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Observing regions of interest on Ganymede and Callisto with JUICE

F. Tosi (1), K. Stephan (2), P. Palumbo (3,1), G. Piccioni (1), Y. Langevin (4), F. Altieri (1), J. Carter (4), G. Cremonese (5), E. D'Aversa (1), V. Della Corte (1), G. Filacchione (1), V. Galluzzi (1), A. Lucchetti (5), M. Massironi (6), A. Migliorini (1), F. Poulet (4), T. Roatsch (2), F. Zambon (1).

(1) INAF-IAPS Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy, federico.tosi@inaf.it. (2) German Aerospace Center (DLR), Berlin, Germany. (3) Università degli Studi di Napoli "Parthenope", Napoli, Italy. (4) Insitut d'Astrophysique Spatiale (IAS), Orsay, France. (5) INAF-OAPd Osservatorio Astronomico di Padova, Padova, Italy. (6) Università degli Studi di Padova, Dipartimento di Geoscienze, Padova, Italy.

Abstract

One major task carried out in recent years in the framework of the JUICE mission concerned the level-0 analysis (so-called "segmentation") related to different mission phases, covering both the Jupiter tour and the dedicated orbit around Ganymede. In the latter case, and focusing on the surface, the scope of this analysis is to identify time segments corresponding to opportunities to observe specific regions of interest by means of remote sensing instruments. Here we focus on JANUS and MAJIS, respectively the framing camera and the visible and infrared imaging spectrometer on board JUICE, to evaluate the frequency of these observation opportunities based on the latest list of regions of interest of Ganymede and on a specific reference trajectory. We perform a similar analysis for Callisto, based on the flybys that will be carried out by JUICE before entering orbit around Ganymede.

The level-0 analysis is the foundation on which, in the years to come, a level-1 analysis will be built, i.e. a real observational timeline that takes into account the instrumental and system resources. An early identification of unique or hardly-repeatable segments is key to prioritize the opportunities, which helps emphasizing any complementarities and/or synergies between different instruments and thus pushing for robust scientific cases.

1. Introduction

The *Jupiter Icy Moons Explorer* (JUICE) mission, whose launch is currently scheduled in 2022, is the first ESA-led mission devoted to explore the Jupiter system with an emphasis on the icy Galilean satellites Europa, Ganymede and Callisto. JUICE will indeed be the first spacecraft ever to enter orbit around an icy satellite, Ganymede, allowing an unprecedented analysis of its surface, interior and tenuous atmosphere. Among the remote sensing instruments onboard JUICE are a multispectral camera (JANUS) equipped with 13 filters covering the spectral range 0.34-1.08 µm, and an imaging spectrometer (MAJIS) whose sensitivity covers the overall spectral range 0.5-5.54 µm.

Once in orbit around Ganymede at 5000-km altitude (GCO-5000 phase), JANUS is committed to achieve global coverage in 4 filters at a resolution better than 400 m/px, but it can reach the maximum achievable resolution of 75 m/px where necessary. In this phase, MAJIS shall achieve global coverage at spatial resolution between 2 and 5 km/px.

In the following orbital phase carried out at 500-km altitude (GCO-500 phase), the actual color coverage will depend on the available data volume, but in principle it may be planned to observe specific regions of interest at the maximum achievable spatial resolution with both JANUS (7.5 m/px), also using contiguous color filters, and MAJIS (75 m/px).

The Consolidated Report on Mission Analysis (CReMA) 3.0 [1], represented by trajectory 141a released in 2015, provides the best surface coverage on Ganymede, while trajectories 3.2 and 4.1, released respectively in 2016 and 2018, have the drawback of a redundant coverage in the GCO-500 orbital phase (i.e. the ground tracks tend to cover the same areas).

A substantial difference in CReMA 3.0 is that the "high" orbital phase at Ganymede is shorter, being limited to the first 248 orbits out of a total of 1495 (~17%), whereas in CReMA 3.2 / 4.1 the same phase lasts for 309 orbits out of a total of 1321 (~23%).

Another important dissimilarity between CReMA 3.0 and those from 3.2 onwards is that the orbits around Ganymede are retrograde, while in 3.0 they are prograde. For JANUS and MAJIS, the differences are mainly in terms of local solar time (LST): CReMA

3.0 explores the morning hours on the dayside of Ganymede, whereas retrograde orbits explore the afternoon hours.

In our analysis, we always assume that the solar incidence angle must be less than 70° (i.e., the Sun zenith angle must be greater than 20°), in order to ensure a proper signal / noise ratio both in JANUS and MAJIS data.

2. Results

Among Ganymede's regions of interest [2], impact crater morphologies and bright terrains are inherently more numerous than other categories such as potential cryovolcanic features, which on the other hand are of utmost importance from a geological viewpoint. The number of observation opportunities therefore depends primarily on this starting point, as well as on the position of the regions of interest: those located at high latitudes (e.g. polar deposits) can only be observed in the early phase of the orbital mission at Ganymede (**Fig. 1**). As a general strategy, while the "high" orbital phase is devoted to global or broadly regional mapping by both JANUS and MAJIS, the "low" orbital phase is focused on the observation of as many local-scale regions of interest as possible, with solar illumination conditions worsening quite rapidly over time.

In a subset of cases, there are good chances to observe regions of interest simultaneously with JANUS and MAJIS (e.g. **Fig. 2**). These opportunities should be given higher priority, in order to be able to observe those regions in identical solar illumination conditions, allowing on one side a cross-calibration of the data of the two instruments in the overlapping spectral range 0.5-1.0 µm and at the same time removing a potential source of discrepancy between the spectral profiles measured by the imaging spectrometer and by the framing camera in its color filters. Coordinated observations shall also provide geological context to the compositional units.

In the "low" orbit phase GCO-500, the number of observation opportunities changes significantly depending on whether CReMA 3.0 or a more recent trajectory is used. However, in the latter case the numbers are distorted by the fact that, as explained in the Introduction, in the GCO-500 phase the ground footprint are redundant, therefore leading to multiple observations of the same regions of interest. The short duration of the "high" orbital phase compared to the "low" orbital phase also affects the overall number of opportunities.

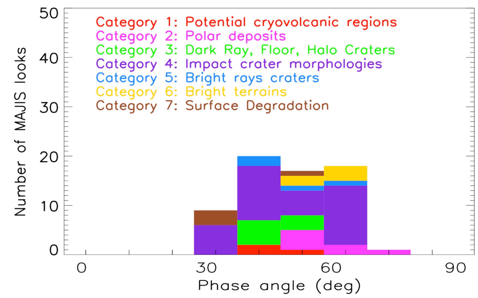

Figure 1. Frequency distribution of MAJIS observation opportunities in the "high" orbital phase at Ganymede (GCO-5000) as a function of solar phase angle. The different colors account for the seven categories of regions of interest identified on the surface of Ganymede.

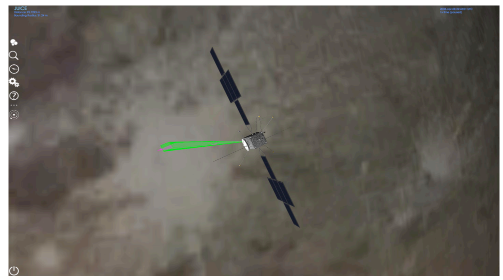

Figure 2. Example of simultaneous observation of crater Shu on Ganymede with JANUS and MAJIS in GCO-500, represented with the SPICE-enhanced Cosmographia Mission Visualization Tool (NASA/NAIF). The fields of view of the two instruments are depicted in green and magenta, respectively.

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