Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC2
https://doi.org/10.5194/gmd-2022-13-RC2, 2022

Comment on gmd-2022-13

Anonymous Referee #2

Referee comment on "Transport parameterization of the Polar SWIFT model (version 2)" by Ingo Wohltmann et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-13-RC2, 2022

This manuscript describes the transport parameterization of the Polar SWIFT model version 2, which is needed when the GCMs do not have a computationally efficient atmospheric tracer advection scheme in the polar vortex. It appears that only four advective tracers (O3, HCl, ClONO2, and HNO3) are required by Polar SWIFT. I am a bit surprised that the models implemented Polar SWIFT (e.g., ECHAM6, AFES4.1, ICON-NWP, ATLAS) do not have a usable scheme for tracer transport and mixing in the stratosphere. Is it because the model top is too low to resolve the stratosphere, or their scheme is so inefficient that adding four tracers will make the model unusable? I suggest the authors provide enough information about this, for example the cost of carrying four additional tracers. Otherwise, their motivations of this work are not clear to me. How are the tracers handled outside the polar vortex in these models? Are they advected?

When more efficient tracer advection scheme is available, GCMs do not need the transport parameterization. I am not familiar with the models mentioned in this manuscript, but the GCMs I have experience with all have tracers (trace gases, aerosols, and artificial tracers) transported and mixed in the stratosphere. A couple of years ago, one additional tracer roughly adds 1% overhead computational cost to the atmospheric model I used. It was a little slow, but still usable if one can keep the tracer number relatively small. Recently with the latest breakthrough of more efficient tracer advection scheme (e.g., Bradley et al., 2019; 2021), the MPI communications can be reduced by 9x in the model I use. Adding ~30 tracers only costs ~15% overhead. So, the tracer advection is not the primary bottleneck anymore (at least for some GCMs). If possible, I would suggest the models adopt more efficient advection schemes, which provides a better solution in the long term. The method here may be used as a temporary fix when needed.

Minor comments:

L1, what does SWIFT stand for?

L37-38, why these 5 levels? Is that where the polar vortex is simulated? Some clarifications are helpful for the readers to understand the choice.

L49, do you mean a single number of ozone change rate from Polar SWIFT is used for a given layer? It is not clear if “the rate of change of ozone calculated by Polar SWIFT” is a single number or different for the grid boxes in the same layer. I feel it’s a single number as SWIFT calculates the vortex-averaged value, but the sentence is a bit unclear. Please clarify.

Figure 6b: years 2010-2012 show a large increase in ozone observation but totally missed by the models. Do you know why?

L227-230, the authors listed almost all the possible causes of why the model failed to capture the mean ozone at southern hemisphere as observed. This is not very helpful. Can the contributions from these potential factors be somewhat quantified?

References

Bradley, A. M., Bosler, P. A., Guba, O., Taylor, M. A., and Barnett, G. A.: Communication-efficient property preservation in tracer transport, SIAM J. on Sci. Comput., 41, C161–C193, 2019.

Bradley, A. M., Bosler, P. A., and Guba, O.: Islet: Interpolation semi-Lagrangian element-based transport, Geosci. Model Dev. Discuss. [preprint], https://doi.org/10.5194/gmd-2021-296, in review, 2021.