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

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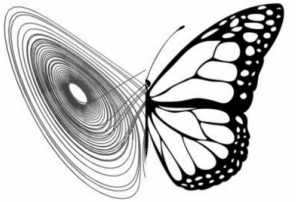
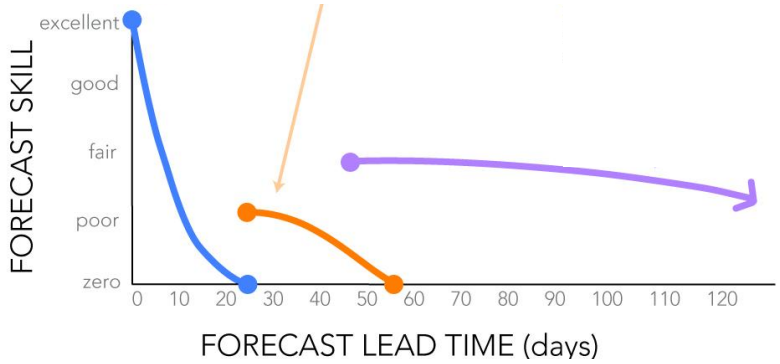
*Equal Contribution

11 June 2024

Subseasonal Timescales (2 weeks ~ 2 months)



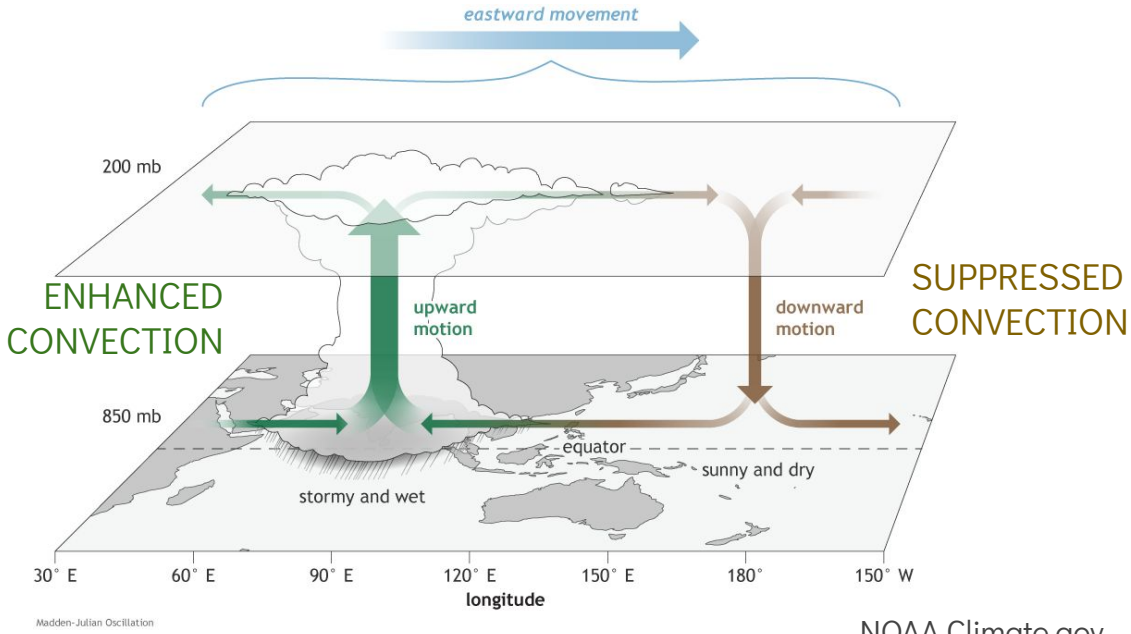
- Difficult to predict - often, neither atmospheric initial conditions or slower-varying boundary conditions provide sufficient information
- “Forecasts of Opportunity”: specific conditions in the earth system that are known to provide improved skill on these timescales



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

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



NOAA Climate.gov

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

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

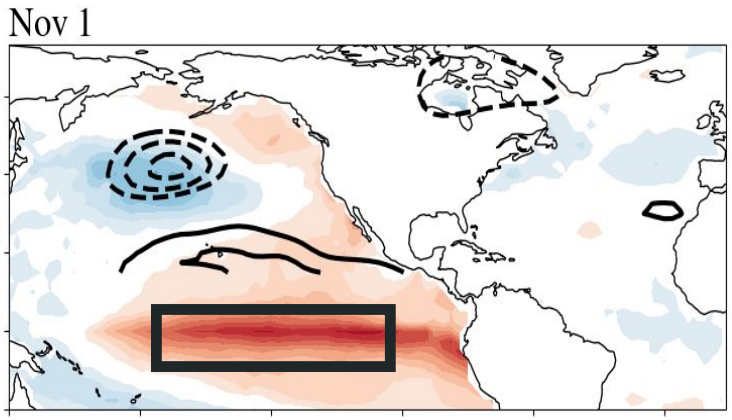


Figure courtesy of Will Chapman

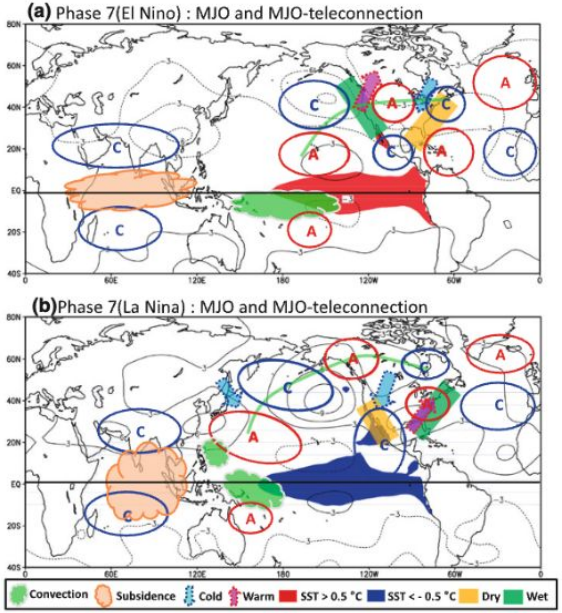


Figure 10 (Moon et al. 2011)

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

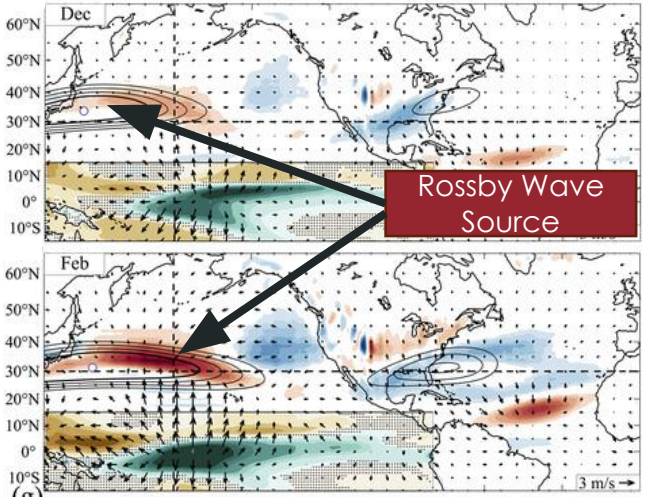
William E. Chapman, Aneesh C. Subramanian, Shang-Ping Xie, Michael D. Sierks, F. Martin Ralph, and Youichi Kamae

Online Publication: 15 Jun 2021

Print Publication: 01 Jul 2021

DOI: https://doi.org/10.1175/JCLI-D-20-0391.1

Page(s): 5899–5921

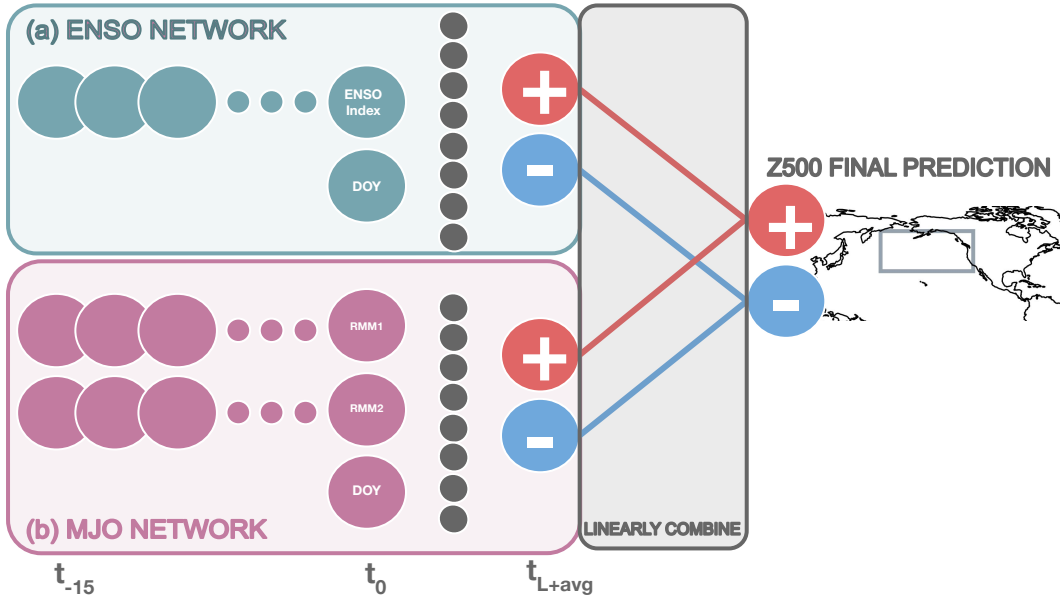


Chapman et al. 2021

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

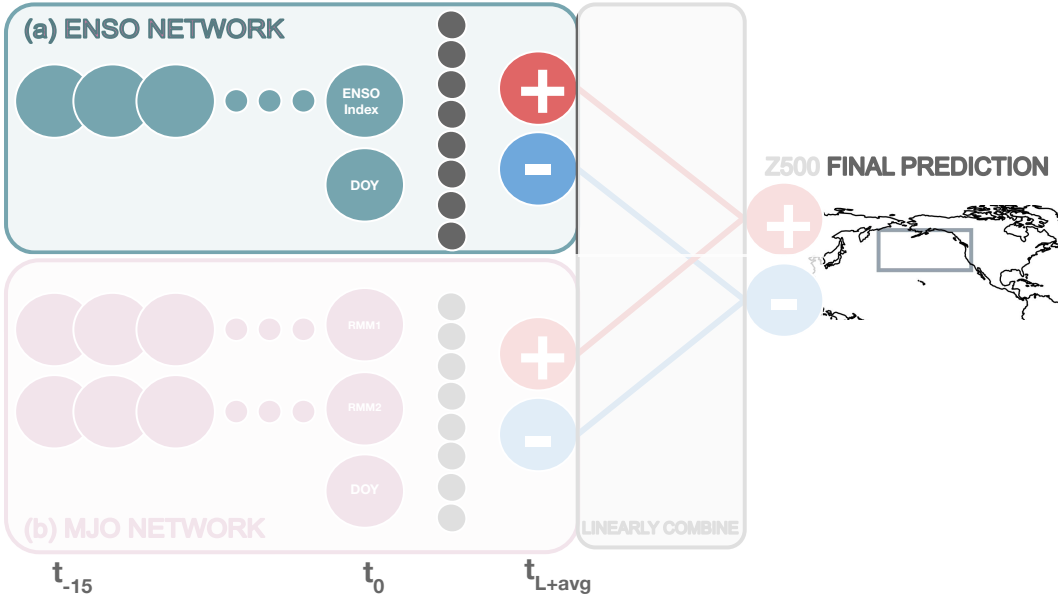
Exploring the relative importance of sources of predictability

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



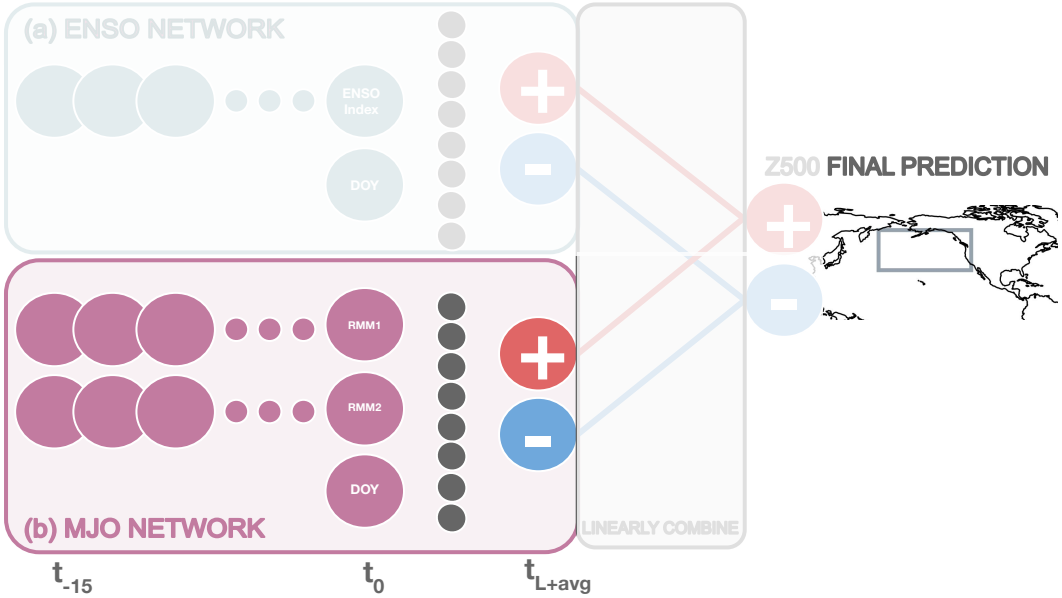
DATA: CESM2-PI

Exploring the relative importance of sources of predictability



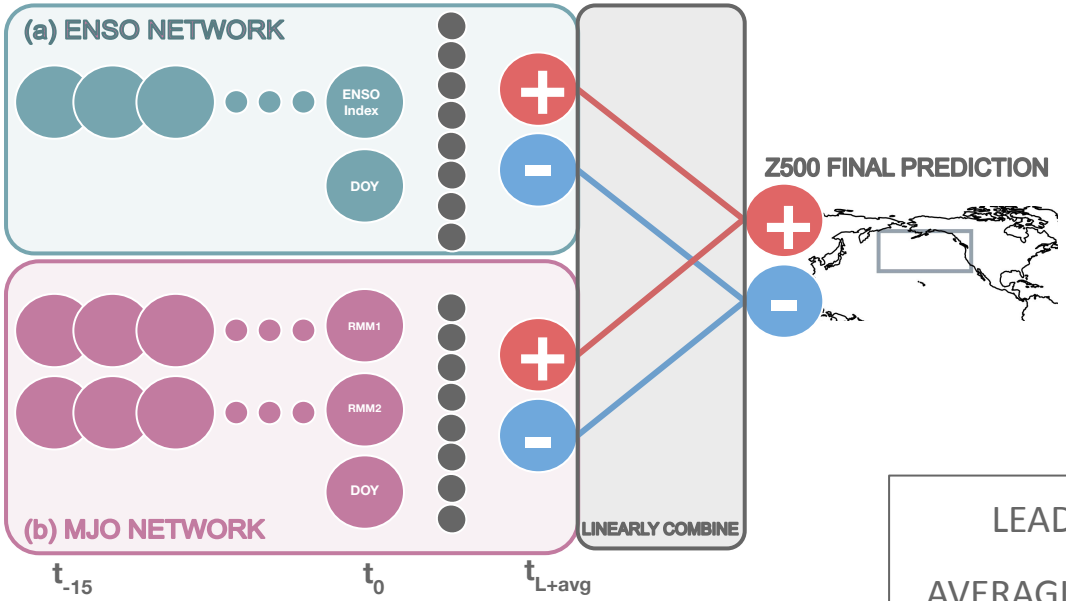
Mayer*, Chapman*, and Manriquez (2024)

Exploring the relative importance of sources of predictability



Mayer*, Chapman*, and Manriquez (2024)

Exploring the relative importance of sources of predictability



LEADS (L): 5-30 days

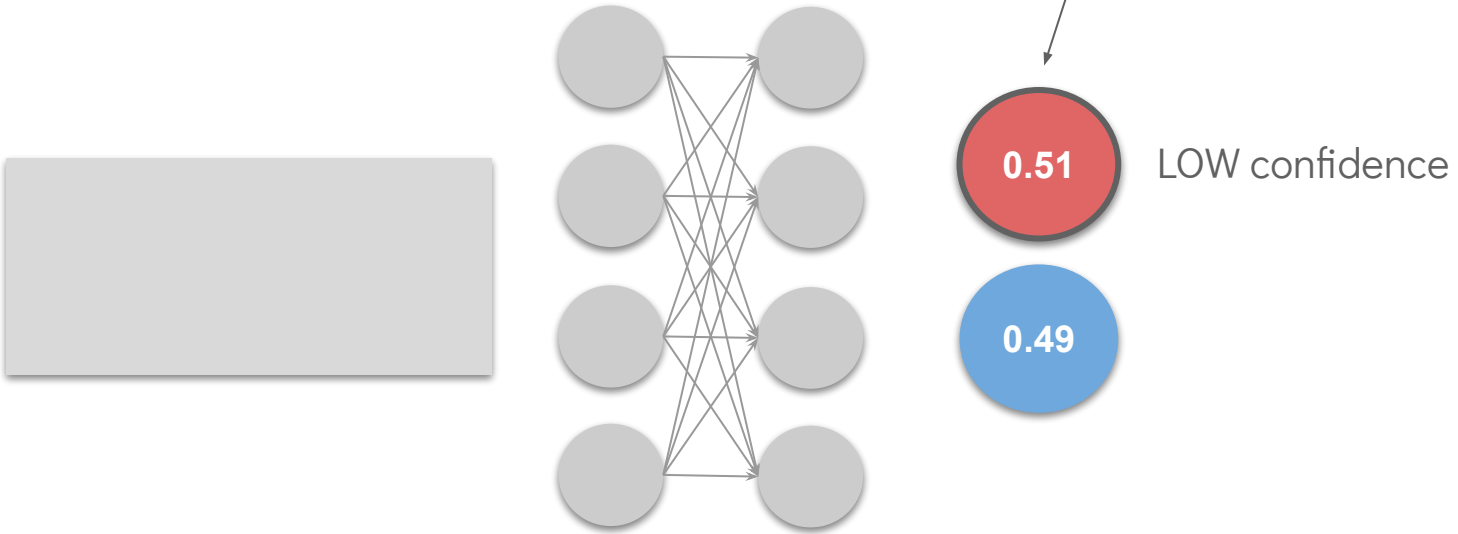
AVERAGING (avg): 2-30 days

Mayer*, Chapman*, and Manriquez (2024)

Forecasts of Opportunity... identified by a Neural Network

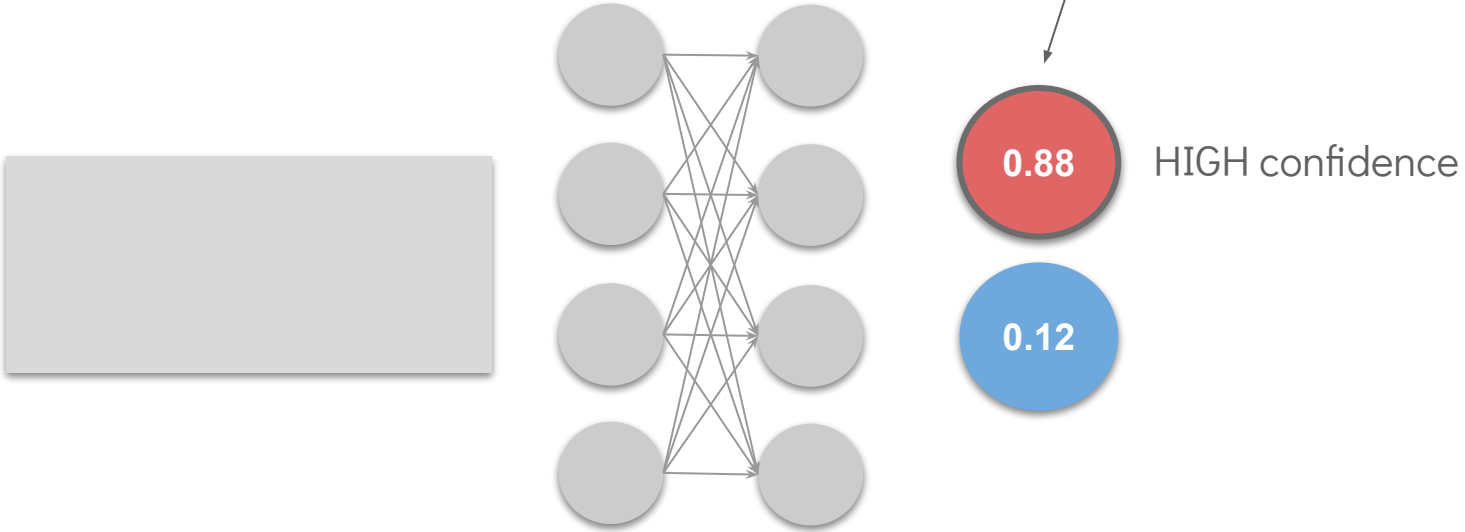
… starting from the end

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

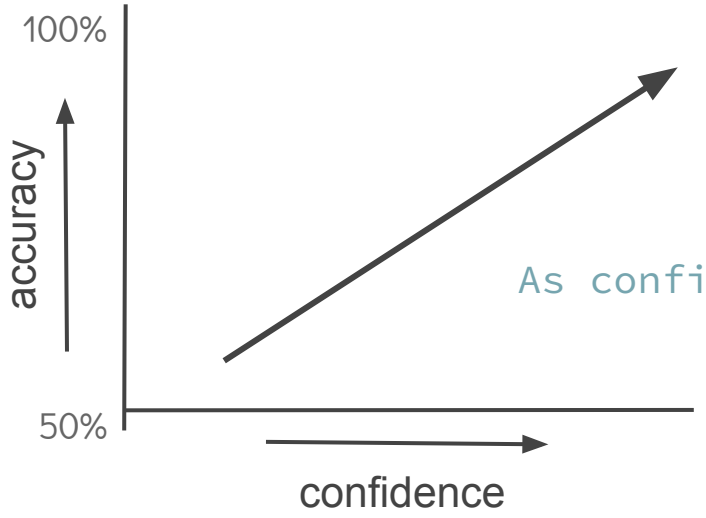


… starting from the end

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

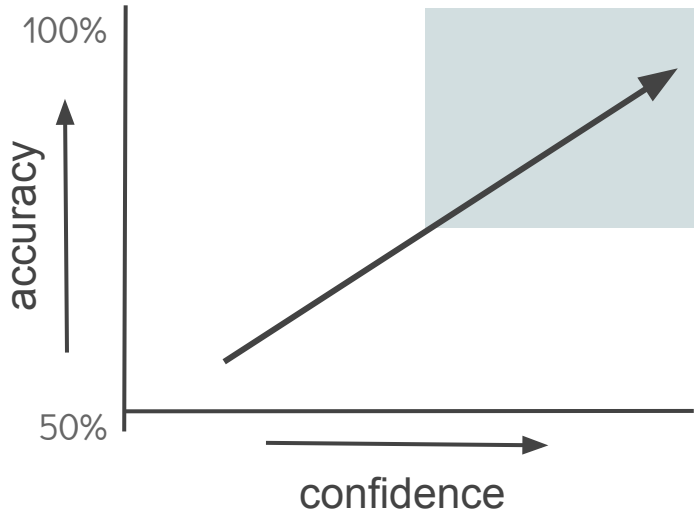


… starting from the end



As confidence increases, does accuracy?

… starting from the end

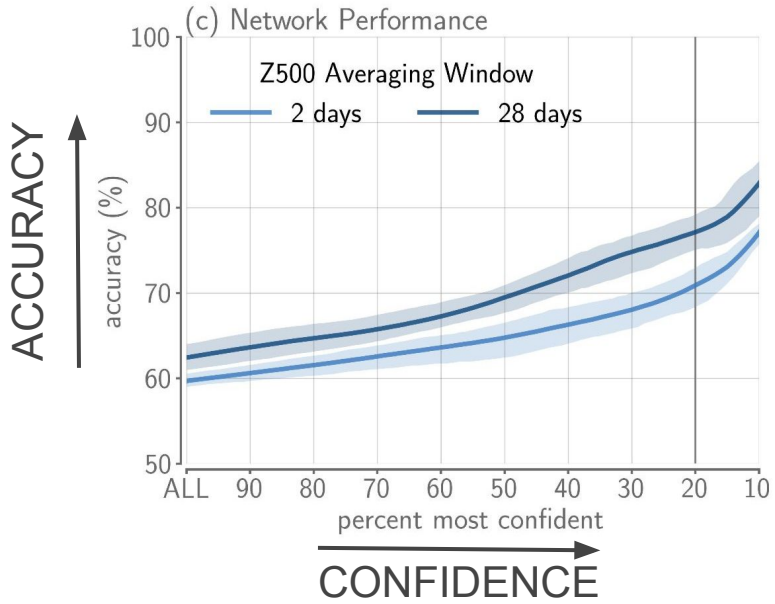


Forecasts of Opportunity

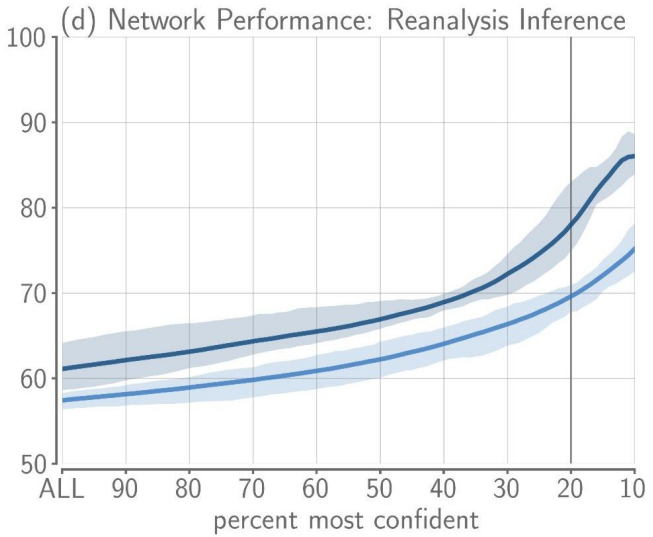
periods of enhanced predictability identified using network confidence (Mayer & Barnes 2021)

Exploring the relative importance of sources of predictability

CESM2-PI:

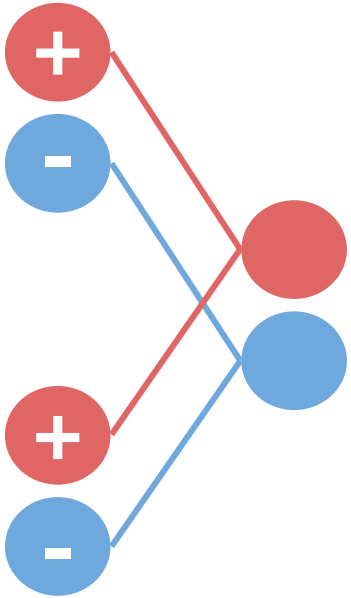


ERA-5:



Mayer*, Chapman*, and Manriquez (2024)

Exploring the relative importance of sources of predictability



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

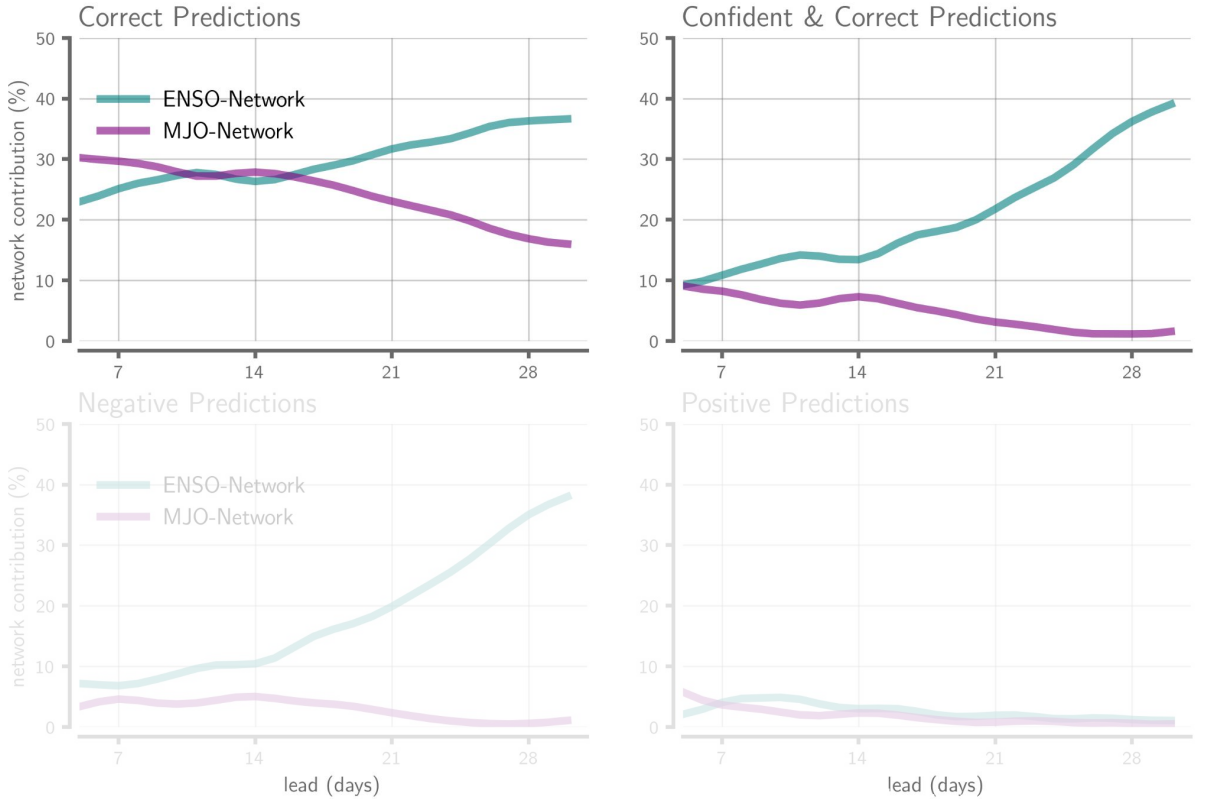
- **ENSO** *and* **MJO** network correctly predict **positive**
- **ENSO** network correctly predicts **positive**
- **MJO** network correctly predicts **positive**

Individual Network Contribution

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

ENSO network contributes more frequently to **correct predictions** than the MJO network after ~2 weeks

ENSO network alone contributes more frequently to **correct & confident predictions** than the MJO network



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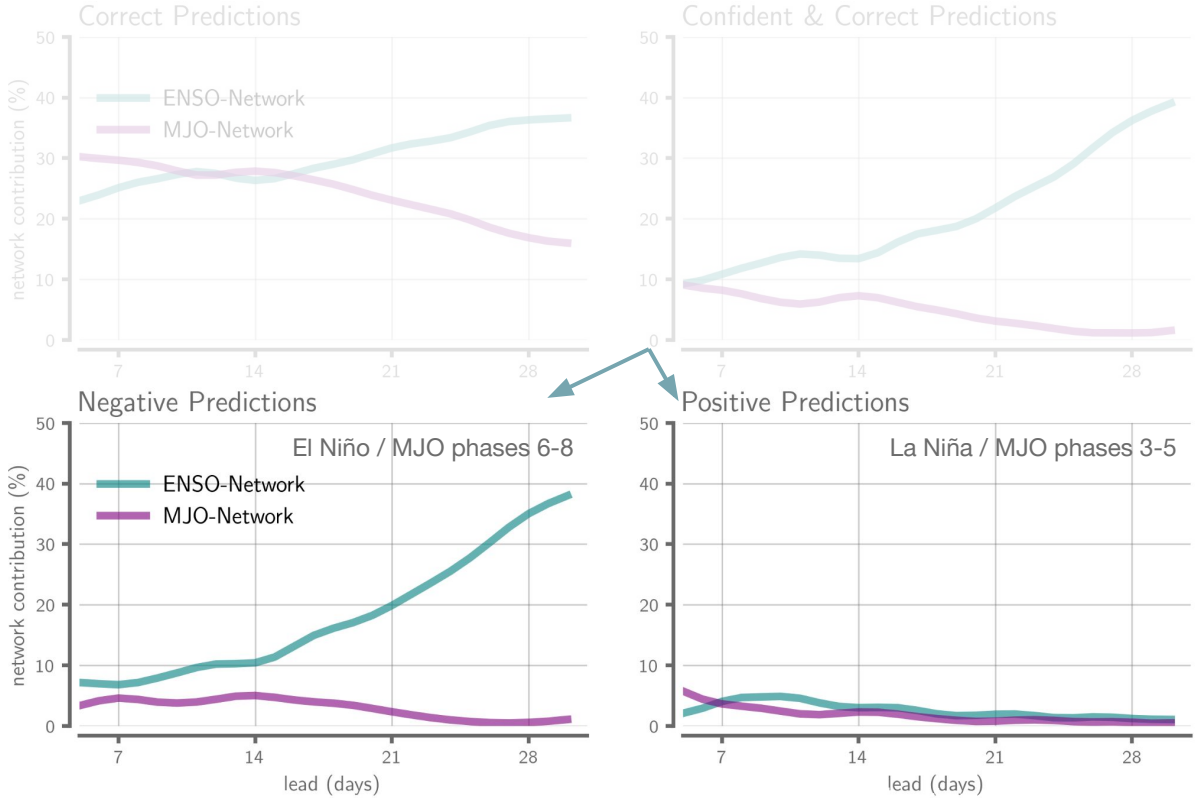
weekly z500 average

Individual Network Contribution

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

Negative Predictions:
Similar to all correct & confident predictions

Positive Predictions:
ENSO and MJO networks contribute equally to correct & confident predictions



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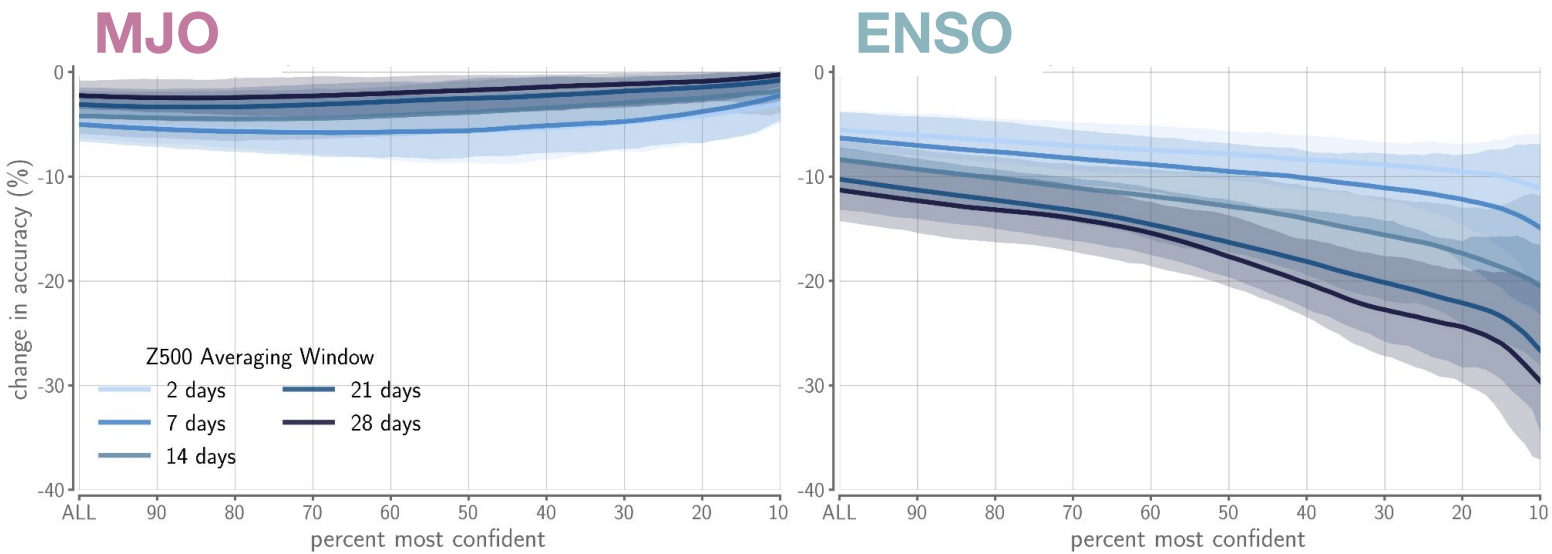
weekly z500 average

Contribution of MJO- & ENSO-network to skill

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



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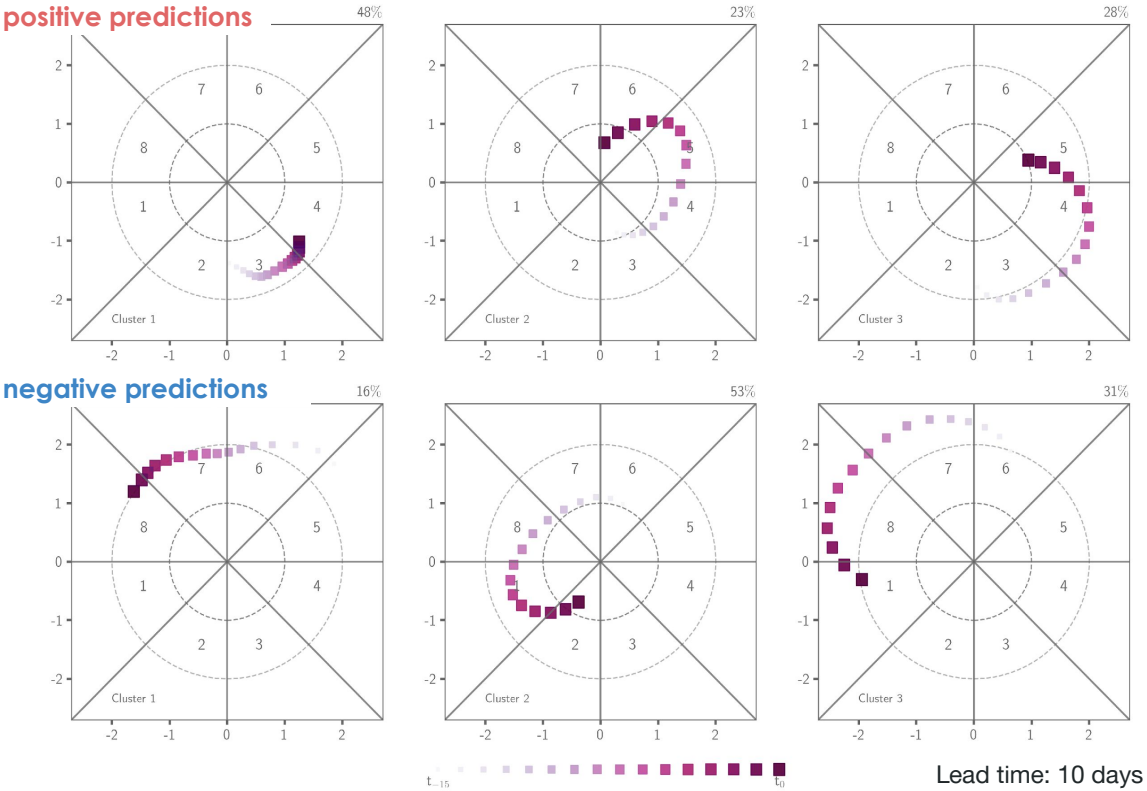
Confident & Correct Predictions: ENSO Neutral



Lead time: 10 days
Averaging window: 5 days

Clustered network-identified MJOs useful for subseasonal predictability:

- Anomalous strong
- Strong then decays to neutral
- Persistent

Mayer*, Chapman*, and Manriquez (2024)

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Conclusions

- 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
- (Forecasts of opportunity mainly during late boreal winter)

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)

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Future Work

- How model dependent are these results?
- How might the relative importance change in a future climate?
- Explore other regions, modes of variability and timescales

Geophysical Research Letters

Research Letter | Open Access

Exploring the Relative Importance of the MJO and ENSO to North Pacific Subseasonal Predictability

Kirsten J. Mayer, William E. Chapman, William A. Manriquez

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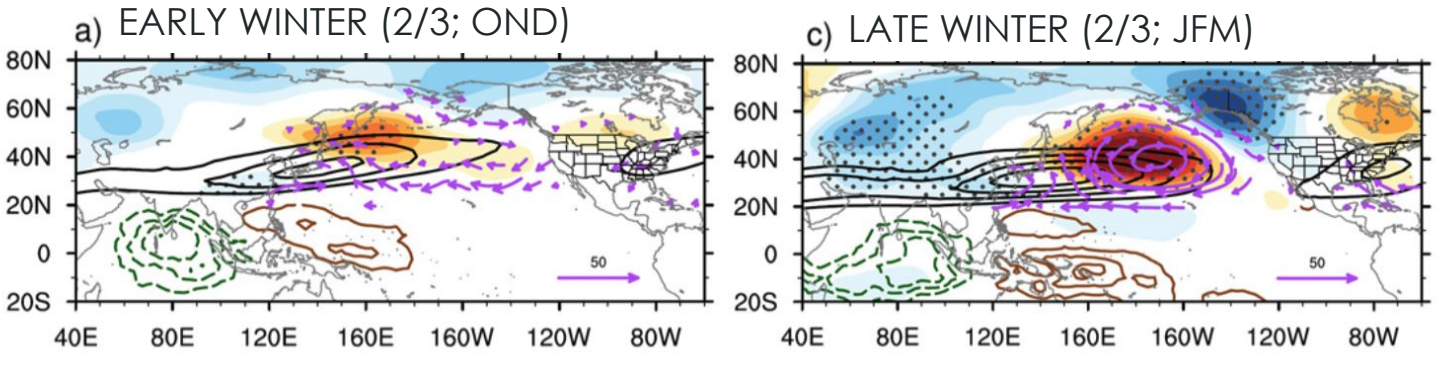
Kirsten J. Mayer and William E. Chapman contributed equally to this work.

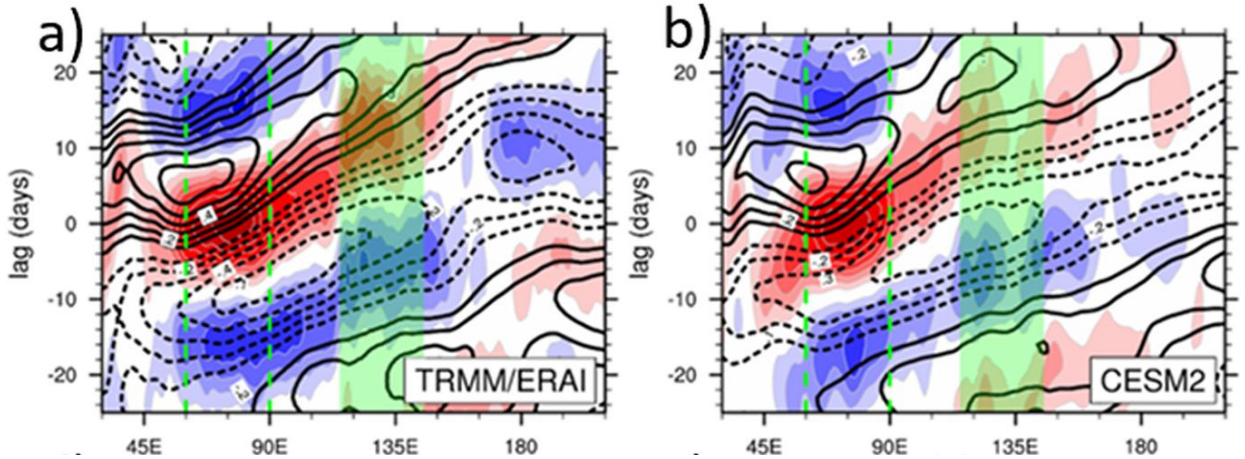
Additional Slides

Subseasonal Evolution of MJO teleconnections



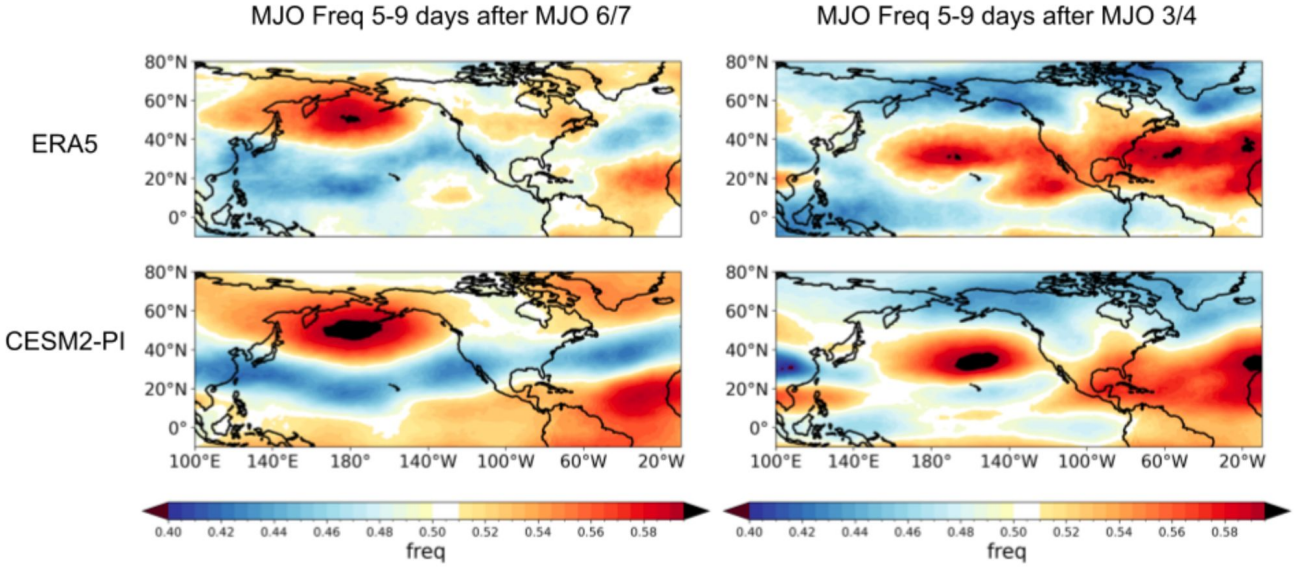
Wang, Jiabao, et al. (2023)

CESM2-Historical MJO



Meehl et al. (2020)

CESM2-PI MJO Teleconnections

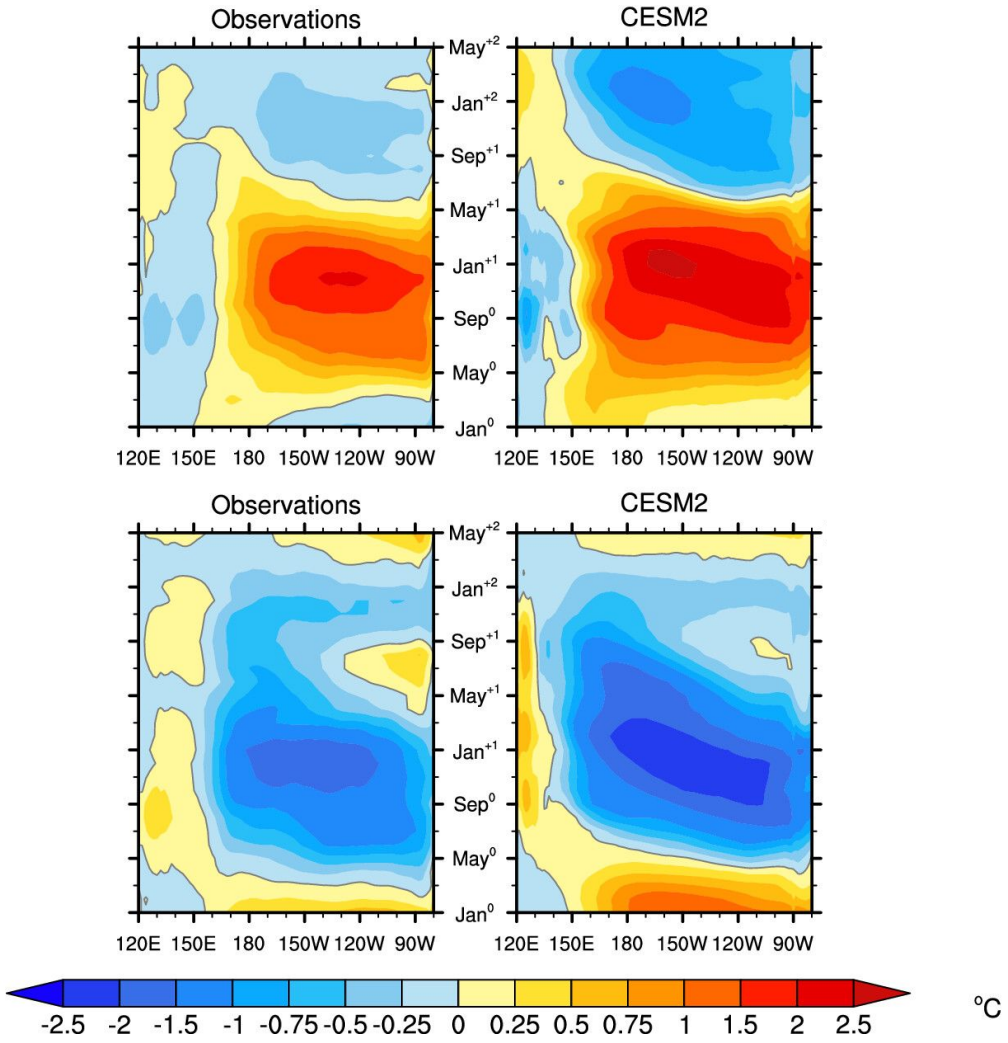


CESM2-PI ENSO

Capotondi et al. (2020)

CESM2-PI simulation:

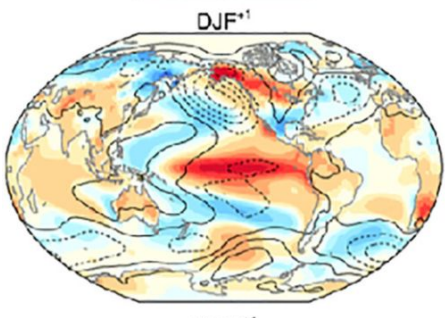
- ENSO amplitude is ~ 30% > observed
- ENSO extends too far westward



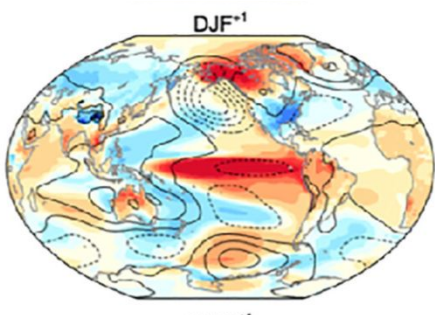
CESM2-PI ENSO (SLP) Teleconnection

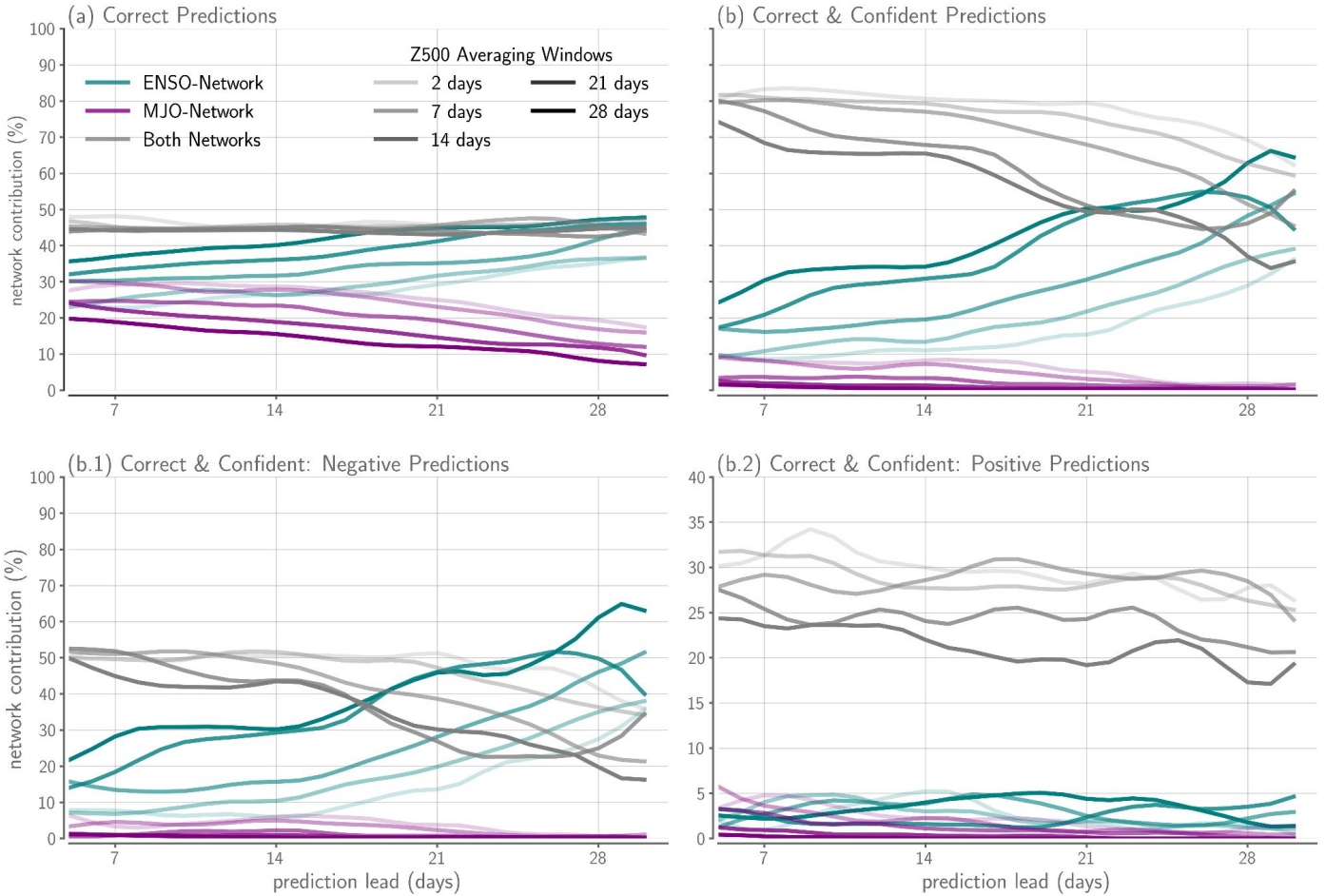
Capotondi et al. (2020)

OBS



CESM




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

Early vs. Late Winter Dependence:

Late winter has more network-identified forecasts of opportunity