A scheme proposal for real time verification of river water level derived from satellite altimetry

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Background

The quality assessment of river water level time series derived from satellite altimetry, by direct comparison to in situ gauging measurements, has been addressed during the past two decades by various research groups (Koblinsky 1993, Birkett 2002, etc.). Ultimately, Irstéa (ex-Cemagref) has developed and implemented (2004-2008) a standardised validation method prototype to automatise such procedures. It gives synthetic quality indicators (Error RMS and Sampling Loss Rate) at the scale of time series. The prototype has been implemented on a wide extent of altimetry products (AVISO, ESA, CASH, HydroWeb, River & Lake, PISTACH, CPP, etc.) from several missions (T/P, ERS-2, Envisat, Jason-2). The quality assessment exercise has been implemented for hundreds of virtual stations of the Amazon basin, where in situ data are easily available. Results from this prototype have shown progresses made by satellite altimetry for the monitoring of river water level and have been communicated on a regular basis (Venice 2006 & 2012 and Lisbon 2010). However, **in situ data usually have some important drawbacks, among which the high latency of data availability imposed by measurement system constraints** (limnimetric scales read by human operator, digital database filling from paper log books, verifications, validations, etc.). **This is really limiting for new and future missions such as SARAL/AltiKa and Sentinel-3**. In such a context, were agencies and data users would like to get an insight on the satellite measurements in real time or so, emerged the need for tools to monitor measurement health, in real time, as new data are acquired.

Verification & Validation overview

Verification is not Validation

For sure, this is the most important point of this poster: ***Verification is not Validation and it is not meant to replace it!*** Verification is meant to ease the real-time monitoing of river water level time series (RWLTS) derived from satellite altimetry.

The CNES-LEGOS HySOpe processor

HySOpe (Hydrométrie Satellitaire Opérationelle) processor, currently under development, is a **new implementation of an automated processing chain of RWLTS derived from satellite altimetry**. It is based on the heritage from LEGOS/HydroWeb [1] and Irstéa (ex-Cemagref) [2] expertise.

Verification tests

Two cases are defined for the monitoring of RWLTS:

- (*Test 1:*) for **know virtual stations** (SARAL/AliKa follower of ENVISAT, etc.),
- (*Test 2:*) for **new virtual stations** (e.g., Sentinel-3) or to check consistency between a rendom set of virtual stations along the same river path.

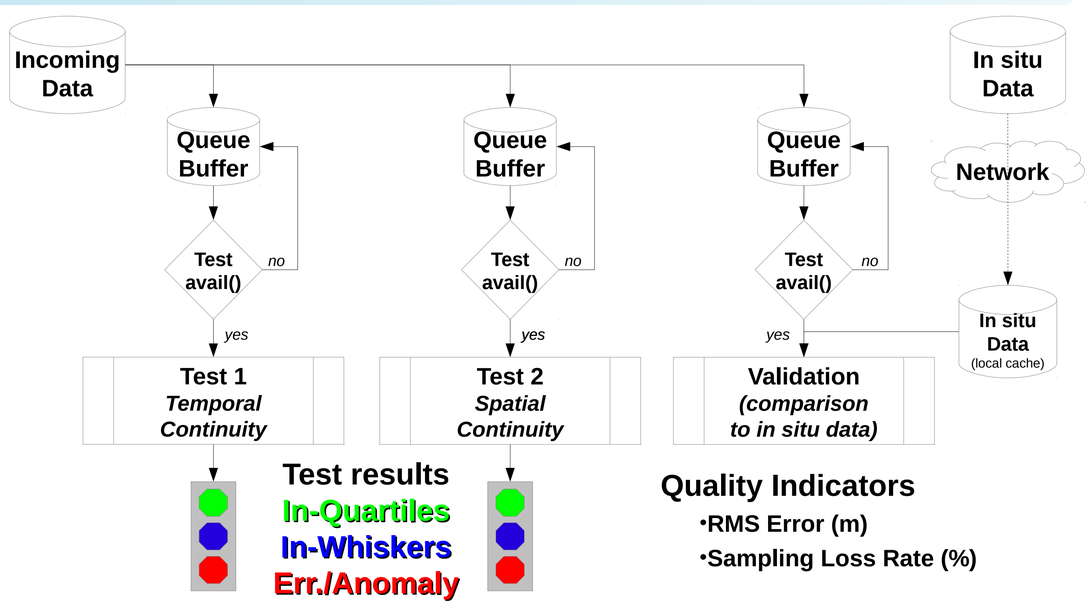
Queuing of altimetry data

Altimetry data are collected from upstream providers (agencies, etc.) and processed by HySOpe. Then, for the sake of verification, and in order for each altimetry measurement to be verified, a simple queing scheme is implemented, one per test.

Basically, each measurement will enter a queue buffer before accessing a test procedure. If the procedure is not available (i.e., there is not enough altimetry or in situ data to perform the test), the altimetry measurement will stay in the buffer queue until the test becomes available.

Tests outputs

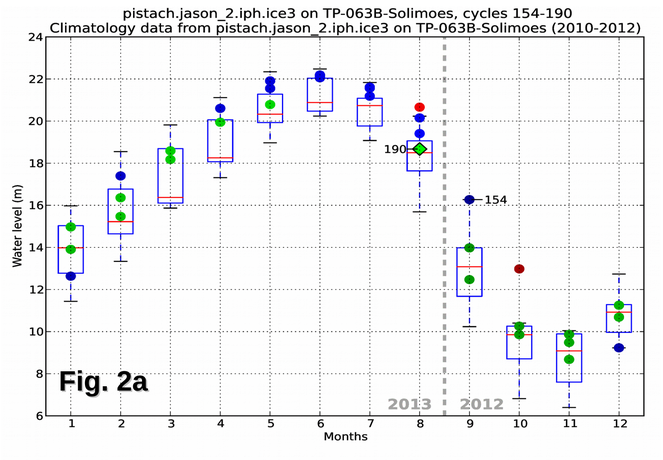
Verification outputs are figures where each measurements is given a color depending on its accordance with climatology data.



Test 1 : known Virtual Station *or Temporal Continuity*

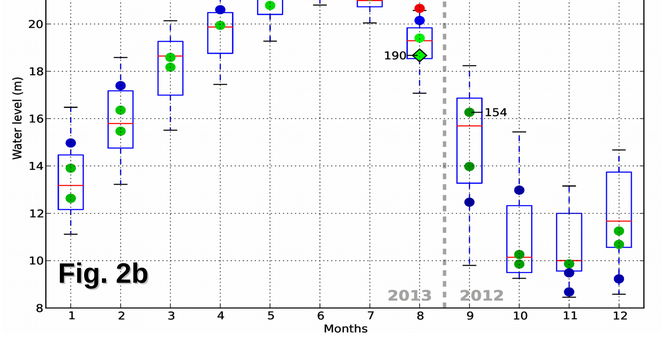
PISTACH Jason-2/Ice3 self-check

Fig.2a below shows the ***temporal continuity monitoring*** of the past 12 months of **PISTACH Jason-2** data, from track 63 crossing the Solimões river. Jason-2 data are collected since July 2008 on this Virtual Station, hence it is possible to check its ***self-consistance*** by deriving climatology boxplots from its own past data (past 3 years 2010-2013).



PISTACH Jason-2 vs. past in situ data

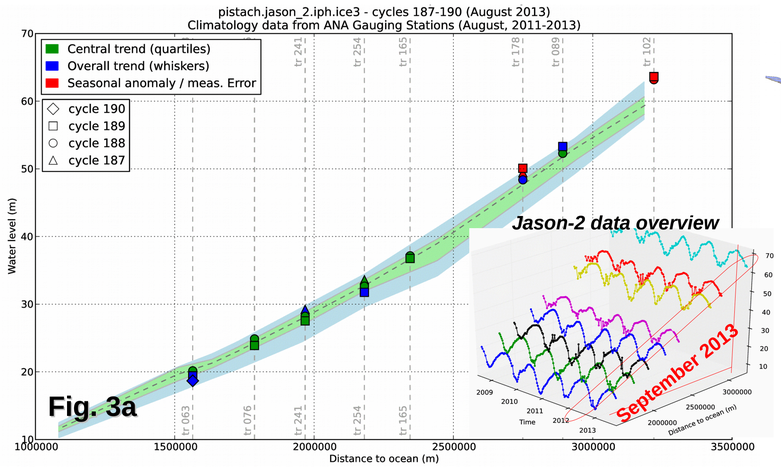
Fig.2b below shows the ***temporal continuity monitoring*** of the past 12 months of **PISTACH Jason-2** data, from track 63 crossing the Solimões river. Jason-2 data are collected only since April 2013 on this Virtual Station (it cannot be self-compared). We are using in situ data archives from the ANA [1] to derive climatology boxplots the past 3 years 2010-2013.



Test 2 : new Virtual Stations *or Spatial Continuity*

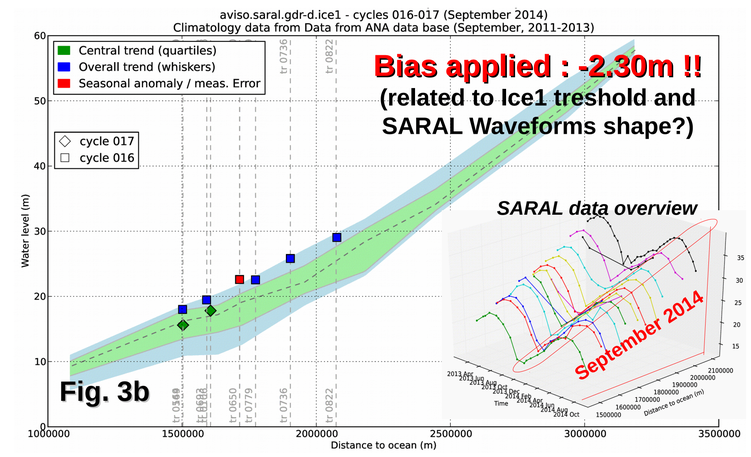
PISTACH Jason2/Ice3 vs. in situ data

Fig.3a below show the ***spatial continuity monitoring*** of the past 30 days of **PISTACH Jason-2** data (August 2013, cycles 187-190, *not up-to-date, sorry!*) from several Virtual Stations crossing the Solimões river. In situ data archives from the ANA [1] is used to **derive climatology** (green/blue patches) **for month September** of the past 3 years 2011-2013.



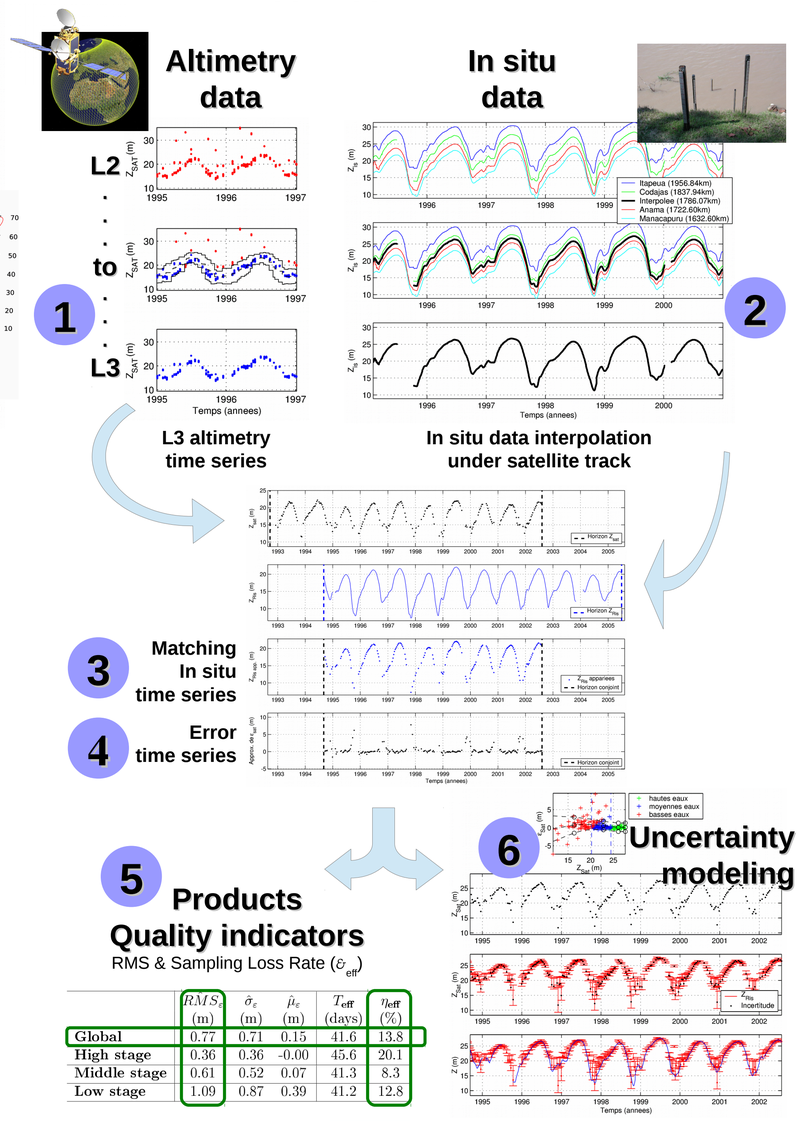
SARAL/AltiKa vs. in situ data

Fig.3b below show the ***spatial continuity monitoring*** of the past 30 days of **SARAL/AltiKa** data (September 2014, cycles 16-17) from several Virtual Stations crossing the Solimões river. In situ data archives from the ANA [1] is used to **derive climatology** (green/blue patches) **for month September** of the past 3 years 2011-2013.



Validation *Comparison to in situ data*

(1) **Building of Alti-Hydrological Product from GDR (L2)**: satellite water level time series are extracted within geographical windows and filters applied. (2) **Interpolation of in situ water level time series** at virtual station location. (3) **Temporal matching of satellite & in-situ water level time series.** (4) **Error time series quantification** (satellite altimetry *minus* in-situ). (5) **Quality indicators of error time series:** **Accuracy** (RMS) and **Sampling Loss Rate** (ηeff). (6) Derive **Uncertainty Model** and estimate satellite measurements **uncertainty bars**. For results, see [3] and [4].



	RMS_ε (m)	$\hat{\sigma}_\varepsilon$ (m)	$\hat{\mu}_\varepsilon$ (m)	T_{eff} (days)	η_{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

Conclusion & perspectives

This poster introduces **two simple verification tests** that help **to monitor**, in a qualitative way, the **integrity of any new incoming satellite measurement in near real time conditions** and without the need for in situ data. These tests are based on past measurements from the same location (temporal continuity) as well as recent measurements acquired by other missions, or in situ means, on upstream or downstream virtual/gauging stations over the same river (profile continuity between virtual stations). The tests highlights **the need for further studies about mission, retracker and product specific systematic bias**. Future integrity tests might rely on basic river discharge estimations, or on hydraulic and/or hydrologic models, at the scale of a basin. Such approaches might also be integrated into time series routines, used as filters prior to validation.

Of course, verification tests are not meant to replace validation (error quanfification).

Bibliography

[1] http://www.legos.obs-mip.fr/soa/hydrologie/hydroweb/

[2] Bercher, N. (2008). “Précision de l'altimétrie satellitaire radar sur les cours d'eau : développement d'une méthode standard de quantification de la qualité des produits alti-hydrologiques et applications”, PhD thesis (french).

[3] Bercher, N. et Kosuth, P. (2012). “Monitoring river water levels from space : Quality assessment of 20 years of satellite altimetry data”. Symp. “20 years of progress in radar altimetry”, 24-29 September, Venice, Italy.

[4] Kosuth, P. and Blitzkow, D. and Cochonneau, G. (2006). “Establishment of an altimetric reference network over the Amazon basin using satellite radar altimetry (Topex/Poseidon)”. Symp. “15 years of progress in radar altimetry”.

Acknowledgments

This study was developed in frame of the **EVALEC** project funded by **CNES TOSCA** programme.

We thank: **SALP (CNES)** for supporting us starting this project, **CTOH** for their valuable help and many other people at **LEGOS**, **CNES** and **CLS**.

In situ data from ANA (Agência Nacional de Águas), Brazil: http://hidroweb.ana.gov.br/.

In situ gauge leveling from Kosuth et al., 2006 [4], **Irstéa.**