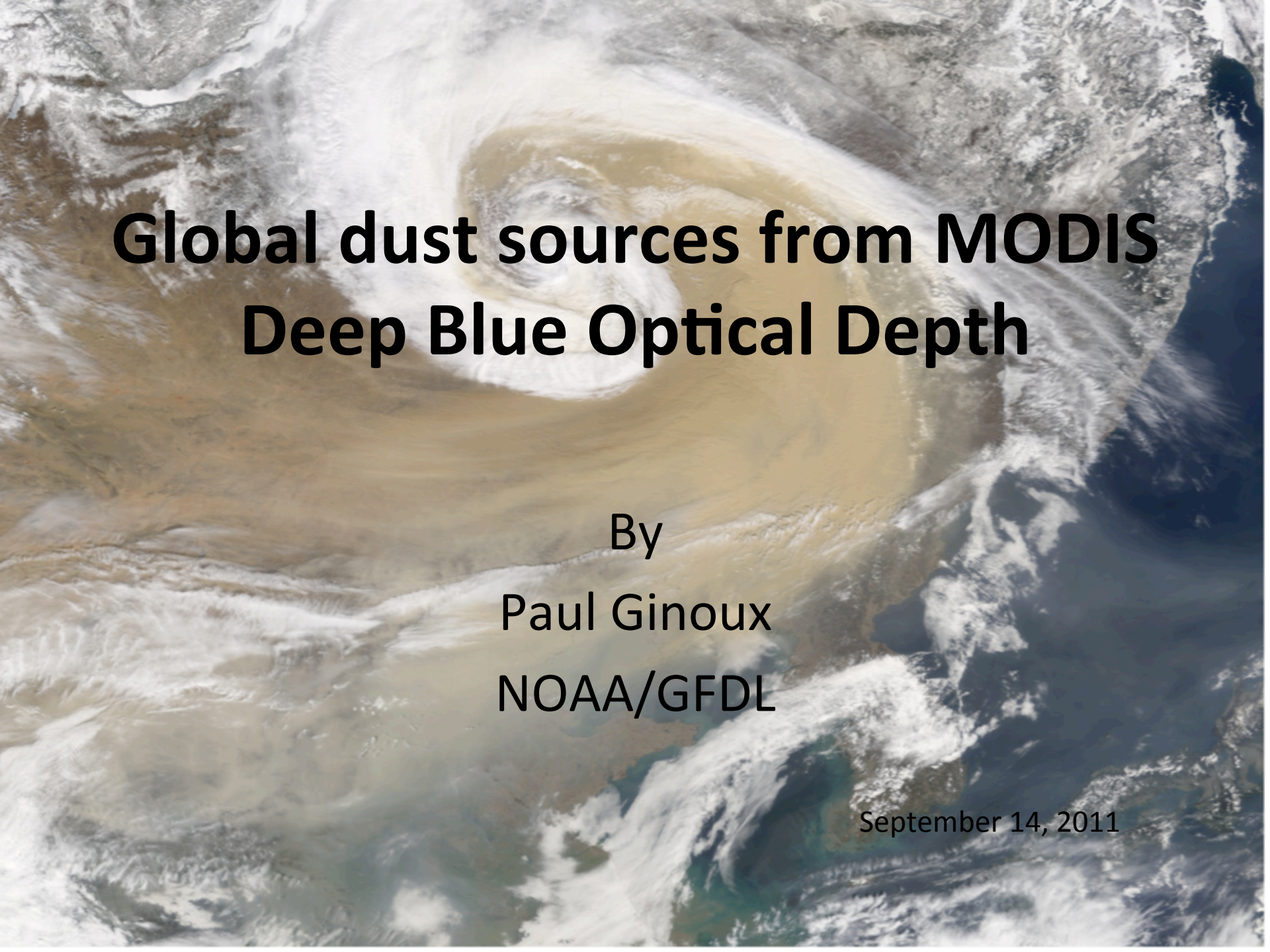


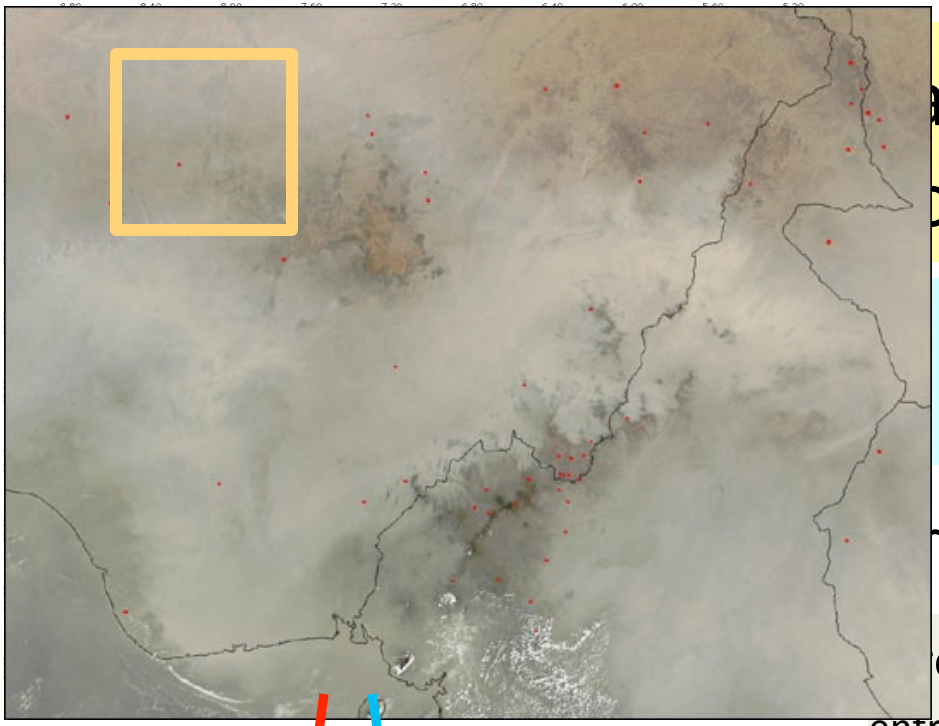
Global dust sources from MODIS Deep Blue Optical Depth

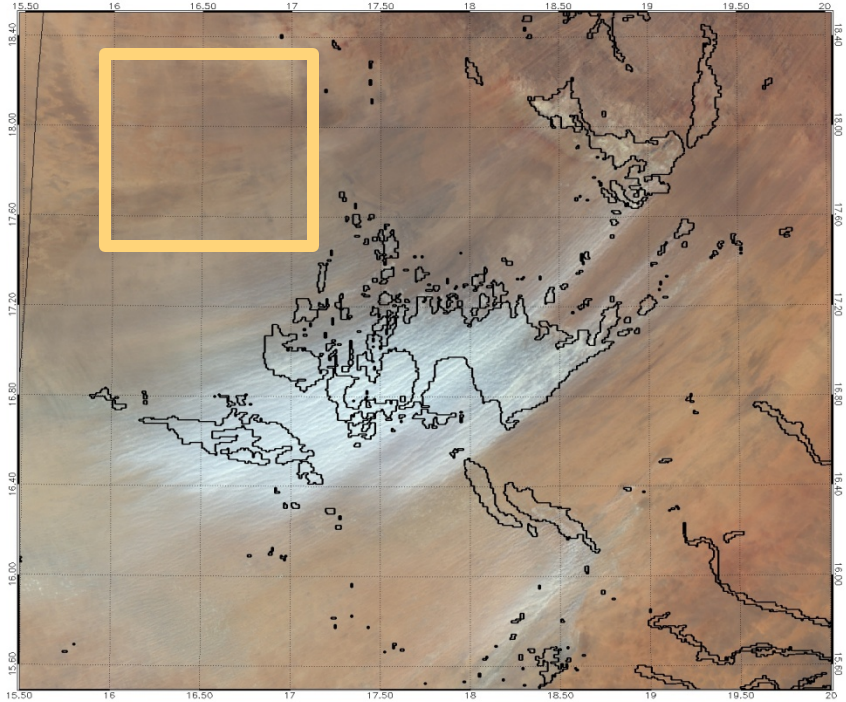
By

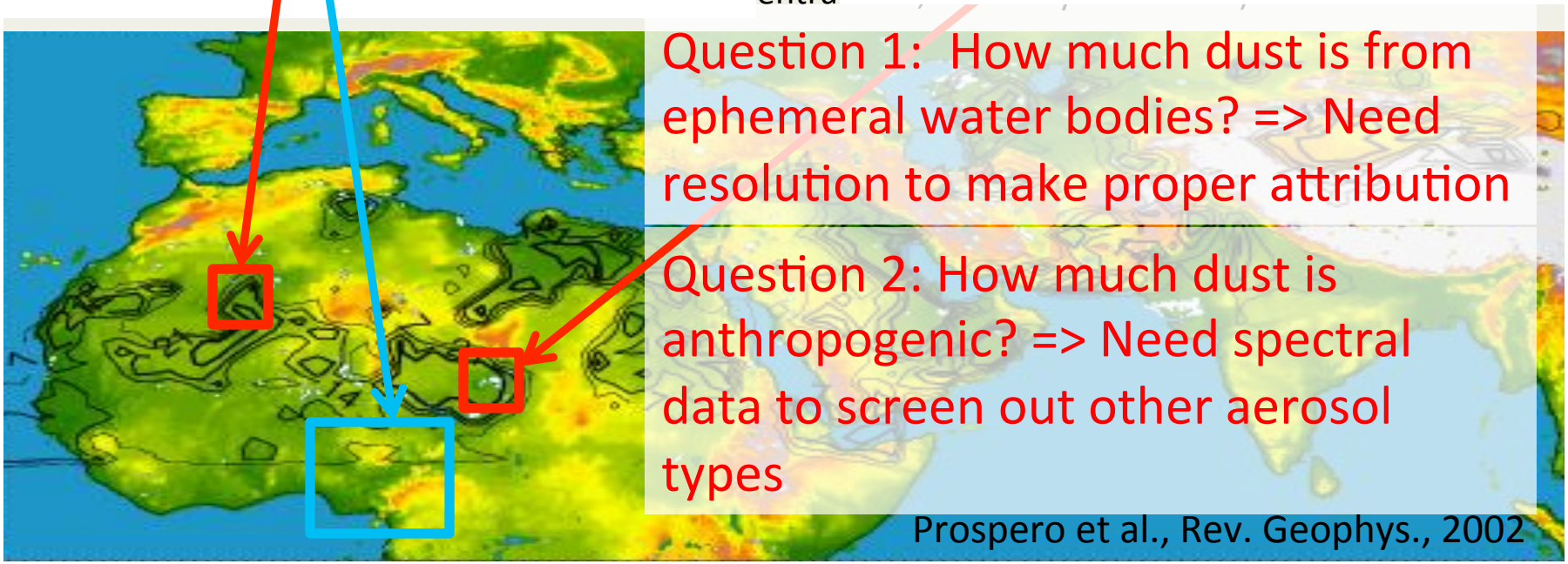
Paul Ginoux

NOAA/GFDL

September 14, 2011







Question 1: How much dust is from ephemeral water bodies? => Need resolution to make proper attribution

Question 2: How much dust is anthropogenic? => Need spectral data to screen out other aerosol types

Prospero et al., Rev. Geophys., 2002

Requirements to detect dust from satellite instruments

Needs:

- High spatial resolution for detection and attribution
- High temporal resolution to capture development of dust events
- Long-term record to create robust statistics
- Spectral variation of optical properties to separate dust from other aerosol types

MODIS Deep Blue (Hsu et al., IEEE, 2004, 2006) aerosol products provide most of these needs:

- Level 2 Resolution: ~10km
- Spectral products: τ, ω at 412, 470, 550 an 670nm
- Daily global data: Aqua (2003-present), Terra (2000-2007)

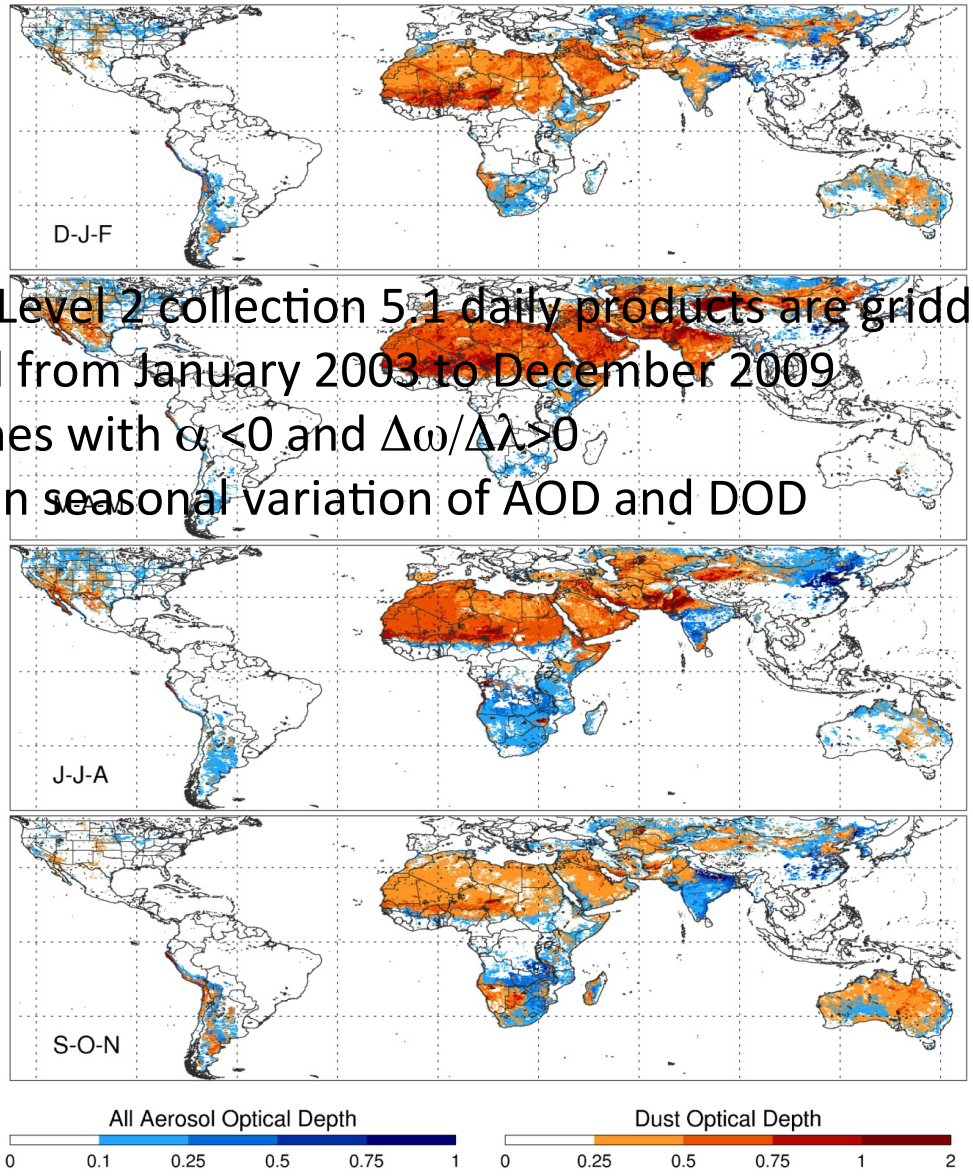
Detection of Dust Sources

- Dust Optical Depth (DOD): 3 criteria used
  - Negative Angstrom exponent
  - Increasing single scattering albedo with wavelength
  - Absorption in the visible
- Frequency of Occurrence (FoO) 2003-2009:
  - DOD>0.2
  - Maxima correspond to sources

MODIS DB C5.1 Dust Optical Depth
Seasonal (2003-2009)

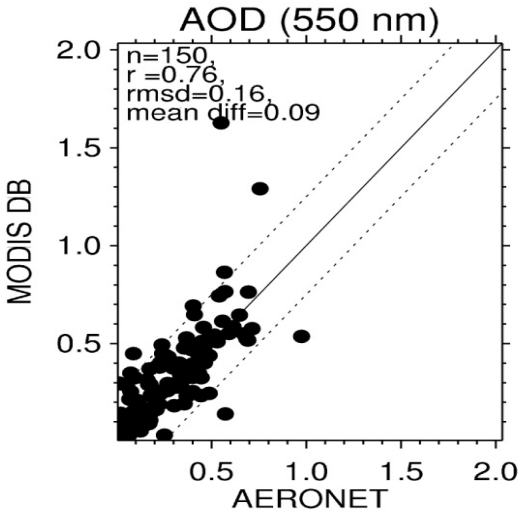
Method:

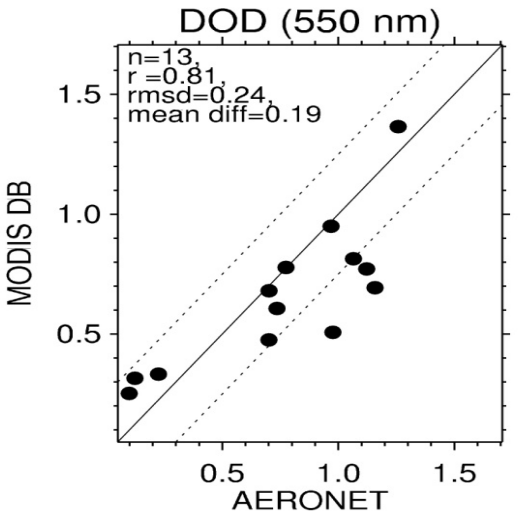
1. MODIS DB Level 2 collection 5.1 daily products are gridded on 0.1x0.1 degree grid from January 2003 to December 2009
2. DOD = scenes with α <0 and $\Delta\omega/\Delta\lambda$>0
3. 7-year mean seasonal variation of AOD and DOD



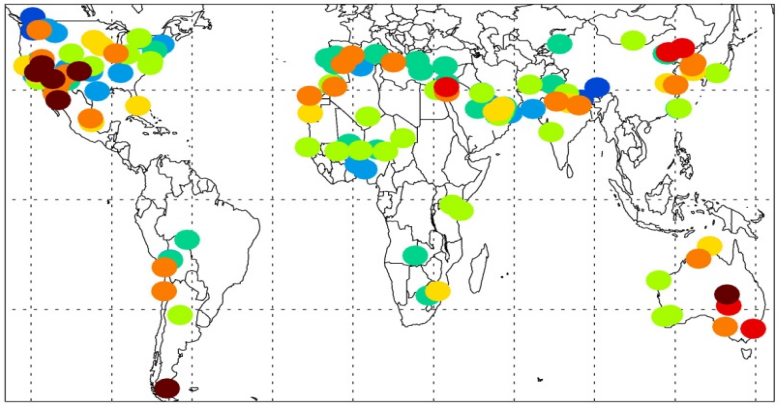
Comparison with AERONET data

Collocated sunphotometers

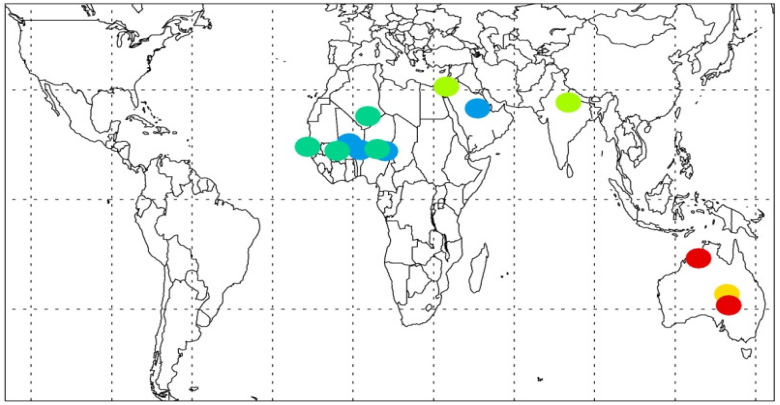


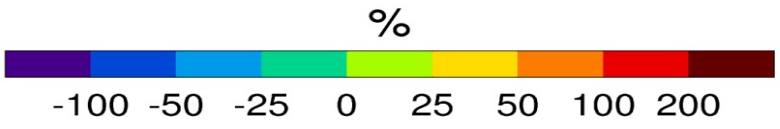


Relative difference(%) of MODIS and AERONET AOD

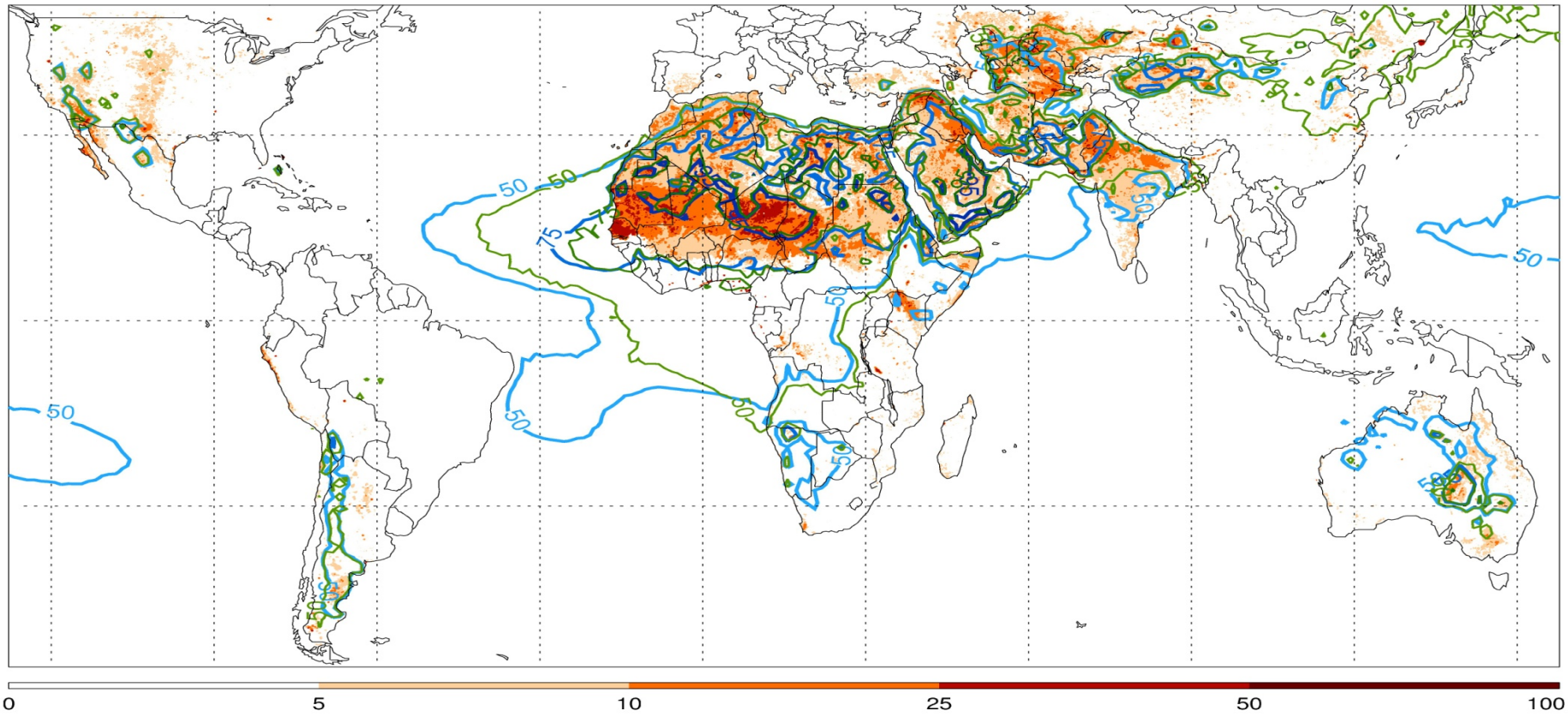


Relative difference(%) of MODIS and AERONET DOD





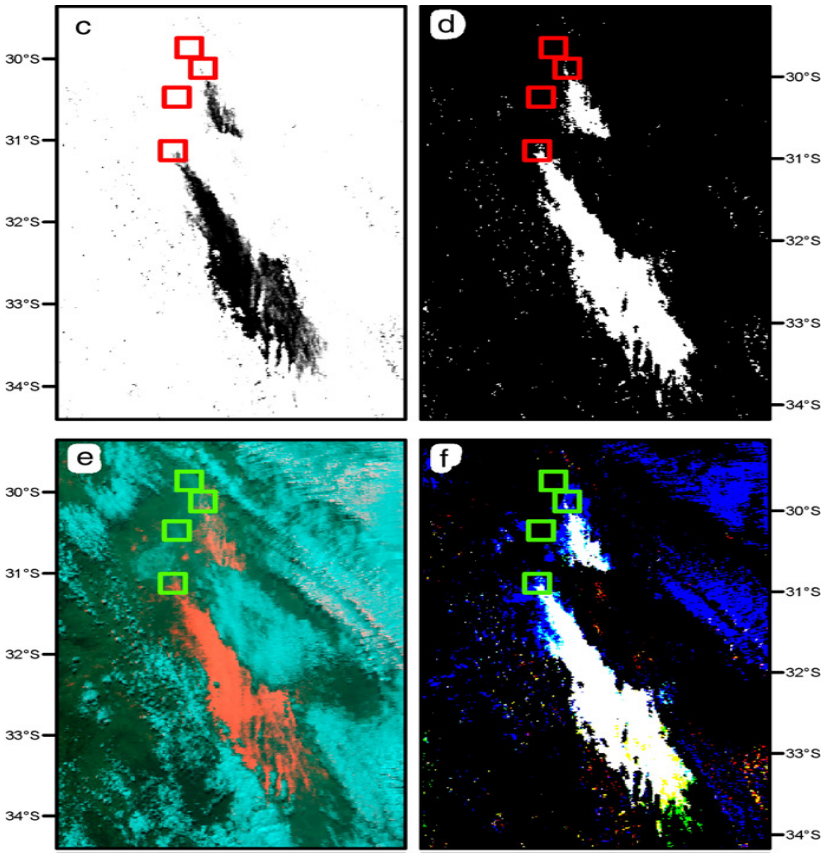
FOO of MODIS DB DOD>0.2, TOMS AI, and OMI AI>0.5



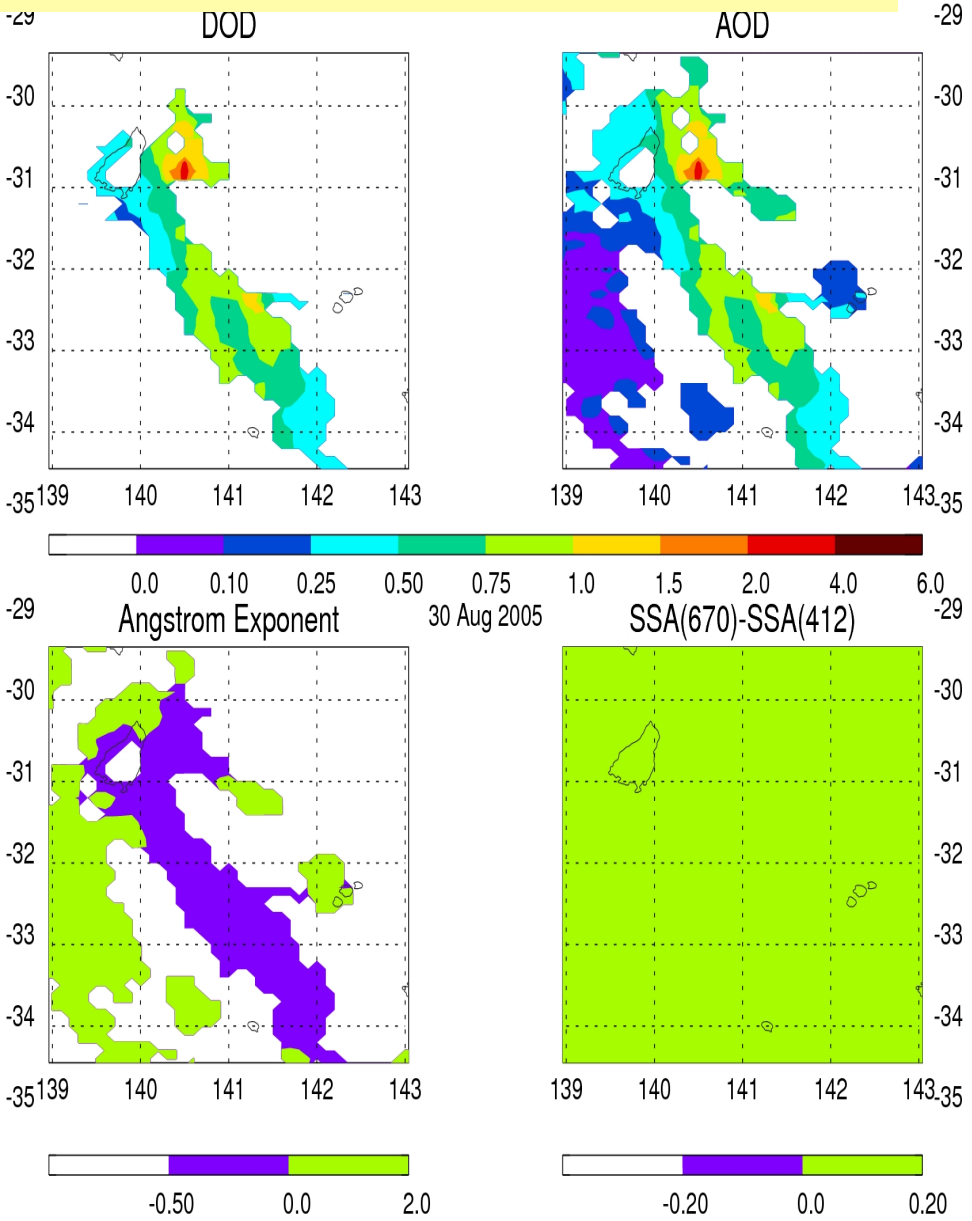
Overlapping of FOO TOMS (Blue) and OMI AI (Green), except East Asia

Overlapping MODIS DB (red shading) and TOMS/OMI AI in most places, except US High Plains, Mediterranean basin, Central Asia, and Australia.

Comparison with other techniques to detect dust sources: 08/30/2005 Lake Eyre (Australia)



Baddock et al., 2009



Attribution of Hydrological and Anthropogenic origins

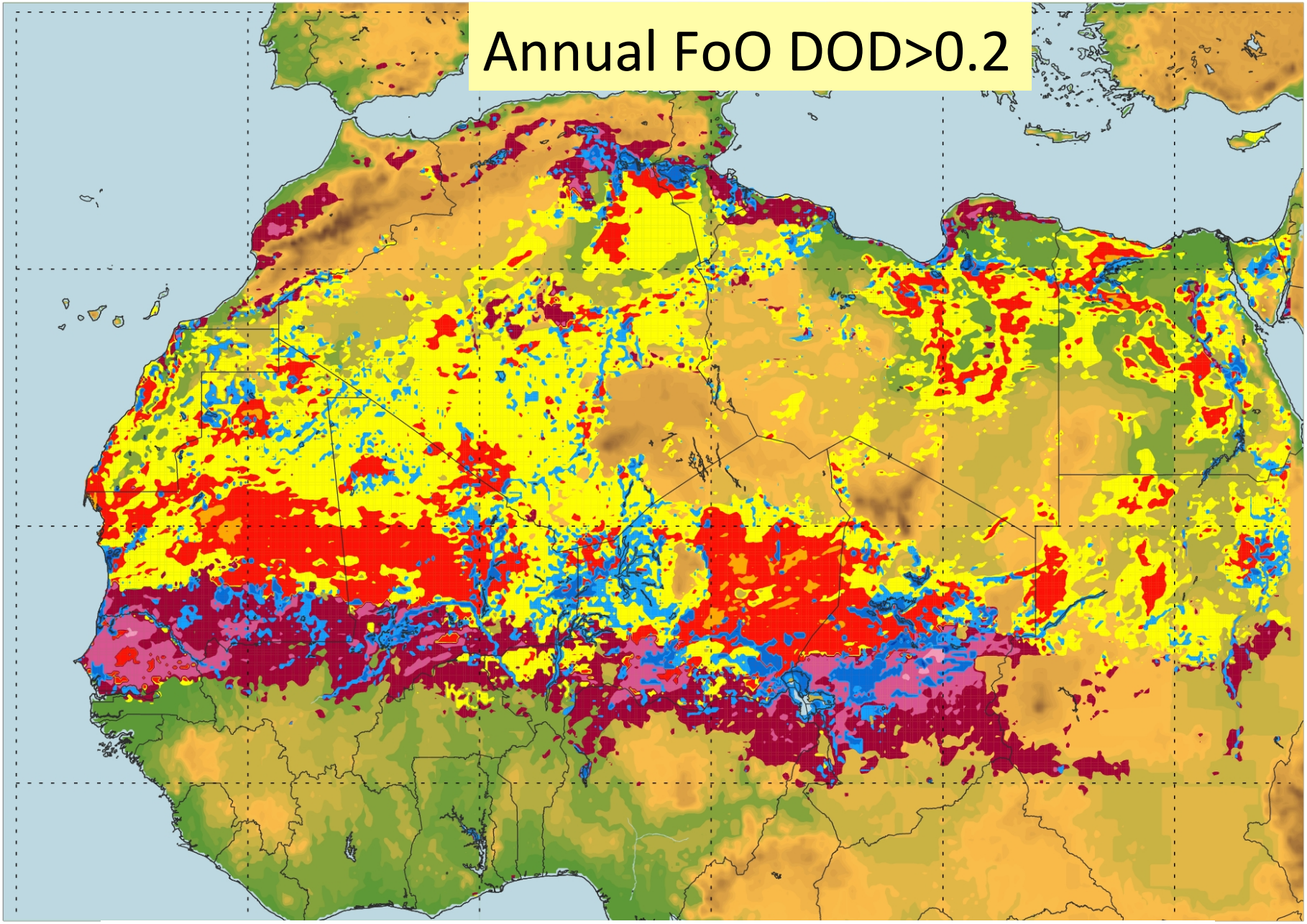
Dust sources identified by frequency of occurrence (FOO) of **DOD > 0.2**

Association of FOO with

1. **hydrographic features**:
   - •ephemeral lakes, rivers, shallow lakes
   - •dataset: 1x1km MODLAND
2. **Land use**:
   - •agriculture +pasture (proxy for anthropogenic activities)
   - •Dataset: 10x10km Klein Goldewijk, GBC, 2001

   Anthropogenic dust if land use > 30%

Annual FoO DOD>0.2

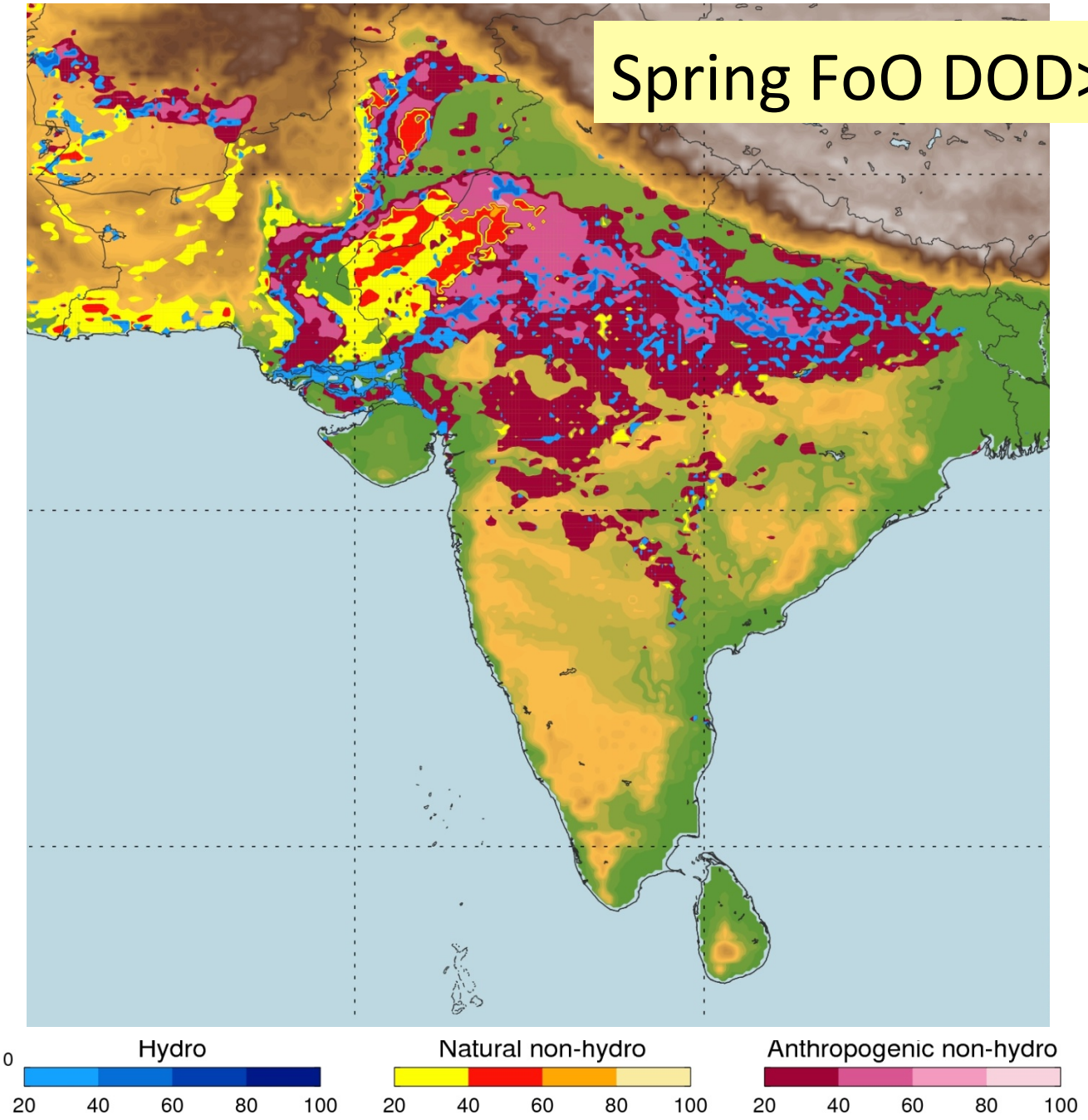


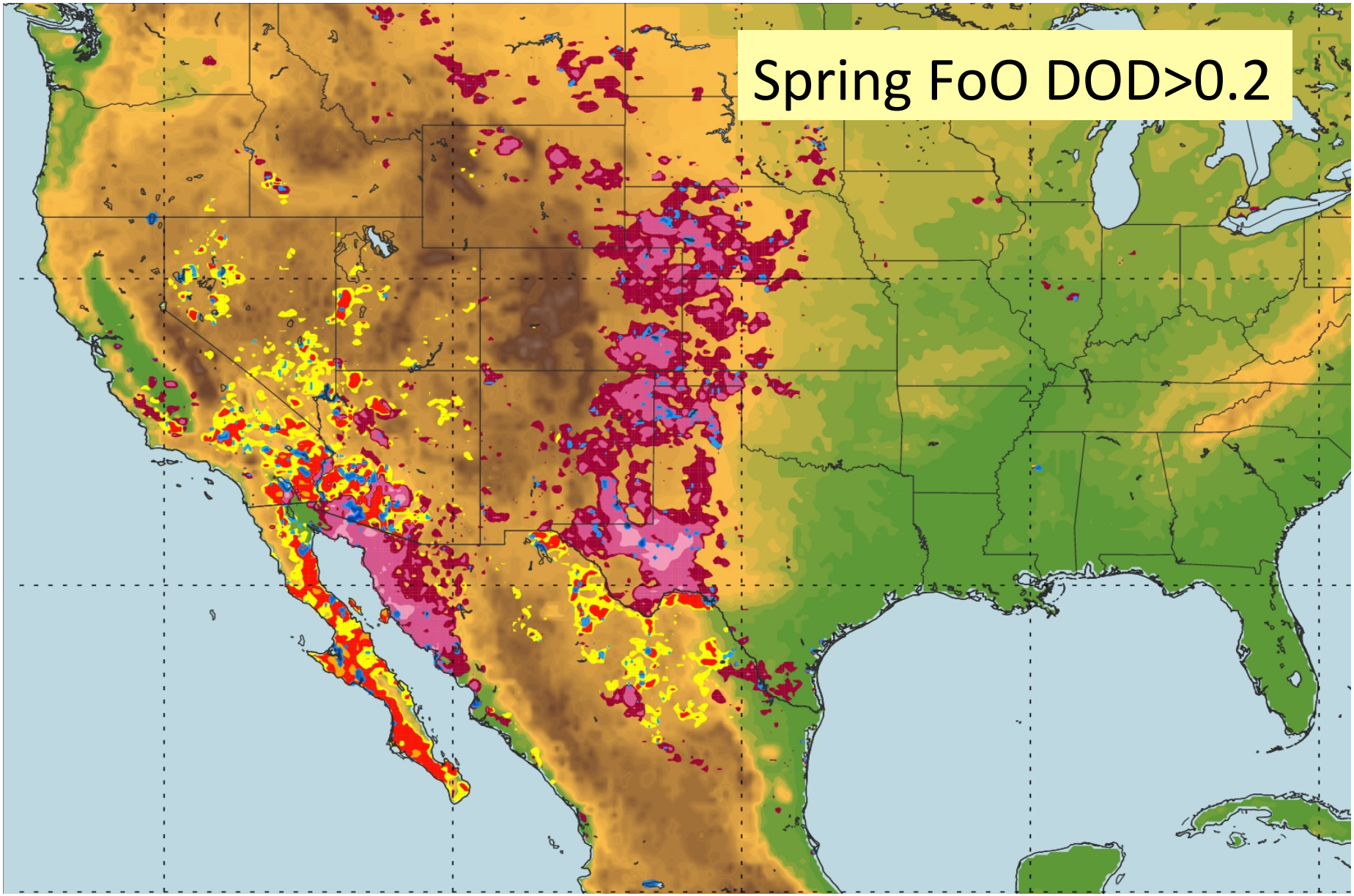
Hydro
10 20 40 60 100

Natural non-hydro
10 20 40 60 100

Anthropogenic non-hydro
10 20 40 60 100

Spring FoO DOD>0.2




Spring FoO DOD>0.2
Hydro
5
10
25
50
100
Natural non-hydro
5
10
25
50
100
Anthropogenic non-hydro
5
10
25
50
100

Parameterization of Dust emission

Emission = $C\ L\ S\ v^2\ (v - v_t)$ [kg m^{-2} s^{-1}] (Ginoux et al., 2001)

C= 10^{-9} kg m^{-5} s^2

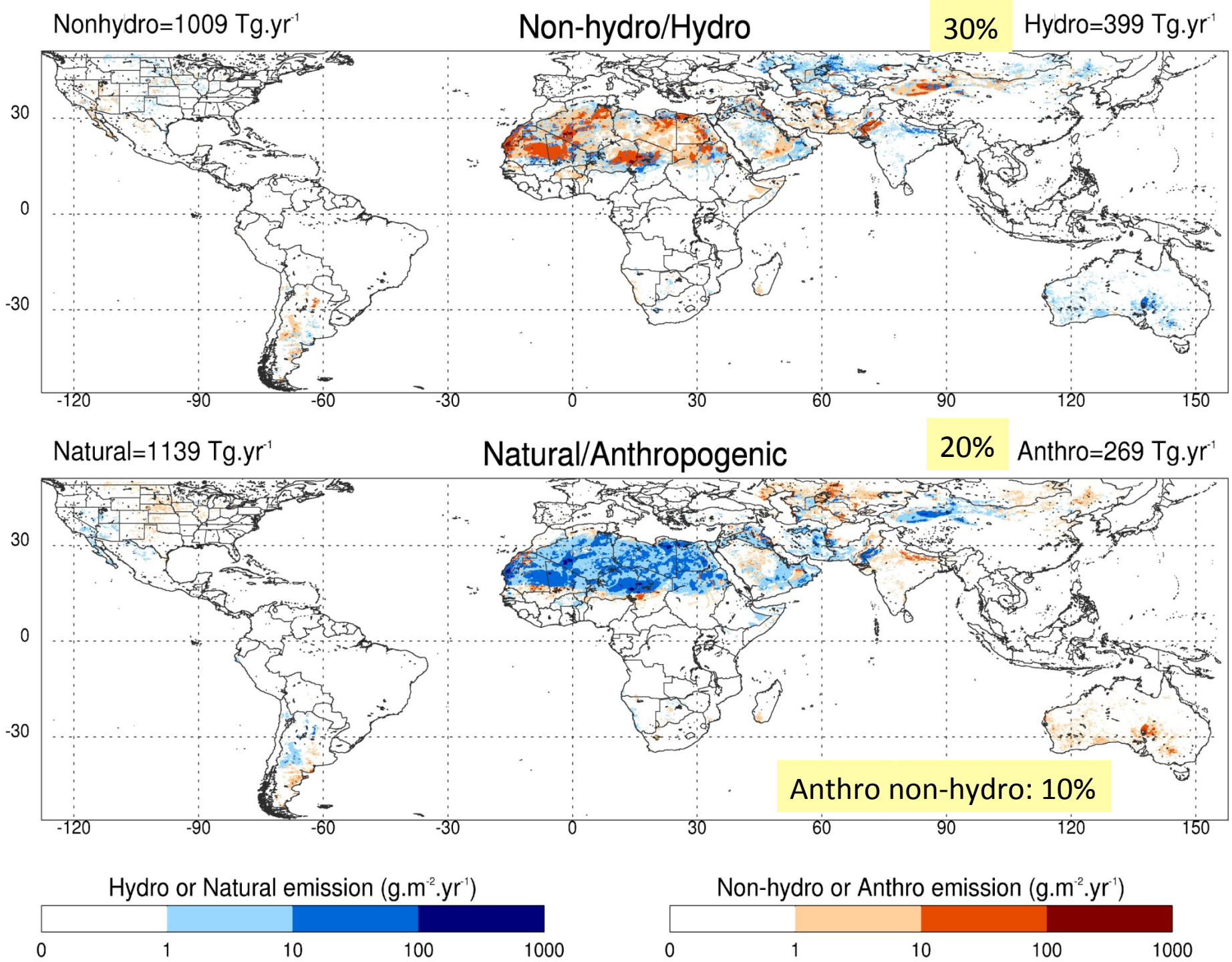
L =[0-1] land use fraction (Klein Goldewijk, GBC 2001)

S=[0-1] from Ginoux et al. (2001)
or MODIS DB FOO

v : 10-meter wind speed [m s^{-1}]

v_t= threshold of wind erosion [m s^{-1}]

One remaining unconstrained parameter: v_t


Nonhydro=1009 Tg.yr-1
Non-hydro/Hydro
30%
Hydro=399 Tg.yr-1
30
0
-30
-120
-90
-60
-30
0
30
60
90
120
150
Natural=1139 Tg.yr-1
Natural/Anthropogenic
20%
Anthro=269 Tg.yr-1
Anthro non-hydro: 10%
Hydro or Natural emission (g.m-2.yr-1)
0
1
10
100
1000
Non-hydro or Anthro emission (g.m-2.yr-1)
0
1
10
100
1000

Conclusions

• To answer our questions: Natural/ephemeral/anthropogenic sources contribute for 50-60, 30 and 10-20% of global emission, with large regional variations.

• Ephemeral sources are sensitive to hydrological cycle (e.g. drought, flooding), and their strength may change with climate change. With 30% contribution from ephemeral sources, feedbacks with hydrological cycle and the biosphere may be significant.

• Anthropogenic contribution is twice as much as estimated by Tegen et al. (2004), but it strongly depends on the threshold of wind erosion which may be constrained by MODIS data.