PROGRESS ON RECTIFYING AND RECALIBRATING GALILEO/NIMS OBSERVATIONS OF THE ICY GALILEAN SATELLITES.

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Introduction: Our goal is to complete a radiometric recalibration and rectification of the Galileo Near Infrared Mapping Spectrometer (NIMS) dataset for the three icy Galilean satellites of Jupiter. As this is completed, we will perform water ice modeling of the recalibrated cubes, including amorphous/crystalline ice mapping that we have done before [1] as well as modeling the full spectrum with ice and non-ice models to determine grain size and abundance of water ice on Ganymede [2], and later possibly Callisto and Europa.

The rectification of about half of the NIMS observations of Ganymede had previously been completed. The recalibration involves starting with the raw instrument data records, removing dark levels and patterns, and applying a new radiometric calibration that principally improves the results at wavelengths below 1 µm. At high phase angles (>95–100°), the instrument viewed through parts of a rotating section of the spacecraft, generically called “booms”, which cause the periodic obscuration of the target with added reflected and thermal energy. The effects of the booms were originally poorly compensated for, and we intend to introduce a procedure that properly identifies the affected data, and that also recovers data that has been only partially obscured. This boom correction is first needed for several high-phase Ganymede observations. Other rectification procedures to be developed include an accurate radiometric calibration for the highest gain state in orbits before E6 (used primarily for Callisto observations), and improved radiation spike removal in observations where the spike density is more than about 50% (used primarily for Europa observations).

The NIMS Instrument and its Data: The NIMS is an imaging spectrometer that records a 0.7–5.3 µm spectrum for each element of an image [3]. There are up to 408 wavelengths that could be measured, recorded in 17 discrete regions corresponding to individual detectors, but often only 200 or fewer were archived. The spectra are built up by making up to 24 exposures on each detector while stepping the spectrometer grating. The spectral image is constructed from instantaneous fields-of-view (IFOV) that are spatially Nyquist sampled, such that adjacent IFOVs from the same grating position overlap by one half. The IFOVs of the other grating positions lie in between these positions, assuming constant scan platform motion, The spatial oversampling allows one to image each observation in a camera projection with pixels about half the size of the IFOV (0.5 mrad square). Ideally, this could be done utilizing detailed telemetry on spacecraft and scan platform position, but in practice, only less accurate modeled motions were available in most cases.

Results: We are studying the observations of the three icy Galilean satellites, Europa, Ganymede, and Callisto. NIMS returned about 30 cubes each for Callisto and Ganymede, and about 60 for Europa (about half of them from the extended mission). About 10-15% of the Ganymede observations are affected by booms, while as many as 30% of the Callisto observations are. Only a few percent of the Europa observations, all in the extended mission, are affected by booms.

Aside from using the correct dark levels and radiometric calibration, we also correct (1) offsets at wavelengths between adjacent detector regions from incorrect dark values or incorrect radiometric calibration, (2) odd-even and other wavelength patterns from incorrect odd-even dark values and/or incorrect spectral reconstruction in regions of high spatial contrast, and (3) improperly corrected booms. Radiation spikes that occur in the data must be removed before projection; we use our own routine that performs well and is well tested (e.g., [1], [5]).

Ganymede: We have completed the recalibration of three new Ganymede observations to date. The camera projection footprint algorithm for projecting the NIMS cubes (NIMSGEOMF) had disappeared from the

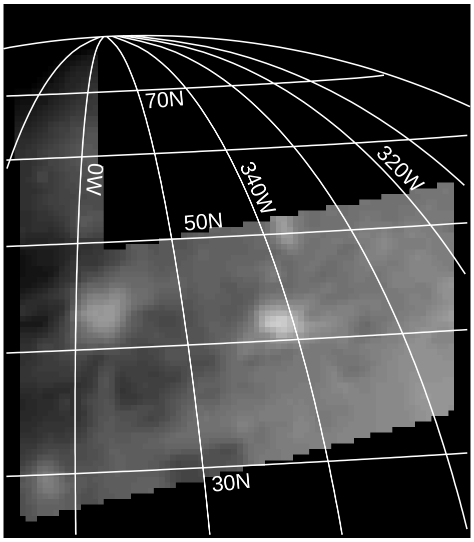

Figure 1. 0.7-µm image of the G7 HILAT observation with location grid.

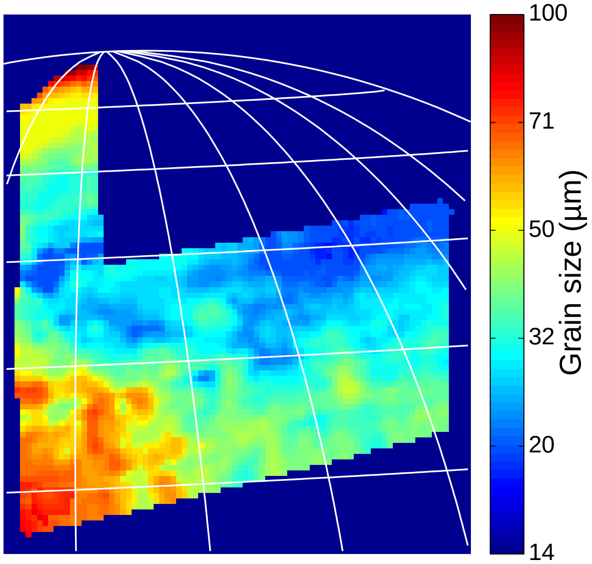

Figure 2. Grain size map for G7 NHILAT.

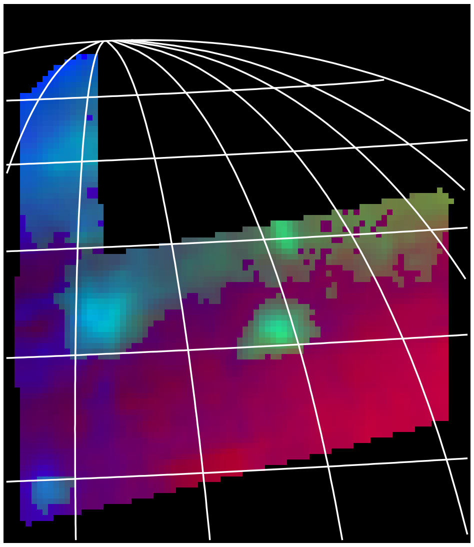

Figure 3. Color map showing Ganymede non-ice as red, Europa non-ice as green and water ice/snow as blue.

latest ISIS releases. So we had to resurrect the program, which now works well. We continued the crystalline/amorphous analysis of these cubes [1], which we have already finished for the 13 Ganymede cubes processed previously (e.g., Figs. 1–2).

We have started on a new method to map the water ice grain size and abundance, starting with these new cubes. The current model uses linear mixing, with only one grain size, and a mixture of two scaled non-ice spectra for Ganymede [4] and Europa [6] (Fig. 3). This model assumes segregated ice and non ice, which we have found to be generally applicable for Ganymede and Callisto [1]. Unlike [1], we are now using a plane-parallel bi-directional reflectance model for the ice spectrum, using the appropriate lighting geometry for each pixel. The fits are good, even though multiple grain sizes and a non-uniform scaling of the non ice spectrum (see [1]) would improve some of the fits.

Gain State 4 Calibration: The latest calibration (mainly detectors 1-2) was derived from a global Europa observation at gain state 2. The gain states 3 and 4 calibration followed by using existing fixed ratios between the gain states. The gain state 4 calibration did not appear to work well with Callisto observations. The calibration after orbit E6 was shown to be good using (1) a low-phase leading hemisphere global observation of Callisto on orbit G7 that was compared to telescopic measurements, and (2) a double observation of Europa in orbit E11 using both gain states 3 and 4. The early gain state 4 calibration is still to be finished.

Europa Despiking: We have successfully completed despiking an observation of Europa (E6 TERINC) that had 70-80% spikes in the region beyond 3 µm. This has revealed surprising results that are being reported elsewhere. We expect that this procedure should be generally applicable to Europa observations.

Boom Detection and Correction: We have completed our first study of boom correction using a distant Callisto observation at 123° phase. Some of the smaller booms seem to block less at longer wavelengths and a thermal model for the partially blocked pixels can be removed. This process can be automated to some extent as we investigate it further.

Future Work: We will continue Ganymede calibration and modeling (dependent somewhat for the full correction of boom-affected cubes). This is straightforward, and the amorphous/crystalline mapping is also fully developed. We may need to also add the Callisto-type non-ice spectrum, non-constant scaling of the non-ice, and mixed grain sizes to the ice modelling routine to improve fits.

The completion of the Ganymede dataset is dependent on a quick adaptation and familiarization of the boom correction routines that we have developed.

We also plan to continue looking at Europa data sets with the goal of repeating the success of our first encounter with the Europa data.

References:

[1] Hansen G.B. and T.B. McCord (2004) *JGR, 109*, E01012. [2] Hansen G.B. *et al.* (2006) *Eos, 87(36)*, Abs. P41B-05; Hansen G.B. *et al.* (2006) *BAAS*, *38*, 540. [3]Carlson R.W. *et al.* (1992) *Space Sci. Rev.*, *60*, 457–502. [4] McCord T.B. *et al.* (2001), *Science*, *292*, 1523–1525. [5] Hibbitts C.A. *et al.* (2000) *JGR*, *105*, 22541–22557; Hibbitts C.A. *et al.* (2003) *JGR*, *108(E5)*, 5036. [6] McCord T.B. *et al.* (1998) *Science*, *280*, 1242–1246; McCord T.B. *et al.* (1999) *JGR*, *104*, 11827–11852.