

Medieval megadroughts in the Four Corners region: Characterization and causes

Richard Seager and Ed Cook

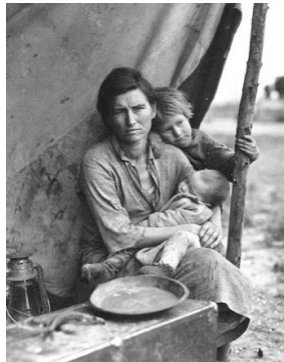
Lamont Doherty Earth Observatory
of Columbia University
Palisades, New York

copies of text and figures at:

<http://www.ldeo.columbia.edu/res/div/ocp/drought/>

work largely funded by NOAA ARCHES program, NSF Climate Dynamics and Earth System History programs,
(opinions mine, not theirs)

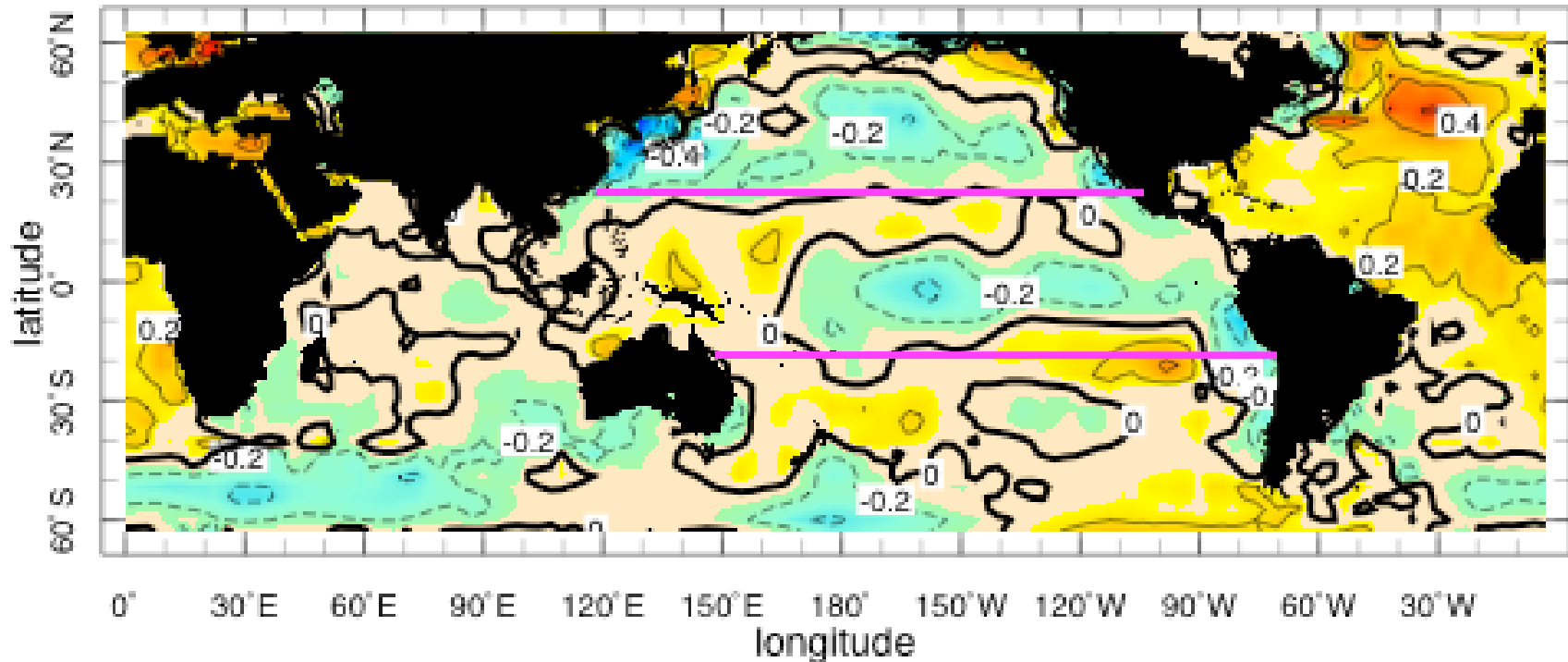
The Dust Bowl drought of the 1930s ...



Was caused by ...

Sea Surface Temperature Anomaly 1932-1939

OBSERVED



Contour interval = 0.2°C

*Critically, a cold, La Nina-like, tropical
Pacific Ocean*

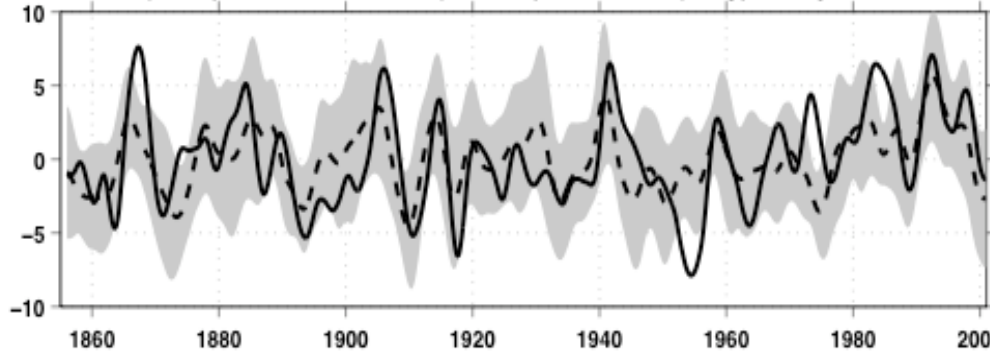
Conclusion based on 3 large ensembles of atmosphere model simulations forced by observed sea surface temperatures (SSTs):

1. Tropical Pacific SSTs only (POGA-ML)
2. Global SSTs (GOGA)
3. Tropical Atlantic SSTs only (TAGA)

Modeled
(dashed) and
observed
(solid)
precipitation
over the
Southwest
1856-2000

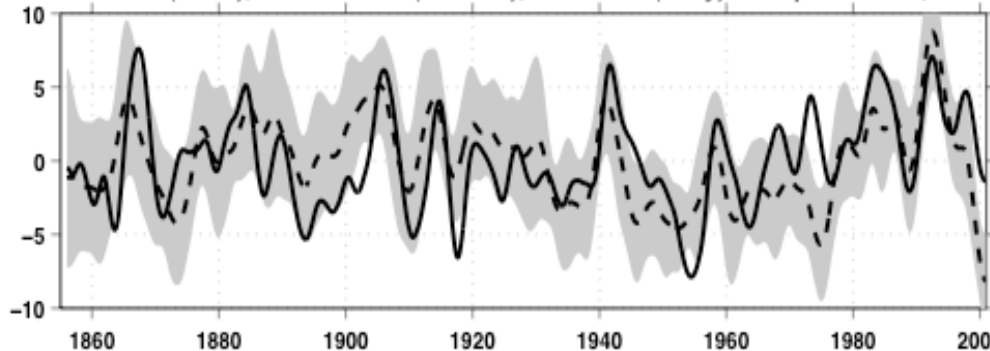
(shading is 2 s.d.
spread of 16
member ensemble)

GHCN Gridded (Solid), POGA-ML Mean (Dashed), +/- 2 STD (Grey) Precip 25N-40N, 95W-120W



POGA-ML

GHCN Gridded (Solid), GOGA Mean (Dashed), +/- 2 STD (Grey) Precip 25N-40N, 95W-120W

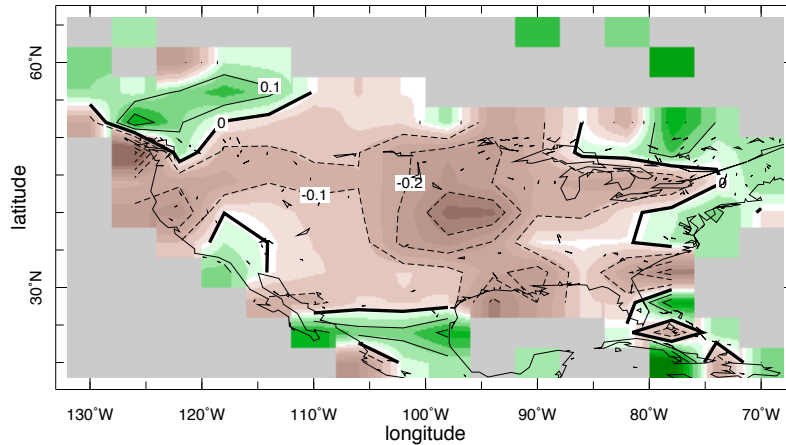


GOGA

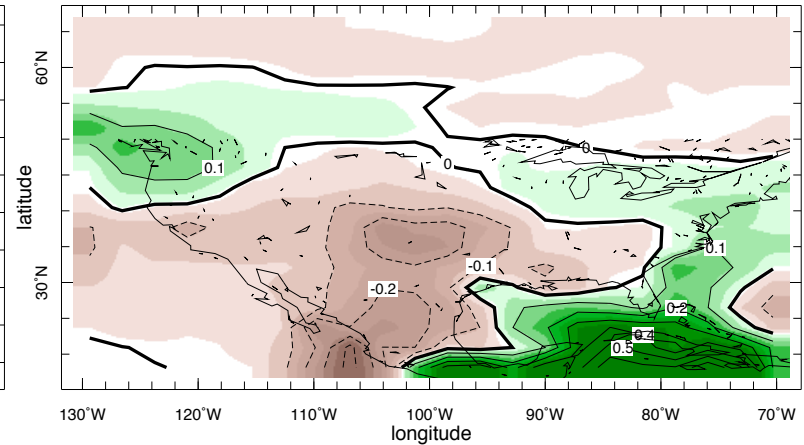
The Dust Bowl: a case of cooperative Pacific and Atlantic SST anomalies

Precipitation 1932-1939

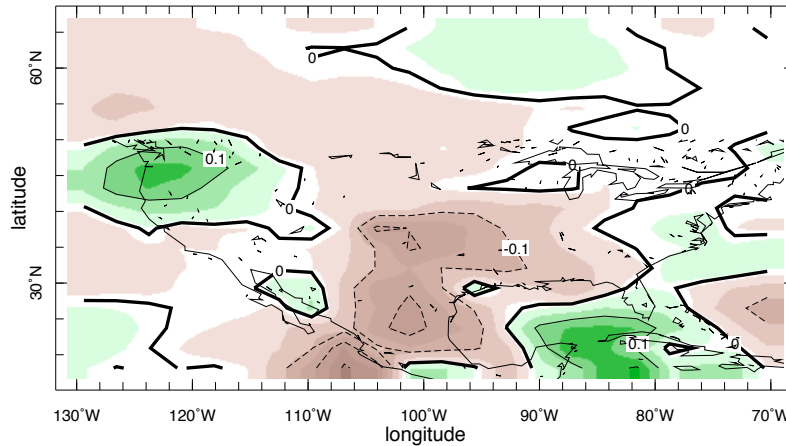
a) GHCN



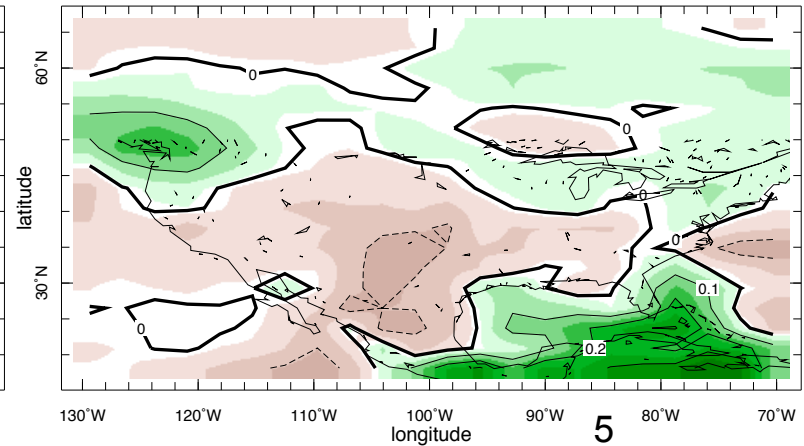
b) GOGA



c) POGA-ML

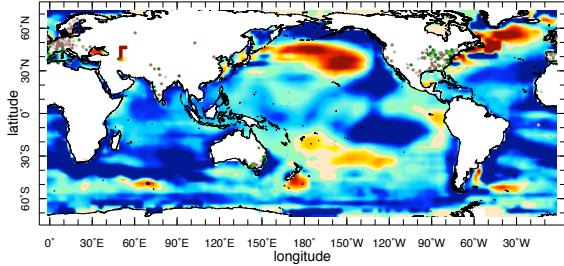


d) TAGA

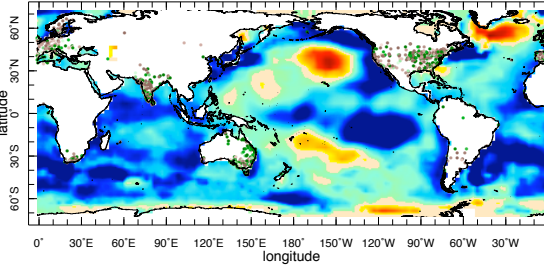


SSTA and GHCN Station Precipitation

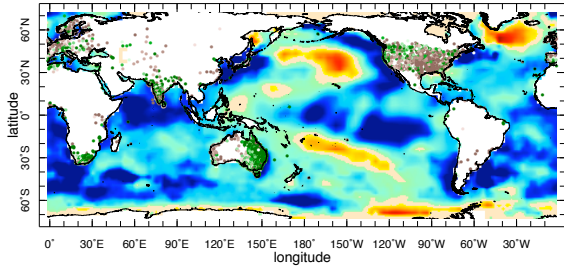
a) 1856-1865



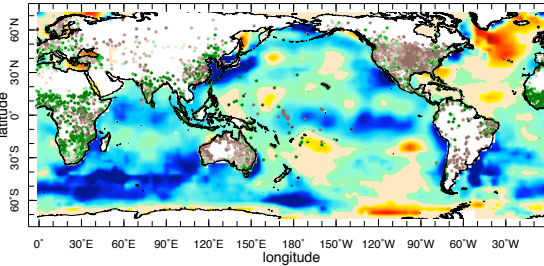
b) 1870-1877



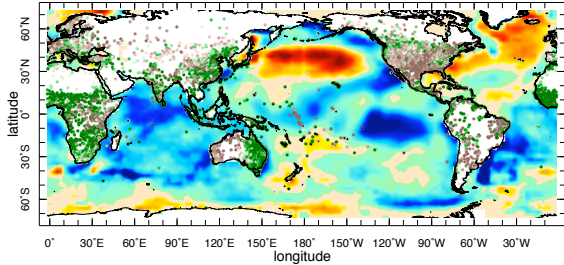
c) 1890-1896



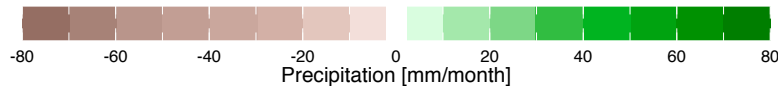
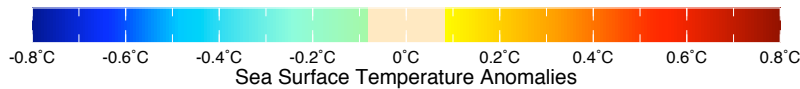
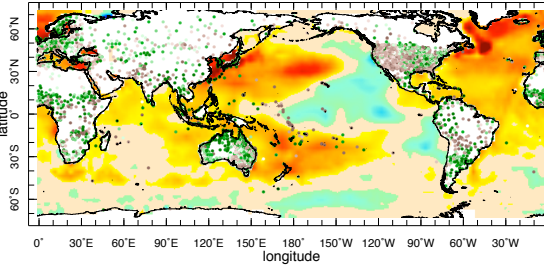
d) 1932-1939



e) 1948-1957



f) 1998-2004



Observed sea surface temperature (color) and precipitation (dots over land) for the six historical N. American droughts

Note La Nina-like conditions for all

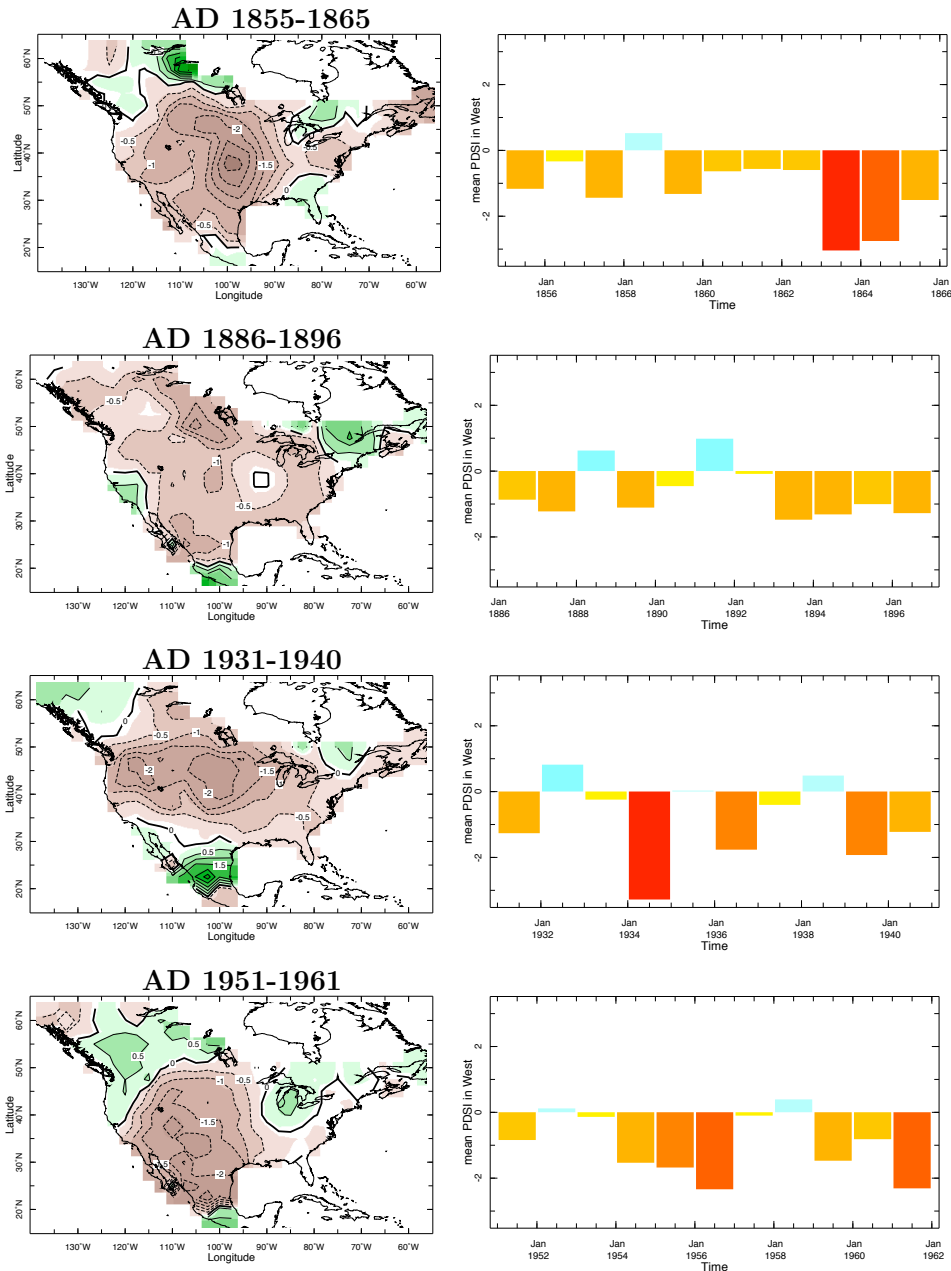
Modern-day droughts

Tree ring records of modern droughts

LHS = spatial distribution

RHS = PDSI history over the 'West'

Modern droughts have lasted at most 10 years



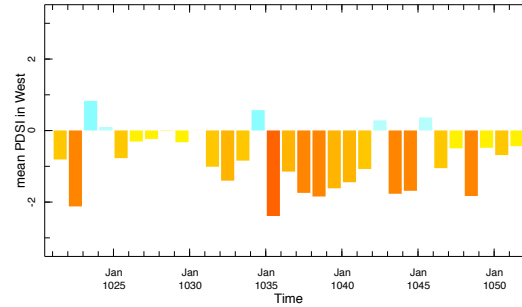
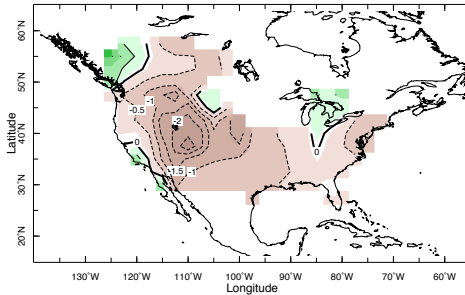
Droughts of Medieval Times

Similar spatial pattern of drought to modern-day: widespread with drought centers in the continental interior, either in the SW and Rockies, or in the Plains, or both.

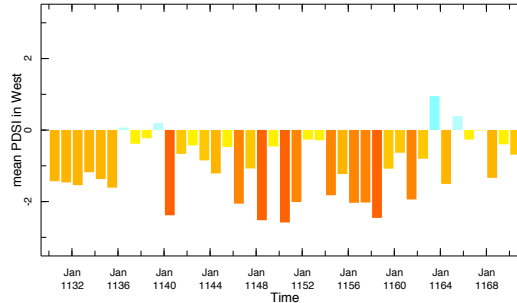
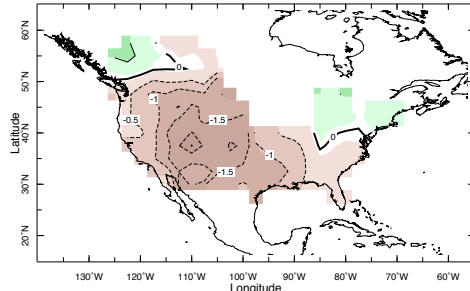
Conditions persisted **MUCH** longer (20-40yrs)

I.E. MEDIEVAL
'MEGA-DROUGHTS'

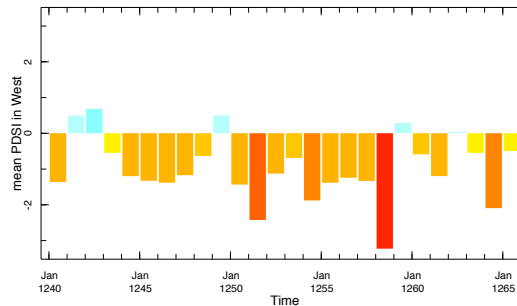
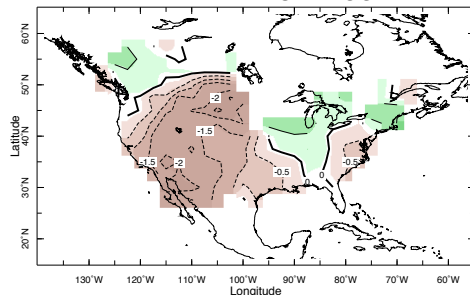
AD 1021-1051



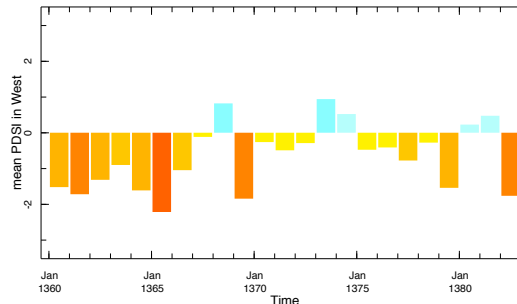
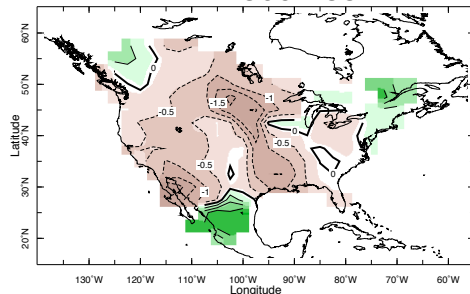
AD 1130-1170



AD 1240-1265

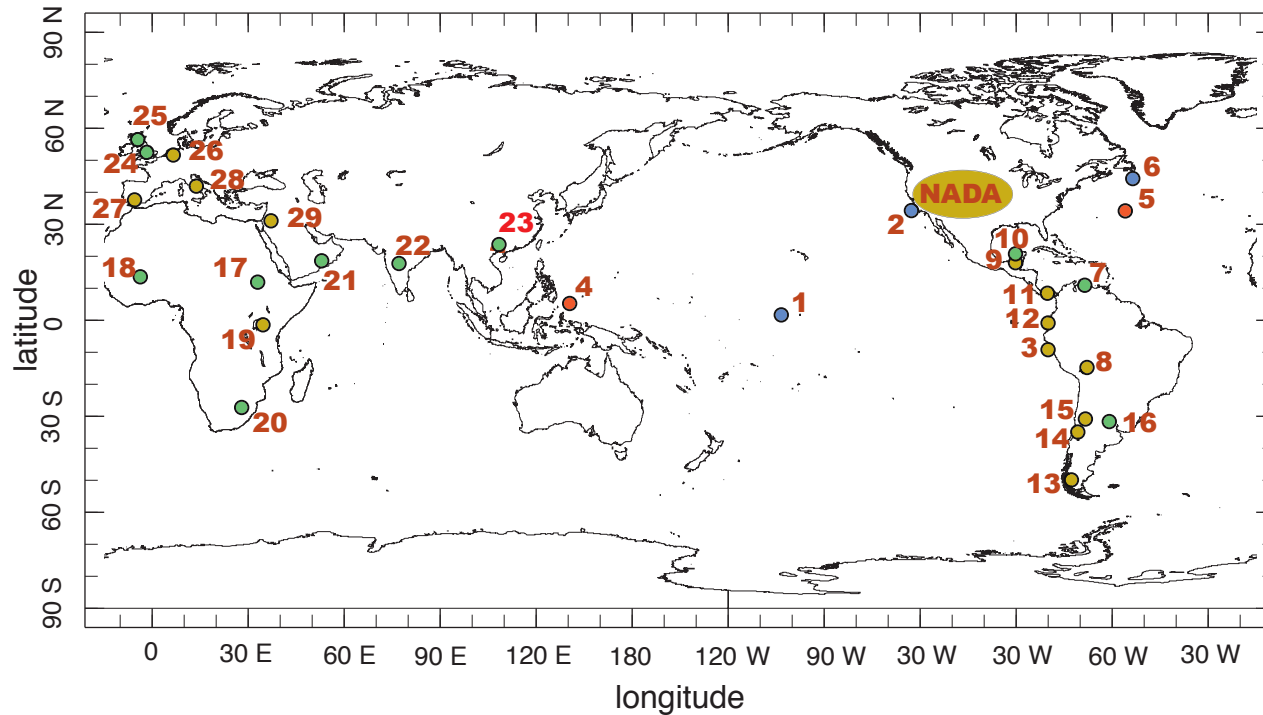


AD 1360-1382



Did permanent La Nina cause the medieval megadroughts?

Records of Medieval Hydroclimate and SST



warm SST - red

Dry - brown

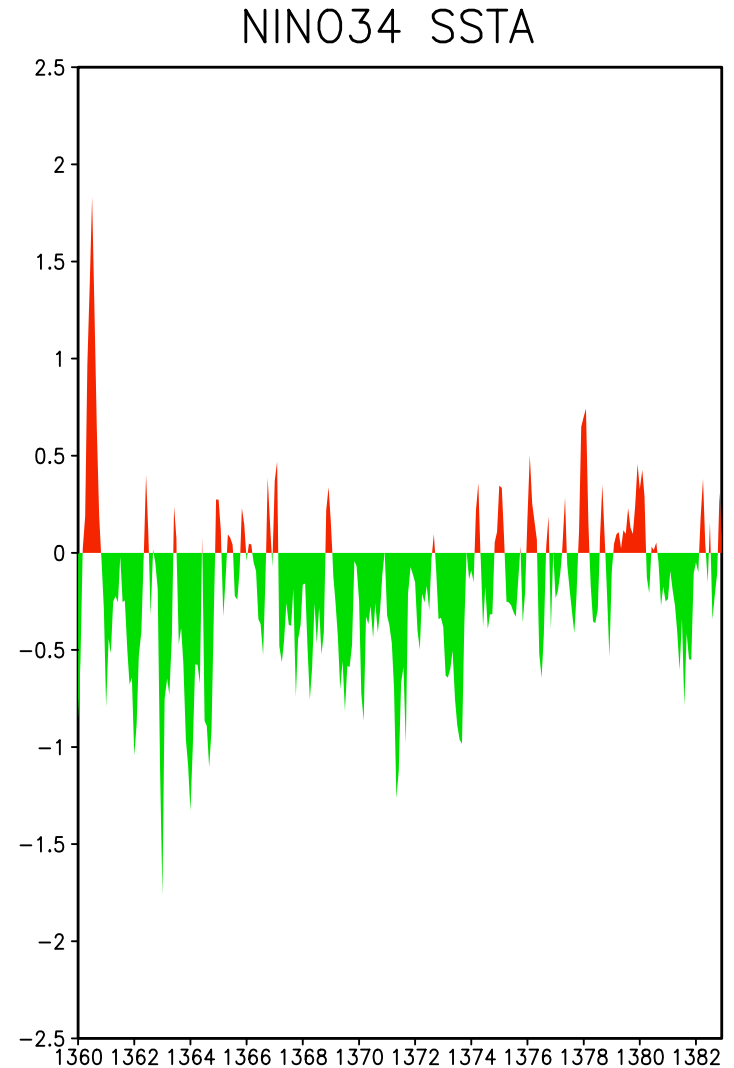
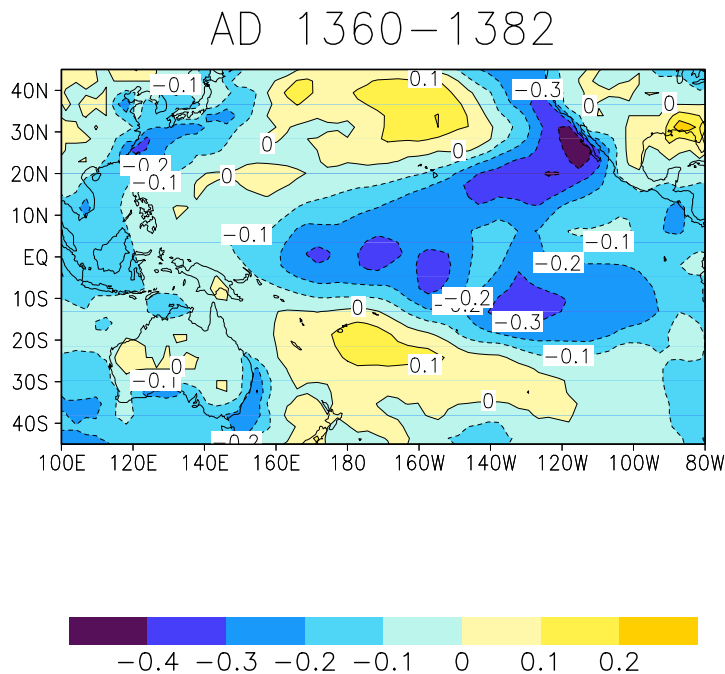
cold SST - blue

Wet - green

NADA=North American Drought Atlas

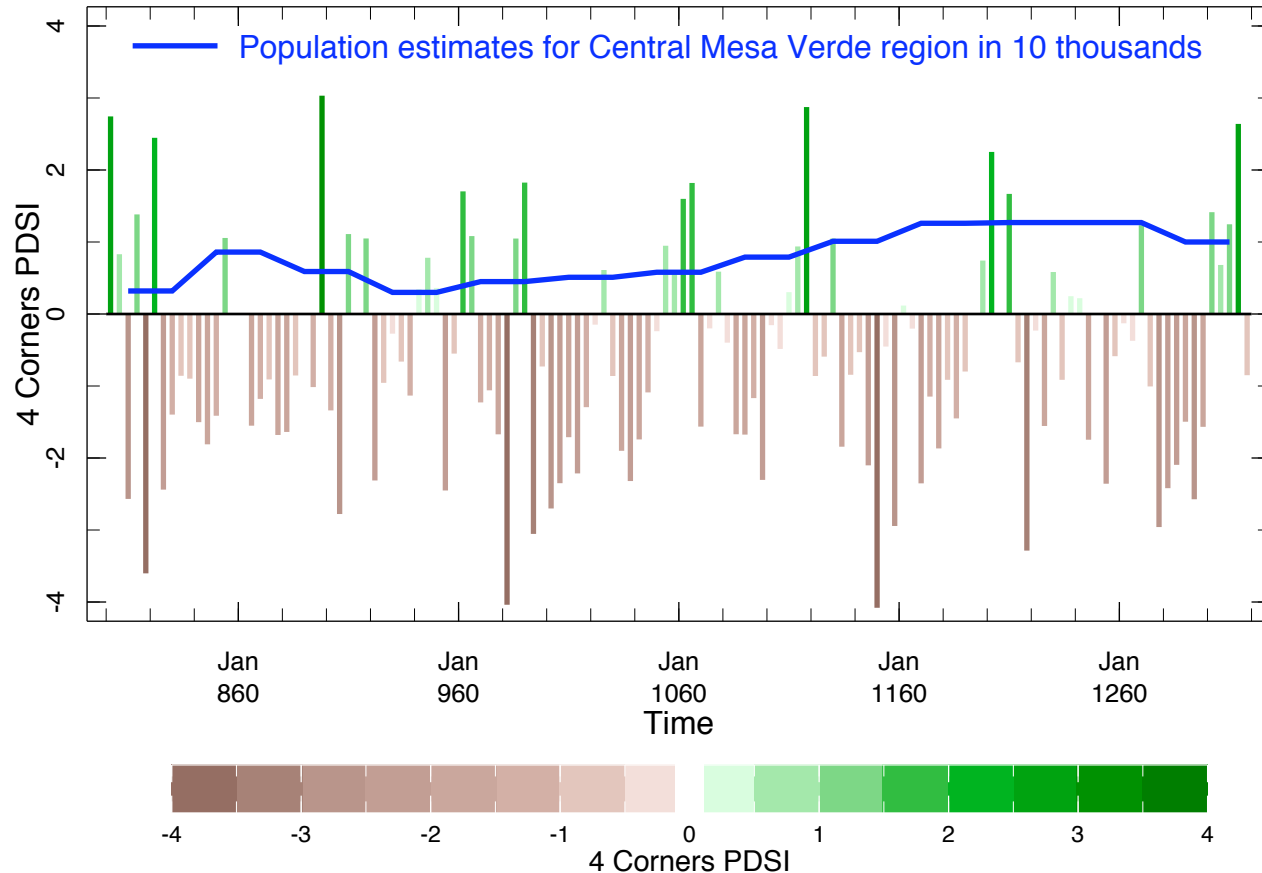
SSTA reconstructed from coral $\delta^{18}\text{O}$ for a 14th Century megadrought

- a persistent La Nina during this megadrought (also other ones)



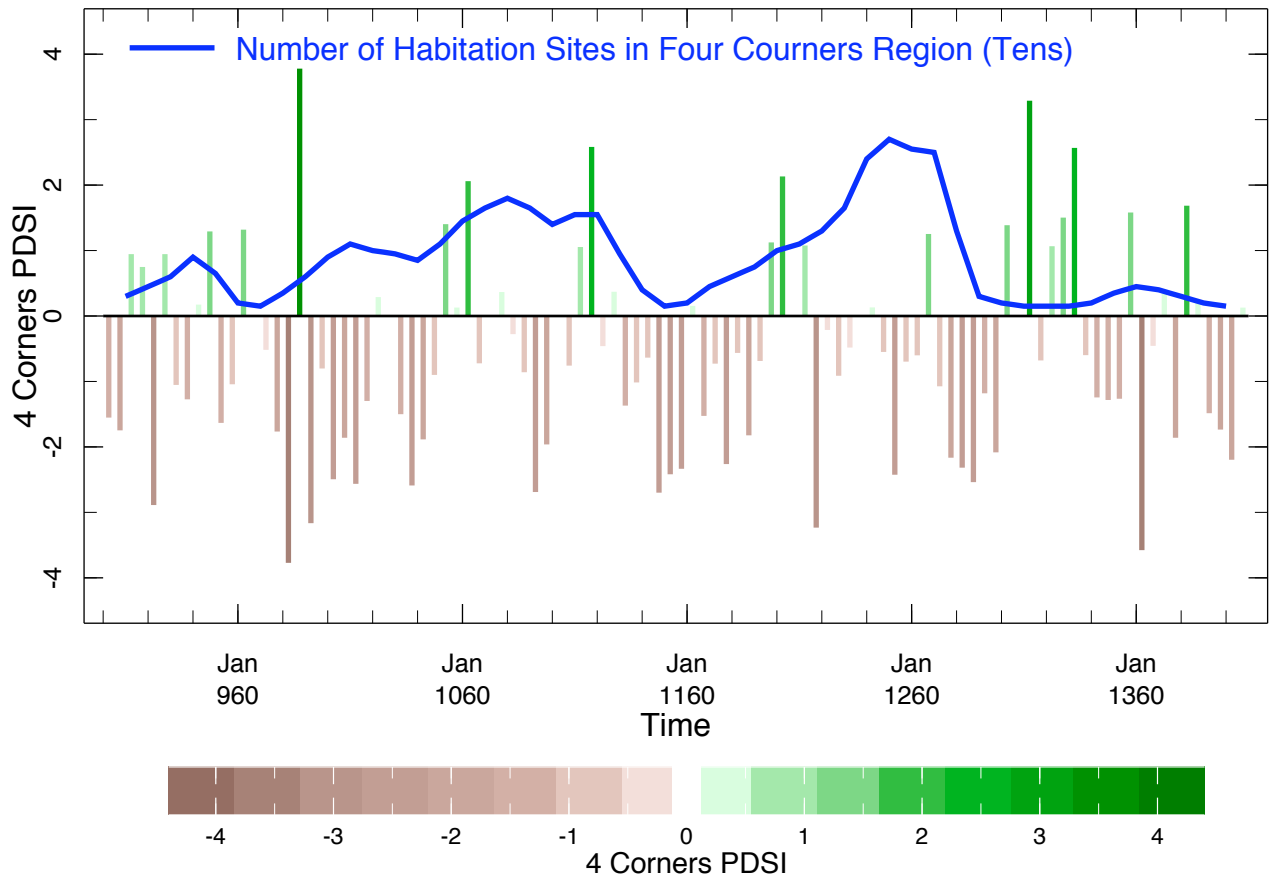
reconstruction by Burgman and Clement (RSMAS) and Seager (LDEO), thanks to Kim Cobb (Georgia Tech)

Four Corners PDSI (bars) and Population Estimates (line)



The new Four Corners tree ring early summer PDSI reconstruction (800-1300 A.D.) plotted with the population estimates of Wilshusen (2002).

Number of Habitation Sites in Four Corners Region (line) and PDSI (bars)



The new Four Corners tree ring early summer PDSI reconstruction (900-1400 A.D.) plotted with number of habitation sites from Benson et al. (2007), after Berry (1982).

Conclusions:

1. Medieval megadroughts were most likely caused by a persistent La Nina-like state in the tropical Pacific combined with a warm subtropical North Atlantic.
2. This set up of the global climate system is a plausible response to suspected high solar irradiance and weak volcanic activity.
3. The entire period from 800A.D. to around 1400A.D. was more arid than now.
4. The end-of-thirteenth century drought was severe, long-lived and subcontinental in scale.
5. But it was not unprecedented and Indian populations in the central Mesa Verde region had grown during earlier severe droughts.