climate change initiative

RIVER DISCHARGE

WP 3.2: River discharge from altimeters and ancillary data

river discharge cci

Laetitia GAL

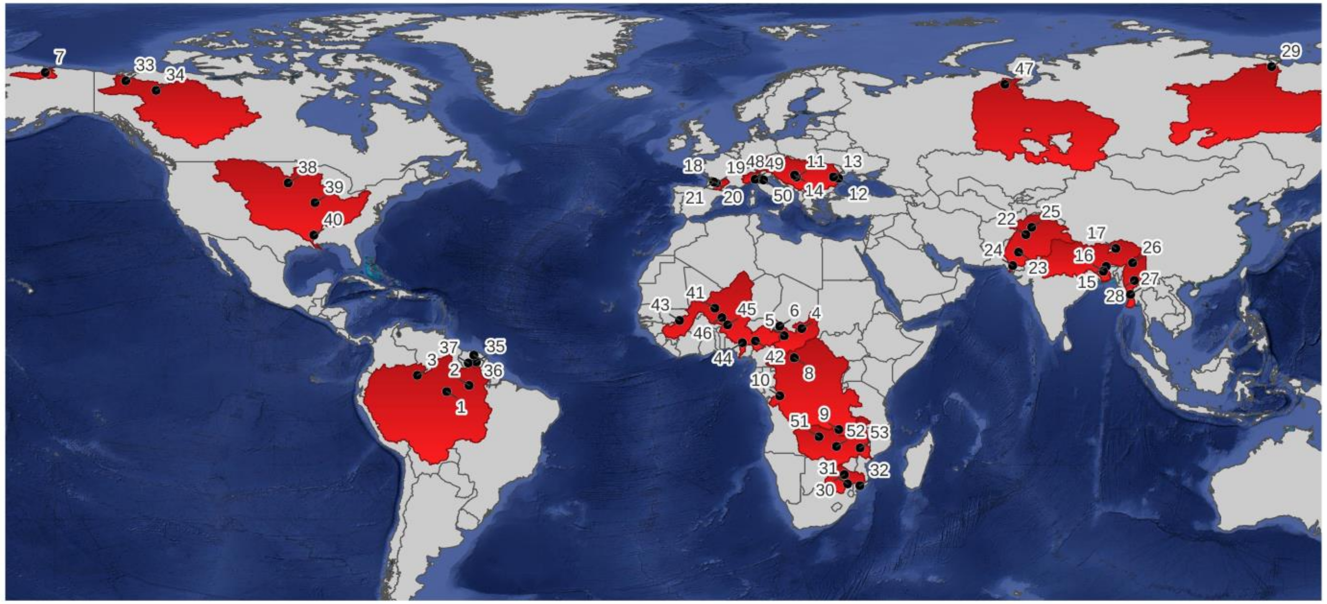
User Workshop

Météo-France, Toulouse

03-04 June 2024

Objectives (1/1)

Objective: Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data



Selected Basins

Selected Stations

- 1-AMAZON-OBIDOS
- 2-AMAZON-SAO-FELIPE
- 3-AMAZON-MANACAPURU
- 4-CHAD-NDJAMENA
- 5-CHAD-AM-TIMAN
- 6-CHAD-LAI
- 7-CHAD-GUELENGDENG
- 8-COLVILLE-UMIAT
- 9-CONGO-CHEMBE-FERRY
- 10-CONGO-BANGUI
- 11-CONGO-KINSHASA
- 12-DANUBE-BOGOJEVO
- 13-DANUBE-BAJA
- 14-DANUBE-LUNGOCI
- 15-DANUBE-CEATAL
- 16-GANGA-BRAHMAPUTRA-YANGCUN
- 17-GANGA-BRAHMAPUTRA-HARDINGE-BRIDGE
- 18-GANGA-BRAHMAPUTRA-BAHADURABAD
- 19-GARONNE-LAMAGISTERE
- 20-GARONNE-TONNEINS
- 21-GARONNE-MARMANDE
- 22-GARONNE-LA-REOLE
- 23-INDUS-KOTRI
- 24-INDUS-CHASHMA
- 25-INDUS-TARBELA
- 26-INDUS-GUDDU
- 27-IRRAWADDY-HKAMTI
- 28-IRRAWADDY-SAGAING
- 29-IRRAWADDY-PYAY
- 30-LENA-KYUSYUR
- 31-LIMPOPO-FINALE
- 32-LIMPOPO-BEITBRUG
- 33-LIMPOPO-SICACATE
- 34-MACKENZIE-ARCTIC-RED
- 35-MACKENZIE-NORMAN-WELLS
- 36-MARONI-LANGA-TABIKI
- 37-MARONI-DEGRAD-ROCHE
- 38-MARONI-TAPA
- 39-MISSISSIPPI-NEAR-BROOKINGS
- 40-MISSISSIPPI-VALLEY-CITY
- 41-MISSISSIPPI-VICKSBURG
- 42-NIGER-KOULIKORO
- 43-NIGER-NIAMEY
- 44-NIGER-LOKOJA
- 45-NIGER-MALANVILLE
- 46-NIGER-ANSONGO
- 47-NIGER-MAKURDI
- 48-OB-SALEKHARD
- 49-PO-PONTELAGOSCURO
- 50-PO-BORGOFORTE
- 51-PO-PIACENZA
- 52-ZAMBEZI-KASAKA
- 53-ZAMBEZI-KABOMPO-PONTOON
- 54-ZAMBEZI-MATUNDO-CAIS

- **18 basins**
- **54 stations**

Step 1 (1/3)

Objective: Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data

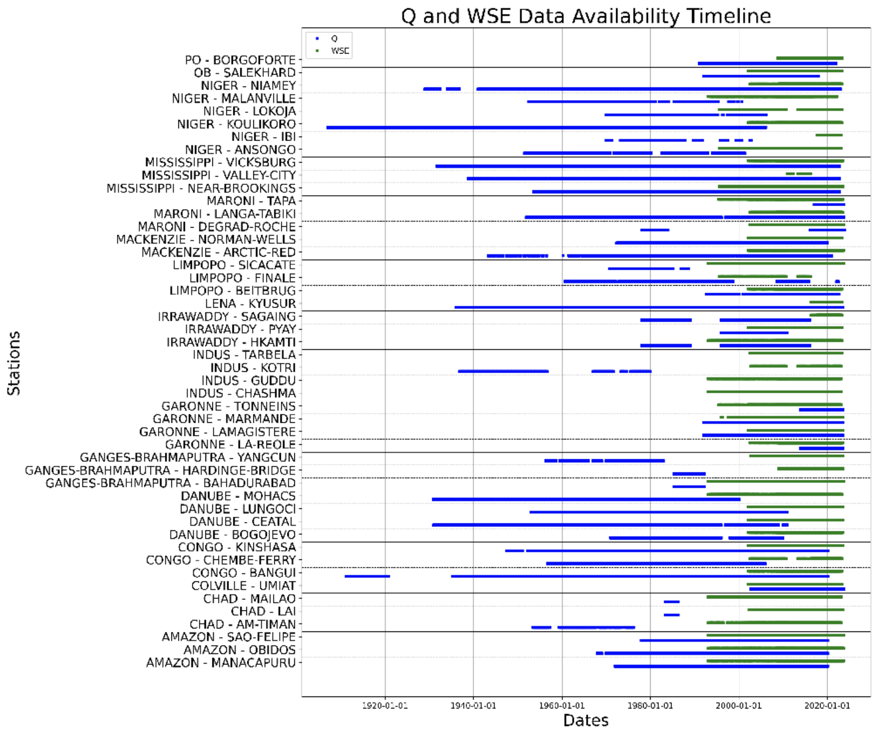
- **Compile all available data** from in-situ and/or model discharge (Q) and merged WSE from altimeters (WP3.1)

Step 1:
Define Cal/Val periods

Step 2:
Compute Rating Curve

Step 3:
Compute Uncertainties

Step 4:
Compute long term River Discharge timeseries



Step 1 (2/3)

Objective: **Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data**

- **Compile all available data** from in-situ and/or model discharge (Q) and merged WSE from altimeters (WP3.1)
- **Identify overlap data** = Closest date with time gap < 24H between WSE and Q

Step 1:
Define Cal/Val periods

Step 2:
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Step 3:
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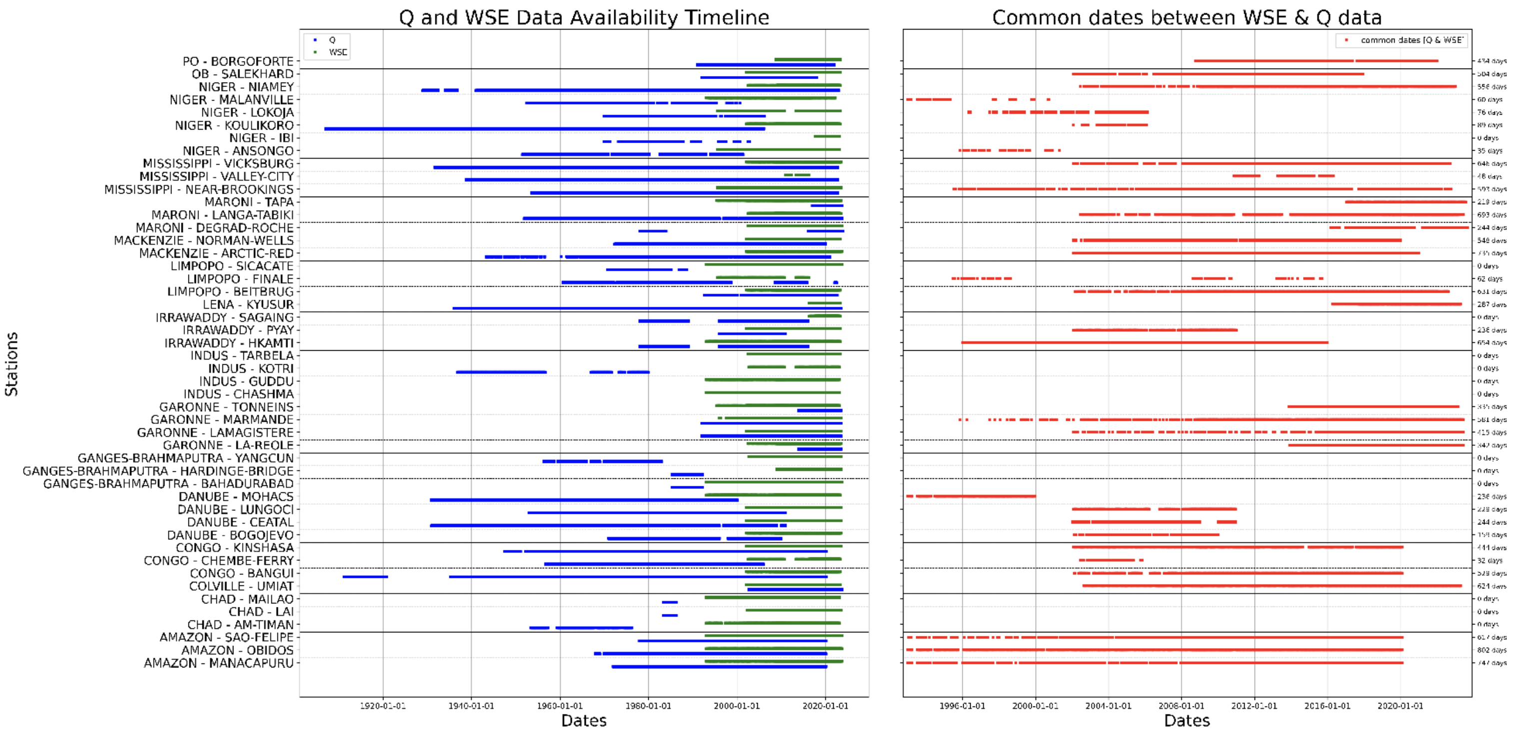
Step 4:
Compute long term River Discharge timeseries



Step 1 (3/3)

esa

Objective: Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data

Step 1:
Define Cal/Val periods

Step 2:
Compute Rating Curve

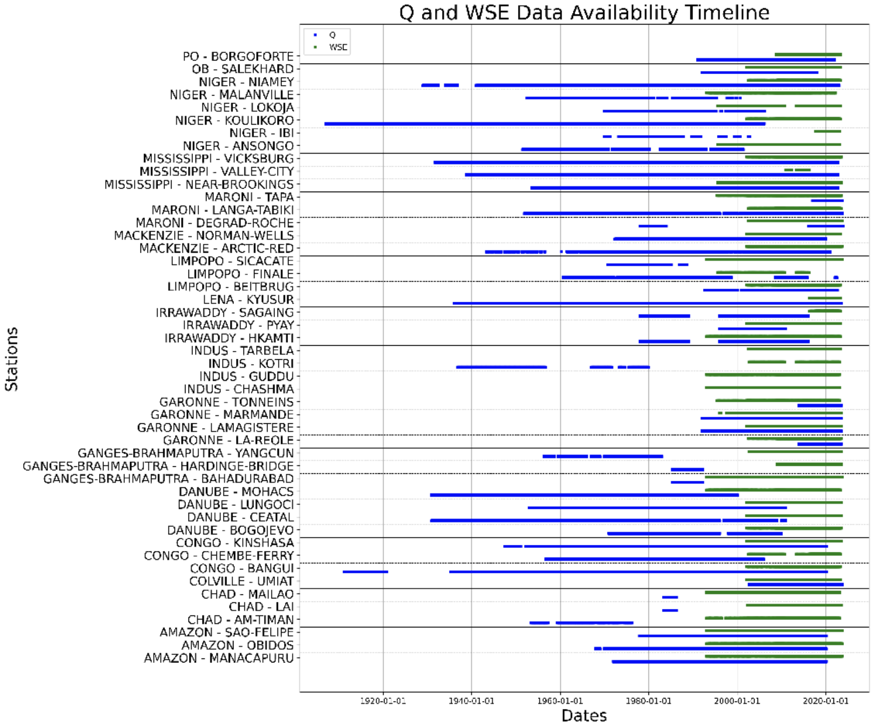
Step 3:
Compute Uncertainties

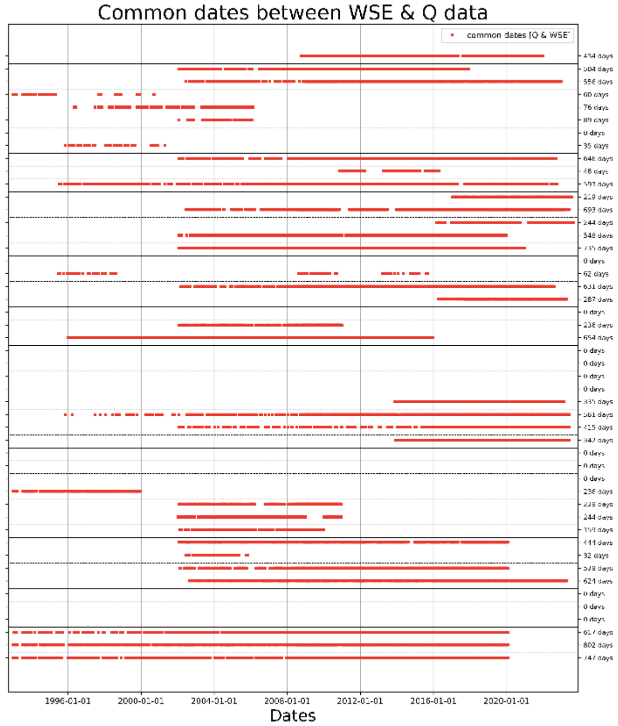
Step 4:
Compute long term River Discharge timeseries

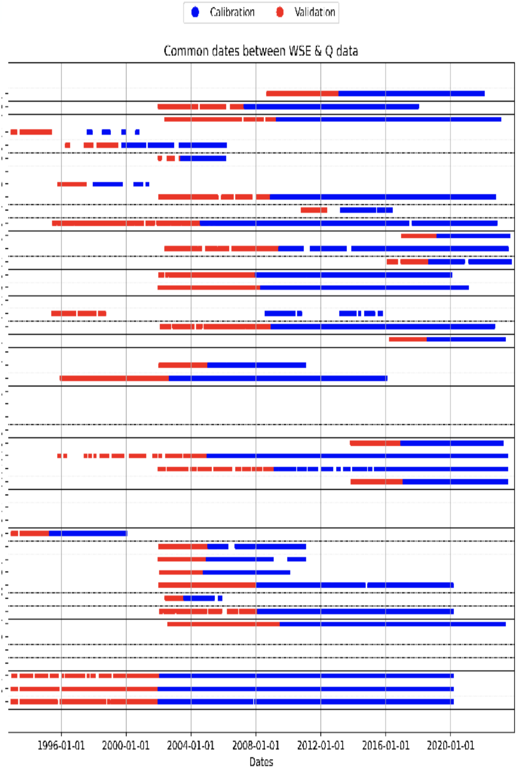
- **Compile all available data** from in-situ and/or model discharge (Q) and merged WSE from altimeters (WP3.1)
- **Identify overlap data** = Closest date with time gap < 24H between WSE and Q
- **Divided** common period **into Calibration/Validation** periods:
  - *First 1/3 part : Validation period - Last 2/3 parts: Calibration period*

CONDITION : If number of common date < 15 = no common period considered, all common data will be used for validation

31 stations : time overlap
4 stations : not enough time overlap
19 stations : without time overlap







Step 2 (1/3)

Objective: Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data

Step 1:
Define Cal/Val periods

Step 2:
Compute Rating Curve

Method 1:
Overlap

Step 3:
Compute Uncertainties

Step 4:
Compute long term River Discharge timeseries

Bayesian Approach to compute Rating Curve between overlap WSE and Q:

- Probabilistic model : $Q = a \cdot (h - z0)^b$
- Prior distribution : a ∈ [0; 3000] - b ∈ [0; 5] - z0 ∈ [min(WSE)-50; min(WSE)
- Parameters estimation through Markov Chain Monte Carlo (MCMC) sampling and the Metropolis-Hasting sampler "MH" algorithm

Step 2 (2/3)

Objective: **Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data**

Step 1: Define Cal/Val periods

Step 2: Compute Rating Curve

Step 3: Compute Uncertainties

Step 4: Compute long term River Discharge timeseries

Method 1: Overlap

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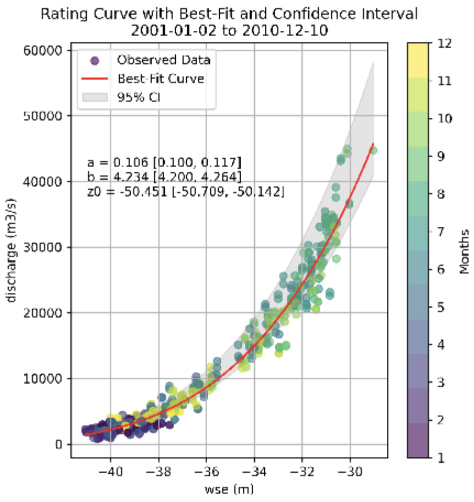
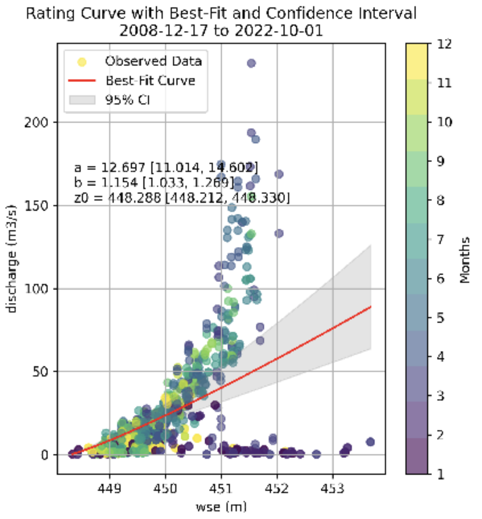
Case 1:

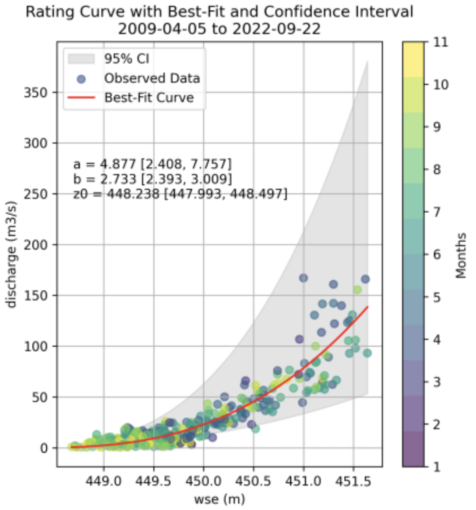
General



Case 2:

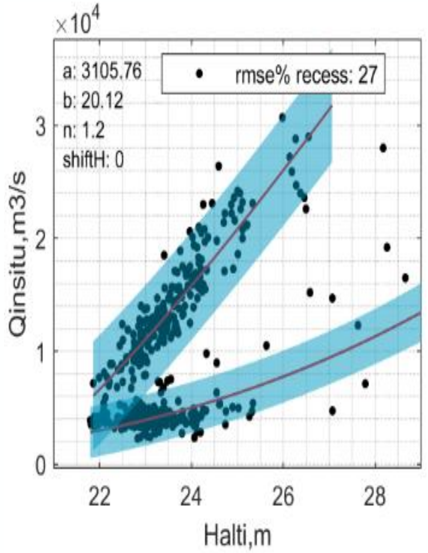
Frozen period time to time
--> remove point based on temperature





Case 3:

Arctic basins
--> Multiples rating curves



Step 2 (3/3)

<u>Objective</u>: Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data

Step 1: Define Cal/Val periods

Step 2: Compute Rating Curve

Step 3: Compute Uncertainties

Step 4: Compute long term River Discharge timeseries

Method 1: Overlap

Bayesian Approach to compute Rating Curve between overlap WSE and Q:

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Case 1: General

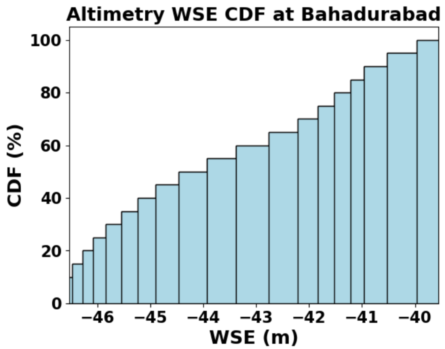
Case 2: Frozen period time to time --> remove point based on temperature

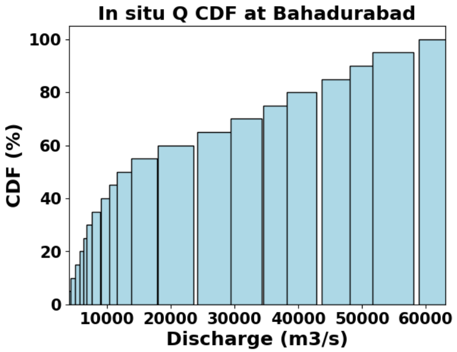
Case 3: Arctic basins --> Multiples rating curves

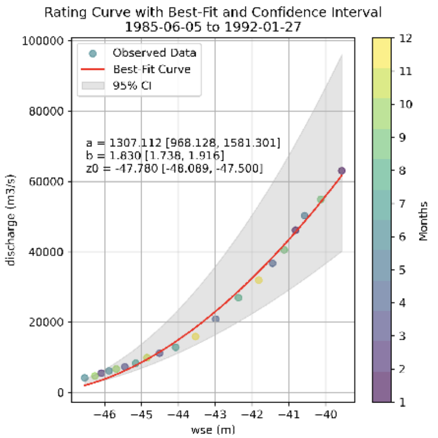
Method 2: No Overlap

Quantile Approach to compute Rating Curve between non-overlap WSE and Q (Tourian et al., 2013):

- Obtain quantile functions of WSE and discharge by sorting ascendingly and normalizing the sorted data using : $P_i = K_i \div (N + 1)$
- Apply Bayesian approach to estimate rating curve parameters







Step 3 (2/2)

Objective: Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data

$$\partial(Q)=\sqrt{\left(\frac{\partial Q}{\partial a}\cdot\partial a\right)^2+\left(\frac{\partial Q}{\partial WSE}\cdot\partial WSE\right)^2+\left(\frac{\partial Q}{\partial b}\cdot\partial b\right)^2+\left(\frac{\partial Q}{\partial z0}\cdot\partial z0\right)^2}$$

$$\partial(Q)=\sqrt{\left((WSE-z0)^b\cdot\sigma a\right)^2+\left(a\cdot b\cdot(WSE-z0)^{b-1}\cdot\sigma WSE\right)^2+\left(a\cdot(WSE-z0)^b\cdot\ln(WSE-z0)\cdot\sigma b\right)^2+\left(-a\cdot b\cdot(WSE-z0)^{b-1}\cdot\sigma z0\right)^2}$$

WARNING : independent variables !

First prior of an end to end uncertainty budget

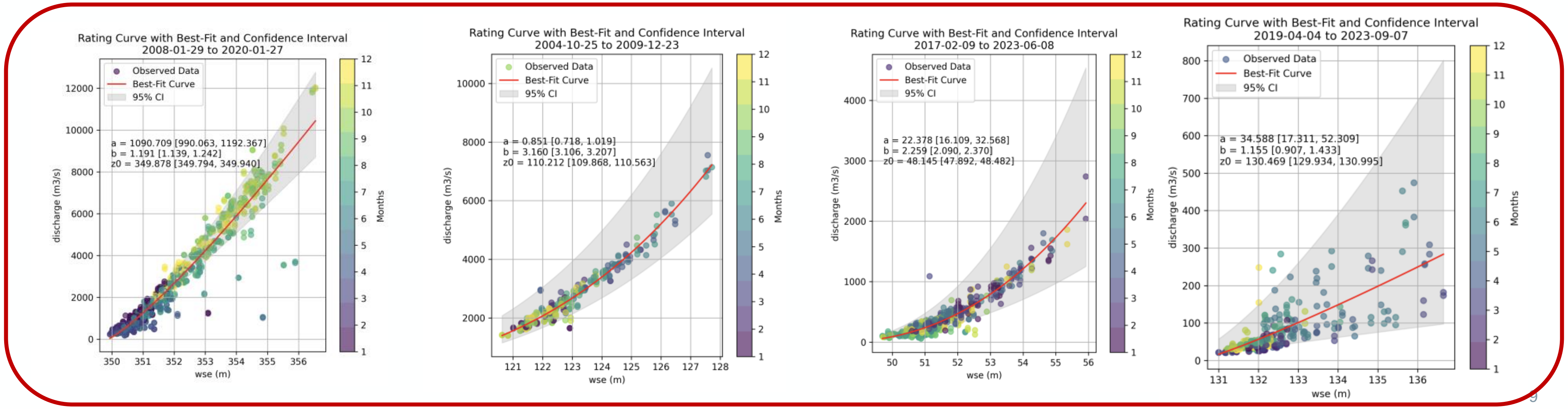
- Sd of power law's coefficients:
- Comes from Bayesian approach

Step 1: Define Cal/Val periods

Step 2: Compute Rating Curve

Step 3: Compute Uncertainties

Step 4: Compute long term River Discharge timeseries



Step 3 (2/2)

<u>Objective</u>: Compute long-term discharge time series at selected locations from altimetry WSE and ancillary data

Step 1:
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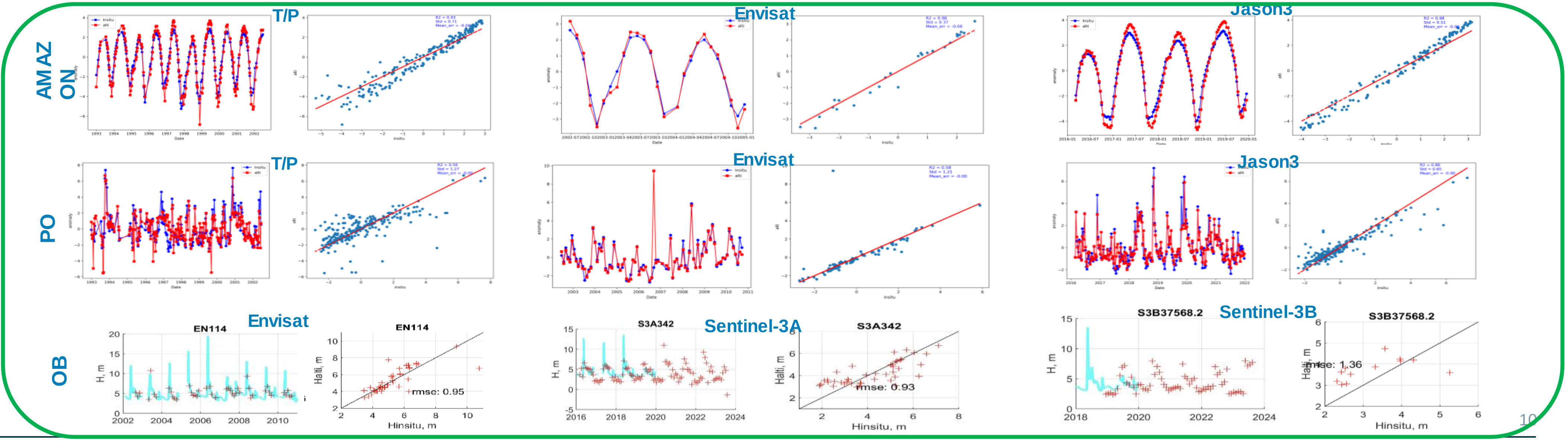
$$\partial(Q)=\sqrt{\left(\frac{\partial Q}{\partial a}\cdot\partial a\right)^2+\left(\frac{\partial Q}{\partial WSE}\cdot\partial WSE\right)^2+\left(\frac{\partial Q}{\partial b}\cdot\partial b\right)^2+\left(\frac{\partial Q}{\partial z0}\cdot\partial z0\right)^2}$$

$$\partial(Q)=\sqrt{\left((WSE-z0)^b\cdot\sigma a\right)^2+\left(a\cdot b\cdot(WSE-z0)^{b-1}\cdot\sigma WSE\right)^2+\left(a\cdot(WSE-z0)^b\cdot\ln(WSE-z0)\cdot\sigma b\right)^2+\left(-a\cdot b\cdot(WSE-z0)^{b-1}\cdot\sigma z0\right)^2}$$

<u>WARNING</u> : independent variables !

<u>First prior of an end to end uncertainty budget</u>

- Sd of power law's coefficients:
- Comes from Bayesian approach
- Sd of WSE:
- error per mission between WSE and In-situ water heigh anomalies



Step 3 (2/2)

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$$\partial(Q)=\sqrt{((WSE-z0)^b\cdot\sigma a)^2+(a\cdot b\cdot(WSE-z0)^{b-1}\cdot\sigma WSE)^2+(a\cdot(WSE-z0)^b\cdot\ln(WSE-z0)\cdot\sigma b)^2+(-a\cdot b\cdot(WSE-z0)^{b-1}\cdot\sigma z0)^2}$$

WARNING : independent variables !

First prior of an end to end uncertainty budget

- Sd of power law's coefficients:
- Comes from Bayesian approach
- Sd of WSE:
- error per mission between WSE and In-situ water heigh anomalies
- Sd applied per mission over all stations/dates to avoid giving more weight to one station
- Sd independent for extreme latitudes stations and other latitudes

	TP	*ers2*	*Envisat*	*Jason 1*	*Jason 2*	*Jason 3*	*Saral*	*Sentinel3a*	*Sentinel3b*	*Sentinel6*
Arctic	-	0.50 (26)	1.13 (681)	-	0.86 (605)	1.02 (550)	1.12 (110)	1.02 (515)	0.87 (274)	-
Other	1.01 (1094)	0.91 (131)	0.83 (663)	0.91 (740)	0.65 (2550)	0.62 (2534)	0.71 (190)	1.02 (253)	0.32 (124)	0.51 (752)

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Step 4 (1/2)

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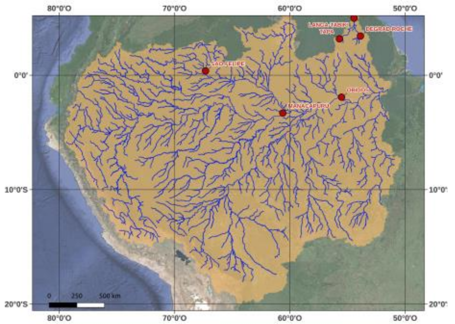

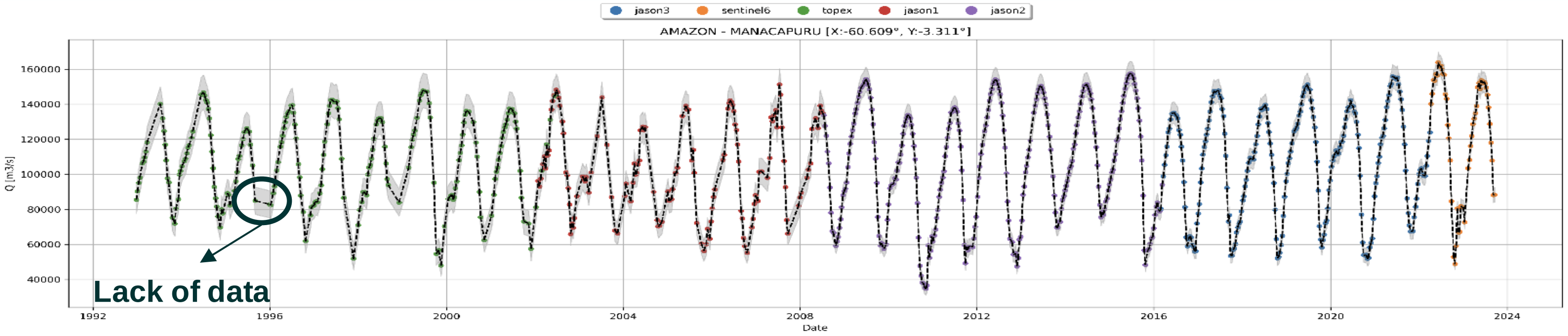

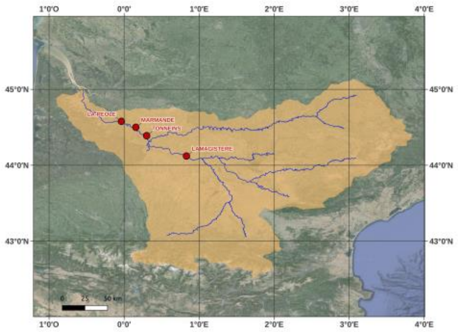

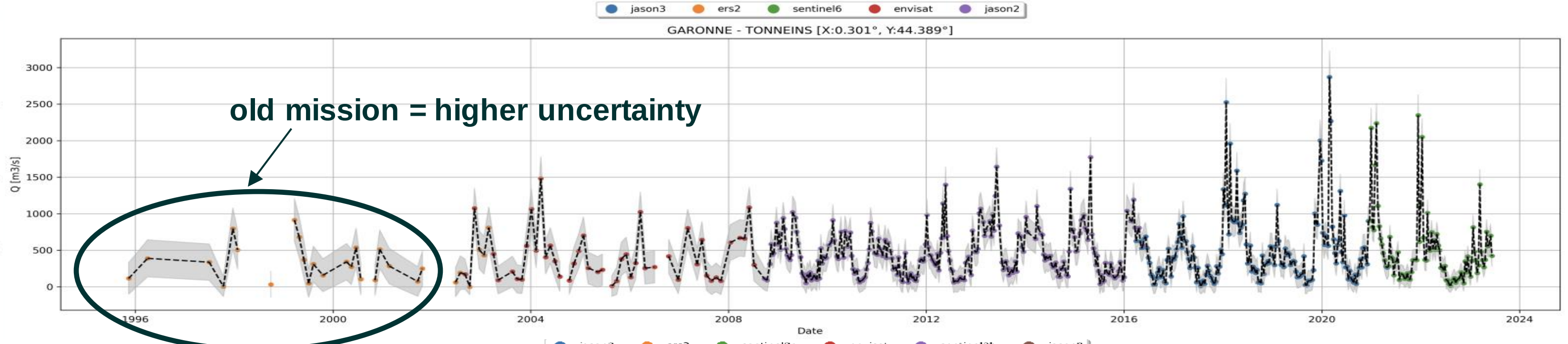

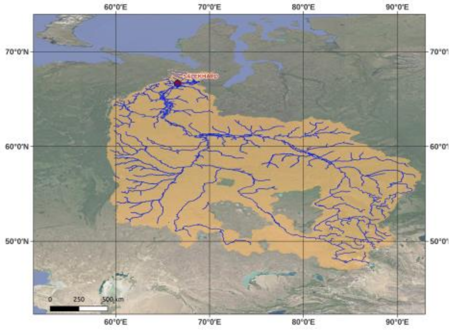

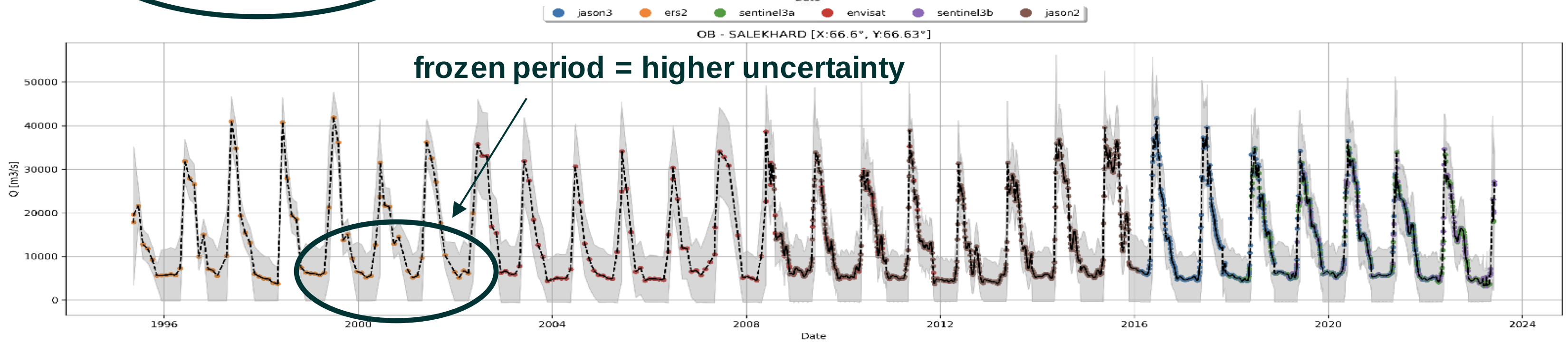

Step 4 (2/2)

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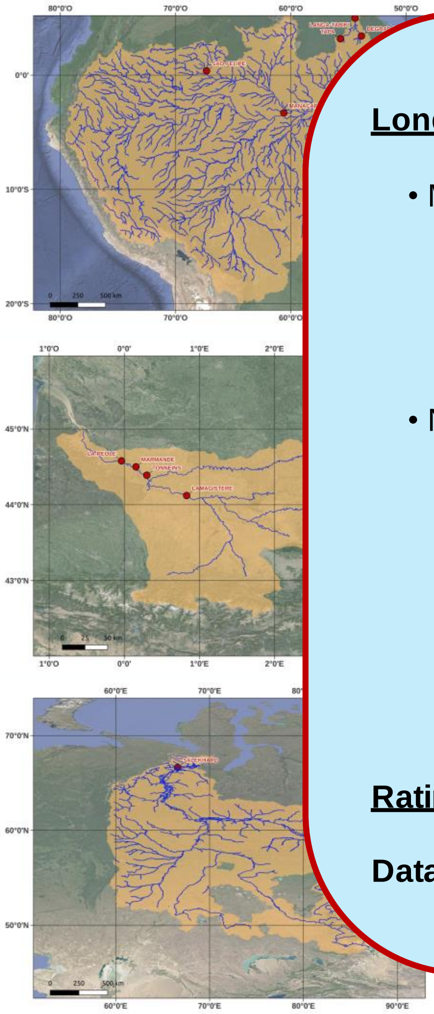

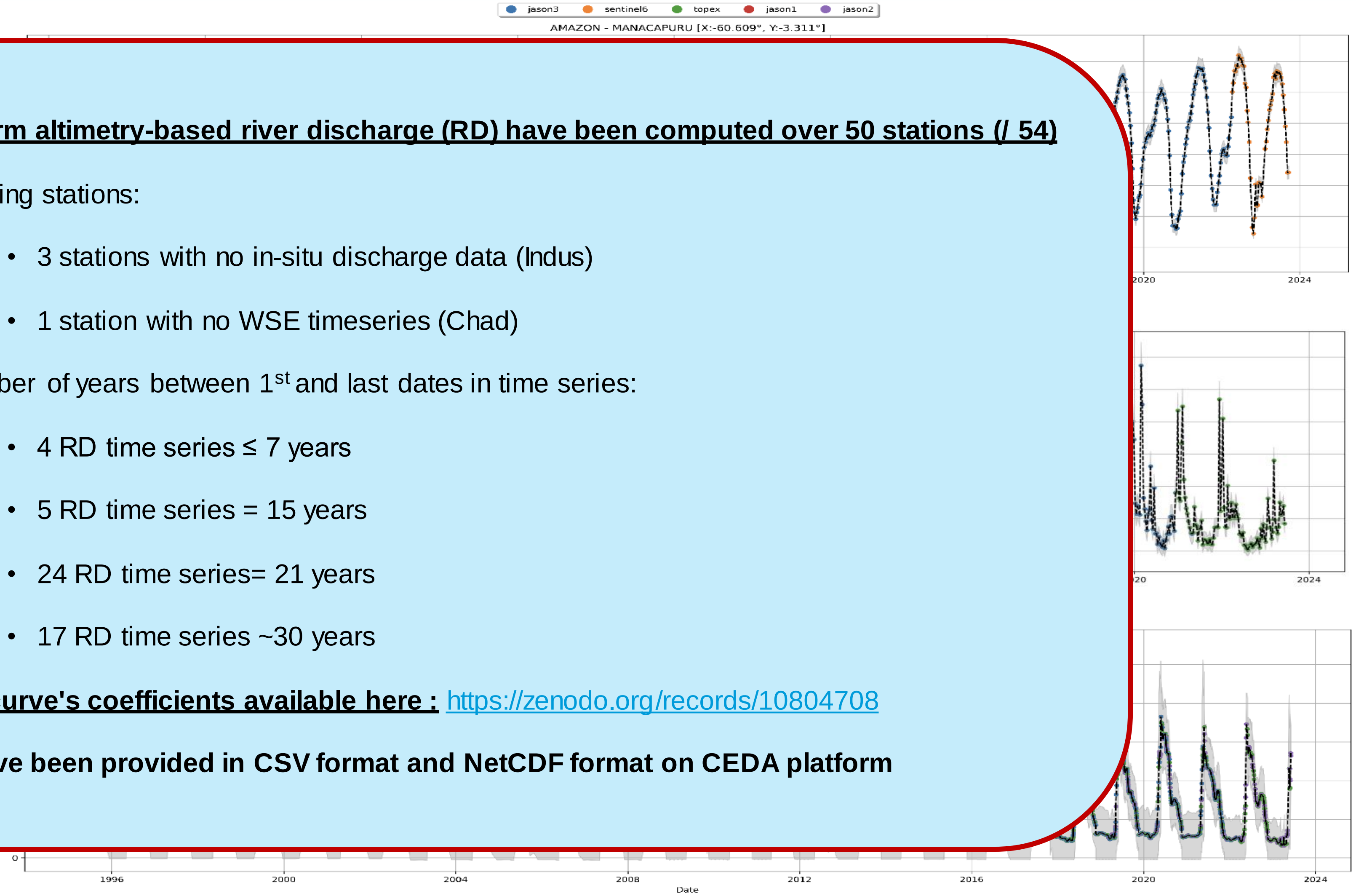

<u>Long term altimetry-based river discharge (RD) have been computed over 50 stations (/ 54)</u>

- Missing stations:
  - 3 stations with no in-situ discharge data (Indus)
  - 1 station with no WSE timeseries (Chad)
- Number of years between 1st and last dates in time series:
  - 4 RD time series ≤ 7 years
  - 5 RD time series = 15 years
  - 24 RD time series= 21 years
  - 17 RD time series ~30 years

<u>Rating curve's coefficients available here :</u> https://zenodo.org/records/10804708

Data have been provided in CSV format and NetCDF format on CEDA platform

river discharge cci

climate.esa.int/projects/river-discharge