

Deep Image Prior for Geophysics: A Physics-Informed Zero-Shot Super-Resolution Framework for Airborne Gravity Downward Continuation

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Abstract

Downward continuation restores short-wavelength gravity that is attenuated at flight altitude, but it also amplifies high-frequency noise exponentially. We propose Physics-Informed Zero-Shot Super-Resolution (PI-ZSSR): an untrained U-Net synthesizes a candidate field at the target altitude, accepted only if its upward continuation matches the observation. We then extend the framework with a Dual Physics Constraint to predict unobserved 0 m gravity from multi-altitude data. On Taiwan airborne surveys, continuation from 5156 m to 1620 m attains 3.55 mGal RMSE against independent 1620 m LSC on the common coverage; LSC-only continuation of the same filled grid yields 3.59 mGal. Dual-constraint prediction of the unobserved 0 m residual is consistent with both LSC grids (fit RMSE 1.38 mGal at 5156 m and 0.69 mGal at 1620 m), with the 5156 m examiner accounting for the Central Range and the 1620 m examiner for the lowlands and offshore. Beyond the EGM2008 truncation, the 0 m residual of the dual-constraint product is coherent with XGM2019e where a 1620 m-only run is not (band coherence 0.41 versus 0.16), although its short-wavelength amplitude over the mountains stays far below that of XGM2019e, as the attenuation over 5 km and the discrepancy stopping rule require.

Keywords: airborne gravity; downward continuation; deep image prior; least-squares collocation; dual-altitude constraint; discrepancy principle