

論文 / 著書情報  
Article / Book Information

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## 論文要旨

THESIS SUMMARY

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### 要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

The increasing stress on terrestrial systems has threatened nearly 2/3<sup>rd</sup> of the prevailing habitats, with over five billion people living in the regions prone to water scarcity of varying levels. This number is most likely to increase due to climate change, population growth, and human activities like groundwater extractions, water impoundments and diversions, urbanization, and land use cover changes. Apart from compromising food production and reduced freshwater availability, unsustainable water usage and subsequent depleting water storage can ultimately affect the economy with a more pronounced and severe impact on the developing agrarian countries like India and Thailand. Therefore, a long-term basin-scale assessment of water storage dynamics and water-related extremes is imperative for understanding the systematic changes in the hydrological system and ensuring timely and equitable water share. This thesis is devoted to addressing the above by jointly assimilating the Gravity Recovery and Climate Experiment (GRACE) gravity data, a global hydrological model (GHM), i.e., PCR-GLOBWB model outputs, auxiliary weather datasets from remote sensing and reanalysis products, and in-situ observations for three Peninsular Indian river basins, namely, Godavari, Krishna, and Mahanadi river basins and Chao Phraya river basin in Thailand.

Quantification of the land water storage (LWS, comprised of biomass, snow cover, surface water, canopy water, and soil moisture and groundwater) and groundwater storage (GWS) deficits (i.e., below normal conditions) in Peninsular India for 35 years from January 1980 to December 2014 shows that the study basins experienced high interannual variations despite the minimal linear LWS trends (0.26-0.56 mm yr<sup>-1</sup>). GWS showed a slow but persistent response (longest deficit spanning ~6 years) to the seasonal variations in the hydrological fluxes and remained the major contributor to LWS and primarily governed the water availability during dry years. The GHM showed potential to analyze LWS and its segregated components beyond GRACE data records and the LWS-based index served as a better drought indicator than traditional drought indices. GRACE-LWS emerged as a proxy indicator of real-time groundwater monitoring without relying upon the intermittent in situ observations. The GHM underestimated both the increasing and decreasing water storage trends and decreasing trends in the recent time highlighted the need for more detailed quantification of the water storage dynamics covering the most recent periods, e.g., starting from GRACE data records in 2002. Decadal trends of terrestrial water storage (TWS; the equivalent of LWS except for water in ice sheets of Greenland and Antarctic) and its constituent components in three basins reveal a stable annual cycle and minimal trends during the period from July 2002 to June 2010, and declining trends (largest for Krishna basin) of TWS, SMS, and GWS during the period from July 2010 to June 2017. GRACE-derived GWS anomalies and those obtained from the in-situ data are in good agreement depicting the profound applicability of satellite observation in quantifying basin-wide water resources.

Further, the developed artificial neural network method coupled with the genetic algorithms ensures the continuity in and between the two GRACE missions. Long-term analysis for the Chao Phraya River Basin, with more complex human interventions, e.g., reservoir management, than the Indian basins, revealed a linear trend of -1.12 cm yr<sup>-1</sup> (equivalent to a volumetric trend of -1.79 km<sup>3</sup> yr<sup>-1</sup>). GWS is a significant contributor (45%) to TWS with a linear trend of -0.51 cm yr<sup>-1</sup> (-0.82 km<sup>3</sup> yr<sup>-1</sup>) followed by surface water storage (i.e., cumulative of the water storage in the reservoirs, flood inundation, and rivers) (36%) and soil moisture storage (19%) during 2002-2020. The variations in precipitation primarily trigger the hydroclimatic extremes detected in TWSA during the monsoon season (May to October) and are further amplified by the subsequent water storage and abstraction. All the flood and drought events are well recorded in TWSA, albeit with a lag time of up to two months from precipitation. The basin's increasing potential for severe drought, as assessed by the effective water storage-based novel drought potential index (DPI), underscored the need for multifaceted water management essentially focused on the demand side rather than the supply side in the basin. Lastly, a physically consistent zero water budget residual was enforced with three different mathematical techniques, and the seasonal and annual variations of the closure constraints (i.e., wet or dry biases) were studied for the inferences of likely over(under)estimation of various water budget components.

The proposed framework for observation-based assessment of the various water cycle components and the water budget closure in this thesis puts forward a blueprint for effectively and efficiently managing the basin-scale water resources and food security and developing the early warning systems for droughts and floods in the data-scarce river basins globally. Future research should focus on disentangling the human-induced and the climate-driven signals in the TWS for an advanced understanding of the earth system processes and adapting and prioritizing the mitigation strategies, especially in the basins vulnerable to the hydroclimate extremes.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note: Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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