The role of atmospheric nanoparticles in climate forcing

J.P. Putaud
European Commission, Joint Research Centre, Institute for Environment and Sustainability, Climate Change Unit
I-21027 Ispra, Italy

Outline

1- Sources, concentration and fate of nanoparticles in the atmosphere

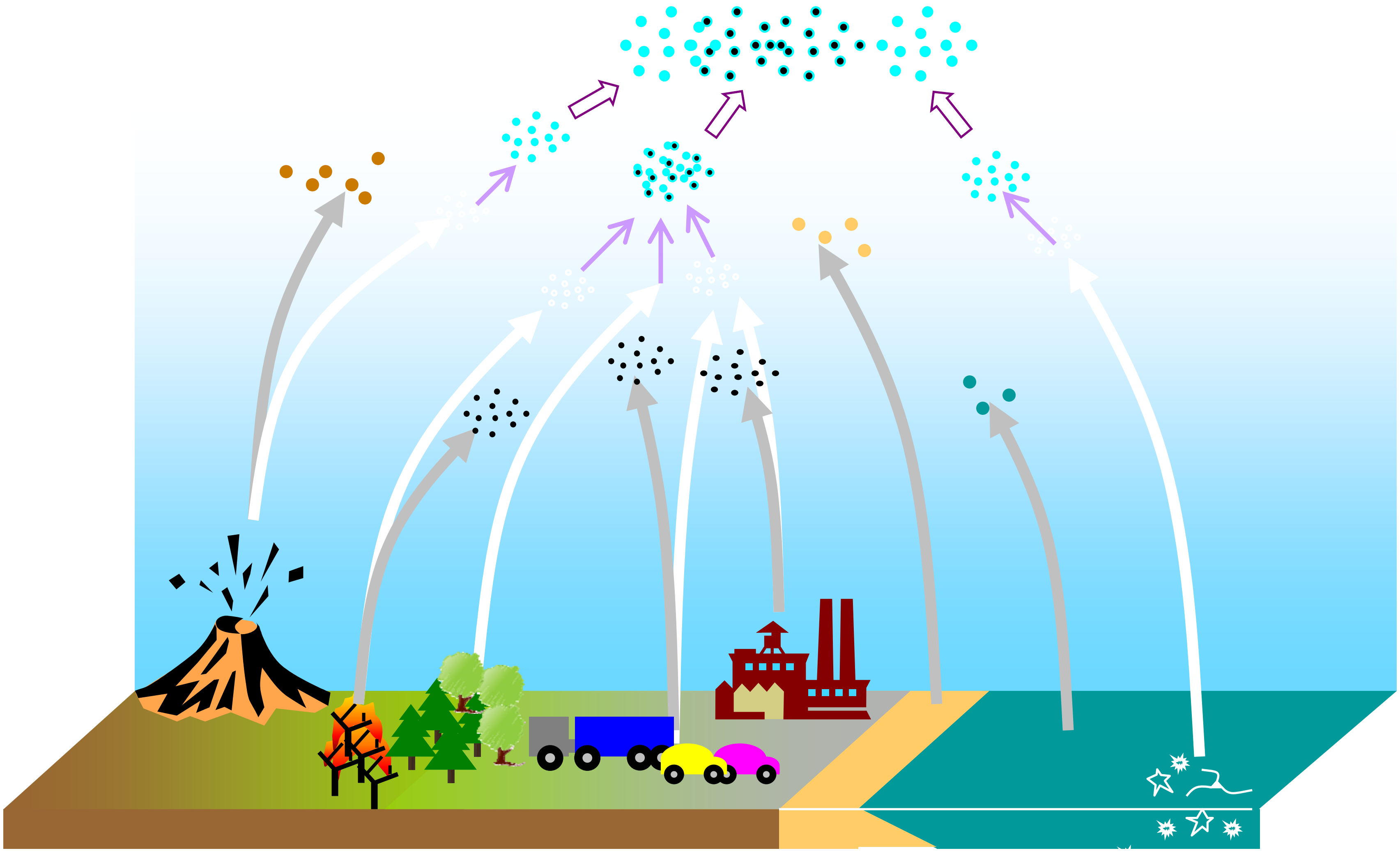
2- Atmospheric particles and climate forcing

3- Consequences for European policy making

4- Remaining uncertainties and new approaches

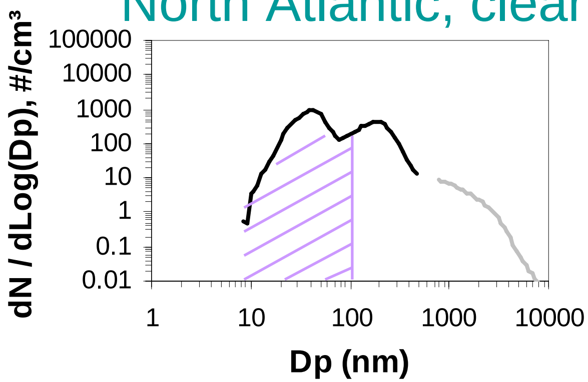
5- Conclusions

Sources of atmospheric particles



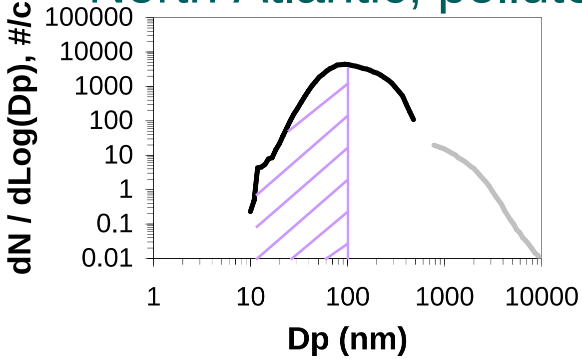
Size distribution of atmospheric particles

North Atlantic, clean



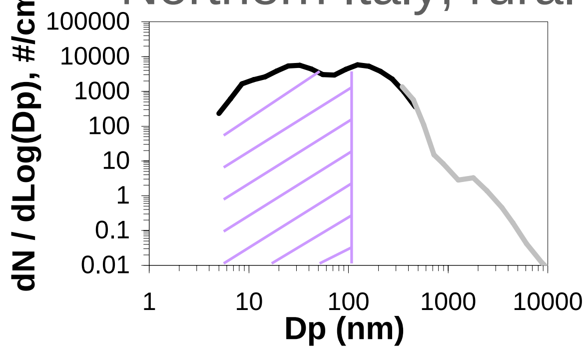
N_{tot} = 1100 cm^{-3}

North Atlantic, polluted



N_{tot} = 6200 cm^{-3}

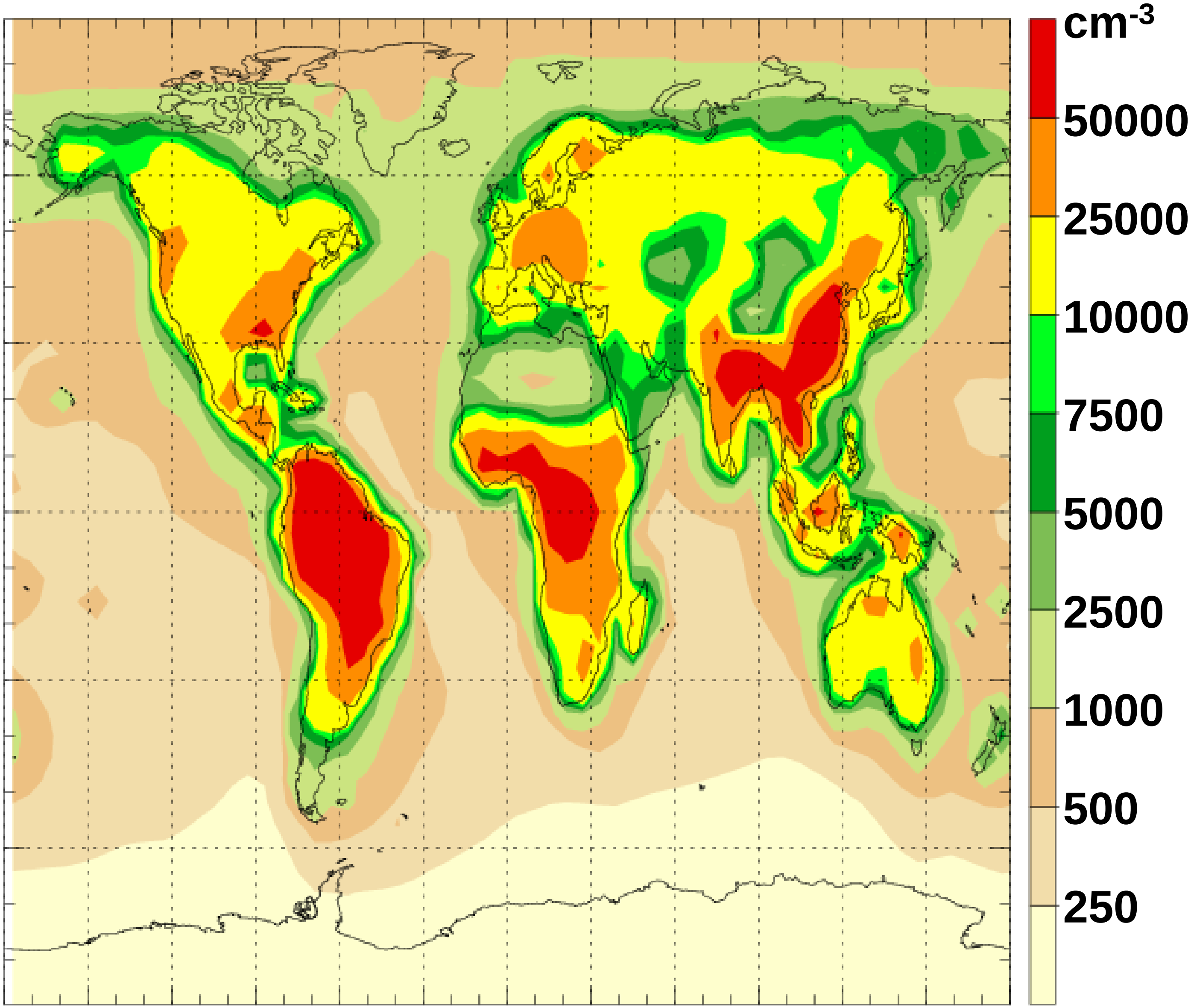
Northern Italy, rural



N_{tot} = 14000 cm^{-3}

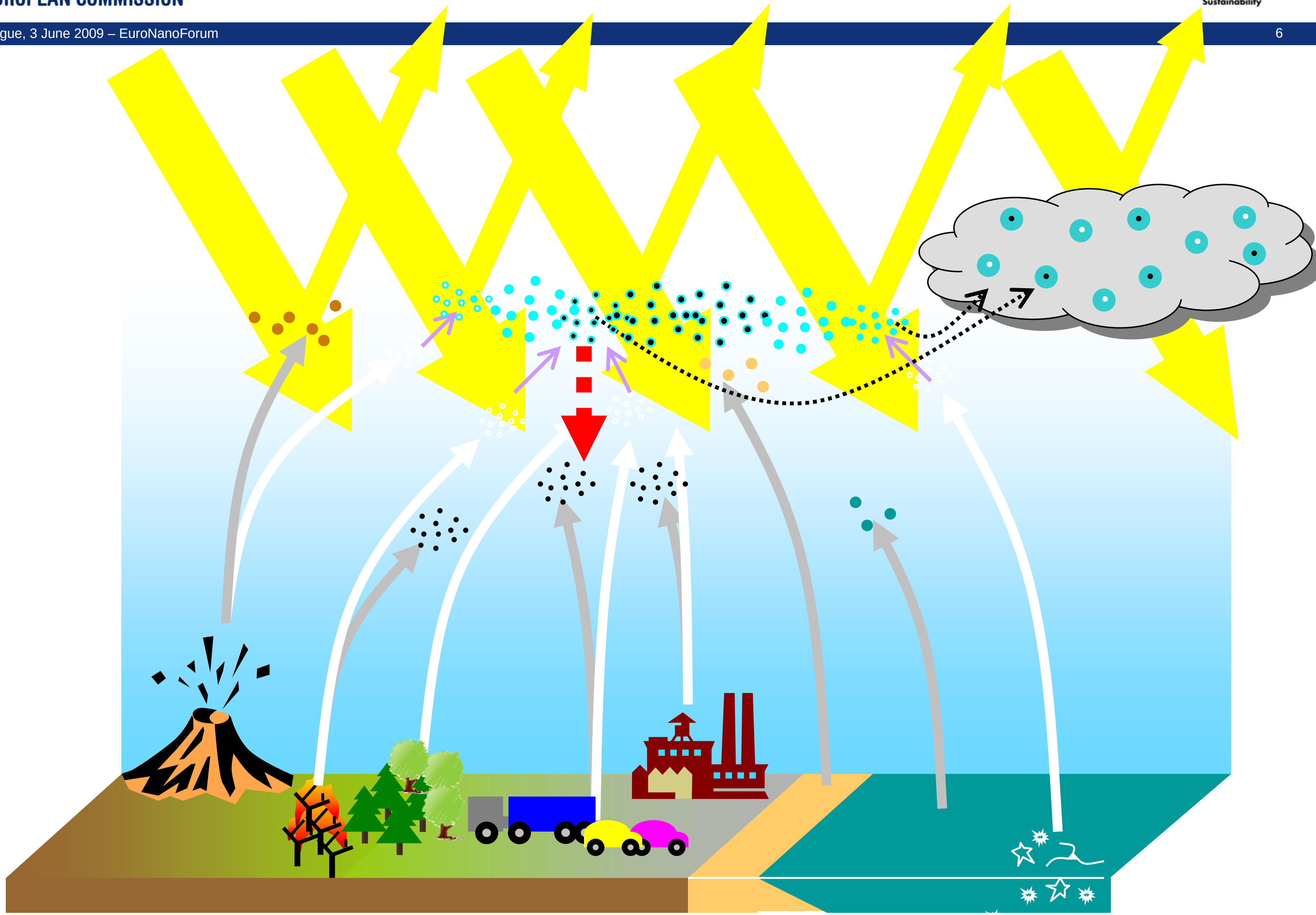
Raes et al., *Atm. Environ.*, 2000

Concentration of atmospheric nanoparticles



E. Vignati, TM5 – M7 model output., 2009

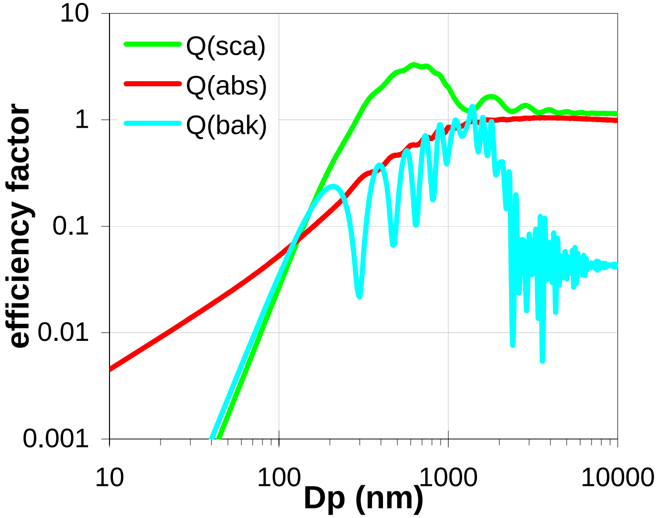
Atmospheric particles and climate



Atmospheric particles and climate

Direct interaction with solar light (550 nm)

60% ultra-fine



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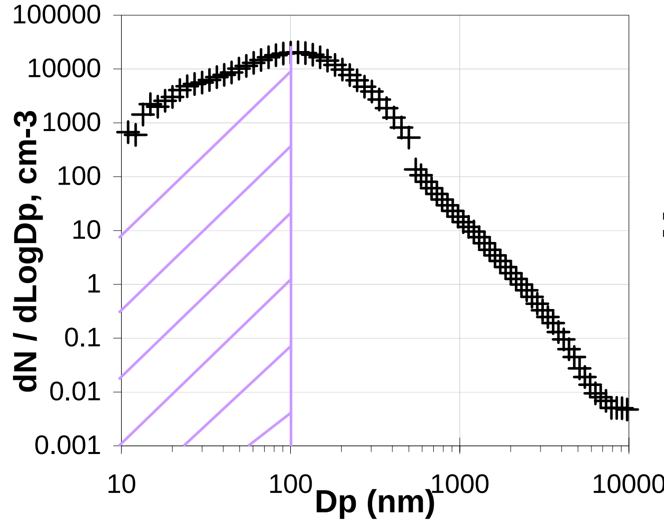

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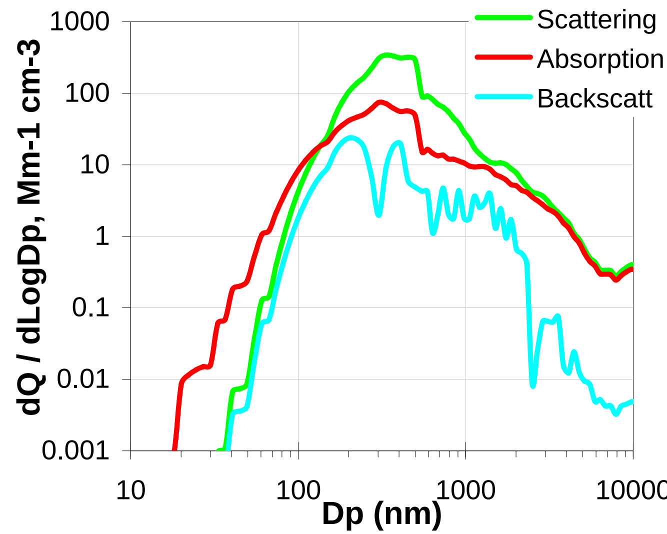
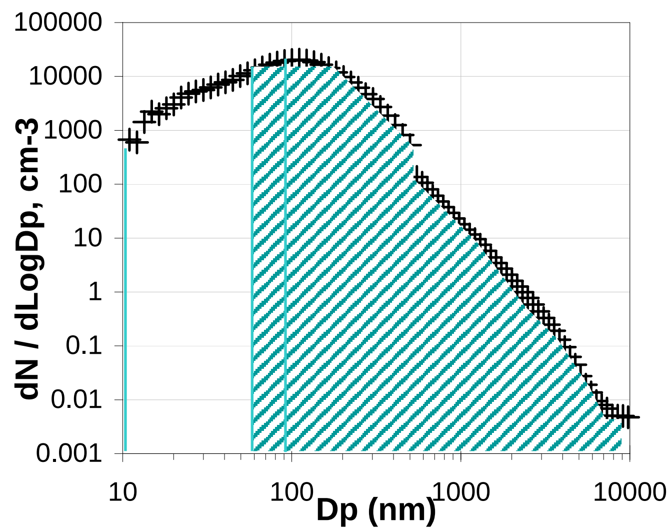


Influence on cloud properties



~ 50% of the nanoparticles can form cloud droplets

Because of suspected health adverse effects of atmospheric particles, air quality legislation aim at reducing PM10 and PM2.5 concentrations and population exposure

Air Pollution (AP) is regarded as a local to regional issue

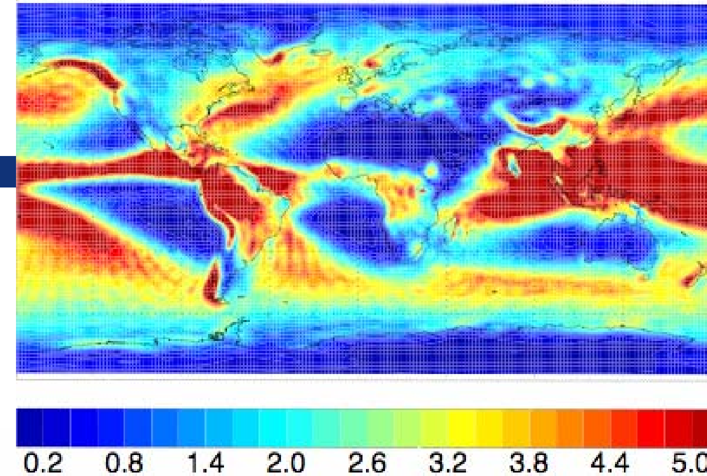
Climate Change is regarded as a global issue

⇒ Policies tend to address these issues separately

But possible co-benefits and trade-offs should be considered

Climate effect of atmospheric particles

Precipitation rate



Currrent (2000): 3.0 mm / d

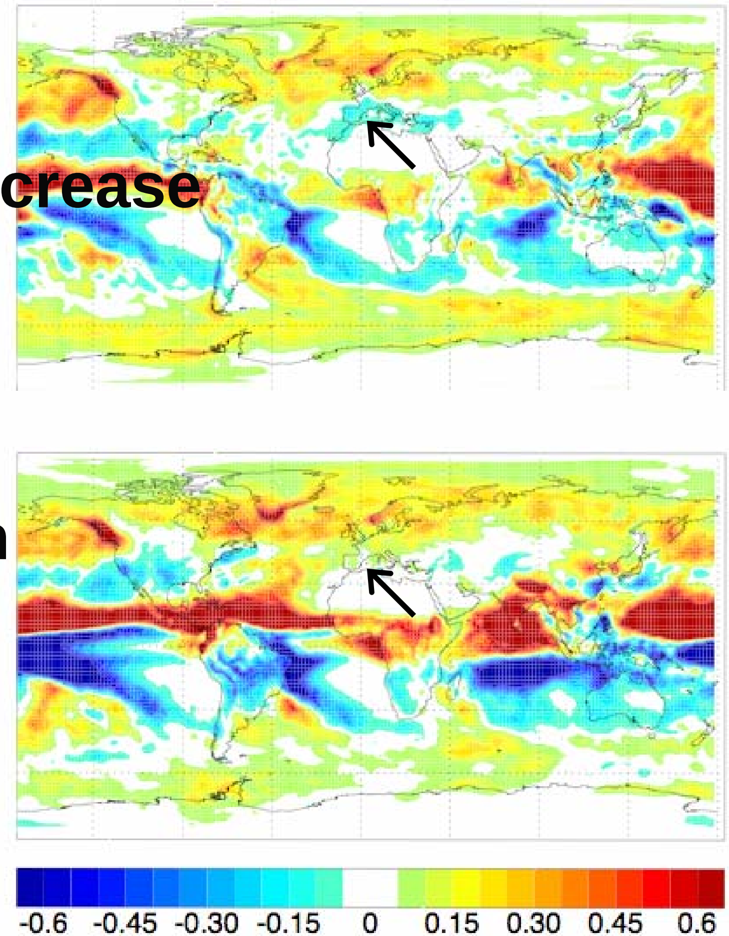
Effect of greenhouse gas concentration increase

2030 GHG ↑ – 2000: +0.07 mm / d

Effect of particulate air pollution reduction

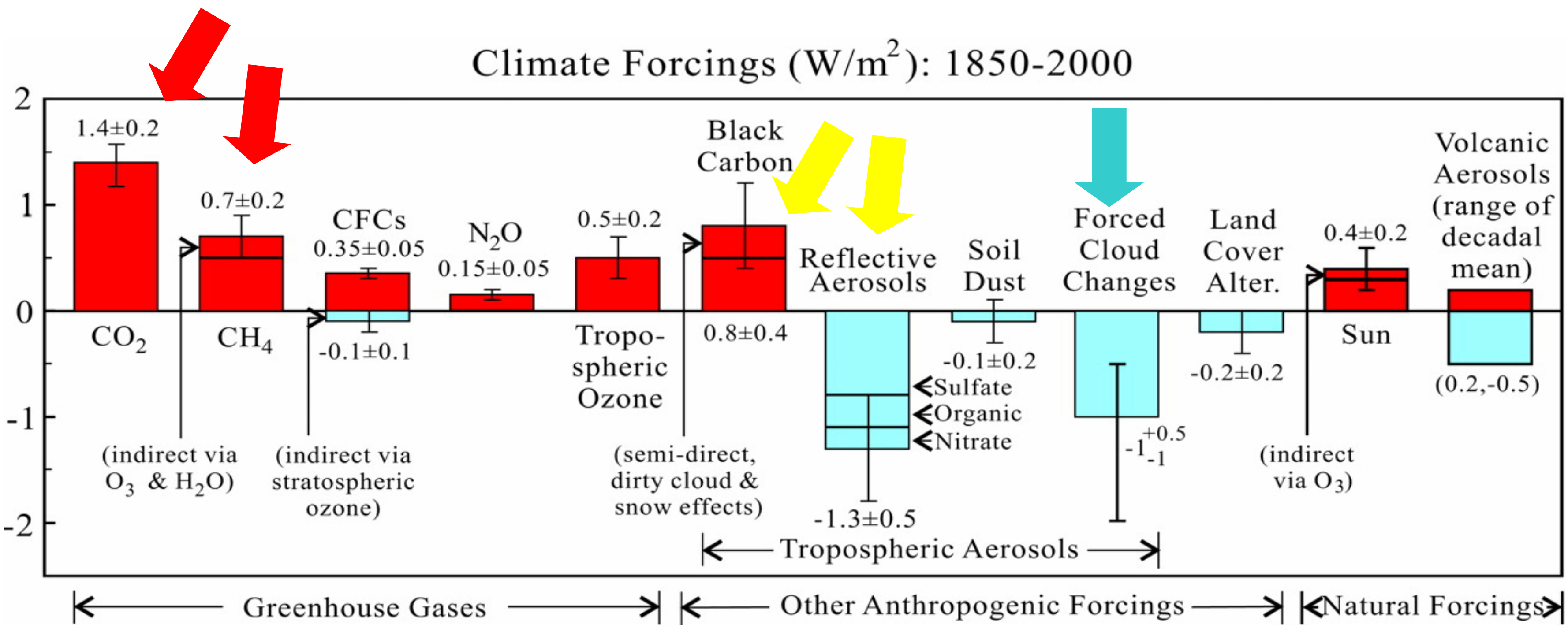
(maximum feasible reduction)

2030 AP ↓ (MFR) – 2000: +0.08 mm / d



Kloster et al., *ACP*, 2009

Estimates of aerosol global radiative forcing from GCMs



Hansen and Sato, *PNAS*, **98**,14778 - 14783, 2001

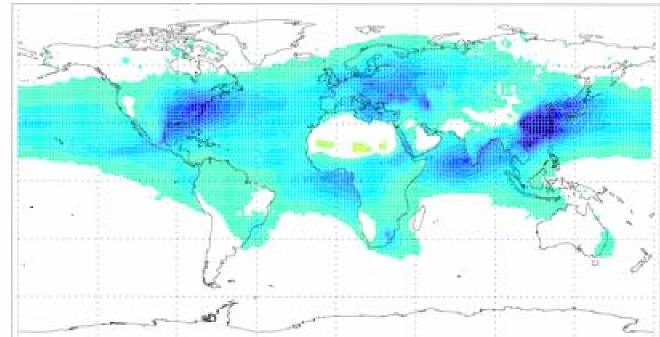
Both direct and indirect radiative impacts of aerosols might be significant

The global forcing by aerosols in negative (cooling)

Past and future radiative effect of atmospheric particles

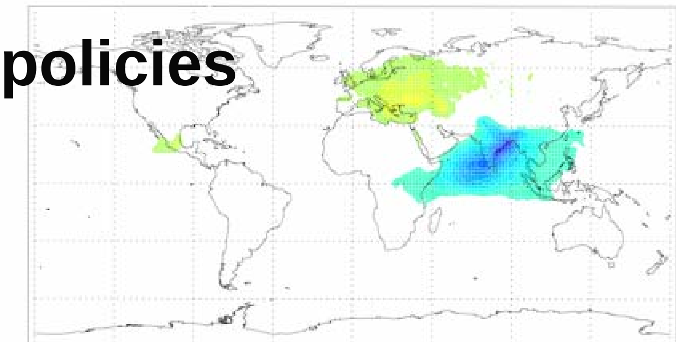
Radiative forcing

2000 – 1750: -2.1 W / m² cooling by aerossols
vs. +2.6 W / m² warming by GHGs

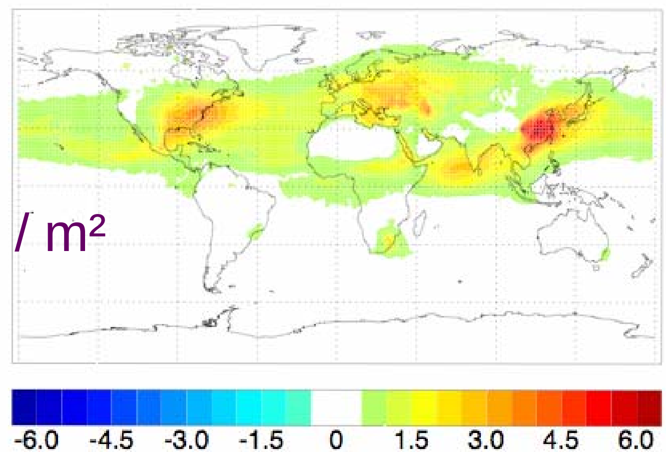


Effect of future particulate air pollution policies

2030 Current Legislation – 2000: +0.02 W / m²



2030 Maximum Feasable Reduction – 2000: +1.1 W / m²
vs. +0.7 W / m² from CO_2



Kloster et al., *ACP*, 2009

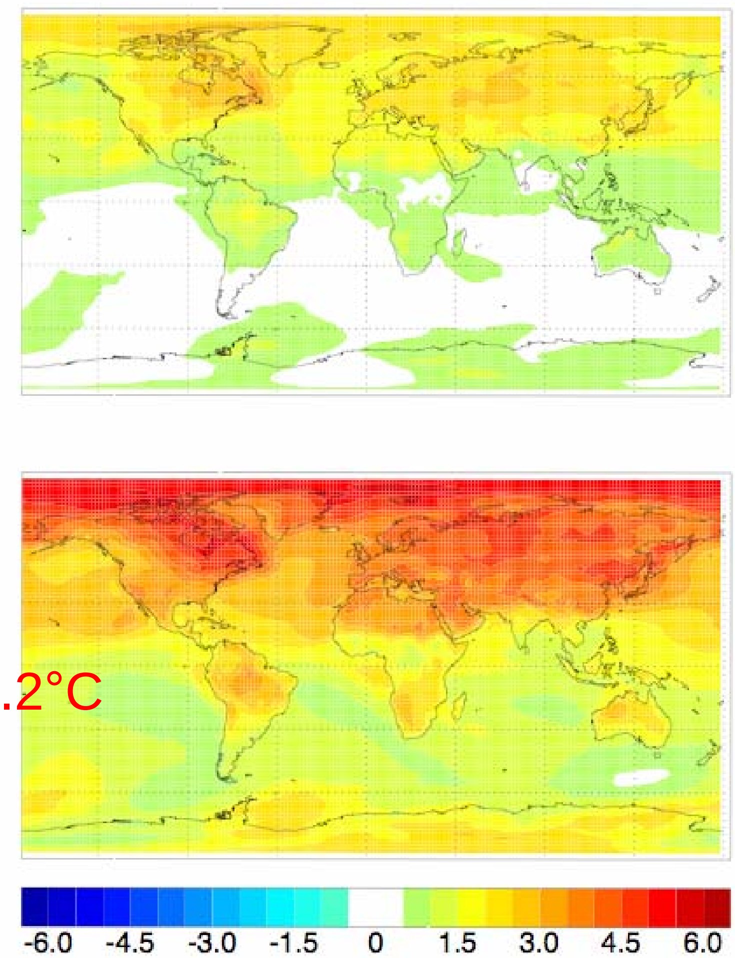
EUROPEAN COMMISSION

Future climate effect of atmospheric particles

Ground level temperature

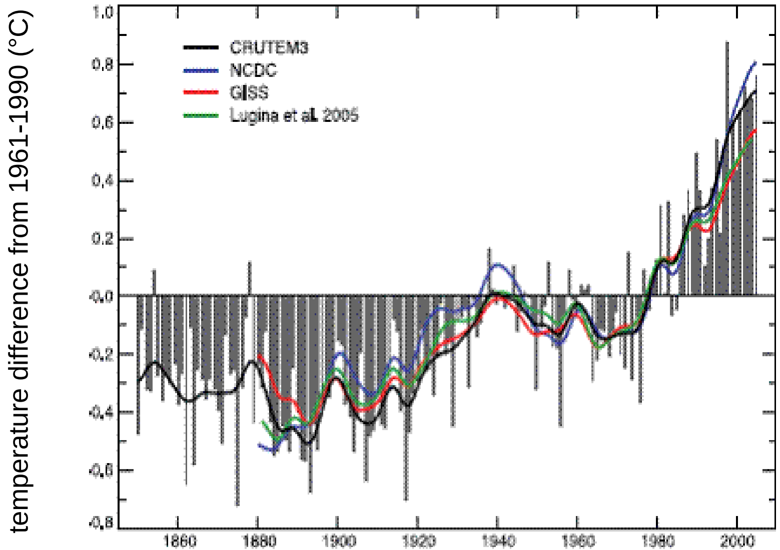
2030 GHG ↑ – 2000: +1.2 °C

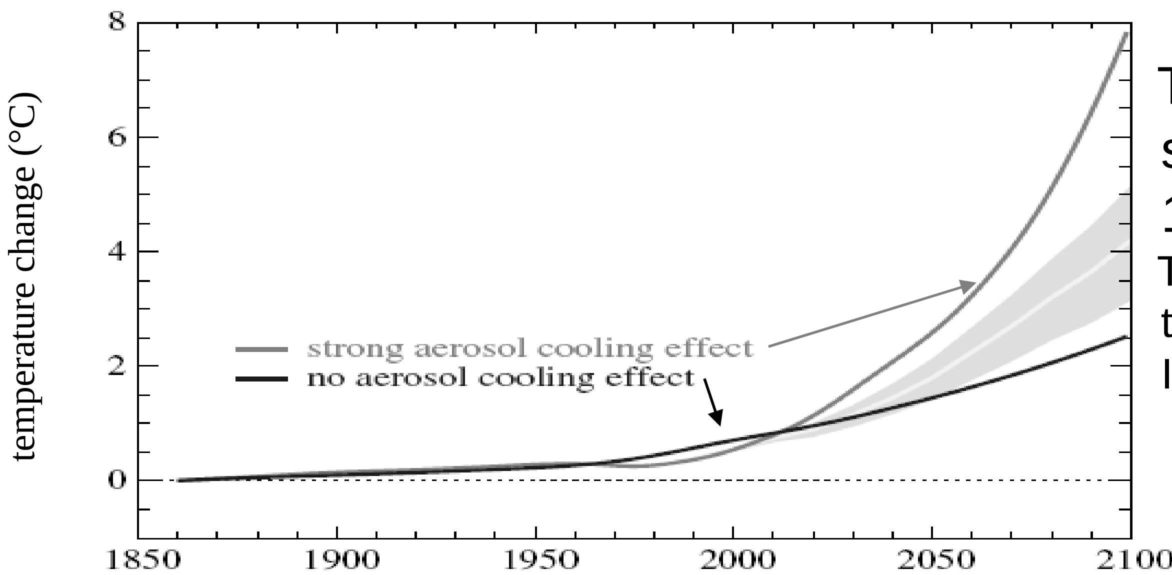
2030 GHG ↑ + Aerosol Pollution ↓ (MFR) – 2000: +2.2°C



Kloster et al., *ACP*, 2009

Greenhouse gas vs. atmospheric particle climate effects





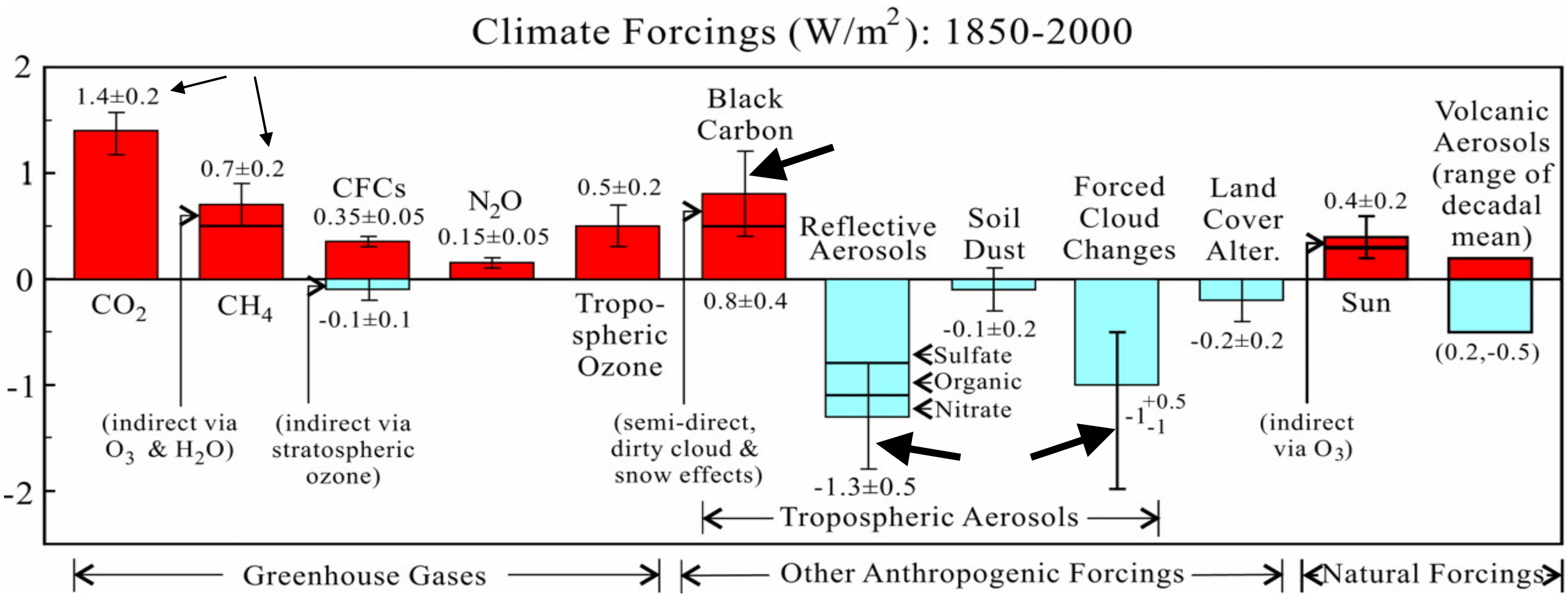
Temperature change simulated by a simple climate model for the period 1850–2100 (Andreae et al., 2005).

The shading and the line within it represent the range and central projection given in IPCC-TAR, based on the same scenario A2.

Andreae, M.O., *Phil. Trans. R. Soc. A* **365**, 1915–1923, 2007

Uncertainties in estimated climate forcings

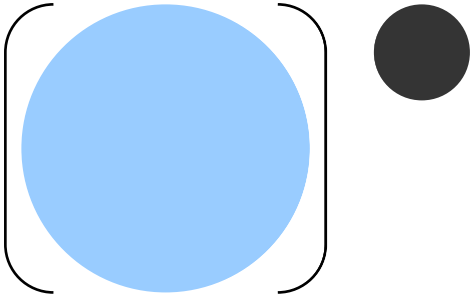
Error bars are partly subjective 1σ uncertainties.



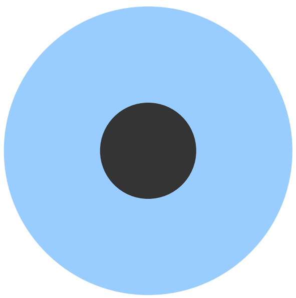
Hansen and Sato, *PNAS*, **98**,14778 - 14783, 2001

Both direct and indirect radiative impacts of aerosols are affected by large uncertainties

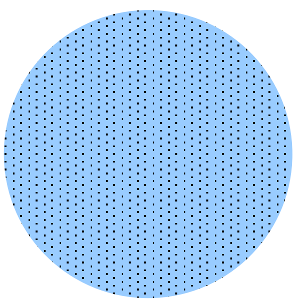
Uncertainties in BC estimated climate forcing



+ 0.27 W m^{-2} for externally mixed BC

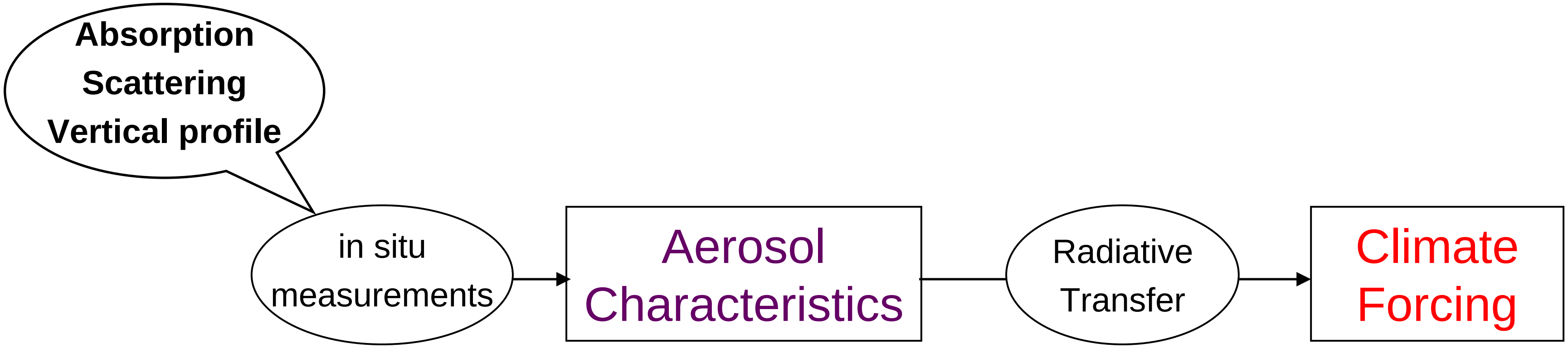


+ 0.54 W m^{-2} for BC as a coated core

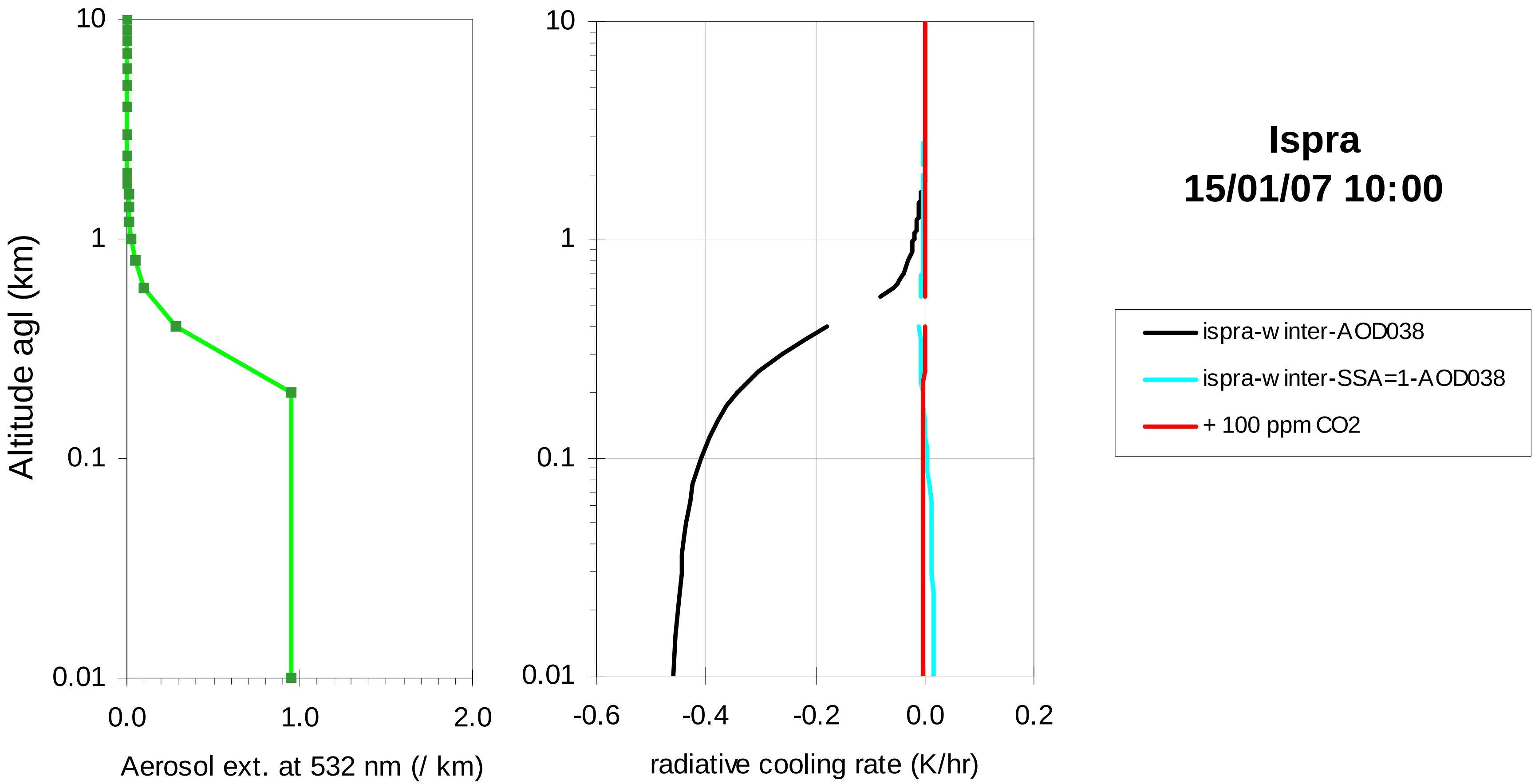


+ 0.78 W m^{-2} for BC as well internally mixed

Reducing uncertainties in aerosols' climate forcing

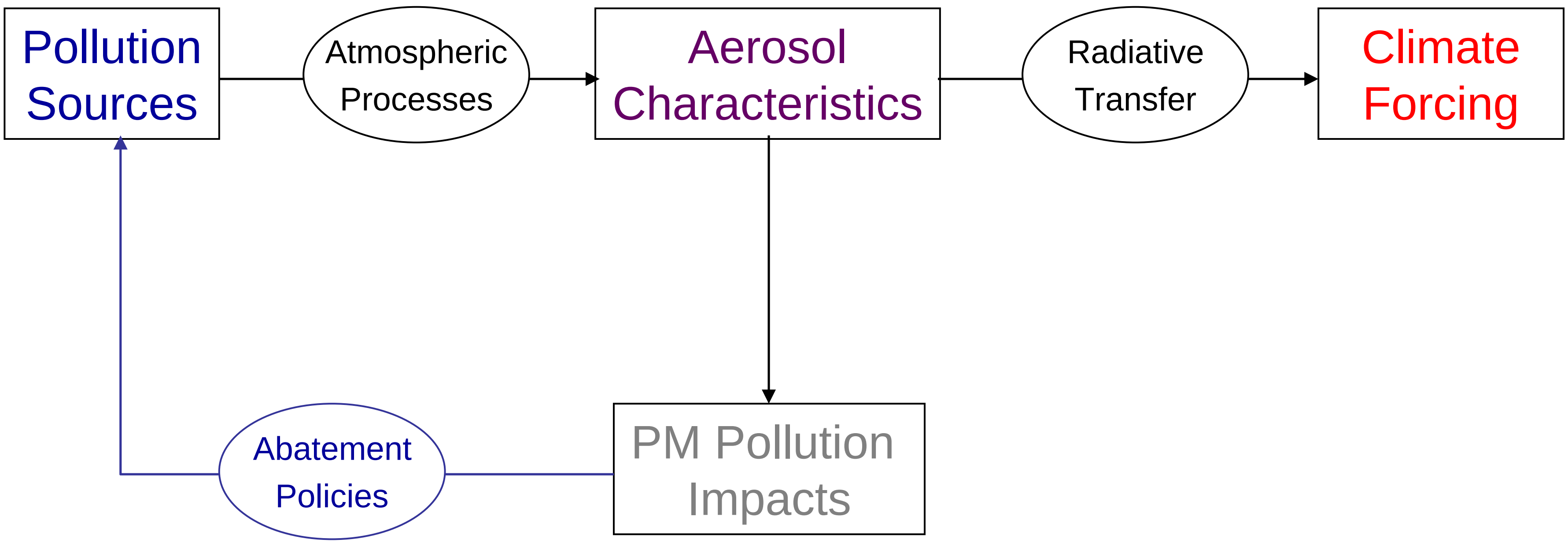


Reducing uncertainties in aerosol climate forcing: Ispra case study



Putaud et al., *unpublished*, 2007

Anticipating the effects of particulate air pollution change on climate forcing



Conclusions

1- The sources of nanoparticles in the atmosphere are numerous (both natural and anthropogenic).

2- Nanoparticles are instable in the atmosphere wrt coagulation and cloud activation and grow to 200 – 600 nm diameter particles.

3- Atmospheric particles exert a possibly large but still uncertain climate forcing through direct and indirect interactions with sunlight.

4- The aerosol radiative forcing should not be forgotten when designing European policies on air pollution and climate change.

5- An experimental approach is being developed for assessing the aerosol radiative forcing from measurements.

THANK YOU

Recent relevant publications from JRC – IES – CCU staff:

Kloster S. et al., A GCM study of future climate response to aerosol pollution reductions, Climate Dynamics, in press, 2009.

Raes F. and Swart R., Climate Assessment: What's Next?, Science, 318, 1386, 2007.

Schulz M. et al., Radiative forcing by aerosols as derived from the AeroCom present-day and pre-industrial simulations, Atmos. Chem. Phys., 12, 5225 – 5246, 2006.

Swart R. et al., A Good Climate for Clean Air: Linkages between Climate Change and Air Pollution. An Editorial Essay, 66, 263 – 269, 2004.