REKLIM Helmholtz-Verbund Regionale Klimaänderungen

Helmholtz Climate Initiative
Regional Climate Change

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RESEARCH FOR GRAND CHALLENGES

The climate impact of interactive stratospheric ozone in ICON-ART climate simulations

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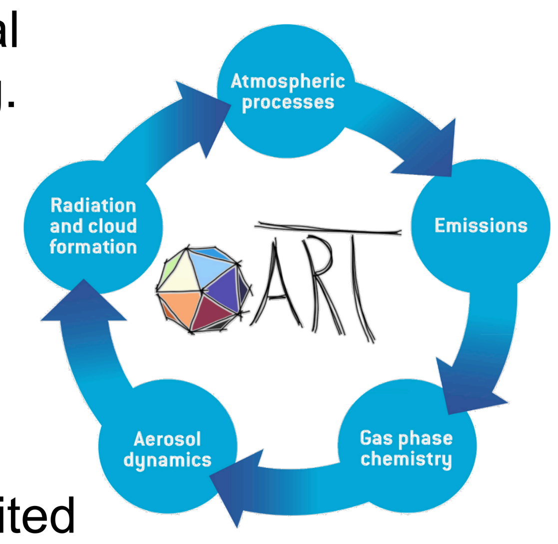
1. Introduction

The warming of the Antarctic Peninsula is a remarkable feature of recent climate change. Recent model studies suggest that this warming might be due to the occurrence of the ozone hole and show a complex pattern of warming and cooling over Antarctica. We use idealized studies with ICON-ART to investigate the impact of the ozone hole on surface climate in Antarctica. Therefore we perform multiannual integrations with and without the ozone hole.

2. The ICON-ART Modelling Framework

- ICON: ICOsahedral Nonhydrostatic modelling framework
  ART: Aerosol and Reactive Trace gases
- ICON is a highly flexible modelling system developed by DWD and MPI-M that can be used for global NWP as well as climate modelling.
- The ART framework allows for the treatment of the spatial and temporal evolution of gases and aerosols within ICON.
- Combined ICON-ART is a well suited modelling system for the simulation of interactions between atmospheric composition and circulation.



3. Model and Experimental Setup

Model Setup:

•Horizontal resolution of 160 km (R2B4 grid) with 47 levels up to 80 km
•Time Step of 10 minutes for dynamics and 120 minutes for radiation
•Climate configuration (ECHAM physics)
•Forcing and Boundary conditions: GHG RCP 4.5 [1]; Tropospheric and Stratospheric Aerosol [2], SST [3], SIC [3] and Solar Irradiation [4]

Experimental Setup:

•Mean Conditions 1998 – 2002 for SST, SIC, GHG and solar irradiation
•Free running linearized ozone scheme (based on LINOZ [5])
•Ozone initialized for year 2000
•Ozone is transported and has a radiative impact
•50 years of simulation

Experiments:

•Experiment I: POC
- Polar ozone chemistry included

•Experiment II: noPOC
- Polar ozone chemistry neglected

4. Results

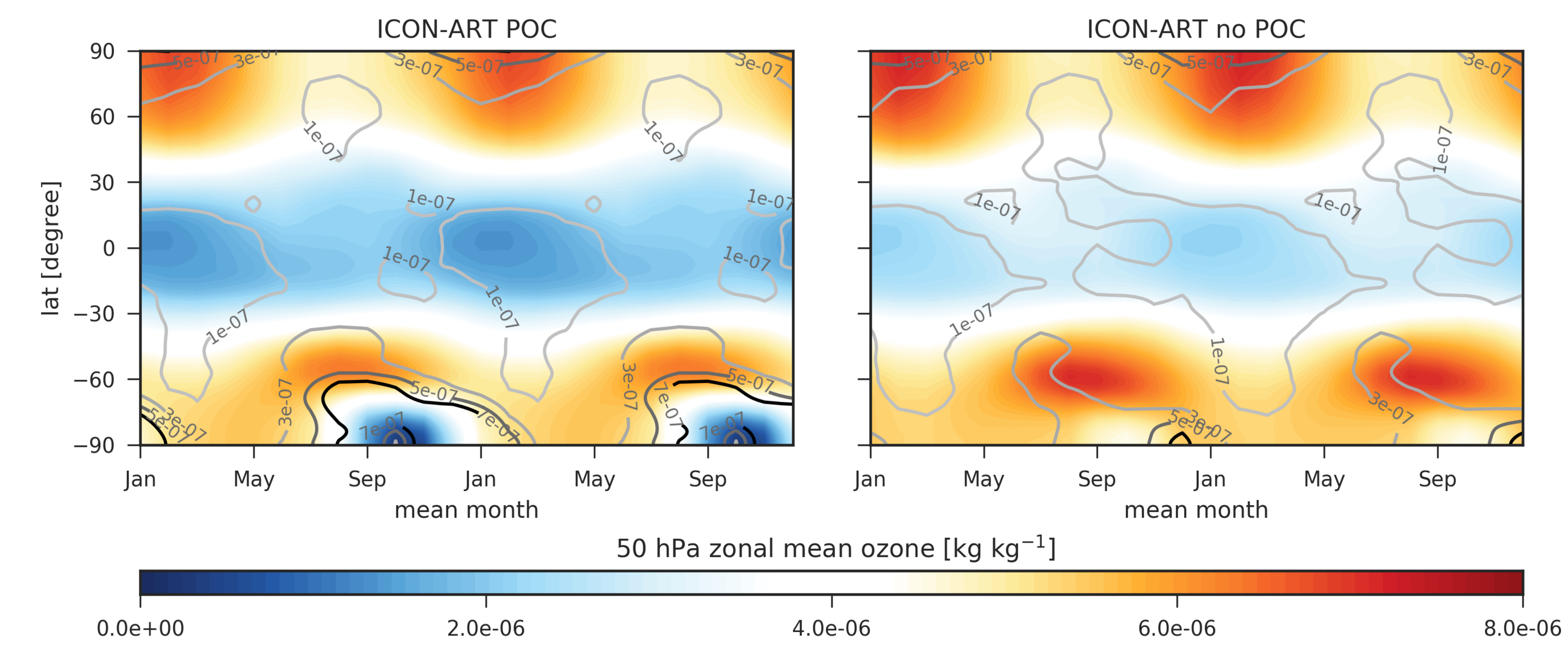


Figure 1: Monthly averaged zonal means of ozone [kg kg^{-1}] at 50hPa (shown twice, shaded). Contour lines represent standard deviation of the monthly means. First ten years neglected for calculation. Left panel: POC; right panel: noPOC.

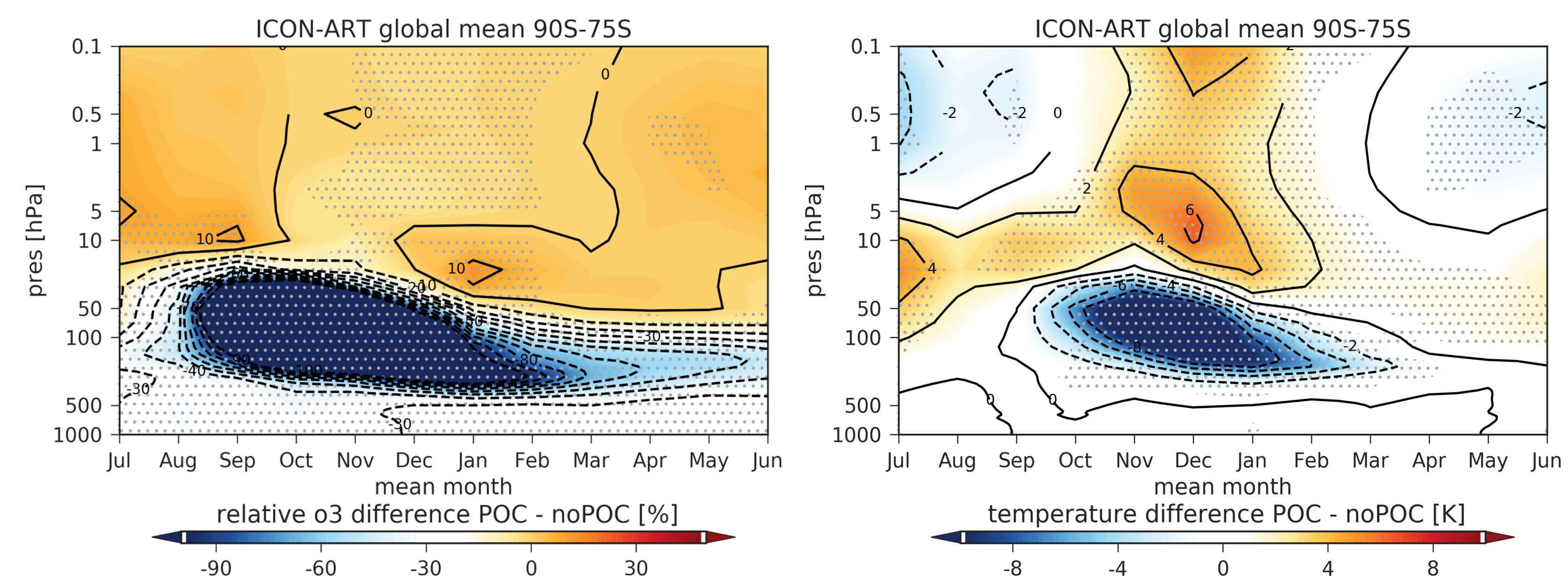


Figure 2: Zonal mean, monthly mean a) relative ozone difference [%] and b) temperature difference [K] between POC and noPOC averaged over 90-75°S. First ten years neglected for calculation. Dots represent significance at the 98% confidence level.

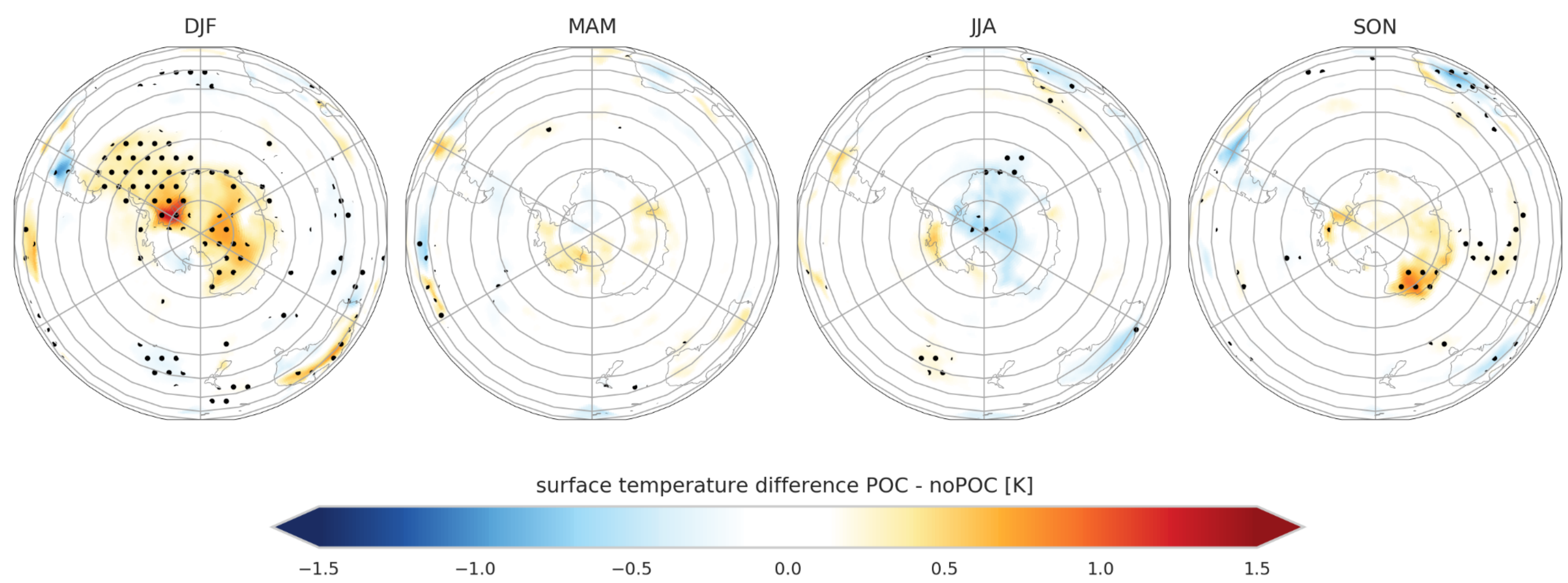
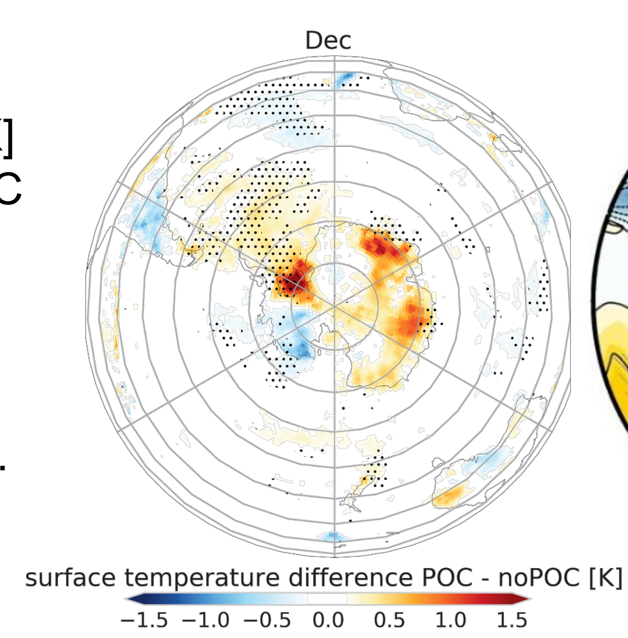


Figure 3: Seasonal temperature difference [K] between POC and noPOC at the surface. First ten years neglected for calculation. Dots represent significance at the 98% confidence level.

Figure 4: December temperature difference [K] between POC and noPOC at the surface. First ten years neglected for calculation. Dots represent significance at the 98% confidence level.



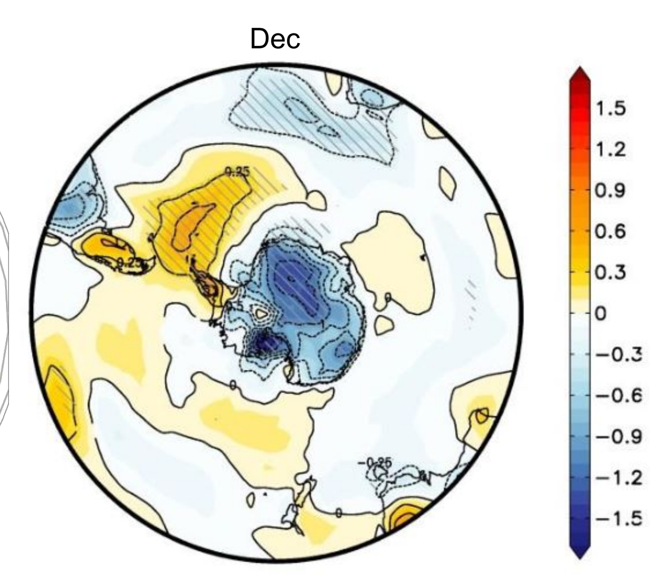


Figure 5: Modelled December temperature difference [K] at the surface. Hatching denotes significance at the 95% confidence level [6].

5. Conclusion and Outlook:

•Vertical and temporal extent of ozone differences are as expected between POC and noPOC integrations; we find a consistent stratospheric temperature difference
•SH surface temperatures are significantly influenced by ozone interactions, especially in the winter season.
•We observe a significant warming of the Antarctic peninsula in winter and a complex pattern of surface warming and cooling, that differs from previous model studies, in response to the ozone hole.

•Further steps will include simulations of longer time series to improve the statistical significance (including a possible signal detection on the NH, where ozone loss is less severe) and simulations with „(no) ozone hole“ climatologies.
•Additionally a local grid refinement over Antarctica and an interactive and consistent SST calculation are envisaged to improve the results.

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References:
[1] Riahi et al. (2007)
[2] Stenchikov et al. (1998, 2004, 2009)
[3] Taylor et al.(2000)
[4] Lean et al. (2005)
[5] Linden et al. (2000)
[6] Keeble et al. (2014)

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