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Variability of tracer transport in spring/summer Arctic stratosphere simulated by CESM-WACCM

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Recent observational and modeling transport studies of Arctic stratospheric final warmings have shown that tropical/subtropical air can be transported to high latitudes and remain confined within a long-lived "frozen-in" anticyclone (FrIAC), embedded in the summer easterlies for several months. A climatology of these sporadic events has shown that their frequency of occurrence considerably increased over the last decade: among the nine cases detected over the period 1960-2011, five occurred between 2002 and 2011.Although a stratospheric favorable preconditioning for their occurrence were identified, the causes of such an increase are not yet understood.
In this study, a chemistry climate model is used for the first time to investigate FrIACs characteristics and variability. Simulations were performed with the NCAR's Community Earth System Model (CESM), a coupled model system including an interactive ocean (POP2), land (CLM4), sea ice (CICE), and atmosphere (NCAR's Whole Atmosphere Community Climate Model (WACCM)). To detect low-latitude air masses characterizing FrIACs, daily 3-D output of temperature, horizontal wind and pressure are used to calculate the potential vorticity equivalent latitude (PVEL) distribution onto various isentropic levels in the range 700 K - 1200 K. Additionally, anticyclones are identified by using an algorithm designed to detect systematically vortex edges. To classify an event as a FrIAC, we require that the intrusion contains air masses from low-latitudes (below PVEL=40°N), reaches the polar region (beyond 60°N), and is collocated with an anticyclonic eddy.
Among the 145 years analyzed (1955-2099), from a simulation with natural forcing conditions only, 20 FrIACs are found. They occur predominantly under a strong and abrupt winter-to-summer dynamical transitions which are driven by large planetary wave activity. FrIACs characteristics (i.e. spatial extent and duration), are overall consistent by comparing with FrIACs detected in ERA-Interim and ERA-40 meteorological reanalyses. However, CESM simulation reveals decadal clustering of FrIAC occurrences that we will discuss by applying our FrIAC detection method to three CESM-WACCM sensitivity experiments, i.e. simulations with (i) natural forcing without Quasi-Biennial Oscillation, (ii) natural forcing with fixed Sea Surface Temperatures, and (iii) anthropogenic forcing based on the RCP8.5 scenario.