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Polar vortex dynamics observed by means of stratospheric and mesospheric CO ground-based measurements carried out at Thule (76.5°N, 68.8°W), Greenland

I. Fiorucci (1), G. Muscari (1), P. P. Bertagnolio (1,2), C. Di Biagio (3), P. Eriksen (4), and R. L. de Zafra (5)

(1) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy (irene.fiorucci@ingv.it), (2) Dipartimento di Scienze della Terra, Università degli Studi di Siena, Siena, Italy, (3) ENEA/UTMEA-TER, Santa Maria di Galeria, Rome, Italy, (4) Danish Meteorological Institute,Copenhagen, Denmark, (5) Department of Physics and Astronomy, State University of New York, Stony Brook, NY, USA

The distribution of carbon monoxide (CO) in the stratosphere and mesosphere is a useful tool to study middle atmospheric dynamical processes during polar winters. CO concentrations exhibit a strong latitudinal gradient (positive moving towards the winter pole) and a large vertical increase in the mesosphere and lower thermosphere. These large gradients, together with a long photochemical lifetime, make CO an excellent tracer for studying both the poleward transport of air masses from lower latitudes and the descent of air inside the polar vortex.
The CO measurements used in this study have been obtained observing the 230 GHz transition by means of a Ground-Based Millimeter-wave Spectrometer (GBMS) with a pass band of 50 MHz and a spectral resolution of 65 kHz. The GBMS was designed and built at the State University of New York at Stony Brook in the early 90's to detect rotational emission spectra of middle atmospheric trace gases at frequencies between approximately 230 and 280 GHz. Since the shape of spectral lines at millimeter-wave frequencies strongly depends on the pressure line broadening, an implementation of the Optimal Estimation technique allows the retrieval of mixing ratio vertical profiles from emission spectra. The GBMS spectral coverage and resolution allows CO mixing ratio profiles to be retrieved between about 30 and 80 km, i.e. at an altitude range where other forms of data used in dynamical studies become increasingly sparse or absent.
In January 2009, the GBMS was installed at the NDACC (Network for the Detection of Atmospheric Composition Change) Arctic station at Thule (76.5°N, 68.8°W), Greenland, to commence a long-term observation plan of the polar middle atmosphere. Three winter campaigns have been carried out since then (winters 2008/09, 2009/10, and 2010/11), and the 2011/2012 campaign has been funded and it is about to get started.
In this contribution, 4 winters of GBMS CO observations will be presented. Owing to the time span of the GBMS data record and the high temporal resolution of its spectral measurements (15 minutes), the GBMS CO vertical profiles allow to capture both the interannual variability of subsidence rates of air masses inside the polar vortex as well as the short-term planetary wave activity observed near the edge of the polar vortex.
Particular emphasis is given to the two record winters of 2008/09 and 2010/11, characterized by opposite extreme events: the most intense Sudden Stratospheric Warming (2008/09) and the most severe Arctic ozone depletion ever observed (2010/11).