Geophysical Research Abstracts
Vol. 12, EGU2010-400-1, 2010
EGU General Assembly 2010

The record 2009 major stratospheric warming observed by lidar and millimeter-wave spectrometer at Thule (76.5° N, 68.8° W), Greenland

Claudia Di Biagio (1,2), Giovanni Muscari (3), Alcide G. di Sarra (1), Irene Fiorucci (3), Robert L. de Zafra (4), Marco Cacciani (5), Paul Eriksen (6), and Daniele Fuà (5)

(1) ENEA/CLIM-OSS, S. Maria di Galeria (Rome), Italy (claudia.dibiagio@enea.it), (2) Department of Earth Science, University of Siena, Siena, Italy, (3) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy, (4) Department of Physics and Astronomy, State University of New York at Stony Brook, New York, USA, (5) Department of Physics, "Sapienza" University of Rome, Rome, Italy, (6) Danish Meteorological Institute, Copenhagen, Denmark

The 2009 Arctic winter has been characterized by the largest major sudden stratospheric warming (SSW) event on record ever observed. In this study ground-based observations of the thermal structure and chemical composition of the middle atmosphere from the Network for Detection of Atmospheric Composition Change (NDACC) station at Thule (76.5°N, 68.8°W), Greenland, are used to show the evolution of the phenomenon in correspondence with the region of maximum warming.

An intensive measurement campaign was conducted during January – early March 2009 at Thule with a lidar and a ground-based millimeter-wave spectrometer (GBMS). Lidar measurements permit to retrieve the atmospheric temperature profiles between 25 and 70 km with a vertical resolution of 150 m, and a 1σ uncertainty that varies from $\sim$1 K at 25 km to $\sim$15 K at the maximum probed altitude. Radiosonde data are used to derive temperatures below 25 km. GBMS measurements are used to derive O_3, N_2O, and CO concentration profiles between 15 and 55 km with a vertical resolution of $\sim$7 km, and a 1σ uncertainty of 13%, 15%, and 16%, respectively. The GBMS retrieval algorithm has recently changed to a standard Optimal Estimation Method (OEM) which was applied to the O_3 and N_2O measurements. During the campaign, measurements were performed mostly on a daily basis, except during periods characterized by poor weather conditions or instrument malfunctioning.

The temporal evolution of the measured temperature, T, has been derived at different potential temperature (θ) levels between 300 ($\sim$10-12 km altitude) and 2000 K ($\sim$48-50 km altitude). Consistently with the typical SSW evolution, the warming affected the upper stratosphere first, and then propagated rapidly from the upper to the lower stratosphere. Before the warming event, in mid-January, the vortex was stably present and a PSC of NAT particles was detected by lidar on January 17 and 18 between 17 and 19 km altitude. The first signs of warming were observed at the 2000 and 1500 K levels on 22 January. After 2-4 days, the warming reached 1000 K, 900 K and 800 K, and after 6-7 days also the 600 K, 500 K, 400 and 300 K levels were affected. The maximum value of T reached at each level decreases approximately linearly with height, from the exceptional value of 289 K at 1500 K to 218 K at 300 K. Comparison of 2009 data with Lidar measurements obtained during past years indicates that the 2009 SSW was the strongest event ever observed at Thule, with temperatures at 1500 K up to 50 K larger than those observed in the period 1994-2007.

The temporal evolution of O_3, N_2O, and CO concentrations, and potential vorticity, at different θ-levels between 500 and 2000 K show the downward progression of the vortex break up, which took about 7-10 days to propagate from the upper to the lower stratosphere. A significant increase in N_2O concentration is associated with the vortex break up between 500 and 1000 K. At higher altitudes (1500 and 2000 K) the vortex break up is marked by a sudden decrease in CO amounts. During the warming, O_3 increased abruptly at higher levels ($\sim$2 ppmv at 1500 and 2000 K) and gradually at lower levels; a large correlation between the behaviour of O_3 and T is observed. At 1000, 1500, and 2000 K levels the vortex reformed between the end of January and the beginning of February, while at lower levels the vortex never restored.