CLIMATOLOGY ON MARS: INTERANNUAL VARIABILITY OF MEAN FIELDS.

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Introduction

In this abstract we present results based on measurements extracted from a data- assimilation set that spans a continuous period over more than three years. We have concentrated here on an analysis of geopotential, stationary wave and vorticity fields over two periods, centered around perihelion respectively aphelion. The motivation to study these field lies in their generic connection to the large scale circulation and its stability. In particular the vorticity field carries information about the presence e.g. of inertial stability. The data set has been created by a combination of the observed data by the Thermal Emission Spectrometer on the Mars Global Surveyor with model data generated by the Oxford-MGCM, described in more detail in [4] and [5].

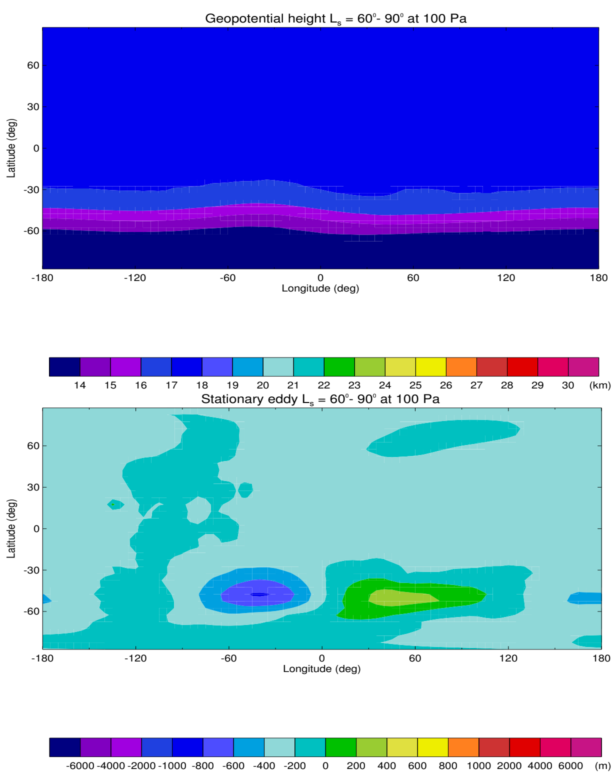

Figure 1: The geopotential height field and its fluctuations at 100 Pa around aphelion during MY25, both fields are time averaged over 30 Sols. Observe that the colorbar are slightly different between the two mean fields, while being constant for the fluctuations

Assimilation with the Oxford MGCM

The model was run with a horizontal resolution equal to a triangular spectral truncation at wave number 31, with non-linear terms evaluated on a 3.75° grid. While 25 σ-levels were are used to resolve the vertical resolution which cover the atmosphere up to 80km height with three sponge layers above to damp vertical propagating waves.

The data cover at present the period $L_s = 142°$ (Sol 301) MY24 to $L_s = 76° L_s$ (Sol 162) MY27. The observational data consists primarily of vertical temperature profiles below 40 km and maps of total column dust opacity. The data, stored in `netcdf`-format, is divided into seasonal units, i.e. each data file spans 30 Sols with data sampled at two-hour intervals. There are eight data fields in each data file : CO_2-distribution, surface temperature and pressure, atmospheric temperature, zonal and meridional winds, wind variance and the total optical dust.

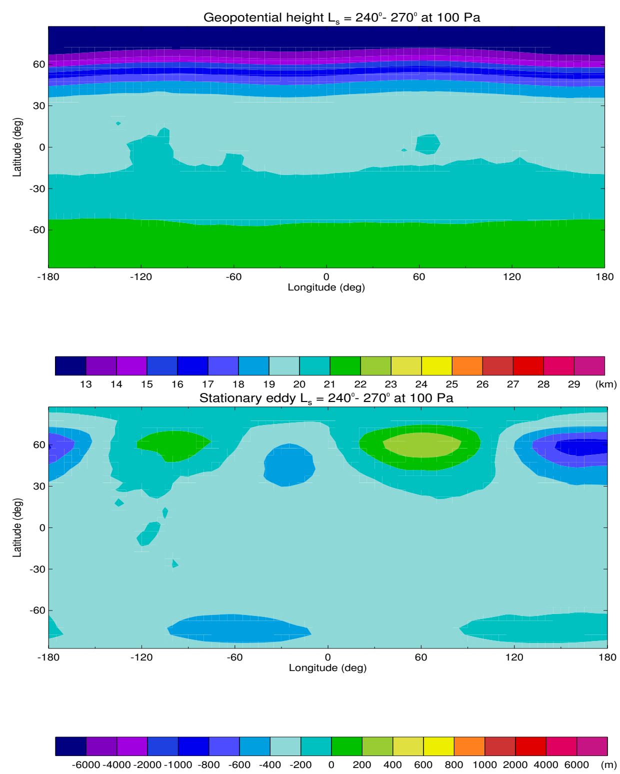

Figure 2: The same fields as for fig. 1 but at perihelion

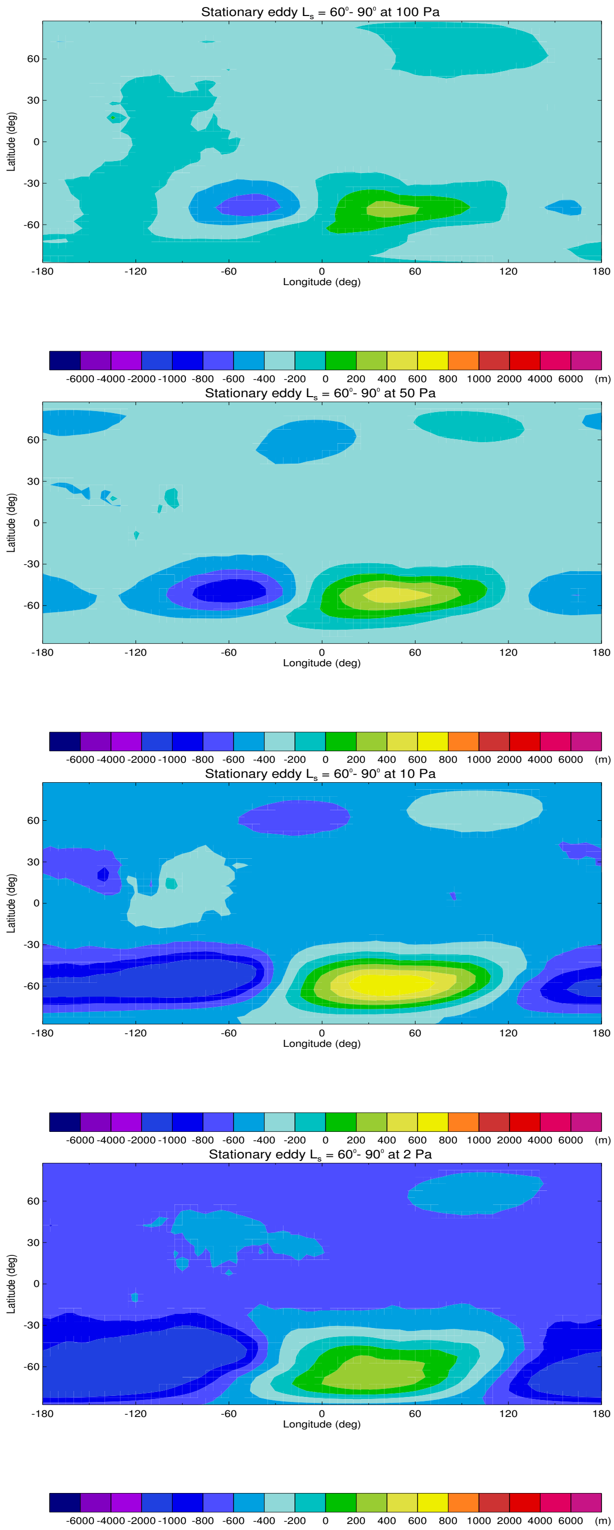

Figure 3: The figure shows fluctuations in the geopotential height field at 100, 50, 10 and 2 Pa around aphelion during MY26

Climatology

We consider two climatological aspects in this abstract, interannual variability and hemispheric asymmetry and their impact on mean fields during the periods for MY25-26 (MY24 is covered only by the later interval) $L_s = 60° - 90°$ and $L_s = 240° - 270°$. The first period, apheilion, coincide with NH summer, while the second, perihelion, occur during the NH winter. Processes affecting global circulation and dust lifting are significantly different during these periods. Whereas the period around aphelion is associated with weak atmospheric activity all over Mars, in contrast NH winter exhibits stronger global circulation and often very intense dust lifting. Indeed almost all major observed dust storms in the past have been observed during this season of the year[1].

Indication of hemispheric asymmetries in stationary wave patterns during NH winter were found in a model study by Hollingsworth and Barnes ([3]). Where they found that the dominating eddies in the NH were typically of zonal wave number 2, while SH eddies were more commonly of wave number 1. The latter were also found to be significant larger in amplitude. Similar trends are clearly apparent in the assimilated record, as evident in Fig. 1 and 2, which shows maps of mean geopotential height at 100 Pa (corresponding to an altitude of around 20 km) togther with its associated stationary eddy fields around aphelion and perihelion. The SH eddies in particular are found to be dominated by $m = 1$, though only over a restricted range of longitude. Both mean and eddie fields display the seasonal impact with the change of geopotential gradient and latitude band with eddies. Furthermore, the planetary orbit makes the geopotential gradient steeper during NH winter as well as increase the eddy amplitude, which is reflected in stronger zonal flow. Fig. 3 display the change of the stationary eddy field with height during one time period, where both wavelength and amplitude increases up to around 10 Pa ($\approx$ 40km). Further aspects of the stationary wave and vorticity fields will be discussed in the presentation.

Inertial instability typically manifests itself in the Earth's atmosphere in association with patches of anomalous potential vorticity[2]. The evolution of the instability in the Earth's stratosphere has shown a correlation with interannual variability of Rossby wave breaking[2]. Such instabilities have not been extensively studied in the Martian atmosphere so far, however. In this presentation we will present diagnostics indicating the climatology of inertial instability on Mars as a function of season.

References

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