The North Pacific SST “Blob” and Alaska Winter Climate

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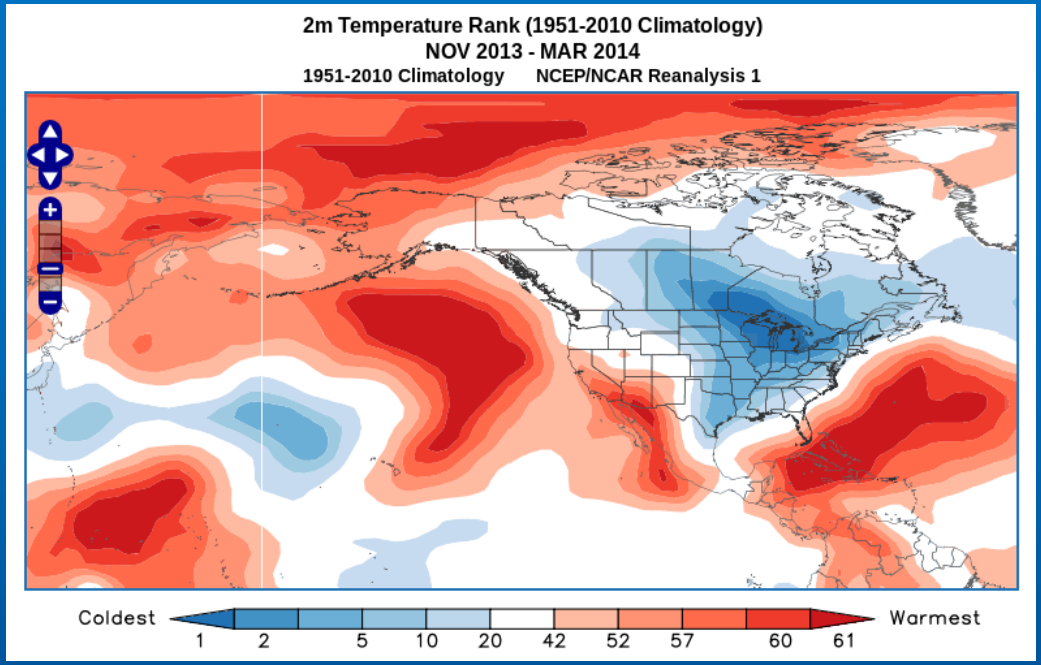
Motivation

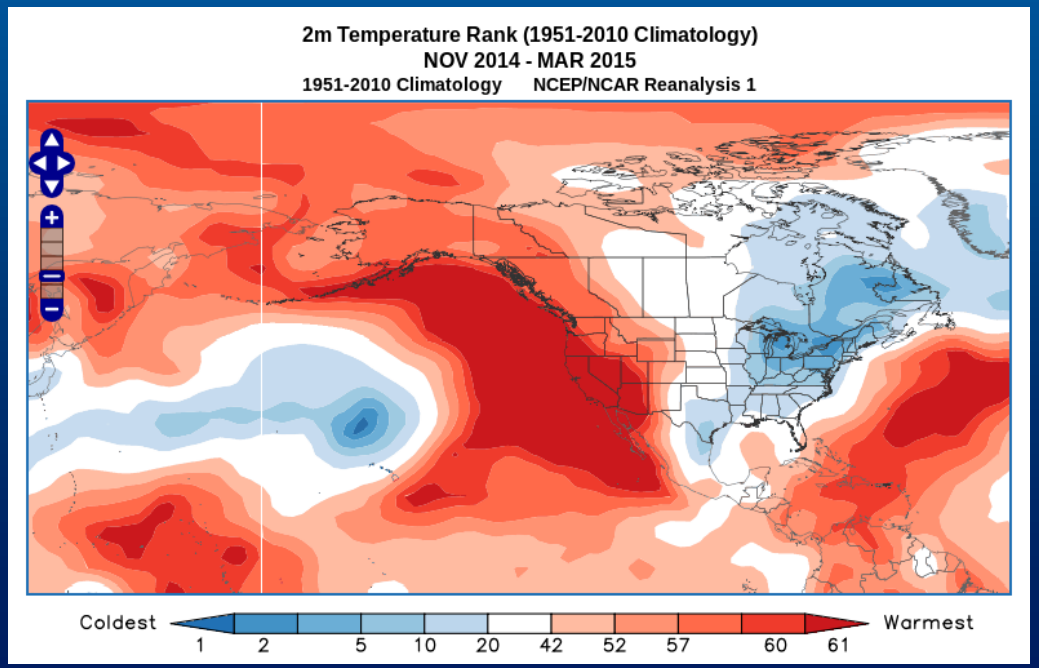
- Unusual winter circulation of the past two years (the “polar vortex”)
- Extreme temperature anomalies in the North Pacific, Alaska, and the lower 48
- Hartmann 2015: the North Pacific Mode

Nov-Mar

2013-2014

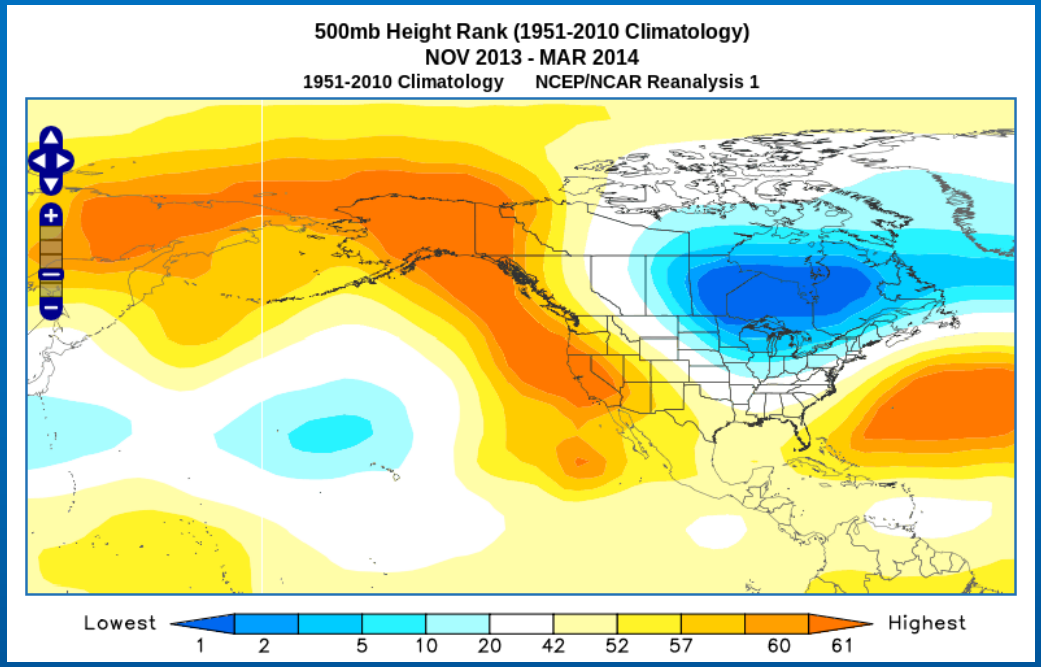


2014-2015

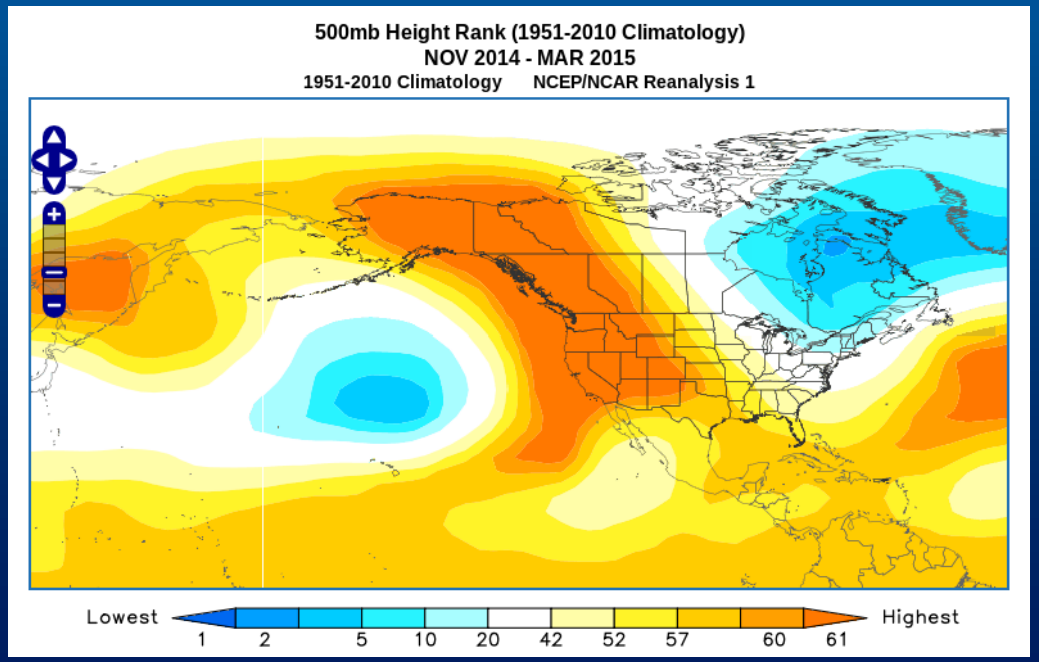


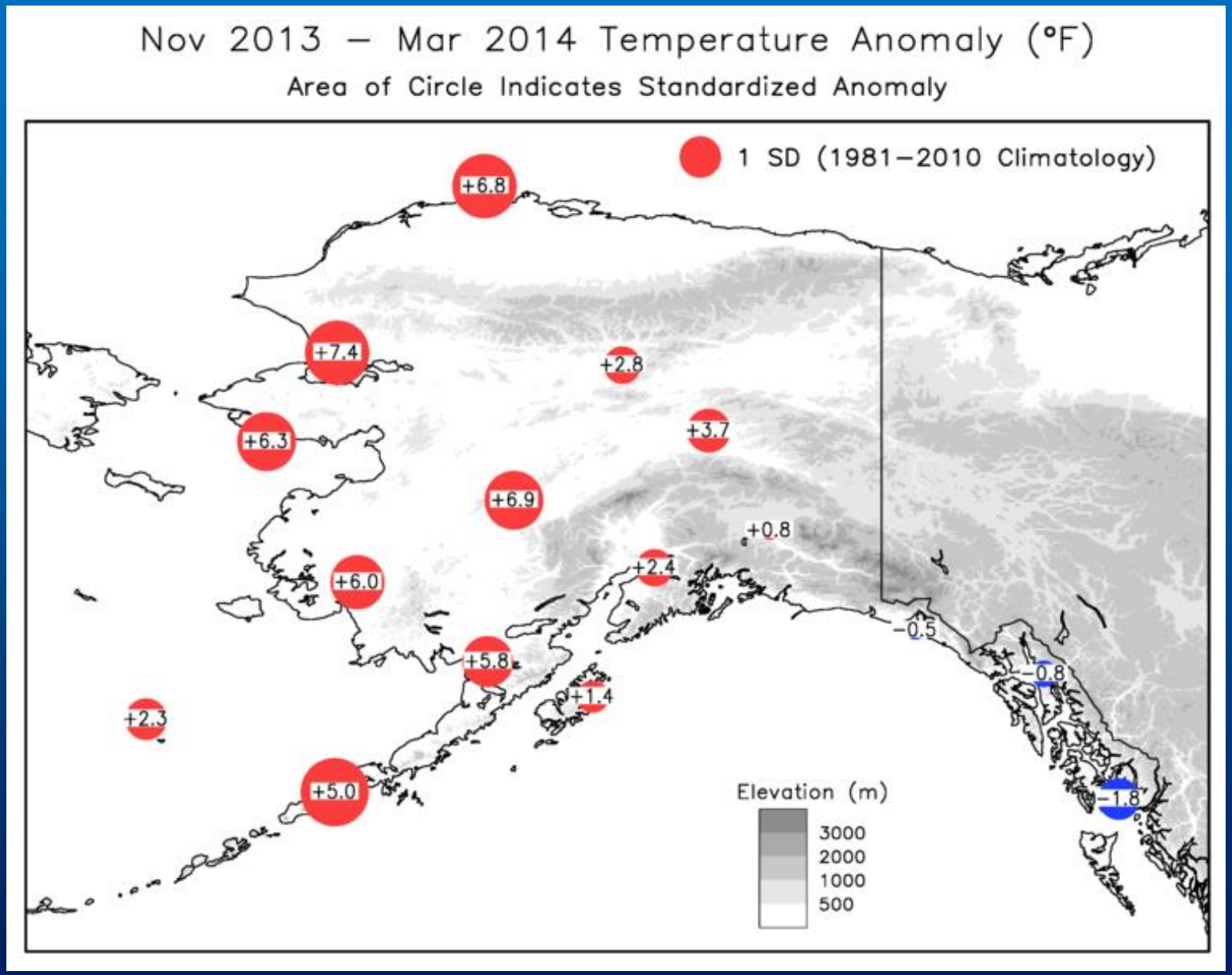
Nov-Mar

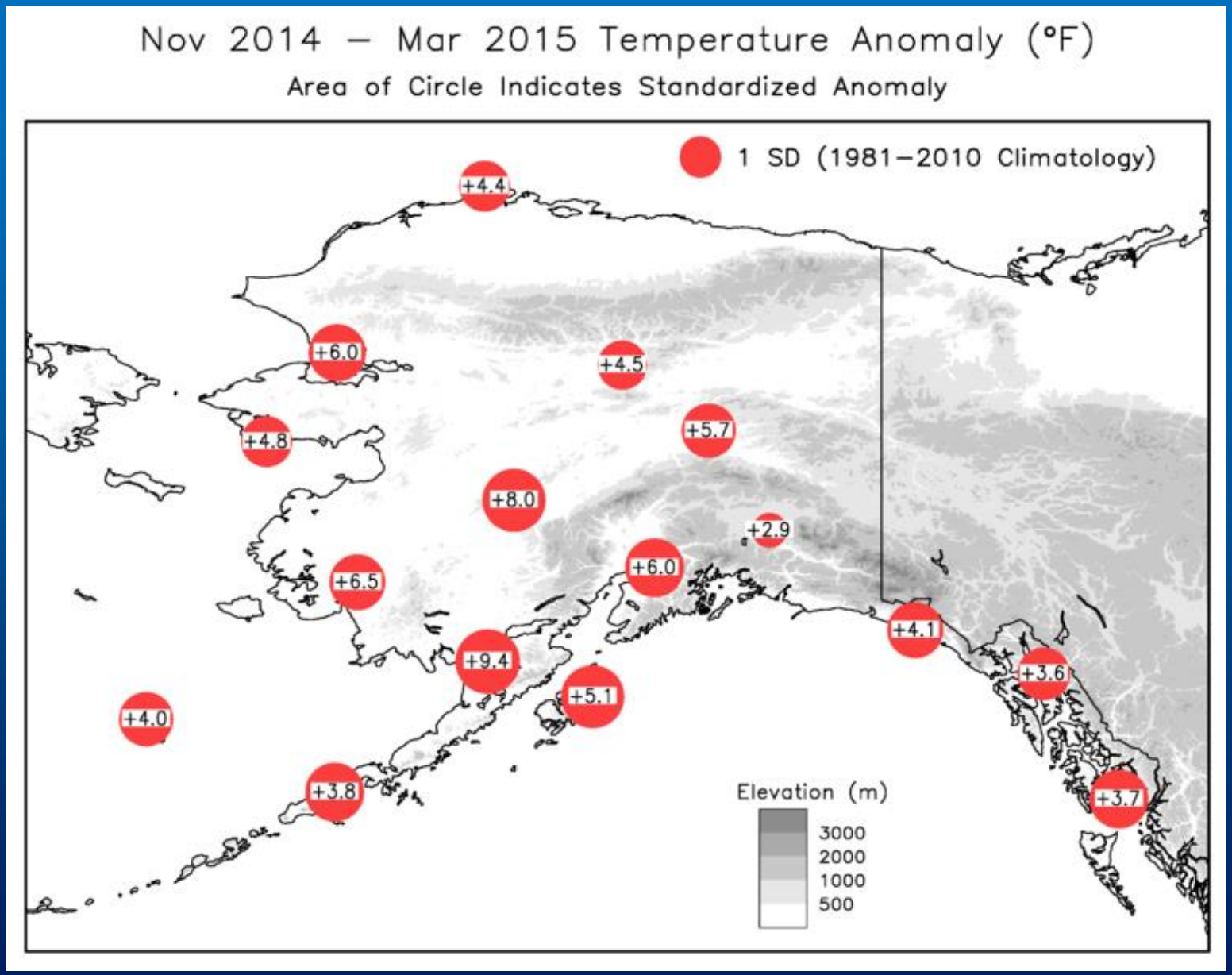
2013-2014

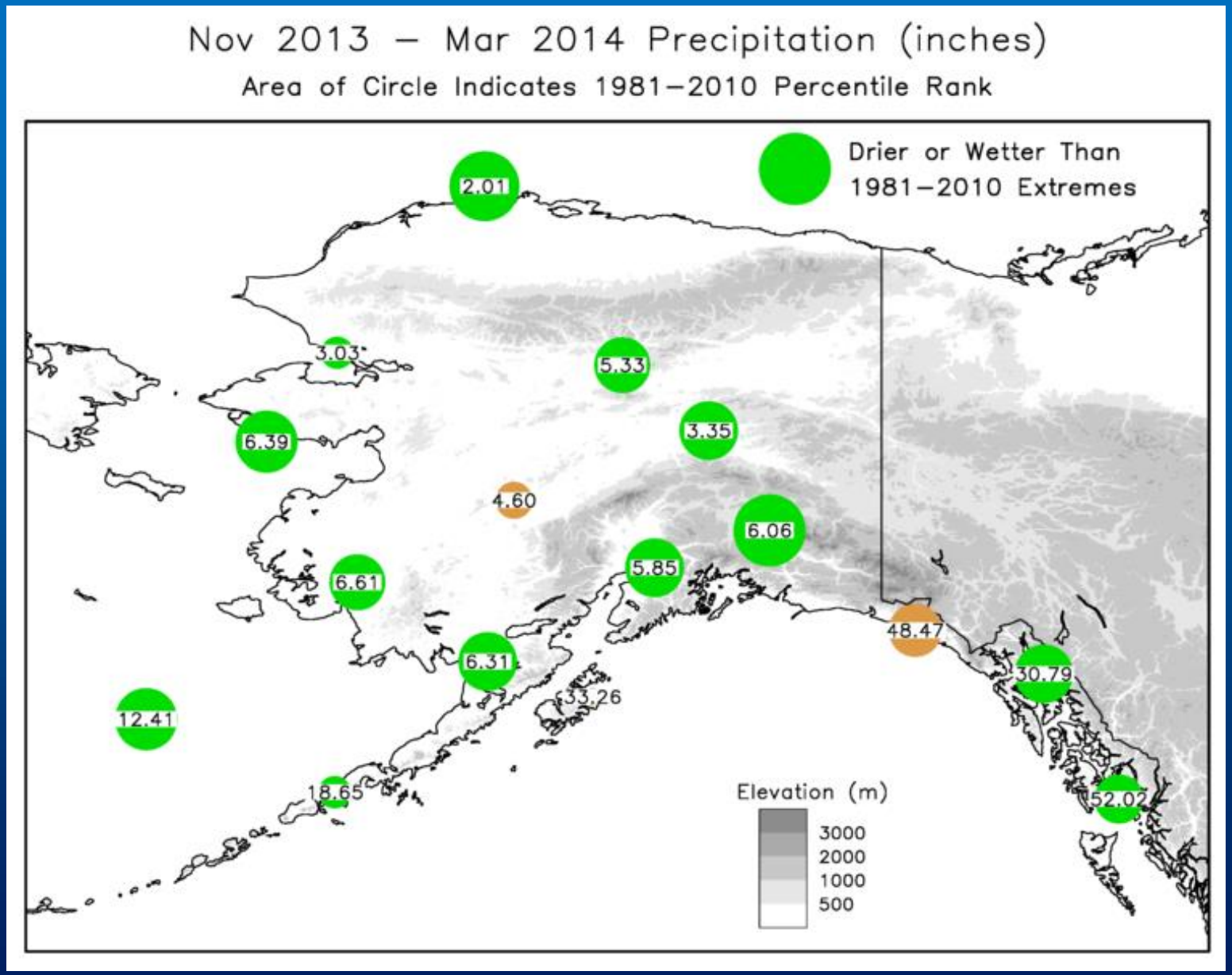


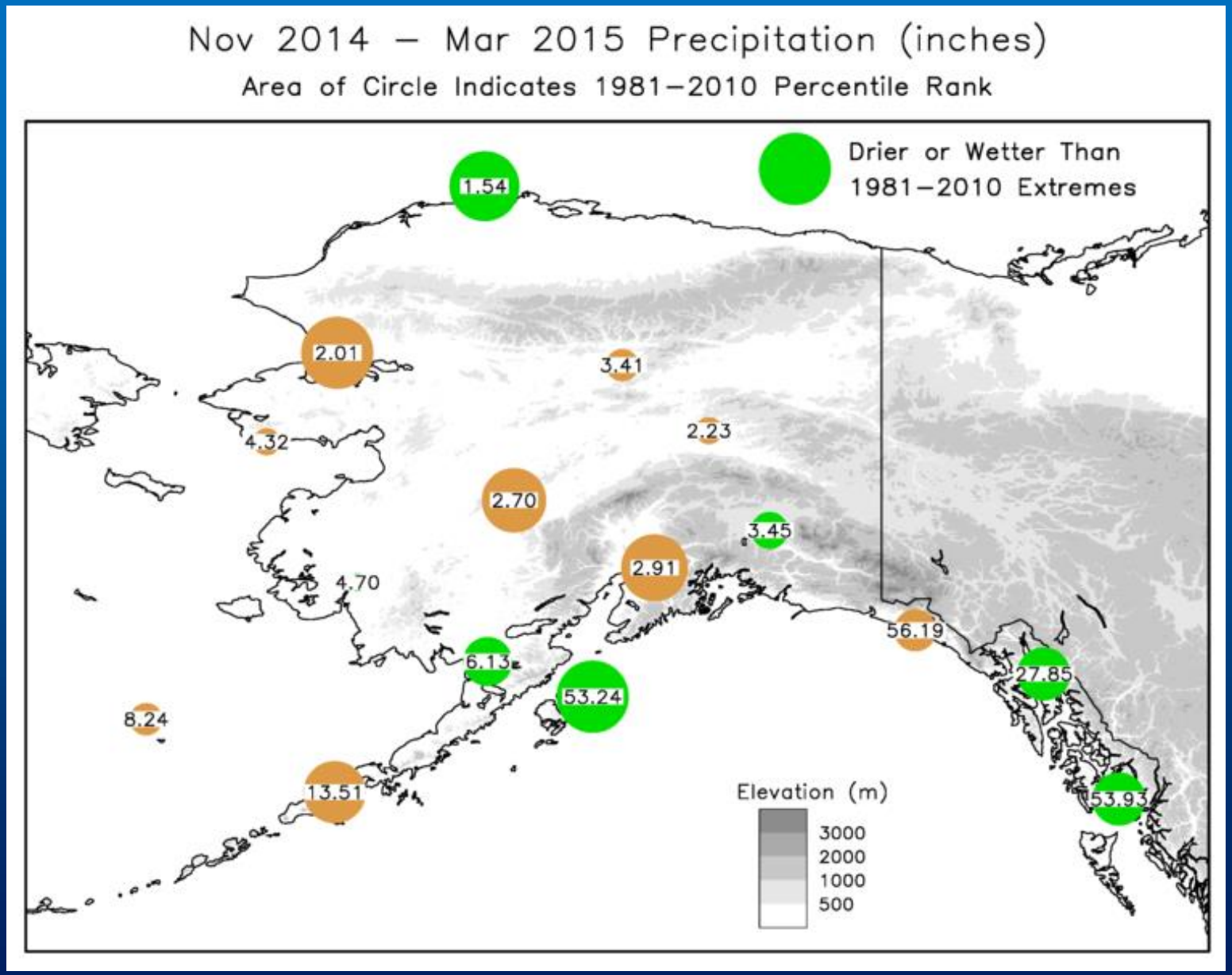
2014-2015




Nov 2013 – Mar 2014 Temperature Anomaly (°F)
Area of Circle Indicates Standardized Anomaly
1 SD (1981–2010 Climatology)
+6.8
+7.4
+2.8
+6.3
+3.7
+6.9
+0.8
+6.0
+2.4
-0.5
+5.8
-0.8
+1.4
+2.3
+5.0
-1.8
Elevation (m)
3000
2000
1000
500


Nov 2014 – Mar 2015 Temperature Anomaly (°F)
Area of Circle Indicates Standardized Anomaly
1 SD (1981–2010 Climatology)
+4.4
+6.0
+4.5
+4.8
+5.7
+8.0
+2.9
+6.0
+6.5
+4.1
+9.4
+3.6
+5.1
+4.0
+3.8
+3.7
Elevation (m)
3000
2000
1000
500


Nov 2013 – Mar 2014 Precipitation (inches)
Area of Circle Indicates 1981–2010 Percentile Rank
Drier or Wetter Than
1981–2010 Extremes
2.01
3.03
5.33
3.35
6.39
4.60
6.06
5.85
6.61
48.47
6.31
30.79
33.26
12.41
18.65
52.02
Elevation (m)
3000
2000
1000
500


Nov 2014 – Mar 2015 Precipitation (inches)
Area of Circle Indicates 1981–2010 Percentile Rank
Drier or Wetter Than
1981–2010 Extremes
1.54
2.01
3.41
4.32
2.23
2.70
3.45
2.91
4.70
56.19
6.13
27.85
53.24
8.24
13.51
53.93
Elevation (m)
3000
2000
1000
500

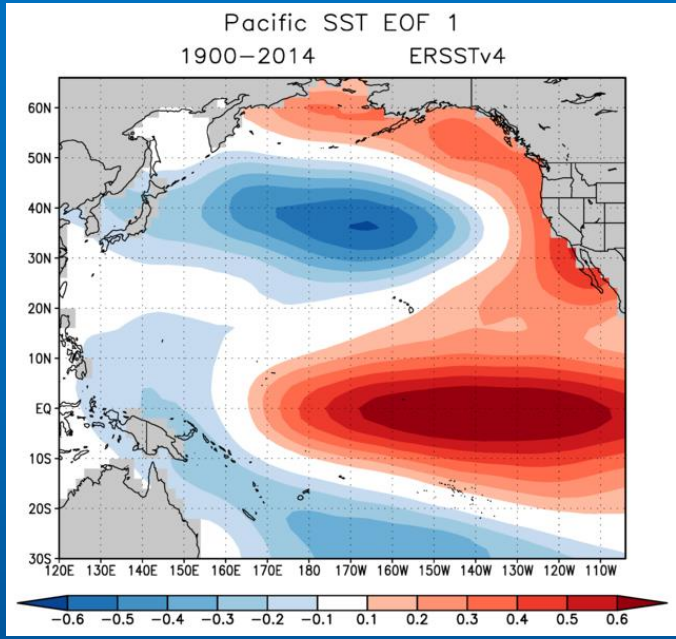
Hartmann 2015: the North Pacific Mode of SST anomalies played a key role in 2013-2014

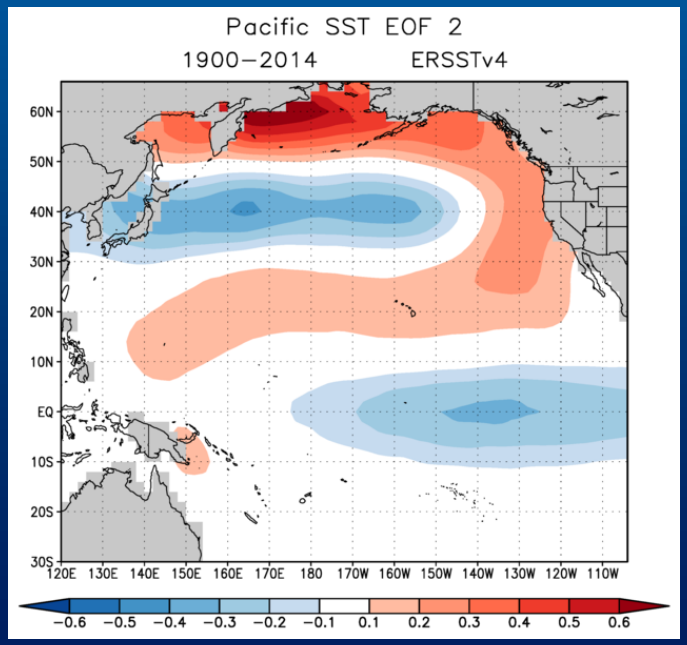
Objectives:

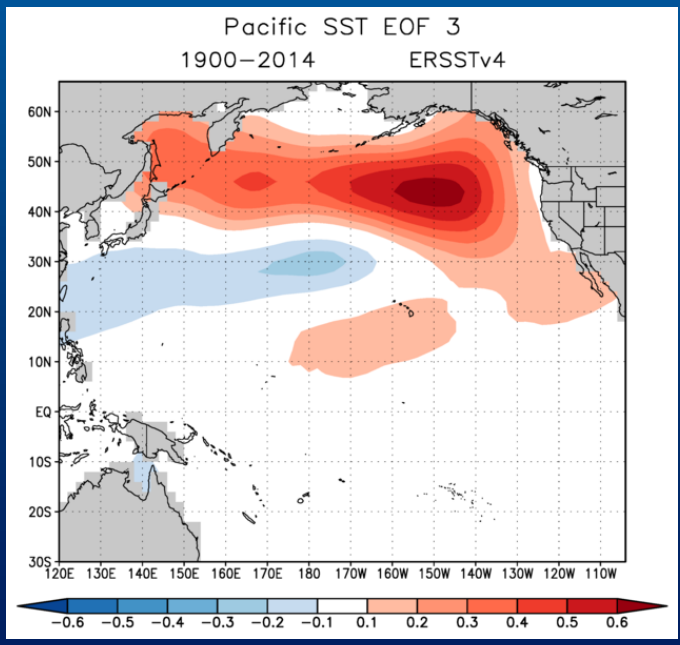
- **Review SST modes**
- **Examine historical connection to North Pacific and Alaska climate**
  - **Reanalysis and station data 1950-present**
  - **Focus on Fairbanks**
- **Explain non-linear climate impacts**

Top 3 modes over 30°S-65°N, 120°E-105°W

EOF 1: ENSO, PDO
EOF 2: PDO?
EOF 3: NPM



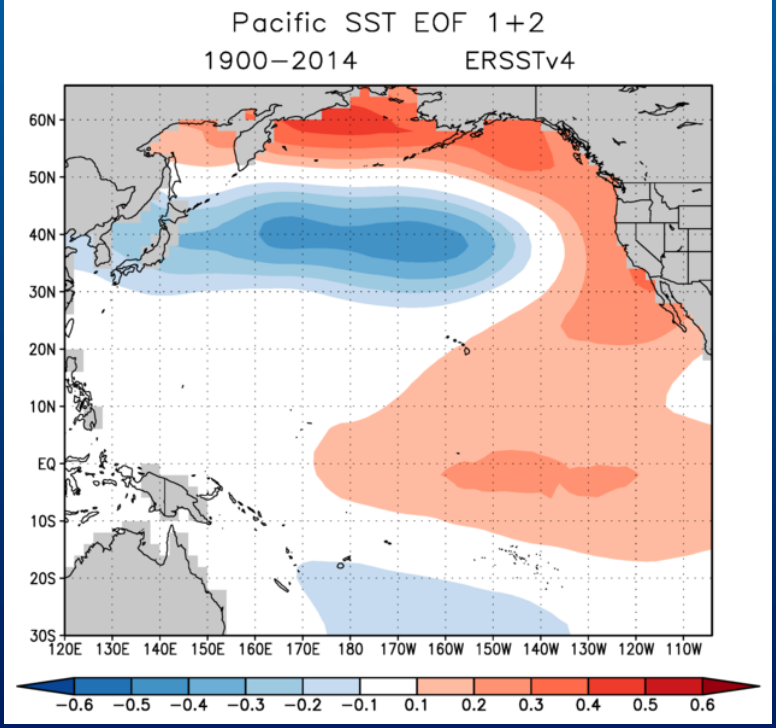


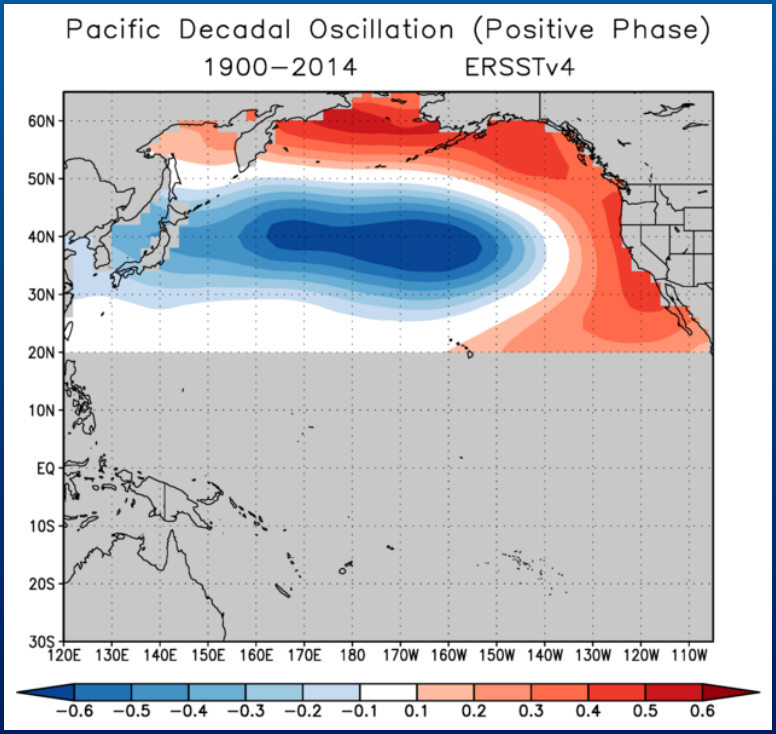


Correlations with ENSO/PDO

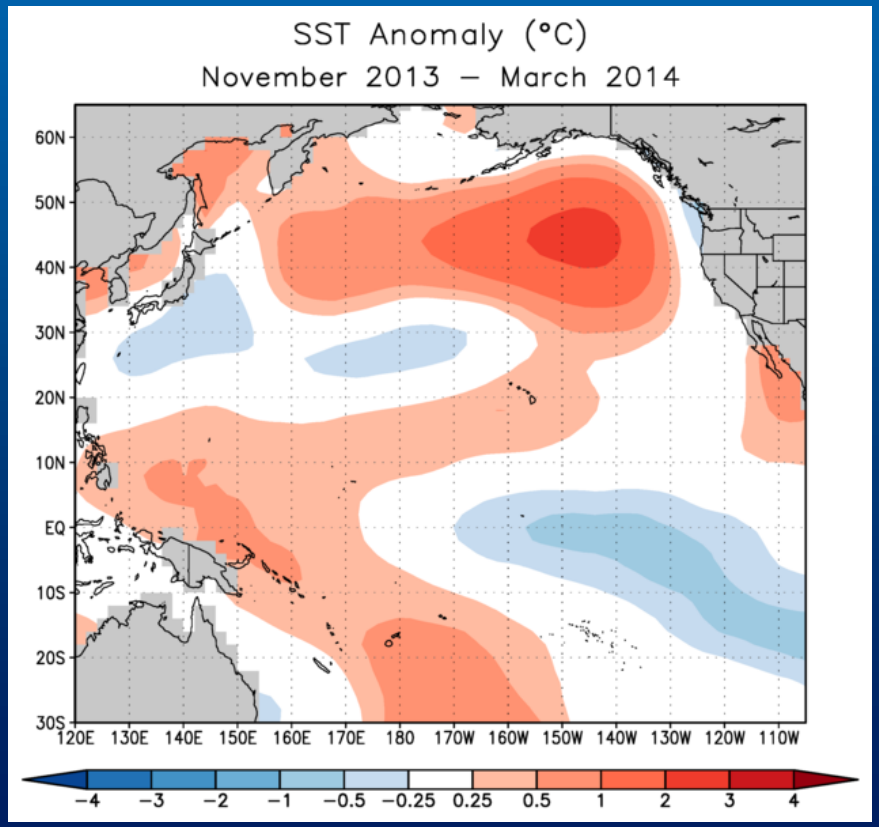
EOF1:	ENSO +0.94	PDO +0.77
EOF2:	ENSO -0.48	PDO +0.42
EOF3:	ENSO +0.05	PDO -0.07
EOF1+2:	ENSO +0.51	PDO +0.99

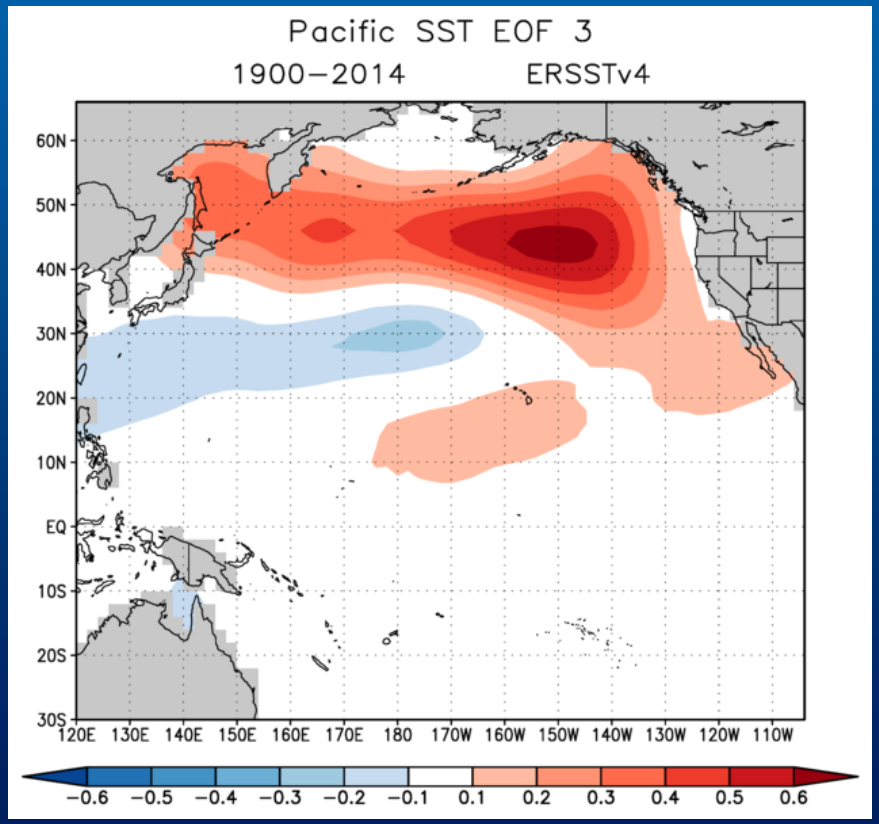
Combination of EOFs 1+2 is nearly identical to the PDO



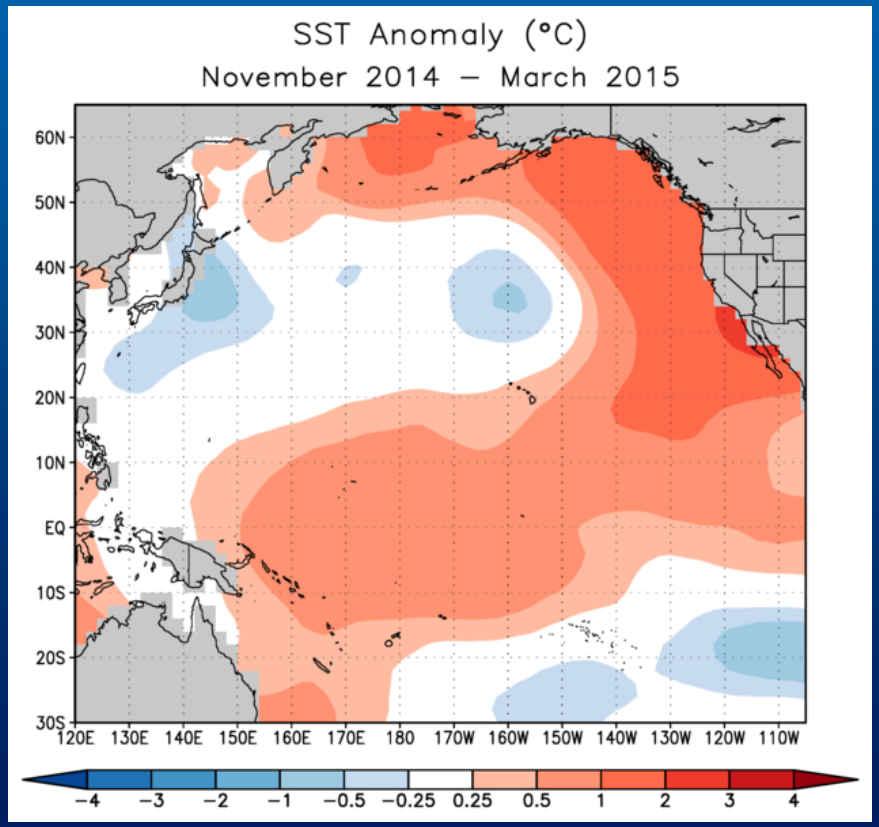


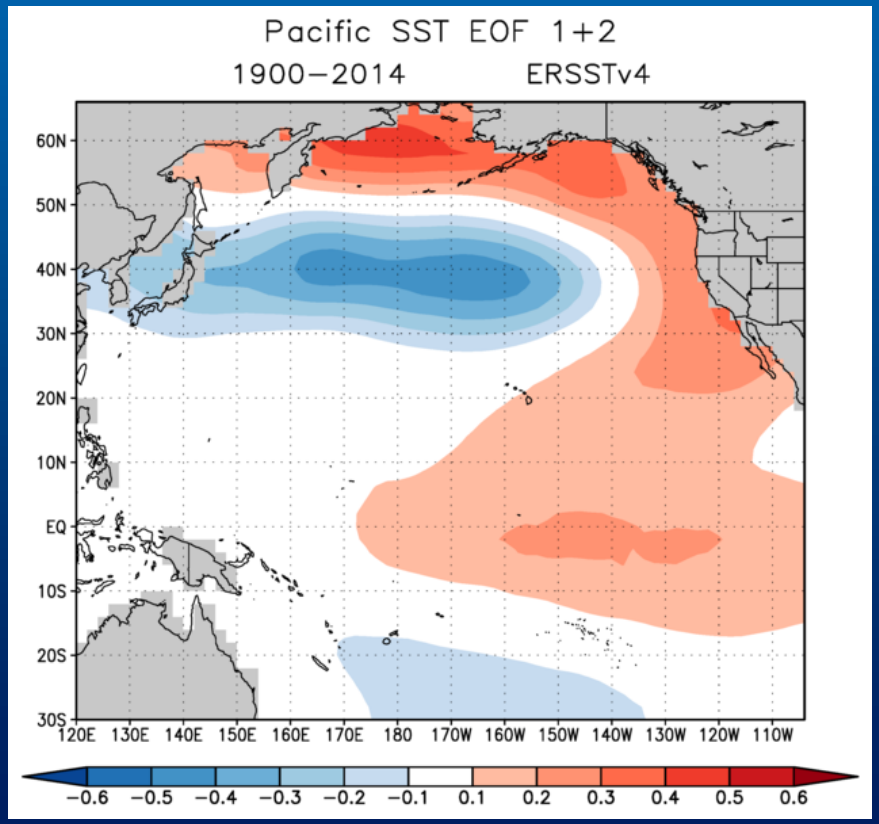
North Pacific SST anomalies resembled the NPM positive phase in 2013-2014…





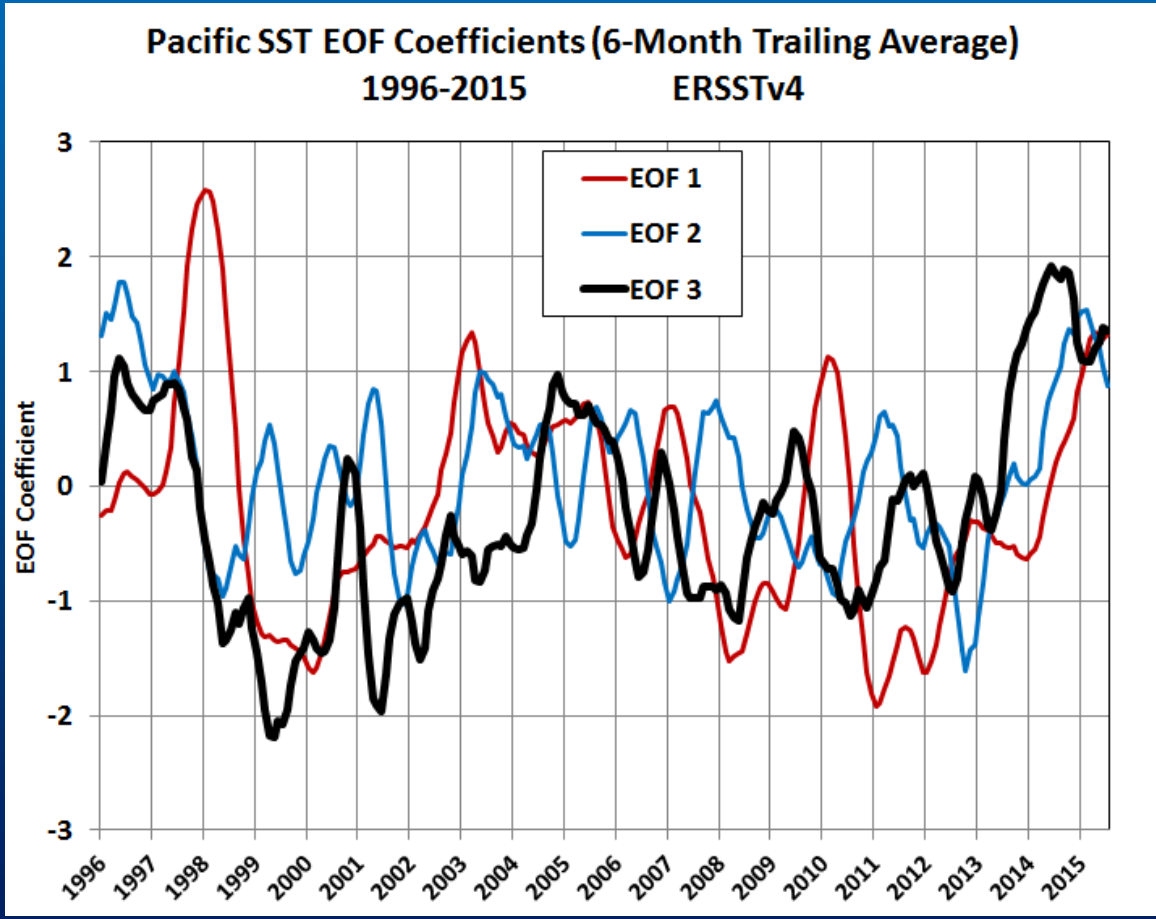
… and the PDO positive phase in 2014-2015



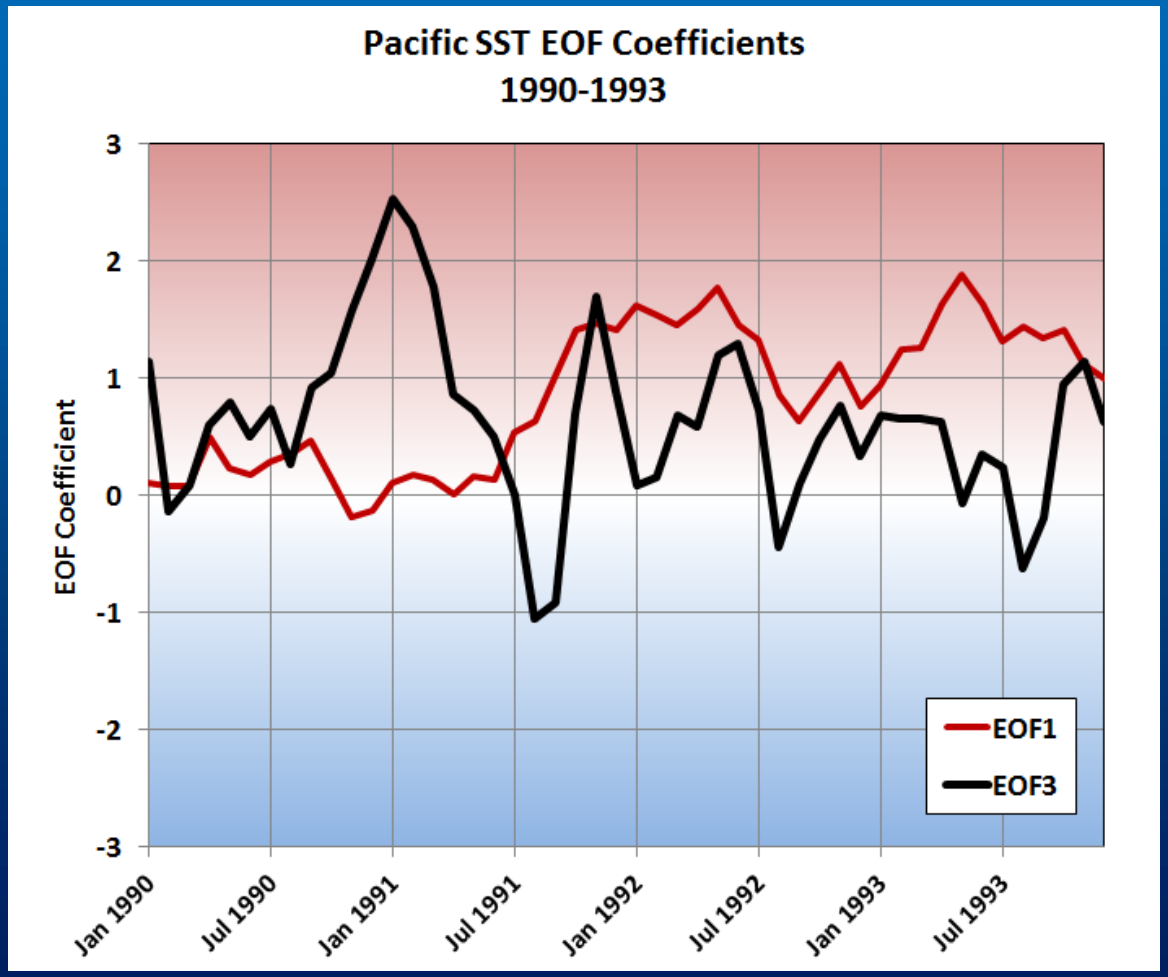


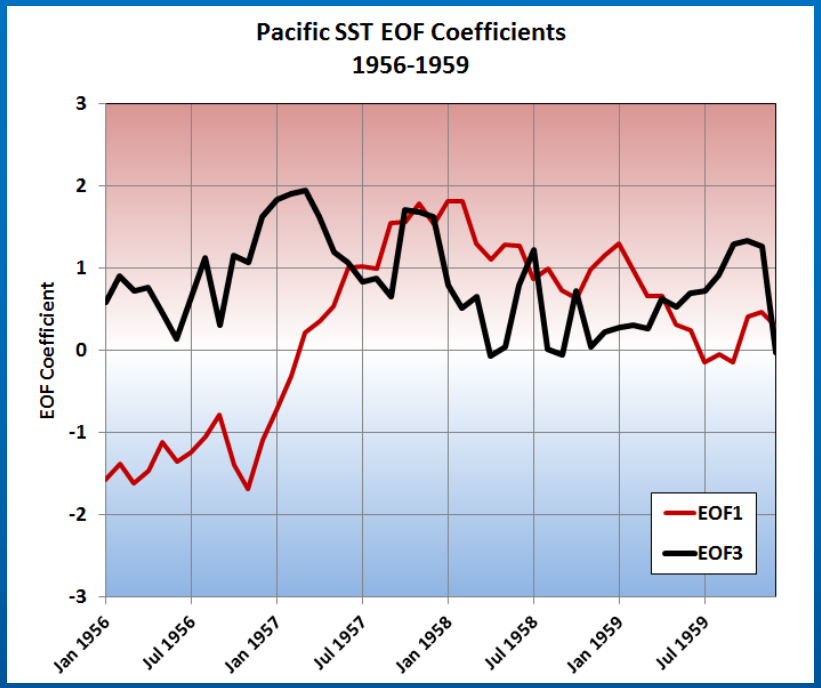
Nov-Mar 2013-2014: 2nd highest EOF 3 loading

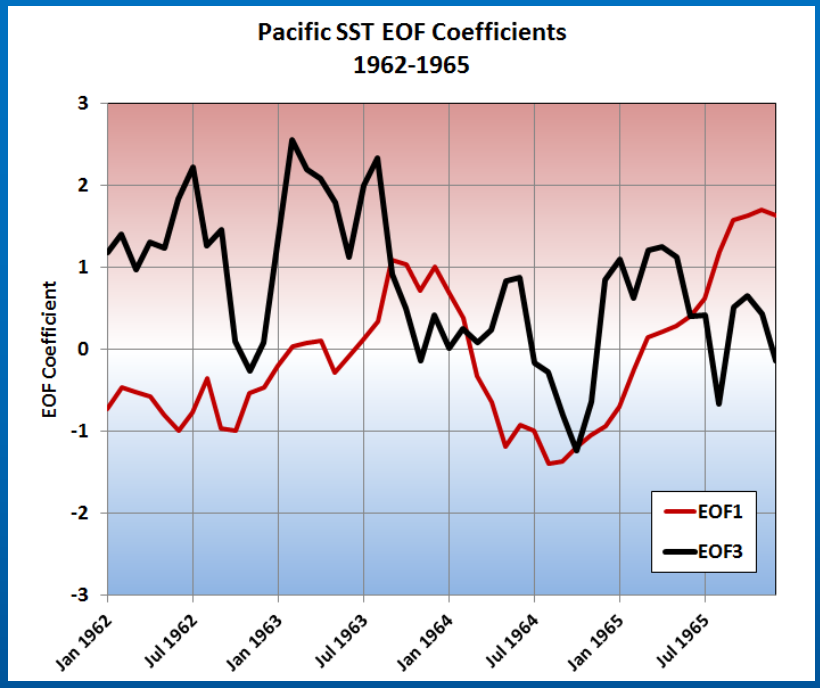
Nov-Mar 2014-2015: Highest EOF 1+2+3 loading

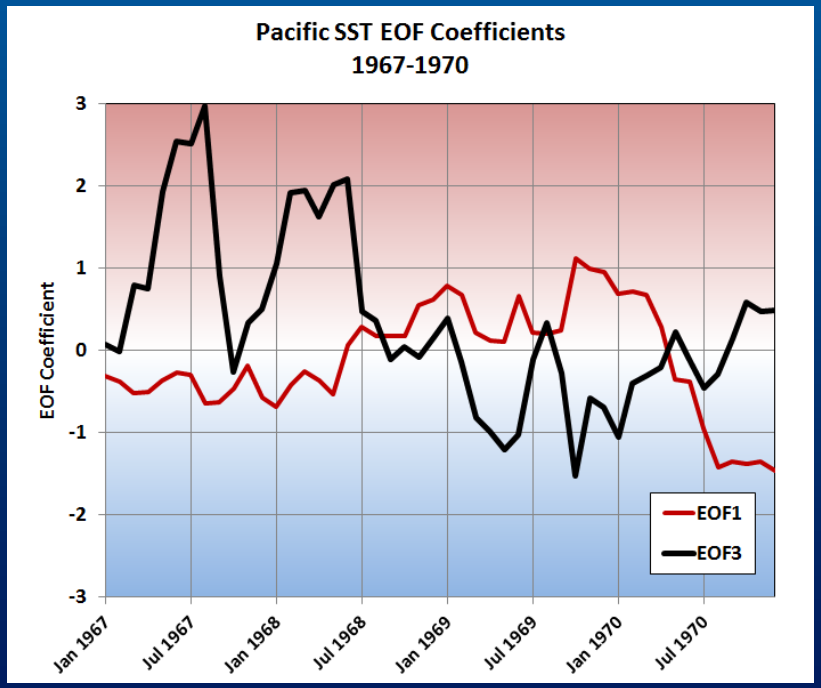


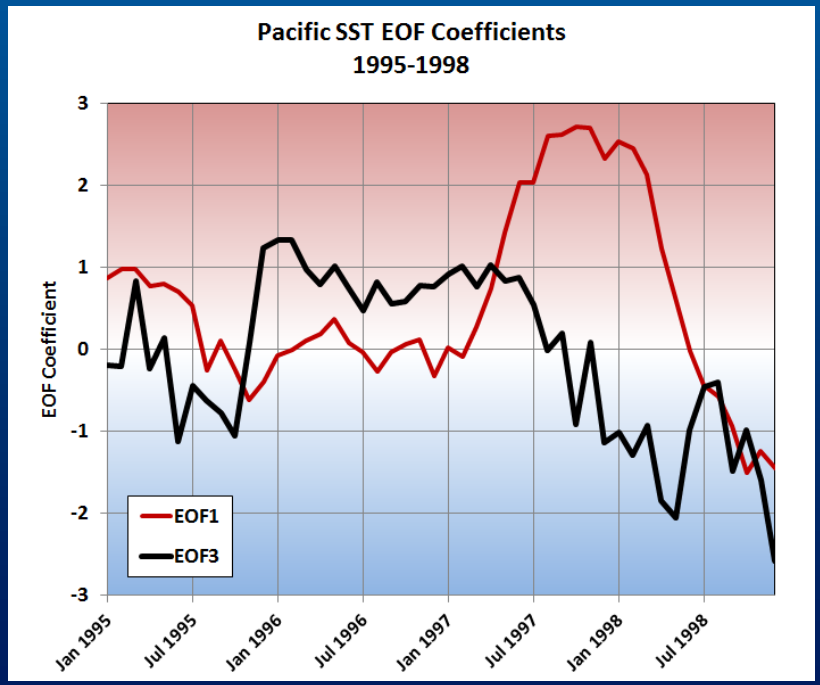
The positive NPM phase tends to precede El Niño ("footprinting mechanism")



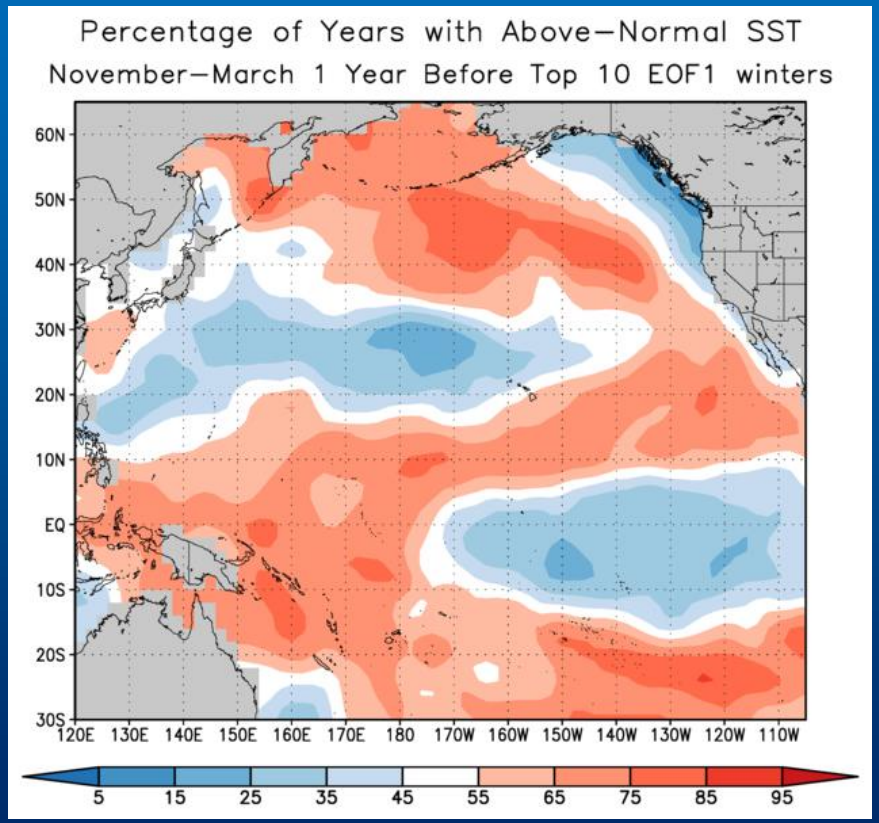

Pacific SST EOF Coefficients
1956-1959
EOF Coefficient
3
2
1
0
-1
-2
-3
Jan 1956
Jul 1956
Jan 1957
Jul 1957
Jan 1958
Jul 1958
Jan 1959
Jul 1959
EOF1
EOF3

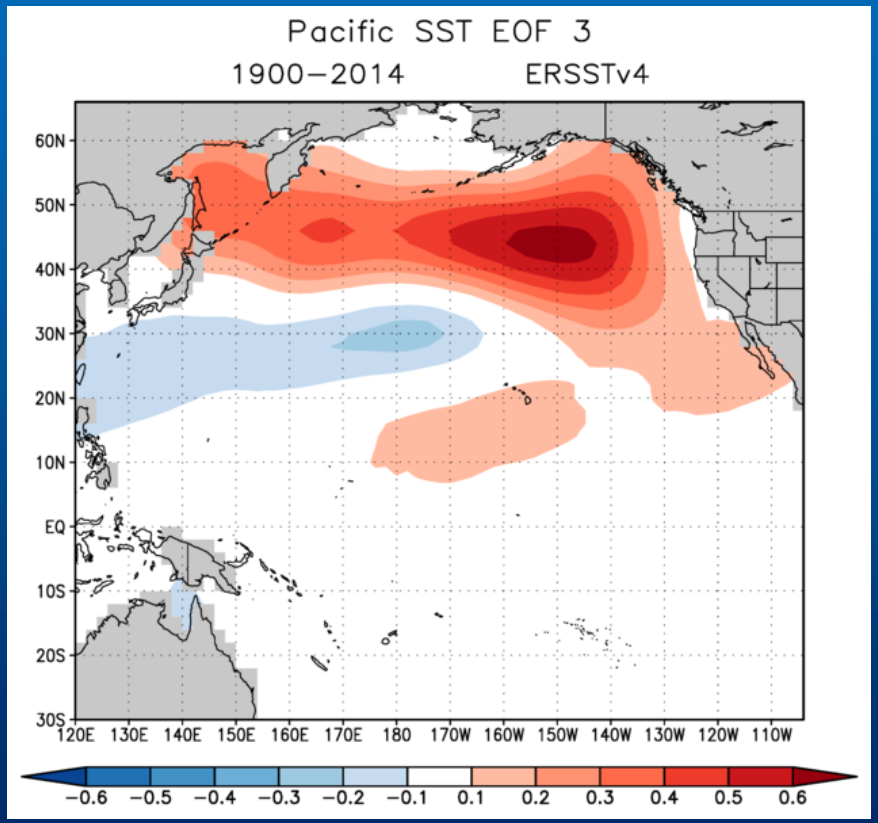

Pacific SST EOF Coefficients
1962-1965
EOF Coefficient
3
2
1
0
-1
-2
-3
Jan 1962
Jul 1962
Jan 1963
Jul 1963
Jan 1964
Jul 1964
Jan 1965
Jul 1965
EOF1
EOF3


Pacific SST EOF Coefficients
1967-1970
EOF Coefficient
3
2
1
0
-1
-2
-3
Jan 1967
Jul 1967
Jan 1968
Jul 1968
Jan 1969
Jul 1969
Jan 1970
Jul 1970
EOF1
EOF3


Pacific SST EOF Coefficients
1995-1998
EOF Coefficient
3
2
1
0
-1
-2
-3
Jan 1995
Jul 1995
Jan 1996
Jul 1996
Jan 1997
Jul 1997
Jan 1998
Jul 1998
EOF1
EOF3

SST pattern 1 year prior to El Niño/positive PDO winters resembles EOF 3



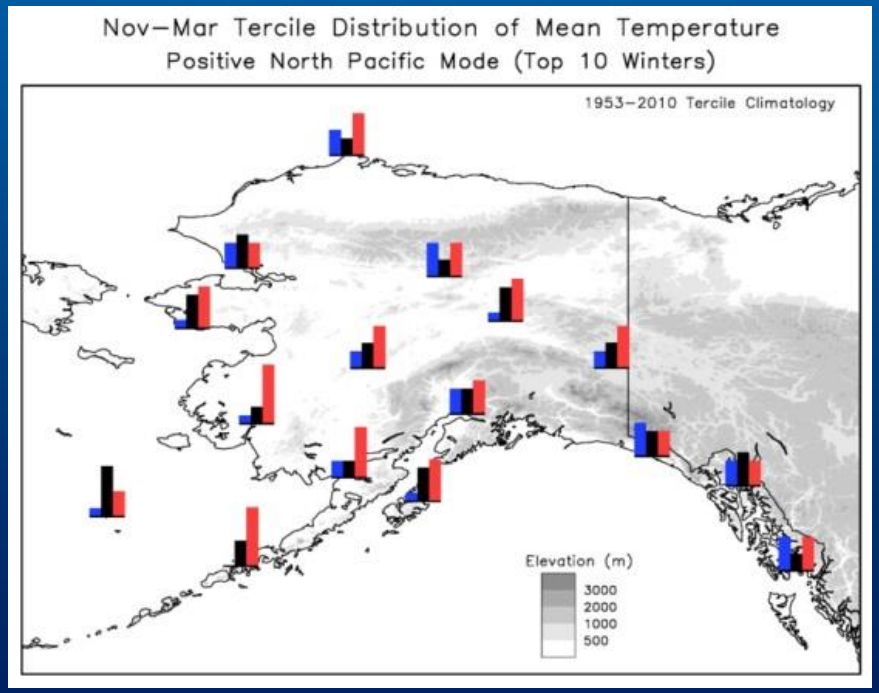


Historical impacts of NPM and PDO

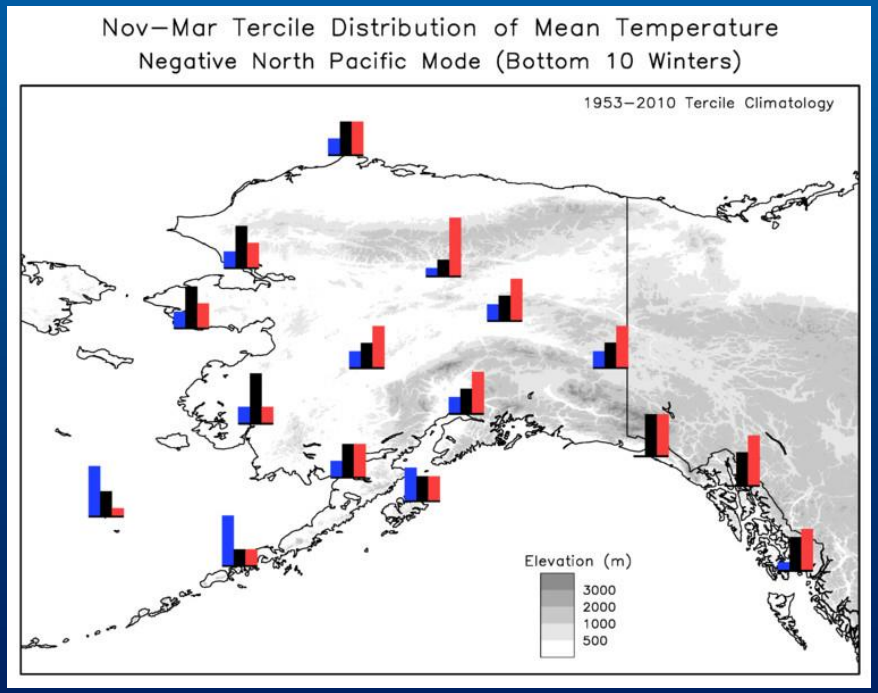
Historical Impacts - NPM

1953-present
November-March Temperature

Positive NPM



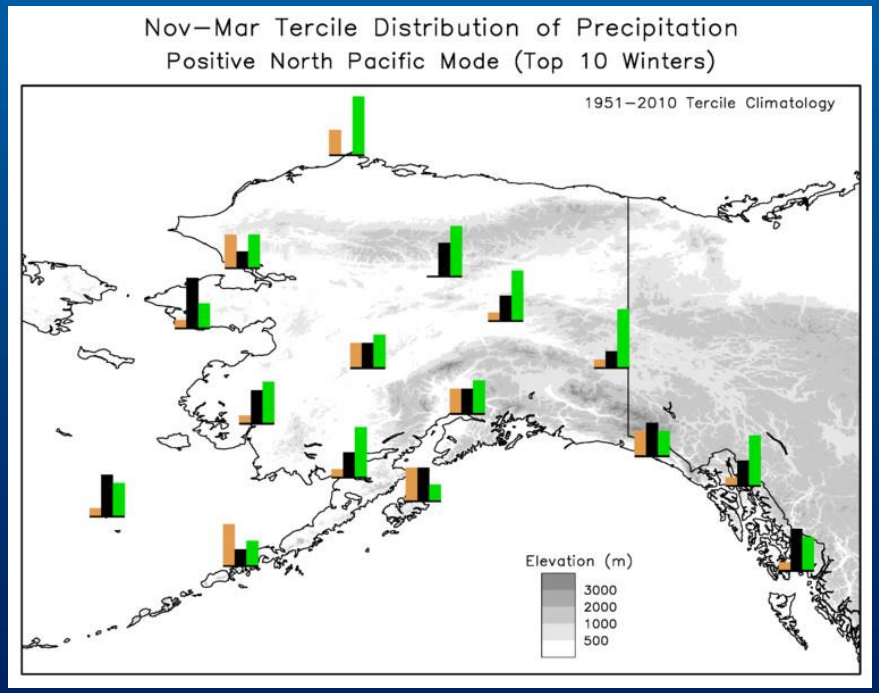
Negative NPM



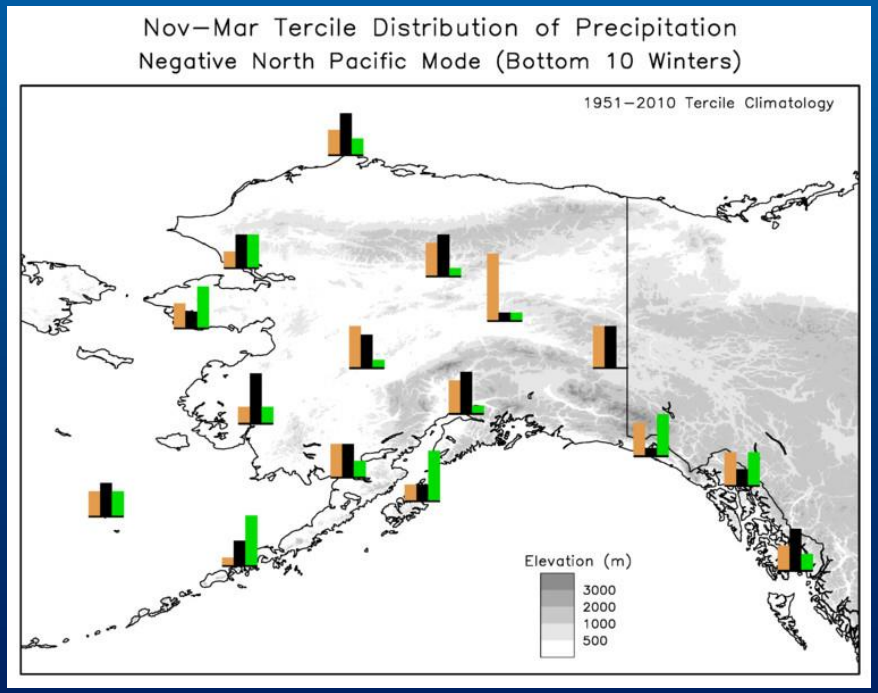
Historical Impacts - NPM

1953-present
November-March Precipitation

Positive NPM



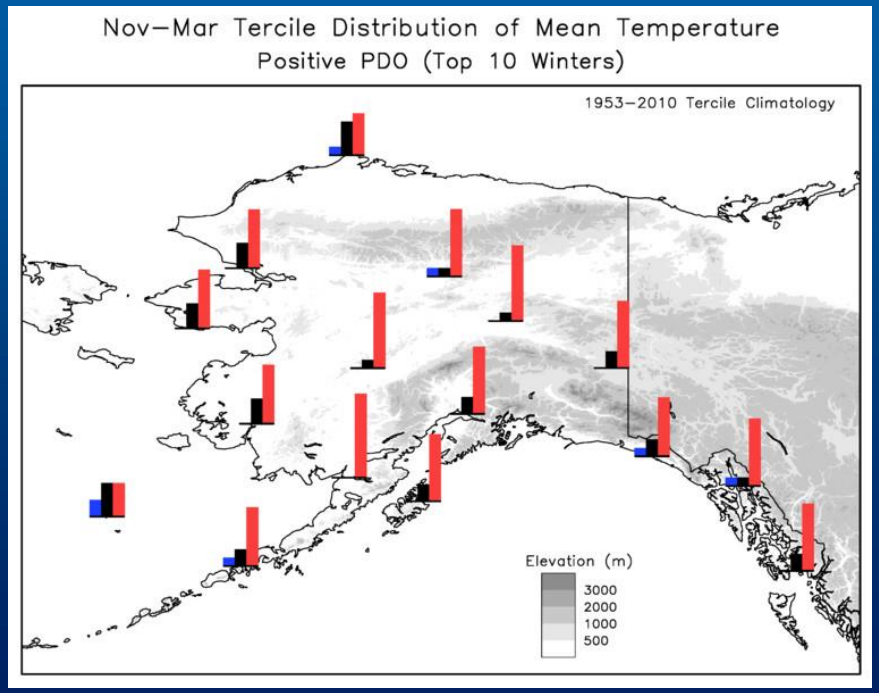
Negative NPM



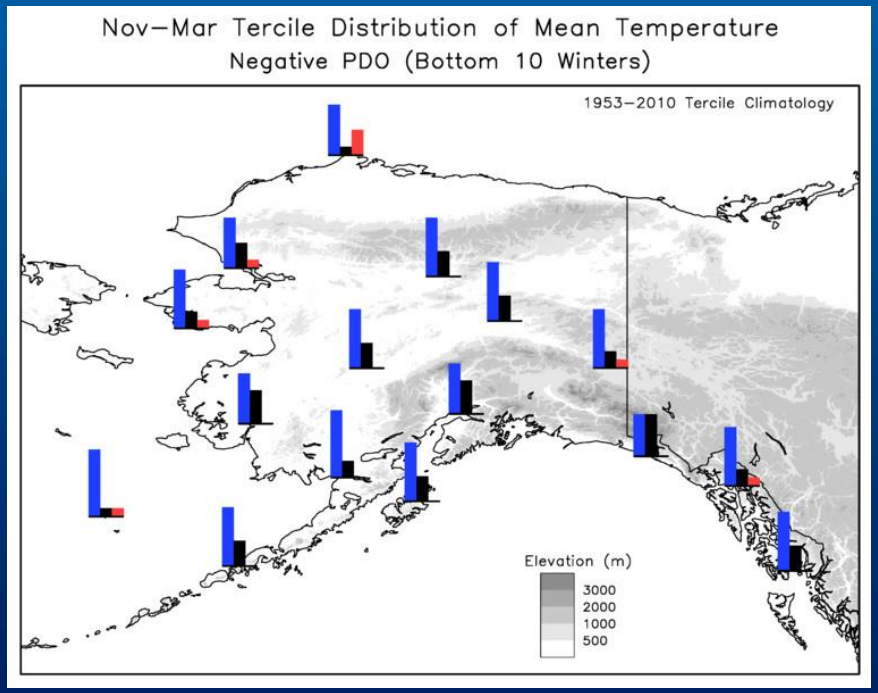
Historical Impacts - PDO

1953-present
November-March Temperature

Positive PDO



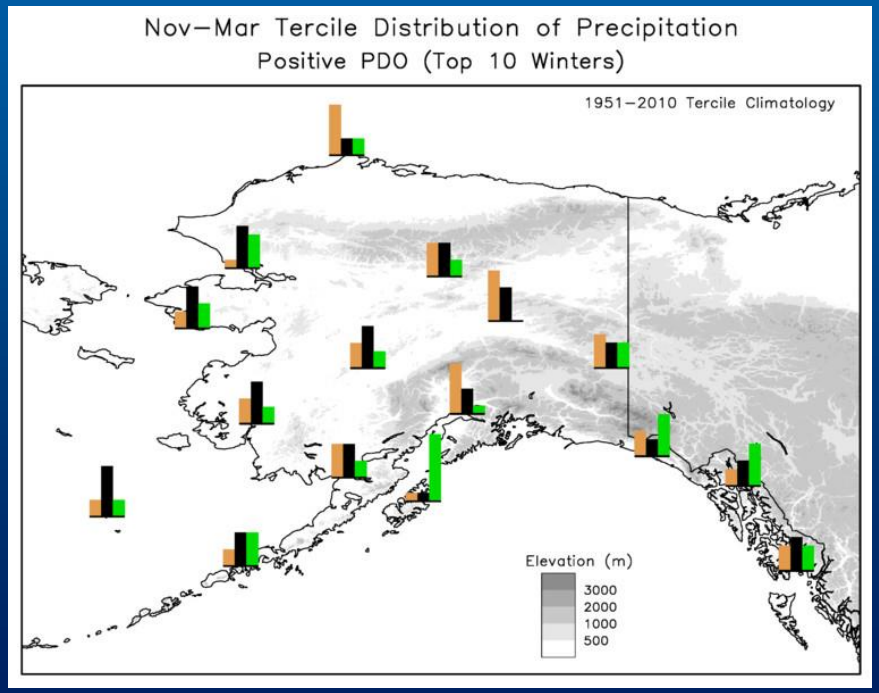
Negative PDO



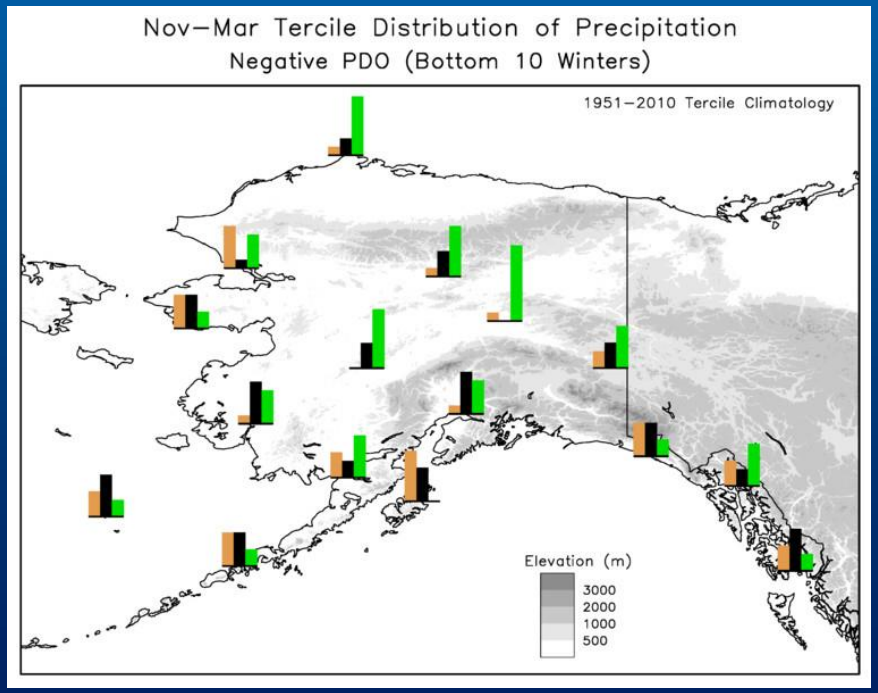
Historical Impacts - PDO

1953-present
November-March Precipitation

Positive PDO

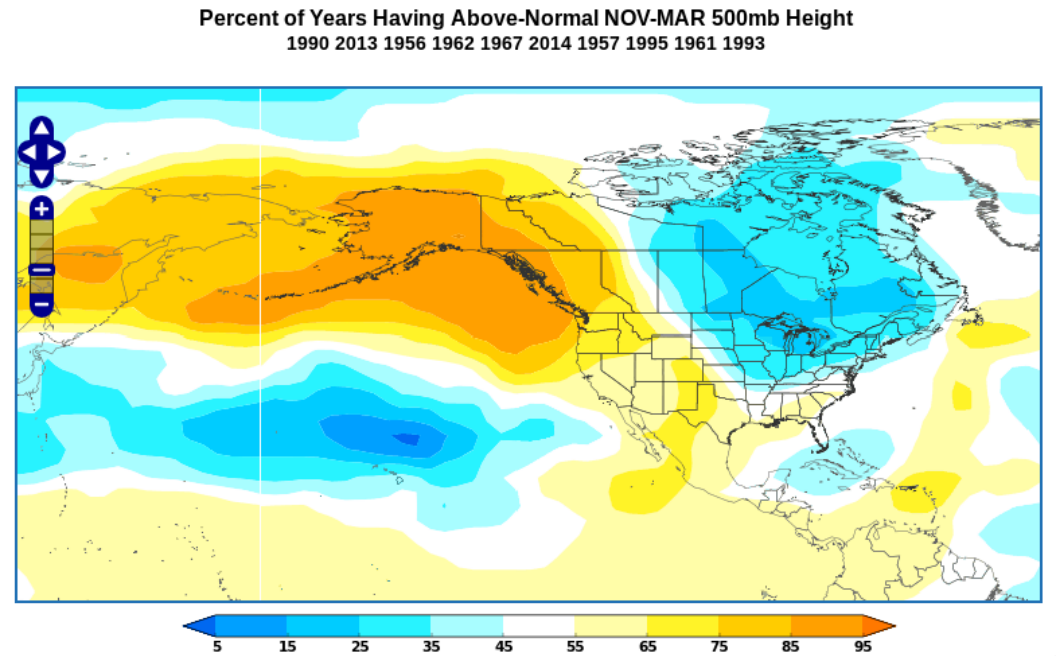


Negative PDO

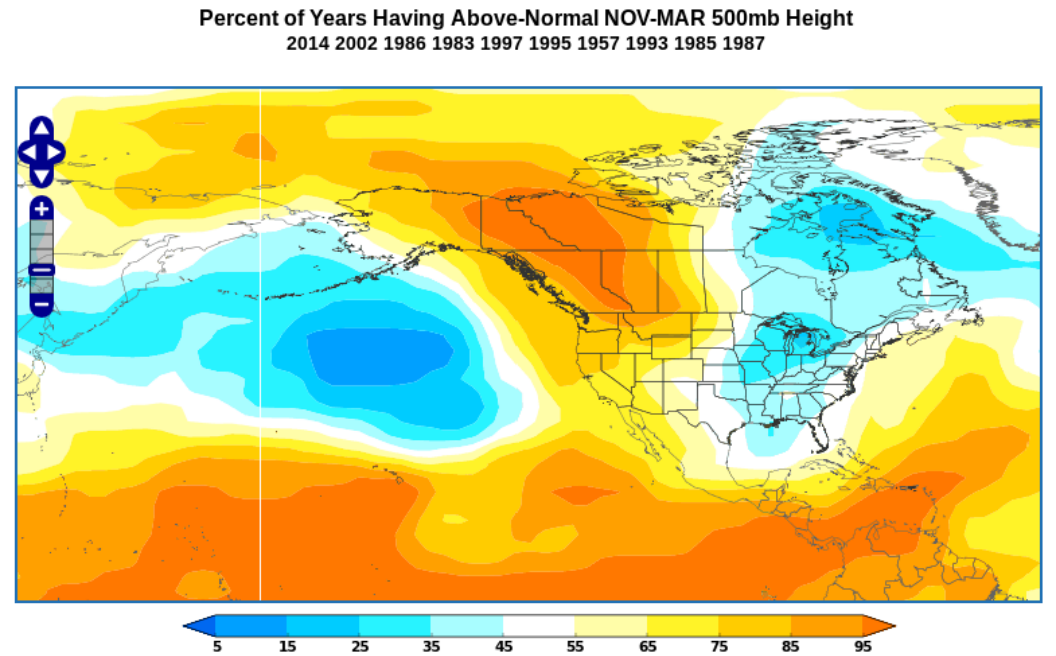


Nov-Mar
Positive Phase

EOF 3
Positive NPM

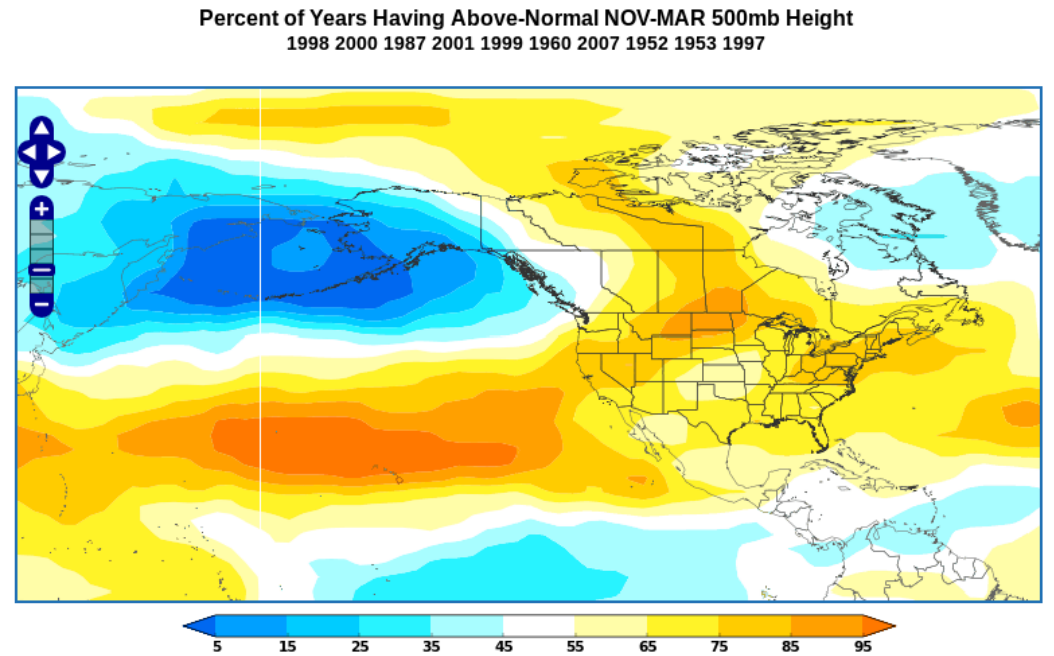


EOF 1+2
Positive PDO

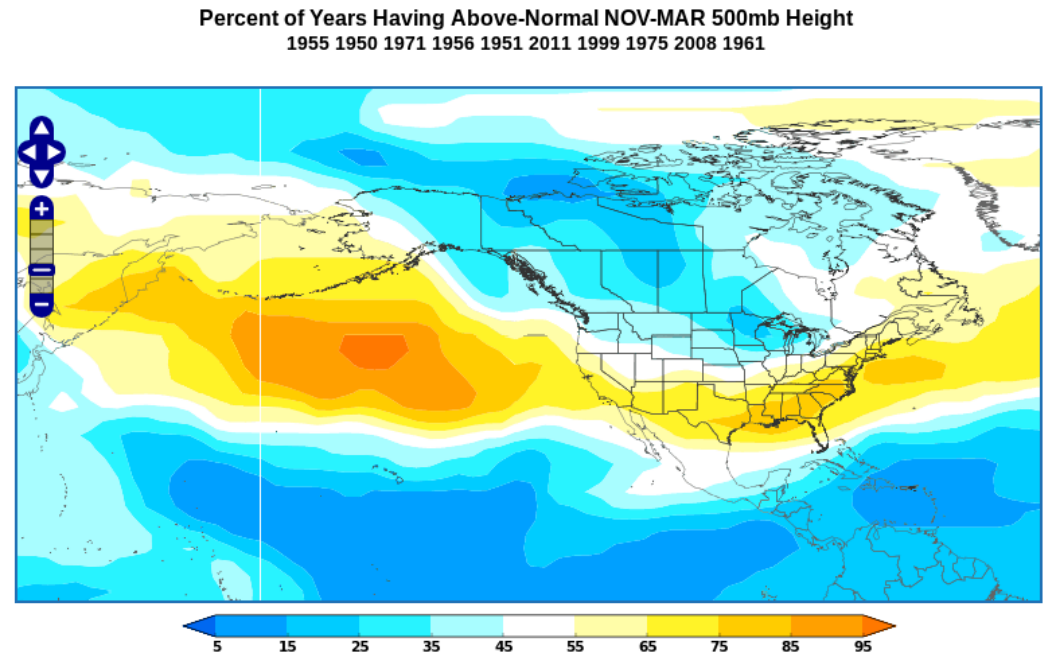


Nov-Mar
Negative Phase

EOF 3
Negative NPM

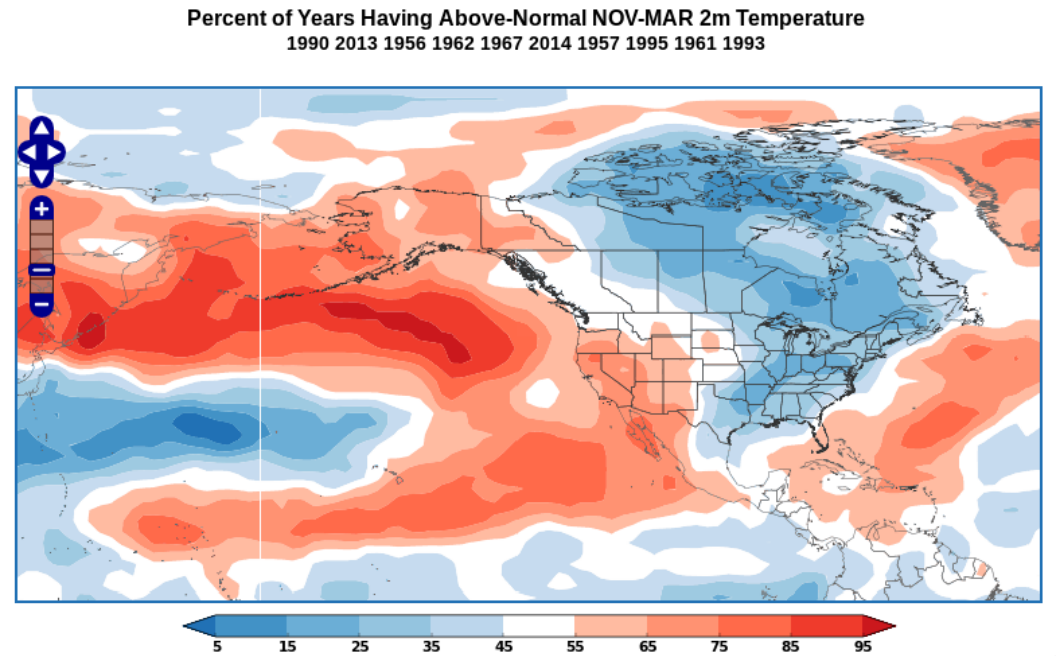


EOF 1+2
Negative PDO

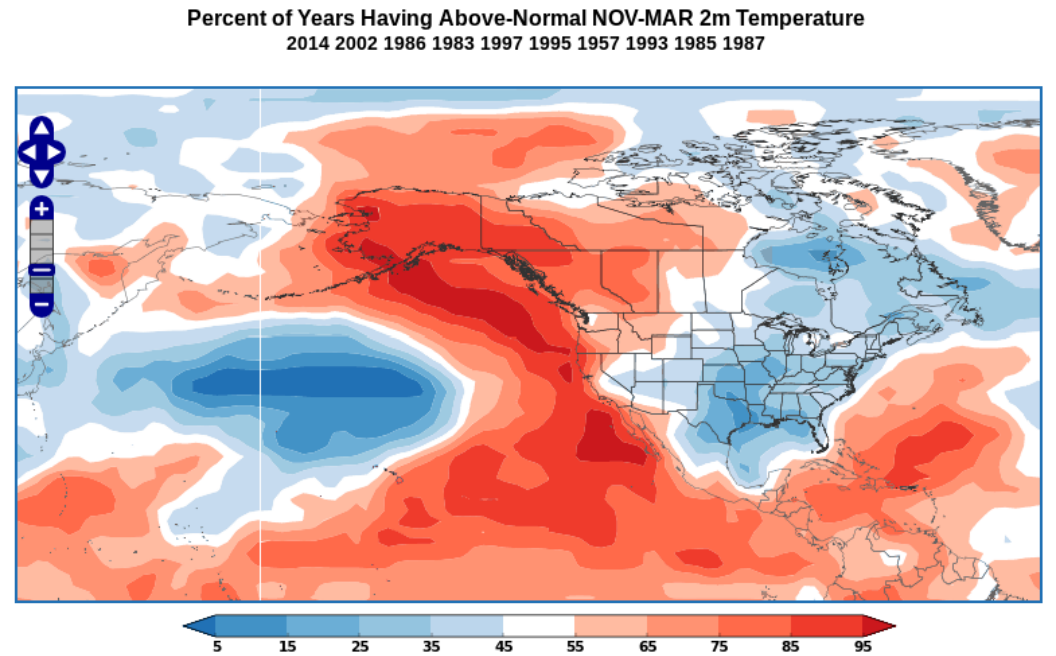


Nov-Mar
Positive Phase

EOF 3
Positive NPM

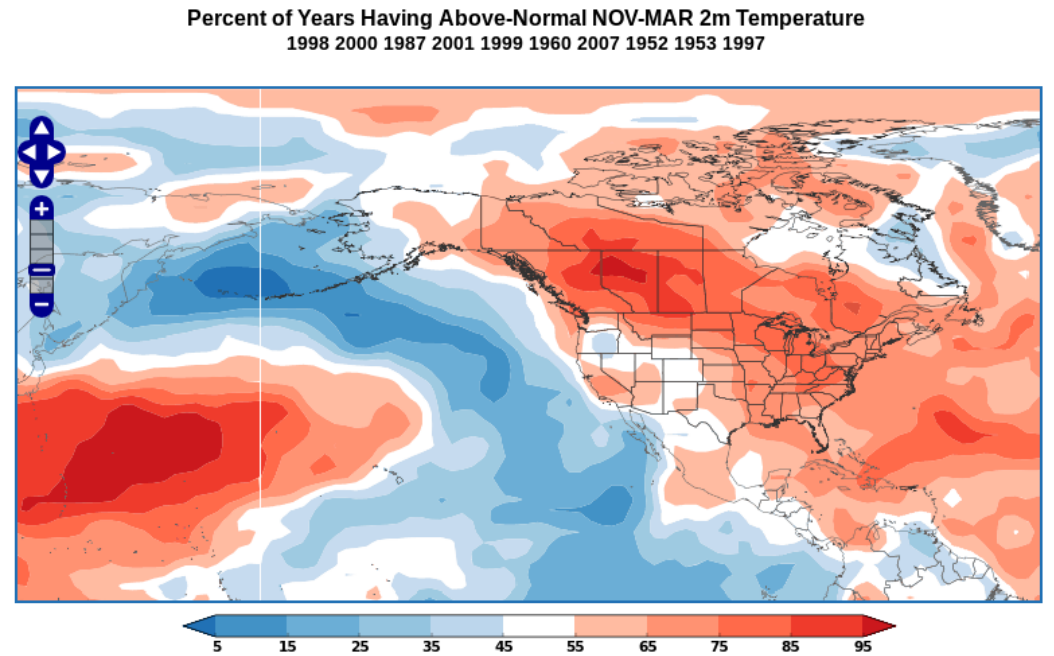


EOF 1+2
Positive PDO

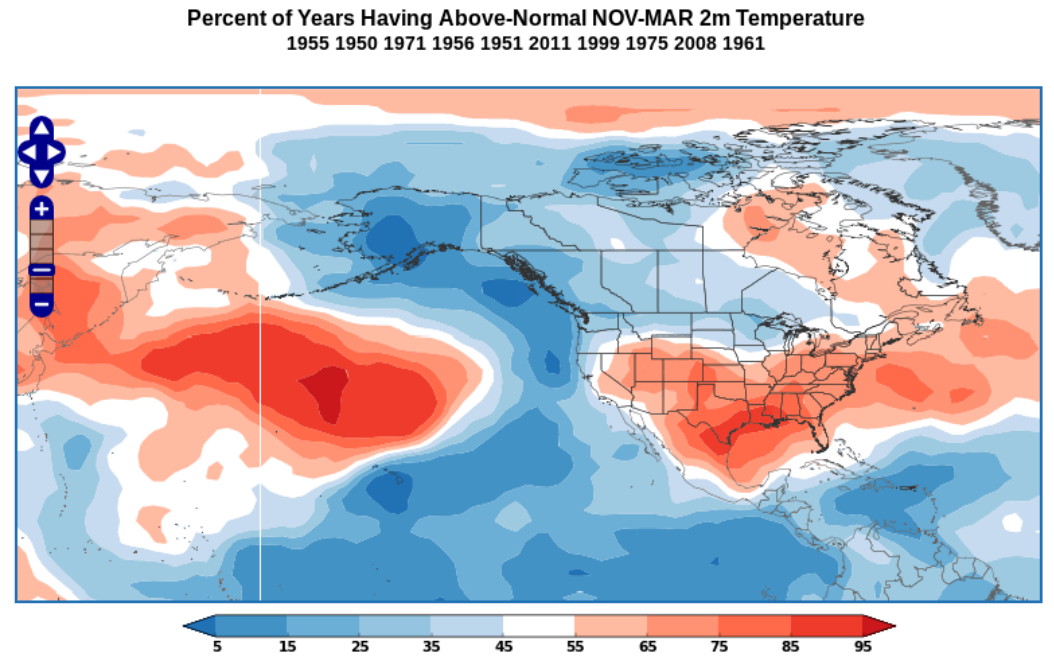


Nov-Mar
Negative Phase

EOF 3
Negative NPM

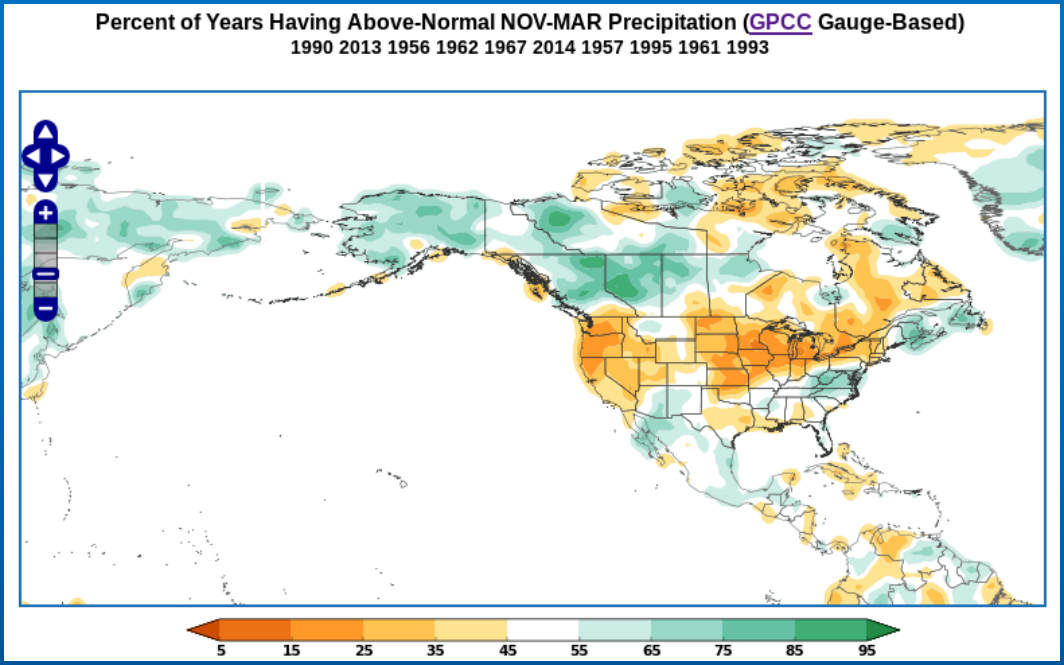


EOF 1+2
Negative PDO

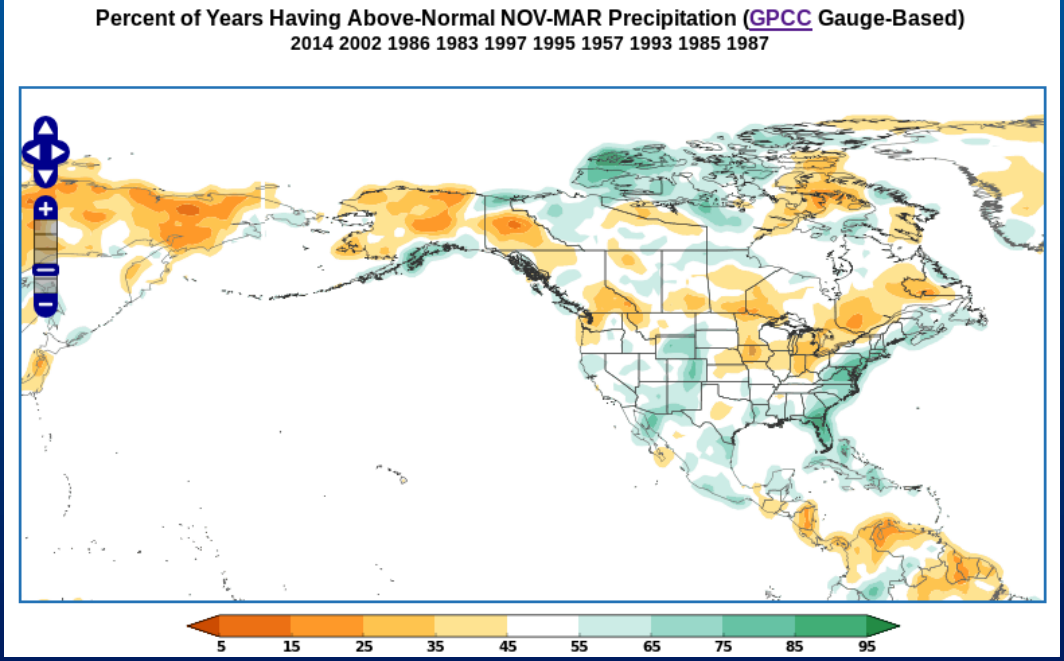


Nov-Mar
Positive Phase

EOF 3
Positive NPM

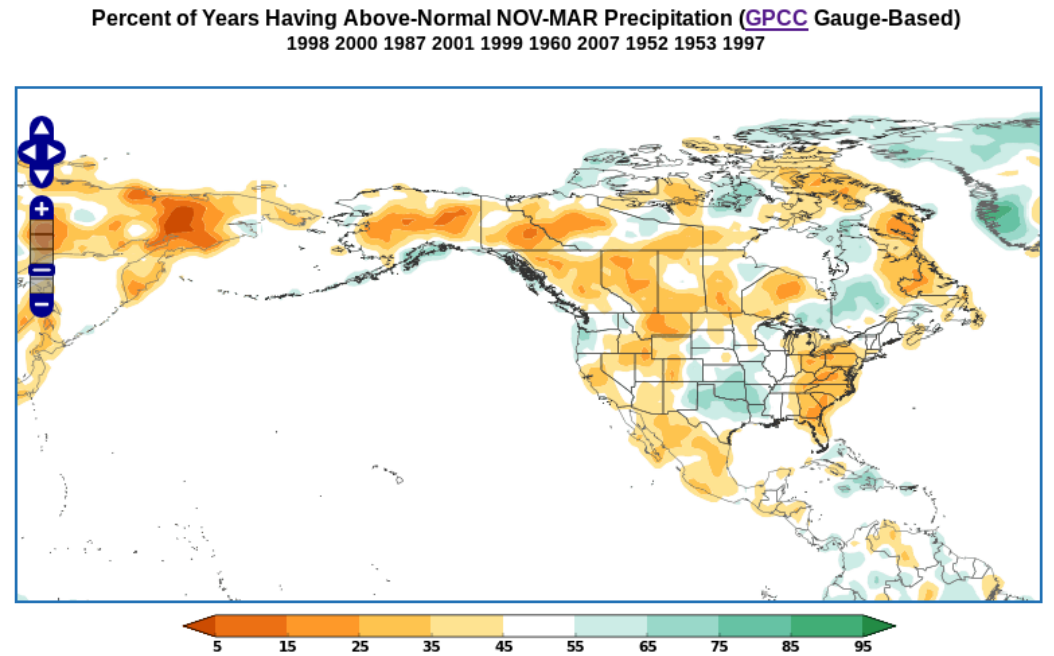


EOF 1+2
Positive PDO

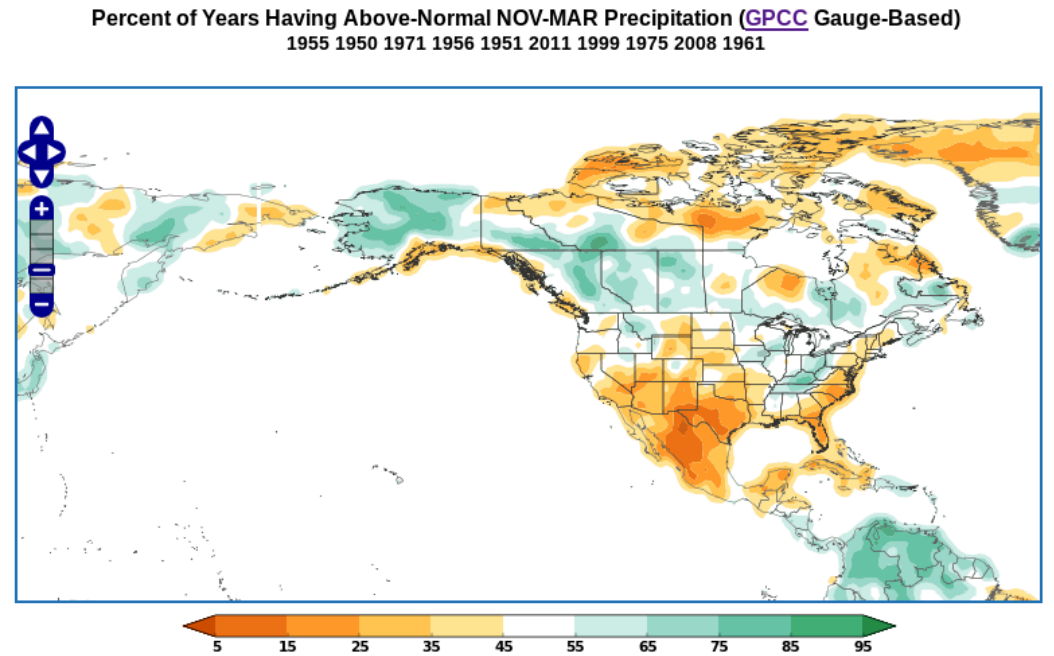


Nov-Mar
Negative Phase

EOF 3
Negative NPM

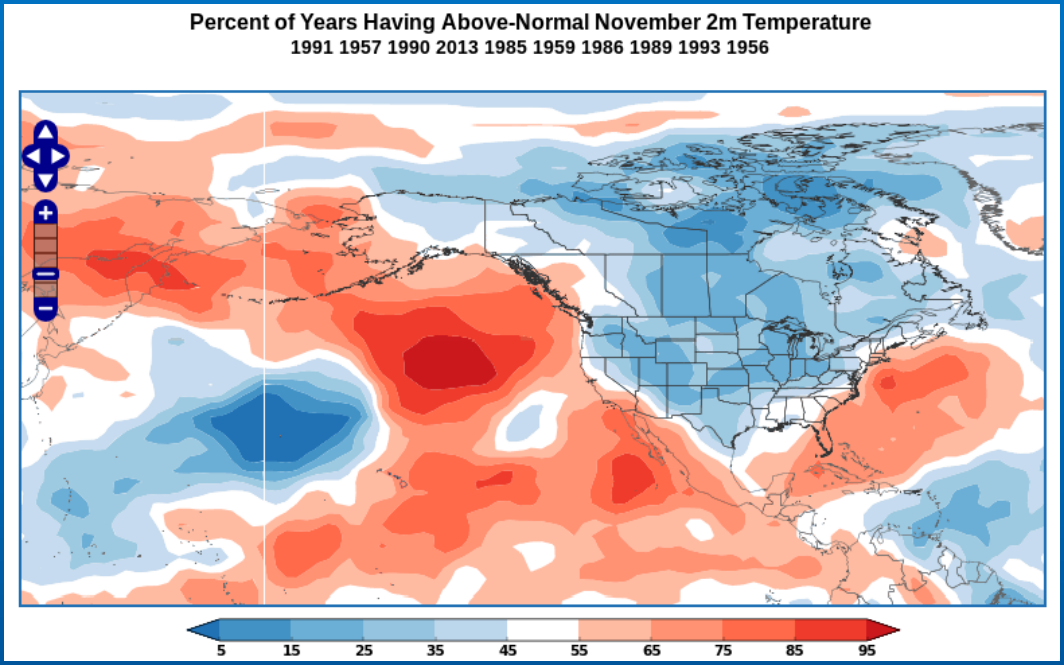


EOF 1+2
Negative PDO

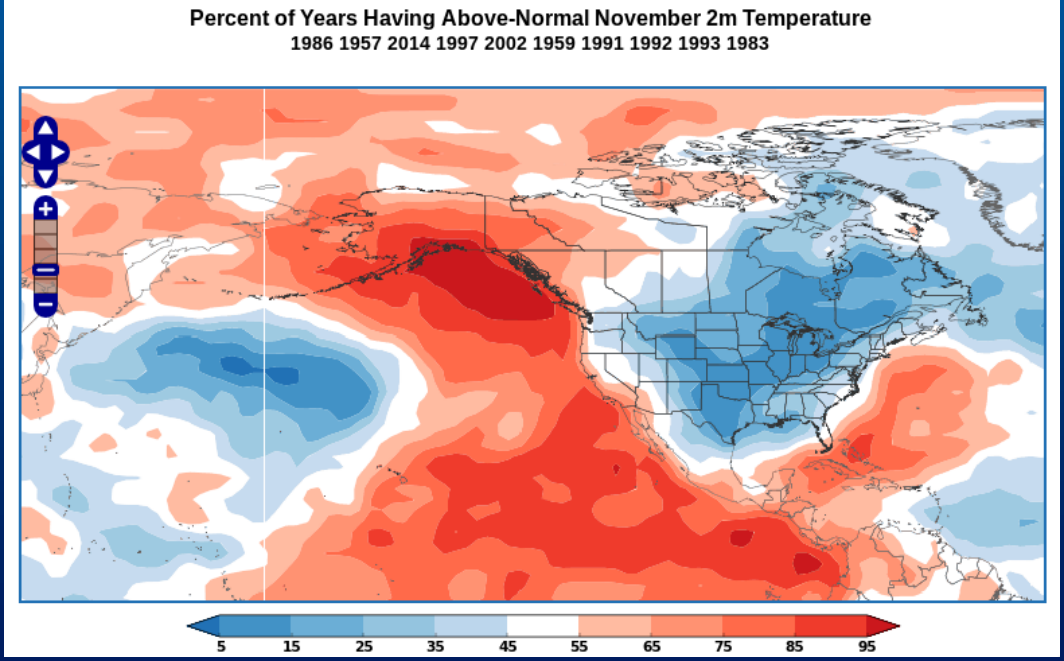


November
Positive Phase

EOF 3
Positive NPM

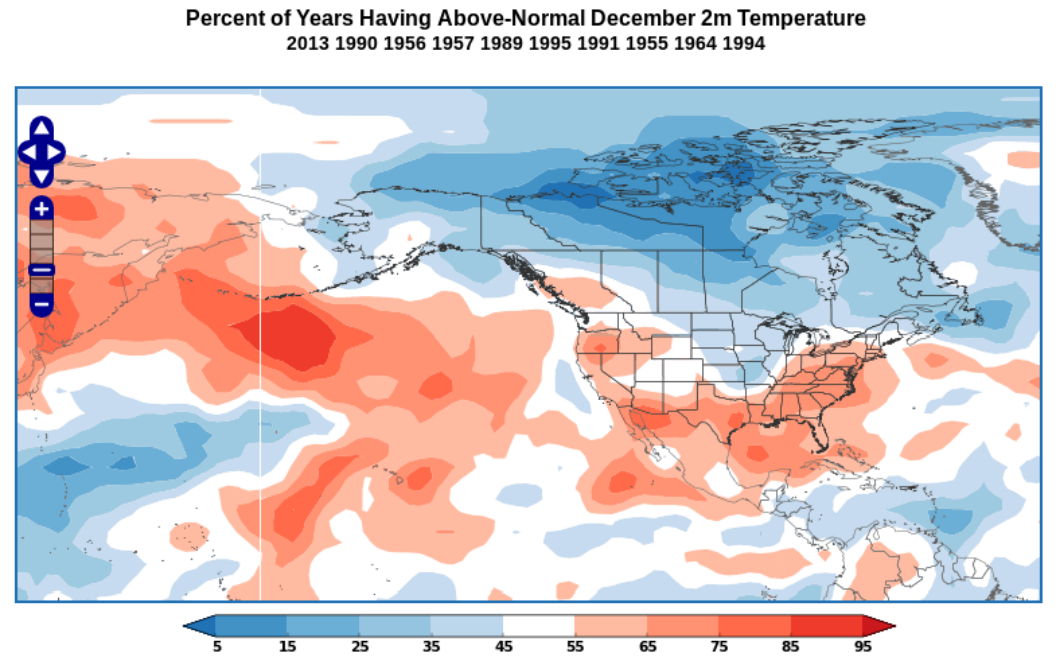


EOF 1+2
Positive PDO

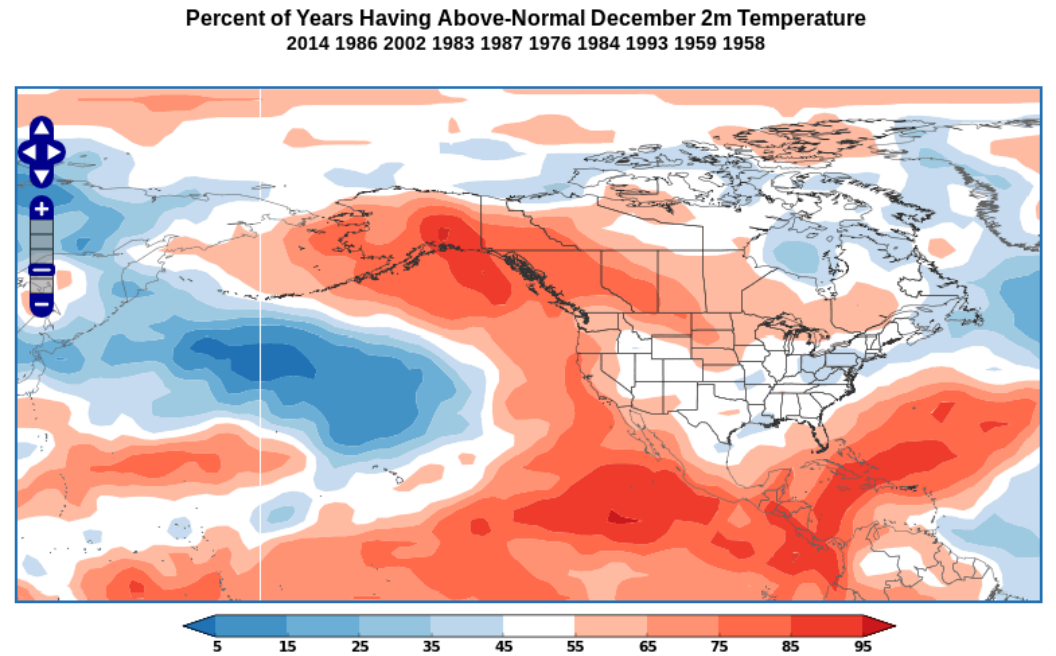


December
Positive Phase

EOF 3
Positive NPM

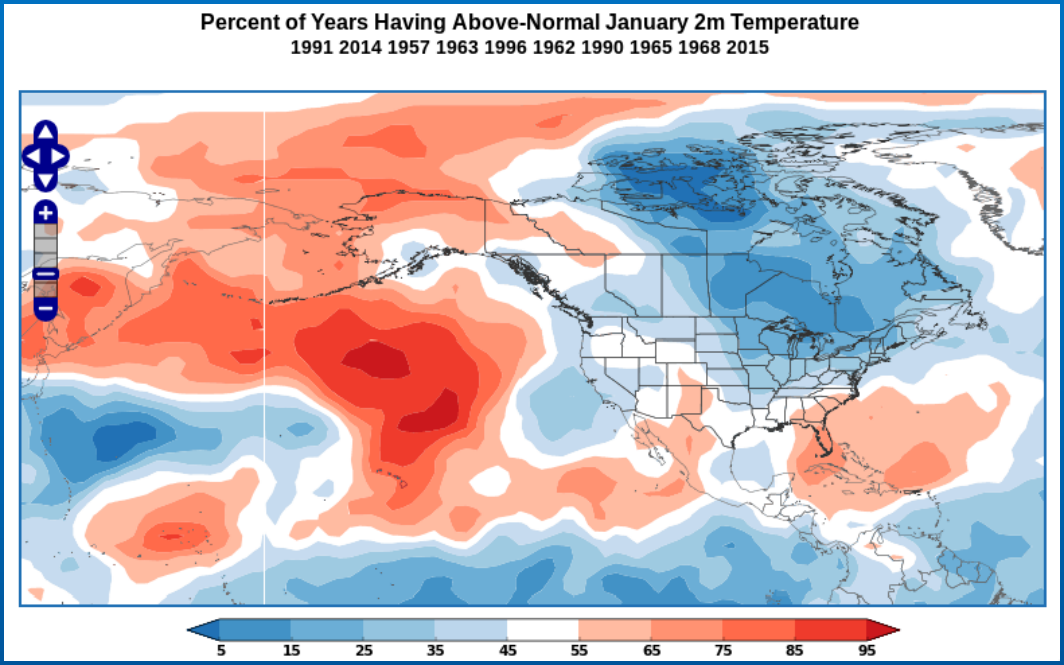


EOF 1+2
Positive PDO

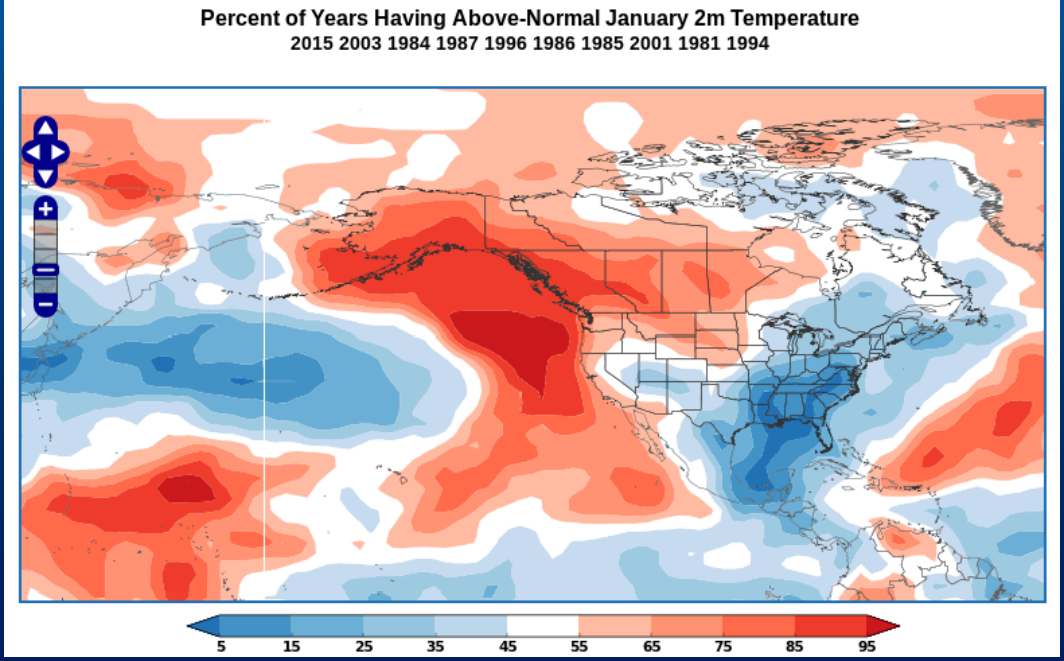


January
Positive Phase

EOF 3
Positive NPM

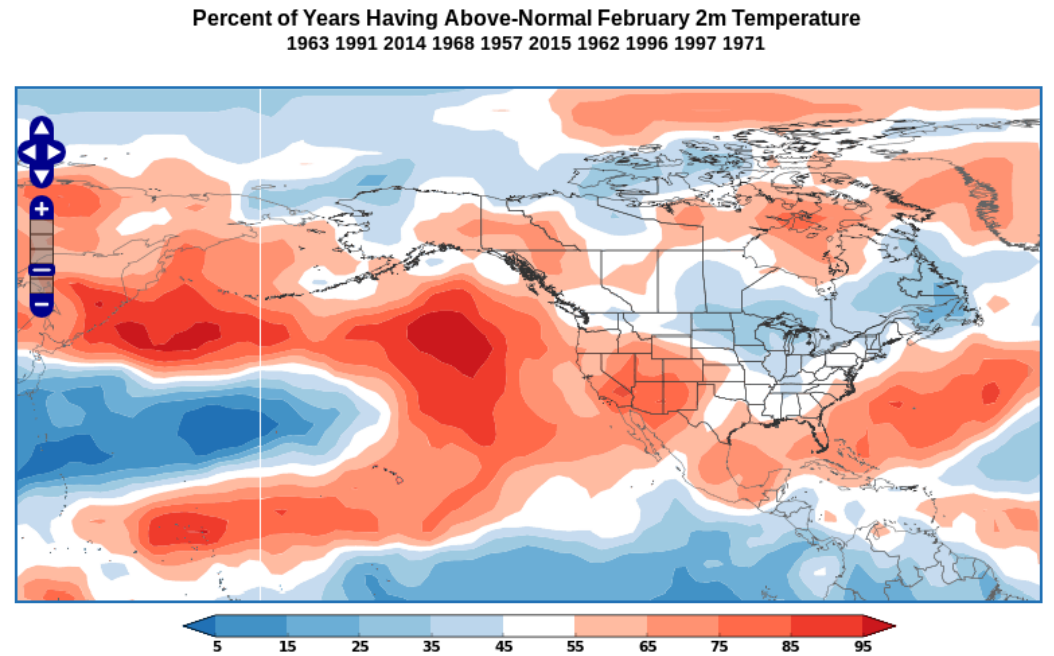


EOF 1+2
Positive PDO

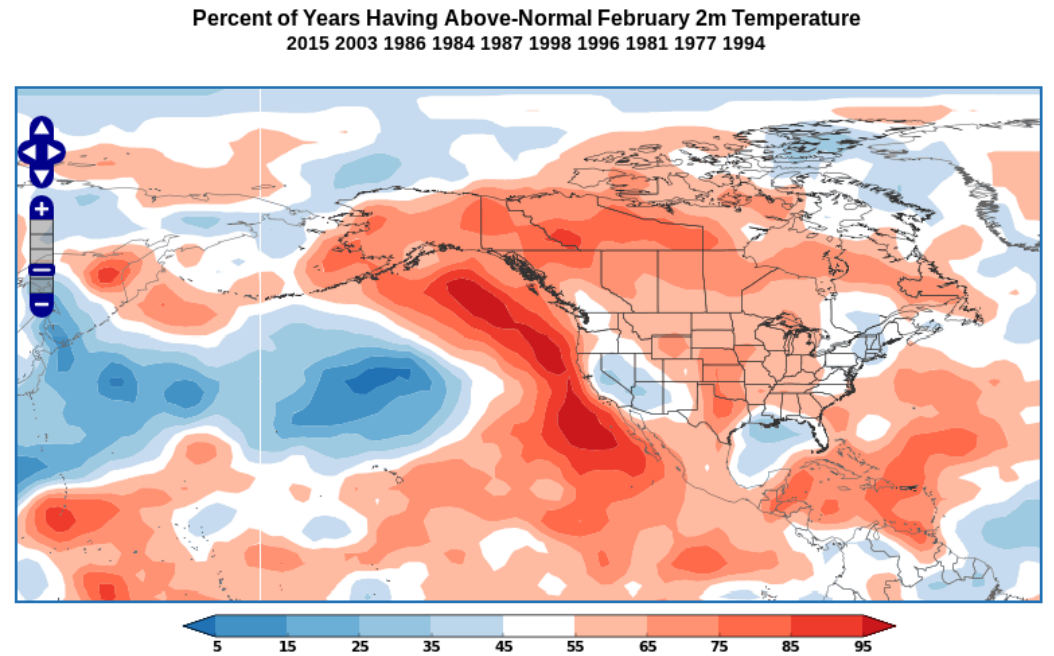


February
Positive Phase

EOF 3
Positive NPM

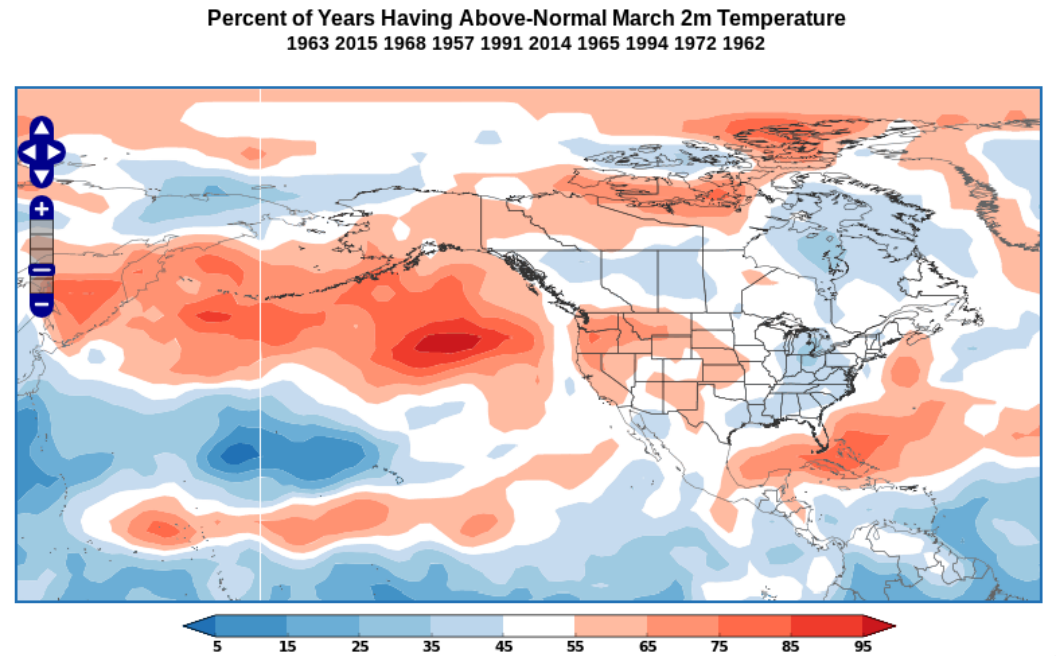


EOF 1+2
Positive PDO

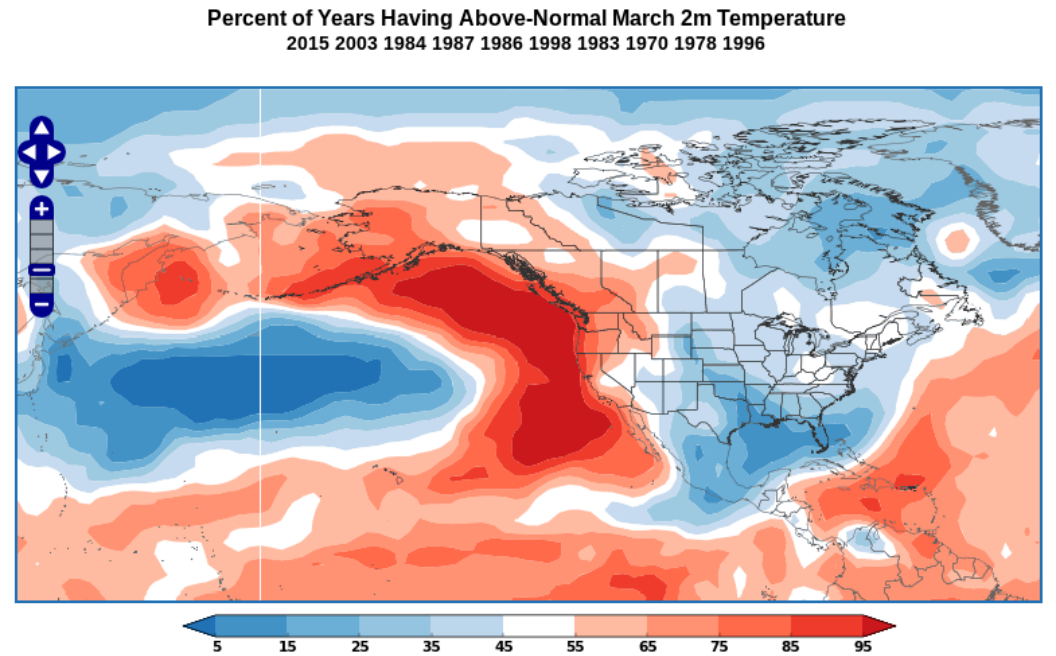


March
Positive Phase

EOF 3
Positive NPM

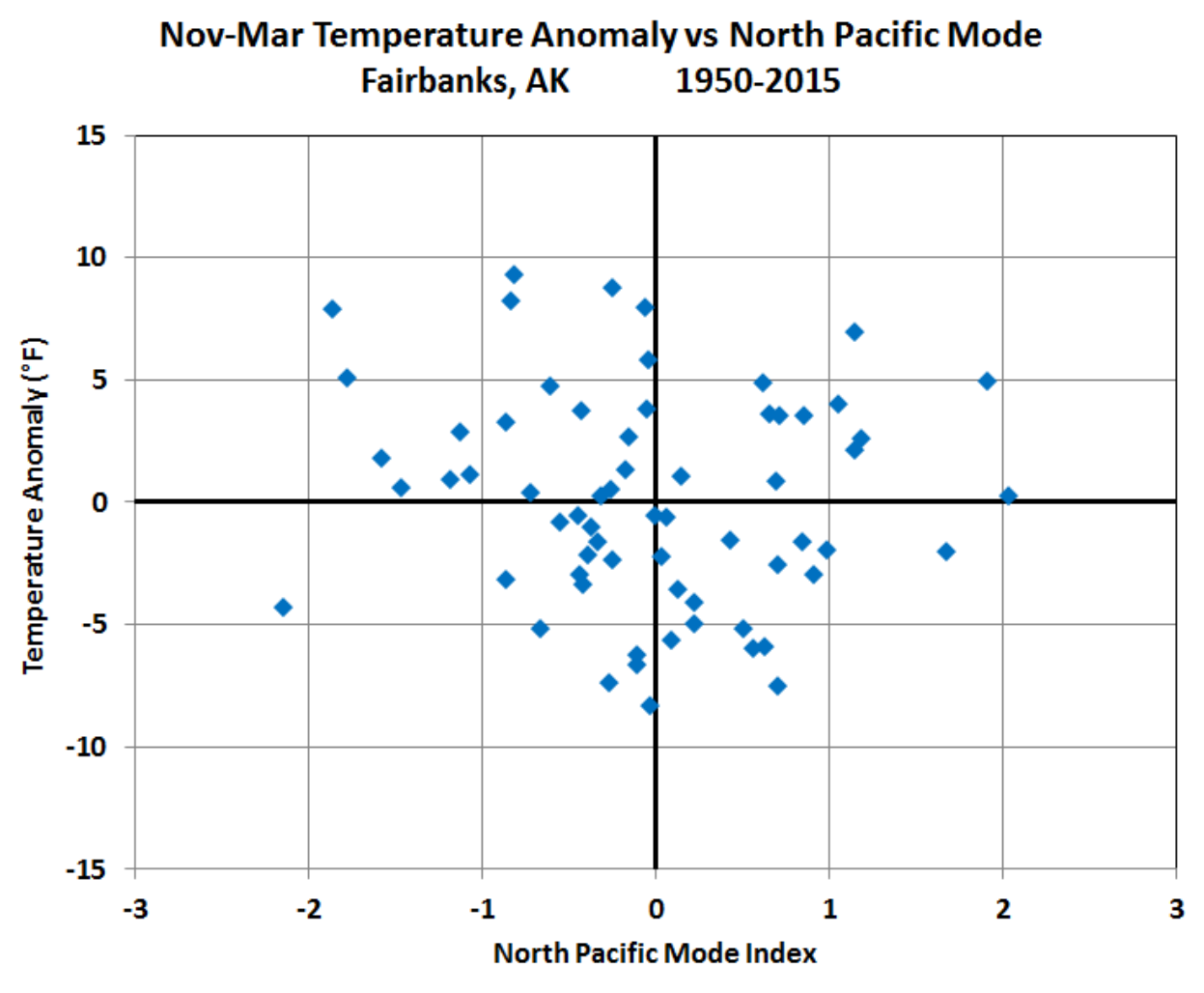


EOF 1+2
Positive PDO

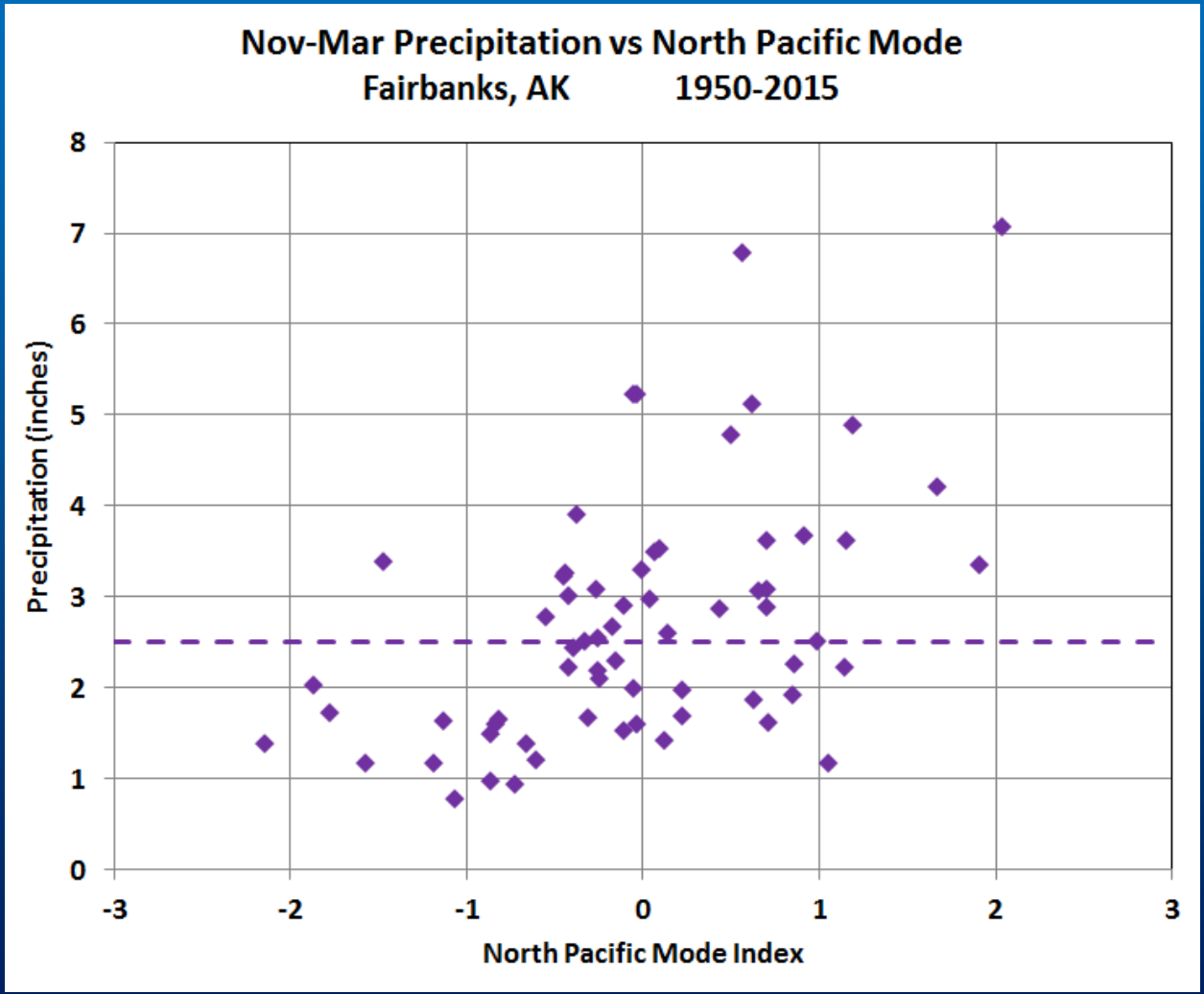


Fairbanks Scatterplots

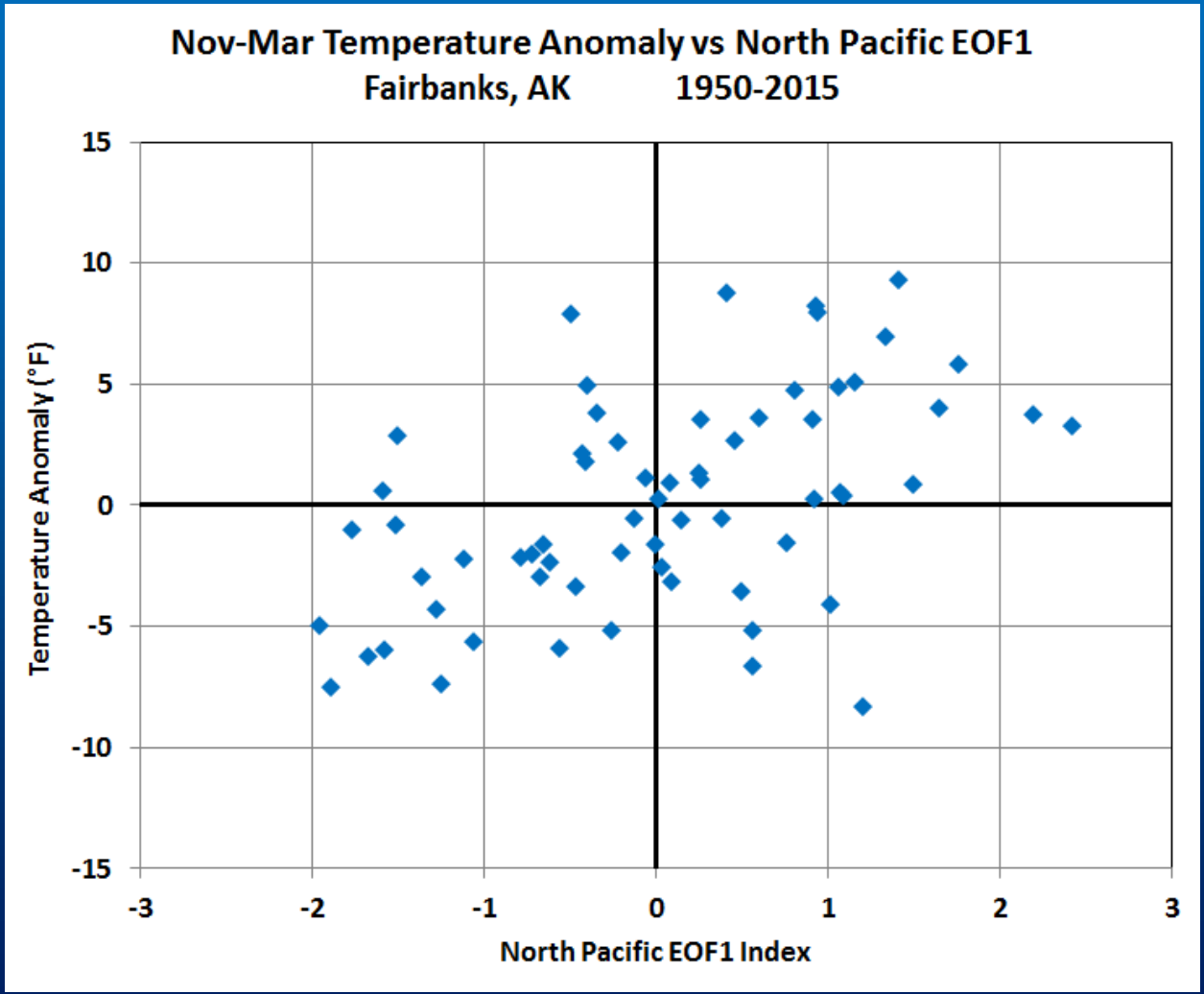
North Pacific Mode



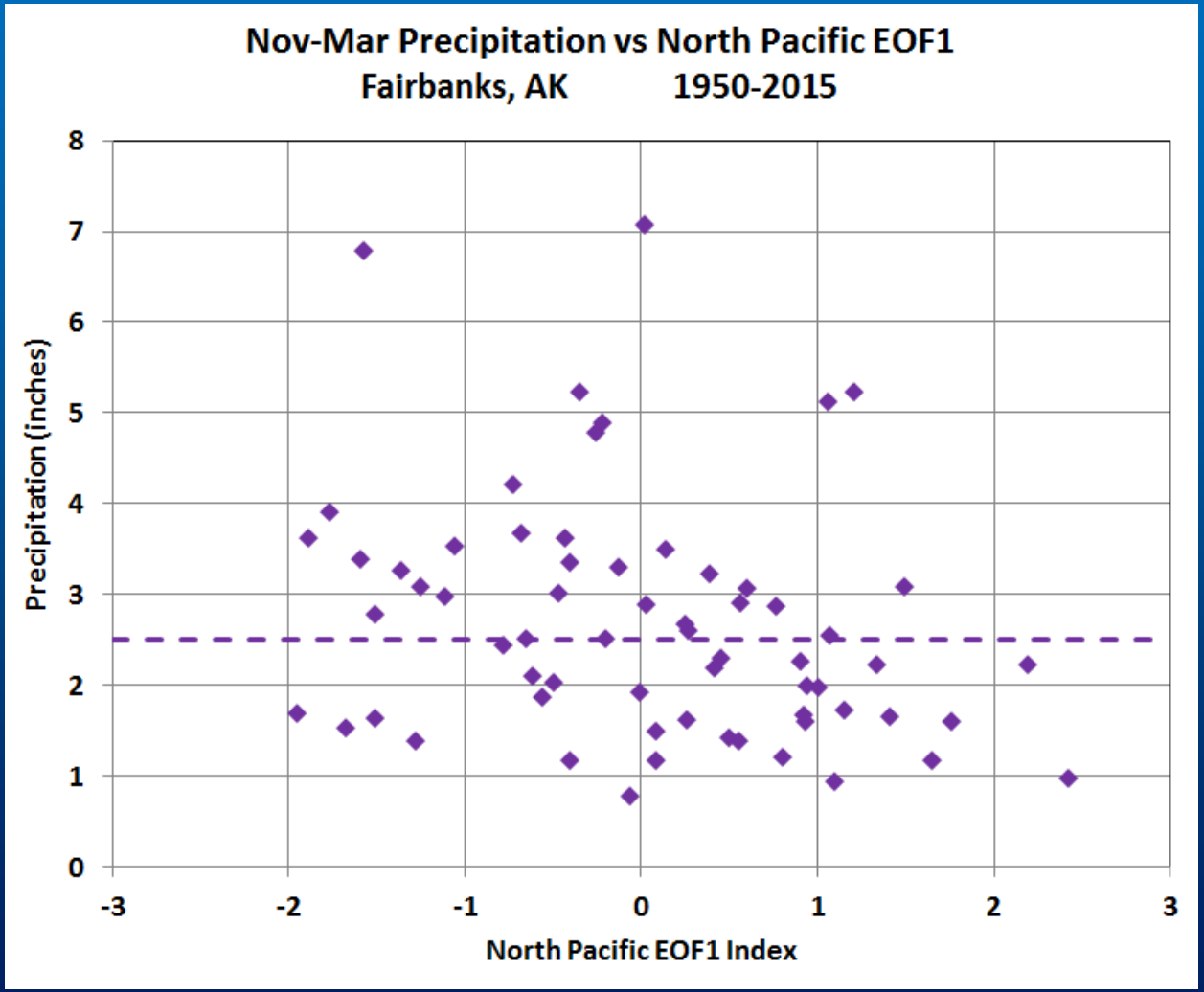
North Pacific Mode



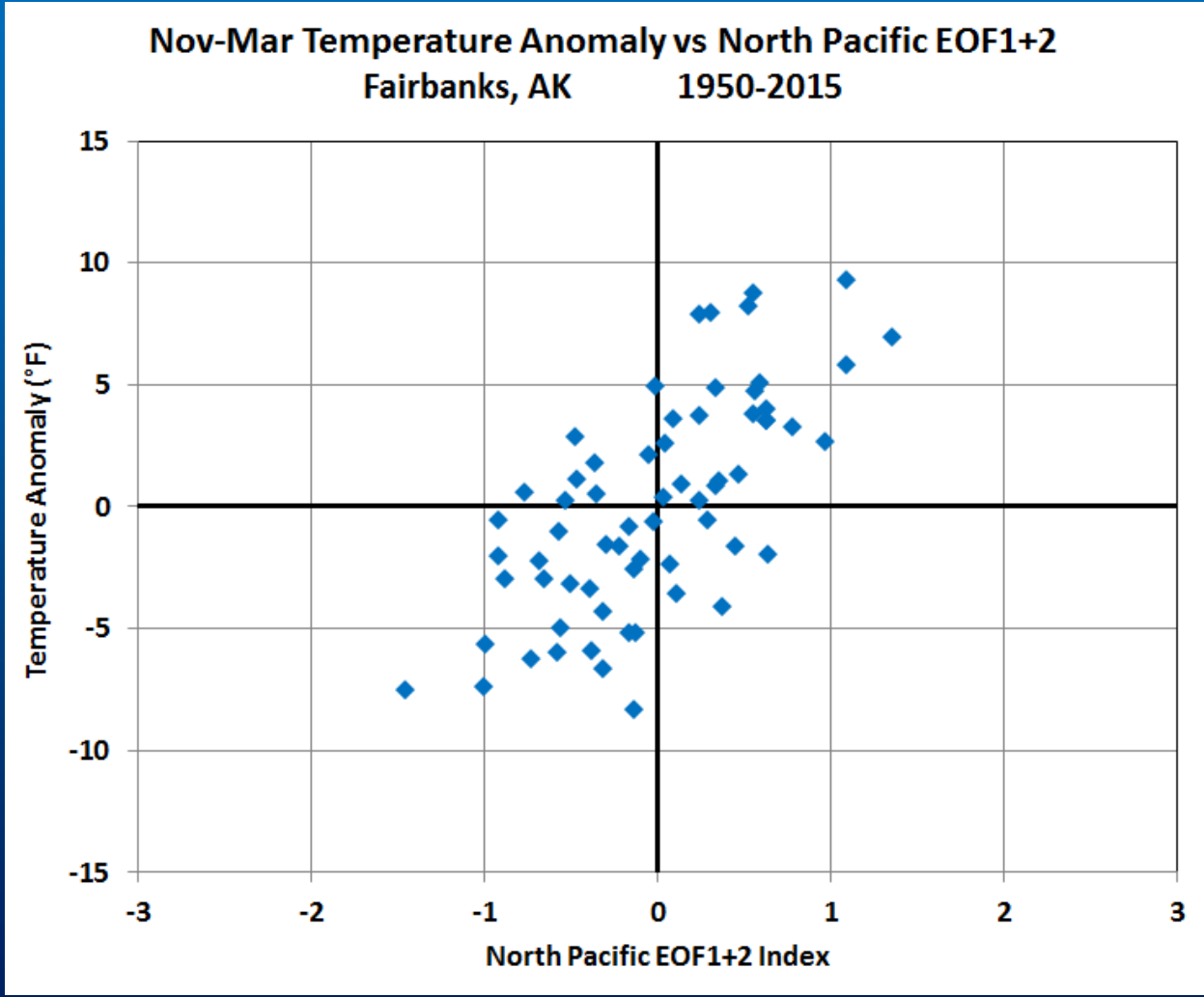
EOF 1 (ENSO)


Nov-Mar Temperature Anomaly vs North Pacific EOF1
Fairbanks, AK 1950-2015
Temperature Anomaly (°F)
15
10
5
0
-5
-10
-15
-3
-2
-1
0
1
2
3
North Pacific EOF1 Index

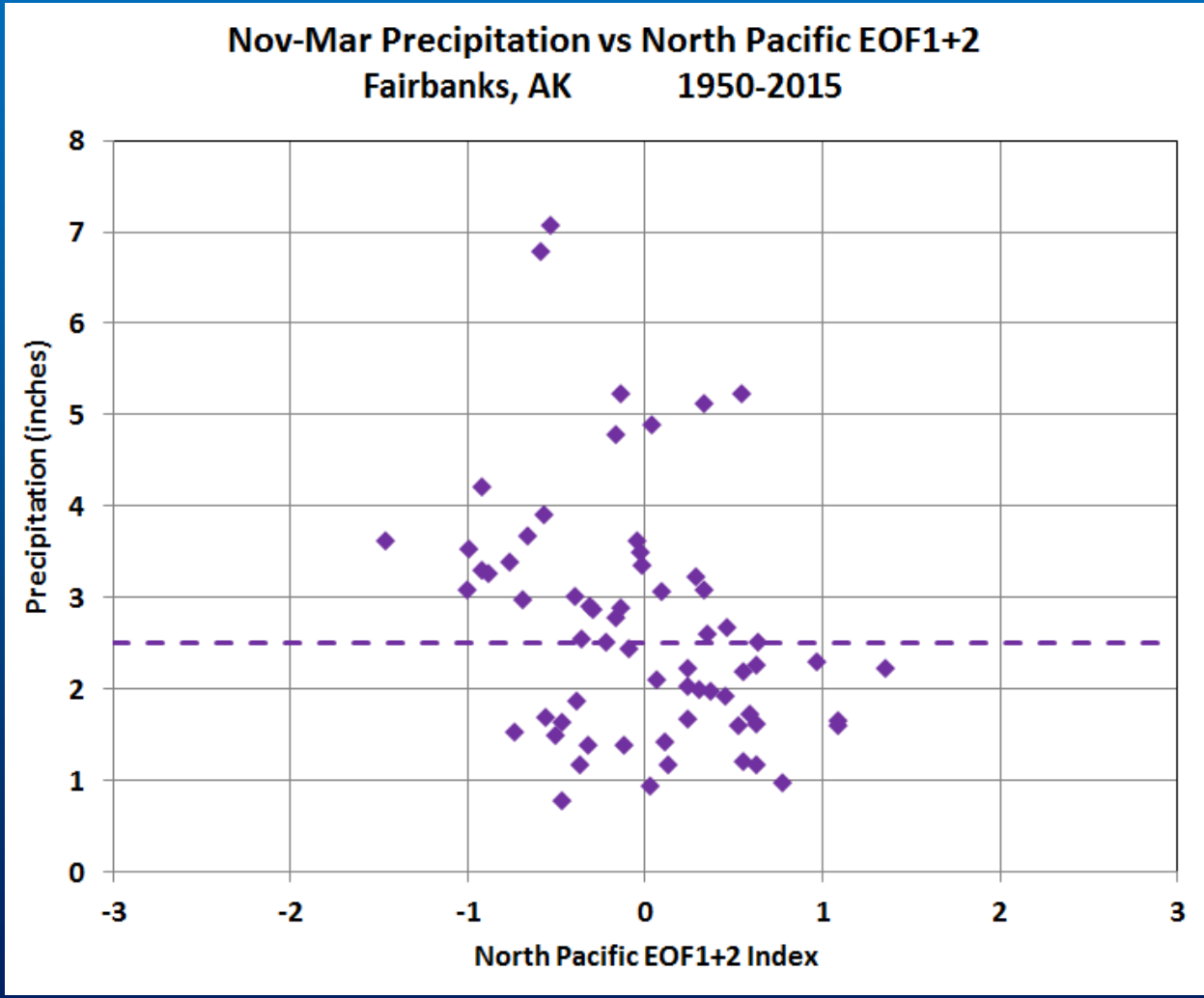
EOF 1 (ENSO)


Nov-Mar Precipitation vs North Pacific EOF1
Fairbanks, AK 1950-2015
Precipitation (inches)
0
1
2
3
4
5
6
7
8
-3
-2
-1
0
1
2
3
North Pacific EOF1 Index

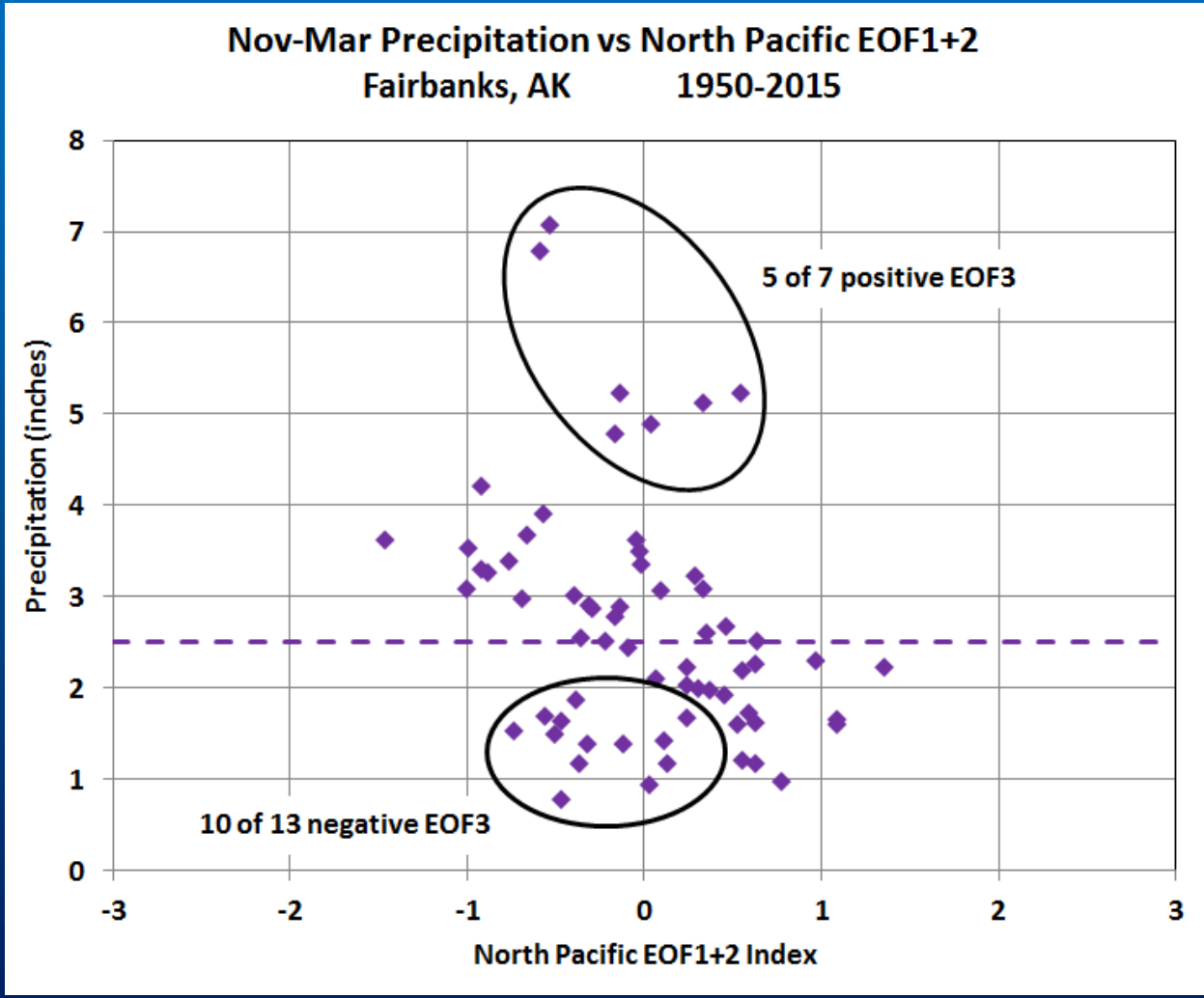
EOF 1+2 (PDO)


Nov-Mar Temperature Anomaly vs North Pacific EOF1+2
Fairbanks, AK 1950-2015
Temperature Anomaly (°F)
15
10
5
0
-5
-10
-15
-3
-2
-1
0
1
2
3
North Pacific EOF1+2 Index

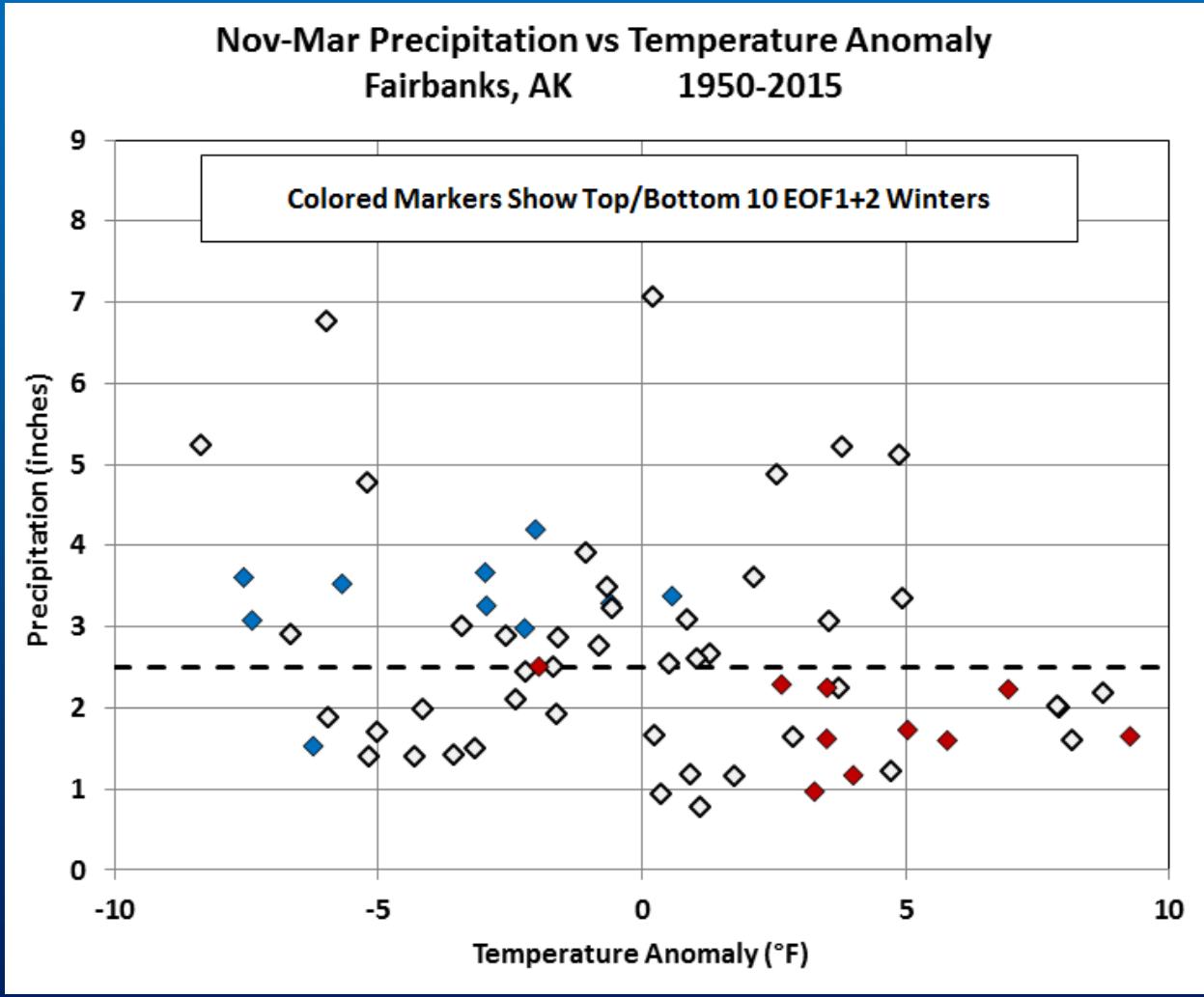
EOF 1+2 (PDO)


Nov-Mar Precipitation vs North Pacific EOF1+2
Fairbanks, AK 1950-2015
Precipitation (inches)
0
1
2
3
4
5
6
7
8
-3
-2
-1
0
1
2
3
North Pacific EOF1+2 Index

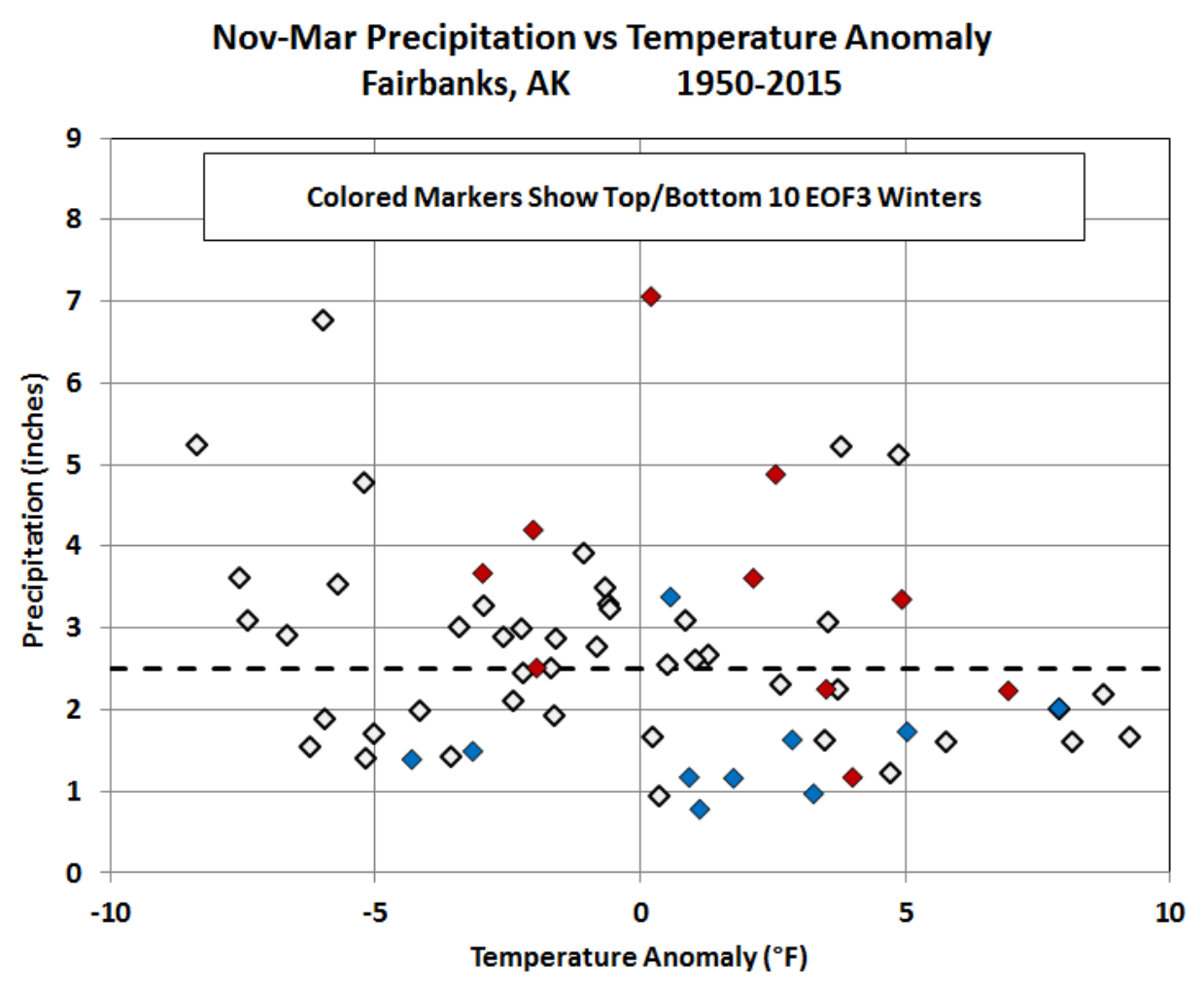
EOF 1+2 (PDO)


Nov-Mar Precipitation vs North Pacific EOF1+2
Fairbanks, AK 1950-2015
Precipitation (inches)
North Pacific EOF1+2 Index
5 of 7 positive EOF3
10 of 13 negative EOF3
8
7
6
5
4
3
2
1
0
-3
-2
-1
0
1
2
3

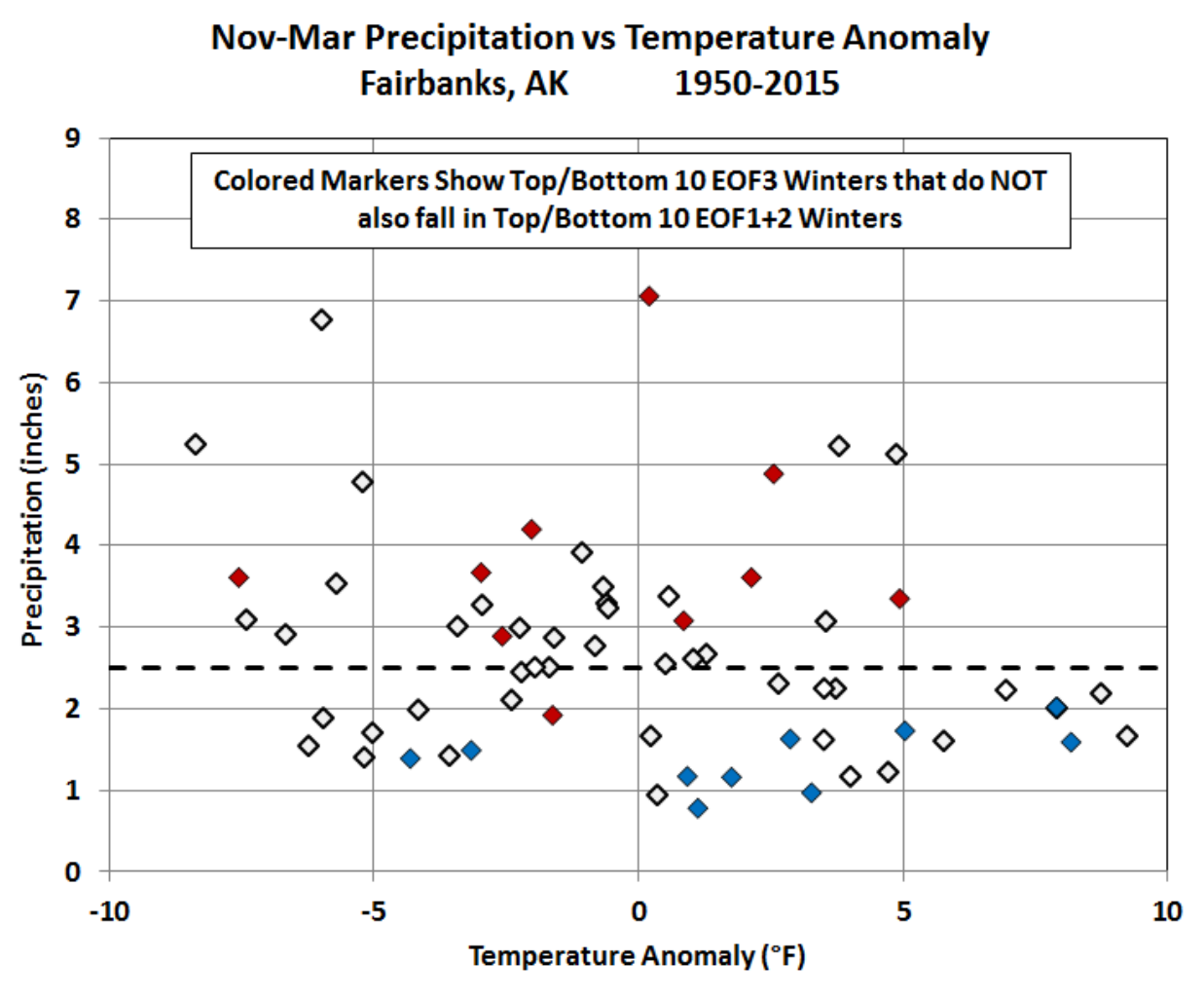
EOF 1+2 (PDO)


Nov-Mar Precipitation vs Temperature Anomaly
Fairbanks, AK 1950-2015
Colored Markers Show Top/Bottom 10 EOF1+2 Winters
Precipitation (inches)
Temperature Anomaly (°F)
0
1
2
3
4
5
6
7
8
9
-10
-5
0
5
10

North Pacific Mode



North Pacific Mode



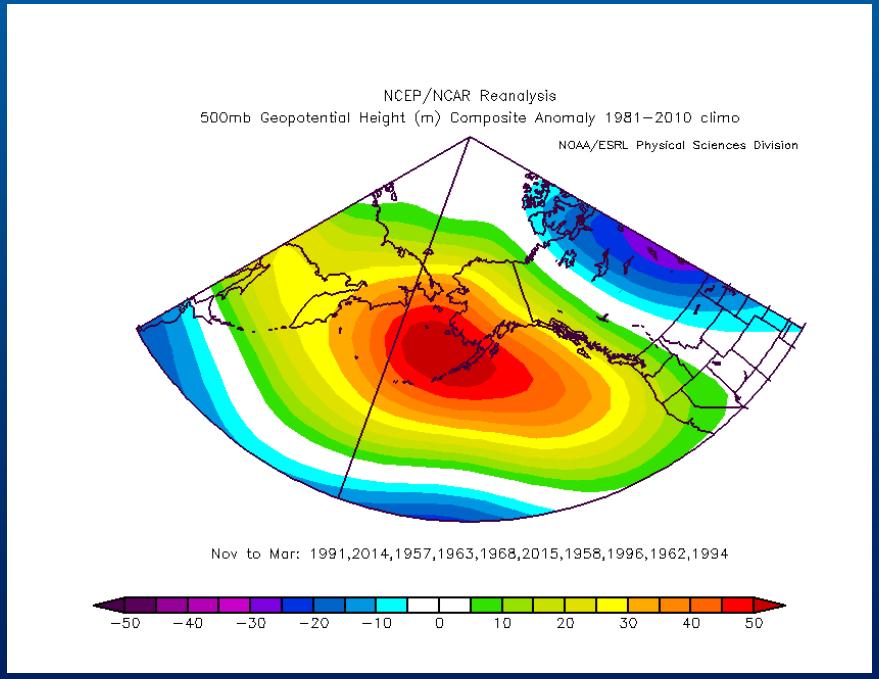
Significant non-linear linkages between NPM and interior Alaska winter climate

- Positive NPM: wet and often warm
- Negative NPM: dry and warm
- Compared to PDO precipitation impacts, NPM precipitation impacts are:
  - Similar in extent and magnitude
  - Opposite in sign
- Cold winters rarely occur with large NPM anomalies!
  - For coldest 11 winters, NPM -0.7 to +0.7

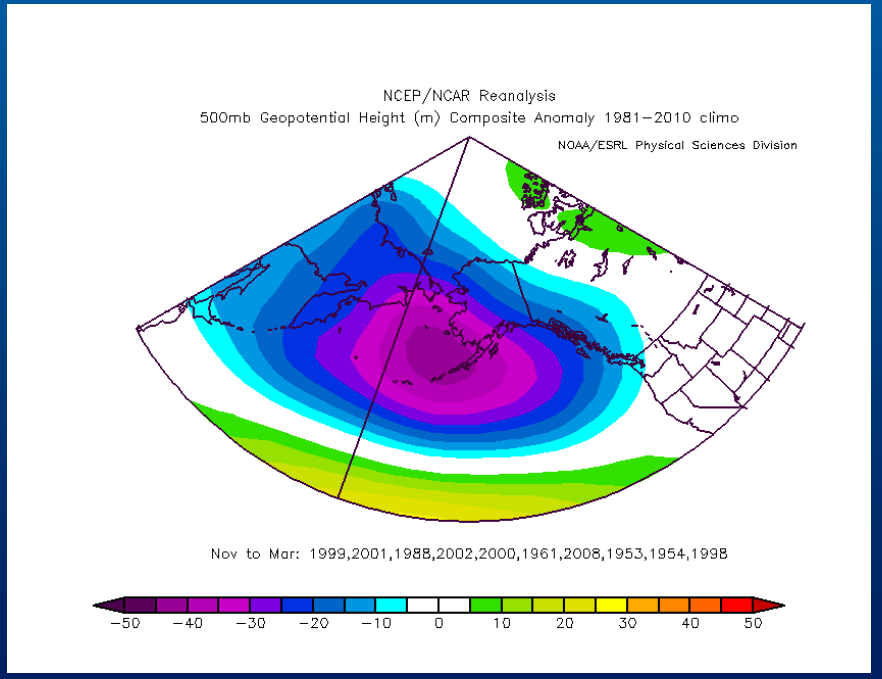
Why?

500mb Height Anomaly

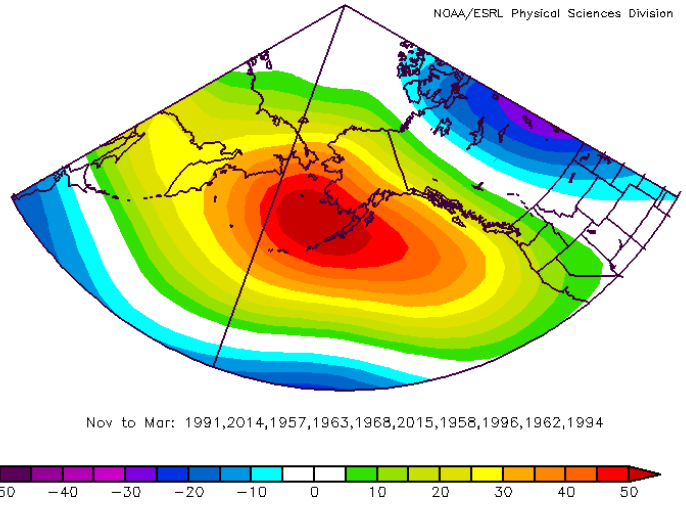
Positive NPM



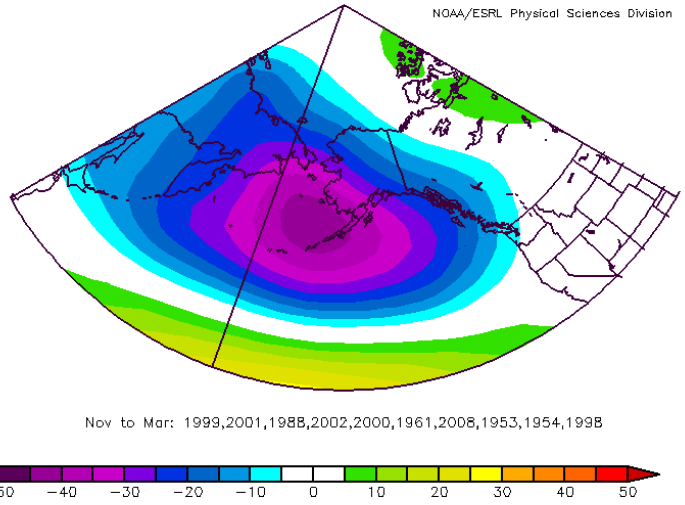
Negative NPM



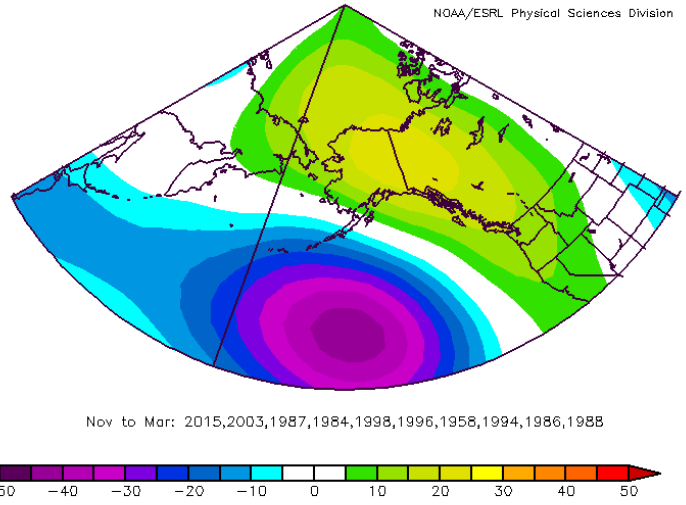
Positive NPM



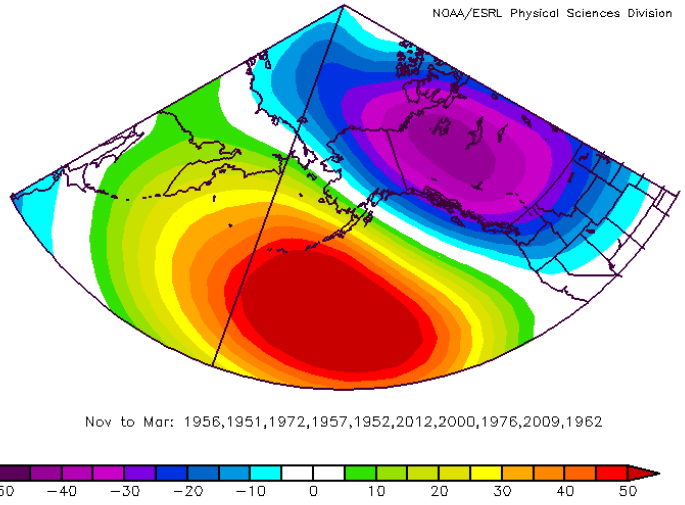
Negative NPM



Positive PDO

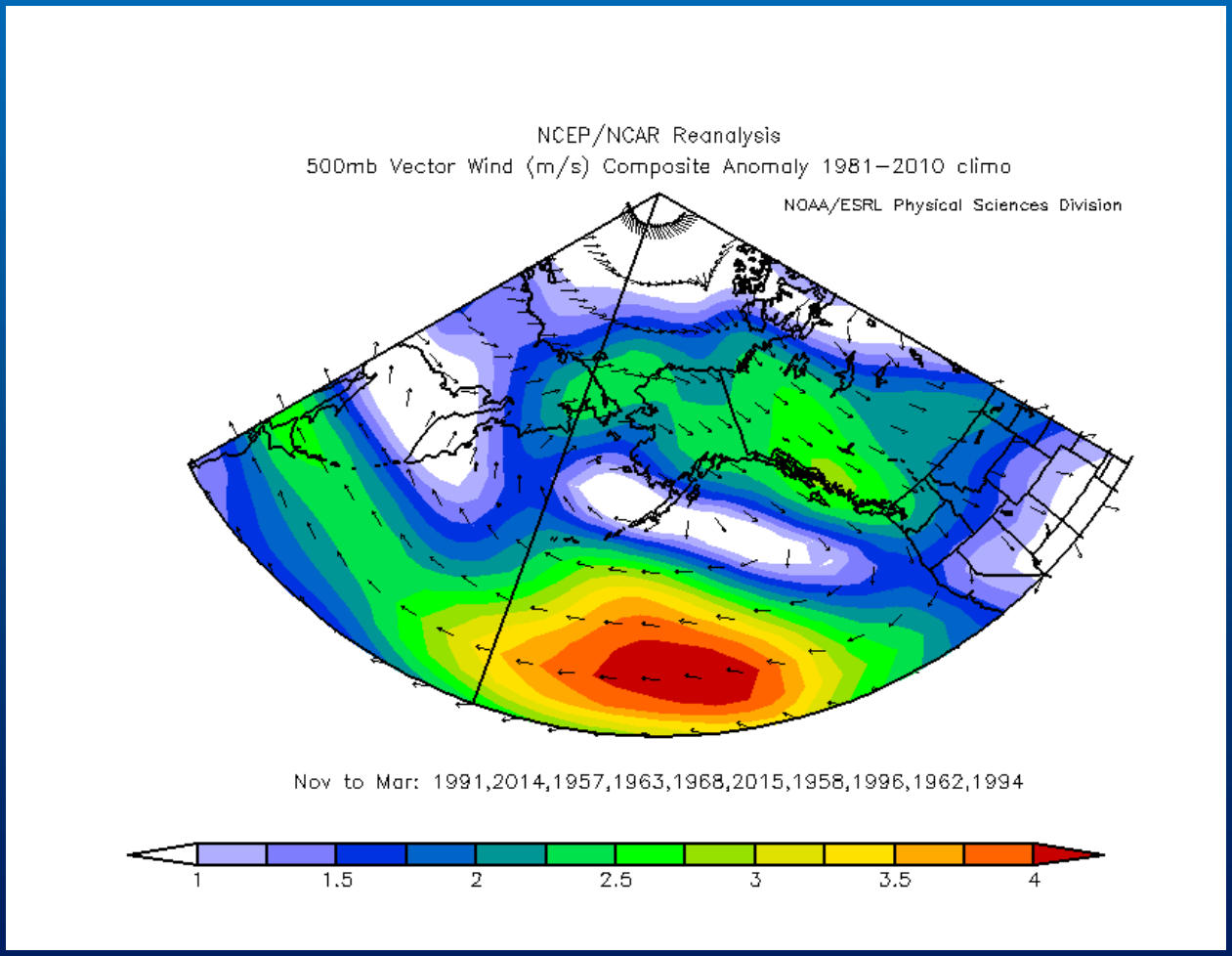


Negative PDO



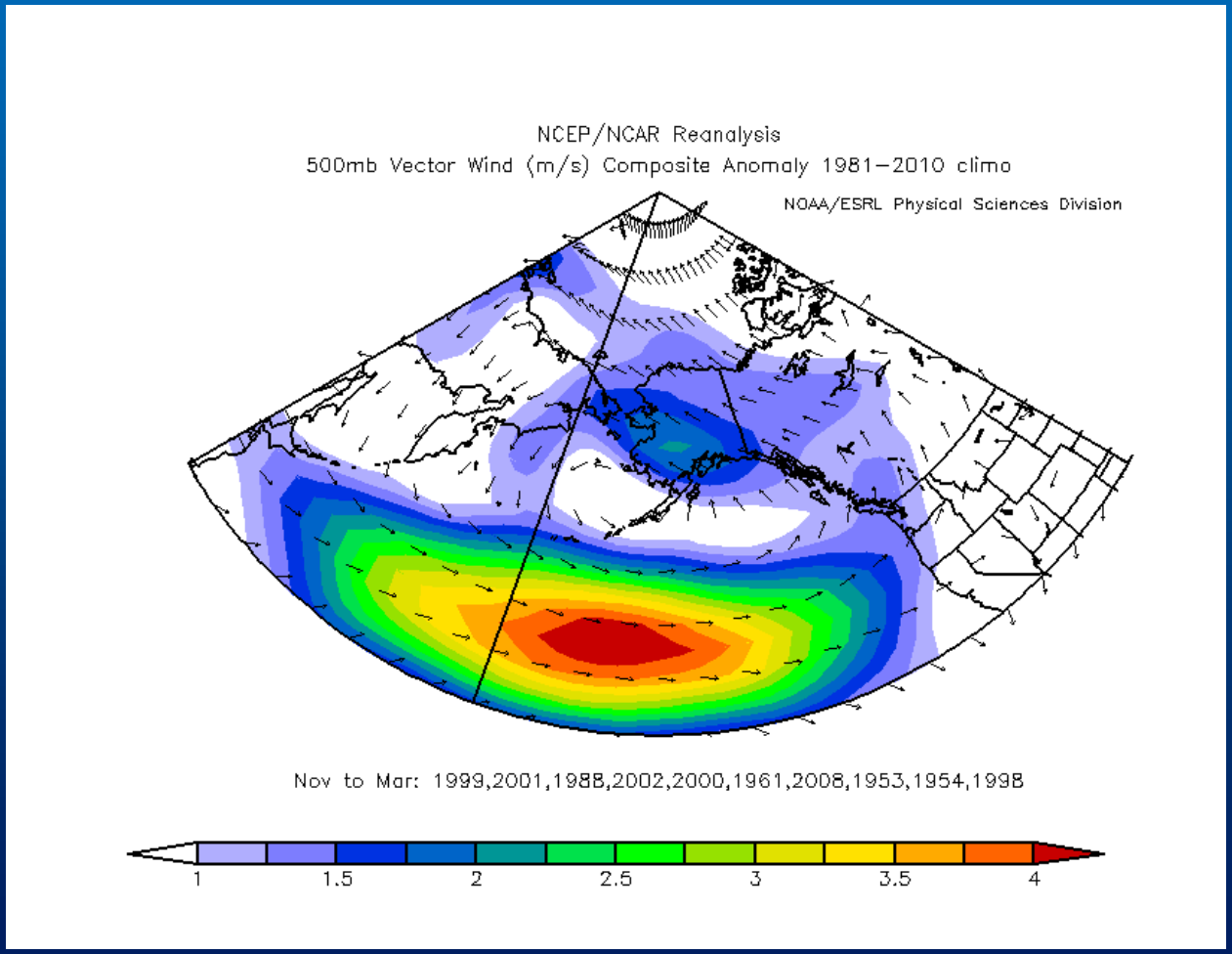
500mb Wind Anomaly

Positive NPM



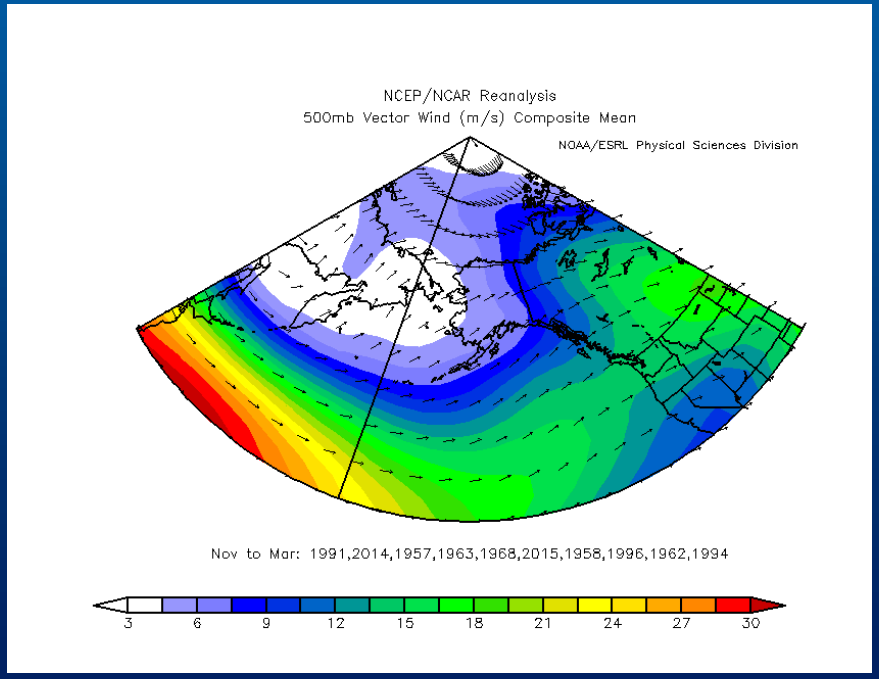
500mb Wind Anomaly

Negative NPM

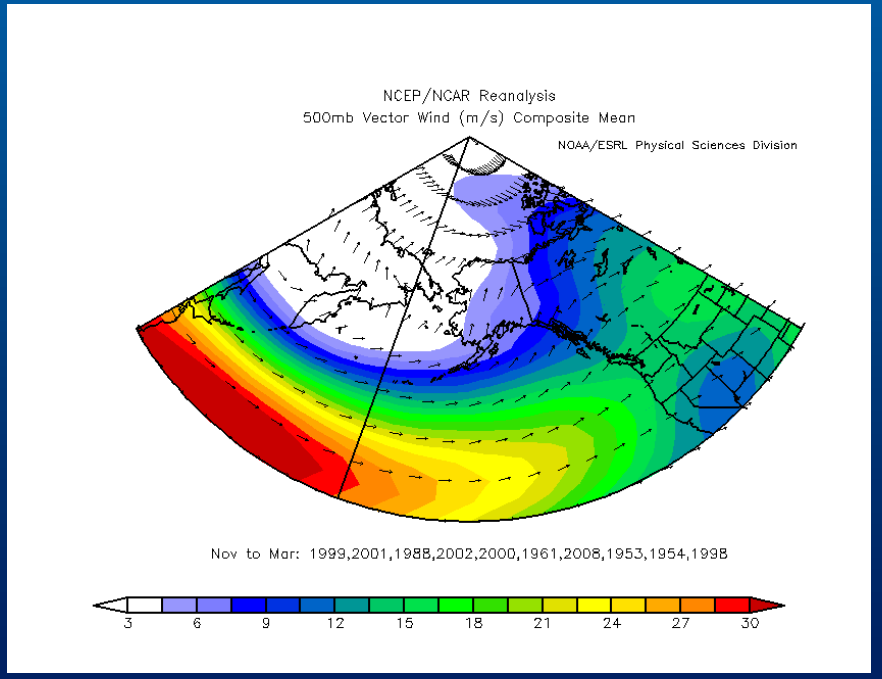


500mb Wind

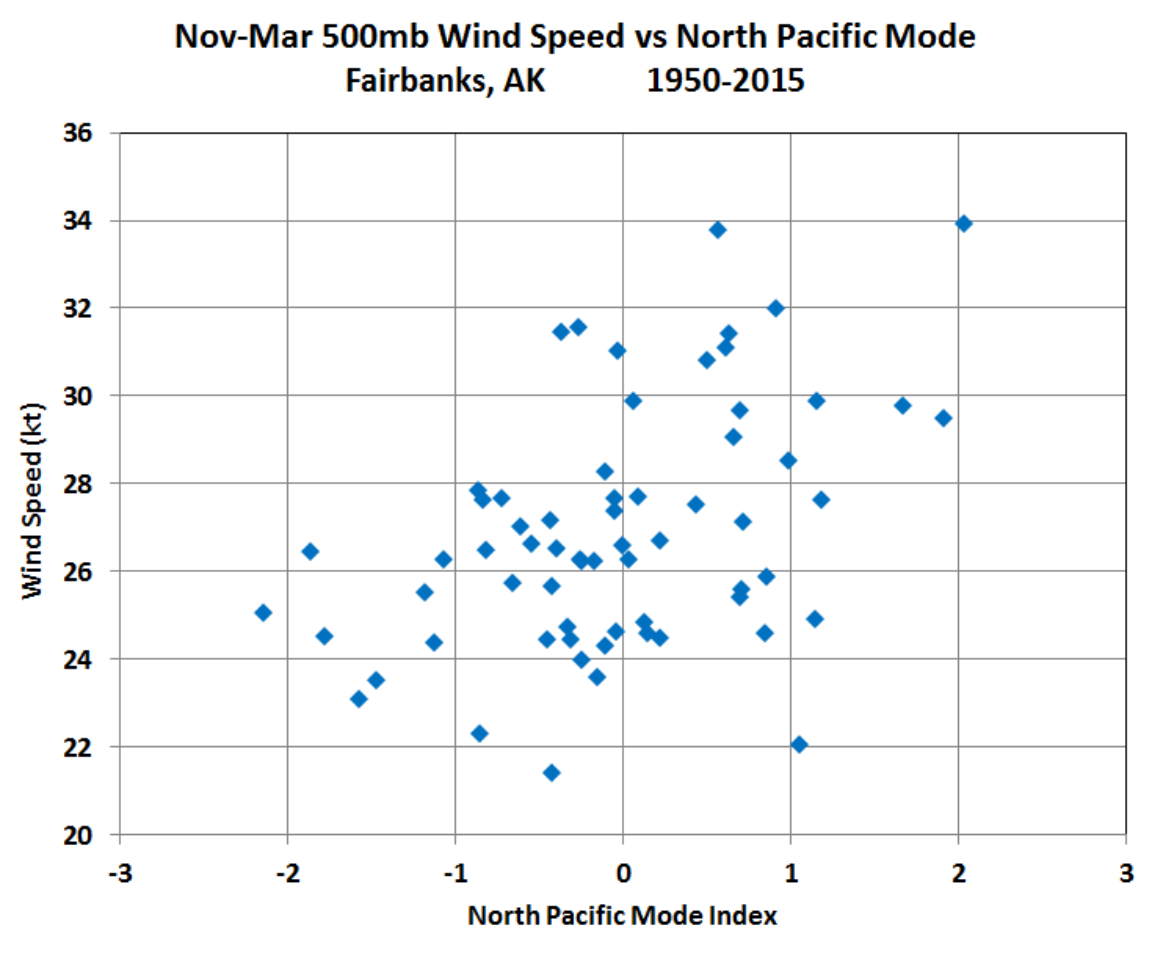
Positive NPM



Negative NPM



Positive NPM is associated with more vigorous westerly flow over Alaska

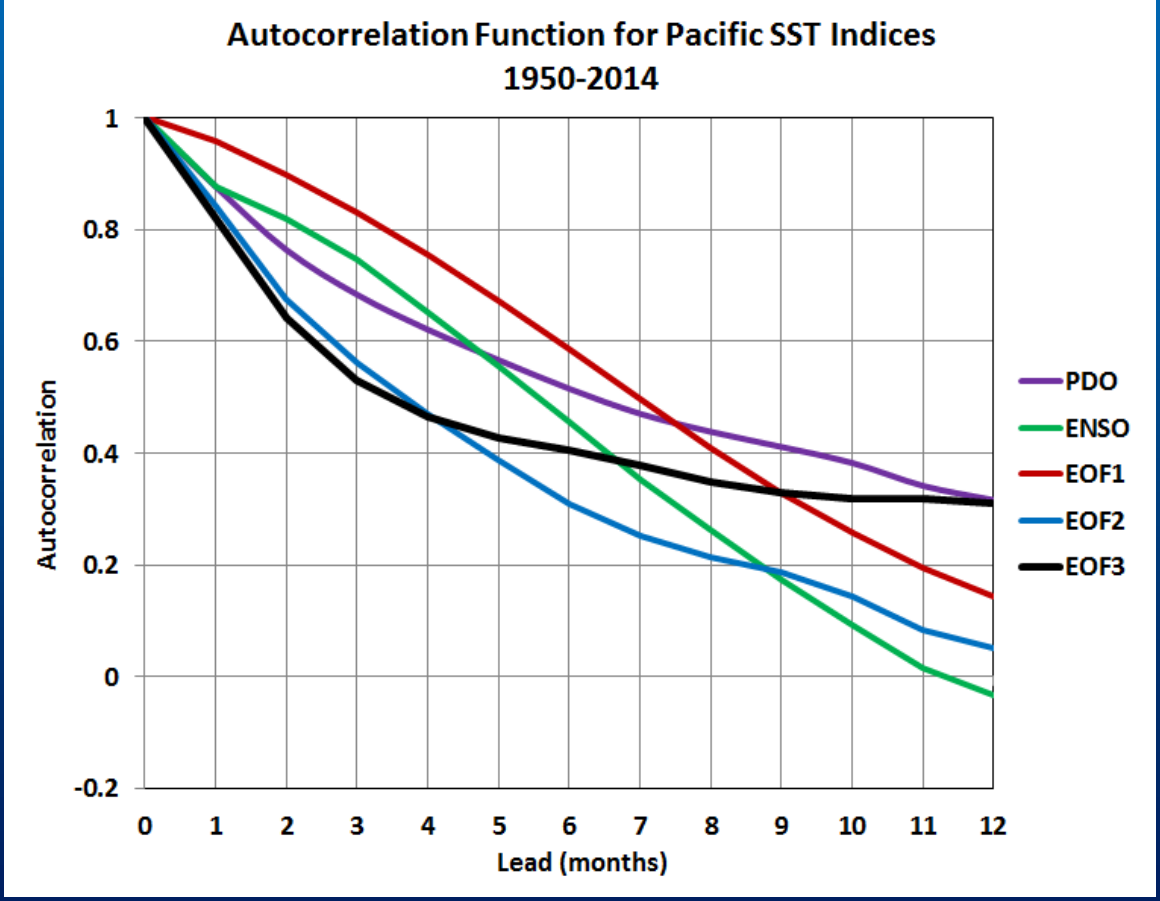


Conclusions

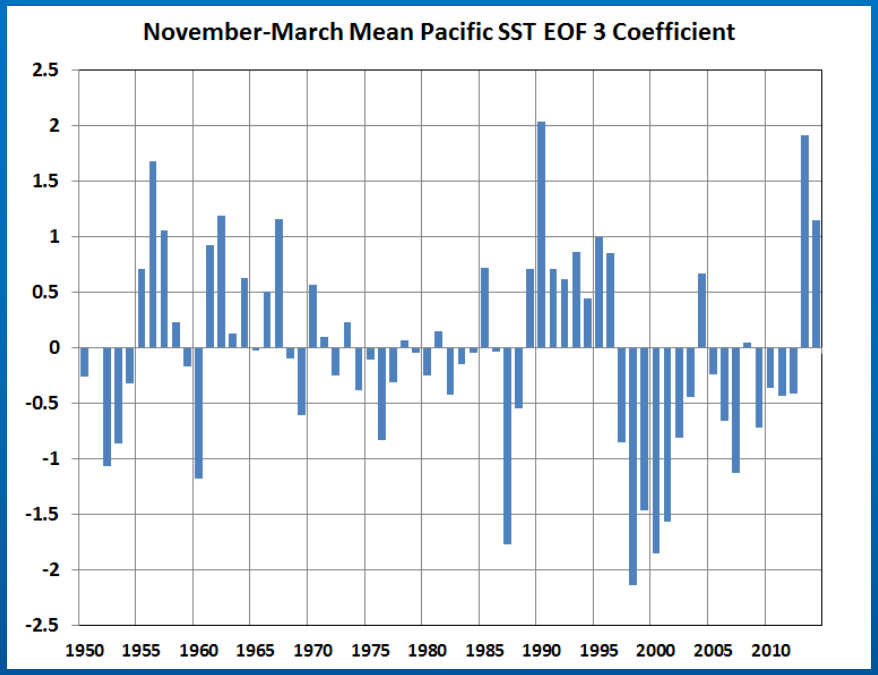
- NPM height pattern is opposite to PDO and northward-shifted (Bristol Bay focus)
- Large positive and negative NPM anomalies both favor a southerly airmass source
- Negative NPM:
  - Southeasterly flow anomaly
  - Downsloping over the interior
  - Dry and warm
- Positive NPM:
  - Enhanced westerly flow
  - Increased cloud cover and precipitation
  - Wet and often warm

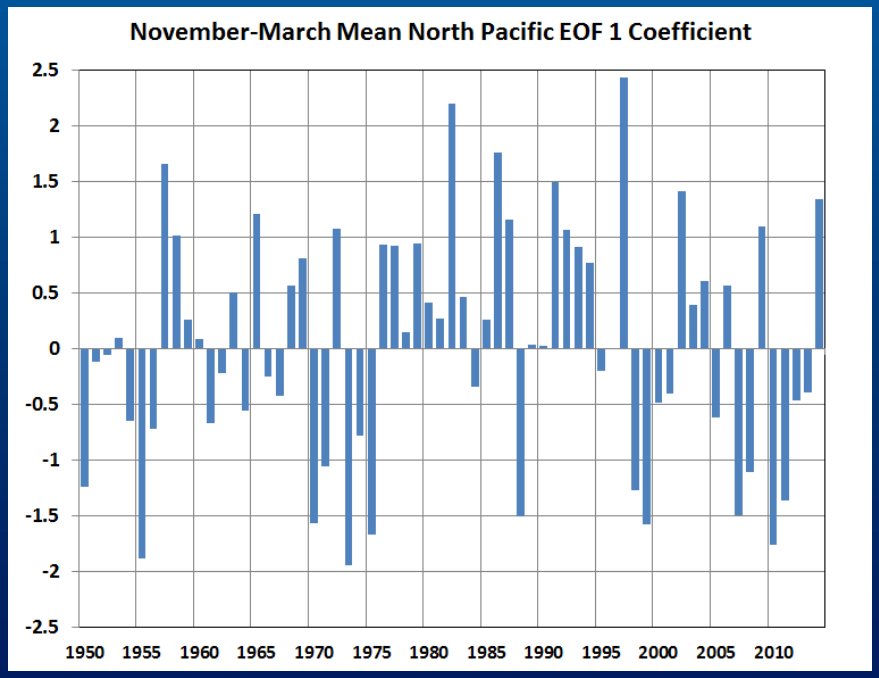
Predictability

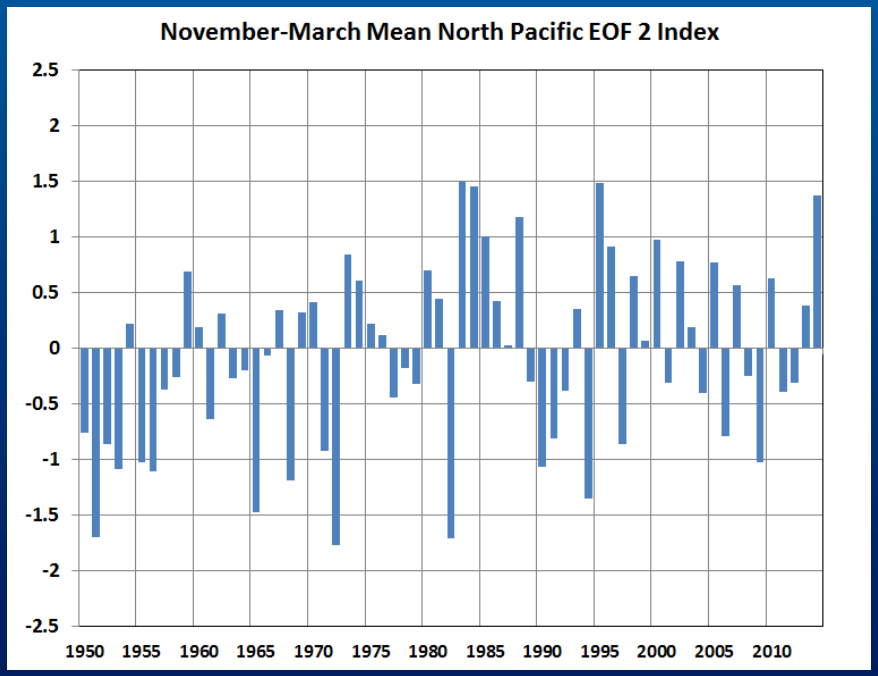
The NPM decays quickly in months 1-3 but has high inter-annual persistence



NPM has higher inter-annual and decadal persistence than EOFs 1 and 2







Thank You

Questions/Comments?