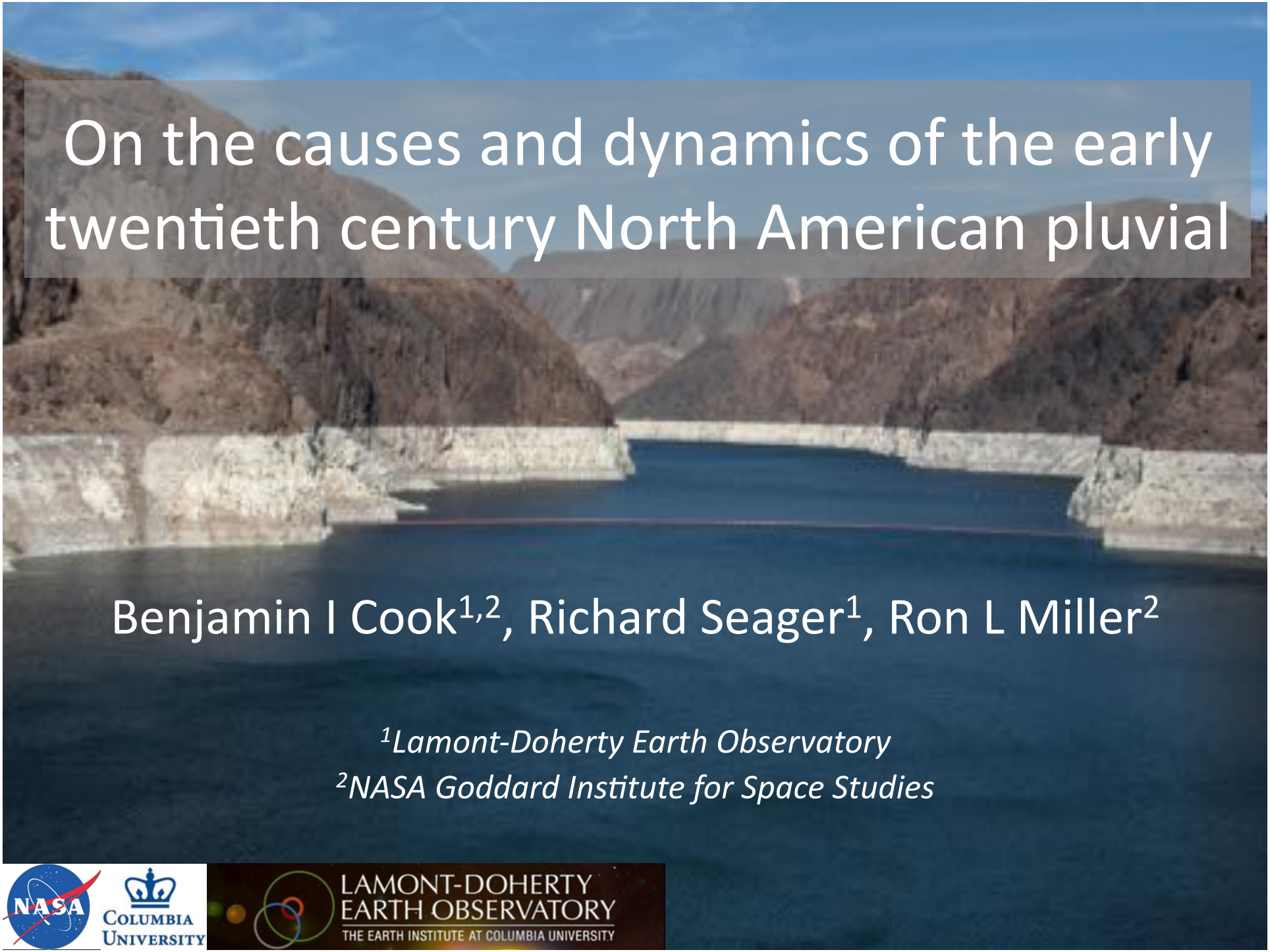

On the causes and dynamics of the early twentieth century North American pluvial

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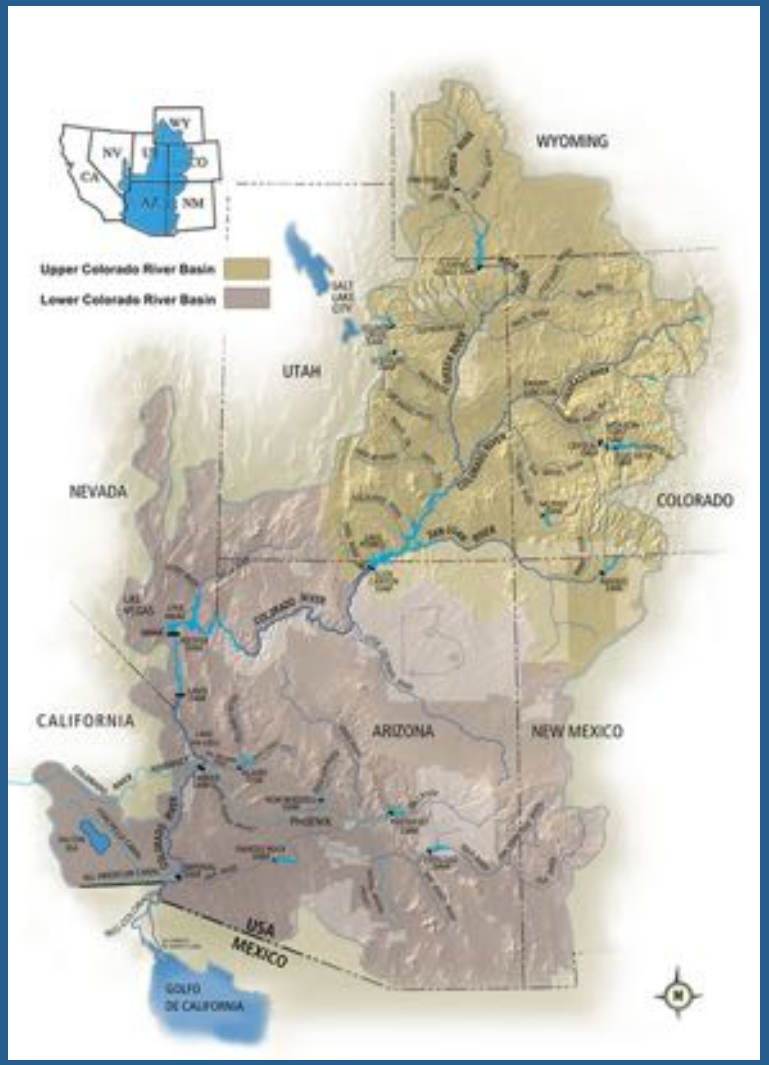
NASA
COLUMBIA UNIVERSITY
LAMONT-DOHERTY EARTH OBSERVATORY
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY

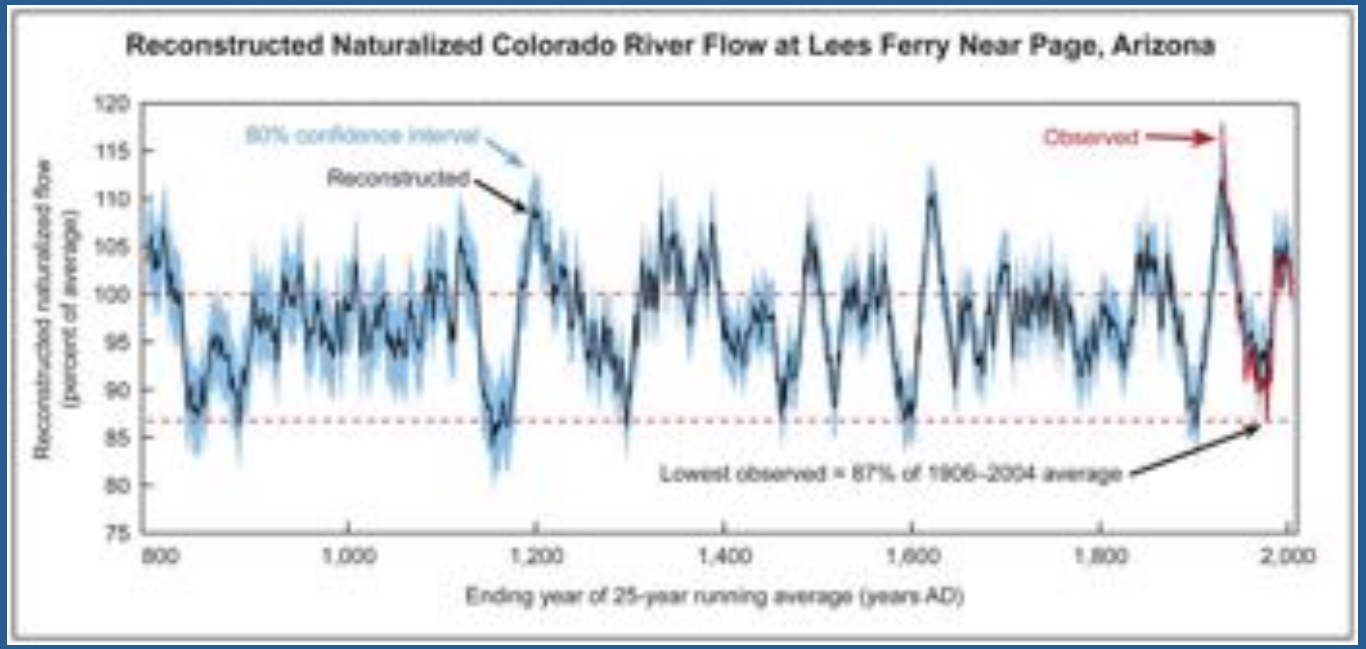
Colorado River Compact

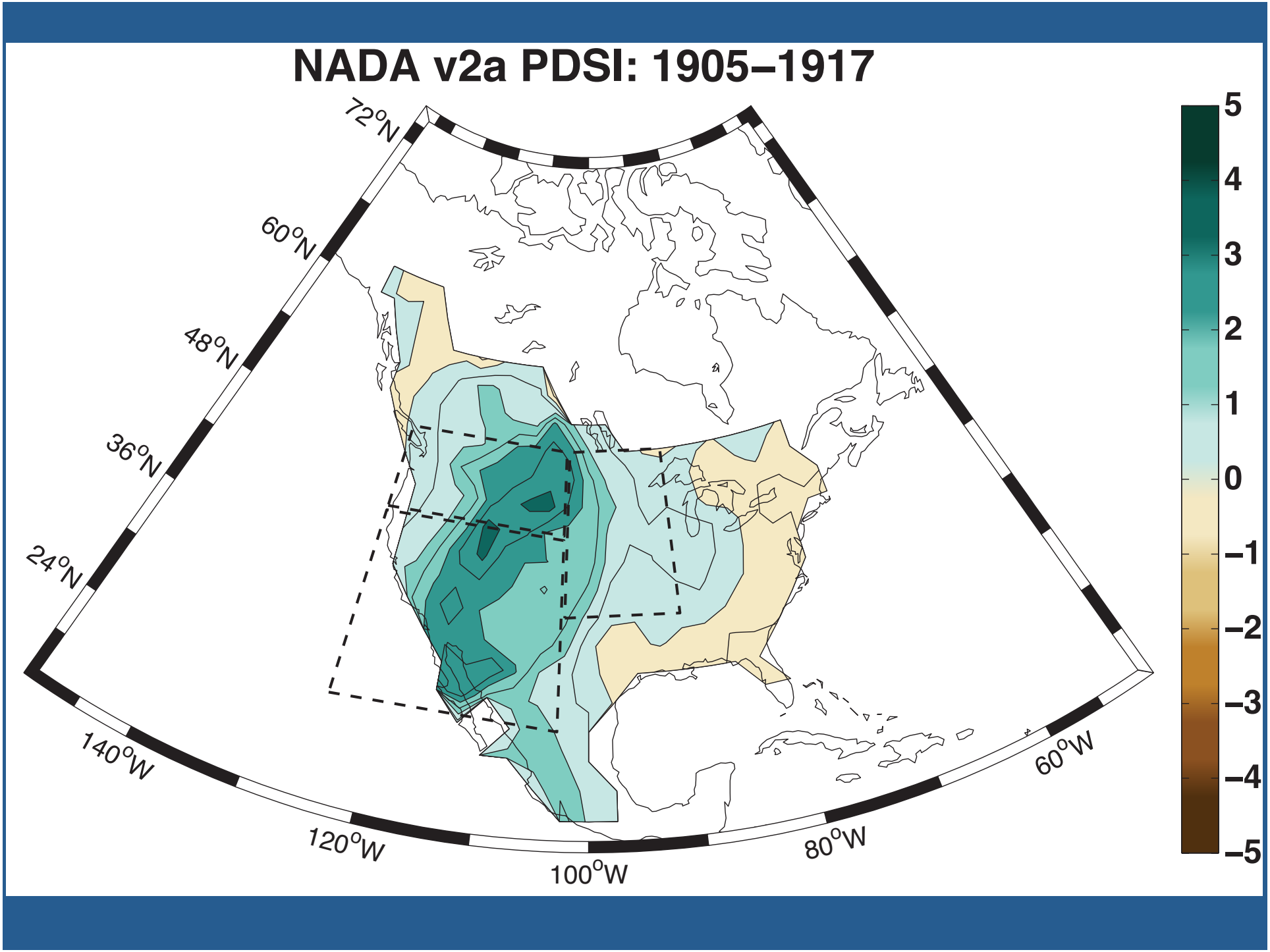
- Signed in 1922
- Apportioned discharge from the Colorado River among Upper and Lower Basin states and Mexico
- Based on early 20th century climatological flows of 22 BCM
- Optimistic…



Long Term Climatology

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




NADA v2a PDSI: 1905–1917
72°N
60°N
48°N
36°N
24°N
140°W
120°W
100°W
80°W
60°W
5
4
3
2
1
0
−1
−2
−3
−4
−5

Questions

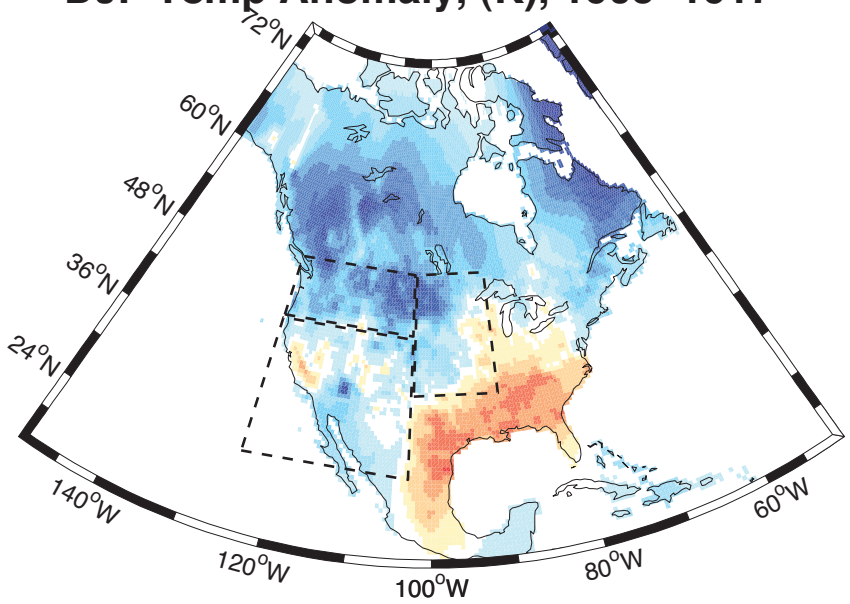
- What is the relative importance of temperature versus precipitation for explaining the pluvial moisture surpluses?

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

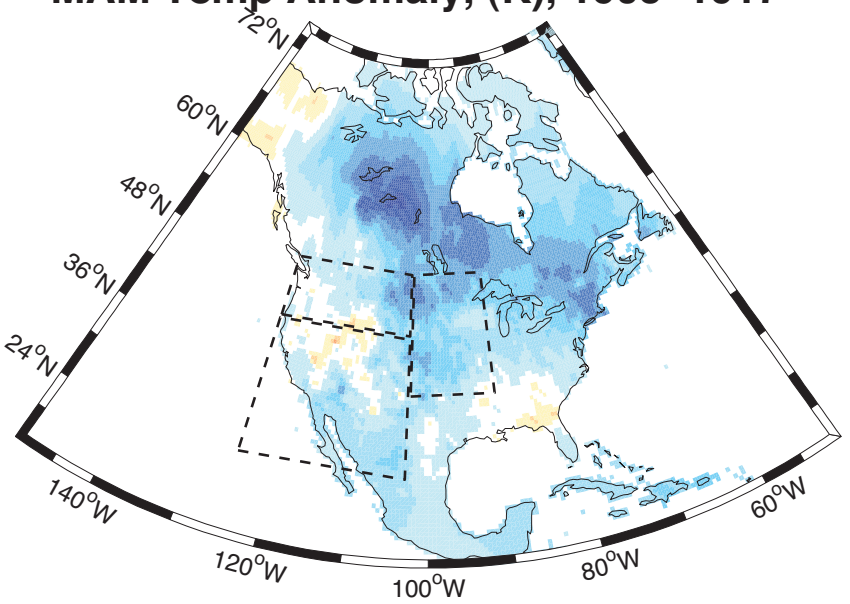
Data

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

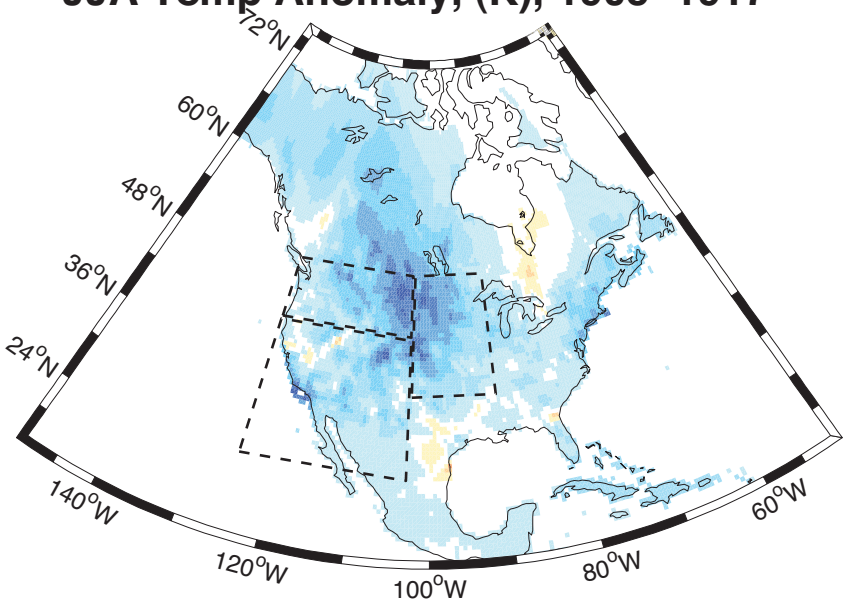
DJF Temp Anomaly, (K), 1905–1917



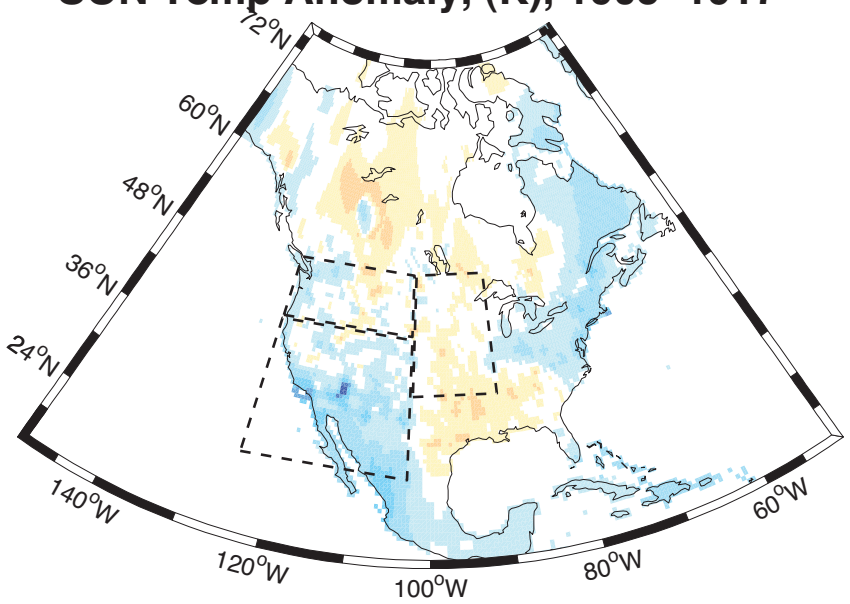
MAM Temp Anomaly, (K), 1905–1917

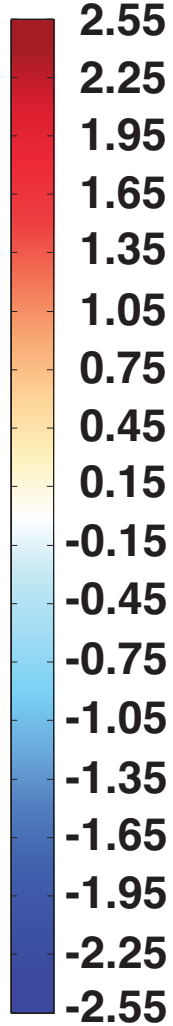


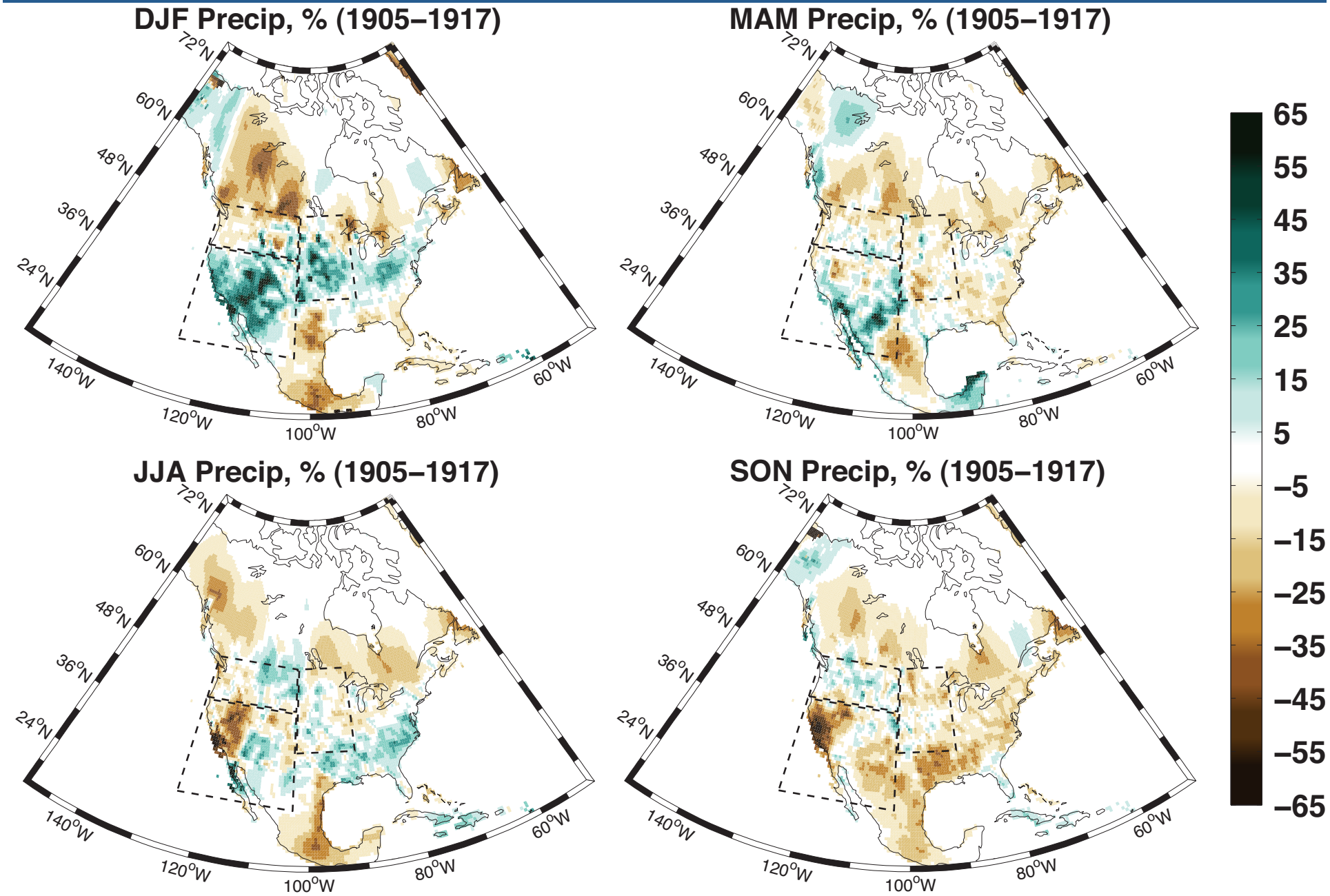
JJA Temp Anomaly, (K), 1905–1917

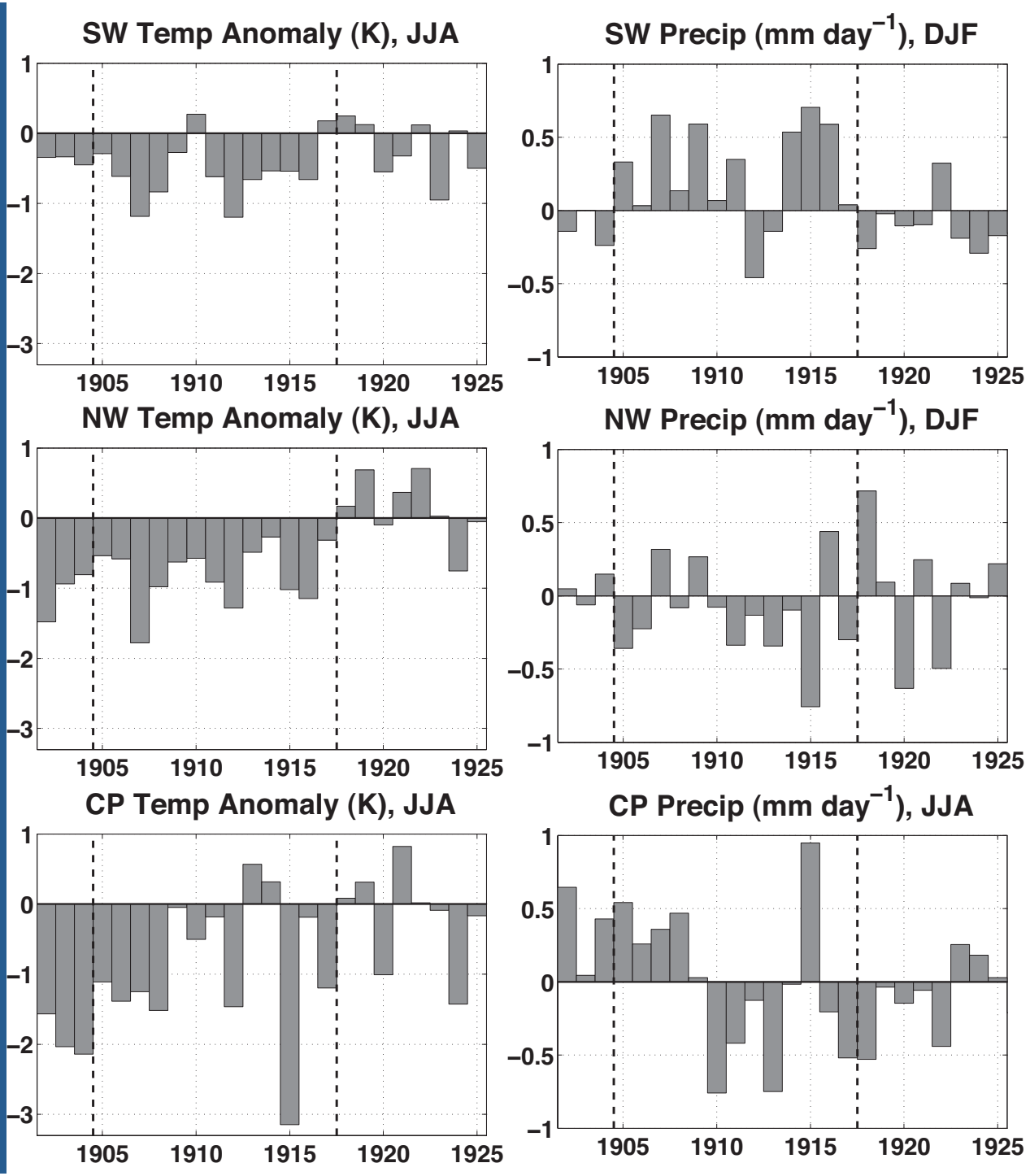


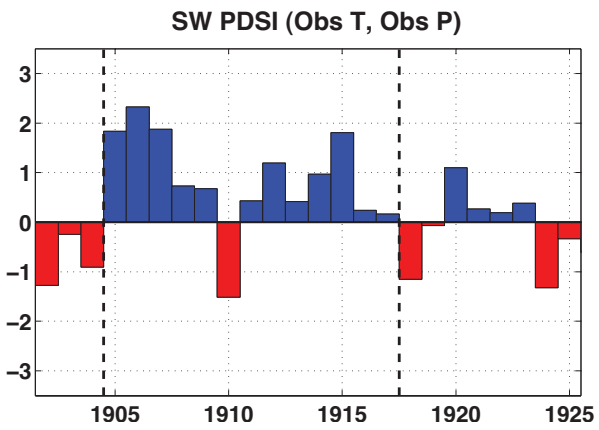
SON Temp Anomaly, (K), 1905–1917

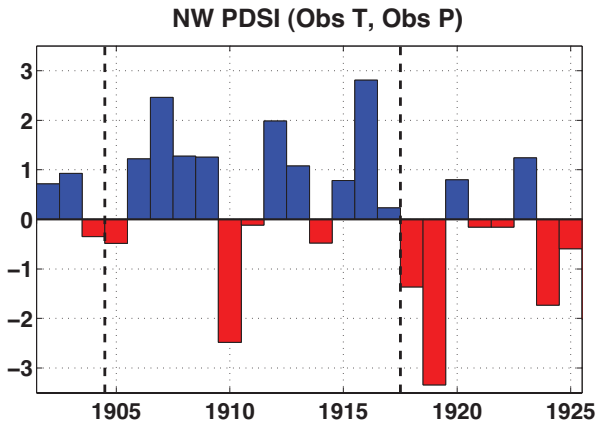


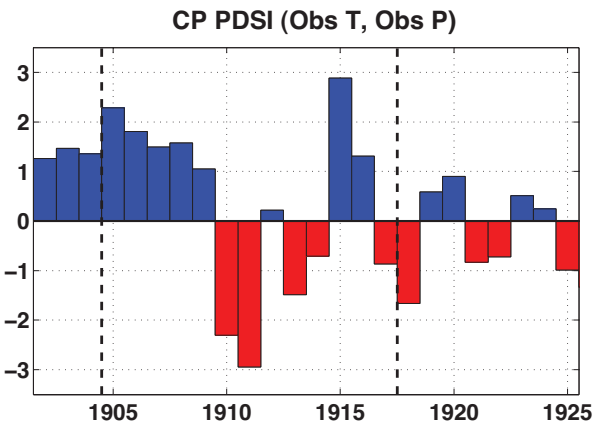


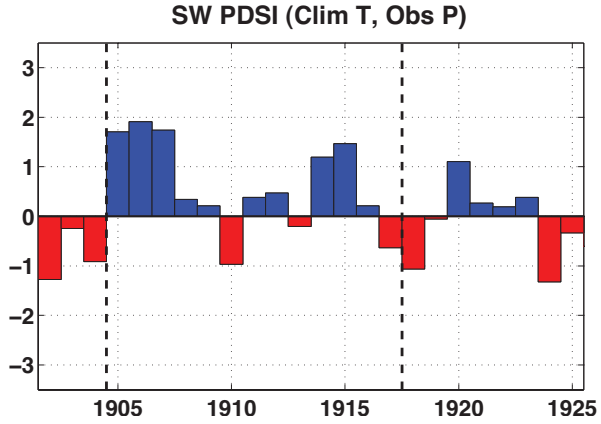

DJF Precip, % (1905–1917)
MAM Precip, % (1905–1917)
JJA Precip, % (1905–1917)
SON Precip, % (1905–1917)
72°N
60°N
48°N
36°N
24°N
140°W
120°W
100°W
80°W
60°W
65
55
45
35
25
15
5
–5
–15
–25
–35
–45
–55
–65

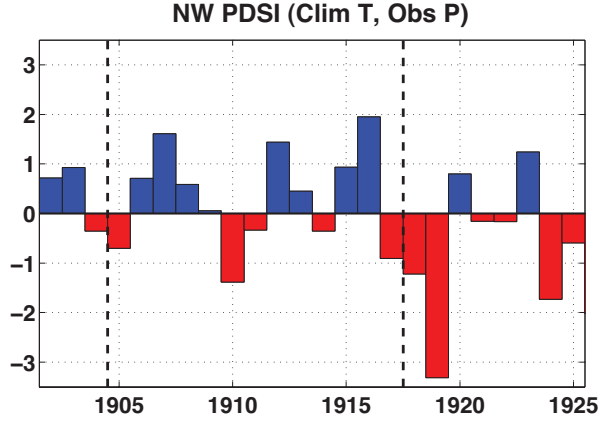

SW Temp Anomaly (K), JJA
SW Precip (mm day^{-1}), DJF
NW Temp Anomaly (K), JJA
NW Precip (mm day^{-1}), DJF
CP Temp Anomaly (K), JJA
CP Precip (mm day^{-1}), JJA
1
0
−1
−2
−3
0.5
−0.5
1905
1910
1915
1920
1925

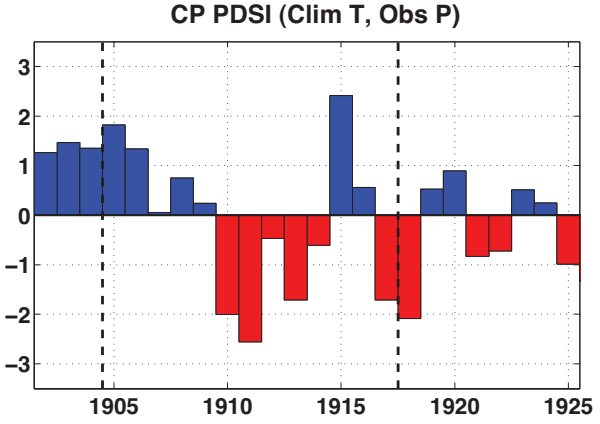

SW PDSI (Obs T, Obs P)
3
2
1
0
−1
−2
−3
1905
1910
1915
1920
1925

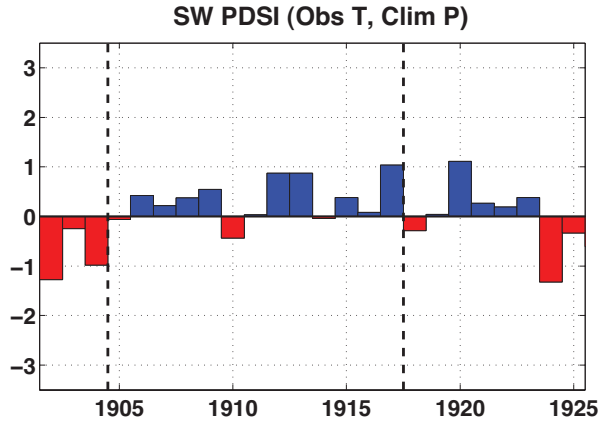

NW PDSI (Obs T, Obs P)
3
2
1
0
−1
−2
−3
1905
1910
1915
1920
1925

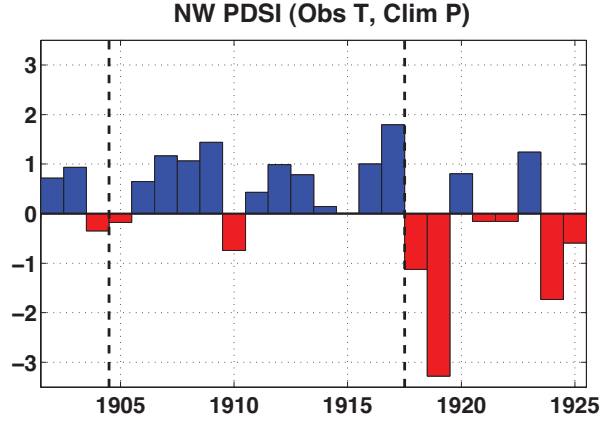

CP PDSI (Obs T, Obs P)
3
2
1
0
−1
−2
−3
1905
1910
1915
1920
1925

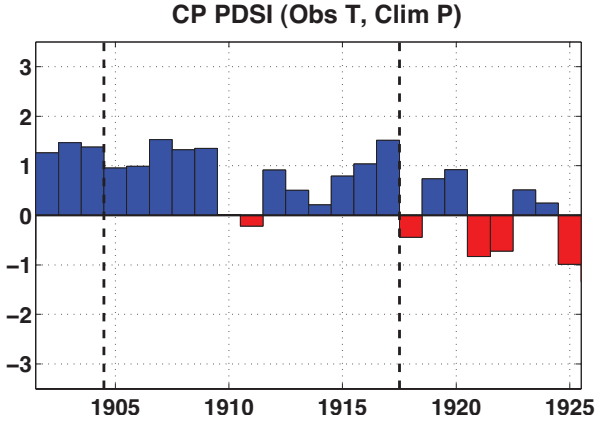

SW PDSI (Clim T, Obs P)
3
2
1
0
−1
−2
−3
1905
1910
1915
1920
1925

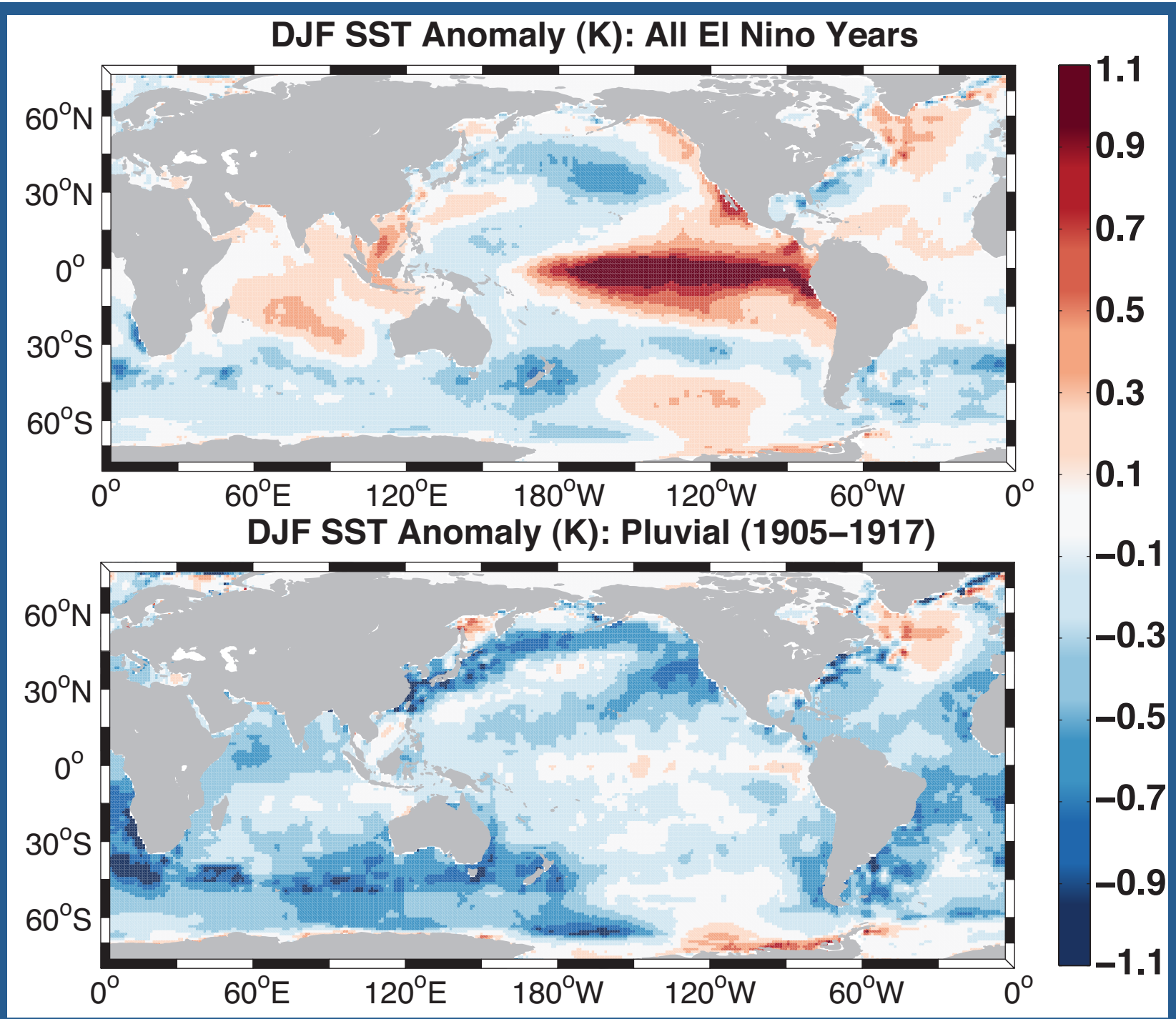

NW PDSI (Clim T, Obs P)
3
2
1
0
−1
−2
−3
1905
1910
1915
1920
1925


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

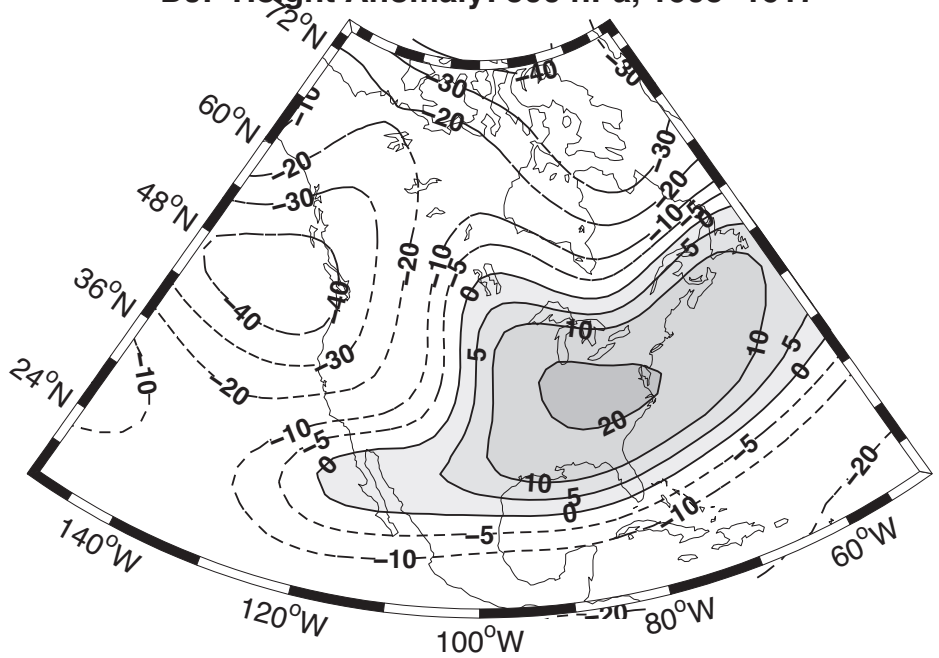

SW PDSI (Obs T, Clim P)
3
2
1
0
−1
−2
−3
1905
1910
1915
1920
1925


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

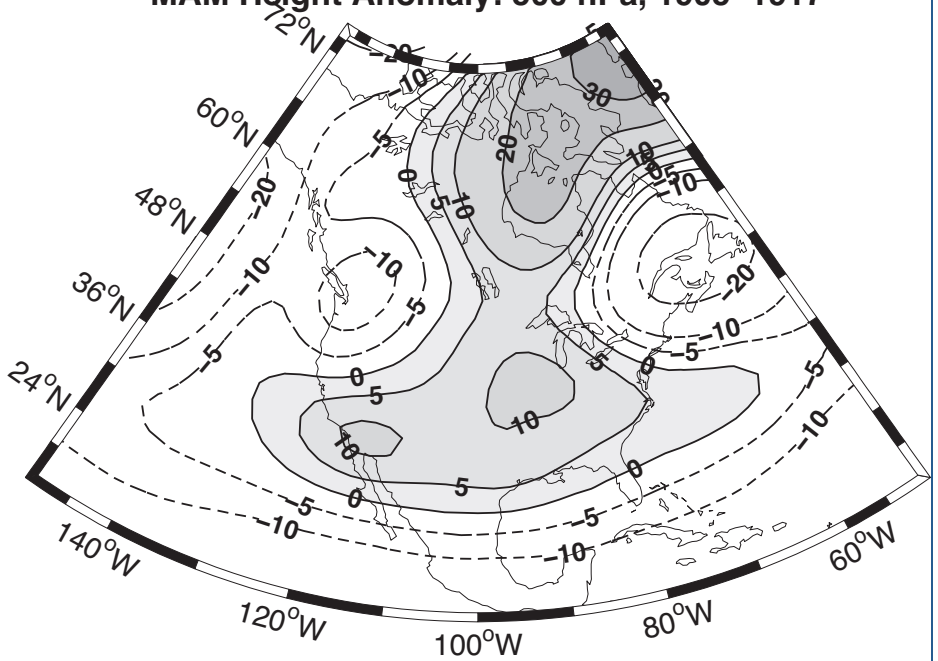

CP PDSI (Obs T, Clim P)
3
2
1
0
−1
−2
−3
1905
1910
1915
1920
1925


DJF SST Anomaly (K): All El Nino Years
60°N
30°N
0°
30°S
60°S
0°
60°E
120°E
180°W
120°W
60°W
0°
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

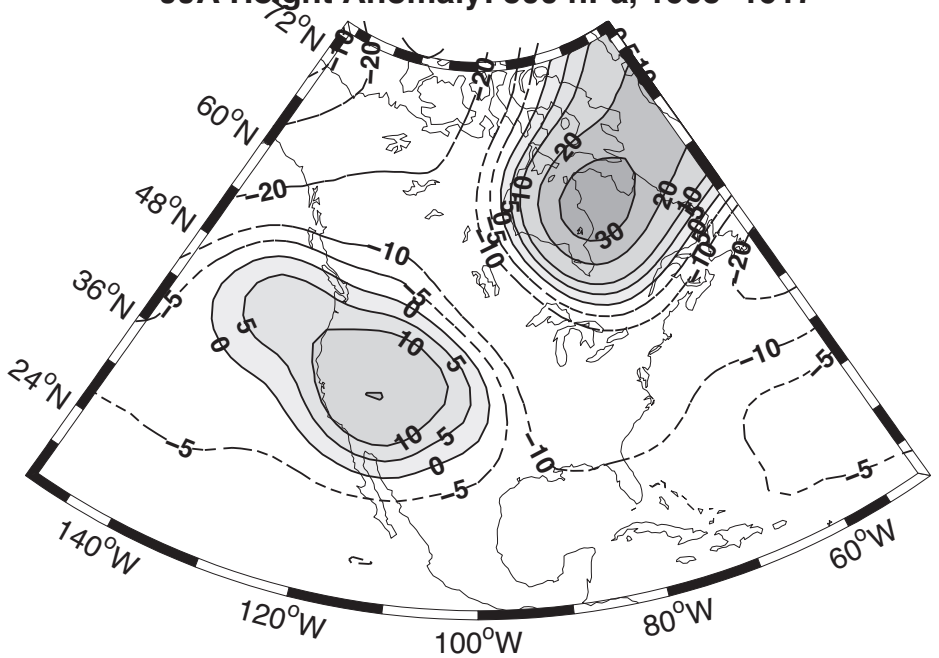
DJF Height Anomaly: 500 hPa, 1905–1917



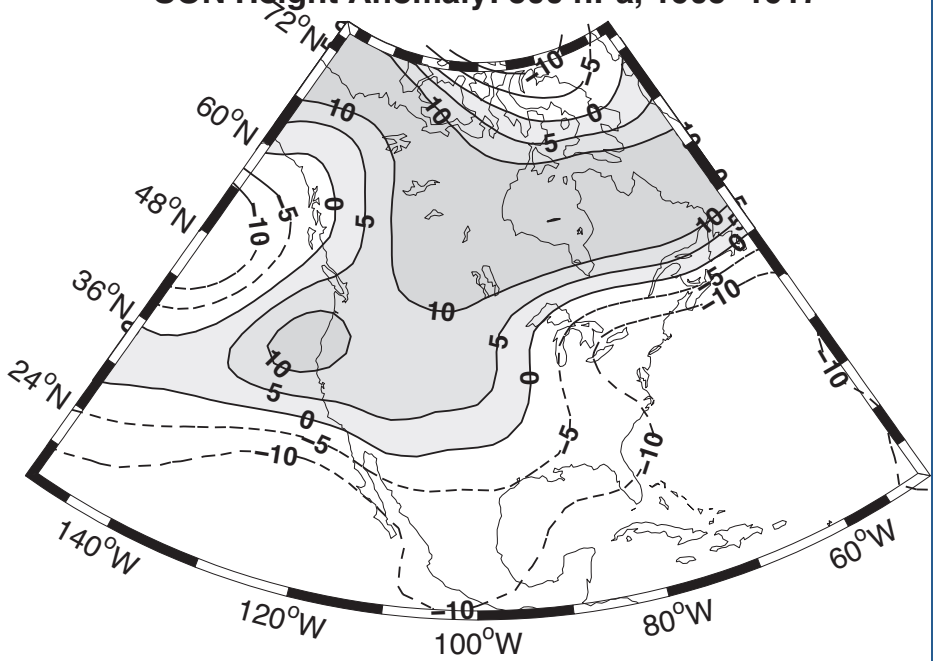
MAM Height Anomaly: 500 hPa, 1905–1917



JJA Height Anomaly: 500 hPa, 1905–1917

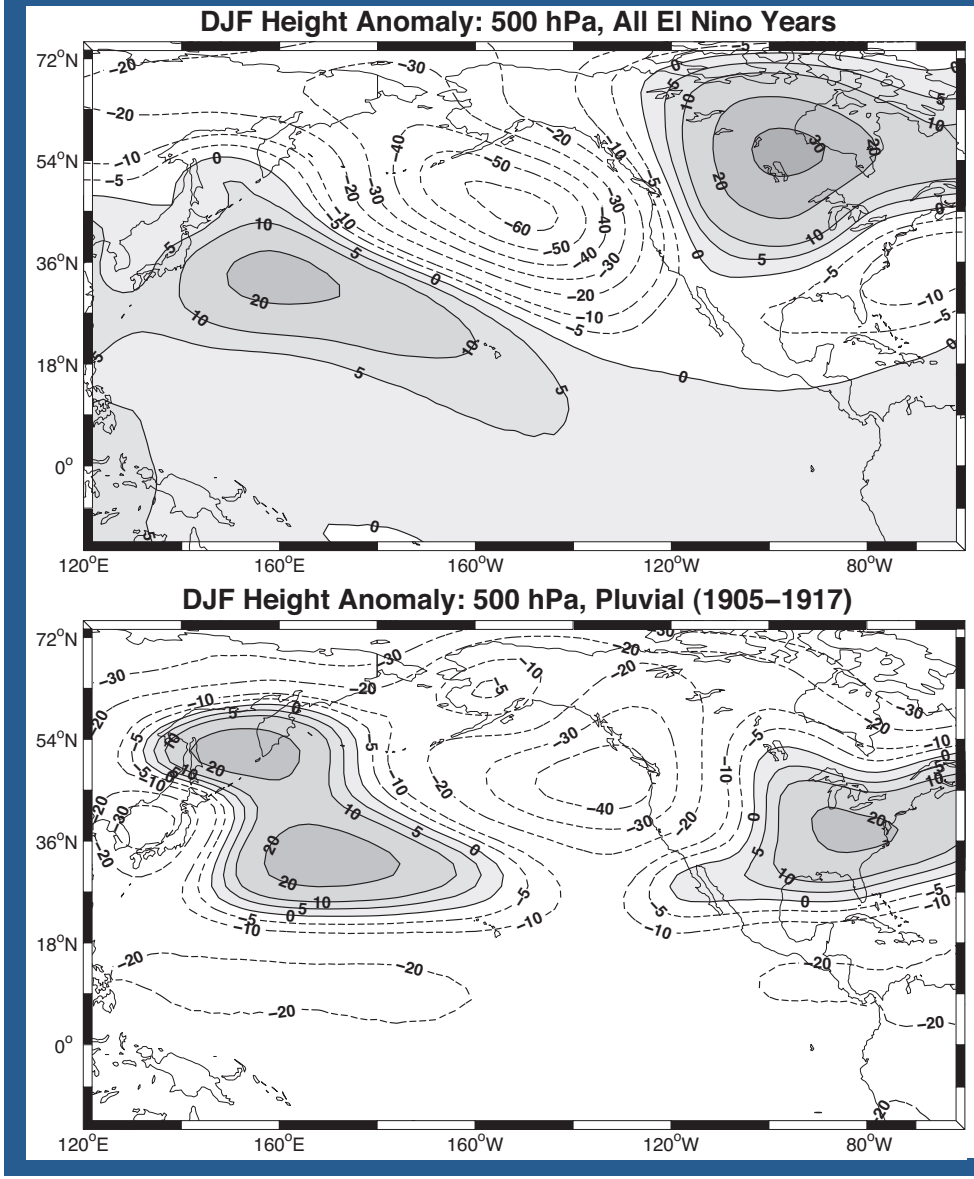


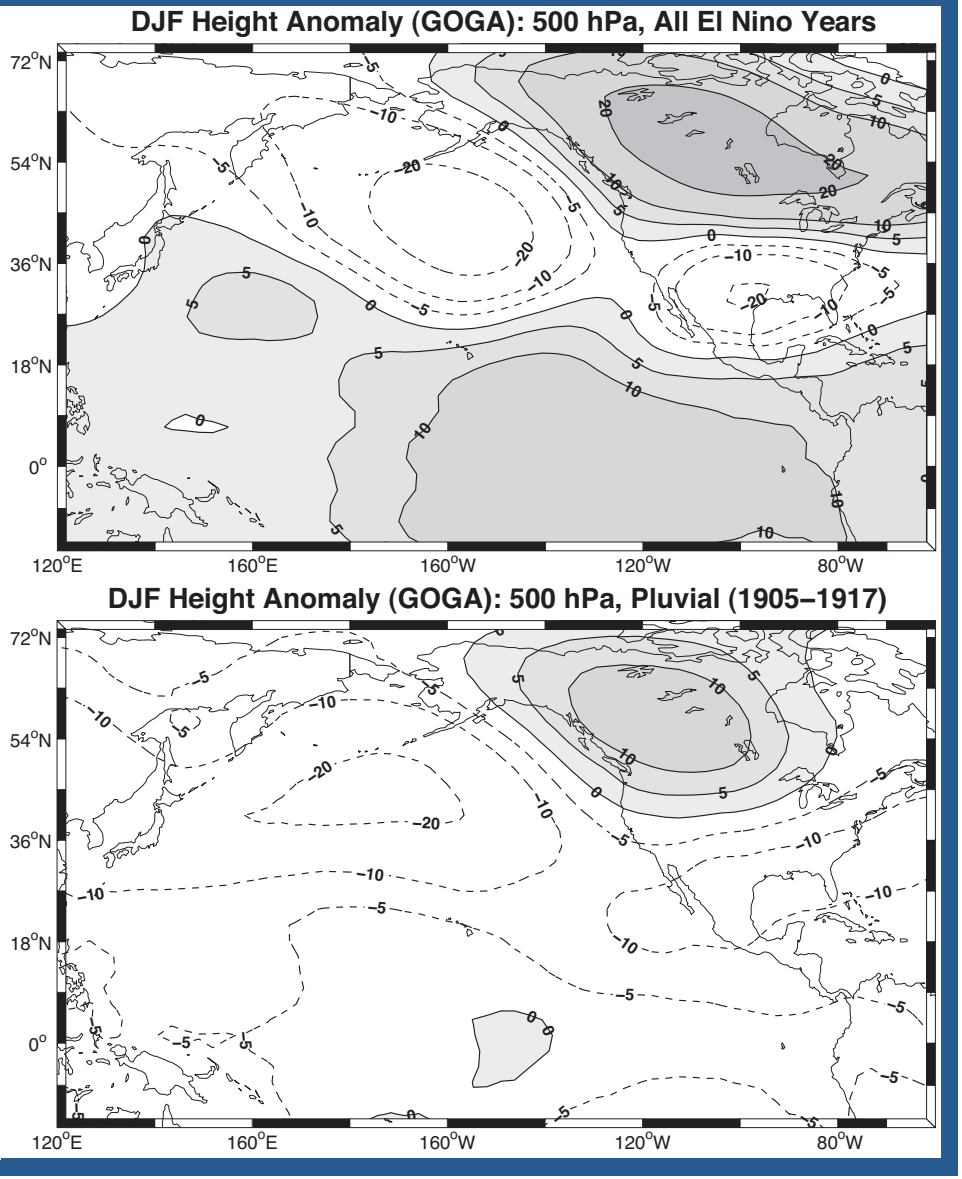
SON Height Anomaly: 500 hPa, 1905–1917



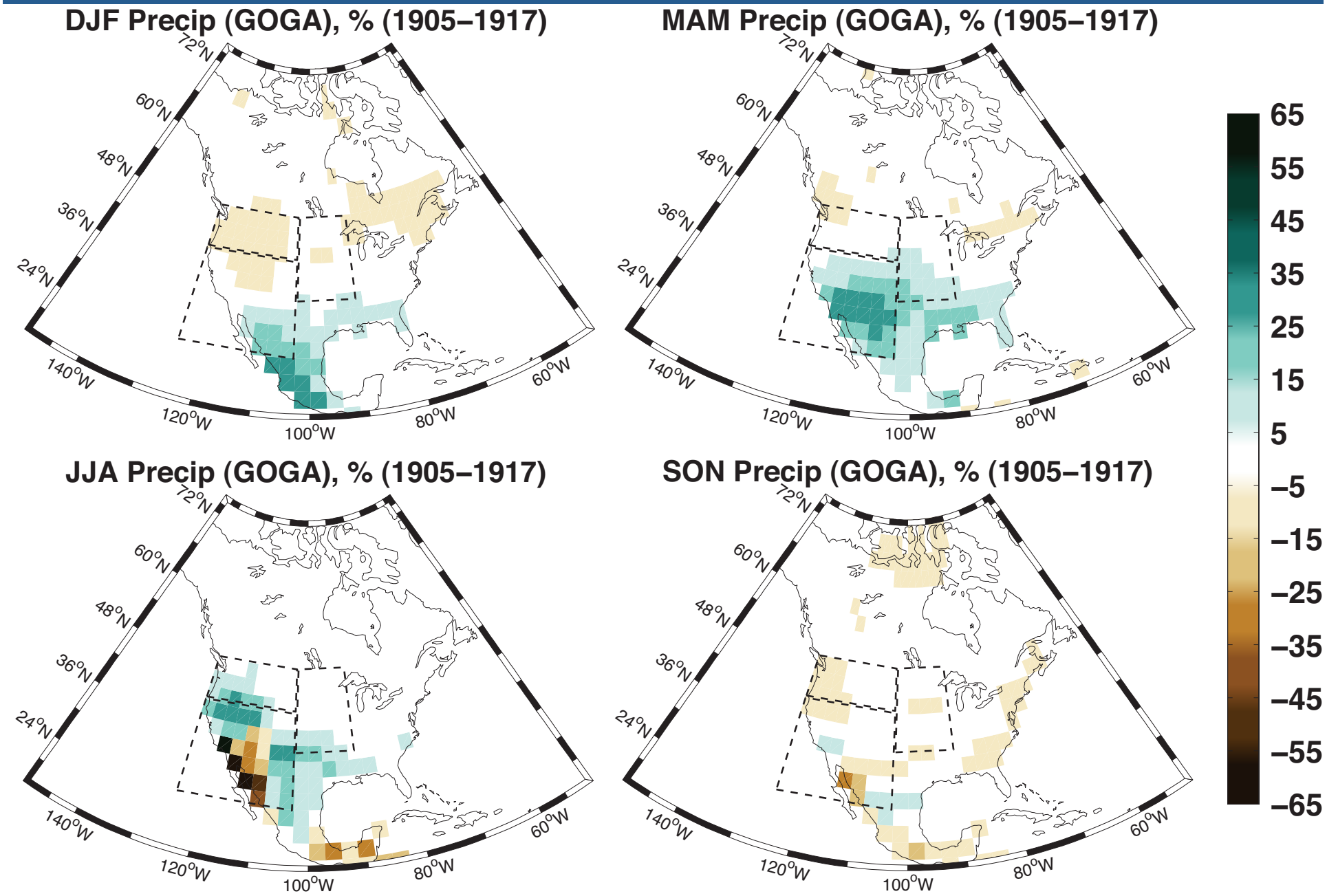
Circulation:

Reanalysis vs Model





Precipitation: Model

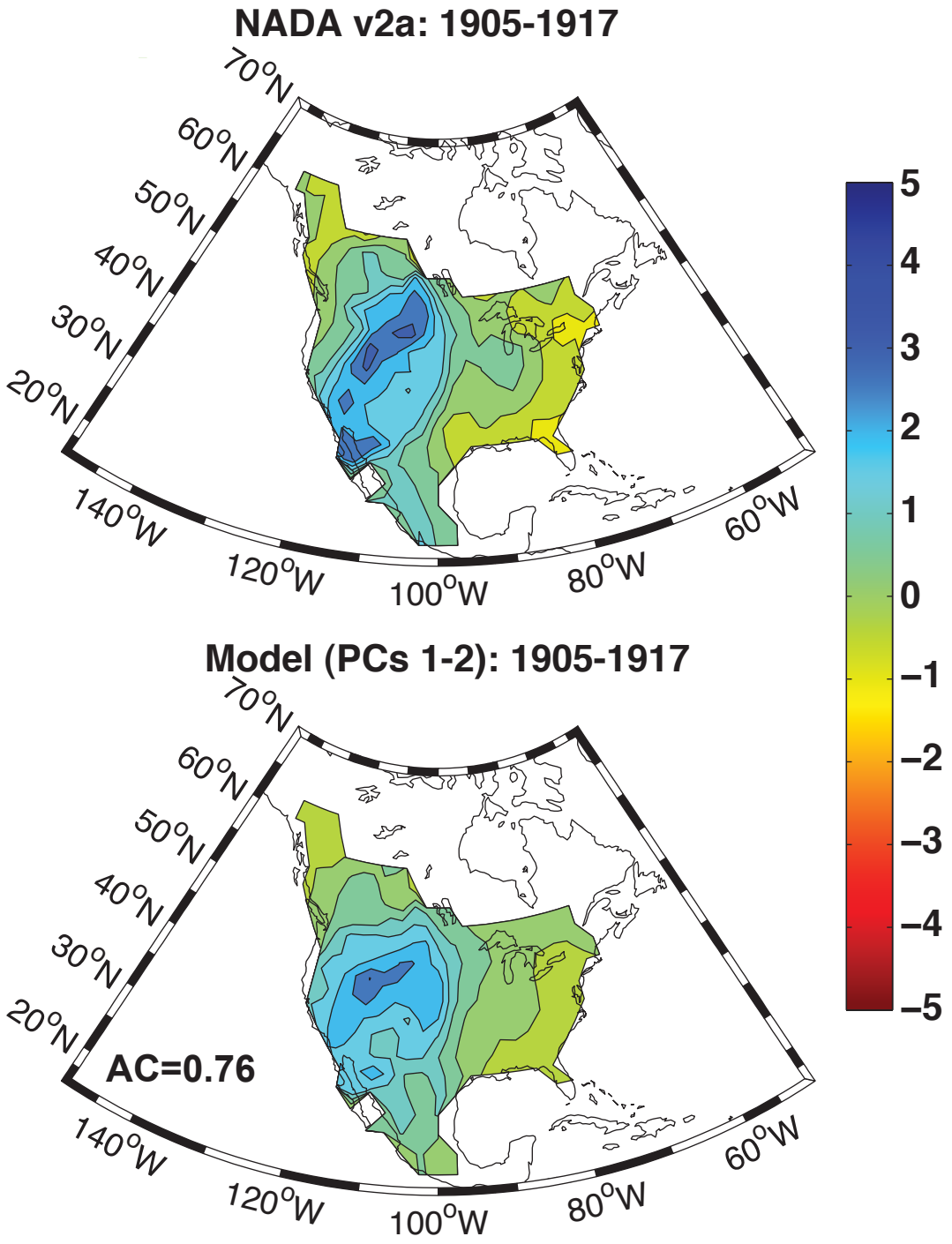


Discussion

- 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?

Cook et al 2010: Statistical Model

Tropical+North Pacific Forcing



Lee's Ferry: Long Term

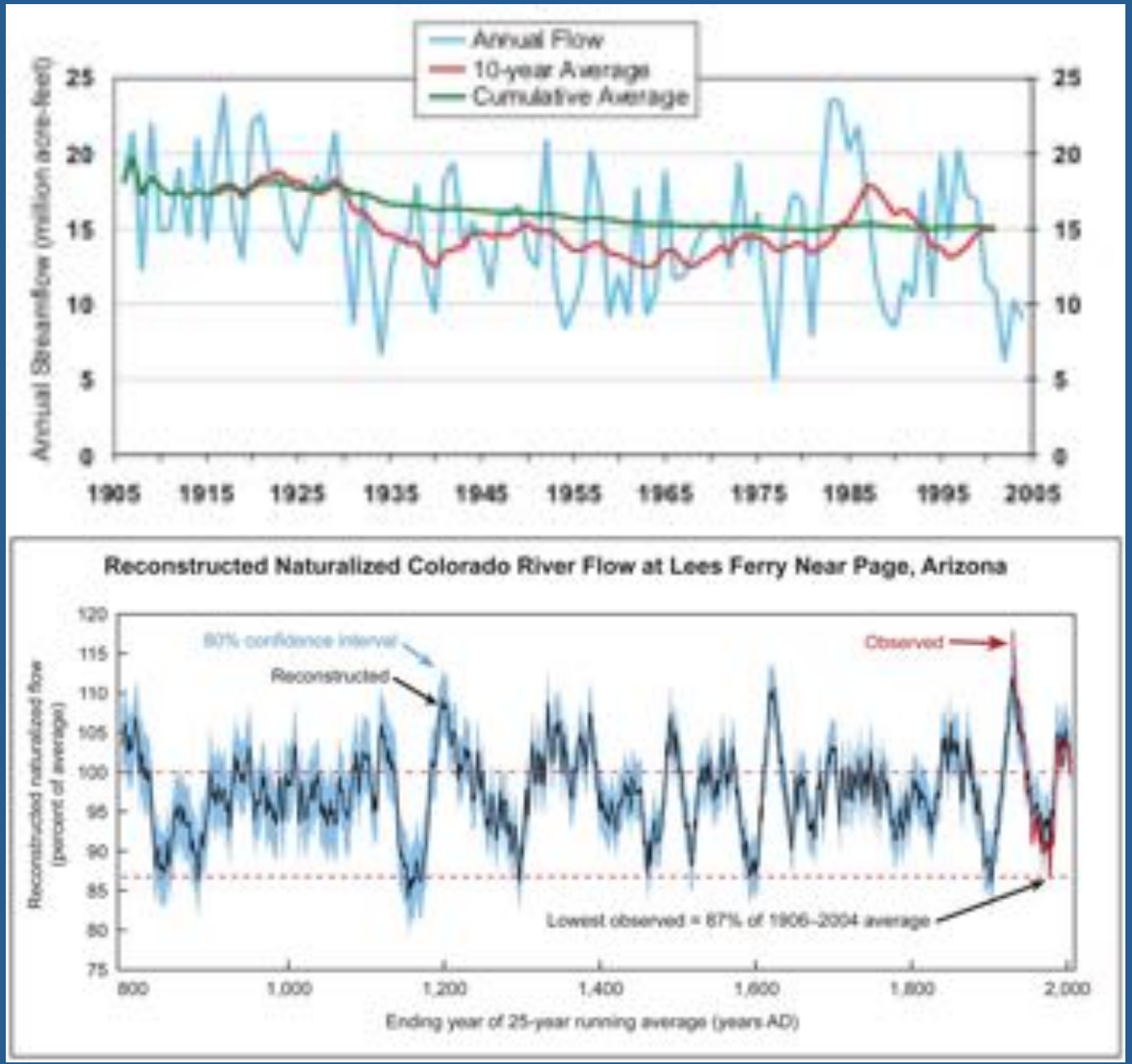
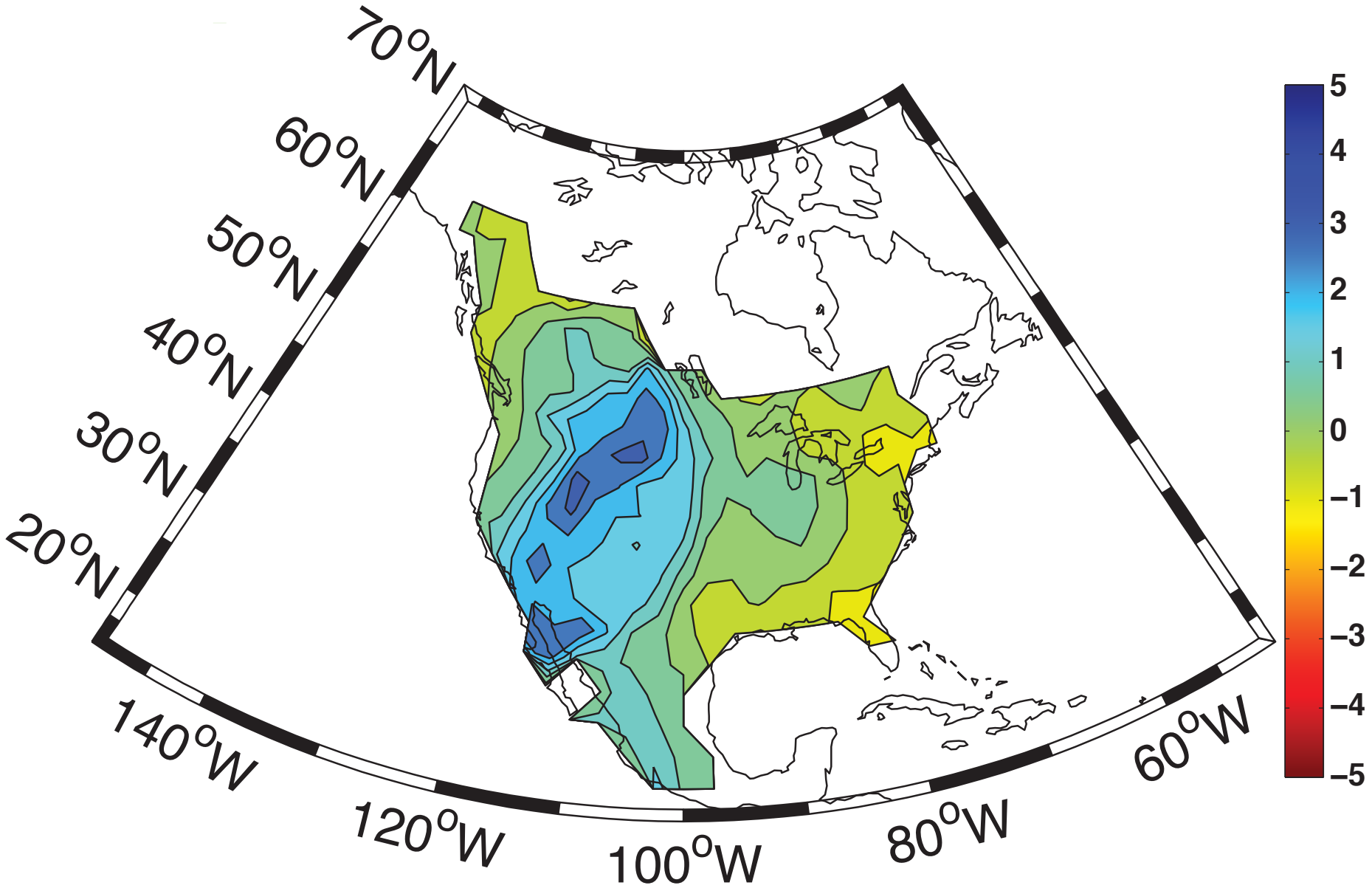
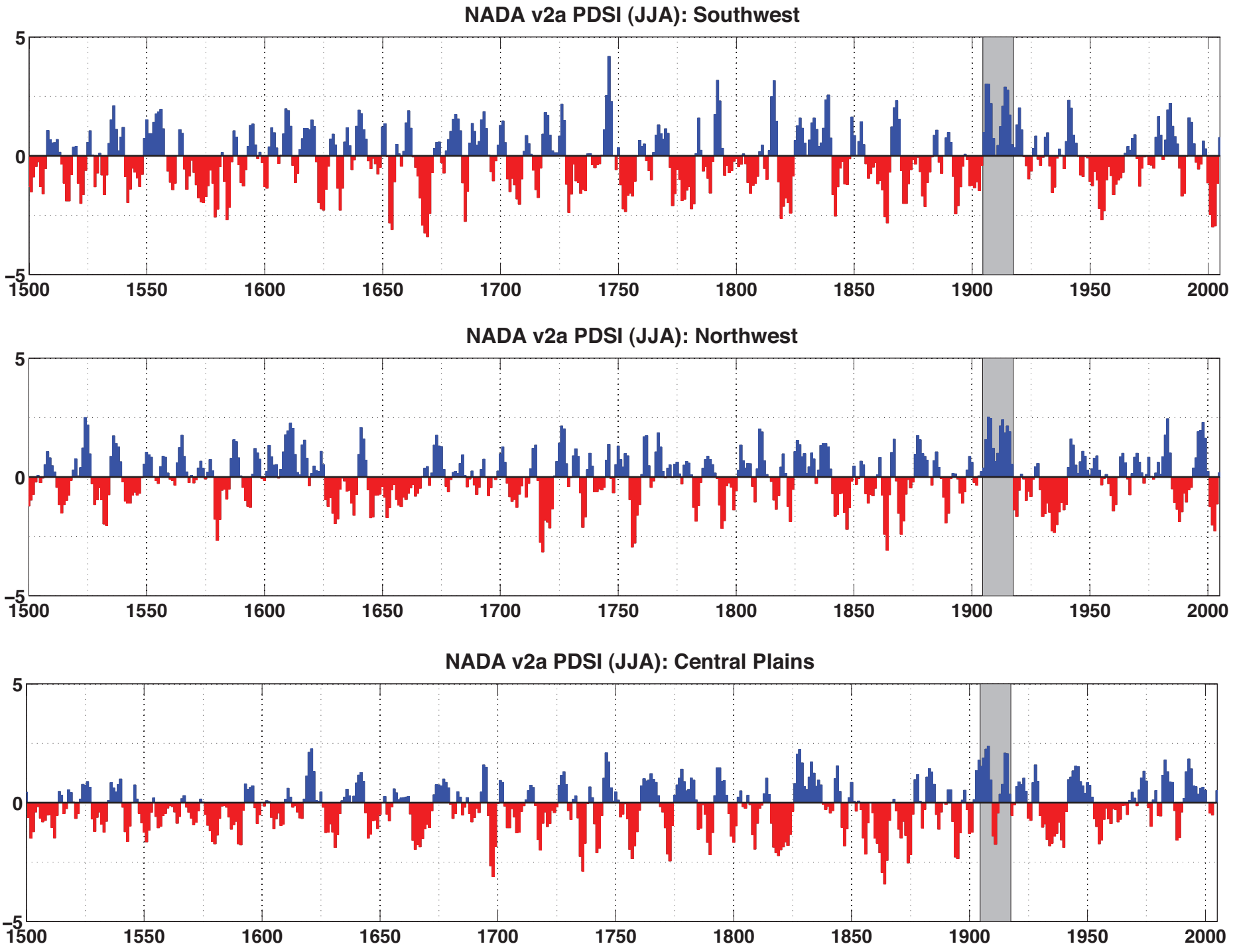


Image credits: Dave Meko

NADA v2a: 1905-1917




NADA v2a PDSI (JJA): Southwest
5
0
−5
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
NADA v2a PDSI (JJA): Northwest
5
0
−5
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
NADA v2a PDSI (JJA): Central Plains
5
0
−5
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000