Effects of asymmetric ozone changes in a coupled ocean-middle-atmosphere-model under present day conditions

Freie Universität Berlin

Ingo Kirchner (1), Axel Gabriel (2), Hans-F. Graf (3), Ines Höschel (1), Dieter H.W. Peters (2)

(1) Freie Universität Berlin, Institute for Meteorology, Berlin, Germany; (2) Leibnitz-Institute for Atmospheric Physics at the University of Rostock, Kühlungsborn, Germany; (3) Centre Atmospheric Science, University of Cambridge, Cambridge, UK

Introduction

In the middle and upper atmosphere the radiative forcing will be controlled by ozone. In coupled climate models of IPCC only the zonal symmetric part of the ozone distribution is implemented.
In contrast to this approximation the observed trends of ozone during the 1990's shows an increased planetary wave one pattern.
The response of such ozone anomalies (Fig.1) is studied with the coupled ocean-atmosphere model COSMOS[1].

Experiments

The model resolution of the atmospheric part ECHAM5[1] is T31 with 90 levels from the surface to about 80 km height.
The ocean model MPI-OM[1] has a 3 degree resolution with 40 levels.
After a spinup phase of 200 years under present day conditions three simulations were launched. In addition to the 80 year reference experiment (R) two 80 year sensitivity experiments (S1, S2) were performed. In both the asymmetric part of the monthly mean observed ozone (ERA-40) during the 1990's is added to the model background ozone at different levels northward of 30N in order to differentiate between whole and only upper stratospheric ozone forcing. (Fig.1 and Fig. 2)

Experiment S1: O_3* 500 hPa - 2 hPa
Experiment S2: O_3* 10 hPa - 2 hPa

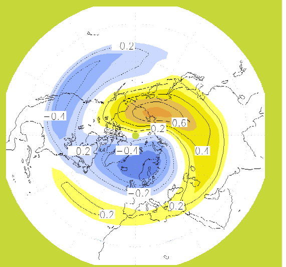

Fig.1: Zonal asymmetric ozone (O_3*) for January at 10 hPa (12.5°N-87.15°N) in mg/kg.

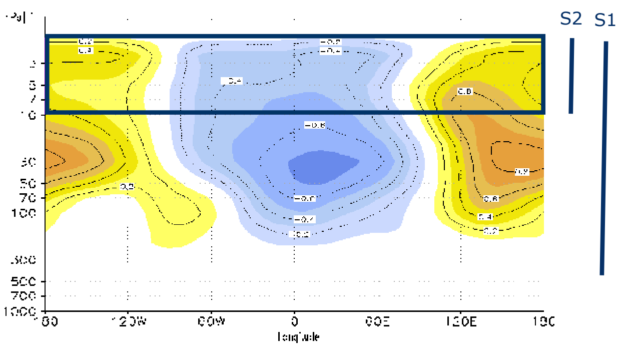

Fig.2: Meridional mean (60N-70N) of O_3* [mg/kg] for January for Experiment S2 and in the blue box for experiment S1.

Results

The inclusion of zonal asymmetric ozone causes corresponding asymmetric changes in the shortwave and longwave heating rates from 250 hPa to 1 hPa in experiment S1 and from 10 hPa to 2hpa in S2.

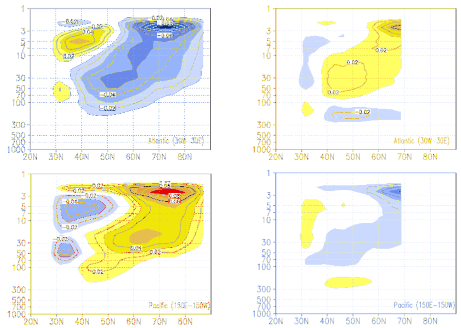

Fig.3: Monthly mean thermal (left) and solar (right) heating rates in K/day for January for North Atlantic (30°W-30°E) in the upper panel and North Pacific region (150°E-150°W) in the lower panel in Experiment S1.

The model responds in both sensitivity experiments with a planetary wave two signal in the upper stratosphere and lower mesosphere.

In both experiments the Island low is weakened and the North Pacific low is intensified during northern winter.

This maybe leads to changes in the wind stress of ocean water and could influence the transport of water.

A stronger North Pacific low may cause an increased transport of water in direction to the Asian Coast. With the intensification of the Kuroshio more warm water arrives at high latitudes, which due to the positive temperature–sea ice melting–albedo feedback leads to significant changes in 2m temperature.

The significant systematic changes in the troposphere are stronger in the experiment with forcing in the upper stratosphere only (S2).

Mean Changes for January at Northern Hemisphere

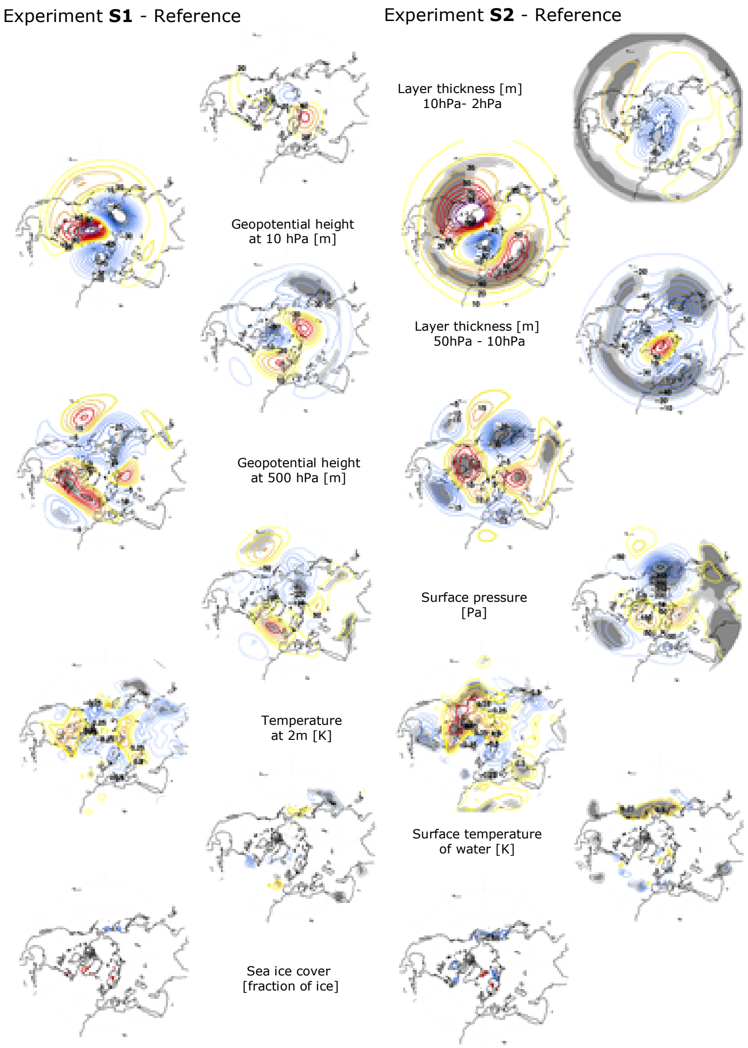

Fig.4: 60-year mean changes for January at 12.5°N to 87.15°N in experiment S1 (left) and S2 (right). Shaded areas are 95% (dark gray), 90% (gray) and 80% (light gray) t-test significance levels.

References / Acknowledgments

1 Climate Models at the Max Planck Institute for Meteorology: Journal of climate Volume 19 Issue 16.
Thanks to the ECMWF who provided the ERA-40 data. This work was supported by the Deutsche Forschungsgemeinschaft under grant DFG-SPP 1176"CAWSES"/PE474/5-1,2

I. Kirchner, ingo.kirchner@met.fu-berlin.de

http://www.geo.fu-berlin.de/met