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Nighttime turbulence at InSight landing site through APSS observations and MRAMS mesoscale modeling

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In this study the Mars Regional Atmospheric Modeling System (hereafter MRAMS [Rafkin et al. 2001]) has been applied to the landing site (∼4.5°N, 136°E in Elysium Planitia) of the InSight mission, that carries onboard the APSS (Auxiliary Payload Sensor Suite) including the TWINS (a pair of Wind and Air temperature sensors) package [Spiga et al. 2018; Banfield et al. 2019]. A full diurnal cycle of air temperature, pressure and wind (speed and direction) obtained from InSight APSS Lander during northern winter, at Ls 295 (landing date) and Ls 315, are compared to data from MRAMS using eight nested grids centered over the landing site. The horizontal grid spacing at the center of the eight grids is 240, 80, 26.7, 8.9, 2.96, 0.98, 0.33 and 0.11 km. We extend our simulations over solstices and equinoxes (Ls 0, 90, 180 and 270).

For northern winter, previous works [Pla-Garcia et al. 2016] suggest strong northerly winds with afternoon heating of the dichotomy producing an upslope flow that reinforce the northerly large-scale (Hadley Cell) surface daytime winds. Furthermore, the source of air during northern winter is found to be from very deep within the cold northern high latitudes [Pla-Garcia et al. 2018].

First modeling results for Ls 315 (InSight mission sol ∼30) at ∼2000-2200 LMST show a decrease in cooling rate (a sudden and unexpected increase in air temperature) that could be produced by enhanced turbulence driven by dynamically-induced downslope windstorms related to gravity wave activity, distinctly different than downslope katabatic winds. This gravity wave amplification activity is produced by strong winds interacting with a sharp topography feature, like Elysium Mons. These dynamic phenomena can oppose buoyancy forces and provide a mechanism for warm air to descend or cold air to rise. These scenarios are fairly common near mountainous terrain on Earth, and are responsible for downslope windstorms (e.g., Chinook winds in the lee of the Rocky Mountains and Foehn winds in the lee of the Alps). Northern clouds captured by MSL Navcam during aphelion cloud belt (ACB) could be putative gravity clouds sculpted by those same gravity waves generated by Elysium Mons and highly related with nighttime turbulence at InSight landing site. Those same gravity waves could be produced tosol, but without a visible counterpart. To study next ACB could be an interesting opportunity to validate this hypothesis.

At ∼21:45-23:45 LMST, the modeling results for Ls 315 show an important increase in both wind velocity (from ∼5 to 10 m/s) and turbulent kinetic energy, that could be produced by enhanced turbulence driven by an increasingly strong shear. As the nocturnal inversion develops, the winds above become decoupled from the surface and the decrease in friction produces a net acceleration. Once the critical Richardson Number is reached (Ri ∼< 0.25), shear instabilities can mix warmer air aloft down to the surface.