The contribution of energetic particle precipitations to ozone and surface climate trends

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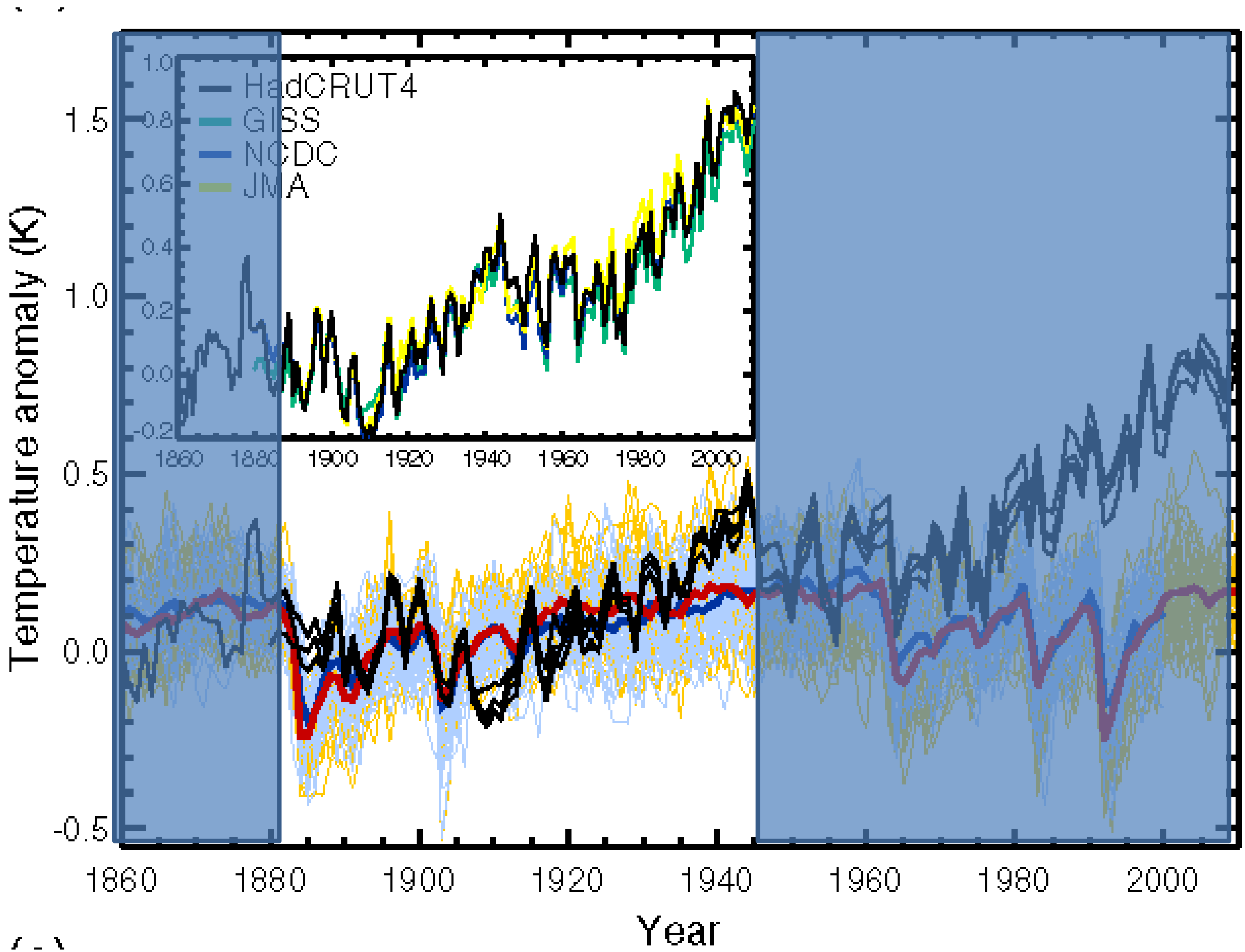
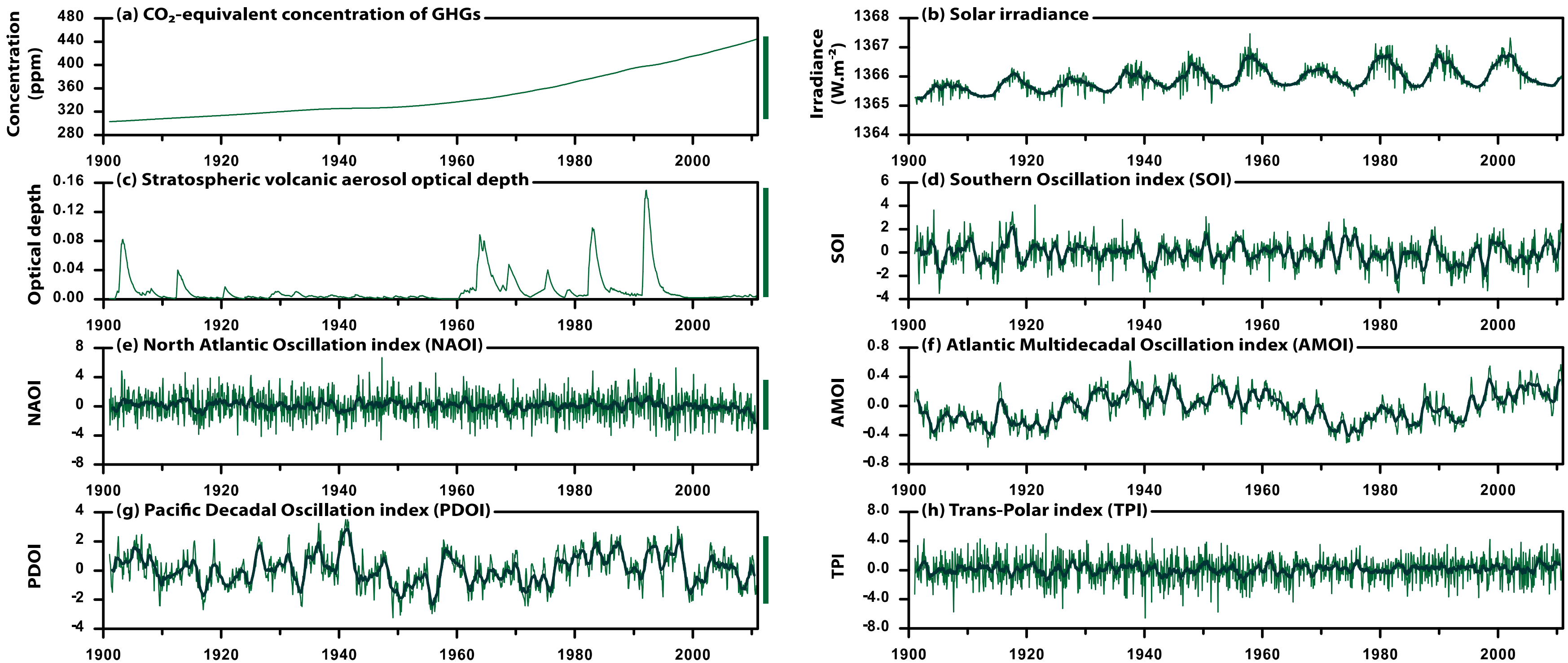
Motivation:
The warming during the first half of 20th century



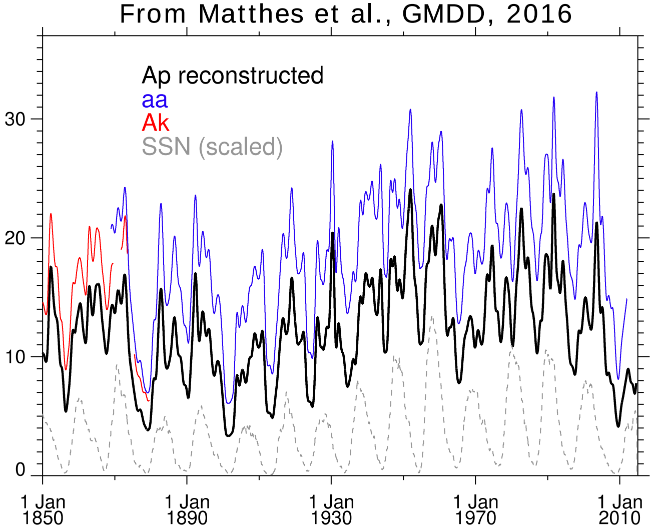
From Jones et al., 2013

Climate drivers

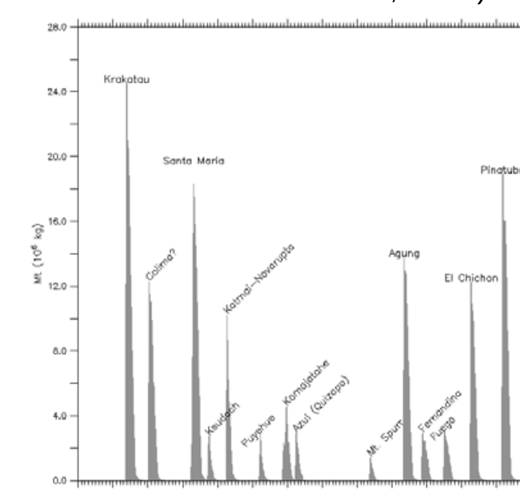
From Mikšovský et al., ESD,2016



From Matthes et al., GMDD, 2016



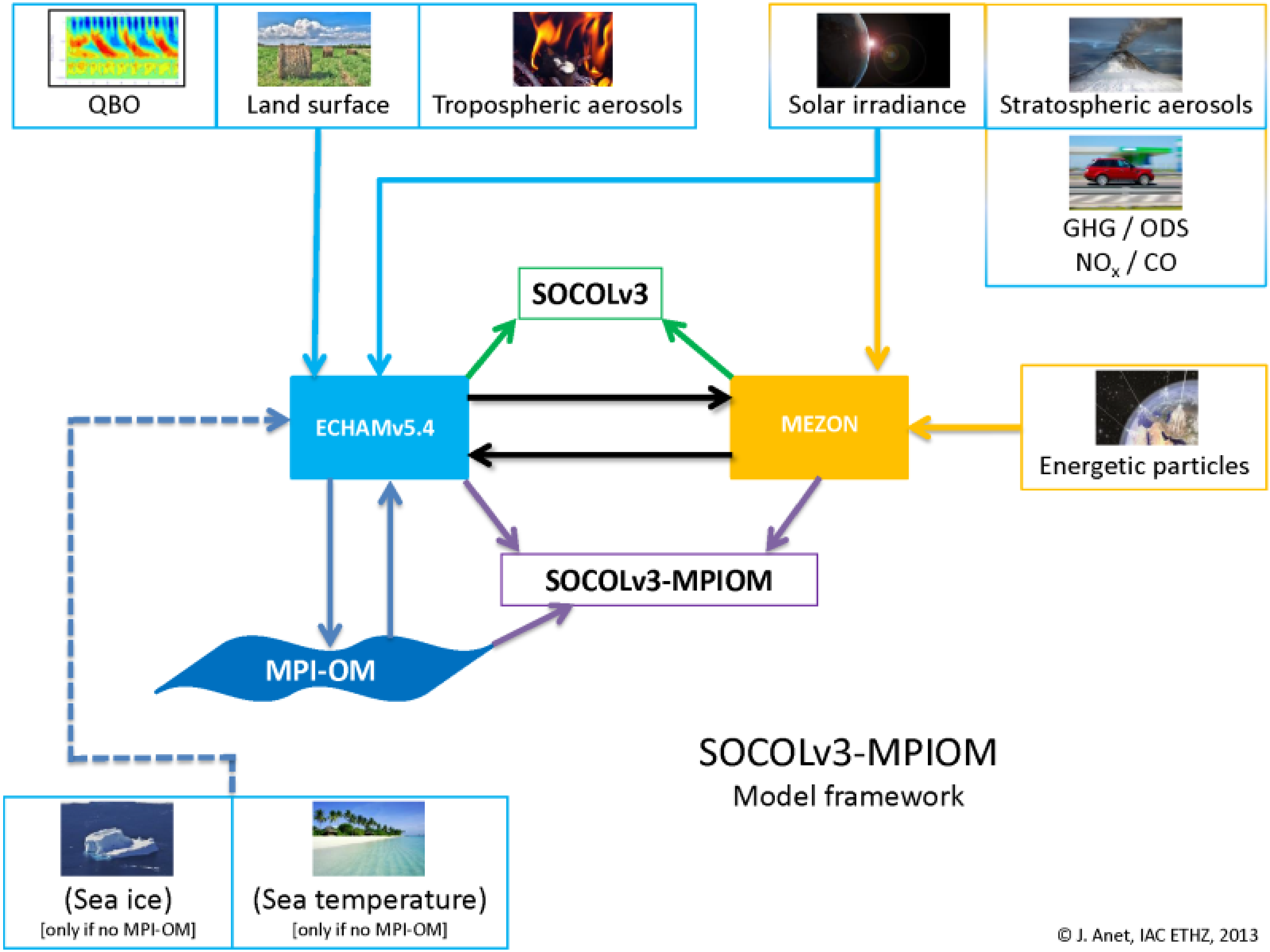
From Annann et al., 2003)



The warming during the first half of 20th century can be explained by:

- Anthropogenic effects
- Recovery after volcanically active period
- Multi-decadal scale variability
- Increase of the solar activity after 1900:
  - ✓ Increase of TSI
  - ✓ Increase of UV
  - ✓ Increase of energetic particle precipitation intensity

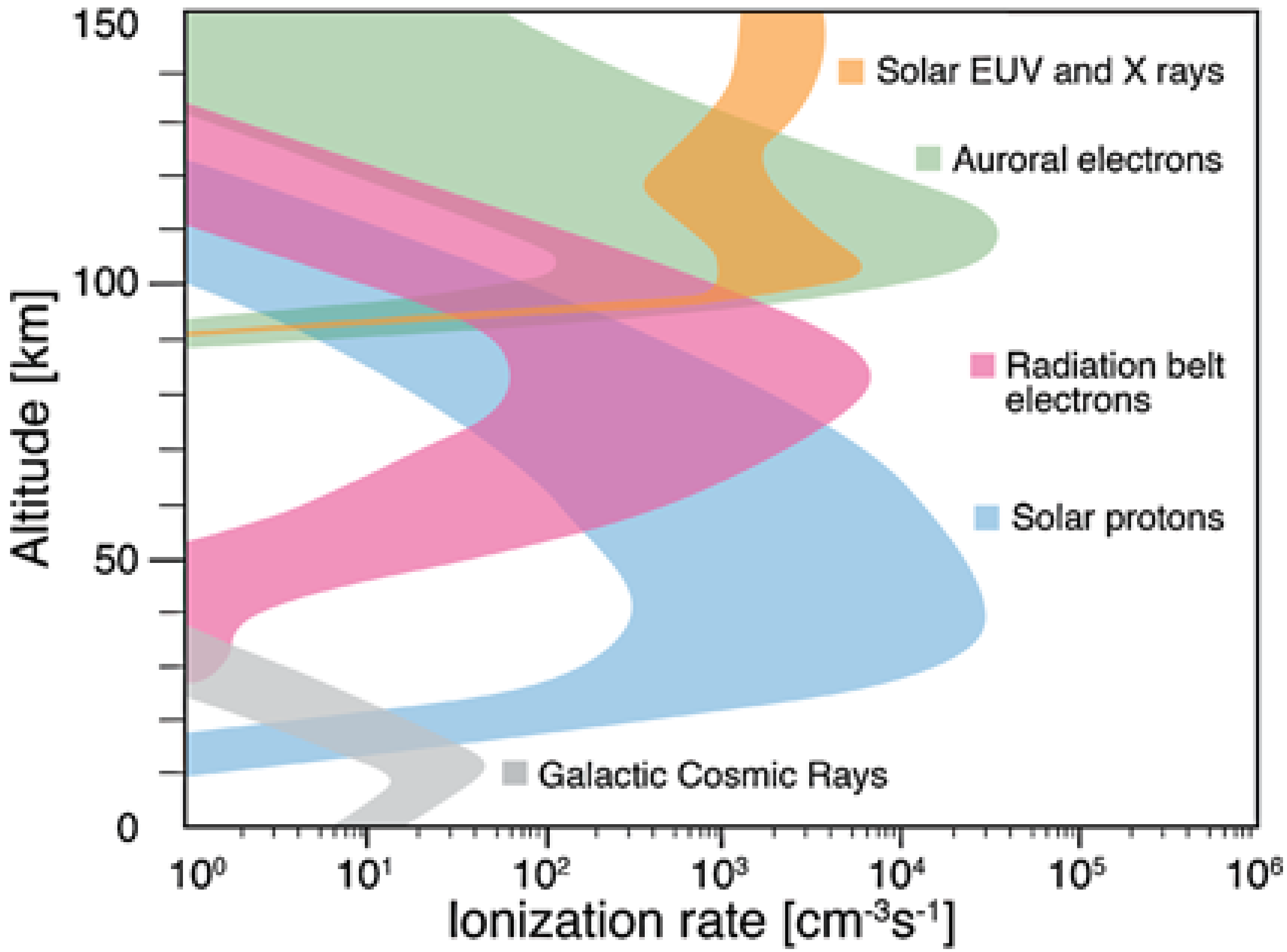
AO CCM SOCOL / MPI-OM



SOCOLv3-MPIOM

Model framework

Types of precipitating energetic particles
based on energy deposition altitude



Instanteneous

Mironova et al., 2015
Matthes et al., 2016

Model's run

11 members

1900 **All drivers except particles (reference run)** **1960**

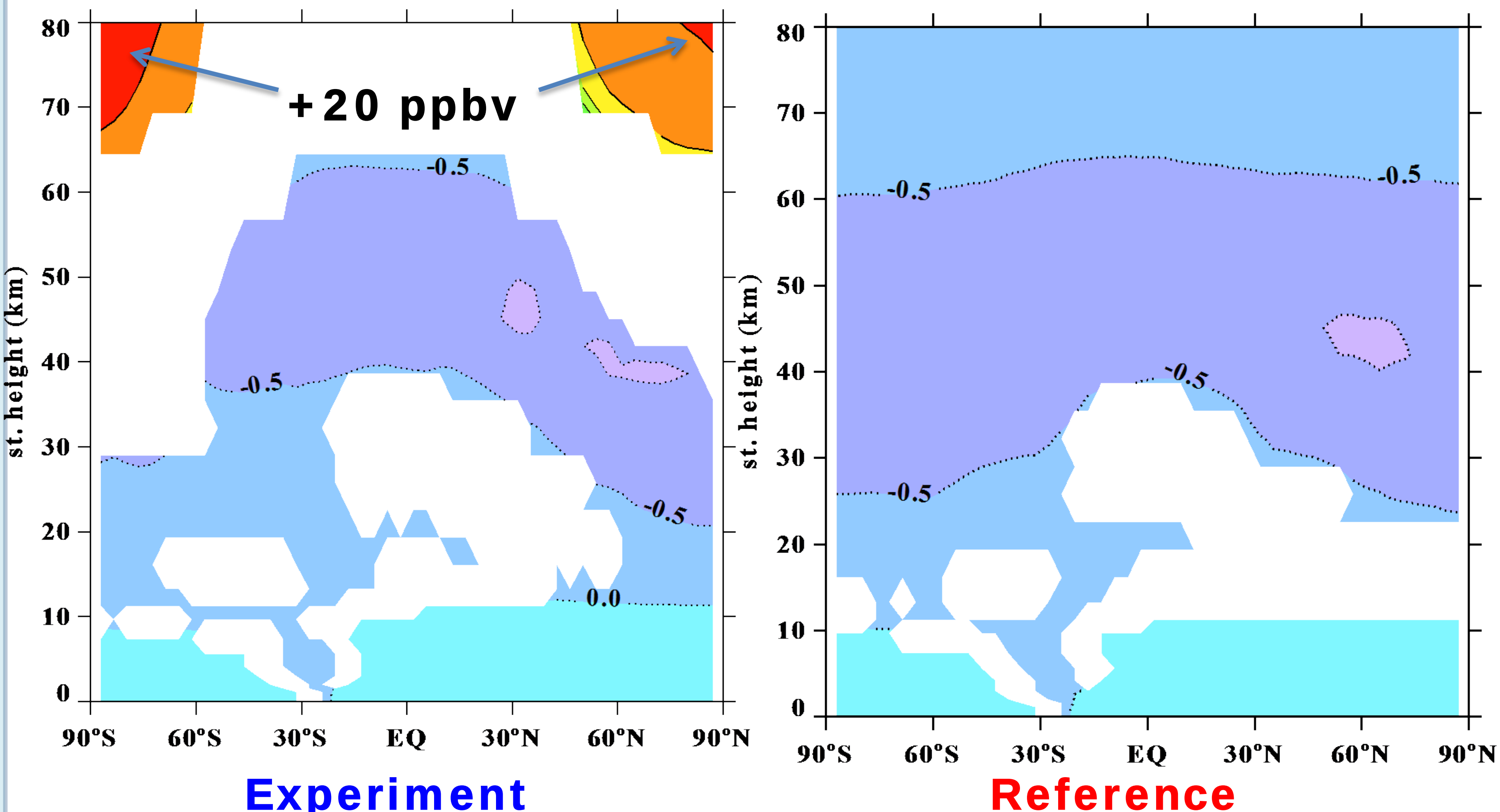
11 members

1900 **All drivers + particles (experiment run)** **1960**

We analalyze TRENDS for1910-1950 calculated using Sen-Mann-Kendall approach.

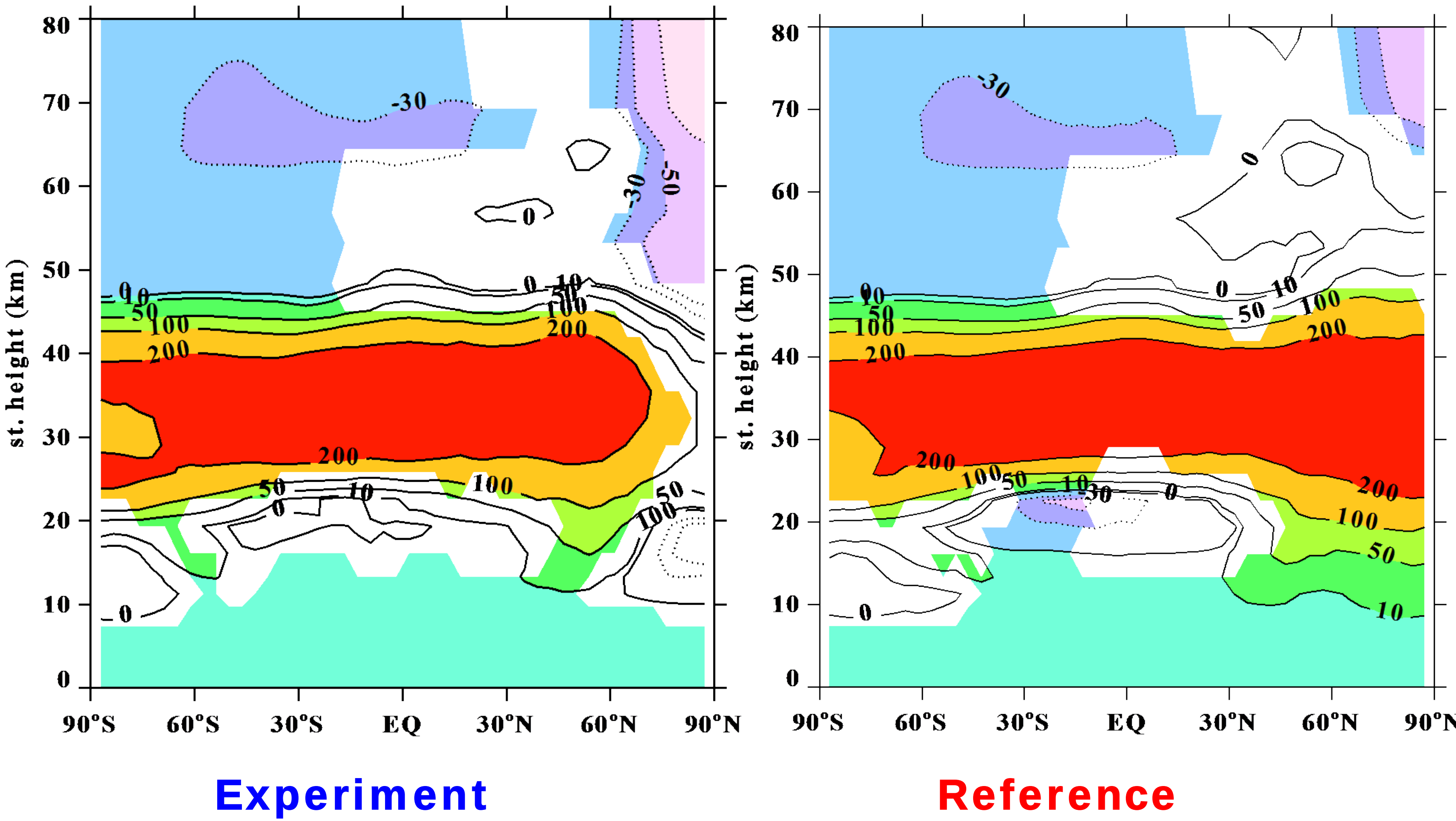
Results: NOy

Linear trend in zonal and annual mean NOy mixing ratio (ppbv) per 40 years



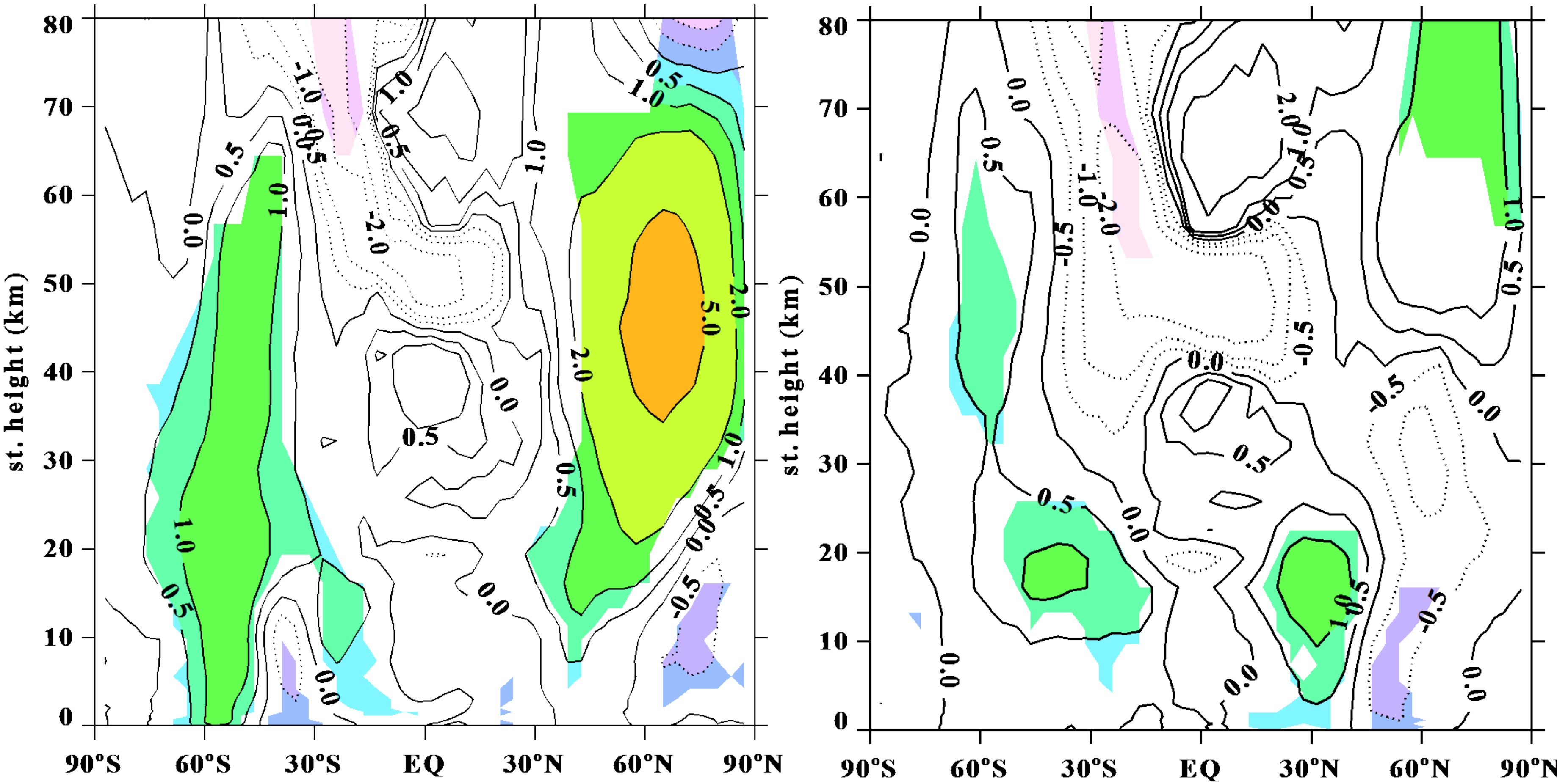
Results: ozone

Linear trend in zonal and DJF mean O3 mixing ratio (ppbv) per 40 years



Results: zonal wind

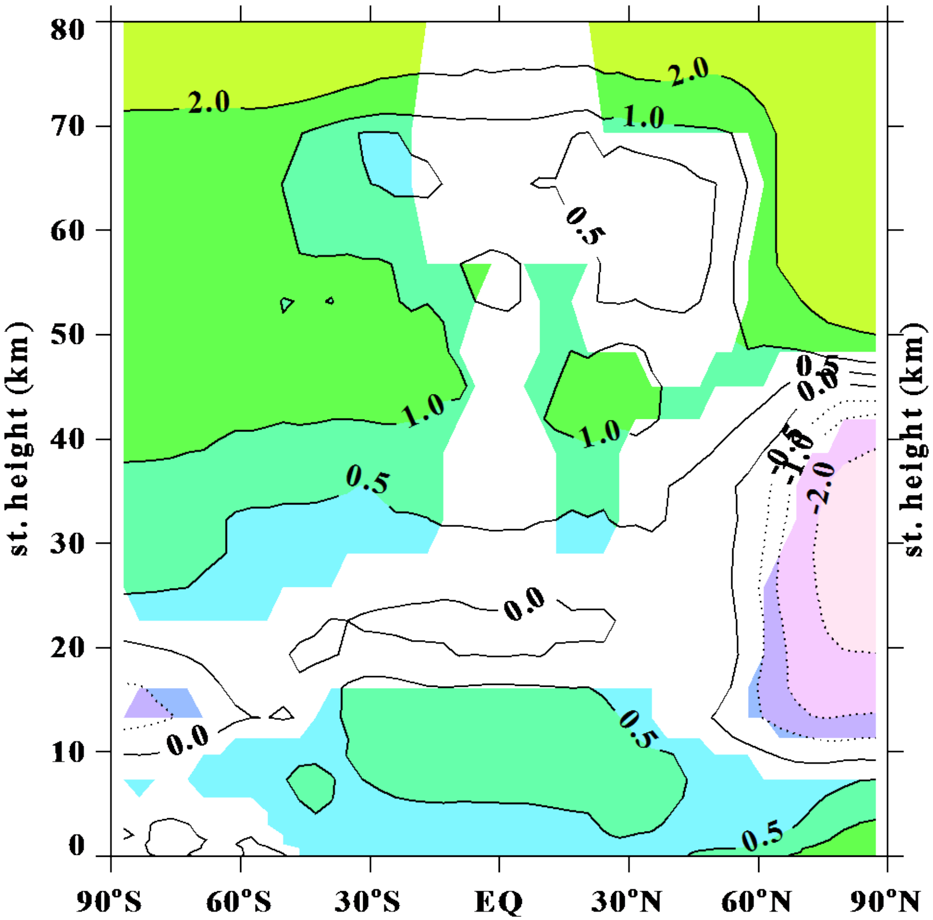
Linear trend in zonal and DJF zonal wind (m/s) per 40 years

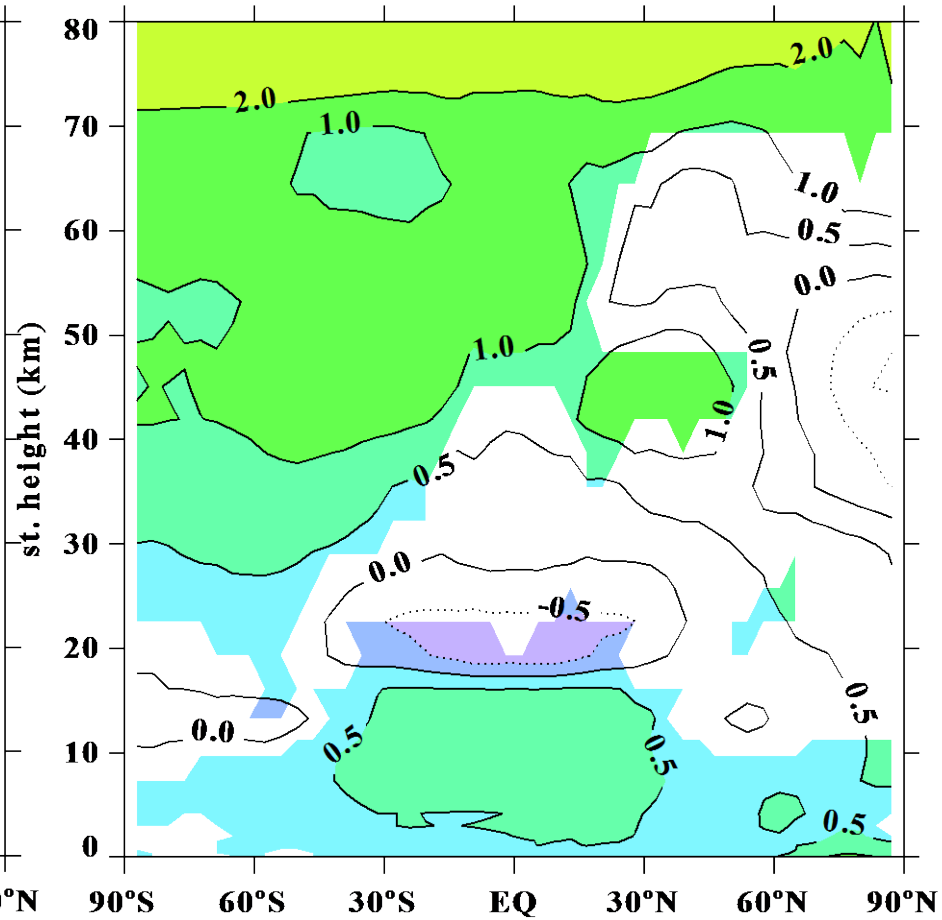


Experiment **Reference**

Results: temperature

Linear trend in zonal and DJF mean temperature (K) per 40 years

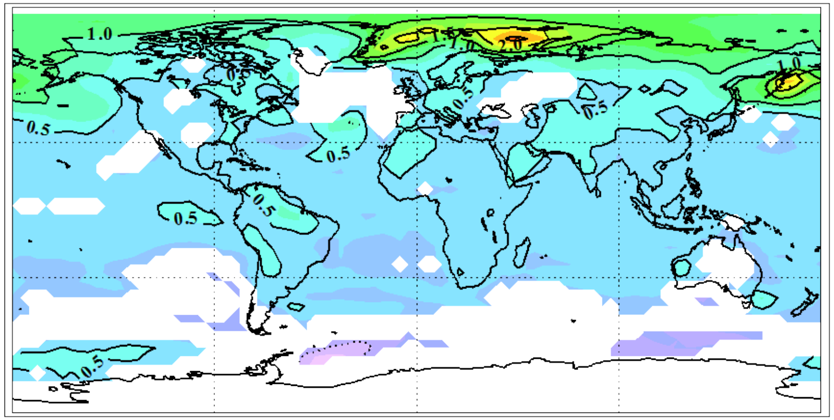




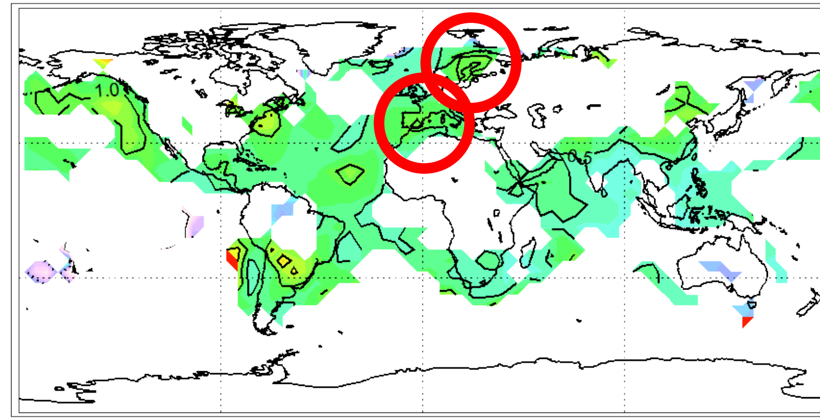
Experiment **Reference**

Comparison: surface air temperature

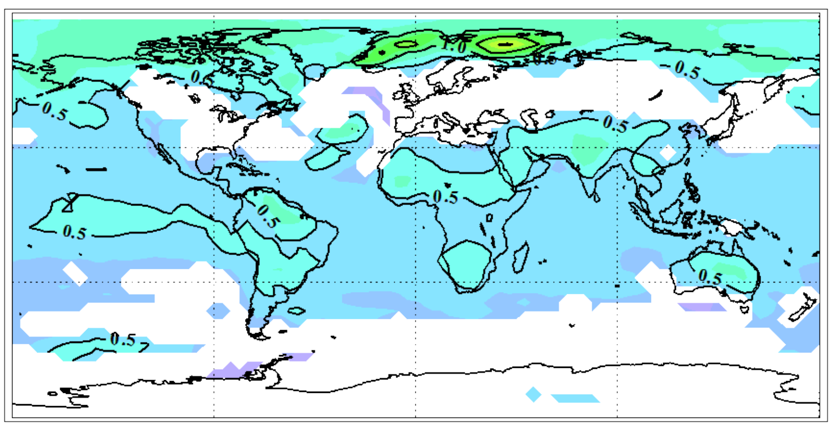
Linear trend in surface air temperature (K) per 40 years



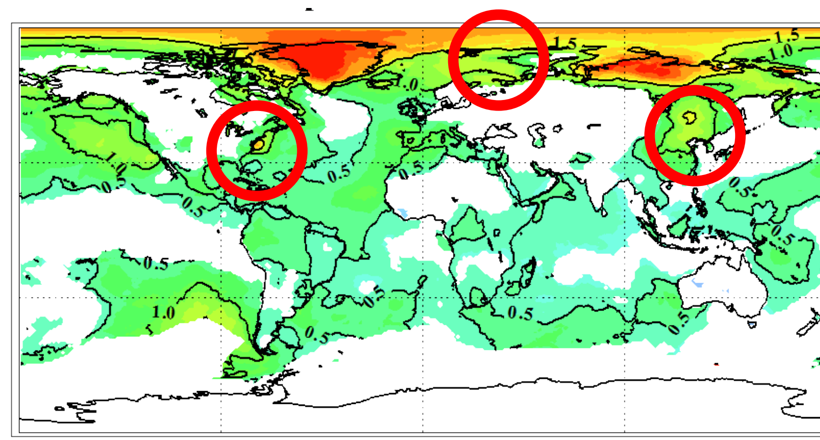
Experiment



Observations NCDC



Reference



Observations BerkeleyEarth

Conclusions

- ✓ Particles warm up Arctic, European and North American surface during the first half of 20th century improving the agreement between model and observations;
- ✓ The ozone depletion, dipole structure of the temperature changes and acceleration of the polar night jet (parts of "top-down mechanism") are visible in the model output.
- ✓ Particle forcing prepared for CMIP-6 model runs should really be used for climate studies

Conclusions

- ✓ Greenland warming is not well reproduced;
- ✓ Arctic warming is not consistent with available theories explaining top-down propagation.

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