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Influence of Stratospheric Ozone Distribution on Tropospheric Circulation Patterns

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In the present study we investigate the cause-and-effect relationship between the stratospheric ozone distribution and tropospheric circulation, focusing our attention mainly on the possible "top-down" side of this interaction: the impact of the stratosphere on tropospheric circulation patterns and the associated weather and climate conditions.

Proceeding from analysis of several decades of observational data performed at the A.I. Voeikov Main Geophysical Observatory, which suggests a clear relation between the stratospheric ozone distribution, temperature field of the lower stratosphere and air-masses boundaries in the upper troposphere, we combine atmospheric reanalyzes and ground-based observations with numerical simulations to identify features of the general circulation that can be traced back to anomalies in the stratospheric ozone field. Specifically, we analyze the time evolution of instantaneous position of the stationary upper-level atmospheric fronts, defining the boundaries of global tropospheric air masses associated with basic cells of general circulation. We assume that stratospheric heating in ozone-related processes can exert its influence on the location of stationary fronts and characteristics of general circulation cells by displacing the tropopause, which itself is defined by a dynamical equilibrium between tropospheric vertical convection and stratospheric radiative heating.

As an example, we consider the Spring season of 2013. Unusually high total ozone column (TOC) values observed in Northern Hemisphere (NH) at the beginning of 2013 induced low tropopause level in the Atlantic region and southward displacement of the polar front, leading to an anomalously cold Spring in Europe. Furthermore, we study manifestations of this mechanism in the aftermath of sudden stratospheric warming (SSW) events. In particular, the November 2013 SSW over Eastern Siberia, which is characterized by abrupt stratospheric temperatures change in the course of one day, can be seen as the origin of the subsequent southward shift of both polar and subtropical fronts in NH with a succeeding displacement of the Intertropical Convergence Zone (ITCZ) and changes of atmospheric circulation pattern in the Southern Hemisphere (SH).