Monitoring River Water levels from Space: Quality Assessment of 20 years of Satellite Altimetry Data

September, 25th 2012

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(1) UMR LEGOS, (2) UMR TETIS

Initial statement

Someone[1] who wants to use altimetry data of river water levels[2]

(1) think of an hydrologist

(2) without any kind of “expert knowledge”

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We propose to :
→ Systematic comparison of altimetry to in situ gauging data
→ Do it on a large number of “virtual stations”

Toward a

Standardized Method

for

“Alti-Hydro Products”

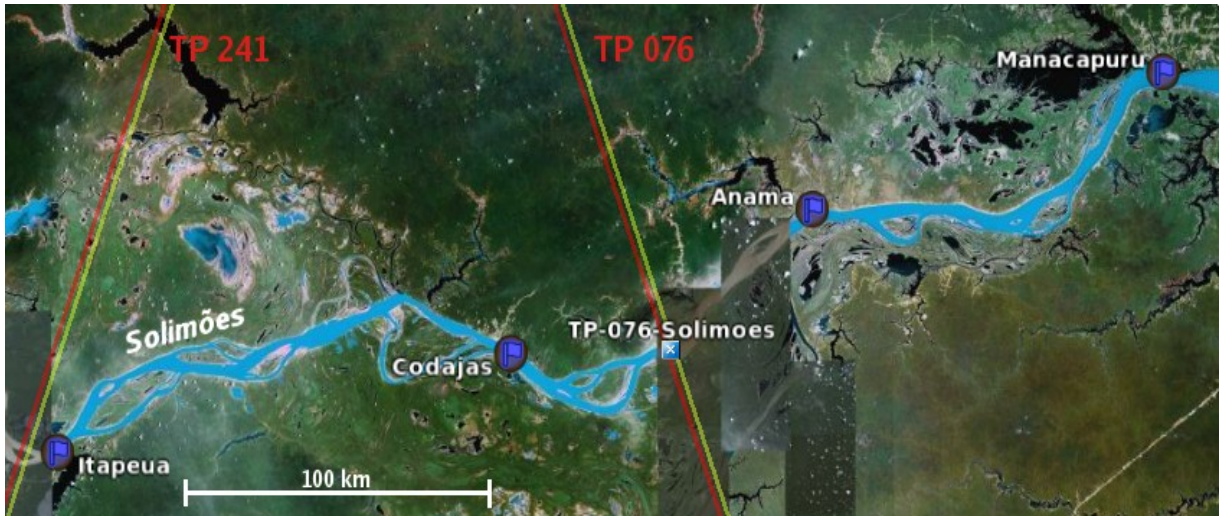
Quality assessment

Input data

"**Alti-Hydro Products**" **:** time series of river water levels derived from altimetry data, one representative measurement per river overflight (i.e., per cycle-track).

"**In situ gauging data**" **:** time series of river water levels, usually delivered as mean daily samples.

Altimetry and in situ data colocalisation



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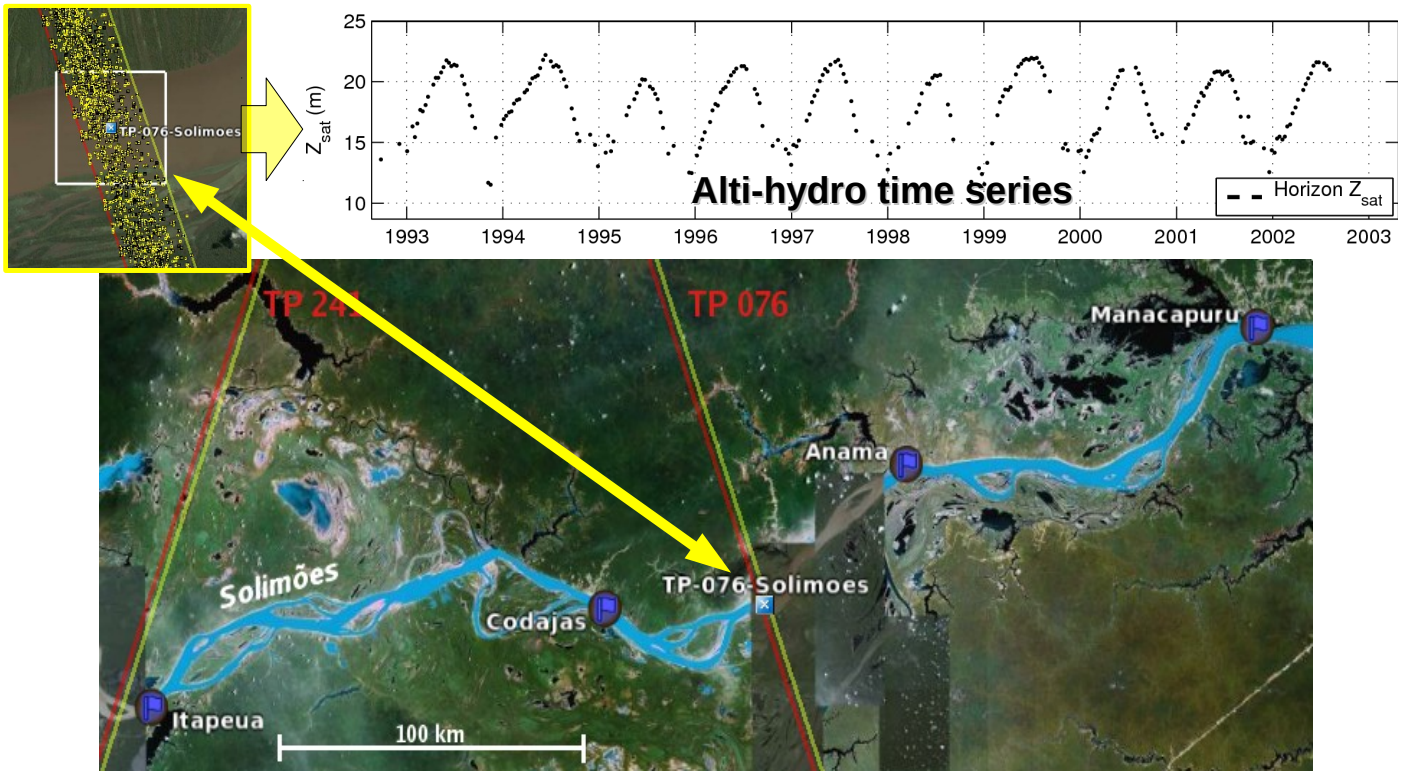

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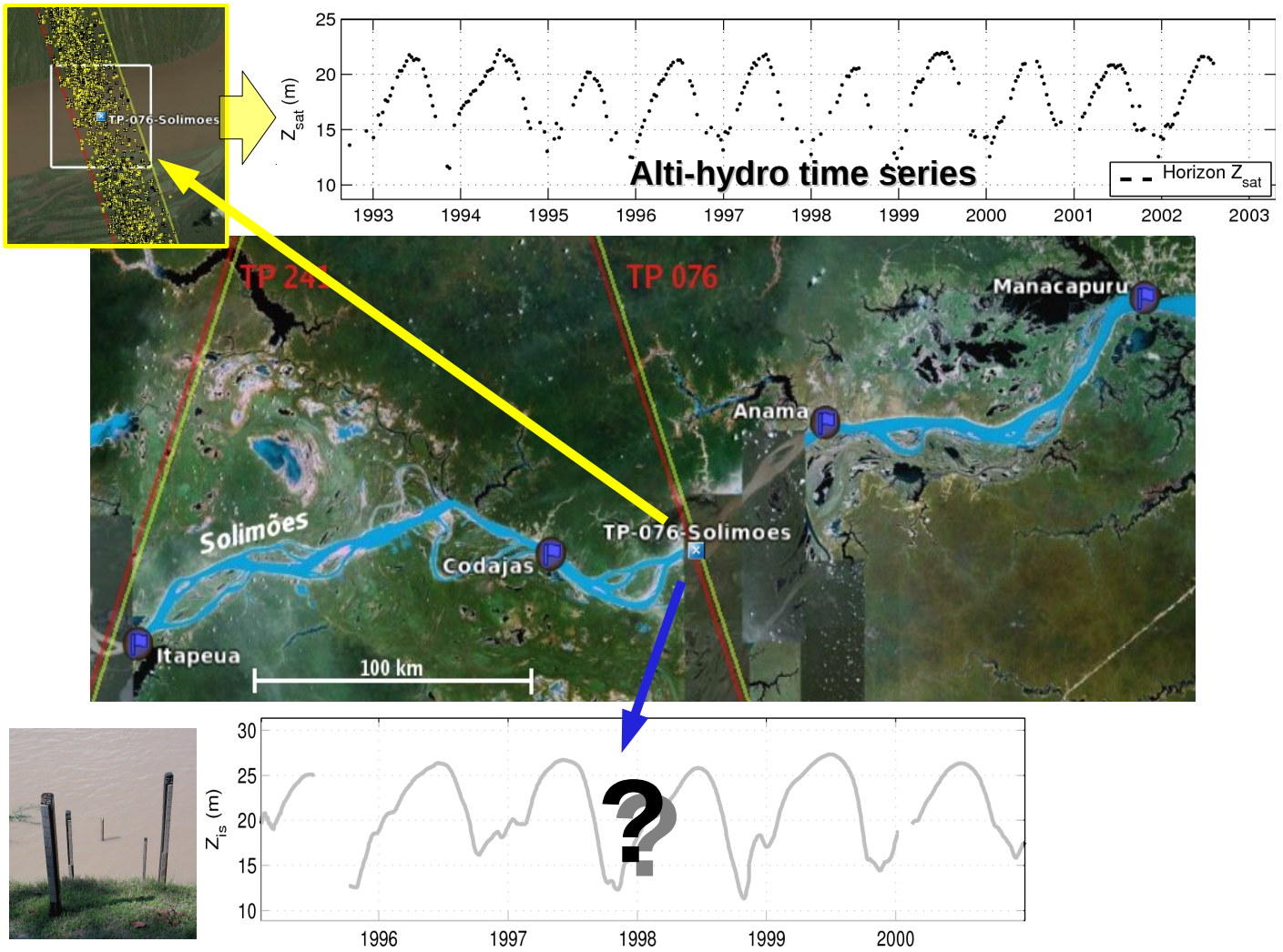
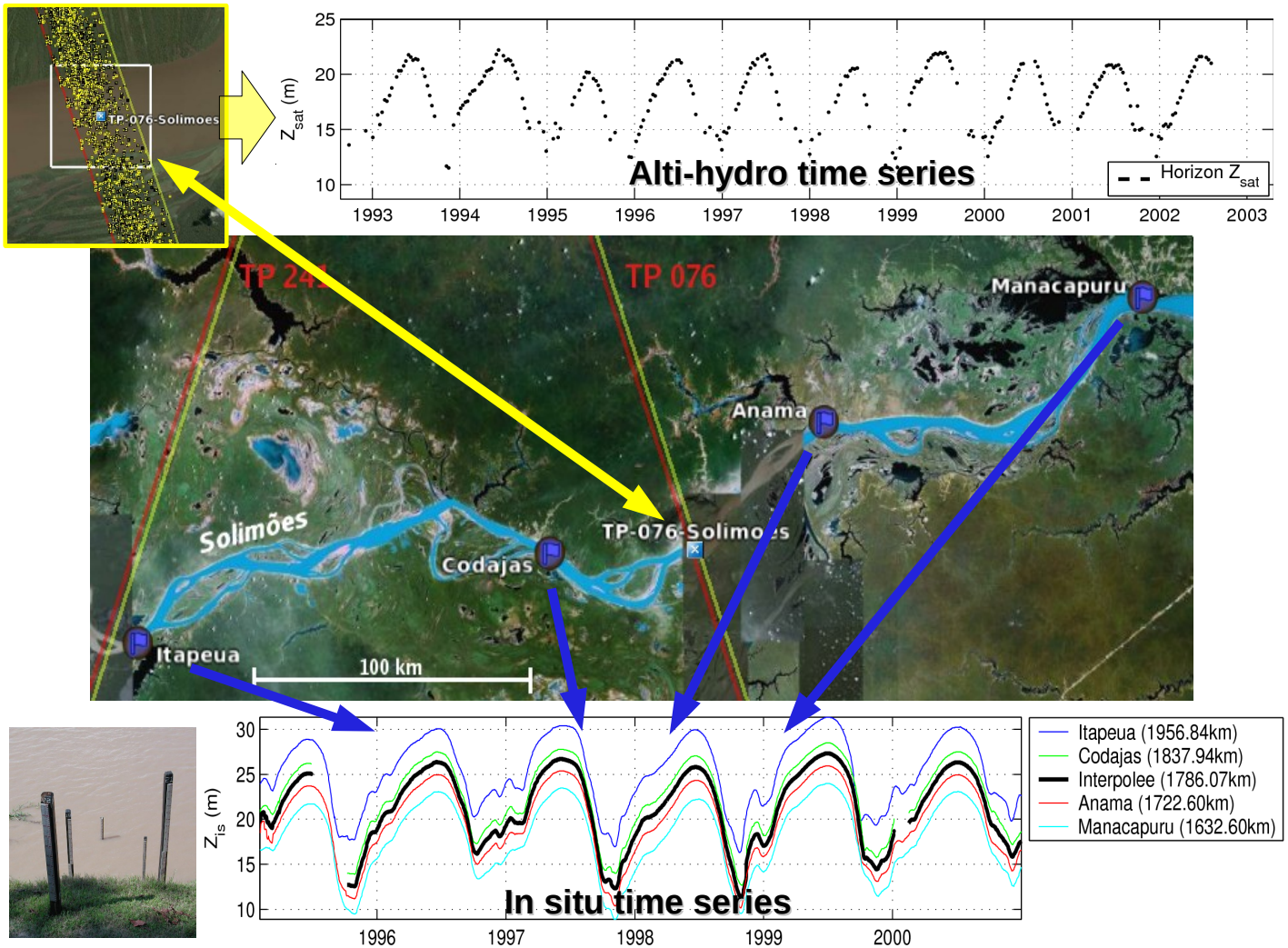


Reconstitution of in situ time series (at virtual station)



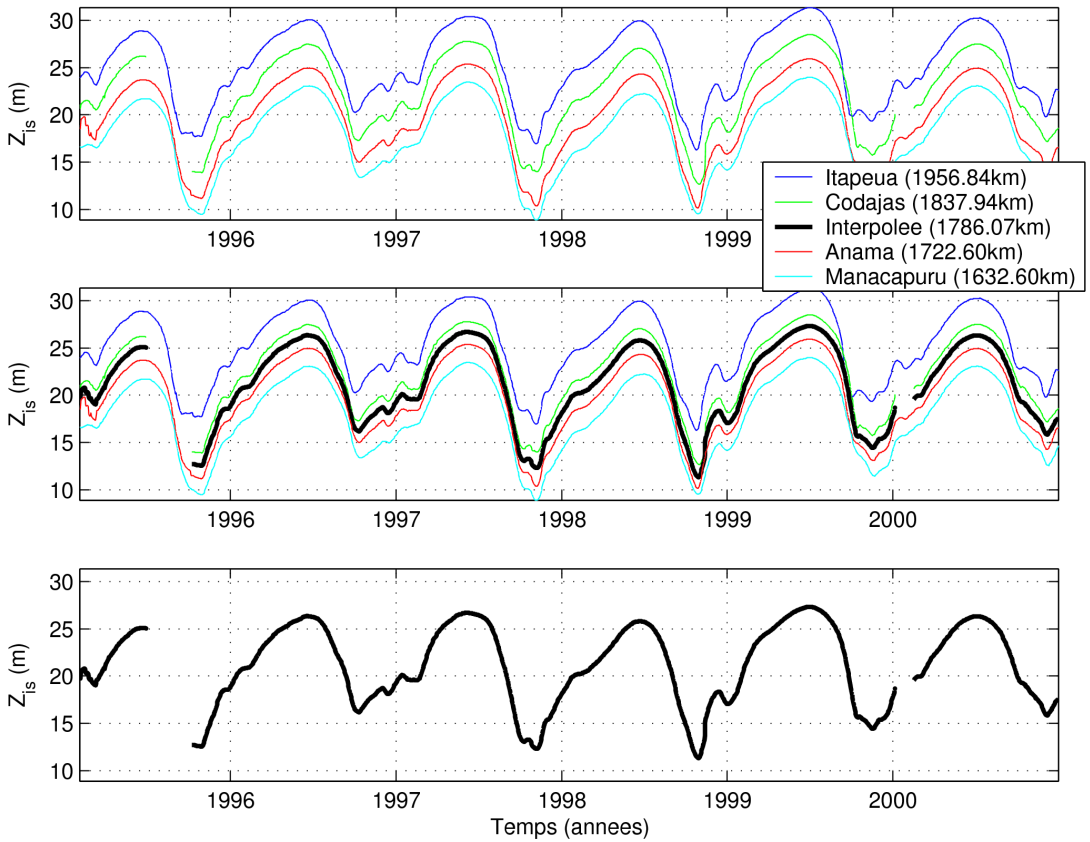
Reconstitution of in situ time series (at virtual station)

Smooth river profile → smoothed interpolation

Upstream & downstream time series

Consistent
slopes > 0

Result
(In situ reconstituted)



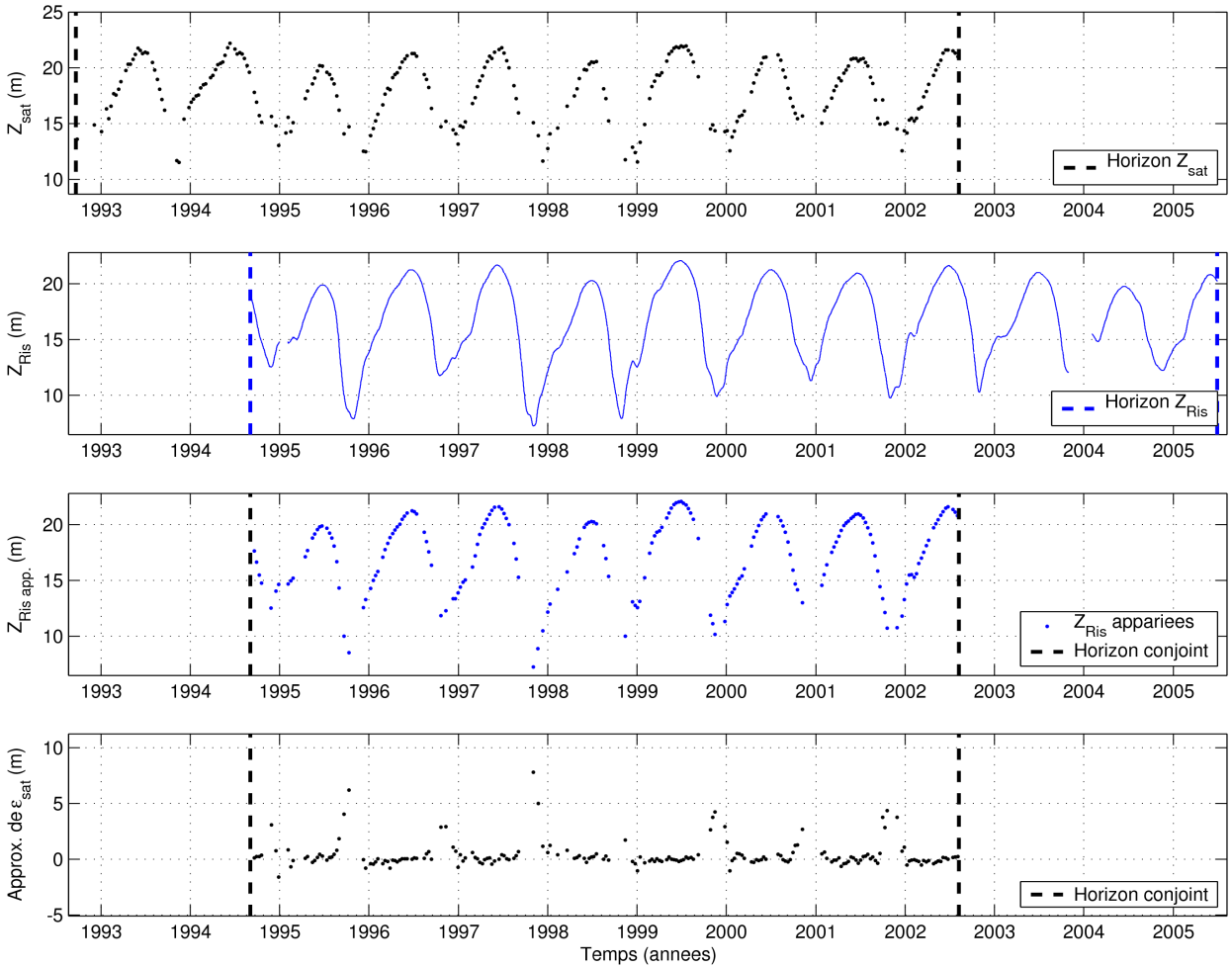
Building Error time series

Altimetry
every available data

In situ
(reconstituted)
every available data

In situ
(paired)
match exact
satellite timings

Error time series
common time interval
& timings



In situ reconstituted : local time to UTC & resample to exact satellite timings

Quality indicators of error time series

Accuracy indicators

- $\mu_{\varepsilon_{Sat}}$: Mean error
- $\sigma_{\varepsilon_{Sat}}$: Error Standard Deviation
- $RMS_{\varepsilon_{Sat}}$: Root Mean Square Error

Sampling efficiency indicators

- T_{eff} : Mean time series sampling period
- η_{eff} : Sampling Loss Rate (T_{eff} independent)

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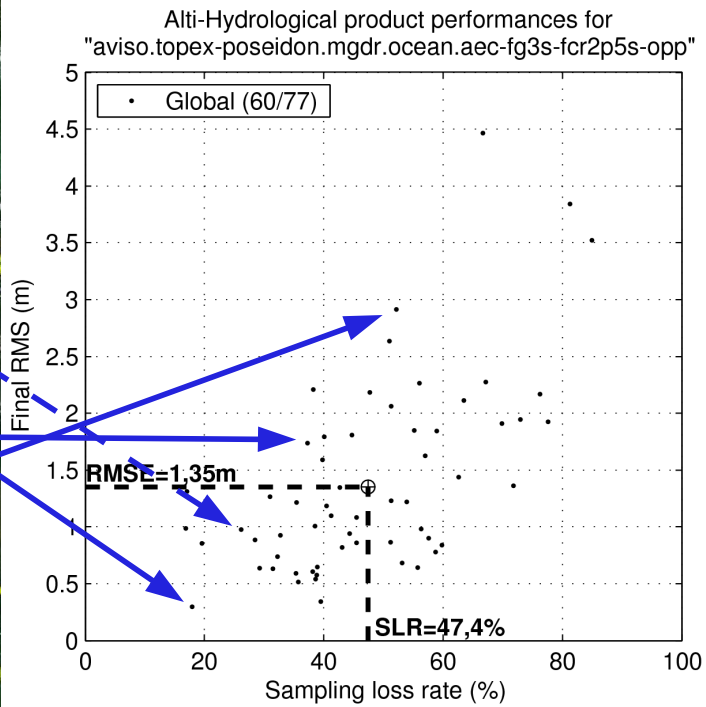
Quality of an Alti-Hydro Product

Try to be as statistically significant as possible :

N virtual stations $\rightarrow$ mean(RMS ; SLR)



Validation Results

Validated Alti-Hydro Products

Publicly available Alti-Hydro products :

- **CASH project** : Topex/Poseidon
- **River & Lake** : ERS-2, ENVISAT
- **HydroWeb** : Topex/Poseidon, ENVISAT

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More documentation welcome :

- Retrackers, editing, filtering, etc. ?
- Expertise ? (i.e., manual cleaning)
- Error-based filtering ? (e.g., “3 sigma filter”)

Validated Alti-Hydro Products

“Homemade” Alti-Hydro Products :

- Automatic processing (reproductible)
- Edited and filtered using custom routines
- Designed with massive distribution in mind

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On top of L2 products :

- **AVISO Topex/Poseidon M-GDRs**
- **AVISO Jason-2 GDR** (Ice1)
- **PISTACH/hydro Jason-2** (Ice3)

The Amazon basin

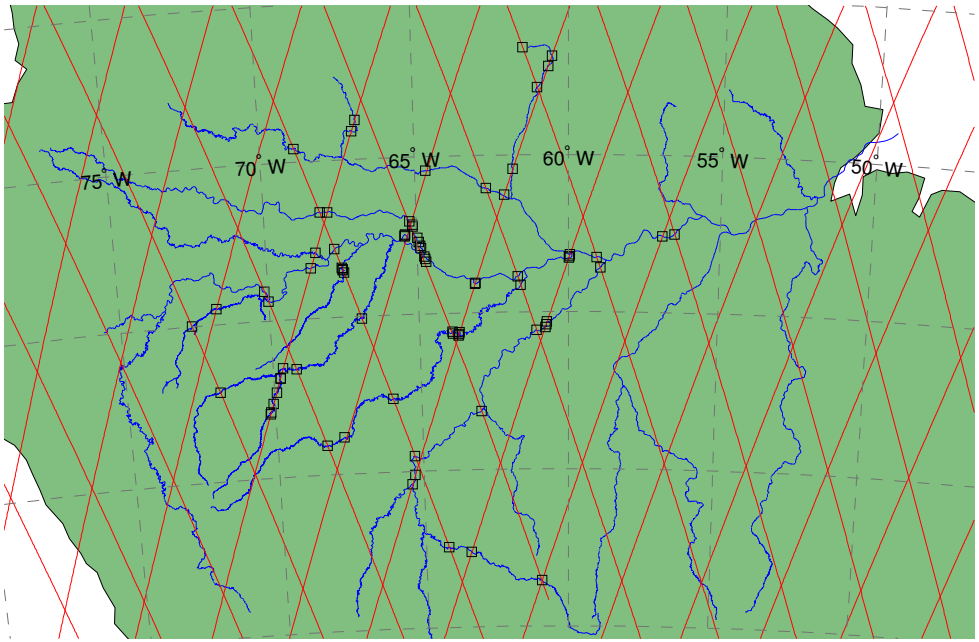
Main characteristics

- Rich variety of river configurations
- Many gauging stations ($\approx$ 400)
- Limnimetric scales are not leveled !

Example :

77 Jason-2 virtual stations used to process our “homemade” products

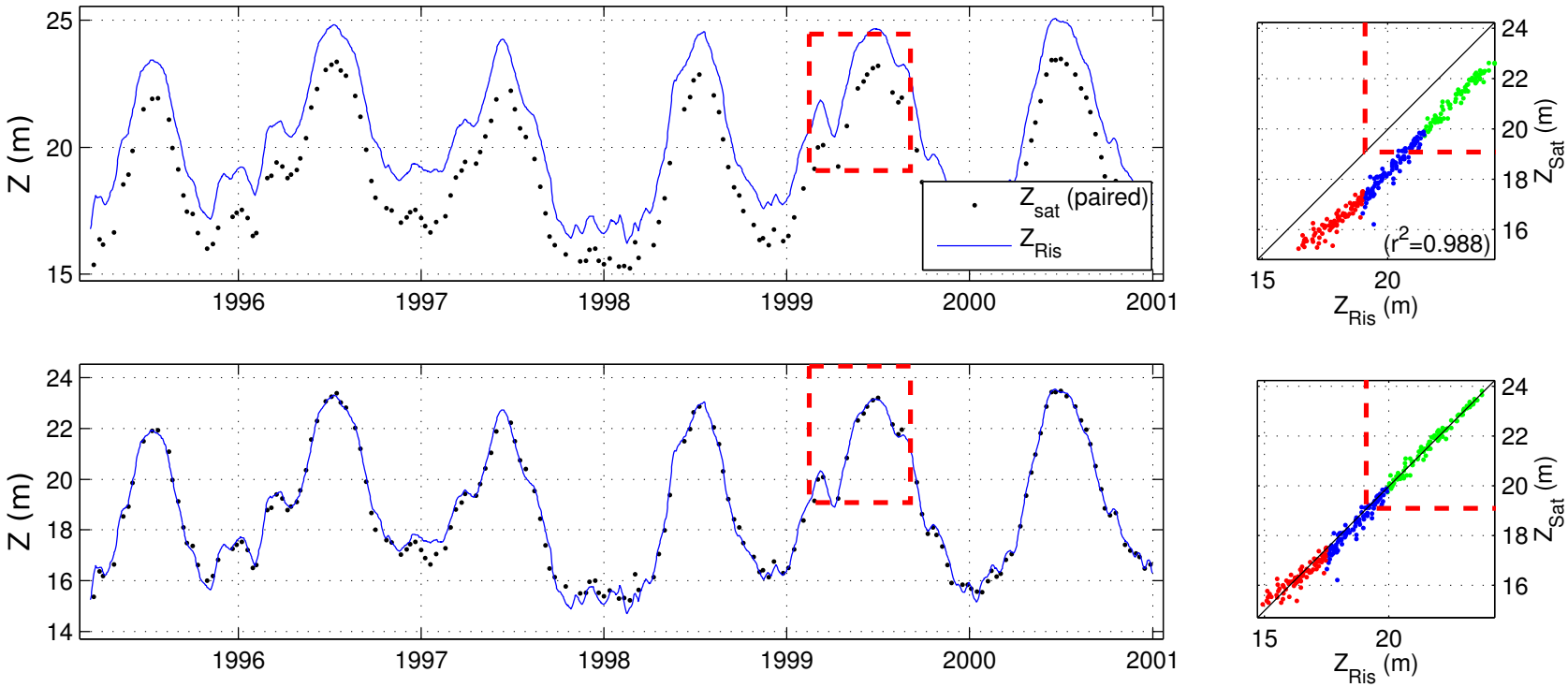
It seems I should switch to GMT !



The Amazon basin

No absolute leveling of gauging stations :

→ Fit altimetry and in situ data during high water flow. . .



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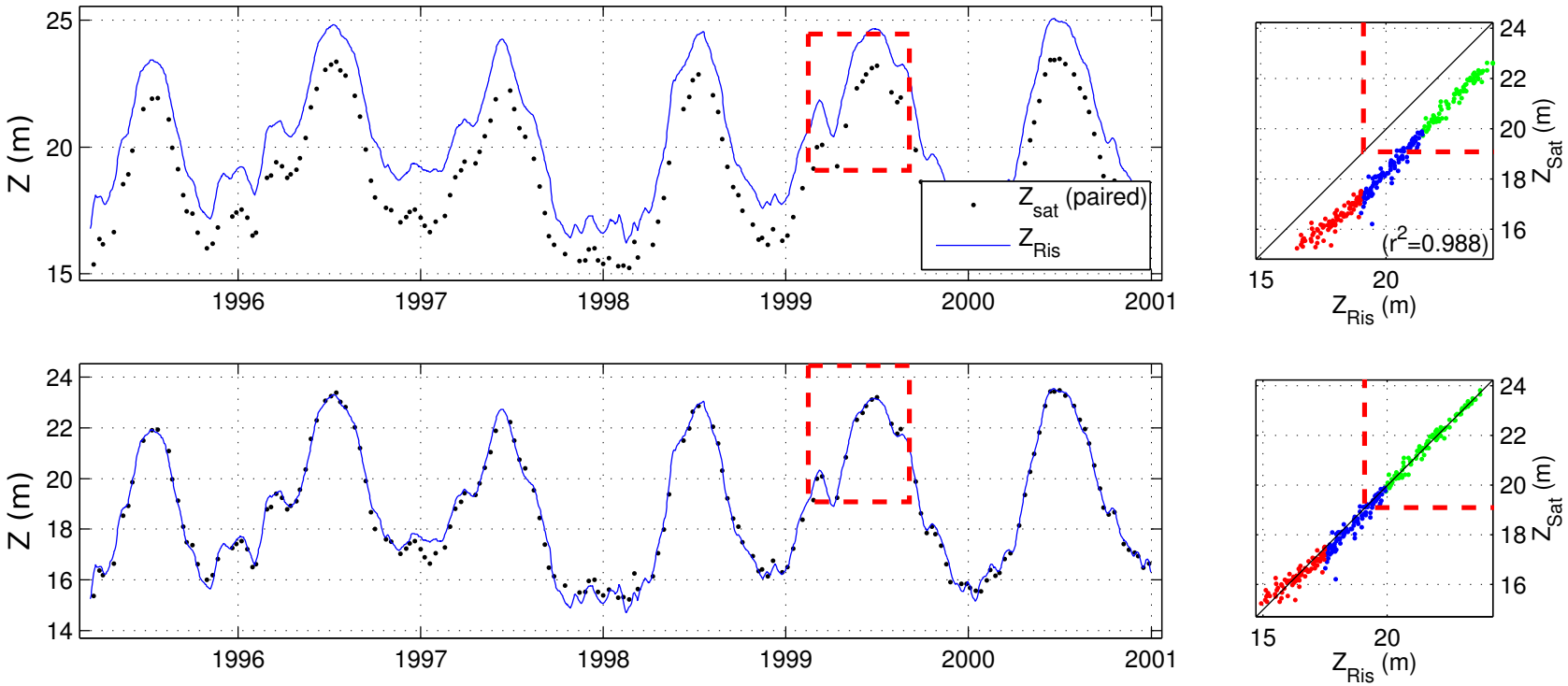

. . . in order to get consistent accuracy indicators ($RMS_{\varepsilon_{Sat}}$)

Product validation results

Validation limited to Amazon, Madeira & Negro rivers

Products Quality

Product	RMS (m)	SLR (%)
*AVISO T/P	1.36	46.1
CASH T/P	0.94	30.2
HW T/P	0.82	32.9
HW ENVISAT	0.66	8.9
R&L ERS-2	0.85	11.6
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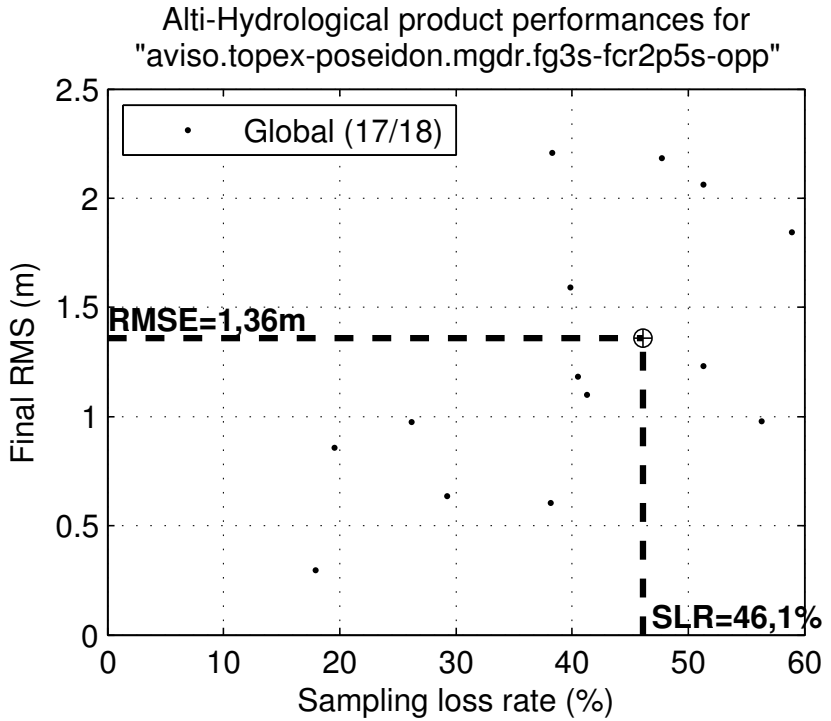

1992-2002

17 virtual stations

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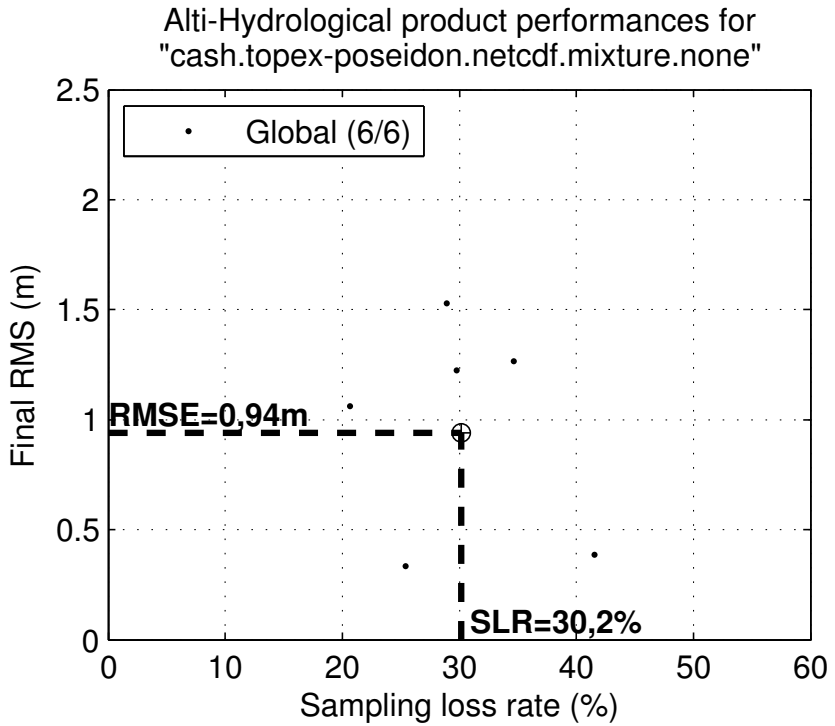

1993-2002

6 virtual stations

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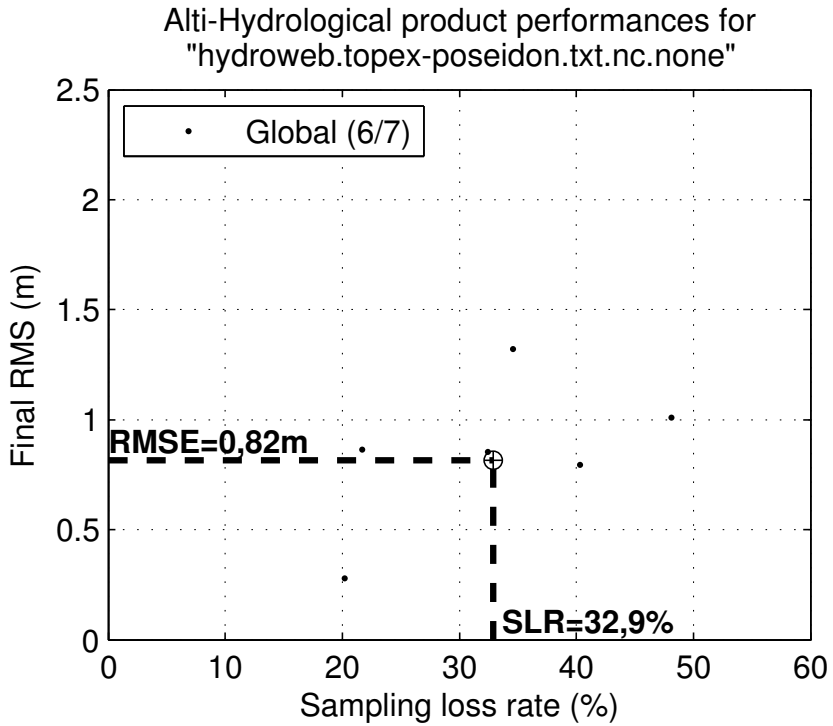

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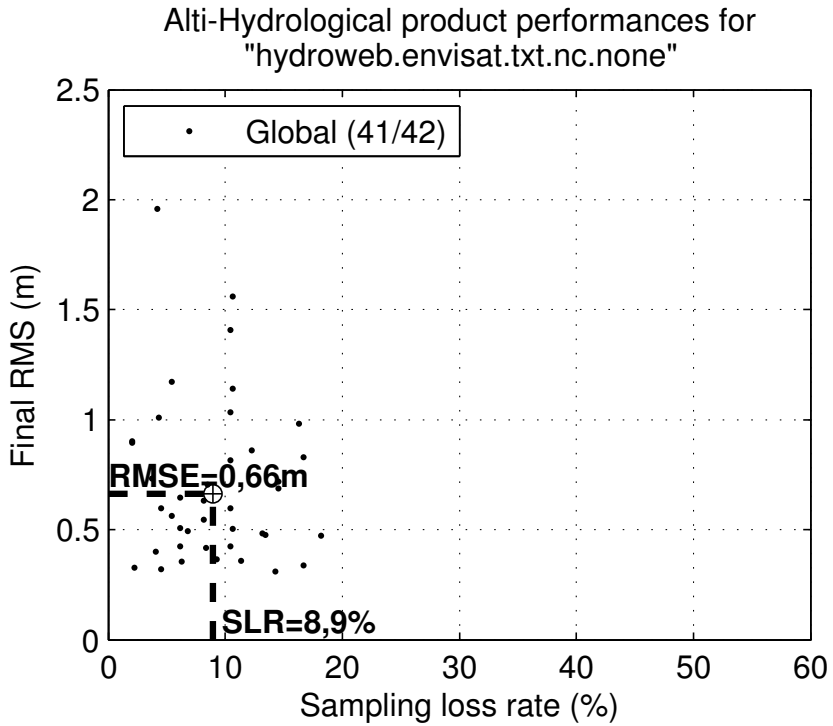

2002-2008

41 virtual stations

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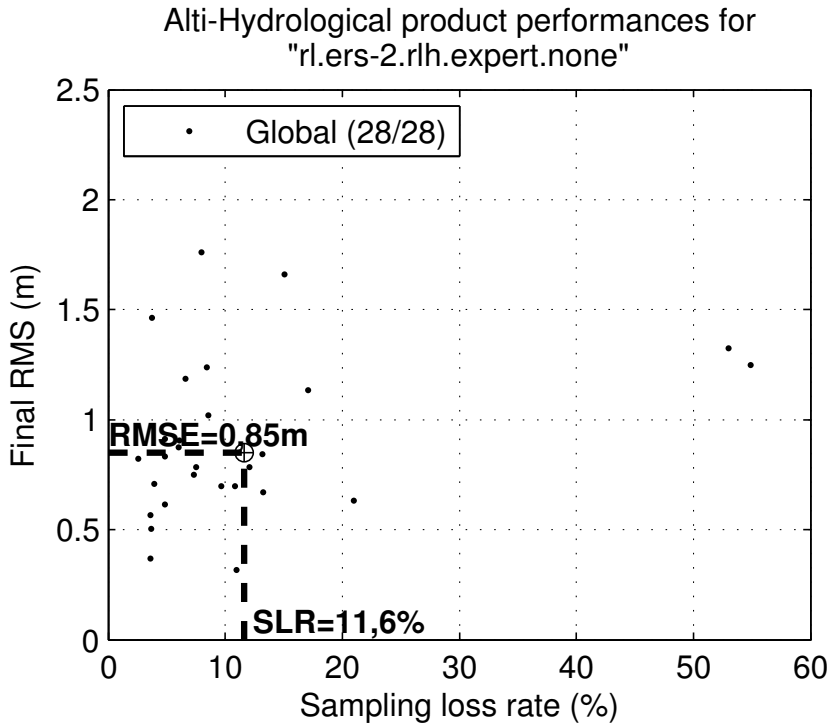

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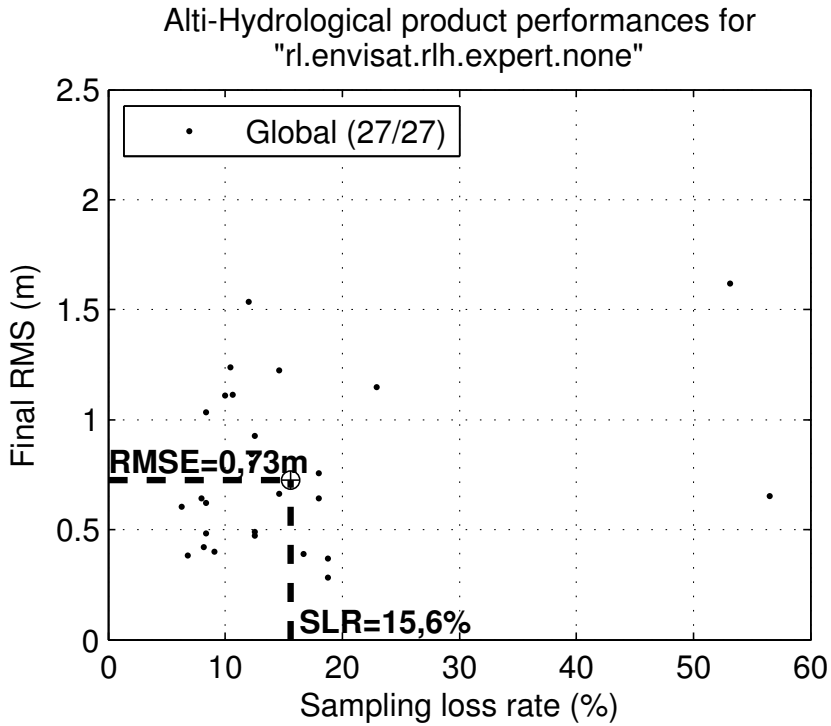

2002-2007

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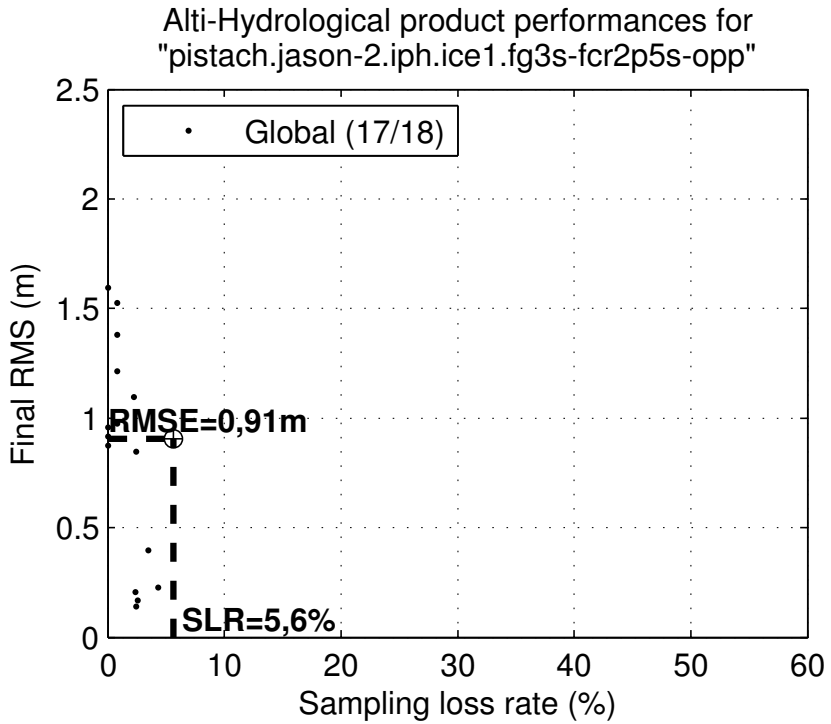

2008-2012

16 virtual stations

Product validation results

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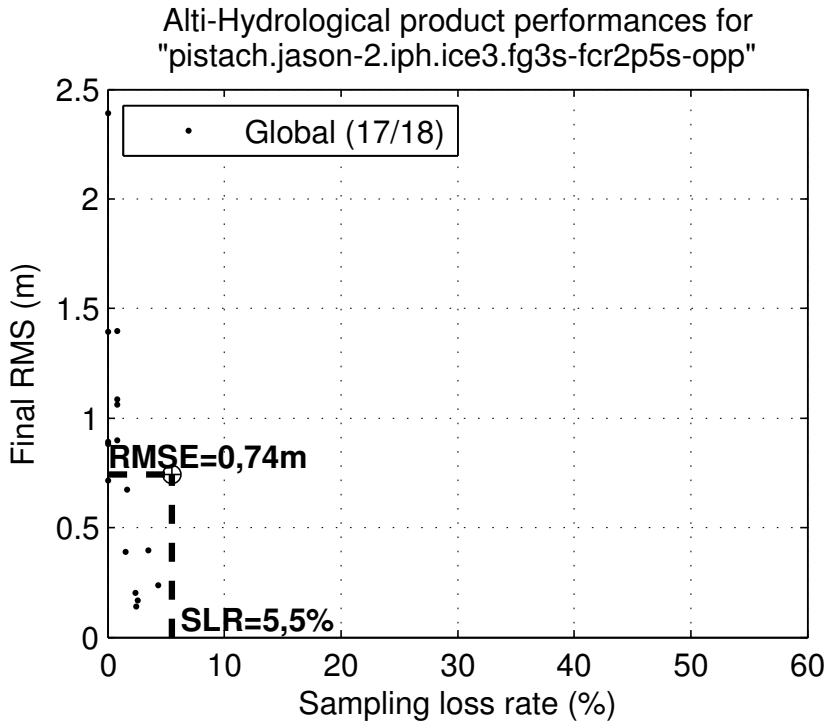

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20 years of progress in Alti-Hydrology

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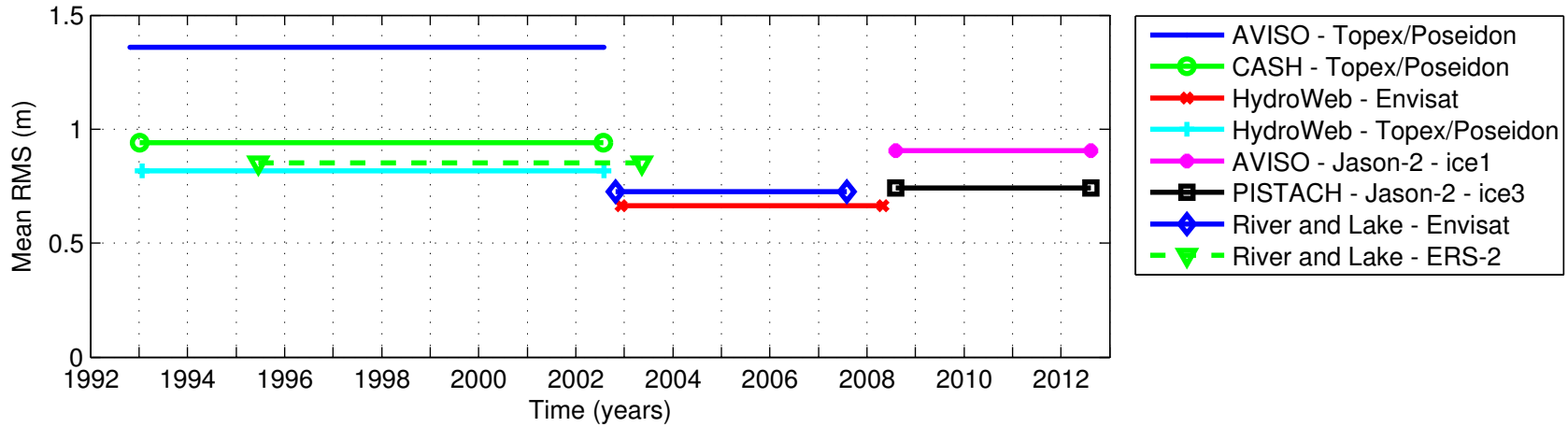

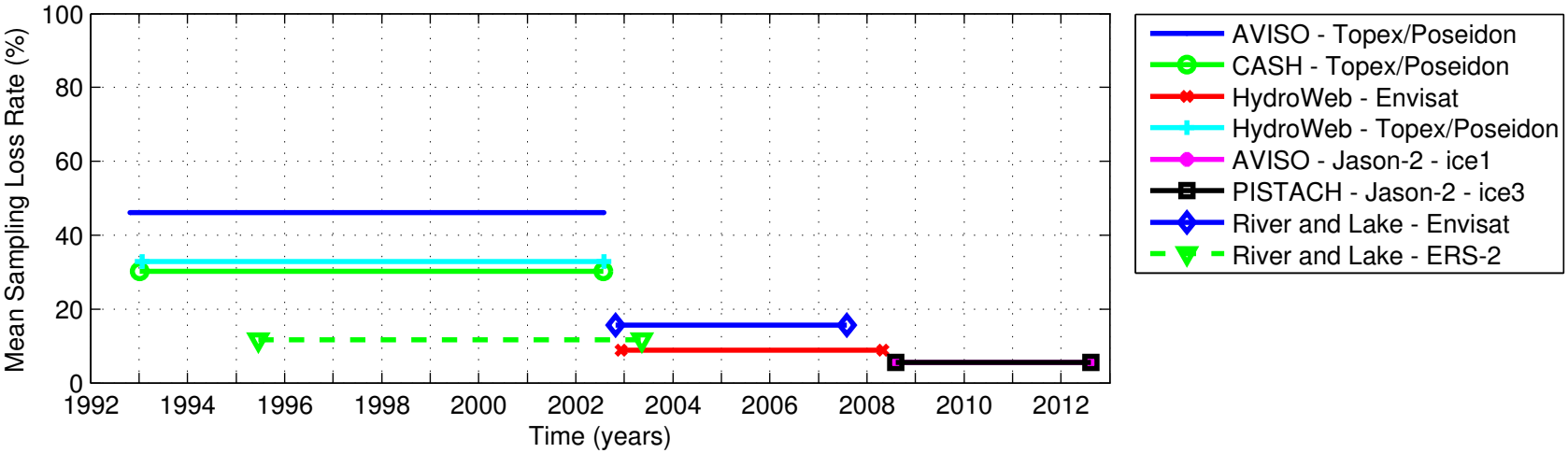

Jason-2/Ice3 unexpected results for 2009-2012

Jason-2 PISTACH/Ice3 RMS increased :

$$\textbf{0.62 m (2010)} \rightarrow \textbf{0.74 m (2012)}$$

Why ?

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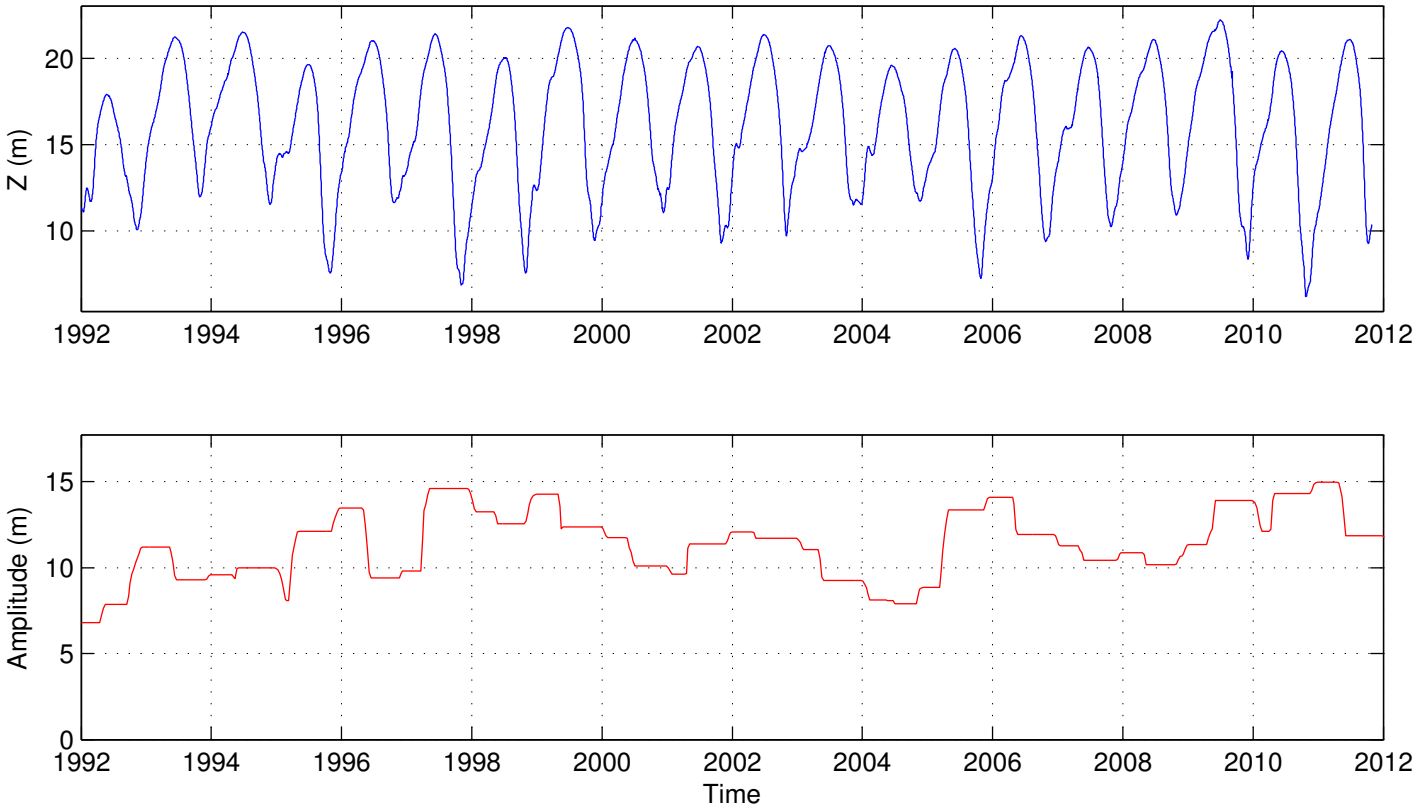

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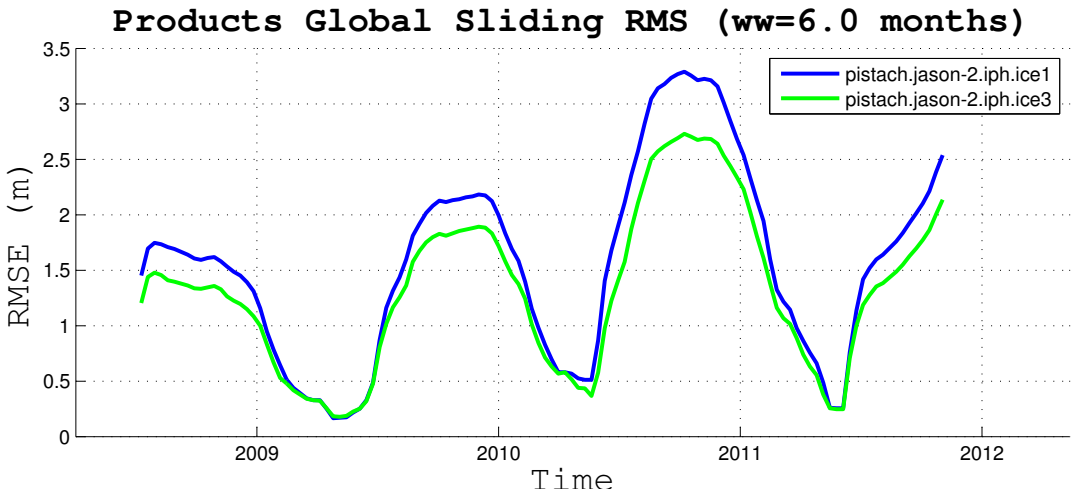
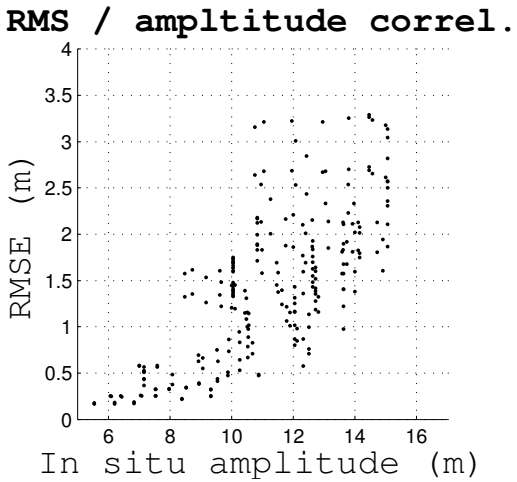


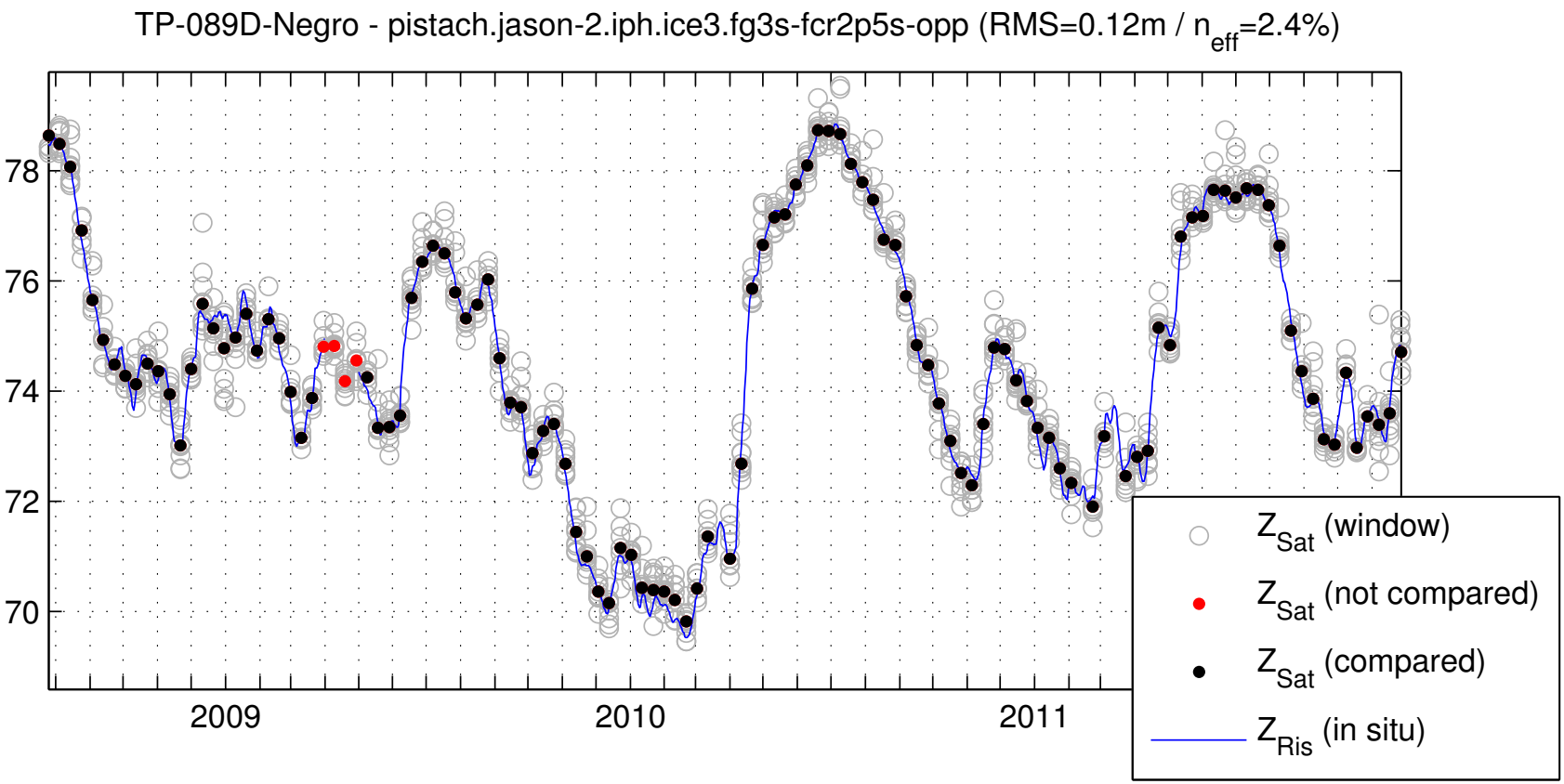


Jason-2 : impressive example, PISTACH/Ice3

Automatically processed Alti-Hydro Product

Able to measure a complex river water level signal

RMS=0.12m ; SLR=2.4%



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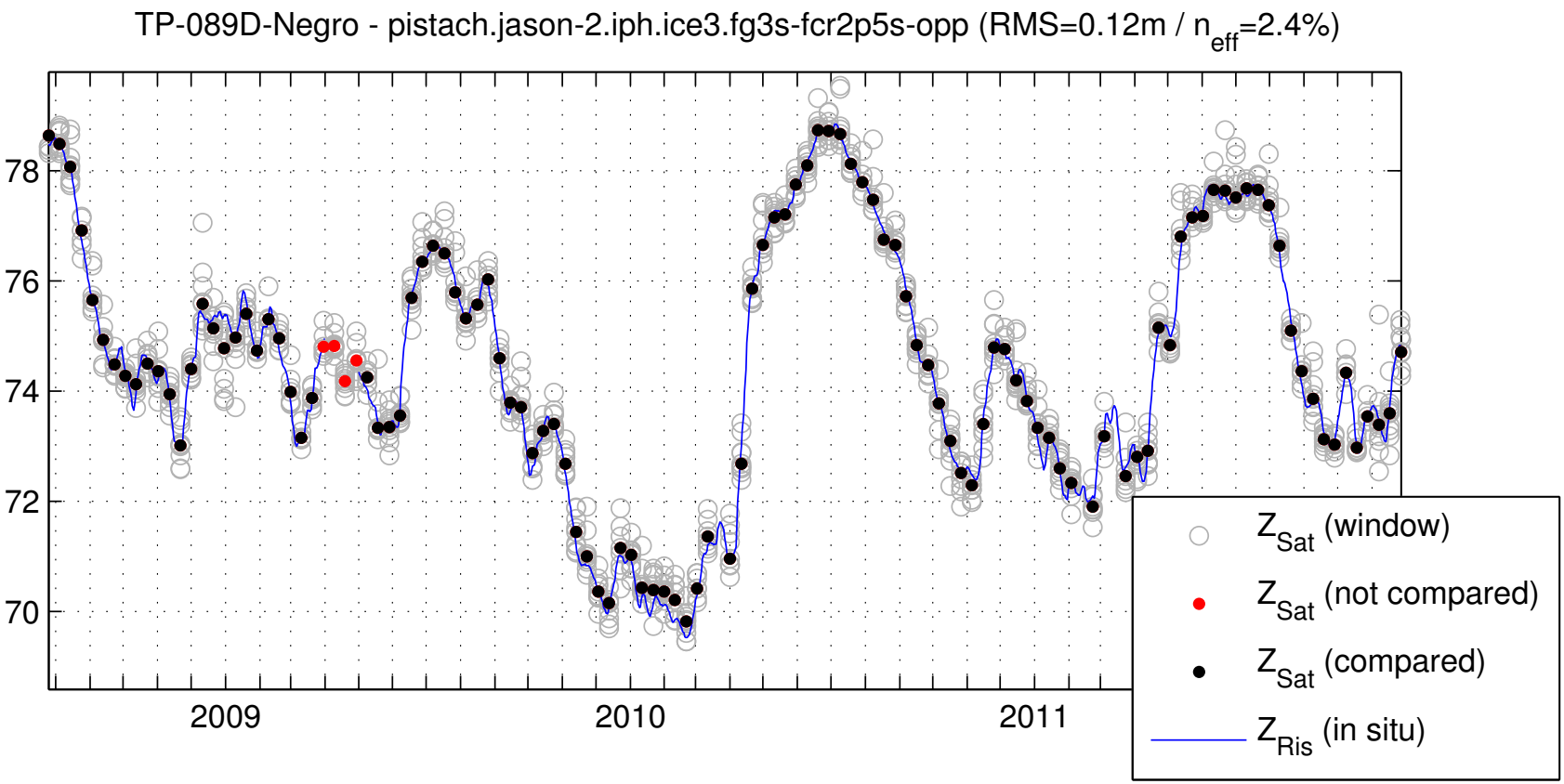

Conclusion

About the results

- Quality assessment, **18 years** of Alti-Hydro Products : **Global trend : -50% RMS error, -90% SLR**
- Quality assessment, **20 years** of Alti-Hydro Products : Exceptional low flow events !

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About the method

- Implemented under contract with River & Lake, PISTACH and CLS
- A useful tool for data producers & end users
- Keep an eye on missions data quality
- A step toward the operational use of the Alti-Hydro data

Perspectives

About the method

- Quality assessment of future missions and products : CryoSat-2 (work in progress, cf. poster), AltiKa, etc.
- Should be implemented in a data processing center (AVISO, CTOH ?), release quality assessment reports

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About Automatic processing (of Alti-Hydro Products)

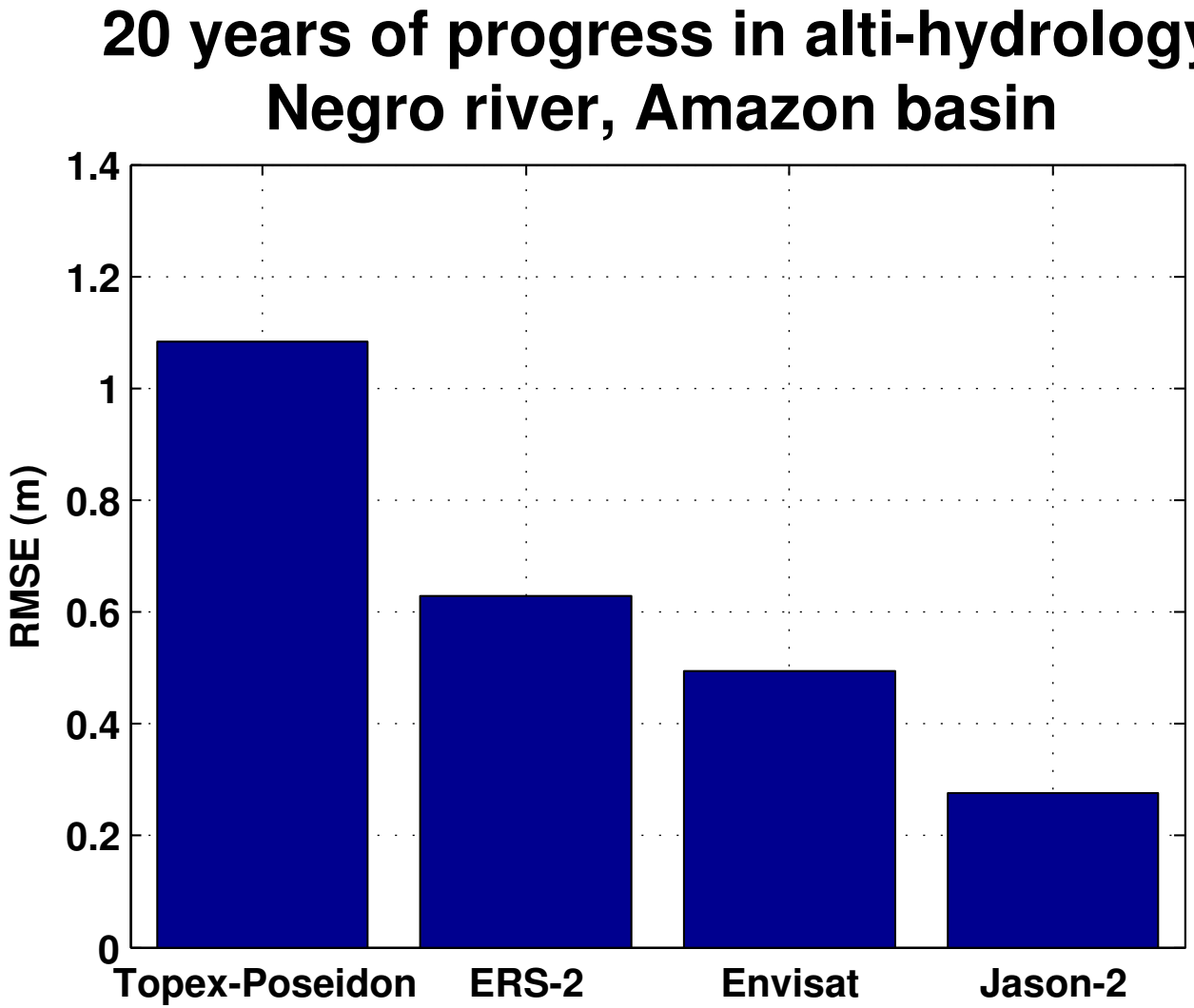
- Improve geolocalized data extraction : use static and dynamic polygons of riverbed contours (SWBD, Sigma0 Ku/C, Waveforms and Waveforms inversion [Tournadre, 2011])

Perspectives (2)

About Alti-Hydrology

- Just like the OST/ST, we need a strong community
  That is : think collective, think open (data & tools), think about the end users
- In an ideal world we would have GDRs with the same retracker outputs & the same geophysical corrections (indeed, this would constitute the basis of a full merged/multi-mission product)
- Address the problem of systematic bias between missions
- Implement an on demand internet service

Thank you !

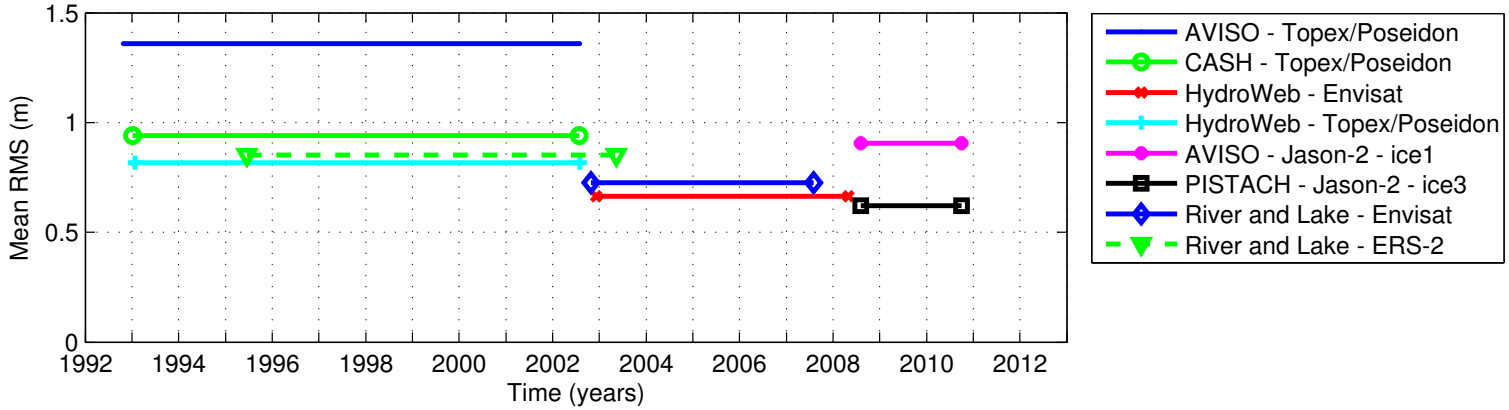


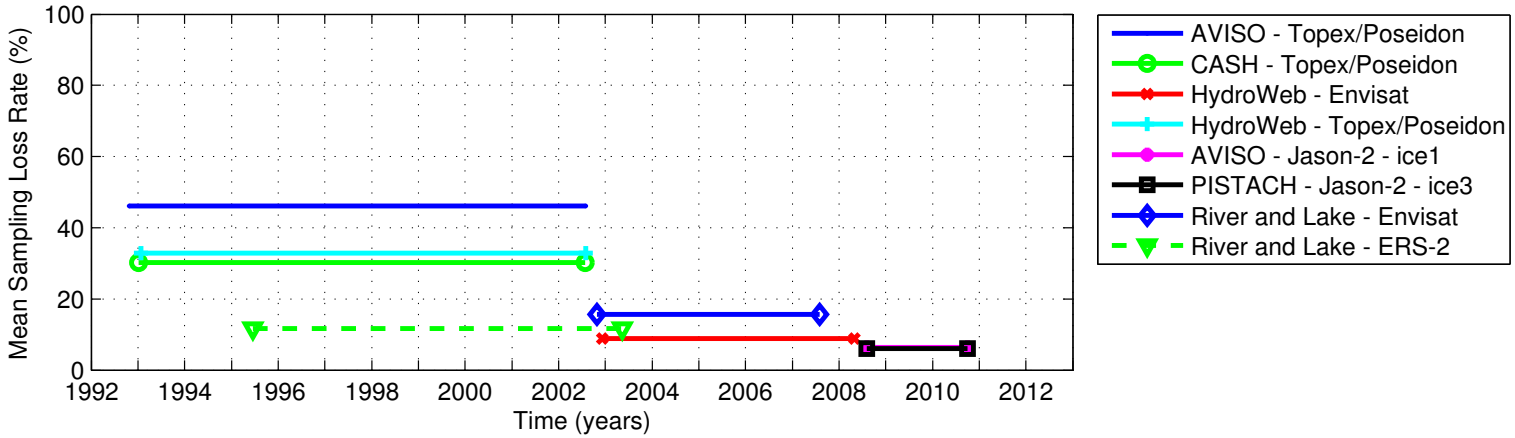
(A figure suggested by Sylvain Biancamaria, May 11th, 2012)

18 years of progress in alti-hydrology

Results of the 2010 validation campaign (OST/ST Lisbon)

Amazon, Negro & Madeira instead of Amazon & Solimões





20 years of progress in alti-hydrology

Results of the 2012 validation campaign (20ypra Venice)

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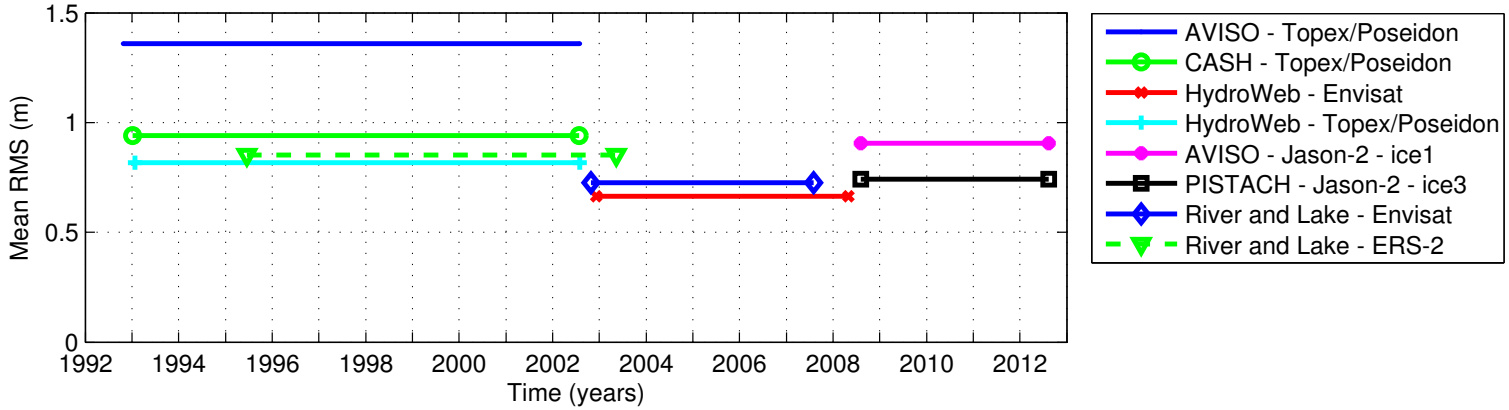
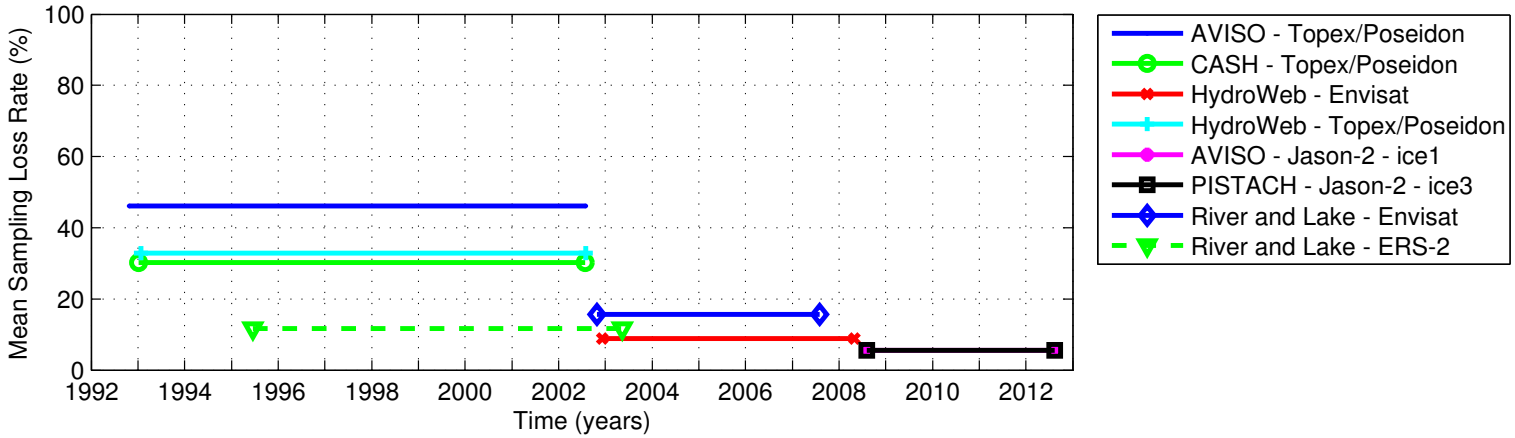
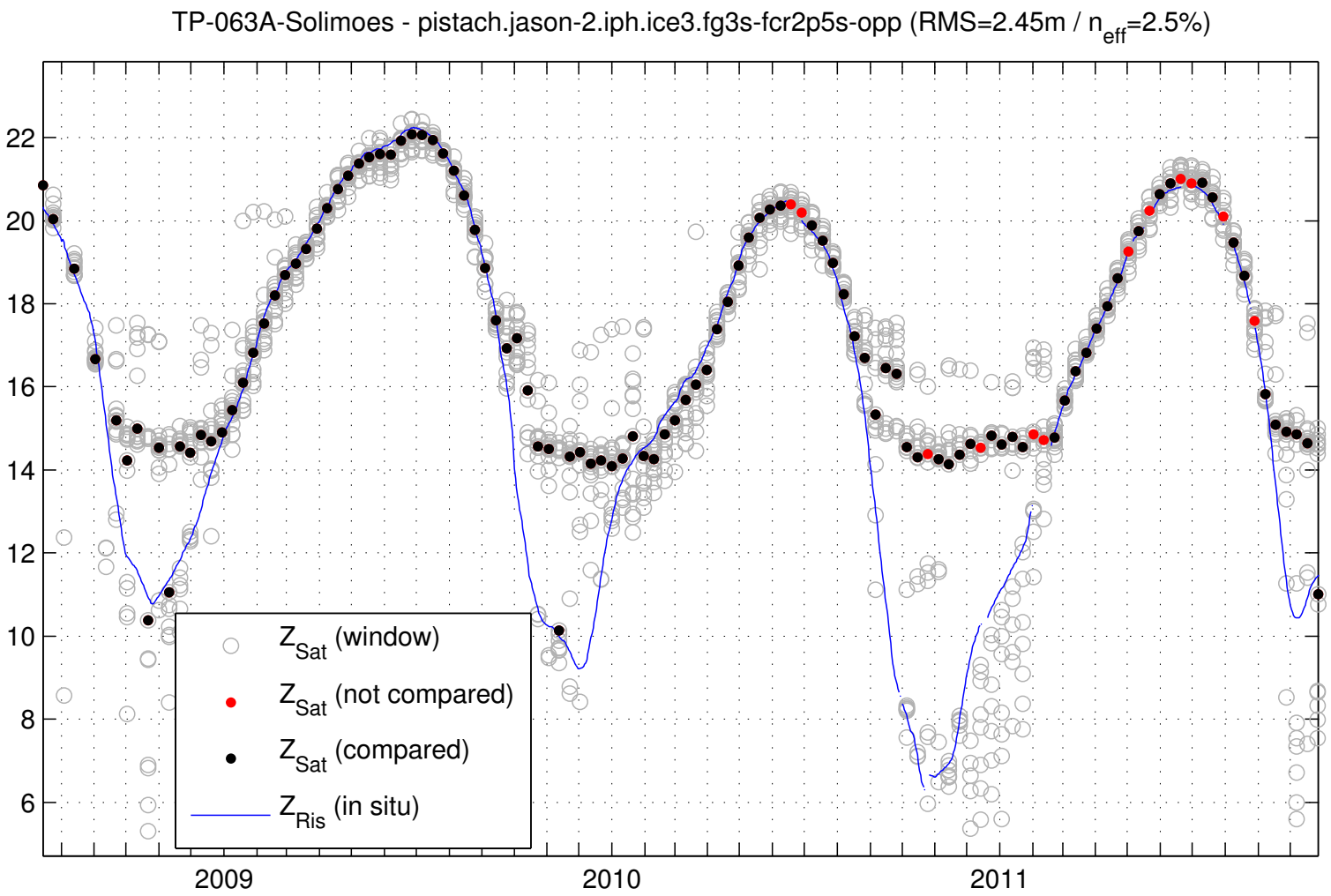




Jason-2 track 63, Solimões



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