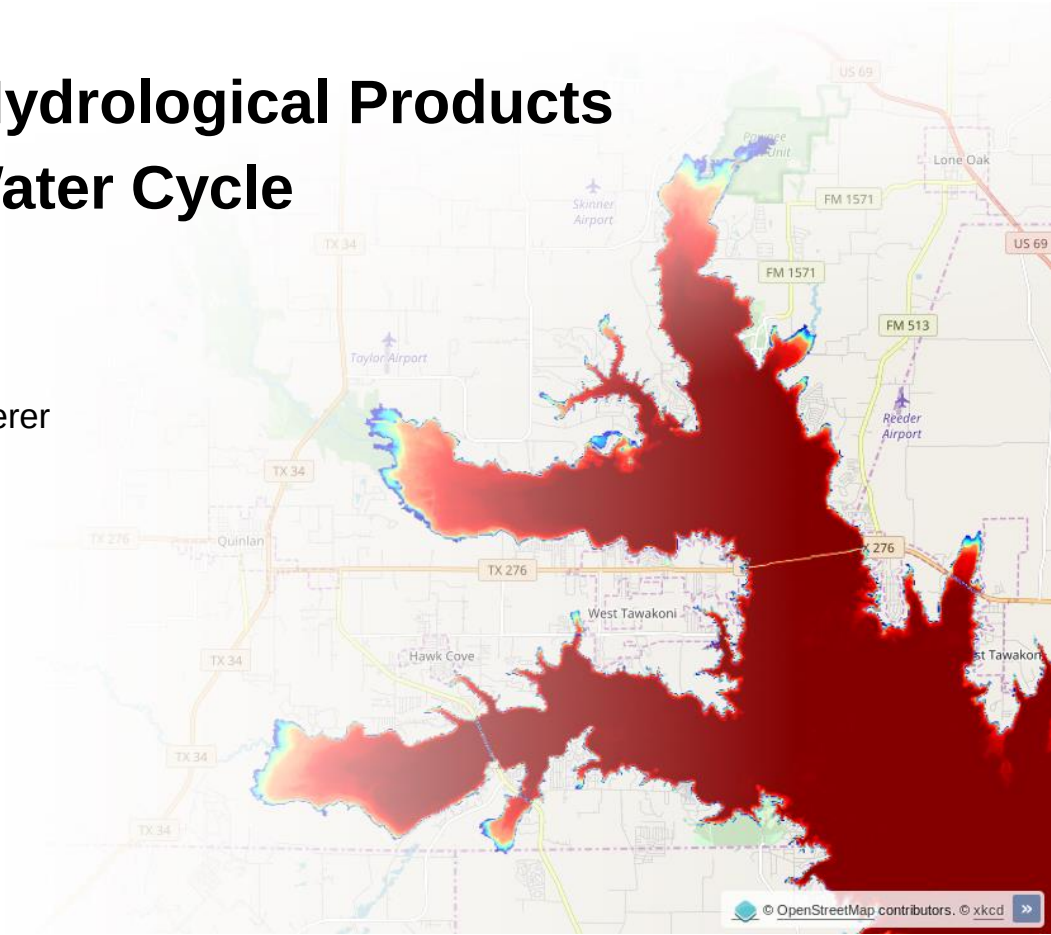
Deutsches Geodätisches Forschungsinstitut
Fakultät für Luftfahrt, Raumfahrt und Geodäsie
Technische Universität München

DAHITI – Satellite-derived Hydrological Products for Monitoring the Global Water Cycle



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Technische Universität München (DGFI-TUM)

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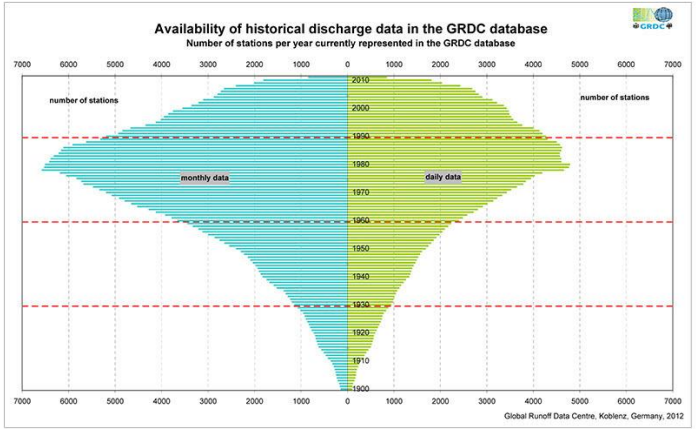
Motivation

- Monitoring and modeling of the Earth`s water cycle has become increasingly important in the last years, especially in the context of climate change.
- The number of **in-situ stations** has been **decreasing** since 1980 (see GRDC)
- **Remote sensing** has the potential to monitor storage changes of lakes and reservoirs also in remote areas by combining **water levels** and **surface areas**



Credit: Global Runoff Data Center (GRDC)

- DGFI-TUM maintains the **“Database for Hydrological Time Series of Inland Waters” (DAHITI, https://dahiti.dgfi.tum.de)** which provides more than **4400 water level time series (+1500 in 2021)** from satellite altimetry and about **200 surface area time series** for inland waters
- Additionally, DAHITI provides **70 time series of volume changes** of lakes and reservoirs derived from water levels and surface areas.

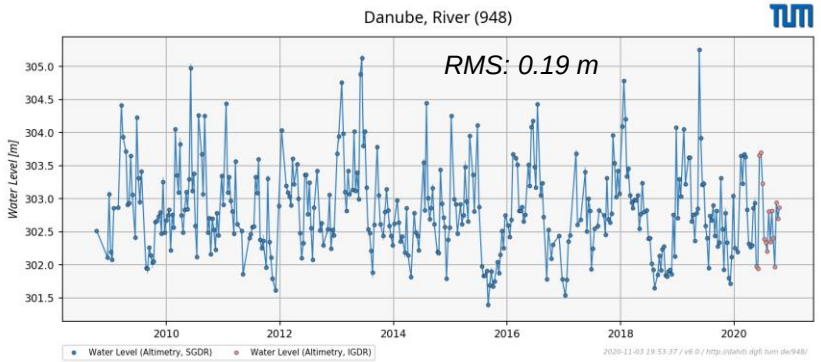
Hydrological Products in DAHITI

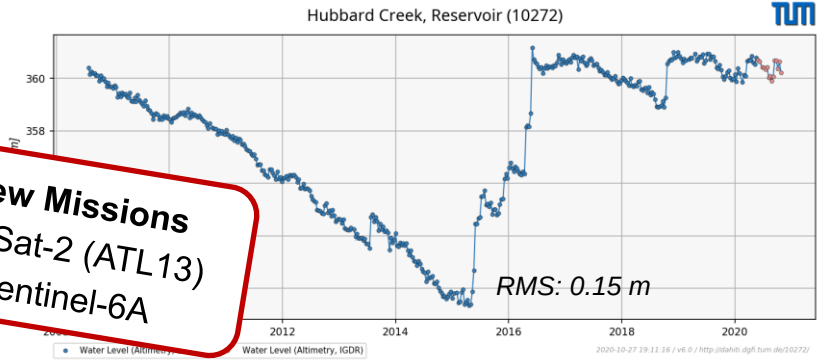
Overview of hydrological DAHITI products

- Water Level Time Series from Satellite Altimetry
- Surface Area Time Series from Optical Imagery
- Time Series of Volume Variations
- Bathymetry
- Water Occurrence Masks
- Land-Water Masks
- Hypsometry
- Time Series of Water Levels from Hypsometry
- Time Series of River Discharge

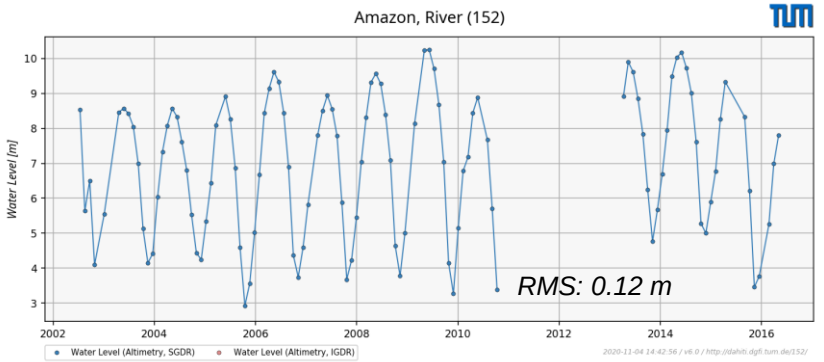
Water Level Time Series from Satellite Altimetry

- Satellite altimetry has been designed for operational monitoring of the Ocean (since 1992)
- Accurate water level time series for smaller lakes/reservoirs can be derived since 2002
- Limitations: Water body has to be crossed by at least one satellite track
- Temporal resolution: 10 - 35 days
- Accuracy: few centimeters (larger lakes) / few decimeters (smaller lakes)
- Methodology: Extended outlier detection and Kalman filter approach (Schwatke et al., 2015)



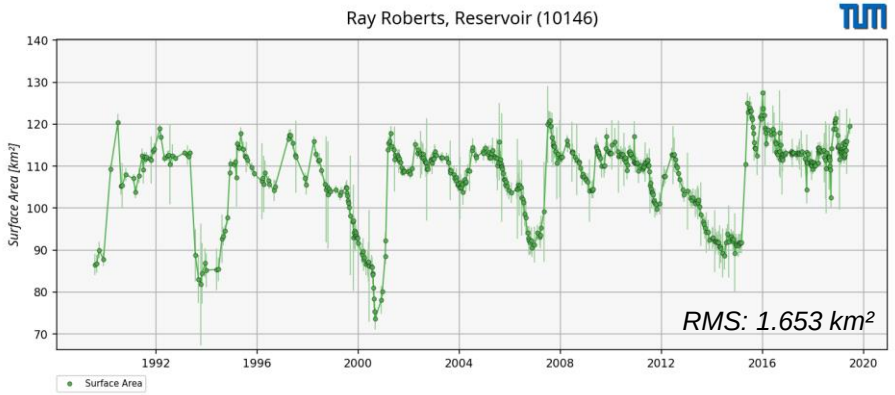


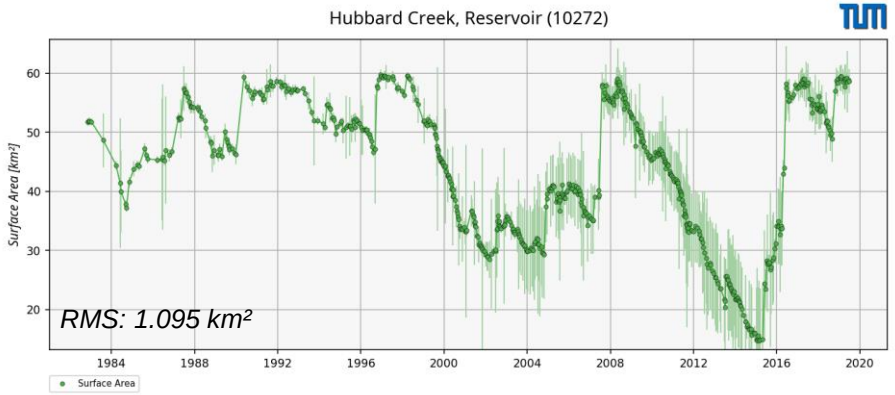
New Missions
ICESat-2 (ATL13)
Sentinel-6A



Surface Area Time Series from Optical Imagery

- Since 1972, the Landsat program is the longest-running for the acquisition of optical satellite images.
- The combination of Landsat-4,-5,-7,-8 and Sentinel-2A/2B provides optical images since 1984.
- An advantage compared to satellite altimetry is that every inland water body on Earth is captured.
- Temporal resolution: 16 days in the 1980s to about 2 – 3 days since 2017.
- Spatial resolution: 10 m – 30 m
- Methodology: Combination of five water indexes and iterative gap filling approach (Schwatke et al., 2019)
- This approach also provides products such as a water occurrence mask and land-water masks

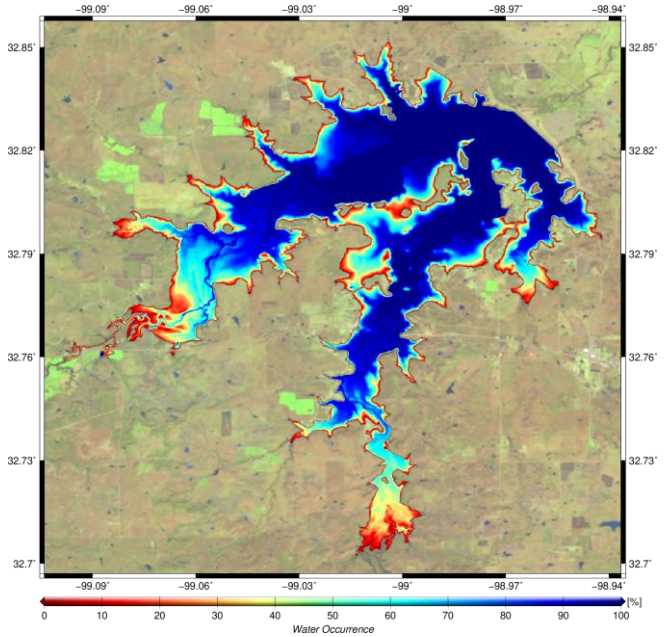


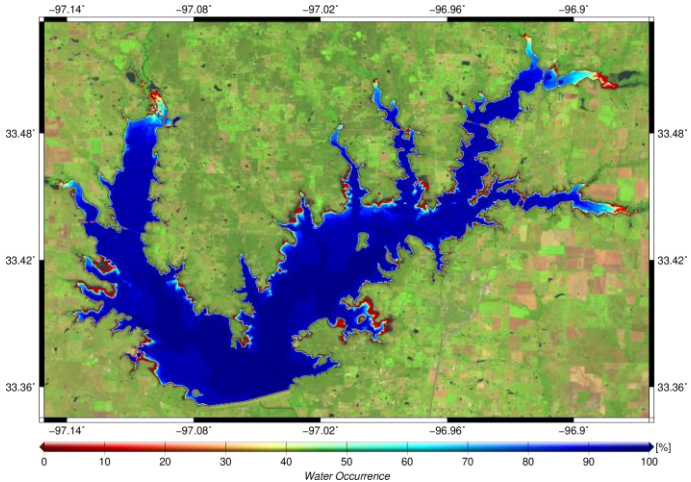


Water Occurrence Masks

- Long-term water occurrence masks are based on all available land-water masks derived from optical imagery since 1984
- They are used in an iterative approach to fill remaining data gaps caused by clouds, ice etc. in single land-water masks which are finally used for the estimation of surface area time series
- Water occurrence masks clearly show the shape of the bathymetry near lake shore

Hubbard Creek, Reservoir (10272)



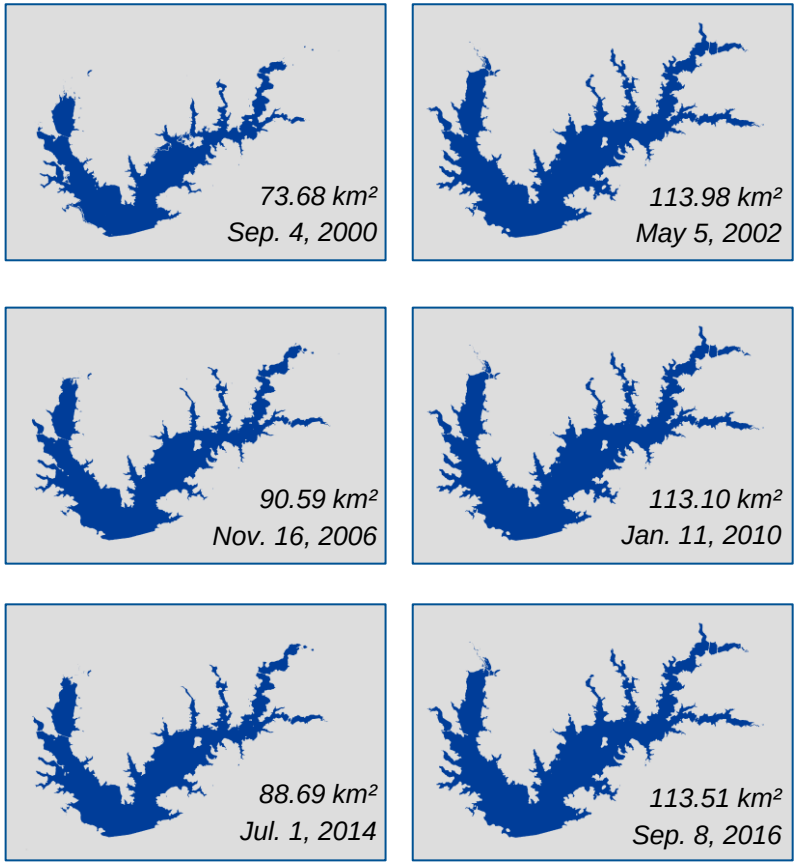


Ray Roberts, Reservoir (10148)

Land-Water Masks

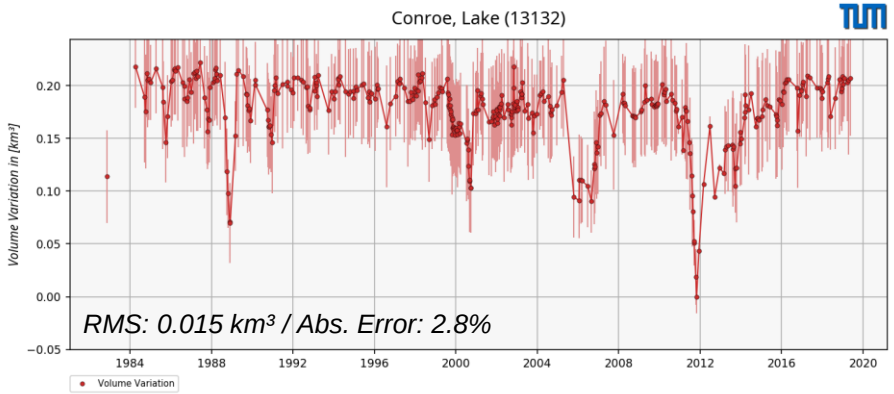
- All land-water masks are already gap-less which means that existing data gaps area already filled by using the water occurrence mask.
- They are finally used for the estimation of the surface area time series.
- All land-water masks and water occurrence masks are freely available in DAHITI

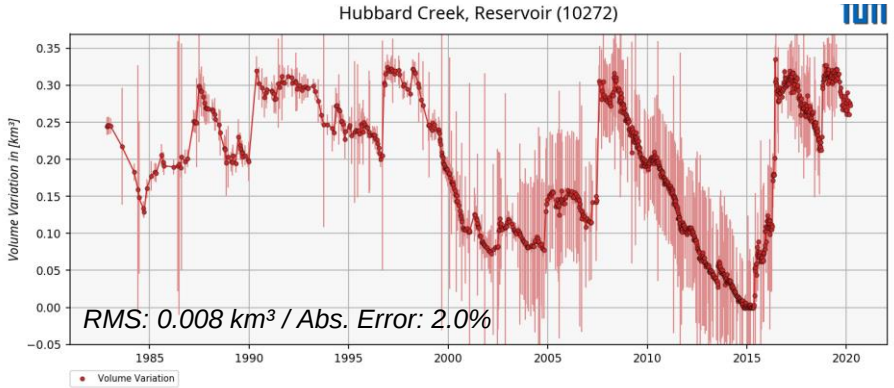
Ray Roberts, Reservoir (10148)



Time Series of Volume Variations

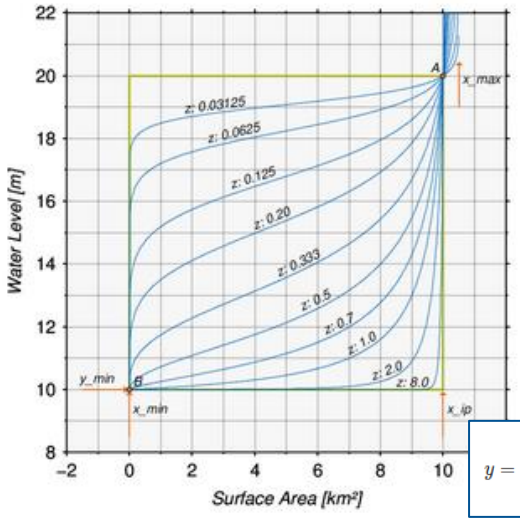
- In hydrological models mainly use storage changes of lakes and reservoirs
- Volume variations are computed by combining water level time series from satellite altimetry and surface area time series
- The methodology is based on a hypsometry model assigning water levels and surface areas in which a modified Strahler approach is applied (Schwatke et al., 2020)
- The time series from volume variations are derived from the computed bathymetry
- This approach also provides products such as bathymetry, hypsometry model and water level time series derived from surface areas using the hypsometry model
- The absolute volume accuracy varies between 1.5% and 6.4%





Hypsometry

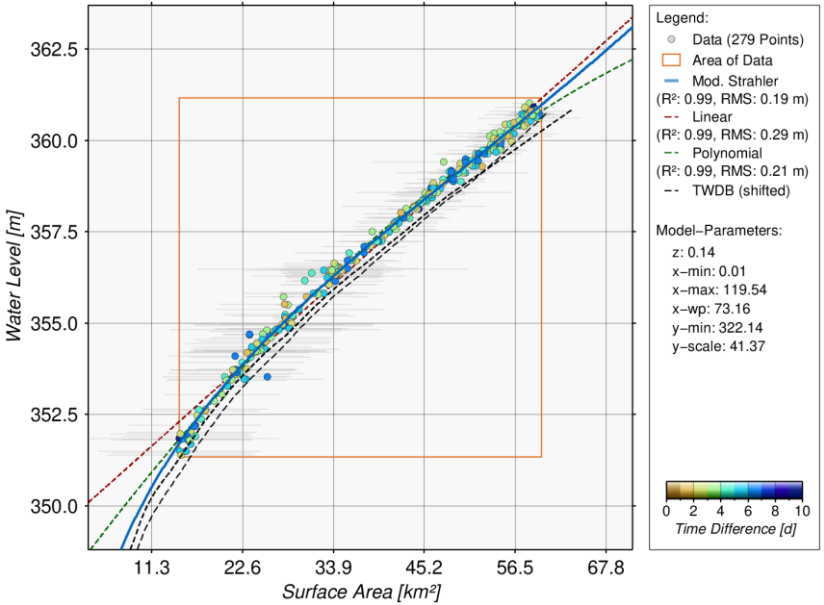
- The relationship between water level and surface area of a lake and reservoir are described by a hypsometric curve
- For this purpose, the function of a modified Strahler approach is fitted. This function describes the relationship better than often used linear or polynomial functions



Example of hypsometric curve using the modified Strahler approach

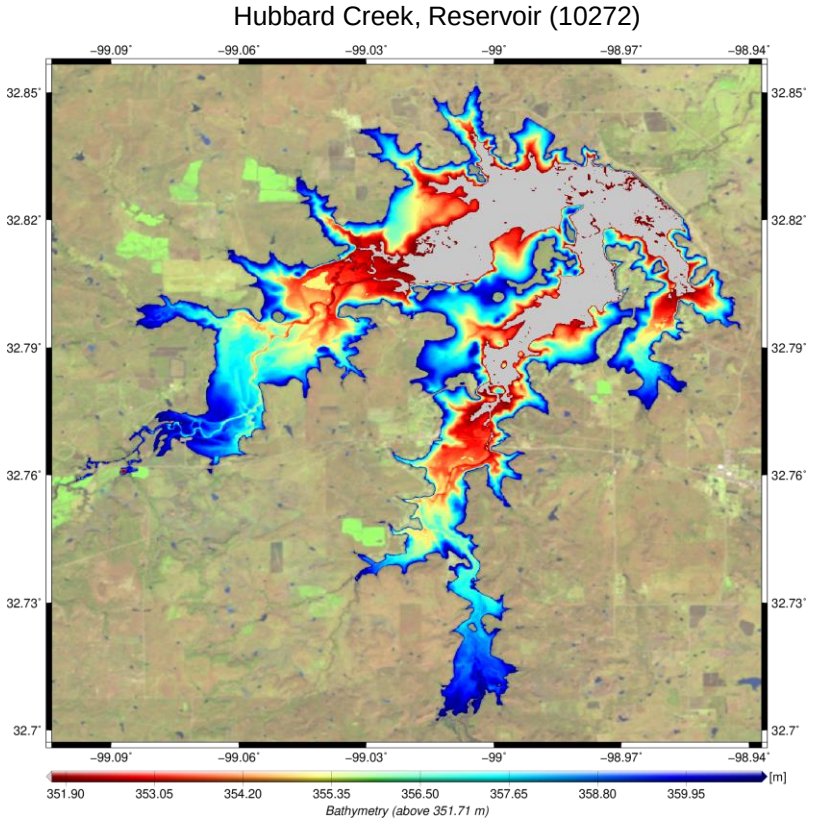
$$y = \left[\frac{(x_{min} - x)}{(x_{min} - x_{ip})} \cdot \frac{(x_{max} - x_{ip})}{(x_{max} - x)} \right]^{z} \cdot y_{scale} + y_{min}$$

Hubbard Creek, Reservoir (10272)



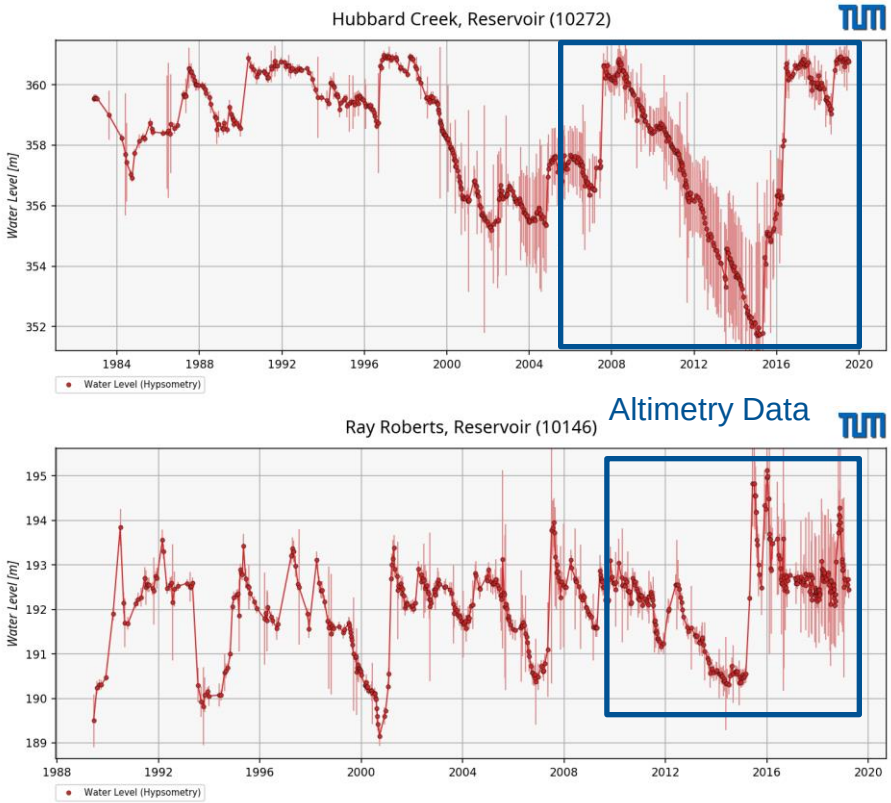
Bathymetry

- The computation of the lake bathymetry is based on the surface area time series and the corresponding water level derived from the hypsometric curve
- All stacked surface areas with corresponding water level exhibit the final bathymetry with respect to the smallest available surface area
- The bathymetry below is unknown because of missing data and therefore highlighted in gray
- The spatial resolution of the high-resolution bathymetry is 10m



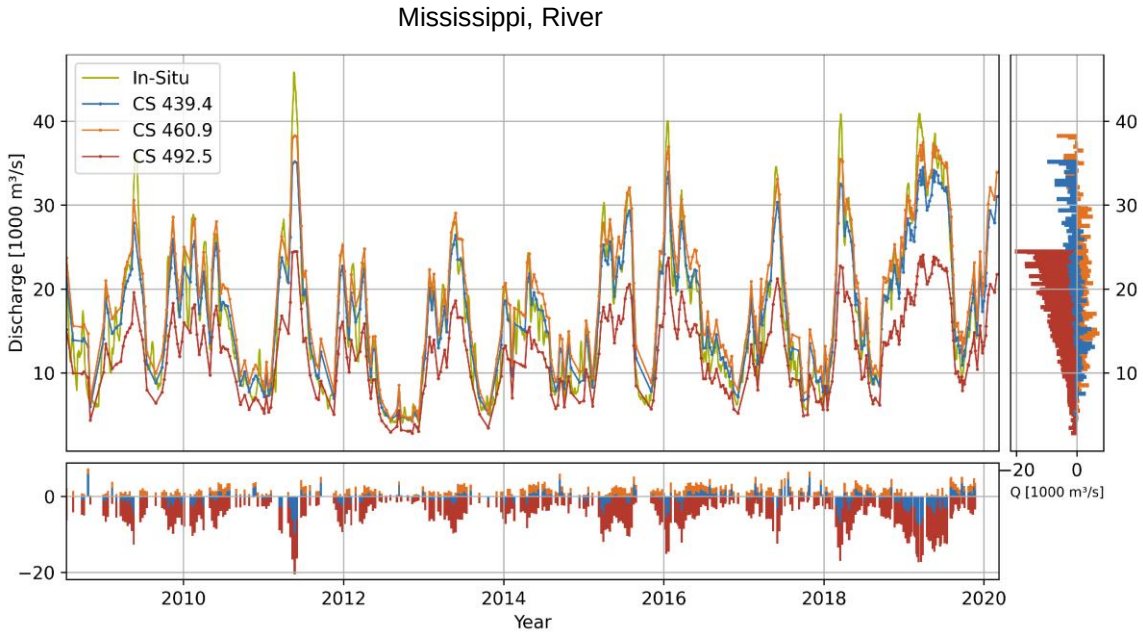
Water Level from Hypsometry

- The water level time series from the hypsometry model used the surface area time series as input data to derive water levels from the hypsometric curves
- This allows us to extend the water level time series from satellite altimetry before satellite altimetry was available
- Additionally, water level time series from satellite altimetry can be densified by this dataset



River Discharge

- River discharge time series is the newest product in DAHITI which will be public available in near future
- This approach uses water level time series from satellite altimetry and surface areas from optical imagery which are combined by a hypsometric curve (Scherer et al., 2020)
- The river discharge time series are computed at single cross-sections along the river using physical flow equations
- The accuracy shows a NRMSE between 10.95% and 28.43% for the Mississippi river



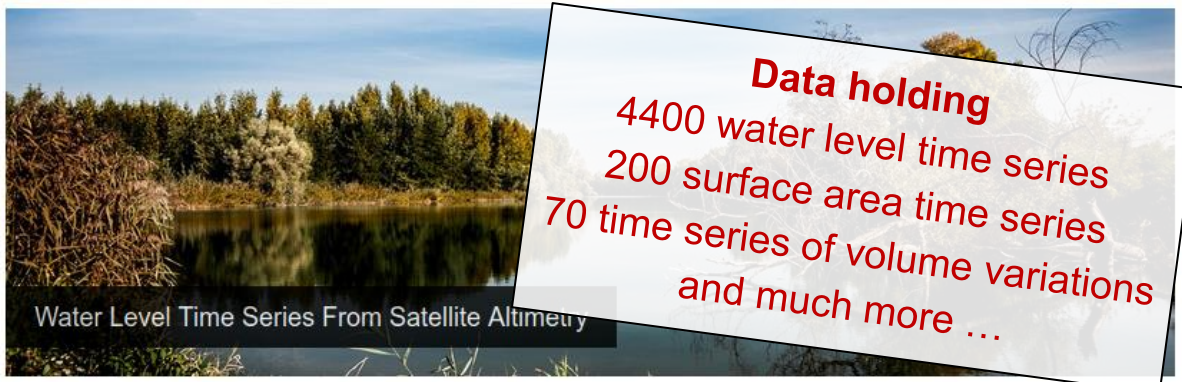
Database for Hydrological Time Series of Inland Waters (DAHITI)
Deutsches Geodätisches Forschungsinstitut
Technische Universität München

Free Data Access on
https://dahiti.dgfi.tum.de

- DAHITI
- Products +
- Virtual Stations +
- Map
- Lake/River not found?
- Publications
- DAHITI-API (Beta)
- Tools
- Projects

Search ...
Extended Search

Database for Hydrological Time Series of Inland Waters (DAHITI)



Data holding
4400 water level time series
200 surface area time series
70 time series of volume variations
and much more ...

WELCOME TO DAHITI ...

The **Database for Hydrological Time Series of Inland Waters** (DAHITI) was developed by the Deutsches Geodätisches Forschungsinstitut der Technischen Universität München (DGFI-TUM) in 2013 to provide water level time series of inland waters. Today, DAHITI provides a variety of hydrologial information on lakes, reservoirs, rivers, and wetlands derived from satellite data, i.e. from multi-mission satellite altimetry and optical remote sensing imagery. All products are available free of charge for the user community after a short registration process.

DAHITI - Products


Water Level Time Series from Satellite Altimetry

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DAHITI-Targets

Africa :	805
Asia :	381
Australia :	21
Europe :	59
North America :	254
South America :	1245
Global :	**2851**

DAHITI-Flyer

Conclusion / Outlook

- Satellite altimetry and optical imagery are valuable remote sensing techniques to derived hydrological products for monitoring the global water cycle

- The “**Database for Hydrological Time Series of Inland Waters” (DAHITI)** provide currently 9 different products which are derived from **four different approaches**
  - Water level time series from satellite altimetry
  - Surface area time series from optical imagery (incl. water occurrence masks, land-water masks)
  - Time series of volume variations (incl. hypsometry, bathymetry, water levels from hypsometry)
  - River discharge time series

- Currently, the data holding of DAHITI contains more the **4400 inland water targets** which will be further extended in future

- All products are freely available on the DAHITI web portal (**https://dahiti.dgfi.tum.de**) after a short registration process

References

Schwatke C., Dettmering D., Bosch W., Seitz F.: **DAHITI - an innovative approach for estimating water level time series over inland waters using multi-mission satellite altimetry**. Hydrology and Earth System Sciences 19(10): 4345-4364, 10.5194/hess-19-4345-2015, 2015 *(Open Access)*

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