Improved Trajectory of Hayabusa2 by Combining LIDAR Data and a Shape Model

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Hayabusa2 spacecraft successfully arrived at the target C-type asteroid 162173 Ryugu on 27 June, 2018, with its “home position” being about 20 km above the sub-Earth point. Soon after arrival, Hayabusa2’s remote sensing instruments started near-global observations. Because map products from these instruments depend on the spacecraft position with respect to the asteroid, it is necessary to provide precise spacecraft trajectory in a timely manner. The basic idea is to find a trajectory correction which makes “LIDAR-derived topography” fit to the reference shape model. The LIDAR-derived topography is, in other words, a sequence of LIDAR footprint positions expressed in asteroid-centered body-fixed rotating frame. The footprints can be computed by using the following information; spacecraft position with respect to the asteroid, spacecraft attitude, LIDAR range, rotational information of the asteroid (orientation and spin period). If all the information above was perfect, the collective footprints would delineate the shape of the asteroid. In reality, however, there are various errors affecting the footprint positions, among which the largest is generally the trajectory error, making the resultant LIDAR footprints deviate from the shape model. We call the deviation as residual. A shape model constructed by stereo photoclinometry (SPC) method is used as reference. We obtain trajectory correction by minimizing the residuals with polynomial functions. We made use of Markov chain Monte Carlo (MCMC) algorithm to explore better parameters. We compared the LIDAR-corrected trajectory with camera positions that are determined through SPC shape modeling. The two estimates agree with each other within about 40 m on 10 July 2018, and 20 m on 20 July 2018. LIDAR-derived topography with such an improved trajectory can be used for analysis of boulder height, crater shape, surface roughness, etc.

Keywords: Hayabusa2, spacecraft trajectory, LIDAR

