MULTI-DECADAL AEROSOL VARIATIONS: SOURCES AND REGIONAL TRENDS

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Objectives

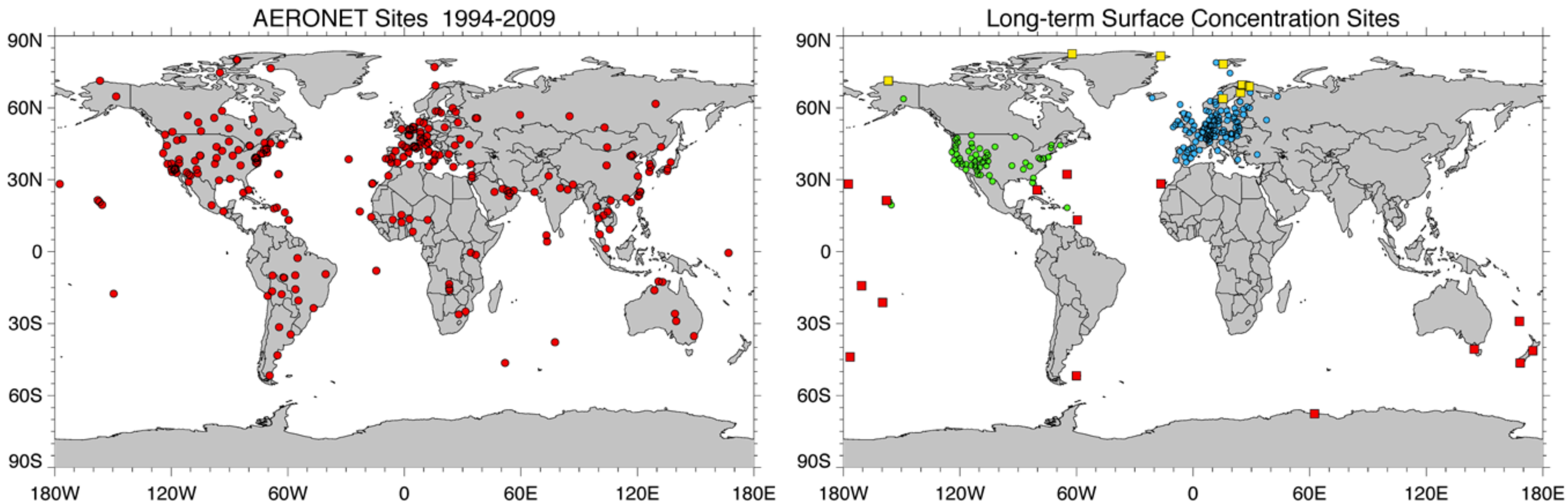
- Simulating 3-decade aerosol variations (1980-2009) in different global regions
- Comparing model results with observations from satellite and ground-based measurements
- Understanding the major driving forces that change the aerosol composition and loading in different regions

Only GOCART model is used in this study (different version from the one submitted to AeroCom), but the same analysis can be performed for multi-model analysis

Model and Data

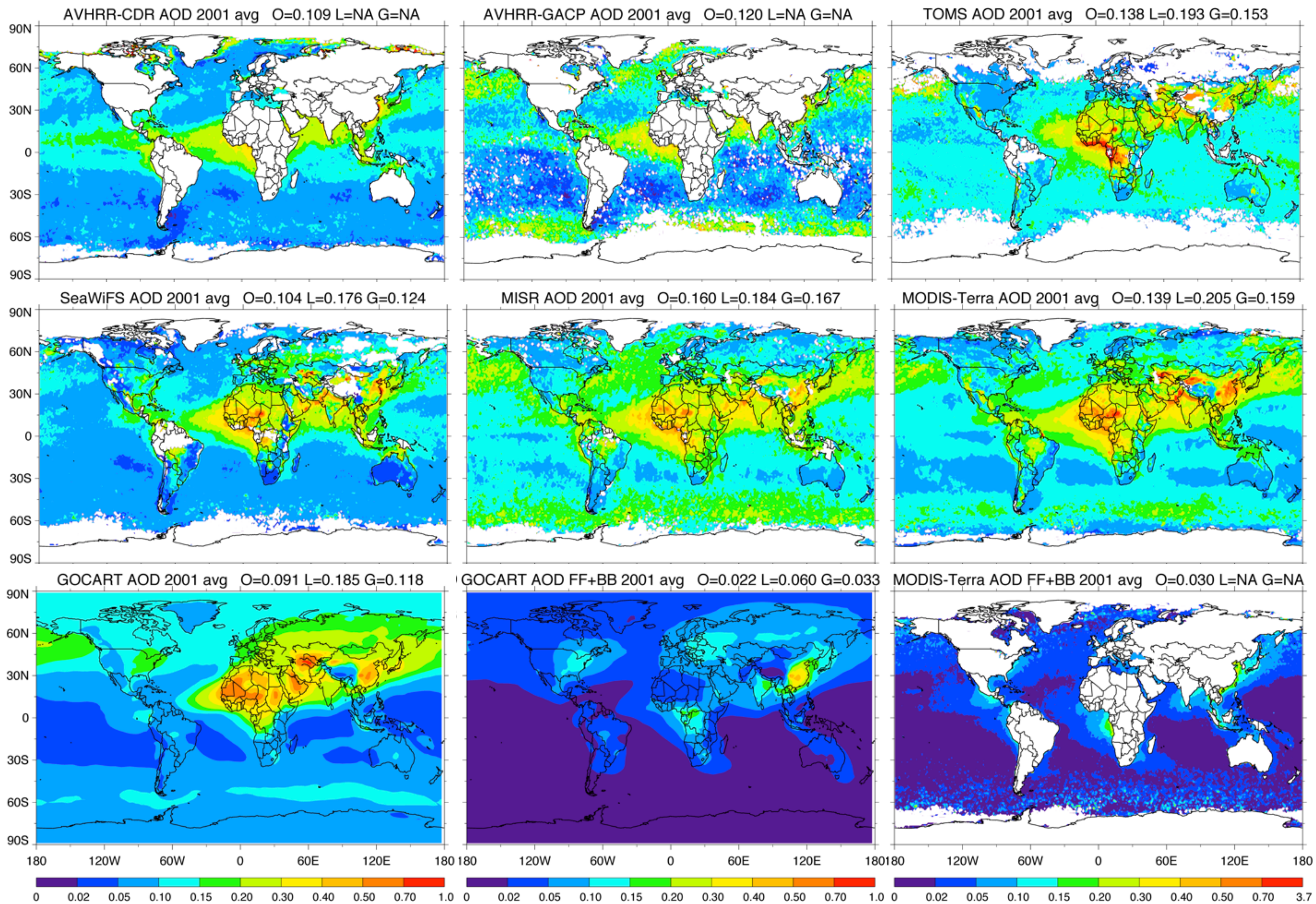
- GOCART model
  - off-line, driven by MERRA reanalysis of meteorological fields
  - Simulation period 1980-2009
  - Emission: anthropogenic and biomass burning from A2-ACCMIP, volcanic from A2-MAP (Diehl et al. 2012), NDVI-based dust source function (Kim et al., 2013)
  - Tagging aerosols generated from fuel combustion + biomass burning (FF+BB) from natural
- Satellite data
  - AVHRR-CDR (1980-2009)
  - AVHRR-GACP (1980-2005)
  - TOMS (1980-2001 with gap years)
  - SeaWiFS (1997-2009)
  - MISR (2000-2009)
  - MODIS-Terra (2000-2009)
  - MODIS-Aqua (2002-2009)
- Ground-based measurements:
  - AERONET AOD
  - IMPROVE concentrations over US
  - EMEP sulfur concentrations over Europe and Arctic
  - University of Miami species concentrations over ocean islands

Surface measurement sites

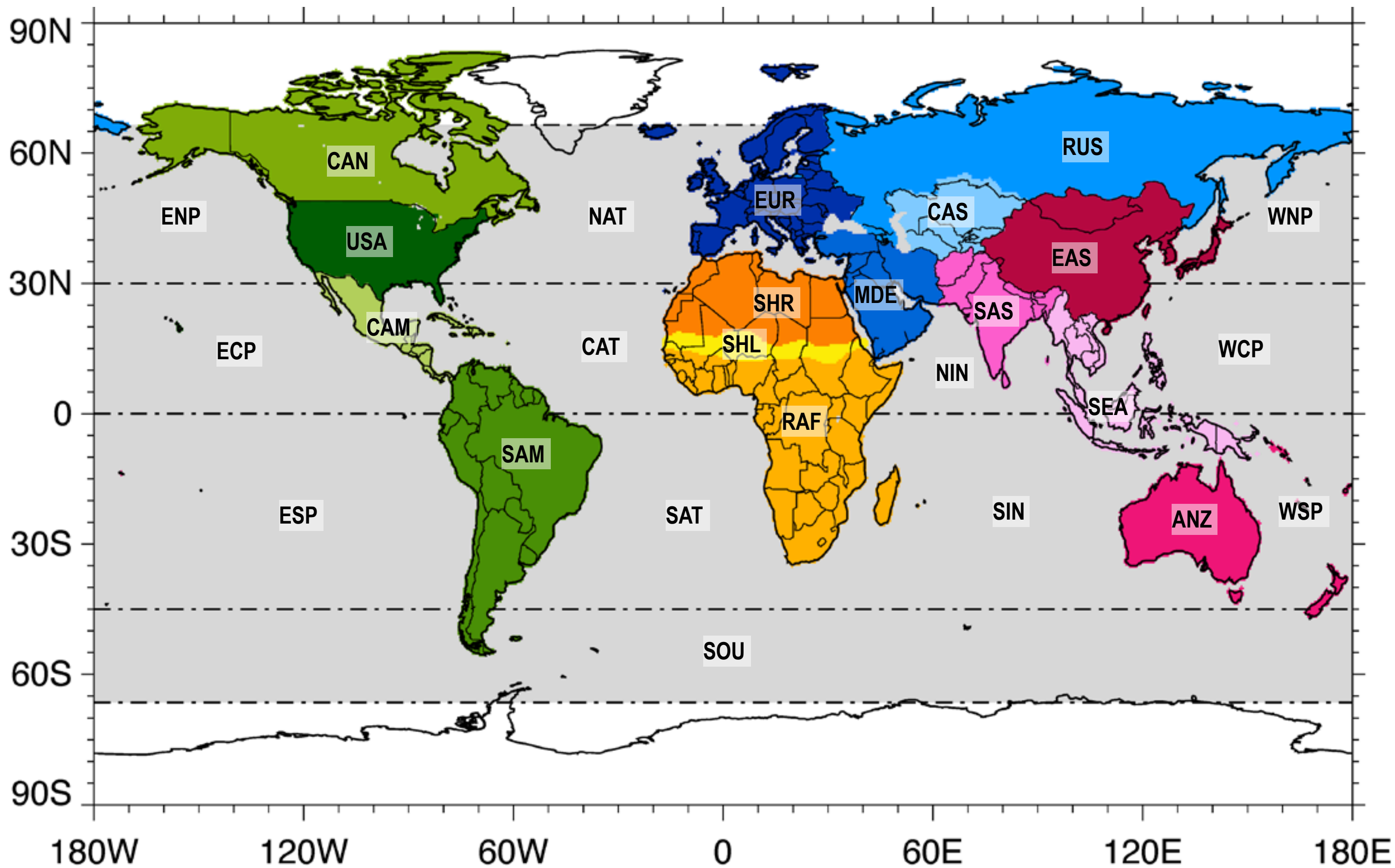


Left: AERONET sunphotometer sites. Right: surface concentrations sites of IMPROVE network in the U.S. (green circles), EMEP network over Europe (blue circles), AMAP sites over the Arctic (yellow squares), and the University of Miami sites in the islands (red squares).

Global distributions, 2001 average



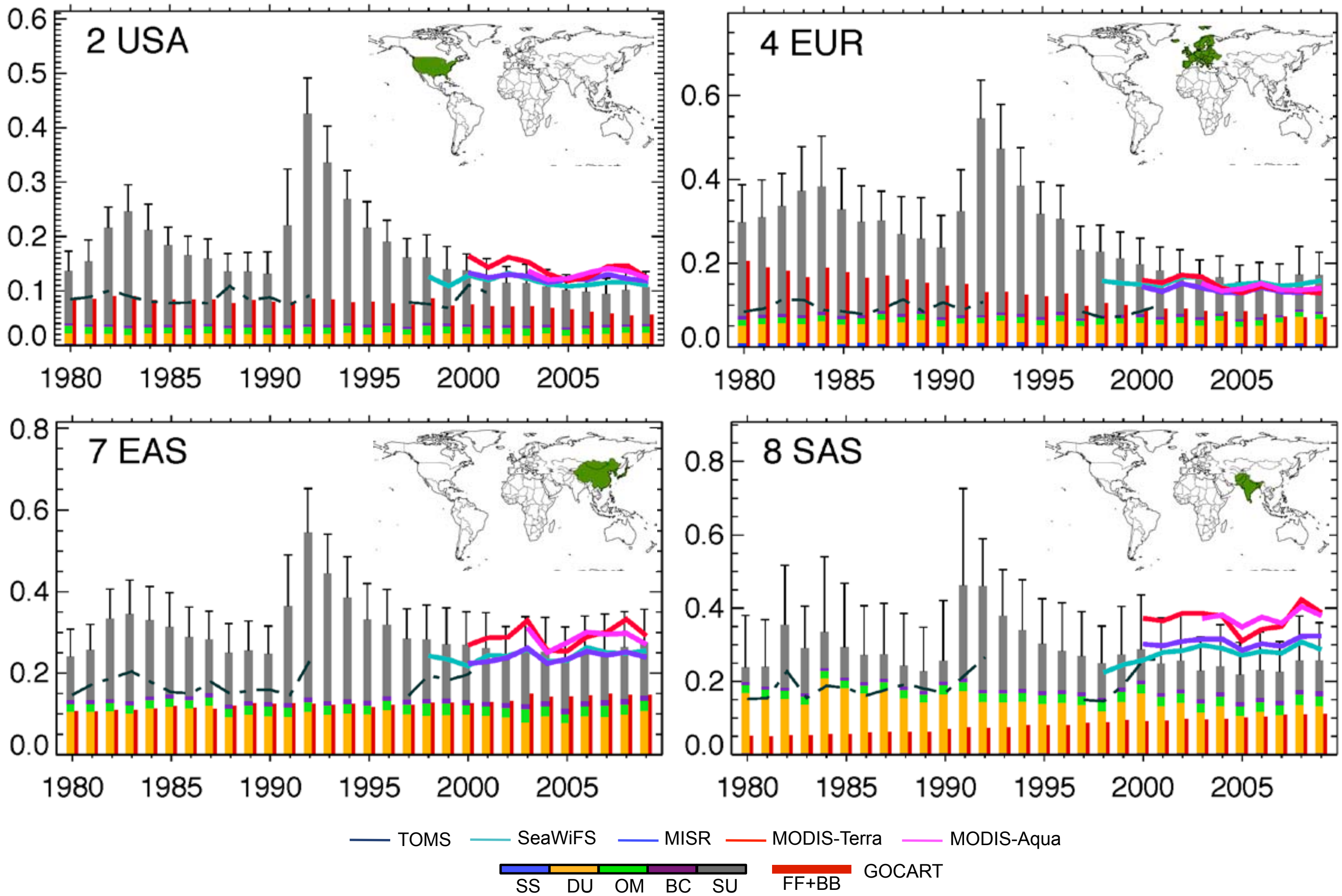
Global land and ocean regions



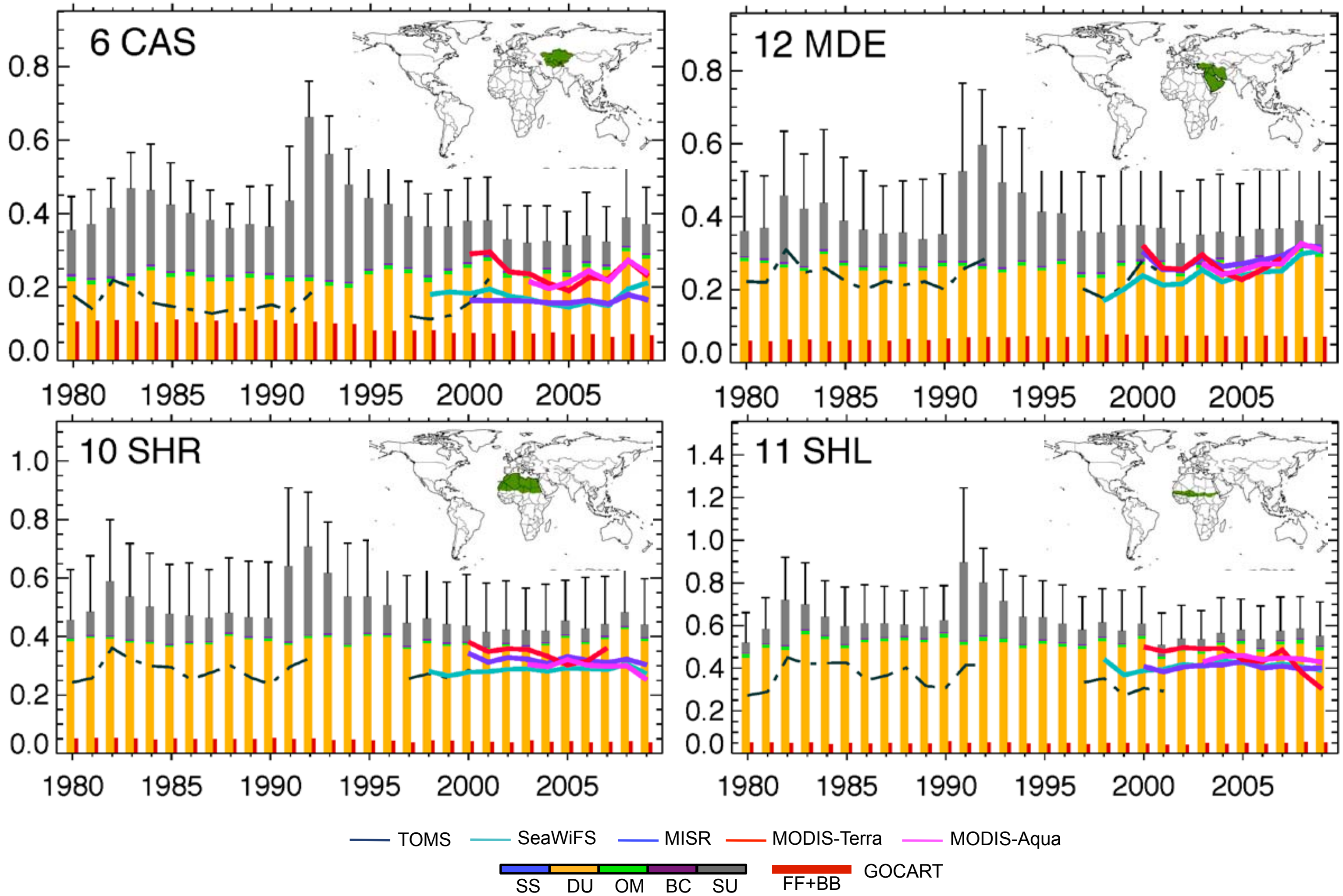
Main conclusions

- Aerosol characteristics and changes have to be examined on regional basis in a global context
- NH pollution regions:
  - The change is mostly driven by the change of regional pollutant emissions, although the change of dust could amplify or mask the trend of pollutants over some regions
- Arctic:
  - SO2 and sulfate concentrations over the Arctic is mainly driven by the European emission changes in past 30 years
- Dust:
  - Dust emissions in Sahel has a decreasing trend since the mid-1980s, mainly due to the decreasing of 10-m winds
  - Dust over Central Asia has increased, largely driven by the surface drying trend Dust over the Middle East has increased in the later half of the 30-year period, controlled by both winds and ground wetness
- Tropical Atlantic:
  - The transatlantic transport of dust has been weakening, which is mostly correlated with the decreasing of Sahel dust emission and the increasing of SST
- Global:
  - No statistically significant trends averaged over land and averaged over ocean

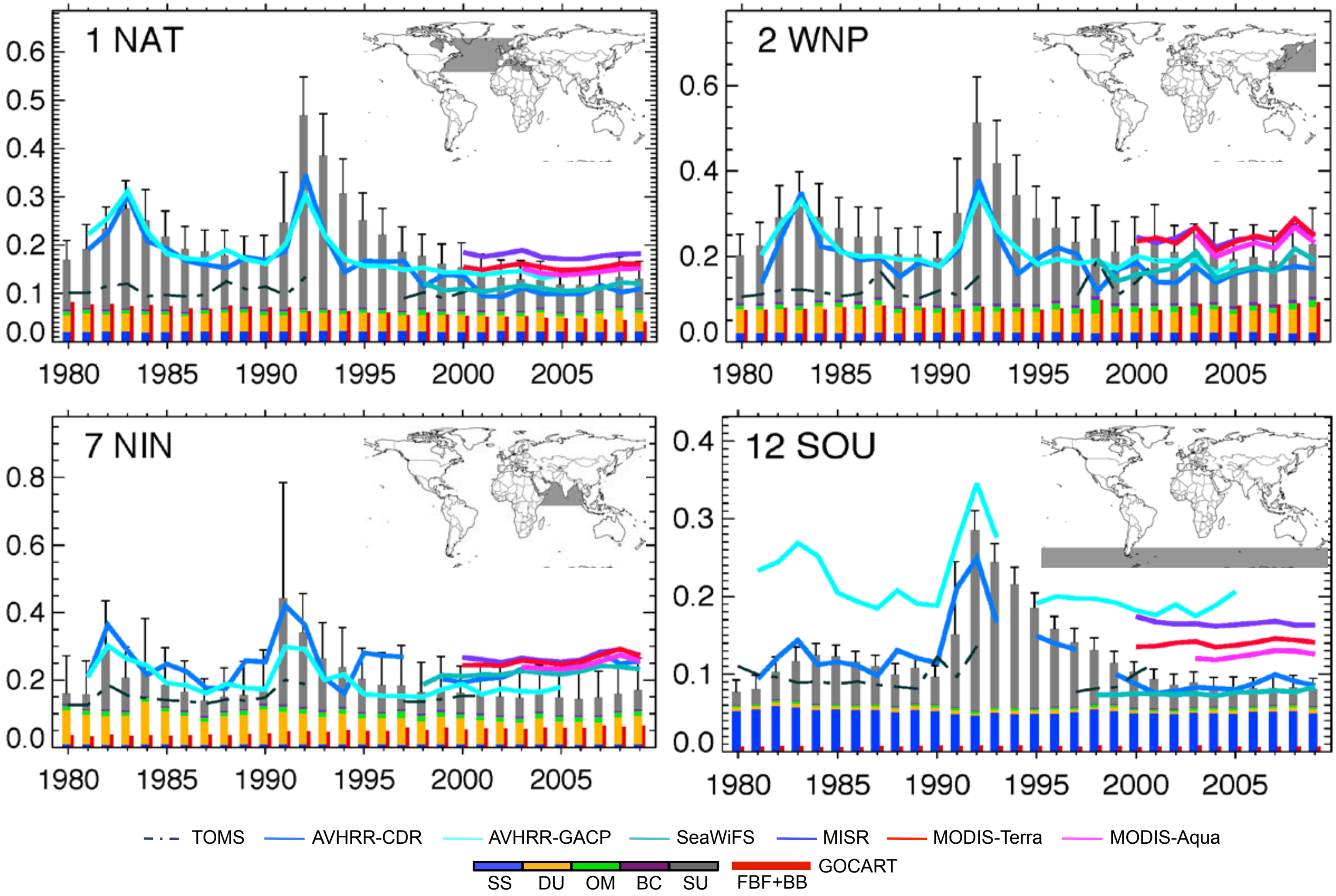
Over polluted NH source regions



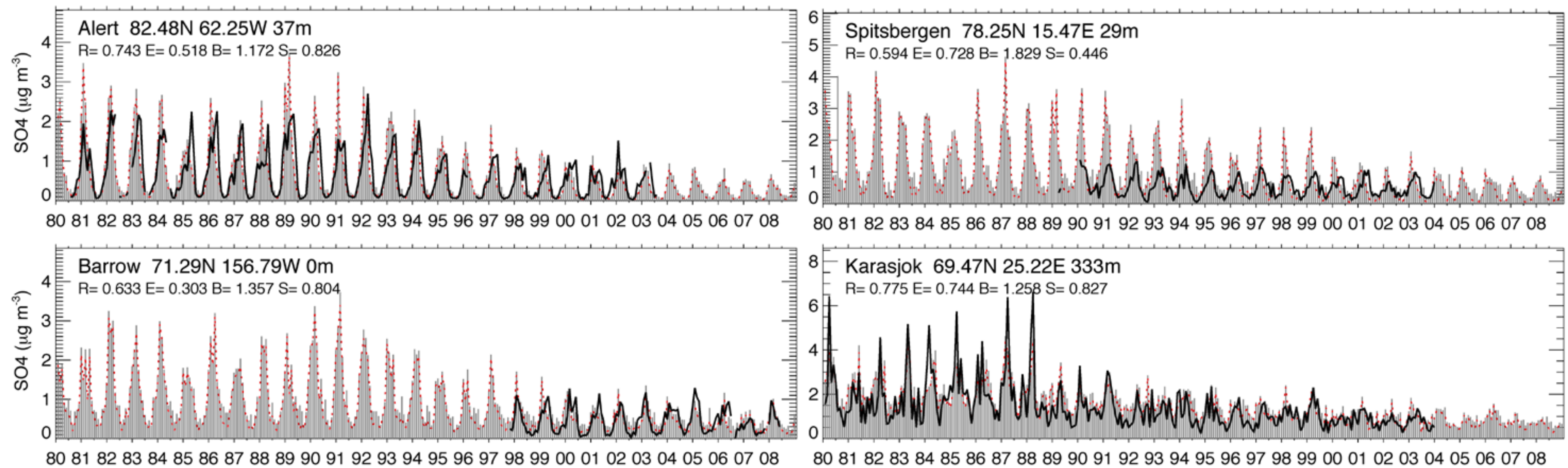
Over dust source regions



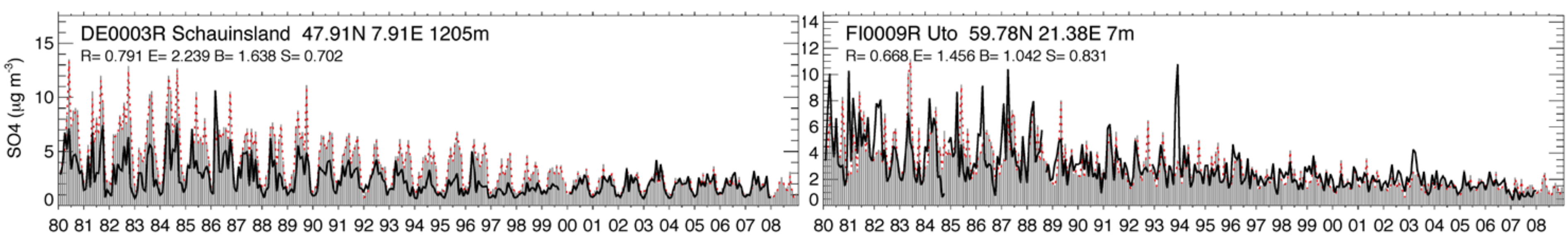
Over ocean regions



Over the Arctic – sulfate concentration

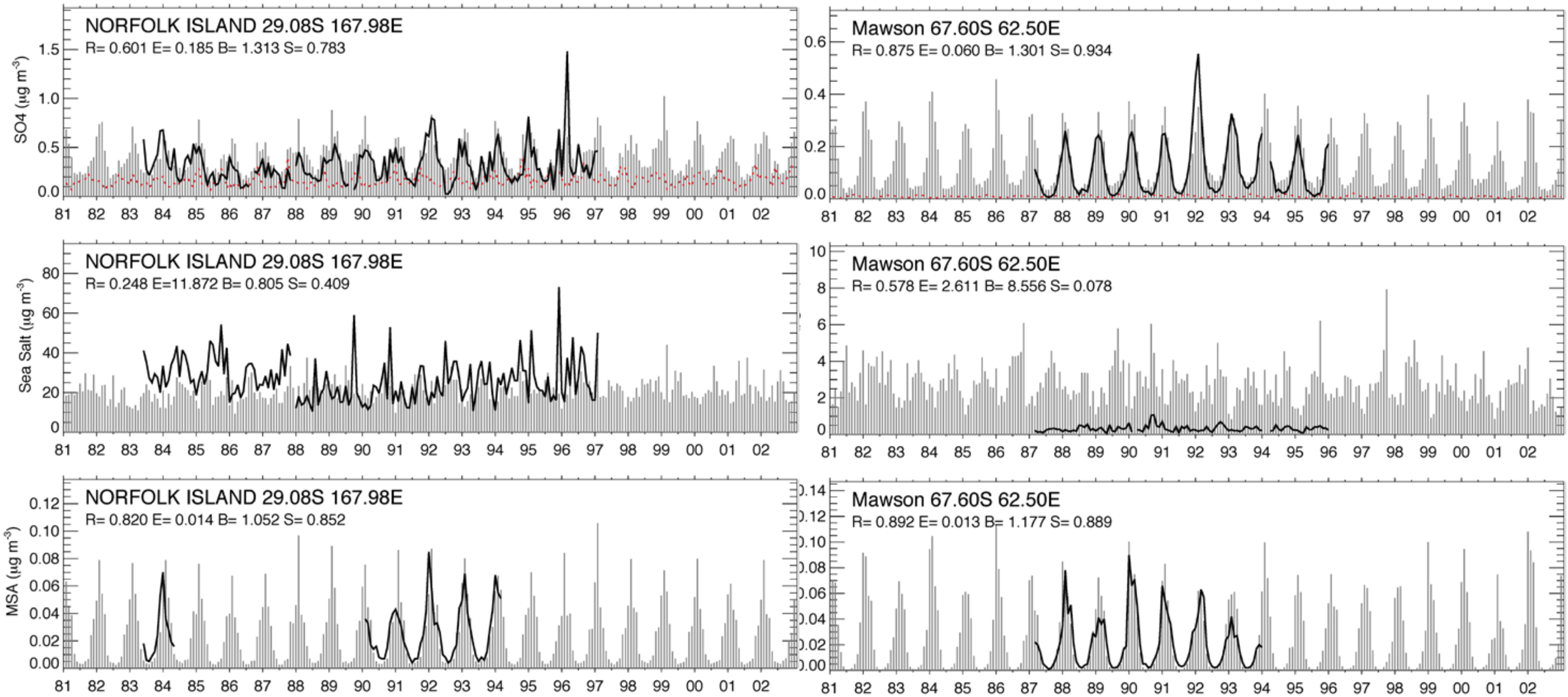


Reduction of the Arctic sulfate is mostly in line with the redution of sulfate in Europe:



Black line: observation. Grey shade: GOCART. Red dotted line: GOCART sulfate from FF+BB sources

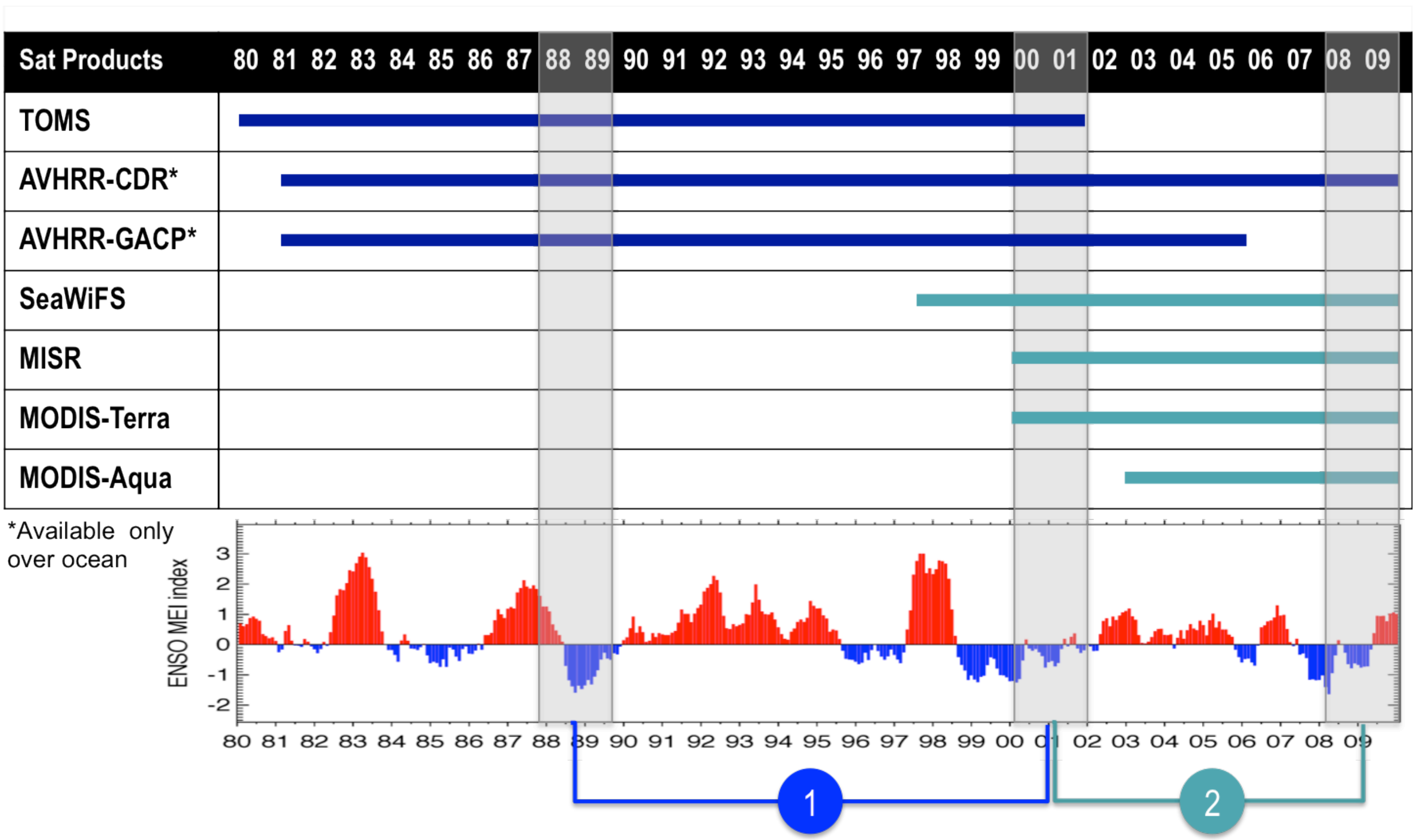
Over remote oceans



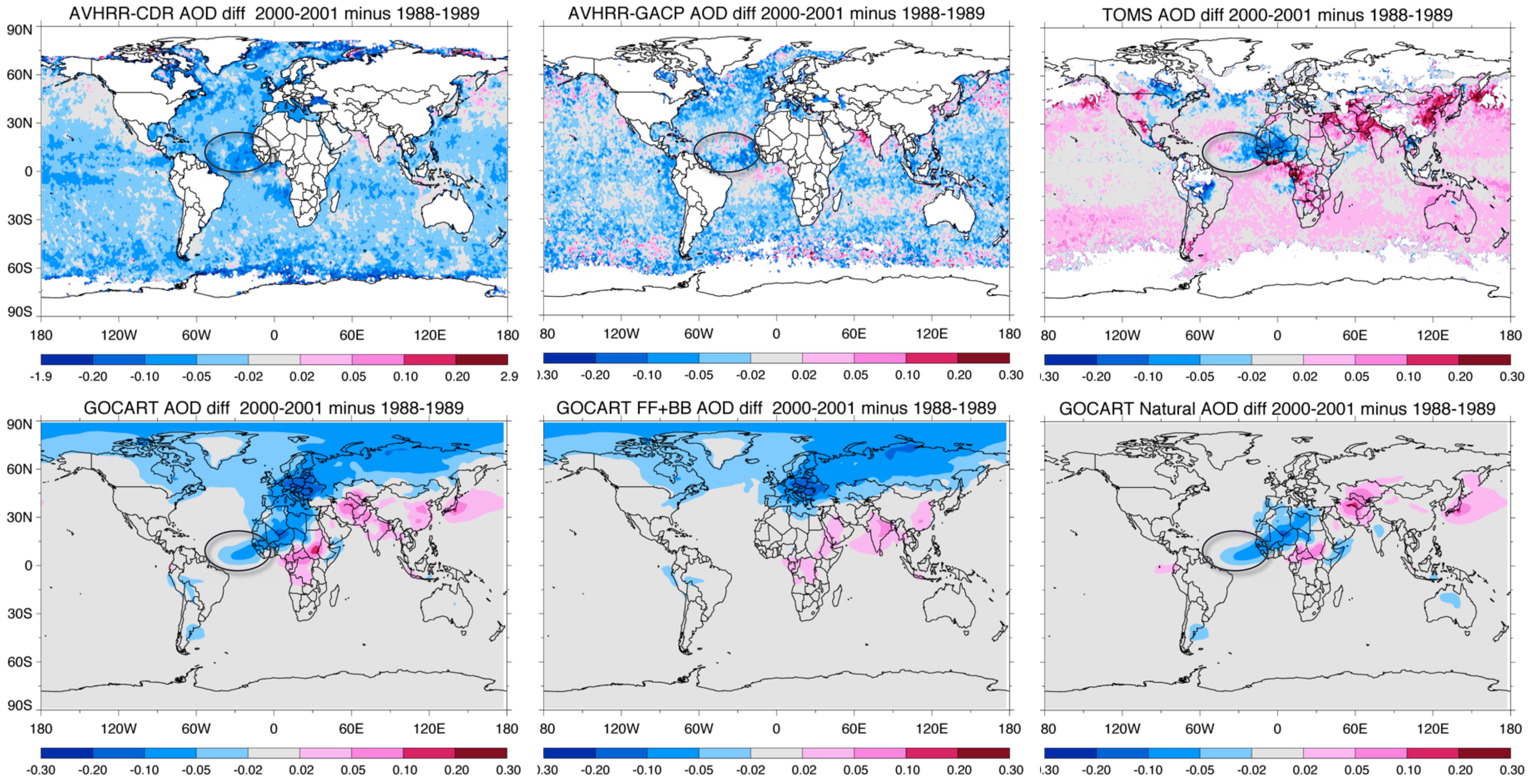
Black line: observation. Grey shade: GOCART. Red dotted line: GOCART sulfate from FF+BB sources

Select periods to reveal change maps

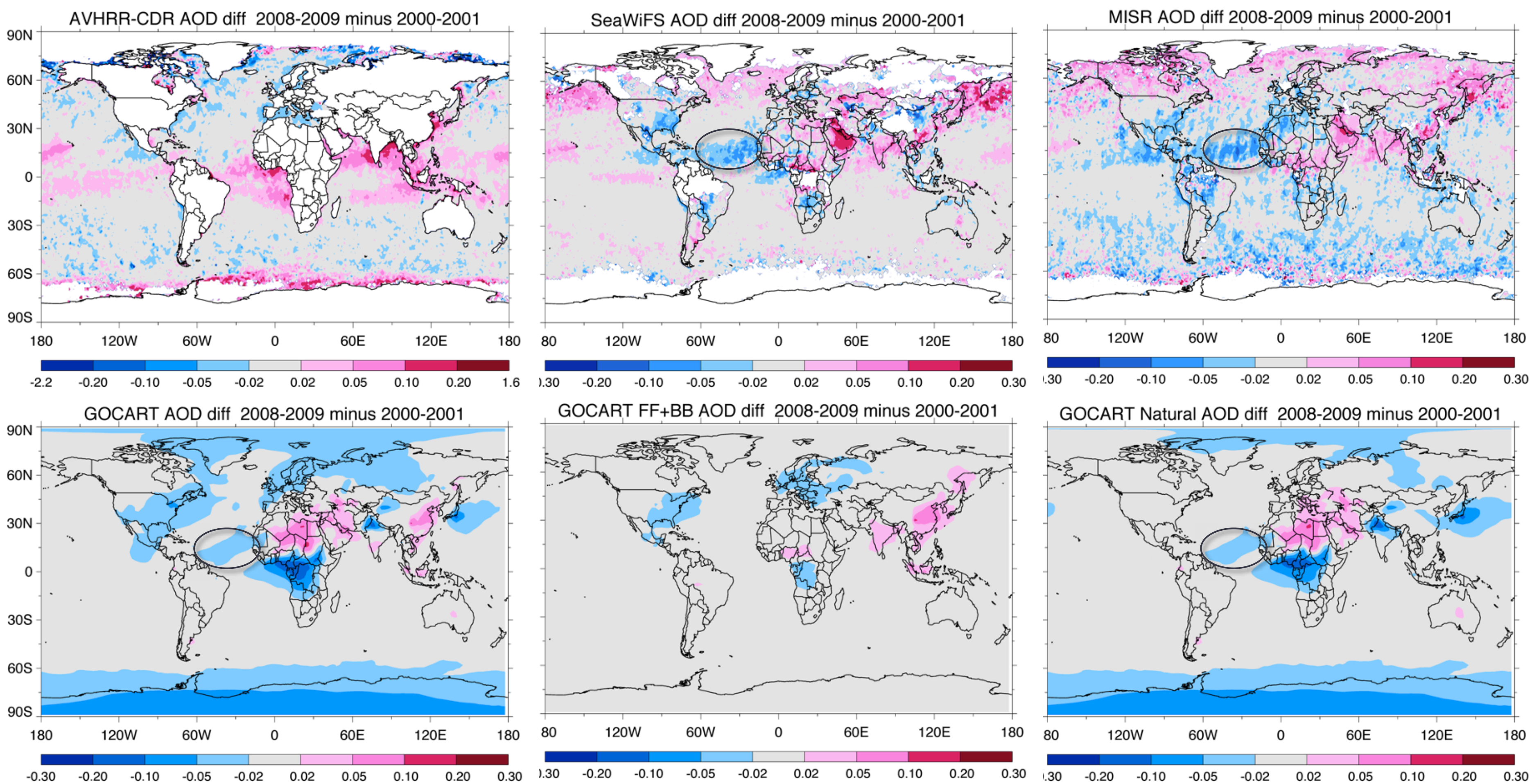
- Have to minimize El Chichon and Pinatubo influences
- Should select “normal” climate conditions



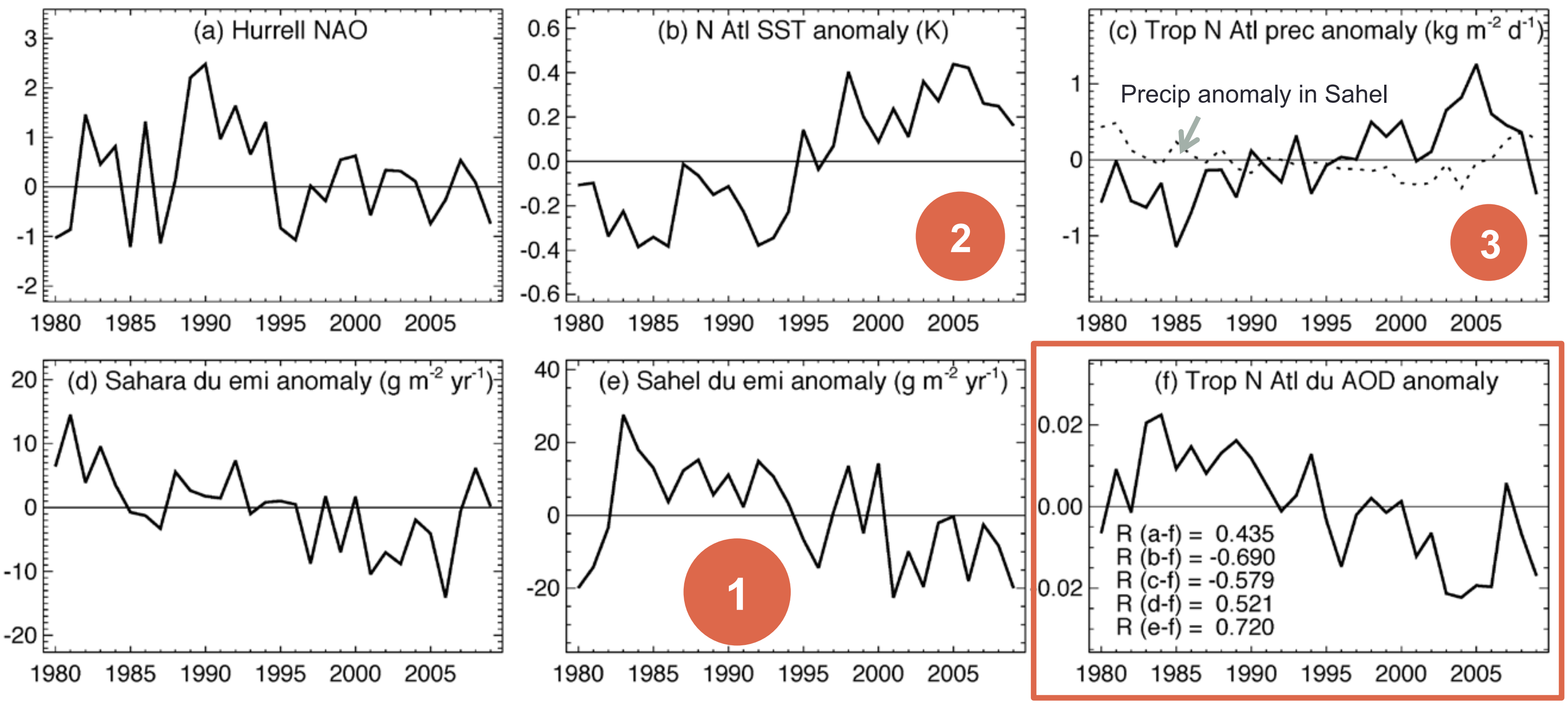
Where the changes occur ? (2000-2001 minus 1988-1989)



Where the changes occur? (2008-2009 minus 2000-2001)

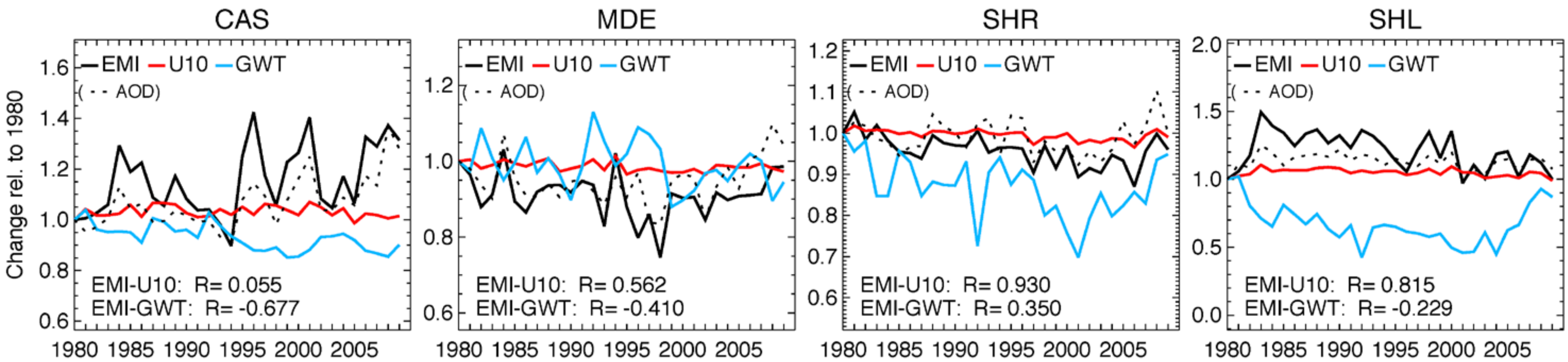


Why is AOD over tropical North Atlantic decreasing?



The change of dust AOD over the tropical North Atlantic is mostly correlated with the change of Sahel dust emission, reversely correlated with the change of SST, and reversely correlated with the change of precipitation over the North Atlantic – they are likely linked to the change of the same climate system

What is driving dust emission change?



Ground wetness driven

Wind and ground wetness driven

Wind driven

Wind driven

Is there a global “trend” of AOD?

Annual and global averaged AOD (% from FF+BB):

Averaged area	1980	1990	2000	2009
Land	0.19 (38%)	0.20 (37%)	0.20 (30%)	0.18 (33%)
Ocean	0.09 (31%)	0.10 (28%)	0.10 (23%)	0.09 (27%)
Globe	0.12 (34%)	0.13 (32%)	0.13 (26%)	0.11 (29%)

- Averaged over entire land, ocean, or global area, there is little “trend” of AOD – **the ups and downs are averaged out**!
- But the contributions from FF+BB have larger variation

Main conclusions

- Aerosol characteristics and changes have to be examined on regional basis in a global context
- ***NH pollution regions:*** Changes mostly driven by the change of regional pollutant emissions
- ***Arctic:*** Change mainly driven by the European emission changes
- ***Dust:*** Sahara and Sahel driven by the change of 10-m winds, Central Asia by ground dryness, and Middle East by both
- ***Tropical North Atlantic:*** The decrease of dust AOD is mostly related to the (a) reduction of Sahel dust emission, (b) increase of SST, and (c) increase of precipitation over the tropical North Atlantic. All are connected with the same climate system change
- ***Global:*** No statistically significant trends averaged over land and averaged over ocean. Therefore using a global average to infer the aerosol variations or trends is meaningless