Correlation of the lower atmosphere and the MLT region in temperature

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ABSTRACT

The airglow temperature in the Mesosphere and Lower Thermosphere (MLT) region has been measured using a Spectral Airglow Temperature Imager (SATI) at Resolute Bay (74.68°N, 94.90°W) since November 2001. The MLT temperature anomalies are compared to the lower stratospheric radiosonde temperature anomalies at Resolute Bay for five years. A positive relationship between the MLT temperature at the altitude 87 km and the lower stratospheric temperature at 22.5 km is found during the period. The MLT temperatures are also compared to the upper stratospheric temperatures acquired by SABER. A negative relationship between the MLT temperature and the upper stratospheric temperature at the altitude 55 km is found during the period. The lower atmospheric temperature and the MLT temperature are also compared with the solar flux variation as a function of QBO phase and season.

Measurements

(1) SATI :

The Spectral Airglow Temperature Imager (SATI) is a spatial scanning Fabry-Perot spectrometer. The SATI instrument consists of a conical mirror, Fresnel lens, a CCD detector, and narrow band interference filters for the O_2 and OH airglow emissions at 94 km and 87 km, respectively. SATI measures the column emission rate for several rotational lines, and the rotational temperature is inferred from their ratios. The exposure time is 120 seconds for each measurement, so the time resolution is about 4 minutes for two airglow layers. The instrument error of the relative temperature measurements for both emissions is approximately 1.7 K standard deviation, and for the emission rate about 2. For more details see Sargoytchev et al. [2004]. The SATI instrument was installed at Resolute Bay (74°N) in November, 2001. Early results for Resolute Bay were shown by Won et al. [2003] and Cho et al. [2004].

(2) Radiosonde :

The Meteorological Service of Canada radiosondes have been launched from a point near the Resolute Bay airport each day at (nominally) 00:00 UT and 12:00 UT since 1966. The sondes provide vertical profiles of temperature, pressure, and humidity and also the magnitude and direction of the winds. The 3-month running mean temperature values from the altitude of 0.5 to 29.5 km are used in this presentation. For more details see Hocking [2001].

(3) UKMO :

UKMO (UK Meteorological Office) stratospheric assimilated data are sets of meteorological analysis comprising 3-D fields of temperature, geopotential height and wind components at 2.5° x 3.75° resolution from 1000 hPa to 0.316 hPa (about 0-55km). Data were originally produced by the UKMO primarily to provide independent correlative data for instruments on the Upper Atmosphere Research Satellite (UARS). Data are currently generated using temperatures from NOAA (National Oceanic and Atmospheric Administration) polar orbiting satellites. The data assimilation is a development of the scheme used at the Met office for operational weather forecasting, with the 3-D system implemented in November, 2000. Further details are given by Swinbank and O'Neill [1994].

(4) SABER :

The SABER instrument on the NASA TIMED (Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics) satellite, successfully launched on December 7, 2001, was chosen for the global temperature measurements. SABER is a 10-channel broadband radiometer, and measures infrared Earth limb emissions such as CO_2, O_3, H_2O, NO, 0H, and O_2. The temperature is obtained from the CO_2 15.2 μm emission that is in LTE (Local Thermal Equilibrium) in the stratosphere and lower mesosphere [Remsberg, 2003]. In the MLT region, the temperature may still be retrieved under non-LTE conditions. The initial retrievals have been presented by Mertens et al. [2004], and the data (Version 1.06 of SABER database presented here) included the non-LTE effects. The latitude coverage is from 83°N to 52°S , with alternate coverage from 83°S to 52°N every two months.

Comparisons

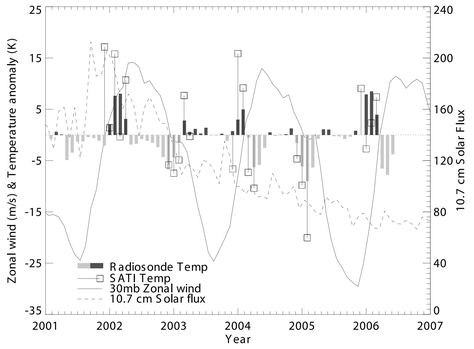

Figure 1-1. SATI temperature anomalies are compared with lower stratospheric temperature anomalies. Dashed lines indicate the 10.7 cm solar flux. The solid line represents the QBO, and positive (negative) wind speed indicates westerly (easterly) zonal mean wind at 30 mb. Square-solid lines denote the OH temperature anomaly at Resolute Bay (74°N). The temperature anomaly at 22.5 km as measured at Resolute Bay shown as vertical bars.

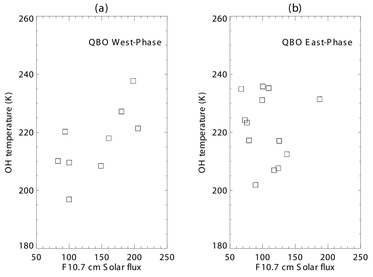

Figure 1-2. The OH temperature at Resolute Bay (74°N) as a function of the 10.7 cm solar flux. Panel (a) presents the correlation of OH temperature and the solar flux in the west phase of the QBO, and panel (b) in the east phase of the QBO.

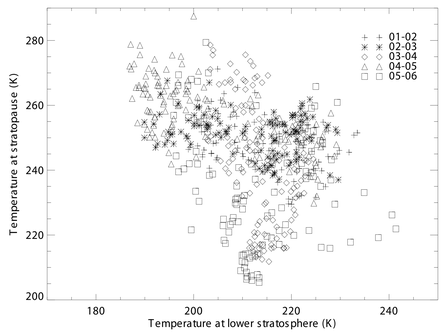

Figure 2-1. The scatter plot of the lower and upper stratospheric UKMO temperature over Resolute Bay, for winter seasons from 2001 to 2005. The pressure level of 31.62 hPa (~24 km) was selected for the lower stratospheric temperature, and 0.316 hPa (~56 km) for the stratopause temperature. The latter value was changed for the years 04-05 and 05-06 for which the pressure level of 1 hPa (~48 km) was chosen for the upper stratospheric temperature. Different symbols indicate different seasons.

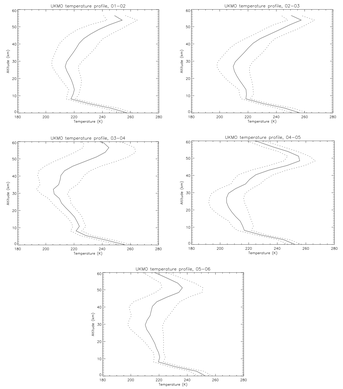

Figure 2-2. The UKMO temperature profiles over Resolute Bay during winter seasons from November to March, 2001-02, 02-03, 03-04, 04-05, and 05-06.

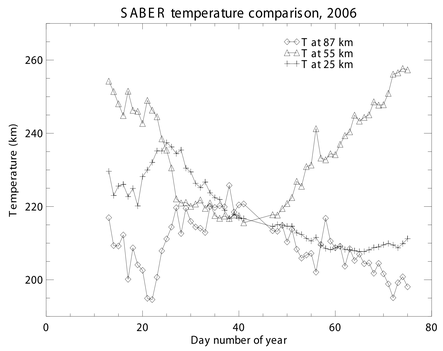

Figure 3-1. SABER daily zonal temperature at the altitudes of 25, 55, and 87 km, from January to March, 2006. The latitude range is from 72°N to 76°N, and the local time is from 21 LT to 4 LT. Different symbols indicate temperatures at the three altitudes.

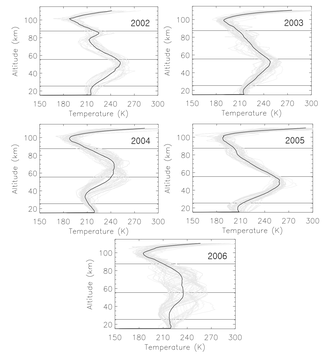

Figure 3-2. SABER daily temperature profiles for winter seasons from January to March, 2002 - 2006. The latitude and local time range are same as Figure 3.1.

Summary

The temperatures at different altitudes are compared using SATI, radiosonde, UKMO assimilated data, and SABER for several winter seasons. The comparison of radiosonde and SATI temperatures at Resolute Bay shows a positive relationship. The temperature anomalies are related to the combined solar variation and QBO phase. The temperatures decrease with the 10.7 cm solar flux during the westerlies QBO phase [Labitzke, 1987]. The UKMO assimilated data shows the negative relationship between the lower stratosphere and stratopause temperature. The SABER satellite measurements also show the relationship between the lower-upper stratosphere and MLT region temperature.

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