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Deep learning in RTM gravity field modeling: A case study over Wudalianchi area

Meng Yang, baoyu Zhang, Lehan Wang, Wei Feng, and Min Zhong
Sun Yat-Sen University, School of Geospatial Engineering and Science, Zhuhai, China (yangmeng5@mail.sysu.edu.cn)

The Residual Terrain Modeling (RTM) technique is commonly used to recover short-wavelength gravity field signals. However, classical gravity forward modeling methods for RTM gravity field determination face challenges such as series divergence, inefficient computation, and errors induced by tree canopy in Digital Elevation Models (DEMs). In this study, deep learning methods are employed to enhance the quality of the computed RTM gravity field. Experiments are conducted at the Wudalianchi airborne gravity gradiometer test site, which provides a large volume of precise gravity measurements. The Random Forest method is used to estimate and correct tree canopy height errors in DEMs. A fully connected deep neural network (FC-DNN) is introduced to efficiently calculate the RTM gravity field. Additionally, to improve the network's generalization capability, a novel terrain information fusion regularization method is applied to create an Improved FC-DNN with a refined loss function. The accuracy, computational efficiency, and generalization performance of the deep learning method are evaluated and compared in the Wudalianchi volcanic region. The results demonstrate a significant improvement in the accuracy of the RTM gravity field when based on tree canopy-corrected DEMs. The RTM gravity fields determined using both FC-DNN and Improved FC-DNN achieve mGal-level accuracy, with a remarkable 10,000-fold increase in computational efficiency compared to the classical Newtonian integration method. The Improved FC-DNN exhibits superior generalization, with accuracy enhancements ranging from 7% to 21% compared to the standard FC-DNN.