Politecnico di Torino
Department of Environment, Land and Infrastructure Engineering
DIATI

FLOW AND MIXING AT RIVER CONFLUENCES

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JUNE 16TH 2025 AT 12.00 PM | AULA BIBOLINI, DIATI DOOR 3, GROUND FLOOR

Abstract:
Although confluence flows are ubiquitous, occurring in geophysical systems, such as river networks, mechanical systems, such as duct or pipe networks, and biological systems, such as arterial or venous networks, understanding of the fluid dynamics of confluences is limited. This research proposes a generalized framework characterizing the fluid dynamics of open-channel confluences with a concordant bed, including an-in depth investigation of the physics of shallow mixing layers developing over a no-slip surface. Using eddy-resolving numerical simulations, we systematically examine the main parameters (confluence angle, velocity ratio) that control confluence fluid dynamics and the influence of this dynamics on mixing between the two incoming streams. In particular, we investigate the role played by the quasi-2D large-scale eddies generated within the mixing interface and by the streamwise-oriented vortical (SOV) cells forming in the vicinity of the mixing interface in mixing. We show that the main reason why SOV cells have a large capacity to enhance mixing and to entrain sediment from the bed in the case of a loose-bed boundary is that their cores are subject to large-scale bimodal oscillations toward and away of the mixing interface. We then discuss how density contrast between the two streams and the development of a lock-exchange flow in transverse planes are affecting the mixing mechanisms at idealized and natural river confluences. Using field measurements of the mean temperature at a small river confluence, we show that accounting for stratification effects is critical for the simulations to accurately capture the mean temperature distribution downstream of the confluence apex. We then show that the presence of sufficiently high density contrast (i.e., densimetric Froude number less than 10) increases the overall rate of mixing at natural confluences and this effect is present at both small and large confluences.

Short biography:
Dr. Constantinescu is a Professor in the Civil and Environmental Engineering Department at the University of Iowa and at IIHR-Hydroscience and Engineering. Dr. Constantinescu got his Ph.D. at the University of Iowa in 1998. Following this, he occupied various research positions at Arizona State University and at the Center for Turbulence Research and the Center for Integrated Turbulence Simulations at Stanford University where he worked on the development of novel numerical algorithms for viscous flows, Detached Eddy Simulation and computational aero-acoustics. He then joined the University of Iowa as an Assistant Professor in 2004. His research program is based on the use of eddy-resolving simulations to understand the physics of several important classes of environmental and geo-physical flows. Dr. Constantinescu's current research focuses on turbulence and transport in rivers and lakes, stratified flows, shallow flows, eco-hydraulics, numerical modeling of floods and flow in porous media.