# A NEW LARGE EDDY SIMULATION MODEL TO STUDY THE CONVECTIVE PLANETARY BOUNDARY LAYER ON MARS.

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## Introduction:

Mesoscale models of the Martian atmosphere have been allowing modelers to examine processes and circulations in the Planetary Boundary Layer (PBL) at higher resolution and in studies that are increasingly more realistic. With improved surface properties, available observations of ground and air temperatures become extremely useful in providing hard constraint of model results. After improvement from tuning the model it becomes increasingly important to determine how realistically the PBL scheme is simulating the effects of convection and turbulence. A real problem, however, is that the PBL is the least observed aspect of the Martian atmosphere; thus, gauging how well a PBL scheme is performing becomes rather difficult.

Gathering enough observations over the extent of the Martian PBL is simply not easy to do. Radio Science data is useful down to an altitude of ~1 km, and satellite limb data might be useful in providing some representation of PBL structure; but, temporal coverage is a big limitation for both of these data sources. Observations gathered with the MET package on Pathfinder do provide some insight into the large turbulent variations and the evolving vertical structure of temperature very near the surface. However, to date, the miniTES instruments on the Mars Exploration Rovers have provided the most useful observations of the temperature structure in the lower PBL, especially since the growth of the mixed layer is observed for an extended period of time. Observations that would describe the vertical turbulent flux of momentum in the PBL do not exist at this time; a meteorology tower would be required.

PBL schemes parameterize the effects of non-resolved turbulent circulations in all larger scale models (GCMs and mesoscale models). Since these schemes are primarily simple adaptations of routines developed by studying turbulent exchange in the terrestrial PBL, a means to qualify the performance of the PBL scheme in a Martian environment is required. An example of how Mars is fundamentally different from Earth (for the specific case of the convective PBL) illustrates why this type of analysis does need to be performed.

For the terrestrial case, the only important heat source is sensible heat flux from the surface; thus, vertical heat flux is seen to decrease upwards from the surface in the terrestrial convective mixed layer. For Mars, due to low densities and the composition of the atmosphere, radiative forcing plays a far more important role (how important is still a very good question). Since air densities are so small the sensible heat fluxes cannot become very large. Thus, radiation from the surface can play an important role in warming the lower atmosphere, causing the vertical heat flux to increase with height from the surface over some relatively shallow distance (~100 m) before it begins to decrease. This shows that there can be a fundamental difference between the structures of the convective PBL on Mars and Earth, which suggests that similarity relationships developed for terrestrial use may not behave reliably when used in a Mars model. Thus, it is actually quite important to examine this fundamental science for Mars.

Since turbulent exchanges are explicitly simulated in a Large Eddy Simulation (LES) model, a PBL scheme is not required. Results from a LES model can provide an alternative to actual observations for qualifying the performance of a Mars PBL scheme. LES models explicitly simulate the smaller scales of convection and the larger turbulent eddies; turbulence closure is still required. Using well-matched simulations, LES results can be used in lieu of data to qualify the performance of a PBL scheme used in a mesoscale model.

## The Model:

We have adapted the LES model of *Skyllingstad* (2003) to study the convective PBL on Mars. To allow the simulation of deep convection the dynamics have been modified from simple boussinesq to be fully anelastic. Additionally the model now utilizes the radiation algorithms from the NASA Ames Mars GCM, as in our mesoscale model, the OSU Mars MM5 [*Tyler et al.* (2002)]. A soil model (as used in this mesoscale model) has been added to the LES model, allowing the prediction of soil and ground temperatures. LES runs are initialized with ground temperatures and atmospheric temperatures provided by the mesoscale model. The code was tested on moderate domains in serial mode on a workstation at OSU. At the time of this writing the LES model has just been ported to the Columbia supercomputer (NASA Ames) and we are performing initial large domain high-resolution simulations on this massively parallel architecture using MPI.

## Results:

Our initial LES simulations are focused on extending our understanding of the environment that will be seen during the Phoenix mission. Results and analysis of at least one such high-resolution large domain simulation will be presented and contrasted against the corresponding location from the "donor" mesoscale simulation.

**References:**

Skyllingstad, 2003, 106, Boundary Layer Meteorology; Tyler et al., 2002, JGR, 107(E4).