Simulated Transmission of the Dengue Virus across the US-Mexico Border Using Remotely Sensed and Ground Based Weather Data

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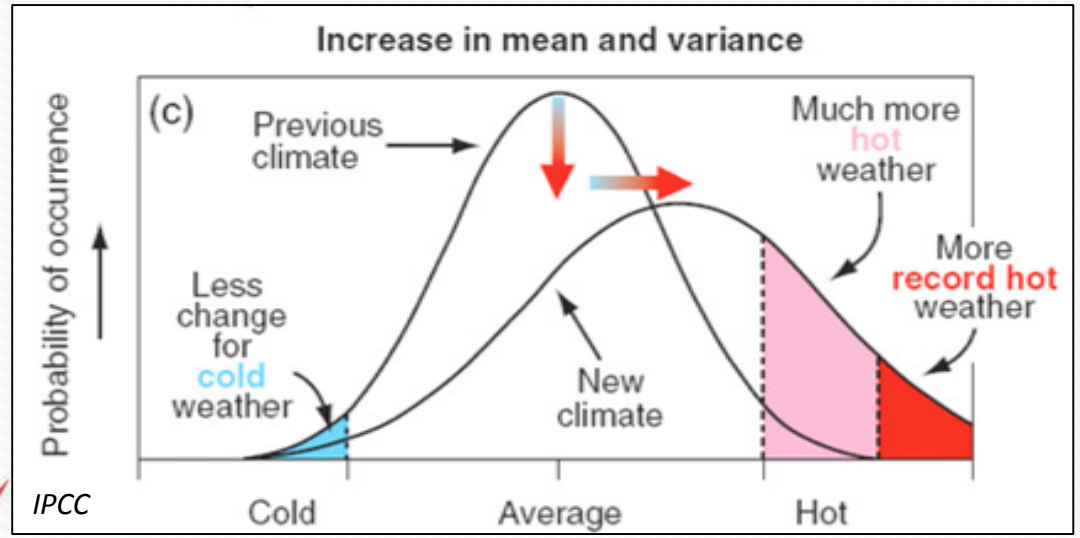
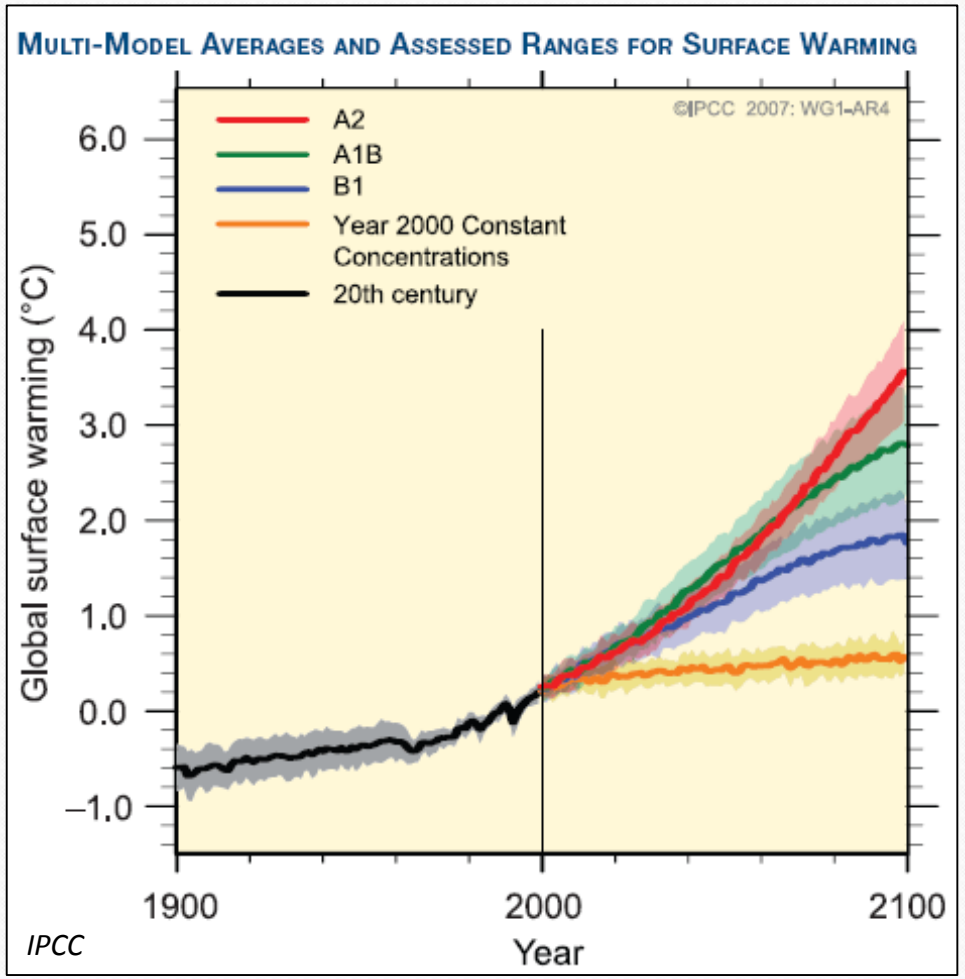
www.vectorbase.org

Climate Variability and Change

- Shift in mean and variance of current conditions
- Increase in frequency of extreme conditions



IPCC

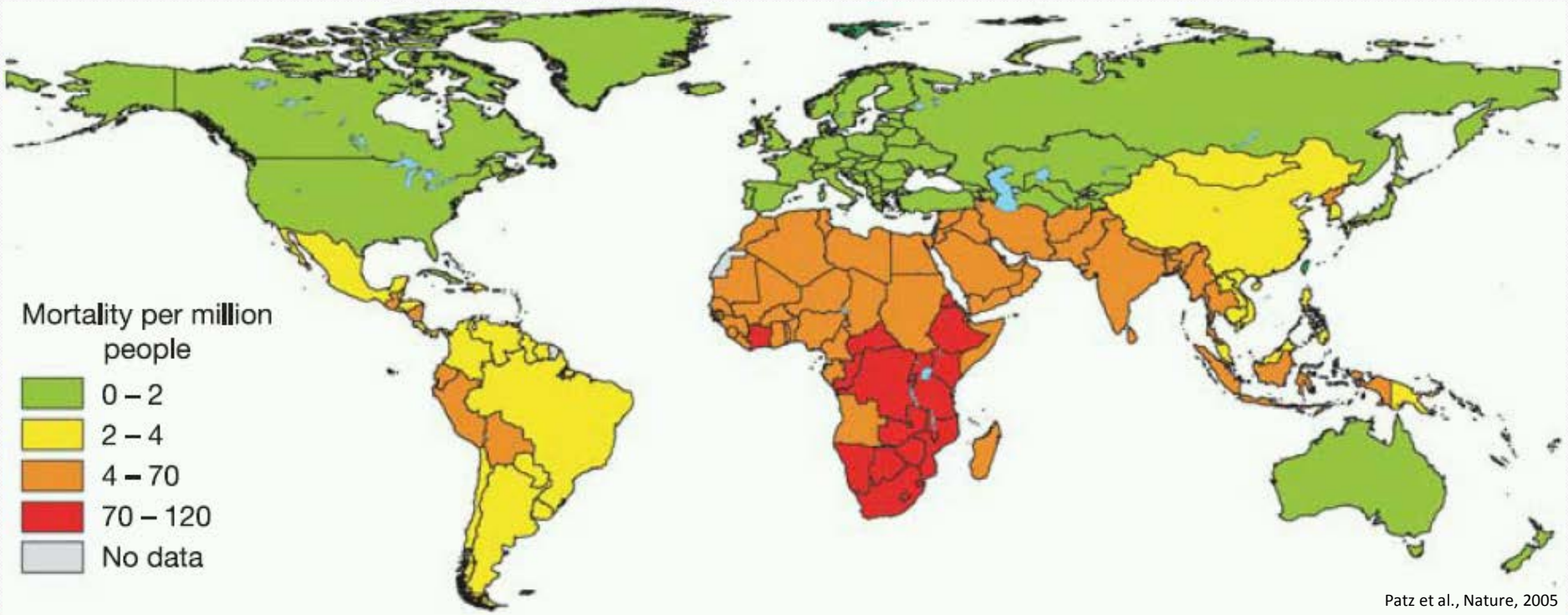


IPCC

Climate Change Deaths

- 150,000 lives annually over last 30 years (WHO)
- Who & where? How & why?

WHO estimated mortality attributable to climate change by the year 2000



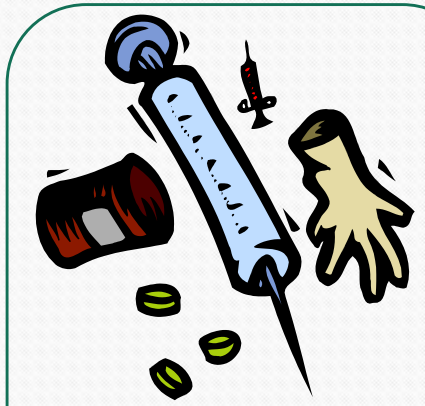
Patz et al., Nature, 2005

Climate Effects on Human Health

Extreme Temperatures

Extreme Weather

- Flooding
- Hurricanes
- Tornadoes



Pathogens

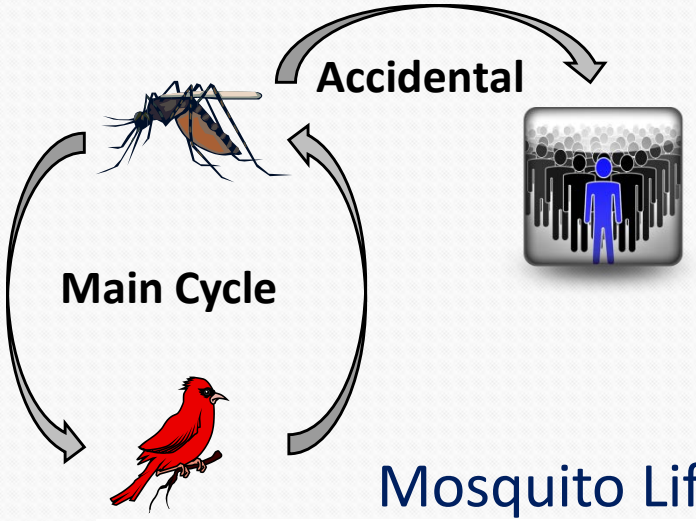
- Vector-borne
- Water-borne
- Air-borne

Air Quality

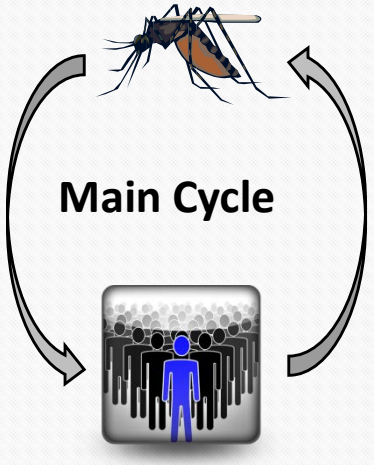
- Pollen
- Ozone
- Particulate Matter

Mosquito-borne Disease Ecology

West Nile Virus



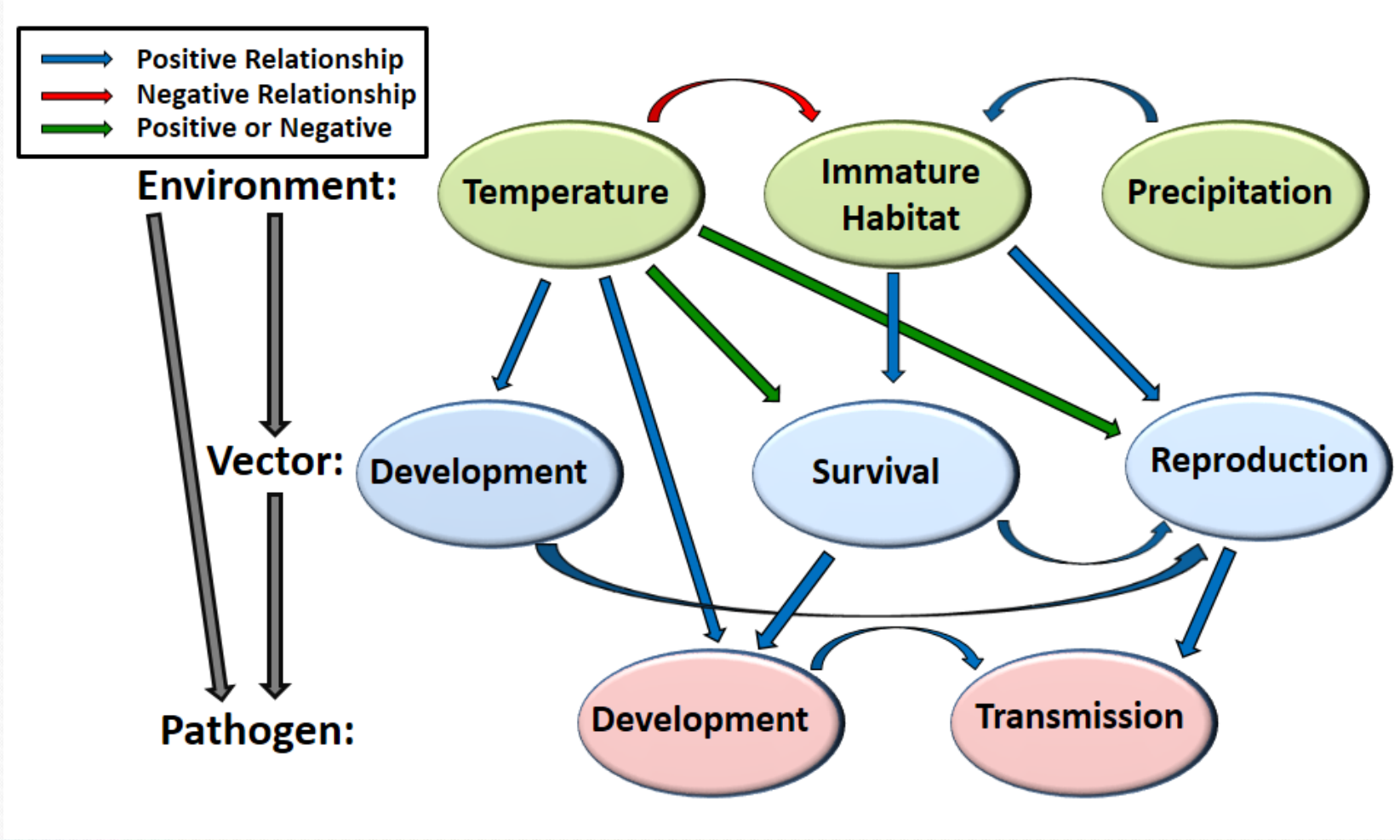
Dengue Virus



- 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

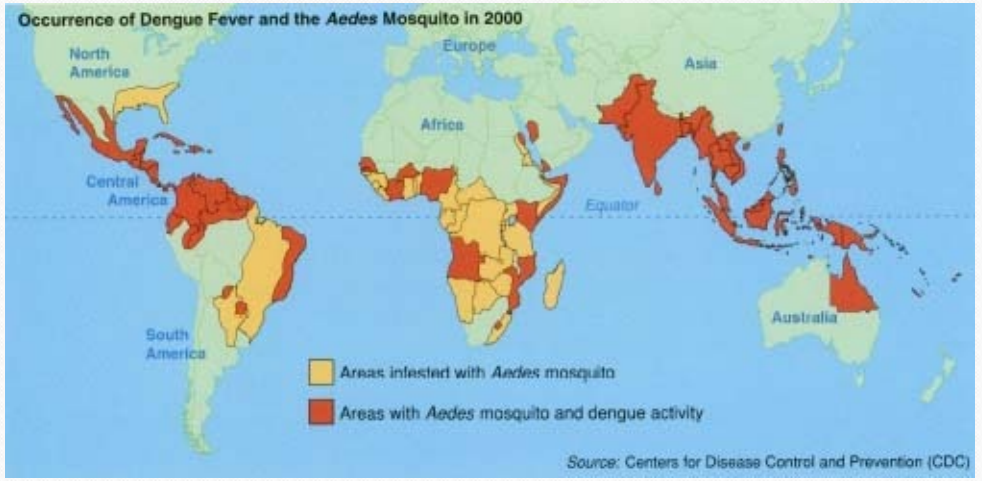
Mosquito Life Cycle

Environment - Vector - Virus Connections



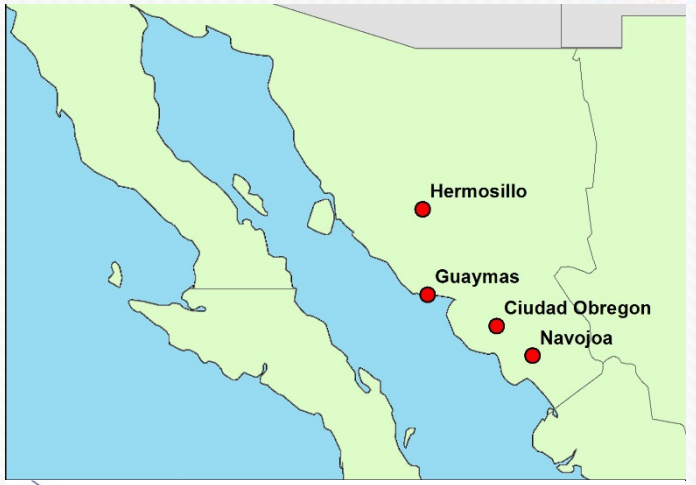
Modeling Dengue Fever in Sonora, Mexico

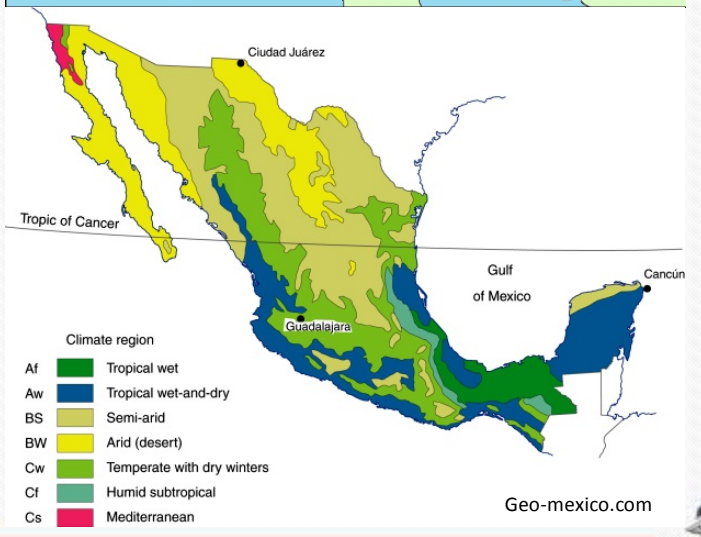
- Vector population are not always reliable measures of transmission risk
  - Added pathogen and human transmission component to the model
- *Aedes aegypti* mosquitoes
  - Urban, container breeding
  - Live in tropical habitats
  - Anthropophilic
- Sonora Mexico
  - Arid climate
  - Monsoon precipitation
  - Seasonal cycles of dengue transmission
  - Large annual variations



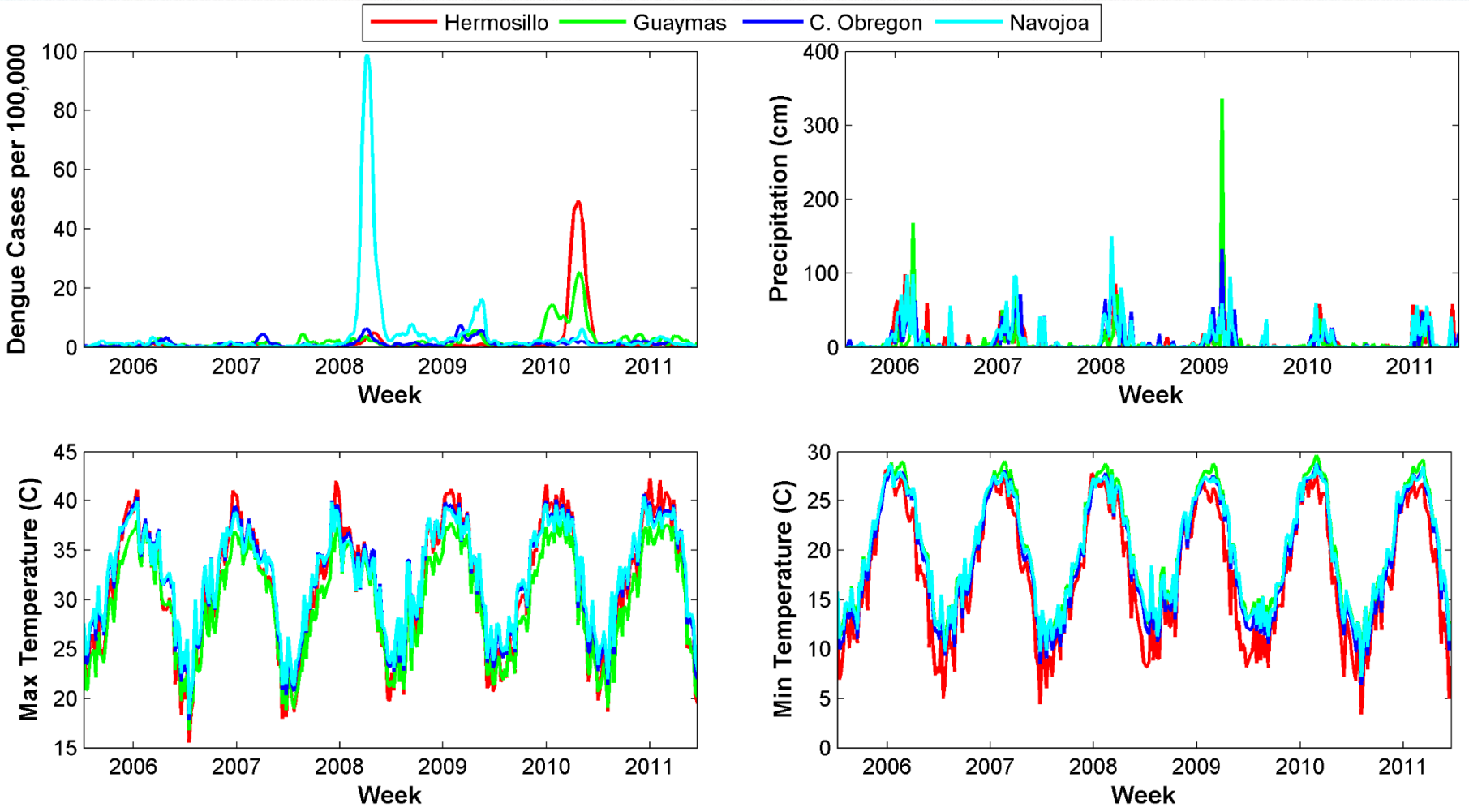
Data and Methods

- Study area
  - 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)

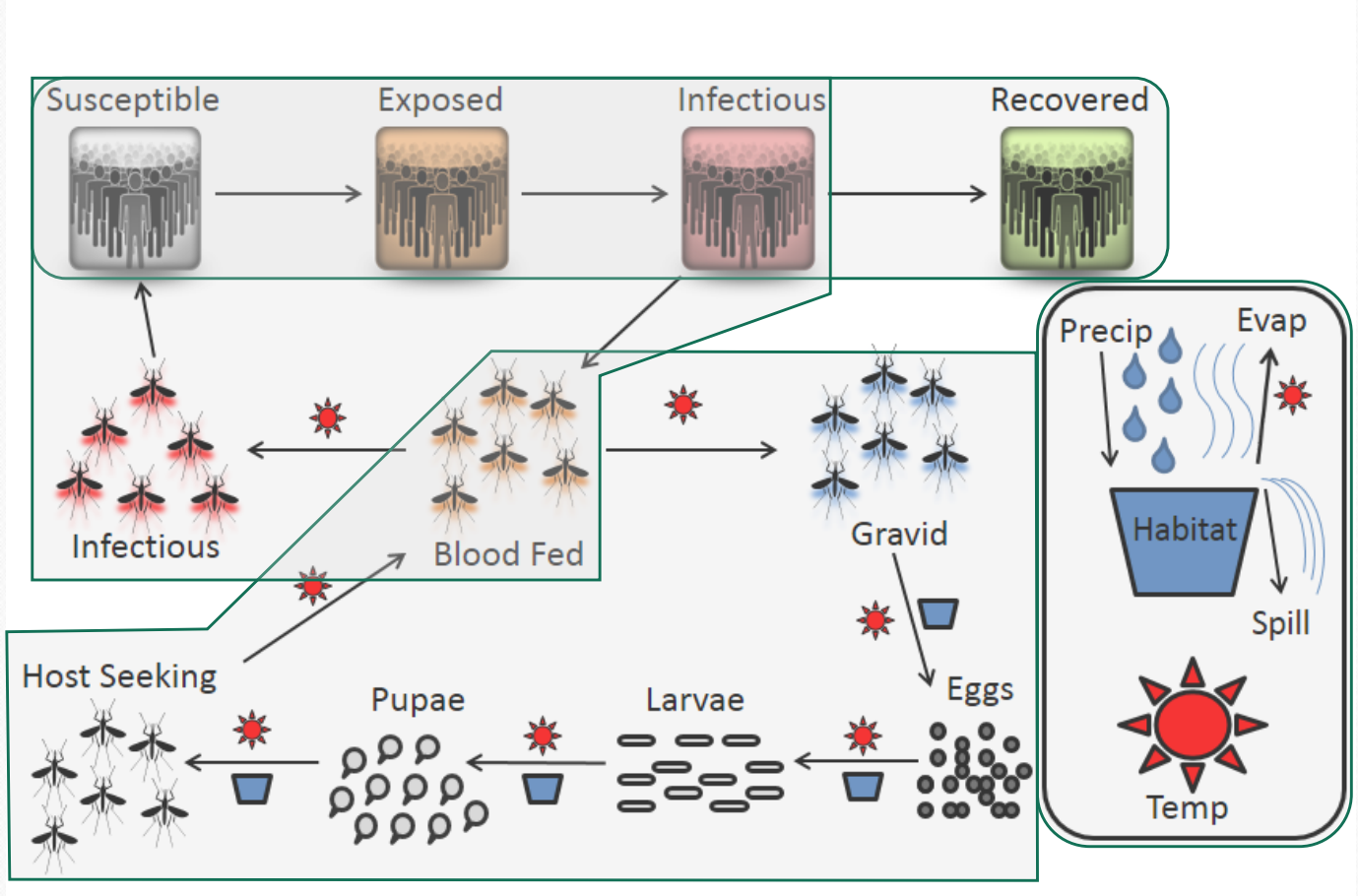




Dengue and Climate Comparisons



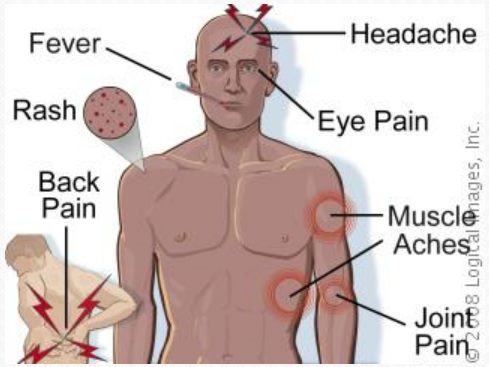
Modeling *Aedes aegypti* and Dengue Virus Ecology



Model Parameter Estimation

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

Mosquitoeater.com beingalison.com

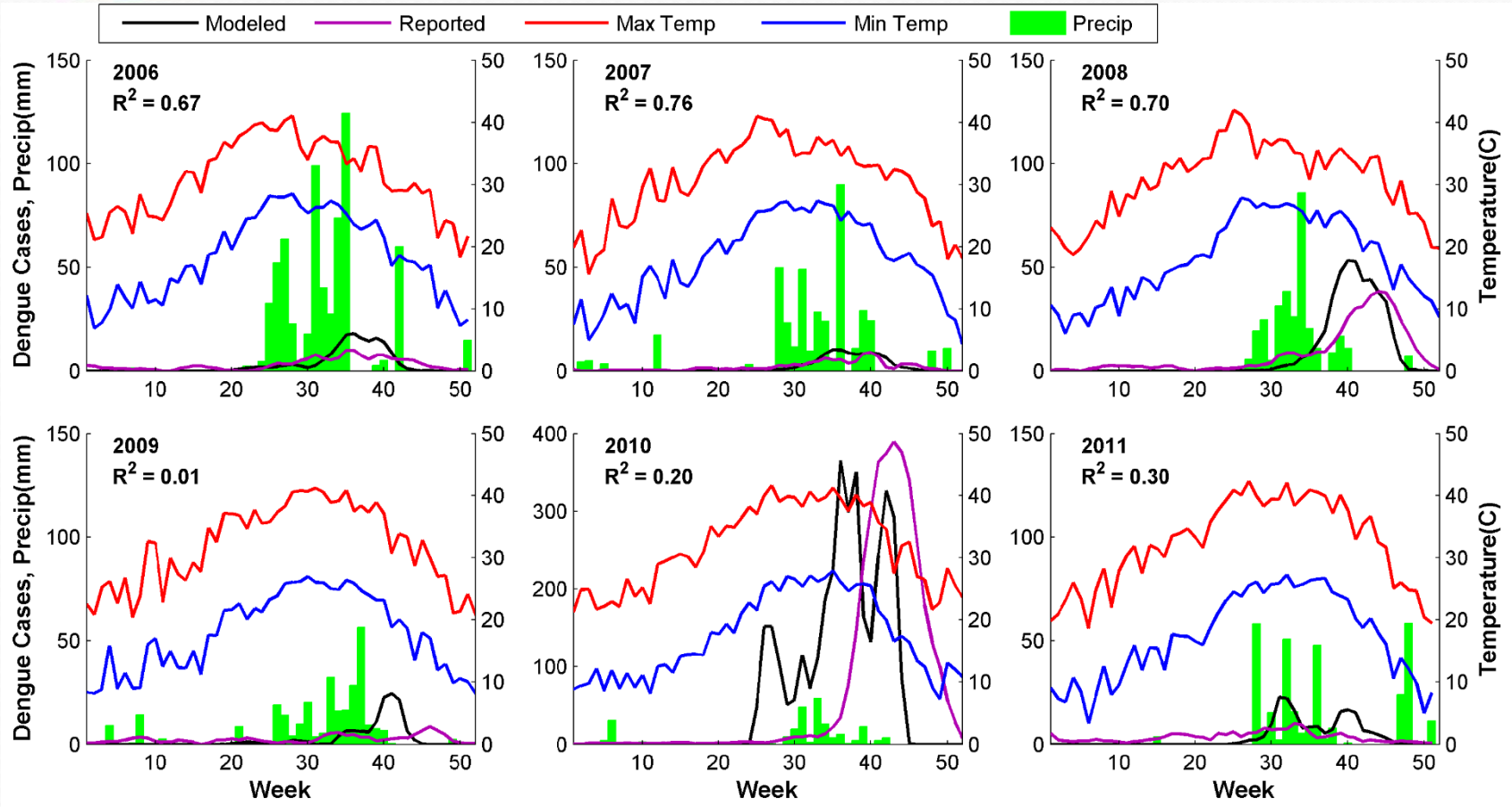


- Minimum infectious rate
  - Minimum amount of infectious humans
  - Maintains virus within the population
  - Based on case data and previous study in San Juan, PR

- Maximum larval density
  - Used to calculate density-dependent mortality
  - Based on observations, literature, and previous study in San Juan, PR

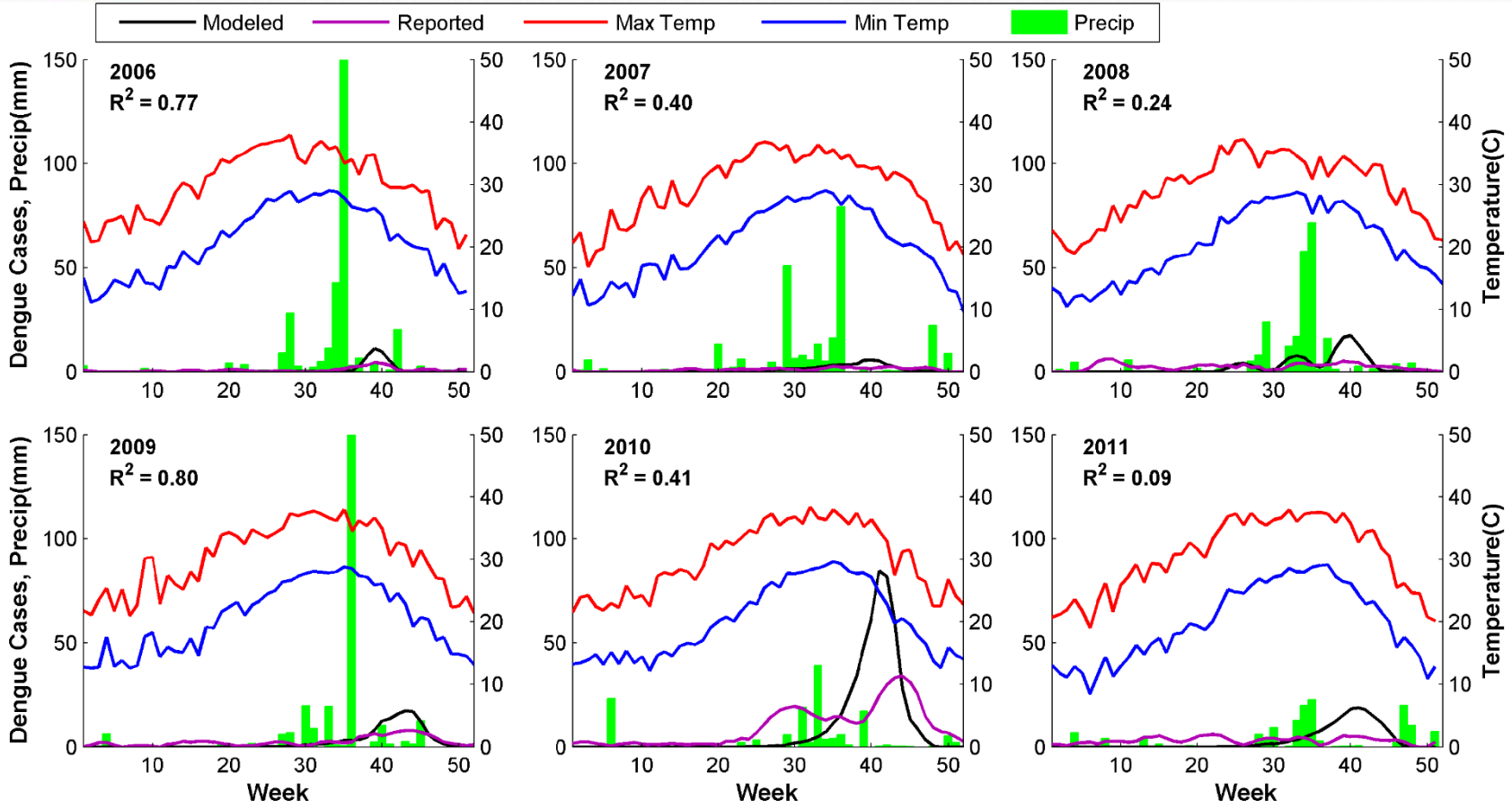
answers.yahoo.com

Climate, Dengue, Parameters: Hermosillo



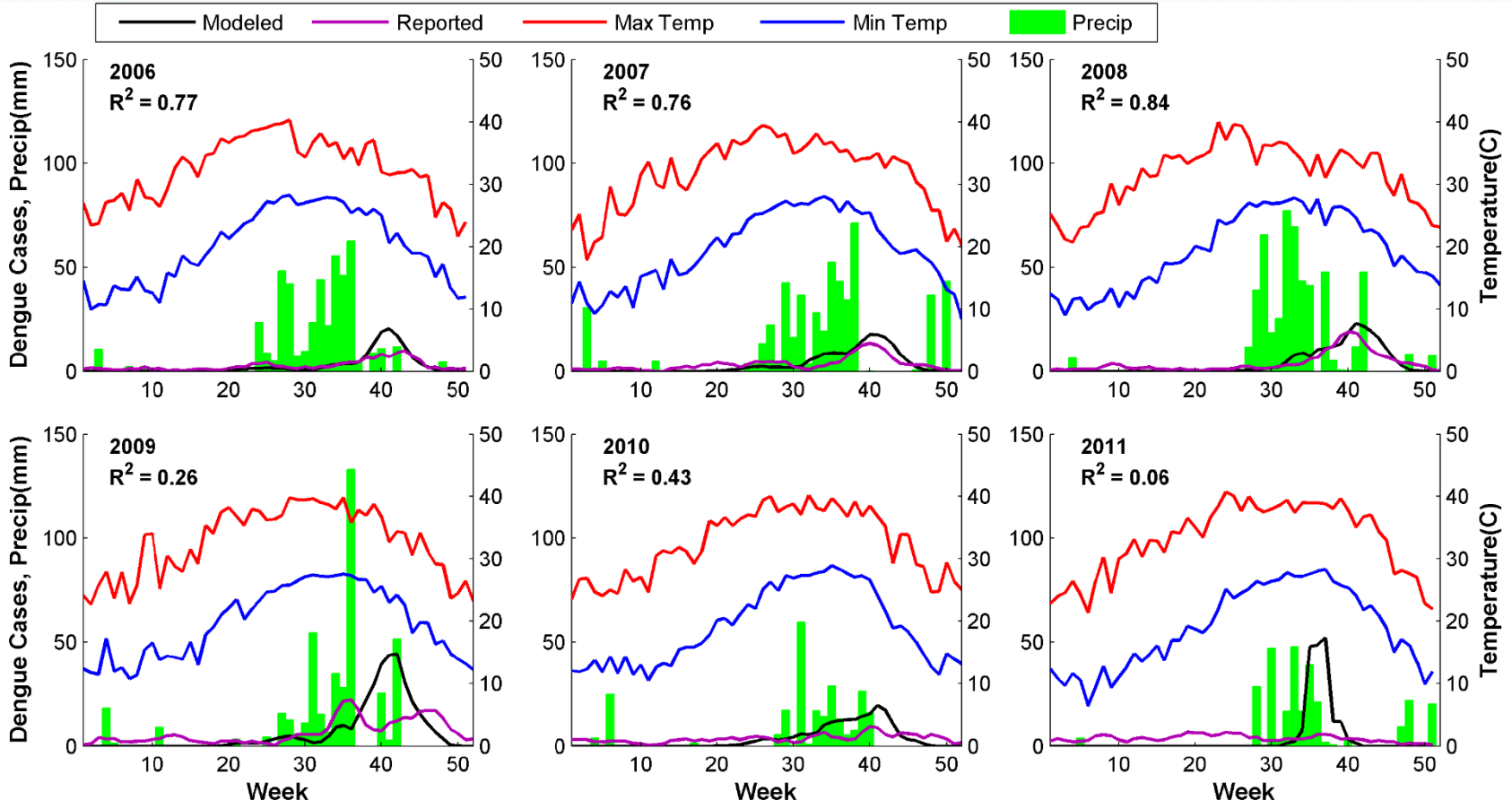
- 2008 and 2010 are largest dengue years
- Generally epidemics follow monsoon rains
- Precipitation magnitude has little influence on dengue magnitude
- Introduction from nearby areas is likely important

Climate, Dengue, Parameters: Guaymas



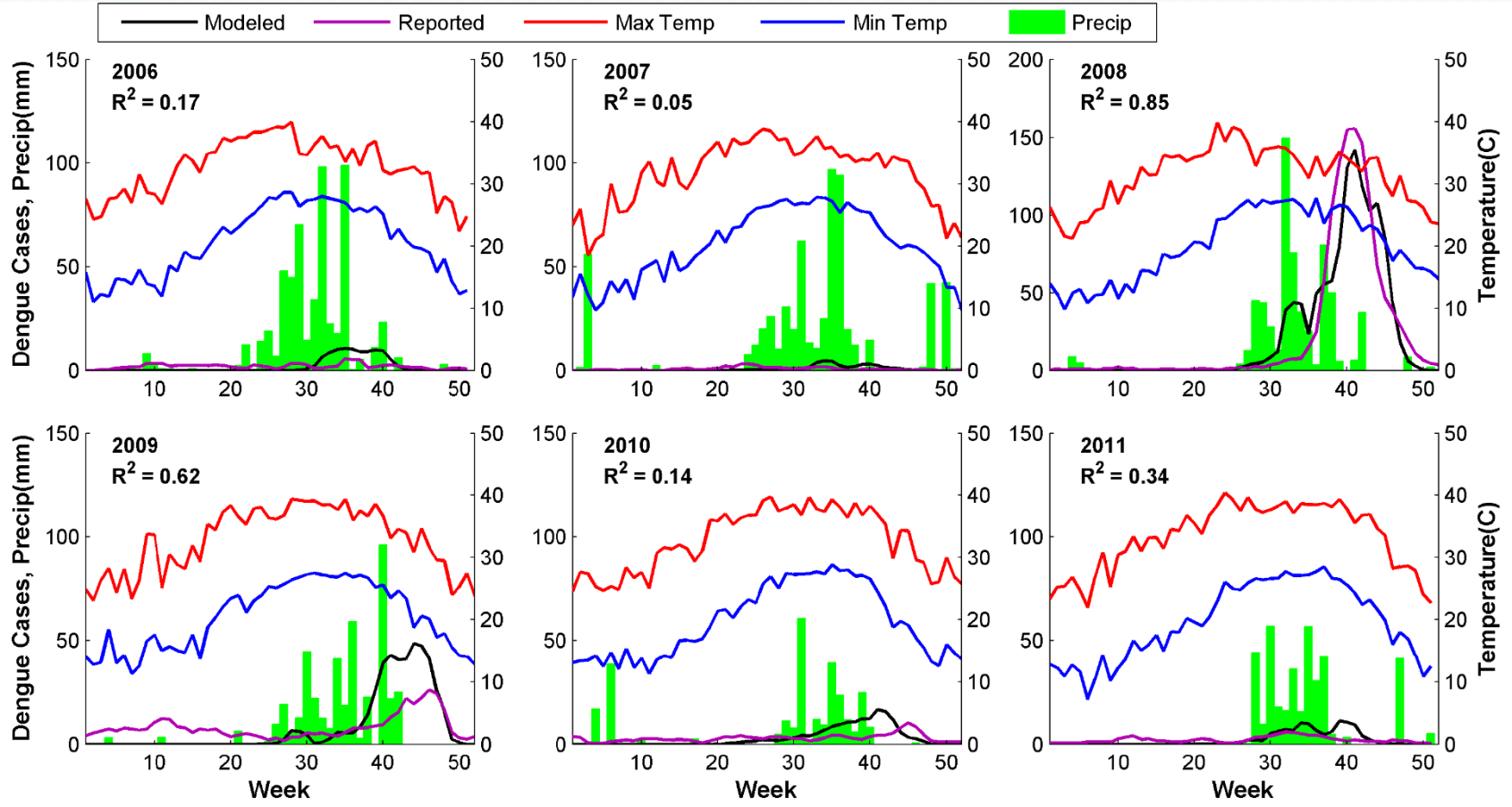
- Dengue is highest in 2010 despite dry conditions
  - Similar to Hermosillo
- Driest of the modeled cities
  - Importance of human managed water sources
- Model has difficulty simulating years without a seasonal peak
  - 2011

Climate, Dengue, Parameters: C. Obregon



- No particularly high dengue years
- Least annual variability in dengue cases
- Unable to model low dengue cases in 2011

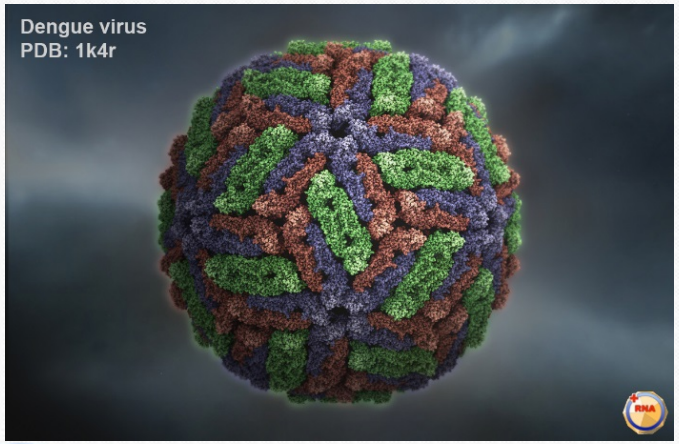
Climate, Dengue, Parameters: Navojoa



- 2008 is the highest dengue year
- Unlike Hermosillo and Guaymas, dengue transmission in 2010 is low
- Model has difficulty simulating low dengue years
  - Randomness

Challenges in Climate and Health Research

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

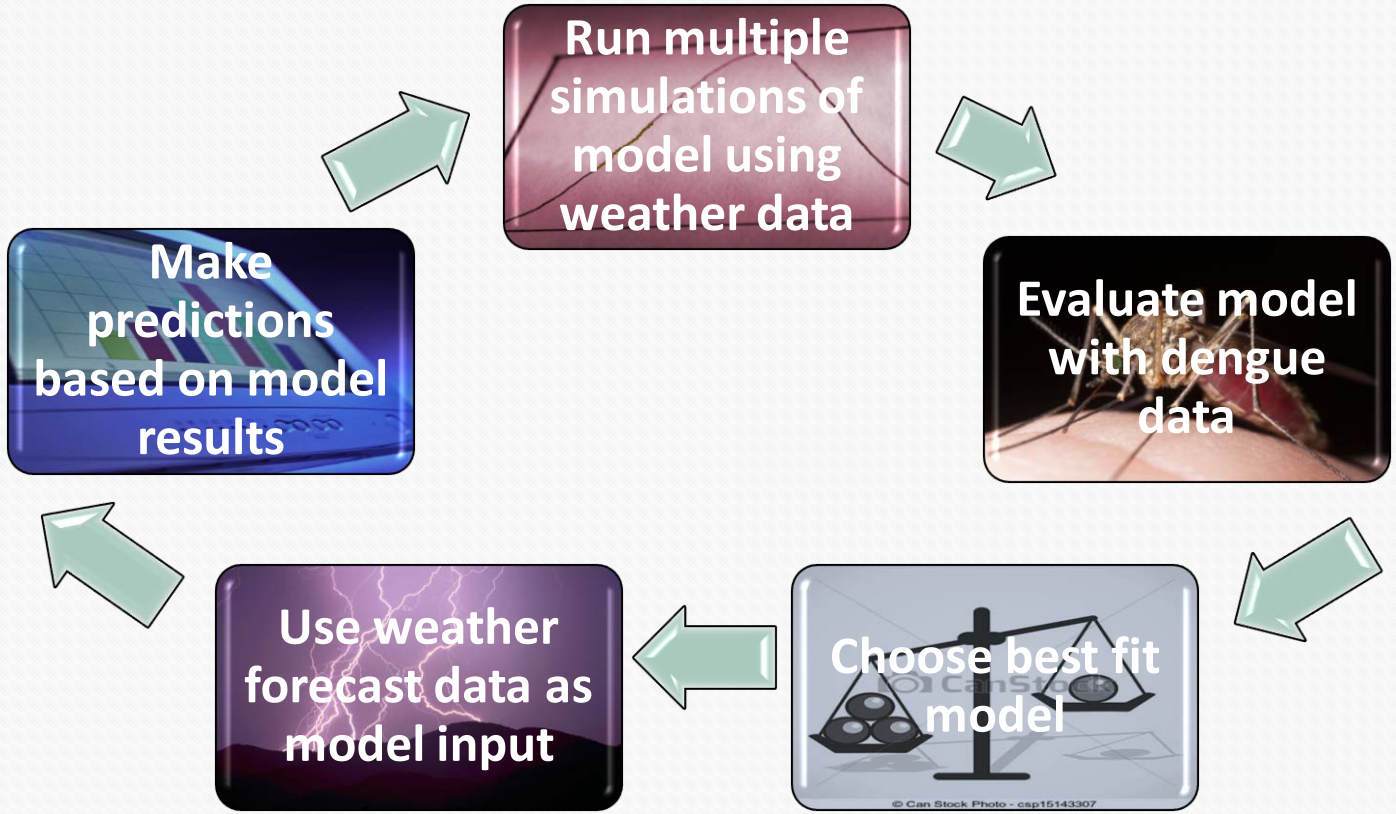


- Knowledge gaps
  - Incubation periods
  - Transmission probabilities
  - Evolution and adaption of virus and human immunity

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

An Operational Model?

- Iterative : Using weather forecast and weekly reported dengue data



Conclusions

- Nearby locations can exhibit very different patterns of dengue transmission
  - Differences in virus introduction
  - Small climatic differences
- Dengue epidemics follows monsoon rains
  - Timing is consistent, however, the magnitude is not well correlated
- Dengue transmission dynamics in northern Mexico may affect dengue risk in the United States
  - Travel, climate change
  - Recent dengue epidemic in Nogales
- Remotely sensed data can be used to inform model input and parameters
  - Temperature, precipitation, land use/cover, soil moisture, ect.

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?

Thank You for Your Attention!

Questions?