EPSC Abstracts
Vol. 13, EPSC-DPS2019-760-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Seasonal and diurnal variation in vertical profiles of the Martian nitric oxide nightglow layer

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1. Introduction

The nitric oxide (NO) nightglow is a reaction rate which traces flux between from the nightside Martian thermosphere to the mesosphere. The process begins in the dayside thermosphere, where solar extreme ultraviolet radiation photo-dissociates atmospheric CO_2 and N_2 molecules. Upper-atmosphere Hadley circulation transports N and O atoms toward the nightside poles, where descending polar winds bring the atoms down into the mesosphere. The atoms combine to form an excited NO molecule, which nearly-instantaneously relaxes, emitting ultraviolet photons in the distinctive NO δ and γ bands. Brighter emission occurs where descending air brings molecules deeper into the mesosphere, so we use the reaction rate as a tracer of the dynamics between Mars' thermosphere and mesosphere [1, 2, 3, 6, 7].

2. Observations

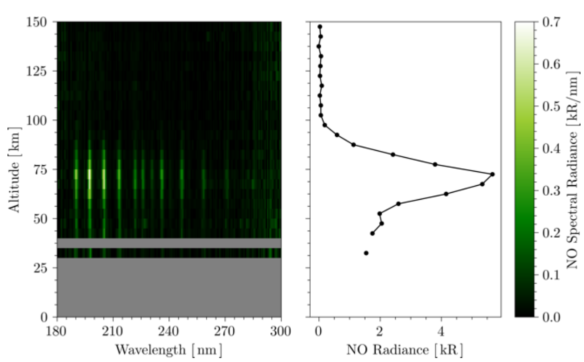

Figure 1: An example of an observed UV spectrum (left panel) and the corresponding derived NO nightglow brightness (right panel) showing a maximum brightness of ~5.5 kR and a peak altitude of 72.5 km.

We use limb scan data from the Imaging Ultraviolet Spectrograph (IUVS) [5] on the Mars Atmosphere and Volatile Evolution (MAVEN) mission [4]. These data have broad seasonal and latitudinal coverage, allowing us to characterize the behavior of the nightglow layer across a range of latitudes, local times, and solar longitudes. Figure 1 shows an example of a calibrated spectrum and the NO brightness derived from it.

3. Results

We report observational analysis of altitude and brightness variation in the NO nightglow layer on seasonal and diurnal timescales, extending the analysis in our previous limb scan study [7]. Using an LMD-MGCM climatology simulation of the NO nightglow, we define arbitrary "seasons" as a function of latitude and solar longitude which we use to analyze how the layer changes with season (figure 2).

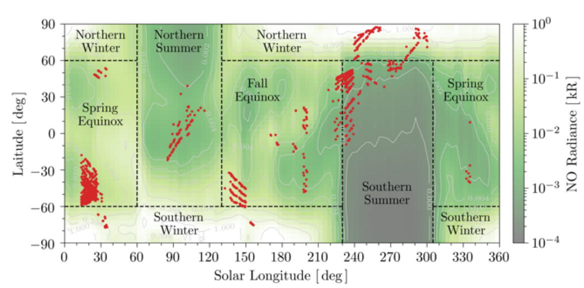

Figure 2: LMD-MGCM simulation of the zonal-mean NO brightness over a Mars year. The red points show the locations of our observations. We have decent coverage during northern winter, equinox seasons, and northern summer, however, southern winter and summer are limited in comparison.

We compute the peak altitude and brightness of the seasonal average and compare across seasons (figure 3b). We also compute the brightness and peak altitude of the layer as a function of local time to determine how the vertical structure of the layer changes over the course of a night (figure 3a).

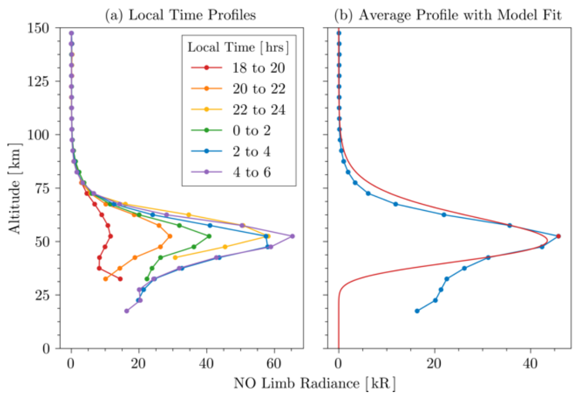

Figure 3: Northern winter vertical profiles of the NO nightglow emission layer. (a) shows the average profile in two-hour local time bins. (b) shows the average of the entire season in blue and a model-fit to the topside of the profile.

We find a peak altitude of 72.5 km during summer and equinox seasons. During winter, the peak is up to 20 km lower in altitude at 52.5 km. We see a difference in the magnitude of the peak brightness consistent with disk-image observations.

During winter, we find the altitude of the layer does not vary with local time, consistent with the constant night during polar winter. During summer and equinox seasons, we see the altitude decrease in the early evening hours, then increase as morning approaches, consistent with the change in temperature over the course of a night.

We also report comparisons of our observations to simulations from the LMD-MGCM and corresponding insights into altitude- and temporal-dependence of temperature, downwelling wind velocity, and atomic N and O densities.

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