Application of Ensemble Kalman Inversion and Model Reduction Using Discrete Cosine Transform in Geo-Electromagnetics

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SUMMARY

In geo-electromagnetic studies, the interpretation of subsurface properties through inverse modeling is crucial for understanding geological structures and resource exploration. Traditional inversion techniques often face challenges such as non-linearity, high computational cost, and sensitivity to noise. This study explores the application of Ensemble Kalman Inversion (EKI) combined with model reduction using the Discrete Cosine Transform (DCT) to enhance the efficiency and accuracy of geo-electromagnetic inversions.

Ensemble Kalman Inversion is a powerful iterative method that assimilates observational data with model predictions to update the subsurface property estimates. By leveraging the statistical properties of an ensemble of models, EKI effectively mitigates the effects of noise and provides robust inversion results. However, the high dimensionality of the model parameterization can make the inversion process computationally expensive.

To address this issue, we integrate model reduction techniques using the Discrete Cosine Transform. DCT efficiently compresses the data by transforming it into a frequency domain, where the significant components are preserved while discarding the redundant information. This reduction not only decreases the computational load but also enhances the stability and convergence of the inversion process.

We apply this combined approach to synthetic data sets to demonstrate its effectiveness. The preliminary results show that the EKI-DCT method may provide accurate subsurface property estimates with reduced computational effort compared to traditional methods. The integration of DCT with EKI allows for maintaining dominant features while ensuring efficient processing, making it a promising tool for large-scale geo-electromagnetic inversions.

This study highlights the potential of combining Ensemble Kalman Inversion with model reduction techniques to improve the practicality and performance of geo-electromagnetic studies, paving the way for more detailed and extensive subsurface investigations.

Keywords: Ensemble Kalman Inversion, Geo-Electromagnetics, Model Reduction, Discrete Cosine Transform, Subsurface Imaging

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