

# Assessing Climate Change Impacts on Mosquito Abundance Associated with West Nile Virus Risks in Ontario

Yuehua (Tony) Liu, Center of Global Change Sciences and Leslie Dan Faculty of Pharmacy, University of Toronto  
Jing Chen, Center of Global Change Sciences and Department of Geography, University of Toronto  
Huaiping Zhu, Laboratory of Mathematical Parallel Systems, Department of Mathematics and Statistics, York University

## Abstract

The latest Inter-government Panel for Climate Change (IPCC) 5<sup>th</sup> Assessment Report (AR5) provided more confidence that climate has been changing and will continue to change. Weather/climate variations affect mosquito populations. Mosquito abundance is a key risk factor in outbreak and spread of vector-borne diseases such as West Nile Virus (WNV). The primary objective of this study is to explore how future mosquito abundance would evolve under the changing climate in Ontario, Canada. This is the first-of-its-kind study on mosquito abundance predictive model development at monthly-temporal and provincial-spatial scales in Ontario. First, relations between climate indicators, temperature and precipitation, and *Culex pipiens* L. and *Culex restuans* mosquito abundance was investigated in each of the 36 public health units of Ontario, Canada, using the best available 2002-2012 mosquito abundance data. Predictive statistical models for monthly mosquito population were developed based on monthly averages of temperature, precipitation and mosquito counts from 2002 to 2011; and then validated using surveillance data in 2012. Results showed that monthly mosquito abundance could be predicted with reasonable accuracy from monthly mean temperature, one-month lagged temperature, precipitation, one-month and two-month lagged precipitation. These constructed models and biological thresholds were used to project the potential spatial and temporal distribution of mosquito abundance over the entire Province of Ontario as well as in its 36 PHUs under a range of potential future climate and habitat conditions. Three time periods were selected to represent future climate conditions, i.e., 2030s (2015–2045), 2050s (2035–2065) and 2080s (2065–2095). Under the potential future climate changes, the developed models projected a general increasing trend in mosquito abundance over almost the entire province with obvious northward spatial expansion, as well as temporal expansion, i.e., longer mosquito seasons. This indicates potentially increased risks of WNV and more intensive mosquito monitoring and controlling measures would be needed in Ontario considering future climate change.

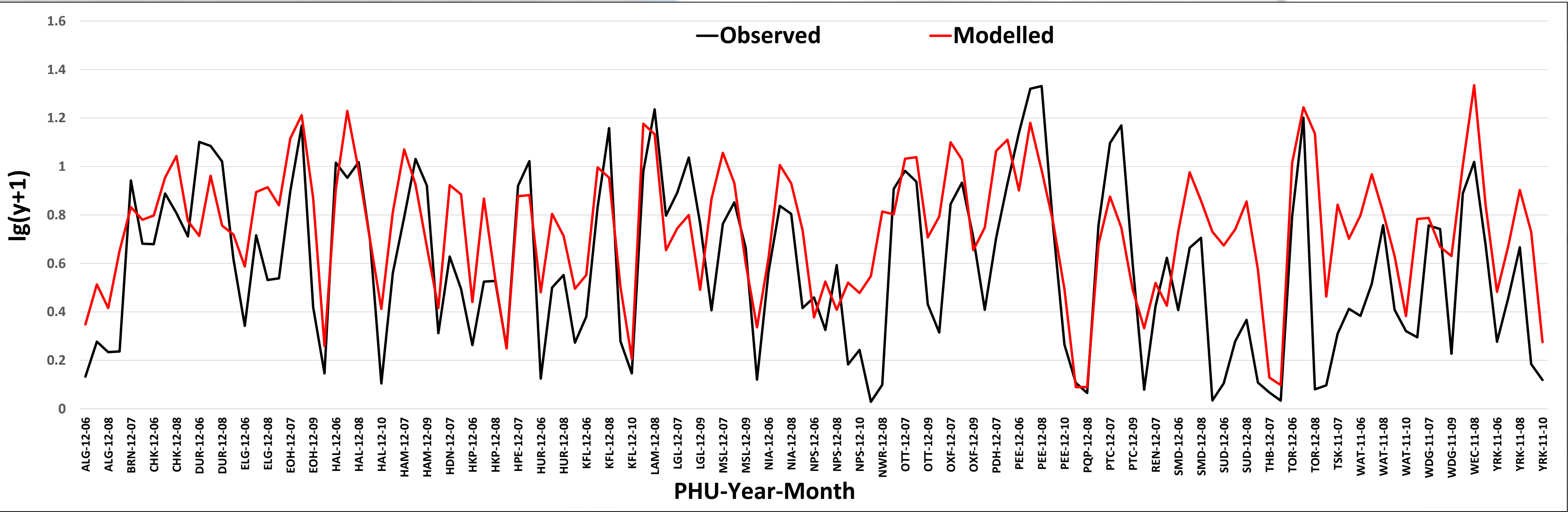
## Model Development and Validations

Predictive statistical models for monthly mosquito population were developed based on monthly averages of temperature, precipitation and mosquito counts from 2002-2011; and then validated using surveillance data in 2012. Results showed that monthly mosquito abundance (y) could be predicted with reasonable accuracy from monthly mean temperature (T), one-month lagged temperature (T<sub>1</sub>), precipitation (P), one-month (P<sub>1</sub>) and two-month (P<sub>2</sub>) lagged precipitation. The following is an example of the developed model at the GBO PHU.

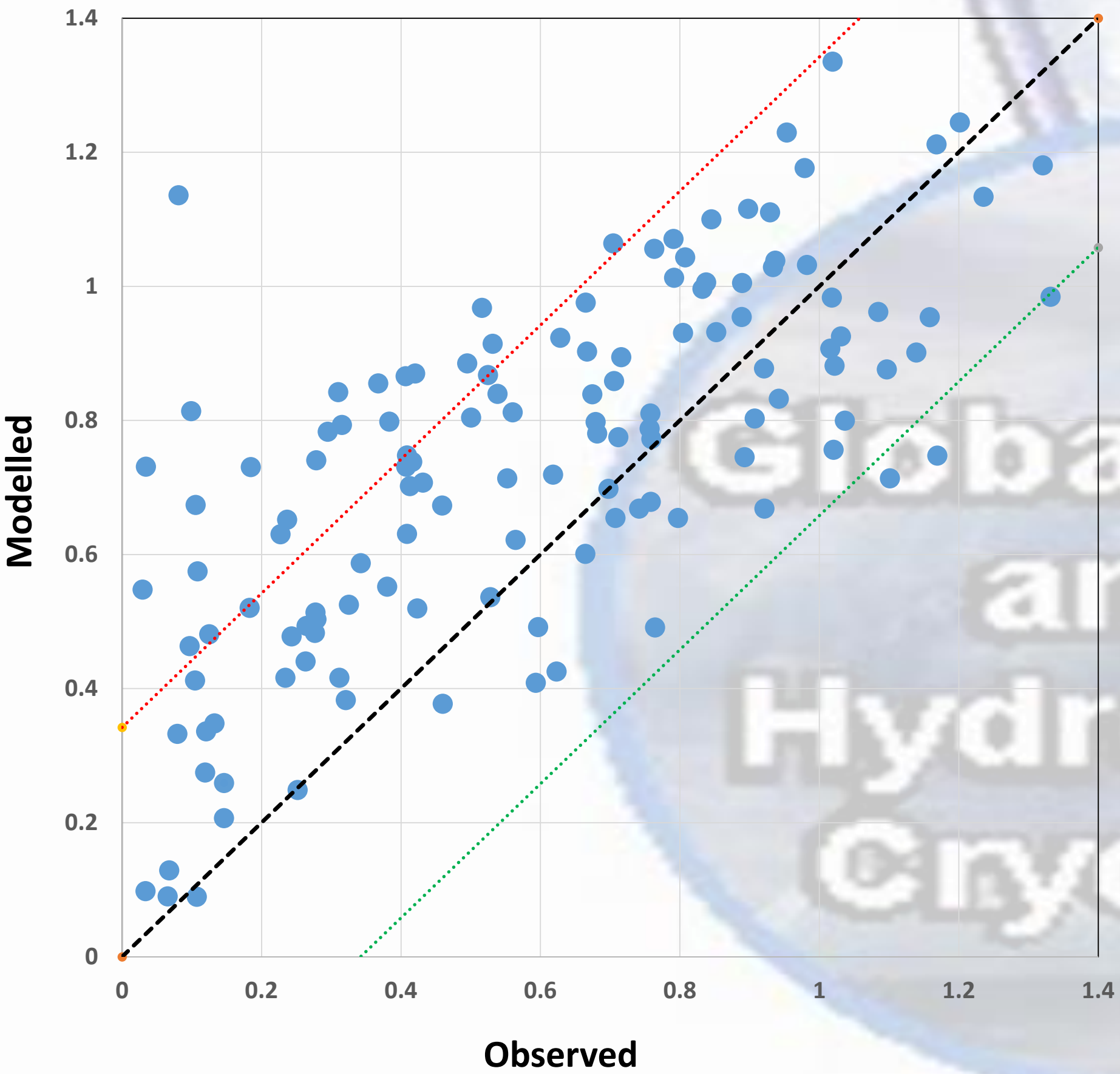
$$lg(y+1) = -0.5868 - 0.00116T_1 + 0.088872T + 0.000148P_2 - 0.00145P_1 - 0.0044P$$

## Modelled vs Observed Mosquito Abundances in the Last Year Across Ontario

The model can replicate the pattern very well with discrepancies in magnitude.

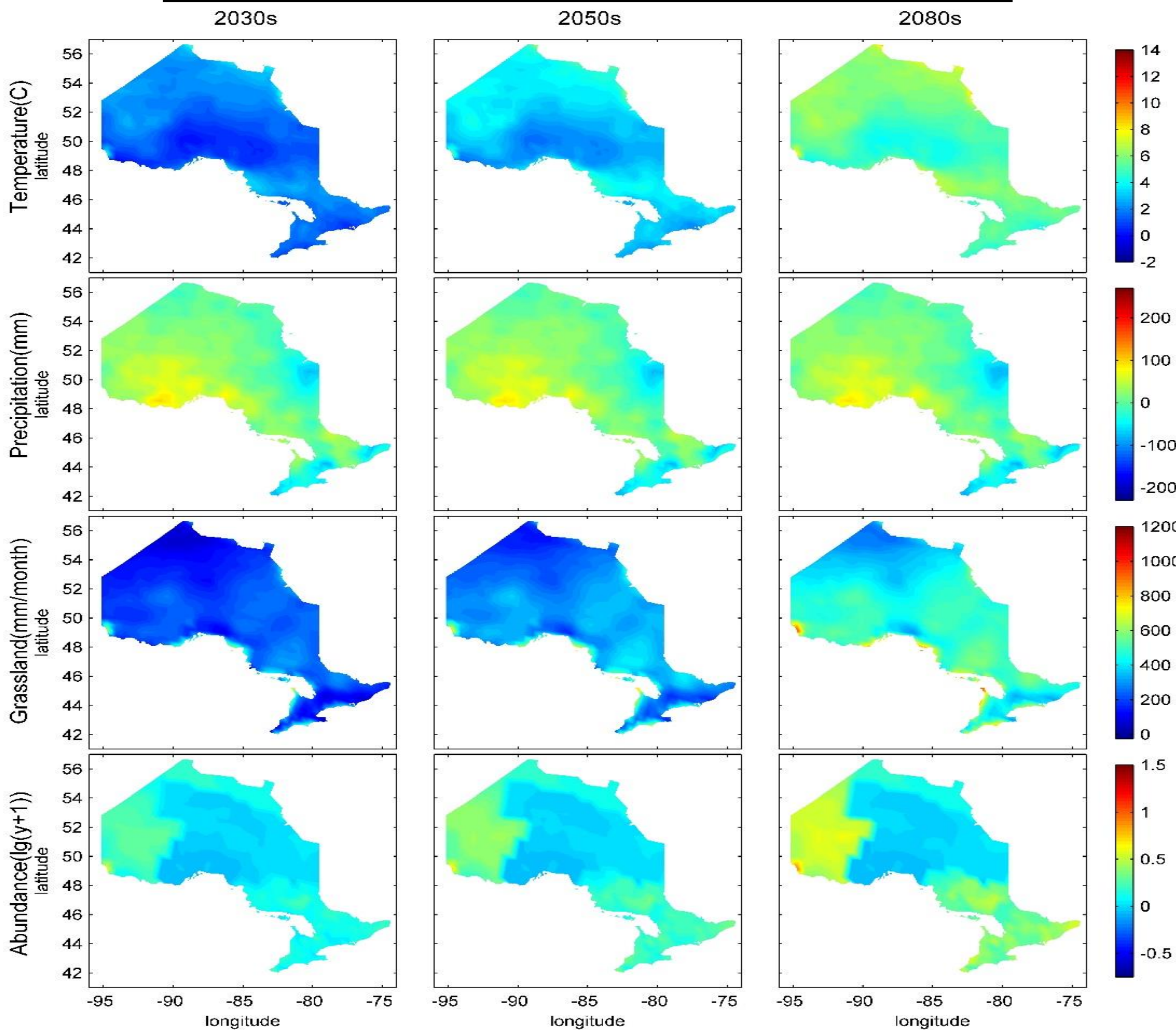


## Q-Q Plot of Modelled vs Observed Mosquito Abundances



- Majority of points lie within 1 standard deviation of the y=x line
- The model tends to slightly overestimate mosquito abundance
- However, the models behavior better at high abundance than lower abundance;
- Model bias should not matter when looking at relative changes between future and current model results because model bias will be cancelled out.
- Calculated root mean squared error (RMSE) over the entire province is 0.28.

## Projected Spatial Distribution of Changes in Abundance Indicates Potential Northward Expansion of Mosquito Habitats over Ontario.



## Projected Temporal Distribution of Changes in Abundance Indicates Potential Expansions of Mosquito Seasons in Ontario (dotted rectangles).

