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Spatial variability in dune morphology is driven by local flow patterns steered by bars and pools

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Bedform occurrence and geometry in sand-bedded rivers is traditionally predicted with phase diagrams and empirical equations, in which regional river characteristic are used. Field observations supporting these equations are often made in regions where bedform fields are known to be present and are spatially uniform. However, bedforms occurrence and geometry can vary significantly at the scale of the river width, limiting the applicability of bedform diagrams and questioning the objectivity of field study area selection. To enable the prediction of dune geometry, its spatial variability needs to be better understood.

In this study, we aim to relate spatial variations in dune characteristic to grain size characteristics, river geometry, and local flow variation governed by the sub-bedform topography. We hypothesize that curvature-induced bars and pools drive local hydrodynamics, which in turn determine local dune characteristics. To test this hypothesis, bathymetric field data and sediment samples were collected in the fluvial-to-tidal-transition zone of the Fraser river, a sand-bedded lowland river in British Columbia, Canada. A 2D hydrodynamic model was created to explore the impacts of spatial variation in hydraulic conditions.

We find that the cross-sectional variability in dune geometry is larger than the longitudinal variability, and that the transition of one type of dune field into another is abrupt rather than gradual. Phase diagrams do not capture these observations accurately. Local hydraulic conditions are more important in determining spatial variability in dune geometry than regional scale changes in river geometry, grain size variation and tidal influence. Dune height has an ambiguous relationship with river depth: the spatial variation in dune height depends on local shear stresses governed by the sub-bedform topography characterized by pools and troughs.