Impact of past changes in European aerosol emissions on Arctic climate

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Motivation

- Anthropogenic aerosols are short-lived atmospheric constituents, which play a dualistic role in the earth system

  - as a forcing agent for the Earth's climate and

  - as environmental pollutants with potentially adverse impacts on fresh water, soils, vegetation and human health

- The changes in the magnitude and spatial patterns of global aerosol emissions have occurred especially during the last two decades of the 20th century and are projected to continue over the 21st century

- Of particular relevance for the Arctic are the reductions in sulphate from industrial activities, domestic heating, and power production that have taken place in Europe since 1980
Tool: **Norwegian Earth System Model** (NorESM)

- **CAM4-Oslo**
  - Atm. Chemistry and Physics
  - 1.9°X 2.5°; 26 levels in vertical

- **CLM4-CN**
  - snicar: snow albedo

- **CICE4**
  - sea-ice albedo

- **MICOM**
  - ~ 1° along the equator
gx1v6
Reference simulations

- Transient simulations where greenhouse gas concentrations and aerosol emissions vary with time according to best estimates
- follow the CMIP5 protocol and cover the time period 1850-2012
- For the present study, only the years 1980-2005 are considered

_Bentsen et al., 2013; Iversen et al., 2013; Kirkevåg et al., 2013_
1980 SO$_2$ EMEP simulations

- For aerosol sensitivity studies, transient simulations for the period 1980-2005 are carried out where the European emission of SO$_2$ is fixed at the 1980 level.

- All the remaining forcings vary with time similar to the reference simulations

- Represented by a 3 member ensemble started from different initial conditions.
Annual mean **globally** averaged column burden SO$_4$
Annual mean **globally** averaged surface temperature
The observed warming at Spitsbergen during the period 1993-2012 (Maturilli et al., 2014) is about +2.6K
Seasonal mean surface temperature anomaly

Reference – 1980 SO$_2$ EMEP
(i.e. warm – cold)

[Maps showing seasonal temperature anomalies]
Ice fraction anomaly

Reference – 1980 SO$_2$ EMEP
(i.e. warm – cold)

Annual mean

Seasonal mean
Conclusions and outlook

✧ Reductions in European SO$_2$ emissions between 1980 and 2005 appear to have had a substantial influence on the Arctic climate.

✧ As more countries adapt different strategies to reduce air pollution, it is important to examine how this will affect surface temperature and other parameters along with the top-of-the-atmosphere radiative forcing since they play a significant role in determining the Earth’s climate.

✧ Analyses currently going on to understand the mechanisms for the relation between changes in aerosol burden, forcing and temperature response.