EGU22-11634
https://doi.org/10.5194/egusphere-egu22-11634
EGU General Assembly 2022

Potential links between tropospheric and stratospheric circulation extremes during early 2020

Philip Rupp[1], Sheena Loeffel[2], Hella Garny[2], Xiaoyang Chen[3], Joaquim Pinto[3], and Thomas Birner[1]
[1]Meteorological Institute Munich, Ludwig-Maximilians-University, Munich, Germany
[2]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany
[3]Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Karlsruhe, Germany

February-March 2020 was marked by highly anomalous large-scale circulations in the Northern extratropical troposphere and stratosphere. The Atlantic jet reached extreme strength, linked to some of the strongest and most persistent positive values of the Arctic Oscillation index on record, which provided conditions for extreme windstorms hitting Europe. Likewise, the stratospheric polar vortex reached extreme strength that persisted for an unusually long period. Past research indicated that such circulation extremes occurring throughout the troposphere-stratosphere system are dynamically coupled, although the nature of this coupling is still not fully understood and generally difficult to quantify.

We employ sets of numerical ensemble simulations to statistically characterize the mutual coupling of the early 2020 extremes. We find the extreme vortex strength to be linked to the reflection of upward propagating planetary waves and the occurrence of this reflection to be sensitive to the details of the vortex structure. Our results show an overall robust coupling between tropospheric and stratospheric anomalies: ensemble members with polar vortex exceeding a certain strength tend to exhibit a stronger tropospheric jet and vice versa. Moreover, members exhibiting a breakdown of the stratospheric circulation (e.g. a sudden stratospheric warming) tend to lack periods of persistently enhanced tropospheric circulation. Despite indications for vertical coupling, our simulations underline the role of internal variability within each atmospheric layer. The circulation extremes during early 2020 may be viewed as resulting from a fortuitous alignment of dynamical evolutions within the troposphere and stratosphere, aided by each layer's modification of the other layer's boundary condition.