Operational river monitoring from Sentinel-3 radar altimetry

A review of the potential to establish a global, operational river monitoring based on Sentinel-3 water surface elevation observations

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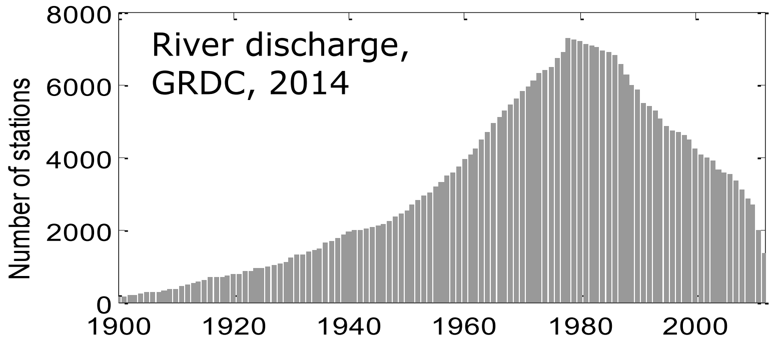
Background and motivation

- In-situ observations declining
- Need for observations for operational and long-term management purposes

- Solution:
  - Alternative observation technologies combined with reliable simulations
  - Remote sensing observations:
    - Observations of important components of the land-surface water balance
    - Global coverage and gridded data
    - New missions are publically accessible and offer new possibilities



SITAEL, 2016

Measuring discharge from space?

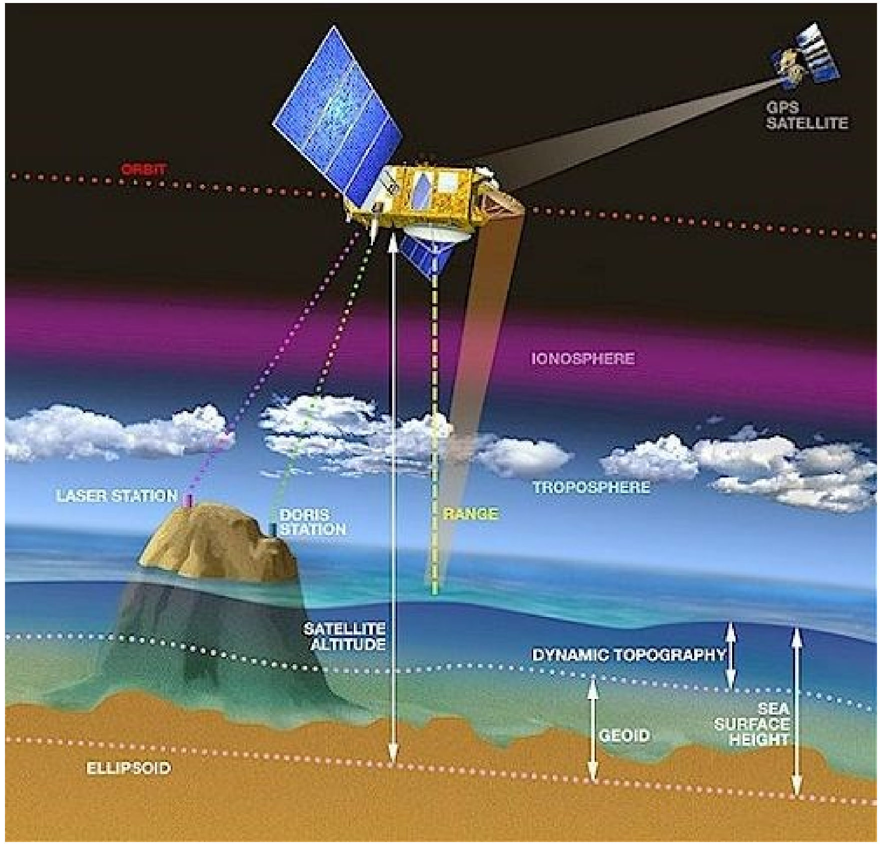
- Discharge not directly observable
- Two evolving approaches:
  - Water level from satellite altimetry
    - Discharge estimated from rating curves or using hydrodynamic models
  - Water surface extent from multi-mission remote sensing data
    - E.g. Pekel et al., Nature (2016)
  - Combining the two: volume/height and extent holds great potential for hydrological applications

- Existing networks with altimetry observations for global water bodies:
  - Hydroweb (Crétaux et al. ASR (2011))
  - DAHITI (Schwatke et al. HESS (2015))

New missions, e.g. Sentinel-3, will ensure continuity

Altimetry observations

- Altimeter sends a pulse and records the return echo
- Waveform is then ”retracked” to extract nadir height
- Water height in inland water bodies.
- Uncertainties in range of 0.5 m
- Main issue for inland water bodies: surrounding land cover and topography
- Position must be precisely known



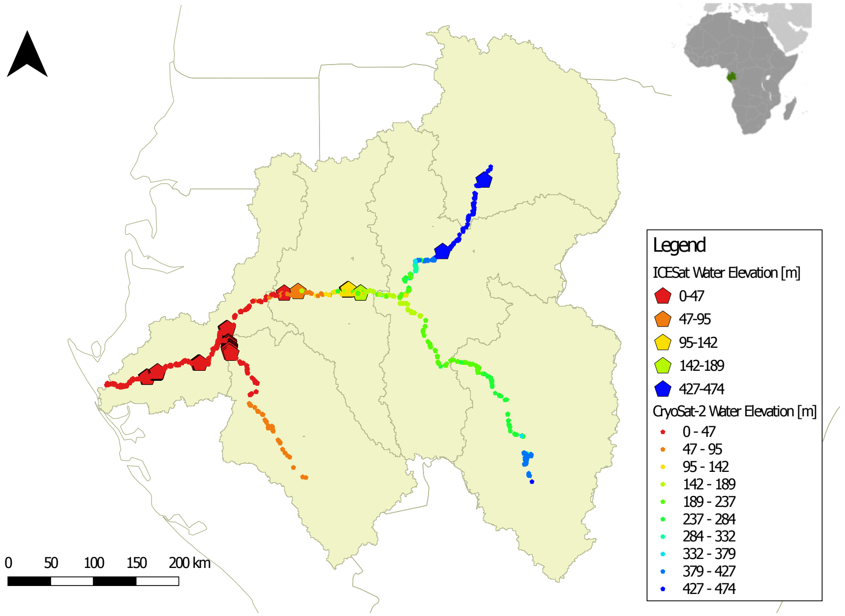
http://altimetry.info, Credits: CNES/D. Ducros

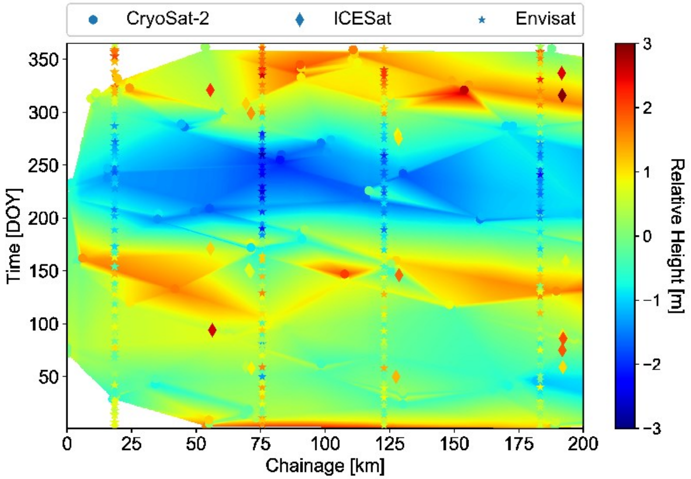
Example: The Ogooué, Africa

- Extracted using Sentinel-1 water mask – four altimetry missions combined (Kittel et al., 2017, HESSD)

- Water surface elevation (WSE) above a reference (geoid) for the entire river
- Interpolate to annual water height amplitude

- Drifting groundtrack = longitudinal WSE profile
- Fixed groundtrack = Time series at “Virtual Station”



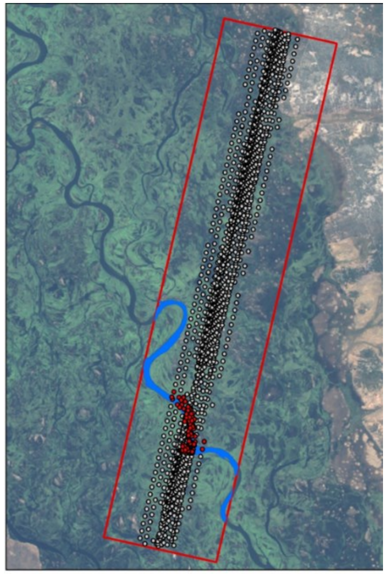


Sentinel-3

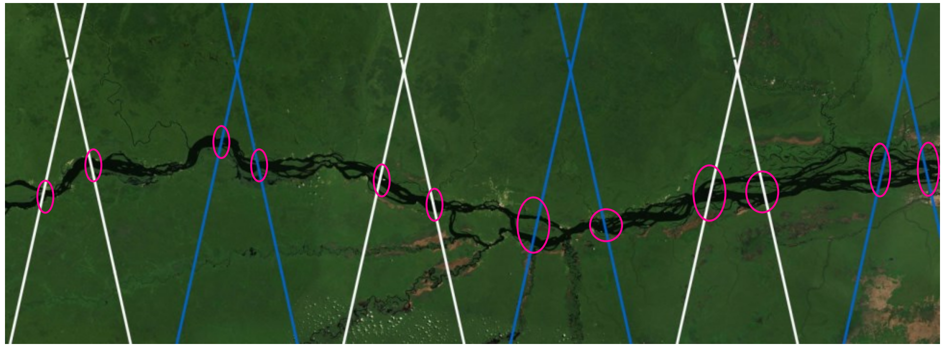
- European Space Agency (ESA) mission
  - Sentinel-3A launched in 2016
  - Sentinel-3B scheduled for launch in 2018
- Operates in Synthetic Aperture Radar (SAR) mode
- Ground track separation of 104 km (52 km with Sentinel-3B)
- Revisit time of 27 days

- For 98 of the worlds largest rivers:
  - 2940-5898 virtual stations
  - One VS every 44 km of river

Virtual stations concept



Sentinel-3 virtual stations, Amazon river

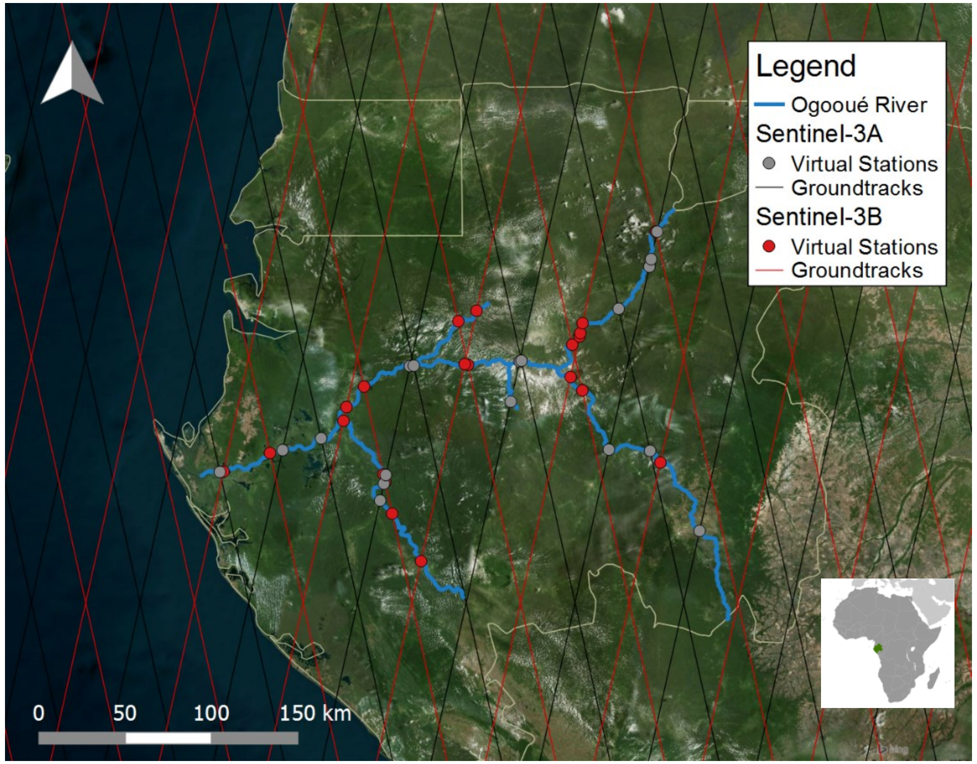


Sentinel-3

What can we expect?

- Unmonitored basin, the Ogooué
  - 39 VS
  - 1540 km river

  - Observations every ~40 km
  - Currently no monitoring



Discharge from water surface elevation (WSE)

Different approaches:

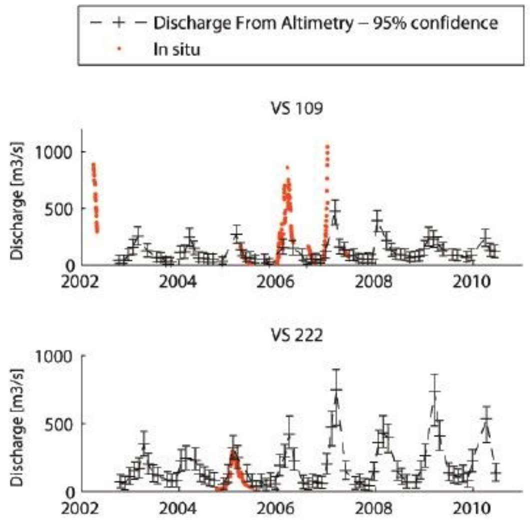
Method 1: Ground surveys at virtual stations to establish rating curve

- Michailovsky et al. HESS (2012)

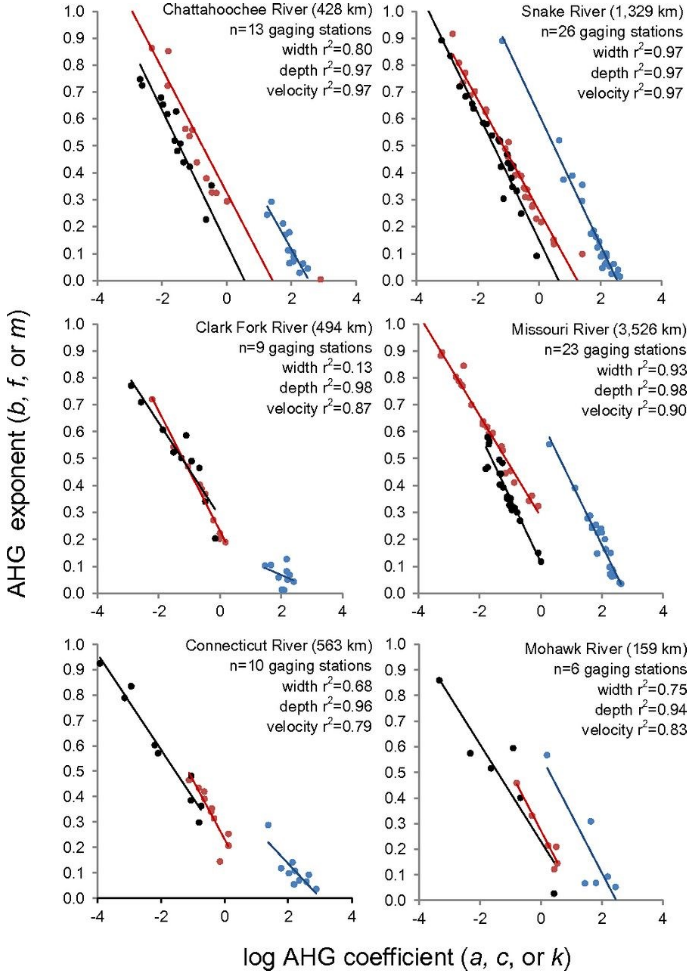
Method 2: Regression results from large global datasets

- Bjerklie et al., J Hydrol (2003)
- Gleason and Smith, PNAS (2014)

Rating curves (Michailovsky et al., 2012)



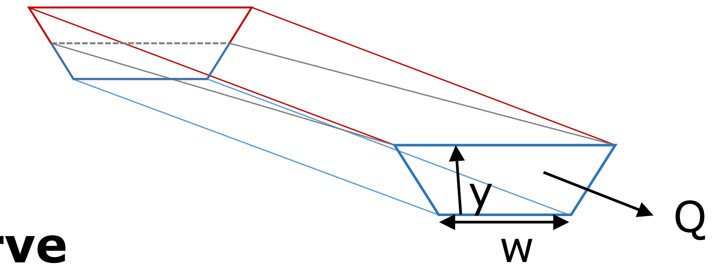
Correlation between hydraulic geometry coefficients (Gleason and Smith, 2014)



Discharge from water surface elevation (WSE)

Method 3: Informing hydraulic models with WSE

- E.g. Kittel et al., HESSD (2017), Schneider et al., HESS (2017)



Method 4: UAV surveys at VS locations to establish rating curve

- Hydraulic variables observable from UAV platform
  - E.g. Bandini et al., J Hydrol (2017)

Conclusion and Outlook

Great potential in operational monitoring using satellite altimetry

- Sentinel-3 will be a significant inland water monitoring asset
- Value will increase significantly if rating curves can be estimated accurately and efficiently
- We need a **new, innovative** technology to properly setup rating curves
- UAVs attractive for estimating rating curves at Sentinel-3 VS locations
  - Bandini et al., Session 8, 17:40

Wang, 2016