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Atmospheric soundings from Mount Abu

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Abstract. An atmospheric science laboratory was set up at Gurushikhar, in the campus of PRL's Infrared observatory, in 1994. A variety of scientific instruments were housed in the atmospheric science laboratory to explore the Earth's ionosphere and neutral atmosphere. A powerful Nd-YAG laser based Lidar, a multi-wavelength all sky imaging system, Day-night-airglow photometer/spectrometer and a proton precession magnetometer are in operation along with a surface ozone sampler, a carbon mono-oxide analyzer and a UV radiometer (measures solar ultraviolet irradiance between 280 and 320 nm). This article highlights the neutral density and temperature measurements by the lidar as well as Atmospheric/Ionospheric parameters derived by other instruments.

1. Introduction

Atmospheric science studies at Mt. Abu had started in the early 1950's with the Ozone observations using Dobson spectrometer at the Hill View building. Due to the very good seeing conditions and very large number of cloud-free days/nights, it was realized by PRL's scientific community that an atmospheric sciences laboratory should be set up at Gurushikhar, alongside the Infrared observatory. In 1994 a small atmospheric sciences laboratory was built and regular optical aeronomy observations were started by operating a variety of instruments viz. the day glow photometer, night glow spectrometer etc. These instruments are passive remote sensing instruments and record day and night glows emanating from different ionospheric heights. During 1996-97, PRL's existing Lidar at Ahmedabad was shifted to the atmospheric science laboratory at Gurushikhar with a 90 cm primary mirror for the study of middle atmospheric dynamics. Pollution free, clear sky and reduced air mass at Gurushikhar (altitude above MSL 1.67 km) facilitates probing heights up to about 80 km. In Fig. 1, a panoramic view of the atmospheric sciences laboratory along with various instruments housed inside the building is shown.

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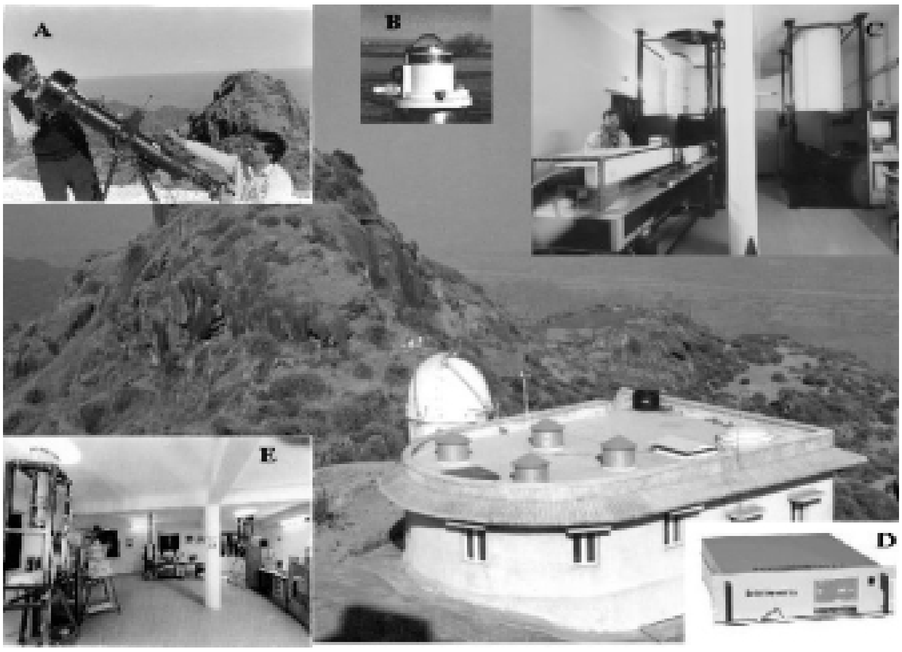

Figure 1. Panoramic view of the atmospheric sciences laboratory at Gurushikhar and the instruments: (A) All Sky Imaging (B) UV Radiometer (C) Inside View of Lidar Laboratory (D) Ozone Analyzer and (E) Inside View of Optical Aeronomy Laboratory.

2. Lidar-based studies of the atmosphere

The Rayleigh scattering by air molecules in the region of 30 to 80 km has been used extensively to determine the density and temperature of the atmosphere (Hauchecorne and Chanin 1980, 1981 and references therein). Due to the presence of aerosols (below the altitude of 30 km) Rayleigh scattering can not be used to get neutral density and temperature profiles. Therefore in this altitude region Raman scattering has been used to obtain neutral density and temperature profiles (Evans et al., 1997). Mie scattering at 532 nm is used to study the tropospheric and lower stratospheric aerosols.

Atmospheric probing using Lidar was initiated at PRL in the early 1990's. A powerful Nd-YAG laser-based lidar (operating at 532 nm) with a 40 cm Cassegrain telescope was set up at Ahmedabad in April 1992 and used primarily for aerosol studies (Jayaraman et al., 1995). The Lidar system was moved to the atmospheric sciences laboratory at Gurushikhar in 1996-97. Since then regular measurements of density/temperature are being made. A high power laser beam is pumped vertically into the atmosphere at 532 nm and Rayleigh backscattered signal at 532 nm (Rayleigh Lidar), Raman scattered signal at 607 nm (Raman Lidar) is recorded (Sharma et al., 2005).

2.1 Lidar observations

Lidar is being operated at Gurushikhar with an objective to study the middle atmospheric dynamics using the neutral density and temperature profiles and to investigate the solar cycle effect on the middle atmospheric parameters. Lidar is operated for 4-5 hours continuously during 8 to 10 nights in every month around new moon period, except during the monsoon period (June to September). The temperature profile is derived from the relative density profile using the hydrostatic equation and ideal gas law assuming an upper level pressure (Hauchecorne and Chanin 1980). A sample profiles of neutral density and temperature obtained by Rayleigh and Raman lidar on 28 March 1998 are shown in Fig. 2. Figure 3 shows a vertical profile of neutral density fluctuations observed at Gurushikhar on 5 November 1997. This profile clearly shows the presence of wave features in the stratosphere and mesosphere over Gurushikhar.

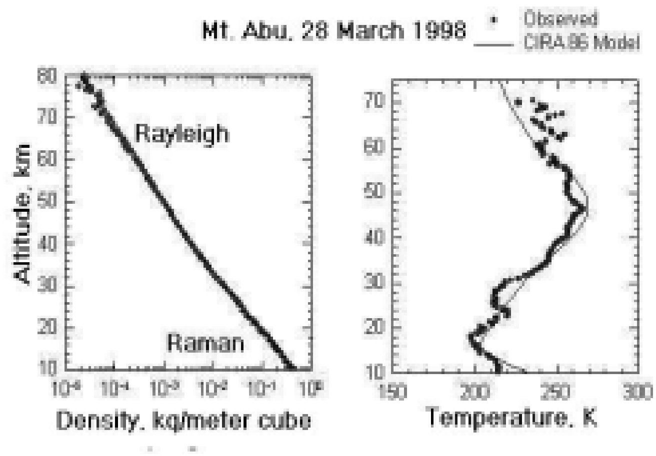

Figure 2. Typical lidar probed profiles of density and temperature over Mt. Abu.

3. Optical aeronomy instruments at Gurushikhar

3.1 All sky imaging of the ionosphere

A Multiwavelength All Sky Optical Imager was developed at PRL. It employs a 180 degree fish-eye lens, an image intensifier (gain 100,000) and a CCD based detector. This Imager is being operated at three different wavelengths viz. 630.0 nm, 557.7 nm and 777.4 nm to study the properties of (a) the ionospheric plasma depletions and (b) the gravity wave parameters. The parameters that can be derived from this experiment include, E-W extent, degree of depletion and orientation with respect to geomagnetic field lines. E-W and N-S scales of gravity waves and their propagation characteristics can also be

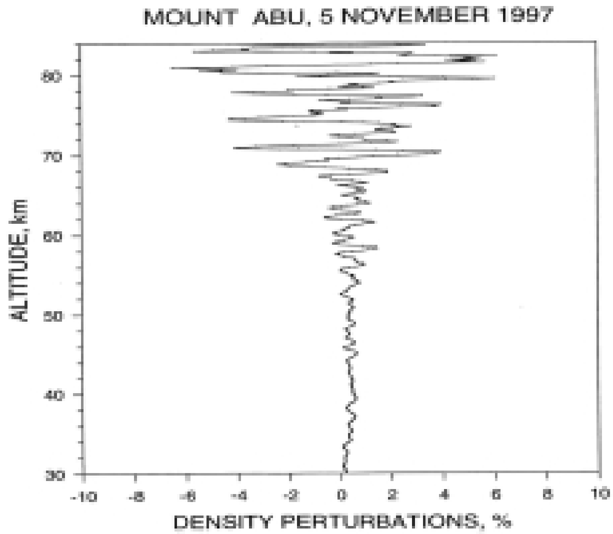

Figure 3. Density perturbations observed over Gurushikhar on 5 November 1997.

estimated (Sinha et al., 1996, 2000, 2003). A typical All Sky Image at 630 nm taken by PRL's All Sky Imager is shown in Fig. 4.

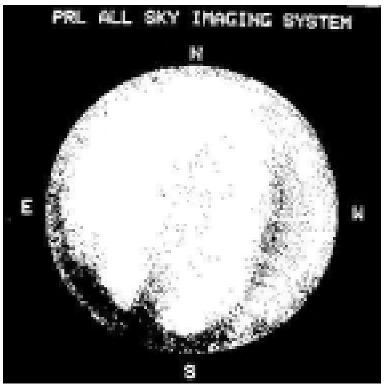

Figure 4. A typical image taken by PRL's Multiwavelength All Sky Imager at 630 nm.

3.2 The day/night airglow studies

Temporal variations of the airglow emission from O(^{1}D) excitations are being monitored regularly using a Fabry-Perot Spectrophotometer. Using this instrument, extensive studies related to Space weather effects, atmospheric gravity waves and coupling aspects of the thermosphere-ionosphere system are being made (Chakrabarty et al., 2002, 2004) . An example of airglow intensity profile recorded on February 3, 2002 is shown in Fig.5.

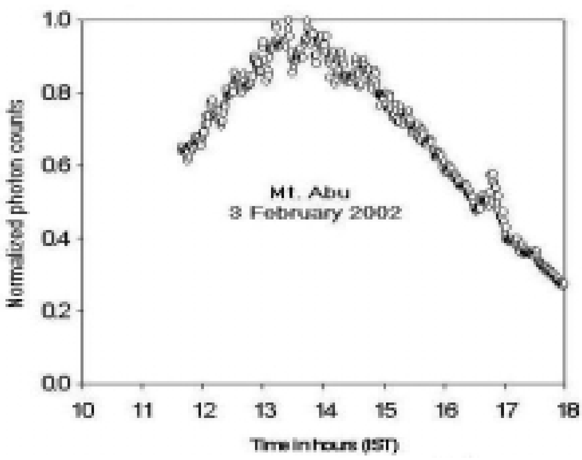

Figure 5. An example of data recorded by Dayglow Photometer on February 3, 2002 at Mt. Abu. The Y-axis (normalized photon counts) indicates the intensity of the airglow emission.

4. Studies of ozone and trace gases

A number of ground-based instruments are operational for monitoring the concentrations of several surface trace gases at Gurushikhar. Continuous measurements of Ozone (O_3) and Carbon Monoxide (CO) are being made since the last 6-7 years. Extremely harmful solar ultraviolet radiation (UV) is also being monitored at the atmospheric science laboratory. The UV radiometer measures global solar ultraviolet irradiance between 280 and 320 nm, peaking around 300 nm, which is part of the solar spectrum that is responsible for sunburns on human skin. (Lal et al., 2000; Subbaraya et al., 2001; Naza et al., 2003)

5. Summary

The atmospheric science laboratory at Gurushikhar, Mt. Abu is well-equipped with a number of state-of-the-art instruments used to address various geophysical phenomena taking place in the Earth's troposphere, stratosphere, mesosphere and ionosphere. With these instruments a study of coupling processes between different regions of the atmosphere is being carried out. Long term data of ground based active and passive remote sensing instruments are useful for modifying/improving existing standard atmospheric models especially for the low latitude regions. In view of the fact that the astronomical signals have to traverse through earth's atmosphere and ionosphere, observations of parameters such as cirrus clouds, aerosols, neutral density fluctuations, and gravity wave phenomena are useful for astronomers as well.

Acknowledgments

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