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

Previous Work and Challenges

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

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

Use Machine Learning to predict the AMV state

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 al. 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?