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Local high-resolution crustal magnetic field analysis from satellite data

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Planetary crustal magnetic fields are key to understanding a planet or moon's structure and history. Due to satellite orbit parameters such as aerobraking (Mars) or only partial coverage (Mercury), or simply because of the strongly heterogeneous crustal field strength, satellite data of planetary magnetic fields vary regionally in their signal-to noise ratio and data coverage. To take full advantage of data quality within one region of a planet or moon without diluting the data with lower quality measurements outside of that region we resort to local methods. Slepian functions are linear combinations of spherical harmonics that provide local sensitivity to structure. Here we present a selection of crustal magnetic field models obtained from vector-valued variable-altitude satellite observations using an altitude-cognizant gradient-vector Slepian approach. This method is based on locally maximizing energy concentration within the region of data availability while simultaneously bandlimiting the model in terms of its spherical-harmonic degree and minimizing noise amplification due to downward continuation. For simple regions such as spherical caps, our method is computationally efficient and allows us to calculate local crustal magnetic field solutions beyond spherical harmonic degree 800, if the data permit. We furthermore discuss extensions of the method that are optimized for the analysis and separation of internal and external magnetic fields.