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Mapping of thermal properties over CG-67/P surface

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Abstract

Surfaces temperature maps of the nucleus of comet 67P have been derived from the visible/infrared VIRTIS-M (Visible InfraRed and Thermal Imaging Spectrometer, Mapping channel) spectra acquired all over the ROSETTA mission by modelling its thermal emission. We modelled the thermal emission measured during the first months of the mission, while the heliocentric distance was > 3AU, in order to estimate the regional variations of the thermal inertia and the surfaces roughness. We then analyzed the correlation between those 2 parameters and the gravity slopes and the gravitational potential, that can provide new insights on the dust deposit dynamic.

1. Introduction

The VIRTIS spectrometer (Visible and InfraRed Thermal Imaging Spectrometer) embedded on the Rosetta probe observed the surface between 1 and 5 microns, to measure the surface temperature of the comet. From these measurements [1], and using a thermal model in the near underground, taking into account the effects of small-scale terrain roughness but also the effects associated with the complex shape of the comet (mutual shadows, mutual heating) it is possible to estimate the thermal properties in each geomorphological region of the comet. These thermal properties can then be compared to the geomorphological signatures and the local gravity field in order to better constrain the evolutionary processes (landslides, cohesion, ballistic transfers of dust ...).

2. Modelling

One big advantage of the VIRTIS Rosetta observations over the previous space missions dedicated to comets studies is the large range of phases angles and local times covered by VIRTIS thanks to the complex orbit of Rosetta. This allows disentangling the surface thermal inertia effects from the surface roughness effects. The thermal emission of a rough surface is not isotropic (not Lambertian) and the same area observed at different phases angles presents different thermal observed fluxes that can be misinterpreted as a variation of the thermal conductivity. At very short wavelengths, typically the sensitivity range of VIRTIS, this effect is critical and affects significantly the Wien's part of the Planck's function. To mimic the VIRTIS data obtained between September 2014 and December 2014, synthetic thermal spectra were generated assuming heat transfer through the subsurface by conduction, and including some roughness properties both at the nucleus shape model resolution scale (few meters) and at sub-pixel scale [2]. Ice content was neglected first as the comet was quite inactive at the beginning of the mission. For about 70 geomorphological regions, 300 spectra were randomly selected and compared to the synthetic ones.

3. Results

In general, the thermal inertia remains in the range 10 – 300 J K^{-1} m^{-2} $s^{-1/2}$, similar to values found on other comets [3]. The surface temperature increases in average by 0.5 K/min just after being illuminated by the Sun. Interestingly, two groups of surfaces were identified: the smooth terrains (dusty units like Imhotep, Hatmeit, etc...) present very low thermal inertia (<30 J K^{-1} m^{-2} $s^{-1/2}$) while rough consolidated terrains with apparent fractures seems to conduct heat more efficiently, with higher thermal inertia values (>110 J K^{-1} m^{-2} $s^{-1/2}$). Figure 1 illustrated the variations of thermal inertia over the surface, in the Northern hemisphere.

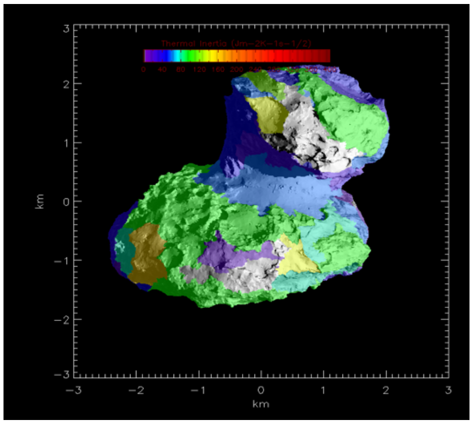

Figure 1. Thermal inertia variations on the northern hemisphere

4. Link to gravity and slopes

We also investigated the link to the gravitational slopes and the gravitational potential (Figure 2). The correlation between thermal inertia and gravitational slopes is not obvious. While we observe an increase of the thermal inertia (i.e. a decreased of the porosity) with the local slopes on most of the regions, as expected, the distribution is bimodal. It is however clear that the gravitational potential drives the dust deposit at the surface.

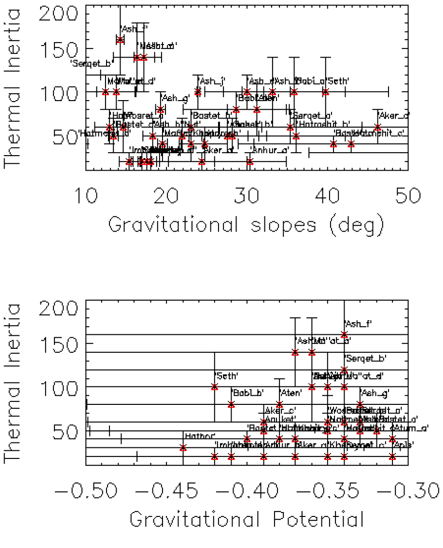

Figure 2. Thermal inertia versus local slopes and gravitational potential for all of the 70 regions.

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