Examining the influence of sudden stratospheric warming in the upper mesosphere-lower thermosphere region using satellite and HF radar data sets

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Abstract

The first ever detection of a major sudden stratospheric warming (SSW) in the Southern Hemisphere occurred during the 2002 Antarctica winter [Baldwin et al., 2003]. This unprecedented event led to the first time split of the South Pole polar vortex into two parts. SSWs are known to be primarily caused by planetary waves which are originally excited at the tropospheric heights and propagate upwards [Matsuno, 71; Andrews et al., 1987]. These planetary waves interact with the mean-flow in the stratosphere and as a result of the interaction an upward and pole ward directed heat and momentum flux leads to decreasing westerly winds and increasing temperature in the polar region. Moreover, the deceleration and reversal of the eastward jet in the high-latitude stratosphere allows eastward propagating gravity waves from the lower atmosphere to penetrate the mesosphere-lower thermosphere (MLT) region depositing momentum and energy through wave breaking and dissipation processes which significantly alters the MLT thermal structure and meridional circulations.

Although there are a number of medium frequency (MF) radars in Antarctica, any available wind measurements especially from a global network of identical instruments like Super Dual Radar Network (SuperDARN) is a desirable option for studying winds dynamics and atmospheric waves and their characteristics in the MLT region. In the present study we have use the high frequency (HF) radar winds data set from the South African National Antarctic Expedition, SANAE (72°S, 3 W), a radar which is part of the SuperDARN to examine the

behaviour of the MLT winds in response to a major SSW event. The National Centre for Environmental Prediction (NCEP) reanalysis temperature and zonal winds data were used to identify the SSW as well as to examine the response of the zonal winds in the stratosphere to the major SSW event. The Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) on board the thermosphere–ionosphere–mesosphere-energetics and dynamics (TIMED) satellite temperature data was use to examine temperature at the stratosphere and MLT region during event.

In the present work the SANAE HF radar has proved its capabilities to study the influence of wave dynamics in the MLT region during the occurrence of major sudden stratospheric warming events. The mean zonal winds (from SANAE HF radar) at the lower thermosphere show reversal in approximately 7 days before the reversal at 10 hPa (from NCEP). This behaviour is also usually observed by MF radars in the northern hemisphere during its usually detected major SSW events, and it indicates that there was a downwards propagation of circulation disturbances. In general, westerly zonal winds dominate the winter MLT, but during the 2002 winter there were many periods of easterly winds observed when compared to the other winters. The SABER vertical temperature profiles show an unusual increase of temperature in the stratosphere, addition to the occurrence of double stratopause cases observed on the 24th and 25th of September. Further, the observed SSW has caused MLT cooling along with signatures of mesosphere temperature inversions (MTI) were identified from the SABER vertical temperature profiles. This behaviour (MTI and the effect of SSW) of the MLT was surely due to the deposition of energy and breaking of propagating waves (Planetary, Gravity and Tides) which are originally from the troposphere.