EFFECT OF SURFACE ROUGHNESS ON THE OBSERVATION OF TIR ONBOARD HAYABUSA2. H. Senshu[1], N. Sakatani[2], Y. Yokota[3,4], and T. Morota[5], [1]Planetary Exploration Research Center, Chiba Institute of Technology (2-17-1 Tsudanuma, Narashino, Chiba, 275-0016 Japan, senshu@perc.it-chiba.ac.jp), [2]Department of Physics, Meiji University (1-1-1 Higashi Mita, Tama-ku, Kawasaki, Kanagawa, 214-8571 Japan), [3]Kochi University, [4]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa, 252-5210 Japan), [5]Graduate School of Environmental Studies, Nagoya University (Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601 Japan).

Introduction: The surface temperature of an airless body is decided by the balance between the solar irradiation, the blackbody radiation, and the heat flow from subsurface, if the surface is smooth and convex and the albedo of the surface is zero. When the surface is rough, the albedo can vary with not only the roughness but also the solar incident angle [1]. Thus the surface temperature should be calculated as a function of the latitude of the simulated area and the local time.

Addition to the dependence of albedo, the roughness affects the apparent temperature [2,3,4]. For example, the north side of a mountain in the northern hemisphere receives less solar energy than the southern side of the mountain. Thus the apparent temperature of the mountain depends on the direction from which the temperature is observed because the apparent areas of the northern and southern sides depends on the observation direction. Similarly the apparent temperature of a rough surface depends on the observation direction.

Hayabusa2 is a Japanese asteroid exploration mission launched on 3 December 2014. It is on cruising course to a C-type asteroid Ryugu and will arrive Ryugu in the summer of 2018. After the arrival Hayabusa2 will stay at “home position” which is on the line between Ryugu and Earth and 20 km above Ryugu. This means the solar phase angle (Sun-Ryugu-Hayabusa2 angle) is kept less than around 20 degrees during the 1-year-long mission phase.

TIR is a thermal infrared imager onboard Hayabusa2 [5,6] to measure the temperature distribution on the surface of Ryugu. However, because TIR is fixed to the spacecraft, it always measures the surface temperature from around the sun direction. This might cause a systematic error for the estimation of thermal inertia if the surface of Ryugu is rough.

Thus in this study we numerically simulate the thermal evolution of rough surfaces and then make a simulated image of TIR. We also conduct the numerical procedure for smooth surface case. By comparison of the simulated images for rough surface case and smooth surface case we discuss the effect of roughness on TIR observation.

Numerical Model: A rough surface is prepared numerically. The surface is originally flat and filled with equatorial triangles with the side length of L. Then each vertex is moved perpendicularly. The distance of the movement is given randomly with variance of σL, where σ is a constant value. This procedure to form a rough surface is similar to previous studies [2,3,4].

Then numerical simulation of thermal evolution is performed for the rough surface. In this numerical simulation we solve one-dimensional thermal evolution for each facet at the same time taking into account the shadowing effect [7] and the re-absorption of thermal radiation from other facets [2,3,4]. The thermal evolution is solved for at least 10 solar cycles.

Finally a TIR image is numerically simulated by using the temperature distribution above. In this simulated image the direction dependence of the apparent temperature is considered.

Numerical Results: Figure 1 show the profile of the apparent temperature as a function of longitude at the latitude of 0, 30, and 60 degrees, at the time of 00:00:00, 1st August 2018. At this time the latitude of sub-solar point is about 42 degrees. In this numerical simulation we adopt the thermal inertia being 300 in MKS unit and σ =0.1, 0.3, and 0.5. As is shown in this figure, the apparent temperature becomes lower with roughness of the surface and its profile becomes broader. For the case with σ =0.5, the profile of apparent temperature shows double peak structure. This is because TIR observes sunlit side of surface roughness at dawn and dusk. The local time at which the maximum temperature achieved becomes slightly later with the surface roughness.

Discussion and Summary: This study demonstrate the effect of the roughness on the apparent temperature distribution which TIR will take. The profile of surface temperature becomes dull with the surface roughness. This effect is not considered in the previous strategy for the analysis of TIR data [7]. However, the local time at which the maximum apparent temperature achieved changes only slightly. In this sense the thermal inertia is still be able to be estimated from the time shift of the maximum temperature as long as the apparent temperature remains a single-peak structure.

Our result indicate that the information not only for the thermos-physical parameters but also for the roughness of the surface can be obtained from TIR observation. This makes independent data from camera images. For this purpose we are preparing large amount of data to construct a look-up table.

References: [1] Senshu, H., Yokota, Y., Morota, T., and Sakatani, N. (2017) *LPS XLVIII*, Abstract #1950. [2] Rozitis, B. and Green, S. G. (2011) *NMRAS*, *415*, 2042-2062. [3] Davidsson, B. J. R. and Rickman, H. (2014) *Icarus*, *243*, 58-77. [4] Davidson, B. J. R. et al. (2015) *Icarus*, *252*, 1-21. [5] Okada, T. et al. (2017) *SSR*, *208*, 255-286. [6] Arai, T. et al. (2017) *SSR*, *208*, 239-254. [7] Takita, J., Senshu, H., and Tanaka, S. (2017) *SSR*, *208*, 287-315.

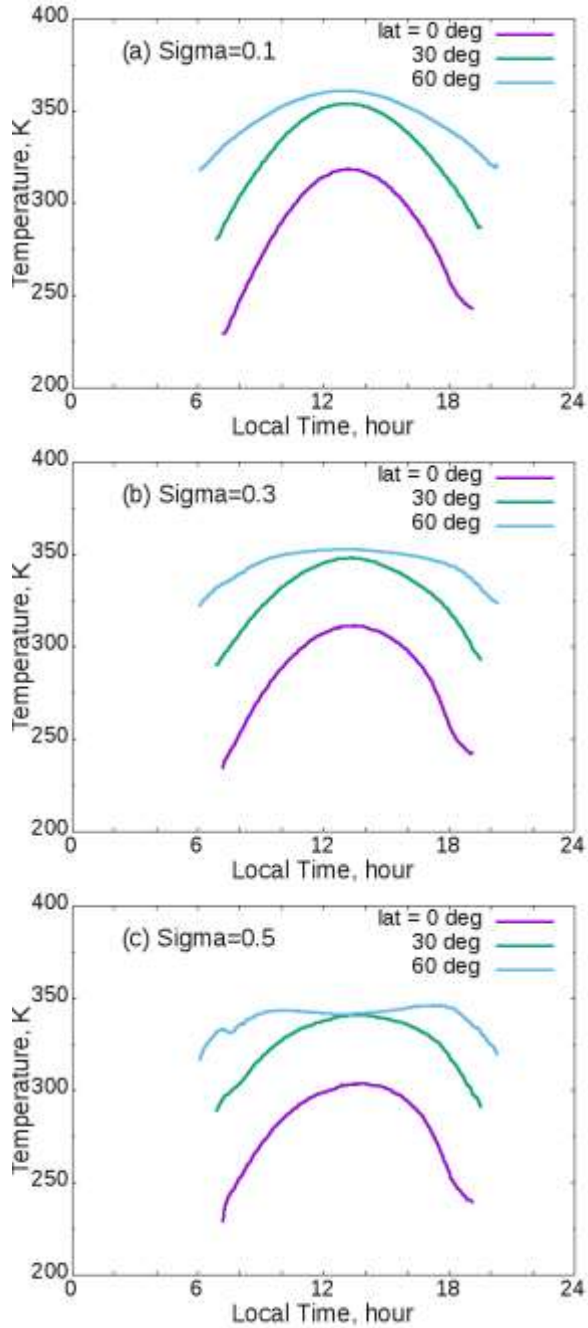

Figure 1: Simulated time profile of apparent temperature which TIR will take. The thermal inertia is assumed to be 300 in MKS unit.