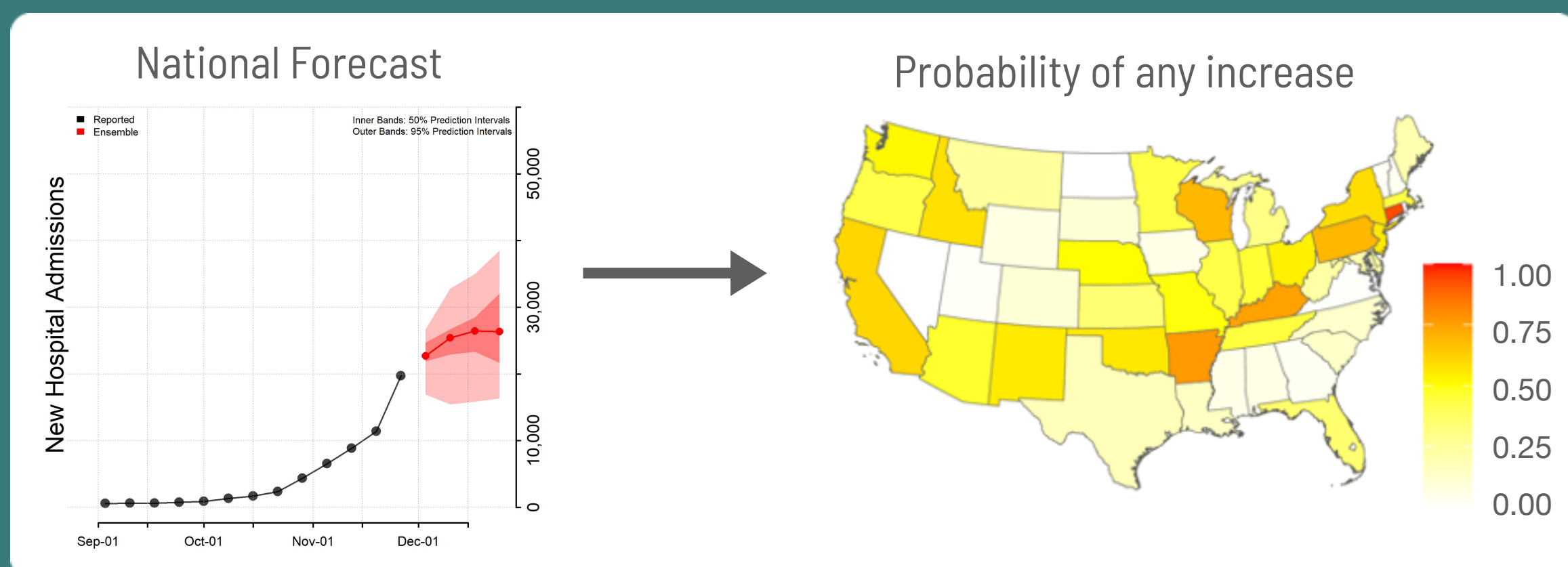


FORECASTING TRENDS IN INFLUENZA HOSPITALIZATIONS: DESCRIBING AN EXPERIMENTAL APPROACH DEPLOYED DURING THE 2022-2023 INFLUENZA SEASON

Rebecca K. Borchering, Jessica Davis, Sarabeth Mathis, Alexander Webber, Logan Brooks, Roni Rosenfeld, Ryan Tibshirani, Matteo Chinazzi, Kunpeng Mu, Alessandro Vespignani, Yicheng Zhang, Leonardo Clemente, Fred Lu, Austin G. Meyer, Mauricio Santillana, Michal Ben-Nun, Pete Riley, James Turtle, V.P. Nagraj, Stephen D. Turner, Evan L. Ray, Nicholas G. Reich, Li Shandross, Martha Zorn, Aniruddha Adiga, Benjamin Hurt, Gursharn Kaur, Bryan Lewis, Madhav Marathe, Srini Venkatramanan, Matthew Biggerstaff

BACKGROUND

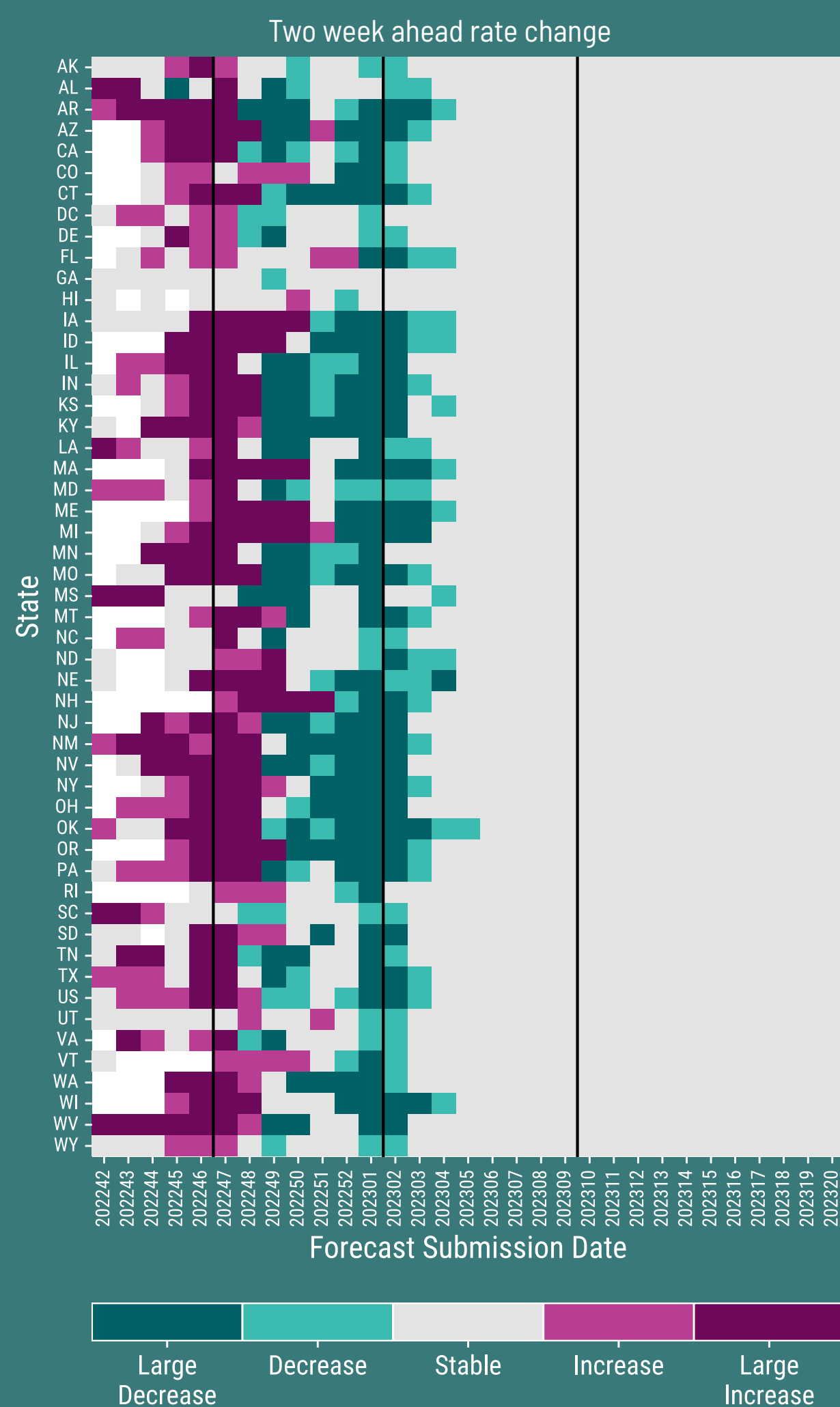
During the 2022-2023 influenza season, the U.S. FluSight forecast consortium piloted a new forecasting target of direction and relative magnitude of change in confirmed influenza hospital admissions observed over two weeks. Research in this area could lead to a more robust forecast indicator for use by public health partners, particularly during periods of rapid changes in hospitalizations when the accuracy of forecasts for the absolute levels of new hospitalizations tends to decline. The adoption of this target was motivated by an atypical early increase of influenza activity. Due to this increase, many forecasting models struggled to predict the uptick in hospital admissions. However, the ensemble predicted changes in direction but missed the magnitude of change. Additionally, categorical trends can be used as a communication tool to inform and improve real-time visualizations for influenza forecasts. Here we assess the performance of the 2022-2023 categorical forecasting results.



METHODS

Categorical trend definitions

The probability of observing a *large decrease*, *decrease*, *stable*, *increase*, *large increase* change with respect to the weekly hospital admissions over a two week period. Classification into these categories is based on rate change and count change thresholds at two-week horizon distributions from FluSurv-NET and HHS-Protect/NHSN.



CHANGES IN COUNTS

$$Hosp_{t+2} - Hosp_t$$

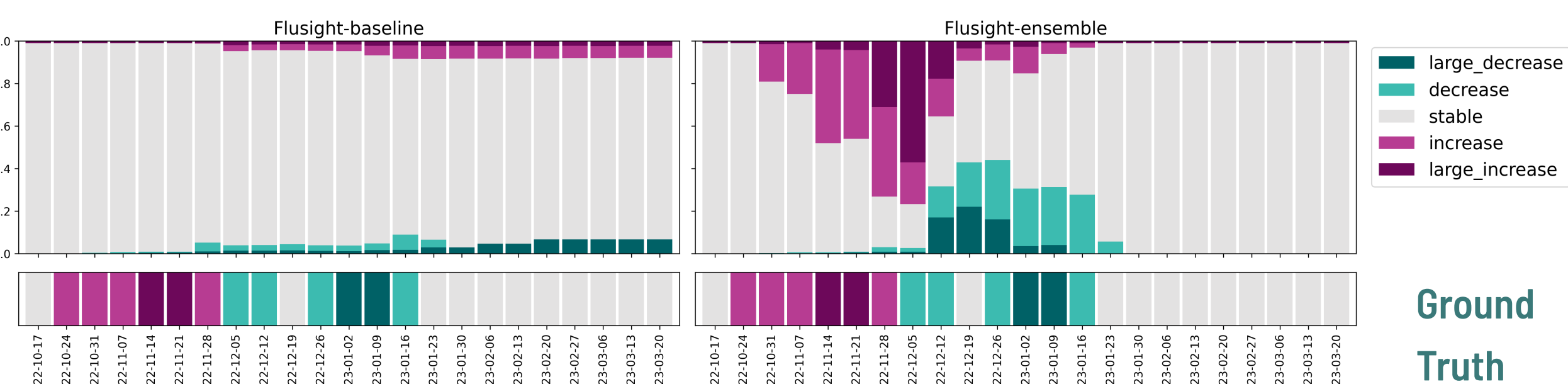
CHANGES IN RATES

$$(Hosp_{t+2} - Hosp_t) * \frac{population}{100,000}$$

- **Stable:** either the magnitude of the rate change is less than $1/100k$ OR the corresponding magnitude of the count change is less than 20.
- **Increase:** the positive magnitude of the rate change is less than $2/100k$ OR the count change is less than 40.
- **Large increase:** positive forecasted rate changes that are larger than or equal to $2/100k$, AND the count change is larger than or equal to 40.
- **Decrease:** negative forecasted rate changes less than $2/100k$ OR the magnitude of the count change is less than 40.
- **Large decrease:** negative forecasted rate changes that are larger than or equal to $2/100k$, AND the count change is larger than or equal to 40.

Model submissions

Probability distributions of the forecasted trend changes over a two week horizon

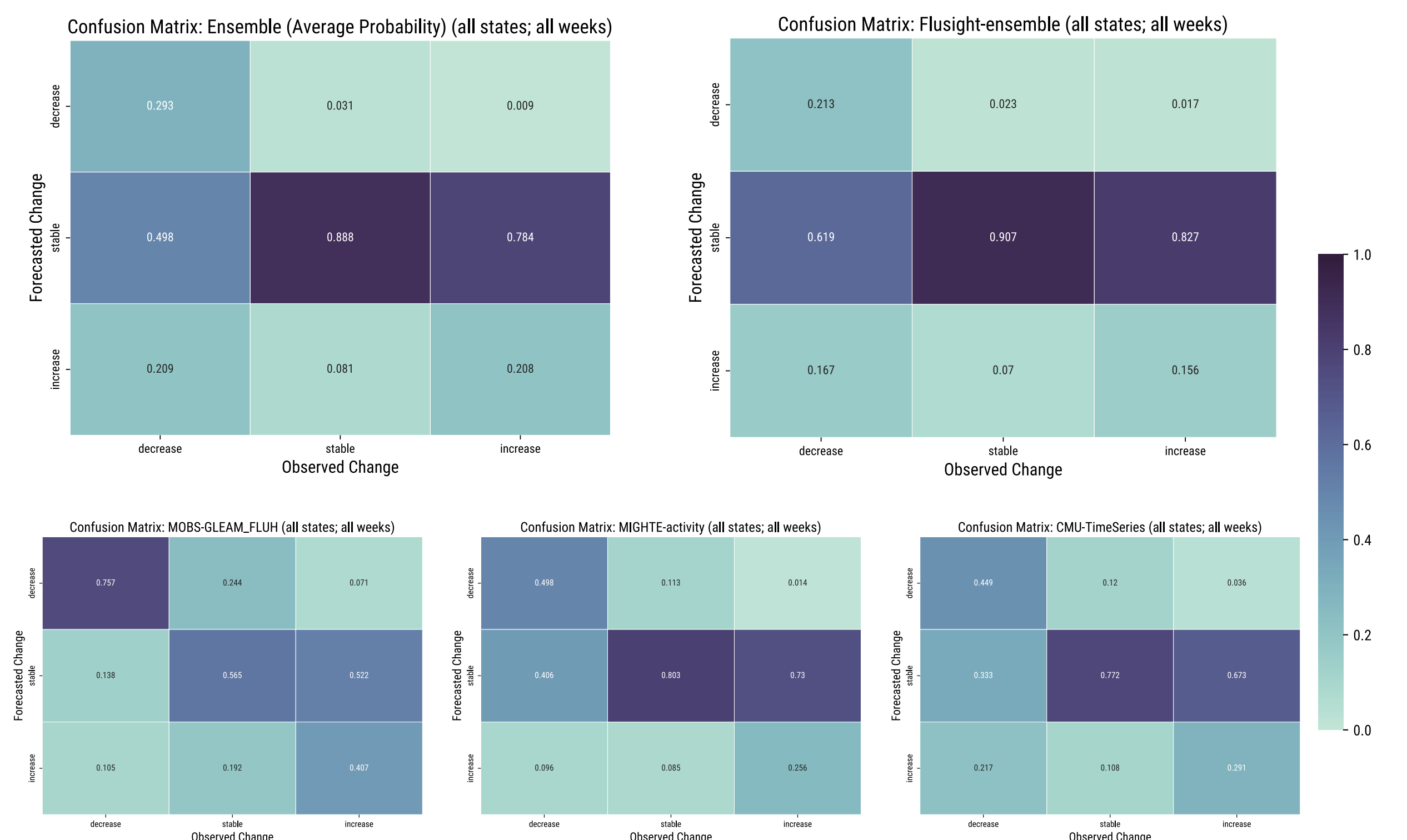


SEASON OUTCOMES AND EVALUATION

Initial submission: December 12, 2022

Number of teams submitted: 7 during the 2022-23 season + 2 Ensemble Models

Comparison to observed data



For each forecast in each state across all weeks the categorical change with the highest probability is extracted and considered to be the forecasted change. The values in each cell represent the probability that the model predicted a specific forecasted change given what was observed.

Comparison across teams

The multiclass **Brier Score** is a strictly proper score used to evaluate probabilistic predictions. It is the mean squared error between the predicted probabilities and the corresponding observed outcomes for each category.

Brier Score:

$$BS = \frac{1}{N} \sum_{t=1}^N \sum_{i=1}^R (f_{ti} - o_{ti})^2$$

N : length of time window || f_{ti} : forecasted probability

R : number of categories || o_{it} : outcome (1 or 0)

Brier Skill Score:

$$BSS = 1 - \frac{BS}{BS_{ref}}$$

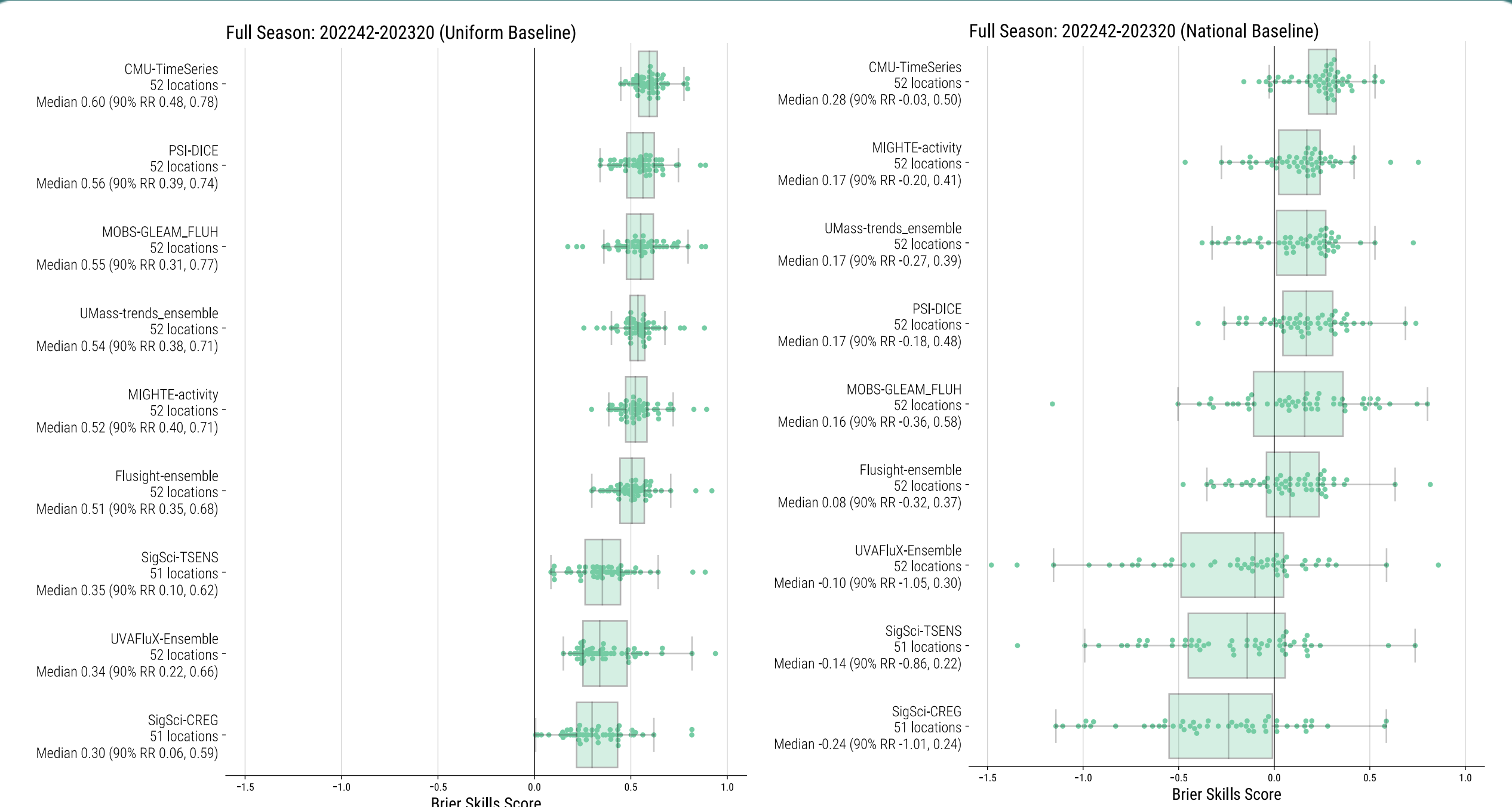
$BSS < 0$: Scores worse than baseline

$BSS = 0$: Scores equivalent to baseline

$BSS > 0$: Scores better than baseline

Two reference models:

- *Uniform baseline*: each of the five categories has a probability = 0.2 (1/5) of being observed in each jurisdiction each week.
- *National baseline*: the probability that a jurisdiction is in each category depends on the percentage of states falling in each category for the most recent observed two-week difference.



BSS distribution comparing different reference models. Each point represents the BSS for a single location.

CONCLUSION

As a part of the US FluSight forecasting challenge, teams were invited to submit probabilities for each trend category across all fifty states, Washington D.C., and the U.S., weekly, starting December 12, 2022. Seven teams submitted trend forecasts based on both statistical and mechanistic forecasting approaches and two ensemble models were contributed. Methods to calculate trend probabilities varied, but many teams used an approximation of their quantile-based distribution of two-week ahead hospital admission forecasts. We compared the submitted trend probabilities of seven modeling teams and two ensemble models. We used the Brier Skill Score to assess performance across the 2022-2023 flu season using two baseline models, one assuming a uniform probability and the other information from the nationally observed values. Trend forecast performance for submissions varied by location but generally outperformed the baseline models. Influenza trend forecasts may increase the potential utility, including robustness and timeliness, of forecasts during traditionally difficult times for prediction. Findings from this pilot season of trend forecasts and corresponding output from the FluSight Ensemble may inform directions to improve real-time usability of influenza forecasts

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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.