Hydrol. Earth Syst. Sci. Discuss., 11, C4711–C4720, 2014
www.hydrol-earth-syst-sci-discuss.net/11/C4711/2014/
© Author(s) 2014. This work is distributed under
the Creative Commons Attribute 3.0 License.

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Swath altimetry measurements of the mainstem Amazon River: measurement errors and hydraulic implications" *by* M. D. Wilson et al.

M. D. Wilson et al.

matthew.wilson@sta.uwi.edu

Received and published: 30 October 2014

The authors would like to thank both reviewers for their constructive comments and feedback, which have allowed the manuscript to be improvement.

Referee comments follow -> followed by author response/ manuscript modifications

Referee 2:

-> The difficulty to estimate the river discharge of Amazon River is well known and mainly due to the influence of ocean elevation and to the width of the river. This width (several kilometres) permits to use measurements from satellites and the future arrival

of SWOT mission will provide more accurate data. The method used in the paper to assess river discharge from satellites data is (classically) based on the bed topography and the water surface slope. The data of water surface elevations from SWOT mission are replaced by water elevations coming from the calculation using hydrodynamic model and distorted to have errors inside the requirements (density and accuracy of points) proposed for SWOT objectives. The input discharge is compared to the results of the method either using the results of the hydrodynamic model or the distorted data (either using one point per cross section of the river or an average of all the points of a cross section).

-> The comparison is limited to two reaches of Amazon River and the only aim seems to optimize the discharge estimate for these two reaches. These two reaches are not representative of a set of American or world rivers; then, only the method can be transferred to other cases; the results of the optimization in term of length of reach or accuracy of discharge (or water surface slope) cannot be transferred. Even, the conclusion of the advantage of using SWOT cannot be transferred to other rivers very different from Amazon River. For Amazon River itself, the real applicability of the method from actual SWOT mission is not so sure because of the complexity of the flood plain, the eventual changes or uncertainties of topography and the influence of the vegetation that can bias the actual measurements.}

Response: The comparison was necessarily restricted to two connected reaches and an optimum discharge estimate using generated SWOT data was obtained – with the express aim of characterizing the contribution of SWOT data to the estimation of discharge. The main Solimões River is, arguably, not representative of other rivers globally due to its size – but the estimation of discharge here is important, nonetheless. The very low water surface slope makes the estimation of discharge for this reach from satellite data a considerable challenge and it was for this reason that the reach was selected – along with the solid baseline available from previously published work for the river in both estimation of discharge (from satellite altimetry and SRTM) and hydraulic modelling. The Purus River tributary was included to increase the transferability of the work to other rivers – at around 1 km in width it may represent a “large” world river. The water surface slope remained a challenge for this reach, but it is clear from the work presented that narrower rivers are likely to be more challenging to estimate accurately due to the limited possibility for cross-sectional averaging.

Further work is required to assess a range of additional rivers – this was stated in the conclusions but is beyond the scope of this paper. However, the observation and accuracy assessment of water surface slope for different reach lengths may be directly transferred (at least in the absence of cross-channel averaging for smaller rivers) – see Figure 9. The transferability of the discharge estimation is more difficult and will depend on the characteristics of the river in question, but this is acknowledged in the text in Section 4.4 (‘we can infer that discharge estimates may be more accurate for rivers with: (i) greater channel widths which permit a greater level of cross-section averaging and the use of shorter reach lengths; and (ii) higher water surface slopes, since, from Eq. 6, the relative error in discharge decreases as slope increases. Conversely, discharge estimation accuracy is likely to be lowest for narrow rivers with low slopes, although further research is required to quantify errors for rivers at this scale.’). We have also provided relative discharge estimate error as percentage and using the Nash-Sutcliffe efficiency coefficient to help with transferability.

Further work is also required to assess vegetation effects and the research was necessarily limited to the main channel – this was stated in Section 2.1 (‘Note that, presently, the performance of the SWOT instrument in the case of flooded vegetation is unknown, thus throughout this paper the words “floodplain” and “wetland” reference those conditions of a clear view of the sky without any flooded vegetation.’), in Section 4.4 (‘Note that the error analysis presented here excluded layover and vegetation effects, as may be found in wetlands and floodplains, or along the edges of rivers. These effects are likely to be greatest for narrower rivers with bank vegetation.’), and is again referred to in the conclusions.

-> The presentation of the results includes both a text with a lot of numerical values that the reader cannot compare easily (one or several tables would have been much better) and graphs that contain the essential information.

Response: The use of tables to summarize numerical values rather than placing all of them in the text is a good idea and this has been incorporated (see attached).

-> From the abstract but also from the whole paper, it is difficult to understand the scientific interest of this paper. A well-known method is applied to virtual data and provides some results for two reaches of Amazon River. As not all the steps (particularly the way virtual data are obtained) are detailed, the readers will not be able to use the same method for other rivers.

Response: The scientific interest is related clearly to the assessment of the potential for SWOT data to assess water surface slope and river discharge for the Amazon, a river of international significance. There is also interest since methods used (i.e. reach and cross-channel averaging and estimation of discharge) are obviously transferrable and easily applicable elsewhere. While “virtual missions” are needed for other rivers and for floodplain areas, once SWOT is launched in 2020, the prior development and assessment of these algorithms will be valuable. Space does not permit a fully detailed description of all methods (e.g. the Fourier transform), but readers are directed to reference papers where appropriate. A schematic of the methods used (suggested by Referee 1) has been included (see attached).

-> Other remarks

-> P. 9402: the values “0.31 m” and “2 mm” are put together without clear explanation of the calculation method for linking them

Response: This has now been clarified in the text – it is double the RMS error (the worst case scenario), divided by the track space (315 km) to obtain the water-surface slope error. The text now reads: “For rivers in the Amazon basin, the OSTM altimeter has been found by Seyler et al. (2013) to have a mean RMS error of ±0.31 m for rivers over 400 m wide. Using two parallel tracks to calculate water-surface slope, as is needed for the estimation of instantaneous discharge in the absence of in-situ rating curves, this RMS error would lead to a maximum water-surface slope error of around 2 mm per kilometer (calculated using 2 x 0.31 m / 315 km)."

-> P. 9403: "32% rivers", "1% rivers" : the authors do not explain what are the rivers concerned by these values: which length? which width? Which water depth? So the values are meaningless.

Response: The percentages are referring to observations of rivers within a global database, rather than particular widths/ depths, based on satellite sampling schemes. The sentence has been clarified in this respect to: "Profiling altimetry was shown by Alsdorf et al. (2007b) to miss entirely 32% of rivers in a global database, compared to only 1% of rivers being missed by an imager (based on the Terra 16-day repeat cycle, 120 km swath, 98° inclination and sun-synchronous orbit)."

-> P. 9406: I understand that the model used includes a series of cross sections and perhaps a 2D flood plain representation; no information is provided about number and spacing of cross sections and cells, topology of the system (1D network, organization of 2D cells, etc).

Response: This information is now provided and the model structure as implemented is clarified: "The formulation of LISFLOOD-FP used here was the one-dimensional diffusive wave formulation of Trigg et al. (2009) for channel flow (floodplain flow was excluded), allowing complex channel bathymetry and back propagation of flow. A detailed series of channel cross-sections were used (124 for the Solimões and 48 for the Purus), with an average along-channel spacing of 2.4 km and each representing the average bed-elevation for that location."

-> P. 9407: what is the time spacing of data for calibration (minimization of RMSE)?

Response: This detail is provided in Trigg et al. 2009, but has now been included here as well – "Friction parameters for the model were obtained through a calibration based on the minimization of RMS error calculated from river levels from four gauging stations internal to the model domain and model water surface elevation obtained at a temporal resolution of 12 hours"

-> P. 9407: does the choice of 100 m influence the results?

Response: This resolution was selected to be representative of the approximate SWOT image resolution – this is fixed by instrument design and an assessment of the influence of variations grid size used is, therefore, beyond the scope of the paper. A clarification regarding this selection has been added: "... 1D channel water elevations were mapped onto channel cross-sections then interpolated onto a 2D regular grid at a spatial resolution of 100 m (selected to approximately match the design requirements of SWOT as specified by Rodriguez, 2014, although this resolution will vary across the swath)."

-> P. 9408 §3.2 l.16-20: the authors do not explain why they pass by "500 m" instead of going straight to "100 m"

Response: The explanation is already included – "resolution limited by computational power"

-> P. 9409: equation 4 should be explained; for instance what is the origin of the x distances?

Response: This is a standard 1D polynomial slope equation and is straightforward to apply. X is the distance (chainage) along the channel of each observation – the origin of this is unimportant, but in this case is the downstream section of the channel; h is the elevation of that observation.

-> P. 9409: equation 5 assumes rectangular cross sections. Is it the case for all the cross sections of the model? How are averaged the width and the water depth along a channel reach (or how is selected the representative cross section)?

Response: Yes, this is the case – and given the large width relative to depth in the channel, this is a reasonable assumption. The average bed elevation for the cross-section was used, so that the cross-sectional area of flow was maintained. This information has been added to Section 3.1.

-> P. 9411-9415: Mots part of the values inserted in the text could appear in tables comparing the various methods, the various parameter values and the various locations.

Response: Much of these values have now been moved to two tables, representing the model output and the errors in estimates of slope and discharge.

-> P. 9412: "added to the according": one word missing

Response: Corrected

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 9399, 2014.

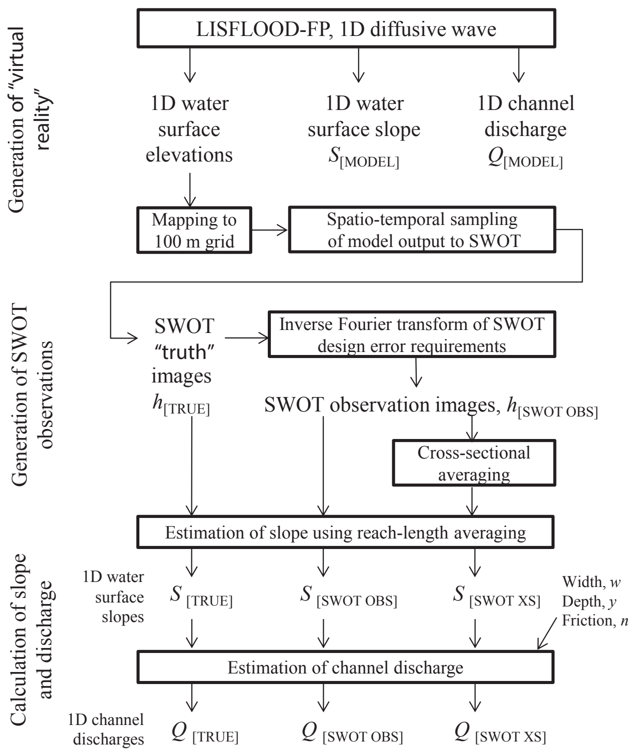

Fig. 1.

		Water level	Minimum	Maximum	Mean	Standard deviation
Solimões	Slope (cm/km)	Low	0.15	9.57	1.37	1.53
		High	0.69	7.43	2.19	0.95
	Discharge (m^3/s)	Low	19,765	32,068	26,346	2,137.9
		High	69,918	116,030	99,783	9,372.3
Purus	Slope (cm/km)	Low	-0.12	4.99	0.5	1.02
		High	0.17	3.01	0.52	0.35
	Discharge (m^3/s)	Low	-2,649	5,314	958	1,276.4
		High	6,665	19,276	13,466	2,958.9

Fig. 2.

	Error		Reach length (km) 5	10	20
Solimões	$S_{[SWOT\ OBS]}$	cm/km	2.55	0.91	0.33
	$S_{[SWOT\ XS]}$	cm/km	0.72	0.26	0.09
	$Q_{[SWOT\ OBS]}$	m^3/s	34,180	18,900	7,190
		%	48.5	26.1	9.7
		E	-1.92	0.23	0.89
	$Q_{[SWOT\ XS]}$	m3/s	15,670	5,950	1,960
		%	22.2	8.3	2.6
		E	0.46	0.93	0.99
Purus	$S_{[SWOT\ OBS]}$	cm/km	2.57	0.9	0.31
	$S_{[SWOT\ XS]}$	cm/km	1.05	0.37	0.13
	$Q_{[SWOT\ OBS]}$	m^3/s	9,682	5,211	2,795
		%	130.9	67.9	35.1
		E	-8.17	-0.92	0.57
	$Q_{[SWOT\ XS]}$	m^3/s	5,764	3,189	1,493
		%	76	40.9	19.1
		E	-1.34	0.44	0.88

Fig. 3.