On the causes and dynamics of the early twentieth century North American pluvial

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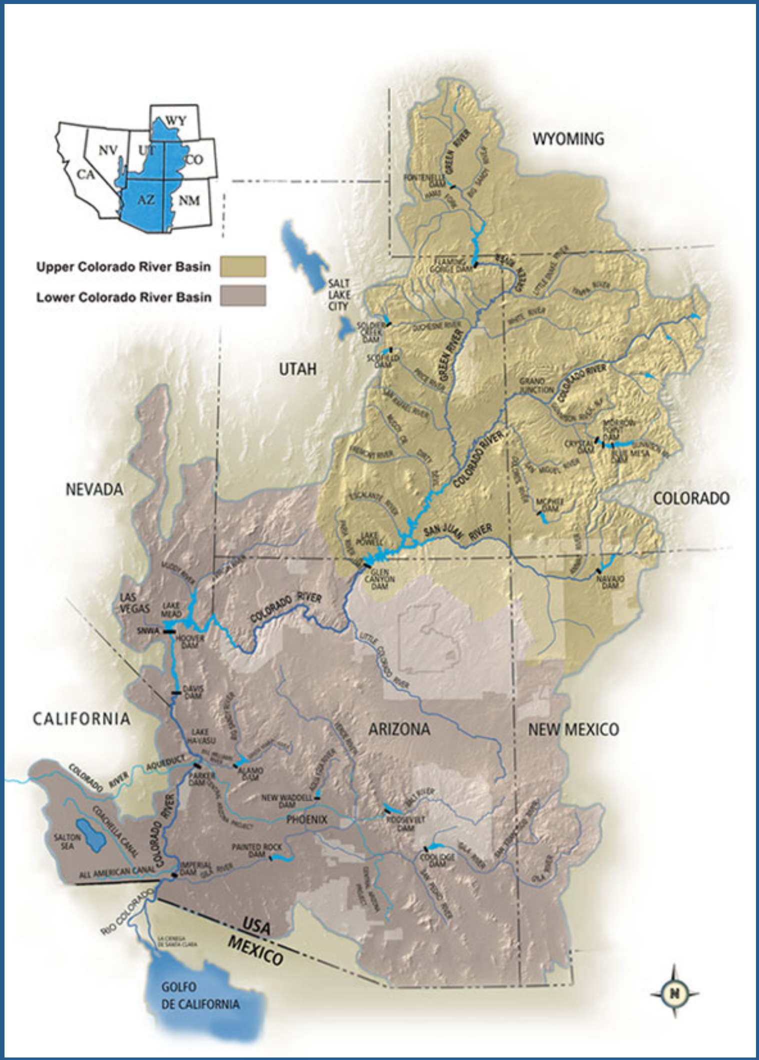
There’s a Reason For Everything:
It’s Just Not Always a Good (Forced) Reason

Colorado River Compact

- Signed in 1922
- Apportioned discharge from the Colorado River among Upper and Lower Basin states
- Based on early 20th century climatological flows of 22 BCM
- Plenty of water; everyone in the west grew oranges and lived happily ever after



http://www.gcdamp.gov/images/ColBasinfinal.jpg

Long Term Climatology

- 1906-2000: 18.6 BCM (6.5-29.6 BCM range)
- Average flow back to 1512: 16.7 BCM

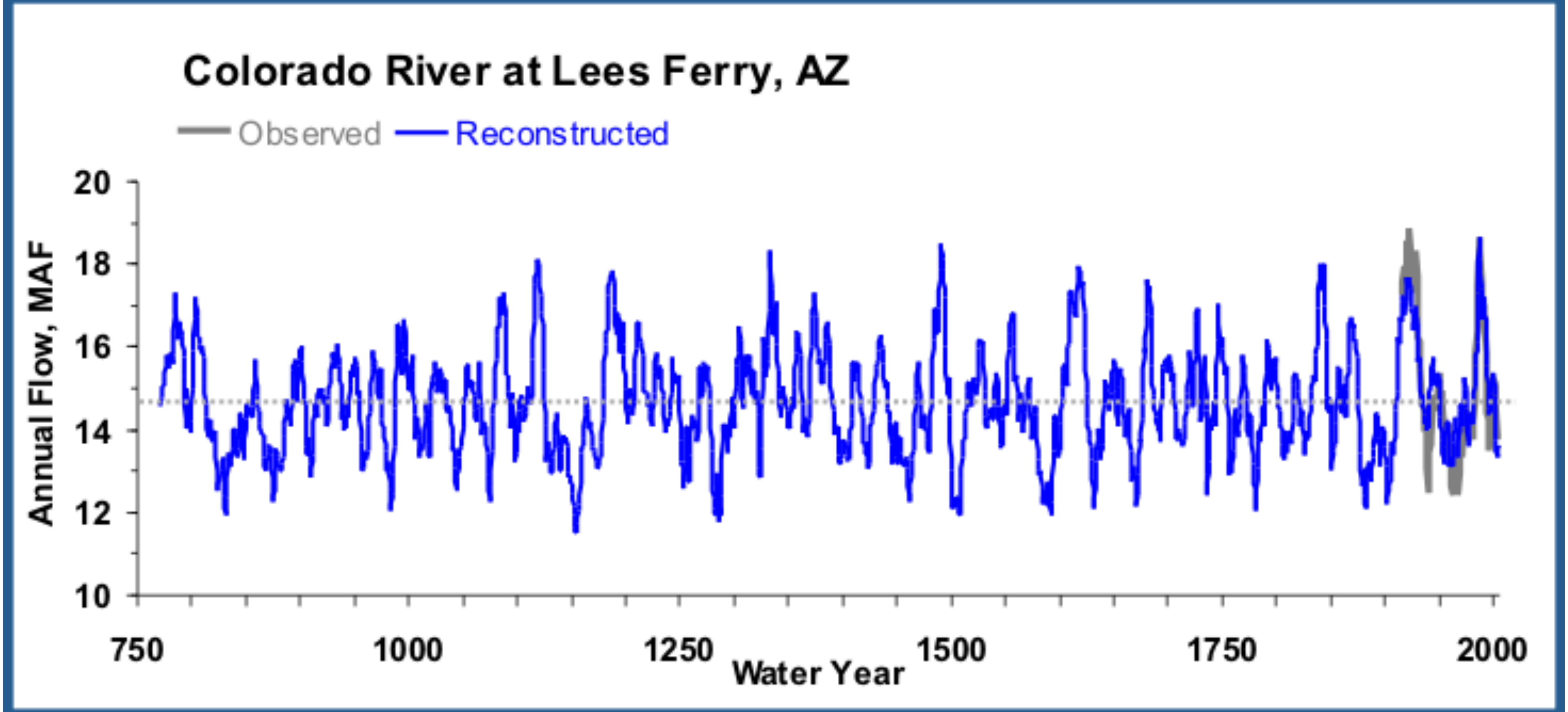
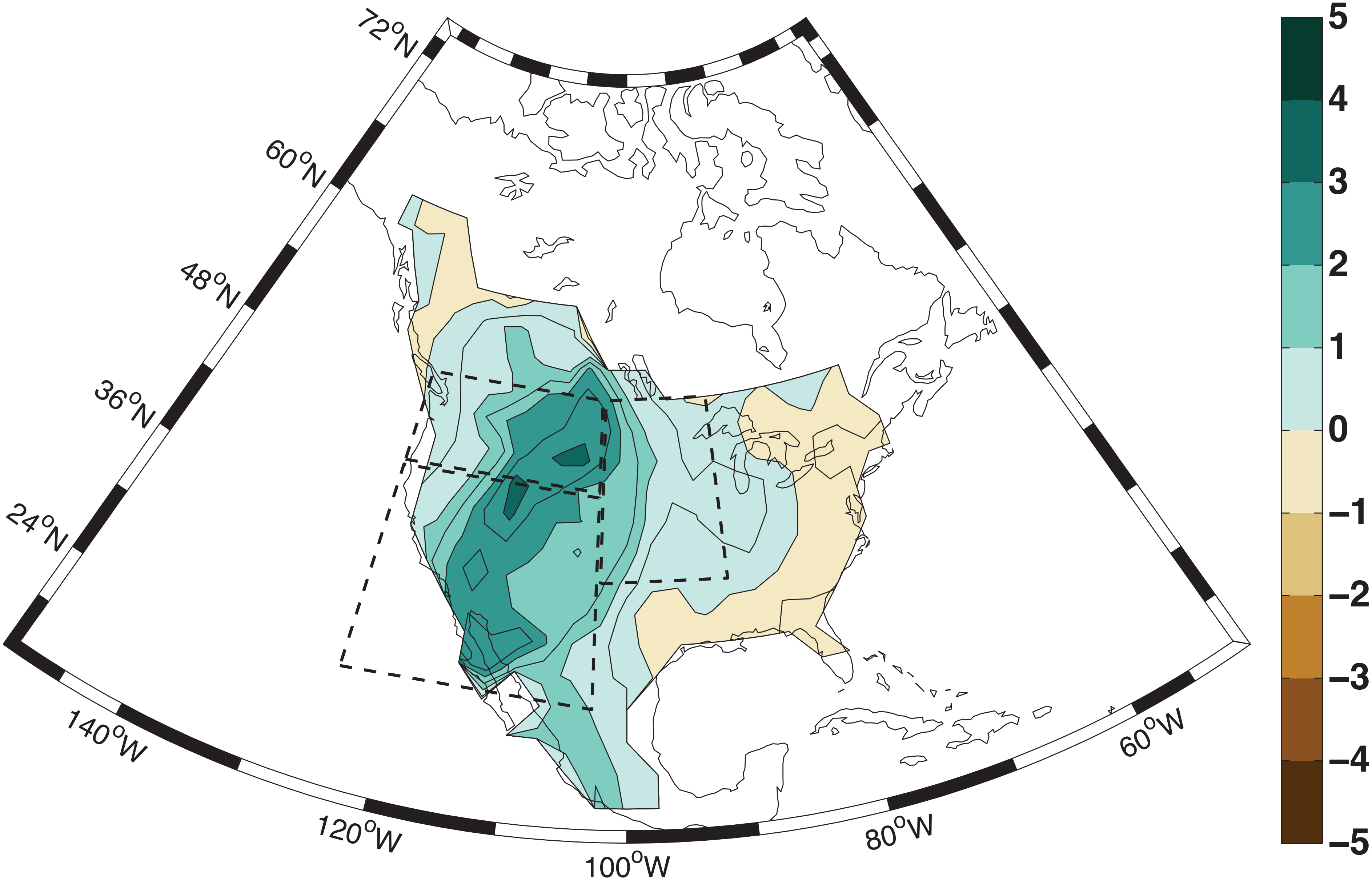


Image Credit: David Meko, http://treeflow.info/upco/coloradoleesmeko.html

NADA v2a PDSI: 1905–1917



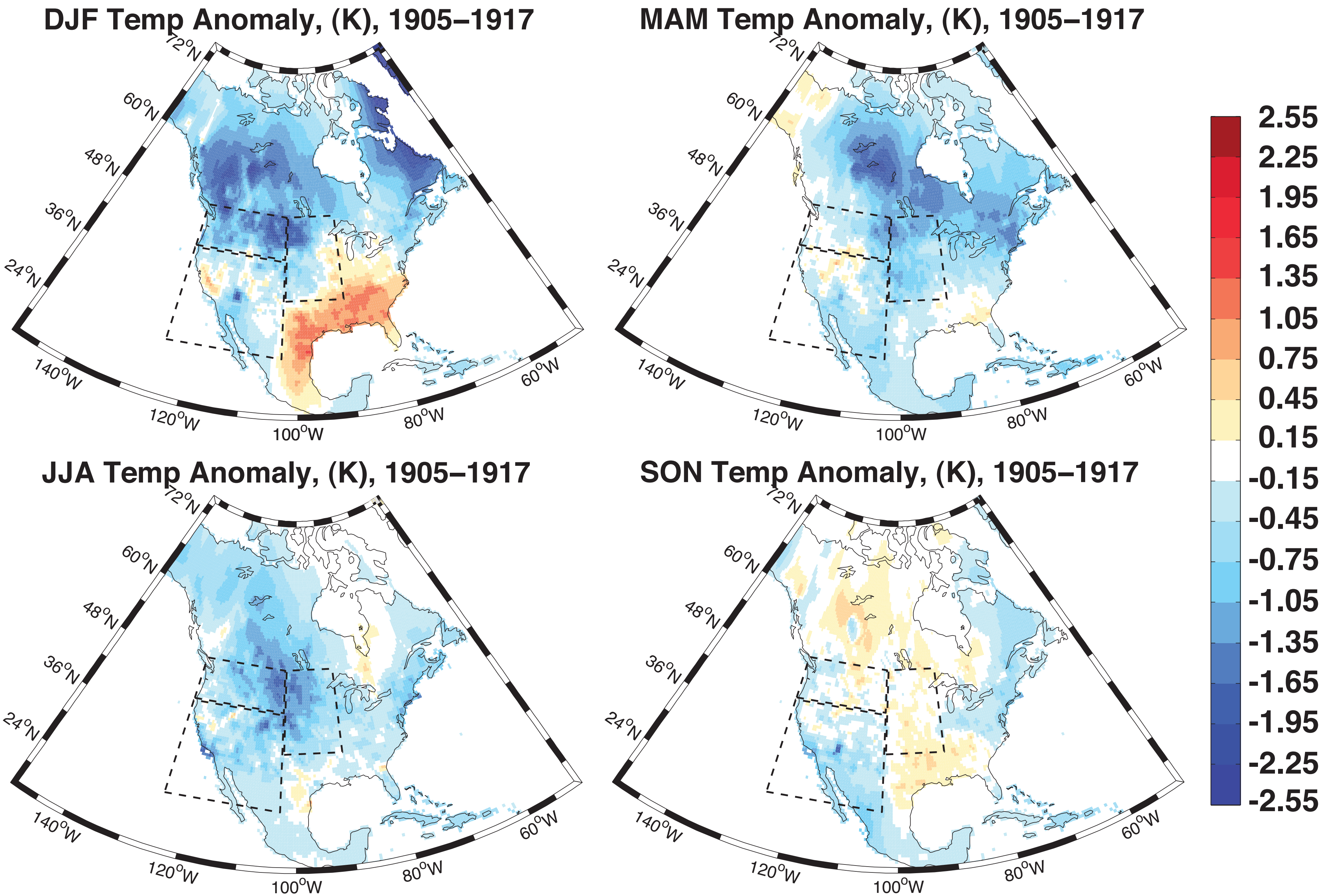
Questions

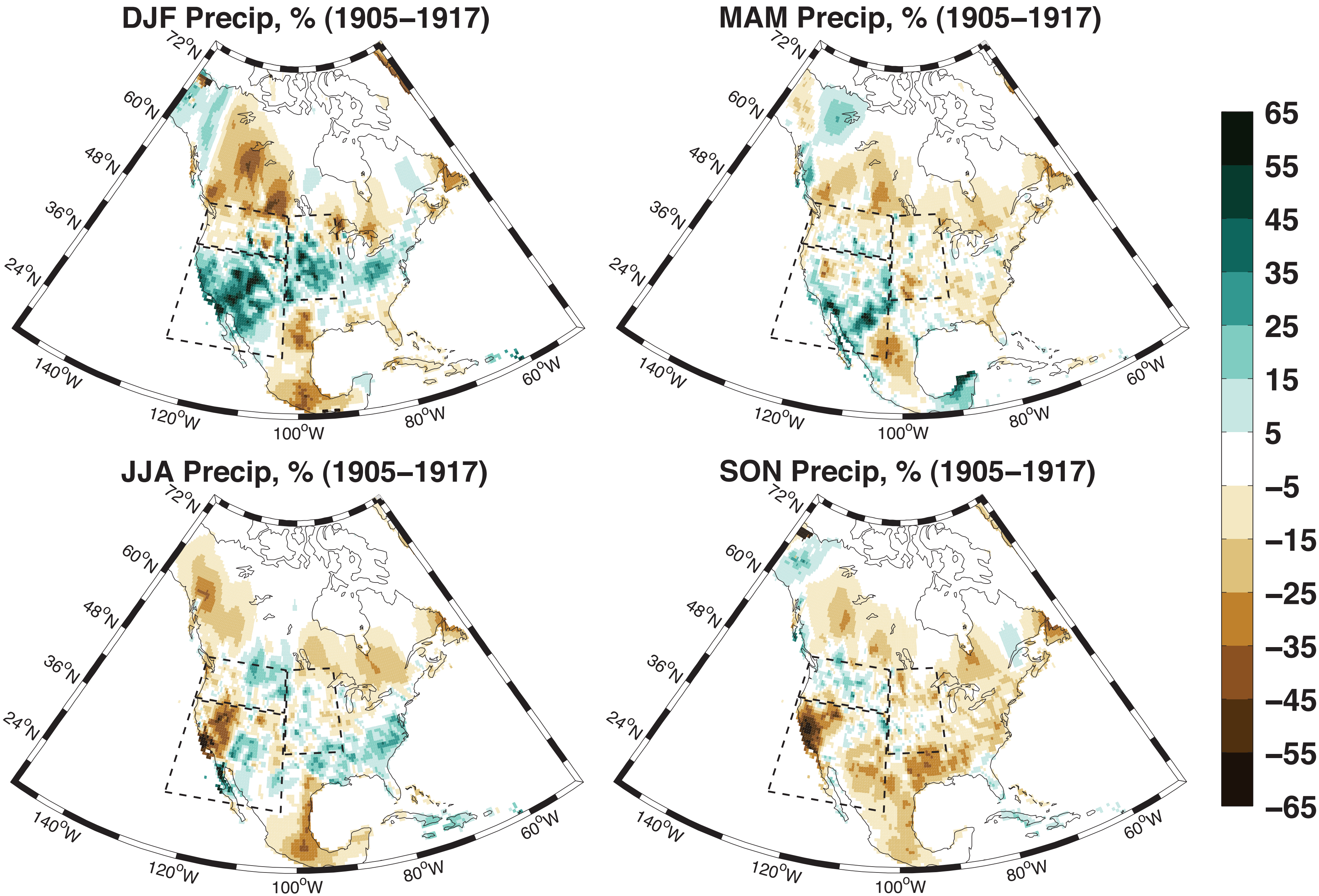
- What is the relative importance of temperature versus precipitation for explaining the pluvial moisture surpluses?

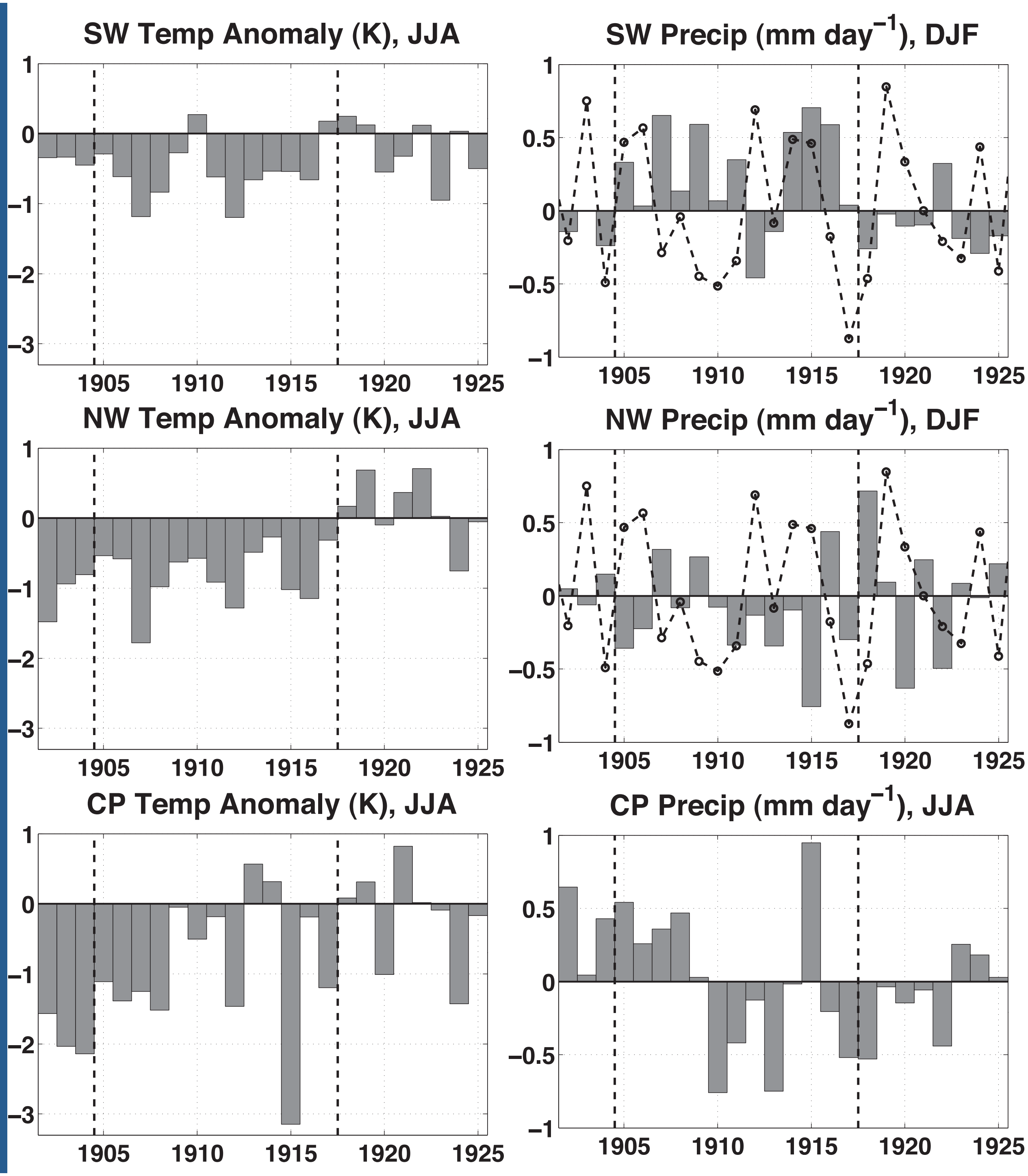
- What are the dynamics underlying these anomalies, and how important was sea surface temperature (SST) forcing during this interval?

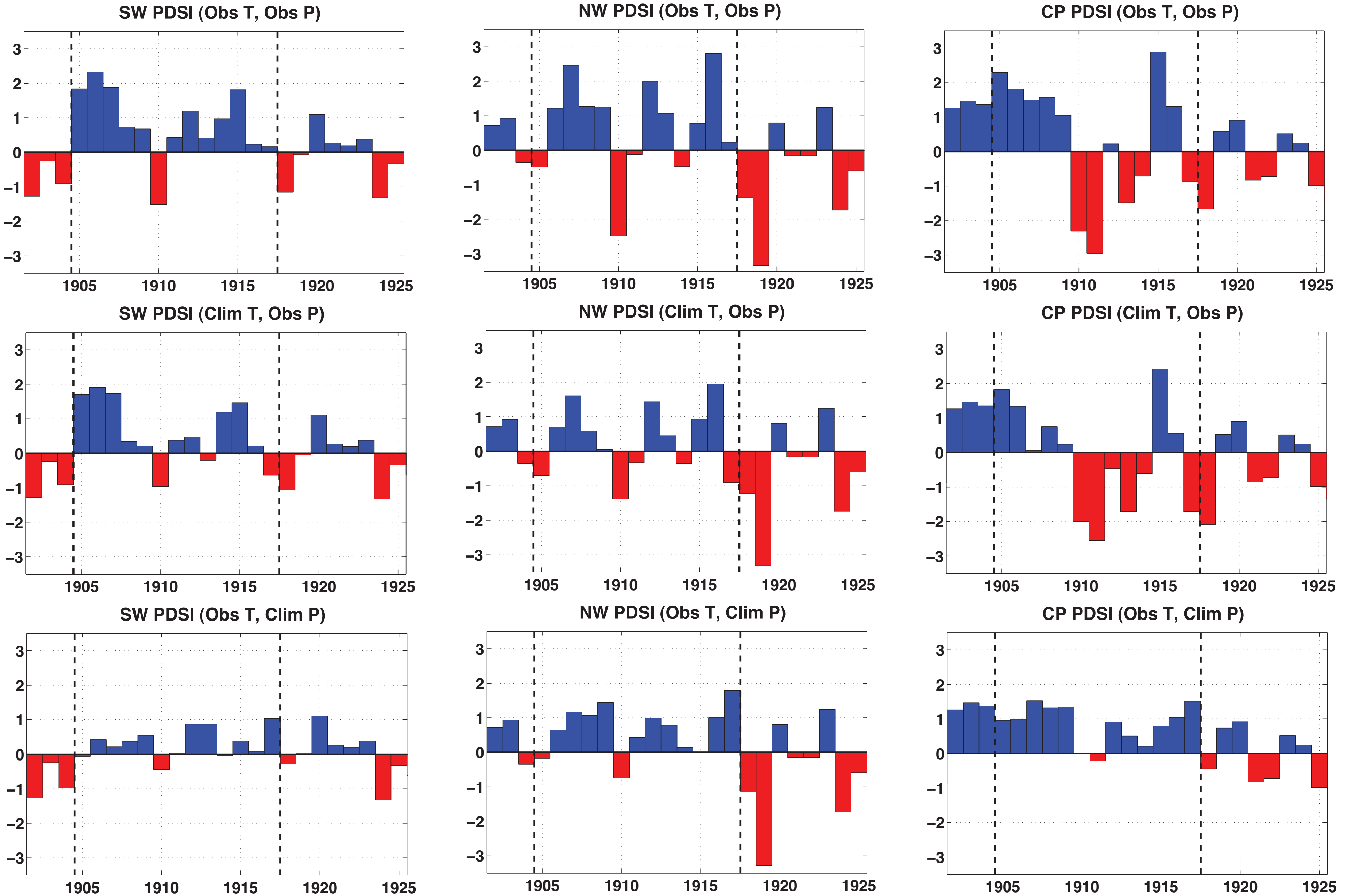
Data

- CRU 2.1 Climate Grids (Mitchell and Jones, 2005)
- Twentieth Century Reanalysis (Compo et al, 2011)
- Hadley Centre SSTs (Rayner et al, 2003)
- 16 Member SST forced GCM ensemble


DJF Temp Anomaly, (K), 1905–1917
MAM Temp Anomaly, (K), 1905–1917
JJA Temp Anomaly, (K), 1905–1917
SON Temp Anomaly, (K), 1905–1917
72°N
60°N
48°N
36°N
24°N
140°W
120°W
100°W
80°W
60°W
2.55
2.25
1.95
1.65
1.35
1.05
0.75
0.45
0.15
-0.15
-0.45
-0.75
-1.05
-1.35
-1.65
-1.95
-2.25
-2.55

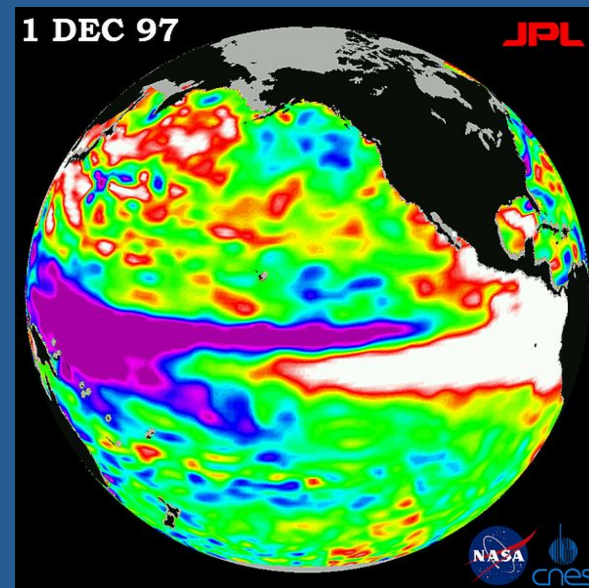

DJF Precip, % (1905–1917)
MAM Precip, % (1905–1917)
JJA Precip, % (1905–1917)
SON Precip, % (1905–1917)
72°N
60°N
48°N
36°N
24°N
140°W
120°W
100°W
80°W
60°W
65
55
45
35
25
15
5
−5
−15
−25
−35
−45
−55
−65

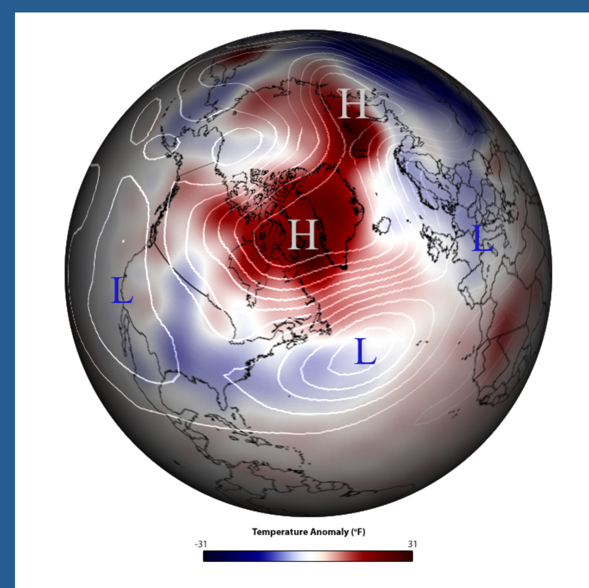

SW Temp Anomaly (K), JJA
SW Precip (mm day^{-1}), DJF
NW Temp Anomaly (K), JJA
NW Precip (mm day^{-1}), DJF
CP Temp Anomaly (K), JJA
CP Precip (mm day^{-1}), JJA
1905
1910
1915
1920
1925

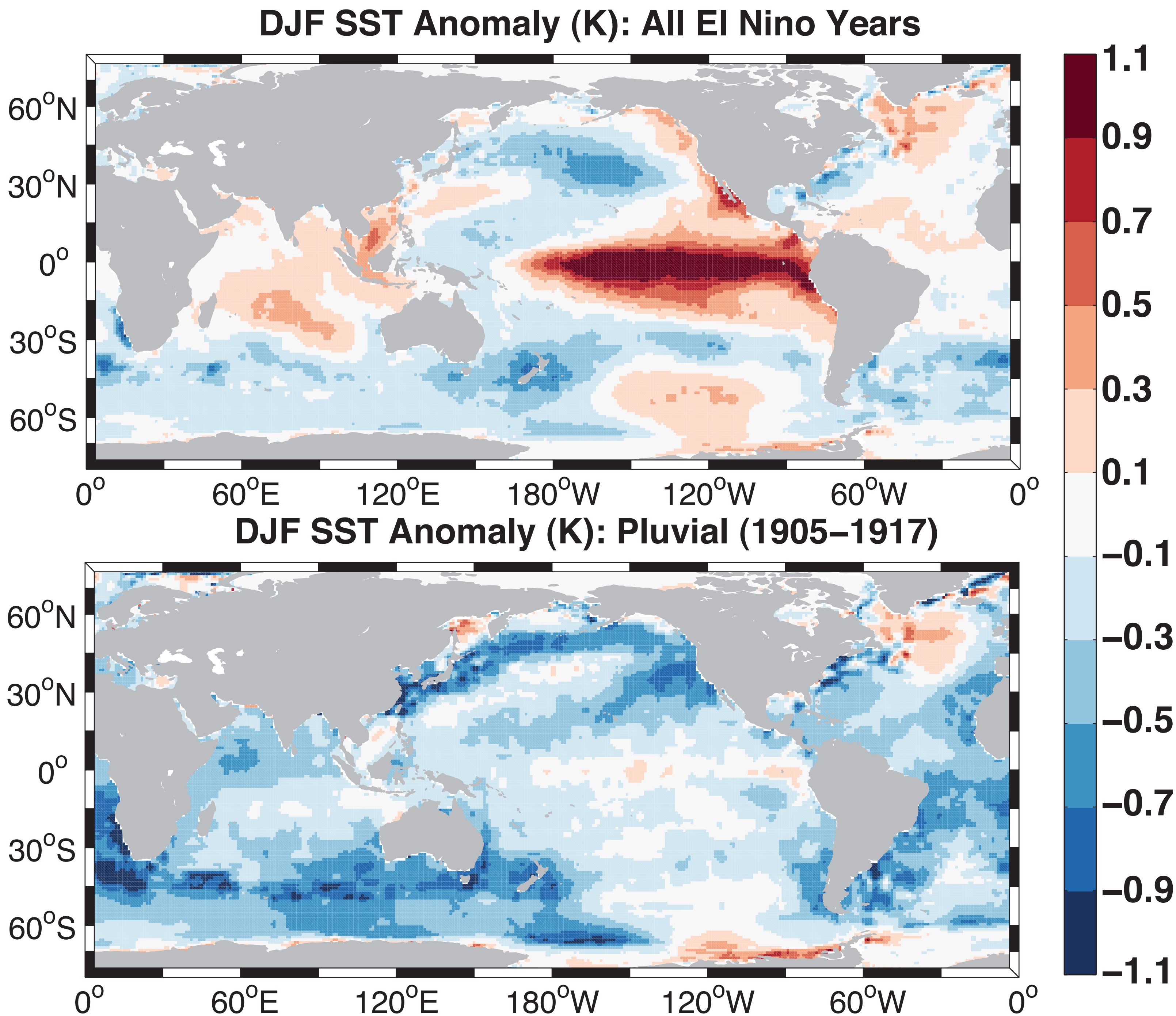

SW PDSI (Obs T, Obs P)
NW PDSI (Obs T, Obs P)
CP PDSI (Obs T, Obs P)
SW PDSI (Clim T, Obs P)
NW PDSI (Clim T, Obs P)
CP PDSI (Clim T, Obs P)
SW PDSI (Obs T, Clim P)
NW PDSI (Obs T, Clim P)
CP PDSI (Obs T, Clim P)
3
2
1
0
−1
−2
−3
1905
1910
1915
1920
1925

Climate Dynamics During the Pluvial

- ENSO?
  - Five El Nino winters (DJF) during the pluvial
  - 1905, 1906, 1912, 1914, 1915
- Extratropical SSTs?
  - Cold North Pacific, impact predicted by Fye et al, 2003
- Arctic Oscillation?
  - Ten out of thirteen winters during the pluvial +AO phase
  - 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1913, 1914, 1916

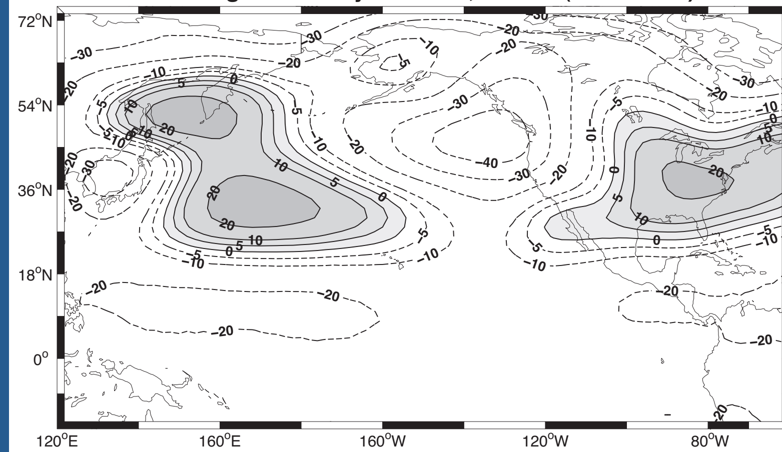





DJF SST Anomaly (K): All El Nino Years
DJF SST Anomaly (K): Pluvial (1905–1917)
60°N
30°N
0°
30°S
60°S
0°
60°E
120°E
180°W
120°W
60°W
0°
1.1
0.9
0.7
0.5
0.3
0.1
−0.1
−0.3
−0.5
−0.7
−0.9
−1.1

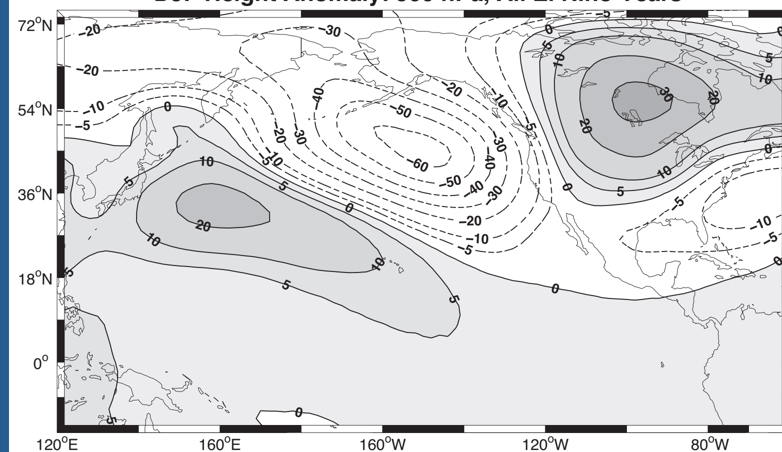
Pluvial Composite

DJF Height Anomaly: 500 hPa, Pluvial (1905–1917)



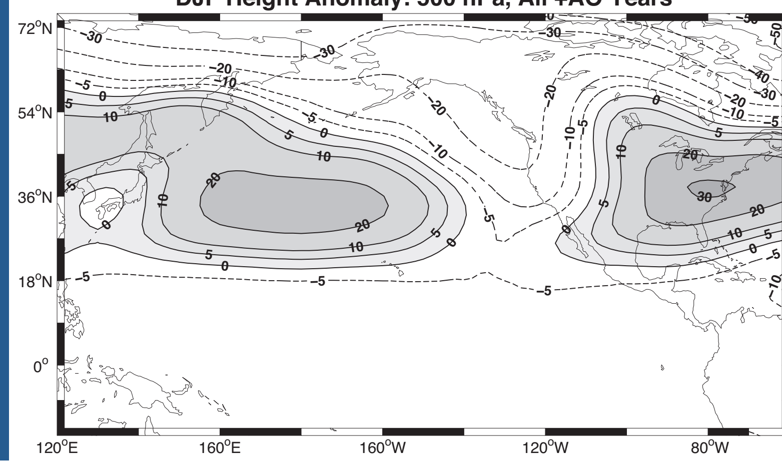
ENSO Composite

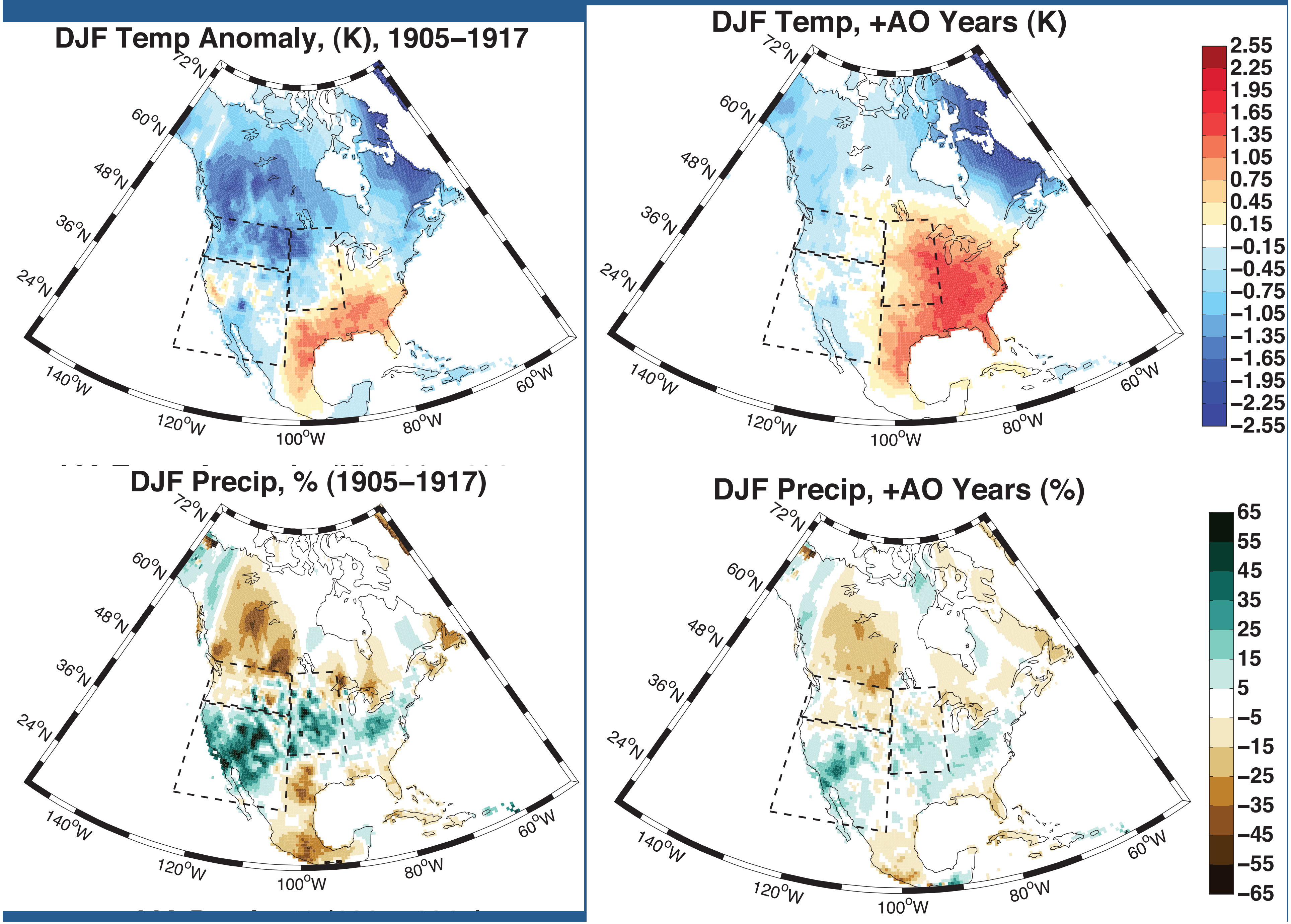
DJF Height Anomaly: 500 hPa, All El Niño Years



AO Composite

DJF Height Anomaly: 500 hPa, All +AO Years




DJF Temp Anomaly, (K), 1905–1917
DJF Temp, +AO Years (K)
DJF Precip, % (1905–1917)
DJF Precip, +AO Years (%)
72°N
60°N
48°N
36°N
24°N
140°W
120°W
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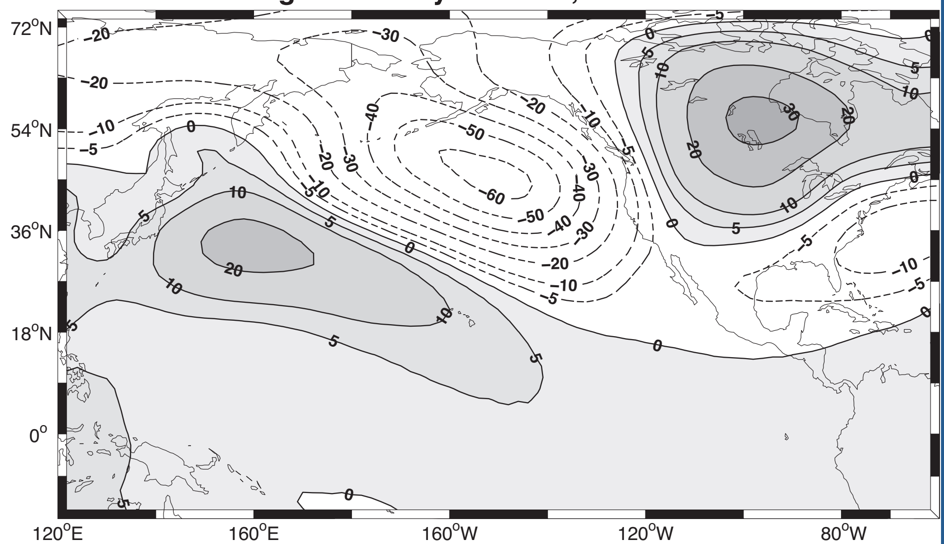
0.75
0.45
0.15
−0.15
−0.45
−0.75
−1.05
−1.35
−1.65
−1.95
−2.25
−2.55
65
55
45
35
25
15
5
−5
−15
−25
−35
−45
−55
−65

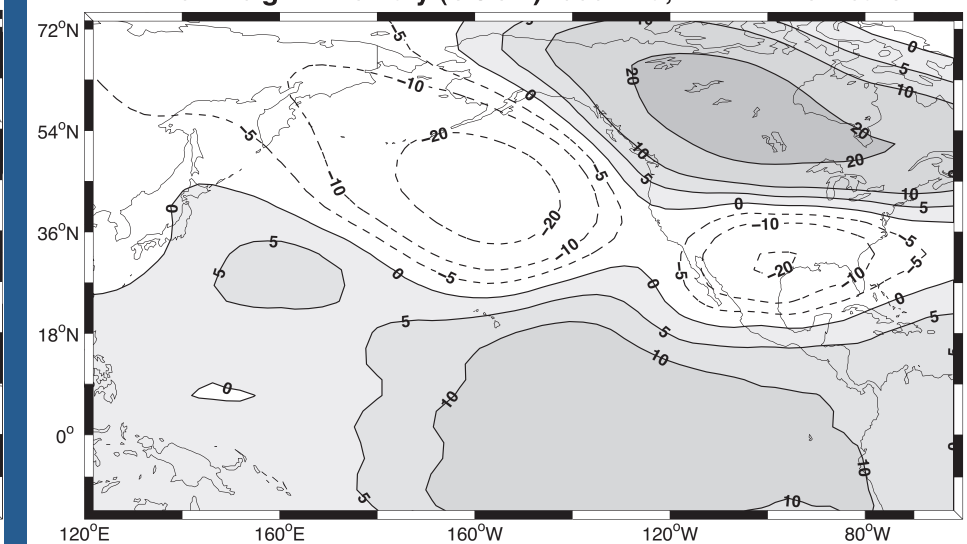
Circulation:

Reanalysis vs Model

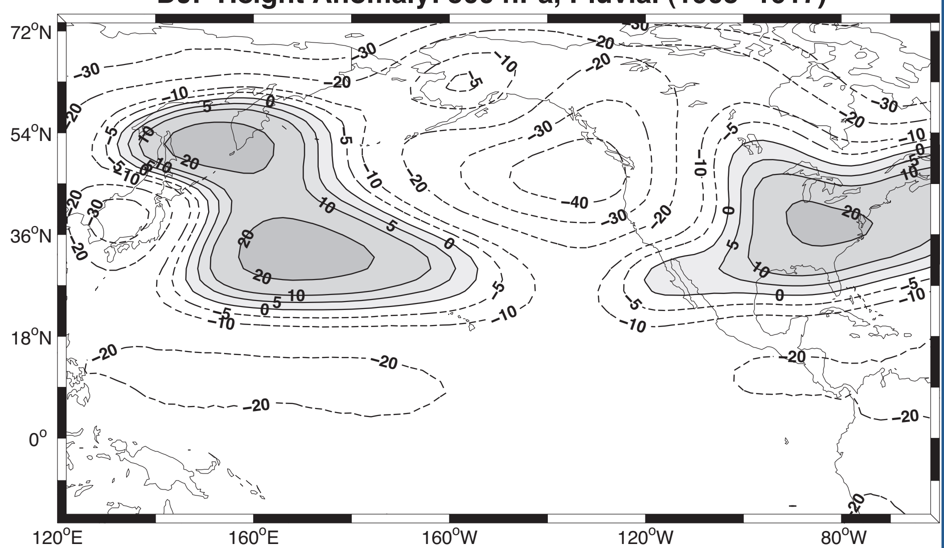
DJF Height Anomaly: 500 hPa, All El Nino Years



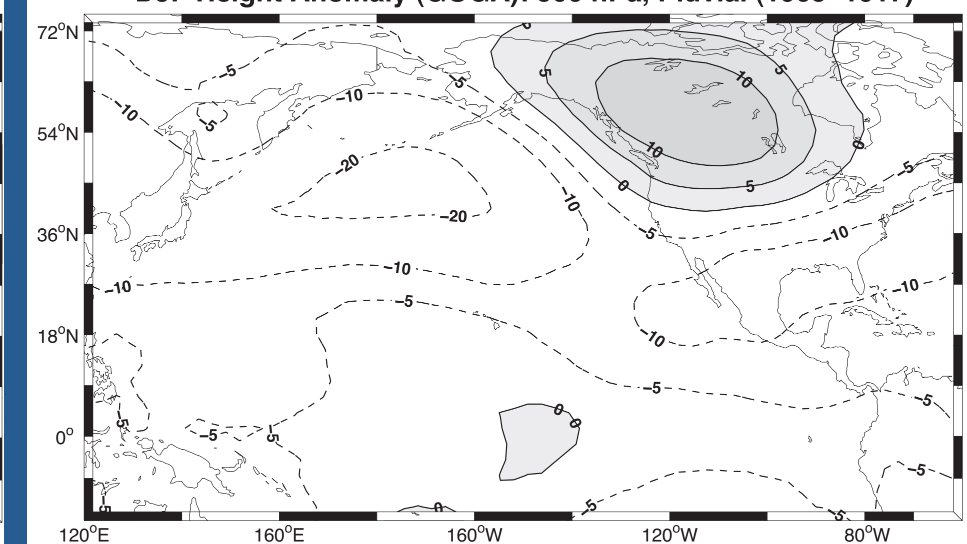
DJF Height Anomaly (GOGA): 500 hPa, All El Nino Years



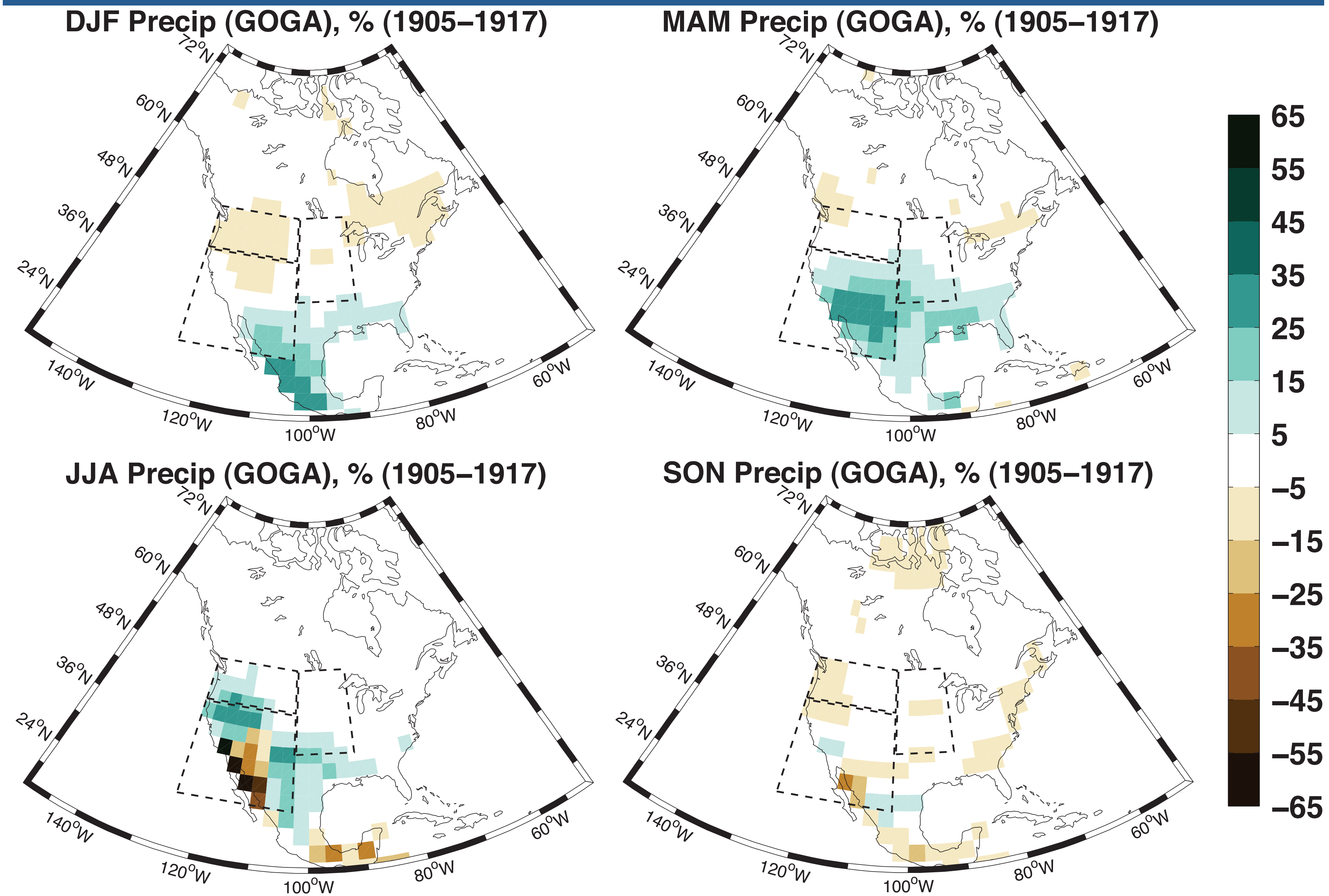
DJF Height Anomaly: 500 hPa, Pluvial (1905–1917)



DJF Height Anomaly (GOGA): 500 hPa, Pluvial (1905–1917)



Precipitation: Model



Discussion

- Causes of the moisture surpluses varied by region: SW (Precip), CP (Temp), NW (Temp+Precip)
- Five El Nino events played a role, primarily for increased precipitation in the SW.
- Internal versus forced variability?
- How different are pluvials?