On the Phosphorous Loading Estimation to Lake Champlain

Emily Wiggans, University of Vermont

Advisor, Dr. Ibrahim Mohammed

RACC Research on Adaptation to Climate Change

VERMONT EPSCoR

Vermont EPSCoR CWDD Center for Workforce Development & Diversity AT SAINT MICHAEL'S COLLEGE

NSF

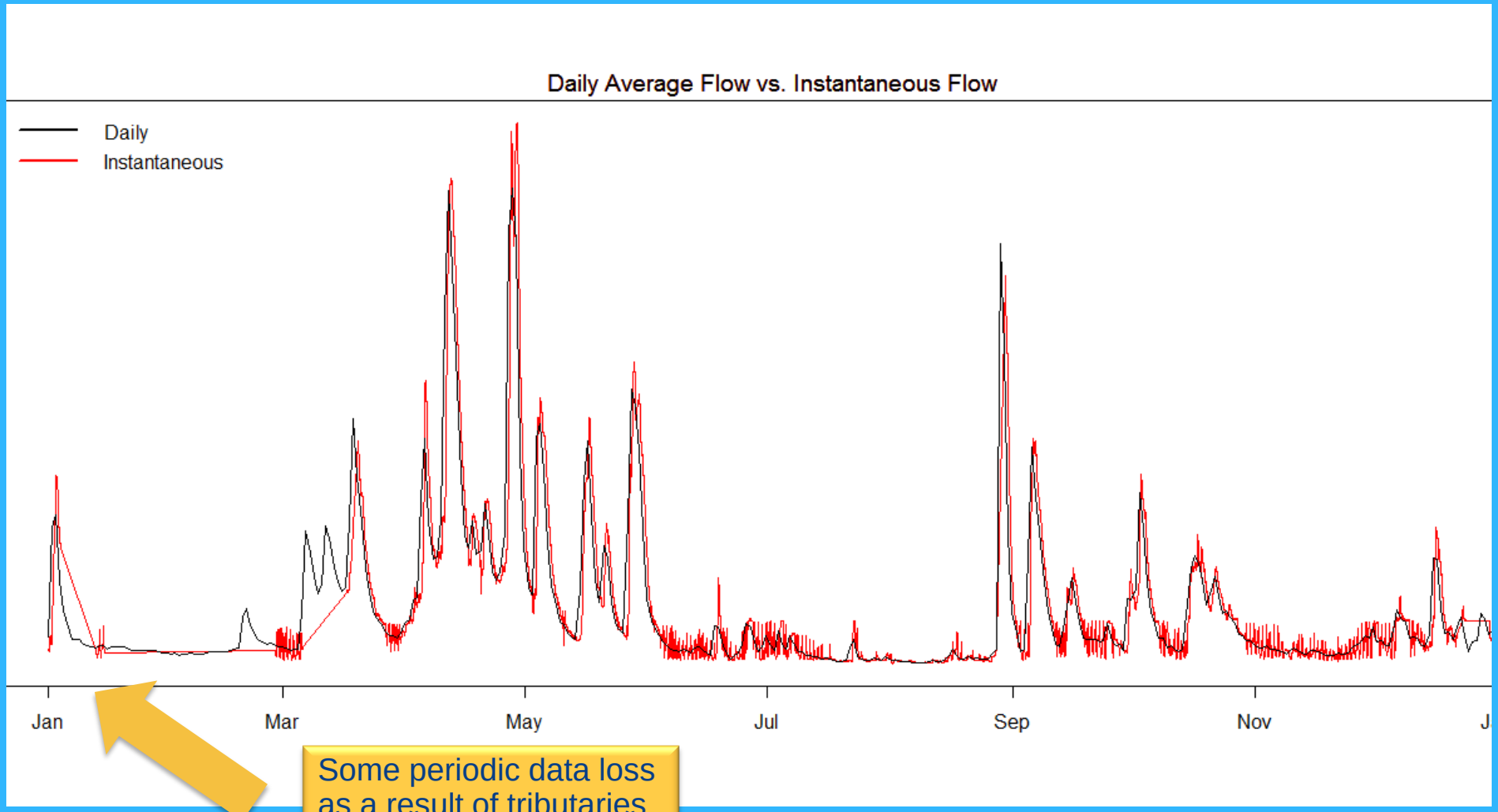
Introduction

- Lake Champlain is plagued by an excessive influx of nutrients
  - Non-point sources: agriculture and urban development upstream of lake basin
  - Point source: waste water treatment plants
- Established correlation between higher concentrations of phosphorus and harmful blue-green (cyanobacteria) algal blooms in Lake Champlain
  - Phosphorus is limiting nutrient in freshwater ecosystems
- Study of phosphorus loading to the lake is a key element to promote a healthy lake, as well as good living conditions for those that inhabit the Lake Champlain Basin

Current System vs. “New” Way

- Current phosphorus loading calculation:
  - Correlating *average* daily flow rates at tributary USGS gages with periodically (1-2/month) taken in situ total phosphorus concentrations
- Improved phosphorus loading calculation:
  - Use the more sensitive *instantaneous* flow at the time the phosphorus concentration was sampled and produce a regression
- Why?
  - River flow changes throughout the day: rain in the afternoon means it will be flowing faster than it was in the morning

Missisquoi Example:

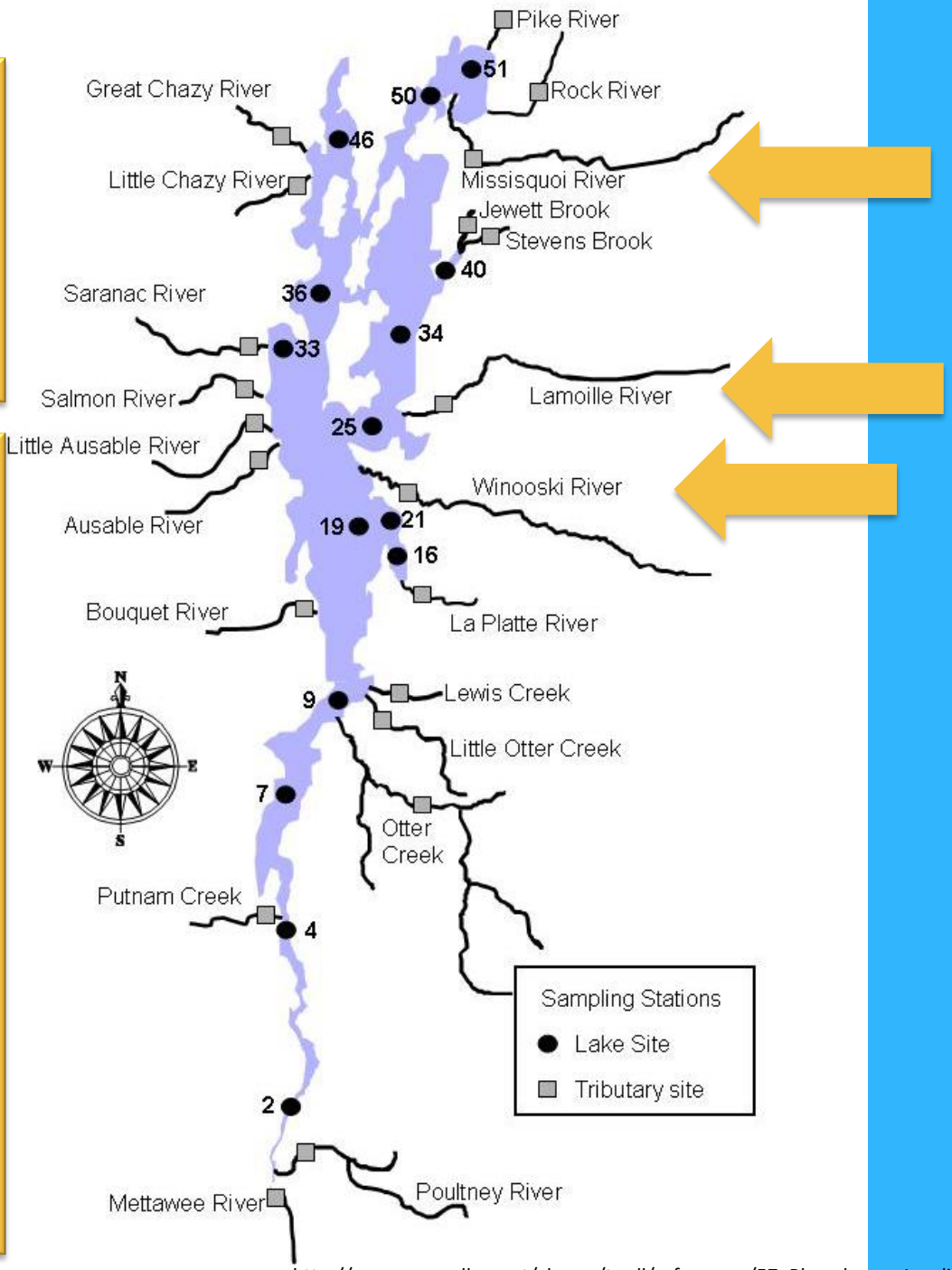


Some periodic data loss as a result of tributaries freezing

Objectives

- Examine past efforts to quantify phosphorus loading
- Propose a different, more flow-sensitive method for determining stream flow and total phosphorus correlation
- Determine new estimates for yearly phosphorus loading to Lake Champlain via three large Vermont tributaries

- Tributary phosphorus measurement sites at same location as USGS gages
- Winooski, Lamoille, and Missisquoi were the focus tributaries based on watershed size and surrounding land use, notably agriculture and cities/towns: Burlington, Milton/Jeffersonville, and St. Albans, respectively



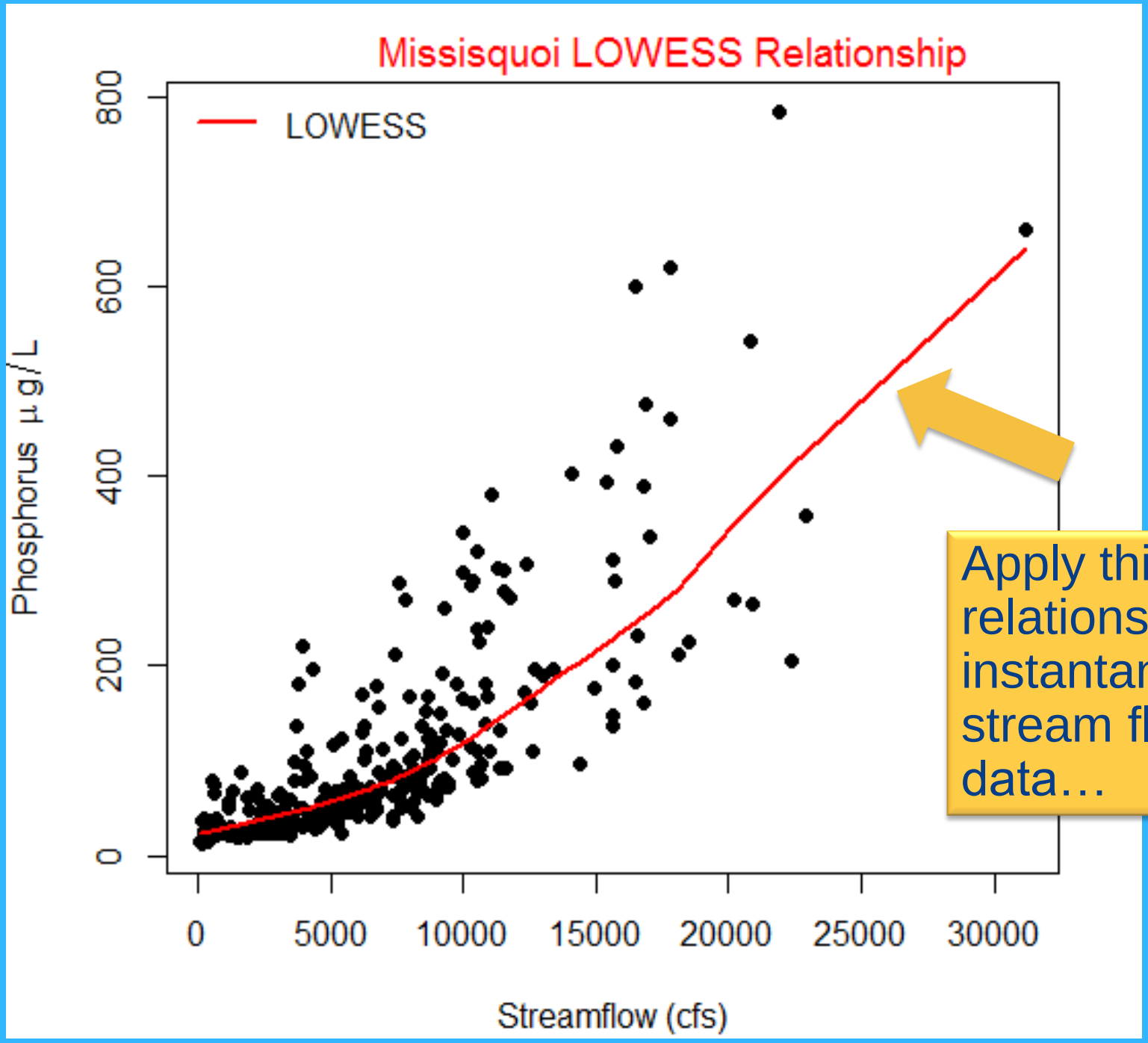
http://www.wwwalker.net/champ/tmdl/references/57_Phosphorus_Loading_1990-2008.pdf

Methods

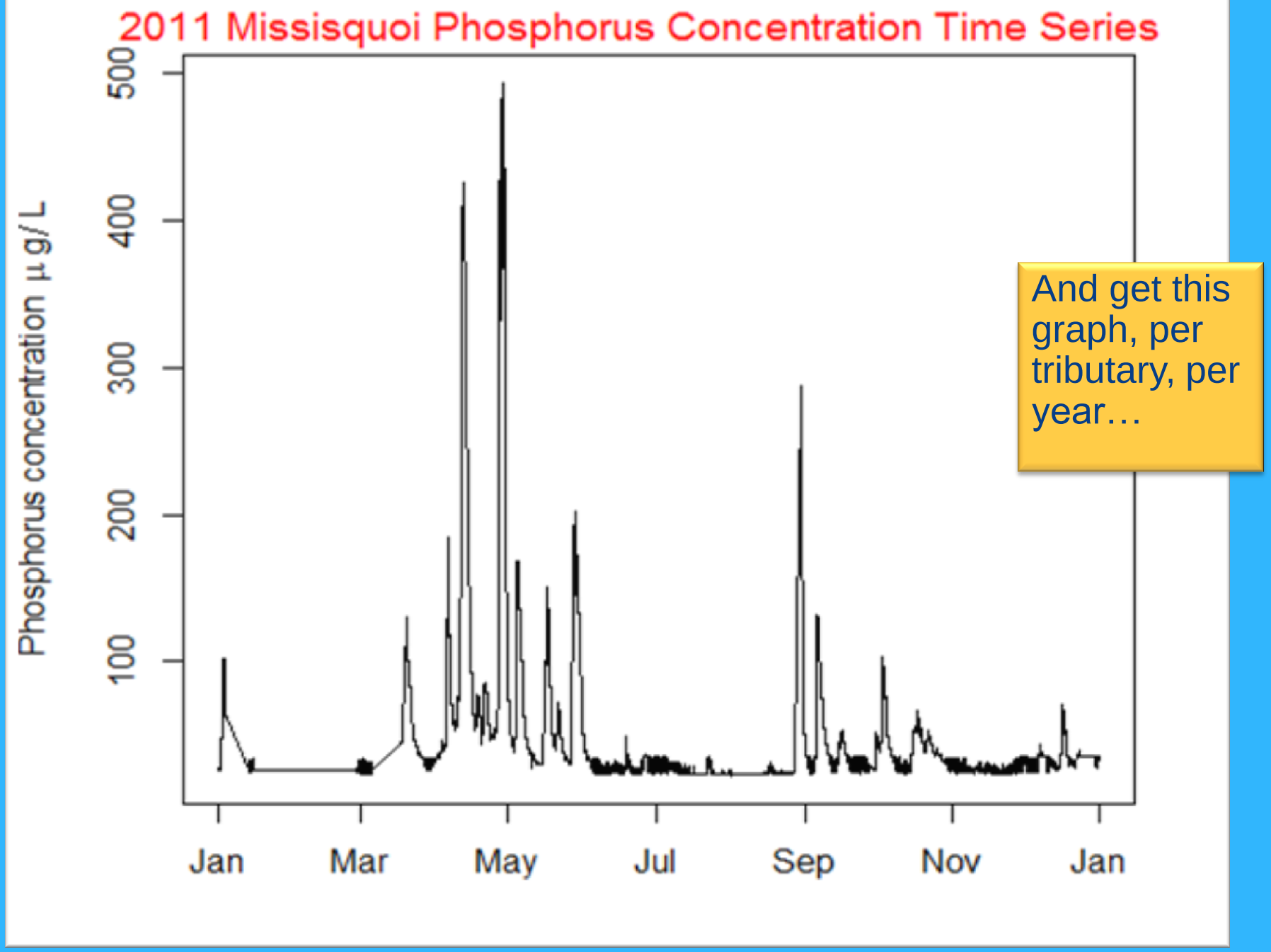
1. Acquire instantaneous, 15 minute interval, stream flow data from USGS from 1990 (initiation of gages) to as current as possible (2013) for each tributary
2. Acquire in situ total phosphorus data from the Vermont Agency of Natural Resources
3. Use R to process data and create a LOWESS (local weighted regression) relationship between phosphorus concentrations and instantaneous stream flow times for each tributary between 1990-2013
4. Apply LOWESS relationship to all instantaneous stream flow values
5. Calculate total yearly phosphorus loads for each tributary

VERMONT
AGENCY OF NATURAL RESOURCES

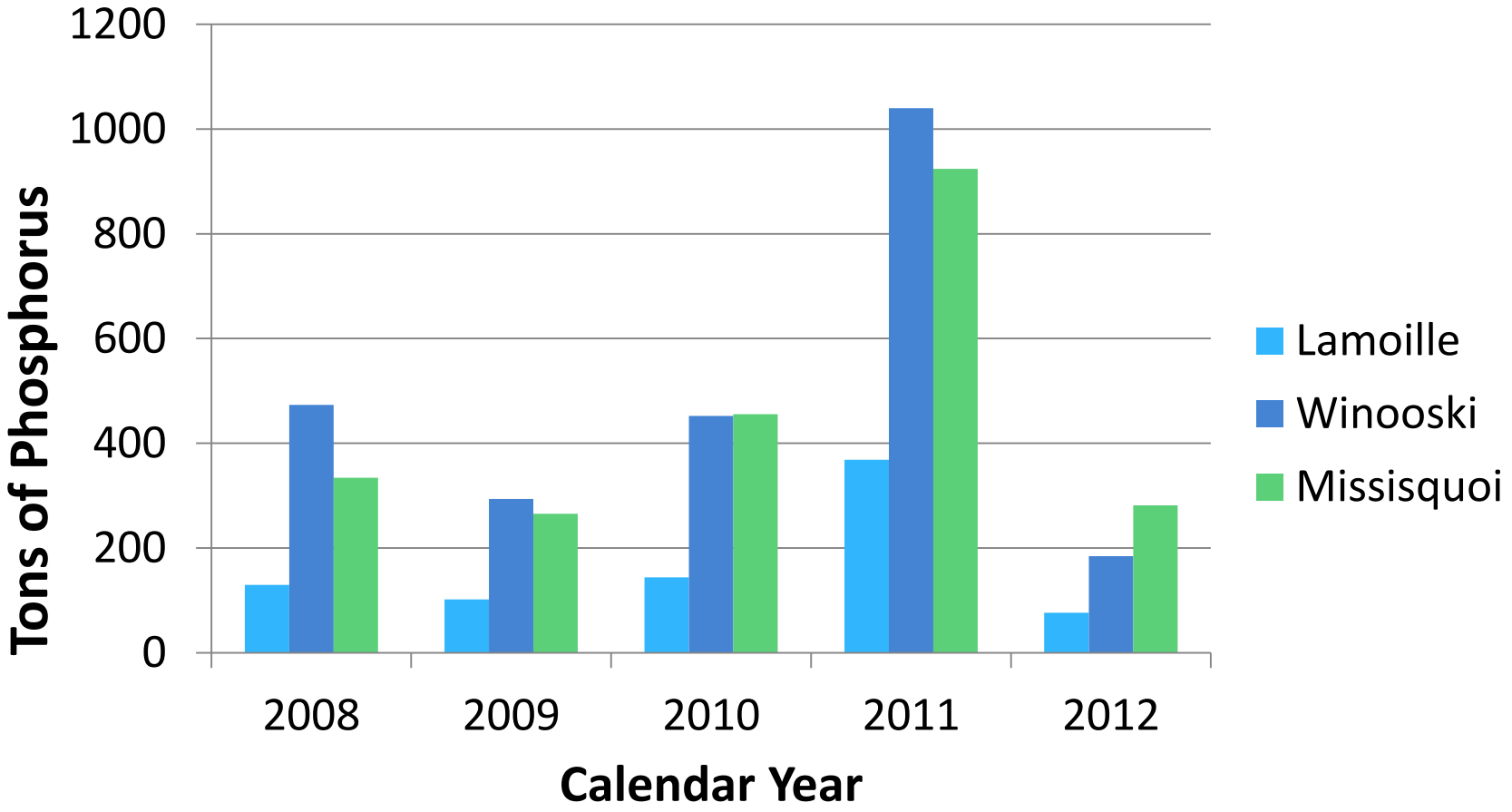
USGS
science for a changing world



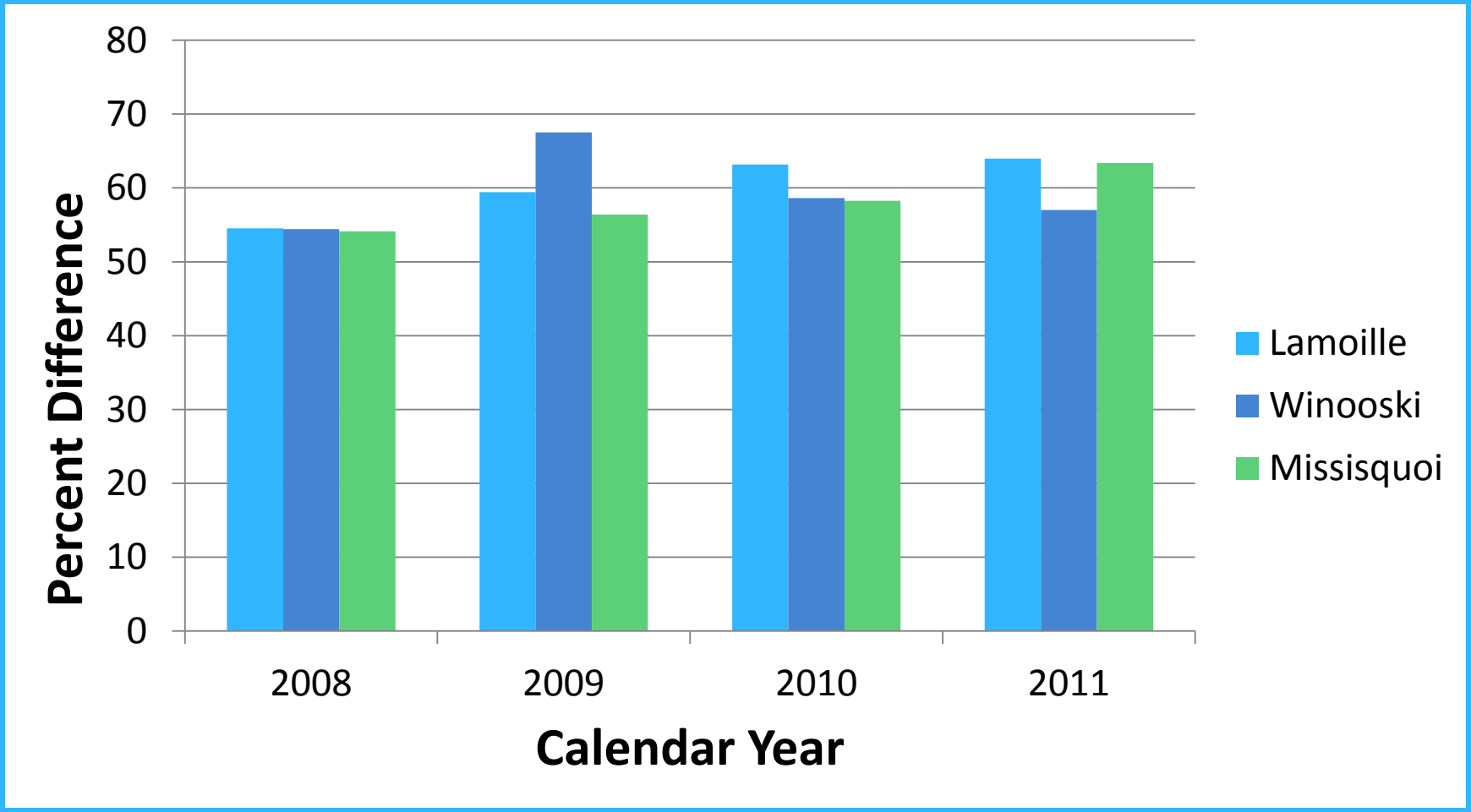
Apply this relationship to instantaneous stream flow data…


2011 Missisquoi Phosphorus Concentration Time Series
Phosphorus concentration µg/L
100
200
300
400
500
Jan
Mar
May
Jul
Sep
Nov
Jan
And get this graph, per tributary, per year…

Results – Total Phosphorus Loads



Results – Percent Difference vs. Medalie 2013



What It Means

- Average percent difference: 59%!
  - Different/improved methodology shows significantly higher phosphorus loads than Medalie's data
- Different/improved methodology can be used as conservative upper limit for phosphorus loading

Conclusions and Future Work

- There may be more phosphorus entering Lake Champlain than previously thought
- Potential future work:
  - Continue process for all significant lake tributaries for which there is phosphorus data and a USGS stream gage,
  - Determine if percent differences vs. Medalie are similar for other tributaries
  - More work to be done to asses sensitivity of instantaneous flow data vs. daily average flow
- Different/improved methodology is essential to the study of Lake Champlain; further research should be pursued to determine the most accurate method of calculating yearly phosphorus loads and to better understand how phosphorus enters the lake

References

- Levine, S. N., A. d. Shambaugh, S. E. Pomeroy, and M. Braner (1997), Phosphorus, Nitrogen, and Silica as Controls on Phytoplankton Biomass and Species Composition in Lake Champlain (USA-Canada), *Journal of Great Lakes Research*, *23*(2), 131-148.
- Medalie, Laura, 2013. Concentration, flux, and the analysis of trends of total and dissolved phosphorus, total nitrogen, and chloride in 18 tributaries to Lake Champlain, Vermont and New York, 1990–2011: *U.S. Geological Survey Scientific Investigations Report* 2013–5021.
- Smeltzer, E., F. Dunlap, and M. Simoneau. 2009. Lake Champlain Phosphorus Concentrations and Loading Rates, 1990–2008. Technical Report No. 57. Lake Champlain Basin Program, Grand Isle, VT.
- Smeltzer, E., A. d. Shambaugh, and P. Stangel 2012. Environmental change in Lake Champlain revealed by long-term monitoring, *Journal of Great Lakes Research*, *38, Supplement 1*(0), 6-18.
- Weller, C., M. Watzin, and D. Wang (1996), Role of wetlands in reducing phosphorus loading to surface water in eight watersheds in the Lake Champlain Basin, *Environmental Management*, *20*(5), 731-739.

Acknowledgements

- Thanks to the the VT EPSCoR Research on Adaptation to Climate Change program and UVM for this fantastic research opportunity.
- Thanks to Dr. Mohammed for his essential guidance and many patient answers to all of my questions and inquiries!

Questions?