

Non-inductive electric fields in Florida and Kīlauea, Hawaii magnetotelluric data: oceanographic signal degrading the transfer functions

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SUMMARY

Magnetotelluric transfer functions estimated from data collected in coastal Florida show mode degradation over a broad geographic area, specifically in the impedances derived from the north-south electric fields (Z_{xy}) at long periods (typically > 3000 seconds). The vertical magnetic field transfer functions (tippers) and the other principal impedance components (Z_{yx}) remain unaffected, implicating the north-south electric field as the causative factor. Furthermore, there are indications that the north-south electric field includes a considerable non-inductive component, which could be caused by a variety of phenomena (e.g., exclusion-diffusion potentials; electrokinetic, thermoelectric, and/or electrochemical effects). Importantly, synchronous data recorded at sites far from the coast (~ 170 - 250 km away) do not show this mode degradation. Degraded transfer functions persist throughout years of data collection, observed in three long-period datasets between 2015 and 2022. The degraded impedances are not due to the “vanishing mode” effect, arising from attenuated electric fields in conductive ground, as apparent resistivities are modest (5-100 ohm-m). Spectra of affected stations have intermittent, high-amplitude signals in the north-south electric fields, spanning the majority of the frequency band (5-10,000 seconds), while similar signals are absent in the magnetic fields. Particularly enigmatic is a station on the east coast of Florida, where the period between high amplitude signals is irregular and significantly less than the usual diurnal period (~ 6 -11 hours). We analyze the spectral density matrix for arrays of synchronous stations (Egbert 1997) incorporating both impacted and clean stations. An examination of the associated signal and incoherent noise power is ongoing and may help to elucidate the source of these non-inductive electric fields.

Magnetotelluric data collected at Kīlauea, Hawaii between May 2022 and August 2023 also show non-inductive electric field signals. Long period impedances (> 1 second) are severely degraded, while tippers are high-quality to periods of 1,000 seconds or longer. Low-quality impedances tend to be near the coastline and summit regions, however high-quality responses are occasionally recovered in these regions. In the spectra and time series, non-inductive electric field disturbances are observed on time scales ranging from 10s of seconds to ~ 1 day with amplitudes that are one to two orders of magnitude greater than the inductive magnetotelluric signal. We focus on the long-period non-inductive electric fields near the coastline, where there is significant seawater intrusion within porous basalt flows. We speculate that these long period non-inductive electric fields are the result of exclusion-diffusion potentials arising from ocean current forcing the saline-freshwater interface beneath the edge of the island.

Keywords: non-inductive electric fields, magnetotelluric, oceanographic, transfer functions, data processing

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