Spatial Disparities in Dengue Risk along the US-Mexico Border

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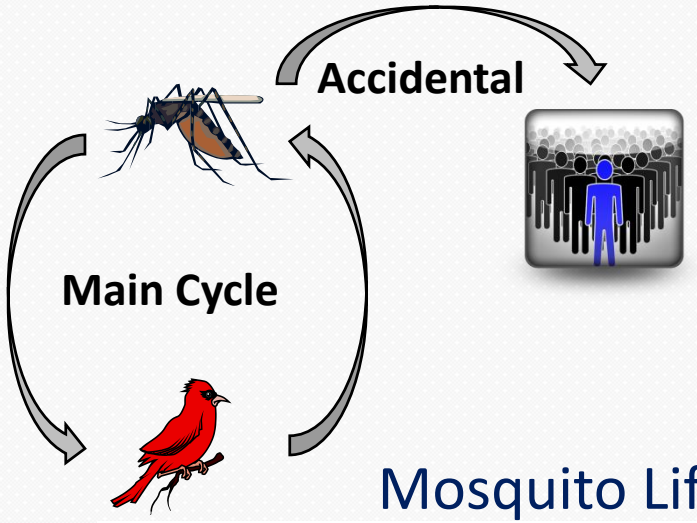
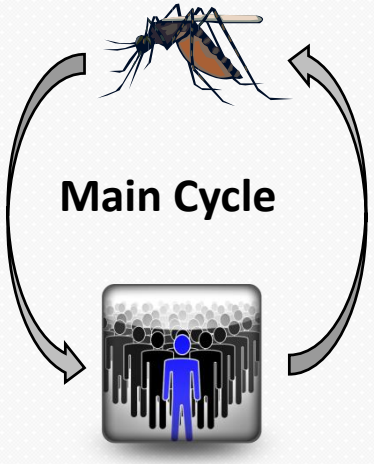
Mosquito-borne Disease Ecology

West Nile Virus



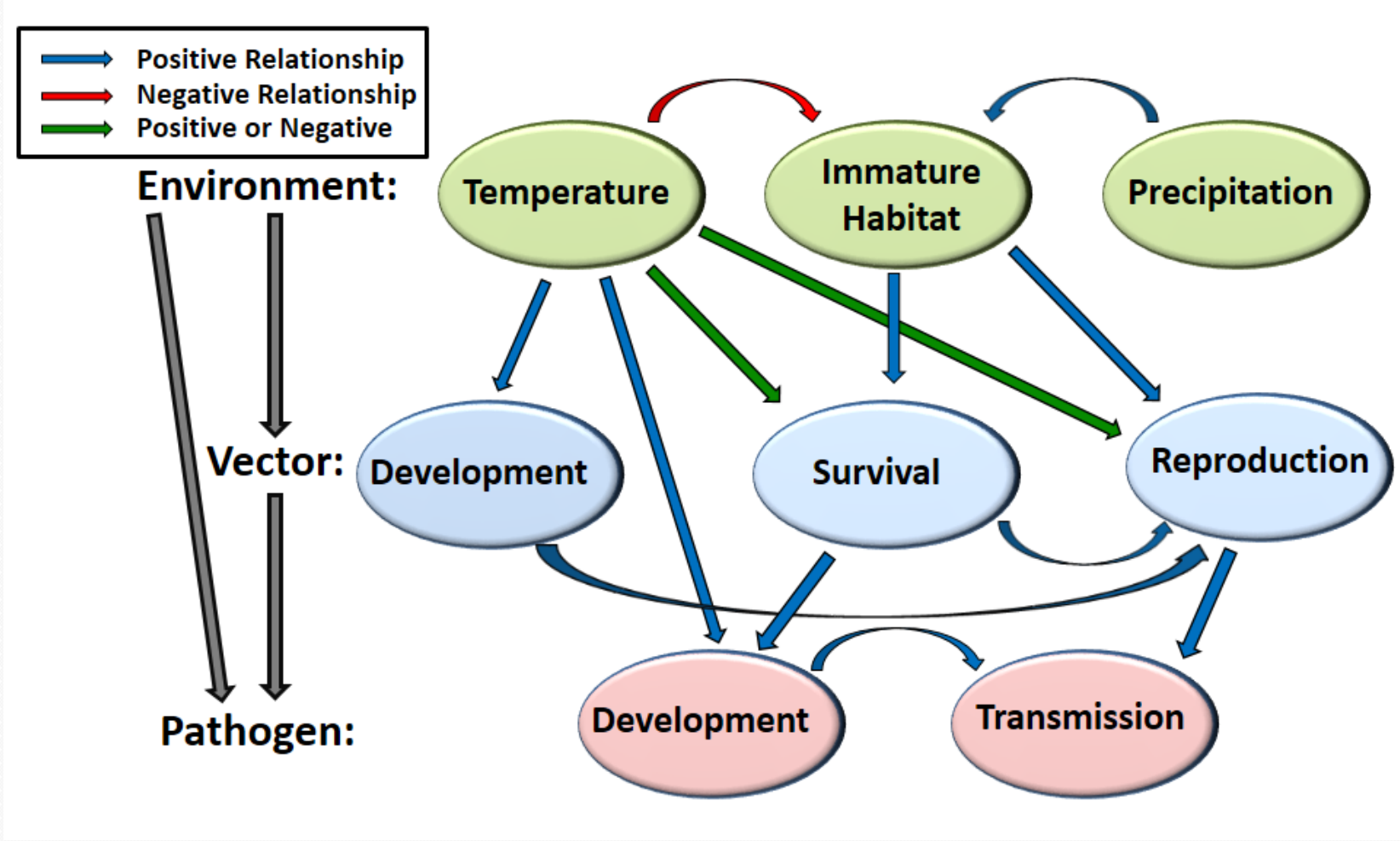
Dengue Virus



- Annually ~96 million cases of disease world wide
- Endogenous transmission in Florida + Texas
- Symptoms: muscle and bone ache, fever, and hemorrhagic manifestations in rare cases
- 4 serotypes of virus

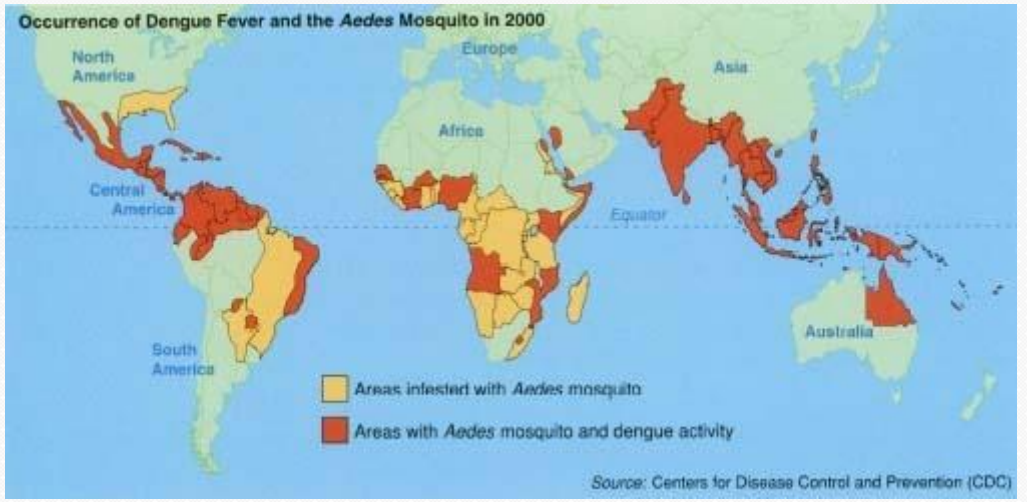
Mosquito Life Cycle

Environment - Vector - Virus Connections



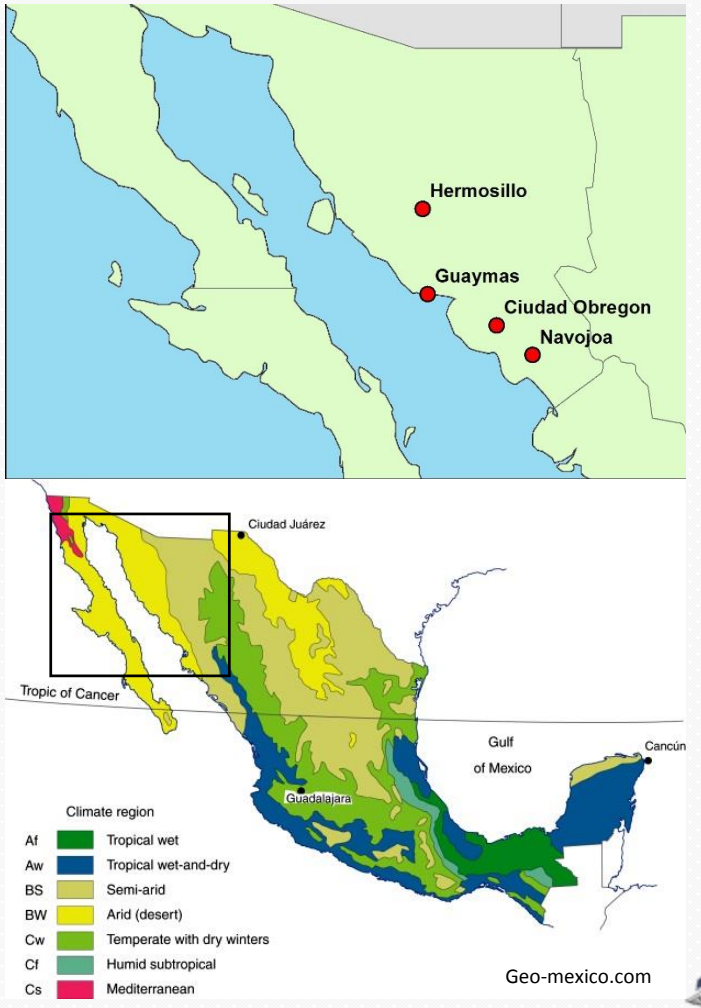
Modeling Dengue Fever in Sonora, Mexico

- Dengue ecology
  - Mosquito population dynamics
  - Virus transmission dynamics
- *Aedes aegypti* mosquitoes
  - Urban, container breeding
  - Live in tropical habitats
  - Anthropophilic
- Sonora Mexico
  - Arid climate
  - Monsoon precipitation
  - Seasonal cycles of dengue transmission
  - Large annual variations in epidemics



Data and Methods

- Study area
  - 4 sites in Sonora, Mexico
- Meteorological/Dengue case data
  - Daily maximum and minimum temperatures (NLDAS)
  - Daily precipitation (TRMM, NLDAS)
  - Weekly suspected dengue cases by city 2006-2011
- Model
  - Parameterized for *Aedes aegypti* mosquitoes, daily time step
  - Run from 2005-2011 under varying parameters (500)
  - Best 3% of runs chosen by comparison with suspected case data (R^2)

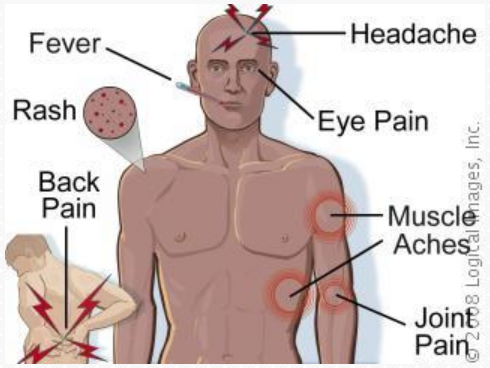


Model Parameter Estimation

- Containers
  - Based on household surveys (Hermosillo)
  - Human managed and open containers
  - Used mean values and +/- 25% and 50%


Mosquitoeater.com


beingalison.com



- Minimum infectious rate
  - Minimum amount of infectious humans
  - Maintains virus within the population
  - Based on case data and previous study in San Juan, PR

- Maximum larval density
  - Used to calculate density-dependent mortality
  - Based on observations, literature, and previous study in San Juan, PR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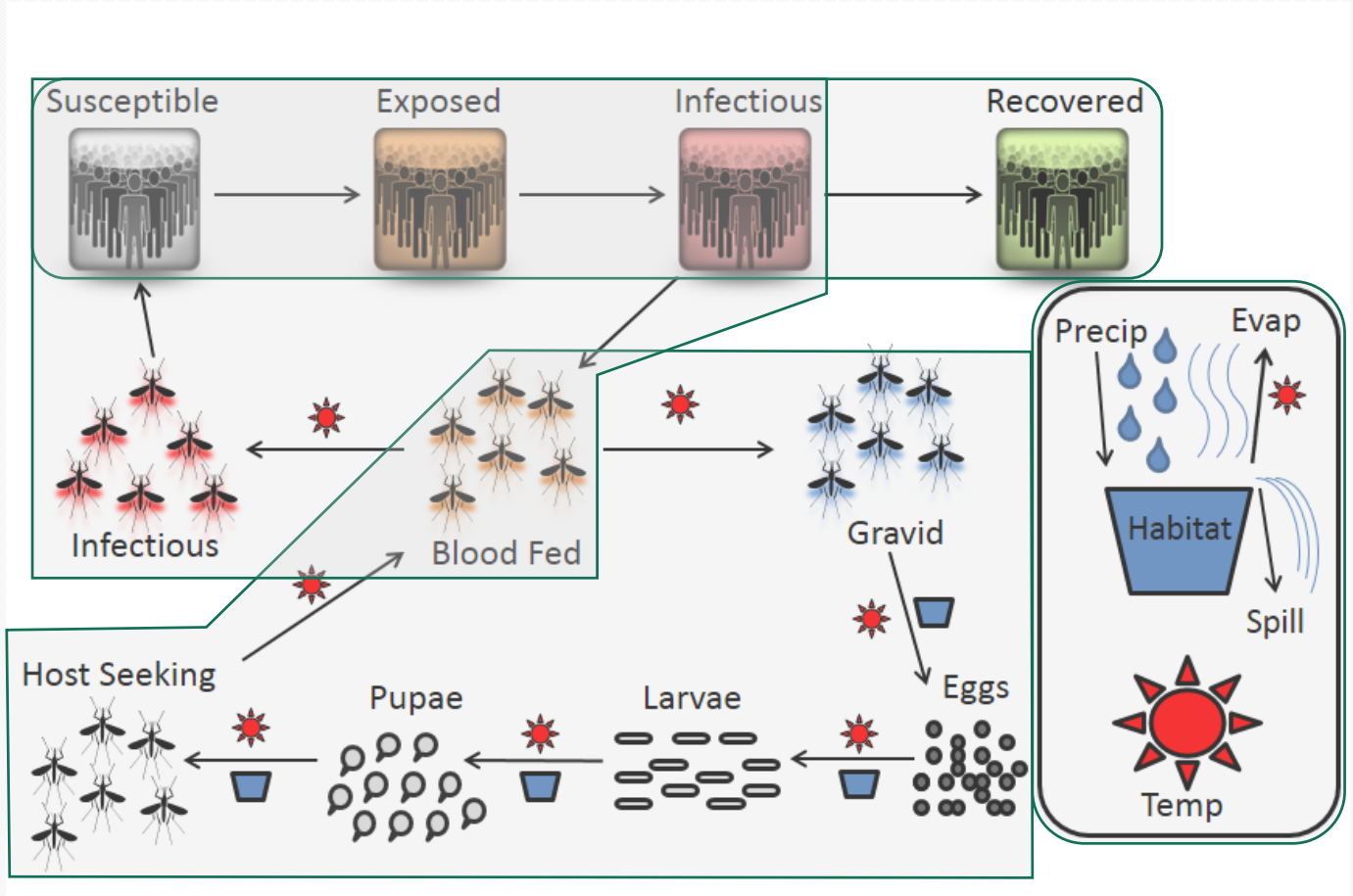
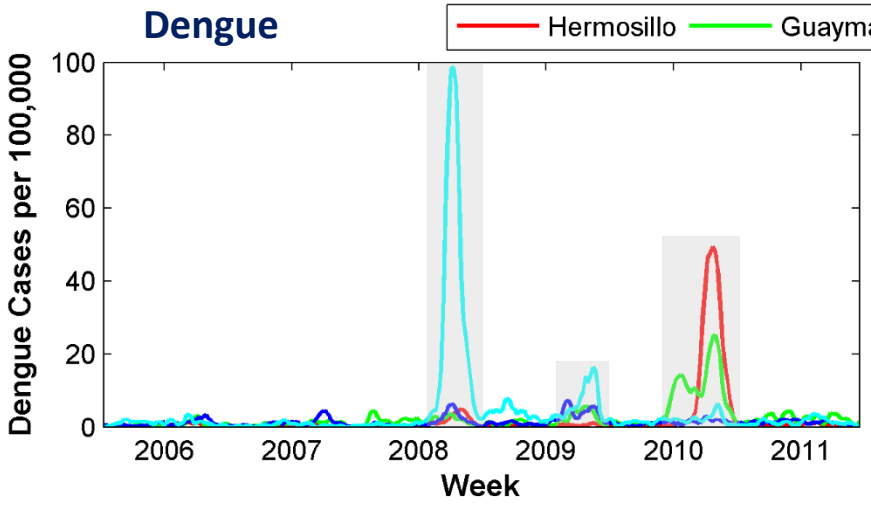
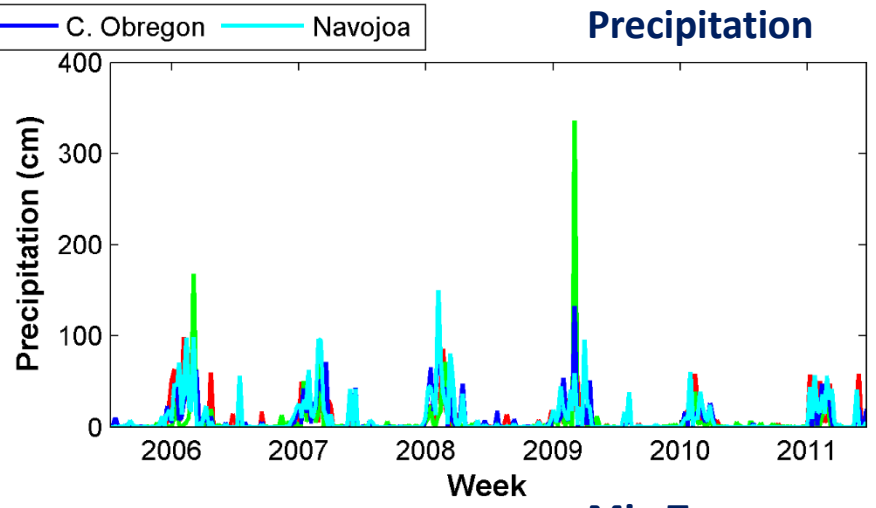
Modeling *Aedes aegypti* and Dengue Virus Ecology



Dengue and Climate Comparisons

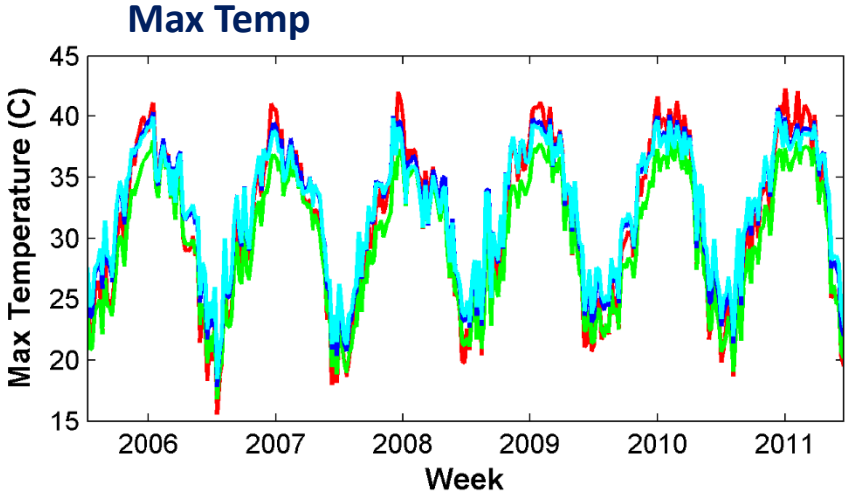
Epidemics asynchronous

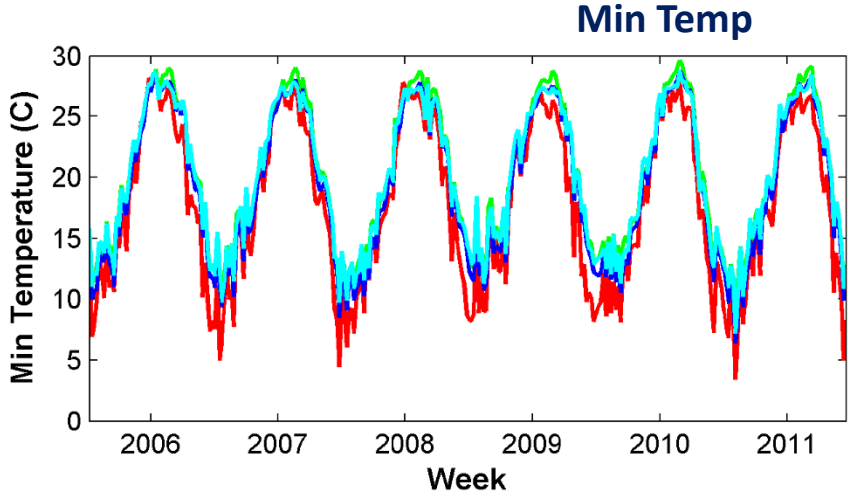




Variable

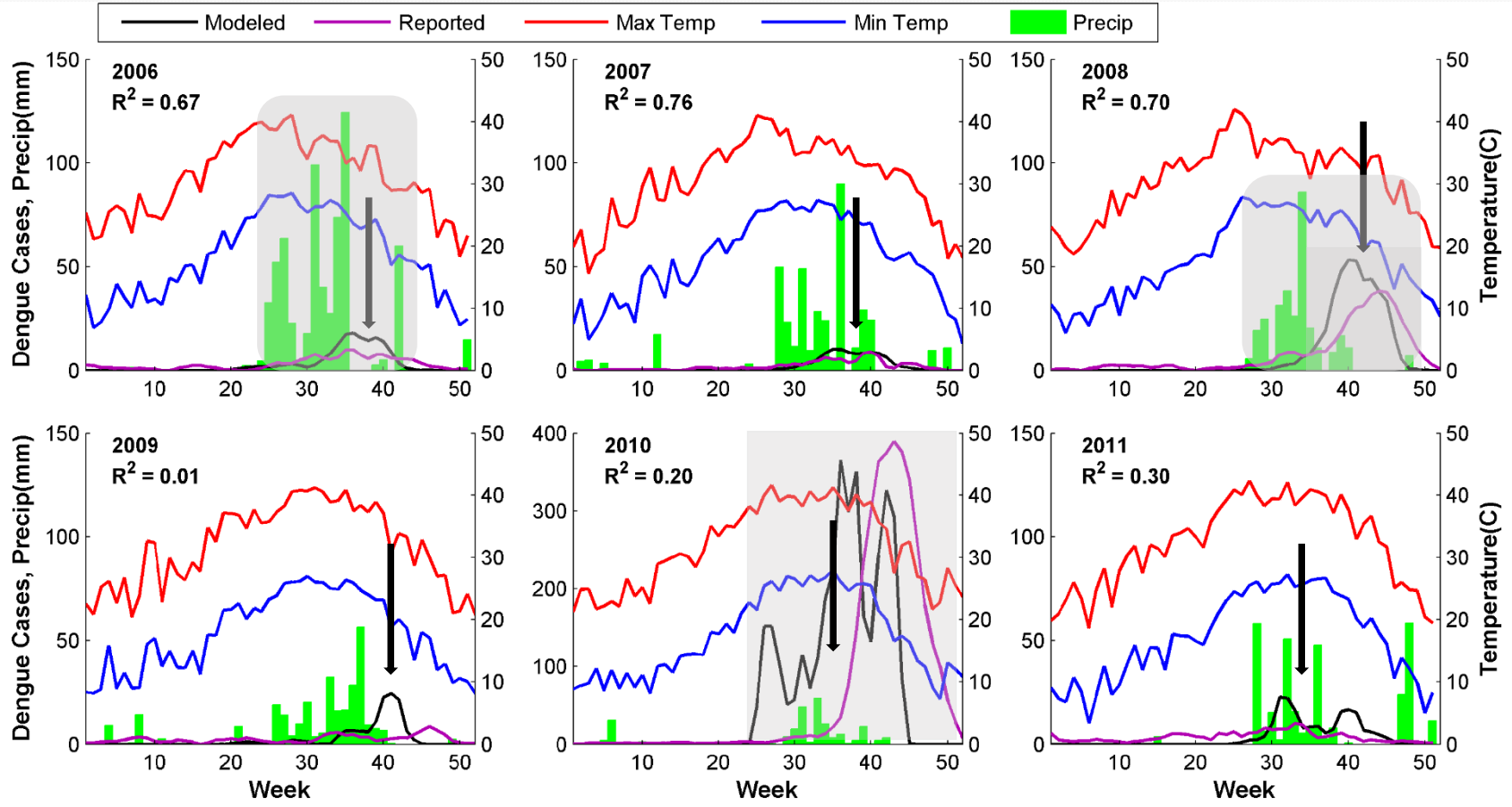
Very Similar

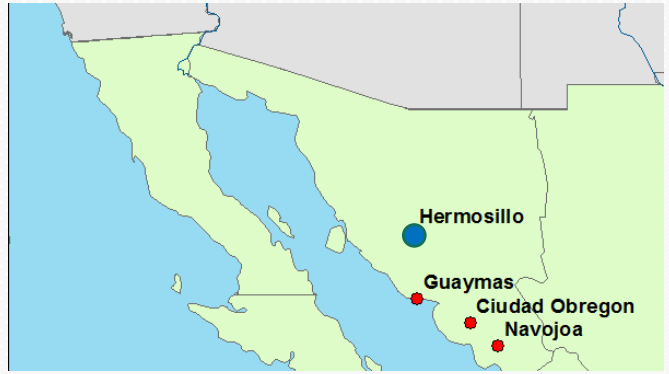




Very Similar

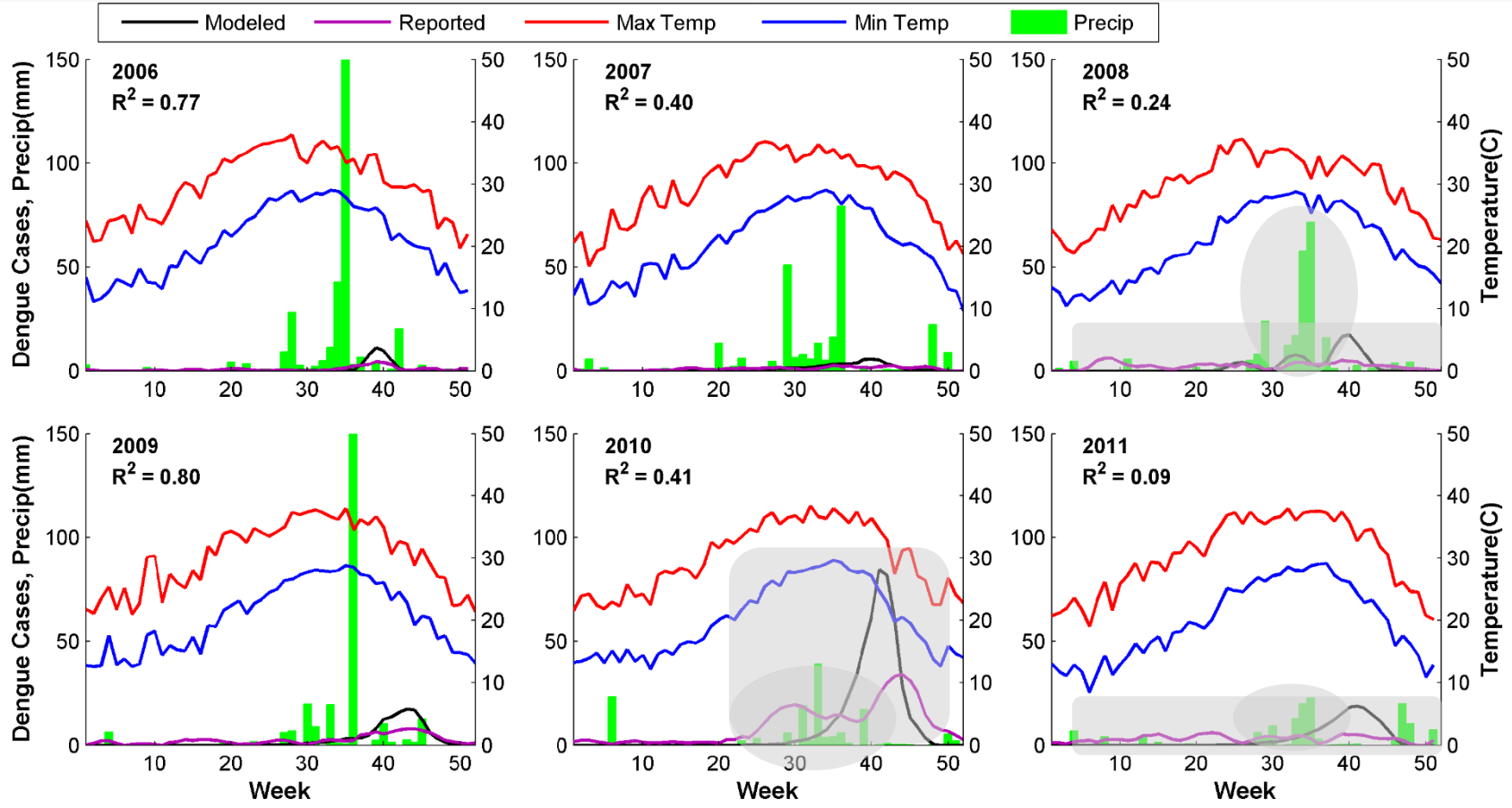
Climate, Dengue, Simulations: Hermosillo

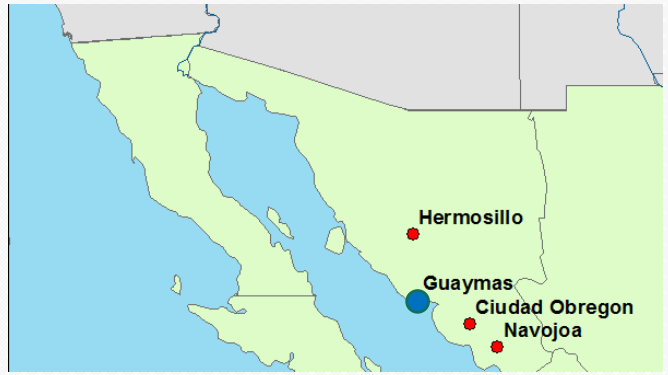




- 2008 and 2010 are largest dengue years
- Epidemics follow monsoon rains
- Precipitation magnitude not correlated with dengue case incidence
  - Introduction rate is likely important

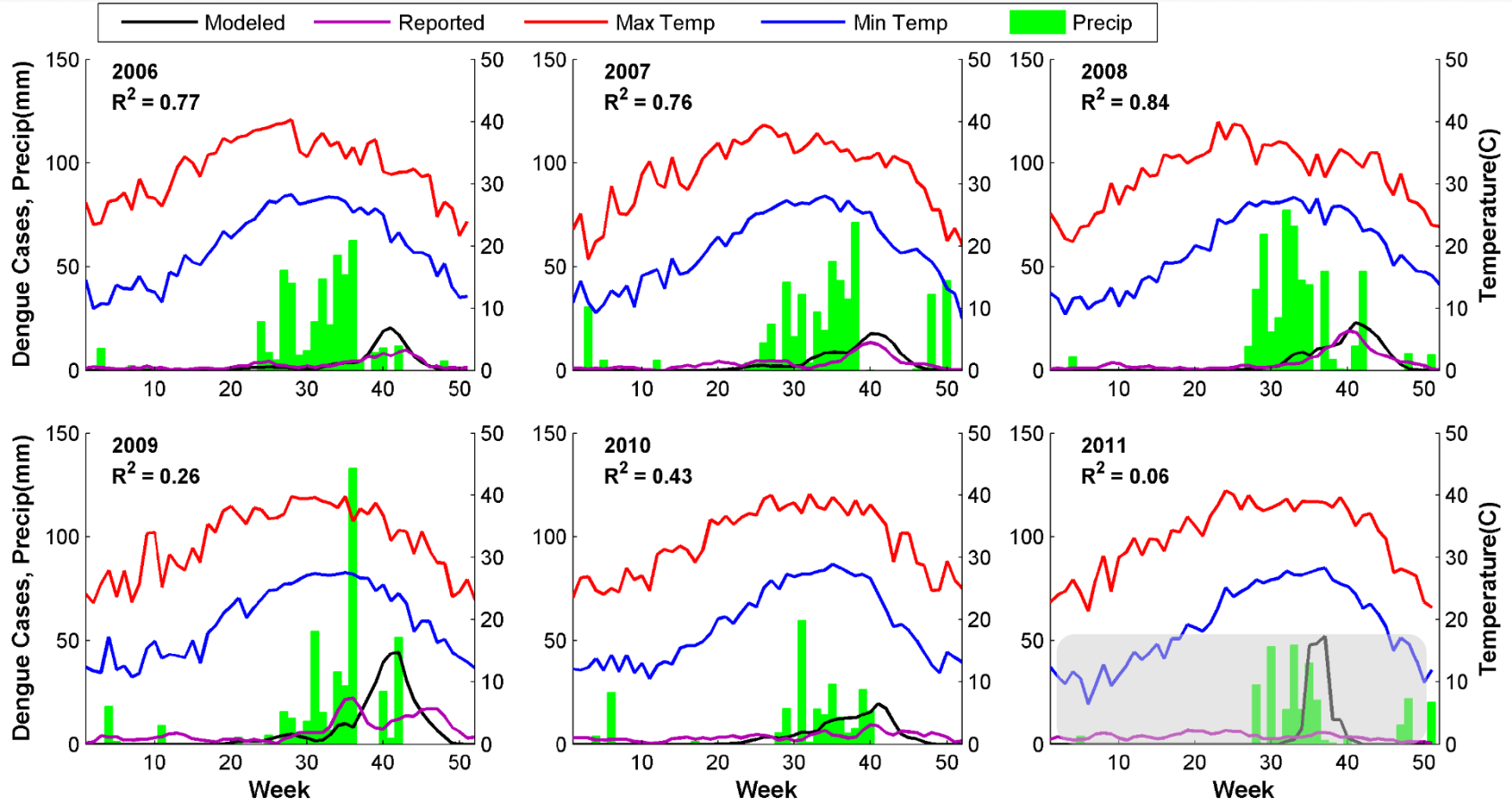
Climate, Dengue, Simulations: Guaymas

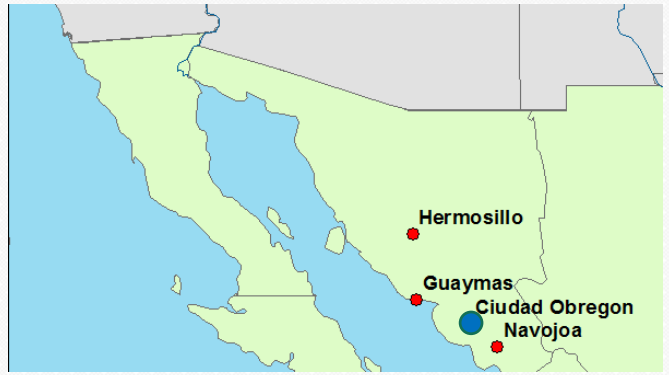




- Dengue is highest in 2010 despite dry conditions
  - Similar to Hermosillo
- Driest city examined
  - Importance of human managed water sources
- Model has difficulty simulating seasons with no peak
  - 2008 + 2011

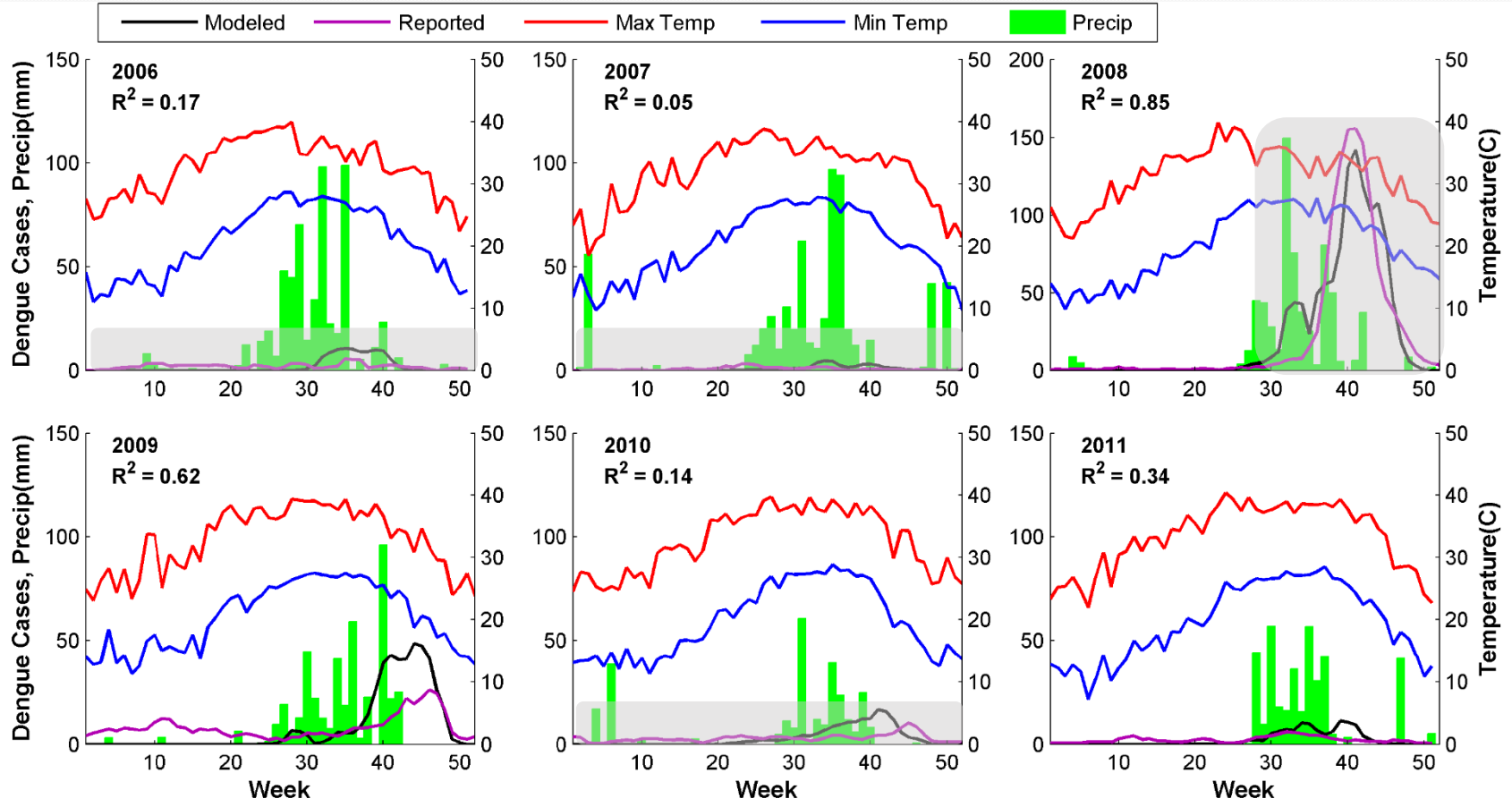
Climate, Dengue, Simulations: C. Obregon

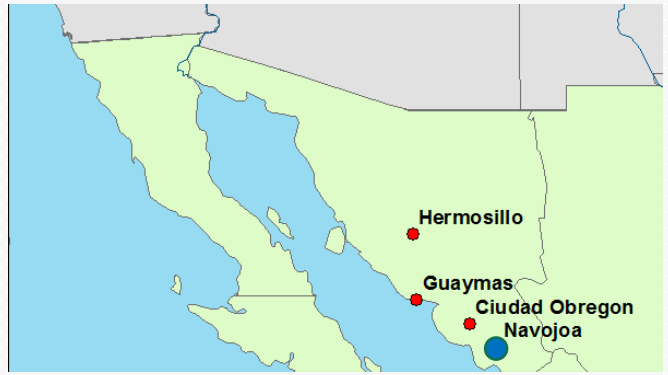




- Lowest annual variability in dengue cases
- Model has difficulty simulating seasons with no peak
  - 2011

Climate, Dengue, Simulations: Navojoa

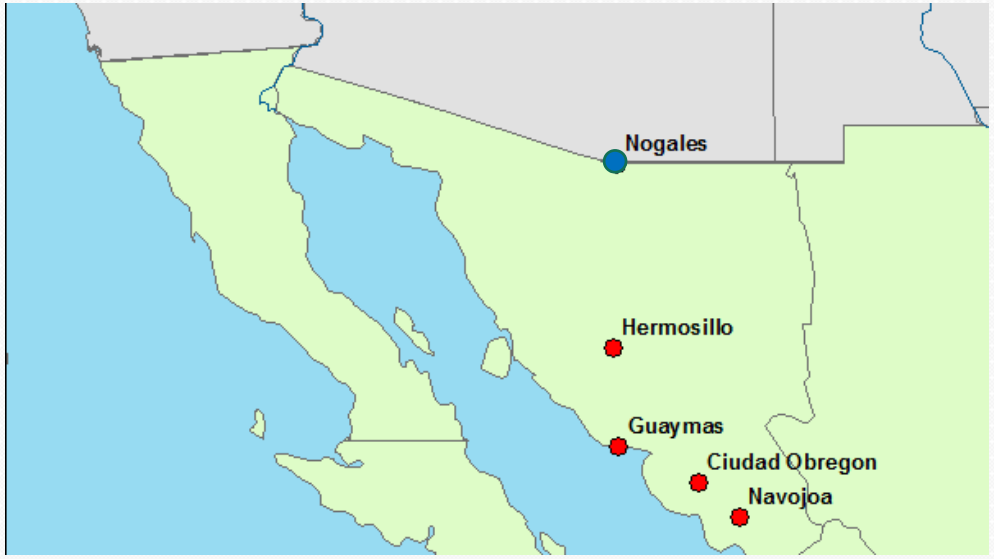




- 2008 is highest dengue year
- Dengue transmission is low in 2010
  - Unlike Hermosillo and Guaymas
- Model has difficulty simulating seasons with no peak
  - 2006, 2007, and 2010

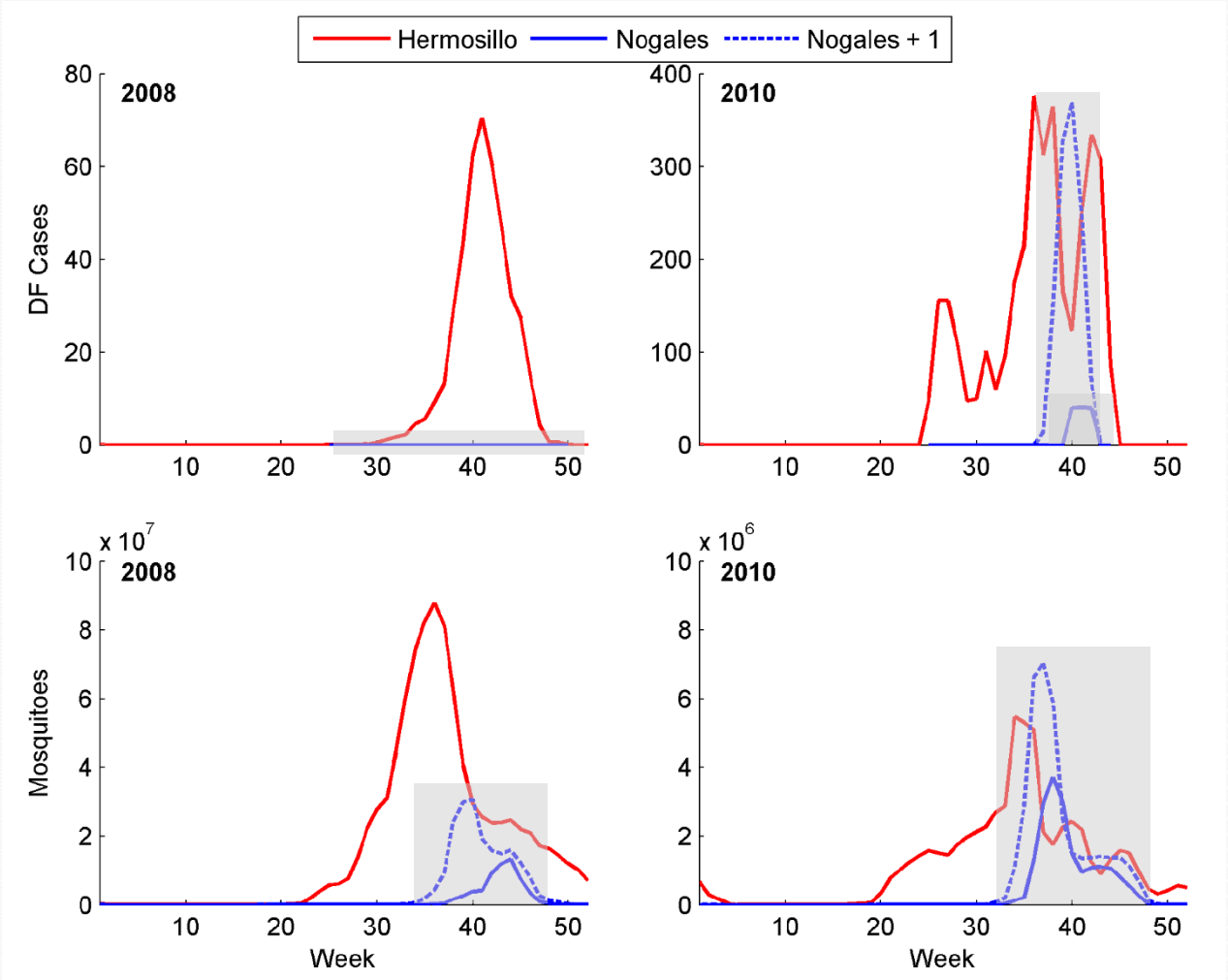
Dengue Transmission in Nogales

- Why is there little/no dengue transmission in nearby Nogales?
- Hypothesis: Climate conditions are cooler
  - Suppression of mosquito population
  - Extension of extrinsic incubation period (EIP)



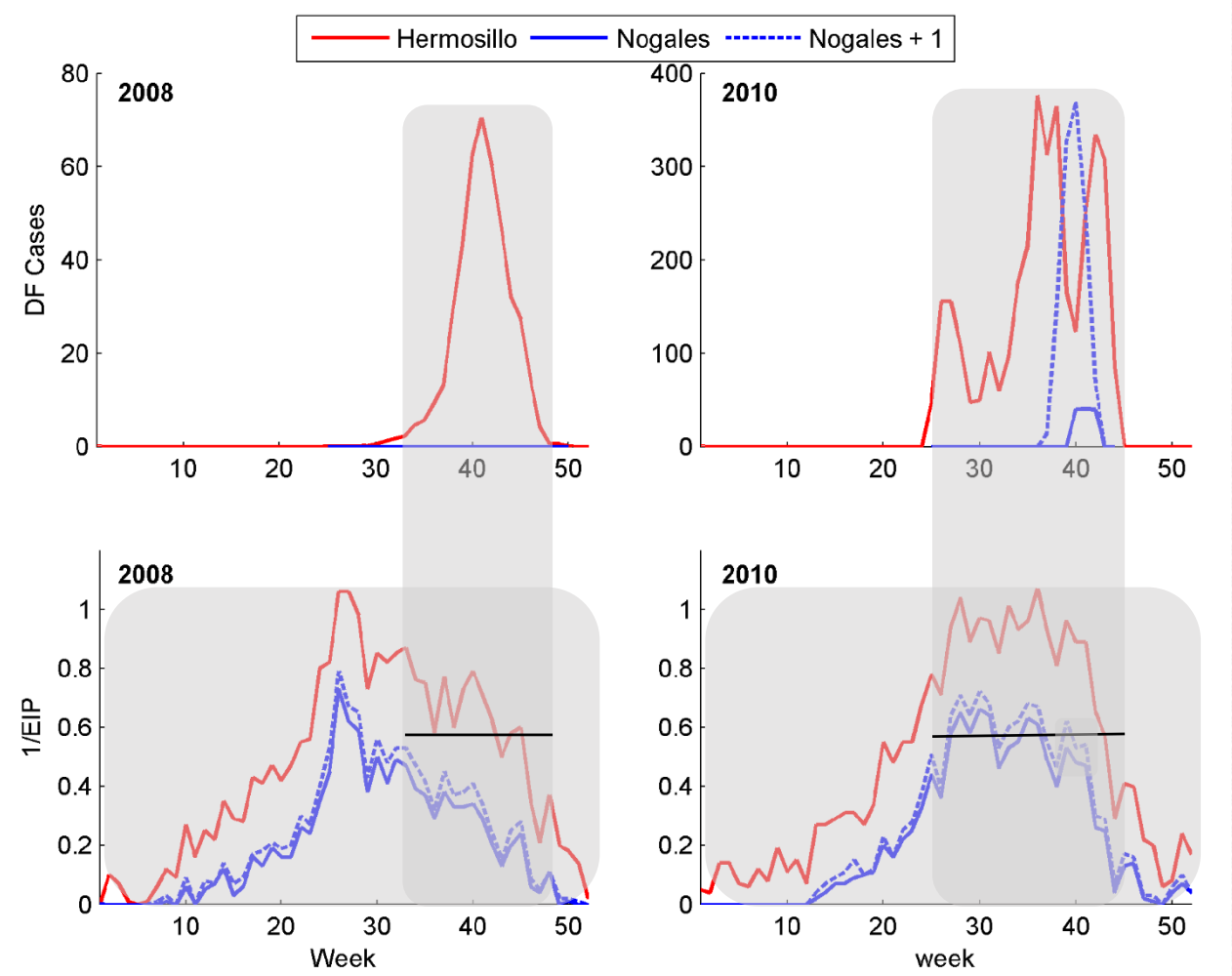
- Experiments:
  - 1: Rerun Hermosillo simulations with Nogales meteorological data
  - 2: Perform experiment 1 with 1°C warming
  - Performed during large epidemic years (2008 and 2010)

Hermosillo/Nogales Comparison: Mosquitoes



- Little/no dengue is simulated under Nogales meteorological conditions
- With warming, there is a modest mosquito population increase in 2008
  - No dengue
- With warming, the mosquito population is higher under Nogales conditions in 2010
  - Results in increased virus transmission

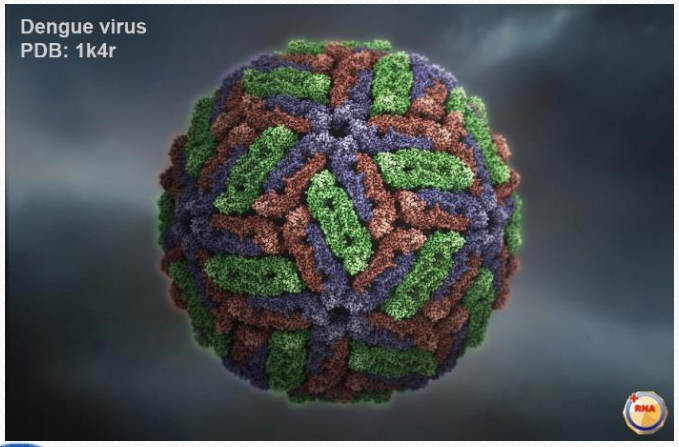
Hermosillo/Nogales Comparison: EIP



- EIP is considerably longer under Nogales conditions
- Under Nogales conditions, the EIP is longer during the transmission season in 2008
  - Prevents completion of EIP during mosquito lifetime
- EIP shortened under 1°C warming conditions
  - Especially during transmission season

Challenges in Climate and Health Research

- Reporting problems
  - Misdiagnosis
  - Subclinical cases
  - Reporting errors/bias
  - Availability of data



- Knowledge gaps
  - Incubation periods
  - Transmission probabilities
  - Evolution and adaption of virus and human immunity

- Human vs. climate influences
  - Socioeconomic status
  - Microclimatic influences
  - Human adaptions to climate

Conclusions

- Nearby locations can exhibit very different patterns of dengue transmission
  - Differences in virus introduction
  - Small climatic differences can make large differences
- Dengue epidemics follows monsoon rains
  - Timing is consistent, however, the magnitude is not well correlated
- Climate is an important regulator of dengue transmission in Nogales
  - Affects mosquito population dynamics and the virus incubation period
  - Year to year variability is important
- Dengue transmission dynamics in northern Mexico may affect dengue risk in the United States
  - Travel, climate change
  - Recent dengue epidemic in Nogales

Next Steps

- Run model for additional locations along US/Mexico border
  - Does transmission vary?
  - Why?
- Perform fine scaled model runs
  - How does risk vary within a city?
- Consider socioeconomic conditions in model

Thank You for Your Attention!

Questions?