Dengue forecasting

Model and challenges

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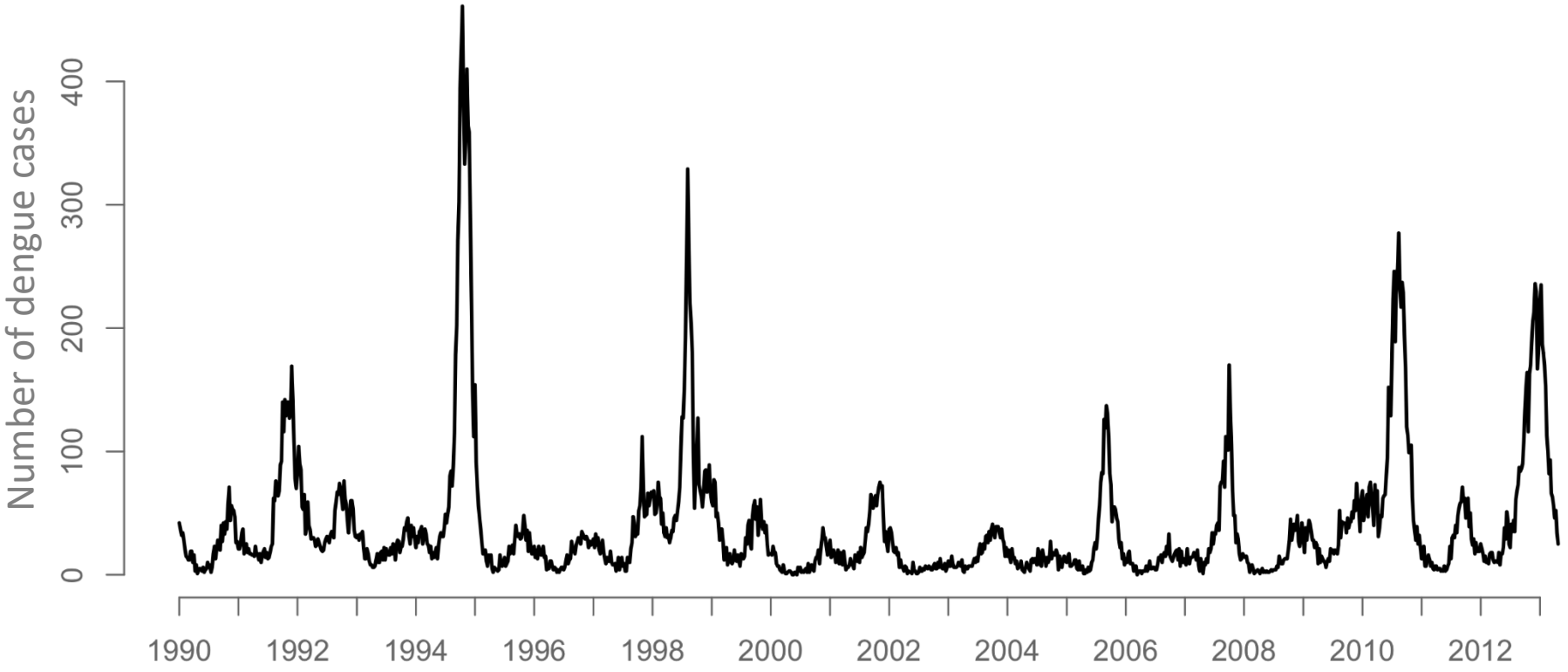
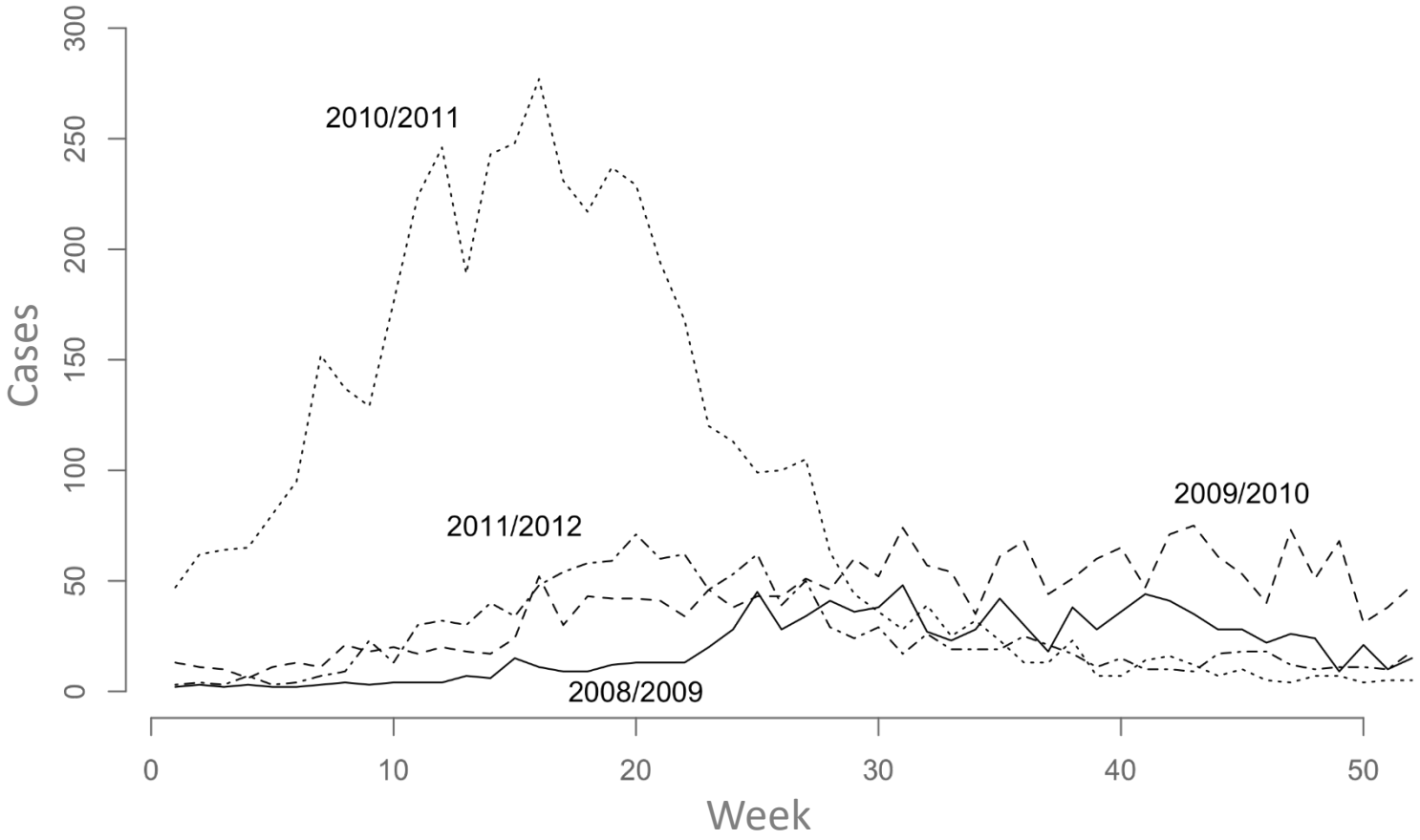
San Juan, Puerto Rico

Dengue – San Juan, Puerto Rico

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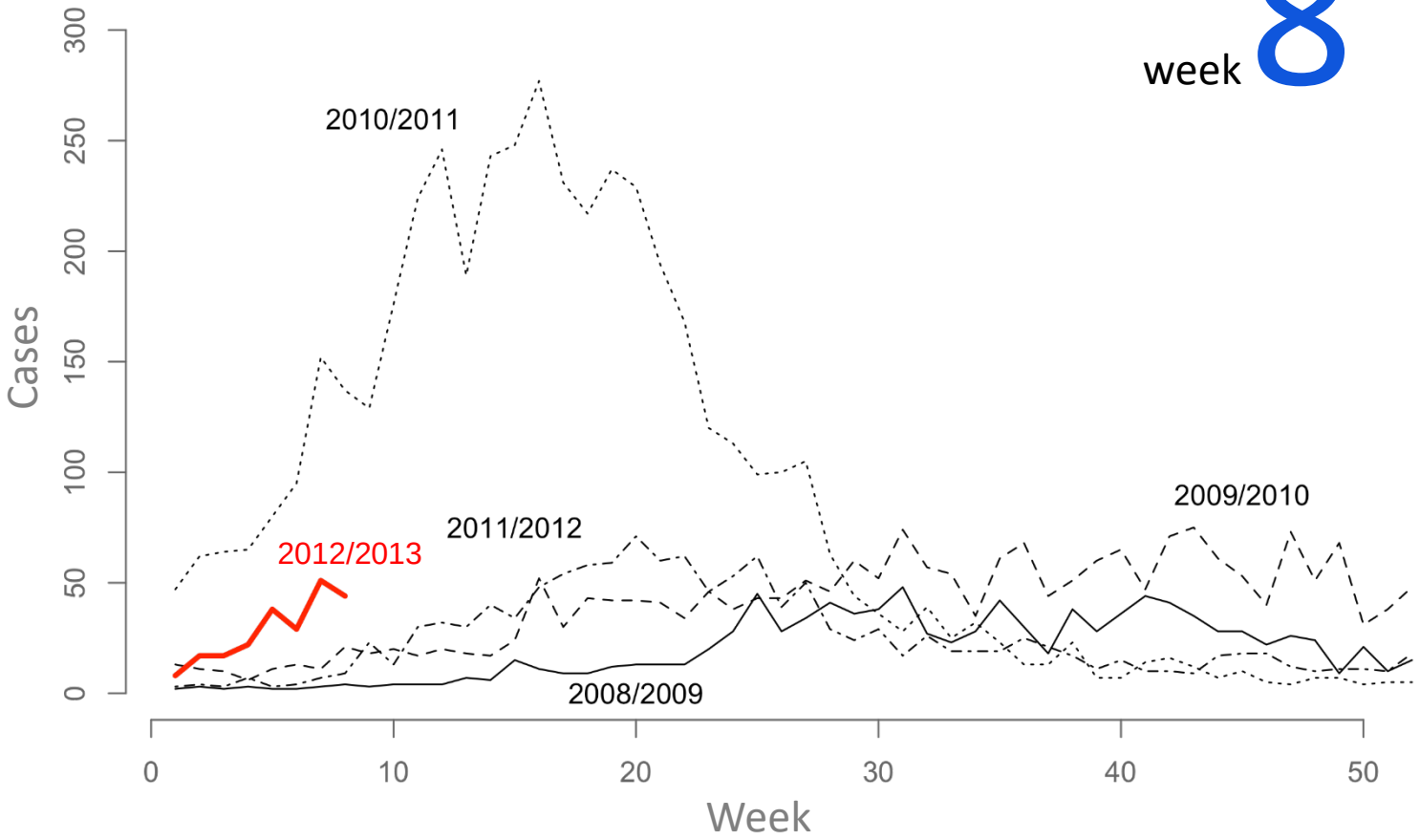
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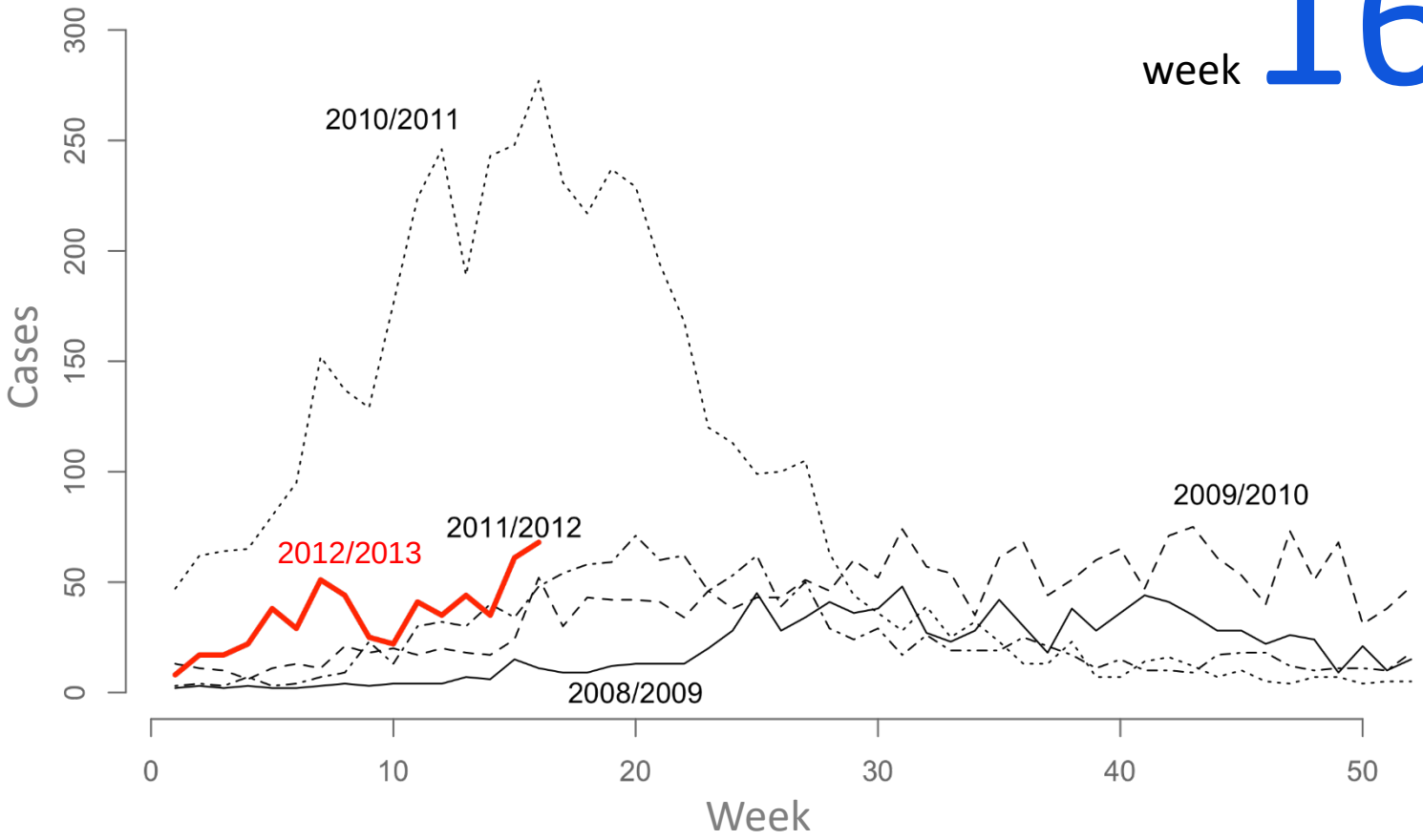
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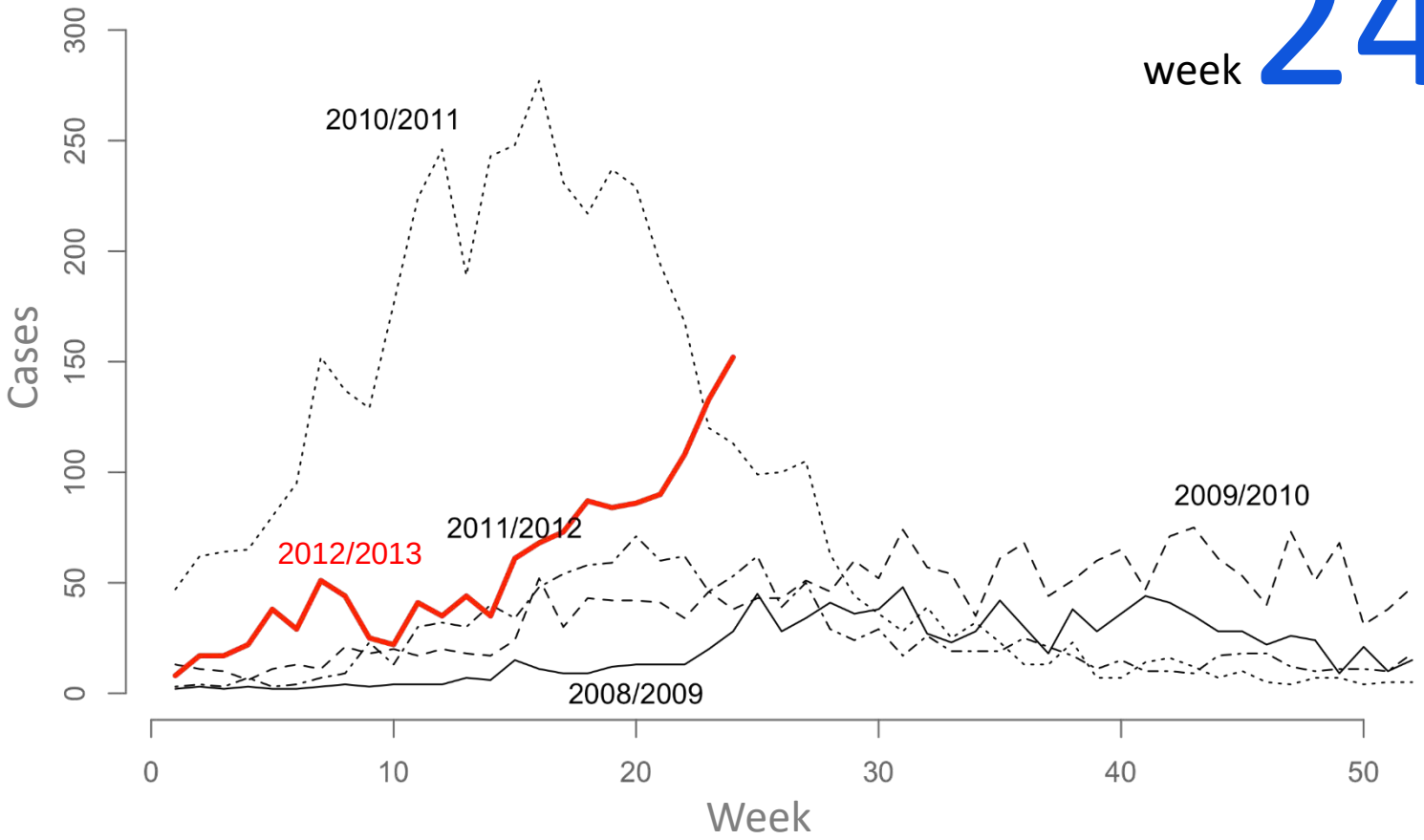
week 24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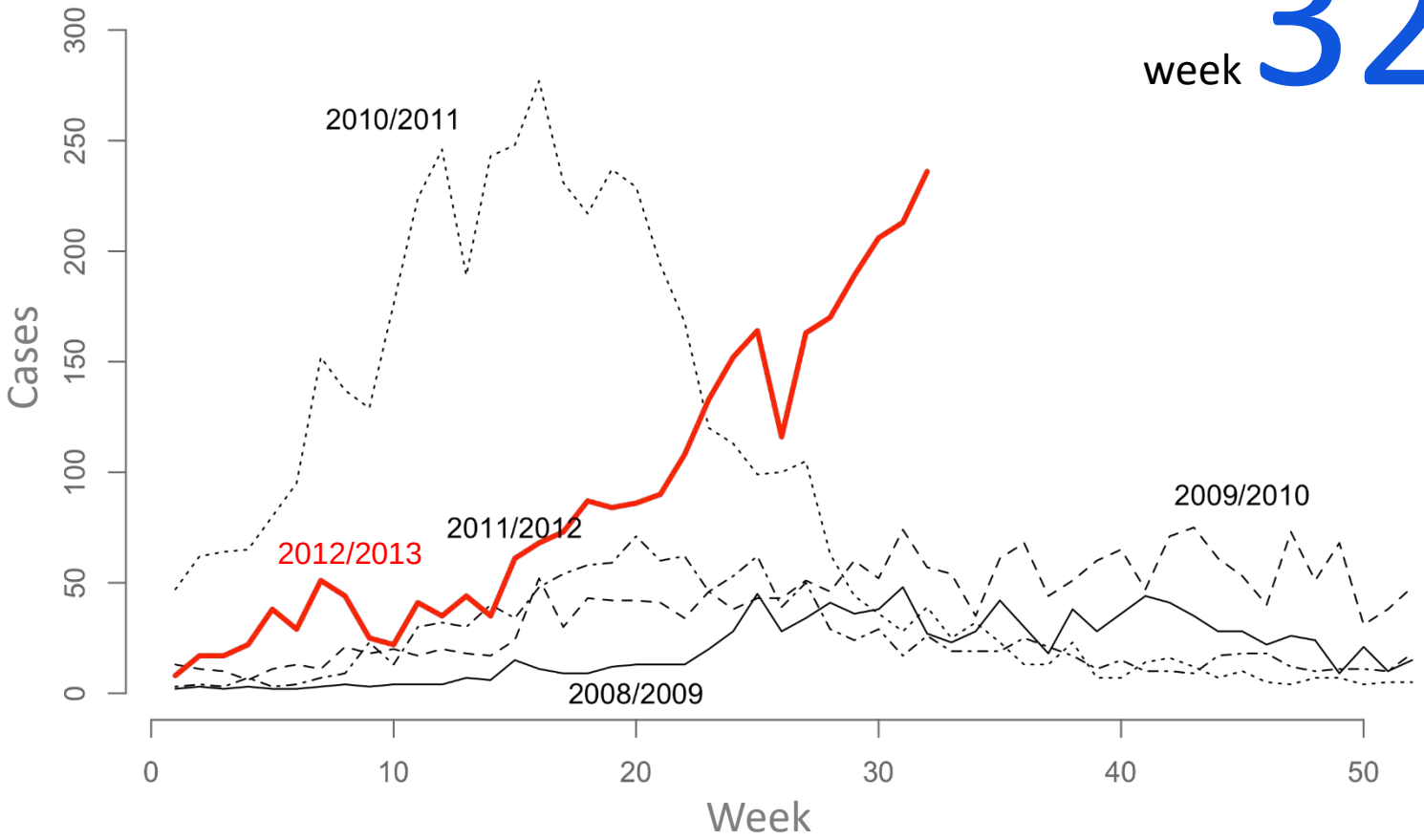
week 32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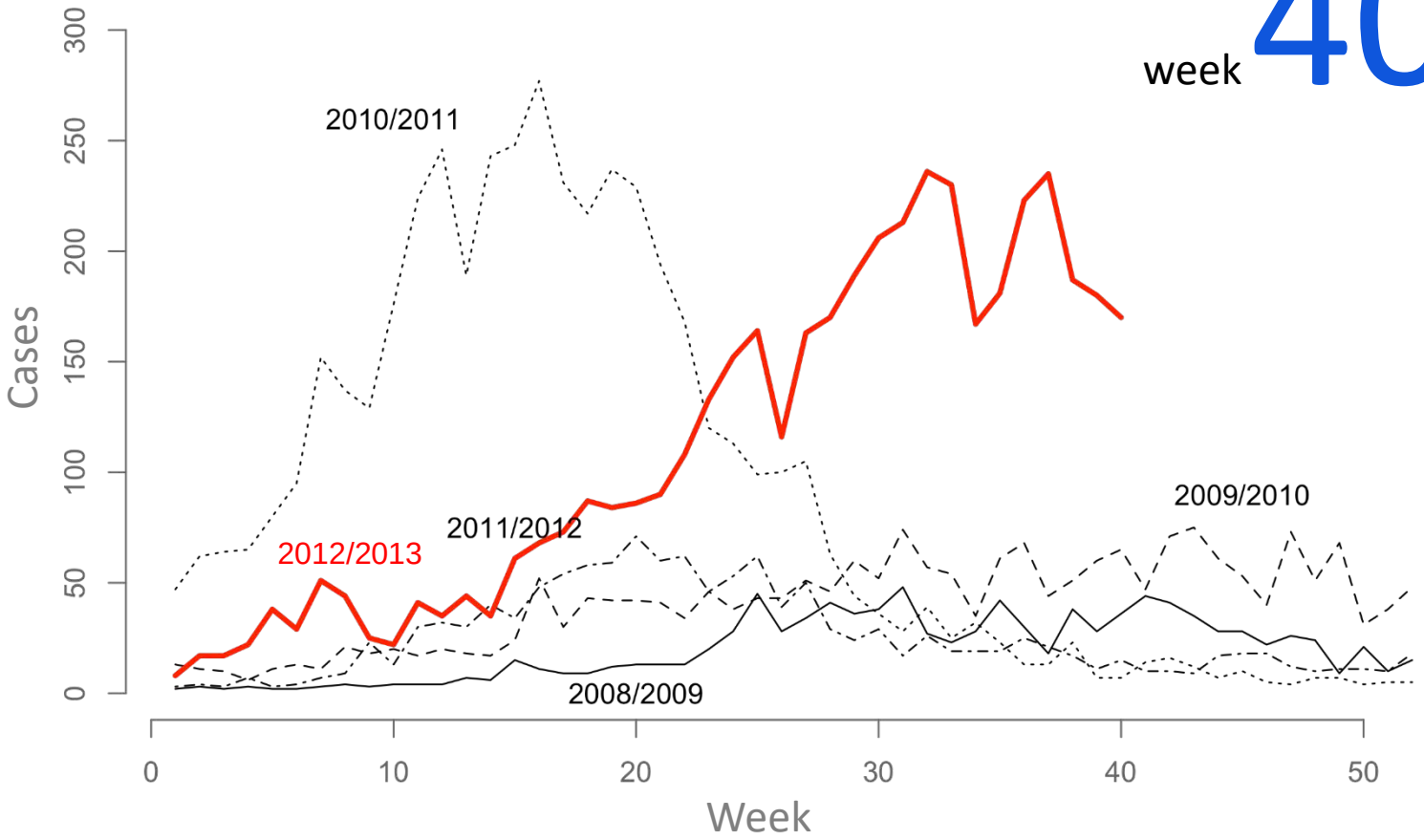
Week

week 40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2010/2011
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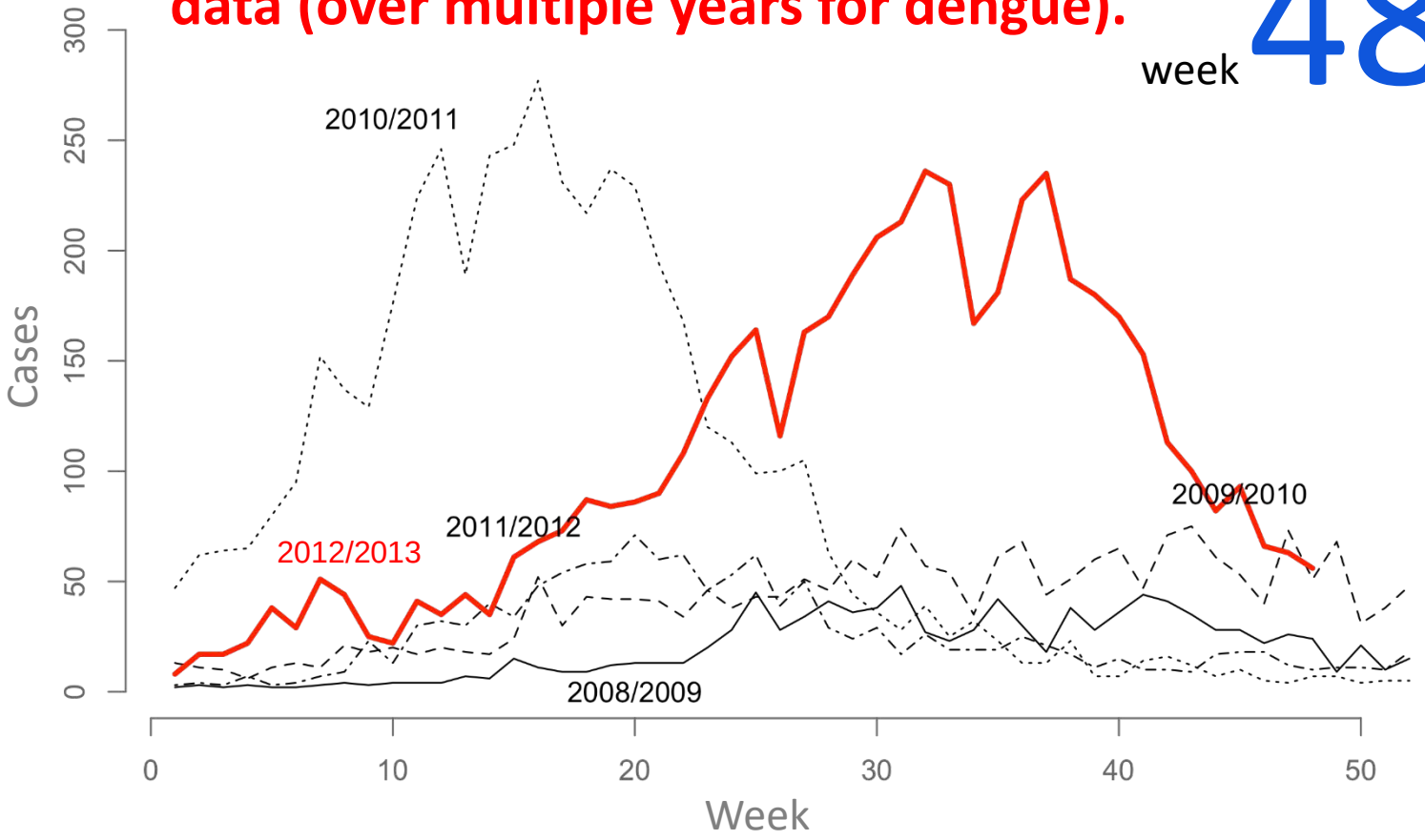
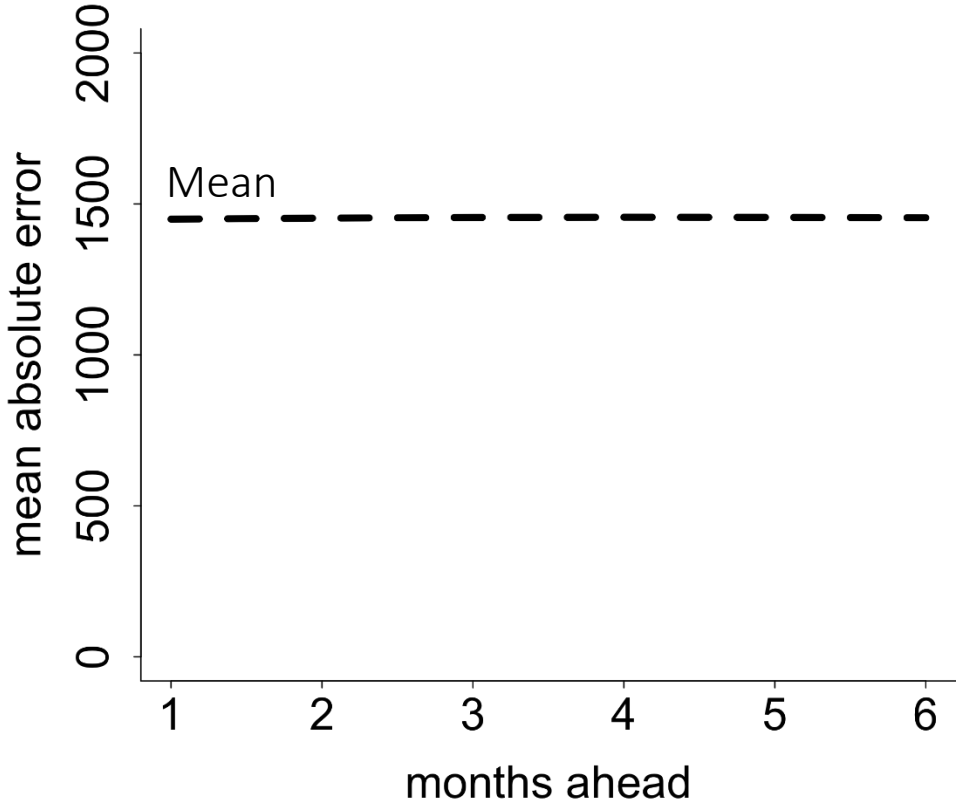
Week

Evaluate forecasts on out-of-sample data (over multiple years for dengue).

week 48

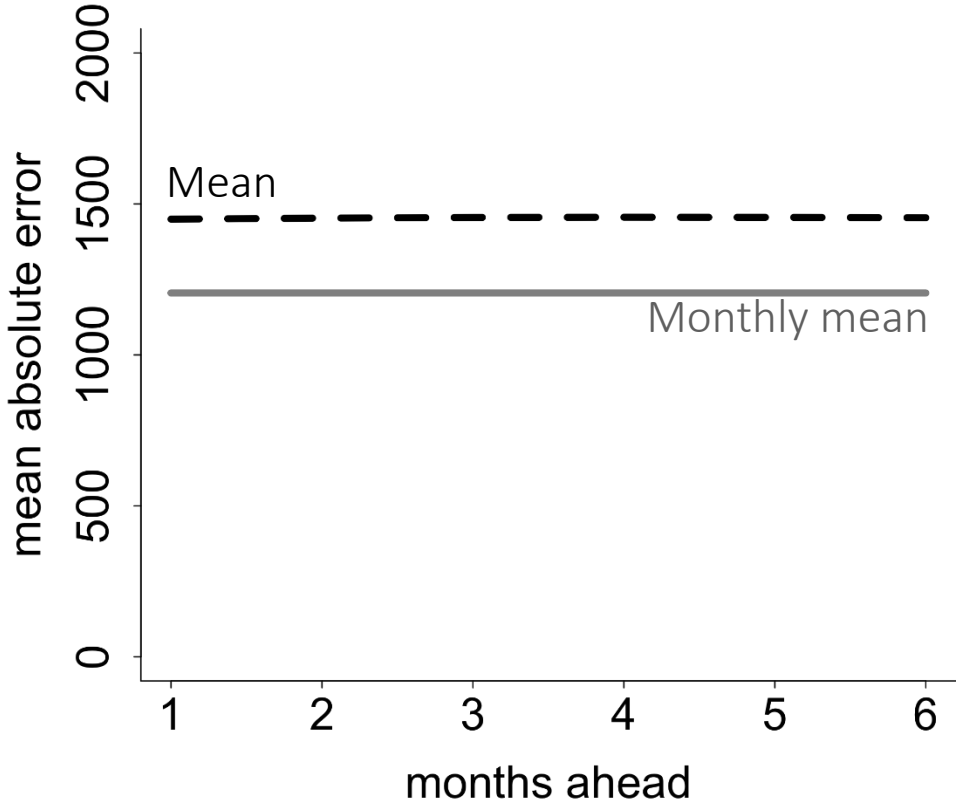


Dengue forecast error - Mexico



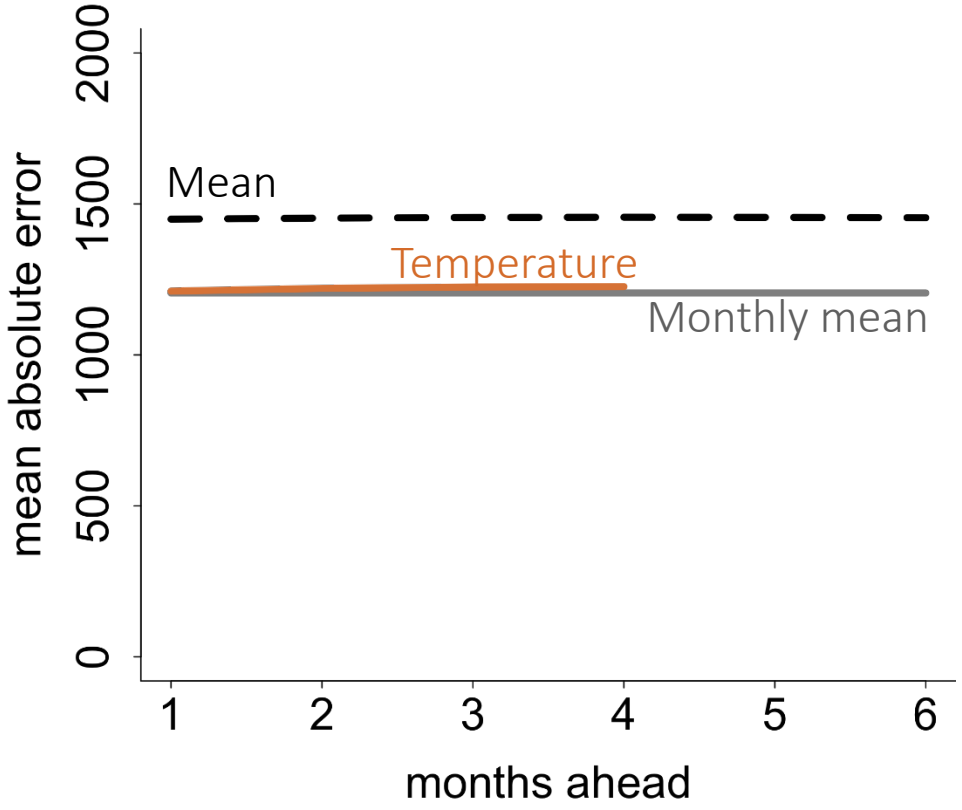
Johansson et al. Scientific Reports 2016

Dengue forecast error - Mexico



Johansson et al. Scientific Reports 2016

Dengue forecast error - Mexico



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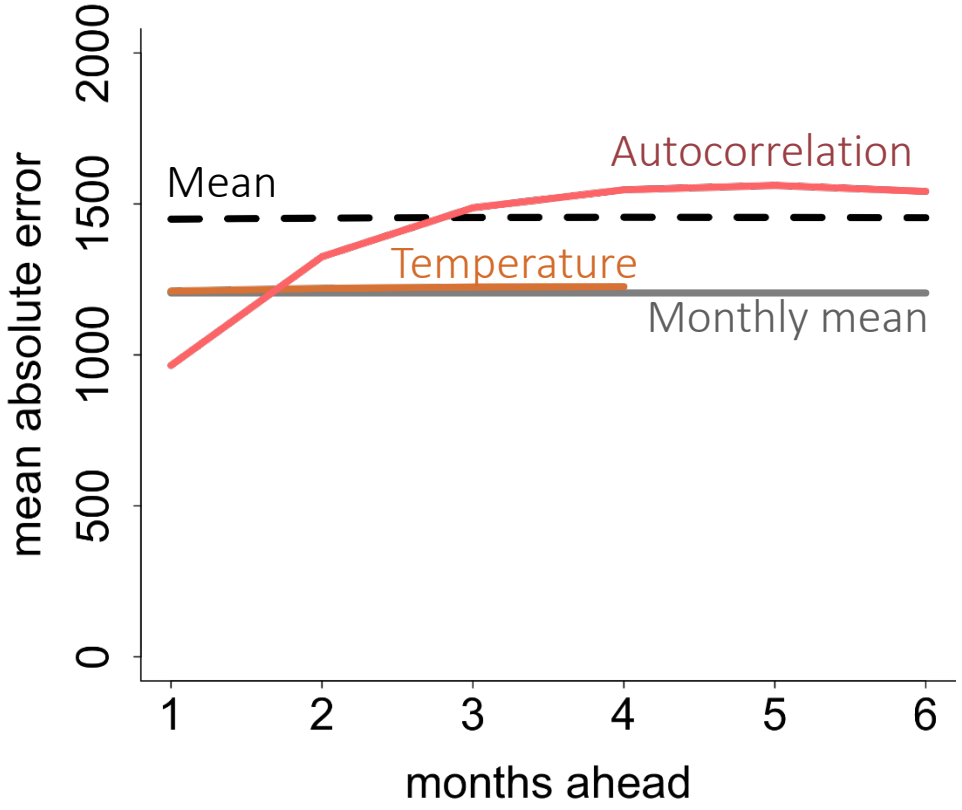
Dengue forecast error - Mexico



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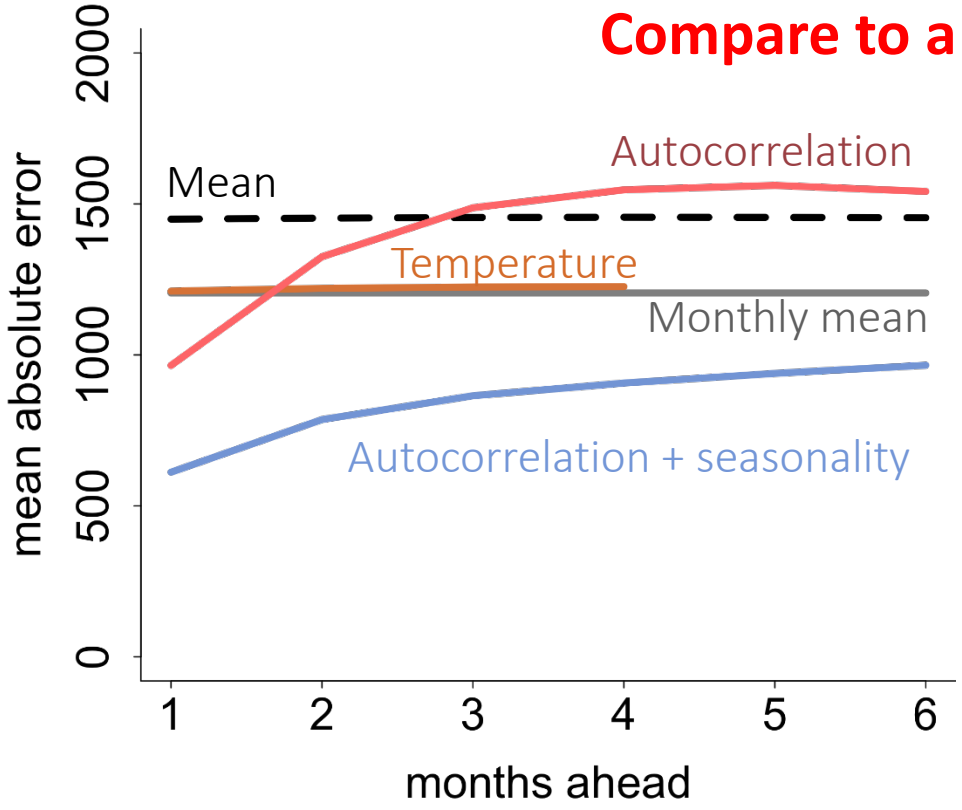
Dengue forecast error - Mexico

Compare to a baseline model.



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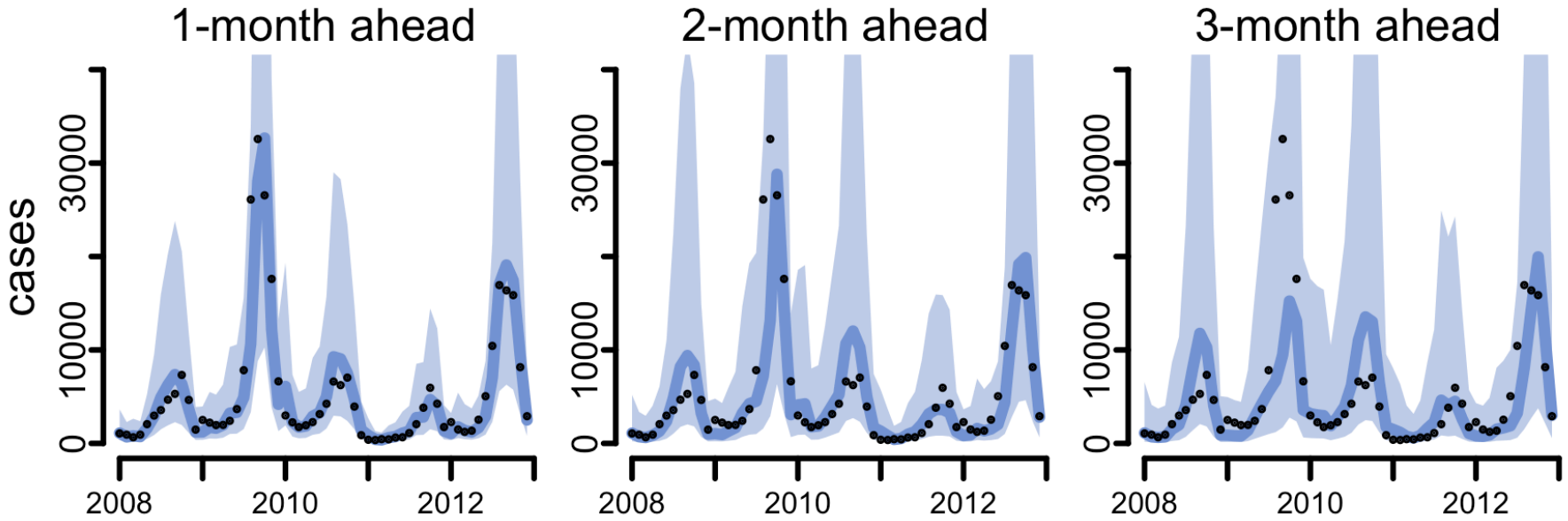
Forecasts - Mexico

Assess the uncertainty.

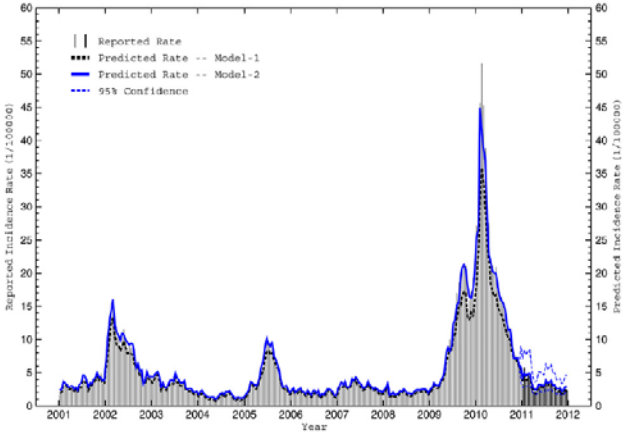


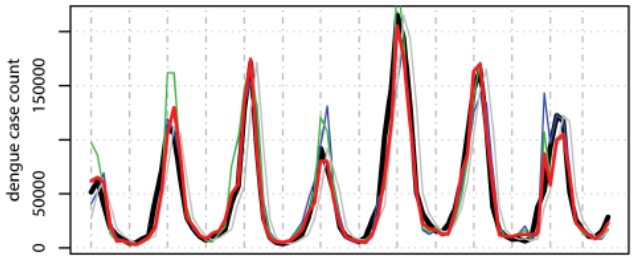
Johansson et al. Scientific Reports 2016

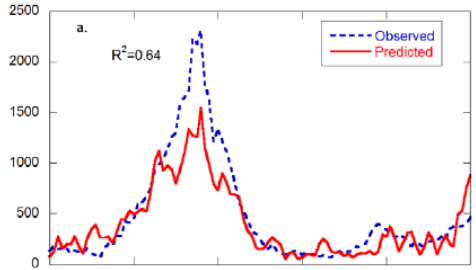
BS Checklist for Forecasts

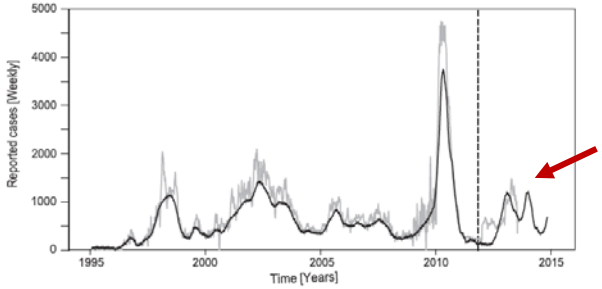
- ☐ Evaluate forecasts on out-of-sample data.
- ☐ Compare to a baseline model.
- ☐ Assess the uncertainty.

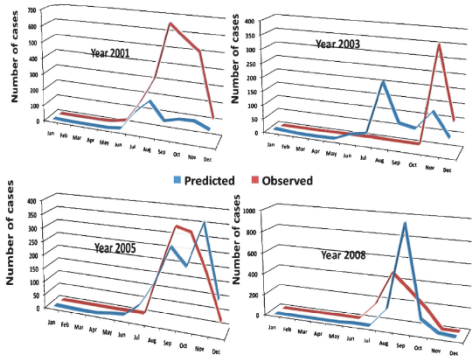
Dengue forecasting research

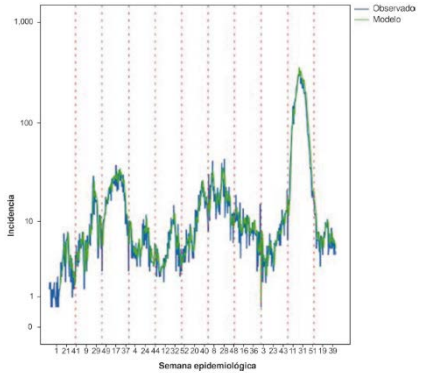




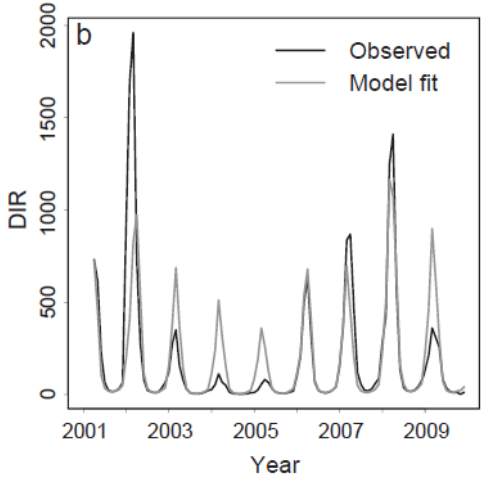






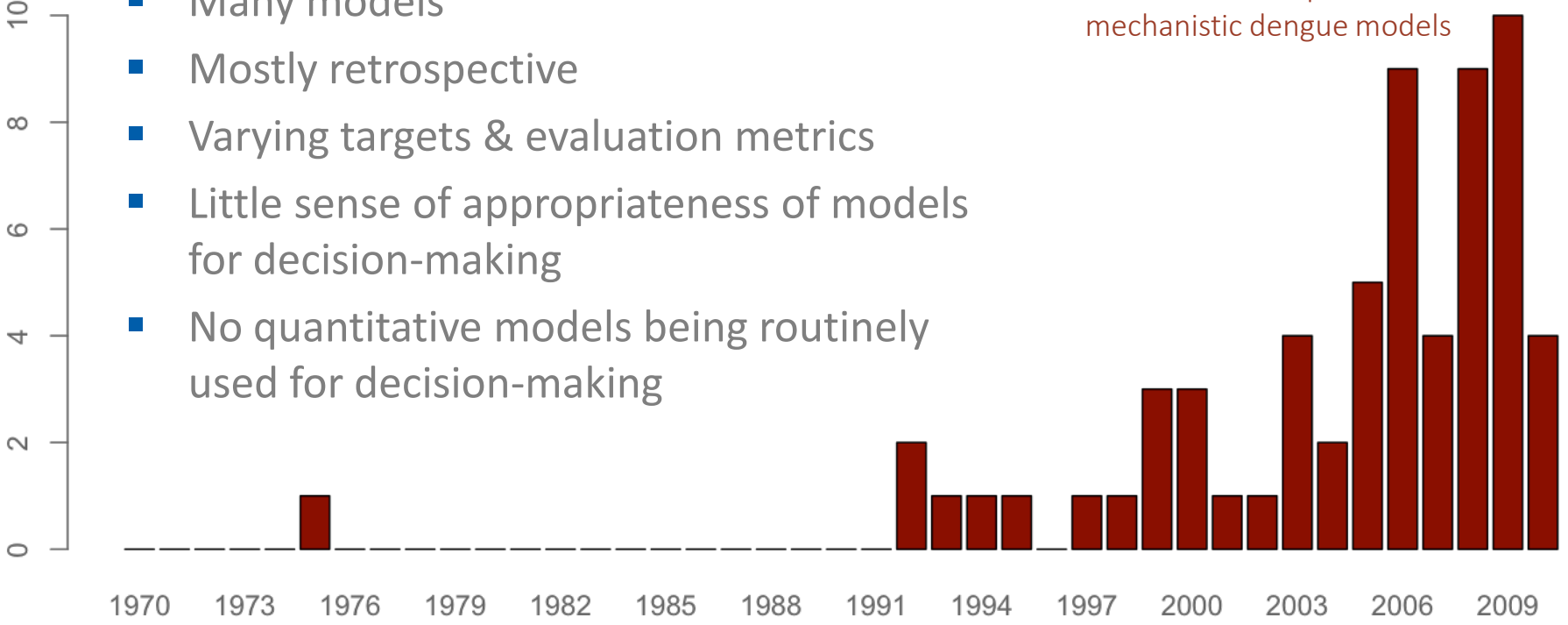


"[poor prediction was] the result of the unusual behavior that occurred between 2009 and 2011"



The state of dengue forecasting

- Many models
- Mostly retrospective
- Varying targets & evaluation metrics
- Little sense of appropriateness of models for decision-making
- No quantitative models being routinely used for decision-making

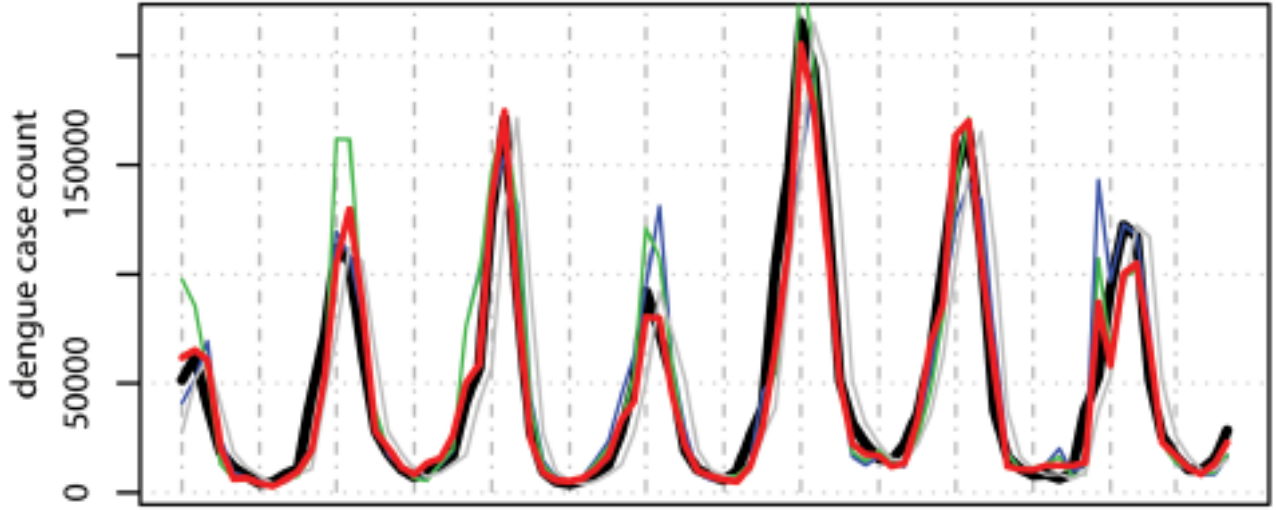


Reiner & Perkins et al. J R Soc Interface 2013, Chretien et al. PLOS ONE 2014

Dengue Forecasting Project

- Pandemic Prediction & Forecasting Science & Technology Working Group
- June–September, 2015
- Targets: Peak week, peak incidence, and total incidence over 8 seasons in Iquitos, Peru and San Juan, Puerto Rico
- 16 teams; 10,000 forecasts
- dengueforecasting.noaa.gov, predict.cdc.gov

Correlation of point forecasts is not enough

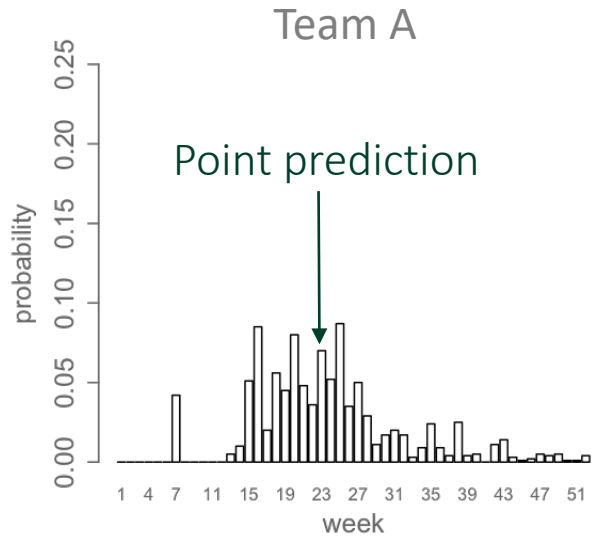


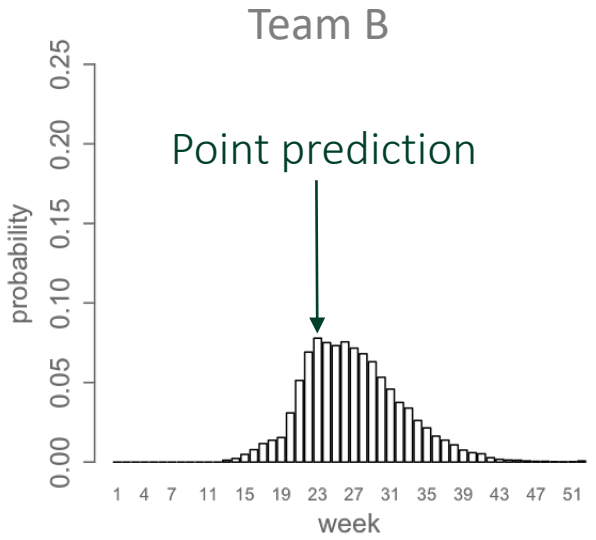
We need to assess both accuracy and confidence (i.e. certainty/uncertainty).

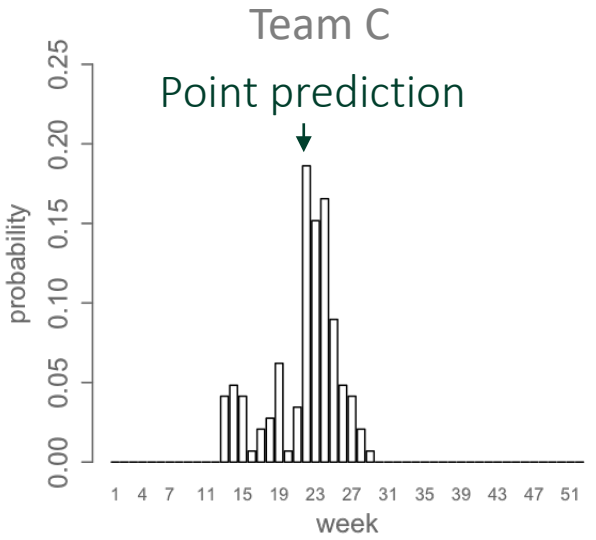
Error metrics are simple and straightforward

	Forecast Peak Week	Observed Peak Week	Error (weeks)
Team A	23	32	9
Team B	23	32	9
Team C	22	32	10

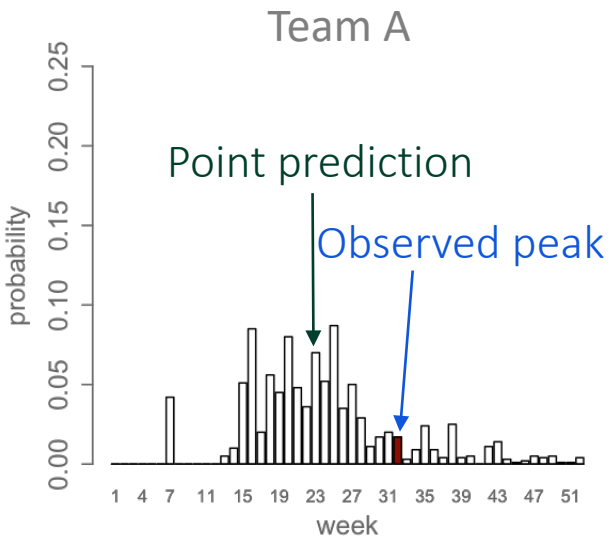
Probabilistic forecasts have more information







Assessing probabilistic forecasts



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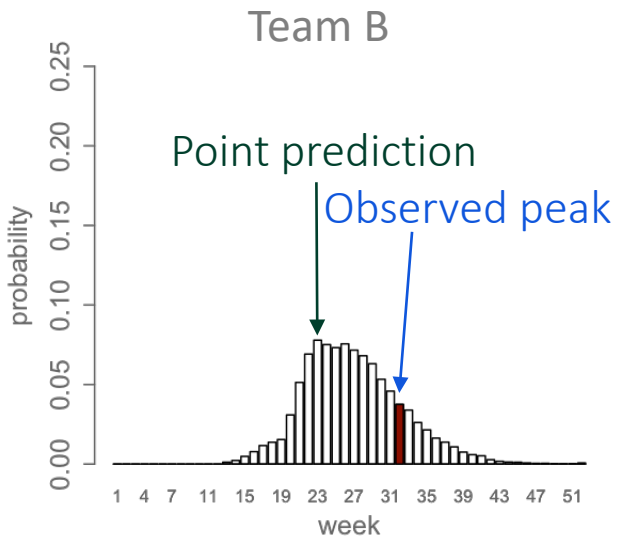

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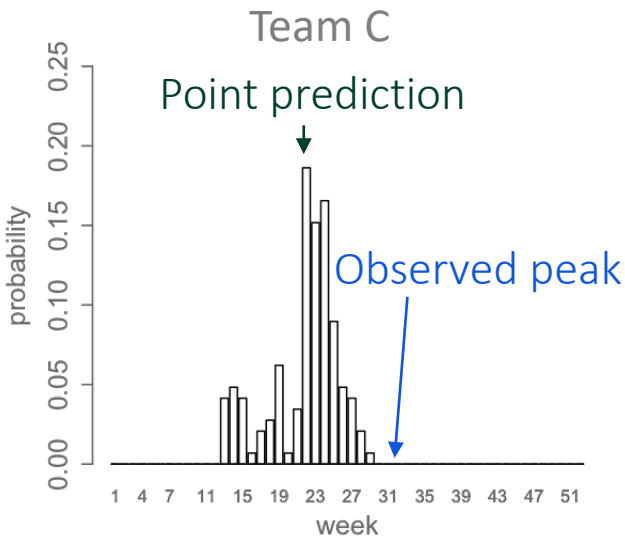
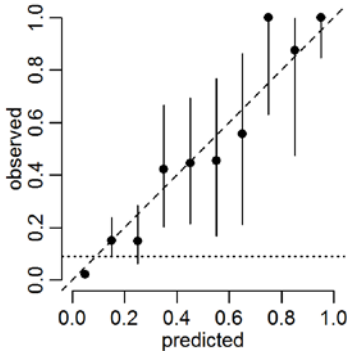


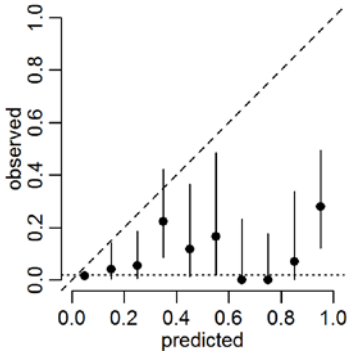
p = 0

Forecast calibration

Well-calibrated



Over-confident



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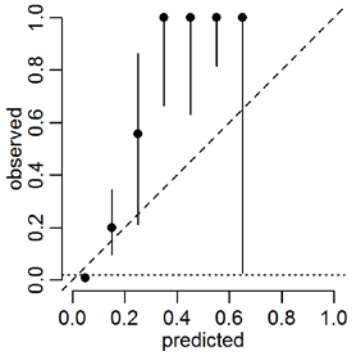
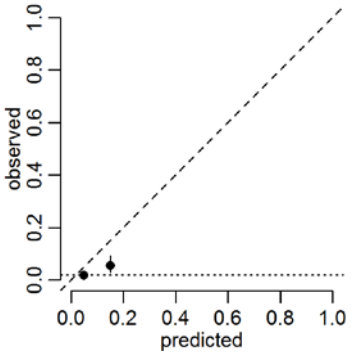
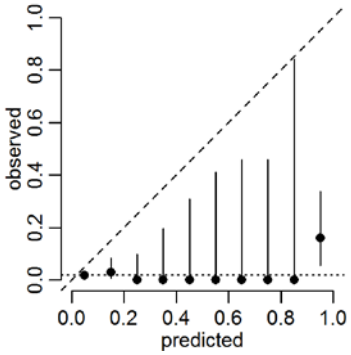


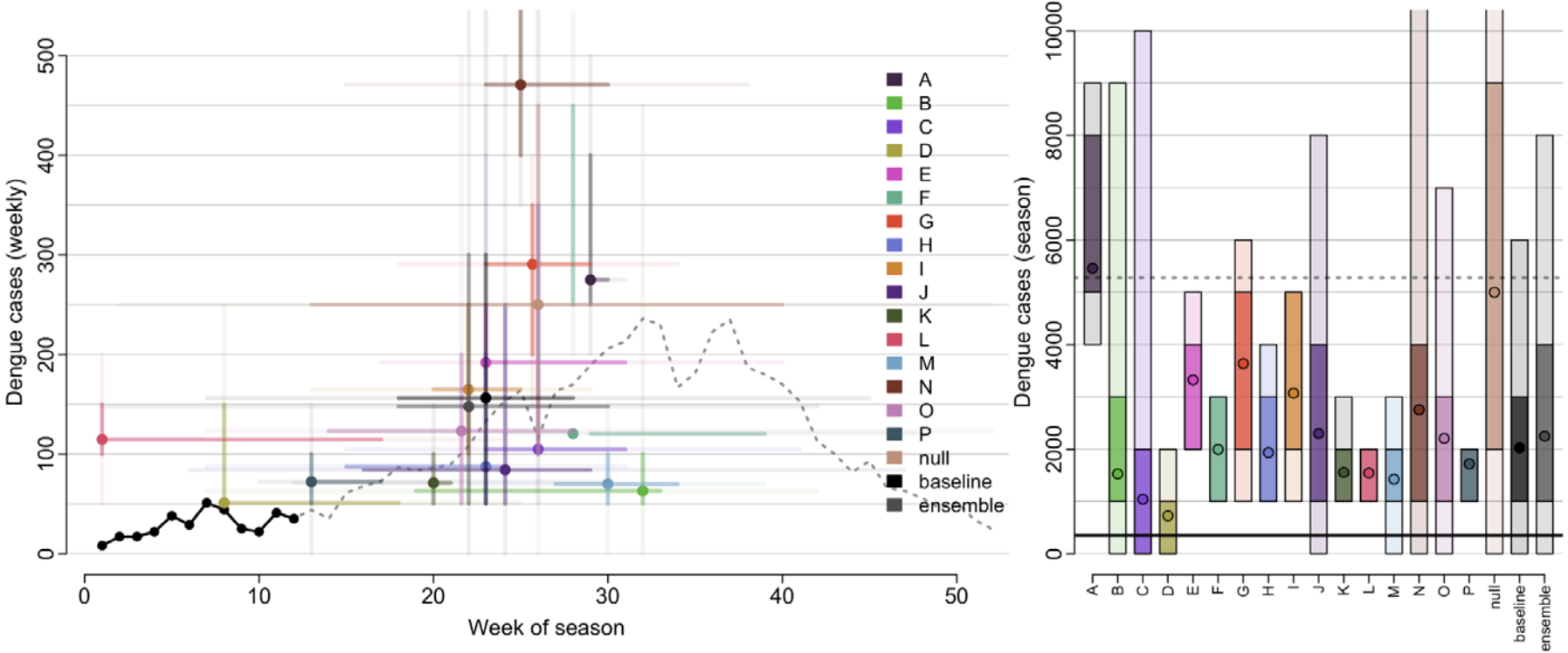
No confidence



No resolution



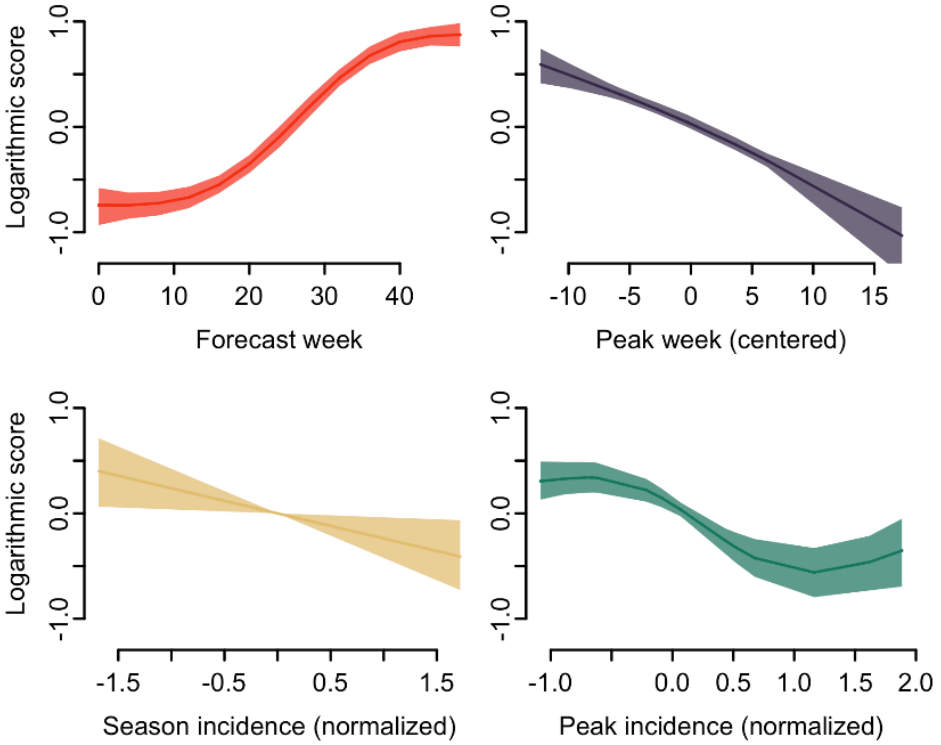
Week 12 forecast for San Juan 2012/2013



When are forecasts best?

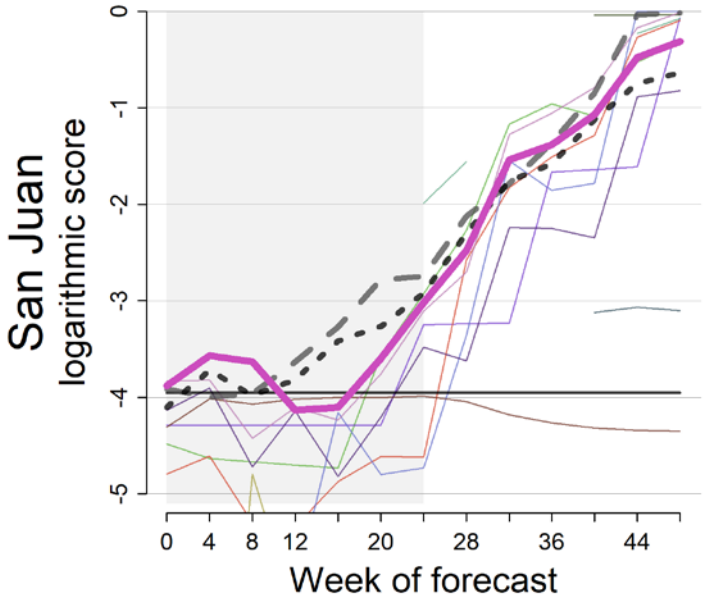
~12,000 forecasts

- 2 locations
- 8 seasons
- 19 models

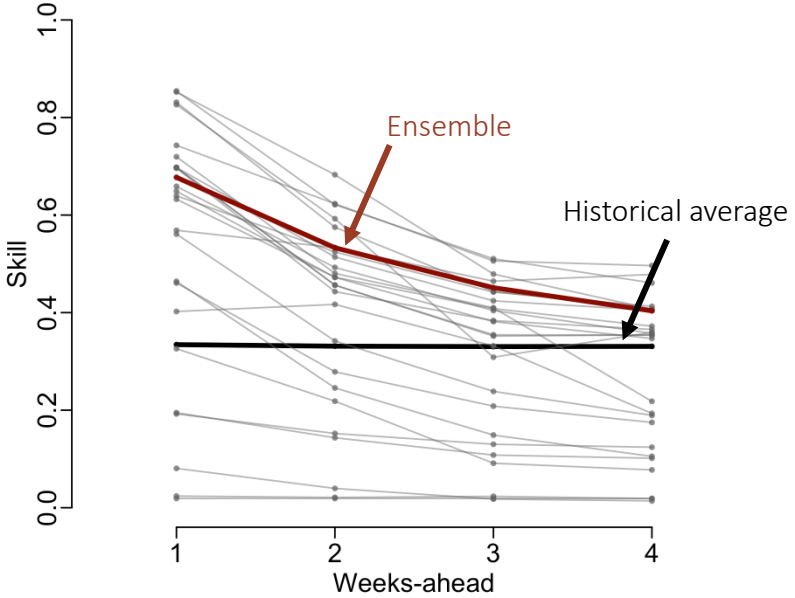


Nowcast/situational awareness

SEASONAL DENGUE
Peak week forecasts

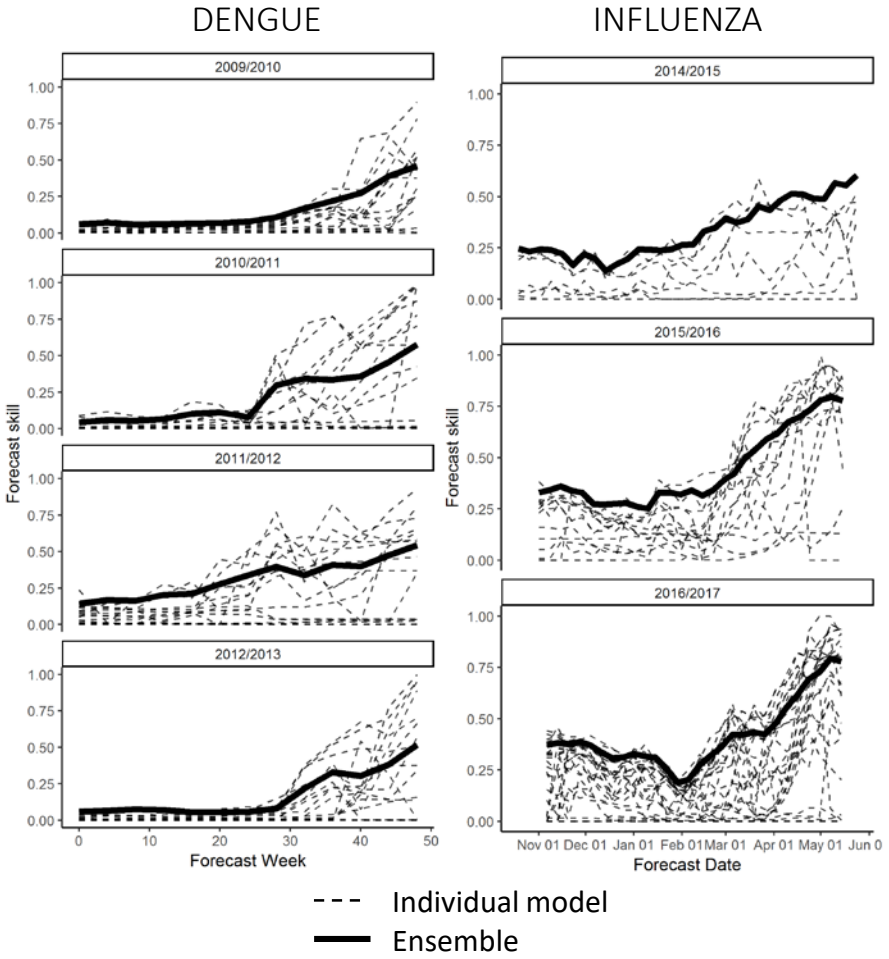


SHORT-TERM INFLUENZA
1- to 4-week ahead forecasts



Promising approaches

- Simpler models
  - No climate data (dengue)
  - No vector model (dengue)
- Ensembles
  - Simple ensembles (across targets, seasons, & diseases)
  - Prospectively defined
  - Current standard for influenza (since 2017/18)



Key questions

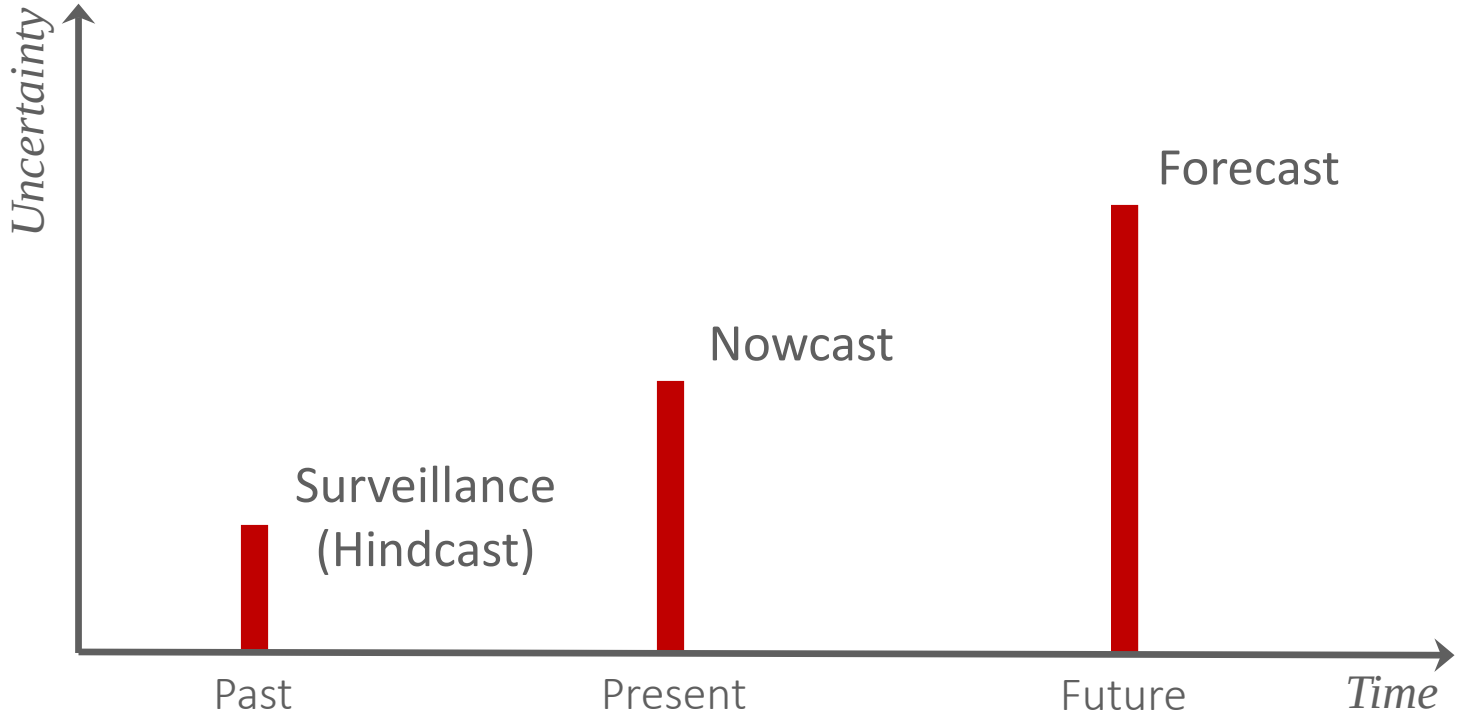
- What are the key surveillance data?
- How much do vectors matter?
- What is the contribution of weather?
- What is the role of immunity and enhancement?
- What is the role of mobility and spatial heterogeneity?

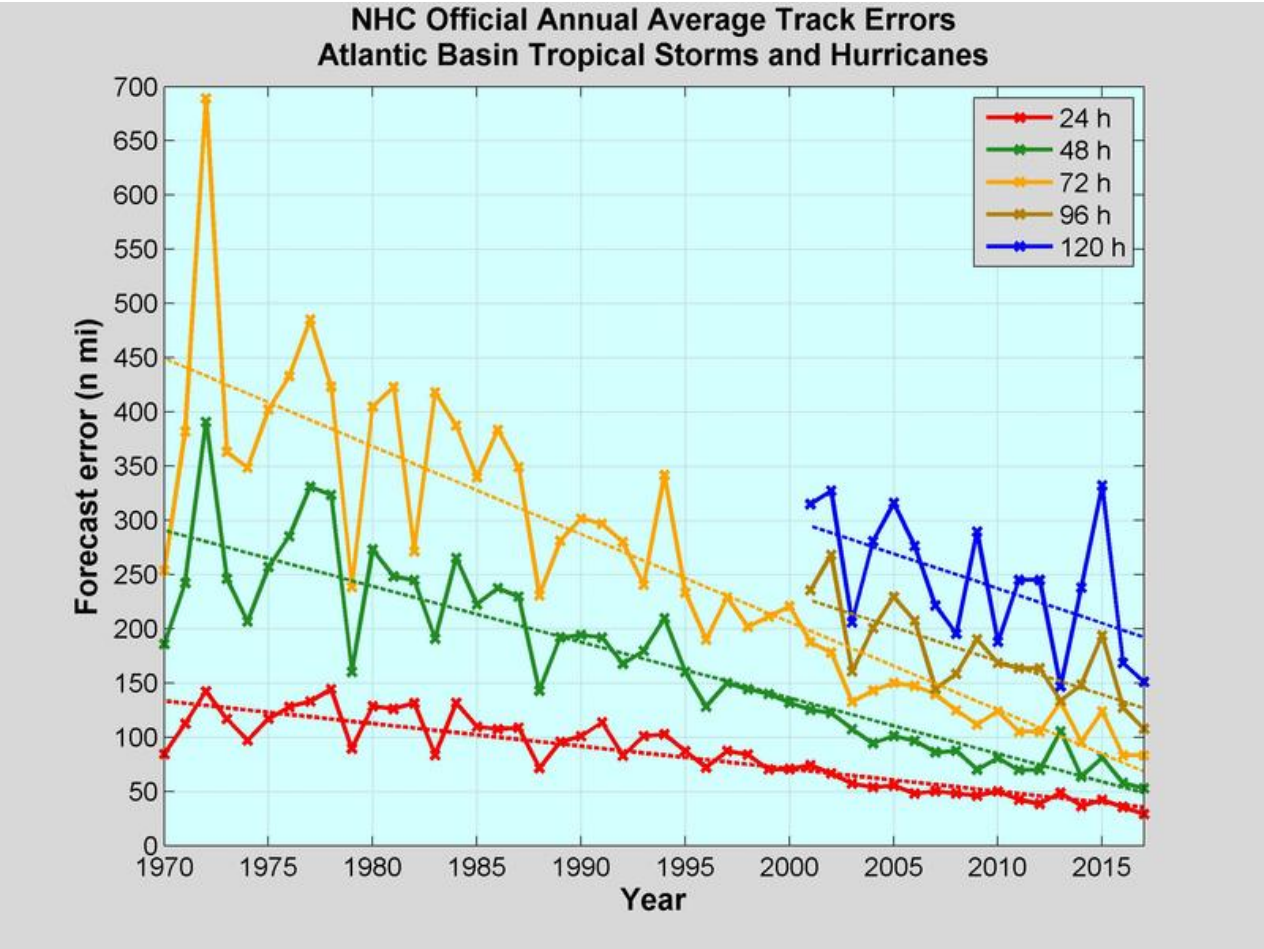
Conclusions

“Dengue is a disease of the tropical and subtropical regions, and within these zones it has a marked preference for the hot season - for summer.”

- Hermann Nothnagel, 1905

“It is difficult to make predictions, especially about the future.”





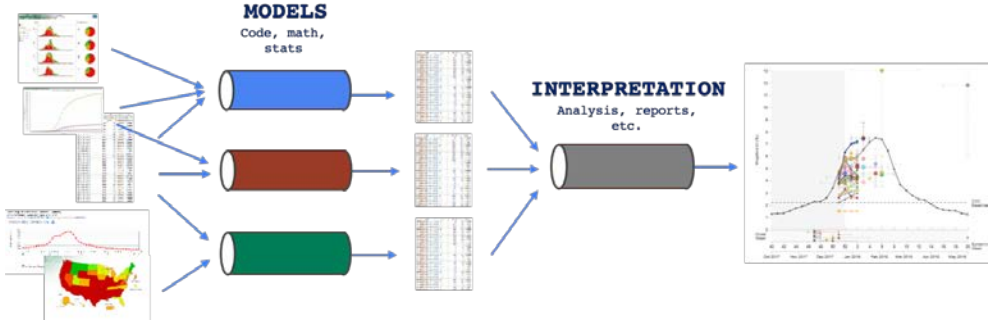
https://www.nhc.noaa.gov/verification/verify5.shtml

How can infectious disease forecasting improve? (How has weather forecasting improved?)

- Data
- Analytical tools
- Computational power
- Evaluation
- Standardization & interoperability

CDC Epidemic Prediction Initiative

- Connect researchers to data
  - Dengue, influenza (github.com/cmu-delphi/delphi-epidata), Zika (github.com/cdcepi/zika)
- Develop an analytical pipeline
  - predict.cdc.gov
  - Current: Influenza, ***Aedes***



- Build a community
  - Centers for Disease Control and Prevention, Researchers, Multiple US Departments & Agencies, Council of State and Territorial Epidemiologists

Conclusions

- Surveillance and forecasting go hand in hand.
- Current forecasting methods improve upon expert knowledge and can be helpful for situational awareness.
- Improved analytics can improve our ability to predict and respond effectively to arboviral disease epidemics.

Key considerations

- Connect forecasts to decision making needs.
- Evaluate forecasts on out-of-sample data.
- Compare to a baseline model.
- Assess the uncertainty (including calibration).
- Use more than one model.
- Use forecasts as one input for decision making.

Acknowledgements

The Epidemic Prediction Initiative community

CDC Epidemic Prediction Initiative

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Luis Mier-y-Teran Romero
Dania Rodriguez Vargas
F. Scott Dahlgren
Chelsea Lutz

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Division of Vector-Borne Diseases
Influenza Division
Council of State and Territorial Epidemiologists

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Mauricio Santillana (Harvard University)
John Brownstein (Boston Children's Hospital)

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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