BAROCLINIC WAVES, INFRASOUND & PRESSURE BURSTS ON MARS FROM INSIGHT. D. Banfield[1], A. Spiga[2], F. Forget[2], C.E. Newman[3], R. F. Garcia[4], D.M. Kass[5], A. Kleinböhl[5]. [1]Cornell Center for Astrophysics and Planetary Science, Cornell University, 420 Space Sciences, Ithaca, NY 14853 (banfield@astro.cornell.edu), [2]Laboratoire de Meteorologie Dynamique (LMD), Paris, France, [3]Aeolis Research, Pasadena, CA, [4]Institut Superieur de l'Aeronautique et de l'Espace (ISAE), Toulouse, France, [4]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

Introduction: We report on three different phenomena observed by the InSight Lander during its first year on Mars, principally using the pressure sensor data. These phenomena include the remnants of the signatures of mid-latitude baroclinic waves that propagate to InSight's tropical location (~4.5°N, 136°E), a catalog of infrasound (defined simply as pressure oscillations faster than typical buoyancy oscillations), and what we are calling "pressure bursts", i.e., when sudden, short-lived (~1-3 minutes) increases in the high-frequency (but broad-band) noise in the pressure signal is detected, typically in the evenings. Where possible we will also present analysis and interpretation of these various signals and/or compare them with complementary data sets (e.g., MSL's pressure measurements or MRO/MCS's temperature profiles).

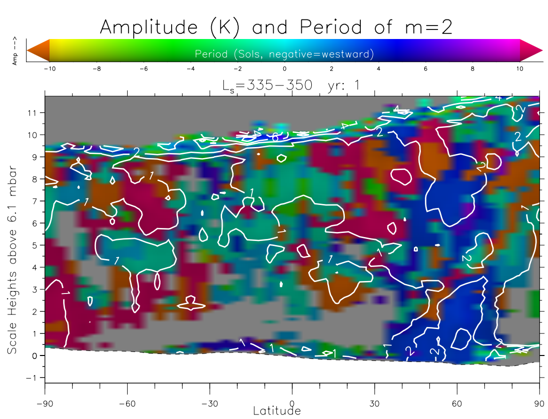

Figure 1. Zonal wavenumber 2 waves from MRO/MCS temperature retrieval meridional cross-section for L_s=335°-350° in 2019. Colors indicate wave periods, and saturation and contours indicate wave amplitude in Kelvin. The blue region at lower right is a ~4-sol m=2 wave propagating Eastward along the Northern winter polar vortex edge.

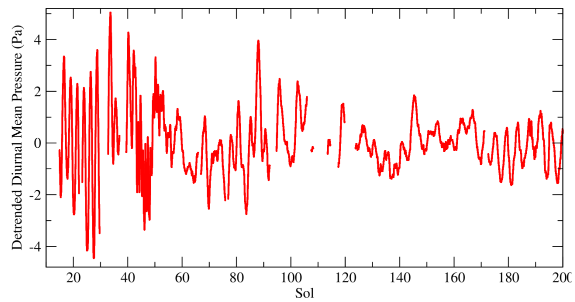

Figure 2. InSight detrended and low-pass filtered pressure removing seasonal pressure changes and diurnal and shorter perturbations, leaving the signature of the mid-latitude baroclinic waves. The first 40 sols are dominated by 2.5-sol waves. Sols 80-155 are dominated by 5-6 sol waves, and sols 155-200 are dominated by 4-sol waves.

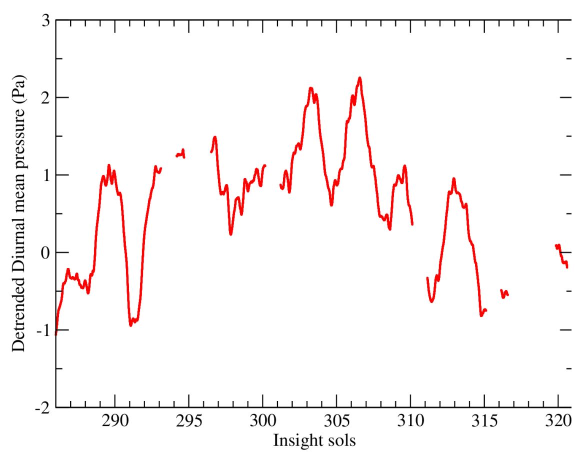

Figure 3. Similar to Fig. 2 showing InSight Sols 285-321 (L_s= 80°-96°) (i.e., southern winter). These ~3.5 sol oscillations may be from traveling waves in the southern hemisphere (although this has not been shown yet).

Baroclinic Wave Signatures: The InSight mission arrived at Mars on Nov 26, 2018 (L_s=295°). At this time, just after the peak of northern winter, there were still significant baroclinic waves propagating around the northern polar vortex. Some of these waves (generally those with zonal wavenumber m=1 & 2, and thus periods >~4 sols) are readily identifiable in the MRO/MCS temperature profiles between 40N and 70N and from the lowest elevations resolved by the limb sounder to ~5 scale heights altitude (See Fig. 1). They are also apparent with some effort in the MSL pressure signal as well (Haberle at al., 2018[1]), which, like InSight, is also located in the tropics.

InSight's pressure signal shows clear evidence of the m=1, 2 & especially 3 waves, with periods of 2.5 sols, 5-6 sols and 4 sols seen during the first 200 sols

(See Fig. 2). The m=3 waves are not well-captured by the MRO/MCS retrievals because they are trapped in the lowest scale height. The waves identified in the InSight and MSL pressure signals has all been from Northern hemisphere traveling waves, but we will report on our search for evidence of southern hemisphere traveling waves (see Fig. 3), which while substantially smaller than those in the north, do exist (e.g., Banfield et al., 2004[2]).

Infrasound: We will report on a search through the data for evidence of infrasound, defined solely by the periodicity in the pressure signal (i.e., not considering possible effects detectable by the seismology on the mission). The criteria we use is simply that the oscillations are faster than the typical Brunt-Vaisala frequency in the boundary layer, i.e., about 0.01 Hz (100 s period).

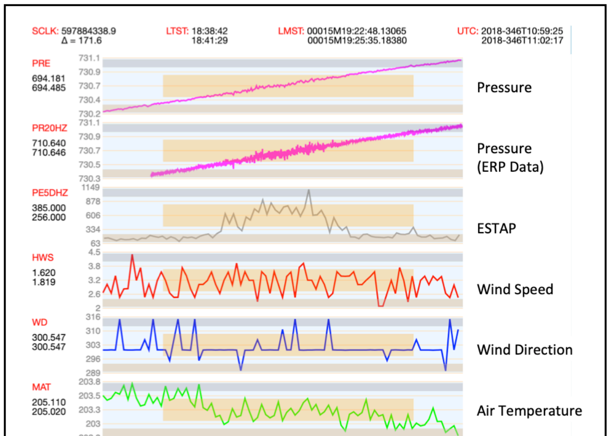

Figure 4. Time series of Pressure, high sampling frequency pressure (labeled ERP Data), hi-pass filtered pressure (labeled ESTAP), wind speed, wind direction and air temperature from InSight on Sol 15 at 18:40 LTST, showing a "pressure burst" (the roughly Gaussian shape bump in hi-pass filtered pressure).

Pressure Bursts: A surprising phenomena was discovered in the InSight data, where the high-frequency (>~1Hz) noise in the pressure signal increases abruptly (by a factor of ~3-10) for a short duration (typically for about 20 seconds to 3 minutes) with the noise amplitude following a roughly Gaussian shape in time (see Fig. 4). The noise spectrum during this time is roughly speaking white (in the high frequencies), with no particular frequencies excited. At the same time, winds are effectively unchanged, suggesting that this is not a wind-induced dynamic pressure phenomenon, but is instead most likely intrinsically something in the ambient pressure field.

We have cataloged the local time and seasonal dependence of these "pressure bursts" and will present them for the first year of InSight operations (See Fig. 5). The general result is that they are much more common in the evening than any other time of day, but sometimes are also found within a few hours after midnight. During the decay phase of the 2019 dust storm, some were found throughout the night, as late as 8AM LTST. Seasonally, the "Pressure Bursts" were present from the start of the mission though to at least Sol 150. By Sol 260 they were completely absent from an 8-sol period. On a few occasions, they were found proximally in time with substantial gravity wave signatures, but it is unclear if they are causally related.

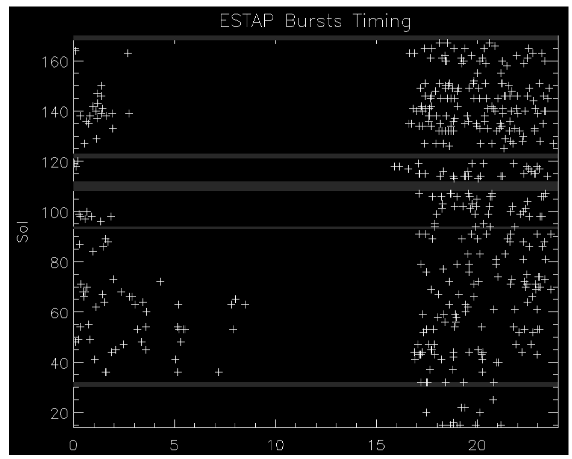

Figure 5. LTST vs Sol number catalog of "Pressure Bursts" in the first 170 sols from InSight. Crosses represent the time of day, and time in the mission when each "pressure burst" was found in the data, showing the preponderance of them in the evening, with a few trailing into mid-morning during the decay phase of the dust storm.

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https://atmos.nmsu.edu/data_and_services/atmospheres_data/INSIGHT/insight.html
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References:

[1] Haberle, R. M. et al. (2018) Icarus, 307, 150-160.

[2] Banfield, D. et al. (2004) Icarus, 170, 365-403.