Argonne NATIONAL LABORATORY

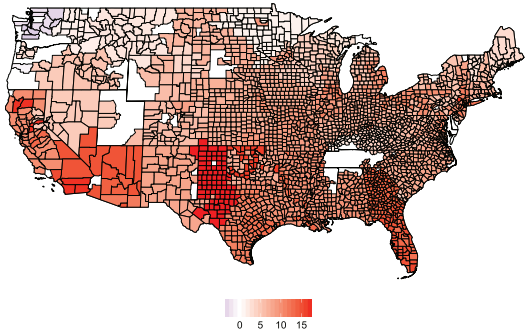
META-MODELING STRATEGY FOR DATA-DRIVEN FORECASTING

DOMINIC SKINNER
Department of Mathematics
Massachusetts Institute of Technology
NSF-MSGI Fellow at Argonne

ROMIT MAULIK
Margaret Butler Postdoctoral Fellow
Argonne Leadership Computing Facility
Argonne National Laboratory

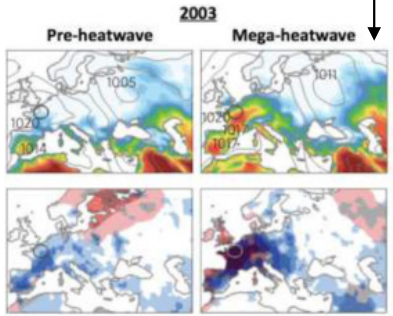
U.S. DEPARTMENT OF ENERGY
Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.

WEATHER FORECASTING AND CLIMATE CHANGE



Increase in peak power demand, *Auffhammer et al.* (2016)

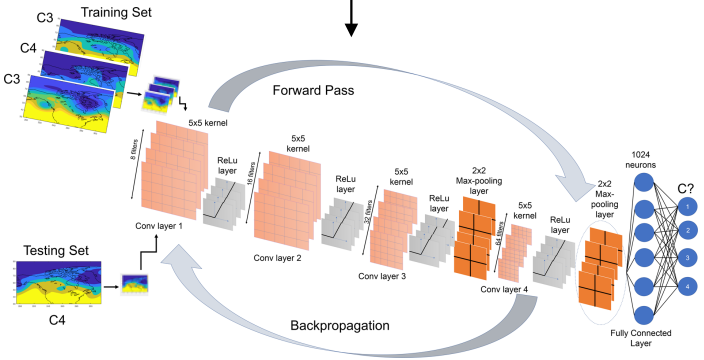
Climate mitigation requires forecasting



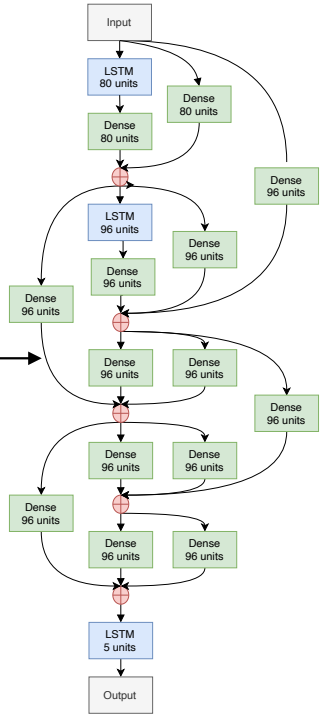
Extreme event forecasting, *Sillmann et al.* (2017)

…but weather is becoming less predictable, *Scher and Messori* (2019)

ML can provide data-driven forecasts, but can be expensive to train/deploy



Convolutional neural networks *Chattopadhyay et al.* (2020)

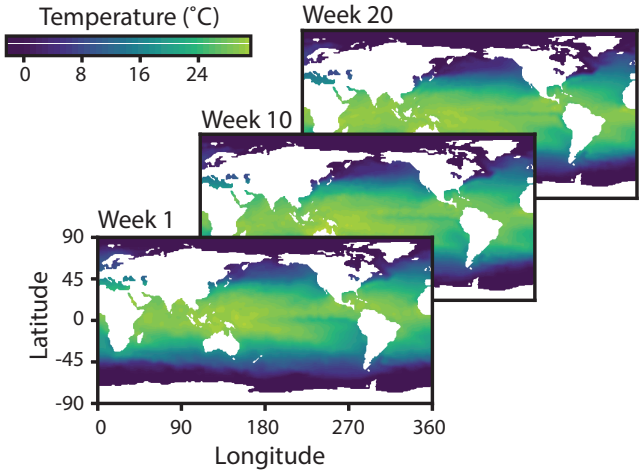


Automated architecture, *Maulik et al. (2020)*

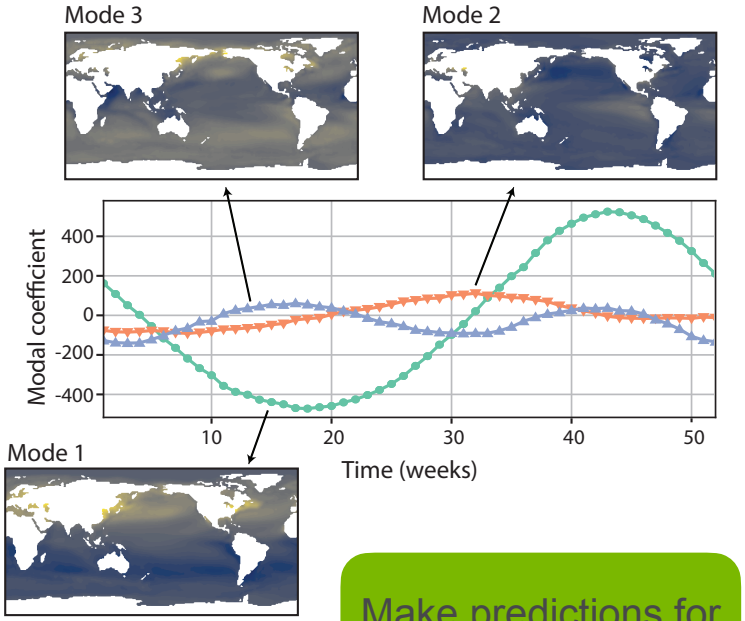
Argonne NATIONAL LABORATORY

NOAA SEA SURFACE TEMPERATURE

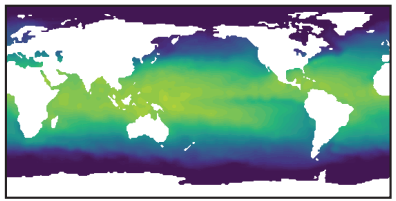
Sea surface temperature measured weekly across 20 years



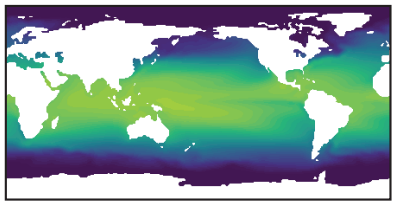
Proper orthogonal decomposition



Measured temperature field



6 mode POD reconstruction



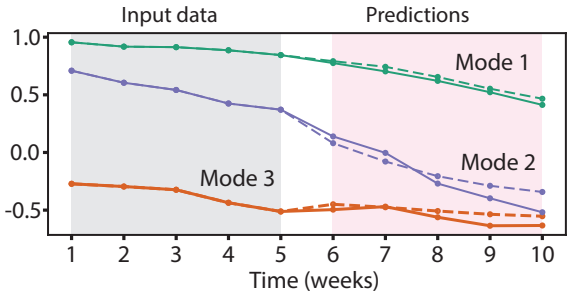
Make predictions for modal coefficients, then reconstruct to compare against data

HIGH AND LOW FIDELITY FORECASTS

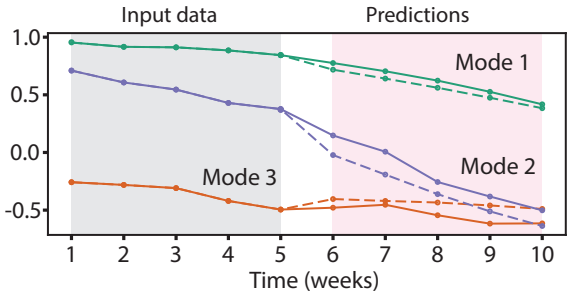
Prototypical high-fidelity model

Prototypical low-fidelity models

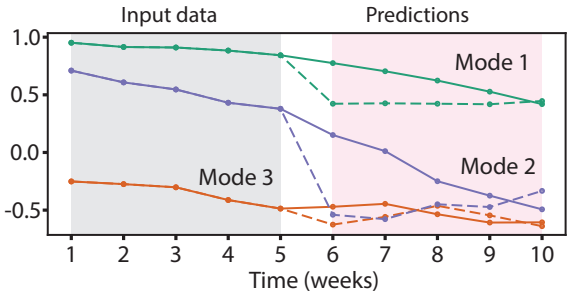
Bi-directional LSTM

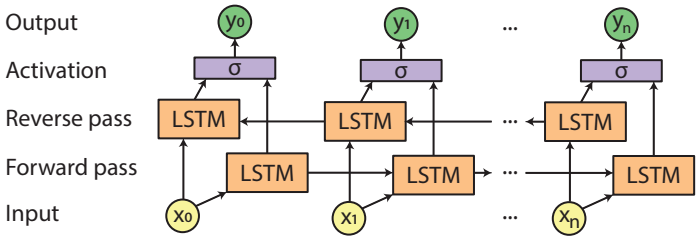


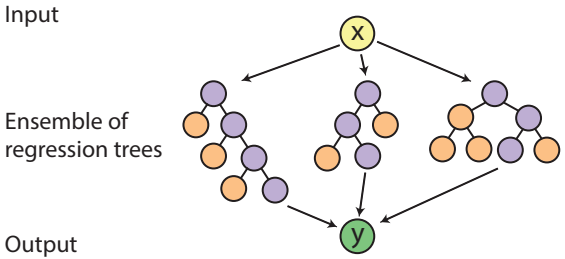
Random forest

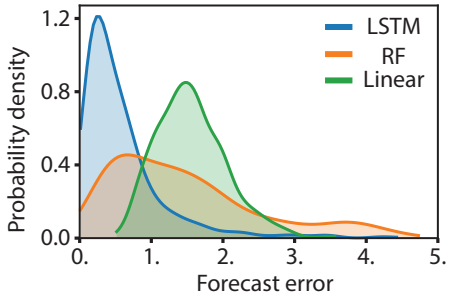


Linear regressor





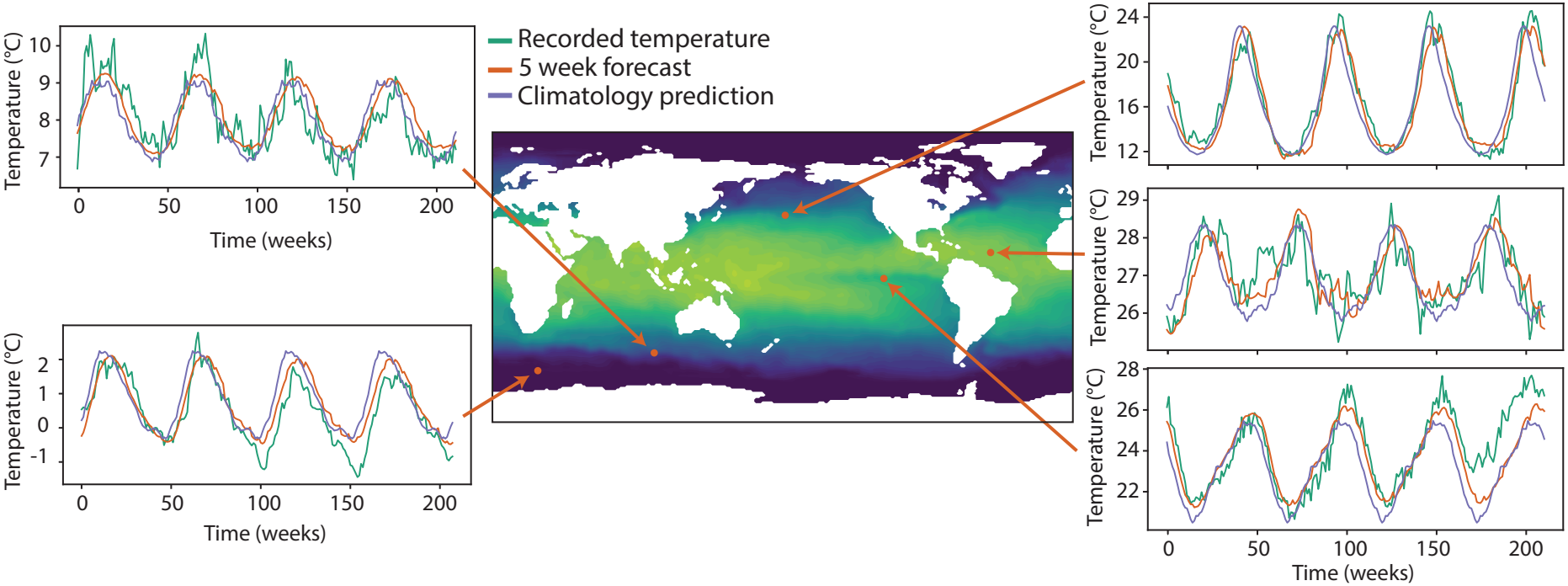




High fidelity performs best on test data

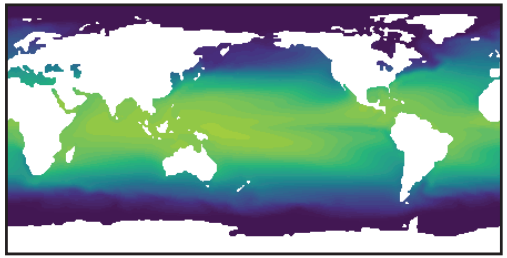
FORECASTING

Method outperforms climatology baseline: The average temperature for that time of year in that location



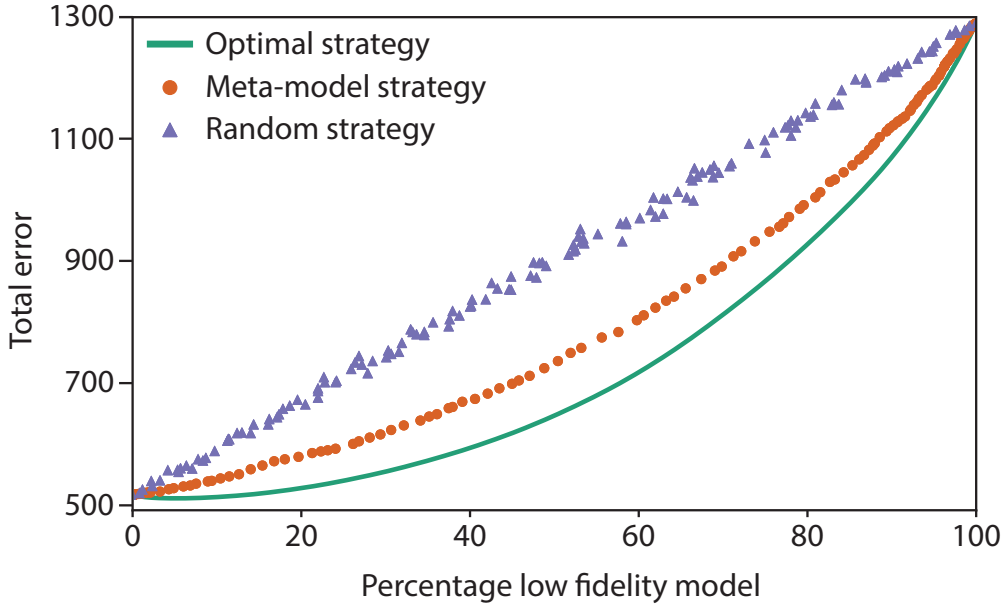
META-MODELING STRATEGY

High fidelity function evaluations are expensive. How can we avoid them, without compromising accuracy?



Algorithm for model selection:

- Take input data and perform low-fidelity forecasts
- Calculate difference between forecasts
- If this exceeds threshold evaluate high-fidelity forecast
- Else use low fidelity forecast



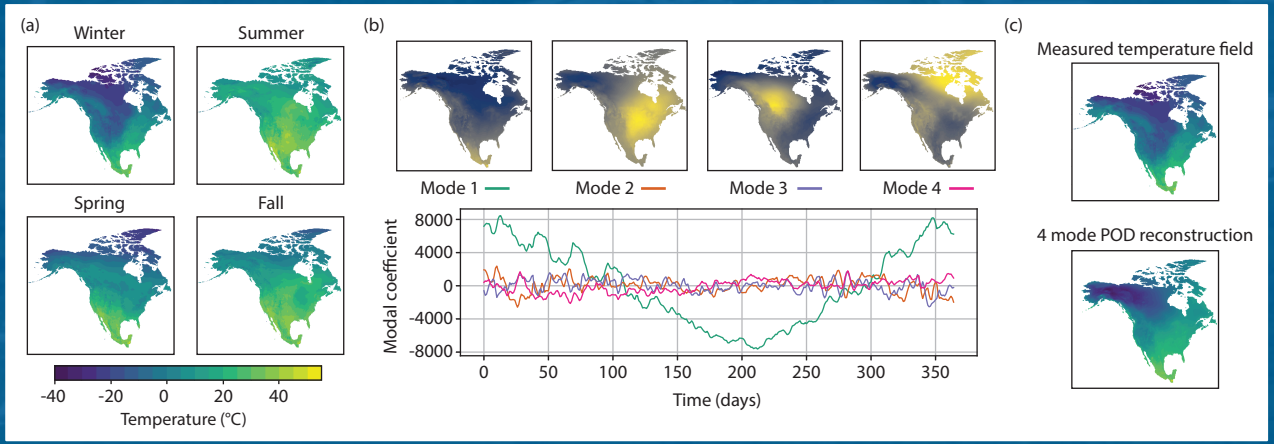
Random strategy chooses to evaluate high or low fidelity models at random

Argonne NATIONAL LABORATORY

SUMMARY:

- Climate mitigation requires accurate weather predictions machine learning methods can play an important role.
- A combination of low and high-fidelity models can make accurate predictions fast and make results interpretable

Also applied to DayMet dataset



For more details see workshop manuscript