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A Comparison between Interactive-ozone and Non-interactive-ozone in ICON-ART

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Stratospheric ozone, radiation and circulation are strongly coupled with each other, and the two-way interaction between ozone and meteorology has been shown to be of great importance for climate projections. Nevertheless, most climate models prescribe averaged ozone climatologies. Here, the ozone is neither transported nor has it sources and sinks. In this study, we use the next-generation chemical-climate model ICON-ART [1] to further examine such effect for our recent climate. We conducted a pair of decadal integration experiments: 1) fully-interactive-ozone (FIO_3), ozone is calculated using a chemistry model and is transported by the models' circulation; 2) non-interactive-ozone (NIO_3), ozone is prescribed from monthly mean climatologies derived from FIO_3. However, the ozone chemistry and transport is still calculated in NIO_3.
Switching on interactive-ozone in ICON-ART, the modelled Antarctic ozone depletion in Winter is stronger. This is associated with a statistically significant cooling (warming) in the Antarctic lower (upper) stratosphere. The heating components of this temperature change are diagnosed and it is found that the cooling is related to the decreased dynamical heating and the warming is related to the increased short-wave heating. The cooling of the lower polar stratosphere is linked to the increase of EP-flux divergence, and a delay of the polar vortex breakdown. The modelled anomaly propagates down to the troposphere, leading to significant surface changes during winter. In addition, the interactive-ozone also has a large impact on the tropical stratosphere and is related to a warmer tropical stratosphere as a result of the increased short-wave heating and colder UTLS region. This study underlines the importance of the choices on how to treat (stratospheric) ozone in climate models.

[1] Schröter, J., Rieger, D., Stassen, C., Vogel, H., Weimer, M., Werchner, S., Förstner, J., Prill, F., Reinert, D., Zängl, G., Giorgetta, M., Ruhnke, R., Vogel, B., and Braesicke, P.: ICON-ART 2.1: a flexible tracer framework and its application for composition studies in numerical weather forecasting and climate simulations, Geosci. Model Dev., 11, 4043-4068, https://doi.org/10.5194/gmd-11-4043-2018, 2018