

Electromagnetic Fields Observations at Underground Laboratory

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SUMMARY

Deep underground laboratories offer advantages for conducting high-precision observations of weak geophysical signals, benefitting from a low background noise level. We conducted synchronous electromagnetic (EM) observations at both ground level and a depth of few hundred meters within different underground laboratories in China. The results show that underground data exhibited significantly lower levels of contamination from background noise. The Allan variance analysis suggested favourable conditions for long-term stable observations in an underground environment. Ground level data exhibited diurnal disturbance noise associated with human activities, a characteristic absent in the underground data. The self-noise of both electrical and magnetic sensors (i.e., electrodes, induction coils, and fluxgates) was calculated using a multiple channel correlation analysis approach. The results show that the self-noise of induction coils is less than the amplitude of observed signals in a frequency band of < 1 Hz at a depth of 848 meters, where the cover layer presents an effective resistivity of approximately $2 \Omega m$. However, the fluxgates are suggested to be insufficient to differentiate signals from self-noise at underground levels. Additionally, we propose an EM field reconstruction method employing a Long Short-Term Memory (LSTM) recurrent neural network with referenced deep underground EM observations. Both theoretical analysis and practical observational data suggest that the proposed method effectively suppresses noise and reconstructs clean EM signals.

Keywords: Electromagnetic fields, Underground laboratory, Self-noise, Recurrent neural network
