Introduction

The purpose of this study was to assess how state-of-the-art numerical models perform in simulating turbulent heat fluxes over the Great Lakes, which is tied to evaporation.

Method

Water vapor budget equation:

\[ P = E - F_v - \frac{dQ}{dt} \]

where \( P \) is precipitation, \( E \) is evaporation, \( F_v \) is divergence of water vapor and \( dQ/dt \) is the change in water vapor mass over time.

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All models used the same meteorological forcings (SNODAS, GVF, and OBS) and resolved the fluxes at 3D mean water temperature. The FVCOM model runs. All the model runs captured the sharp rise in LE and H on the 17th.

NAM and CFSv2 significantly overestimated, likely due to their coarser spatial resolution.

Analysis

- Heat fluxes were reconstructed using nine FVCOM model runs.
- Simulated heat fluxes were validated at two eddy covariance stations: Long Point Lighthouse and the Toledo crib intake (Perms2).
- The water vapor budget equation shows majority of the moisture came from Lake Erie and not a larger synoptic system.
- Lake-wide LE and H were calculated and translated into cumulative evaporation.
- Cumulative SWE was added to the secondary y-axis in Fig. 6.

Figure 3 shows lake surface temperature at (a) 45005, (b) 45132, and (c) 45742, as well as change of 3.6°C near water temperature (d). The grey region represents the max and min of the nine FVCOM model runs.

Figure 4 shows a map of Lake Erie. The red dots indicate locations of the three different NDBC buoys. The blue squares indicate the locations of the two eddy covariance measurement sites.

• Meteorological forcing elements were validated using observational data from three buoy sites (Fig. 3a-c).
• 3D mean water temperature was calculated to show corresponding lake heat content (Fig. 3d).

Figure 5 shows time series of the lake-wide mean (a) latent heat and (b) sensible heat fluxes from the model results. The grey region represents the max and min of the nine FVCOM model runs.

Figure 6 shows simulated lake-wide cumulative evaporation (primary y-axis) and snow water equivalent (SWE, secondary y-axis). “10” and “30” denotes values over the large and small domain.

Figure 7 shows the contribution of water vapor to the control volume integrated over time. Black lines show the amount of precipitation, red lines show the amount of evaporation, and the green lines show the summation of horizontal divergence and time-changing term dQ/dt.

Figure 8 shows the spatial snow water equivalent from CFSv2, NAM, and the analysis from SNODAS.

Conclusion

- The FVCOM-simulated LE and H agreed with direct flux measurements better than other models.
- This study emphasized the importance of accurate simulation of turbulent heat fluxes to better predict these intense LES events in the Great Lakes region.

Acknowledgements & References

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