

# Rapid Response to Assess the Risk of Arbovirus Outbreaks Triggered by Climate Events

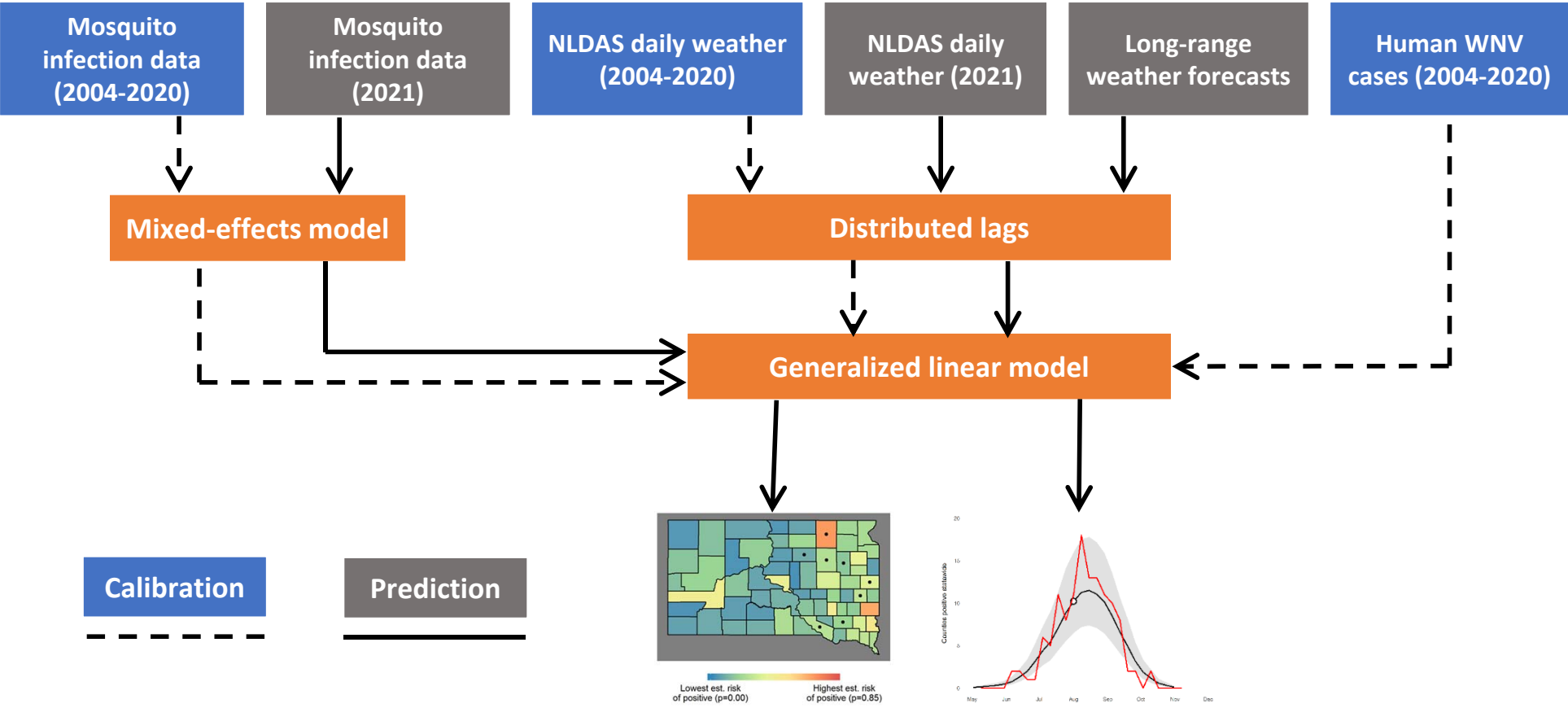
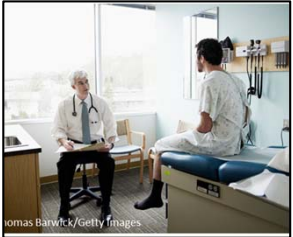
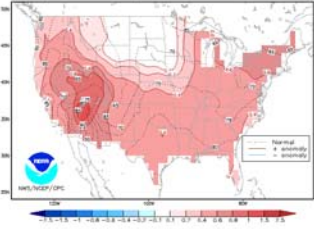
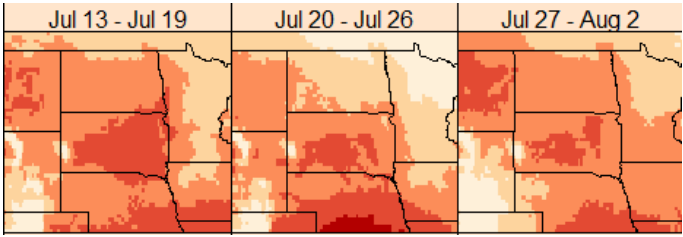
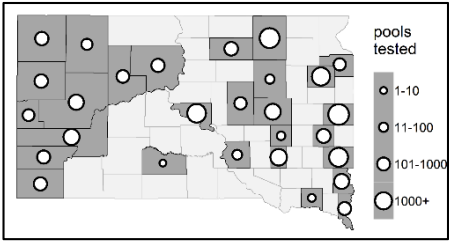
NASA Health and Air Quality Application Program Review  
October 20, 2021

Michael C. Wimberly and Dawn M. Nekorchuk

# Project Objectives

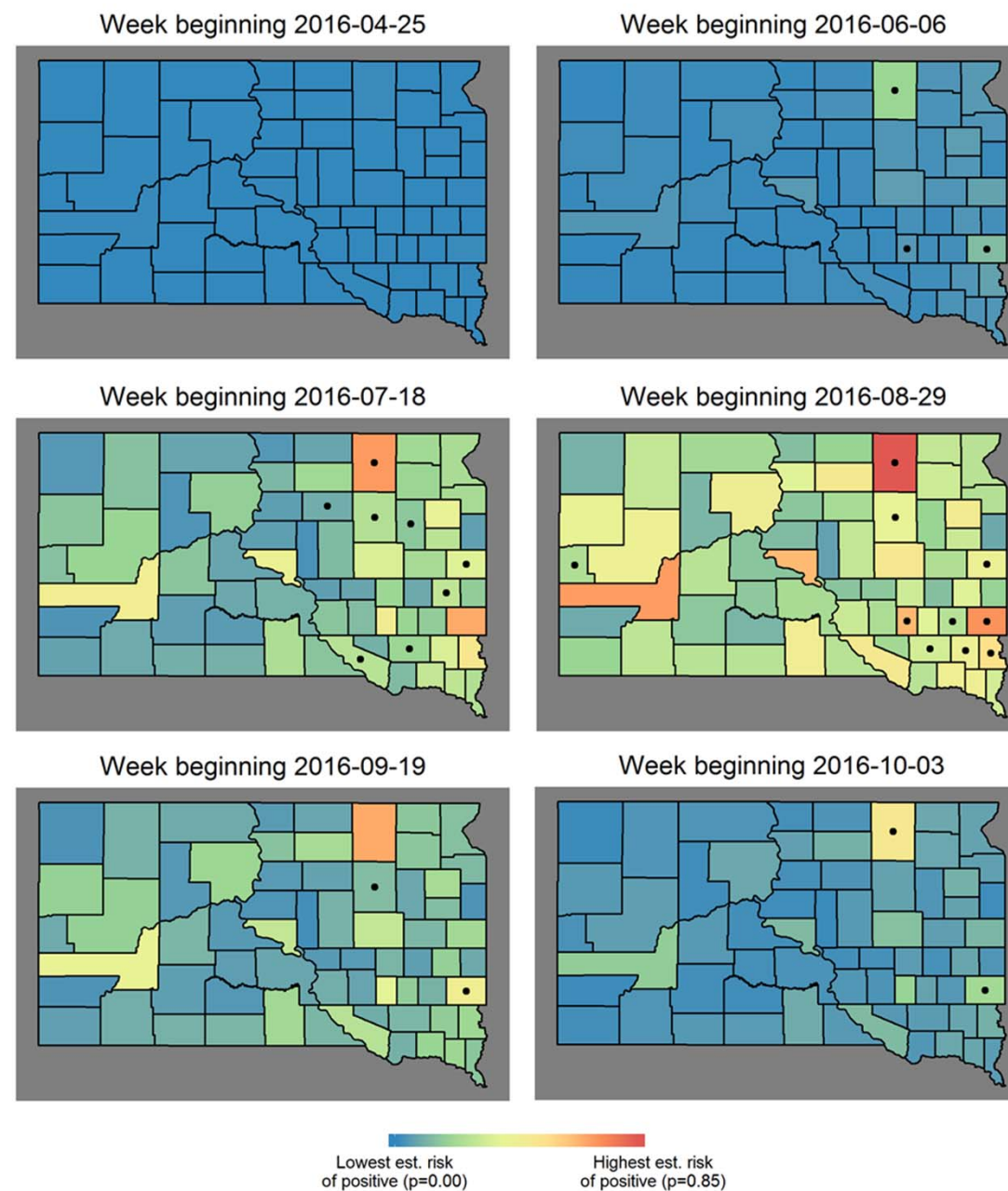
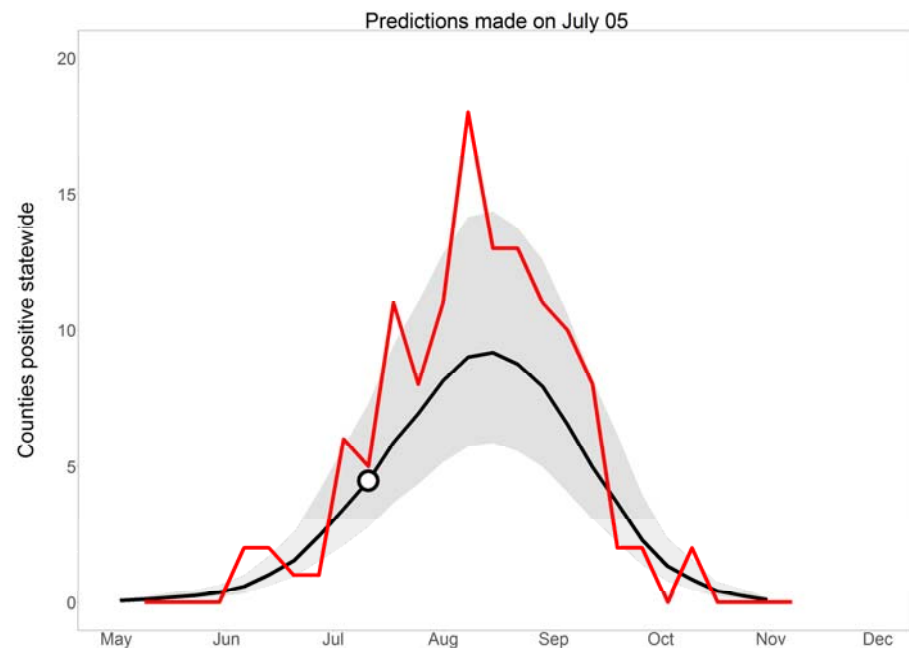
- The Arbovirus Monitoring and Prediction (ArboMAP) system was originally developed to forecast West Nile virus risk in South Dakota using NASA environmental monitoring datasets.
- The aim of the current project is to extend ArboMAP to multiple states and test its effectiveness there
  - Different biogeographic setting
  - Different vector and host species
  - Different institutional environment for public health and mosquito control
- Focus on Louisiana, but also currently working with Oklahoma and Michigan

ArboMAP integrates environmental monitoring data with mosquito surveillance data to generate weekly predictions of human WNV cases by county.



ArboMAP produces weekly WNV risk maps for the upcoming week (right).

Predictions can also be extrapolated multiple weeks into the future to predict WNV cases throughout the entire season (below).



Davis et al. (2017) *PLoS Currents: Outbreaks*

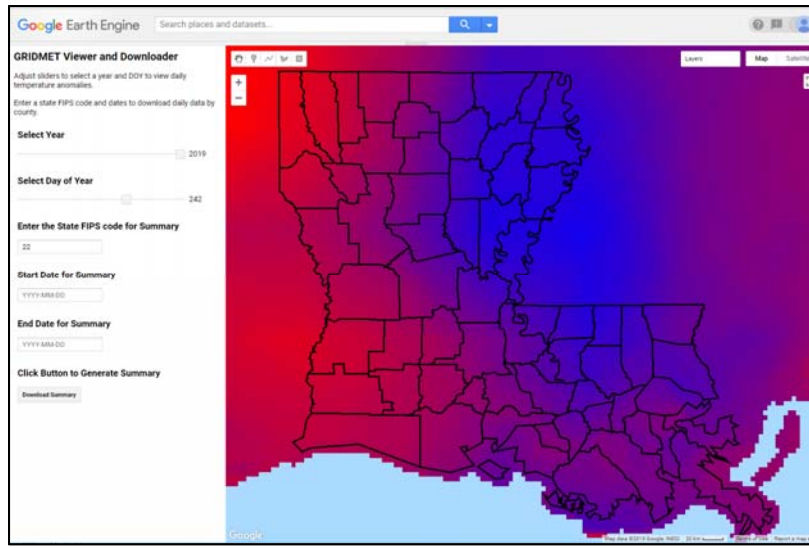
# RStudio

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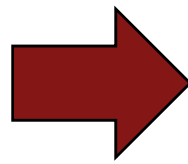
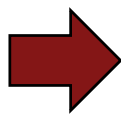
1 # title: "ArboMAP: arbovirus modeling and prediction - into forecast mosquito-borne disease
2 outbreaks"
3 authors: "summary of model outputs (v2.0)" (Justin K. Davis and Michael C. Wimberly,
4 university of oklahoma) (geography and environmental sustainability,
5 date: "updated" format Sys.time(), "%m/%d/%y")
6 output: pdf_document
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8 # [[ setup, include=FALSE ]]
9 knitr::opts_chunk$set(echo = TRUE)
10 # define some helpful functions
11 "toLine" = function(x) c("LINE", x, y)
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13 options(show=1)
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# Google Earth Engine



Human and mosquito surveillance



## ArboMAP: Arbovirus Modeling and Prediction to Forecast Mosquito-Borne Disease Outbreaks

Summary of Model Outputs (v2.0)  
Justin K. Davis and Michael C. Wimberly

Vector infection data  
There are 16274 samples in the vector testing database. For 2018, there are 1627 tested samples, with 66

Model results  
Statewide trends

Results for 2018-08-12 to 08-18

We visualize the raw estimated risk for 2018-08-15 below. If a district is darkest blue, then we estimate that there should be no human cases reported for this district, during this week. If a district is lightest red, we are certain that there will be at least one human case reported for this district, during this week.

Estimate for week beginning 2018-08-12

This map indicates whether probabilities reported in the previous map are higher (red) than average, lower (blue) than average, or right about normal (yellow) compared to the same week in previous years.

Risk for 2018-08-12 to 08-18

# South Dakota

- Trained Anita Bharadwaja (new vector-borne disease epidemiologist) at SDDOH
- She has used ArboMAP independently and disseminated information to stakeholders



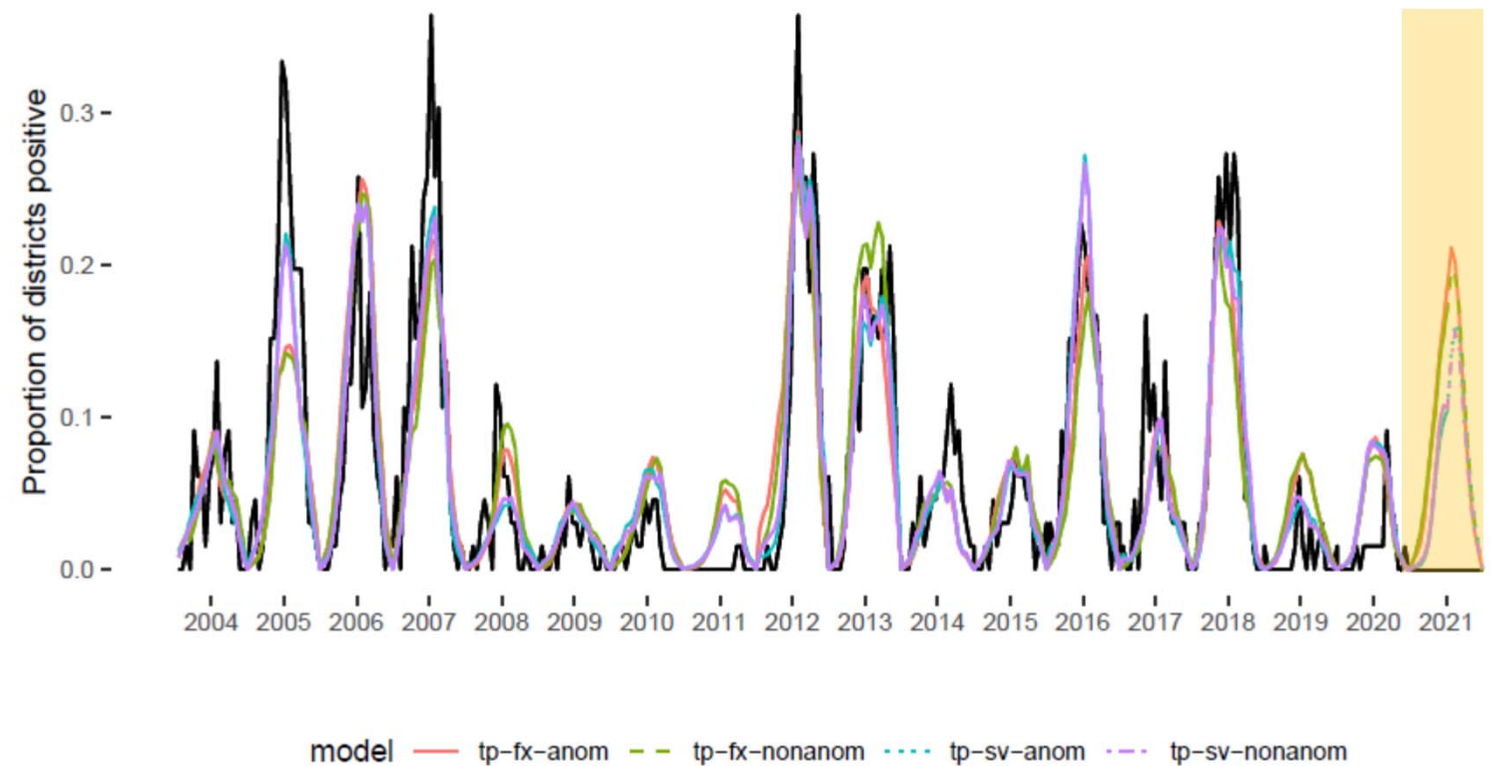
ArboMAP predicted more cases in 2021 compared to 2019 and 2020

At this point, reported cases appear to support this prediction

- 37 cases reported as of Oct 19, 2021 (still incomplete)

- 17 cases reported in 2020

Statewide model predictions



# Louisiana

- Trained Julius Tonzel (public health epidemiologist) and Emma Ortega (surveillance epidemiologist) at LADOH
- Provided additional support after Julius had to redirect effort to COVID-19 surveillance

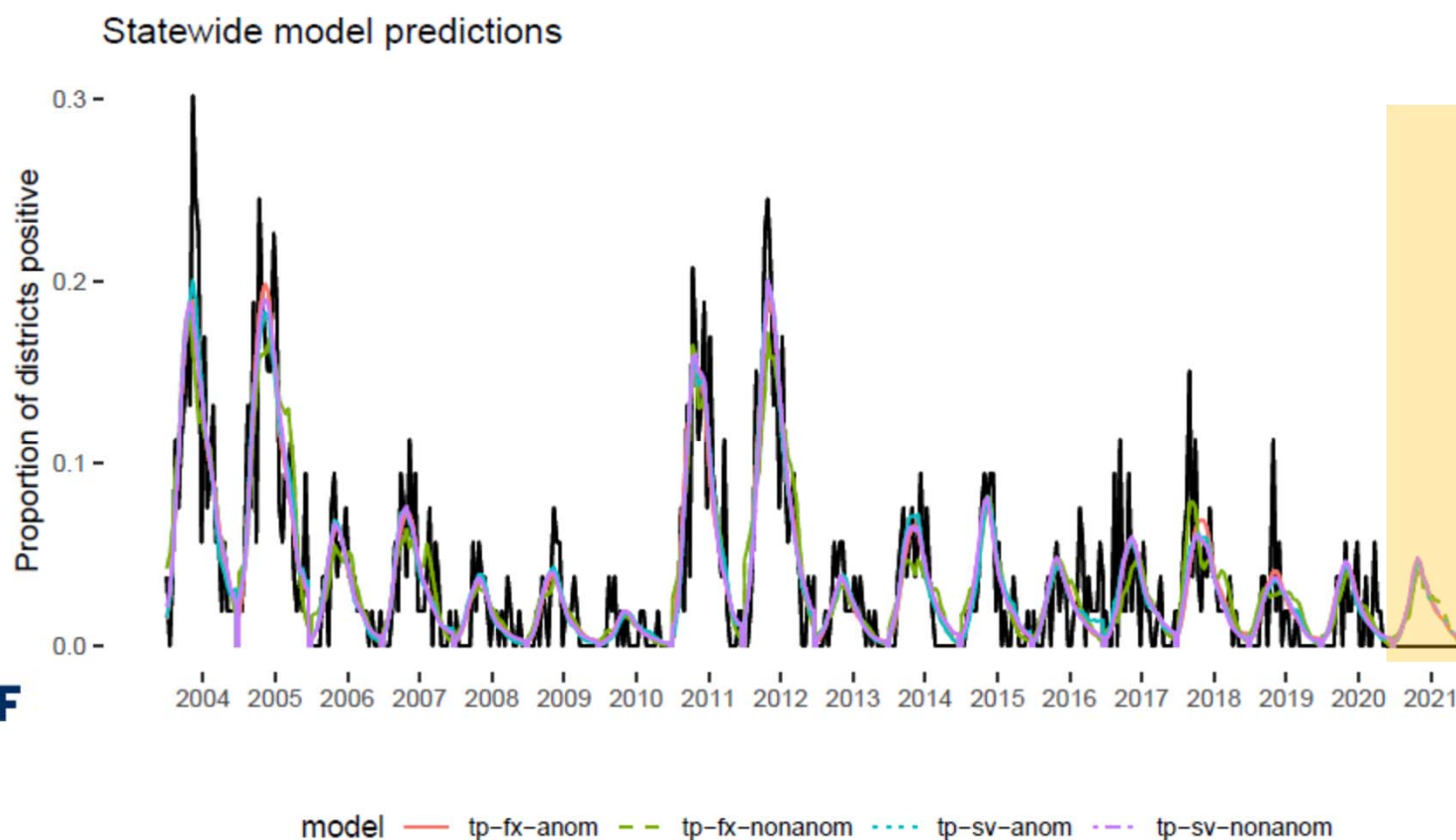


ArboMAP predicted low cases in 2021, similar to 2019 and 2020

At this point, reported cases appear to support this prediction

- 15 cases reported as of Oct 19, 2021 (still incomplete)

- 23 cases reported in 2020



# Oklahoma

- Trained Caio França (mosquito biologist) and a team of students at Southern Nazarene University
- They have been able to independently run ArboMAP and disseminate information to stakeholders

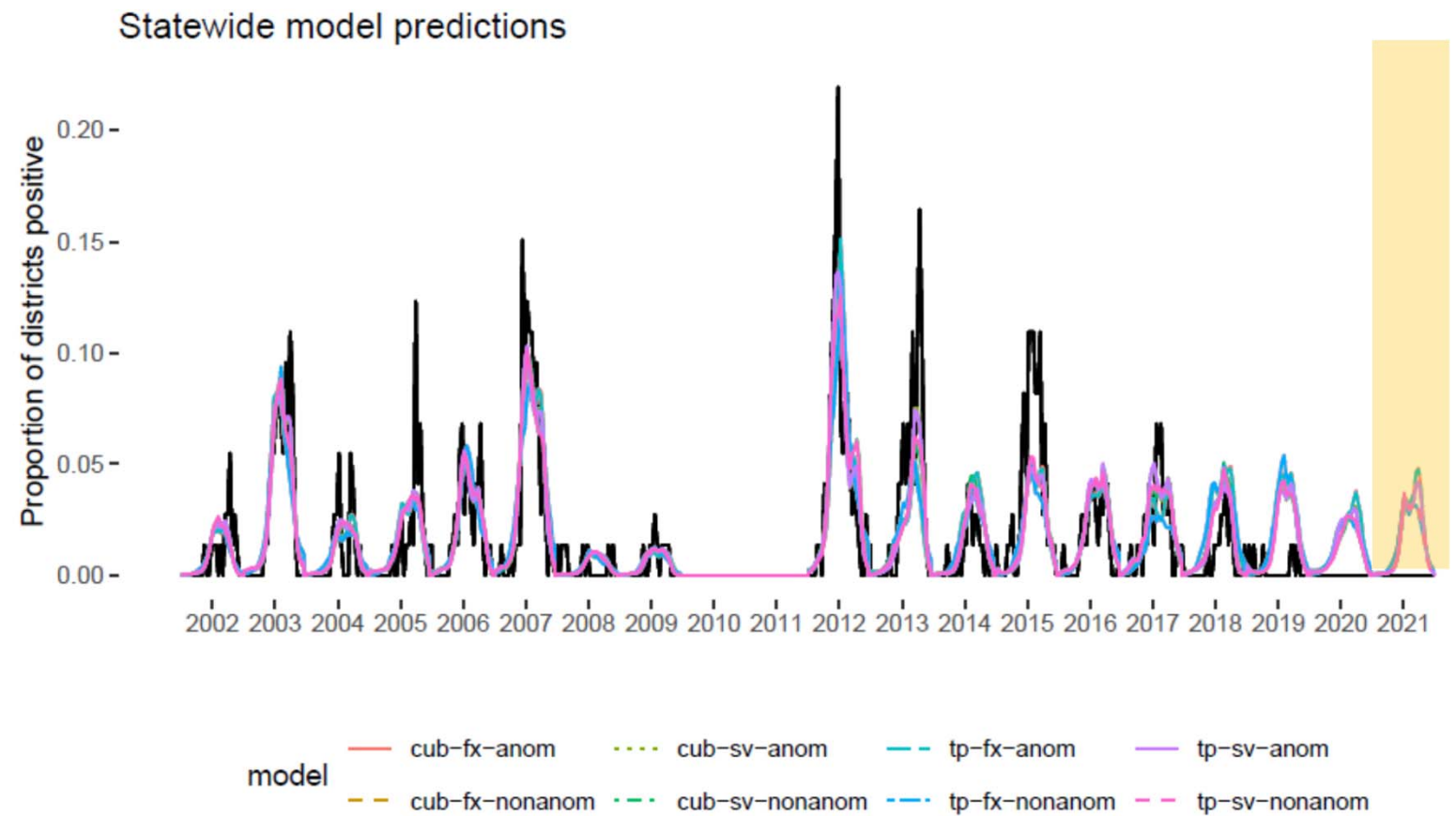


ArboMAP predicted low cases in 2021, similar to 2019 and 2020

At this point, reported cases appear to support this prediction

- 3 cases reported as of Oct 19, 2021 (still incomplete)

- 8 cases reported in 2020





# We conducted a retrospective validation of ArboMAP in South Dakota from 2016-2019

Manuscript completed, submitted, and currently under review

Update calibration data through the preceding year

Mosquito + environmental data through year y-1

Human case data through year y-1

Model human cases as a function of mosquito and environmental data

$$\text{Hum} = f(\text{Mosq} + \text{Env})$$

Update current year data through the forecast week

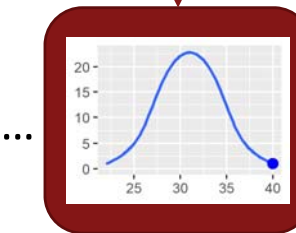
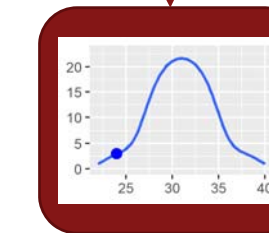
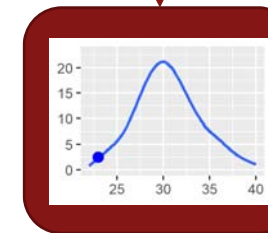
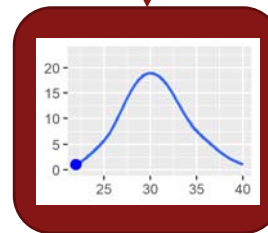
Mosq + Env data through year y forecast week 1

Mosq + Env data through year y forecast week 2

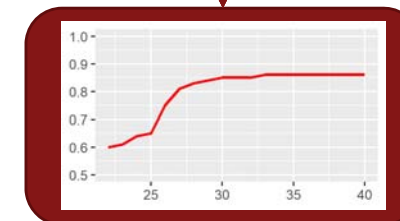
Mosq + Env data through year y forecast week 3

Mosq + Env data through year y forecast week 17

Predict WNV occurrence for each county-week in the current year



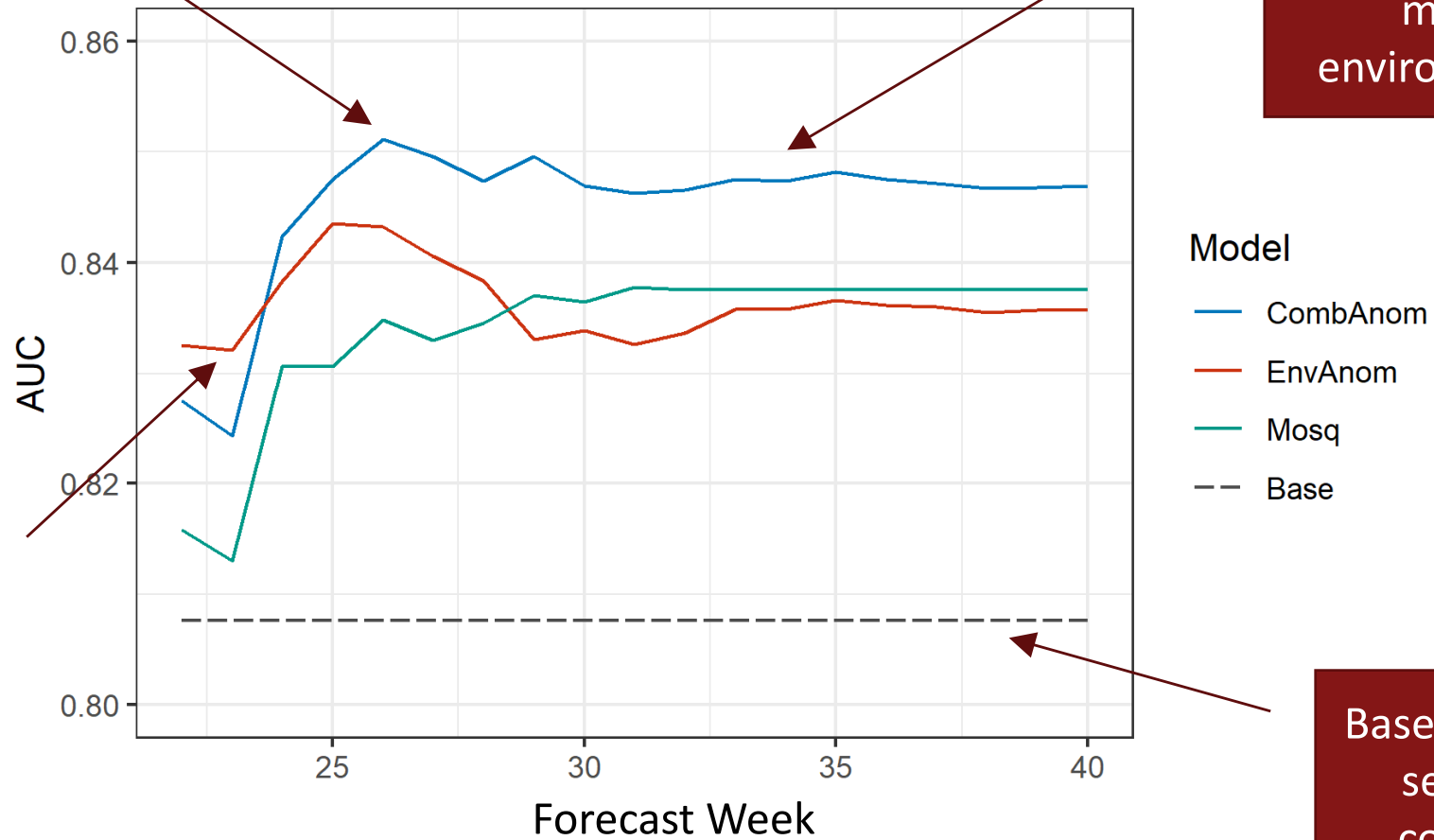
Summarize accuracy for each forecast week



Highest accuracy is achieved early in the WNV season (late June)

The combined model is more accurate than the mosquito and environmental models

Environmental variables are better predictors early in the WNV season



Baseline model based on seasonal trend and county-level means

AUC: Area under the receiver operating characteristics curve (scaled between 0.5-1.0)

# Plans for the upcoming (no-cost extension) year

- Meeting with multi-state partners scheduled for Nov 3, 2021
  - Will include SD, LA, OK, and MI
  - Focus on obtaining feedback on system usability and report design
- Based on user input, we will make upgrades to ArboMAP
- The improved, multi-state version of ArboMAP will be transferred to partners in spring 2022
- Comparisons of the forecasting models across multiple states
  - Technical issues related to model specification and parameterization
  - Relative importance of meteorological drivers
  - Potential to use alternative data sources (e.g., NLDAS, MODIS/VIIRS, GPM)
  - Upcoming presentations at ASTMH, AGU, AMS, and AMCA with manuscript planned for spring 2022

# Application Readiness Level

- Currently 6 (Demonstration in Relevant Environment)
  - Prototype application system beta-tested in a simulated operational environment
  - Projected improvements in performance of decision making activity demonstrated in simulated operational environment
- Moving to 7 (Application Prototype in Partner's Decision Making)
  - Prototype application system integrated into end-user's operational environment
  - Prototype application functionality tested & demonstrated in decision making activity
- Goal is 8 (Application Completed & Qualified) at the end of the project
  - Finalized application system tested, proven operational, and shown to operate as expected within user's environment
  - Application qualified and approved by user for use in decision making activity
  - User documentation and training completed