climate change initiative

RIVER DISCHARGE

Altimetry river Water Surface Elevation

river discharge cci

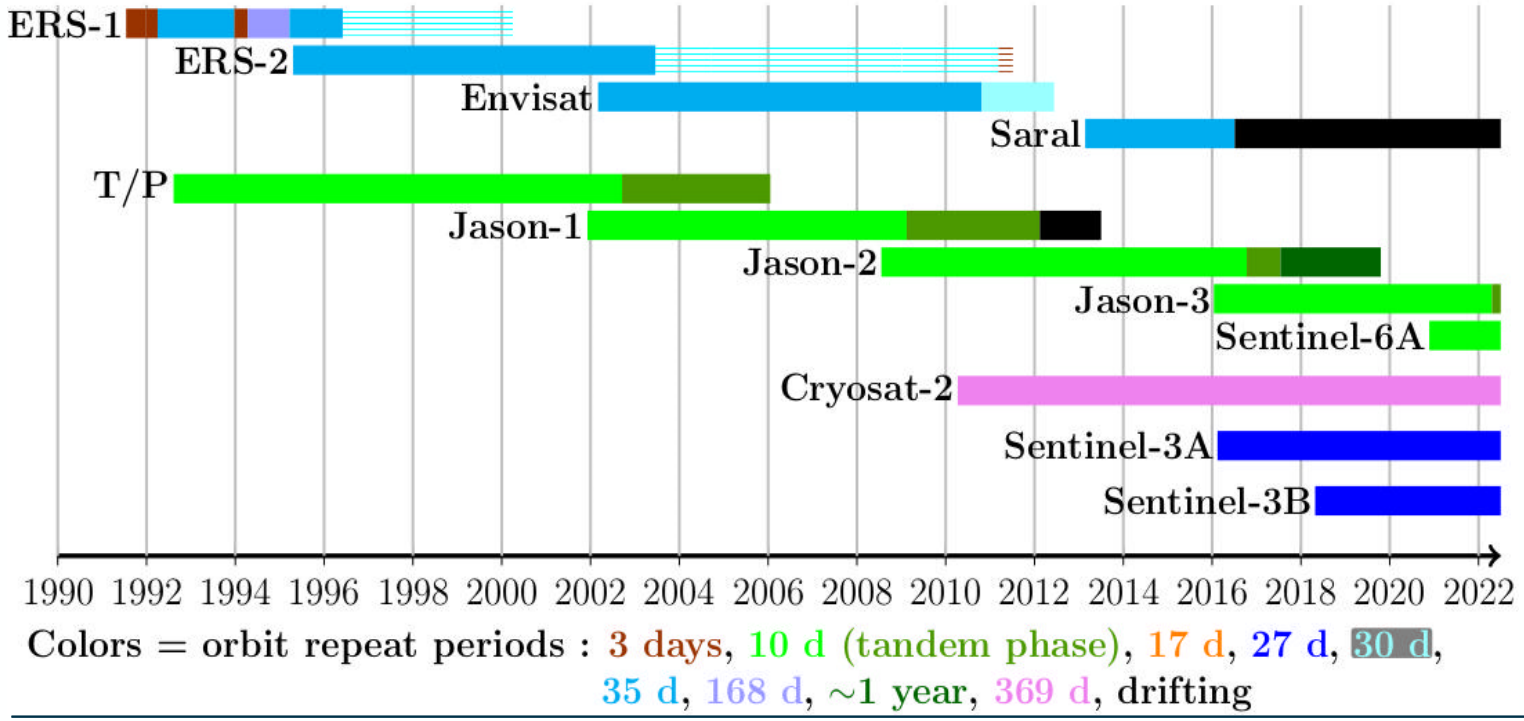
User Workshop

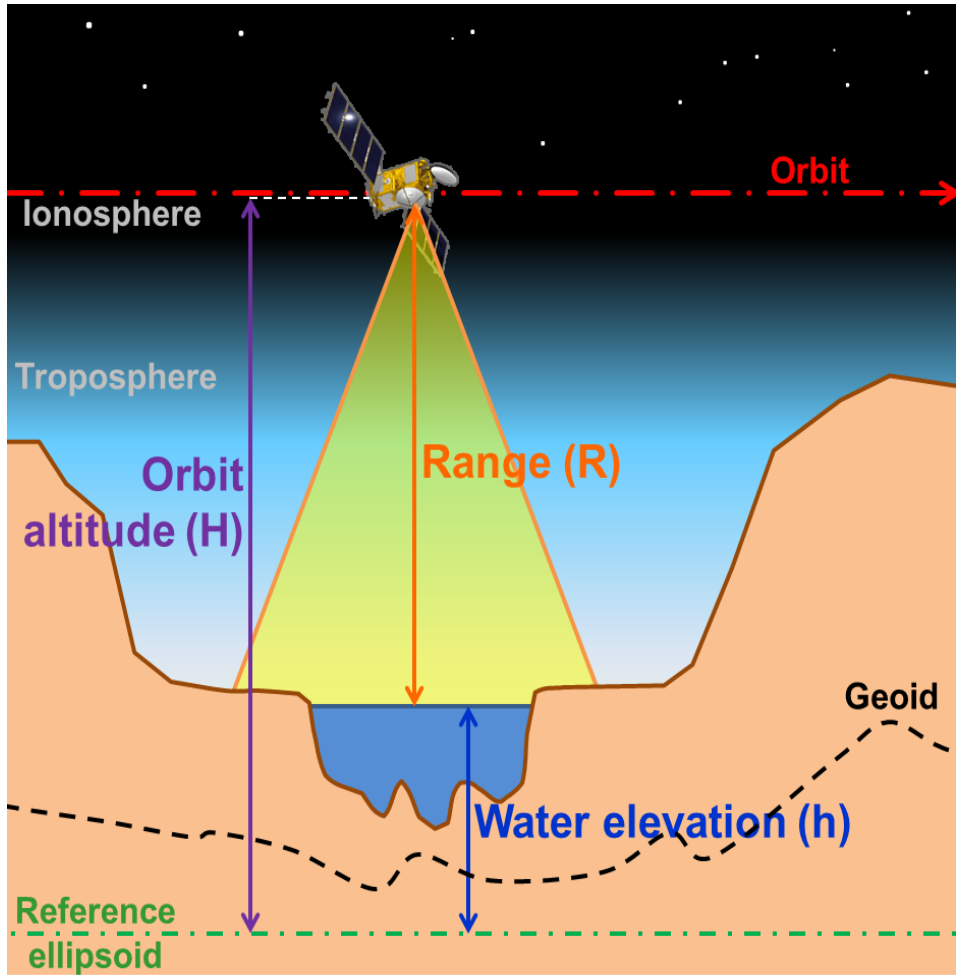
Météo-France, Toulouse

03-04 June 2024

Context and purpose

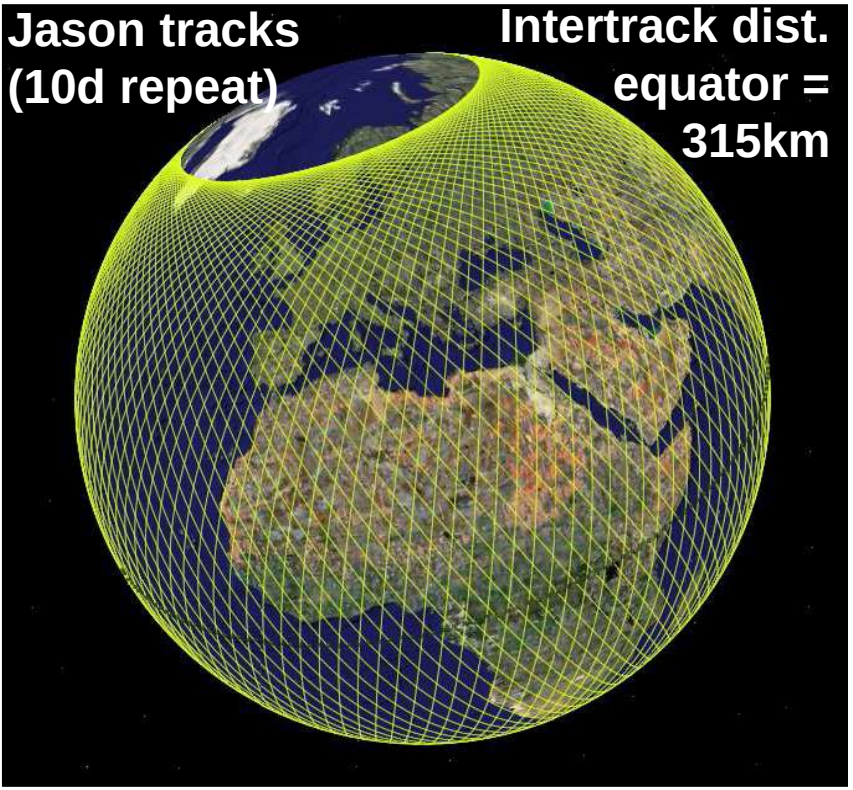
- Context: River Water Surface Elevation (WSE) is an ECV and can be used as river discharge proxy (see next presentation)
- Objectives: Compute river WSE time series from radar nadir at selected locations, at least from 2002-2022 (goal: 1992-2022)
- Altimetry missions used:

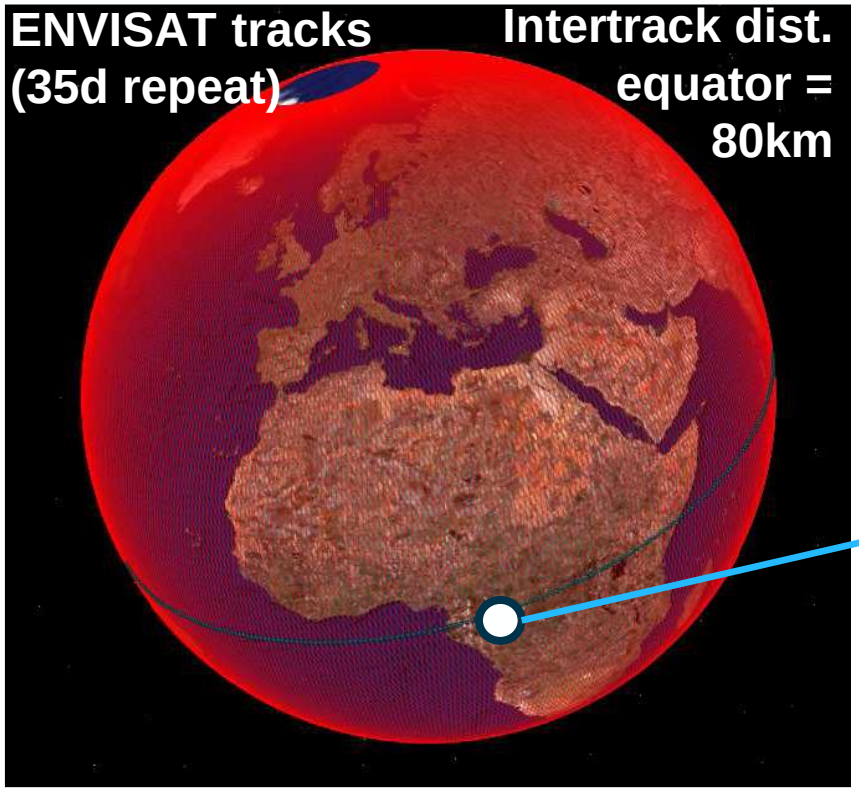




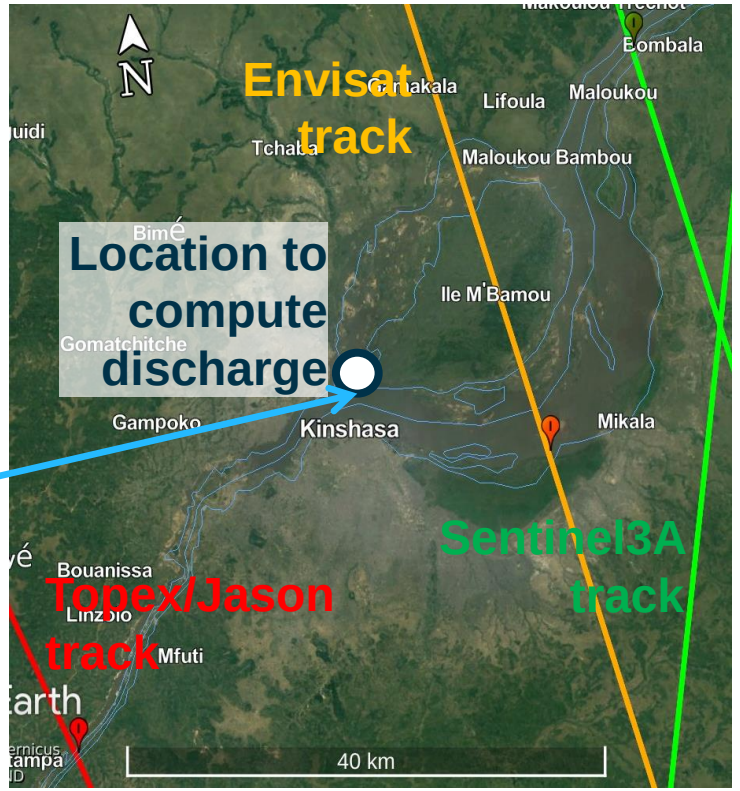
Space and time sampling

- Measure elevations along the satellite track -> low spatial coverage
- Time sampling = orbit repeat time (from 10 days to 35 days) -> low temporal resolution
- Higher time sampling -> lower spatial sampling (and vice versa)





Alti. tracks selected for Kinshasa station:



Methodology (1/3)

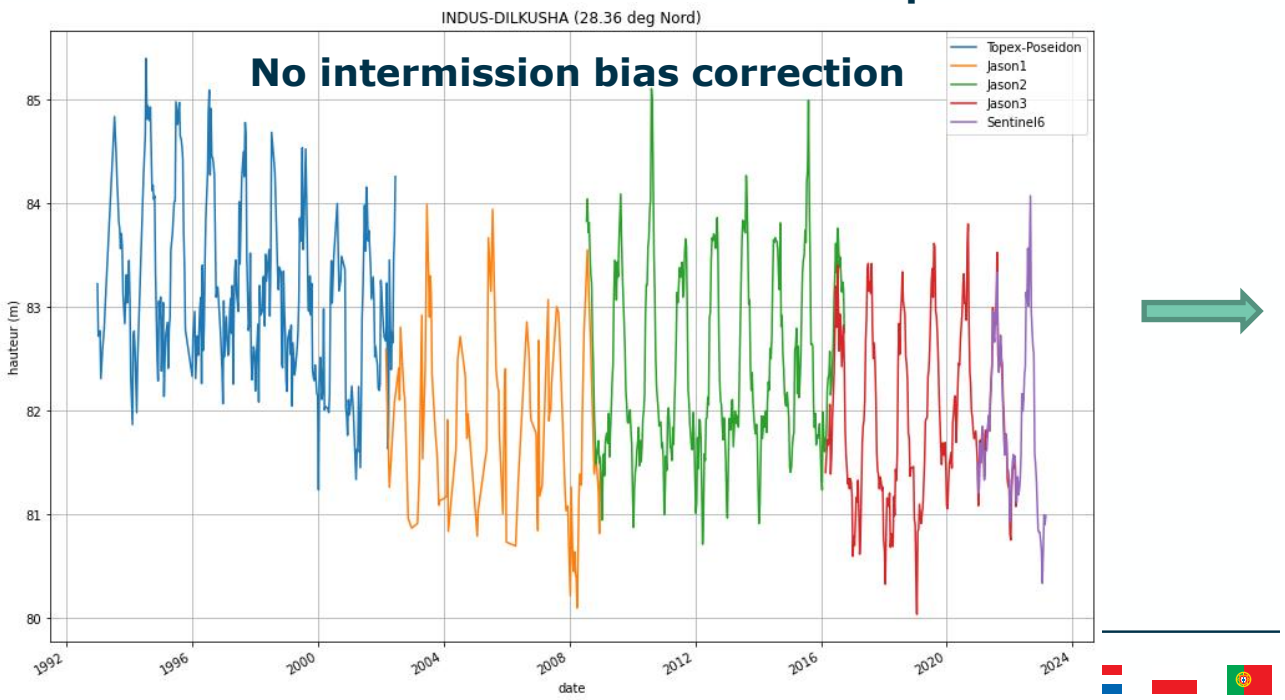
- Virtual stations (VS, i.e. intersection btw sat. track and river) near selected locations, for each mission track(s)
- WSE time series for each track and each mission:
  - WSE are referenced to WGS84 ellipsoid
  - Some time series already available from https://hydroweb.next.theia-land.fr/
  - Most time series computed from “official” altimetry files from space agencies (i.e. Geophysical Data Record, GDR)
  - No river slope correction used to correct +-1km satellite drift (no such slope correction available at global scale for the moment)

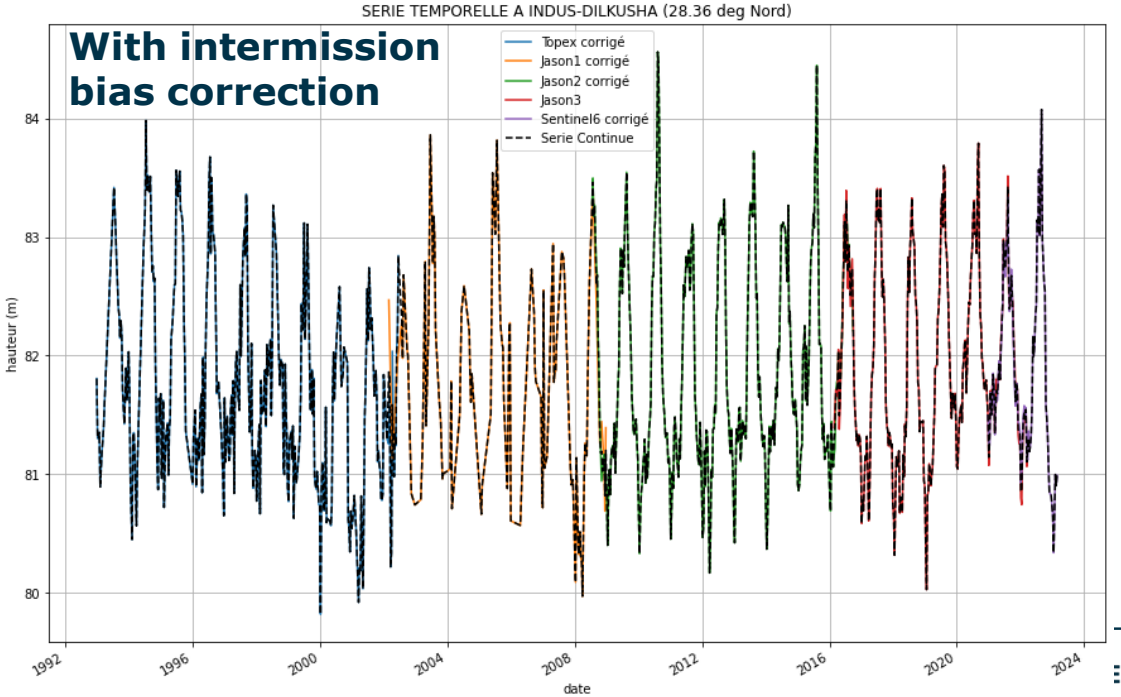
Note: Algorithm Theoretical Basis Document (ATBD) available at:
https://climate.esa.int/media/documents/CCI-Discharge-0009-ATBD-WSE_v1-2.pdf

Methodology (2/3)

- Merged WSE time series combining multimission:
  - A “reference” VS and mission should be selected. If available, it should be a J3, otherwise an Envisat one, and if no J3 or Envisat VS, then it should be a S3A VS
  - For mission on the same orbit and time overlap between mission : bias correction (mean difference over the common time period if no main outliers, otherwise the decreasing/low flow period is used) to be coherent with “reference” time series.

Example on the Indus river at Dilkusha:

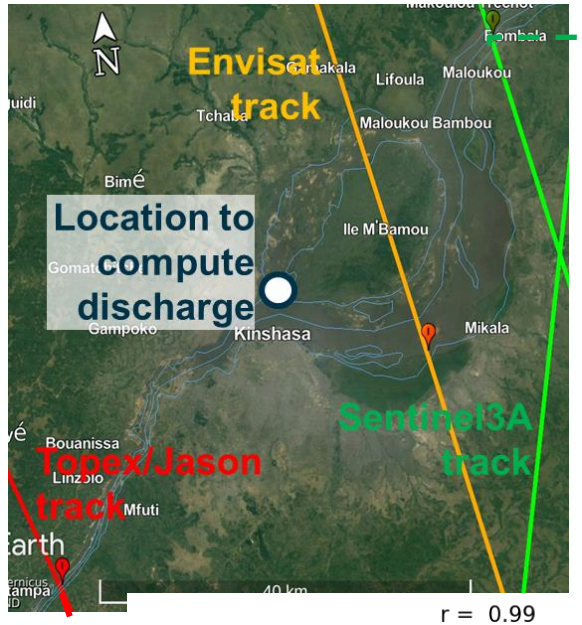


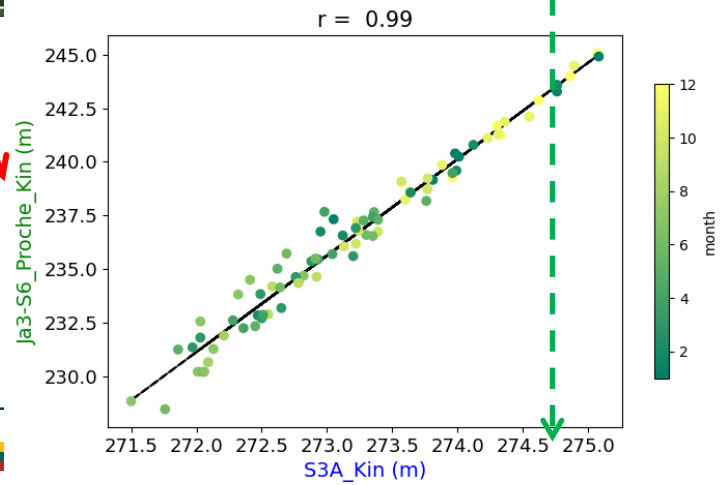


Methodology (3/3)

- Merged WSE time series combining multimission:
  - For missions not on the same orbit and with time overlap between missions :
    - There should be no main tributaries between reference VS and other VS (if possible less than few dozens km apart) -> issue for some locations, where ERS-2/Envisat/Saral could not have been complemented with other missions (Jason series)
    - A linear/polynomial fit between VS and the reference VS, to correct WSE from bathymetry difference
  - Missions without time overlap: “average long-term method” = the time average WSE is computed for both time series and then the bias is computing on these 2 averages

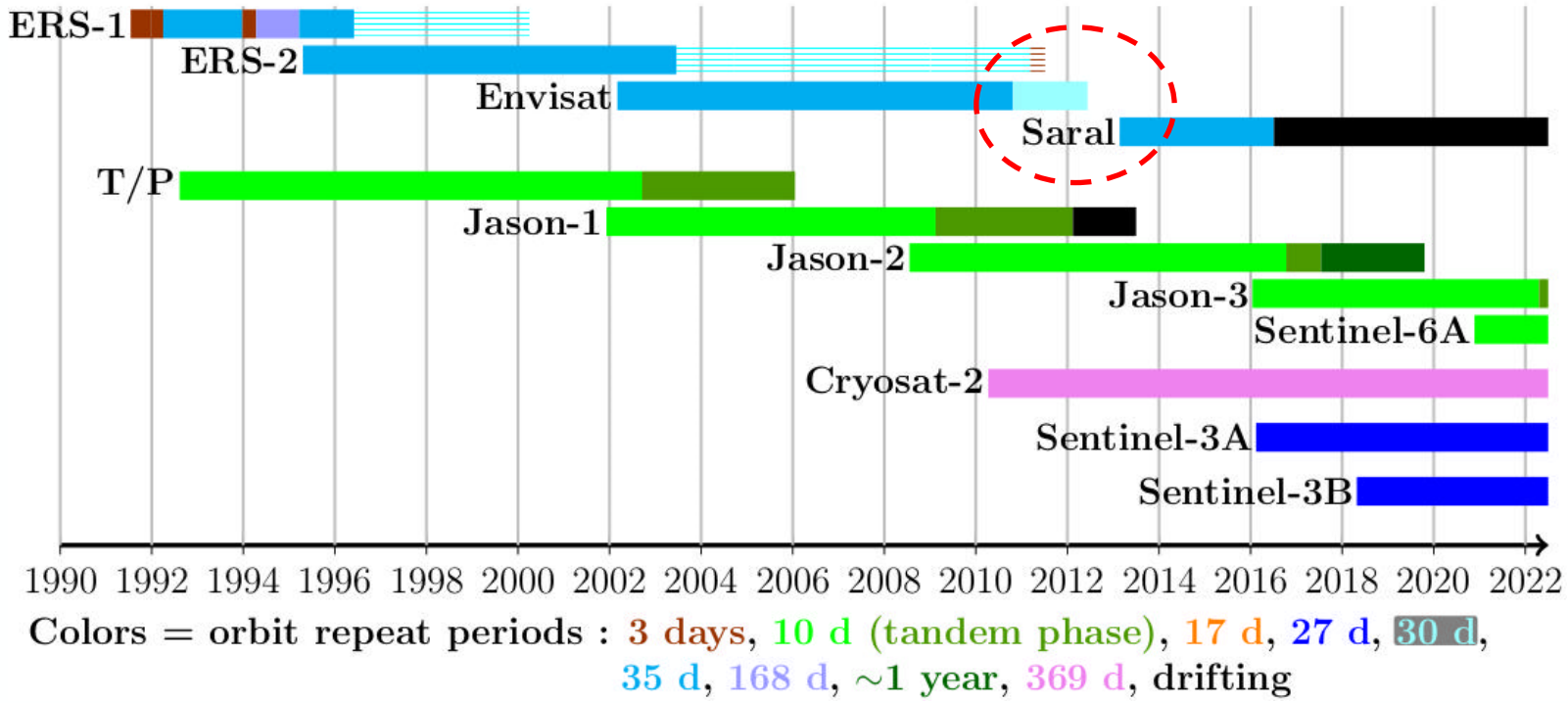
Merging WSE time series near Kinshasa station:





Issues explaining data gaps

- For Jason series: Jason-1 has many missing data; Jason orbit has less ground tracks than Envisat, but better time sampling
- ERS-2/Envisat/Saral: no overlap between Envisat and Saral (on a drifting orbit since 2016) -> bias correction might have some issue btw Envisat and Saral and some data gap might occur
- Oldest mission (i.e. Topex/Poseidon and ERS-2) time series are noisier than following missions



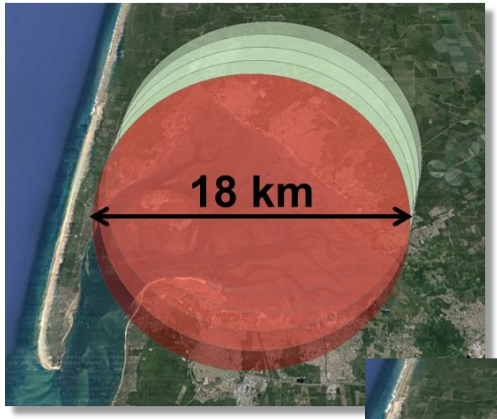
Issues explaining WSE errors

- Nadir alti footprint in Low Resolution Mode = large footprint (8km, 18km and 30km diameter for Saral, Envisat & Jason, respectively) => -> information from different water bodies in radar waveform -> uncertainty
- Tracking window ~60m with ~128 bins (~50cm wide) -> retracker algorithm could fit the needed position below the bin width, but source of uncertainty.
- Specific case of Envisat that could have a tracking window with adaptive size (64m, 256m, 1024m) with same number of bins -> more errors with longer tracking window but less data loss than Topex for example
- Jason series altimeters could saturate -> source of errors
- Atmospheric corrections from models -> source of errors

Conclusion: WSE on river computation depends of: the surrounding topography, observation configuration (complexity of the scene and orbit orientation/river), previous measurements and the instrument design

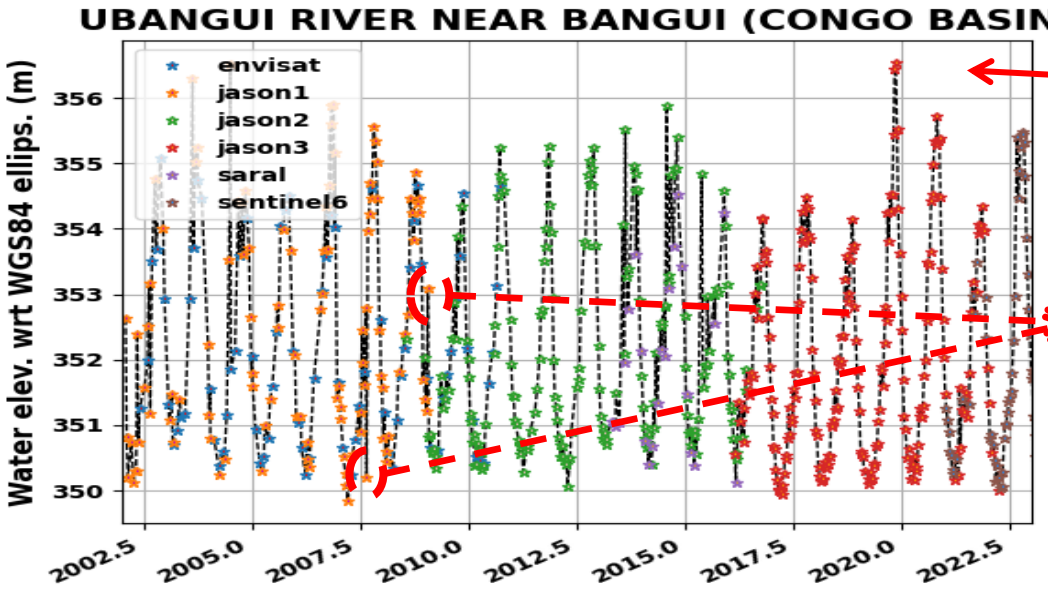
"footprint" LRM (note: for Jason series ~30km):

ENVISAT

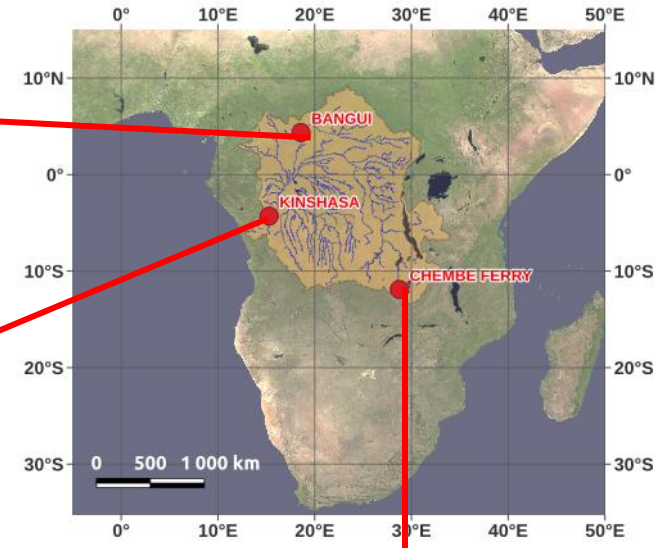


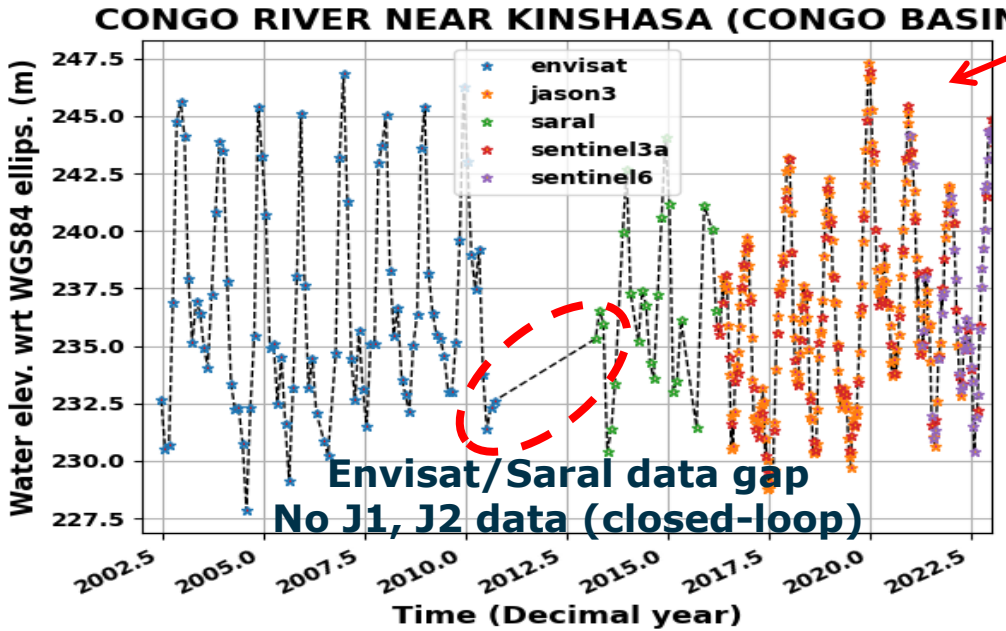
SARAL

Results: example on the Congo Basin



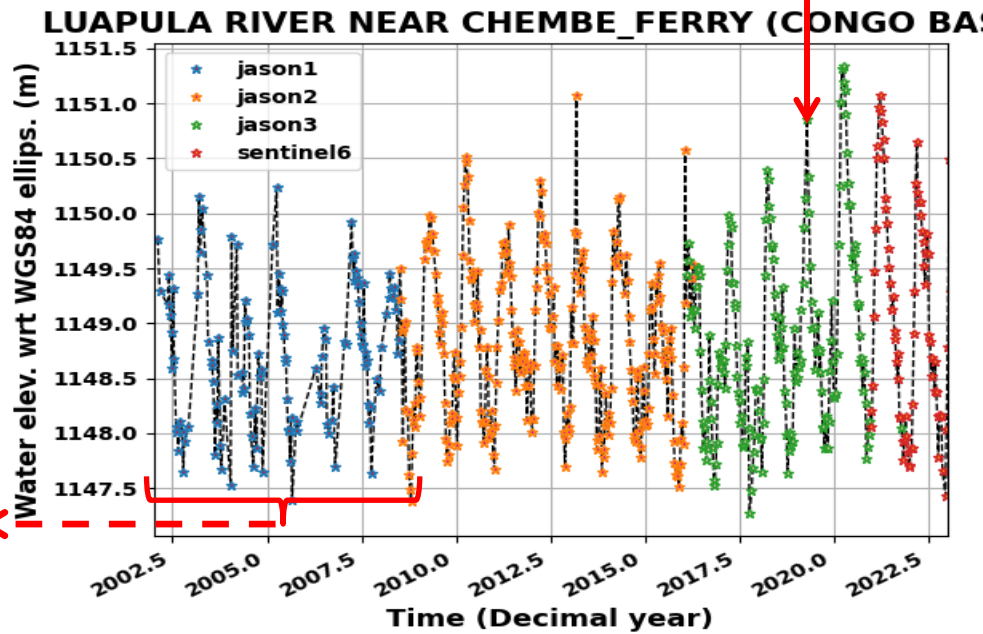
WSE issue might be due to surrounding water body, sometime impossible to filter only from altimetry data



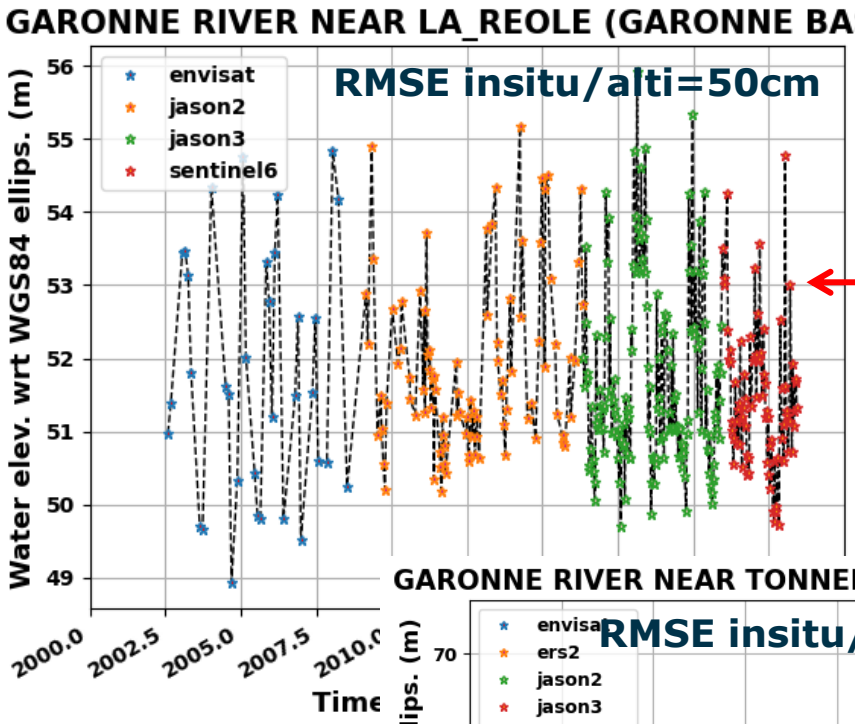


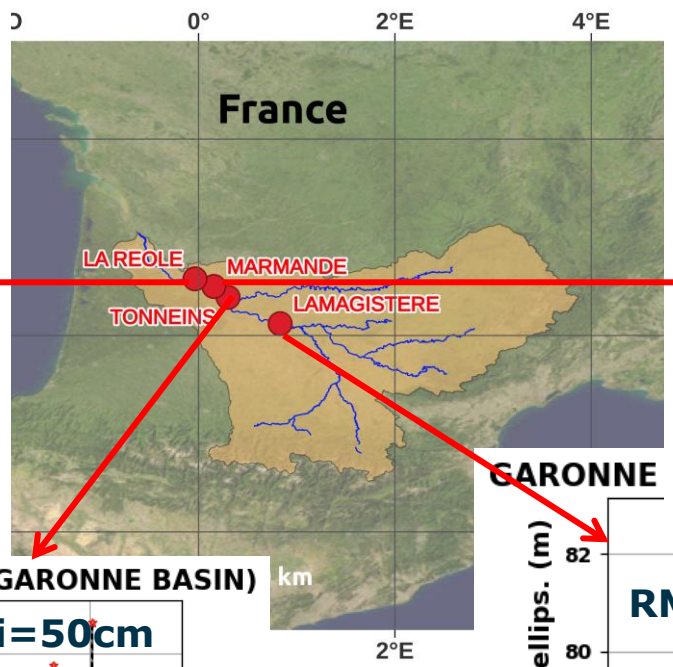
Envisat/Saral data gap
No J1, J2 data (closed-loop)

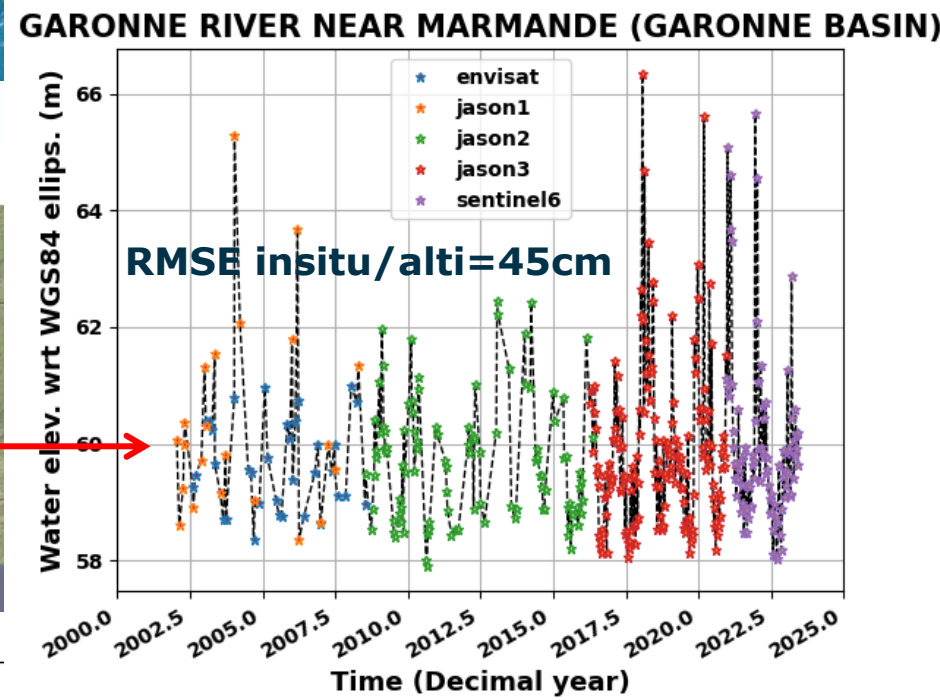
Oldest mission, like Jason-1, has less cycles and more uncertainties

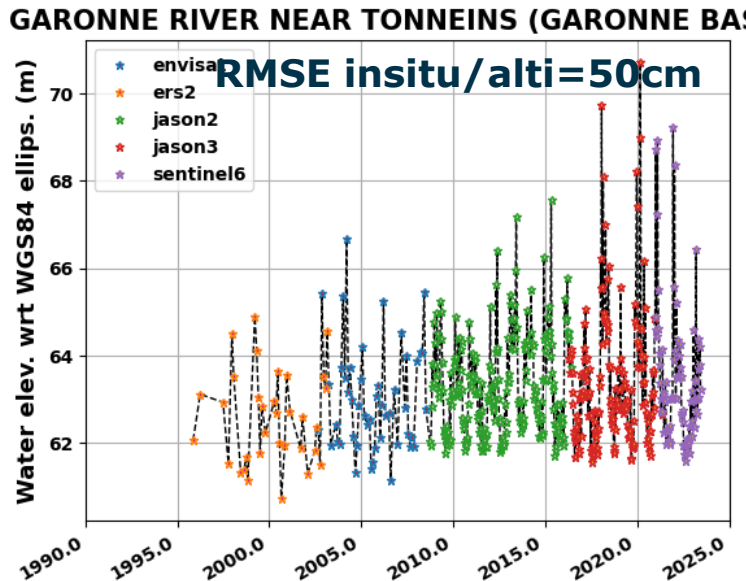


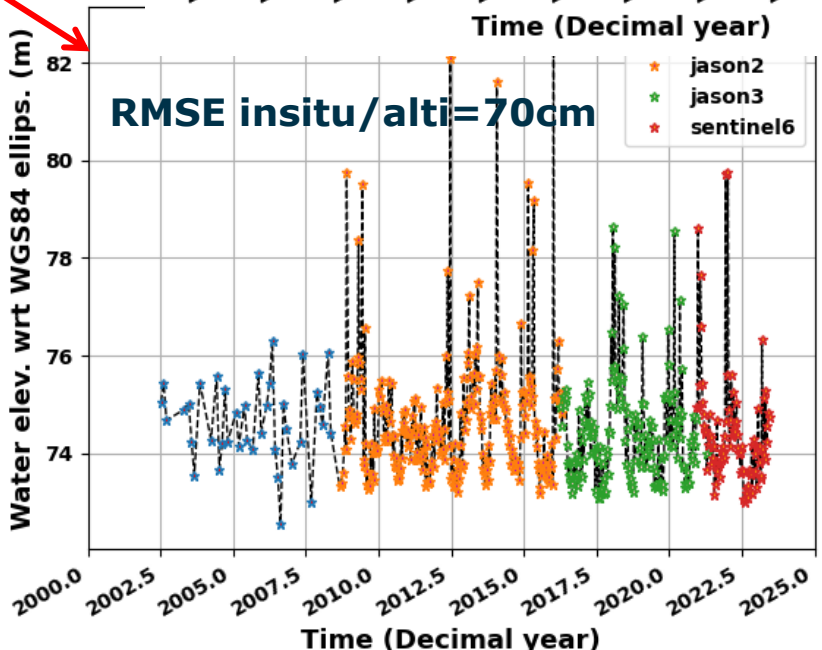
Results: example on the Garonne Basin



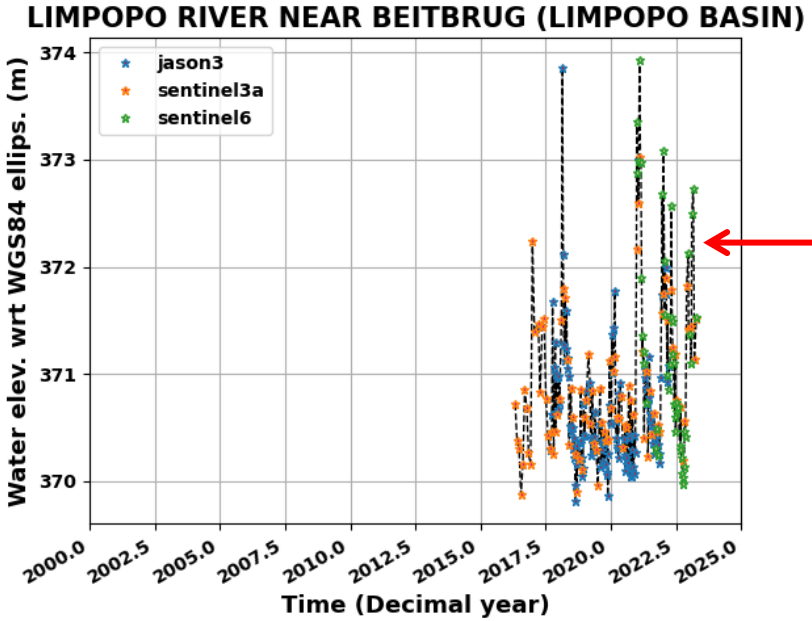


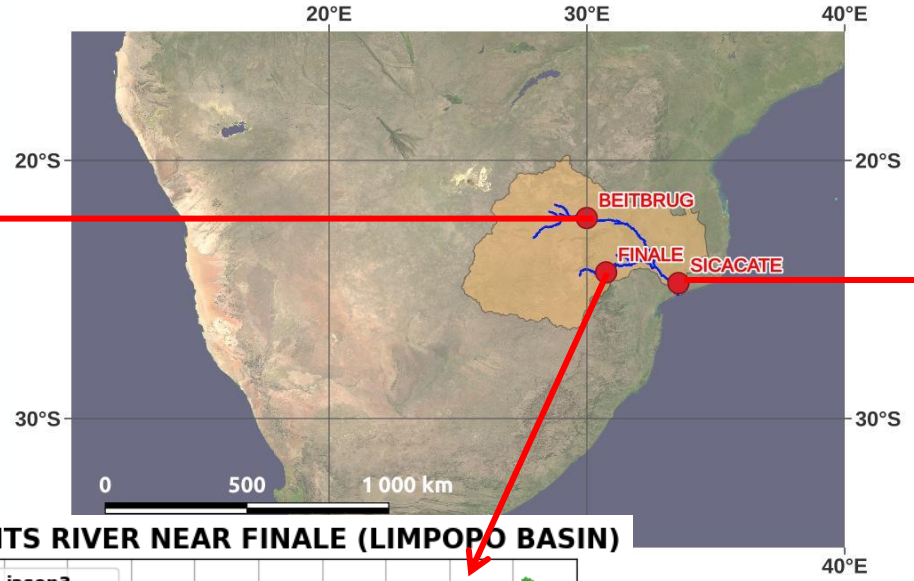


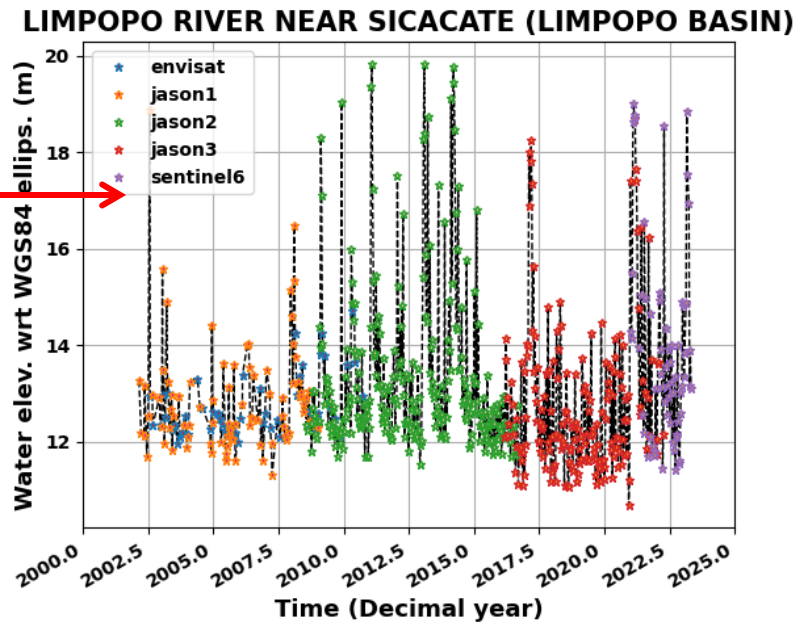


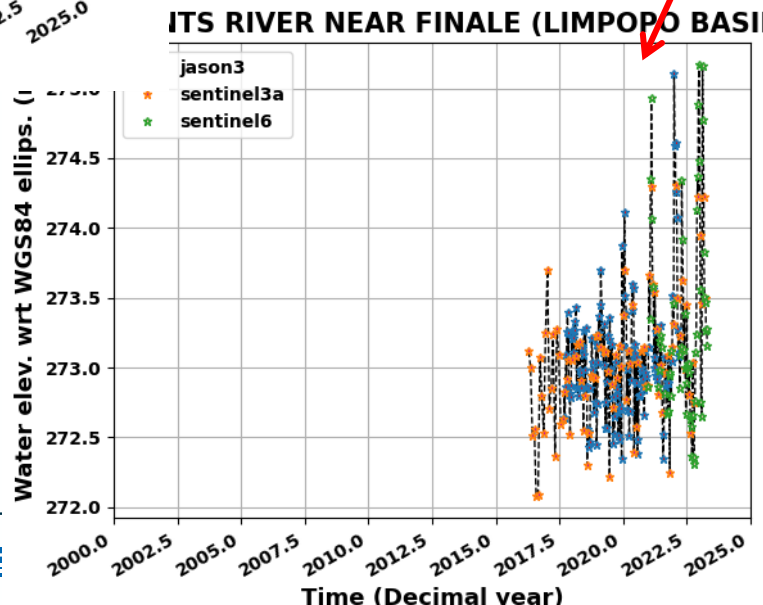


Results: example on the Limpopo Basin





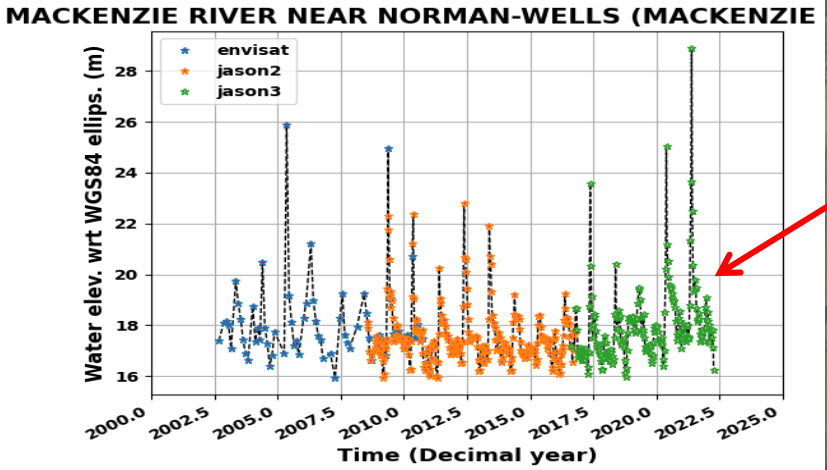


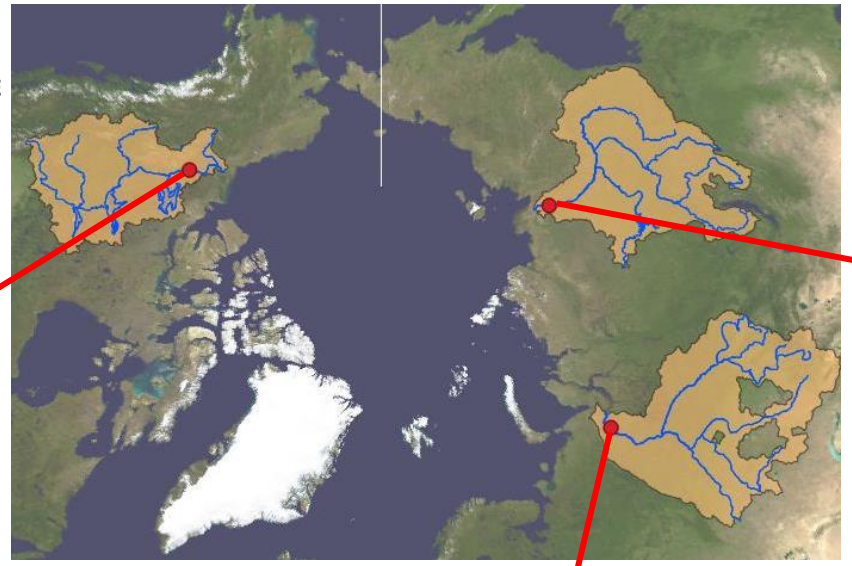


Near Beitbrug and Finale stations, all missions in closed-loop mode are locked on surrounding hills -> only data after 2017

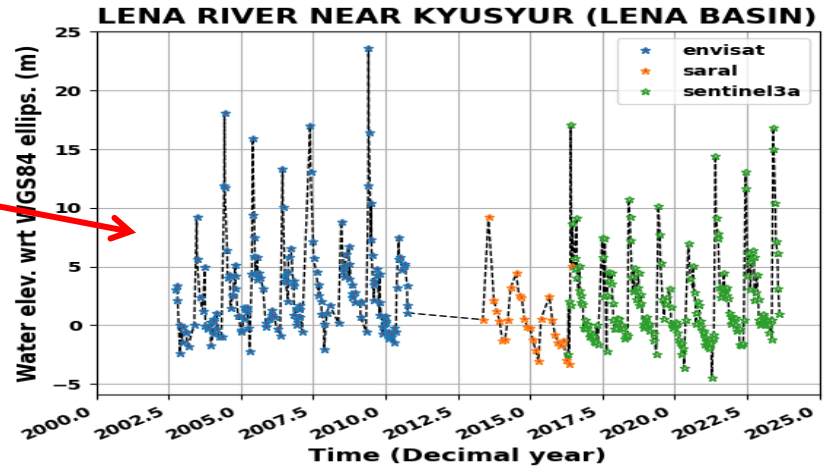
Results: examples on Arctic Rivers

Ice & snow covers combined with high banks result in data loss during winter before open-loop era:

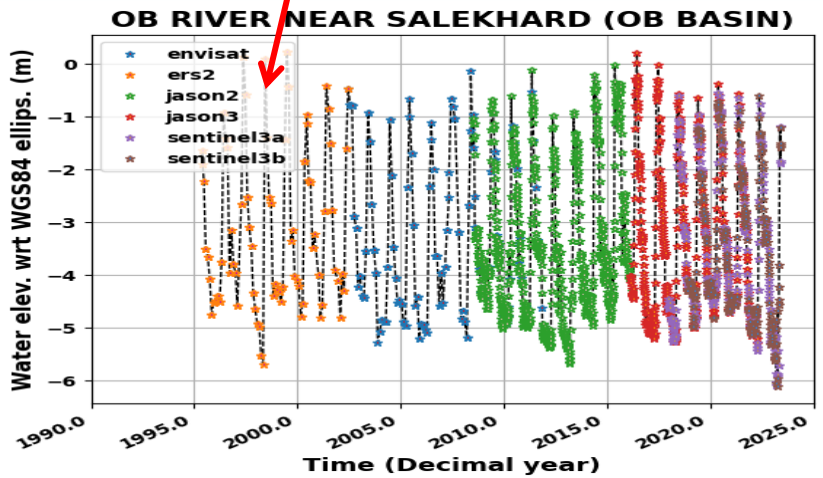




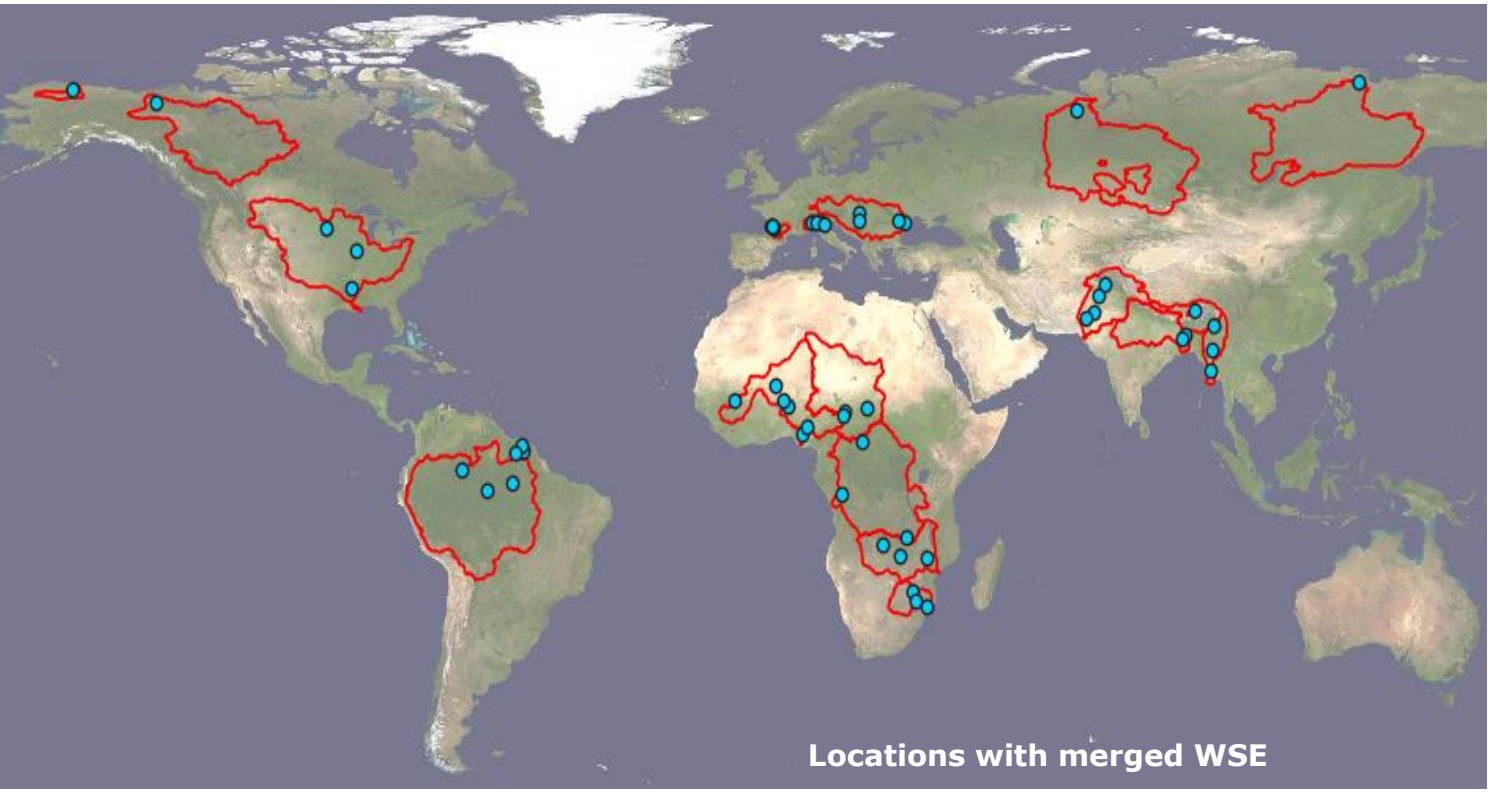
Above 66.6° N, rivers seen only by polar-orbiting satellites with 35- and 27-days repeat period:



With Jason-2/3/S6 (since 2008) + Sentinel-3A/B (since 2016) significant increase in time sampling on the Ob River:



Summary of river WSE product



- 341 single mission WSE time series
- 53 merged WSE time series near selected locations:
  - 3 time series ≤ 7 years
  - 2 time series = 15 years
  - 28 time series = 21 years
  - 20 time series ~30 years
- Only 1 location with no time series
- Single and merged WSE time series provided in both csv and netcdf4 formats

WSE product v1.0 delivered in November 2023, V1.1 late February 2024

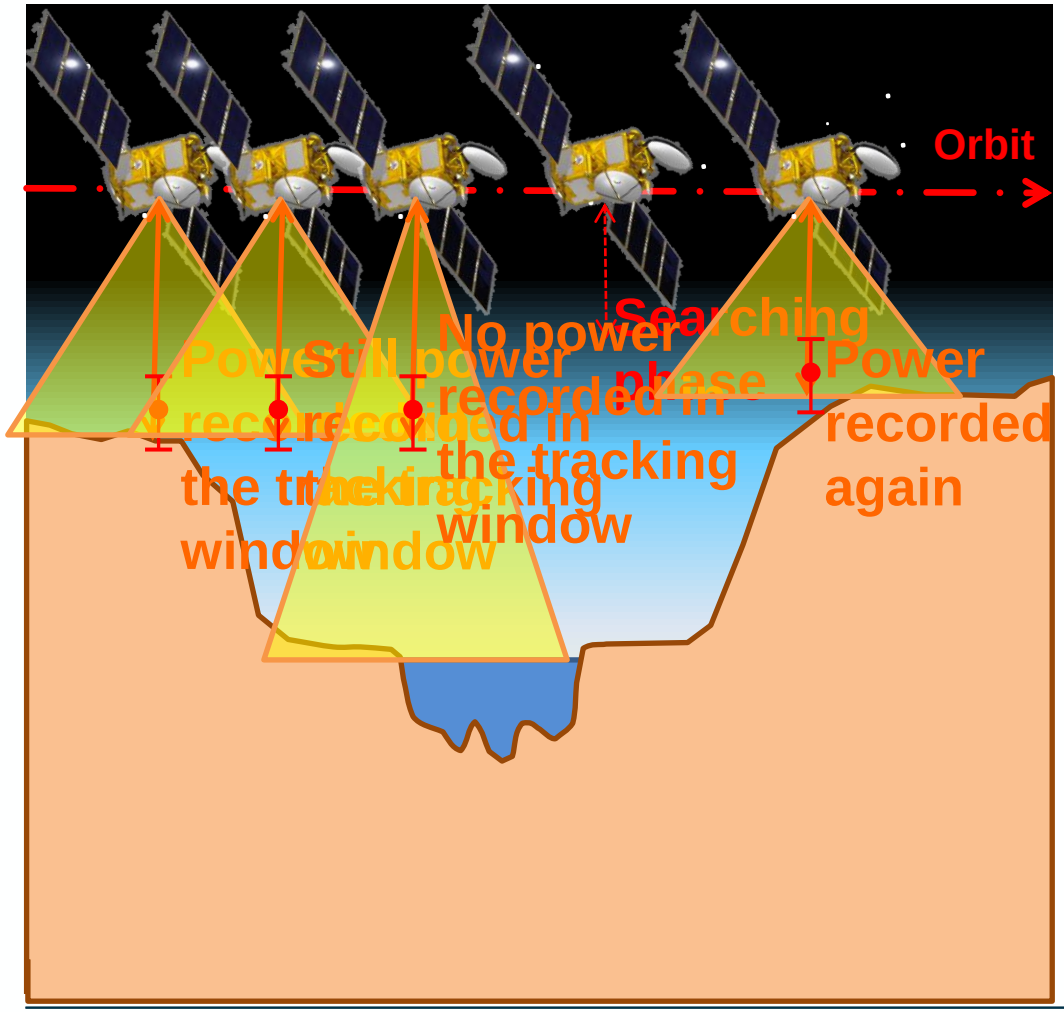
Time series available on CEDA platform: https://data.ceda.ac.uk/neodc/esacci/river_discharge/data/WL/v1.1

river discharge cci

climate.esa.int/projects/river-discharge

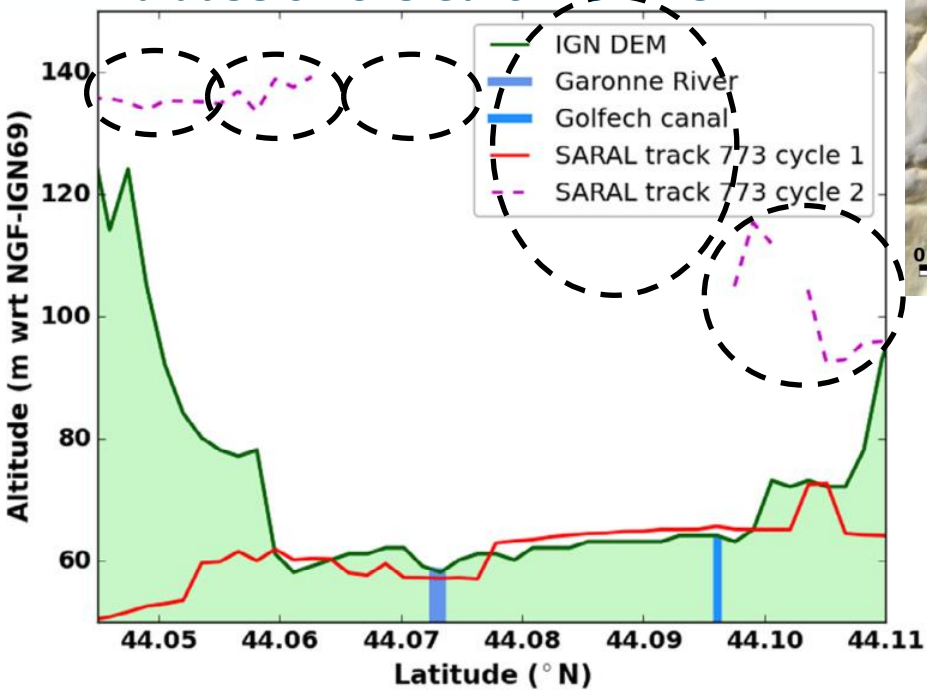
Issues explaining data gaps (2/2)

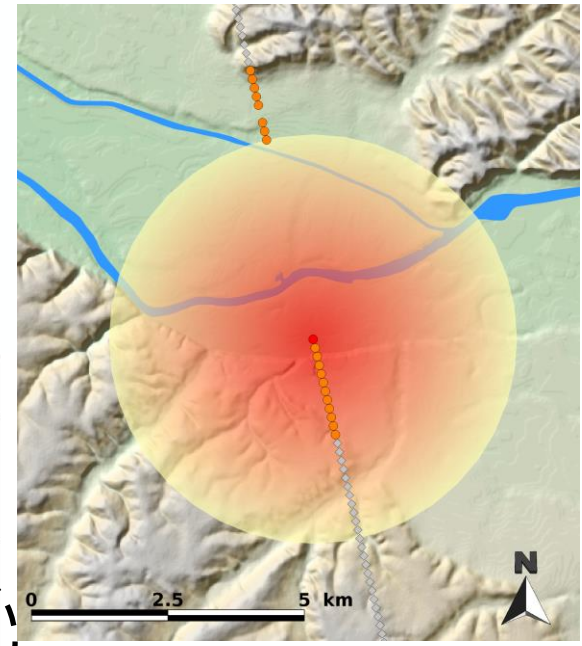
- Loss of data on past missions with closed-loop tracking mode (T/P, J1, J2, ERS2, Envisat, Saral):



Note: tracking window size is ~60m

Saral meas. (Feb. 2013) near Malause on the Garonne River :





Issue mainly solved on Jason-3 and S3A/B with an on-board DEM to fix the tracking window position (open-loop tracking mode)

Results: example on the Po Basin