

Meteorological Factors Limit *Aedes aegypti* Longevity and Dengue Virus Transmission in the Sonoran Desert



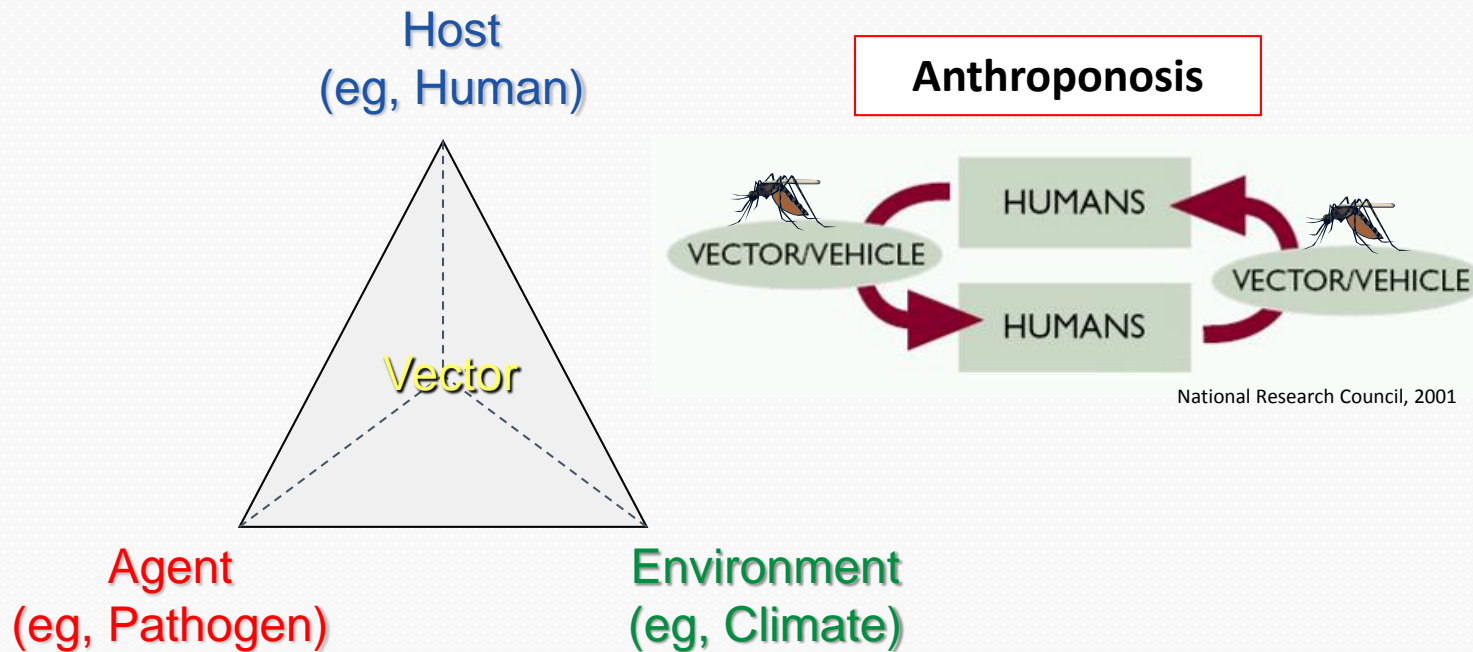
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Vector-borne Disease Ecology

A *multi-factorial* relationship between hosts, agents, vectors and environment



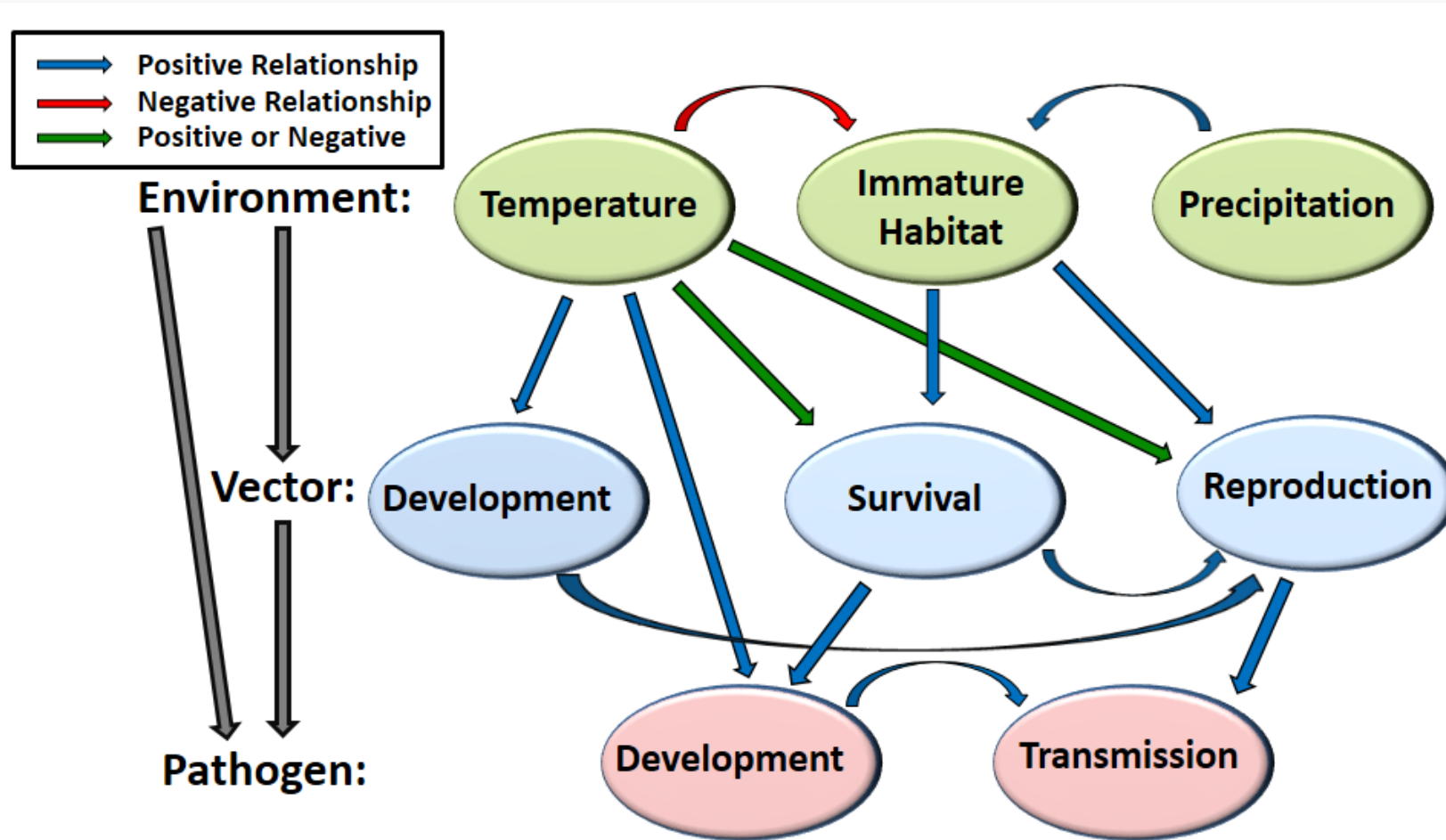
Dengue Viruses

- Annually ~ 96 million cases of symptomatic disease (WHO)
- Endogenous transmission in Texas and Florida
- Symptoms: muscle and bone ache, fever, and hemorrhagic manifestations in rare cases

Chikungunya Virus

- In 2013 first locally acquired cases reported in the Americas
- Symptoms include fever, joint pain, headaches, and rash

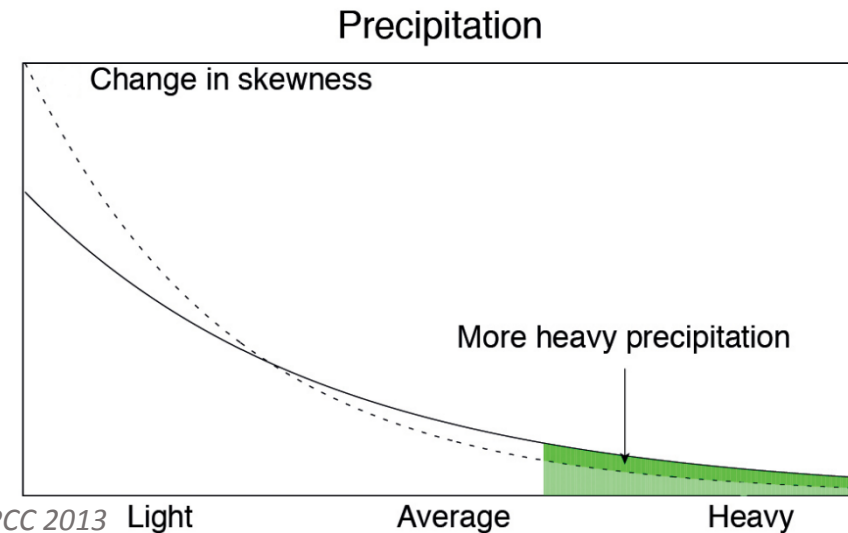
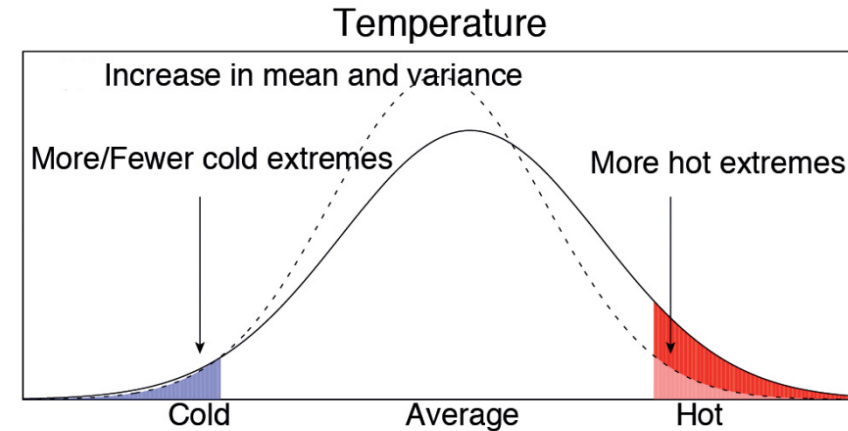
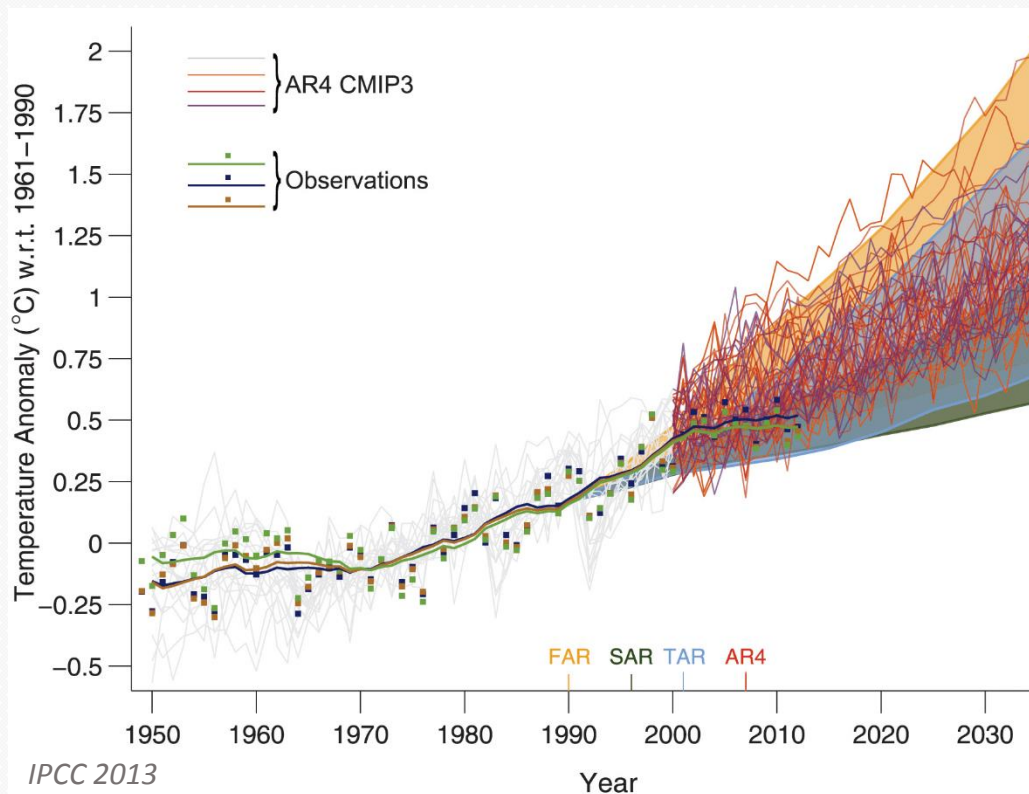
Weather/Climate Influences on Vector-borne Disease Ecology



Morin et al. 2013

Climate Variability and Change

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



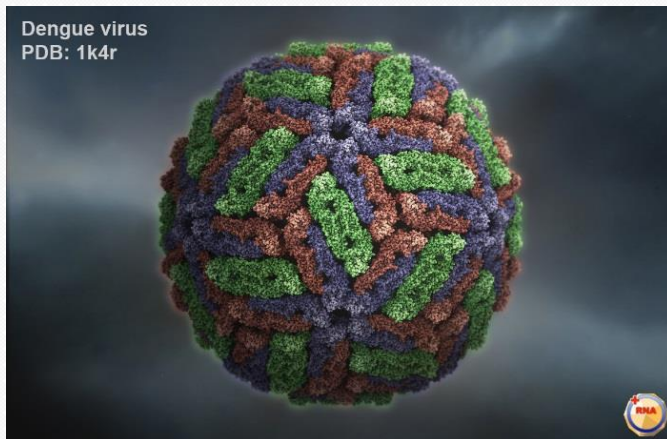
Challenges in Weather/Climate and Health Research (Vector-borne Diseases)



- Knowledge gaps
 - Vector population dynamics
 - **Extrinsic Incubation Period (EIP)**
 - Transmission probabilities
 - Evolution and adaptation of virus and human immunity
- Reporting problems
 - Misdiagnosis
 - Subclinical cases
 - Reporting errors/bias
 - Availability of data



- Climate data
 - Availability/Reliability
 - Resolution
 - Predictability
- Human vs. climate influences
 - Socioeconomic status
 - Microclimatic influences
 - Human adaptations to climate



CDC.gov

Investigating Dengue Transmission in Sonora, Mexico

- Sonora, Mexico
 - Arid climate, monsoon precipitation
 - Seasonal/annual cycles of dengue transmission
 - Large variations in case loads between the northern and southern regions
 - Inhabited by *Aedes aegypti* mosquitoes
 - Anthropophilic, dengue vector
- Why is dengue transmission common in Hermosillo while there is little/no transmission in nearby Nogales?
- Hypothesis: Cooler temperatures in Nogales
 - Suppression of mosquito population
 - Extension of extrinsic incubation period (EIP)

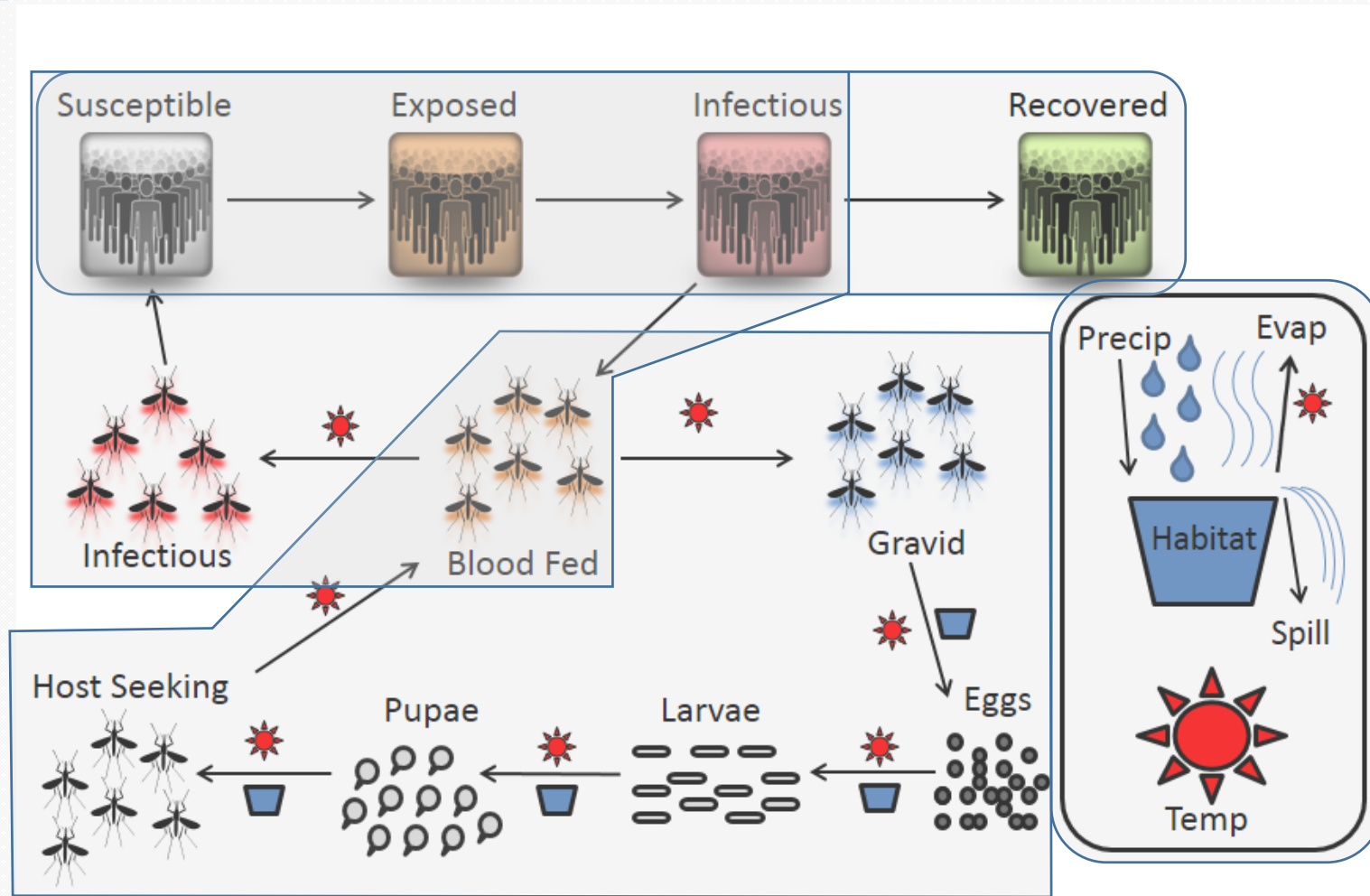


Data and Methods

- **Meteorological/Dengue case data**
 - Daily maximum and minimum temperatures (NLDAS)
 - Daily precipitation (TRMM, NLDAS)
 - Weekly suspected dengue cases for Hermosillo, MX 2006-2011
- **Dynamic Mosquito Simulation Model (DyMSiM)**
 - Simulates *Aedes aegypti* population and dengue virus transmission dynamics
 - Run from 2006-2011 (500 simulations)
 - Parameterization performed using suspected dengue case data
- **Experiments**
 - Control: Performed simulations for Hermosillo and evaluated with reported case data
 - 1: Rerun simulations using Nogales meteorological data
 - 2: Rerun experiment 1 with 1°C warming



Modeling *Aedes aegypti* and Dengue Virus Ecology



Model Parameter Estimation

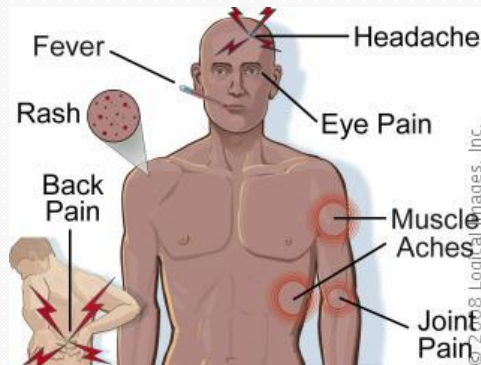
- Containers

- 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

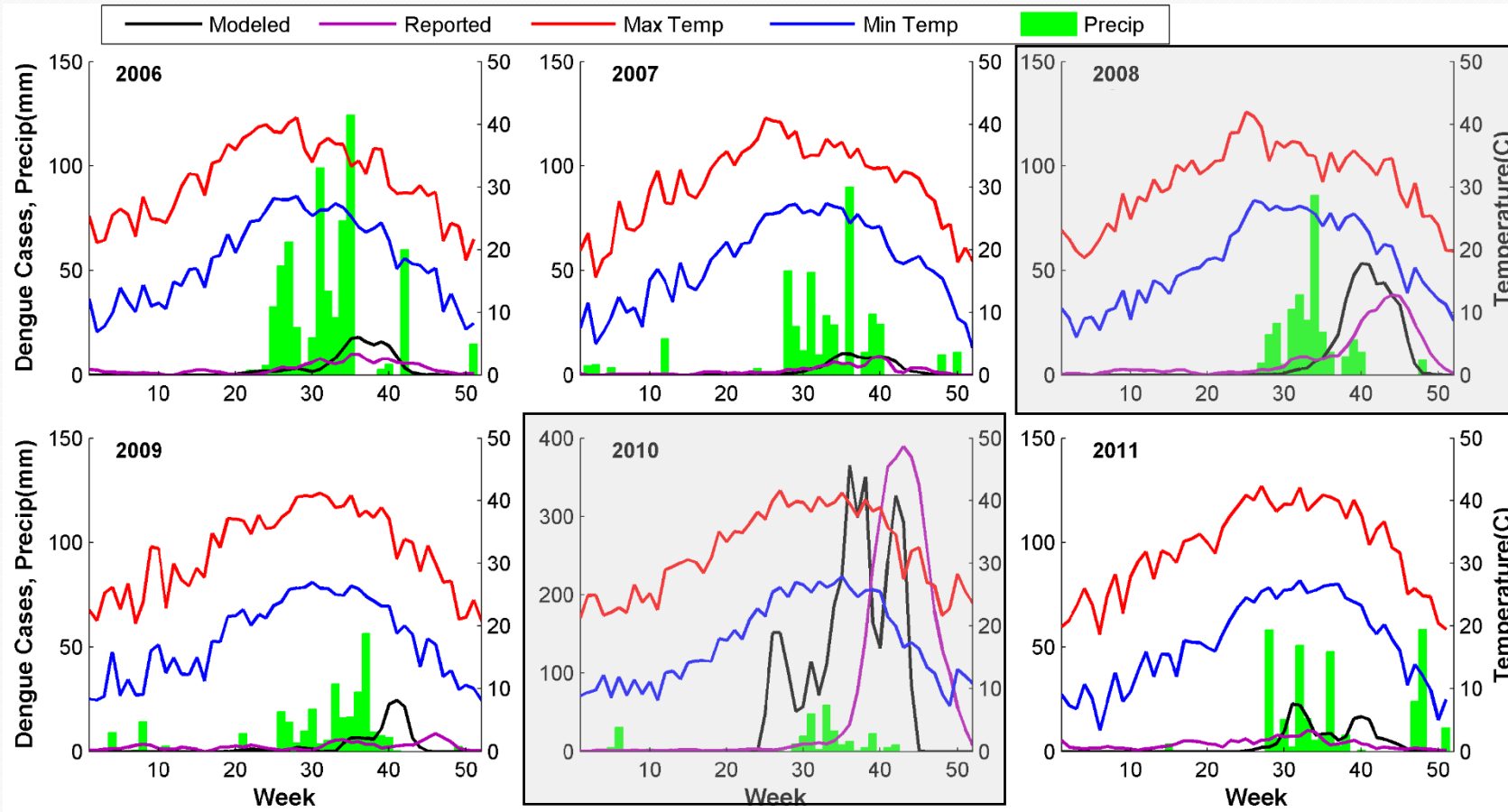
- Maximum larval density

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



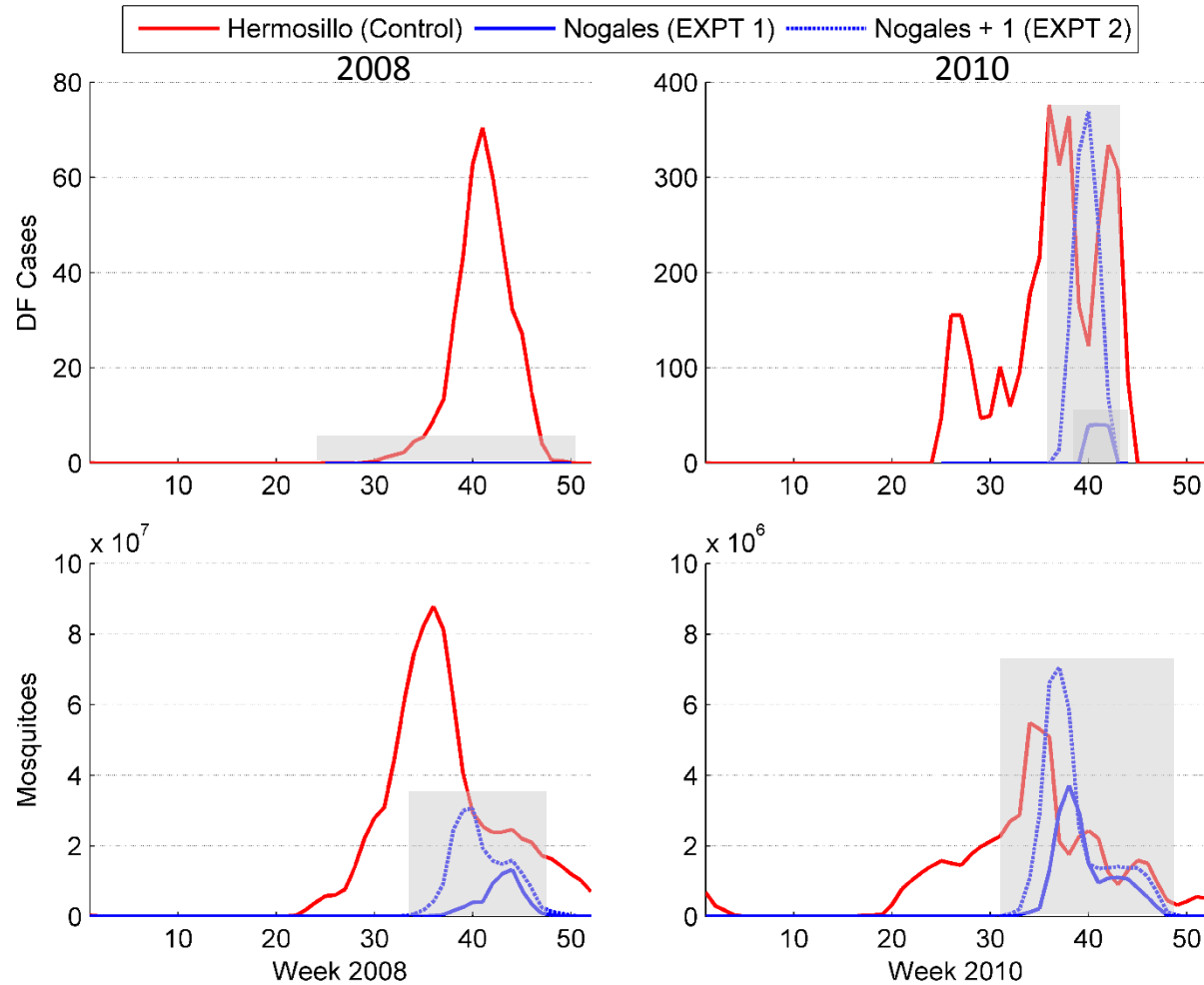
answers.yahoo.com

Control: Simulating Dengue Cases in Hermosillo



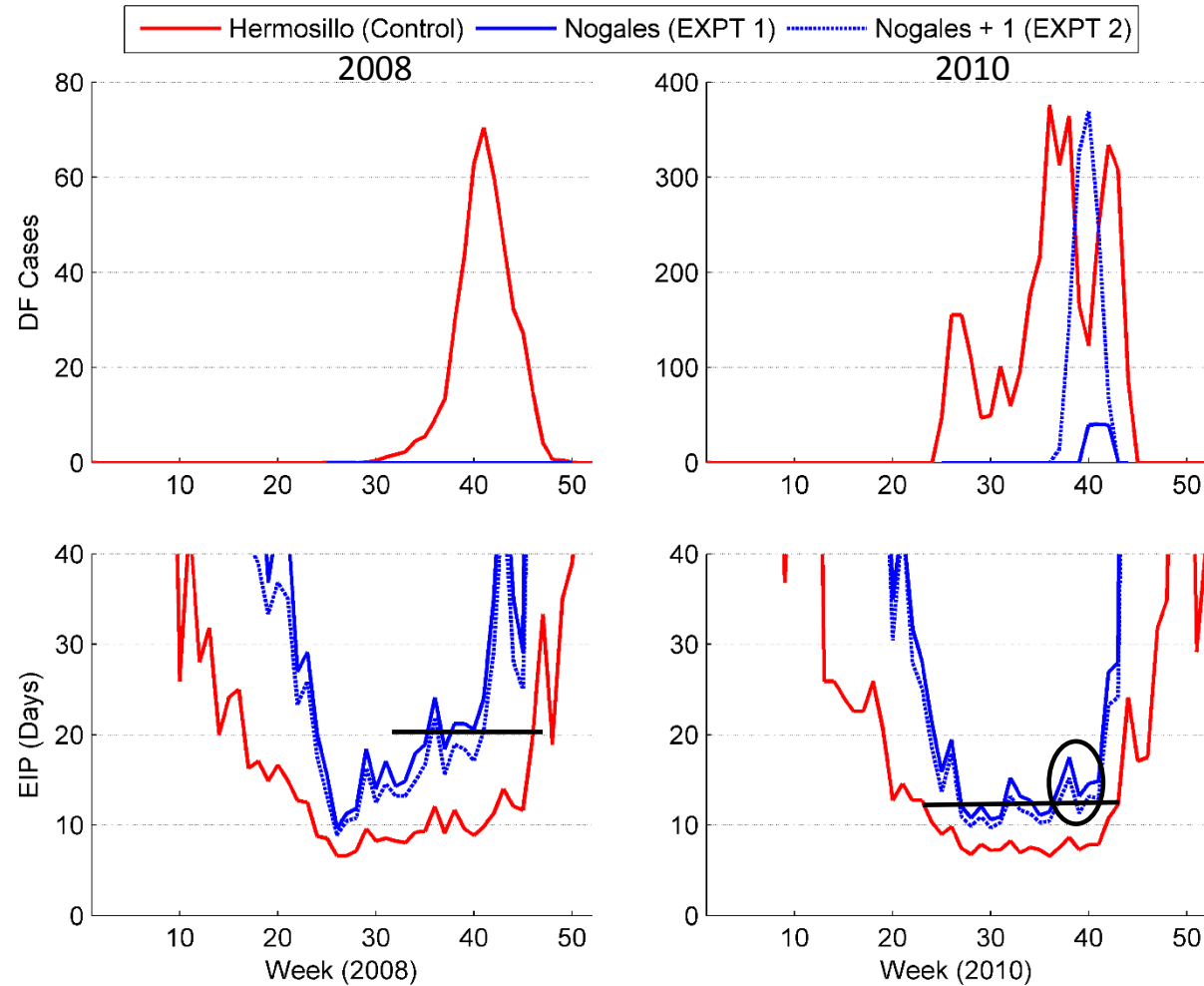
- 2008 and 2010 are largest dengue years
 - Use for Nogales comparison simulations
- Generally epidemics follow monsoon rains
- Precipitation magnitude has little influence on dengue magnitude
- Introduction from nearby areas is likely important

Experiments: Dengue Cases and Mosquitoes



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

Experiments: Dengue Cases and EIP



- EIP is considerably longer under Nogales conditions
- Under Nogales conditions, the EIP is longer during the transmission season in 2008 compared to 2010
 - Prevents completion of EIP during mosquito lifetime
- EIP shortened under 1°C warming conditions
 - Small change produces dramatic shift in dengue fever cases

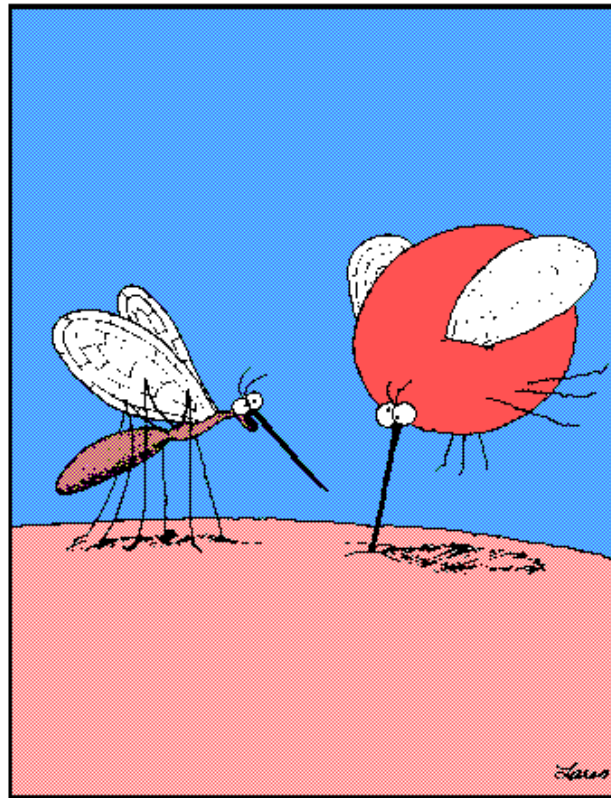
Conclusions

- Climate is an important regulator of dengue transmission in Sonora, MX
 - Precipitation influences the timing but not magnitude of dengue epidemics
 - Temperature influences mosquito population dynamics and the virus EIP
 - Small changes in temperature can have significant impacts on transmission
 - Year to year climate variability is important especially along fringe regions
 - Difference in dengue transmission suitability in Nogales between 2008 and 2010
- Dengue transmission dynamics in northern Mexico may affect dengue risk in the United States
 - Travel, climate change
 - Recent dengue epidemic in Nogales



Thank You for Your Attention!

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"Pull out, Betty! Pull out! ... You've
hit an artery!"