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Insolation and Resulting Surface Temperatures of Study Regions on Mercury.

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The imaging spectrometer MERTIS (Mercury Radiometer and Thermal Infrared Spectrometer) is part of the payload of ESA's BepiColombo mission, which is scheduled for launch in 2014 [1]. The instrument consists of an IR-spectrometer and radiometer, which observe the surface in the wavelength range of 7-14 and 7-40μm, respectively. The four scientific objectives are to a) study Mercury's surface composition, b) identify rock-forming minerals, c) globally map the surface mineralogy and d) study surface temperature and thermal inertia [1, 2].

In preparation of the MERTIS experiment, we performed detailed thermal models of the lunar surface, which we extrapolated to Mercury. When calculated with lunar parameters, this allows us to compare the results to lunar temperature measurements of the Apollo, Clementine, Chandrayaan, and Lunar Reconnaissance Orbiter missions [e.g., 3-6]. For our simulation, we use topography data from the Moon and idealized crater geometries and transfer them as model regions to the surface of Mercury. It also allows a direct comparison of the insolation and thermal variation between craters on the lunar and Mercurian surface.

Previous studies of the lunar surface have shown that thermal emission contributes to the observed signal from the surface and can influence the spectral characteristics, e.g., the depth of absorption bands [e.g., 5, 7, 8]. Therefore accurate knowledge of the solar insolation and resulting thermal variations is necessary for the correct interpretation of long-wavelength spectral data. In order to calculate insolation and surface temperatures, we use a numerical model which has been described by [9]. Surface temperatures are dependent on the surface and subsurface bulk thermophysical properties, such as bulk density, heat capacity, thermal conductivity, emissivity, and albedo. Topography also influences surface temperatures, as it changes the angle of solar incidence, but also leads to shadowed areas, e.g., the floors of polar craters.

Lunar and Mercurian surface temperatures show the same general characteristics. Both have very steep temperature gradients at sunrise and sunset, due to the lack of an atmosphere. However, there are major differences due to the orbital characteristics. At local noon, the near- and farside of the Moon receive sunlight under similar solar elevation angles. However, at this time of the lunar day, the surface on the farside is slightly warmer than the nearside, because of the shorter distance to the Sun. During the orbit around the Sun, the distance varies due to the eccentricity of the Earth-Moon-System, which results in different temperatures during a year.

On Mercury the 3:2 resonant rotation rate and the eccentric orbit cause distinct characteristics. At longitudes 0° and 180° local noon coincides with perihelion, which leads to a "warm pole". At longitudes 90° and 270° local noon coincides with aphelion, which results in a "cold pole". At these longitudes secondary sunrises and sunsets are visible, when Mercury's orbital angular velocity exceeds the spin rate during perihelion.

The slow rotation and close distance of Mercury to the Sun require a detailed analysis of shadowing effects at low elevation angles. During these times of the day, a fraction of the solar disk is below the horizon and the solar constant must be modified. The Sun can not be treated as a point source, as it would indicate darkness for areas where the sun is partially eclipsed. On the Moon this effect is less pronounced. Due to the larger distance the angular radius of the Sun appears much smaller and the faster rotation period leads to relatively quick sunrises. However, when investigating polar areas, where the Sun is only partially visible over long times, or areas at local sunrise or sunset this effect needs to be included in the computation of solar insolation.

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