

## Weak El Niño Results in a Positive Pacific-North American (PNA) Pattern

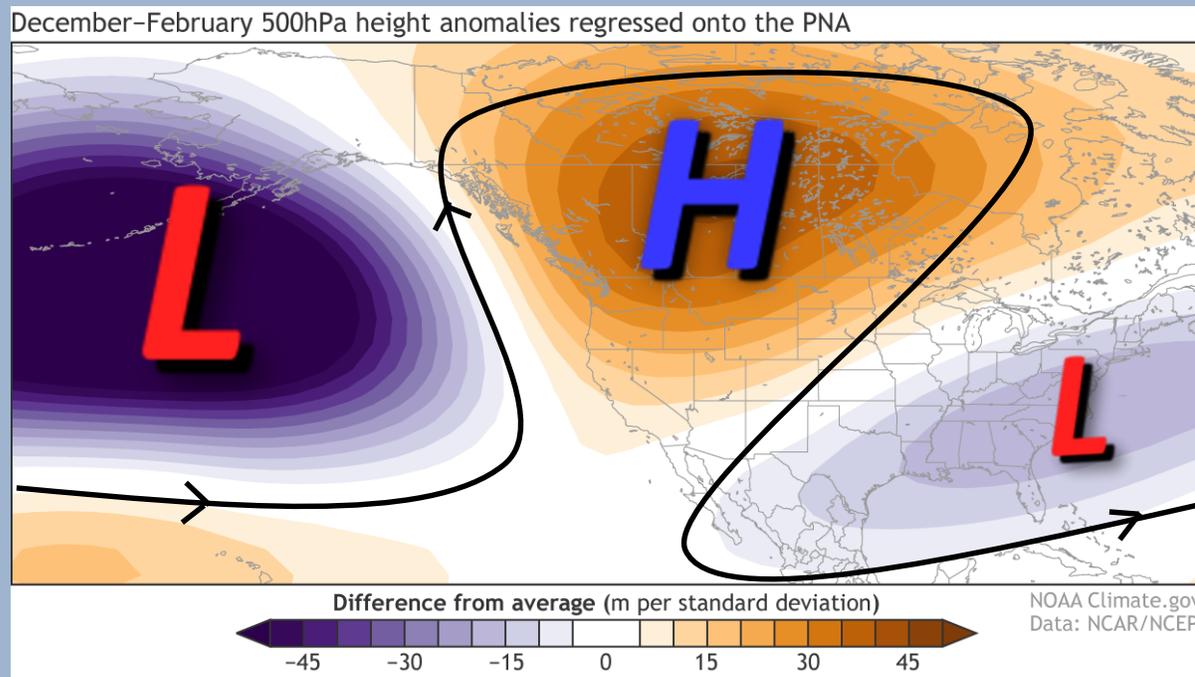


Figure 1. Idealized Positive PNA Pattern During Winter

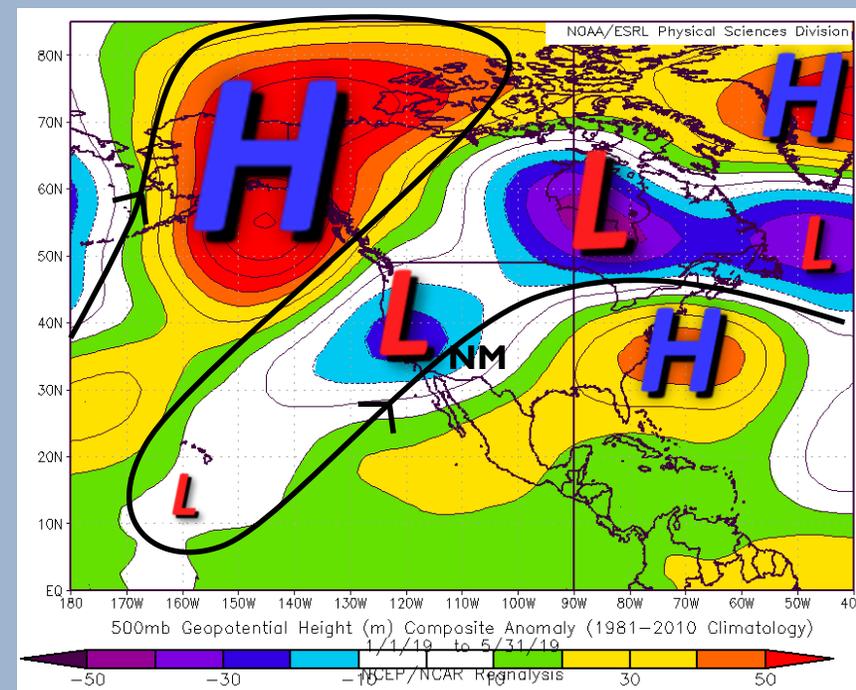


Figure 2. 2019 Positive PNA Pattern

Let's begin this climate outlook with by first discussing why the weather has been so cool and relatively wet since the start of 2019. A weak El Niño has resulted in a positive state of the **Pacific-North American Teleconnection Pattern (PNA)**. The image on the left is an idealized version of a positive PNA during December, January, and February while the middle image shows where the pattern set up in 2019. Will the positive PNA pattern continue into July and if so, how could it impact the **North American Monsoon (NAM)**?

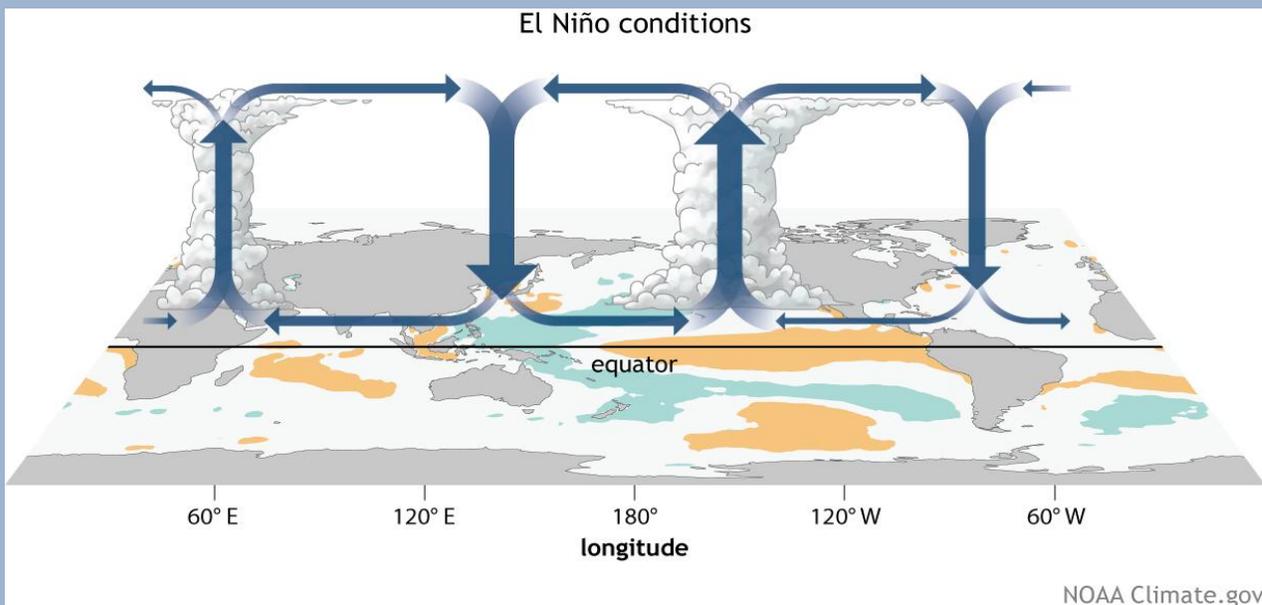
# 2019 Monsoon Outlook

For Central & Northern New Mexico

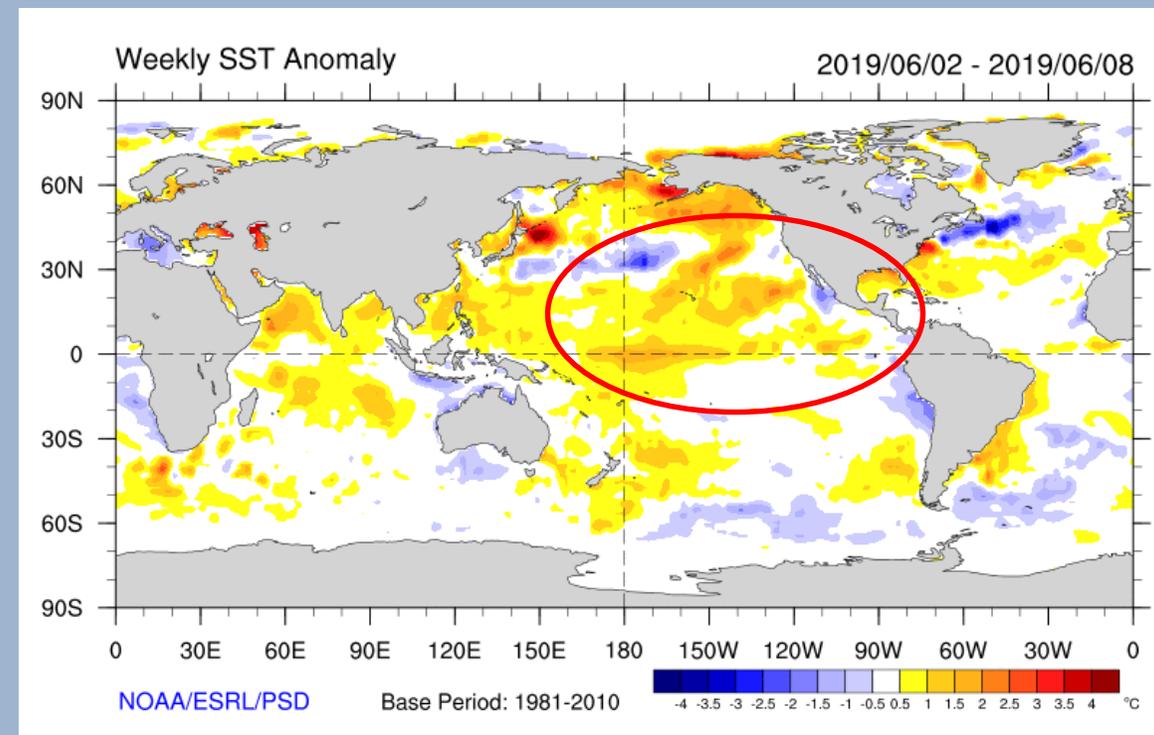


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**Figure 3.** An idealized Walker circulation shifted westward during El Niño



**Figure 4.** Observed Weekly Sea Surface Temperature Anomalies

What controls the strength of the North American Monsoon (NAM)? Does deep snowpack in late spring and early summer in the southern and Central Rockies make a major difference in the onset date or strength of moisture surges? The answer is multi-faceted and not entirely understood but the common denominator seems to be the strength and location of the Walker Circulation, a pattern in the tropical Pacific of air rising in the west and sinking in the east with westward moving air at the surface. Anomalous ocean warming in the central and eastern Pacific (orange) help to shift the rising branch of the Walker Circulation westward. Climate.gov drawing by Fiona Martin.

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## North American Monsoon (NAM) – What is it?



Courtesy: Todd Shoemake

The North American Monsoon (NAM), like its much stronger cousin the Asian or Indian Monsoon, is the result of the polar jet stream and sub-tropical upper-level highs migrating northward during the warm season. The **word “monsoon”** comes from the Arabic word **mausim**, meaning **season**. Essentially, it describes a seasonal wind shift over a region that is usually accompanied by an increase in moisture and precipitation, accounting for nearly half of annual precipitation for much of New Mexico. Source regions for the moisture include, the Gulf of Mexico, Gulf of California and the eastern Pacific Ocean. Monsoon onset dates in the U.S. Southwest typically begin in mid to late June in northwest Mexico (Sonora, Chihuahua, Sinaloa, and Durango) and early July in New Mexico and Arizona.

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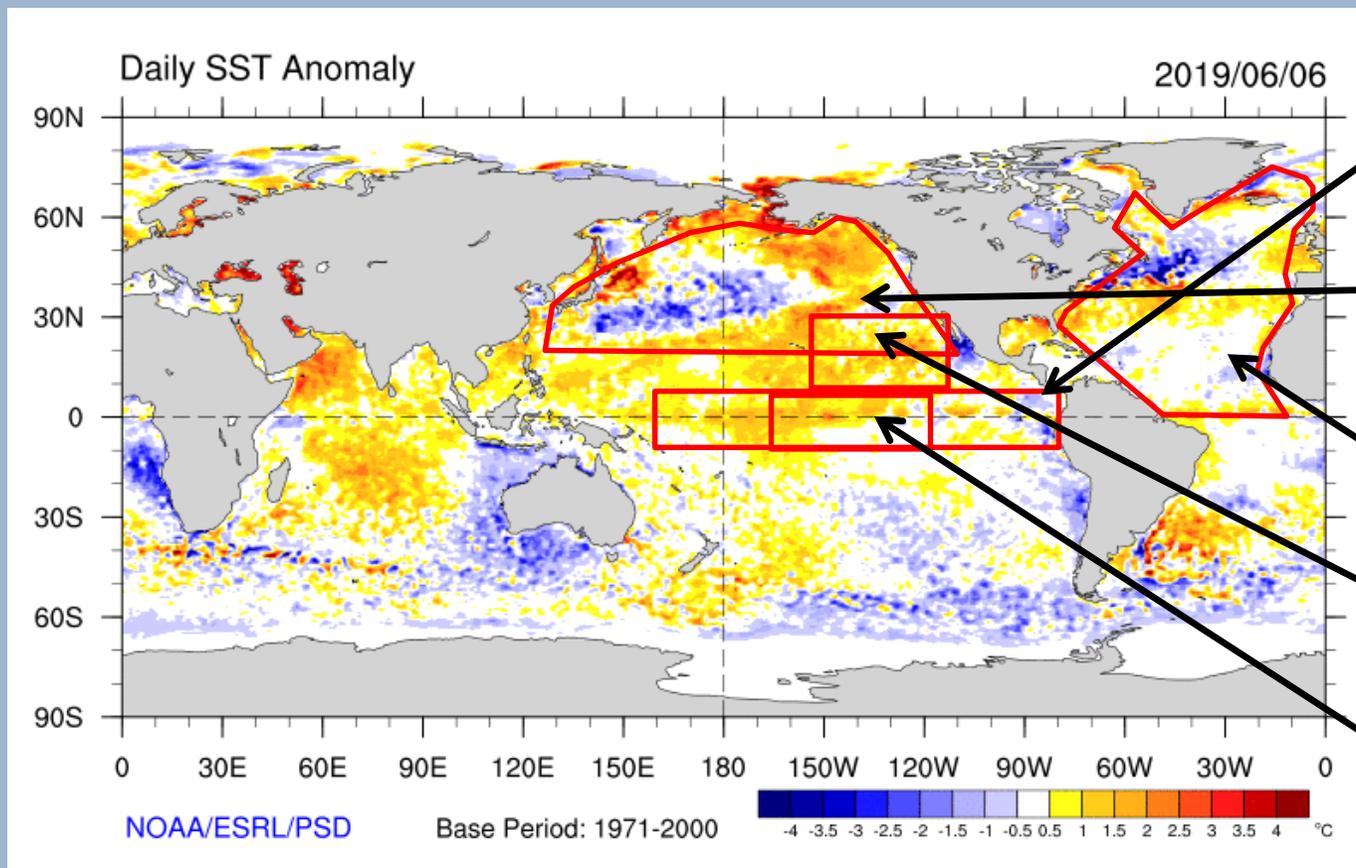
## Current Sea Surface Temperatures (SSTs)



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\*SSTs are what drive tropical & sub-tropical thunderstorms. It's these thunderstorms that drive global weather & climate.



➤ Multivariate ENSO Index (MEI) for APR-MAY 2019: **+0.3**

➤ Pacific Decadal Oscillation (PDO) for MAY 2019: **+1.03**

➤ Atlantic Multidecadal Oscillation (AMO) for MAY 2019: **+0.087**

➤ Pacific Meridional Mode (PMM) for MAY 2019: **+3.01**

➤ Oceanic Niño Index (ONI) (uses Niño 3.4 region - inner rectangle) for MAM 2019: **+0.8**

**Figure 5.** SST Anomalies in the Equatorial Pacific Ocean in early June 2019 showing neutral conditions in the equatorial Pacific.

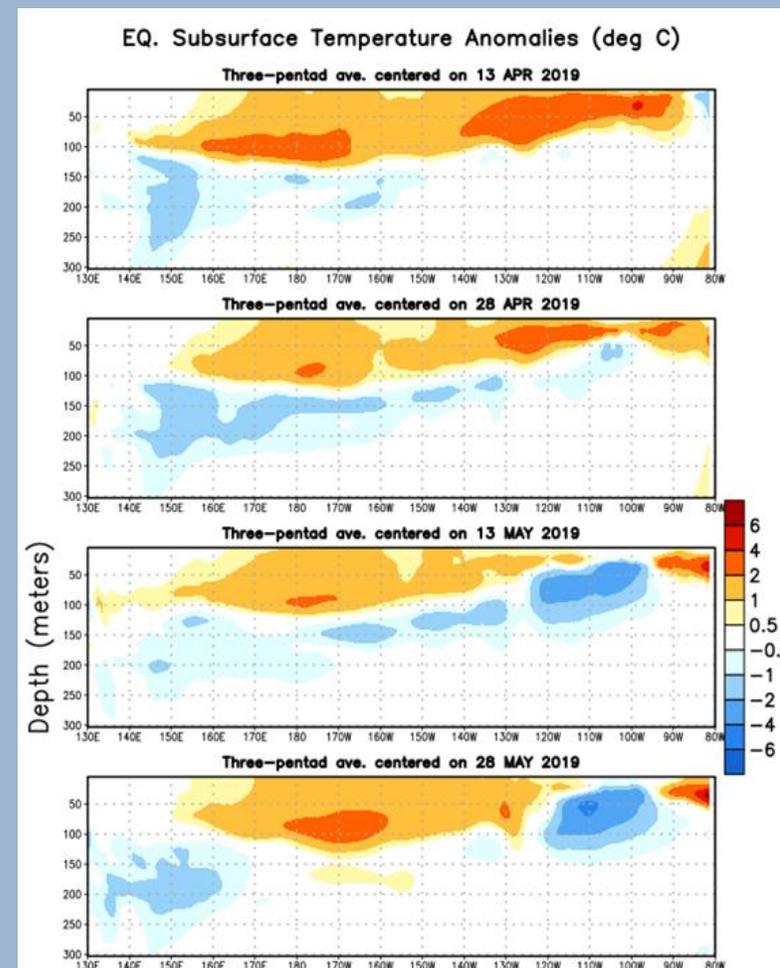
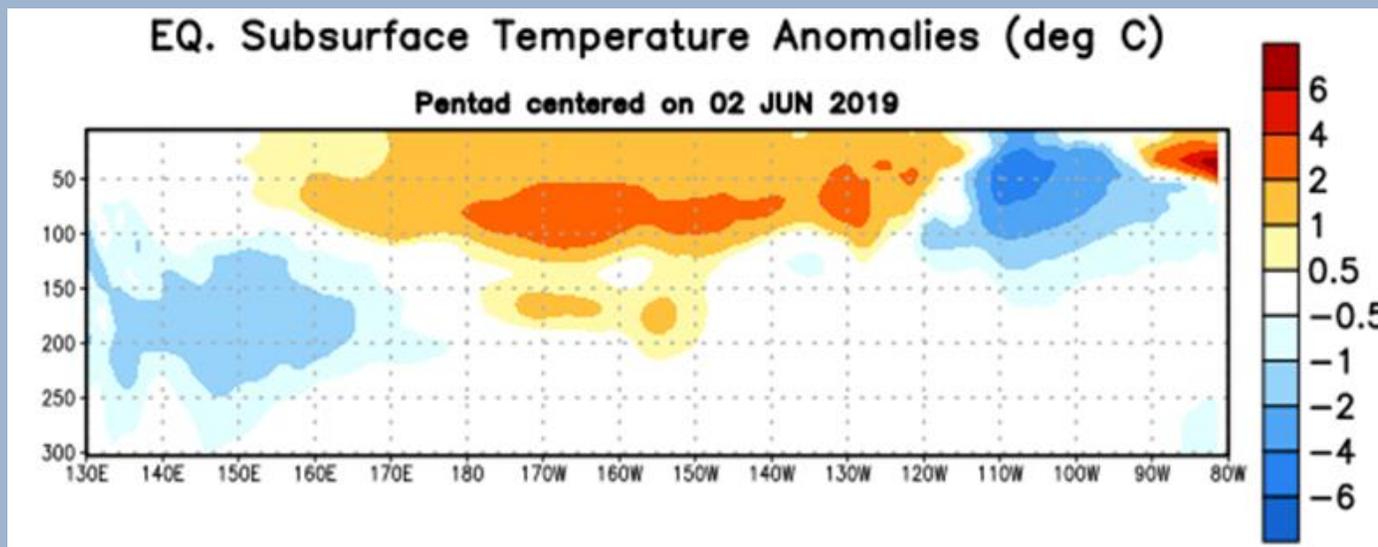
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## Sub-surface Temperatures



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**Figures 6 & 7.** Sub-surface temperature anomalies at the equator. Sub-surface temperatures often lead the surface temperatures by several months. An increasing amount of warm water under the surface provides confidence in climate models that are forecasting weak El Niño conditions continuing through summer and into early fall. Sub-surface temperatures remain warm across the central Pacific Ocean.

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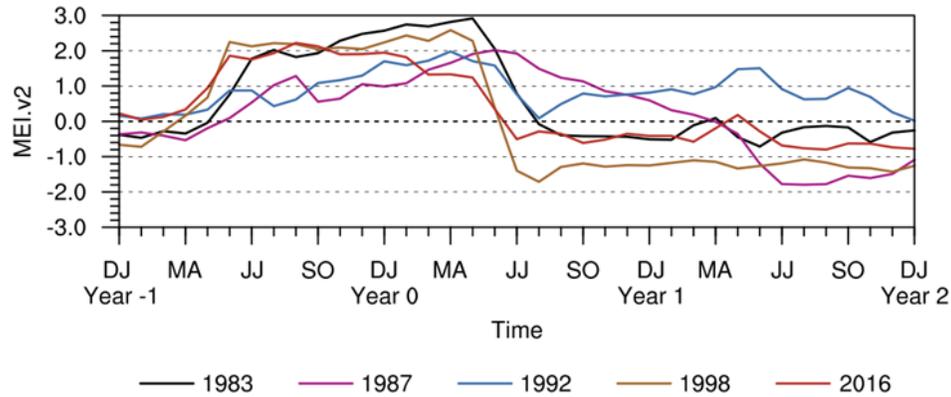
## Multivariate El Niño Index (MEI) - Analog Years



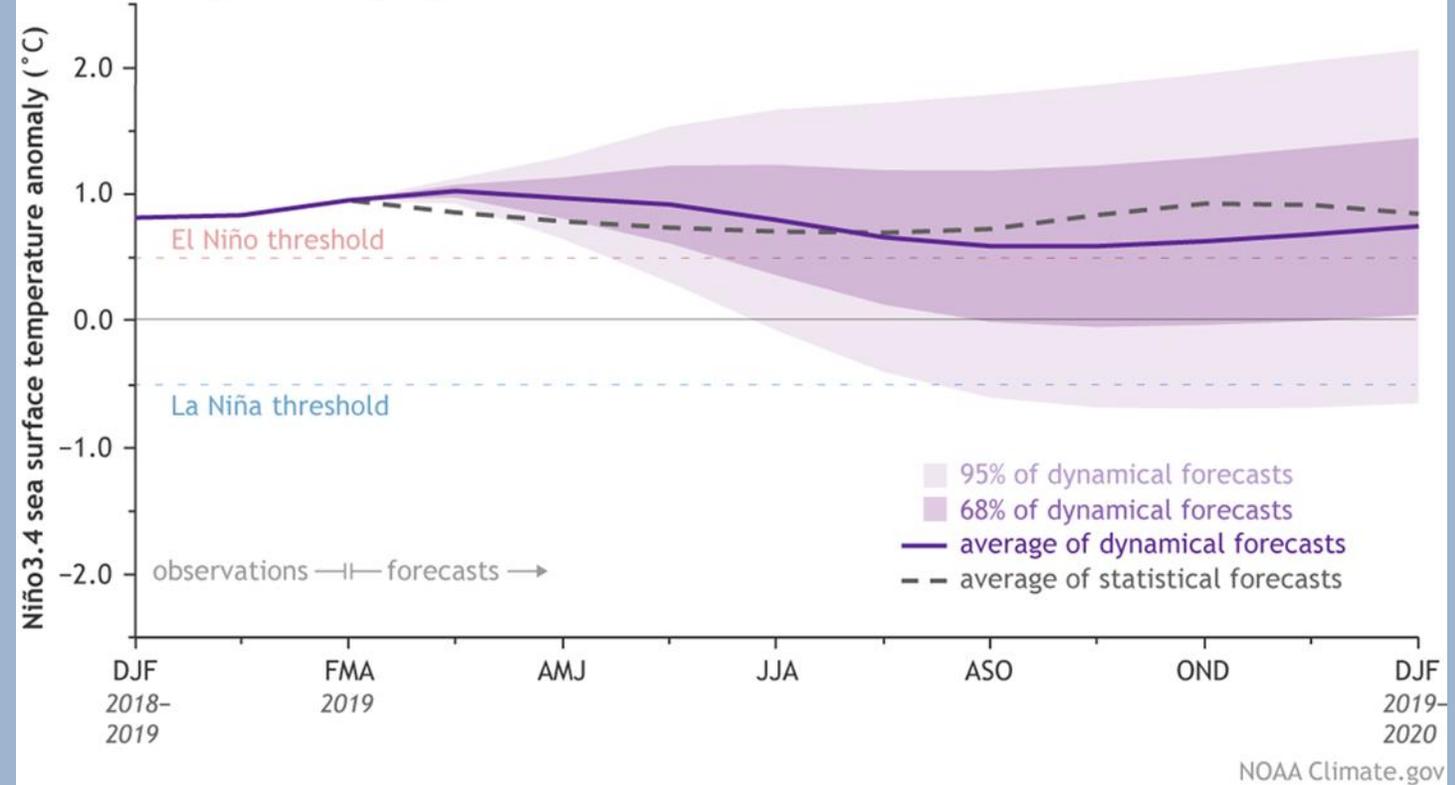
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MEI.v2 Evolution of Historical ENSO Events

(a) El Niño



NMME monthly forecasts, May 2019



NOAA Climate.gov

**Figures 8 & 9.** Five similar El Niño events using the Multivariate El Niño Southern Oscillation Index (MEI) since 1950 (left). It would be unprecedented (since 1950) for El Niño to maintain its strength or slightly strengthen through the summer months as forecast (right).

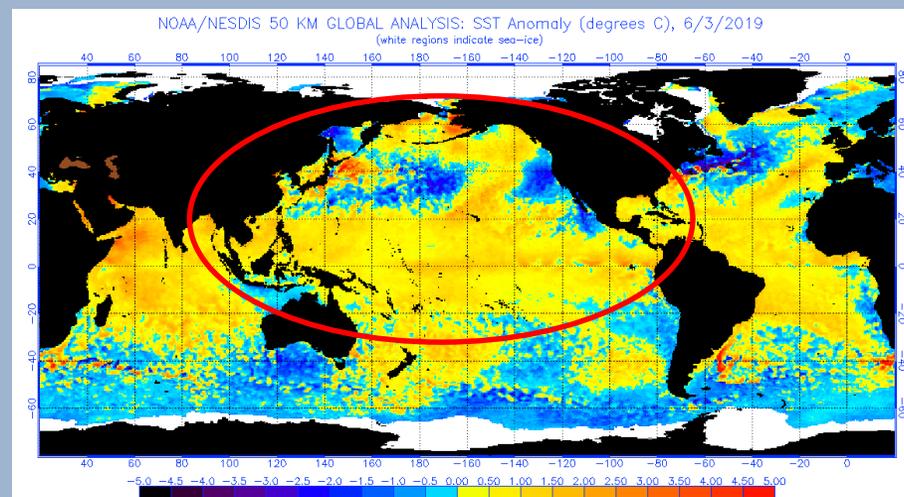
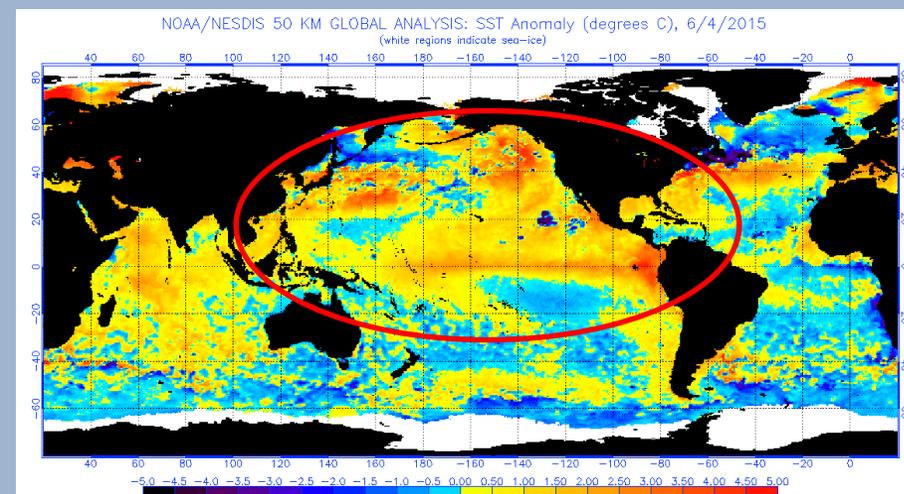
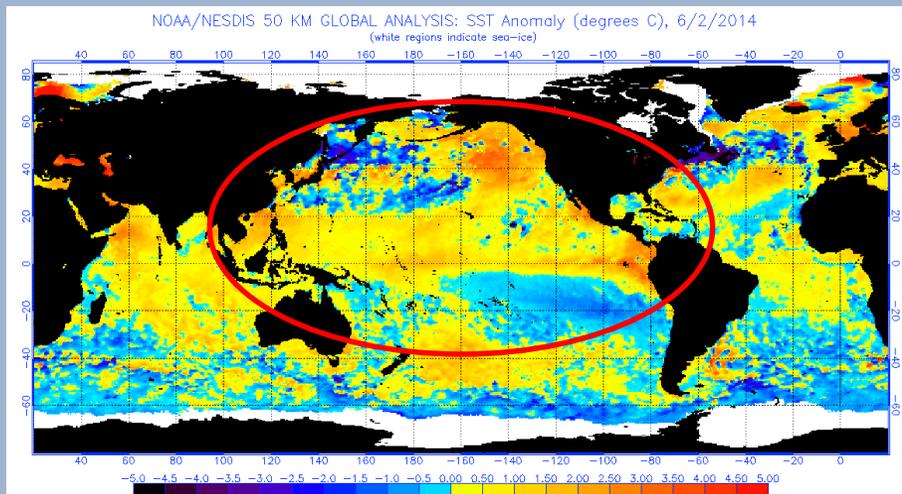
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## Analog Years – 2014 & 2015



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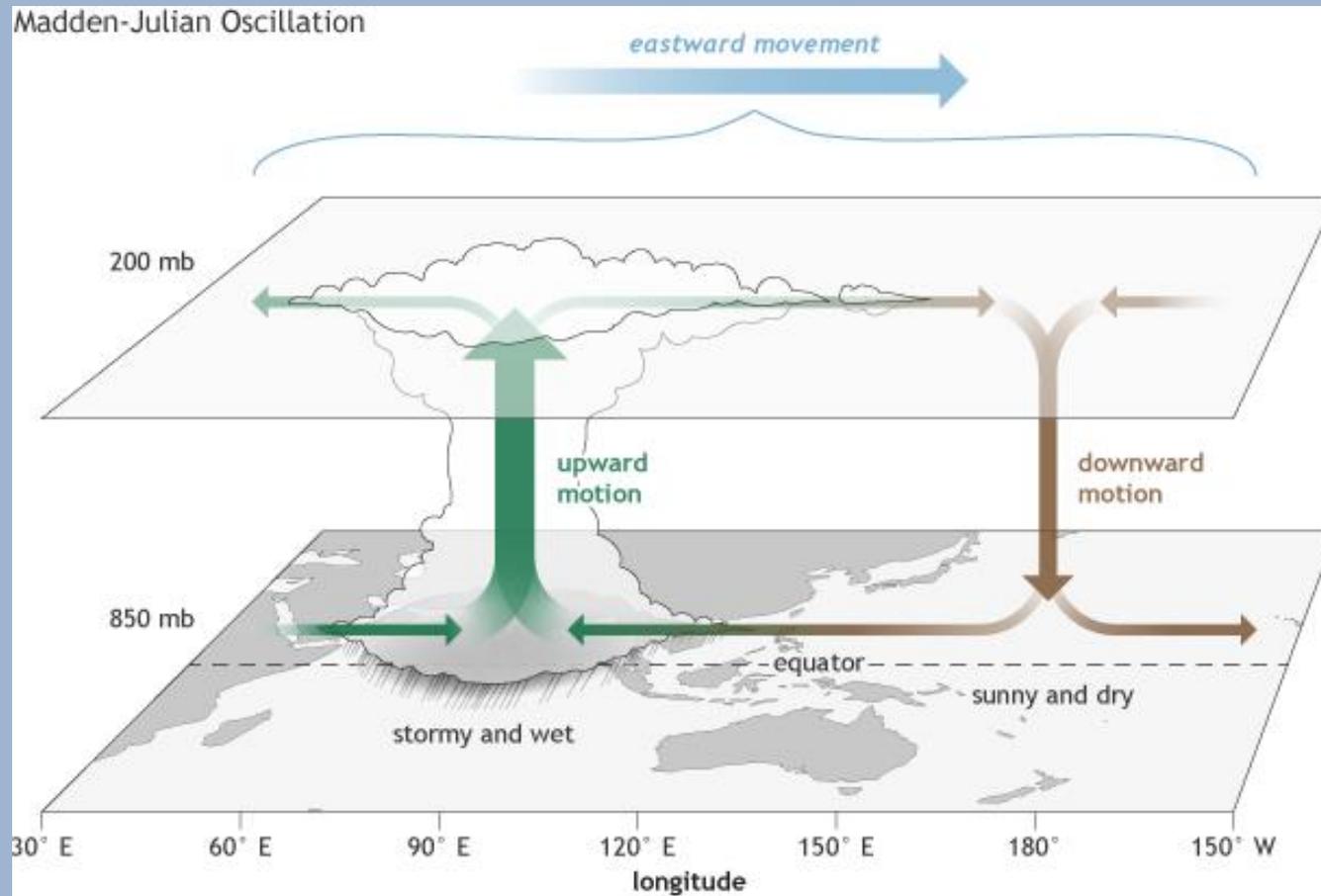
**Figures 10-12.** SST Anomalies from the two most recent analog years June 2014 and June 2015, and current conditions. Warmer-than-average waters (orange) tend to evaporate more water and warm the air above, creating more rising motion and clouds/thunderstorms compared to average.

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## Madden-Julian Oscillation (MJO)



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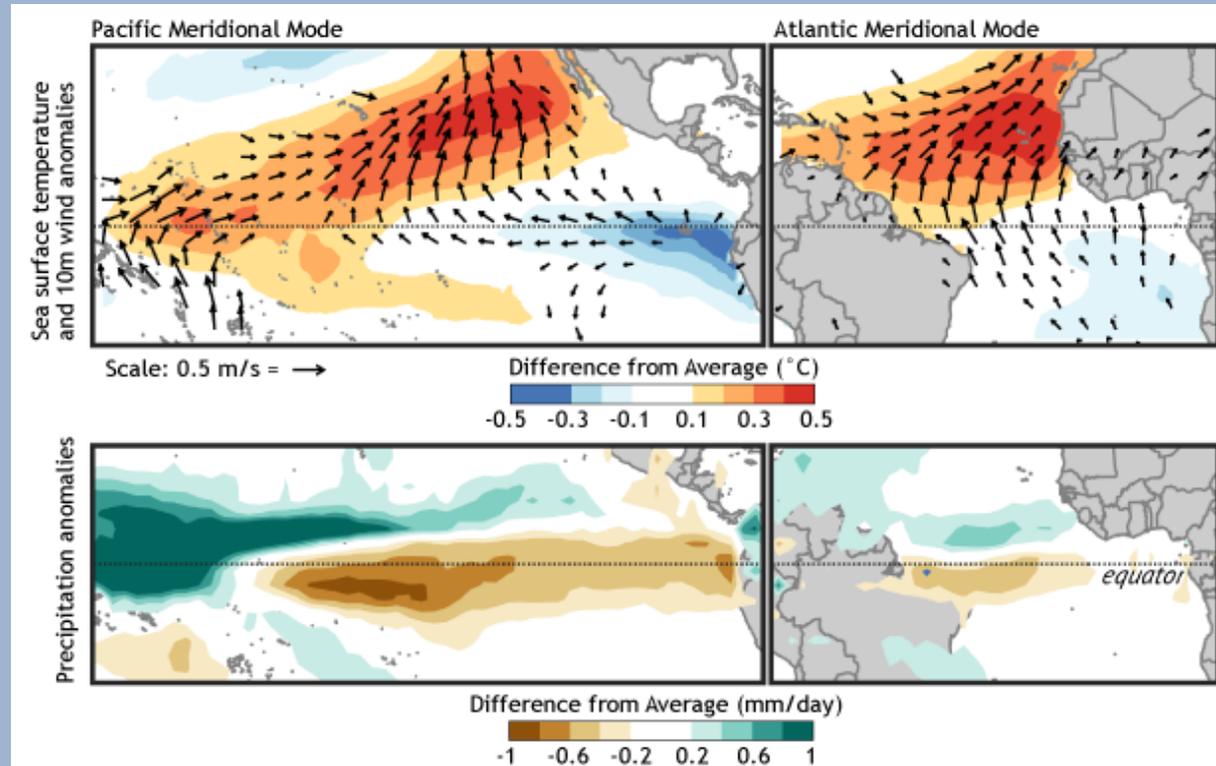
**Figure 13.** The MJO is an area of enhanced thunderstorms that travels around the world every 30 to 60 days from west to east along/near the equator. Ahead and behind the active stormy area are areas of suppressed convection and drier conditions. The MJO affects near-surface wind patterns, because the rising air in the stormy area causes surface winds to blow toward the active area. The MJO can play a role in New Mexico's weather at any time of year but it tends to have its greatest impacts during September.

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## Pacific Meridional Mode (PMM)



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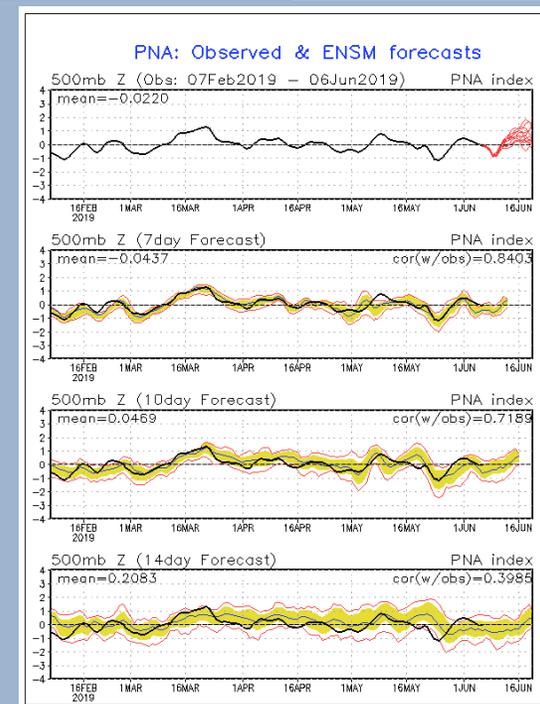
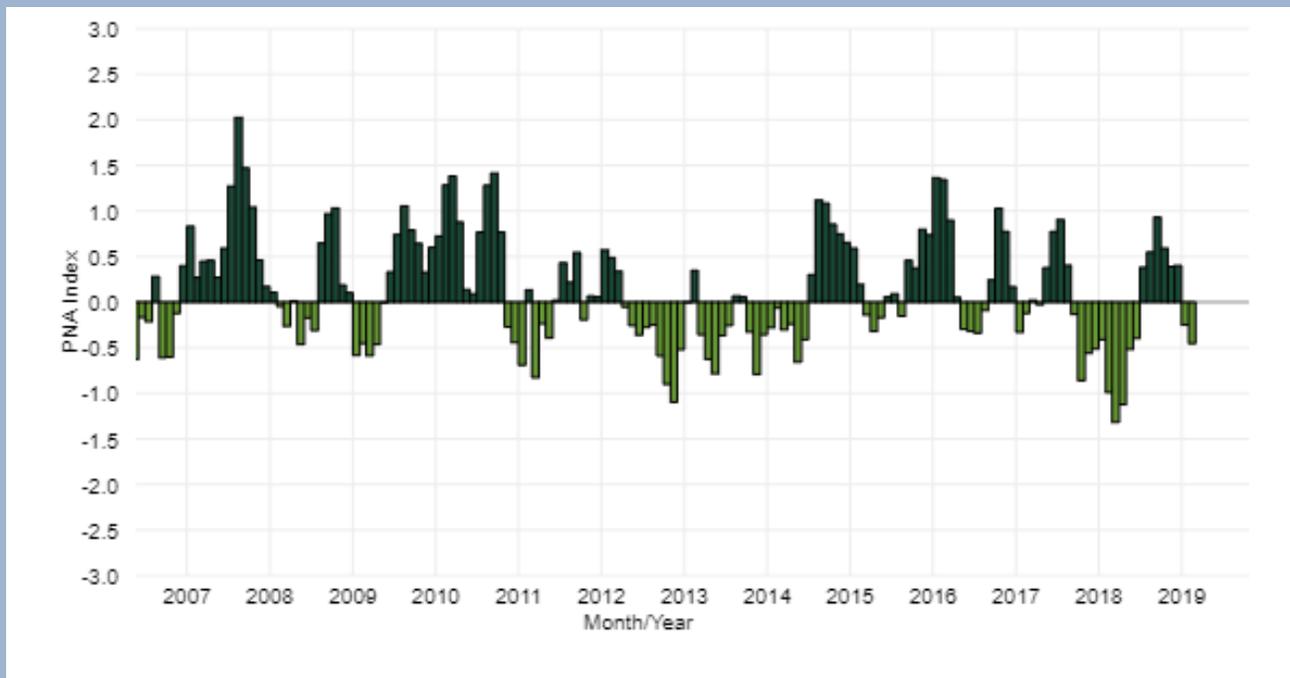
**Figure 14.** Tropical patterns associated with the positive state of the Pacific (left) and Atlantic (right) Meridional Modes (MM). The top panels show SST anomalies (shading) and near-surface wind anomalies (arrows), and the bottom panels show precipitation changes vs. average. Red (green) shading indicates above-average SST (precipitation) and blue (brown) shading indicates below-average SST (precipitation). MMs are defined by a distinctive sea-surface warming and southwesterly wind anomaly in the vicinity of the Intertropical Convergence Zone (ITCZ) during boreal spring. In other words, a positive PMM leads to stronger low level moisture advection northeastward toward the southwest U.S. during the North American Monsoon. Additionally, the majority of El Niño events over the past four decades are preceded by a positive PMM (Chiang and Vimont 2004, Chang et al., 2007).

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More on the PNA



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**Figures 15 & 16.** In the positive state of the PNA, above-average pressure is found over the sub-tropical Pacific and centered over western Canada. Below-average pressure occurs over the North Pacific Ocean and along the southeast United States. The negative state of the PNA results in the same pattern except with opposite anomalies. One recent study showed that when the MJO-related convection (an area of rising air that lead to clouds and rainfall) is located over the Indian Ocean and Maritime Continent, negative PNA-like patterns become more likely, while a positive PNA is more likely when MJO-related convection is located closer to the central Pacific. Tropical and sub-tropical convection in winter and spring 2019, thanks in large part to a weak El Niño, has been centered over the central Pacific and a positive PNA is the result. Who cares? Once a particular phase of the PNA develops, it takes major changes (not anticipated) in the tropics to switch PNA phases for more than a few weeks. In other words, it's a 'preferred' atmospheric pattern that is expected to last through summer 2019. What could it mean for the North American Monsoon (NAM)? Possibly stronger than average troughs along/near the west coast, forcing the sub-tropical high typically over the Great Basin and Southwest U.S. farther east or southeast over Texas leading to greater than average deep monsoon moisture plumes.

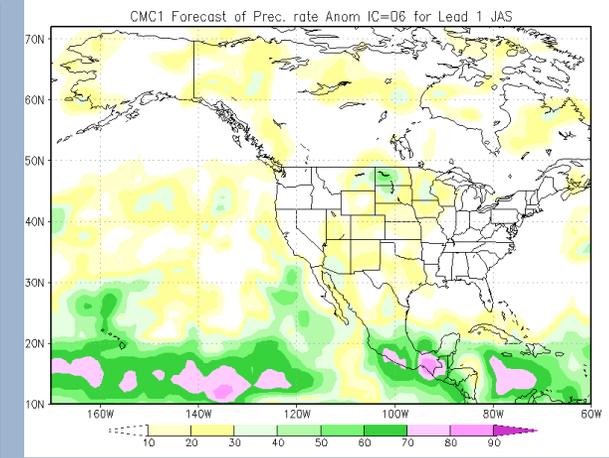
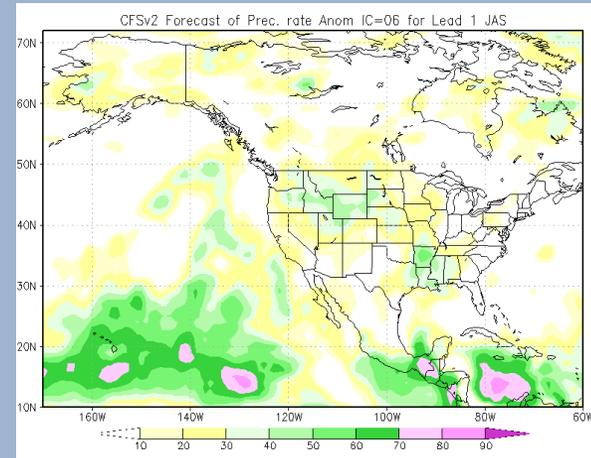
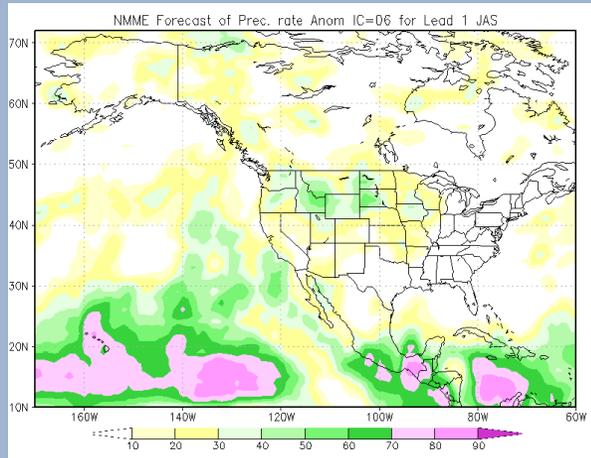
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## Precipitation Forecasts for July, August & September (JAS)

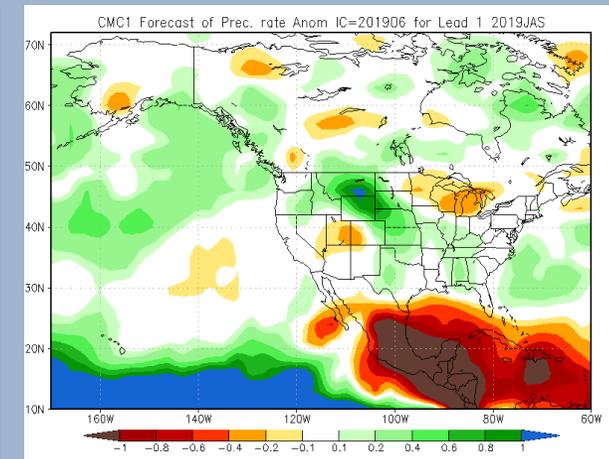
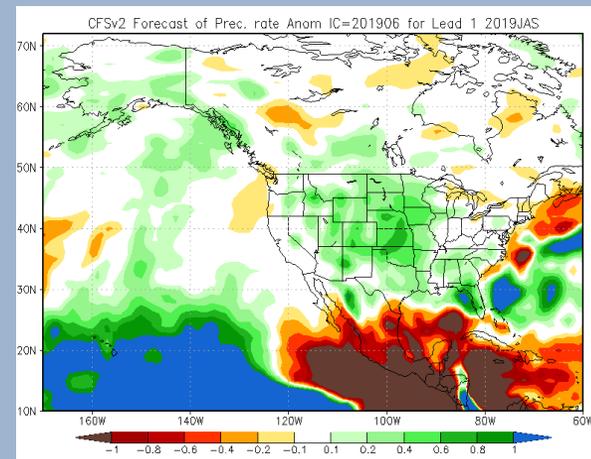
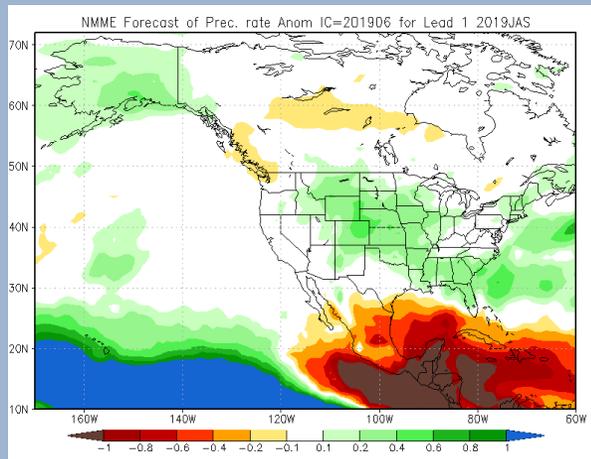


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Skill



Precipitation  
rate anomaly  
forecast



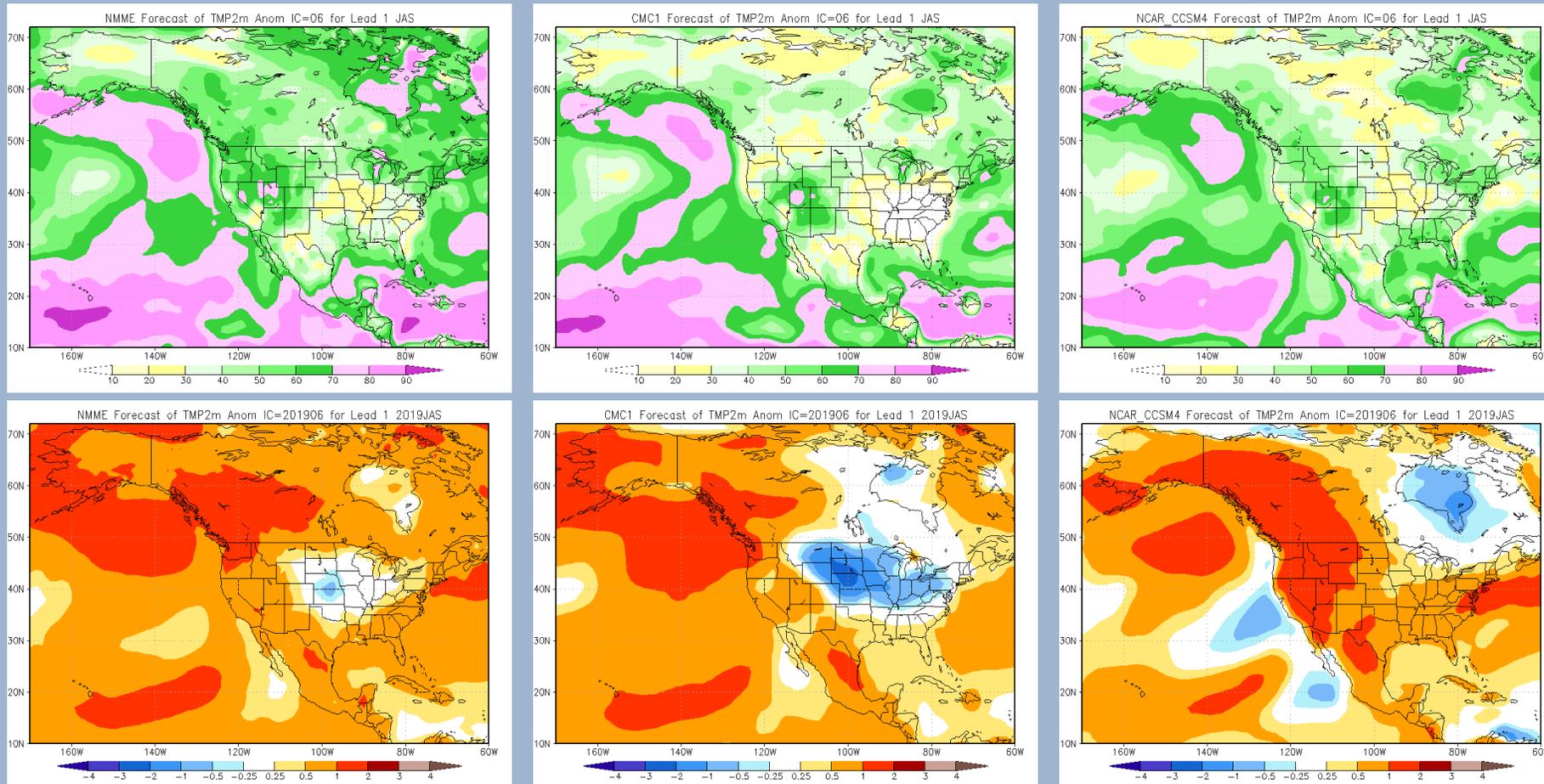
**Figures 17-22.** Climate model precipitation rate anomaly plots from the three climate models which have the highest skill percentages (top images), the North American Multi-Model Ensemble (NMME), Coupled Forecast System (CFSv2), and the Canadian Meteorology Center (CMC1) model. All three model forecasts (bottom images) are forecasting near to slightly above average precipitation for July, August, and September (JAS) precipitation in New Mexico.

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## Temperature



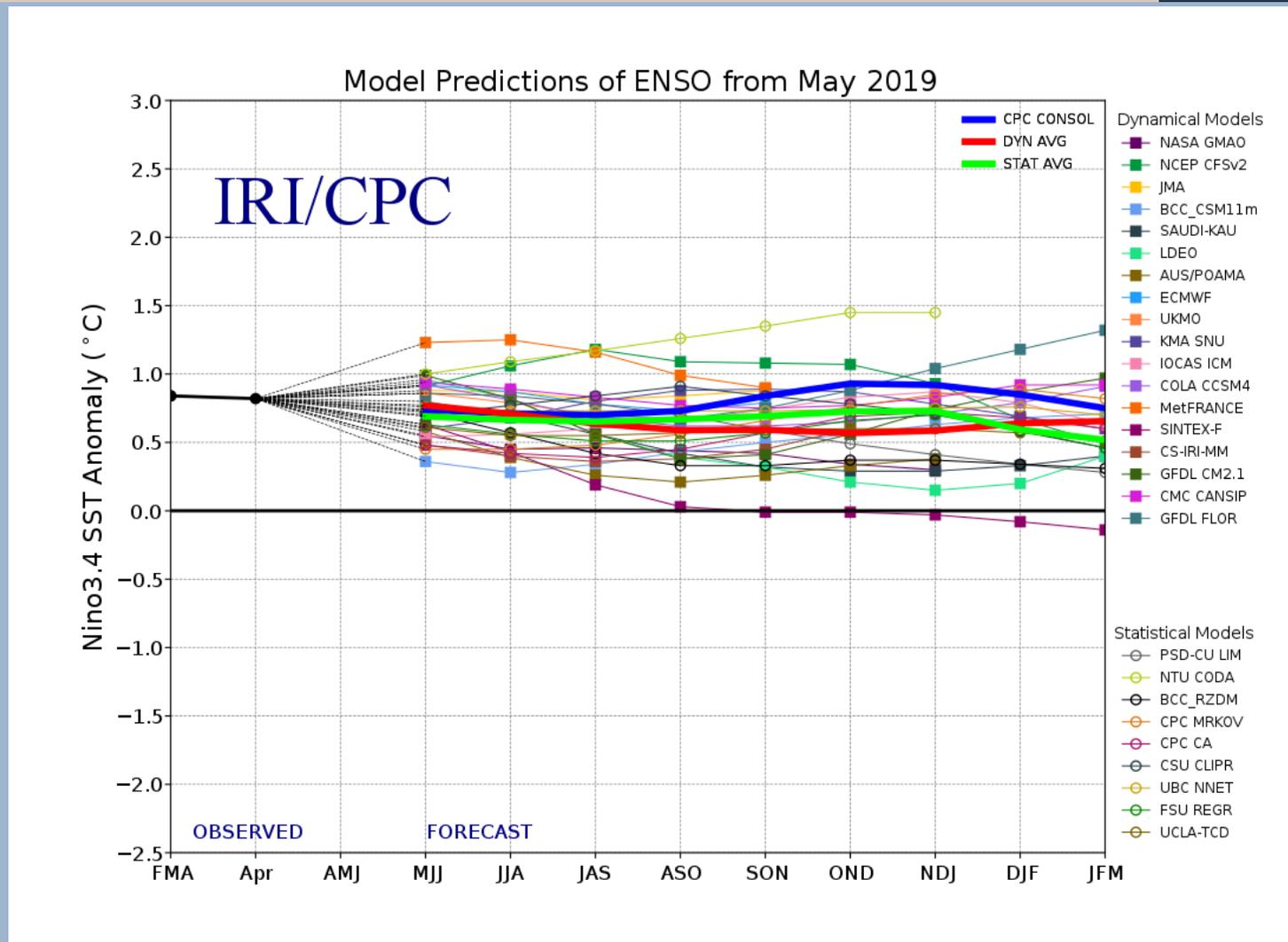
**Figures 23-28.** Climate model temperature anomaly plots from the three climate models which have the highest skill percentages (top images), the North American Multi-Model Ensemble (NMME), Canadian Meteorology Center (CMCI) and the National Center for Atmospheric Research (NCAR) Community Climate Model Version 4. Model forecasts (bottom images) indicate near to slightly above average temperatures in JAS. The NMME output is from a group/ensemble of model runs while the CMCI and CFSv2 are single runs. Typically, single model runs will show greater precipitation and temperature extremes.

# 2019 Monsoon Outlook

## ENSO Predictions



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**Figure 29.** El Niño is likely to continue through the Northern Hemisphere summer 2019 (70% chance) and fall (55-60% chance).

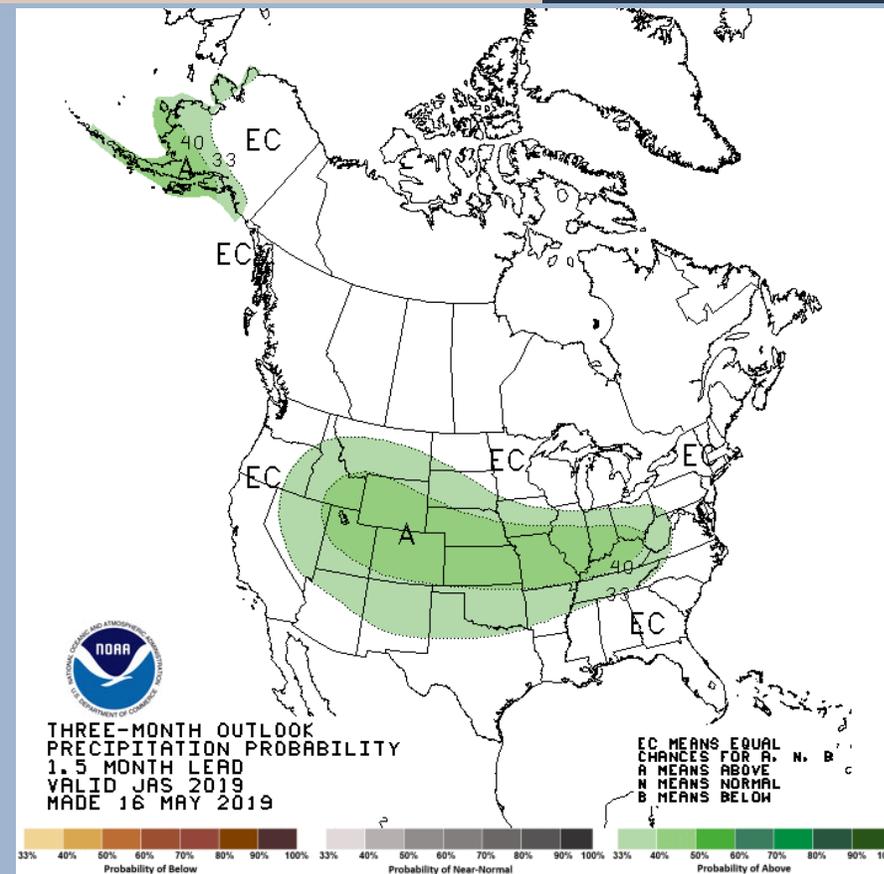
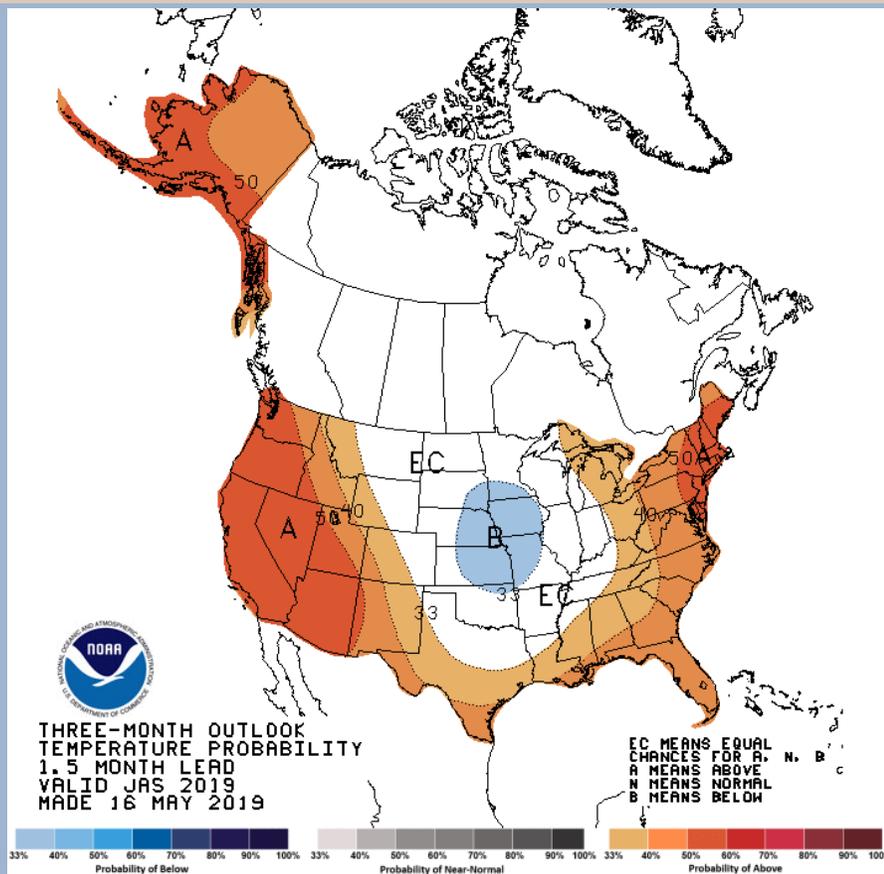
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Climate Prediction Center

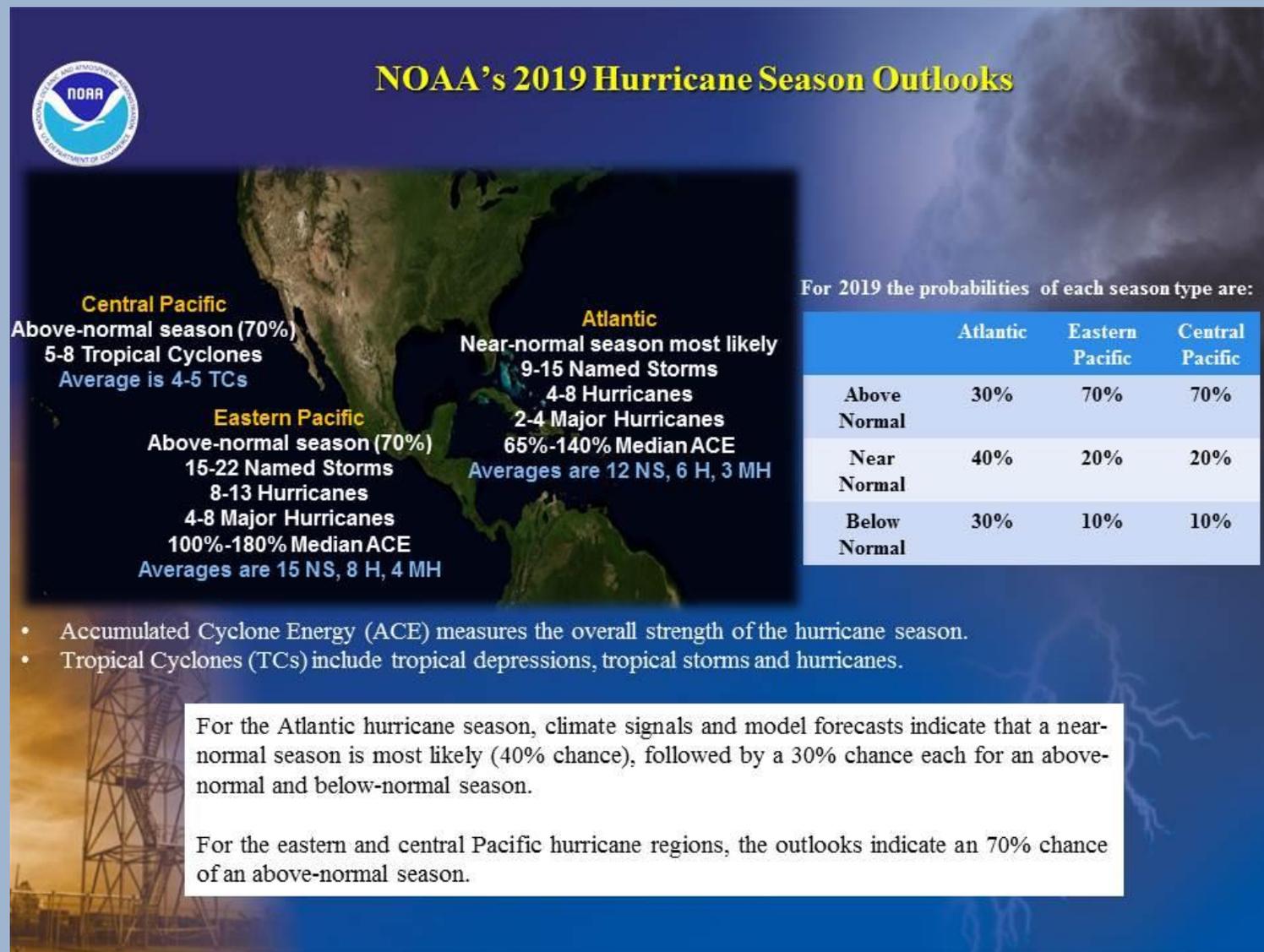


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**Figures 30 & 31.** CPC agrees with the climate model consensus of near to slightly above average chances for above average precipitation. Generally speaking in summer, above average thunderstorm activity would lead to high temperatures near to slightly below average with low temperatures near to above average given higher dew point temperatures and increased cloud cover. It's worth noting that below average summer temperatures in New Mexico are a rare occurrence these days. Since 2000, only four July through September periods have experienced slightly below average temperatures with the 13 remaining years above to well above the average statewide mean of 83.7°F.



**Figure 32.** Hurricane Season Outlooks forecast a 70% chance for an above-average season in the Eastern Pacific Basin.

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## Summary

- Forecasts from the most highly skilled climate forecast models indicate that precipitation in central and northern New Mexico during July, August and September 2019 will most likely range from near to slightly above 1981-2010 climatological averages.
- Climate model forecasts along with recent temperature trends indicate that temperatures in central and northern New Mexico during JAS 2019 will most likely range from near to slightly above average.



## References

- Chiang, J. C. H., D. J. Vimont, 2004: Analogous Pacific and Atlantic Meridional Modes of Tropical Atmosphere–Ocean Variability. *J. Climate*, **17**, 4143-4158.
- Chang, P., L. Zhang, R. Saravanan, D. J. Vimont, J. C. H. Chiang, L. Ji, H. Seidel, M. K. Tippett, 2007: Pacific meridional mode and El Niño—Southern Oscillation. *Geophysical Research Letters*. Vol. 34, Issue 16.

➤ **Outlook provided by National Weather Service Forecast Office Albuquerque, NM.**

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