Epidemic Prediction Initiative: Advancing Forecasting for Public Health

Infectious Disease Forecasting for Public Health Professionals Webinar Series

Thursday, November 2nd, 2017
2:00-3:00 pm Eastern

Council of State and Territorial Epidemiologists

Webinar Housekeeping

CSTE

Webinar Housekeeping

- **Please note that today's webinar is being recorded**
  - The webinar recording and presentation slides will be available in the webinar library on CSTE's website: http://www.cste.org/?page=WebinarLibrary
- **All phone lines have been placed on mute**
- **There will be a question-and-answer session at the end of the webinar**
  - To ask a question, please use the Chat Box on the right side of your screen

To Ask a Question

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- Send questions to All Panelists
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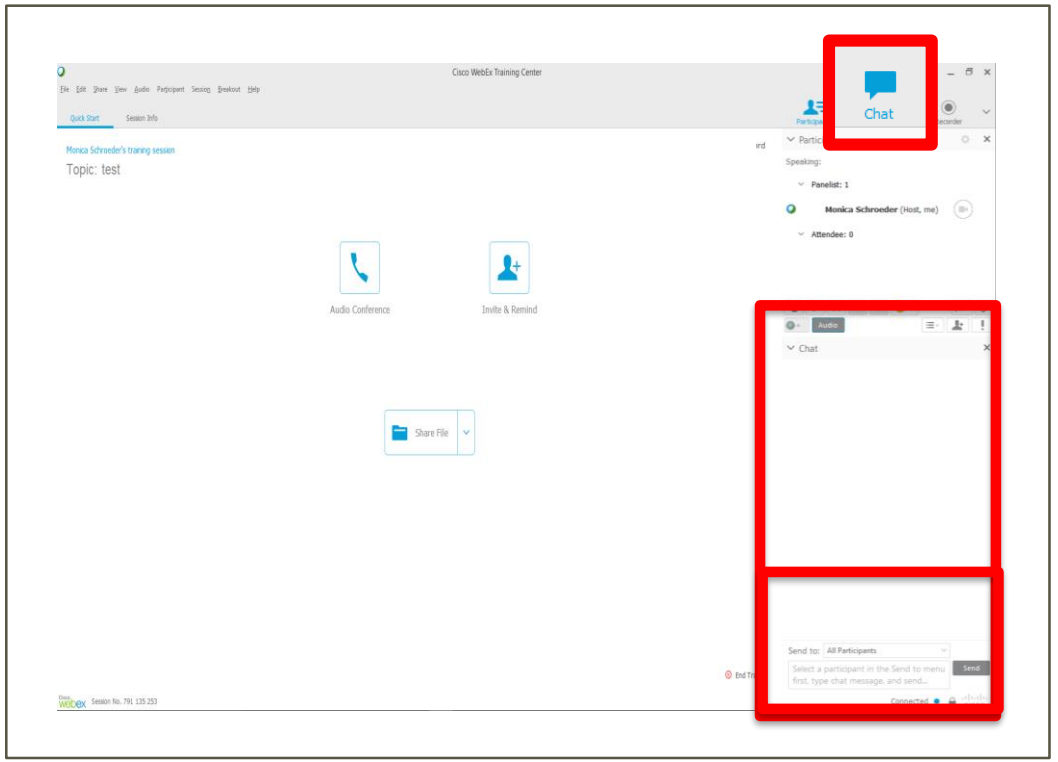


Learning Objectives

By the end of the webinar, participants will be able to:

- Discuss challenges in infectious disease forecasting
- Describe methods to determine forecast accuracy and precision
- Describe forecasting projects of the Epidemic Prediction Initiative

Epidemic Prediction Initiative

Advancing Forecasting for Public Health

Matthew Biggerstaff, ScD, MPH, Epidemiologist

Michael Johansson, PhD, Biologist

Craig McGowan, MS, ORISE Fellow

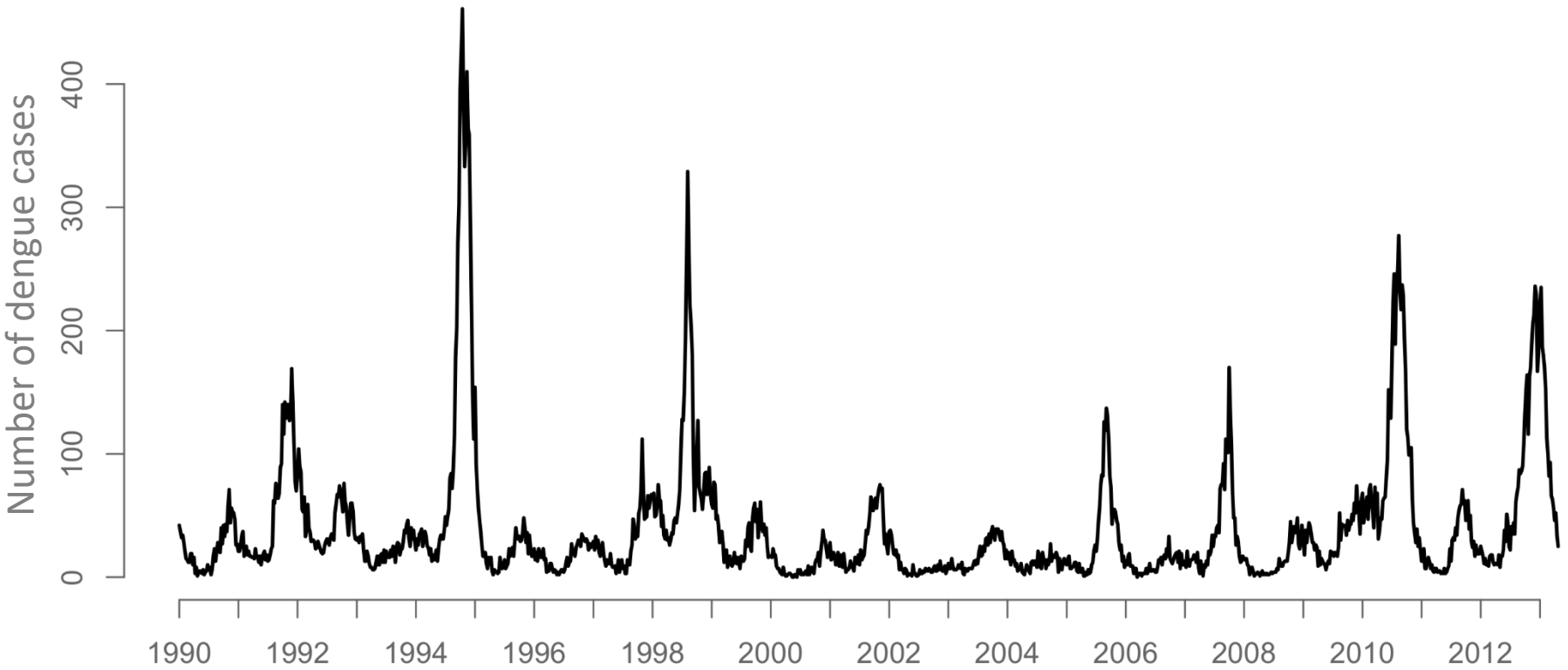
Infectious Disease Forecasting for Public Health Professionals

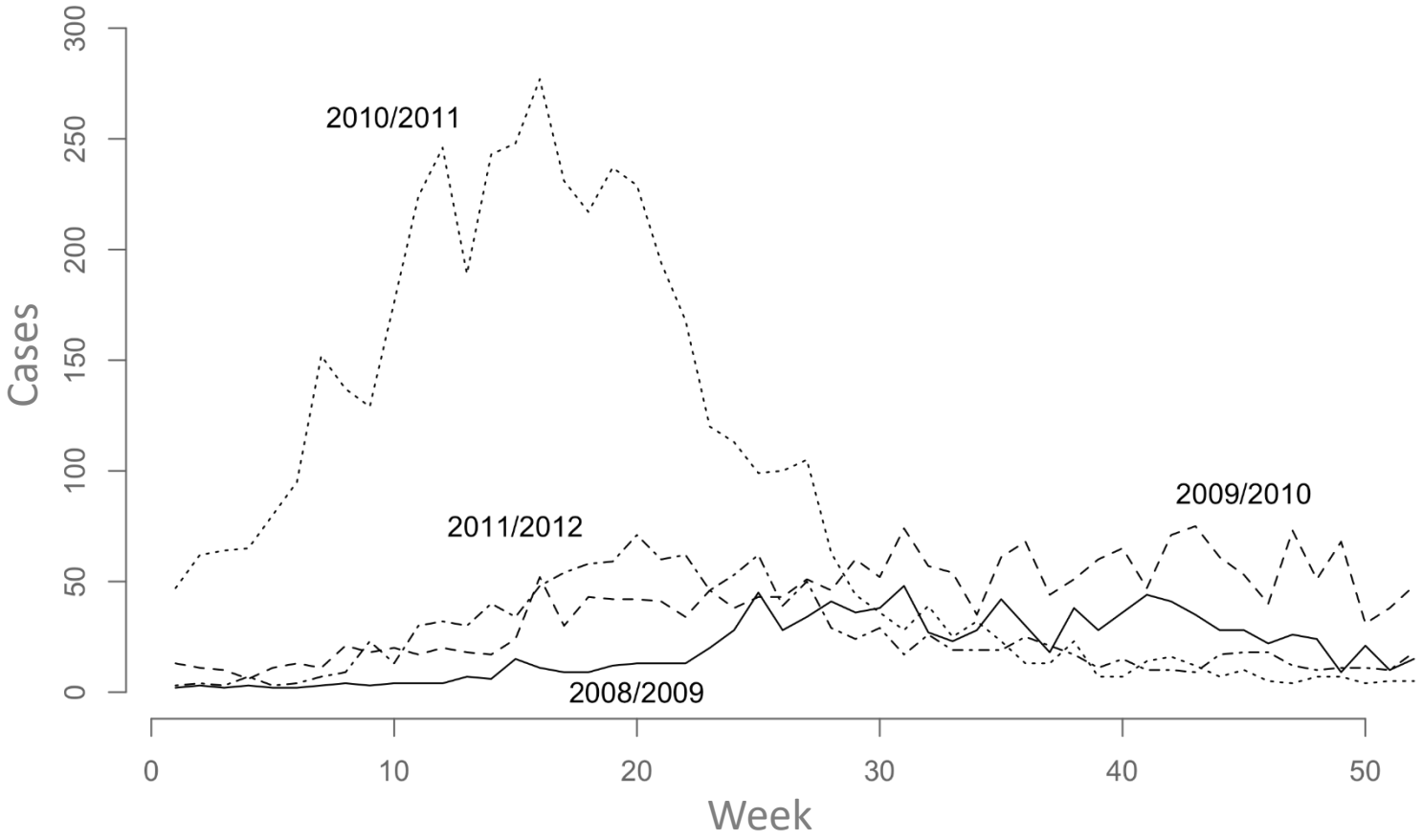
November 2, 2017

Every decision is based on a model.

Public health decisions can be informed by quantitative models.

Dengue – San Juan, Puerto Rico

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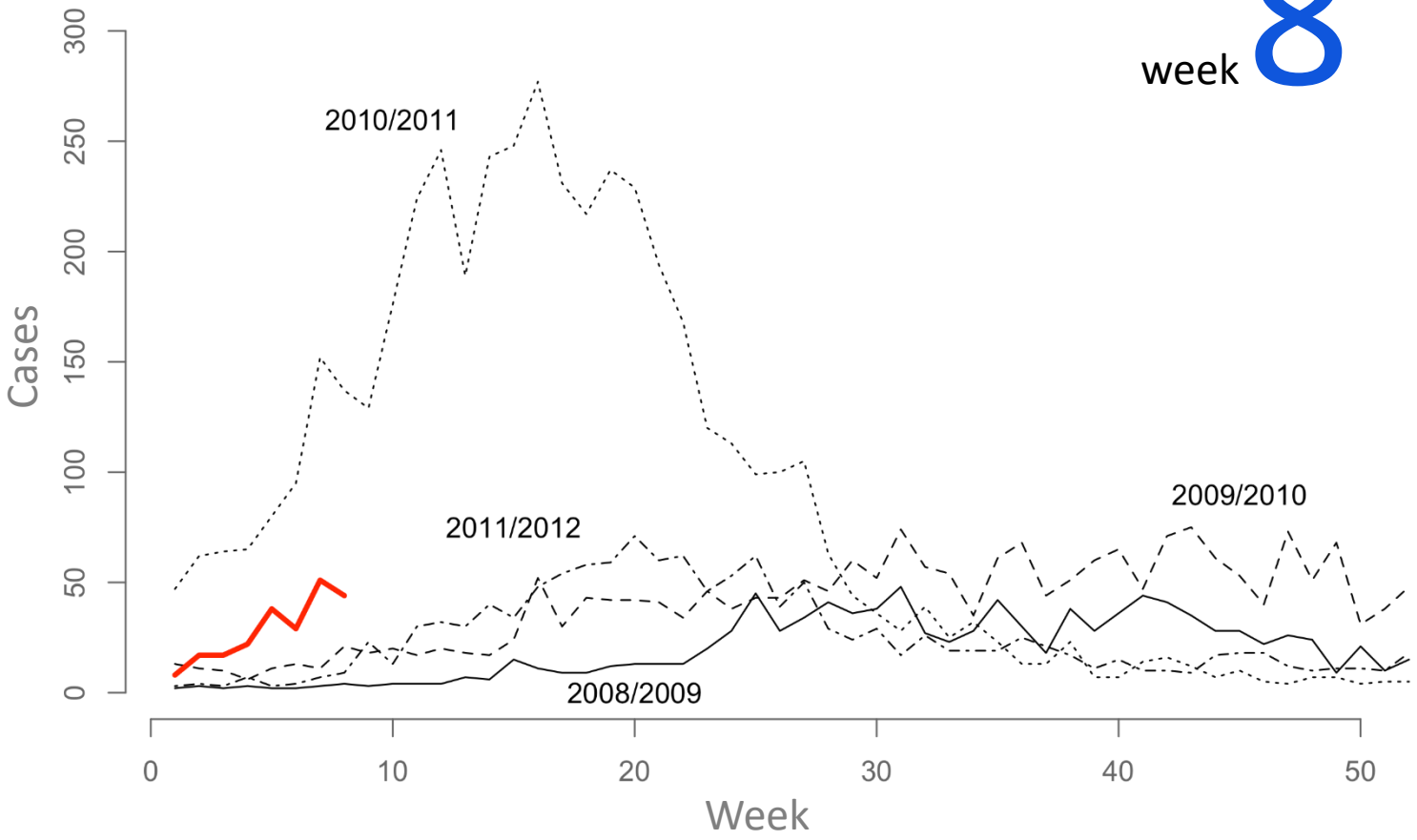
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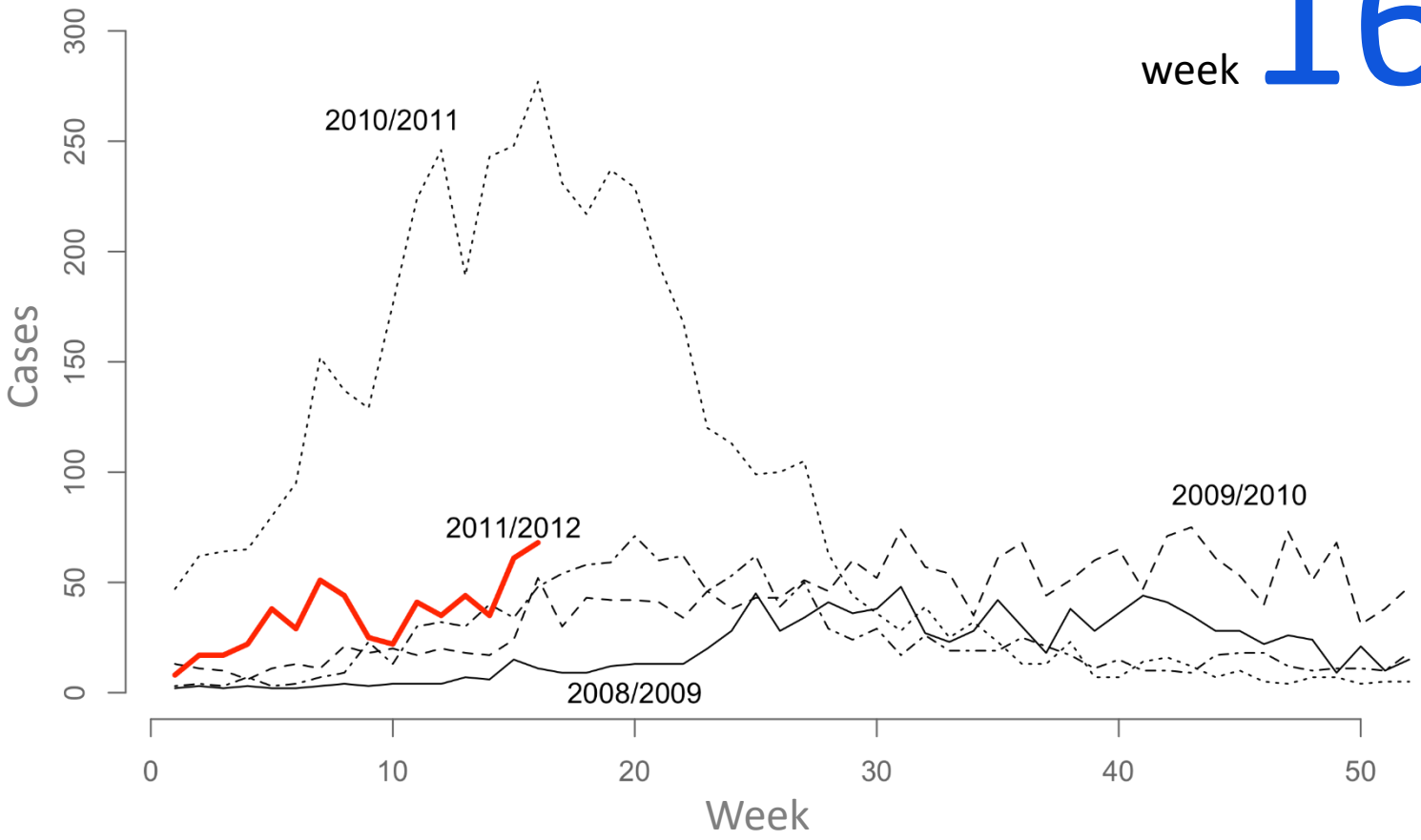
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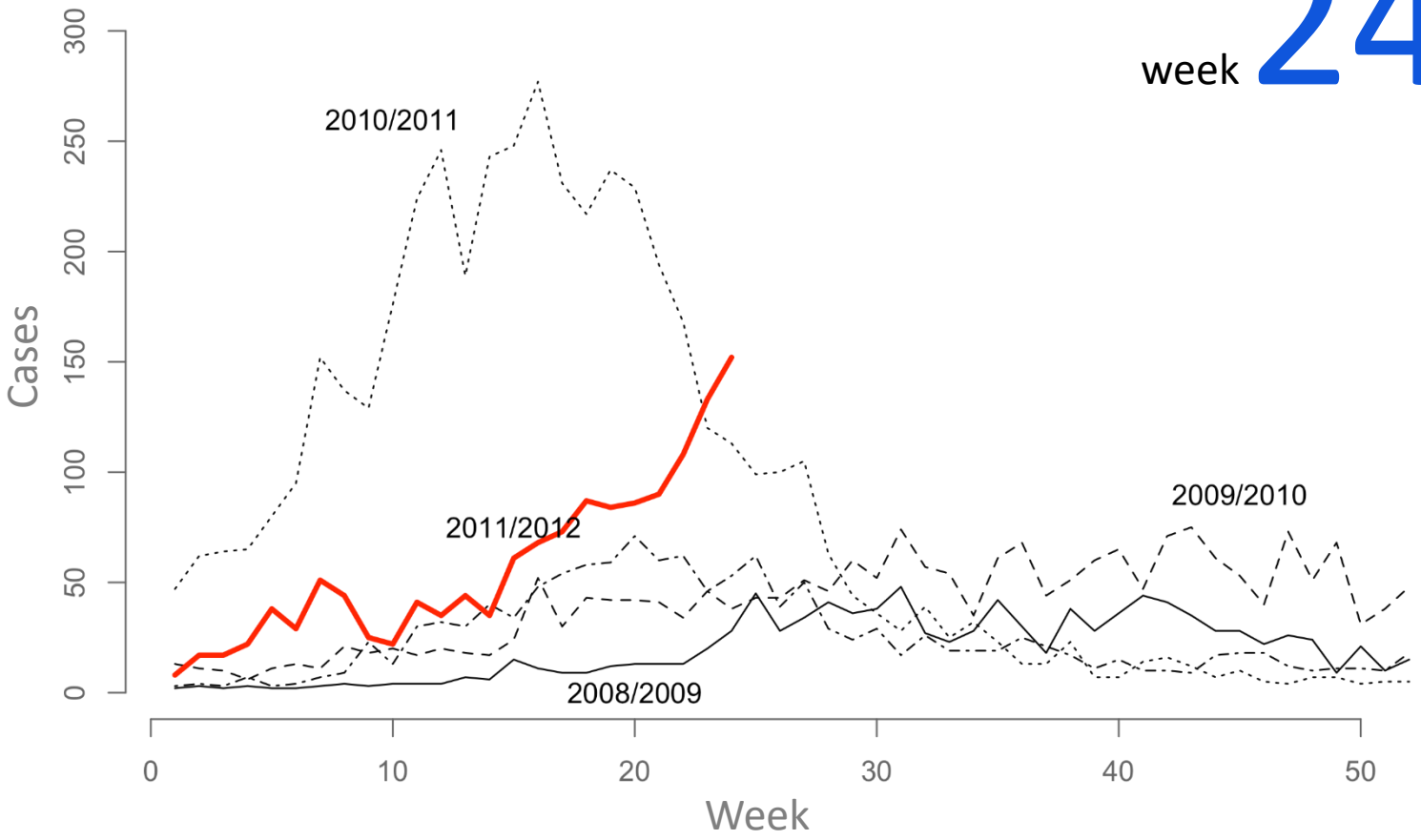
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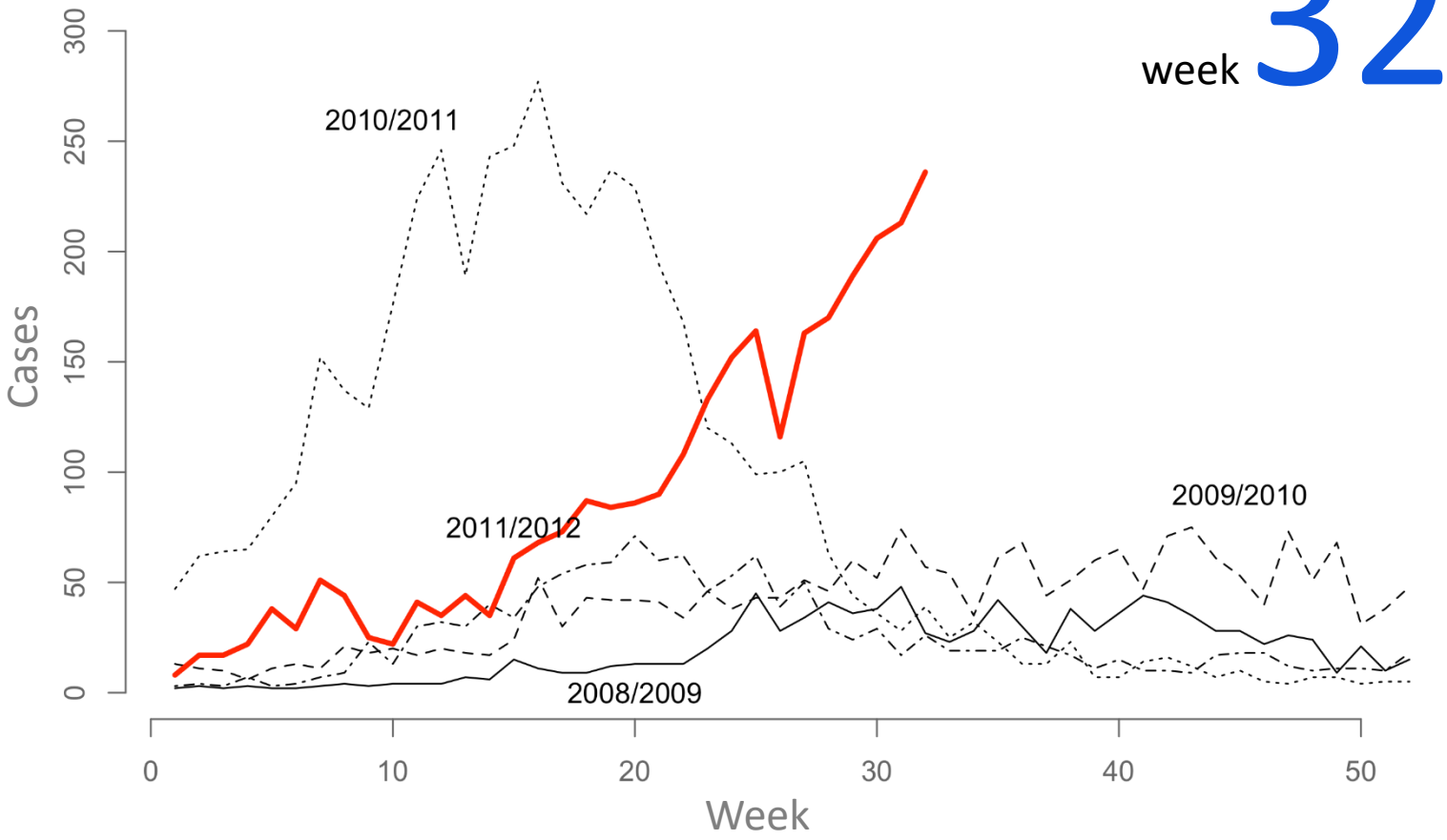
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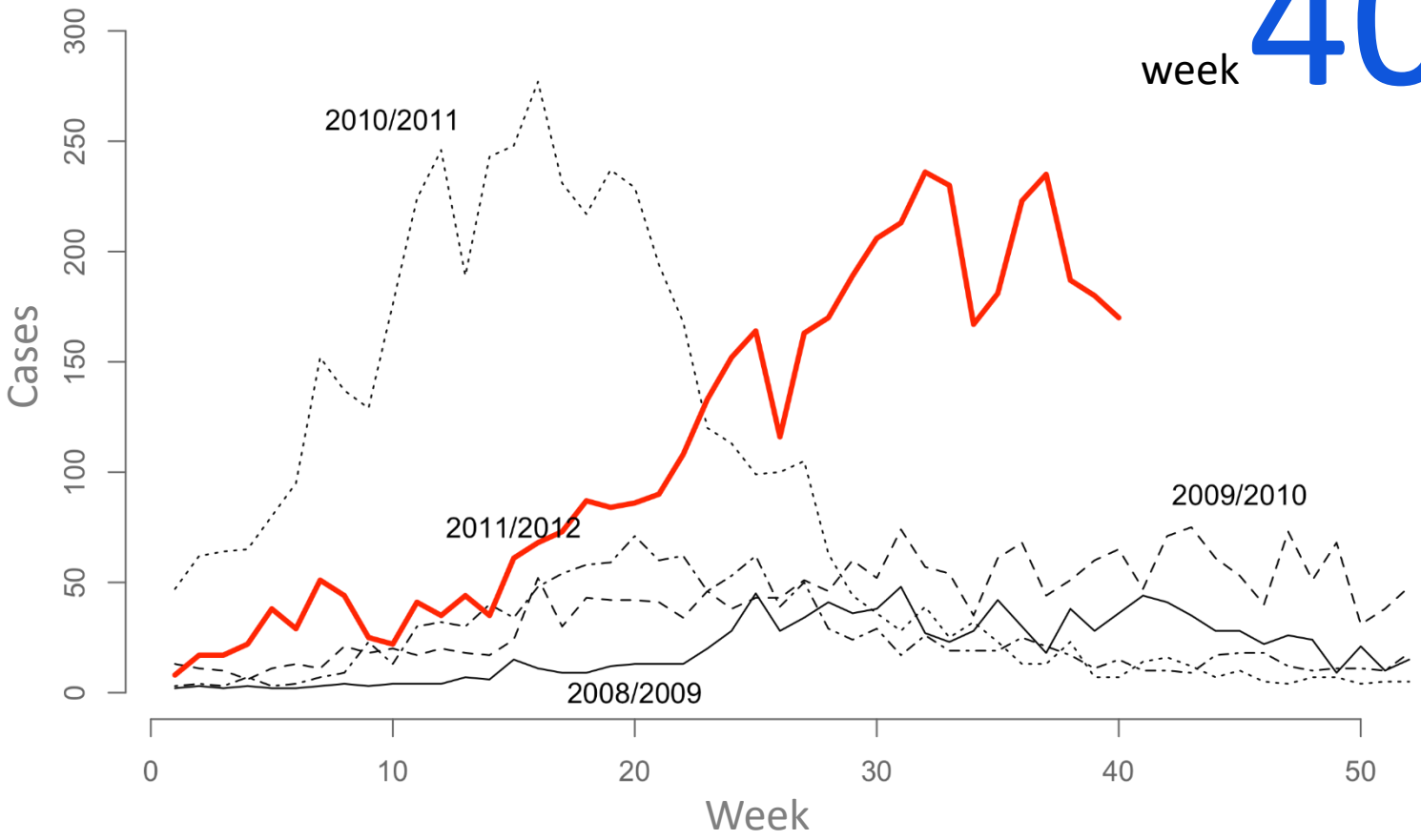
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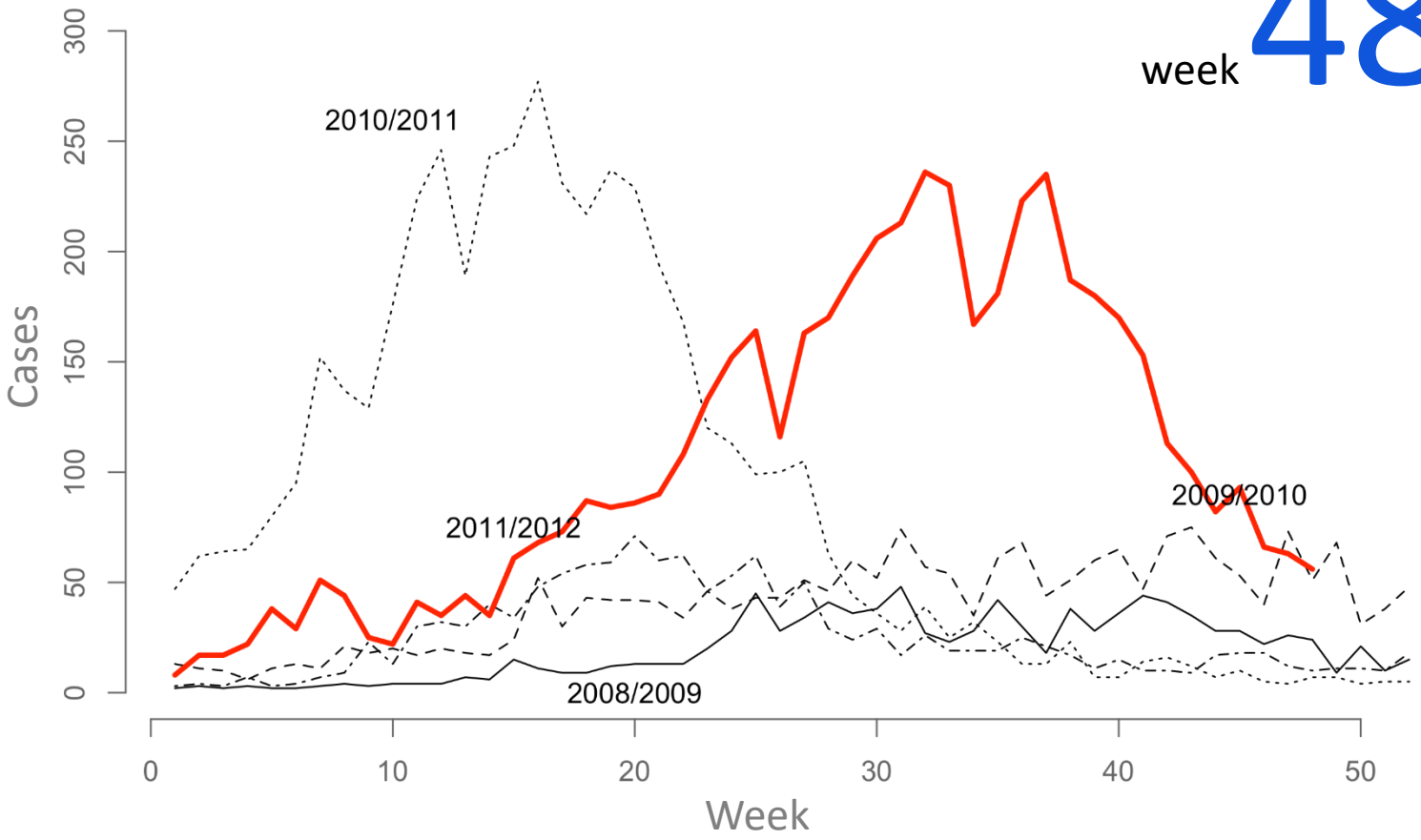
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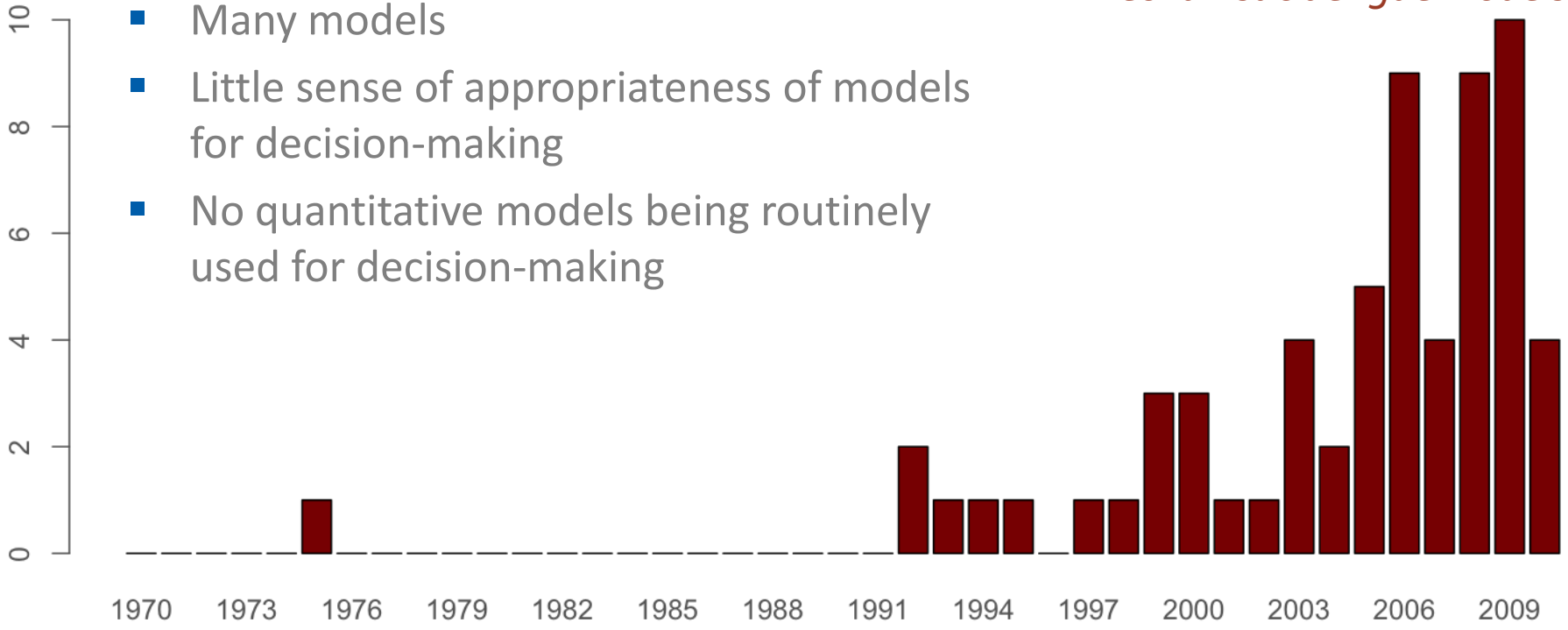
Forecasting approaches

- Statistical (time-series, regression)
  - Historical data
  - External drivers
- Mechanistic (SIR/SEIR, agent-based)
  - Biological processes
  - Infectious processes
- Machine learning
- Ensembles

The state of dengue modeling

As of 2010: 60+ published mechanistic dengue models

- Many models
- 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

The state of influenza forecasting

> "Comparing the accuracy of [influenza] forecasting applications is difficult because forecasting methods, forecast outcomes, and reported validation metrics varied widely."
>
> *- Chretien et al., PLOS ONE, 2014*

- Many models
- Most were published months to years after the forecasted event
- Different targets
  - Weekly incidence, epidemic duration, monthly visits, time of peak
- Different evaluation metrics
  - Mean absolute error, median absolute error, correlation

Epidemic Prediction Initiative

- Started in 2014
- Funded by CDC Office of Public Health Preparedness and Response
- Objectives:
  - Facilitate forecasting research
  - Connect forecasts to decision making needs
  - Evaluate forecast skill
  - Operationalize forecasting

A framework for forecasting

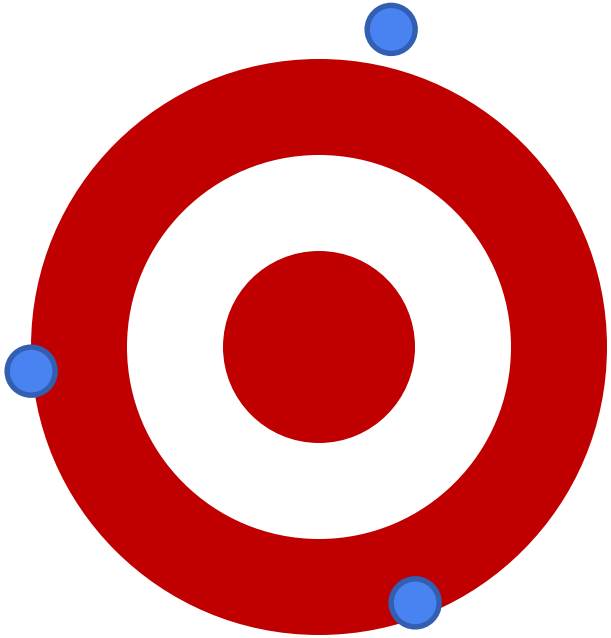
1. Establish objectives and targets
2. Identify, acquire, and/or simulate data
3. Formulate models
4. Evaluate predictions
5. Forecast

Forecast Evaluation

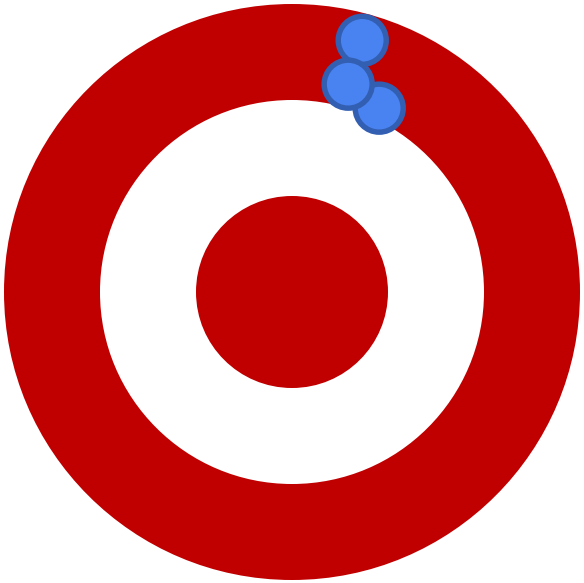
“It ain’t what you don’t know that gets you into trouble. It’s what you know for sure that just ain’t so.”

- Mark Twain

Accuracy



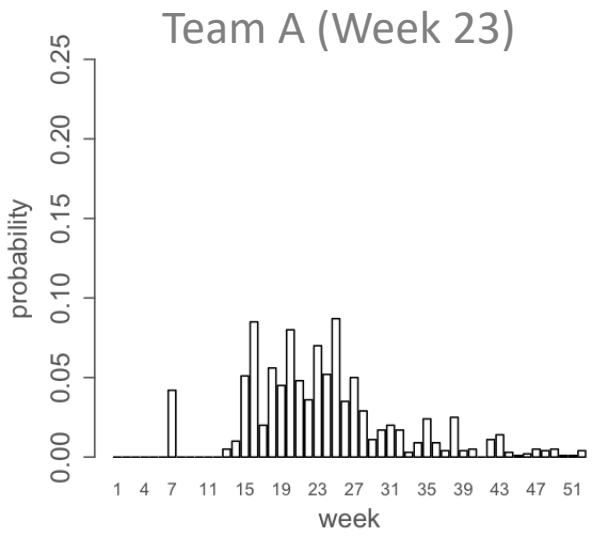
Precision

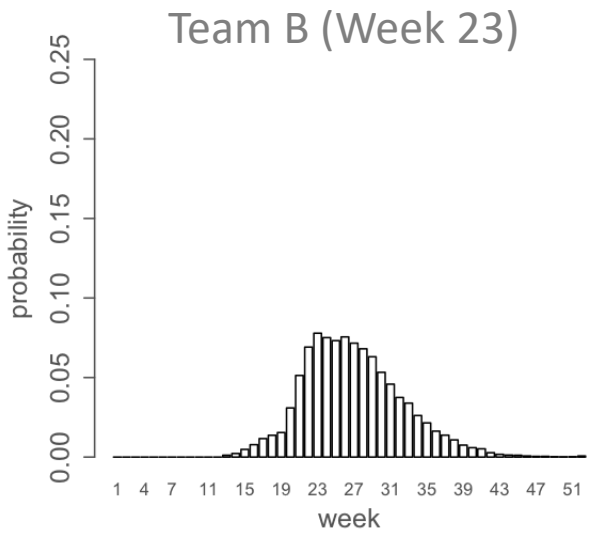


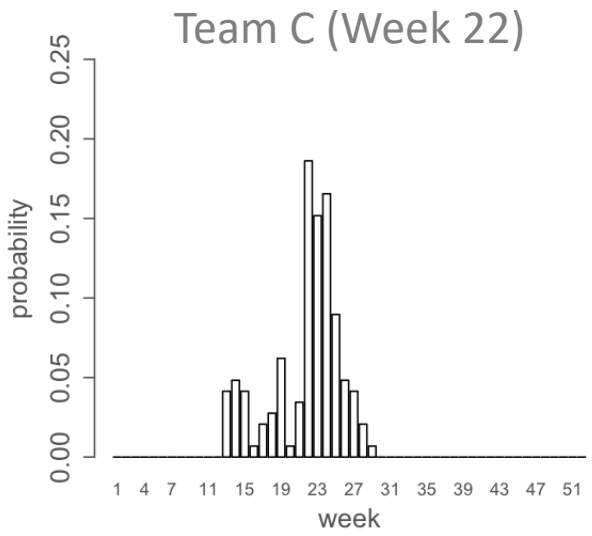
Peak week forecast example

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

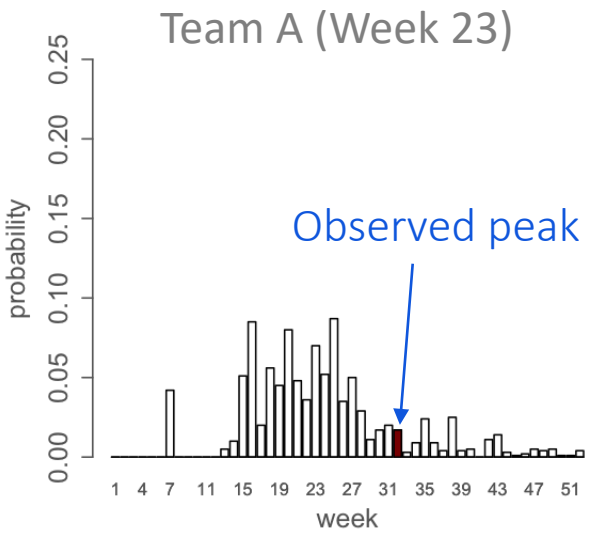
Peak week forecast example







Peak week forecast example



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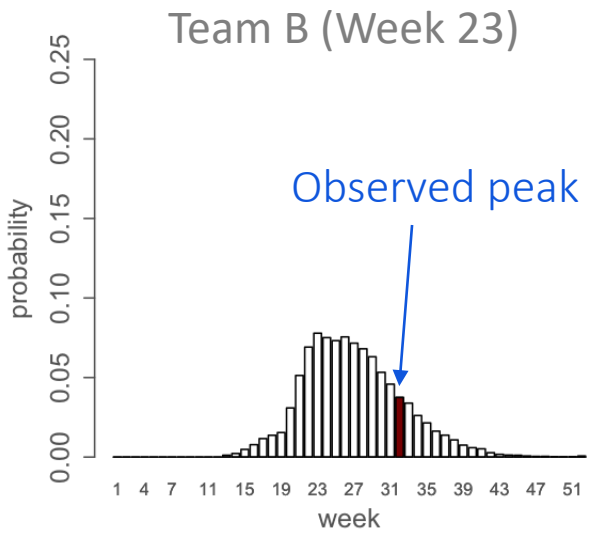

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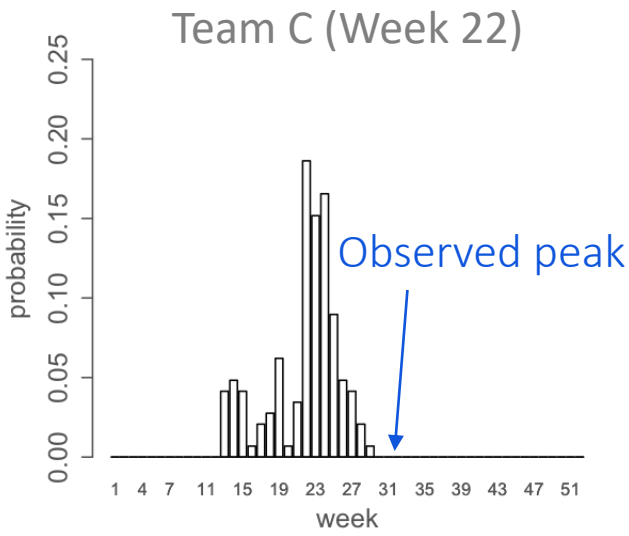

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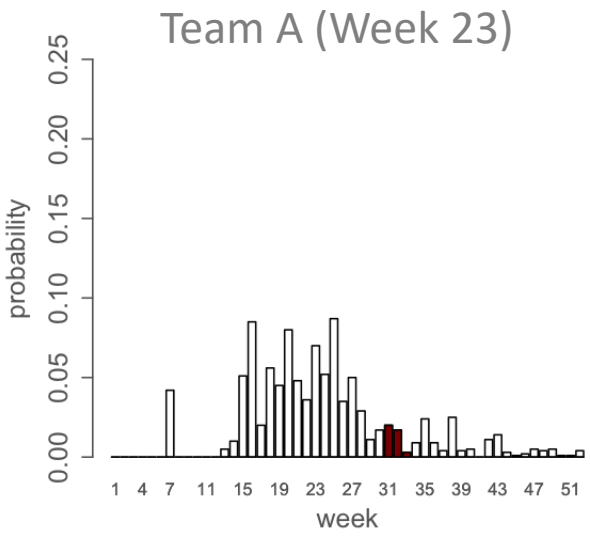
Peak week forecast example



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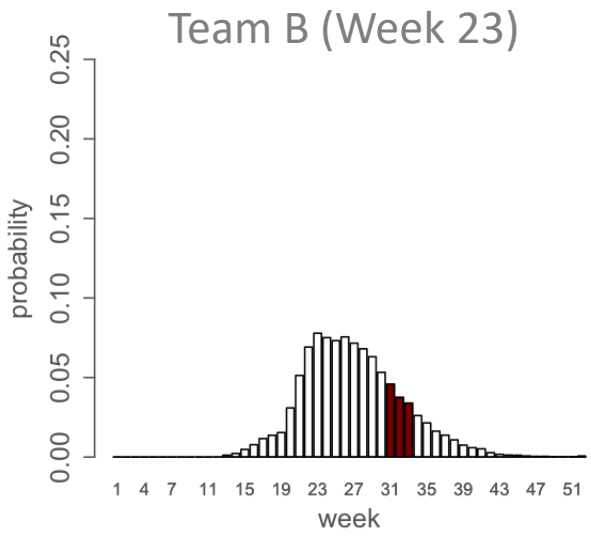

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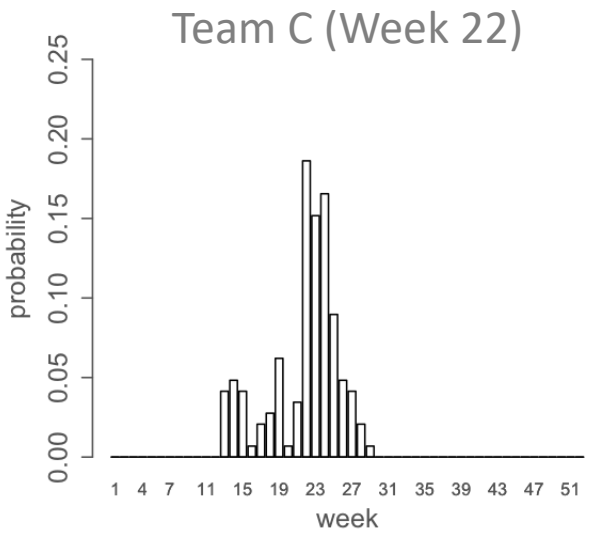
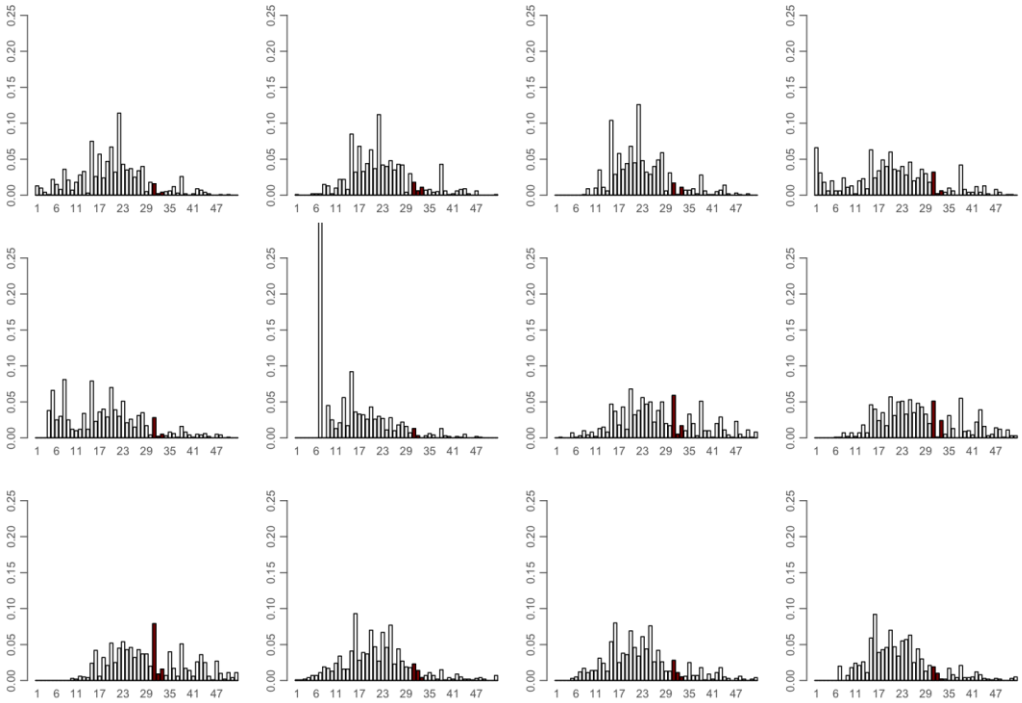


p = 0

Evaluating multiple forecasts



Log Score =
average log probability

Forecast Skill =
exponentiated Log Score

0 = Worst case scenario
1 = Perfect forecast

Forecasting Projects

Dengue Forecasting Project

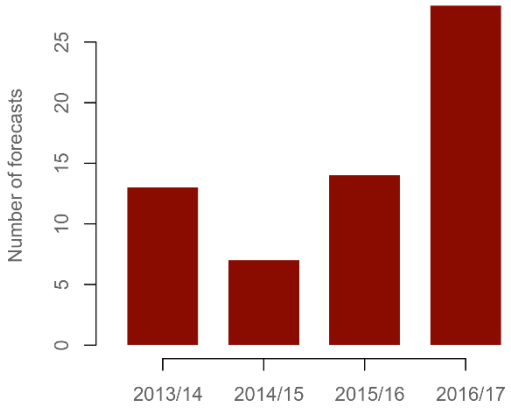
dengueforecasting.noaa.gov
predict.phiresearchlab.org

- June–September, 2015
- 16 teams; 10,000 forecasts
- Methodological results
  - Ensembles generally had higher performance
  - Climate, serotype, mechanistic, vector – remains to be determined
- Forecasting results
  - Early season forecasting is challenging
  - Some forecast models may be useful for situational awareness

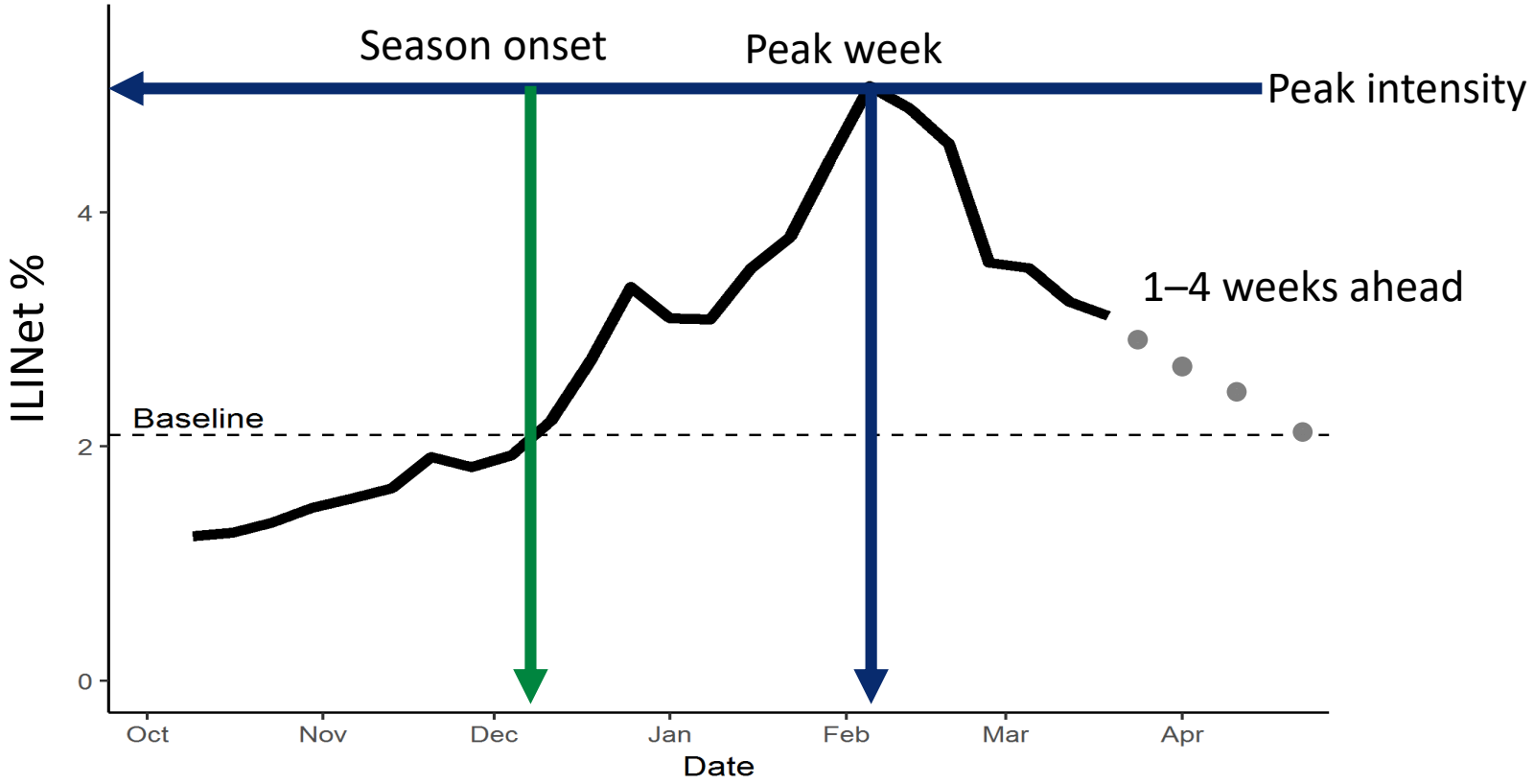
Influenza Forecasting Project

predict.phiresearchlab.org

- Started in the 2013–14 influenza season, entering our fifth year
- Network of public health, academics, and private companies
  - Groups and CDC co-develop challenge targets, accuracy measures, and forecast visualizations
  - Forecasts shared in real-time
  - Grown from 13 models in 2013-14 to 28 models in 2016-17
  - Over 60,000 forecasts received in 2016–17

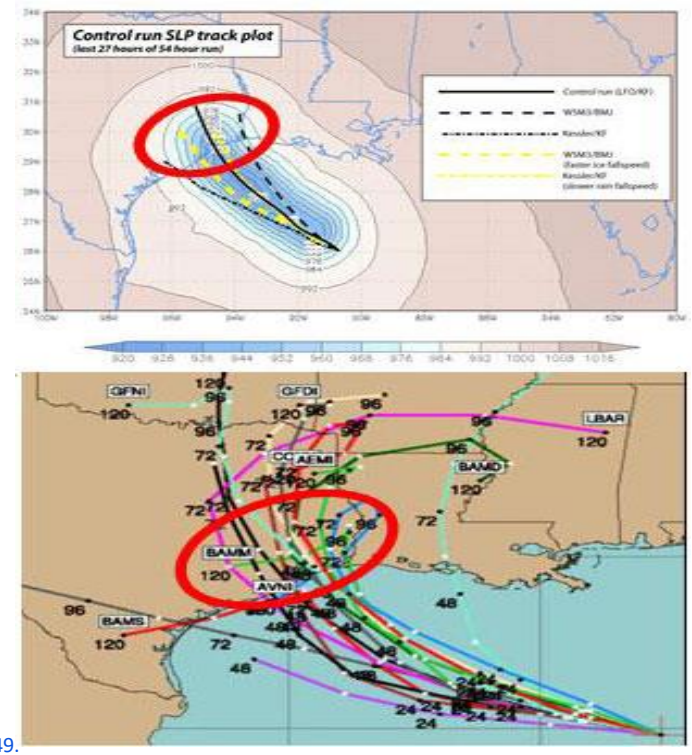


Forecasting Targets



FluSight Ensemble Forecast

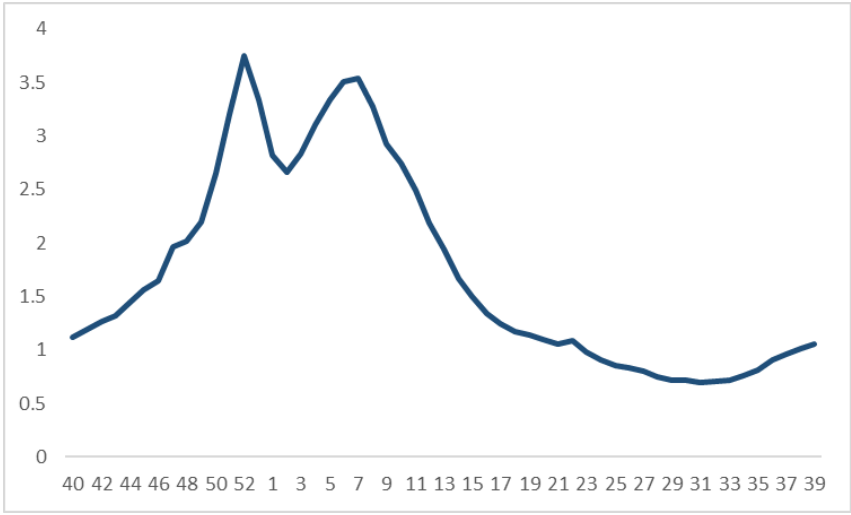
- We construct a simple ensemble by taking the mean of all forecasts
- Ensemble methods have record of success in both weather and infectious disease forecasting[1, 2]
- More ensemble research ongoing



1. Gneiting, T. and A.E. Raftery, *Weather forecasting with ensemble methods.* Science, 2005. **310**(5746): p. 248-249.
2. Yamana, T.K., S. Kandula, and J. Shaman, *Superensemble forecasts of dengue outbreaks.* Journal of The Royal Society Interface, 2016. **13**(123).

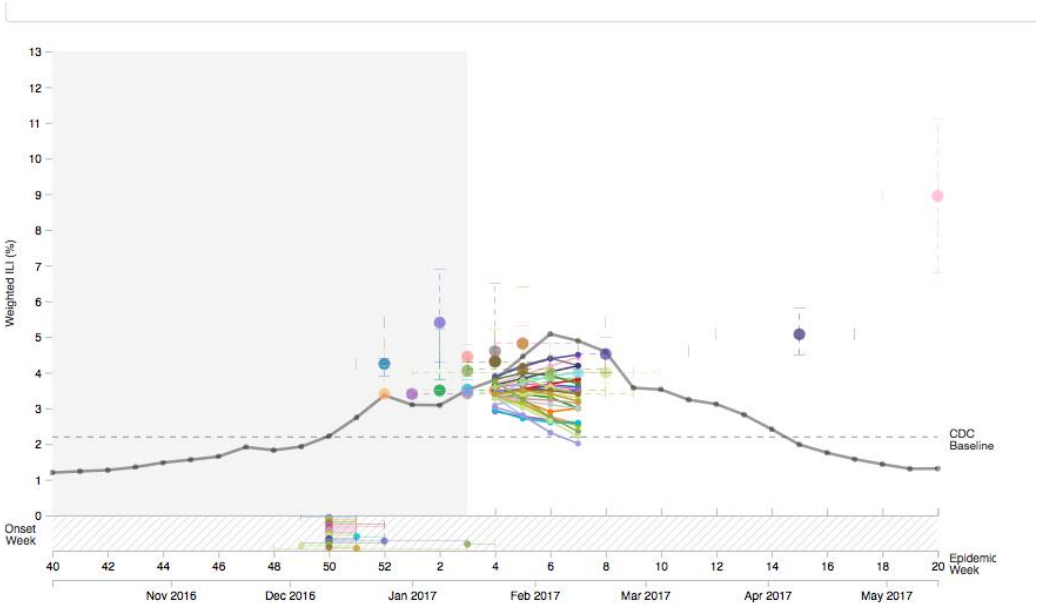
Historic Average Forecast

- CDC creates benchmark forecast based on historic ILINet data
- Do other forecasts outperform or underperform what we would predict based solely on past data?



Forecast Communication

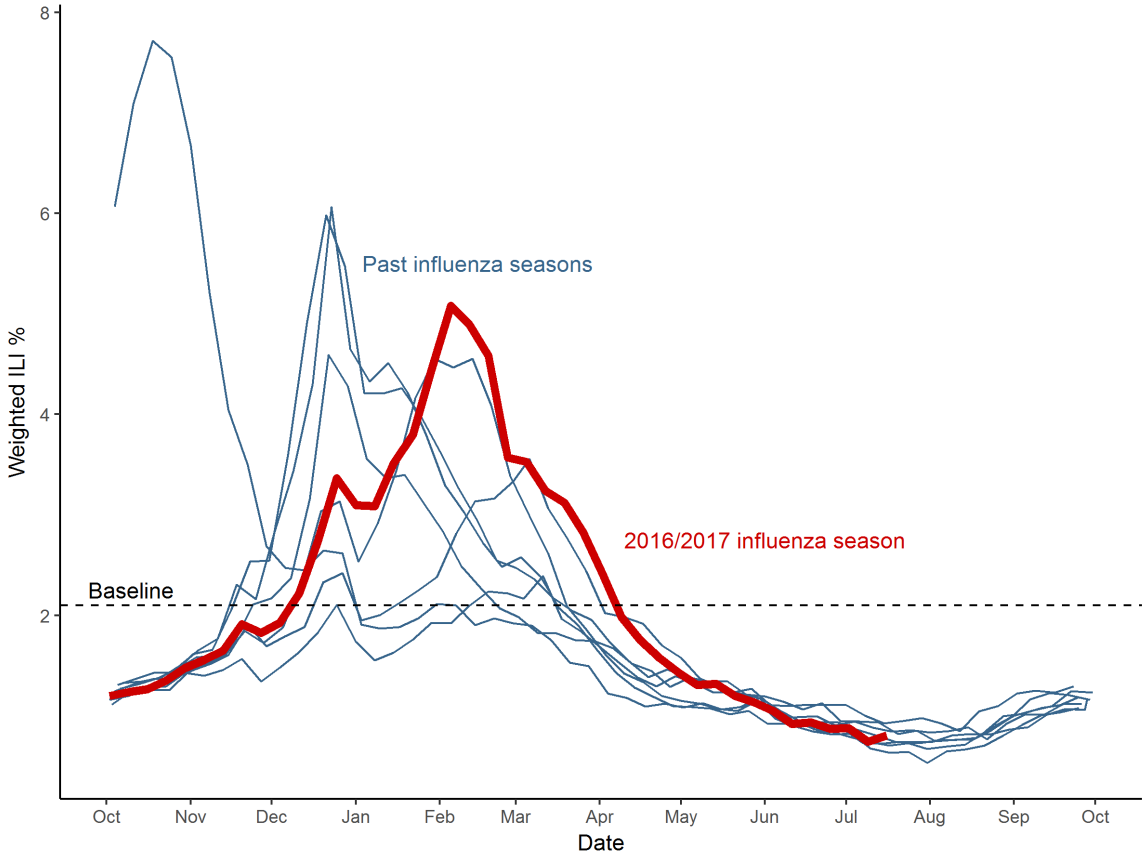
- Forecasts submitted to CDC each week
- Forecasts processed and visualized in real-time at http://predict.phiresearchlab.org
- Interactive plots for 2016-17 season available
- More details next session (Nov. 16)



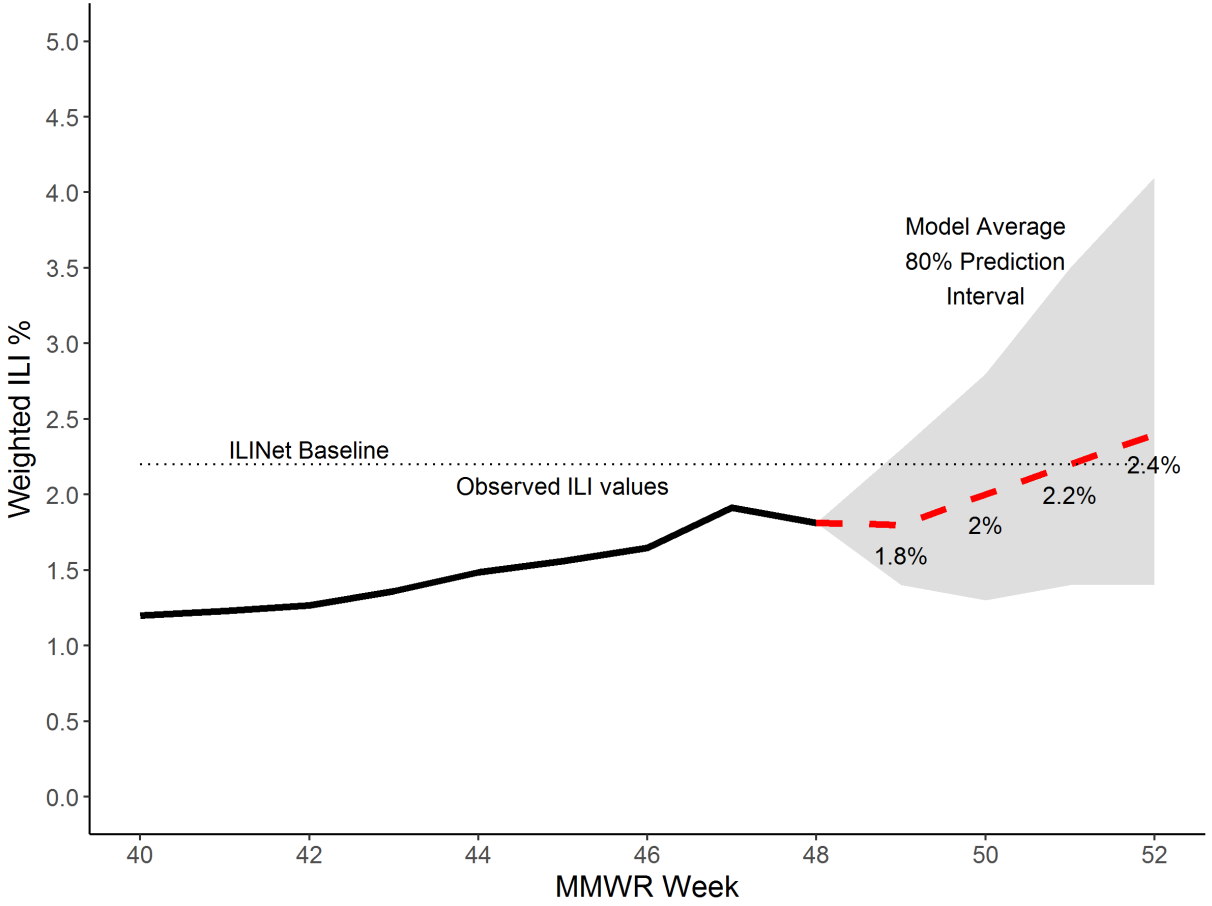
Participating Models

- 19 teams submitted results from 28 models
- 12 models used mechanistic models (SEIR, agent-based)
- 16 used statistical models (time series, regression)
- Data sources included ILINet, influenza laboratory data, EHR data, weather attributes, Twitter, Wikipedia, Google Trends, school vacation schedules, crowd-sourced forecasts

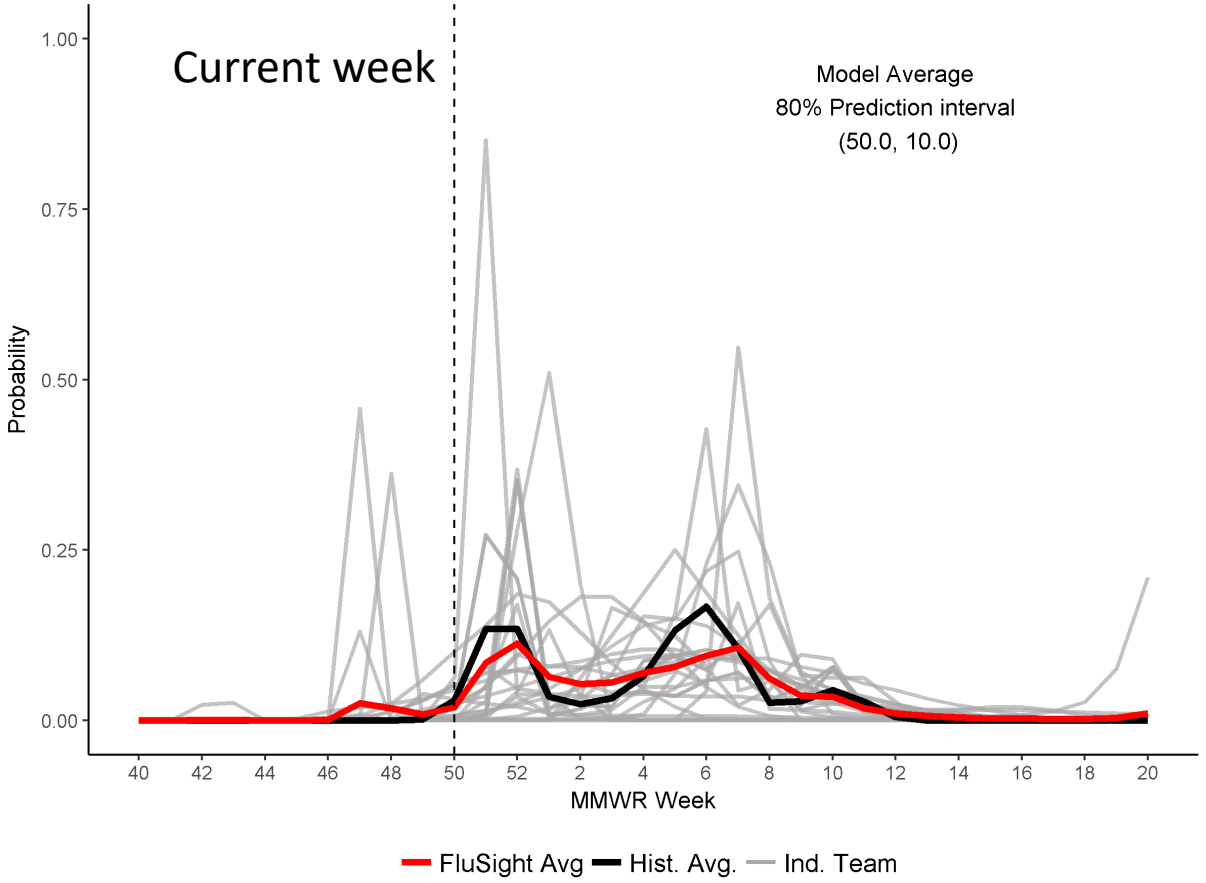
2016/2017 Influenza Season



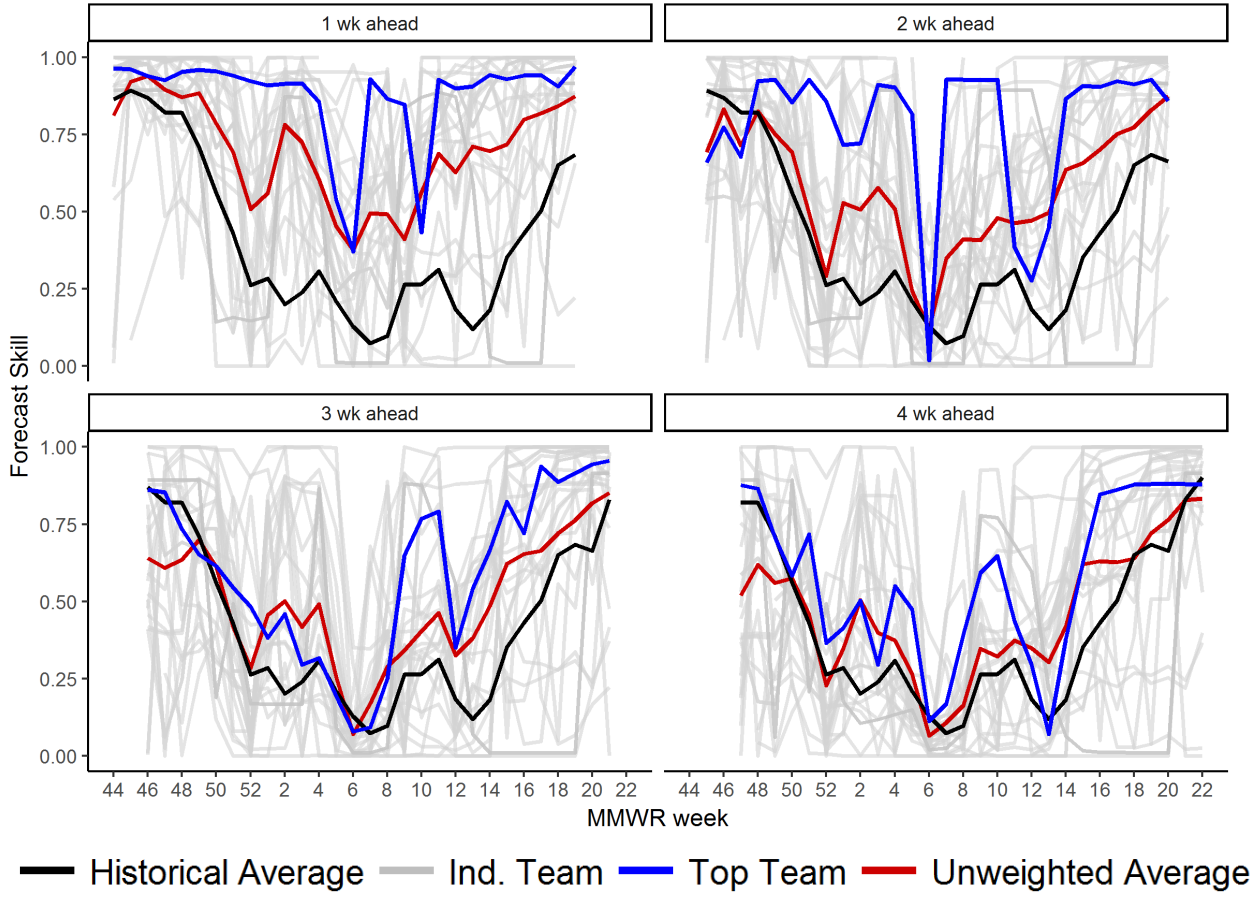
Short-Term ILI Predictions



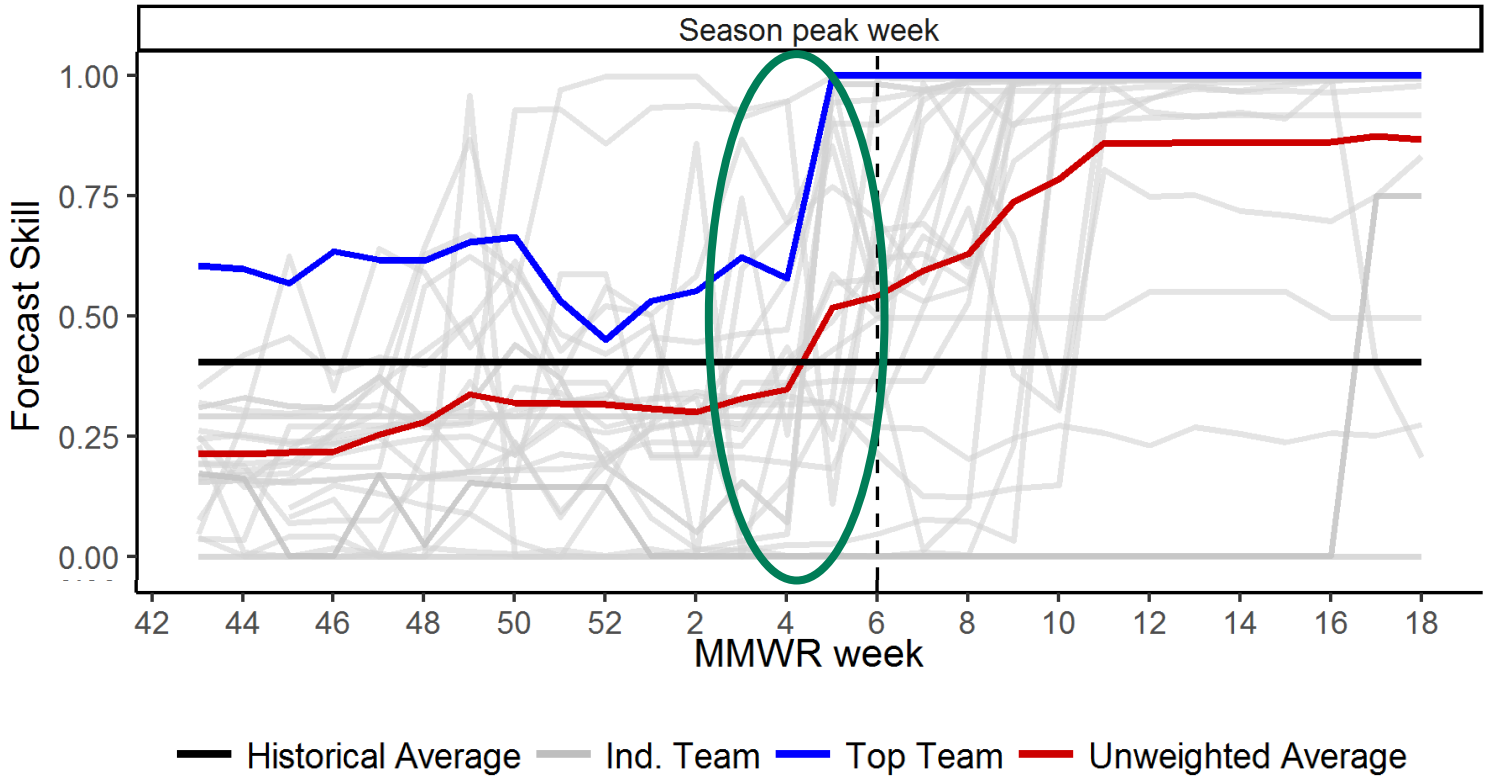
Season peak week



US Weekly Forecast Skill – Week-ahead Targets



Weekly Forecast Skill



Forecasting results

Forecasts

- Forecasts more accurate for near-term targets
- Near-term forecasts most accurate early and late in the season
- Seasonal target accuracy increased 2-3 weeks prior to peak

Models

- Returning teams
- Multiple data sources
- Ensemble approaches

Influenza Forecasting Conclusions

- Rare example of an operational forecasting system for an infectious disease
- Simple ensemble performed well for all targets and outperformed historic average
- Epidemic Prediction Initiative provides space for exploration of projects that may increase utility of forecasts

Next Webinar

Accessing and Interpreting Influenza Forecasts During the 2017-18 Influenza Season

Thursday, November 16th, 2017 from 2:00-3:00pm EST

In the 2017-18 influenza season, the CDC is expanding its influenza forecasting challenges to include forecasts of state level influenza activity, as well as forecasts of influenza hospitalizations. Forecasts will be displayed online and communicated to CDC influenza leadership weekly during the influenza season. We will review how to interpret information from these forecasts so public health decision makers at all levels can benefit.

Working group

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Craig McGowan, cmcgowan@cdc.gov

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

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.

To Ask a Question

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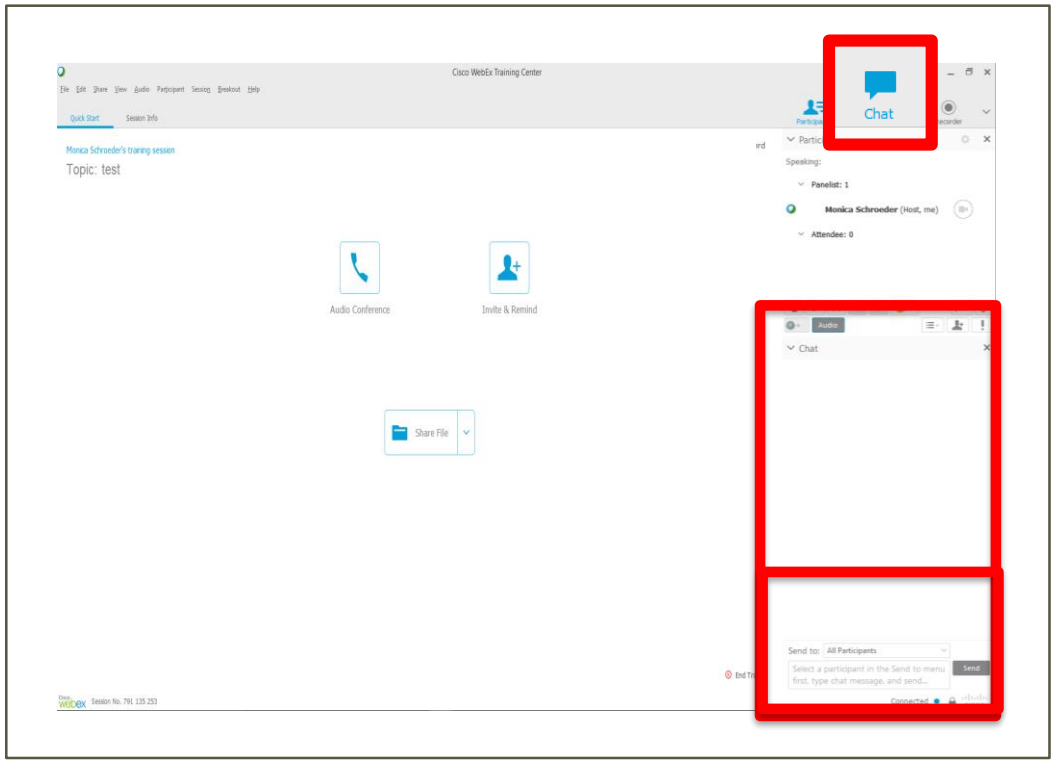

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- After completing the evaluation, you will be provided the opportunity to submit your contact information to receive additional communications about future activities
- Please join us Thursday, November 16th @ 2pm ET for *Accessing and Interpreting Influenza Forecasts During the 2017-18 Influenza Season*
- The webinar recording & slides will be available CSTE's website in the webinar library: http://www.cste.org/?page=WebinarLibrary

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