North Dakota Water Resources Research Institute (NDWRRI) Seminar Series

Mathematical models for lateral momentum transfer in ice-covered rivers

Javad Souri, North Dakota State University

Date and Time: Mon. 09/22/2025

3:30 - 4:30 PM (CDT)

Via Zoom, Meeting ID: 995 0056 5246 Passcode: 920171

https://ndsu.zoom.us/s/99500565246

Abstract:

River ice occurs yearly across the northern hemisphere, and its presence substantially modifies the hydrodynamics of natural rivers. By introducing additional surface roughness, ice cover influences the redistribution of momentum and alters bed shear stress, thereby affecting overall channel dynamics. In this seminar, existing theoretical models to describe lateral momentum flux in rivers will be discussed. We proposed a new analytical framework by applying a quartic distribution of turbulent viscosity and velocity into the Reynolds-Averaged Navier–Stokes (RANS) equations. The resulting momentum flux model establishes a relationship between depth-averaged velocity and water depth under ice cover. To assess model validity, extensive field campaigns were carried out during the winters from 2022 to 2025 on a meandering reach of the Red River of the North (Fargo, ND, USA). Using an Acoustic Doppler Current Profiler (ADCP), time-averaged velocities were obtained. Our results demonstrate that this model successfully obtains the lateral distribution of depth-averaged velocity. Also, measurements reveal the secondary flow contributes to lateral momentum flux at magnitudes comparable to Reynolds stresses, while field observations confirm that ice cover significantly modifies the development of coherent secondary flow cells. Our novel models offer practical tools for monitoring velocity profiles as well as predicting bank erosion in ice-covered rivers.

Speaker biography:

Javad Souri is a PhD student in Civil Engineering at North Dakota State University, Fargo, ND, under the supervision of Dr. Trung Le. He earned his bachelor's degree in Civil Engineering from Razi University, Iran, and a master's degree in Water Engineering and Hydraulic Structures from Tarbiat Modares University, Iran. He received a fellowship from the North Dakota Water Resources Research Institute (NDWRRI) in 2024. His research focuses on river hydraulics, with a particular interest in ice-covered rivers. By integrating field measurements with analytical modeling, he aims to improve our understanding of how ice coverage alters river dynamics. Javad also led a session at the UCOWR 2025 conference.

Outside of research, Javad enjoys cooking, watching movies, and spending time with his family. He also listens to historical podcasts, though he's not entirely convinced that counts as a hobby. Despite daydreaming about leaving academia to become a farmer, his tomato plants have refused to grow no matter how many YouTube gardening tutorials he consults. Until further notice, he has decided to stick with river hydraulics—because, unlike his tomatoes, rivers at least cooperate enough to publish papers about.