PRELIMINARY LARGE EDDY SIMULATION (LES) OF THE FLOW OVER MARTIAN DUNES USING MARSWRF AND HIRISE DTM TOPOGRAPHY. M. I. Richardson[1], C. E. Newman[1], [1]Aeolis Research (600 N. Rosemead Blvd., Suite 205, Pasadena, CA 91107, mir@aeolisresearch.com, claire@aeolisresearch.com).

In this presentation, we will describe preliminary Large Eddy Simulations (LES) of the air flow over Barchan dunes on Mars. Simulation of flow over any kind of topography on scales of O(1-100m) is very rare for Mars and the preliminary simulations presented here will be amongst the first for dune forms on Mars (indeed for any planet, including the Earth [1]).

We use the MarsWRF model [2] in LES mode. The model includes a full treatment of radiative heating of the surface and atmosphere including aerosol and gas effects, and including treatment of surface slope and shadowing. The surface layer is modeled using Monin–Obukhov similarity theory [3]. The major difference in using WRF in LES vs. meso- or global scale is in the treatment of unresolved mixing.

Even at LES scales, some fraction of the turbulent eddy spectrum remains unresolved. The effects of these eddies are treated in this work using a 3D eddy viscosity model based on the dynamic Smagorinsky deformation (see discussion in [4] regarding this and other approaches, and the options within WRF). In meso- and global scale models, rather different 1D diffusion models are instead used to

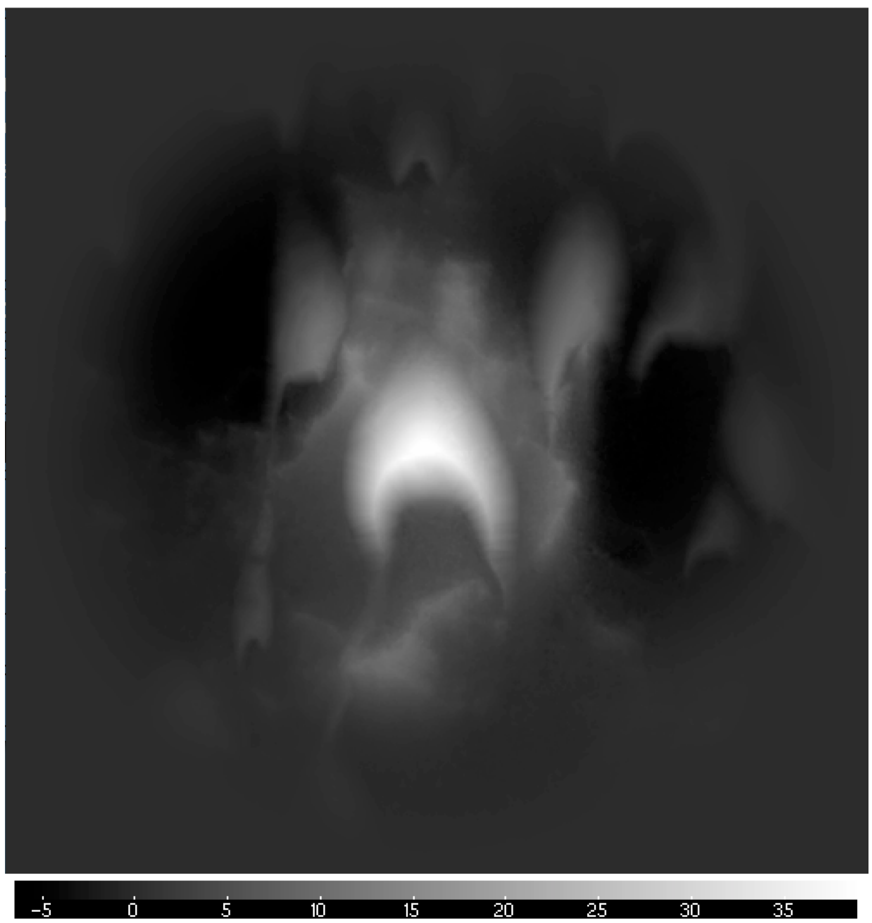

Figure 1: Barchan dune in McLaughlin Crater on Mars. The topography is from the HiRISE DTM based on the left/right pairing of 036859_2020 / 036569_2020. The pixel spacing is approximately 1m, the main dune is about 200m in width and the peak height is about 40m. Smaller dunes of peak height <10m are evident to the north, north east, and northwest of the central dune. The area around the dune has been 100m and 500m from the dune center has been radially smoothed to a uniform flat surface at 0m elevation to allow the map to be used in a doubly periodic LES domain.

emulate the full spectrum of unresolved Planetary Boundary Layer (PBL) mixing, in some cases additionally attempting to estimate the impact of non-local deep mixing through the full depth of the PBL.

Two different approaches have been taken to simulating the wind flow within the LES. (1) A semi-idealized domain has been devised in which a HiRISE dune has been isolated for study by radially filtering the domain (see Figure 1 and caption for details). This allows the domain to be used in a doubly periodic boundary configuration. (2) A fully-nested configuration has been designed in which the domain boundary conditions are forced from output from a lower resolution domain.

The advantages of the doubly periodic domain are that the simulation is simpler (less computationally expensive) but significantly that the absence of forced nested walls means that there is no spectral truncation of turbulence embedded within the inflow boundary. Proper treatment of inflow turbulence and the tendency for spuriously large-scale structures to become “frozen into” the flow at inflow boundarys is a problem that remains unsolved even in terrestrial LES modeling [*e.g.* 5]. In addition to the McLaughlin Crater barchan, we have also used this semi-idealized approach to successfully model Victoria Crater in Terra Meridiani and flow over the very small dune field in the crater bottom.

For some domains, the semi-idealized configuration will not work due to significant slope across the domain or because of the extended nature of the surface bedform under examination. The Namib Dune in Gale Crater represents such a location (see Figure 2), which was the target of a major observation campaign by the Curiosity rover including the measurement of near surface winds at multiple locations around the dune [6]. In these cases, nesting of the LES within a broader domain is necessary, and we will describe the practical implications of this more complex approach.

In this presentation, we will discuss preliminary results of the LES modeling, practical condiserations for modeling, and comparison of the model output with observations.

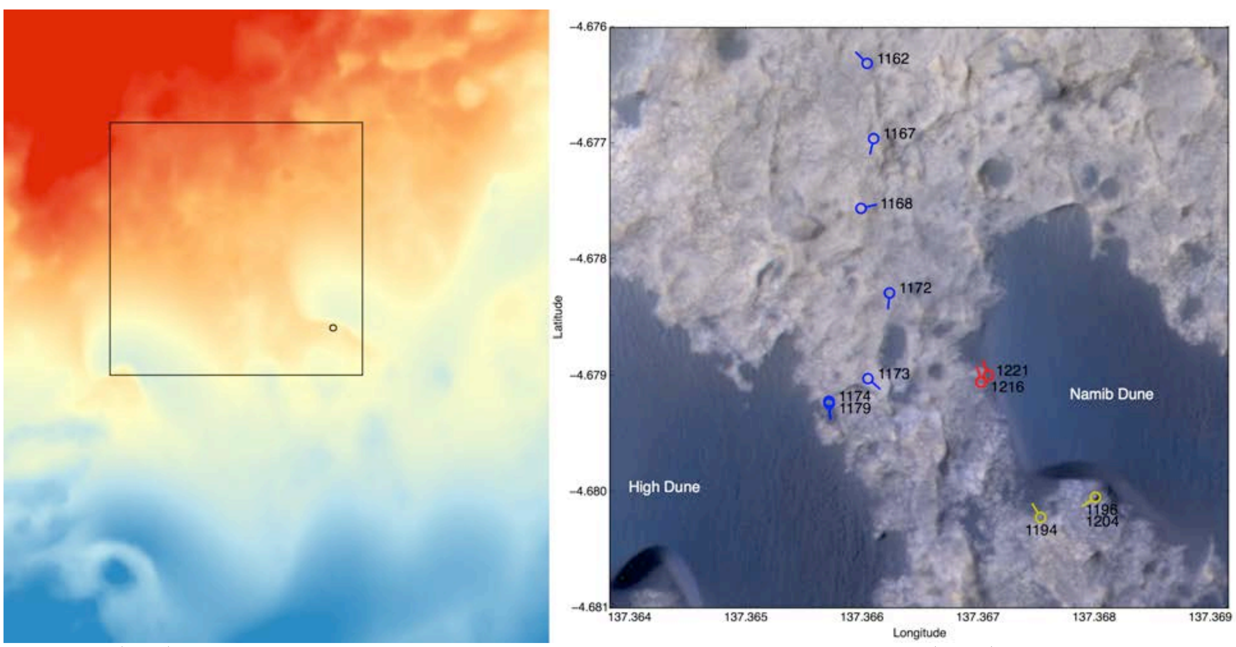

Figure 2: (Left) HiRISE mosaicked topography with box highlighting inset image (right) and circle indicating Curiosity location on Sols 1196 / 1204. Red colors represent lower elevation and blue higher elevation. (Right) HiRISE color image basemap overlain with indicators showing when (mission Sol indicated) and where REMS observations were collected during the first Bagnold Dunes campagin. In this image, the Curiosity rover is contained within the Sol 1196/1204 location marker. Right hand figure is from [6].

References: [1] Smyth T.A.G. (2016) *Aeolian Research*, 22, 153-164. [2] Richardson, M.I. et al. (2007) *J. Geophys. Res.*, 112, E09001. [3] Jimenez, P.A. et al. (2012) *Mon. Wea. Rev.*, 140, 898-918. [4] Kirkil, G. et al (2012) *Mon. Wea. Rev.*, 140, 266–284. [5] Goodfriend, E. et al. (2015) *Mon. Wea. Rev.*, 143, 3310-3326. [6] Newman, C.E. et al. (2012) *Icarus*, 10.1016/j.icarus.2016.12.016.