PRELIMINARY RESULTS OF ATMOSPHERIC PARAMETERS VARYING WITH LT AROUND VOLCANOES FROM PFS-MEx OBSERVATIONS

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Introduction:

We present a new type of observations (scan mode) to study atmospheric parameters varying with LT over volcanoes in the Tharsis region. Scan orbits are measured by the Planetary Fourier Spectrometer (PFS) across the track of Mars Express spacecraft. We focus on observations from the southern summer season in MY 35. In order to improve fits between modeled and observed spectra, a correction on surface pressures was introduced. We found a hot air close to the top of Olympus while the cold air is observed at 40 – 50 km of altitude. As a result, potential temperatures are almost constant from 15 to 30 km of altitude. Thus, the very deep vertical mixing layer occurs there. Atmospheric thermal fields can be used to study the planetary boundary layer and local circulation around volcanoes. The depth of the planetary boundary layer can be estimated from a behavior of atmospheric temperatures. It turns out that the depths of the planetary boundary layer are larger over the Tharsis than over the other regions [1]. Here, we report the LT variations of dust and water ice opacities along with atmospheric and surface temperatures. In the future we will investigate the behavior of the planetary boundary layer with LT and thus the local circulation around volcanoes by means of atmospheric temperatures obtained from the PFS observations.

Methodology:

The observations are measured across the track of Mars Express spacecraft orbits. Thanks to the observations, PFS aboard the Mars Express can measure radiation from the atmosphere over regions at different longitudes but similar latitudes so different local time zones. This way, we analyze LT variations of vertical temperature profiles, total column dust, water ice opacities and surface temperatures. Atmospheric parameters such as vertical temperature profiles, total dust, water ice opacities and surface temperatures are retrieved from the long-wavelength channel of PFS [2]. The retrieval is performed for spectra from 300 to 1000 cm^{-1}. Because of noisy spectra near 250 cm^{-1} and 1000 cm^{-1} we constrain our spectral range to 300 – 900 cm^{-1} to check the quality of fit between modeled and observed. For this purpose, the mean absolute percentage error (MAPE) is calculated in the latter spectral range. This spectral range includes absorption bands by CO2, dust and water ice. Eventually, dust and water ice opacities are weighted by the PFS field of view (FOV). We found that around volcanoes MAPEs were as large as 7% during the daytime and 30% during the night. This means that the model does not match well to observations. We notice an inappropriate fit mainly in the wings of the CO_2 absorption band due to over- or underestimated pressures. Thus, a correction of our retrieval code on surface pressures helped a lot in obtaining better fits. Surface pressures are necessary to determine a vertical pressure grid for a retrieval from each spectrum. Orbits in scan mode are performed where the spacecraft is quite far away from the pericenter at altitudes above around 2000 km. Regarding this, the PFS field of view (FOV) is larger than at the pericenter which is very important when the spacecraft flies over volcanoes. Pressure variations are very large along the slope of volcanoes. Thus, we calculated the average of surface pressures from the whole PFS FOV and introduced into the retrieval procedure. It turned out that the model fitted better to observed spectra for orbits performed at high spacecraft altitudes. MAPEs averagely reduced to 2 – 4% during the daytime around volcanoes.

Results:

An example of preliminary results is presented in Figure 1 after the correction on surface pressures for orbit 21216. Figure 2 represents thermal fields with dust and water ice opacities before the correction for the same orbit.

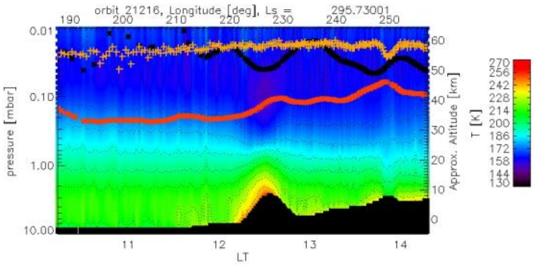

Fig.1. Thermal fields after the correction on surface pressures. MAPE is plotted as yellow ‘+’. Black and red lines are water ice and dust opacities, respectively.

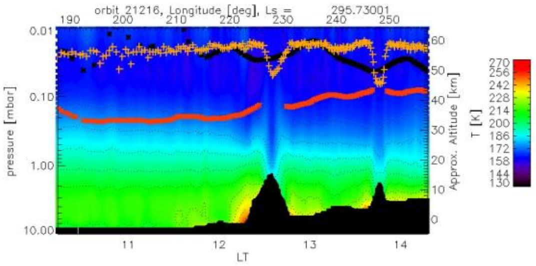

Fig.2. Thermal fields before the correction. MAPE is plotted as yellow '+'. Black and red lines are water ice and dust opacities, respectively.

Figure 1 and 2 present two different thermal structures over volcanoes. The correct version is given in Fig.1. Changes of thermal structures are observed over Olympus with respect to Fig.2. The hot structure is observed over the highest sounding point of Olympus. While the cold air is found at 40 – 50 km of altitude.

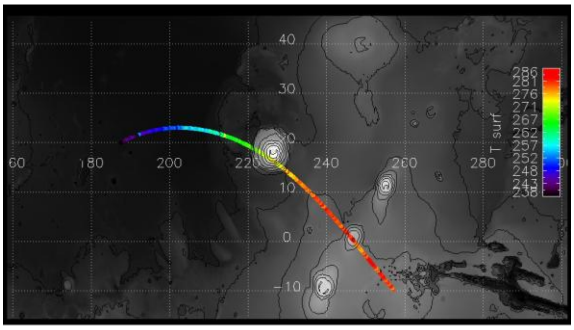

Fig.3. Surface temperatures along the orbit 21216.

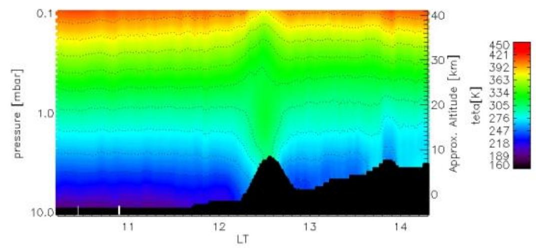

Fig.4. Potential temperatures along the orbit 21216.

Figure 3 and 4 present surface temperatures along the track of the same orbit (21216) and potential temperatures. Surface temperatures increase with LT and southward (Fig.3) as expected. Potential temperatures are almost constant from the top of the volcano up to 30 km (Fig.4). Thus, we conclude that the atmosphere over Olympus is in the neutral stability. Thereby, the vertical mixing layer occurs with a depth of around 10 km.

Conclusions:

We presented the example of scan orbit measured by PFS. For this orbit, we noted the hot air over the highest sounding point of Olympus close to the surface while the cold air is observed at 40-50 km of altitude. The planetary boundary layer has around 10 km of depth. In future we will then study the planetary boundary layers around volcanoes for different LTs derived from atmospheric temperatures by means of potential temperatures and their derivatives.

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Bibliography:

[1] Hinson D.P. et al., *Icarus*, 326, (2019), 105 – 122. [2] Grassi, D. et al., (2005). *Planetary and Space Science, 53* (10), 1017–1034.