Reference frame and map projection for irregular shaped celestial bodies

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Abstract:

Recent advancements of technology resulted in greater knowledge of the Solar System and the need for mapping small celestial bodies significantly increased. However, creating a good map of such small objects is a big challenge for the cartographer: they are usually irregular shaped, the usual reference frames like the ellipsoid of revolution is inappropriate for their approximation.

A method is presented to develop best-fitting irregular surfaces of revolution that can approximate any irregular celestial body. (Fig. 1.) Then a simple equal-area map projection is calculated to map this reference frame onto a plane. The shape of the resulting map in this projection resembles the shape of the original celestial body.

The usefulness of the method is demonstrated on the example of the comet 67P/Churyumov-Gerasimenko. This comet has a highly irregular shape, which is hard to map. Previously used map projections for this comet include the simple cylindrical, which greatly distorts the surface and cannot depict the depressions of the object. Other maps used the combination of two triaxial ellipsoids as the reference frame, and the gained mapping had low distortion but at the expense of showing the tiny surface divided into 11 maps in different complicated map projections (Nyrtsov et. al., 2018). On the other hand, our mapping displays the comet in one single map with moderate distortion and the shape of the map frame suggests the original shape of the celestial body (Fig. 2. and 3.).
Figure 2. Map of comet 67/P Churyumov-Gerasimenko in our map projection. Blue: original spherical graticule; orange: planetocentric graticule on the general surface of revolution.

Figure 3. Part A: A geomorphological map of the comet (Birch et al., 2017); part B: the same map reprojected into our map projection

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References
