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Estimation of Lunar Surface Temperatures: a Numerical Model

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About 40 years after the Apollo and other lunar missions, several nations return to the Moon. Indian, Chinese, Japanese and American missions are already in orbit or will soon be launched, and the possibility of a “Made in Germany” mission (Lunar Exploration Orbiter – LEO) looms on the horizon [1]. In preparation of this mission, which will include a thermal infrared spectrometer (SERTIS - SElenological Radiometer and Thermal infrared Imaging Spectrometer), accurate temperature maps of the lunar surface are required. Because the orbiter will be imaging the Moon’s surface at different times of the lunar day, an accurate estimation of the thermal variations of the surface with time is necessary to optimize signal-to-noise ratios and define optimal measurement areas. In this study we present new global temperature estimates for sunrise, noontime and sunset.

This work provides new and updated research on the temperature variations of the lunar surface, by taking into account the surface and subsurface bulk thermophysical properties, namely their bulk density, heat capacity, thermal conductivity, emissivity and albedo. These properties have been derived from previous spacecraft-based observations, in-situ measurements and returned samples [e.g. 2-4]. In order to determine surface and subsurface temperatures, the one-dimensional heat conduction equation is solved for a resolution of about 0.4°, which is better by a factor of 2 compared to the Clementine measurement and temperature modeling described in [2]. Our work expands on the work of Lawson et al. [2], who calculated global brightness temperatures of subsolar points from the instantaneous energy balance equation assuming the Moon to be a spherical object [2].

Surface daytime temperatures are mainly controlled by their surface albedo and angle of incidence. On the other hand nighttime temperatures are affected by the thermal inertia of the observed surface. Topographic effects are expected to cause earlier or later sunrises and therefore high-standing areas receive sunlight for longer time, while sloping surfaces lead to a time displacement of the temperature cycle. For our model, some simplifications were necessary. In order to determine the solar influx, the Moon is assumed to be spherical. As there are only few landing sites from which soil properties were determined, the subsurface conditions are considered as homogeneous over the whole Moon.

Our study shows that the maximum surface temperatures for latitudes between 75°N and 75° vary between 240K at high latitudes and 390K at the mare regions near the equator. Temperatures for latitudes higher than 75° have been excluded because topographic effects intensely influence the temperatures. Nighttime temperatures are around 100K, which is in good agreement with the Apollo 15 and 17 temperature measurements described by Keihm and Langseth [5]. In order to determine the albedo influence on surface temperatures a map that shows the difference between albedo influenced temperatures minus temperatures of a uniform surface has been created. Maximum temperatures differ about ±15K between mare regions and highlands.

Topographic effects due to sloping surfaces have also been investigated. For example surfaces having a slope of 20° reach their maximum temperatures about 2 days before or after a plane surface, depending on their orientation. Temperature differences of 150K have been found between sloping (20°) and non-sloping surfaces shortly after sunrise.

[1] Jaumann, R. et al. (2008) LPSC XXXIX, Abstract #1253; [2] Lawson, S. L. et al. (2000) JGR 105, E2, 4273-4290; [3] Langseth, M. G. et al. (1972) The Moon, Vol. 4, 390-410; [4] Racca, G. D. (1995) Planet. Space Sci., Vol 43, No. 6, 835-842; [5] Keihm, S. J. and Langseth, M. G. (1973) Proc. Lunar Sci. Conf. 4th, 2503-2513