TWO SOURCES OF UNCERTAINTIES IN MODELLING BLACK CARBON AT GLOBAL SCALE

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Background

- BC is important for:
  - air quality due to possible health effect
  - and its influence on climate (direct effect, Radiative Forcing: 0.20 ± 0.15 Wm^{-2}; surface albedo change, RF: 0.10 ± 0.10 Wm^{-2} (IPCC, 2007))

→ need of assessing its impact using Chemistry-Transport and Global Circulation Models

Difficulties

The uncertainties related to the model are difficult to evaluate:

- Emission inventories have an uncertainty of a factor of 2 (Bond et al., 2004)
- Inclusion of ageing processes of BC can change BC lifetime by an order of magnitude (Croft et al., 2005)
- Wet deposition is the most uncertain process in the model (Textor et al., 2006)

However

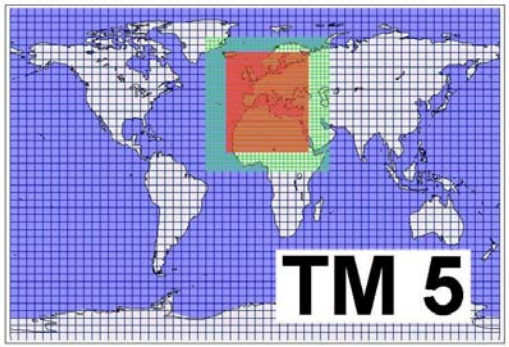
- The evaluation of the uncertainties of the modeled concentrations is model dependent
- The model evaluation is dependent also on the dataset used for the comparison

Purpose of the work

- Studying two types of uncertainties related to modelling BC coming from using
  - different treatment of BC, which results in different modelled concentrations
  - non-homogeneous dataset of observations, due to different measurement methods, that may not give a global homogeneous model evaluation

Methodology

- Chemistry Transport Model TM5 (Krol. et al., 2005): 25 vertical hybrid sigma-pressure layers, global resolution of 6°x4° and a two-way zoom down to 1°x1°, driven by ECMWF ERA40 reanalysis data



- BC emission inventories:
  - Fossil and bio fuel, 4.67 TgC (Bond et al., 2004)
  - Large scale biomass burning, 3.62 TgC (van der Werf et al., 2004)

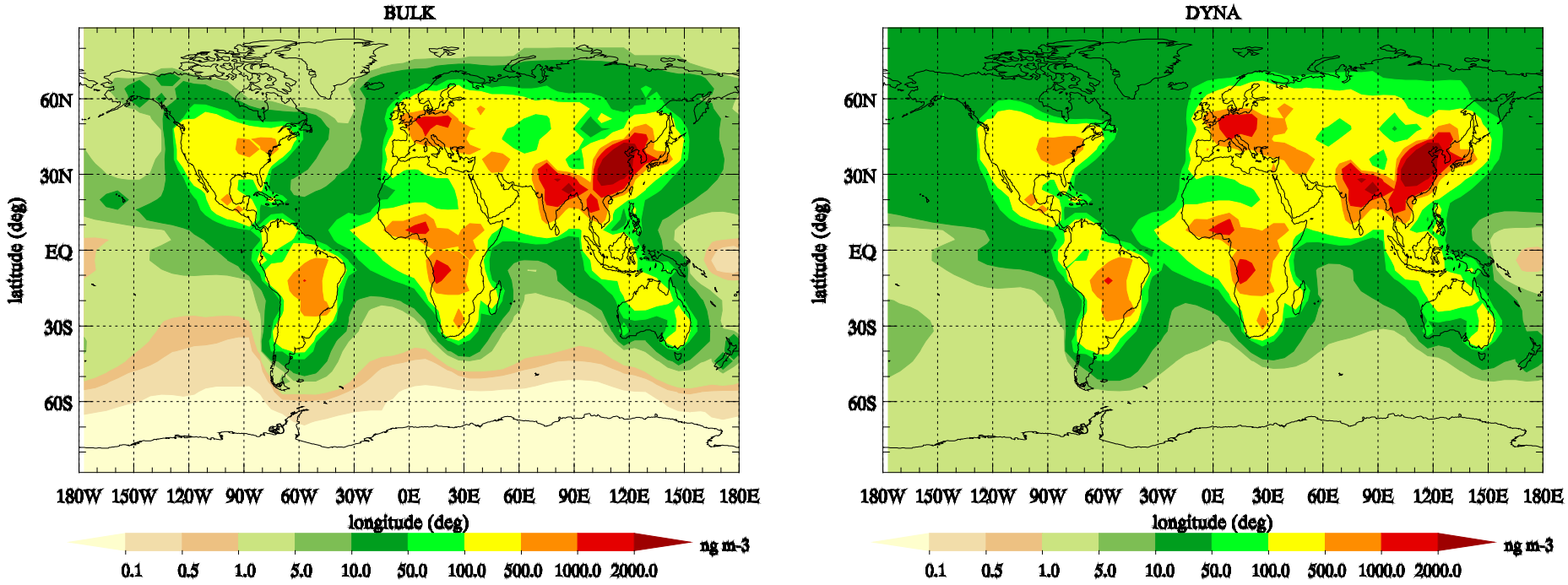
- Runs with meteorology of 2002-2003, 2 aerosol schemes

Two schemes for BC

- BULK:
  - mass
  - considered accum. mode for removal processes (mass mean radius = 0.14 μm)
  - cloud-free atmosphere: hydrophobic
  - in cloud: 30% interstitial, 70% scavenged (stratiform clouds); 0% interstitial in convective clouds

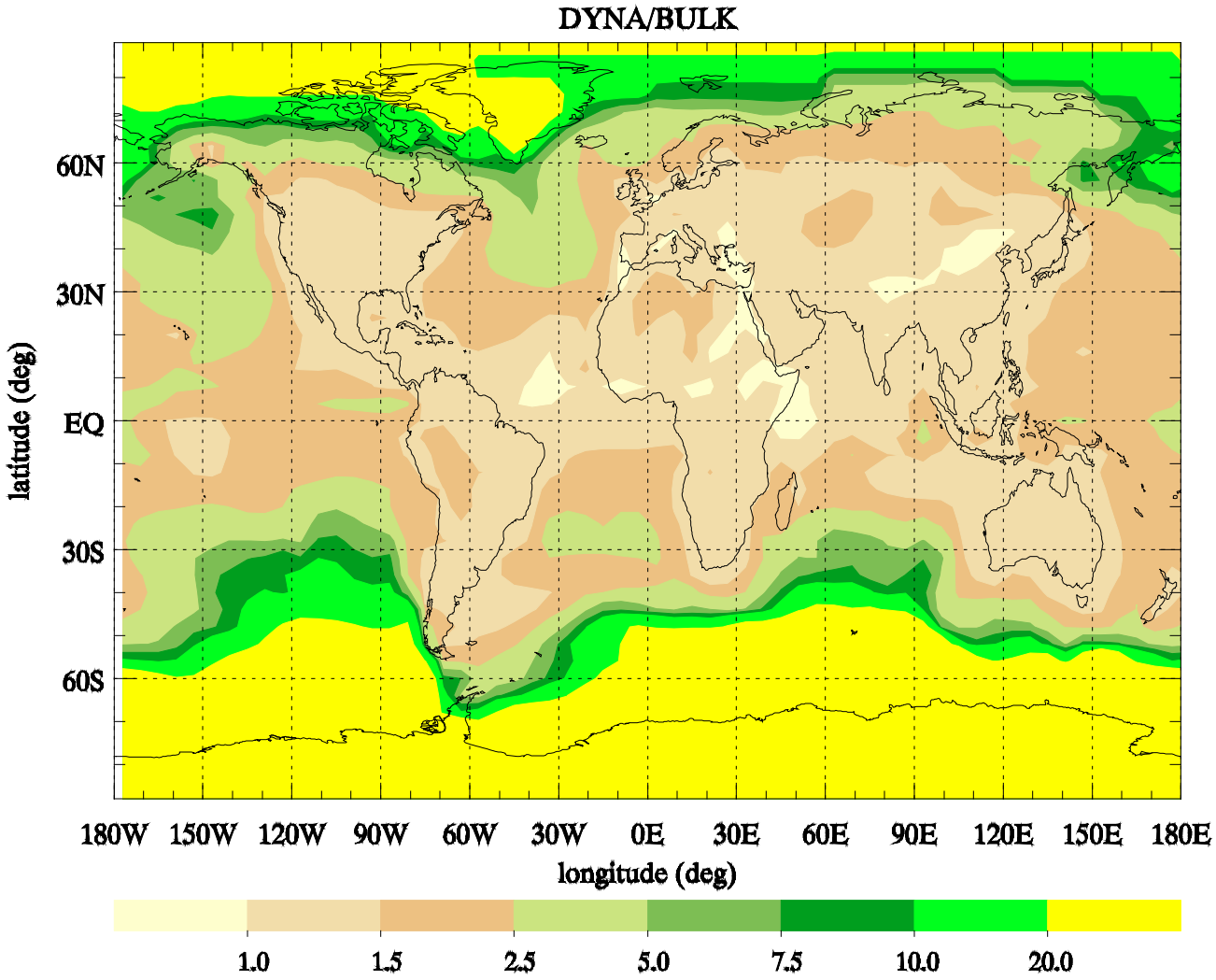
- DYNA:
  - size resolved BC, mass and number in: insoluble Aitken; soluble Aitken, accumulation and coarse modes
  - aerosol dynamics in the microphysical aerosol model M7 (Vignati et al., 2004): nucleation, coagulation, condensation of H_2SO_4
  - in-cloud processing of accumulation and coarse soluble modes

Model results

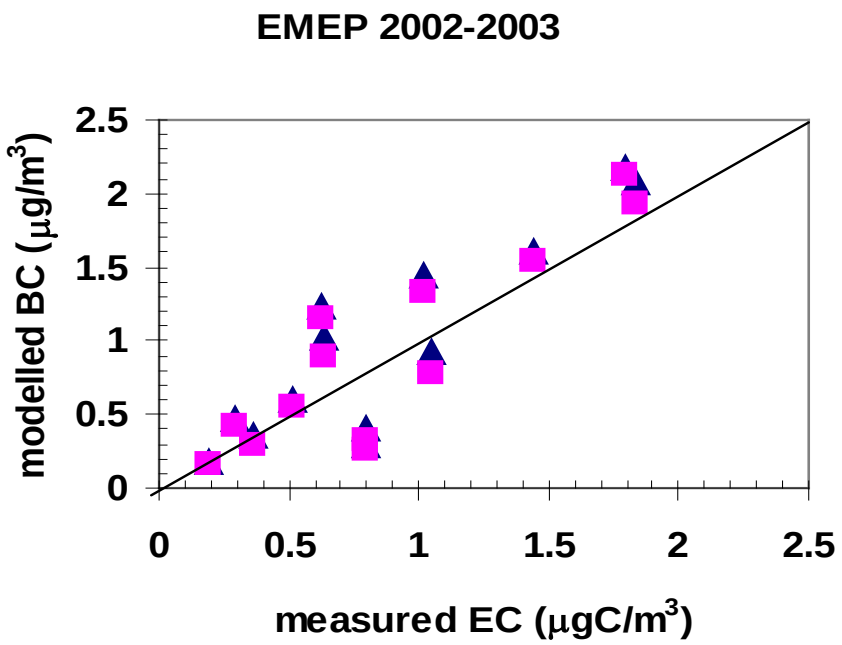


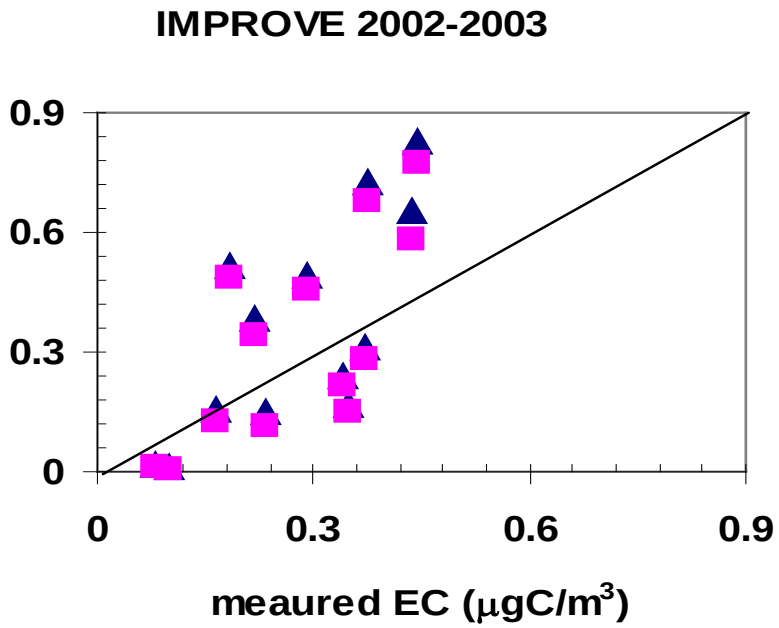
Annual mean surface layer BC concentrations

Ratio of Black Carbon surface concentrations



European and U.S.A. networks



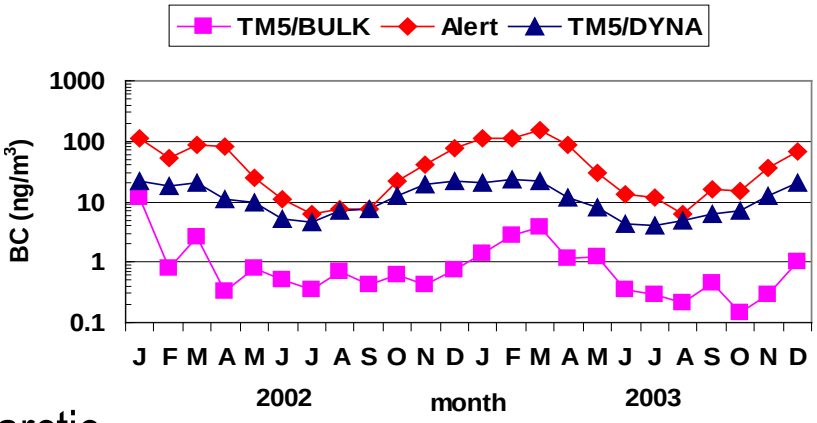


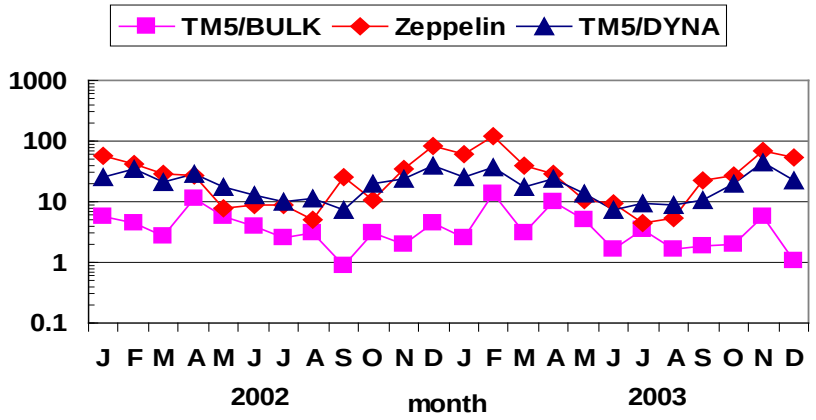
BULK

DYNA

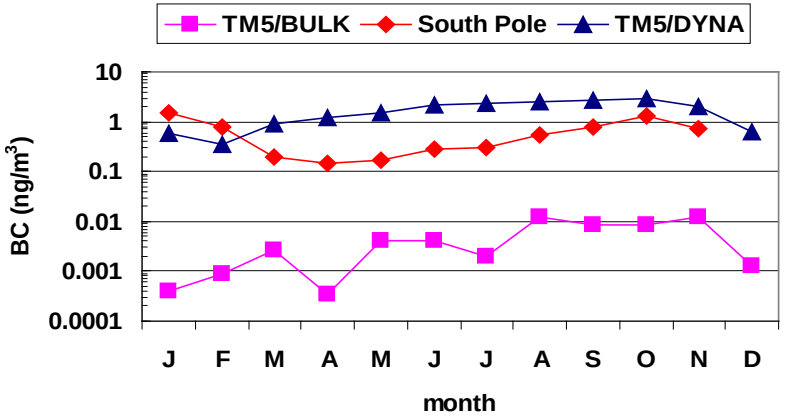
Remote stations

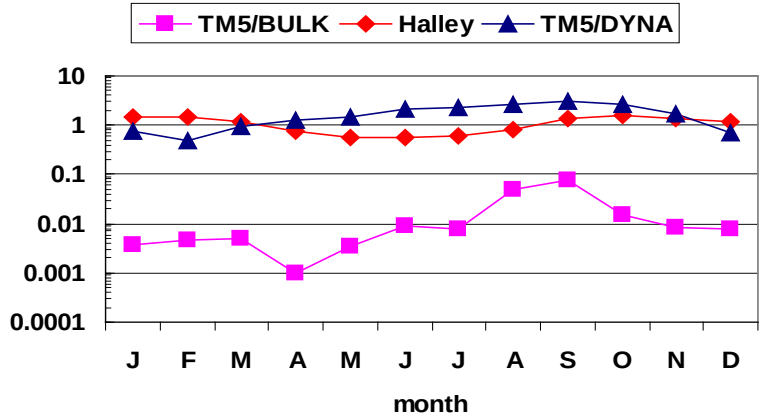
Arctic



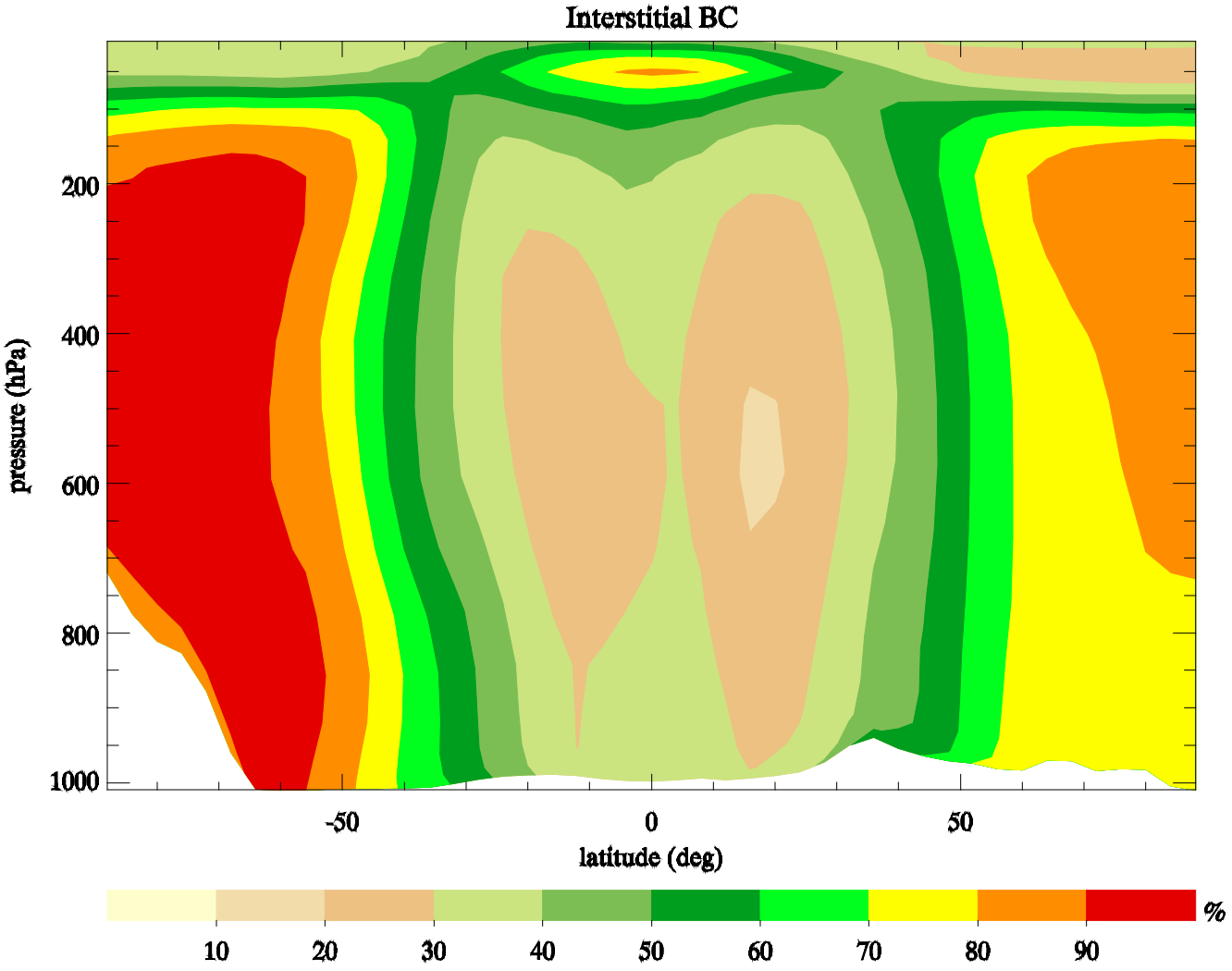


Antarctic





Interstitial BC from DYNA case



Global and annual average

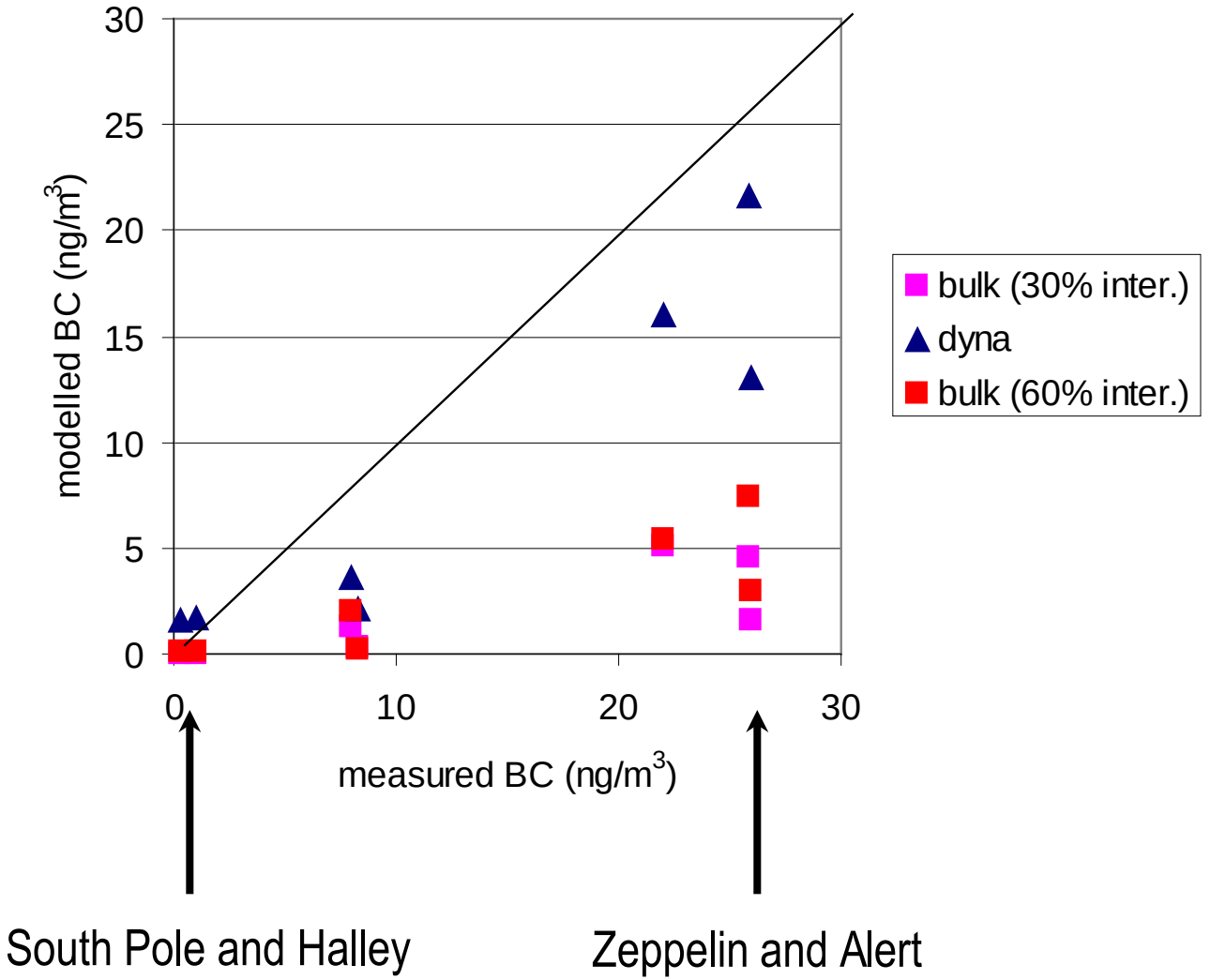
up to 700 hPa: 60% interstitial BC

↓

Substitute the BC interstitial mass from 30 to 60% in bulk

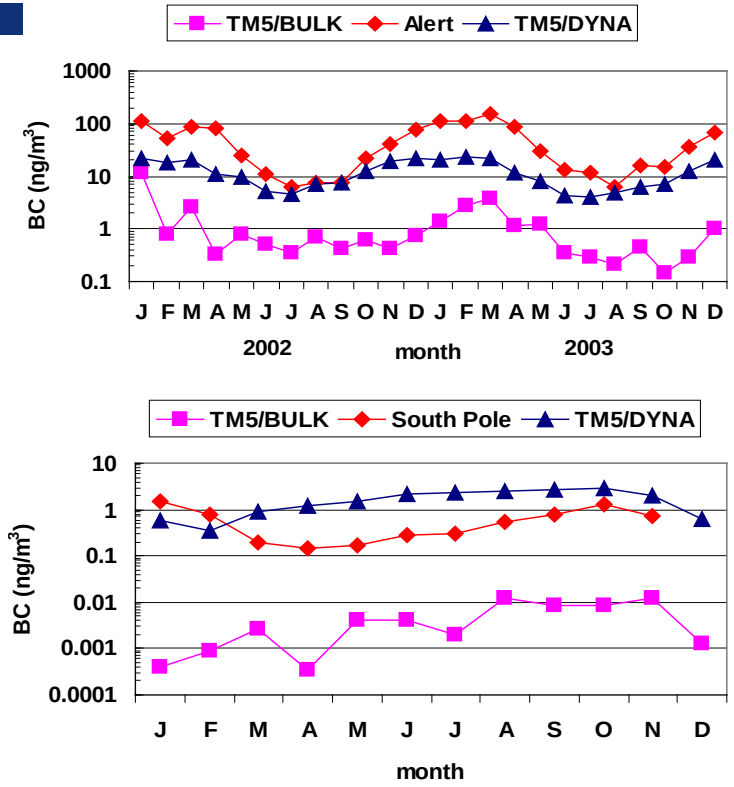
Annual and zonal mean concentrations of insoluble BC + aitken soluble BC

How much do we improve?

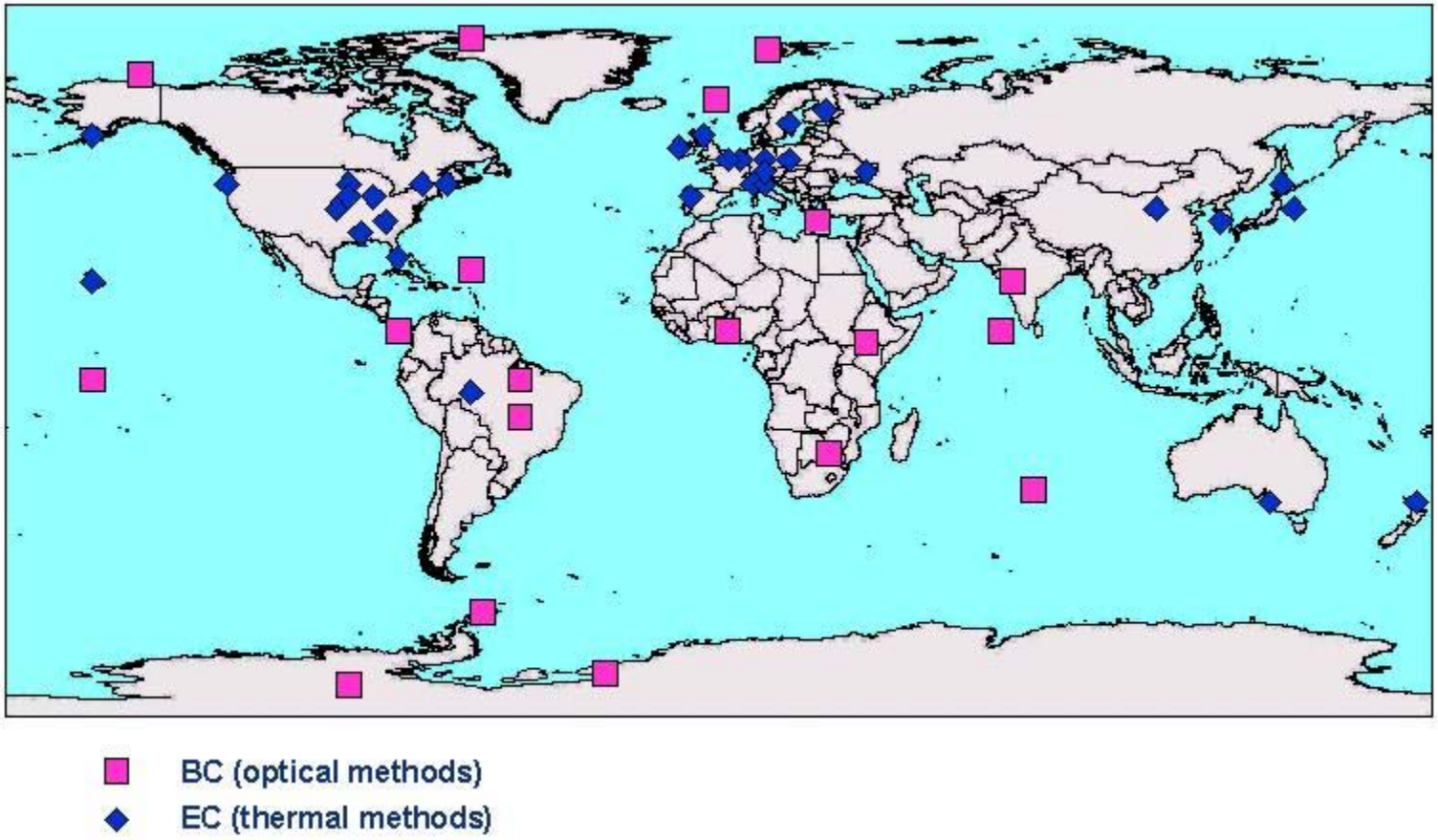


Model and measurement uncertainties

- The uncertainties related to the single measuring method are unknown



Measurements used for comparison



Differences in experimental methods

- BC and EC concentrations can differ by up to a factor of 7 among different methods (Watson et al., *Aeros. and Air Quality Res.*, 2005)
- BC up to a factor of 2-3 (Reisinger et al., *Environ. Sci. Technol*., 2008)
- EC meas. with thermal evolution: factor of 2 or more (Malm et Hand, *Atm. Env*., 2007)
- EC measurements: up to a factor of 4 (ten Brink et al., *Atm. Env*., 2004)

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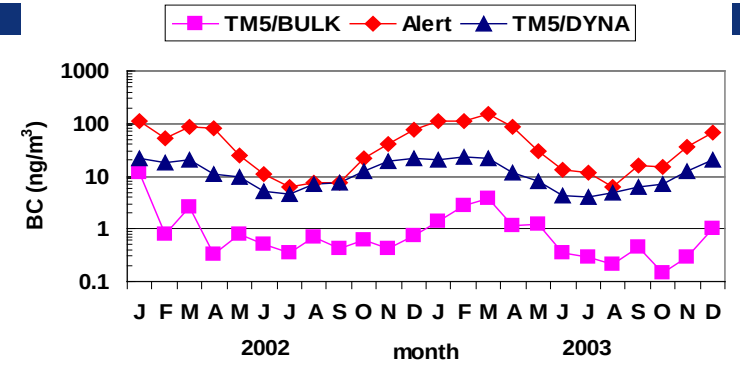
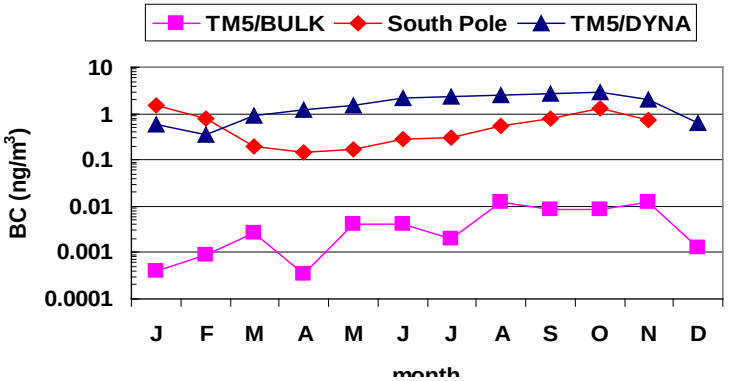
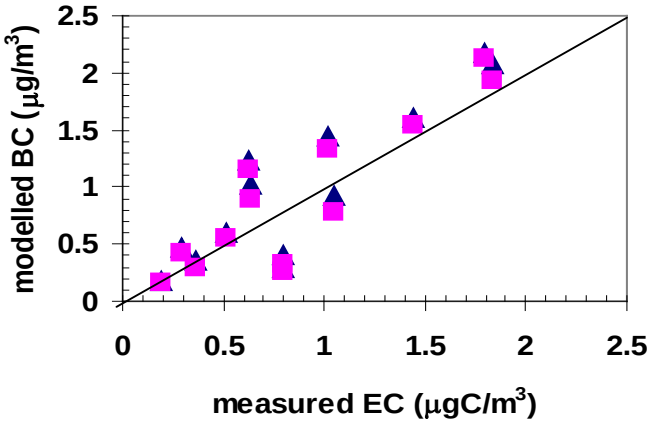




EMEP 2002-2003

- Uncertainties related to the use of a non-homogeneous dataset
- EC or BC: uncertain input from the emission inventories



Conclusions

- The dynamics approach seems to give better results far away from the sources than bulk
- Transport to remote stations with bulk approach does not improve much by doubling interstitial BC mass
- BC model bias to measurements is not homogeneously evaluated due to use of concentrations determined with various methods
- Harmonization of the dataset is required not only to give a more coherent phenomenology of BC at global scale but also for model development

Acknowledgments

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