

Predicting the 2023/24 El Nino and its climate impacts over North America

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Climate Analysis Section, NSF NCAR

With Steve Yeager, Adam Phillips, Nan Rosenbloom and others

CESM Tutorial, 5 August 2024

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Geoscientific
Model Development



The Seasonal-to-Multiyear Large Ensemble (SMYLE) prediction system using the Community Earth System Model version 2

Stephen G. Yeager¹, Nan Rosenbloom¹, Anne A. Glanville¹, Xian Wu¹, Isla Simpson¹, Hui Li¹, Maria J. Molina¹, Kristen Krumhardt¹, Samuel Mogen², Keith Lindsay¹, Danica Lombardozzi¹, Will Wieder¹, Who M. Kim¹, Jadwiga H. Richter¹, Matthew Long¹, Gokhan Danabasoglu¹, David Bailey¹, Marika Holland¹, Nicole Lovenduski², Warren G. Strand¹, and Teagan King¹

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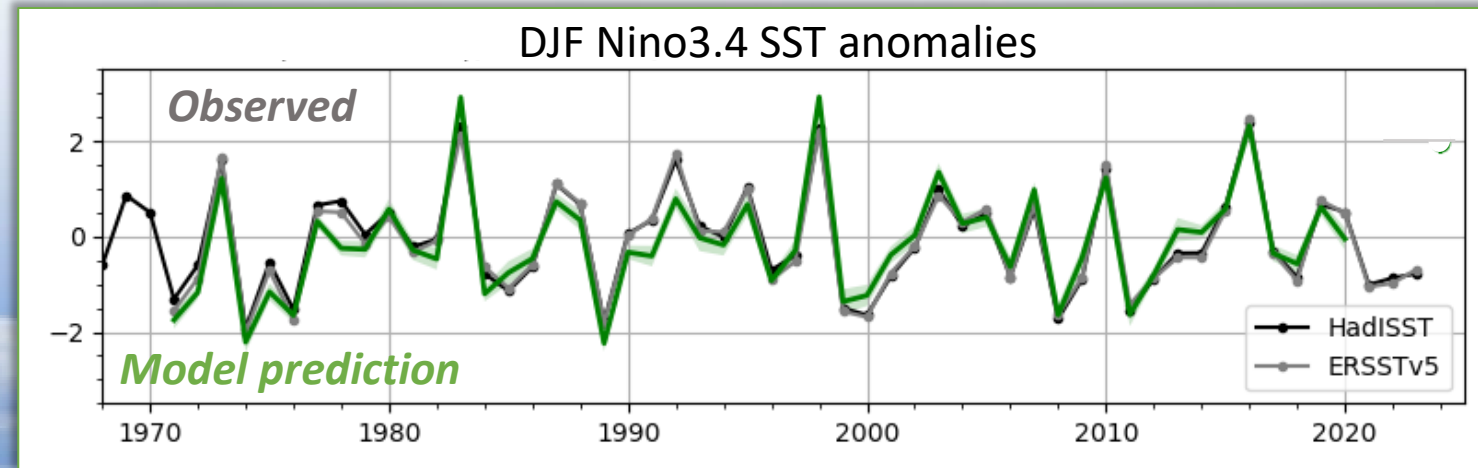


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**Boreal winter (DJF)
El Nino predictions
initialized from
November 1st are highly
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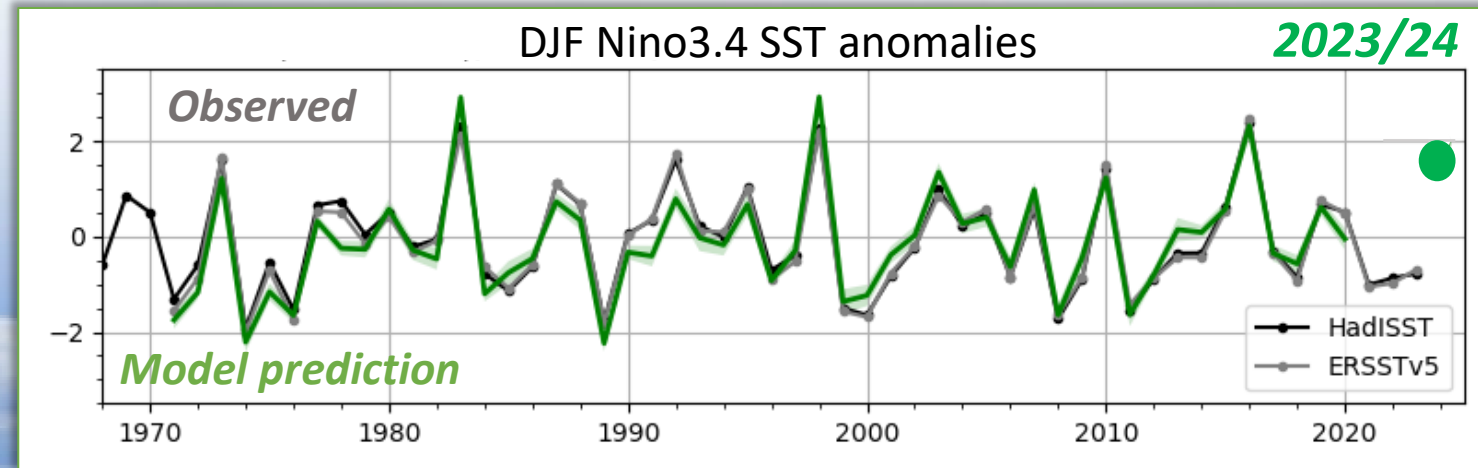


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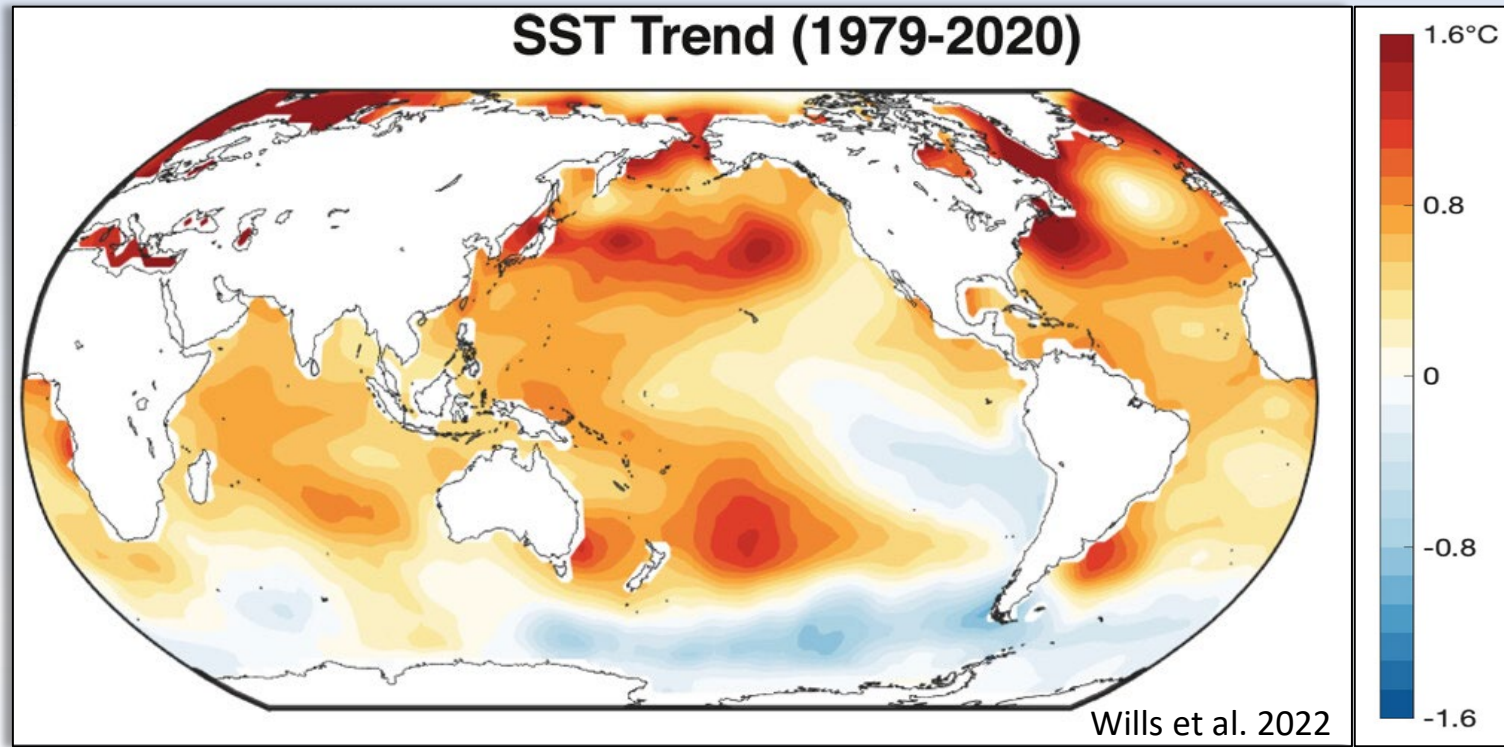
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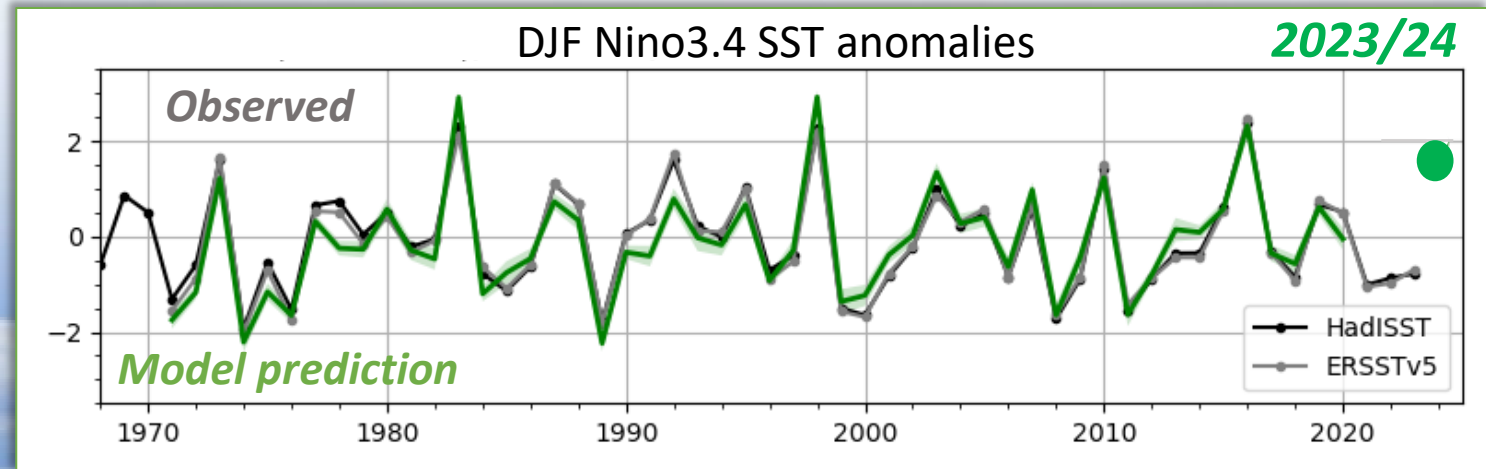
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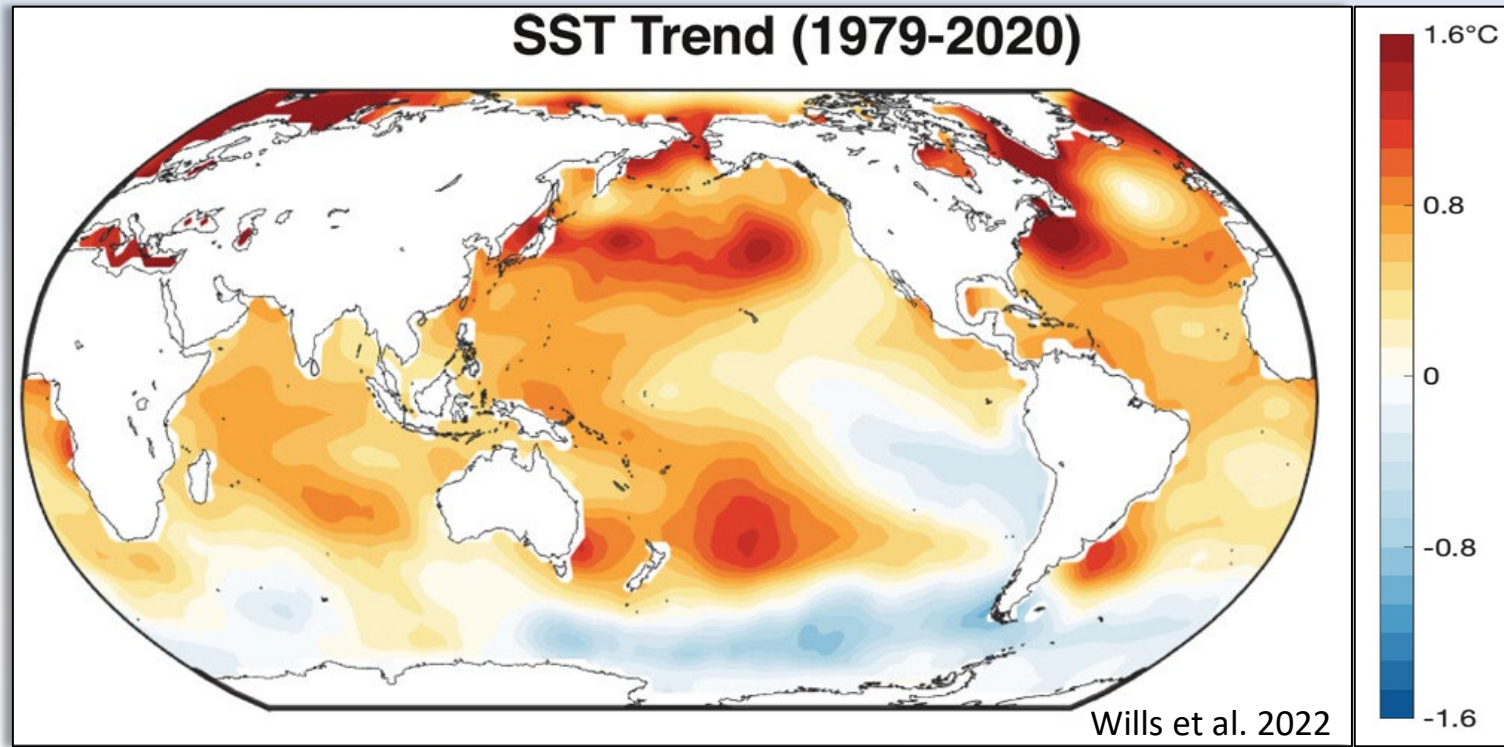
**Observed
background
climate
change**



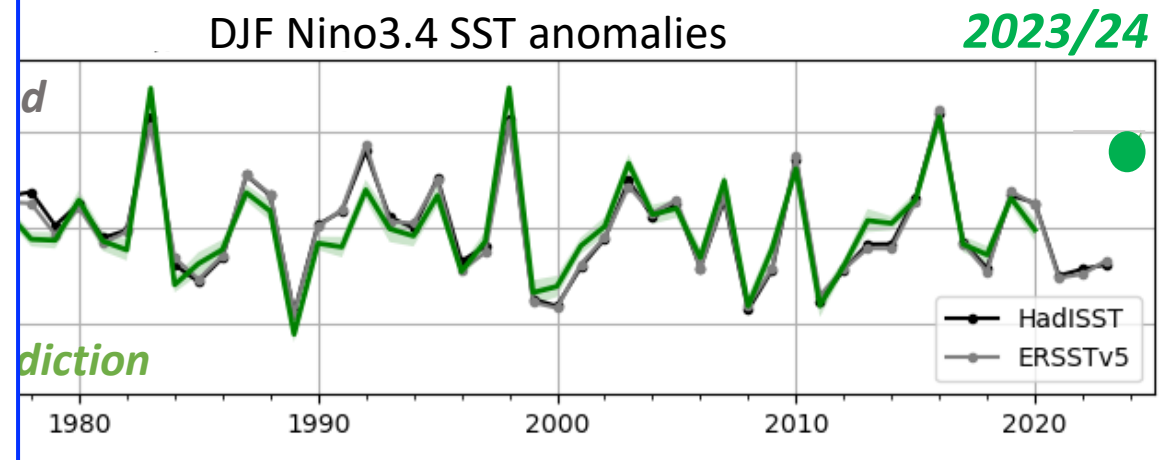
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**What are the climate impacts
from the 2023/24 El Nino and
how are they modified by
background climate change?**

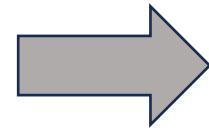


Experimental Design

COUPLED MODEL PREDICTIONS

SMYLE SST anomalies
Nov 2023 – Jun 2024
initialized predictions
from 1 Nov 2023
(20-member means)

**Plus observed SST
mean state + trends**



ATMOSPHERE/LAND MODEL

CAM6-1° AMIP
& 2023/24
radiative forcings
50 members

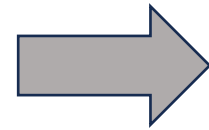
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Role of background climate change

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CAM6-1° AMIP
1979 counterfactual
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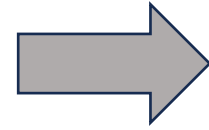
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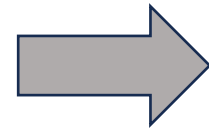
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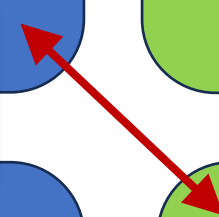
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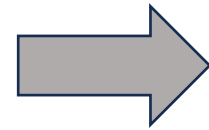
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COUPLED MODEL PREDICTION

Impact of observed SST trend & radiative forcing change

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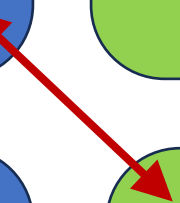
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MODEL

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Experimental Design

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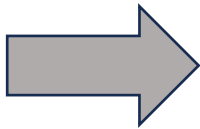
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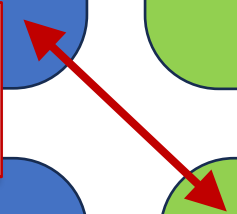
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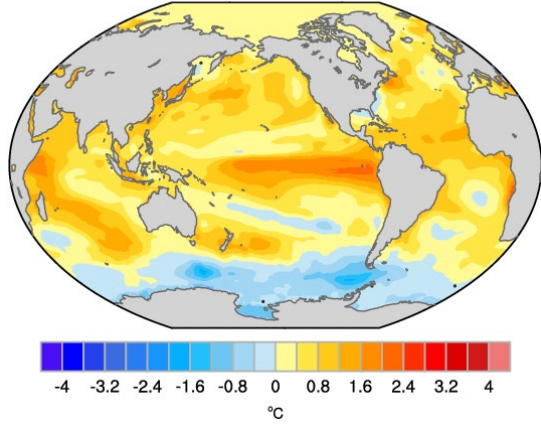
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DJF 2023/24

**El Nino +
Background
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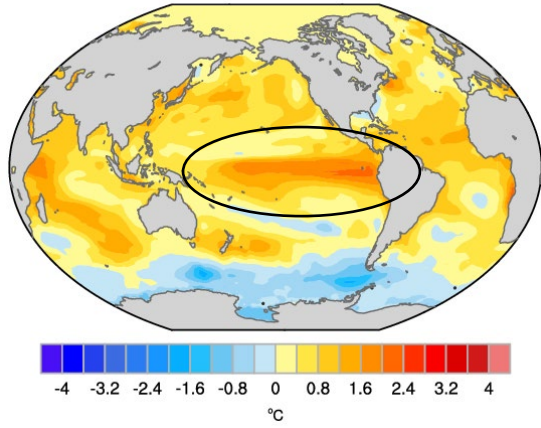
SST (prescribed)



DJF 2023/24

**El Nino +
Background
climate change**

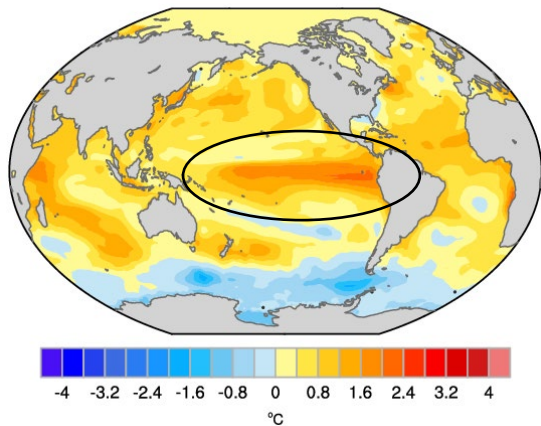
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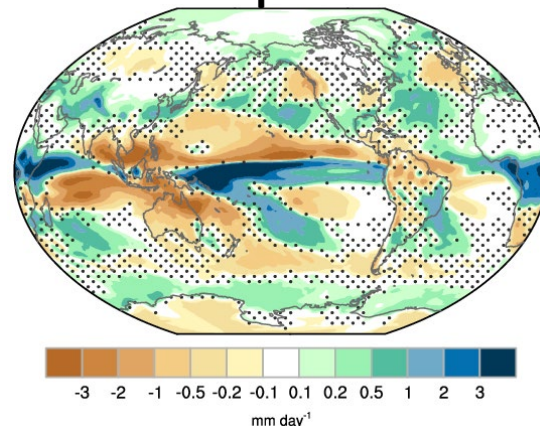
DJF 2023/24

El Nino + Background climate change

SST (prescribed)



Precipitation

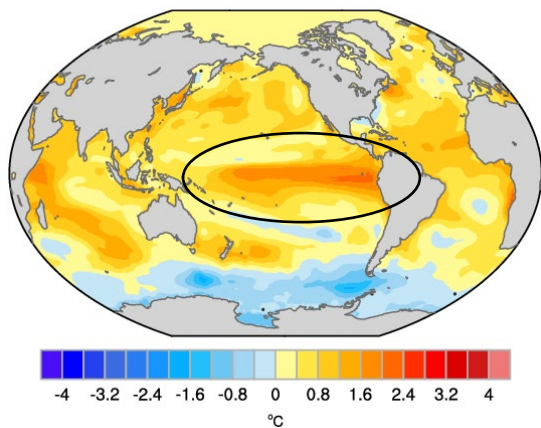


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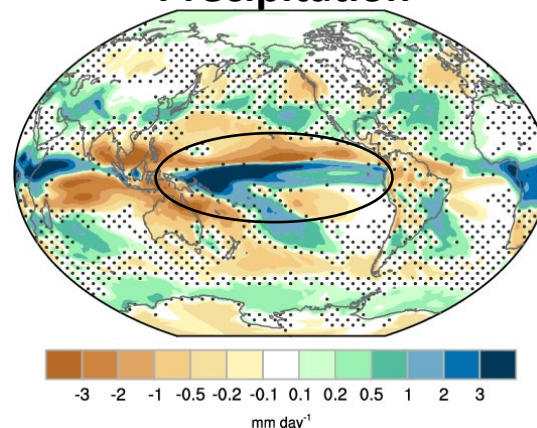
DJF 2023/24

El Nino + Background climate change

SST (prescribed)



Precipitation

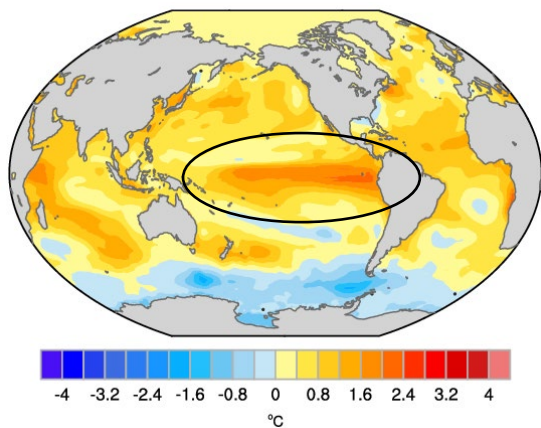


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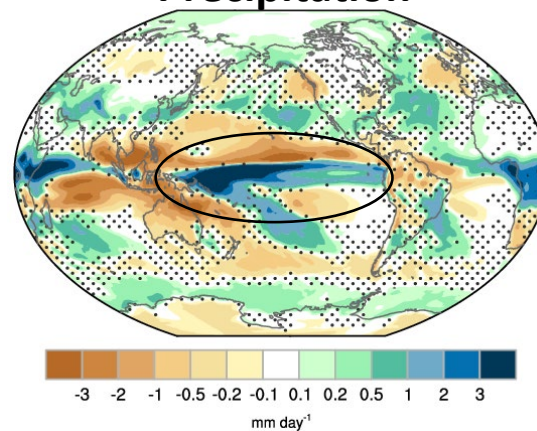
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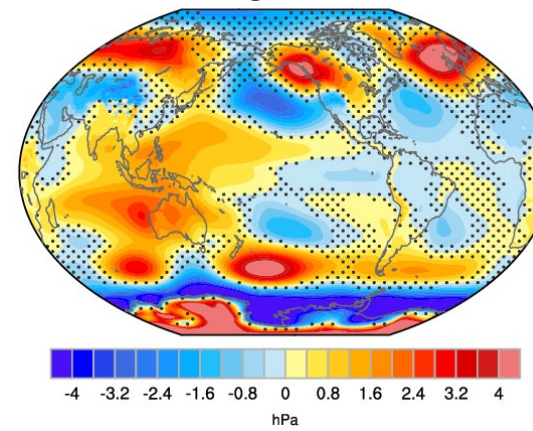


Precipitation



Stippling: insignificant

SLP

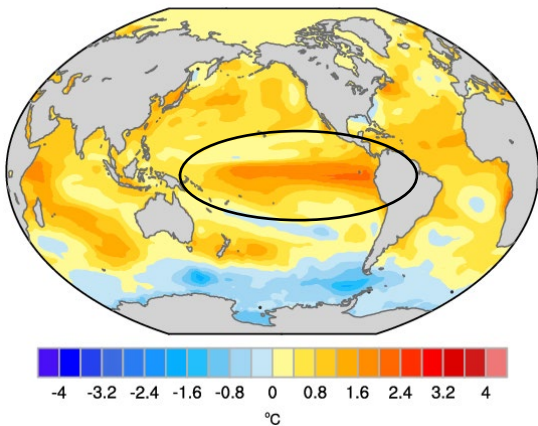


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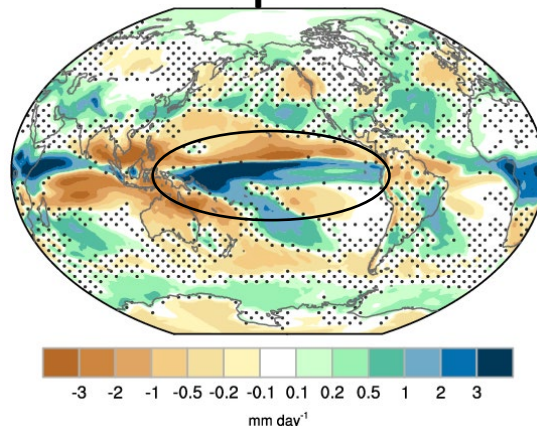
DJF 2023/24

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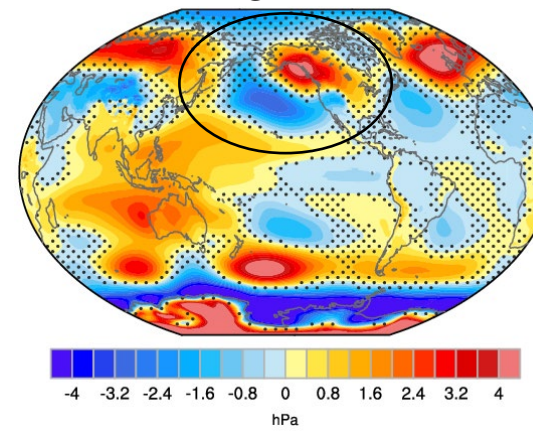


Precipitation



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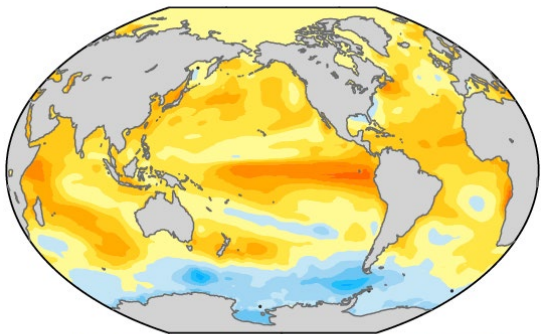


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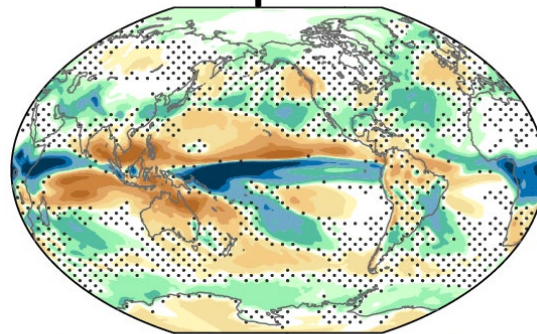
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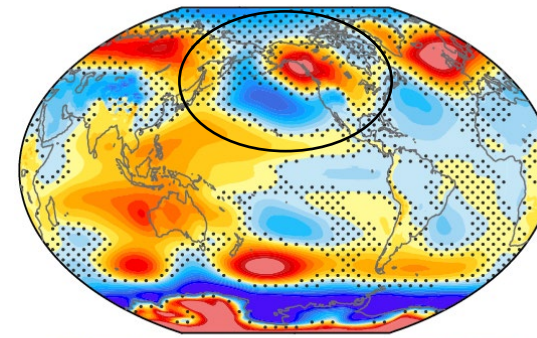
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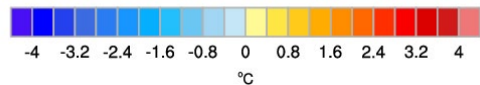
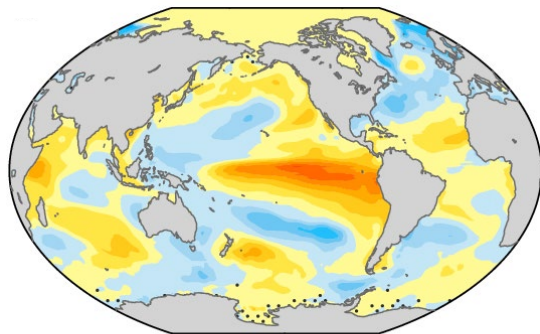
Precipitation



SLP



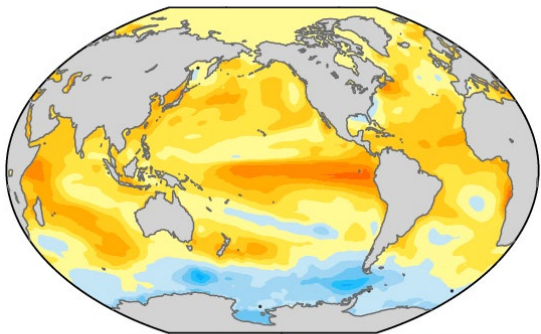
El Nino



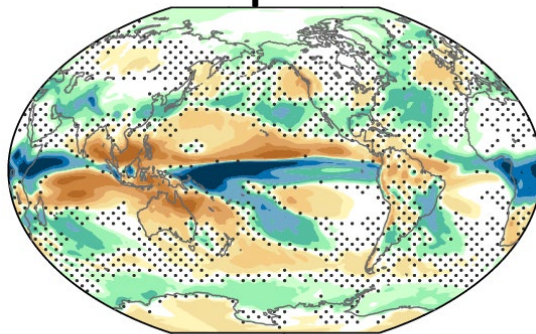
DJF 2023/24

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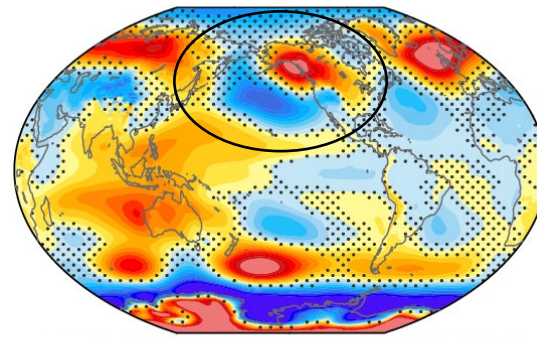
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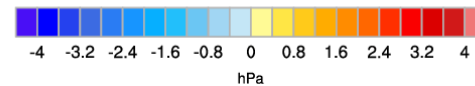
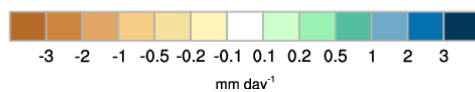
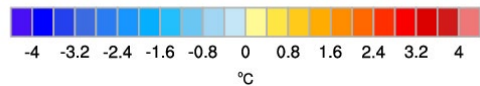
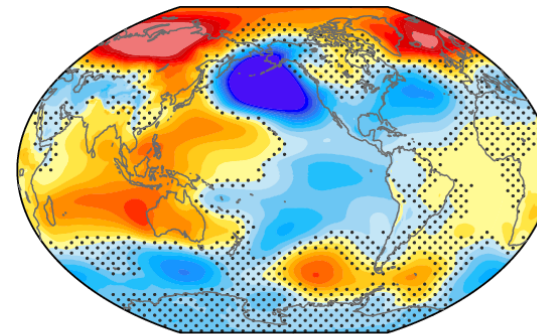
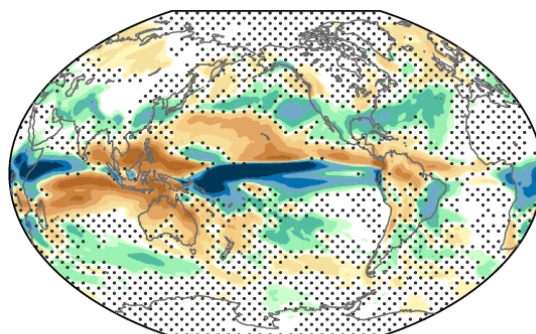
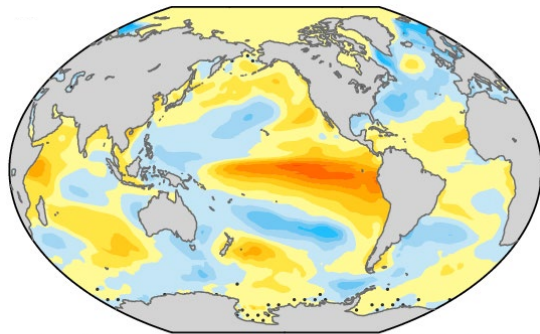
Precipitation



SLP



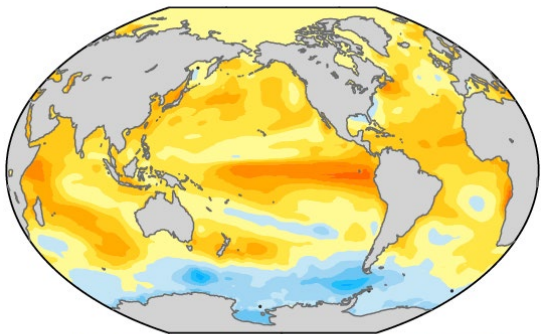
El Nino



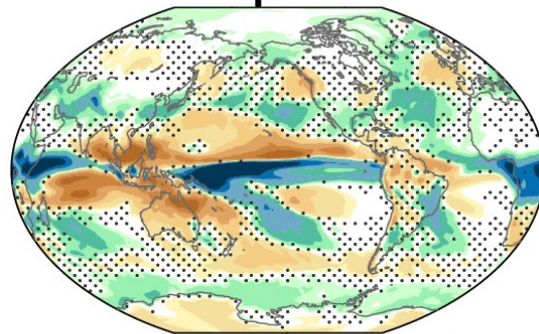
DJF 2023/24

El Nino +
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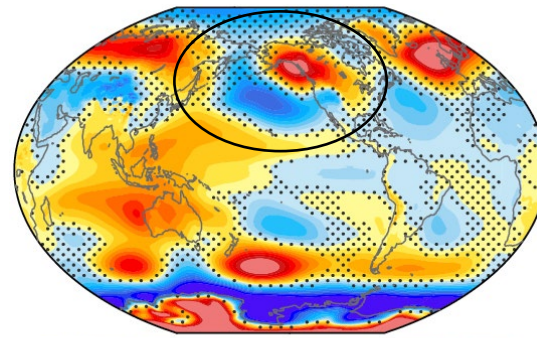
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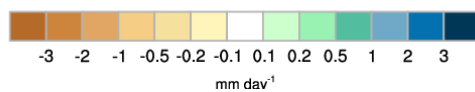
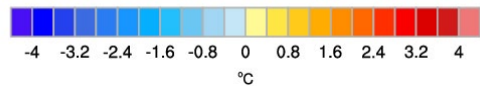
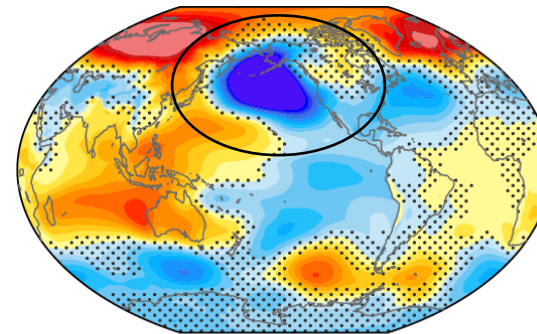
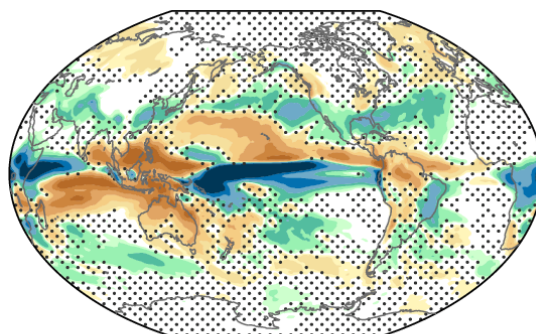
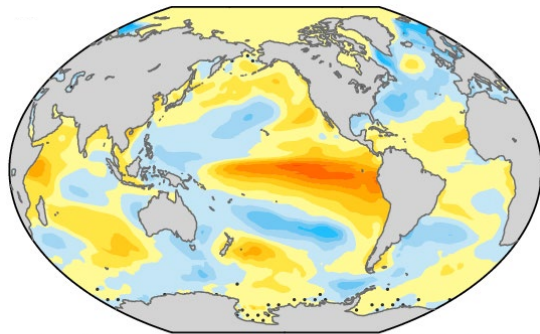
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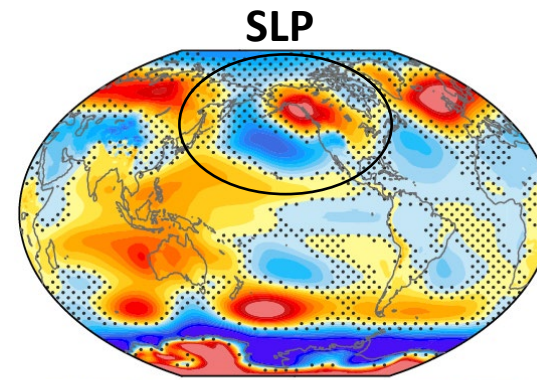
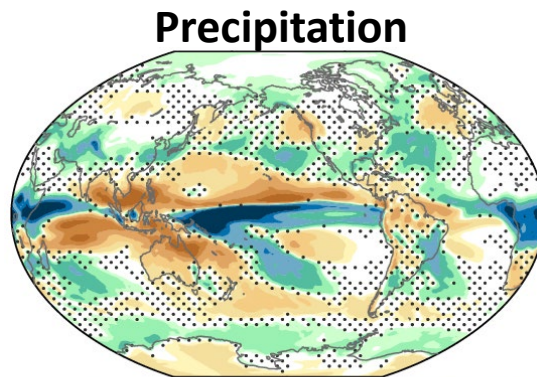
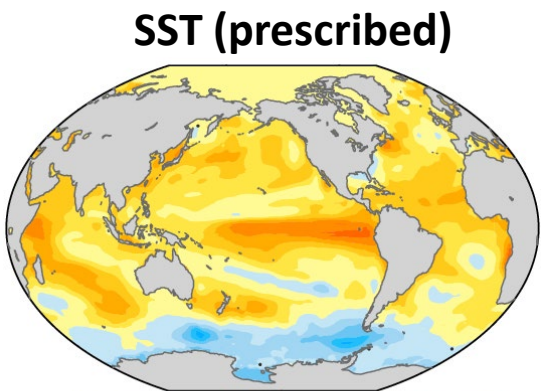


El Nino

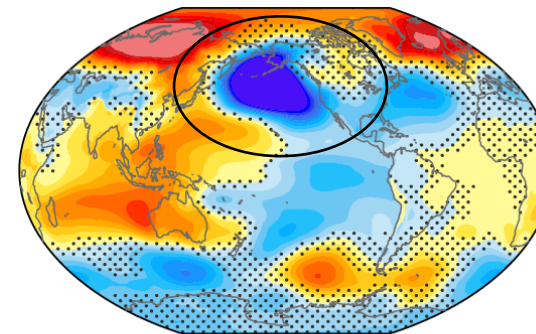
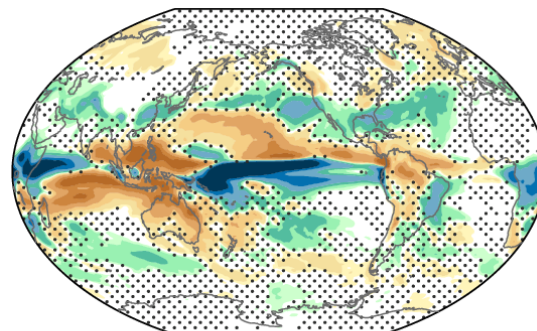
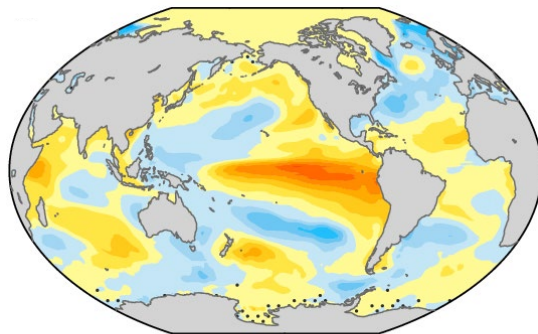


DJF 2023/24

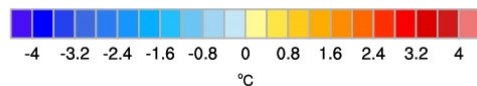
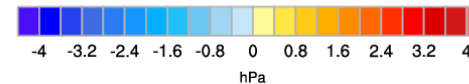
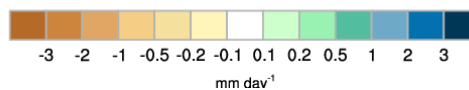
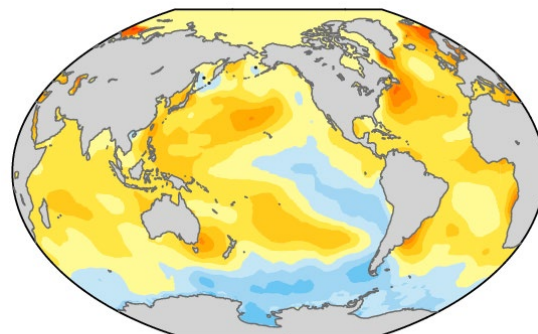
El Nino +
Background
climate change



El Nino



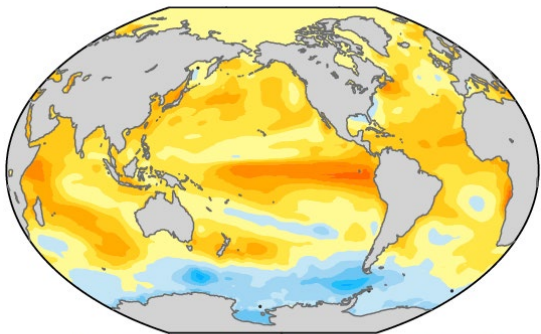
Background
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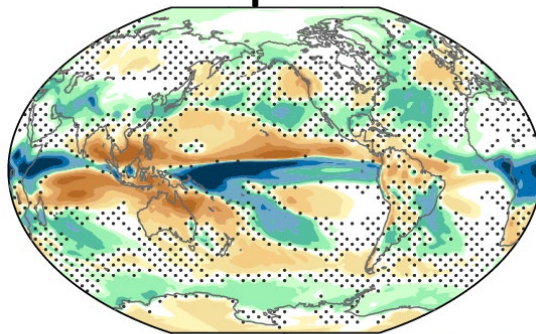
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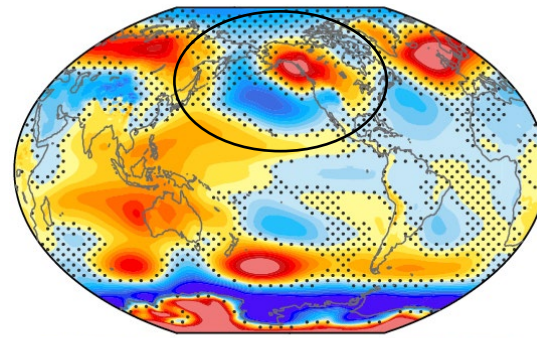
SST (prescribed)



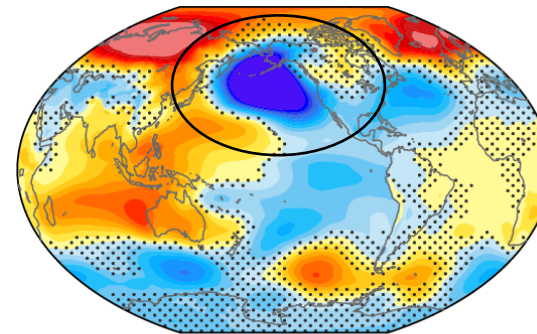
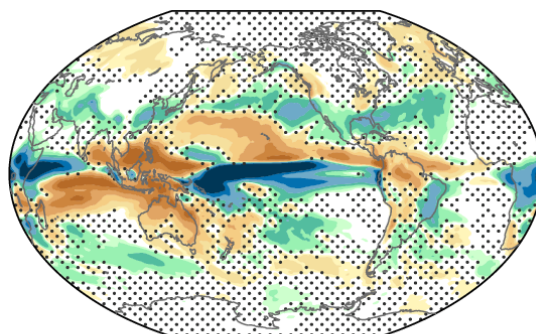
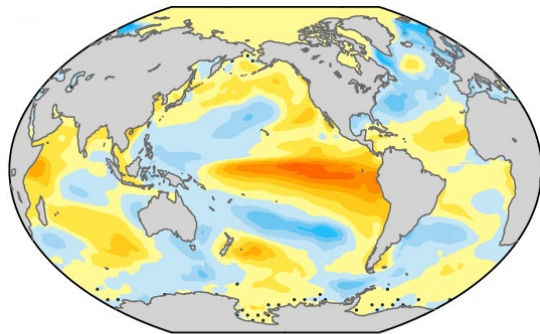
Precipitation



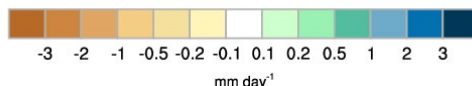
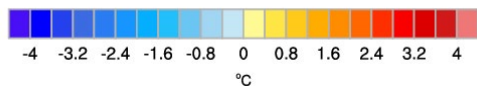
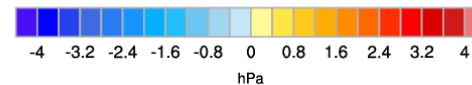
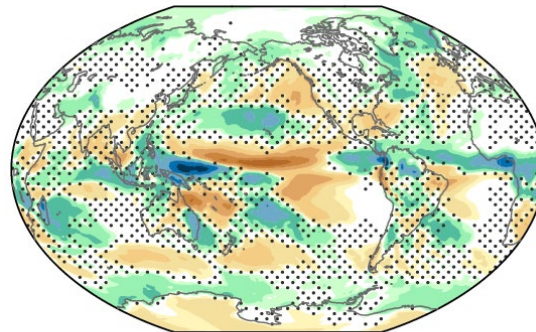
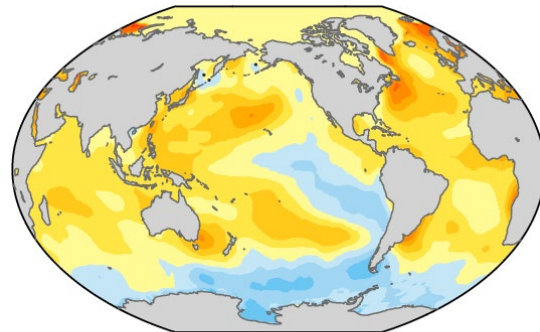
SLP



El Nino

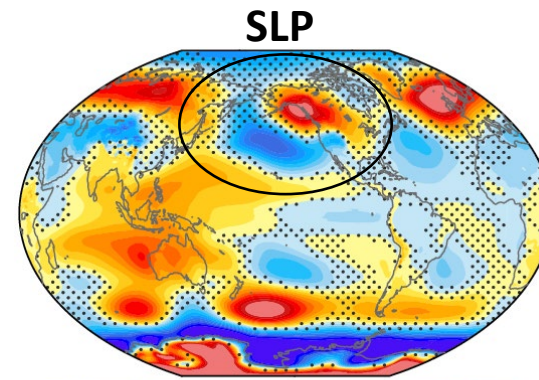
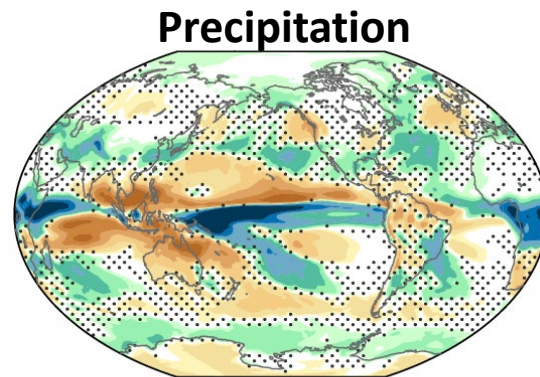
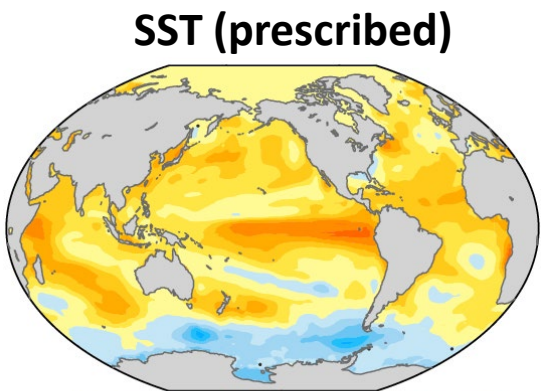


Background
climate change

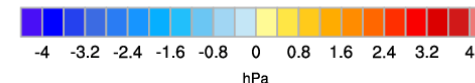
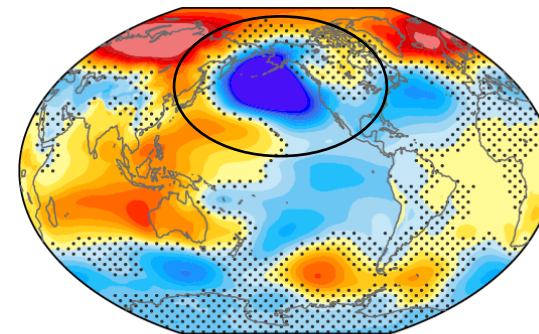
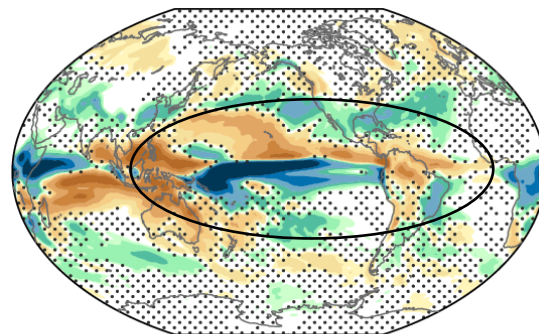
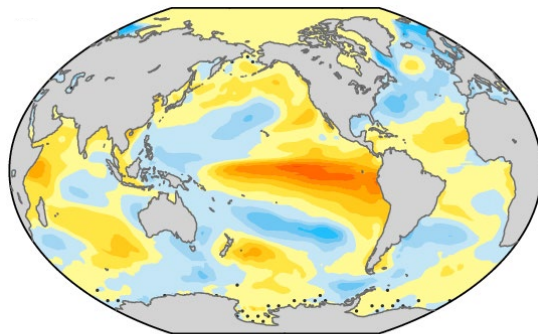


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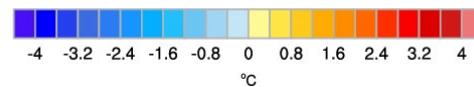
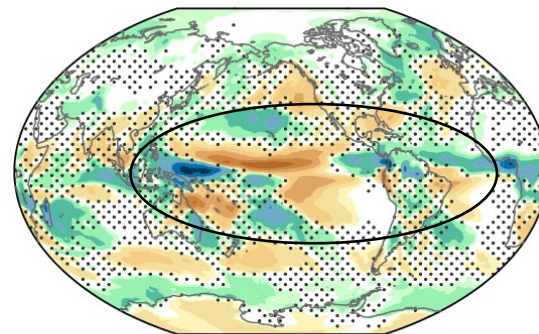
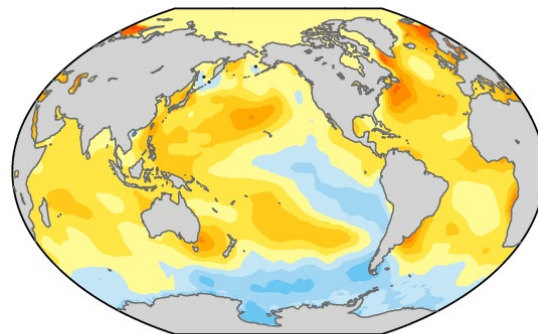
El Nino +
Background
climate change



El Nino

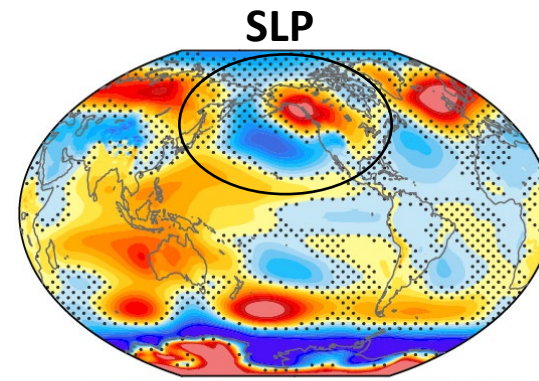
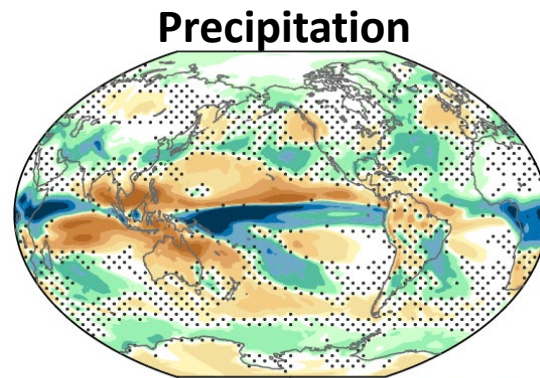
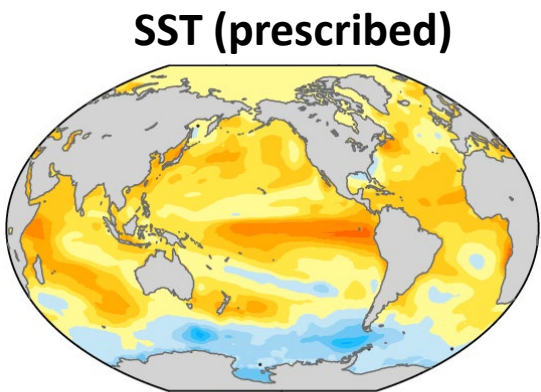


Background
climate change

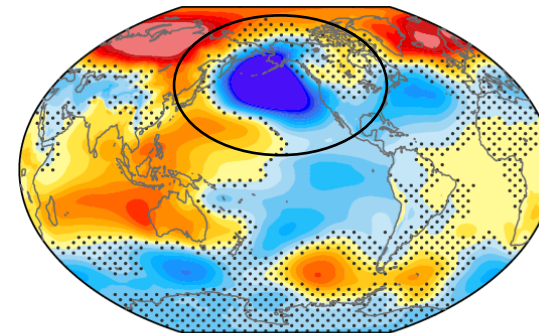
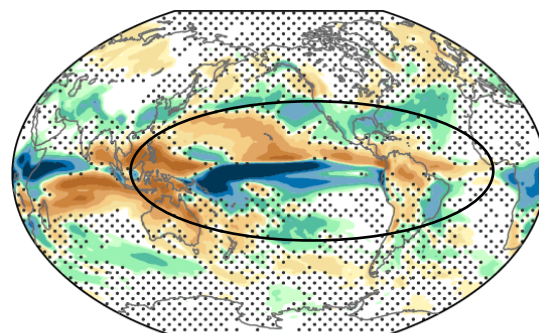
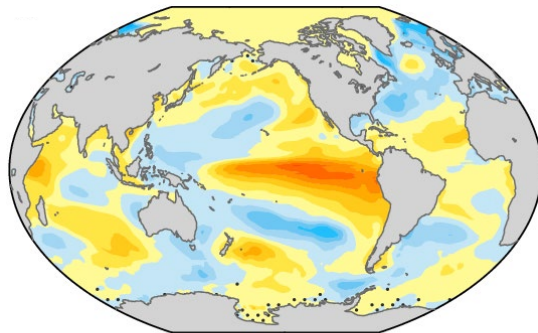


DJF 2023/24

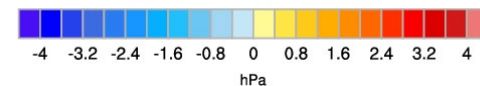
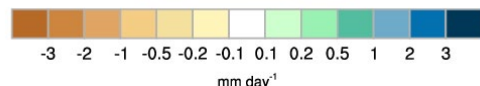
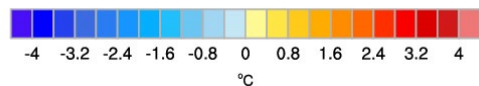
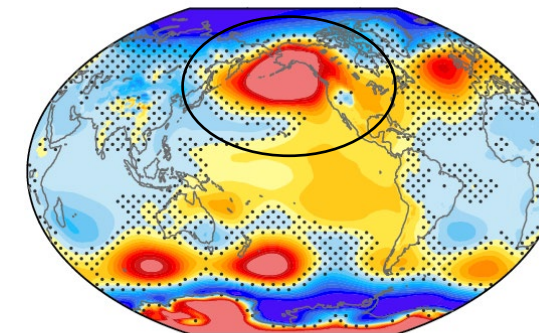
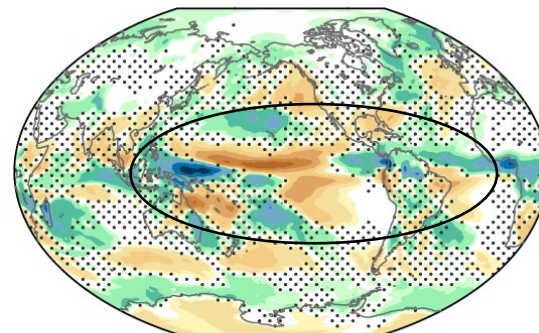
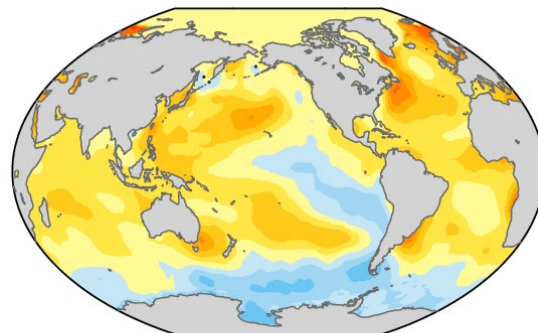
El Nino +
Background
climate change



El Nino

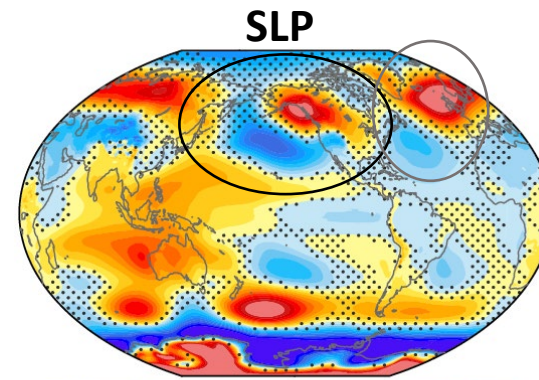
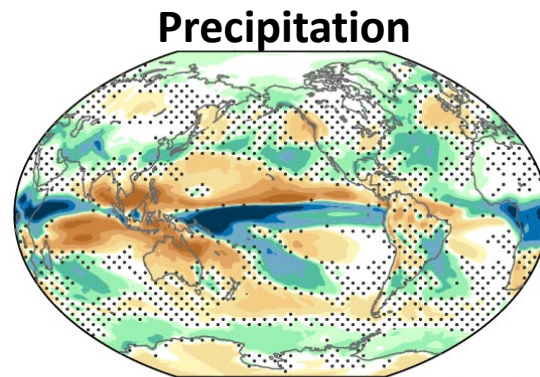
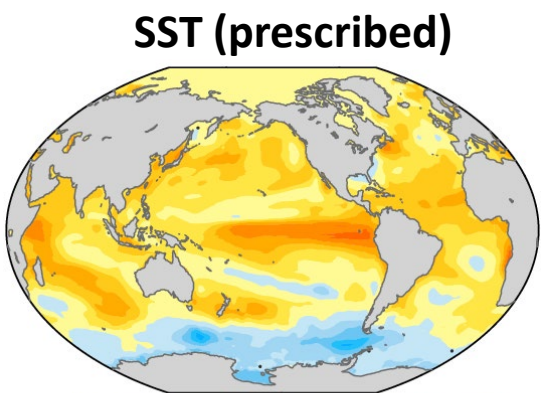


Background
climate change

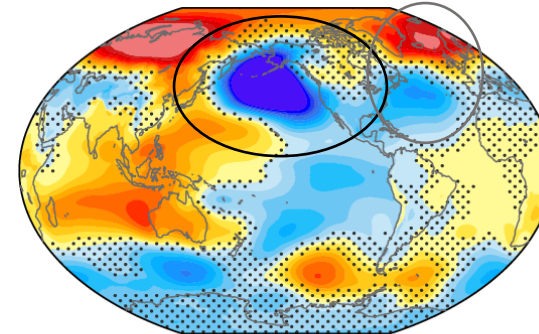
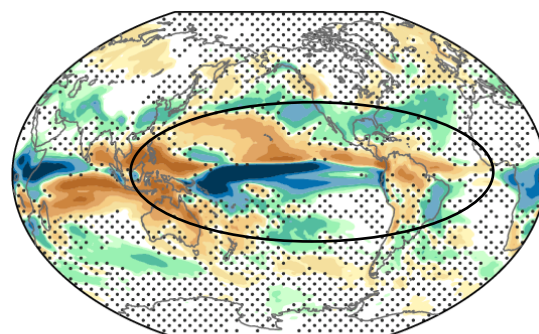
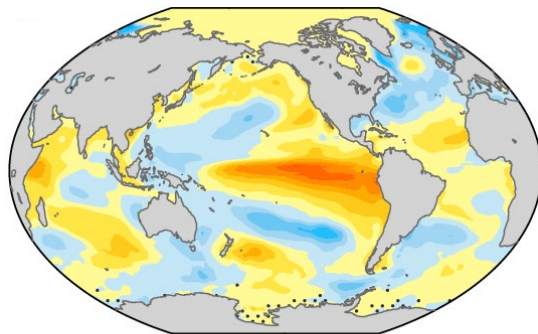


DJF 2023/24

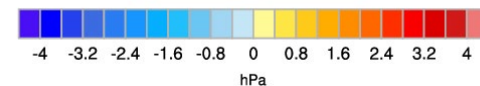
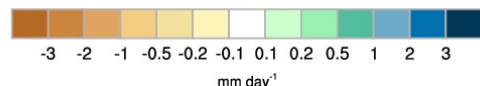
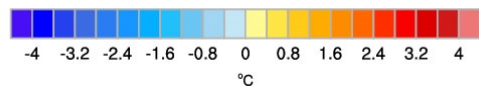
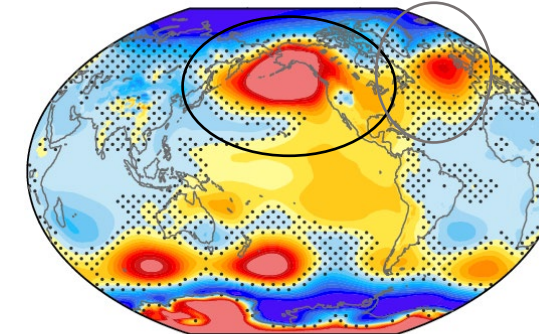
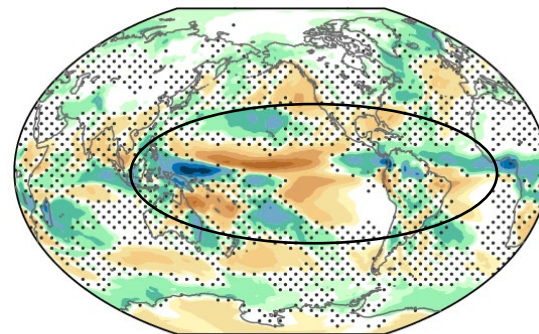
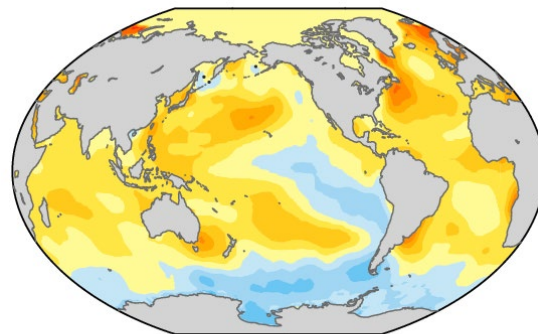
El Nino +
Background
climate change



El Nino

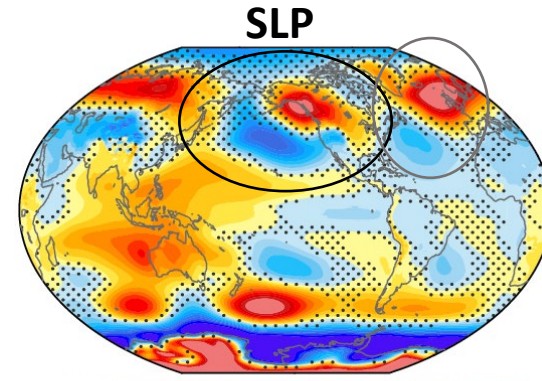
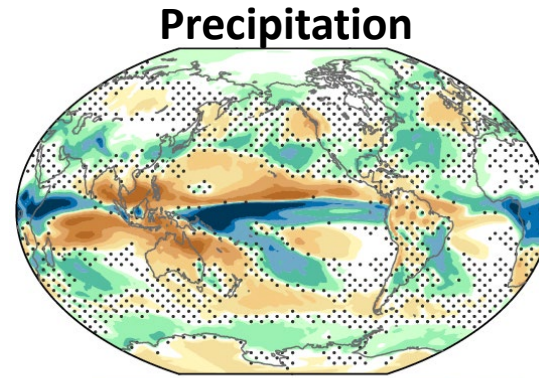
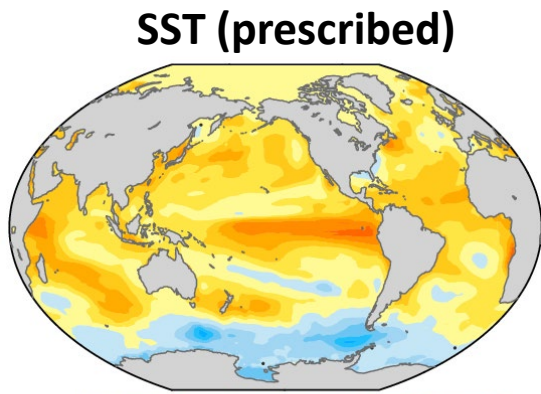


Background
climate change

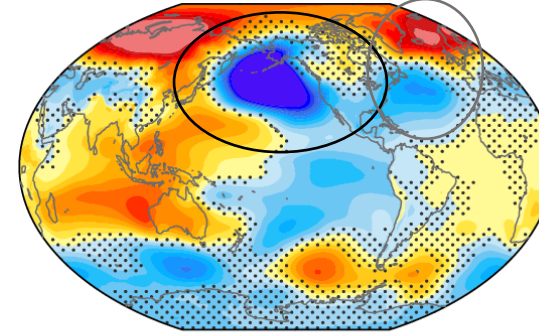
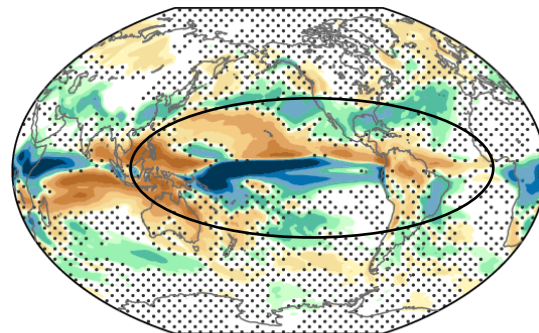
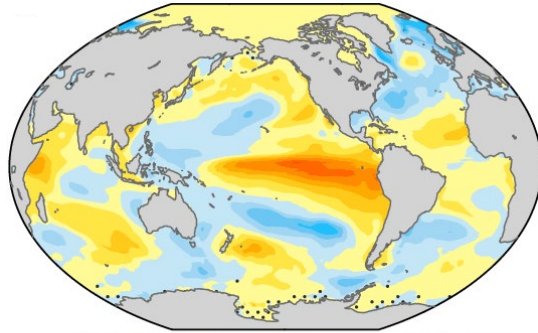


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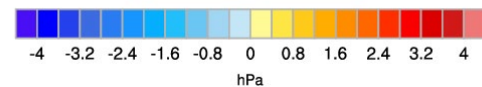
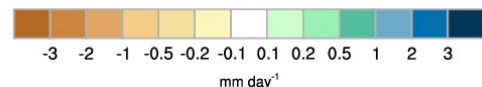
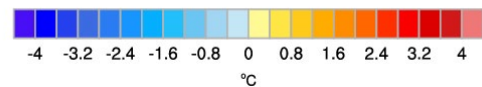
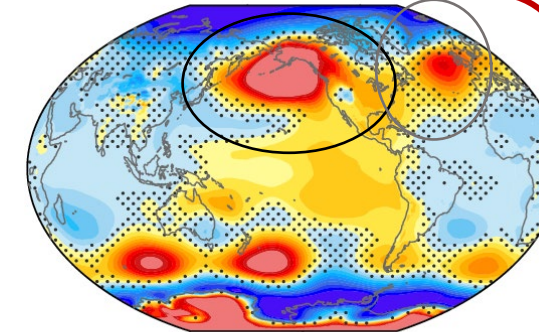
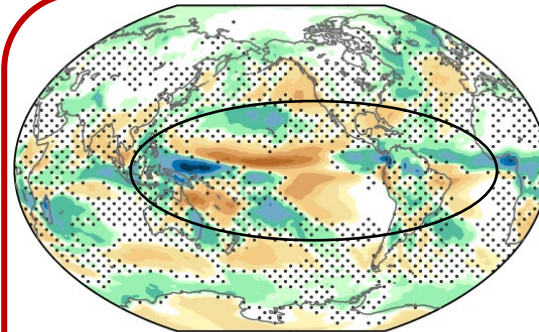
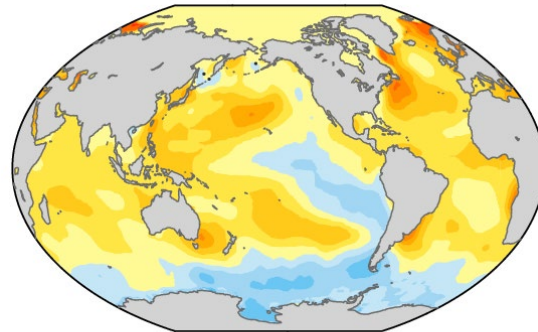
El Nino +
Background
climate change



El Nino



Background
climate change



**Role of Observed SST Trend vs.
Radiative Forcing Change**

DJF 2023/24

El Nino +
Background
climate change

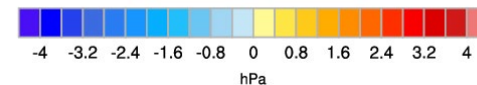
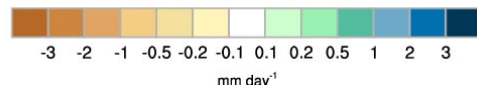
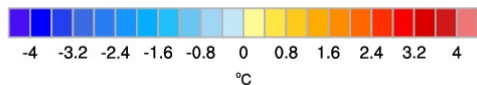
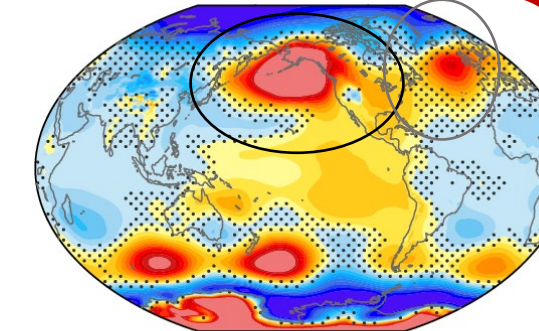
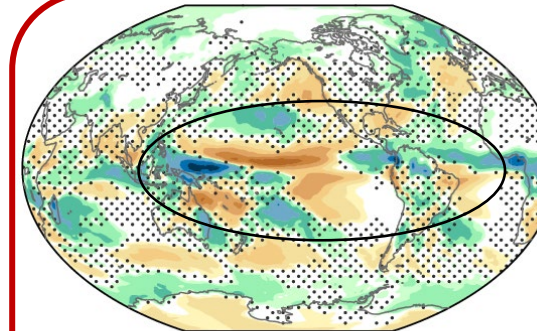
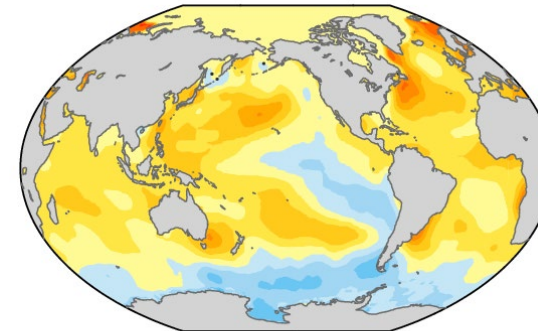
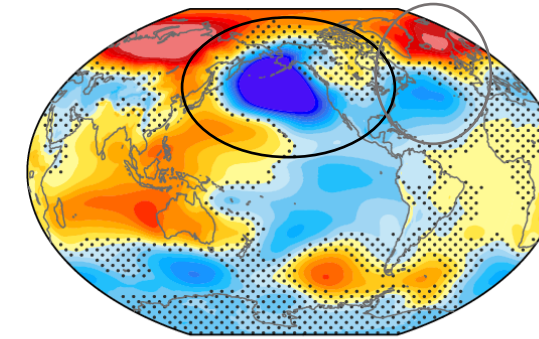
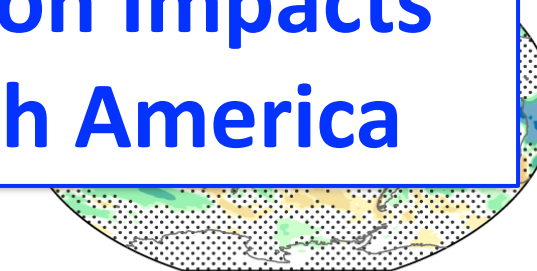
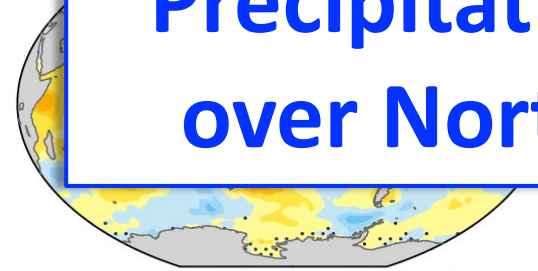
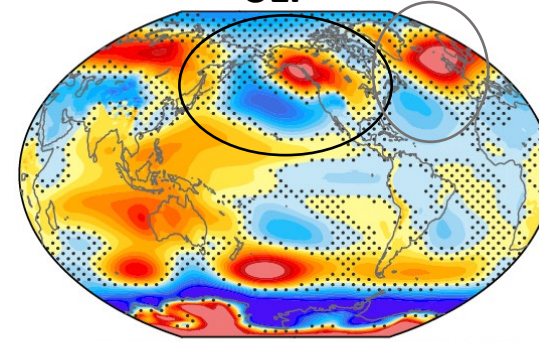
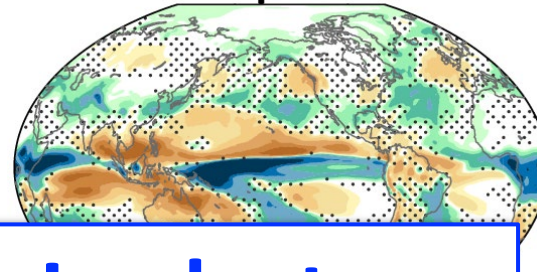
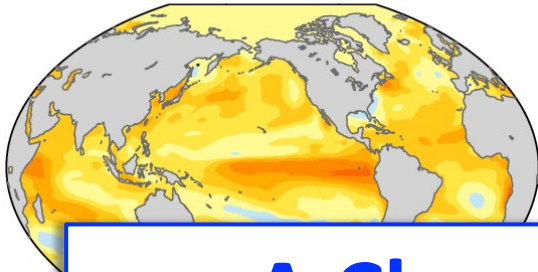
El Nino

Background
climate change

SST (prescribed)

Precipitation

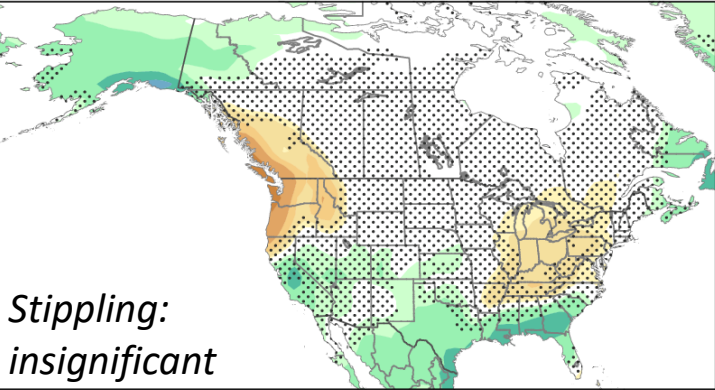
SLP



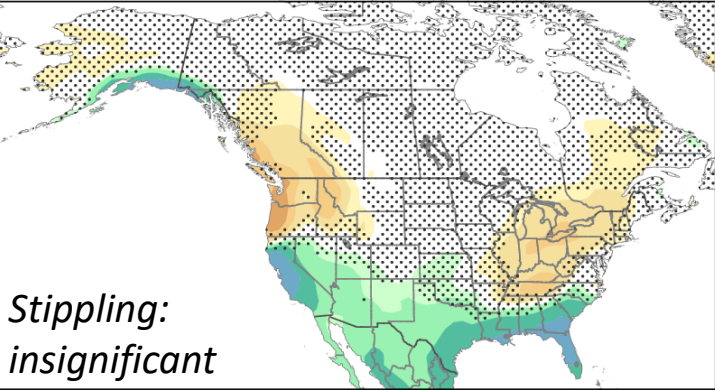
**A Closer Look at
Precipitation Impacts
over North America**

**Role of Observed SST Trend vs.
Radiative Forcing Change**

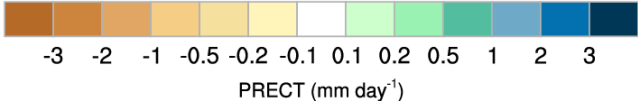
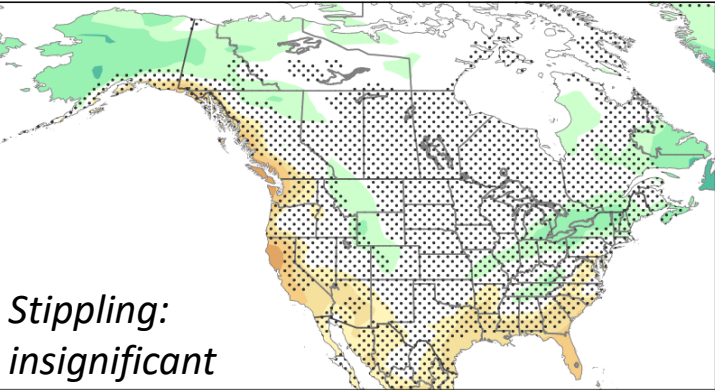
2023/24 El Nino + Background climate change



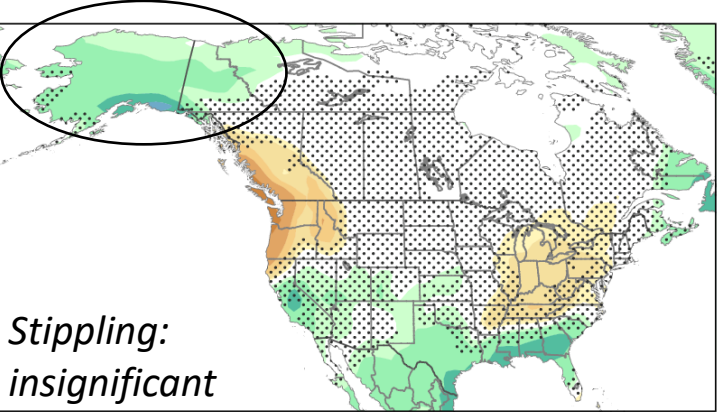
2023/24 El Nino



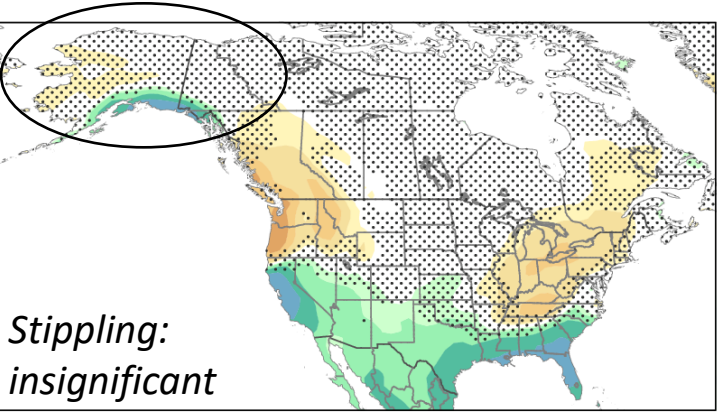
Background climate change



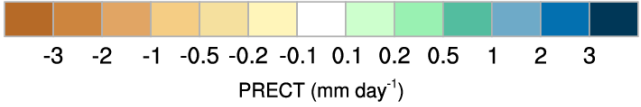
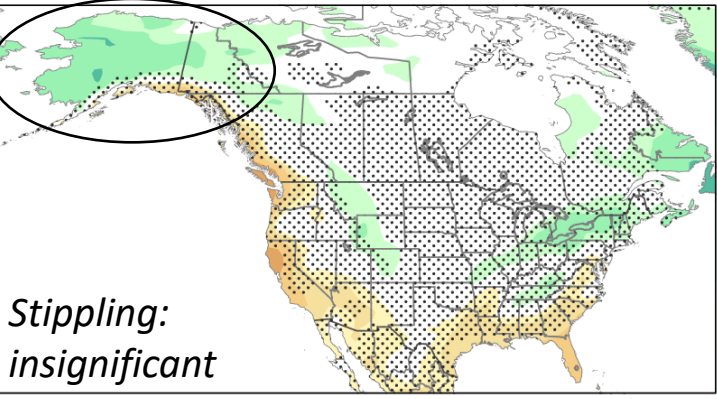
2023/24 El Nino
+ Background
climate change



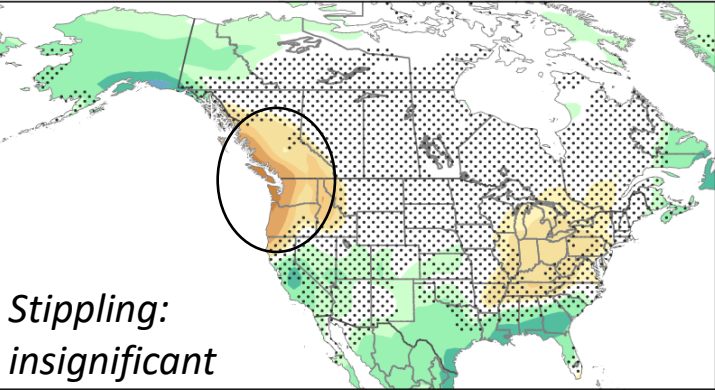
2023/24
El Nino



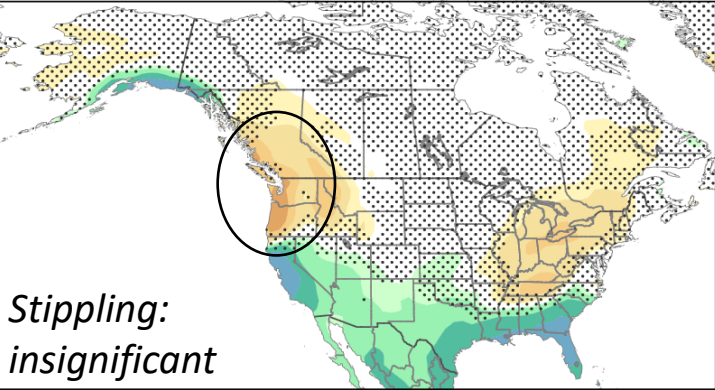
Background
climate change



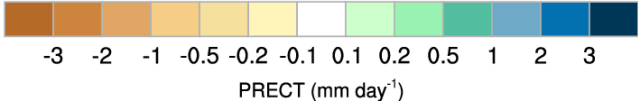
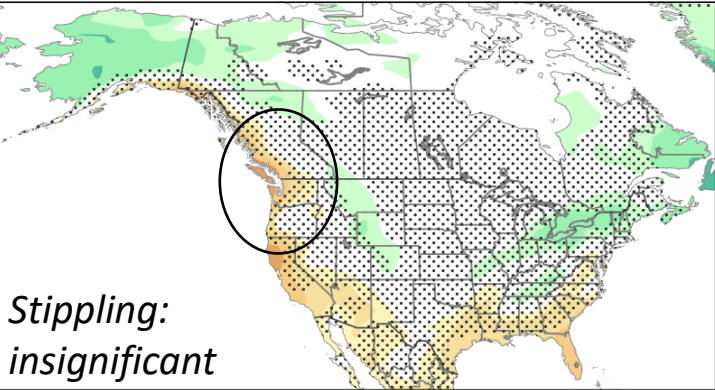
2023/24 El Nino + Background climate change



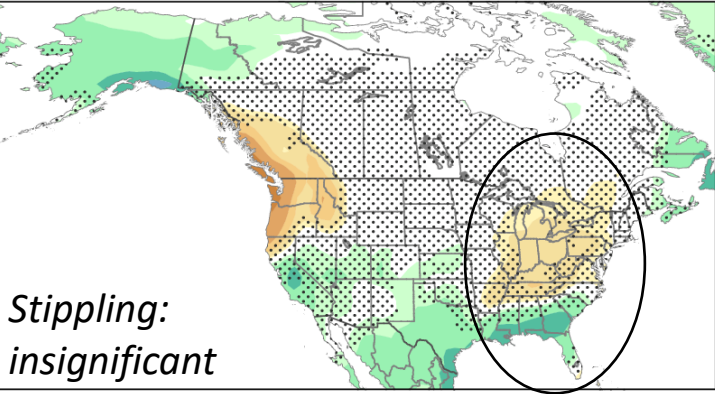
2023/24 El Nino



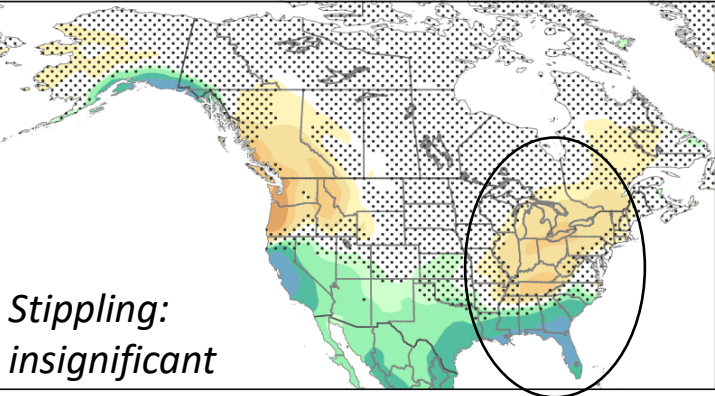
Background climate change



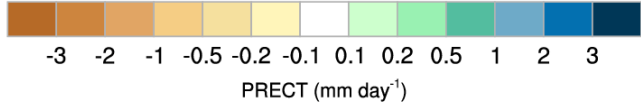
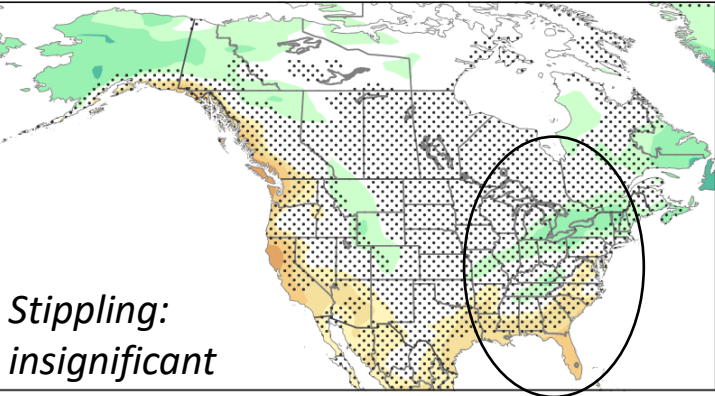
2023/24 El Nino + Background climate change



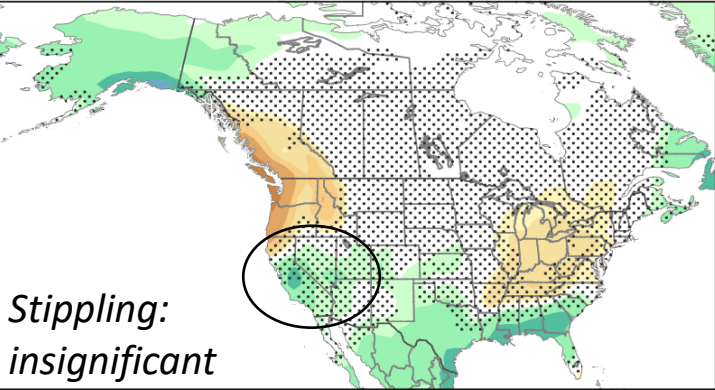
2023/24 El Nino



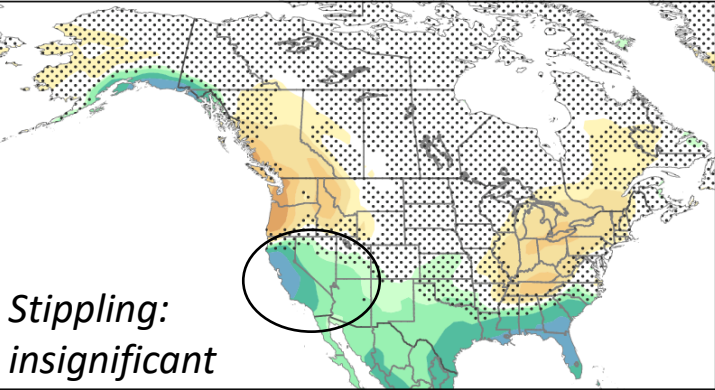
Background climate change



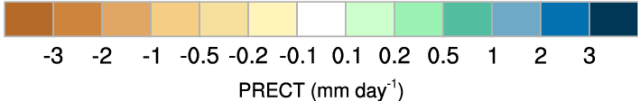
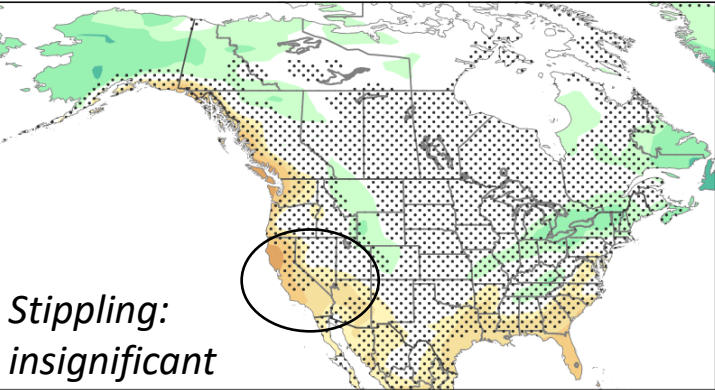
2023/24 El Nino + Background climate change



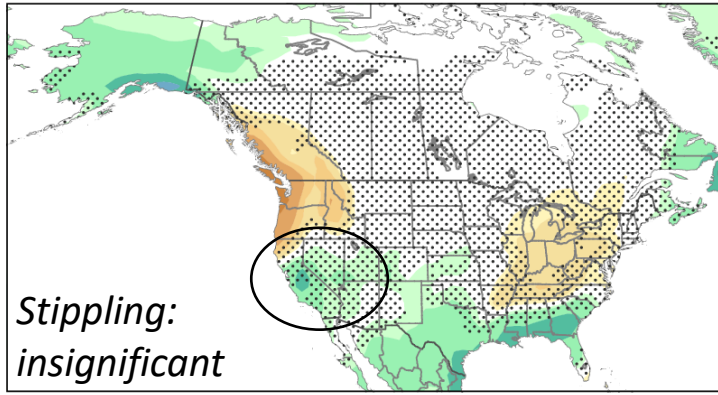
2023/24 El Nino



Background climate change

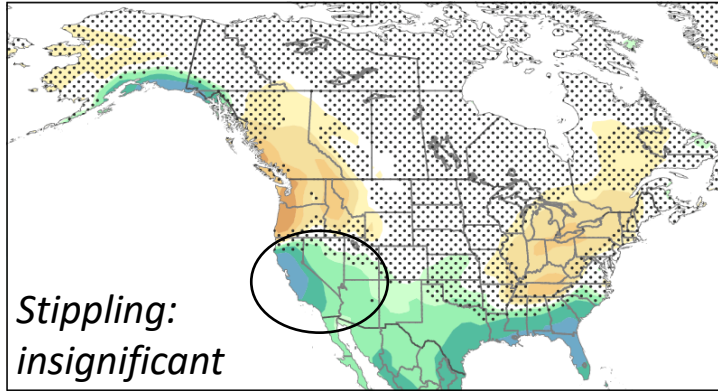


2023/24 El Nino
+ Background
climate change

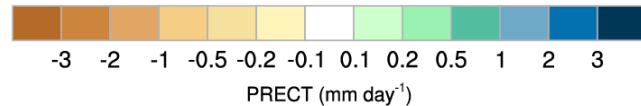
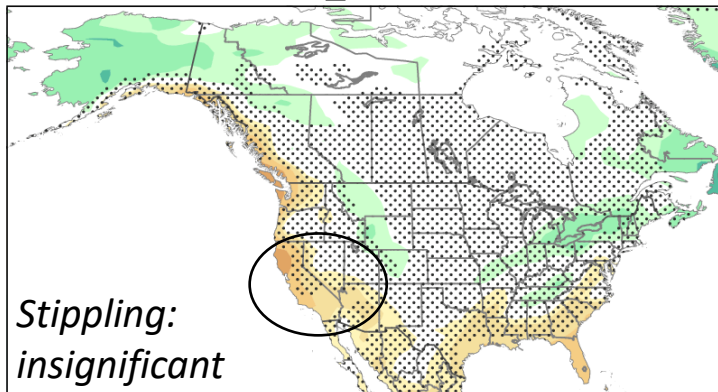


**NOAA Probability Forecast:
Chances of falling within the lower, middle and
upper terciles of the control distribution**

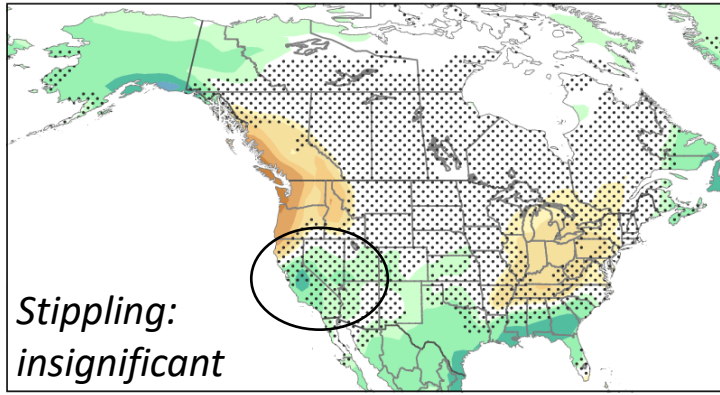
2023/24
El Nino



Background
climate change

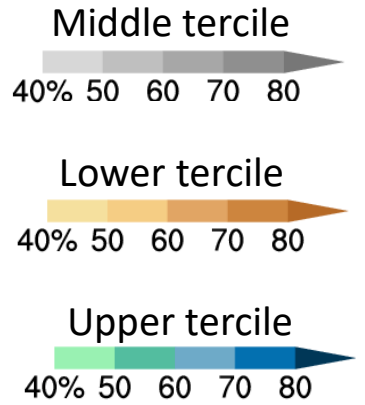
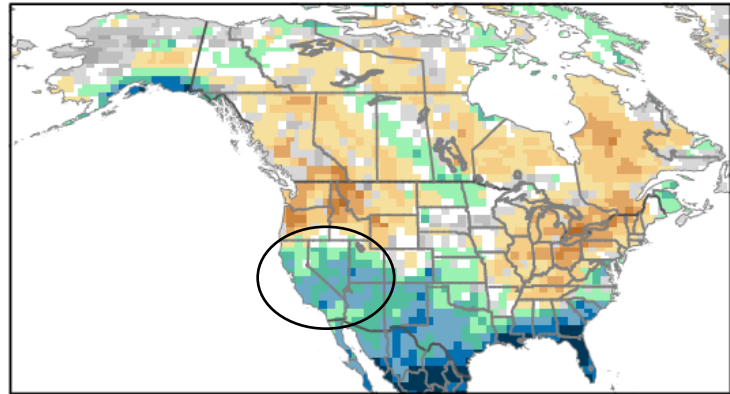
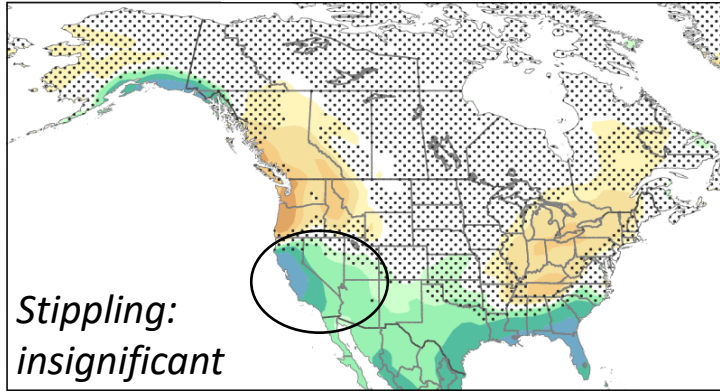


2023/24 El Nino
+ Background
climate change

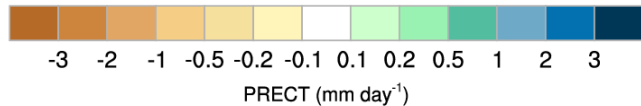
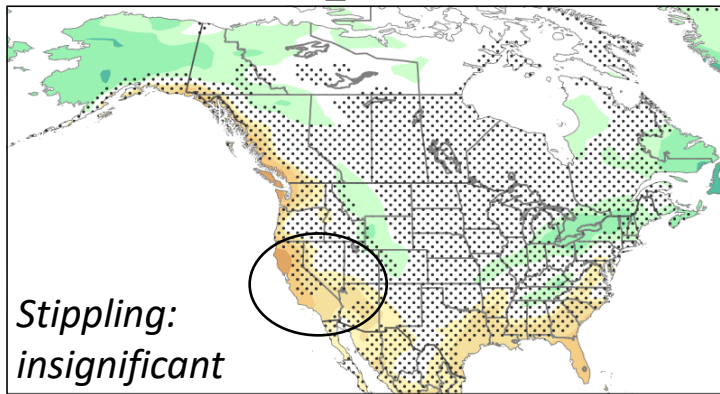


**NOAA Probability Forecast:
Chances of falling within the lower, middle and
upper terciles of the control distribution**

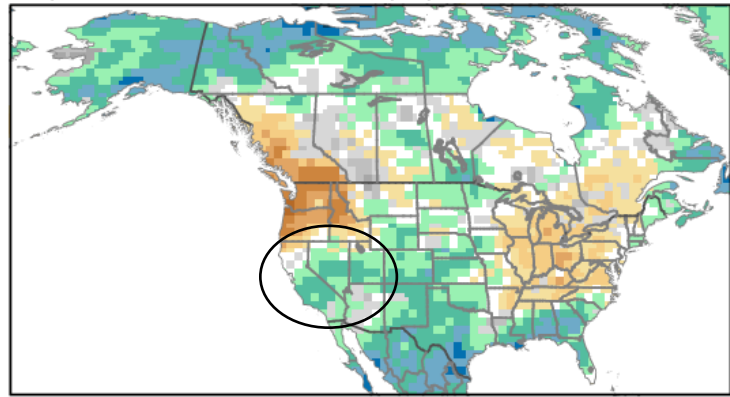
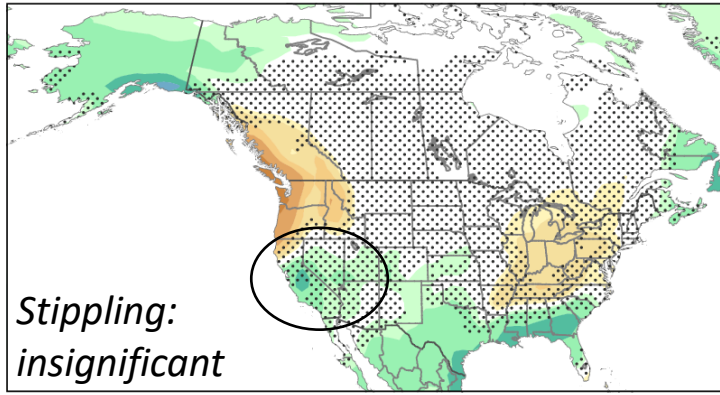
2023/24
El Nino



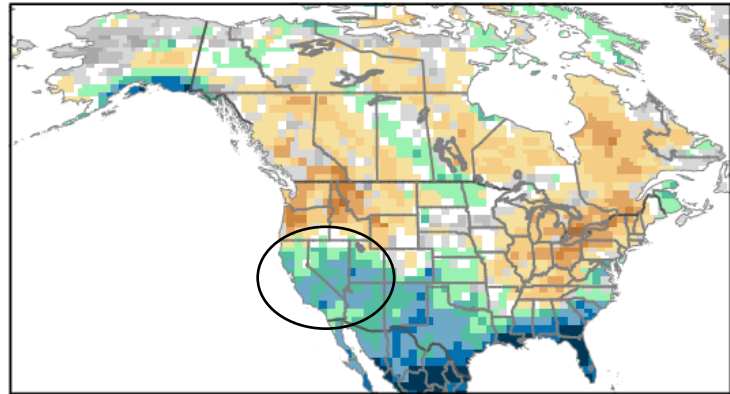
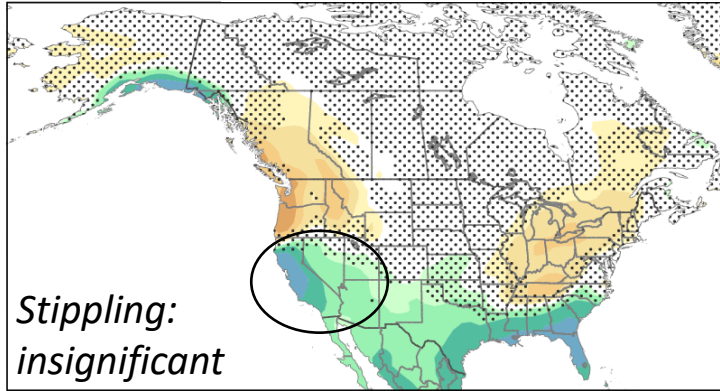
Background
climate change



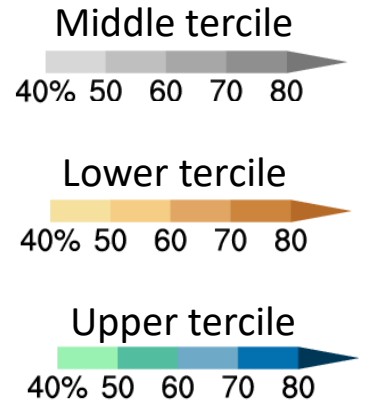
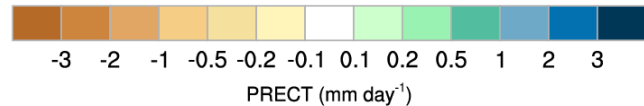
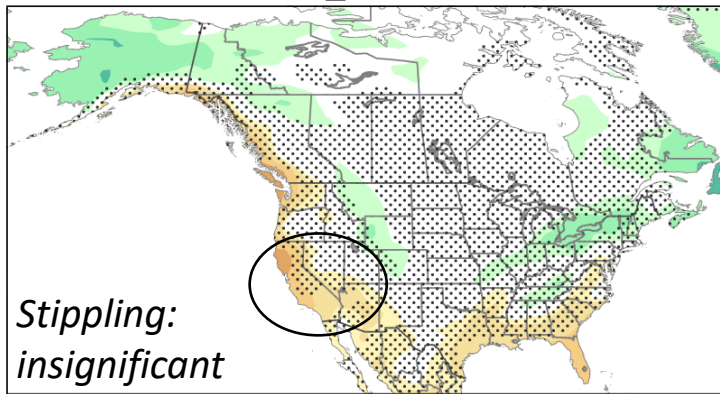
2023/24 El Nino + Background climate change



2023/24 El Nino

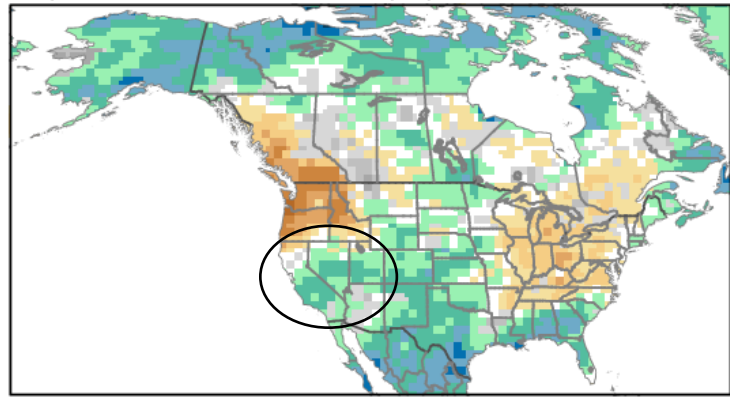
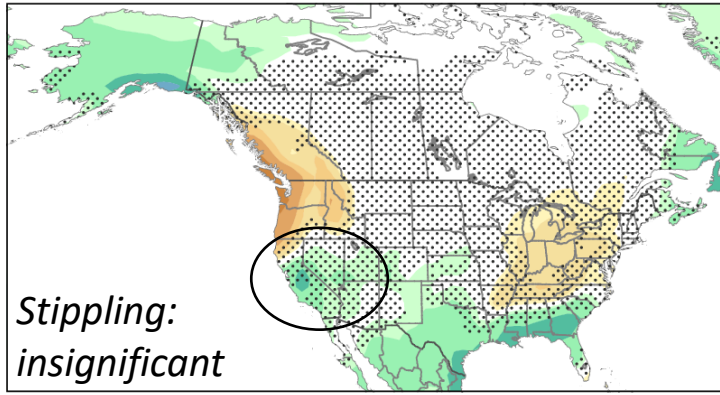


Background climate change

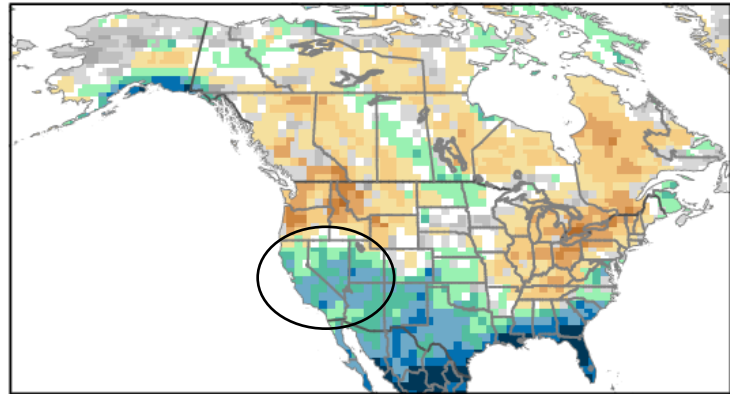
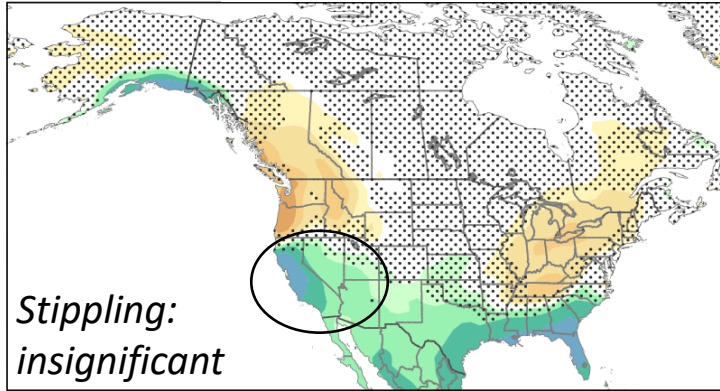


Probability Forecast

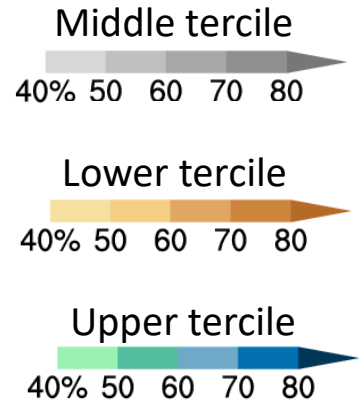
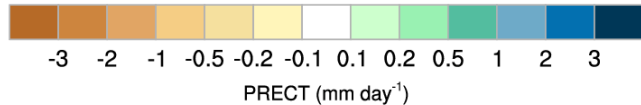
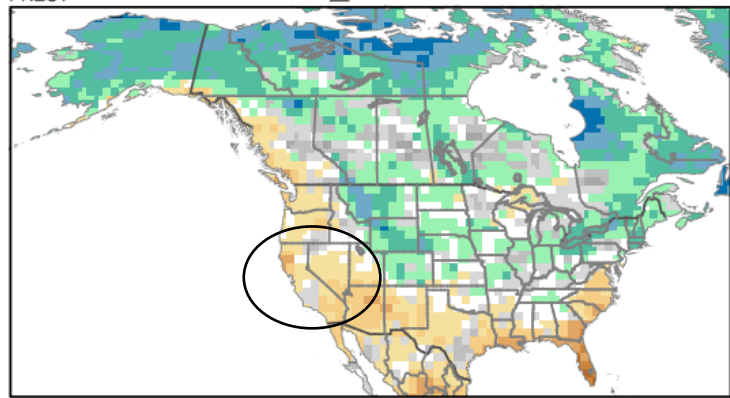
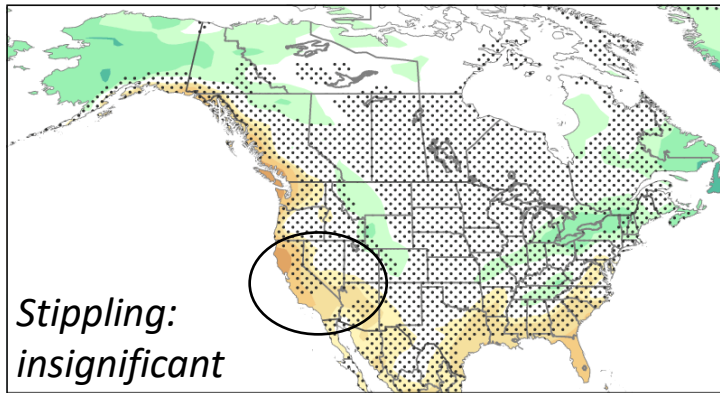
2023/24 El Nino + Background climate change



2023/24 El Nino

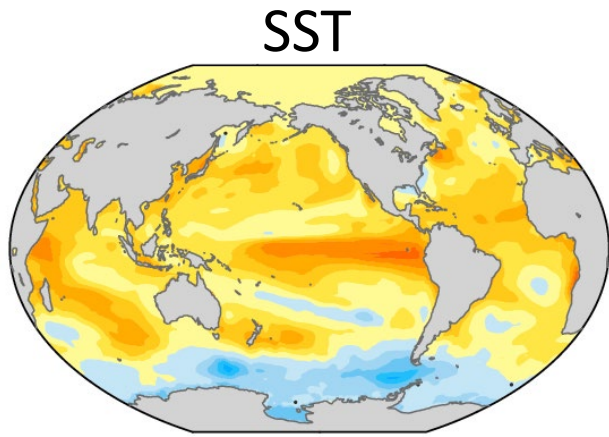
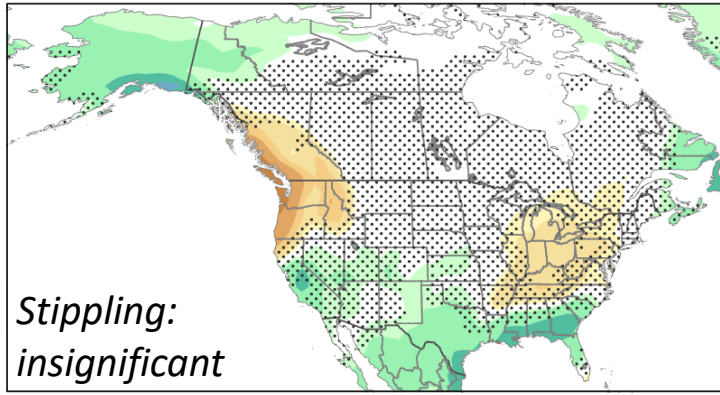


Background climate change

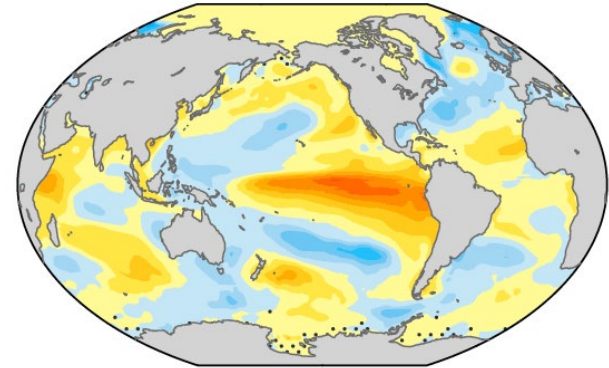
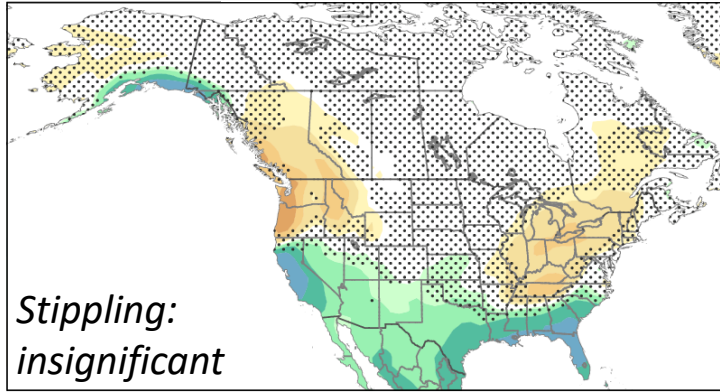


Probability Forecast

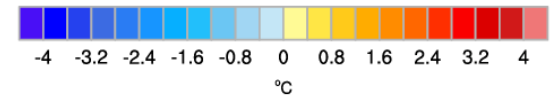
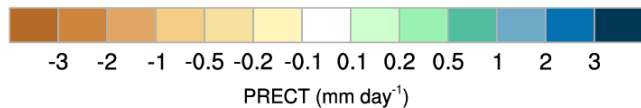
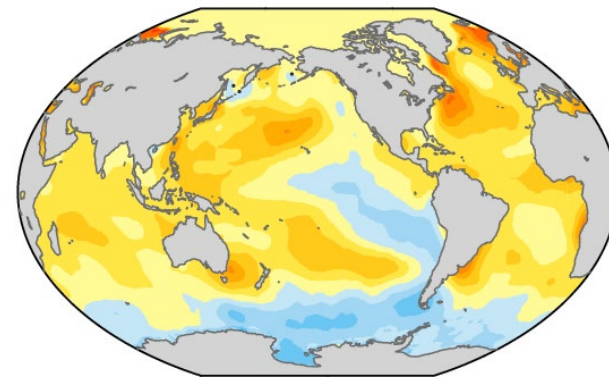
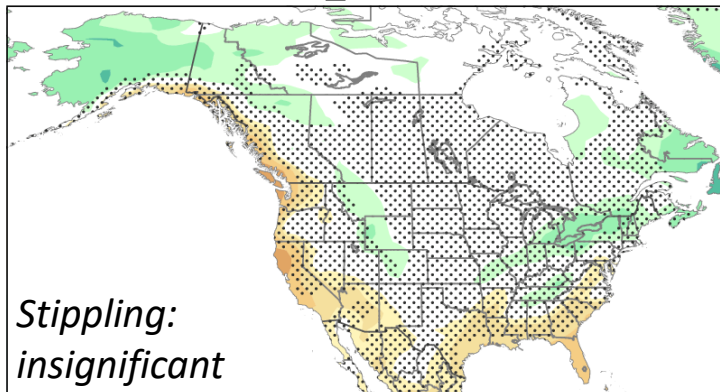
2023/24 El Nino + Background climate change



2023/24 El Nino



Background climate change



Summary

Observed background
SST Trends modify the
climate impacts from
the 2023/24 El Nino.

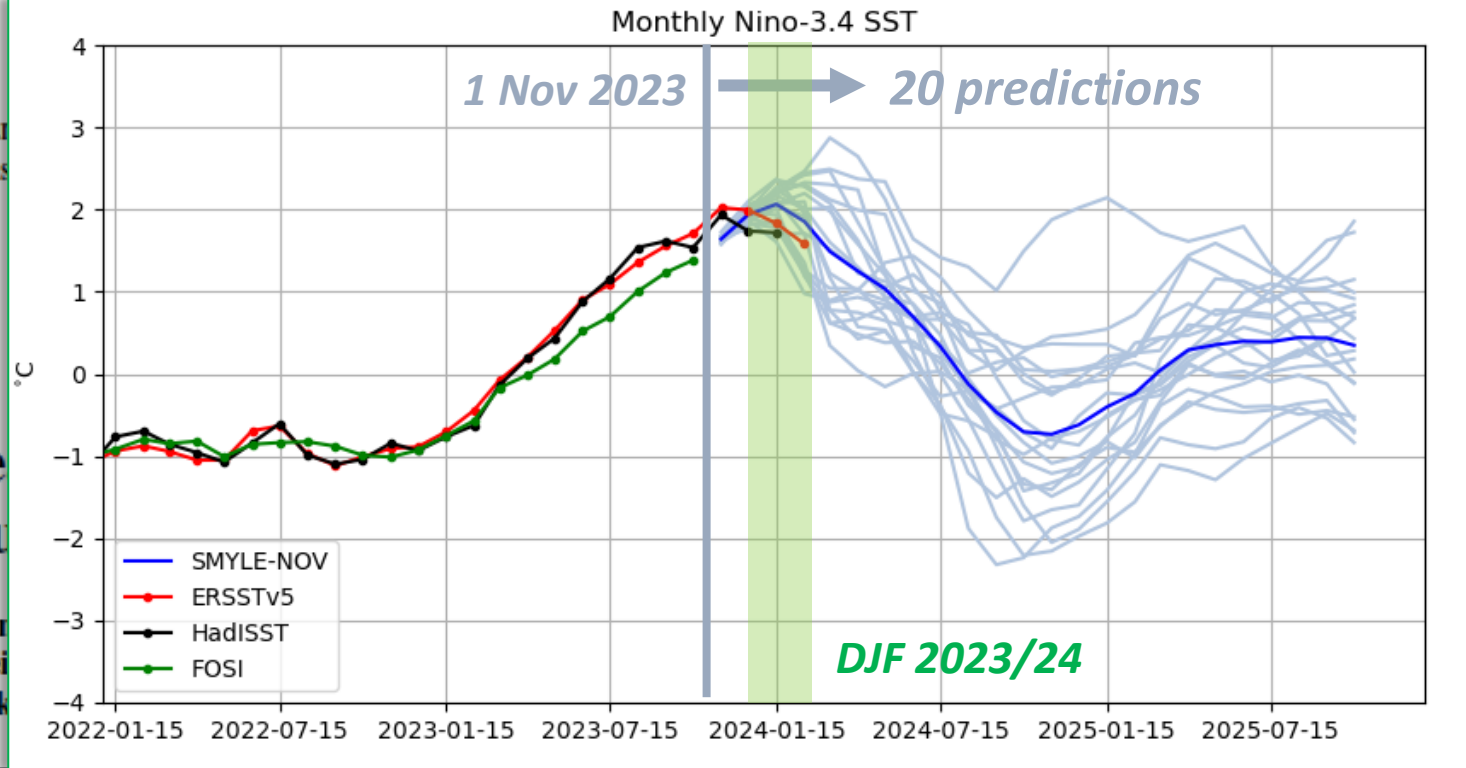
Extra Slides

Geosci. Model Dev., 15, 6451–6493, 2022
<https://doi.org/10.5194/gmd-15-6451-2022>
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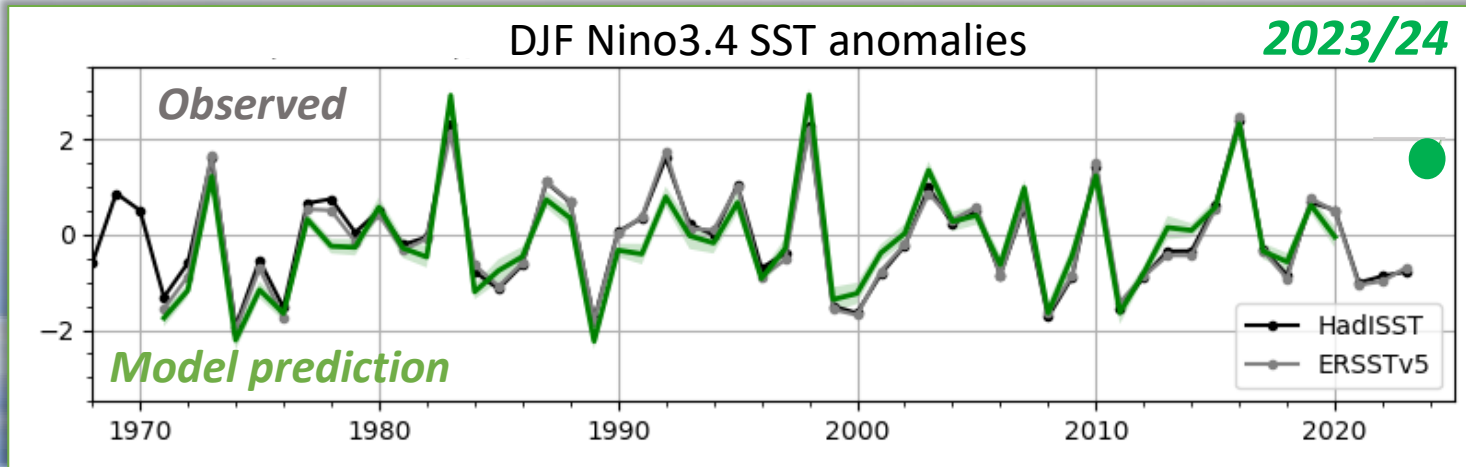


The Seasonal-to-Multiyear system using the Community

Stephen G. Yeager¹, Nan Rosenbloom¹, Armin
Kristen Krumhardt¹, Samuel Mogen², Kei
Jadwiga H. Richter¹, Matthew Long¹, Gokul
Warren G. Strand¹, and Teagan King¹



**Boreal winter (DJF)
El Niño predictions
initialized from
November 1st are highly
skillful.**

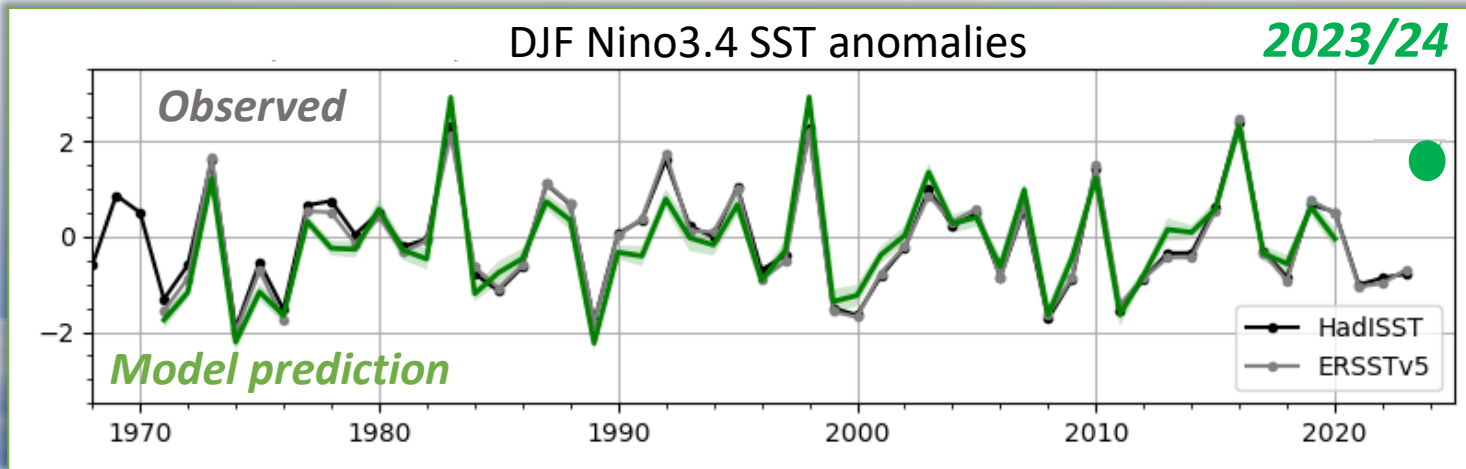
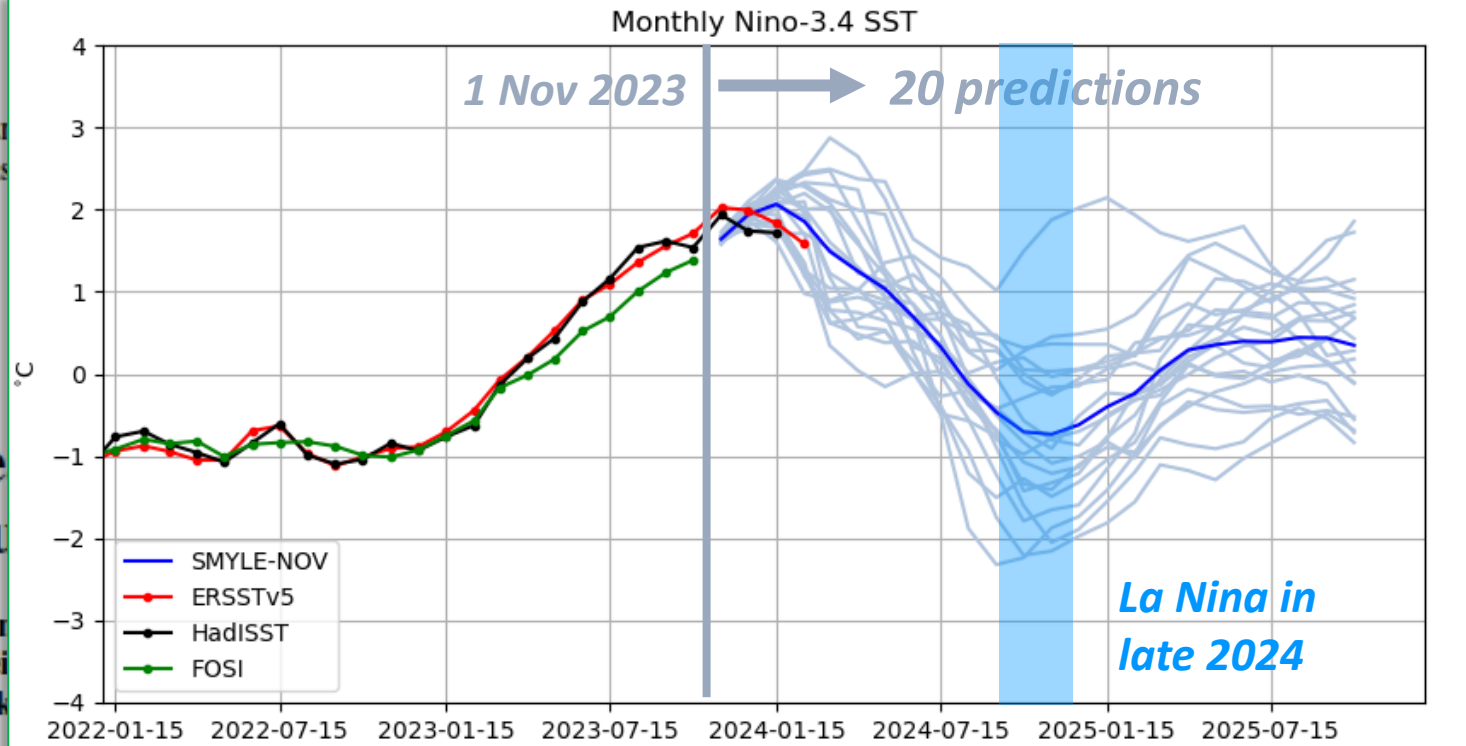


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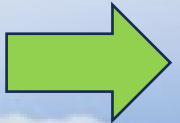


The Seasonal-to-Multiyear system using the Community Earth System Model

Stephen G. Yeager¹, Nan Rosenbloom¹, Armin M. Macdonald¹, Kristen Krumhardt¹, Samuel Mogen², Keiichi Motoki¹, Jadwiga H. Richter¹, Matthew Long¹, Gokulakrishnan Viswanathan¹, Warren G. Strand¹, and Teagan King¹

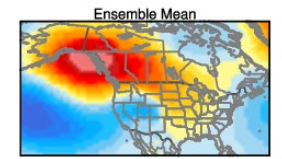


Boreal winter (DJF) El Niño predictions initialized from November 1st are highly skillful.

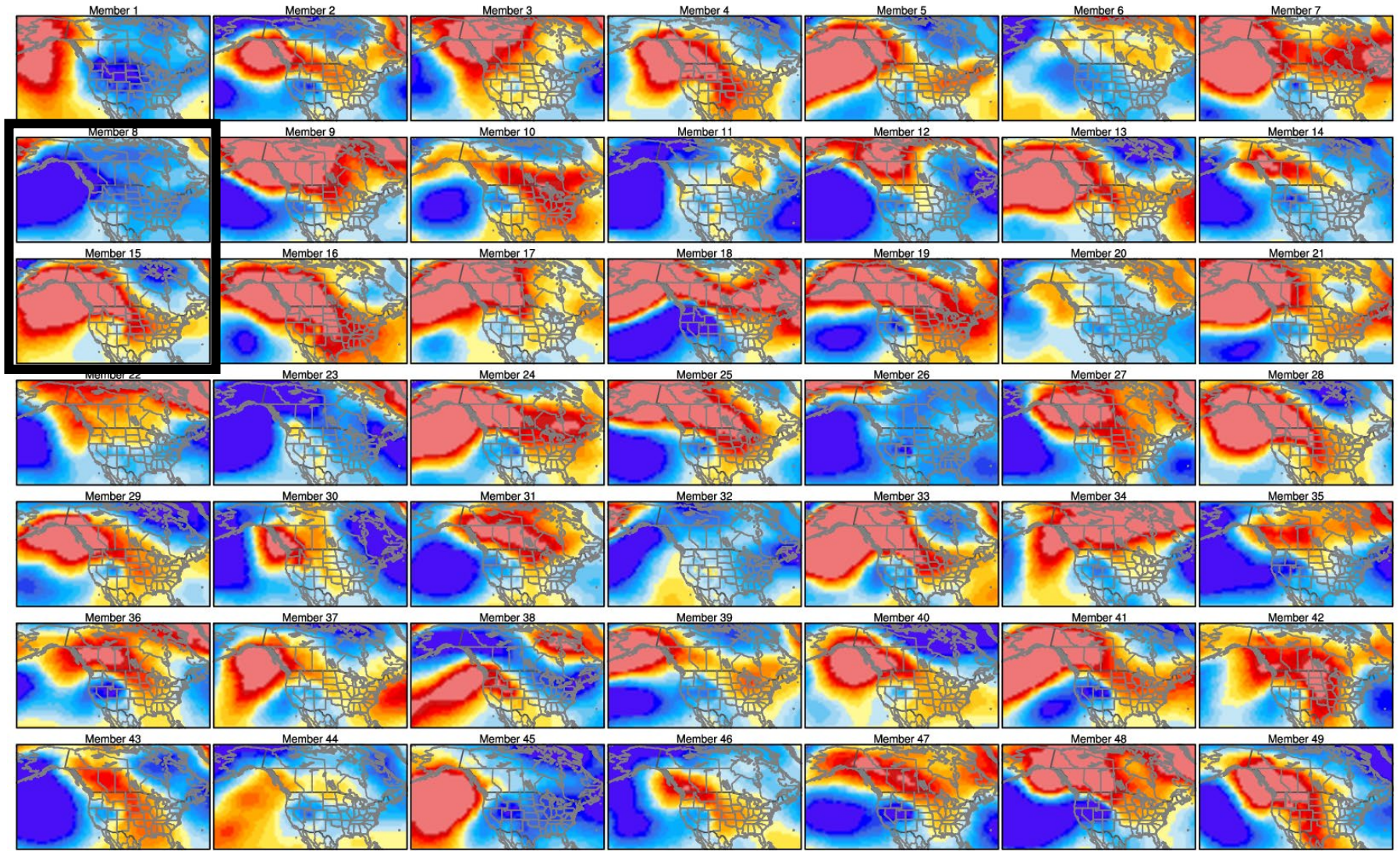
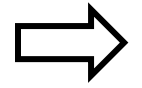


CAM6 - 1979 Control
(El Nino + SST Trend + Δ RF)

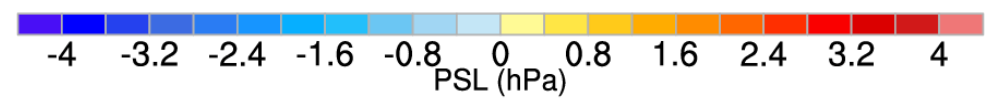
Another Look at Probability Forecasts



SLP
Response

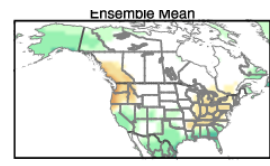


Response
+
Internal
Variability

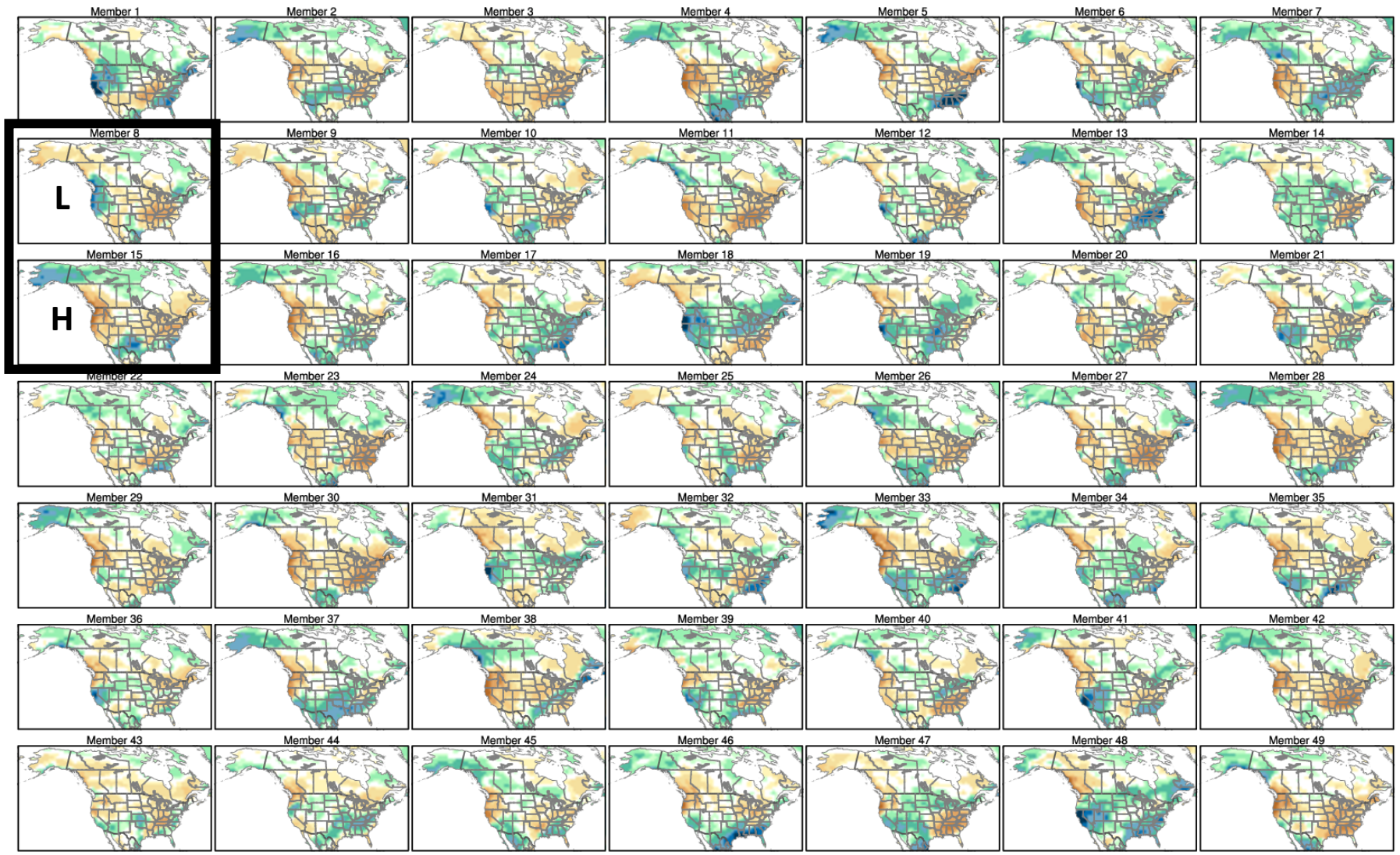
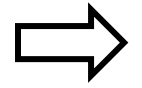


CAM6 - 1979 Control
(El Nino + SST Trend + Δ RF)

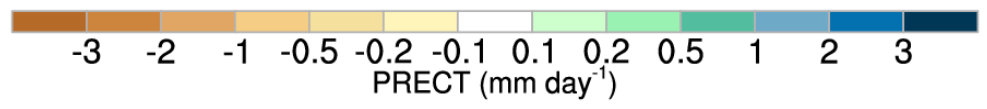
Another Look at Probability Forecasts



PRECt
Response

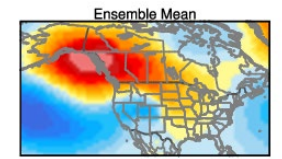


Response
+
Internal
Variability

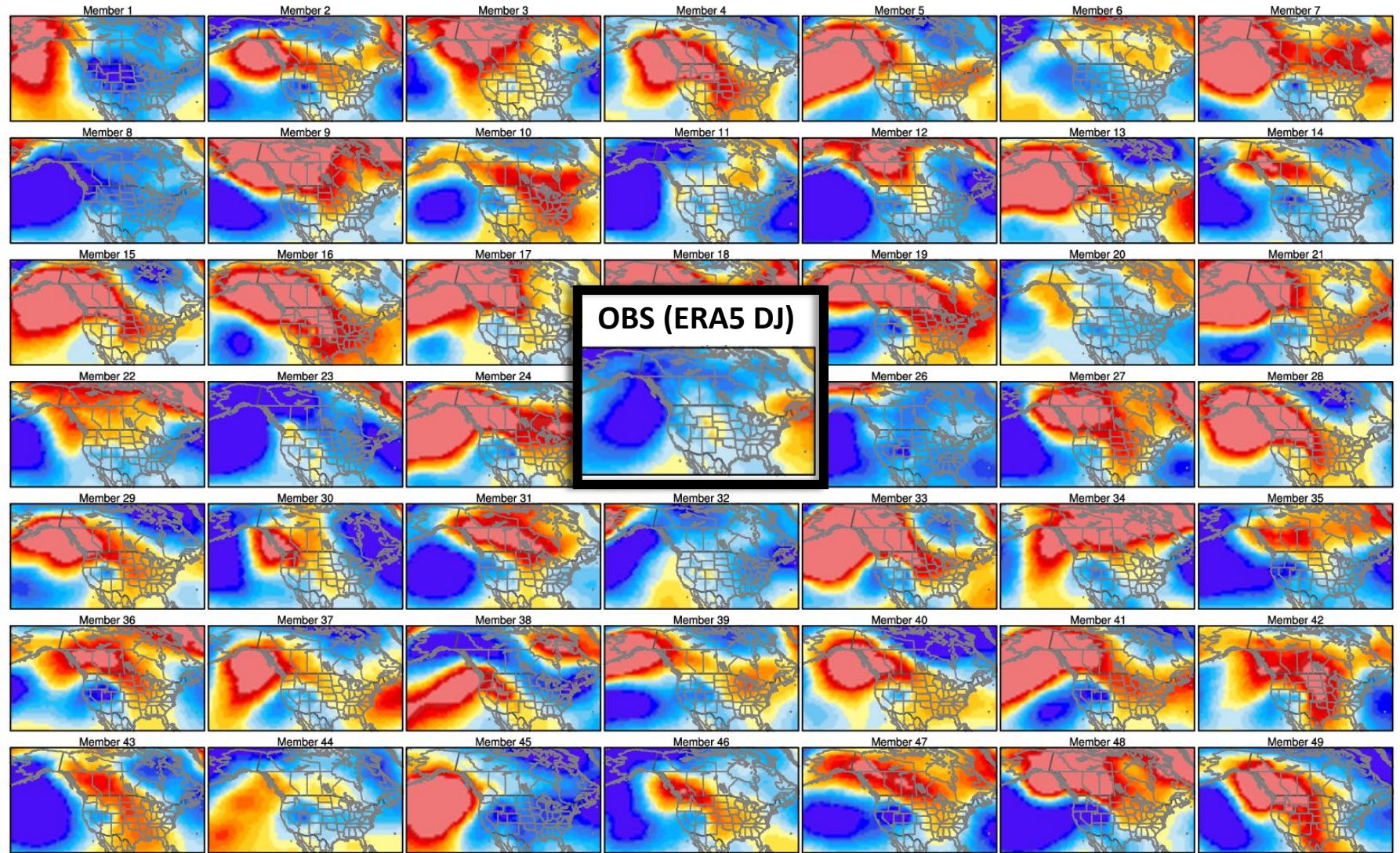


CAM6 - 1979 Control
(El Nino + SST Trend + Δ RF)

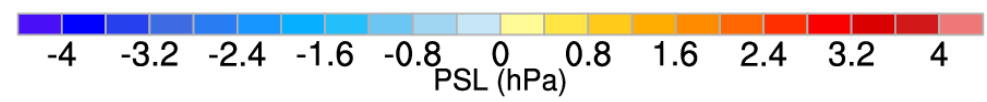
Another Look at Probability Forecasts



SLP Response

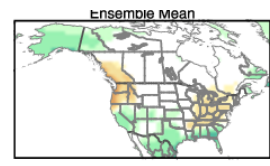


Response
+
Internal
Variability

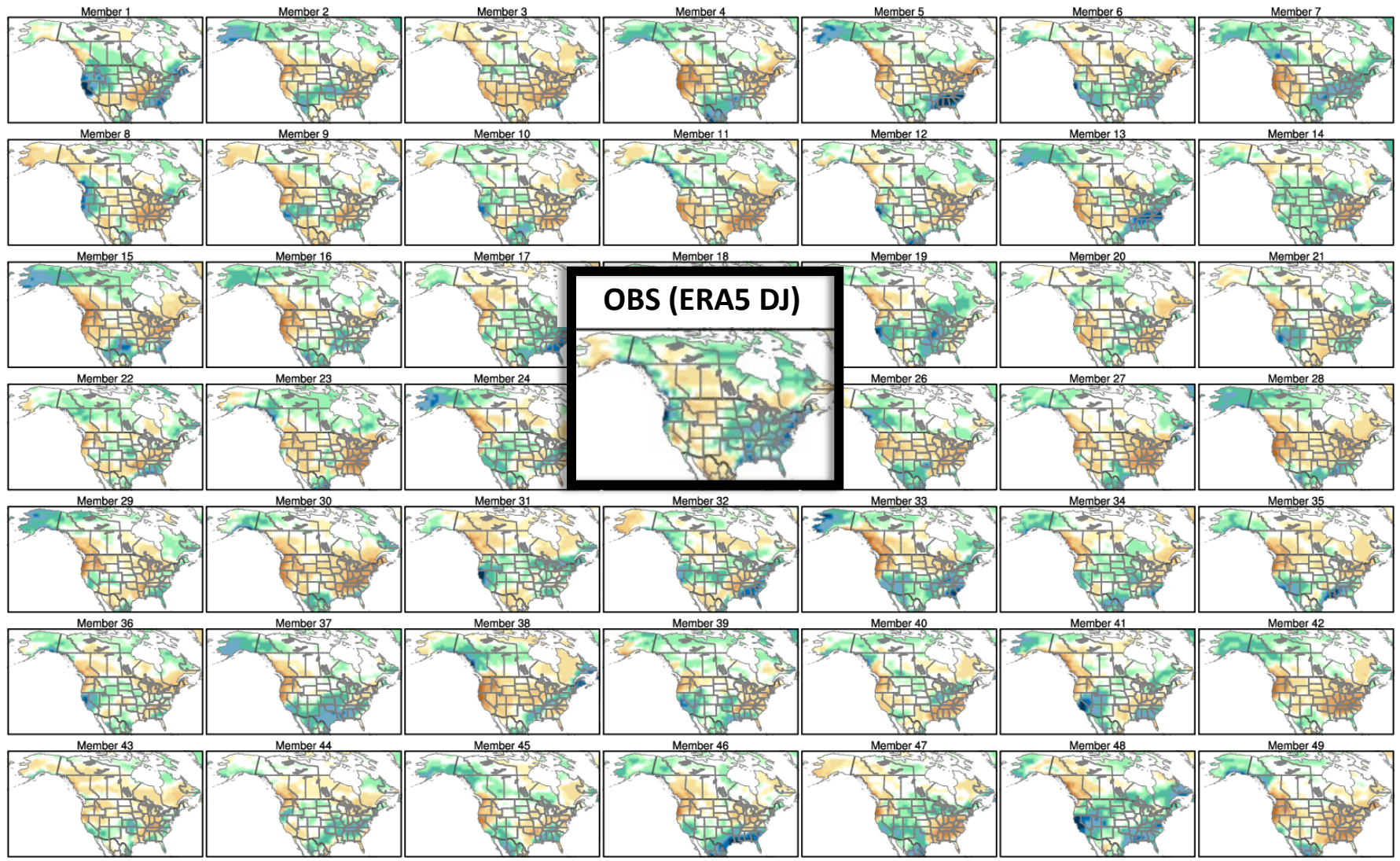


CAM6 - 1979 Control
(El Nino + SST Trend + Δ RF)

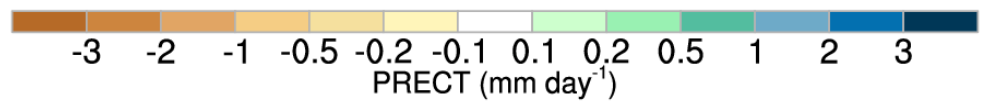
Another Look at Probability Forecasts



PRECT
Response



Response
+
Internal
Variability



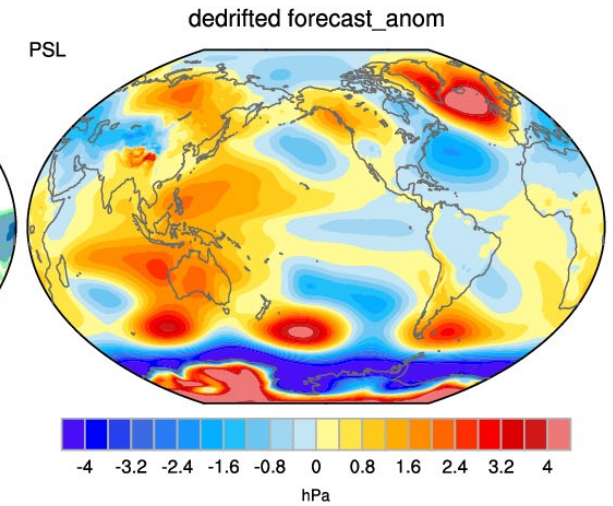
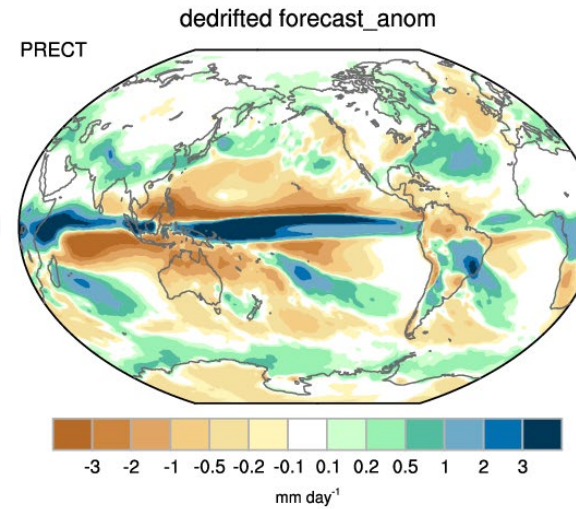
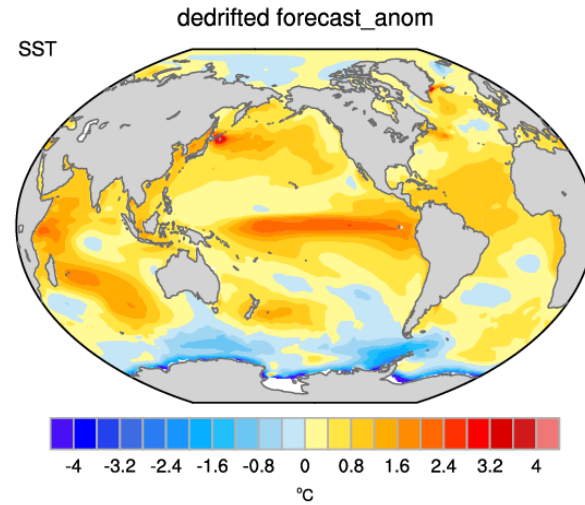
DJF SMYLE vs. AMIP

SST

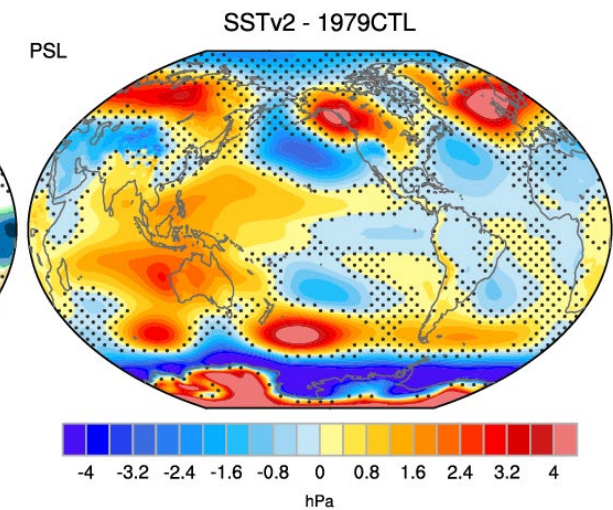
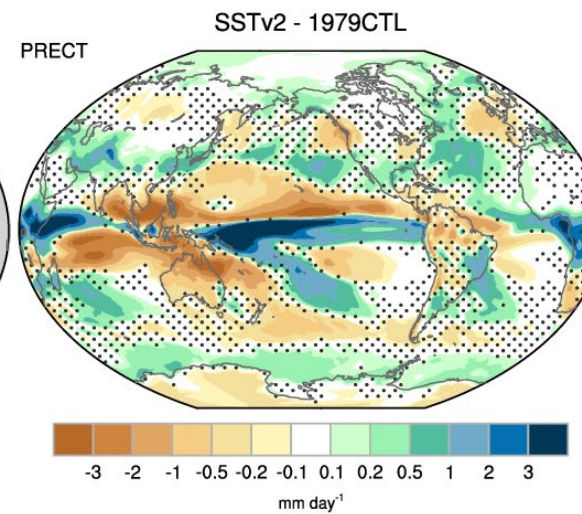
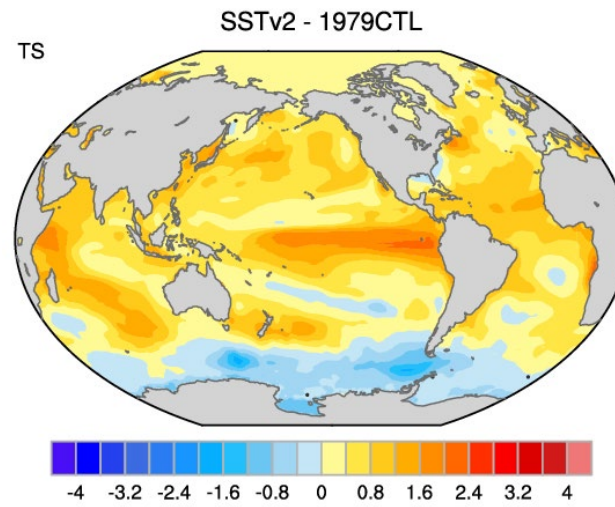
PRECT

SLP

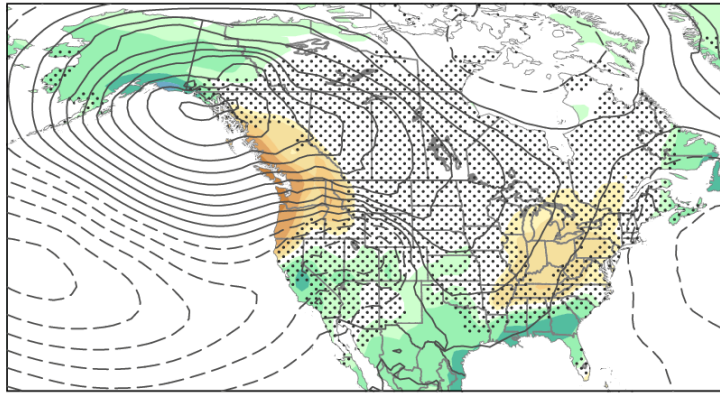
20-member SMYLE



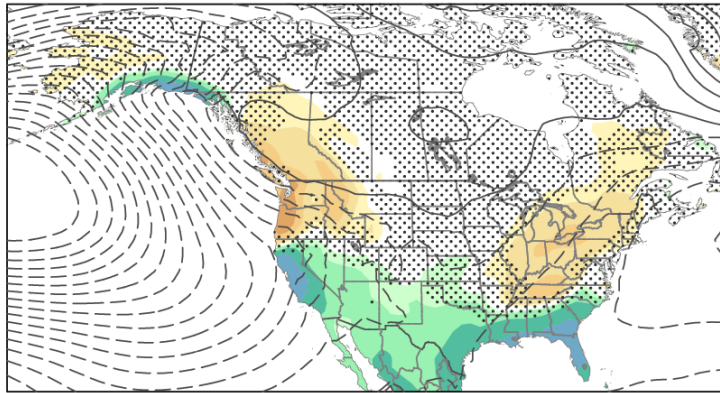
50-member AMIP



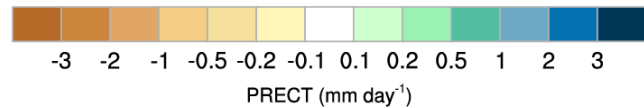
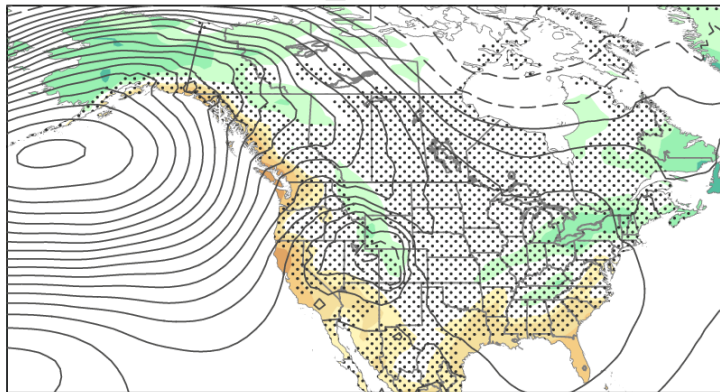
**CAM6 AMIP
minus
1979 Control**



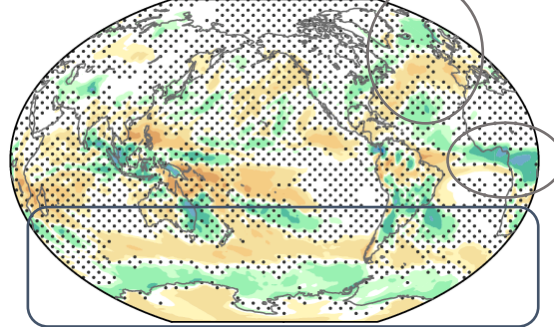
**Counterfactual
minus
1979 Control**



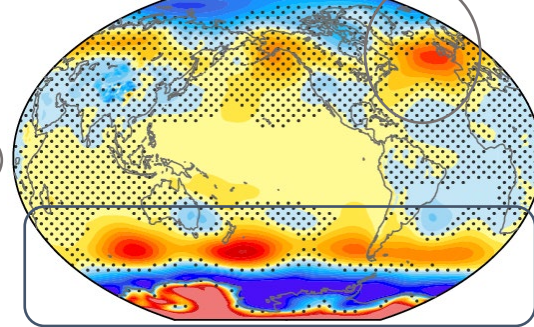
**Difference
(= SST trend +
 Δ Rad. Forcing)**



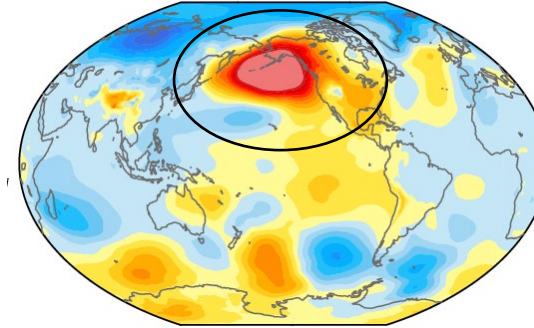
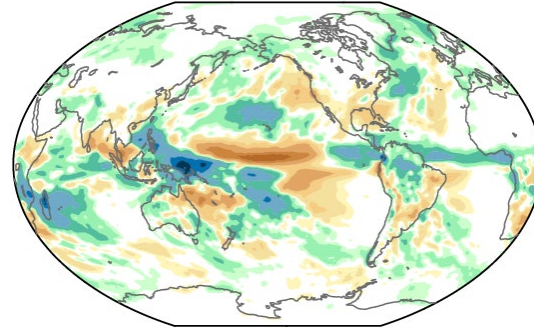
Precipitation



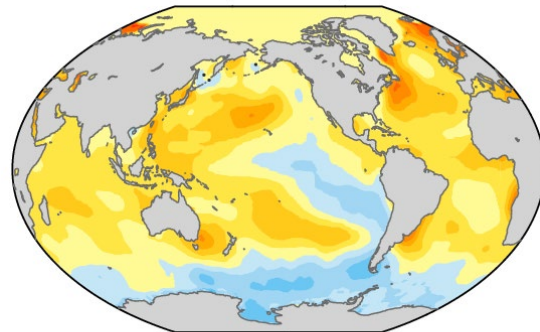
SLP



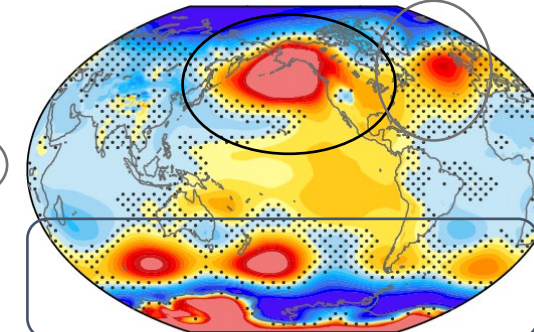
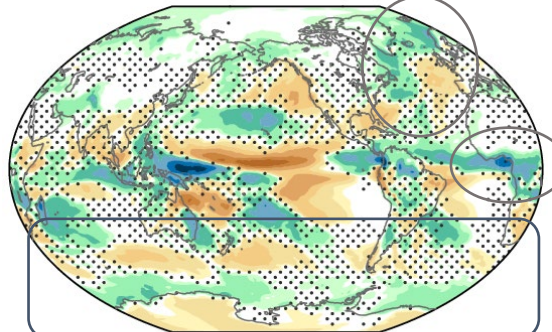
Δ Rad. Forcing



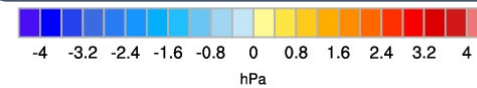
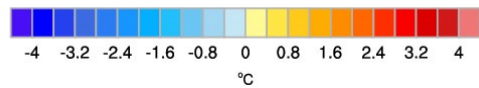
SST trend



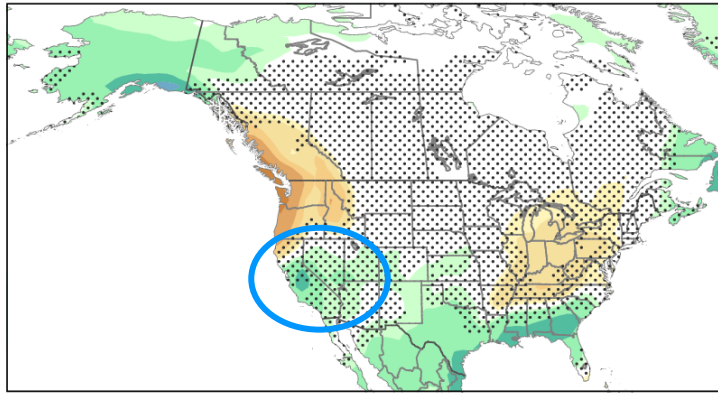
Difference
(SST trend + Δ RF)



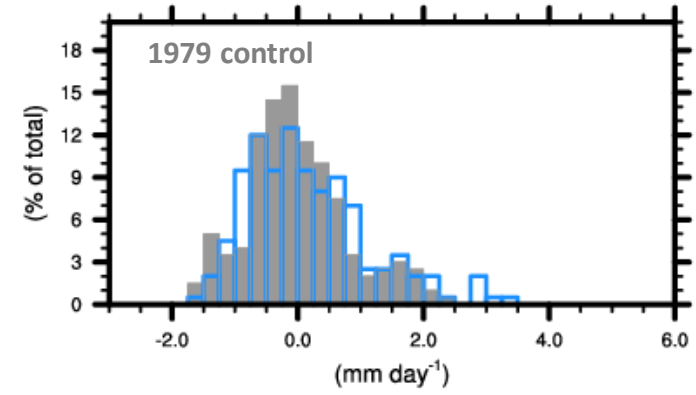
SST trend +
 Δ Rad. Forcing



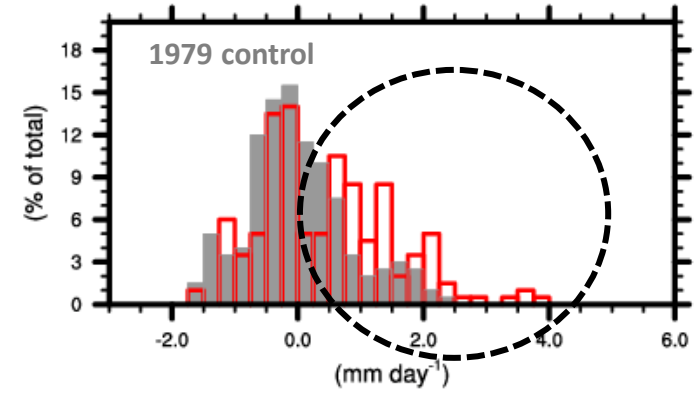
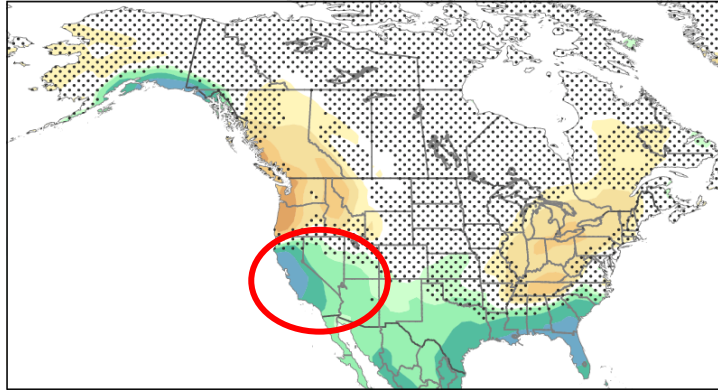
El Nino +
Background
climate change



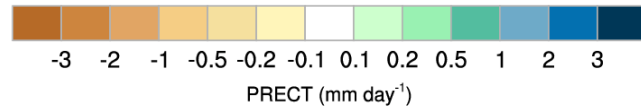
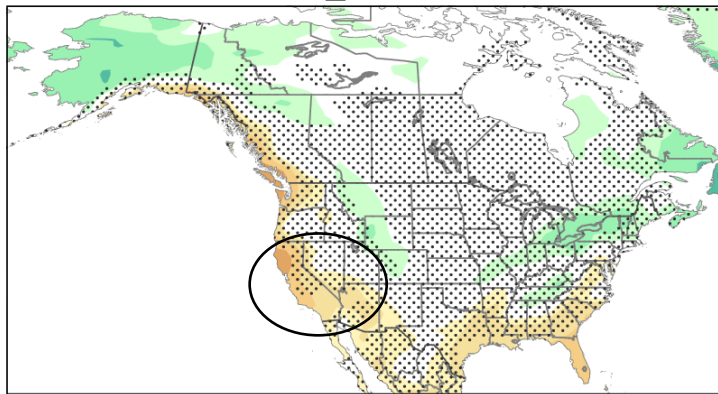
CA/SW



El Nino



Background
climate change



Monthly anomalies
relative to 1979 control