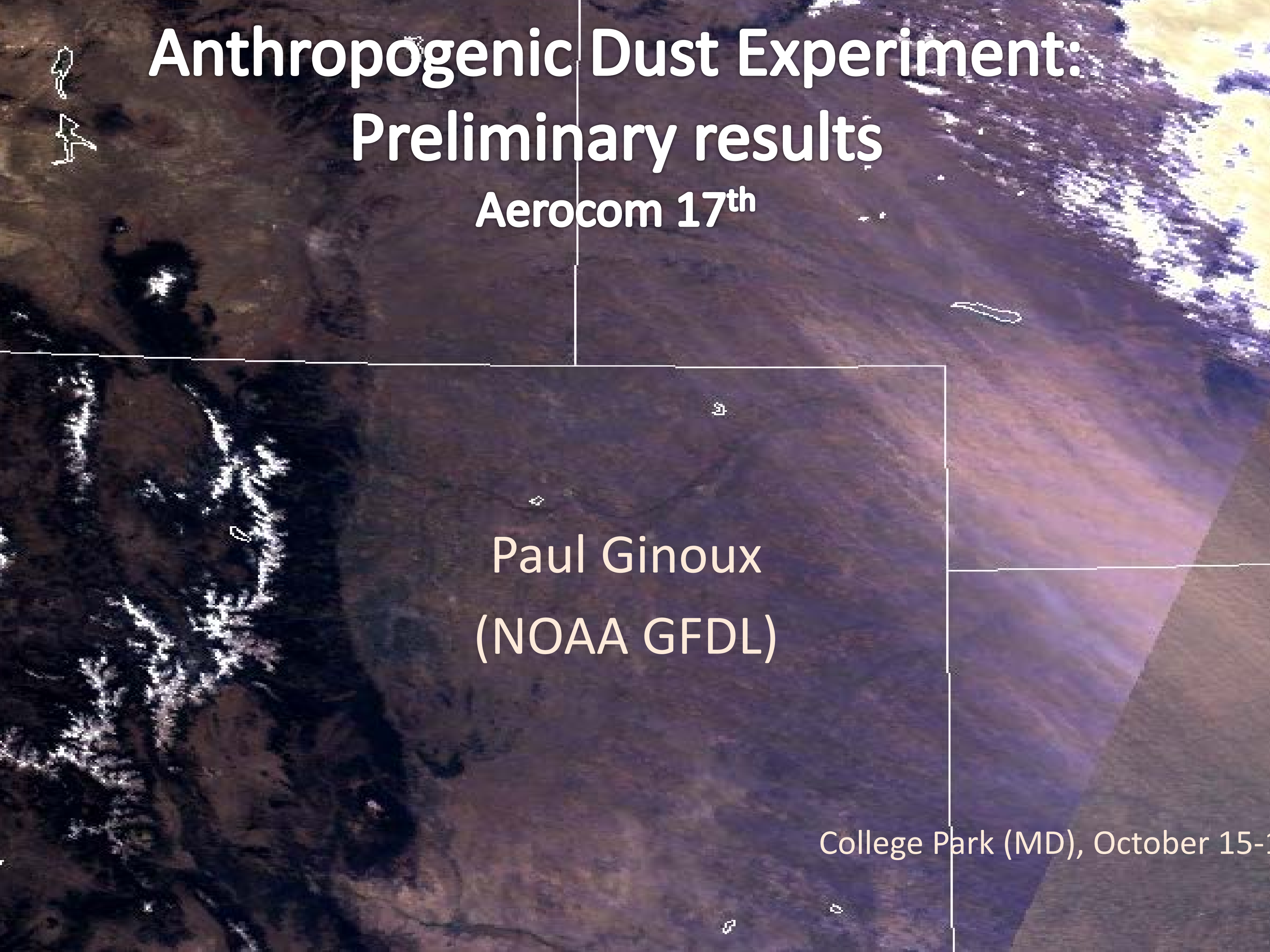
Anthropogenic Dust Experiment: Preliminary results

Aerocom 17th



Paul Ginoux
(NOAA GFDL)

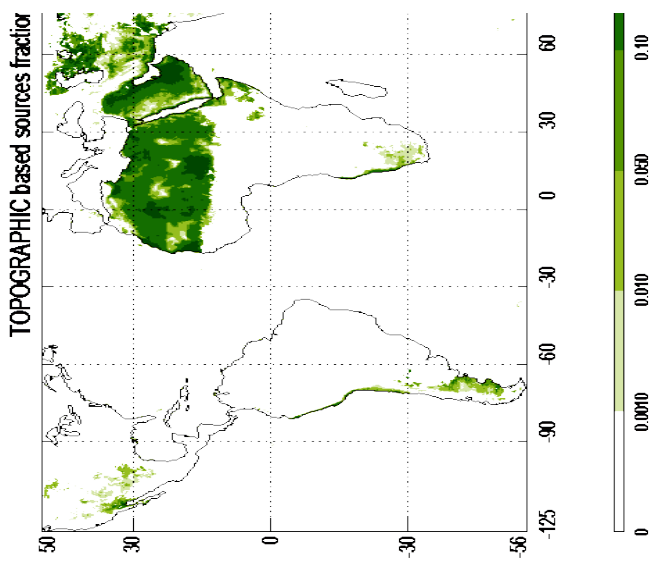
College Park (MD), October 15-

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)

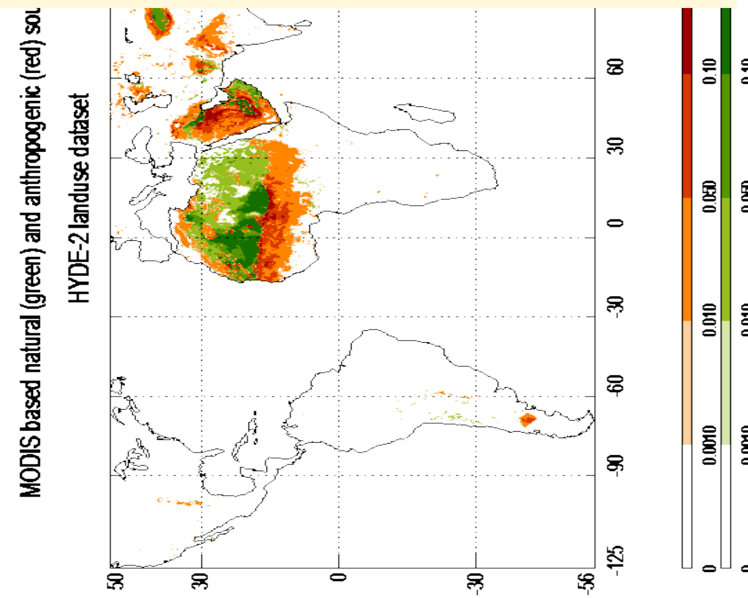
TOMS based dust sources

- Frequency of Occurrence (FoO) of TOMS AI > 0.7 indicates dust sources preferentially located in topographic depressions (Prospero et al., Rev. Geophys., 2012)
- Natural sources = function of topography over bare soils (Ginoux et al., 2001)



MODIS based dust sources

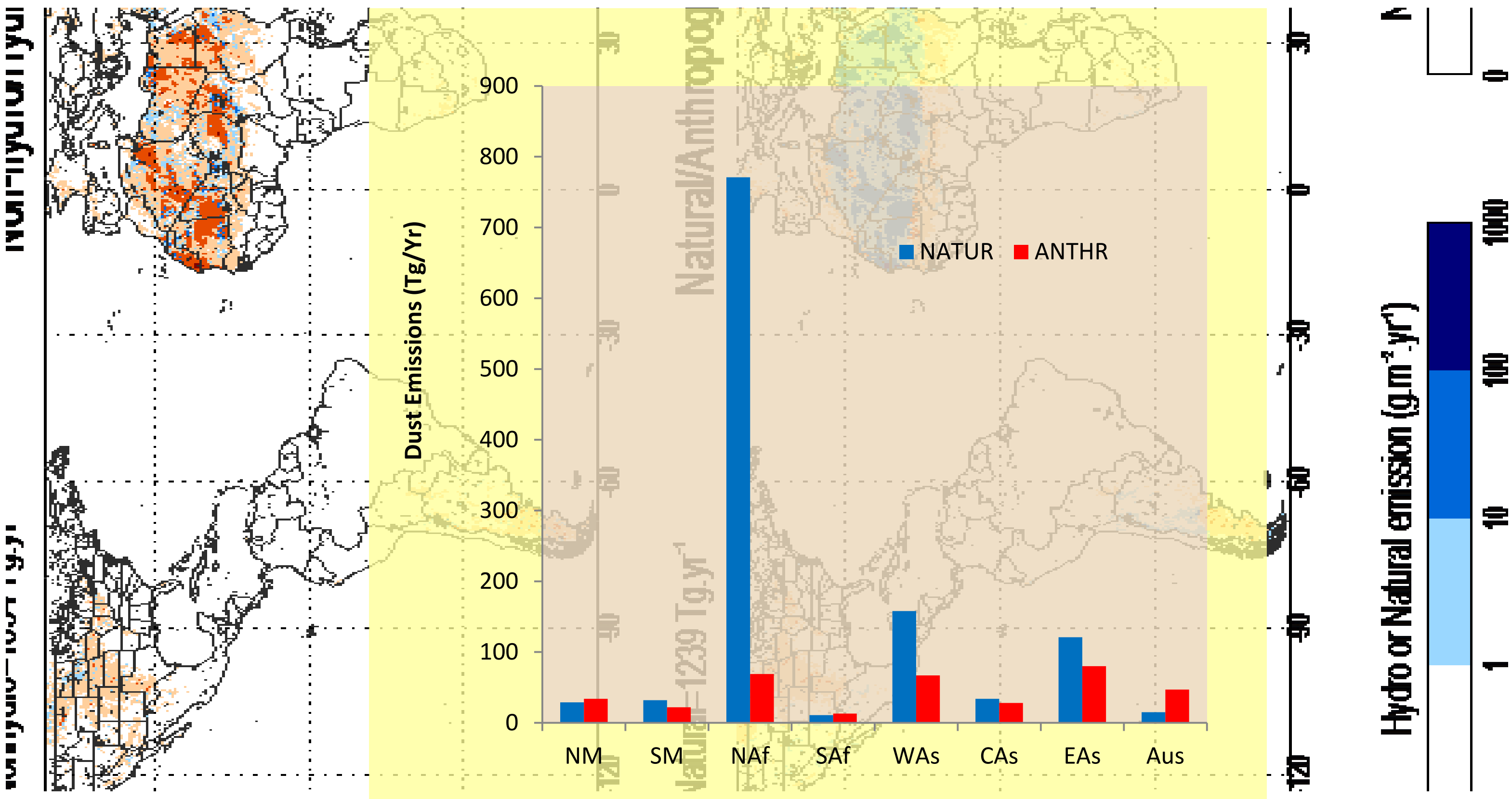
- Dust Optical Depth (DOD) derived fom daily MODIS-DB level-2 C6 (Hsu et al., J. Geophys. Res., 2013) aerosol products (AOD(λ), QA, and SSA) from 2003-2014,
- Frequency of Occurrence (FoO) of DOD>0.2 per year over 12 years = dust sources (Ginoux et al., Rev. Geophys., 2012)
- Anthropogenic sources = FoO>0 and landuse>30% (landuse dataset for 2005 from *Klein Goldwijk, Global Biogeochem. Cycles, 2001*)



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

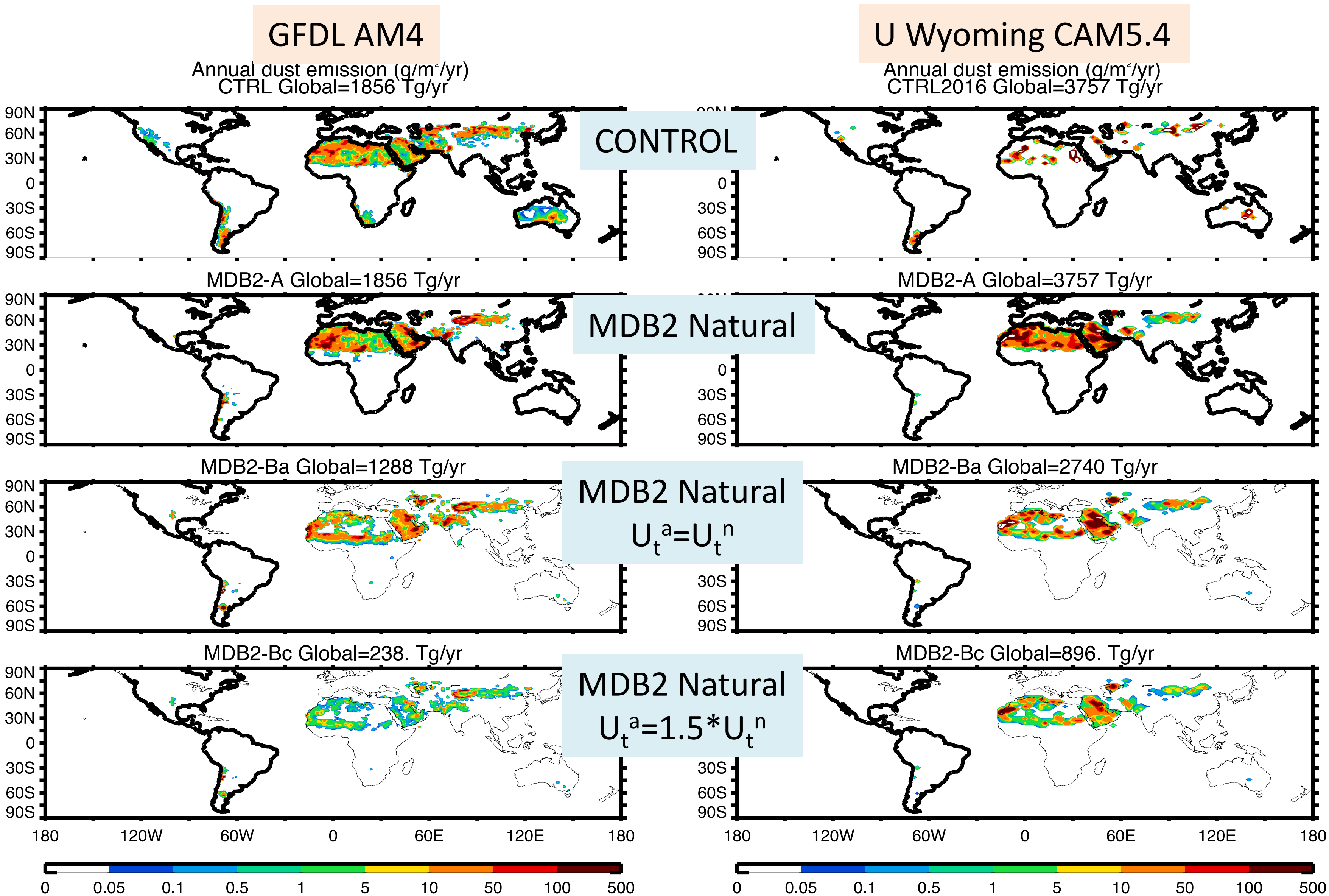
Experiments

- **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

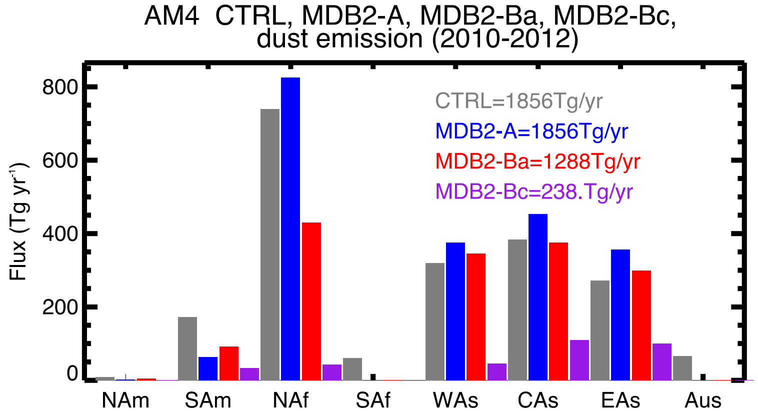
Participating Models

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

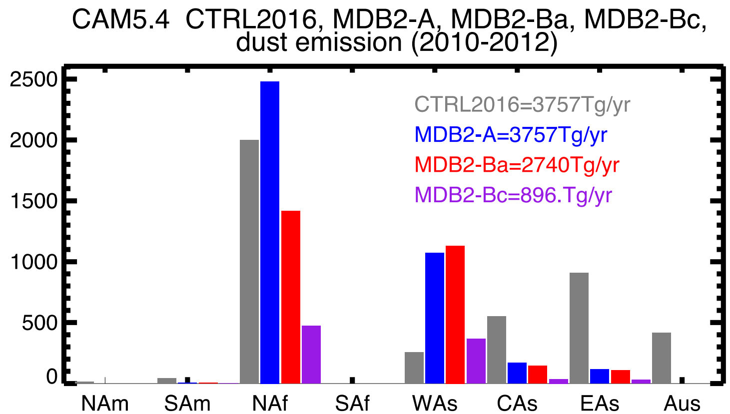


High sensitivity to Ut: Dust emission decrease by a factor 3 when the threshold of wind erosion over agricultural sources is 1.5 higher than for natural sources.

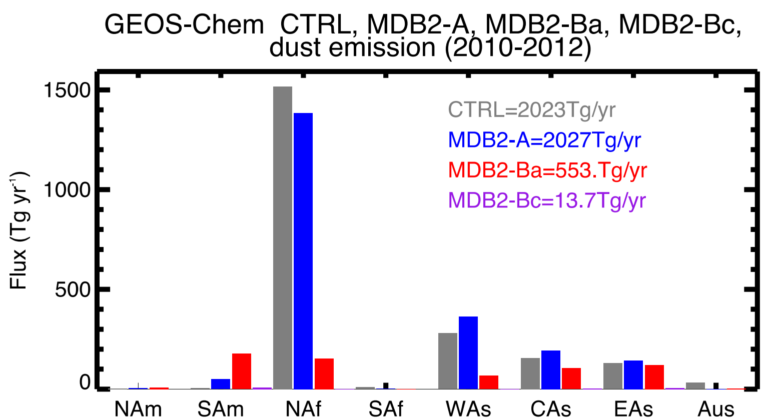
GFDL AM4



U Wyoming CAM5.4



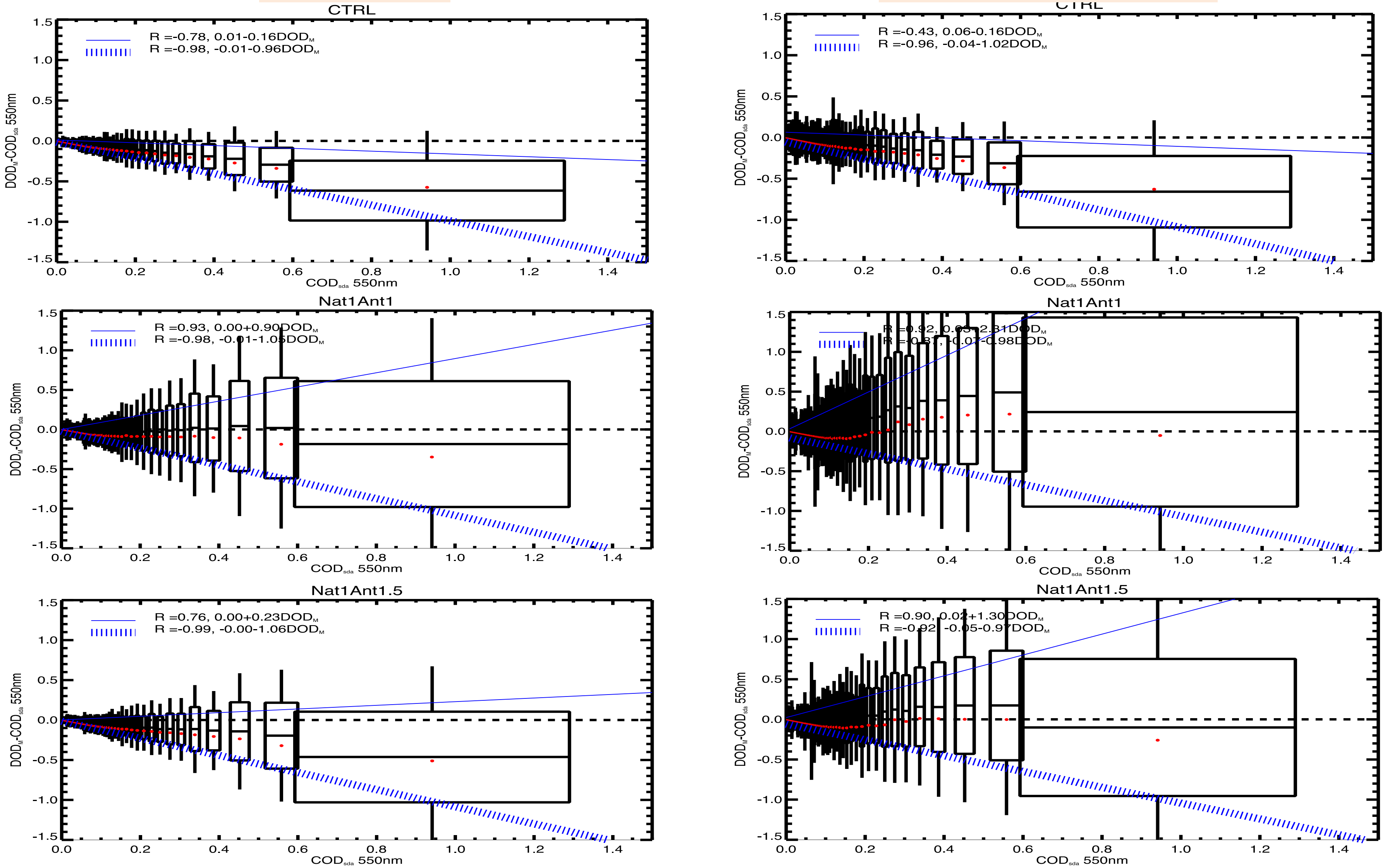
U l'Aquila
GEOS-Chem



Model Variability:
Global Emission varies by a factor 2 between models (cf. Huneeus et al., Atm. Chem. Phys., 2013)

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 $U_t^a = 1.5 * U_t^n$

GFDL AM4 | U Wyoming CAM5.4

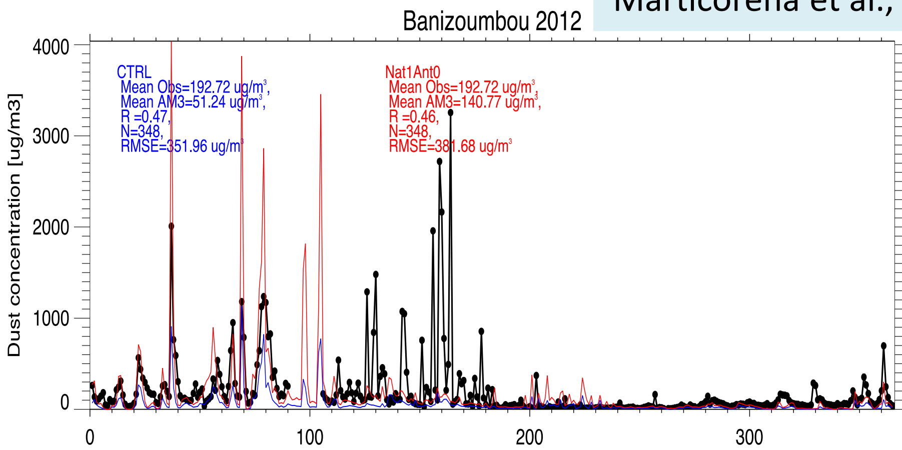


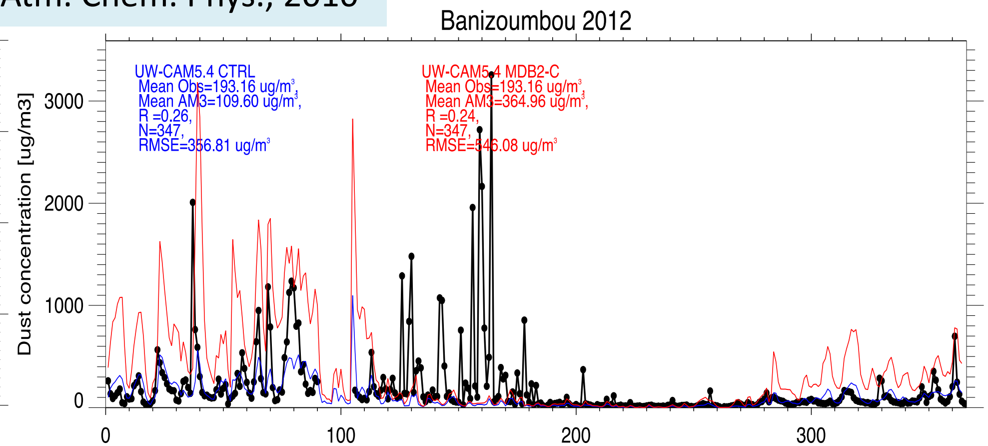
Mean bias decreases from CTRL to MDB2 $U_t^a = U_t^n$ to MDB2 $U_t^a = 1.5* U_t^n$ but error increase specially for CAM5.4

GFDL AM4

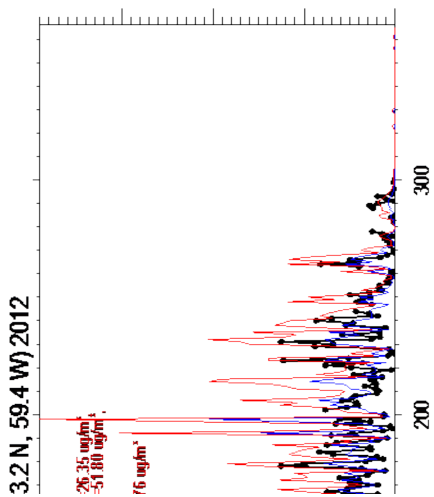
U Wyoming CAM5.4

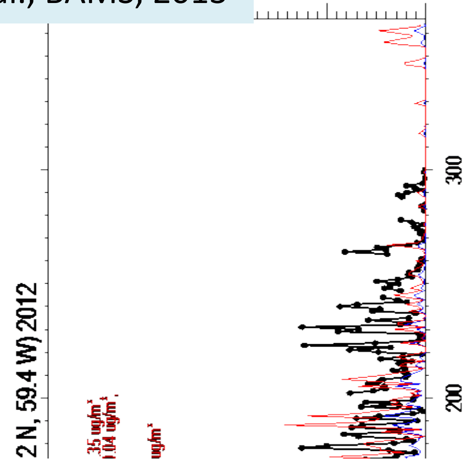
Marticorena et al., Atm. Chem. Phys., 2010





Prospero et al., BAMS, 2013

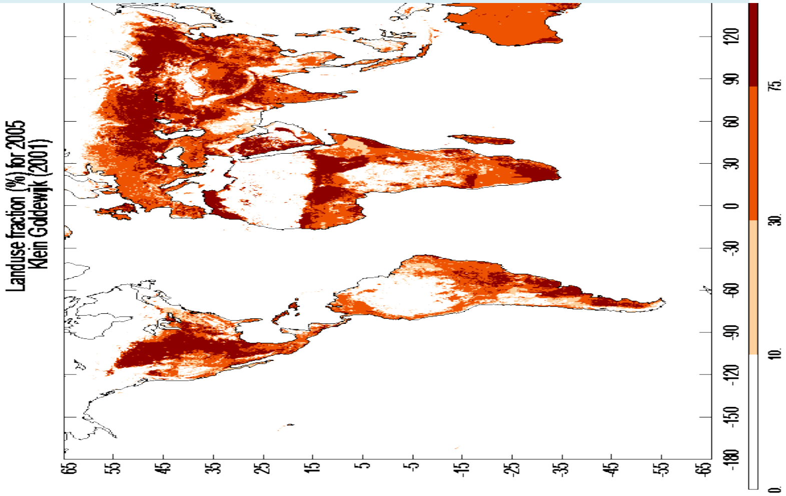




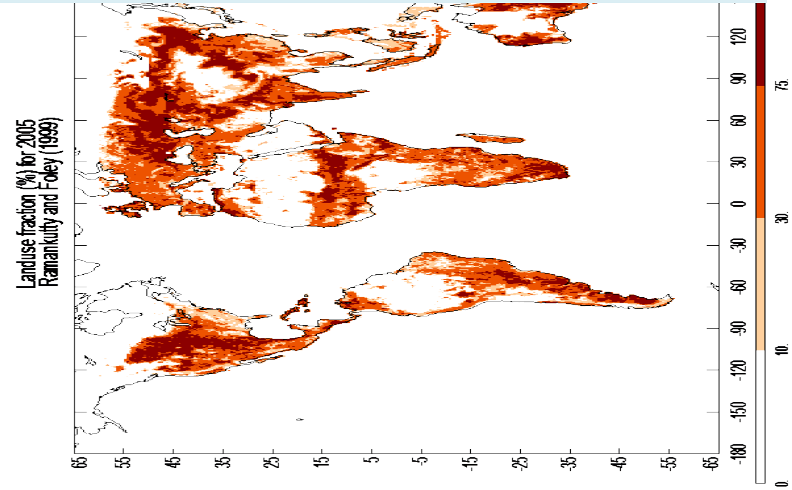
Using comparison of dust concentration with observations far away from sources is not useful as models treat transport and removal very differently (cf. Huneeus et al., Atm. Chem. Phys., 2011).

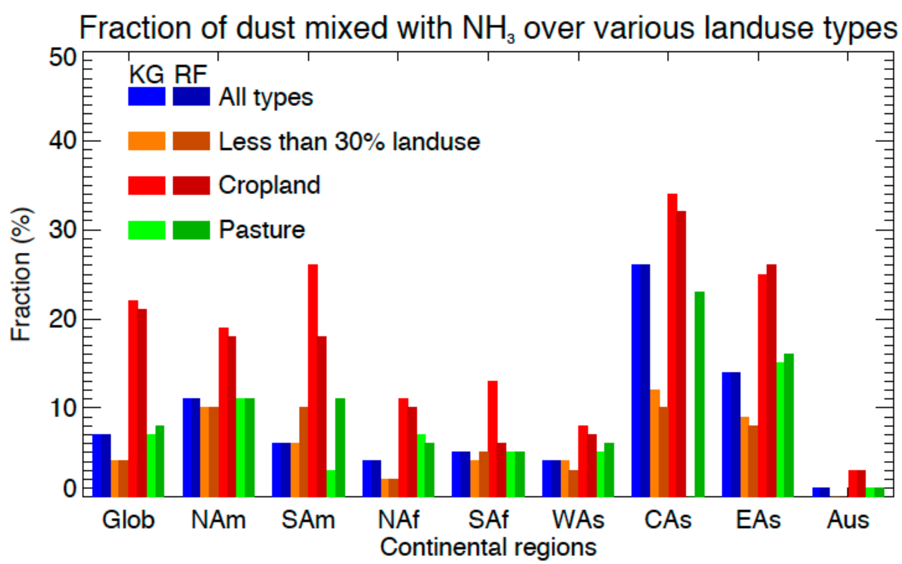
Uncertainties associated with landuse dataset

Klein Goldwijck, Global Bio. Cycles, 2001

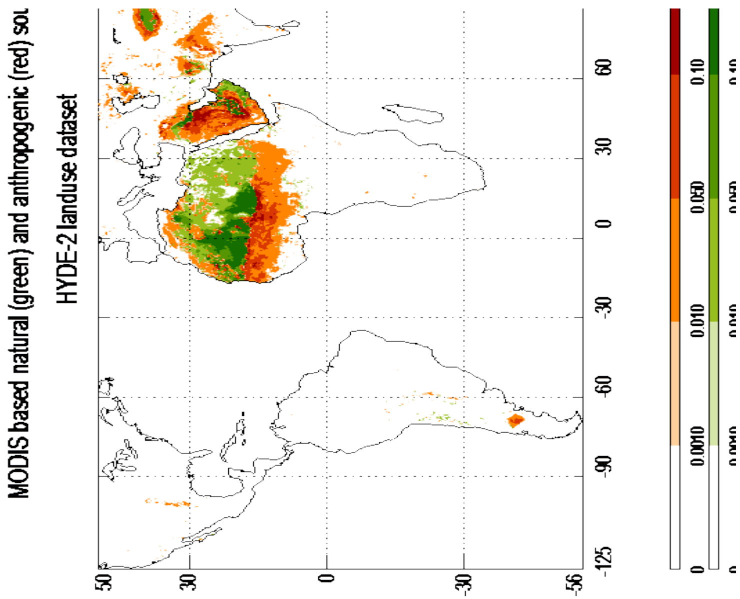


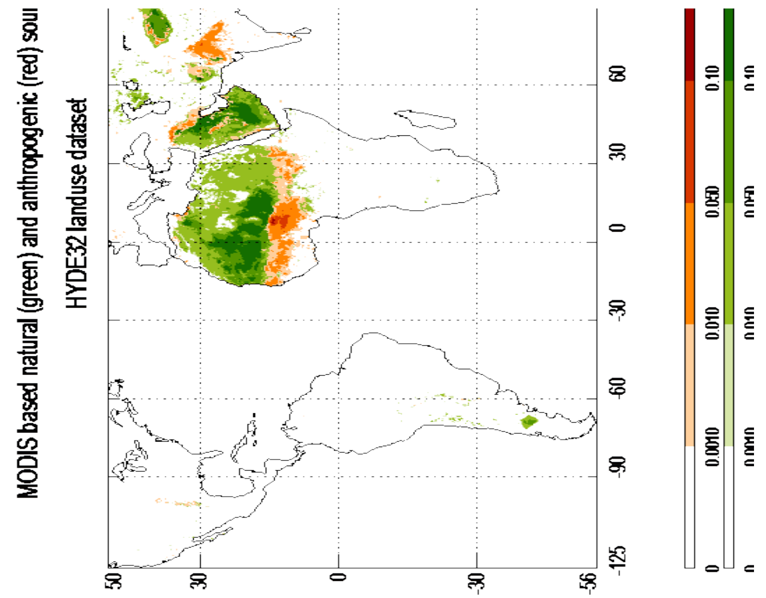
Ramankutty and Foley, Global Bio. Cycles,1998





Uncertainties associated with version of landuse dataset





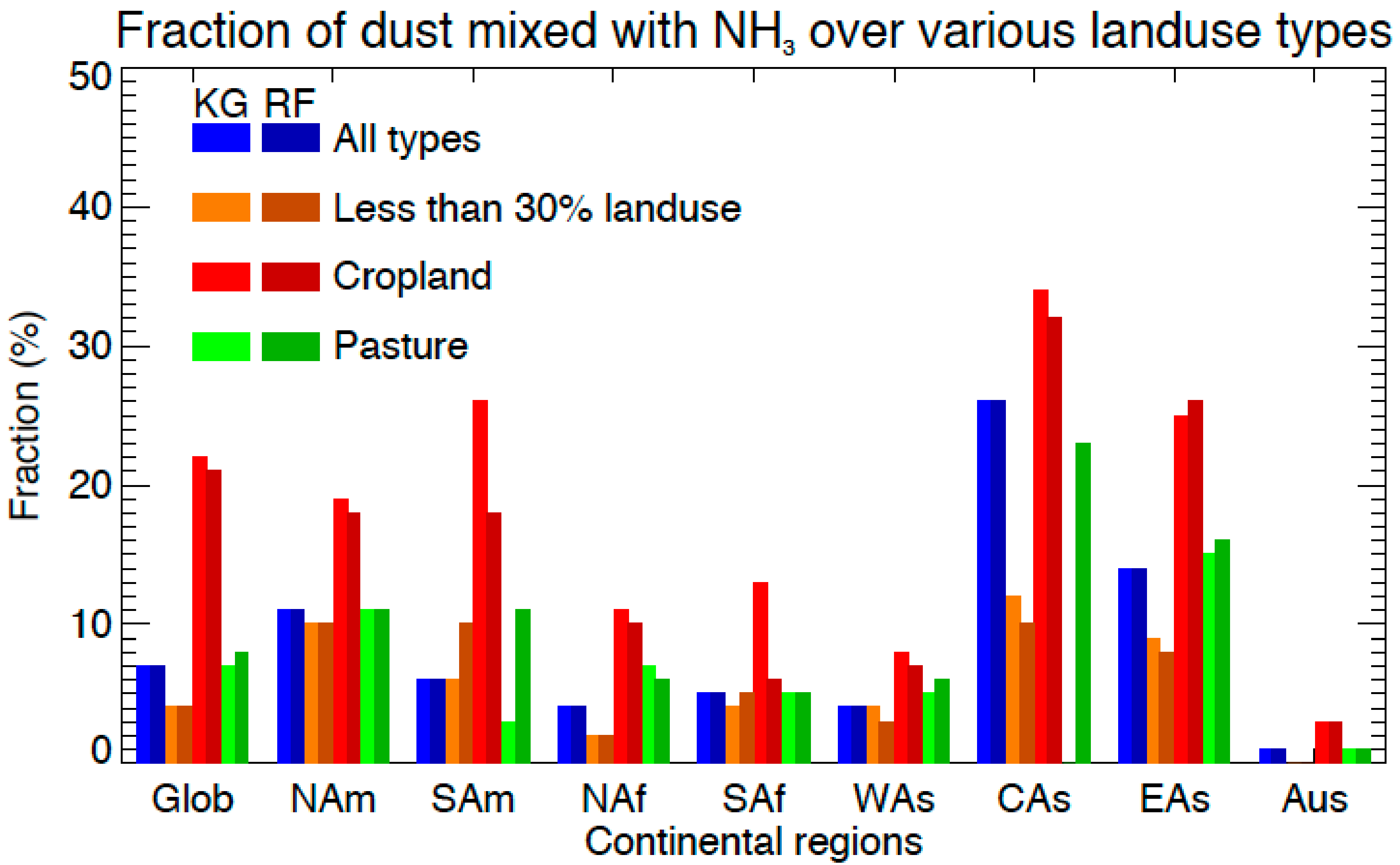
Klein Goldwijck, Global Bio. Cycles, 2001

Klein Goldwijck et al., Earth Sys. Sci. Data, 2017

Natural= 1144 Tg/yr (80%)
Anthro = 273 Tg/yr (20%)

Natural= 1373Tg/yr (92%)
Anthro = 113 Tg/yr (8%)

Summary



Fraction of dust mixed with NH3 over various landuse types
KG RF
All types
Less than 30% landuse
Cropland
Pasture
Fraction (%)
0
10
20
30
40
50
Glob
NAm
SAm
NAf
SAf
WAs
CAs
EAs
Aus
Continental regions