Strengthening cross-agency bi-national partnerships to improve water prediction and management capabilities

Andrew D. Gronewold[1], Lauren Fry[2], Vincent Fortin[3], James Noel[4]

[1]NOAA Great Lakes Environmental Research Laboratory, [2]U.S. Army Corps., Detroit, [3]Canadian Meteorological Centre, [4]NOAA NWS Ohio River Forecast Center

PA41C-13293

Government of Canada

Abstract

Addressing data management and forecasting needs for regional water management commonly requires coordination between multiple state and federal agencies, and reconciliation of discrepancies between disparate sources of information. These requirements become all-the-more challenging when water monitoring infrastructure is sparse, or when that infrastructure design protocols follow (and differ across) jurisdictional boundaries. Here, we present novel advancements in partnerships between federal government representatives from the United States (US) and Canada that have addressed many of these requirements specifically for the Laurentian Great Lakes. The Great Lakes constitute the largest collective surface of fresh unfrozen water on Earth (Lake Superior alone is the largest lake by surface area), and the Great Lakes basin is effectively bisected by the US-Canada border. The suite of models and data sets needed to manage, forecast, and understand intrinsic changes in the Great Lakes hydrologic and climate system therefore depend critically on a range of experts with diverse backgrounds ranging from coastal engineering and meteorology, to ice climatology and hydropower facilities management. Here, we present a subset of partnerships within the Great Lakes basin that have evolved over several decades to address these needs. We emphasize how those partnerships have led to the development and communication of information that directly targets the needs of regional water management planning agencies on both sides of the international border.

Background – A Basin Divided

Figure 1 – International river basins of North America. Great Lakes - St. Lawrence basin is outlined in red.

Reconciling gaps and inconsistencies in hydrometeorological data and modeling platforms that intersect international boundaries can be a challenge. Across the Great Lakes – St. Lawrence River basin, this challenge is particularly profound because the United States – Canada border nearly bisects the basin, and because the Great Lakes constitute such a large proportion of the basin's area.

Filling these gaps has required the aggregation and alignment of efforts from federal, state, and provincial governments, as well as representatives from the academic research community. This presentation summarizes some of the key recent and ongoing multi-agency and bi-national initiatives addressing the needs for water management information across Earth's largest lake system.

Table 1 – Lake and land surface area estimates for each of the Great Lakes basins.

Lake basin	Total basin area (km²)	Lake surface area (km²)	Land surface area (km²)
Superior	210,100	82,100 (39%)	128,000 (61%)
Michigan–Huron	369,400	117,400 (32%)	252,000 (68%)
Erie (including St. Clair)	103,510	26,810 (26%)	76,700 (74%)
Ontario	83,000	19,000 (23%)	64,000 (77%)
Total	766,010	245,310 (32%)	520,700 (68%)

Blending Binational Precipitation Products

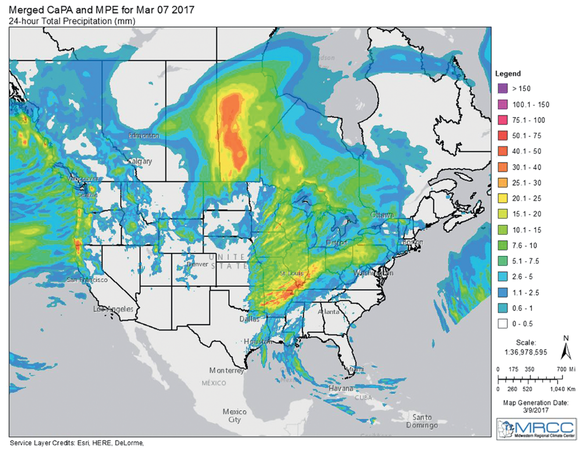


Figure 2 – New binational blended precipitation product developed and hosted by the Midwest Regional Climate Center (MRCC).

The Meteorological Service of Canada's Canadian Precipitation Analysis (CaPA) and National Weather Service Multisensor Precipitation Estimate (MPE) data are two promising sources of precipitation for long-term application to the Great Lakes. Through a strong binational partnership, both MSC and NWS agreed to expand the domain of their products over the surfaces of the lakes. The Midwestern Regional Climate Center (MRCC) has subsequently led the development of a new binational precipitation product that merges CaPA and MPE data over the Great Lakes basin (Figure 2).

A Legacy Water Level Monitoring Network

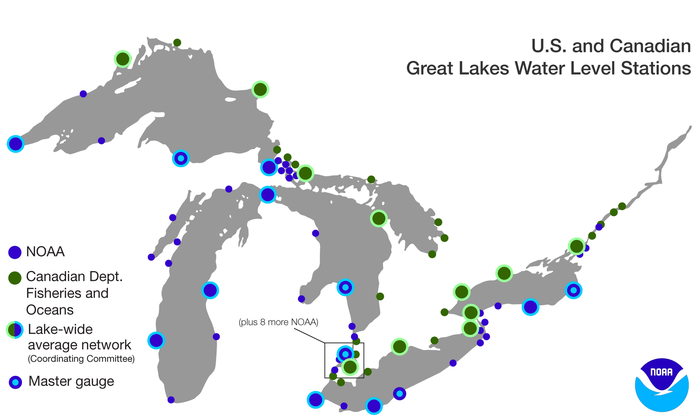


Figure 3 – Great Lakes shore-line based water level monitoring stations. Some stations were deployed in the mid-1800s, and are part of network providing the basis for a long and robust historical record.

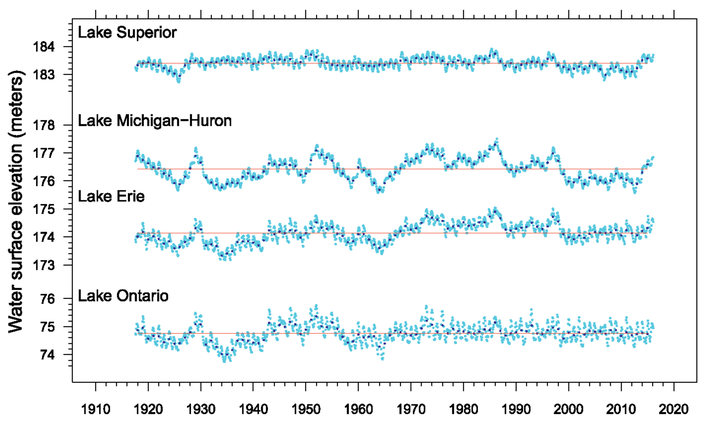
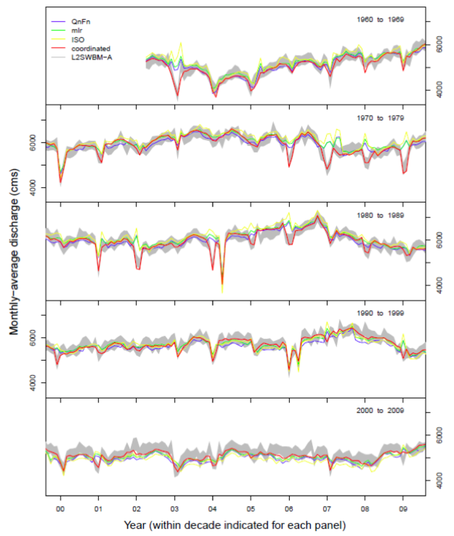


Figure 4 – Monthly (light blue) and annual average (dark blue) water levels of the Great Lakes. Red line represents the historical long-term average

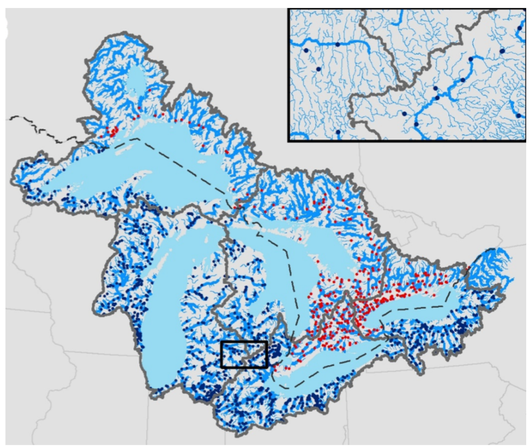
Statistical Water Balance Modeling



Through a binational partnership between the International Joint Commission and NOAA's Great Lakes Environmental Research Laboratory (GLERL), regional scientists developed a new statistical water balance model for the entire Great Lakes system. The model, referred to as the L2SWBM (large lake statistical water balance model), is encoded in a Bayesian framework to infer historical components of the Great Lakes water balance (see grey regions Figure 5).

Figure 5 – L2SWBM results for the Detroit River. Colored lines represent reference legacy measurements and models. The grey band represents the 95% credible interval of inferred flows from the L2SWBM.

Basin-scale Hydrological Modeling and Forecasting



Regional hydrological model developers have advanced the state-of-the-art in water supply forecasting across the Great Lakes through the development and testing of the GEM-Hydro and WRF-Hydro systems. Each initiative required consideration of a suitable binational land surface scheme (see, for example, figure 6). Both products are being evaluated through the current phase of the long-term GRIP (Great Lakes runoff intercomparison) project, which focuses on Lake Erie (previous phases focused on Lake Ontario and Lake Michigan).

Figure 6 – New Great Lakes land surface representation developed by scientists at NCAR and the University of Michigan to support expansion of the WRF-Hydro system across the entire Great Lakes basin.

Summary of Binational Data Resources

	Temporal range (for historical data)		Spatial resolution	Temporal resolution					Reference	Data distribution
	Begin	End		Annual	Monthly	1/4 monthly	Daily	Subdaily		
Official basin-scale Coordinating Committee products										
Over-lake precipitation	1900	Present	Average over lake surfaces	✖					—	www.greatlakescc.org/
Overland precipitation	1900	Present	Average over lake watersheds	✖					—	www.greatlakescc.org/
Connecting channel flows	1900	Varies	Average over channel length		✖	✖			—	www.greatlakescc.org/
Lakewide average water levels	1918	Present	Average over lake surfaces	✖	✖		✖		—	www.greatlakescc.org/
Residual net basin supplies	1900	Present	Average over lake surfaces		✖	✖			—	www.greatlakescc.org/
Seasonal water-level forecasts	—	—	Average over lake surfaces		✖				—	Monthly Bulletin of Great Lakes Water Levels
International Great Lakes datum	—	—	—						(Mainville and Craymer 2005)	Included in water-level data
Associated basin-scale products developed and maintained by Coordinating Committee members										
Over-lake precipitation (GLM-HMD)	1900	Present	Average over lake surfaces	✖	✖			✖	(Hunter et al. 2015)	NOAA-GLERL GLM-HMD
Overland precipitation (GLM-HMD)	1900	Present	Average over subwatersheds	✖					(Hunter et al. 2015)	NOAA-GLERL GLM-HMD
Over-lake evaporation (GLM-HMD)	1950	Present	Average over lake surfaces	✖	✖			✖	(Hunter et al. 2015)	NOAA-GLERL GLM-HMD
Lateral runoff into lakes (GLM-HMD)	1900	Present	Average over subwatersheds	✖	✖			✖	(Hunter et al. 2015)	NOAA-GLERL GLM-HMD
Component NBS (GLM-HMD)	1950	Present	Average over each lake surface	✖	✖			✖	(Hunter et al. 2015)	NOAA-GLERL GLM-HMD
Basinwide precipitation hindcast (CaPA)	2002	2012	Interpolated on 10-km grid					✖ ✖	(Lespinas et al. 2015)	CaPA-RDPA v2.4
Basinwide precipitation operational analysis (CaPA)*	2011	Present	10-km grid (see reference for details)					✖	(Fortin et al. 2015)	CaPA-RDPA real time (last month) (archive)
Component NBS (GEM system)*	2016	Present	10-km grid					✖	—	Web mapping server
Regulation and routing model	—	—	Average over channel length						—	Available from CCGLBHHD on request
International gauging stations	2015	Present	Point station data					✖	—	
Basin-scale products under development										
Water balance uncertainty estimates	1950	Present	Average over lake surfaces		✖				(Gronewold et al. 2016)	L2SWBM research site
Binational precipitation tool*	2002	Present	Gridded at 10-km resolution				✖	✖	—	http://mrcc.isws.illinois.edu/

Acknowledgements & References

Funding for this research was provided by the International Joint Commission (IJC) through the International Watersheds Initiative (IWI). Funding was also provided by NOAA, USACE, and ECCC.

Fortin, V., G. Roy, T. Stadnyk, K. Koenig, N. Gasset & A. Mahidjiba (2018). Ten Years of Science Based on the Canadian Precipitation Analysis: A CaPA System Overview and Literature Review, *Atmosphere-Ocean*, 56:3,178-196.

Fry, L. M., Gronewold, A. D., Fortin, V., Holtschlag, D., Buan, S., Clites, A. H., (and others), Restrepo, P. (2014). The Great Lakes Runoff Intercomparison Project Phase 1: Lake Michigan (GRIP-M). *Journal of Hydrology*, 519(Part D), 3448–3465.

Gaborit, E., Fortin, V., Tolson, B. A., Fry, L. M., Hunter, T. S., & Gronewold, A. D. (2017). Great Lakes runoff inter-comparison project, phase 2: Lake Ontario (GRIP-O). *Journal of Great Lakes Research*, 43(2), 217–227.

Gronewold, A. D., Fortin, V., Caldwell, R., & Noel, J. (2018). Resolving hydrometeorological data discontinuities along an international border. *Bulletin of the American Meteorological Society*, 99(5), 899–910.

Hunter, T. S., Clites, A. H., Campbell, K. B., & Gronewold, A. D. (2015). Development and application of a monthly hydrometeorological database for the North American Great Lakes - Part I: precipitation, evaporation, runoff, and air temperature. *Journal of Great Lakes Research*, 41(1), 65–77.

Mason, L. A., et al (Accepted). A new transboundary hydrographic dataset for advancing regional hydrological modeling and water resources management. *Journal of Water Resources Planning and Management.*