ASSESSING MARTIAN THERMAL FORCING FROM SURFACE PRESSURE DATA: THE MY34 MAJOR DUST STORM.
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Introduction:

Thermal tides are a global-scale atmospheric response to the diurnally varying component of thermal forcing resulting from aerosol heating within the atmosphere and radiative and convective heat exchange with the surface. The thermal tide includes 'migrating' westward propagating (sun-synchronous) waves driven in response to solar heating, as well as 'nonmigrating' (non-sun-synchronous) waves arising from longitude structure in the thermotidal forcing resulting from variations in surface topography and surface thermal properties and the distribution of radiatively active dust and water ice clouds. The migrating tides provide the most direct insight into the zonally averaged thermal forcing. The surface pressure observations from the Rover Environmental Monitoring Station (REMS) aboard the Mars Science Laboratory (MSL) rover in Gale Crater are yielding a multiyear record of the diurnally-resolved surface pressure from which it becoming possible to derive a climatology of the pressure component of the thermal tide [1]. Tide theory provides a framework for relating aspects of the observed response of individual diurnal harmonics to the corresponding forcing frequencies. In particular, the migrating semidiurnal surface pressure variation (SW2) is expected to be an efficient measure of global thermal forcing during major dust storms. This was prominently evident during the two global dust storms observed by Viking in Mars Year 12 [2]. Tide theory also suggests a significant response by higher frequency migrating tides, including the terdiurnal, quaddiurnal and hexadiurnal harmonics.

Figure 1 shows the seasonal variation of the diurnal and semidiurnal harmonic components of the diurnal variation of surface pressure observed by REMS. The tide amplitudes have been normalized by the diurnal mean surface pressure. The two tide harmonics are referred to as S_1 and S_2. There are two striking features. First, there is a very well defined seasonal variation in the amplitude and phase for these harmonics. Second, the response to the global dust storm of MY34 stands out very prominently. Though not shown, these features are also present in higher tide harmonics: S_3 to S_8. In general, the interpretation of the tide response at a single lander is complicated the possible presence of additional nonmigrating tides whose response is not simply related to the planetary-scale thermal forcing. For example, the S_1 response at a given location is dominantly influenced by both the diurnal migrating tide (DW1) and a resonantly enhanced diurnal period Kelvin wave (DE1). In addition, it has been found that S_1 within a crater (like Gale) has additional contribution that is evidently localized to the crater and is distinct from the global-scale thermal tide. Mars global climate models (MGCMs) include detailed physical parameterizations (radiative transfer, convection) that yield the thermal forcing due to dust and water ice clouds. Atmospheric temperature and surface pressure are then self-consistently simulated in response. The extent to which the simulated diurnal variation of atmospheric temperature and surface pressure correspond to observations provides insight into how well the thermal forcing field is represented in the model

For this presentation, we have employed the NASA Ames MGCM to relate the observed pressure response within Gale crater to an evolving dust distribution. We have examined the tide responses to a range of dust scenarios in order to assess the sensitivity of the surface pressure field to different aspects of the aerosol forcing. As a starting point, we have been using the V3.2 column dust opacity scenario for MY34 provided by Luca Montabone, based on the most recent version of the dust profile retrievals by the MCS team [3]. This basic derivation of this kind of daily-varying dust scenario is described in [4]. A further description of our MY34 dust storm simulations appear in a companion presentation [5]. One notable aspect of some of our simulations that they are carried out at very high spatial resolution (0.25°x0.25°) so that we can address issues related to the tide response in craters [6].

A brief summary of our results follows. The semidiurnal and higher frequency tides are indeed dominated by their respective migrating tide components and it is fairly straight-forward to obtain good agreement between simulations and observations. The detailed response of S_1 is more complicated. In addition to the expected increase in amplitude of the diurnal migrating tide (DW1), there is a rapidly changing contribution from the Kelvin wave (DE1) that is responding to the zonal wave 2 component of the evolving dust distribution. A further complication is the localized crater response, which appears to be influenced by the dust loading within the crater. Changes in these influences account for rapid variations in S_1 during the developing stage of the dust storm. These influences on S_1 are also present during regional storms, particularly in the post-solstice season.

References:
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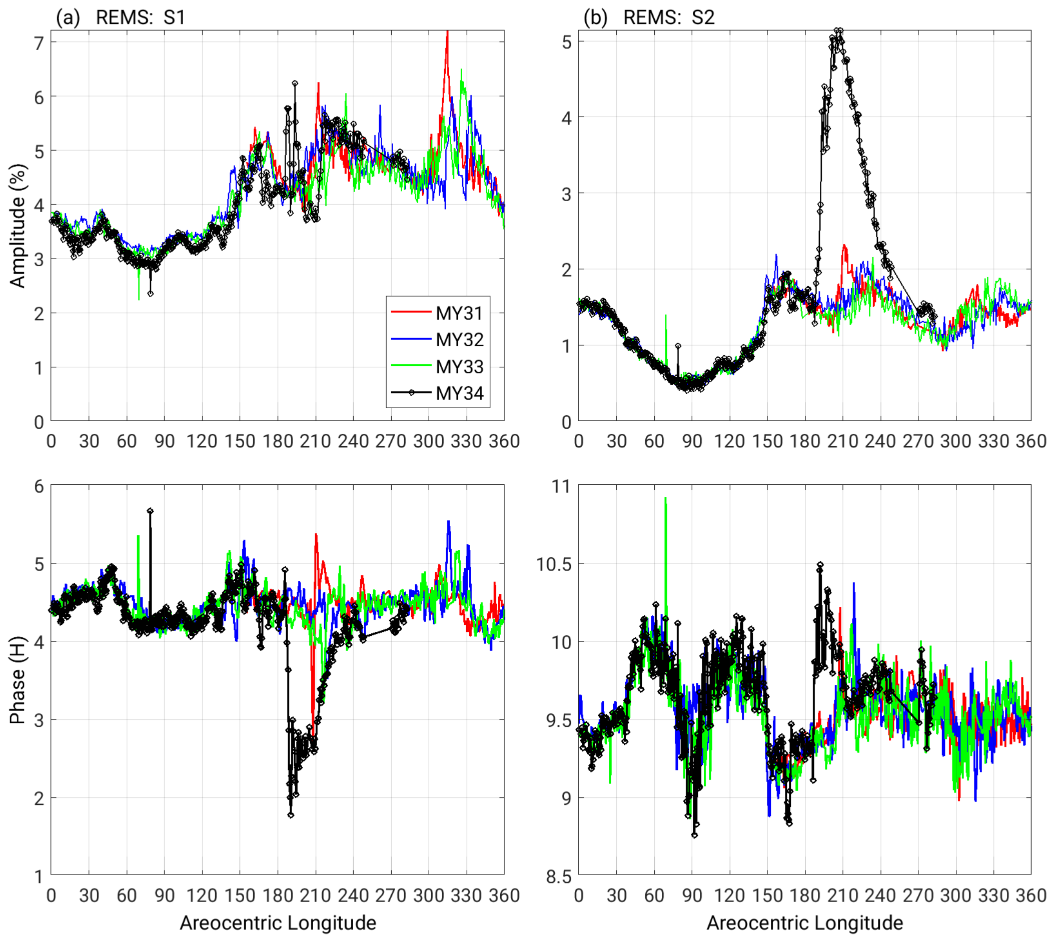

Figure 1. Amplitudes (top row) and phases (bottom row) of the diurnal (left column) and semidiurnal (right) column surface pressure harmonics derived from the time series of surface pressure observations observed by