Predicting
Atlantic Multidecadal Variability

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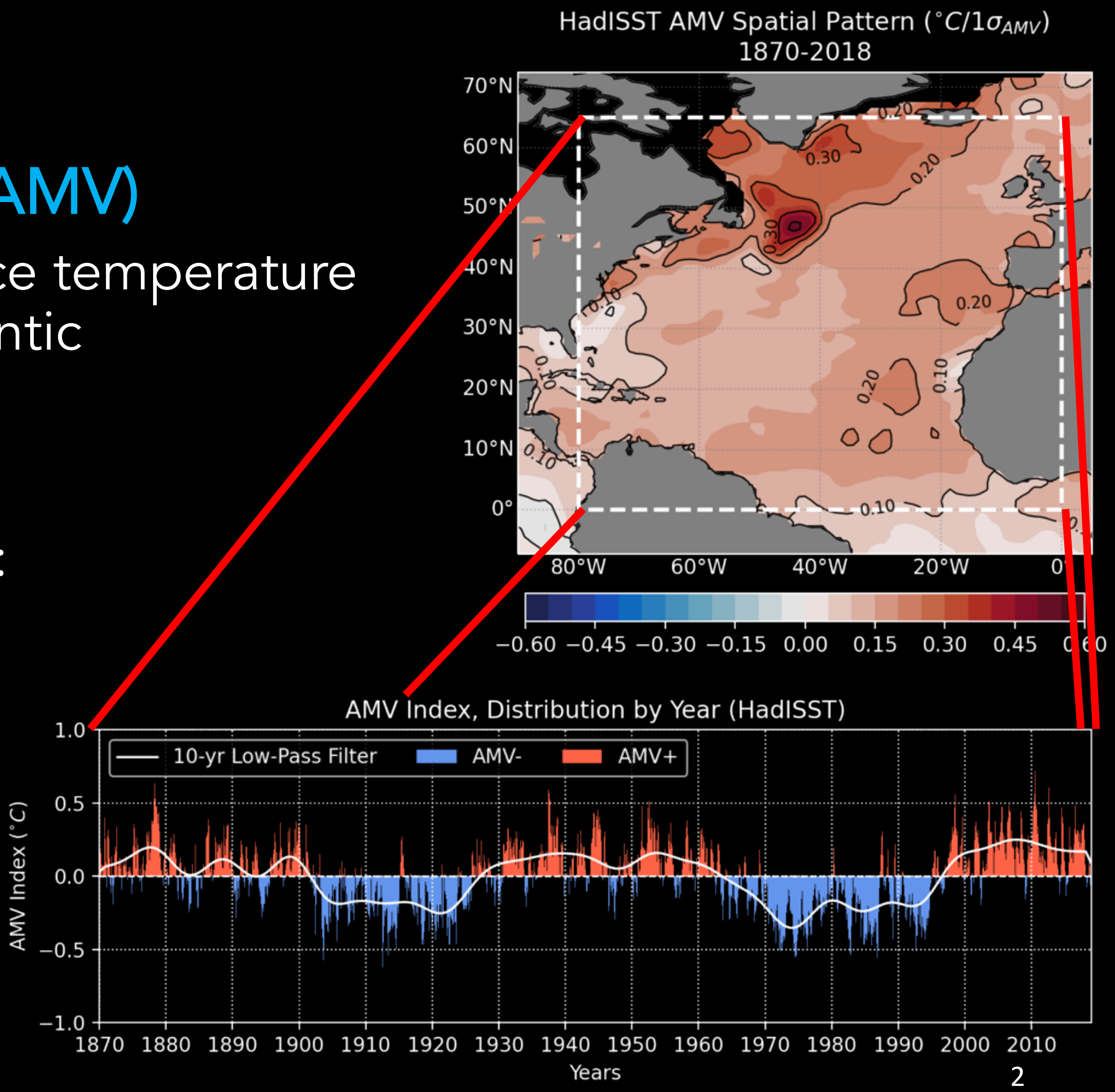
Atlantic Multidecadal Variability (AMV) and Climate Change

- Atlantic Multidecadal Variability (AMV)
  - ~60-70 year fluctuation in sea surface temperature (SST) anomalies over the North Atlantic
- Relevance to Climate Change
  - AMV has been linked to variation in:
    - Atlantic hurricane activity
    - Extreme weather events
    - Fisheries/ Ecosystem Regime Shifts
  - Quantify natural climate variability and response to anthropogenic warming/change



Problem and Background

- The Question: Can we predict the AMV state ahead of time (0-year to 24-year lead time)?

- Previous Work and Challenges

Existing Physical Prediction Models:
- Computationally Intensive
- Sensitive to Initial Conditions

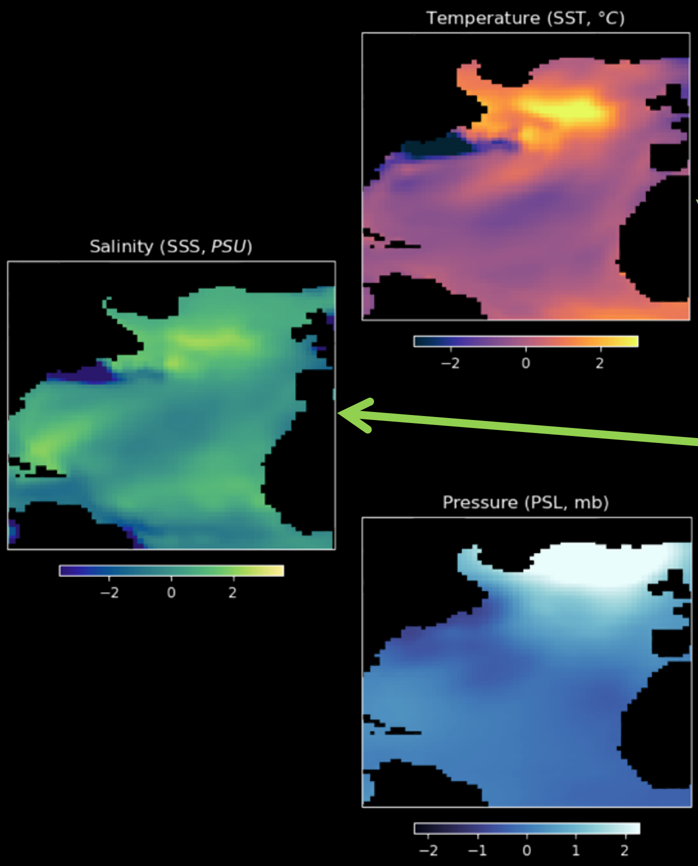
→ Use Machine Learning to predict the AMV state

Insufficient Data in Observations
1870-2021 (~150 years)

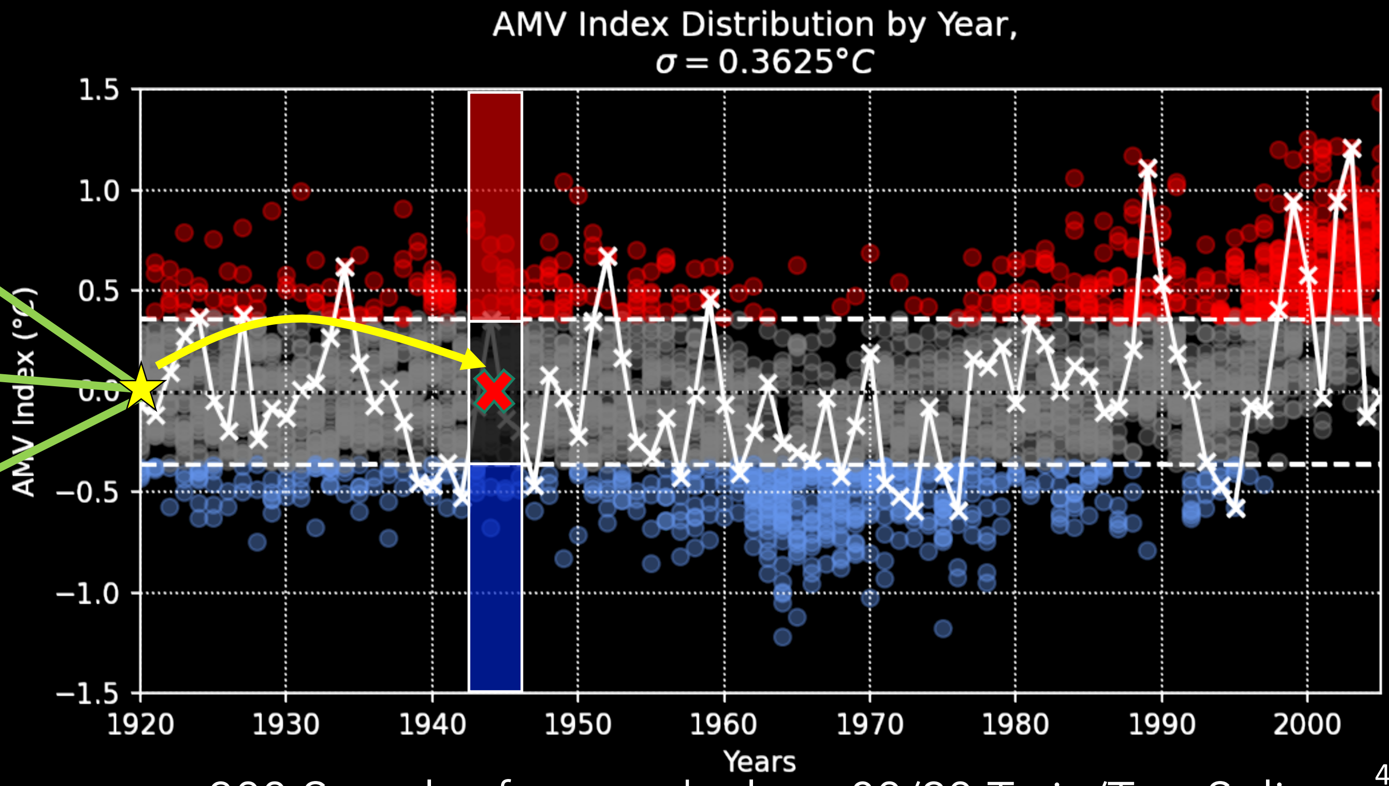
→ Community Earth System Model 1.1
40-member Large Ensemble Simulations
40 x (1920-2005) = 3,440 Years

Prediction Objective

- Objective: Use snapshots of anomalous sea surface temperature, salinity, and atmospheric pressure, to predict AMV N-years ahead (N=0, 3, …, 24)



Success Metric: Accuracy of Predictions (by each class)



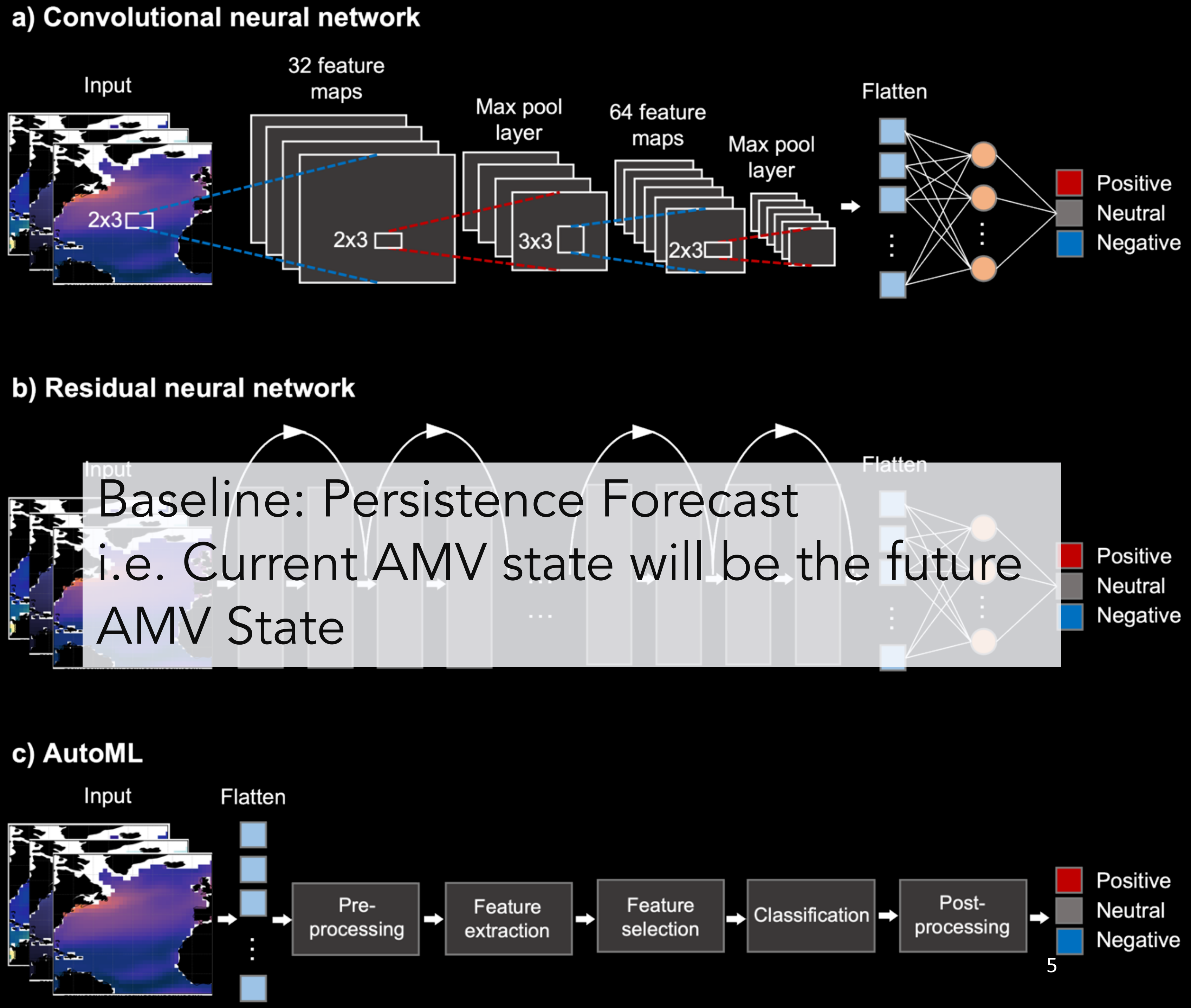
300 Samples from each class, 80/20 Train/Test Split

Network Architectures

Successful in
ENSO forecasting
(Ham et a. 2019)

Evaluate Transfer Learning
Performance for
Pretrained Networks
(Imagenet and FractalDB)

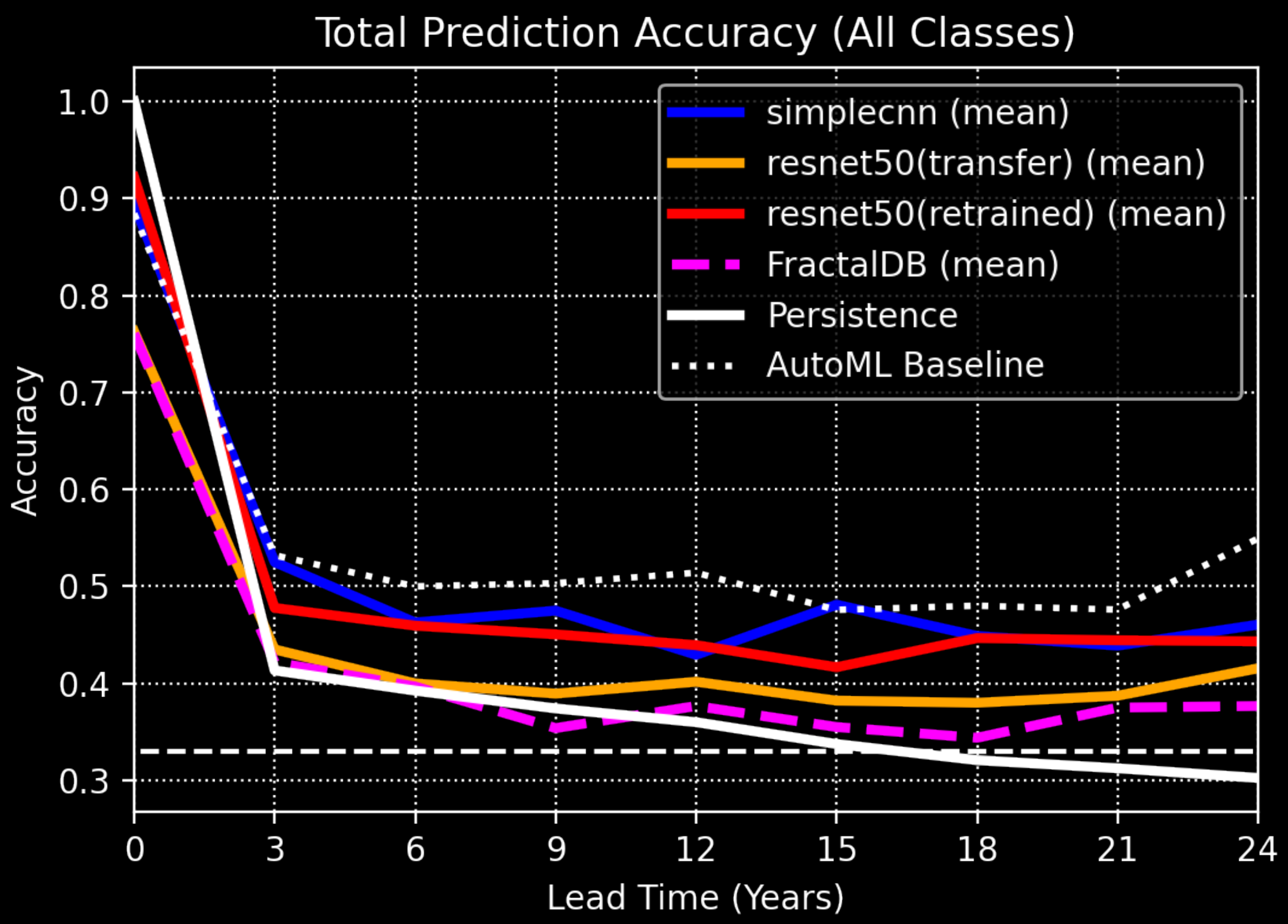
Examine other ML
architectures and
Test AutoML



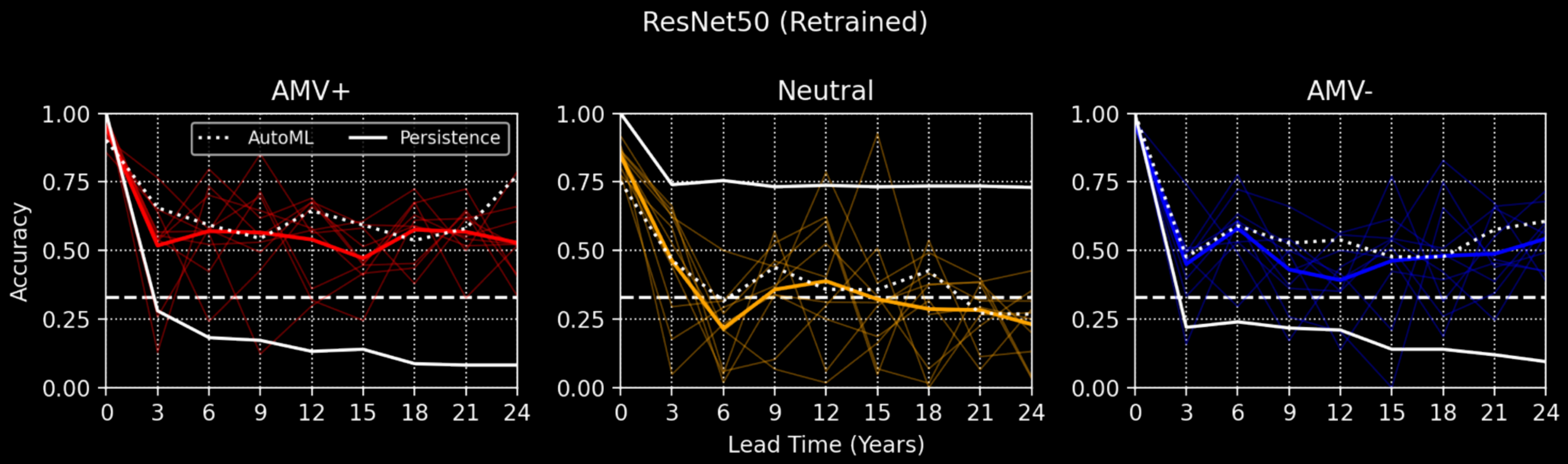
Baseline: Persistence Forecast
i.e. Current AMV state will be the future AMV State

Overall AMV Prediction

- All the machine learning based models outperform baseline persistence forecast at almost every lead time.
- AutoML has the best performance over simple CNN, resnet50 and FractalDB.



Prediction skills for different AMV states



- Machine learning based models are better at predicting the extreme states, which is of greater societal benefits.

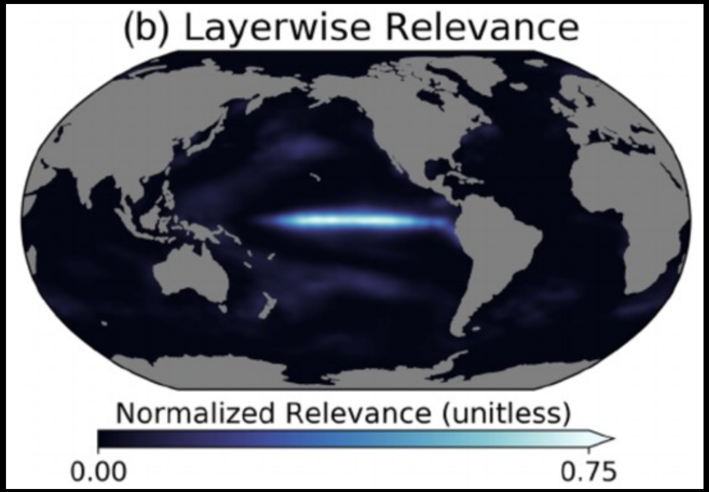
- AutoML still outperforms all the other machine learning models for predicting extreme AMV states.

Conclusions and future steps

- Predicting AMV, especially for extreme states, are of great societal benefits, and all the machine learning based models outperform baseline persistence forecast.

- AutoML, with minimal user-end tuning, has the best performance. This provides potential for stakeholders or local climate centers to use such method without many technical barriers.

- For the next steps, we will focus on the interpretability:
  - Which specific regions in North Atlantic contributes the most to the prediction of extreme AMV states?
  - Natural variability and anthropogenic climate change, which component contributes the most to the predictability?



From Toms et al. 2020