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Dynamical structure and formation mechanisms of local ozone anomalies

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Stratospheric ozone distribution exhibits features and variations on different scales in space and time. Synoptic-scale deviations in the total ozone column (TOC) field, having a characteristic lifetime of about a week or a few days, constitute an important component of this variability and are commonly referred to as local ozone anomalies, or as mini-holes and mini-highs respectively for negative and positive anomalies. Being universally recognized as formations of predominantly dynamical origin, they pose a significant interest both from fundamental and practical points of view.

The present study is devoted to investigation of the dynamical structure and formation mechanisms of local ozone anomalies. First, we process observational and reanalysis data to obtain statistics of all cases of negative and positive anomalies that have occurred over the territory of Europe during the last two decades, paying attention to such issues as the definition of local ozone anomalies, their possible classification, and algorithms for their automated objective identification. Furthermore, we investigate formation, evolution and decay of several prominent cases of both negative and positive anomalies, focusing on the underlying atmospheric dynamical processes. For that purpose, we combine observations and reanalysis with global-scale numerical simulations by ECMWF OpenIFS model and regional simulations by WRF model, treating ozone as a tracer. Special attention is paid to the cases of deepest negative ozone anomalies (e.g., the 1997-1998 ozone mini-hole, which is responsible for the minimal TOC value ever observed over Belarus – 163 DU), and of springtime and summertime ozone mini-holes, when sufficiently low TOC values coincide in time with intense solar irradiation. Analysis reveals several dynamical mechanisms responsible for local ozone anomalies formation, the dominating mechanism being different for various types of anomalies. Finally, we discuss the connection of local ozone anomalies with surface weather phenomena, their predictability in numerical weather modelling, and the role of local ozone anomalies in the broad context of stratosphere-troposphere interactions research.