Identifying predictable sea surface temperature patterns by incorporating uncertainty into regression neural networks

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Predicting SST evolution
- Sea surface temperature (SST) predictability on decadal (2-10 year) timescales can arise from both external forcing and internal variability.
- Recent studies suggest that predictability on decadal timescales can be influenced by the initial state of the system i.e. some initial states are more predictable than others (e.g. Mariotti et. al 2020).
- Aim to identify oceanic patterns that are associated with more predictable SSTs in the North Pacific and North Atlantic oceans.
- Using output from the CESM2 pre-industrial control simulation for CMIP6 to examine predictability due to internal variability.

Using an artificial neural network (ANN) to predict SSTs with uncertainty
We train neural networks to predict SST anomaly 1-5 years in the future.

Key Points
- Artificial neural networks (ANNs) learn to predict SST evolution on decadal timescales
- ANNs learn more predictable oceanic states by assigning lower uncertainty to more predictable patterns
- More predictable initial states coincide with specific combinations of patterns of decadal variability (e.g. Atlantic Multi-Decadal Variability, AMV, and Interdecadal Pacific Oscillation, IPO)

Leveraging uncertainty predictions to identify predictable SST patterns
The neural network identifies more predictability by assigning lower uncertainty values to more predictable samples.

Prediction error (difference between predicted and true anomaly) decreases for predictions with lower uncertainty.

What predictions lead to lower predicted uncertainty?
Examine only the 20% most confident predictions of negative anomaly.
Look for commonalities between confident predictions
E.g. in the North Atlantic (53N, 35W) low uncertainty predictions (orange) are mostly positive

Predictable North Atlantic Variability
- Predict SST anomaly at 1-5 year lead time at a point in the North Atlantic Ocean (53N, 35W)
- Examine 20% most confident predictions of positive anomaly

Predictable North Pacific Variability
- Predict SST anomaly at 1-5 year lead time at a point in the North Pacific Ocean (43N, 175E)
- Examine 20% most confident predictions of negative anomaly

Predictable North Atlantic Variability
- Composite of OHC input for confident predictions shows anomalously positive heat in the subtropical North Atlantic Ocean
- Composite SST 1-5 years later shows heat transport into North Atlantic Sub-polar Gyre
- Anomalously northward heat transport leads to increased predictability in North Atlantic Sub-polar Gyre agrees with e.g. Borchert et. al 2018

What about modes of decadal-multidecadal variability?
Predictable initial states (i.e. 20% most confident predictions) are most likely to occur with the combination of
- Positive AMV
- Negative IPO

REFERENCES
- Mariotti et. al 2020, Windows of Opportunity for Skillful Forecasts Subseasonal to Seasonal and Beyond, BAMS

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