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Thermophysical model of the Moon from 3.7 to 15 μm

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We present a thermophysical model (TPM) of the Moon which matches the observed, global, disk-integrated thermal flux densities of the Moon in the mid-infrared wavelength range for a phase angle range from -90° to +90°.
The model was tested and verified against serendipitous multi-channel HIRS measurements of the Moon obtained by different meteorological satellites (NOAA-11, NOAA-14, NOAA-15, NOAA-17, NOAA-18, NOAA-19, MetOp-A, MetOp-B). The sporadic intrusions of the Moon in the deep space view of these instruments have been extracted in cases where the entire Moon was within the instruments' field of view. The HIRS long-wavelengths channels 1-12 cover the range from 6.5 to 15 μm, the short-wavelengths channels 13-19 are in the 3.7 to 4.6 μm range.

The model is based on an asteroid TPM concept (Lagerros 1996, 1997, 1998; Müller & Lagerros 1998, 2002), using the known global properties of the Moon (like size, shape, spin properties, geometric albedo, thermal inertia, surface roughness, see Keihm 1984; Racca 1995; Rozitis & Green 2011; Hayne et al. 2017), combined with a model for the spectral hemispherical emissivity which varies between 0.6 and 1.0 in the HIRS wavelength range (Shaw 1998; ECOSTRESS data base: https://ecostress.jpl.nasa.gov/). The spectral emissivity as well as characteristics of the surface roughness are crucial to explain the well-calibrated measurements.

Our Moon model fits the flux densities for the currently available 22 epochs (each time up to 19 channels) with an absolute accuracy of 5-10%. The phase curves at the different wavelengths are well explained. The spectral energy distributions are very sensitive to emissivity and roughness properties. Here, we see minor variations in the model fits, depending on the origin (phase and aspect angle related) of the thermal emission. We also investigated the influence of reflected sunlight at short wavelengths.

Our TPM of the Moon has a wide range of applications: (i) for Earth-observing weather satellites in the context of field of view and photometric calibration (e.g., Burgdorf et al. 2020); (ii) for interplanetary space missions (e.g., Hayabusa2, OSIRIS-REx or BepiColombo) with infrared instruments on board for an in-space characterization of instrument properites (e.g., Okada et al. 2018); (iii) to shed light on the thermal mid-infrared properties of the lunar surface on a global scale; and, (iv) to benchmark thermophysical model techniques for asteroids in the regime below 10 μm (e.g., observed by WISE in the W1 and W2 bands at 3.4 and 4.6 μm, by Spitzer-IRAC at 3.55 and 4.49 μm or from ground in M band at around 5 μm).

References:

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