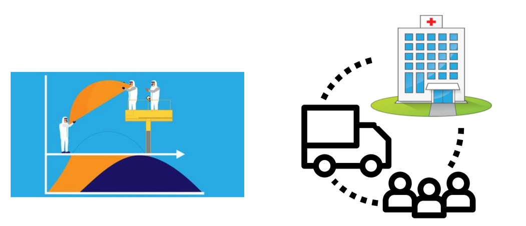
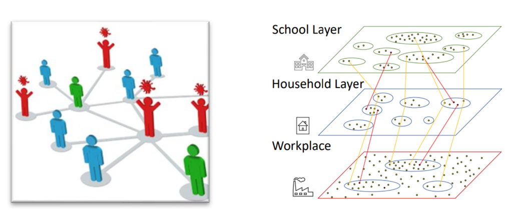
AI Frameworks for Data-centric Epidemic Forecasting

Alexander Rodríguez; Advisor: B. Aditya Prakash
College of Computing, Georgia Institute of Technology, USA
Email: arodriguezc@gatech.edu Web: cc.gatech.edu/~acastillo41/

INTRODUCTION

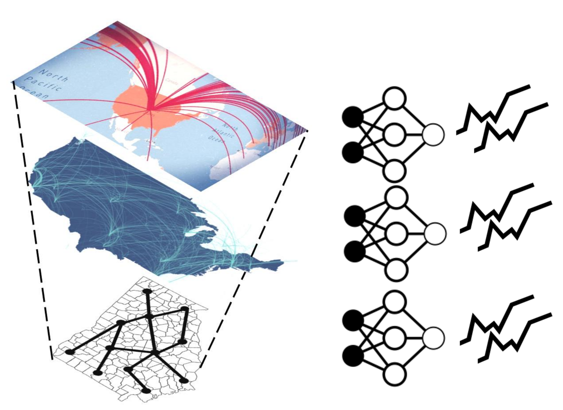


Forecasting Infectious Diseases:
- Allows communities to allocate resources/budget, inform public policy, improve preparedness.



- Traditional methods are based on ordinary differential equations and agent-based models. Calibration is non-trivial.

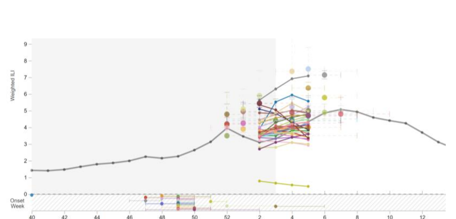
- Data collection has increased, but traditional methods have difficulties ingesting these data sources.



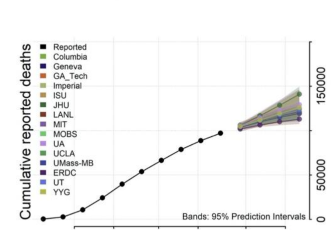
Why computational data-driven models?
- Epidemic spread is a spatiotemporal phenomena over multi-scale networks.
- New end-to-end methods available capable of modeling data with minimal assumptions.

Our response to the COVID-19 pandemic:
- Explored performance and utility of purely data-driven models in short-term forecasting in CDC initiatives real-time forecasting

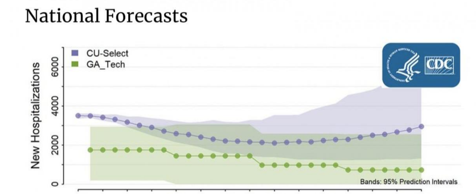
Target 1: Influenza like illness per week



Target 2: Weekly Covid Mortality



Target 3: Daily Covid Hospitalizations



IMPACT & OUTREACH

Top-5 in CDC Forecast Hub

Only individual Deep Learning model in top-5 accuracy in the CDC-led evaluation for 1+ year

Workshops and Tutorials

Tutorial at KDD 2022 & Workshop for West-African Countries

1st place

Out of 115 global participants

2nd place

Out of 777 participants

CHALLENGES

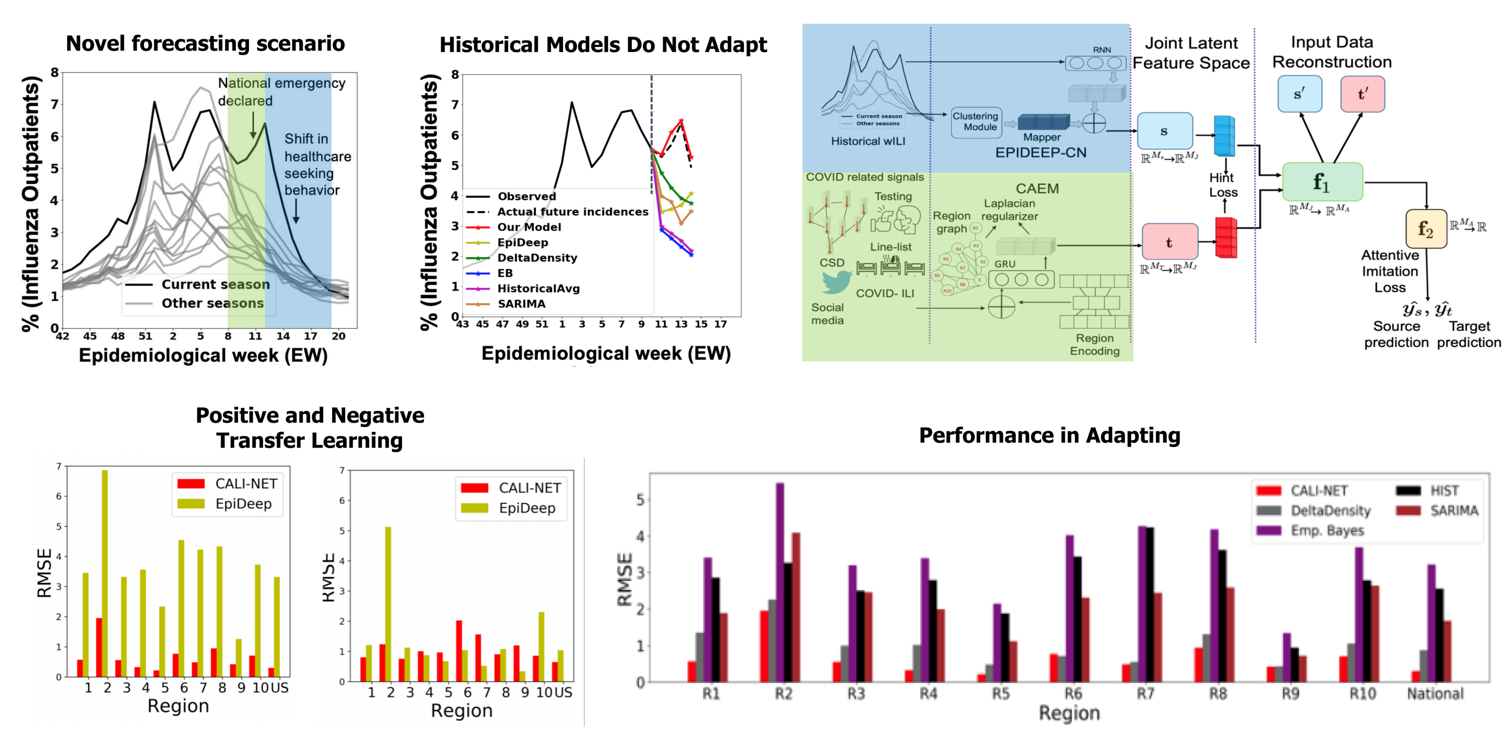
During our real-time forecasting experience, we have identified multiple challenges, which we study in our work:

Aspect	DISEASE SPREAD	DATA	UTILIZATION
Challenges	Spatial Transmission	Sparse data	Interpretability
	Mobility	Data revisions	Uncertainty quantification
	Mask adoption; Social distancing	Anomalies	Actionable forecasts

DEEP LEARNING FRAMEWORKS

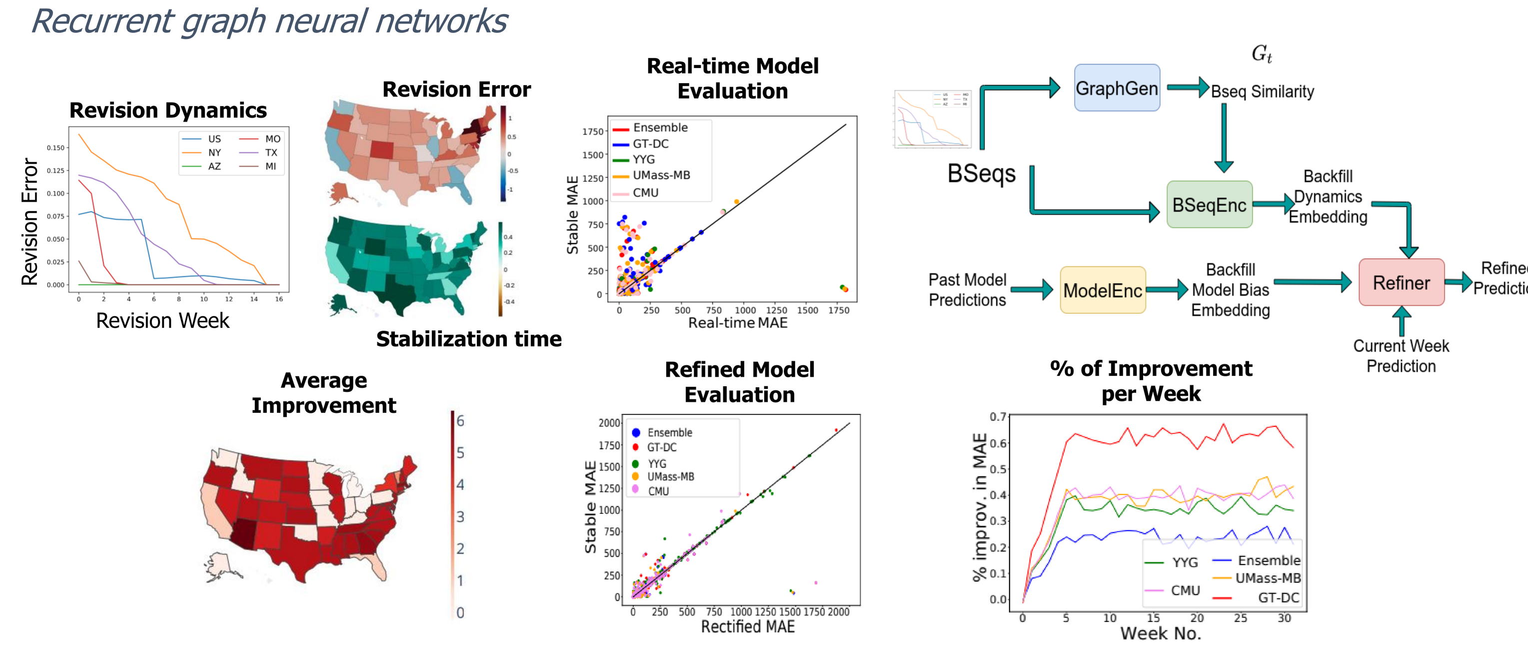
[1] Steering a historical influenza model for the COVID pandemic

Spatio-temporal modeling + heterogenous domain transfer learning



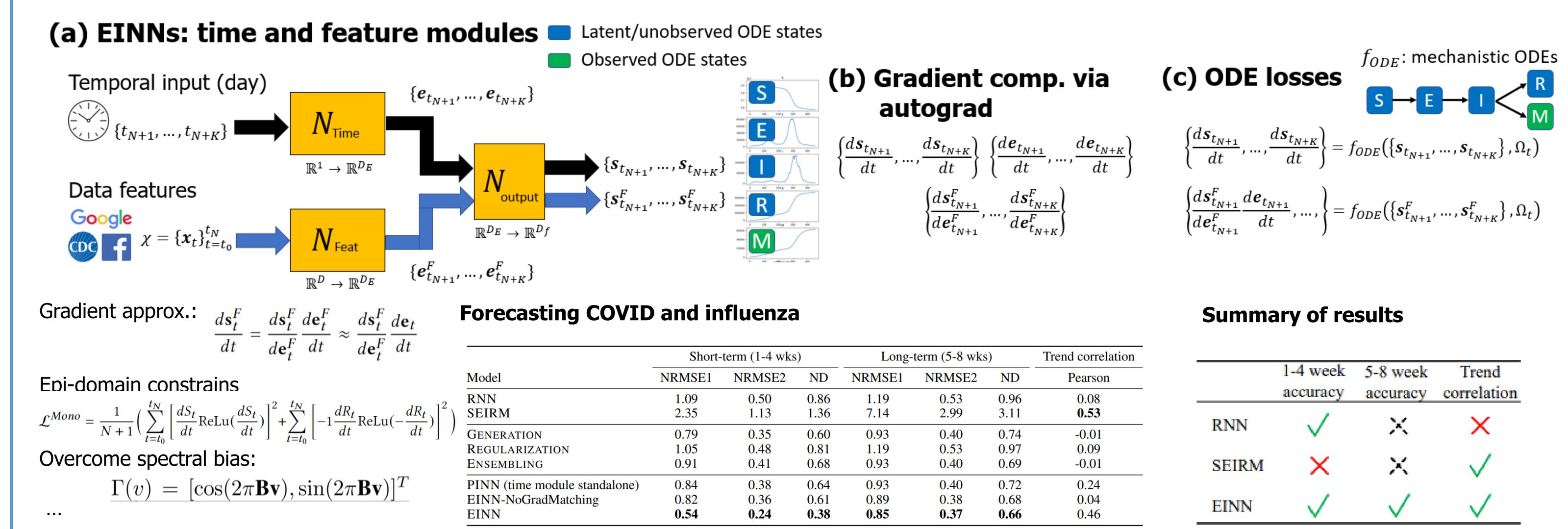
[2] Leveraging data revision dynamics to refine forecasts

Recurrent graph neural networks



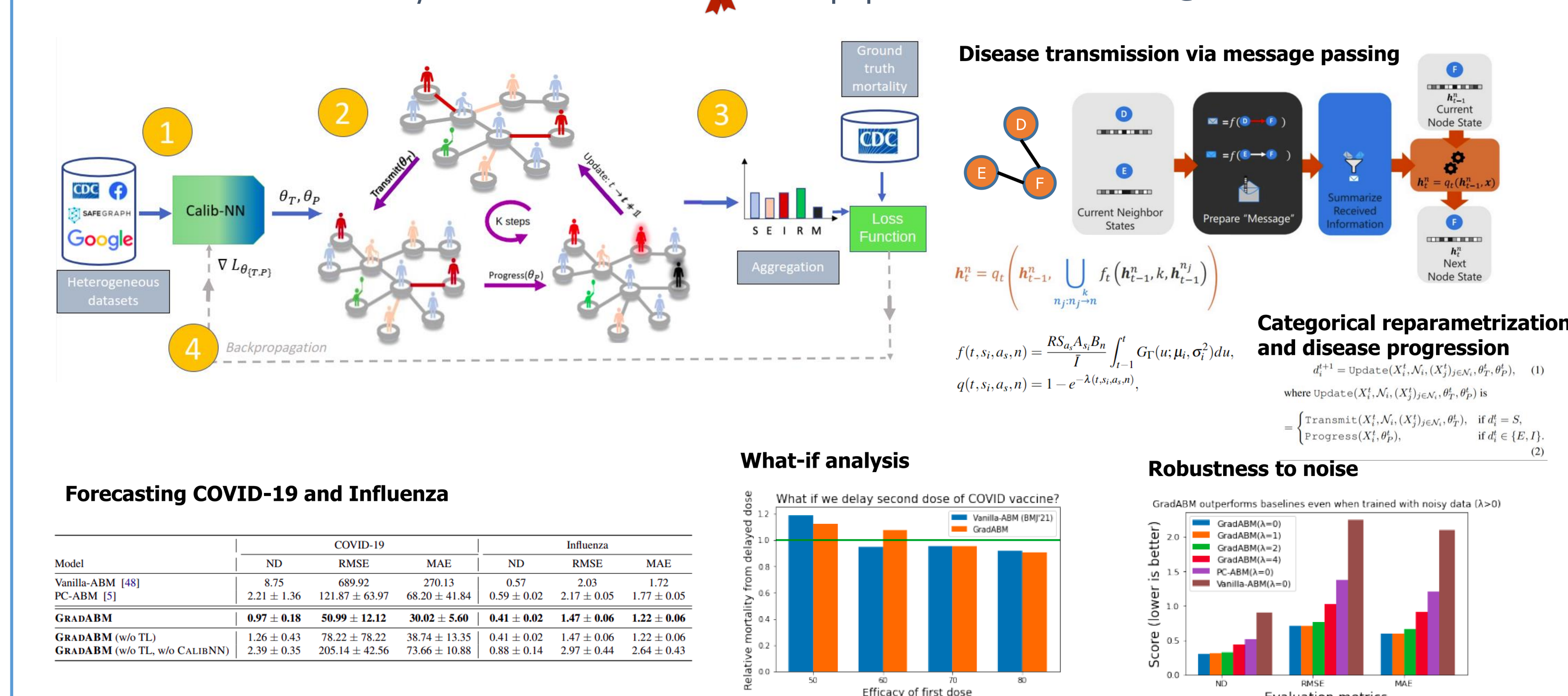
[3] Epidemiologically-informed neural networks

Physics-informed neural networks + sequential networks



[4] Differentiable Agent-based Epi Modeling for End-to-end Learning

Differentiable ABM+ deep neural networks Best paper award at AI4ABM@ICML



CONCLUSIONS

We have showed different facets of the utility of data-driven and theory-informed neural models in epidemic forecasting, even in emerging pandemics. Our methods have enabled applications and moved forward the state-of-the-art performance in epidemic forecasting.

REFERENCES

- Alexander Rodríguez, Nikhil Muralidhar, Bijaya Adhikari, Anika Tabassum, Naren Ramakrishnan, B. Aditya Prakash. Steering a Historical Disease Forecasting Model Under a Pandemic: Case of Flu and COVID-19. In AAAI-21.
- Alexander Rodríguez, Anika Tabassum, Jiaming Cui, Jiajia Xie, Javen Ho, Pulak Agarwal, Bijaya Adhikari, B. Aditya Prakash. DeepCOVID: An Operational DL-driven Framework for Explainable Real-time COVID-19 Forecasting. In IAAI-21.
- Alexander Rodríguez et al., Data-Centric Epidemic Forecasting: A Survey (under review)
- Alexander Rodríguez et al. Differentiable Agent-based Epidemiology (under review)
- Harshavardhan Kamarthi, Lingkai Kong, Alexander Rodríguez, Chao Zhang, B Aditya Prakash. When in Doubt: Neural Non-Parametric Uncertainty Quantification for Epidemic Forecasting. In NeurIPS 2021.
- Alexander Rodríguez, Bijaya Adhikari, Naren Ramakrishnan, and B. Aditya Prakash. "Incorporating Expert Guidance in Epidemic Forecasting." In epiDAMIK @ KDD 2020.
- Harshavardhan Kamarthi, Alexander Rodríguez, B. Aditya Prakash. Back2Future: Leveraging Backfill Dynamics for Improving Real-time Predictions in Future. In submission.
- Estee Cramer, et al. Evaluation of individual and ensemble probabilistic forecasts of COVID-19 mortality in the US. In submission.

GRANT ACKNOLEDGEMENTS