NCAR | ATMOSPHERIC CHEMISTRY OBSERVATIONS & MODELING

Virtual ACOM Seminar

How Does Coupled Tropospheric Chemistry Affect Climate? An Investigation Using the Community Earth System Model Version 2

Noah Stanton

York University

Date: Monday, August 29th, 2022, 3:30pm-4:30pm

Link: https://operations.ucar.edu/live-acom

ABSTRACT

The depiction of tropospheric chemistry in climate models has greatly improved in recent years. The Community Earth System Model version 2 with Whole Atmosphere Community Climate Model version 6 (CESM2-WACCM6) has implemented fully-coupled tropospheric chemistry with 231 chemical species, an updated aerosol scheme, as well as a fully-coupled ocean. In addition to their effects on the chemical composition of the troposphere and stratosphere, these model improvements also affect climatological parameters like cloud radiative effect (CRE), surface temperature and sea level pressure. To further examine these impacts, 100-year preindustrial control simulations were run using the following two configurations 1) a "simplified" CESM2-WACCM6 configuration in which coupled chemistry is confined to the middle atmosphere, and 2) the standard CESM2-WACCM6 configuration with fully-coupled chemistry over all atmospheric levels. Differences of climatological mean parameters between the model configurations were analyzed. Regional differences in surface temperature and the CRE range between -5 K and 5 K and -10 W m^{-2} to 10 W m^{-2}, respectively. There are also significant differences in the number concentration of ozone. Compared to the simplified CESM2-WACCM6 configuration, the standard CESM2-WACCM6 produces 1.5×10^{17} to 3.0×10^{17} molecules m-3 more ozone in the upper troposphere, an increase of 10-20%. The standard CESM2-WACCM6 also produces 1.5×10^{17} molecules m^{-3} (3%) more ozone in the southern polar stratosphere compared to simplified CESM2-WACCM6. These ozone changes do not appear to drive dynamical changes, rather they appear to be driven by dynamical changes that extend up from the troposphere. These dynamical changes include an equatorward shift of the mid-latitude jets and weakening of the Southern Hemisphere stratospheric polar vortex. The equatorward shifts of the jets are due to widespread tropospheric cooling which is partially due to increases in NOy, a component of which is organic nitrate. Decreases in the troposphere of primary organic matter aerosol (POM) and black carbon (BC), about -30% to -80% and -20% to -60% respectively, also contribute to tropospheric cooling. These changes in turn influence cloud distribution, precipitation patterns, and sea ice area.

For more information please contact Shaun Bush, sbush@ucar.edu, phone 303-497-8060.