Development of a dynamic dust source function for atmospheric model simulation of dust emission

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Dust source S

- Currently, dust emission in the GOCART model is calculate as:

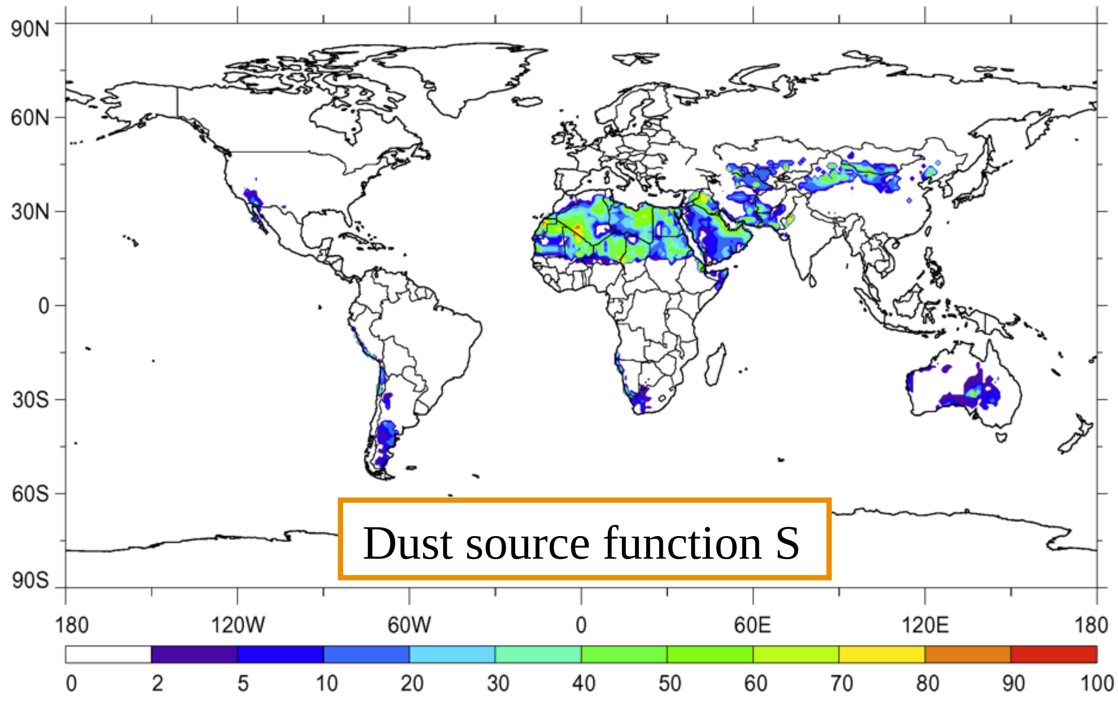
$$E_p = C\, S\, f\, u_{10}^2\, (u_{10} - u_t)$$

p : bin of particle size
C : dimensionless factor
S : source function
f : fraction of particle size
u_{10} : horizontal wind at 10 m
u_t : threshold wind velocity (wind speed, soil moisture)

- The source function S is the probability of dust uplifting (0-1) based on the Ginoux scheme (topography scheme, bare surface, topographically depressed area)

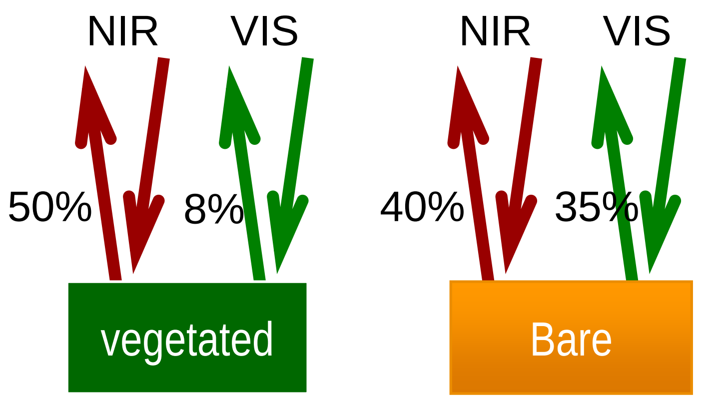
Dust source

- S is a global static map, with "bareness" determined from the AVHRR 1987 annual average vegetation map
- The static dust source S function does not reflect long-term land use change and seasonal variation of non-permanent desert areas



NDVI

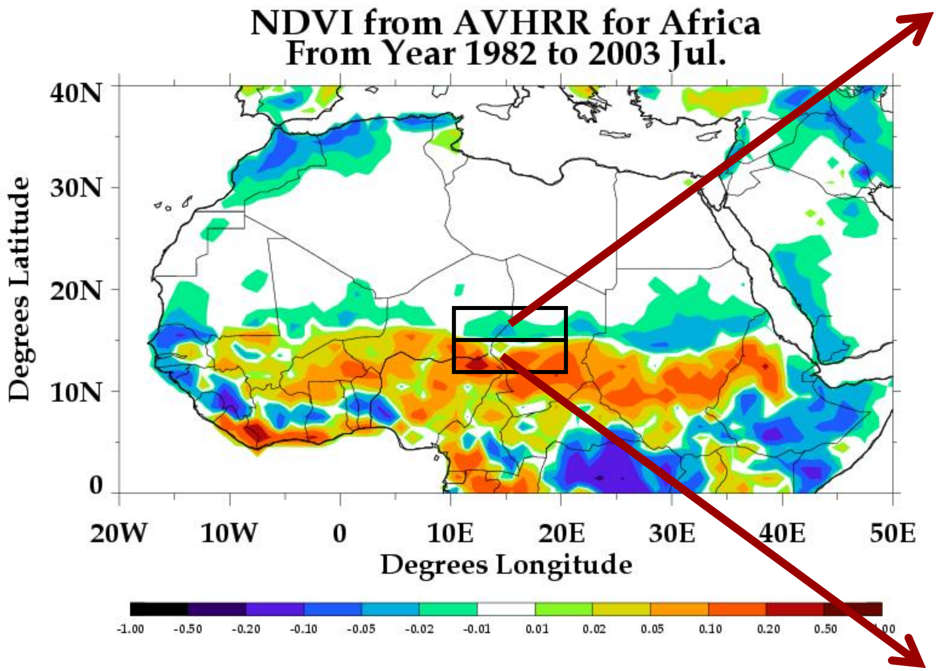
- NDVI is calculated from the visible and near-infrared light reflected by vegetation.
- NDVI = (NIR — VIS) / (NIR + VIS)
- AVHRR: NIR = 0.73-1.0 µm, VIS = 0.55-0.7 µm
- Healthy vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. Sparse vegetation or bare ground reflects more visible light and less near-infrared light.

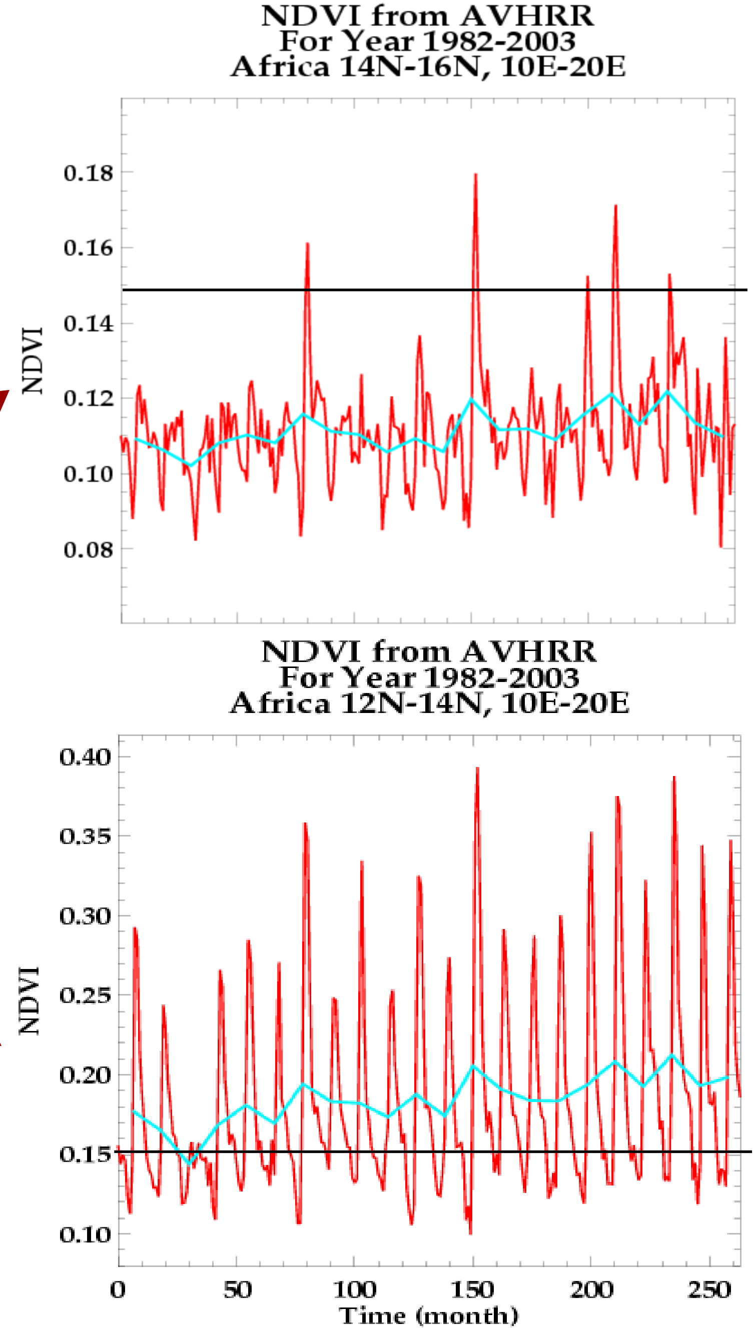


$$\frac{0.50-0.08}{0.50+0.08}=0.72$$

$$\frac{0.40-0.35}{0.40+0.35}=0.07$$

NDVI for Africa



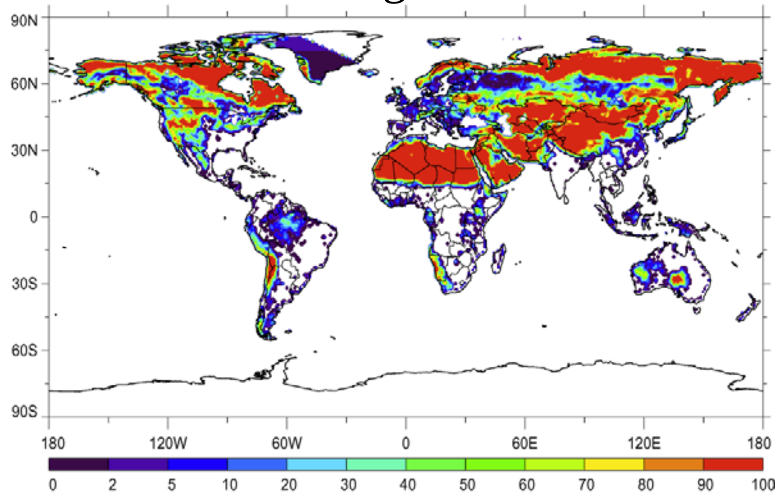


Development of a dynamic dust source function from 1982 to 2003

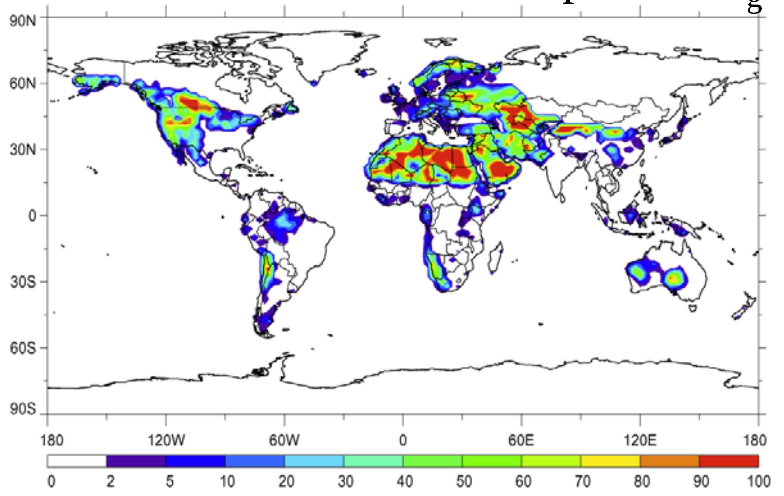
1. Using 8-km resolution AVHRR NDVI data to create global 1°x1° percentage bareness map:
   - Choosing threshold NDVI = 0.15
   - % bareness = no. of 8-km NDVI<0.15 / total no. of 8-km data within the 1°x1° gridbox
2. Screening out the bare surfaces which are not dust source – using FAO soil depth map
3. Masking with ground temperature – if the ground is frozen then the possibility of dust mobilization is 0
4. Combining with topographic features

Example: January 2001

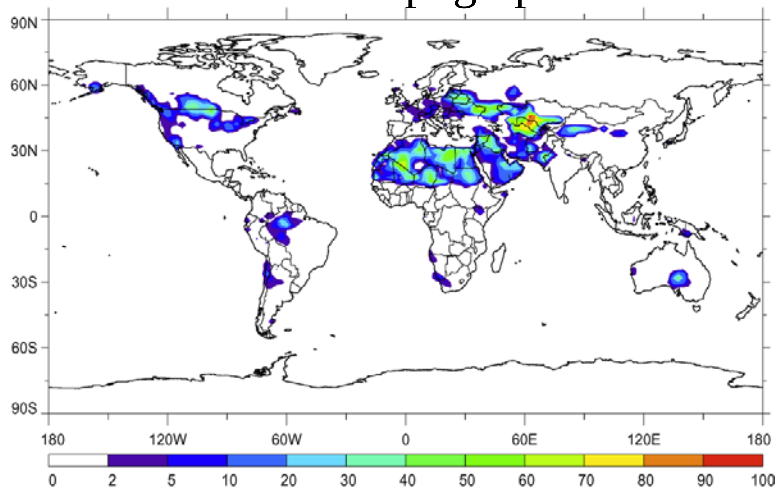
1. Percentage bareness



2 & 3. Masked with soil depth and T_g



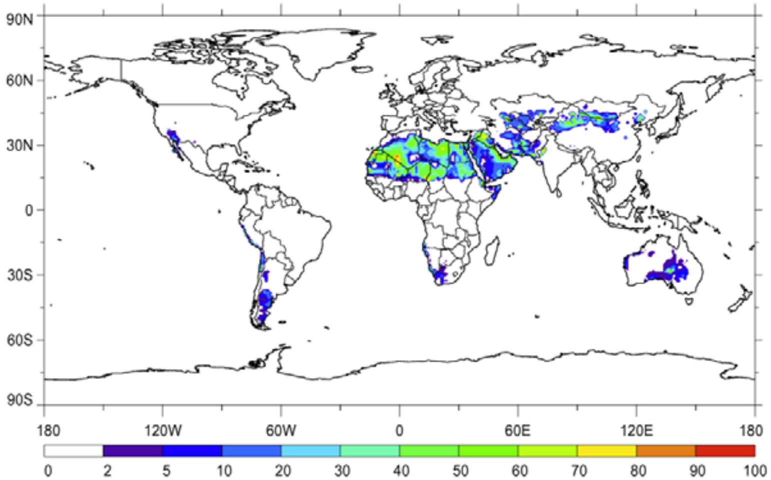
4. Masked with topographic feature



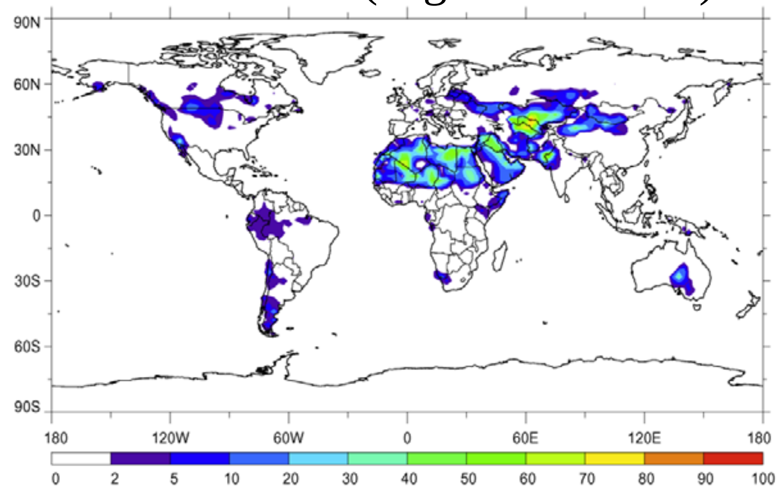
Global dust source S

Annual average dust source map S

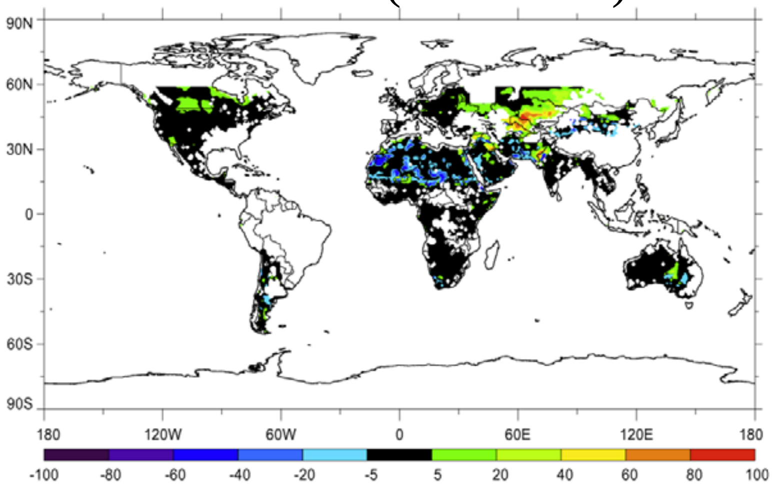
Old source



New source (avg 2000 – 2005)



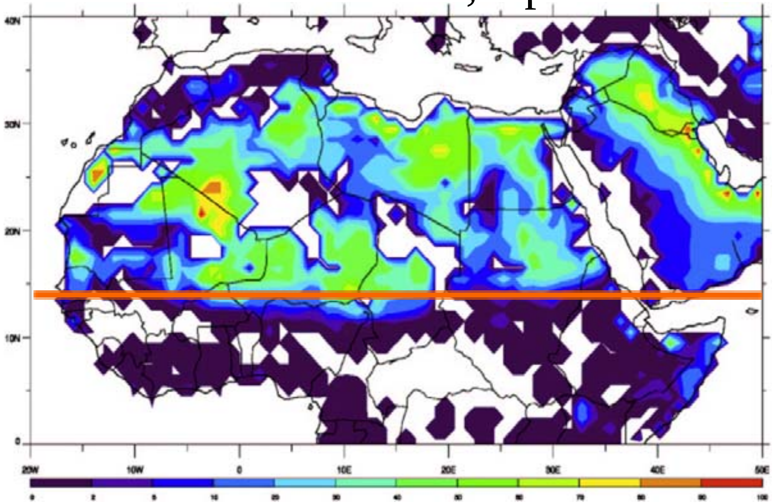
Difference (New – Old)



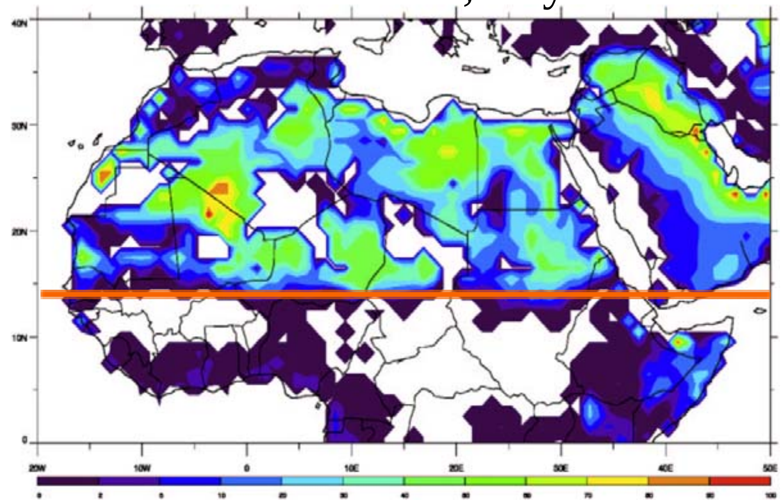
- Western Asia: S increased
- Sahara: S decreased
- Northern N. America: S increased
- Australia: S increased/decreased

Seasonal variation of dust source S

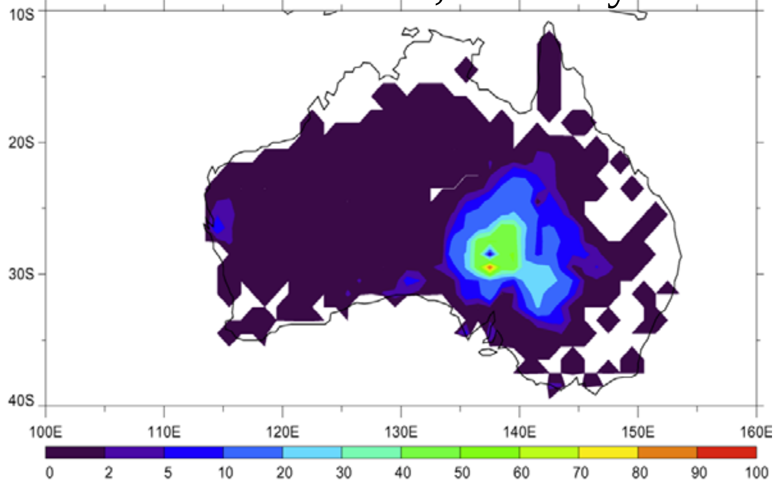
Dust source S, April



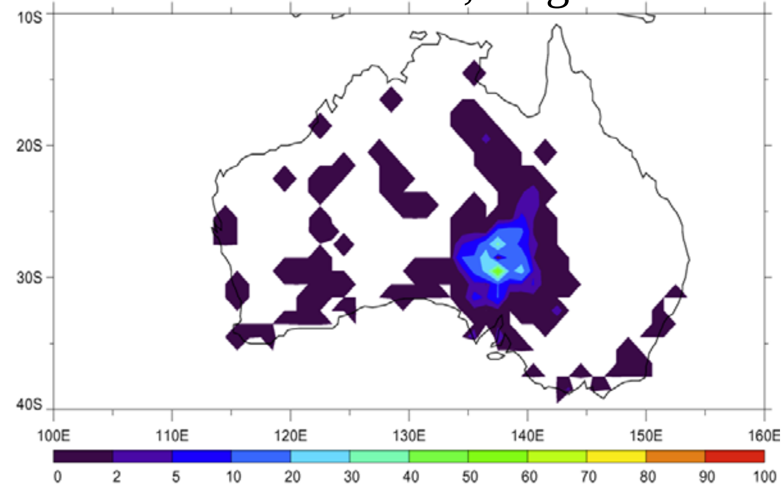
Dust source S, July



Dust source S, February

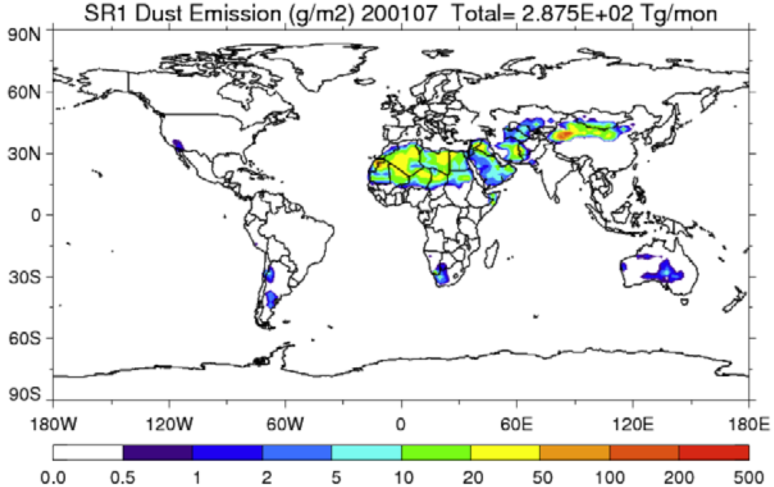


Dust source S, August

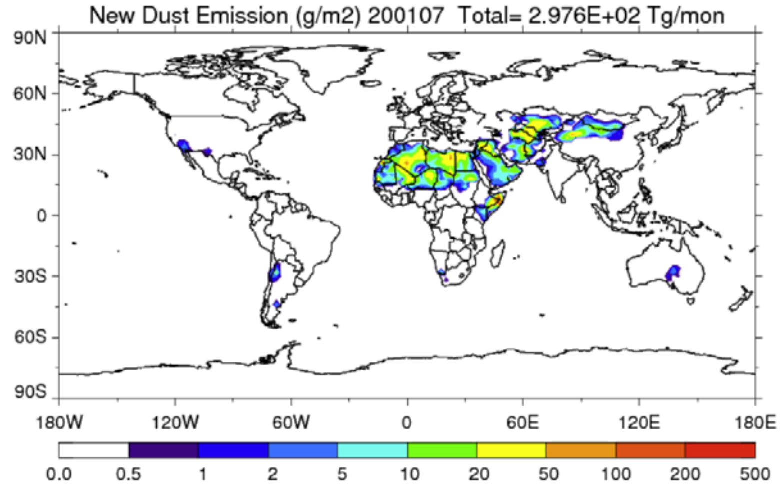


Dust emission E 200107

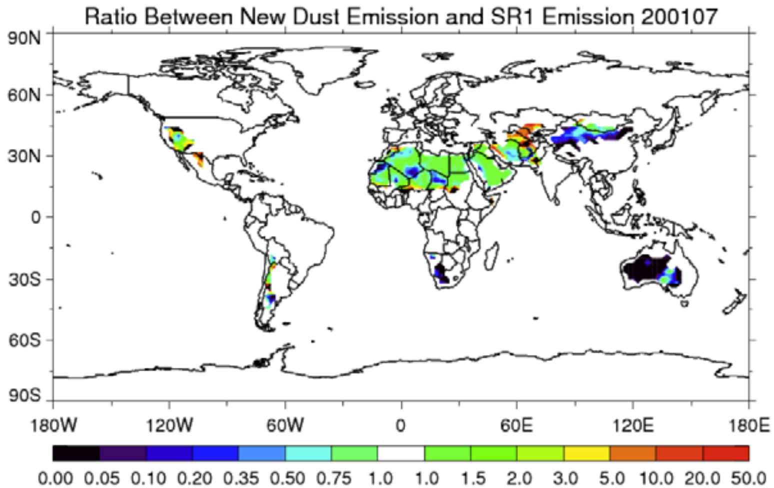
Dust emission with old source, 200107

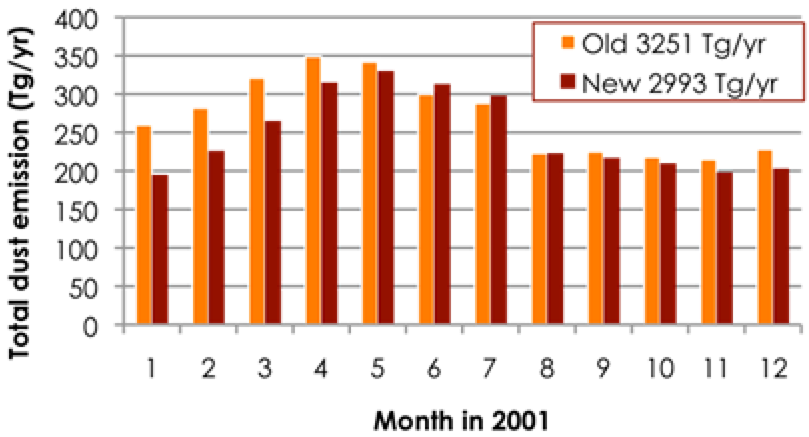


Dust emission with new source 200107



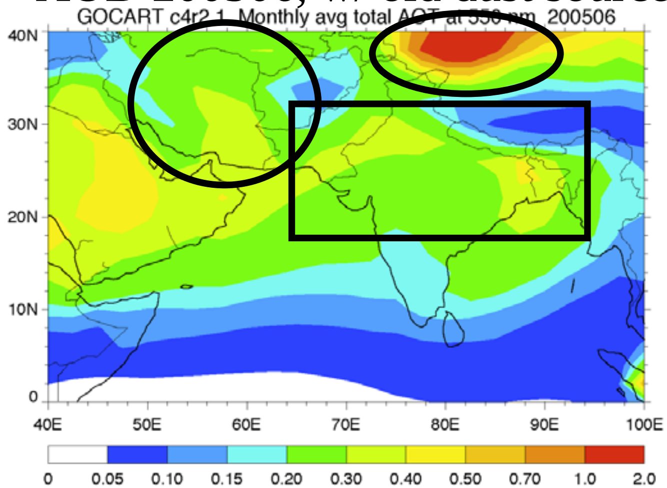
Difference New/Old



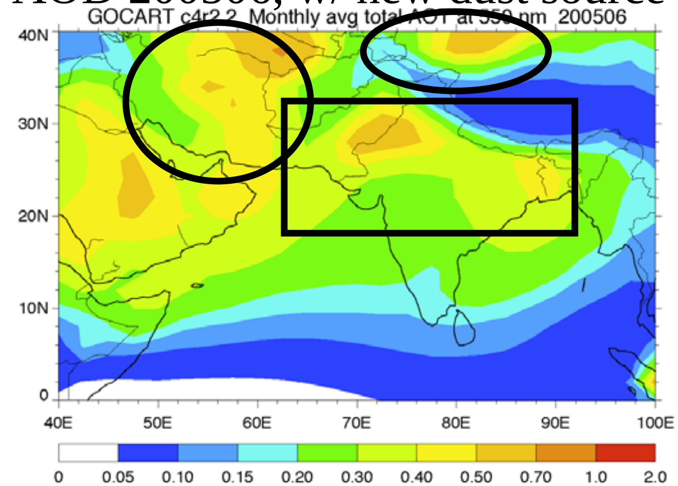


Total aerosol optical depth 550 nm

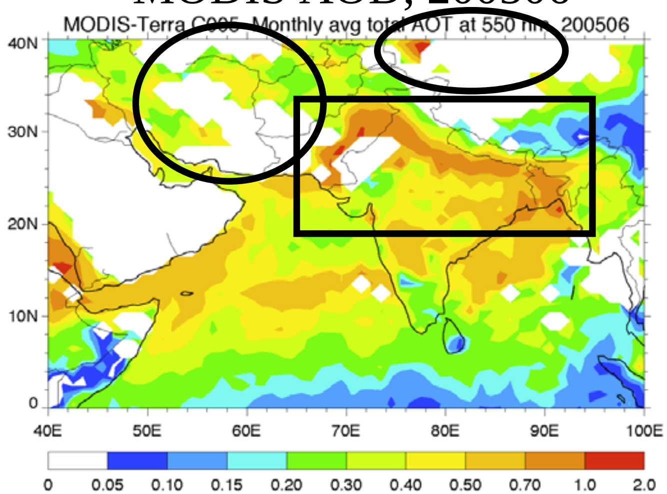
AOD 200506, w/ old dust source



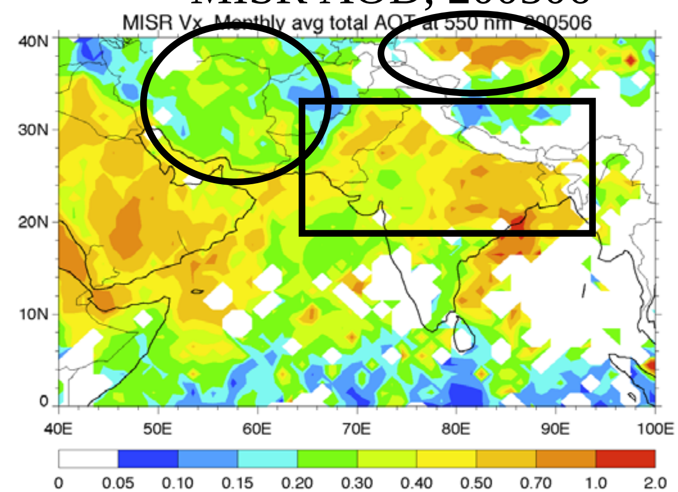
AOD 200506, w/ new dust source



MODIS AOD, 200506



MISR AOD, 200506



Next steps and considerations

- Currently we use somehow arbitrary threshold NDVI for “bareness” at 0.15 everywhere. This number should be soil type dependent
- We should also consider the NDVI uncertainty – e.g. in Brazil. We may further mask the source with vegetation type
- We will evaluate the differences in dust concentrations and AOD between simulations using the static and dynamic dust sources at different regions