Multi-decadal variation of atmospheric aerosols and their impacts – Hindcast analysis

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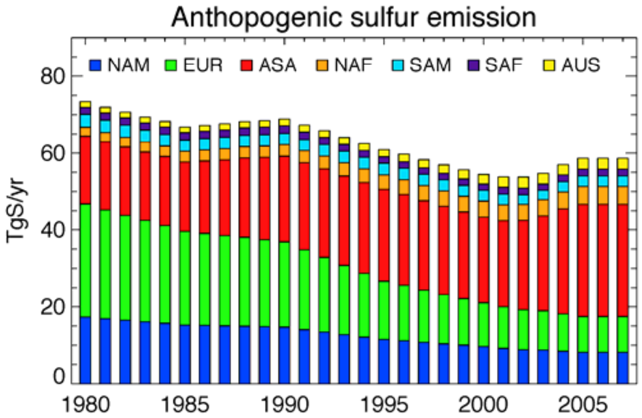
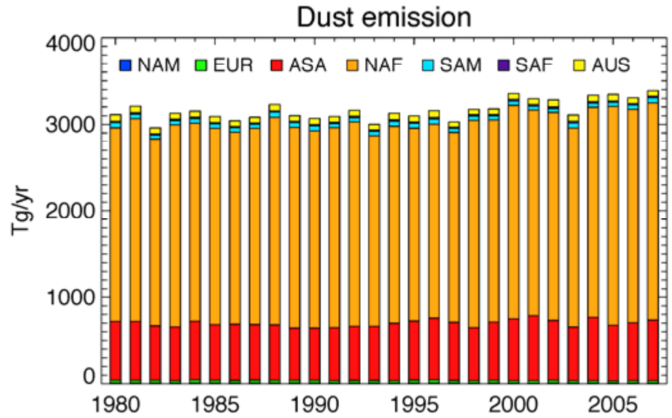
Topics of analyzing hindcast model experiments

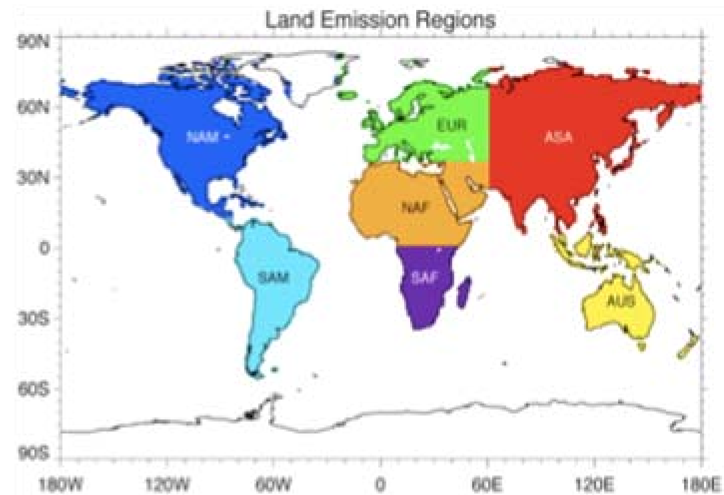
- A2 HC model output:
  1. Multi-decadal aerosol trends and their effects on surface radiation trends – dimming/brightening
  2. Aerosols over Asia – magnitudes, trends, model problems
  3. Multi-decadal variations of dust aerosols

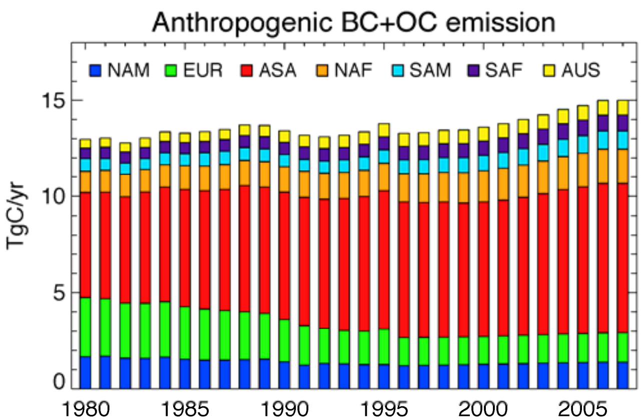
- Additional "tagged" experiments:
  4. Arctic haze – variations of source attribution
  5. Stratospheric sulfate aerosol trends – volcanic or anthropogenic

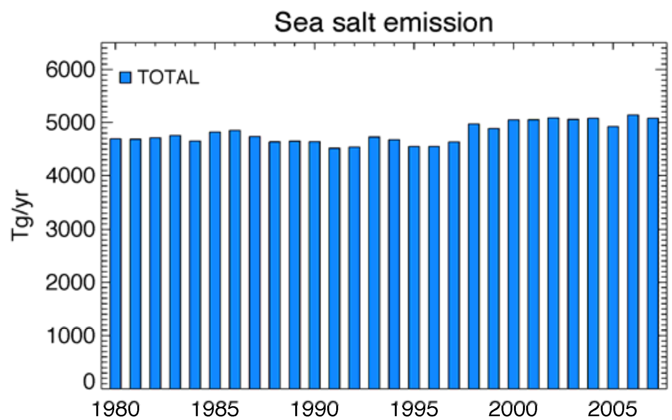
Anthropogenic and natural emissions of aerosols and precursors – 1980 to 2007

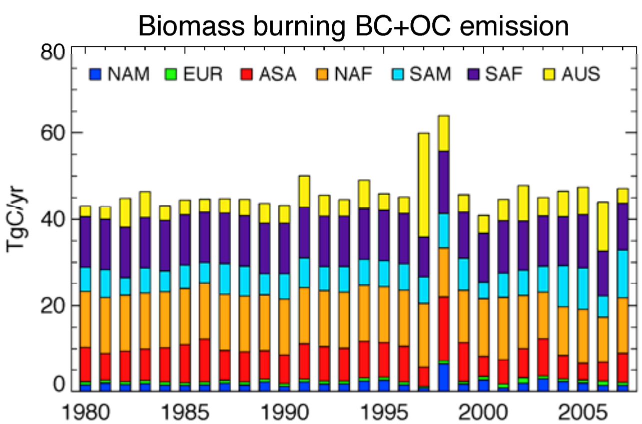


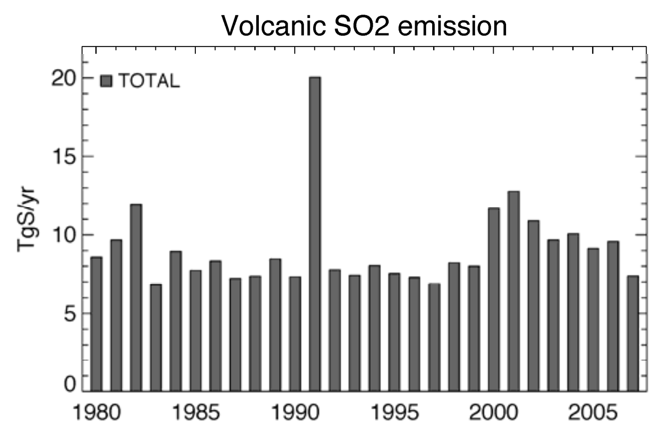










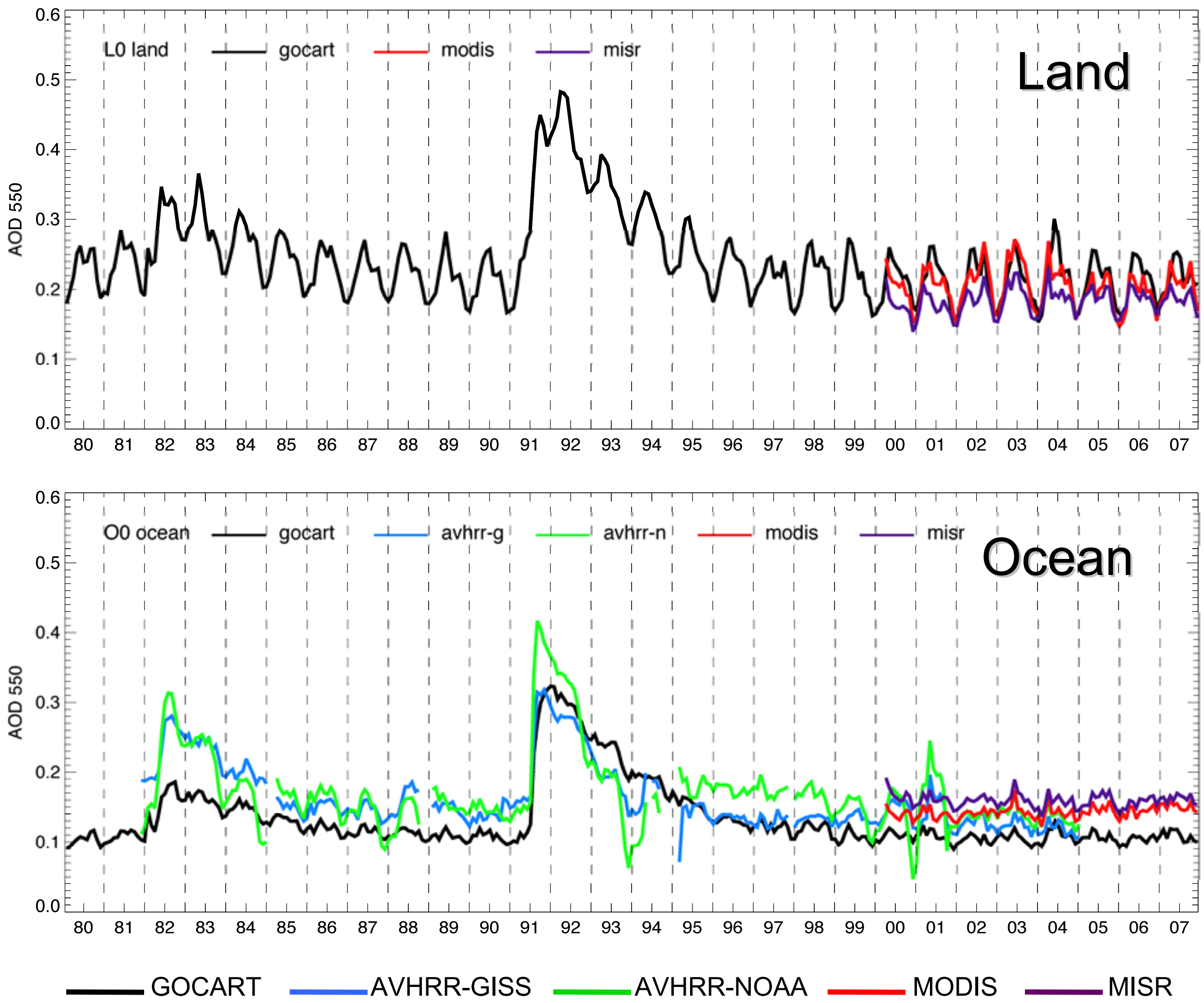


Anthropogenic emission:
- Decreased over North America and Europe, increased over Asia and other regions

Biomass burning and natural emissions:
- Varying from year to year (and place to place)

1. Multi-year variation of AOD and surface radiation

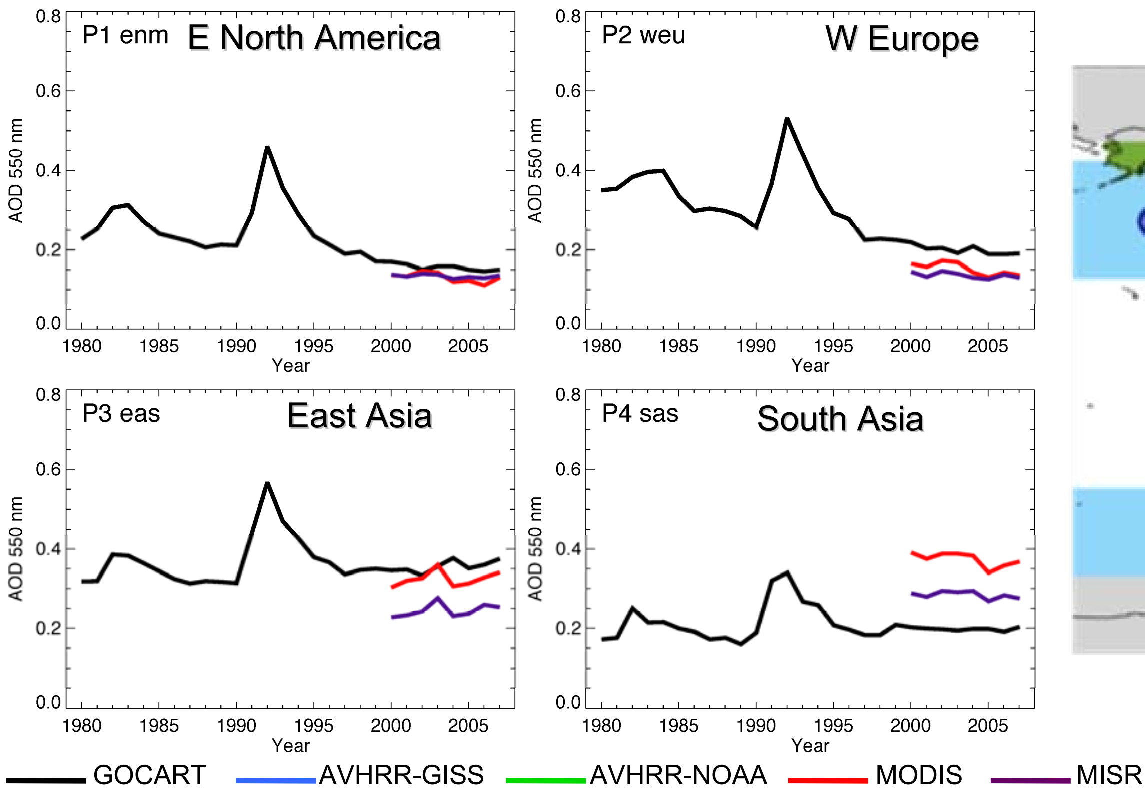
Comparison of monthly average AOD over land and ocean

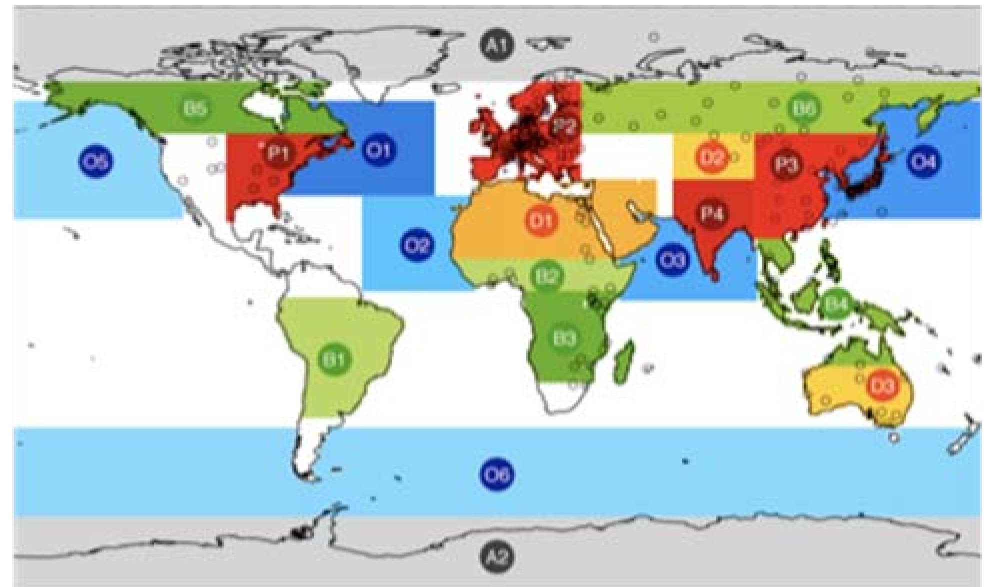


- Over land: Model simulated AOD agrees with MODIS and MISR
- Over ocean: model is in general lower than satellite data
- There are also differences among different satellite datasets

AOD trends over pollution source regions

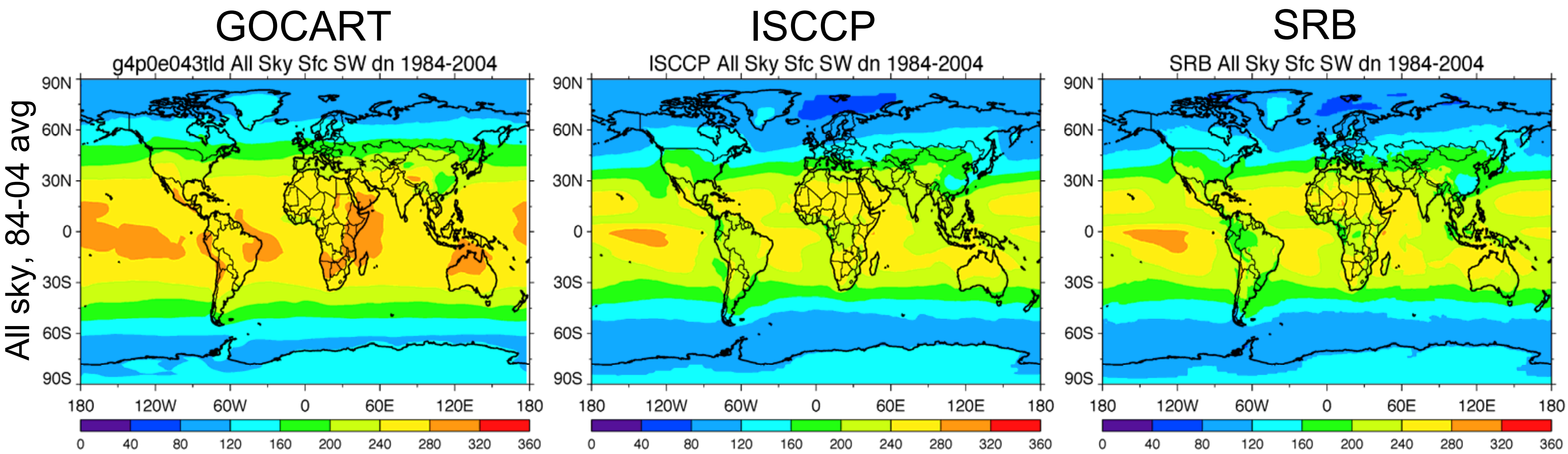
AOD trends over pollution regions (de-seasonalized)





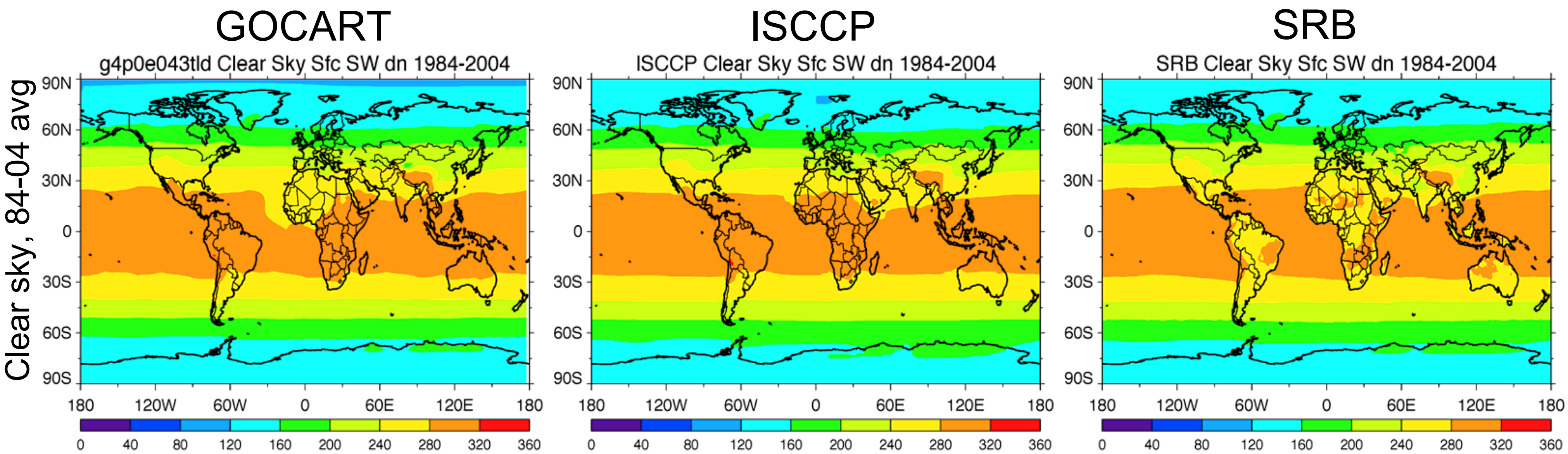
- Over E North America and Europe: AOD decreasing
- Over E Asia: AOD increasing
- El Chichon and Pinatubo volcanoes have large global influences
- Modeled AOD is much lower than MODIS and MISR over S Asia

Climatology (1984-2004) of downward surface shortwave radiation (SSR) – All sky



– Under all sky condition, model calculated surface SWDF is about 20 – 60 W m^{-2} higher than that from ISCCP and SRB, most likely because of the difference in cloud fields

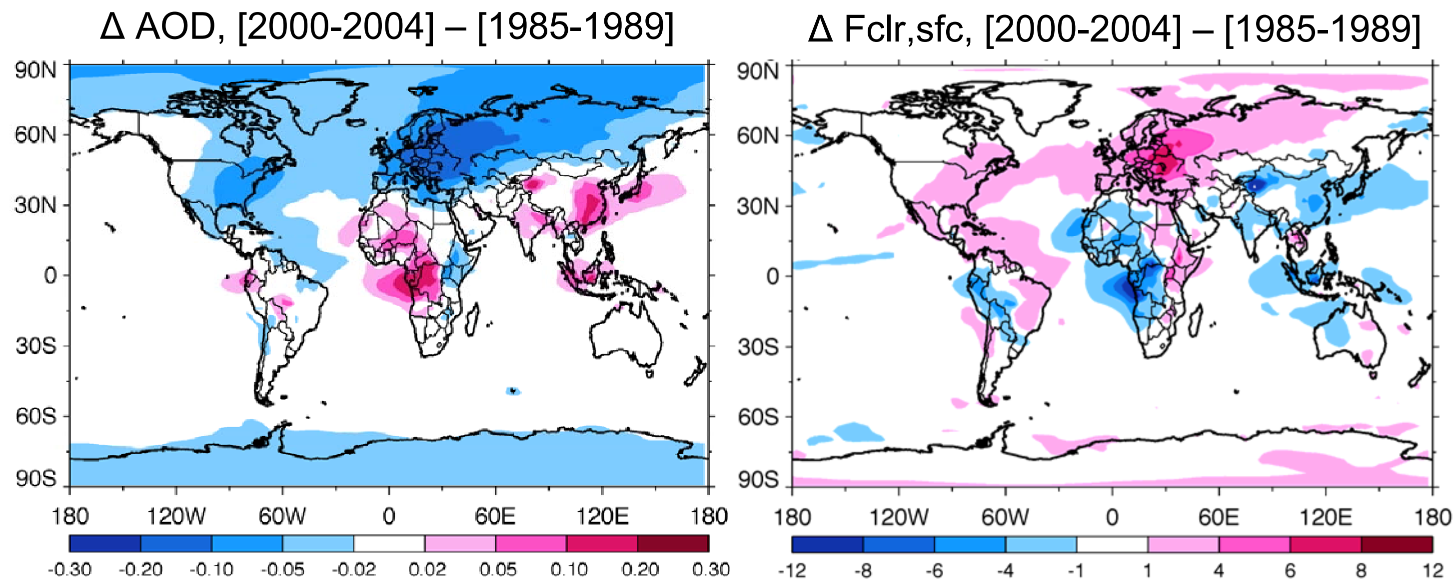
Climatology (1984-2004) of SSR – Clear sky



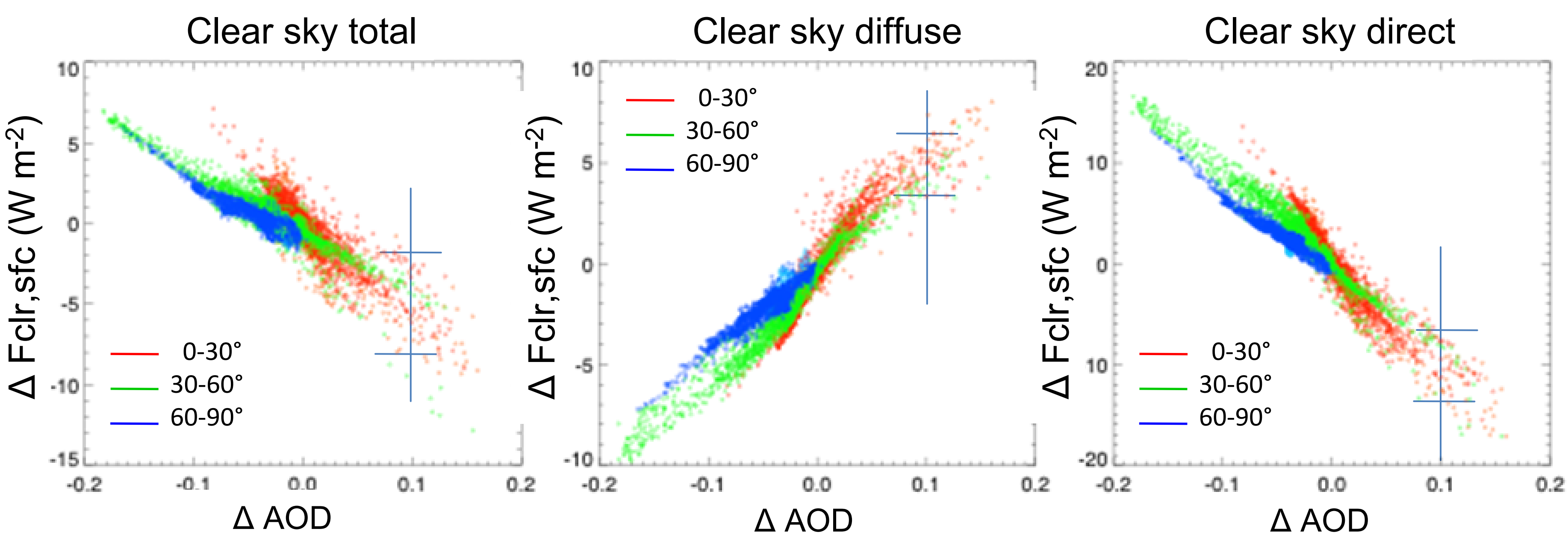
– Under clear sky condition, the model agrees with ISCCP and SRB in most location (Note: clear sky data from ISCCP and SRB are extracted with cloud fraction < 10%)

Aerosol effects on SSR will be best revealed in clear sky conditions because cloud forcing is much larger than aerosol

Relationship between changes of AOD and SSR

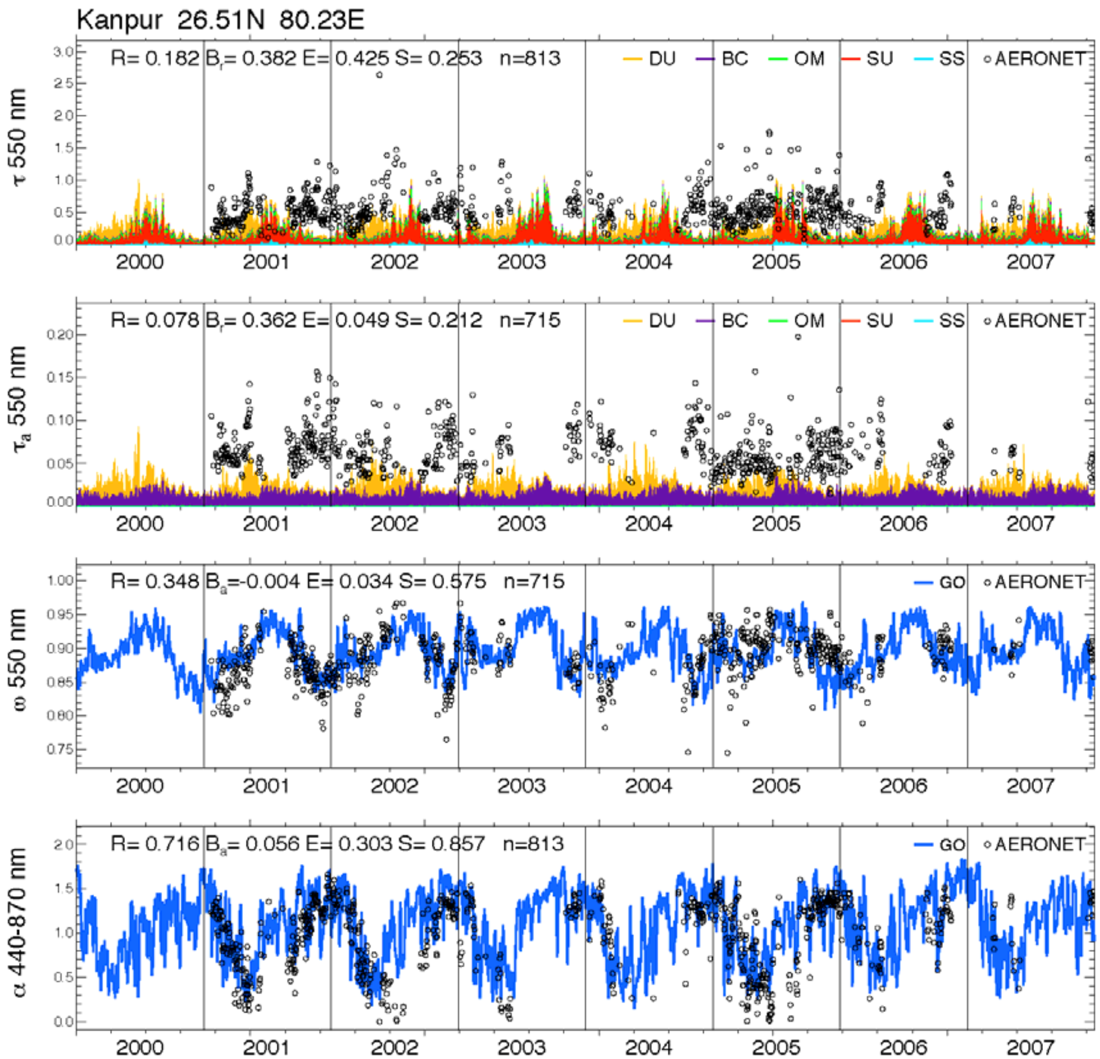


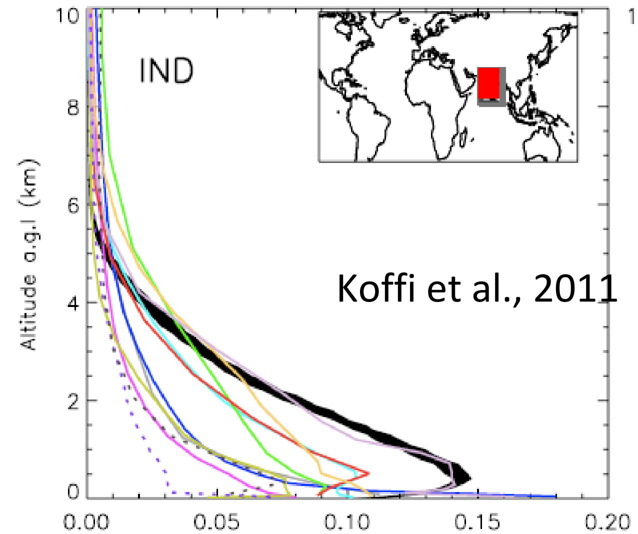
- Under clear sky conditions, aerosols control the change of solar radiation reaching the surface
- “Dimming “ efficiency dep. on location, season, and aerosol type



2. Aerosols over Asia – most problematic place for a lot of models

Chin et al., 2009





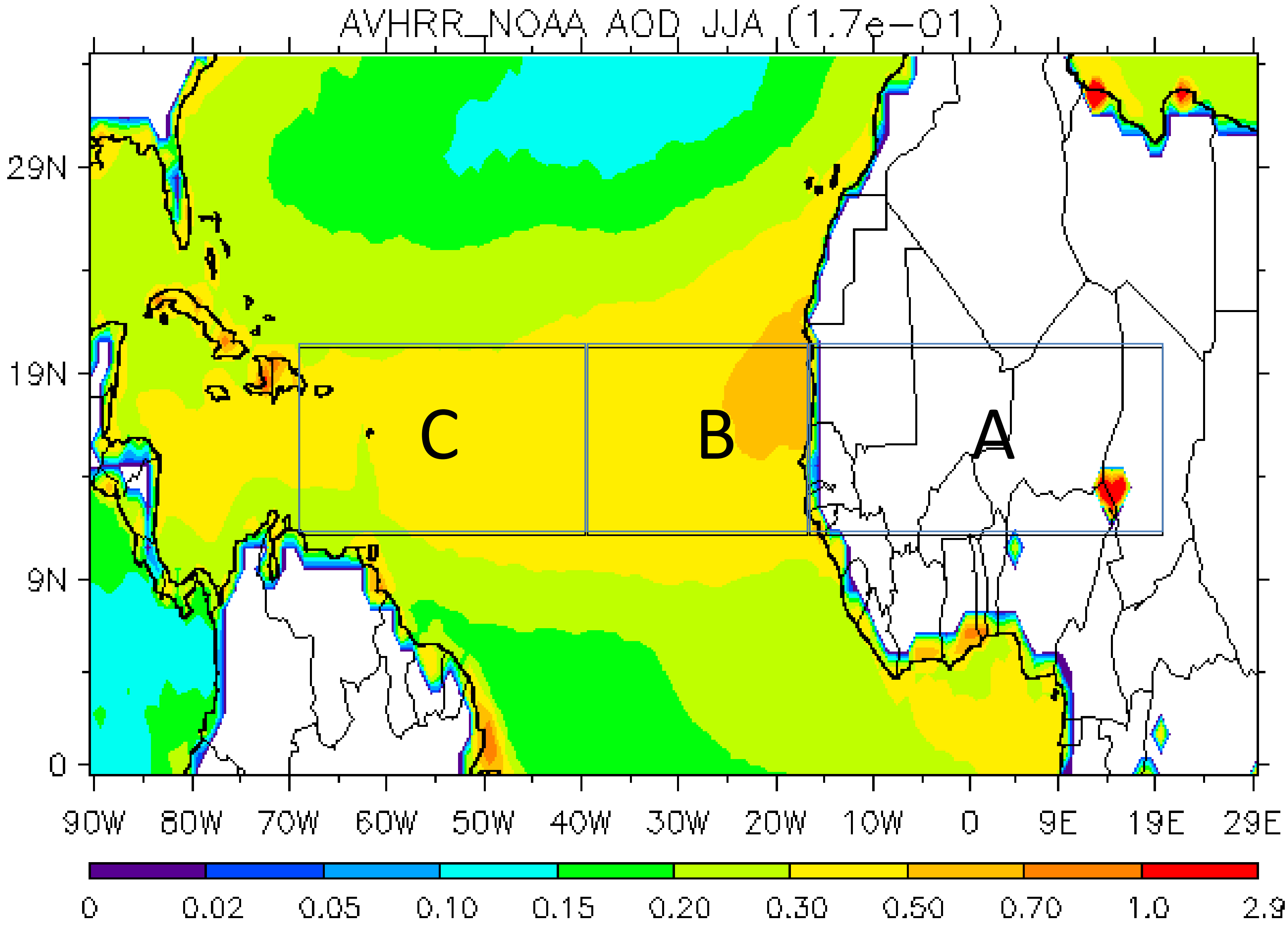
Koffi et al., 2011

Models usually significantly underestimate aerosol amount over India (and China too)

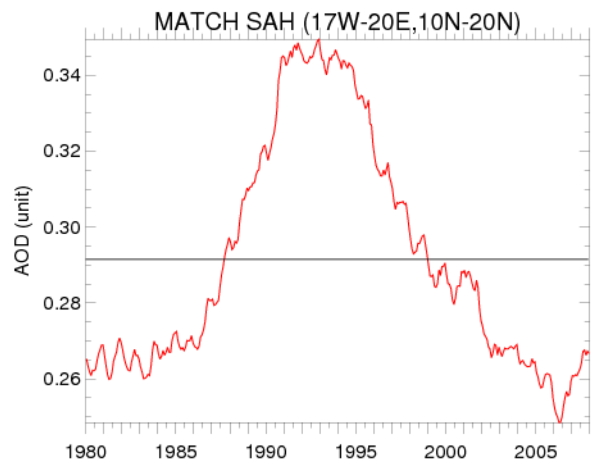
Shortage of accessible data may prevent break-through progress in model improvements

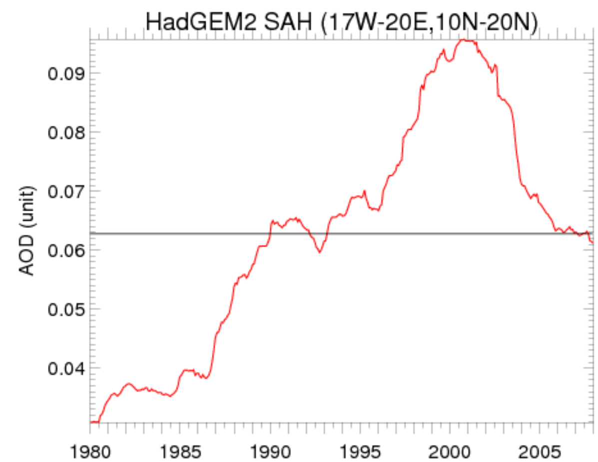
Currently we have obtained some new and more detailed emission over China and India and limited surface data as well so we plan to have a more in-depth analysis

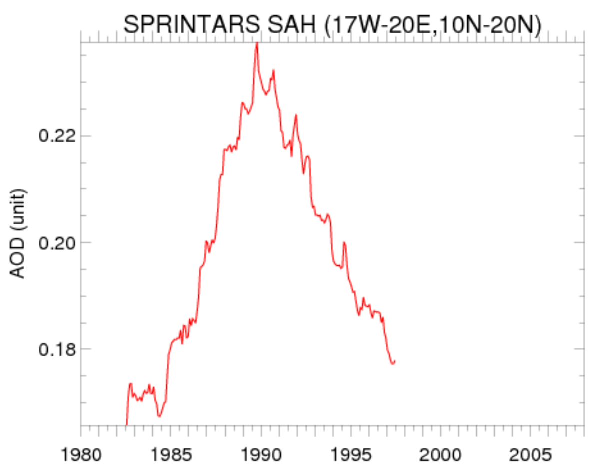
3. Dust trends over N Africa and tropical Atlantic

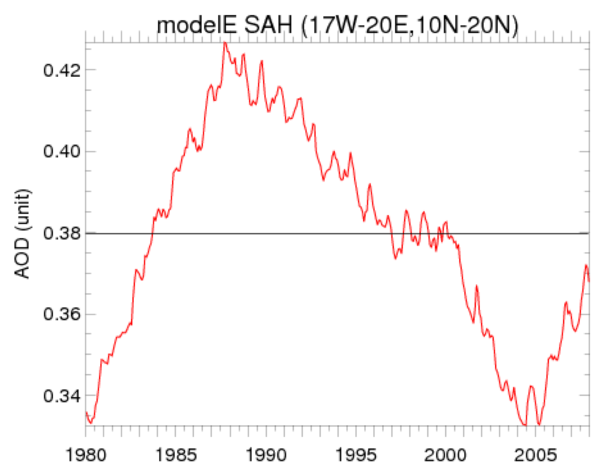


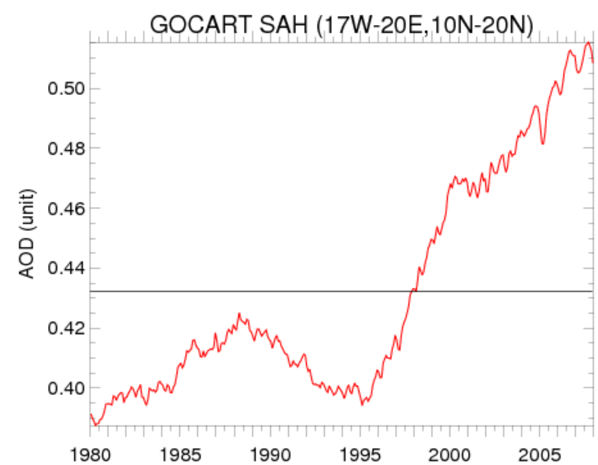
Over region A (land)



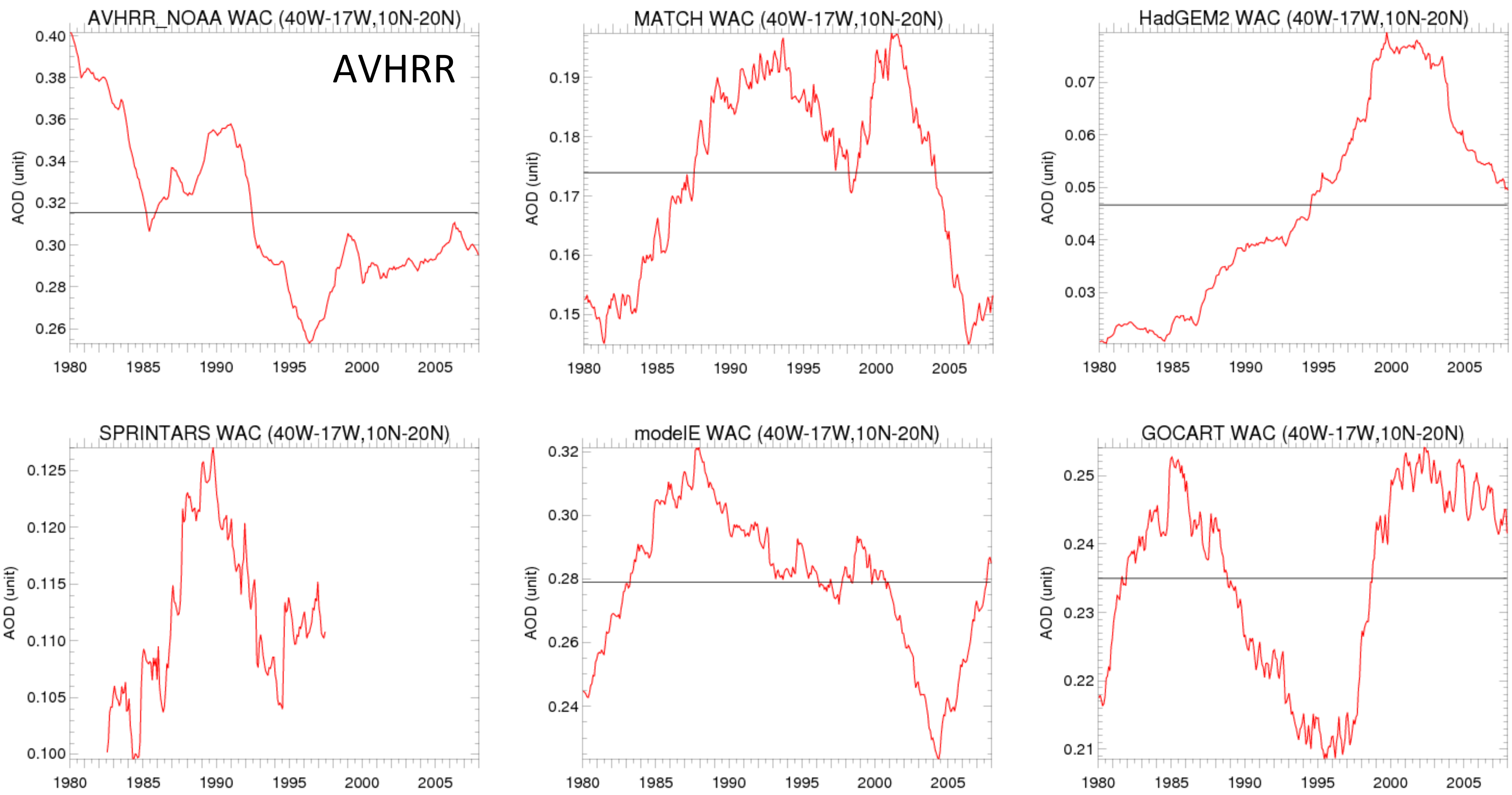




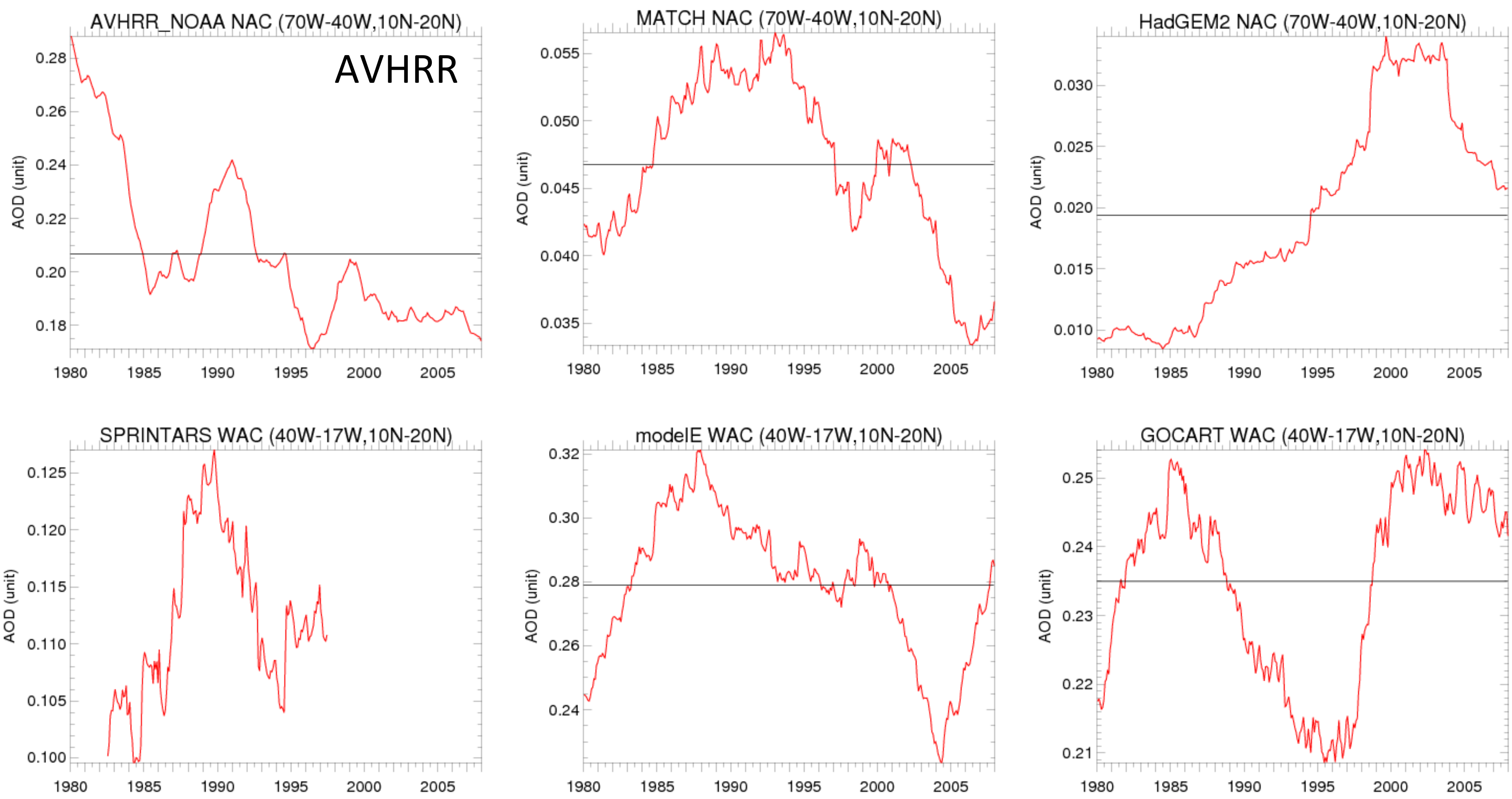




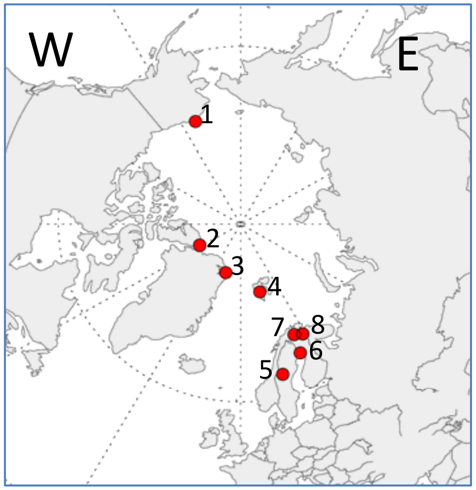
Over region B (eastern tropical Atlantic)



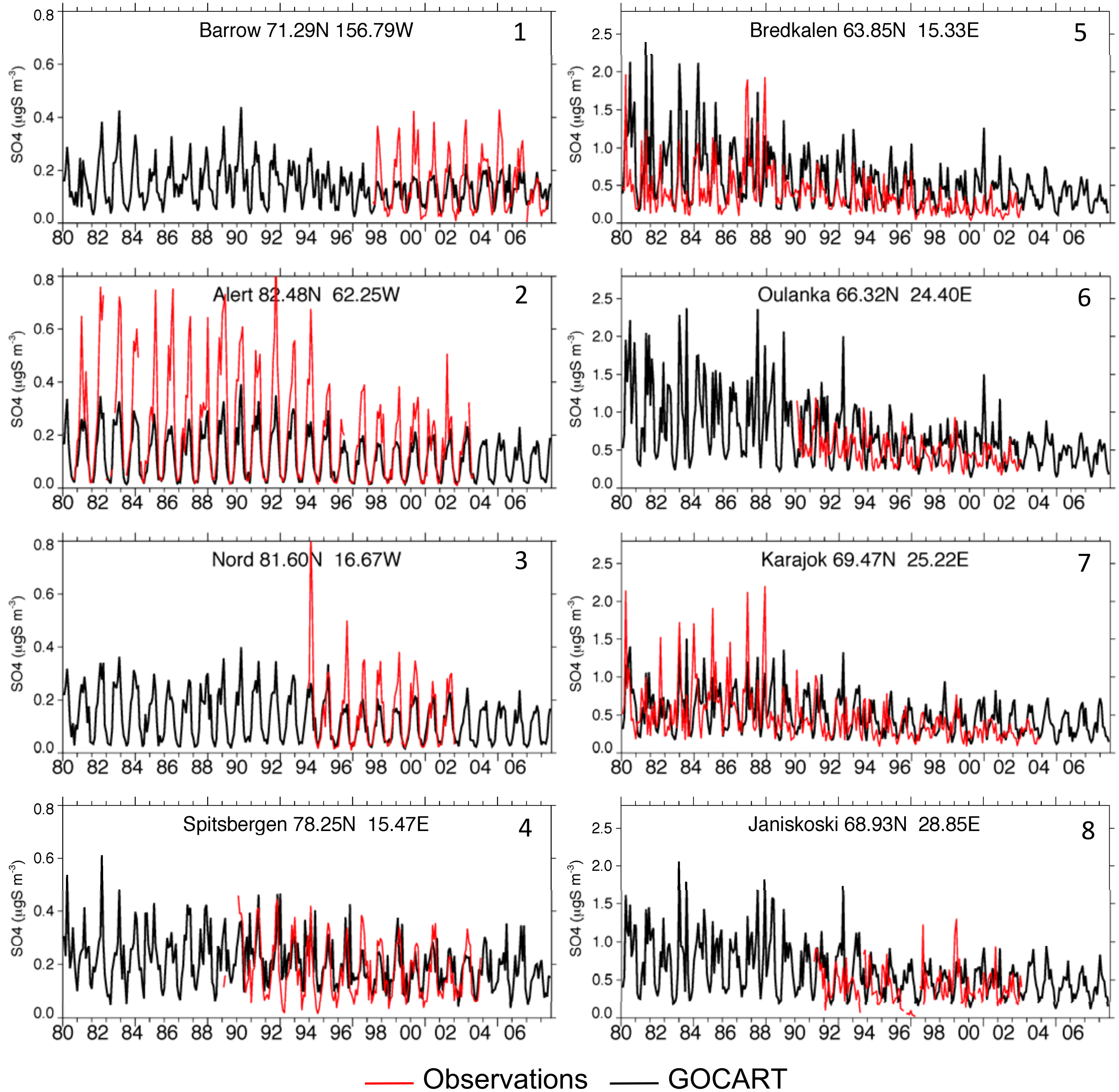
Over region C (western tropical Atlantic)



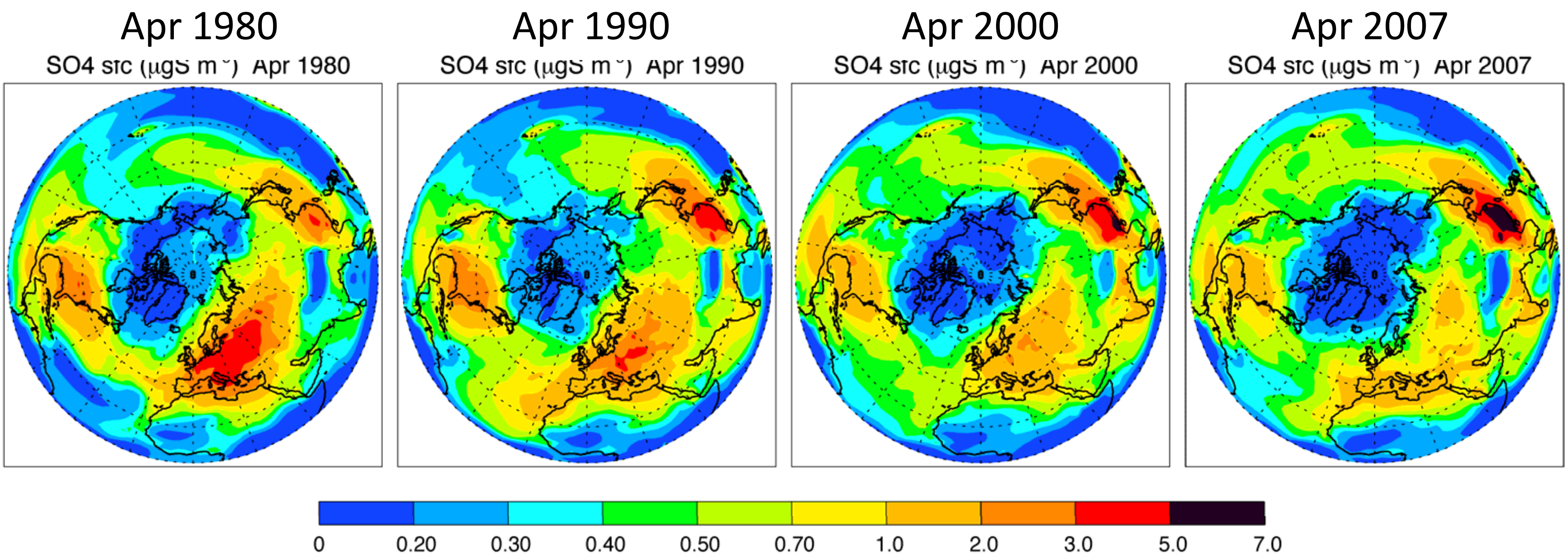
4. Arctic Haze – sulfate surface concentrations



- Both observations and model simulation have shown a general decrease of sulfate concentration over the Arctic
- Over the eastern Arctic the magnitude of such decrease is much stronger than that over the western Arctic
- Over the western Arctic the sulfate concentration seems to have stopped decrease since the late 1990's
- Modeled concentration is about 2x lower than observations over the western Arctic

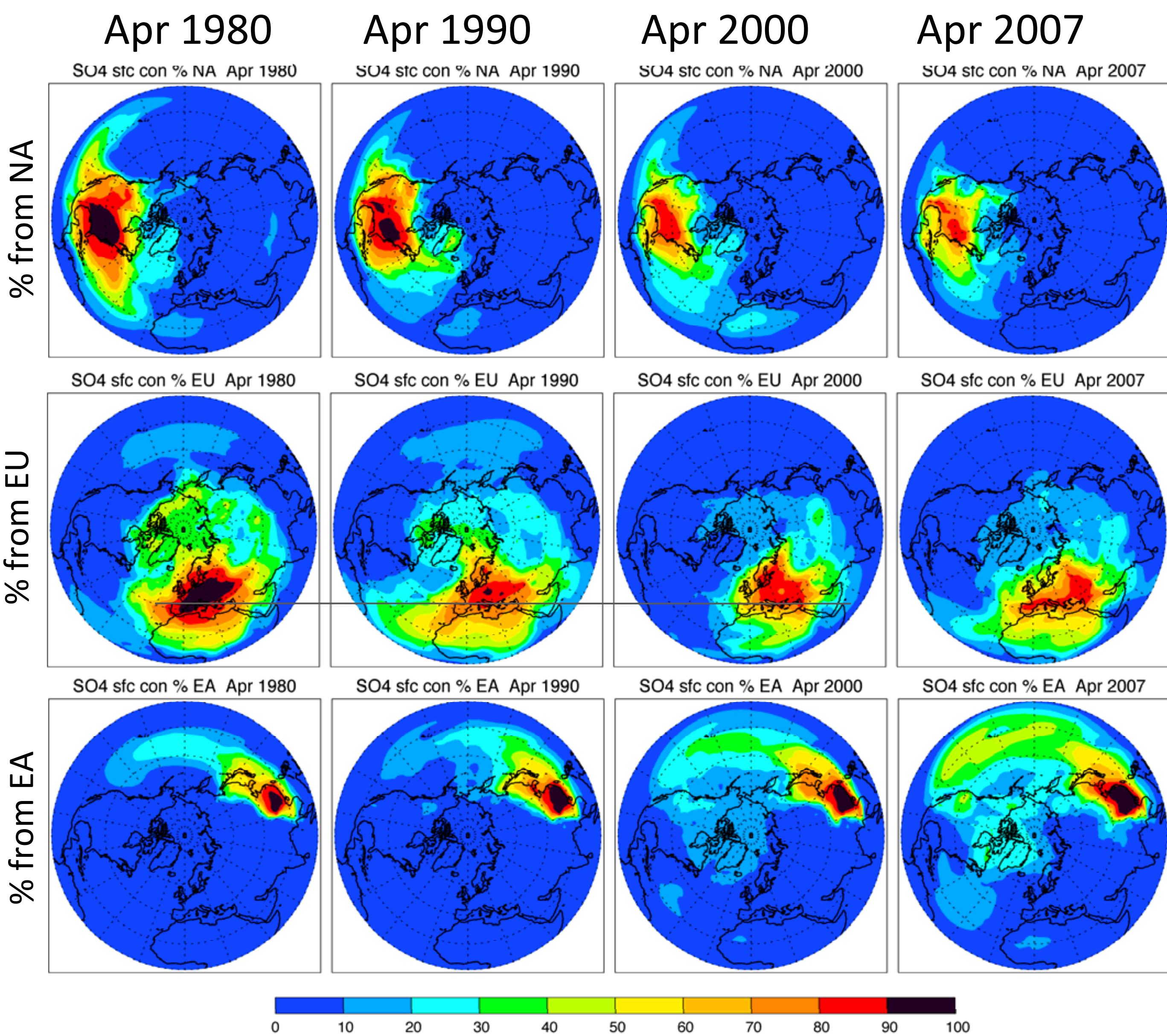


Arctic haze – surface sulfate concentration



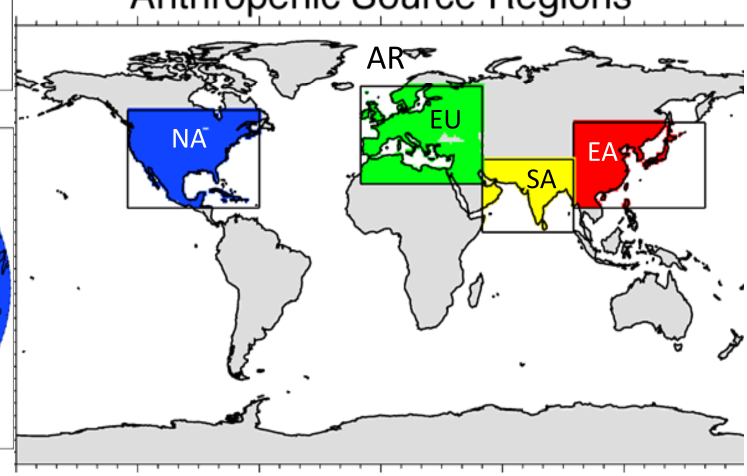
- Anthropogenic sources dominate the surface sulfate at the source regions
- Sulfate has been decreasing over NA and EU but increasing over EA and SA
- Concentrations in the Arctic are much lower than that in the mid latitudes and have been decreasing between 1980 and 2007

Anthropogenic attributions (%) of surface sulfate from major source regions



- NA and EU anthropogenic sources are expected to be the major anthropogenic components over the western and eastern Arctic, respectively
- EA anthropogenic sources increasingly influence sulfate concentrations over the North Pacific and the western Arctic

Anthropenic Source Regions



5. Stratospheric aerosol trends – volcanic or anthropogenic?

- See my poster →