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SWOT for Monitoring Terrestrial Water Storage Changes: Quality Assessment and Combination with other Remote Sensing Data

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Introduction

Monitoring and modeling of the Earth's water cycle has become increasingly important in the last few years, especially in the context of climate change. For this purpose, different sensors can be used to retrieve valuable data sets even in remote areas. Satellite altimetry has the capability to monitor water levels of inland waters. Optical imagery has the potential to provide high-resolution information about surface area changes of inland waters. However, the classical nadir altimeters are missing many water bodies due to reduced spatial resolution. Moreover, currently, simultaneous measurements of water levels and surface areas of inland waters are hardly possible since different satellites have to be used. This limitation is addressed by SWOT.

The SWOT Project

DGFI-TUM maintains the "Database of Hydrological Time Series of Inland Waters" (DAHITI, https://dahiti.dgfi.tum.de). It provides freely available products for hydrological applications such as water level time series for lakes, reservoirs and rivers derived from multi-mission satellite altimetry. Surface area time series for lakes and reservoirs derived from optical imagery are also provided, as well as volume variations derived from combining water levels and surface area.

In this project, SWOT nadir altimeter measurements as well as the new SWOT KaRin data will be integrated into the DAHITI approach for estimating water level time series of inland water bodies (Schwatke et al., 2015). Furthermore, SWOT surface datasets will be integrated into the processing of surface area time series of lakes and reservoirs (Schwatke et al., 2019). Finally, water levels and surface areas are combined in order to estimate of volume variations for lakes and reservoirs (Schwatke et al., 2020). SWOT is expected to contribute significantly to the processing of storage changes, as it is the first satellite, which provides water level and high-resolution surface information simultaneously. This will significantly improve the estimation of hypsometry, i.e. the relation between water levels and surface areas. Furthermore, the new SWOT orbit as well as its wide swath will enable the processing of inland water bodies, which have never been captured before.

The resulting SWOT-only and multi-mission products will be validated by using in-situ data. Finally, all resulting products using SWOT will be available on DAHITI (https://dahiti.dgfi.tum.de).

Methodology

SWOT data will be integrated in the DAHITI processing scheme, which is shown in flow chart of Figure 1. In a first step, the data will be used to derive time series of water level, surface area and storage changes for global distributed lakes and reservoirs. The products will derived as SWOT-only products as well as in a combination with other remote sensing data. Within this process, the consistency will be ensured by calibrating the data in a pre-processing step.

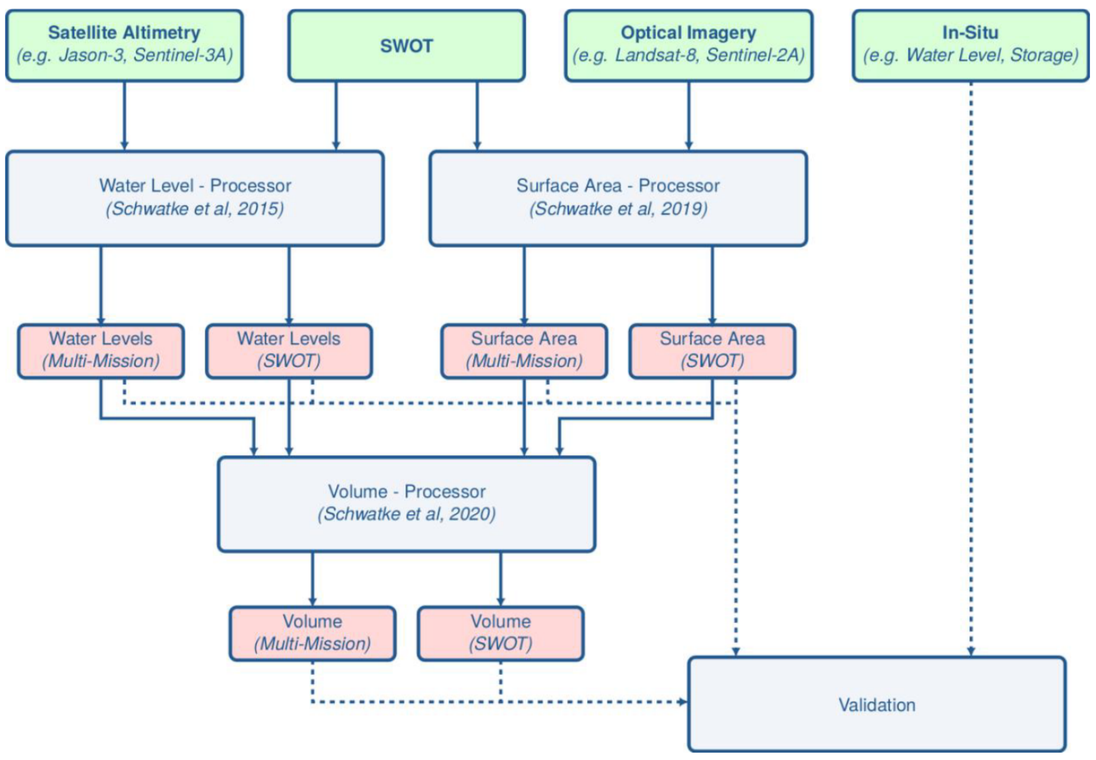
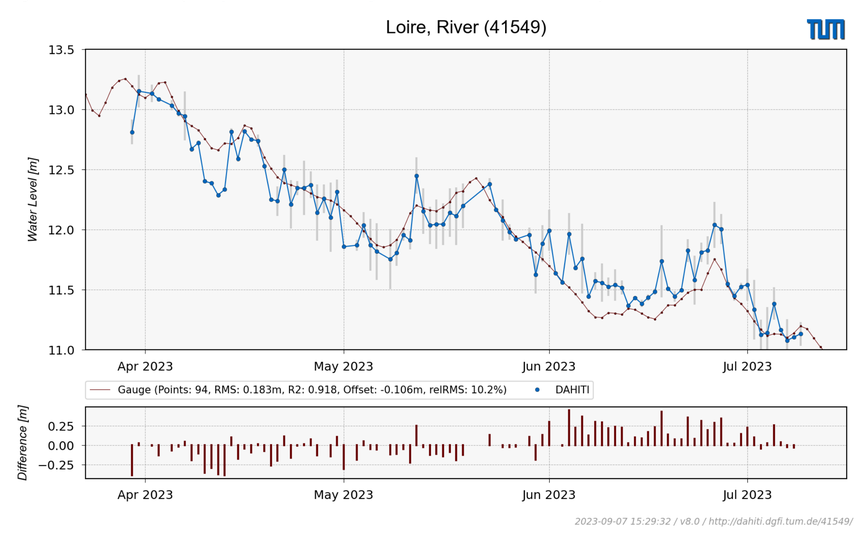
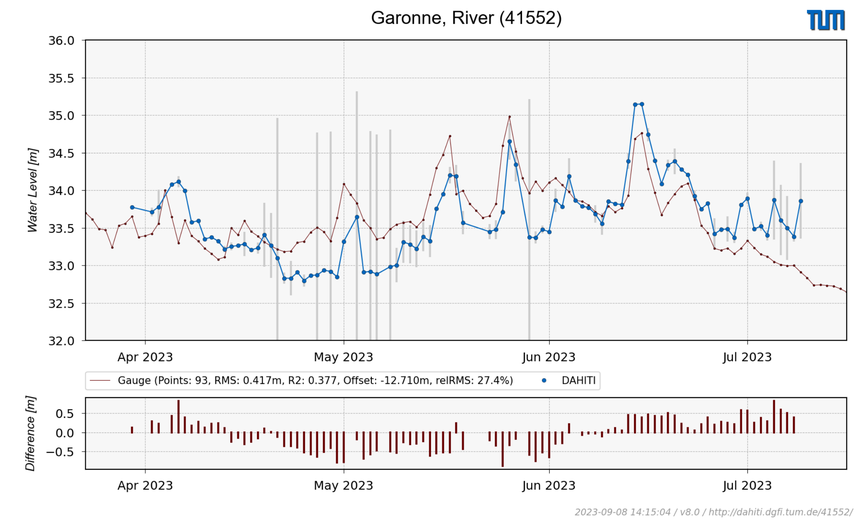


Figure 1: DAHITI-Approach for processing multi-mission water level, surface area and volume time series. Additional SWOT-only processing is added for the purpose of validation and quality assessment and for the processing of target that are not covered by the classical altimetry missions

Preliminary Results

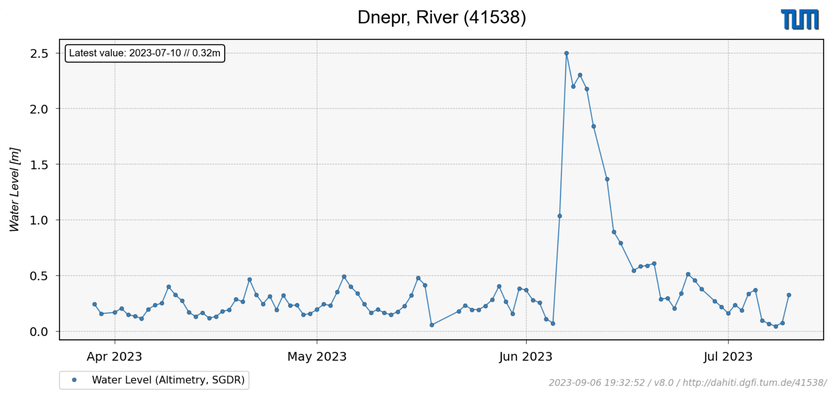
In this section, we present preliminary results of water level time series for selected virtual stations using SWOT nadir altimeter data (SWOT_L2_NALT_IGDR_v1). For validation, the water level time series are compared with in-situ gauge data provided by HydroPortail (https://www.hydro.eaufrance.fr).





Preliminary results using SWOT nadir altimeter data at the Loire River and Garonne River show similar performance as Jason-3. For the Garonne River, however, systematic time-dependent differences between altimetric and in-situ water levels can be observed. Applying a multi-mission cross-over analysis (MMXO) should decrease the time-dependent range biases in future and improved the quality of the water level time series.

The following example of the Dnepr River shows the advantage of the 1-day repeat cycle in the Cal/Val phase. The water level time series clearly shows the flood wave after the dam of the Kakhovka reservoir in Ukraine was blown up on 6 June 2023.



Summary, Conclusion and Outlook

- SWOT nadir altimeter data was added to the DAHITI approach
- Preliminary results of water level time series show RMSE values of 18.3 cm (Loire, River) and 41.7 cm (Garonne, River)
- In future, a multi-mission cross-over analysis (MMXO) should be applied to further improve the quality of water level time series
- Once publicly available, the SWOT KaRin data will be integrated into the DAHITI approach to estimate surface areas and storage changes

References

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SWOT Science Team Meeting, 19-22 September 2023, Toulouse, France