AN EDDY-DIFFUSIVITY/MASS-FLUX TURBULENCE PARAMETERIZATION FOR THE MARTIAN CONVECTIVE BOUNDARY LAYER. M. L. Witek¹, M. I. Richardson², C. E. Newman³ and N. G. Heavens⁴,
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Introduction: The Eddy-diffusivity/Mass-flux (EDMF) parameterization has been extremely successful in simulating the evolution of terrestrial atmospheric boundary layers. It is particularly suited for representing strong and moderate convection, where turbulence organizes in coherent structures and transports heat, humidity and pollution throughout the extent of the boundary layer. The EDMF’s ability to explicitly represent turbulent updrafts and associated fluxes is key to a proper depiction of the thermodynamic structure of the atmosphere. It is the most appropriate tool currently available to address the outstanding issues in representation of boundary layer mixing in Mars atmosphere models on a global and regional scale.

Model Features: For the reason mentioned above, we developed an integrated turbulent kinetic energy (TKE) based EDMF closure for the Martian convective boundary layer. The main model features include:
a) the intensities of both mass-flux and eddy-diffusivity turbulent transports depend on the simulated TKE, which allows for a consistent and physically-based formulation of parameters in the model,
b) the mass-flux component includes contribution from organized downdrafts, in addition to organized updrafts,
c) the realistic simulation of TKE is achieved through the use of EDMF approach to the vertical transport of TKE, and
d) surface sensible heat flux and near surface infrared radiative heating contribute to updraft initialization.

In this investigation we capitalize on the results by [1] and develop an EDMF parameterization for the Martian convective boundary layer based on a terrestrial analog developed by [2] and [3]. It is a one-dimensional TKE-based EDMF closure with an additional mass flux transport of TKE [3] and a simplified parameterization of downdrafts.

Results: The scheme is implemented in a one-dimensional model and its performance compared to large-eddy simulation (LES) results for a variety of surface conditions. The simulated mean profiles, turbulent fluxes, updraft characteristics, and boundary layer evolution are in very close agreement with LES (Figure 1). The synergistic integration of all the model features allows for a realistic depiction of the Martian convective boundary layer.

Figure 1 MarsWRF LES simulation and 1D model results for Olympus Mons (~13 km height, p$_{surf}$=146 Pa, flat domain). LES setup includes 1600×1600×120 grid points, Δx=Δy=30 m, variable Δz up to ~22 km, and the Smagorinsky SGS scheme. The 1D model can very realistically represent the evolution of an extreme case of the convective boundary layer on Mars.