PREPARATION FOR THE MAPPING OF ASTEROID RYUGU WITH HAYBUSA2 ONC CAMERAS.

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Introduction: We present our work on the preparation for the arrival of the Hayabusa2 spacecraft at asteroid Ryugu. This work consists in two distinct parts: 1) the ground-based observation of the Hayabusa2 target using the IRTF, 2) the implementation of a processing pipeline for the creation of higher-level image products to help the Hayabusa2 science team with sample collection and rover deployment activities. The creation of global color image mosaics of Ryugu will allow the Hayabusa2 team to better understand the surface composition and alteration state of asteroid Ryugu. Our work will support mission planning (production in real time of data products), data archiving and supplementing the science performed by the Hayabusa2 science team. The production of global and local maps using clear and color images will be critical for mission operations, especially for the selection of the sampling site. Our goal is to generate calibrated multicolor global mosaics, color ratio mosaics, photometrically corrected color image cubes, and other color parameter maps of the entire surface of Ryugu during Hayabusa2 mission operations. Most of the image processing work is done using routines from USGS ISIS3 software.

Ground-based observations with IRTF: We took advantage of the opposition of asteroid Ryugu in the summer of 2016 to observe Ryugu with the NASA InfraRed Telescope Facility (IRTF) on Mauna Kea, HI. The Hayabusa2 team was also looking for more ground-based observations of Ryugu during opposition to prepare better for spacecraft operations. We obtained two sets of observations with one usable for analysis. Observations were obtained on July, 12 2016 using the SpeX low-resolution (R~100) spectrometer (0.8-2.5 microns). We reduced the data using SpeXtools. The spectra acquired cover 0.6 and 0.8 rotations phases. We also created a movie of Ryugu using images from the MORIS guider.

ONC cameras: The scientific instrument package onboard the spacecraft includes the Optical Navigation Cameras (ONC-T, ONC-W1 and ONC-W2), Near Infrared Spectrometer (NIRS3), Thermal Infrared Imager, Sampler, Lidar altimeter, Deployable Camera used to observe the impactor experiment, Small Carry-on Impactor (SCI), two rovers and a lander. Important data sets required for landing site selection are high spatial resolution color maps of the surface and shape model of the asteroid based on ONC images. ONC consists in three sub-systems with a telescopic camera (ONC-T) and wide-angle cameras (ONC-W1 and ONC-W2). Each camera has a 1024 x1024 pixel dimension charge-couple device (CCD) with a field of view (FOV) of 5.7 x 5.7 degrees for ONC-T, and 60 x 60 degrees FOV for ONC-W1 and –W2. ONC-T has a different set of filters from the Hayabusa multiband camera AMICA with six medium-breadth color filters (0.4-1.0 μm), one narrow band sodium filter, and one broadband clear filter (called WIDE) covering the range 0.35 to 1.2 μm. The ONC-T scientific data will be acquired during three different phases depending on the distance to the target asteroid: 1) home position (HP) when the spacecraft is in stable position around the target at an altitude between ~20 km, 2) mid-altitude observations at an altitude of ~5/-7 km, 3) and proximity operations, when Hayabusa2 reaches low-altitude orbits at 1-0.1 km above the surface of the asteroid, to allow for detailed regional mapping of the selected candidate sampling sites and for the search of the SCI impactor-induced crater. During HP, ONC-T will acquire v-band images of the entire surface of asteroid to provide data for shape modeling, as well as 6-color band observations for identification of the lithology on the surface of the target. All images from HP will be acquired at spatial resolution of 2 m/pixel. The ONC-T color data covers the entire surface of Ryugu during this observational phase enabling global compositional mapping.

Mosaicking pipeline implementation: Based on similar work by our team using Hayabusa AMICA images, we implemented a preliminary pipeline for the creation of calibrated I/F data products. The systems and optics of AMICA and ONC-T are similar, although there are some difference in mechanics. Thus, the reduction processes could be done in the almost same way. We have already in place several scripts that could do simple calibration steps such as flat field, linearity, bias correction and exposure time in case the image data distributed to the team is not fully calibrated. Color ratios RGB composite images could be used to bring out subtle compositional variations across the surface that are not easily visible in simple RGB color images. In the case of Ryugu, the 0.70-μm feature is one of the most prominent bands that falls within the wavelength range (0.39-0.95 μm) of the ONC-T camera. Detection of this 0.70 μm absorption band, which is primarily associated with phyllosilicates, can be accomplished using color ratio maps of various filters that encompass this feature. Another possible method of detecting this feature is by using a three-color filter equation using ONC-T filters. Even though we have a preliminary image processing pipeline for the clear and color images, we still need to implement specific ingestion routines and camera model definition with distortion model in ISIS3.

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