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TOPOGRAPHY-ENHANCED ULTRA-COLD TRAPPING AT THE LCROSS IMPACT SITE

Abstract

Although the Lunar Reconnaissance Orbiter's Diviner Lunar Radiometer Experiment has produced excellent global temperature maps, there still exists significant uncertainty regarding surface temperatures below the Diviner pixel scale. Recent work has shown that surface roughness at scales down to approximately 10 cm can create "micro cold traps" on otherwise sunlit terrain, providing additional area for lunar volatiles to resist sublimation over geological timescales. We have explored this effect within the larger polar cold traps by modelling the temperatures at the Lunar Crater Observation and Sensing Satellite (LCROSS) impact site at a resolution of 1 m px^{-1}. Our modelled terrain is upscaled from the 20 m px^{-1} LOLA south polar DEM and overlaid with a physically realistic crater population. The terrain is illuminated by scattered sunlight and IR emissions from nearby sunlit terrain, as well as Earthshine.

The maximum surface temperatures experienced at the LCROSS impact site span a range of nearly 60 K, including "micro ultra-cold traps" that experience temperatures that are much lower than have been measured by Diviner at this location. These results reinforce the fact that Diviner temperature measurements do not fully capture the volatile storage potential of the Moon's polar cold traps. To assess the spatial variability of the surficial abundances necessary to replicate the LCROSS abundances, we smooth the maximum temperatures over a region equal in size to the expected size of the LCROSS impact crater. We find that the in-situ surficial abundances needed to recreate those measured by LCROSS are strongly dependent on where the impact occurred, with some species varying by a factor of >2–3 over a few dozen metres. The abundances of C_2H_4 and CH_4 are most closely tied to the ultra-cold traps, as the inter-cold-trap "highlands" are generally warmer than the stability threshold of these two species. If LCROSS did not impact an ultra-cold trap, higher delivery rates or a greater cold-trapping efficiency of C_2H_4 and CH_4 would be necessary for the surficial abundances to be consistent with the LCROSS measurements.