Can Transfer Learning help identify Tropical State-Dependent Bias relevant to Midlatitude Subseasonal Predictability?

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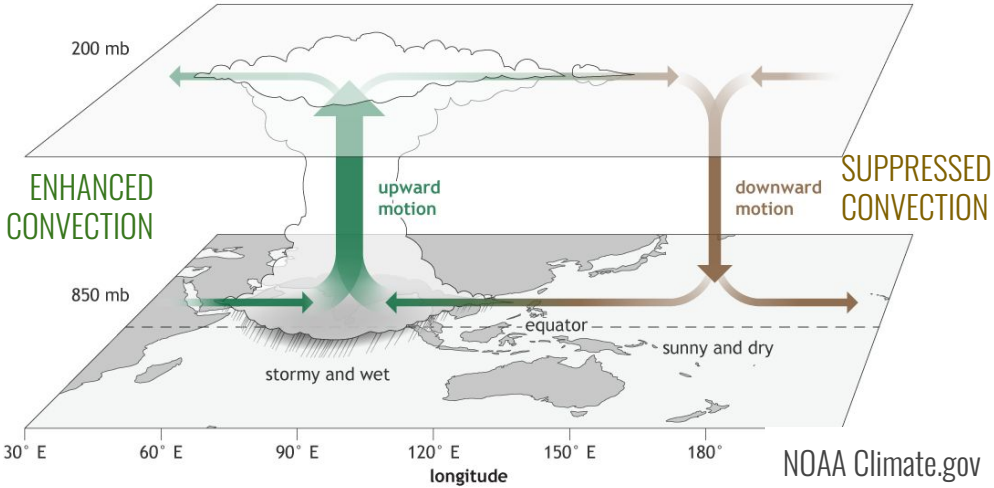
State-Dependent Predictability

Forecasts of Opportunity - certain conditions can lead to more predictable behavior than others

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

Madden-Julian Oscillation (MJO)

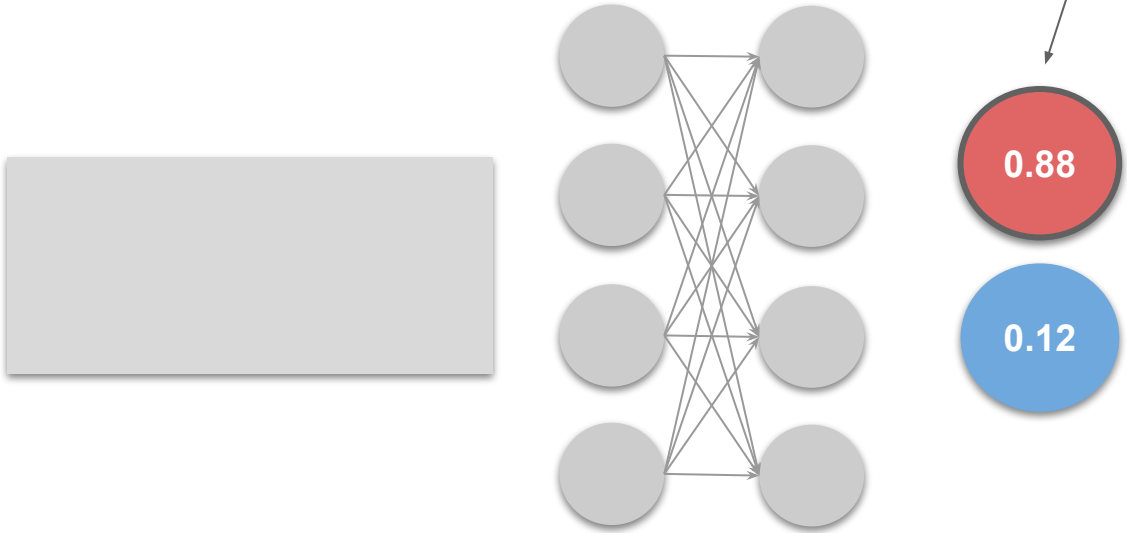


MJO is a convective dipole that propagates from the Indian Ocean into the central Pacific Ocean over about 20-90 days

State-Dependent Predictability

… identified by a neural network

Final layer uses the softmax function to convert the output into two values that sum to one

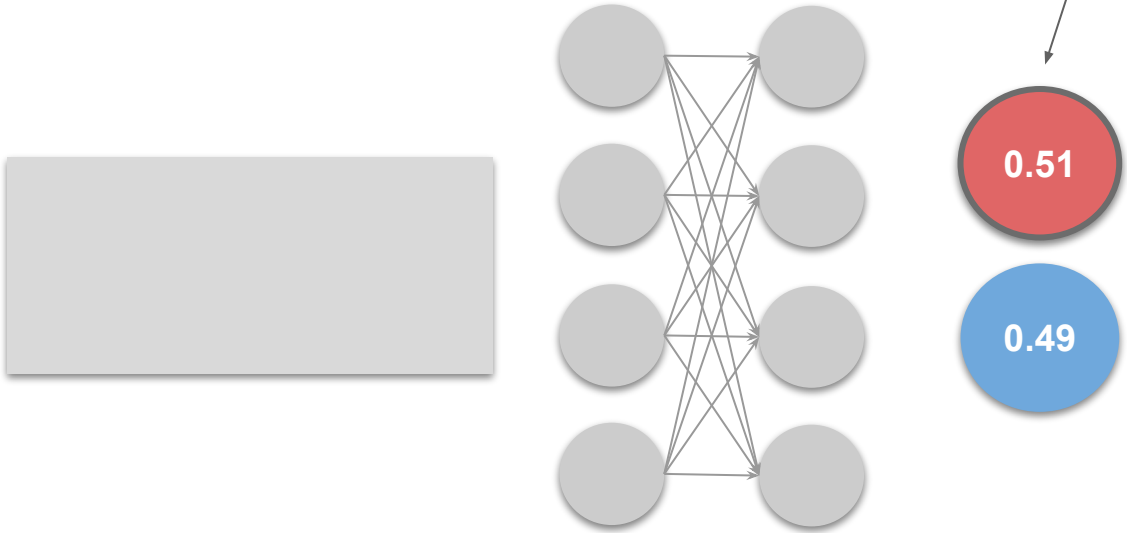


HIGH confidence

State-Dependent Predictability

… identified by a neural network

When the value is closer to one, is the network more often correct?



LOW confidence

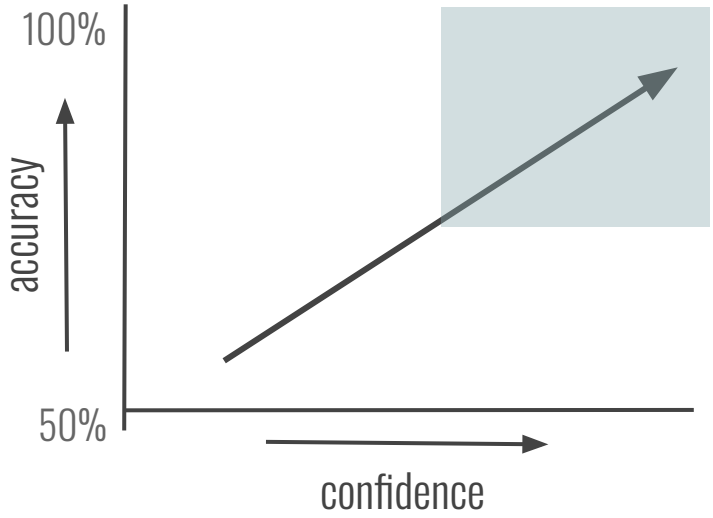
State-Dependent Predictability

... identified by a neural network

As confidence increases, does accuracy?

State-Dependent Predictability

... identified by a neural network

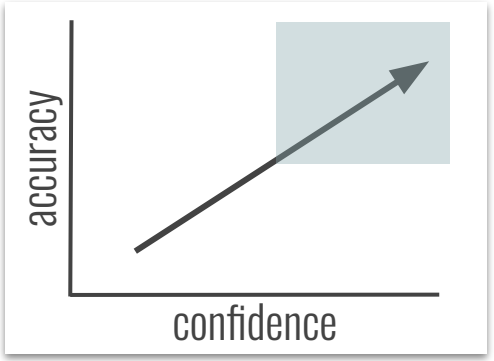


Forecasts of Opportunity

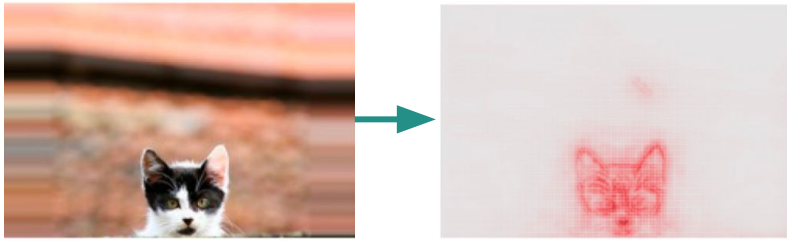
periods of enhanced predictability identified
using network confidence (Mayer & Barnes 2021)

State-Dependent Predictability

... identified by an explainable neural network



with eXplainable Artificial Intelligence (XAI), we can identify sources of enhanced prediction skill



Montavon et al. 2017

State-Dependent Predictability Bias

... identified by an explainable neural network

bias: systematic differences in sources of enhanced predictability between model & obs

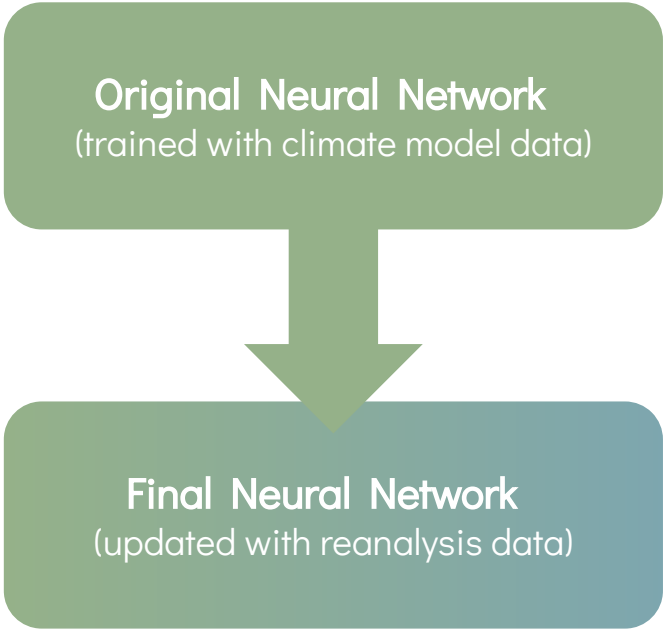
Mayer et al. (under review)

State-Dependent Predictability Bias

Transfer Learning

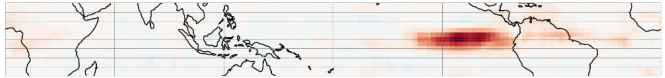
LOTS of data - biased

limited data - unbiased



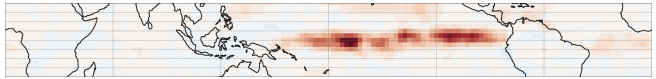
State-Dependent Predictability Bias

Transfer Learning and XAI



XAI

Original Neural Network
(trained with climate model data)



XAI

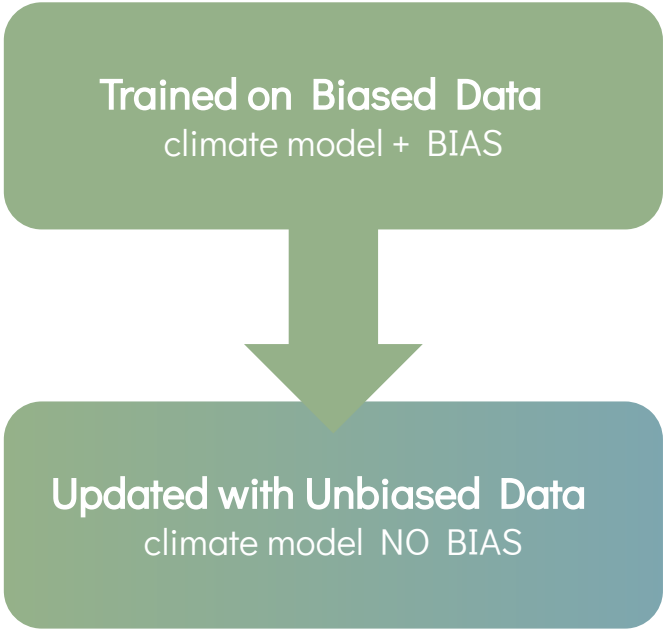
Final Neural Network
(updated with reanalysis data)

State-Dependent Predictability Bias

Transfer Learning and XAI

To test the feasibility of this approach...

perfect model framework

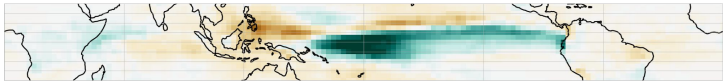


Mayer et al. (under review)

State-Dependent Predictability Bias

The prediction problem

E3SMv2



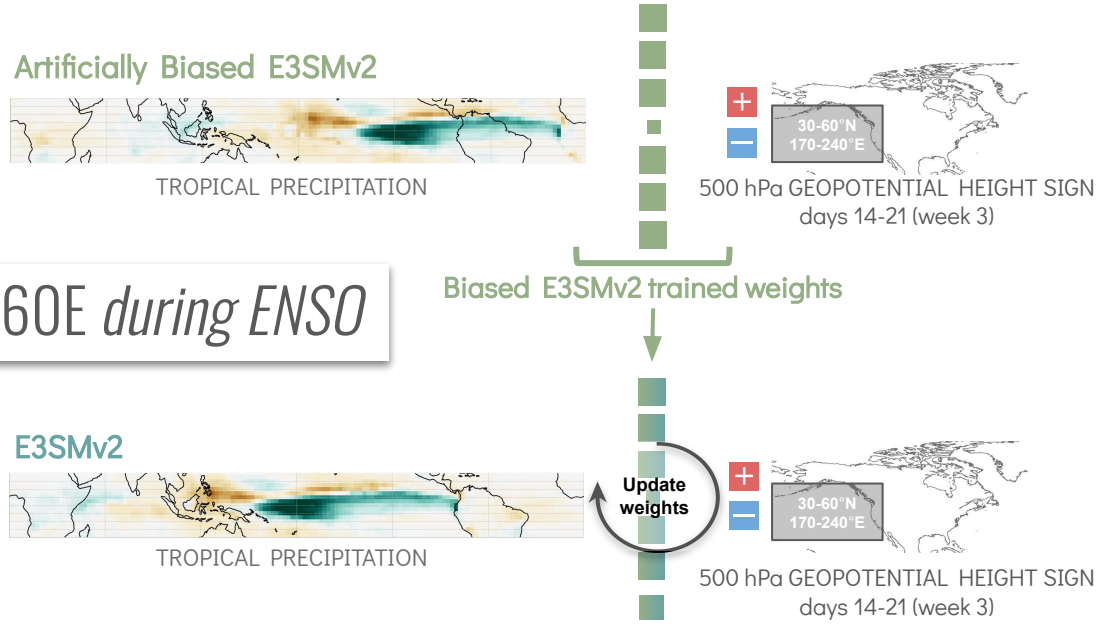
TROPICAL PRECIPITATION

500 hPa GEOPOTENTIAL HEIGHT SIGN
days 14-21 (week 3)

State-Dependent Predictability Bias

Transfer Learning

BIAS = tropical precipitation + 60E *during ENSO*



Mayer et al. (under review)

State-Dependent Predictability Bias

Transfer Learning

If transfer learning works... (once the network corrects the shift)
we expect the performance

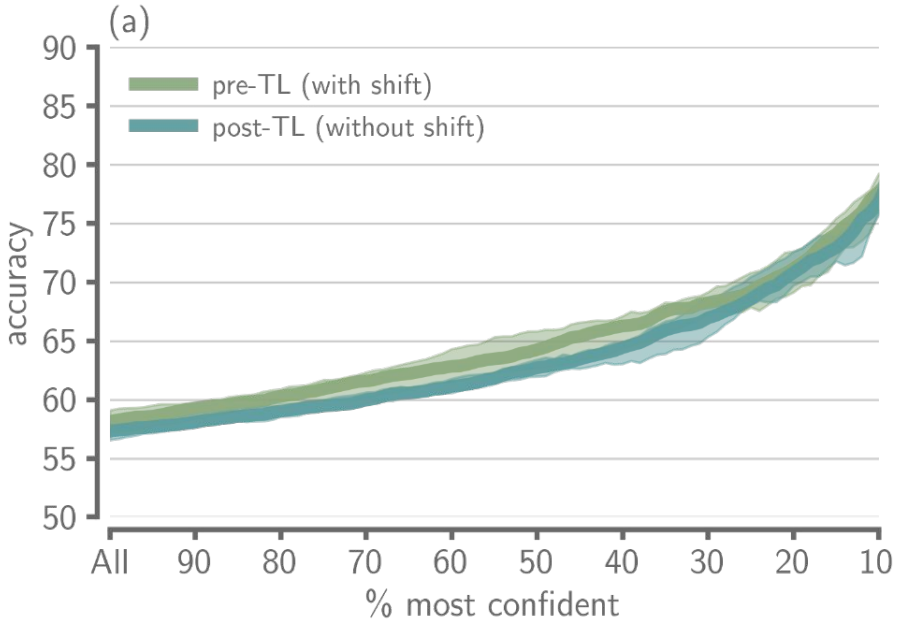
post-TL network ≅ pre-TL network

State-Dependent Predictability Bias

Transfer Learning

Both networks are skillful and able to identify forecasts of opportunity

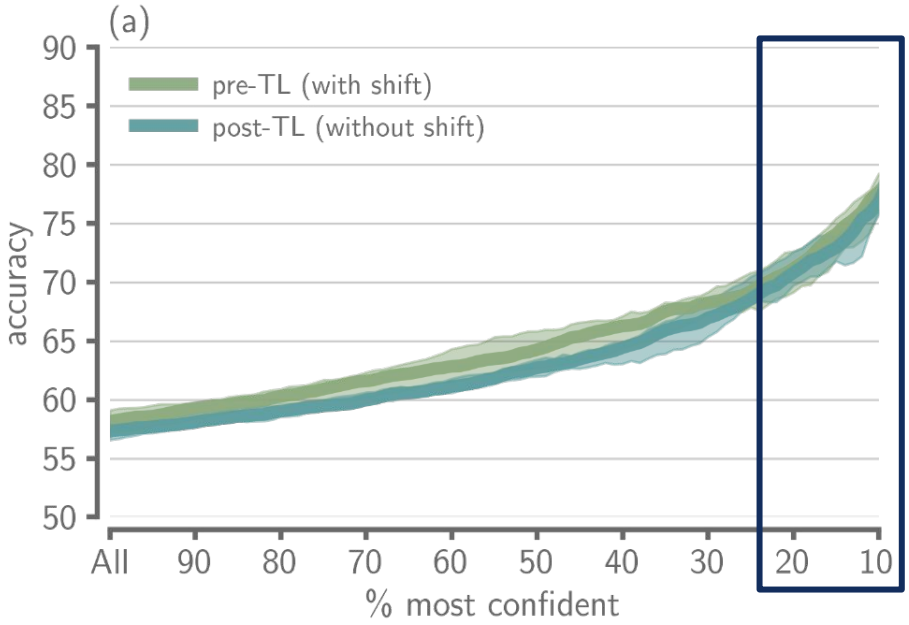
Transfer learning worked!



State-Dependent Predictability Bias

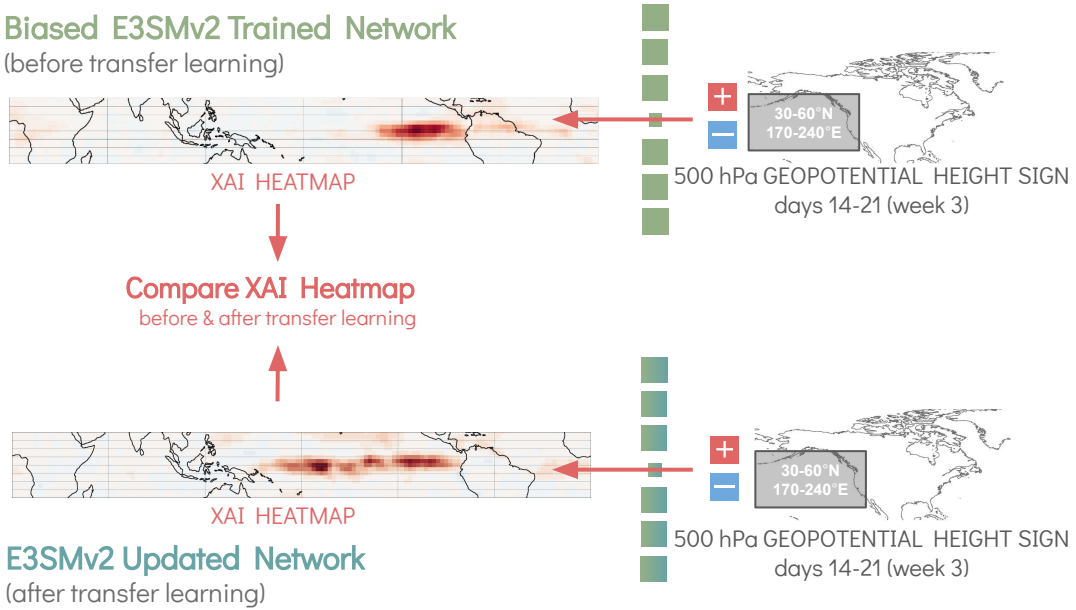
Transfer Learning

Let's pretend we don't know the true bias & look at network-identified forecasts of opportunity



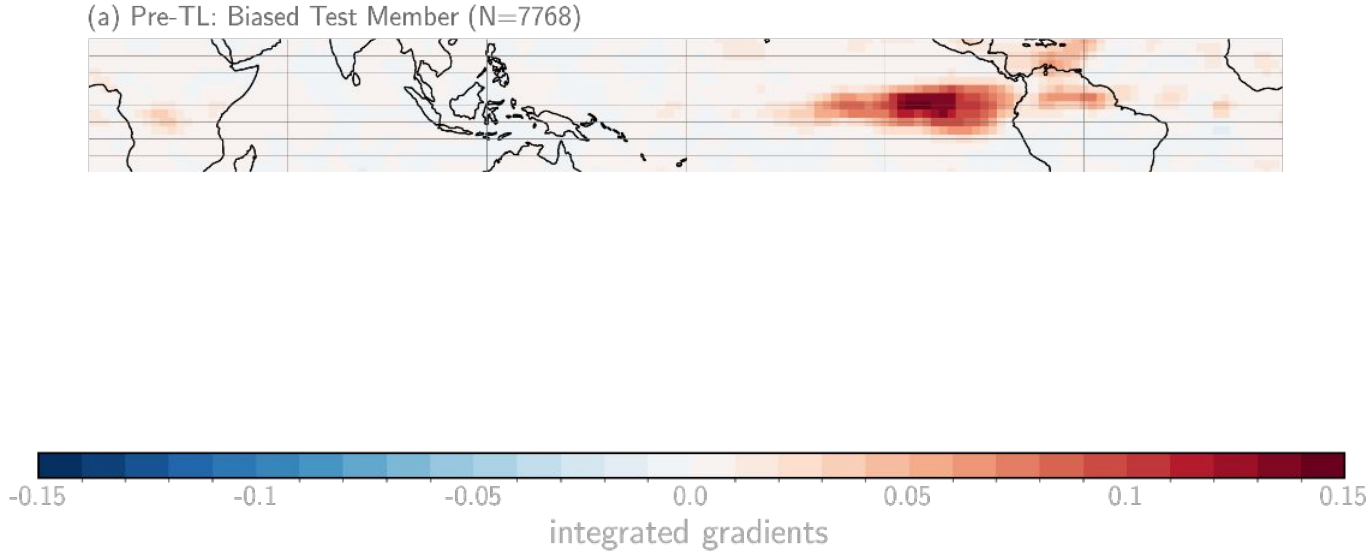
State-Dependent Predictability Bias

Transfer Learning with XAI



State-Dependent Predictability Bias

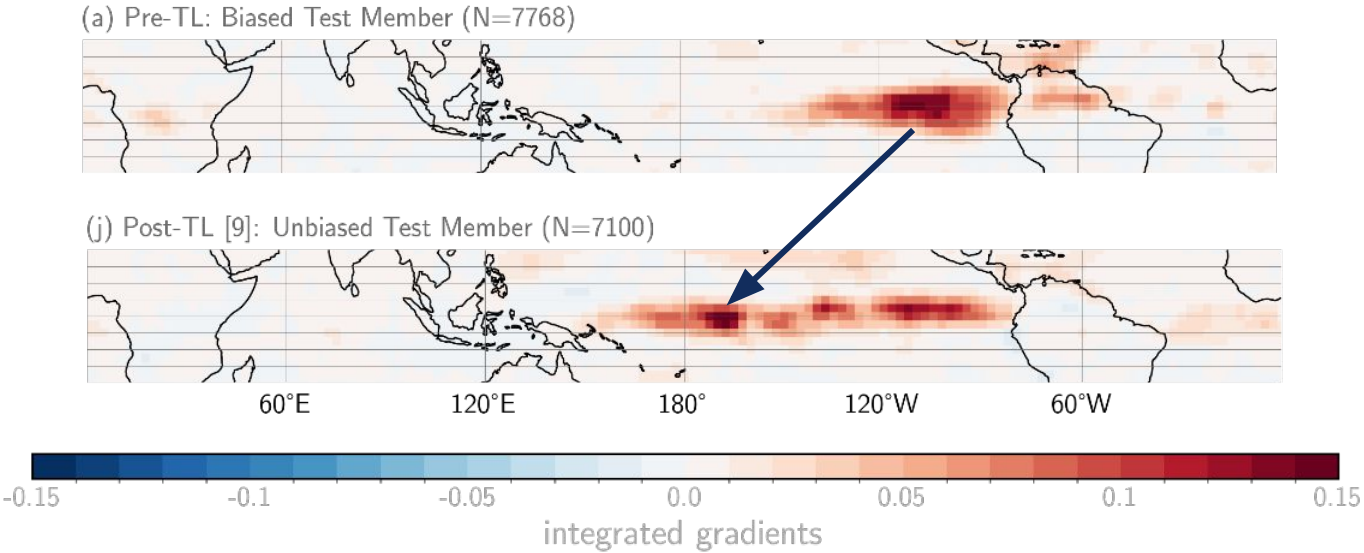
Transfer Learning with XAI



Mayer et al. (under review)

State-Dependent Predictability Bias

Transfer Learning with XAI



State-Dependent Predictability Bias

Transfer Learning with XAI

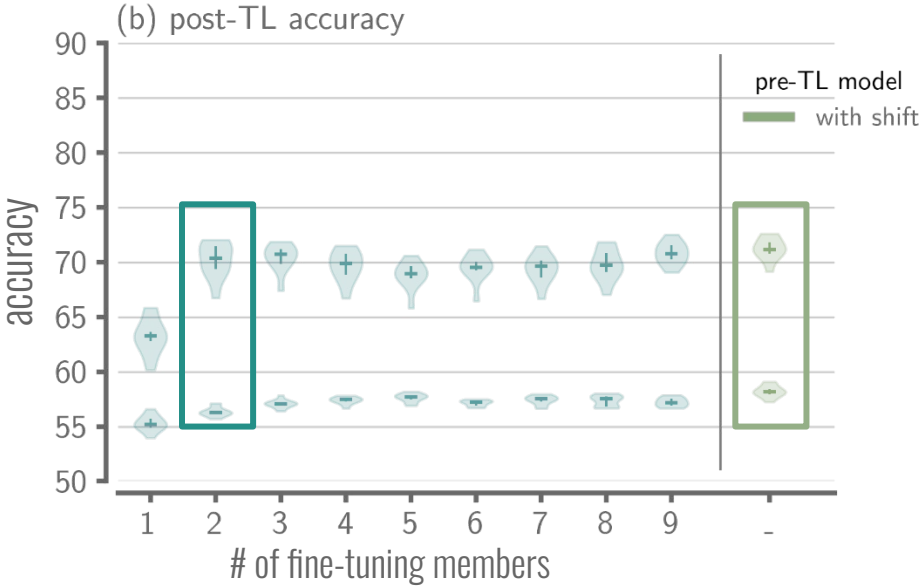
These results use NINE ensemble members to re-tune…
what if we only had ONE ensemble member

State-Dependent Predictability Bias

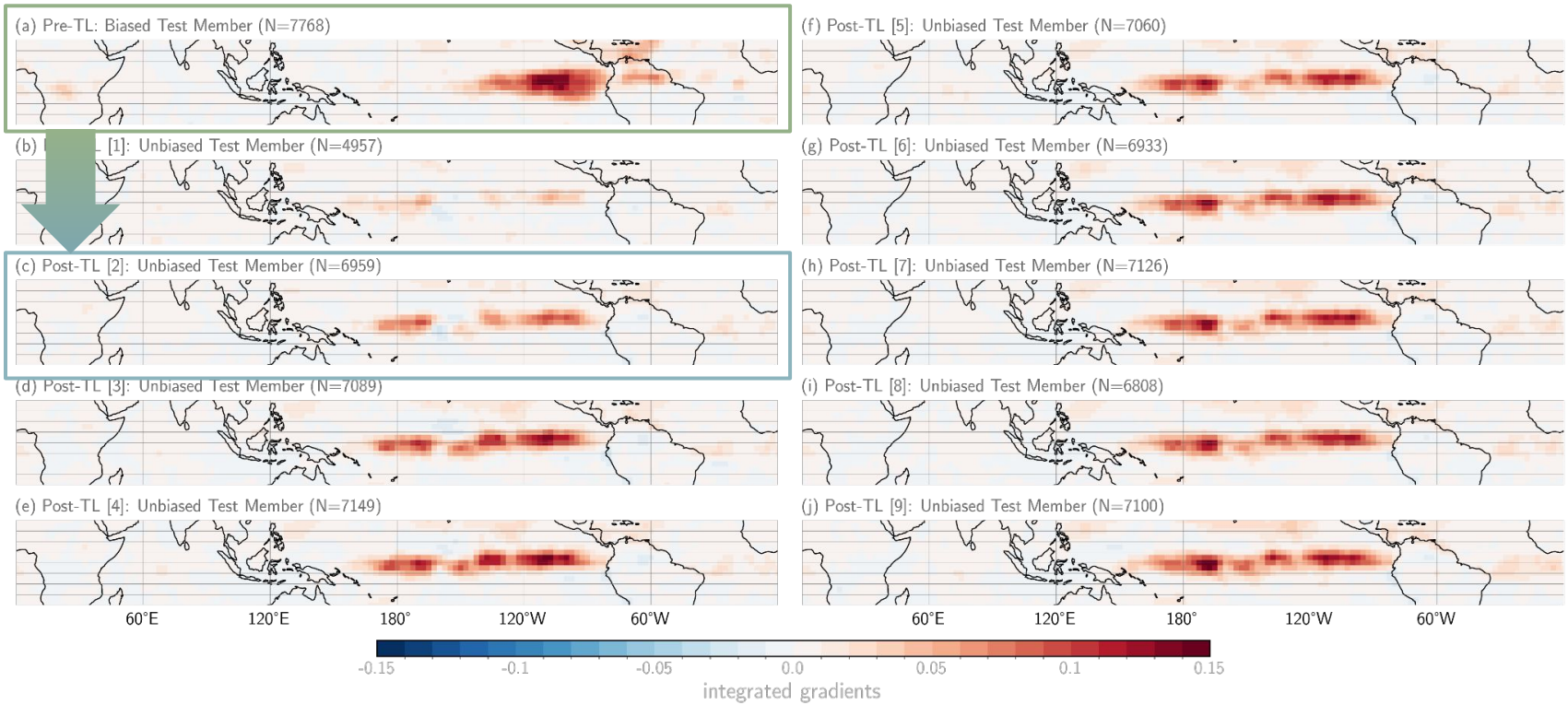
Transfer Learning

Need ~2 tuning members to get to similar accuracy as the original model....

128 years of data (<1900-Today)



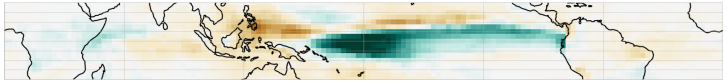
State-Dependent Predictability Bias



State-Dependent Predictability Bias

E3SMv2 + Biased

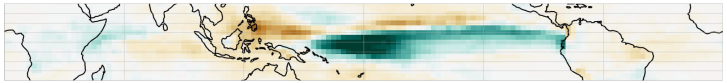
E3SMv2



500 hPa GEOPOTENTIAL HEIGHT SIGN
days 14-21 (week 3)

State-Dependent Predictability Bias

E3SMv2



TROPICAL PRECIPITATION

500 hPa GEOPOTENTIAL HEIGHT SIGN
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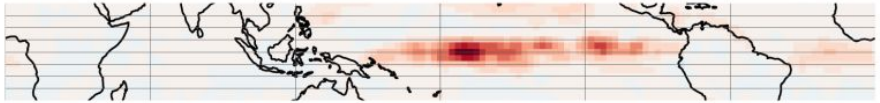
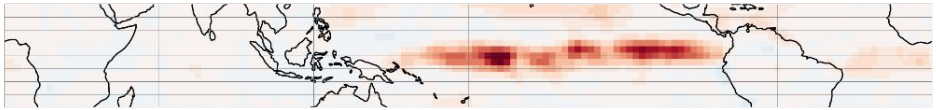


No Transfer Learning



Post-Transfer Learning

Can Transfer Learning identify Tropical State-Dependent Bias Relevant to Midlatitude Subseasonal Predictability?

... kinda ...

but not with reanalysis

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State-Dependent Predictability Bias

Transfer Learning

This is common across different testing data.

State-Dependent Predictability Bias

Convolutional Neural Network

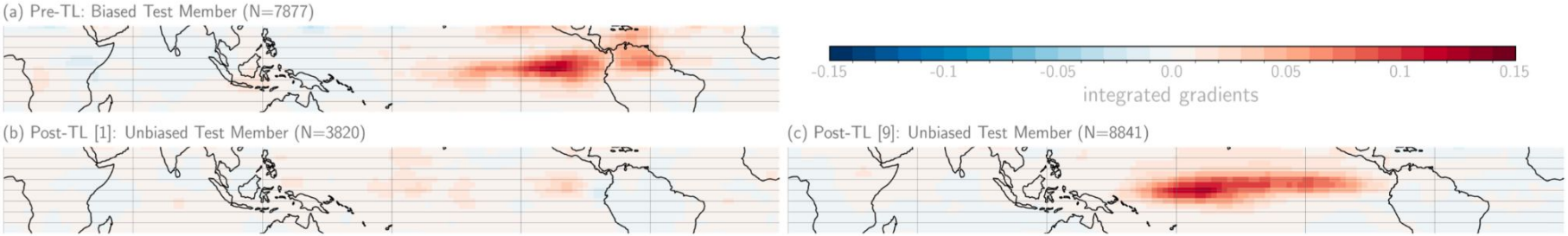

FIG. A1. As in Figure 3, but for negative predictions from a convolutional neural network for (b) one or (c) nine retraining members.