EGU2020-4281, updated on 21 Apr 2021
https://doi.org/10.5194/egusphere-egu2020-4281
EGU General Assembly 2020

Assessing numerical impacts on stratospheric dynamics and transport using the age of air and the leaky pipe theoretical model

Aman Gupta[1], Edwin Gerber[2], and Peter Lauritzen[3]
[1]Courant Institute of Mathematical Sciences, New York University, New York, United States of America (ag4680@nyu.edu)
[2]Courant Institute of Mathematical Sciences, New York University, New York, United States of America (epg2@nyu.edu)
[3]National Center for Atmospheric Research, Boulder, Colorado, United States of America (pel@ucar.edu)

Accurate representation of tracer transport --- the movement of trace constituents by the atmospheric flow --- continues to be a challenge for climate models. Differences in the resolved circulation, biases due to physical parameterizations, and differences in the numerical representation of trace gases result in large variations in transport, even among state-of-the-art climate models. These differences result in disagreement among model projections of the evolution of stratospheric ozone throughout the 21st century particularly in the recovery of the Antarctic ozone hole. In addition to transport, the delicate momentum balance in the upper-troposphere and lower-stratosphere (UTLS) also presents a stiff challenge for model numerics, exposing the impacts of numerical dissipation, the resolution of waves, and the consequences of imperfect momentum conservation. Biases in this region impact the global circulation, e.g., influencing the extratropics jets and stratospheric polar vortices, and alter the transport and exchange of trace gases between and through the troposphere and stratosphere.

In this study, we compare 2 modern dynamical cores (dycores) that employ very different numerics: the cubed sphere finite volume (CSFV) core from GFDL and the spectral element (SE) core from NCAR-CAM5. We force these dycores using identical Held-Suarez diabatic forcing in the troposphere and Polvani-Kushner diabatic forcing in the stratosphere, varying the horizontal and vertical resolution. We observe significant differences in circulation, between the two models at high vertical resolution in the lower and middle tropical stratosphere. While the finite volume core is relatively insensitive to any changes in vertical resolution, the PS and SE dycores resolve considerably different tropical stratospheric dynamics at high vertical resolution (80 levels). These models develop QBO-like westerly winds in the tropics and induce a secondary meridional circulation in the tropical stratosphere, which sets of transport between the models. Using the theoretical leaky pipe transport model we analyze and separate out the transport differences due to differences is diabatic circulation and isentropic mixing and infer that this secondary circulation strikingly modulates stratospheric tracer transport (age of air) by altering the tropical-extratropical mixing, and impacts the extratropical circulation through the subtropical jets. Implications for comprehensive atmospheric modeling are discussed.