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Local thermal models of atmosphereless planetary bodies based on digital terrain data

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Abstract

For a better understanding of the evolution and composition of a planetary body good knowledge of its thermal regime is necessary. The selection of potential landing sites for spacecrafts, the planning of *in situ* experiments, as well as astrobiological investigations depend on the temperature situation of specific local surface and sub-surface regions. Therefore, thermal models of local areas on planetary bodies, based on high-resolution digital terrain data, are computed and will be described in this presentation.

1. Introduction

Physical, chemical and biological processes are strongly influenced by the ambient temperature. Thus, thermal models are often the basis for investigations of small bodies, like moons, asteroids and comets. It can be distinguished between global and local thermal models. For global thermal models the respective bodies are assumed to be of simple geometrical shape, e.g. spherical or ellipsoidal, without consideration of surface details as mountains, craters, etc., as described in [1] and [2], or only coarse meshed digital terrain data are used. In contrast, surface features and their effects (shading, radiation, reflection, é) are particularly taken into account in a local thermal model, where a small surface area is considered in high detail. This is done in the course of a project named ñ*SterLim* ï Feasibility studies and tests to determine the sterilisation limits for sample return planetary protection measuresò. The project is implemented in ESAôs Aurora MREP activity in the context of Phobos Sample Return, for which a verification of the planetary protection classification of Phobos is needed. In general, such local thermal models will be applied to provide a better understanding of the temperature regime of atmosphereless planetary bodies, e.g. the comet 67P/Churyumov-Gerasimenko.

2. Digital terrain data

The Martian moon Phobos is a small, irregularly shaped object which can be approximated as a tri-axial ellipsoid with dimensions of 27 x 22 x 18 km. Phobos is orbiting relatively close to its central body in a bound rotation state with a period of about 7.5 h. A global digital terrain model (DTM) of Phobos with a resolution of 100 m per pixel was derived by [3] using Viking Orbiter images and High Resolution Stereo Camera (HRSC) images of the Mars Express mission (Figure 1).

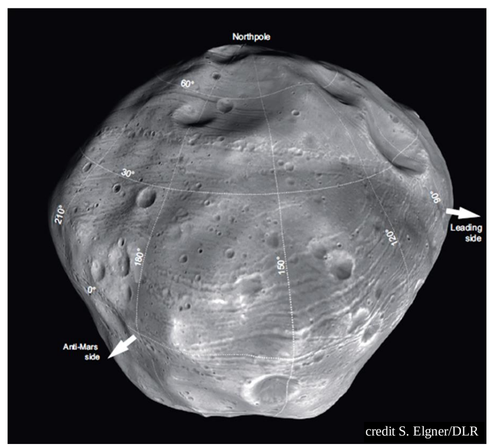

Figure 1: Perspective view of Phobos DTM with the draped HRSC image mosaic [3].

3. Thermal model

As one can see in Figure 1 Phobos is pitted with craters, grooves and streaks, where the most prominent crater is called Stickney with a diameter of 9 km. Some of these surface features are of interest for the studies and tests performed in the frame of *SterLim*, where the results of thermal simulations are used for setting up the test environment. The thermal model for Phobos includes radiative input from the Sun, Mars and the moon itself. Phobos is, according to [1] and [2], an atmosphereless, regolith-covered body, where an inner heat source is not present, due to its small mass. Several factors are influencing the temperature distribution on the surface and in the sub-surface layers of Phobos. The most important ones are the highly eccentric Mars trajectory (leading to a high temperature difference between perihelion and aphelion), the very low albedo of Phobosô surface (resulting in practically complete absorption of the solar radiation), the synchronous rotation of Phobos, and the heat flux resulting from the reflected and thermal radiation of Mars, as shown schematically in Figure 2.

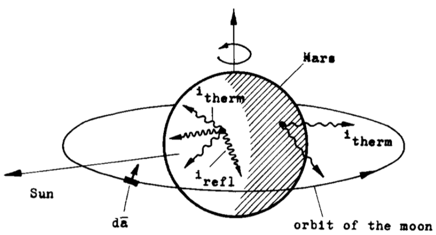

Figure 2: Sketch of the Mars radiation received at a surface element $d\bar{a}$ of the moon [1].

Including all these global factors and all the local effects, as shading of the crater walls as well as radiation and reflection inside craters or local cavities into the thermal model for any point on the moonôs surface and along Marsô trajectory is the goal of the work reported here.

Acknowledgements

The thermal model of Phobos was created within the scope of the project ñ*SterLim* ï Feasibility studies and tests to determine the sterilization limits for sample return planetary protection measuresò under ESAôs Aurora MREP activity.

References

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