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Estimating river surface slopes from ICESat-2 to inform hydrodynamic models

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ICESat-2 measures the ground surface elevation with 6 laser beams grouped in three pairs of two, and pairwise separated by 3.3 km across track. This measurement configuration provides an unprecedented opportunity to measure local the water surface slope. Local water surface slopes can inform hydrodynamic models and improve performance.

The slopes are estimated by a linear regression of the water surface height as a function of the distance along the river. Water surface slopes are estimated for all intersections, independent of intersection angle, between ICESat-2 crossings and the river centerline where data is available and of reliable quality. The package is applied to the Amur river basin using 3.5 years of ICESat-2 data. More than 3700 slope estimates were produced with a median relative standard error of 2.1% across 1502 SWORD reaches out of 3360 reaches that intersect ICEsat-2 tracks.

In this study, an automatic method for estimating river surface slopes is developed and implemented in an R package. The package uses ICESat-2 ATL13 data and the SWOT River Database (SWORD) as the only compulsory input data. The R package can be tuned to fit the application of interest based on the user settings. This enables slope estimates to be computed globally with minimal additional effort.

This R package provides a tool that is easy to use and systematically gives local water surface slope estimates for a specified area of interest. Studies have shown how information of river slopes from twin in-situ gauge stations can improve discharge estimates from models. The global sparseness of in-situ stations limits the usability of models informed with slope estimates from gauge stations. Water surface slope estimates on local scale from satellite data increases the usability of these models.