The Health-Climate Landscape for Zika transmission in Latin America and the Caribbean

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Countries with active zika transmission (as of May 26, 2016)

http://www.cdc.gov/zika/geo/active-countries.html

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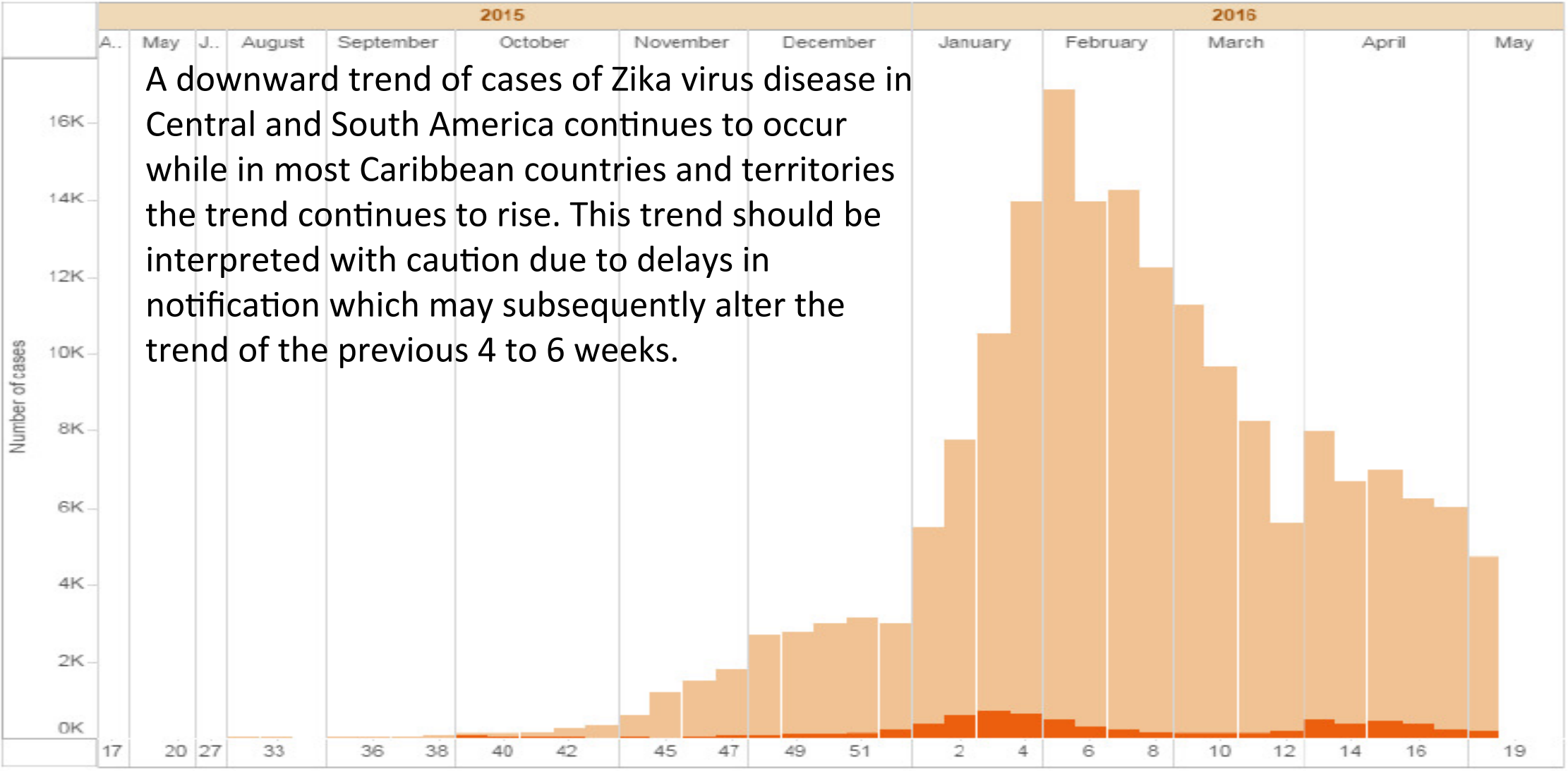
Pan American Health Organization
World Health Organization
Americas

Suspected and confirmed Zika cases reported by countries and territories in the Americas, 2015-2016

New cases by Epidemiological Week. Updated as of 19 May 2016



A downward trend of cases of Zika virus disease in Central and South America continues to occur while in most Caribbean countries and territories the trend continues to rise. This trend should be interpreted with caution due to delays in notification which may subsequently alter the trend of the previous 4 to 6 weeks.

Cases

- Suspected Zika
- Confirmed Zika

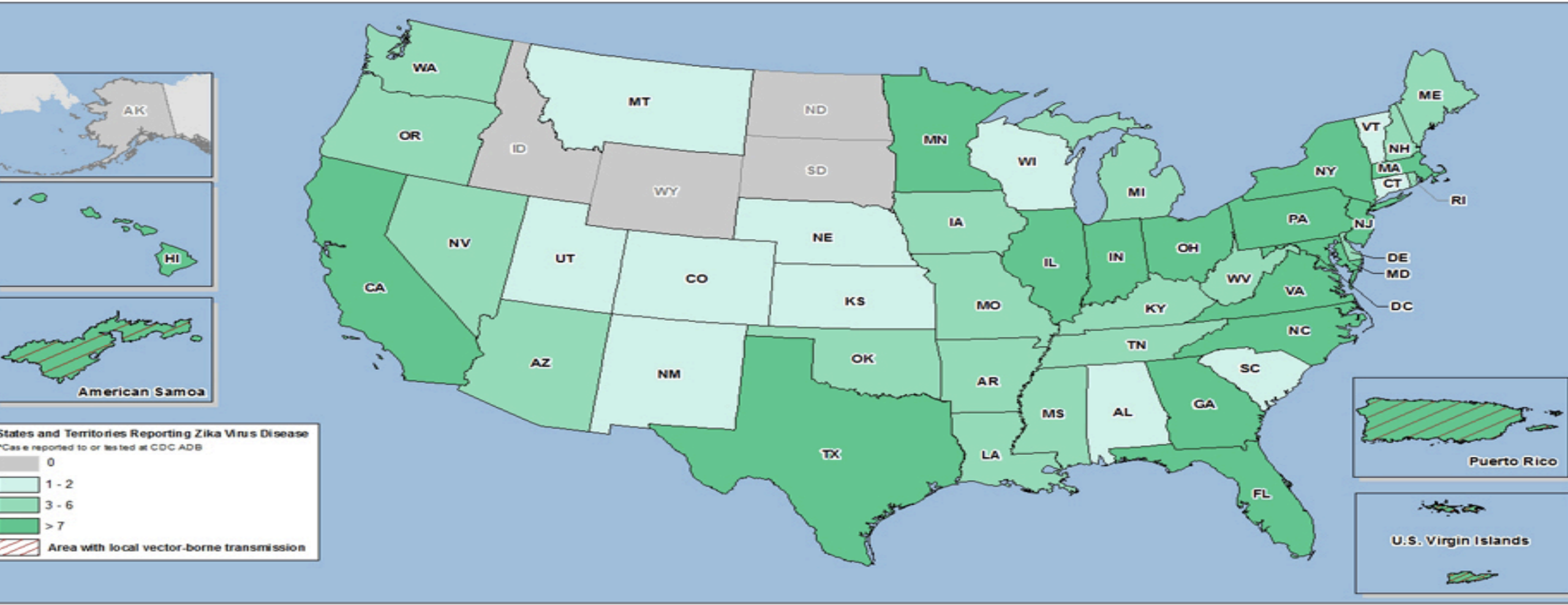
Country / territory

- (All)
- Argentina
- Aruba
- Barbados
- Belize
- Bolivia
- Bonaire
- Brazil
- Colombia
- Costa Rica
- Cuba
- Curacao
- Dominica
- Dominican Republic
- Ecuador
- El Salvador
- French Guiana
- Grenada
- Guadeloupe
- Guatemala
- Guyana
- Haiti
- Honduras
- Jamaica
- Martinique
- Mexico
- Nicaragua
- Panamá
- Paraguay
- Peru

Zika cases in the US (2015-2016) as of June 01, 2016

http://www.cdc.gov/zika/geo/united-states.html

618 Travel associated cases
11 STI cases
1 GG case



Is it valid to use the same parameters for dengue to estimate Zika risk?

Anderson, Endy, & Thomas. The Emergence of Zika. Annals of Internal Medicine. 2016.

How is Zika different from dengue?

- STI. Perinatal transmission. Blood transfusions. Other modes of transmission?
- First wave of invasion (all are susceptible, See Perkins et al.)
- Other mosquito vectors?
- Evidence of Sylvatic transmission cycle similar to YF
- Long persistence in semen
- Association with birth complications and neurological disorders (microcephaly, GB)

How is it the same?

- Clinical presentation of most cases similar to mild dengue
- Flavivirus (like dengue, yellow fever)
- Dominant urban transmission cycle
- *Same* mosquito vector (*Aedes aegypti* and *Aedes albopictus*)
- High proportion of asymptomatic cases

Early predictions of zika risk use a range of modeling approaches, which incorporate climate information

These early models provide important first attempts to characterize disease transmission, which will be validated using field and epi data in the coming months and years.

Examples:

Bogoch et al – ENM – spatial distribution of risk

Messina et al – ENM statistical modeling – spatial distribution of risk

Perkins – R01 first wave modeling – predictions of pregnant women infected

Monaghan et al 2016 – Meteorological model with mosquito mechanistic model to diagnose historical monthly risk across the US

Mordecai et al – Mechanistic modeling of vector parameters (R0) with temperature

Mordecai's work shows that temperature is a key driver of Zika risk

- Temperature is an important driver due to mosquito physiology, and our studies show that it is an important predictor of Zika-dengue-chikv transmission (Mordecai et al, in prep, prior studies by Stewart et al in Ecuador).
- We know that RH and rainfall are important for *Aedes sp.*, but effects on disease risk are more complex (depend on local social context, e.g., water storage) and spatially heterogenous.

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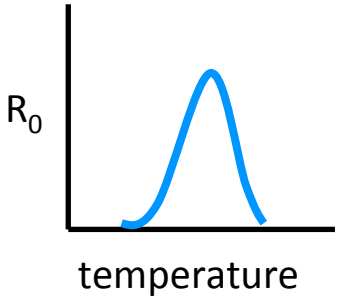
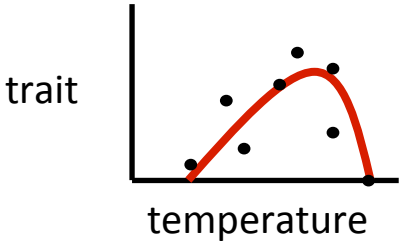
Transmission models

General framework for VBD transmission

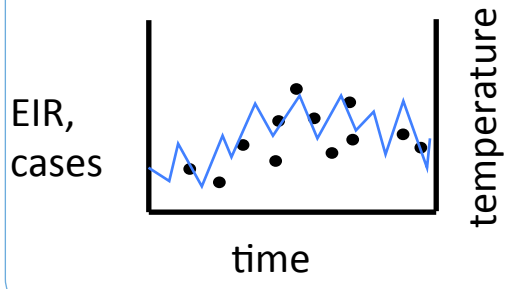


Field validation in Ecuador and Kenya

Existing empirical data - 13 diseases

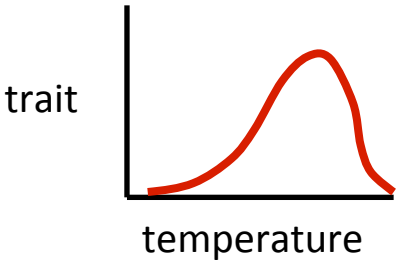


New dengue field data

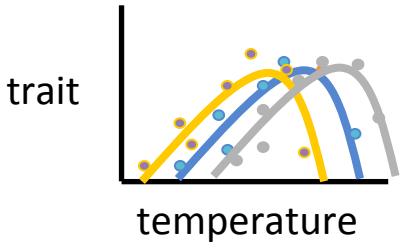


Local adaptation of thermal responses

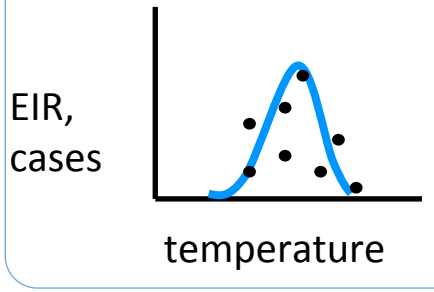
Metabolic theory general predictions



New lab data

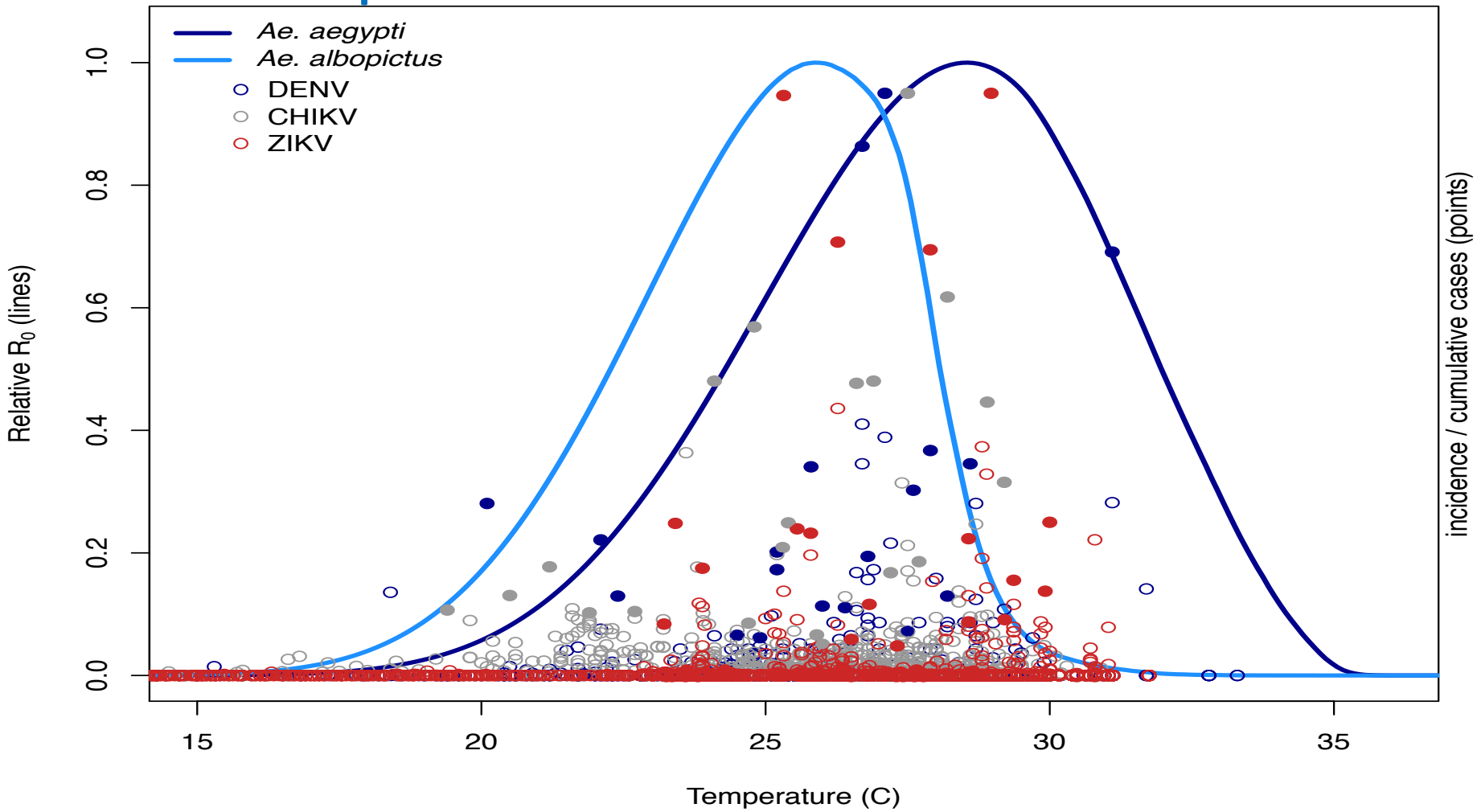


Existing field data



NSF EEID: Erin Mordecai, Matt Thomas, Sadie Ryan, Anna Stewart, Leah Johnson, Jason Rohr, Van Savage

Temperature defines fundamental risk



Data: weekly PAHO incidence data, relativized by cumulative cases up to the previous week, plotted against mean temperature two weeks prior to each case report, from Weather Underground. Filled points: maxes within each temperature bin (20 bins per virus).

E. Mordecai et al. in prep

So, how important is climate for Zika, compared to other key factors?

For example:

Dengue

Malaria

How important is climate for Zika, compared to other key factors?

Zika

Can we use DENV as a proxy for ZIKV? Within a year our team will know!

Dengue

Malaria

Can we forecast Zika? Not yet… BUT

Zika

Climate	Immunology & Socio-economic conditions	Human behavior

Extremely Unpredictable!

?

Can we forecast Zika? Not yet… BUT

Zika

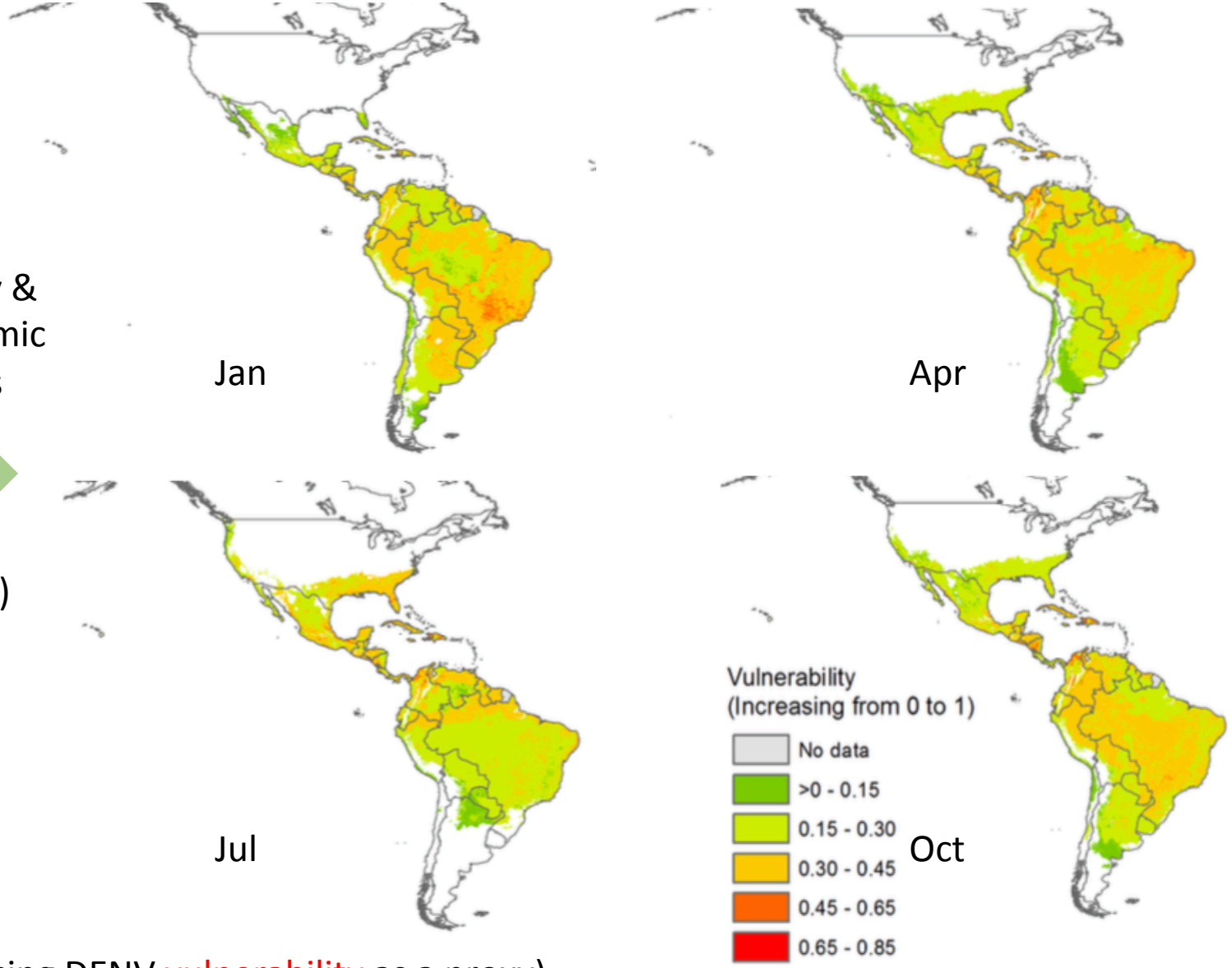
Climate	Immunology & Socio-economic conditions	Human behavior
Partially Predictable	Knowable	Extremely Unpredictable!

?

Health landscape

Immunology &
Socio-economic
conditions

(Knowable)



(Using DENV vulnerability as a proxy)

Fullerton, Dickin, Schuster- Wallace (2014)

Climate landscape

Muñoz, Thomson, Goddard, Aldighieri (2016)

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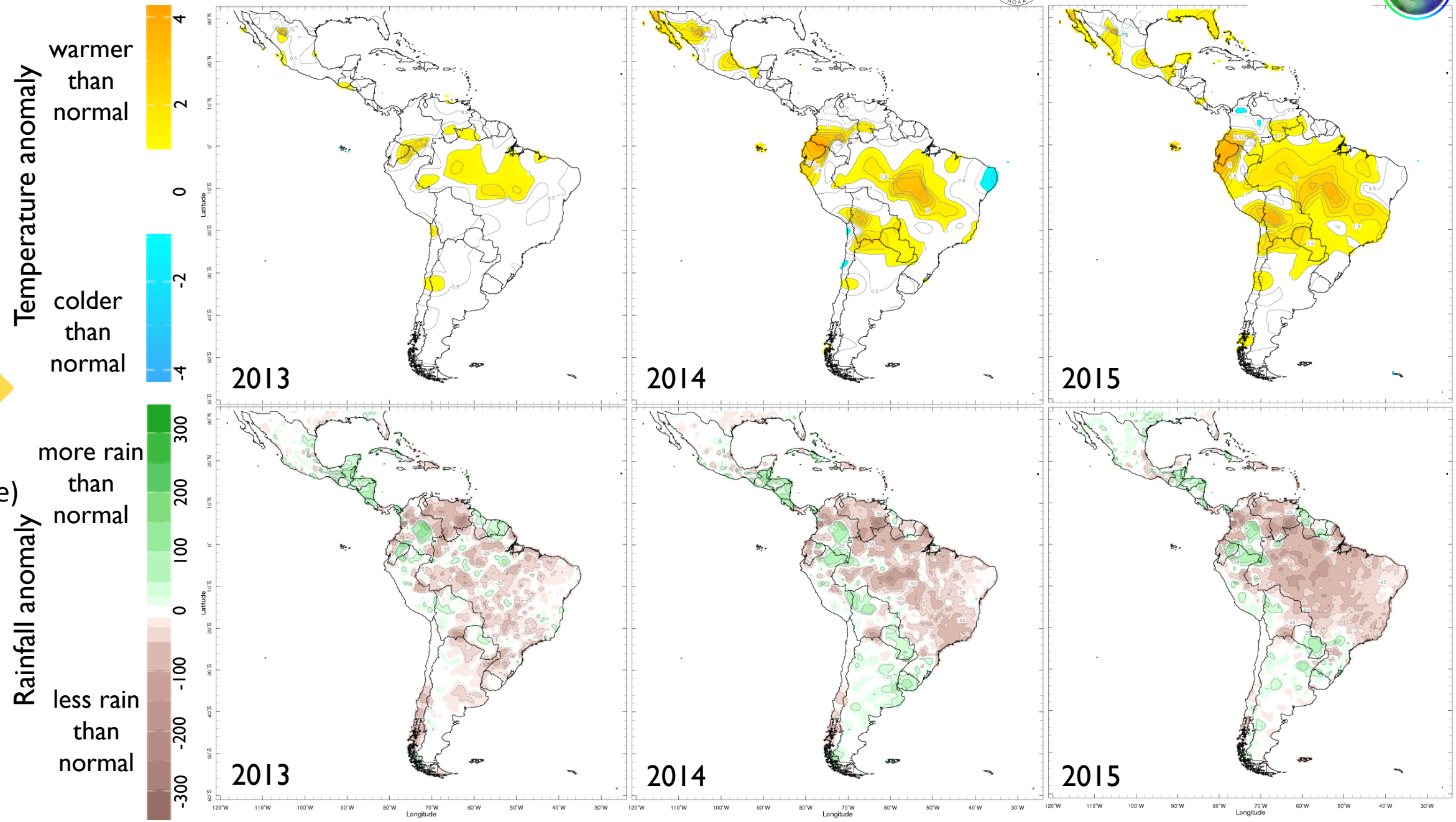
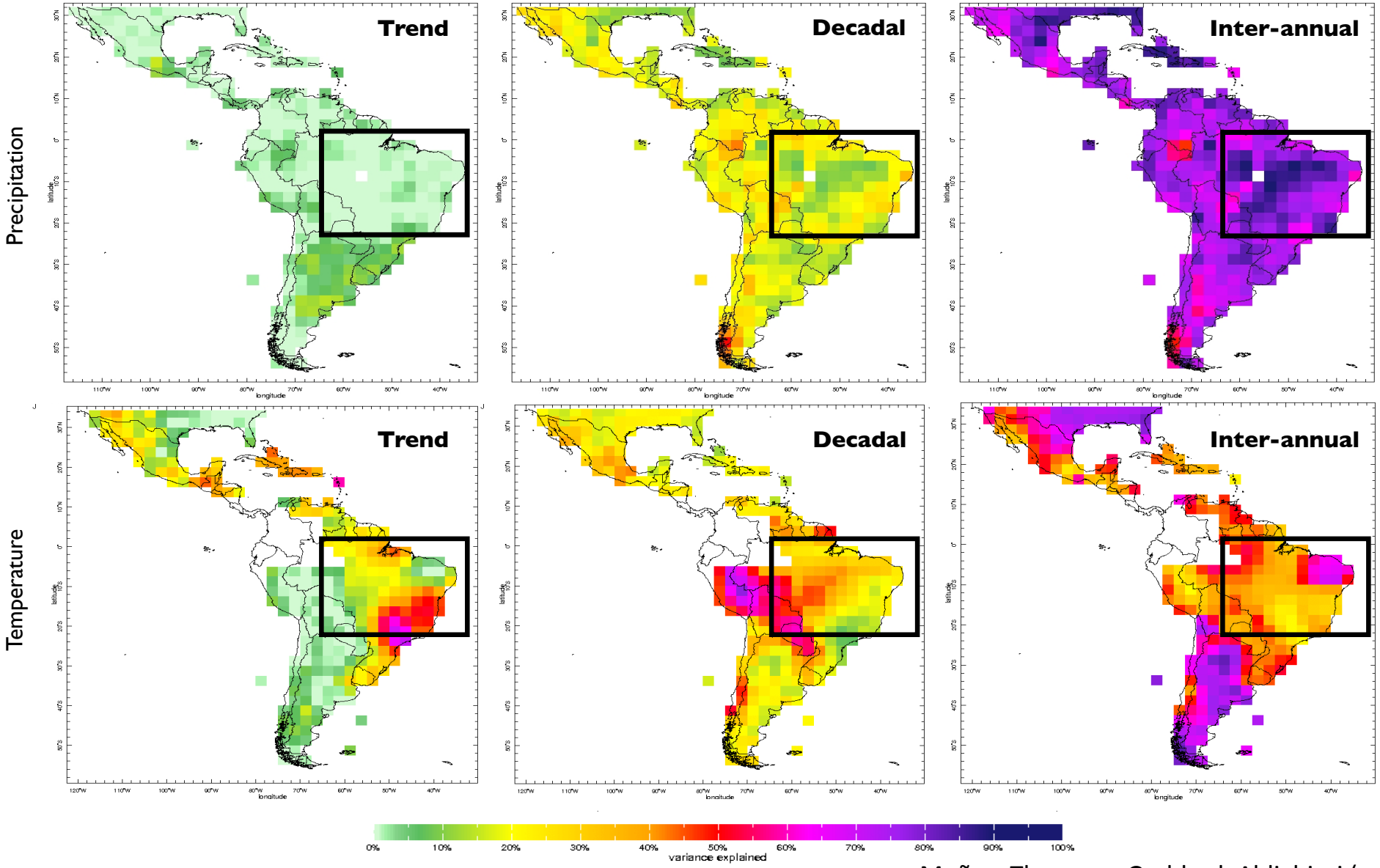
Climate

(Partially Predictable)



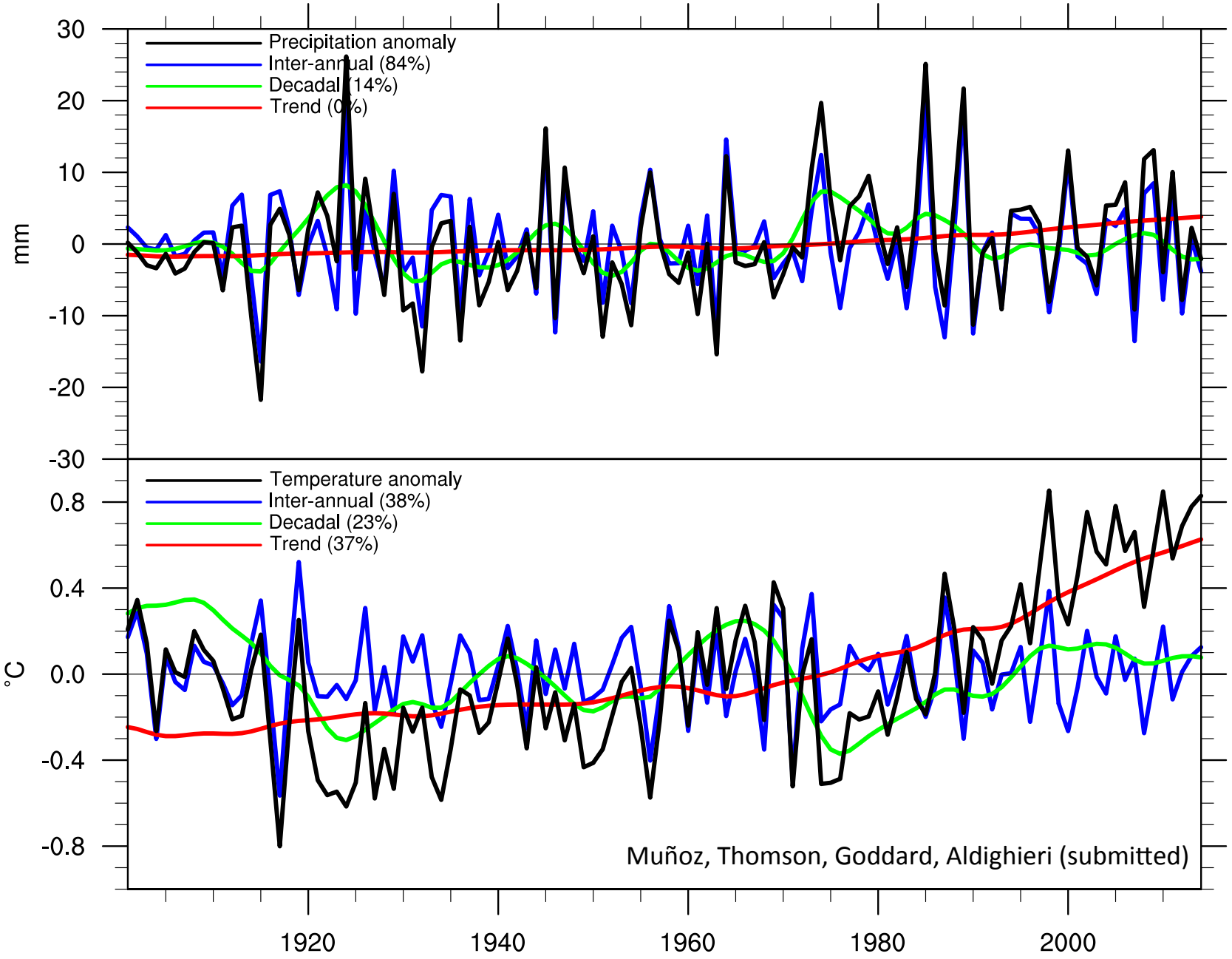
Timescale Decomposition (à la IRI)

Climate varies at different timescales… remember Goddard's video



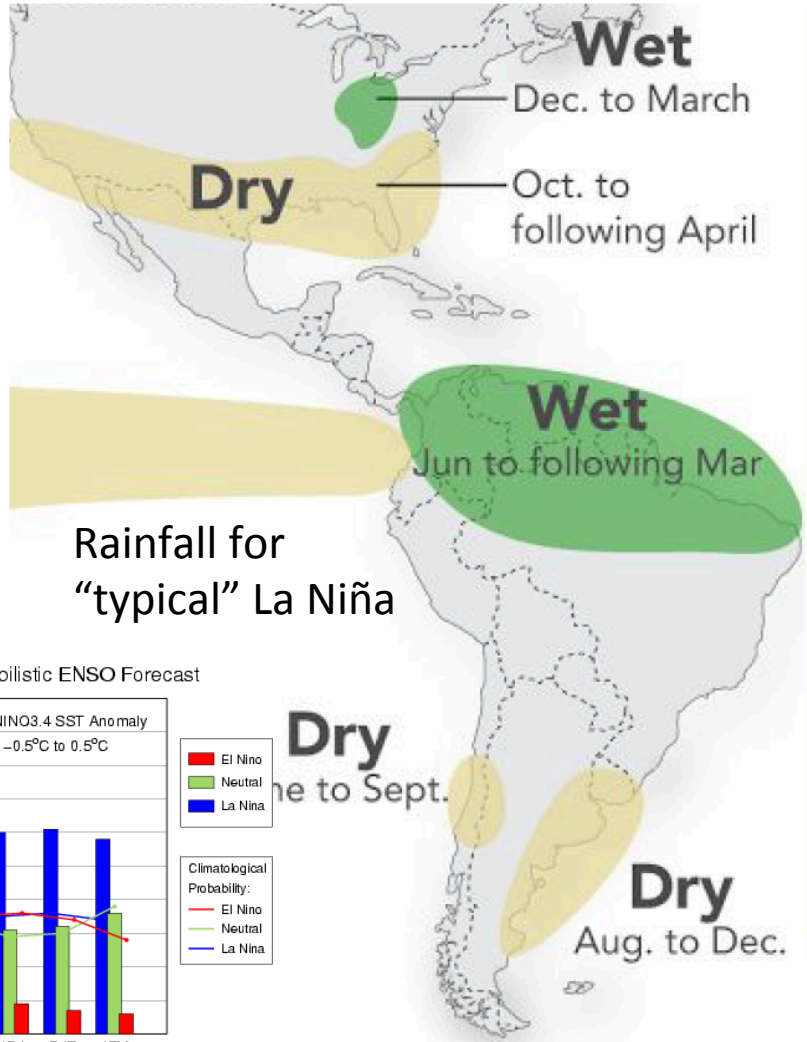
Muñoz, Thomson, Goddard, Aldighieri (submitted)

Timescale decomposition (Jan-Dec)

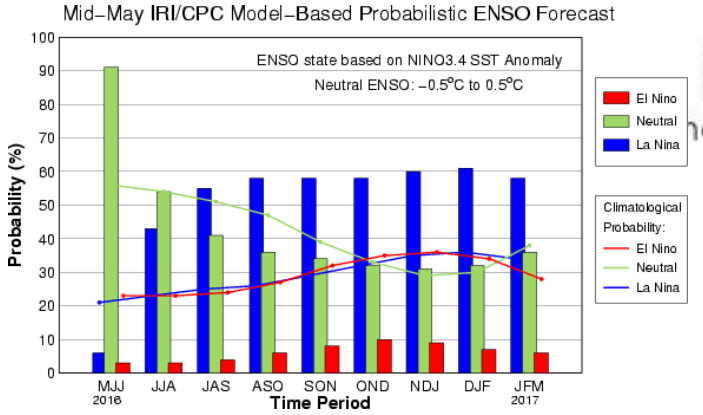


What to expect for 2016-2017?

Climate

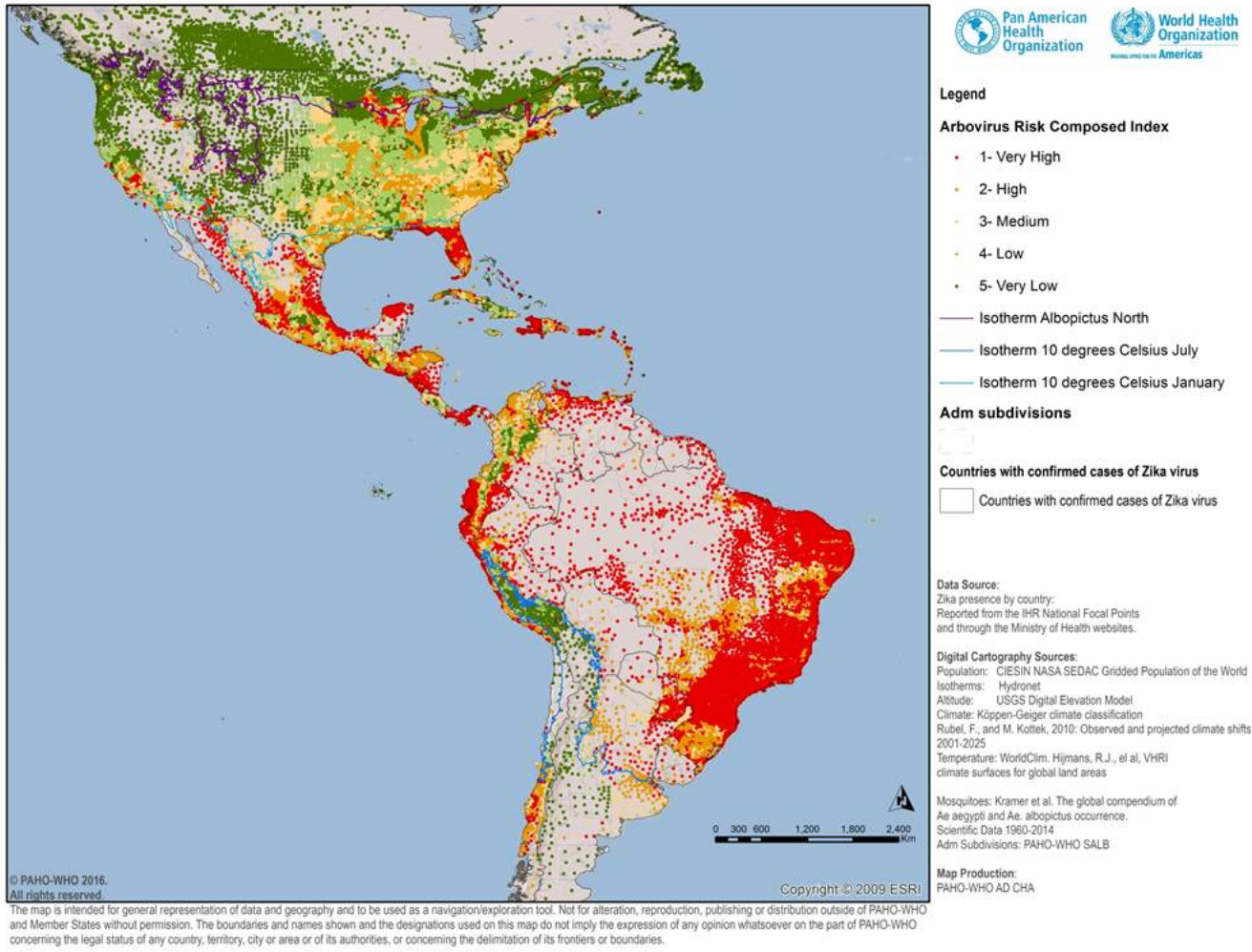


Rainfall for "typical" La Niña



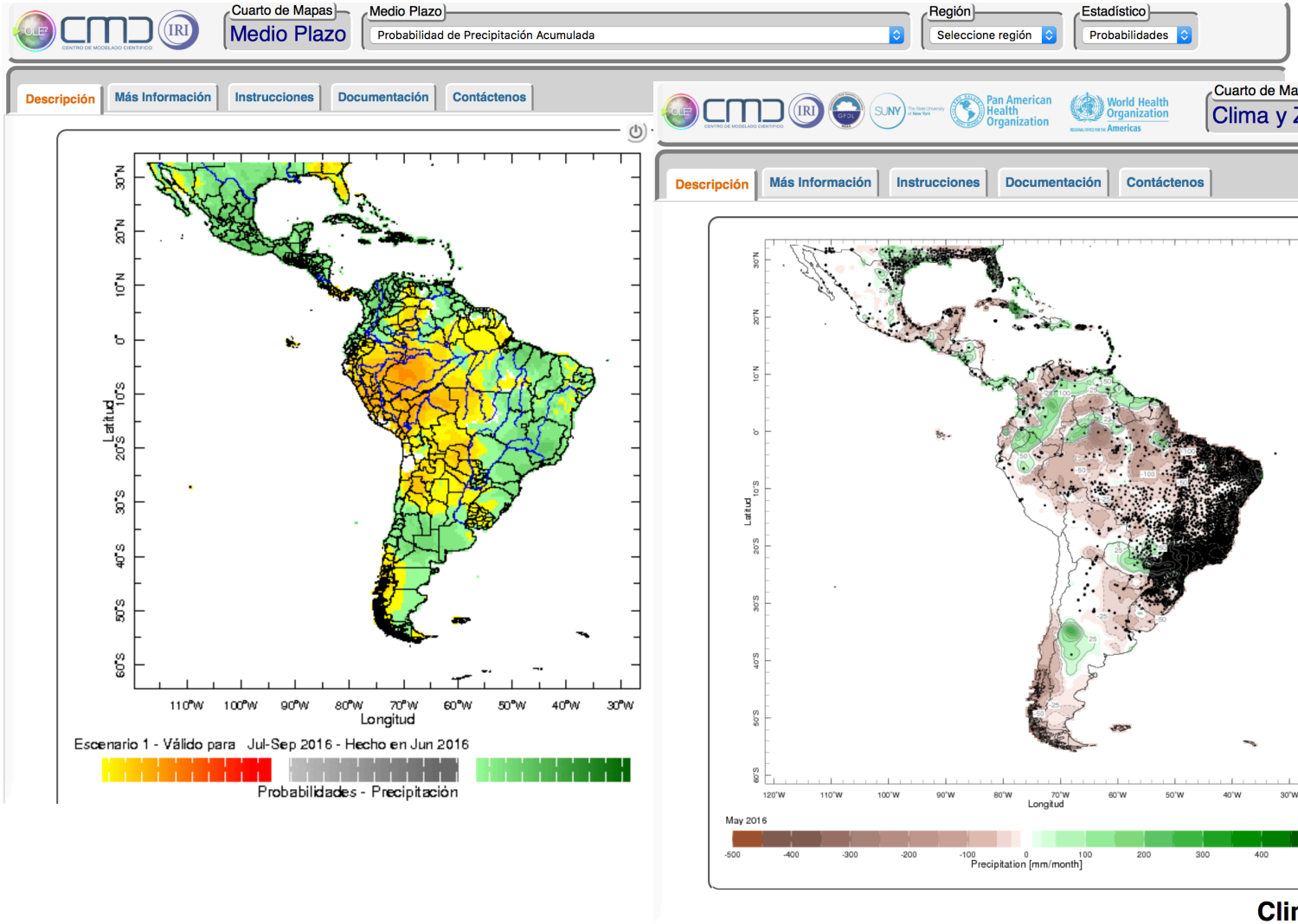
Source: International Research Institute for Climate and Society, Earth Institute | Columbia University

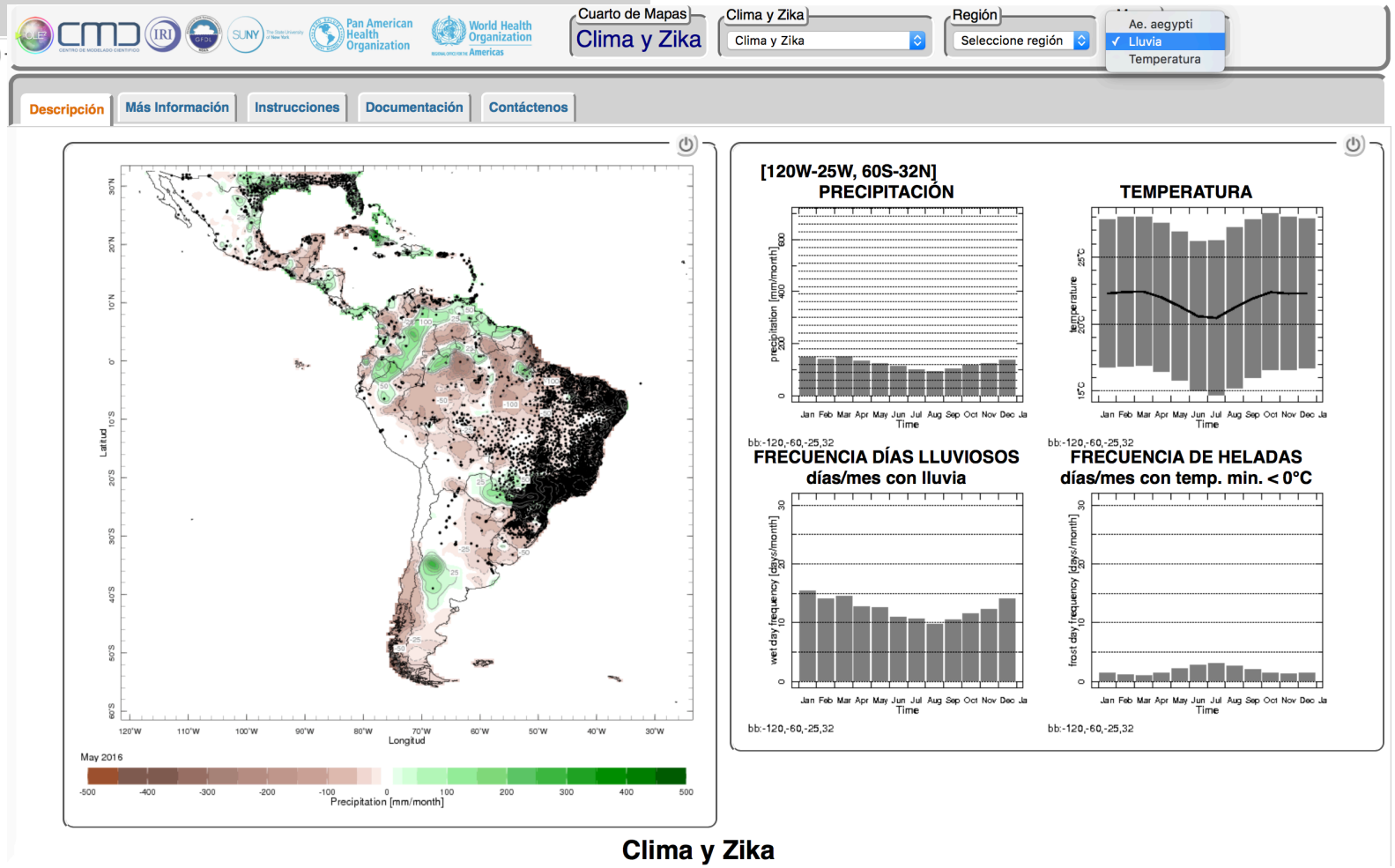
Health



Source: P. Nájera – PAHO – WHO (2016)

Towards a climate-health service for ZIKV in the Latin American Observatory





Clima y Zika

http://datoteca.ole2.org/maproom/Sala_de_Salud-Clima/

Visit our poster this afternoon!

Summary

- The end of this year will most likely (>70%) see a weak-to-moderate La Niña, associated with cooling Pacific Ocean temperatures.
- If La Niña is too weak, other modes (e.g., in the Atlantic) could be important for Latin America and the Caribbean.
- Our decomposition indicates that we will see warmer than average temperatures in most of Brazil and northern South America despite La Niña, due to decadal variability and long term trend (climate change).
- We anticipate above-normal rainfall in northern South America, and below-normal rainfall in south eastern South America.

Summary

What does this mean for Zika in late 2016 and early 2017?

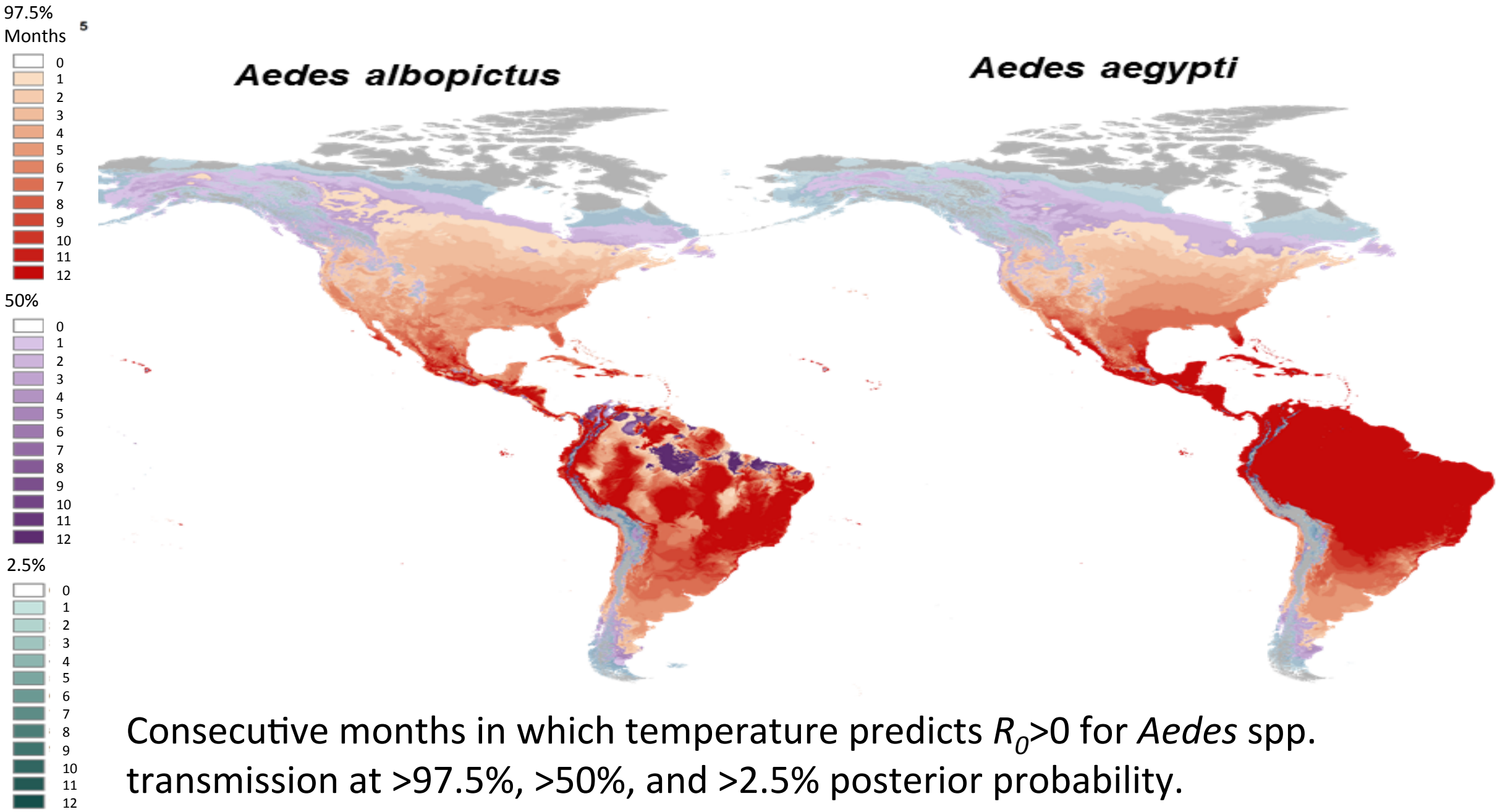
- The first wave of infection will have passed, suggesting herd immunity, lowered active transmission, and lower Zika cases reported. However, we anticipate increased reporting of birth complications due to infected mothers from 2016, and increased surveillance efforts.
- Above-normal temperatures will increase the risk of Zika transmission.
- In areas with more rainfall, interventions should focus on elimination of abandoned/discarded water bearing containers around the home.
- In areas with less rainfall, interventions should target neighborhoods with problematic access to piped water, and should focus on covering or using larvicide in containers used for water storage.
- Social political context (e.g., conflict in Venezuela, and earthquakes in Ecuador) increase dramatically the vulnerability of the population to Zika.

Interested in Zika and Climate?

It’s a date! Come tomorrow to
Room 205 at 14:00 h

(Best anti-Zika alcoholic beverage will be available)

Extra slides



Consecutive months in which temperature predicts R_0>0 for *Aedes* spp. transmission at >97.5%, >50%, and >2.5% posterior probability.

E. Mordecai et al. in prep

Monaghan AJ, Morin CW, Steinhoff DF, Wilhelmi O, Hayden M, Quattrochi DA, Reiskind M, Lloyd AL, Smith K, Schmidt CA, Scalf PE, Ernst K. On the Seasonal Occurrence and Abundance of the Zika Virus Vector Mosquito Aedes Aegypti in the Contiguous United States. PLOS Currents Outbreaks. 2016 Mar 16

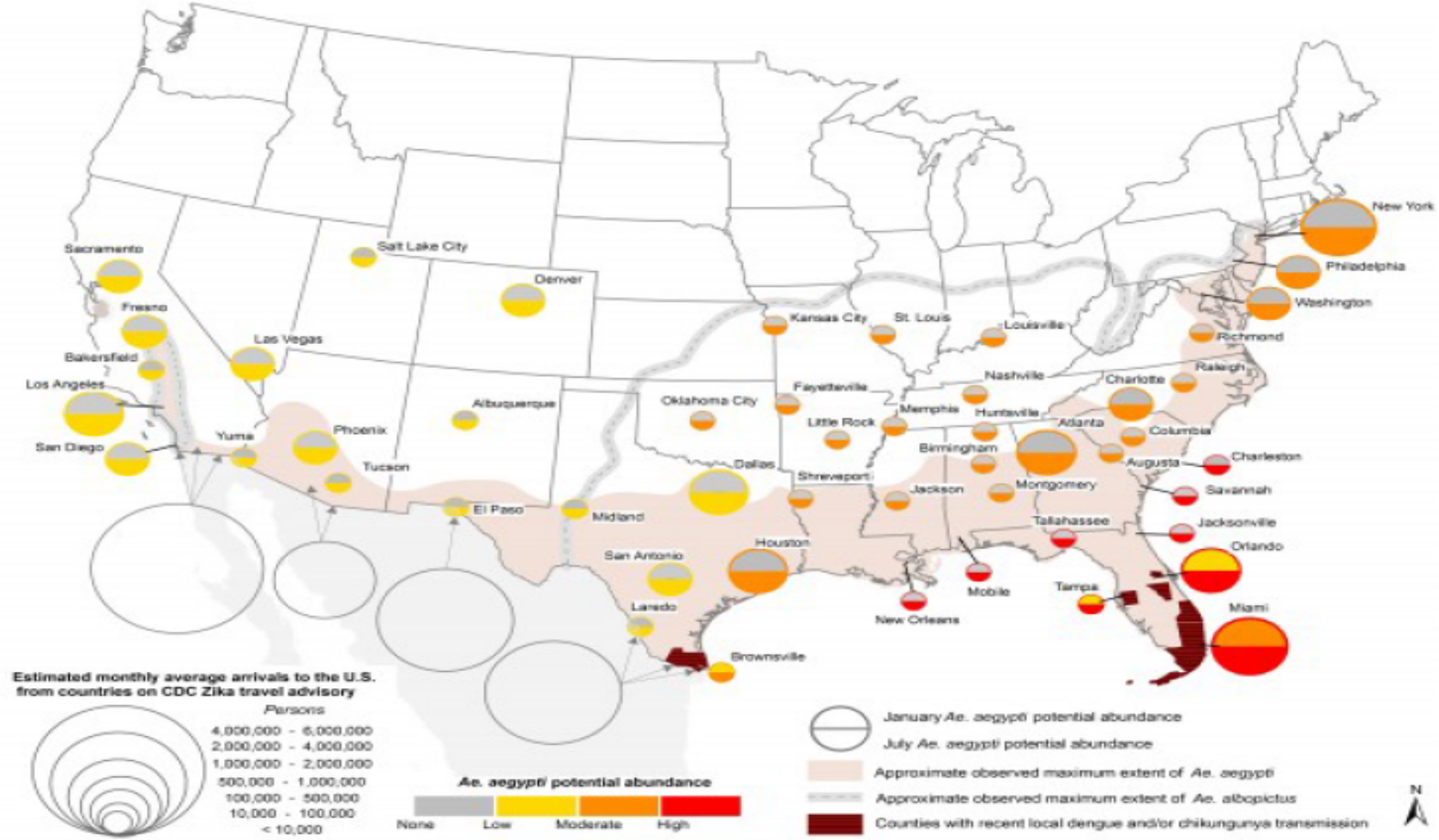


Fig. 1. U.S. map showing 1) *Ae. aegypti* potential abundance for Jan/July (colored circles), 2) approximate maximum known range of *Ae. aegypti* (shaded regions) and *Ae. albopictus* (gray dashed lines), and 3) monthly average number arrivals to the U.S. by air and land from countries on the CDC Zika travel advisory. Additional details can be found in the text.

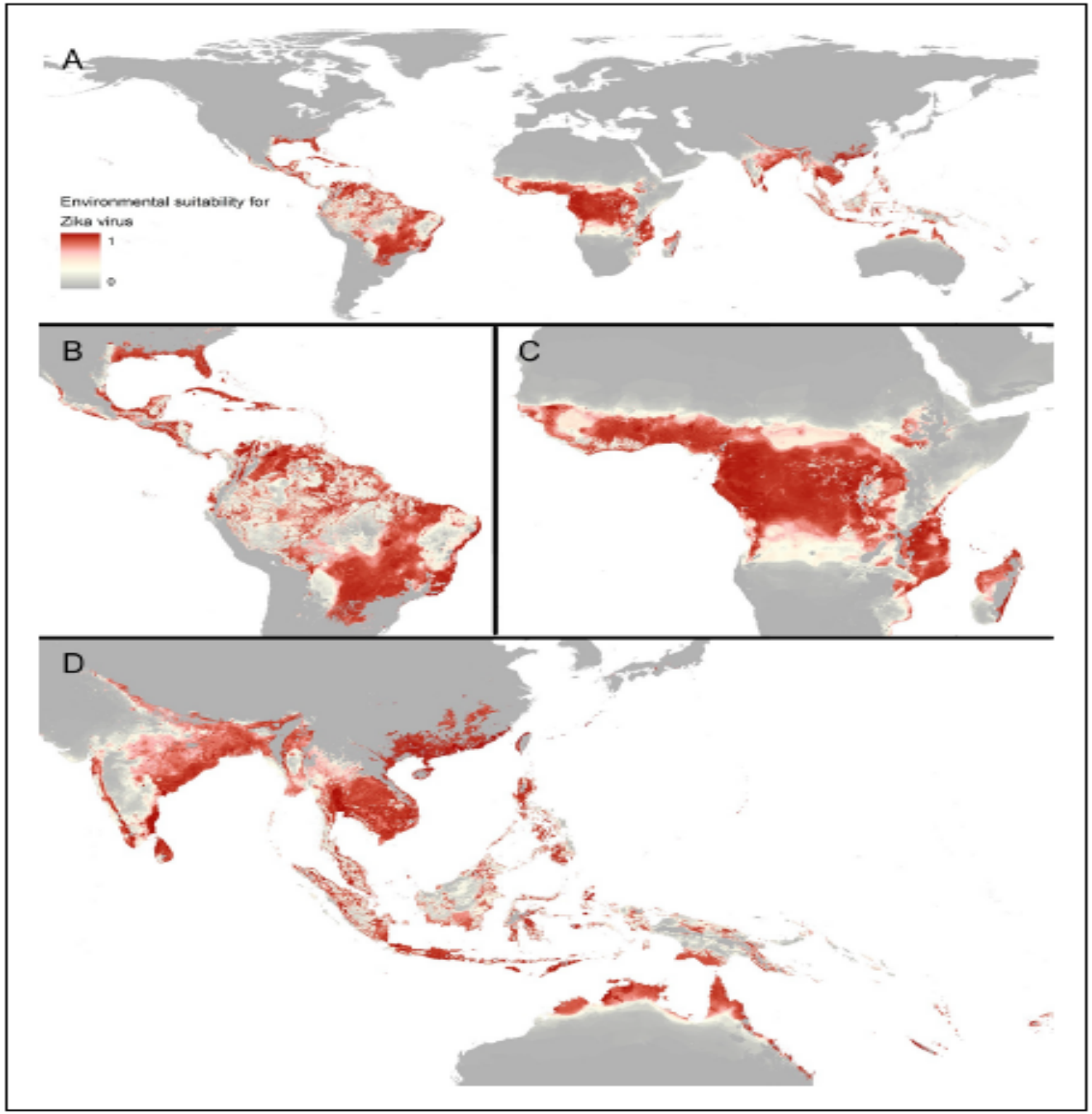
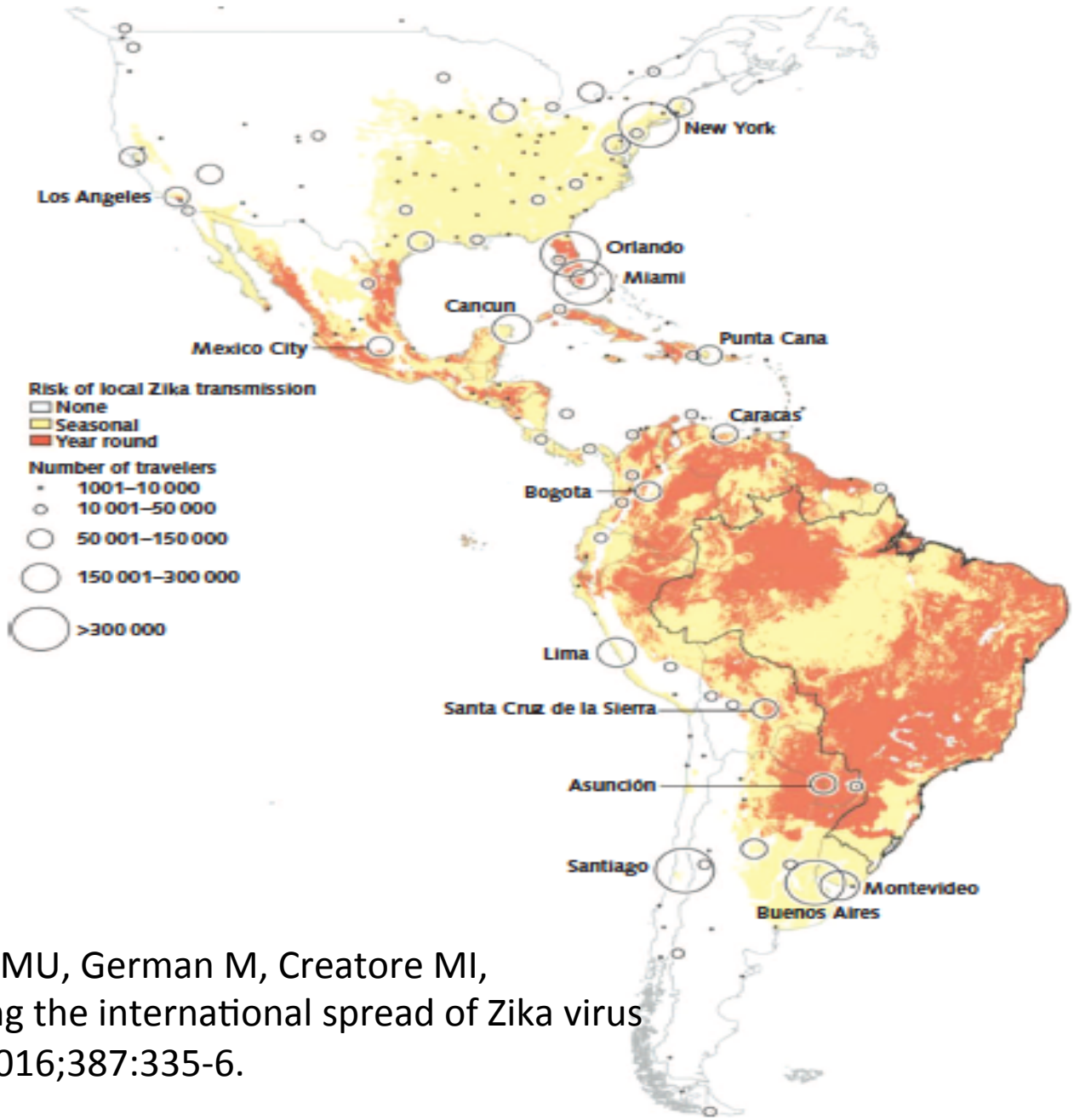


Figure 2. Maps of (A) global environmental suitability for ZIKV, ranging from 0 (grey) to 1 (red), showing greater detail for (B) the Americas, (C) Africa, and (D) Asia and Oceania.

Messina et al, Elife. 2016

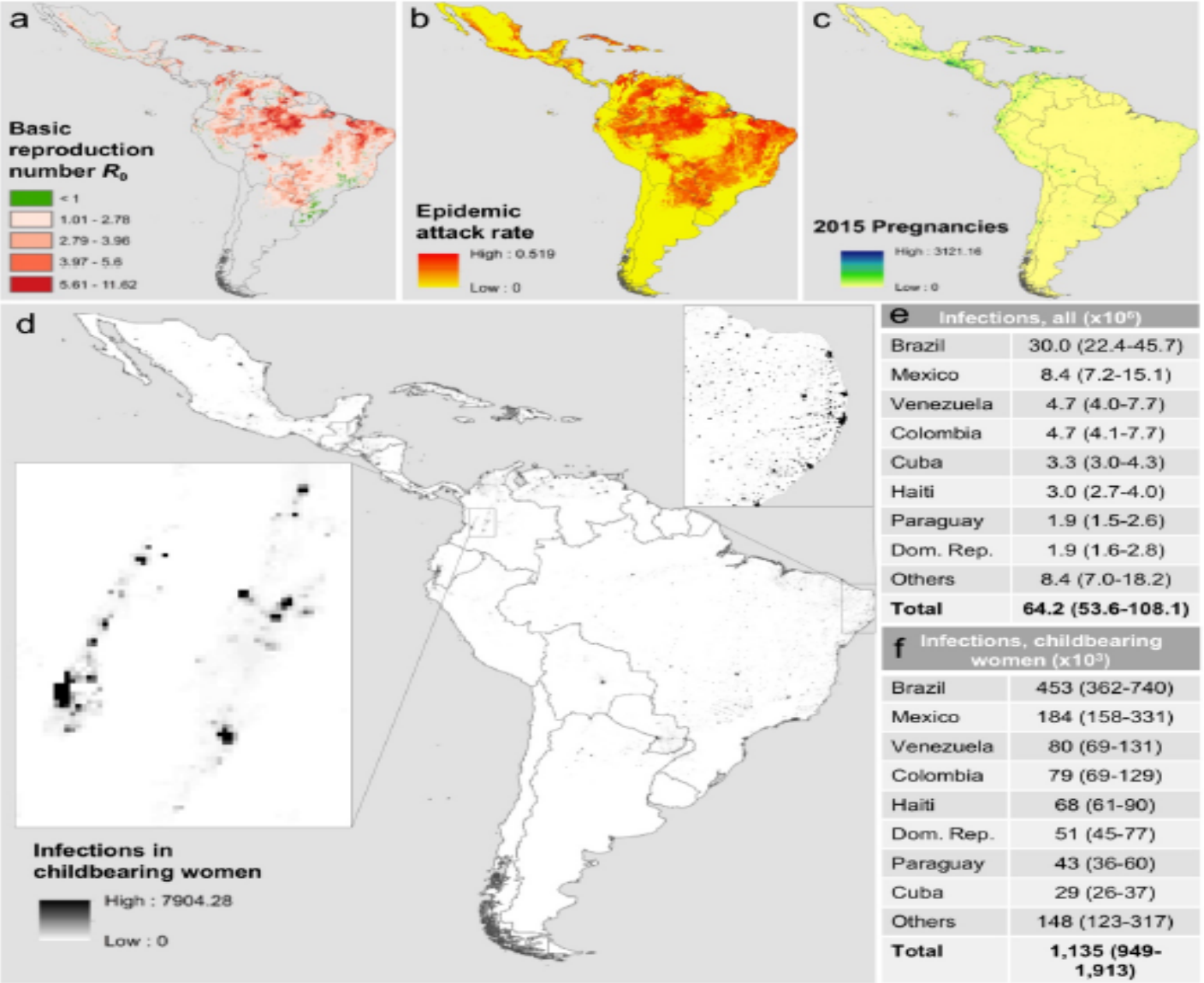
Figure 1. Predicted risk for local Zika transmission, based on final destinations for travelers departing Brazil and incorporating ecological niche information for *Aedes aegypti* and *A albopictus*.



Bogoch II, Brady OJ, Kraemer MU, German M, Creatore MI, Kulkarni MA, et al. Anticipating the international spread of Zika virus from Brazil [Letter]. Lancet. 2016;387:335-6.

Model-based projections of Zika virus infections
in childbearing women in the Americas

T. Alex Perkins1*, Amir S. Siraj1, Corrine Warren Ruktanonchai2, Moritz U.G. Kraemer3,



e Infections, all (x10⁶)	
Brazil	30.0 (22.4-45.7)
Mexico	8.4 (7.2-15.1)
Venezuela	4.7 (4.0-7.7)
Colombia	4.7 (4.1-7.7)
Cuba	3.3 (3.0-4.3)
Haiti	3.0 (2.7-4.0)
Paraguay	1.9 (1.5-2.6)
Dom. Rep.	1.9 (1.6-2.8)
Others	8.4 (7.0-18.2)
Total	**64.2 (53.6-108.1)**

f Infections, childbearing women (x10³)	
Brazil	453 (362-740)
Mexico	184 (158-331)
Venezuela	80 (69-131)
Colombia	79 (69-129)
Haiti	68 (61-90)
Dom. Rep.	51 (45-77)
Paraguay	43 (36-60)
Cuba	29 (26-37)
Others	148 (123-317)
Total	**1,135 (949-1,913)**

Figure 1. Gridded spatial projections of component variables (a-c) that combine to yield a gridded spatial projection of Zika infections in childbearing women across Latin America and the Caribbean (d). Projections of total numbers of Zika infections in all people (e) and in childbearing women (f) for the top eight countries in each category were derived from 5x5 km gridded spatial projections such as (d). Numbers in e and f represent mean (lower bound – upper bound) with respect to relationships between environmental variables and transmission potential.