Evaluation of Surface Temperature Variation on Asteroid Ryugu caused by Space Weathering

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Recently, space weathering is known as the phenomenon that causes spectral differences between meteorites and asteroids by ground observations (Clark et al., 2002). A result of analysis for a returned sample of Hayabusa spacecraft revealed surface modification on the asteroid Itokawa occurred due to space weathering (Noguchi et al., 2011). An inverse correlation was found in the observed parameters of the surface albedo and the characteristic peak of infrared spectra, known as the Christiansen feature, on the lunar surface (Lucey et al., 2017). These results imply that spectral shape in the thermal infrared range of asteroids may be changed due to space weathering. This study evaluates the effect of space weathering that occurred on the surface of the asteroid 162173 Ryugu by numerical calculation and compares that with the observed temperature by the Thermal Infrared Imager (TIR) onboard Hayabusa2 observation (Okada et al., 2017). TIR observed surface temperature of Ryugu with a spatial resolution of 0.051 degrees from June 27, 2018, to November 13, 2019 (Watanabe et al., 2019). TIR reveals the evolutional history of Ryugu, such as the physical properties of the coalesced bodies, and the thermal changes of the surface and inner materials. Thermal inertia is the main target, and surface roughness (Groussin et al., 2013) is also an important parameter that caused by surface shadows of light, and multiple radiations apparently change the local temperature of the surface. Both thermal inertia and surface roughness affects the peak shift of diurnal time on the surface temperature of Ryugu and probably cause the orbital changes as studied as the Yarkovsky effect (Bottke et al., 2002). The space weathering will be minor effects for the temperature change of Ryugu. In this study, we compare the anticipated temperature on Ryugu due to space weathering and the observed temperature with TIR. We assumed the solar spectral irradiance at the orbit of Ryugu and the surface composition of carbonaceous chondrites similar to the asteroid Ryugu. The amount of space weathering is assumed in dissociation energy as energetic erosion due to ion radiation of <10^6 years (Kracher and Sears, 2005). The result of the spectral change in an anticipated flux was a few W/m^2 in the spectral range of 8-12 micrometers. Therefore, TIR is not able to resolve such a faint difference in radiation. However, space weathering also changes in the whole range of spectra, and that will cause the darkening and reddening on the surface material (Thompson et al., 2019). These effects will decrease the bond albedo and increase the surface emissivity. The space weathering may cause an increase in temperature of the inner material, as well as the uppermost surface. Thus, the observed brightness temperature may be increased. We calculated the variation of radiation temperature with the reflection of solar flux, which is depended on the value of the bond albedo using the thermal model code of TIR (Takita et al., 2017). The result of this calculation indicated that variation of the surface temperature due to space weathering is a few Kelvin. Therefore, TIR is potentially able to detect the temperature variation due to space weathering, as well as surface thermal properties, depended on the thermal inertia and the surface roughness.

Keywords: Hayabusa2, Space weathering, Thermal Infrared Imager

