Quality and uncertainty of satellite altimetry measurements of river water levels

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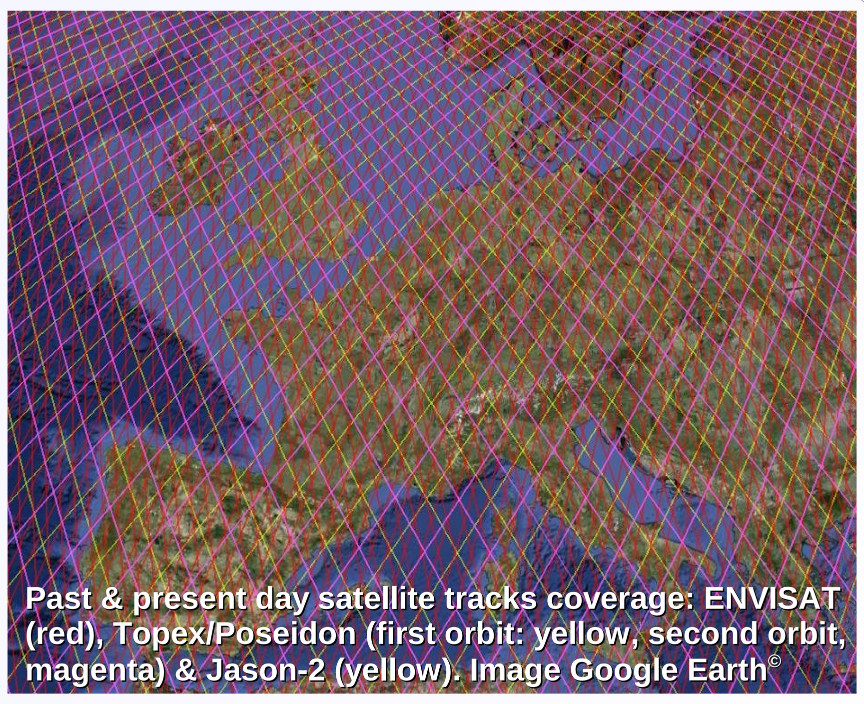
I. Introduction & context

An important challenge about Earth observation from space and global warming is about monitoring continental water resources. In such scientific fields, satellite radar altimetry has generated a growing interest since the early 90's. Satellite missions such as CNES/NASA (Topex/Poseidon, Jason-1 and Jason-2) and ESA ones (ERS-1, ERS-2 and Envisat), initially designed to observe ocean surfaces, have been progressively exploited to monitor "large" water surfaces ; this includes lakes, floodplains and large rivers around the world.

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 on the base of error measurement knowledge and combined into water level products. This way, satellite derived products are ready to be used in various fields such as hydrology.



Past & present day satellite tracks coverage: ENVISAT (red), Topex/Poseidon (first orbit: yellow, second orbit, magenta) & Jason-2 (yellow). Image Google Earth©

II. "Standard method" for quality & uncertainty computation

The proposed "standard method" aims to provide quality and uncertainty knowledge about satellite derived products (water levels) for hydrology users.

(1) **Satellite data extracted within a geographical window** (so called virtual stations or altimetry stations) are processed (editing, geographical extraction, filtering, etc.) in order to build satellite derived river water level time series.

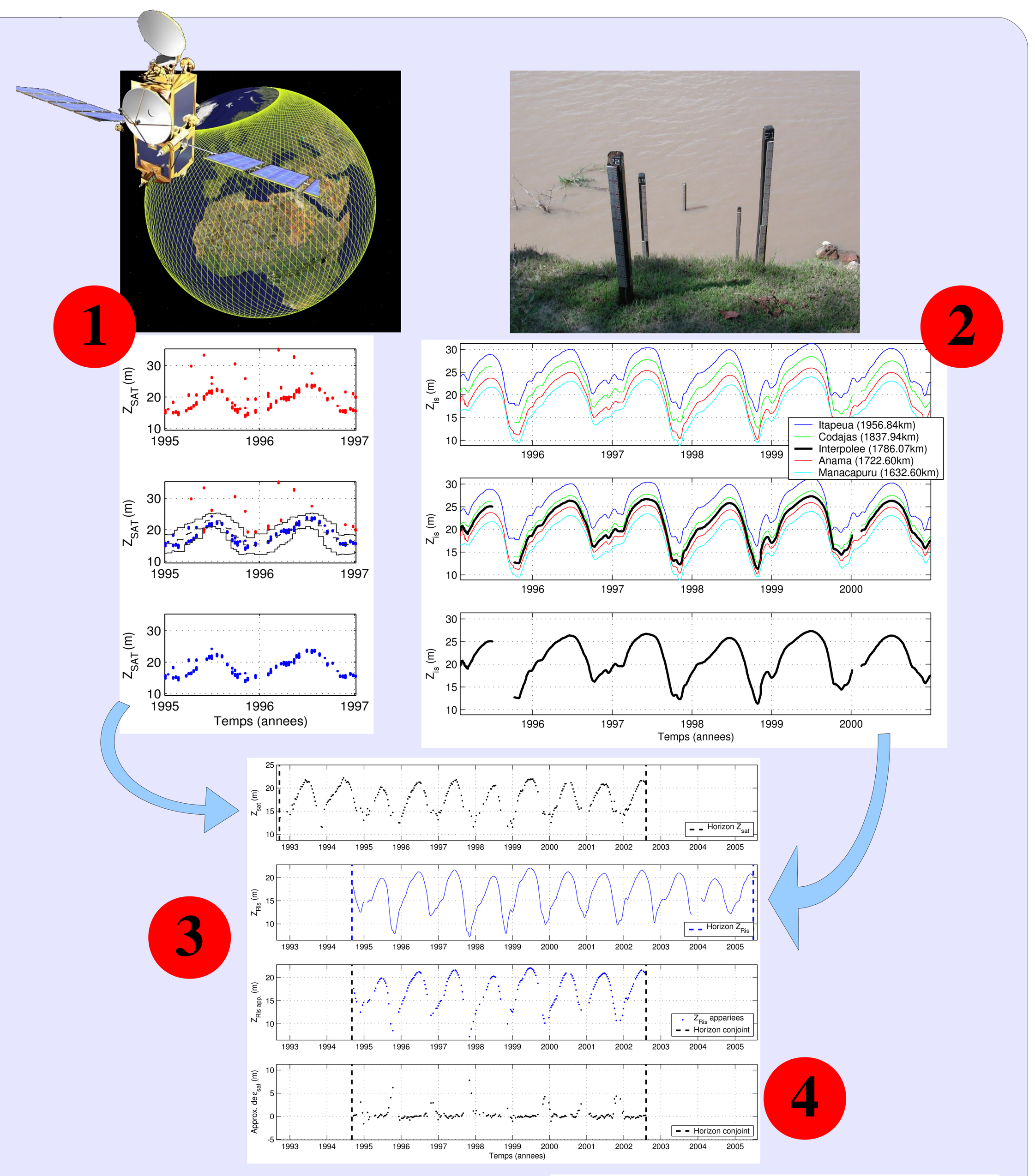
(2) The chosen approach was first to design a process that can be applied to a wide variety of measurements sites (so called virtual stations or altimetry stations), thus requiring the knowledge of reference in-situ data everywhere satellite tracks crosses large rivers. For that matter, **an interpolation technique (based on constrained polynomials) was developed to estimate the river water level at the virtual station**.

(3) **Spatio-temporal matching of satellite & in-situ water level time series**: measurements are then selected over a common time span, in-situ time series are interpolated to the exact satellite overflight timings.

(4) The **error time series computation** is done thanks to the comparison of previously paired satellite & in-situ river water level measurements.

(5) **Quality indicators are derived from the error time series**: they describes both satellite **measurements accuracy** (RMS) and **sampling efficiency** (ηeff, the Sampling Loss Rate).

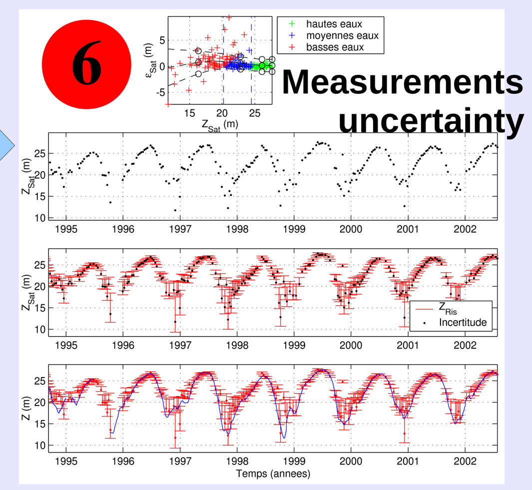
(6) Error-based analysis can be used to produce **uncertainty models**: satellite time series are qualified by uncertainty bars, thus **final users can knowingly use satellite derived river water levels for hydrological purposes**.



5 **Products Quality indicators**

RMS & sampling rate loss (η_{eff})

	$\hat{RMS}_\varepsilon$ (m)	$\hat{\sigma}_\varepsilon$ (m)	$\hat{\mu}_\varepsilon$ (m)	$T_{\mathbf{eff}}$ (days)	$\eta_{\mathbf{eff}}$ (%)
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



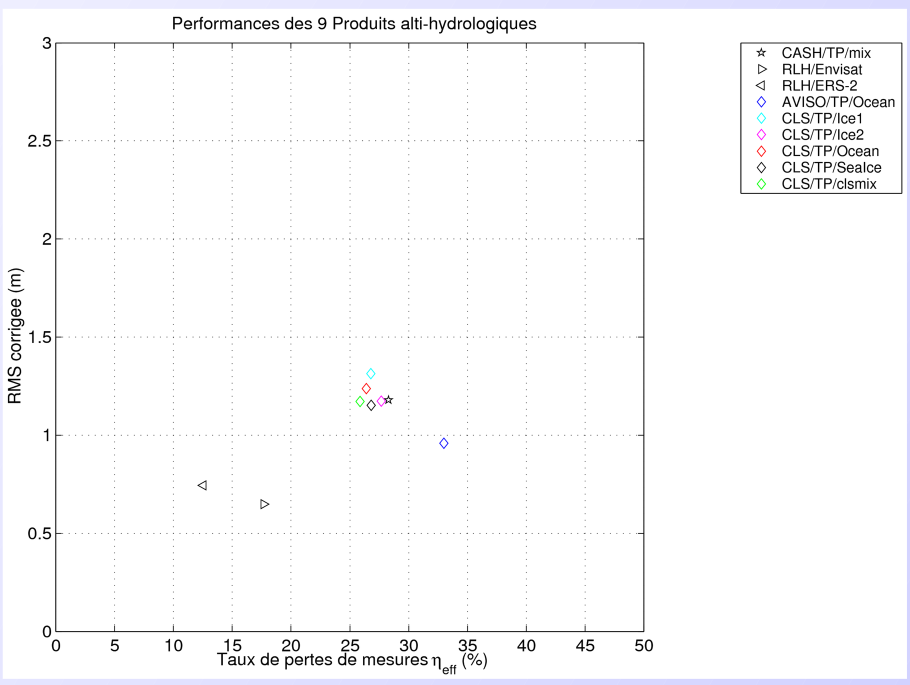
III. Applications & results

1. Products quality

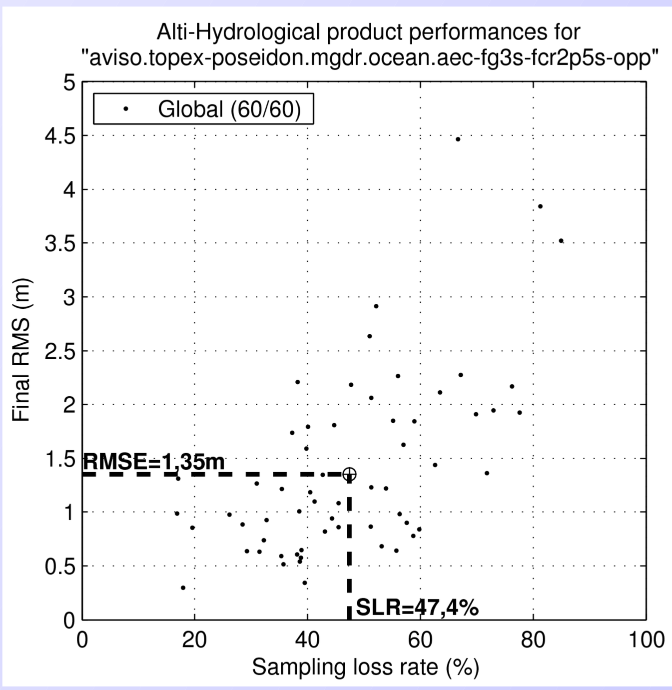
Various altimetry derived products for hydrology have been processed thanks to the introduced method. Figures on the right presents some product quality results, processes were achieved independently on heterogeneous sets of virtual stations (note that some virtual station may not provide suitable data). Results from these four figures **are not directly comparable**.

The figure below illustrates a valid product quality comparison on a set of nine selected virtual stations.

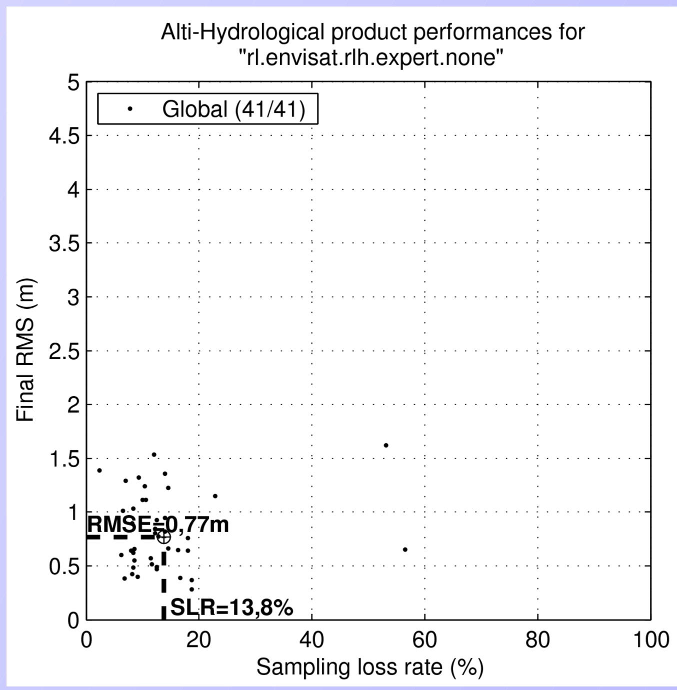
Example of a valid products comparison on 9 virtual stations



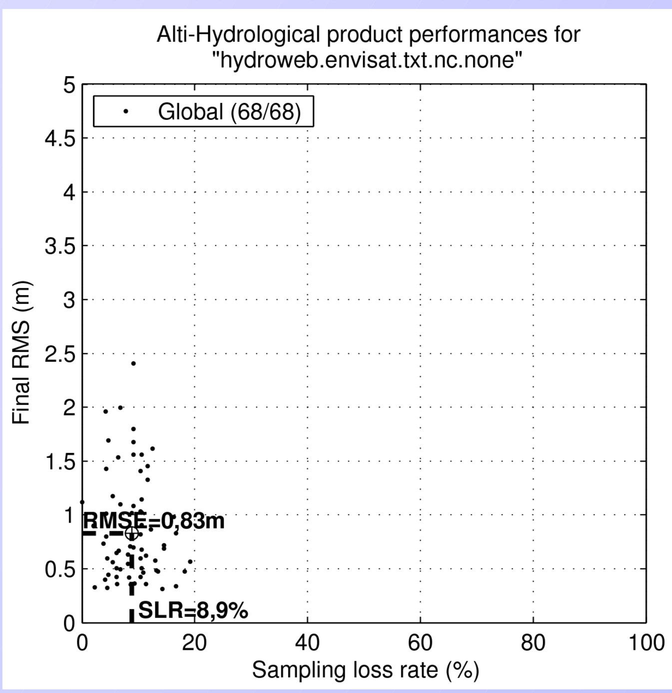
AVISO - MGDR - Topex/Poseidon
1993-2002 – 60 virtual stations



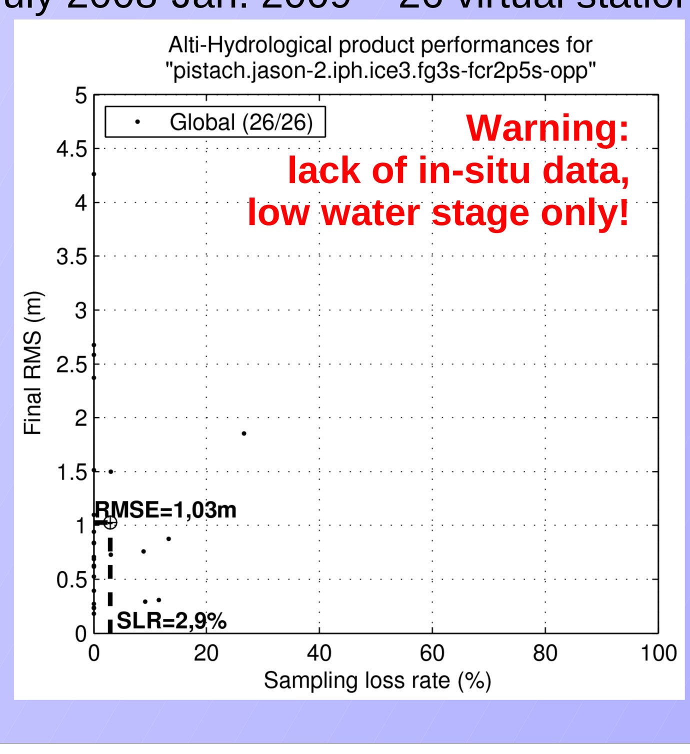
River & Lake Hydrology - ENVISAT
2003-2007 – 41 virtual stations



HydroWeb database - ENVISAT
2003-2007 – 68 virtual stations

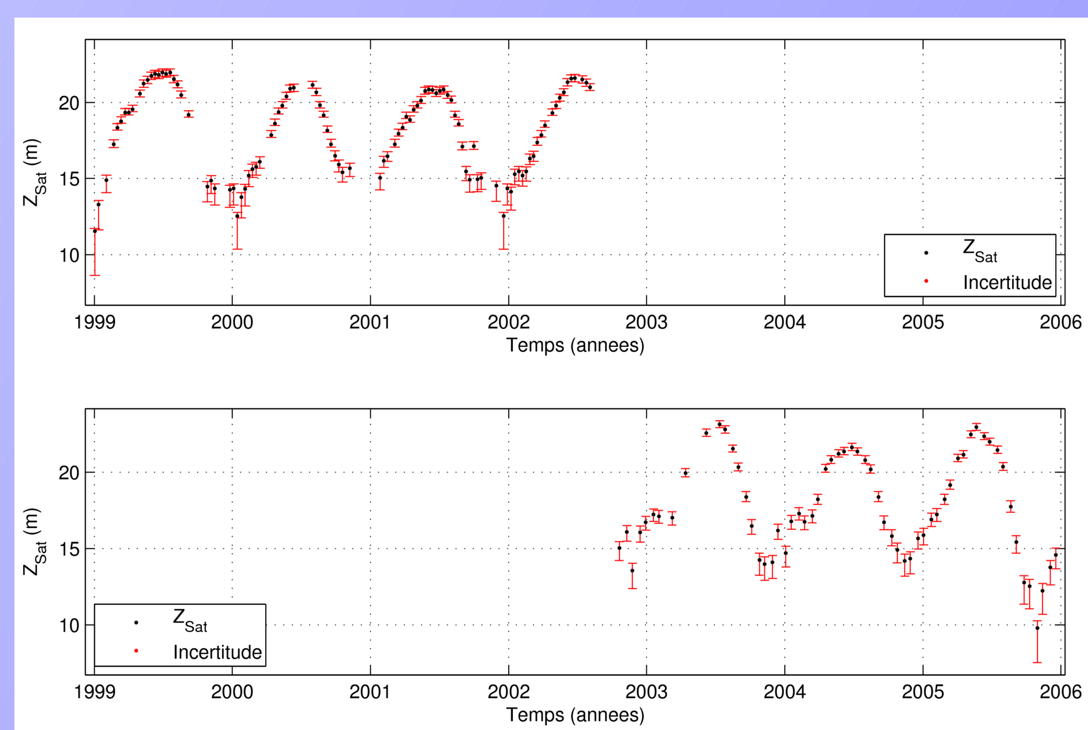


Preliminary PISTACH/Hydro - Jason-2
July 2008-Jan. 2009 – 26 virtual stations



2. Measurements uncertainty

Uncertainty bars can be derived from analysis of satellite altimetry measurements error. Uncertainty is a key information needed to deliver ready-to-use satellite derived altimetry products for hydrological applications.



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

IV. Conclusion & perspectives

• The **"standard method"** presented here allows to **estimate the quality of Altimetry derived Hydrological Products** and **derive uncertainty bars** in order to deliver ready-to-use products.

• Results show **encouraging progresses of the quality of satellite measurements** for monitoring large rivers water levels as well as radar sensors techniques and data processing evolves. With the launch of recent satellite Jason-2 (June 2008), and preliminary results presented here, **the use of satellite altimetry data coupled with uncertainty information is close to be straightforward**.

• Future works will focus on multi-mission datasets, systematic uncertainty computation and altimetry products optimizations for hydrological purposes.

Acknowledgments

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