Comprehensive evaluation of the SWOT discharge data product: What will we learn about the world's rivers?

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The Surface Water and Ocean Topography (SWOT) mission will measure river height, width, and slope globally for rivers wider than 100 m. River discharge will be computed using simple flow laws via a combination of SWOT measurements, and unmeasured "parameters" such as river bathymetry and friction coefficient. The Science Requirement Document specifies that the Science Team in place during the SWOT mission compute the flow law parameters offline from the SWOT mission operations, and that discharge uncertainty estimates be made available. The Discharge Algorithm Working Group (DAWG) of the 2016-2020 Science Team has defined discharge algorithms and integrators in order to fulfill this purpose. The DAWG has also specified that two data products be created: one constrained by in situ streamflow gages, and the other unconstrained. Our partner project (led by Colin Gleason, University of Massachusetts) will undertake the computational effort to compute these parameters using a newly developed computational environment known as "Confluence". In collaboration with our partner project, we will to do three things.

First, we will contribute new components to Confluence needed for full functionality, including a comprehensive uncertainty model. The DAWG has recommended that the official gage-constrained and gage-unconstrained discharge data products be computed as a consensus among several discharge algorithms and integrators developed independently by multiple research groups and tested as part of DAWG activities. We propose to do the necessary work to determine the optimal way to produce a consensus discharge estimate and discharge uncertainty estimate for SWOT mission operations. We will compare two candidate consensus algorithms, and work with the DAWG to select the optimal approach. We also propose a candidate for comprehensive discharge uncertainty budget for each algorithm, and for the consensus algorithms. We will test, implement, and work to see the optimal methods deployed for SWOT mission operations.

Second, we will comprehensively evaluate the SWOT discharge accuracy, as well as the discharge uncertainty estimates, working with datasets compiled by the SWOT Calibration/Validation team. As we expect discharge accuracy to vary across reaches, we here propose a set of classes for global river reaches, on which to stratify discharge accuracy analyses. The discharge uncertainty estimate data product is a critical complement to the discharge estimates themselves. We will assess discharge uncertainty estimates across a range of rivers, to ensure users have information about discharge accuracy. Finally, we will perform quality control of all discharge parameters computed by Confluence before these are written to a database and delivered to the SWOT project for use in mission operations.

Third, we will quantify the overall improvement in global knowledge of streamflow due to SWOT discharge data products. Figure 2 below shows the step-change improvement in *coverage* of global rivers by SWOT over against what is available from a global gage dataset.

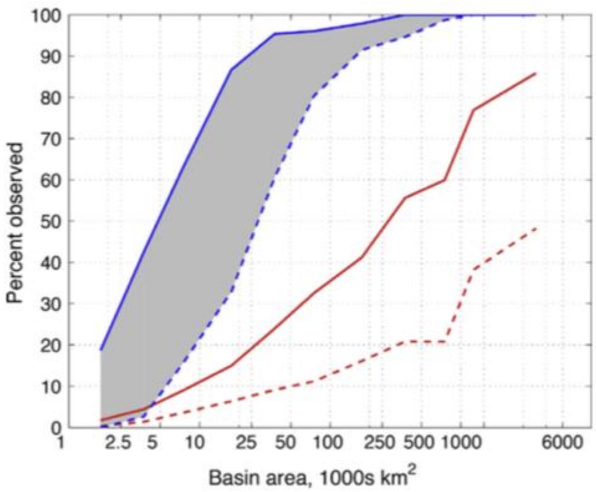

Figure 1. Percentage of global river basins observed by SWOT and GRDC. The dashed and solid blue lines show SWOT coverage assuming rivers wider than 100 m and wider than 50 m are seen, respectively. The dashed and solid red lines show GRDC coverage with criterion being whether data is available with latency less than five years, and whether any data is available in the GRDC record. From Pavelsky et al. (2014).

We will assess the extent to which SWOT river discharge improves upon global knowledge of discharge available by information external to SWOT, exemplified by hydrological models. We will compare the gage-constrained and gage-unconstrained data products to calibrated and uncalibrated global hydrological models, respectively. We will use SWOT discharge and its uncertainty to characterize and present the first ever global distribution of river discharge computed directly from river observations. We will assess this by analyzing both bias and random error in river discharge. As an example, Figure 2 shows predicted precision of discharge temporal variations, which can be estimated to within 10-20%; total discharge will be available less accurately. Both absolute discharge and discharge variations have the potential to lead to transformative new hydrologic science. The ability to estimate streamflow variations, which correspond to event flow, will lead to a tremendous advantage over models that rely on accurate precipitation inputs. SWOT discharge estimates will provide invaluable resources for calibration of global models, allowing them to better capture response of streamflow to rainfall. In completely ungaged basins, even discharge estimated to within 50% normalized RMSE will provide a valuable resource as global models can often have RMSE > 100%. Thus, it is critical that the hydrologic community take care in how the data product is used in order to maximize the scientific impact of the data.

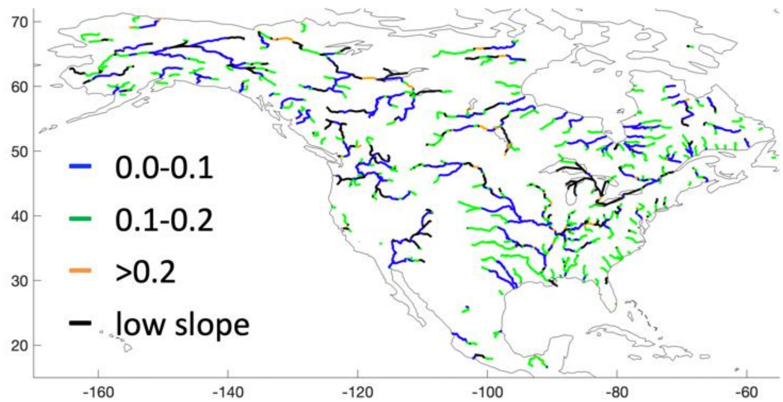

Figure 2. Estimated uncertainty in discharge variations across North America.

References

Pavelsky, T., Durand, M., Andreadis, K., Beighley, R., Paiva, R., Allen, G., Miller, Z. (2014). **Assessing the potential global extent of SWOT river discharge observations** Journal of Hydrology 519(), 1516-1525. https://dx.doi.org/10.1016/j.jhydrol.2014.08.044