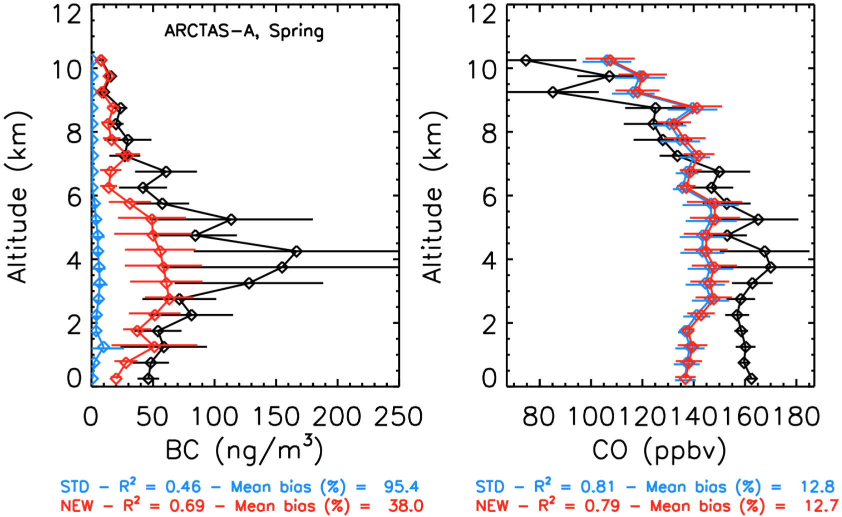


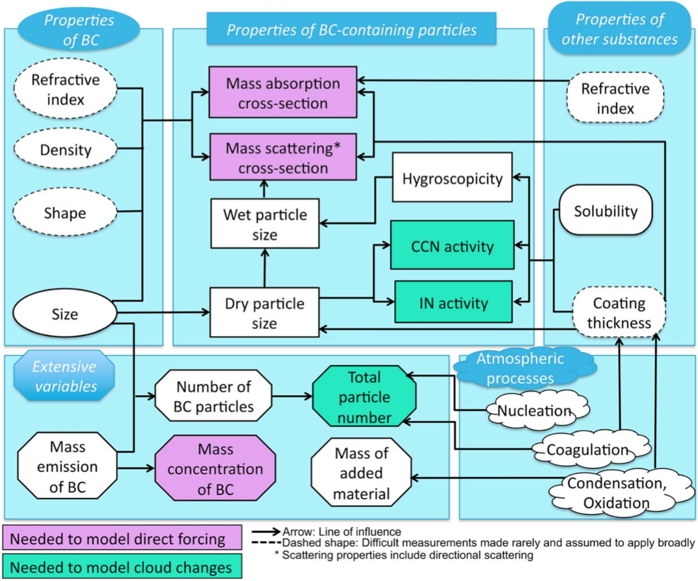
Fig. 7.15 (IPCC, 2013)

Transport to the Arctic



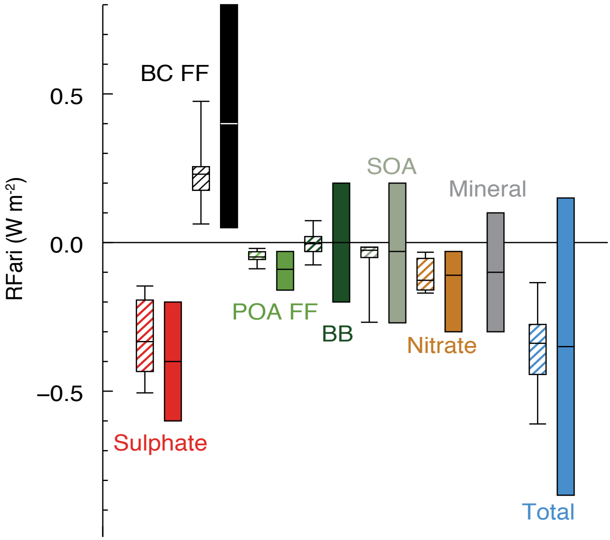
Bourgeouis and Bey, JGR (2011)

Properties of BC and BC-containing particles and their connections to climate models



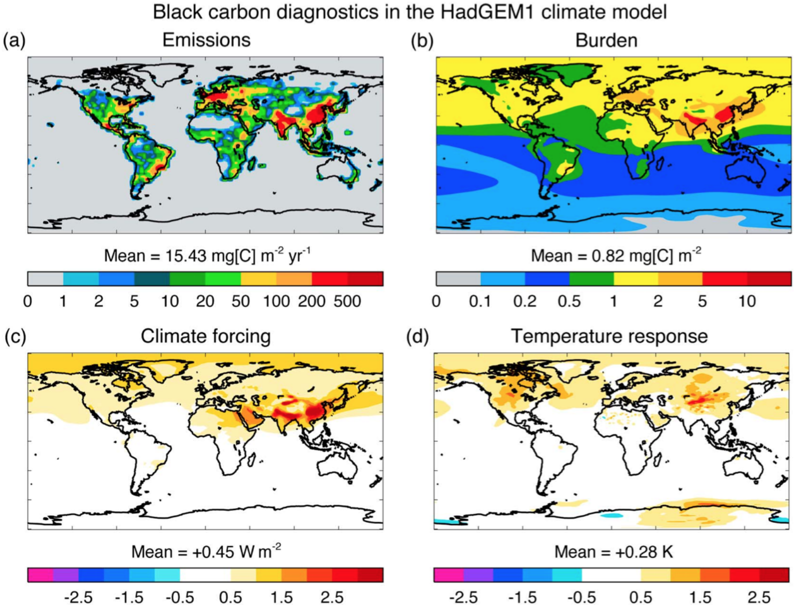
Bond et al., JGR (2013)

Aerosol radiative forcing 1750-2010

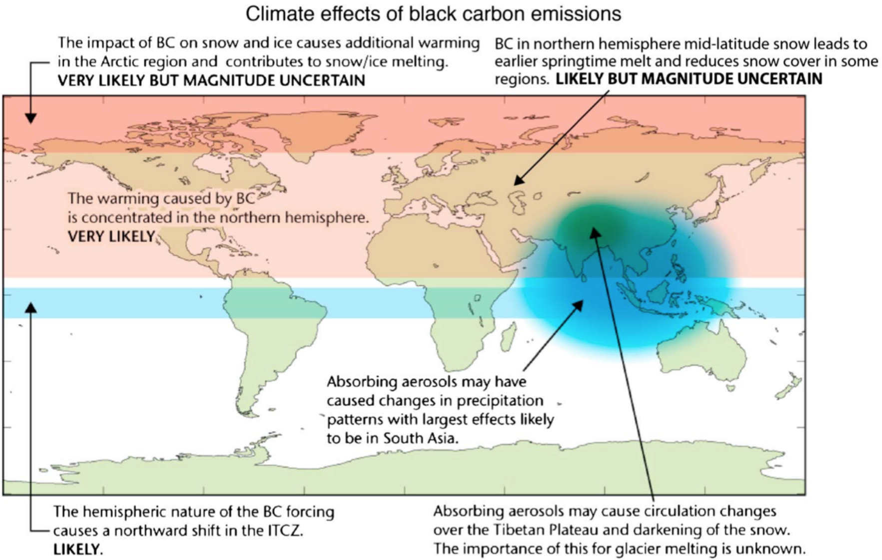


hatched: AeroCom II models
solid: AR5 estimates

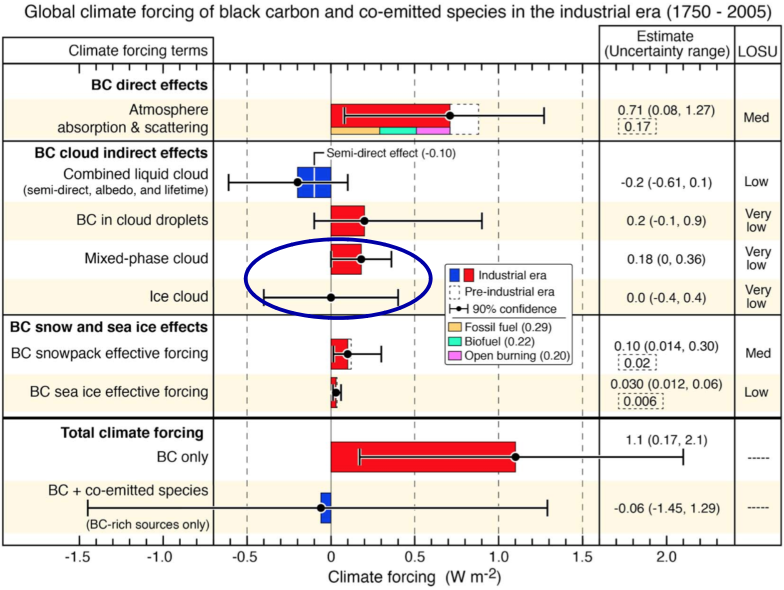
(IPCC, Fig. 7.18, 2013)



Bond et al., JGR (2013)

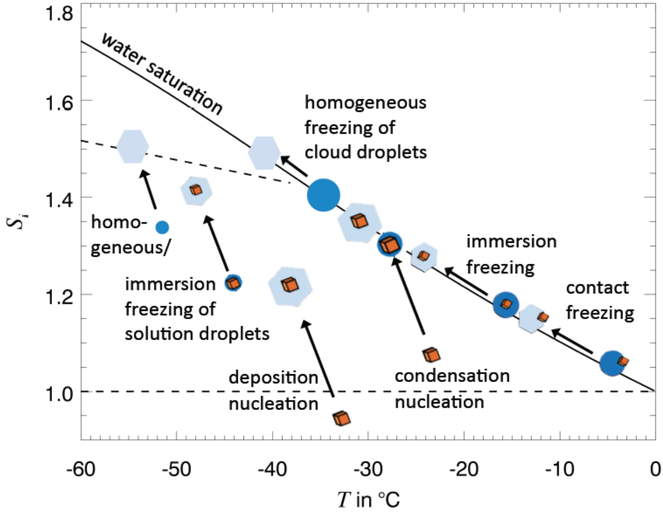


Bond et al., JGR (2013)



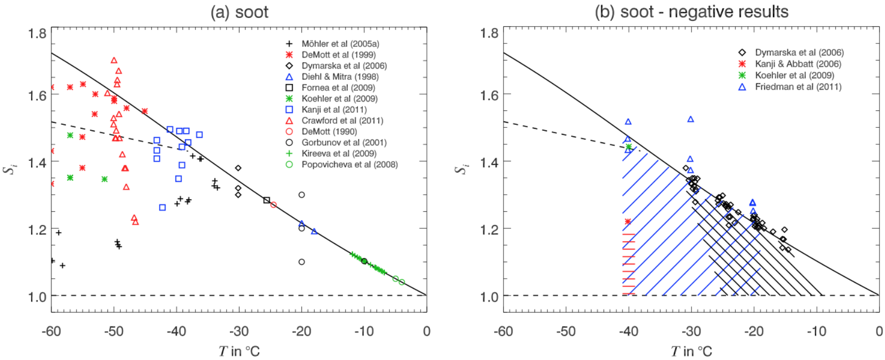
Bond et al., JGR (2013)

Heterogeneous freezing



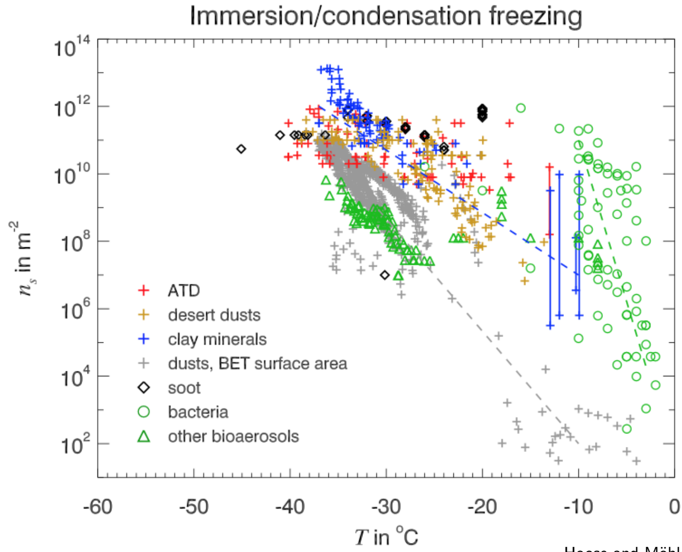
Hoose and Möhler, ACP (2012)

Compilation of freezing data on soot



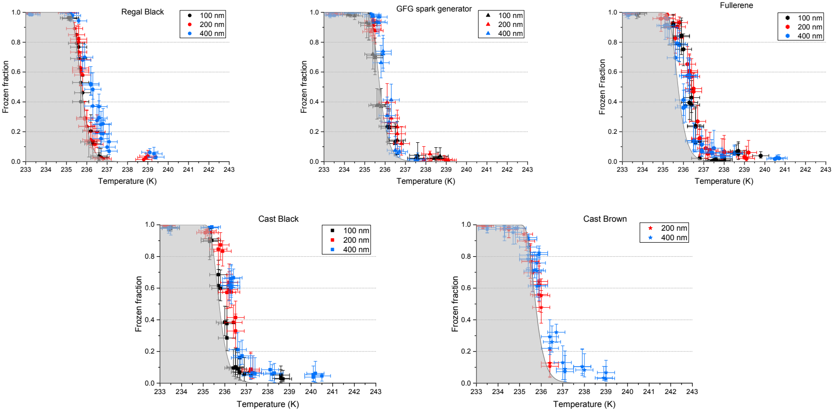
Hoose and Möhler, ACP (2012)

Ice nucleation active surface site (INAS) density



Hoose and Möhler, ACP (2012)

Frozen fraction of droplets containing BC



Courtesy André Welti and Zamin Kanji (ETHZ)

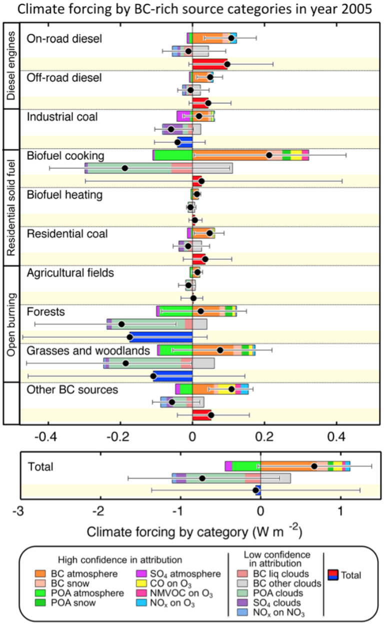
Conclusions

BC as ice nuclei:

- BC nucleates ice only at rather cold temperatures
- The studies testing BC as an ice nuclei obtain conflicting results

Climate effects of BC:

- The total climate forcing of BC is positive, but could be close to zero if co-emitted species are considered as well
- The effect of BC on clouds seems to counteract its direct radiative effect, but they are much more uncertain



BC-rich sources comprise 99% of all BC emissions

- Top bar: direct forcing by aerosol and most gases and aerosol cryosphere forcing
- Middle bar: cloud effects and nitrate
- Bottom bar: net climate forcing by each emission source

Bond et al., JGR (2013)