Analyses of long-exposure NAC imagery in lunar PSRs: implications for exposed volatiles

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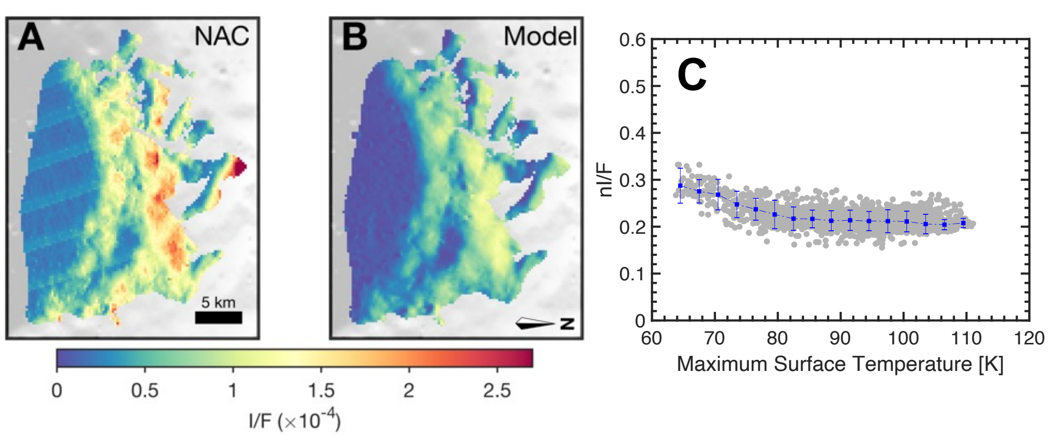
Abstract. The Narrow Angle Cameras (NACs) on board the Lunar Reconnaissance Orbiter have successfully imaged permanently shadowed regions (PSRs) while faintly illuminated by sunlight reflected from the surrounding terrain. In addition to allowing for the examination of surface morphology at meter-scales, these images also provide a means to study the vis/NIR reflectance properties, and, in turn, search for the presence of exposed volatiles. In this work, we employ a detailed radiometric model of reflected sunlight to derive reflectance quantities from NAC long-exposure images using a photometric normalization technique. The figure below provides a comparison of NAC image data along with the corresponding model data for the Amundsen crater PSR located at the south pole. Here, as in the majority of observations, we find that NAC images appear consistently brighter than the modeled data. Using a theoretical mixing model, we explore the possibility that the brightness offset is the result of exposed, pure water ice, and find that concentrations in the range of 5-30% are needed to account for the brightness differential. In several craters, such as Amundsen (panel C), Cabeus and Cabeus B, clear temperature-reflectance correlations are observed, where the reflectance increases with decreasing maximum temperature for $T_{max} < 80$ K. This behavior, consistent with the presence of water ice, has been observed in the aggregate for lunar south polar PSRs, although it has yet to be observed within individual craters containing permanent shadow. We note, however, that while all PSRs examined are enhanced in brightness relative to their surroundings, this temperature-reflectance behavior is not observed in every case. As has been previously shown, the derived reflectance for PSR surfaces is found to be systematically brighter than the non-PSR reflectance immediately surrounding the PSR; however, our data show brightness offsets 35-50% larger than previously reported[1], which may be due in part to the presence of out-of-field stray light.



[1] Fisher et al., *Icarus, 292* (2017)