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Middle atmospheric ozone and water vapor anomalies during a sudden stratospheric warming in January 2010 as observed by different ground-based microwave radiometers

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A major sudden stratospheric warming occurred in the northern hemisphere in January 2010. The warming started on the 21th of January 2010, was most pronounced by the end of January and was accompanied by a polar vortex shift towards Europe and Asia. After the warming, the polar vortex has split into two weaker vortices. The mean temperature in the polar upper stratosphere increased by about 25 Kelvin in a few days, while there was a decrease in temperature in the lower stratosphere and mesosphere. Local temperature maxima were around 325 K in the upper stratosphere and minima around 175 K and 155 K in the lower stratosphere and mesosphere, respectively.
In this study, we present water vapor and ozone measurements obtained by European ground-based microwave radiometers from Bern (47°N), Onsala (57°N) and Sodankylä (67°N). The instruments in Bern and Onsala are part of the Network for the Detection of Atmospheric Composition Change (NDACC). Effects of the sudden stratospheric warming were observed at all three locations. The temporal variation in water vapor and ozone was different between the three locations. In Bern, we observed an increase in water vapor in the stratopause region during the warming. In Onsala and Sodankylä, the water vapor increase during and after the warming was more pronounced and ranged from the middle stratosphere up to the mesosphere. The changes in the stratospheric ozone concentration showed the same behavior for all locations: During the warming, the ozone concentration decreased. In the two polar locations, the ozone concentration increased to normal spring time values after warming and the breakdown of the polar vortex. In Bern, there was a large increase in the ozone concentration of about 50 percent shortly after the warming followed by a normalization to typical spring time values.
The observed anomalies are explained by a trajectory analysis with ECMWF analysis data. Most of the observed anomalies in water vapor and ozone during the warming can be attributed to the location of the polar vortex, depending on whether a measurement site is inside or outside the vortex. The observed increase in mesospheric water vapor at high latitudes is explained by advection of relatively moist air from lower latitudes, whereas the observed increase in upper stratospheric water vapor at midlatitudes is explained by advection from high latitudes. Similar explanations are valid for the observed ozone anomalies, but the relative importance between dynamics and ozone chemistry is still unclear.