Introduction: The JAXA Hayabusa2 spacecraft approached the C-type Near-Earth asteroid 162173 Ryugu on 27th June 2018 [1] and since then, images and spectral data of surface have been acquired.

The payload of spacecraft includes a Thermal Infrared Imager TIR [2], the NIRS3 spectrometer [3] and the Optical Navigation Camera-Telescopic, with a wideband and seven narrow band filters (ONC-T) [4]. Ryugu is a top-shaped Cb type asteroid and ONC images revealed a surface covered by a large number of boulders, characterized by different roughness and albedo [5,6]. Reflectance spectra acquired by NIRS3 span from 1.8 to 3.1 µm and detected a narrow absorption feature centered at 2.72 µm across the entire observed surface, indicating the ubiquitous occurrence of hydroxyl (OH)-bearing minerals on the surface of Ryugu [7].

NIRS3 data also detected Ryugu as a very dark object with a globally-averaged reflectance value at 2.0 µm of about 0.017 [7].

Detection of Bright and Dark areas on Ryugu:
Although Ryugu is an homogeneously dark object, the aim of this work was to detect bright and dark areas by using spectral data acquired by NIRS3. We used calibrated and thermally corrected data acquired on 10 and 11 July 2018 and on 19 July 2018, when NIRS3, operating in scanning mode, obtained a near-global coverage of Ryugu surface. The data acquired on 10 and 11 July are characterized by a spatial resolution of 40 m, since the spacecraft was at an altitude of 20 km (Home Position), whereas the data of 19 July have a spatial resolution of 20 m, since the spacecraft’s altitude was of 13 km.

We used a method yet validated for Ceres and Vesta [8,9] to detect bright and dark areas on Ryugu surface.

For each pixel, we obtained the reflectance factor at 1.9 µm and we estimated the mean value of reflectance at wavelength of 1.9 µm, i.e. 0.017. Bright areas have been defined as regions with a reflectance factor at 1.9 µm larger than the 5.5% than the mean value; dark areas are the regions with a reflectance factor lower than the 8% of the mean value and larger than 0.01 (to avoid false positive due to low S/N).

Results: A total of 36 Bright areas and 28 Dark areas have been detected by the application of method. Bright areas are mainly localized on the equatorial ridge, whereas dark areas are mainly located at middle latitudes and few of them are on the poles.

Figure 1. Distribution of bright (top) and dark (bottom) areas on the Ryugu surface superposed on the reflectance map estimated at 1.9 µm.

Most of Bright areas are boulders, two are coincident with saxa (Catafo saxum and Otohime saxum) and 9 of them are crater rim of impact craters.

Dark areas are mainly boulders. Anyway, 4 dark areas are coincident with the floor of impact craters and 6 dark areas are located in Tokyo Fossa.

The reflectance map of Ryugu estimated at 1.9 µm, superposed on Ryugu shape model (Figure 2), highlights the different reflectance level between crater floors (darker) and crater rim (brighter).
Figure 2. Reflectance map of Ryugu estimated at a wavelength of 1.9 µm (ranging from 0.014 to 0.019), superposed on Ryugu shape model.

By comparing dark and bright areas with the spectral slope estimated between 1.9 and 2.5 µm, a more positive slope can be observed in darker areas.

Both dark and bright area spectra show a weak absorption band at 2.72 µm, suggesting a widespread occurrence of hydroxylated minerals on the surface of Ryugu. However, by relating the distribution of dark areas on Ryugu surface and the intensity of 2.72-µm band (Figure 3), a moderate anti-correlation emerges in the southern hemisphere, with a Pearson coefficient value of -0.47. Dark areas located toward the south pole seems to be richer in hydroxylated compounds and D28, corresponding to a large boulder located in Tokoyo Fossa, is the most hydrated dark area on the surface of Ryugu.

This result suggests a possible dichotomy in the Ryugu surface, represented not only by the enrichment of hydroxylated compounds but even by a redder slope of the southern hemisphere [10].

Figure 3. Scatterplot of 2.7 µm band depth vs latitude for dark areas (blue diamonds).