Predicting Atlantic Multidecadal Variability

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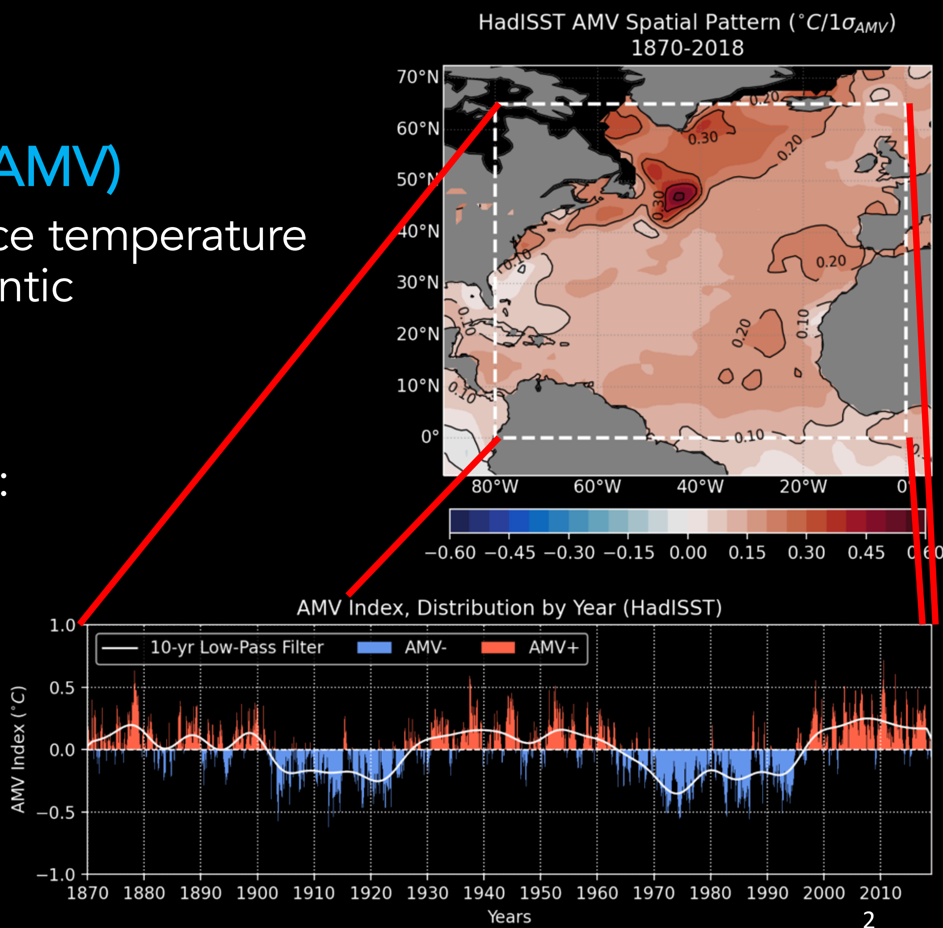
Atlantic Multidecadal Variability (AMV) and Climate Change

- **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

- 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

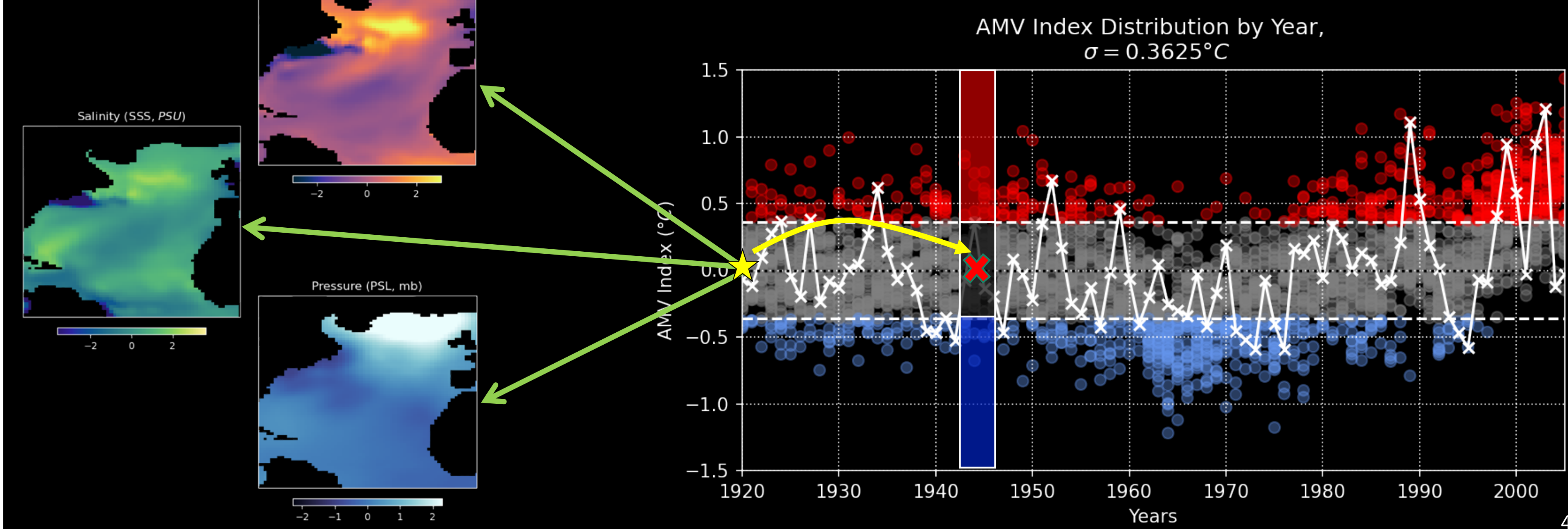
Insufficient Data in Observations
1870-2021 (~150 years)

→ Community Earth System Model 1.1
40-member Large Ensemble Simulations
40 x (1920-2015) = 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)

<u>Success Metric</u>: Accuracy of Predictions (by each class)

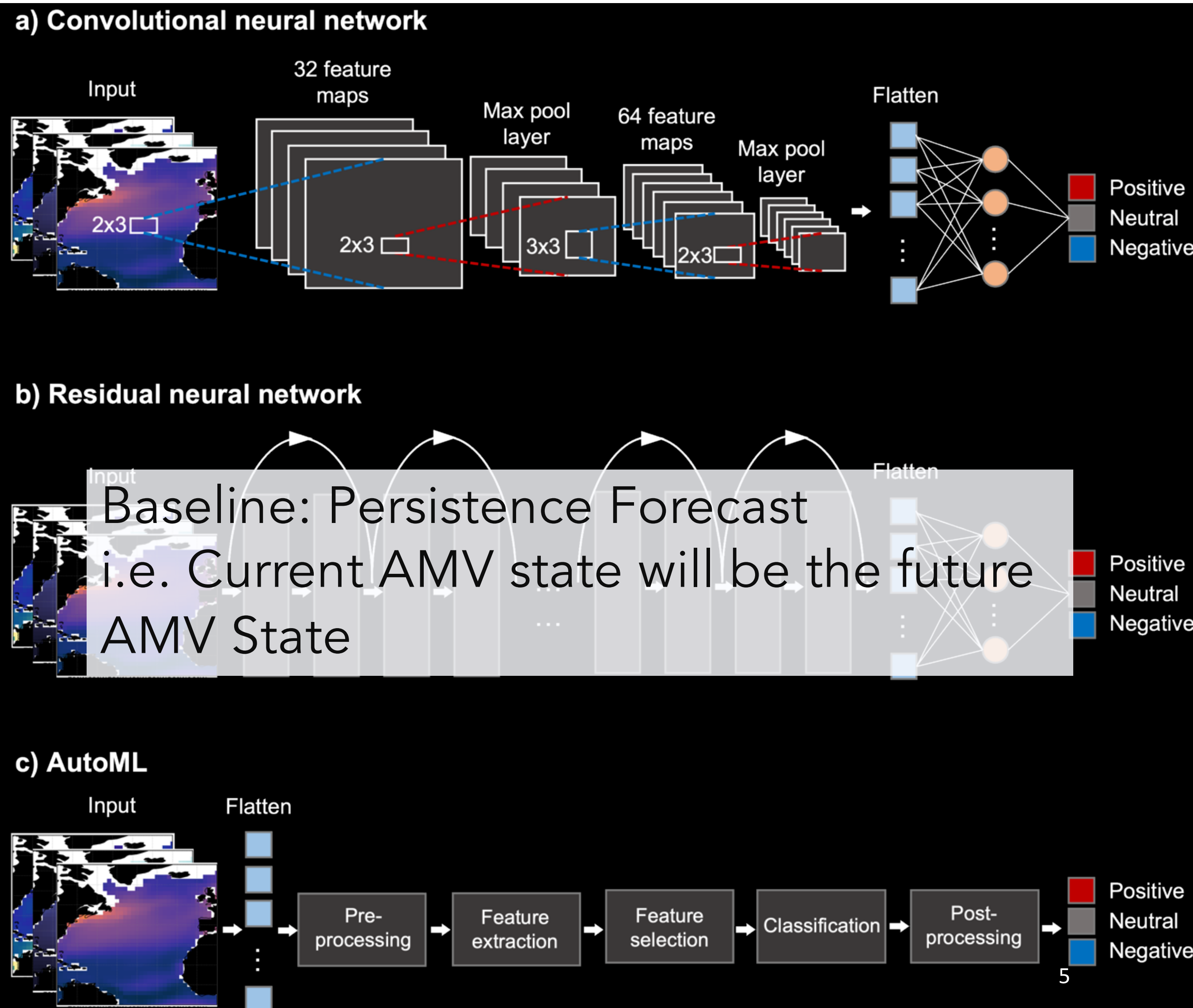


Network Architectures

Successful in ENSO forecasting (Ham et a. 2019)

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

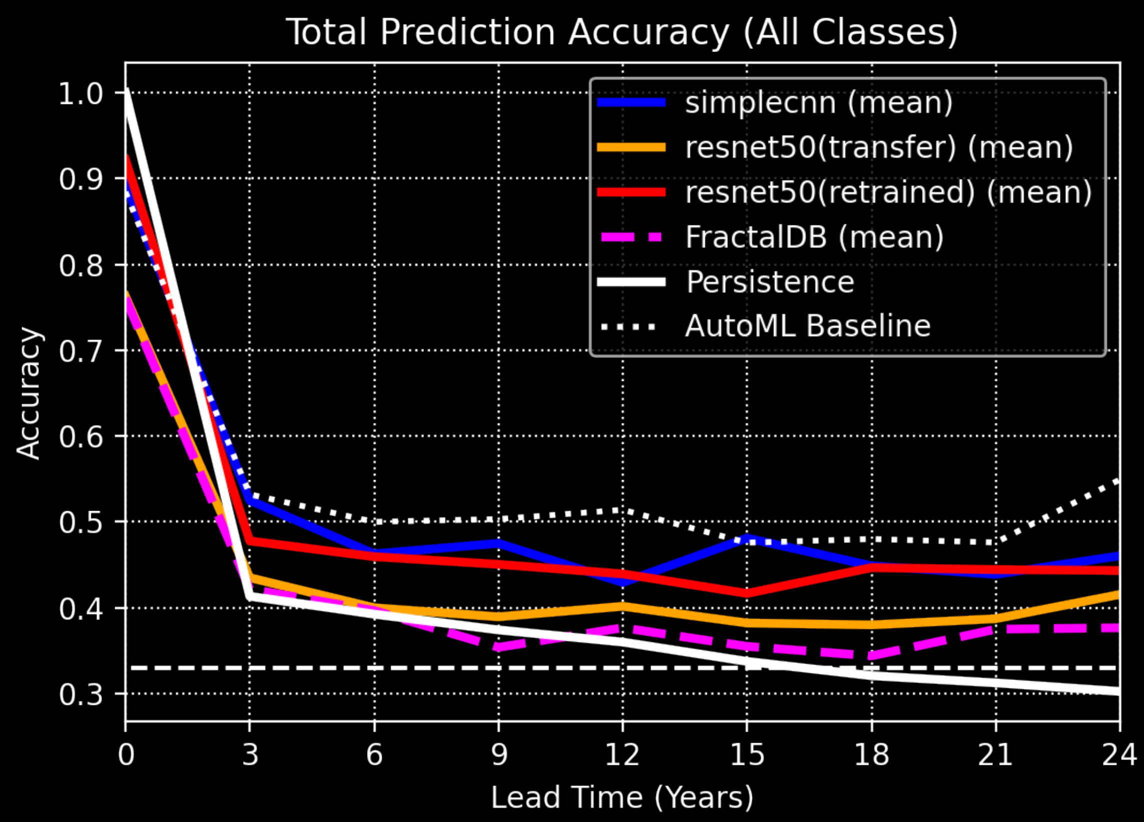
Examine other ML architectures and Test AutoML



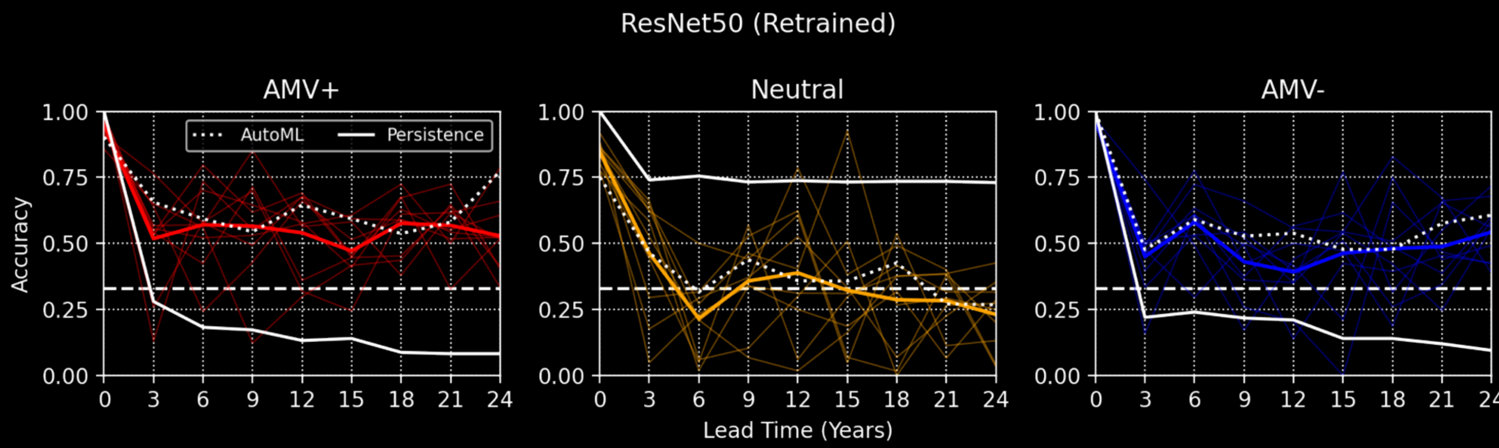
Baseline: Persistence Forecast
i.e. Current AMV state will be the future AMV State

Overall AMV Prediction

- All the machine learning based models outperform traditional 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 social 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 social benefits, and all the machine learning based models outperform traditional 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.

- Next steps: interpretability, diagnose physical mechanism using machine learning:
  - Which specific regions in North Atlantic contributes most to prediction of extreme AMV states?
  - Is AMV mainly driven by atmospheric or oceanic processes?