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.

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

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

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 moisture content.
- for \( h < 10\% \)
  - \( m = 0.03229 + 0.281073h - 0.000578hT \)
- for \( 10\% < h \leq 50\% \)
  - \( m = 2.22749 + 0.160107h - 0.01478T \)
- 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)

- Max wind speed (m/s)
- Min RH (%)

Graphs showing distribution of wind speed and RH percentage, with categories weak, moderate, extreme.
Climatology: seasonal variability
Diurnal variability
Long term trend for DWEs

**Frequency**

- **Oct**: $S = 0.03, P = 0.03$
- **Nov**: $S = 0.01, P = 0.51$
- **Dec**: $S = 0.01, P = 0.7$
- **Jan**: $S = 0, P = 0.96$
- **Feb**: $S = 0.01, P = 0.65$

**Duration**

- **Oct**: $S = 0.03, P = 0.41$
- **Nov**: $S = 0.3, P = 0.02$
- **Dec**: $S = -0.02, P = 0.91$
- **Jan**: $S = -0.11, P = 0.25$
- **Feb**: $S = -0.04, P = 0.71$
The average frequency (event yr\(^{-1}\)) of DWEs

<table>
<thead>
<tr>
<th></th>
<th>Before 1998 (first 20 years)</th>
<th>After 1998 (second 20 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Oct</td>
<td>1.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Nov</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Dec</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Jan</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Feb</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Three categories of DWEs:
- **Weak DWEs**: 40 > maximum FFWI \(\geq\) 30
- **Moderate DWEs**: (55> maximum FFWI \(\geq\) 40)
- **Extreme DWEs**: (maximum FFWI \(\geq\) 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)
Ratio of DWE Occurrence over positive phase of climate indices

Based on 95% bootstrap confident interval

- upper bound
- lower bound
Ratio of DWE Occurrence over eight MJO phases
Mechanisms linking the PNA and MJO to the DWE occurrences

• Pressure gradient mechanism

• Jet steam displacement mechanism

(a) SLP (hPa) and 10-m winds (m/s)

300-hPa zonal wind speed
Mechanisms linking the PNA to the DWE occurrences

Pressure gradient mechanism

SLP anomalies (hPa)

Jet stream displacement mechanism

300-hPa U
Mechanisms linking the MJO to the DWE occurrences

Pressure gradient mechanism

SLP anomalies (hPa)

Jet stream 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.