



Subseasonal Forecasts of Opportunity Identified by an Explainable Neural Network

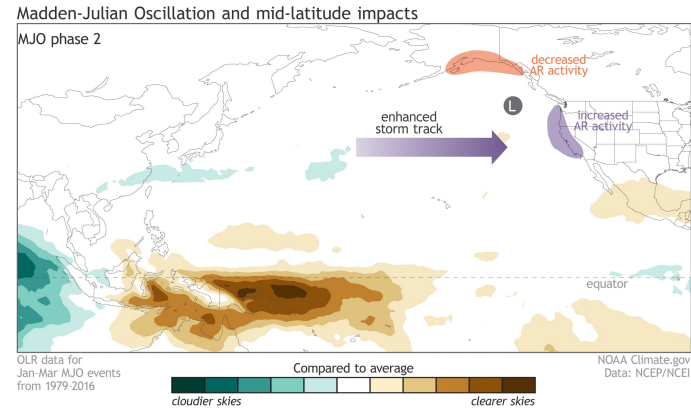
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Forecasts of Opportunity

Forecasts of Opportunity:
the idea that certain conditions lead to more predictable behavior than others

Beyond weather timescales we must look for specific states of the earth system (i.e. “opportunities”) that lead to enhanced predictable behavior

Forecasts of Opportunity Example: Madden-Julian Oscillation [MJO]



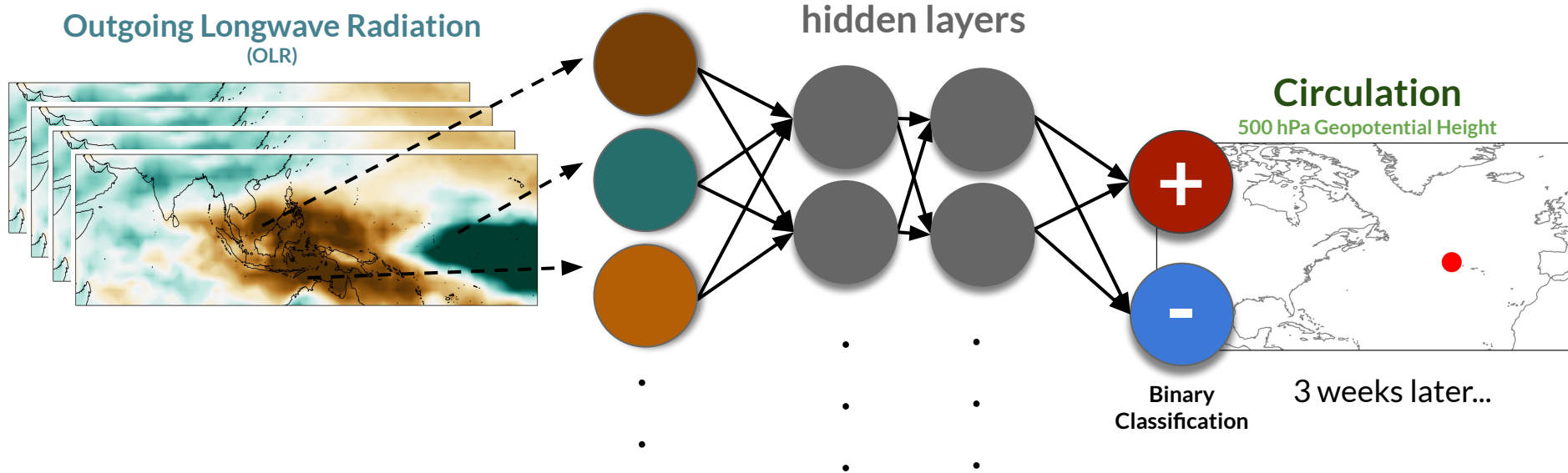
When the MJO is active, we use information about the state of the MJO today to predict what will happen NH weather in the coming weeks

MJO is a convective dipole that propagates from the Indian Ocean into the central Pacific Ocean over about 20-90 days

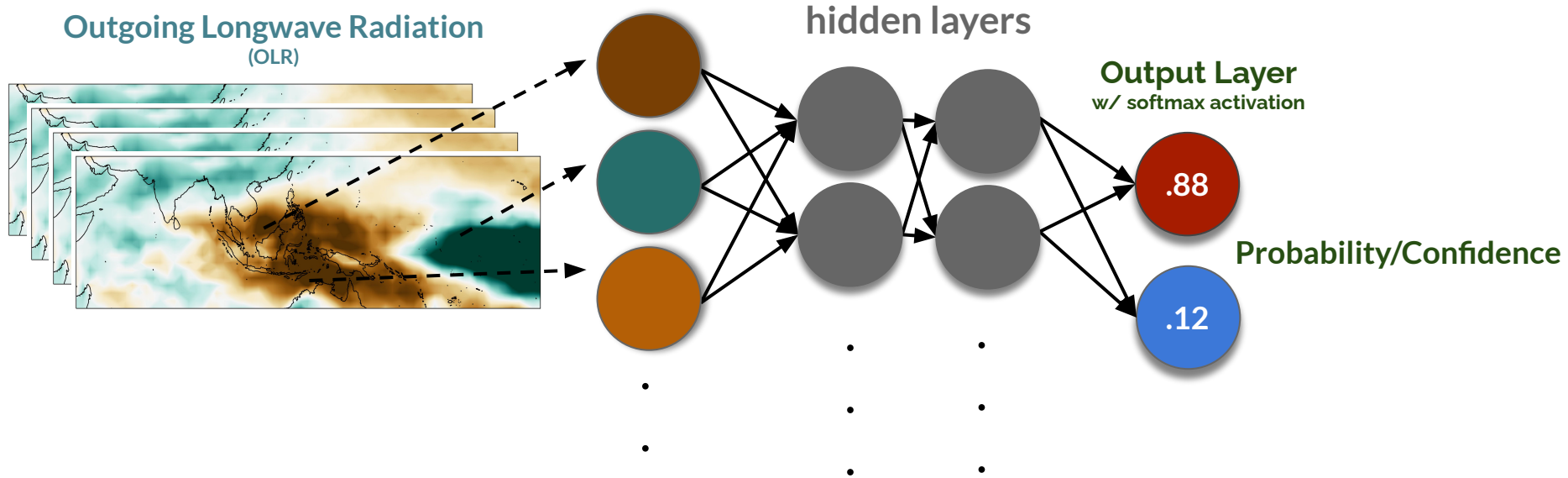
How can we utilize neural networks* to identify forecasts of opportunity for subseasonal prediction?

*See supplemental material for description of neural networks

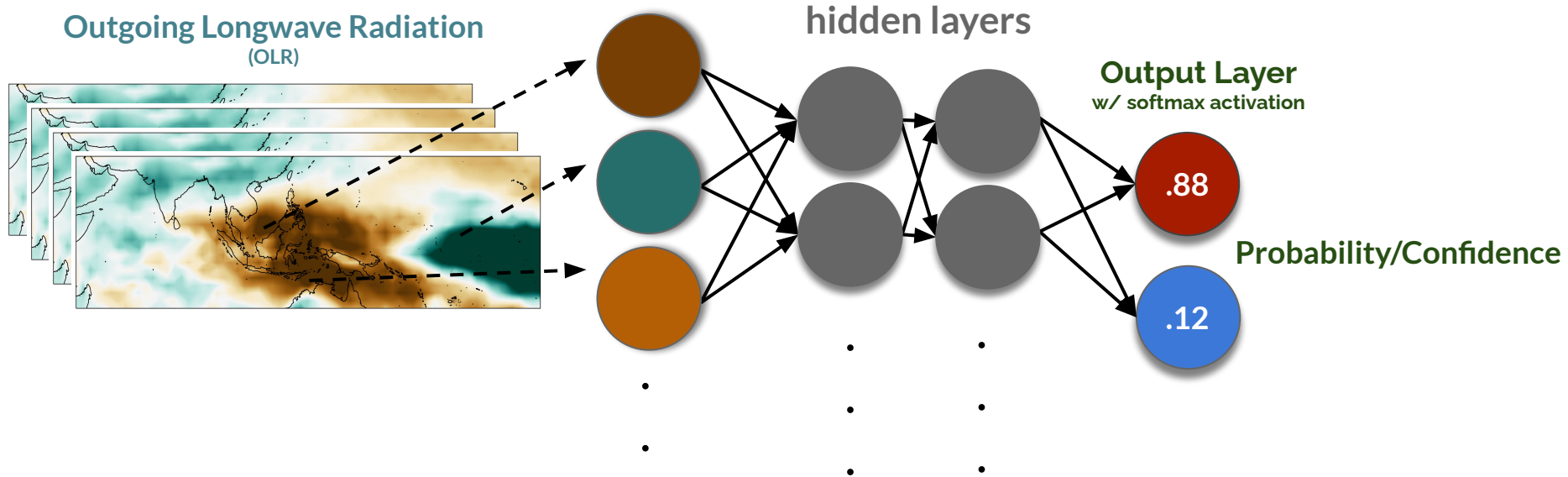
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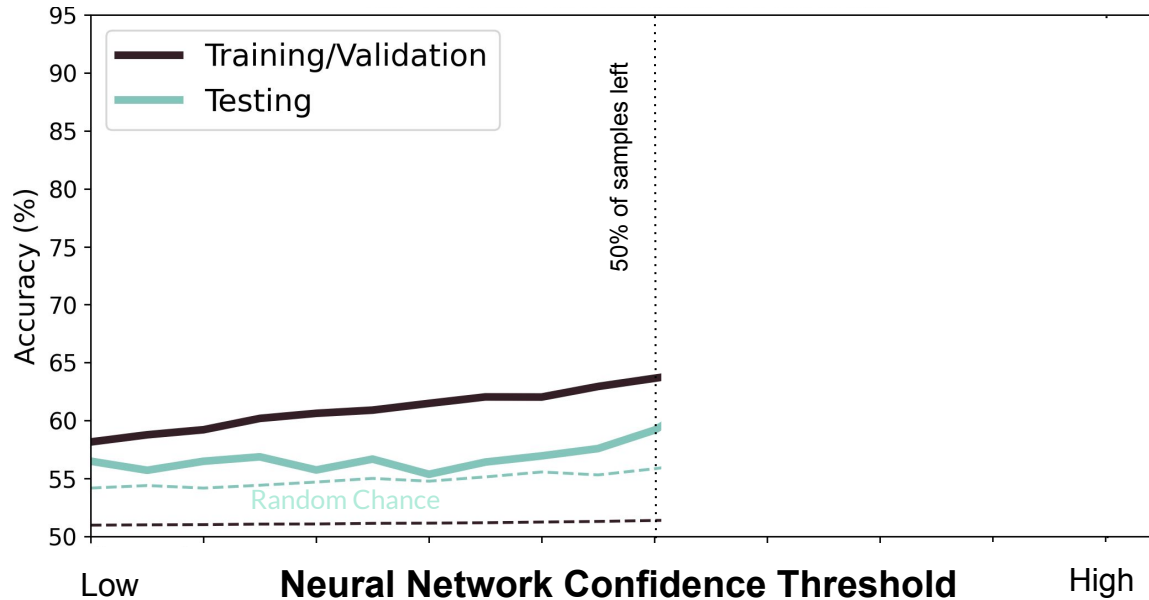


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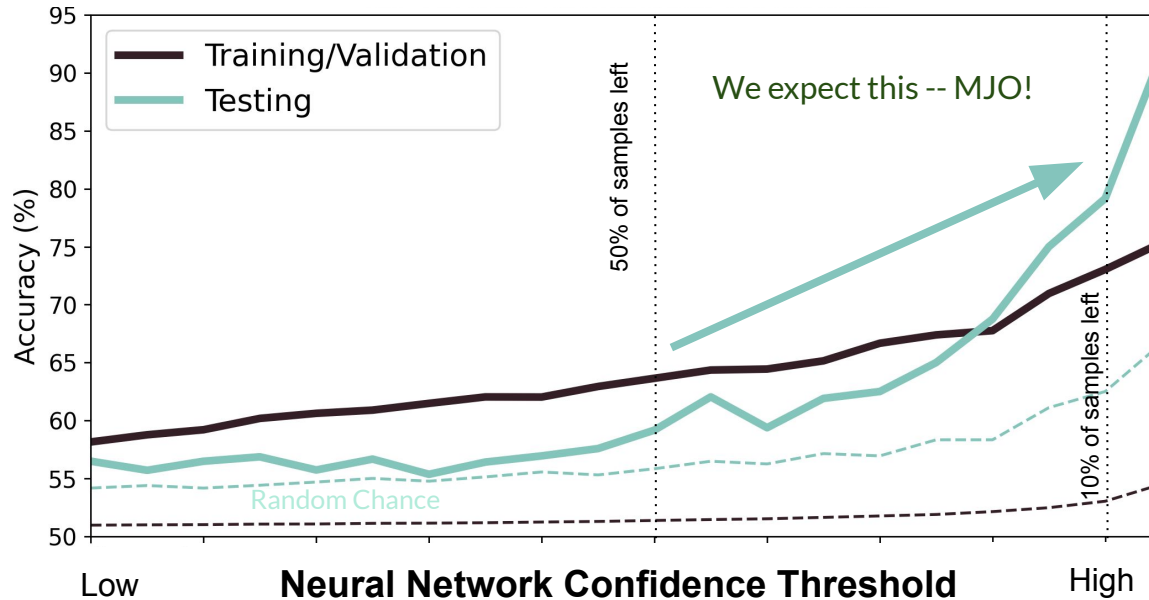


With this confidence we can determine when we have periods of predictability

Model Confidence as Forecasts of Opportunity



Model Confidence as Forecasts of Opportunity

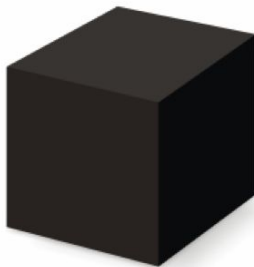


As confidence threshold \uparrow s, accuracy \uparrow s

Cool.
... but where is this predictability coming from?

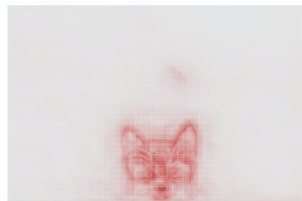
Layerwise Relevance Propagation

Trained Neural Network

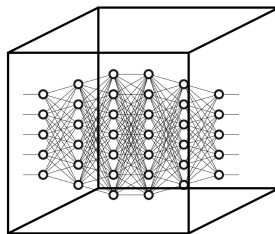


Prediction: CAT ✓

Trained Neural Network



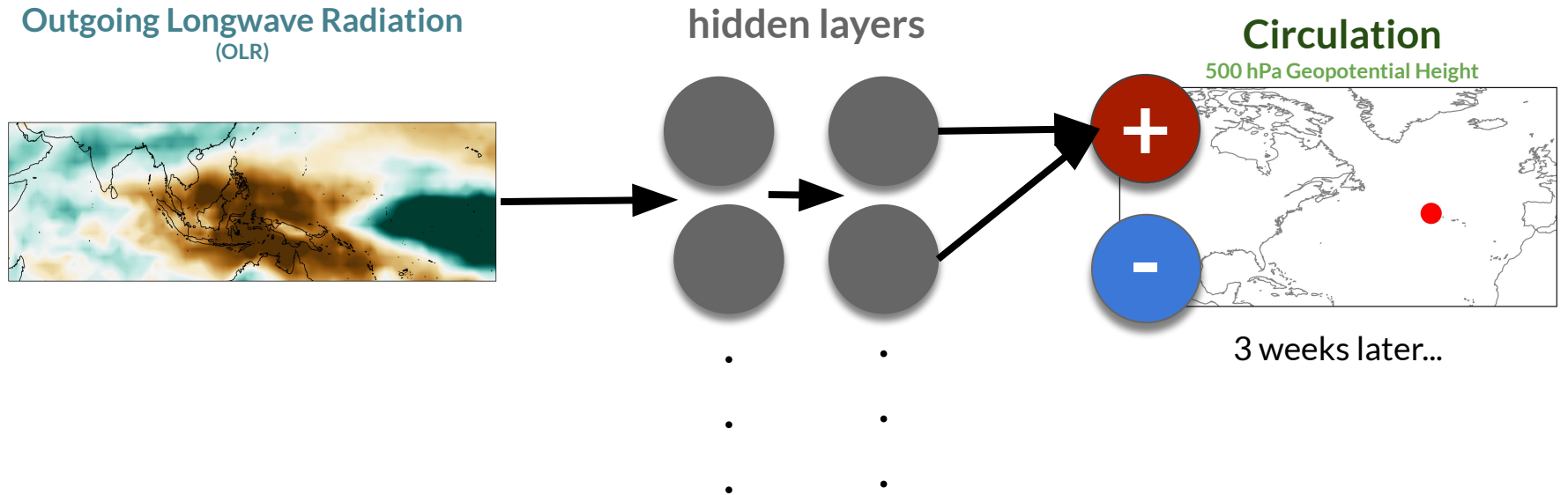
where the network looked to determine it was a "cat"



Prediction: CAT ✓

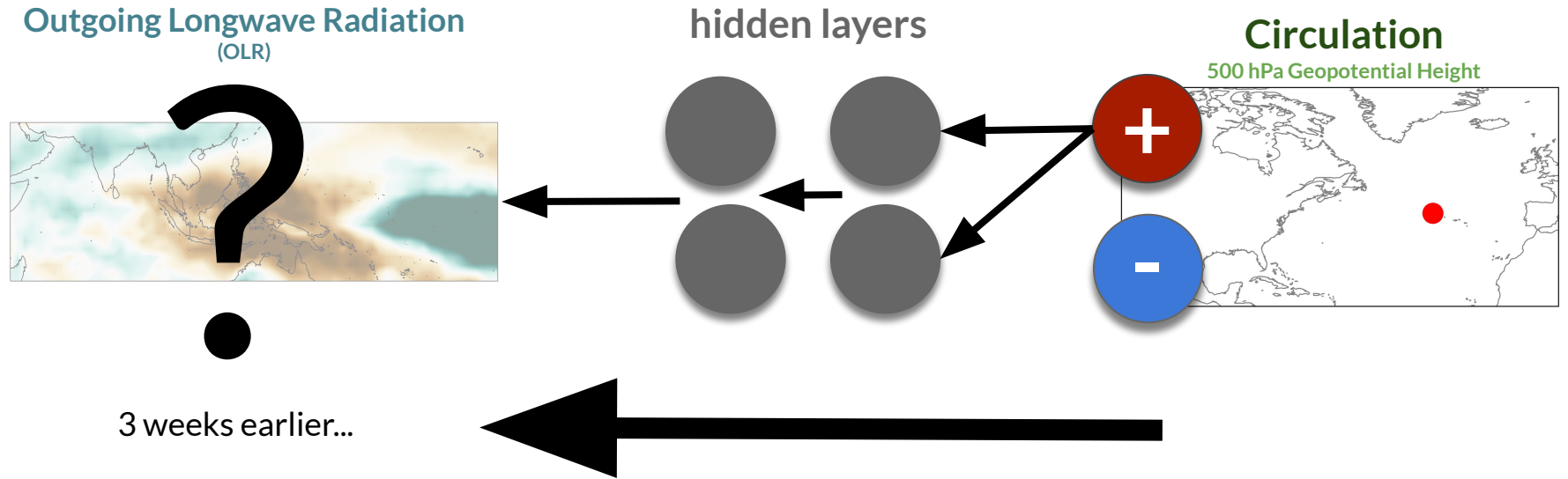


Subseasonal prediction network set-up



Example: network correctly guesses the sign of the circulation is positive

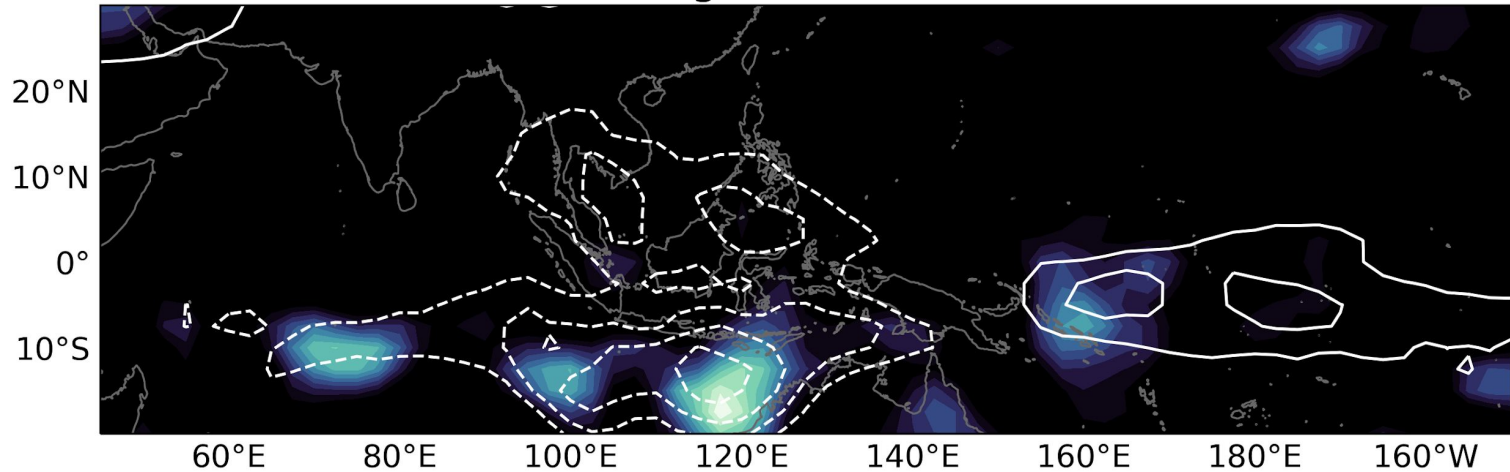
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What are *relevant physical structures of OLR* in the tropics for prediction over the North Atlantic?

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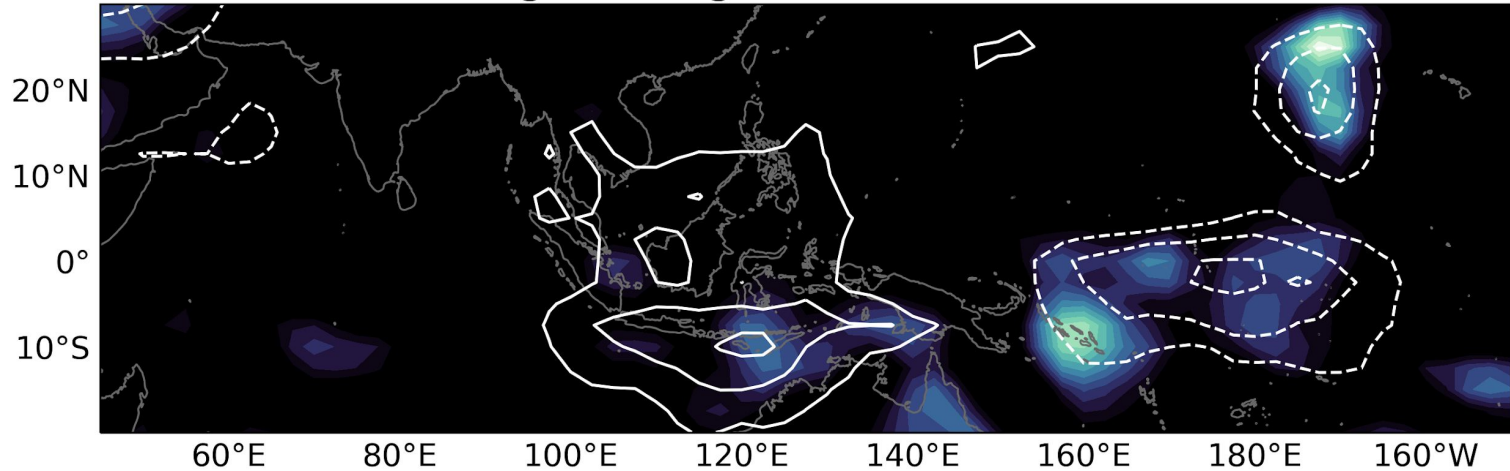
c) Positive Sign Predictions (N=168)



LRP map (shading) highlights OLR anomalies (contours) that looks like MJO phases 3-4

What are *relevant physical structures of OLR* in the tropics for prediction over the North Atlantic?

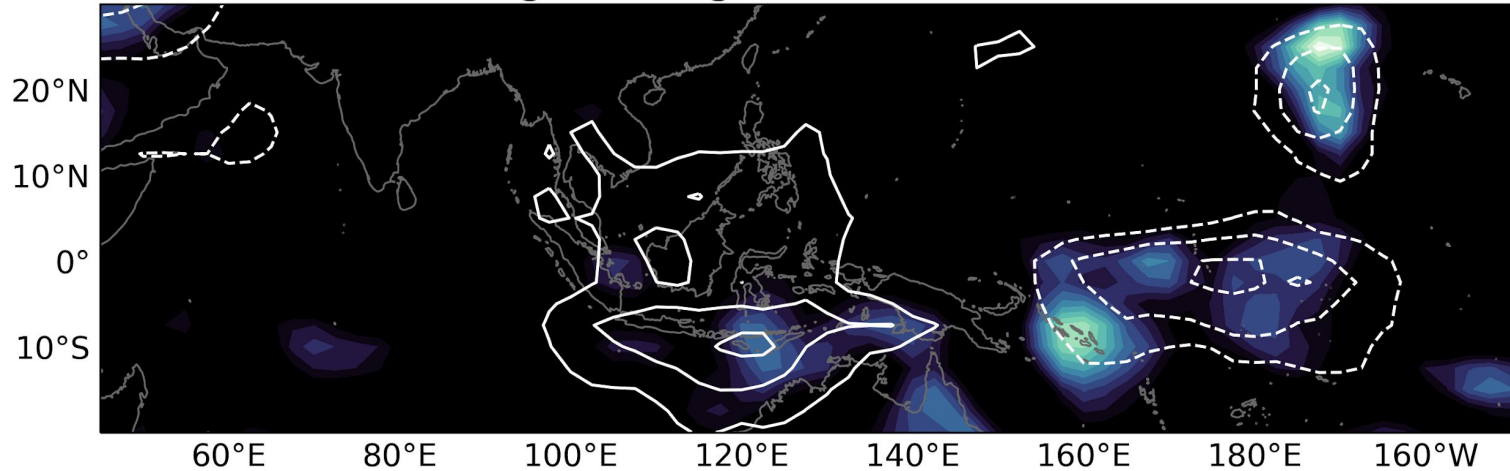
d) Negative Sign Predictions (N=175)



LRP map (shading) highlights OLR anomalies (contours) that looks like MJO phases 7-8

What are *relevant physical structures of OLR* in the tropics for prediction over the North Atlantic?

d) Negative Sign Predictions (N=175)



LRP has identified MJO-like dipole structure

General workflow:

1. Identify research problem
2. Create neural network to answer research question
3. Use **model confidence** to identify opportunities for enhanced predictability
4. Use **LRP/NN explainability** to:
 - a. determine trustworthiness of forecasts of opportunity identified by NN
 - b. identify *new* patterns of predictability



Conclusions

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Graduation (expected): Fall 2022

We can use Neural Networks to further understand subseasonal prediction

- **Model Confidence** can identify *opportunities* for increased accuracy
- **Layerwise Relevance Propagation** opens the ‘black box’
 - We can *learn how the network made its prediction*
 - We can find new sources of predictability from extracting knowledge from the neural network

Mayer, Kirsten J. & Elizabeth A. Barnes: Subseasonal Forecasts of Opportunity Identified by an Explainable Neural Network, Earth and Space Science Open Archive, <https://doi.org/10.1002/essoar.10505448.2>.