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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 ）

Management of water resources is pivotal to society, as surface waters are vulnerable to floods and droughts. River discharge is one of the important hydrodynamic characteristics in assessing the water resources. However, the limitations of the hydrodynamic modelling and heterogeneity of in-situ gauges limit predictability of water resources. Uncertainty in global river model simulations lead to uncertainties in estimating river discharge. With the recent developments in the satellite technology have enabled the estimation of river discharge from remote sensing data. But the river discharge cannot be directly measured from space, hence data assimilation can be used to reduce the uncertainty of hydrodynamic models using the satellite observations of water surface, such as satellite altimetry.

The next-generation satellite altimetry mission Surface Water and Ocean Topography (SWOT) is slated to launch in 2020. This satellite mission is intended to provide simultaneous mapping of inundated areas and inland WSE (i.e., river, lakes, wetlands, and reservoirs), which change both temporally and spatially, using a Ka-band radar interferometer. The channel centerline and width (above 50 m), which can be extracted from the dynamic water mask in SWOT, can be used to measure water storage changes in terrestrial water bodies and to characterize river discharge. Although indirect estimation of WSE from the spatial intersection of a water mask and a digital elevation model is possible, shoreline methods were not able to characterize WSE in the context of complex floodplain geomorphologies,

Large-scale hydrodynamic data assimilation demands an efficient Kalman filtering technique with a low computational burden. The computationally efficient Local Ensemble Transformation Kalman Filter (LETKF) has been used at the global scale in numerical weather prediction studies, because it can process a large number of variables efficiently in a local patch. In addition, LETKF is simple in calculation of prior covariance matrix and flow-dependent covariance models can be used. Therefore, LETKF has the potential to be an efficient algorithm for estimating river hydrodynamics with a low computational burden.

We derived a physically based empirical data assimilation method which uses an empirical local patch. The empirical local patches were derived adaptively for each river pixel, by considering the spatial auto-correlation of water surface elevation (WSE) modelled by hydrodynamic model for 1980 to 2000.The derived empirical localization parameters were tested using -25% biased runoff experiment to assess the potential of using empirical localization parameters with LETKF algorithm. We were able to use the maximum number of observations for assimilation without promoting error covariance due to the limited sample size by using empirical local patches. Conventional local patches cannot filter based on error covariance of observations, which lead to spurious errors from small tributaries. Using the empirical local patch technique allows use of distant observations, which cannot be effectively used with the conventional local patch method. Therefore, the limitations of conventional patches can be overcome using empirical local patches.

Then, the potential of estimating accurate river discharge considering different scenarios of runoff errors using the physically based empirical data assimilation method. We conducted three experiments, namely biased, blind and different runoff

experiments. In the biased runoff experiment the input runoff 25% bias was added. Different year's runoff was used in blind runoff experiment. Whereas runoff data from a different Land Surface Model (LSM) was used in different runoff experiment. The hydrodynamics of continental-scale rivers can be reasonably estimated by assimilating SWOT observations using an empirical local patch, even when the model formulation and input runoff forcing have errors. Furthermore, our assimilation scheme shows the ability to improve discharge even without true runoff forcing using empirical local patches. Hence, our study provides knowledge useful for improving the frequency of SWOT observations and performing data assimilation at the global scale with less computational burden.

We assimilated river bathymetry using single called as "zero local patch" assimilation and "empirical local patch assimilation" to investigate the potential of assimilating river bathymetry using state-parameter assimilation. Our assimilation scheme showed the potential of estimating the bed elevation and water depths from SWOT observations, resulting in improved estimates of river discharge using SWOT observations. Bed elevation was successfully estimated without any in-situ measurements of river bathymetry from this assimilation framework. At the end 1 year of assimilation, river bathymetry was rescued reaching improved by 68.0% (reduction of global mean root mean square error) in the zero local patch experiment compared to corrupted bathymetry but some downstream river reaches were found to be have some large errors and discontinuities in the river bathymetry. On the other hand, empirical local patch assimilation not only reduced the discontinuities of large downstream river reaches but also improved the global river bathymetry by 15.0% (reduction of global mean root mean square error). Therefore, empirical local patch method has the potential to improve the global river bathymetry but more complex river bathymetry errors should be tested in future studies