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Bare-earth DEM Generation in Urban Areas Based on a Machine Learning Method

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Precise representation of global terrain is of great significance for estimating global flood risk. As the most vulnerable areas to flooding, urban areas need GDEMs of high quality. However, current Global Digital Elevation Models (GDEMs) are all Digital Surface Models (DSMs) in urban areas, which will cause substantial blockages of flow pathways within flood inundation models. By taking GPS and LIDAR data as terrain observations, errors of popular GDEMs (including SRTM 1” void-filled version DEM - SRTM, Multi-Error-Removed Improved-Terrain DEM - MERIT and TanDEM-X 3” resolution DEM -TDM3) were analysed in seven varied types of cities. It was found that the RMSE of GDEMs errors are in the range of 2.3 m – 7.9 m, and that MERIT and TDM3 both outperformed SRTM. The error comparison between MERIT and TDM3 showed that the most accurate model varied among the studied cities. Generally, error of TDM3 is slightly lower than MERIT, but TDM3 has more extreme errors (absolute value exceeds 15 m). For cities which have experienced rapid development in the past decade, the RMSE of MERIT is lower than that of TDM3, which is mainly caused by the acquisition time difference between these two models. A machine learning method was adopted to estimate MERIT error. Night Time Light, world population density data, Openstreetmap building data, slope, elevation and neighbourhood elevation values from widely available datasets, comprising 14 factors in total, were used in the regression. Models were trained based on single city and combinations of cities, respectively, and then used to estimate error in a target city. By this approach, the RMSE of corrected MERIT can decline by up to 75% with target city trained model, though less significant a reduction of 35% -68% was shown in the combined model with target city excluded in the training data. Further validation via flood simulation showed improvements in terms of both flood extent and inundation depth by the corrected MERIT over the original MERIT, with a validation in small sized city. However, the corrected MERIT was not as good as TDM3 in this case. This method has the potential to generate a better bare-earth global DEM in urban areas, but the sensitive level about the model extrapolative application needs investigation in more study sites.