Diablo Winds in the Bay Area California: Their climatology and extremes

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Motivations

- Strong linkage to wildfires in Northern California.
- Lacking understandings of long-term climatology of Diablo winds (DWs) and relationships with large-scale climate variabilities.

Terrain in North CA

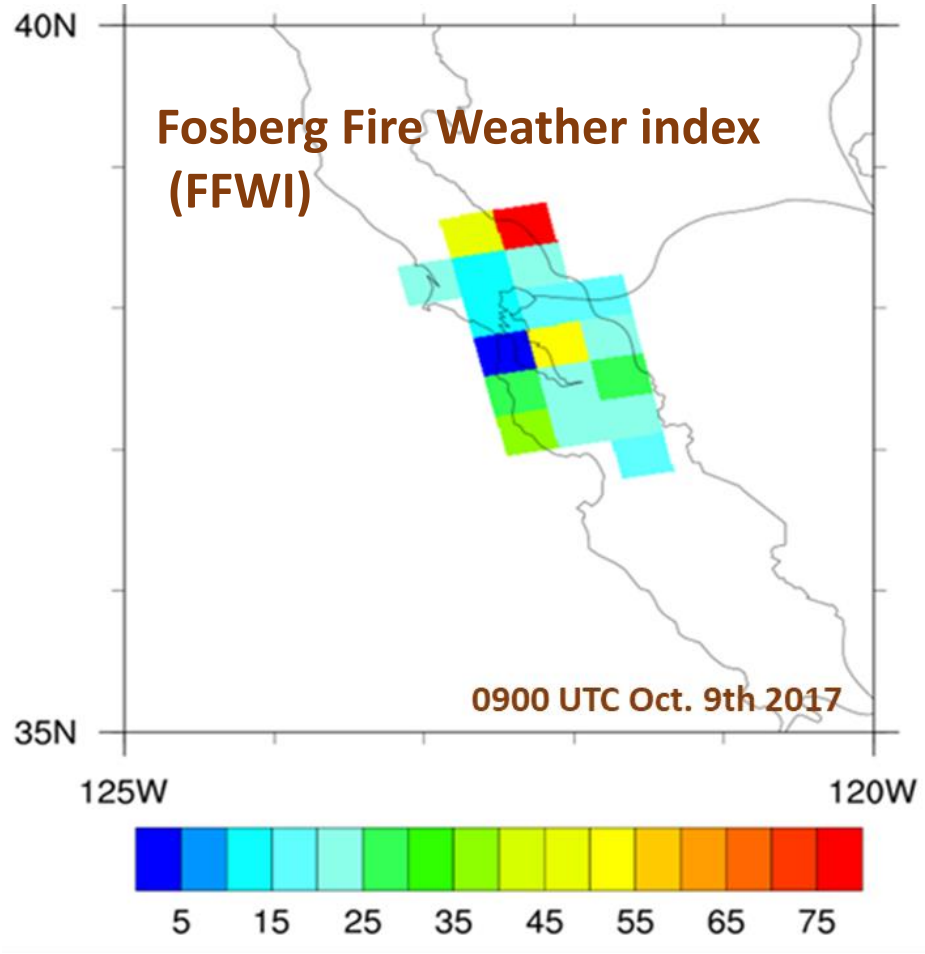
Study Goals

- Document DWs climatology with a particular attention to extremes.
- Explore the relationship with large-scale climate variabilities from a climatological perspective.

Data

- 3-hourly and daily NARR data from 1979 to 2018.
- Months of interest: September to February
- Area of interest: San Francisco Bay Area Air Basin.

Data (Cont'd)
NARR data distribution within the Bay Area



The Fosberg Fire Weather Index (FFWI) : measure the potential influence of weather on a wildfire based on temperature, wind and relative humidity

FFWI = n*[(1+U^2)^.5]/0.3002

where U=wind speed in mph and n=moisture damping coefficient.

n=1-2(m/30)+1.5(m/30)^2-0.5(m/30)^3

where m=equilibrium mositure content.

for h < 10 %

m=0.03229 + 0.281073h - 0.000578hT

for 10% < h <= 50%

m=2.22749 + 0.160107h - 0.01478T

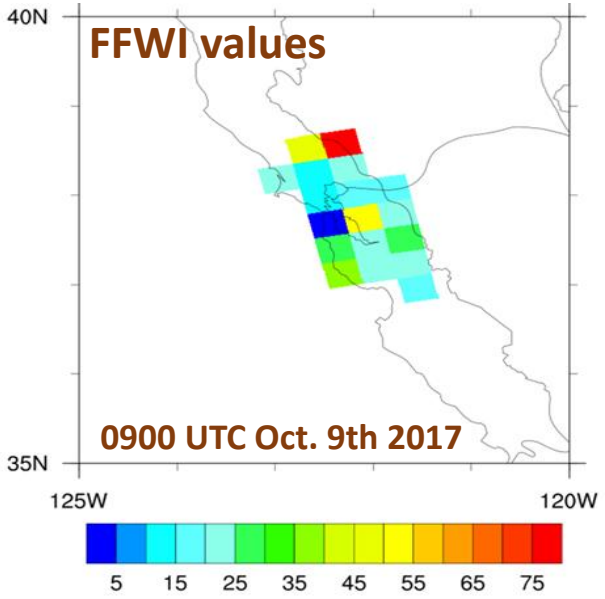
for h > 50%

m=21.0606 + 0.005565H^2 - 0.00035hT - 0.483199h

where T=temperature in F and h=relative humidity in percent.

Definition for DW events (DWEs)

- Average wind direction is northerly or northeasterly or southeasterly (350˚ to 135˚)
- Average Fosberg Fire Weather Index (FFWI) is larger than 30
- First two criteria are met and persist for six or more consecutive hours

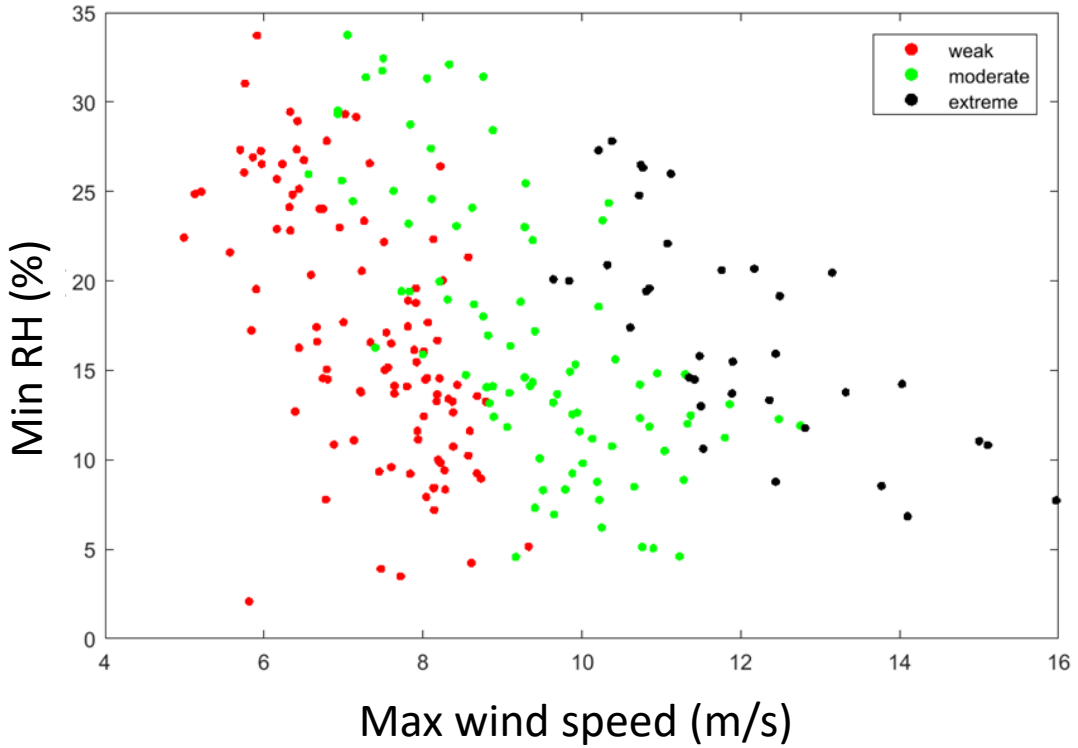


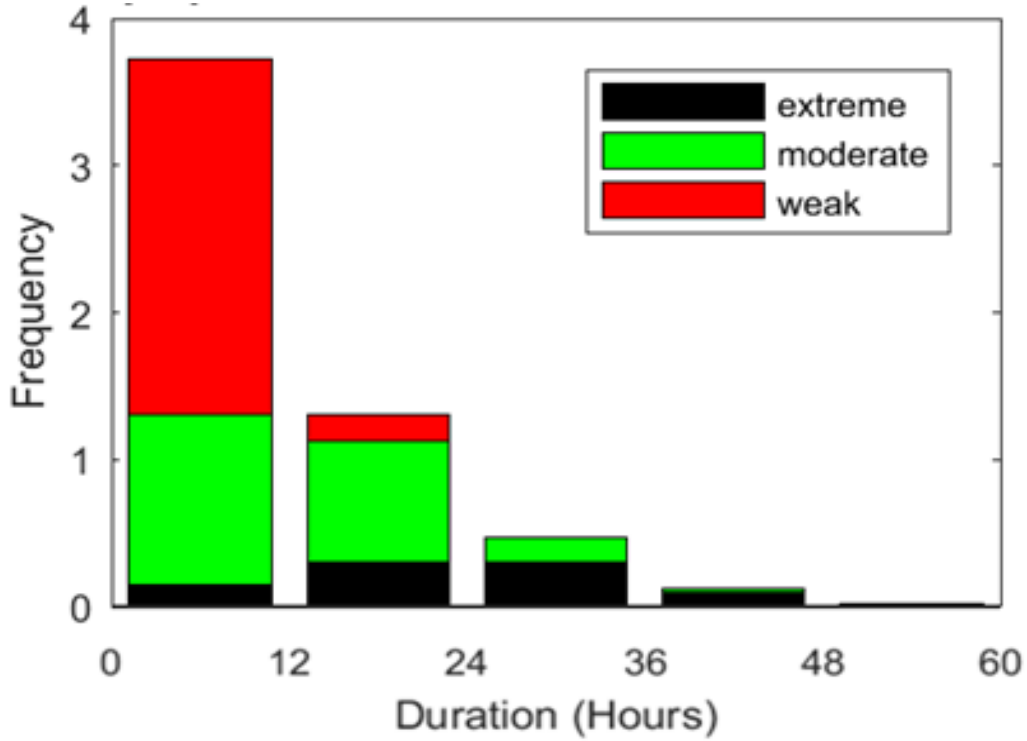
Three categories of DWEs:

- **Weak DWEs : 40 > maximum FFWI >= 30**
- **Moderate DWEs: (55> maximum FFWI >= 40)**
- **Extreme DWEs: (maximum FFWI >= 55)**

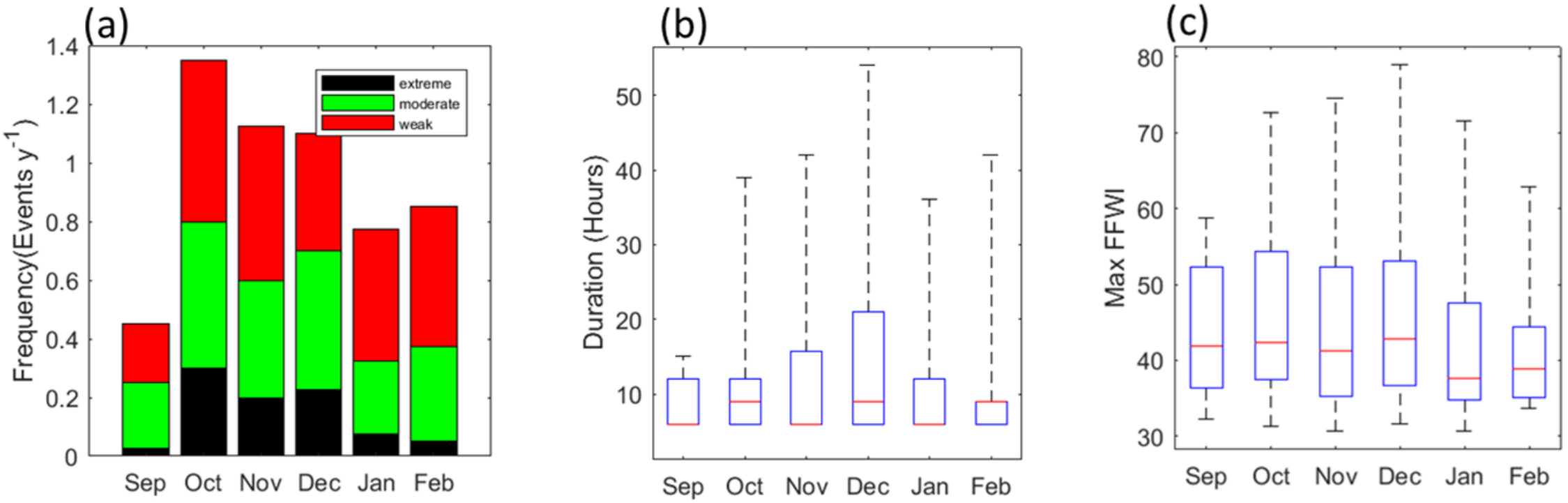
Climatology: Overall Characteristics

226 DWEs (Sep to Feb, 1979 to 2018)

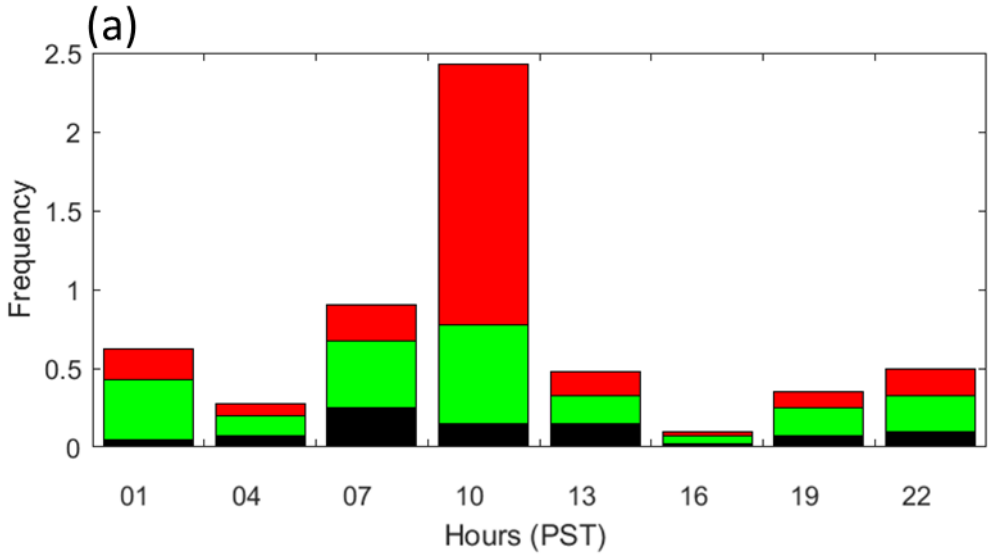


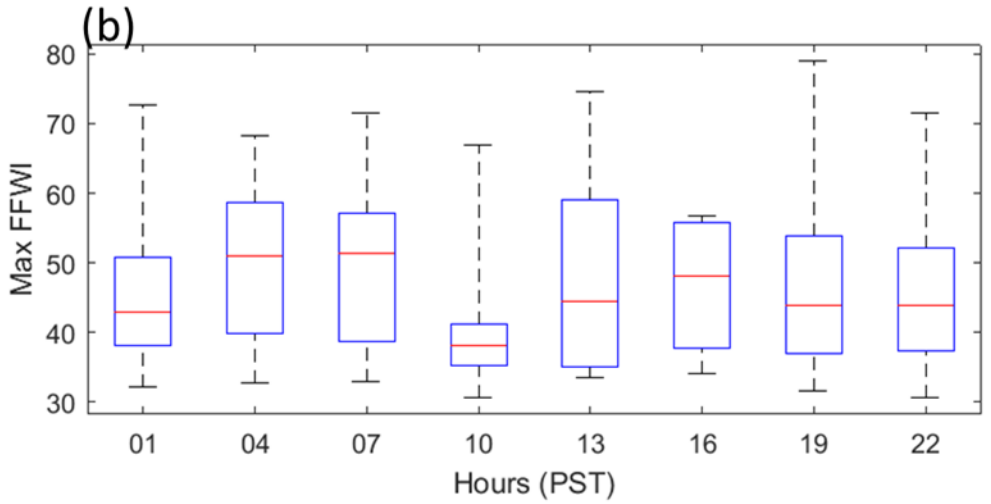


Climatology: seasonal variability



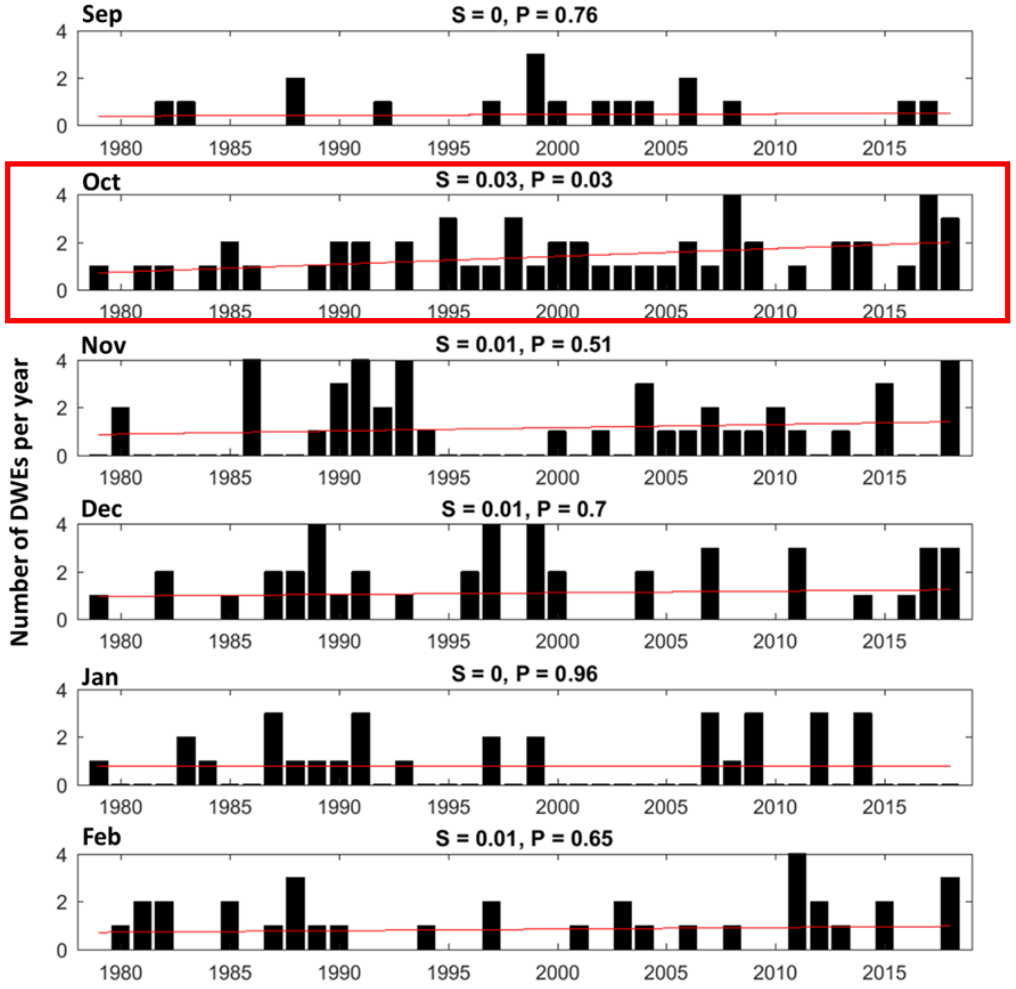
Diurnal variability



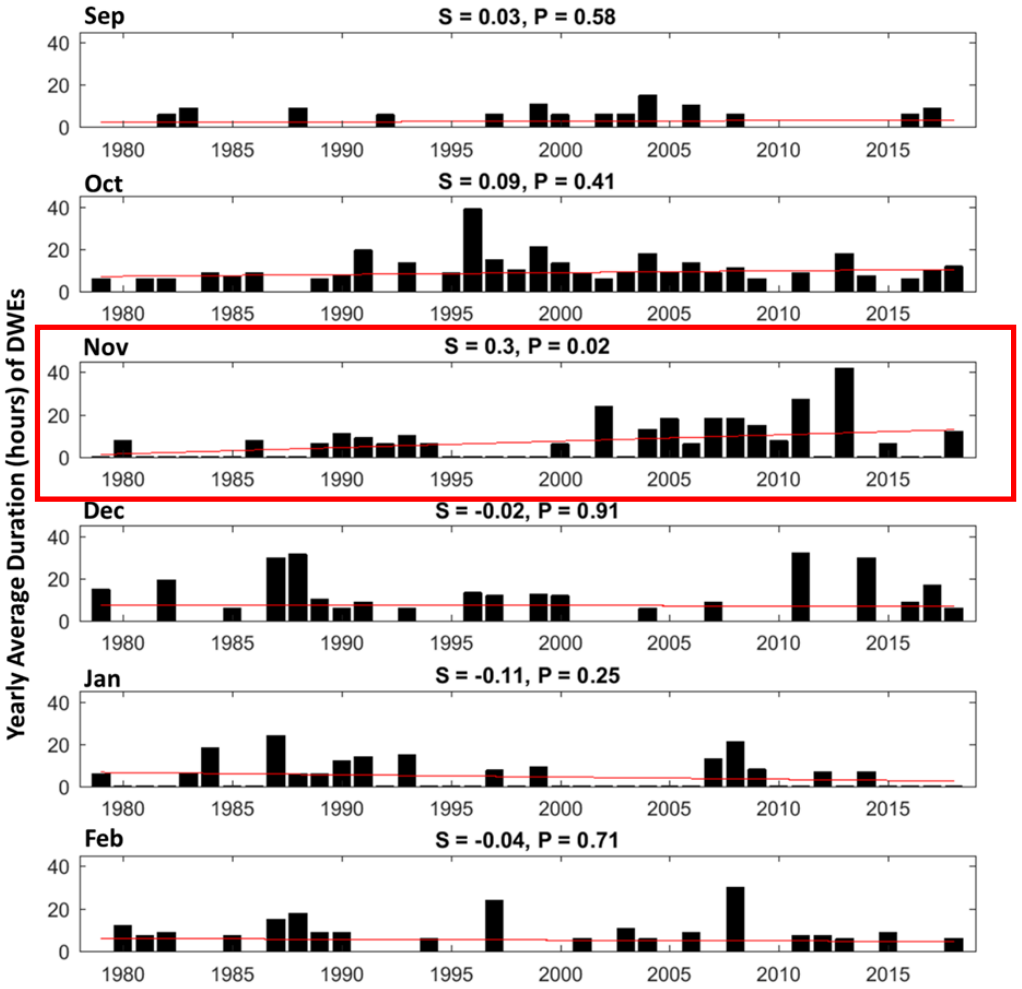


Long term trend for DWEs

Frequency



Duration



DWE Frequency before and after 1998

The average frequency (event yr^{-1}) of DWEs

	Before 1998 (first 20 years)	After 1998 (second 20 years)
Sep	0.3	0.6
Oct	1.1	1.6
Nov	1.1	1.2
Dec	1.1	1.1
Jan	0.8	0.8
Feb	0.8	0.9

Three categories of DWEs:

- **Weak DWEs : 40 > maximum FFWI >= 30**
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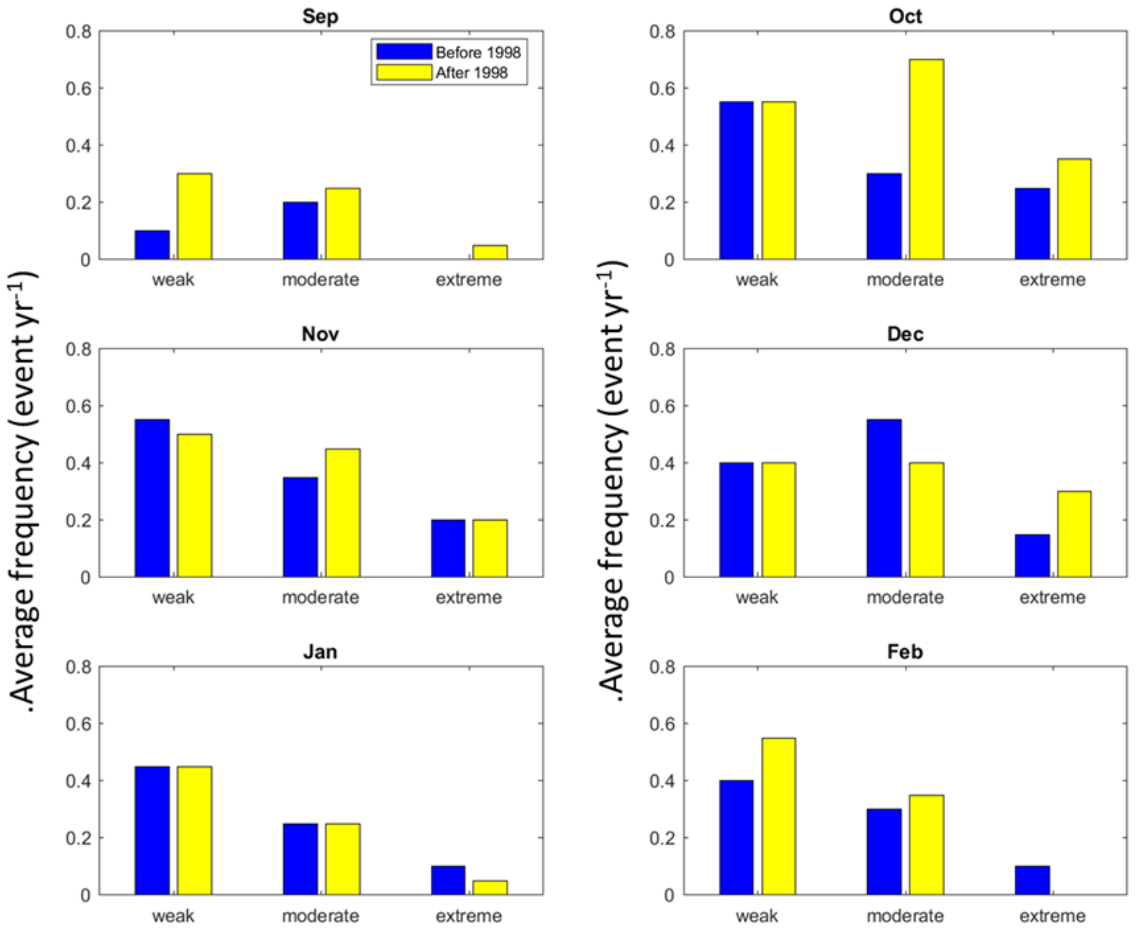
- **Extreme DWEs: (maximum FFWI >= 55)**



Relationship between DWEs and Climate Indices - Potential Predictability

- Low-frequency climate variabilities
  - North Atlantic Oscillation (NAO),
  - West Pacific Oscillation (WPO),
  - Arctic Oscillation (AO),
  - East Pacific Oscillation (EPO),
  - Pacific/North American teleconnection pattern (PNA)

- Intraseasonal variability
  - Madden-Julian oscillation (MJO)

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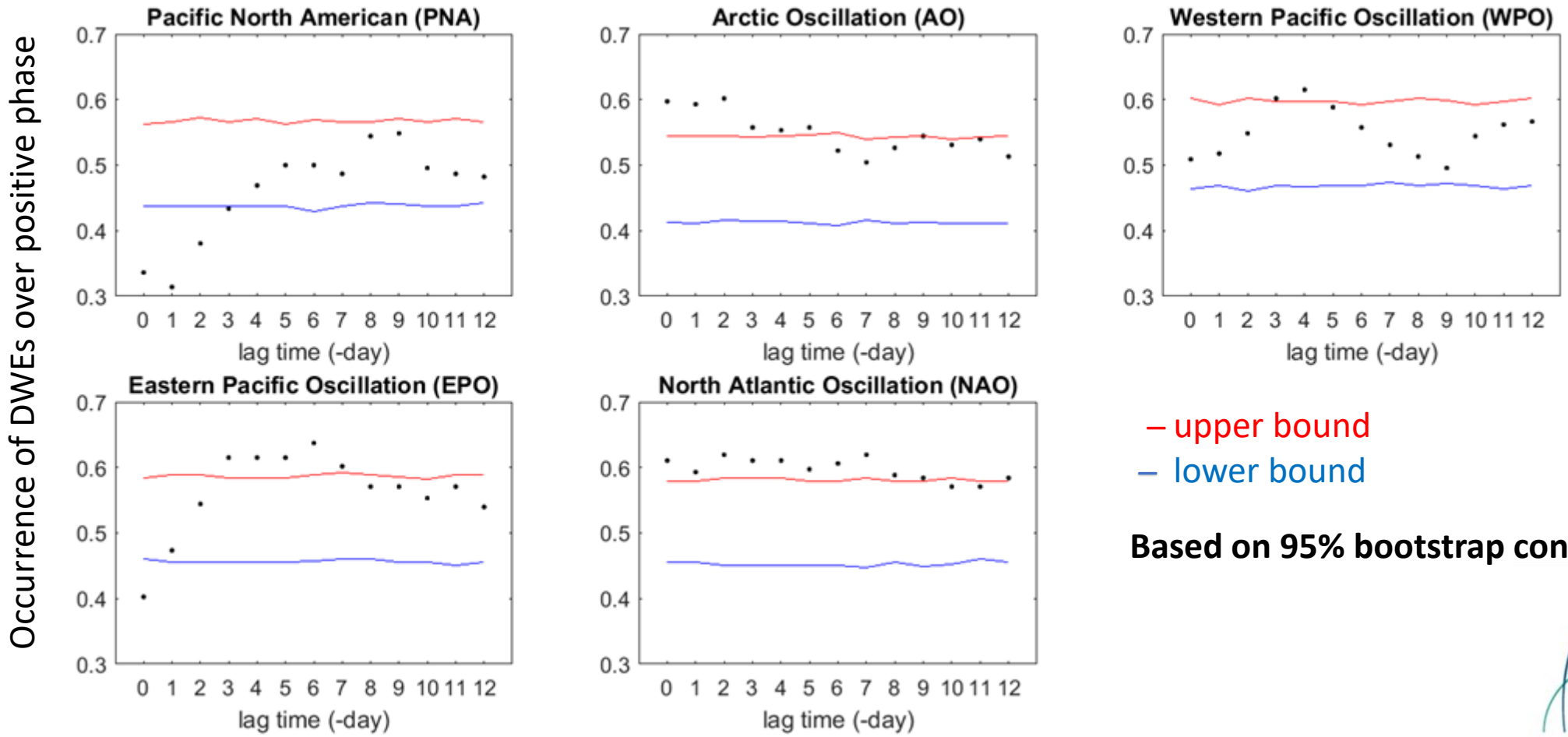
Ratio of DWE Occurrence over positive phase of climate indices



– upper bound

– lower bound

Based on 95% bootstrap confident interval

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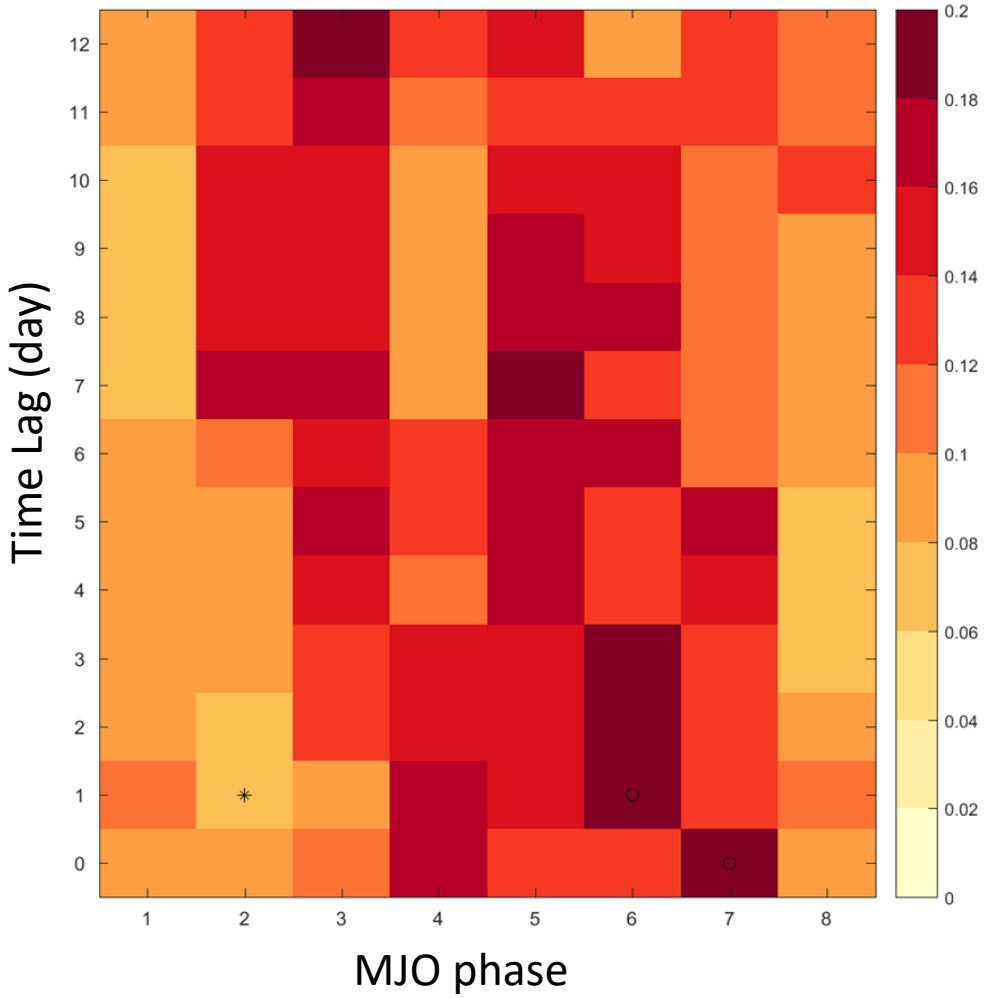
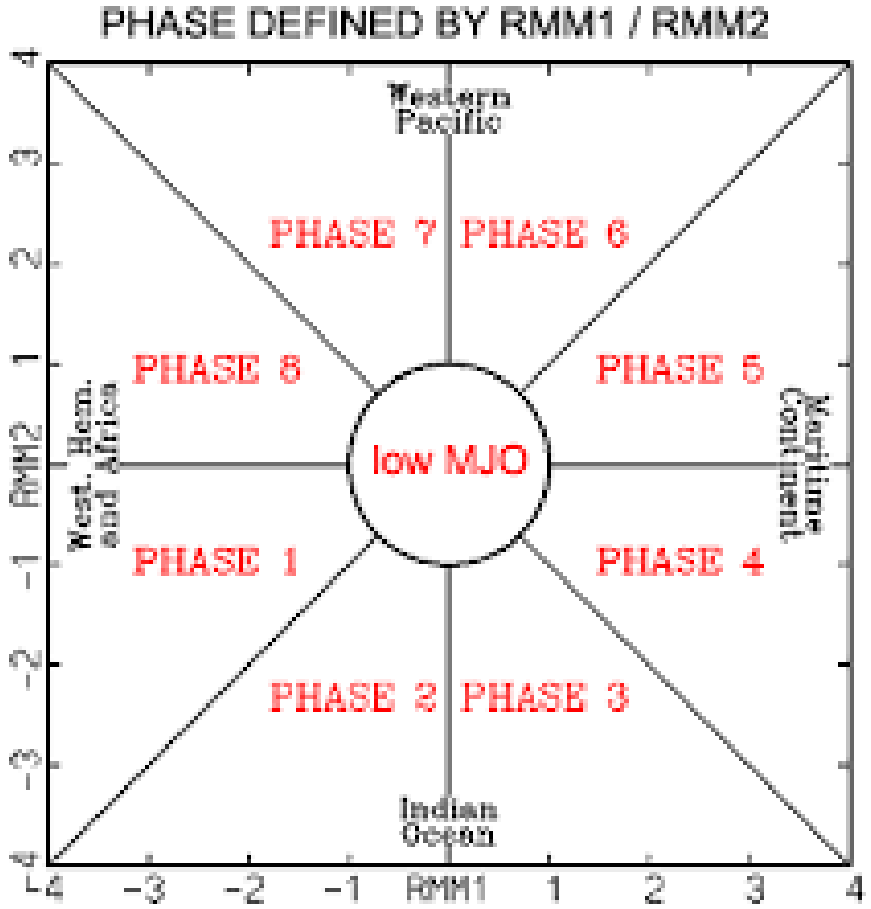
Ratio of DWE Occurrence over eight MJO phases

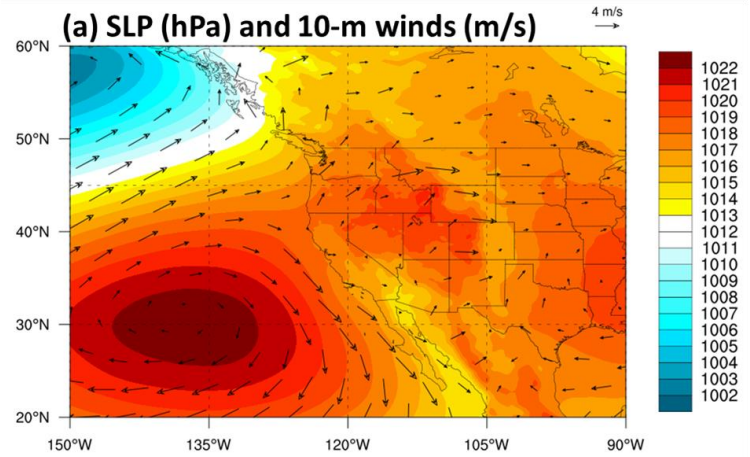




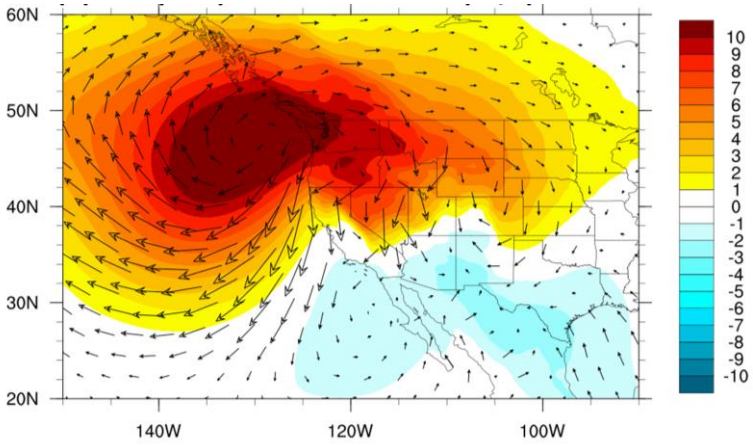
Mechanisms linking the PNA and MJO to the DWE occurrences

- Pressure gradient mechanism

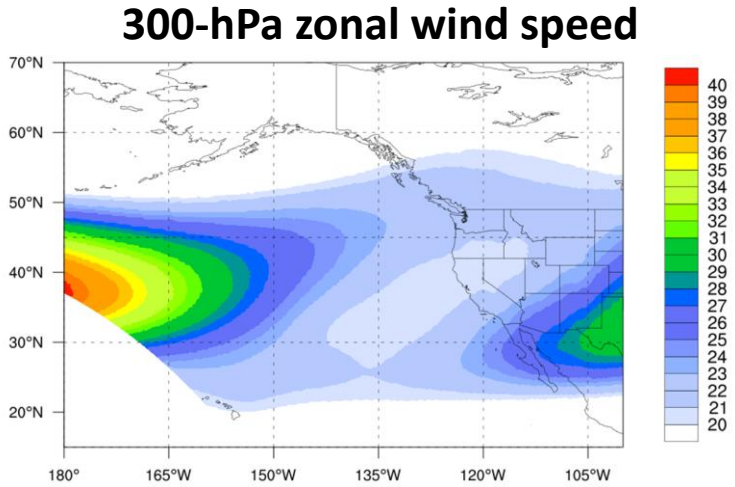
Climatology (full fields)



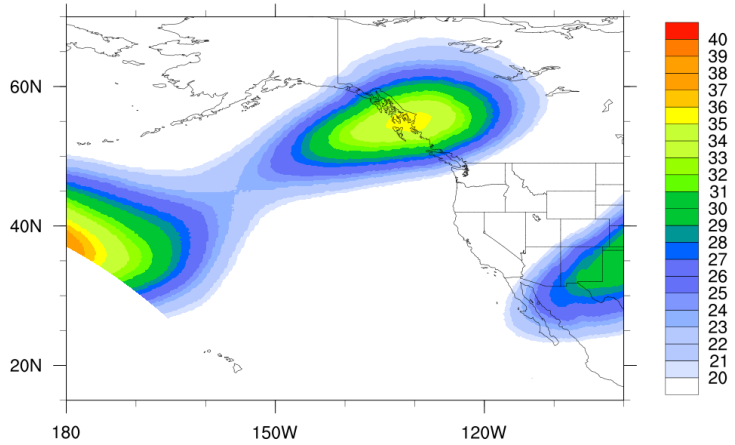
DWE (anomalies)



- Jet steam displacement mechanism



Climatology (full fields)



DWE (full fields)

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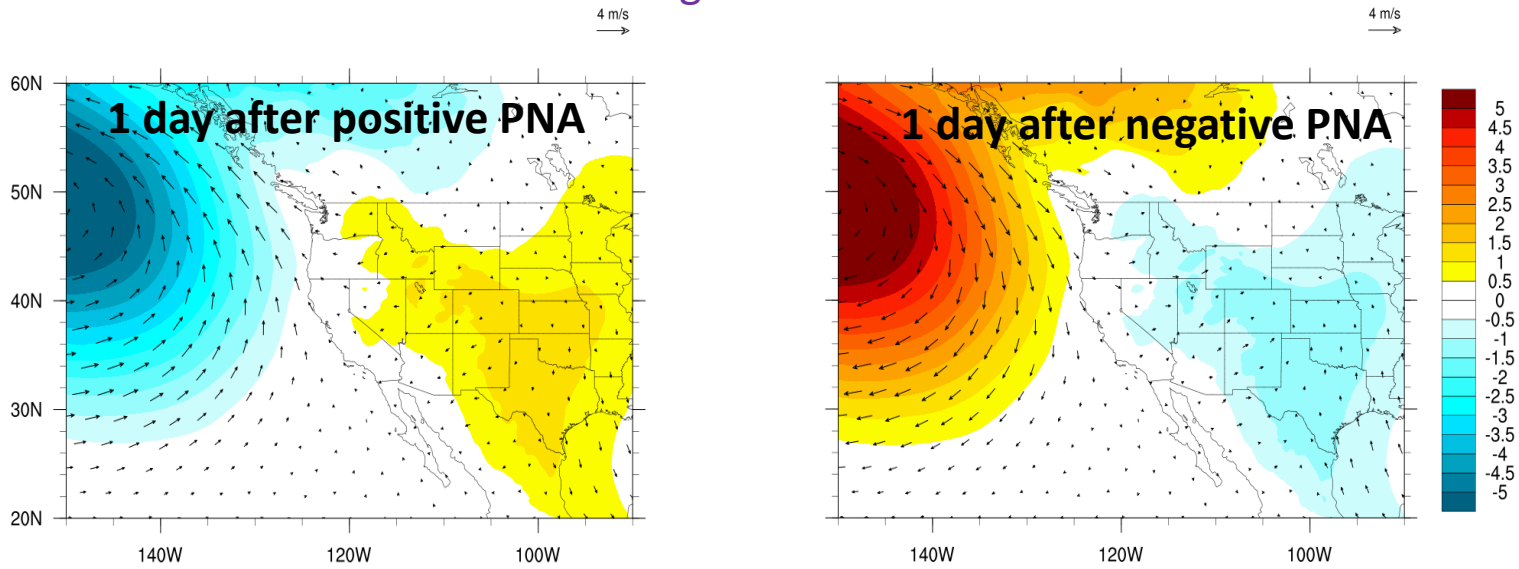
Mechanisms linking the PNA to the DWE occurrences

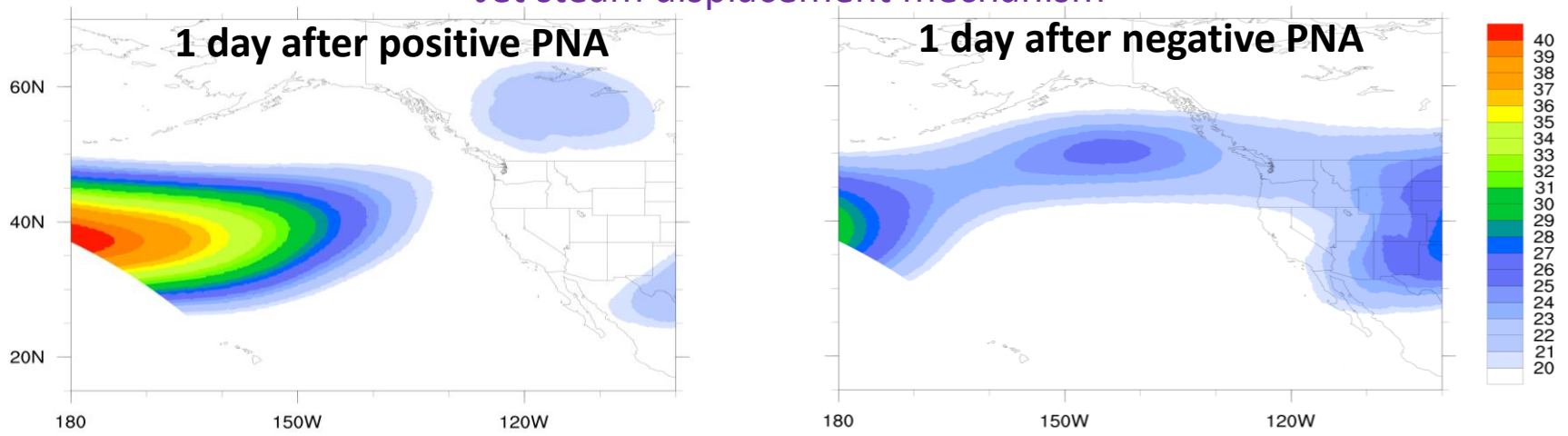
Pressure gradient mechanism

SLP anomalies (hPa)



Jet steam displacement mechanism

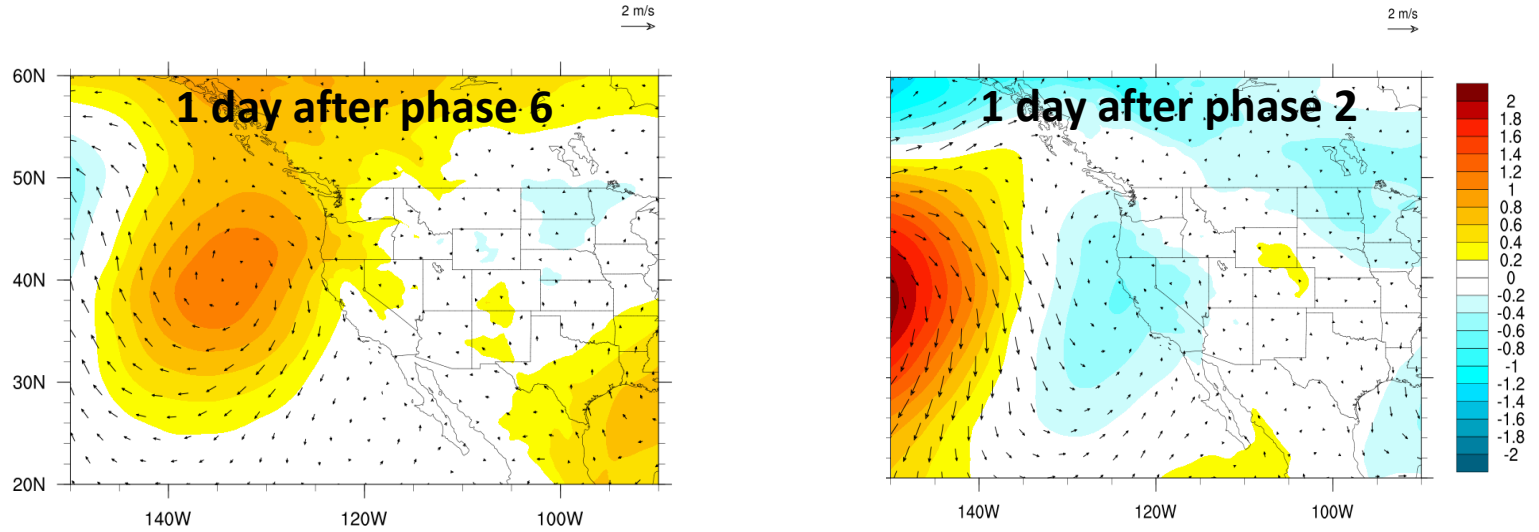
300-hPa U



Mechanisms linking the MJO to the DWE occurrences

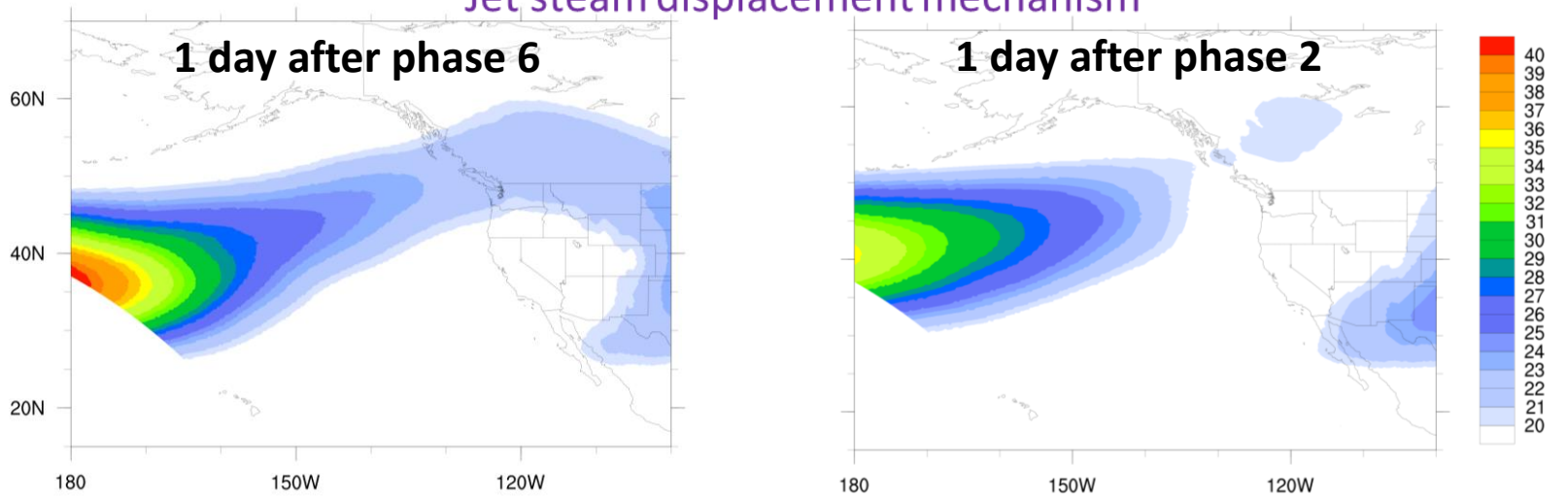
Pressure gradient mechanism

SLP anomalies (hPa)



Jet steam displacement mechanism

300 hPa U



Conclusion

- Diablo Wind Events have strong seasonable variabilities for frequency, duration, and intensity. October has the highest frequency of DWE as well as extreme DWE cases.

- The diablo wind hour occurrence has increased significantly in late fall since 1998. This may imply a higher potential to cause wildfire due to the dryness in the late fall.

Conclusion

- Negative phase of PNA with 1-day time lag and phase 7 of MJO with 1-day time lag show promising potential for DWEs predictability.

- PNA and MJO might modulate DWE development through two mechanisms: the pressure gradient mechanism, and the Pacific jet stream displacement mechanism.