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

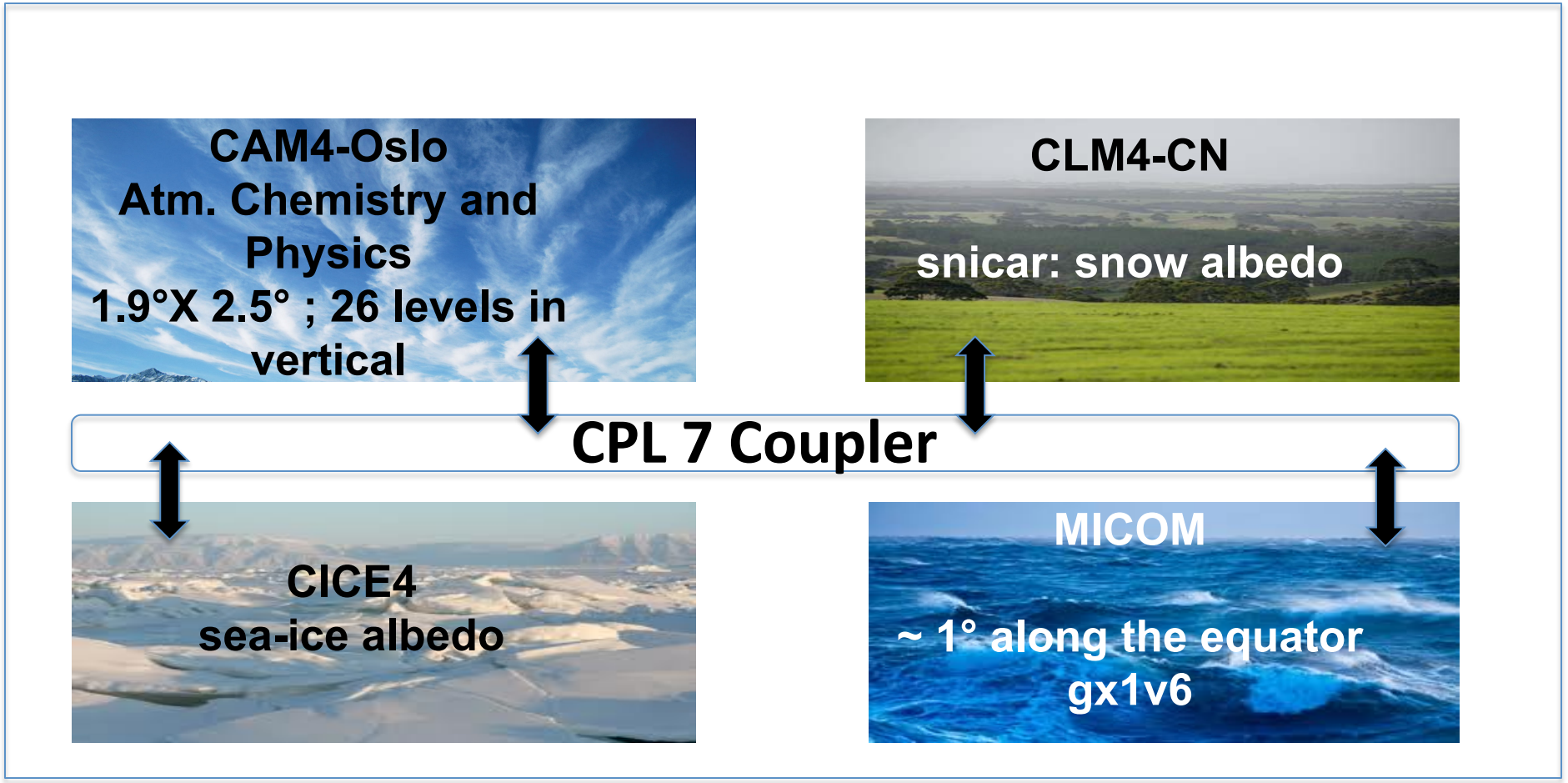
➢ as a forcing agent for the Earth's climate and

➢ 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 20^{th} century and are projected to continue over the 21^{st} century

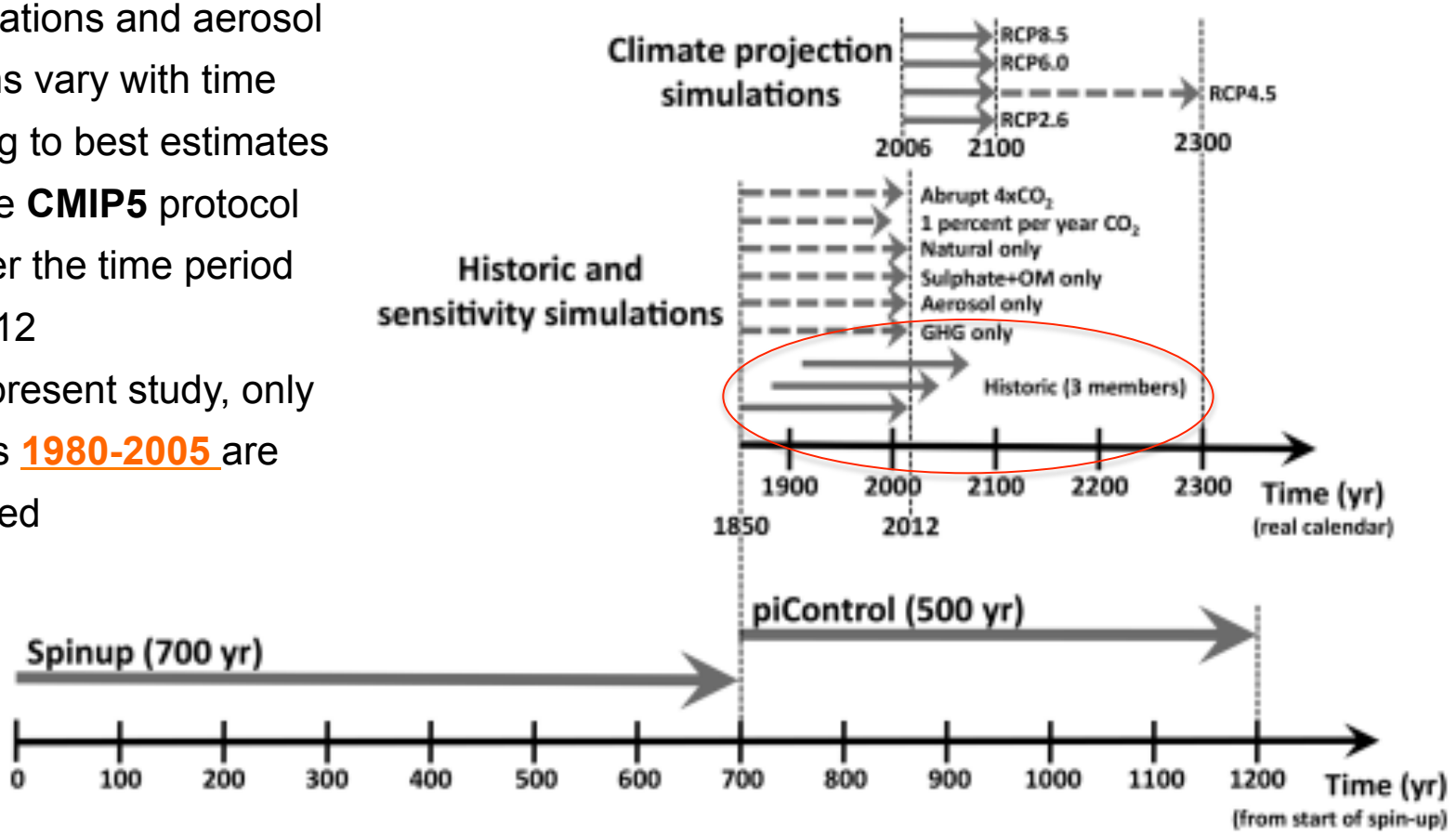
• Of particular relevance for the Arctic are the reductions in sulphate from industrial activities, domestic heating, and power production that have taken place in Europe since 1980

Tool: **Nor**wegian **E**arth **S**ystem **M**odel (NorESM)



Reference simulations

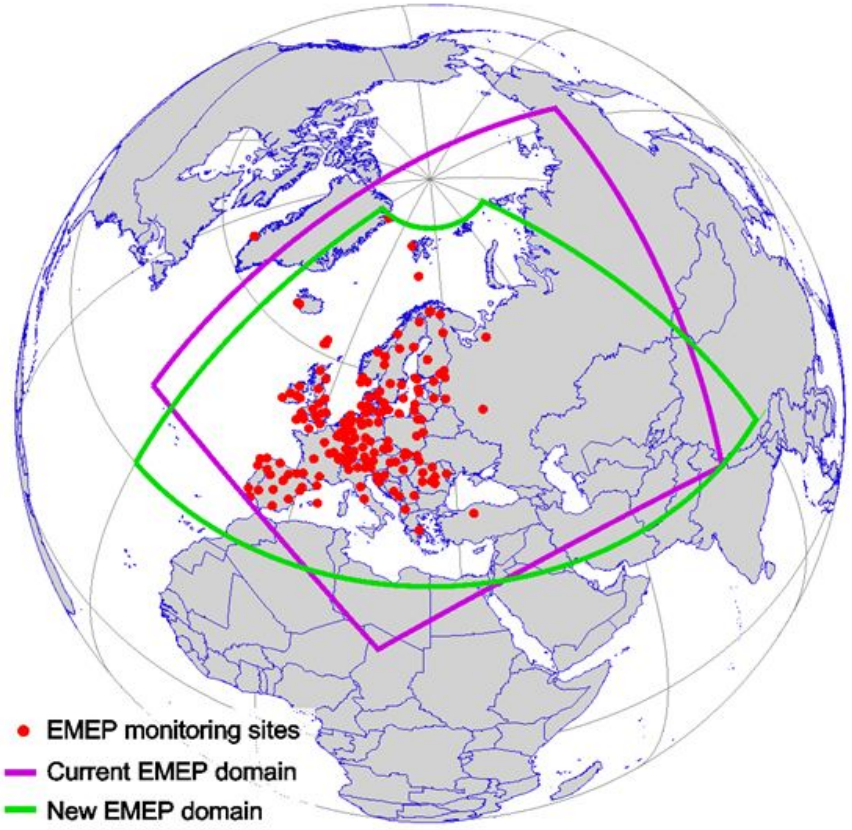
- Transient simulations where greenhouse gas concentrations and aerosol emissions vary with time according to best estimates
- follow the **CMIP5** protocol and cover the time period 1850-2012
- For the present study, only the years **1980-2005** are considered



Bentsen et al., 2013; Iversen et al., 2013; Kirkevåg et al., 2013

1980 SO_2 EMEP simulations

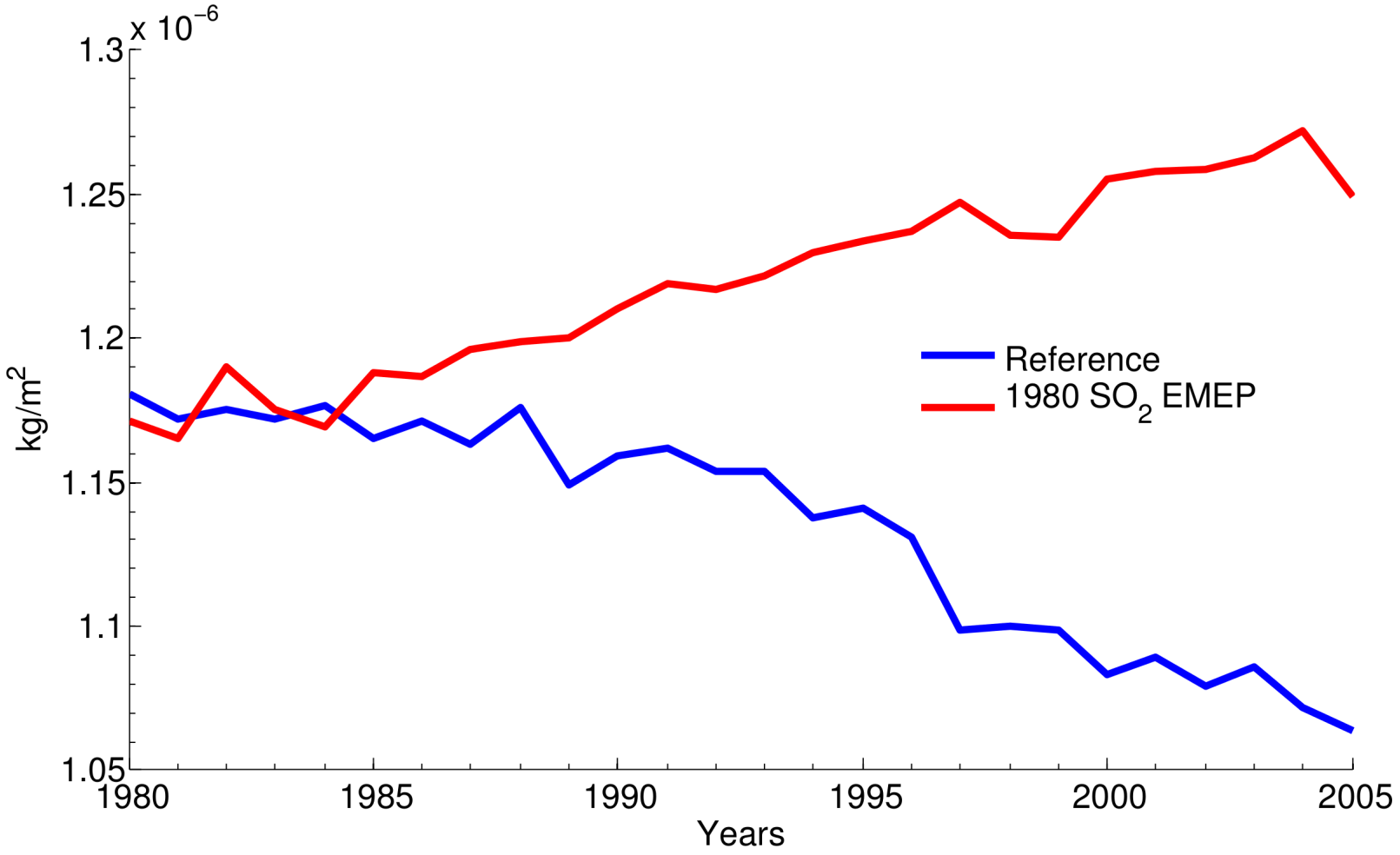
- For aerosol sensitivity studies, transient simulations for the period 1980-2005 are carried out where the European emission of SO_2 is fixed at the 1980 level.



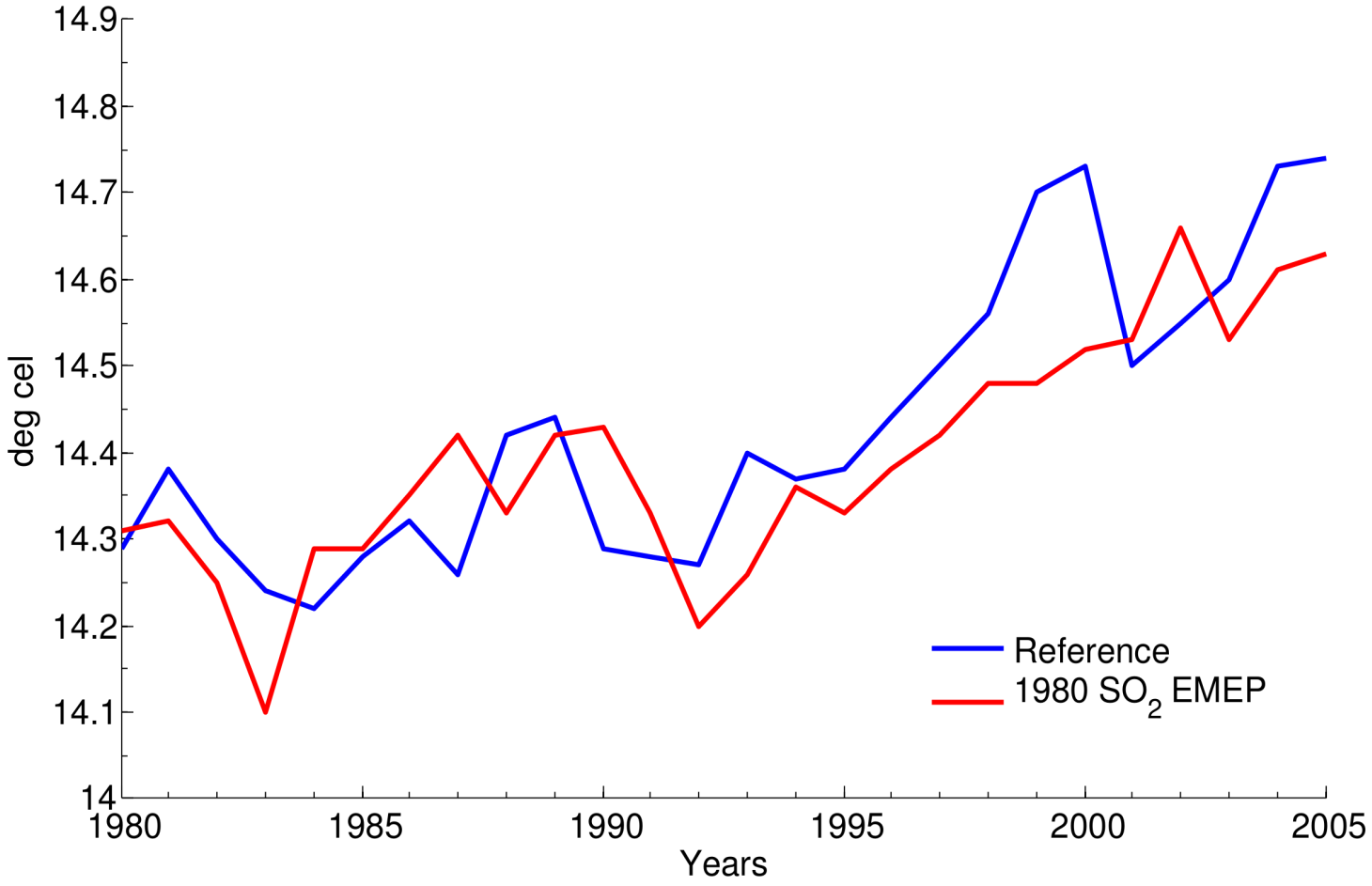
- All the remaining forcings vary with time similar to the reference simulations

- Represented by a 3 member ensemble started from different initial conditions.

Annual mean <u>globally</u> averaged column burden SO_4



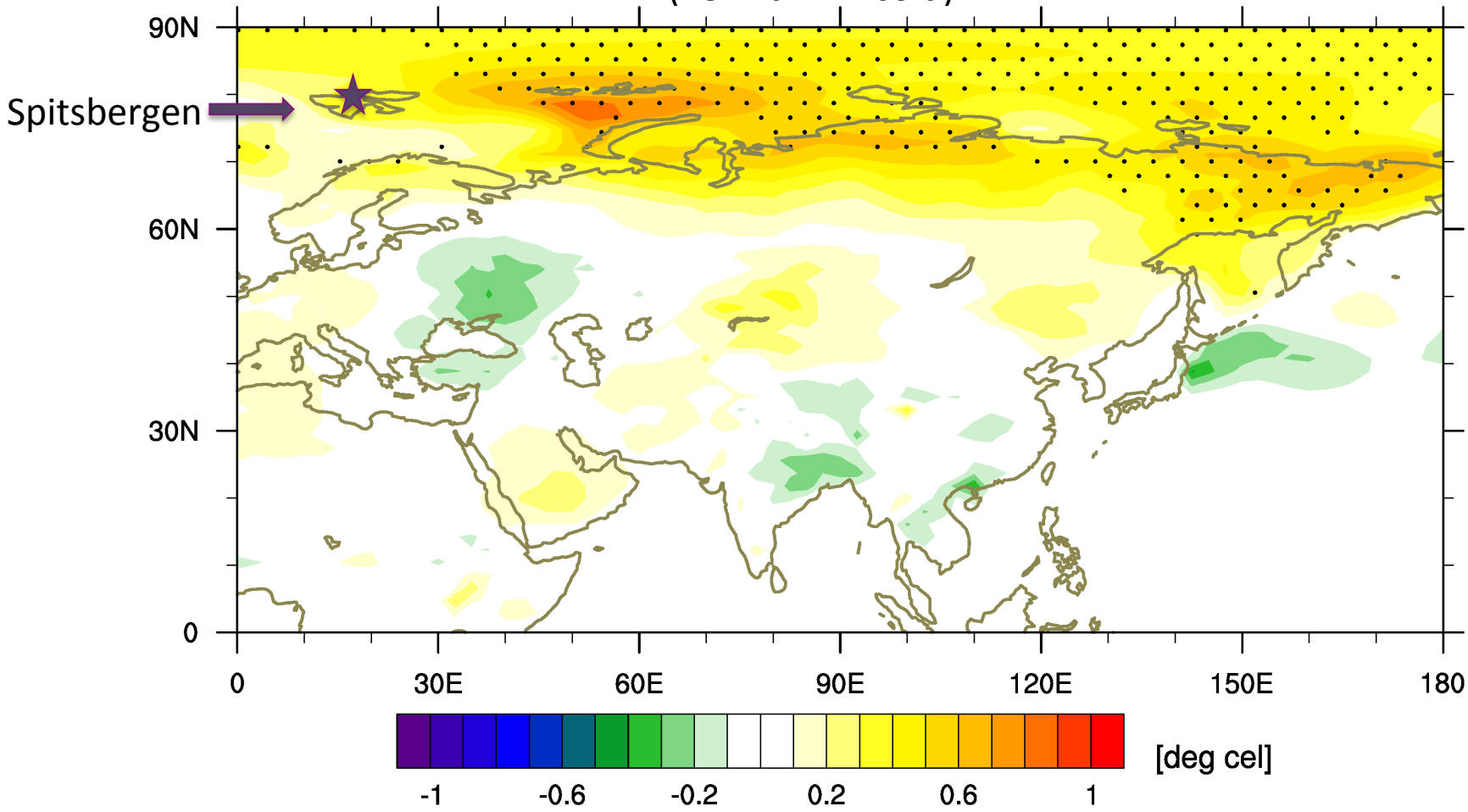
Annual mean globally averaged surface temperature



Annual mean surface temperature anomaly

Reference – 1980 SO_2 EMEP

(i.e. warm – cold)



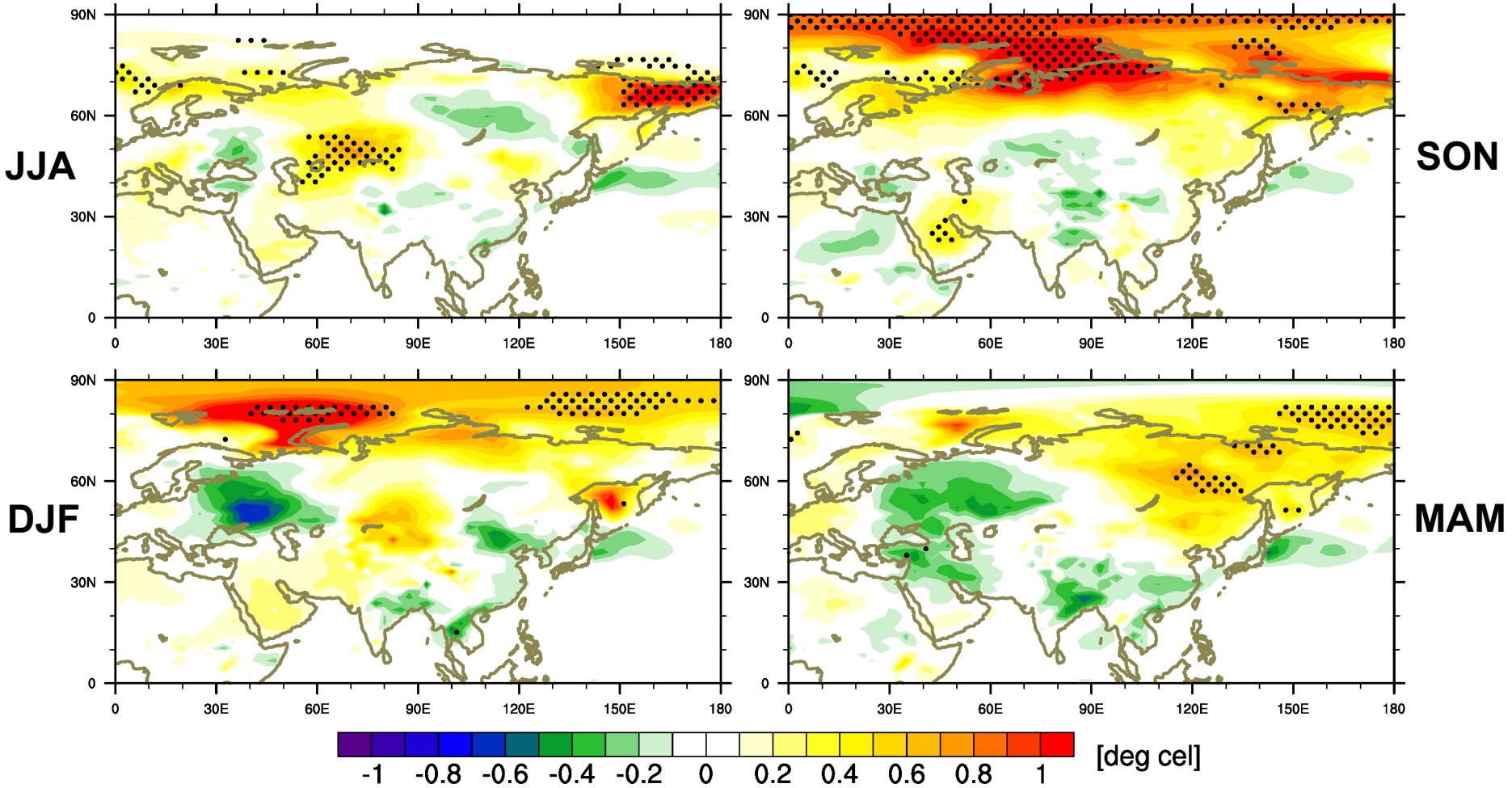
The observed warming at Spitsbergen during the period 1993-2012 (*Maturilli et al., 2014*) is about +2.6K

Stippling indicates statistical significance at 0.05 level

Seasonal mean surface temperature anomaly

Reference – 1980 SO_2 EMEP

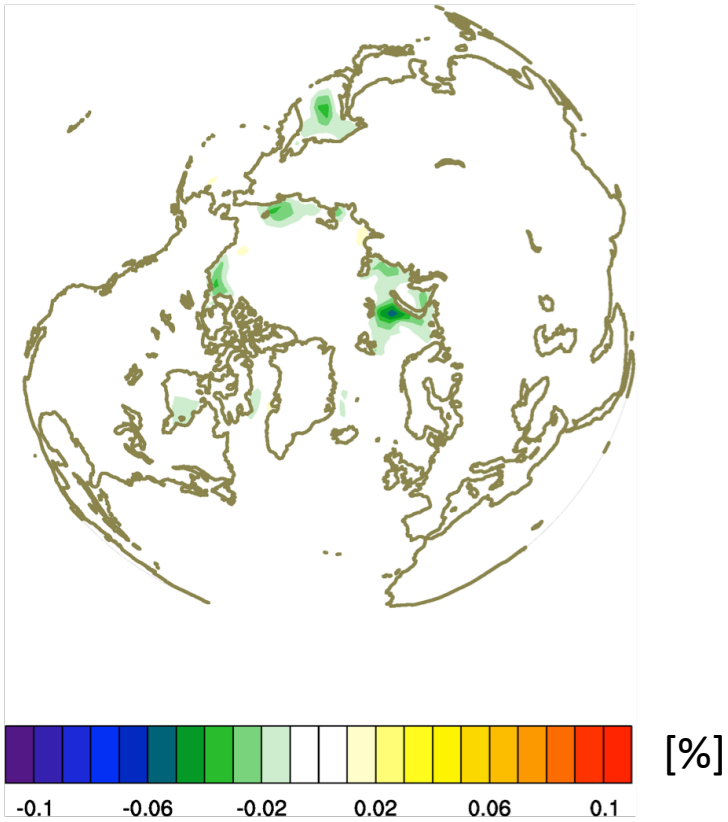
(i.e. warm – cold)



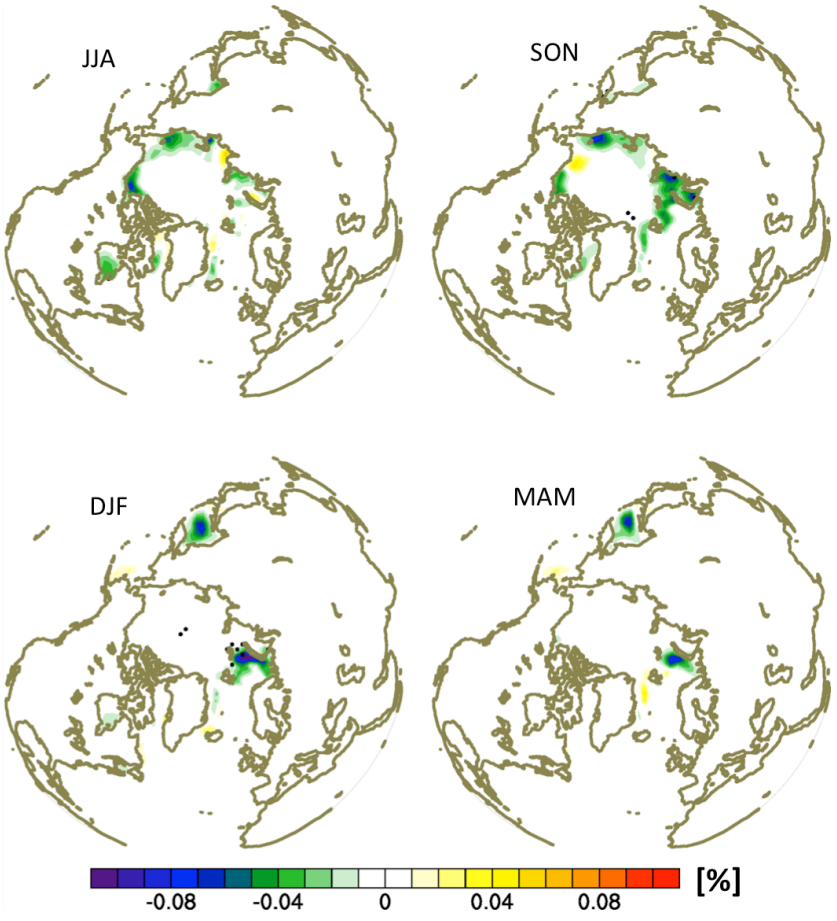
Ice fraction anomaly

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