Reconstructing total water storage changes in the Yangtze River Basin based on deep learning models

Jielong Wang\textsuperscript{1,2}, Yunzhong Shen\textsuperscript{1}, Joseph Awange\textsuperscript{2}, Ling Yang\textsuperscript{1}, and Qiujie Chen

\textsuperscript{1}College of Surveying and Geo-informatics, Tongji University, Shanghai, 200092, PR China
\textsuperscript{2}School of Earth and Planetary Sciences, Spatial Sciences Discipline, Curtin University, Perth, WA, Australia

Understanding long-term total water storage (TWS) changes in the Yangtze River Basin (YRB) is essential for optimizing water resource management and mitigating hydrological extremes. While the Gravity Recovery and Climate Experiment (GRACE) and its follow-on (GRACE-FO) mission have provided valuable observations for investigating global or regional TWS changes, the approximately one-year data gap between these missions and their relatively short 20-year data record limits our ability to study the continuous and long-term variability of YRB's TWS. In this study, two deep learning models are employed to bridge the data gap and reconstruct the historical TWS changes within YRB, respectively. For the data gap filling task, a noise-augmented u-shaped network (NA-UNet) is presented to address UNet's overfitting issues associated with training on limited GRACE observations. Results show that NA-UNet can accurately bridge the data gap, exhibiting favourable and stable performance at both the basin and grid scales. Subsequently, we introduce another deep learning model named RecNet, specifically designed to reconstruct the climate-driven TWS changes in YRB from 1923 to 2022. RecNet is trained on precipitation, temperature, and GRACE observations using a weighted mean square error (WMSE) loss function. We show that RecNet can successfully reconstruct the historical TWS changes, achieving strong correlations with GRACE, water budget estimates, hydrological models, drought indices, and existing reconstruction datasets. We also observe superior performance in RecNet when trained with WMSE compared to its non-weighted counterpart. In addition, the reconstructed datasets reveal a recurring occurrence of diverse hydrological extremes over the past century within YRB, influenced by major climate patterns. Together, NA-UNet and RecNet provide valuable observations for studying long-term climate variability and projecting future hydrological extremes in YRB, which can inform effective water resource management and contribute to the development of adaptive strategies for climate change.