Short-term climate variability and prediction

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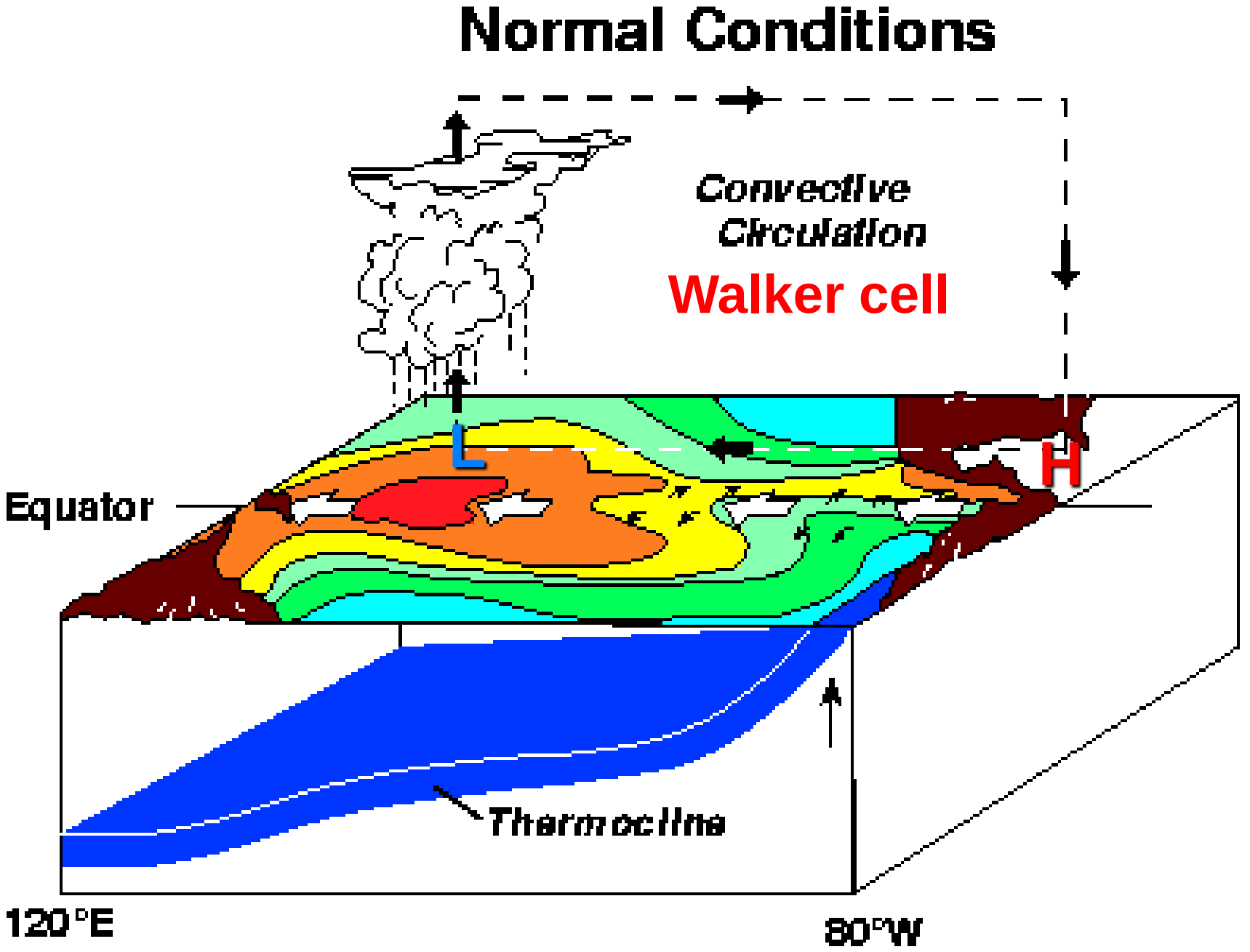
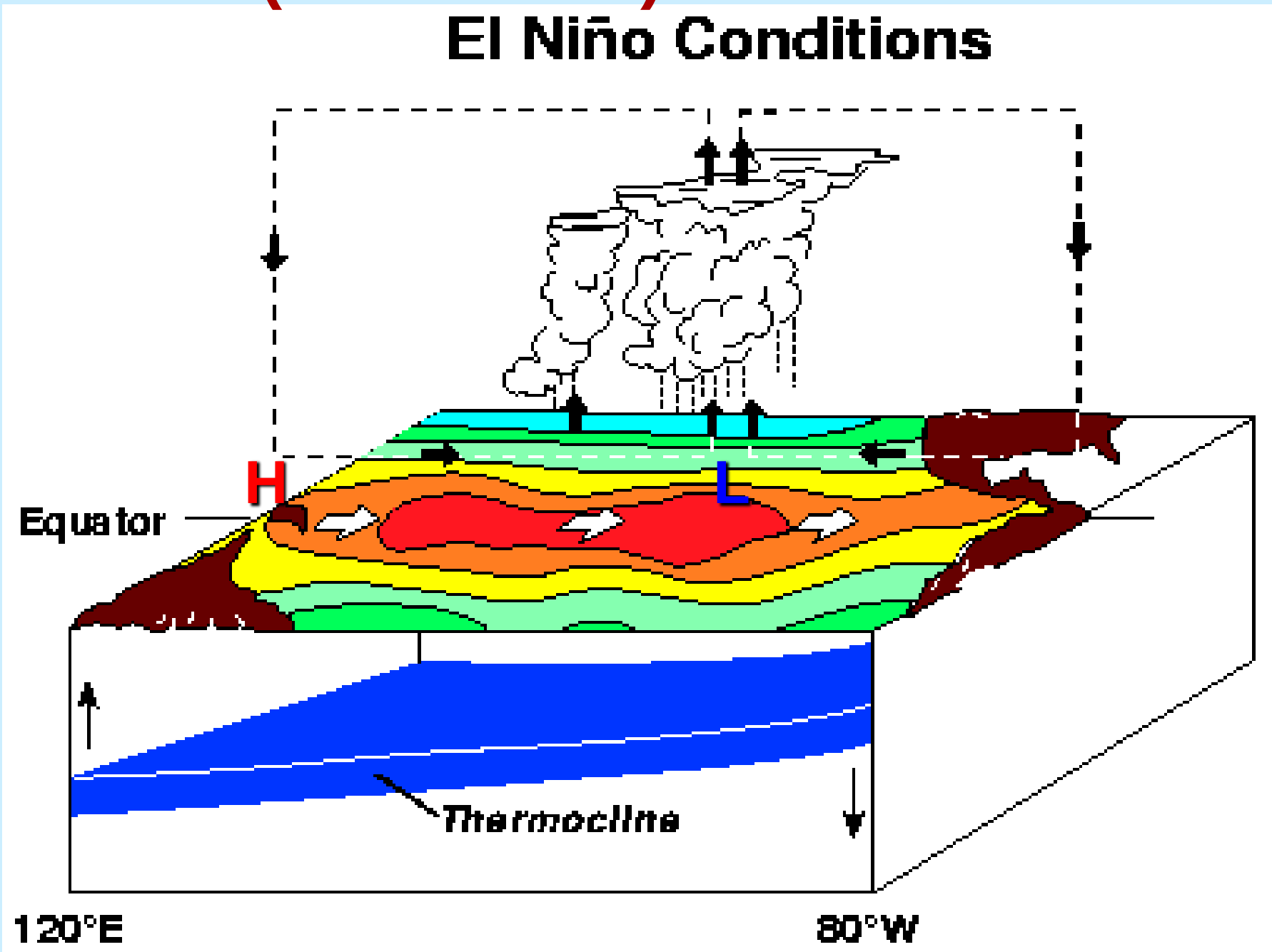
Goals for today:

- **Describe modes of climate variability: e.g. El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation, Arctic Oscillation, etc.**
- **Apply to seasonal climate prediction**

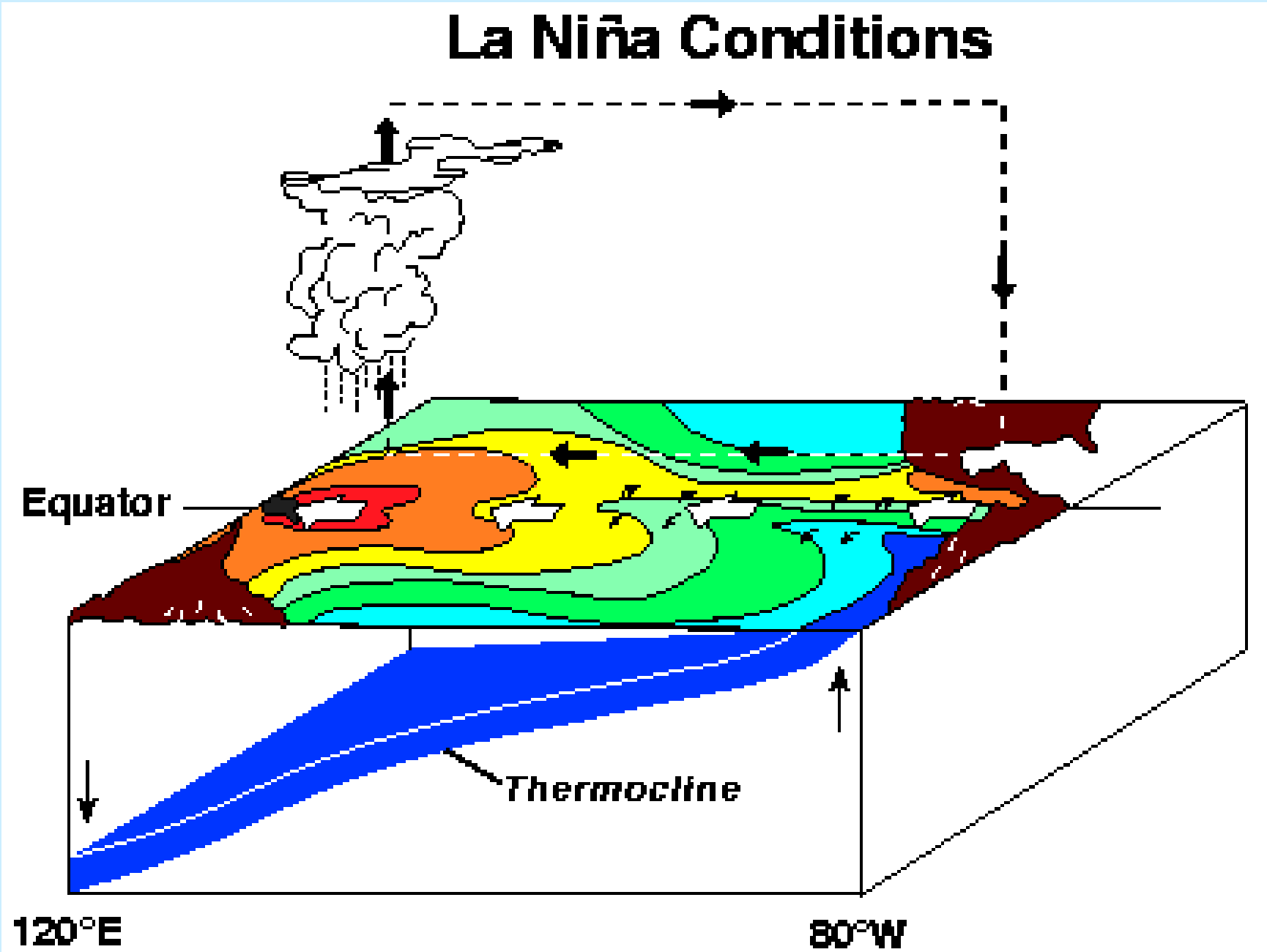
Normal conditions in Equatorial Pacific

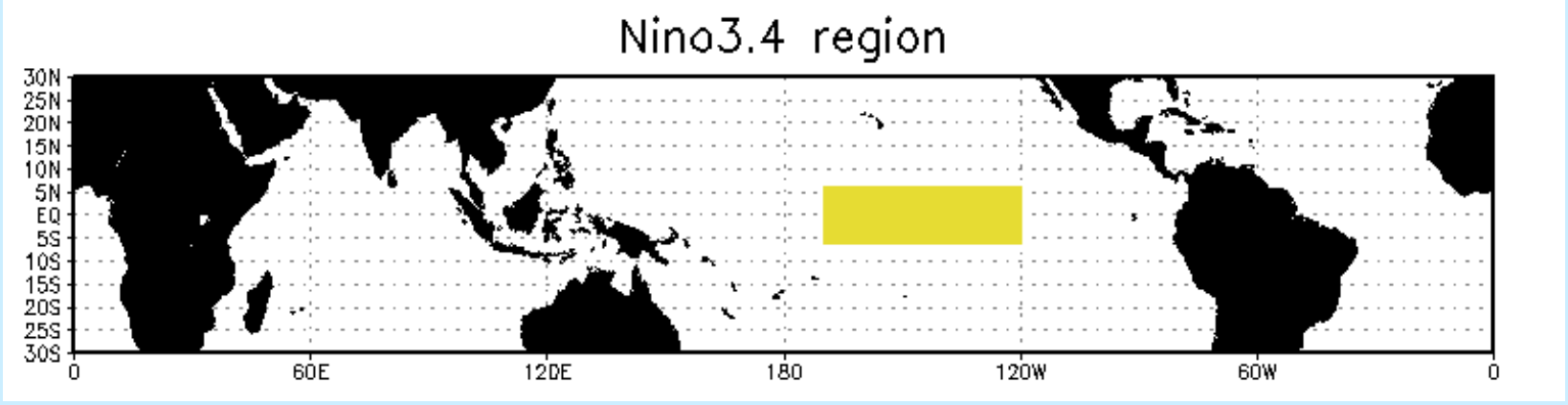


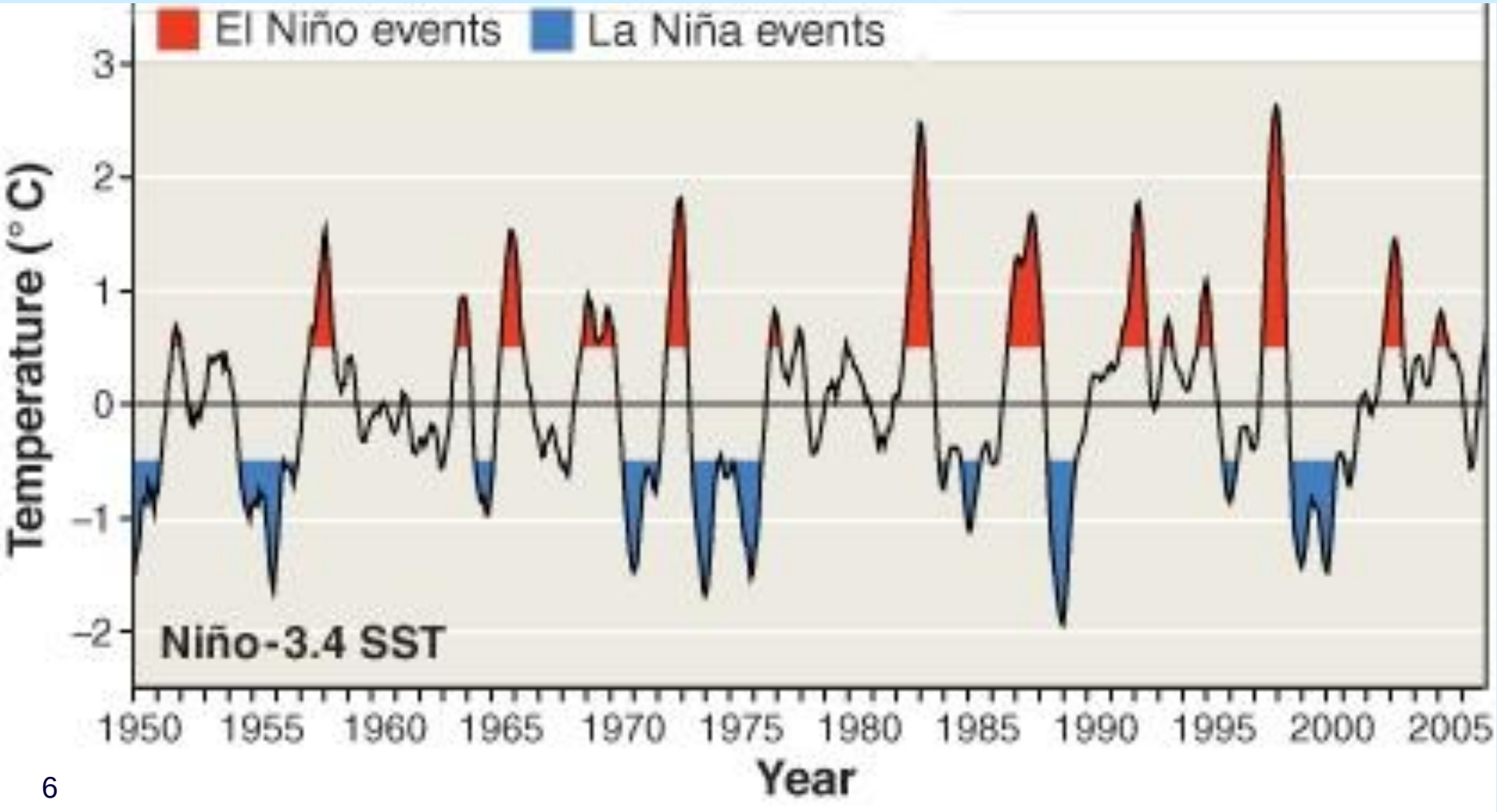
El Niño (warm state)

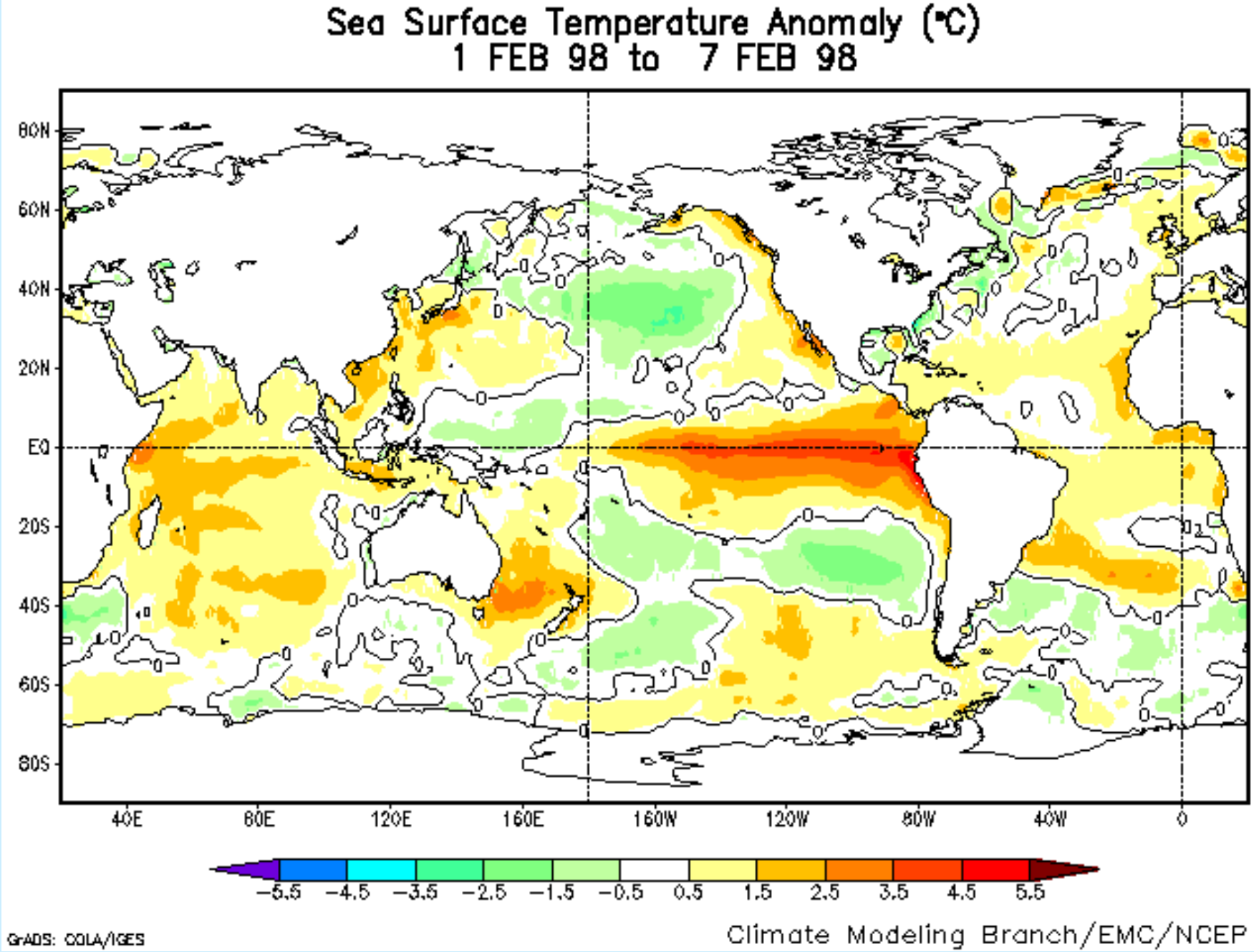


La Niña (cool state)



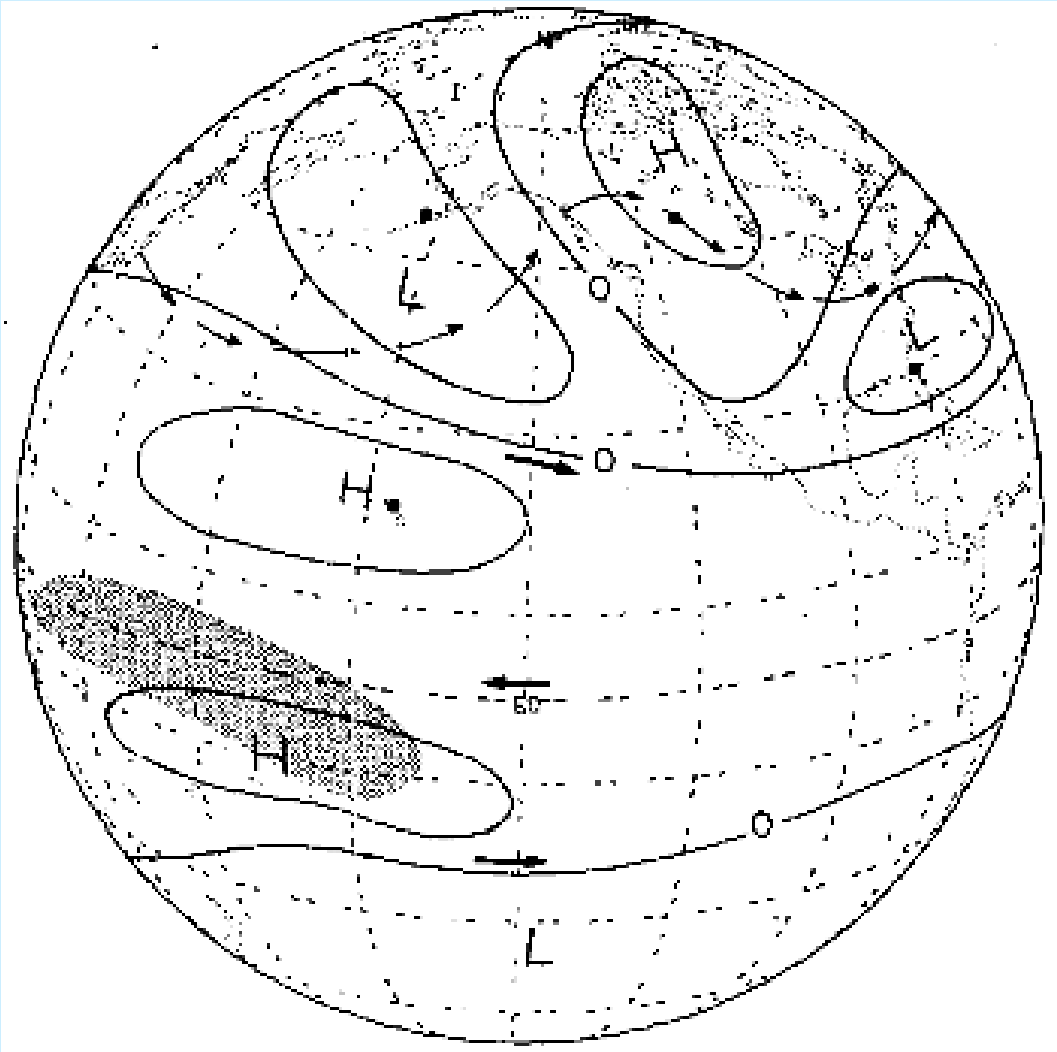

Nino3.4 region
30N
25N
20N
15N
10N
5N
EQ
5S
10S
15S
20S
25S
30S
0
60E
120E
180
120W
60W
0


El Niño events
La Niña events
Temperature (°C)
3
2
1
0
−1
−2
Niño-3.4 SST
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year


Sea Surface Temperature Anomaly (°C)
1 FEB 98 to 7 FEB 98
80N
60N
40N
20N
EQ
20S
40S
60S
80S
40E
80E
120E
160E
160W
120W
80W
40W
0
−5.5
−4.5
−3.5
−2.5
−1.5
−0.5
0.5
1.5
2.5
3.5
4.5
5.5
GrADS: COLA/IGES
Climate Modeling Branch/EMC/NCEP

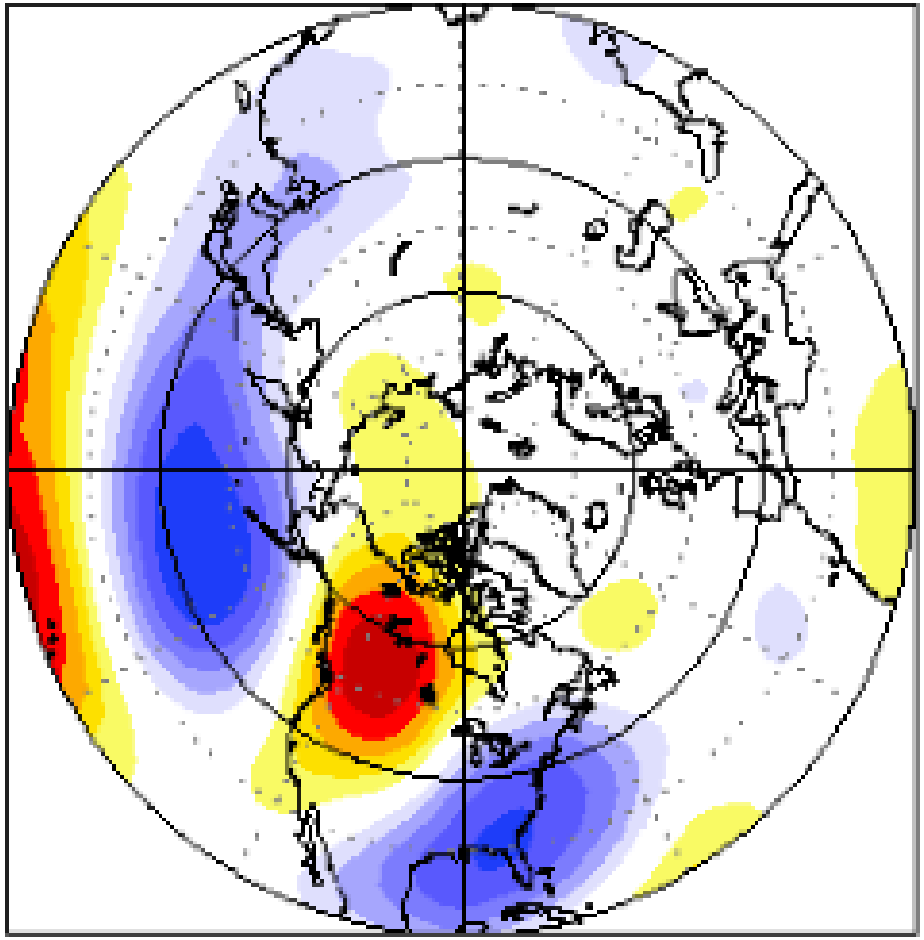
Spreading ENSO effects to higher lat.

- W. Coast of N. America serves as waveguide for warm SST to propagate northward.
- Atmospheric teleconnection: Pac.-N.American (PNA) teleconnection

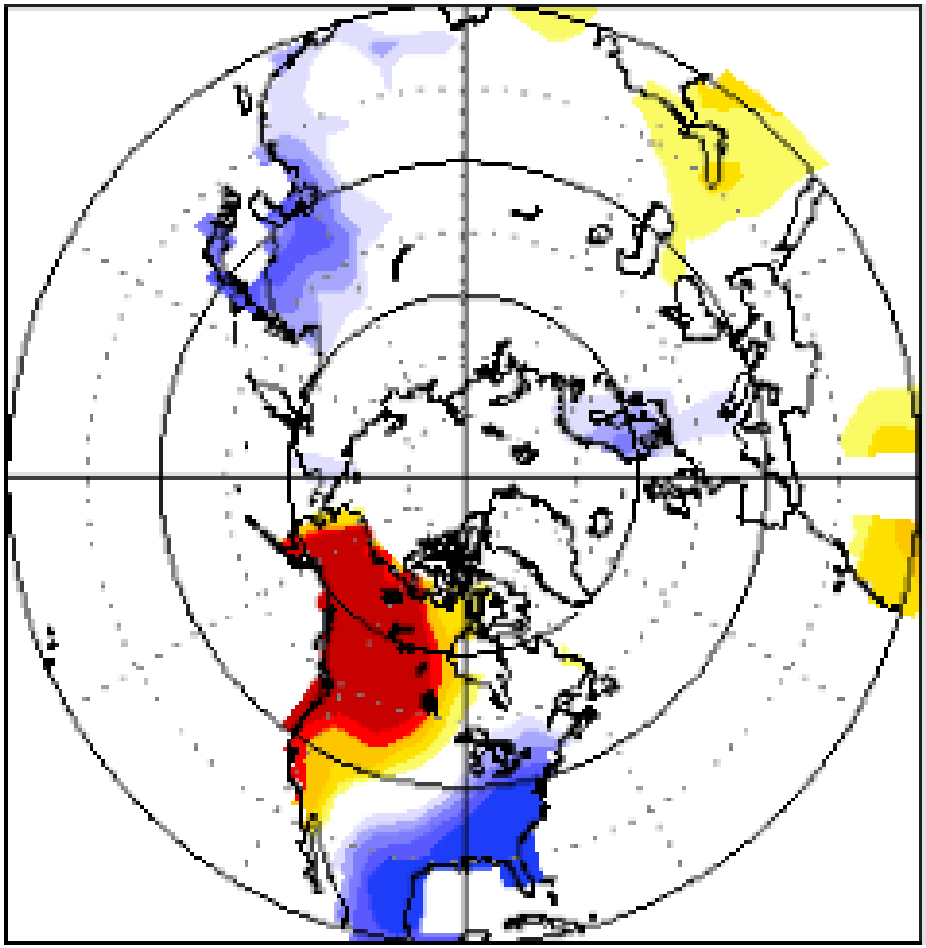


PNA anomalies

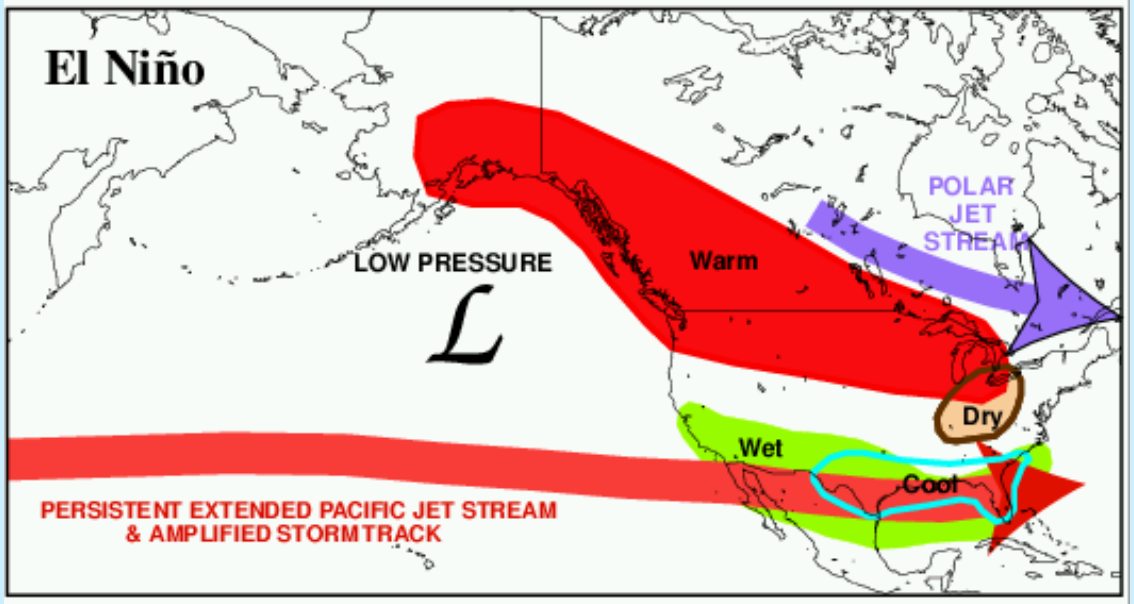
500 mb height anomalies

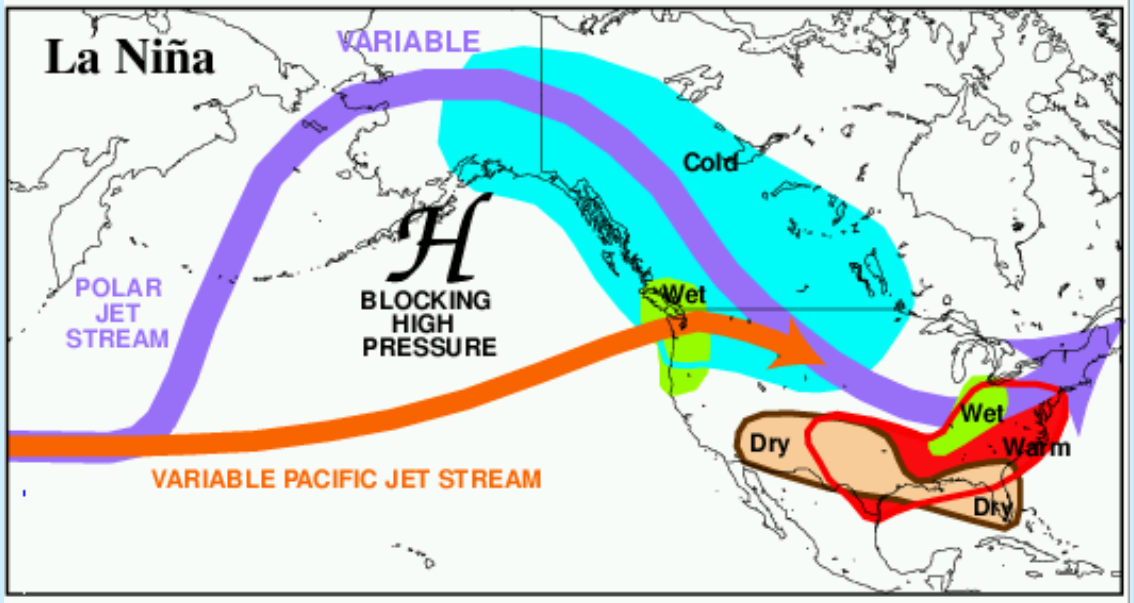


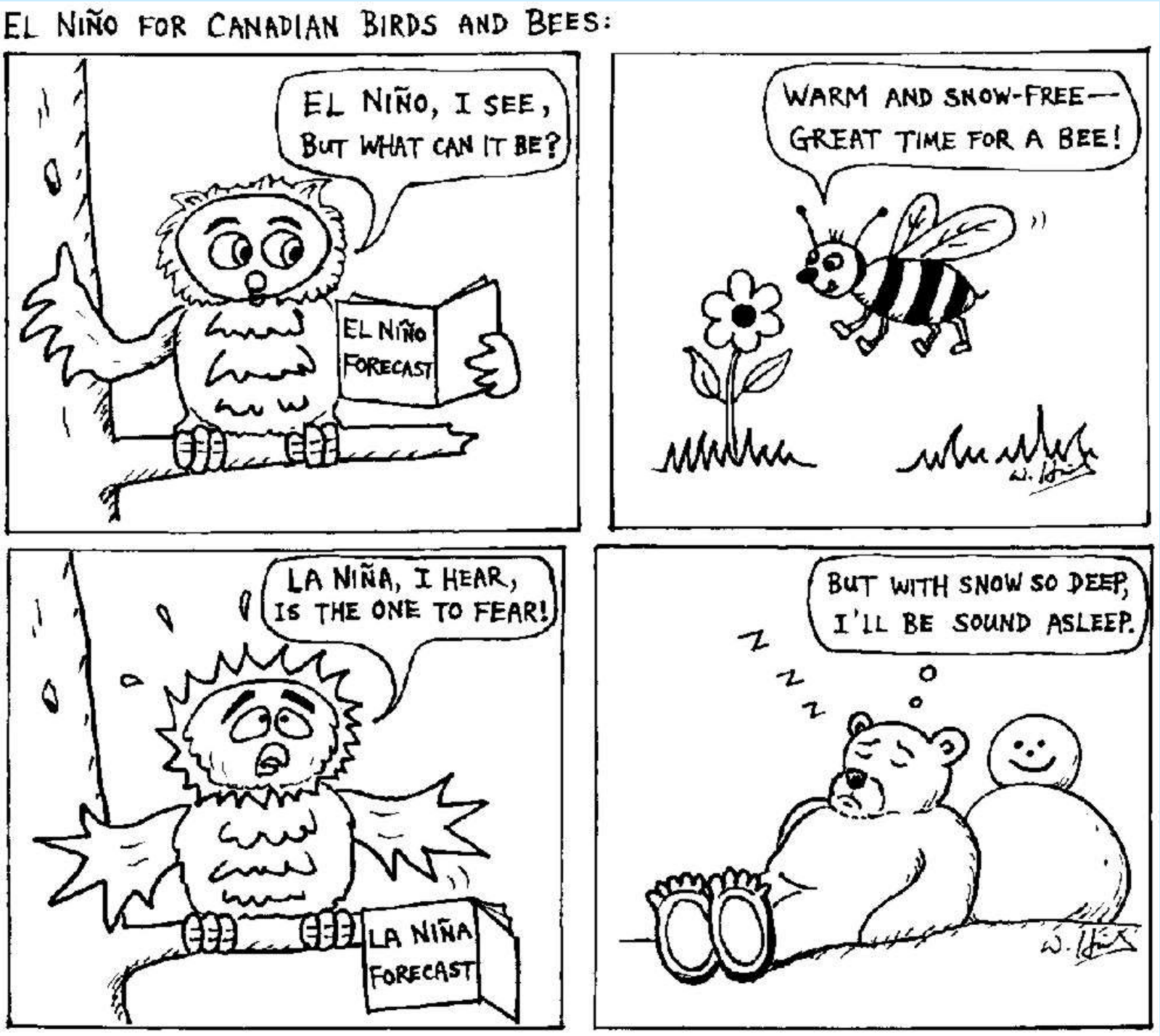
Surface air temperature anomalies



TYPICAL JANUARY-MARCH WEATHER ANOMALIES AND ATMOSPHERIC CIRCULATION DURING MODERATE TO STRONG EL NIÑO & LA NIÑA



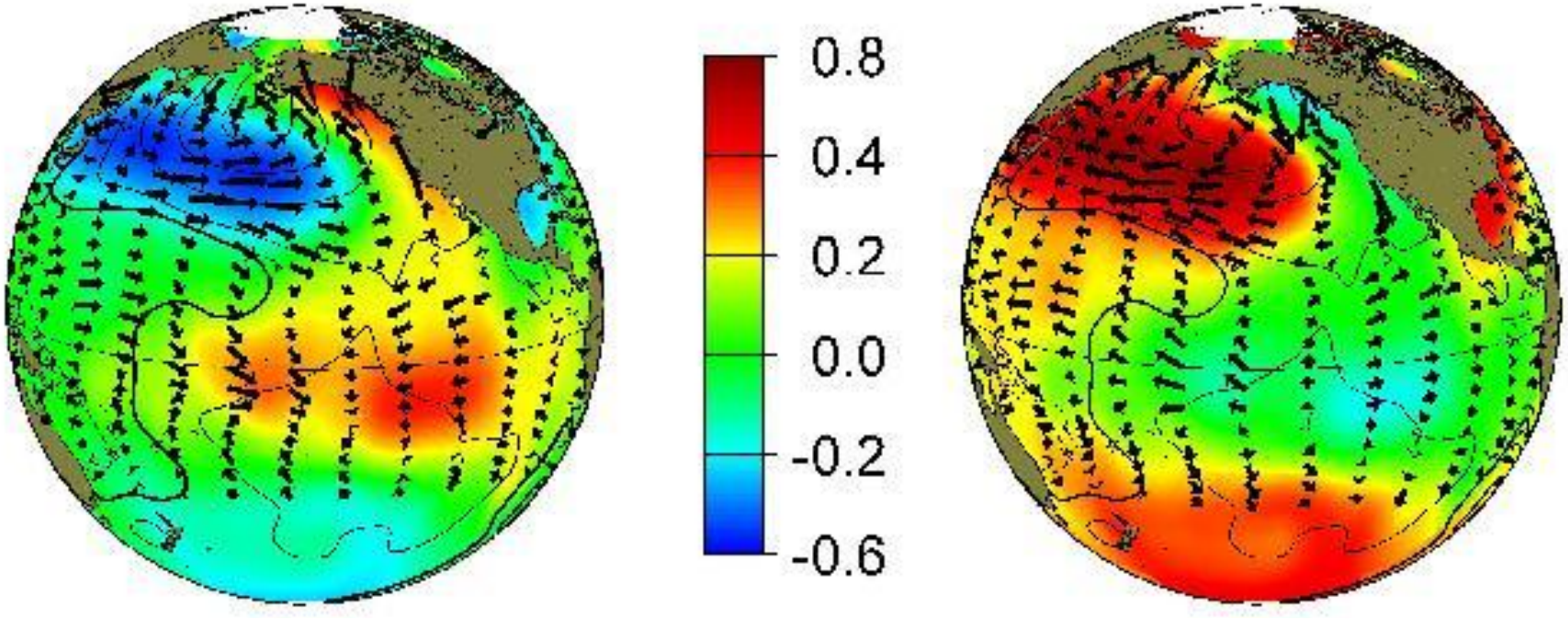



EL NIÑO FOR CANADIAN BIRDS AND BEES:
EL NIÑO, I SEE, BUT WHAT CAN IT BE?
EL NIÑO FORECAST
WARM AND SNOW-FREE— GREAT TIME FOR A BEE!
LA NIÑA, I HEAR, IS THE ONE TO FEAR!
LA NIÑA FORECAST
BUT WITH SNOW SO DEEP, I'LL BE SOUND ASLEEP.

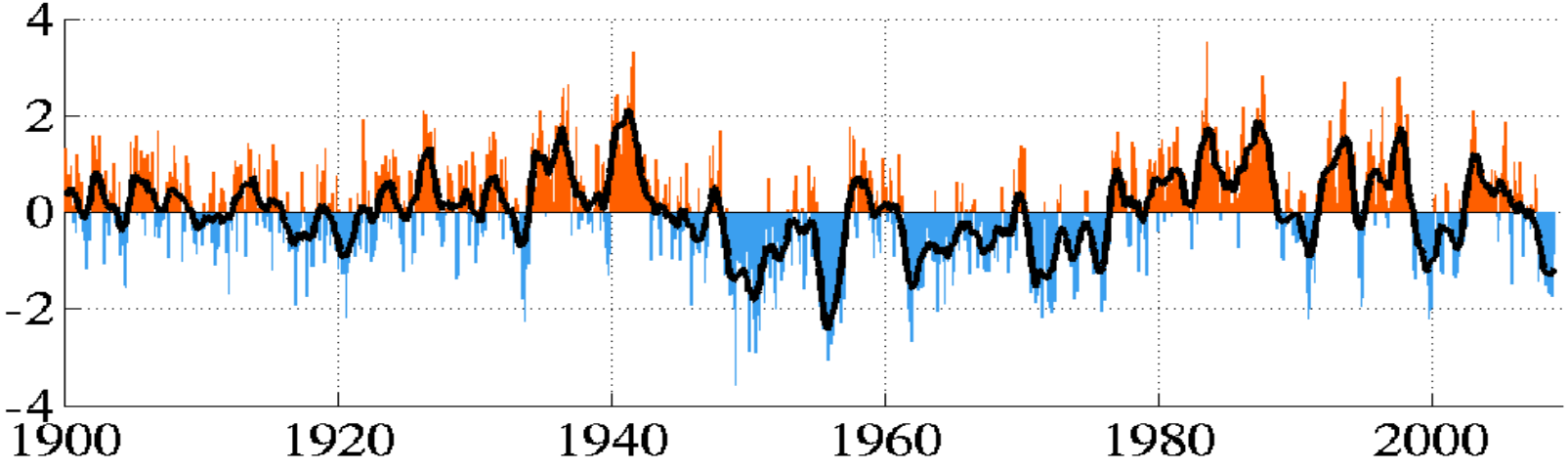
In terms of profit, B.C. Hydro loves

A. El Nino winters as B.C. is warmer
B. La Nina winters as B.C. is colder
C. neither El Nino nor La Nina
D. El Nino winters as there is less snow
E. La Nina winters as there is more snow.

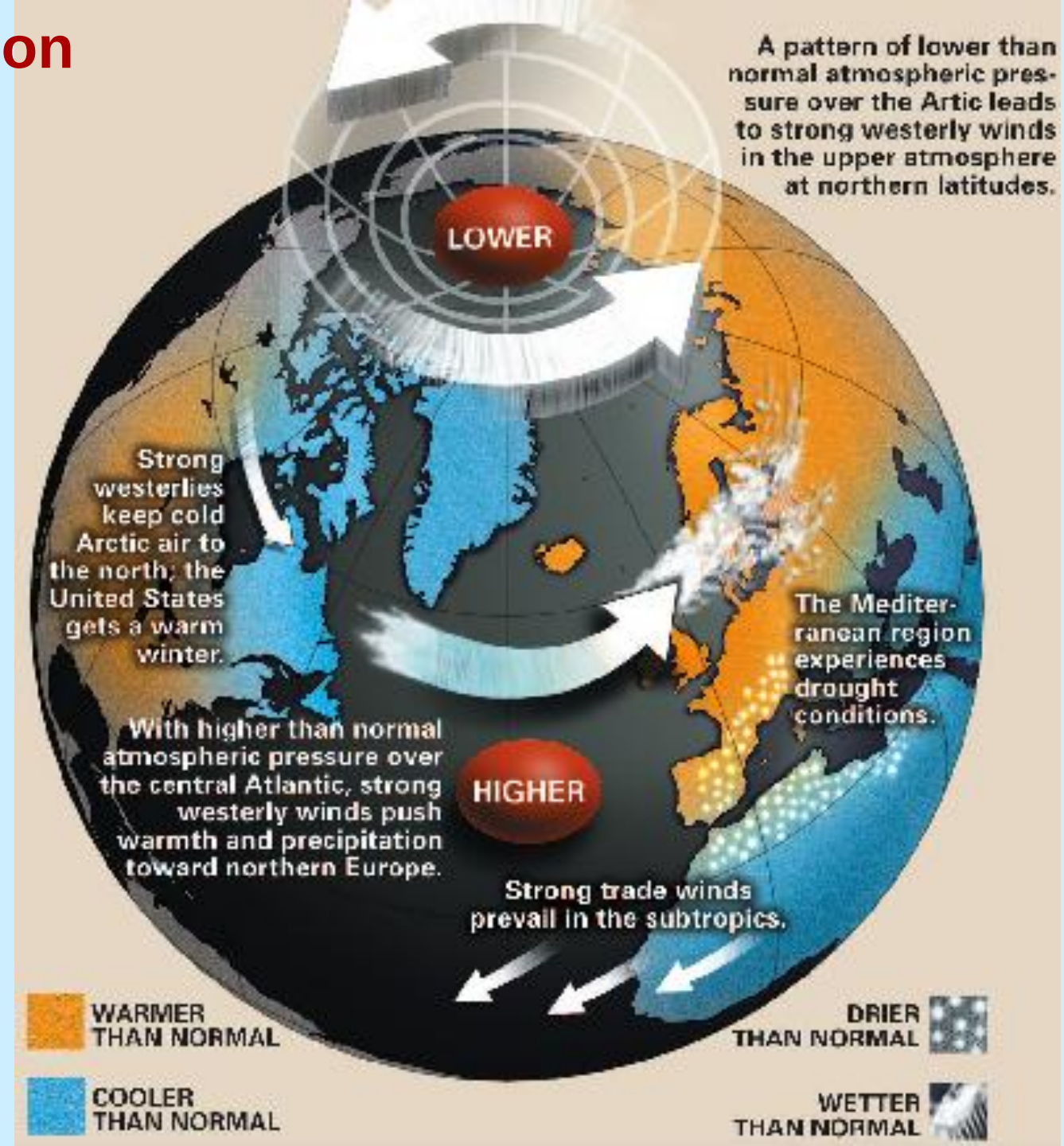
Pacific Decadal Oscillation (PDO)



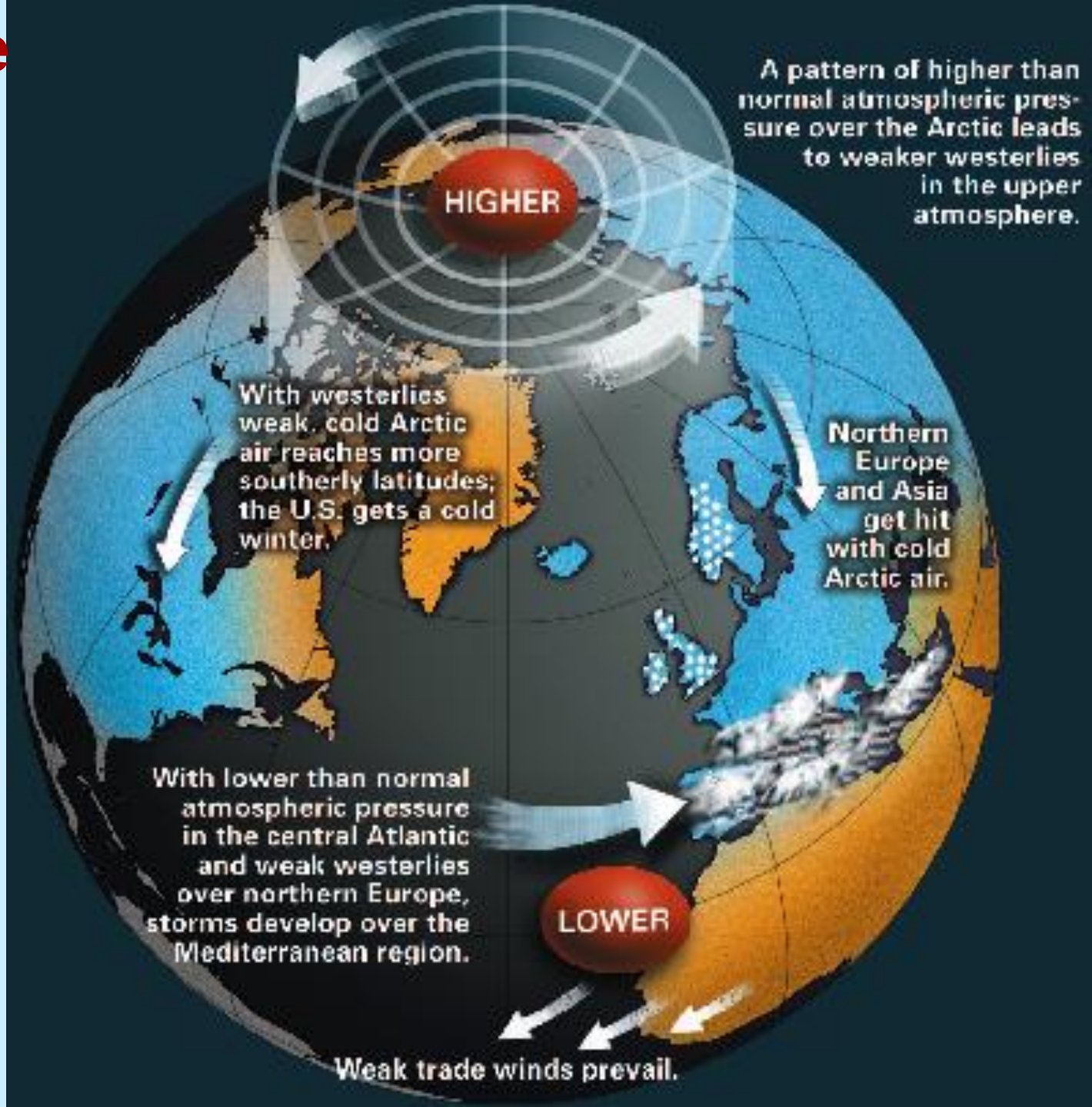
monthly values for the PDO index: 1900-2008

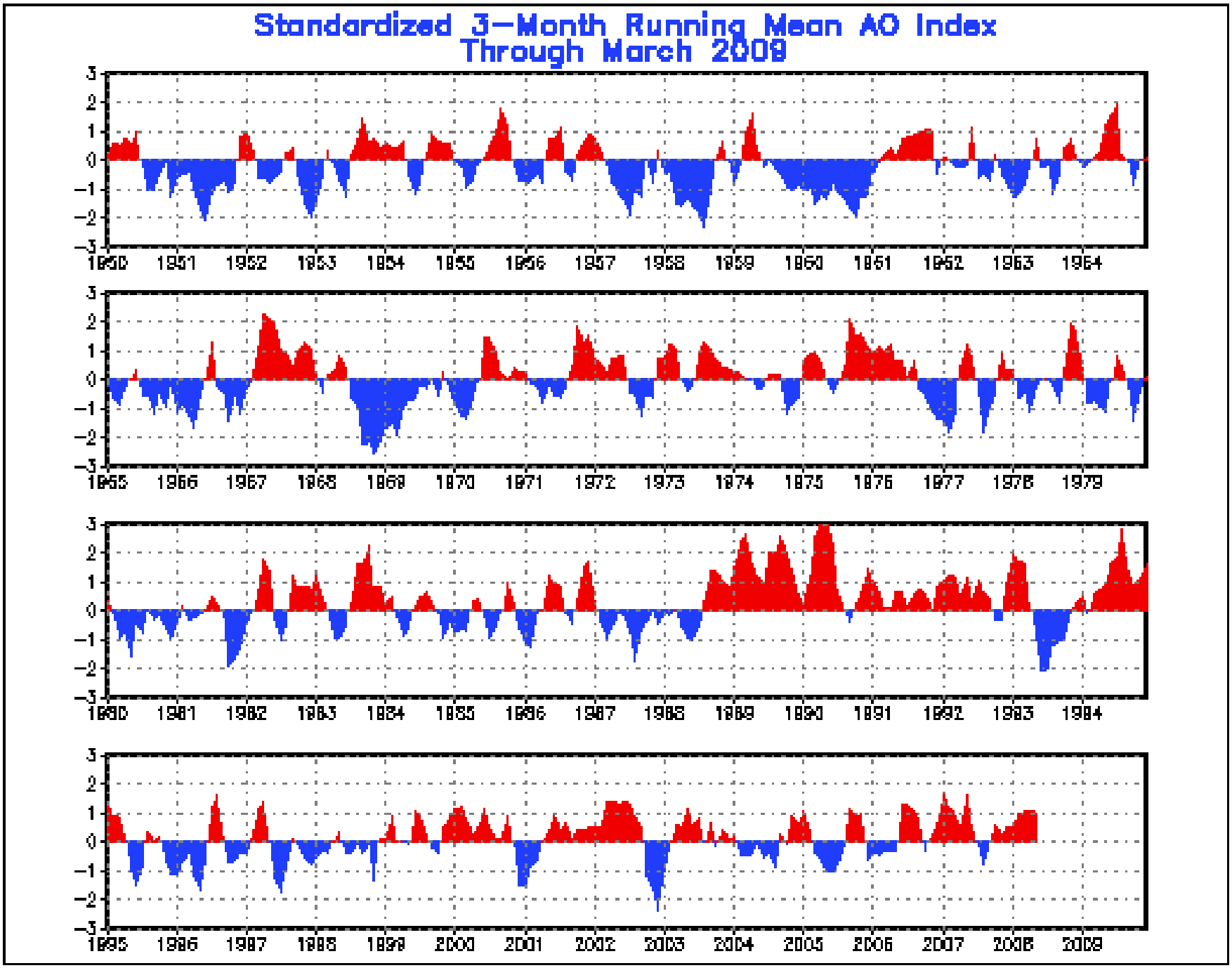


Arctic Oscillation (AO): positive phase during winter



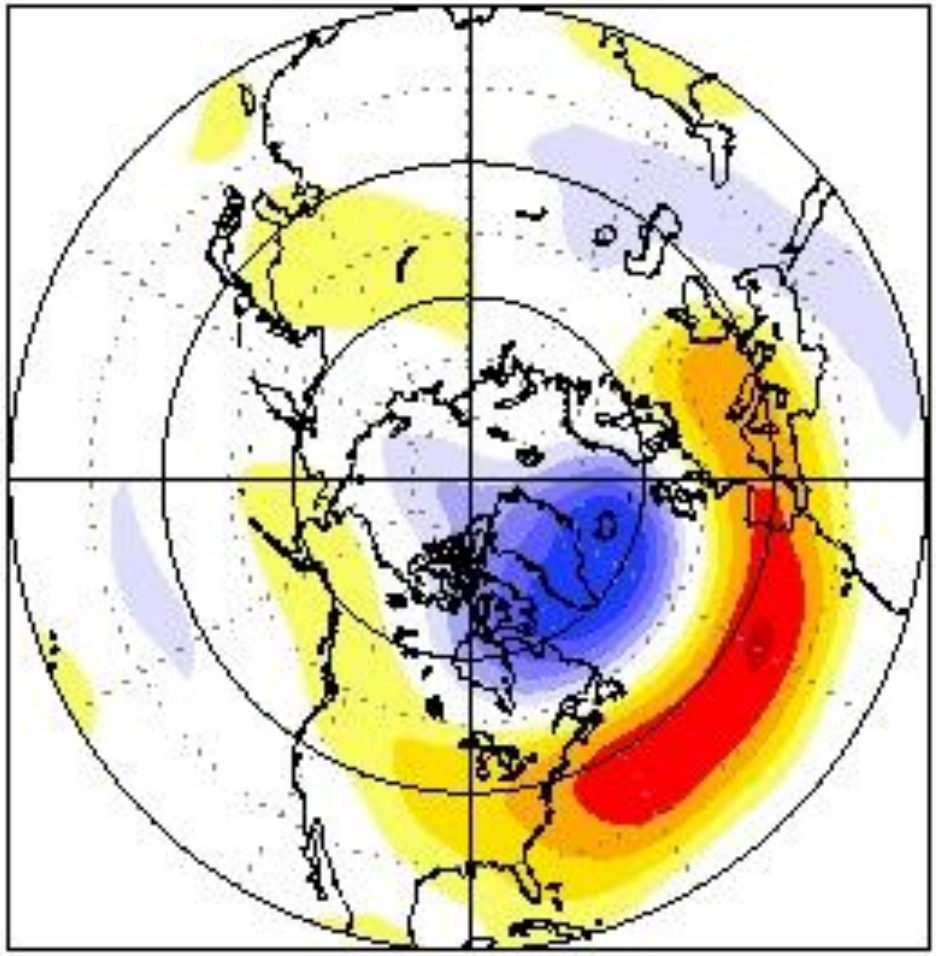
AO negative phase



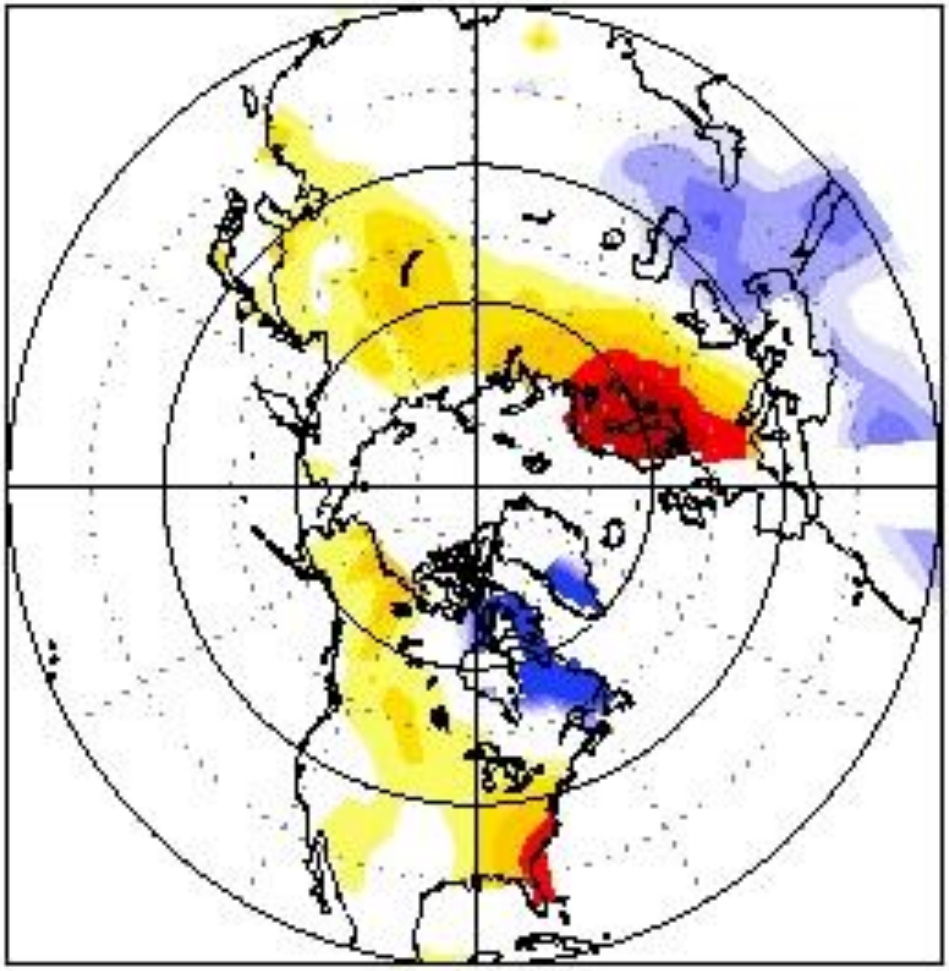

Standardized 3-Month Running Mean AO Index
Through March 2009
3
2
1
0
-1
-2
-3
1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964
1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

Positive NAO phase

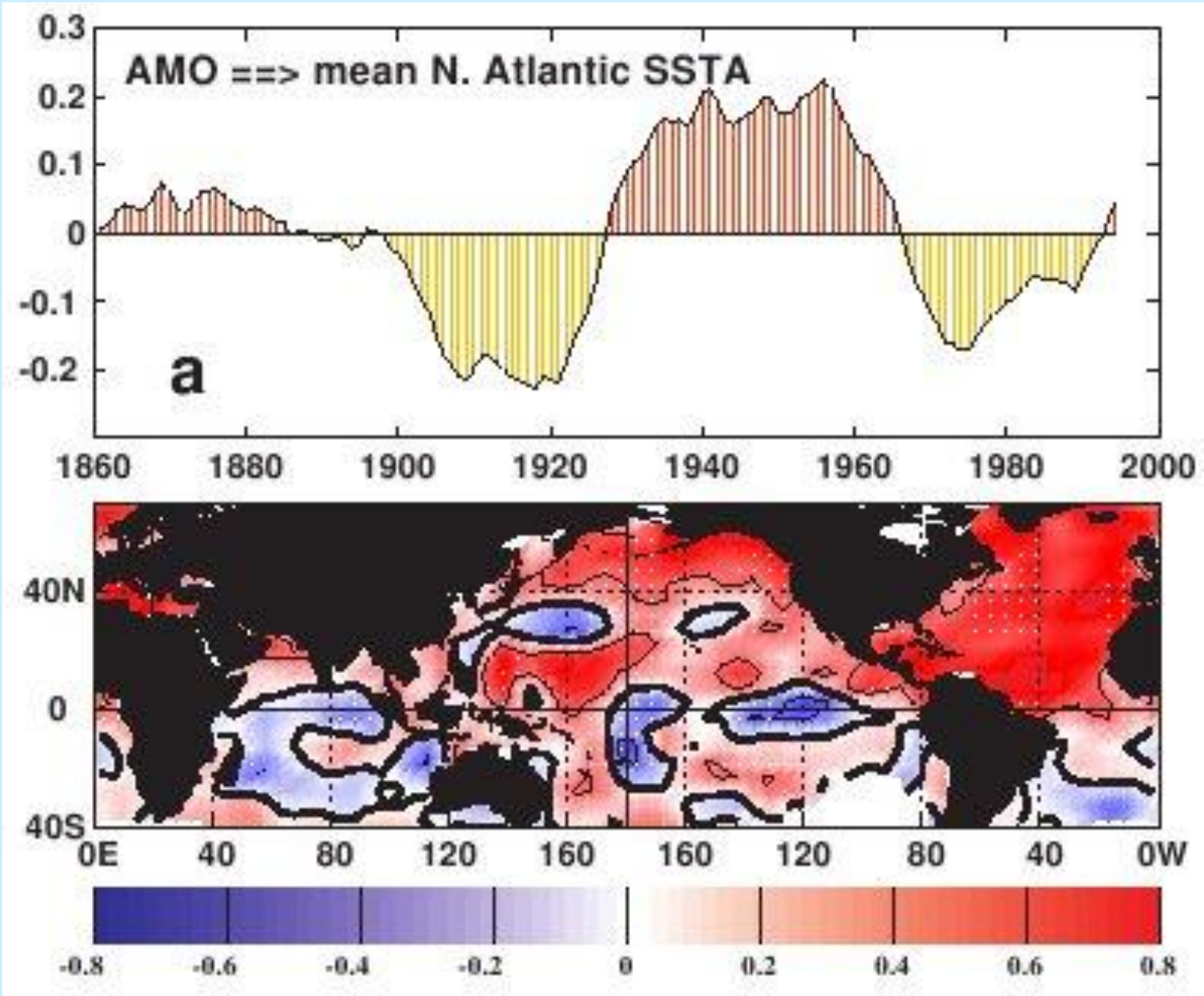
500 mb height anomalies



Surface air temp. anom.

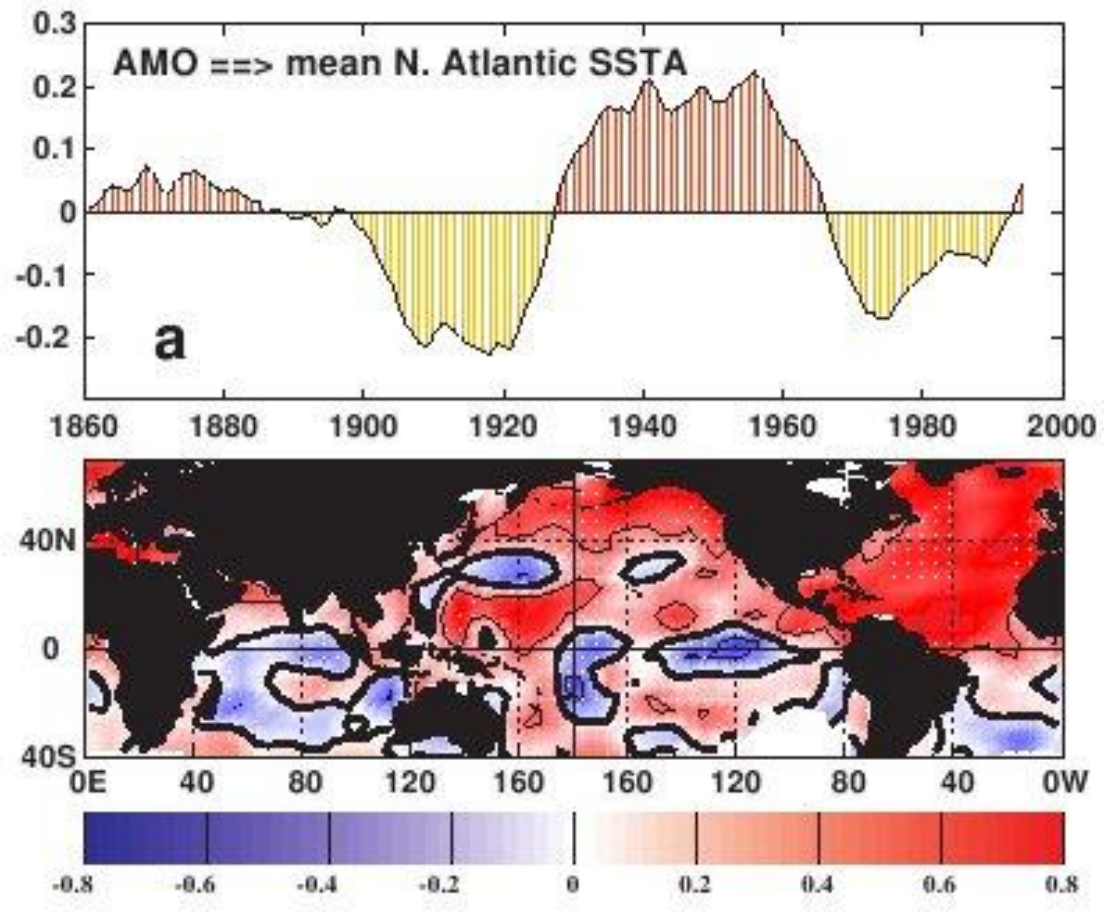


Atlantic Multidecadal Oscillation (AMO)

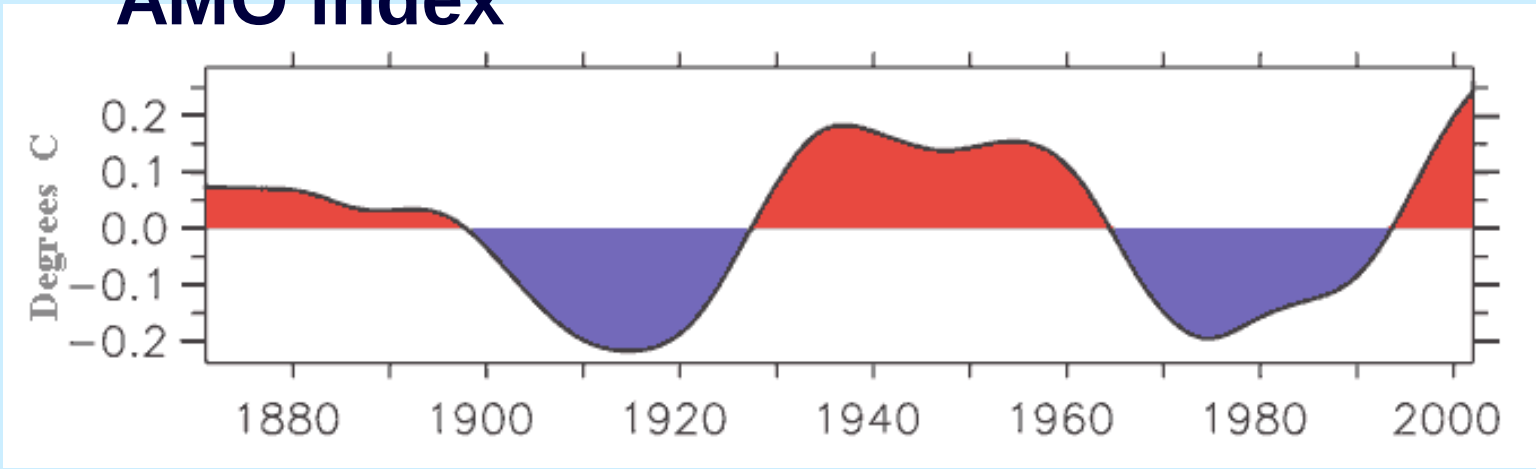


The number of hurricanes in the N.Atlantic is expected to be

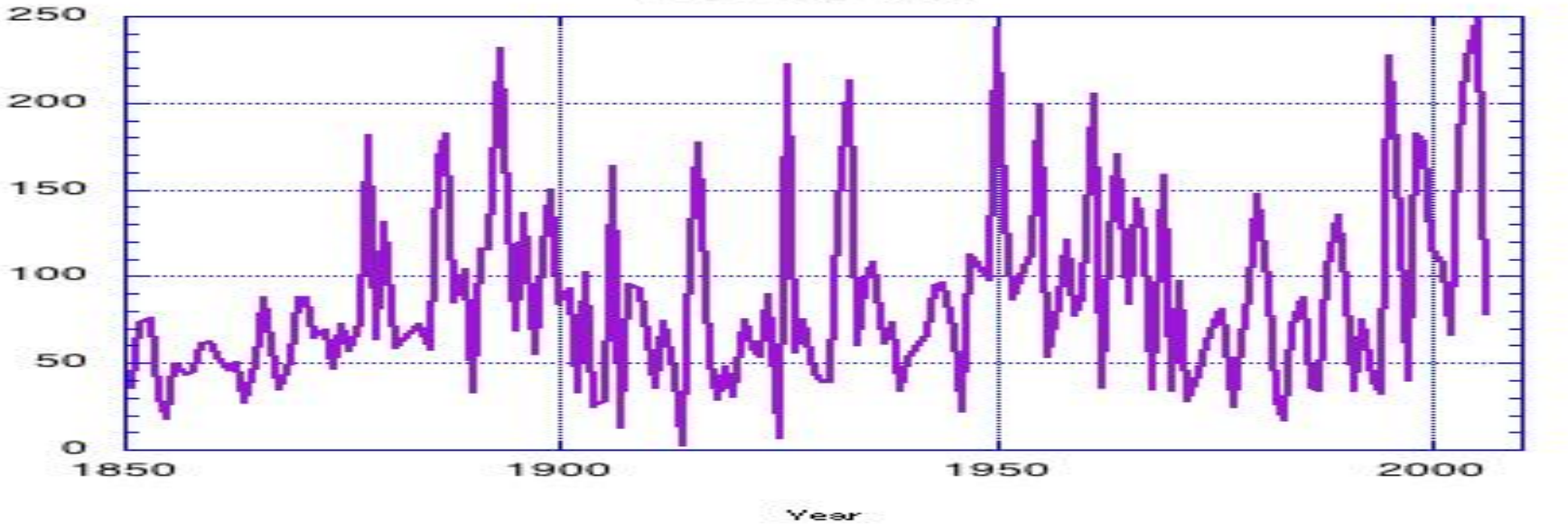
A. Lower when the AMO is negative
B. Higher when the AMO is negative



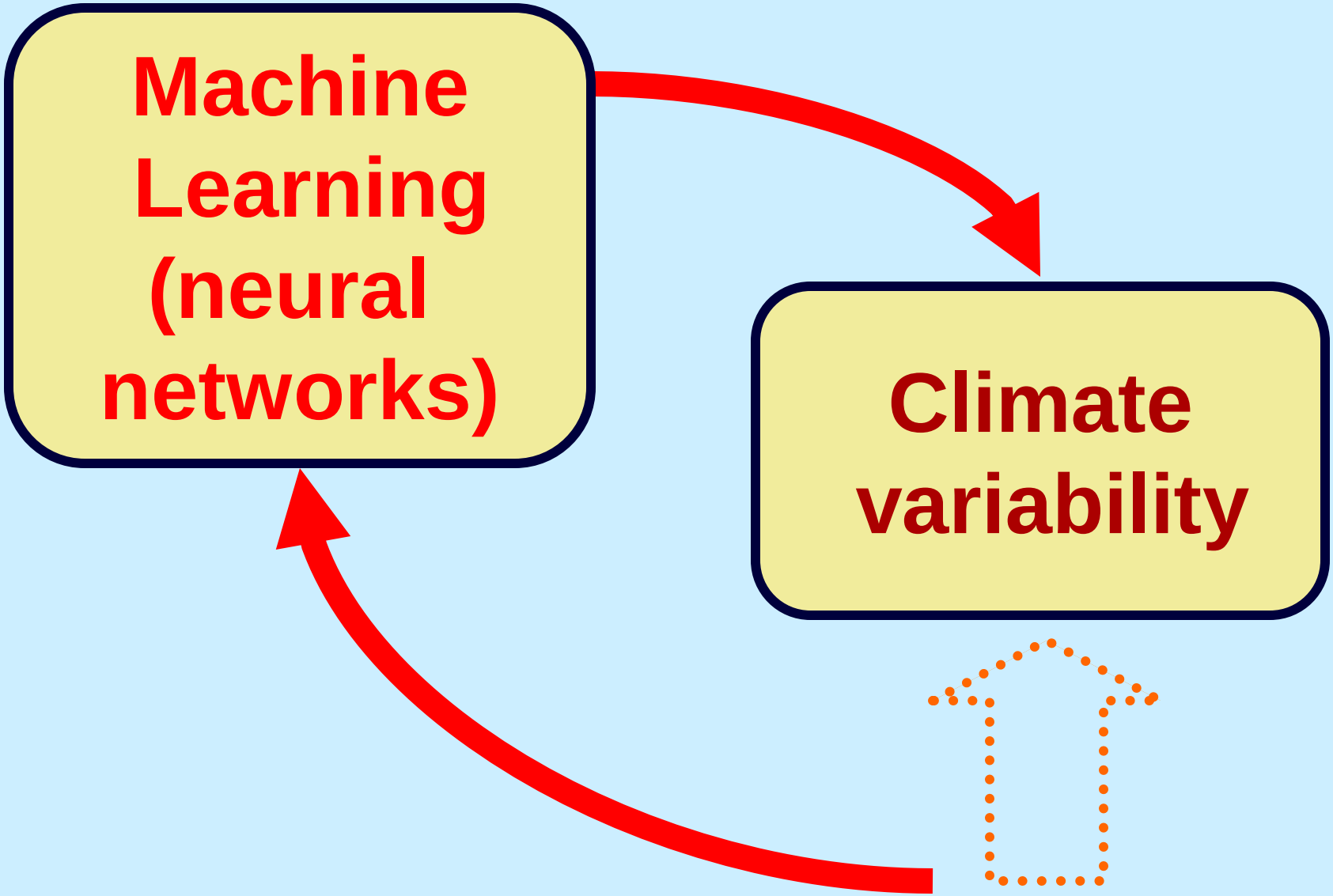
AMO index



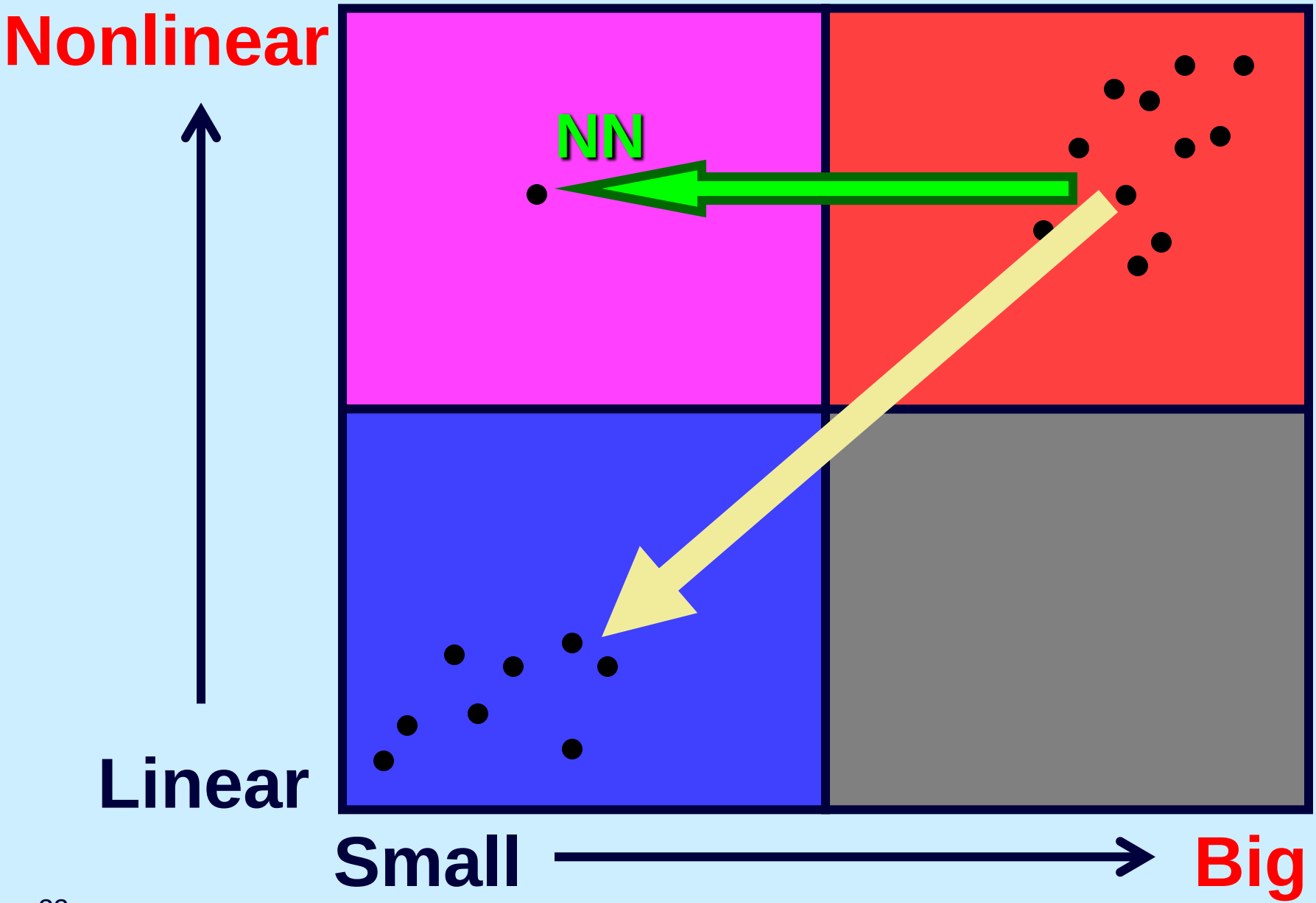
Accumulated cyclone energy (ACE)



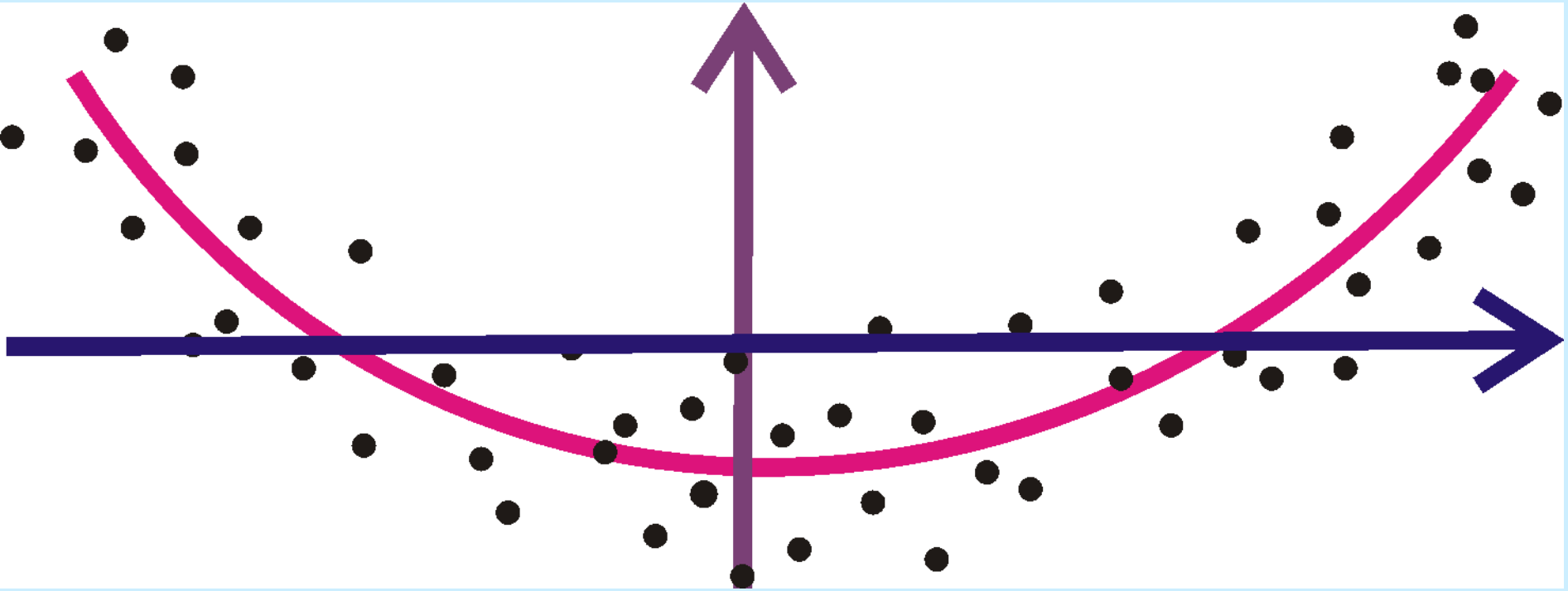
Game plan of our research group



Models



Nonlinear principal component analysis (NLPCA) by neural networks



- **Compare 1st mode of tropical Pacific SST anom. from NLPCA and PCA.**

QuickTime™ and a
Cinepak decompressor
are needed to see this picture.

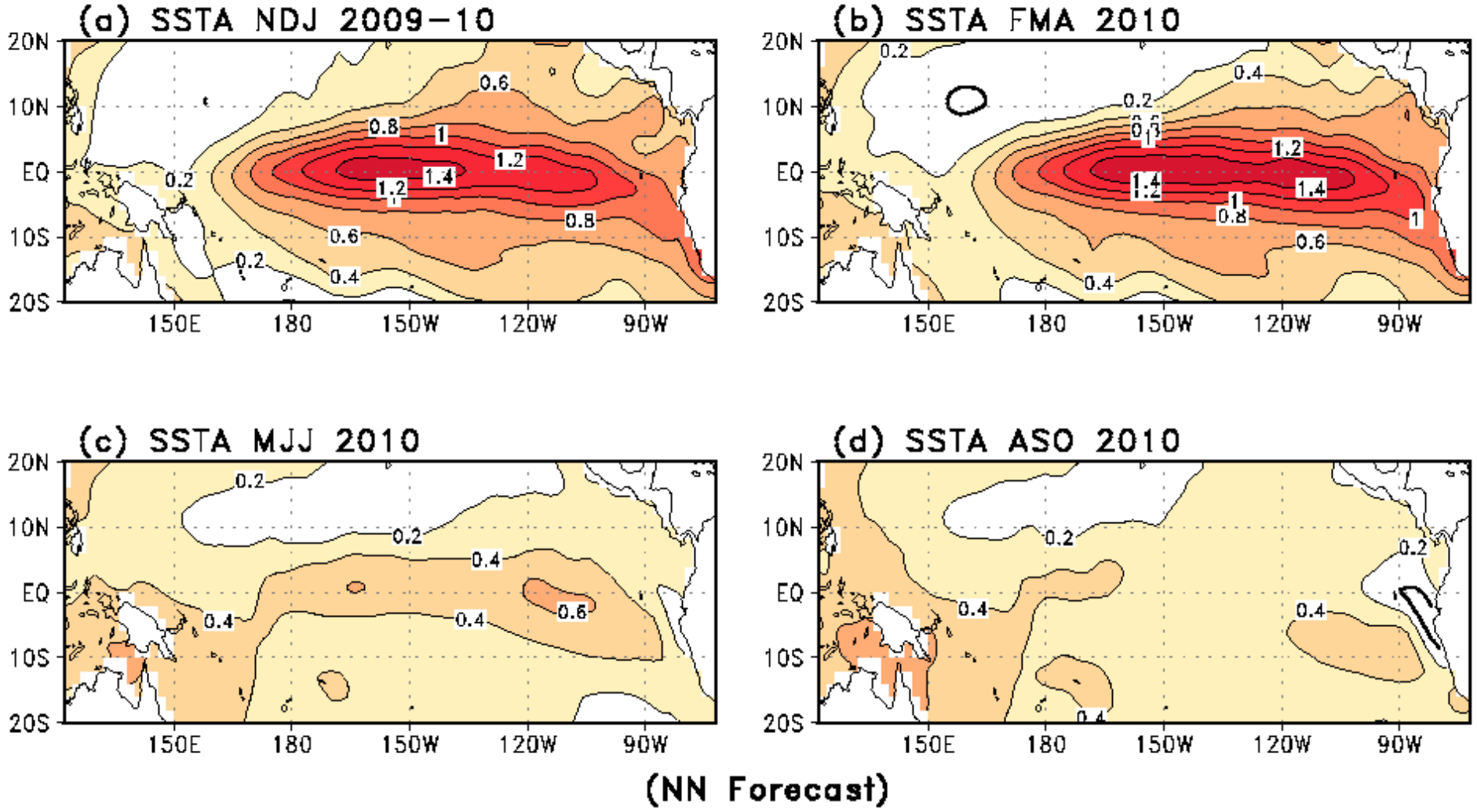
Nonlin. CCA (canonical correlation analysis) of sea level pressure (SLP) & SST

QuickTime™ and a
Cinepak decompressor
are needed to see this picture.

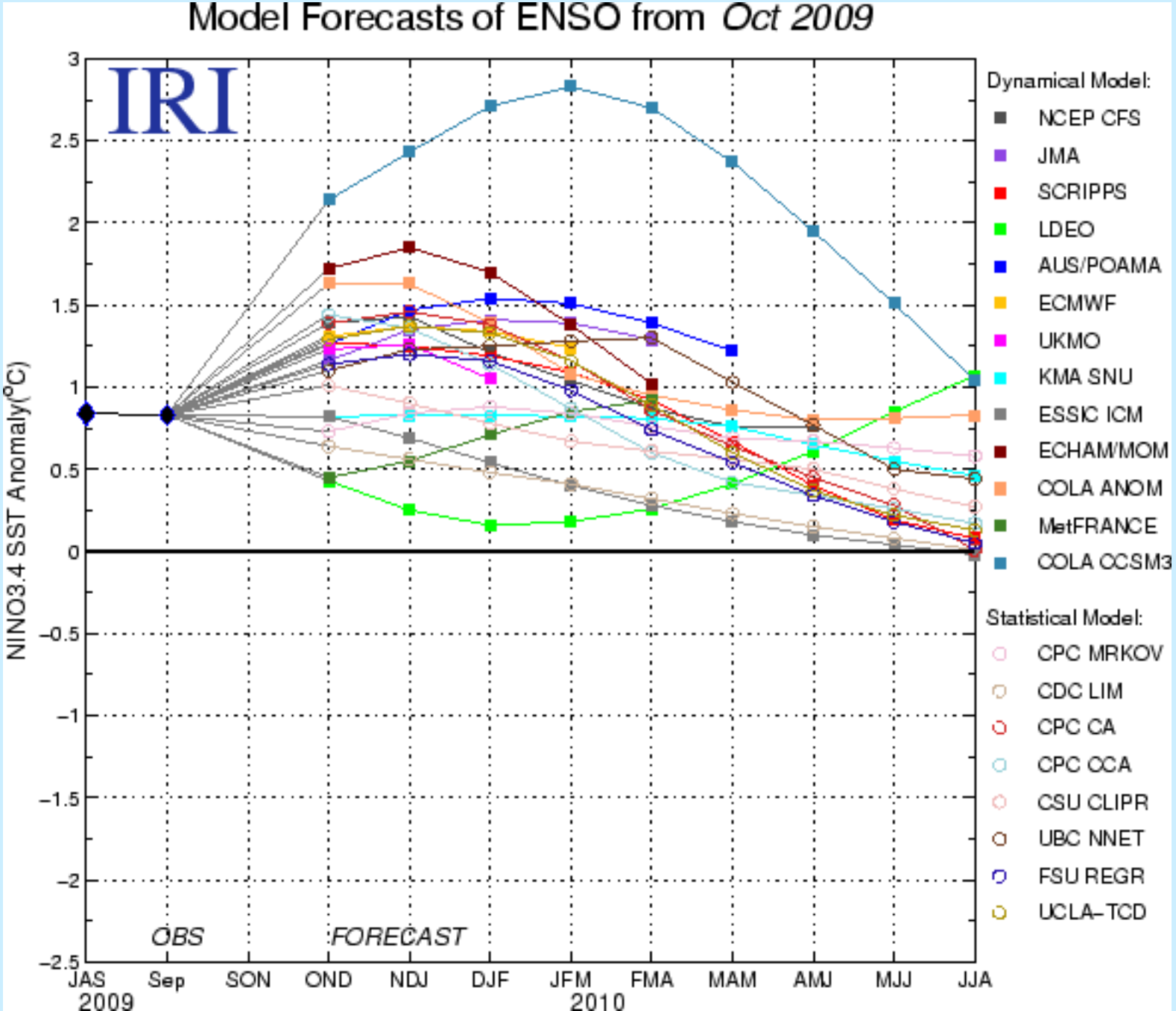
Predicting ENSO

- Dynamical coupled atmosphere-ocean models: Expensive.
- Linear regression (LR): $y = ax + b$
- Nonlinear regression (NLR): $y = f(x)$
  - Use neural networks (NN) for NLR.
  - Predictands: tropical Pac. SST anomalies
  - Predictors: SLP & SST anomalies.
  - http://www.ocgy.ubc.ca/projects/clim.pred/

Forecast of tropical Pacific SST anomalies made on 12 Oct. 2009



http://iri.columbia.edu/climate/ENSO/currentinfo/SST_table.html



Summary

- **Modes of climate variability, e.g. ENSO, PNA, PDO, AO (NAO), AMO**
- **Seasonal climate prediction possible due to signals like ENSO.**