Next-Hour Lake-Effect Quantitative Precipitation Forecasting Over the Great Lakes With Deep Learning

Tyagi, Atharva (School: Ridge High School)

Lake-effect precipitation, which significantly impacts regions downwind of the Great Lakes, poses unique forecasting challenges due to its dependence on localized processes and intricate interactions, making it an ideal candidate for deep learning. This study introduces a novel approach toward next-hour quantitative precipitation forecasts (QPF) for lake-effect precipitation by leveraging an improved generative adversarial network (GAN). Key innovations include testing multiple input variable groupings, introducing a modern generator architecture, and expanding predictions to four Great Lakes: Superior, Michigan, Erie, and Ontario. A modified pix2pix GAN framework with a UNetFormer generator is employed to develop a model to predict next-hour QPF for lake-effect precipitation events. A novel dataset is developed for the model with High-Resolution Rapid Refresh (HRRR) analysis fields for input and Multi-Radar/Multi-Sensor System precipitation data for the target. Five input variable groupings are tested to identify the optimal predictors for each of the four lakes. The developed model outperforms the HRRR's predictions in critical metrics such as mean absolute error and structural similarity index measure (SSIM), with gains of up to 40 and 50 percent respectively over the HRRR. Fractions skill score (FSS) indicates both spatial and quantitative superiority of the developed model in low-intensity events, with gains of up to 23 percent over the HRRR. SSIM and FSS used in tandem illustrate the spatial supremacy but quantitative underestimation of the developed model in medium- and high-intensity events. The developed model's competitive performance notably displays the significant potential of modernized GANs to advance lake-effect precipitation prediction.

Awards Won: