Exploring the Relative Contribution of the MJO and ENSO to Midlatitude Subseasonal Predictability

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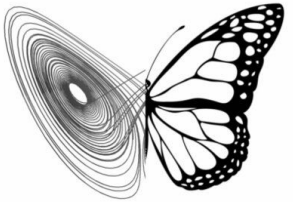
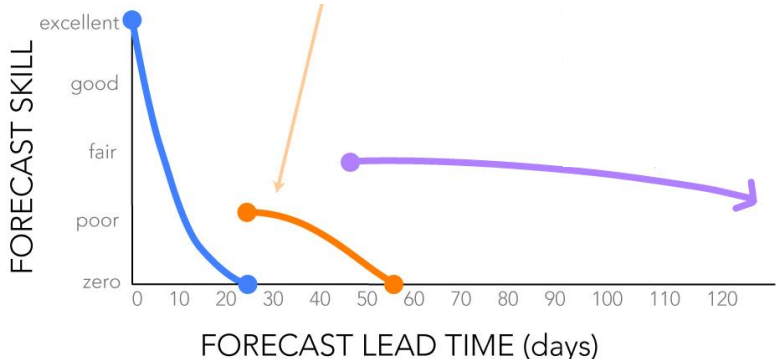
SOARS

Subseasonal Timescales (2 weeks ~ 2 months)



- Difficult to predict - often, neither atmospheric initial conditions or slower-varying boundary conditions provide sufficient information
- “Forecasts of Opportunity”: specific conditions in the earth system that are known to provide improved skill on these timescales



Infographic of forecast skill from weather to seasonal lead times from the S2S Prediction Project. Adapted by Elisabeth Gawthrop from figure by Tony Barnston.

Vitart et al., 2012, 2017; Mariotti et al., 2020

The Madden-Julian Oscillation (MJO)

The MJO is an eastward propagating anomalous tropical heating (~20 to 90 days) that can affect midlatitude weather on subseasonal timescales

Produced by the Adames group

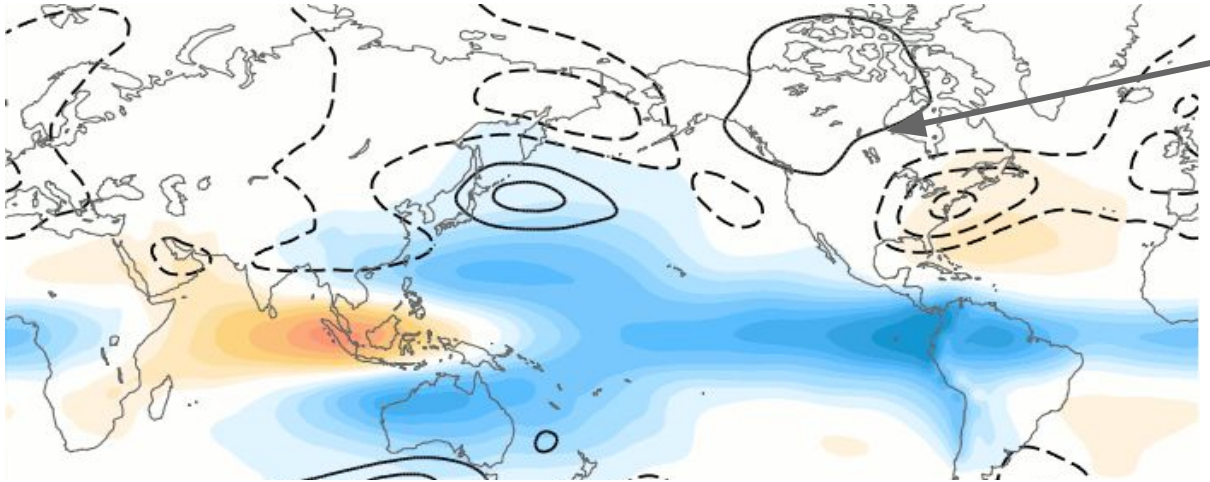


Figure courtesy of Will Chapman

El Niño Southern Oscillation (ENSO)

ENSO is an anomalous sea surface temperature pattern in the tropical Pacific, which can influence midlatitude weather on seasonal timescales

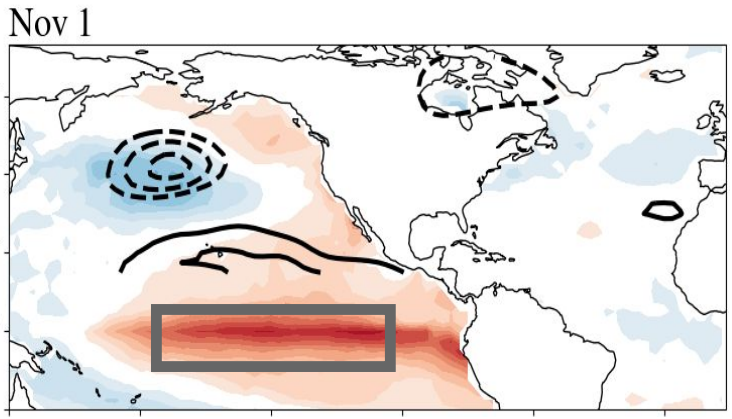


Figure courtesy of Will Chapman

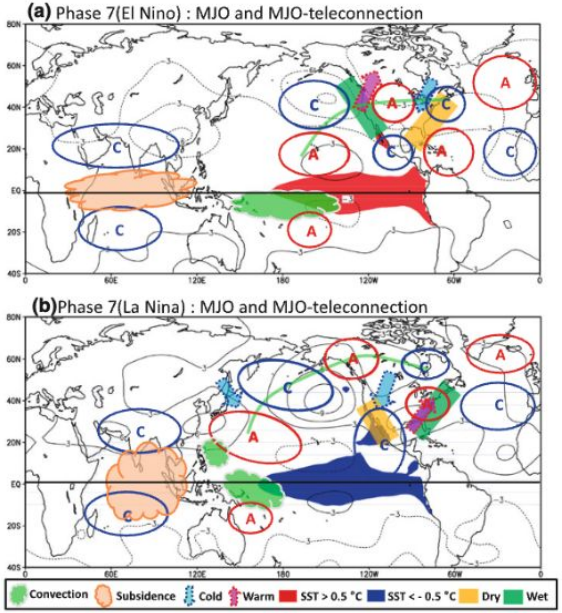


Figure 10 (Moon et al. 2011)

e.g., Trenberth, 1997, Gibson et al., 2021; Winkler et al., 2001

e.g. Pohl & Matthews 2007; Moon et al. 2011; Johnson et al. 2014; Tseng et al. 2020; Arcodia et al. 2020; Arcodia & Kirtman et al. 2023

Subseasonal Evolution of ENSO teleconnections

ENSO teleconnection evolves over boreal winter due to changes in strength of midlatitude jet

Editorial Type: Article

Article Type: Research Article

Monthly Modulations of ENSO Teleconnections: Implications for Potential Predictability in North America

William E. Chapman, Aneesh C. Subramanian, Shang-Ping Xie, Michael D. Sierks, F. Martin Ralph, and Youichi Kamae

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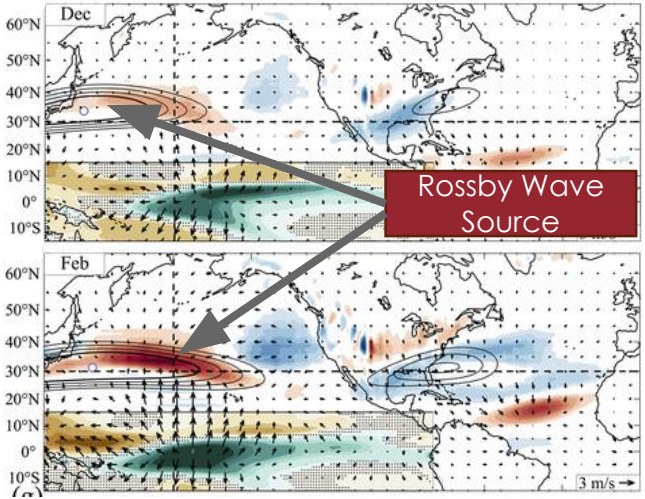


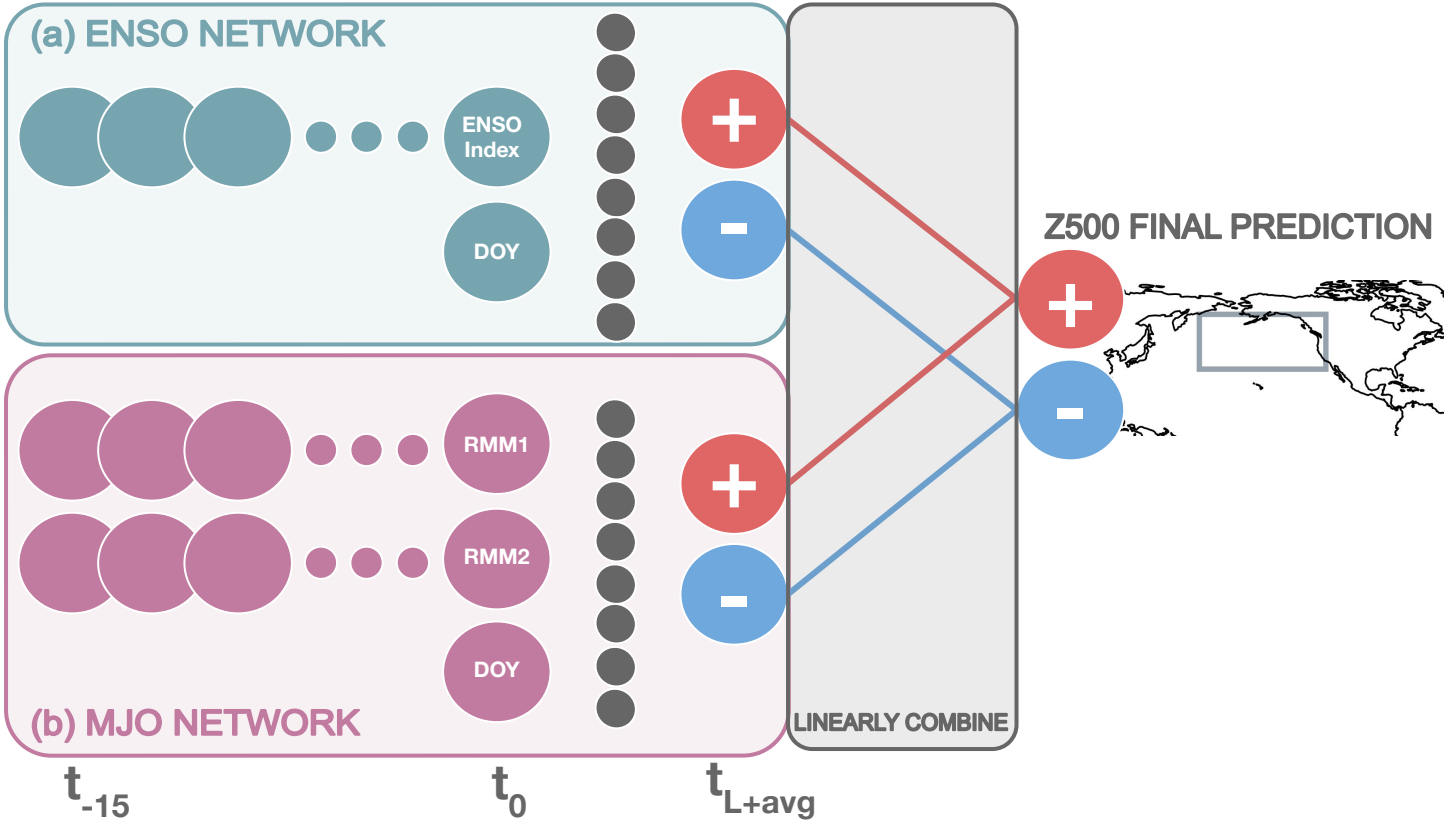
Chapman et al. 2021

e.g. Newman and Sardeshmukh 1998; Kumar & Hoerling 1998

What is the relative role of the MJO and ENSO in midlatitude subseasonal predictability?

Interpretable Neural Network**

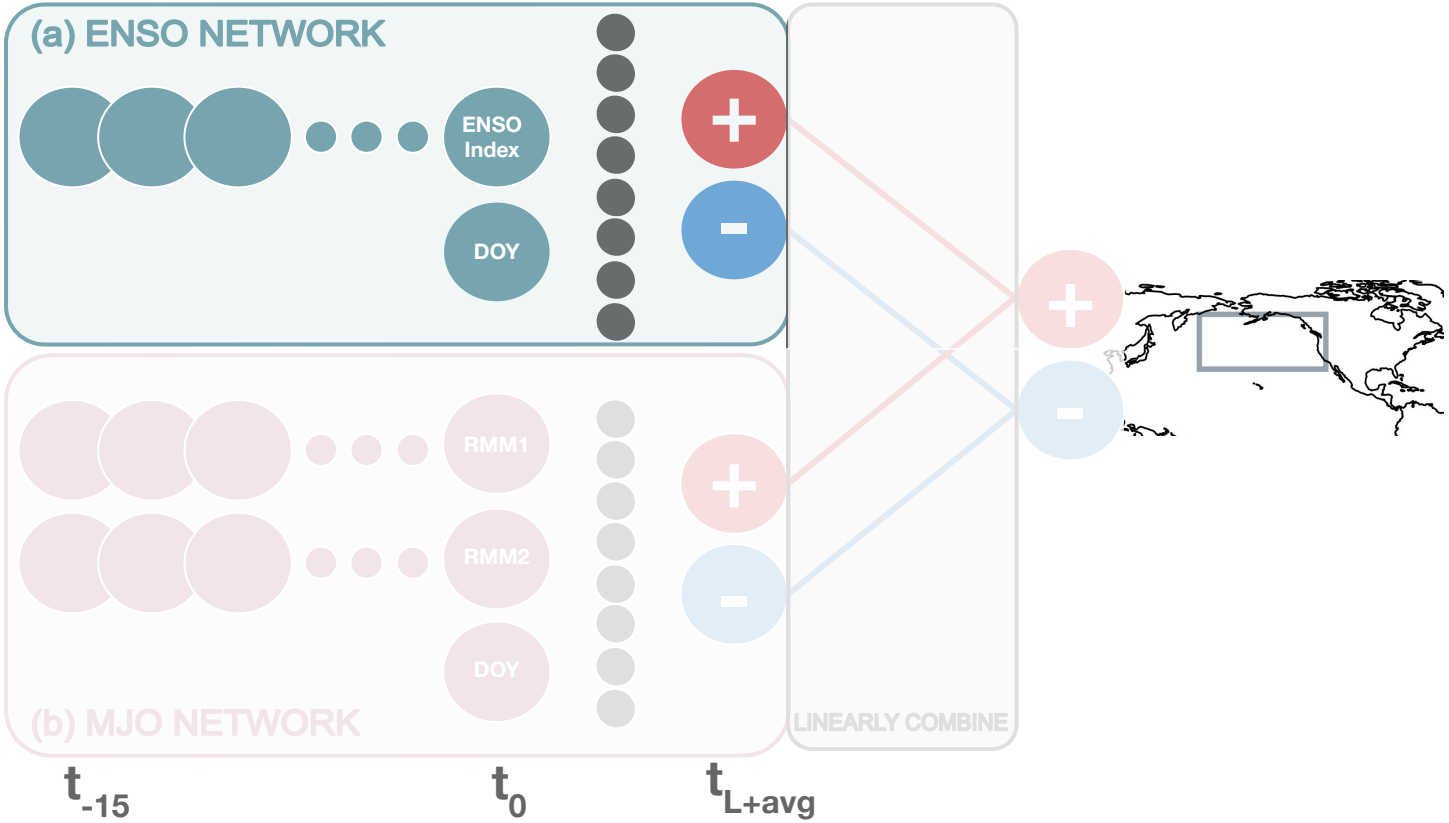
DATA: CESM2-PI



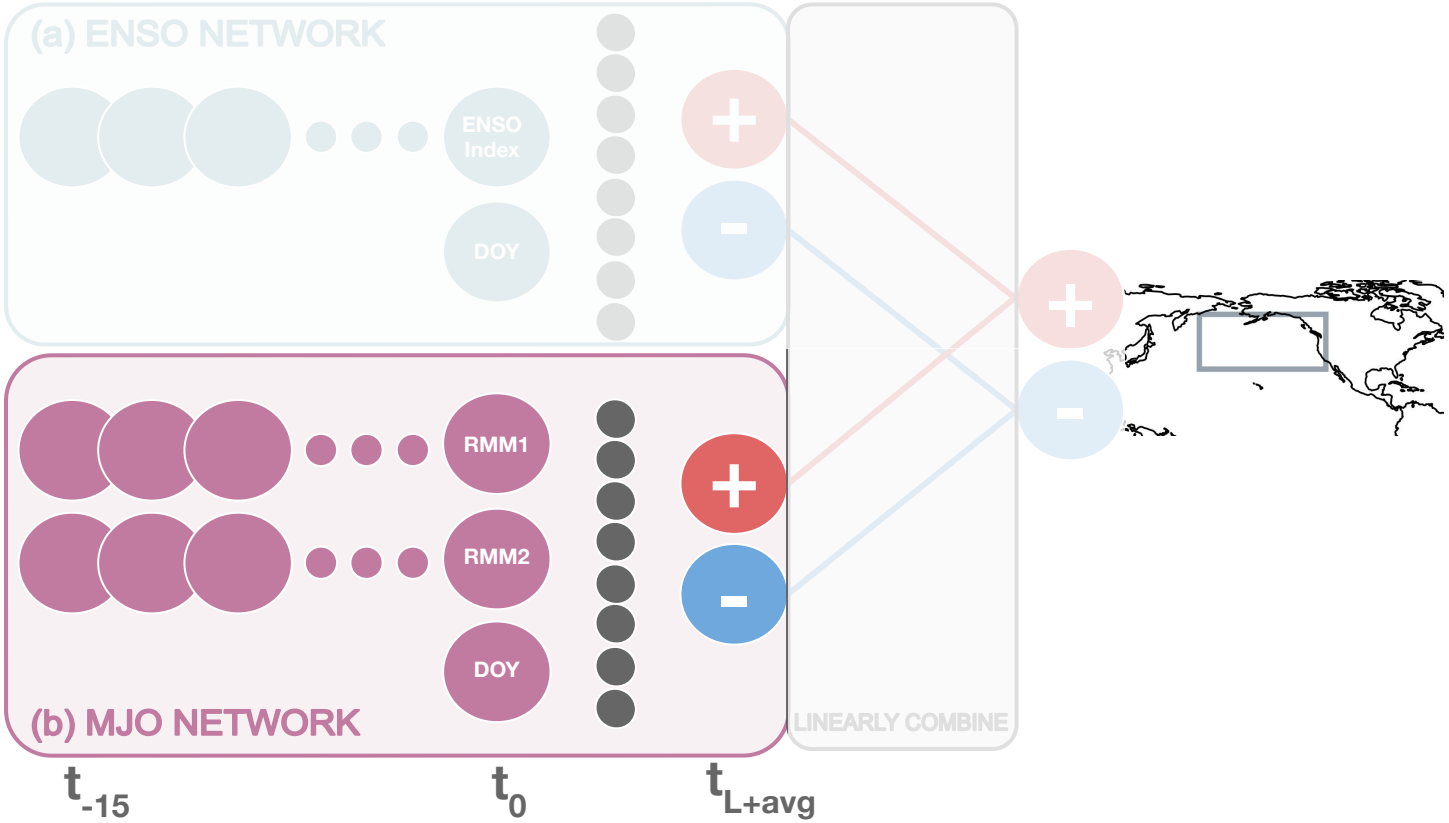
**network architecture adapted from Gordon et al. (2023)

Mayer*, Chapman* & Manriquez (under review)

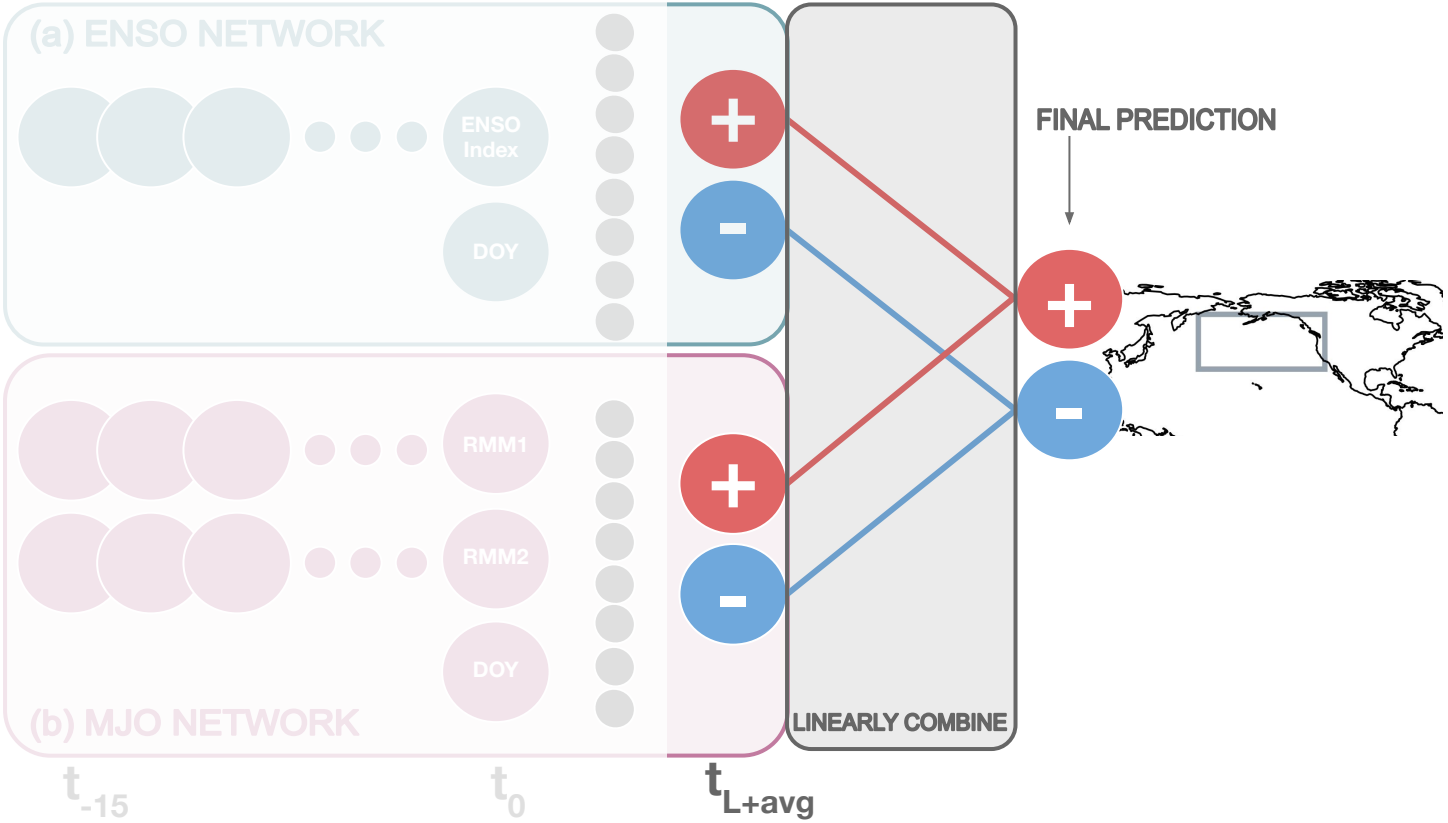
Interpretable Neural Network



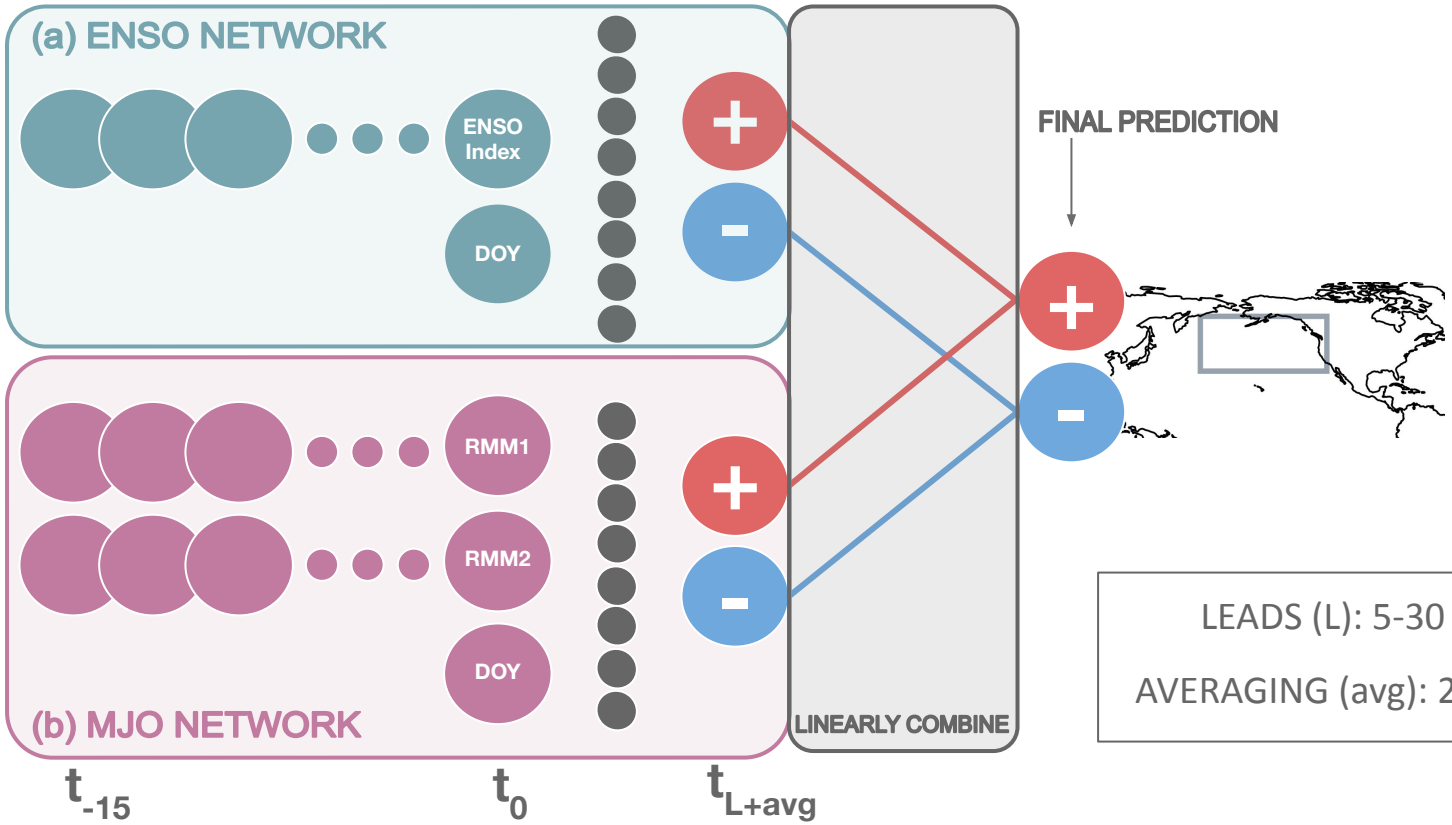
Interpretable Neural Network



Interpretable Neural Network



Interpretable Neural Network

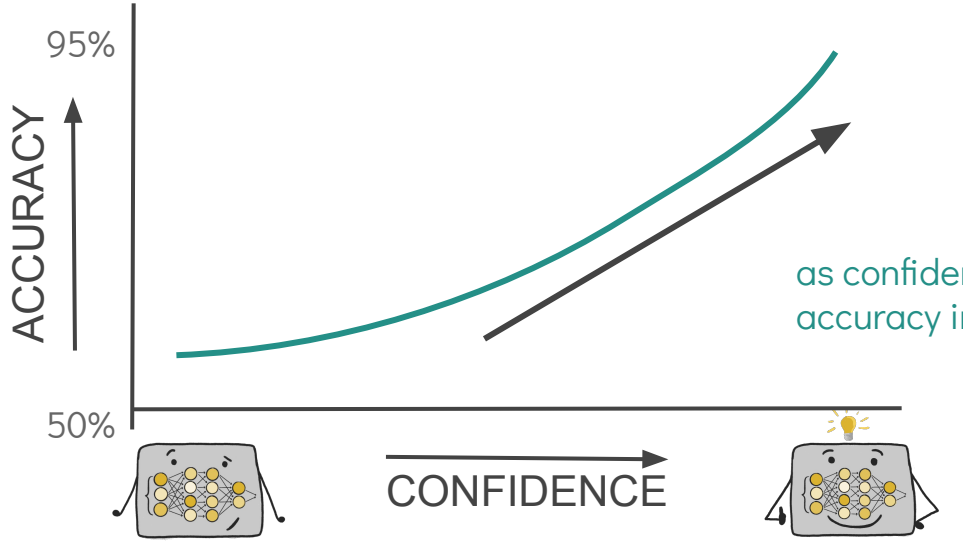


LEADS (L): 5-30 days

AVERAGING (avg): 2-30 days

Forecasts of Opportunity

... identified by a Neural Network



Using confidence, we can identify opportunities for enhanced midlatitude subseasonal prediction skill

HIGH confidence

0.88

0.12

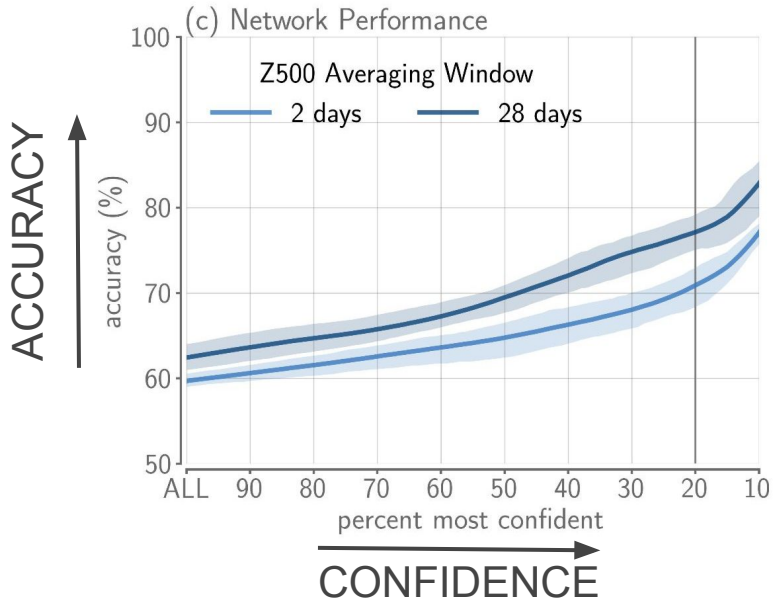
0.51

0.49

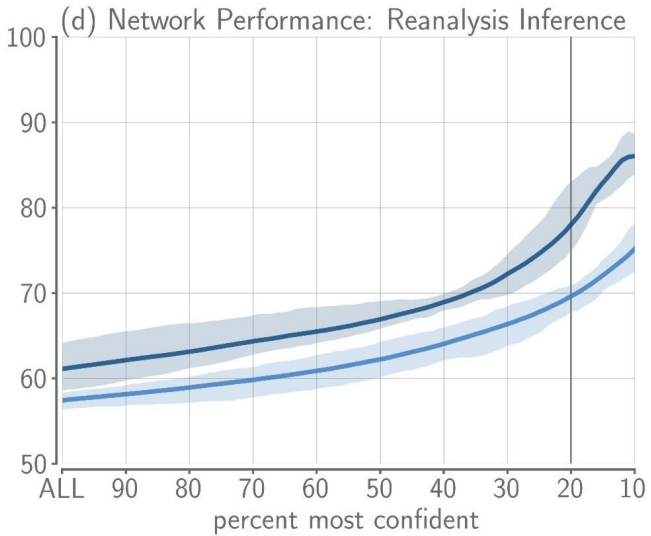
LOW confidence

Can the network identify forecasts of opportunity?

CESM2-PI:

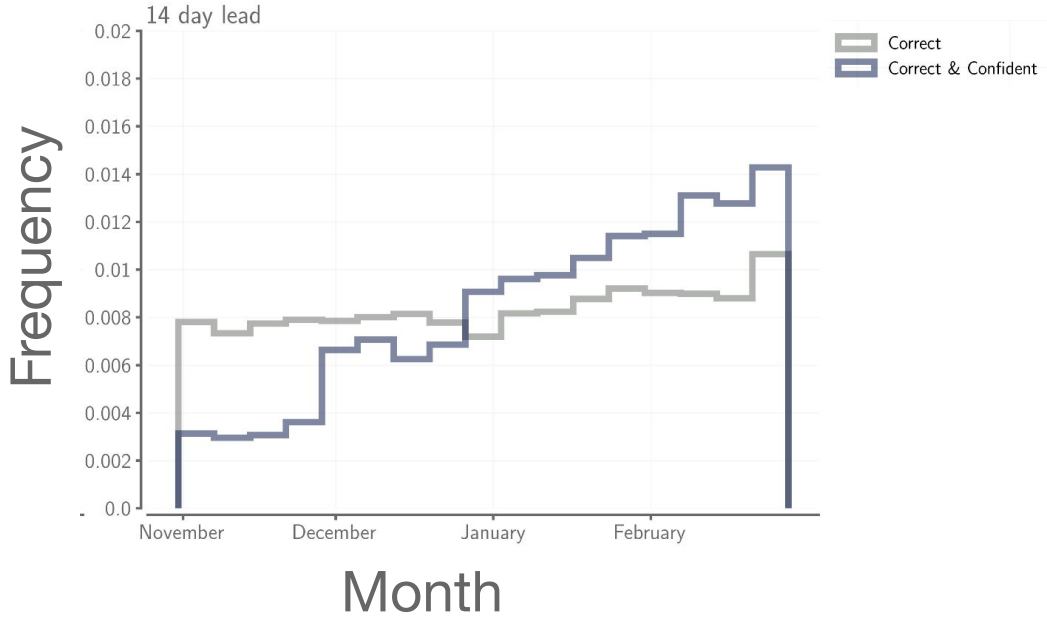


ERA-5:

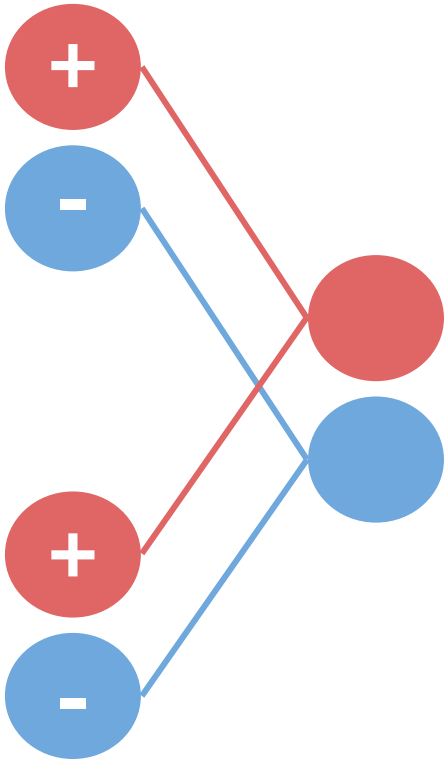


Early vs. Late Winter Dependence:

Late winter has more network-identified forecasts of opportunity



What is the relative role of the MJO and ENSO in midlatitude subseasonal predictability?



Let's say the correct prediction is **positive**… there are a couple ways to get a correct prediction:

- **ENSO** network correctly predicts **positive**
- **MJO** network correctly predicts **positive**
- **ENSO** ***and*** **MJO** network correctly predict **positive**

Individual Network Contribution

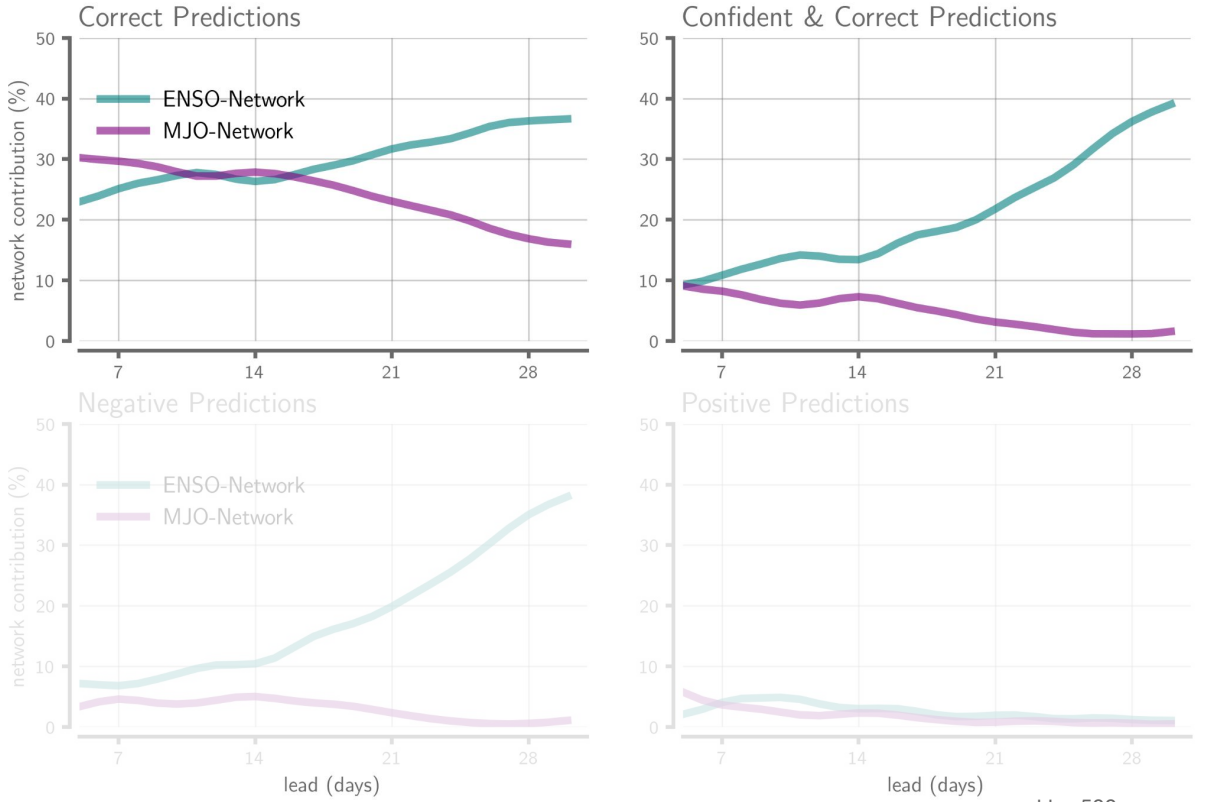
frequency that a specific network makes a correct (and confident) prediction

Correct Predictions:

- MJO: until ~10 days
- ENSO: after 2 weeks

Confident & Correct:

- ENSO > MJO



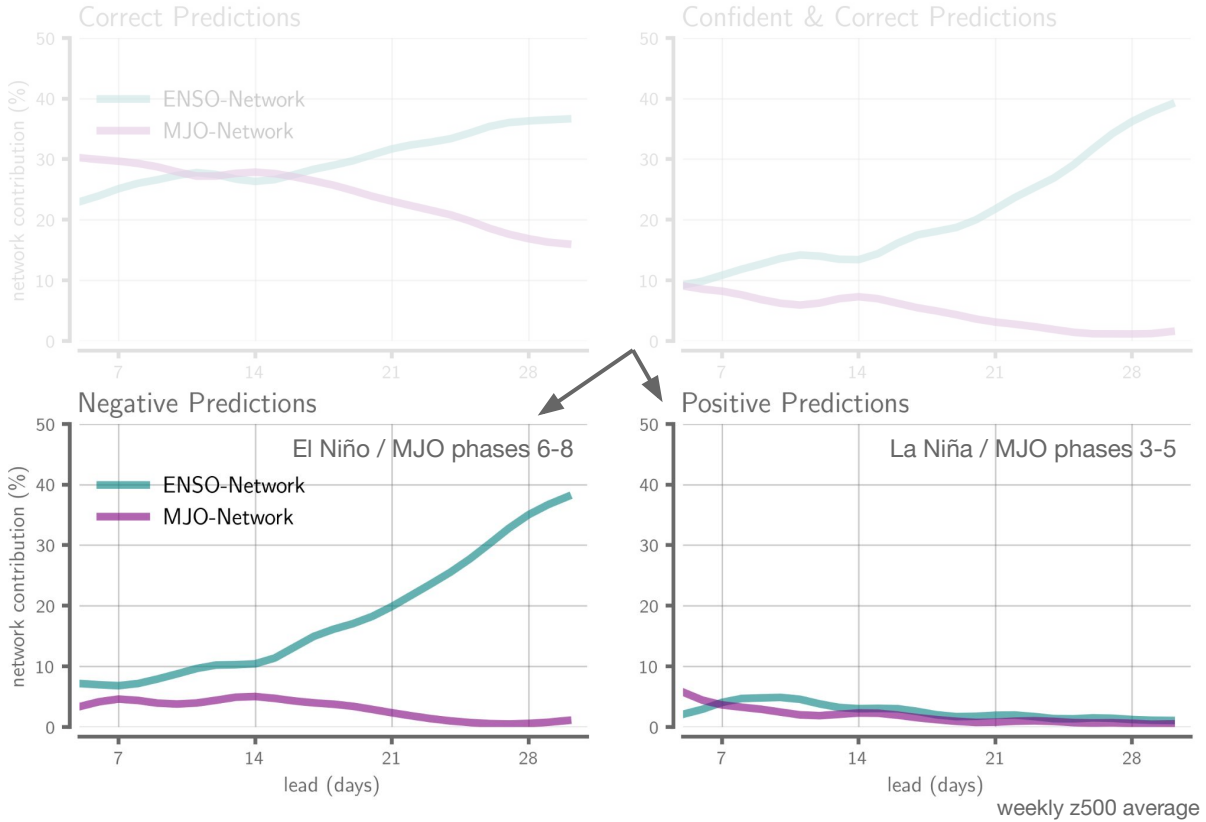
weekly z500 average

Individual Network Contribution

frequency that a specific network makes a correct prediction

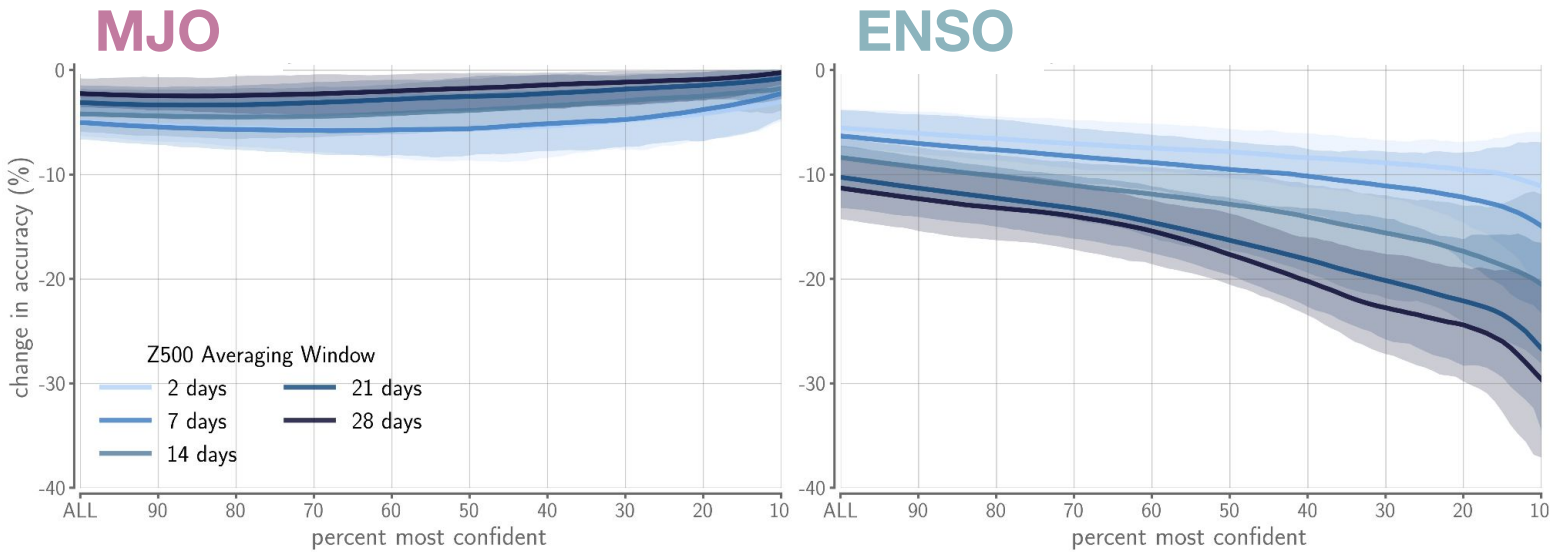
Negative Predictions: ENSO > MJO

Positive Predictions: ENSO ~ MJO

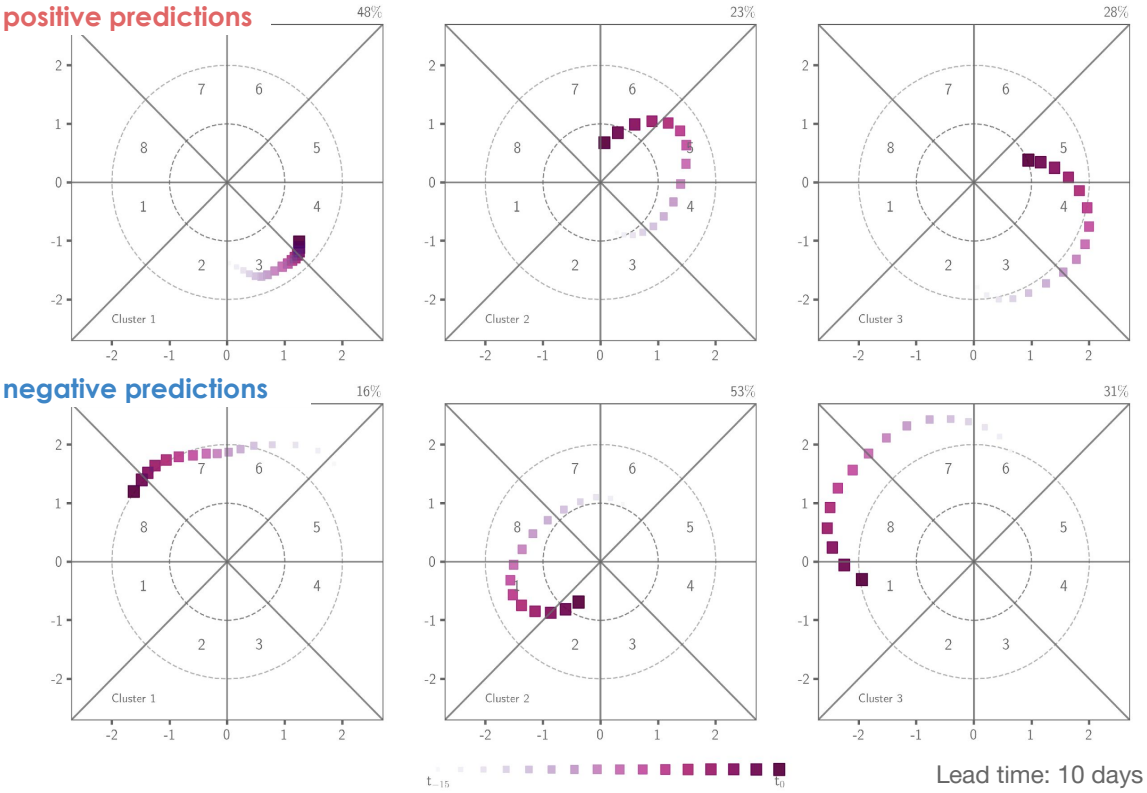


Contribution of MJO- & ENSO-network to skill

difference in skill when either the MJO or ENSO input is randomly shuffled



Confident & Correct Predictions: ENSO Neutral



Lead time: 10 days
Averaging window: 5 days

Clustered network-identified MJOs useful for subseasonal predictability:

- Anomalous strong then decays to neutral
- Persistent

Positive predictions are 2.5x more likely than negative predictions when ENSO is neutral

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Conclusions

- Forecasts of opportunity mainly during late boreal winter
- ENSO is a greater source for state-dependent subseasonal predictability
- When ENSO is neutral:
  - Anomalously strong and/or persistent MJO events provide the most midlatitude subseasonal predictability
  - MJO is particularly useful when predicting positive anomalies

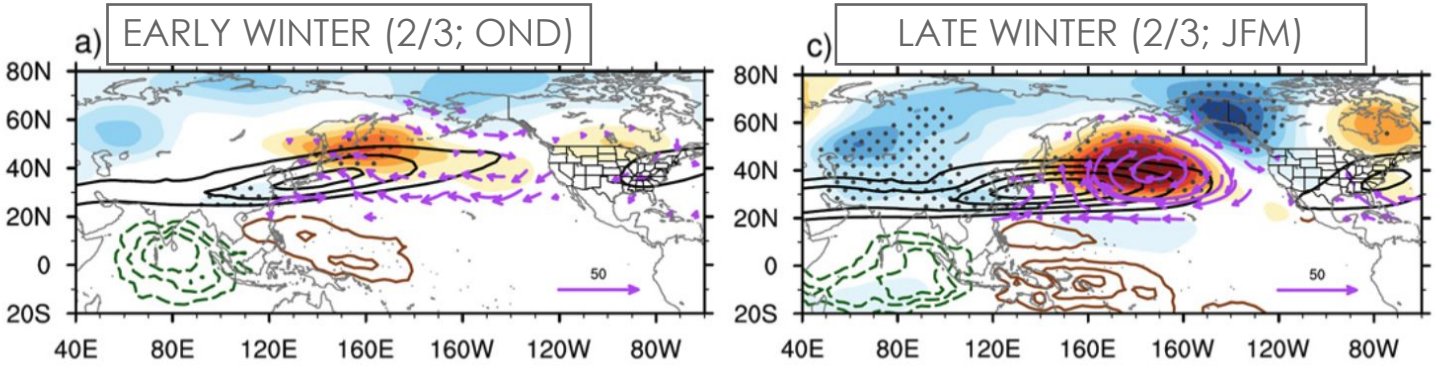
Caveats

- Predict the sign of the anomaly - results could change if framed as a regression problem
- Results are for the pre-industrial control run
  - results may change under a future, warmer climate

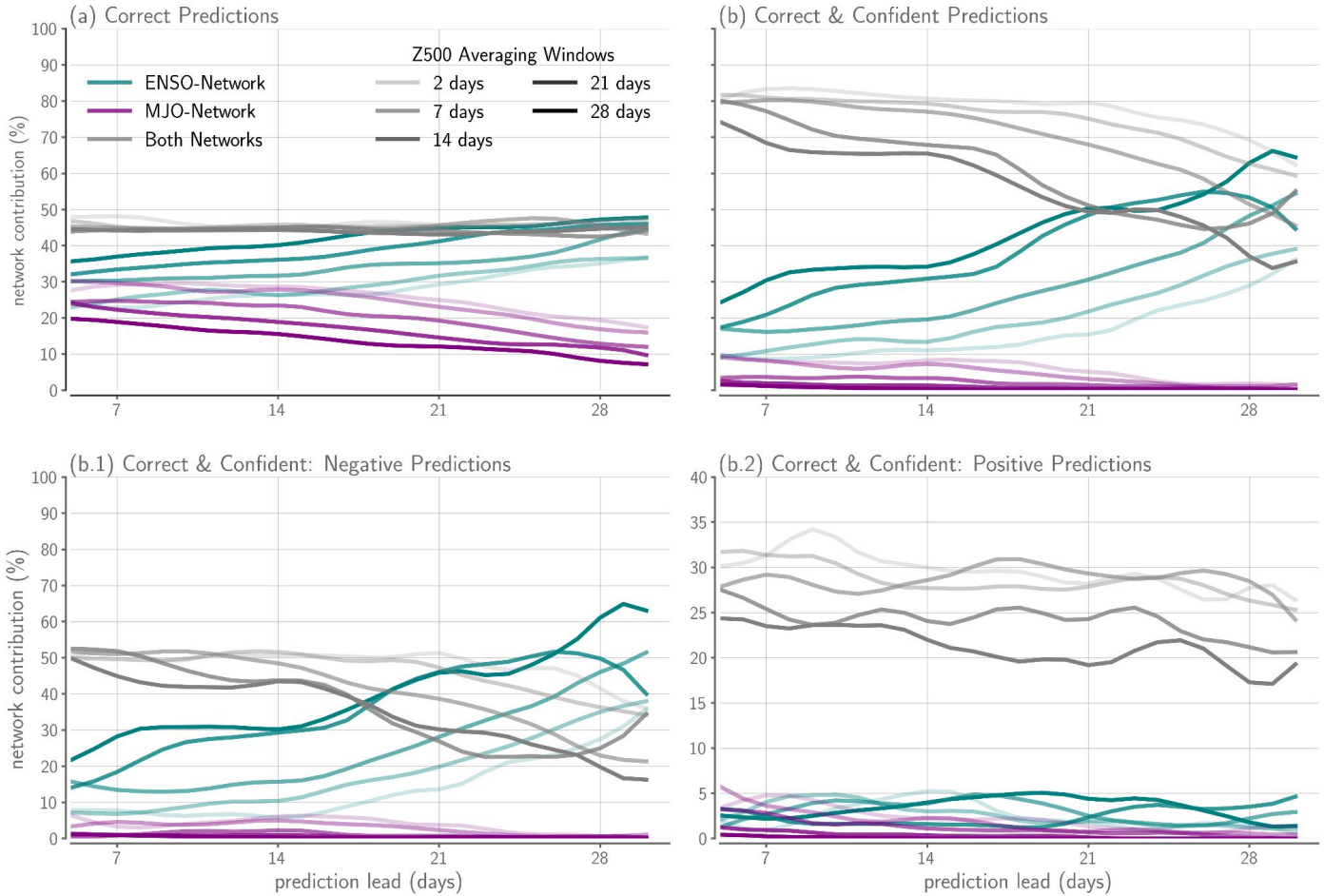
(Mayer & Barnes 2022; Du et al. 2023)

Additional Slides

Subseasonal Evolution of MJO teleconnections



Wang, Jiabao, et al. (2023).


(a) Correct Predictions
(b) Correct & Confident Predictions
(b.1) Correct & Confident: Negative Predictions
(b.2) Correct & Confident: Positive Predictions
Z500 Averaging Windows
ENSO-Network
MJO-Network
Both Networks
2 days
7 days
14 days
21 days
28 days
network contribution (%)
prediction lead (days)