How California's winter storms go south (rather than north)

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Wet winters on West Coast: "Circumglobal wave train"

Roles of SST versus Internal Atmospheric Variability in Winter Extreme Precipitation Variability along the U.S. West Coast

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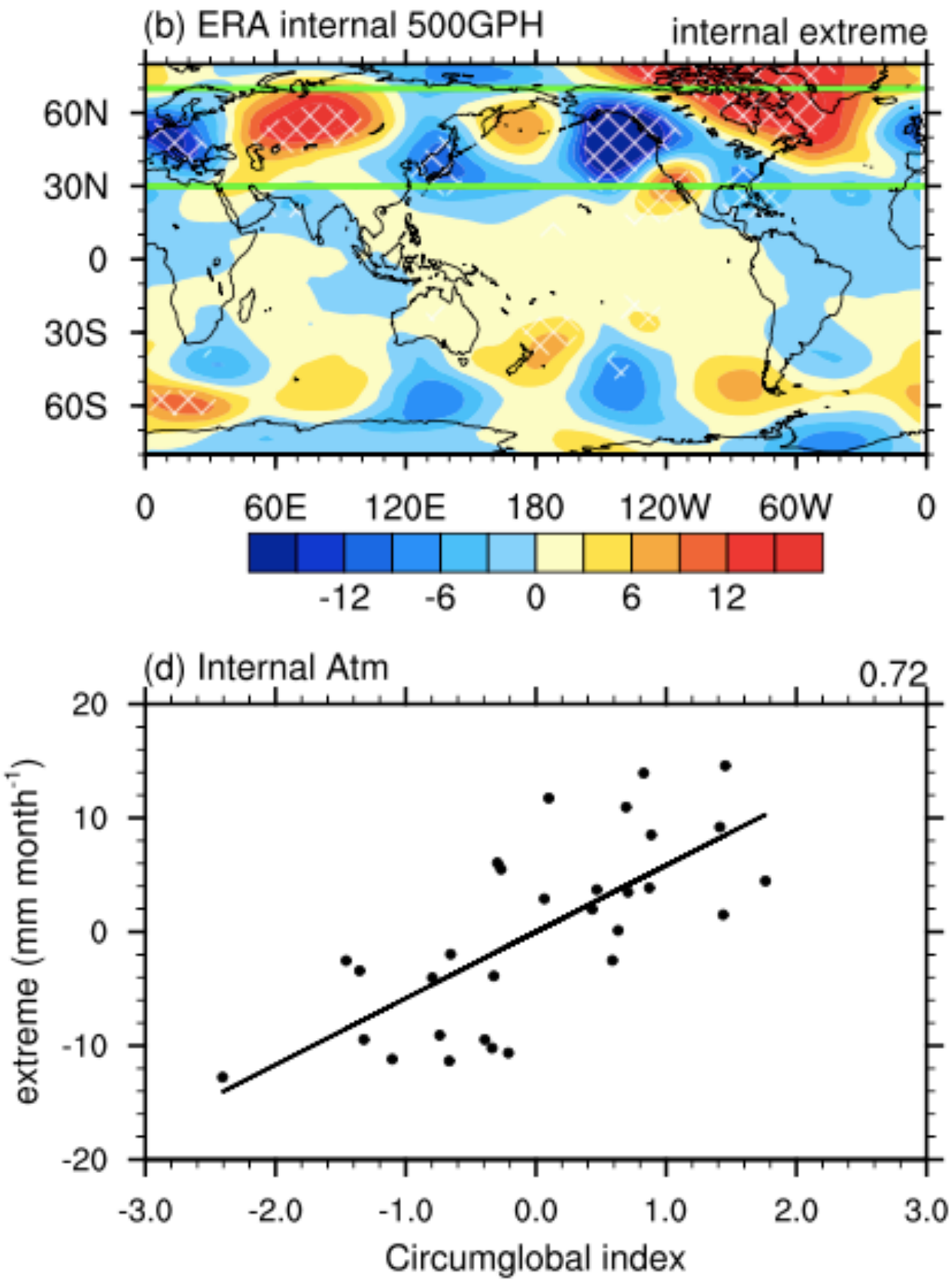
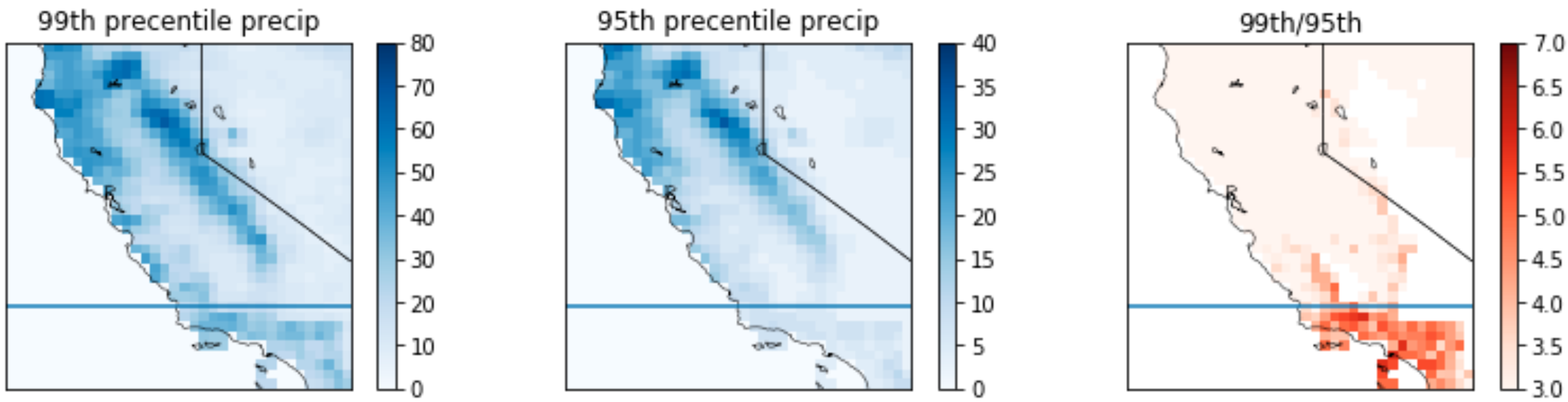
Coupled Model Intercomparison Project (CMIP5) are analyzed. It is found that SST forcing only accounts for about 20% of the variance of both extreme and nonextreme precipitation in winter. Under SST forcing, extreme precipitation is associated with the Pacific–North American teleconnection, while nonextreme precipitation is associated with the North Pacific Oscillation. The remaining 80% of extreme precipitation variations can be explained by internal atmospheric dynamics featuring a circumglobal wave train with a cyclonic circulation located over the U.S. West Coast. The circumglobal teleconnection manifests from the


(b) ERA internal 500GPH
internal extreme
60N
30N
0
30S
60S
0
60E
120E
180
120W
60W
0
-12
-6
0
6
12
(d) Internal Atm
0.72
20
10
0
-10
-20
extreme (mm month-1)
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
Circumglobal index

Precip variability is (much) higher in Southern California

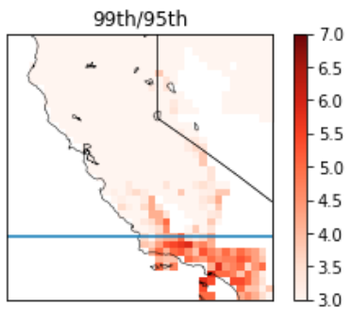
CPC Uni precip

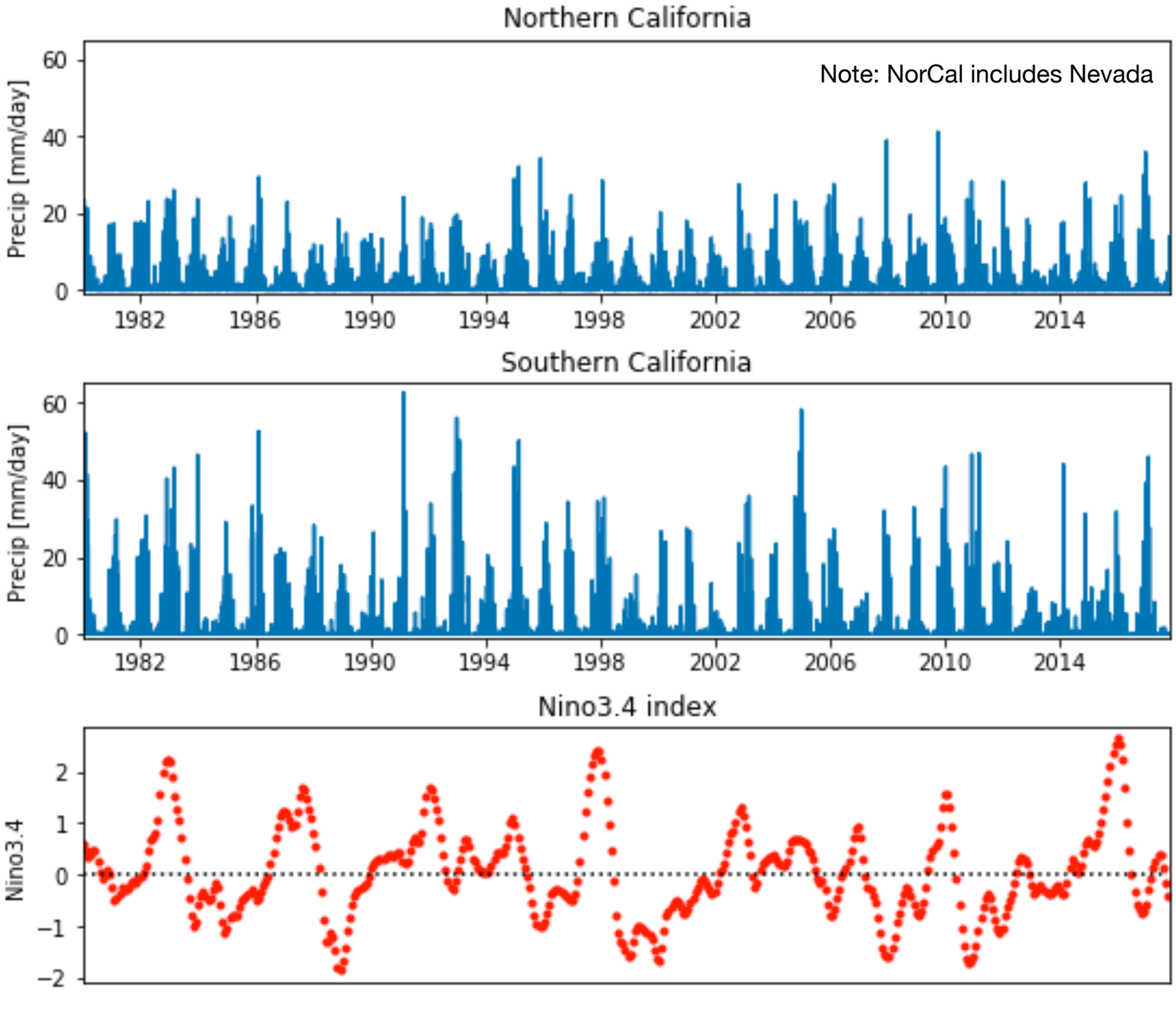


Blue line is 35th parallel

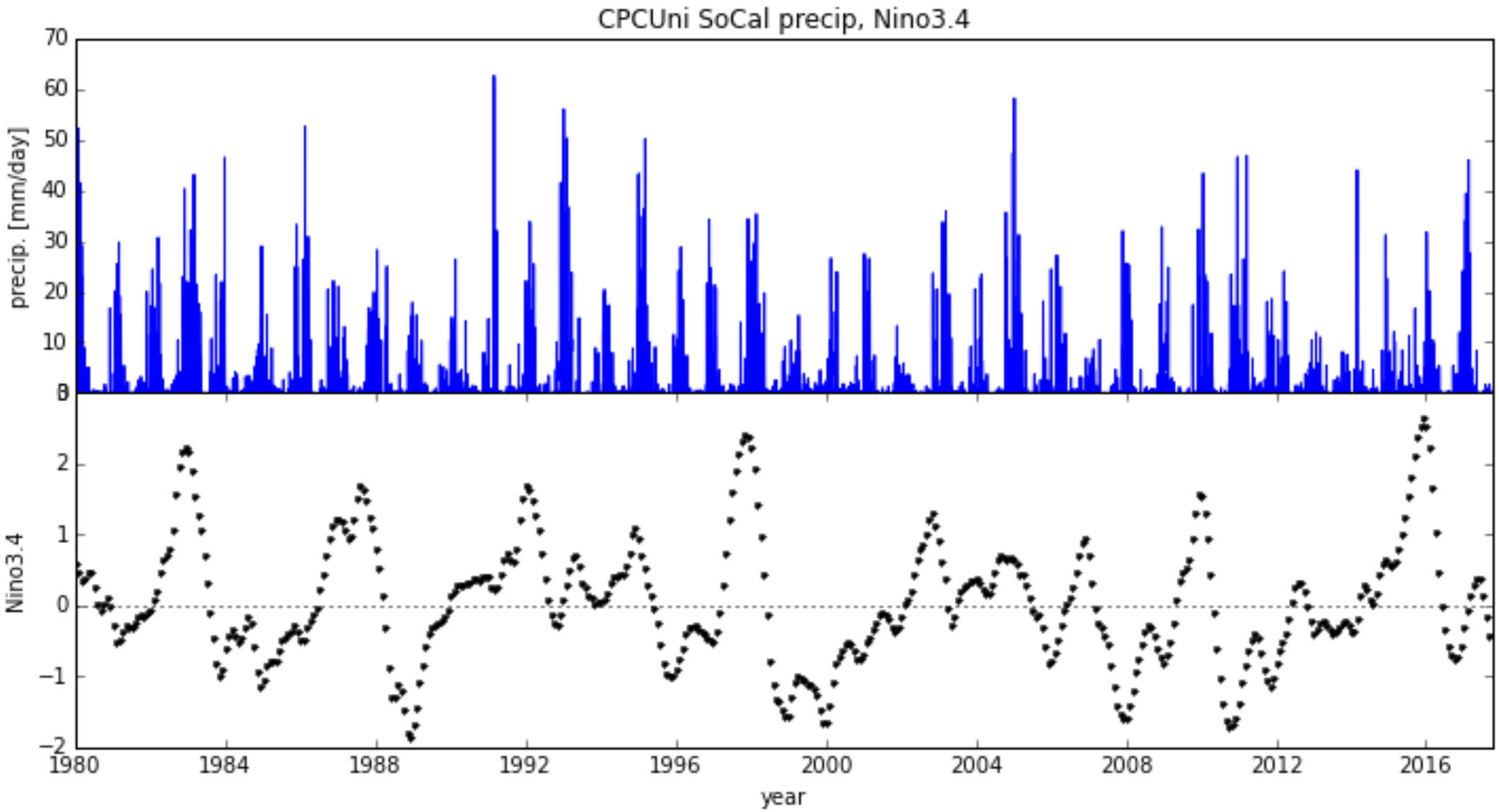
CPC US Unified Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at https://www.esrl.noaa.gov/psd/

SoCal's precip typically comes in extremes





el Niño is not a great predictor of Southern California precip



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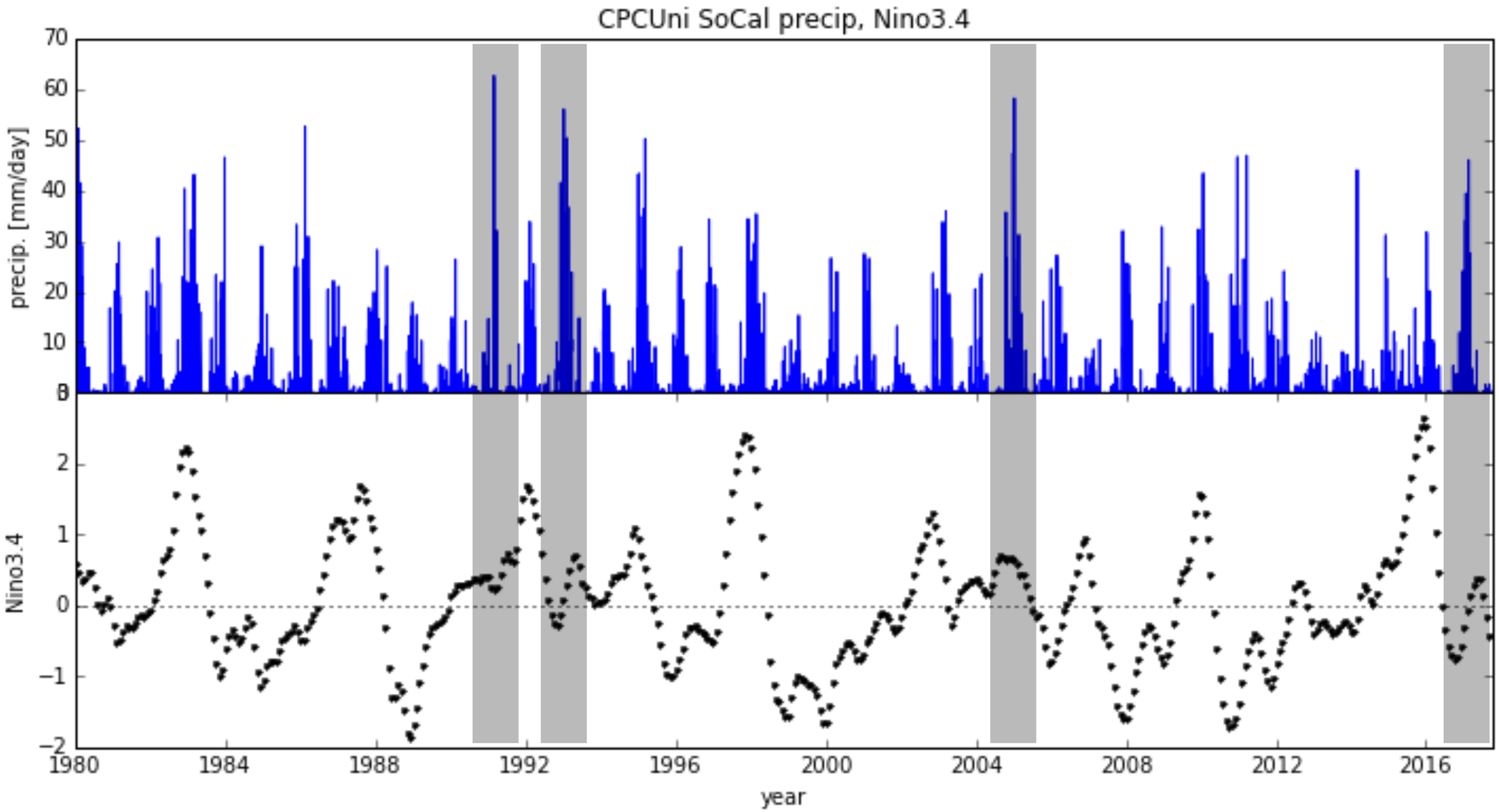

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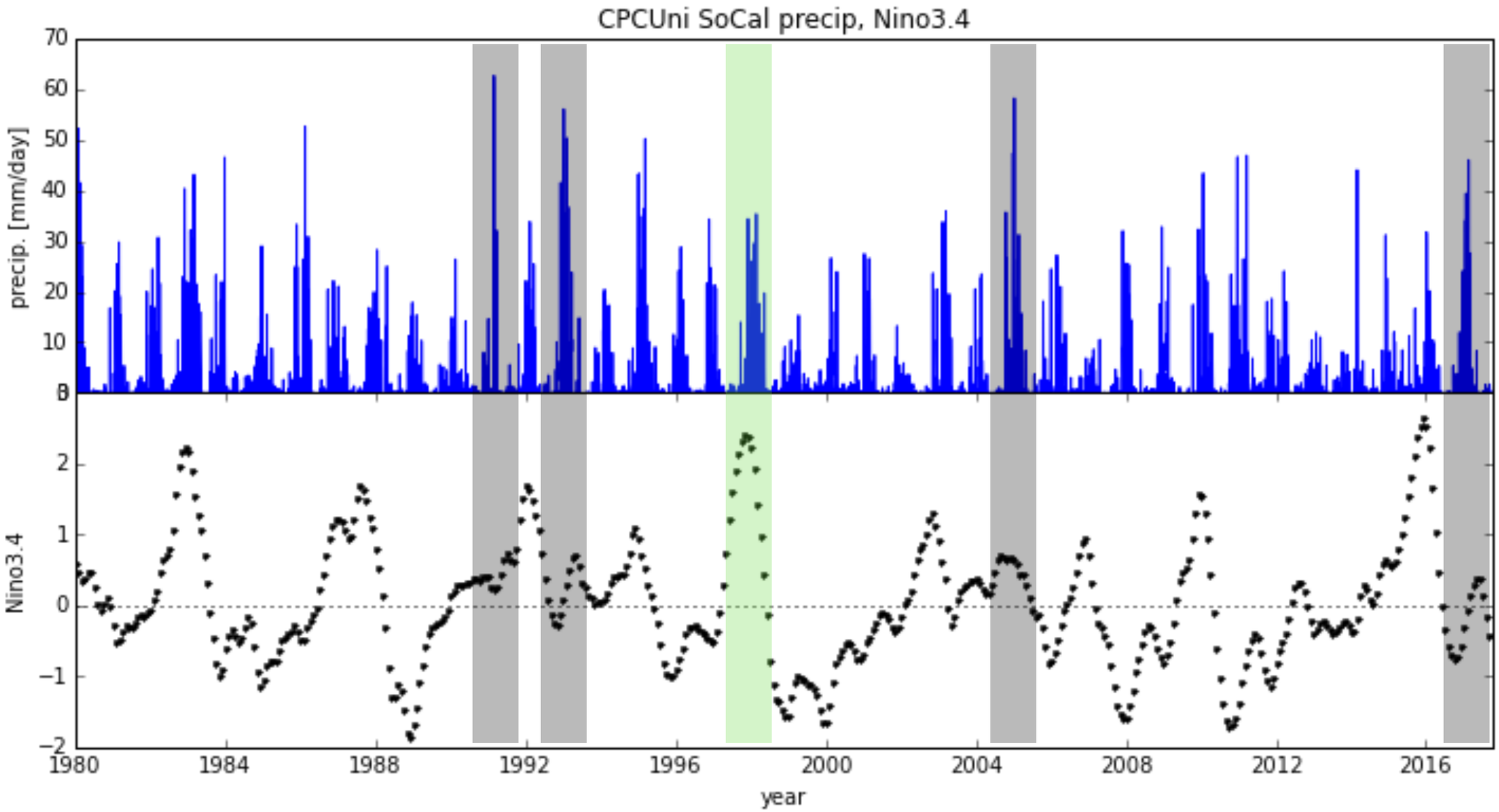
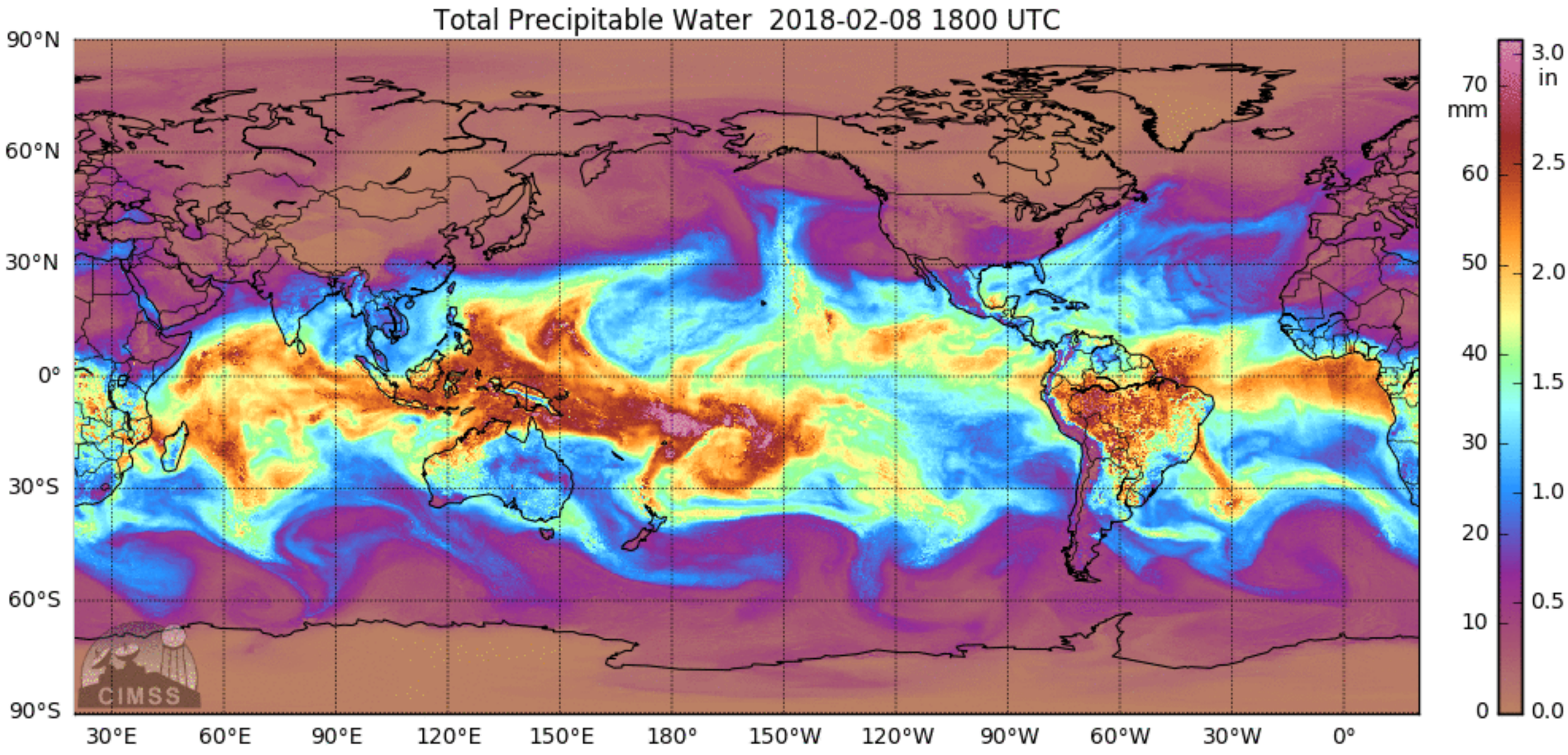


Extreme precip ≈ Atmospheric River



MIMIC-TPW ver 2 obtained at http://tropic.ssec.wisc.edu/real-time/mtpw2

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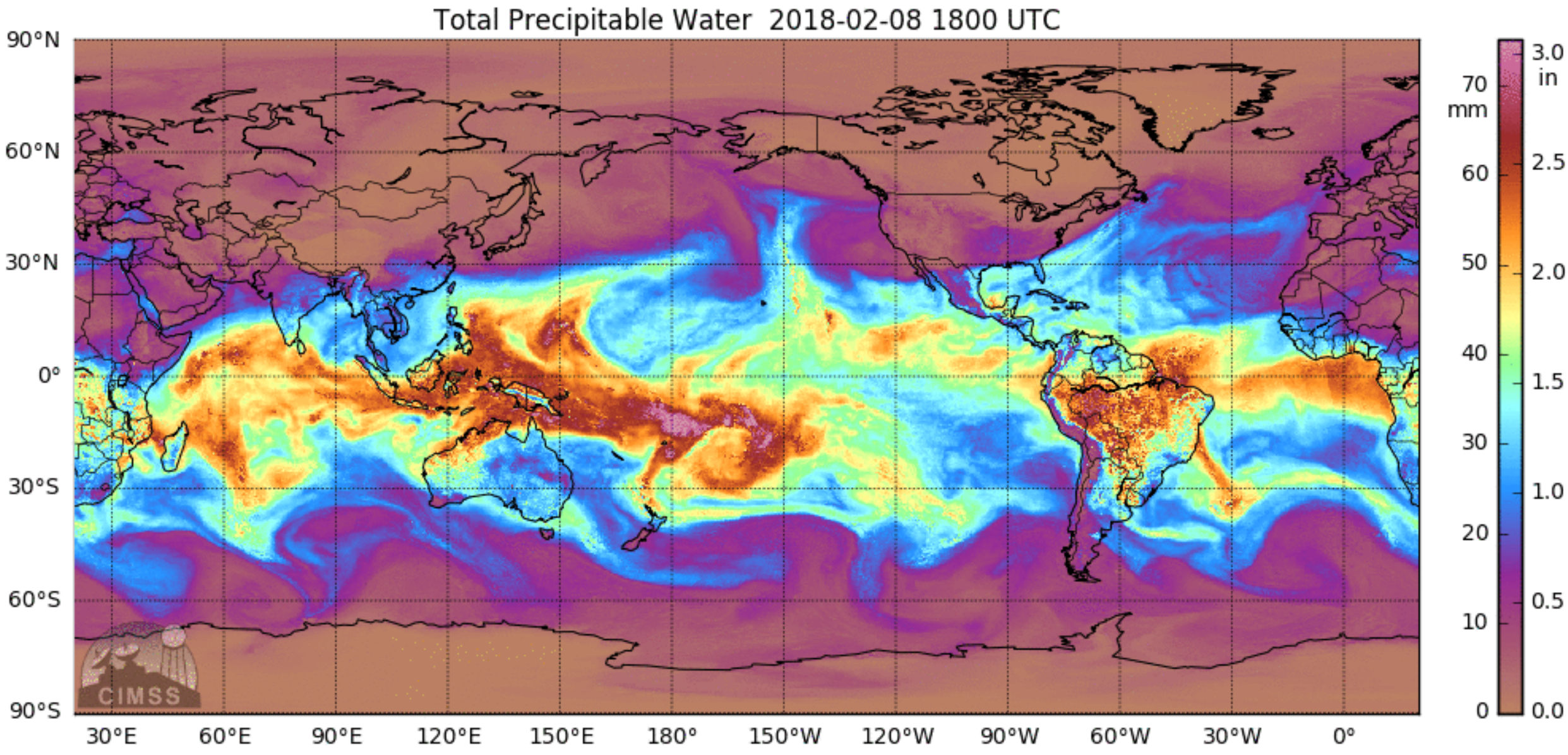
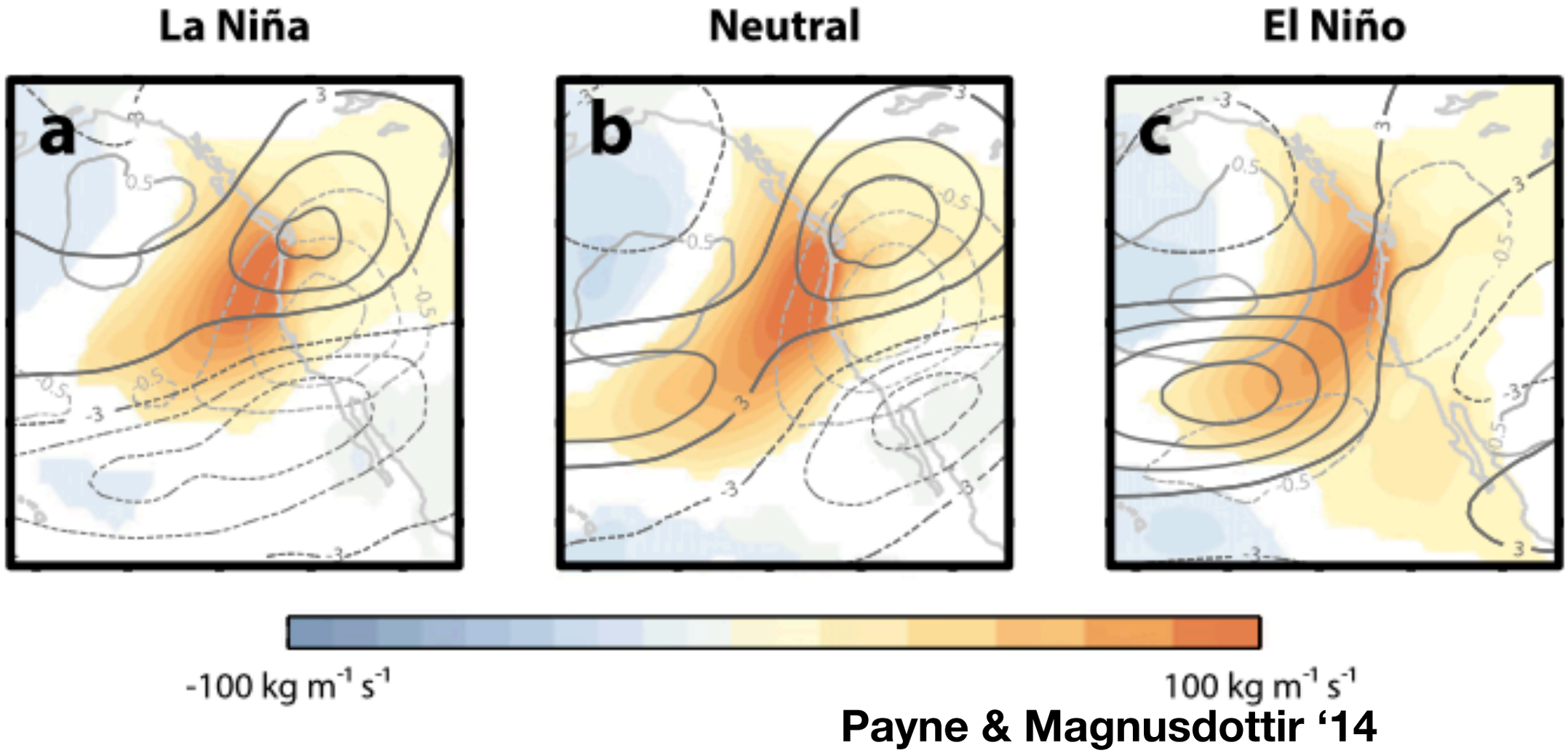


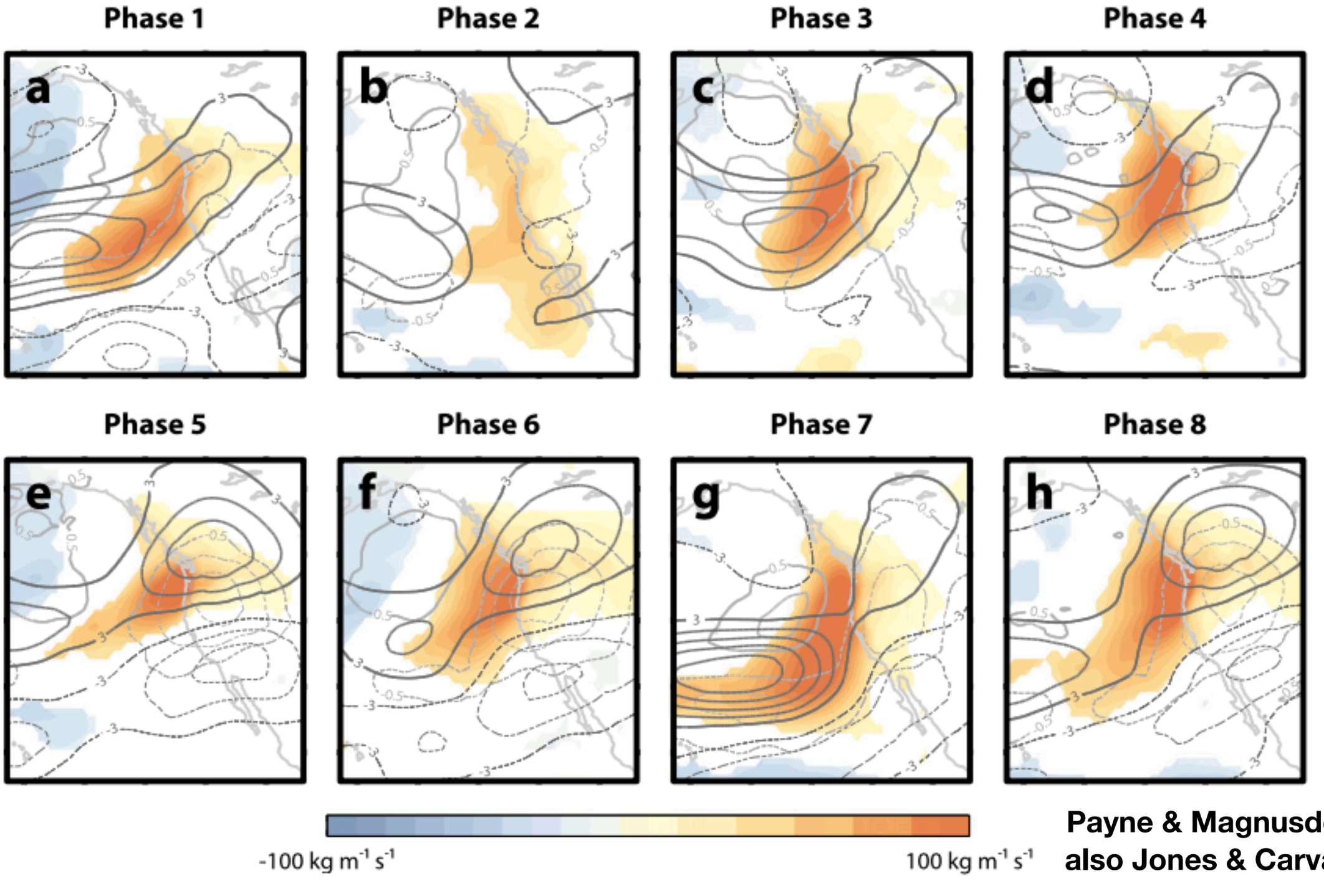
MIMIC-TPW ver 2 obtained at http://tropic.ssec.wisc.edu/real-time/mtpw2

El Niño favors atmospheric river spatial variability (not intensity), but…



Payne & Magnusdottir ‘14

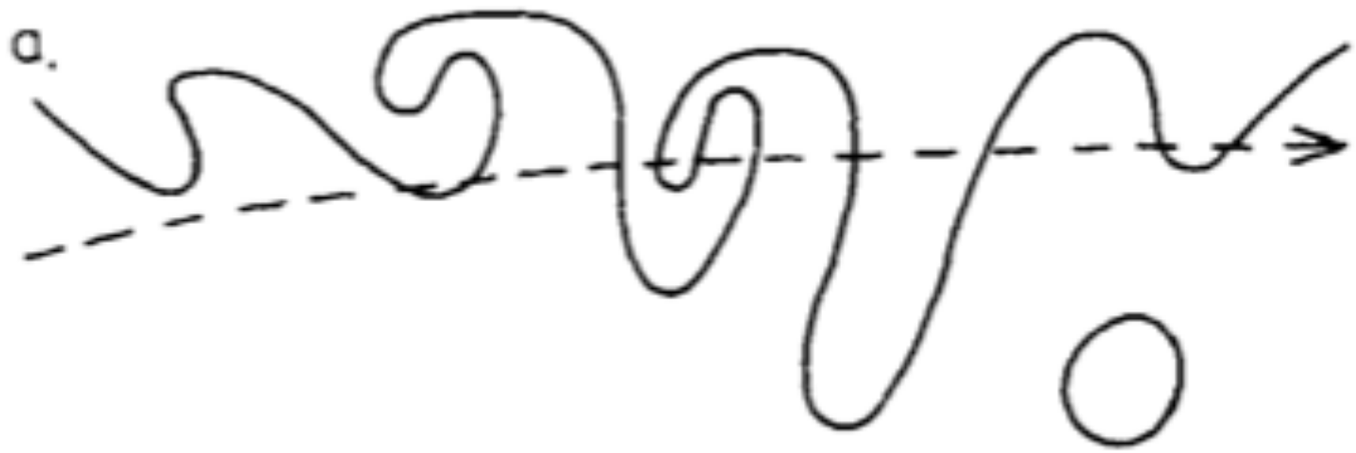
…the MJO has a bigger impact on AR spatial variability.



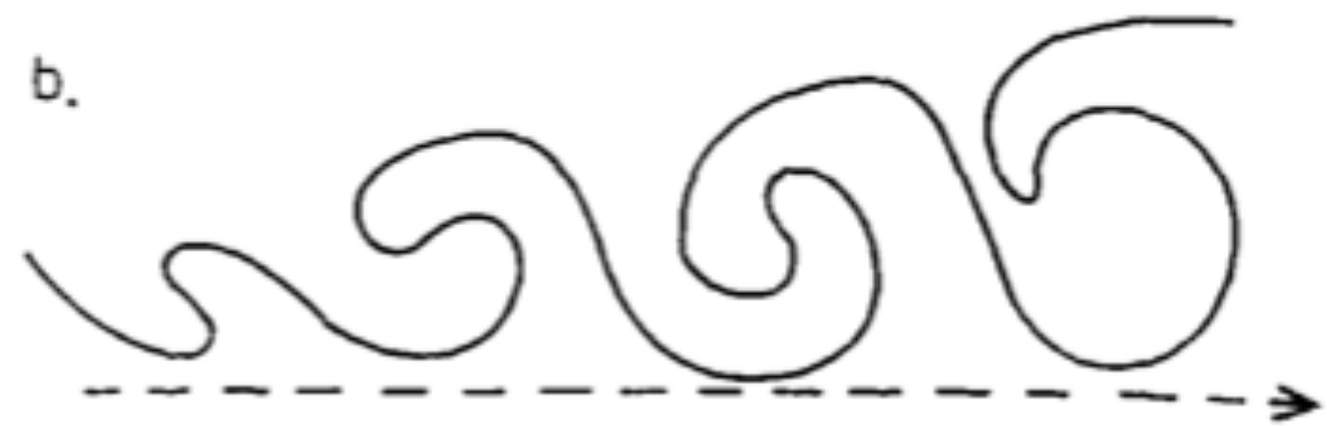
Payne & Magnusdottir ’14
also Jones & Carvahlo ‘14

Rossby wave breaking: The link to the large scales

- Anticyclonic Wave Breaking



- Cyclonic wave breaking



Thorncroft et al. ‘93

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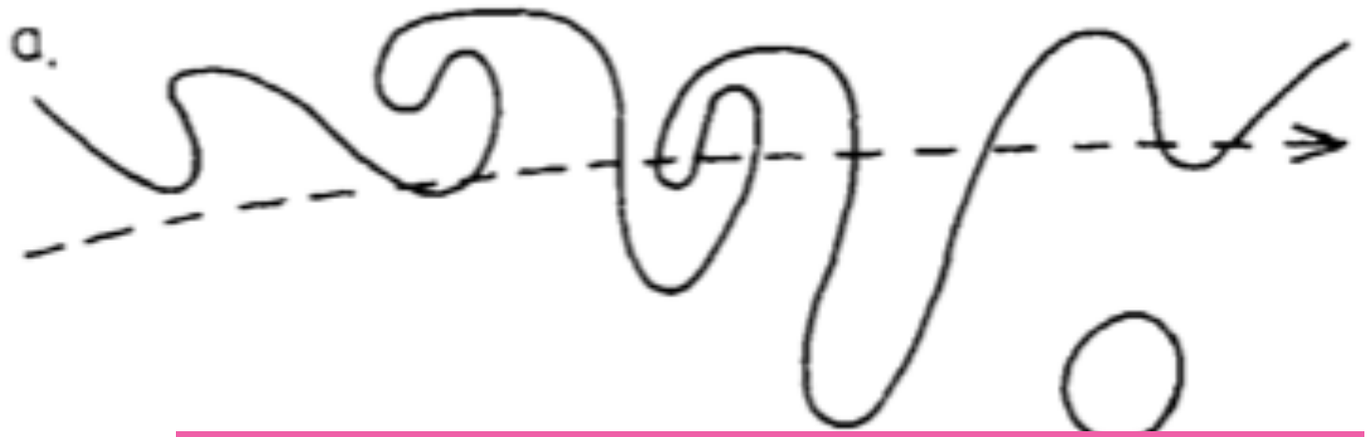
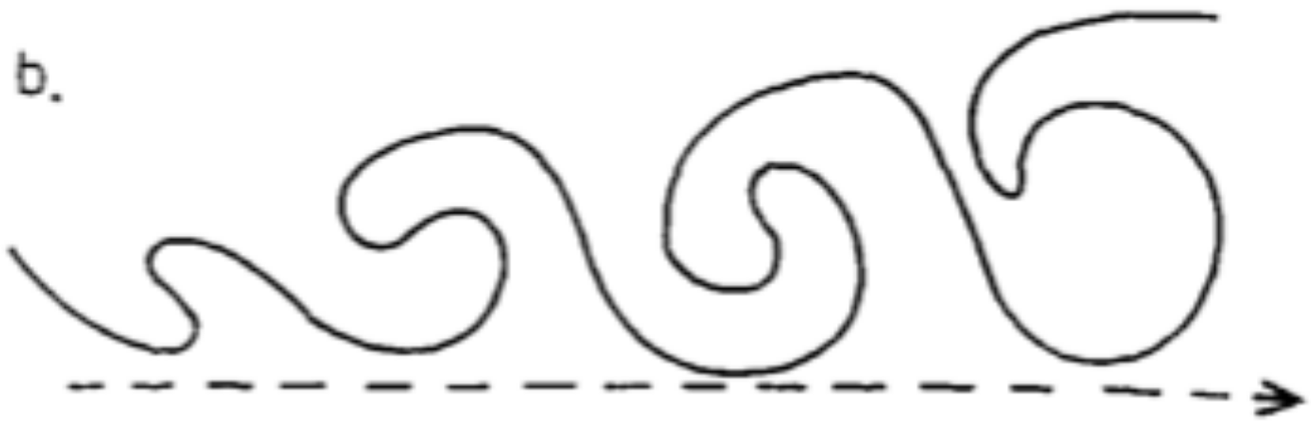


AR formation by local, mid-latitude dynamics (Payne & Magnusdottir ’14)

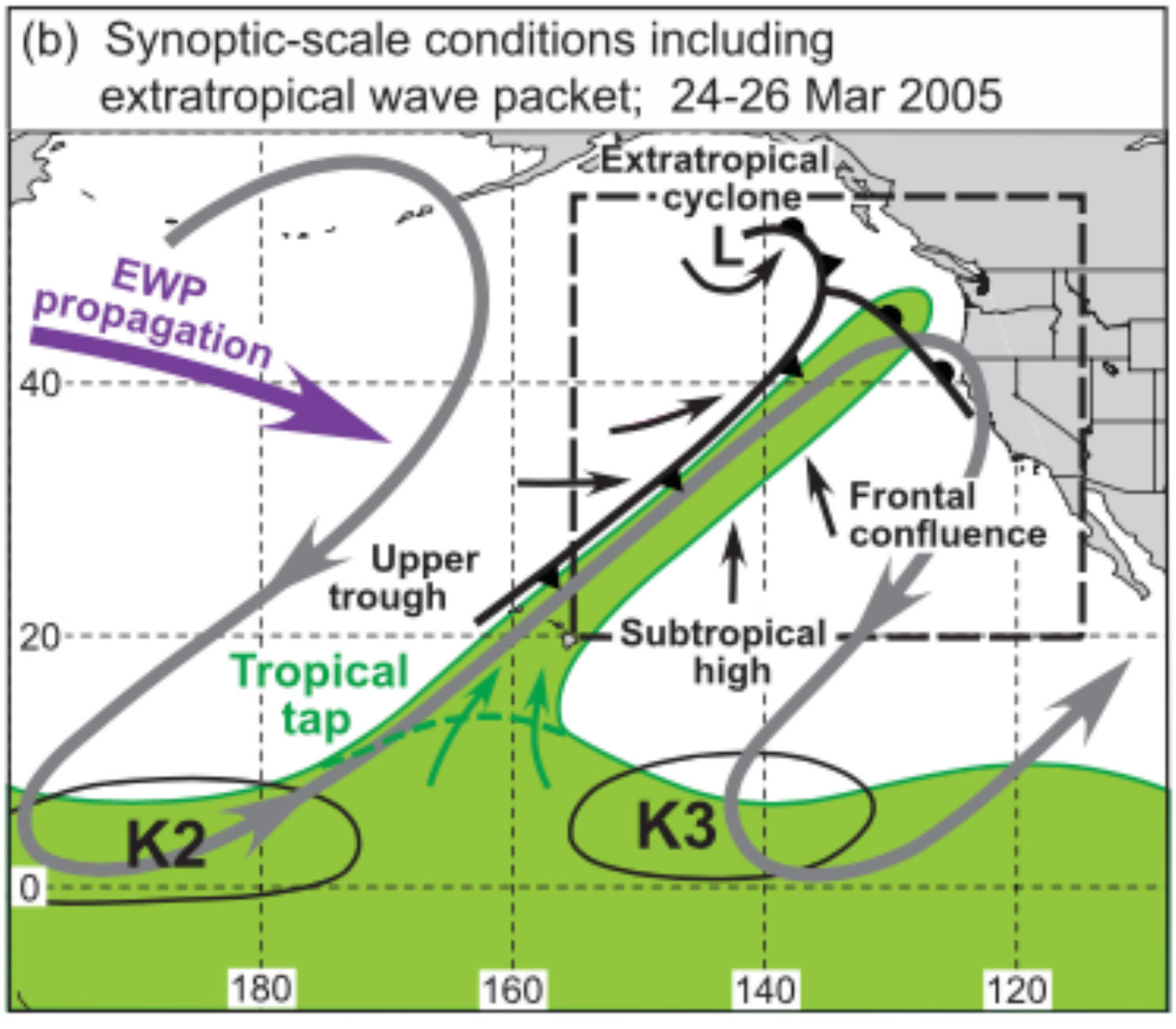
- Cyclonic wave breaking



Thorncroft et al. ‘93

AWB breaking leads to AR formation

- Blocking high and trough formation
- Frontal convergence
- Tropical “tap”



Ralph et al. ‘11

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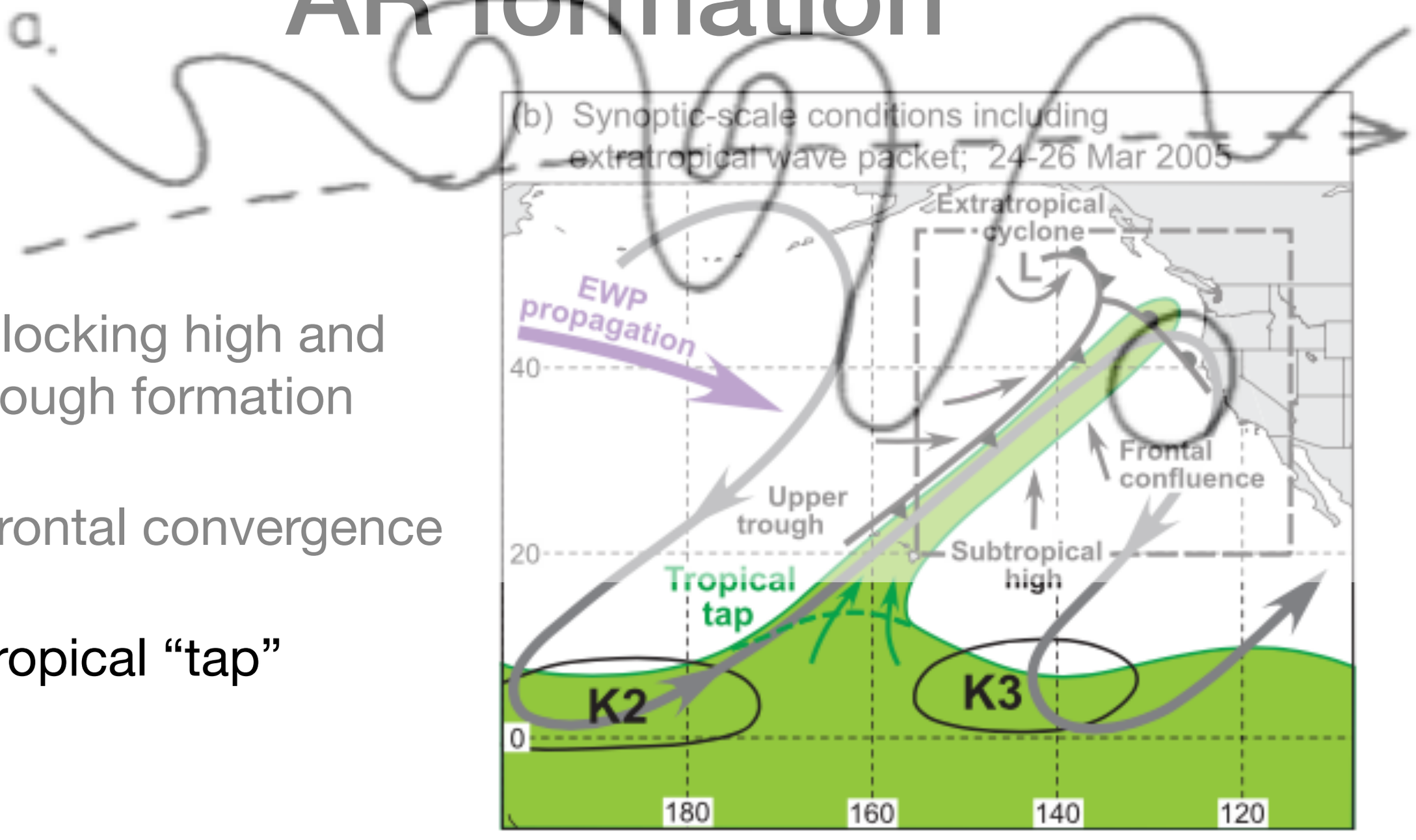
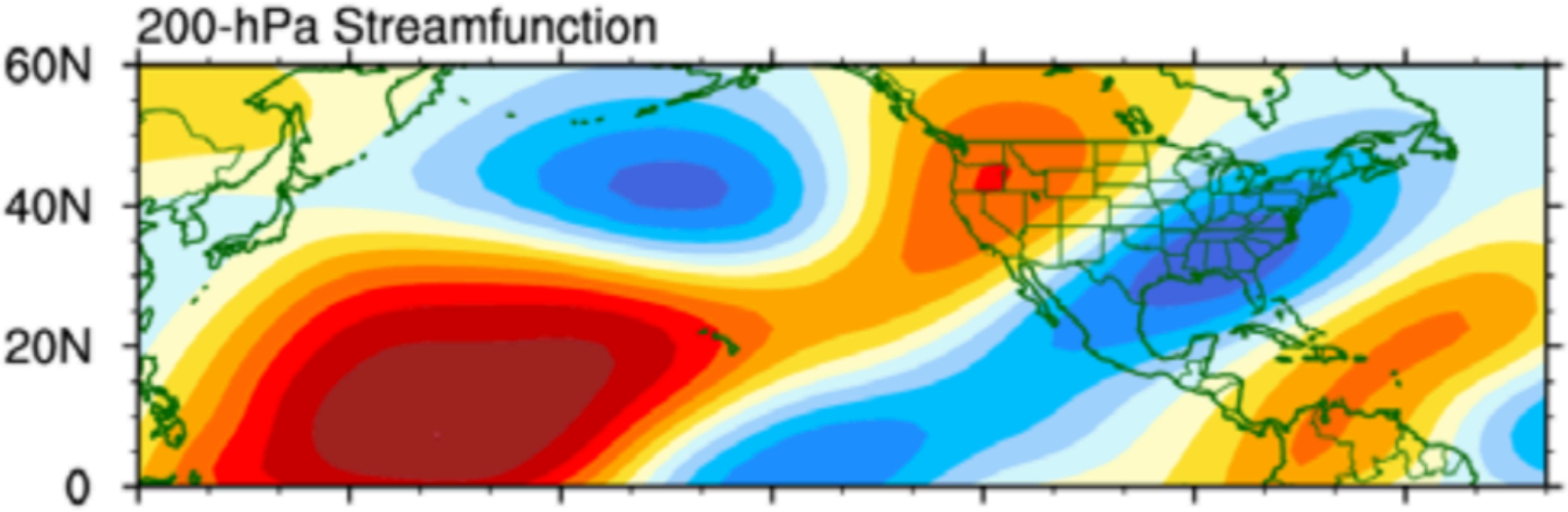


Ralph et al. ‘11

The Pacific-North American teleconnection links large-scales to AWB

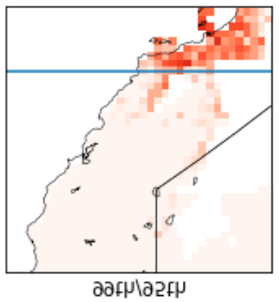


Schreck and Margolin ‘12

California Precip Cookbook

MERRA2 upper-level geopotential
Composite on 99th percentile CPCUni precip

SoCal



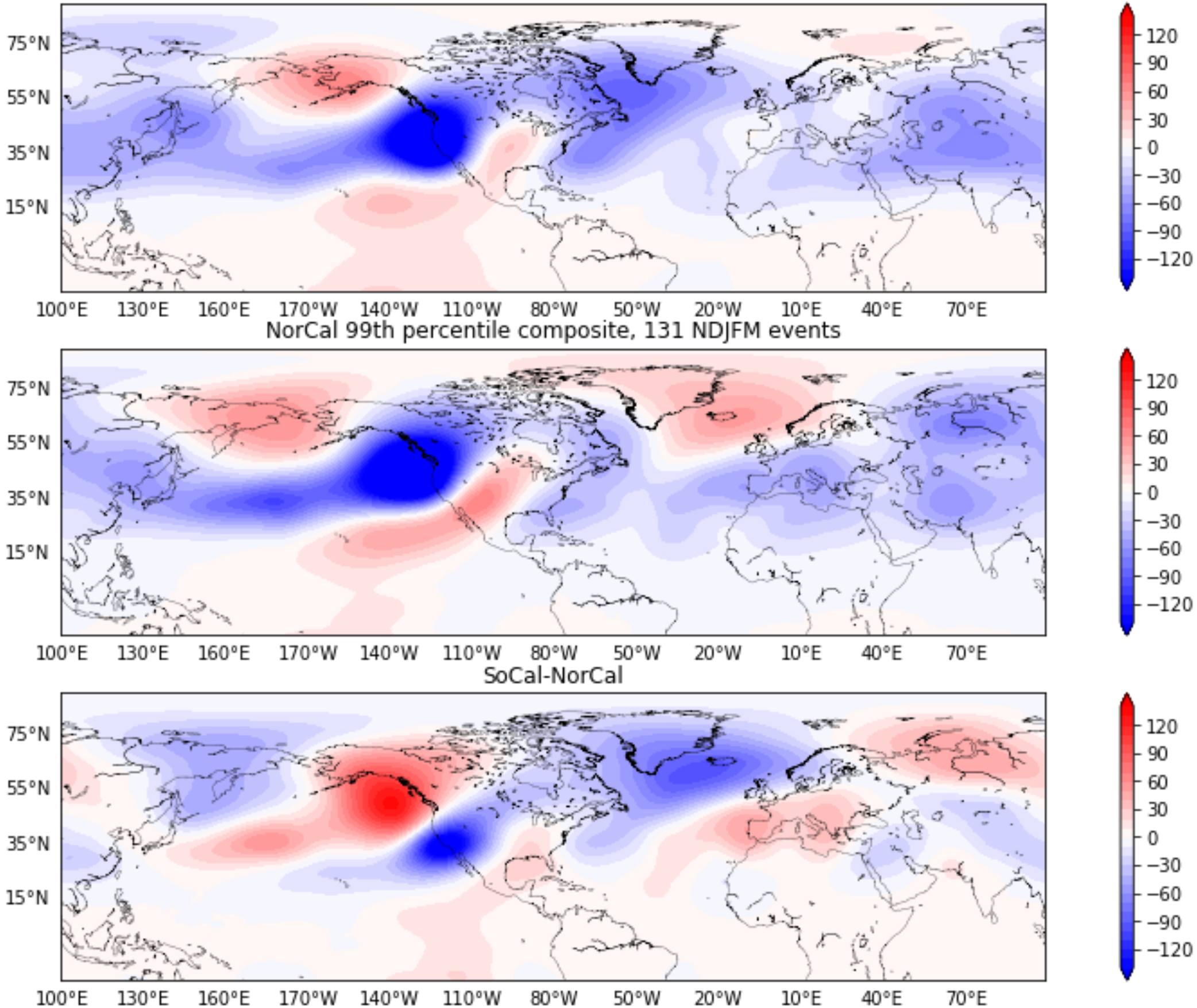
NorCal

Difference

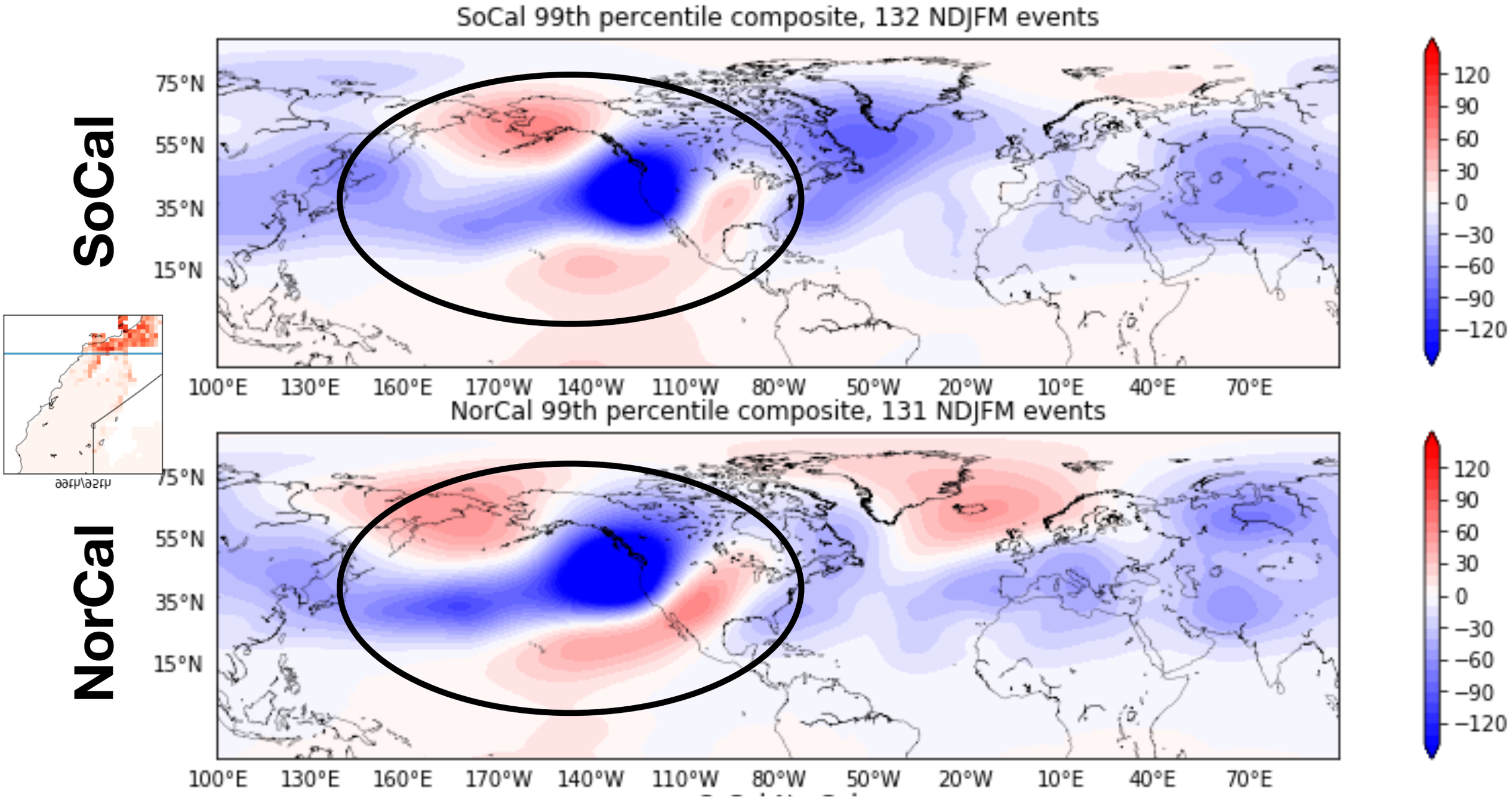
SoCal 99th percentile composite, 132 NDJFM events

NorCal 99th percentile composite, 131 NDJFM events

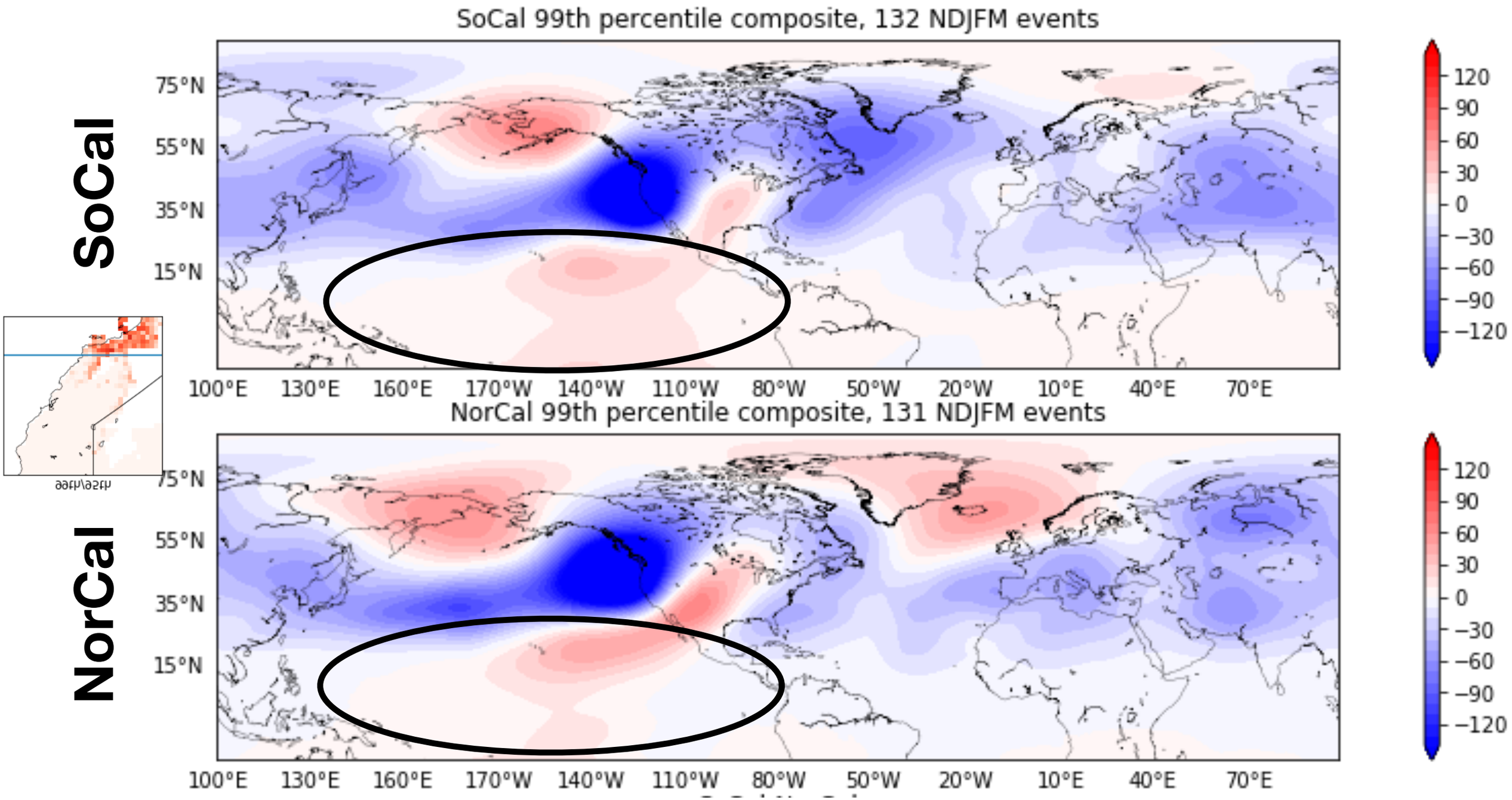
SoCal-NorCal



~PNA shows equal favor,…

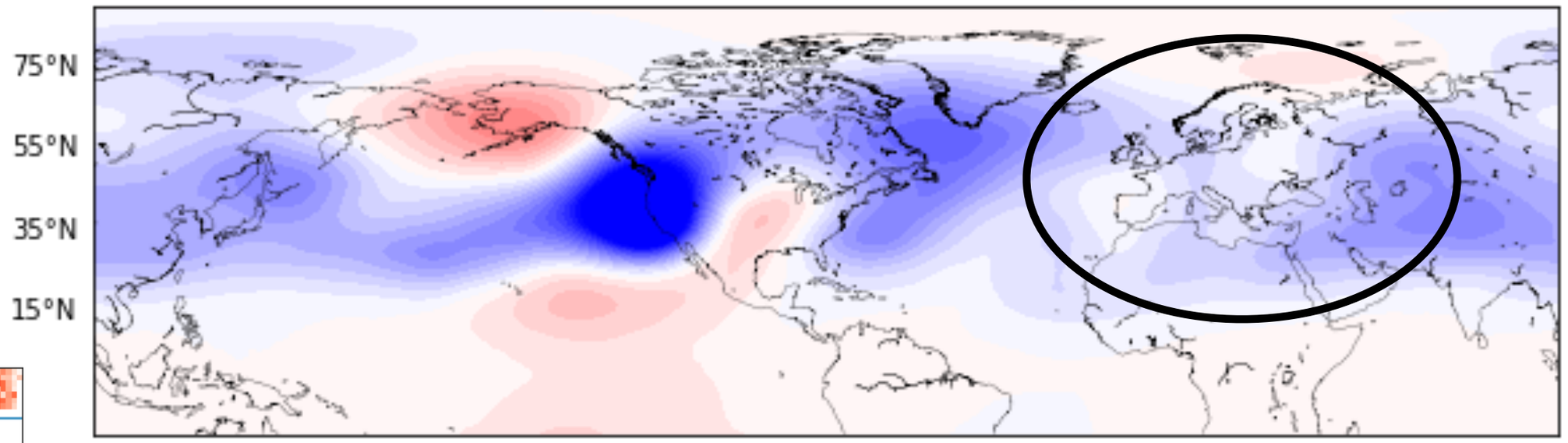


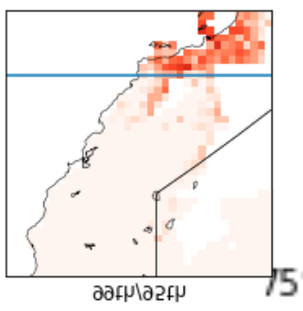
A tropical mode (MJO?) does as well,…



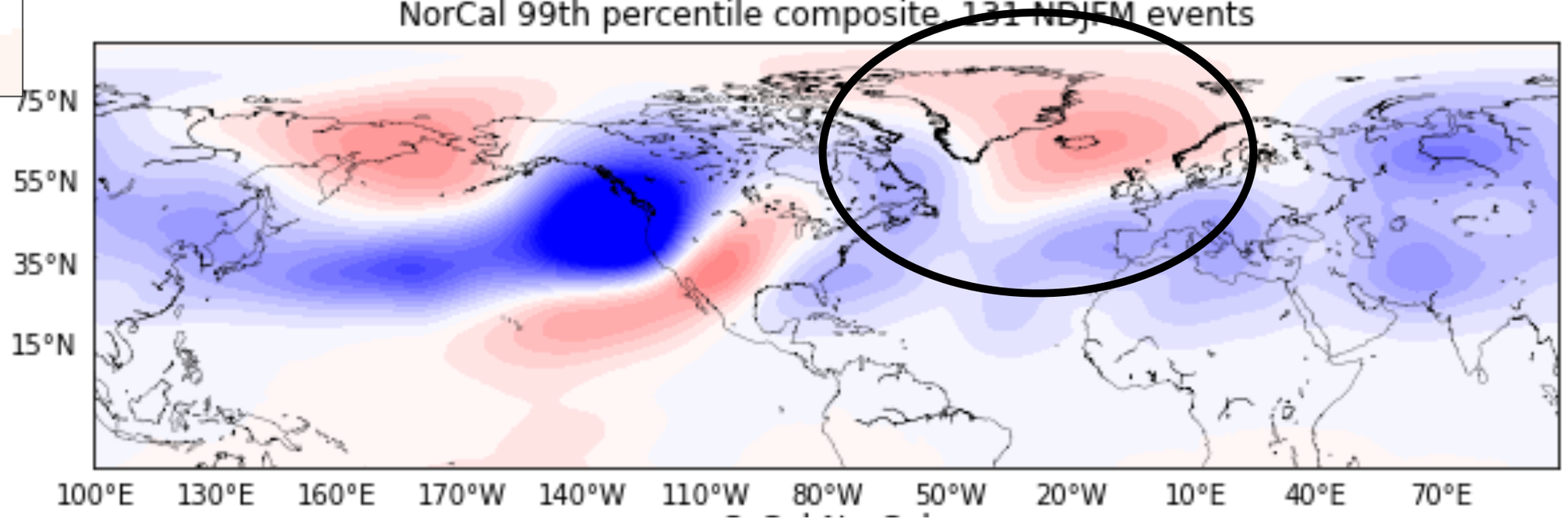
…phasing of AO/NAO seems important.

SoCal

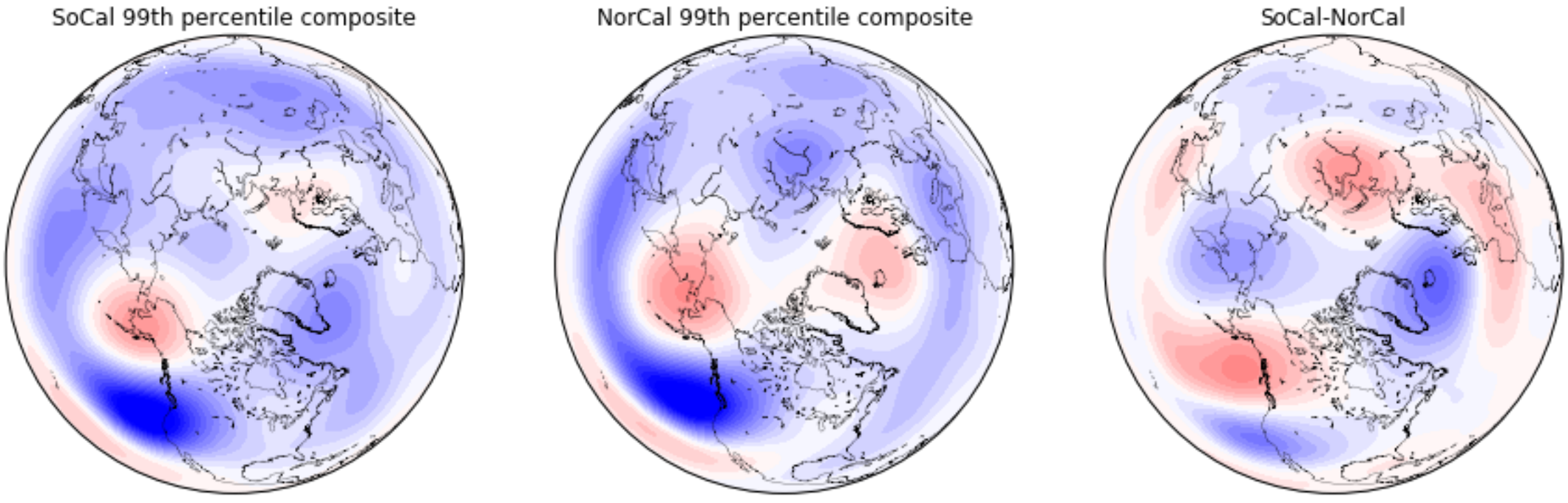




NorCal



This might work by AO-PNA phasing over the Bering Strait

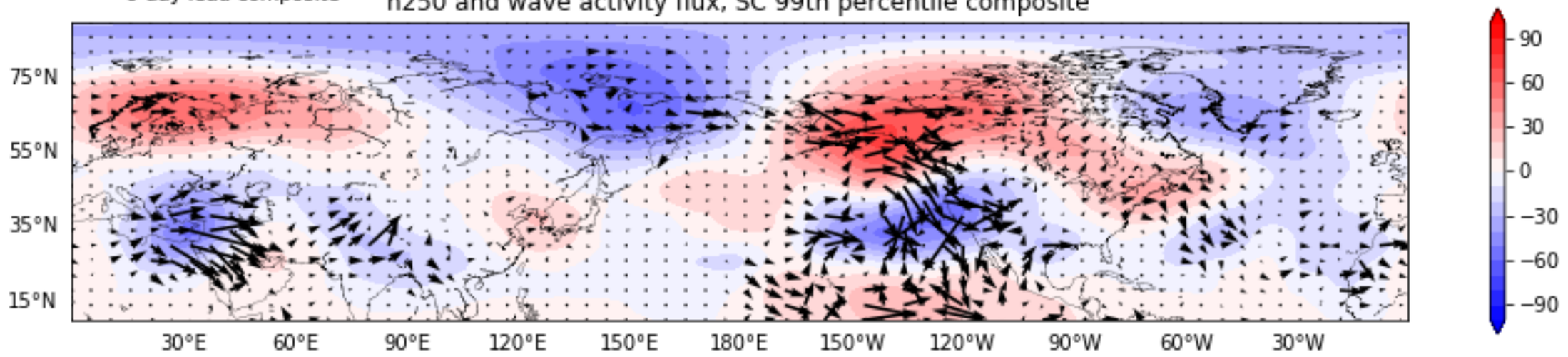


10-day running mean h250

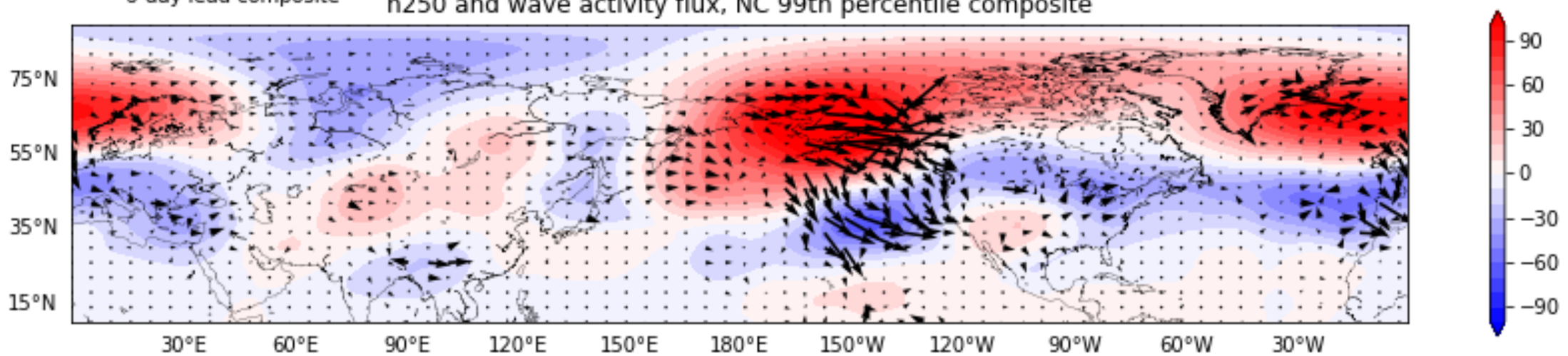
Wave activity flux suggests a role for subtropical waveguide

6-day lead

SoCal



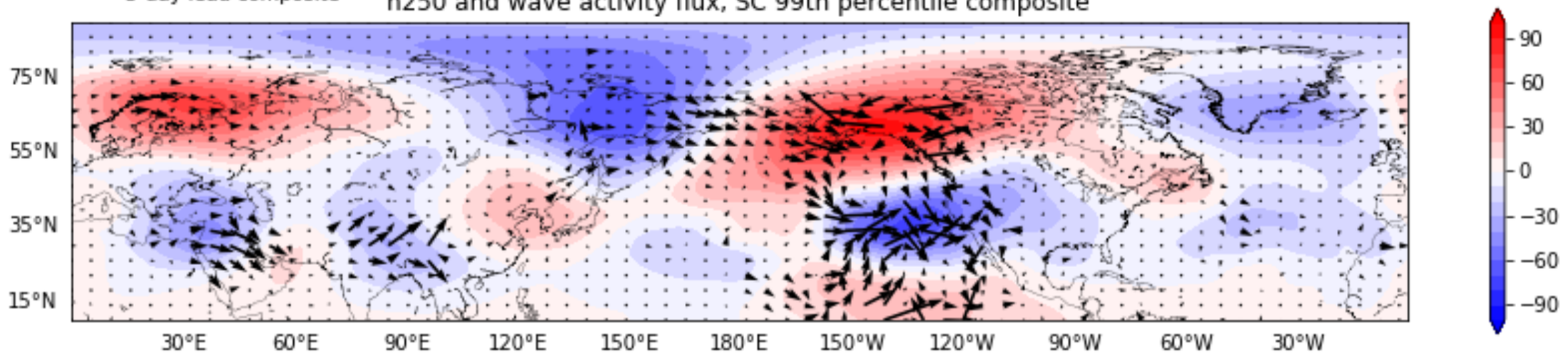
NorCal



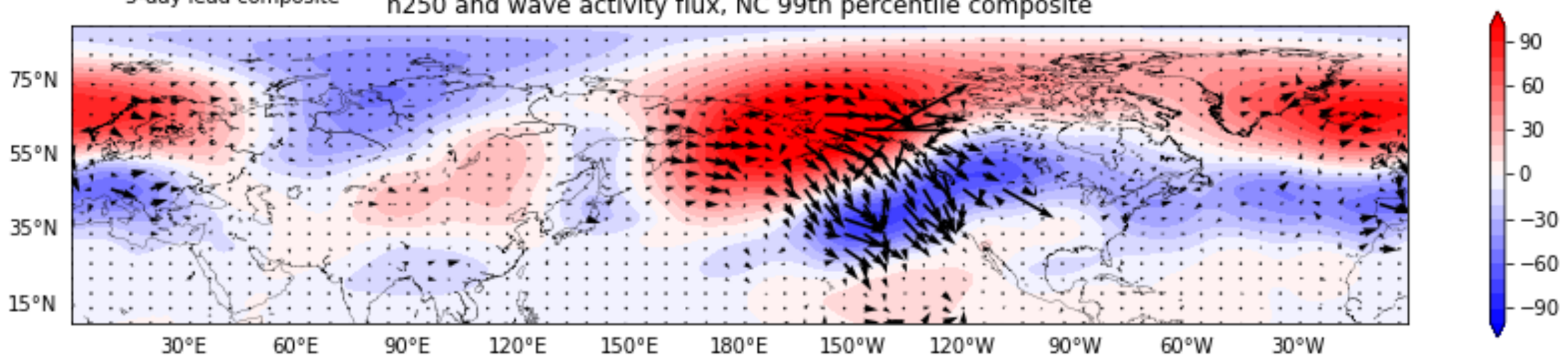
Wave activity flux suggests a role for subtropical waveguide

5-day lead

SoCal



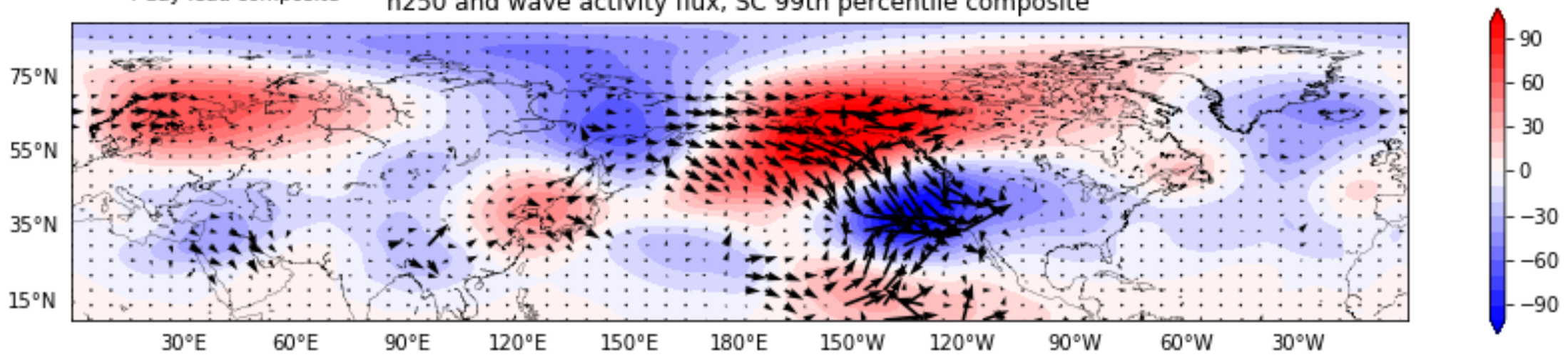
NorCal



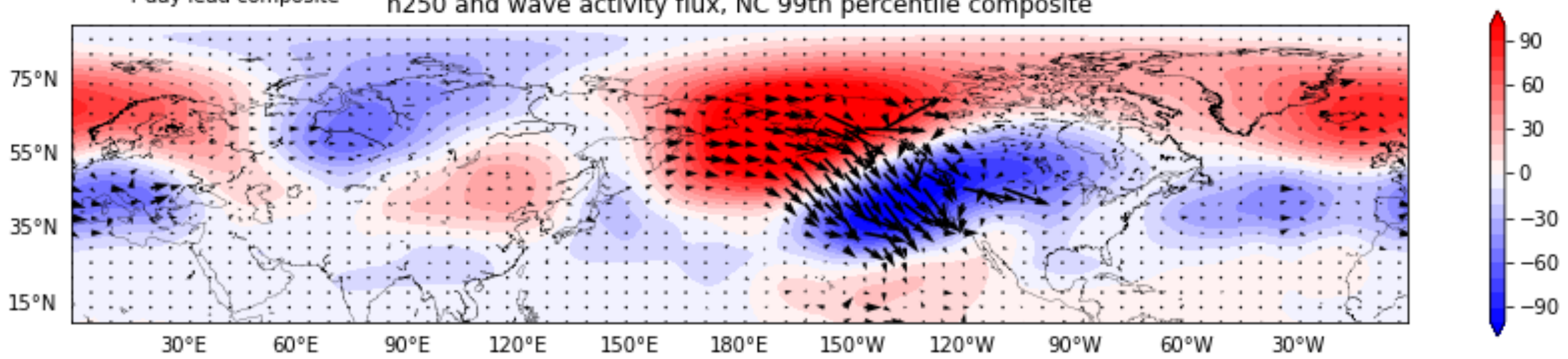
Wave activity flux suggests a role for subtropical waveguide

4-day lead

SoCal



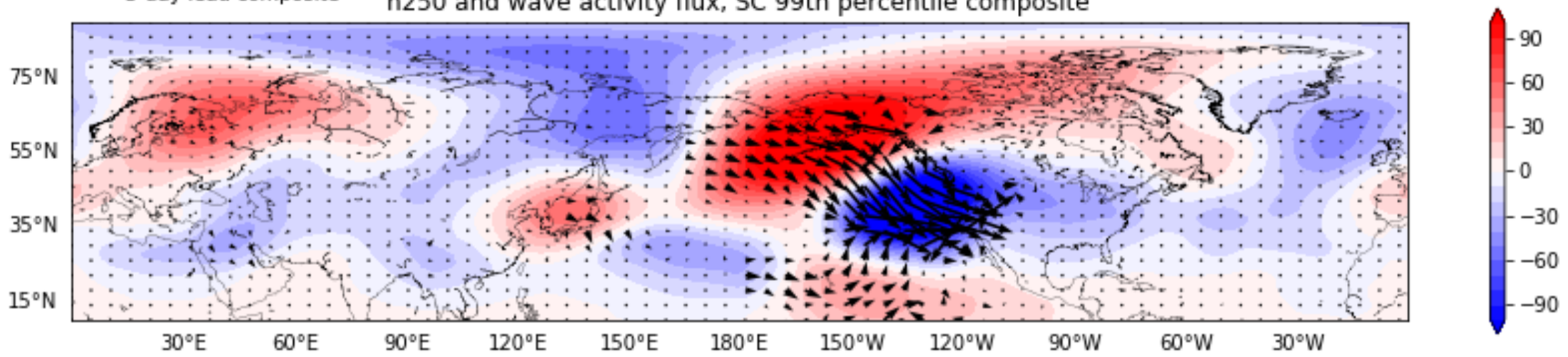
NorCal



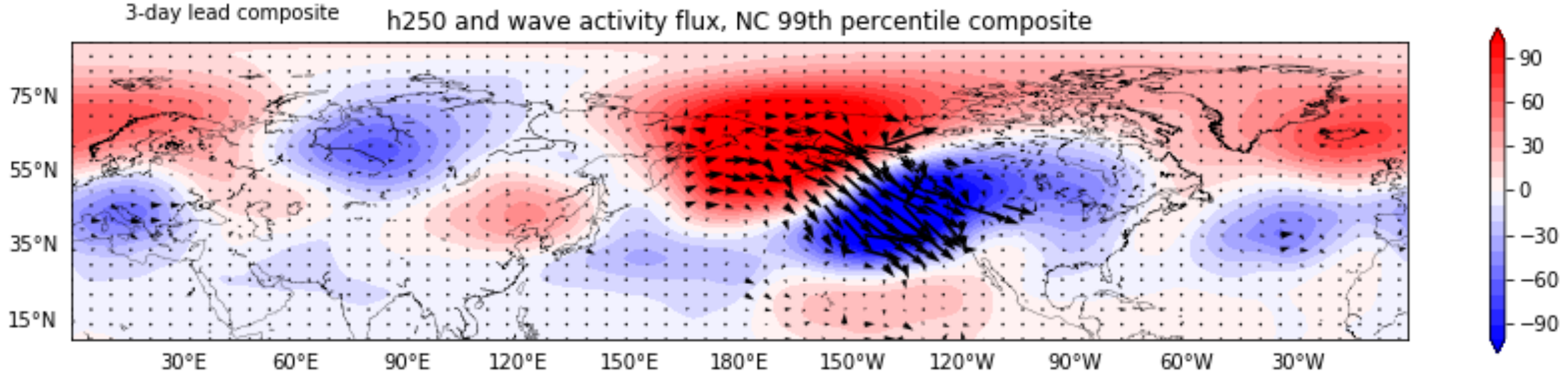
Wave activity flux suggests a role for subtropical waveguide

3-day lead

SoCal



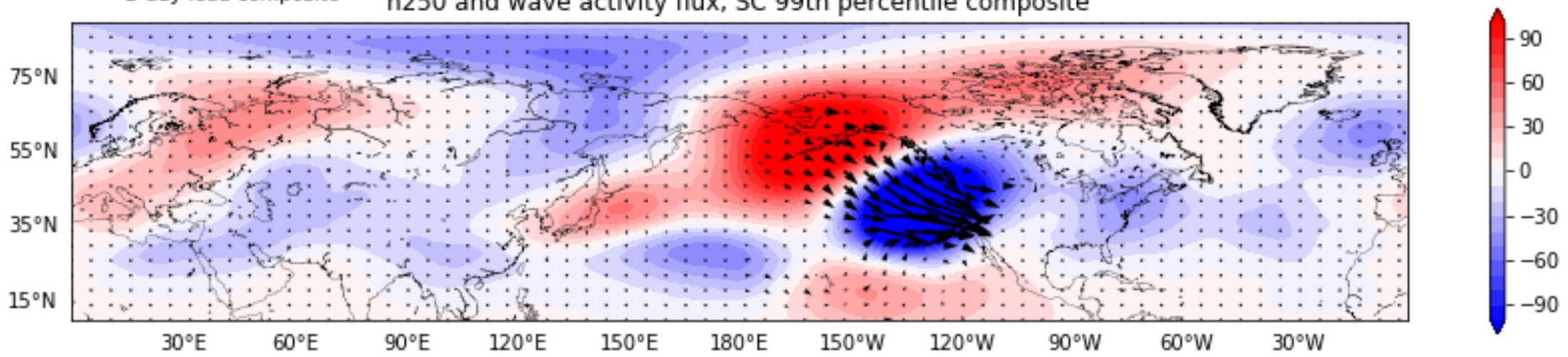
NorCal



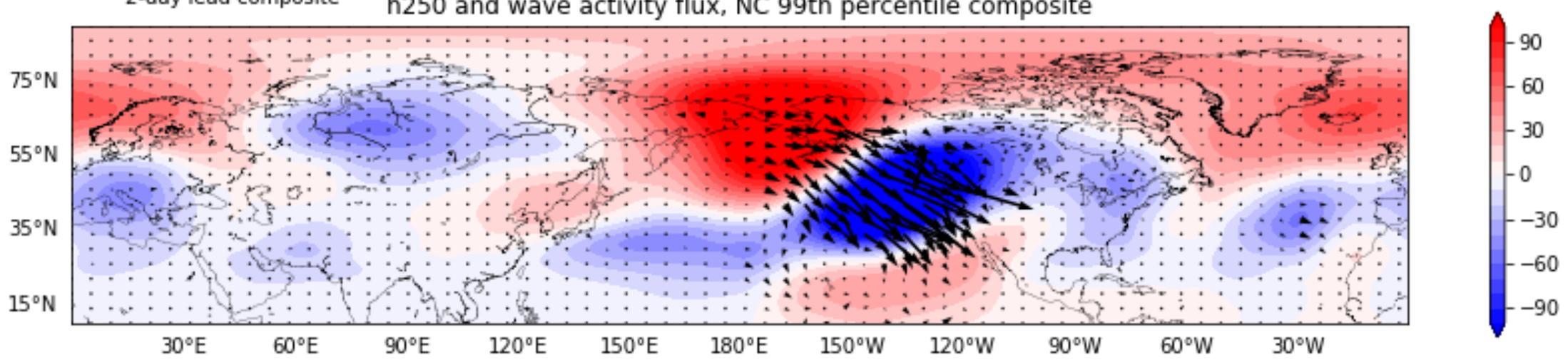
Wave activity flux suggests a role for subtropical waveguide

2-day lead

SoCal



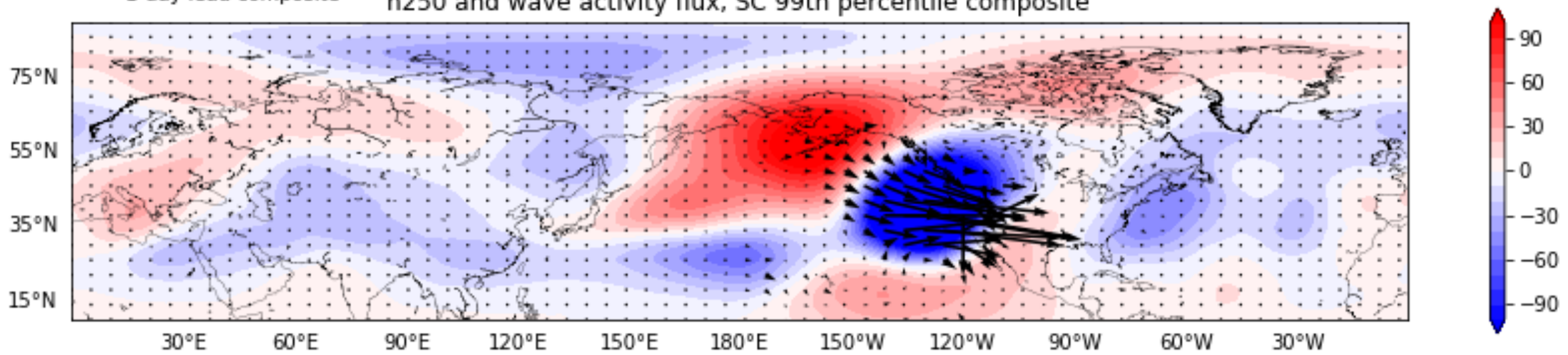
NorCal



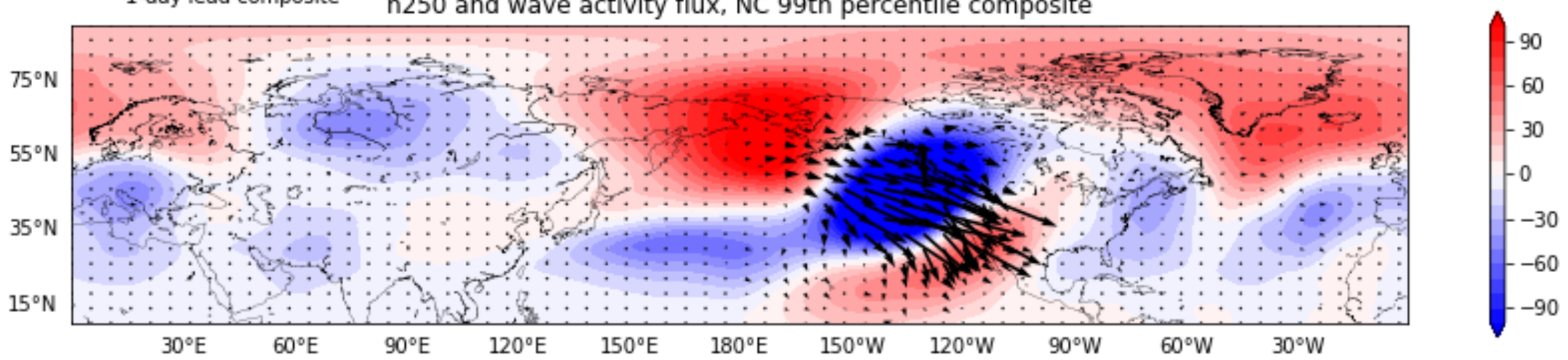
Wave activity flux suggests a role for subtropical waveguide

1-day lead

SoCal



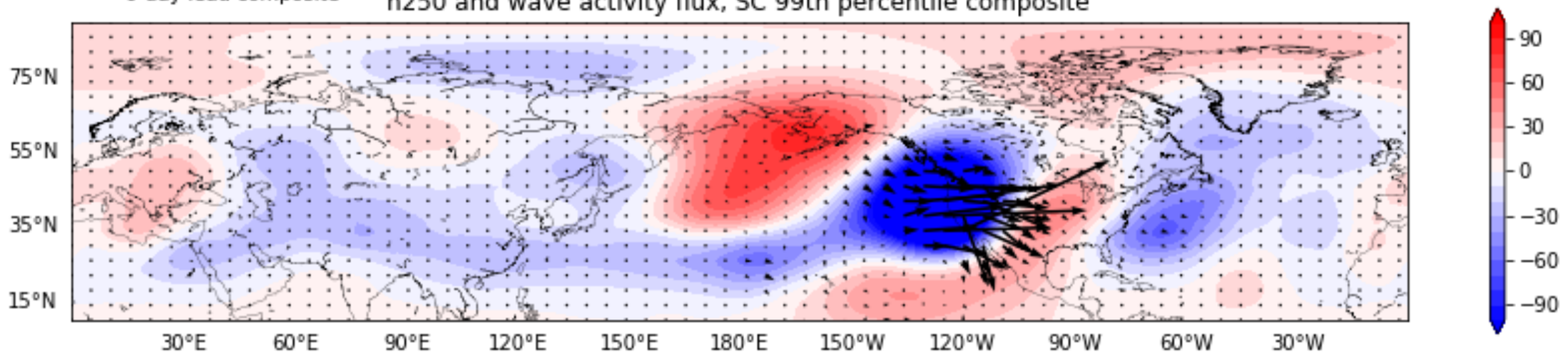
NorCal



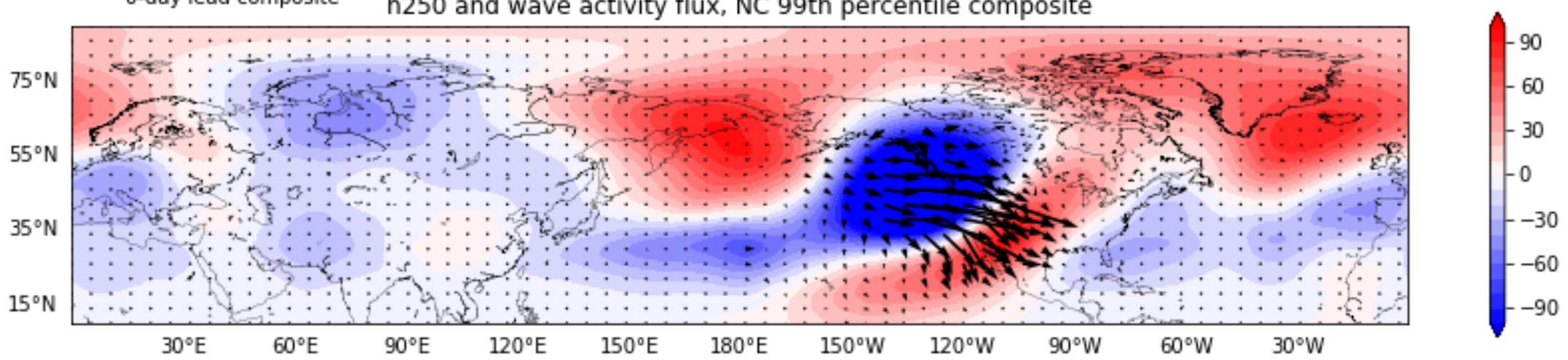
Wave activity flux suggests a role for subtropical waveguide

0-day lead

SoCal



NorCal



What makes CA storms?

- Dong et al. 2018: Internal, extratropical, circumglobal mode accounts for 80% of West Coast precip extremes

- We find PNA and a tropical mode (MJO?) favoring West Coast landfalling atmospheric rivers

- This could be through their influence on AR formation by anticyclonic wave breaking

What makes CA storms *go south?*

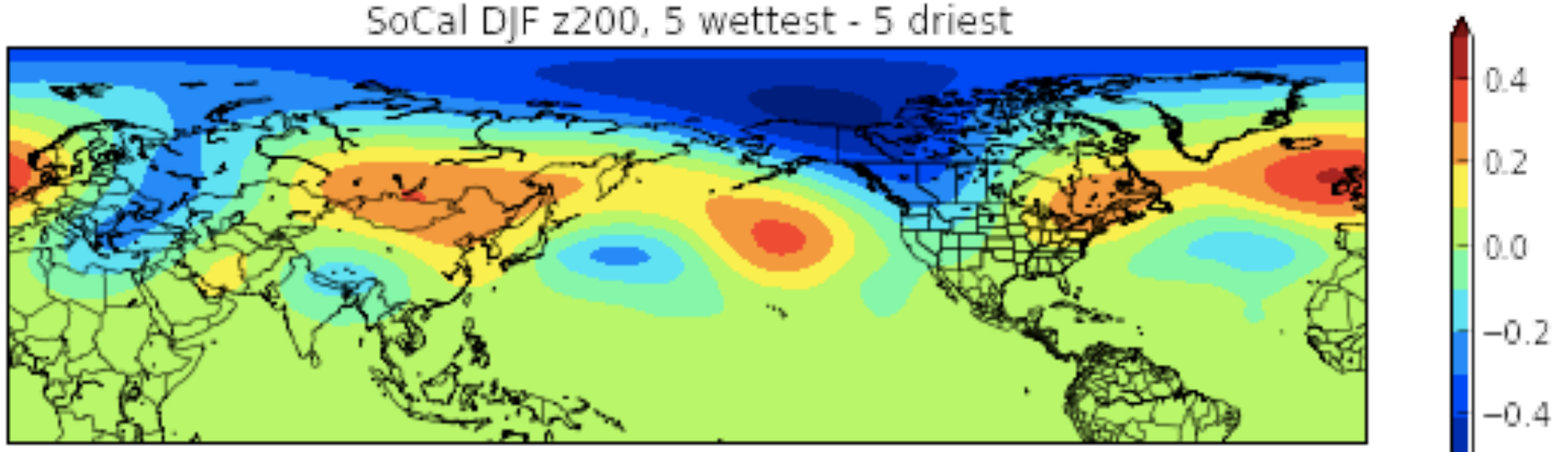
- Particular phasing of the AO with PNA over the Bering Strait may favor north vs. south

- A subtropical waveguide effect may be important for SoCal storms, and if so, there should be ways of diagnosing this in advance

- Do we see this in the CESM Large Ensemble (LENS)?

LENS z200 trends, 5 wettest-5 driest

SoCal



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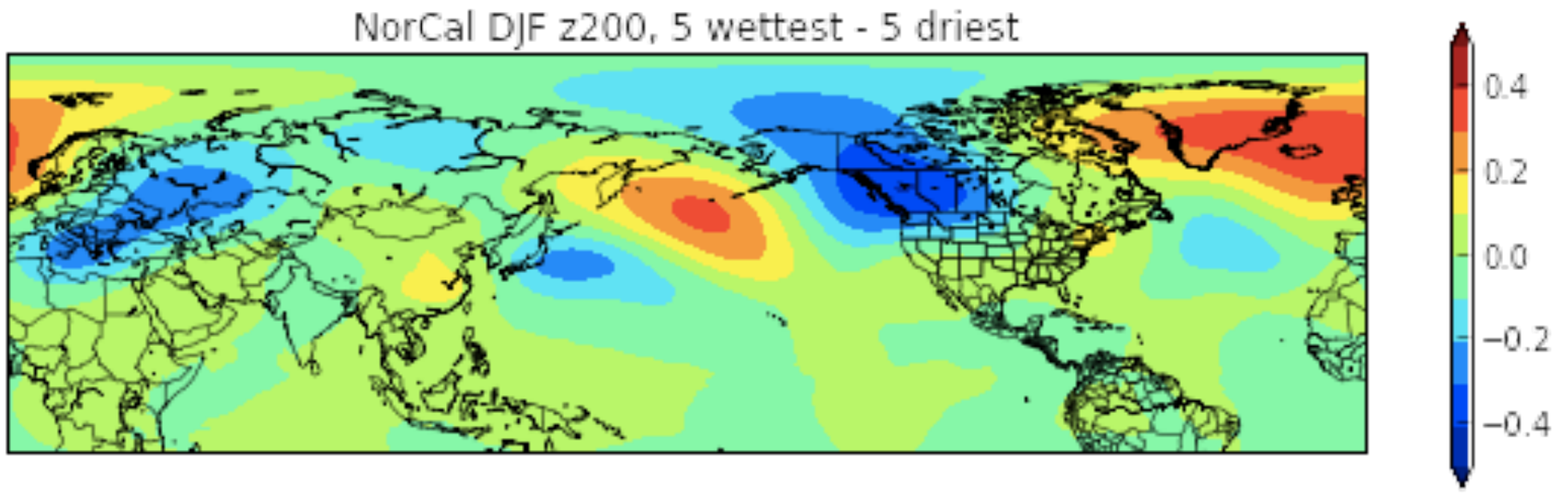
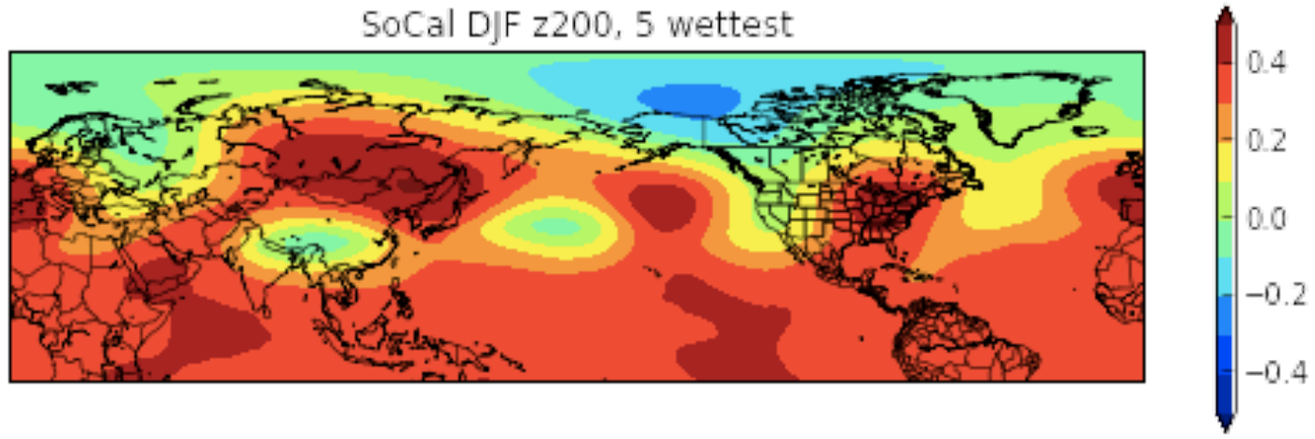
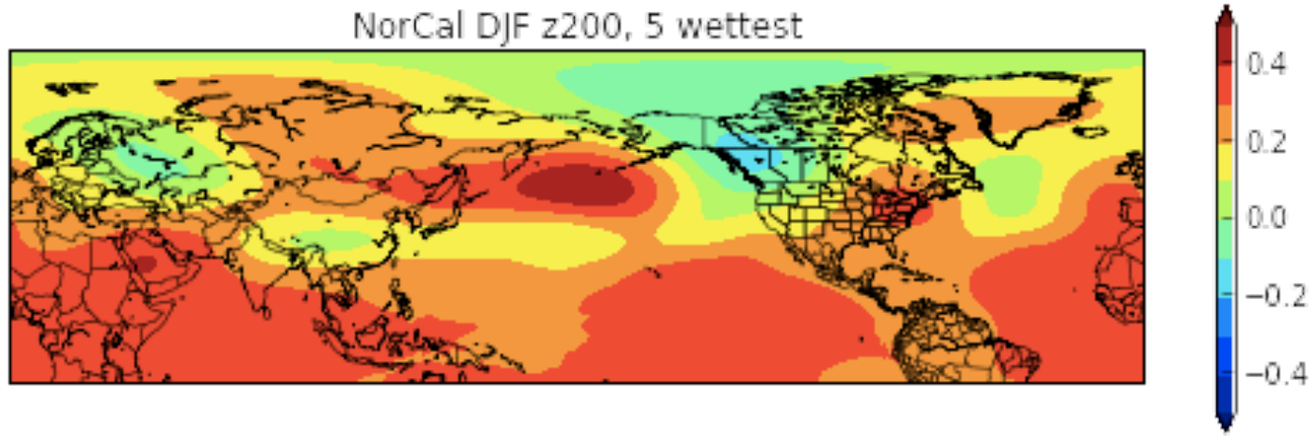


The biggest SoCal-NorCal difference is subtropical waveguide and AO

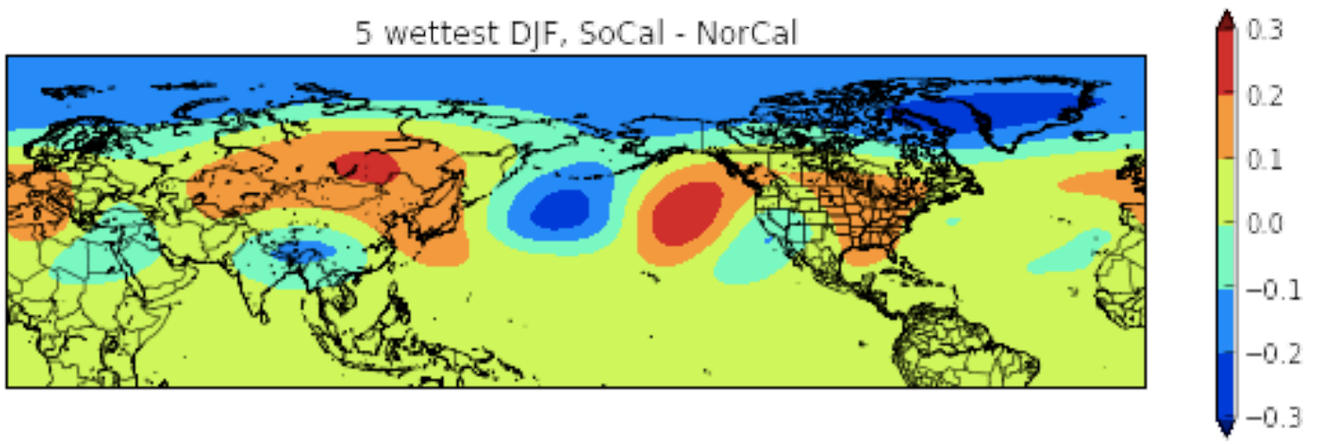
SoCal

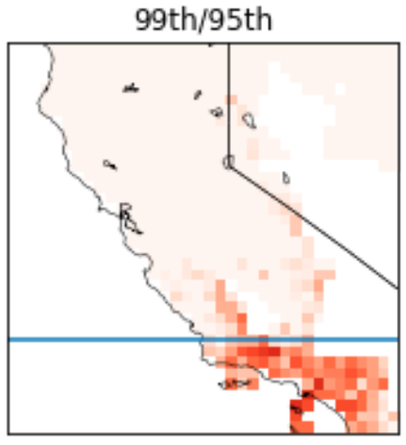


NorCal

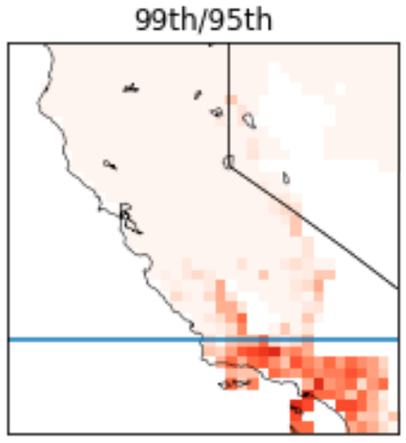


Difference



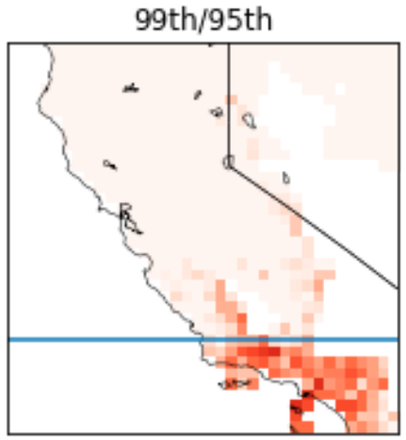


Summary



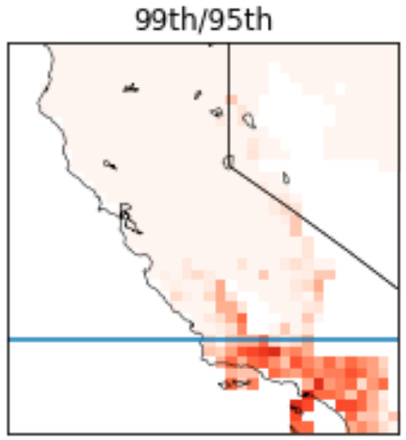
Summary

- Southern California’s precipitation is more variable/ extreme than Northern California



Summary

- Southern California's precipitation is more variable/ extreme than Northern California
- Phasing of the PNA and AO over the Bering Strait determines where ARs make landfall



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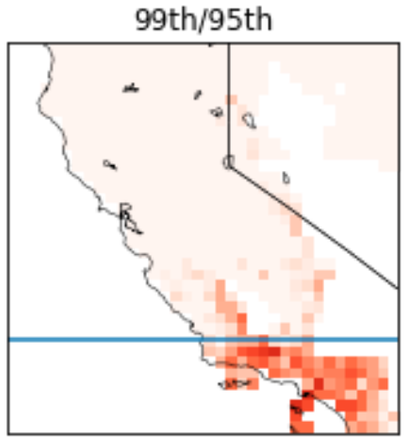

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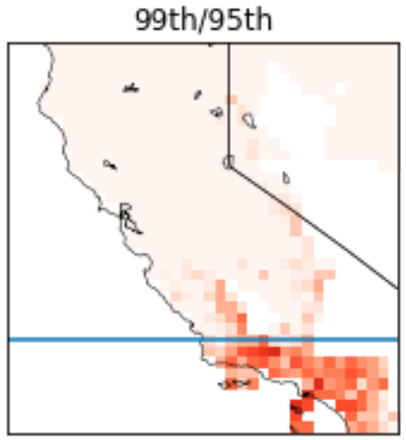
- Phasing of the PNA and AO over the Bering Strait determines where ARs make landfall
- Subtropical waveguide is important for SoCal storms
- LENS may offer a way to establish the role of subtropical waveguide



Summary

- Southern California's precipitation is more variable/ extreme than Northern California
- Phasing of the PNA and AO over the Bering Strait determines where ARs make landfall
- Subtropical waveguide is important for SoCal storms
- LENS may offer a way to establish the role of subtropical waveguide
- Next steps: AGCM experiments with interseasonal forcing

Correlation of DJF SoCal precip with ERSST