Turbulent Heat Fluxes during an Extreme Lake Effect Snow Event: Direct Measurements and Model Ensemble

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An extreme North American winter storm near eastern Lake Erie in November 2014 triggered the largest lake-effect snowfall event in southwest New York since the 1940s. While the large-scale atmospheric conditions of the southward migrating polar air mass are believed to be responsible for producing the extreme amounts of lake-effect snowfall, there has not yet been an assessment of how state-of-the-art numerical models performed in simulating the turbulent heat fluxes from Lake Erie, which is critical to accurate forecasts of lake-effect snow. To examine the turbulent heat fluxes during the extreme lake-effect snowfall event, this study utilized direct measurements of the turbulent heat fluxes and a suite of numerical weather and lake models that are operationally and experimentally used to provide nowcasts and forecasts of weather and lake conditions. Analysis of the water vapor budget in the weather models showed that lake evaporation accounted for the majority of snow precipitation during the event. Overall, the models captured the sharp rise of the turbulent heat fluxes during the event, while the peak values showed significant variation. In the hydrodynamic model results, the variation of the turbulent heat flux resulted in the range of the 3D-mean water temperature increasing from 9.2-10.1 °C (0.9 °C) to 6.4-8.5 °C (2.1 °C) and in the range of cumulative evaporation increasing from 2-3 cm (1 cm) to 5.5-7 cm (1.5 cm) during the four-day duration of two storm waves. These increased ranges caused by the single extreme event are large enough to impact simulations at longer time scales, including seasonal ice forecast and water balance prediction.

Keywords: North American Great Lakes, Lake Effect Snow, Hydrodynamic, Ice, and Weather numerical models