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Dynamical Mechanisms of Ozone Anomalies Formation as Revealed by Global-Scale and Regional Simulations with PlanetWRF and CAM modelling systems

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Local ozone anomalies, defined as synoptic-scale deviations in total ozone column (TOC) field from its average climatic values, constitute an important short-term component of stratospheric ozone variability. Their formation and evolution is a manifestation of subtle dynamical processes related to stratosphere-troposphere interactions. Various studies of local ozone anomalies attributed their formation to such mechanisms as northeast horizontal motions of air patches with low ozone content [1], uplift of air masses and the local tropopause resulting in decrease of the pressure thickness of the ozone layer [2], displacement with the ozone depleted stratospheric polar vortex [1] and the anticyclonic anomalies in the stratosphere [2, 3]. It has also been argued that the potential vorticity (PV) field can be used as a "proxy" for ozone if the latter is treated as a passive tracer. However, this is valid only for large-scale adiabatic processes, for which the PV is a conserved variable.

To investigate the role of different processes and scales in formation, evolution and decay of local ozone anomalies we perform a series of comparative simulations with global, regional and mesoscale models. For global-scale modelling we use the standalone version of the Community Atmosphere Model (CAM) in several configurations suitable for simulating stratospheric ozone dynamics. On the other hand, we utilize a modified version of the Weather Research & Forecasting (WRF) system to evaluate the possible impact of finer-scale dynamics and mesoscale processes on ozone anomalies. For that purpose, we combine the PlanetWRF system with the WRF-Chem extension and introduce some further modifications to improve representation of stratospheric processes with simulation of ozone as an active tracer. Special attention is paid to radiative transfer parameterizations, since in situ radiation absorption by ozone and the associated heating plays a crucial role in the stratosphere and the radiation parameterization scheme should allow for the possible radiative feedback on ozone dynamics. We perform global simulations with the PlanetWRF – WRFChem system and compare results with those obtained with the CAM system. Furthermore, to perform regional simulations on finer grids resolving mesoscale processes we use nested domains following spatial region of local ozone anomalies of interest.

We perform studies of several cases of both negative (miniholes) and positive local ozone anomalies over the territory of Europe. Furthermore, we investigate the connection between ozone anomalies dynamics in the stratosphere and tropospheric weather phenomena. For that purpose we introduce perturbations to the initial conditions. First, we modify the variable fields on stratospheric model levels to see its possible impact on tropospheric phenomena. Independently, in a subsequent numerical experiment we introduce disturbances in surface and tropospheric variable fields in order to trace its influence on the stratospheric ozone dynamics.

Intercomparison of modelling results is given, revealing interactions of the synoptic pressure formations with features of the stratospheric circulation. Apart from that, we analyze the role of vertical motions and ozone radiative heating on local anomalies formation.

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