Joint inversion of magnetotelluric tippers and geomagnetic depth sounding transfer functions constrains electrical conductivity beneath islands

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Geomagnetic field variations recorded at island geomagnetic observatories are one of the data sources that can be used to constrain the electrical conductivity beneath oceans. Hitherto, magnetotelluric (MT) tippers (period range from a few minutes to 3 hours) and geomagnetic depth sounding (GDS) transfer functions (TFs; period range from 6 hours to a few months) were inverted separately to reveal the electrical conductivity structure underneath island observatories. In this study, we develop a quasi 1-D tool to simultaneously invert MT tippers and GDS TFs. To account for source complexity, we resort to GDS TFs that relates a set of spherical harmonics coefficients describing the source (of ionospheric or magnetospheric origin) to a locally measured vertical magnetic field component. Joint inversion of multiple data sets from different sources helps to improve vertical resolution and reduce uncertainties in the recovered conductivity models. The stochastic optimization method, known as Covariance Matrix Adaptation Evolution Strategy, is applied to solve the inverse problem. The term “quasi” is used here to stress the fact that during 1-D inversion the 3-D forward modeling operator is exploited to account for the ocean induction effect (OIE), which is known to strongly influence the island electromagnetic (EM) responses. To efficiently model MT tippers and GDS TFs, the Cartesian-to-Cartesian and spherical-to-Cartesian 3-D EM modeling engines, based on a nested integral equation approach, are adopted. We apply the developed tool to jointly invert MT tippers and GDS TFs estimated at Honolulu geomagnetic observatory, located at Oahu island (Hawaii) in Pacific Ocean, and discuss the recovered conductivity structure.