EAST-WEST COMPARISON OF THE PHOTOMETRIC PROPERTIES ON ASTEROID RYUGU. Y. Yokota[1], R. Honda[2], E. Tatsumi[3], D. Domingue[4], S. E. Schröder[5], M. Matsuoka[1], L. Riu[1], S. Sugita[6], T. Morota[6], N. Sakatani[7], C. Honda[8], Y. Cho[6], S. Kameda[7], T. Kouyama[9], M. Yamada[10], M. Hayakawa[1], H. Senshu[10], H. Suzuki[11], K. Yoshioka[6], H. Sawada[1], and K. Ogawa[1], [1]ISAS/JAXA, (3-1-1 Yoshino-dai, Chuo-ku, Sagamihara, Kanagawa, Japan, yokota@planeta.sci.isas.jaxa.jp). [2]Kochi Univ., Japan, [3]Instituto de Astrofisica de Canarias, Univ. of La Laguna, Spain, [4]Planetary Science Institute, USA, [5]DLR, Germany, [6]Univ. of Tokyo, Japan, [7]Rikkyo Univ., Japan. [8]Univ. of Aizu, Japan. [9]AIST, Japan, [10]Chiba Inst. Tech, Japan, [11]Meiji Univ., Japan.

Introduction: From Hayabusa2 observations, it has been found that the surface of the Cb-type asteroid Ryugu (equatorial radius = 502 ± 2 m [1]) is divided into east and west regions by troughs [1,2] (Figure 1). The western region (160°E–290°E [3]) is called the western bulge, and the larger region to the east is called the eastern hemisphere. The western bulge is less cratered [2,4] and thus is smoother than the other side [2]. Additionally, a study of boulder size-frequency distributions (D > 5 m) reported that the western bulge has a smaller number of boulders than the eastern hemisphere [5].

Photometric analyses of Ryugu in visible wavelengths has been performed using ground-based observations and Hayabusa2 Telescopic Onboard Navigation Camera (ONC-T) [2,6,7,8] data. A globally representative set of Hapke parameters [9,10] has been obtained [2,11,12]. Previous studies [2,6] reported that the western bulge has a slightly higher v-band (0.55 μm) reflectance than the reflectance of the Eastern hemisphere. Similar dichotomy is also seen in the Near-Infrared observation [13]. However, in the opposition observation (zero phase angle observations) of ONC-T v-band, both regions showed similar value ranges in normal albedo [14]. Therefore, we perform a regional photometric analysis based on the hypothesis that the East-West difference in optical properties may be due to surface properties other than albedo.

Data: In some ONC operational sequences, the camera observed Ryugu over one rotation (7.6 h) from a distance of 20 km. In these operational sequences, an image was obtained at every 30° in rotational phase. We use seven rotation sets acquired in the v-band (0.55 μm) for this study. The phase angle of the observations range from 0 to 42°. The spatial resolution of these images is 2.1 m/pixel.

Method: A global average Hapke parameter set with five parameters was determined in the recent photometric study of Ryugu [12]. In order to reduce the number of free parameters in the regional analysis, we use the average values of [12] for four of the five Hapke parameters. The fixed parameters are: single scattering albedo w = 0.044, opposition surge strength B_0 = 0.98, opposition surge width h = 0.075, and phase function parameter b = 0.388. We performed the photometric model fitting to the regional ONC intensity data to determine variations in the macroscopic roughness ($\bar{\theta}$) using the following steps:

1. A 32x32 meters (4x4 deg) mesh is defined on Ryugu's surface.
2. To make datasets for fitting, the radiance factor (I/F) values of the image pixels and viewing geometry angles (incidence angle i, emission angle e, and phase angle α) are collected from the input images for each mesh. The maximum value of i and e of the adopted pixel was restricted to 70°.
3. Averaging binning was used to mitigate the bias of the data distribution in the three dimensional photometric angle space. For the incidence angle i and emission angle e, the binning width Δi and Δe were both set to 1 degree. For the phase angle α, the binning width was changed with the phase angle range ($\Delta\alpha$ = 0.1° for the range α = 0-2°, $\Delta\alpha$ = 0.2° for α = 2-5°, and $\Delta\alpha$=1° for α>5°).
4. Finally, Hapke model fitting (Levenberg-Marquardt method, MPFIT) is performed for each region (mesh) to determine $\bar{\theta}$. This parameter is theoretically a quantity less than 40°, but we also allowed values greater than 40°.

Figure 2 shows an example of the data obtained for one mesh.

Results: Fig. 3 shows the relationship between obtained roughness and longitude. The result graphs are divided into three latitude bands (Figs. 3abc).

In Figs. 3a and 3c, the western bulge shows relatively smaller $\bar{\theta}$ than the eastern hemisphere. Although we use only one free parameter, we can show that the photometric property of the western bulge is different from that of the eastern hemisphere.

In the equatorial region data (Fig. 3b), the east-west dependence is not clear. Morota et al. (2020) proposed an evolution model of Ryugu in which pebbles/regolith migration occurred from the equatorial ridge to mid-latitudes, and the smaller $\bar{\theta}$ at the equator may be related to this pebbles/regolith migration.

The present analysis shows that regional differences in photometric property can be detected from ONC data. It will be important to compare the ONC photometric results with other roughness-related studies (e.g., crater density, boulder density, thermal infrared observation, and LIDAR observation) in order to further investigate the origin of the western bulge.

References: [1] Watanabe S. et al. (2019) *Science* 364, 268. [2] Sugita S., et al. (2019) *Science* 364, 252. [3] Hirabayashi M. et al. (2019) *ApJL* 874, L10. [4] Cho et al., submitted. [5] Michikami T. et al. (2019) *Icarus* 331, 179–191. [6] Kameda S. et al. (2017) *SSR* 208, 17–31 [7] Suzuki H. et al. (2018) *Icarus* 300, 341–359. [8] Tatsumi E. et al. (2019) *Icarus* 325, 153–195. [9] Hapke B. (1981) *JGR* 86(B4), 3039–3054. [10] Hapke B. (2012) Theory of Reflectance and Emittance Spectroscopy (2nd ed.). Cambridge Univ. Press. [11] Ishiguro M. et al. (2014), *ApJ*, 792, 74. [12] Tatsumi E., et al. (2020) *A&A* 639, A83. [13] Barucci M.A. et al. (2019) *A&A* 629, A13. [14] Yokota Y. et al. submitted. [15] Morota T. et al. (2020) *Science* 368, 654–659.

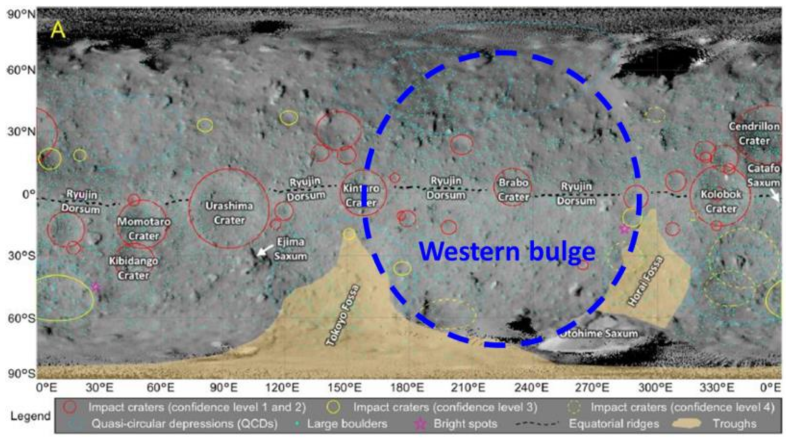

Figure 1. Geology of Ryugu surface. After Sugita et al. (2019) [2]. The western bulge region is roughly indicated by a blue dashed circle.

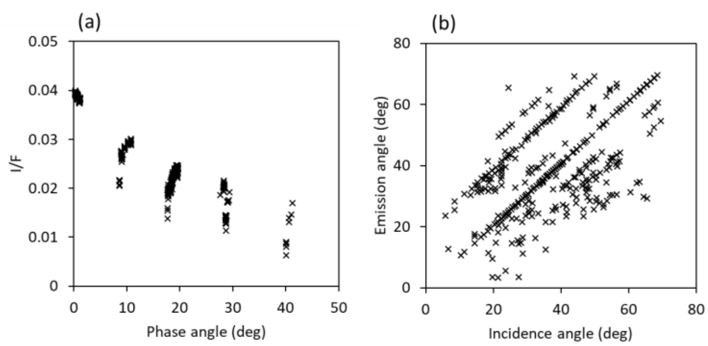

Figure 2. Example data from one 32x32 m (4x4 deg) mesh region. (a) I/F is shown as a function of phase angle. (b) Distribution of emission angle and incidence angle.

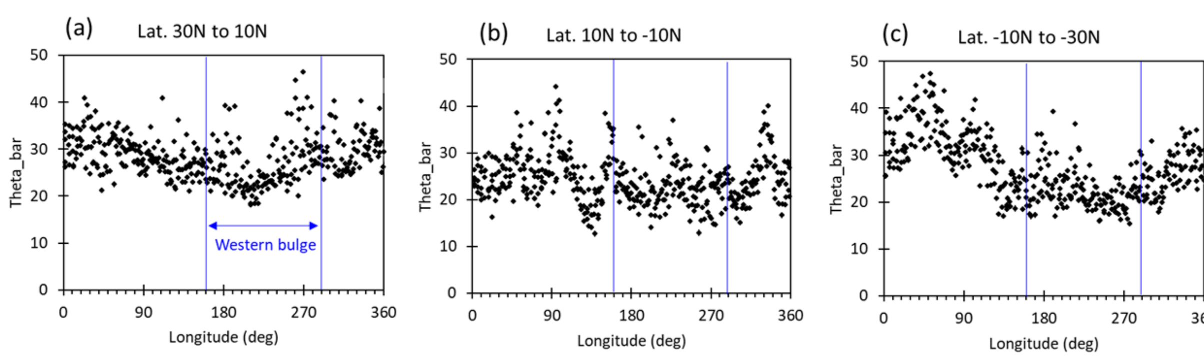

Figure 3. Derived macroscopic roughness parameter $\bar{\theta}$ is shown as a function of longitude. (a) Latitude range between 30°N and 10°N. (b) Latitude range between 10°N and -10°N. (c) Latitude range between -10°N and -30°N.