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Modeling turbulent flows in the atmospheric boundary layer of Mars: application to Gale crater, Mars, landing site of the Curiosity rover

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Mars is a dry planet with a thin atmosphere. Aeolian processes – wind-driven mobilization of sediment and dust – are the exclusive mode of landscape variability on Mars. Craters are common topographic features on the surface of Mars, and many craters on Mars contain a prominent central mound (NASA's Curiosity rover was landed in Gale crater). Using density-normalized large-eddy simulations, we have modeled turbulent flows over crater-like topographies that feature a central mound. We have also run one simulation of flow over a digital elevation map of Gale crater. Resultant datasets suggest a deflationary mechanism wherein vortices shed from the upwind crater rim are realigned to conform to the crater profile via stretching and tilting. This was accomplished using three-dimensional datasets (momentum and vorticity) retrieved from LES. As a result, helical vortices occupy the inner region of the crater and, therefore, are primarily responsible for aeolian morphodynamics in the crater. We have also used the immersed-boundary method body force distribution to compute the aerodynamic surface stress on the crater. These results suggest that secondary flows – originating from flow separation at the crater – have played an important role in shaping landscape features observed in craters (including the dune fields observed on Mars, many of which are actively evolving).