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Effects of Major Sudden Stratospheric Warmings Identified in Midlatitude Mesospheric Rayleigh-Scatter Lidar Temperatures
Effects of Major Sudden Stratospheric Warnings Identified in Midlatitude Mesospheric Rayleigh-Scatter Lidar Temperatures

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Abstract

Sudden Stratospheric Warnings (SSWs) are major disturbances in the polar region of the winter hemisphere, characterized by sudden changes in stratospheric temperature and circulation. SSWs are identified by the characteristic temperature increase of degrees Kelvin, observed over 60°-90° latitude, and the weakening of the polar vortex that persists for the order of a week at the 10 hPa level (nearly 32 km) (Labitzke and Naujokat, 2000). This event is important because it marks the reversal of the polar stratospheric jet (PSJ), the polar wind that defines the polar vortex and carries cold air poleward. The weakening of the polar jet allows warmer air to invade the stratosphere, leading to the establishment of an anticyclonic vortex, which can transport warm air to midlatitudes. This process is known as the thermal wind, and it is a key factor in the formation of midlatitude weather patterns.

Introduction

In this study, we present a study of the behavior of the mesosphere, from a midlatitude Rayleigh lidar site, during six major sudden stratospheric warmings. Our conclusions include:

- A dense temperature dataset, acquired by the USU Rayleigh lidar, overlaps significantly with nearly all of the major SSW events from 1993-2004.
- The observed midlatitude mesosphere, from 45°-90°, undergoes a winter-to-summer temperature reversal from the time of the stratospheric zonal wind reversal at 60° N.
- The mesospheric temperature anomalies, in the upper mesosphere, are roughly the same magnitude at midlatitudes as they are in the polar region.

This work will be furthered by examining the behavior of the midlatitude Rayleigh lidar in future observations with the recently upgraded USU RSLS, which has an observational range of 70-118 km (Wickwar et al., 2014).

Conclusions and Future Work

In this study, we focused on the response of SSWs above Logan, UT, over a period when there were major SSW events during the USU State University Rayleigh-Scatter Lidar (RSLS) operational run (Table 1). A major SSW is characterized by both a stratospheric temperature increase and a westward wind reversal. The results of this study support the hypothesis that the warming is caused by the sudden warming of the stratosphere and the subsequent westward wind anomalies that occur in the polar region. These effects are also observed in the mesosphere, as seen in NASA’s Modern Era Retrospective Analysis for Research and Applications (MERRA) dataset.

Figure 1 (a) presents the daily mean temperature averaged between 60°–90° N and (b) the daily mean zonal winds at 60° N from NASA’s MERRA database. Vertical line bars indicate the periods with significant warming in the stratosphere. The red vertical line indicates the period of the stratospheric warmings. The data show a clear warming in the mesosphere, which is consistent with the stratospheric warming, and it occurs approximately 15-20 days after the peak of the stratospheric warming.

Figure 2 (a) shows the zonal mean temperatures averaged between 60°–90° N and (b) the daily mean zonal winds at 60° N from NASA’s MERRA database. Vertical line bars indicate the periods with significant warming in the stratosphere. The red vertical line indicates the period of the stratospheric warmings. The data show a clear warming in the mesosphere, which is consistent with the stratospheric warming, and it occurs approximately 15-20 days after the peak of the stratospheric warming.

References


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MERRA NASA MERRA Database Website (http://gcmd.nasa.gov/WWW/cdo/downref/merra_data.html)

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