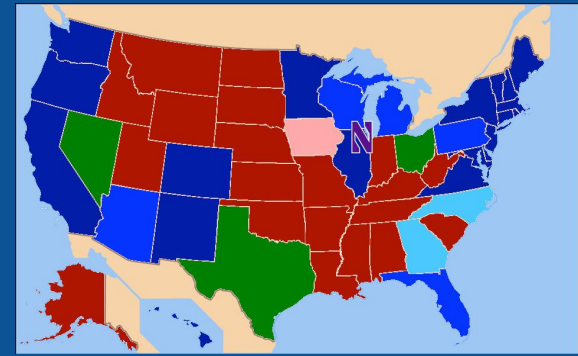


Northwestern
University



Mathematical Modeling of U.S. Election Dynamics

William He and Emily Mansell

Research advisor: Alexandria Volkening

Our code and 2020 forecast:

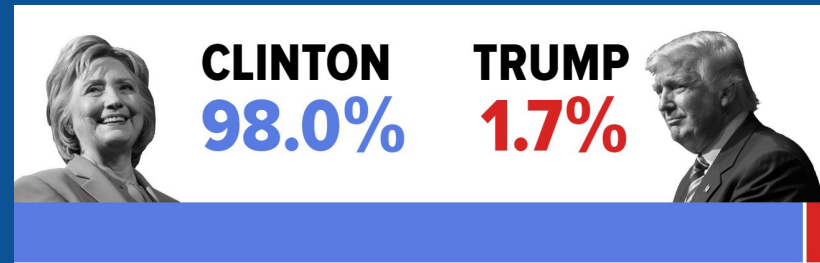
[https://modelingelectiondynamics.gitlab.io/
2020-forecasts](https://modelingelectiondynamics.gitlab.io/2020-forecasts)

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Motivation

Goals:

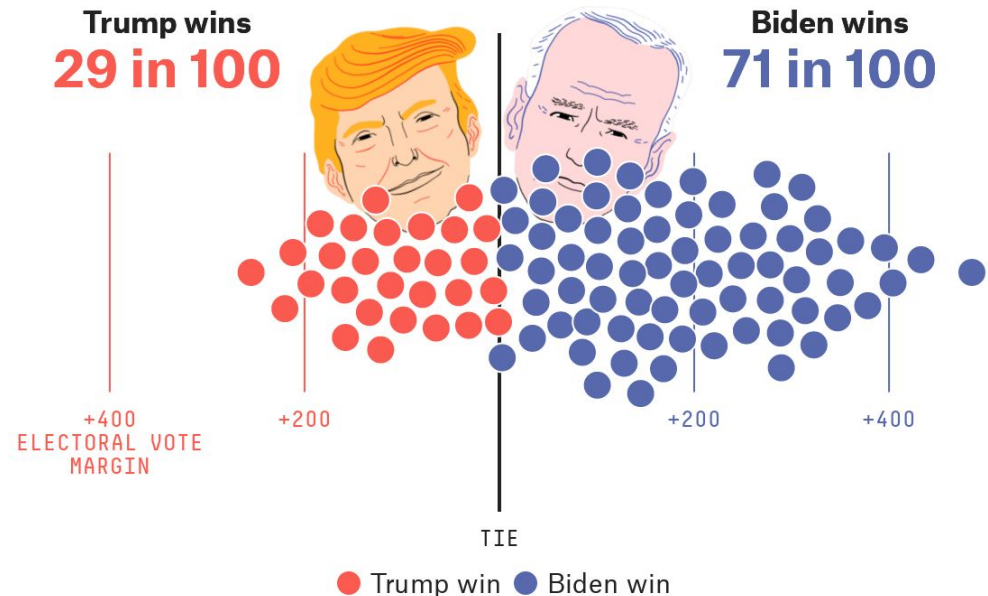
- Forecast the 2020 elections using mathematical modeling
- Better understand uncertainty and accuracy in forecasting
- Build and update a website with our forecasts in real time



Huffington Post 2016 Forecast²

Biden is *favored* to win the election

We simulate the election 40,000 times to see who wins most often. The sample of 100 outcomes below gives you a good idea of the range of scenarios our model thinks is possible.



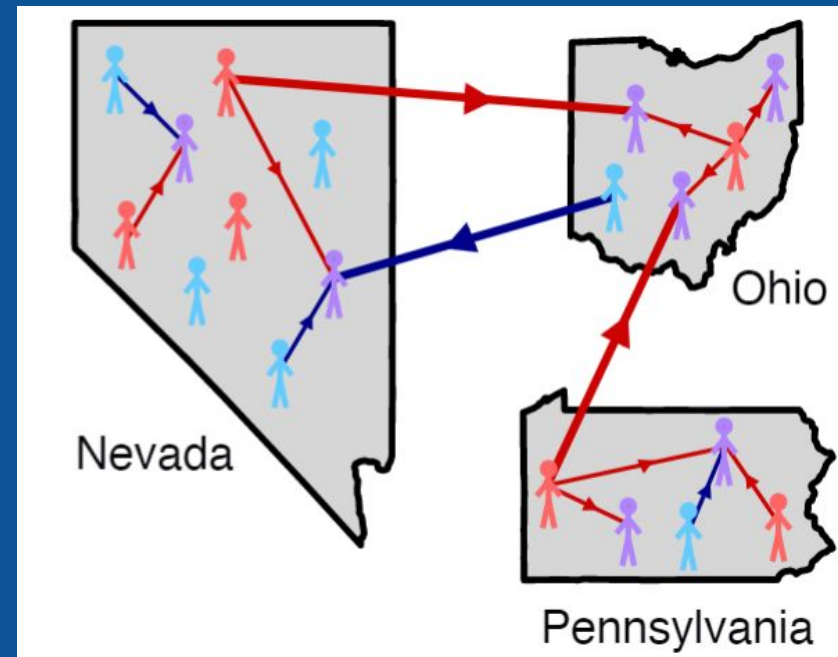
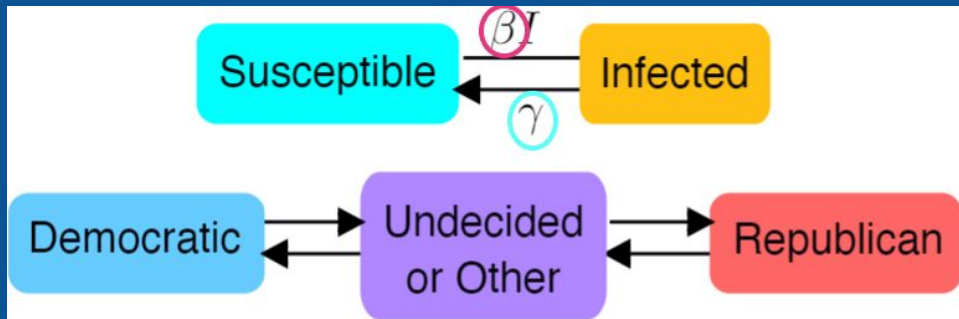
FiveThirtyEight 2020 Forecast¹

¹<https://projects.fivethirtyeight.com/2020-election-forecast/>
Accessed May 9, 2021

²<https://elections.huffingtonpost.com/2016/forecast/president>.
Accessed July 20, 2020

1. Model & Methods: General Approach

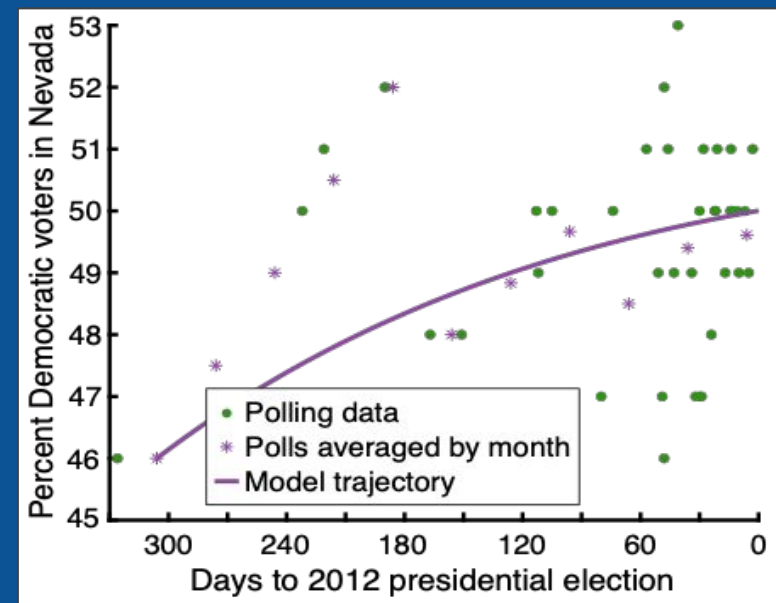
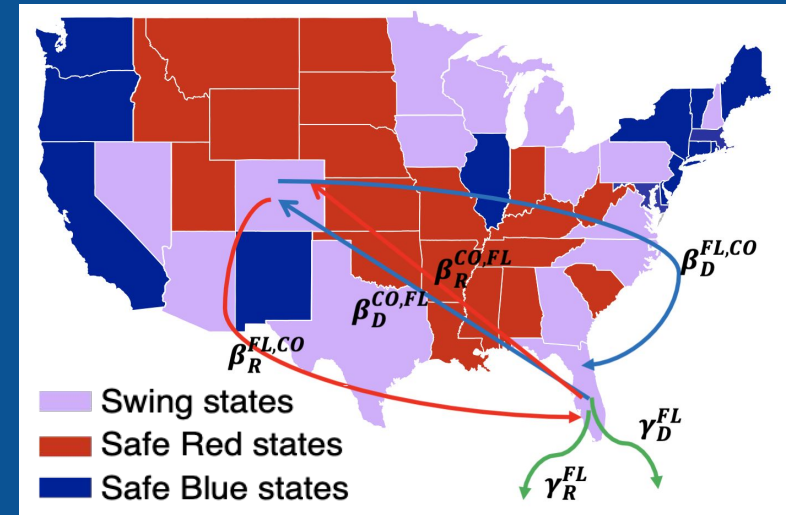
- We adapted a Susceptible-Infected-Susceptible (SIS) disease model to represent opinion dynamics
- “Infected” individuals are Democratic and Republican voters; undecided voters are “susceptible”
- Infected voters can "recover" to undecided; undecided voters can "catch" an opinion



1. Model & Methods: Fitting Parameters

Before fitting parameters, we:

- Organize states into swing states and superstates
- Group polls by month



Public polling data from HuffPost Pollster. <https://elections.huffingtonpost.com/pollster>.

Images sources: U.S. image adapted from Brian Hsu

Volkering, Linder, Porter, Rempala. [2020]. Forecasting Elections Using Compartmental Models of Infection, SIAM Review, Vol. 62, No. 4:

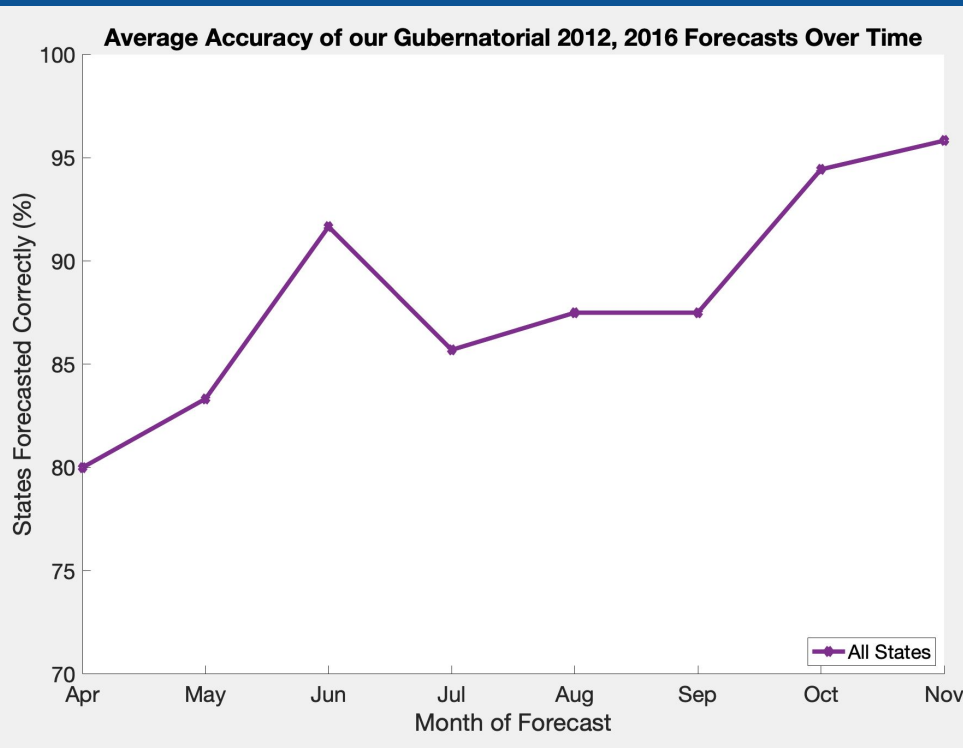
2. Historical Accuracy: Previous Elections

Methods for measuring accuracy:

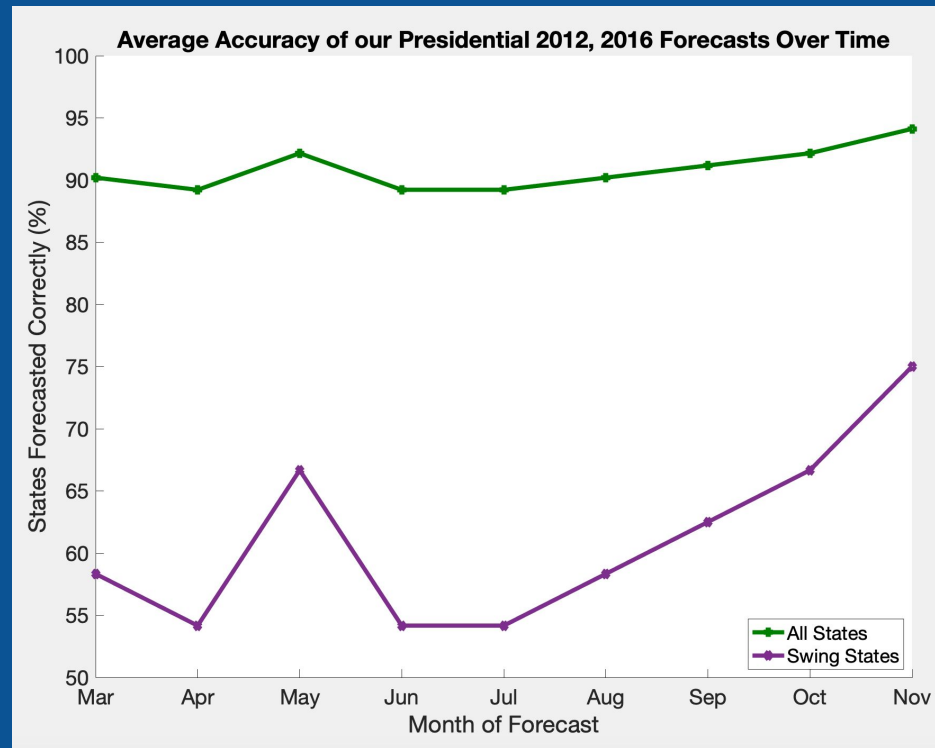
- 1. Forecast outcome accuracy**
- 2. Vote margin error**
- 3. Confidence and uncertainty**

2. Historical Accuracy: Forecast outcome accuracy

Governor

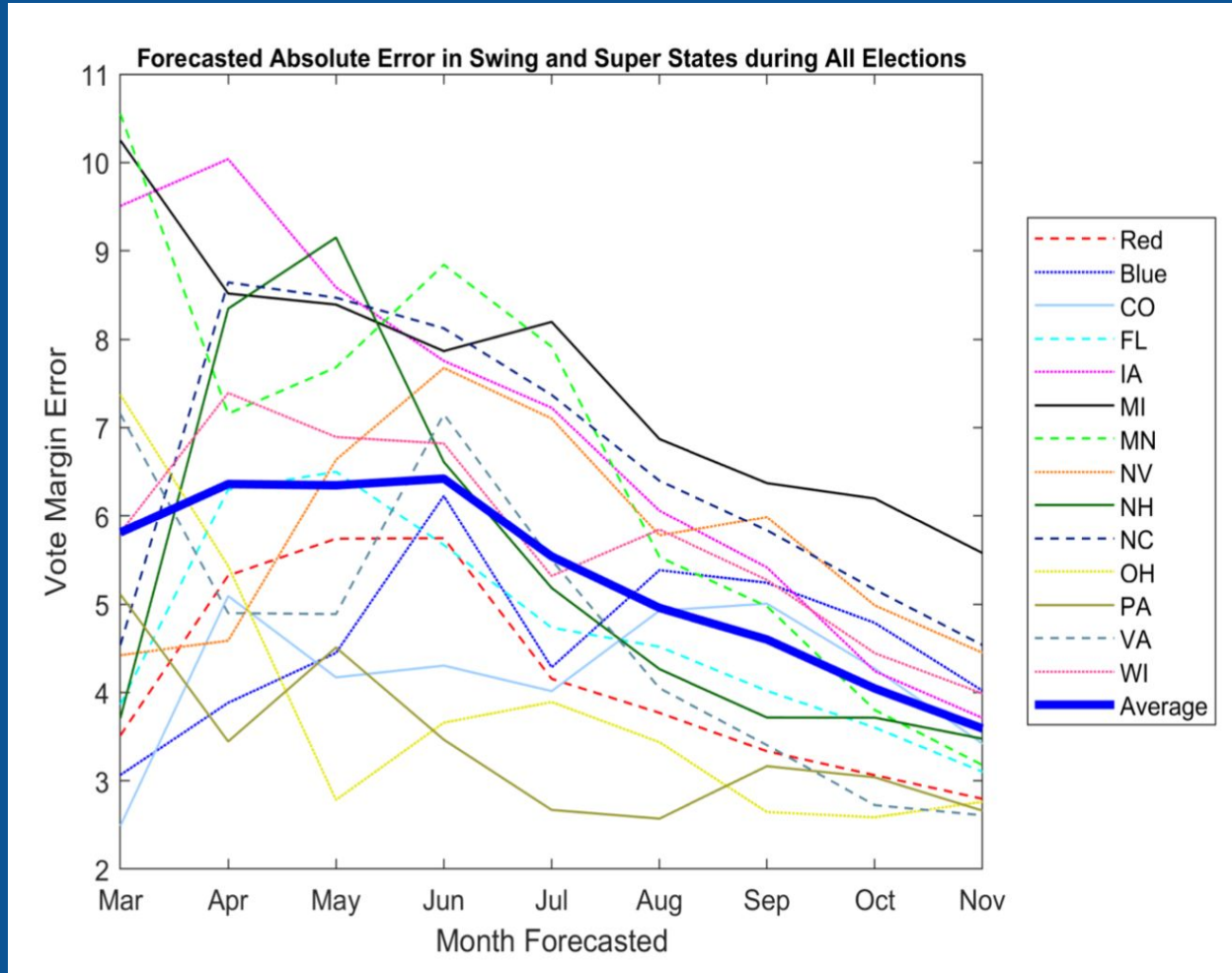


President



- Our prediction accuracy improves in time
- We predict >90% states correctly by October

2. Historical Accuracy: Vote Margin Error



- Vote margin is the candidate's margin of victory
- Our vote margin error decreases in time from 6 to 4 points

3. Our 2020 Forecast Website

2020 U.S. Election Forecasts with a Compartmental Model

[2020 President](#)[2020 Senate](#)[2020 Governor](#)[Learn More + References](#)[Contacts](#)

Overview

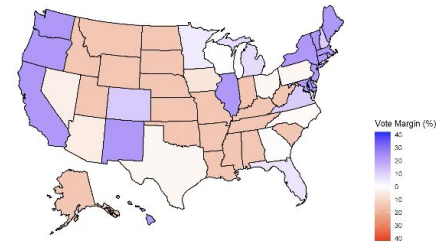
Welcome! This website holds our forecasts for the 2020 U.S. elections. Our work centers around compartmental modeling and uses the methods introduced by A. Volkening, Daniel F. Linder, Mason A. Porter, and Grzegorz A. Rempala in this [article](#). It is part of our undergraduate research mentored by Alexandria Volkening at [Northwestern University](#).

Our forecasts are probabilistic: we simulate 10,000 stochastic elections and calculate the mean vote margins across our simulations. To visualize uncertainty, we show a random sample of 500 simulated elections in the video on the right.

To reproduce or build on our forecasts, **all of the model code is available here**.

– Samuel Chian, William He, and Christopher Lee

2020 Presidential Election Forecast



State groupings

For the presidential elections, we forecast the vote margin in swing states individually and group the other states into either safe red or safe blue "superstates", in which we forecast the mean vote margin. Click below to expand the breakdown of our swing states and superstates.

▼ State categorizations

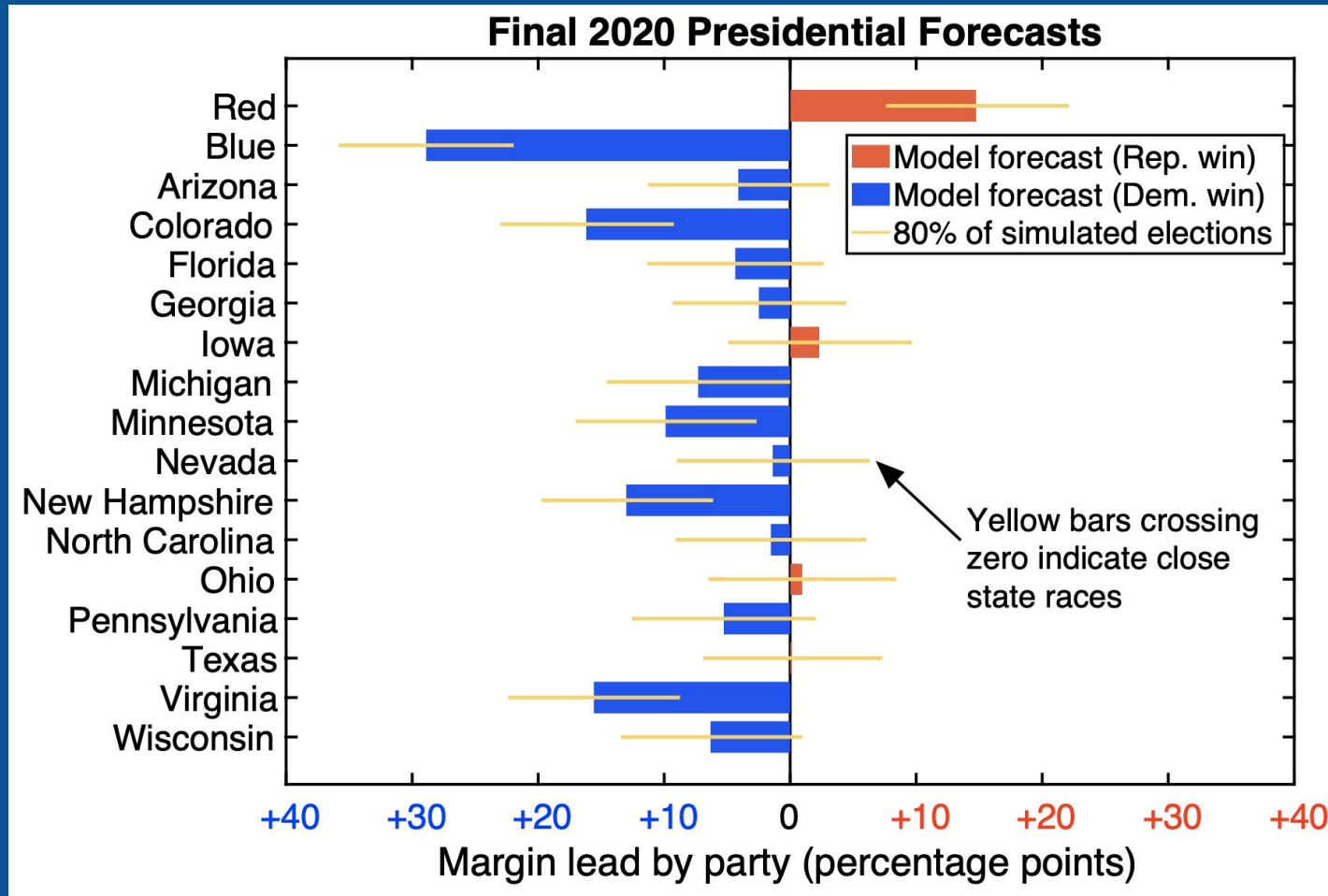
Final Forecast of the 2020 U.S. Presidential Election

According to our final forecast, Georgia, Iowa, Nevada, North Carolina, Ohio, and Texas have the closest races, with less than a 2.5 percentage-point margin of victory for the leading candidate. We give former Vice President Joe Biden an 88% chance of winning. Our model forecasts a

See our 2020 forecasts and our code at:
<https://modelingelectiondynamics.gitlab.io/2020-forecasts>

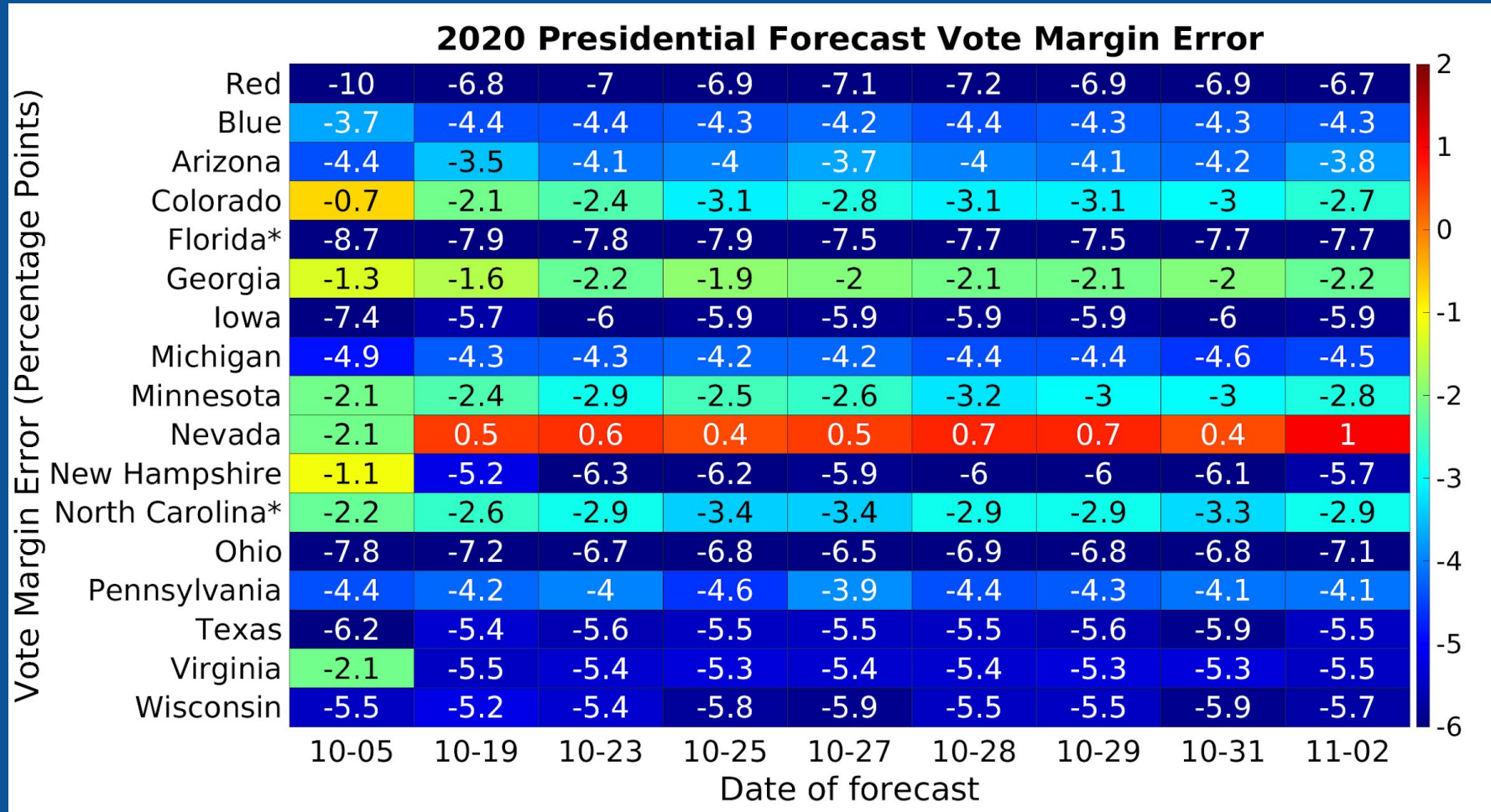
3. Forecasts of 2020 Elections

Our Forecast Chance of Winning: 88% Biden, 11% Trump



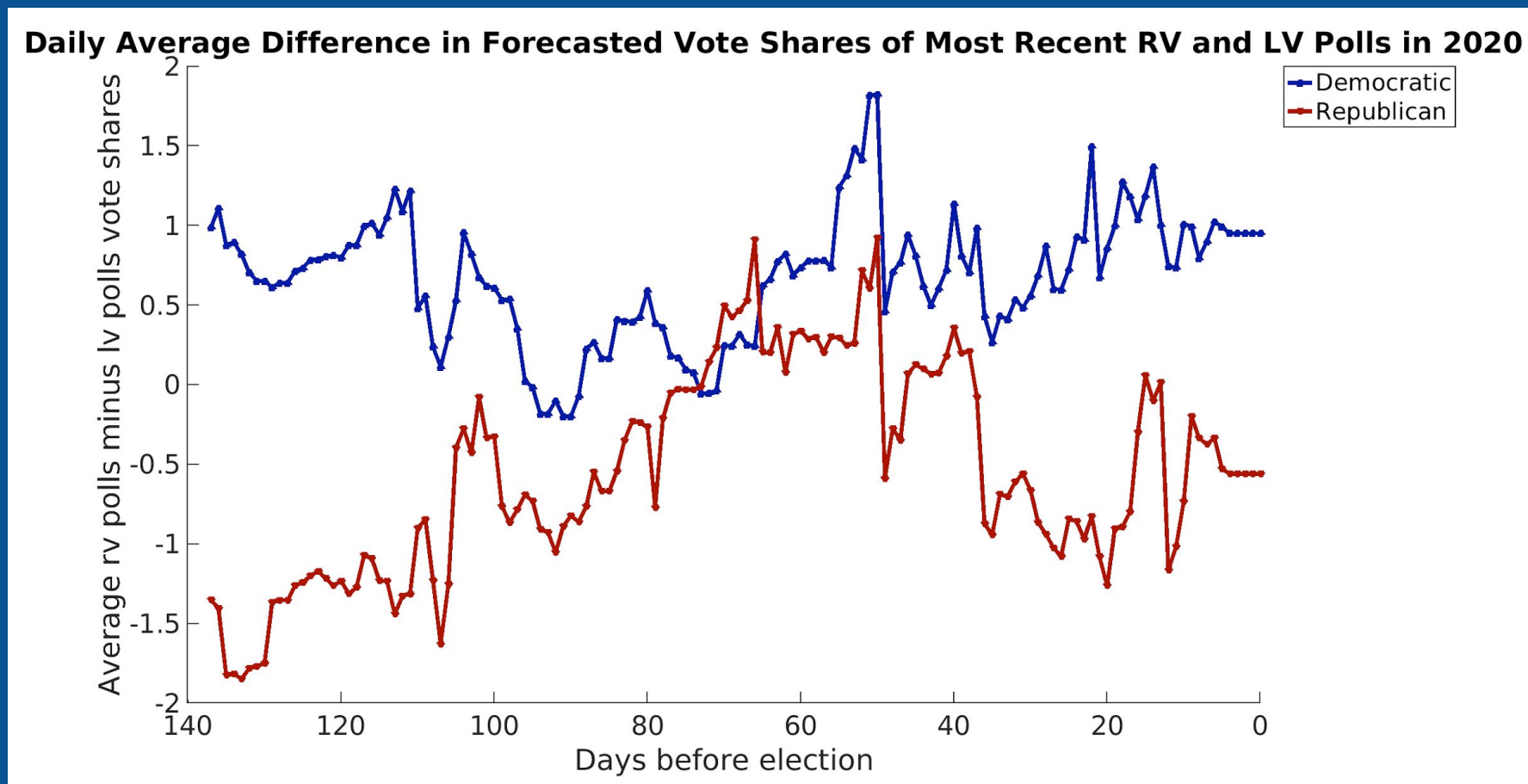
- Our predictions were incorrect in FL and NC (same as 538)

3. Evaluating our 2020 Forecasts



- Our vote margins tended to be overly Democratic

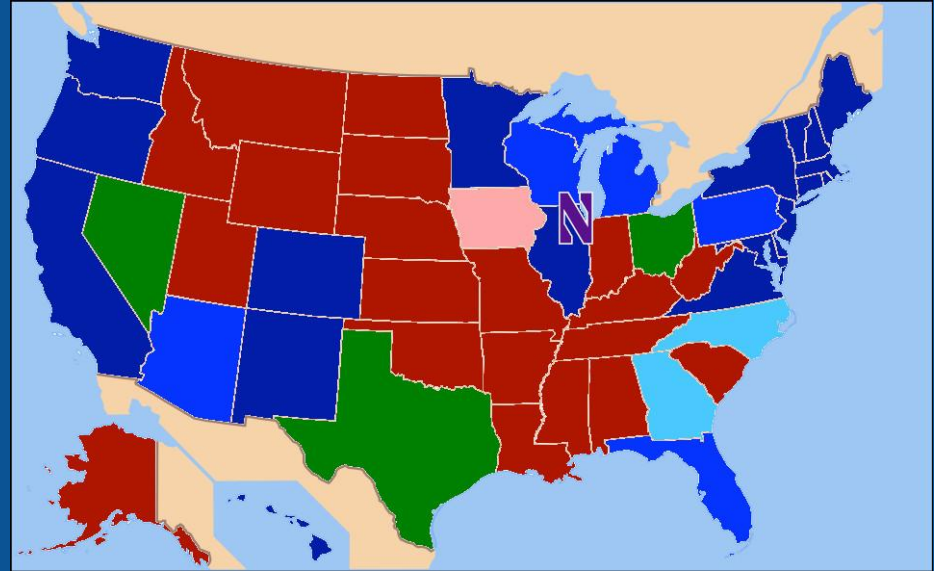
4. Future: Accounting for Types of Polls



- Polls can be of all adults, registered voters, or likely voters
- Adjusting the polls based on type may improve our forecasts

Key Takeaways

- The model performs well across elections from 2004 to 2020.
- Our accuracy improves closer to each election.
- Future work includes modifying how we handle uncertainty and adjusting based on the quality of polling data.



Collaborators: Samuel Chian, Christopher Lee
Support from: NU Office of Undergraduate Research

Our code and 2020 forecast:

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