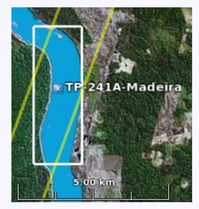
# Quality and uncertainty of satellite derived river water level time series

**Nicolas Bercher[1], Pascal Kosuth[1], Franck Mercier[2]**
Contact: nicolas.bercher@teledetection.fr (+ 33 467 548 716)
[1]UMR TETIS-Cemagref, Montpellier, France. [2]Collecte Localisation Satellites, Ramonville, France.

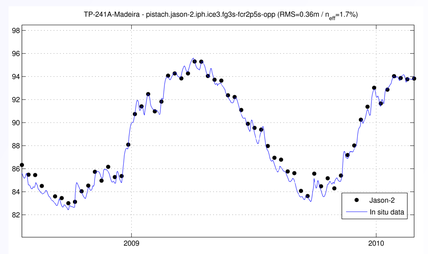
## 1. Introduction & context

During the **last 20 years**, **satellite radar altimetry data** have been intensely used **to derive river water level time series** in order to elaborate **"Alti-hydrological Products"** (CASH, River and Lake and PISTACH projects, HydroWeb database, etc.). They provide a high value information for **river monitoring at global scale** and an **interesting complement to in situ measurement networks**.

The present study proposes a **standard method to asses the quality** (accuracy & sampling efficiency) of **satellite derived river water levels**. Moreover, **uncertainty outputs can be computed** (based on error quantification) and combined into water level products, thus making **useful data sets for end users**.




**Virtual station: Madeira river, Amazon basin. Image Google Earth©**




**Extracted, edited & filtered Jason-2/PISTACH (ice3) time series at Madeira river virtual station, Amazon basin.**

## 2. Standard method for quality and uncertainty estimation

The **"standard method"** allow to estimate **quality** (accuracy and sampling efficiency) and **uncertainty** of **satellite derived river water levels time series** for a **wide variety of sites** (track / rivers crossings) for **statistical significance**.

(1) **"Level 3" product for hydrology**: satellite water level time series are extracted within geographical windows.

(2) **Interpolated in situ river water level time series where satellite tracks cross rivers.**

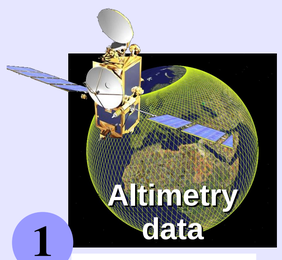
(3) **Spatio-temporal matching of satellite & in-situ water level time series.**

(4) **Error time series** (satellite (1) *minus* in-situ (2) measurements).

(5) **Quality indicators of error time series: accuracy** (RMS) and **sampling loss rate** ($\eta$eff).

(6) **Uncertainty models** build to estimate satellite measurements **uncertainty bars**.

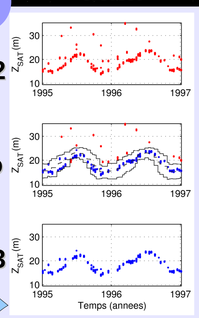
**Finally, satellite "measurements + uncertainty" can be used as an input for hydrological models (see fig. A, panel 3).**





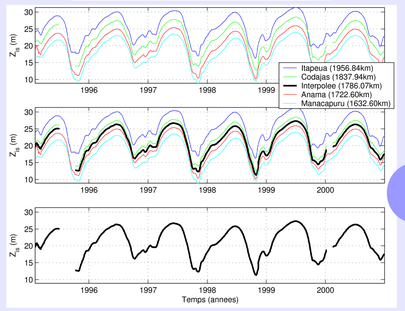
1

L2 . . . . to . . . . L3

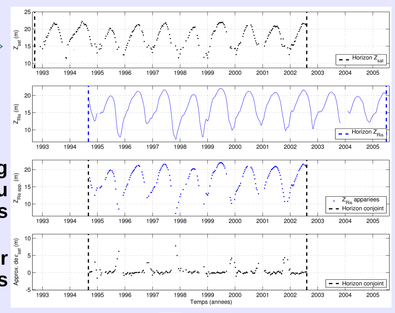



**L3 altimetry time series**

2




**In situ data interpolation under satellite track**




3 **Matching In situ time series**

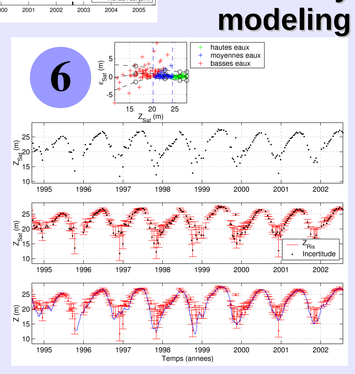
4 **Error time series**

**Uncertainty modeling**

5 **Products Quality indicators**
RMS & Sampling Loss Rate ($\eta_{eff}$)

| | $RMS_\varepsilon$ (m) | $\hat{\sigma}_\varepsilon$ (m) | $\hat{\mu}_\varepsilon$ (m) | $T_{eff}$ (days) | $\eta_{eff}$ (%) |
|---|---|---|---|---|---|
| Global | 0.77 | 0.71 | 0.15 | 41.6 | 13.8 |
| High stage | 0.36 | 0.36 | -0.00 | 45.6 | 20.1 |
| Middle stage | 0.61 | 0.52 | 0.07 | 41.3 | 8.3 |
| Low stage | 1.09 | 0.87 | 0.39 | 41.2 | 12.8 |

6




## 3. Applications & results

The method have been applied on **a wide variety of "Level 2" products** (AVISO M-GDR, CASH Ice2, PISTACH) and **"Level 3" products** (River & Lake, HydroWeb) including **ERS-2**, **ENVISAT**, **Topex/Poseidon** and **Jason-2** missions.

Products were extracted and characterized on **tens of virtual stations** (typically ~80) over the Amazon basin.

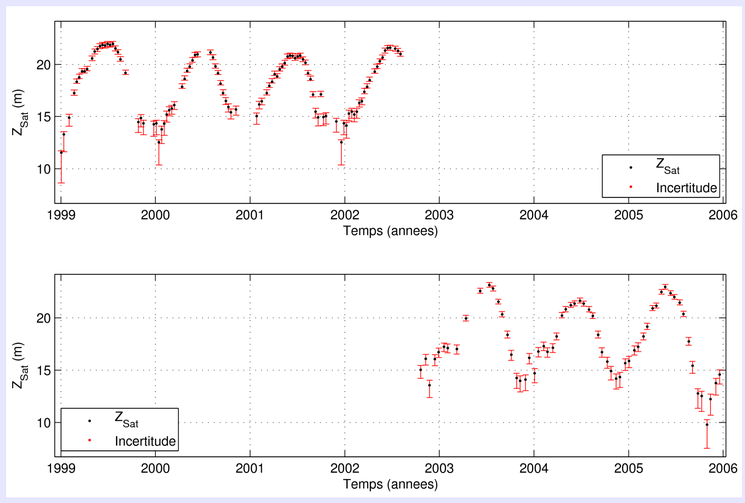
Multiple L2 to L3 scenarios are processed (different filtering chains, etc.), best results only are taken into account for the presented comparisons.

**Indicators pairs (RMS ; Samplig Loss Rate)** are computed for each of these extractions.

**Mean indicators**, mean RMS (m) vs mean Sampling Loss Rate (%), are used to **represent synthetic quality results**, see figures B1, B2 and C.

### A. Measurements uncertainty bars

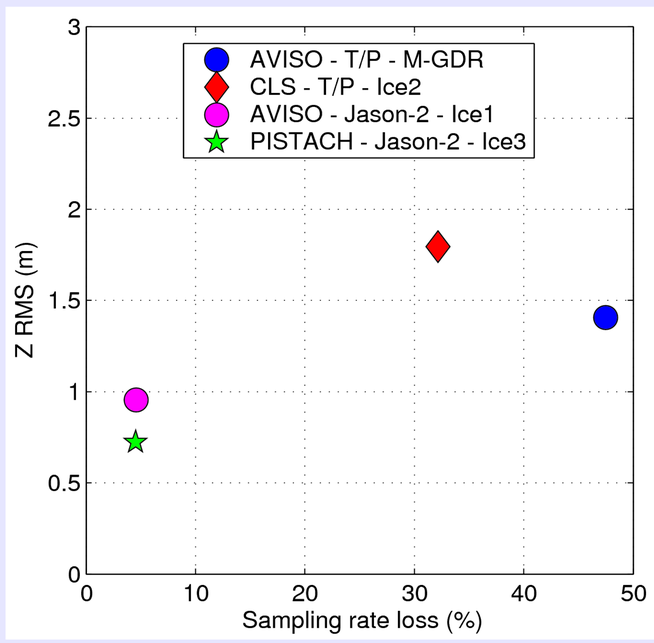
Satellite measurements error results allow **uncertainty modeling** and **uncertainty bars estimation**.




Topex/Poseidon (top) & ENVISAT (bottom) times series over the Solimões river with uncertainty bars.

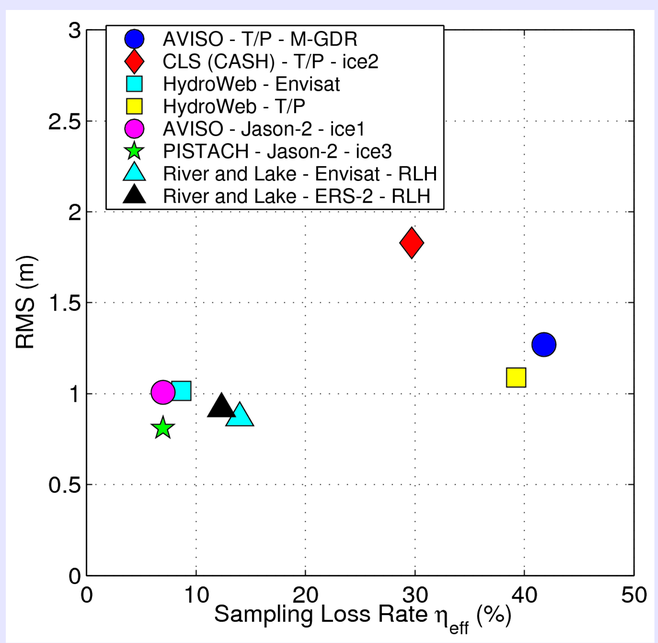
### B1. Performance comparison

Comparison: same orbit, same 55 sites (Amazon basin)




### B2. Thematic comparison

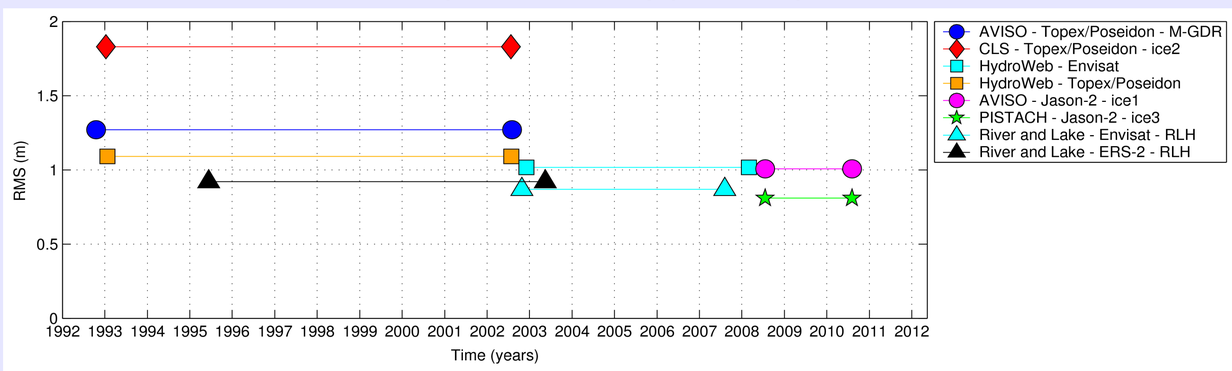
Aptitude to monitor ~2400km of Amazon & Solimoes



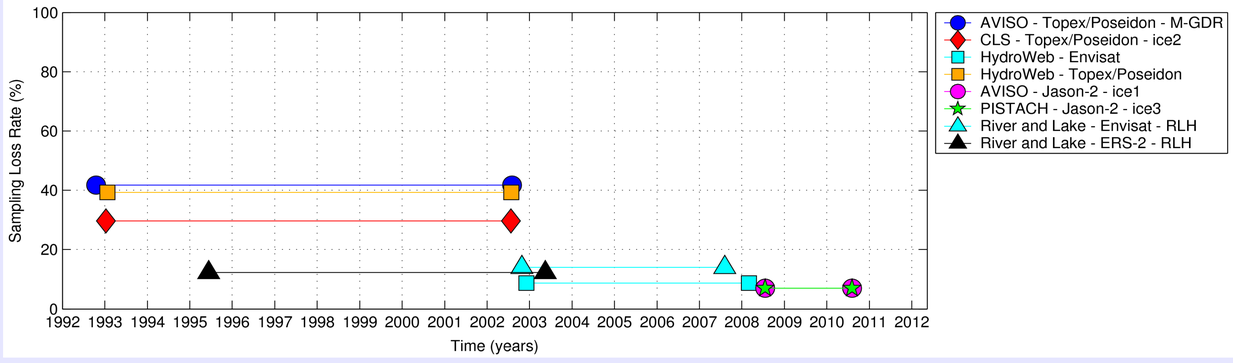

### C. "*18 years of progress in radar altimetry for rivers monitoring...*"

Monitoring of Amazon and Solimões rivers results for most important altimetry products processed

**Mean RMS error *improvement* through time**




**Mean Sampling Loss Rate *improvement* through time**




## 4. Conclusion & perspectives

- The presented **method** allows to **estimate quality & uncertainty** of **"Level 3" Alti-Hydrological Products**
- It produces **uncertainty models** and **uncertainty bars:** qualified products for hydrological models, etc.
- Overall results show **encouraging progresses of satellite measurements quality** for large rivers monitoring, recent missions such as Jason-2 (PISTACH, ice3) provides impressing results: RMS=0.07m at best

- **Future works & perspectives:** mixed **multi-mission / in situ datasets**, better uncertainty modeling, **improvement of "Level 2" to "Level 3" processing**, validation over **Niger basin**, dynamic web services for **end user data delivering**.

**Altimetry for Oceans and Hydrology, Lisbon, 18-22 October 2010**
Ocean & hydrology applications workshop

## Acknowledgments

Thanks to all of our partners & funders: **CNES/SALP**, **CLS**, **ESA**, **Thales Alenia Space**, **De Montfort University (EAPRS)**, **CTOH/LEGOS, IRD**.

- **Satellite data** from **AVISO** (Topex/Poseidon, Jason-2), **HydroWeb** (Topex/Poseidon, ENVISAT), **River & Lake project** (ERS-2, ENVISAT), **CLS** (CASH) and the **PISTACH Project** (Jason-2).
- **Amazon basin in situ water levels** provided by **ANA** (Agência Nacional de Águas), Brazil.

**This poster was designed using the LibreOffice suite**
http://www.documentfoundation.org