Vertical Atmospheric Coupling during the September 2019 Antarctic Sudden Stratospheric Warming

Yosuke Yamazaki¹, Vivien Matthias², Yasunobu Miyoshi³, Claudia Stolle¹, Tarique Siddiqui¹, Guram Kervalishvili¹, Jan Laštovička⁵, Michal Kozubek⁵, William Ward⁶, David Themens⁶, Samuel Kristoffersen⁶, and Patrick Alken⁷,⁸

¹GFZ German Research Centre for Geosciences, Potsdam, Germany
²Potsdam Institute for Climate Impact Research, Potsdam, Germany
³Department of Earth and Planetary Sciences, Kyushu University, Fukuoka, Japan
⁴Faculty of Science, University of Potsdam, Potsdam, Germany
⁵Institute of Atmospheric Physics CAS, Prague, Czech Republic
⁶Department of Physics, University of New Brunswick, Fredericton, New Brunswick, Canada
⁷Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, CO, USA
⁸National Centers for Environmental Information, NOAA, Boulder, CO, USA

A sudden stratospheric warming (SSW) is an extreme wintertime meteorological phenomenon occurring mostly over the Arctic region. Studies have shown that an Arctic SSW can influence the whole atmosphere including the ionosphere. In September 2019, a rare SSW event occurred in the Antarctic region, following strong wave-1 planetary wave activity. The event provides an opportunity to investigate its broader impact on the upper atmosphere, which has been largely unexplored in previous studies. Ionospheric data from ESA's Swarm satellite constellation mission show prominent 6-day variations in the dayside low-latitude region during the SSW, including 20-70% variations in the equatorial zonal electric field, 20-40% variations in the electron density, and 5-10% variations in the top-side total electron content. These ionospheric variations have characteristics of a westward-propagating wave with zonal wavenumber 1, and can be attributed to forcing from the middle atmosphere by the Rossby normal mode “quasi-6-day wave” (Q6DW). Geopotential height measurements by the Microwave Limb Sounder aboard NASA’s Aura satellite reveal a burst of global Q6DW activity in the mesosphere and lower thermosphere at this time, which is one of the strongest in the record. These results suggest that an Antarctic SSW can lead to ionospheric variability by altering middle atmosphere dynamics and propagation characteristics of large-scale waves from the middle atmosphere to the upper atmosphere.
