THE FIRST RESONANCE LIDAR OBSERVATIONS OF MESOSPHERIC SODIUM OVER GADANKI (13.5°N, 79.2°E), INDIA

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ABSTRACT

Recently a resonant scatter lidar system has been setup at the National Atmospheric Research Laboratory (NARL), Gadanki (13.5°N, 79.2°E; dip 12.5°N, 6.3° magnetic latitude), India to study the aeronomy of the mesopause region over this tropical low latitude part on regular basis. Using the lidar system, we have successfully observed Na layer at altitudes between 80 and 105 km during January 2005 for the first time over the Indian sub-continent and also observed sporadic formation of thin dense layers of sodium at early morning hours. We report the preliminary observations recorded using the system during 2005.

1. INTRODUCTION

The existence of atomic sodium near mesopause is a natural phenomenon. Meteoric ablation is believed to be the major source for the formation of mesospheric sodium and the other metal layers in this region of the atmosphere. As meteors enter the atmosphere, they burn-up or ablate and leave debris in their path. This ablation occurs near altitudes of 80 to 100 km. A part of this debris contains metals atoms such as sodium, potassium, iron and calcium in neutral atomic state, which is a unique characteristic of this region. This region of atmosphere also hosts the airglow layers. Since the mesospheric region is difficult to measure, being too low for satellites and too high for balloons, most of the studies rely on remote-sensing techniques. The metal atoms are useful for remote sensing as they are shiny at specific resonant wavelengths. The resonant wavelength for sodium, appears bright orange in color, is 589 nm. It corresponds to the frequency of the Na atomic transition from the ground state to the first-excited state. The resonance scatter occurs when the absorbed radiation is reemitted by the Na atoms.

Recently a lidar system was installed at Gadanki in India to probe the pertinent layer of neutral sodium atoms exist between 80 and 110 km. The lidar employs a flash lamp pumped dye laser as a transmitter. The dye laser is tuned to the sodium D sub 2 line at 589.0 nm. The lidar has achieved “first light” on 10 January 2005. These are the first mesospheric sodium measurements from India. The lidar measured vertical profiles of resonant backscatter is found with sufficient signal strength for deriving the mesospheric sodium density profiles. Using the system, sodium number density profiles are obtained with a vertical resolution of 300 m and a time sampling of 120 s. These features allow the system to detect the time and space variability of Na density profiles.

2. PRELIMINARY RESULTS

The preliminary analyses of the sodium density measurements during 2005 show peak sodium concentrations found to appear at 95 km altitude. Fig. 1 shows the average sodium profile obtained for January 2005. The mean sodium profile starts to appear around 80 km. During the measurement period, only once, we see sodium lower than this but not below 75 km. The sodium rises to a peak close to 95 km and then falls to zero around 105 km. The measured profile structure of the sodium layer is very similar to that observed at other

locations. The peak density value is around 3400 cm^{-3}. The occurrence of peak Na concentration was similar to that reported by Kirchhoff and Clemesha (1973) from the other low latitude location. Above the peak, the vertical gradient in sodium concentration was seen with a smaller scale height, which is about 2 km.

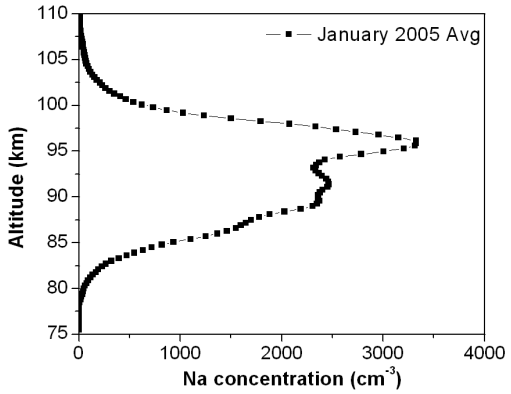

Fig. 1. Vertical profile of mesospheric Na observed over Gadanki during January 2005

Wave like structures in the sodium layer have been observed with characteristics similar to propagating gravity waves. Wave structures shown in Fig. 2 in the sodium layer were observed with typical wavelengths of 3-10 km and downward phase velocities of about 1 km hr^{-1}.

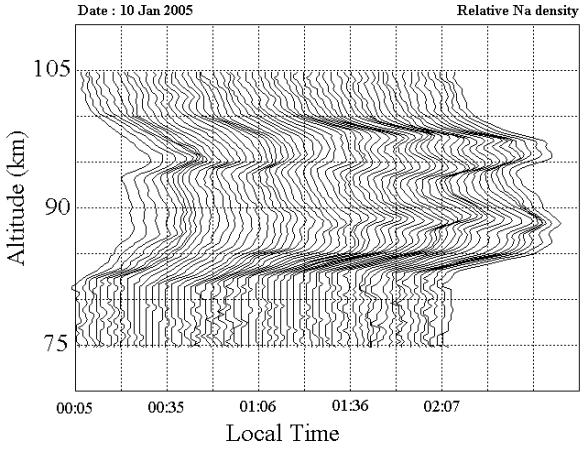

Fig. 2 Typical wave signatures in Na layer

We also observed a sudden formation of a dense thin Na layer superimposed on a background Na layer such as shown in Fig. 3 on several occasions during 2005.

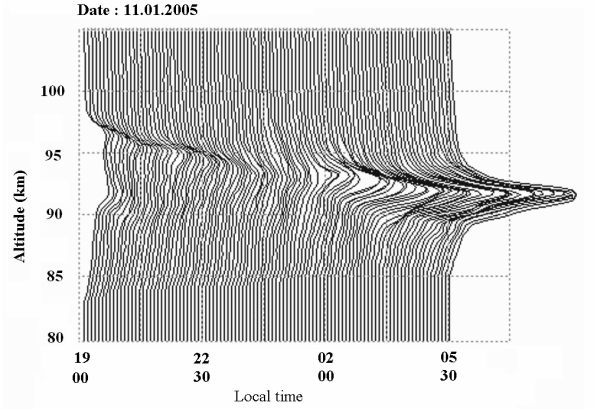

Fig. 3.A typical Ns also called as sudden sodium layer (SSL) observation over Gadanki

The main characteristics of SSL are high peak density, narrow peak width, and short developing time.

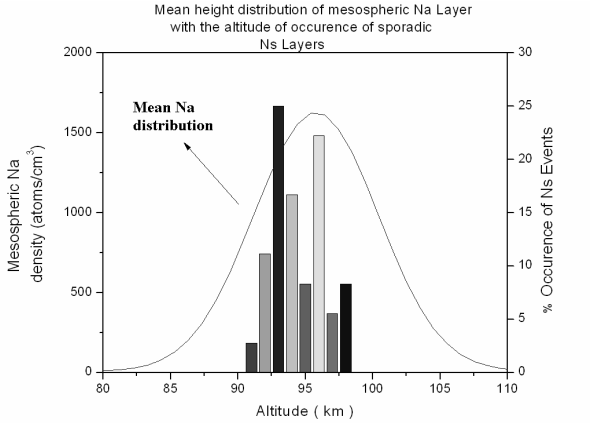

Fig.4. Statistical details of altitude occurrence of SSL observed over Gadanki in 2005

We detected 36 SSL events in 290 h of observation in 2005, with a SSL occurrence rate of 1 event per 8 h. We observed that these SSL events were located at the altitude range of 90–98 km with occurrence distribution as shown in Fig. 4. The majority of these SSLs observed to occur during early hours of the day.

Reference

1. Kirchhoff, V.W.J.H., and Clemesha, B.R.: Atmospheric sodium measurements at 23°S, *J. Atmos. Terr. Phys.*, 35, 1493-1498, 1973.