INFLUENCE OF MAP PROJECTION ON DIRECTIONS MEASURED OVER HIRISE AND MOC IMAGES.

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Introduction: Since their launching HiRISE and MOC cameras have been extensively used to study quantitative aspects of features like dust devil tracks. As examples, some authors [3-5] have been inferring wind directions by measuring dust devil [1, 2] tracks (and also other aeolian features like wind streaks) orientations. Such information can be used to verify and improve predictions of the General Circulation Model (GCM). One thing that should be carefully addressed when measuring directions (and also lengths and areas) is the influence of the map projection of the product. As HiRISE and MOC NA projected products are not conformal (that is, angles are distorted), measured directions will not agree with real directions on Mars surface. The problem could be easily overcome by reprojecting the images into a conformal system, but many users may not have the knowledge (or resources) necessary to perform that transformation. This abstract analyses the angular distortion in HiRISE and MOC images in order to report if the amount of distortion makes it mandatory to reproject the scenes prior direction measurements.

HiRISE camera: HiRISE images ranging from 65°N to 65°S are processed in Equirectangular projection, which is an equidistant cylindrical projection. The latitude of true scale is not set to the center of the image but to the next lowest rounded 5-degree latitude. Thus between 65°N to 65°S the image's latitude of true scale is set to one of twenty-six 5-degree latitude bands. In such projection only meridians are represented in true scale. It is neither conformal nor equivalent, which means that directions and areas measured over this projection do not correspond accurately to those measured on Mars surface. Fig. 1 shows the angular distortion expected for Equirectangular projection along 70°N to 70°S and 180°W to 180°E. The equator is represented in true scale but the angular distortion grows fast for latitudes far from that standard line and may reach 60° distortion at 70°N or S.

MOC camera: MOC NA images ranging from 65°N to 65°S are processed in Sinusoidal projection, which is an equivalent or equal area projection. Thus, directions are also not presented in true scale. Distances are true scale only along the central meridian and vertically along the parallels. Fig. 2 shows the angular distortion expected for Sinusoidal projection along 70°N to 70°S and 180°W to 180°E. As seen from Fig. 2 the angular distortion in Sinusoidal projection is a function of both latitude and longitude whereas the angular distortion in Equirectangular projection is a function solely of latitude. In both Figs. 1 and 2 the calculations were performed adopting a sphere of radius 3,396.19 km, which corresponds to the semi-major axis of the ellipsoid recommended by IAU [6]. The projections equations may be found in [7].

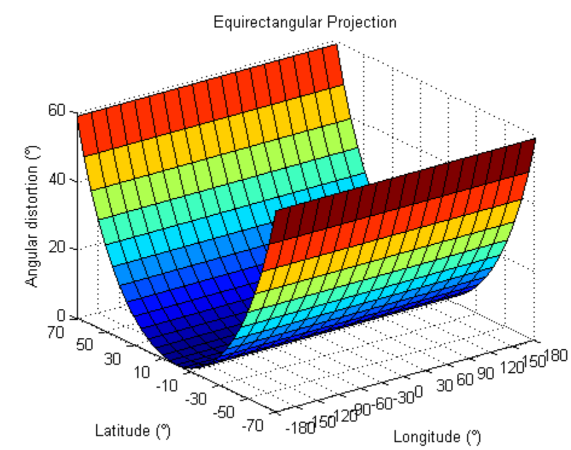

Fig. 1: Angular distortion surface for Equirectangular projection.

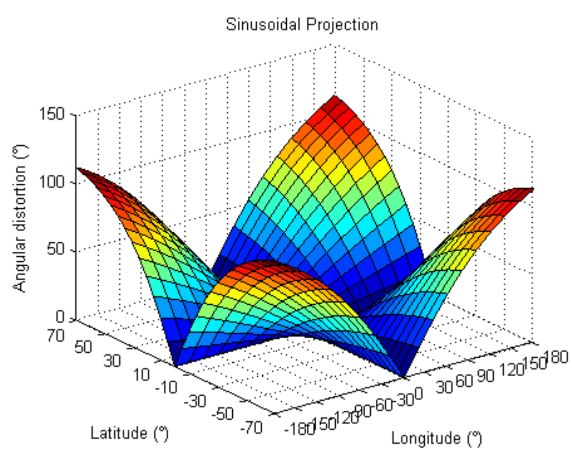

Fig. 2: Angular distortion surface for Sinusoidal projection.

Evaluation: In order to quantify the influence of map projection on direction measures in HiRISE and MOC images Figs. 3, 4 and 5 present real examples. Fig. 3 shows portions of the images PSP_006163_1345 (a) and MOC M12-02214 (b). The center coordinates of the HiRISE image are φ = -45.303° and λ =

316.288° (φ and λ being latitude and longitude respectively). The center of projection is φ = -45° and λ = 180°. As the image is approximately 8 km wide and 24 km long (according to the image label) and assuming a local radius of 3,386.15 km, the extent of the scene in degrees is 0.1354° by 0.4061°. The angular distortion expected to occur in the HiRISE image is shown in Fig. 4. As it is a function solely of latitude, the distortion is not affected by the fact that the longitudinal center of projection is 180°, far away 136.288° from the scene center longitude.

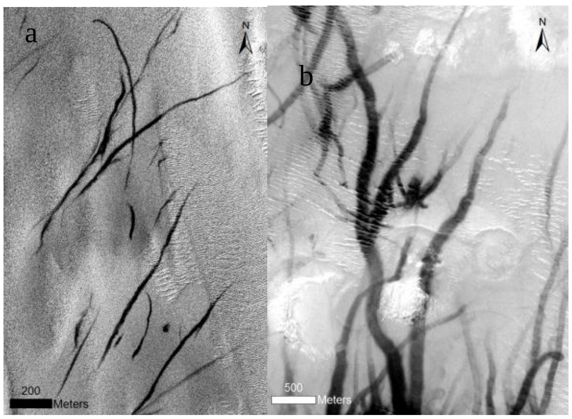

Fig. 3: Images HiRISE PSP_006163_1345 (a) and MOC M12-02214 (b).

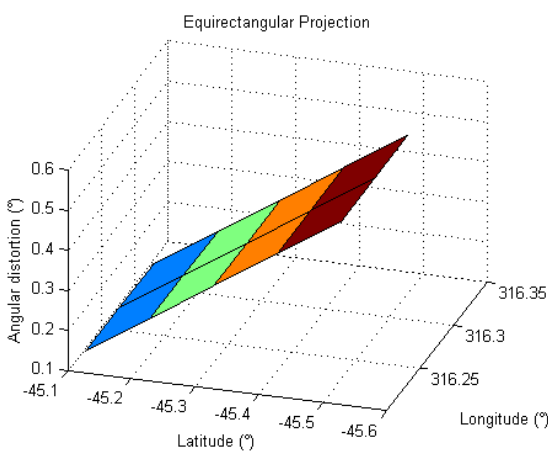

Fig. 4: Angular distortion for PSP_006163_1345 HiRISE image.

On the other hand, the latitudinal center of projection does not lie on scene and contributes to increase distortion over the region. Even though, the maximum distortion expected to be found in direction measures is about 0.6°.

The MOC image has center coordinates φ = -51.21° and λ = 44.90°. The projection center coordinates are φ = 0° and λ = 44.90°. The image is approximately 0.048° wide and 0.2964° long (according to the image label). Fig. 5 shows the angular distortion expected to occur in the MOC image, which is a function of both latitude and longitude. The center meridian of projection is set close to the center of the image, which is relatively narrow, so the distortion is well behaved, reaching a maximum of about 0.02° as seen if Fig. 5.

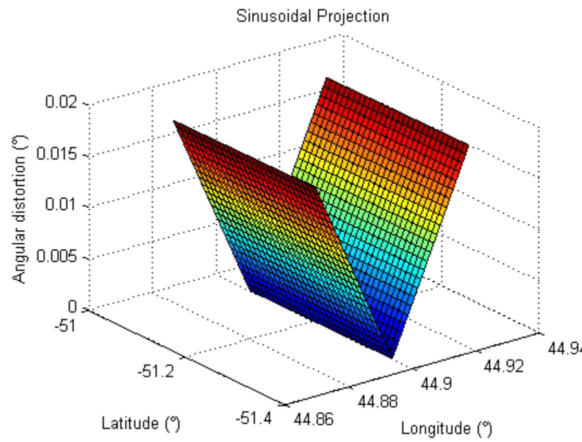

Fig. 5: Angular distortion for M12-02214 MOC image.

Conclusion: HiRISE and MOC images are processed and map projected into Equirectangular and Sinusoidal projections, respectively. Based on these results one should be careful when measuring directions from such images. Despite that, the center projection is always close to the center images and because the extent of the images is relatively small (generally a few degrees in latitude), the amount of distortion may not be significant. In the examples shown here the maximum distortions were about 0.6° for the HiRISE and about 0.02° for the MOC**.** Therefore, if the accuracy of the method used to measure directions is coarser than the maximum distortion there is no need to reproject the images into a conformal system. When map projection errors are considerable, which is common for more regional or global studies, an alternative would have been to perform geodesic calculations through a software such as “Tools for Graphics and Shapes”, available freely online [8].

References: [1] Brooks H. B. (1960) *J. Meteorol.*, 17, 84-86. [2] Balme M.R. et al. (2003) *JGR, 108, E8*. [3] Statella et al. (2013) *44th LPSC*, 1092. [4] Örmo and Komatsu (2003) *JGR*, 108, E6, 5059. [5] Fenton et al. (2005) *JGR*, 110, E06005. [6] Duxbury et al. (2002) *ISPRS XXXIV*, 512. [7] Snyder, J.P.(1926) *Map projections - a working manual*. [8] Jenness, J. (2011) Tools for Graphics and Shapes Manual.