A tensor measurement with simultaneously transmitted Electromagnetic Accurately Controlled, Routinely Operated Signal System: utilization of distortionless response tensor

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The Electromagnetic Accurately Controlled, Routinely Operated Signal System (EM-ACROSS) is a specially designed system for controlled source electromagnetic investigation. The EM-ACROSS combines with a stable transmitter system and at least one receiver for obtaining the electric and magnetic field at the observation site. The core purpose of this system is a specifically designed signal which is repeatedly transmitted with high accuracy and precision to against the noise.

For obtaining a tensor measurement to solve the galvanic distortion issue, two independent signals were transmitted respectively by the different grounded sources for tensor electromagnetic fields. Two signals were specially designed for different antennas with specifically chosen frequency sets. Which were detectable in the data processing due to its accurately controlled properties. This system provided vector source current at the transmitter and the vector electric field measurements at an observation site without interference, leading to the observation of a “source-current” to “electric-field” tensor response. As the source was precisely controlled, the receiver could get a high signal-to-noise ratio data from the data stacking process.

A forward modeling code was developed for this system by utilizing the finite element method with tetrahedral unstructured meshes. For comparing the calculated electric fields from the forward modeling with those observed, the local distortion effect due to the near surface inhomogeneities was addressed by a new tensor function, which dived out the distortion effect.

This distortionless tensor function was utilized to verify the temporal change in the inversed resistivity models with magnetotelluric (MT) data at Kusatsu-Shirane volcano, Japan. To evaluate the detectability by this tensor system, two 3D resistivity models were prepared. One is the 3D inverted model which inverted from a 2001-2005 MT dataset, and the other is the 3D inverted model from a 2017-2018 MT dataset. For the respective two inverted resistivity models the numerical responses from forward modeling and the observed EM-ACROSS responses (in 2017-2018) were compared by utilizing the distortion-removed electric field tensors. The EM-ACROSS data (2018-2018) fit better with the 3D modeling response using the 2017-2018 MT data than to that using 2001-2015 MT data.

This study provided an alternative method to verify the temporal changes in a volcanic hydrothermal

system with joint time-lapse MT monitoring and controlled source electromagnetic observation. The developed system provides a solution for the environmental noise issue and distortion effect. The final product could be the new conception in future exploration and monitoring in the volcanos.

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