ILLUMINATION AND TEMPERATURE MODELLING OF THE LUNAR POLAR REGIONS.

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Introduction: We have produced a model for determining the illumination and thermal conditions inside the permanently shadowed regions near the lunar poles. The lunar poles experience lighting conditions that are unique in the solar system. The spin axis of the Moon is nearly perpendicular to the ecliptic plane. This means that low regions, such as the floors of impact craters, are often always shielded from the Sun. Conversely, regions of local topographic high may receive illumination for extended periods of time, possibly even constantly. These areas of extreme illumination are important from an exploration perspective as they offer abundant solar energy. Additionally, the thermal conditions in the illuminated areas are of interest to exploration such that thermal loading of equipment can be correctly assessed and temporal scales below the resolution of Diviner.

Current Knowledge:

Illumination Conditions. The current quantitative illumination maps were produced using the first month of Clementine data [1, 2] These data corresponded to a lunar day in winter at the south pole and summer in the north pole. They are inadequate to fully characterize the illumination conditions for both poles.. Lunar Orbiter IV also acquired polar data, but unfortunately it was taken during the same seasonal conditions as the Clementine data. These data are still useful, however, as they provide a snapshot of the regional illumination conditions for sub-solar longitudes not covered by Clementine.

Thermal Modeling. Vasavada et al. [3] modeled the temperature of a flat surface and inside impact craters for both the Moon and Mercury. His model used a two layer physical model of the planetary surface and utilized a 32 x 32 finite element grid. His model was used to predict temperature variation throughout the lunar day.

Our Model: Based on an earlier modeling effort that investigated thermal erosion in lava channels [4, 5] we have produced a model to calculate lunar surface and sub-surface temperatures (Figure 1). Our model is similar to the Vasavada et al, [3] model, but can simulate more realistic cater shapes, as it uses a higher density grid, 500 x 500, versus 32 x 32. When identical parameters are used, our results match those of the Vasavada work.

A future version of the model will use a variable spatial resolution model, where the grid density is inhomogeneous, with a higher density used for surface features that benefit in realism, e.g., a central peak, and a lower resolution used when it is adequate, e.g., for areas of the flat floor. Additionally the efficiency of the model will be improved to permit larger total array sizes to be modeled.

Because our temperature model considers permanently shadowed regions, it calculates the local horizon for all locations within the crater. A by-product is that our model also calculates very precisely the location of shadow for a chosen Sun location, including allowing for the curvature of the Moon, something that typical ray-tracing software does not do (Figure 2). We therefore use our model to generate maps showing permanent shadow within craters. Due to the current lack of high-resolution topography data for the lunar poles, our model uses idealized crater shapes based on the work of Pike [6] and others. As future higher-resolution data become available, e.g., from the laser altimeter on the Kaguya mission (data acquired but not yet released) we will be able to use our model to map out the exact illumination conditions at the poles.

A key question as to where ice can exist is locations that never get above ~110 K.. For a spherical Moon the subsurface temperature below about 1 m is constant, the actual number varying as a function of latitude, from about 250 K at the equator to 40 K near the poles. However, a vertical surface near the poles receives illumination analogous to a flat surface at lower latitudes; therefore the subsurface temperature will be higher. We will develop a new thermal model that calculates the subsurface temperature by allowing for lateral heat flow below the surface. All current models only consider radial heat flow. For example we will calculate the temperature with depth of a near-vertical portion of a crater wall (which will be warmer than the crater floor) and calculate how effectively the heat will migrate into the surface. This will identify more precisely the temperature with depth, thus showing the locations where ice can exist.

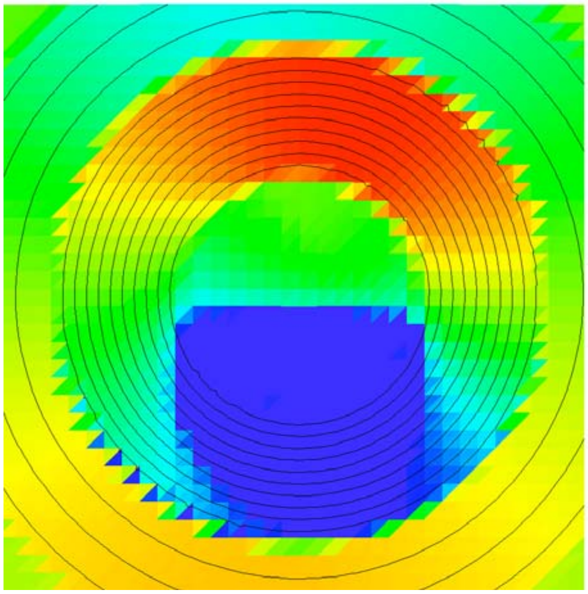

Figure 1. Our model predicts the surface and subsurface temperatures. This example shows a simulation for a 20 km crater; blues are colder, reds are warmer.

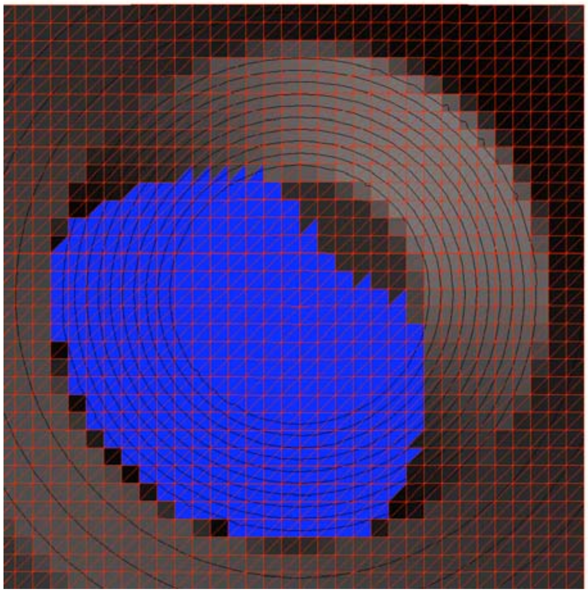

Figure 2. A side-benefit of our temperature model is that it precisely calculates the location of shadows inside the crater. It can therefore be used to determine the amount of permanent shadow insde polar craters.

References:

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