Extending ICON-ART - Comparison of Simulations with Aircraft Data in the Tropical and Extra-Tropical UTLS

Jennifer Schröter¹, Roland Ruhnke¹, Barbara Dix², Samuel Hall², Sebastian Schmidt⁴, Kirk Ullmann², Rainer Volkmann³,⁵, and Peter Braesicke¹

¹Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT), ²Earth System Laboratory, National Center for Atmospheric Research, Boulder, CO, ³Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, ⁴Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO

Introduction

The ICON-ART³⁻⁵ model is an extension of the non-hydrostatic modelling framework ICON⁴, jointly developed by the German Weather Service (DWD) and Max-Planck-Institute for Meteorology (MPI-M), and is used for numerical weather prediction as well as for future climate predictions. ICON-ART is developed at KIT with the goal to simulate interactions between trace substances and the state of the atmosphere. We have extended ICON-ART by introducing an online photolysis module. This module uses in its core the latest version of Cloud-J³⁵. In this study we present first insights of the performance of this module by comparing the results to aircraft campaign data.

ICON: ICON-eddled Nonhydrostatic moulding framework
ART: Aerosols and Reactive Trace substances

General Information about ICON-ART

The extended modelling framework ICON-ART is developed in an analogous way to its predecessors COSMO-ART³⁻⁵. For the dynamics (transport and diffusion) of gaseous tracers, the original ICON tracer framework is used. For the model physics, numerical intergration follows a process splitting approach separating physical processes. Each process is called independently via an interface module. The processes of emission, dry and wet deposition, sedimentation, and first order chemical reactions are included.

ICON uses a triangular grid structure, which gives computational advantages. It allows to do efficient simulations from the global to the regional scale using the nesting technique, due to the hierarchical structure.

TORERO Campaign

https://www.eol.ucar.edu/field_projects/torero

The values of the time series are binned to pressure values. For the two cases, clear sky and cloudy case for both shown flights, the agreement between measurement and simulation lies within the standard deviation. Both flights are chosen to be representative as best and worst case regarding to the correlation coefficient R (0.83 for Research Flight RF01 and 0.98 for RF11 in clear sky).

Results

We compared 11 flights of the TORERO campaign for five different photolysis rates. Those are covering up different wavelength regions. Flights which has been excluded showed a fragmented time series after building up the clear sky category. A reasonable interpretation does not seem possible.

To investigate the statistical results, all timeseries are merged into one dataset.

The relative bias (ICON-ART - TORERO) is below ±10 % which indicates that we do not have to take into account systematical errors. The Root Mean Square Error (RMSE) lies within the expected measurement error. The correlation coefficient indicates that within the simulation the general variability is captured well. For JNO2, the value of R is relatively low compared to the values of the other reactions. But it should be noted, that the correlation between measurement and simulation is very variable from flight to flight, ranging from 0.31 to 0.98.

The values of R indicate that the simulation is able to capture variations due to temporal and spatial variability caused by variations in temperature, pressure, overhead ozone column etc., for the clear sky case, reasonable.

Conclusion

The online photolysis module shows a good quantitative agreement to the measurement even when clouds are present.

We can state that with this extension we are able to perform reasonable simulation of photolysis rates on the regional scale. The extension of ICON-ART by the online photolysis module allows further development of the modelling framework. At the final stage, ICON-ART will give the ability to study tropospheric and stratospheric chemical processes, aerosol chemistry and aerosol dynamics.

References and Further Information


For more information, contact: jennifer.schroeter@kit.edu

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