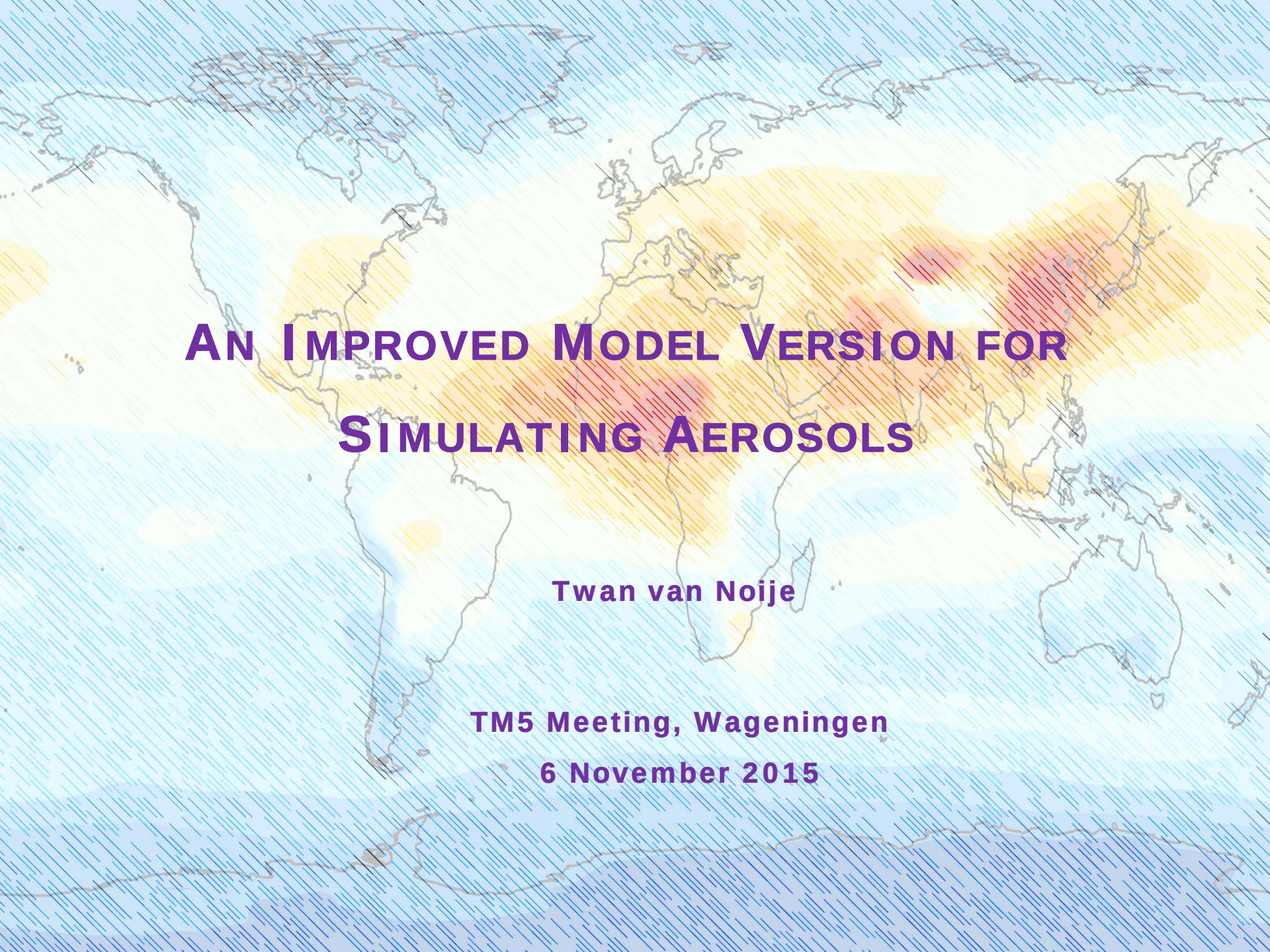


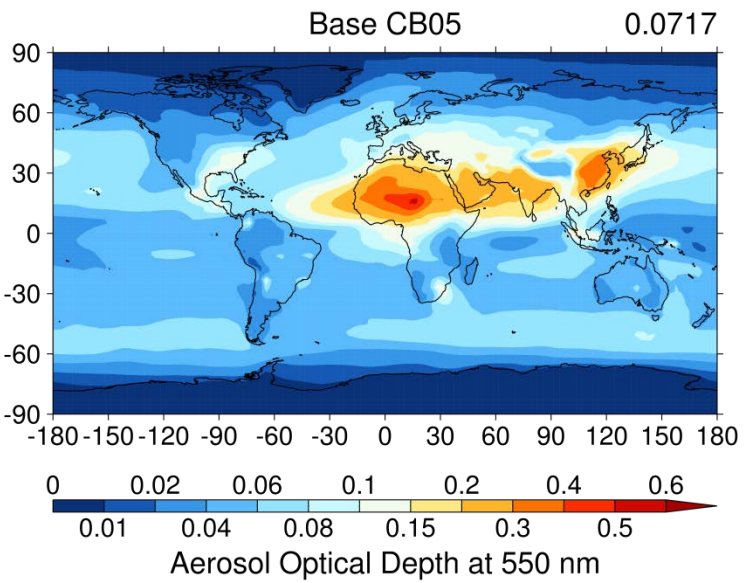
An Improved Model Version for Simulating Aerosols

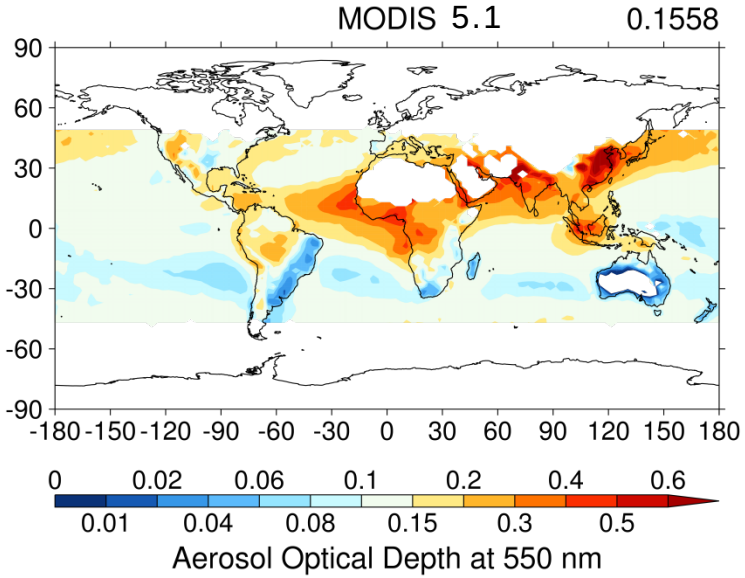
Twan van Noije

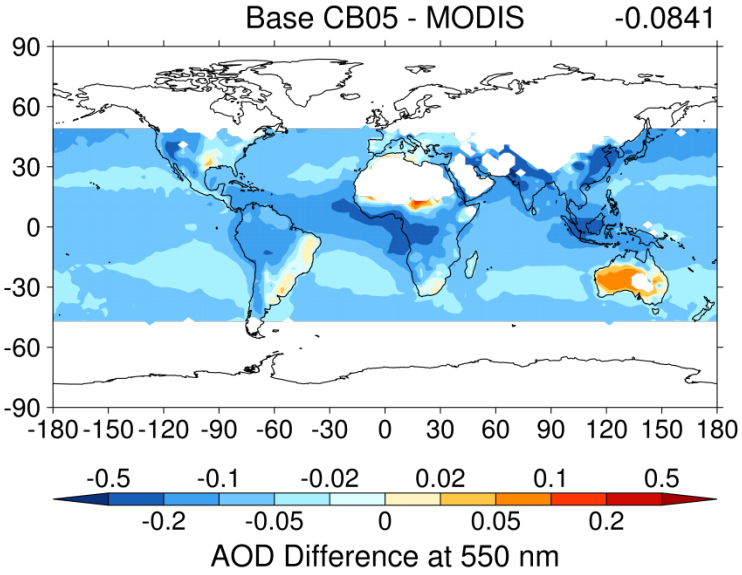
TM5 Meeting, Wageningen

6 November 2015

Long-standing problem with TM5/M7



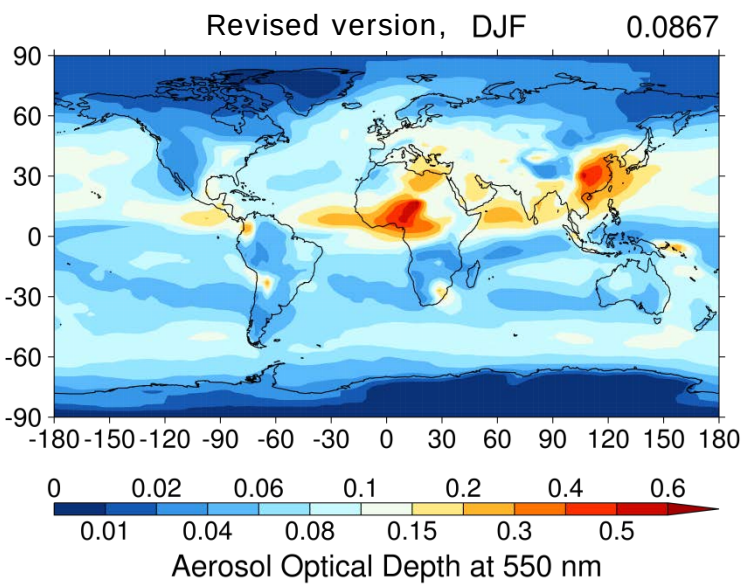


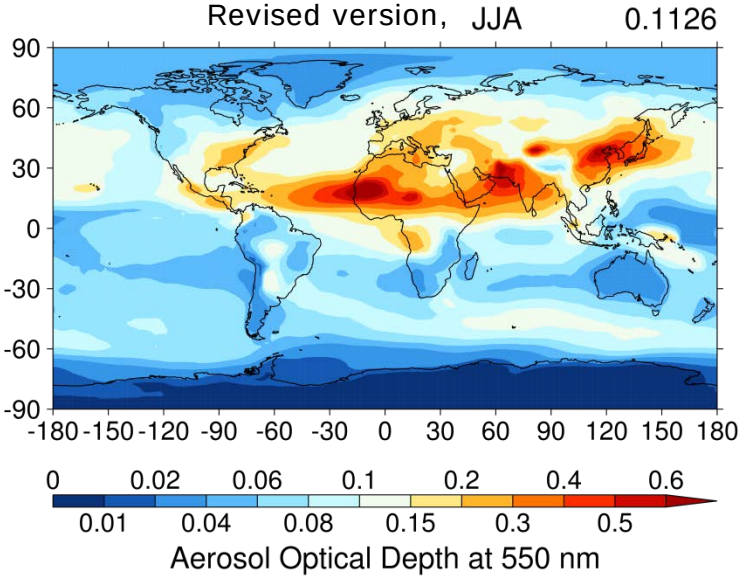


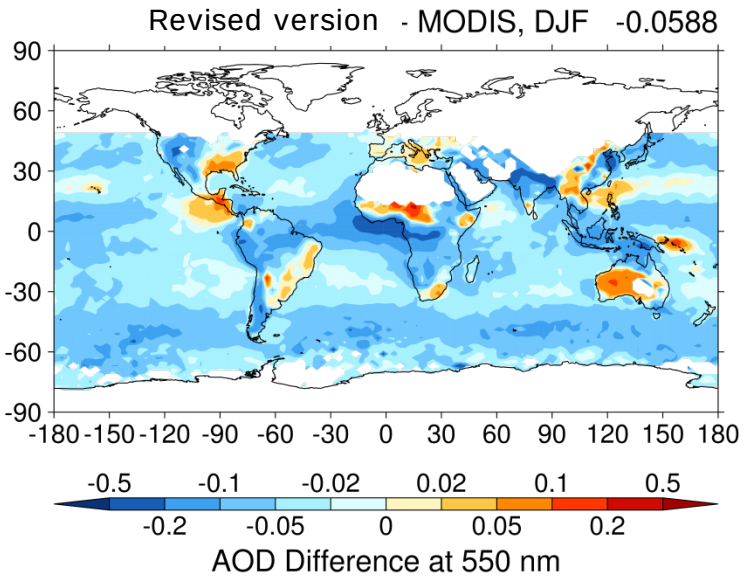
Earlier revisions (status last meeting)

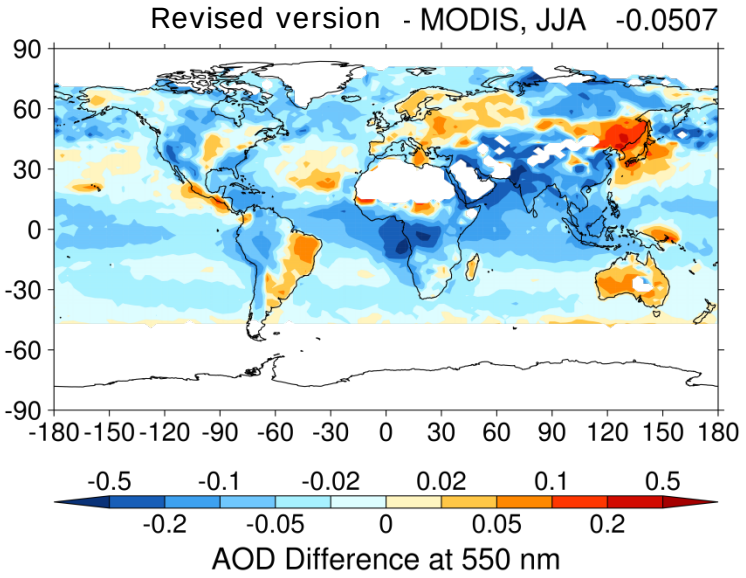
- Added contribution of ammonium-nitrate to aerosol optical properties
- Updated wet scavenging coefficients and reduced sub-grid mixing
- Online calculation of mineral dust source

Annual/global mean AOD increased from 0.072 tot 0.099 (+38%)





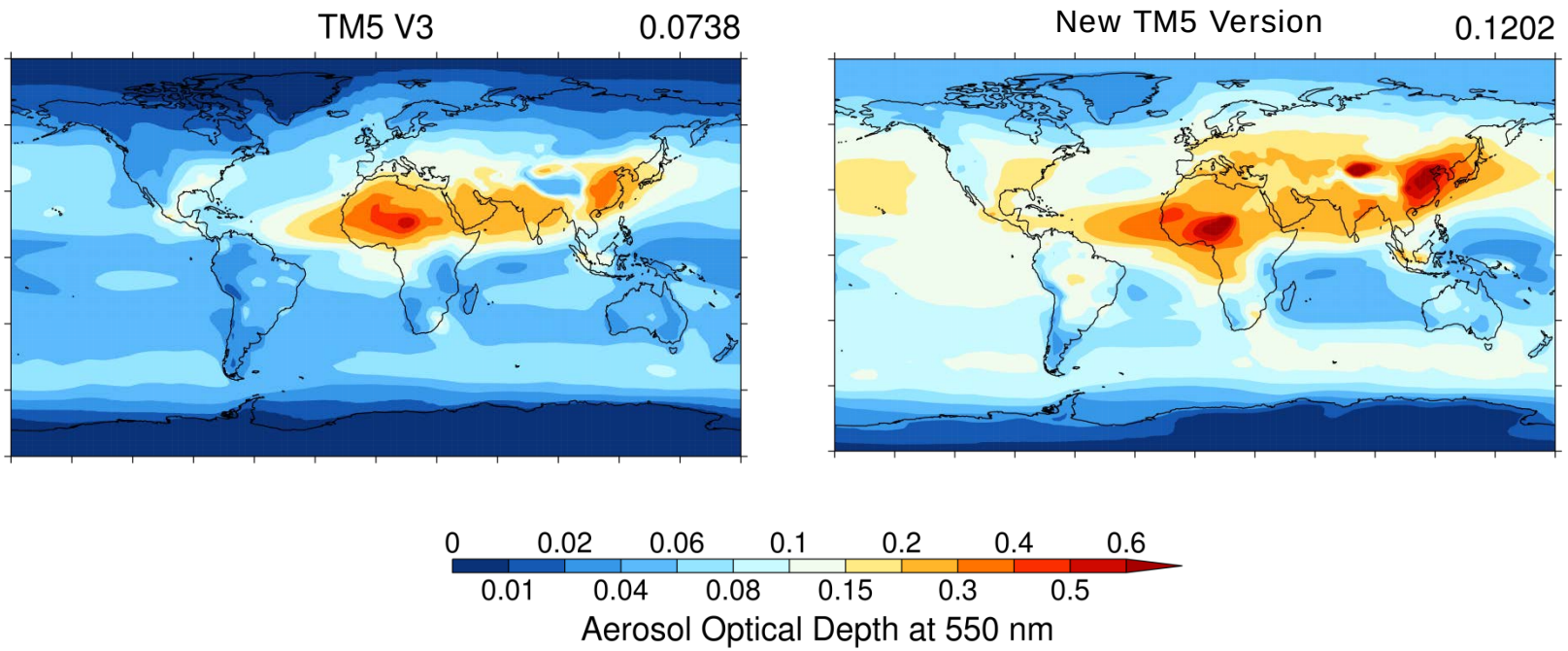




What has changed since then?

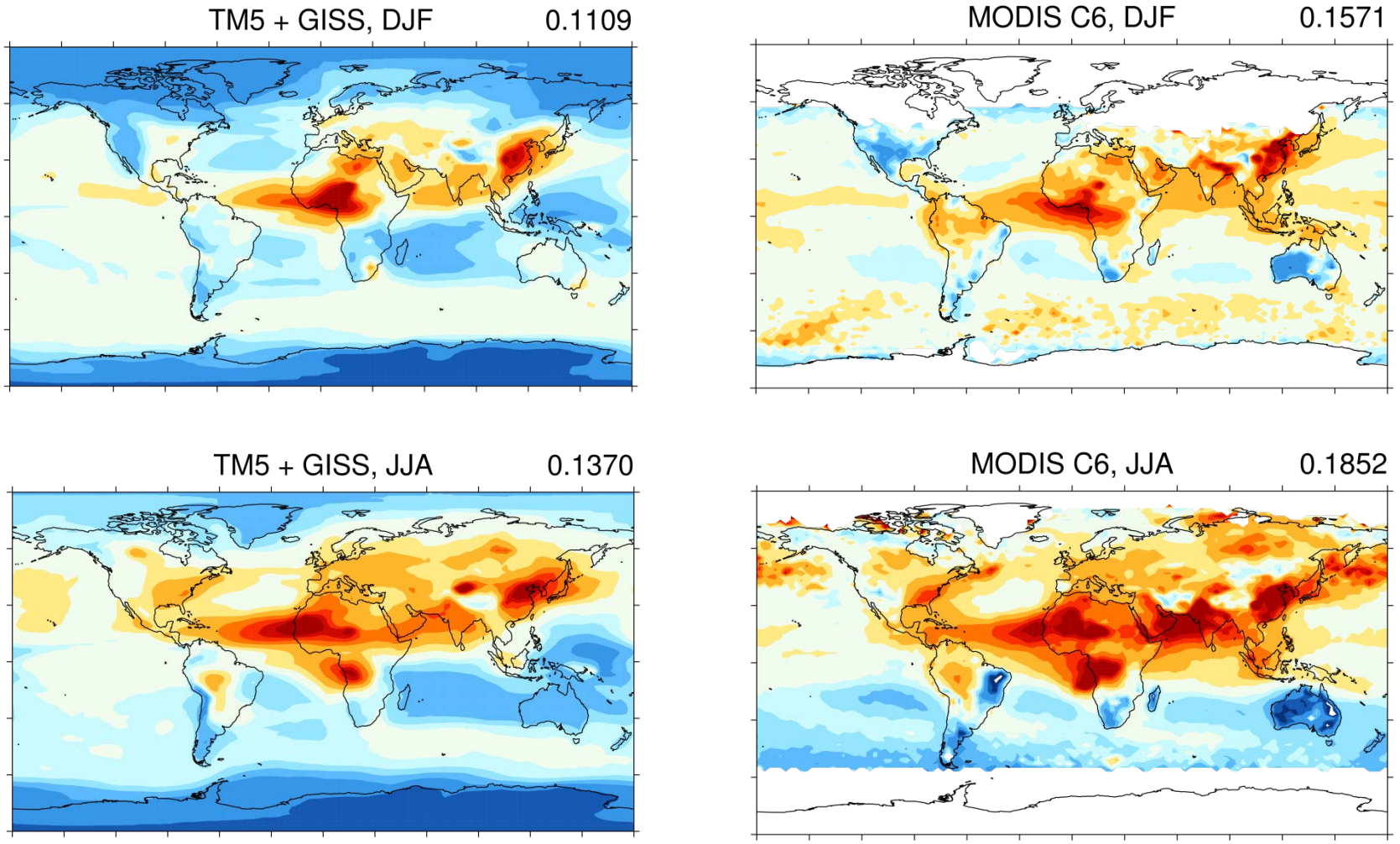
- Reduced particle densities of OA and BC
- Increased OA/OC mass ratio
- Updated mean particle emission radii
- Updated BC refractive index
- Corrected and modified online dust emissions
- Modified sea-salt source: reduced wind speed dependence

Model performance: current status



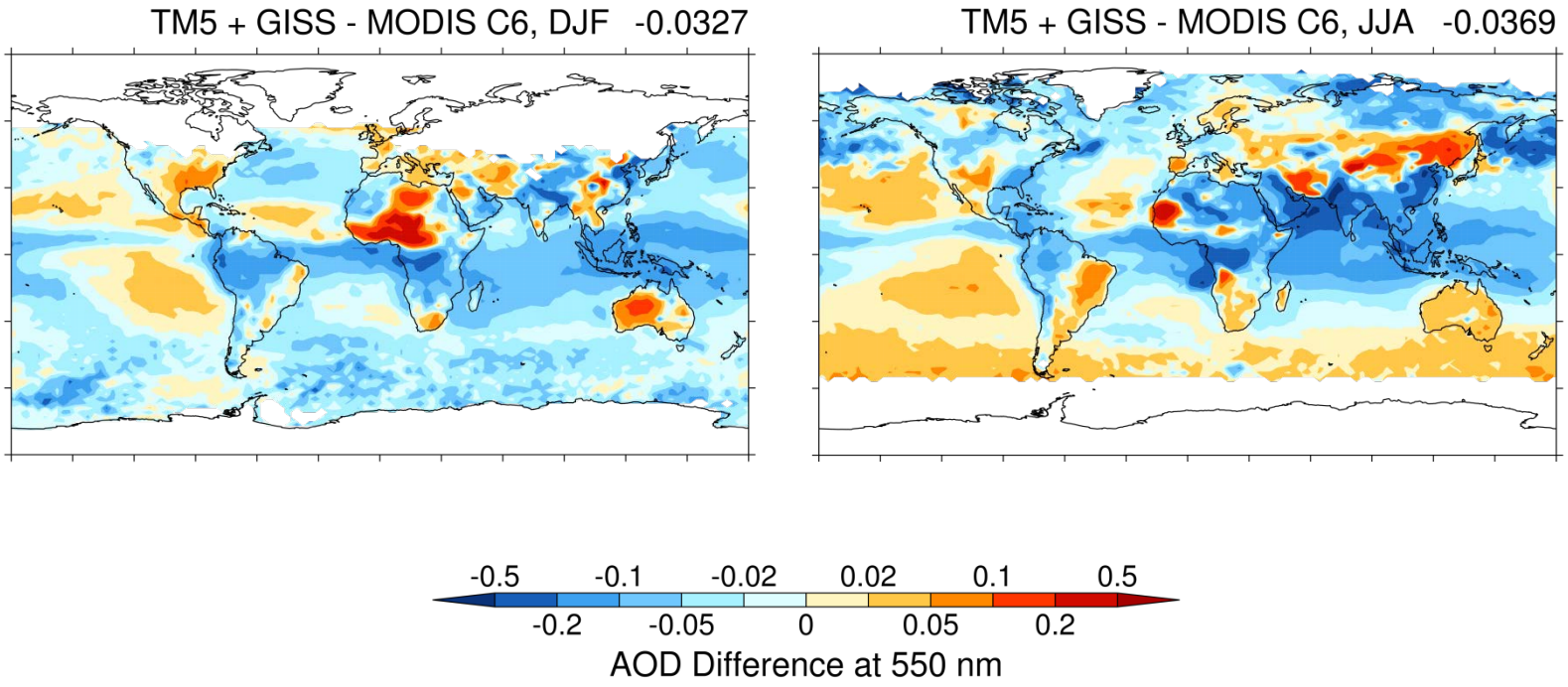
Annual global mean AOD +63%

Comparison with MODIS AOD (Collection 6)



MODIS global mean values are increased due to incomplete spatial coverage

Biases compared to MODIS AOD (Collection 6)

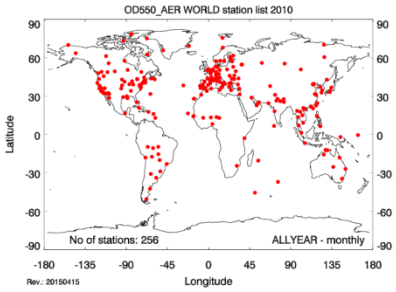


Comparison based on unsampled model output

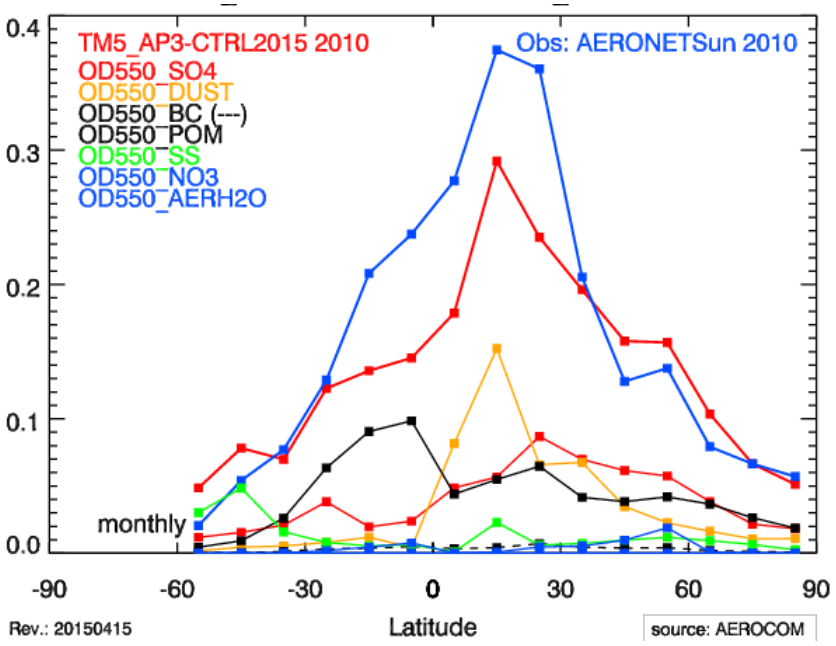
Comparison with AERONET AOD

Evaluation of AeroCom Phase-3 control simulation for 2010

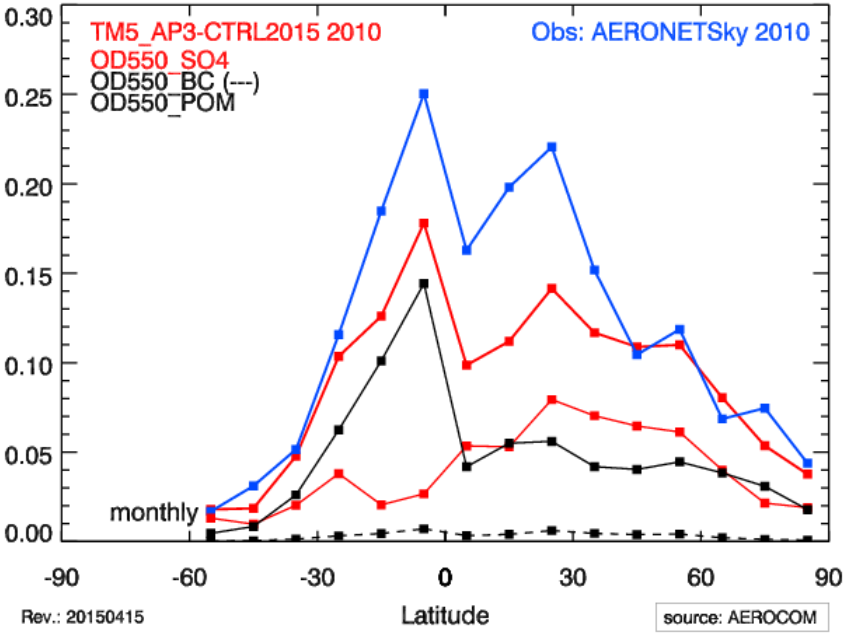
(based on new TM5 version)



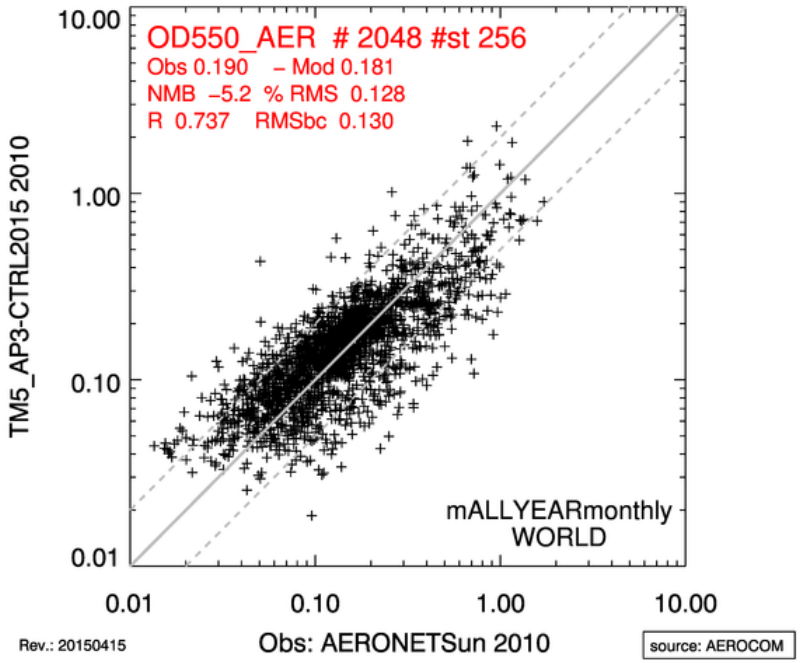
Total AOD



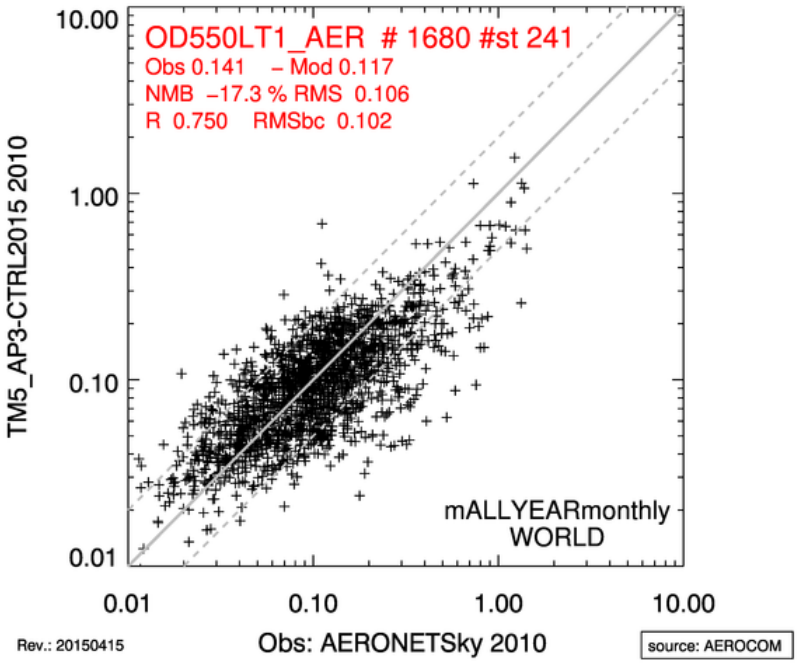
Fine-mode AOD

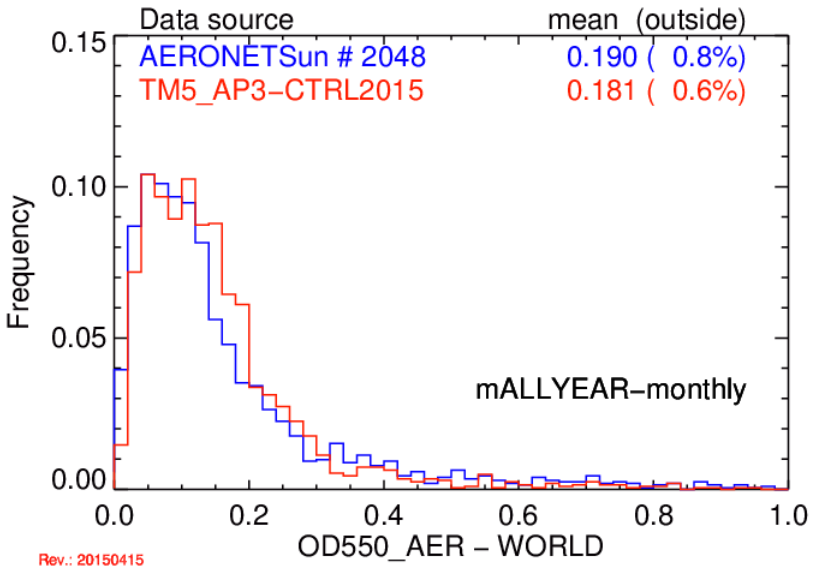


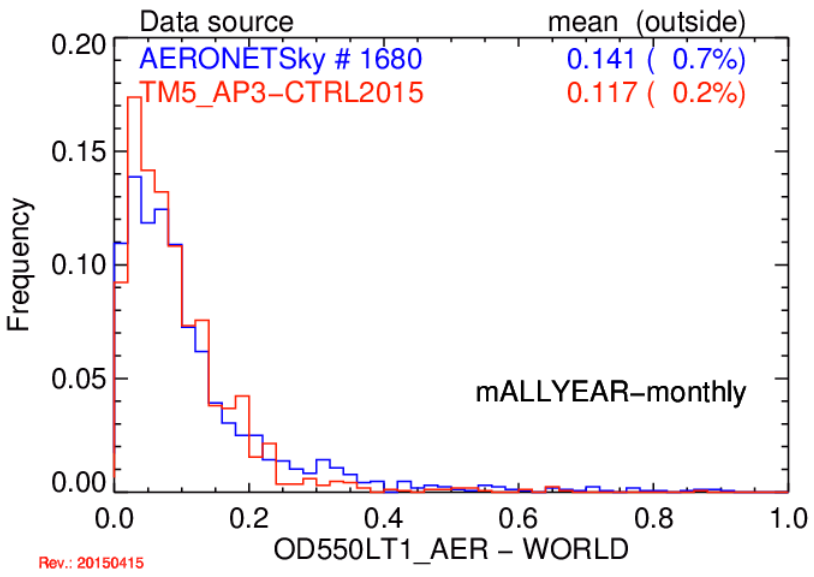
Total AOD



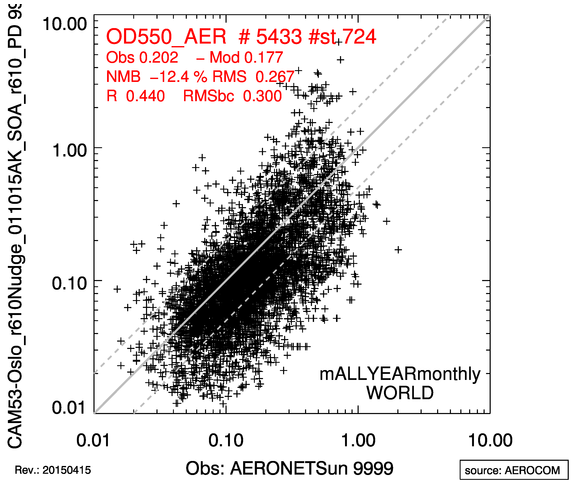
Fine-mode AOD

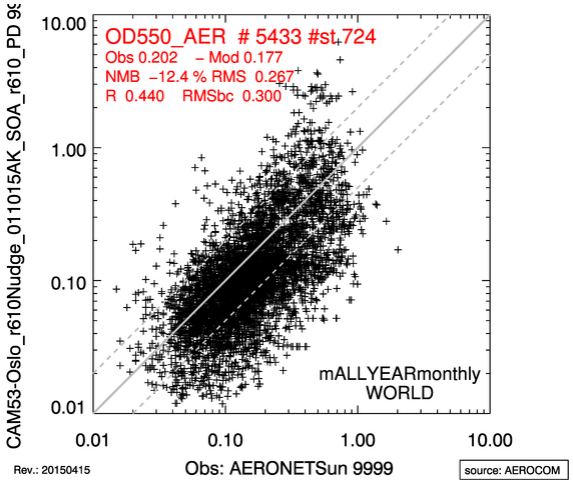


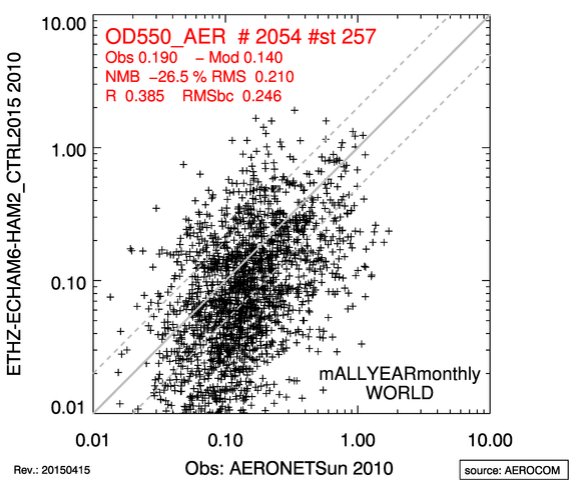


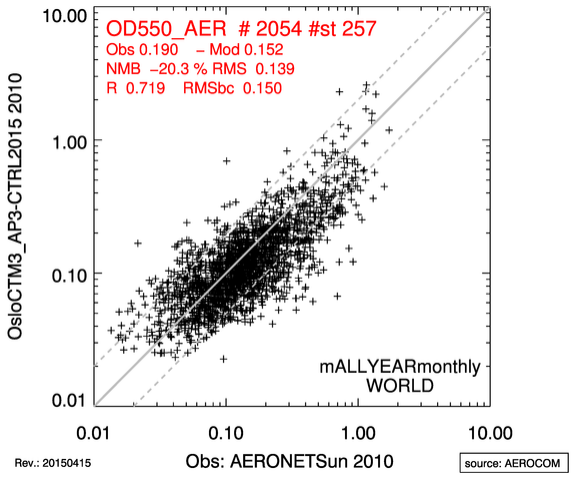


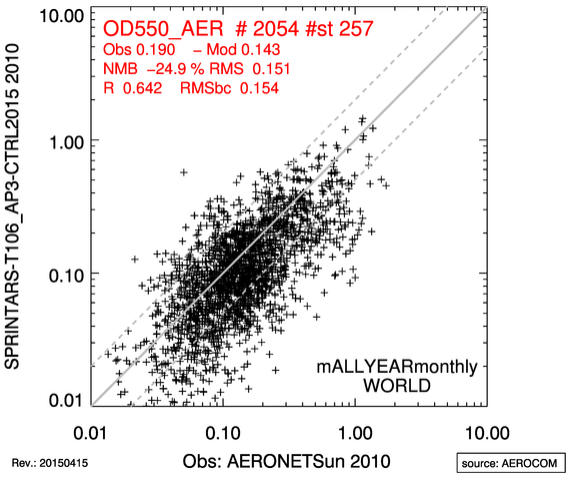
Comparison with other AeroCom models

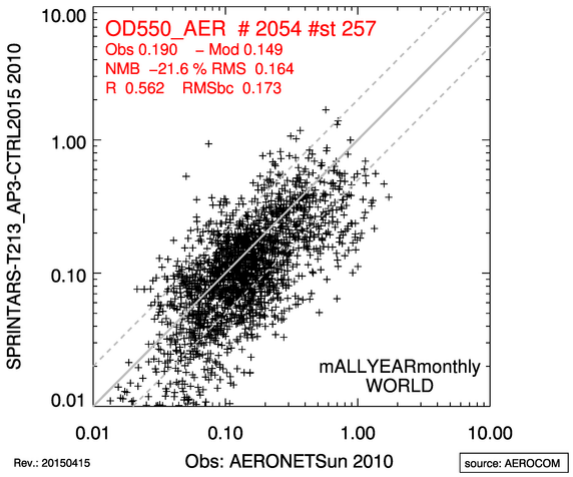






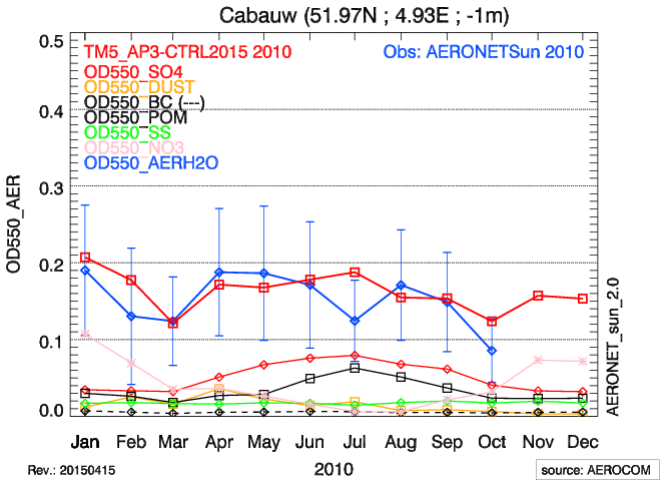


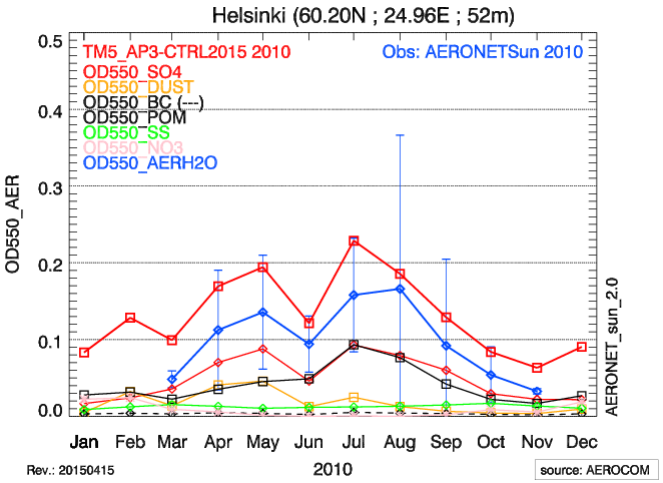


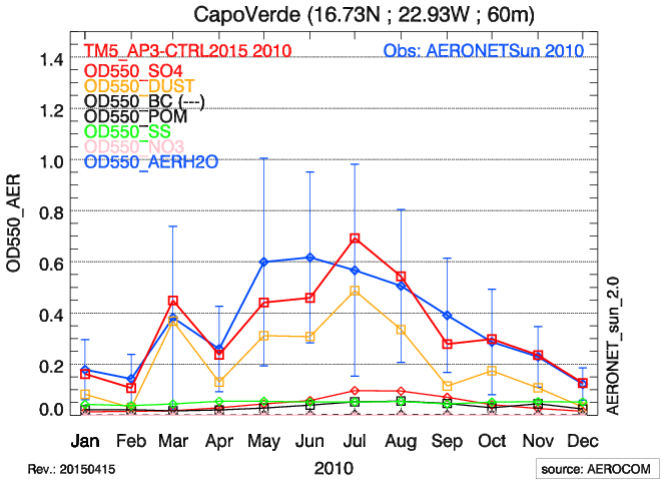


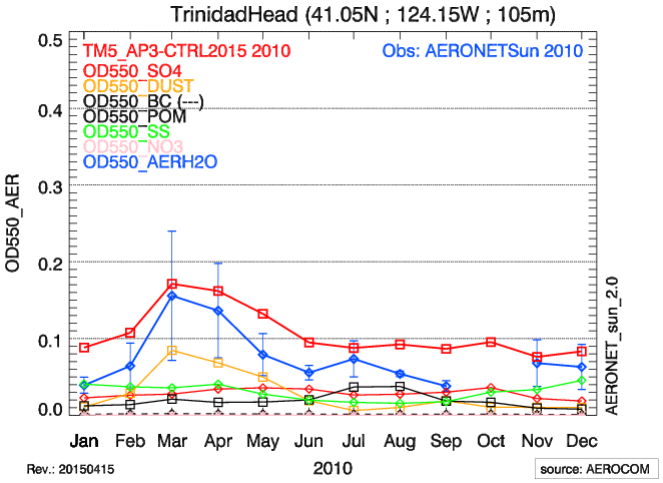
TM5 shows highest correlation and lowest mean bias of all AP3-CTRL2015 simulations currently available.

Comparison with AERONET AOD (some examples)

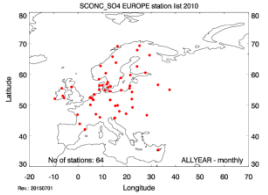


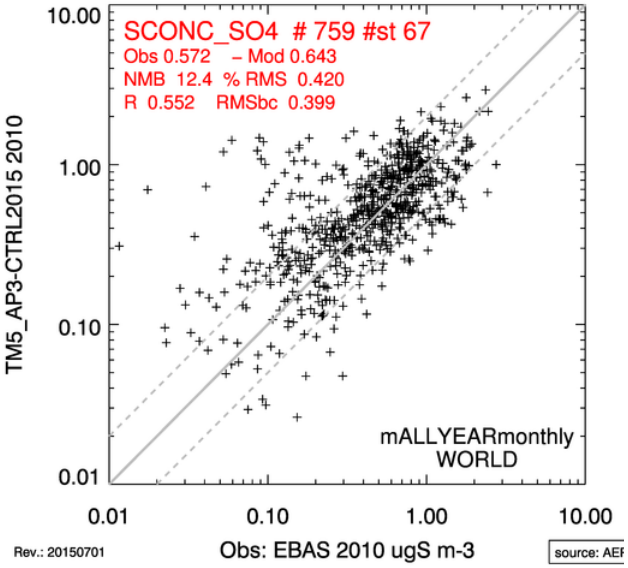


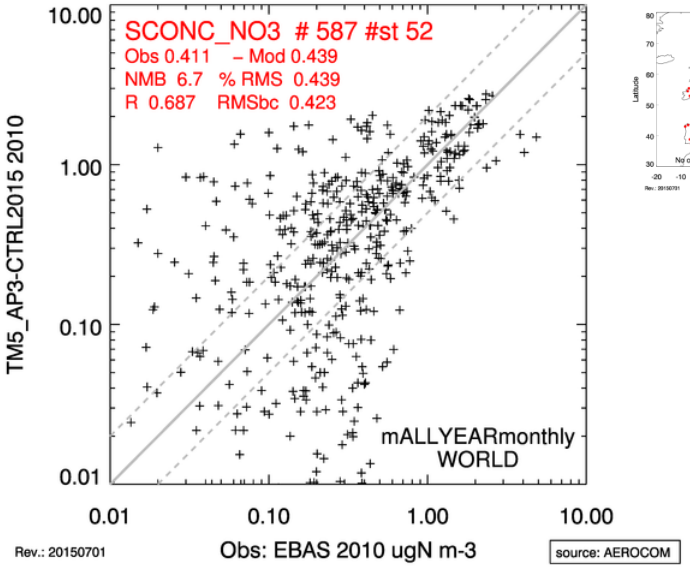


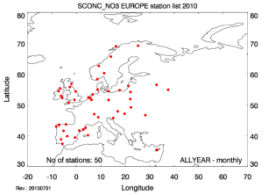


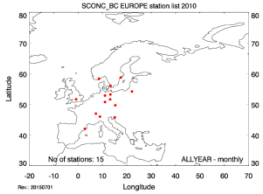
Comparison of surface concentrations (Europe)

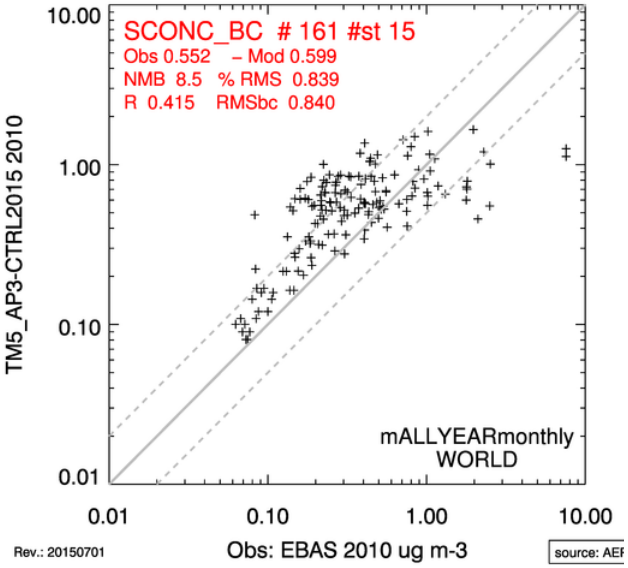


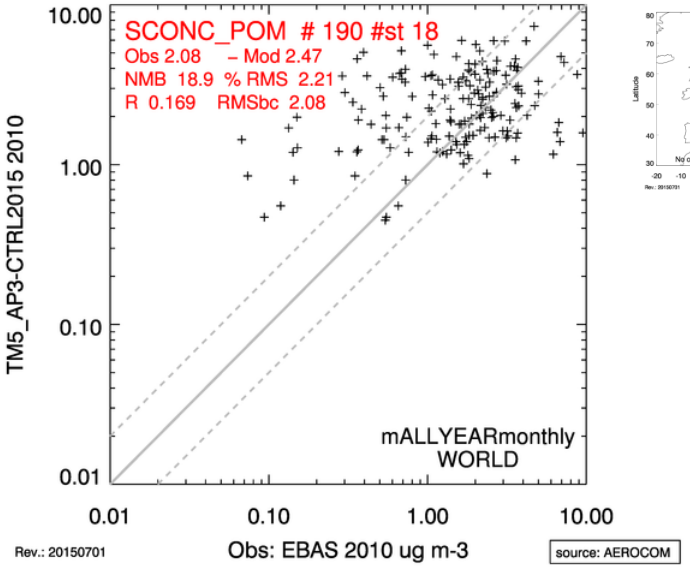


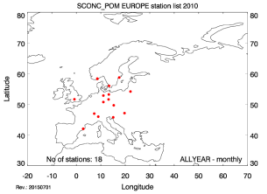




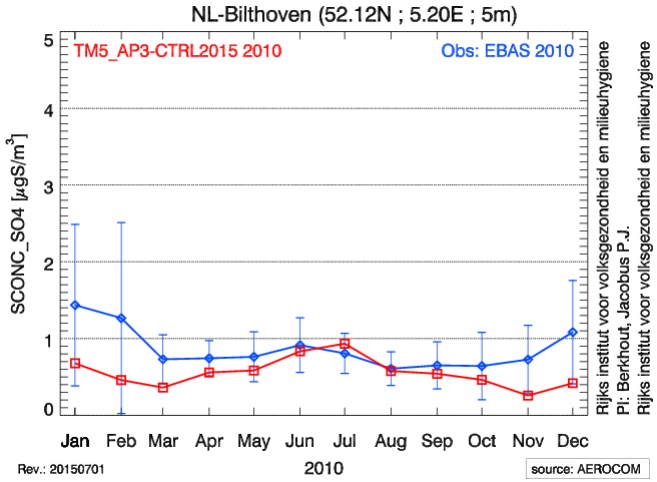


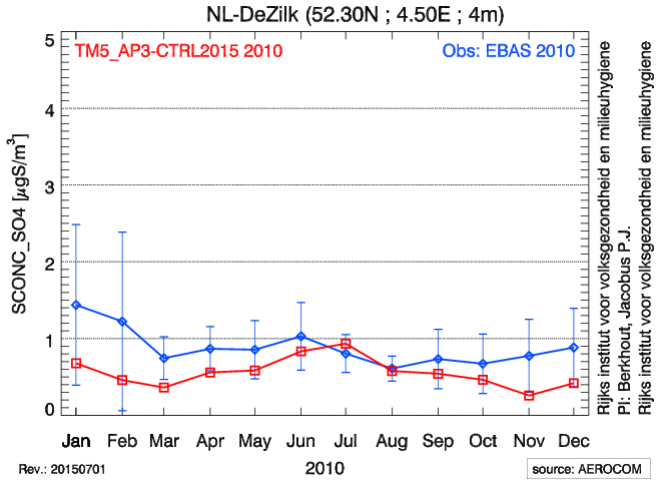


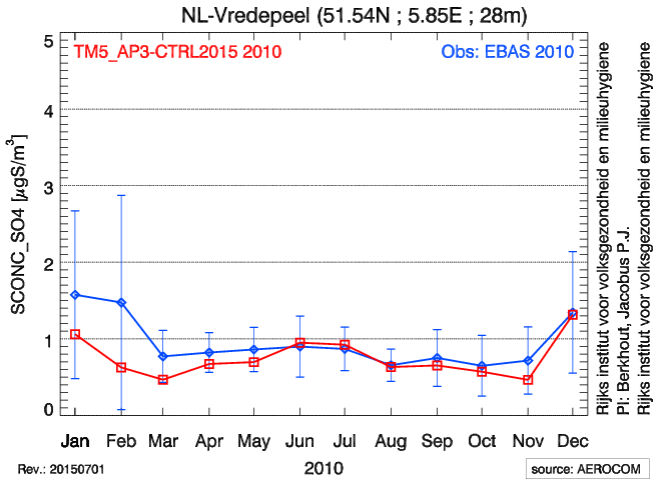


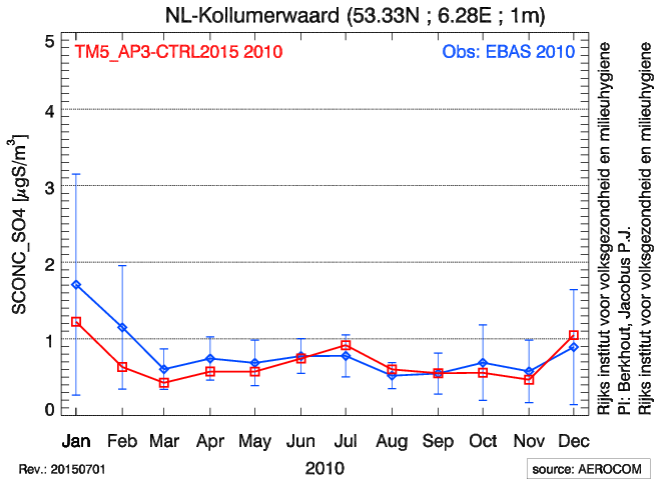


Surface concentrations of sulfate (Netherlands)

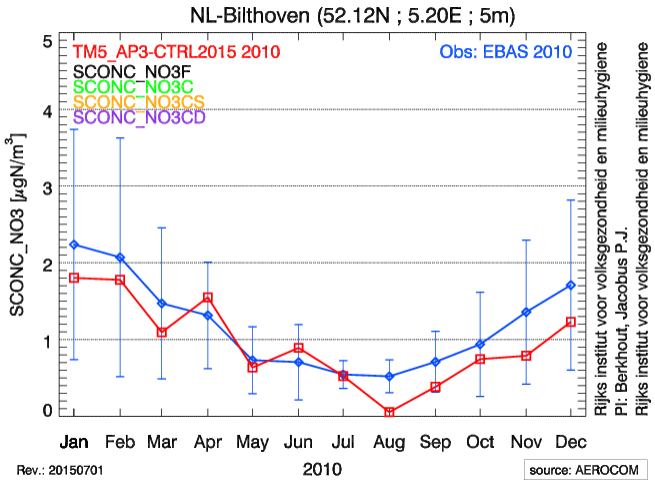


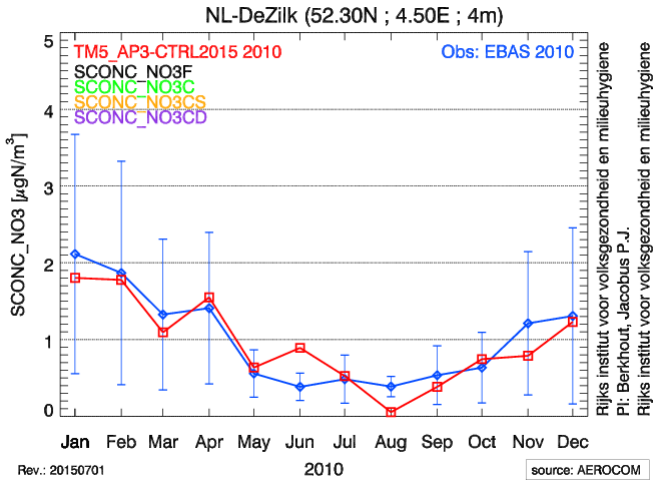


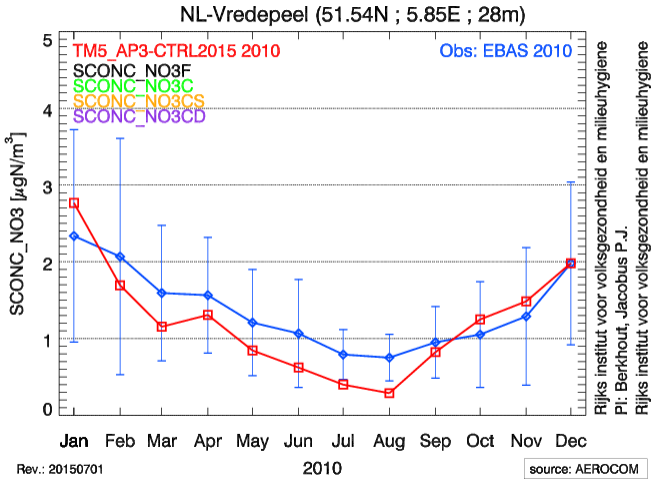


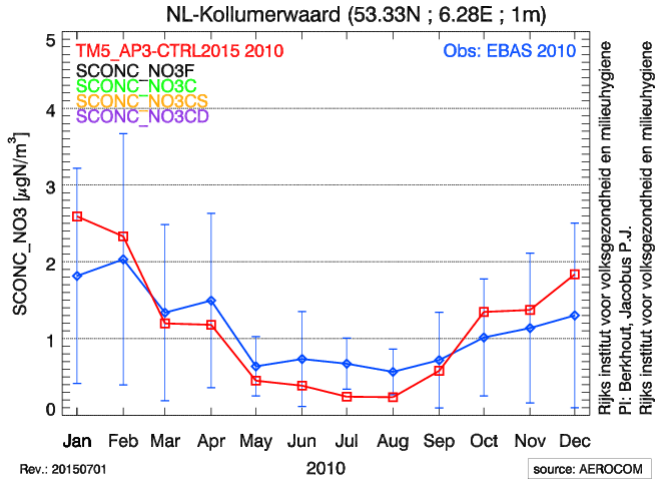


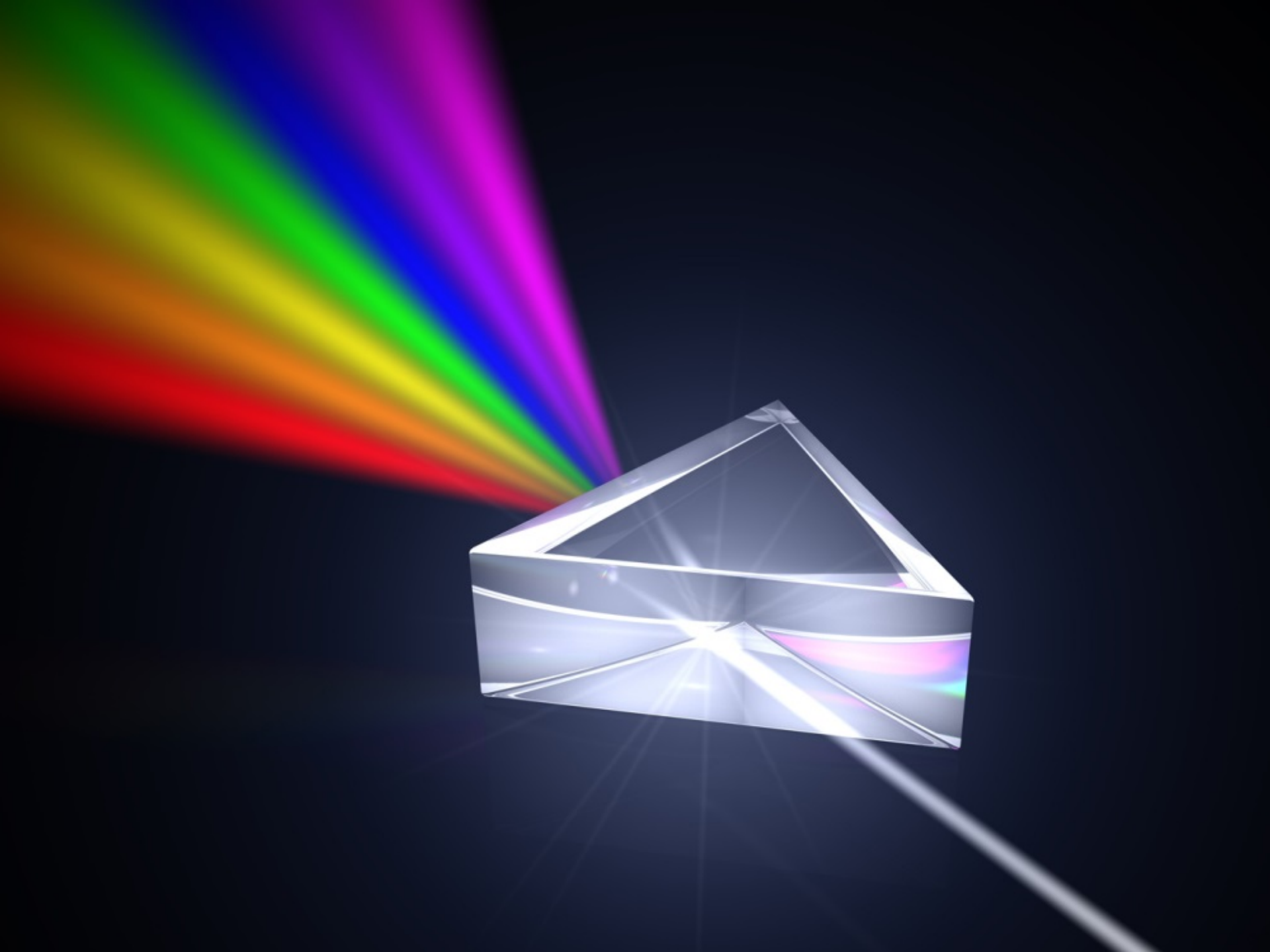
Surface concentrations of nitrate (Netherlands)







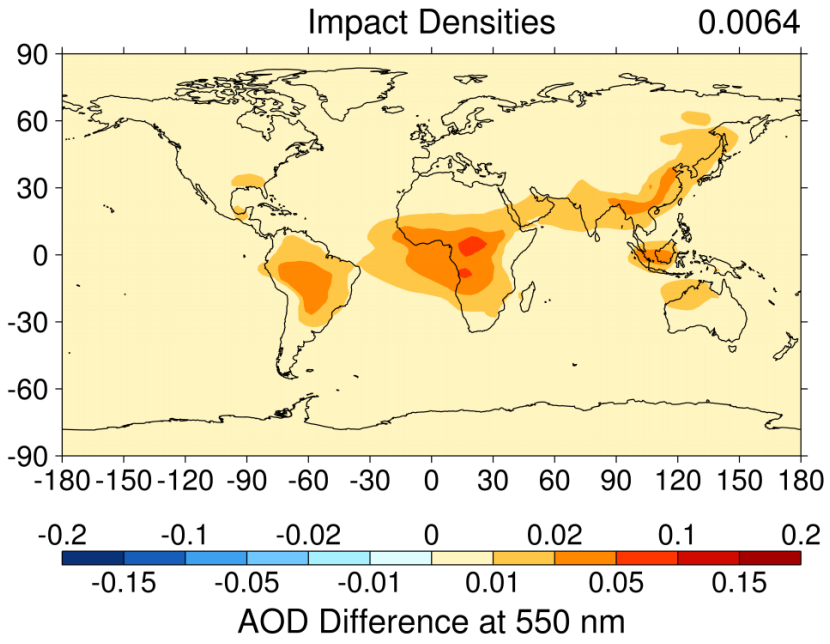


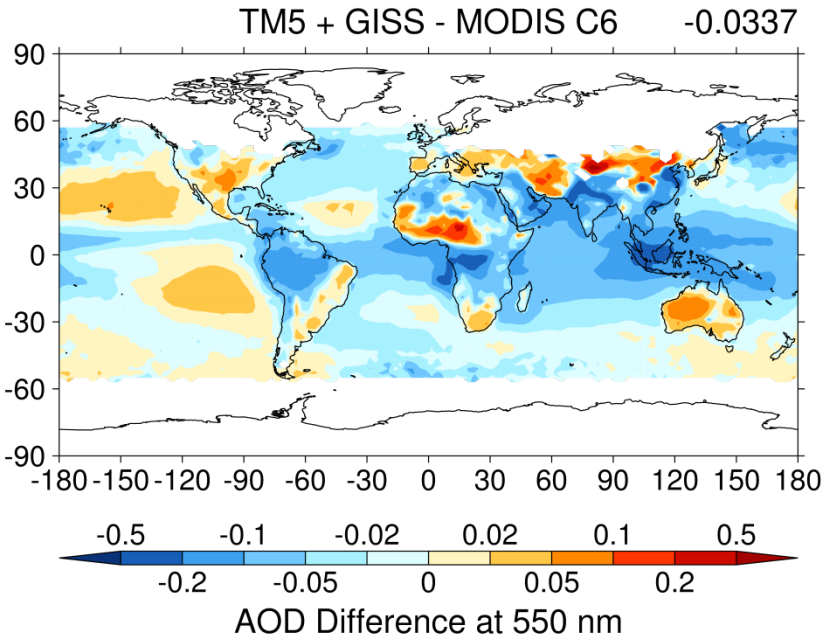


Reduced particle densities

Reduced densities of carbonaceous particles from 2.0 g/cm^3 to:

- 1.3 for OA (medium value of range found in literature)
- 1.8 for BC (1.7 to 1.9 according to *Bond and Bergstrom, 2006*).





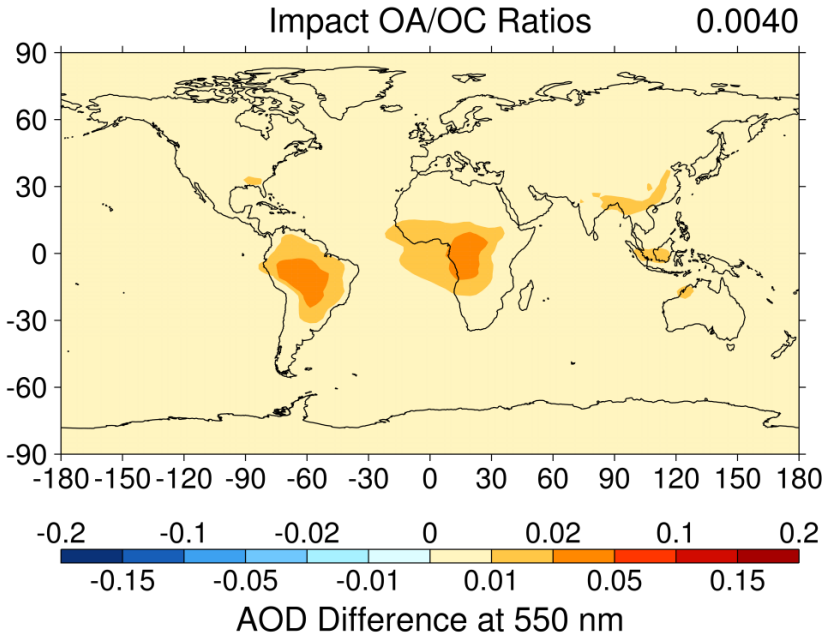
Bias of new model version

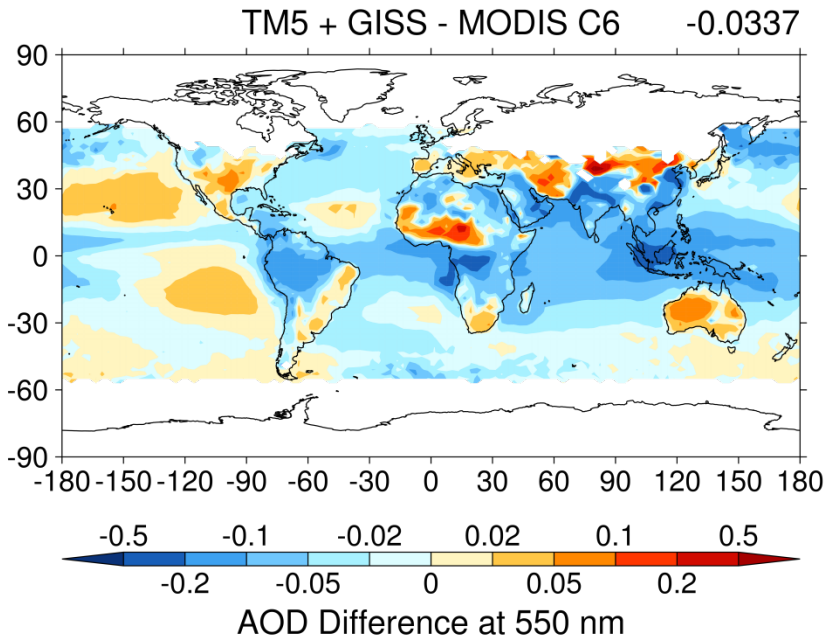
Increased OA/OC mass ratio

Increased the OA/OC mass ratio from 1.4 to:

- 1.6 for primary emissions
- 2.4 for SOA

(*Turpin and Lim, 2001; Reid et al., 2005; Aiken et al., 2008; cf. Tsigaridis et al., 2014*)

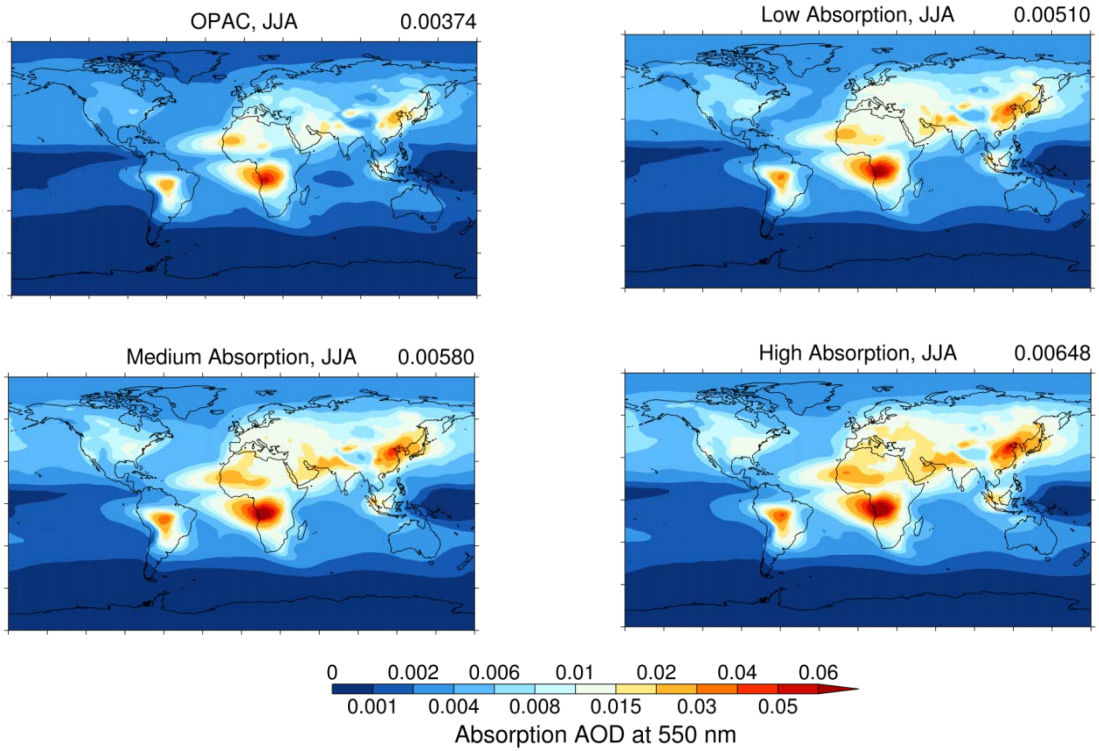




Bias of new model version

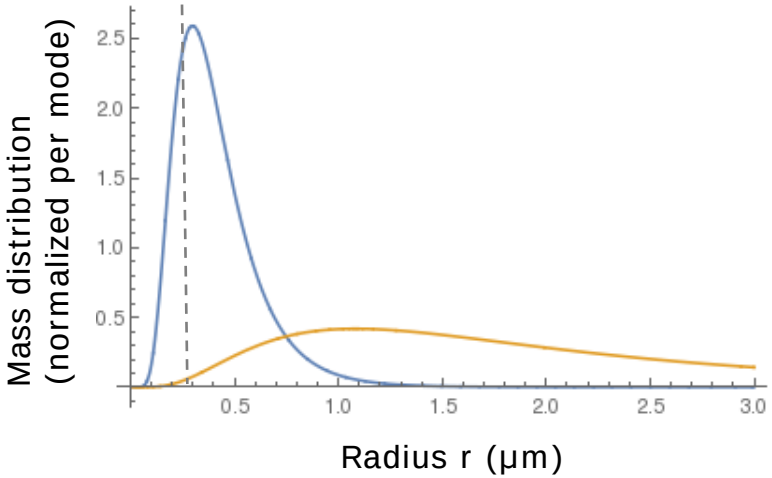
Updated BC refractive index

- Old value based on OPAC (imaginary part k = 0.44 at 550 nm; *Shettle and Fenn, 1979*)
- *Bond and Bergstrom (2006)* propose a range of values which all have higher absorption (0.63 < k < 0.79)
- Tested values for low, medium and high absorption



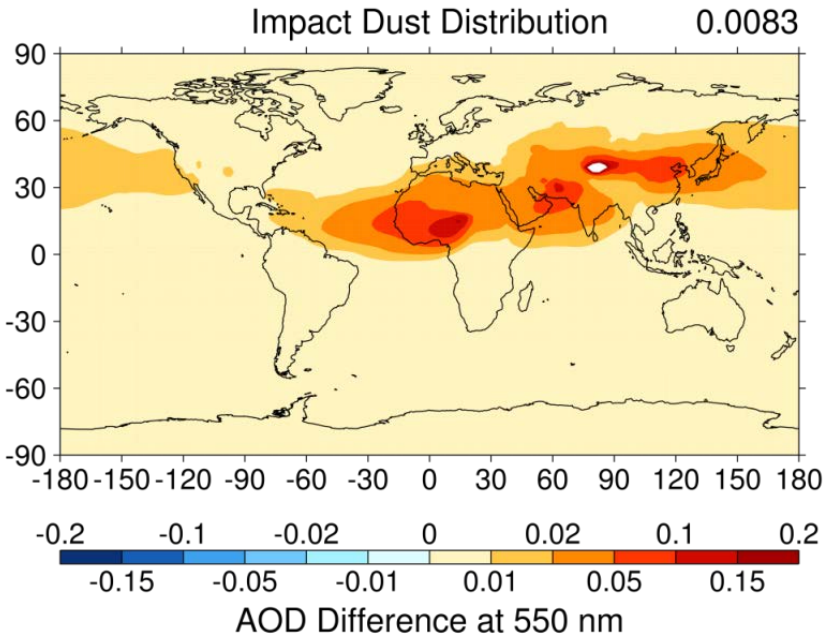
Revisions to mineral dust source

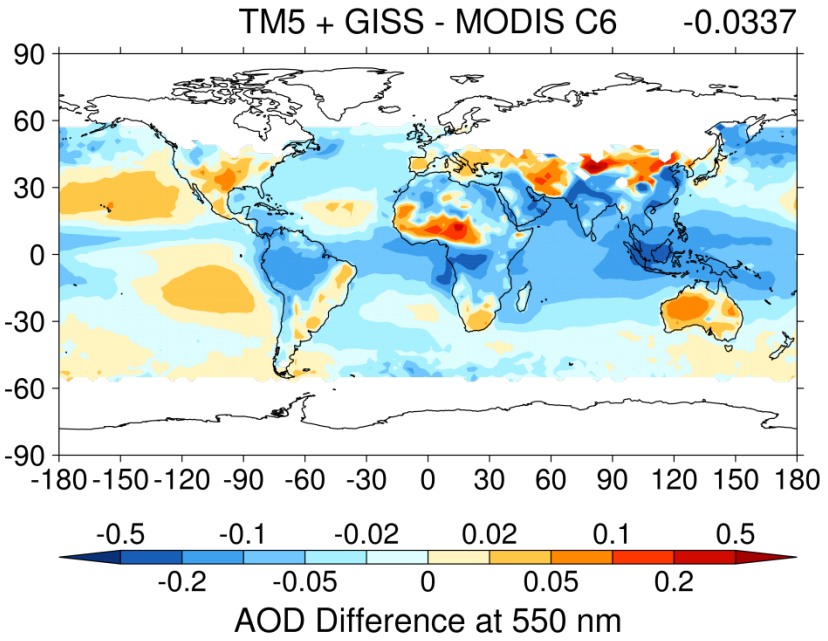
- Parameterization of *Marticorena and Bergametti (1995)* and *Tegen et al. (2002)*
- Non-linear dependence on friction velocity u_*, for $u_* >$ threshold value
- Size resolved calculation dependent on soil properties
- Emitted mass distributed over accumulation and coarse modes (*Stier et al., 2005*):



- Previously, all particles with r > ~0.3 μm were assigned to coarse mode
- A substantial part of these particles should go into accumulation mode

Revisions to mineral dust source

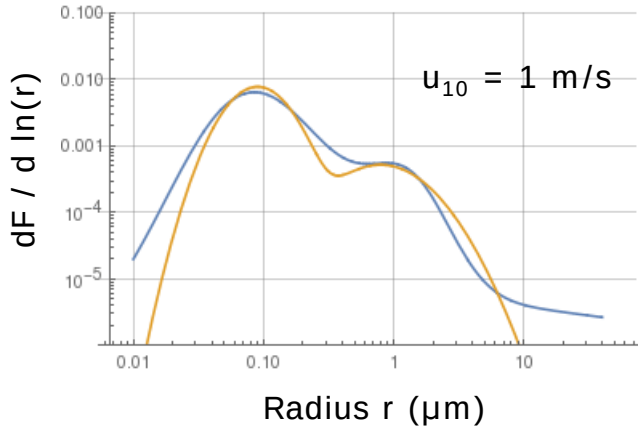




Some additional changes in dust parameterization, e.g. related to surface roughness

Revisions to sea-salt source

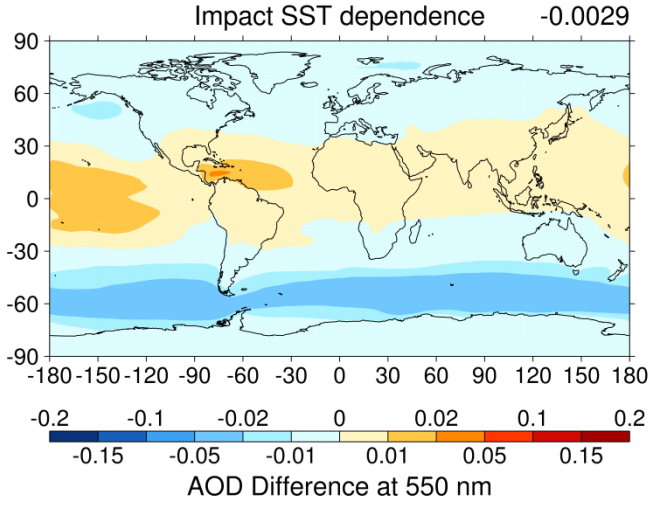
- Parameterization of *Gong et al. (2003)*: flux F ~ $(u_{10})^{3.41}$
- Distributed over accumulation and coarse modes

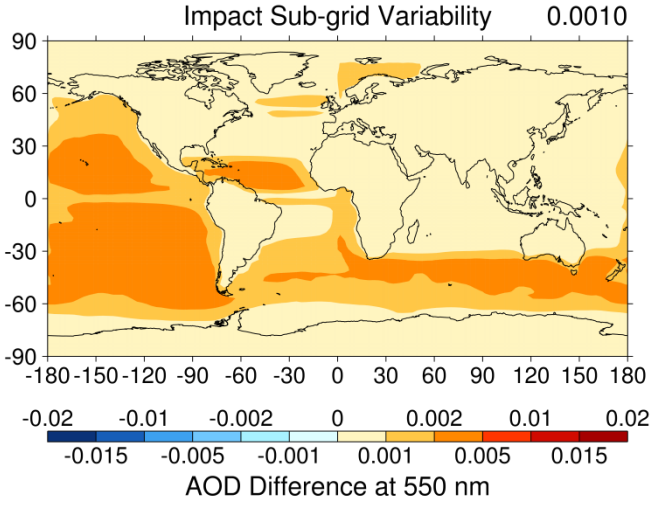


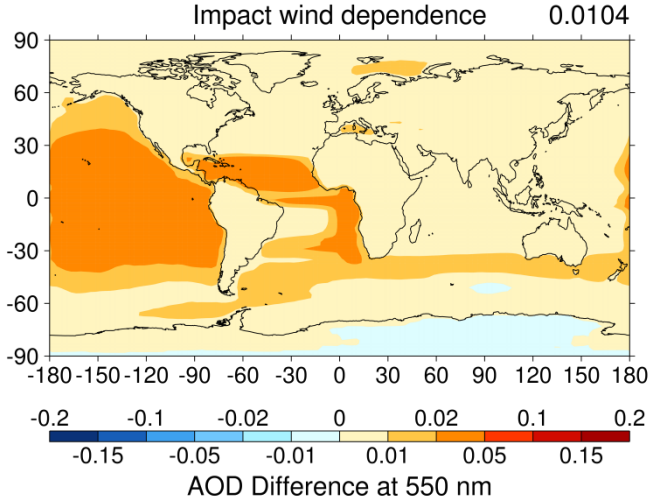
Tested various options:

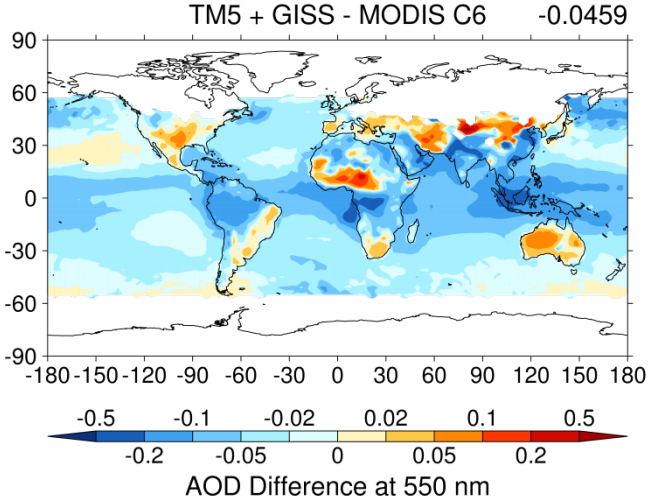
- Temperature dependence (Jaeglé et al., 2011)
- Effects of sub-grid variability on wind speed (Mahrt and Sun, 1995; Redelsperger et al., 2000; Zeng et al., 2002; Monahan et al., 2006)
- Reduced wind-speed dependence: F ~ $(u_{10} + 2.0)^{2.0}$ (*Albert et al., 2015*)

Revisions to sea-salt source









Bias map based on original parameterization from Gong et al.

Conclusion

- An improved model version for simulation aerosols
- Part of TM5-MP, both with CBM4 and CB05
- Used for AeroCom Phase-3 control simulation (AP3-CTRL2015)
- More evaluation on:

  aerocom.met.no/cgi-bin/aerocom/surfobs_annualrs.pl