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Mesospheric Temperature Variability and Seasonal Characteristics Over the Andes

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Introduction

The Andes region is an excellent natural laboratory for investigating gravity wave influences on the Upper Mesospheric and Lower Thermospheric (MLT) dynamics. The instrument suite that comprised the very successful Maui-MALT program was relocated to the new Andes Lidar Observatory (ALO) located high in the Andes mountains (2,520 m) near the Cerro Pachon astronomical telescopes, Chile (30°3′, 70.7°W). As part of this instrument set the Utah State University (USU) CEDAR Mesospheric Temperature Mapper (MTM) has operated continuously since August 2009 measuring the near infrared OH(6,2) band and the O(2,1) Atmospheric band intensity and temperature perturbations to obtain in-depth seasonal measurements of MLT dynamics over the Andes.

This poster presents results of an ongoing analysis of nighttime OH (6,2) band intensity and rotational temperatures and their seasonal variability (20 months of data to date). These are compared with our results from the Maui-MALT program, Maui, HI (19.5° N, 155.8° W).

Example Nocturnal Variability and Quasi-Periodic Wave Analysis

The above figures show data obtained November 6-7, 2010 illustrating the quality of the temperature measurements and the typical variability observed at Cerro Pachon. Plot (a) shows new intensity data for the OH (6,2) bands and the O(2,1) measurements during the course of the night (typically 8 hours in duration). The steep slopes at the beginning and end of the plot show sunset and sunset. The OH and O2 show significant wave-like variability throughout the course of the night. The green curve shows the background sky emissions while the blue curve shows the camera dark current. Plot (b) shows the superposition of the derived OH (6,2) band intensity and rotational temperature. During the night the intensity decreases significantly probably due to large scale wave which is more easily seen in the temperature data. The temperature variation during the night is ~27K and appears typical at this site. The black horizontal line represents the mean nocturnal curve.

Instrumentation

The USU CEDAR Mesospheric Temperature Mapper (MTM) is a high performance CCD imaging system designed to provide accurate measurements of mesospheric temperature variability at two altitudes and gravity wave intensity and rotational temperature perturbations using precise observations of the OH (6,2) band and O(2,1) airglow emissions at nominal altitudes of ~87 and ~94 km.

Field of view: ~90°, (180 x 180 km).  
• Spectral observations (60 sec. exp.) of:  
  - NIR OH (6, 2) Band ~87 km  
  - O2 (0,1) A Band ~94 km  
  - Background (~857.5 nm)  
• Cycle time: ~3 min per OH emission  
• Temperature precision: ~2 K

The MTM took sequential 60 second exposures using narrow-band (~1.2 nm) filters centered on the P(2), and P(4) lines for the OH (6,2) band followed by similar observations of the O2 (0,1) emission. In addition, a background measurement and a dark image were also recorded resulting in a cadence time of ~6 minutes. Data were recorded nightly except during the full moon period (~25 nights/month). To date we have obtained nearly 2 years of observations, comprising ~450 nights of high quality data.

For this study we have focused our analysis on the OH emission. The data were analyzed using software developed at USU to determine the band intensity and rotational temperatures variability during each night. OH rotational temperatures were computed using the well-established “ratio method” (Menwedh et al., 1984). Comparisons of the MTM OH temperatures with those observed by other well calibrated instruments (Na temperature lidars, TIMED satellite, and FTR spectrometers) indicate that our absolute temperatures referenced to the 87 km lidar temperatures are accurate to ±5 K (Pendleton et al., 2000).

OH Temperature Analysis

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Comparing Seasonal Variability at Maui and ALO

These plots show 20 months (450 nights) of mean MTM OH Band Intensity and temperature data from ALO. The error bar show the standard deviation of the nocturnal temperature variability as described above. The black curve shows the 15 day smoothing to the data and as well as a ALO and SAO, there is evidence of ~90 day oscillation during the first year of measurements.

Summary and Future Work

• Nocturnal variations at Cerro Pachon are highly variable and at times can exhibit large amplitudes, exceeding 40 K during the course of a night observations. Other nights show evidence for large amplitude gravity waves in intensity and temperature data with well-defined periods of a few to several hours (The image data also show periods of less than 1 hr).

• A initial sinusoidal wave analysis applied to the OH intensity and temperature data has been used to study the wave amplitudes and periods in the data.

• The 20 months of mesospheric OH temperature data acquired to date exhibit ALO and SAO signatures and unexpected short-term oscillations (~90 day) that is currently under investigation at USU. Comparison with data from nearby El Leoncito, Argentina is in progress (Courtesy J. Sheer).

• Investigation of long-and short period gravity waves using MTM and collaborative Na lidar and meteor radar when to investigate intrinsic wave characteristics, propagation and momentum fluxes.

• Perform a detailed comparison with SABER temperatures from the TIMED satellite as we conducted during the Maui-MALT program.

• Comparative study of OH and O2 temperature data to investigate phase relationships of wave events and to study wave growth and/or dissipation.

• Ongoing seasonal measurements will be used to build a clearer understanding of the temperature variability and its intra-annual variability.

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