An environmentally informed statistical model and forecast system for West Nile virus infection rates among mosquitoes in the Coachella Valley, CA

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ECOSTRESS

Mount Sinai

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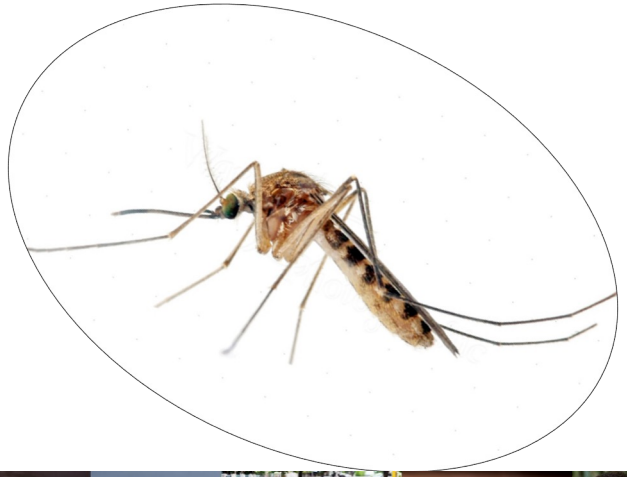
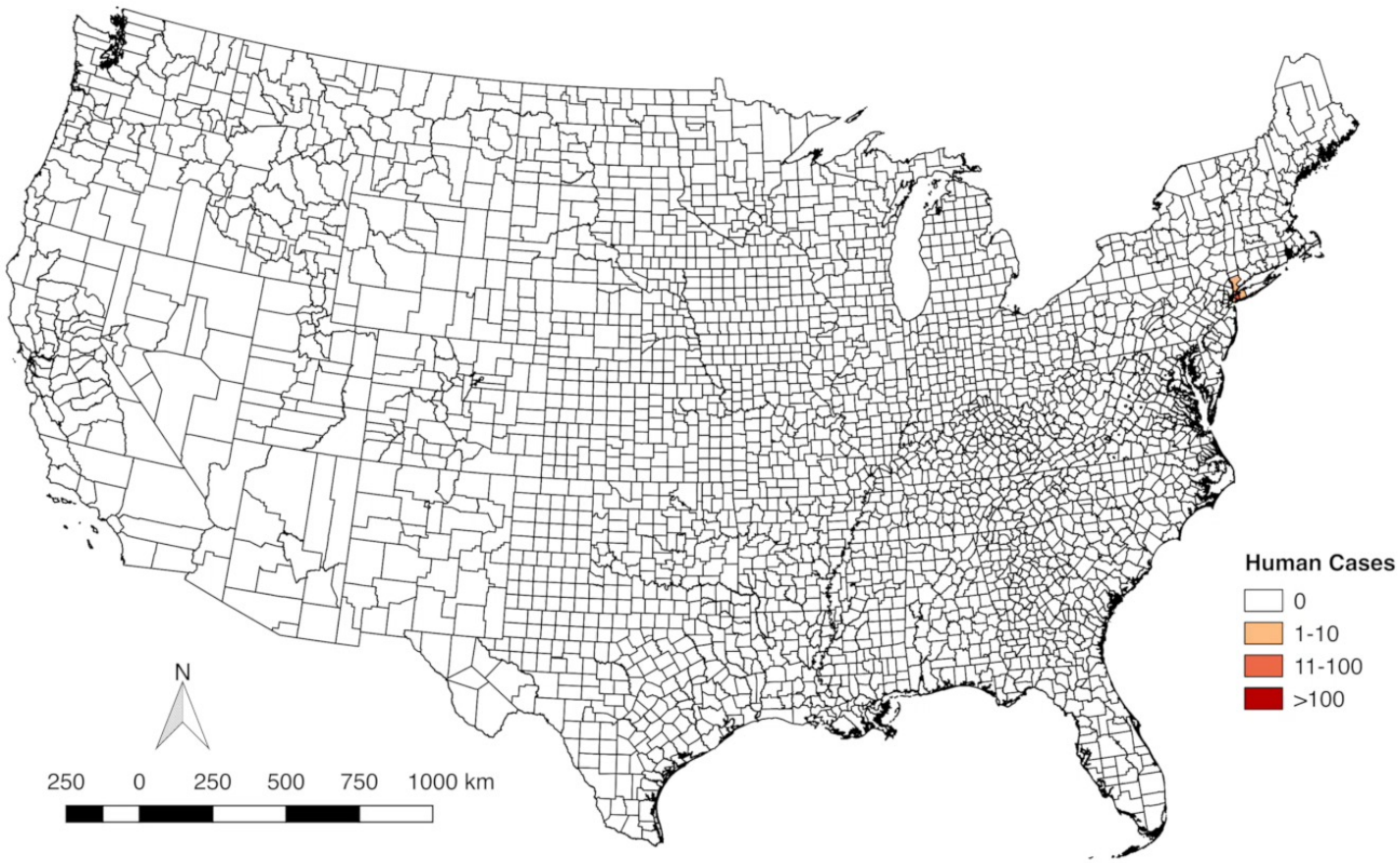
Why Forecast Infectious Diseases?

- Infectious disease patterns continually shift
- Within infectious disease outbreak response is reactive
  - Based on ongoing surveillance
- Accurate, reliable forecasts with sufficient lead times would provide greater opportunity to plan adaptive mitigation and control efforts
- Influenza, Ebola, Dengue, West Nile virus

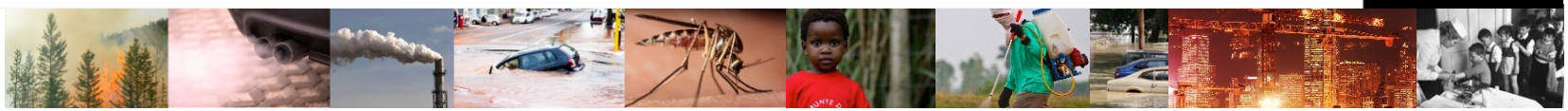


Background

Impact of WNV in the US

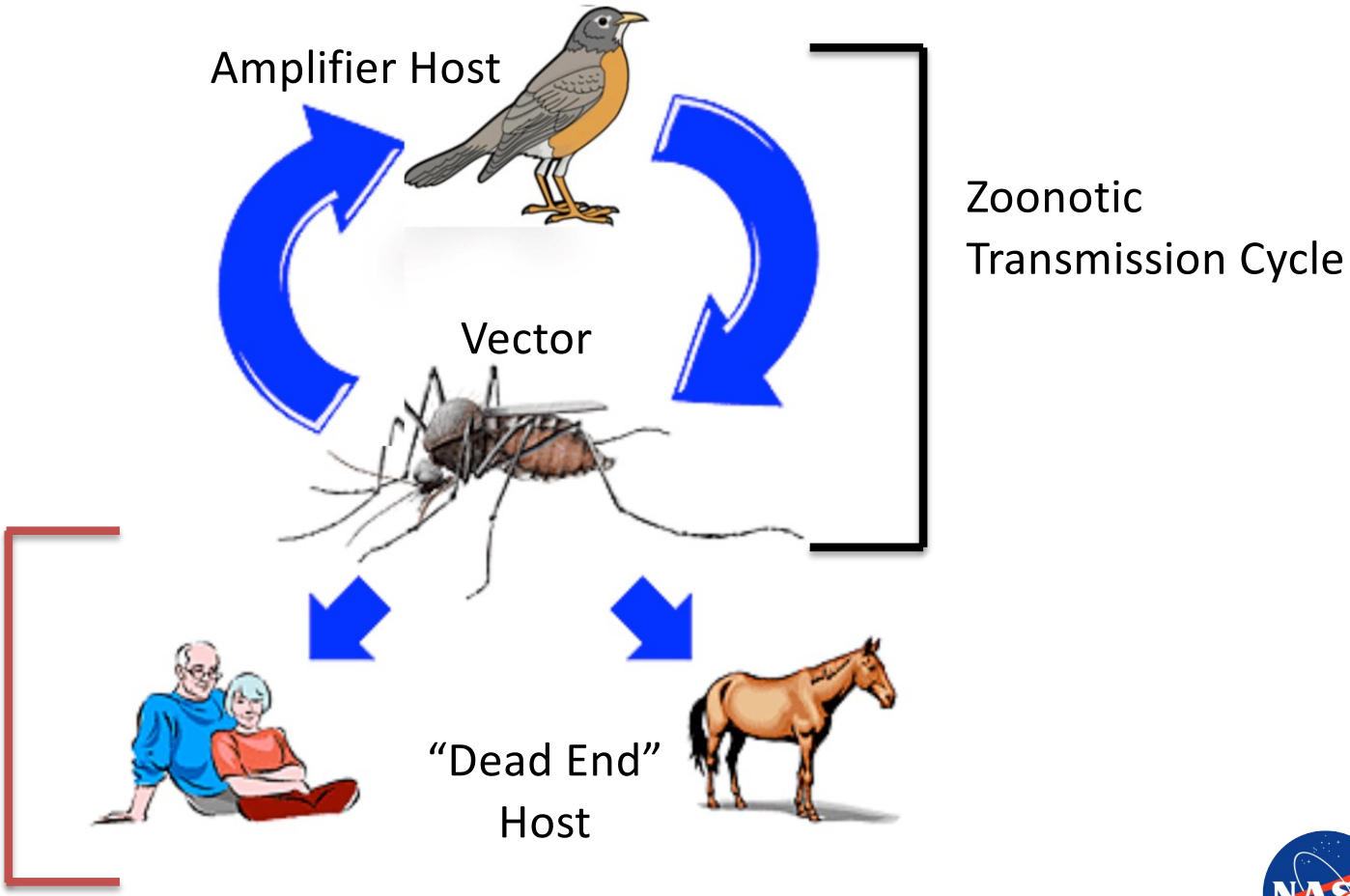


Mount Sinai



Background

West Nile Virus Transmission Cycle



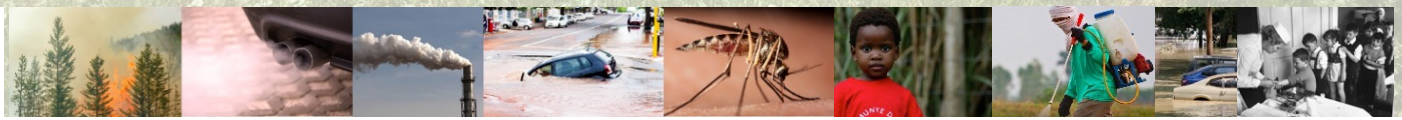
Background

Environmental Components Influence the Transmission Cycle

Humidity

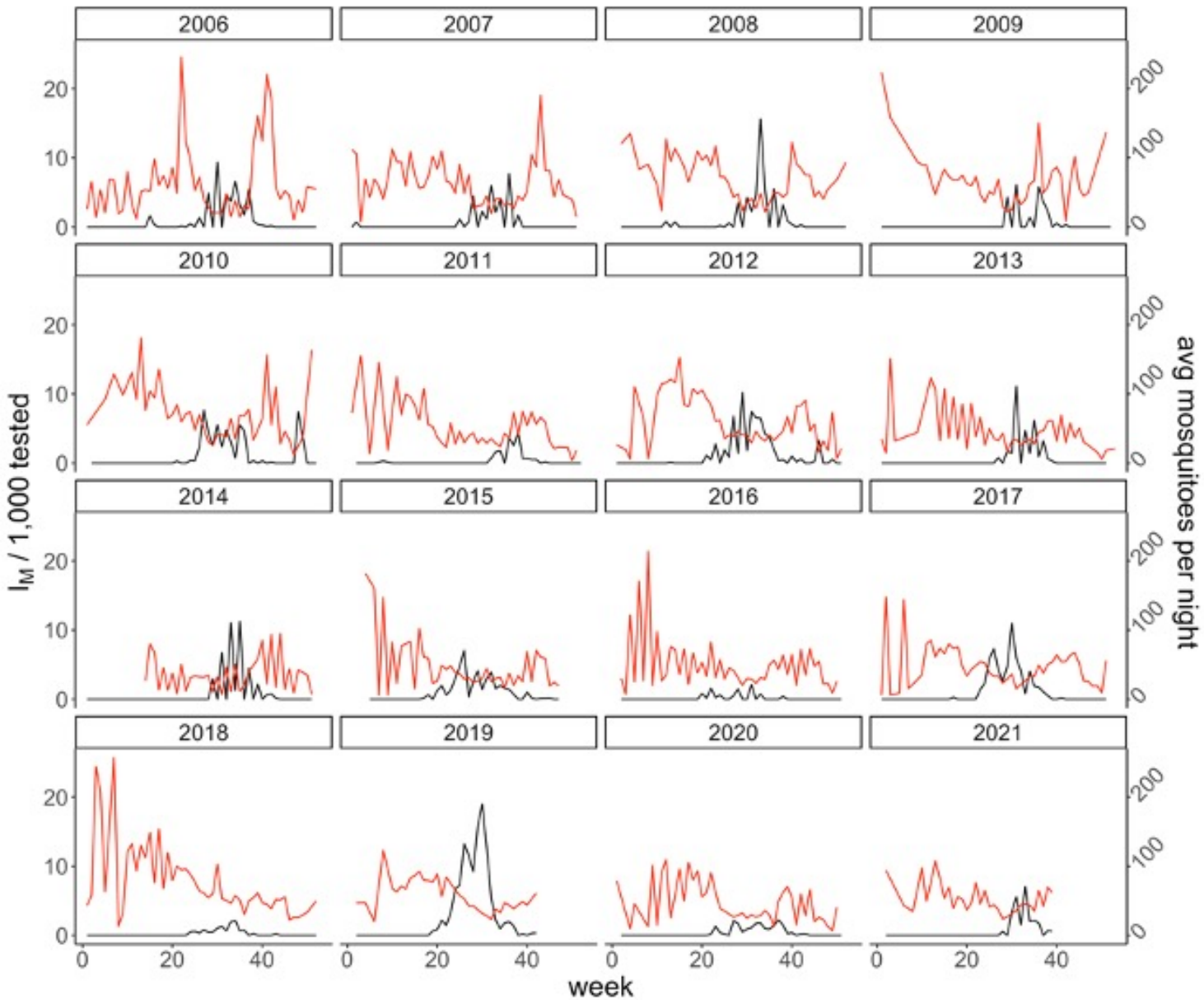
Temperature

Hydrology/Precipitation



Background

Temporal variability of Mosquito infection rates



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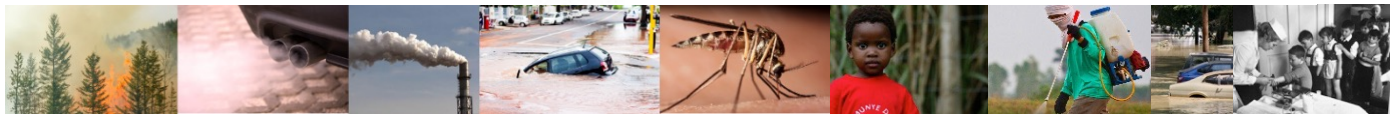

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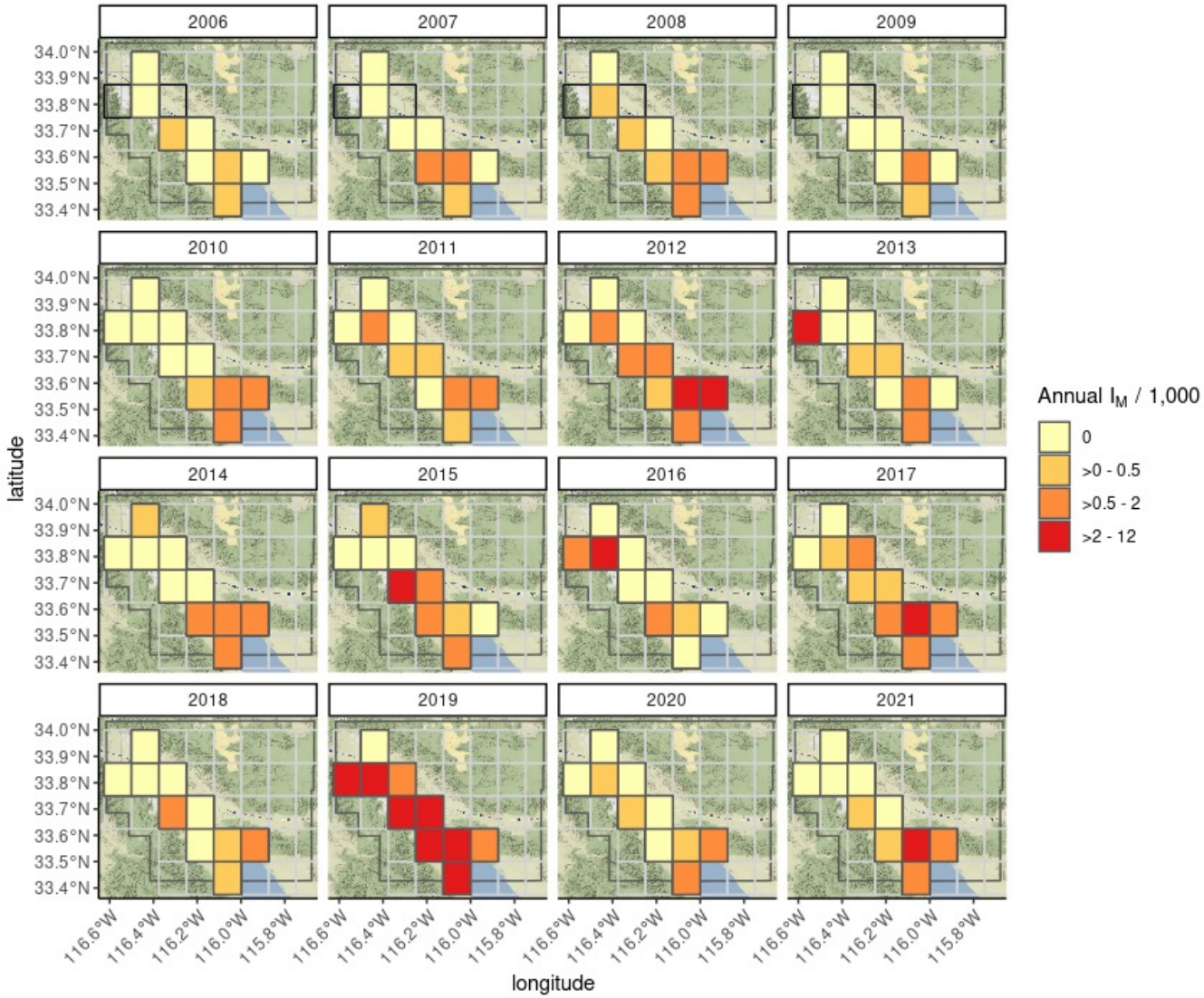
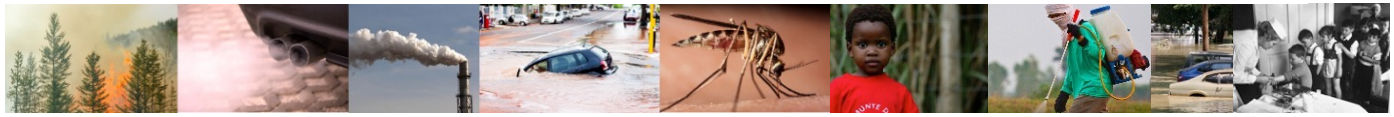
Background

Spatial variability of mosquito infection rates

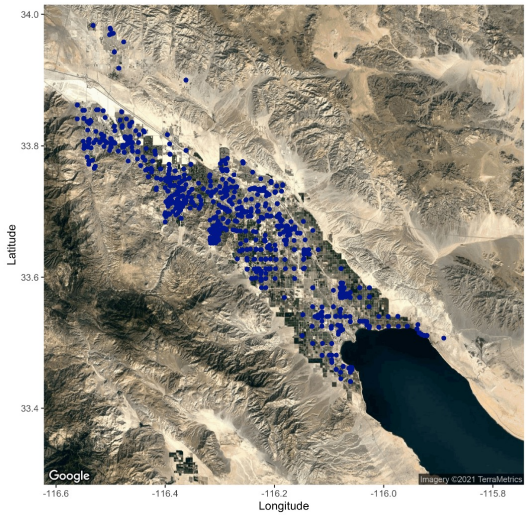


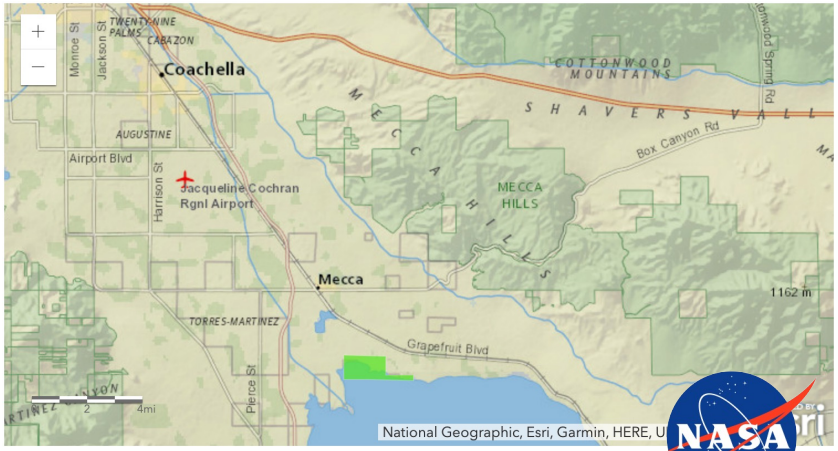


Background

Prevention

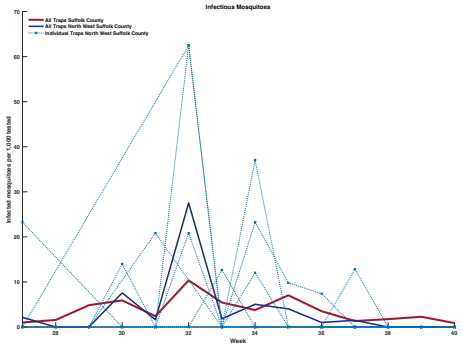
- No human vaccine or specific treatment
- Personal protection
  - Mosquito repellent
  - Long sleeve shirts and pants
- Community based mosquito control programs

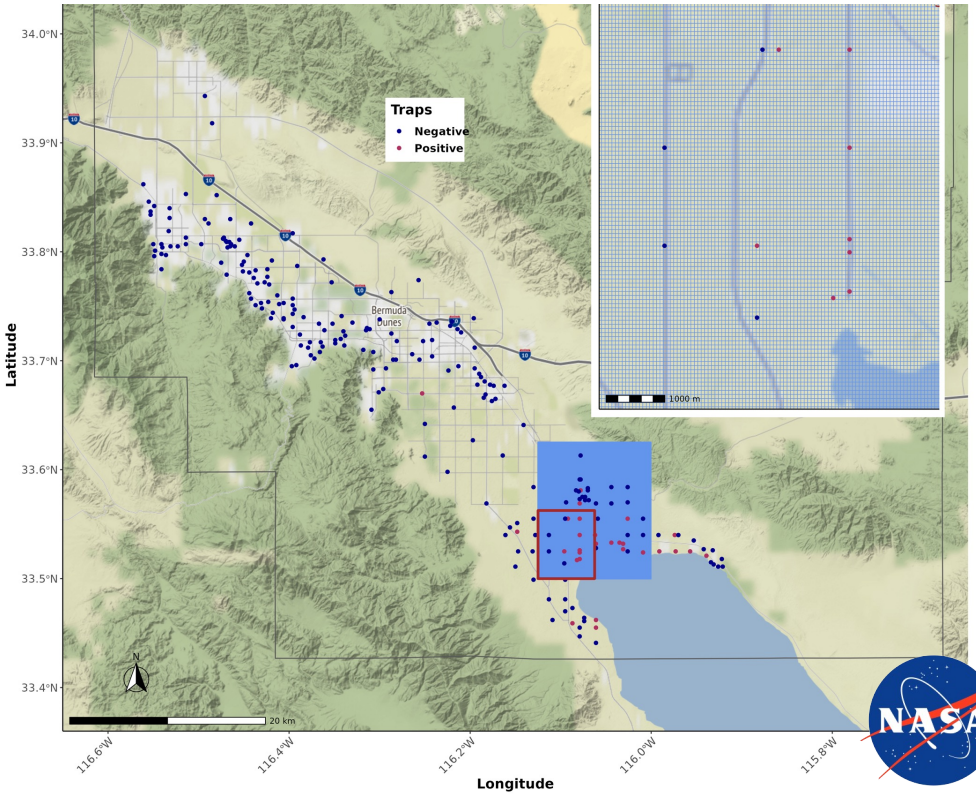




Aim

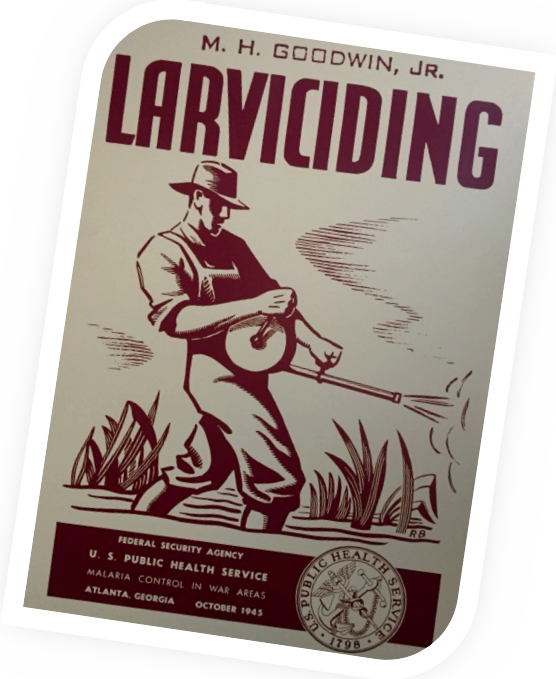
- Identifying the key environmental conditions that facilitate and accelerate West Nile transmission
- Identify this at an appropriate spatial scale to effectively inform vector control.

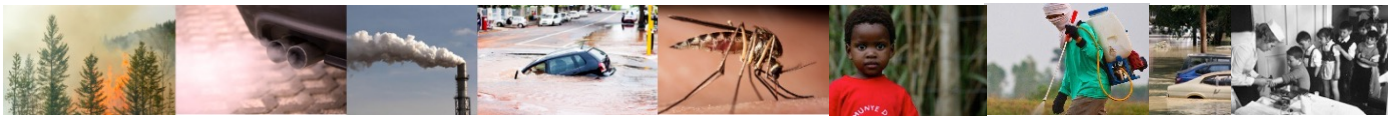




Environmental parameters that drive infections rates

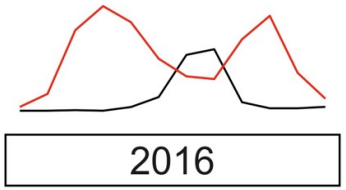
- ECOSTRESS
  - Land surface temperature
  - Evapotranspiration
- Multimodel inference system
  - Ensemble of statistical models
  - All parameters statistically significant
  - Model weights were generated relative to best fit model

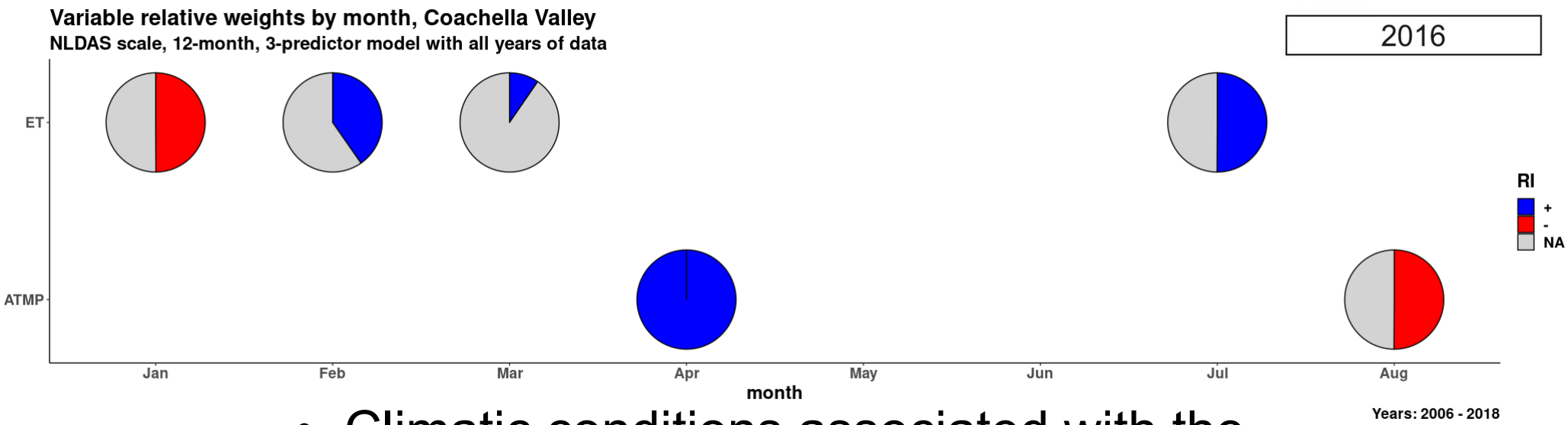




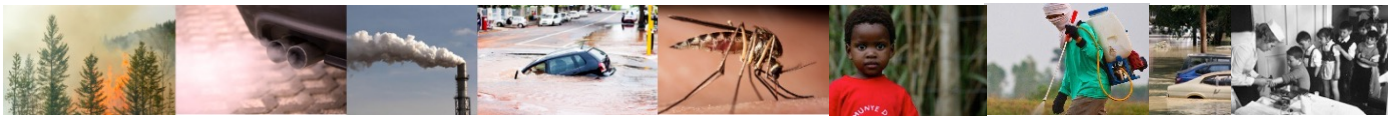
Results

Environmental predictions at 13 km^2



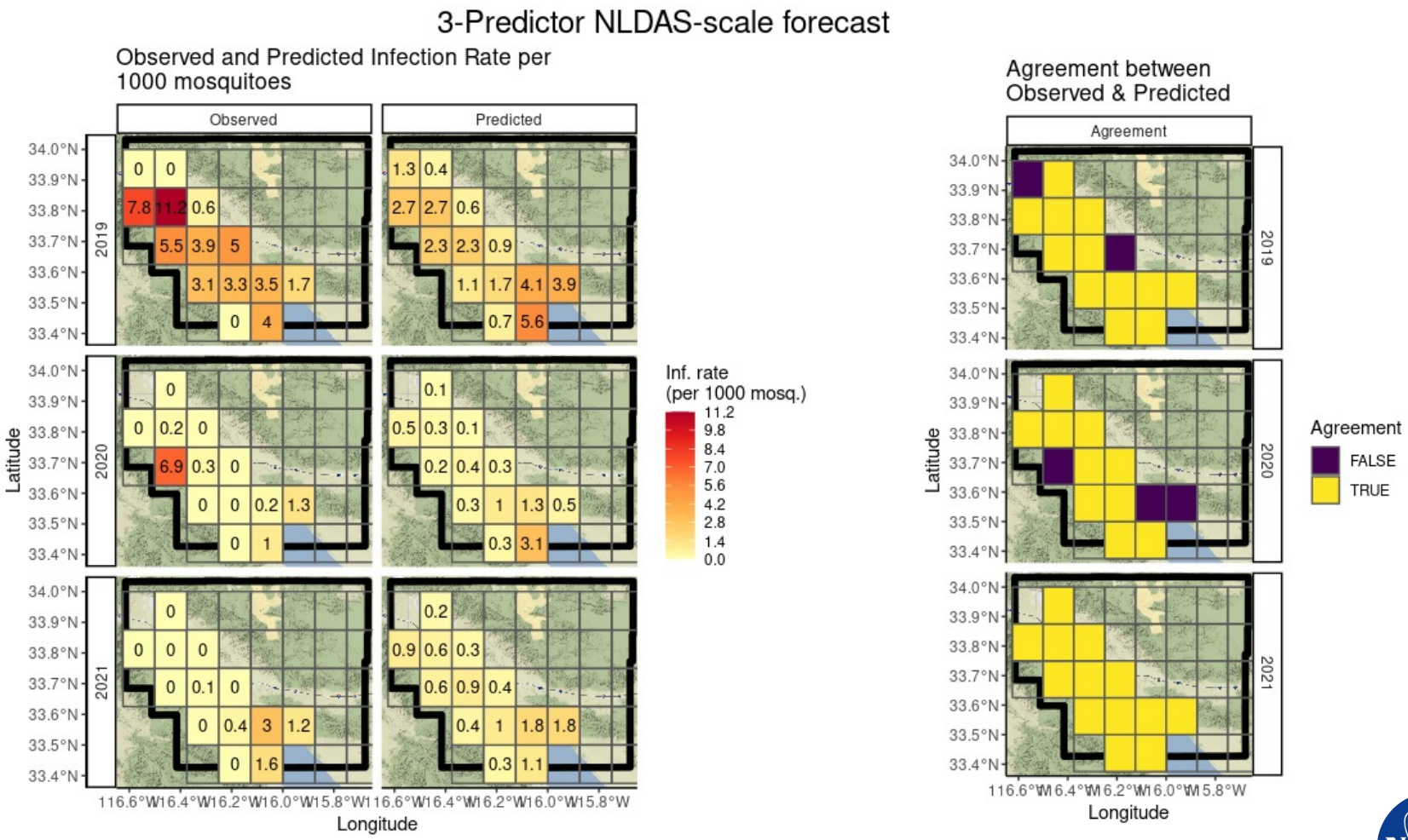


- Climatic conditions associated with the enzootic cycle between mosquito vectors and bird hosts.
  - Dry to wet winter
  - Followed by a warm spring
  - Cool summer

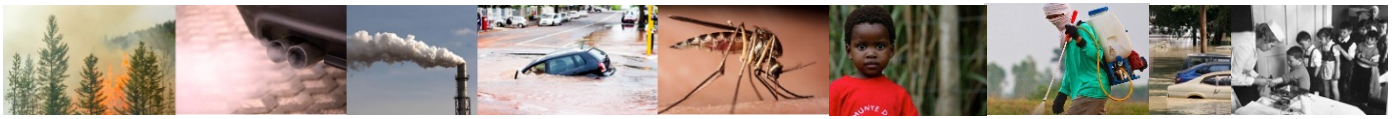


Results

Retrospective Forecasts 2019, 2020 and 2021



Threshold absolute difference: 1 infected mosquito per 1000 tested



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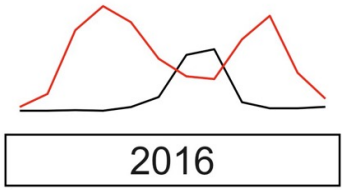

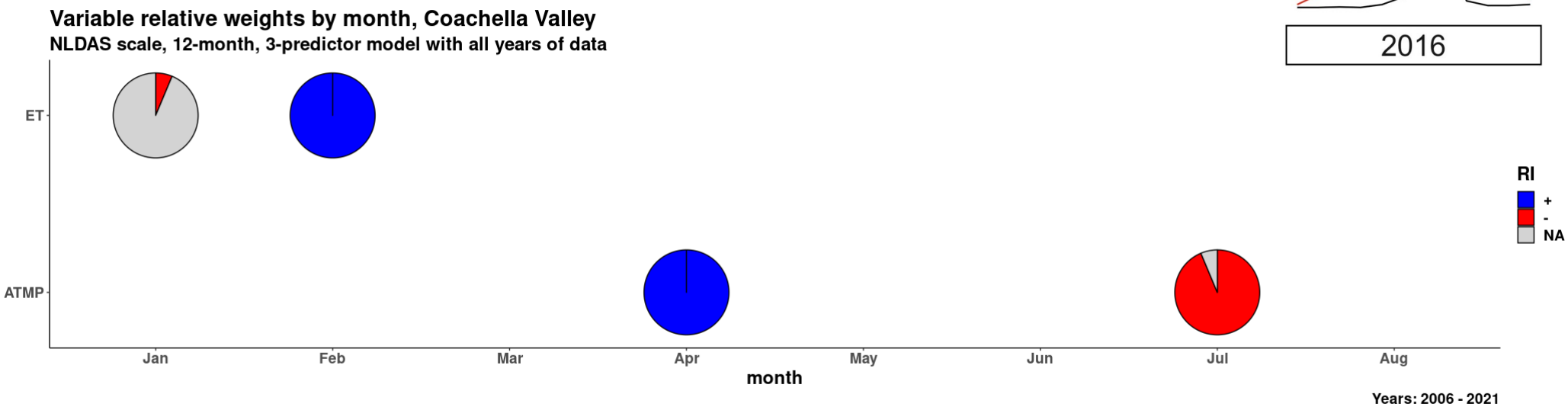

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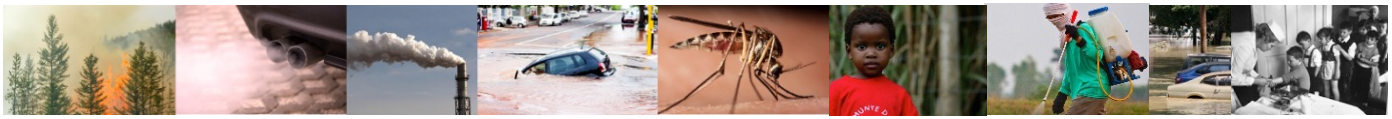
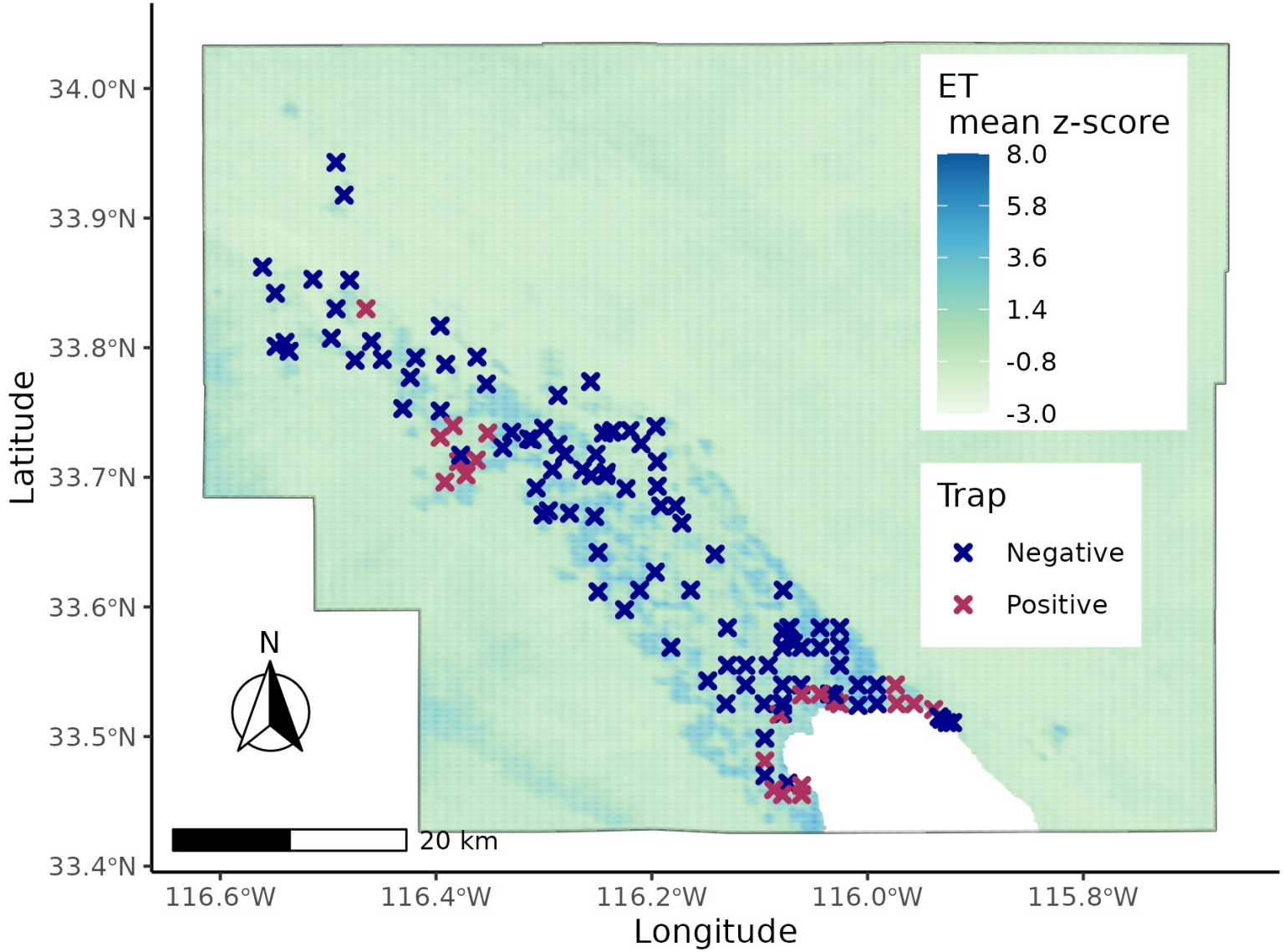


Results

ECOSTRESS 2020



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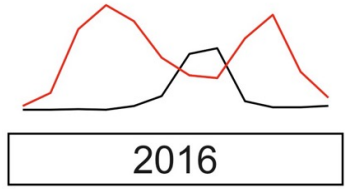
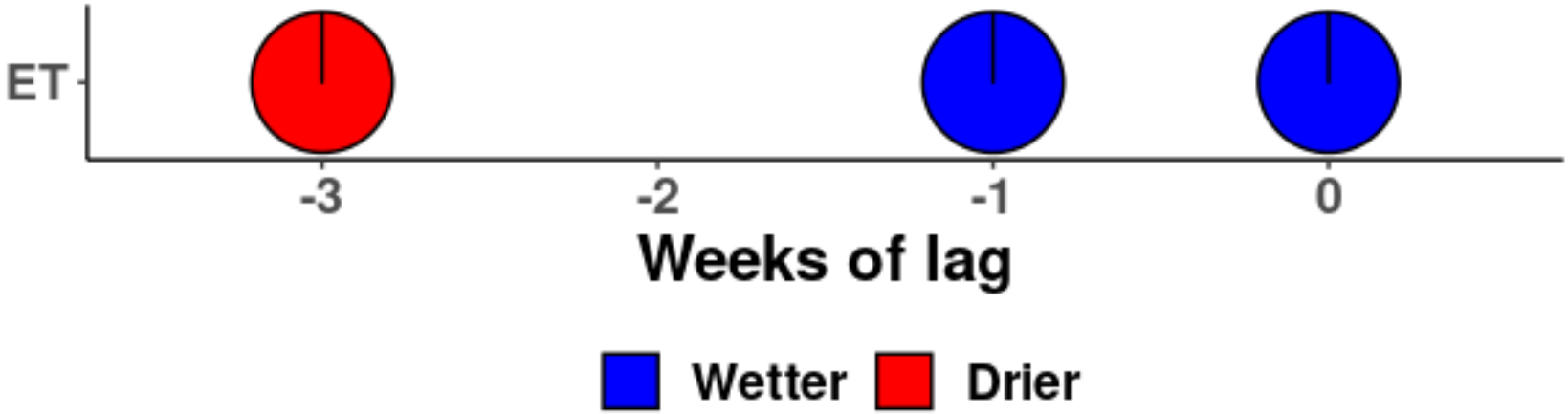
Results

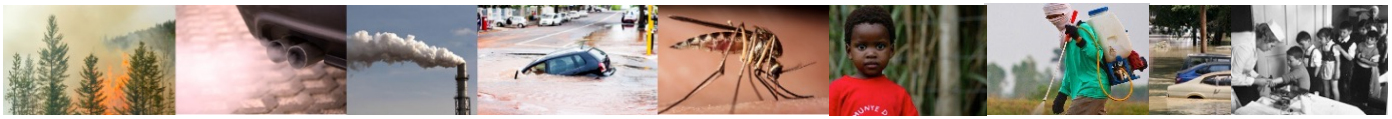
WNV Disease Emergence





Changes in the hydrological conditions associated with the onset of detecting WNV in a localized area.

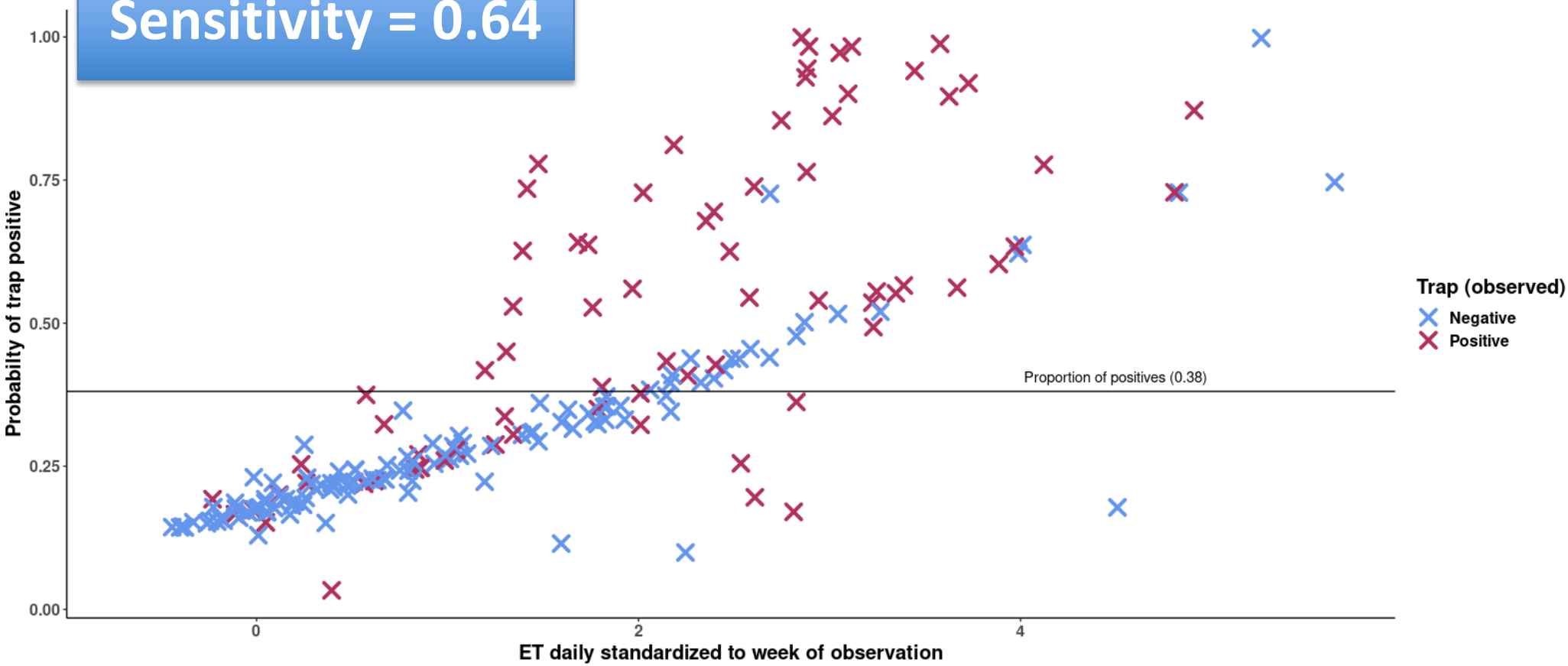
- Dry to wet



Results

ECOSTRESS Predicting Onset

Specificity = 0.83
Sensitivity = 0.64



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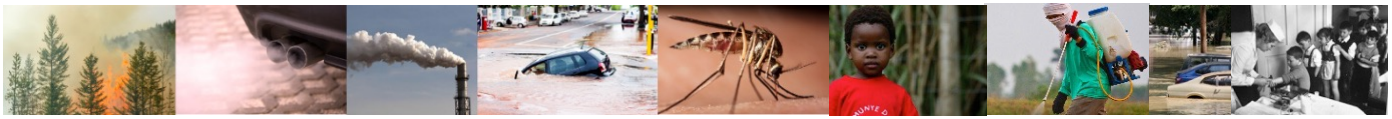

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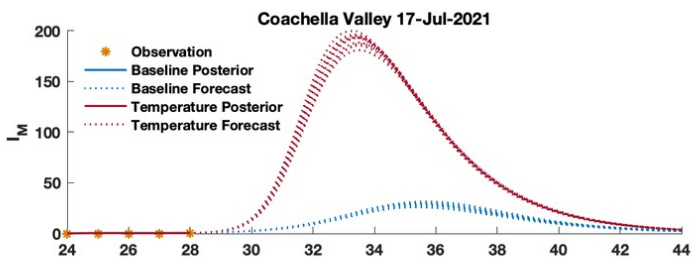
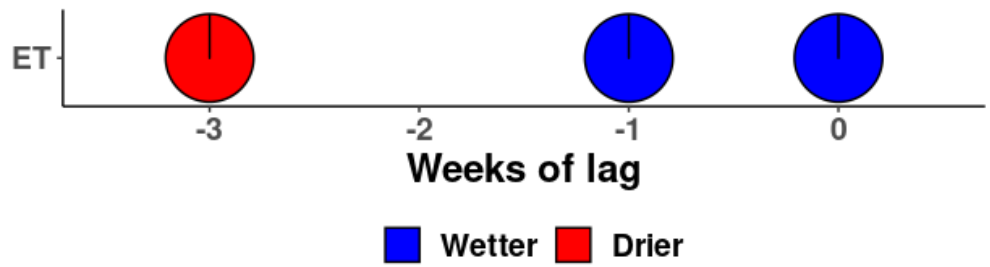
Potential to help guide public health interventions

- WNV transmission is driven by an enzootic cycle between mosquito vectors and bird hosts
- Identifying key environmental conditions that facilitate and accelerate this cycle may be used to inform effective vector control
- Statistical models using ECOSTRESS', 70 m resolution, showed that drier than normal conditions followed by an increase in moisture was associated with an increase in detecting WNV infected mosquitoes for the region
- ECOSTRESS has the potential to identify changes in hydrologically rich areas where mosquitoes and birds interact during warm spring months at the start of seasonal WNV transmission



Forecasted infection rates 2021, Coachella Valley, CA.



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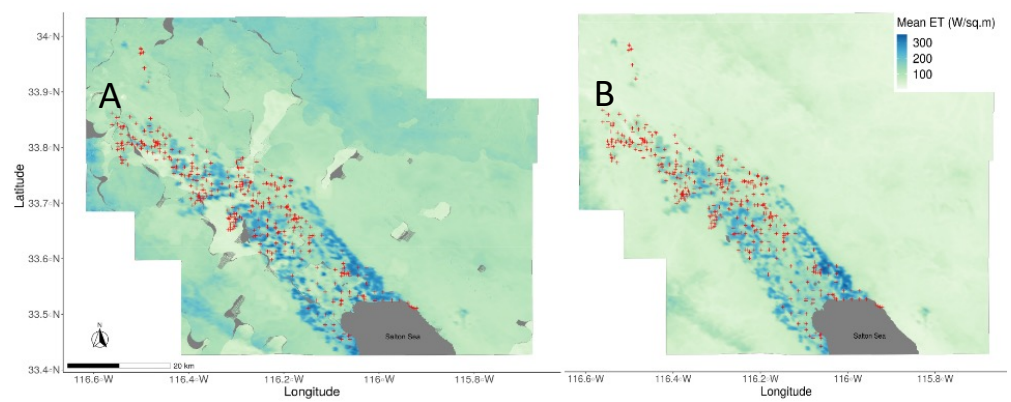

Mean evapotranspiration (ET) (W/m^2) as measured by ECOSTRESS in the Coachella Valley, CA during the early season (Panel A: March - May) and late season (Panel B: June - Aug) with trap locations (red X) for 2019.

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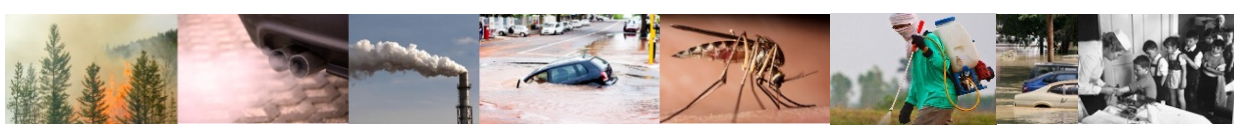

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- Mosquito abatement and health departments:
  - Shamika Smith and the rest of the staff of the city of Chicago's arboviral surveillance efforts
  - Kelly Bemis and the Cook County health department
  - Paul Geery and the staff of the Des Plaines Valley Mosquito Abatement District,
  - Patrick Irwin and the staff of the Northwest Mosquito Abatement District,
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  - The staff of the Southern Nevada Health District, especially Heather Anderson-Fintak and Vivek Raman, and Christopher T. Bramley
  - Kevin Caillouet and the staff of St. Tammany Parish Mosquito Abatement District
  - Clark County Department of Public Works
  - the staff of Iberia Parish Mosquito Abatement District
- Mosquito abatement and health departments:
  - Maricopa County Environmental Services Department and assistance from Irene Ruberto and Hayley D. Belisle-Yaglom at the Arizona Department of Health Services;
  - Michael "Doc" Weissmann and the staff at the Colorado Mosquito Control, and Leah Colton at the Colorado Department of Public Health and Environment; and
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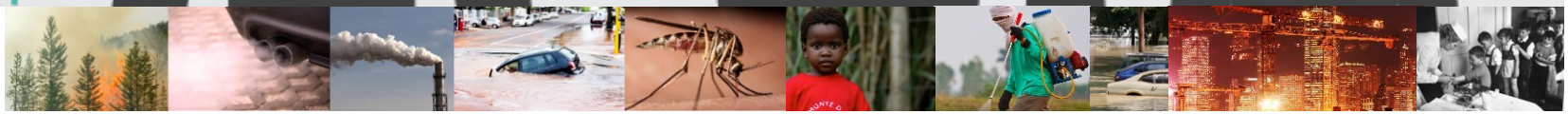
  - Jennifer Lehman, Dr. Erin Staples, and the CDC Division of Vector-Borne Infectious Diseases who provided us with weekly human WNV case data.
  - Vector Control & Environmental Services Fort Wayne-Allen County Department of Health and Taryn Stevens of the Vector-Borne Epidemiology Resource Center Indiana State Department of Health
- Funders:

Questions?

Mailman School's
Transmission
newsletter 2017

Mount Sinai