NITRIC OXIDE NIGHTGLOW MAPPING FROM IUVS IMAGES AND IMPLICATIONS FOR SEASONAL TRANSPORT IN MARS' MESOSPHERE

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Abstract:
We analyze the ultraviolet nightglow in the atmosphere of Mars through Nitric Oxide (NO) δ and γ bands emissions. These emissions are accumulated on a large dataset of nightside disk images performed by the Imaging Ultraviolet Spectrograph (IUVS) instrument when the *Mars Atmosphere and Volatile EvolutioN (MAVEN)* spacecraft is at its apoapse phase along its orbit. NO nightglow reveals the complex dynamics in Mars' mesosphere. We present discussion on the variability in the brightness of the emission with geographical position and local time and possible interpretation for local and global changes in the mesosphere dynamics.

Introduction:
Nitric oxide UV nightglow comes from de-excitation of NO($C^2\Pi$) molecules, which result from radiative recombination.
On the dayside thermosphere of Mars, solar extreme ultraviolet radiation photodissociates CO_2 and N_2 molecules. O(^{3}P) and N(^{4}S) atoms are carried by the day-to-night hemispheric transport. They preferentially descend in the nightside mesosphere in the winter hemisphere, where they can radiatively recombine to form NO($C^2\Pi$).
The excited molecules directly relax by emitting photons in the UV δ bands and in the γ bands through cascades via the $A^2\Sigma$, v' = 0 state. These emissions are thus indicators of the N and O atom fluxes transported from the dayside to Mars' nightside and the winter descending circulation pattern from the nightside thermosphere to the mesosphere.
NO Nightglow was previously observed in the limb mode (when the line of sight of the instrument is parallel to the surface) by the SPICAM (Bertaux et al., 2005, 2006; Cox et al., 2008; Gagné et al., 2013; Stiepen et al., 2015) and the IUVS (McClintock et al., 2014; Stiepen et al., submitted) instruments at Mars. It was also observed in several different modes at Venus by IUE (Feldman et al., 1979), PV-OUVS (e.g. Stewart and Barth, 1979 ; Stewart et al., 1980 ; Gérard et al., 1981. ; Bougher et al., 1990) and SPICAV (e.g. Bertaux et al., 2007; Gérard et al., 2008; Royer et al., 2010; Stiepen et al., 2012, 2013).
Recent analysis (Stiepen et al., submitted) based on IUVS observations and comparisons to the LMD-MGCM (described in great detail by Gonzàlez-Galindo et al., 2009; Lopez-Valverde et al., 2011) showed that the model correctly predicts the brightness and altitude of the NO nightglow emission at equinox. These authors however found a large discrepancy between the model and the observed NO Nightglow at winter: the predicted brightness is up to 50 times lower than observed at mid-to-high latitudes and the emission layer is predicted up to 25 km higher in the atmosphere than observed.
Stiepen et al., submitted also showed a possible impact of waves and/or tides in the mesosphere, coinciding with an increase of NO Nightglow brightness by a factor up to 3 in the region 120°-180° longitude. The LMD-MGCM also predicts that NO Nightglow in the morning sector should be brighter than in the evening sector. This could not be denied nor confirmed, because of a lack of adequate coverage to address this question.

Pending questions:
These studies showed the increasing need for new observations of the NO nightglow and direct imaging of the emission. To fully characterize the longitudinal influence on the emission, in addition to the known seasonal control of the emission, as well as the possible impact of local time, requires images of the night disk.

We use in this study images of the night disk by the IUVS instrument accumulated over 317 MAVEN orbits (from 01 April 2016 – LS = 131 - to 06 June 2016 – LS = 164). Data collected so far maps the NO nightglow emission in the southern hemisphere during winter.

Figure 1 shows the UV NO nightglow image taken by IUVS during on the 4th of May 2016 on a geographic grid. This image reveals un unexpected complex structure of the emission. The brightest emission is observed close to the southern winter pole. The emission is also surprisingly more intense in some sectors situated close to the equator : at 120° and 150° longitude. The image also reveals spots and streaks, indicating irregularities in the wind circulation pattern.

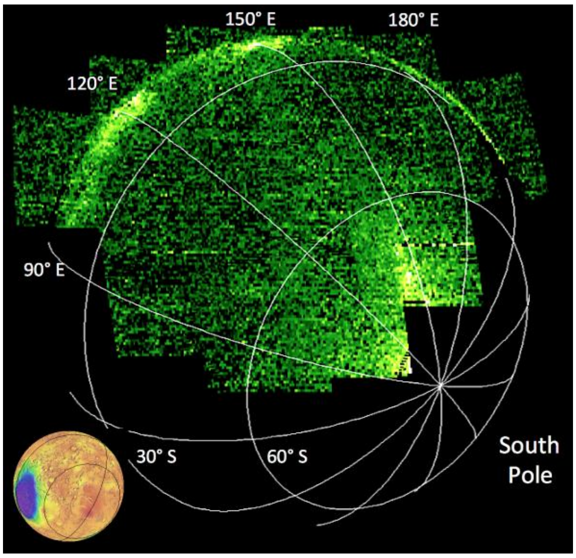

Figure 1 - Adapted from Jakosky et al., submitted. The green/white color-code indicates the brightness of the NO nightglow emission during winter in the southern hemisphere. A topographic map and the white latitude/longitude grid show that the emission is brighter towards the winter pole. We also note two regions of enhanced brightness close to the equator: at 120°E and 150°E.

The disk images are compared to the LMD-MGCM model (see Gonzàlez-Galindo et al., this issue) to focus on the local time and geographical influences on the NO Nightglow emission. Our analysis will focus on the latitudinal, longitudinal and local time control of the emission. We will also provide a statistical study of the regions of enhanced brightness (i.e. splotches and streaks) and deliver possible interpretation from the comparison to the GCM.

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