Topographic Mapping of the Galilean and Other Icy Satellites: Prospects and Problems for Stereo and Photoclinometry

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Techniques for Topographic Mapping on Icy Satellites

The utility (read: need) of topographic data in formulating and testing hypotheses for the formation of geologic features is undisputed. In the absence of laser altimeters, however, image-based methods (each with its advantages and disadvantages) must be used to extract local and regional topography.

Limb profiling: Offers controlled topography over long-wavelengths but is restricted to a single linear trace along the surface (per image). Negative topography is particularly compromised by projection effects. This technique has seen only limited use and only on Io (Thomas et al., 1998).

Photoclinometry: Offers high-frequency topographic data at spatial scales of image resolution, but may require sacrificing long-wavelength topographic information. PC (or shape-from-shading) has been maligned in the planetary community because of its sensitivity to inherent albedo variations and its lack of control over long distances (due to the cumulative build-up of errors or the failure of one or more of the numerous assumptions built into the technique). PC can be useful for investigating certain types of features, assuming one has a firm grasp on the limitations and what information is "thrown-out" in the processing. PC's primary applicability has been for features with assumed symmetry (Schenk, 1991a; 1991b), allowing the user to "control" the profile. We have been exploring alternative methods for extracting PC topography in 2-dimensions, and will discuss these methods and their potential uses on the Galilean satellites.

Stereo Imaging: Offers semi-controlled topography over long-wavelength structures. Stereo topography of course requires two images under similar lighting conditions. The data rate challenges of the *Galileo* mission severely restricted stereo opportunities, but the obvious utility of this method led to limited programmed stereo targeting. Serendipitous imaging increased stereo coverage by several factors and I concentrate on these observations. Stereo digital elevation models, DEMs, are limited by the resolution of the lowest-resolution images of the stereo pair, however. In the absence of global topography, even stereo DEM's can be controlled only in the internal sense (that is to say across the DEM itself and not with respect to the center of planet).

Topographic Mapping on Icy Satellites

Topographic mapping based on stereo analysis has been completed for the Galilean satellites. Some preliminary results have already been reported for the three inner satellites. Stereo topography on Io is most relevant for the heights of mountains, volumes of landslides and slopes of volcanoes (Schenk et al., 1997; Schenk and Bulmer, 1998; Wilson and Schenk, 2001; Schenk et al., JGR in press, 2001). For Europa, stereo observations reveal topographic doming of up to 1 km that was only marginally suspected (Schenk and McKinnon, 2001). Stereo measurements have also proved important for supplementing shadow measurements of crater depths (Schenk, 2001), and for testing models of chaos formation (Schenk and Pappalardo, 2001). Albedo variations are even more chronic on Ganymede and stereo provides the only long-wavelength (i.e., 100's of km) controlled topography on this satellite. Combined *Voyager-Galileo* stereo

has been used for mapping the relative topography of geologic units and investigating the role of volcanism in bright terrain formation (Schenk et al., 2001). Thus, while global shape and many regional-scale problems cannot be addressed with available data, stereo and photoclinometry allow a wide range of issues associated with Galilean satellite geology to be investigated.

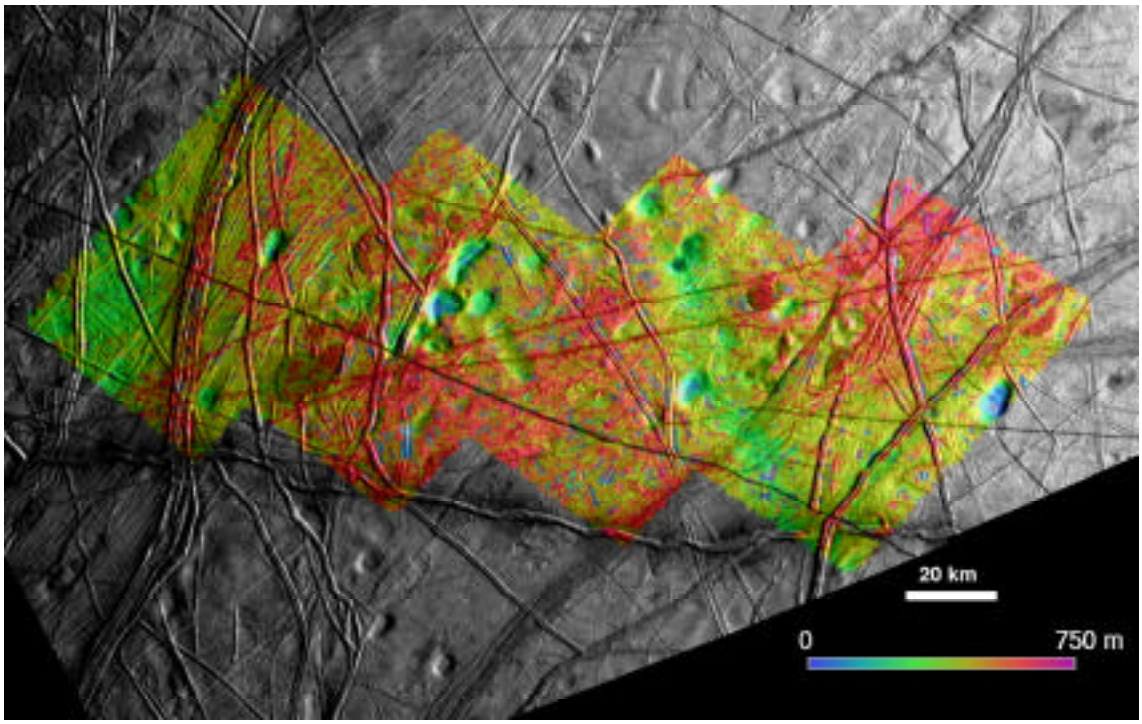

Figure 1. A representative stereo-derived DEM of part of Europa.

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