North Dakota Water Resources Research Institute (NDWRRI) Seminar Series

Hydrologic and Nutrient Export Changes to Recent Wetting in Cold Region Plains

Presenter: Dr. Taufique Mahmood, University of North Dakota

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Abstract

A novel wet continuum has exerted strong control over the hydrology of the cold-region plains in the Northern Great Plain region over the last three decades. Amid this wet continuum, a series of multiyear wet climatic states alternate between cooling and warming conditions. Such wetting, with intermittent mild dry conditions, influenced snow processes, contributing areas, and watershed storage, thereby increasing streamflow, leading to a subsequent rise in lake level, and causing massive flooding. Elevated streamflow also increased nutrient export, leading to a subsequent algal bloom. In addition, snow processes, infiltration (frozen, partially frozen, and unfrozen soil infiltration), and snowmelt and rainfall percolation influence groundwater recharge. The mechanisms by which hydrologic and nutrient export change in this wet continuum under a fluctuating temperature regime remain poorly understood in a terminal lake basin. Here, this study uses a set of field-based snow, soil moisture, and water-quality observations, remotely sensed data, a field-tested cold-region hydrologic-water quality model, and machine learning to elucidate the mechanisms of hydrologic and nutrient-export change in the Devils Lake Basin (DLB). The DLB is a 9900 km2 terminal lake basin located in northcentral North Dakota. The results indicate contrasting responses of the lateral flux-to-precipitation ratio (Q/P) and the vertical flux-to-precipitation ratio (V/P) between cooling-wetting (CW) and warming-wetting (WW) climatic states. The Q/P remained steady during the CW period and varied substantially during the WW period. Furthermore, the wet period experiences high snowmelt streamflow, resulting in lower nutrient concentrations and higher nutrient export, whereas the relatively dry period has very little streamflow, causing higher nutrient concentrations and lower nutrient export. A hysteresis loop between lake water evaporation and remotely sensed lake area, reflecting wetting (1996–2011) and drying (2013–2018) phases, highlights a nonlinear response to shifting climate conditions. Finally, current findings highlight the roles of snowmelt, rainfall, altitude, land cover, and depressions (lakes and wetlands) on groundwater recharge.

Speaker biography

Dr. Taufique Mahmood is an associate professor at the Harold Hamm School of Geology and Geological Engineering at the University of North Dakota. He is also the founding director of the Center for Water Research. He earned his undergraduate degree in Geology from the University of Dhaka, his MS in Engineering Science at the University of Mississippi, and his PhD in Geoscience (Hydrology) from Arizona State University. His research interests are in hydrology, nutrient export, aquifer recharge, and environmental remote sensing. He has also received numerous awards and honors, including the NSF CAREER Award (2022), Dean's Outstanding Faculty Award (2022), and Founders Day Faculty Award (2024).