PHOTOCLINOMETRY OF TERRESTRIAL & PLANETARY SURFACES. L. Wilson (a), J.S. Hampton (b) and H.C. Balen (a). (a) Dept. of Environmental Science, (b) Dept. of Mathematics, Univ. of Lancaster, Lancaster LA1 4YQ, England.

The rarity of high-resolution stereoscopic spacecraft imagery for planetary surfaces has prompted interest in generating topographic information from monoscopic images (1-4). Such techniques may be applied to LANDSAT images of the Earth, and we are devleloping software in UCSD PASCAL for this on a Joyce-Loebl MAGISCAN 2 image analysis system.

One essential step in analysis is to use a mathematical function relating apparent brightness of a surface element to its orientation relative to the Sun and the observer. For this we have used the function recently developed by Hapke (5, 6), in which physical surface properties are characterised by five parameters: W (single scattering albedo), H (packing density of individual scattering elements as a function of depth in the uppermost surface layer), T (mean slope of surface roughness on the largest spatial scale not resolved at pixel level) and B and C (characterising angular light scattering efficiency of individual surface elements).

It is, of course, important to select correct values for the parameters in order to interpret the brightness variations in an image correctly. However, systematic determinations of these parameters as a function of surface geology have only been made so far for Ganymede (7). The contamination of Ganymede's outer layers by varying amounts of water ice means that the parameters deduced for its surface are unlikely to be typical for rocky surfaces of inner solar system bodies. The vegetation cover of much of the Earth in any case presents special additional problems.

Fortunately, photoclinometry only requires use of ratios of brightness values for tilted and untilted surface elements, rather than absolute values of these brightnesses. We have, therefore, explored the sensitivity of the tilt/brightness-ratio relationship to variations in the five adjustable parameters of Hapke's function. In lieu of other information we have used as typical values those deduced for the darker areas of Ganymede (7) [W = 0.4, H = 0.5, T = 25 degrees, B = 0.4, C = 0.5] and have calculated brightness ratio as a function of local surface tilt for typical overall viewing and illumination geometries as each parameter is varied in turn over its mathematical range.

Figures 1 and 2 show some results for a typical spacecraft image geometry: the detector is looking vertically downwards onto the surface and the solar incidence angle is 50 degrees. It is generally found that brightness of a planetary surface element is a strong function of brightness longitude but only a weak function of brightness latitude; the Figures represent corresponding calculations for tilts parallel to, and perpendicular to, the plane containing the solar incidence vector, respectively. We find that the brightness ratio/tilt relationship is relatively insensitive to variation in the parameters. The strongest dependance is on T, macroscopic surface roughness; but even this can be allowed to reach physically unreasonably large values (greater than about 50 degrees in the examples shown) before unacceptable changes in the nature of the relationship occur. In particular, the relationship is smooth and single-valued for all physically plausible parameter values. This is most important for use of the function in photoclinometry; if it were not the case then more than one orientation of a surface element would exist giving the same brightness ratio, rendering the technique useless. There is, in fact, a measure of ambiguity in interpreting brightness ratios, since a surface element will in general have tilt components both in, and normal to, the solar incidence plane. However, comparison of Figures 1 and 2 shows that a given tilt in the plane of incidence will produce about a ten-fold greater brightness change than the same tilt perpendicular to the plane: this suggests the maximum absolute accuracy of the technique to be approximately 90%. We plan to test this expectation shortly by applying photoclinometric topography generation methods to LANDSAT images of well-mapped areas of the Earth.

References: (1) K. Watson, U.S.G.S. Prof. Paper 599-B, 10pp, 1968; (2) B. Hapke et al., J.G.R. 80, 2431, 1975; (3) P.J. Mouginis-Mark and L. Wilson, Computers and Geosci. 7, 35, 1981; (4) L. Wilson and M.A. Brown, L.P.S.C. XIV, 849, 1983; (5) B. Hapke, J.G.R.86,3039,1981;

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Figure 1

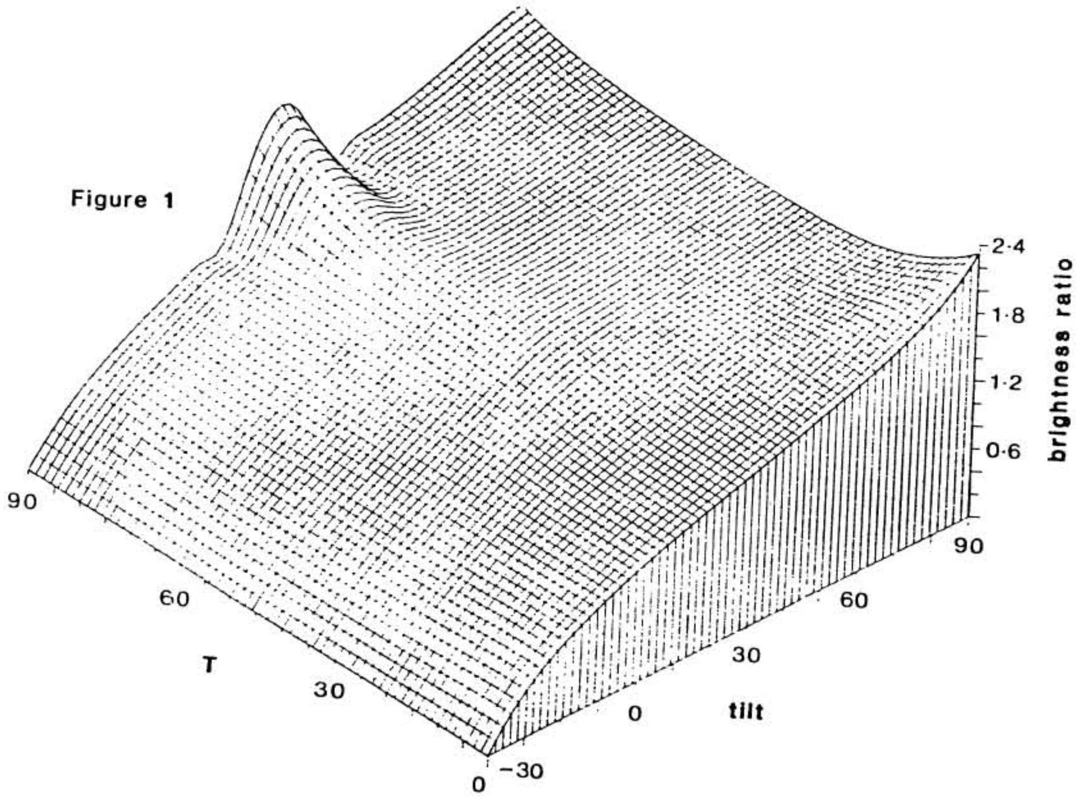


Figure 2