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Monsoon Circulations and Tropical Heterogeneous Chlorine Chemistry in the Stratosphere

Doug Kinnison (1), Susan Solomon (2), Rolando Garcia (1), Justin Bandoro (2), Catherine Wilka (2), Ryan Neeley III (3,4), Anja Schmidt (3), John Barnes (5), Jean-Paul Vernier (6,7), Michael Höpfner (8), and Michael Mills (1)

(1) NCAR, Atmospheric Chemistry Observations & Modeling, Boulder, CO, USA (dkin@ucar.edu), (2) Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA, (3) School of Earth and Environment, University of Leeds, Leeds, UK, (4) National Centre for Atmospheric Science, University of Leeds, Leeds, UK, (5) Mauna Loa Observatory, NOAA, Hilo, Hawaii, USA, (6) NASA Langley Research Center, Hampton, Virginia, USA, (7) Science Systems and Applications, Inc., Hampton, Virginia, USA, (8) Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Karlsruhe, Germany

Heterogeneous chlorine chemistry on and in liquid polar stratospheric particles is thought to play a significant role in polar and subpolar ozone depletion. Previous studies have not provided evidence for heterogeneous chlorine chemistry occurring in the tropical stratosphere. Using the current best understanding of liquid stratospheric particle chemistry in a state-of-the-art numerical model, we examine whether such processes should be expected to affect tropical composition, particularly at and slightly above the cold tropical tropopause, in association with the Asian and North American summer (June-July-August) monsoons. The Specified Dynamics version of the Community Earth System Model version 1 (CESM1) Whole Atmosphere Community Climate Model (WACCM) is used in this study. This model is nudged to externally specified dynamical fields for temperature, zonal and meridional winds, and surface pressure fields from the NASA Modern Era Retrospective Analysis for Research and Applications (MERRA). Model simulations suggest that transport processes associated with the summer monsoons bring increased abundances of hydrochloric acid (HCl) into contact with liquid sulfate aerosols in the cold tropical lowermost stratosphere, leading to heterogeneous chemical activation of chlorine species. The calculations indicate that the spatial and seasonal distributions of chlorine monoxide (ClO) and chlorine nitrate ($ClONO_2$) near the monsoon regions of the northern hemisphere tropical and subtropical lowermost stratosphere could provide indicators of heterogeneous chlorine processing. In the model, these processes impact the local ozone budget and decrease ozone abundances, implying a chemical contribution to longer-term northern tropical ozone profile changes at 16–19 km.