Anthropogenic Dust Experiment: Preliminary results

Aerocom 16th

Paul Ginoux

(NOAA GFDL)

Helsinki, October 9-12 2017

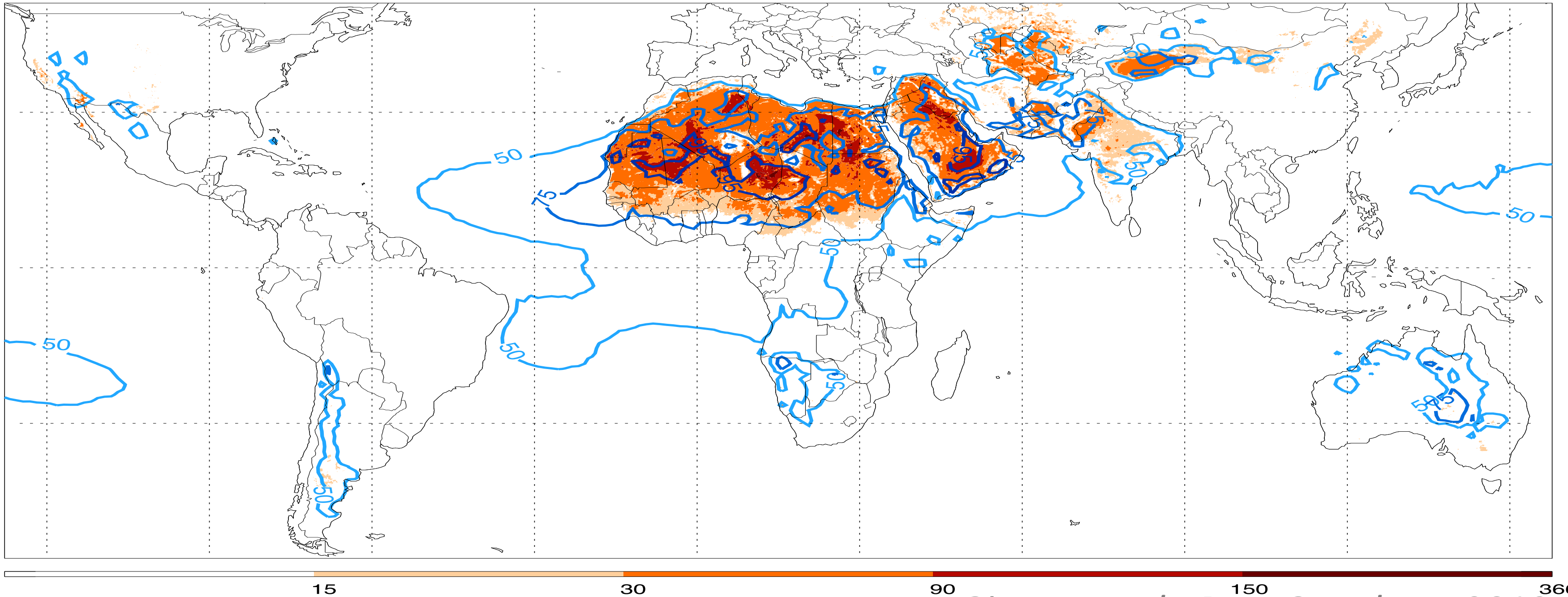
Motivation

- Dust from landuse (cropland and pasture) represents 25% of global emission (*Ginoux et al., Rev.. Geophys., 2012; Stanelle et al., J. Geophys. Res., 2014*) with large continental variability, but is generally ignored in aerosol models,
- Mineralogy of natural and landuse dust differs, which has implication for radiative forcing, ocean biogeochemistry, heterogeneous reactions with gas phase chemistry,
- Landuse dust and NH_3 hotspots are often collocated (*Ginoux et al., Atm. Chem. Phys., 2012*) which has implication for nitrate production (*Paulot et al., Atm. Chem. Phys., 2016*).
- Increase dustiness in Southwest in the late 21st century (Pu and Ginoux, Scientific Reports, 2017)

MODIS based dust sources

- Dust Optical Depth (DOD) derived from daily MODIS-DB level-2 C6 aerosol products (AOD(λ), QA, and SSA) from 2003-2014,
- Frequency of Occurrence (FoO) of DOD>0.2 per year over 12 years = dust sources
- Anthropogenic sources = FoO>0 and landuse>30% (landuse dataset for 2005 from *Klein Goldwijk, Global Biogeochem. Cycles, 2001*)

Comparison FoO TOMS AI>0.7 (contours) and M-DB DOD>0.2 (shading)

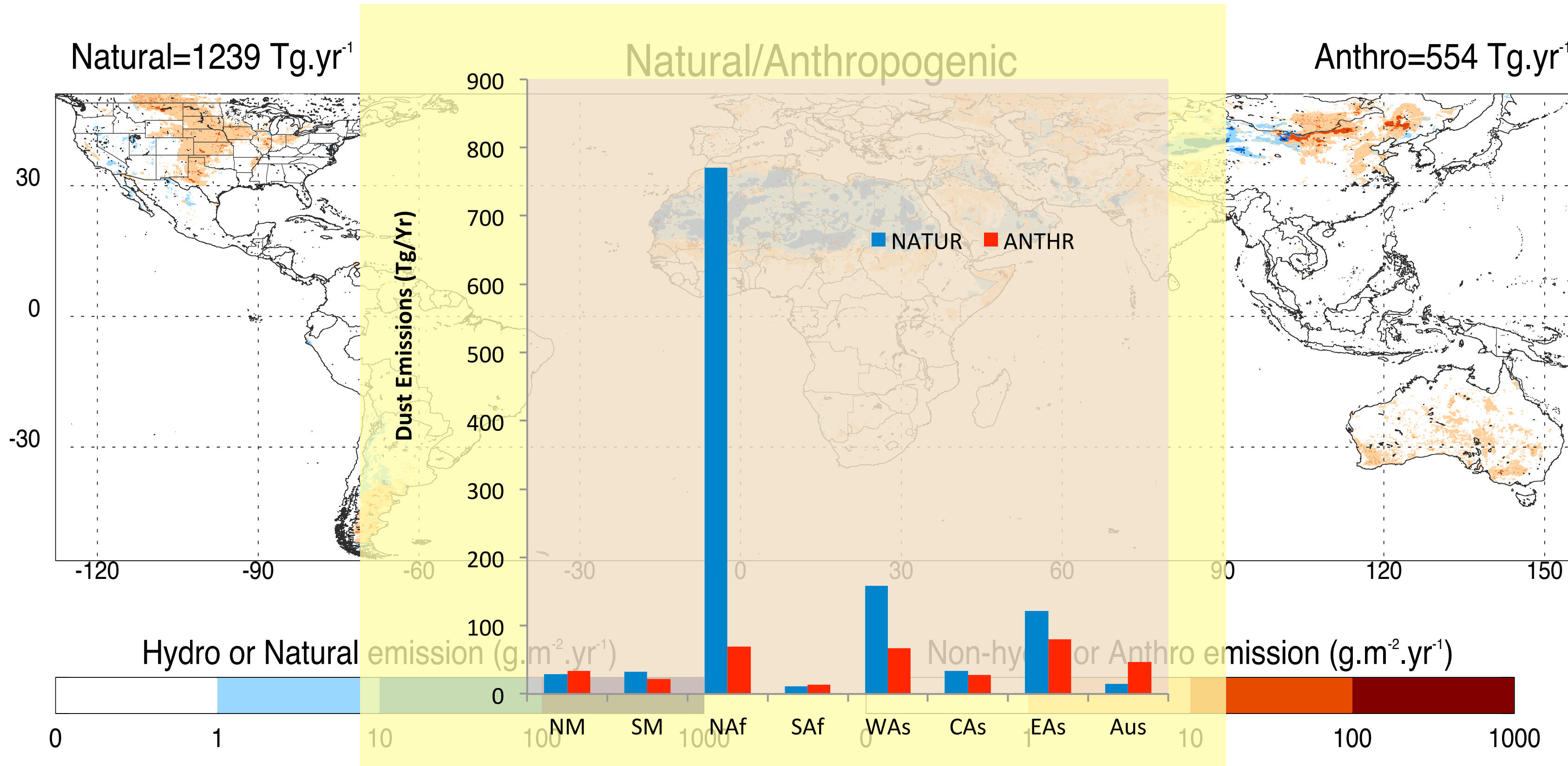


Ginoux et al., Rev. Geophys., 2012

Anthropogenic and natural dust emissions

- $Emission = C * FoO * u^2 * (u - u_t)$

  with threshold velocity u_t= 6 m/s (landuse<30%) and 10 m/s (landuse>30%)



Ginoux et al., Rev. Geophys., 2012

Experiments

- **CTRL**. Simulate with your own sources using your own C0 and Uto.
- **MDB2-A**. Simulate with MDB2 natural sources with Uto, then calculate global emission Cnew to have same global mean annual emission as in 1. Cnew=C0 * (global mean annual emis exp1)/(global mean annual emis exp2)
- Simulate with MDB2 anthropogenic sources with Cnew and with:
  MDB2-Ba a) Uto
  MDB2-Bb b) 0.5*Uto
  MDB2-Bc c) 1.5*Uto
- **MDB2-C**. Simulate with MDB2 natural and anthropogenic sources with Cnew and Uto

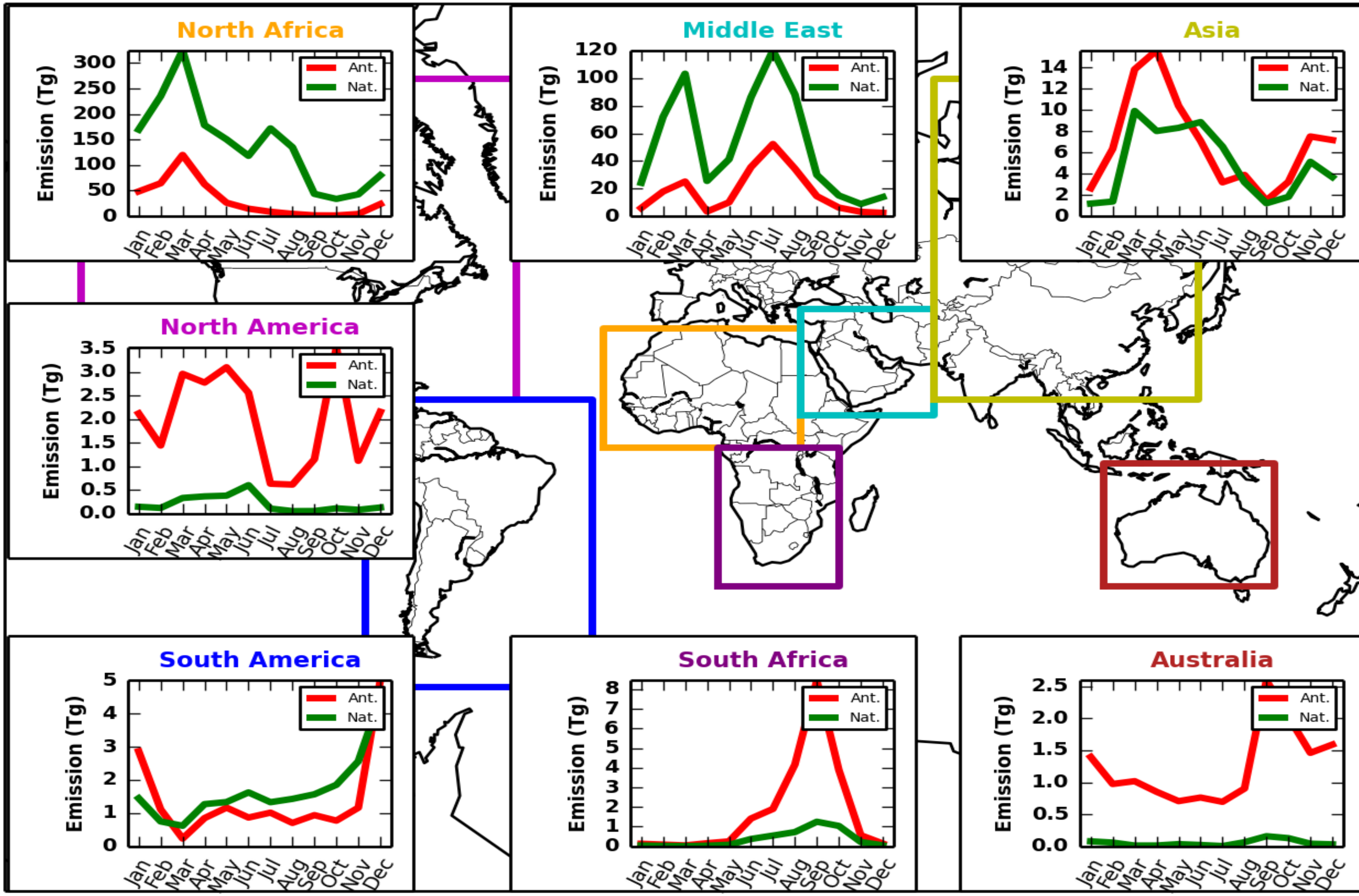
Simulations from 2010 to 2012

Model input

- Source = FoO MODIS DB C6 DOD > 0.5 at 1x1

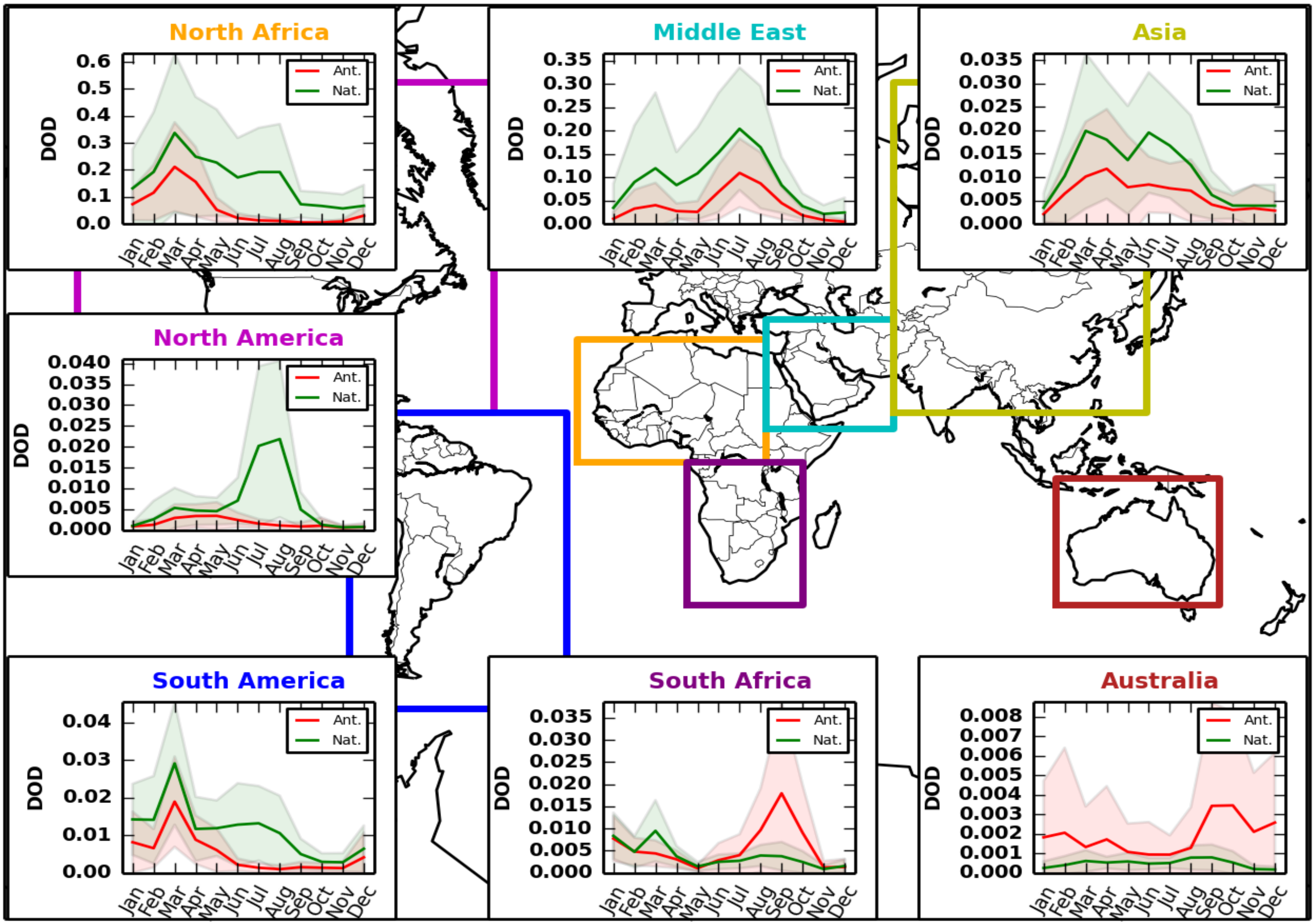
Model output

- Static:
  - Vertical coordinate system
  - Altitude above sea level
  - Land/sea mask
- 2-D daily:
  - Surface pressure
  - for each dust size bins
    - Emission
    - Deposition (wet and dry)
    - Dust burden
- 3-D daily:
  - Temperature
  - Specific humidity
  - For each dust size bins: Dust concentration



NMMB-BSC model

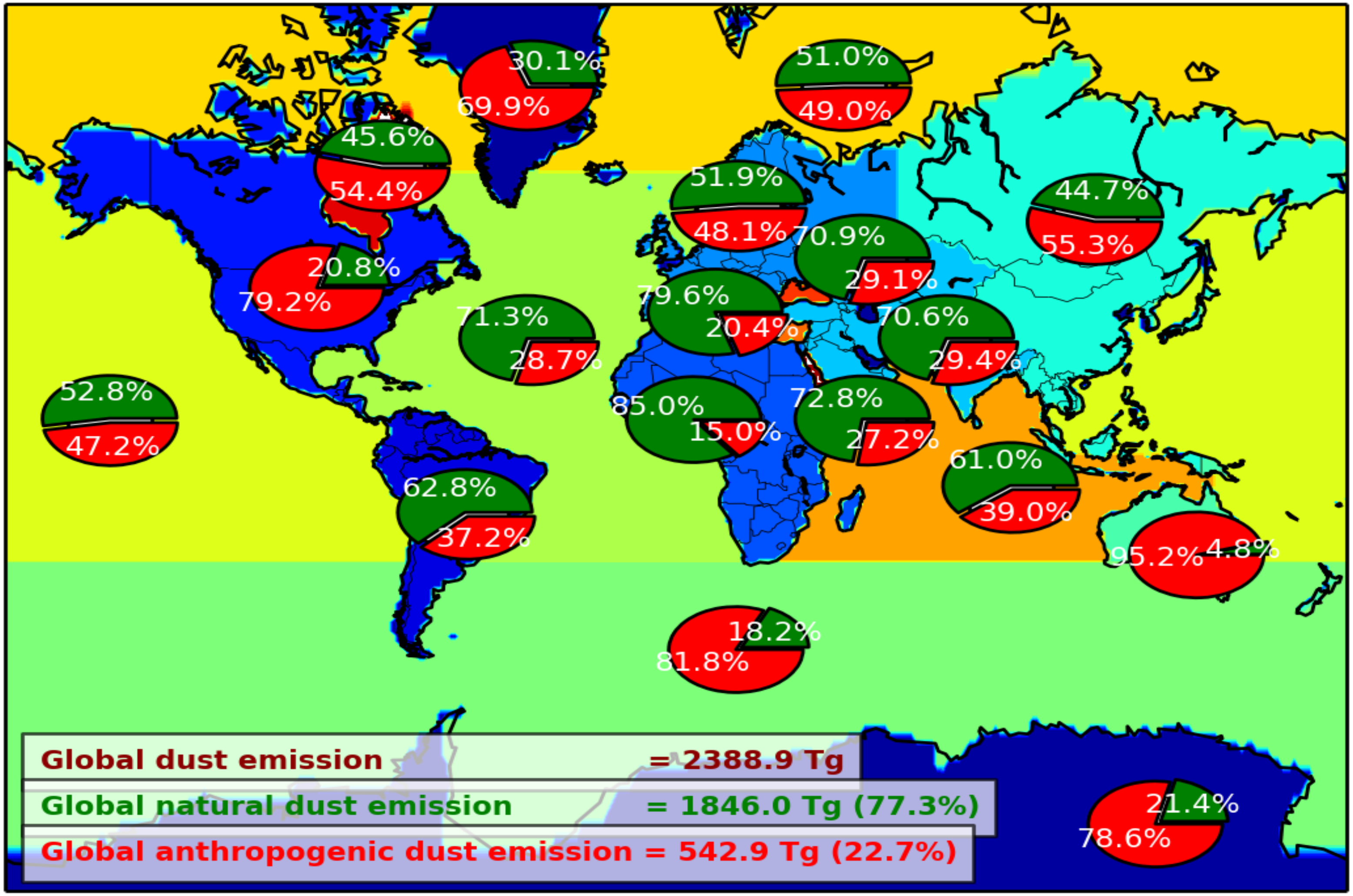
Collaboration with C. Perez and A. Deroubaix



NMMB-BSC model

Collaboration with C. Perez and A. Deroubaix

Annual dust deposition

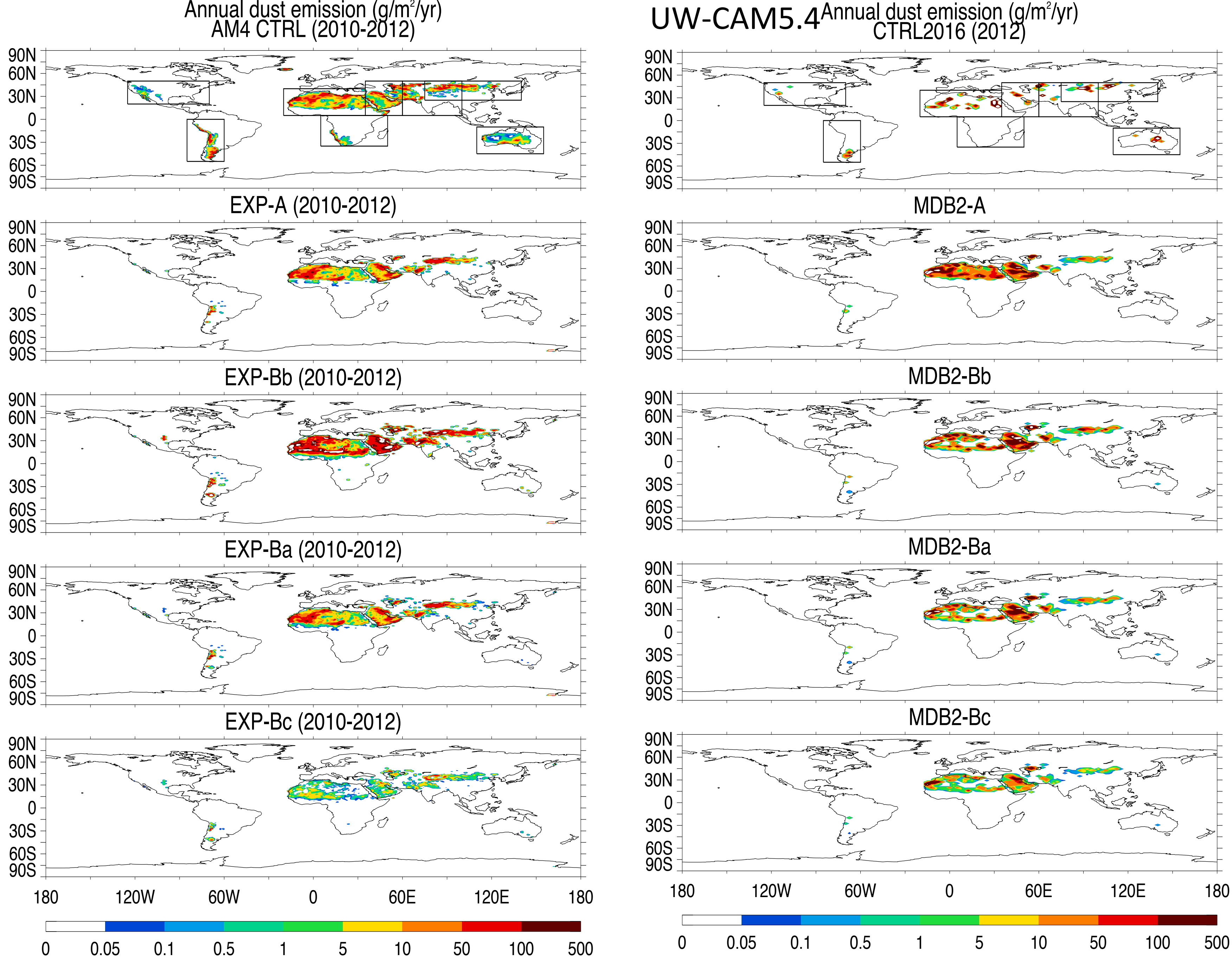


NMMB-BSC model
Collaboration with C. Perez and A. Deroubaix

Participating Models

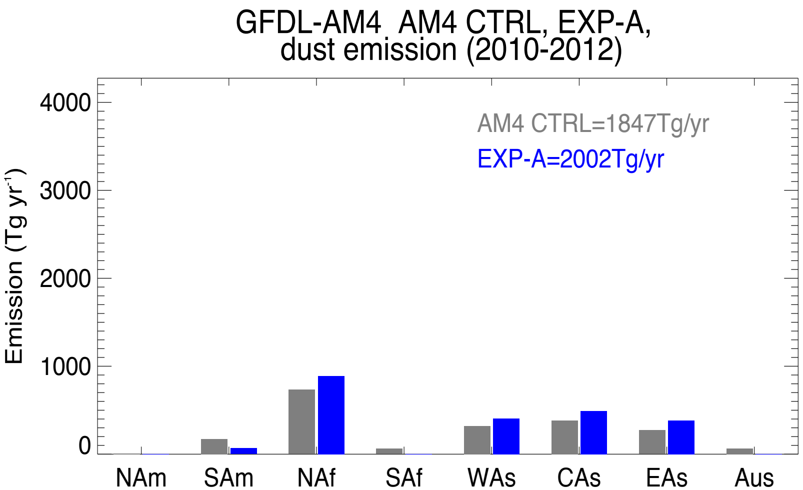
- GFDL AM4 (Zhao et al., 2017)
  - 0.5^ox0.5^ox33L
  - Aerosols: SU, OC, BC, SS, DU
  - Dust as of Ginoux et al. (2001)
  - Nudging: U & V with NCEP re-analysis (Kalnay et al., 1996)
  - Contact: paul.ginoux@noaa.gov
  - Affiliation: NOAA GFDL

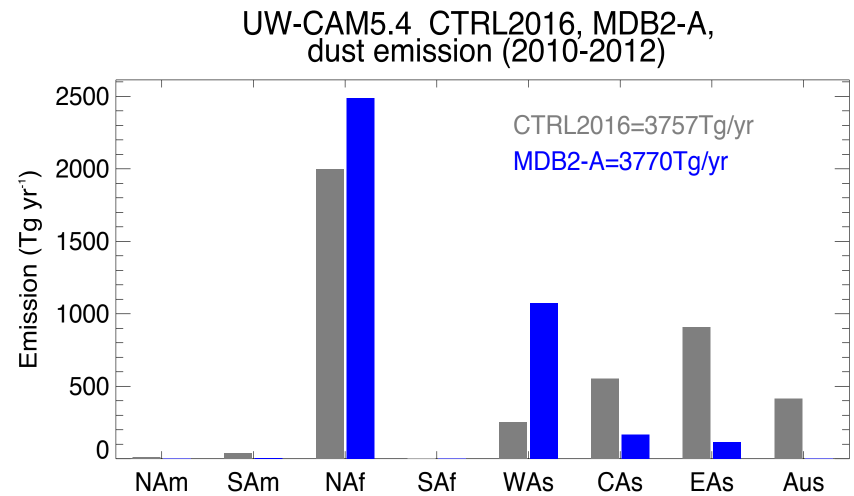
- U Wyoming CAM5.4 (Neale et al., 2010)
  - 1.9^ox2.5^ox30L
  - Aerosols: MAM4 (Liu et al., 2012, 2016)
  - Dust as of Zender et al. (2003)
  - Nudgin: U & V with ERA-interim (Zhang et al., 2014)
  - Participants: Mingxuan Wu, Chenglai Wu, Xiaohong Liu
  - Affiliation: Department of Atmospheric Science, University of Wyoming, Laramie, Wyoming

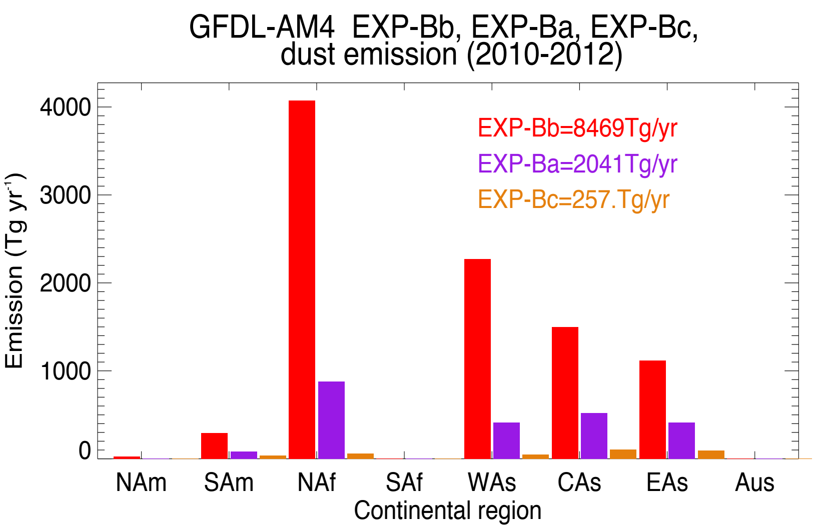


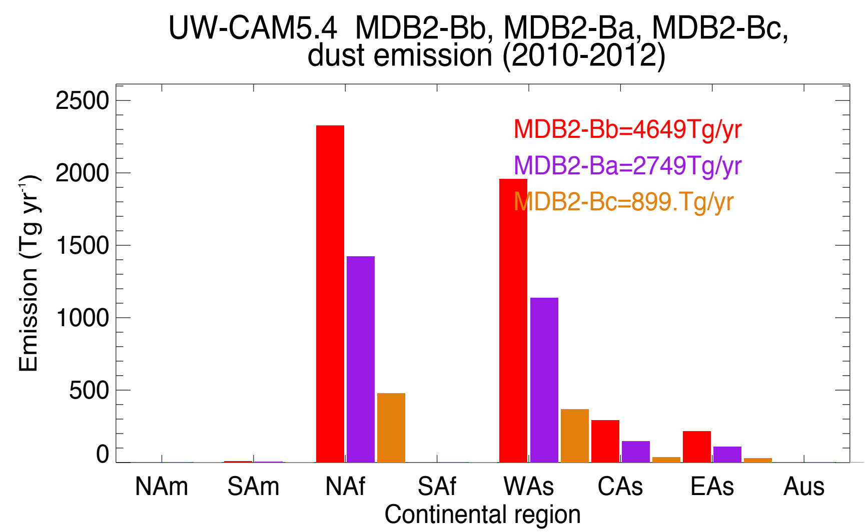
Annual dust emission (g/m²/yr)
AM4 CTRL (2010-2012)
UW-CAM5.4
CTRL2016 (2012)
EXP-A (2010-2012)
MDB2-A
EXP-Bb (2010-2012)
MDB2-Bb
EXP-Ba (2010-2012)
MDB2-Ba
EXP-Bc (2010-2012)
MDB2-Bc
90N 60N 30N 0 30S 60S 90S
180 120W 60W 0 60E 120E 180
0 0.05 0.1 0.5 1 5 10 50 100 500

Emission by region

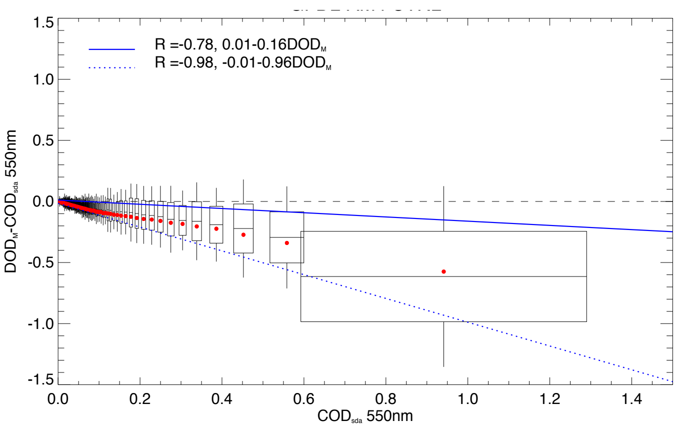


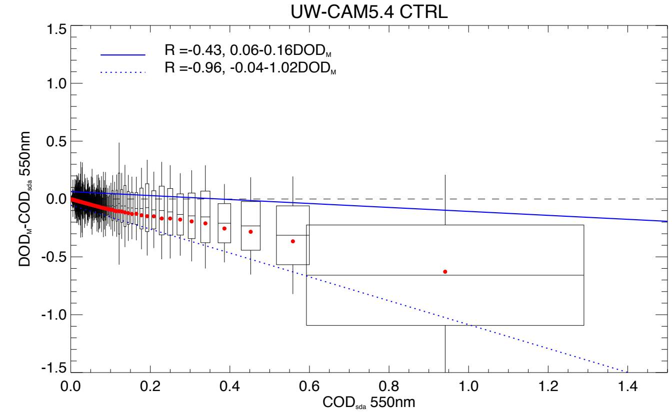


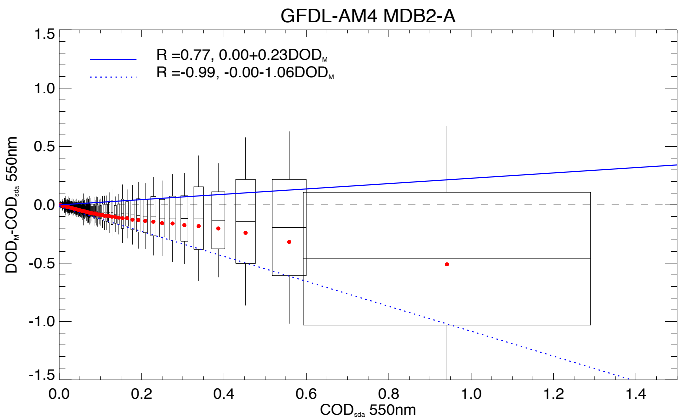


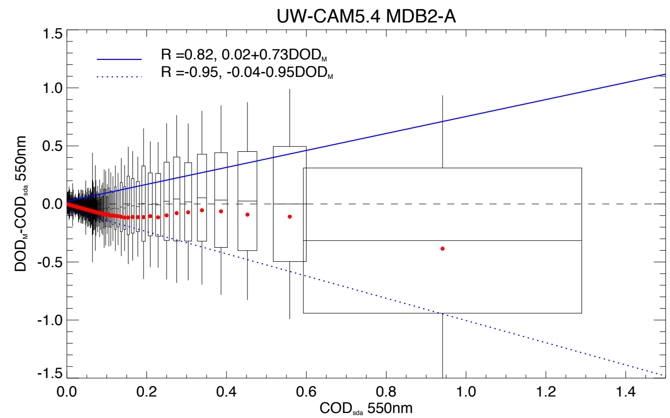


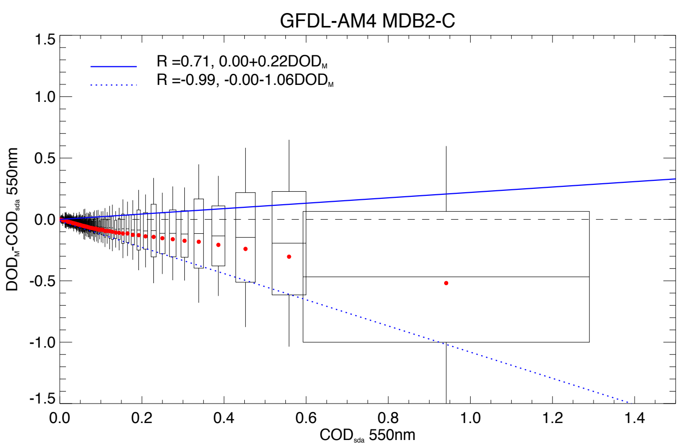
Error estimate of model DOD using AERONET coarse mode SDA

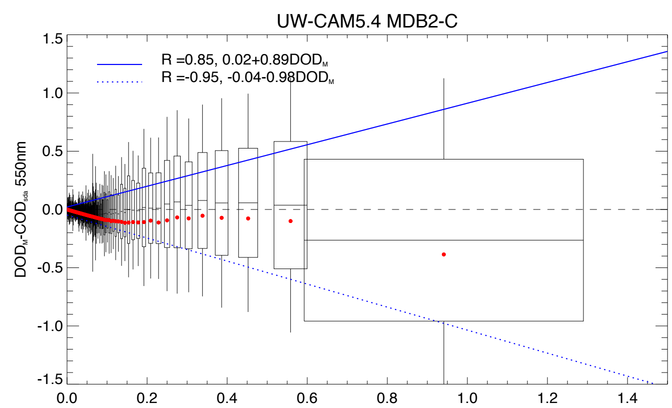


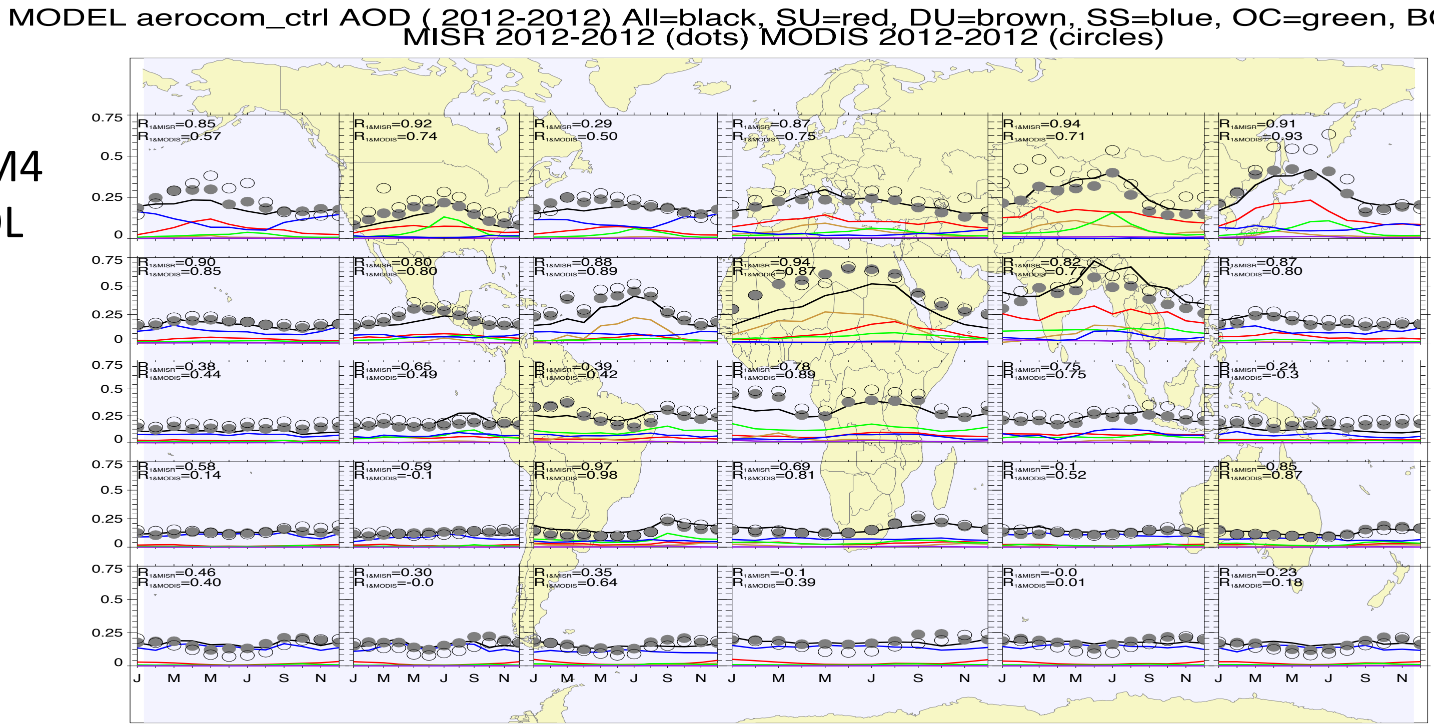




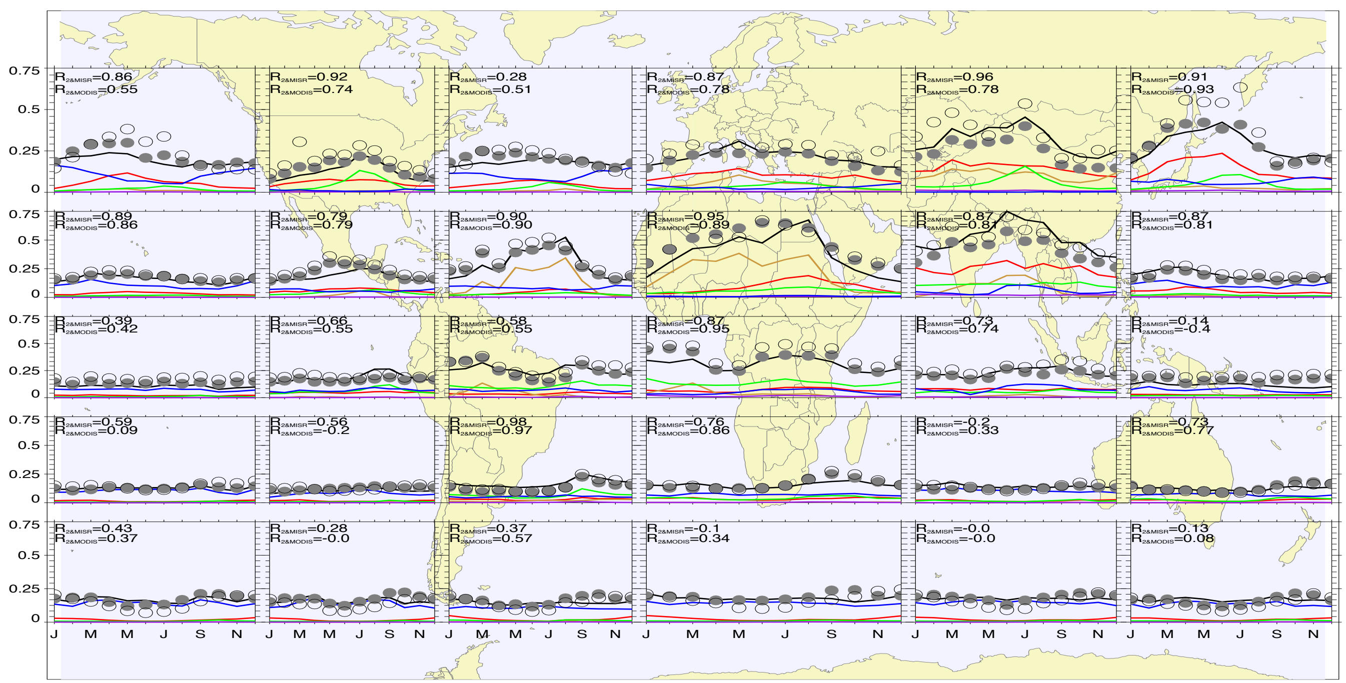






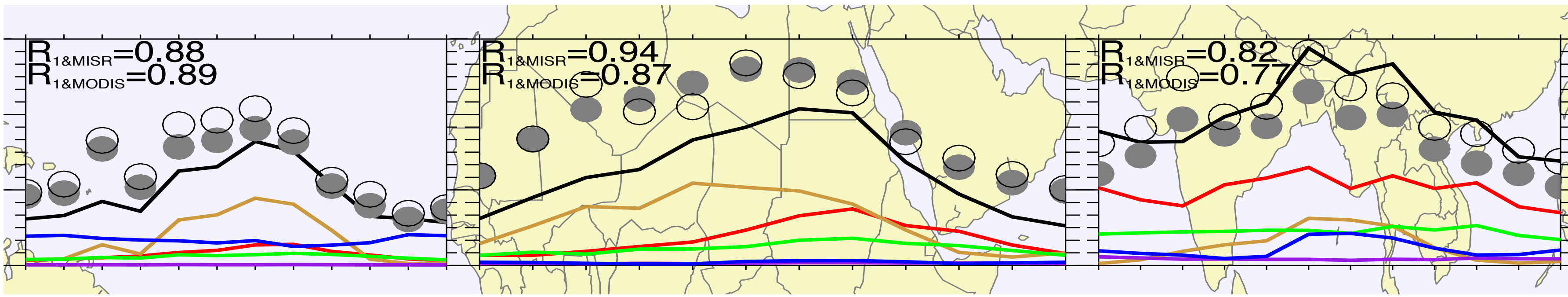


GFDL-AM4
CONTROL

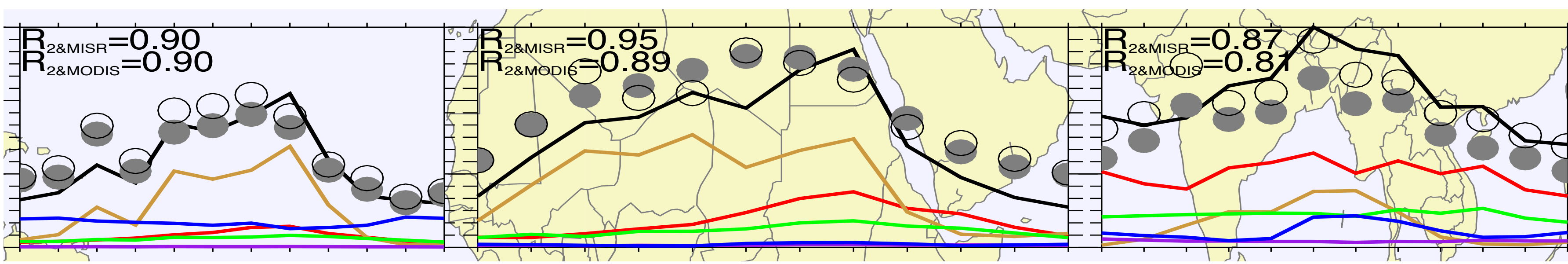


GFDL-AM4
MDB2-C

GFDL-AM4
CONTROL

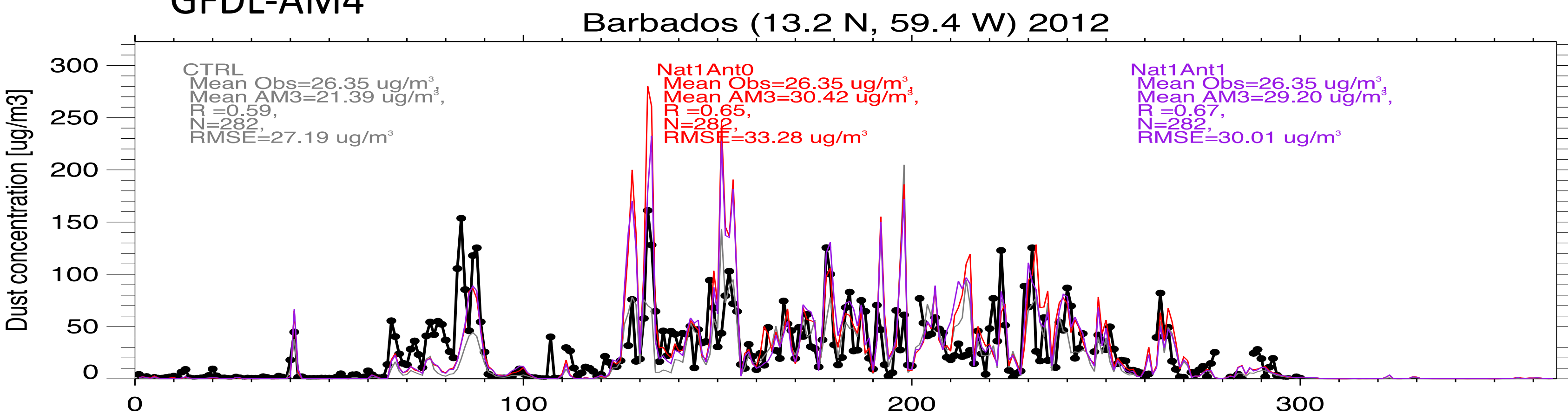


GFDL-AM4
MDB2-C

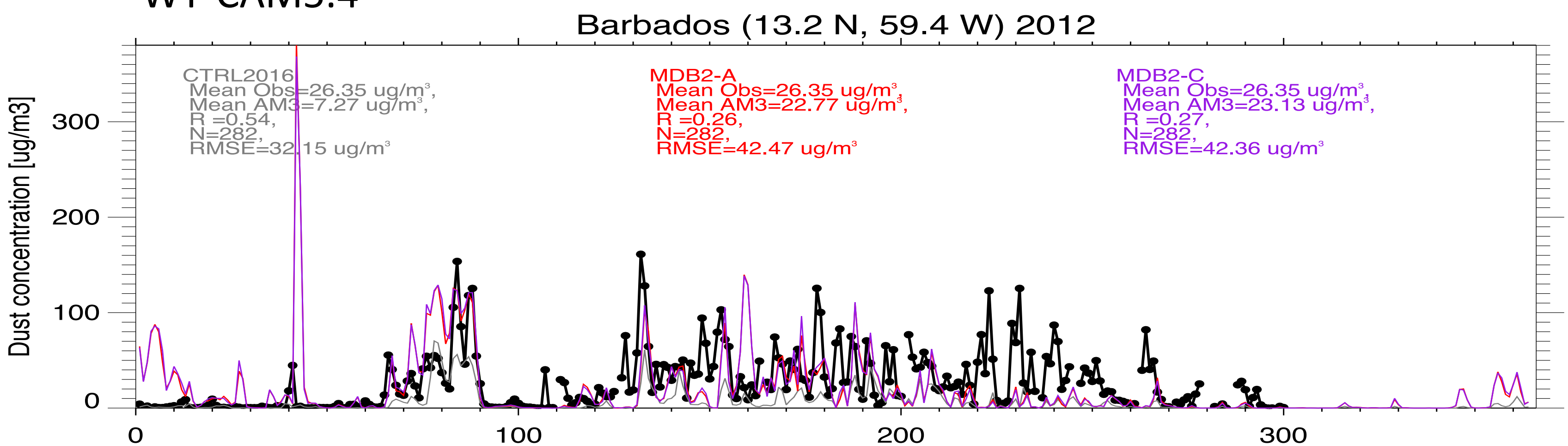


Surface Dust Concentration at Barbados (2012)

GFDL-AM4



WY-CAM5.4



Day of the year

Summary

- MODIS DB source seems to improve comparisons with observations for threshold of wind erosion greater than 1.
- However DOD > 0.5 is too high for detecting sources outside “Dust Belt”. Need to use DOD > 0.2 over other less dusty regions
- Variability between models appears right from emission although same sources and nudged winds, but different method to calculate the threshold of wind erosion
- Additional datasets for model comparison: AERONET direct measurements and inverted properties, CALIOP, U Miami surface concentration and wet deposition, etc.
- Threshold of wind erosion can be calculated specifically for each model knowing MODIS FoO, surface winds and properties
- More participants are needed