

Coupling Quantitative Precipitation Estimate and Great Lakes Hydrologic Models

Primary Investigator: Tom Croley - NOAA GLERL (Emeritus)

Co-Investigators: Kevin Kelleher, David Jorgensen, Ken Howard, J. J. Gourley - National Severe Storms Laboratory (NSSL), David Watkins - Michigan Technological University

Overview

Understanding a changing aquatic ecosystem requires knowing the physical forces that drive it and how those forces interact with the ecosystem. Meteorological and hydrological forces are largely responsible for changes in the Great Lakes aquatic ecosystem; rainfall and associated run-off are those driving forces. GLERL has developed sophisticated state-of-the-art hydrologic models; however, these models are limited by the quality and quantity of available input data in real time. Since precipitation is the major source of input to the water budget, it is paramount to the accuracy of these models that real time precipitation data be made available and incorporated usefully into the models.

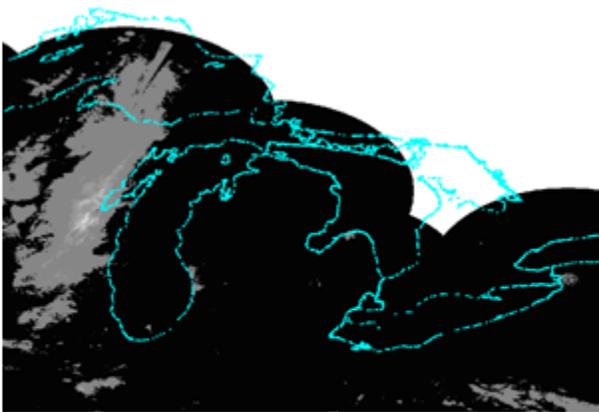


Figure 1. Precipitation Over Great Lakes Basin for 01:00:00—04:00:00 27 August 2005 from US radar sites.

The National Severe Storms Laboratory (NSSL) and the Great Lakes Environmental Research Laboratory (GLERL) are involved in a joint project on Great Lakes Runoff Ecosystem Coupling. (The coupling of High Resolution, Multiple Sensor Quantitative Precipitation Estimations with Great Lakes Hydrologic Models).

Objectives

1. Integration of US and Canadian radar systems encompassing the Great Lakes region and creation of seamless mosaics,
2. Implementation and refinement of high resolution quantitative precipitation estimates for the Great Lakes and associated watersheds,
3. The direct coupling of high resolution quantitative precipitation estimates (at 1 km grid scales) with GLERL's hydrological models of the Great Lakes.

Scientific Rationale

The ability to provide accurate runoff estimates not only impacts forecasting of the water levels of the Lakes, but will also allow a better accounting of the amount of water that runs off of the highly agricultural basins and enters the lakes. This runoff often carries phosphates and nitrates that are potentially harmful to the water supply and the ecosystem; in some cases causing premature aging of the lakes. A better accounting of the present and forecast water levels is not only important to safe navigation of the Seaway, but can help business such as commercial shippers, marinas, and hydropower and nuclear plants to manage and plan for extreme events.

Proposed Work

We propose to obtain optimal estimates of rainfall from NSSL's Quantitative Precipitation Estimation and Segregation Using Multiple Sensors product and to couple this with GLERL's Large Basin Runoff Model (LBRM) and with our Advanced Hydrologic Prediction System (AHPS). These are in turn being coupled with various Great Lakes ecosystem dynamical models in other projects. (Currently, as of November 14, 2005, the LBRM and AHPS are used with a network of 234 stations reporting daily precipitation and maximum and minimum air temperature, 232 in the US and only 2 in Canada, and with a network of 88 stations reporting daily air temperature, dew point, wind speed, and cloud cover, 61 in the US and 27 in Canada.) NSSL will continue its QPE-SUMS research in a new environment, the Great Lakes basin, and GLERL will improve its LBRM to hourly computations and its AHPS forecasts to take advantage of the additional information in near real time.

This project will use a two-dimensional rainfall-runoff model, based on GLERL's current distributed-parameter LBRM (DLBRM) for application to Great Lakes watersheds, which is under development in another project, Next Generation Large Basin Runoff Models. Both projects will investigate model concept improvements through model recoding and simulation comparisons with observations. These will include:

- Restructuring the model to use hourly data appropriately, including meteorological database construction and handling within the model, diurnal model concepts, model calibration to daily flows with hourly data, and appropriate graphical model output/animations.
- Restructuring AHPS's daily data streams to handle QPE-SUMS input during the daily production of Great Lakes hydrologic forecast products

- Building a data stream between NSSL and GLERL for transmission of hourly data at all points on a 1-km grid over the entire Great Lakes basin.
- Constructing automated processing facilities (software) to reduce this data appropriate for direct use in DLBRM simulations and data archiving.
- Designing and coding data archives, support software, and additional automated processing for translation to daily values over each watershed and lake surface for use daily in AHPS probabilistic forecasts.
- Preparing appropriate graphical products for both precipitation and various hydrological (model) quantities.

Once we get the systems in place between our laboratories, we can concentrate on accommodating data improvements as they occur; our near real time data stream becomes GLERL's entry point as QPE-SUMS improve and expand with respect to growing Canadian data involvement, additional data types such as wind speed and humidity, and so forth. In later research, we anticipate evaluating the worth of our new data streams to our hydrology models, improving the quality of quantitative precipitation estimates over the Great Lakes, and using QPE-SUMS data streams with DLBRM in ecosystem forecasting, most particularly on the Saginaw River and Maumee River basins.

GLERL will also interact with Michigan Technological University in developing an internet GIS display of model inputs and results, recommended parameterizations for diurnal models, comparing NSSL QPE-SUMS to NWS MPE (multi-sensor precipitation estimates), or documentation. With GLERL support, MTU will define a student project in one or more of these areas under the supervision of Professor David Watkins.

Accomplishments

2005

- Built an hourly station data base from data available from NOAA's National Climatic Data Center (NCDC), including all computer code for maintaining it in the future.
- Wrote programs to correct the hourly station data, arrange it synoptically, and generate spatial-average hourly meteorology over areas of interest.
- Built code to generate hourly spatial data fields for each meteorology variable of interest in appropriate order.
- We are downloading and archiving detailed QPE-SUMS raw data obtained from NSSL (see Figure 1) and analyzing it for use in both hourly and daily hydrologic models.
- Built a gridded data base of hourly QPE-SUMS precipitation and support software to read hourly synoptic precipitation, fill in missing values, reduce it for a given watershed, and store it for the period of record for subsequent use. (Filling in missing values involves both nearby synoptic QPE-SUMS and nearby synoptic station-based data.)

- We changed all data handling routines and data structures within the many hydrology model code modules from daily data to hourly data and added appropriate diurnal cycles.
- Student interns at Michigan Technological University compared QPE-SUMS to other precipitation estimates, built display software, and incorporated results into a web site (see Products below).
- We are using actual hourly meteorology and runoff data to calibrate the hourly distributed watershed model in the Maumee watershed.

Results

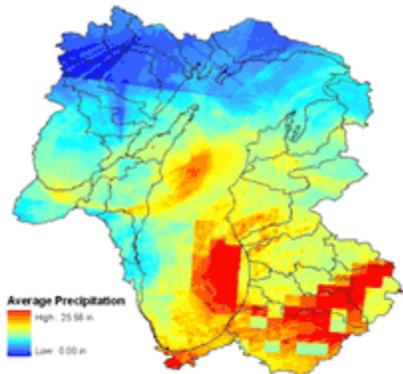


Figure 2. Precipitation Over the Lake Michigan Basin on 15 December 2004—28 February 2005 (from QPE-SUMS).

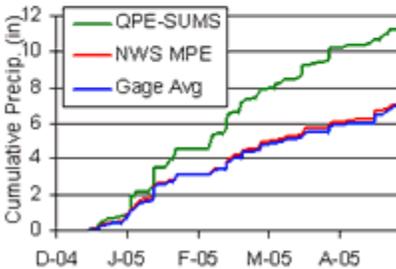


Figure 3. Cumulative Precipitation Comparisons for December 2004—April 2005 for the Lake Michigan basin.

Student interns at Michigan Technological University, under the direction of David Watkins, plotted seasonal totals taken from the NSSL QPE-SUMS-based precipitation product; see Figure 2. Errors can be seen arising from beam blockage and overshoot, as well as the coarseness of the mosaic algorithms they used. They also compared daily totals to the National Weather Service (NWS) Multisensor Precipitation Estimator (MPE) hourly gridded precipitation estimates (used at NWS River Forecast Centers in their operational hydrology models) and to daily gage-only products produced simply by using Thiessen-weighted measurements; see Figure 3, which shows that QPE-SUMS algorithms estimate more precipitation than either the

MPE or the gage average methods. These differences result from fewer zero measurement days in the QPE-SUMS data set and a greater number of days measuring large precipitation events, possibly as a result of satellite, lightning, and multiple radar systems data used to augment the WSR-88D radar data.

They also focused on the processing and display of NSSL's hourly precipitation. They built software to extract data from the NSSL binary encoded database to a text file for a user-specified set of dates and to pixilate and overlay the data onto a base image, producing a graphic image of precipitation in the Midwest region. They incorporated both of these programs into an easy to use web site which allows the user to run either program from their own computer; see Figure 4.