SOCTOC - Effects of anthropogenic stratospheric ozone changes on climate sensitivity and tropospheric oxidation capacity

Abstract:

The overall goal of our project is to improve the understanding of effects of anthropogenic changes of stratospheric ozone on climate sensitivity (i.e. the globally averaged near-surface temperature change in response to a change in radiative forcing, for instance through a doubling of atmospheric CO_2) and the oxidation of the greenhouse gas methane. More specifically, our scientific goals are to

1) better understand how the tropical tropopause layer (TTL) responds to global warming, which role ozone in the lower tropical stratosphere plays for this response, and what the consequences of changes in the TTL are for climate sensitivity;

2) better understand how changes of global stratospheric ozone affect the oxidation capacity of the troposphere and hence the greenhouse gas methane; and

3) estimate the usefulness of numerically cheap, linearized or otherwise reduced, interactive ozone schemes for climate and chemistry simulations, which would allow to represent ozone effects also in high-resolution models.

Furthermore, we have the infrastructure goal to advance the development of the atmospheric general circulation model ICON-A (in the following just mentioned as ICON) and its coupling to chemistry schemes of different complexity.

Future stratospheric ozone will be influenced by both changes in the anthropogenic halogen loading and changes in the Brewer-Dobson Circulation. We propose to study effects of these ozone changes on a) the tropical tropopause layer (TTL) and climate sensitivity, and on b) tropospheric oxidation capacity and hence the greenhouse gas (GHG) methane and climate.

Increased upwelling in the tropical stratosphere, as simulated robustly by climate models for global warming, would reduce ozone in the lower tropical stratosphere. Recent publications have provided very different estimates of the impact of such an ozone change on climate sensitivity, ranging from a 25% reduction to zero net effect compared to models that don't represent these ozone changes.

Globally, due to decreasing stratospheric halogen content, a recovery of the ozone layer is expected for the next decades. This would alter the UV radiation flux into the troposphere with consequences for the primary production of OH radicals and hence tropospheric chemistry, for instance in terms of the lifetime of CH_4, which is responsible for about 20% of the GHG induced warming since preindustrial times. Whether changes in the emissions of methane or in tropospheric OH concentrations are the cause of the observed flattening in the CH4 trend in the early 2000s is under debate.

Using a hierarchy of numerical models from 1D radiative convective equilibrium to the global ICON model with interactive chemistry we will try to narrow down the uncertainties related to these two effects of stratospheric ozone changes.

Besides the scientific goals, this project aims at a further development of the ICON atmospheric GCM and its coupling to chemistry packages. We will implement and apply configurations of ICON coupled via the ART module to both a comprehensive chemistry code and computationally cheap linearized ozone chemistry. This will allow us to evaluate the usefulness of the latter approach for climate studies.