Deutsches Geodätisches Forschungsinstitut
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DAHITI - Monitoring water levels of Nile river and its reservoirs using satellite altimetry

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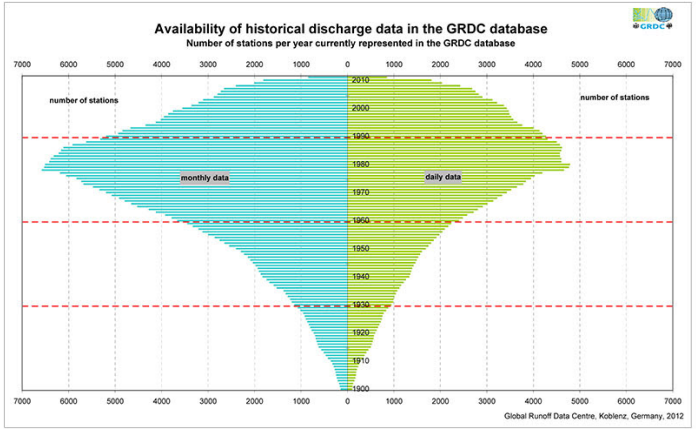
Motivation

- **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 **declining** since 1980 (see GRDC)
- **Satellite altimetry** has the potential to monitor water level changes of **river, lakes, reservoirs and wetlands** also in **remote areas**

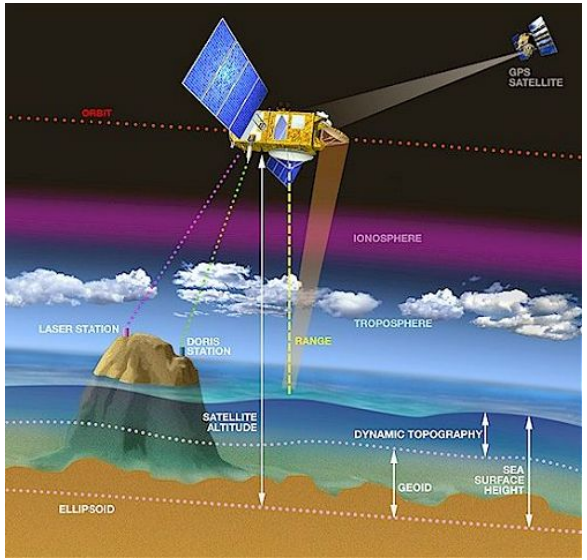


Credit: Global Runoff Data Center (GRDC)

- DGFI-TUM developed and maintains the **“Database for Hydrological Time Series of Inland Waters” (DAHITI)** which provides more than **3000 water level time series** from satellite altimetry and other hydrological products (e.g. surface areas, volume changes)
- In this presentation, we demonstrate the potential of satellite altimetry to monitor water level changes of the **Nile river** and **its reservoirs**

Water Levels from Satellite Altimetry

- **Satellite altimetry** was **originally designed** for measuring the **sea level of the ocean** (since 1992)
- For two decades, **satellite altimetry** has been proven to be **suitable for monitoring inland water bodies** such as rivers, lakes, reservoirs and wetlands.
- The **measurement techniques** is based on measuring the run-time time of the **emitted radar pulse** from the satellite to the water surface and back
- **Satellite altimetry** is measuring only in **nadir direction** which means that the water bodies of interest have to be crossed directly by the satellite track.
- The **measured ranges** have to be **corrected by geophysical corrections** (e.g. troposphere) and a **geoid model** has to be applied in order to achieve **orthometric heights**



Credits: CNES/D. Ducros

Water Levels from Satellite Altimetry

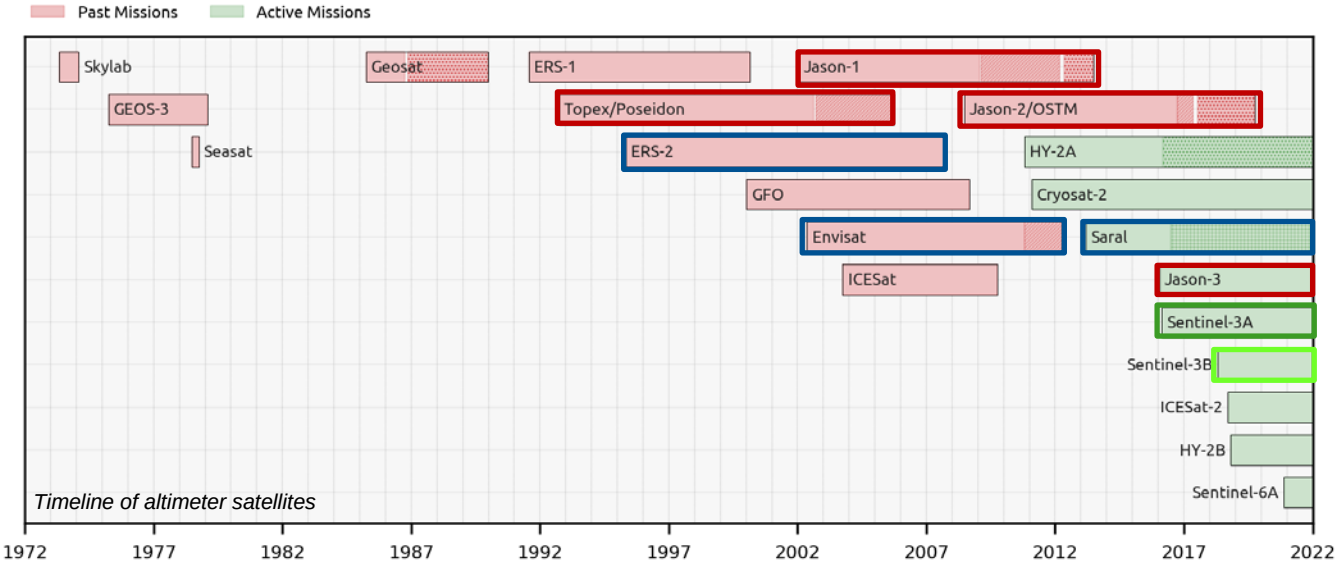
- The **DAHITI approach** for deriving water level time series is based on
  - an individual **analysis of radar echos** (retracking),
  - an **extended outlier rejection**,
  - and a **Kalman filtering step**

  using **cross-calibrated multi-mission altimeter data** (Schwatke et al., 2015)

- The **accuracy** of the water levels depend on the **size and shape of the water body** but also on the **quality of the used altimeter mission**

- Nowadays, one can say that for **larger lakes** an **accuracy** of **few centimeters** can be achieved, respectively **few decimeters** for **small rivers** (~200m river width) and **small lakes** (~5km²)

Altimeter Data



Mission(s)	Repeat Cycle	Track Distance at Equator
ERS-2, Envisat, SARAL	35 days	~80 km
Topex/Poseidon, Jason-1/-2/-3	10 days	~300 km
Sentinel-3A	27 days	~104 km
Sentinel-3B	27 days	~104 km

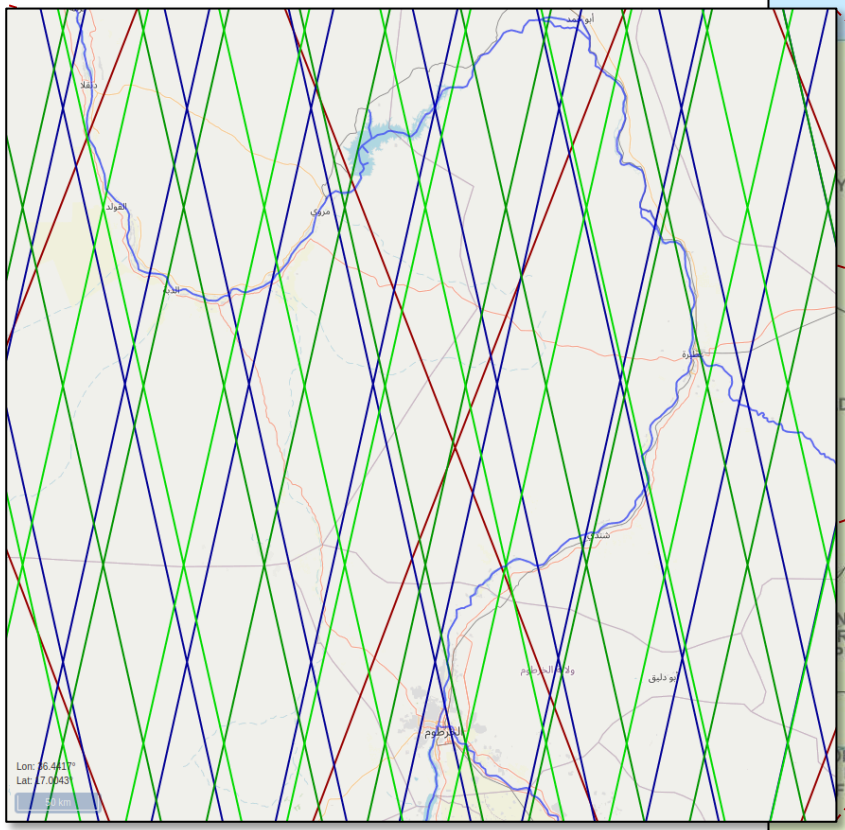
Study Area

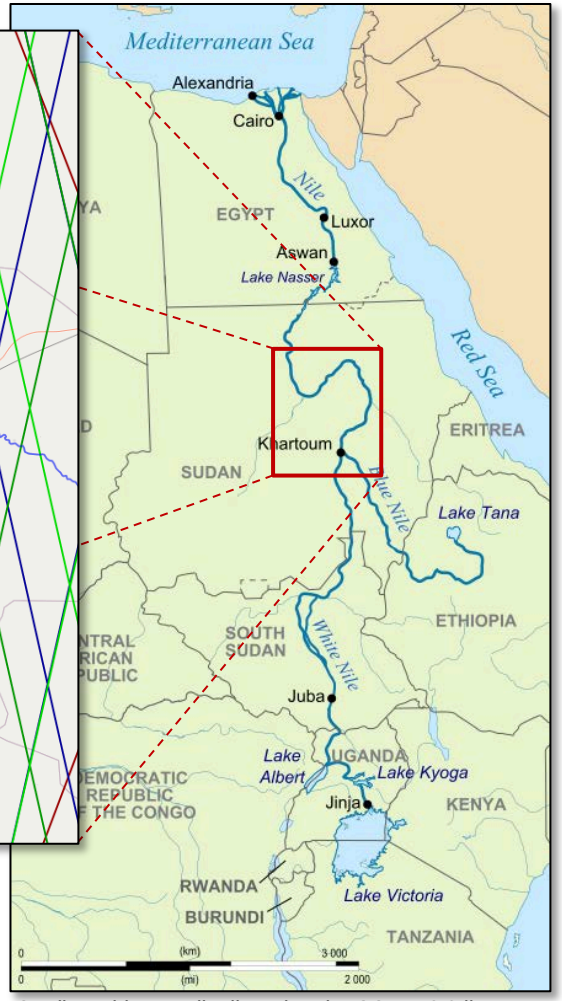
Rivers:

- Nile, River
- White, River
- Blue, River
- etc.

Lakes/Reservoirs:

- Nasser, Lake
- Roseires, Lake
- Merowe, Lake
- Albert, Lake
- etc.





ERS-2, Envisat, SARAL

Topex/Poseidon, Jason-1/-2/-3

Sentinel-3A

Sentinel-3B

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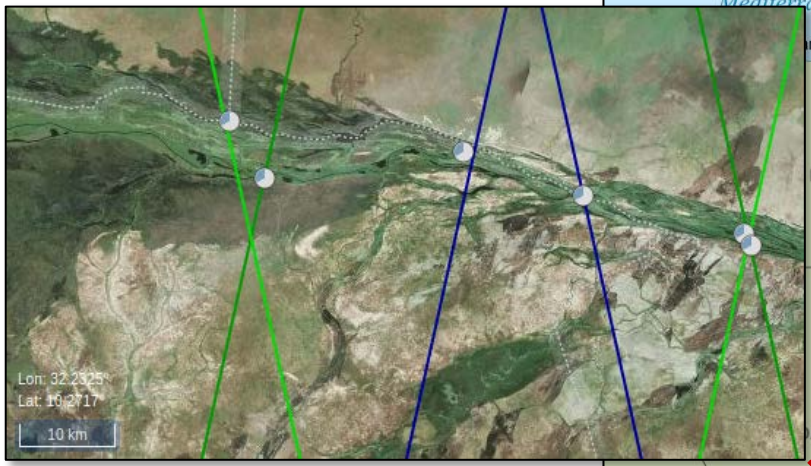
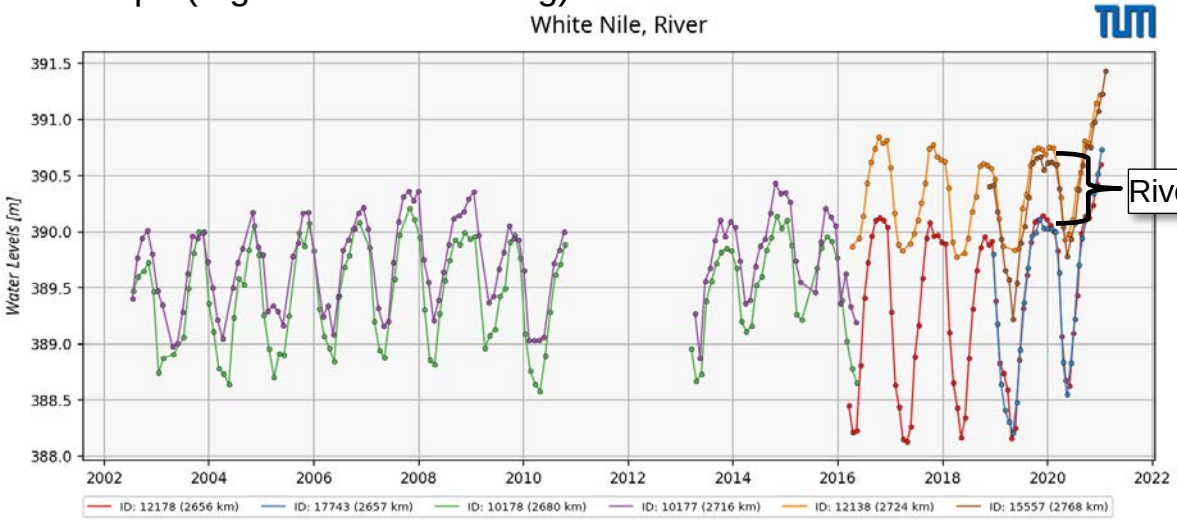
White Nile, River

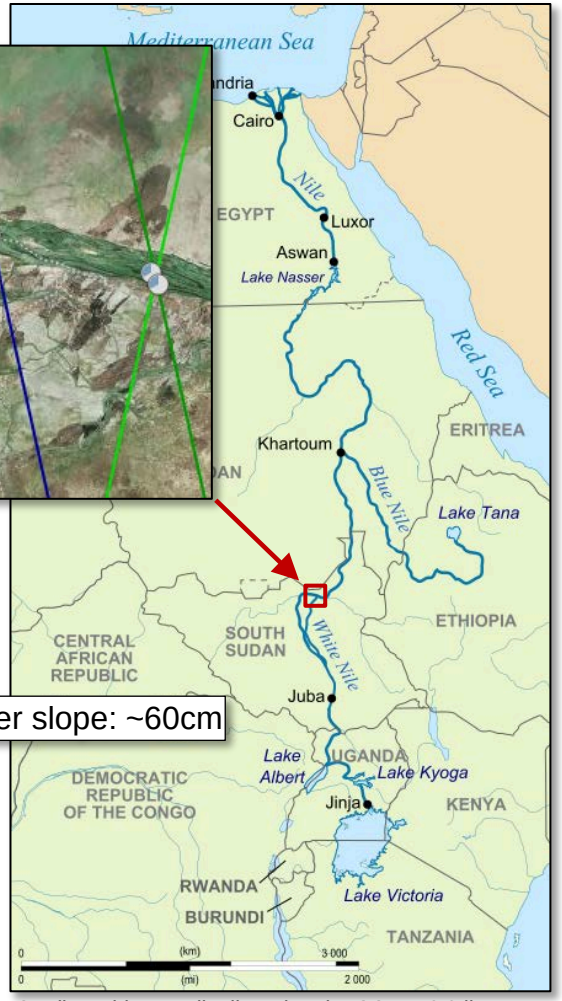
- River reach length of about 60 km near Malakal
- River crossed by 6 altimeter tracks
- Very good agreement between virtual station next to each other
- Combination allows the determination of river slope (e.g. for river modeling)

Envisat, SARAL, Sentinel-3A, Sentinel-3B





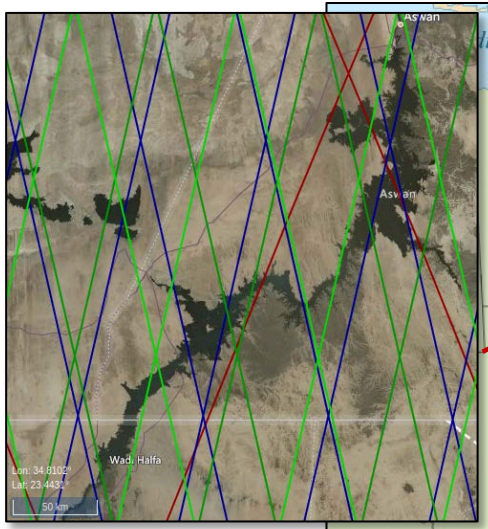
River slope: ~60cm

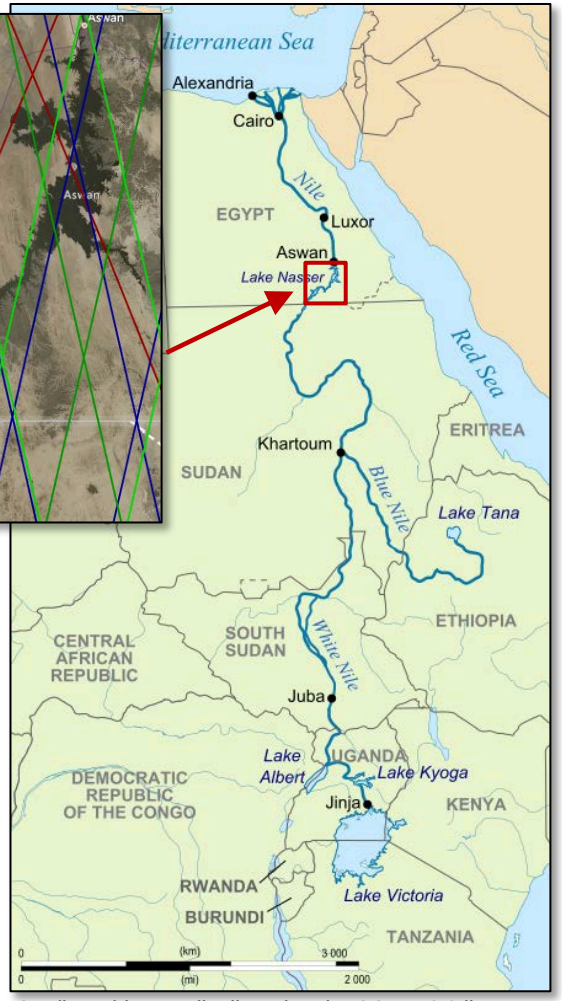


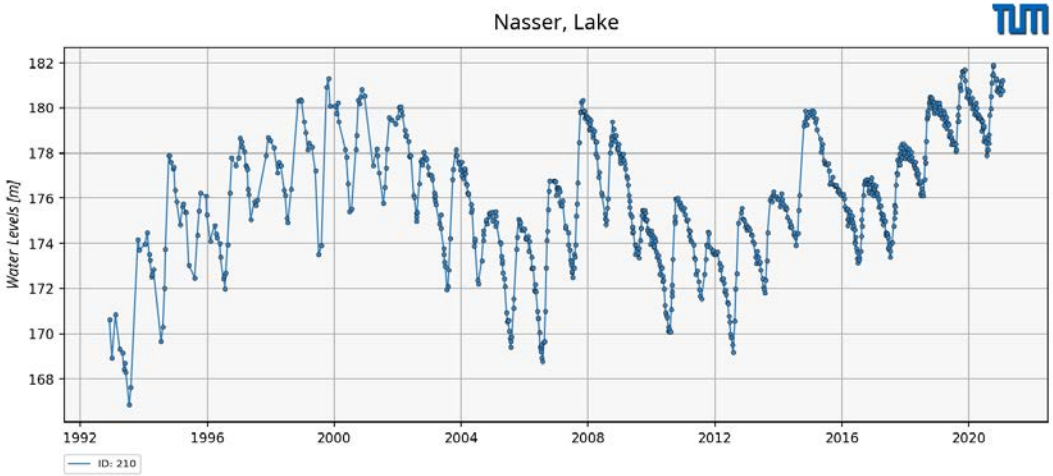
Nasser, Lake

ERS-2, Envisat, SARAL
Topex/Poseidon, Jason-1/-2/-3
Sentinel-3A, Sentinel-3B

- Largest reservoir along the Nile river (~ 5250 km²)
- Nasser, Lake is crossed by 15 altimeter tracks
- The orthometric heights of different altimeter tracks can be combined in order to derive a long-term water level time series (since 1993)
- Water level time series shows clear seasonal variations and trends
- Nowadays, a temporal resolution of few days can be achieved







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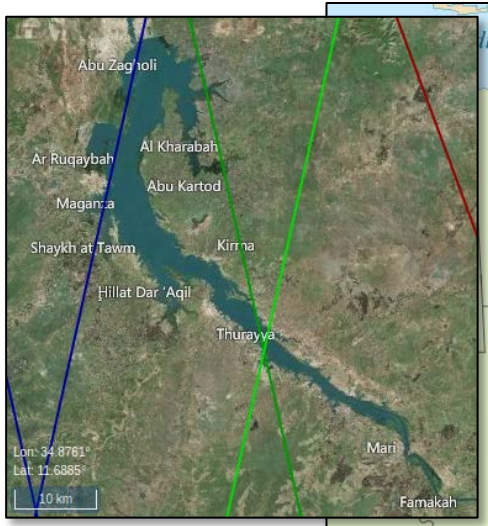
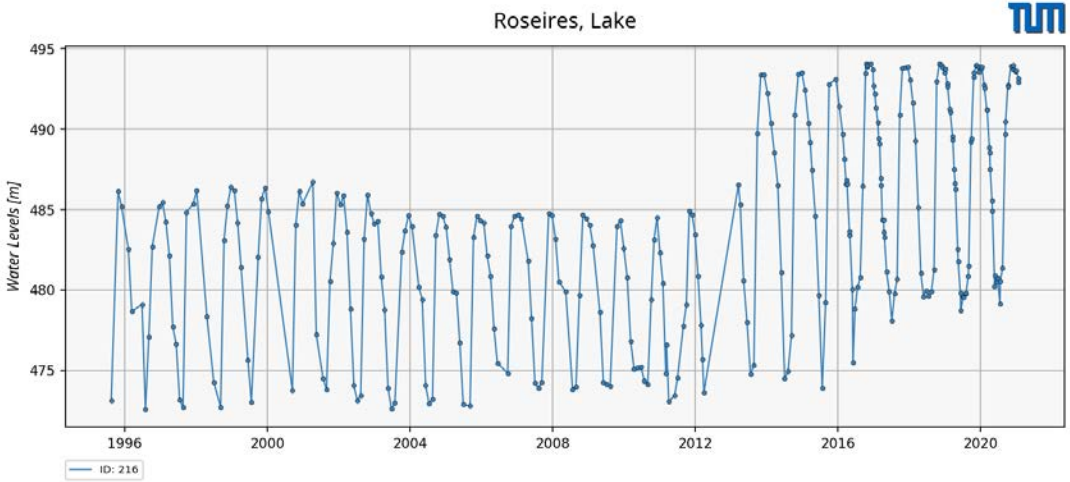
Roseires, Reservoir

ERS-2, Envisat, SARAL
Sentinel-3A, Sentinel-3B

- Roseires, Reservoir has a surface area of about 290 km² which is selected as an example for a small reservoir
- It is crossed by only 3 altimeter tracks
- The water level time series shows very clear seasonal variations since 1996
- Also the increase of the dam by 10 m in 2013 is visible in the water level time series





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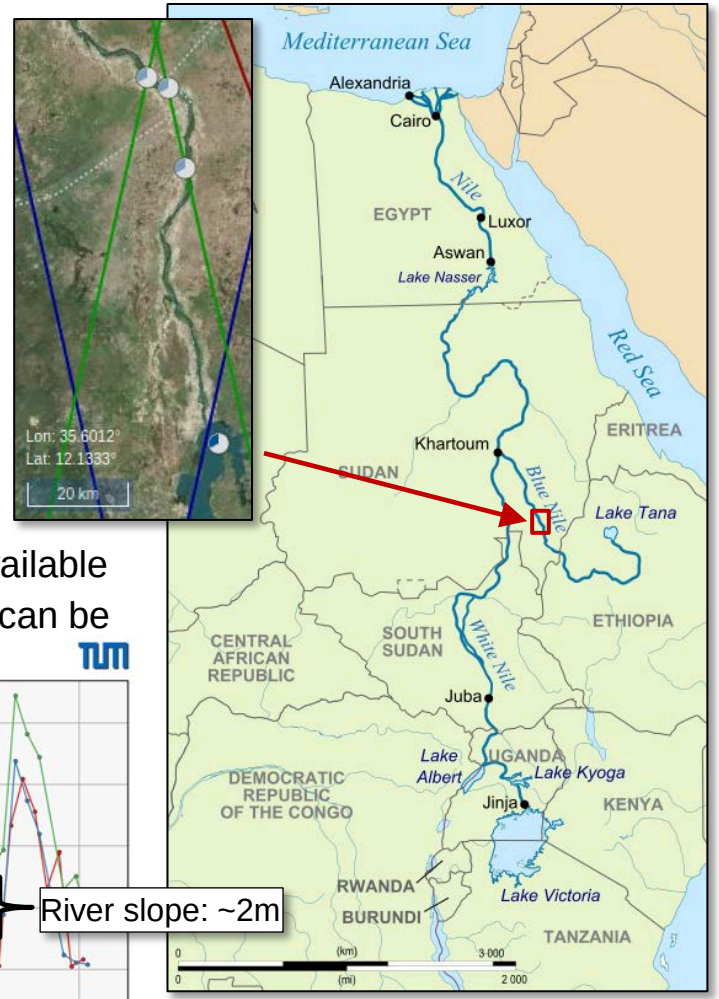
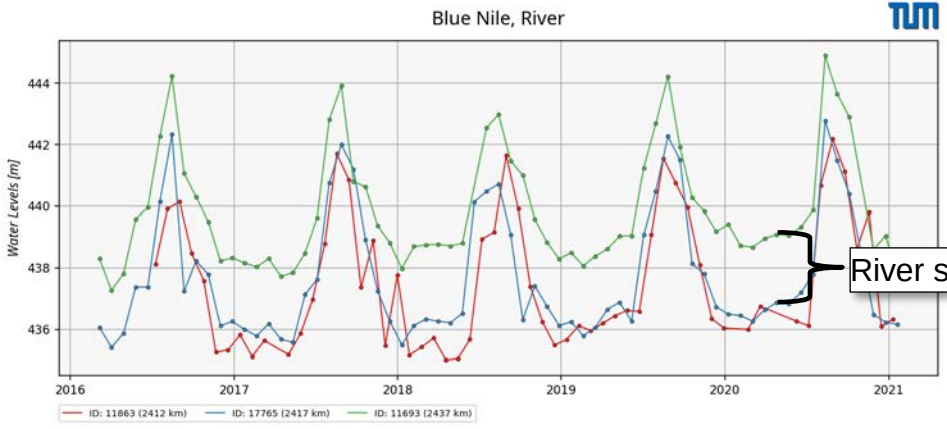
Blue Nile, River

- Satellite altimetry has also the potential to monitor the outflow of reservoirs
- This study area is located about 50 km downstream from the outflow of the Roseires Reservoir at the Blue Nile
- Two Sentinel-3A tracks are used to derive 3 water level time series
- Two water level time series derived from a single altimeter track can be used for quality assessment if no in-situ data are available
- High correlation between green and blue water level time series can be achieved





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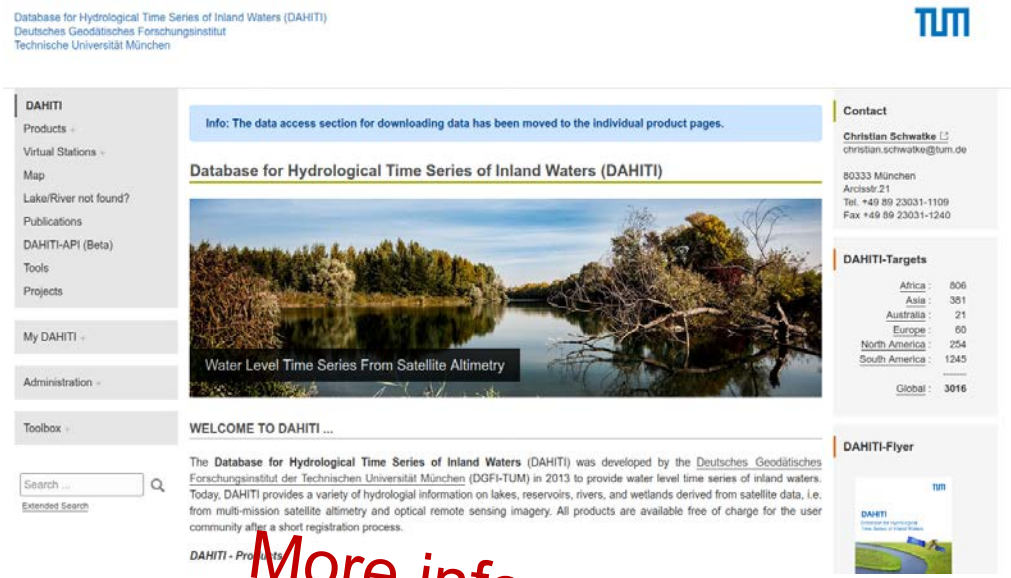
Conclusion

- **Satellite altimetry** has the potential to **monitor water level changes** of the **Nile river** and **its reservoir**
- It is an **valuable dataset** to monitor inland waters especially in **remote areas** where no in-situ data is available
- **Water level time series** in DAHITI are also provided in **near “real-time”** depending on the **data availability**



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