National Aeronautics and Space Administration

THE THERMOPHYSICAL PROPERTIES OF LUNAR RED SPOTS FROM LRO DIVINER LUNAR RADIOMETER EXPERIMENT OBSERVATIONS

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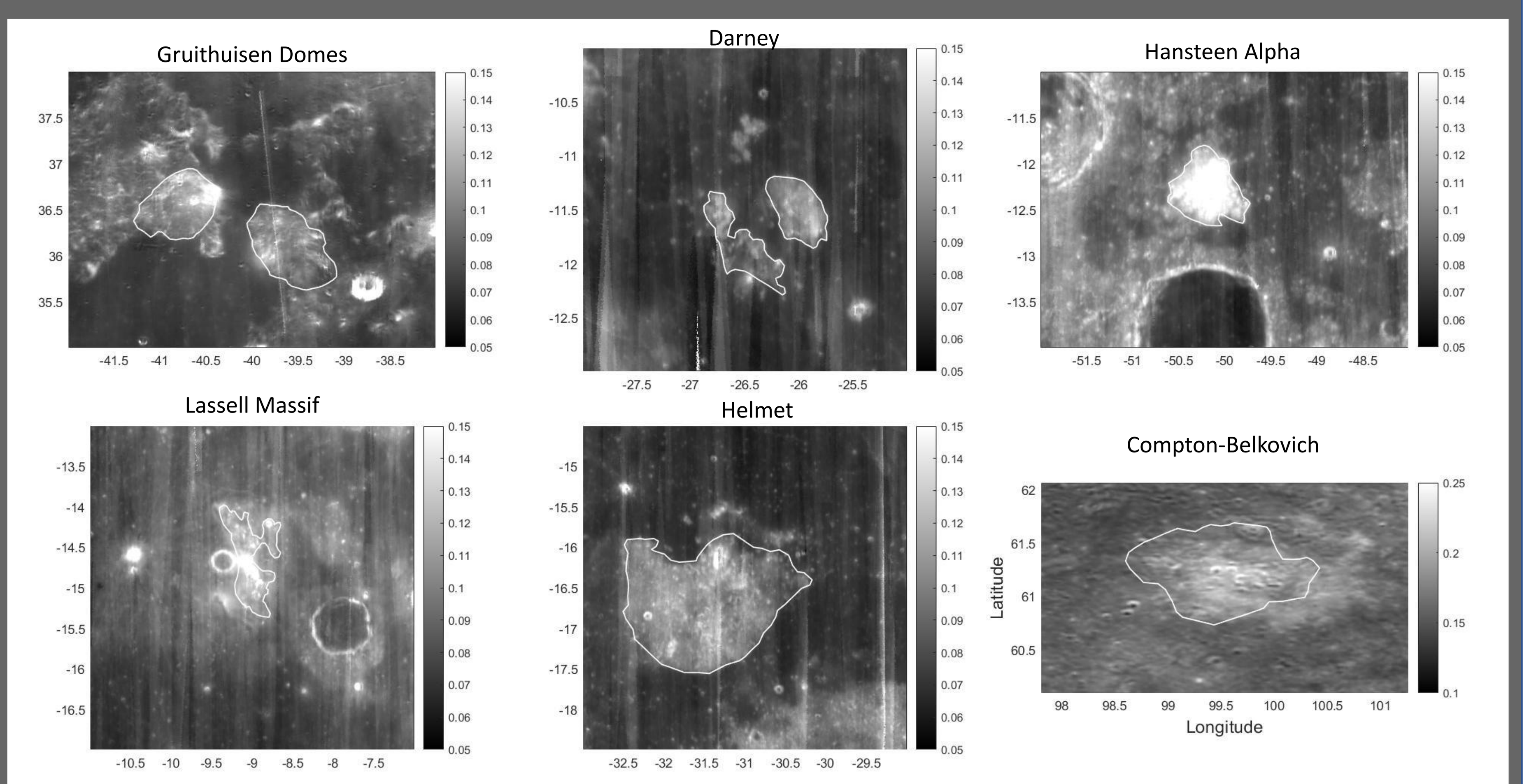
Lunar Red Spots

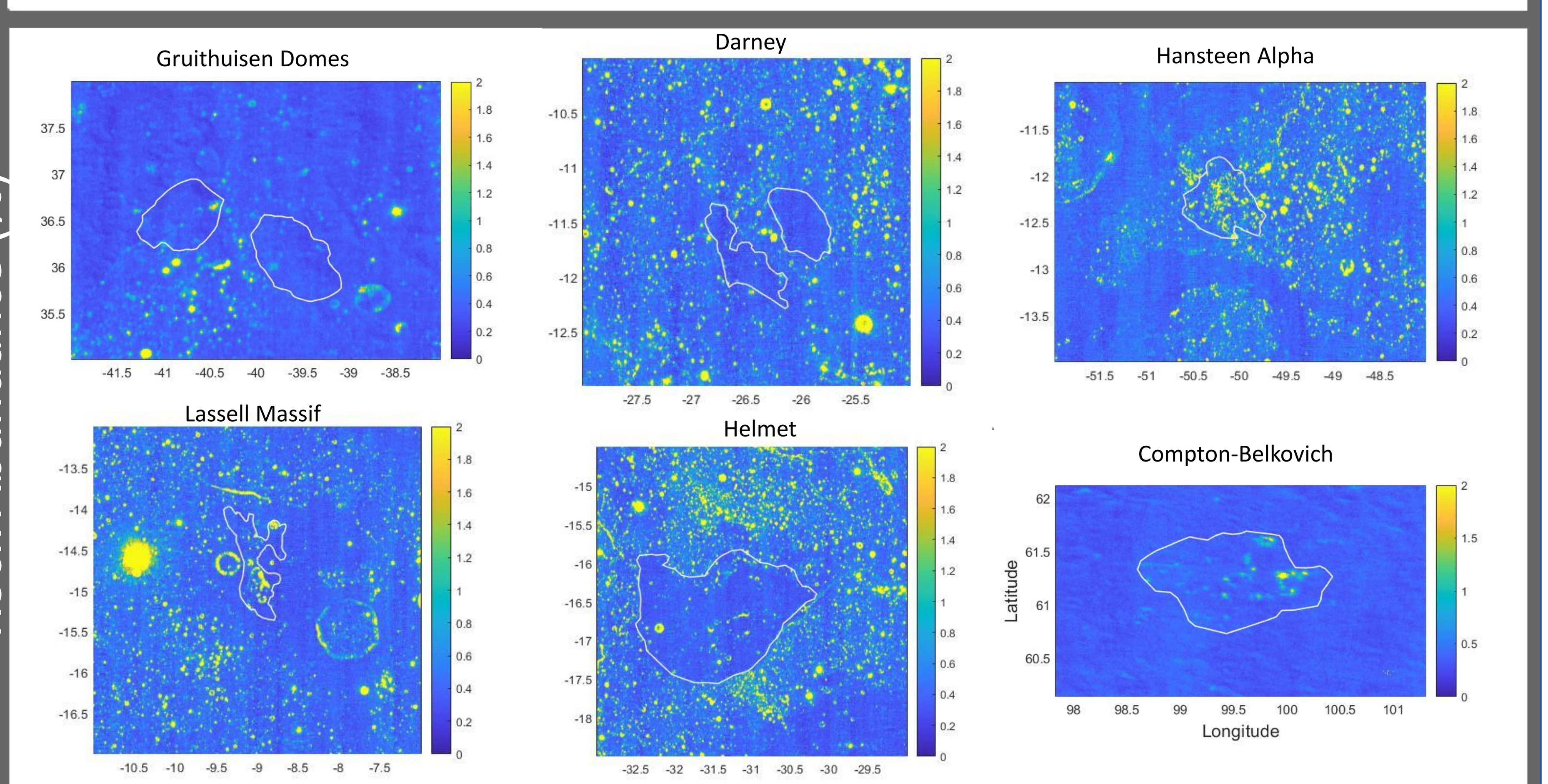
Red Spots are anomalous spectral features in the nearside lunar maria that appear spectrally red and are proposed to be the result of non-mare volcanism. Previous studies using Diviner data suggested that red spots have low regolith thermal inertia, but were unable to determine if the signal was real or due to their anomalous albedo affecting the model. We create updated albedo maps to definitively rule out the albedo effect and determine the thermophysical properties of these enigmatic volcanic features.

LRO Diviner Data

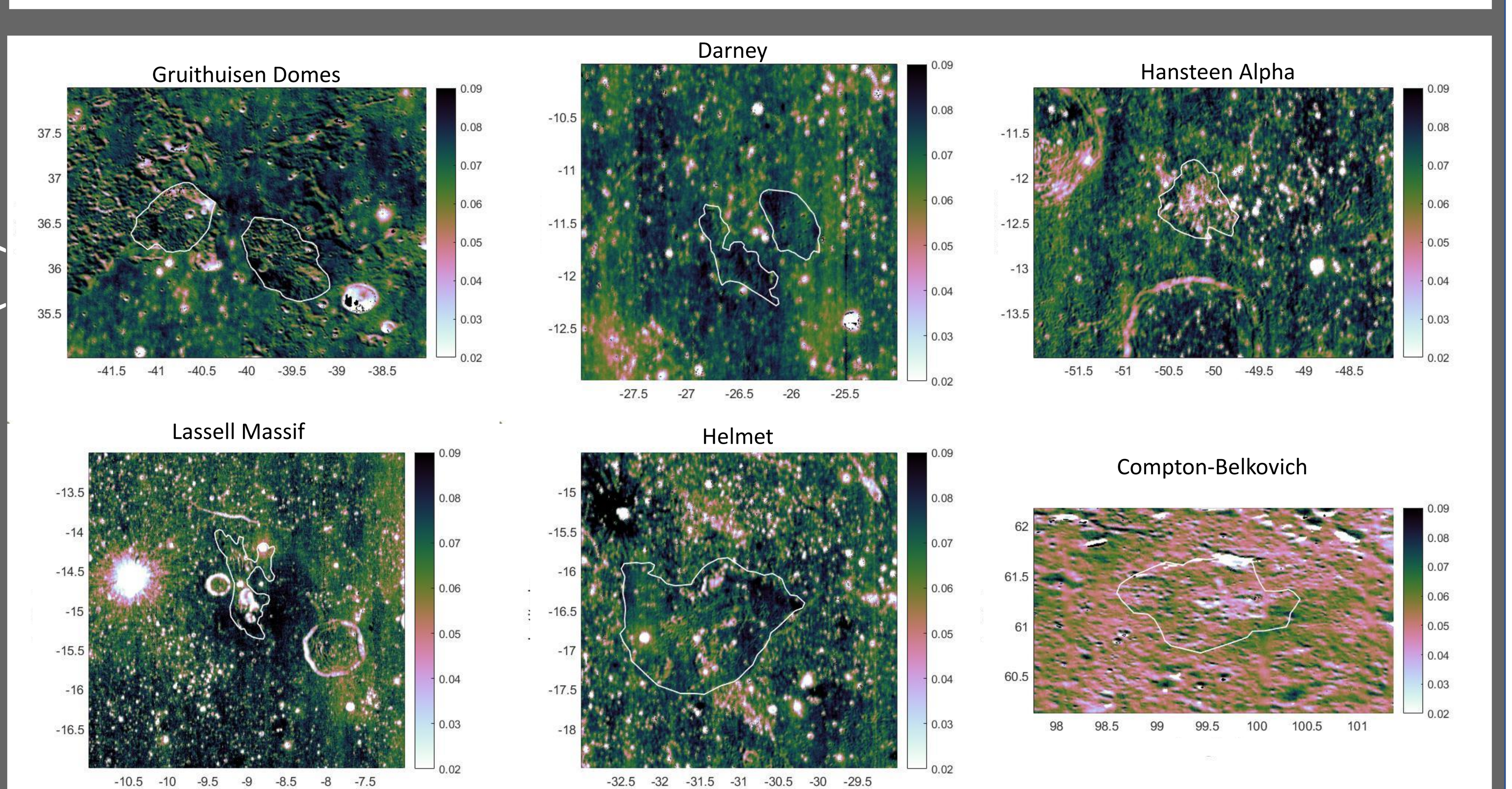
Lambert Albedo



Rock Abundance (%)



H-Parameter (m)

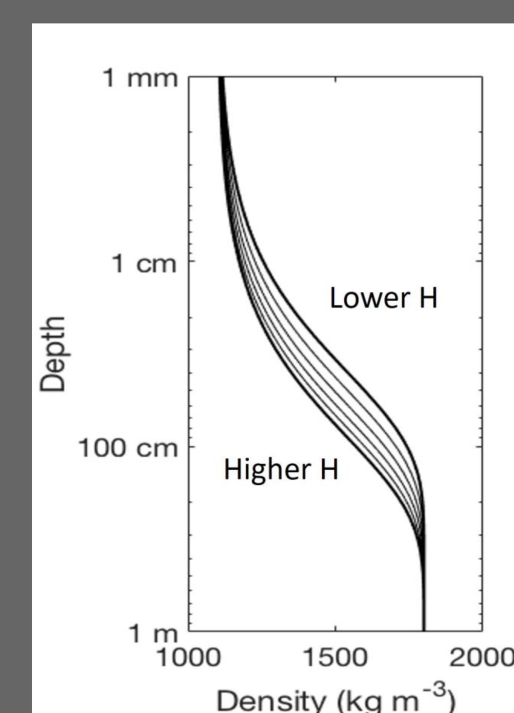


After implementing the updated albedo maps into the model, the red spots do not have uniformly high H-parameter but contain smaller regions of high H-parameter. Most of the red spots additionally display lower rock abundance (RA) than surrounding maria.

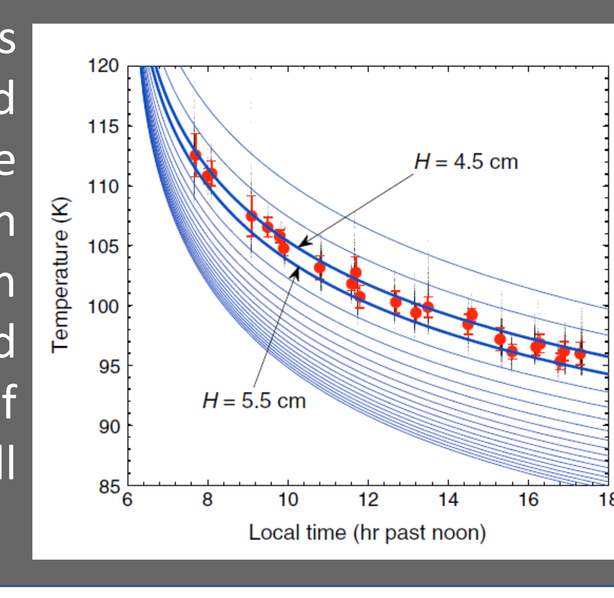
Thermophysical Model

Using nighttime temperature data from Diviner, it is possible to infer the thermophysical properties of the lunar regolith. The 1D heat flow model from Hayne et al. (2017) was found to provide a good fit to the Diviner data, with the variation in density with depth being explained by the following exponential density profile:

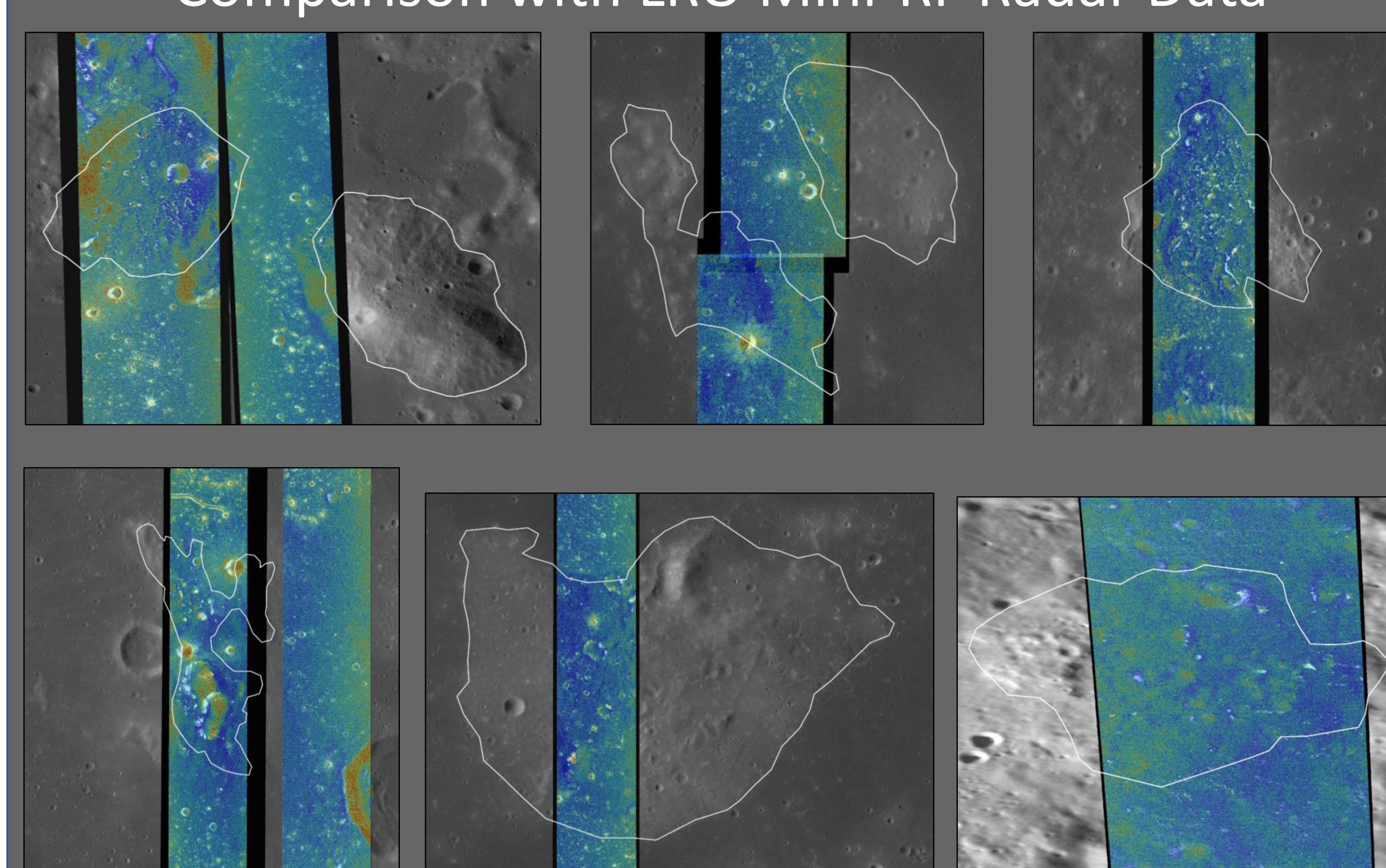
$$\rho(z) = \rho_d - (\rho_d - \rho_s)e^{-z/H}$$



The parameter H in the above equation controls the change in density and conductivity with depth, and can be solved for in the model. We fit the Diviner nighttime temperature data to the thermal model, solving for H and creating maps of the lunar regolith H-parameter for the red spots. H-parameter in this model can be considered analogous to thermal inertia, with high H corresponding to low thermal inertia. On the Moon, thermal inertia is primarily affected by the regolith packing density, the size/shape of the regolith grains, or the presence of small rocks within the diurnal skin depth (~10 cm).



Comparison with LRO Mini-RF Radar Data



At S-band (12.6 cm) wavelengths red spots generally appear radar dark and have low Circular Polarization Ratio (CPR). A low CPR could indicate a lack of surface/subsurface scatterers in the top ~1 m, or that the regolith is relatively fine-grained. This is generally consistent with the Diviner H-parameter results, which suggest a lack of small rocks in the top ~10 cm. Locations within the red spot where there are disagreements between CPR and H-parameter likely occur due to the different sensing depths of radar and IR (i.e., high H-parameter and high CPR could result from a thin layer of rock poor regolith overlying a rockier layer at depth that only radar wavelengths can observe).

Conclusions

- Red Spots have lower rock abundance and higher H-parameter than surrounding mare regions
- Low RA and thermal inertia is consistent with the presence of finer-grained or rock-poor regolith
- CPR data from LRO Mini-RF radar instrument is consistent with Diviner H-parameter results

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