Sección Especial: 37th AMASON / Special Section: 37th AMASON
Ionosphere, Mesosphere and Lower Thermosphere

# Wave activity detected in Granada (Spain) during the first NDMC measurement campaign by using SATI data

# Actividad de ondas detectada en Granada (España) usando medidas de SATI durante la primera NDMC campaña de medidas

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**ABSTRACT:**

The presence of wave oscillations in the mesosphere/lower thermosphere region during the first global measurement campaign of the Network for the Detection of Mesopause Change (NDMC) has been investigated at Sierra Nevada Observatory (37.06º*N*, 3.38º*W*) by using airglow observations taken with a Spectral Airglow Temperature Imager (SATI) intrument. Airglow data of the column emission rate of the $O_2$ Atmospheric (0-1) band and of the OH Meinel (6-2) band and deduced rotational temperatures from September 2009 to October 2009 have been used in this study.

**Keywords:** Airglow, Temperature.

**RESUMEN:**

La presencia de oscilaciones en la mesosfera/baja termosfera durante la primera campaña de la Red para la Detección de Cambios en la Mesopausa (RDCM) ha sido investigada analizando las medidas obtenidas por un instrumento llamado SATI instalado en el Observatorio de Sierra Nevada (37.06º*N*, 3.38º*W*). Datos de la emisión de la banda (0-1) del sistema atmosférico del oxígeno molecular y de la banda (6-2) del sistema de Meinel del OH y de las temperaturas rotacionales deducidas de Septiembre a Octubre de 2009 han sido utilizadas en este estudio.

**Palabras clave:** Emisiones Atmosféricas, Temperatura.

**REFERENCIAS Y ENLACES / REFERENCES AND LINKS**

[1]. http://wdc.dlr.de/ndmc

[2]. M. J. López-González, E. Rodríguez, R. H. Wiens, G. G. Shepherd, S. Sargoytchev, S. Brown, M. G. Shepherd, V. M. Aushev, J. J. López-Moreno, R. Rodrigo, Y.-M. Cho, "Seasonal variations of $O_2$ atmospheric and OH(6-2) airglow and temperature at mid-latitudes from SATI observations", *Ann. Geophysicae* **22**, 819-828 (2004).

## 1. Introduction

Wave type oscillations play an important role in the dynamics of the mesosphere and lower thermosphere (MLT). Atmospheric gravity waves can be generated in the lower atmosphere by different mechanisms (topography, convection, etc), tides are the global response of the atmosphere to the periodic forcing of solar heating, and planetary waves are presumed to originate in the troposphere and stratosphere by topographic forcing, land-sea heating contrast and large scale weather disturbance. The presence of these oscillations in the MLT region make this region a very interesting place to study the dynamic and coupling of these atmospheric layers. The NDMC is a global program with the aim of investigating the mesopause region. The program involves the coordinated study of the atmospheric variability at all scales. The first global NDMC campaign was conducted from September 01 to October 31, 2009 (see [1]). The measurements taken by a SATI instrument at Sierra Nevada Observatory (SNO) at 2900 m height, during this first global NDMC measurement campaign together with some of the results derived after the analysis of the data are presented in this paper.

## 2. Data analysis

### 2.a. Data

SATI instrument is a spatial and spectral imaging Fabry-Perot spectrometer in which the etalon is a narrow band interference filter and the detector is a CCD camera. The instrument uses two interference filters, one centred at 867.689 nm (in the spectral region of the $O_2$ Atmospheric (0-1) band) and the second one centred at 836.813 nm (in the spectral region of the OH Meinel (6-2) band).

SATI is working regularly at SNO since 1998 (see [2]). However, no SATI measurements are available from 2008 to September 2009 due to major technical problems of SATI instrument. After technical reparation SATI is working again since September 2009 and SATI data from 18 September 2009 could be obtained to contribute to the first NDMC measurement campaign from our place. The SATI data obtained during this campaign at SNO are shown in Fig. 1.

### 2.b. Long wave oscillation analysis

The Lomb-Scargle periodogram method was applied to time series of 20 consecutive days to study oscillations of periods greater than a few days. Figure 2 shows the contour maps of the periodograms obtained for 20-days time series slided with 1 day step for both emission rates and temperature. Oscillations of periods around 6 days are stronger in September in both OH and $O_2$ temperatures and emission rates.

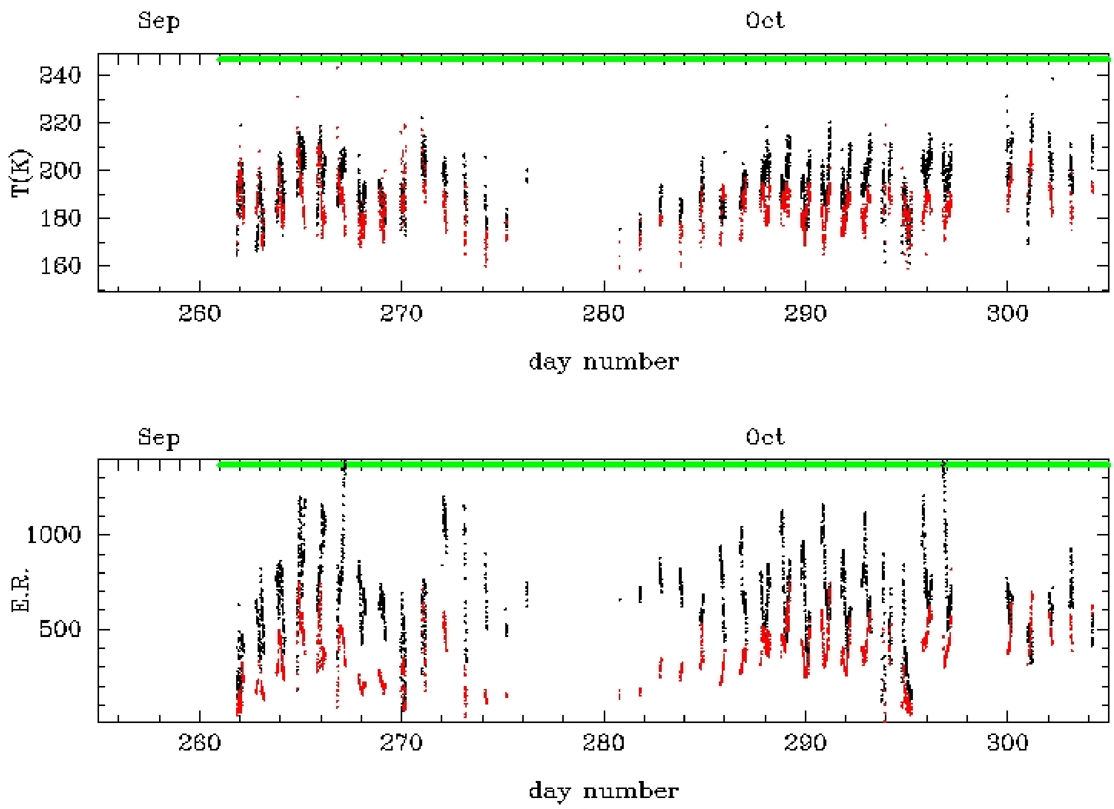


Fig. 1: Upper panel Temperatures. Bottom panel: Emission rates. Black points: from OH measurements. Red points: from $O_2$ measurements..

 

These 6-day wave type oscillations seem to evolve to oscillations of longer period (around 10 days period) by the end of September and beginning of October for both temperatures and $O_2$ emission rate. By the end of October a long periodic oscillations of around 16 days period, or longer, are marked in both temperatures and $O_2$ emission rate.

## 2.c. Short wave analysis

Wave oscillations of periods corresponding to the diurnal tide (1 day) and shorter periods are hard to see in Fig. 2. Figure 3 shows the peridograms obtained for September and October when the whole set of data measured during the corresponding month has been used as a time series. During October, the peak corresponding to the semidiurnal oscillation is the most significant peak in the periodograms. During September after the subtraction of the oscillation corresponding to the main peak around 5-7 day period, a second peak, corresponding to a 12h period, remains. This oscillation corresponds to the semidiurnal tide. The presence of these marked peaks, in one-month series periodograms, is an indication of the persistent character of the semidiurnal tide oscillations in the data.

In order to study wave type oscillation of periods shorter than 1 day a frequency analysis has been performed to each night of data. Periods of around 12h together with other possible periods of 8h, 6h, and 4h, are generally present in the data. As the semidiurnal tide is a persistent oscillation in our data, this oscillation has been analysed first. Figure 4 shows the amplitudes and phases of maximum amplitude obtained for each night of data. A different behaviour in the phase of maximum amplitude of the tide is observed from September to October (see Fig. 4). The phase of maximum amplitude is close to midnight during September while during October the phase of maximum amplitude is, preferentially, at the beginning of the night.

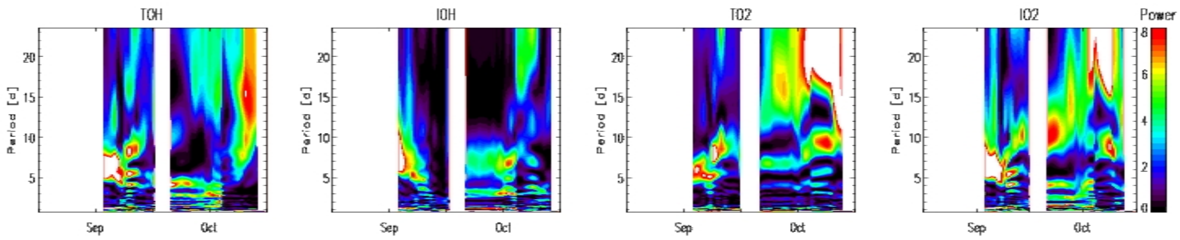


Fig. 2: Periodograms.

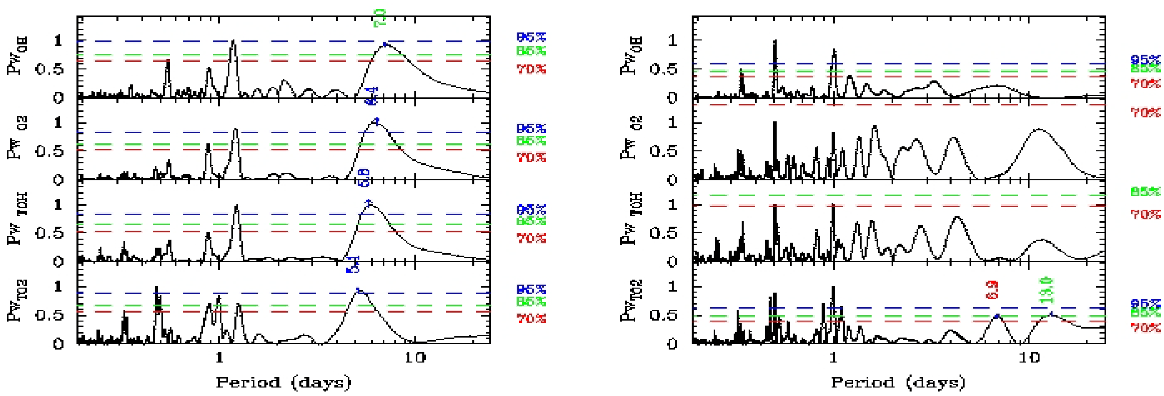


Fig. 3: Wave analysis for one month data. Left panel: for September data. Right panel: for October data.

 

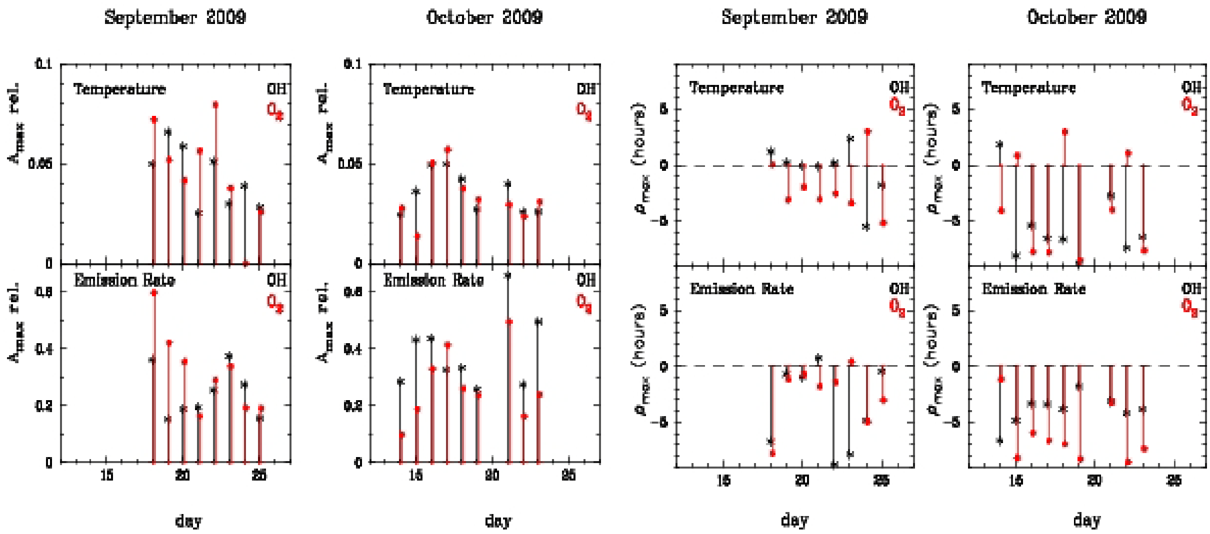


Fig. 4. Left panels: Amplitudes of the semidiurnal tide. Right panels: Phase of maximum amplitude (0.0h=midnight). Black from OH emission. Red from $O_2$ emission.

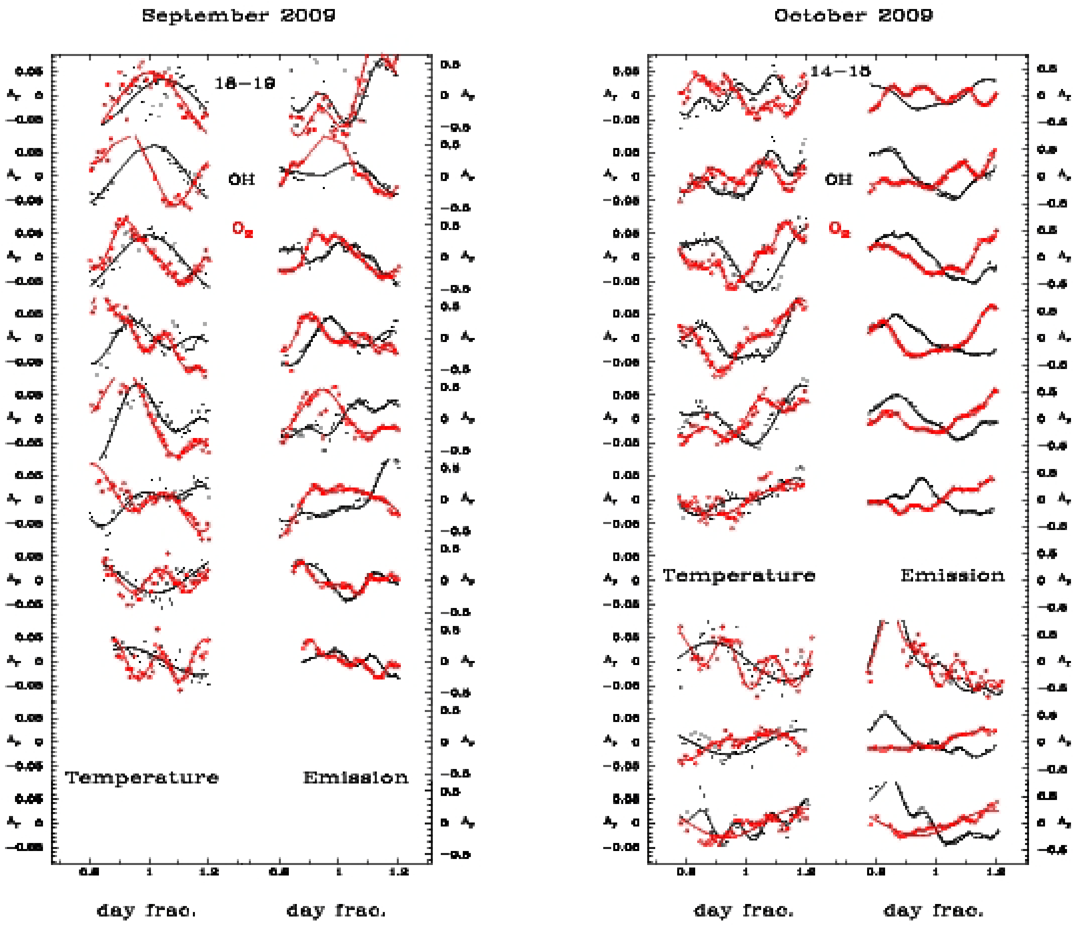


Fig. 5: Short period wave analysis . Left panel: September 09 results. Right panel: October 09 results. Points: Measurements. Solid line: Numerical calculation. Black: OH measurements. Red: $O_2$ measurements.

Other short-period oscillations still present in the data after subtracting the semidiurnal oscillation each of the individual nights have been derived by using frequency analysis. The results obtained following this procedure are shown in Fig. 5 where the calculated numerical perturbations deduced from the analysis together with the measurements taken each night are compared.

## 3. Conclusions

The analysis of SATI measurements during September and October 2009 has shown the presence of a strong oscillation of period close to 6 days, during September in both emission rates and temperatures. This oscillation seems to evolve to an oscillation of period close to 10 days by the end of September and first half of October in $O_2$ emission rate and temperature. A possible oscillation of period of 16 days or longer seems to be present in both temperatures and in $O_2$ emission rate.

A great wave type activity of periods smaller than 1 day is detected every night. The predominant oscillation corresponds to de semidiurnal tide. A clear change in the behaviour of the phase of maximum amplitude of this semidiurnal oscillation is detected from September to October.

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