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Comparison of variations in ice particle sizes across Callisto's and Ganymede's surface

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1. Introduction

Ratios of band depths of different H_2O ice absorptions at 1.04, 1.25, 1.5 and 2 µm as measured by the Near Infrared Spectrometer NIMS onboard the Galileo spacecraft [1] have been found to be semi-quantitative indicator of changes in the particle size of ice across the surfaces of the Jovian satellite Ganymede [2-4]. This method is now applied to Ganymede's neighboring satellite Callisto.

2. Spectral variations

Individual water ice absorptions are affected by abundance and particles size. The deeper absorptions at 1.5 and 2 µm, however, are already saturated due to the large-grain sizes of ice on these surfaces (in most locations) and thus are mainly affected by the abundance of ice. In contrast, the weaker absorptions at 1.04 and 1.25 µm show a stronger influence on particle size variations. These particle size variations are strongly enhanced in the band depth ratios of these absorptions, which allow the mapping of particle size variations across a satellite's surface on a pixel by pixel base without extensive spectral modeling. Although the non-ice material that occurs on Ganymede and Callisto affects the overall spectral continuum and the depths of the 1.04 and 1.25-µm water ice absorptions, it does not significantly affect their band depth ratios. Intriguingly, particle size variations show almost no correlation to the geology but change continuously with geographic latitude on both satellites (Fig. 1). On Ganymede, sizes reach from 1 µm near the poles to 1 mm near the equator [2]. Smallest particles occur at latitudes higher than ±30° where the closed magnetic field lines of Ganymede's magnetic field change into open ones and Ganymede's polar caps become apparent. Thus, the formation of these polar caps has often been attributed to brightening effects due to plasma bombardment of the surface [5,6]. Other models, however, also discuss the thermal migration of water vapor to higher latitudes [7].

Callisto, which does not exhibit an intrinsic magnetic field, however, also shows an increase of ice particle sizes toward the equator independent of surface geology (Fig. 1). Most NIMS observations of Callisto exhibit a distinct lower SNR and induce a high variance in the measured band depth ratios compared to similar latitudinal measurements on Ganymede. Nevertheless, ratios values in general show the same trend as observed on Ganymede but are slightly lower i.e. there are larger particle sizes on Callisto than on Ganymede at low and mid latitude whereas the ratio values converge toward the poles indicating similar particle sizes.

3. Summary and Conclusions

Ganymede's polar caps are visible in the Galileo SSI images. In contrast, Callisto does not show any hint of polar caps at visible wavelengths. In comparison to Callisto no changes in the ice particle size on Ganymede can be exclusively associated to the existence of its polar caps i.e. a sharp border between relatively large particle sizes in the equatorial region where sputtering and sublimation are the dominating processes and relatively small ice particles either freshly deposited and/or irradiated by magnetospheric particles in the polar regions where the magnetic field lines are open.

Similar trends in the particle size variations on Callisto as well as on Ganymede imply that these variations are caused by similar surface processes. Our measurements rather point to a continuous decreasing of ice particle sizes toward the poles on both satellites that is related to the surface temperatures. Maximum temperatures during the day reach 150 K and 165 K near the equator of Ganymede and Callisto [8, 9], respectively and sublimation of ice particles and crystal growth [10] is expected to be the dominant surface process in these regions. In contrast, polar temperatures do not exceed 80 ± 5 K [11, 7]. Larger particles in the equatorial region of Callisto than on Ganymede could be explained due to the slight higher maximum temperature but also a longer Callistoan day (Callisto: ~ 17 Earth days; Ganymede: ~ 7 Earth days).

Acknowledgements

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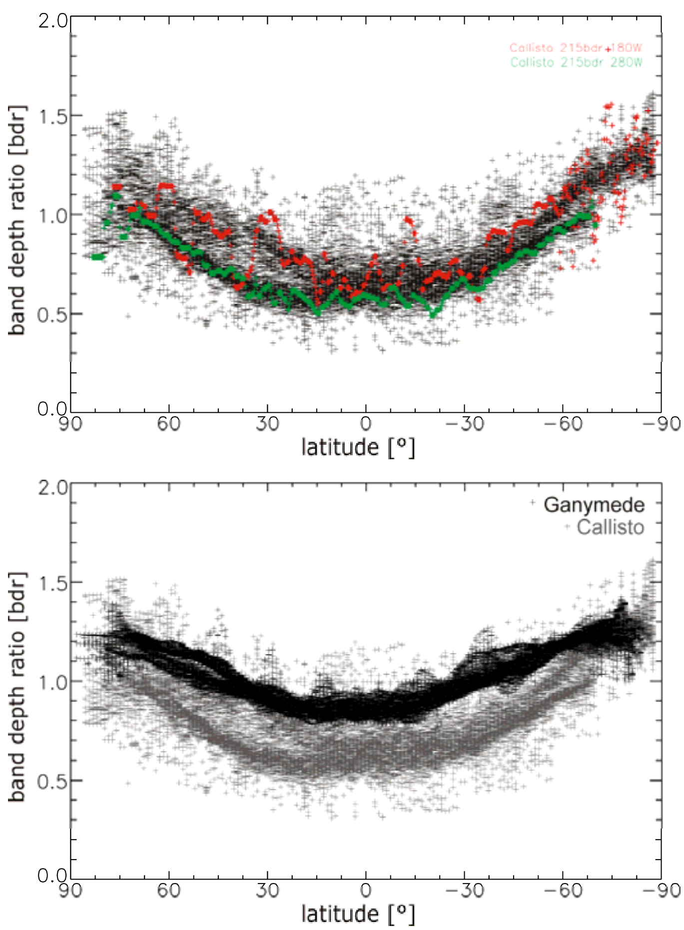

Fig. 1: Ratio of the absorptions band depths at 2 and 1.5µm measured depending on geographic latitude across the entire surface of Callisto (top) and Ganymede in comparison of Callisto (bottom). Note that the relative high standard variation of values measured on Callisto is caused by the low SNR of the corresponding NIMS observations (see for example red colored values measured near 180°W). NIMS observation that does exhibit a sufficient SNR (covering the surface around 280°W; green values) show a similar narrow particle size range like observed on Ganymede.