Great Lakes Net Basin Supply and Water Level Modeling

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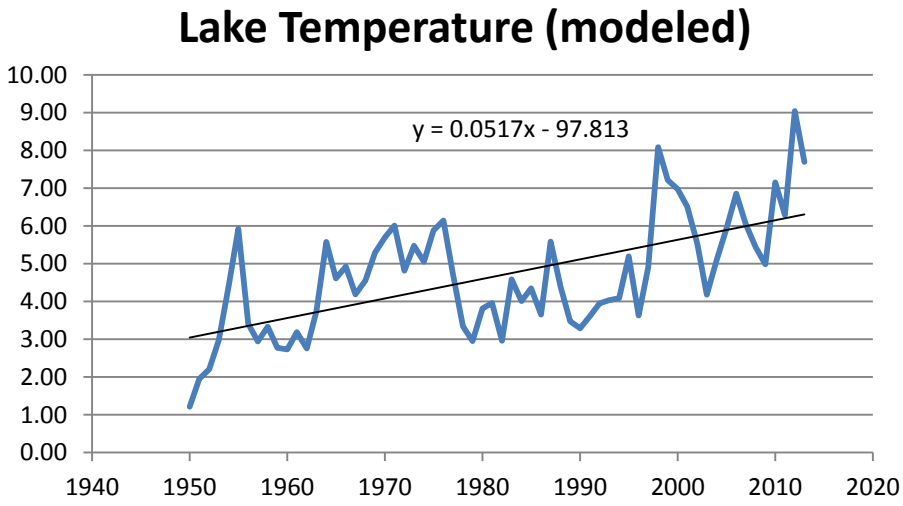
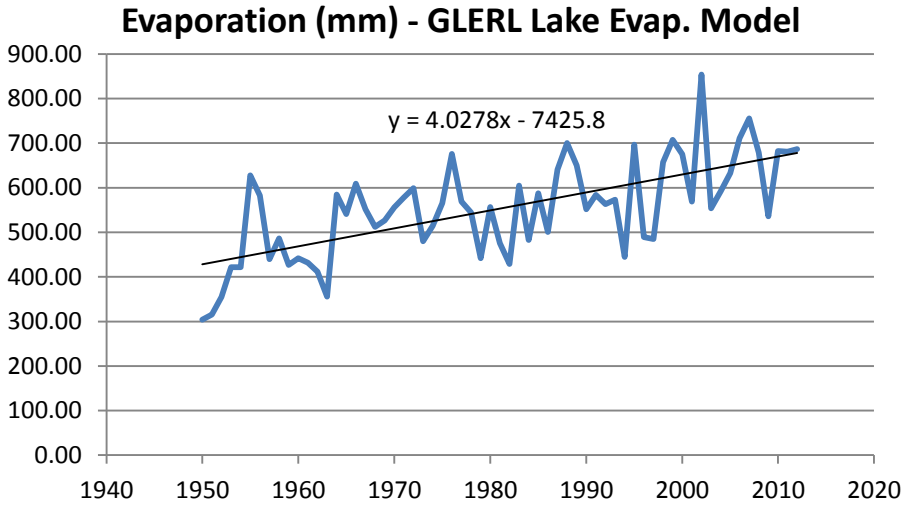
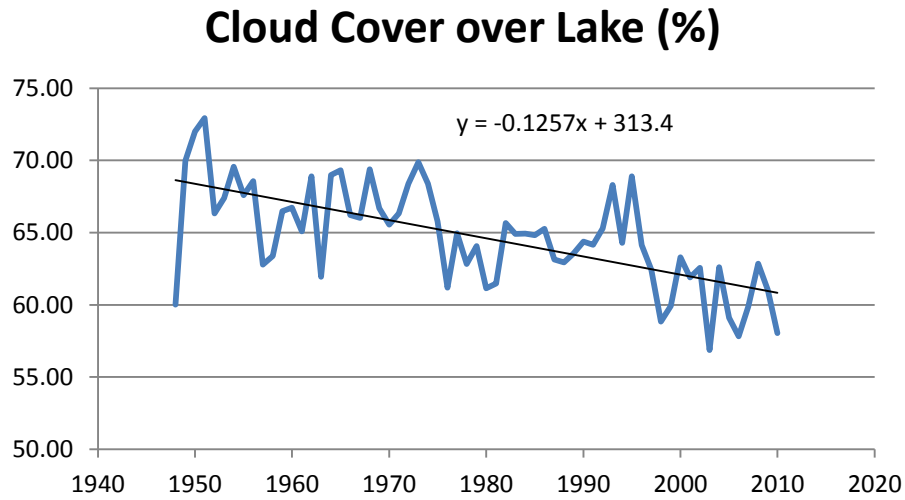
March 19, 2015

Hydroclimatic Data for Lake Superior



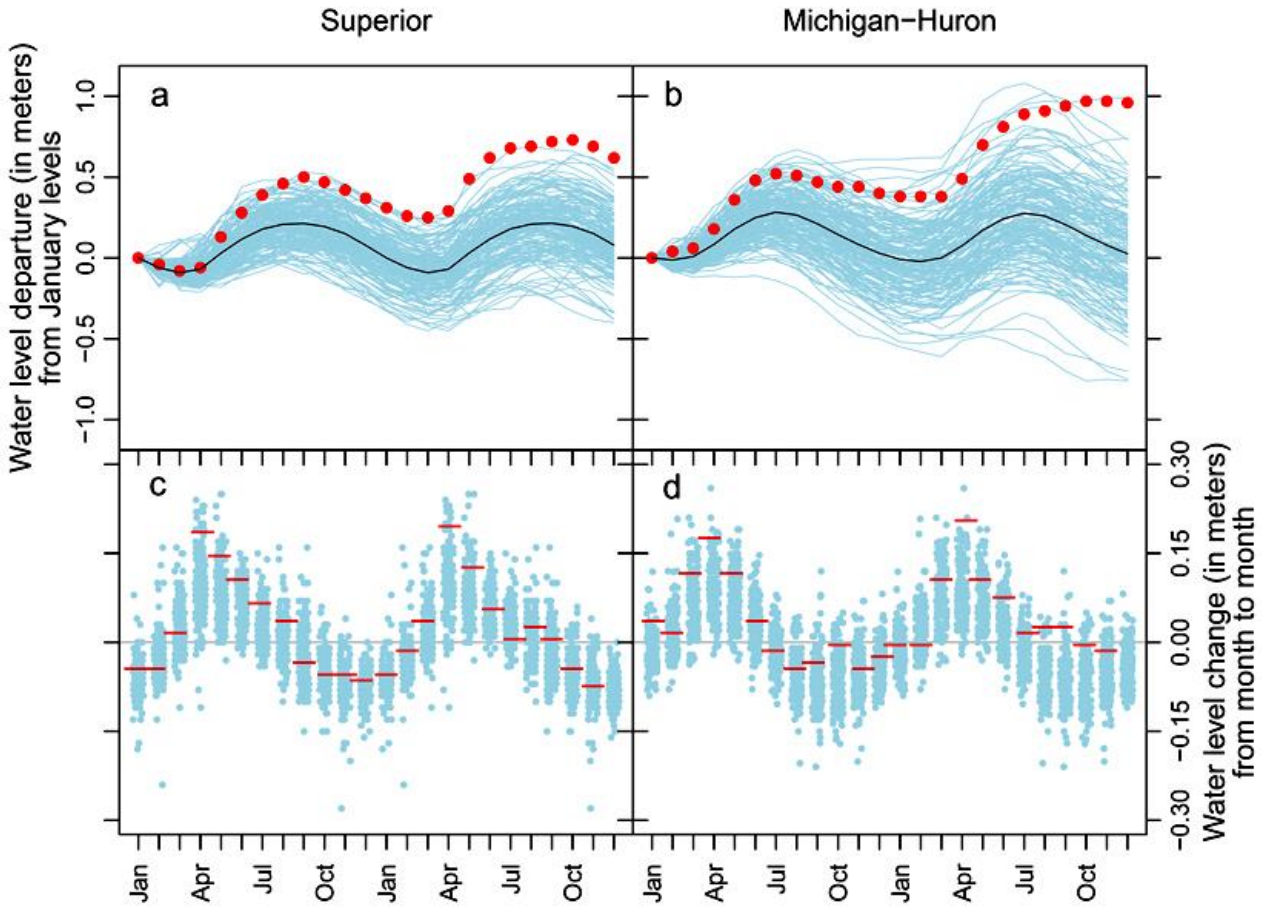




Source:
http://www.glerl.noaa.gov/ftp/publications/tech_reports/glerl-083/UpdatedFiles/

GLERL
Great Lakes Environmental Research Laboratory

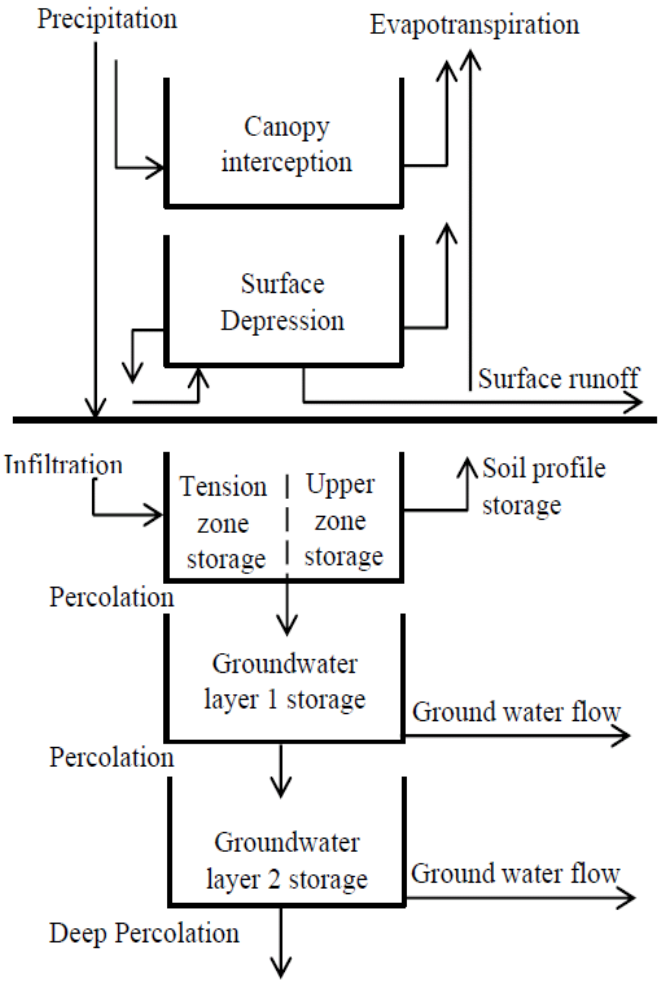
Surging Water Levels in 2013-14



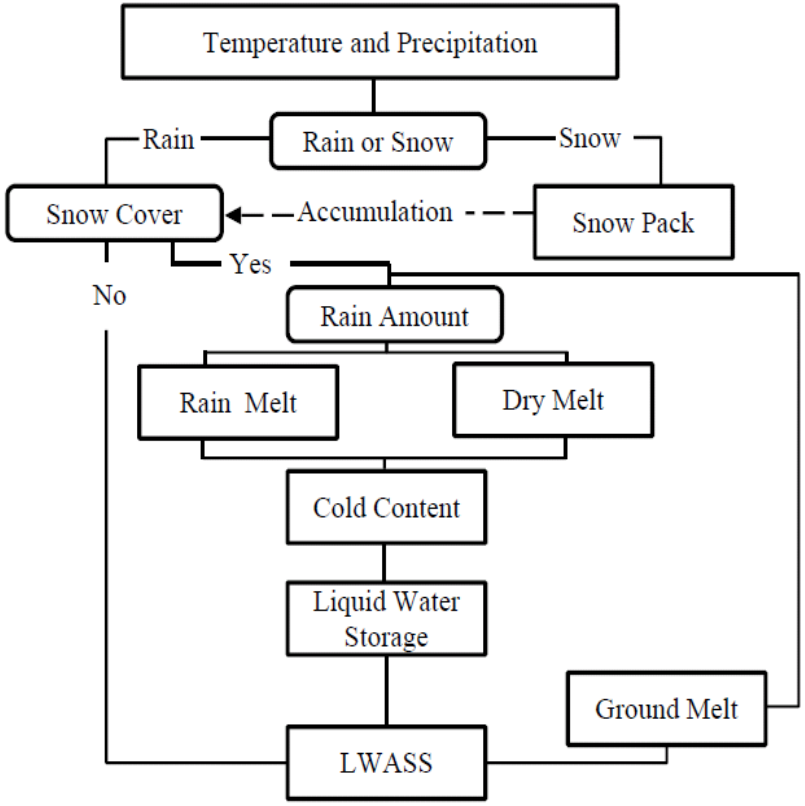
Gronewold, A. D., A. H. Clites, J. Bruxer, K. W. Kompoltowicz, J. P. Smith, T. S. Hunter, and C. Wong (2015), Water levels surge on Great Lakes, *Eos, 96,* doi:10.1029/2015EO026023. Published on 17 March 2015.

Hydrologic Models: Physically Based

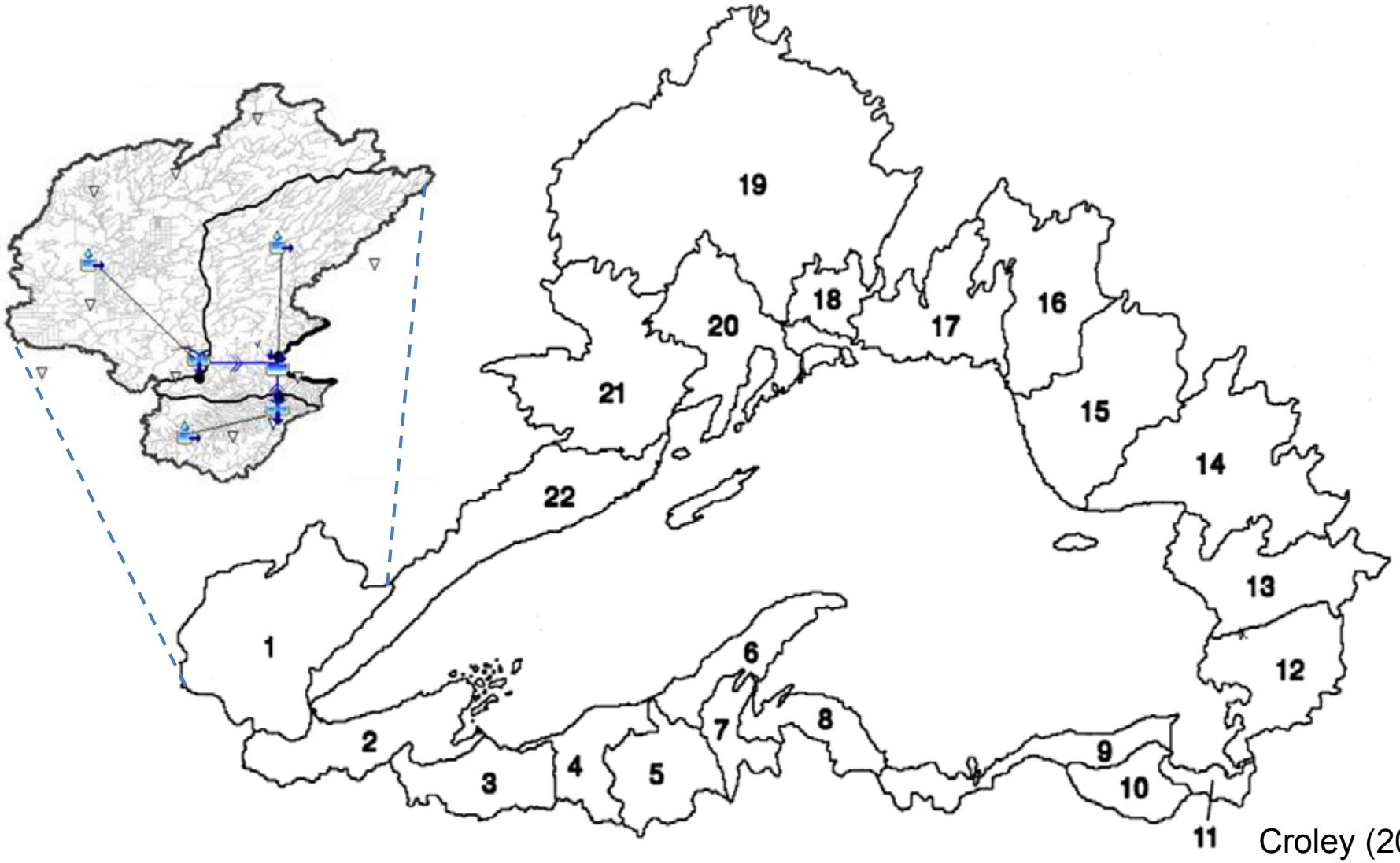
Soil Moisture Accounting Algorithm in HEC-HMS



Snow Melt Algorithm (USACE, 2008)

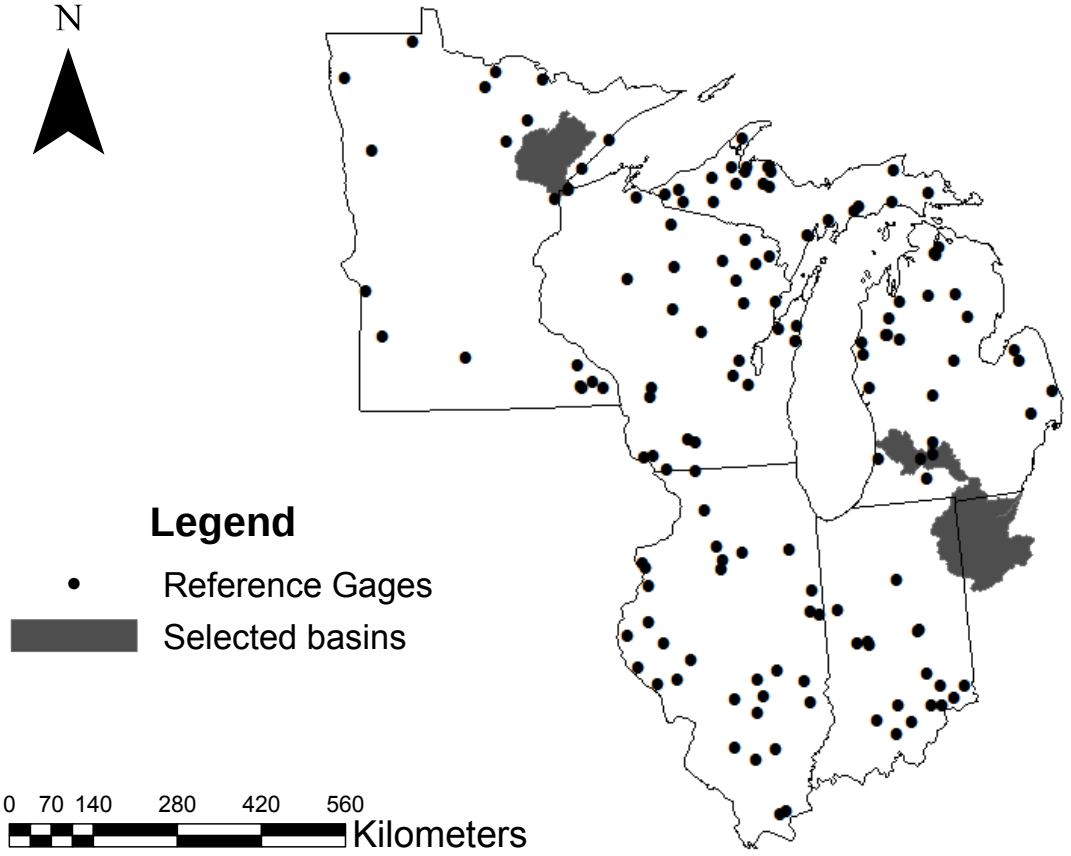


Hydrologic Models: Lumped and Semi-Distributed



Croley (2002)

Hydrologic Models: Regional Regression Models



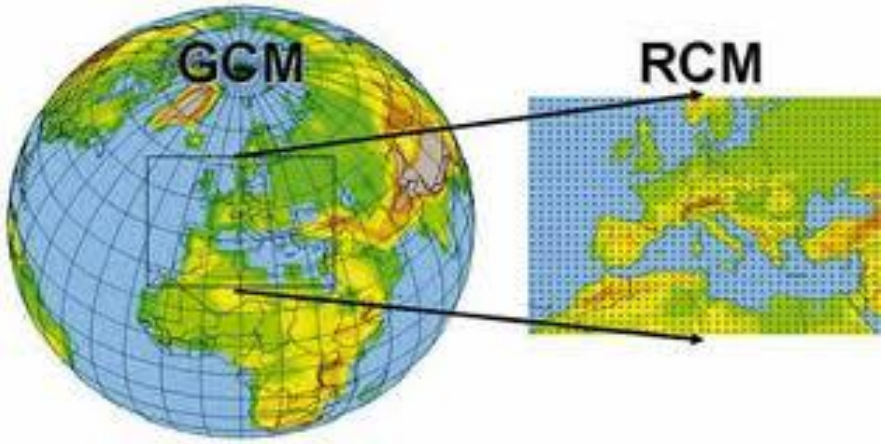
Geospatial **A**ttributes of **G**ages for **E**valuating **S**treamflow**,** version **II**, provides geospatial data and classifications for 9,322 stream gages maintained by the USGS (Falcone, 2012).

$$\ln(Q_i) = \ln(\beta_0) + \beta_1 \ln(Z_{i1}) + \beta_2 \ln(Z_{i2}) \ldots + \beta_p \ln(Z_{ip}) + \varepsilon$$

Gyawali et al. (2014b)

Climate Change Projections

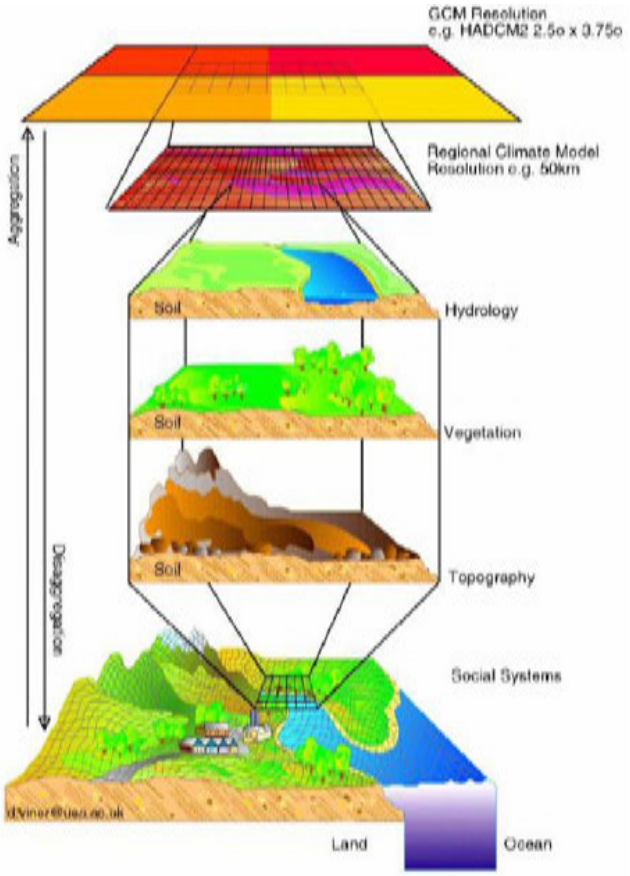
Dynamical Downscaling



Some Regional Climate Models:

- Regional Atmospheric Modeling System (RAMS)
- Providing REgional Climates for Impacts Studies (PRECIS)
- Canadian Regional Climate Model (CRCM)

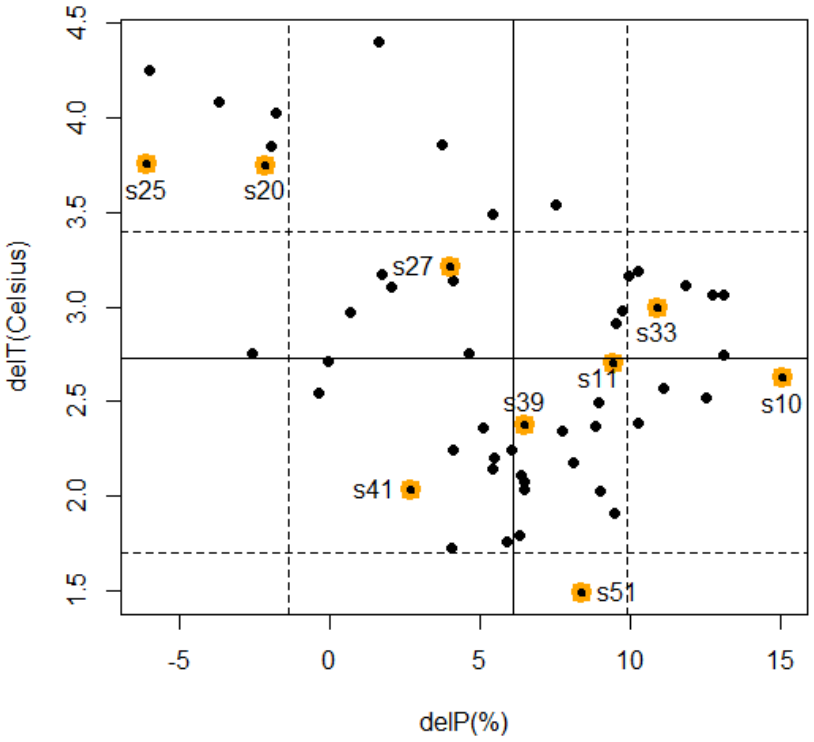
Statistical Downscaling



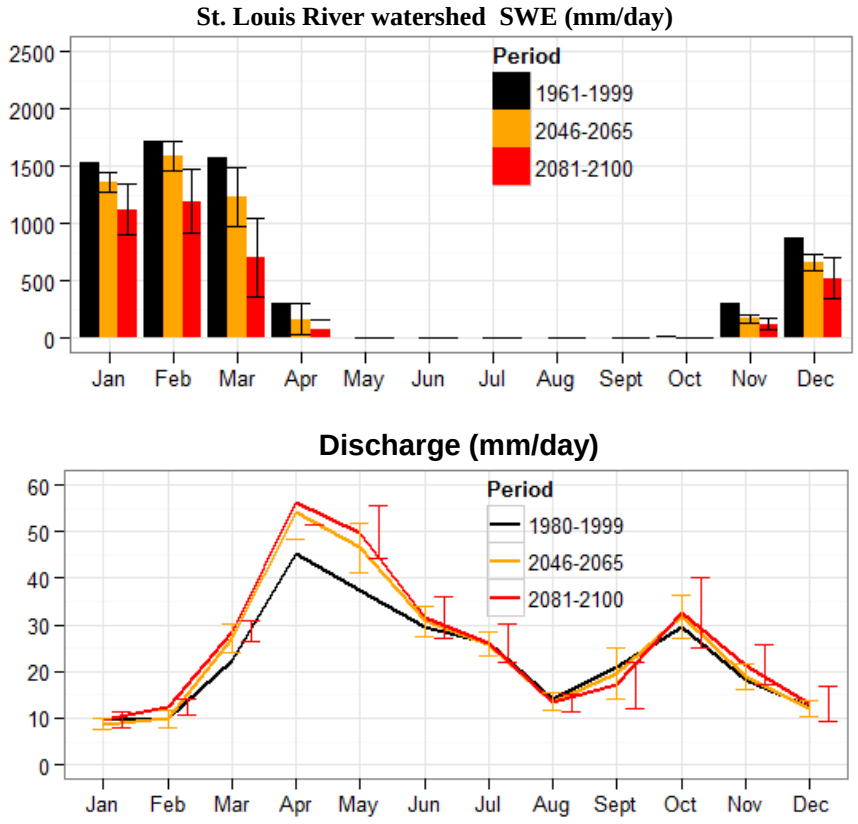
Wilby and Dawson (2004)

Some Results

Climate Projections (CMIP 3)

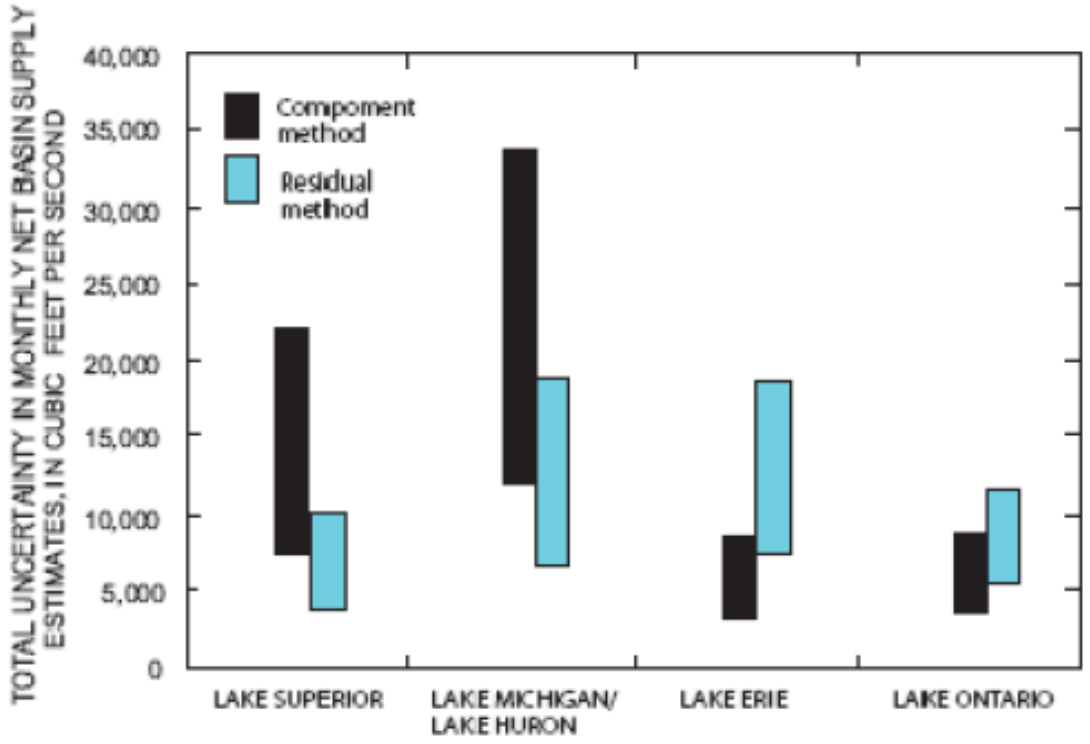


Hydrologic Projections



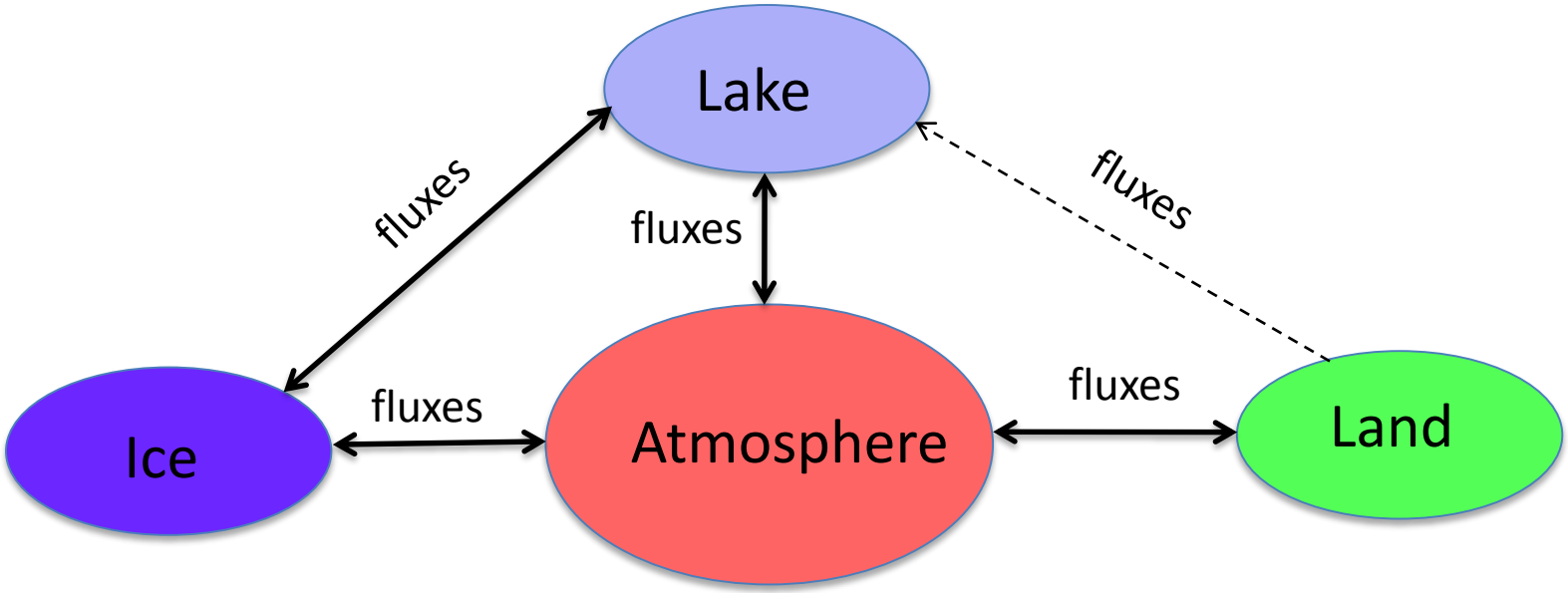
Gyawali et al. (2014a)

Uncertainty in Net Basin Supplies



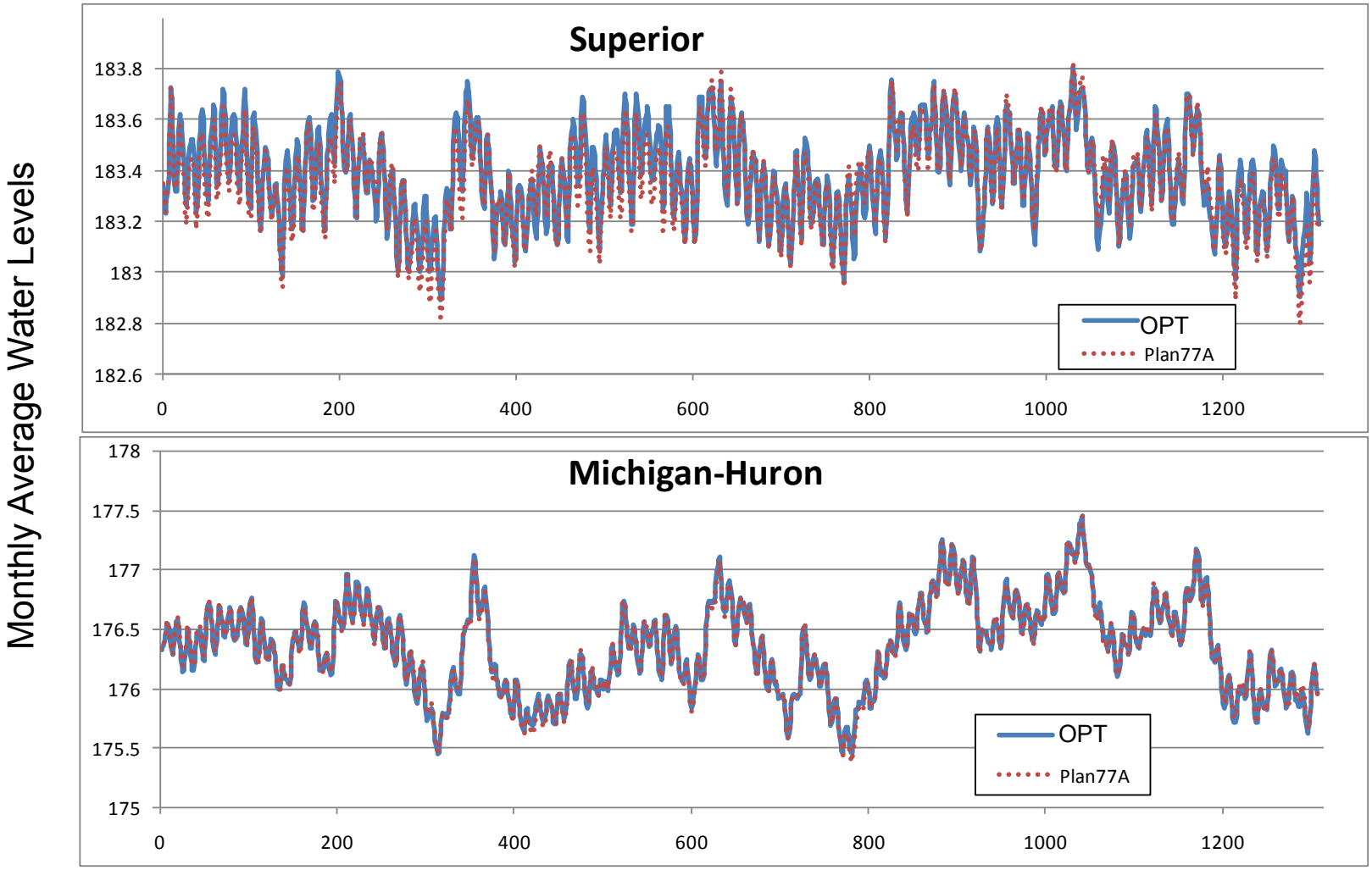
Uncertainty in net basin supply using component and residual methods. (Neff and Nicholas, 2005)

Coupled Atmosphere-Surface Modeling

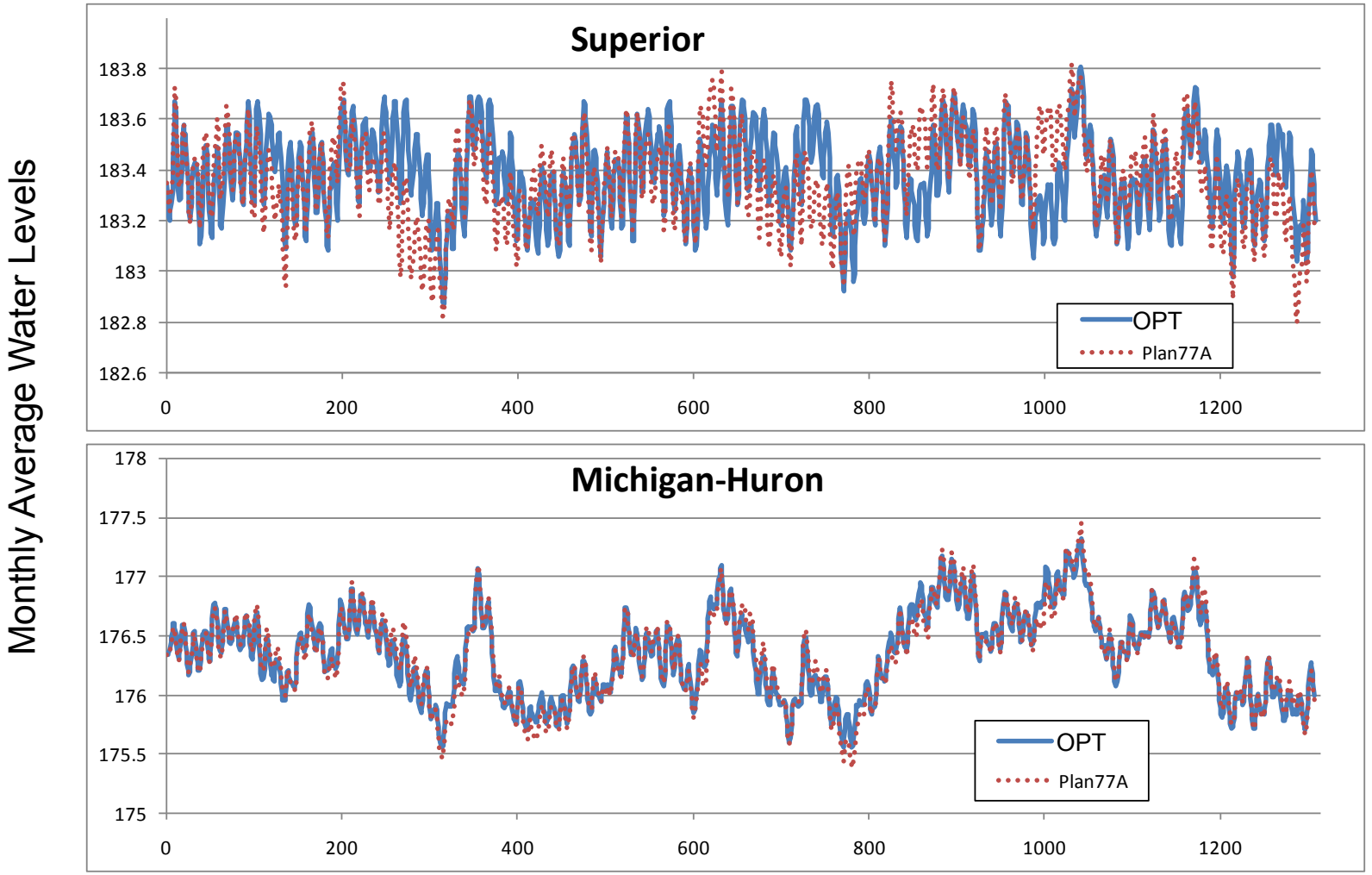


- The understanding that air temperature *causes* evapotranspiration has prevailed in the past.
- Coupled atmosphere-surface modeling recognizes energy constraints and feedbacks. - Lofgren (2010)

Robust Lake Regulation Plan



Potential Value of Seasonal Forecasts



References

- Croley, T.E.,II. " Great Lakes Large Basin Runoff Model." P*roceedings, Second Federal Interagency Hydrologic Conference*, Las Vegas, NV, July 28-Aug. 1, 2002.
- Falcone, J. (2012). GAGES-II: Geospatial Attributes of Gages for Evaluating Streamflow. NSDI Node. U.S. Geological Survey, Reston, Virginia.
- Gyawali, R., D.W. Watkins Jr., V.W. Griffis, B.F. Lofgren (2014a). "Energy budget considerations for hydro-climatic impact assessment in Great Lakes watersheds," *Journal of Great Lakes Research*, doi: 10.1016/j.jglr.2014.09.005.
- Gyawali R., V.W. Griffis, D.W. Watkins Jr., N.M. Fennessey (2014b). "Regional regression models for hydro-climate change impact assessment," *Hydrol. Process*es, doi: 10.1002/hyp.10312.
- Lofgren, B.M. (2010). GLERL review presentation (http://www.glerl.noaa.gov/review/presentations/lofgren.pdf) , accessed May 11, 2011
- Neff, B.P., J.R. Nicholas (2005). Uncertainty in the Great Lakes Water Balance, U.S. Geological Survey Scientific Investigations Report 2004-5100, 42 p. (http://pubs.water.usgs.gov/sir2004-5100/)
- U.S. Army Corps of Engineers (USACE) (2010).*Hydrologic Modeling System User's Manual*, (http://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Users_Manual_3.5.pdf), accessed 15 March 2012.
- Wilby, R.L., C.W. Dawson (2004). SDSM User Manual, (http://unfccc.int/resource/cd_roms/na1/v_and_a/Resoursce_materials/Climate/SDSM/SDSM.Manual.pdf, accessed May 11, 2011.


Questions?