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Regional study of Europa's photometry

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Abstract

Studying Europa's surface from a photometric point of view gives us insight on its physical state. We studied 20 areas scattered across the surface and estimated their photometric behavior using the Hapke model and a Bayesian framework. We have found that most of them were consistent with the bright backscattering behavior of Europa, already observed at a global scale, indicating the presence of grains maturated by space weathering. However, we have identified areas showing a narrow forward scattering possibly indicating the presence of fresh deposits that could be linked to recent cryovolcanism or jets. We have also found rough areas near the equator on the leading side in agreement with the possible presence of penitentes in this region.

Introduction

Europa is of great interest in the search for habitability. The surface of the moon is the youngest of the Jovian icy satellites despite signs of erosion by space weathering and possible sublimation [1]. Europa's activity appears to be driven by a global water ocean directly in contact with the rocky mantle [2]. Studying the photometric behavior of Europa gives us insights in the physical state of the surface – roughness, aggregation state etc. It will also be helpful to the development of ESA's JUICE mission navigation system [3]. Significant work has been done using the Voyager and telescopic observations [4-7]. We propose to improve our knowledge of the regional photometric behavior of Europa by combining the Voyager 1, Voyager 2 and New Horizon datasets.

1. Dataset

We use images from the Voyager probes dataset taken with the Imaging Science System (ISS) [8] and from the New Horizons spacecraft taken with the LOng Range Reconnaissance Orbiter (LORRI) [9].

2. Method

A photometric study necessitates two elements: reflectance and geometry. The first can be obtained after radiometric calibration. The second necessitates accurate projections of each pixel.

2.1 Correction of meta-data

We simulated images with SurRender [10] and compared those simulations to the real images to correct for spacecraft pointing and moon attitude. Additional distortion and distance corrections were needed and implemented on the Voyager images.

2.2 Model and Bayesian Inversion

For this study we are considering Hapke direct model detailed in Hapke, 1993 [11]. Six parameters are to be estimated: b, c, ω, θ, h and B0.

We have developed an inversion tool using a Bayesian approach based on previous work done on Mars [12] and recent improvements [13]. No a priori knowledge of the parameters were inferred except for their physical domain of variation. We modified our previous algorithm [14] to estimate a correction factor on the absolute calibration of each images [15].

3. Results

We conducted this regional study on 20 different areas. Results show a lot of variability across the surface. Fig. 1 shows the results for the macroscopic roughness. We see elevated values close to the equator on the leading side, coherent with the formation of possible penitentes via sublimation [1]. Fig. 2 shows results for the asymmetry parameter b and the backscattering function c plotted with the Hockey stick relation [16] and physical descriptors related to the particles [17].

We see that most regions are backscattering in agreement with previous studies [4,5,6,7]. However, three areas, #8, #9 and #16 show a narrower forward

scattering indicative of smoother and clearer particles with few internal scatterers.

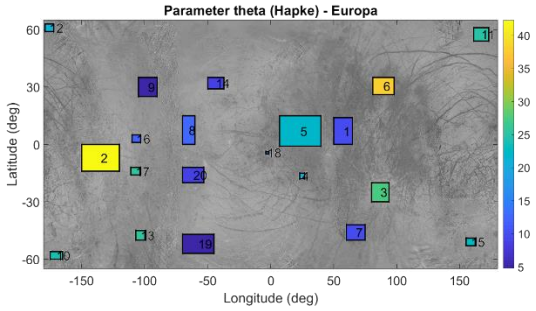

Figure 1: Macroscopic roughness over the different regions of interest in this study

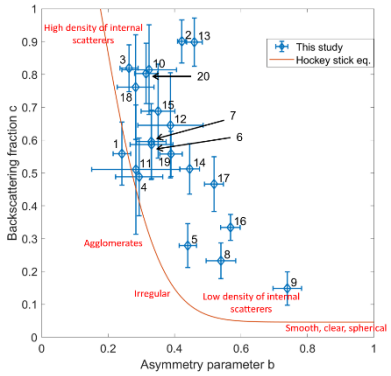

Figure 2: Particle phase function parameters b & c

The complete results of this study are currently under review [18].

Conclusion

Most regions in this study are coherent with Europa's typical bright backscattering behavior that could be explained by space weathering and impact gardening creating more complex particles and aggregates and increasing internal scatterers. We have also highlighted areas showing a different, narrow forward scattering behavior (b>0.5 & c<0.5) around longitude -70° and latitude 15°. This could be indicative of fresh deposits of cryovolcanism or plumes which makes this region interesting for future missions such as ESA's JUICE (JUpiter ICy moons Explorer) that will launch in 2022 and NASA's Europa Clipper that will follow soon after.

The entire pipeline we have developed for this study is adaptable to any additional dataset and photometric model. We plan to extend this to models that can accommodate the most extreme geometries (i,e >70°).

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