

08 February 2016

The Potential Impacts of 21st Century Climatic and Population Changes on Human Exposure to the Virus Vector Mosquito *Aedes aegypti*

A.J. Monaghan¹, K.M. Sampson¹, D.F. Steinhoff¹, K.C. Ernst², K.L. Ebi³, B. Jones⁴ and M.H. Hayden¹

¹National Center for Atmospheric Research, Boulder, CO

²University of Arizona, College of Public Health, Tucson, AZ

³University of Washington, School of Public Health, Seattle, WA

⁴CUNY Institute for Demographic Research, New York, NY

This research was supported by the National Science Foundation (GEO-1010204) and the National Institutes of Health (IR01AI091843).



NCAR



The virus transmitting mosquito *Aedes aegypti*

Transmits dengue, chikungunya, Zika and yellow fever

Lives in close association with humans

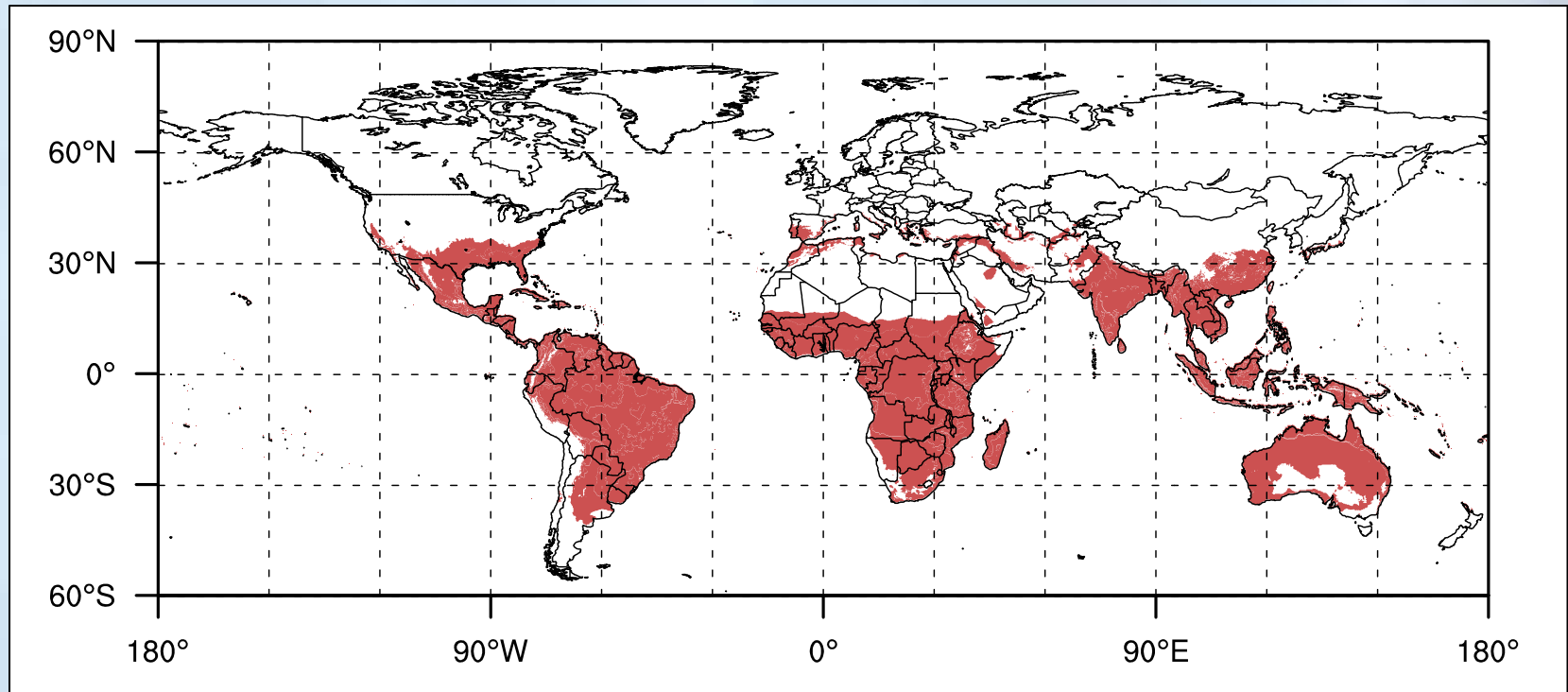
- Exploits artificial containers for immature life stages
- Adults live near or in homes

Requires favorable climatic conditions

- Warm temperatures with low variability
- Water for immature development (rain or human mediated)



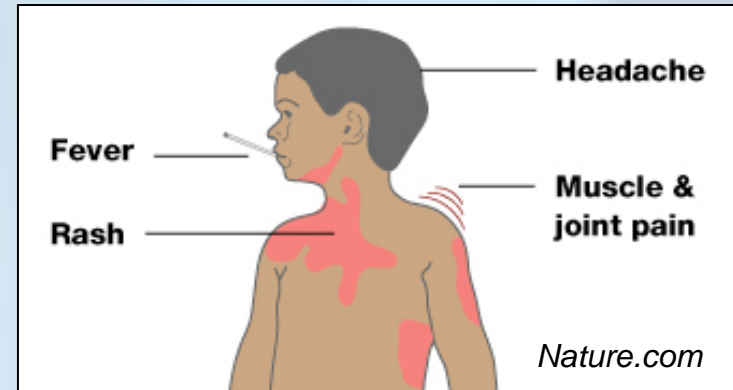
Global Range of *Ae. aegypti*



(Monaghan et al. 2016, Climatic Change)

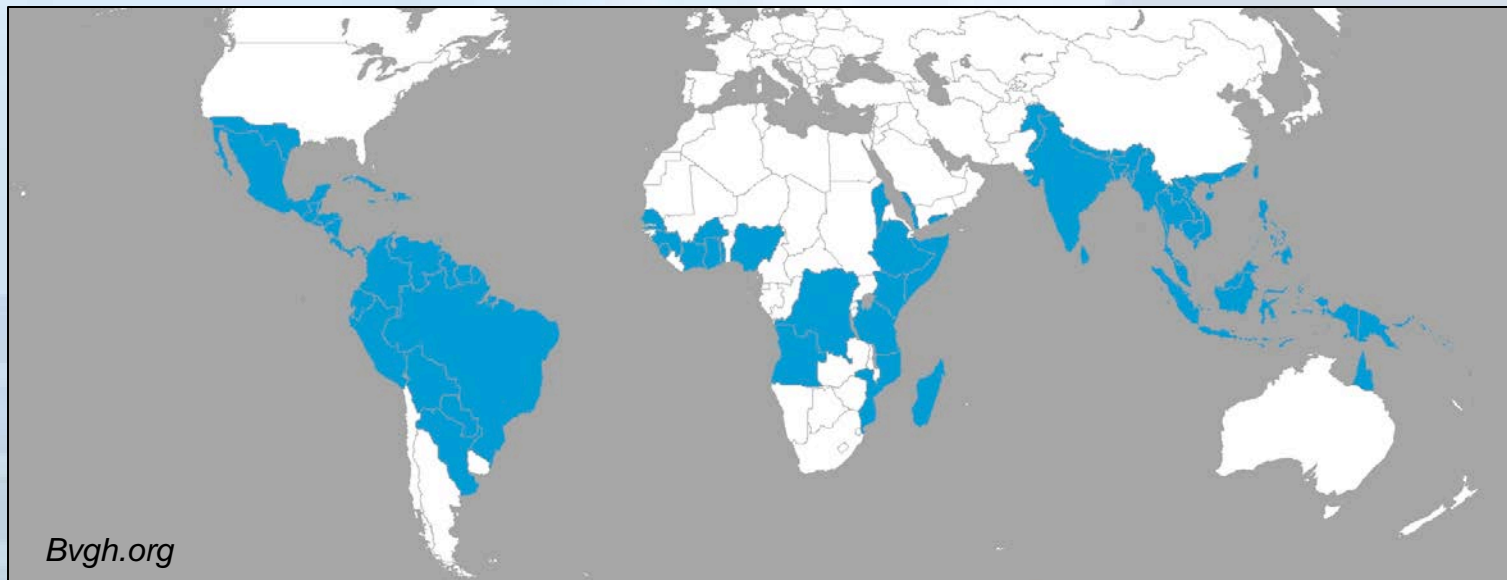
Dengue Fever

Dengue Fever and Dengue Hemorrhagic Fever are caused by dengue viruses transmitted by *Aedes* mosquitoes



Annually, ~400 million people contract dengue worldwide

- No approved vaccine available
- Increasing number and severity of cases in the Americas, including U.S.



Zika

W.H.O. Cites Health Emergency Over Fast-Spreading Zika Virus

By **SABRINA TAVERNISE** and **DONALD G. McNEIL Jr.**

The World Health Organization declared the Zika virus and its suspected link to birth defects an international public health emergency on Monday, a rare move

cases, damaged brains. Reported cases of microcephaly are rising sharply in Brazil, ground zero for the disease, though researchers have yet to establish that Zika



BRACE

-Benefits of Reduced Anthropogenic Climate Change

-Under NCAR's Climate and Human Systems Project

-Difference in impacts between two greenhouse gas emissions scenarios

Mitigation (RCP4.5) versus non-mitigation (RCP8.5)

-Two alternative societal development pathways

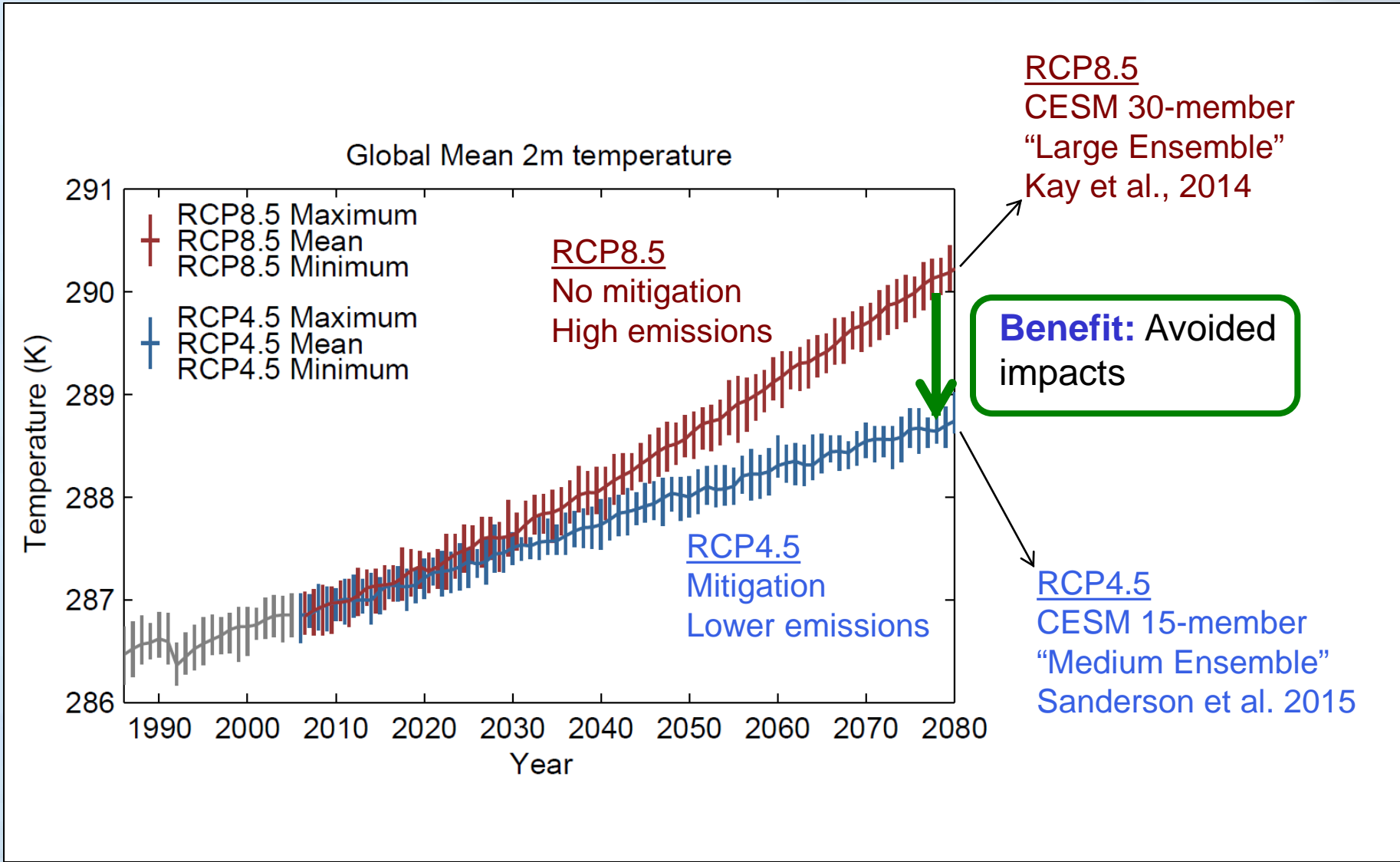
High vulnerability (SSP3) and low vulnerability (SSP5)

-23 papers, special issue of *Climatic Change*

O'Neill & Gettelman, eds.

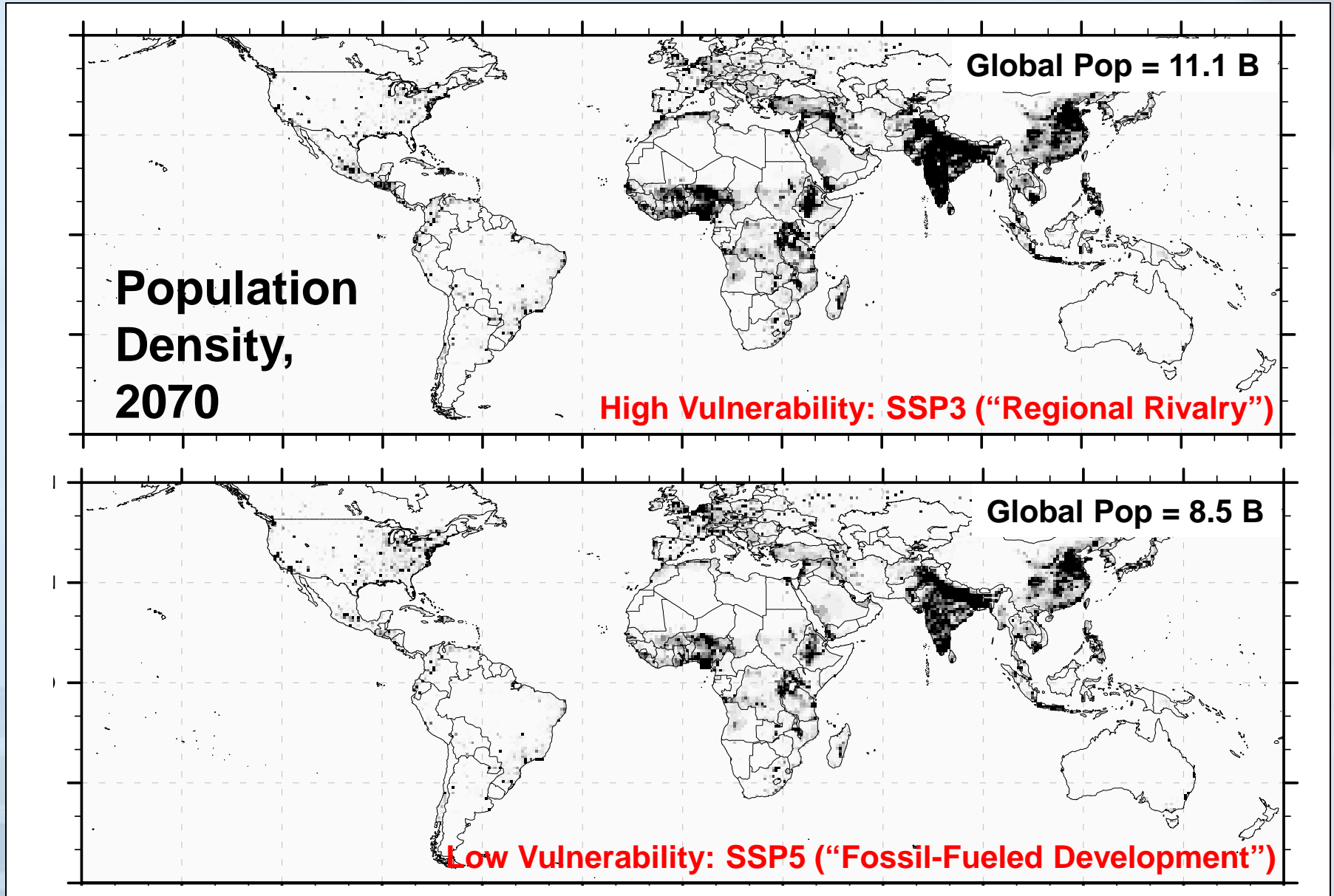
-50+ participants from NCAR and 18 other institutions

Representative Concentration Pathways (RCPs)



Adapted from B. O'Neill, NCAR

Shared Socioeconomic Pathways (SSPs)



Population Growth in the SSPs

**Ratio of
Population
Density,
2070:2000**

High Vulnerability: SSP3 ("Regional Rivalry")

Low Vulnerability: SSP5 ("Fossil-Fueled Development")



0

1

2

3

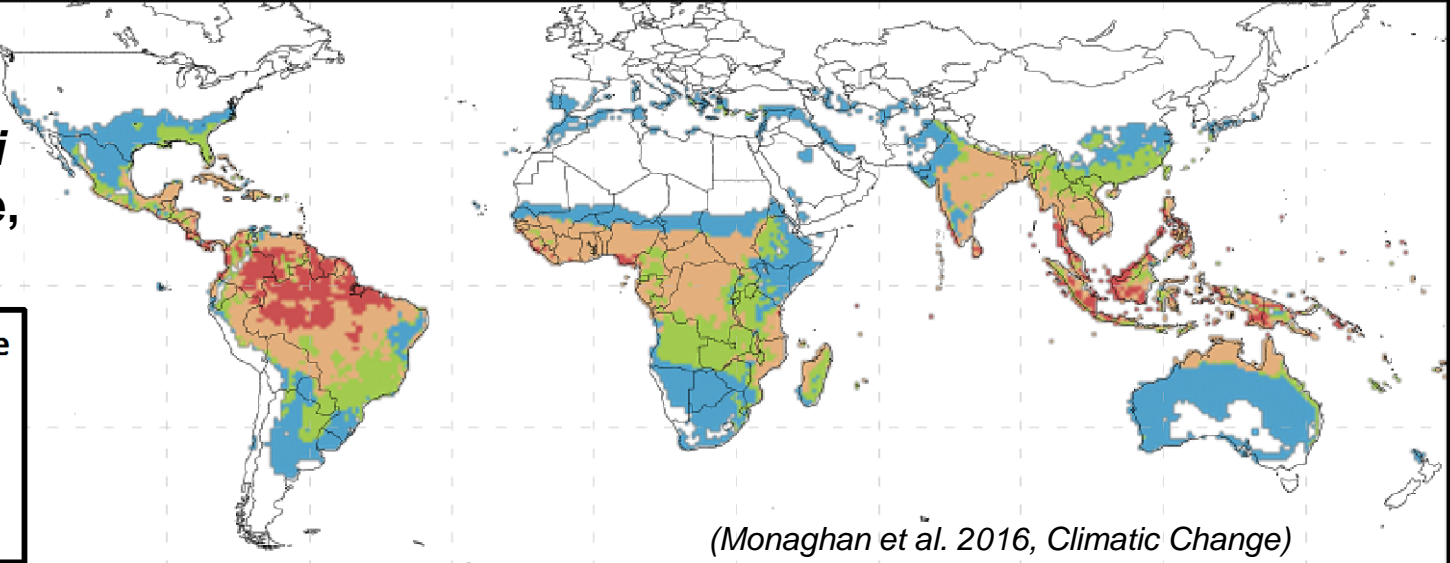
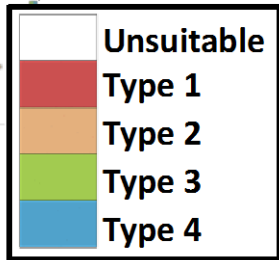
4

Research Questions Addressed

- 1. Can we map global range of *Ae. aegypti* as a function of climate?**
 - Employ climate thresholds of Eisen, Monaghan et al. (2014) using Worldclim
- 2. What is the projected future range of *Ae. aegypti*?**
 - Apply CESM RCP4.5 and RCP8.5 climate projections for 2061-2080
- 3. How many humans may be exposed to *Ae. aegypti* in the future?**
 - Apply SSP3 and SSP5 population projections for 2061-2080

Q1: Current Global range of *Ae. aegypti*

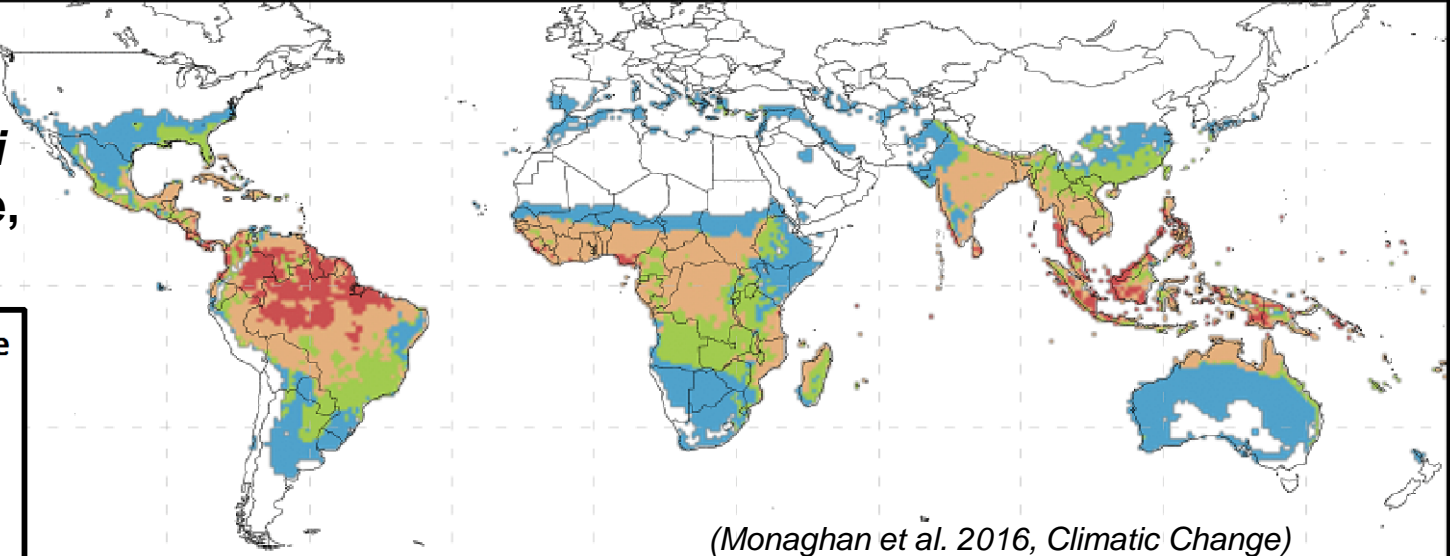
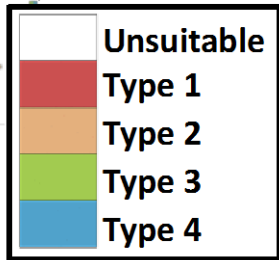
Simulated
Ae. aegypti
occurrence,
1950-2000



(Monaghan et al. 2016, Climatic Change)

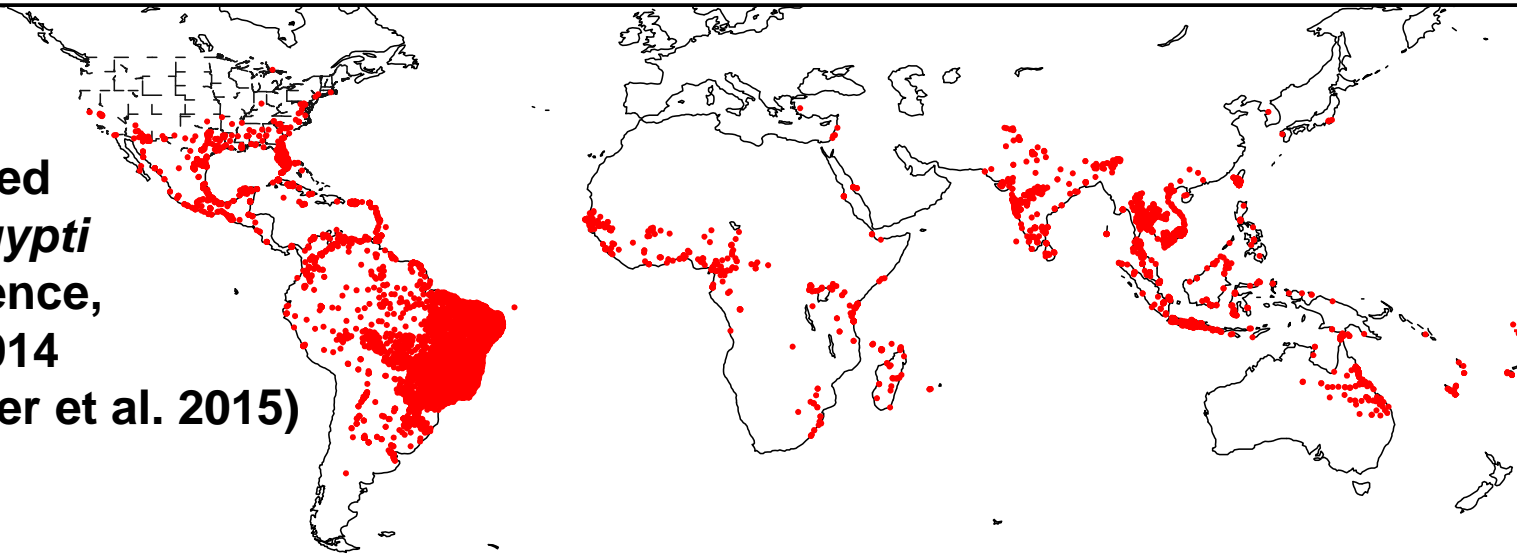
Validation: Historical global range of *Ae. aegypti*

**Simulated
Ae. aegypti
occurrence,
1950-2000**



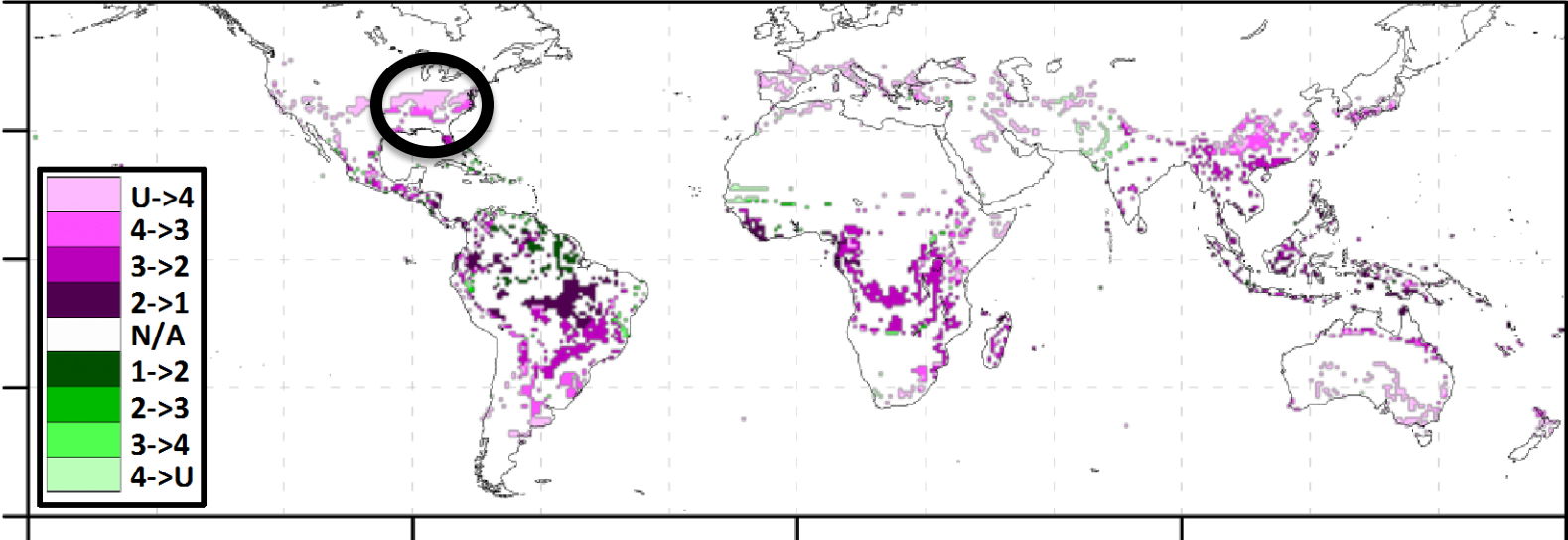
(Monaghan et al. 2016, Climatic Change)

**Observed
Ae. aegypti
occurrence,
1960-2014
(Kraemer et al. 2015)**

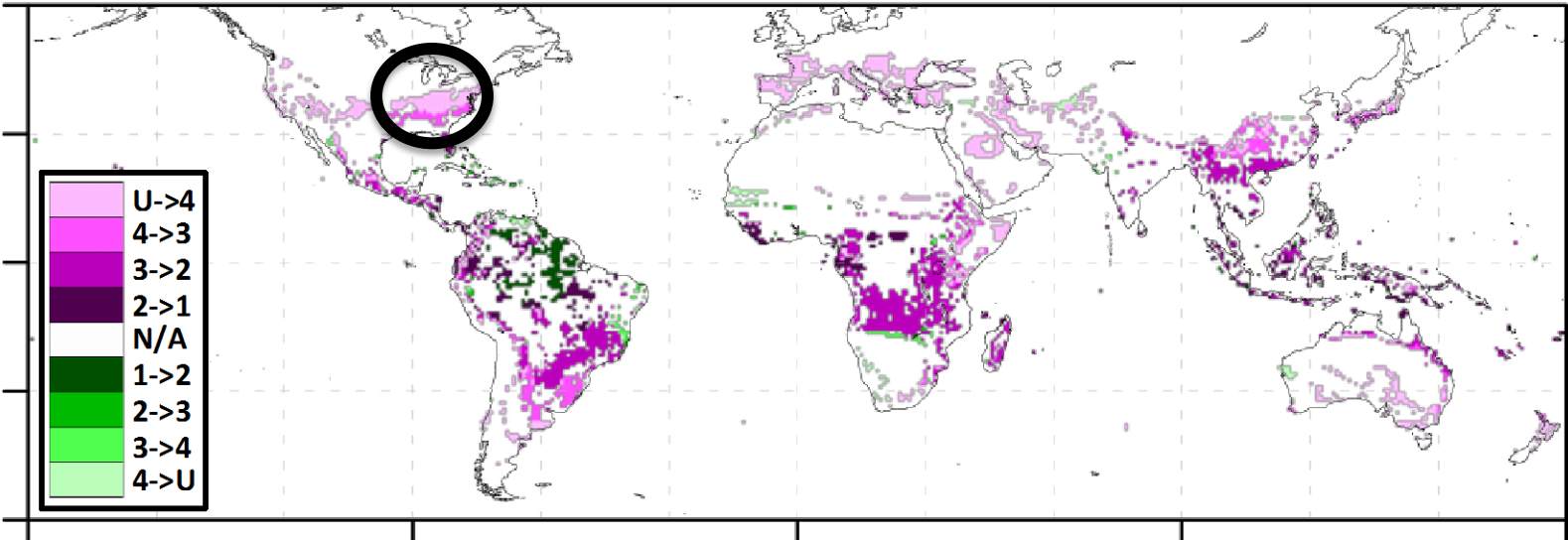


Q2: Projected global range of *Ae. aegypti*, 2061-2080

b) 2061-2080 (RCP4.5 minus Reference)

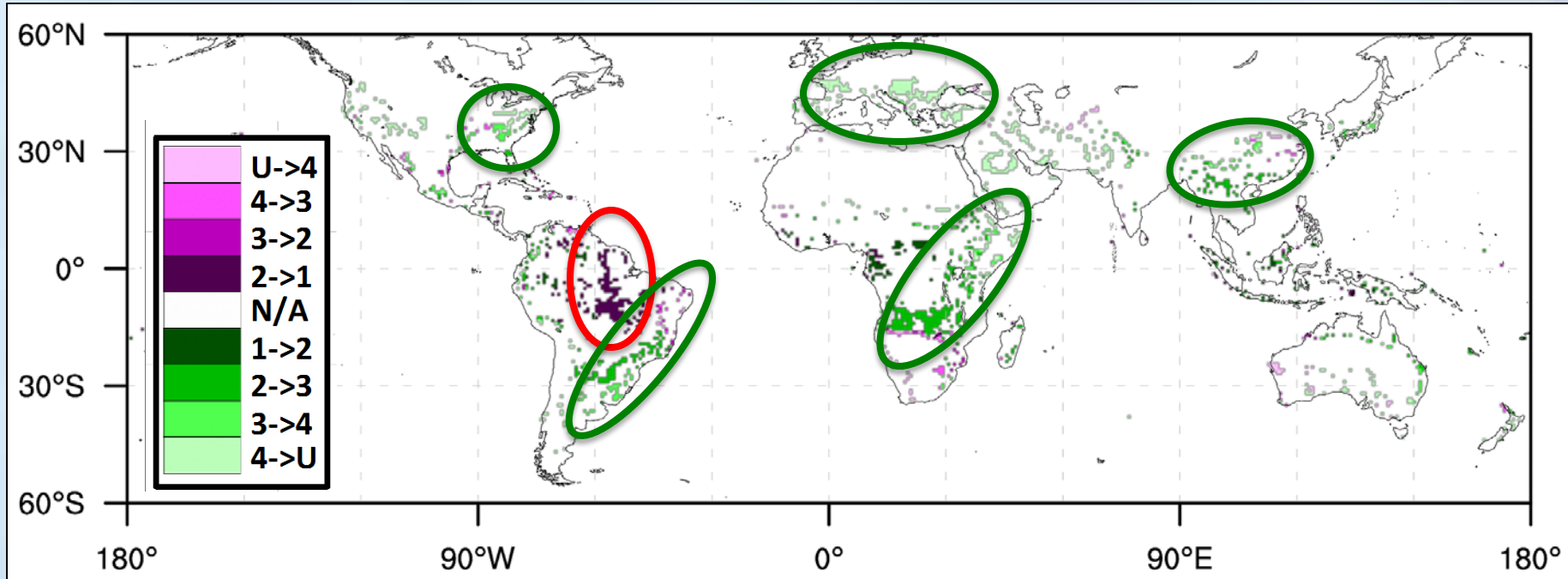


c) 2061-2080 (RCP8.5 minus Reference)

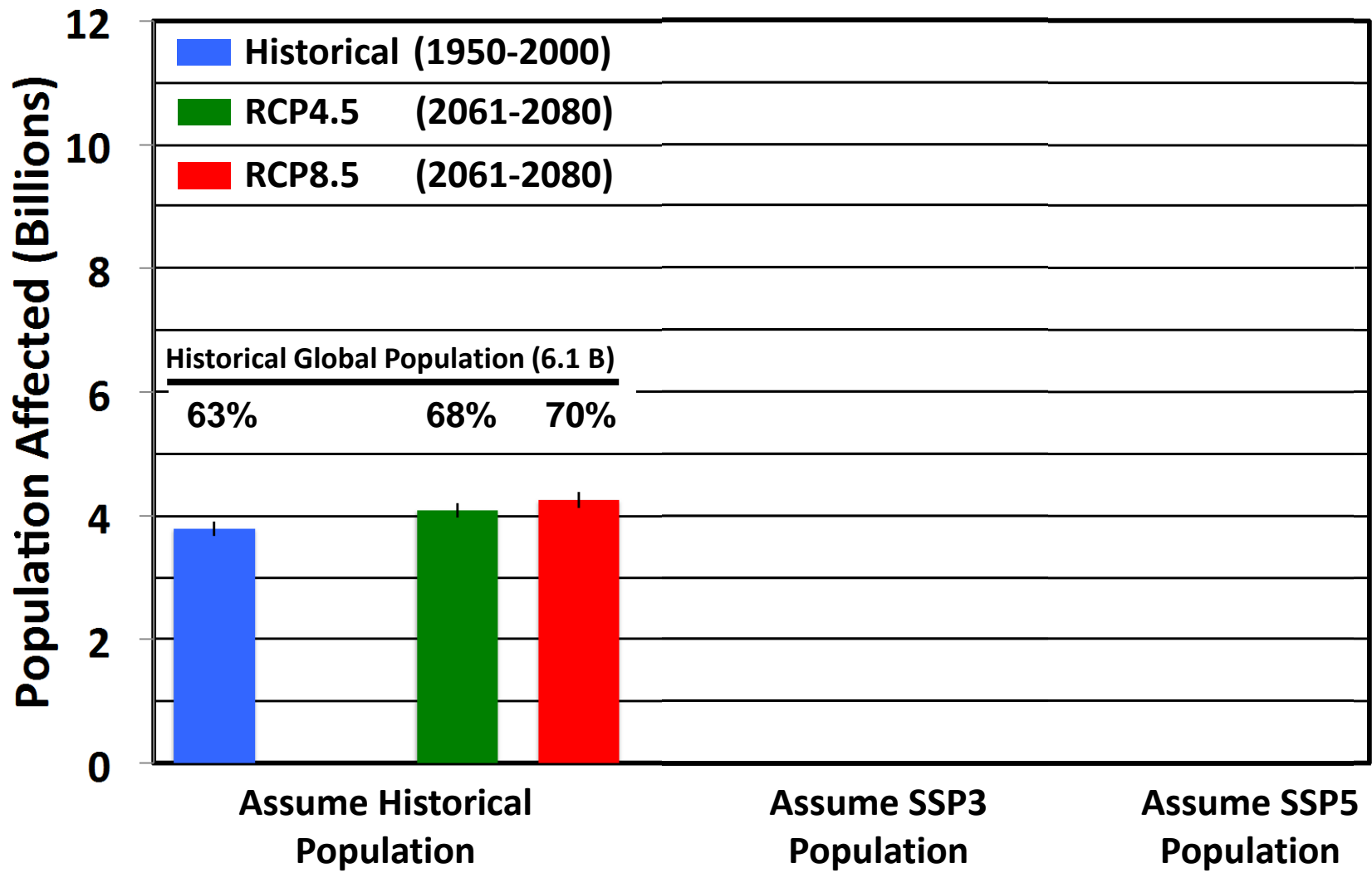


(Monaghan et al. 2016, Climatic Change)

Avoided Impacts: RCP4.5 minus RCP8.5, 2061-2080



Q3: Projected human exposure to *Ae. aegypti*, 2061-2080



Conclusions

- **Globally both climate change and population change may increase human exposure to *Aedes aegypti* by 2061-2080**
 - 8-12% increase over Year 2000 exposure for climate change alone.
 - 127-134% increase for SSP3; 59-65% for SSP5.
- **The devil is in the details!**
 - On a percentage basis climate change alone would may increase exposure from 63% to 68-70%. Climate & Pop change: 71-80%.
 - Large shift from seasonal to year-round exposure in developing countries, particularly for more vulnerable SSP3 scenario.
 - Avoided exposure due to taking RCP4.5 vs RCP8.5 pathway is large in wealthy countries.
- **Lots of uncertainty (modeling approach, future geopolitics, interventions, behavior, transportation, interspecies competition)**



Questions?