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Sounding the Earth's electrical structure with satellite-detected ocean tidal magnetic signals

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Over the last decade, the quality of satellite data, processing and modeling methods have experienced substantial improvements leading to a stage where satellite-observed tidal magnetic signals can be used to image electrical conductivity of the subsurface. In 2015, a collaborative project supported by ESA's STSE program was kicked off with the primary goal of performing the necessary data processing and their inversion.
We present the first radial electrical conductivity model of the oceanic lithosphere and upper mantle obtained by inverting ocean tidal magnetic signals on the global scale. Specifically, the oceanic M2 tidal magnetic field was extracted as a part of the comprehensive magnetic field model (CM5) based on the twelve years of data from pre-Swarm satellite missions and magnetic observatories. The magnetic field was shown to exhibit structure on multiple spatial scales providing uniform global spatial coverage. In order to accurately model the tidal signal, we built the source by using the latest generation of the high-resolution HAMTIDE oceanic tide model and also derived laterally variable electrical conductivity of the world ocean. A surface conductance map that takes into account continent/ocean conductivity and sea-bottom sediment conductivity was used to account for the near-surface inhomogeneous layer. The integral equation forward solver was combined with a global stochastic optimization method and random sampling to carry out the inversion and uncertainty quantification. The obtained model is consistent with the existing regional models and provides a view on global lithosphere-asthenosphere boundary.