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 lives 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.