Simultaneous sodium airglow and lidar measurements over India: A case study

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[1] In order to understand the substantial variation of sodium (Na) airglow intensity from one night to another, a case study is performed using simultaneous, campaign-based measurements of Na airglow and Na lidar during March 2007 from Gadanki (13.5°N, 79.2°E), India, during postmidnight hours. The altitude profiles of mesospheric ozone, temperature, and pressure available for the nearest location during the local postmidnight hours are also obtained from the SABER instrument on board the TIMED satellite and are used in conjunction with the above measurements. The average Na airglow intensity level on 20 March 2007 is found to be less compared to that on the next night despite average Na concentration being larger by at least a factor of three. In order to explain the observation, volume emission rates of Na airglow are calculated for both of the nights using the measured parameters. The enhanced quenching due to the ambient gas is suggested to be responsible for the reduced Na airglow intensity level on 20 March 2007 despite higher Na concentration.


1. Introduction

[2] It is generally believed that the following chemical scheme proposed by Chapman [1939] is responsible for the sodium (Na) airglow.

\[
Na + O_3 \rightarrow NaO + O_2 \quad (1)
\]

\[
NaO + O \rightarrow Na^* (2P_J) + O_2 \quad (1-\alpha)k_2 \rightarrow Na(2S) + O_2 \quad (2)
\]

\[
Na^* (2P) \rightarrow Na(2S) + h\nu(589.0, 589.6 \text{ nm}) \quad (3)
\]

where \(k_1\), \(k_2\) are the temperature-dependent reaction rate coefficients and \(\alpha\) is the branching ratio for reaction (2).

[3] The Na airglow intensity exhibits considerable variability from one night to another [e.g., Kirchhoff et al., 1979]. The chemical scheme mentioned above suggests that simultaneous measurements of the parameters like number density of neutral Na atoms, mesospheric ozone and temperature are needed to understand the observed night-to-night variation of Na airglow intensity. Several simultaneous measurements of Na airglow intensity and Na concentration were carried out over low-latitude stations [e.g., Clemesha et al., 1978, 1979]. However, the simultaneous measurements of most of the parameters involved in the Chapman mechanism were sparse until recently making it difficult to address the variation in Na airglow intensity comprehensively.

[4] Although the importance of the chemical channel proposed in the above scheme in producing Na airglow at the mesopause altitudes is realized over the years, there has been considerable debate regarding the value of the branching ratio \(\alpha\) which effectively determines the fraction of the Na atoms that ends up emitting Na airglow. Based on rocketborne photometry, airglow imager and lidar measurements, the range of \(\alpha\) is found to lie between 0.02 to 0.2 [e.g., Clemesha et al., 1995; Hecht et al., 2000]. As the reaction (1) is rate determining [Plane, 2003], the measurement of mesospheric ozone in the Na airglow study is crucial. With the availability of altitude profiles of mesospheric ozone, it is now possible to examine the impact of ozone variation on the Na airglow intensity. Therefore, in the present investigation, a case study that involves substantial variation in the observed Na airglow intensity, is performed using Na concentration (derived from Na lidar), mesospheric ozone, pressure and temperature profiles obtained from SABER on board the TIMED satellite. The importance of quenching processes in determining Na airglow emission is also discussed.

2. Experimental Techniques

[5] A portable narrow-band photometer capable of measuring mesospheric Na airglow emission intensity, was designed and fabricated at Physical Research Laboratory, Ahmedabad, India. The field of view of this photometer is 3°. A temperature-controlled, narrow band (0.3 nm) interference filter with the central wavelength around 589.1 nm was used in the photometer. The photometer was calibrated against a