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Study of gravity waves propagation in the thermosphere of Mars based on MAVEN/NGIMS density measurements

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Abstract

By measuring regular oscillations of the density of CO_2 in the upper atmosphere (between 120 and 190km), the mass spectrometer MAVEN/NGIMS (Atmosphere and Volatile EvolutioN/Neutral Gas Ion Mass Spectrometer), reveals local effects of gravity waves, and conversely, yields precious information on the conditions for propagation and activity of gravity waves.

Using these datasets, and combined to the Mars Climate Database (MCD: www-mars.lmd.jussieu.fr), we study some possible interpretations of the observed variability in the activity of gravity waves.

1. Introduction and background

Gravity waves can be responsible for significant dynamical and thermal perturbations of the mean flux, as they transfer their momentum and energy by breaking ([3]). They also alter local profiles of the meteorological variables as they propagate. They originate from perturbations of the stratified atmospheric fluid, which makes gravity and buoyancy forces compete to restore equilibrium. Sources for such perturbations include topography, convection, fronts or jet-streams.

Gravity waves amplitude increases with altitude, as the density decreases. Their amplitude at a given atmospheric level are controlled by two factors at lower levels: obviously the sources that trigger gravity waves, but also the occurrence of breaking and dissipation while the emitted gravity wave propagates upward. Gravity waves can break and/or dissipate either when they reach a critical level (where the ambient wind equals the phase speed c, first Eliassen-Palm theorem, see [3] and [2]) or when they reach convective instability (considering the mean plus the perturbed atmospheric state). This means that the upward propagation of gravity waves is impacted both by the horizontal wind and static stability; for instance in weak horizontal winds conditions, stationary gravity waves (c=0) vanish.

The aim of our study is to propose an interpretation of the influence of these different background parameters on the gravity waves observed by MAVEN/NGIMS.

2. Data processing

For each orbit, the wandered longitude, latitude, solar longitude, local time, altitude, CO_2 density, as well as the elapsed time from the periapsis were extracted (NASA PDS archives). The distance from the periapsis is deduced from the latitude and longitude displacement. The density deviation is calculated by subtracting the instantaneous density, $dens_{1s}$, to the mean density, $dens_{40s}$, taken here to be the 40-second sliding averaged density (see 1). The perturbations are then normalized to this same mean density over 40-seconds (i.e. about 120km horizontally) to provide an estimate of the relative density perturbation $dens_{rel}$, i.e. $dens_{rel} = \frac{dens_{1s} - dens_{40s}}{dens_{40s}}$. The analysis of the relative density instead of the absolute value allows a direct view of the effect of the gravity waves on the unperturbed meteorological variable, estimated by the average on 40 seconds. We distinguish different altitude levels to study the datasets: between 170 and 200km altitude (each side of the periapsis: ingress and egress data) and under 170km (near to the periapsis). Figures 2 and 3 display the seasonal variability respectively of the mean latitude, and of the root mean square of the relative density of each orbit for the three datasets.

3. Discussion and current state

The seasonal variability of gravity waves reveals a clear tendency of strong peaks and off-peaks activity. This pattern doesn't seem to depend on the considered altitude range.

The MCD allows to obtain the wind velocity, and other meteorological variables at the considered

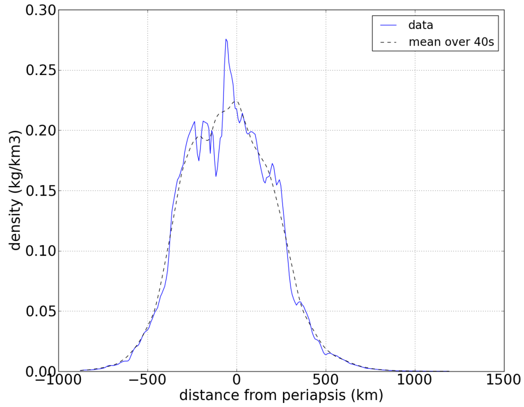

Figure 1: Example of density variations in function of the distance from periapsis in kilometers for orbit 3606 with Ls (Solar Longitude) = 198.22°

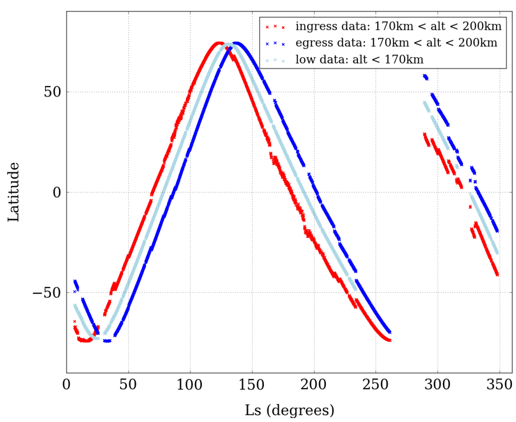

Figure 2: Mean latitude wandered by each orbit along the solar longitude for the different altitude datasets (ingress, egress, periapsis)

locations, seasons and local times, and this from the ground, up to the considered altitudes. Observations don't display strong correlation with the horizontal wind extracted from the MCD. However, the temperature seems to present a good anti-correlation to the observed amplitude variability.

4. Summary and Perspectives

We discussed the atmospheric properties controlling the activity of gravity waves in the thermosphere. The next step, which is ongoing and will be presented in

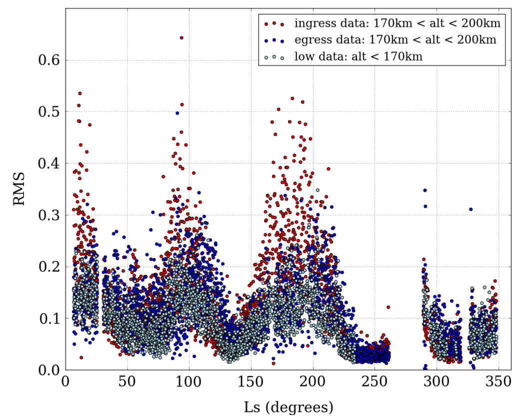

Figure 3: Root Mean Square (RMS) of the relative density calculated for each orbit along the solar longitude for the different altitude datasets (ingress, egress, periapsis)

the frame of the conference, consists in an analysis at pressure levels of the data.

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