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Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Using modelled discharge to develop satellite-based river gauging: a case study for the Amazon Basin" *by* Jiawei Hou et al.

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We thank the reviewer for the thoughtful comments and constructive suggestions, which will help us to improve the quality of the manuscript. Below please find our response to reviewer's comments in detail.

Comment #1

"The idea of SGR is quite interesting, but its performances should be evaluated more comprehensively, especially for potential application in ungauged regions (as suggested by the authors). For instance, how would SGR behave over pixels where the

correlation between surface water extent and modelled discharge is low (pixels excluded from the study)? How does the method compare with existing ones? What are the main limitations?"

Response #1

We thank the reviewer for these valuable suggestions. We would like to make it clear that the gauging data are only used for validation and evaluation. Therefore, even river reaches with gauging stations can effectively be considered as examples of ungauged regions. In truly ungauged regions, we would not be able to evaluate the SGR method.

We did not exclude any pixels in this study. In the Window Mean method, we used all the pixels within a window, but we did not select all the pixels as target pixels because some of them did not have enough modelled discharge. In the Optimal Selection method, we picked the best pixel in a window, we did not use others as they were not the most suitable ones to develop SGRs.

We compared our model-based SGRs to gauge-based SGRs from previous research (Van Dijk et al., 2016), which can help analyse the sources of uncertainties of model-based SGRs (Table A below). Both gauge-based and model-based GFDS SGRs at gauging station G12 and G19 have higher Pearson correlations than the model, which suggests value to implement data assimilation to improve the model. At gauging station G1, G5, G21, and G24, the model behaves much better than both gauge-based and model-based SGRs, which suggests that uncertainties in SGRs at these locations are mainly coming from remote sensing. Errors and uncertainties of the model, such as from input data, routing, and conceptual structure, can also affect the performance of SGRs. For instance, for GFDS SGRs at gauging station G6 and MODIS SGRs at gauging station G31, gauge-based SGRs produced higher Pearson correlations than model-based SGRs. We will add this comparison with existing method in the revised manuscript.

We will add more discussion about the main limitations of SGRs (see response to comment #4 from reviewer #2).

Comment #2

"The paper is quite well organized, but could be improved by: - explaining the concept of SGR in the introduction - providing a workflow scheme of the overall methodology - better justifying the interest and added value of SGR compared to existing methods and models."

Response #2

Thank you for your suggestions. We will change the introduction to explain the concept of SGRs better.

We will also add a figure with a workflow of the overall methodology in Figure B below.

We will add discussion of our method compared to existing methods and models in the revised manuscript. Previous research demonstrated that both gauging data and hydrology modelling can be used to calibrate the remote sensing signal for estimating river discharge (Brakenridge et al., 2012; Revilla-Romero et al., 2014). Van Dijk et al. (2016) developed gauge-based SGRs using optical and passive microwave derived water extent observations, which is valuable to gap-fill and extend gauging discharge records. In addition to that, we prove that SGRs can be also developed using hydrological modelling. Compared to gauge-based SGRs, the main advantage of our method is the practical applicability in both gauged and ungauged rivers. Our results show the model outperforms SGRs in most cases. Nonetheless, we consider SGRs as an alternative, simple and automated approach for river discharge prediction using satellite observation only. For example, SGR would be useful as an alternative if the model was unable to provide real-time estimations due to delayed rainfall estimates. If more accurate and reliable hydrological models are available, SGRs can be redeveloped to estimate river discharge with greater accuracy.

Comment #3

"P6L3-4. Is there any quantitative criterion which motivated this choice?"

Response #3

10ˆ2 m3s-1 was an empirical threshold that we chose as it shows the main river network in the Amazon Basin (Figure 1). We assume that rivers with mean discharge above 10ˆ2 m3s-1 have wider channels and broader floodplains than those with mean discharge below this threshold. In addition, annual mean discharge at all gauging stations ranges from 235 to 172,167 m3s-1 except G29 with very low discharge of 84 m3s-1. Thus, this threshold seemed a reasonable choice to cover river reaches with gauging stations for validation and evaluation.

Comment #4

"P6L12-13. Not clear"

Response #4

Agreed. We will change this sentence to make it clear.

Comment #5

"P7L30-31. Is it a quantitative or qualitative result?"

Response #5

The Optimal Selection method was chosen based on quantitative analysis as it shows highest correlations compared to the Window Mean method, while the selection of window size was decided based on qualitative interpretation.

Comment #6

"Figure 4. Colors of SGR sites (purple and black) are not clearly visible."

Response #6

Thank you for your suggestion. We will improve this figure (Figure 4 below).

Comment #7

"Figure 5. The figure is too small."

Response #7

Agreed. We will enlarge it to cover two pages.

Comment #8

"P12L14. Not clear"

Response #8

We will change this sentence to make it clearer.

Comment #9

"P12L29-30. Is it because of model biases?"

Response #9

Correct (see P12L32-P13L2). We will explain this.

Reference

Brakenridge, G. R., Cohen, S., Kettner, A. J., De Groeve, T., Nghiem, S. V., Syvitski, J. P. M., and Fekete, B. M.: Calibration of satellite measurements of river discharge using a global hydrology model, Journal of Hydrology, 475, 123-136, doi:10.1016/j.jhydrol.2012.09.035, 2012.

Revilla-Romero, B., Thielen, J., Salamon, P., De Groeve, T., and Brakenridge, G. R.: Evaluation of the satellite-based Global Flood Detection System for measuring river discharge: influence of local factors, Hydrology and Earth System Sciences, 18, 4467-4484, doi:10.5194/hess-18-4467-2014, 2014.

Van Dijk, A. I. J. M., Brakenridge, G. R., Kettner, A. J., Beck, H. E., De Groeve, T., and Schellekens, J.: River gauging at global scale using optical and

passive microwave remote sensing, Water Resources Research, 52, 6404-6418, doi:10.1002/2015WR018545, 2016.

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Table A Performance comparison between gauge-based SGRs, model-based SGRs and the W3 model (Pearson correlations between predicted and observed discharges).

		G1	G5	G6	G12	G14	G19	G21	G24	G31	Mean
MODIS SGRs	**Gauge-based**	0.75	0.77	0.74	0.86	0.77	0.88	0.48	0.60	0.92	0.75
	Model-based	0.76	0.75	0.71	0.86	0.78	0.75	0.68	0.58	0.86	0.75
GFDS SGRs	**Gauge-based**	0.88		0.85	0.96		0.95			0.85	0.90
	Model-based	0.90		0.77	0.92		0.93			0.85	0.87
Model		0.98	0.93	0.84	0.85	0.83	0.86	0.92	0.94	0.94	0.90

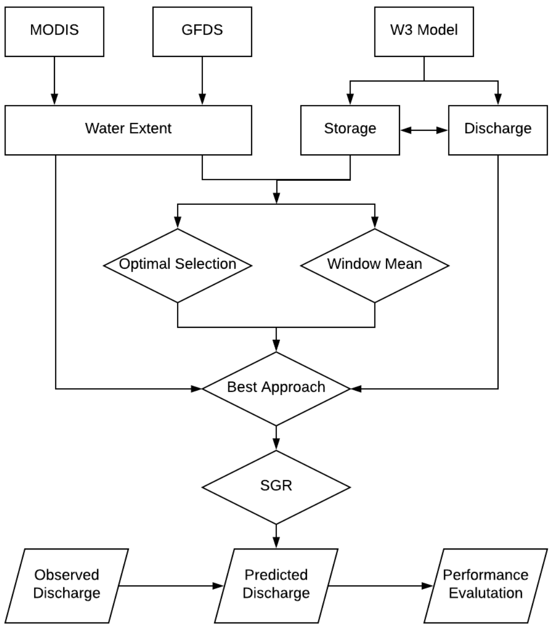

Figure B Workflow of the overall methodology (rectangle: data; diamond: method; parallelogram: validation).

(a)

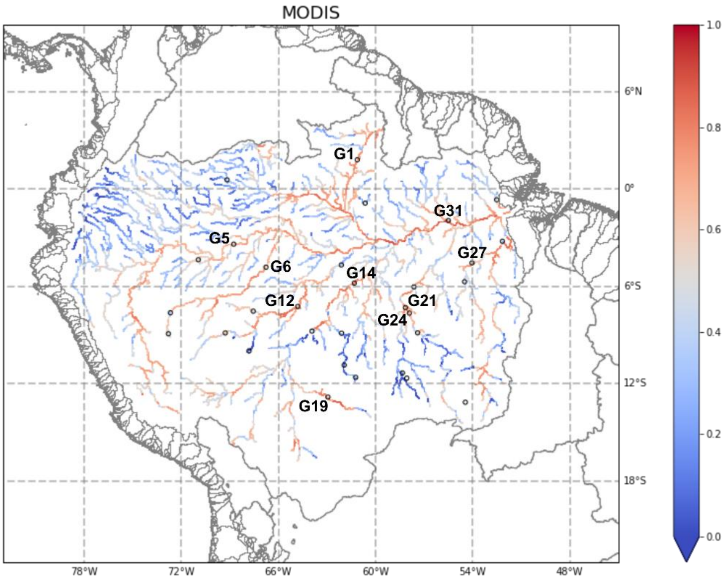

Figure 4 Spearman correlation (ρ) between modelled river channel storage and MODIS (a) and GFDS (b) water extent using the Optimal Grid Cell Selection method (Method A) with a search window of 0.55°×0.55° (circle: gauging station; circle with black label: potential SGRs sites where gauging data is available).

(b)

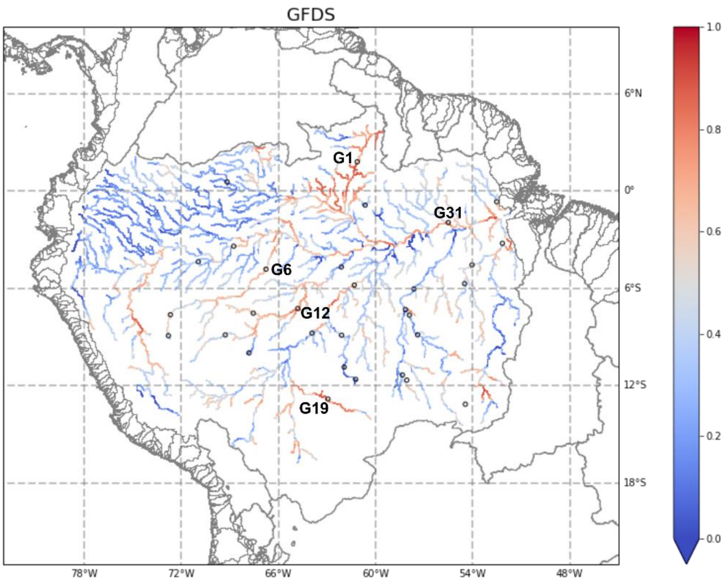

Figure 4 Spearman correlation (ρ) between modelled river channel storage and MODIS (a) and GFDS (b) water extent using the Optimal Grid Cell Selection method (Method A) with a search window of 0.55°×0.55° (circle: gauging station; circle with black label: potential SGRs sites where gauging data is available). (continued)