A SPECTRAL VIEW OF THE TERRA SIRENUM / CIMMERIA CRUSTAL MAGNETIC FIELD.

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Introduction

The Martian crustal magnetic field is strongest over Terra Sirenum / Cimmeria, a region in the southern hemisphere centered around the antimeridian. The pattern of the crustal magnetic field in this region hints at the dynamic history of the planet but the lack of small-scale resolution has hampered conclusive geological interpretation. In this contribution we aim to focus our interpretation of the crustal magnetic field on its well-resolved components, the low- to midscale spherical-harmonic degrees. For this purpose we make use of the regional power spectral calculation methods presented by [1, 2]. Their method uses spatially concentrated, spectrally limited tapering functions to smoothly window the magnetic field around the region of interest. A robust estimate of the regional spectrum is then obtained by calculating the spectrum of the windowed spatial field for each tapering function, and then averaging the resulting spectra. Here we use this approach to calculate regional spectra for several subregions within Terra Sirenum / Cimmeria from the crustal magnetic field presented by [3].

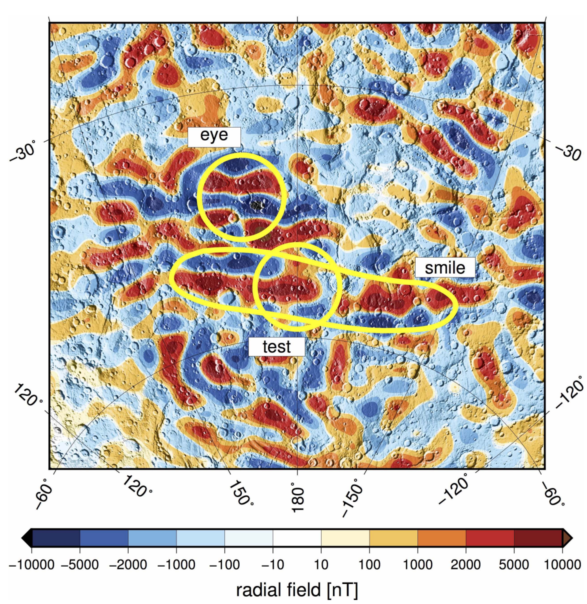

Figure 1: Radial component of the crustal magnetic field model presented by [3] over the Terra Sirenum / Cimmeria region. Fig. 2 shows the regional spectra for the three indicated subregions.

Regional Spectra

Fig. 1 shows the radial component of the crustal magnetic field model by [3] within Terra Sirenum / Cimmeria evaluated on the planet's surface. Fig. 2 shows the regional spectra calculated for the three regions indicated in Fig. 1 using the approach by [2]. We use tapering bandwidth $L_{\mathrm{tap}} = 30$ leading to Shannon numbers 1.8 (see [2] for nomenclature) for the 5° caps "eye" and "test", and a Shannon number of 4.7 for the "smile" region. We observe that the spectrum for the region "eye" has a different shape compared to the spectra for regions "test" and "smile". The regions "smile" and "test" have a relatively flat spectrum beyond spherical harmonic degree $L = 20$, while the region "eye" has an increasing slope. Following [4], for magnetic sources that are randomly oriented at depth, a more steeply increasing slope can be interpreted as a shallower depth to the sources. We fit our regional spectra to simple parameterized models of the form derived by [4] as arising from an infinitely thin layer of randomly oriented dipoles buried at decorrelation depth d. We do not interpret these as actual depths. Instead, we use them as observables parameterizing the shape of each regional spectrum. The dashed lines in Fig. 2 show the fitted decorrelation spectra for spherical-harmonic degrees $L = 20$–80. The corresponding decorrelation depths are reported in the legend.

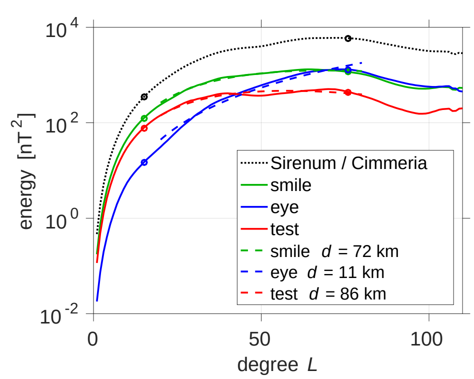

Figure 2: Subregional spectra (solid lines) for the regions shown in Fig. 1. Multitaper bandwidth $L_{\mathrm{tap}} = 30$. Decorrelation depths d obtained from fitting decorrelation spectra (dashed lines) to spherical-harmonic degrees $L = 20$–80. Dotted line is spectrum for entire Terra Sirenum / Cimmeria region.

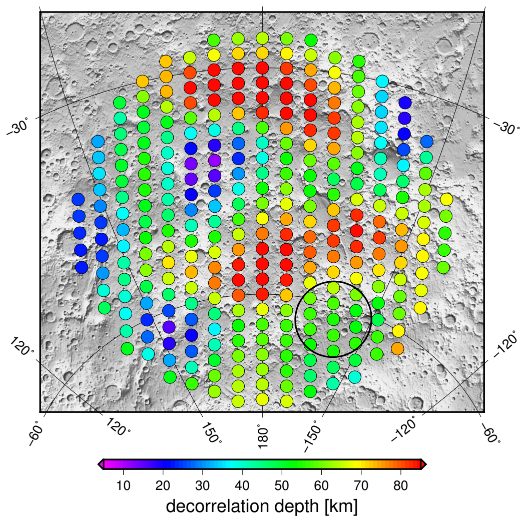

Figure 3: Decorrelation depths for 5° spherical caps, tapering bandwidth $L_{\text{tap}} = 30$. Filled circles represent the decorrelation depth values. Black circle indicates the footprint of a single 5° spherical cap.

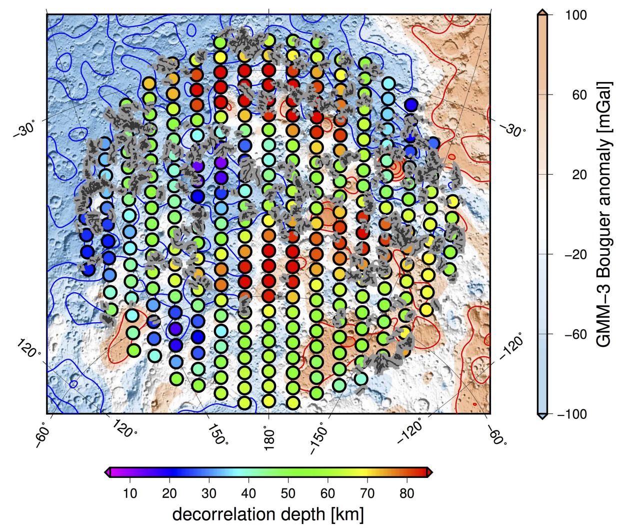

Figure 4: Valley networks by [5] plotted over decorrelation depths shown in Fig. 3 and Bouguer gravity anomaly by [6].

Spatial Distribution of Decorrelation Depths

We calculated decorrelation depths for the regional spectra of a series of 5° spherical caps arranged in a regularly spaced lattice. Fig. 3 shows the decorrelation depths for each region as a colored dot. We observe an area of shallow decorrelation depts overlapping with the region "eye" and an area of deeper decorrelation depths over the region "smile" (Fig. 1). We notice a second area with shallow decorrelation depths to the south-west of "smile" and a second area of deeper decorrelation depths north of "eye". All areas of shallow decorrelation depth appear to be concentrated within the area of the footprint of a 5° spherical cap. This may be the consequence of confined areas with strong shallow magnetic sources that, in our analysis, get aliased due to the 5° footprint of our method. The areas of deep decorrelation depths, on the other hand, appear to be broader, spanning several 5° spherical caps. Fig. 4 shows the overlay of our decorrelation depths (Fig. 3) over the valley networks by [5] and the Bouguer gravity anomaly by [6]. We observe that within the region "eye", shallow decorrelation depths overlap with a negative Bouguer anomaly. The area is surrounded by valley networks. The "smile" region overlaps with a positive Bouguer anomaly and contains no valley networks. The region south-west of "smile" has shallow decorrelation depths but only a single valley network. For the region north of "eye", containing deep decorrelation depths, we observe a negative Bouguer anomaly and valley networks. This last region coincides with a weaker crustal magnetic field (Fig. 1).

Summary and Discussion

We investigated the crustal magnetic field model presented by [3] over the Terra Sirenum / Cimmeria region. To circumvent difficulties with spatial interpretation of satellite-based crustal magnetic field anomalies we calculated regional crustal field spectra and compared spectral slopes for spherical-harmonic degrees $L = 20$–80 of different areas. The decorrelation depths, revealed by parameterized fits to the spectral slopes, vary strongly within the Terra Sirenum / Cimmeria region. Areas of shallow decorrelation depths appear to be spatially more confined, while areas of deep decorrelation depth appear to cover broader areas. Comparisons with valley networks and Bouguer gravity anomalies show, at this point, little obvious correlation.

Acknowledgements

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References

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