Emerging infectious diseases in a new climate

Rachel Lowe

London School of Hygiene & Tropical Medicine
Barcelona Institute for Global Health

IMED, Vienna, 12 Nov 2018

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Climate and infectious diseases make headlines

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The Guardian

Tropical disease outbreaks are growing threat in Europe as temperatures rise

After West Nile virus kills 22 people in heatwave, experts warn of more mosquito and tick-borne diseases due to climate change

▲ Researchers predict the risk of transmission of dengue fever, Zika and other mosquito-borne disease will rise as climate change alters weather patterns. Photograph: Jeff Miller/AP

The Telegraph

News

Heavy rainfall and soaring temperatures behind spike in mosquito-borne fever in southern Europe

share Save

A child cools off in a fountain in Turin during a heatwave CREDIT: MARCO BERTORELLO/AFP

THE LANCET Infectious Diseases

NEWSDESK | VOLUME 18, ISSUE 11, P1184, NOVEMBER 01, 2018

West Nile virus spreads in Europe

Europe has seen more than 1,600 cases of West Nile virus this year

Confirmed and probable cases of human West Nile virus infections, 2018

300+ cases · 225-299 · 150-224 · 75-149 · less than 75 · no reports

Source: The Telegraph

Climate services for health

- Transform climate information into relevant, usable decision-support tools.

- Manage the risks of environmental change.

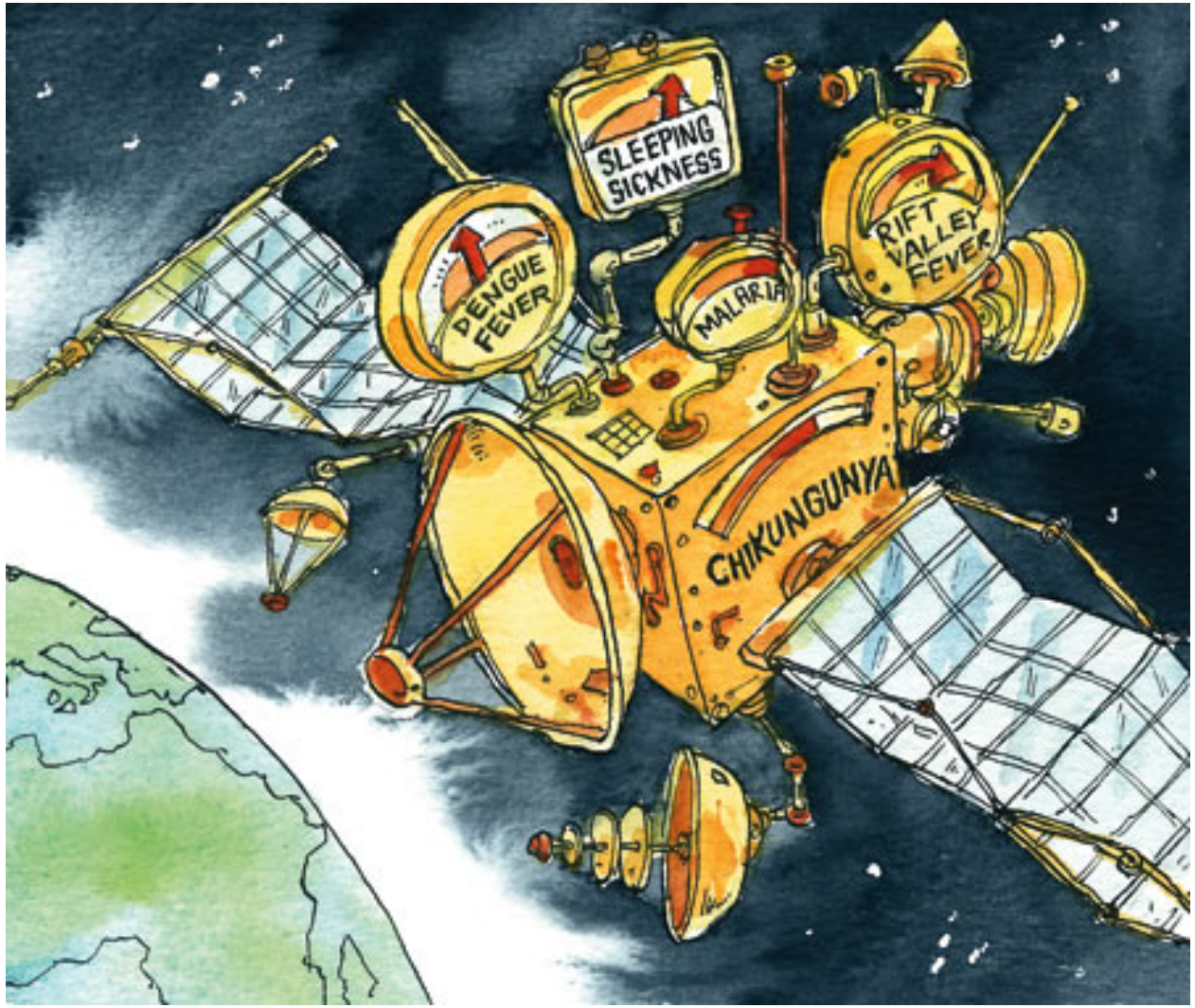
Key components

- Partnership, Research, Product development & delivery, Evaluation, Capacity building.

- Co-developed by health and climate professionals.

GFCS HEALTH
GLOBAL FRAMEWORK FOR CLIMATE SERVICES

From global observations to local interventions



Source: The Economist

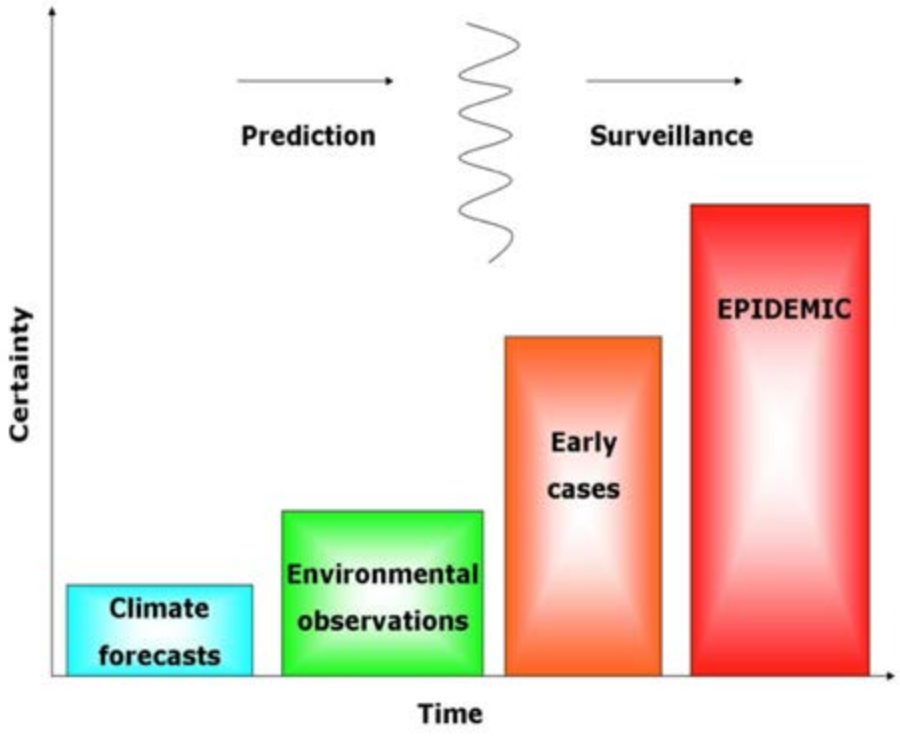
Early warning and response systems

- **Early warning systems** based on climate information can help to implement timely control measures.

- **Seasonal climate forecasts** provide an opportunity to anticipate epidemics several months in advance.

- **Bayesian model framework** used to make probabilistic statements about future disease risk (e.g. probability of an epidemic during a mass gathering or natural disaster)?

- Cases studies: **Brazil**, **Ecuador** and **Barbados**



Towards an early warning system for dengue in Brazil

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journal homepage: www.elsevier.com/locate/cageo

Formulate

Spatio-temporal modelling of climate-sensitive disease risk: Towards an early warning system for dengue in Brazil

Rachel Lowe[a,*], Trevor C. Bailey[a], David B. Stephenson
Marilia Sá Carvalho[d], Christovam Barcellos[d]

Develop

Statistics in Medicine

Research Article

Received 22 August 2011, Accepted 3 July 2012 Published online 24 August 2012 in Wiley Online Library

(wileyonlinelibrary.com) DOI: 10.1002/sim.5549

The development of an early warning system for climate-sensitive disease risk with a focus on dengue epidemics in Southeast Brazil‡

Rachel Lowe,[a*†]
Tim E. Jupp,[b] R
Marilia Sá Carv

Apply

Evaluate

Dengue outlook for the World Cup in Brazil: an early warning model framework driven by real-time seasonal climate forecasts

Rachel Lowe, Christovam Barcellos, Caio A S Coelho, Trevor C Bailey, Giovanini Evelim Coelho
Marilia Sá Carvalho, David B Stephenson, Xavier Rodó

eLIFE elifesciences.org

RESEARCH ARTICLE

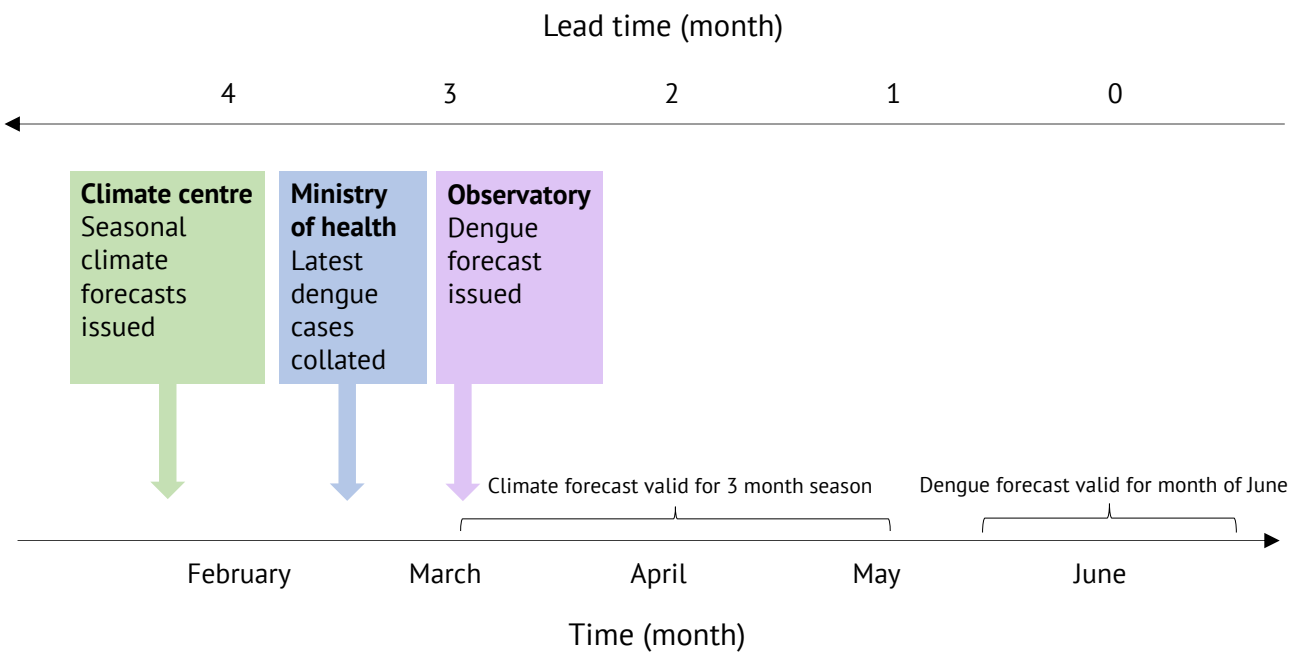
Evaluating probabilistic dengue risk forecasts from a prototype early warning system for Brazil

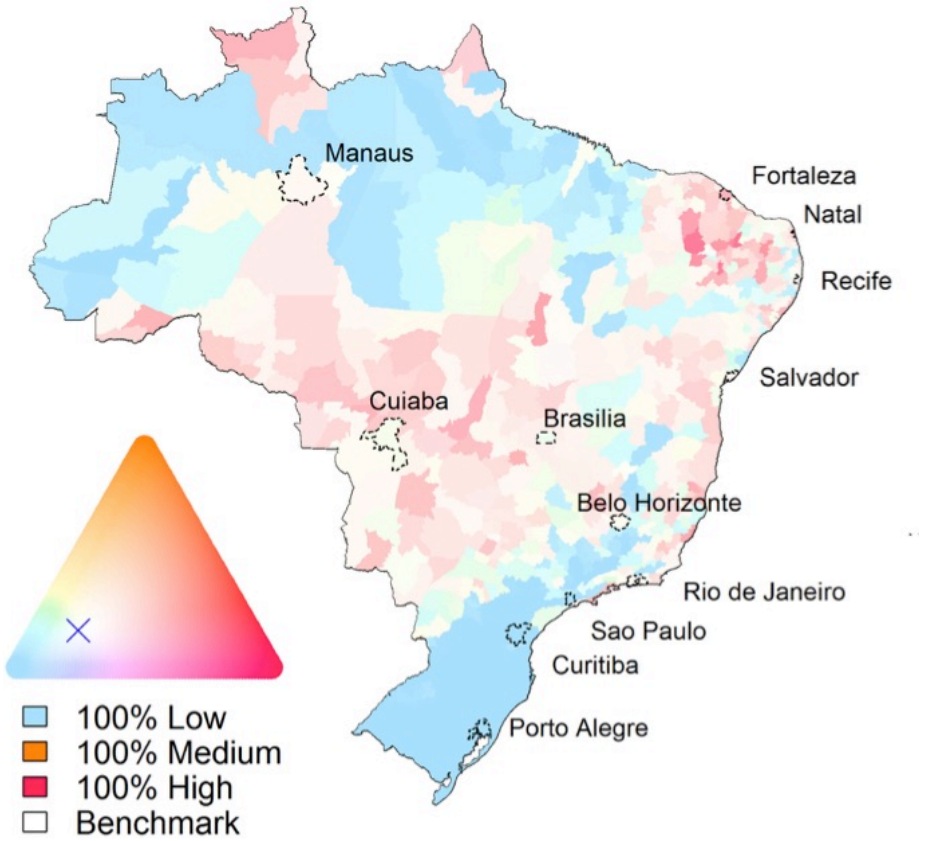
Rachel Lowe[1*], Caio AS Coelho[2], Christovam Barcellos[3], Marilia Sá Carvalho[3], Rafael De Castro Catão[1,4], Giovanini E Coelho[5], Walter Massa Ramalho[6], Trevor C Bailey[7], David B Stephenson[7], Xavier Rodó[1,8]

The Leverhulme Trust

CAPES

Probabilistic dengue early warning

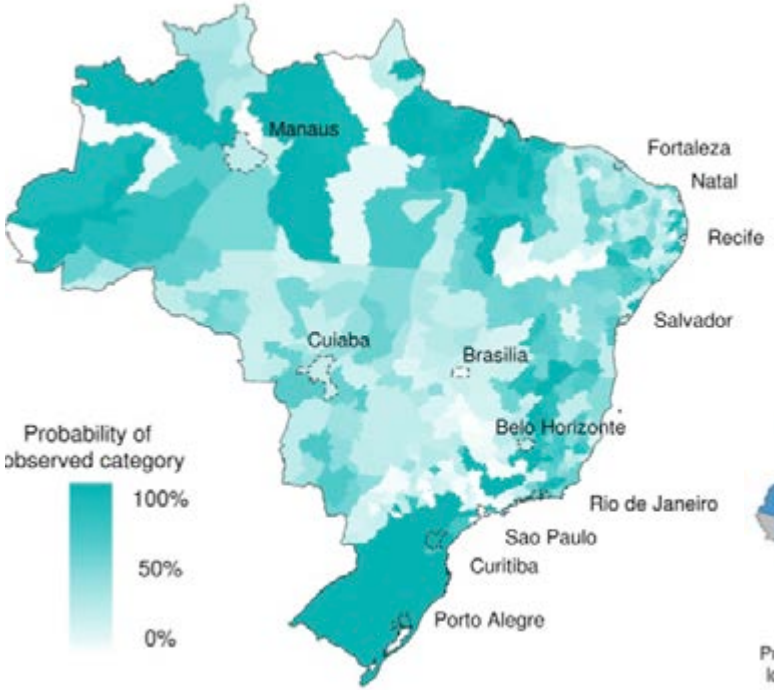




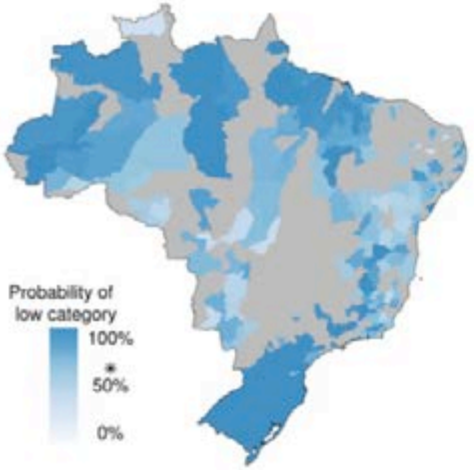
- Early warning framework applied to predict dengue risk for the World Cup in Brazil.
- Category boundaries: 100 and 300 cases per 100,000 inhabitants.

Lowe *et al.*, 2014, *Lancet Infect Dis*

Probability of observing correct category



Low

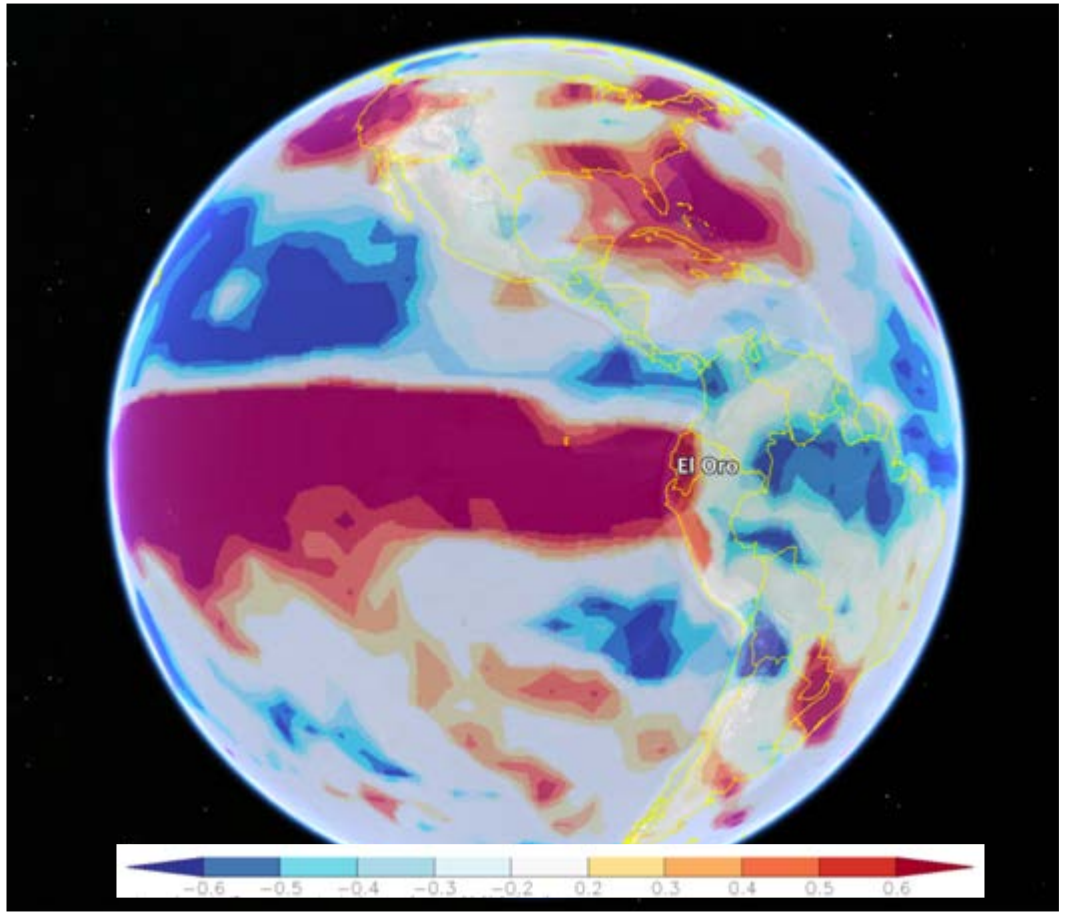


Medium

High

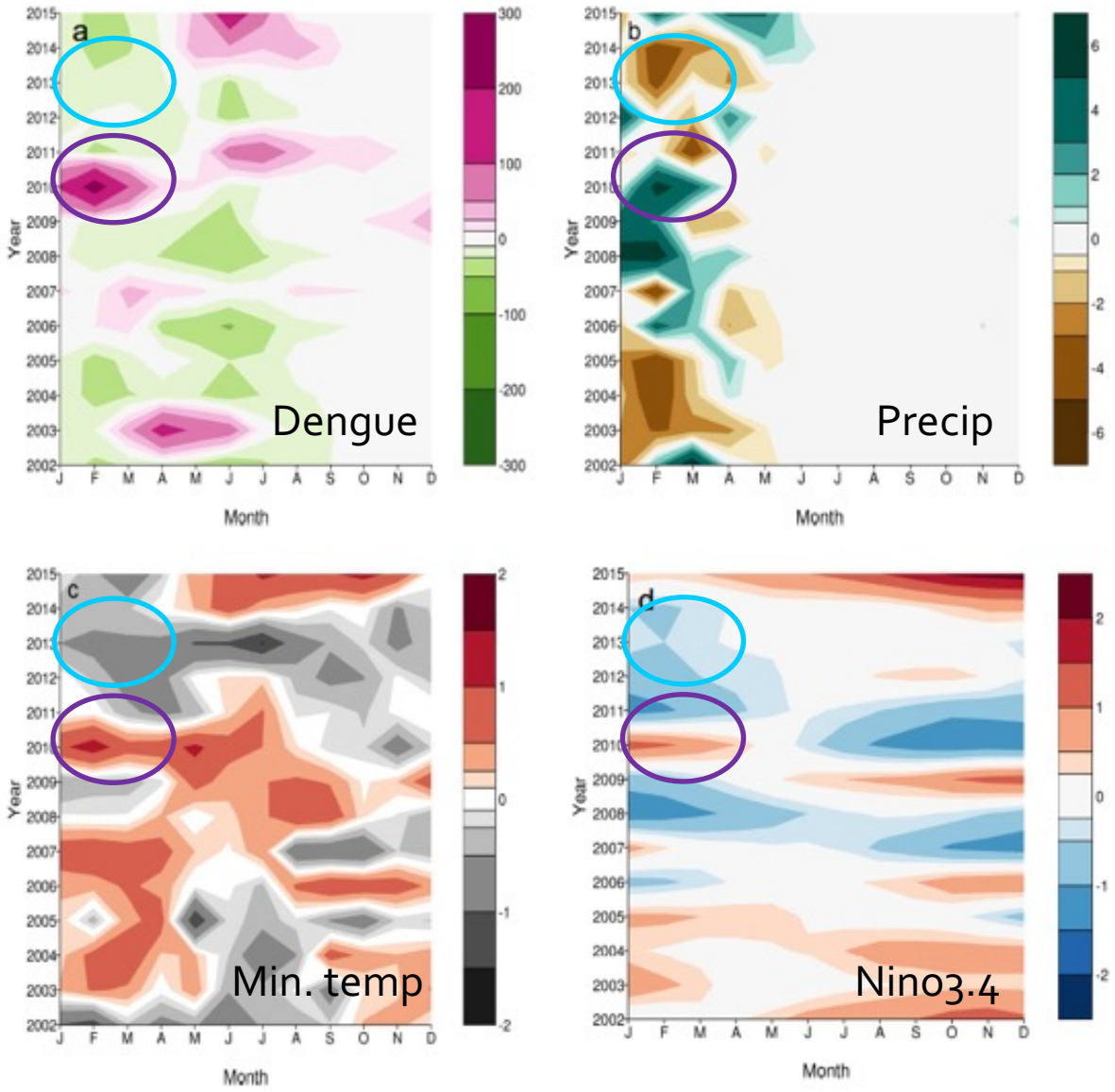
Lowe *et al.*, 2016, *eLife*

El Niño, flooding and dengue in Ecuador



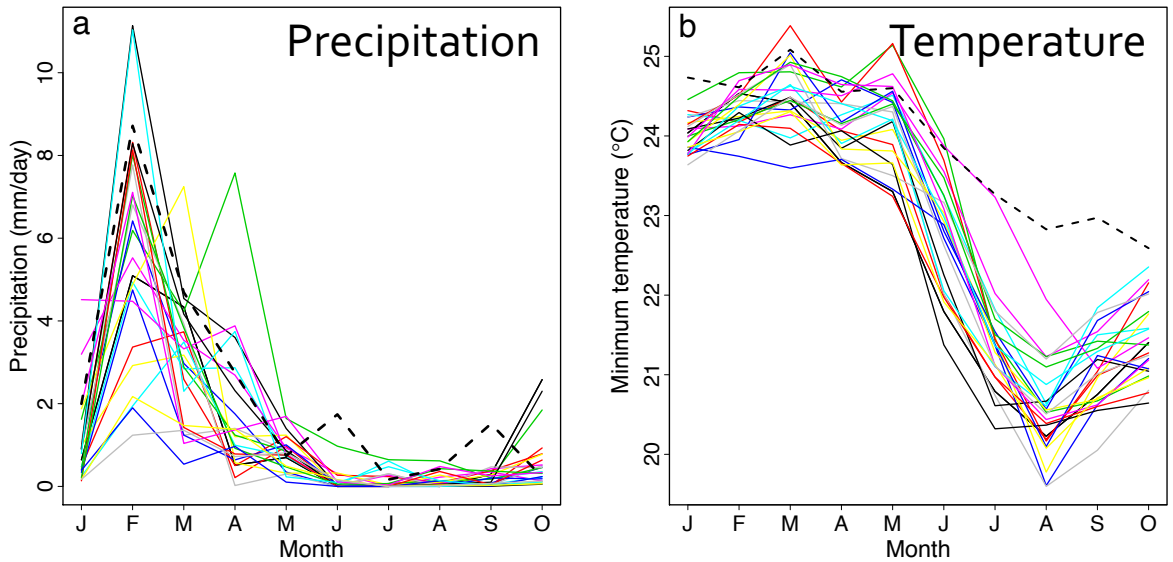
In Feb, 2016, intense rainfall combined with high tides, causing the worst flooding in Machala, Ecuador since the 1997-1998 El Niño.

Climate and dengue associations



Cooler and drier than usual → less dengue

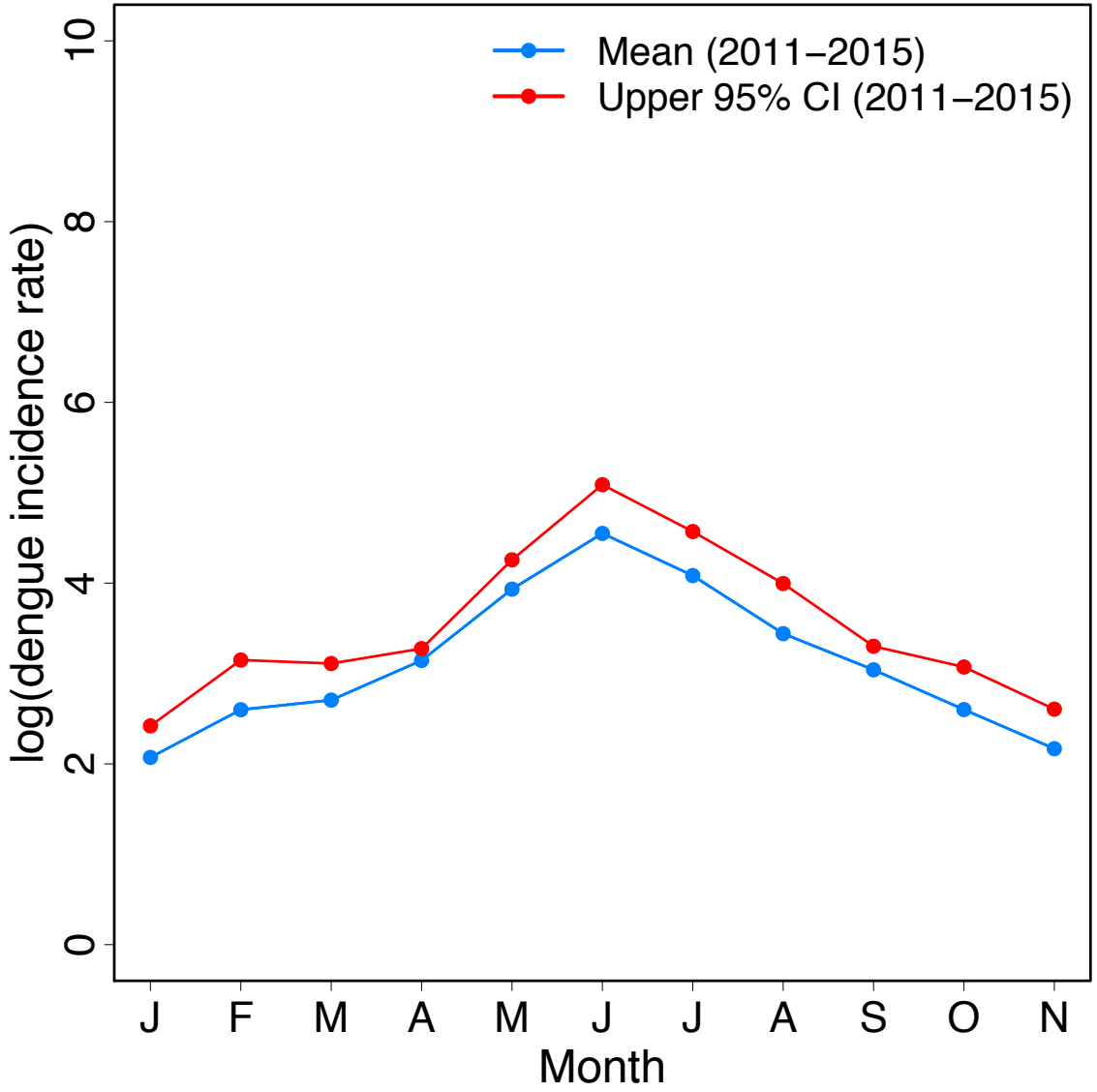
Warmer and wetter than usual → more dengue



Ensemble precipitation and min. temperature forecasts (24 members) for Jan – Oct 2016

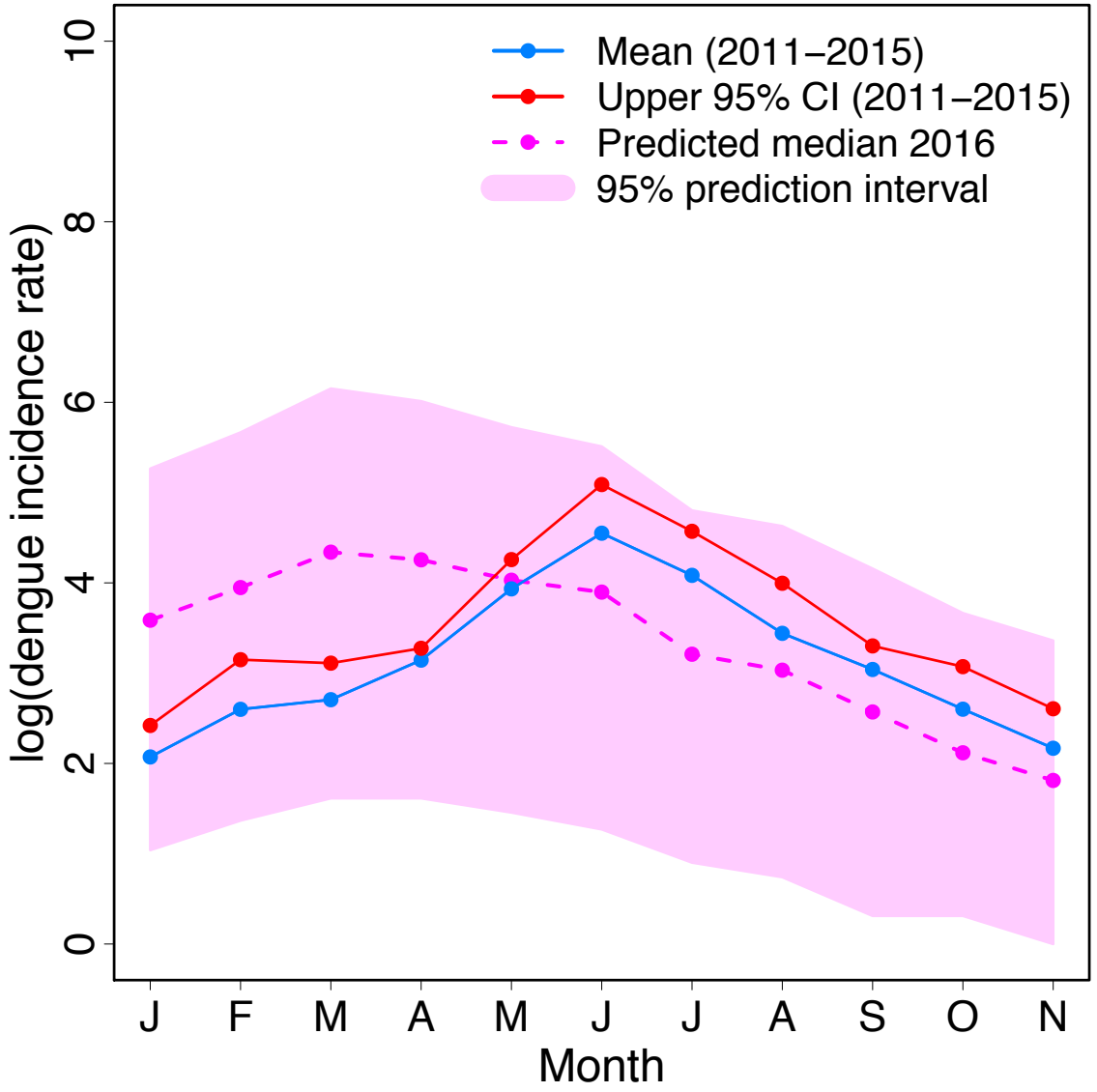
Lowe *et al.*, 2017 *Lancet Planet Health*

Current practice: average over last 5 years



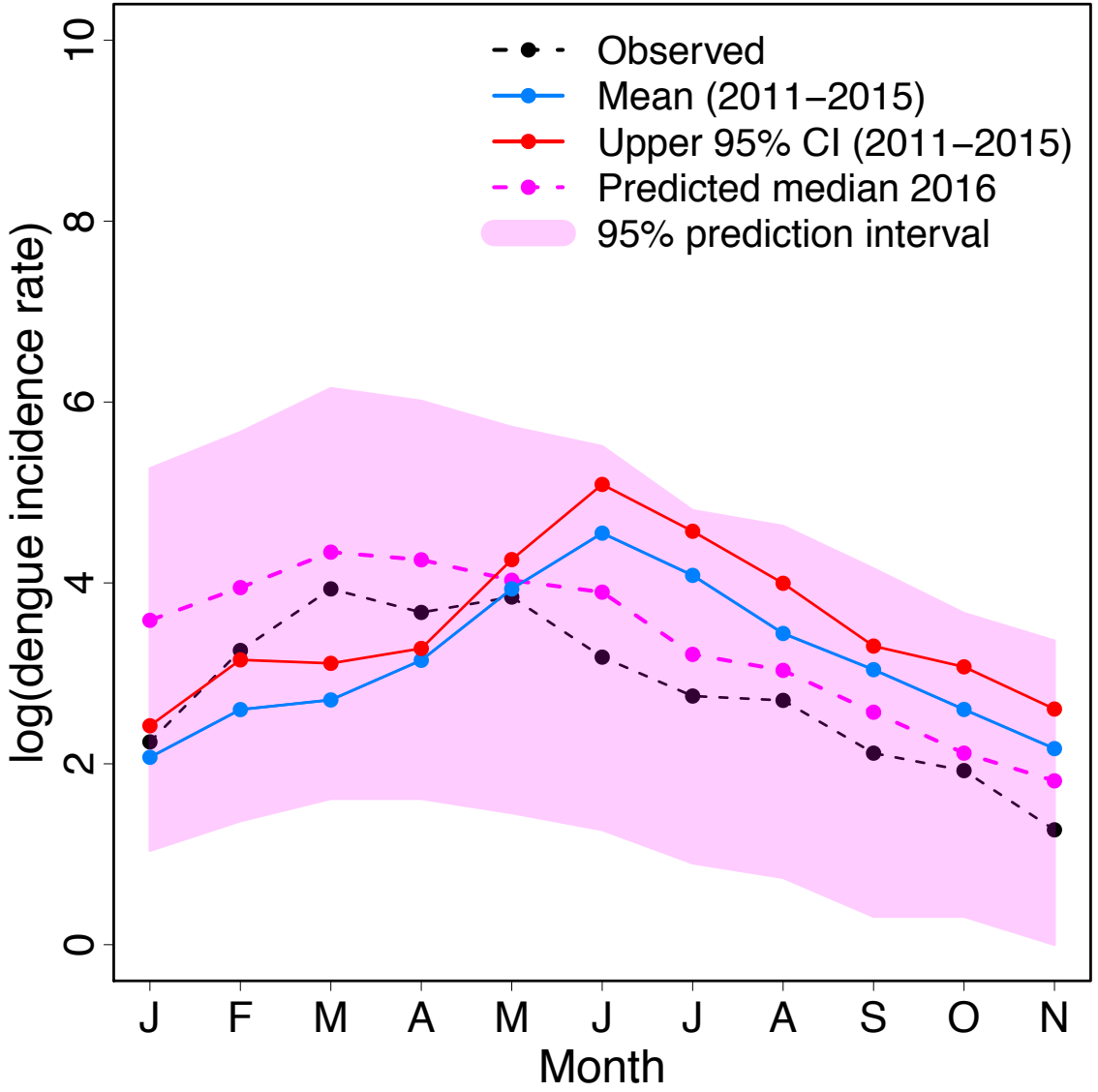
Mean and 95% upper CI for previous five years in Machala.

Climate-driven dengue forecast, Machala 2016



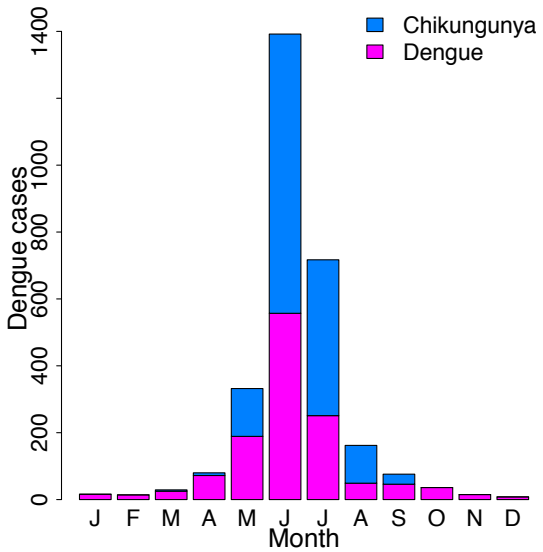
In March 2016, 85% chance of exceeding threshold of 95% upper CI for previous five years.

Peak occurred earlier than expected



Timing: climate forecasts

Magnitude: correct misreporting



Lowe *et al.*, 2017, *Lancet Planet Health*

Drought, water storage and arboviruses in Barbados

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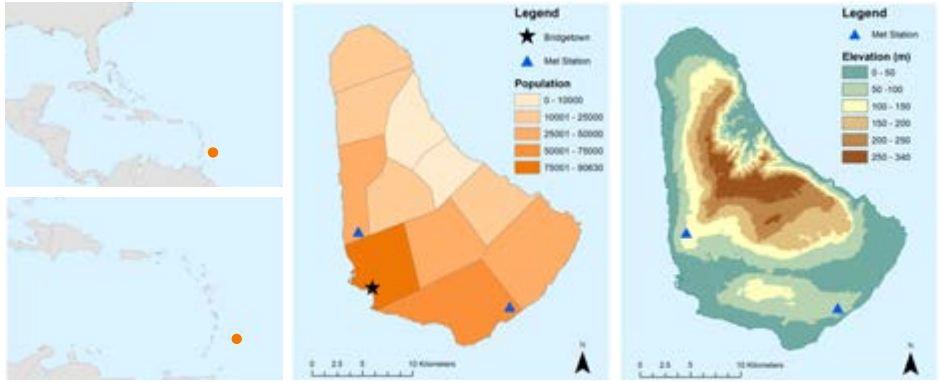
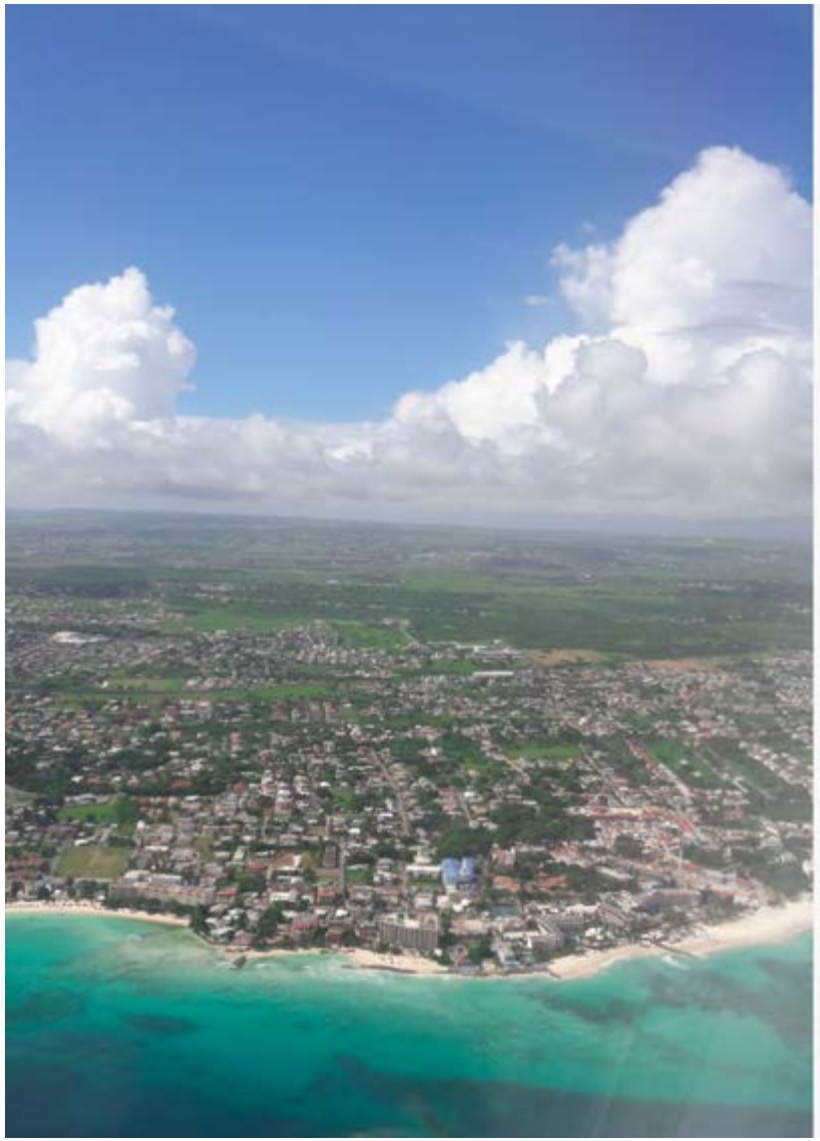
- The Caribbean region is facing a major crisis of co-occurring epidemics of **dengue**, chikungunya and Zika viruses.

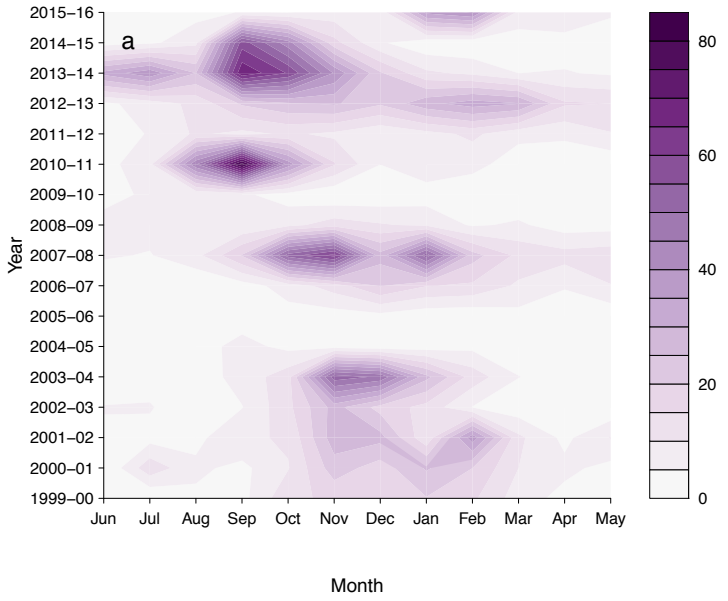
- An increase incidence of dengue suspected in **Barbados** following **drought** events.



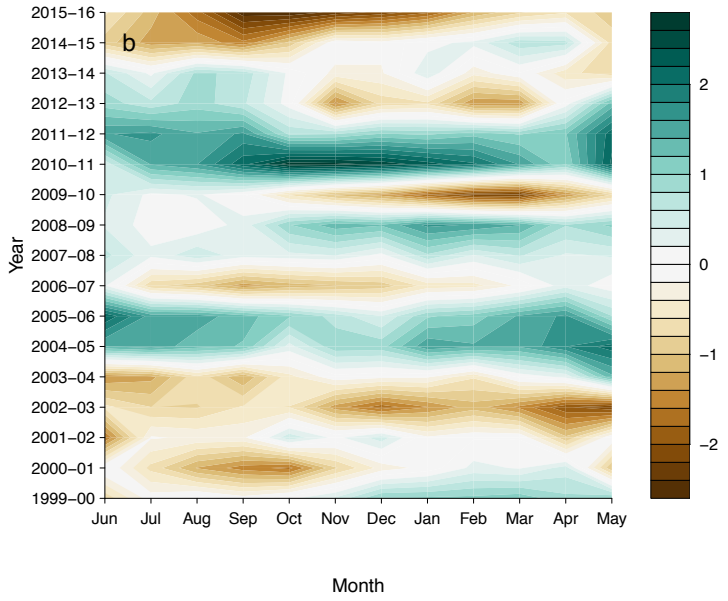


Combined impact of dry and wet periods on dengue

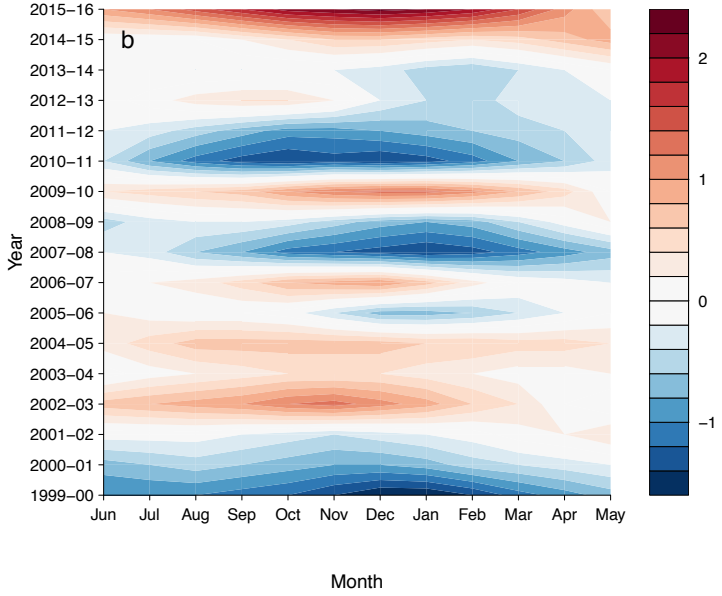
Dengue incidence rate



Standardised precipitation index



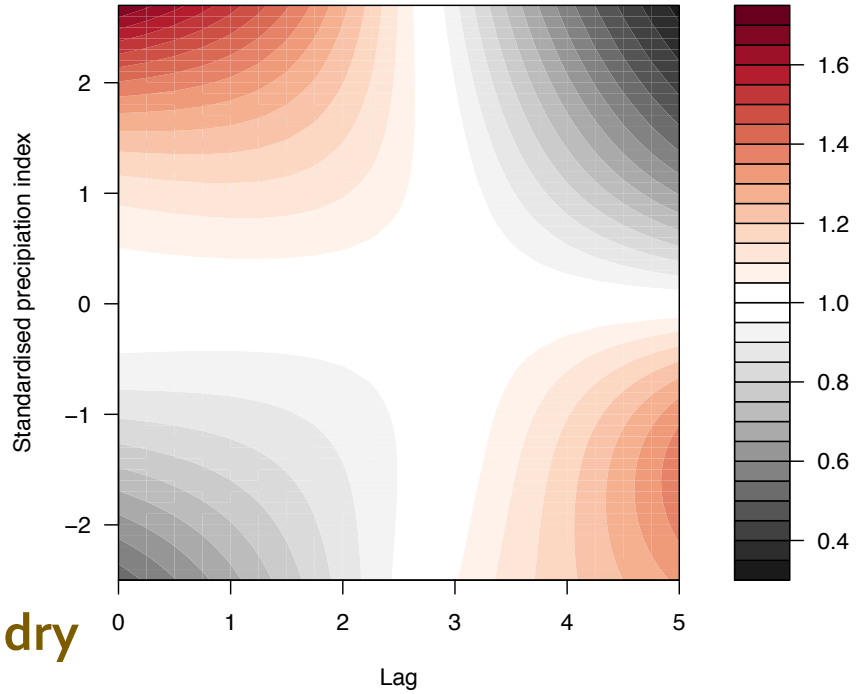
Oceanic Niño index



We used **distributed lag non-linear models** (Gasparrini, 2013) coupled with a **Bayesian hierarchal model** (Lowe et al, 2017) to understand exposure-lag response associations between dengue, temperature, drought and rainfall.

Exposure-lag-response associations

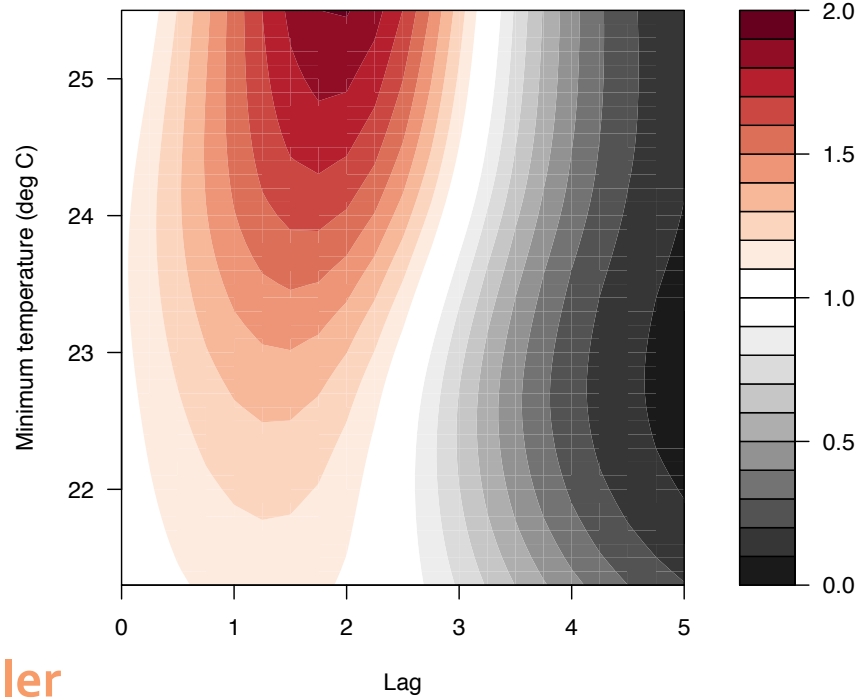
Exceptionally wet



Exceptionally dry

Short lag Long lag

Warmer



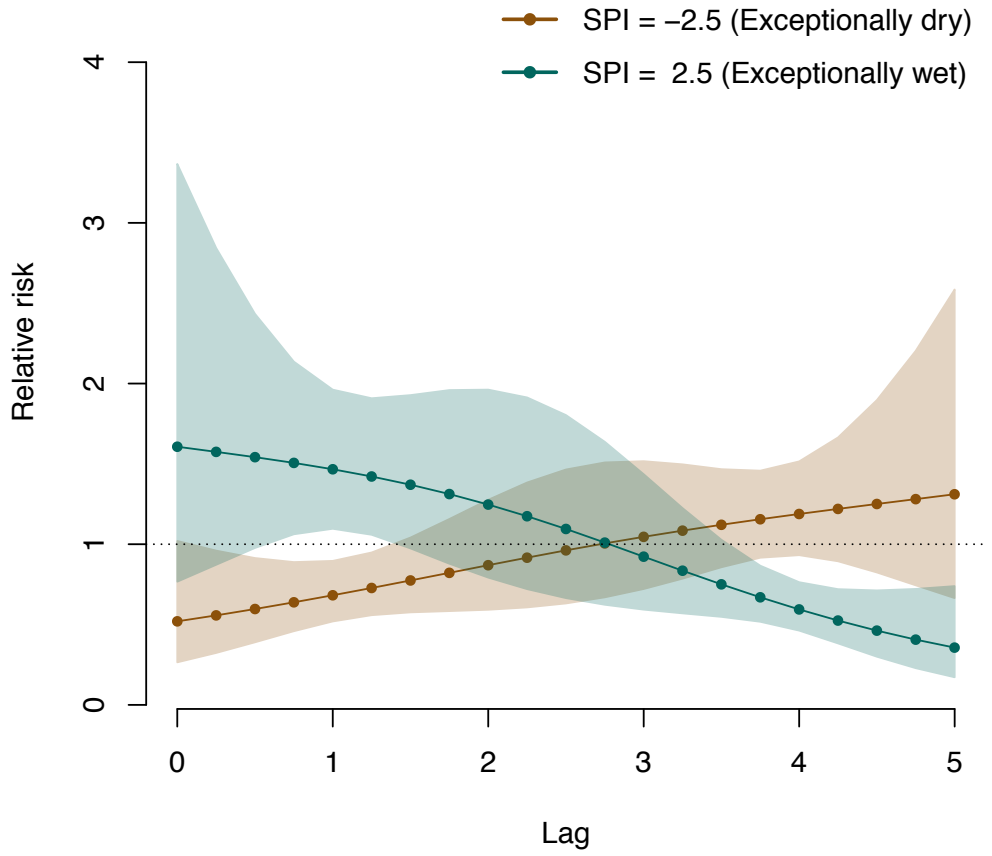
Cooler

Short lag Long lag

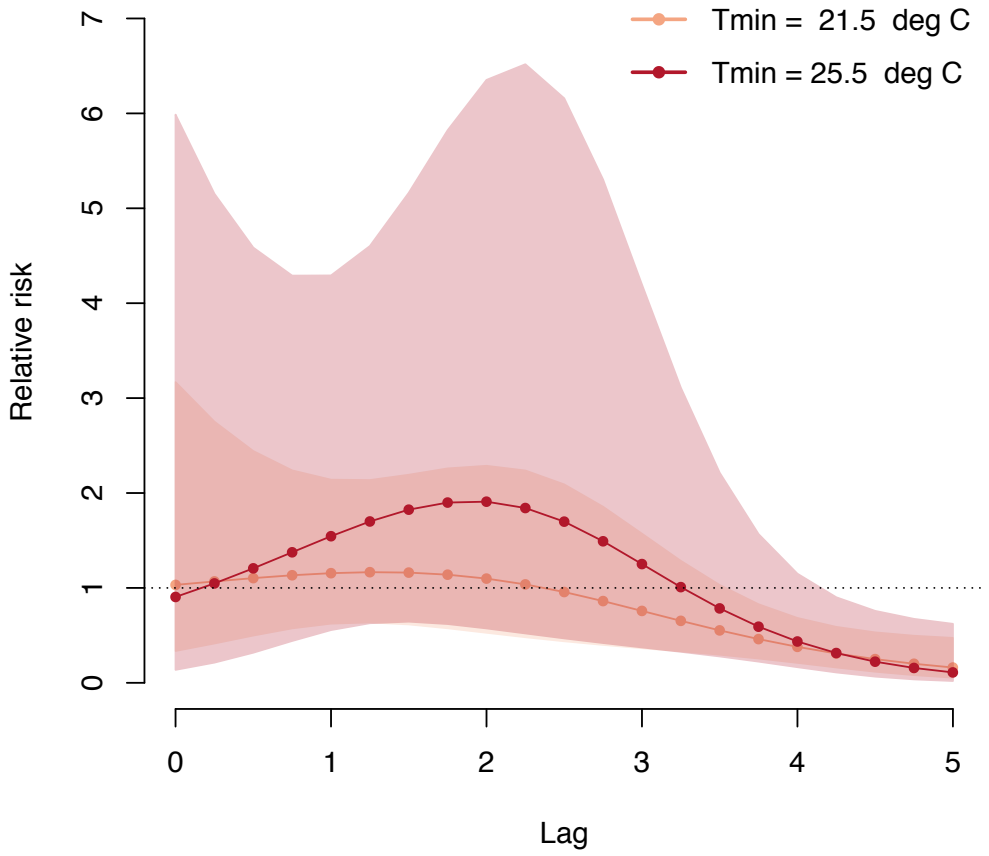
Lowe *et al.*, 2018 *PLOS Medicine*

Lag response for extreme climate scenarios

Standardised precipitation index

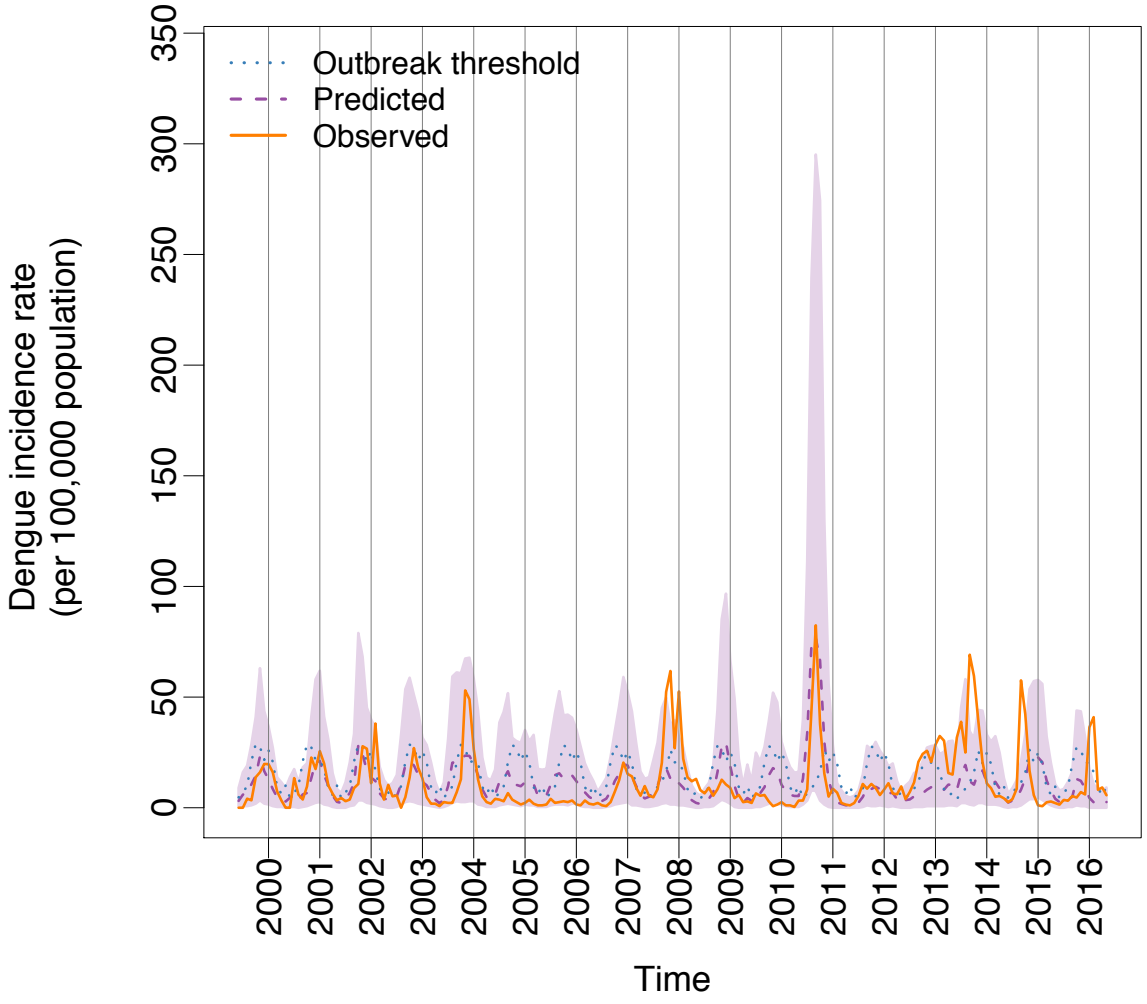


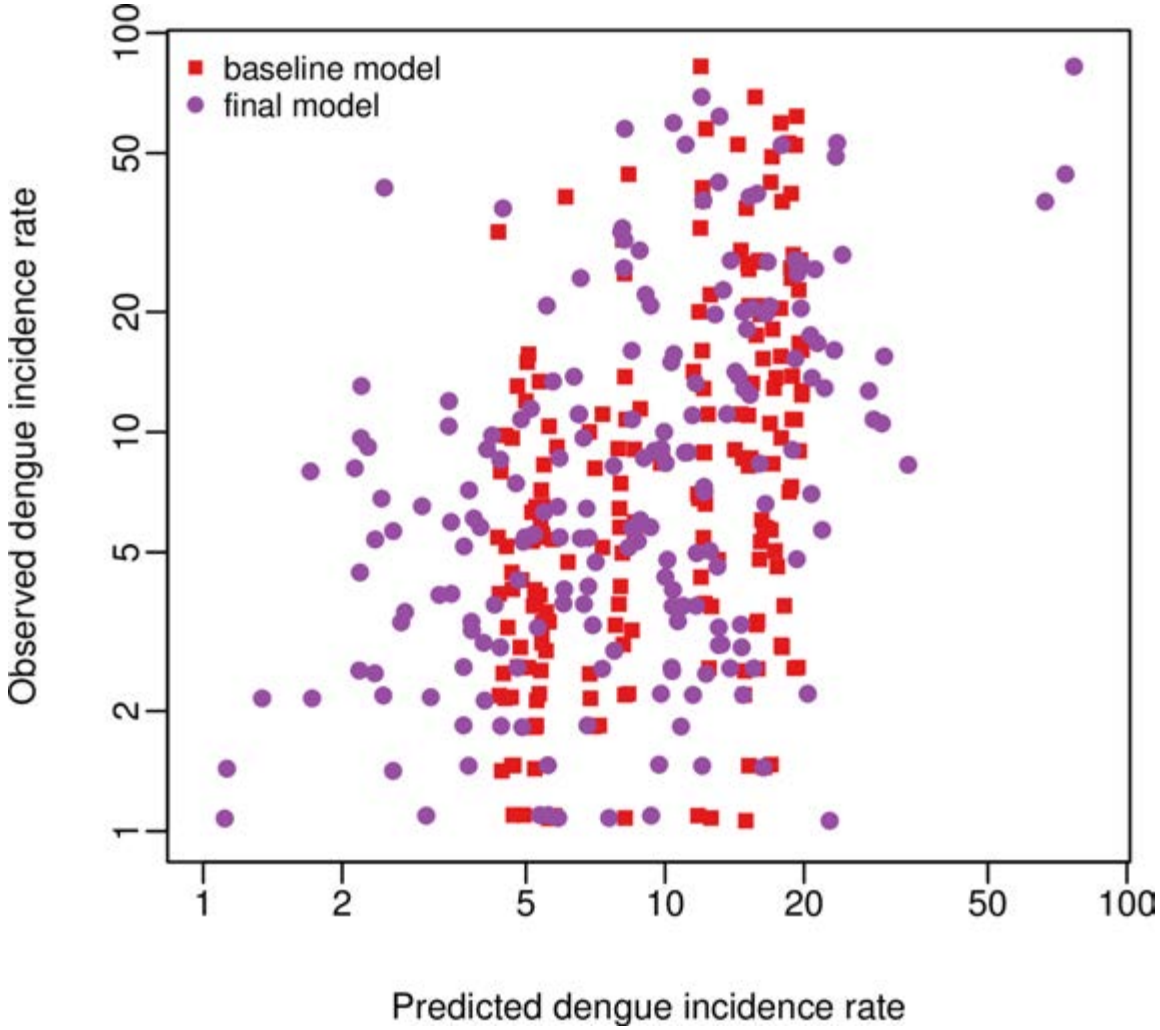
Minimum temperature



Greatest relative risk following dry (~5 month lag) and wet (<1 month lag) periods and warmer months (~2 month lag).

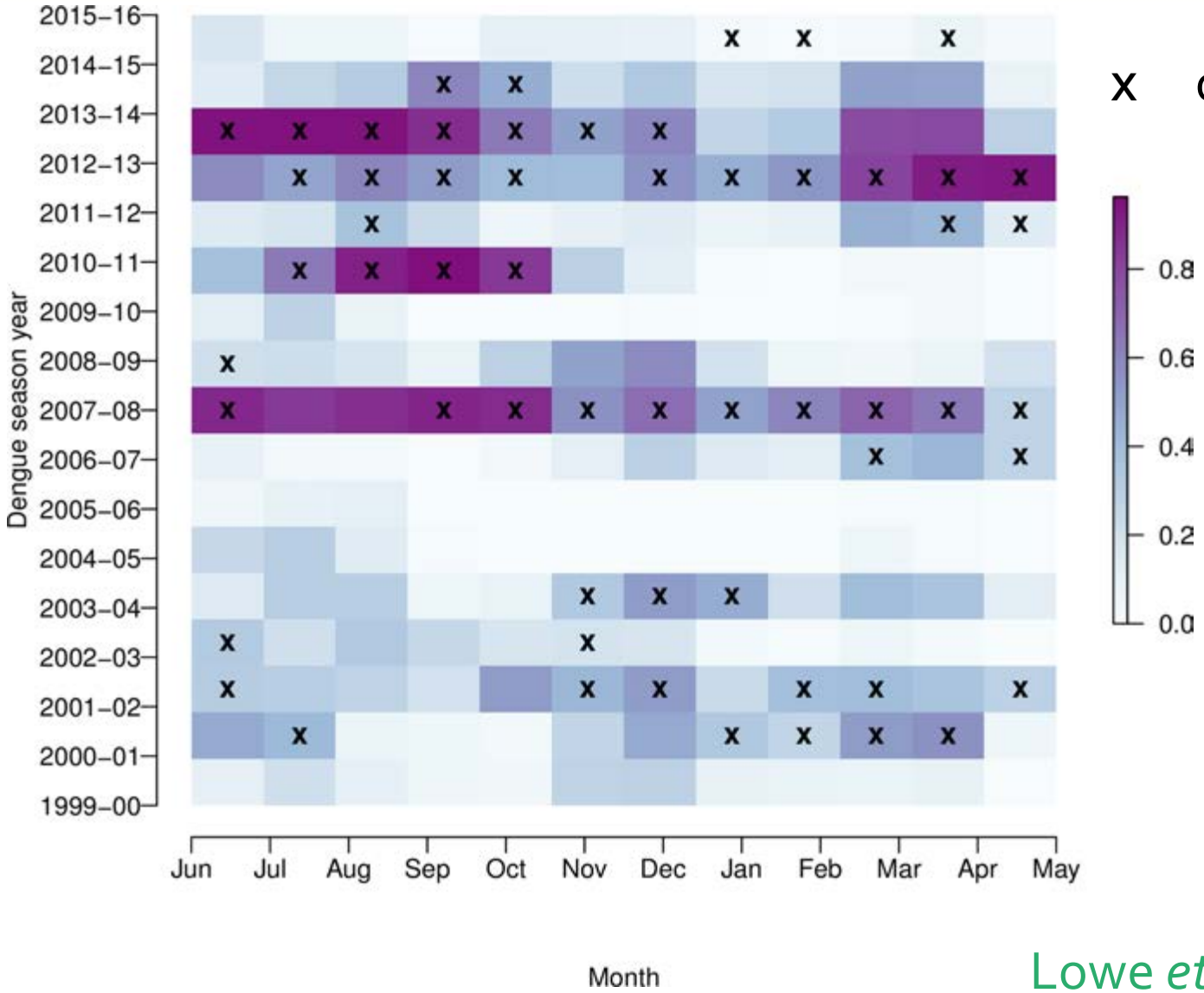
Outbreak detection using cross-validation





Moving outbreak threshold 75th percentile excluding year for which prediction valid.

Probability of exceeding outbreak threshold



x outbreak occurred

Probability trigger threshold of 30%

Lowe *et al.*, 2018 *PLOS Medicine*

Sensitivity and specificity of exceeding threshold

Performance measures	Final model	Baseline model
Area under ROC curve	0.9 (0.85, 0.94)	0.75 (0.71, 0.79)
Probability trigger threshold	0.3	0.27
Hit rate	0.9 (0.82, 0.97)	0.79 (0.69, 0.9)
False alarm rate	0.31 (0.22, 0.39)	0.57 (0.51, 0.63)
Proportion correct	0.86 (0.81, 0.91)	0.64 (0.58, 0.71)

The selected model produced **more hits** and **less false alarms** than a null model accounting only for seasonality.

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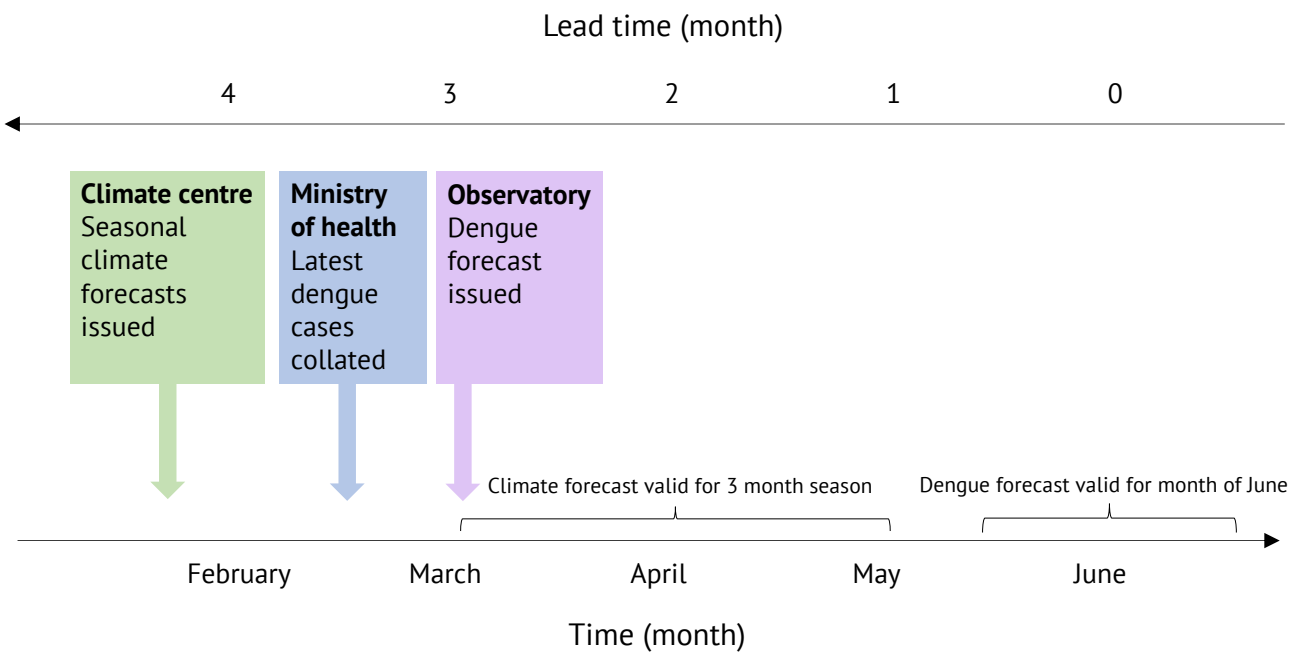
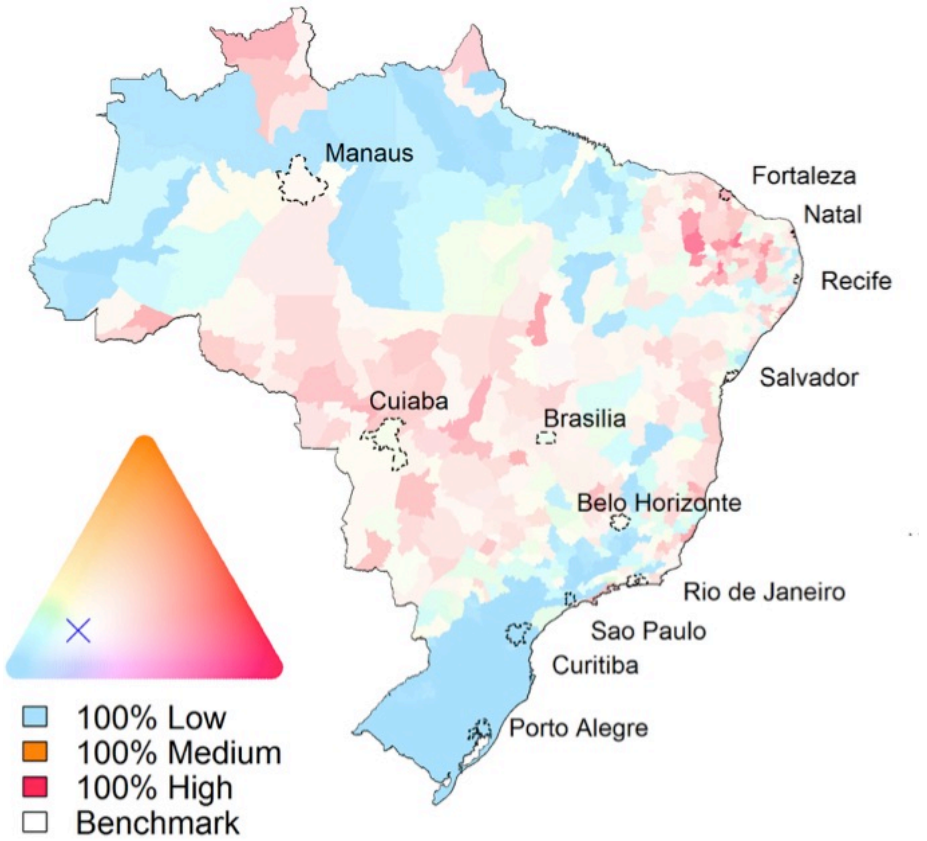
How can we transition from a theoretical to operational prediction framework for mosquito-transmitted diseases?

Early warnings 3 months in advance

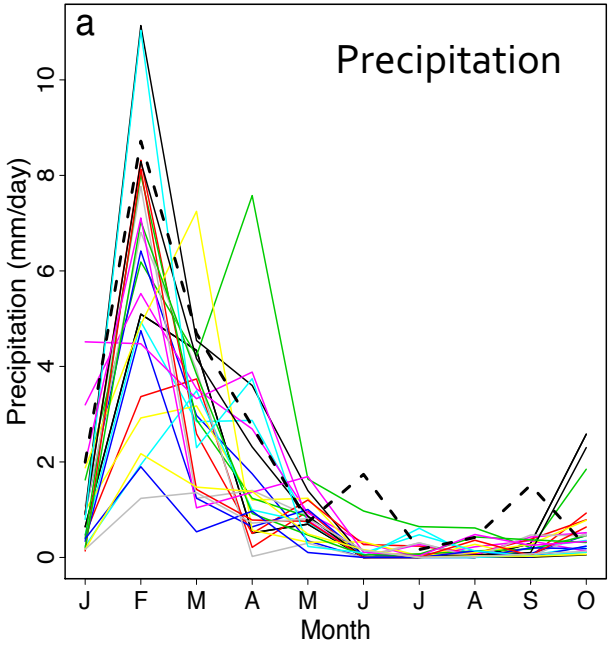


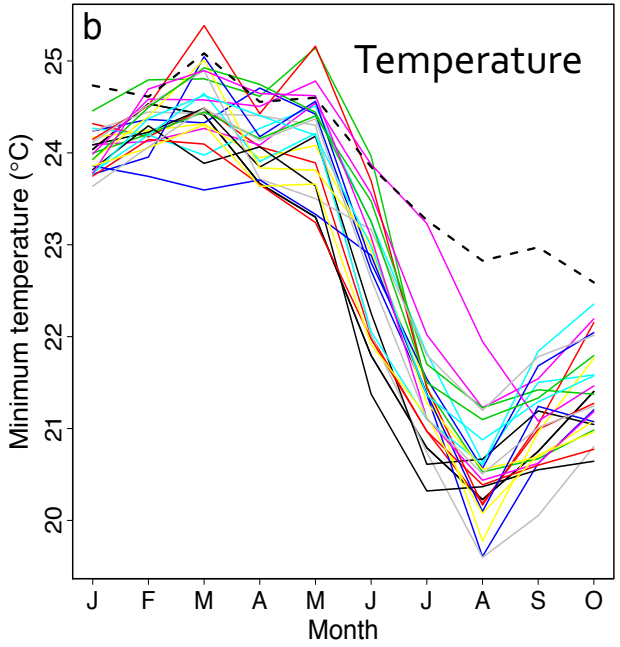


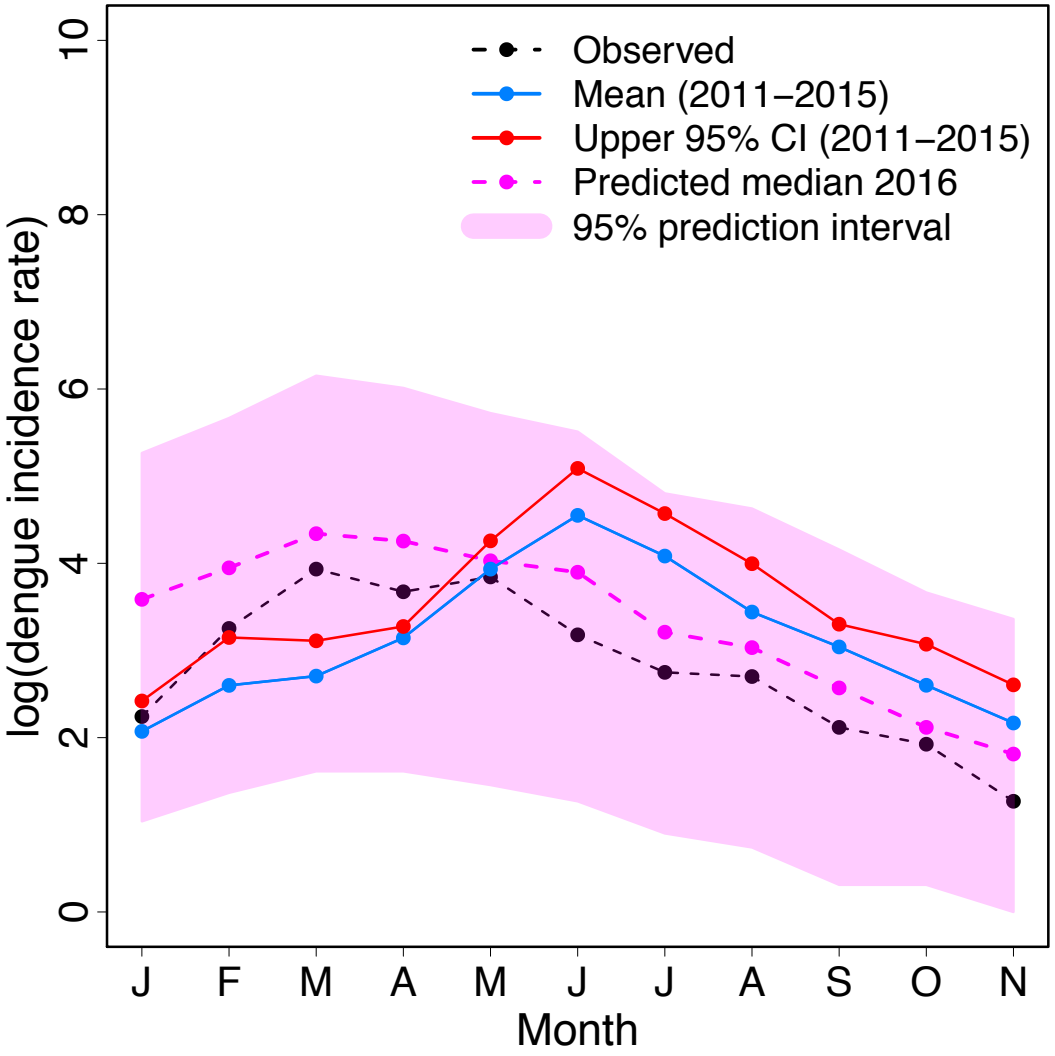
Seasonal climate forecasts issued in Feb, valid for Mar-May, combined with surveillance data at time of forecast (Mar) to predict dengue risk in June (i.e. 3 month lead-time).

Lowe *et al.*, 2014, *Lancet Infect Dis*

Predict season using multi-lead climate forecasts



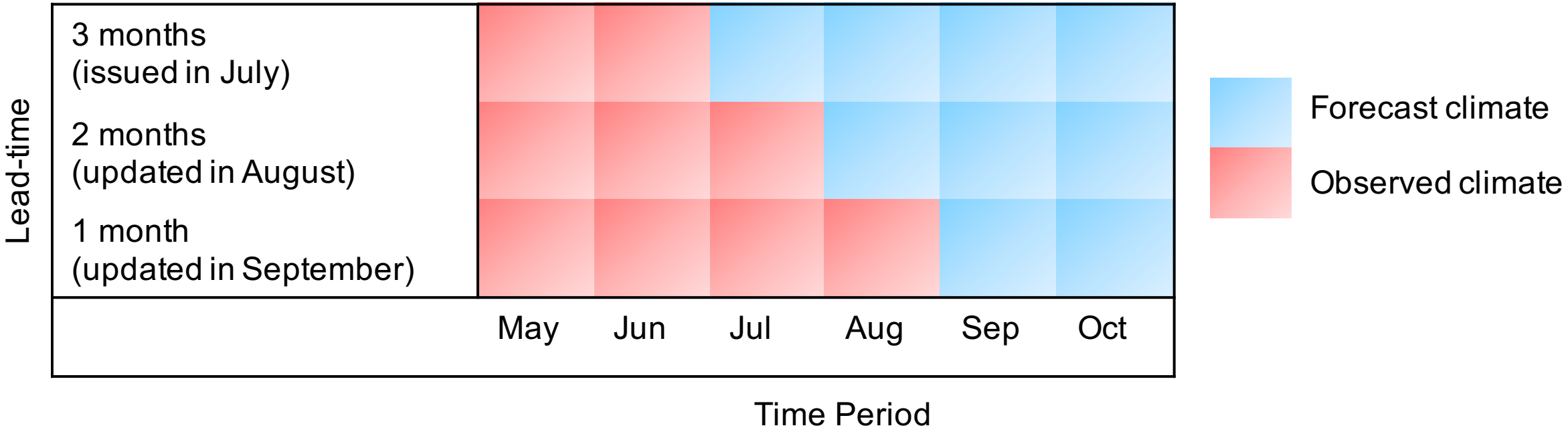




Ensemble climate forecasts (24 members) used to produce probabilistic dengue forecasts for Machala, Ecuador 1-11 months ahead.

Lowe *et al.*, 2017 *Lancet Planet Health*

Approaching a target: multiple lags and leads



Lowe *et al.*, 2018 *PLOS Medicine*

What did we find, why is it important?

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Findings

- Drought periods followed by warm & wet conditions could provide optimum conditions for imminent outbreaks.
- Model predicted months with dengue outbreaks v non-outbreaks in most years, but last 2 years complicated by CHIKV & ZIKV introductions.

Impact

- Climate change contributing to more intense / frequent droughts and hurricanes in the Caribbean region.
- Basis of a Caribbean-wide early warning system for dengue, Zika and other mosquito-transmitted diseases.

CARPHA

Pan American Health Organization

Caribbean Health Climatic Bulletin

Source: https://rcc.cimh.edu.bb/caribbean-health-climatic-bulletin/

Thank you for your attention, questions?

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rachel.lowe@lshtm.ac.uk

@drrachellowe

Nonlinear and delayed impacts of climate on dengue risk in Barbados: A modelling study

Rachel Lowe, Antonio Gasparrini, Cédric J. Van Meerbeeck, Catherine A. Lippi, Roché Mahon, Adrian R. Trotman, Leslie Rollock, Avery Q. J. Hinds, Sadie J. Ryan, Anna M. Stewart-Ibarra

BRCCC PROGRAMME

Programme for Building Regional Climate Capacity in the Caribbean

USAID