METER-SCALE 3-D MODELS OF THE MARTIAN SURFACE FROM COMBINING MOC AND MOLA DATA.
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Introduction: We have extended our previous efforts to derive through controlled photoclinometry, accurate, calibrated, high-resolution topographic models of the martian surface. The process involves combining MGS MOLA topographic profiles and MGS MOC Narrow Angle images. The earlier work [1] utilized, along with a particular MOC NA image, the MOLA topographic profile that was acquired simultaneously, in order to derive photometric and scattering properties of the surface and atmosphere so as to force the low spatial frequencies of a one-dimensional MOC photoclinometric model to match the MOLA profile. Both that work and the new results reported here depend heavily on successful efforts to: 1) refine the radiometric calibration of MOC NA; 2) register the MOC to MOLA coordinate systems and refine the pointing; and 3) provide the ability to project into a common coordinate system, simultaneously acquired MOC and MOLA with a single set of SPICE kernels utilizing the USGS ISIS cartographic image processing tools [2, 3, 4].

The approach described in this paper extends the MOC-MOLA integration and cross-calibration procedures from one-dimensional profiles to full two-dimensional photoclinometry and image simulations. Included are methods to account for low-frequency albedo variations within the scene.

Approach: The goal is to derive reliable, high resolution DEMs (1-10 meter horizontal resolution with 0.1-1 meter vertical resolution) by using MOLA topography to "control" methods and programs for photoclinometric modeling (developed by one of us, RLK [5]) of MOC NA images. We introduce the MOLA topography in the process in five ways: 1) planimetric control (when we project radiometrically calibrated MOC images onto the MOLA gridded topographic models using the new USGS ISIS cartographic system, we get dead-reckoned registration typically of <200m; we shift the MOC image to register a shaded version to reduce this to <50m), 2) for precise modeling of surface and atmospheric reflectance and scattering (we solve for photometric parameters that when used in a photoclinometric inversion on the radiometrically calibrated and geometrically controlled MOC NA image give the best fit to the MOLA topography), 3) to account for subtle

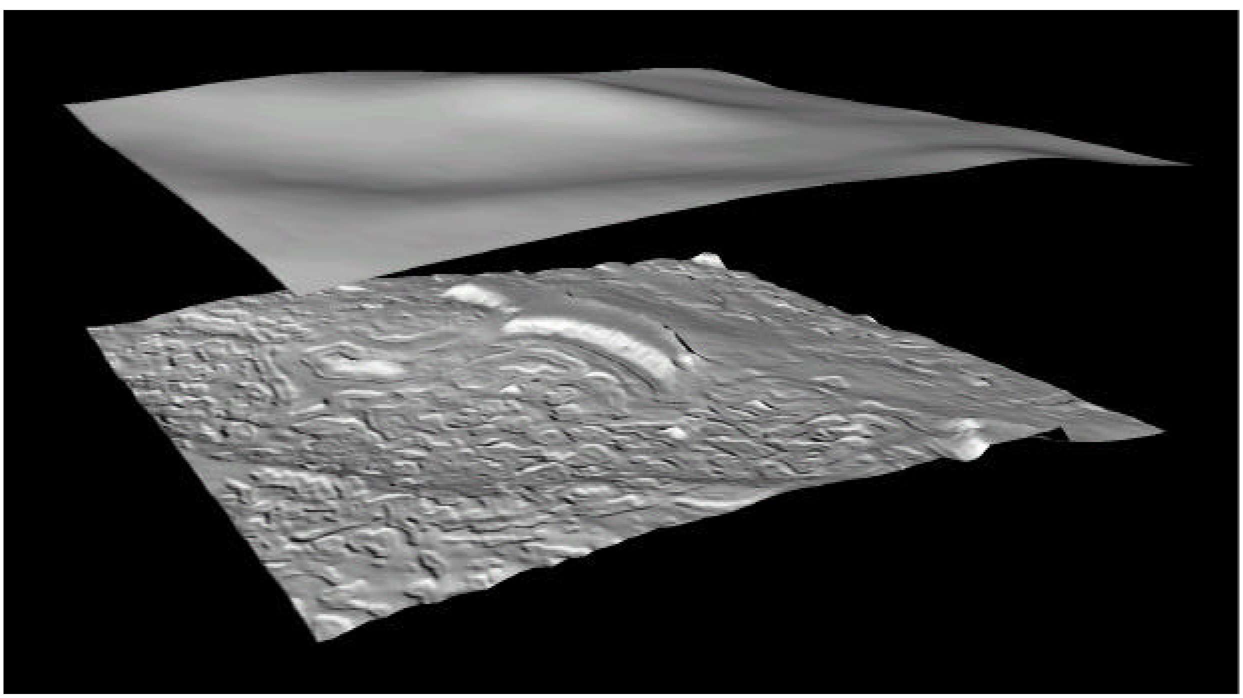

Figure 1. Results of the application of the procedures to a high-resolution south polar scene (MOC NA m0906496, ~2.3m/pix). *Upper:* MOLA topography gridded at 231 m/pixel. *Lower:* High-resolution DEM derived from MOLA-controlled photoclinometry applied to the MOC NA image. Modeling includes derivation of surface and atmospheric reflectance and scattering properties as well as albedo variations across the surface. Both (upper and lower) perspective views have a 10x vertical exaggeration and cover ~2.5 x 2.5 km.

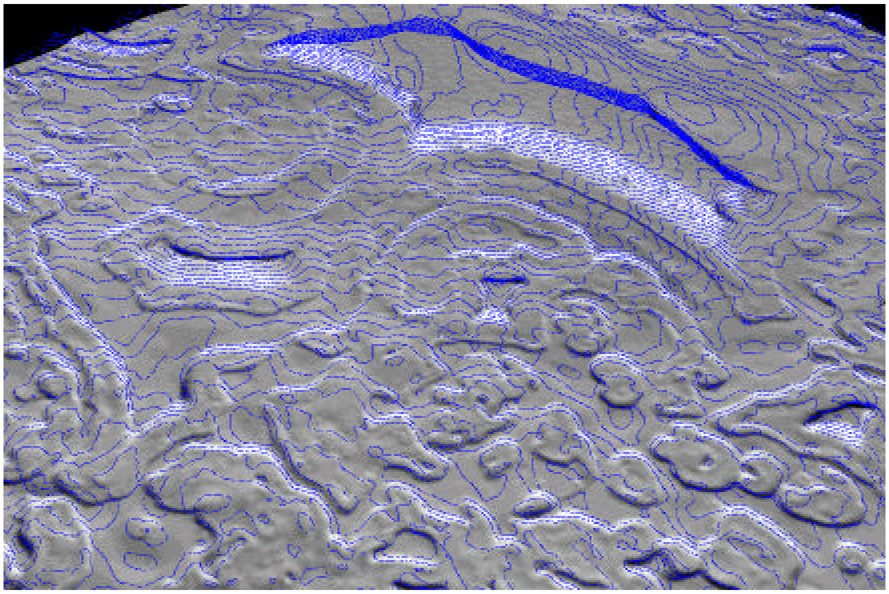

Figure 2. Perspective view of same model shown in Figure 1 with half-meter contours overlaid. The vertical exaggeration is 10x; the mesa in the top center is about 5 meters high and roughly a km in length.

variations in surface albedo (even the frost-covered south polar images that we have been using because they have minimal albedo variations, have some albedo variations that contaminate the photo-clinometry; we use the MOLA gridded topography to model the low-frequency content of the MOC NA image and thereby to model low resolution variations in what we assume to be surface properties, ie. as opposed to atmospheric variance), 4) as the starting solution for the photoclinometry model (albeit the MOLA topography is much lower in spatial resolution than the MOC NA image by as much as 200 times) but this provides the low frequency content that cannot be accurateldy derived from photoclinometry of the MOC NA image alone; the result is that the low-frequency topography is inherited from MOLA and the high-frequency, high-resolution content, comes from MOC), 5) as the DEM base map on which the MOC NA high-resolution DEMs are mosaicked (because we use the MOLA gridded model both as the planimetric control and as the low-frequency model to start the solution, the MOC NA products register precisely in x, y, and z to the MOLA base and can be mosaicked directly on top).

Results and Implications and Future Work: Figures 1 and 2 illustrate an example of the complete set of procedures just described applied to a largely frost-covered high-resolution MOC NA scene in the martian south polar region. The results we are encouraging and we believe these techniques could open new vistas of Mars geoscience research. The implications for the ability to derive detailed topography of this quality are very important for our quantitative understanding of a myriad of geological processes that have acted on the martian surface. We will be able to explore models for rates of erosion and deposition, detect distortion of polar stratigraphic layers due to plastic flow, create digital models of volumetric changes in the polar frost deposits to name but a few.

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