Environmental Modeling of Mosquito Population Dynamics: A Comparison of AMSR-E and Ground-Based Measurements

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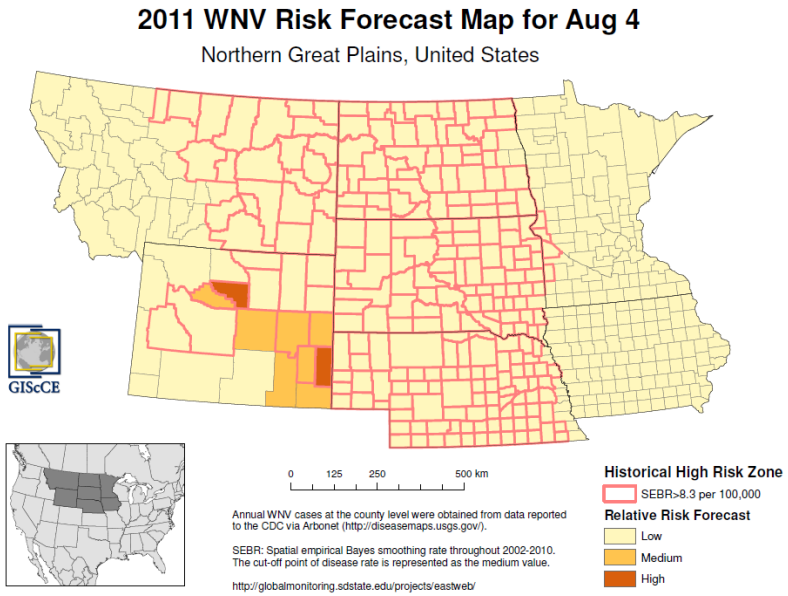
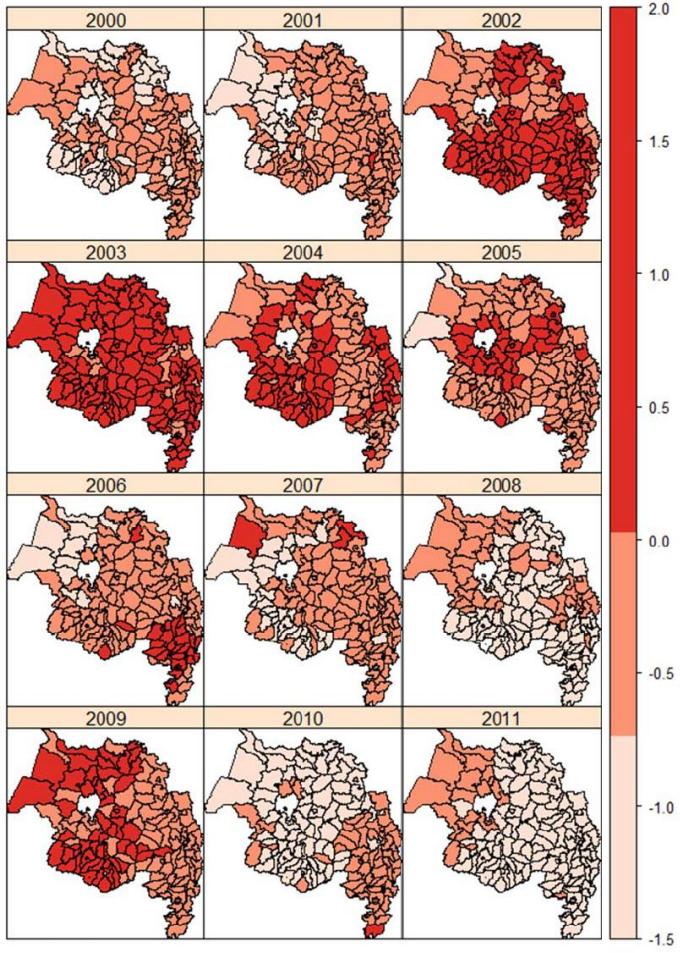
Early Warning Systems for Mosquito-Borne Diseases

- Epidemic malaria – Amhara region of Ethiopia
- West Nile virus – northern Great Plains





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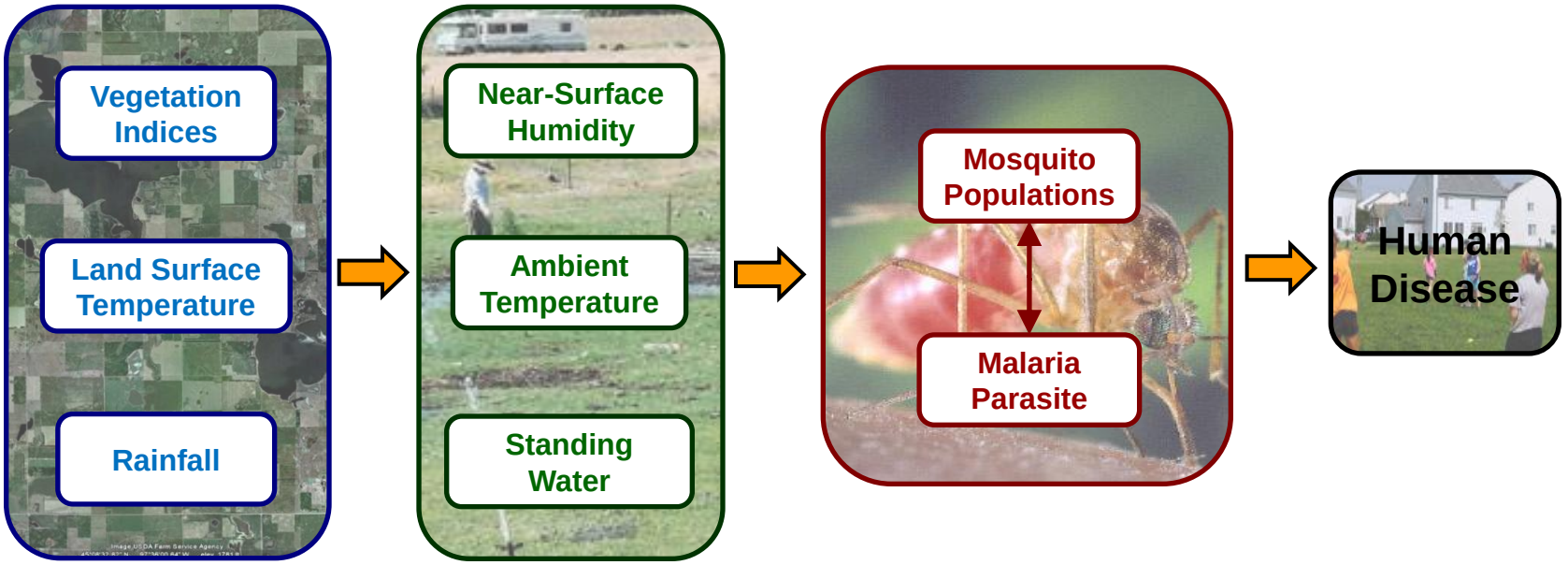
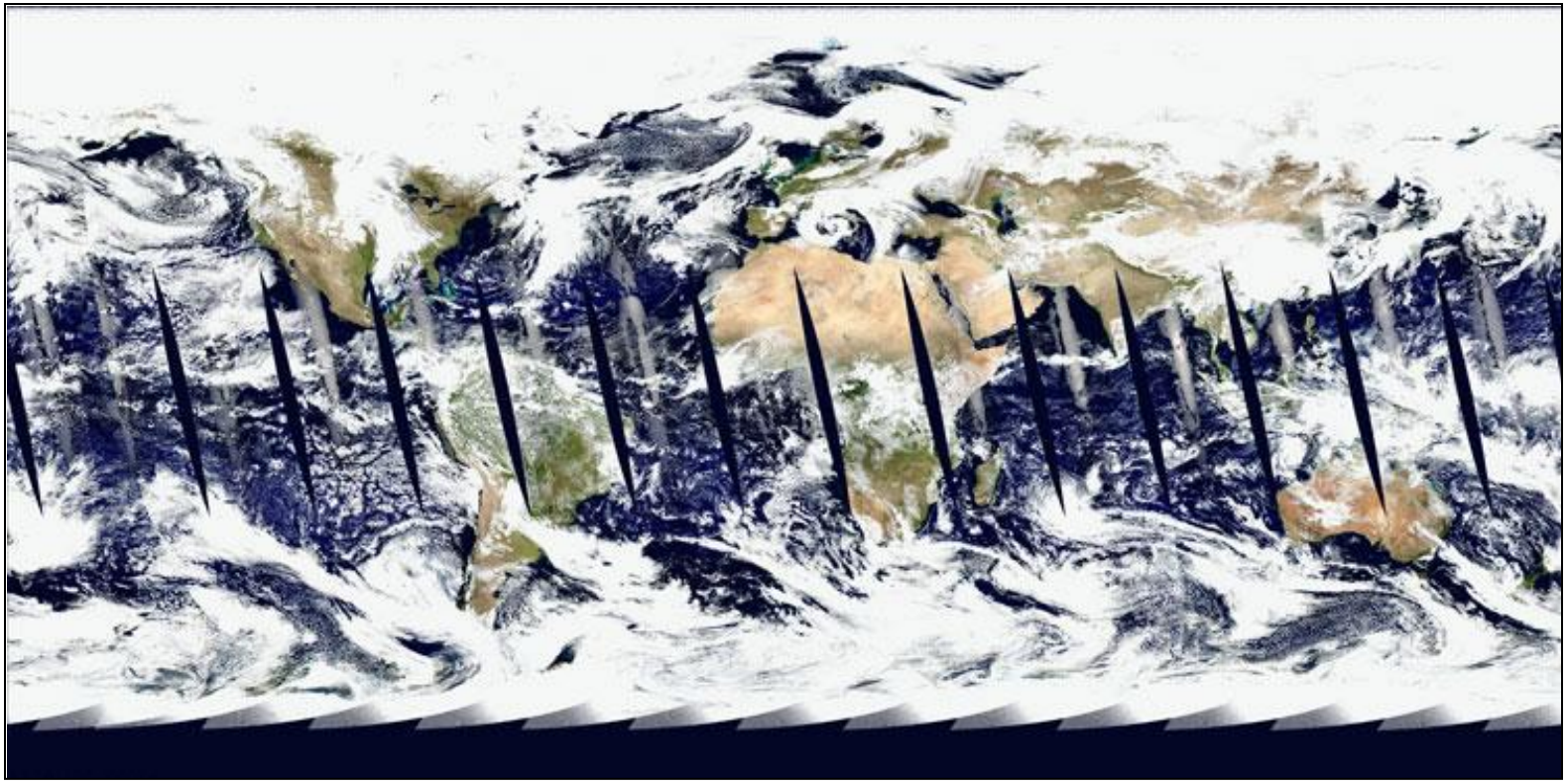
Limitations of Remotely-Sensed Environmental Indices

- MODIS Vegetation Indices
- MODIS Land Surface Temperature
- TRMM Rainfall

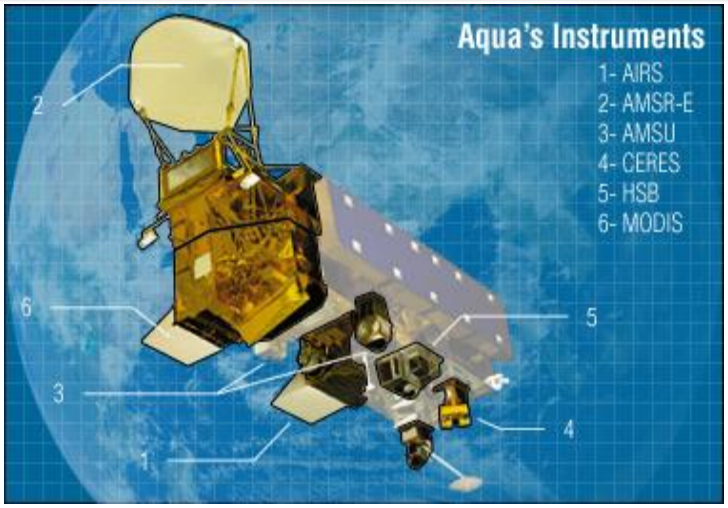


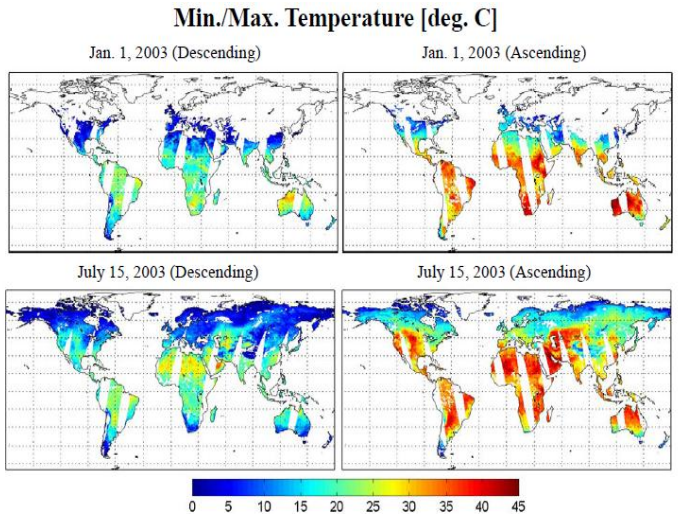
Other Challenges – Clouds, Atmosphere



The Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E)

- AMSR-E is the total power passive microwave radiometer system on the Aqua Satellite (launched in 2002) which detects Earth-emitted microwave radiation
- The long wavelength of microwaves can penetrate through cloud, haze, and dust
- Global daily land surface parameters derived from AMSR-E (AE_L2A swath product, V3)
  - Near-surface air temperature
  - Soil moisture
  - Water fraction
  - Vegetation index
- Temporal resolution: Daily
- Spatial resolution: 0.25 degree ~(25 KM)





NASA Earth Science Applications Feasibility Study

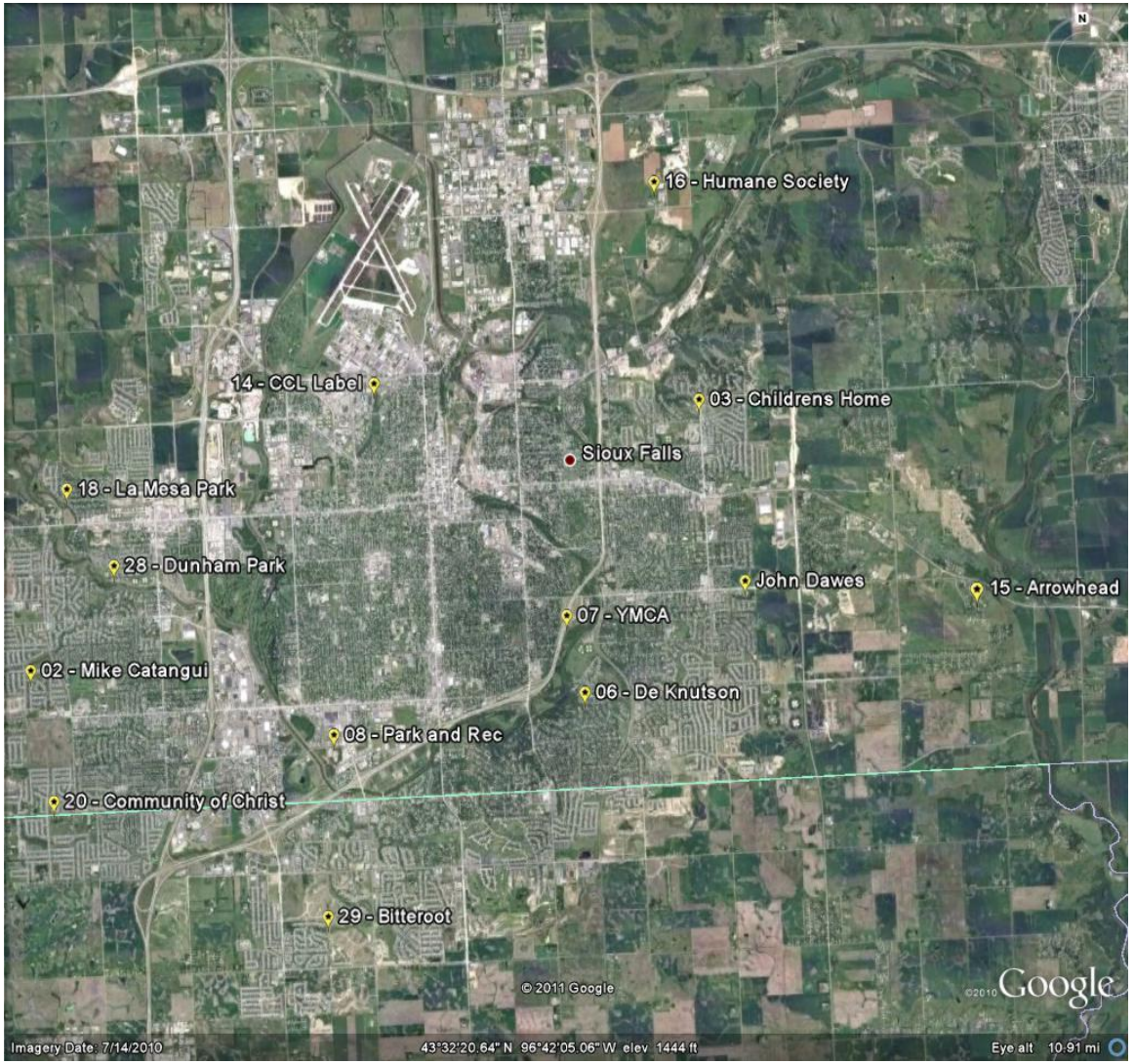
- **Enhanced Forecasting of Mosquito-Borne Disease Outbreaks Using AMSR-E**
  - Develop models of mosquito population dynamics and WNV incidence using environmental parameters derived from AMSR-E.
  - Compare the performance of the AMSR-E driven models with models derived from other environmental data sources.
  - Generate WNV risk forecasts from models based on AMSR-E variables, disseminate these predictions to public health practitioners, and obtain feedback on the value and utility of these predictions.

Objectives of the Current Presentation

- The environmental variables derived from the advanced microwave scanning radiometer-earth observing system (AMSR-E) and weather stations were compared to model the population dynamics of *Culex tarsalis* and *Aedes vexans* in Sioux Falls, SD from 2005-2009
- These initial models will provide an initial framework for developing AMSR-E based decision support tools for public health workers to enhance their efficiency on vector-borne disease surveillance and prevention

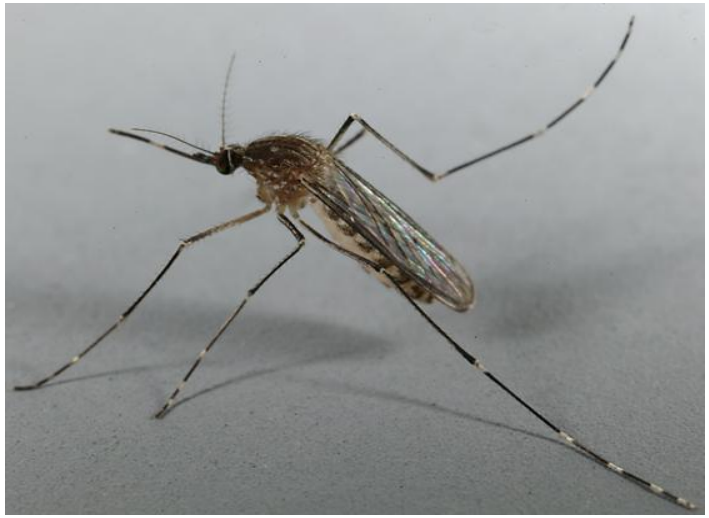
Study Location—Sioux Falls, South Dakota

- The largest city in South Dakota, population 157,935
- Urban/Suburban landscape
- Surrounded by cultivated croplands, pastures, and hayfields
- Sioux Falls Health Department monitors annual mosquito population regularly for mosquito control and disease surveillance



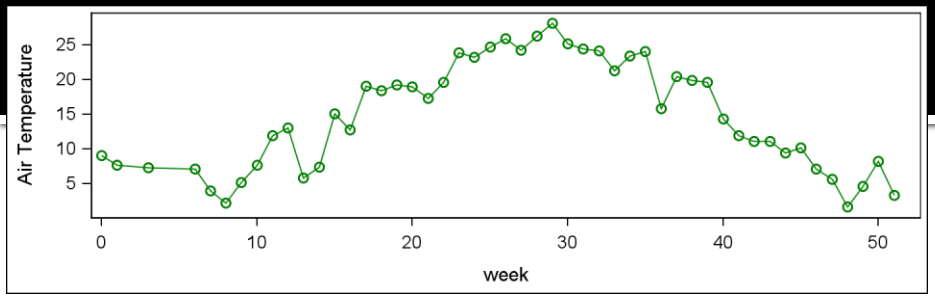
Study Design—Data Collection

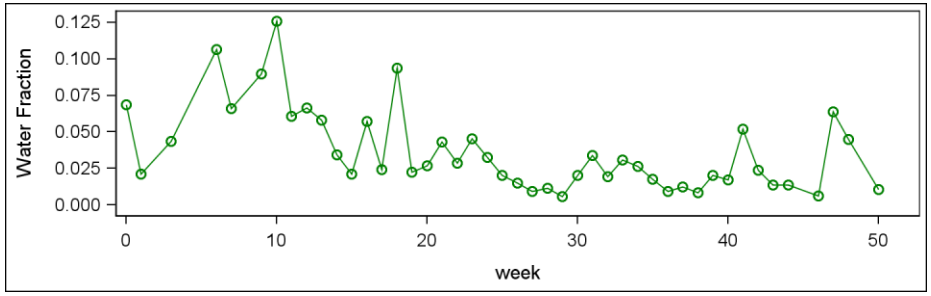
- Two major mosquito species in were analyzed
  - ***Culex tarsalis*— the key vector of West Nile virus (WNV) transmission in the Northern Great Plains**
  - ***Aedes vexans*—the dominant nuisance mosquito, also a potential WNV vector**
- Ground-based weather data was collected and averaged from three weather stations in Sioux Falls
  - **Daily average temperature, precipitation, and relative humidity**
- Environmental variables derived from AMSR-E were summarized within Sioux Falls study areas
  - **Daily air temperature, water fraction, soil moisture, and vegetation index**
- All variables were summarized to weekly averages

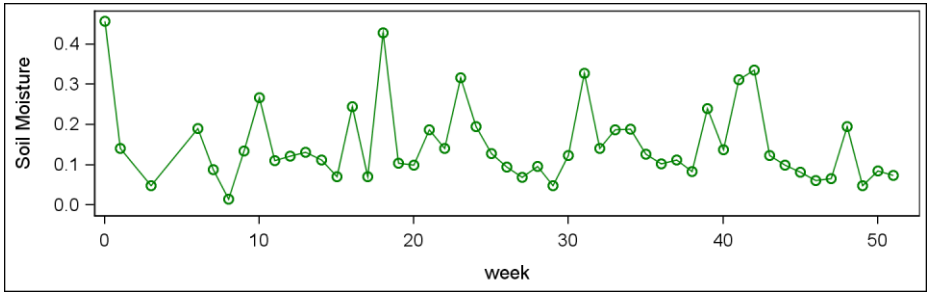


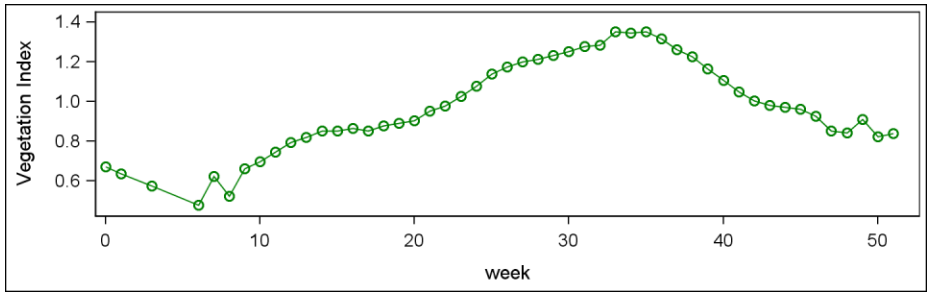
AMSR-E

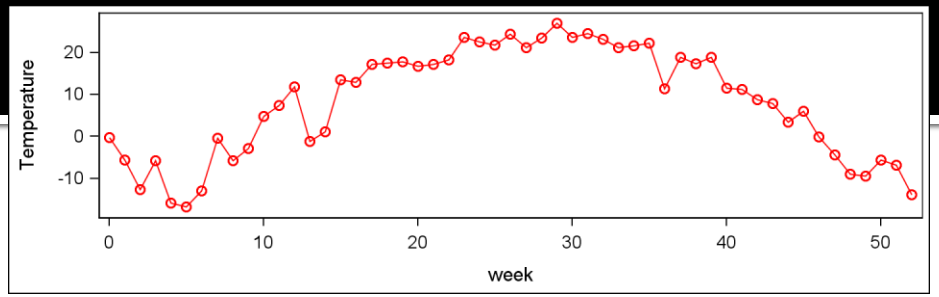
Weather Station

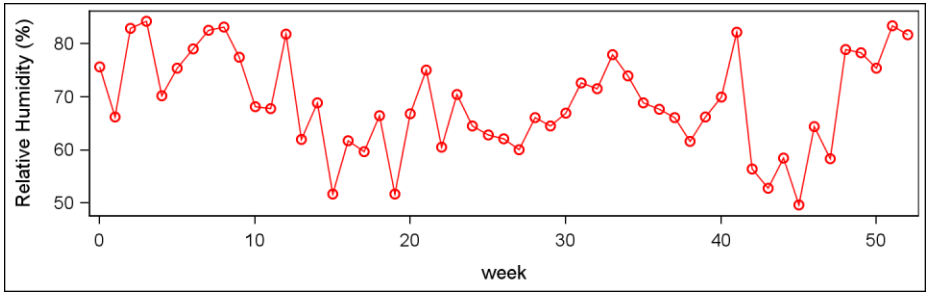


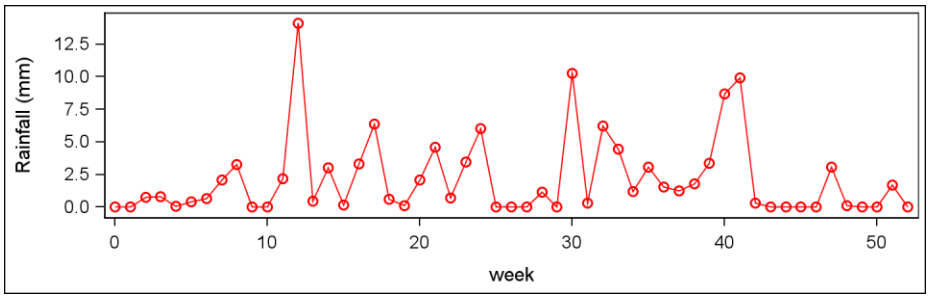










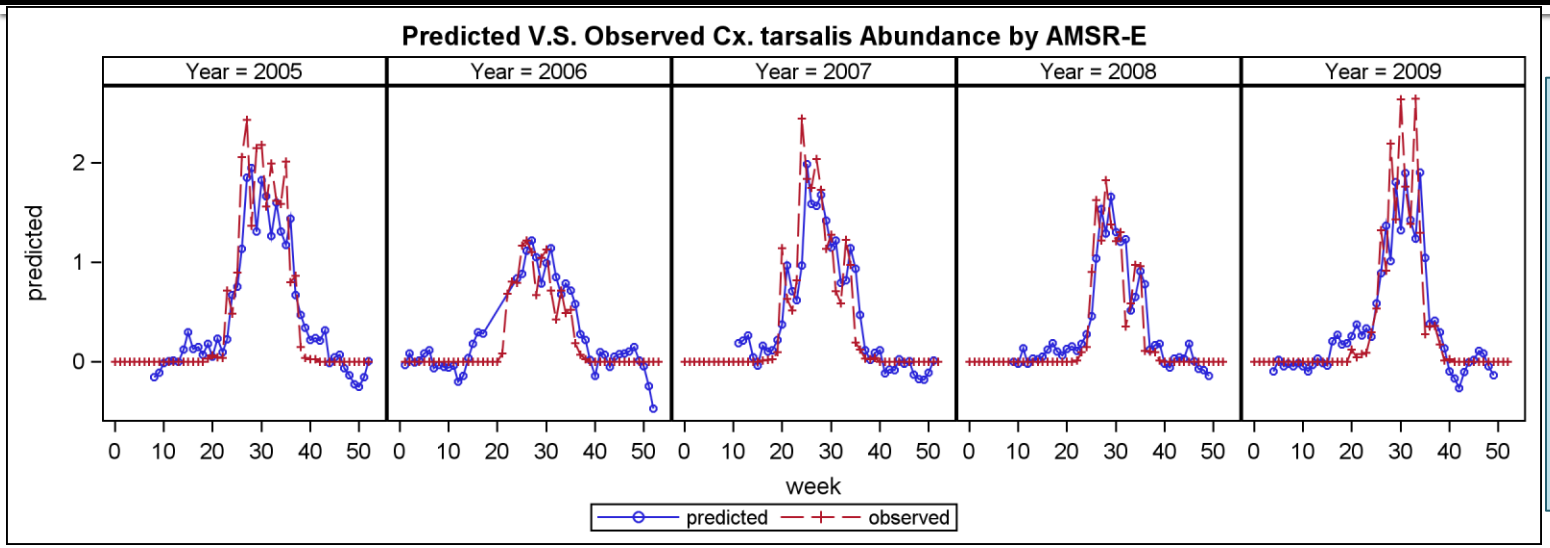


Environmental measurements in 2007

Study Design—Data Analysis

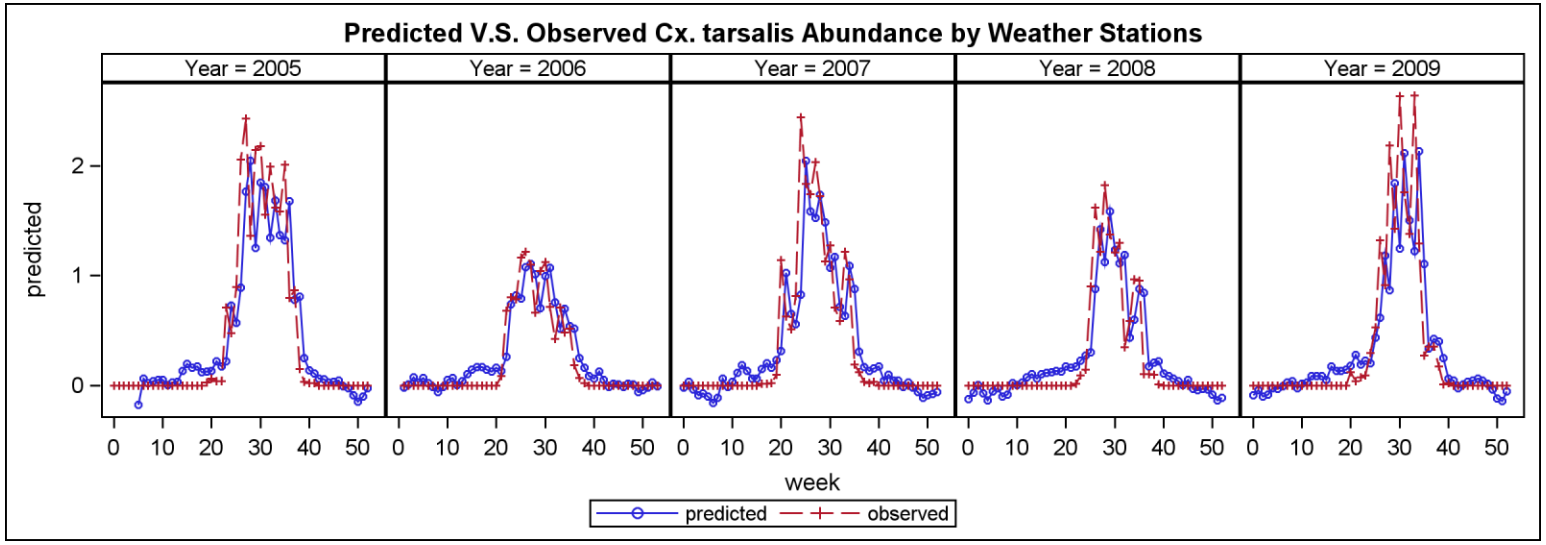
- Study period was from 2005-2009
- 0-3 week temporal lags were used to capture the lagged effects of environmental influences on mosquito populations
- Polynomial distribution lag (PDL) models were used
- Corrected Akaike information criterion (AICc) was used for model selection
- Model performance was presented by comparing the predicted and observed values

Cx. tarsalis



Variables in the best model:
Temperature
Vegetation Index

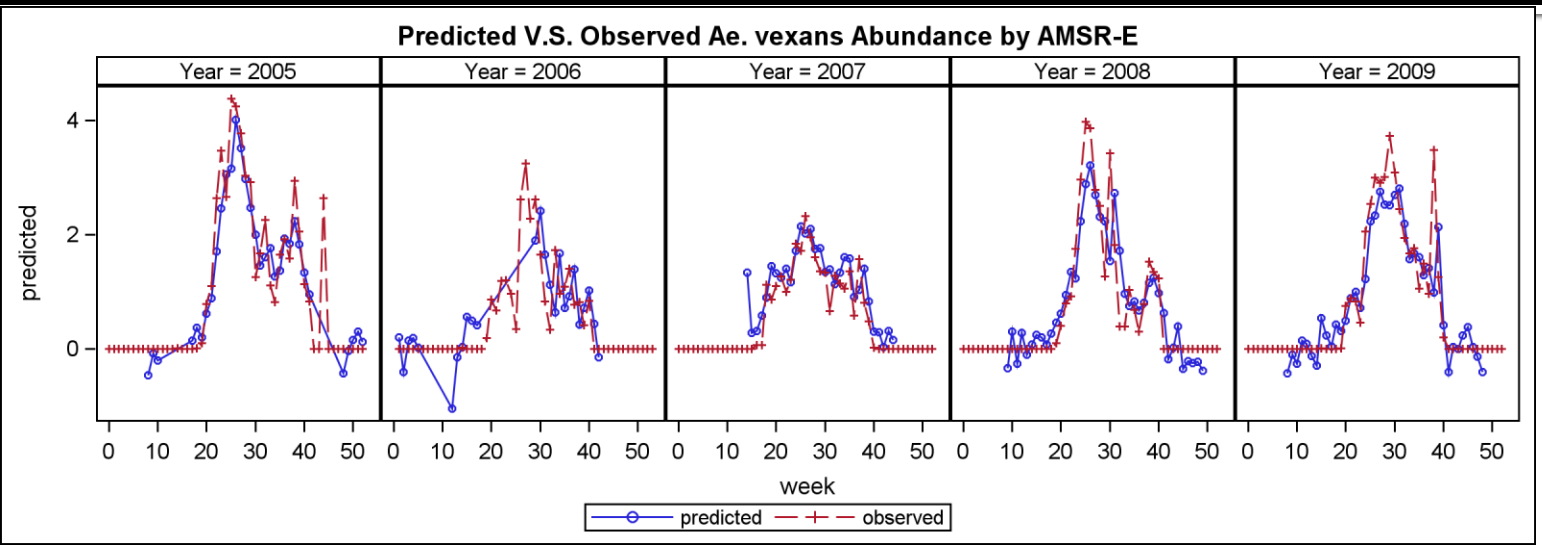
AICc=140.94
RMSE=0.32



Variables in the best model:
Temperature

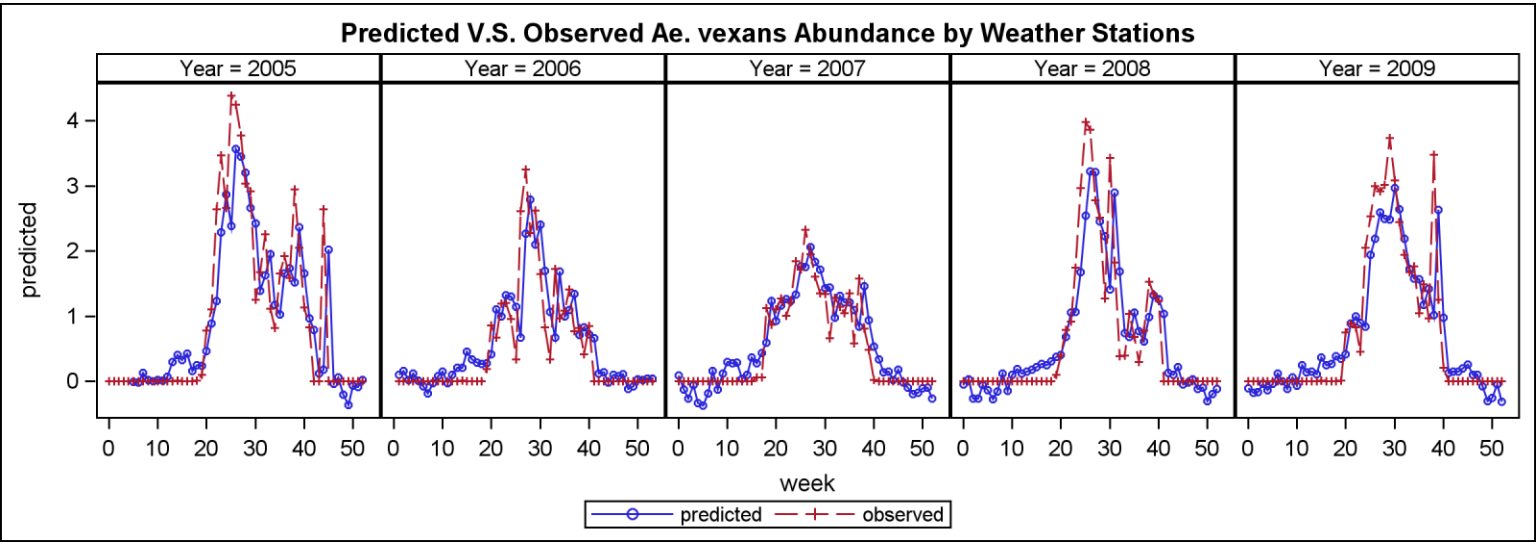
AICc=140.46
RMSE=0.31

Ae. vexans



Variables in the best model:
Temperature
Water Fraction

AICc=278.13
RMSE=0.52



Variables in the best model:
Temperature

AICc=424.12
RMSE=0.54

Summary

- Both AMSR-E and weather station are good predictors of the abundance of both species
- The AMSR-E has better model performance than weather station at predicting *Ae. vexans*
- The different responses to the environmental variables between two species is consistent with their distinctive mosquito ecology
- AMSR-E data can be used to model or forecast mosquito populations when local weather stations are not available

Potential habitats for *Ae. vexans*

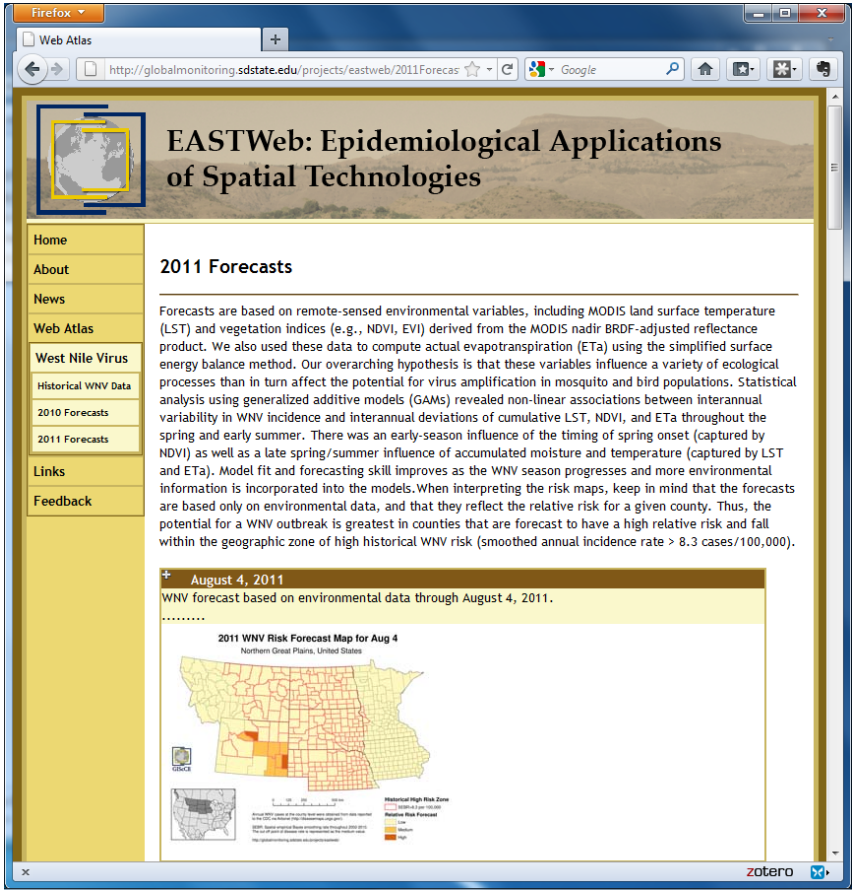
Summary

- Remote sensing techniques provide different measurements that are potentially more relevant for mosquito ecology (e.g., water fraction versus rainfall, air temperature versus land surface temperature)
- The diversity of environmental parameters generated from remote sensing data can improve mathematical models

Potential habitats for *Cx. tarsalis*

Future Study

- Apply the statistical models to multiple locations to verify their transferability to different ecological settings
- Compared with environmental variables from different remote sensing datasets (e.g. MODIS)
- Develop models to forecast human WNV risk
- Communicate results to decision makers (SD and other state departments of health)



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Acknowledgements

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