Anthropogenic Dust Experiment: Model Results

AeroCom 18th

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Barcelona (Spain), September 2

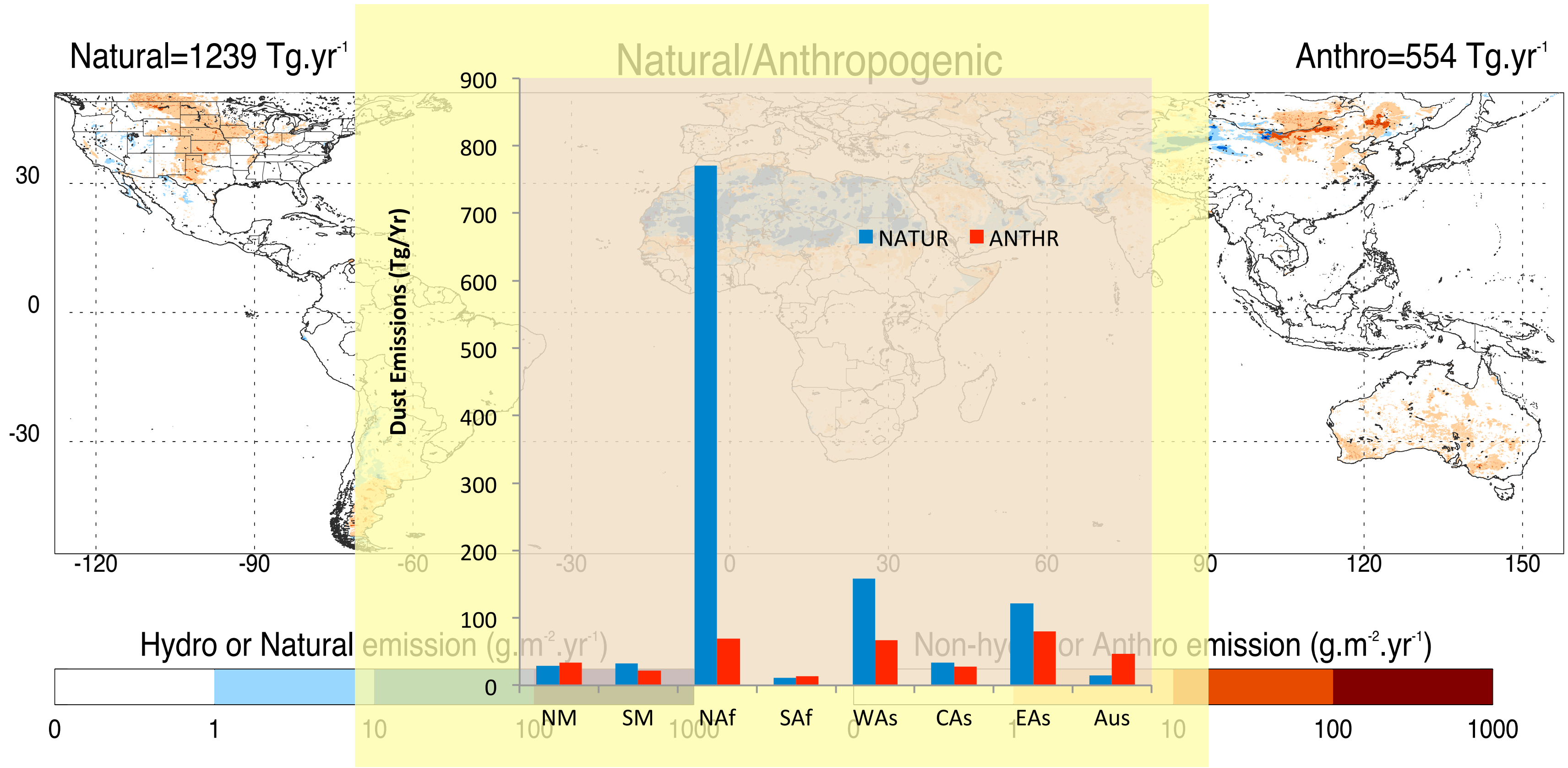
Motivation

- 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 Southern High Plains in the late 21st century (Pu and Ginoux, Scientific Reports, 2017)

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

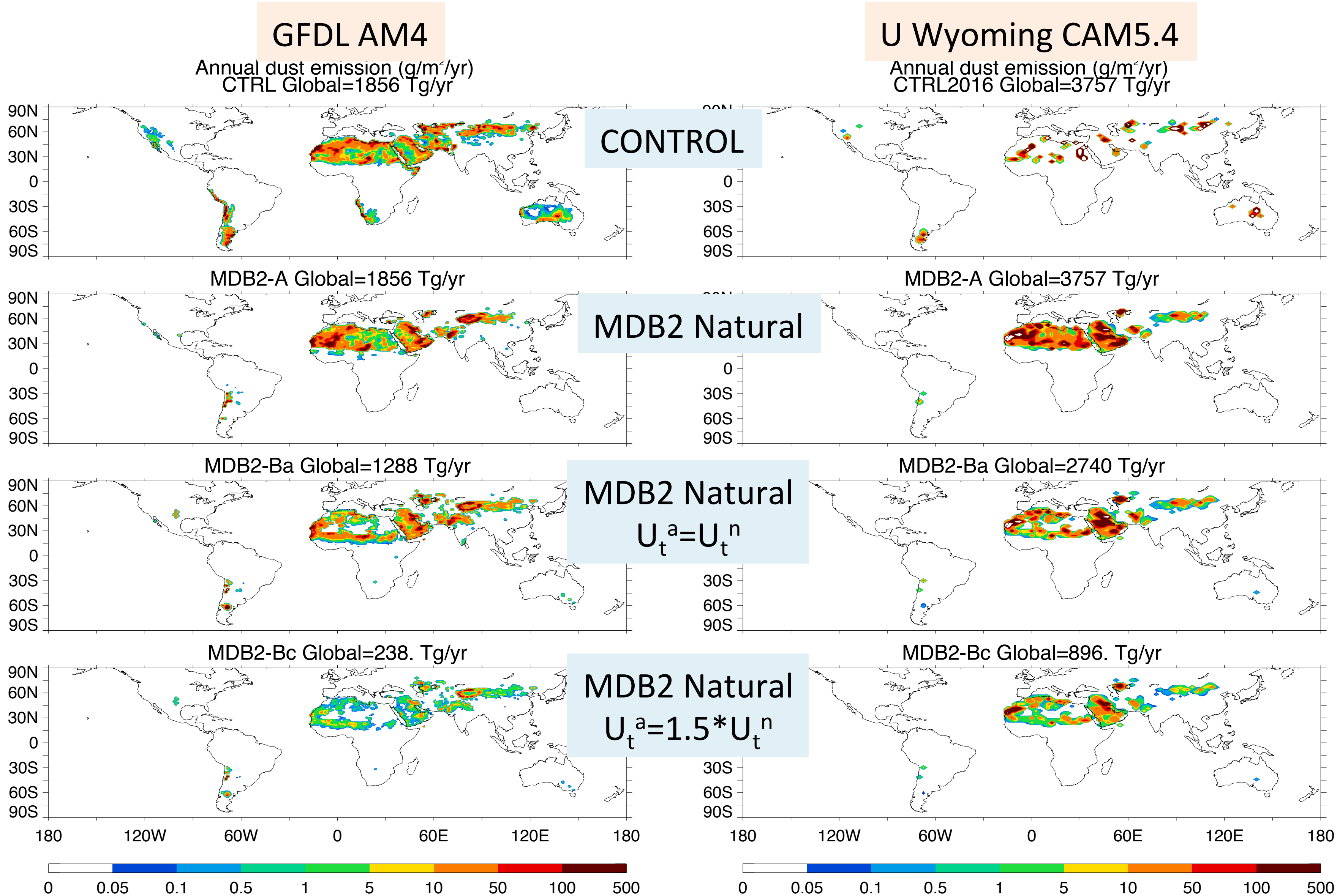
Experiments

- **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

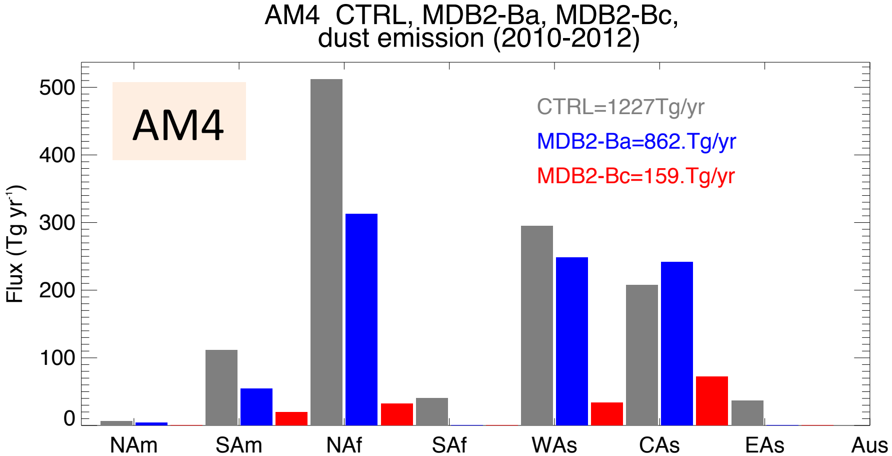
Participating Models

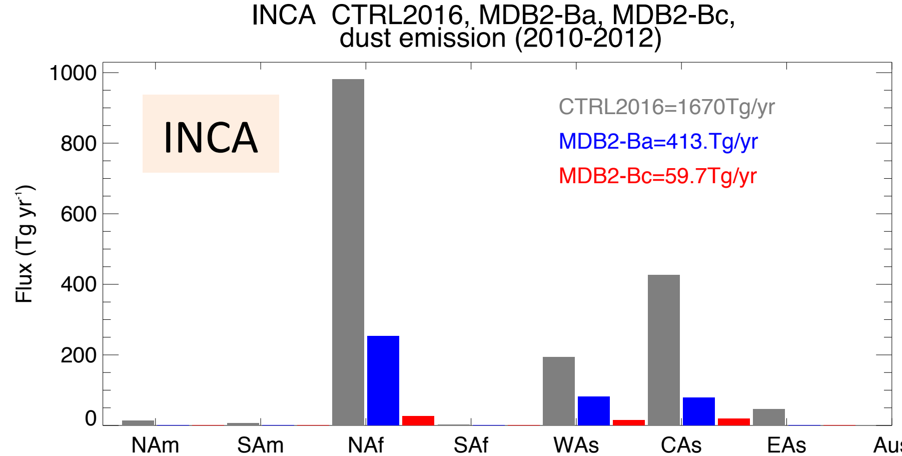
Model	Resol.	Lev	Dust Scheme	Size	Reference	contact
NOAA GFDL AM4	0.65x0.5	33	Ginoux et al., 2001	5 Bins 0.1-10 μm	Zhao et al., 2018	Paul Ginoux
U Wyoming CAM5.4	2.5x1.9	30	Zender et al., 2003	4 Modes 0.01-10 μm	Liu et al., 2016	Xhiaohong Liu
U Aquila GEOS-Chem	2.5x2	47	Ginoux et al., 2001	4 Bins 0.1-6 μm	Fairlie et al., 2007	Paolo Tuccella
LSCE-Paris INCA	2.5x1.25	39	Schulz et al., 2007	5 lognormal modes	Folbert et al., 2006	Yves Balkanski

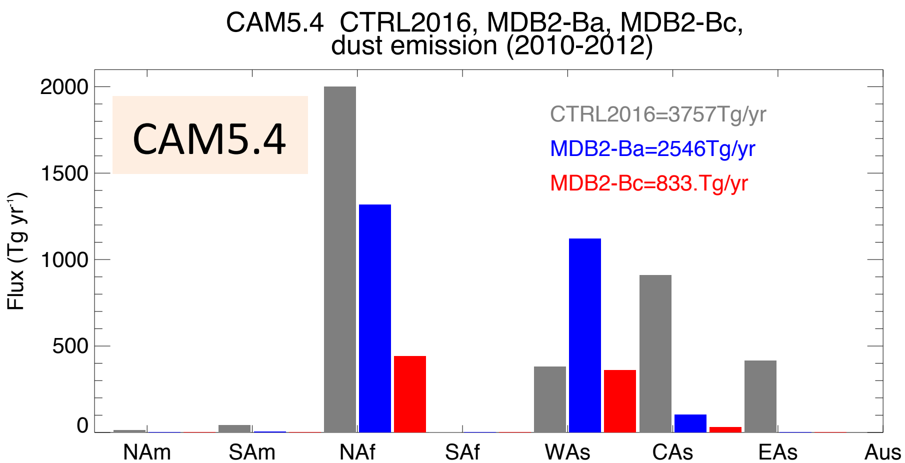


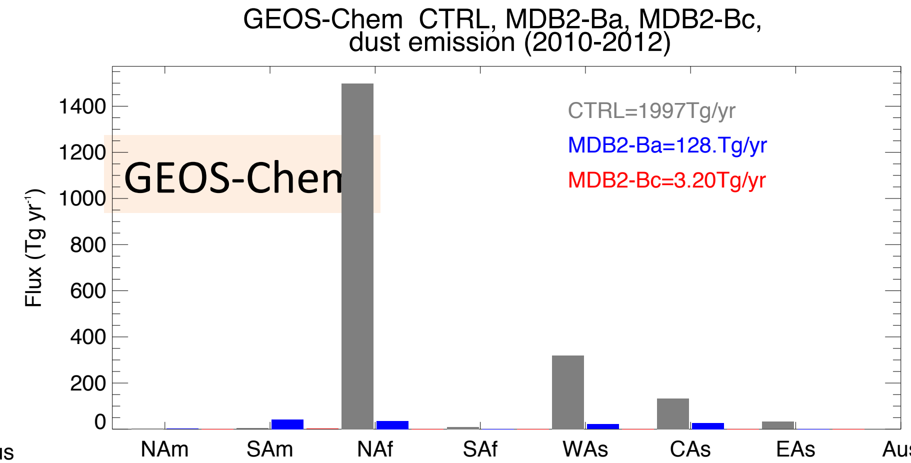
High sensitivity to Ut: Dust emission decrease by a factor 3 when the threshold of wind erosion over agricultural sources is 1.5 higher than for natural sources.

Global and regional emissions







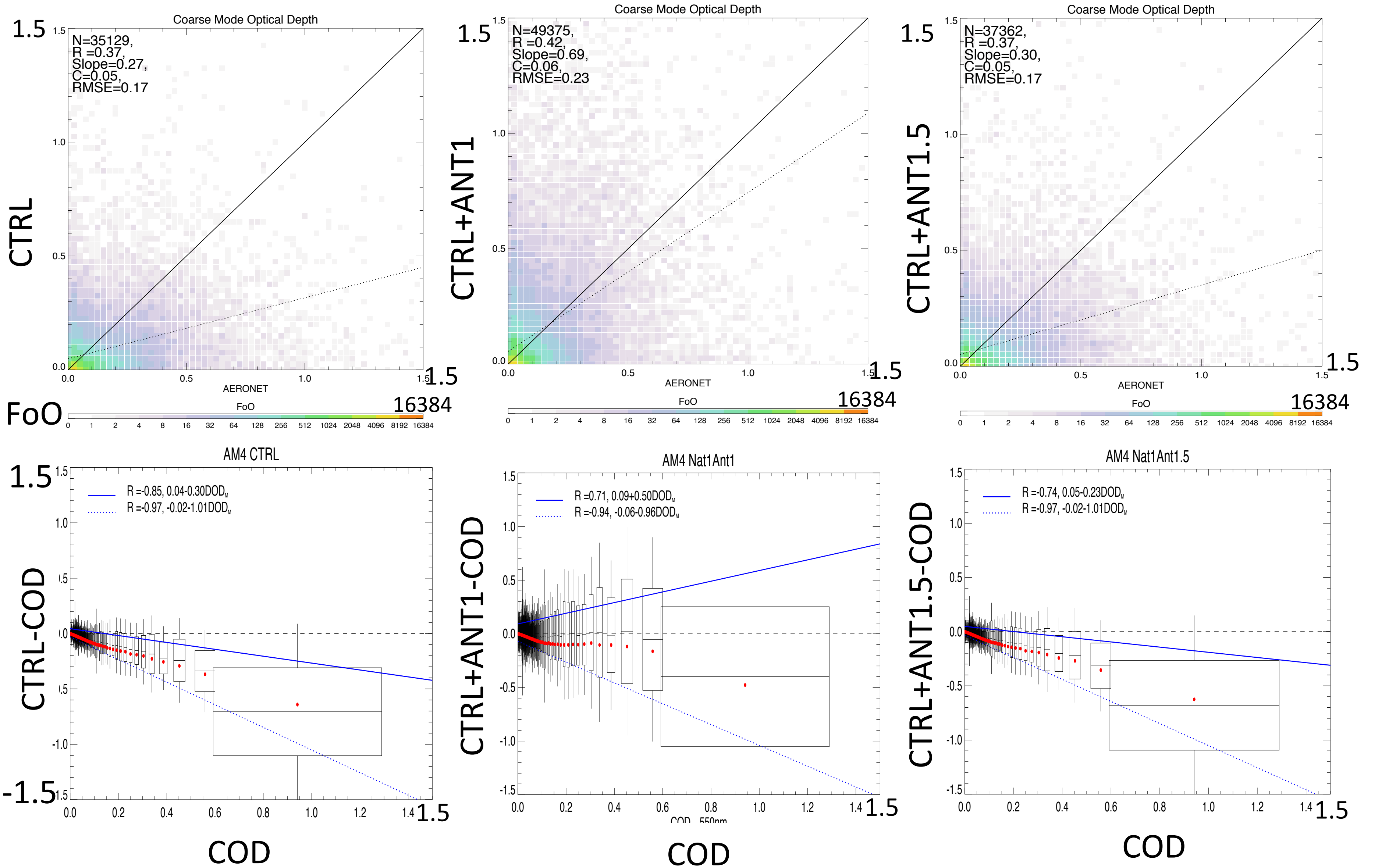


Sensitivity to Ut:

Not shown $U_t^a = 0.5\ U_t^n$ with values over the roof.

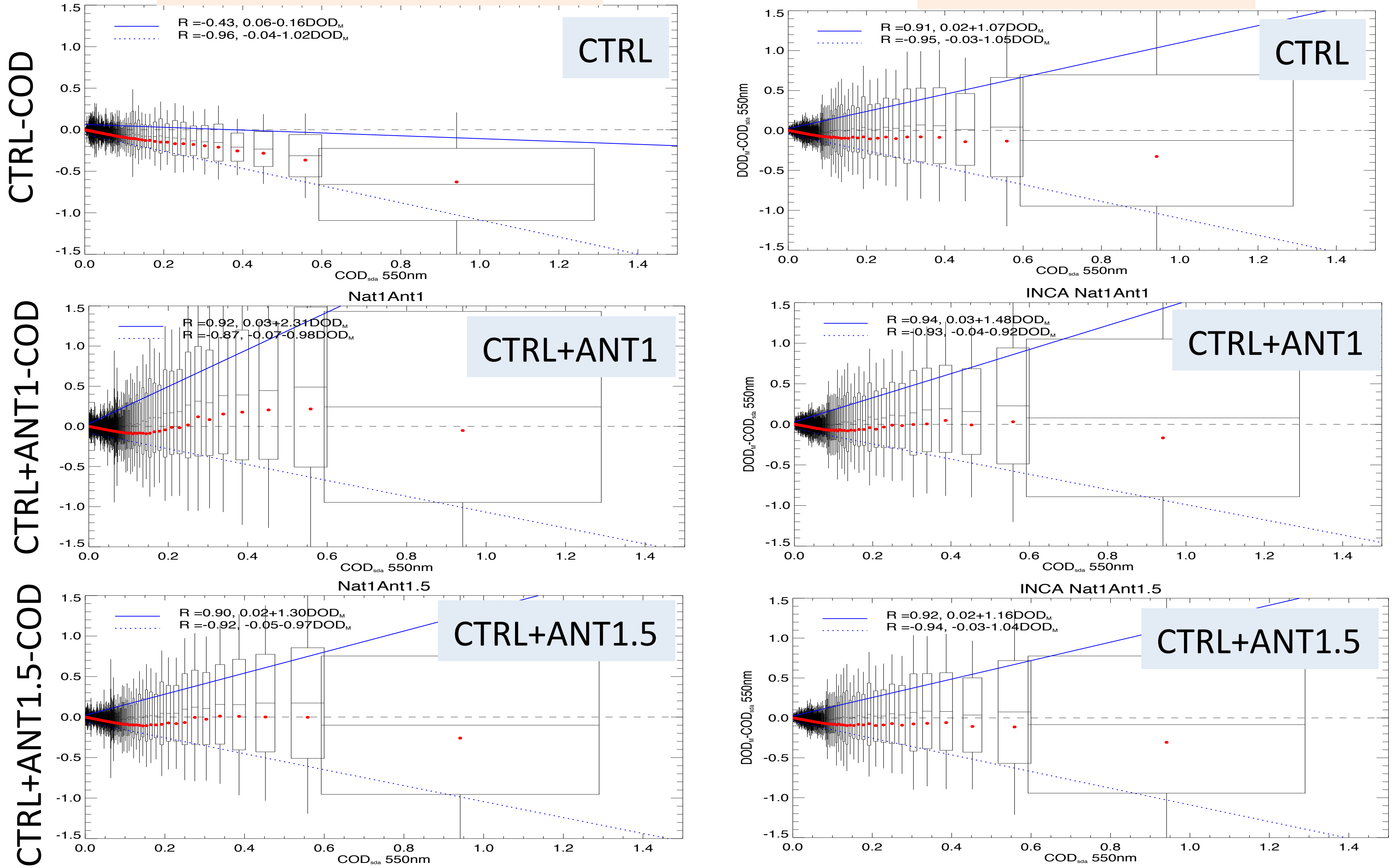
Percentage of total anthropogenic dust emission drops from ~50% with $U_t^a = U_t^n$ to less than 1% with $U_t^a = 1.5 * U_t^n$

Comparison AM4 DOD for CTRL, CTRL+ANT(Ut), CTRL+ANT(1.5Ut) with AERONET SDA coarse mode optical depth (COD)



U Wyoming CAM5.4

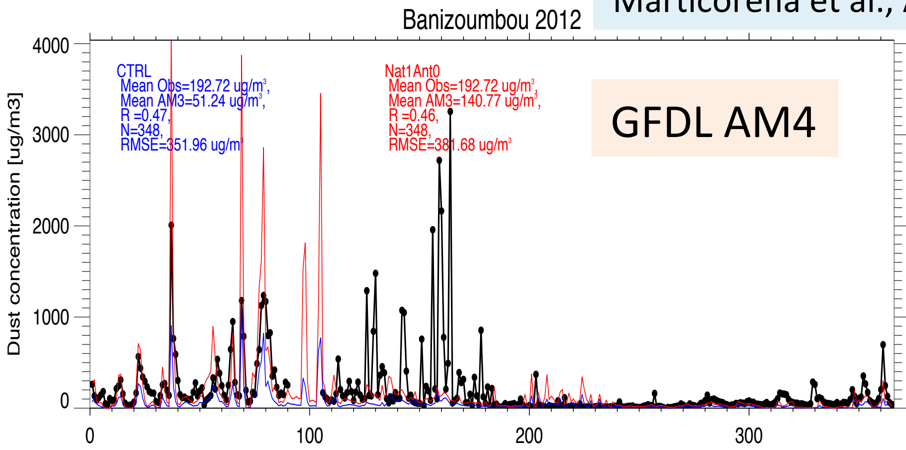
LSCE-IPSL INCA

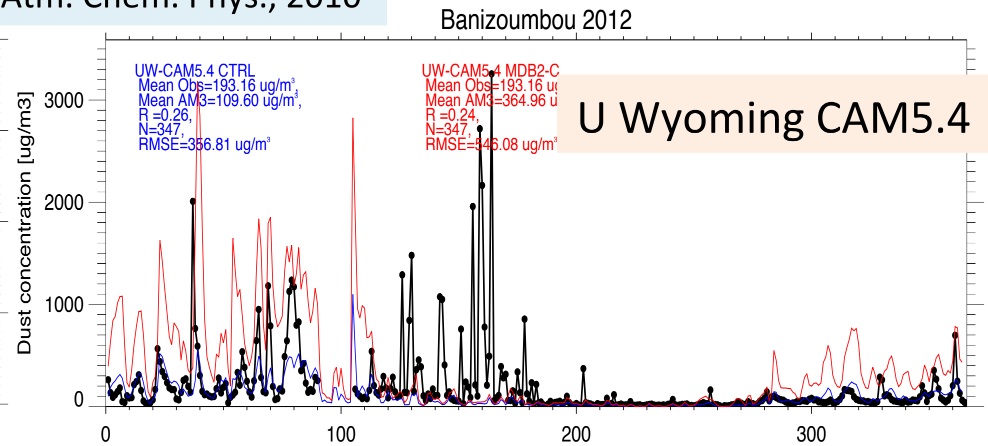


Mean bias decreases from CTRL to MDB2 $U_t^a = U_t^n$ to MDB2 $U_t^a = 1.5 * U_t^n$ but error increase specially for CAM5.4

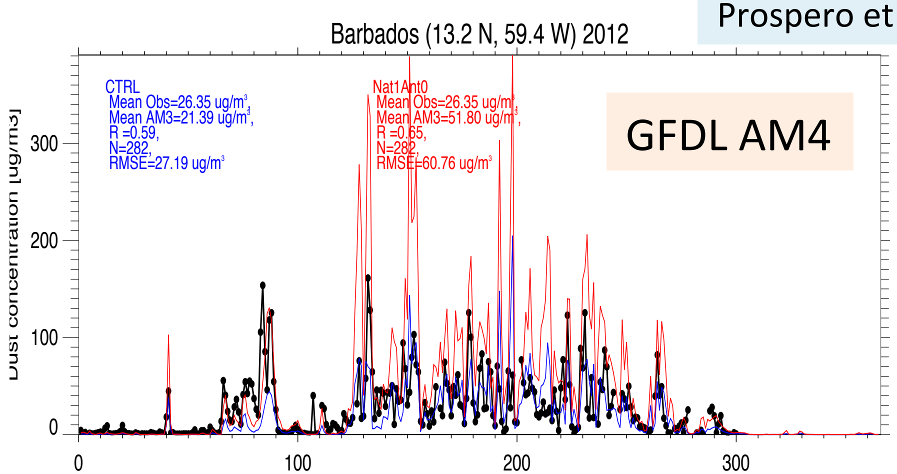
Comparison of daily surface concentration (2012) at Banizoumbou and Barbados

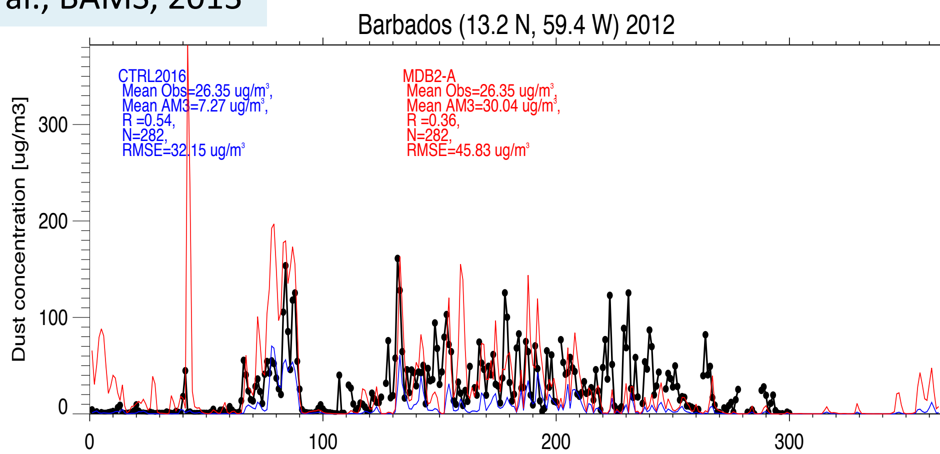
Marticorena et al., Atm. Chem. Phys., 2010





Prospero et al., BAMS, 2013



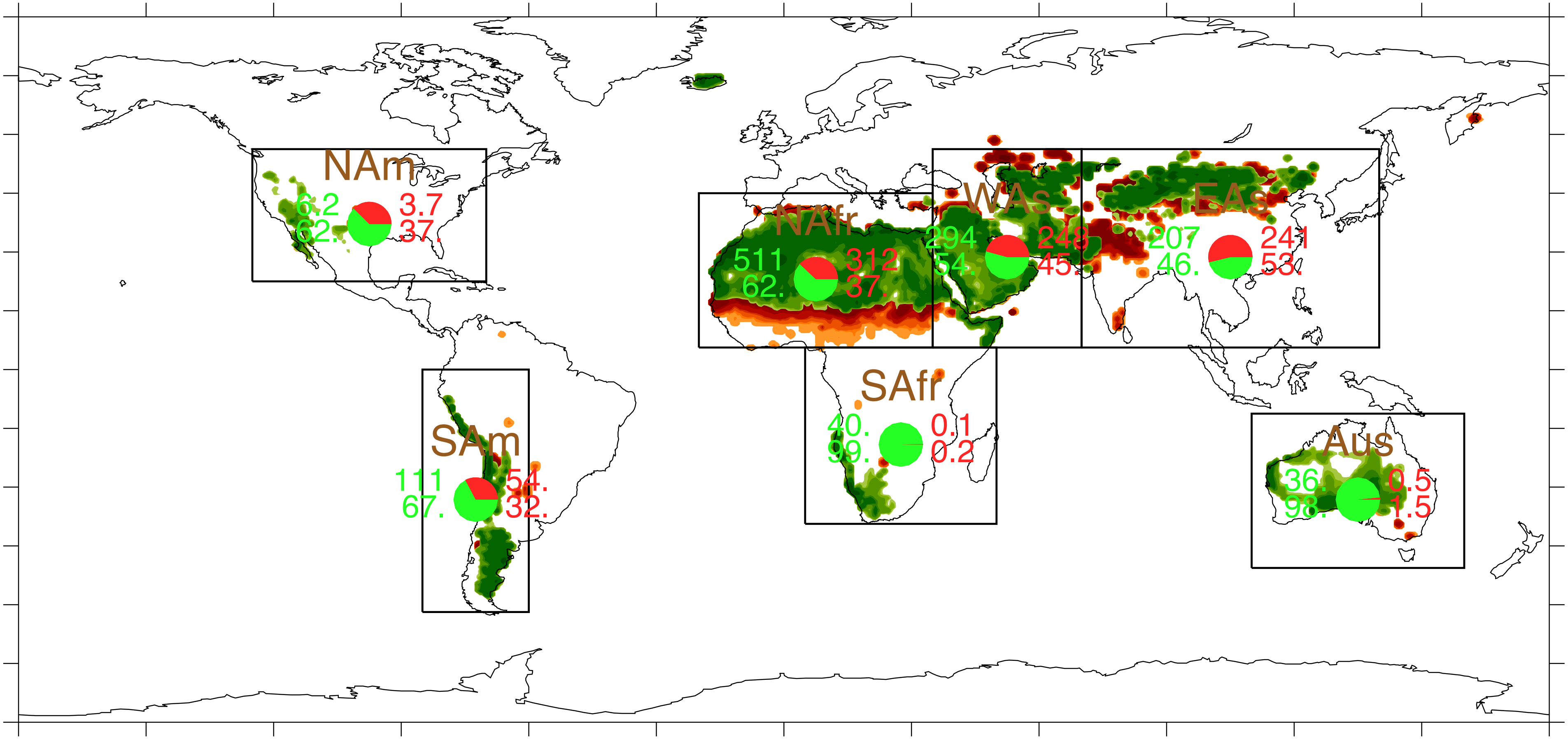


Using comparison of dust concentration with observations far away from sources is not useful as models treat transport and removal very differently (cf. Huneeus et al., Atm. Chem. Phys., 2011).

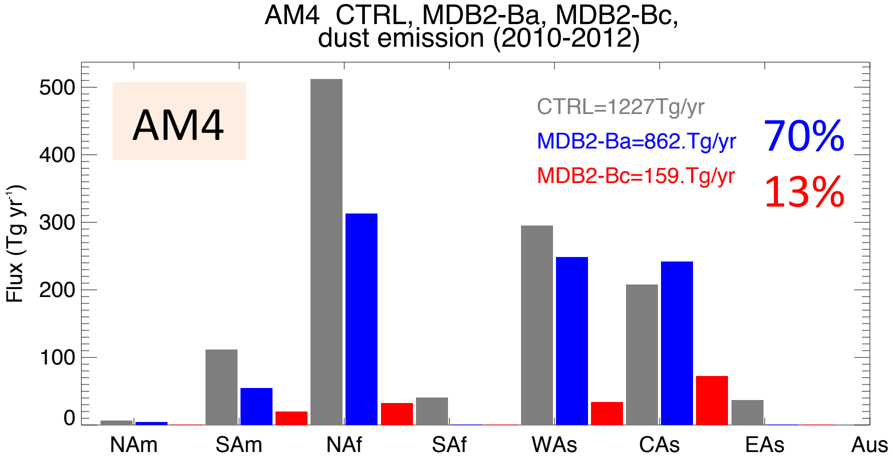
Annual Natural and Anthropogenic Emissions

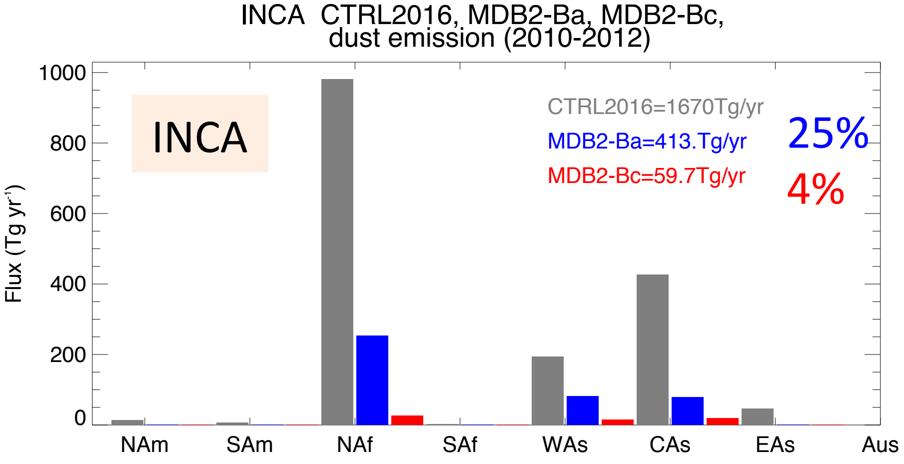
AM4 CTRL+ANT1

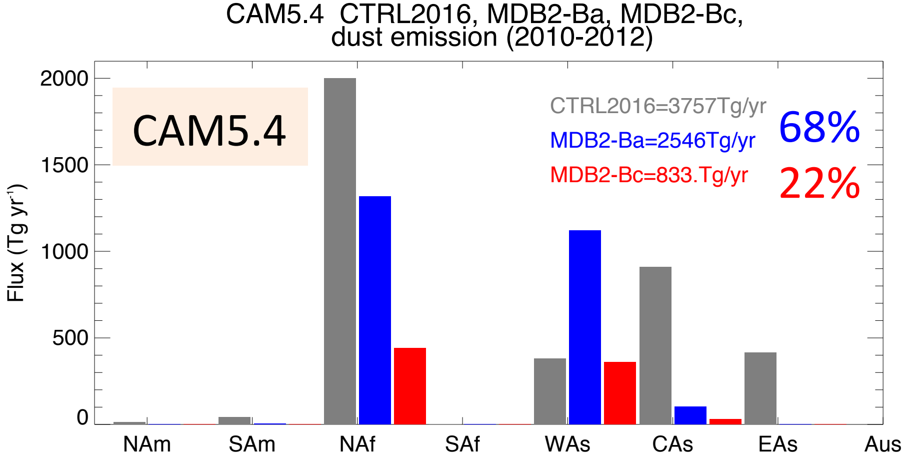
Annual dust emission ($g/m^2/yr$)

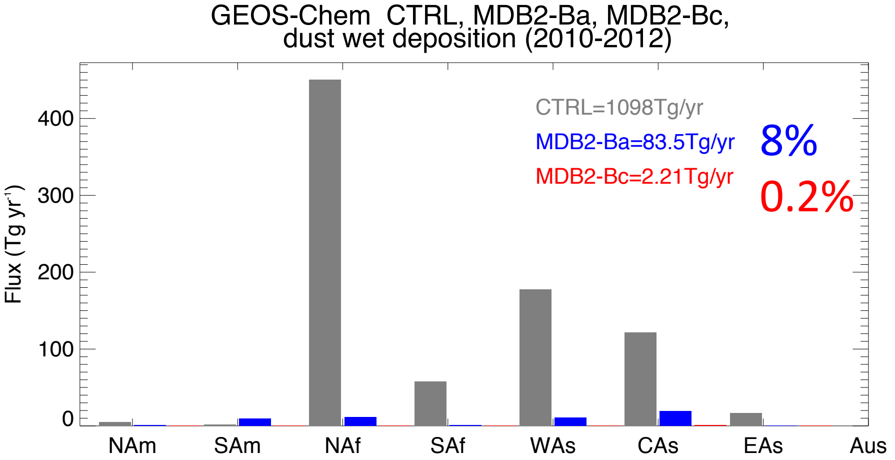


Global and regional annual emissions





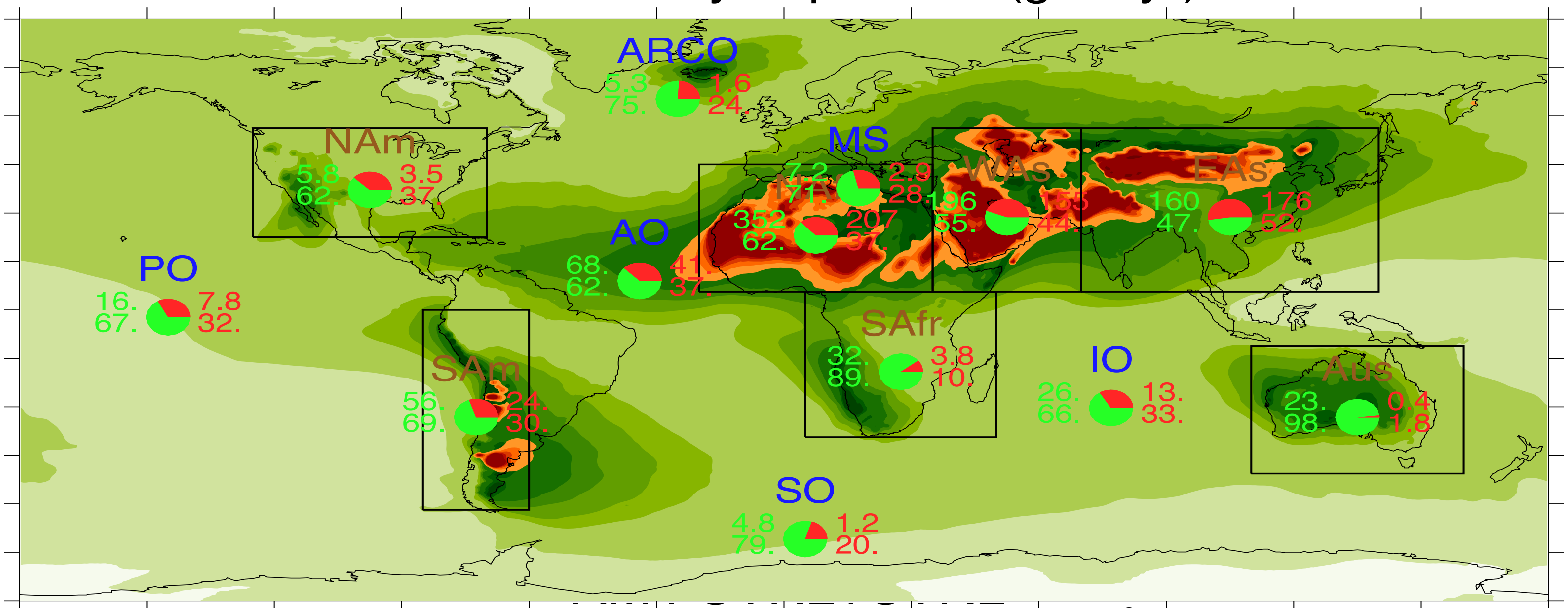




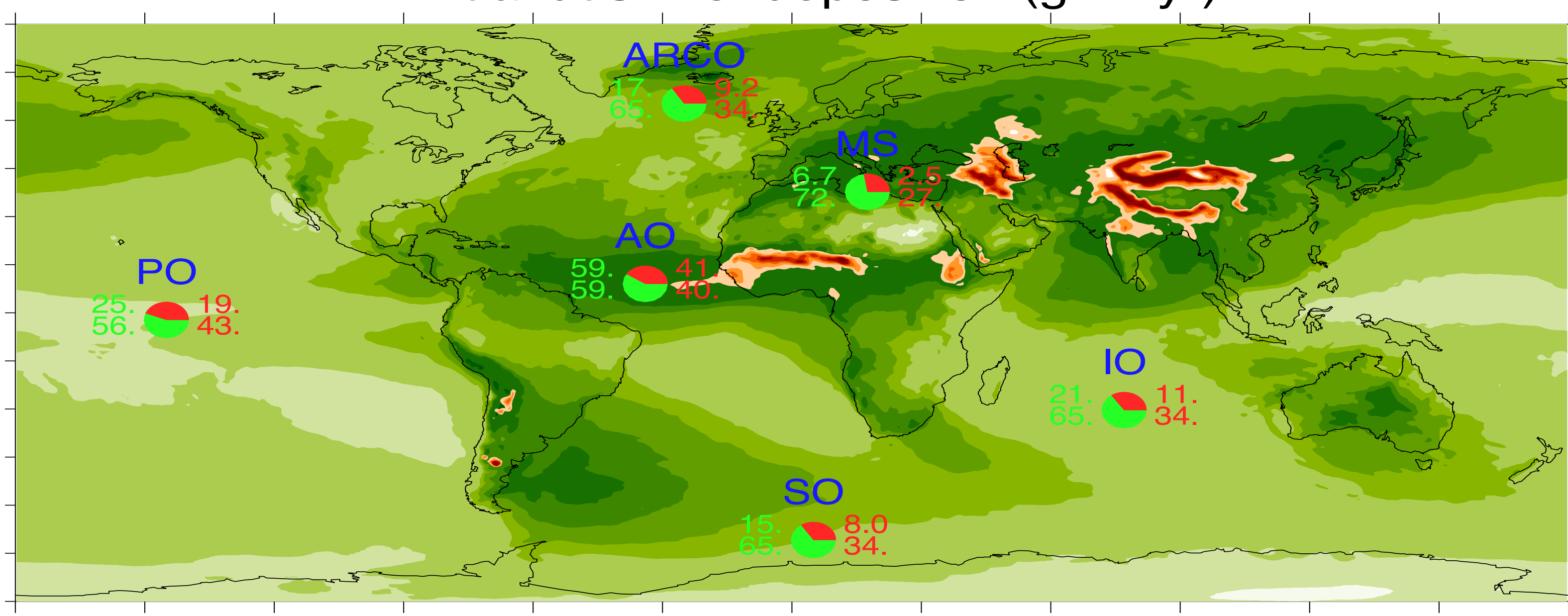
Model Variability: 1100 < NAT < 3800 Tg/yr
413 < ANT1 < 2546 Tg/yr
60 < ANT1.5 < 833 Tg/yr

Annual Natural and Anthropogenic Depositions

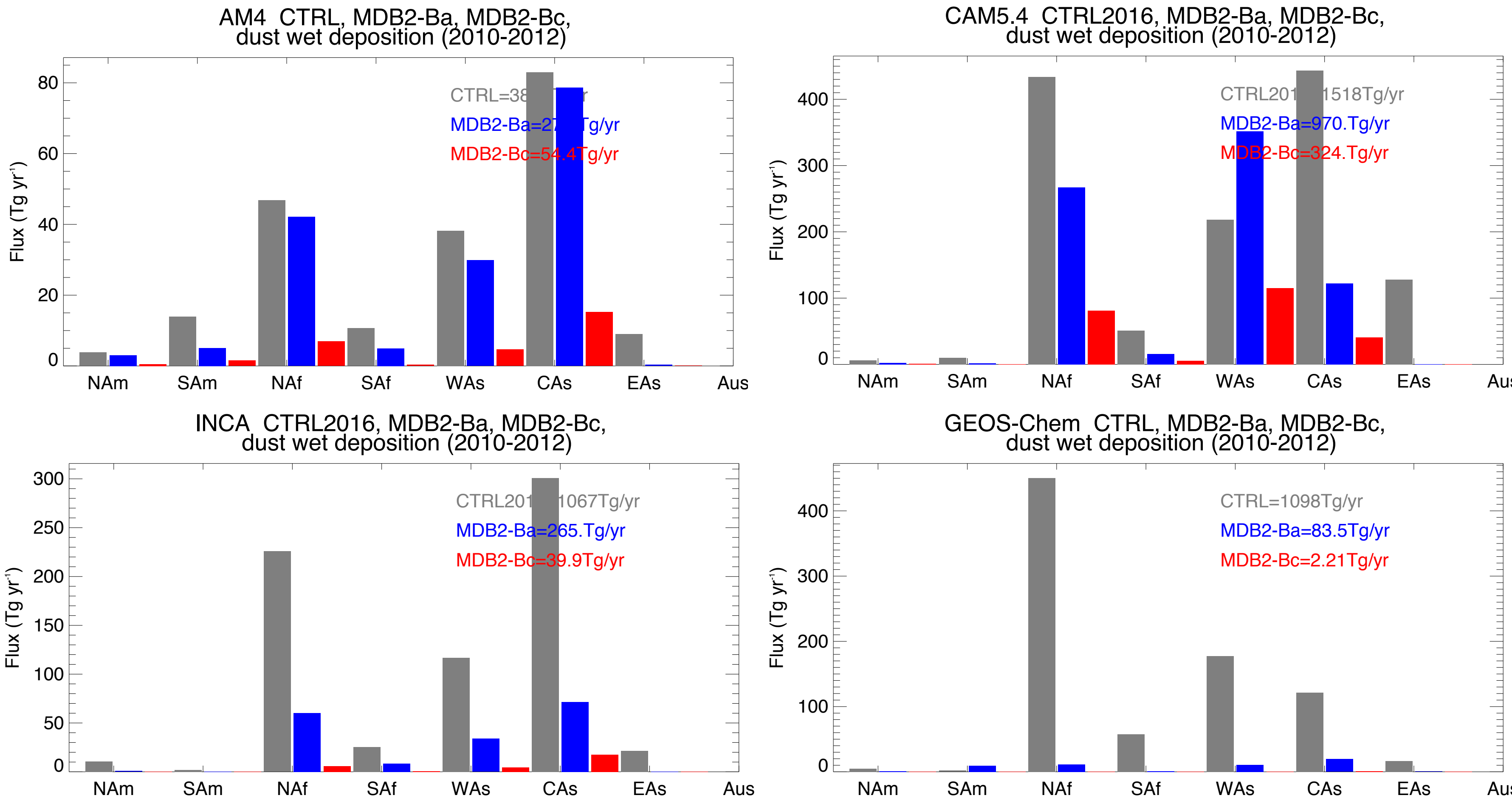
Annual dust dry deposition ($g/m^2/yr$)



Annual dust wet deposition ($g/m^2/yr$)



Global and regional annual depositions

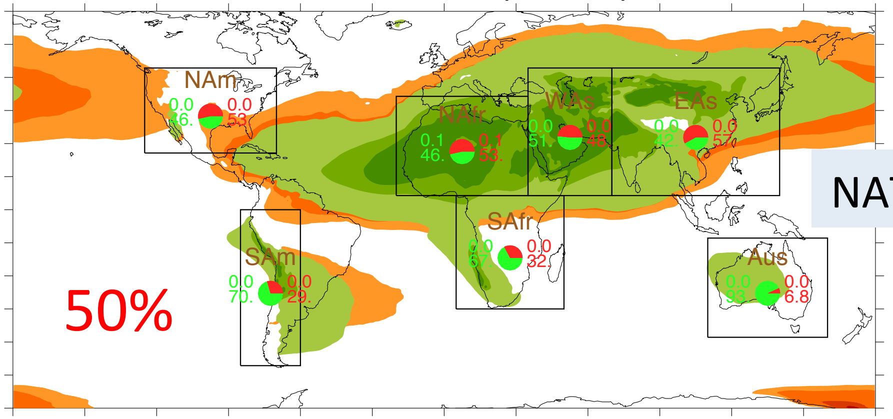


Model Variability: 1100 < NAT < 1520 Tg/yr
265 < ANT1 < 970 Tg/yr
40 < ANT1.5 < 324 Tg/yr

Natural and Anthropogenic Optical Depth

AM4 | CAM5.4

Annual Mean Dust Optical Depth



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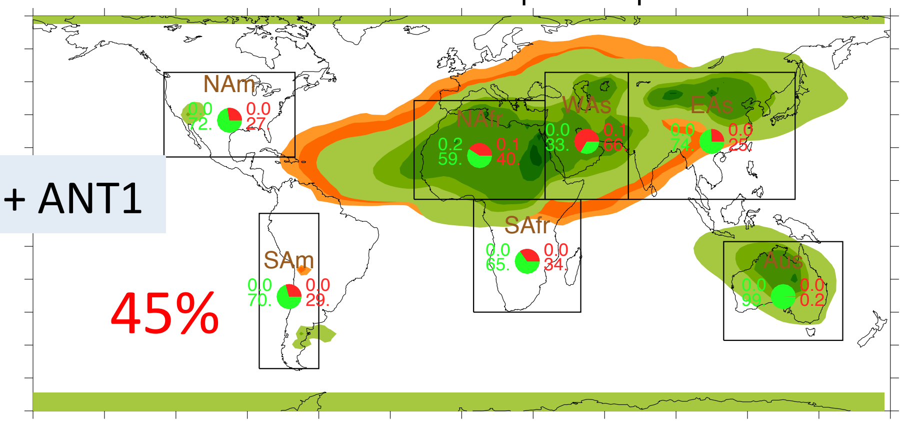
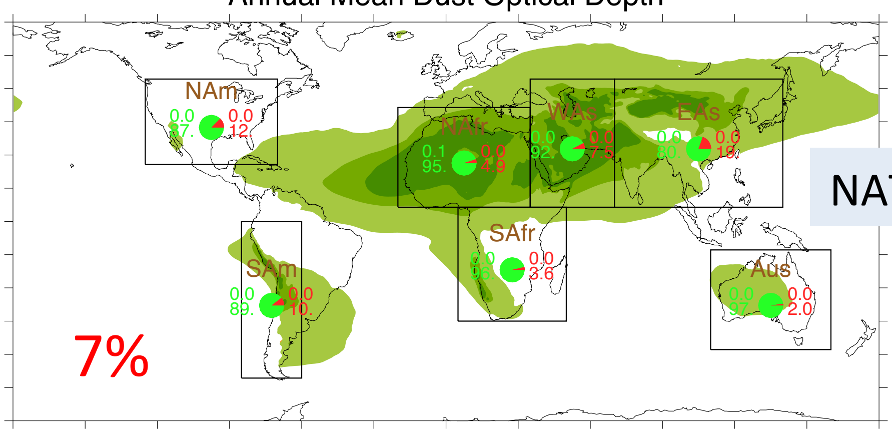


NAT + ANT1

Annual Mean Dust Optical Depth



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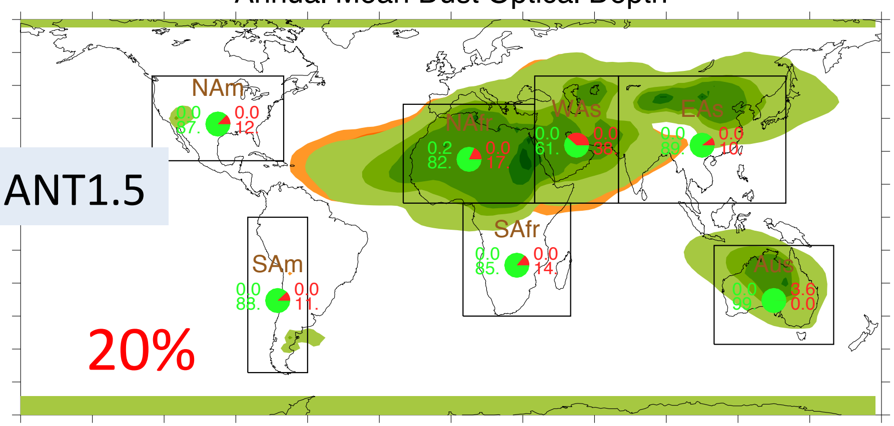

NAT + ANT1.5

Model Variability: 22 (INCA) < ANT1 < 50 (AM4, CAM5.4) %

2 (INCA) < ANT1.5 < 20 (CAM5.4)%

Summary

- Anthropogenic dust emission from agriculture based on MODIS Deep Blue aerosol products was estimated to be around 20% (Ginoux et al., 2012).
- Anthropogenic Dust Experiment was proposed to AeroCom modelers to assess the variability between models.
- 4 models have participated.
- Uncertainty associated with U_t was supposed to be main uncertainty.
  - $U_t^a < U_t^n$: unrealistic results
  - $U_t^n < U_t^a < 1.5\ U_t^n$: lower bias and error
- Variability between models >> variability associated with Ut
- The second uncertainty is related to model treatment of dust transport and removal (objective of this experiment):
  - Anthropogenic contribution of dust emission (+/-similar for DOD):
  - $U_t^a < U_t^n$: 25 to 70%
  - **$U_t^a < 1.5\ U_t^n$: 4 to 22%**
- Contribution may be reduced depending on landuse datasets (cf. Martina Klose's poster)