Water level Modelling of the Mekong River Based on Multi-Mission Altimetry

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Background  
Half of the global drinking water is extracted from rivers and river fed reservoirs which are nowadays under stress both due to climate change and human developments in the basin. The monitoring of rivers is essential for evaluating the impact of these changes for the riparians. I aim to develop and improve methods for the observation and modelling of the flow of rivers based on satellite altimetry. For this, the Mekong River basin in South-East Asia is chosen as a study case.

While satellite altimetry is by now well established for the water level observation of large rivers, the observation of small rivers is still challenging. The first part of my work focuses on the retrieval of water levels of rivers, with a focus on small rivers, from satellite altimetry. The second part aims at combining water levels observed by different satellite missions to a temporally and spatially denser “multi-mission” water level.

Altimetric water level estimation  
Pulse limited altimetry, which was for example on board of the Envisat satellite, are prone to off-nadir measurements before and after the crossing of a water body such as a river. These off-nadir measurements form a distinct parabolic shape in the along-track collection of the heights which is called hooking effect (see Figure 1). It is shown in this project, that by including such observations rather than discarding them, the accuracy of water level estimations can be improved over small rivers (width of less than 500 m). A water level time series can be built from the repeated overflights of the satellite over the same location. The resulting time series show good results in a validation against in situ gauging data (Boergens et al., 2016). The identification of the water observations in all altimetry data of one pass is difficult for small rivers with inaccurate land-water-masks. For this, a classification method is applied to identify the water returns in CryoSat-2 SAR data.
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Fig. 1: Principle of the Hooking effect and its correction with an estimated parabola at the Mekong River.

The classification method employs the unsupervised k-means algorithm with features derived from the SAR and Range Integrated Power (RIP) waveforms. The altimetry observations classified as water are then used to estimate water levels at each crossing of the satellite with a river in the network (Boergens et al., 2017). Figure 2 shows all water level observations derived with this method in the Mekong Basin.

Fig. 2: CryoSat-2 water levels in the Mekong Basin

Combination of Multi-Mission Altimetry

As long as only one satellite altimetry mission is used for the observation of the river, both the spatial and temporal resolution is limited. However, if several missions are used, the spatial and temporal coverage of the measurements is improved. Here, the geostatistical method of spatio-temporal kriging is applied for the combination of single-mission altimetry to multi-mission altimetry. Kriging requires a covariance model between the observations that mirrors the flow of the river and that is estimated from the empirical correlations between the data.

Two covariance models are developed and tested (a stationary model, and a non-stationary model), and two kriging approaches are used (ordinary kriging to combine only data collected by satellite missions with a short-repeat time orbit, Boergens et al. (2017); and universal kriging for the combination of data of all available missions, short, long and non-repeat orbit, Boergens et al. (2018). In the latter kriging approach also data along the tributaries are included. Both methods result in time series with a five day resolution. These time series represent the water level variations of the river and the inter-annual change of the flood well, especially the extreme events of the two floodings in 2008 and 2011.

References


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