STEREO AND PHOTOCLINOMETRIC COMPARISONS AND TOPOGRAPHIC ROUGHNESS OF EUROPA. F. Nimmo, *Dept. Earth & Planetary Sciences, U.C. Santa Cruz, Santa Cruz CA 95064 (fnimmo@es.ucsc.edu)*, P.M. Schenk, *Lunar & Planetary Institute, Houston TX 77058 (schenk@lpi.usra.edu)*.

Quantifying the topography and roughness of icy satellites is important for at least three reasons. First, the topography may be used to infer properties, such as rigidity, of the near-surface [e.g. 1]. Second, the wavelength-dependence, or power spectrum, of the topography, may constrain how the topography is being modified [e.g. 2,3]. Finally, it is important to quantify short-wavelength topographic roughness to design radar instrument characteristics [4] or understand hazards to spacecraft landers.

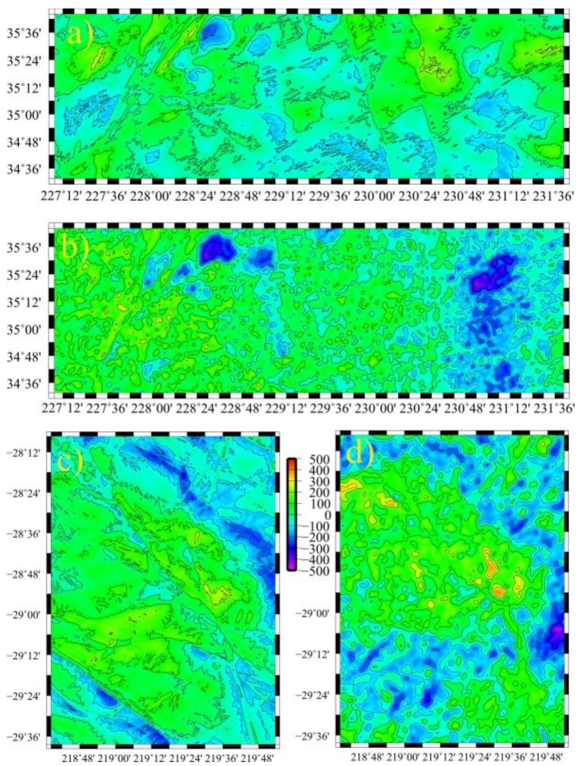

Figure 1: Topography for Erhad (a-PC b-stereo) and Ediss (c-PC d-stereo) regions of Europa. Colour scale (in m) applies to all images; mean elevation set to zero.

At present, only stereographic or photoclinometric (shape-from-shading) techniques can be used to derive icy satellite topography. These techniques are described elsewhere [5,6]. In general stereo techniques are expected to yield more robust results, but at the expense of a resolution that is intrinsically poorer (by a factor of ≈3-5) than photoclinometry. Comparisons of MOLA topography with (primarily) stereo topography on Mars show a generally good agreement, with the normalized mismatch increasing at the shortest wavelengths [7]. Here we carry out a similar comparison between stereo (S) and photoclinometric (PC) topography, and use the results to infer short-wavelength topographic roughness.

Figure 1 shows two typical topography comparisons: Erhad (Fig 1a,b) and Ediss (Fig 1c,d). In each case it is apparent that the long-wavelength agreement is quite good, but that the PC topography contains more short-wavelength information than the stereo topography, as expected. Table 1 summarizes the characteristics of the six areas investigated.

data set	Δx	RMS	dev.$_{(100)}$	dev.$_{(1)}$
	m	m	m	m
e86-32_Z	32	106.2	7.7	0.21
ediss_Z	55	87.2	8.5	0.27
eplains_Z	21	51.4	7.1	0.22
erhad_Z	65	75.3	5.6	0.20
etyre-33_Z	33	55.9	15.9	1.5
manan-80_Z	80	73.9	14.9	1.2

Table 1: 'Z' denotes a stereo data set. Δx is the pixel size; RMS and dev. are the RMS height and the RMS deviation as defined by [9]. The RMS deviation at the specified wavelength (100 m and 1 m, respectively) is derived by extrapolation from the fitted roughness plots shown in Fig. 5.

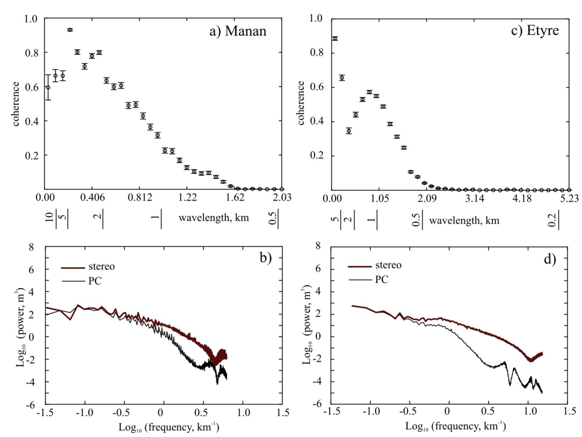

Figure 2: a) Coherence between PC and S topography as a function of wavelength for Manan. b) Power in PC and S topopgraphy as a function of 1/wavelength, calculated using grdfft from [10]. c-d) As for a-b), but for Etyre.

Figures 2-4 investigate the topographic characteristics as a function of wavelength. The top panels plot the coherence [8] between the S and PC topography: high coherence indicates a good agreement. In general the coherence is higher at long wavelengths and decreases at short wavelengths. This effect is primarily because the intrinsic resolution of the stereo technique is typically 3-5 times worse than the coarser of the two images used [5]. At shorter wavelengths, the stereo topography therefore contains no information and exhibits zero coherence with the PC data. The bottom panels plot the power in the S and PC topography [10]. At long wavelengths, the power in the two data sets is generally similar. The change in slope at short wavelengths for the stereo data is an artefact resulting from the method by which stereo data are generated. Several of the PC data sets show strikingly non-monotonic behaviour at short wavelengths, which is almost certainly an artefact and suggests that these data sets should be treated with considerable caution.

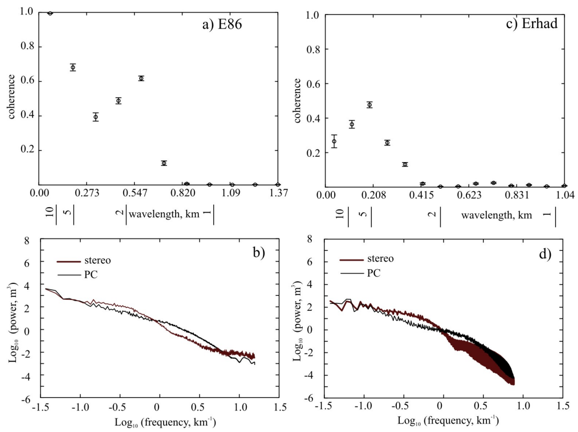

Figure 3: a-b) As for Fig 2 but for E86. c-d) As for Fig 2 but for Erhad.

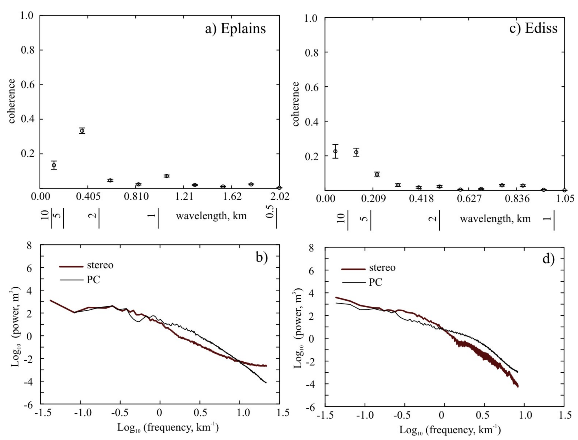

Figure 4: a-b) As for Fig 2 but for Eplains. c-d) As for Fig 2 but for Ediss.

Topographic roughness can be measured in different ways [9]. The simplest measure is the RMS roughness, tabulated in Table 1 for the stereo data sets. However, it is more useful to be able to specify roughness at a particular wavelength, in which case the RMS deviation should be used [9]. Figure 5 plots the RMS deviation as a function of step spacing for the six stereo data sets. In general the plots exhibit curvature, which we have fitted assuming two linear segments [11]. The short-wavelength linear segment then allows extrapolation to the wavelength of interest. Table 1 tabulates the expected RMS deviation at 100 m and 1 m, the latter lengthscale being appropriate to lander dimensions. Etyre and Manan show larger short-wavelength roughnesses than the other data sets, probably because of ejecta from nearby craters. Table 1 suggests that such ejecta-strewn areas are likely to prove extremely hazardous to landers.

References

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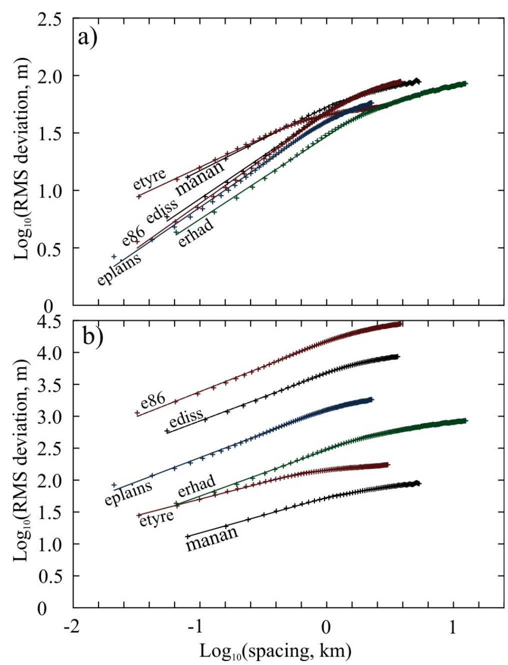

Figure 5: a) RMS deviation [9] as a function of step size for stereo data sets. Each data set is fit by two straight line segments [10]. b) As for a) but successive data sets are offset by 0.5 log units for clarity.