Quality of river water level time series issued from satellite radar altimetry: influence of river hydrology and satellite measurement accuracy & frequency

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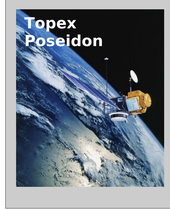
Context & objectives

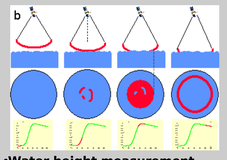
During the past 15 years, Satellite Radar Altimetry (SRA) have shown its potential contribution for monitoring river water levels. But nowadays, it is still not operational because the quality of SRA time series is not yet systematically quantified, and moreover because not any methodology have ever been defined.

In this study, we wish to introduce efforts we have done toward a standardized methodology for quantifying the quality of the SRA derived times series. This framework aims to be used on SRA data sets from various configuration, produced by various altimetry research teams.

Satellite Radar Altimetry principle reminder

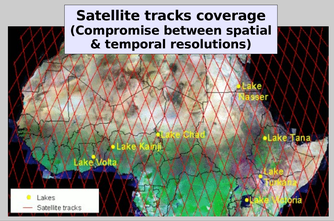


Return echo analysis

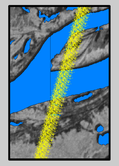


- Water height measurement
- Analysis of the returned waveform

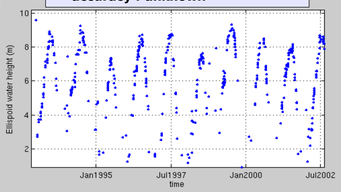
Satellite tracks coverage (Compromise between spatial & temporal resolutions)



Data localization & extraction

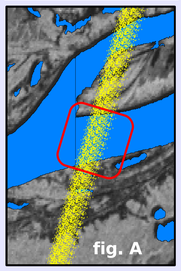


Radar Altimetry measurements:
- 10 to 35 days (theoretical)
- accuracy : unknown



I. Method for quantification of altimetry measurements accuracy

Topex Poseidon Track 63 Solimoes river Manaus, Brazil



3 river level stages approach (fig. B):

- error distribution is **correlated** with *in situ* river level (fig. C)
- **improved accuracy** quantification while considering each stage (fig. F)

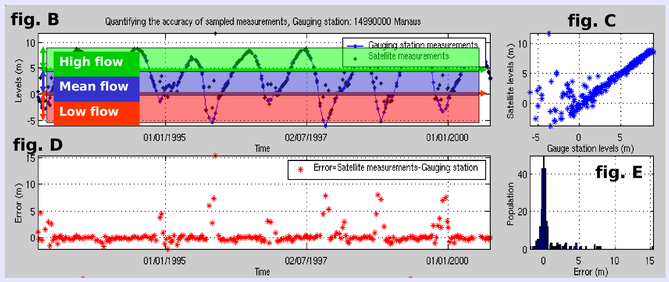


Fig. F: Error distribution according to the *in situ* river level
--- mean error
--- standard deviation

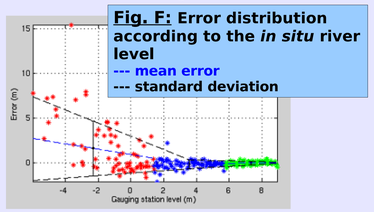
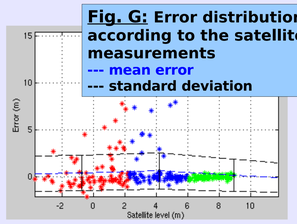


Fig. G: Error distribution according to the satellite measurements
--- mean error
--- standard deviation



Accuracy of Topex Poseidon on Solimões river (track 63)

(m)	Zmin	Zmean	Zmax	RMS	Mean error		stand. dev.
Global	*-6.00*	*1.47*	*8.93*	**1.88**	0.44	+/-	1.83
High flow	*5.76*	*7.35*	*8.93*	**0.20**	0.00	+/-	0.20
Mean flow	*1.43*	*3.59*	*5.76*	**0.50**	-0.12	+/-	0.49
Low flow	*-6.00*	*-2.30*	*1.43*	**3.42**	1.63	+/-	3.03

Uncertainty of Topex Poseidon on Solimões river (track 63)

(m)	Zmin	Zmean	Zmax	RMS	Mean error		stand. dev.
Global	-3.75	4.01	11.76	1.88	0.44		1.83
High flow	6.10	8.93	11.76	**1.70**	0.21		1.70
Mean flow	2.27	4.18	6.10	**2.00**	0.65		1.90
Low flow	-3.75	-0.74	2.27	**1.92**	0.46		1.88

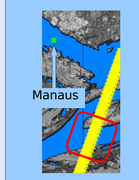
WARNING: Quantifying SRA measurements accuracy is not quantifying the inner dispersion !

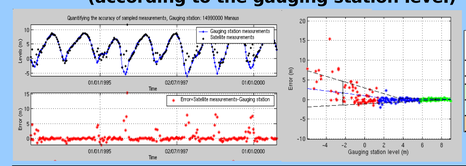
- Correlation between *in situ* & SRA measurements clearly shows a good correlation on high level stage (20cm, fig. C & F) while it declines as the river level falls (up to ~300cm)
- Building such SRA time series is a process sensible to: the **extraction window size** (dispersion, fig. A), the **selection of a representative measurement** (dispersion immunity) per cycle/overflight and the fact that ***in situ* & satellite site does not often coincide** (needs spatio-temporal interpolation along the river)

Fig. F: Error model according to the river level: useful for retracking methods comparison
Fig. G: Error model according to the satellite level: useful for near real time accuracy qualification

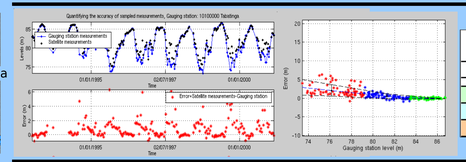
This method for quantification of measurements accuracy...
- ...does not take into account the effects of measurements lacks particularly during low stage
- ...enables accuracy comparison between various retracking algorithms

Results illustration on 3 study site in the Amazonian basin (according to the gauging station level)

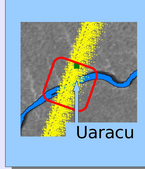


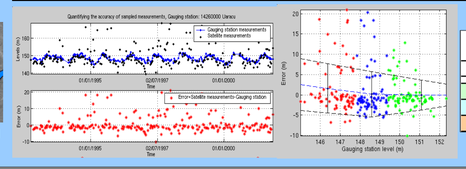


RMS	Mean error		stand. dev.
1.88	0.44	+/-	1.83
0.20	0.00	+/-	0.20
0.50	-0.12	+/-	0.49
3.42	1.63	+/-	3.03



RMS	Mean error		stand. dev.
1.56	0.84	+/-	1.31
0.20	0.00	+/-	0.20
0.86	0.53	+/-	0.68
2.60	2.08	+/-	1.57

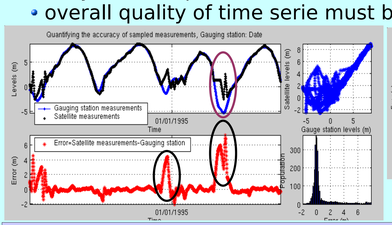


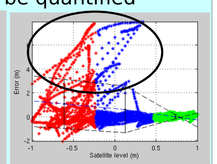


RMS	Mean error		stand. dev.
5.11	0.50	+/-	5.09
3.52	0.00	+/-	3.54
5.52	0.29	+/-	5.54
6.02	1.28	+/-	5.92

II. Quantification of oversampled water level time series accuracy

- **Hydrologists requirements:**
  - daily oversampled time series
  - overall quality of time serie must be quantified

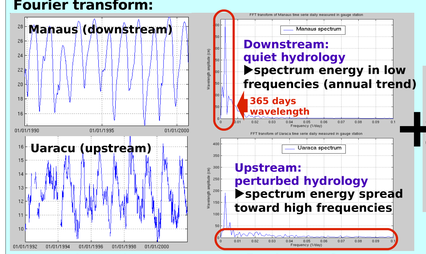




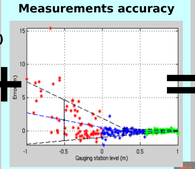
- Such a standardized methodology could allow the comparison between various satellite data processing including altimeter performances, retracking algorithms, oversampling methods, etc.
- **But oversampling introduces more error...**
  - Need to improve the rough data filtering process

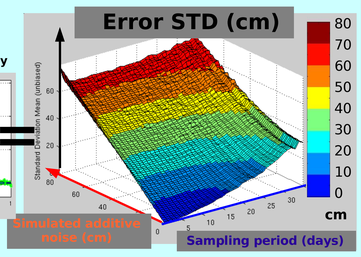
III. Coupled impact of accuracy & sampling period

- **Differences between upstream and downstream hydrological behaviour can be shown thanks to the Fourier transform:**



Measurements accuracy



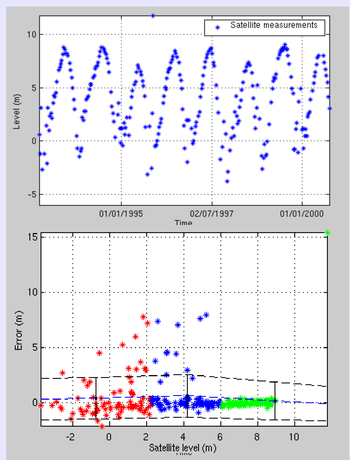


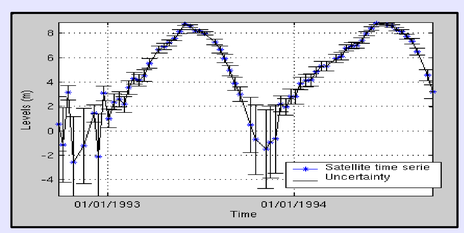
Satellite sampling period over site has an important impact on the overall quality of oversampled water level time series

Example: Error standard deviation comparison between satellites:
An "idealized satellite" (err std=0cm), 35 days period
gives the same overall accuracy than
A real satellite (err std ~20cm), 10 days period

IV. Method for uncertainty computation

- A statistical approach is used to generate an error model according to the river level measured *in situ*. Each model is dedicated to a given "satellite/river site" configuration
- The model is then used to compute the associated uncertainty along the whole oversampled time serie:





Advantages:
- provide **characterized** and **daily oversampled time series** to hydrologists
- compare different retracking algorithm, satellites and monitored rivers

Remaining troubles:
- does not take into account the impact of the **effective sampling period**
- moreover: error modelling is based on a non-uniform data set (lack of measurements during low water level stages)

Conclusion & Perspectives

- **The presented methodology allow the comparison between different data sources or study cases (including various satellite, retracking algorithms, study sites, etc.)**
- **Satellite radar altimetry derived time series are provided with a quantification of their quality**
- **Oversampling & uncertainty computation process needs to introduce the spectral information (effective sampling period impact)**
- **Spatio-temporal interpolation of *in situ* measurements under the satellite track from 1, 2 or more gauging stations measurements will be developed**
- **Challenge: *a priori* uncertainty computation without any *in situ* knowledge ?**
  - **Needs to link physical parameters to the error structure in order to estimate the error from these parameters**

References

Bercher N., Kosuth P., Bruniquel J.,"*Characterizing the quality of river water level time series derived from satellite radar altimetry: Efforts toward a standardized methodology*", ESA-CNES Venice 2006 "*15 years of progress in radar altimetry*" Symposium's proceedings (coming soon).

Thanks to...

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