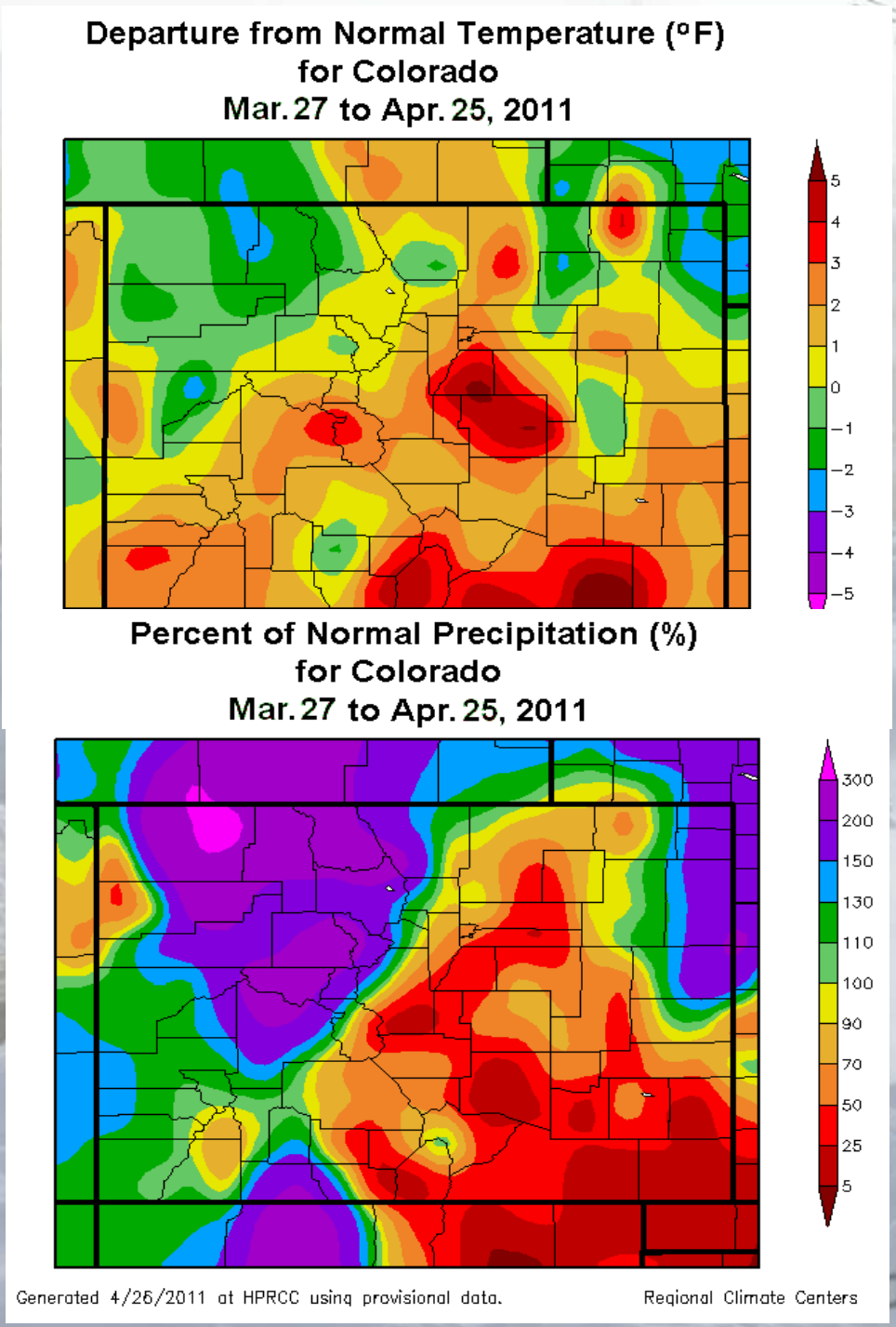
The Winter 2011-2012 Outlook for Colorado and the Latest on ENSO

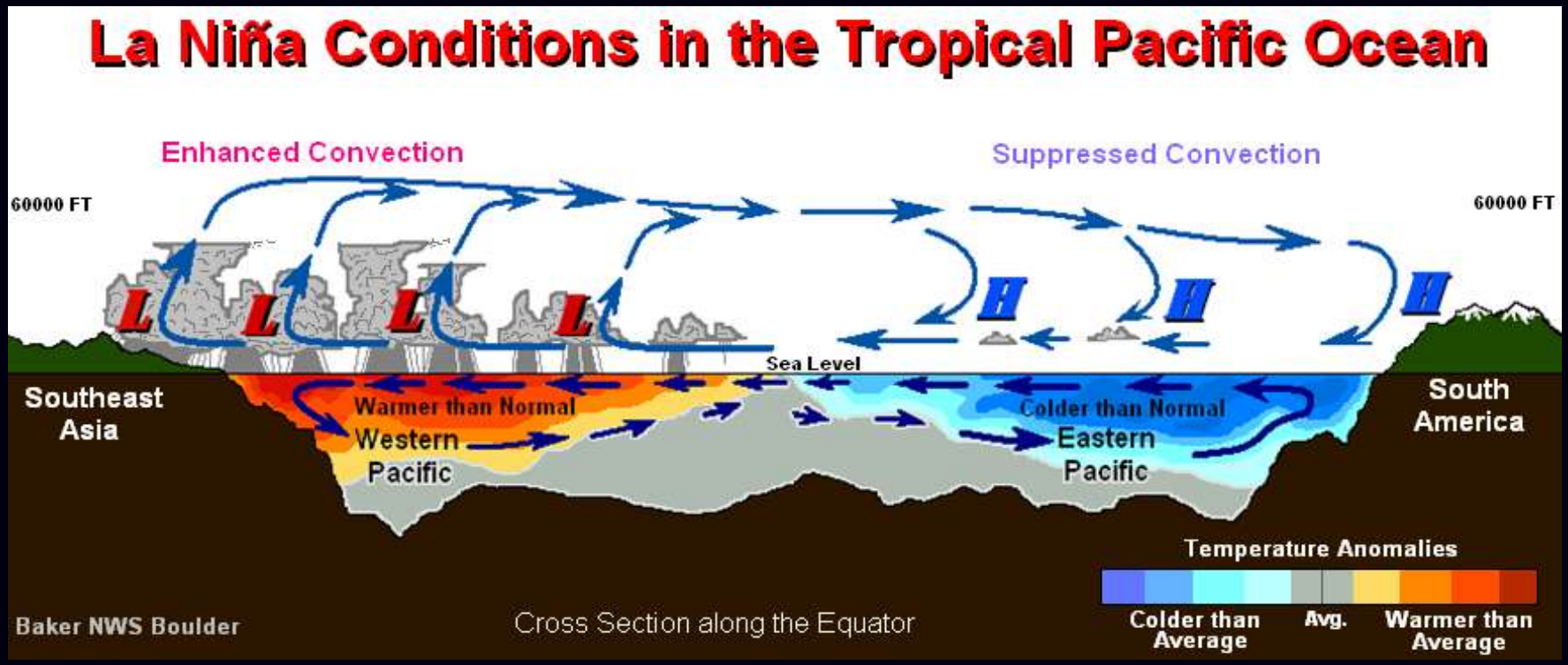
Mike Baker
National Weather Service
Boulder, Colorado
October 12, 2011

Baker - National Weather Service, Boulder, Co



Could We See a Repeat of Last Winter's Extreme Weather with a Return of La Niña?

Winter 2010-2011
on the Colorado Western Slope

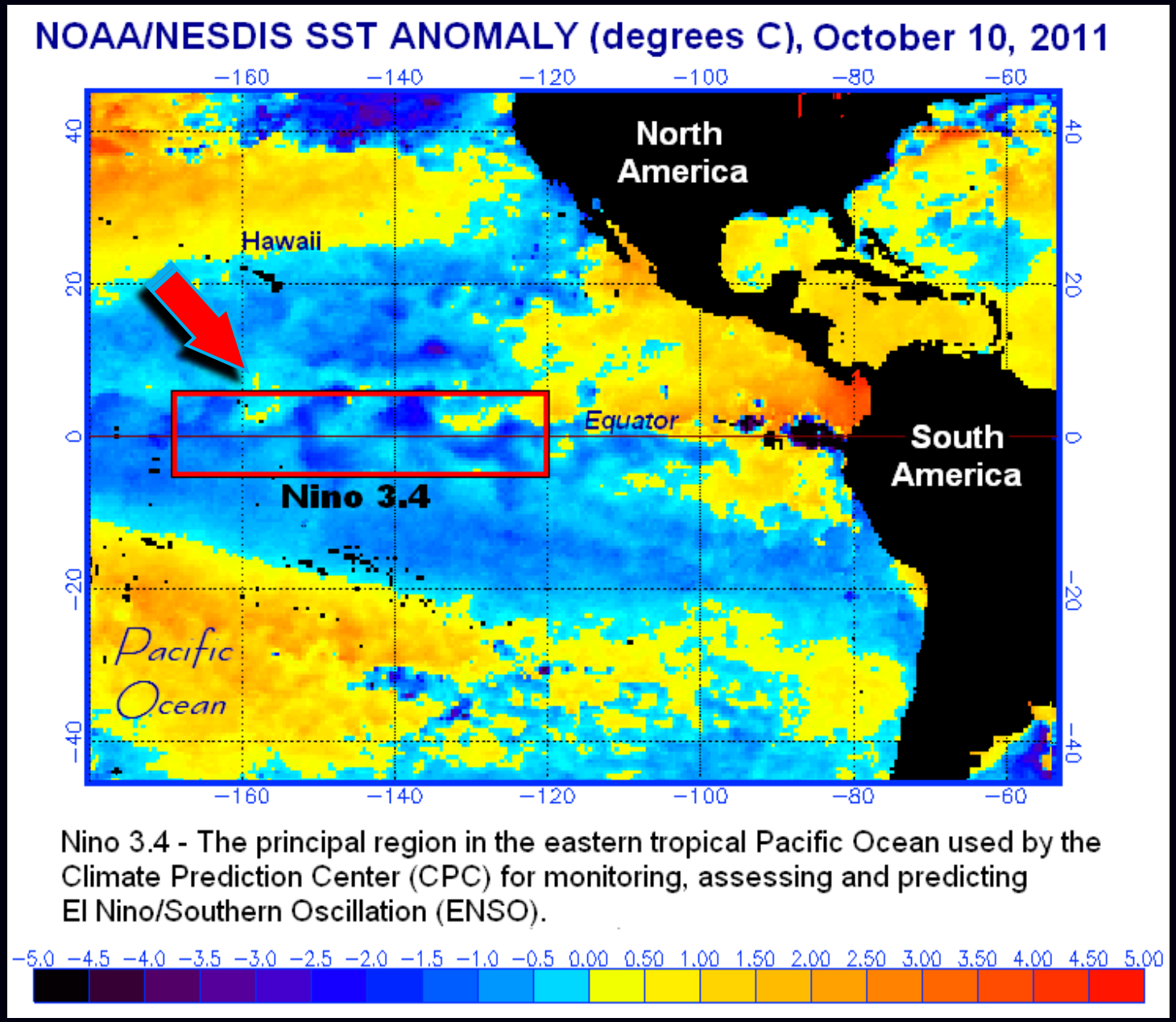


La Niña Advisory Now in Effect

La Niña conditions have returned to the Pacific and are expected to gradually strengthen and continue through the North American winter of 2011-2012.

Atmospheric circulations over the tropical Pacific Ocean exhibited La Niña characteristics during September and October. During this period, anomalous low-level easterly and upper level westerly winds and easterly subsurface ocean currents have persisted along the Equator in the Pacific Ocean. However, these circulation variables remain weaker and less extensive than those observed at the same time last year.

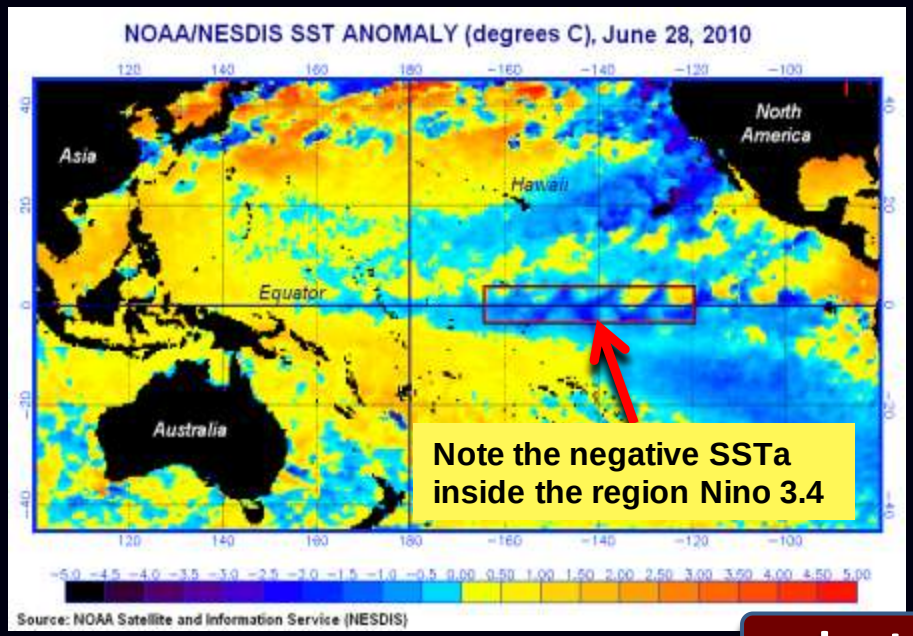
Collectively, these oceanic and atmospheric variables reflect the return of *La Niña* ***conditions.***

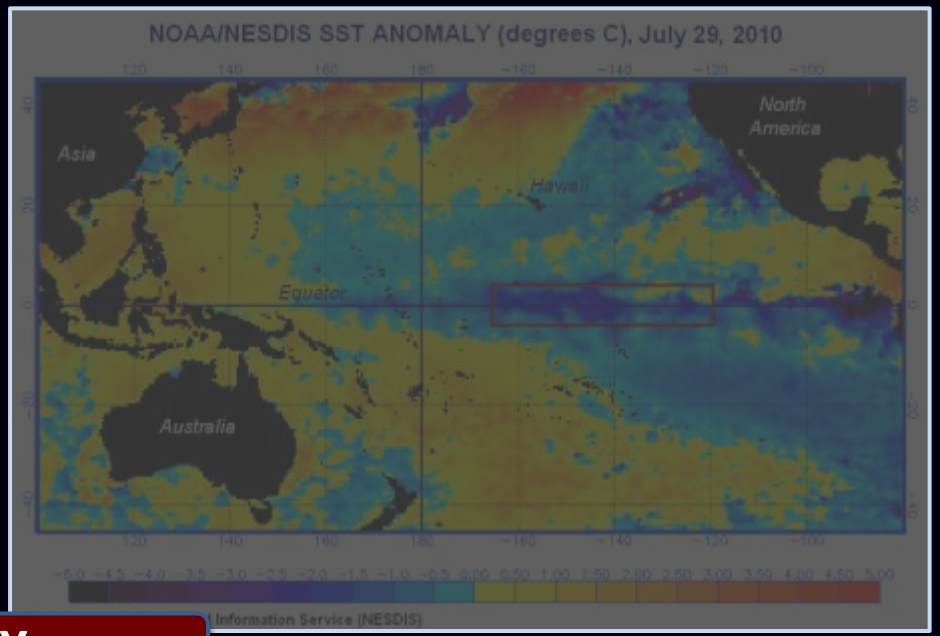


Nino 3.4 - The principal region in the eastern tropical Pacific Ocean used by the Climate Prediction Center (CPC) for monitoring, assessing and predicting El Nino/Southern Oscillation (ENSO).

Negative sea surface temperature anomalies (SSTAs) continue to cool in the eastern tropical region of the Pacific Ocean known as Nino 3.4.

How do the current SSTAs compare to those observed in the same region and at the same time last year during the early stages of a strong La Niña?


NOAA/NESDIS SST ANOMALY (degrees C), June 28, 2010
Asia
North America
Hawaii
Equator
Australia
Note the negative SSTa inside the region Nino 3.4
Source: NOAA Satellite and Information Service (NESDIS)


NOAA/NESDIS SST ANOMALY (degrees C), July 29, 2010
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North America
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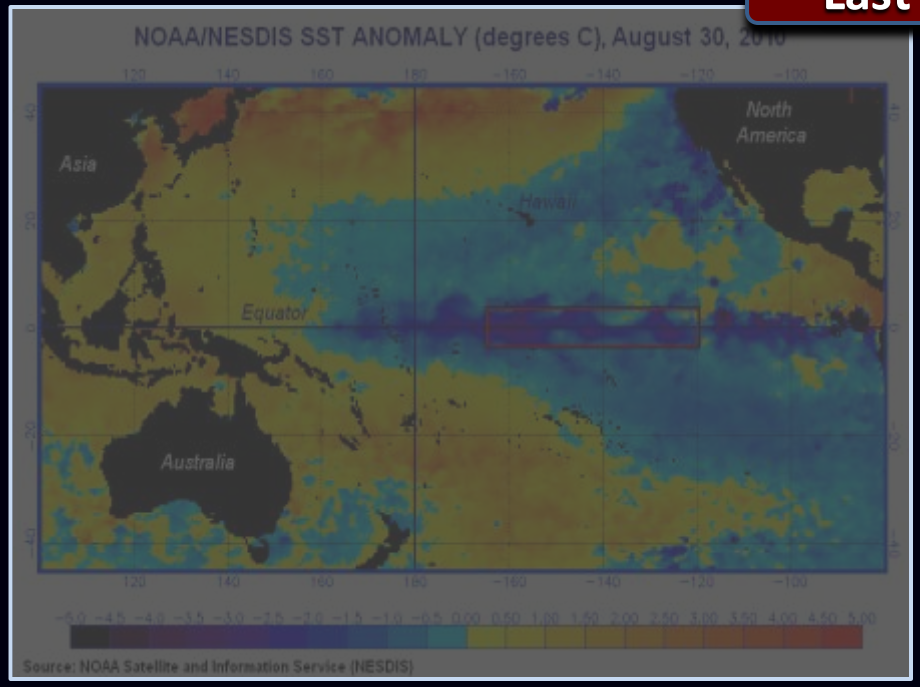
Last Year…


NOAA/NESDIS SST ANOMALY (degrees C), August 30, 2010
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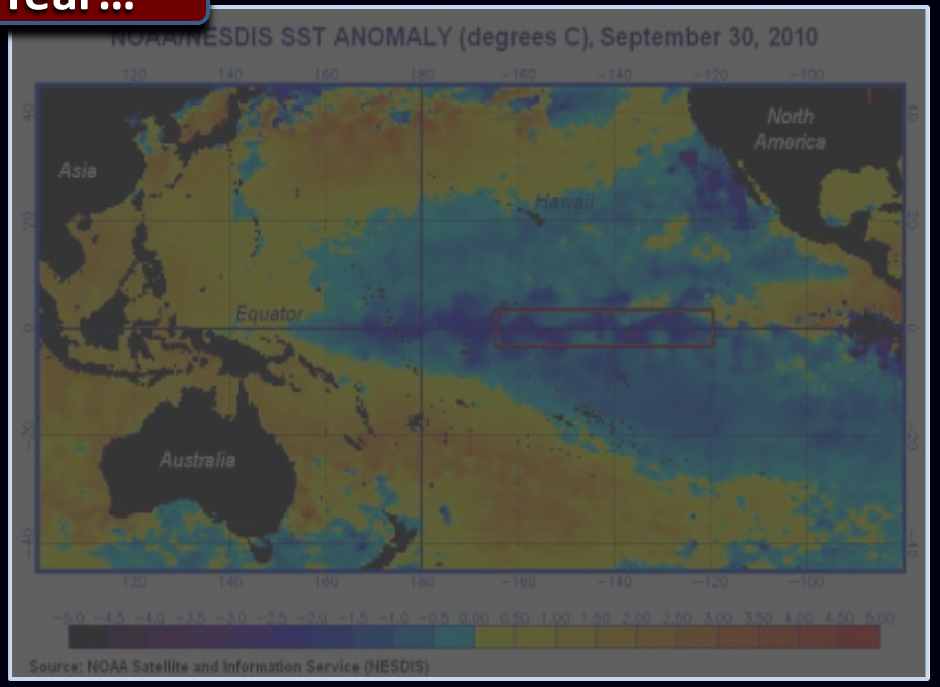
Source: NOAA Satellite and Information Service (NESDIS)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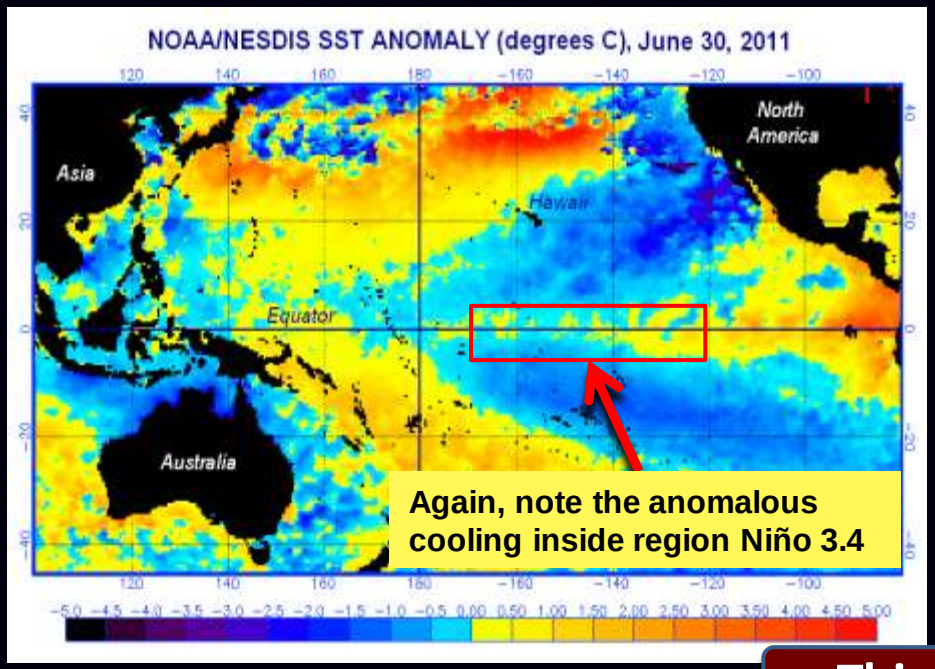
NOAA/NESDIS SST ANOMALY (degrees C), June 30, 2011
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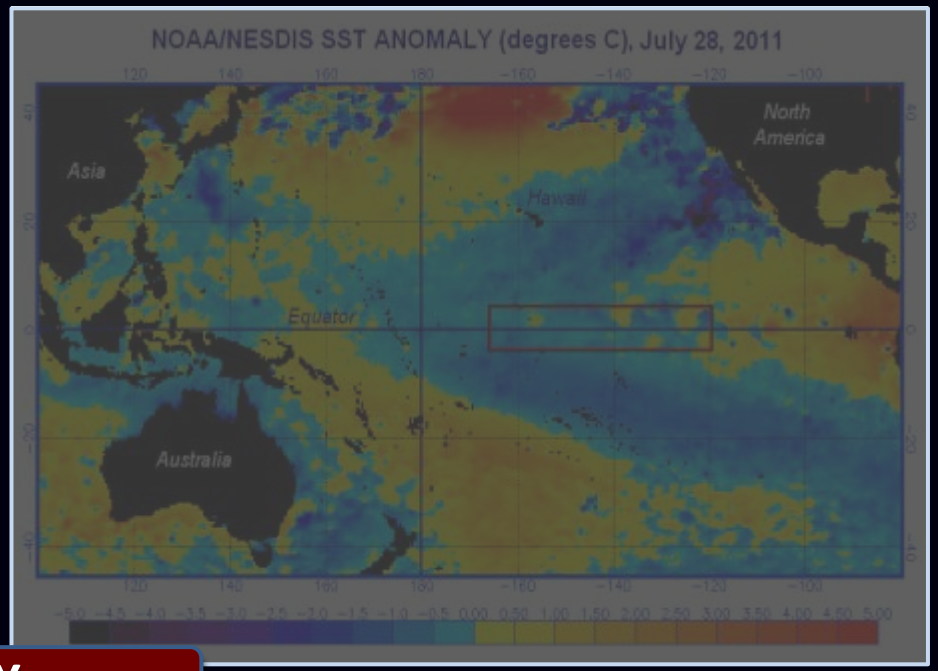
North America
Hawaii
Equator
Australia
Again, note the anomalous cooling inside region Niño 3.4


NOAA/NESDIS SST ANOMALY (degrees C), July 28, 2011
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North America
Hawaii
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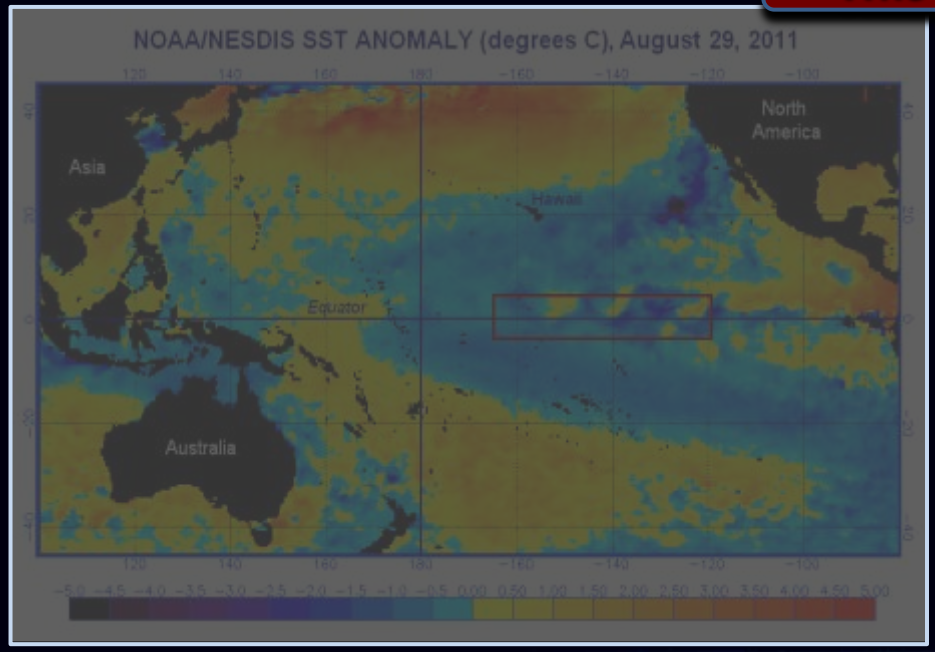
This Year…


NOAA/NESDIS SST ANOMALY (degrees C), August 29, 2011
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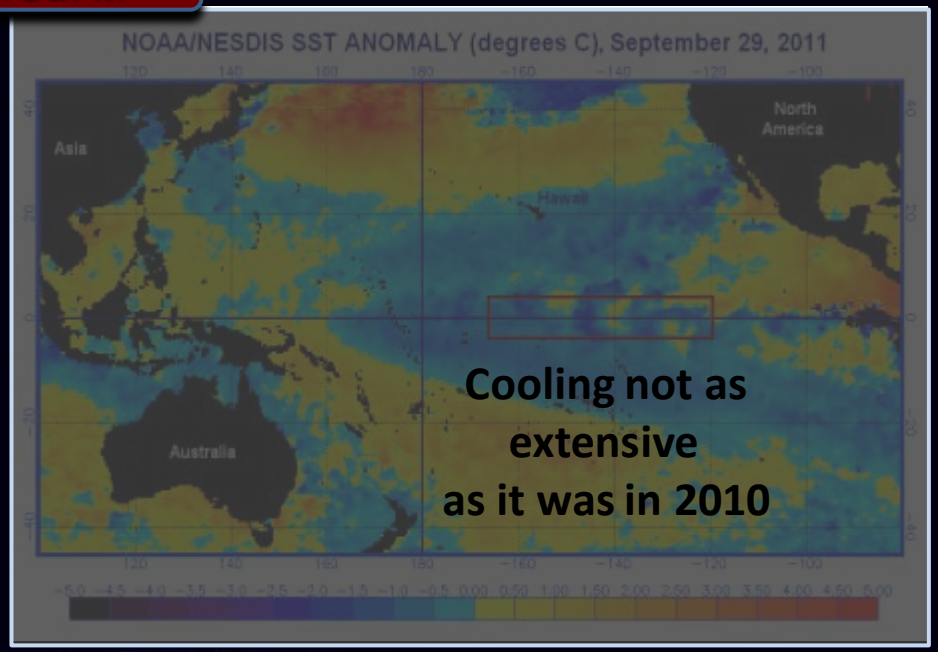
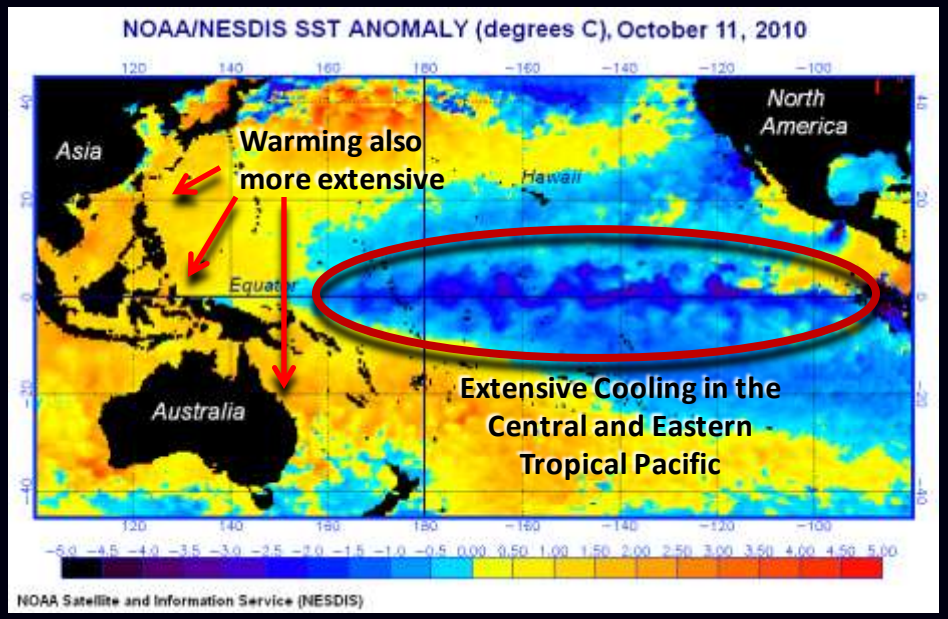
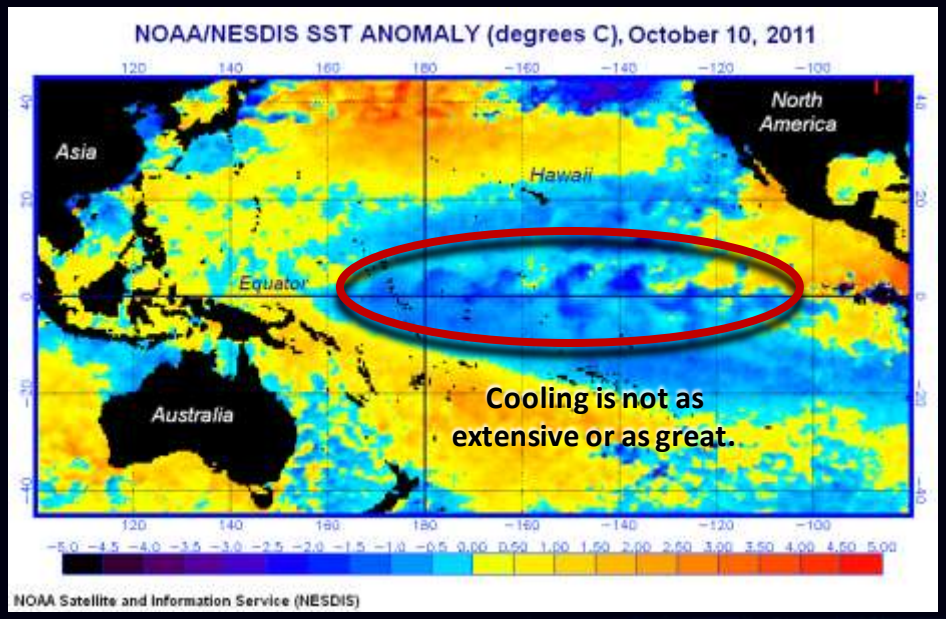

NOAA/NESDIS SST ANOMALY (degrees C), September 29, 2011
Asia
North America
Hawaii
Australia
Cooling not as extensive as it was in 2010

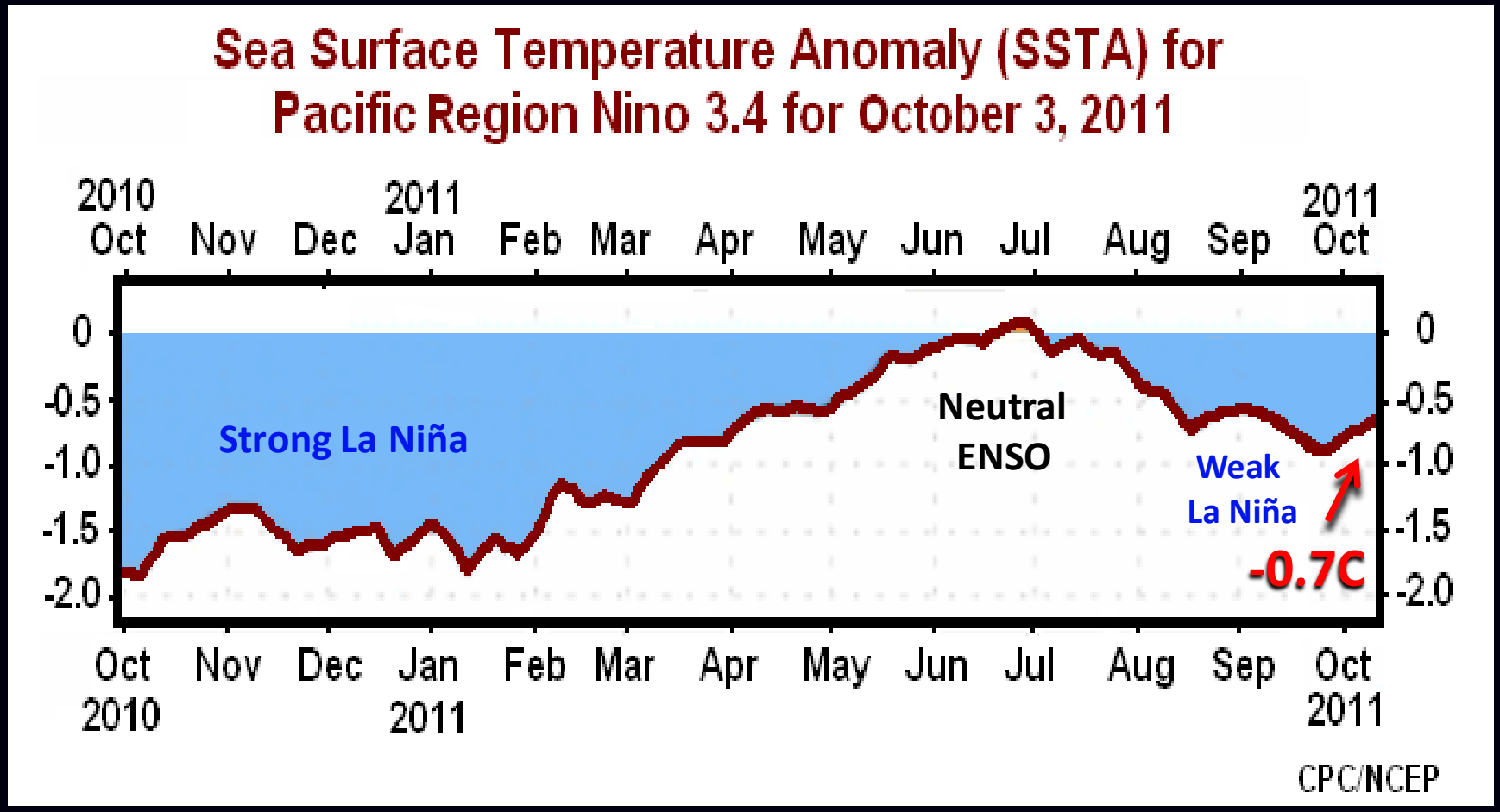
Comparing October 2010 to October 2011



The degree of anomalous cooling in the Pacific Ocean was far greater during the fall of 2010 compared to 2011. Sea surface temperature anomalies (SSTAs) in the central and eastern tropical Pacific in October of 2010 were 2 to 5 degrees C colder than those observed this year in the same region of the Pacific.

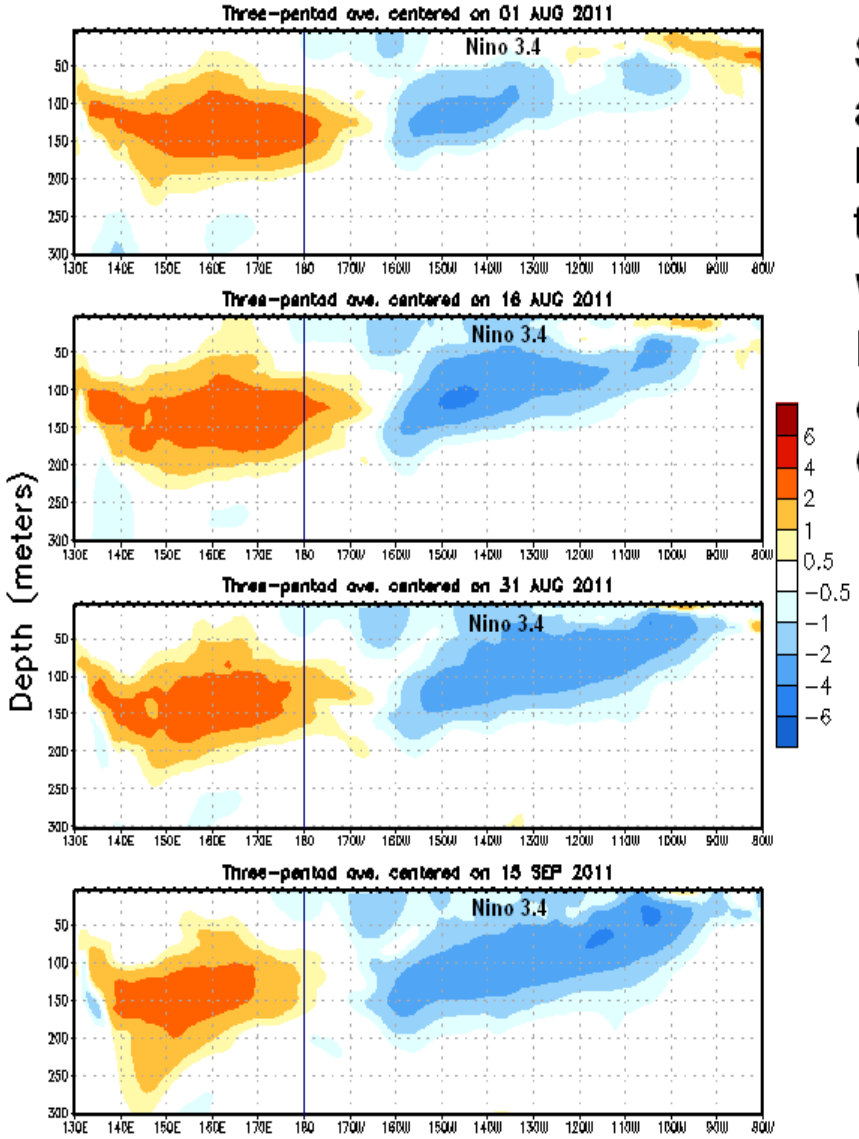


A horseshoe pattern of above average SSTs existed during both periods. However, above average SSTs covered a far greater expanse of the western Pacific during the fall of 2010; another indication that the 2010 La Niña (during its early stages) was comparatively stronger than current La Niña conditions.



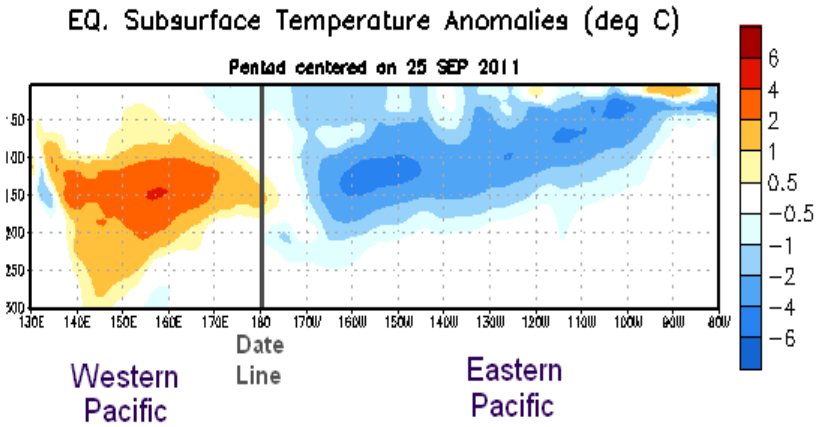
The latest weekly (10-03-11) SSTA for Niño 3.4 is -0.7C.

Subsurface Temperature Anomalies (in Deg C) for the Equatorial Pacific Ocean

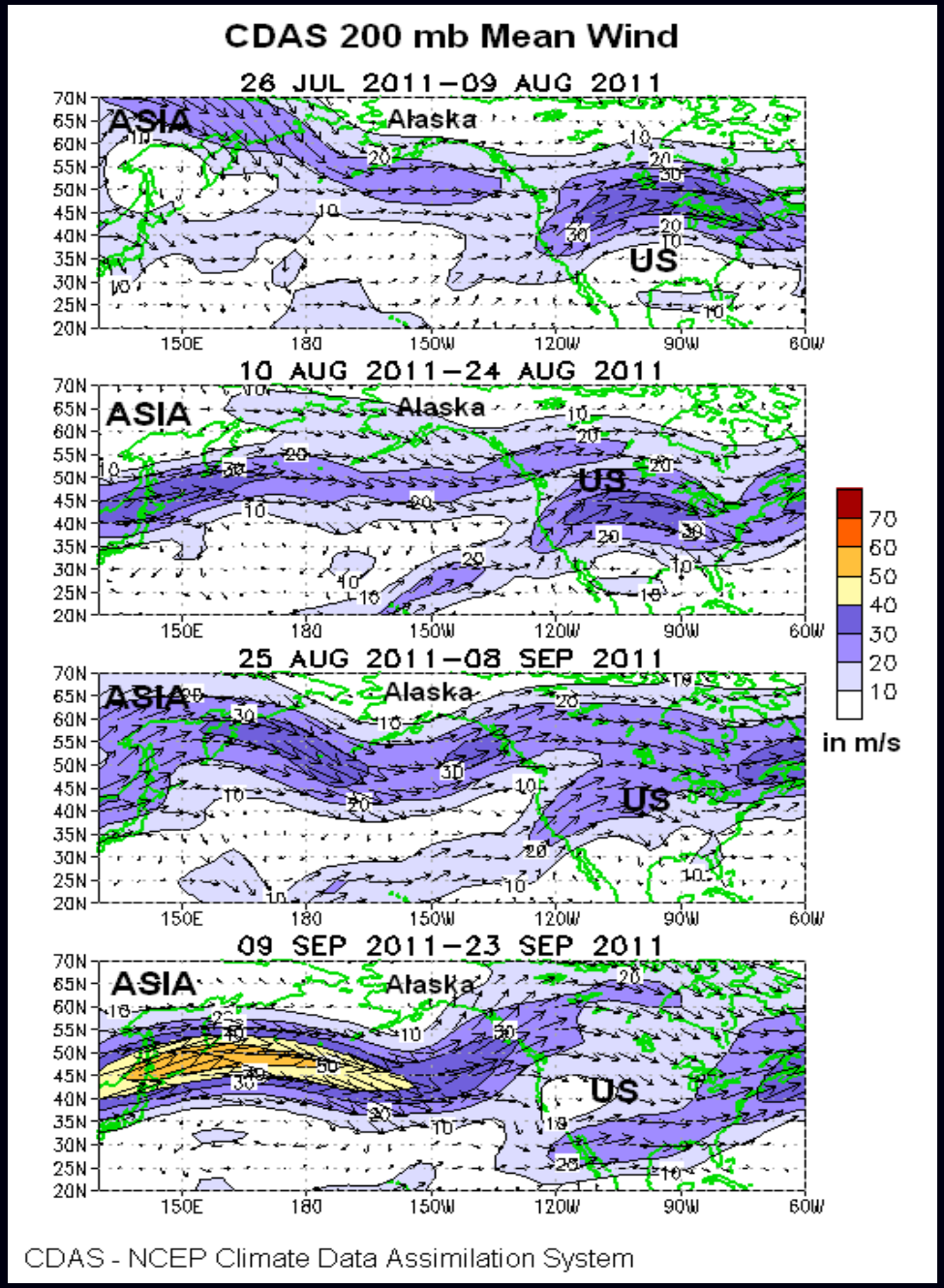


Since August of this year, temperature anomalies at depths of 100 to 300 meters have continued to warm in the western tropical Pacific Ocean.

While in the central and eastern tropical Pacific, subsurface temperatures have cooled to values several degrees Celcius below average.



CPC/NCEP



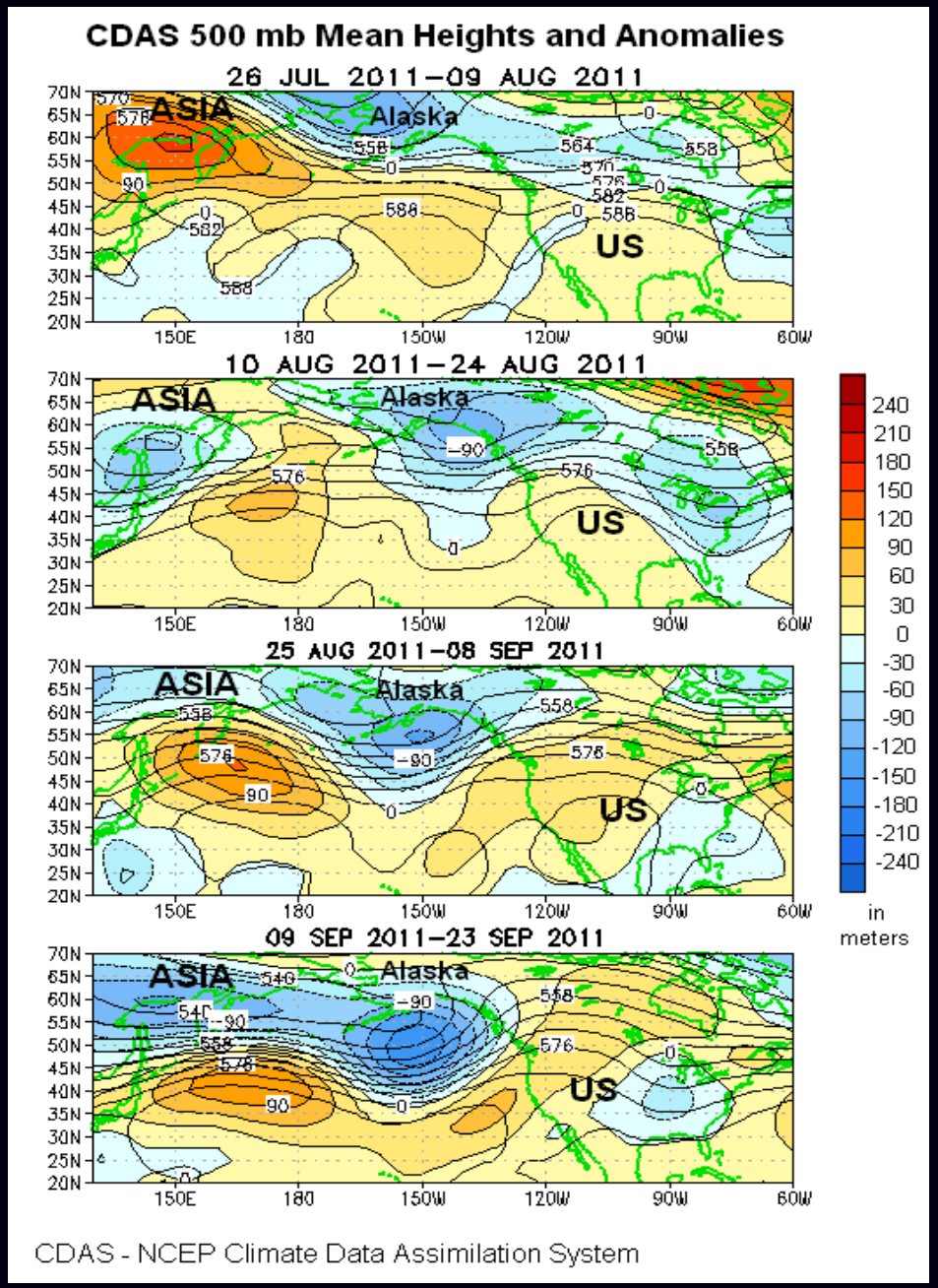
Jet stream level (200mb) wind velocity has gradually increased over the Pacific Ocean since August of this year.

A persistent southward dip in the Pacific jet stream over the central Pacific during September produced a high amplitude upper level ridge over western North America. The Pacific Jet remained well north of Colorado during most of September resulting in the abnormally warm temperatures observed across much of Colorado during this period.

Jet streams are depicted by shades of purple, yellow and orange. (1 m/s = 1.94 kts)

Global 200 mb Height Anomalies as of September 29, 2011

http://www.cpc.ncep.noaa.gov/products/intraseasonal/z200anim.shtml



The strengthening jet stream over the Pacific Ocean is also associated with strong negative height falls (troughing) over the eastern Pacific west of North America during the last couple of weeks.

The deepening mean upper level trough off the west coast of NA coincided with a large and persistent upper level ridge over the western United States and central Canada.

Northern Hemisphere 500 mb Height Anomalies as of September 29, 2011

http://www.cpc.ncep.noaa.gov/products/intraseasonal/z500_nh_anim.shtml

Oceanic Niño Index - ONI

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2000	-1.6	-1.4	-1.0	-0.8	-0.6	-0.5	-0.4	-0.4	-0.4	-0.5	-0.6	-0.7
2001	-0.6	-0.5	-0.4	-0.2	-0.1	0.1	0.2	0.2	0.1	0	-0.1	-0.1
2002	-0.1	0.1	0.2	0.4	0.7	0.8	0.9	1.0	1.1	1.3	1.5	1.4
2003	1.2	0.9	0.5	0.1	-0.1	0.1	0.4	0.5	0.6	0.5	0.6	0.4
2004	0.4	0.3	0.2	0.2	0.3	0.5	0.7	0.8	0.9	0.8	0.8	0.8
2005	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.2	-0.1	-0.4	-0.7
2006	-0.7	-0.6	-0.4	-0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.1	1.1
2007	0.8	0.4	0.1	-0.1	-0.1	-0.1	-0.1	-0.4	-0.7	-1.0	-1.1	-1.3
2008	-1.4	-1.4	-1.1	-0.8	-0.6	-0.4	-0.1	0	0	0	-0.3	-0.6
2009	-0.8	-0.7	-0.5	-0.1	0.2	0.6	0.7	0.8	0.9	1.2	1.5	1.8
2010	1.7	1.5	1.2	0.8	0.3	-0.2	-0.6	-1.0	-1.3	-1.4	-1.4	-1.4
2011	-1.3	-1.2	-0.9	-0.6	-0.2	0	0					

Latest ONI

El Niños (warm phase events): ONI of +0.5 and higher (red numbers)

La Niñas (cold phase events): ONI of -0.5 and lower (blue numbers)

ENSO-Neutral (near average conditions): ONI below 0.5 and above -0.5 (black numbers)

An ONI of 0.0 is an indication of ENSO-neutral conditions in the Niño 3.4 region during the three-month climate season of June-July-August of 2011.

NOAA/CPC Sep 21 2011

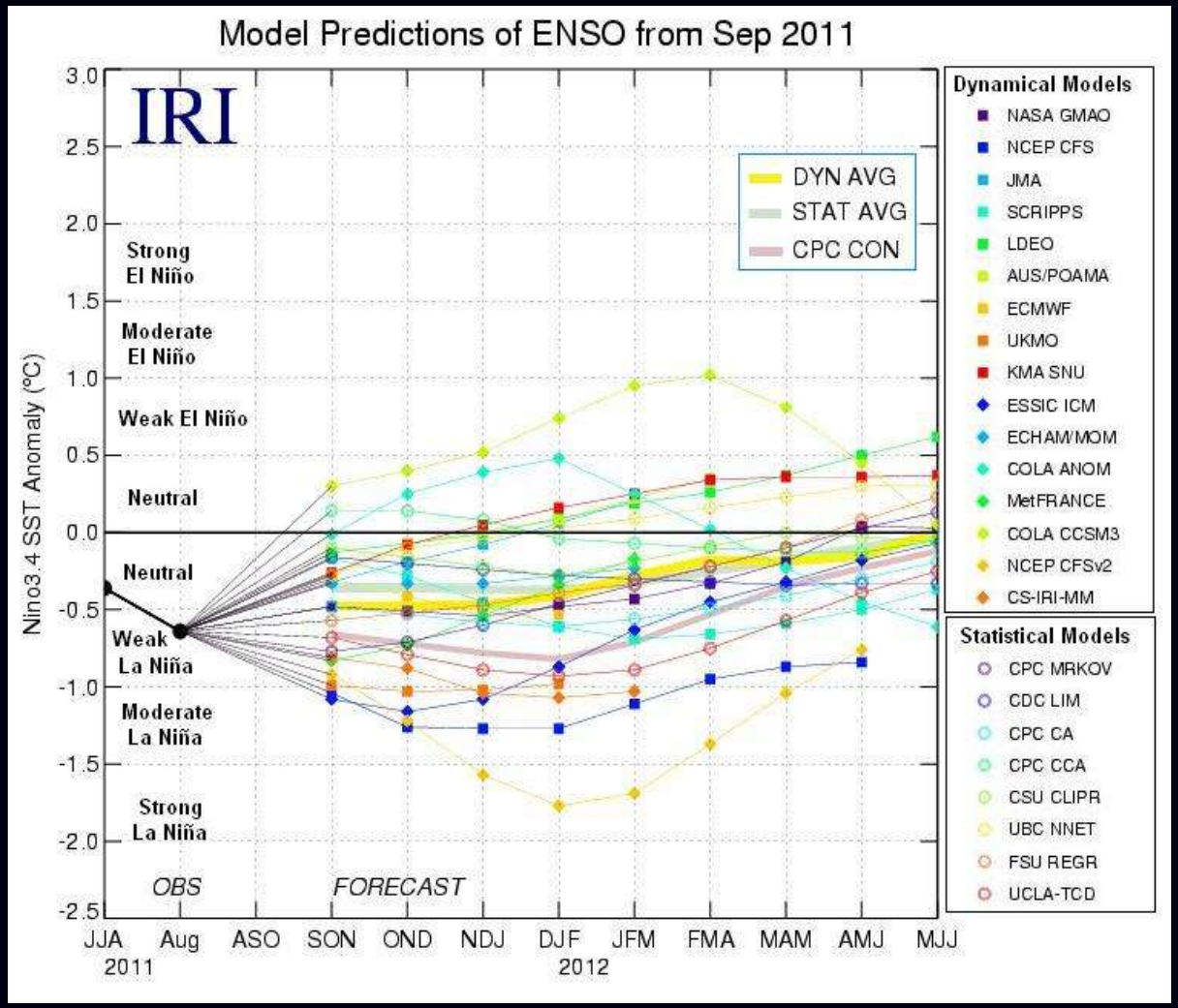
The ONI is based on sea surface temperature (SST) departures from average in the Niño 3.4 region of the eastern tropical Pacific and is a principal measure for monitoring, assessing and predicting ENSO.

ONI is defined as the three-month running-mean SST departures in the Niño 3.4 region.

ONI is used to place current ENSO and non-ENSO events into a historical perspective.

NOAA's operational definitions of El Niño and La Niña are keyed to the ONI index.

Model Predictions for El Niño/Southern Oscillation (ENSO) Through May-June-July of 2012

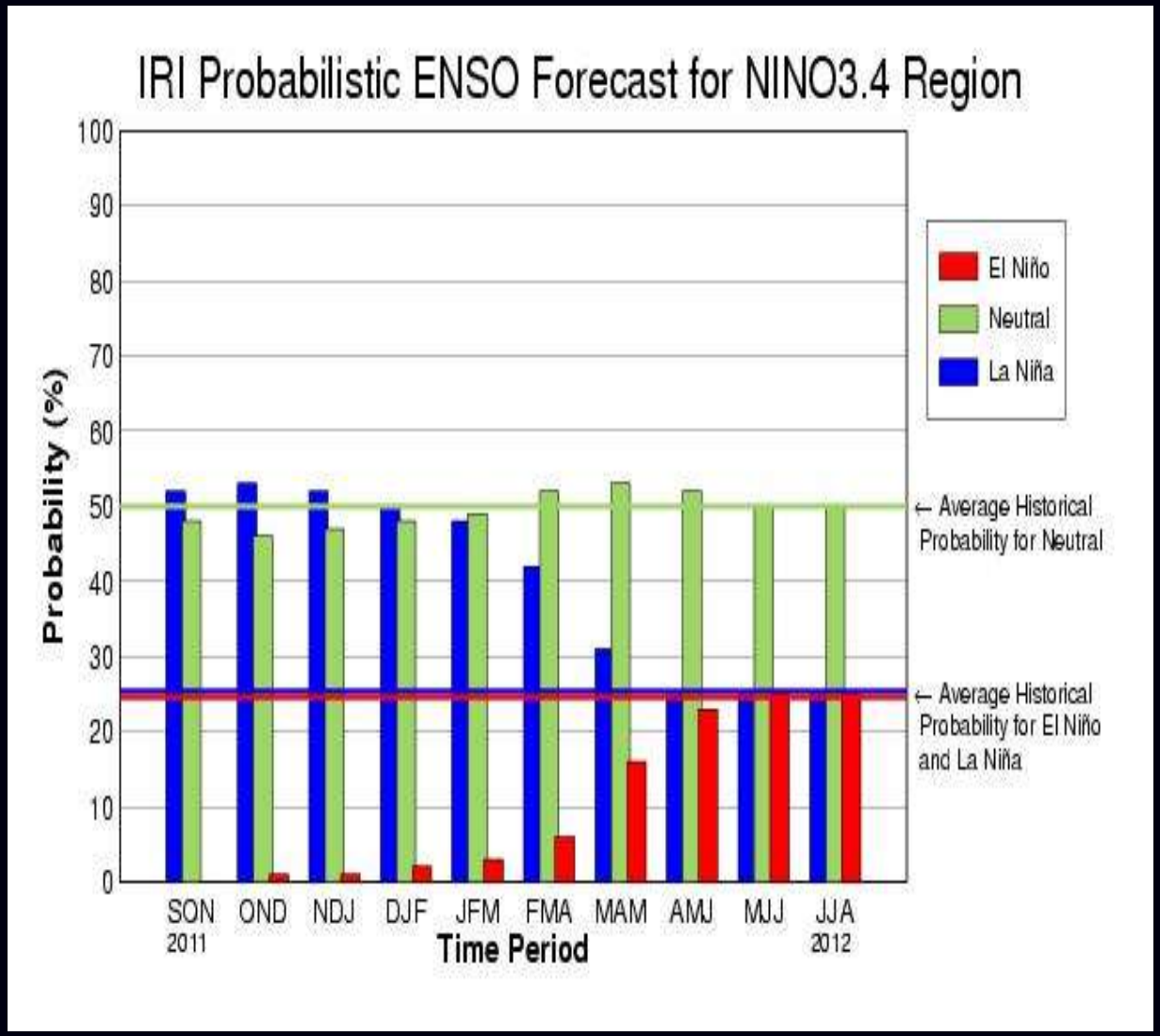


Source: International Research Institute for Climate and Society (IRI) – Updated 9/15/11

Since August of this year, weak La Niña conditions have existed in the tropical Pacific Ocean.

Based on a majority of the dynamical and statistical ENSO models, weak La Niña conditions will continue in the Pacific through early this winter and ENSO-neutral conditions during the latter half of the 2011-2012 winter season.

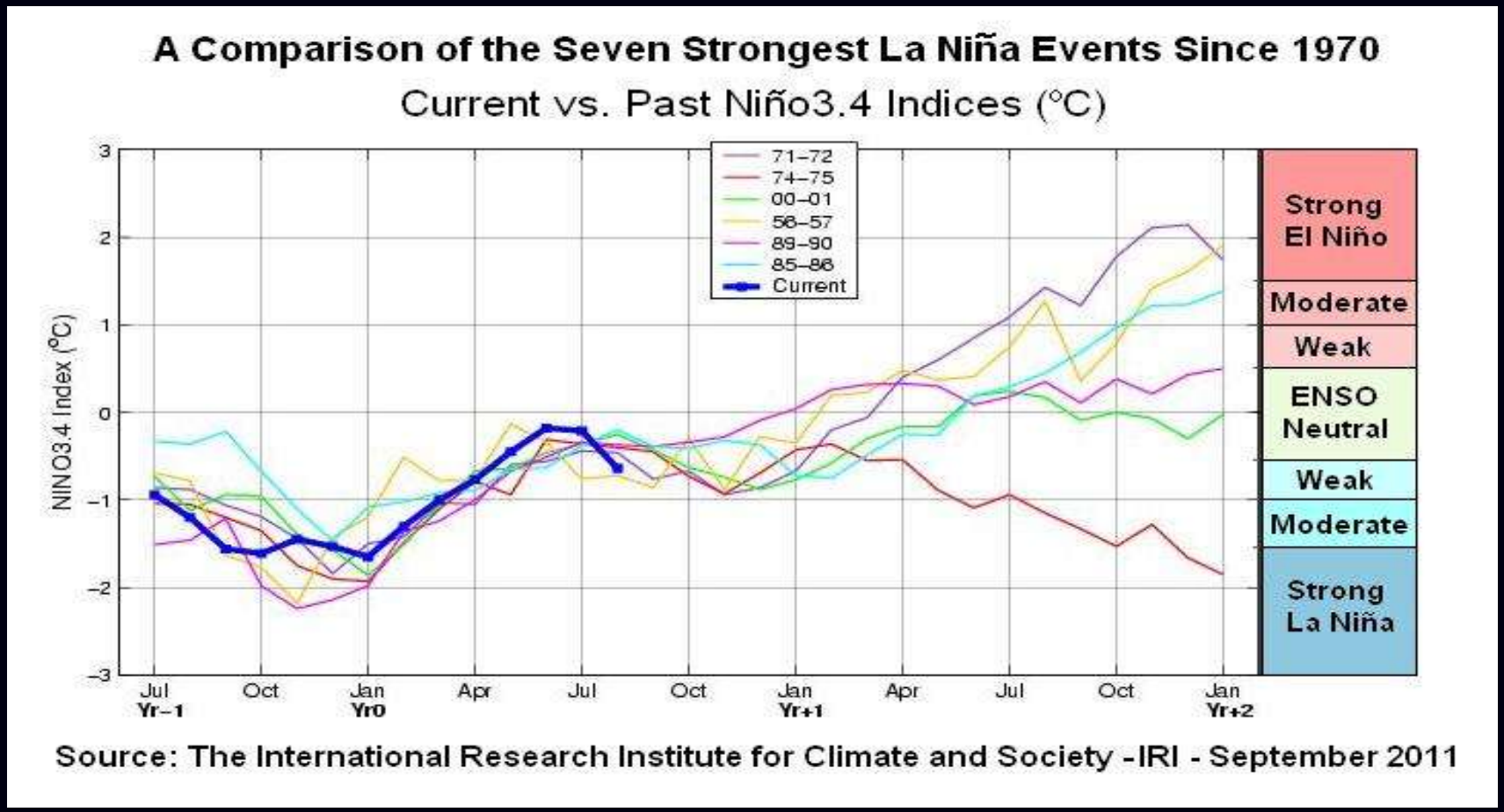
However, as of this date, a growing number of these models including NCEP's Coupled System Forecast Model (CFS), predict weak to even moderate La Niña conditions through the January-March 2012 climate period. Only one model went so far as to predict El Niño conditions this winter.



Considering the latest atmospheric and oceanic observations, there is a 52% and 50% chance that La Niña conditions will exist during the November-January and December-February climate periods, with corresponding probabilities for ENSO-neutral conditions of 47% and 48%.

Probabilities for El Niño conditions are 2% or less for the climate period December-February 2011-2012.

Source: International Research Institute for Climate and Society (IRI) – Updated 9/15/11



Above is a comparison of the present and past Niño 3.4 indices for the seven strongest La Niña events since 1970. A majority of these events were classified as weak cold phase ENSO events (-0.5 to -1.0C) during their subsequent winter season. Only one of these events (the La Niña of 1989-1990) transitioned to ENSO-neutral conditions by the following fall and winter.

The present Niño 3.4 index (thick blue line) has decreased at a steeper rate than most during the months of July and August, and only one event (the 1956-1957 event) exhibited an index lower than the current Niño 3.4 index for the same period. All subsequent events became ENSO-neutral by the following spring.

Up to this Point:

- La Niña conditions returned to the Pacific Ocean in August after several weeks of ENSO-neutral conditions earlier in the summer.
- Sea surface temperature anomalies (SSTa) in the central and eastern equatorial Pacific have continued to cool and expand westward beyond the International Date Line with light anomalous easterly trade winds.
- The latest weekly SSTa value for ENSO 3.4 is -0.7C; one indication that *weak* La Niña conditions exist in the Pacific.
- Subsurface temperature anomalies in the central and eastern Pacific have also continue to cool (increase negatively) at greater depths; another indication that La Niña conditions continue to strengthen.
- However, atmospheric circulations remains weak and deep layer convection remains largely suppressed over much of tropical Pacific Ocean.
- **The latest prediction is for weak La Niña conditions to continue through the November-January 2011-2012 climate period. Afterwards, ENSO-neutral conditions are expected to develop and continue through the spring of 2012.**

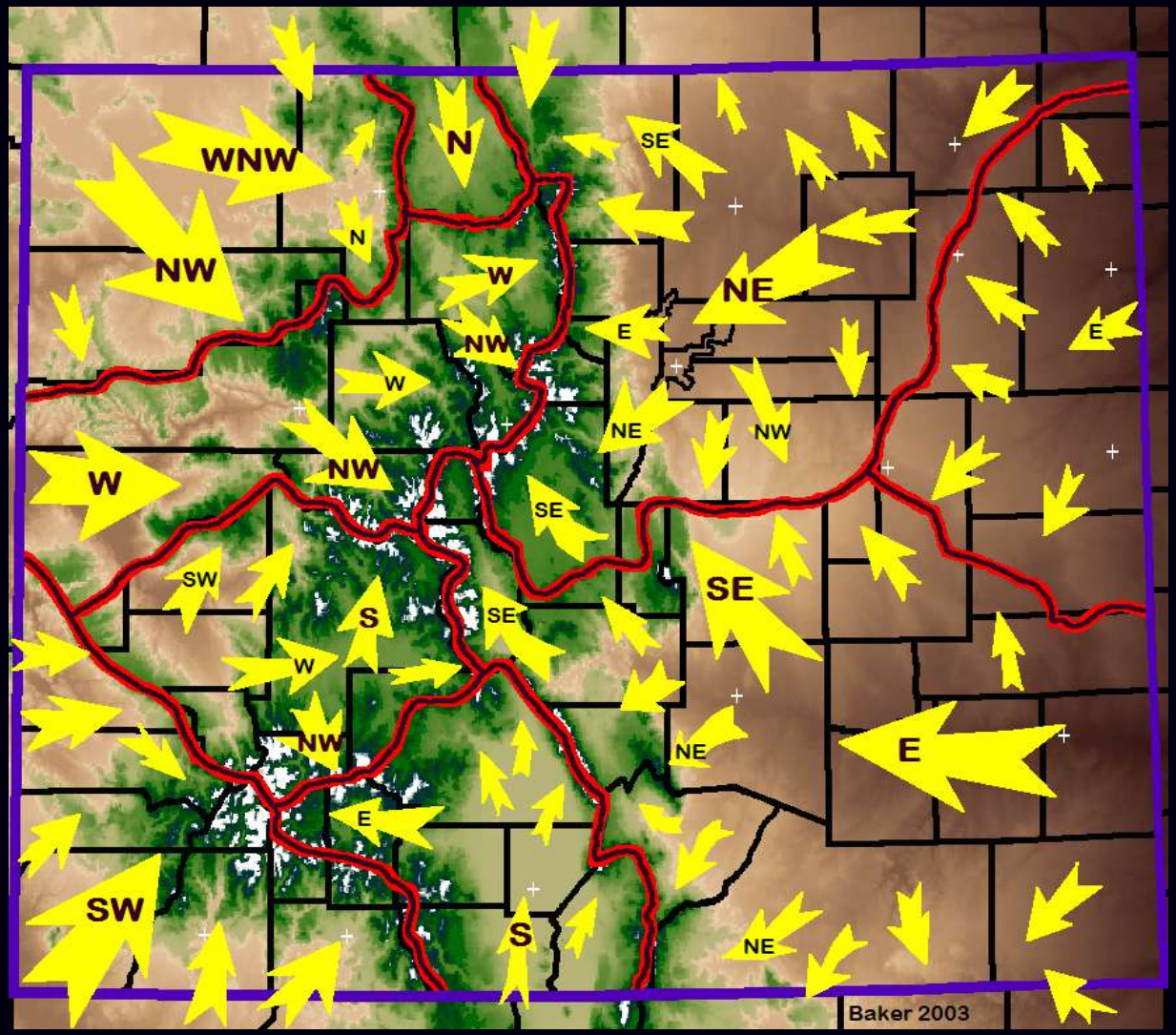
Understanding Colorado Weather

Looking Southwest from the High Plains of Northeast Colorado

Baker - National Weather Service, Boulder, Co

To better understand Colorado weather, one must recognize the important role topography (mountains, plateaus, valleys, plains, etc.) has on wind, temperature and precipitation patterns and even on the movement of storms.

Favorable Orographic (Upslope) Wind Components for the Production of Thunderstorms and Precipitation



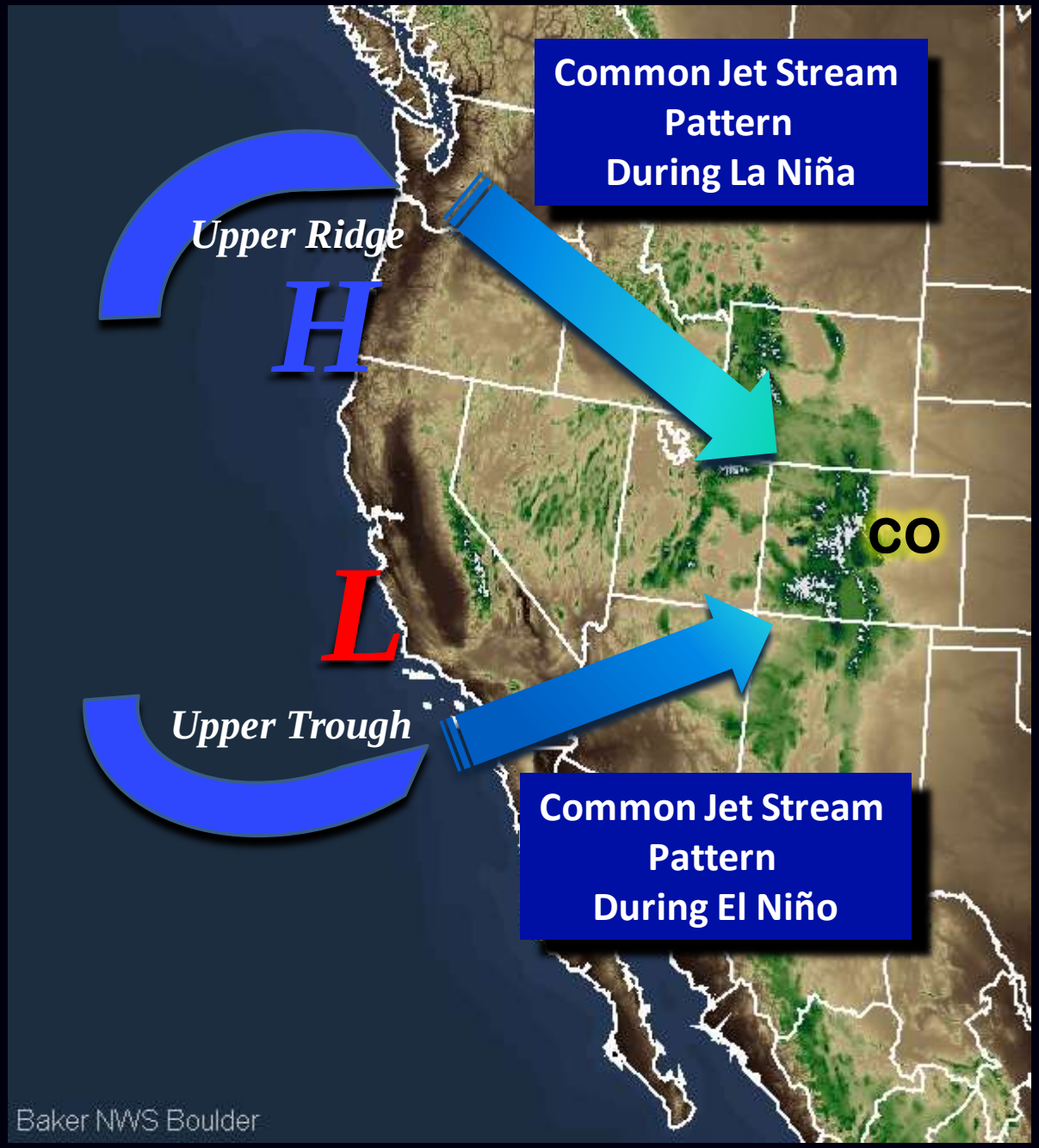
In northwest Colorado, the favorable upslope wind component is a northwesterly direction.

In west-central Colorado, it is principally a westerly component.

In southwest Colorado, it is principally a southwesterly component.

In northeast Colorado, it is principally an east-northeasterly direction.

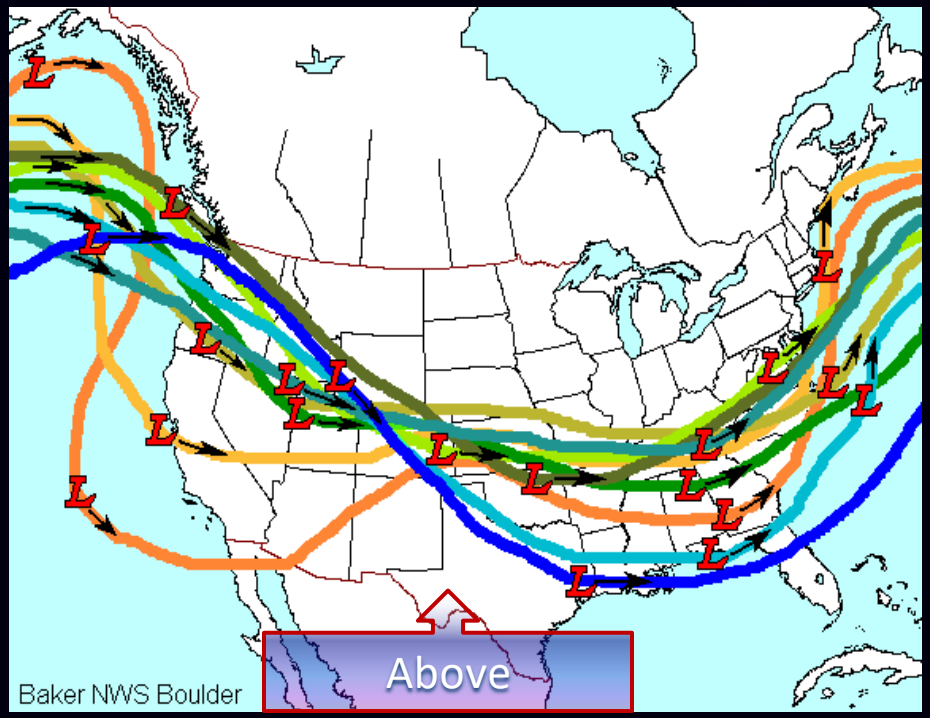
And, in southeast Colorado, the optimum upslope component is an east-southeasterly wind direction.



The **Pacific jet stream,** a meandering river of strong winds in the mid-latitudes generally 18000 and 30000 feet ASL, plays an important role in the distribution and production of precipitation in Colorado, particularly during the winter and spring.

Under moderate to strong La Niña conditions, the Pacific jet typically curves northward over a large, often quasi-stationary upper level high pressure ridge along the west coast of the continental U.S.

During moderate to strong El Niño conditions, the Pacific jet stream is often seen curving around the bottom of a large, quasi-stationary upper level low pressure trough along the west coast of the U.S.

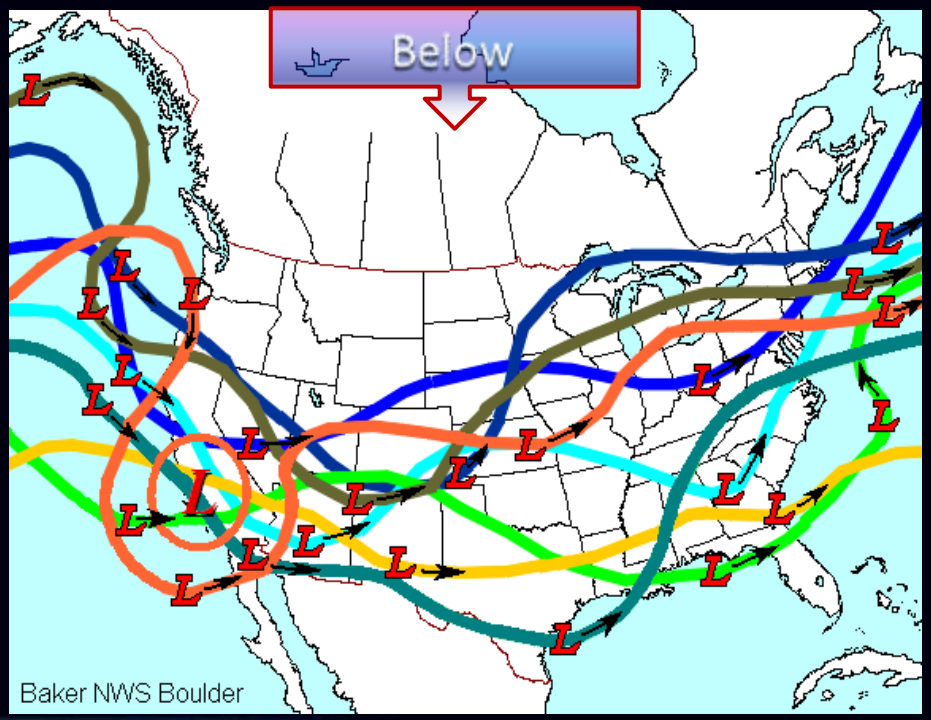


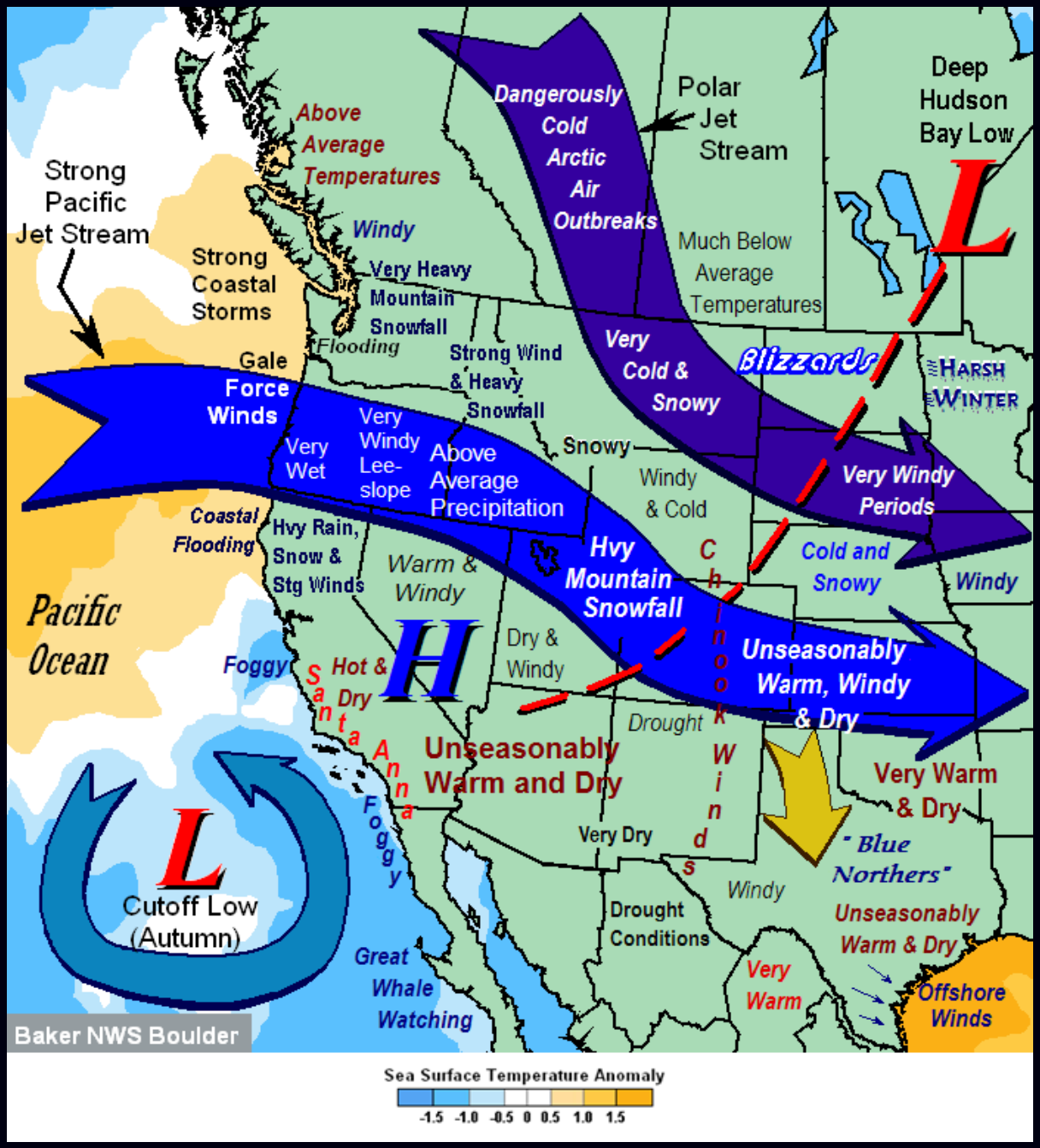
Typical Wintertime Storm Tracks During Moderate to Strong El Niños

A majority of wintertime storms affecting the western CONUS, in the presence of moderate to strong El Niño conditions, follow a relatively broader path that takes them farther south over California and the desert southwest, and eventually across the Rocky Mountains of Colorado and New Mexico. These storms generally move slower and therefore have a potential to produce greater precipitation, particularly at high mountain elevations. Southern and eastern Colorado tend to a see its share of wet and snowy weather with this storm track pattern.

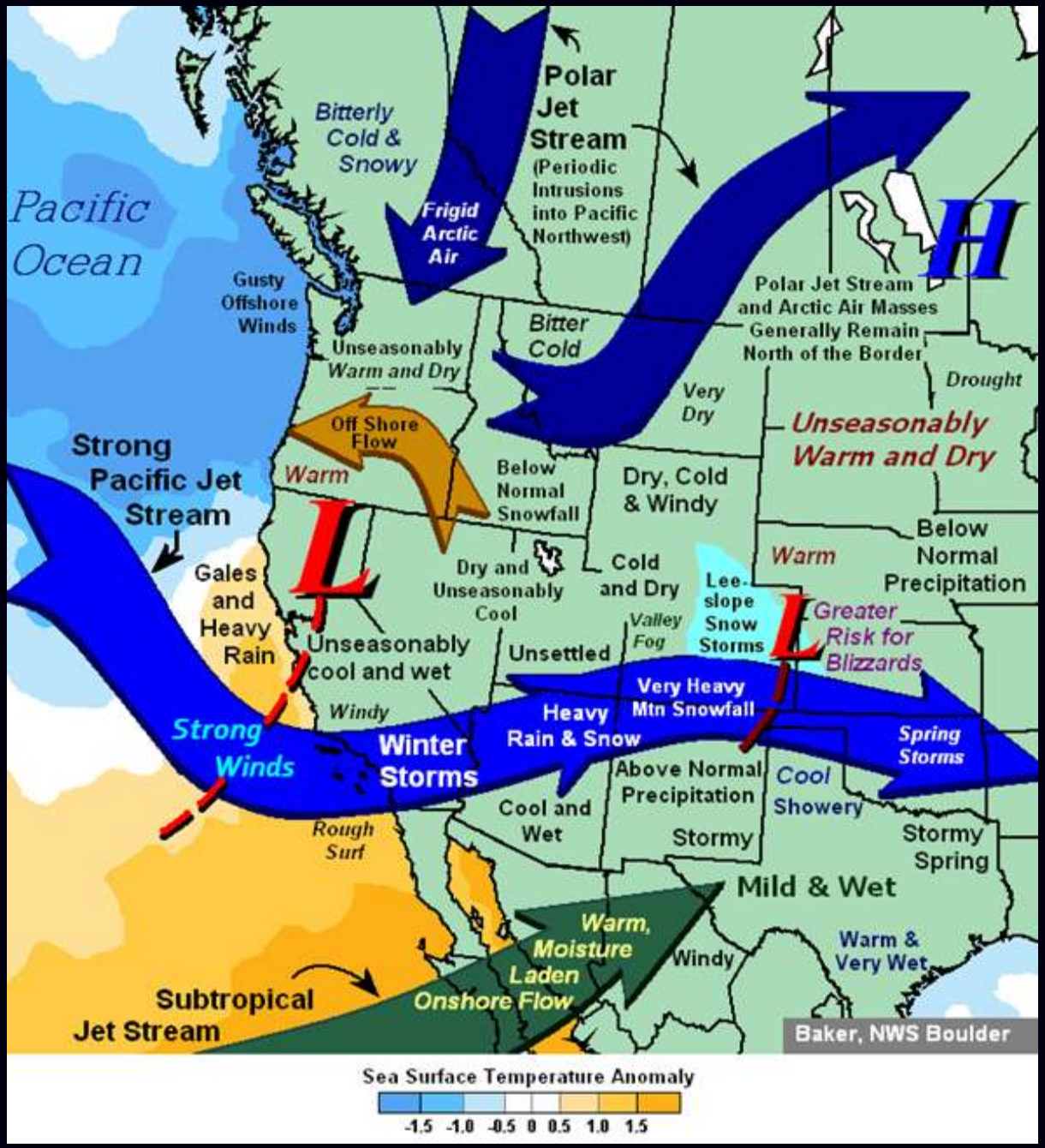
Typical Wintertime Storm Tracks During Moderate to Strong La Niñas

A majority of wintertime storms affecting the western continental United States (CONUS) during moderate to strong La Niña conditions originate in the Pacific northwest (Washington, Oregon) with the Pacific jet stream. These fast moving storms are often laden with moisture and contain strong winds. Many of these storms follow a relatively narrow path southeastward across the central Rockies. However, some storms, on occasion, may take a more southerly track should the west coast high pressure ridge move farther out over the eastern Pacific.





Typical
Jet Stream
and
Winter Weather
Conditions
During
Moderate to Strong
La Niñas



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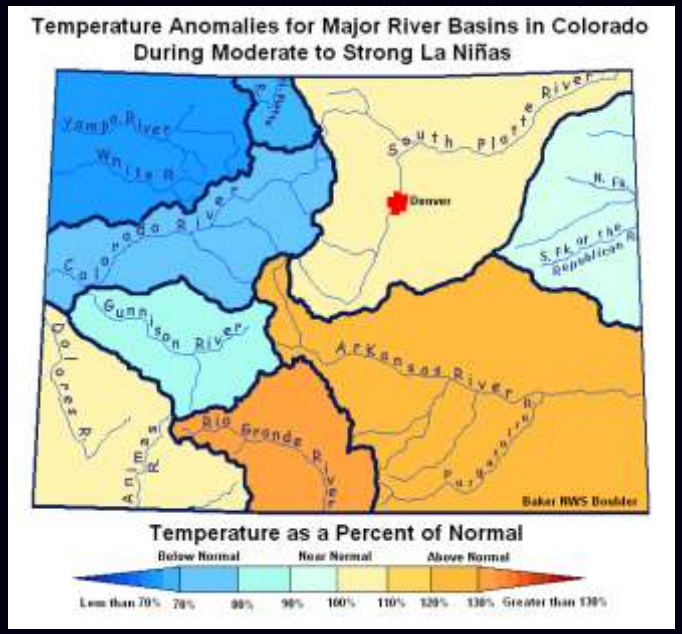
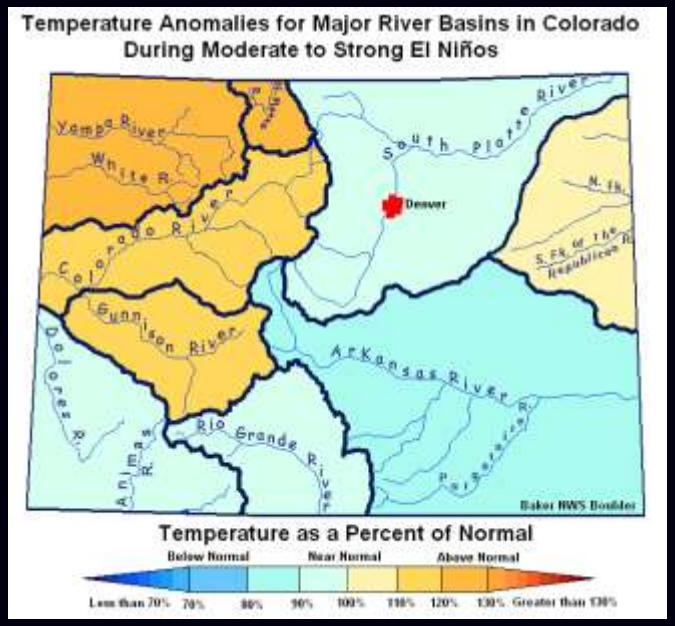
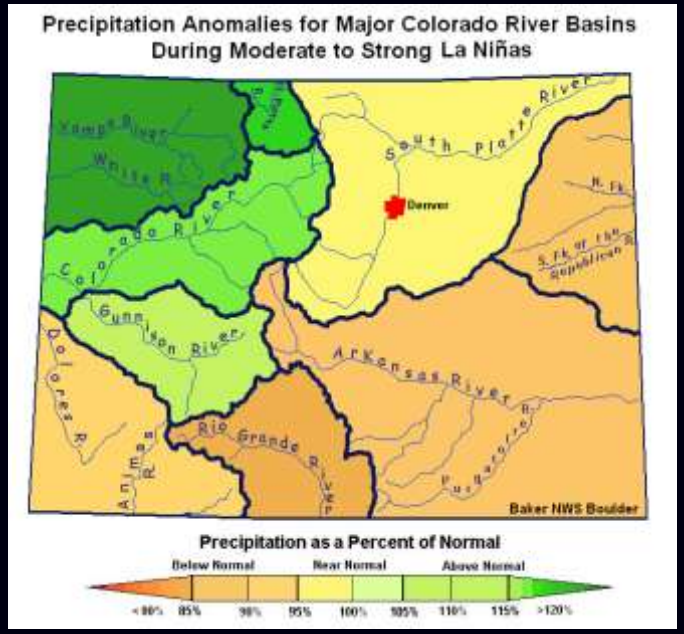


Temperature

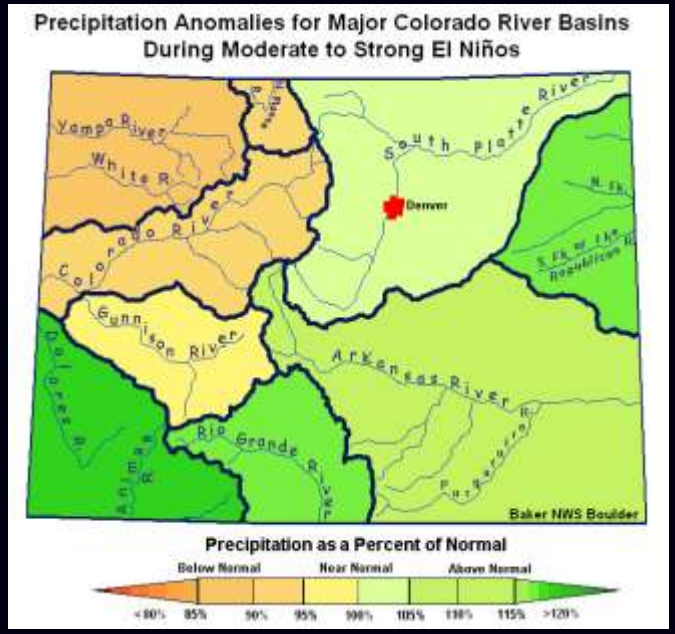
Temperatures typically run colder than average in northwest Colorado and warmer than average across southern and eastern Colorado during La Niñas. Under El Niño conditions, the winter season temperature pattern is reversed with the northwest warmer and the south and east colder than average.





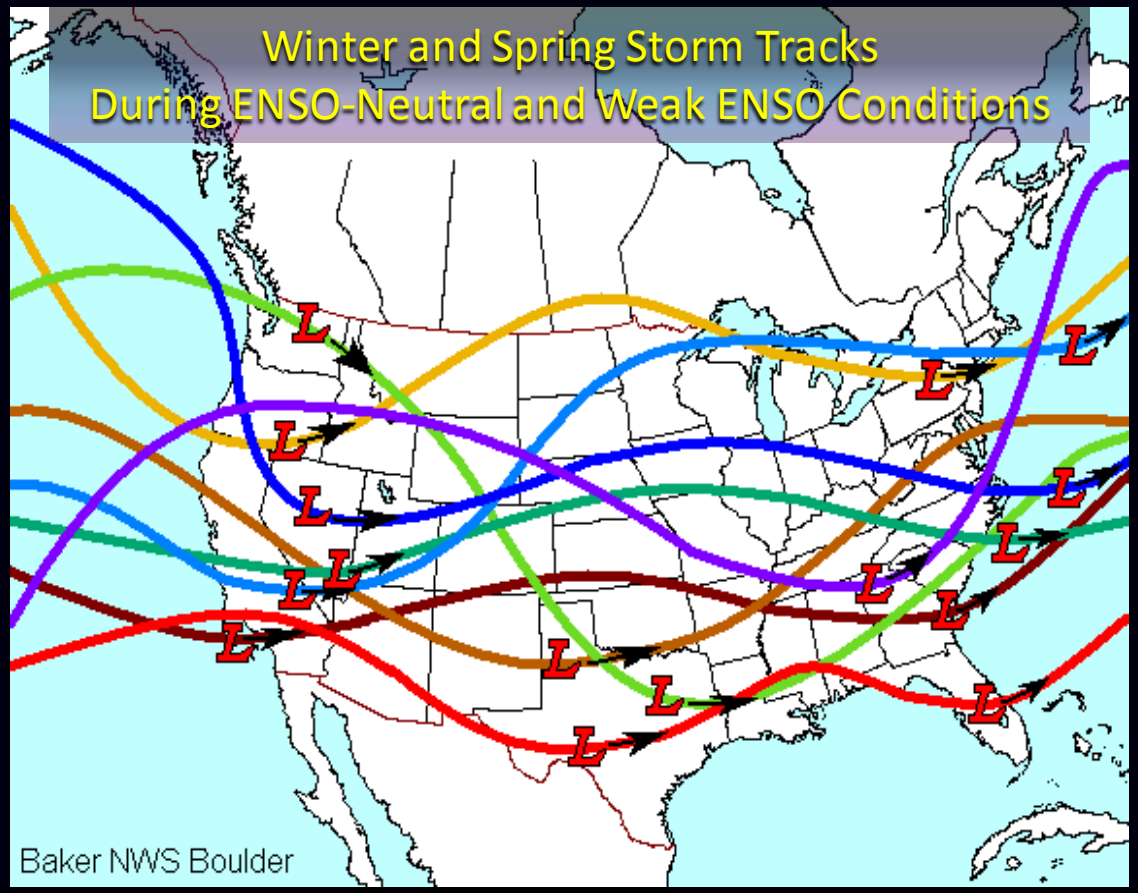
Precipitation

A similar reversal happens with wintertime precipitation. During La Niña conditions, precipitation has historically been wetter/snowier than average across northwest Colorado and drier than average across the remainder of the state. During El Niños, the northwest is drier and the south and east tend to be wetter/snowier than average.

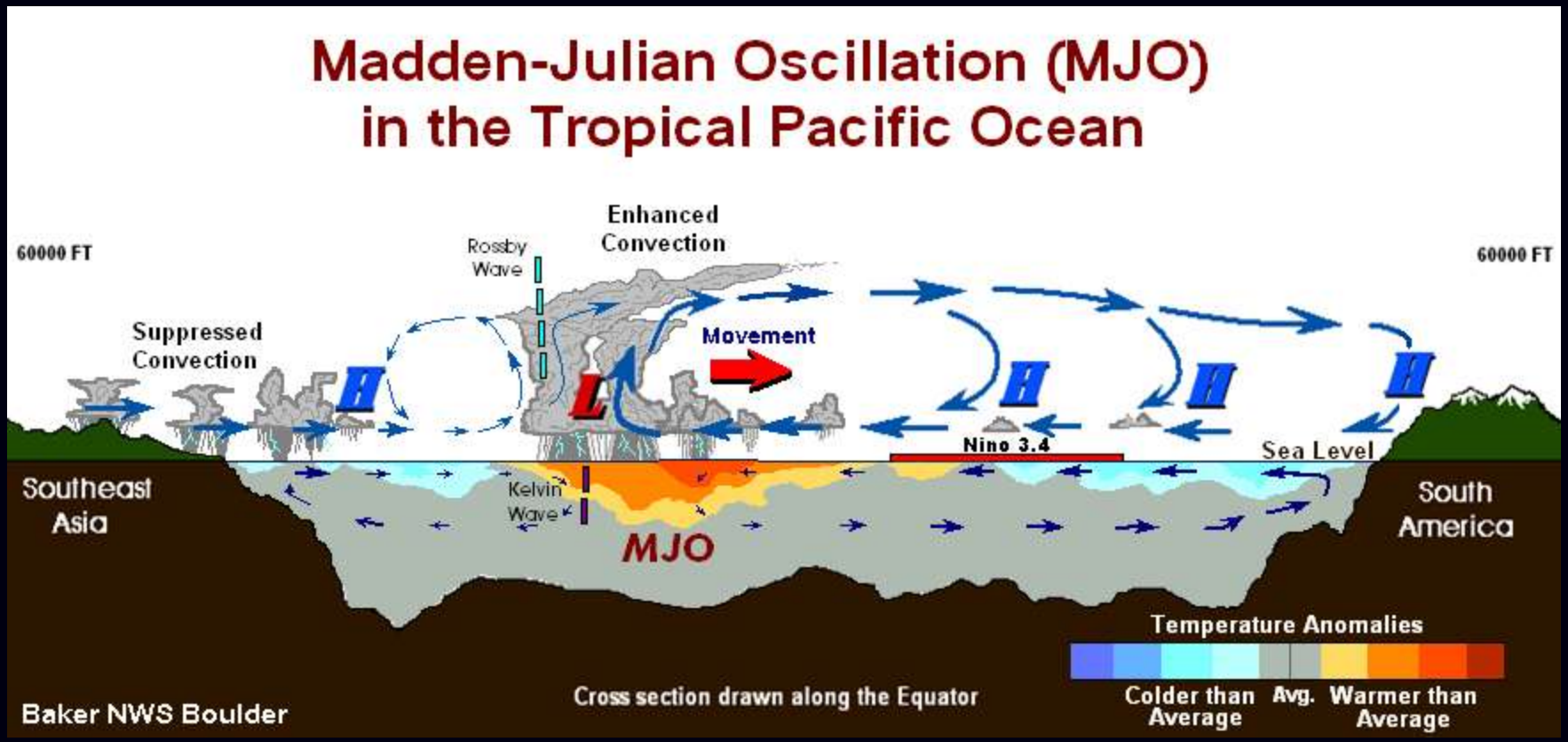


So What May We Expect This Winter with ENSO-Neutral and Weak La Niña Conditions?

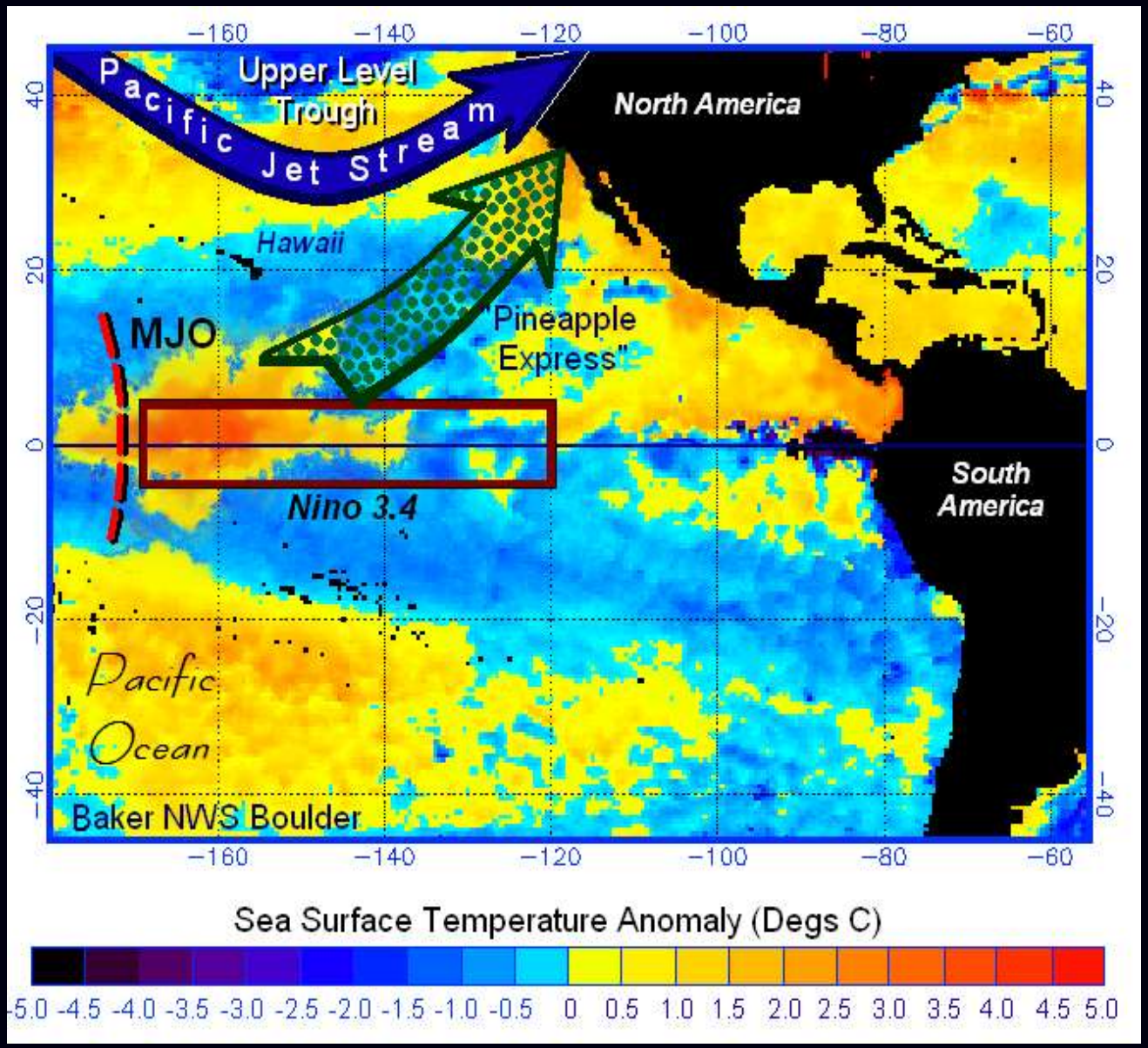
Just About Anything
Equal or Unknown Chances for Above, Below and Near Average Temperature and Precipitation
COLORADO



Wintertime storms crisscross the country in more of a random fashion during ENSO-neutral and weak ENSO conditions. Storms may still follow paths similar to those taken during moderate to strong La Niñas and El Niños, but with less regularity. For instance, one week a storm may drop down from the Pacific Northwest bringing heavy snow and strong wind to the northern mountains of Colorado; the next week a powerful storm may lift up from the Arizona desert bringing heavy snowfall to portions of southern and eastern Colorado; and the next a powerful storm from northern California brings rain, snow and strong winds to the entire state. Overall, the jet stream and storm track pattern over the western U.S. is more variable, resulting in fewer temperature and precipitation extremes for Colorado.

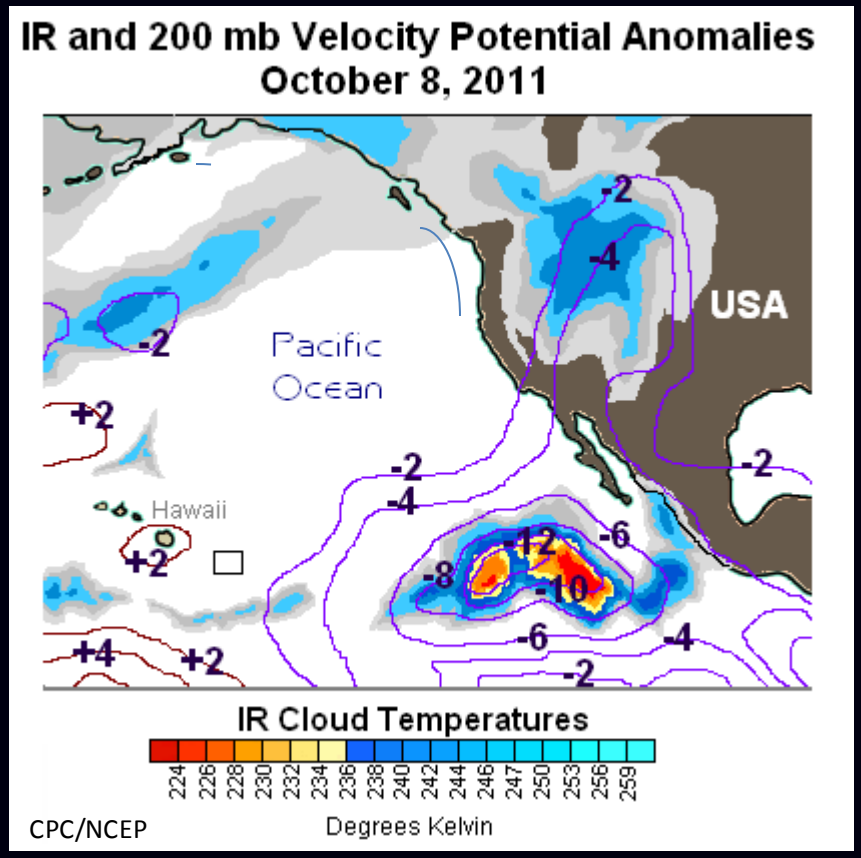


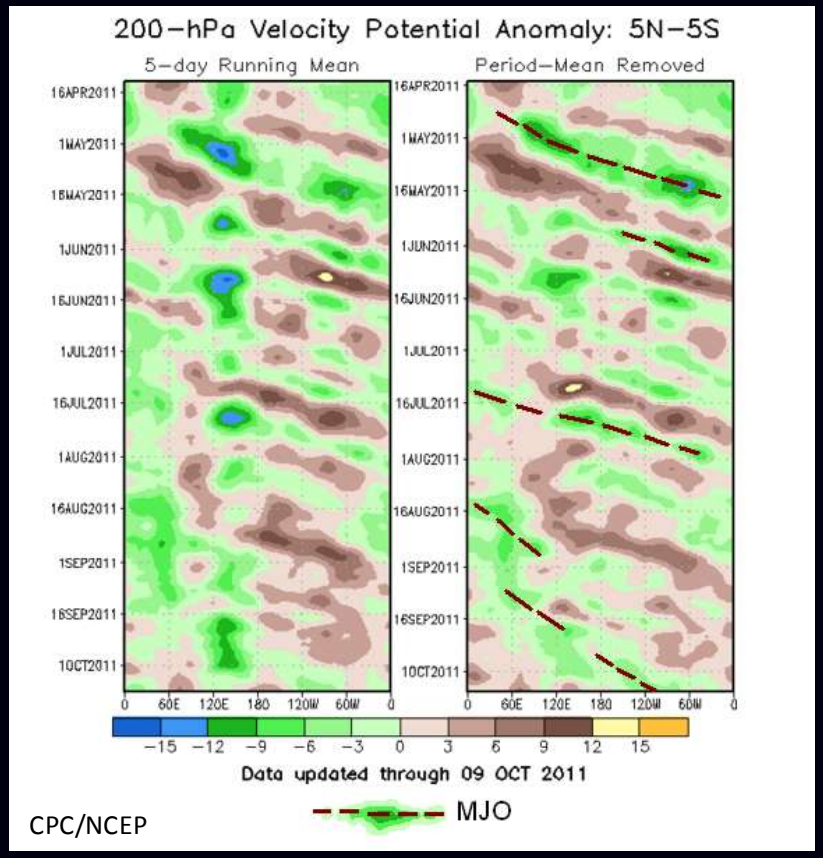
Interseasonal changes in atmospheric variables (wind and temperature), related to the Madden-Julian Oscillation (MJO), can significantly impact atmospheric and oceanic circulations over and under the Pacific Ocean. These oscillations of relatively short duration can have a significant impact on weather patterns in the United States, including Colorado. MJO conditions of sufficient strength can weaken La Niñas and strengthen El Niños. Predicting MJOs and their behavior with any degree of accuracy beyond a few weeks is difficult at best.



The divergence aloft produced by a MJO Kelvin wave entering the Niño 3.4 region of the Pacific will enhance deep layer convection in the region, particularly if warmer than average sea surface temperatures are present.

An atmospheric Rossby wave generated by the divergence aloft and coupled to the Kelvin wave will typically elicit a response in the form of a long wave low pressure trough over the western continental U.S. The resultant large scale circulation pattern transports moisture laden air expelled by the deep tropical convection up over the western U.S.

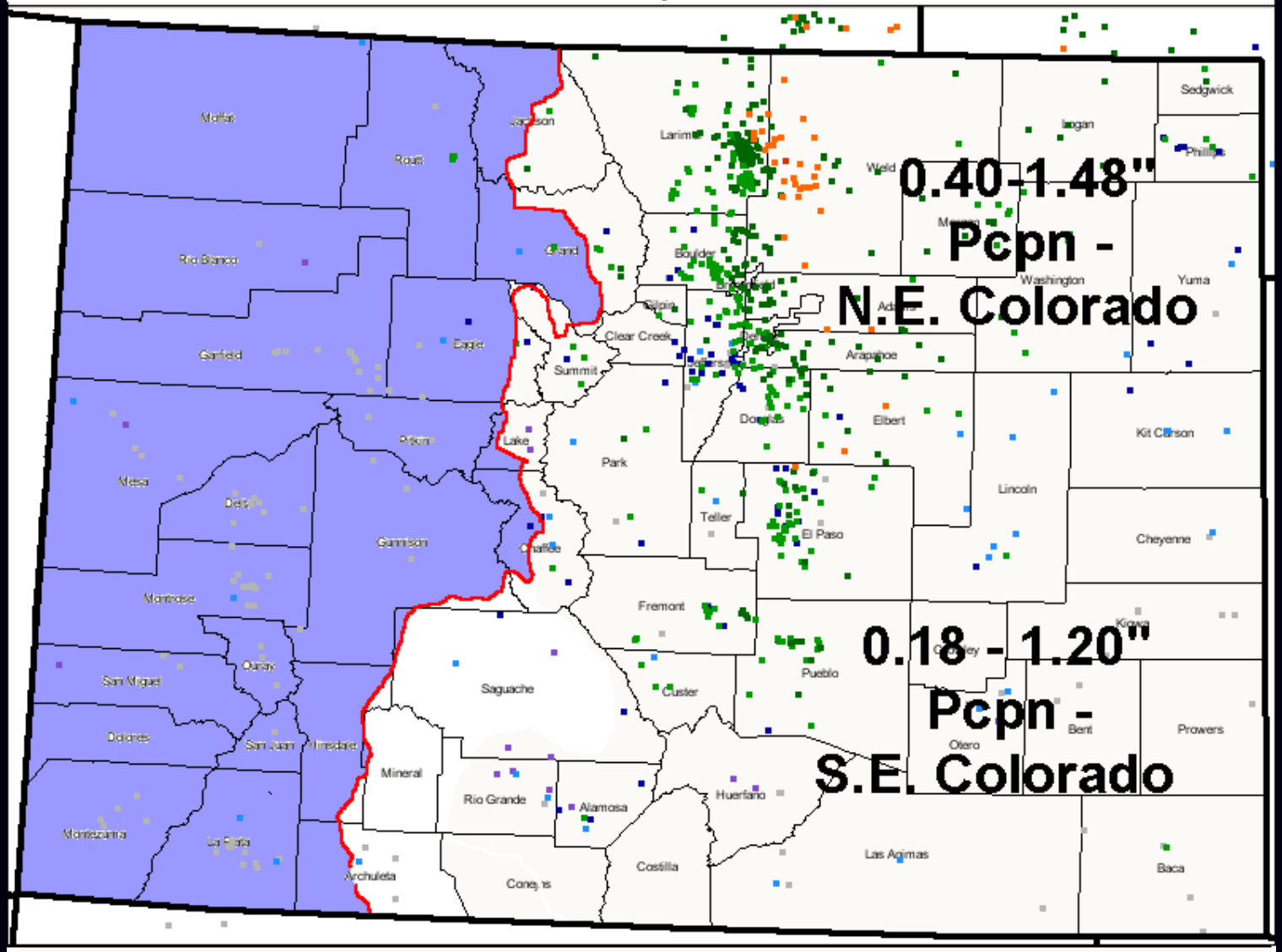


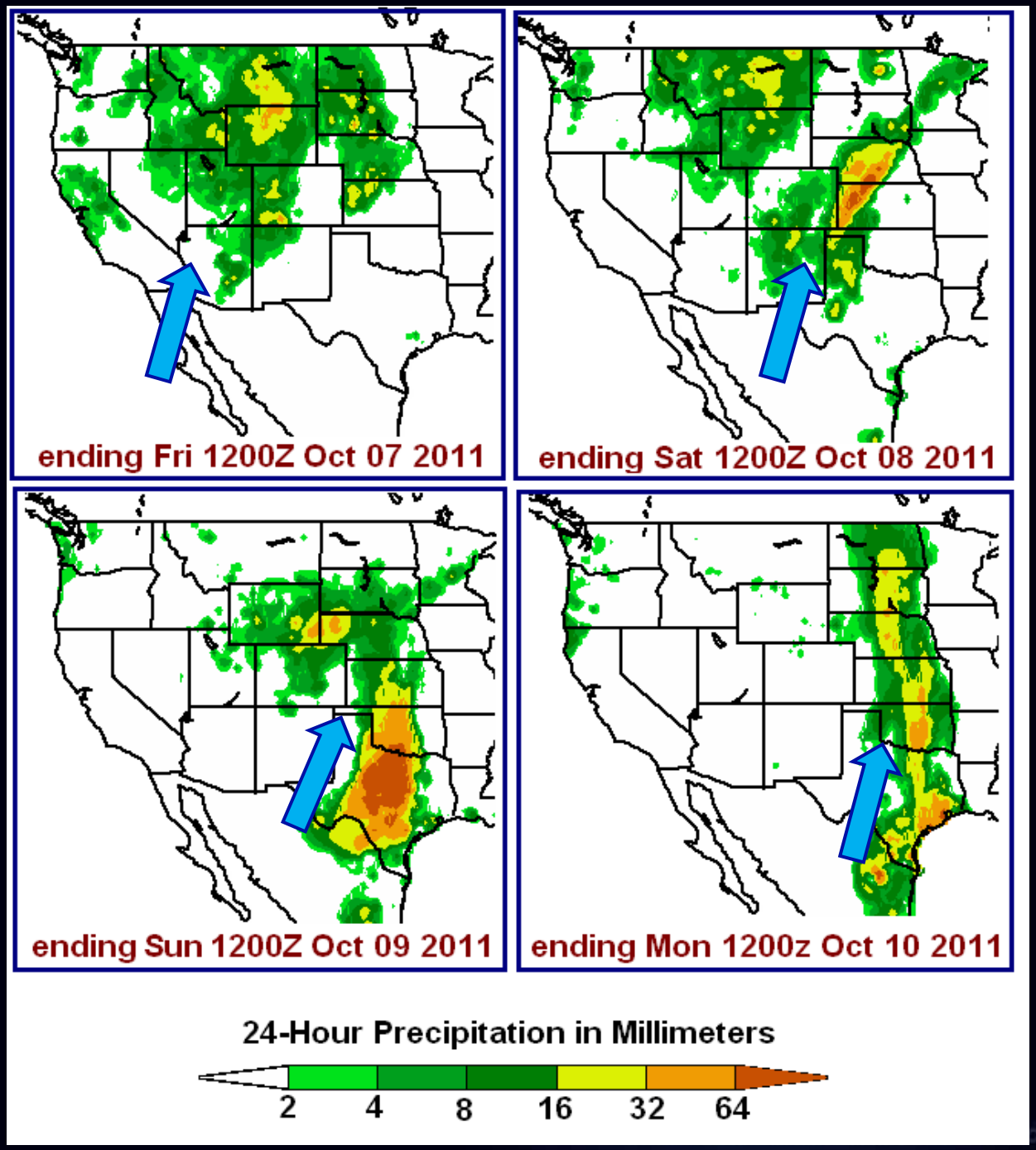


MJOs can travel around the globe along the Equator. They have an average forward velocity of about 5 knots. Few retain their strength after departing their source regions of the Indian and western Pacific Oceans.

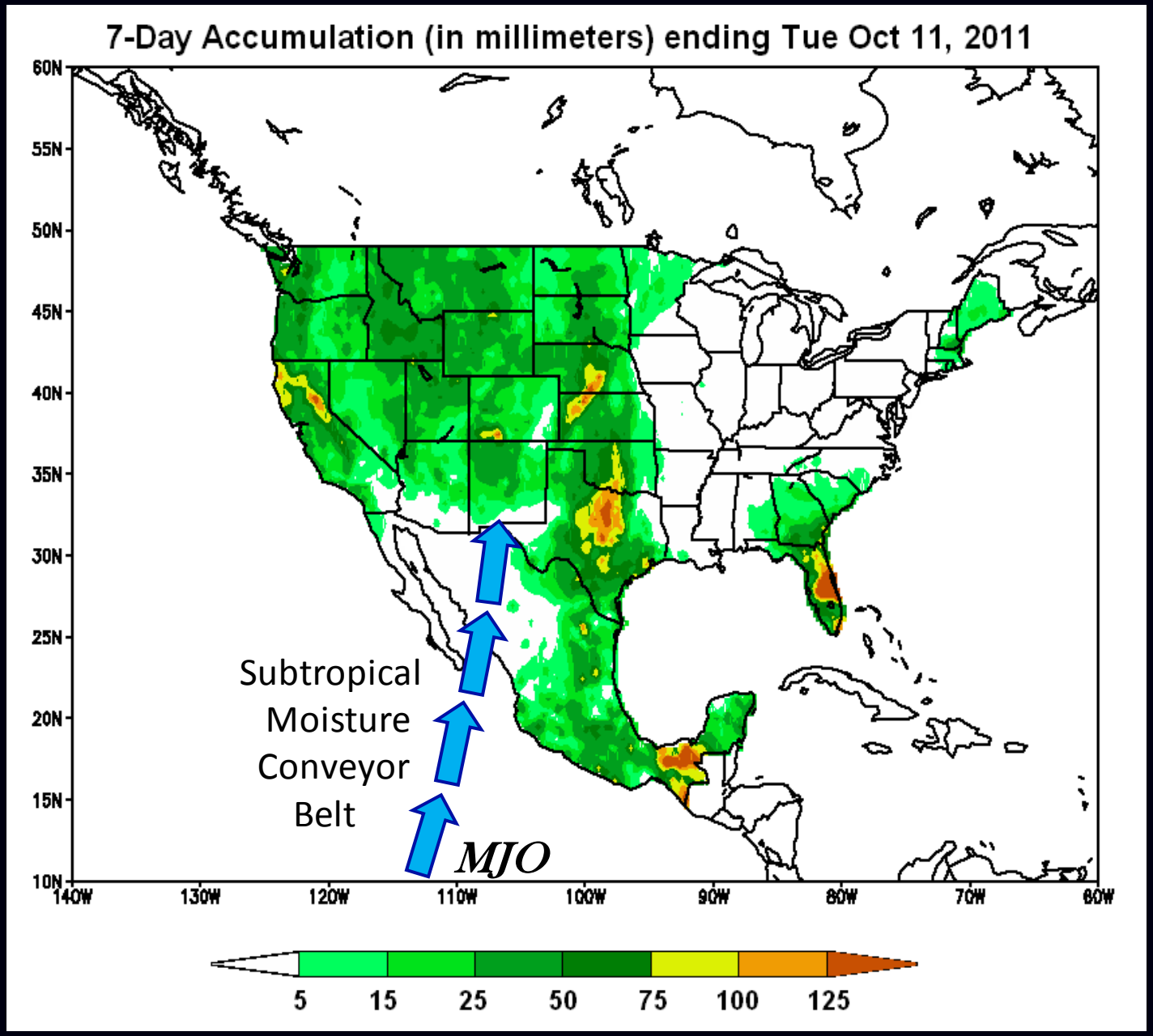
Latest oceanic and atmospheric observations and model analyses indicate the presence of a weak to moderate MJO in the eastern tropical Pacific Ocean between 120W and 60W latitudes. Surface and subsurface water temperatures in the region have remained abnormally warm during the past 15 days. During this period deep layer convection increased significantly in the region of the Pacific. This included the formation of a tropical storm and hurricane off the west coast of Central America. On October 08, 2011, the 200 mb velocity potential anomaly plot (upper left) indicates MJO conditions as far north as the western U.S. The 200 mb PVA chart (upper right) shows the eastward propagation of this MJO along the Equator of the Pacific since mid- September.

24-Hr CoCoRahs Precipitation for Colorado





As the MJO migrated eastward through NINO 3.4 so did the shield of heavy precipitation across the Rocky Mountains and eventually out across the Great Plains.



MJO Breaks Record Breaking Dry Spell

This was the first measurable precipitation for the much of the central and southern Great Plains in over a half year.

Parts of Texas received around a half foot of rain causing serious flooding.

Comparing Historical Trends in Temperature and Precipitation for Colorado During La Niña, ENSO Neutral and El Niño Conditions

Using CPC Whisker Plots

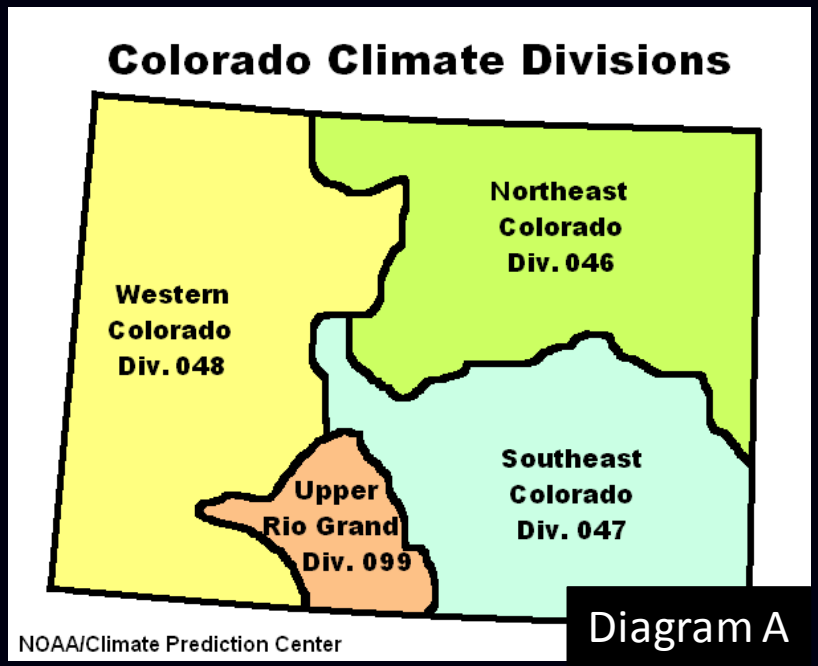


Diagram A

Diagram A: Colorado is sub-divided into four climate divisions. Climate divisions 046, 047 and 099 are located east of the Continental Divide, and division 048 west of the Divide.

NOAA's Climate Prediction Center (CPC) has produced historical distributions of 3-month temperature and precipitation associated with three different ENSO categories – El Niño, La Niña and neutral (non-ENSO) events – for each climate division.

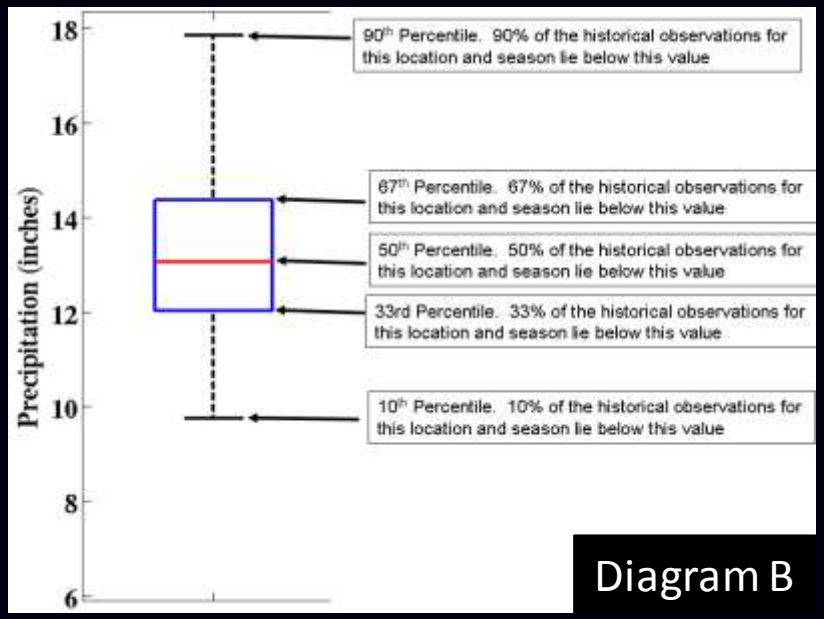
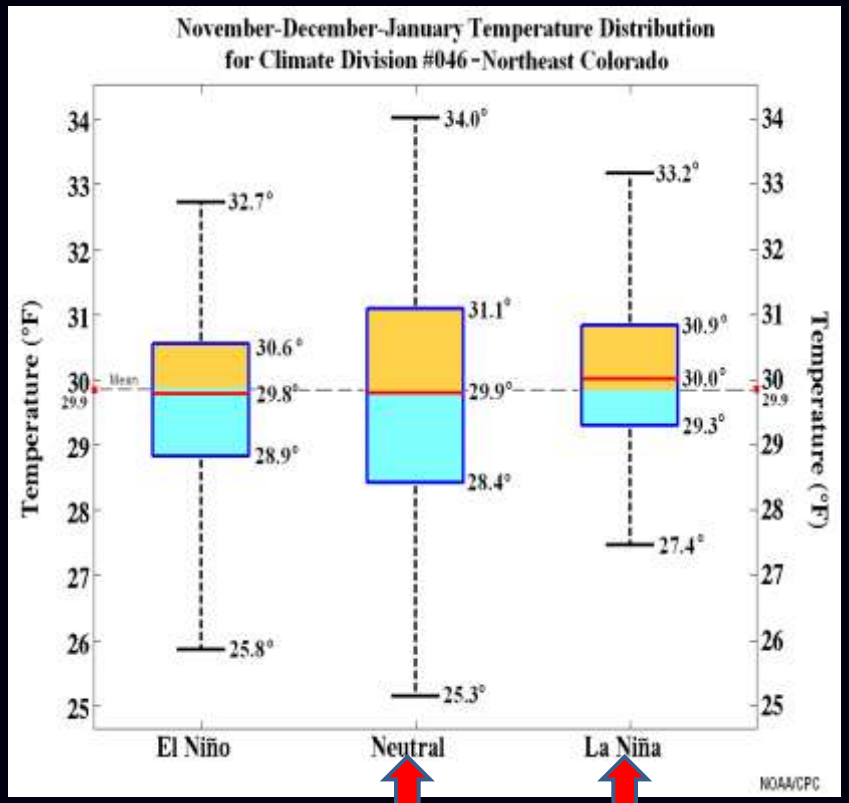


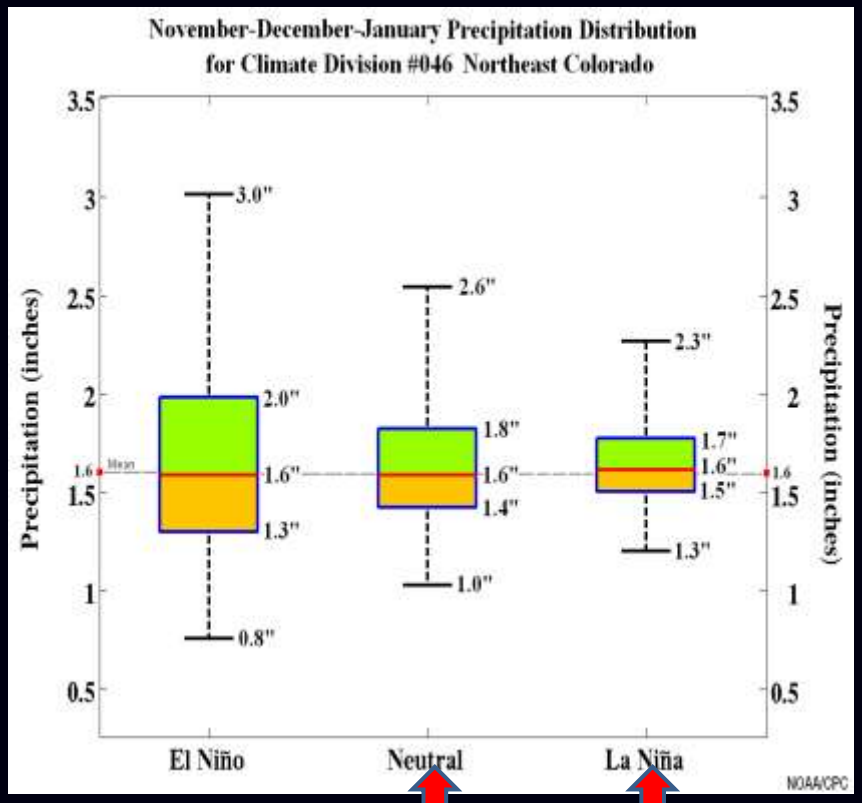
Diagram B

Diagram B: These historical temperature and precipitation distributions can be viewed using an ENSO box and whisker analysis plot (explanation to the left).

The red line inside the ENSO box represents the mean or 50th percentile of the data (temperature or precipitation) distribution. Approximately 34% of the total observations exist within the ENSO box, and the remaining observations (or 66%) outside of the box.

ENSO Box and Whisker Analysis Plots for the Northeast Colorado Climate Division #046 for the 3-Month Season November-January

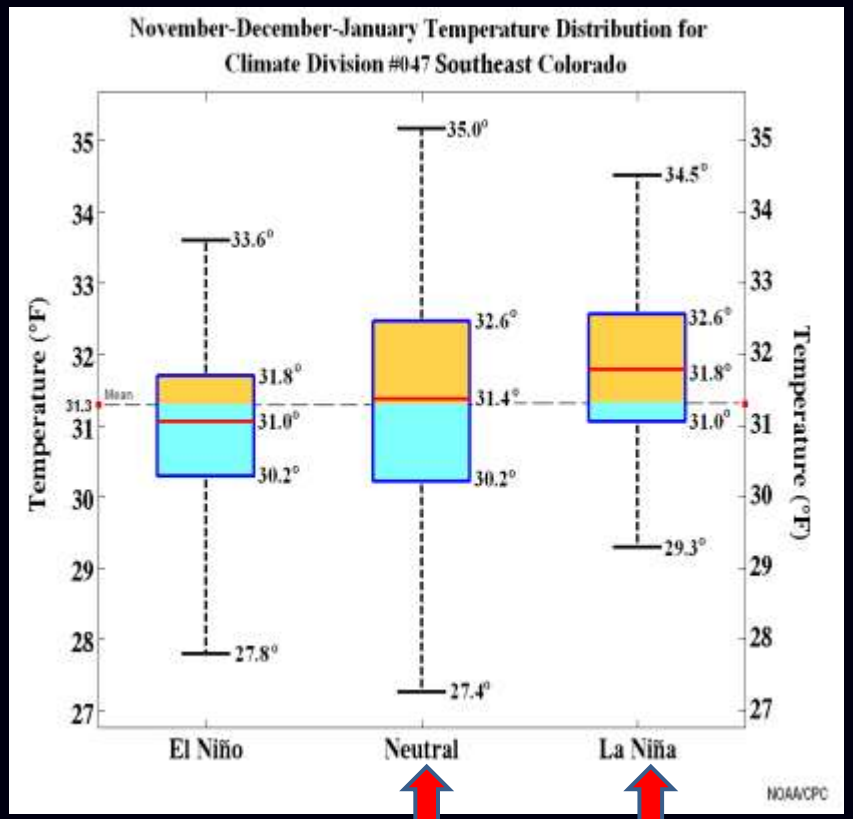


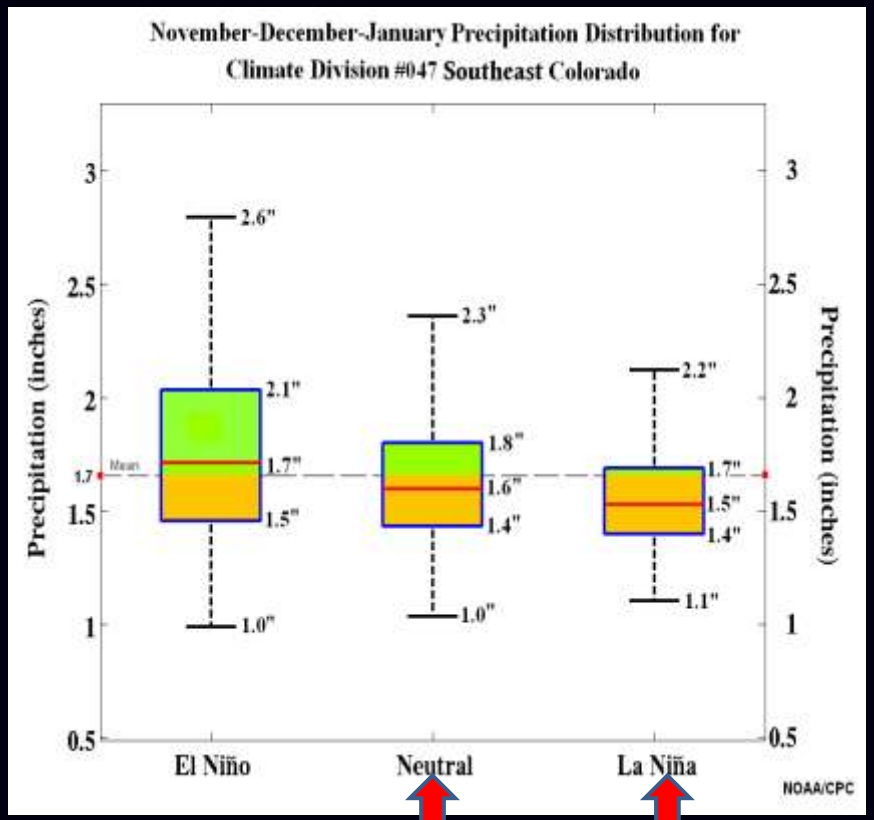


According to historical composites prepared by CPC, temperatures for northeast Colorado during the 3-month climate season of November-January were near average during El Niño, ENSO-neutral and La Niña conditions.

Precipitation for northeast Colorado during this three month period historically was near average during El Niño, ENSO-neutral and La Niña conditions.

ENSO Box and Whisker Analysis Plots for the Southeast Colorado Climate Division #047 for the 3-Month Season of November-January

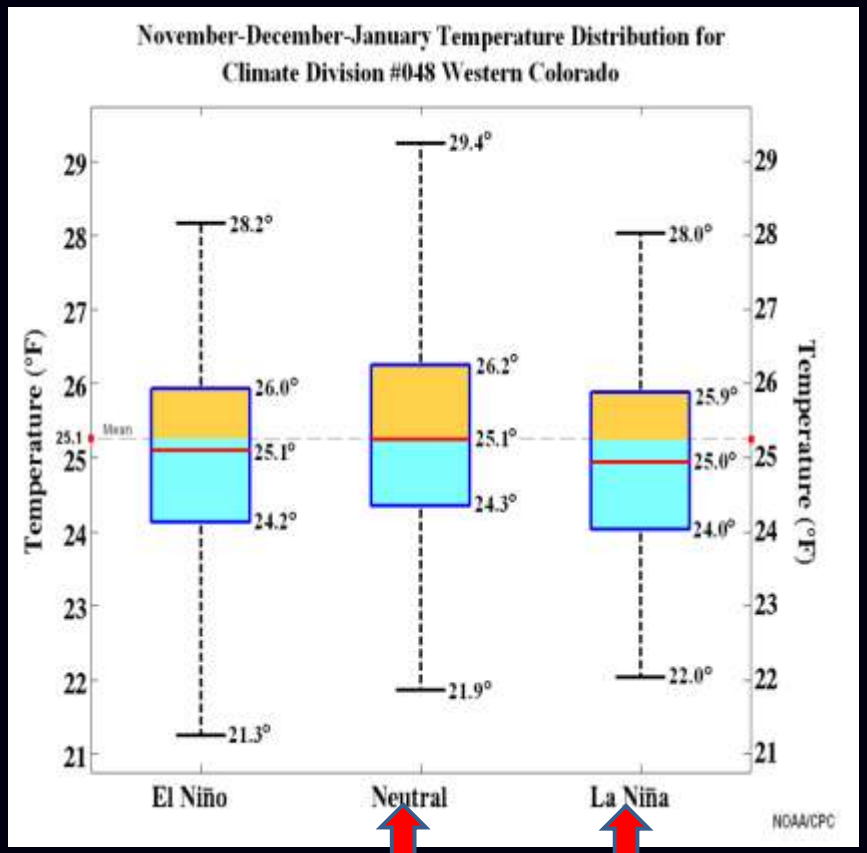


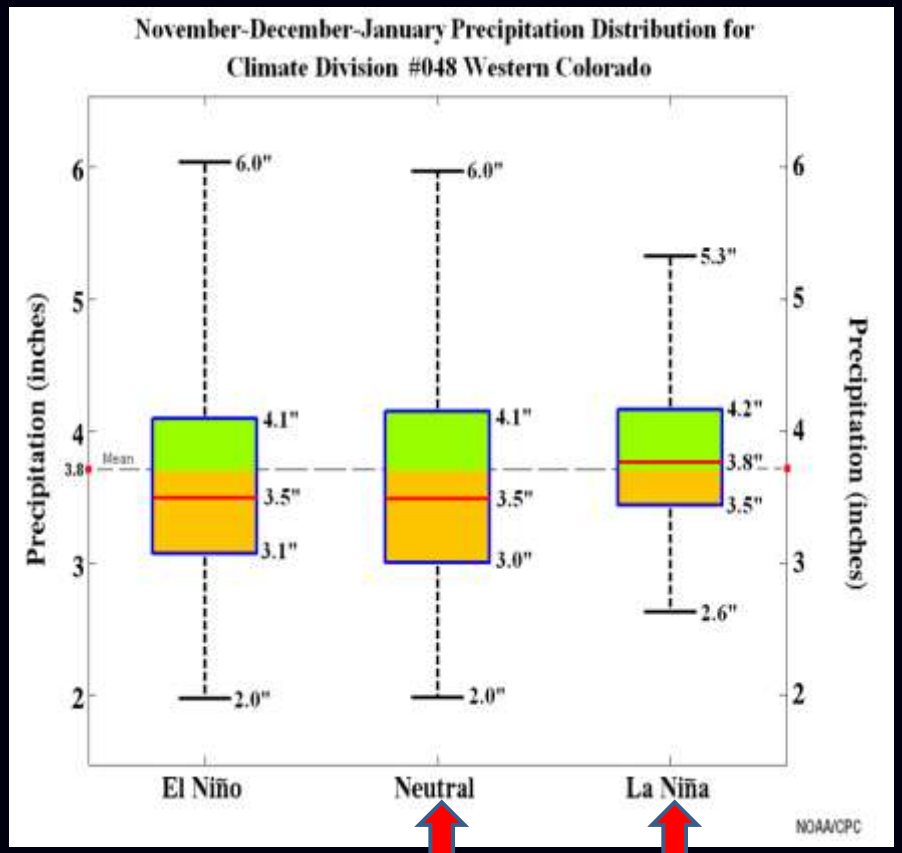


For southeast Colorado, temperatures for the period November-January historically were near average, with a slight bias towards cooler than average during El Niño conditions and leaning towards warmer than average temperatures during La Niña conditions.

Precipitation for southeast Colorado was near average during El Niño and ENSO-neutral conditions and slightly below average during La Niña conditions for this three-month period.

ENSO Box and Whisker Analysis Plots for the Western Colorado Climate Division #048 for the 3-Month Season of November-January





Temperature for western Colorado during this three-month period have been near average during El Niño and ENSO-neutral conditions and slightly below average during La Niña conditions.

Finally, precipitation in western Colorado during November-January was slightly below average during El Niño and ENSO-neutral conditions and near average during La Niña conditions.

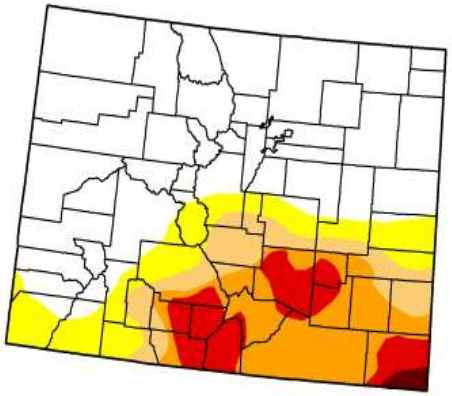
U.S. Drought Monitor

September 27, 2011
Valid 7 a.m. EST

Colorado

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	60.62	39.38	27.69	19.99	7.88	0.56
Last Week (09/20/2011 map)	60.62	39.38	27.69	19.99	7.88	0.56
3 Months Ago (06/28/2011 map)	49.91	50.09	34.36	28.89	16.64	0.91
Start of Calendar Year (12/28/2010 map)	40.40	59.60	49.57	10.13	0.00	0.00
Start of Water Year (09/28/2010 map)	28.86	71.14	10.70	0.00	0.00	0.00
One Year Ago (09/21/2010 map)	46.23	53.77	0.00	0.00	0.00	0.00



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

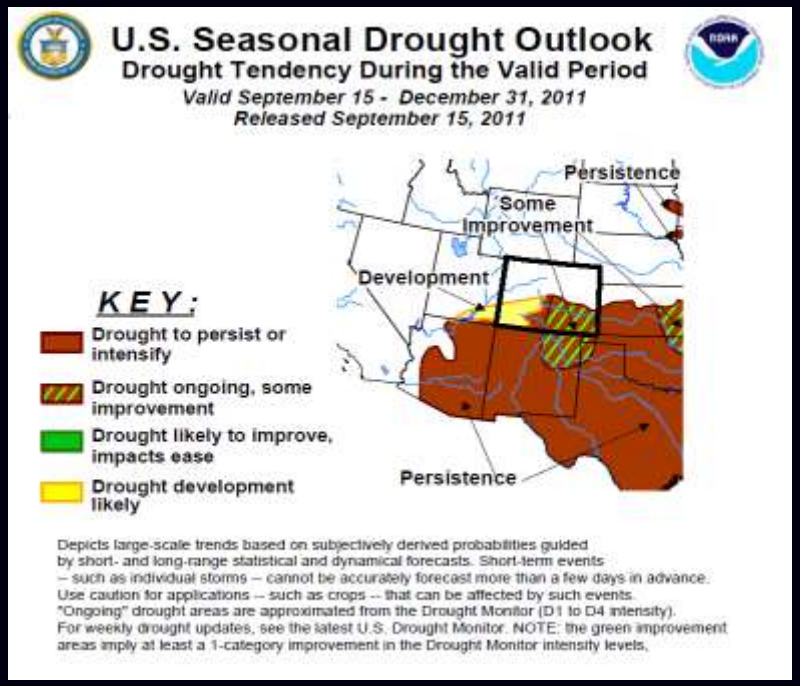
Released Thursday, September 29, 2011
Michael Brewer, National Climatic Data Center, NOAA

Current Drought Conditions In Colorado

In recent weeks, drought conditions have eased across southern and eastern Colorado due to a recent increase in precipitation, slightly cooler temperatures and lower evapotranspiration rates. However, portions of southeast and south central Colorado continue to see extreme to exceptional drought conditions.

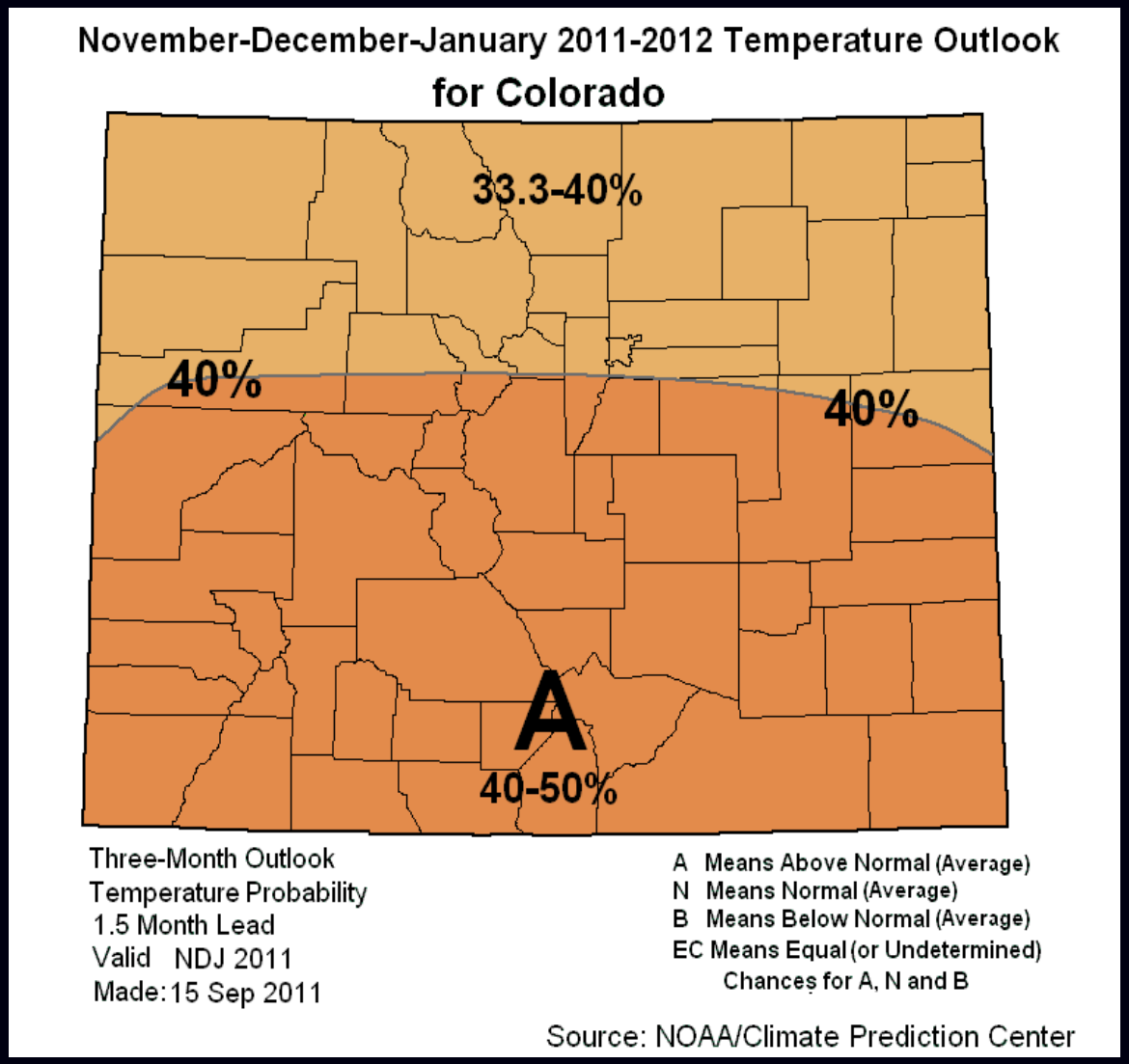
Drought Outlook for Colorado

As of the middle of September, the outlook is for some improvement in drought conditions in southeast Colorado and a persistent or intensification in the drought for the San Luis Valley in south central Colorado. The latest drought outlook from the National Drought Mitigation Center in also forecasting the development of drought across southwest Colorado from now until December 15th.



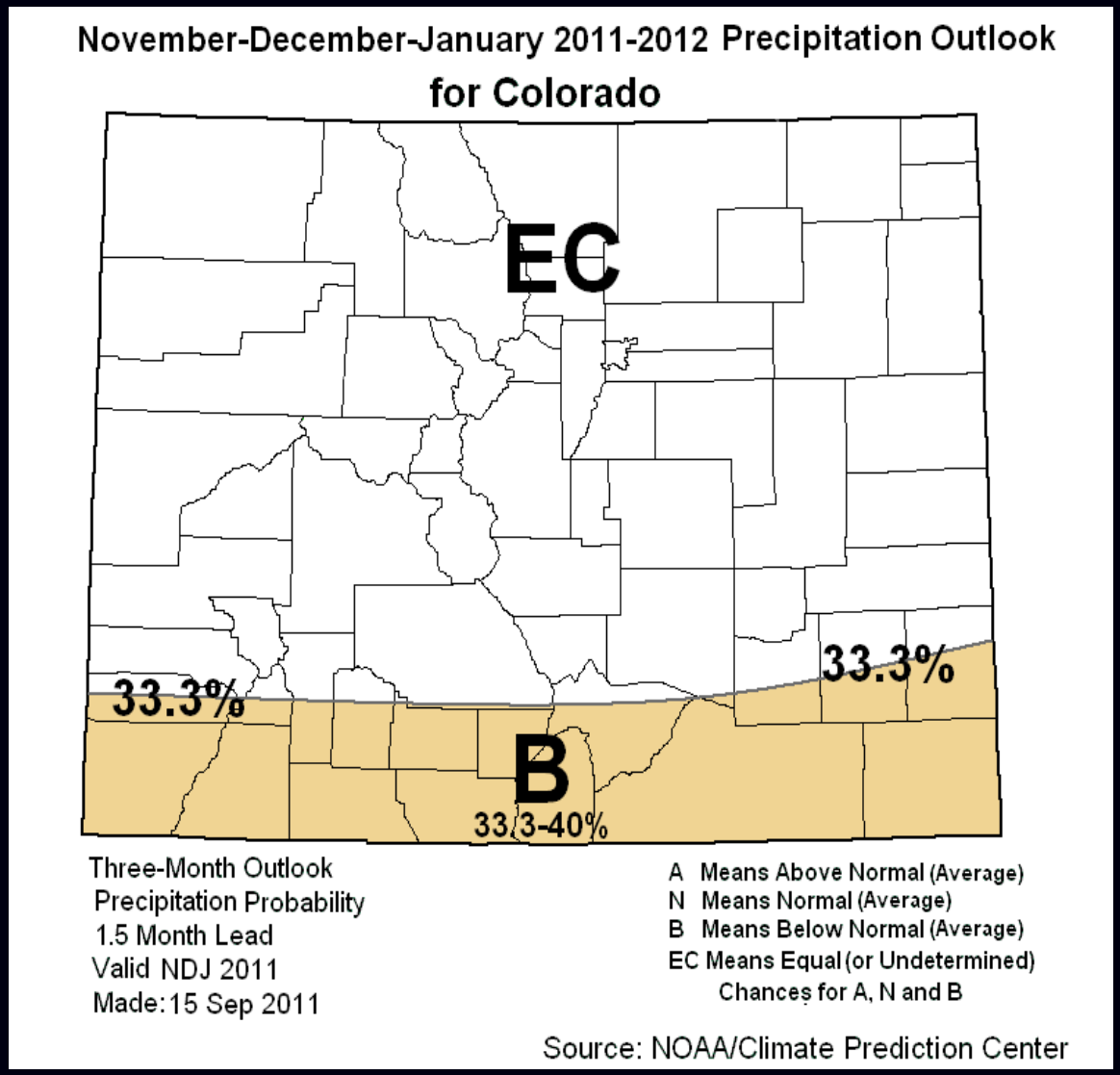
Source: National Drought Mitigation Center

November-January 2011-2012 Temperature and Precipitation Outlooks for Colorado Issued by NOAA's Climate Prediction Center



NDJ 2011 Temperature Outlook for Colorado

The latest outlook from NOAA's Climate Prediction Centers calls for above average temperatures across Colorado (a 33.3-50% chance) during the 3-month winter season NDJ 2011-2012.



NDJ 2011 Precipitation Outlook for Colorado

As of September 15th, CPC was calling for at least a 33.3% percent chance for below average precipitation across the southern one-quarter of Colorado during NDJ 2011-2012.

The precipitation outlook for the remainder of the state was less certain, as indicated by the EC symbol used by CPC forecasters.

Climate Prediction Center
will release their
new
2011-2012
Winter Season Outlook
later this month.

Wrap-Up

- After the strong La Niña of last winter and brief ENSO-neutral conditions this past summer, weak La Niña conditions have returned to the Pacific Ocean.
- A majority of the ENSO-climate models predict weak La Niña conditions through the November-December-January climate season, and ENSO-neutral conditions beyond that. Based on the performance of six previous bi-seasonal moderate to strong La Niña events, this prediction appears plausible.
- In the absence of a moderate to strong ENSO signal, the temperature and precipitation outlook for Colorado this winter is more uncertain. Historically speaking, temperature and precipitation across Colorado were near average during ENSO-neutral and weak ENSO conditions.
- However, interseasonal climate changes due to phenomena such as the Madden-Julian Oscillation (MJO), could temporally produce conditions typically associated with El Niños.
- Could we see a repeat of the extreme weather conditions that occurred across Colorado last winter? Of course, it's always possible, *but probably not likely*, even with a return to La Niña conditions.