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River flow regime from remote sensing: what to expect from lifetime SWOT mission

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A Flow Duration Curve (FDC) exemplifies the relationship between the frequency and magnitude of streamflow at given location and it is of interest for many hydrological problems (e.g., water management and supply, human and irrigation purposes, etc.). However, relying on historical streamflow records, FDCs are constrained to gauged stations and, thus, typically available for a small portion of the world's rivers. The SWOT (Surface Water and Ocean Topography) satellite mission (in orbit from 2021) will provide unprecedented bi-dimensional observations of rivers wider than 100m, providing water surface heights, width and slope, enabling the estimation of river discharge at global scale and in ungauged basins.

This work considers the mission lifetime (three years) and the three satellite orbits (i.e. 211, 489, 560) that will monitor the Po River (Northern Italy). The aim is to test the ability to observe the river hydrological regime, which is, for this test case, synthetically reproduced by means of a quasi-2D hydraulic model.

For each satellite overpass, discharge estimation is pursued considering different river stretches (5, 10 and 20 km) and using synthetic remotely sensed measurements derived from a numerical hydraulic model corrupted with minimal observational errors. FDCs obtained with synthetic observations are compared with those defined referring to daily discharge values recorded at four gauging stations along the studied reach. Discharge assessment is performed using the Manning equation, under the assumption of a trapezoidal section, known bathymetry, and roughness coefficient.

Results highlight the potential of the mission to provide a realistic reconstruction of the flow regimes at different locations. Higher errors are obtained at the FDC tails, where very low or high flows have lower likelihood of being observed or might not occur during the mission lifetime period. Among the tested discretizations, 20 km stretches provided the best performances, with root mean absolute errors, on average, lower than 13.3%.