ANALYSES OF BRIGHT CLUSTERS DETECTED AT THE SURFACE OF RYUGU. L. Riu[1], T. Nakamura[2], E. Tatsumi[3], C. Sugimoto[3], S. Sugita[3], K. Kitazato[4]. [1]ISAS/JAXA, Sagamihara, Japan (riu.lucie@jaxa.jp), [2]Tohoku University, Sendai, Japan, [3]University of Tokyo, Tokyo, Japan, [4]Aizu University, xx, Japan.

Introduction: The Hayabusa2 spacecraft has been hovering close to asteroid (162173) Ryugu for more than a year [1]. Numerous information has been gathered from orbit and *in situ* regarding the asteroid surface properties. Namely, the NIRS3 instrument, which operates between 1.8 and 3.2 µm, showed that the spectral properties in this range and as seen from orbit, are very homogeneous. Ryugu surface presents a low albedo (~1.4% on average) and a sharp 2.72 µm absorption feature, that is detected globally at the surface [2]. The visible camera ONC-T onboard Hayabusa2 reported the several spots extraordinary brighter than the average [3]. It is expected that NIRS3 can find bright regions with closer, higher resolution, and multiple time observations even if it seems homogeneous from the one global observation by [2]. Here we report the bright regions observed by NIRS3.

Dataset: We propose here to do a systematic analysis of the NIRS3 spectra that displayed high albedo value in order to characterize, from orbit, large bright areas at the surface of Ryugu. We use thermally and photometrically corrected NIRS3 near infrared spectra. The photometry correction is still subjected to change due to refinement on the spacecraft geometry information. The uncertainties on albedo based on the improvement in incidence and emergence angles values are under study. However, first order analysis comparing different sets of photometrically corrected data showed that the bright areas on Ryugu are consistently located on the equatorial ridge (see previous map in [4]). The methodology for our study is as follows, we extract for each day of observation the 10 brightest spectra (based on the albedo value at 2 µm), corresponding to a total of 420 "bright" spectra associated to the 42 observations campaigns from the end of June 2018 to end of February 2019, which include the resolution from ~40 m to ~10s cm/pixel. The data acquired after February 2019 still needs geometrical information before being added to this analysis. In order to ensure that the detected bright spots correspond to actual brighter areas consistently, we regrouped the bright spectra into clusters of spectra. We defined a cluster if more than 10 spectra, of at least 2 different days of observation, falls within the same area within a 8° x 8° grid on the asteroid surface. The majority of NIRS3 observations are acquired with a resolution of 40 m per pixel which roughly corresponds to 8° at the equator.

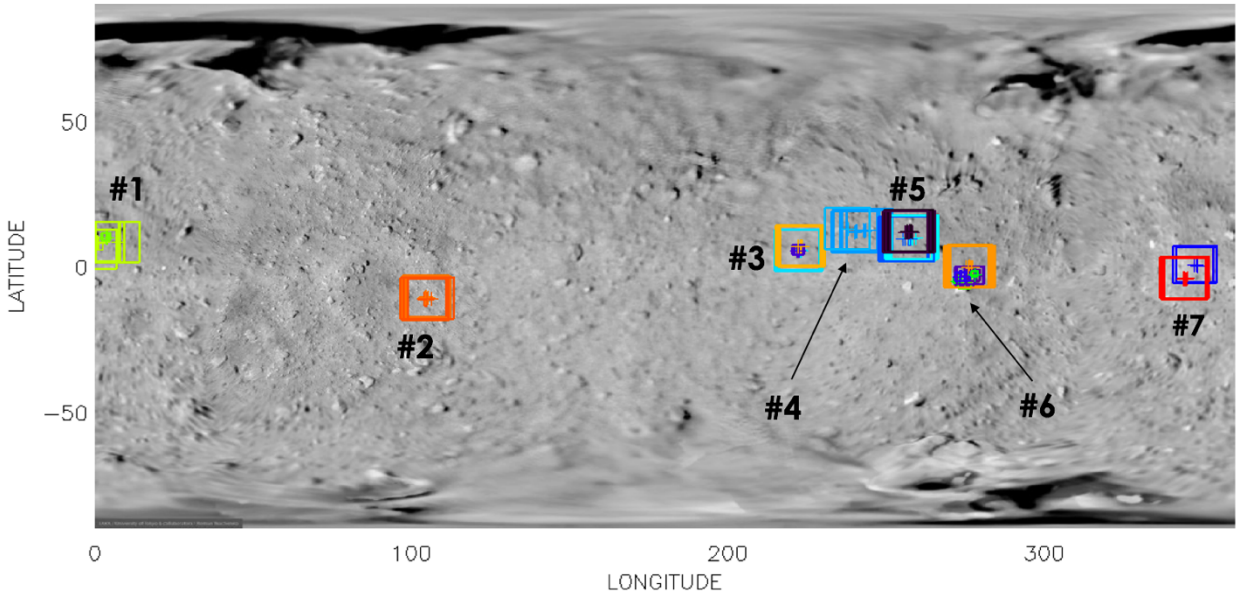

Figure 1 - Preliminary map of bright clusters on the surface of Ryugu. Each color is associated to one day of observation. The approximate size of the NIRS3 spot size, based on spacecraft altitude, corresponds to the size of the boxes on the map.

Results: We found a total 7 clusters, all located on the equatorial ridge (see Figure 1). The clusters are composed of 11 at minimum (cluster #1) and 39 at maximum (cluster #5) spectra. Note that among the 42 observations used for this analysis, 31 of them only covers the equatorial ridge regions. Observing the bright clusters gathered on the equatorial ridge may thus be a biased from the observation campaigns. Only two of the clusters have an "average" resolution < 30 m and include high resolution spectra (clusters #2 and #6). All other clusters are low resolution spectra, which would mean that they represent a rather big area on Ryugu's surface (on average ~ 40 m x 40 m). The clusters are relatively concentrated on the western bulge. This is consistent with slightly brighter nature observed by ONC-T [5].

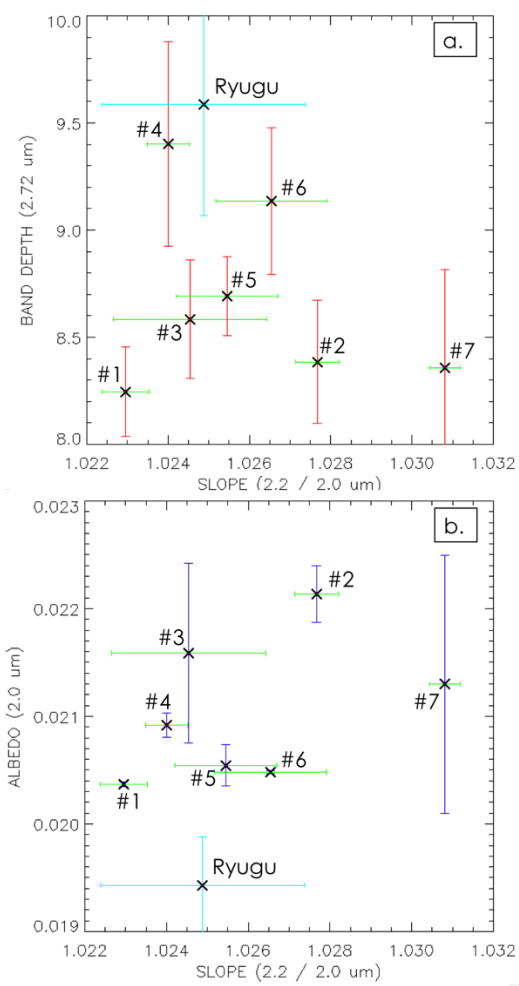

Figure 2 – (a) Evolution of the band depth at 2.72 µm with respect to the slope (reflectance at 2.2 µm / reflectance at 2.0 µm). (b) Evolution of the albedo at 2.0 µm with respect to the slope (reflectance at 2.2 µm / reflectance at 2.0 µm).

For each cluster, we evaluate the spectral variations, albedo, band depth characteristic (at 2.72 µm), slope (between 2.0 and 2.2 µm) and resolution of observation. We also evaluate the variation of these values amongst each cluster by calculated the standard deviation on all spectra within a cluster (represented as error bars on Figure 2). The highest albedo found in a cluster is ~2.2% (cluster #2). The cluster #2 is located at the rim of the largest crater Urashima. The fluffiness and less porosity of the crater rim may explain the brightness on this region.

All clusters present average albedo greater than 2% (Figure 2b), although the latest photometry correction provides an average albedo at standard condition on the overall surface > 1.9% in comparison with older dataset that provided an average albedo < 1.7 %. We observe a possible correlation between the slope and the band depth at 2.72 µm (Figure 1a), which seems to show a decrease in the band depth (i.e. less hydrated spectra) with increasing slope (i.e. redder spectra), with the exception of the cluster #1. No clear correlation is observe between the average albedo and the average slope (Figure 2b), which is observed in visible wavelength by ONC-T [5].

The next step of this study will be to combined those results with the ONC visible camera images [4] to access the geomorphological features at the defined clusters locations and understand the spectral variations observed with NIRS3 and to combine and compare the spectral variations observed in the near-infrared with the variations observed in the visible to be able to contribute to the story of Ryugu's formation and evolution.

References: [1] Watanabe, et al., Science (2019). [2] Kitazato et al., Science (2019). [3] Sugimoto et al, JPGU (2019). [4] Riu et al., AGU abstract (2019). [5] Sugita et al., Science (2019).