

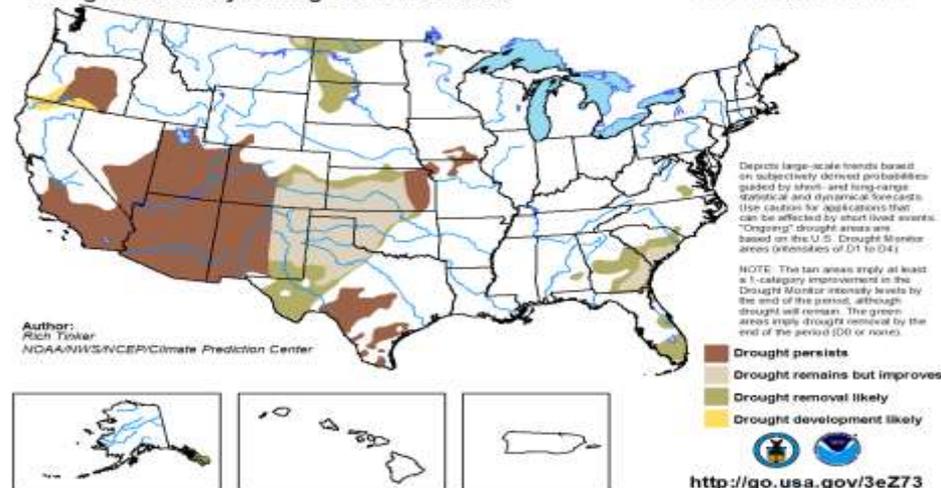
Drought Prediction, Verification, and New Tool Development at CPC



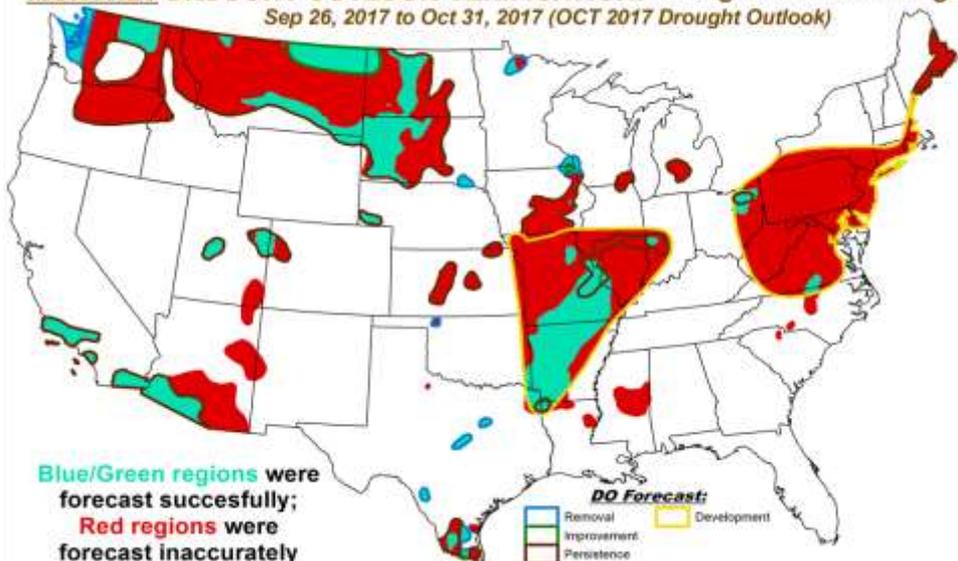
Photo: NCEI/NOAA

U.S. Seasonal Drought Outlook Drought Tendency During the Valid Period

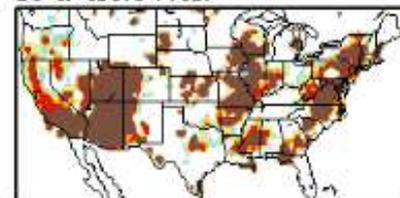
Valid for April 19 - July 31, 2018
Released April 19, 2018



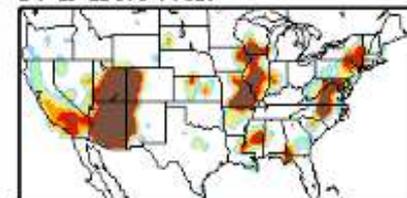
MONTHLY DROUGHT OUTLOOK VERIFICATION: Drought Monitor Change Sep 26, 2017 to Oct 31, 2017 (OCT 2017 Drought Outlook)



D0 & above Prob.

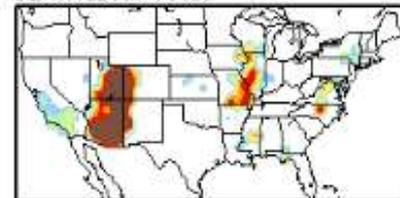


D1 & above Prob.

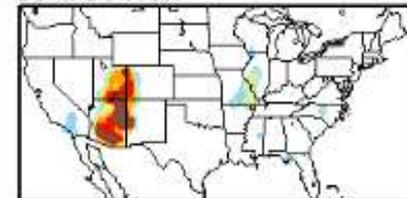


Probability for Dx and above

D2 & above Prob.



D3 & D4 Prob.



CONTENT

1. Drought Outlook process at CPC (**30- and 90-day**)
2. Drought Verification
3. New Tools
4. Some issues specific to Canada and Mexico

1. Drought Outlook Process at CPC (30- & 90-day)

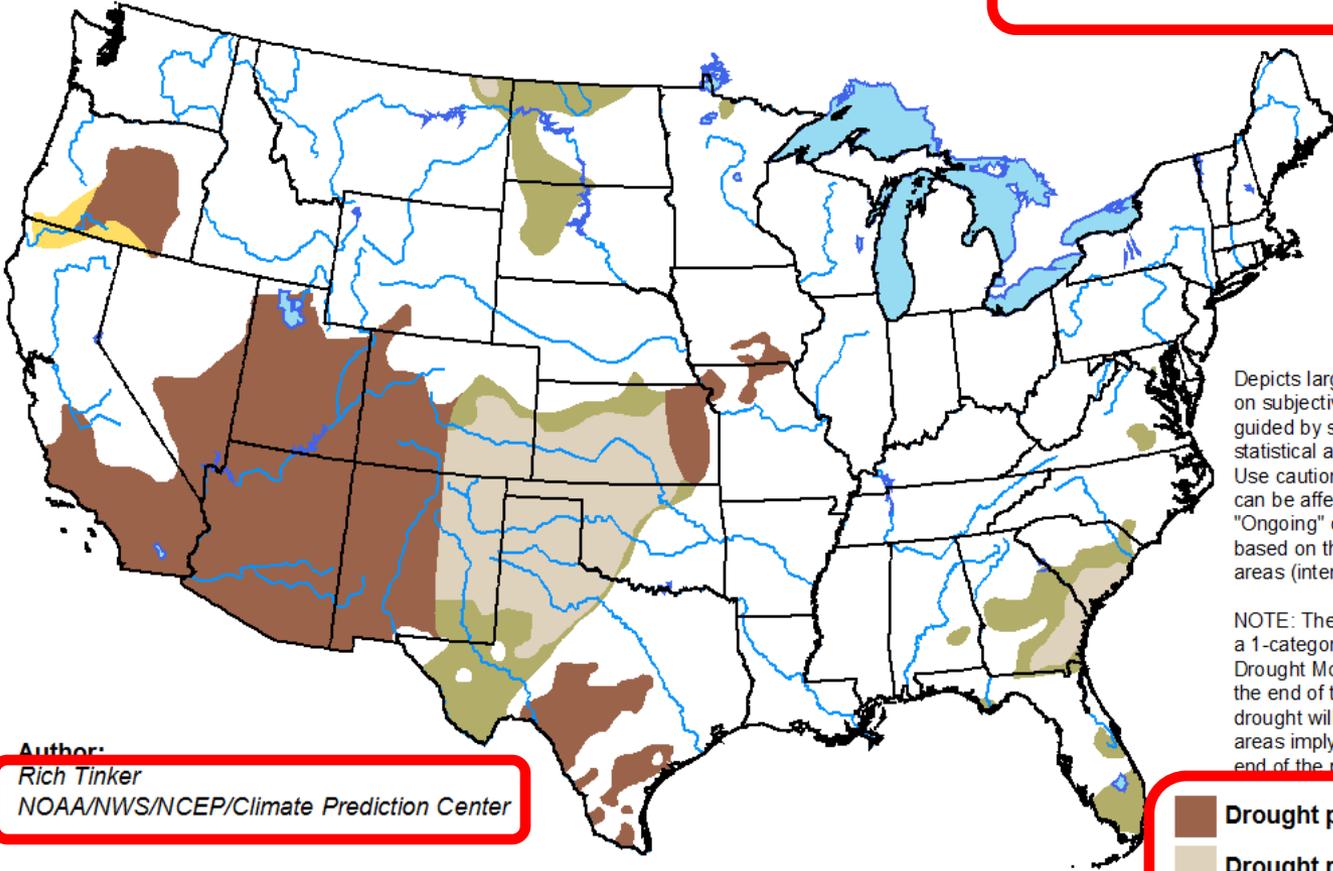




U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid for April 19 - July 31, 2018
Released April 19, 2018

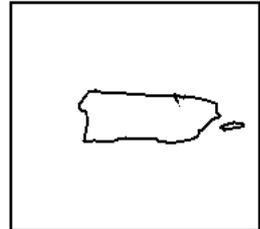
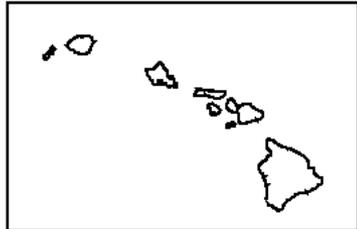
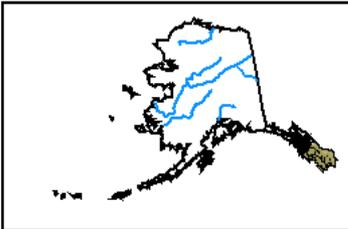


Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to D4).

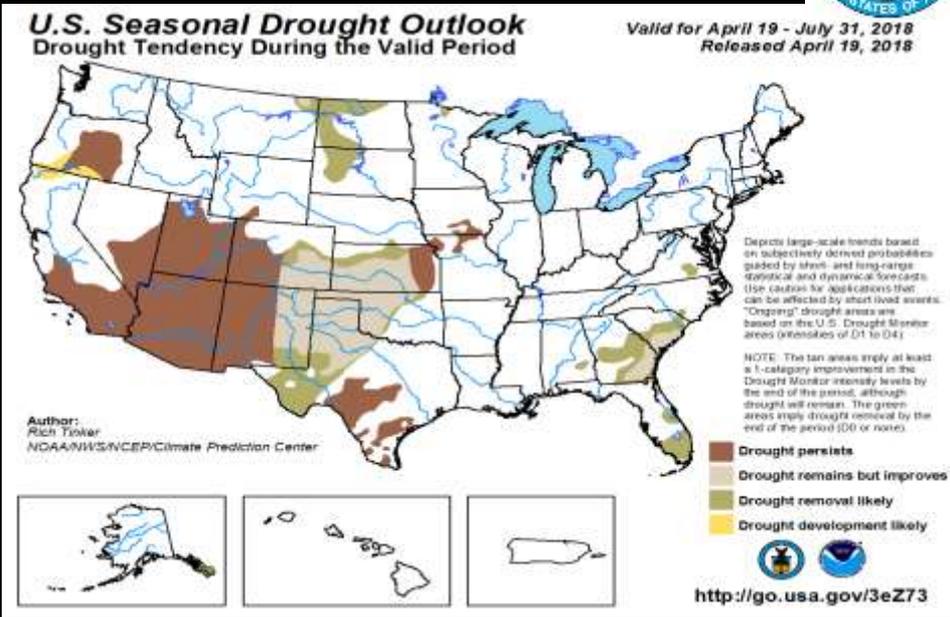
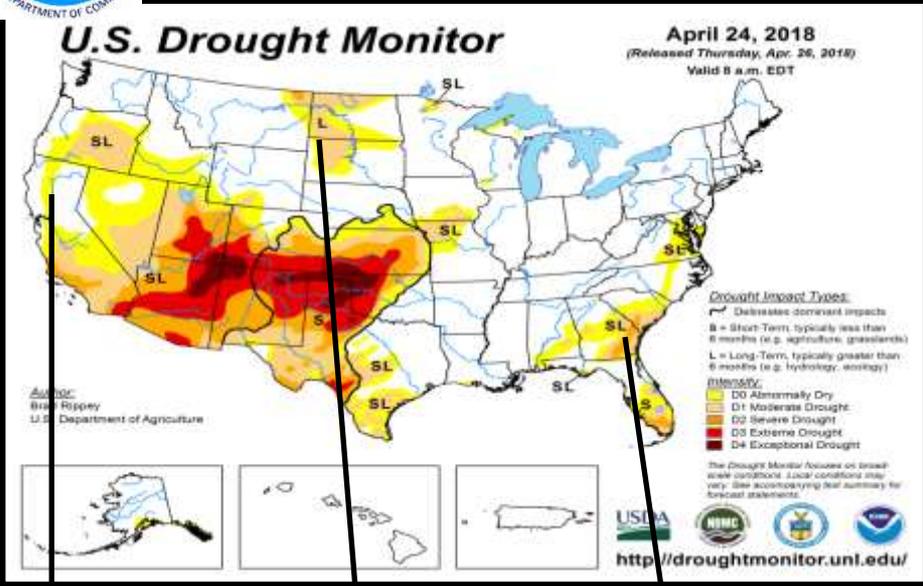
NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

Author:
 Rich Tinker
 NOAA/NWS/NCEP/Climate Prediction Center

- Drought persists
- Drought remains but improves
- Drought removal likely
- Drought development likely

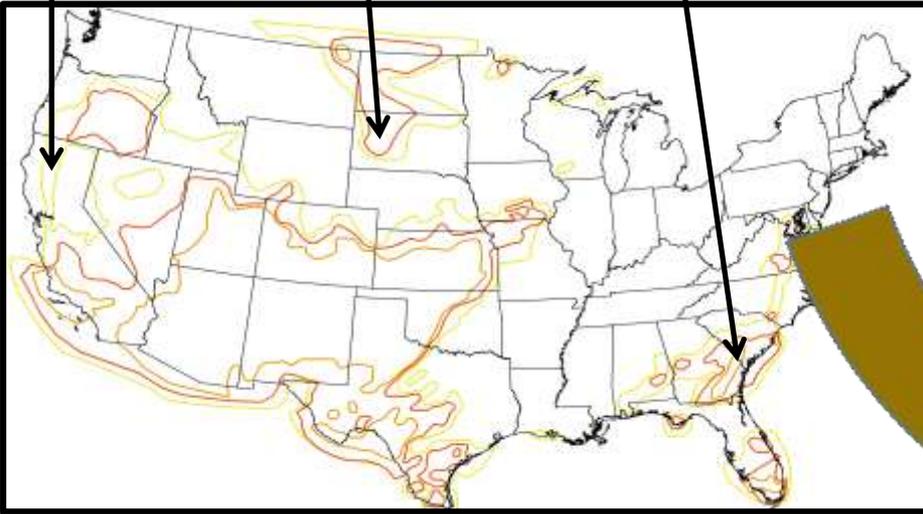


<http://go.usa.gov/3eZ73>



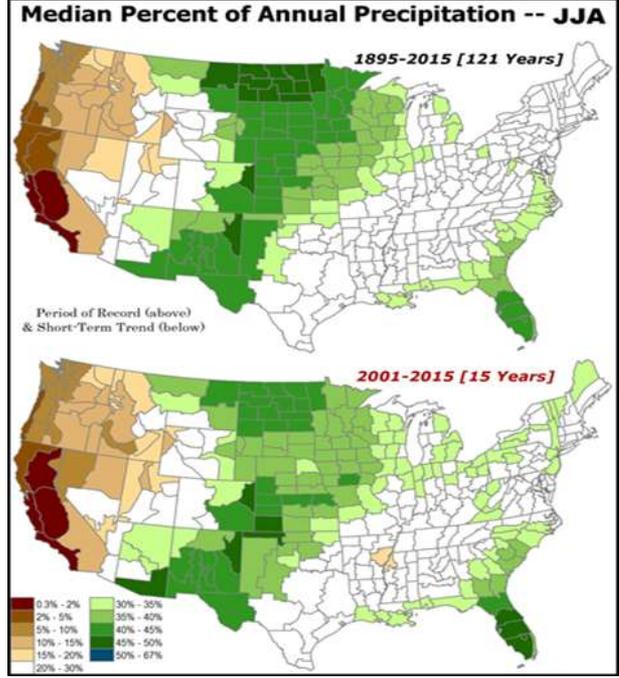
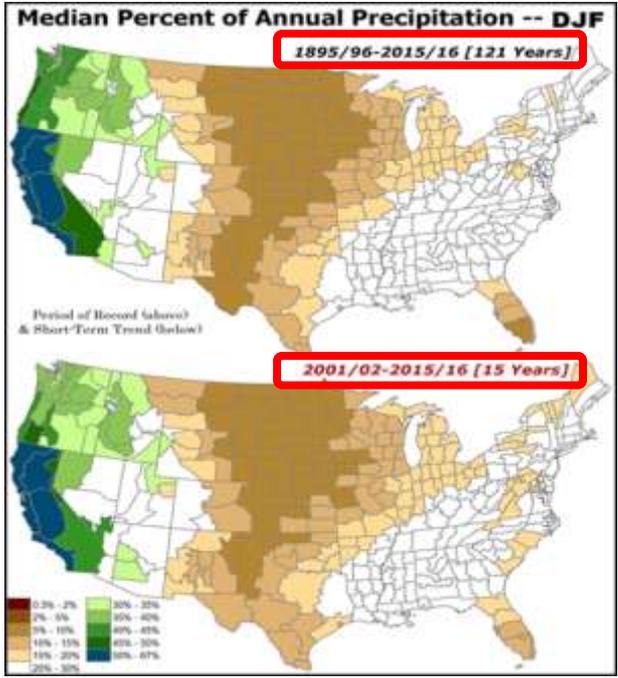
Use the latest U.S. Drought Monitor
D0 & D1 & D2 shape file areas

Objective + Subjective Mix



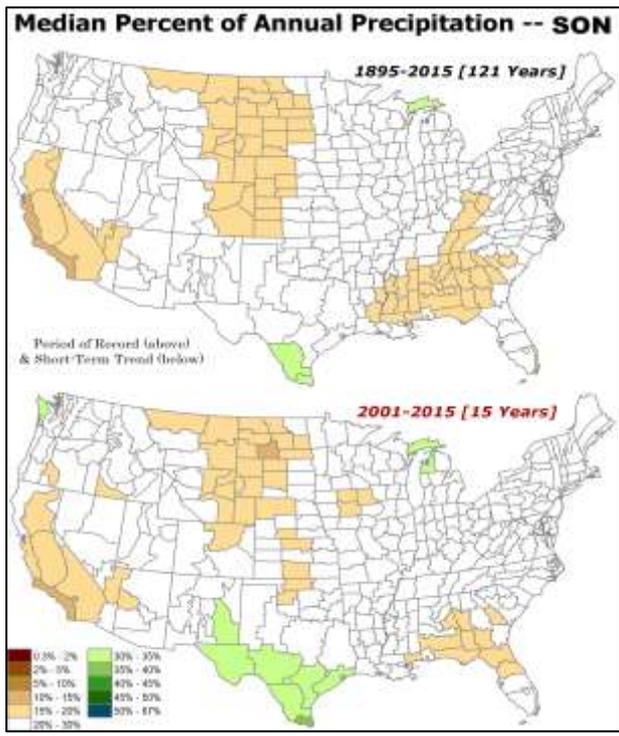
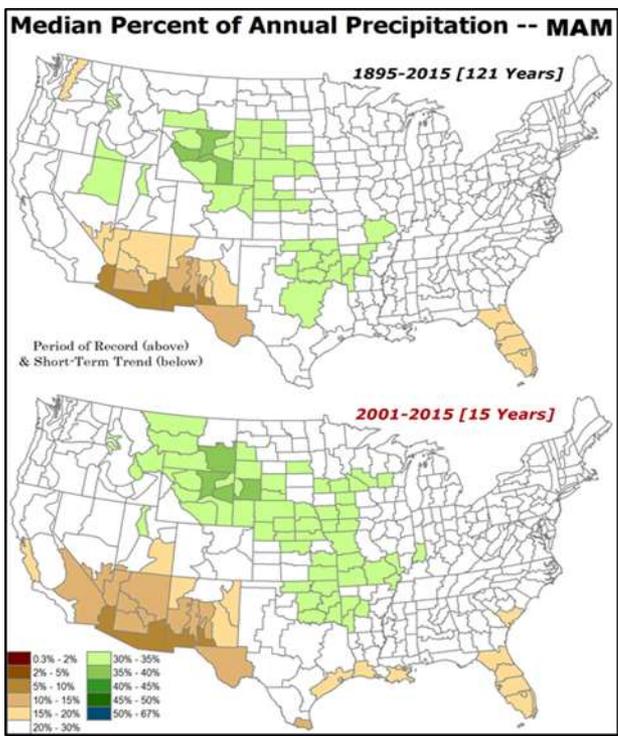
From Tools - Determine if D1-D4 areas will: **Persist**, **Improve**, or be **Removed**; and if D0 & normal areas will **Develop**

→
Winter
DJF



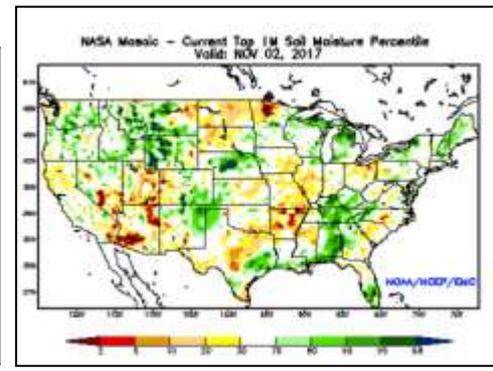
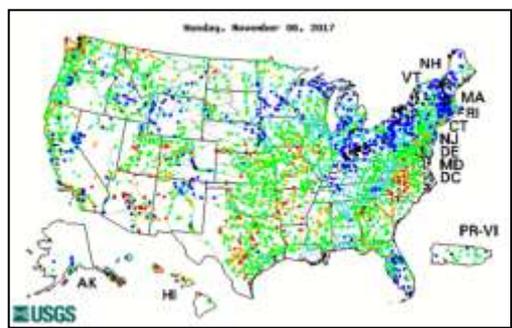
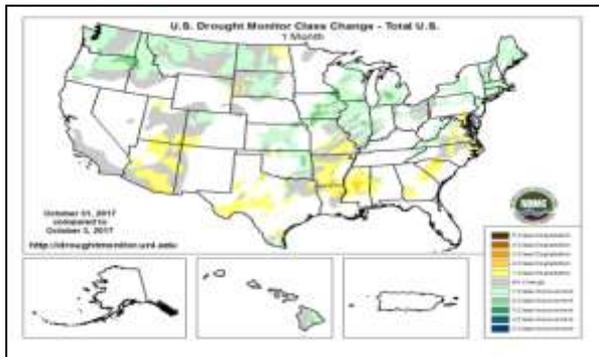
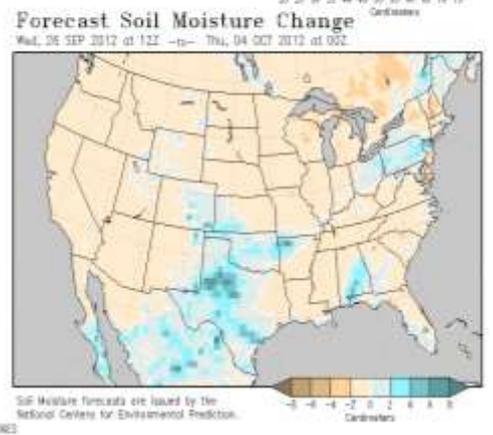
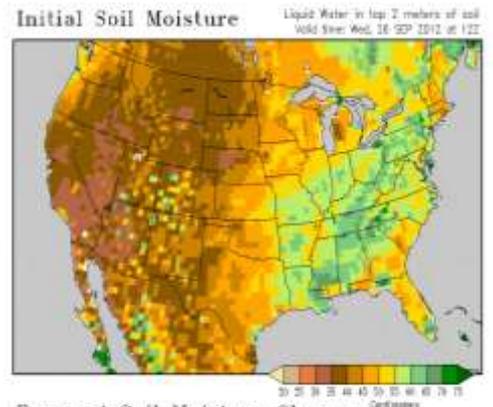
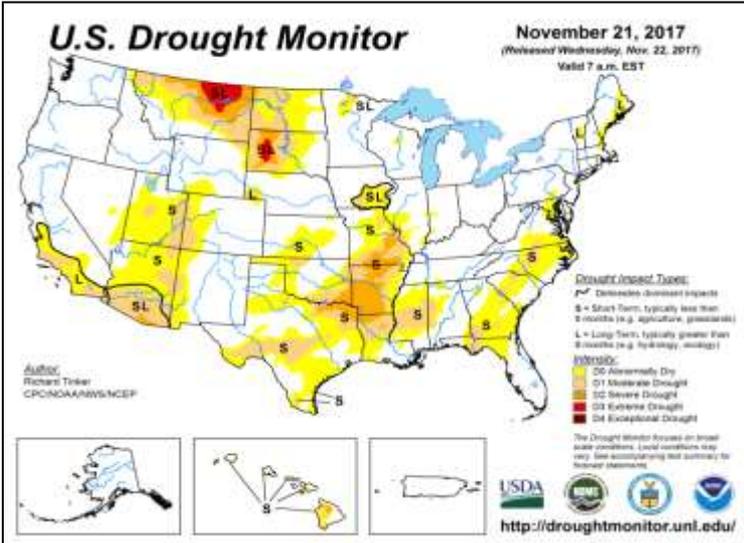
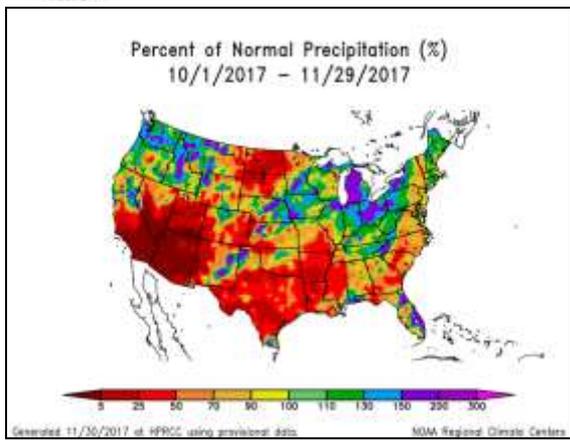
←
Summer
JJA

→
Spring
MAM



←
Fall
SON

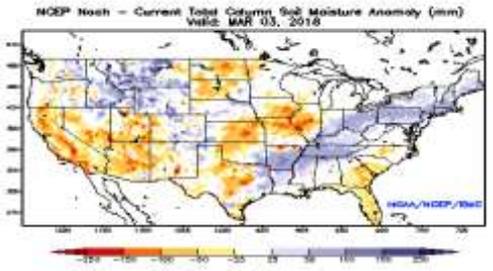
Start with Current Conditions (e.g. Prcp, SMT, Temp, Streams)



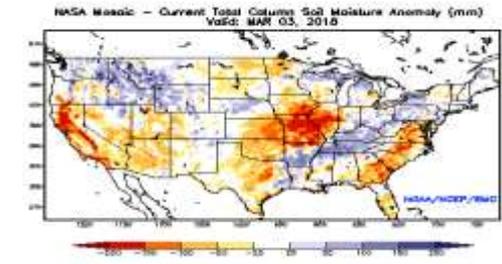
North American Land Data Assimilation System (NLDAS) (Soil Moisture)

Merra

NOAH

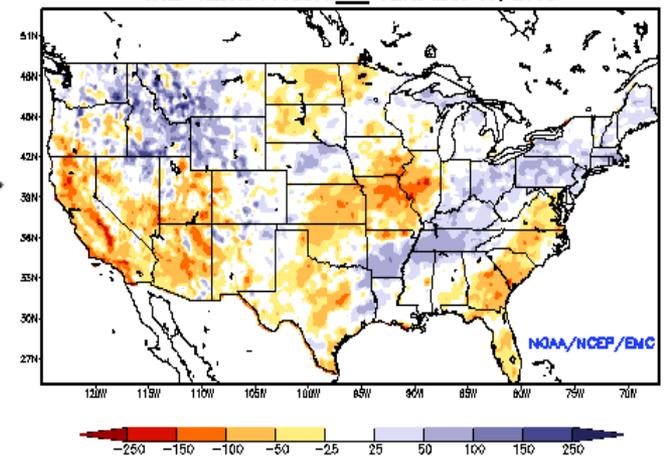


MOSAIC

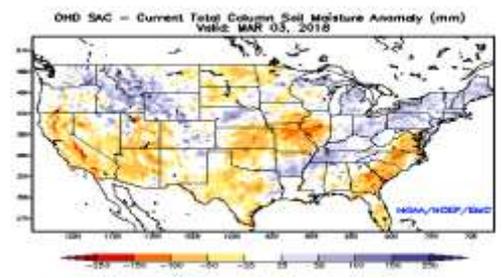


Ensemble Mean
Land Surface Model Output

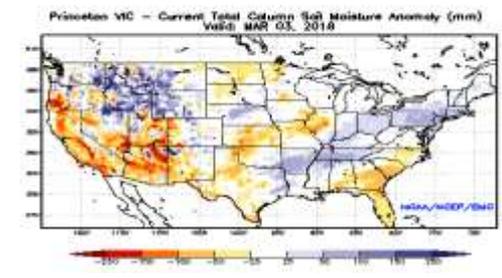
Ensemble-Mean - Current Total Column Soil Moisture Anomaly (mm)
NCEP NLDAS Products Valid: MAR 03, 2018



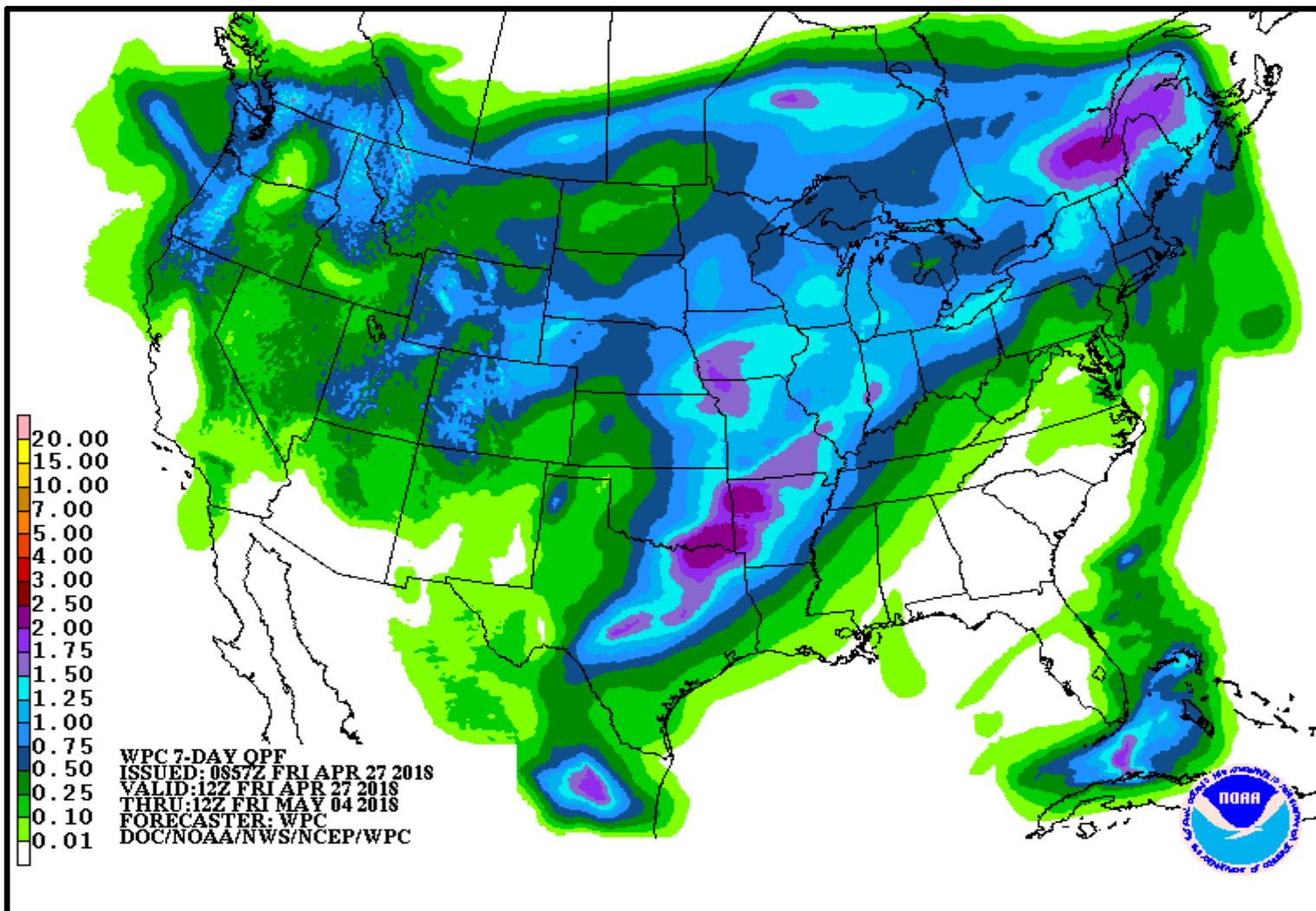
SAC



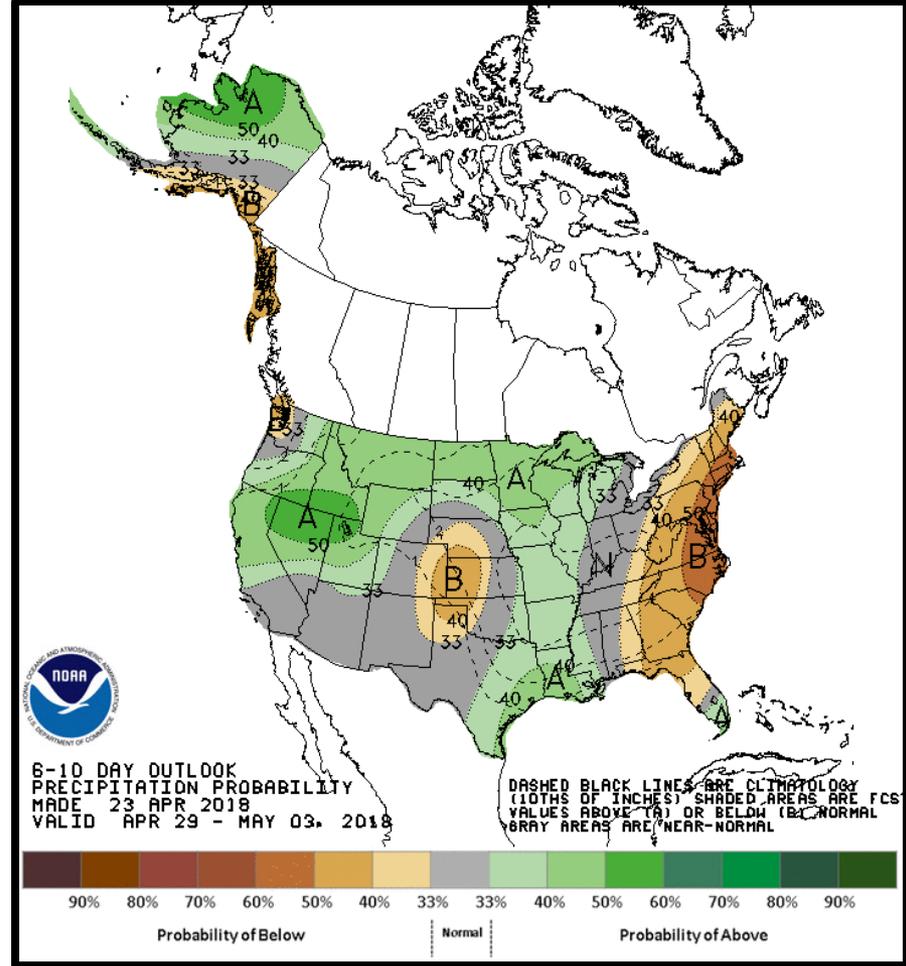
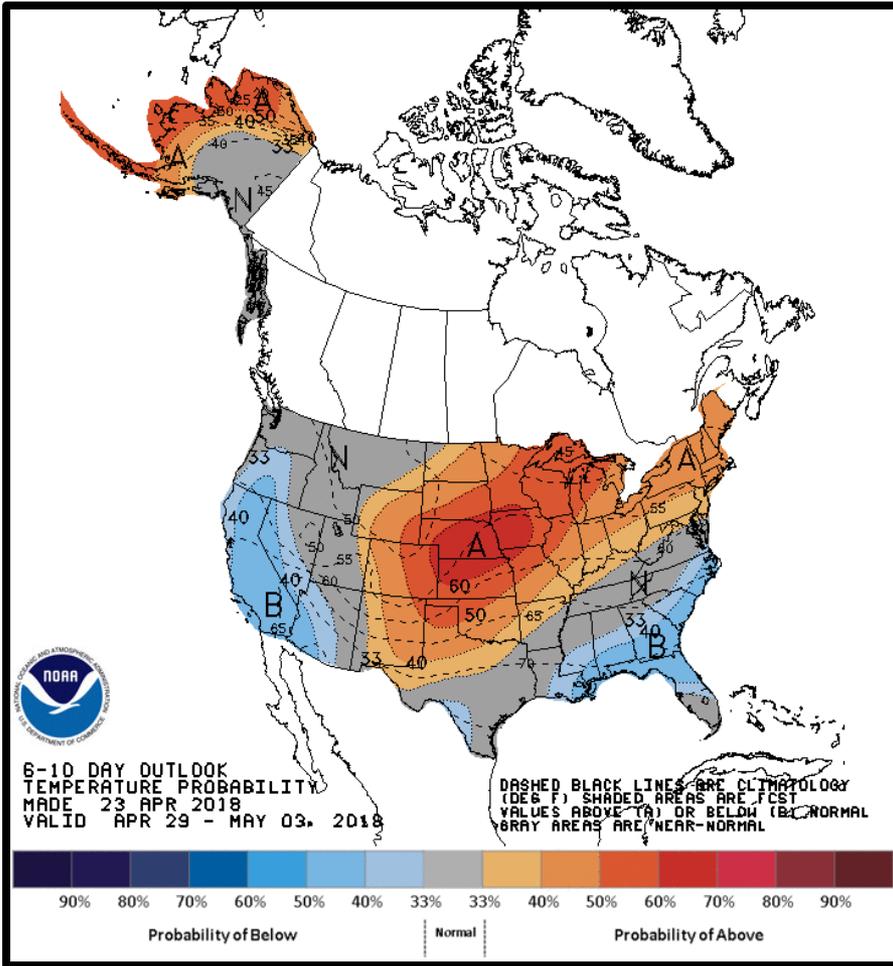
VIC



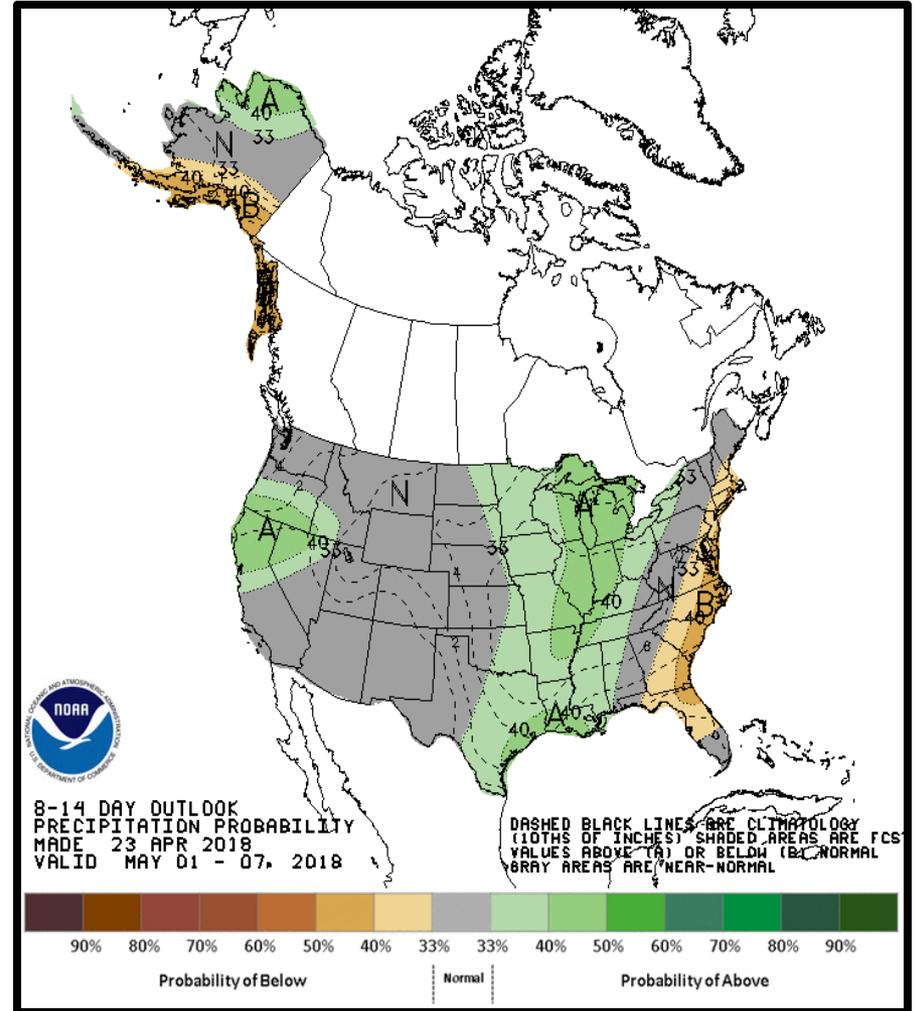
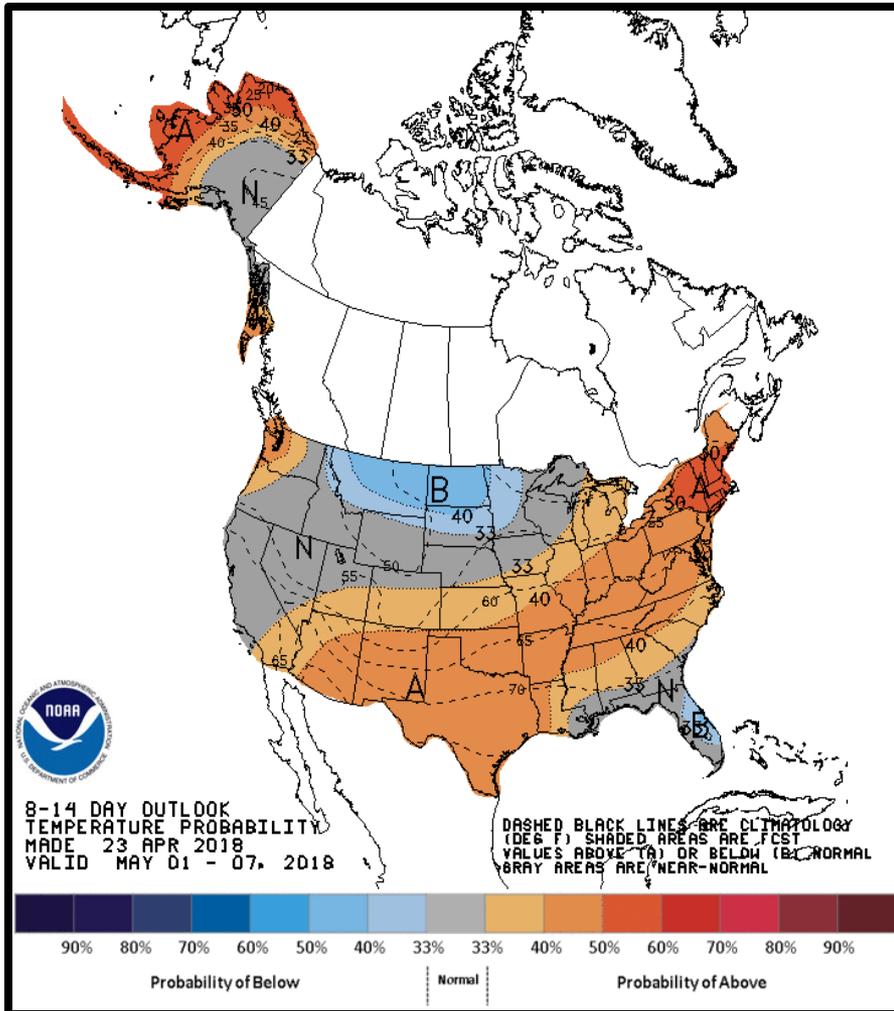
Current Forecasts (WPC's 7-Day Total Precipitation)



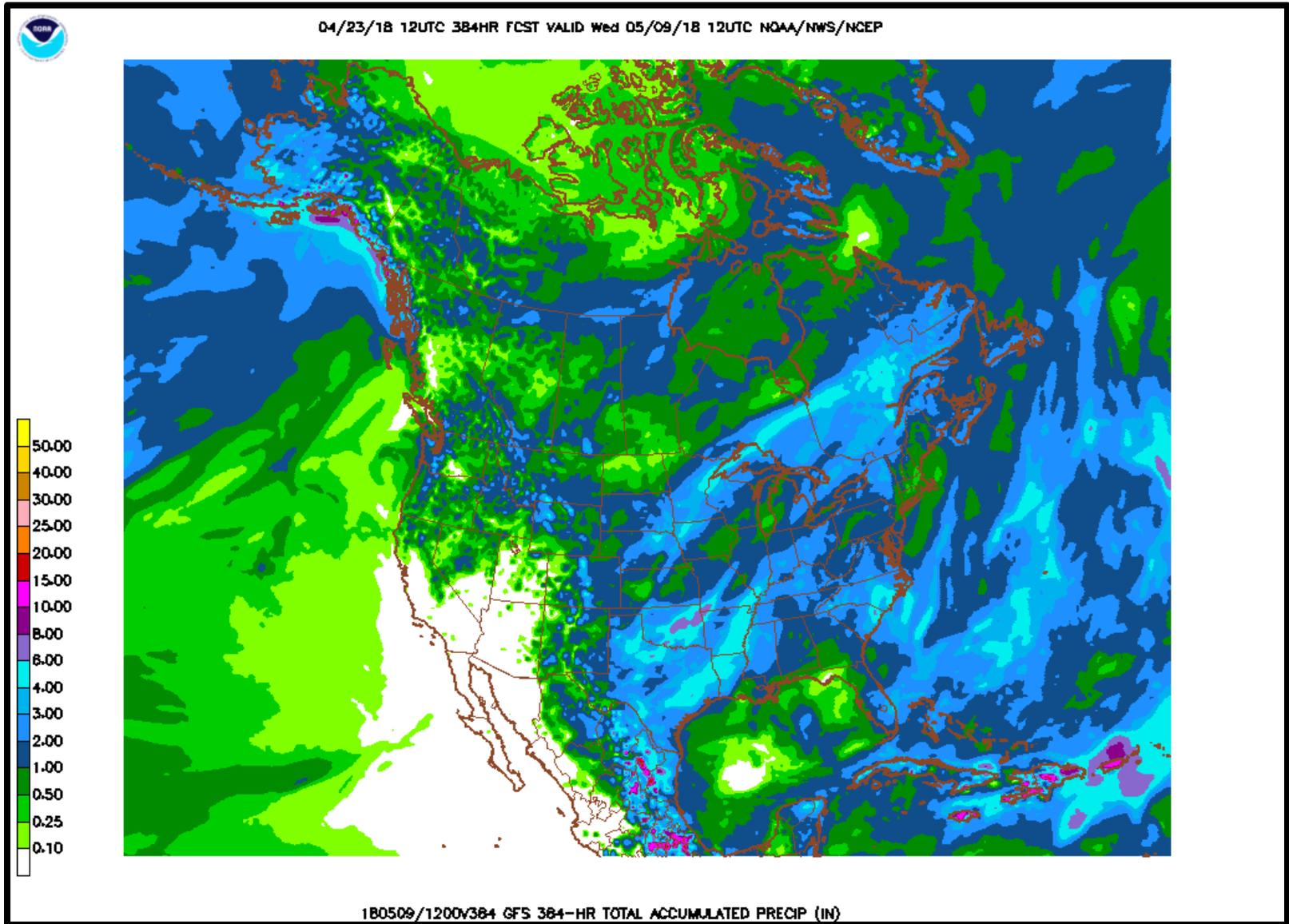
Current Forecasts (6-10 Day Outlooks)



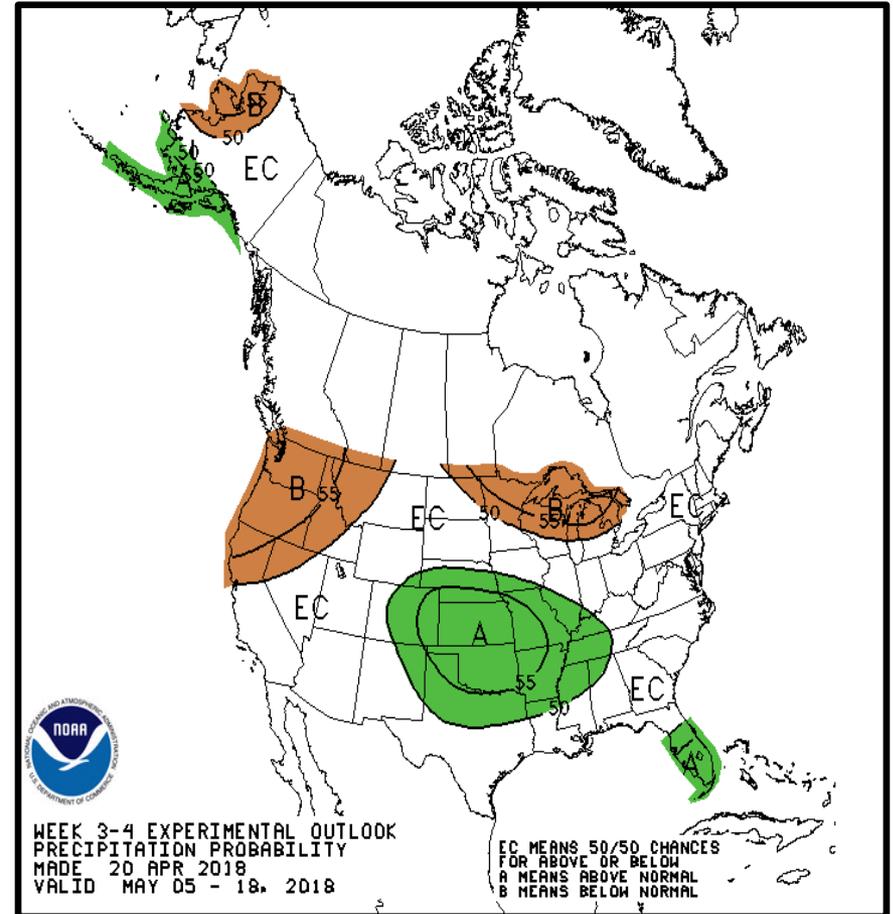
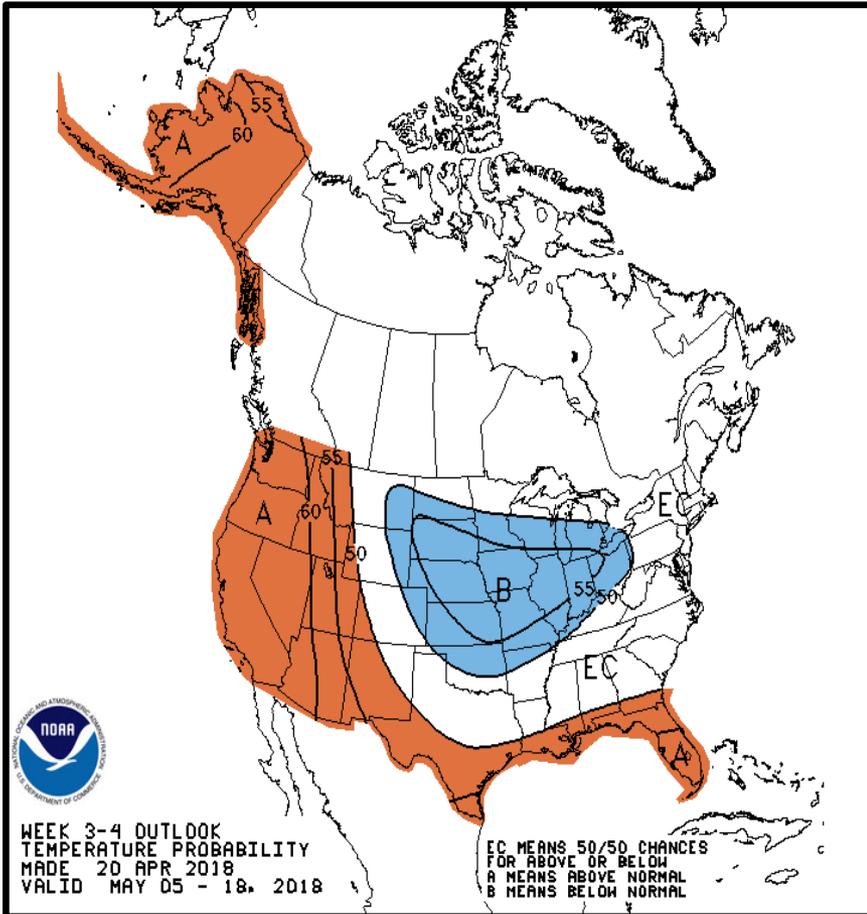
Current Forecasts (8-14 Day Outlooks)



Total 2-week Precipitation from GFS 12z

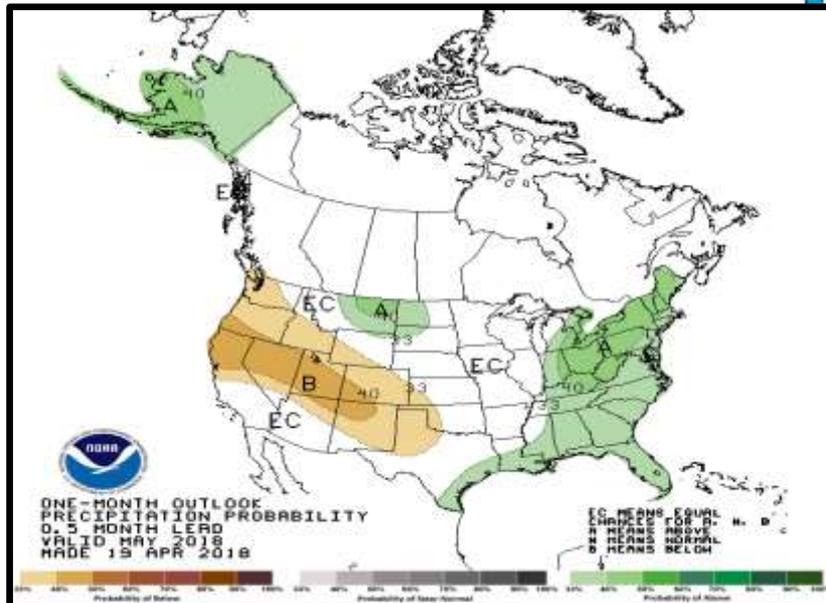
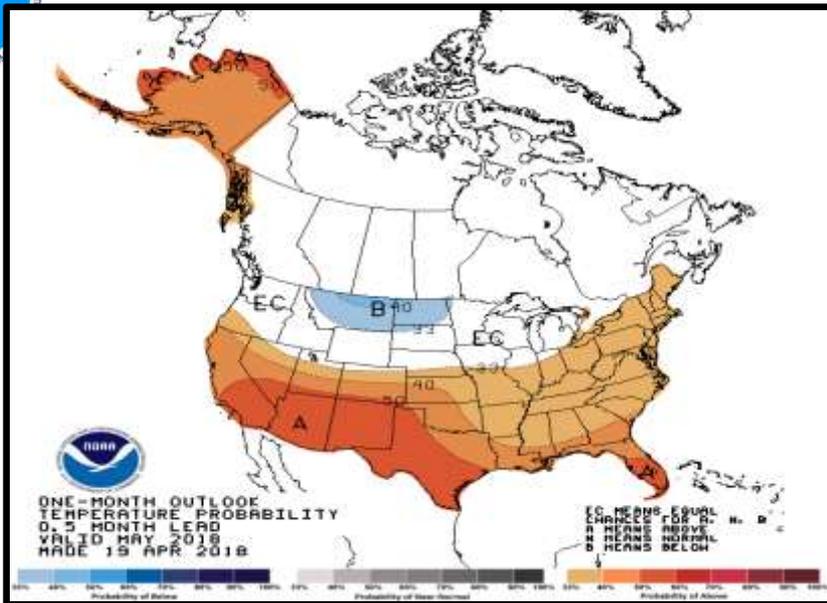


Current Forecasts; Week 3-4 Temp & Precip Outlooks

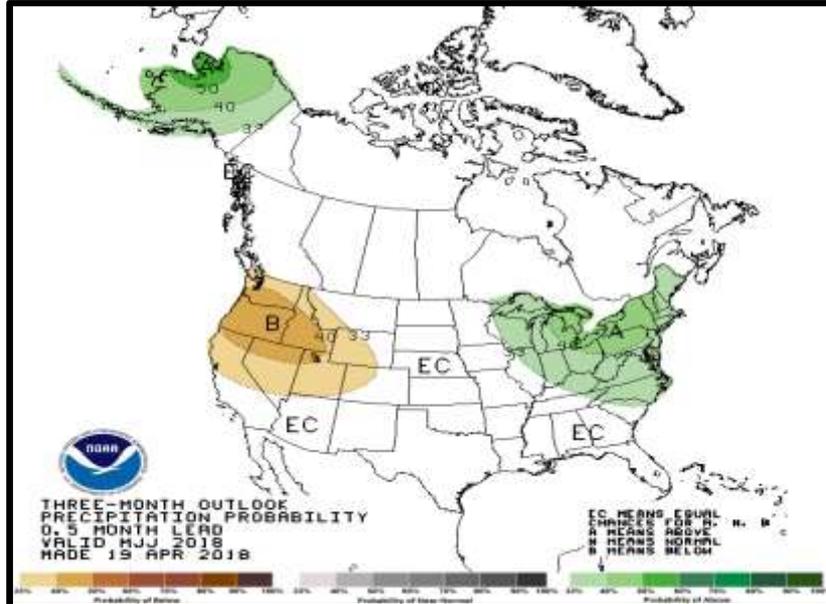
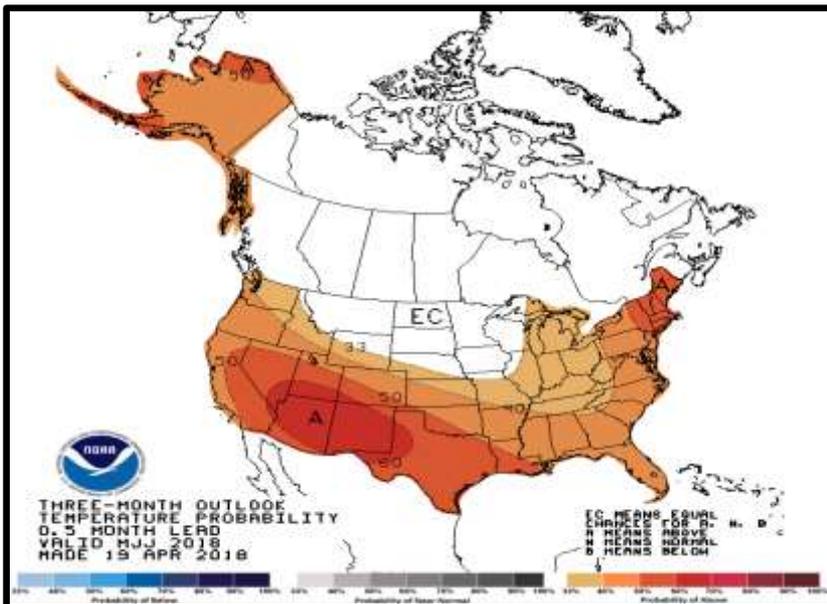


Experimental

Current *Monthly* Temp/Prcp Outlooks



Current *Seasonal* Temp/Prcp Outlooks

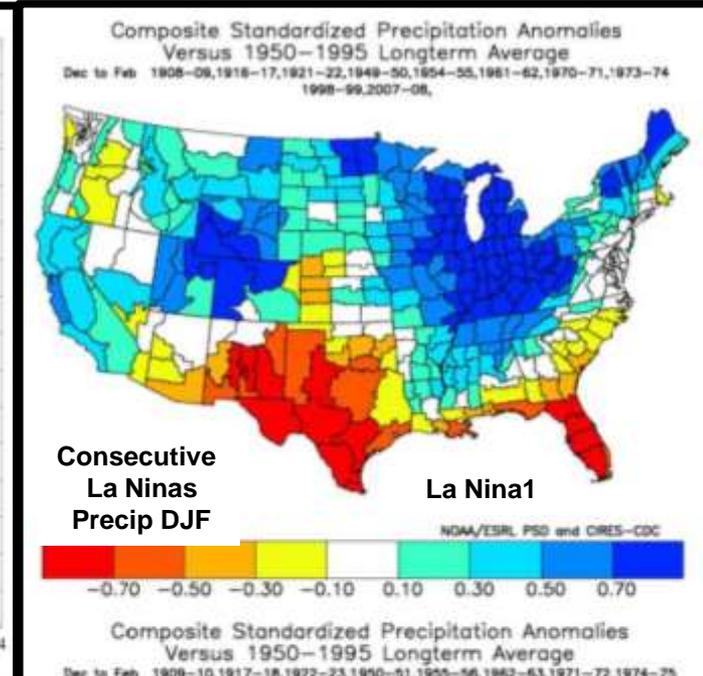
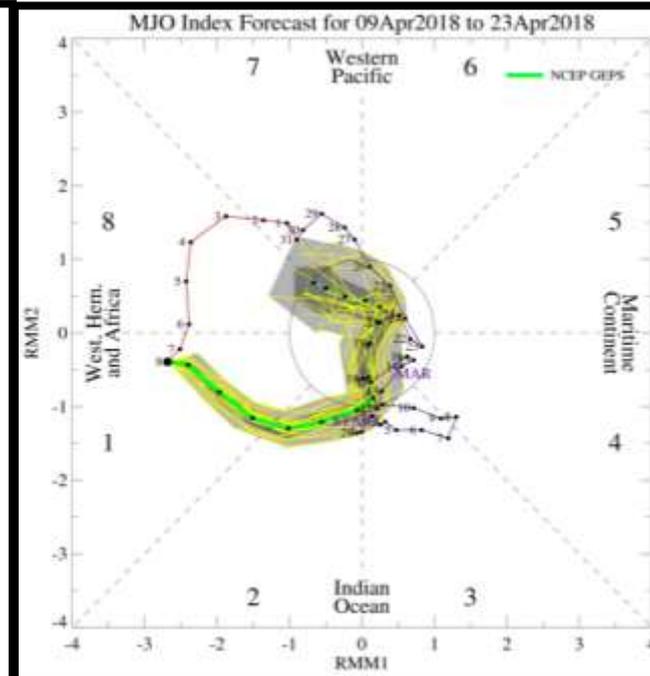
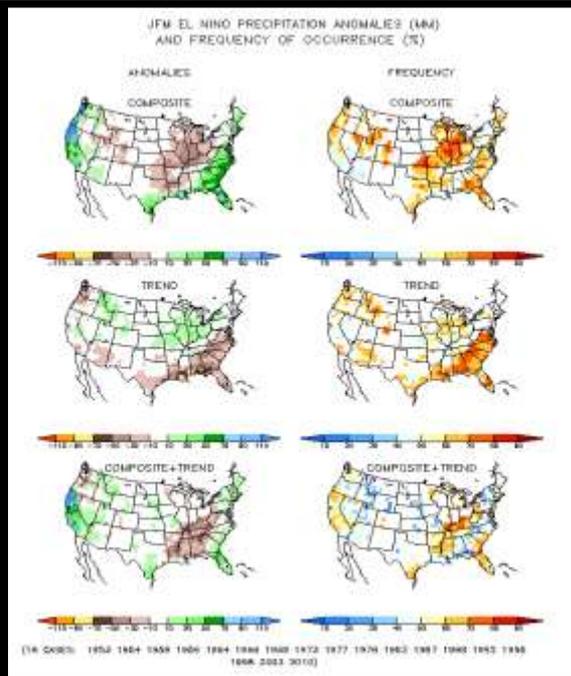


Other Indicators

ENSO composites

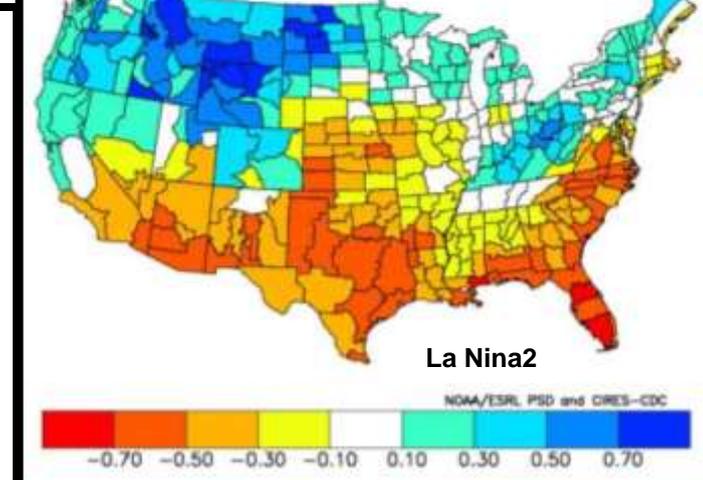
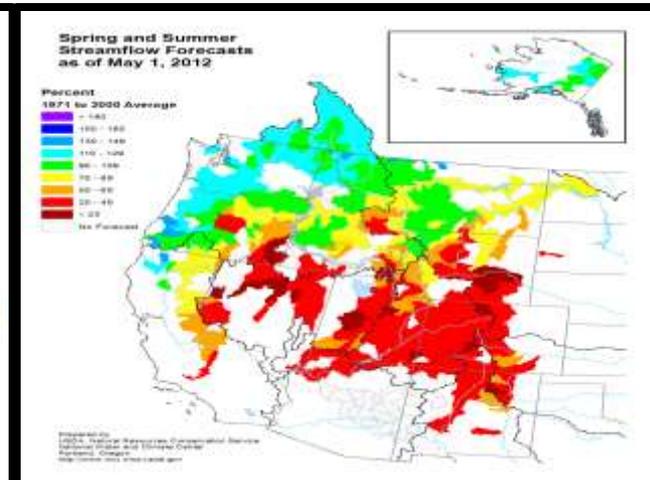
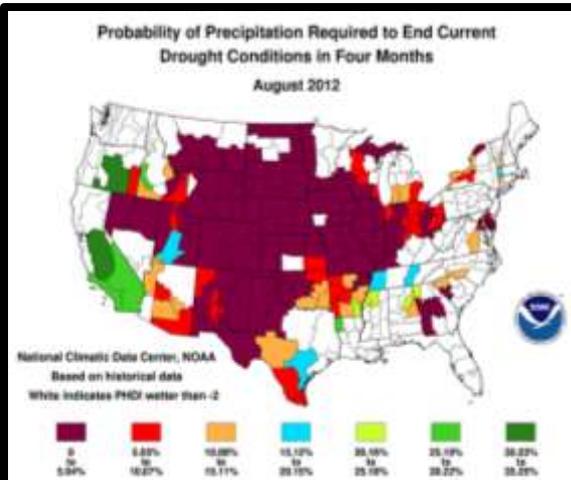
MJO

Analogs

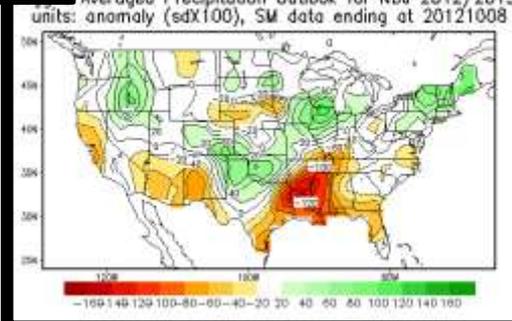
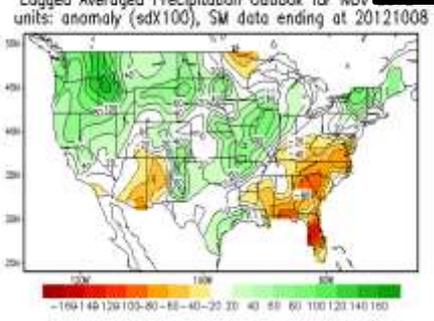
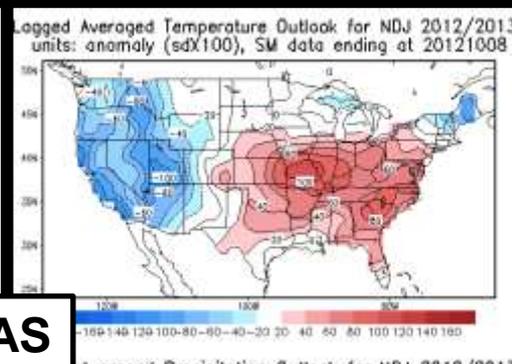
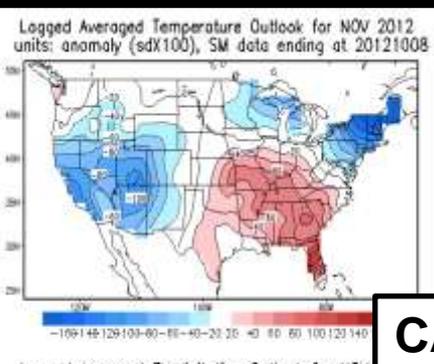
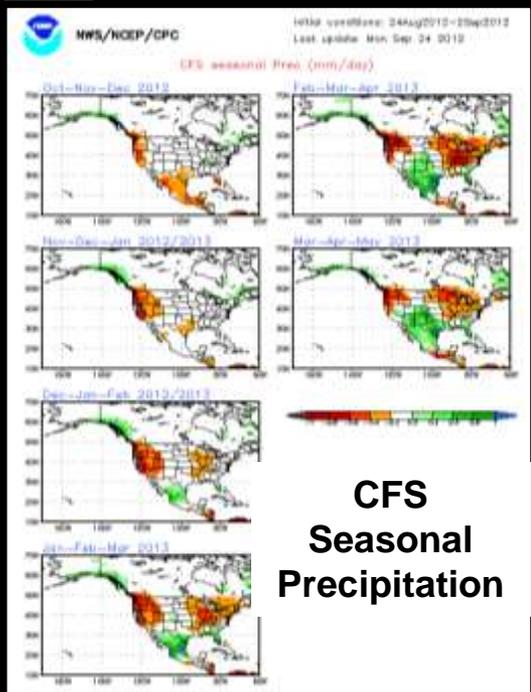
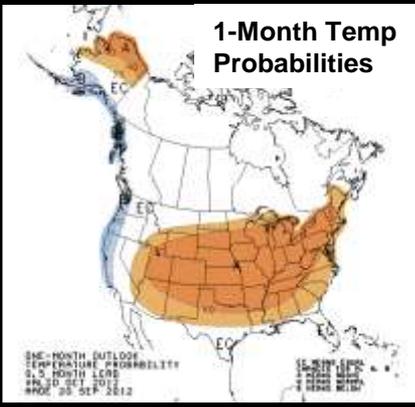
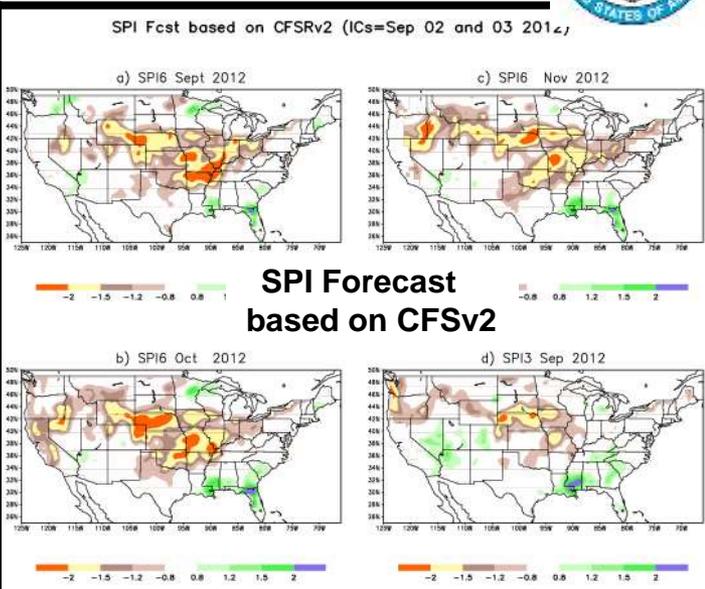
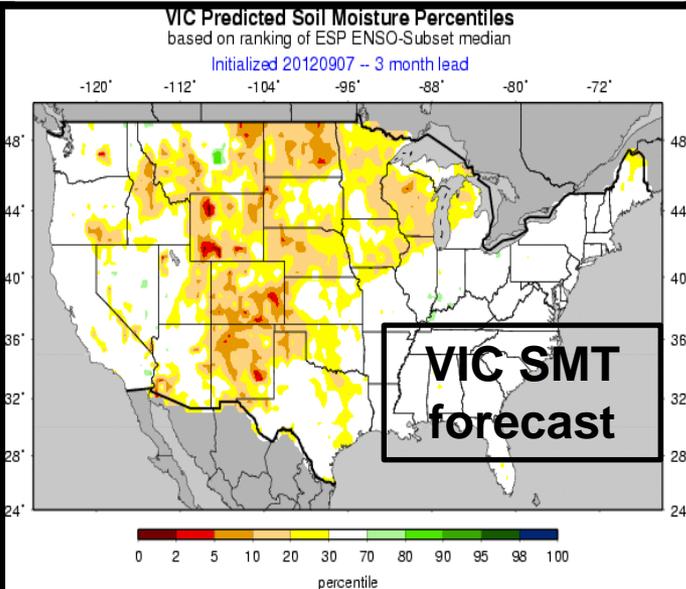
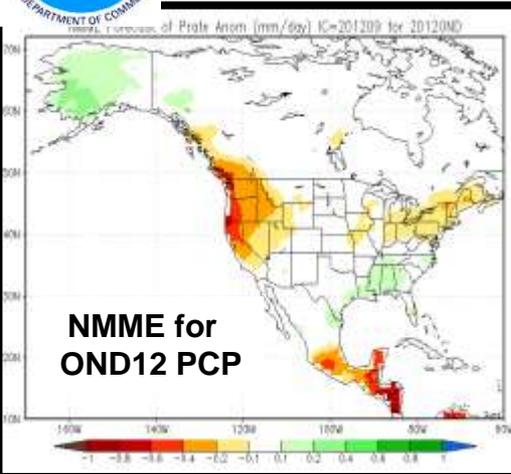


Amelioration

Streamflow Forecasts



Long Term Indicators



CAS

Let me show you
all the tools that
go into the
Drought Outlook

That would
be great!



Some time later

Hey, still
with me?

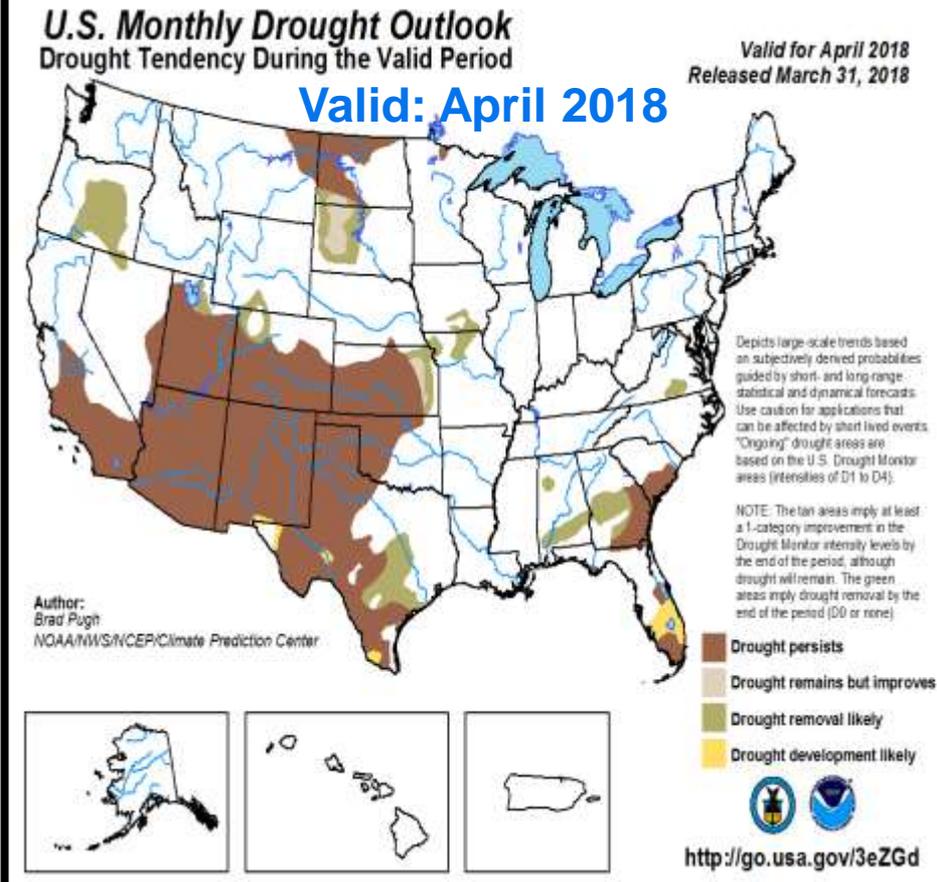
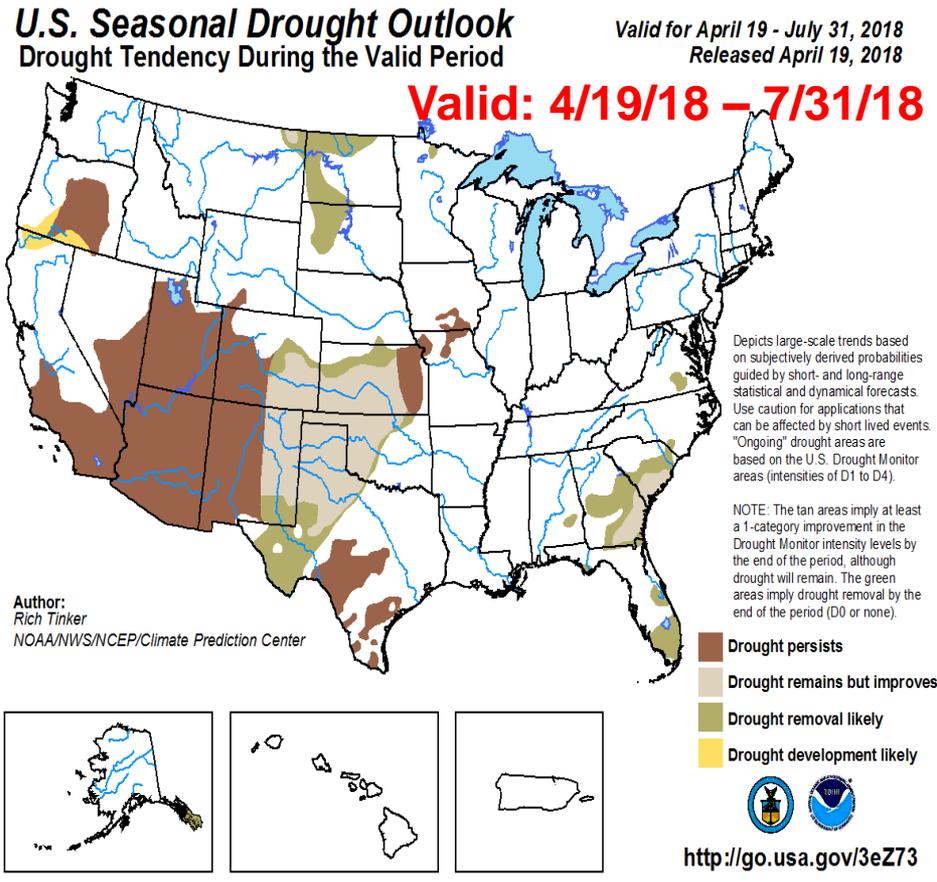
Sound of crickets ...



D.O. Samples

Seasonal D.O.

Monthly D.O.





Drought Outlook Narratives



Summary

Discussion

Latest Monthly Assessment - The Monthly Drought Outlook (MDO) for December 2017 is primarily based on official precipitation forecasts from both the Weather Prediction Center (WPC, Week-1), and the Climate Prediction Center (Week 2, Week 3/4, and the 30-day precipitation update for December). Dynamical model precipitation guidance from the CFS, GFS, and ECMWF was also used. The overall picture that emerges is one that is "front loaded"; that is, significant precipitation is predicted to fall during the early stages of the outlook period, in this case Week-1. Beyond this time, a succession of polar air masses and northwesterly flow are expected to dominate the Nation east of the Rockies, which is typically associated with a much drier pattern. Should enhanced convection associated with the tropics-based Madden-Julian Oscillation (MJO) emerge over the West Pacific early in the period as dynamical model forecasts suggest, it may also play a role in the mid-latitude North American circulation pattern by prolonging the duration of colder, drier weather across the United States, compared to what would normally be expected by extratropical influences alone. Precipitation patterns typically associated with cold season La Niñas favor drier conditions across the southern tier of states, and wetter conditions across the northern tier of states (the latter being associated with a poleward-displaced jet stream and main storm track). However, this climate signal is often more robust after the month of December, and the utility of this signal for this MDO is therefore limited.

The factors noted above, as well as climatology based on a long historical record (121 years) favor the maintenance of drought conditions across a significant portion of the contiguous United States during December 2017. Several areas of new drought development are anticipated as well. These potential development regions are indicated over the southern CONUS, and are loosely associated with abnormally dry (D0) regions depicted on the latest U.S. Drought Monitor (valid 28 November). Though some of the tools used favor precipitation across portions of the South and Southeast during Week-1, it does not look like the forecasted amounts will warrant drought improvement or removal. The normally wet winter season in California is off to a slow start this year, and with the possible exception of the end of December, the next few weeks look relatively dry as well. With the approach of Hawaii's core rainy season, most of the islands are expected to see drought improvement and/or removal. One exception may be along and near the leeward slopes of western Maui, which has received well below-normal rainfall during November. The persistent trade wind pattern that has dominated the Hawaiian Islands is forecast to continue in December. There is no drought in Alaska or Puerto Rico at this time.

Forecaster: Anthony Artusa

Next Monthly Outlook issued: December 31, 2017 at 3 PM EST

Discussion for the Seasonal Drought Outlook

Tools used in the U.S. Seasonal Drought Outlook (SDO) included the official Climate Prediction Center (CPC) temperature and precipitation outlooks for December 2017 through February 2018 (DJF 2017-18), various short- and medium-range forecasts and models such as the 7-day quantitative precipitation forecast (QPF) totals from the Weather Prediction Center (WPC), the 6-10 day and 8-14 day CPC extended-range forecasts (ERFs), Weeks 3-4, dynamical models at the seasonal time scale, 304-hour total precipitation forecasts from several runs of the GFS, 240-hour total precipitation forecasts from the ECMWF, climatology for the DJF season including median soil moisture changes, and initial conditions (the U.S. Drought Monitor valid on November 14, 2017). La Niña conditions are predicted to continue (~65-75% chance) at least through boreal winter 2017-18.

Across the Northeast during the past 30-days, the Departure from Normal Precipitation (DNPP) map depicts wetter-than-normal conditions across approximately the western and eastern thirds of this region, with intervening near- to drier-than-normal conditions for the central third. A few areas, such as near and along the New Hampshire-Maine border, and northern New York's Tug Hill Plateau area, report precipitation surpluses of at least 4 inches during the past 30 days. Looking back over the past 121 years of record, the Northeast typically receives 20-30 percent of its annual precipitation during this three-month period. Though there are a few widely scattered areas of abnormal dryness (D0) on the U.S. Drought Monitor in the Northeast, there is no drought at this time. It is unlikely that drought will redevelop across this region during the winter.

Confidence for the Northeast is moderate to high.

Thirty-day precipitation anomalies in the Southeast indicate mostly below- to near-normal precipitation, with the exception of far western sections of Virginia and the Carolinas, and over southern Florida, where above-normal precipitation fell. Typically during the DJF season, most of this region receives 20-30 percent of its annual precipitation. The exception is the Florida Peninsula, where the historical record reveals a gradation of values ranging from 15-20 percent in the north to 5-10 percent in the south. Existing moderate drought (D1) from the Carolina Piedmont region into southern Virginia (and over a localized area along the southern border of Alabama/Georgia) is expected to persist and/or intensify during the DJF period, as precipitation predictions at nearly all time-scales out to one season in advance support below normal precipitation. Drought development is also anticipated across portions of the Southeast region. This is a common (though not guaranteed) occurrence during La Niña winters. Across most of peninsular Florida, drought development is considered much less likely, as it received copious rainfall from both Hurricane Irma earlier in the season and from a record wet season this year.

Confidence for the Southeast is moderate to high.

Summary - Short overall narrative.

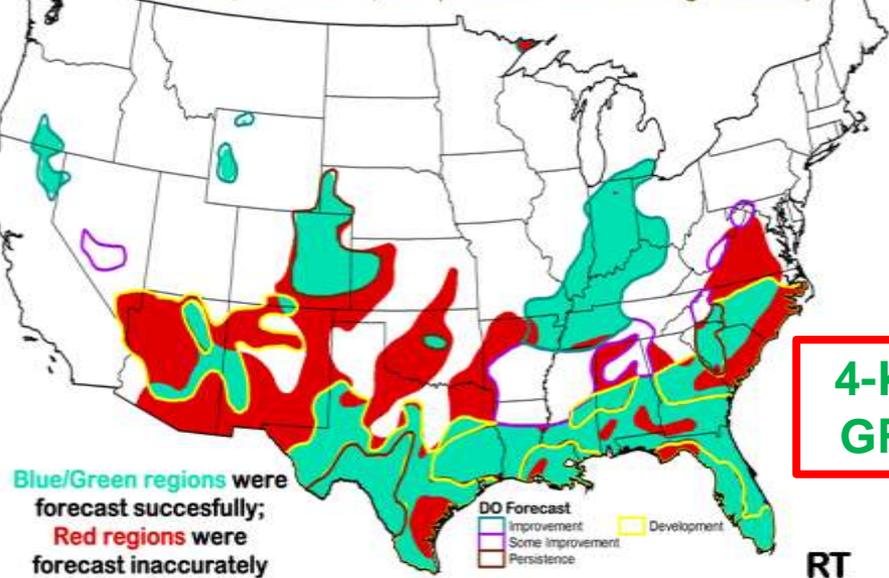
Discussion - Long, detailed narrative

by region that includes reasoning & confidence rating.

2. Drought Verification



DROUGHT OUTLOOK VERIFICATION: Drought Monitor Change
 Nov. 16, 2010 - Mar. 1, 2011 (Initial DJF 2010/11 Drought Outlook)



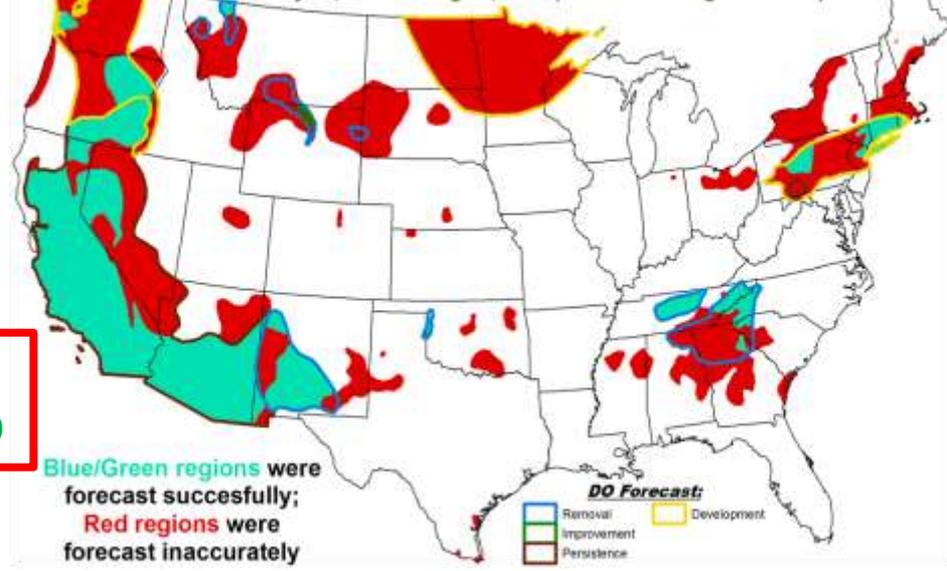
**4-KM
GRID**

RT

FORECAST	HIT	MISS
Improvement	20,998	1,138
Persistence	38,283	1,869
Development	33,369	66,912
TOTAL	92,650	69,919
SCORE	57.0%	
PERSISTENCE FORECAST BASELINE	50,571	106,634
PERSISTENCE FORECAST SCORE	32.2%	

"SKILL" (forecast score) minus (persistence score) +24.8

DROUGHT OUTLOOK VERIFICATION: Drought Monitor Change
 May 17, 2016 to Aug 30, 2016 (JJA 2016 Drought Outlook)



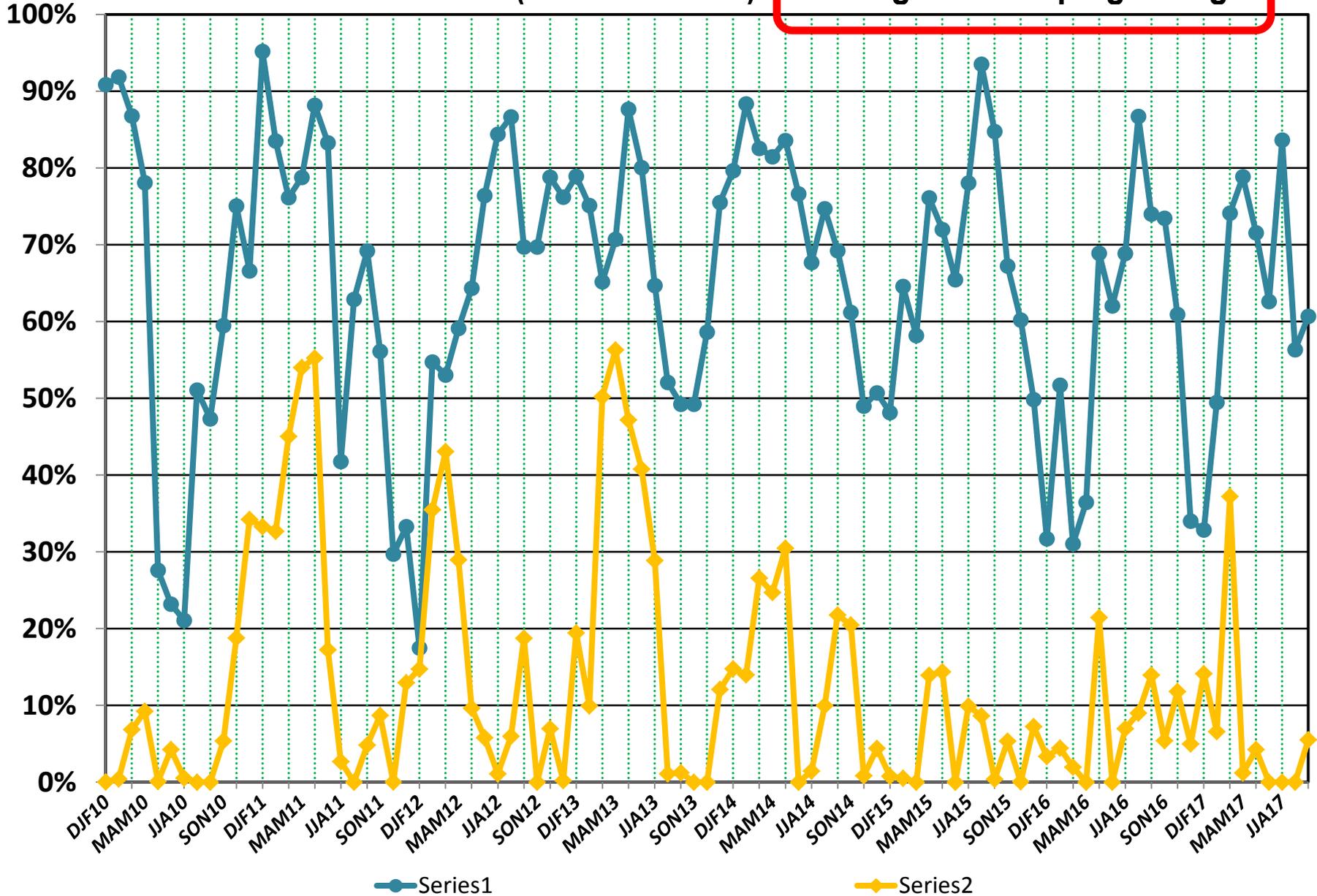
FORECAST	HIT	MISS
Improvement/Removal	7,741	8,824
Persistence	38,401	12,048
Development	5,331	71,231
TOTAL	51,473	92,103
SCORE	35.9	
PERSISTENCE FORECAST BASELINE	47,227	62,330
PERSISTENCE FORECAST SCORE	43.1	

"SKILL" (forecast score) minus (persistence score) -7.2

Good Forecasts during developing La Nina & El Nino

Not so good Forecasts during Summer & ENSO Neutral

Seasonal D. O. Verification (% of Pixels Hit) - Existing & Developing Drought



3. New Tools



©SabraJ Photography 2014

Moose (Lake Louise)

http://www.alaska.org/assets/content/photo-contest/_large/His_Majesty_copyright.jpg

(First Guess) Objective Drought Monitor based on NLDAS (4 LSMs used)

SMT

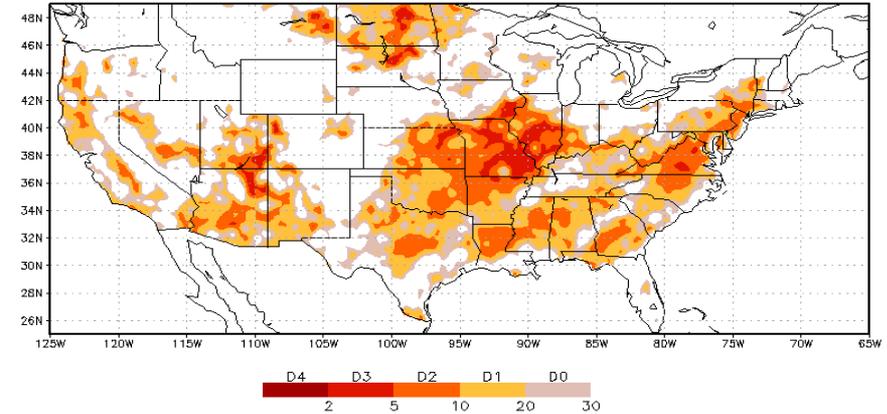
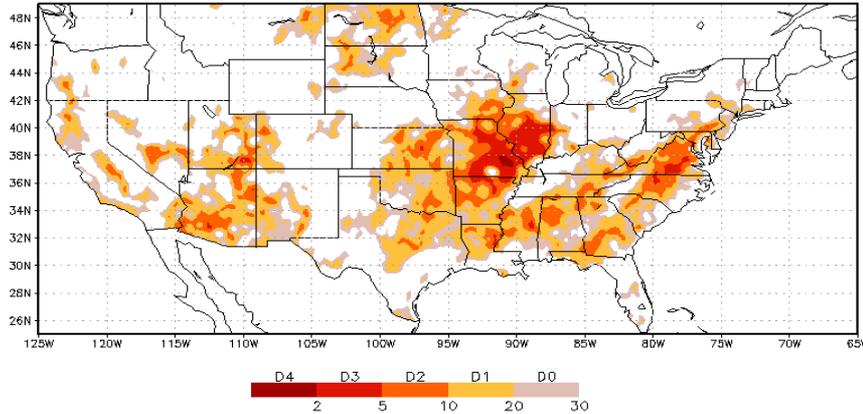
Mean Drought Indices

22Jan2018–21Feb2018

SRI3

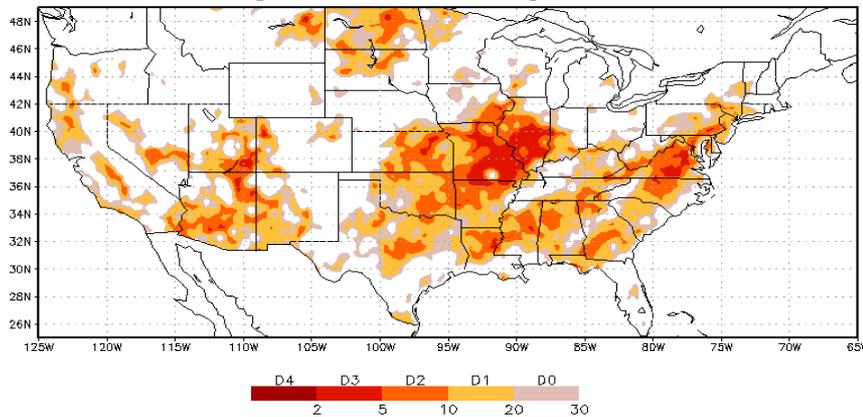
Soil Moisture Percentile

Standardized Runoff Index 3mo



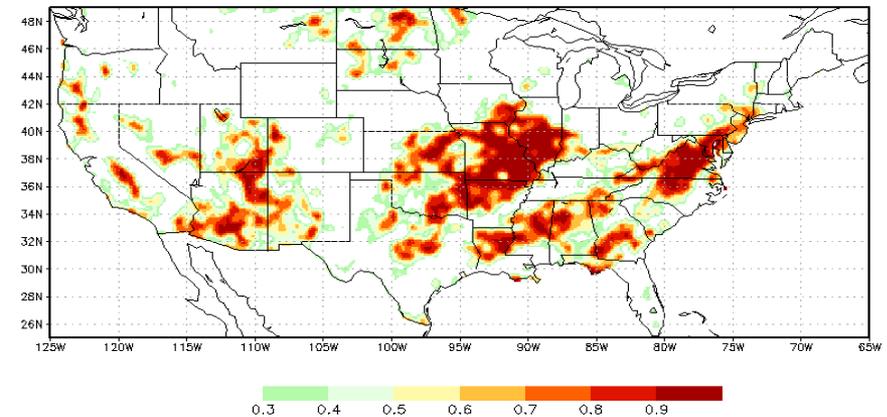
IDI

Integrated Drought Index



CON

Concurrence D1 & Above



IDI: take mean of 4 SMT and 4 SRI3 percentiles and map to a uniform distribution, so values range between 0 and 1 (probs)

Concurrence measure : percentage of members that agree with the IDI (which measures the uncertainty of the IDI)

Early Stages of a Probabilistic D.O. **SPI6 only!**

(Drs. Kingtse Mo & Li Xu at CPC)

NMME models:

CMC 1– CanCM3, CMC 2–CanCM4, GFDL (Flor), NASA, CFSv2 & NCAR CCSM

6 models * 10 members each = 60 ensemble members

- * Use Model Prcp to get respective **SPI6** forecasts
 - * Map onto a uniform distribution function (end up with values between 0 & 1) for Probs
 - * For ex: at each grid point:
 - If all ensemble members agree – 100% probability
 - If only half of the members agree – 50% probability
 - Verification against CPC's Unified Precip Analysis (daily, gauge-based, CONUS, 0.25x0.25-deg)
-

D1: $-0.8 > \text{SPI} > -1.2$

D2: $-1.3 > \text{SPI} > -1.5$

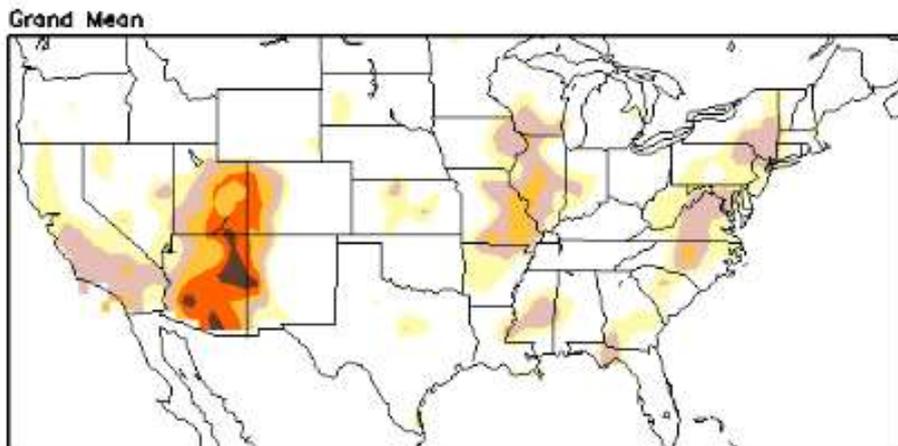
D3: $-1.6 > \text{SPI} > -1.8$

D4: $\text{SPI} < -2.0$



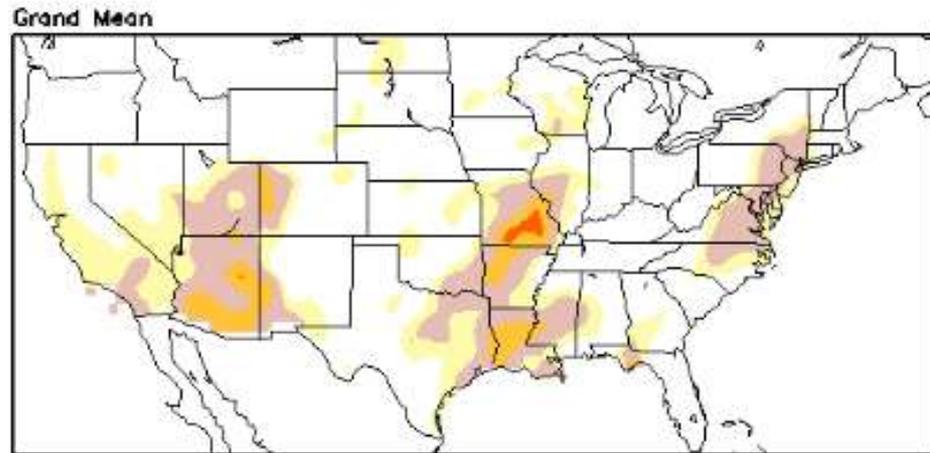
Probabilistic Drought Forecast for Jan2018

NMME initial 01Jan2018



Probabilistic Drought Forecast for Feb2018

NMME initial 01Jan2018

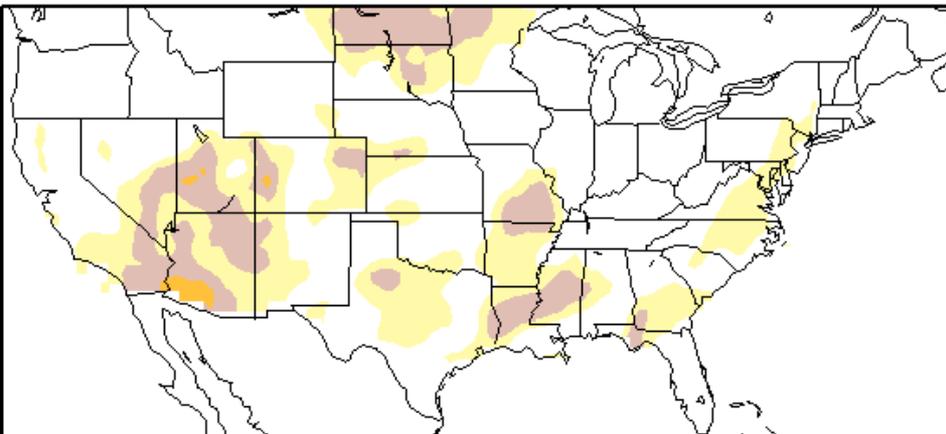


Likelihood of Drought & Intensity & longer time ranges for Decision Support Services

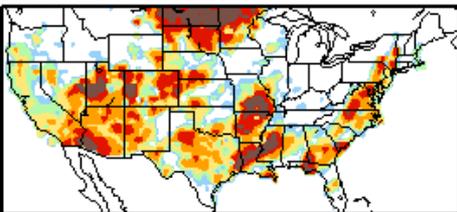
Probabilistic Drought Forecast for Mar2018

NMME initial 01Jan2018

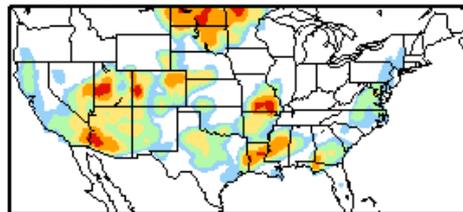
Grand Mean



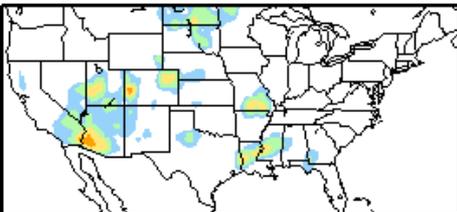
D0 & above Prob.



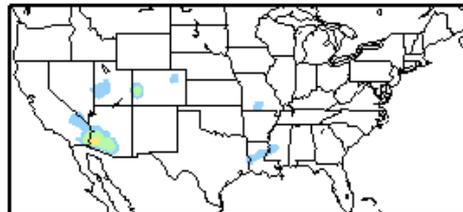
D1 & above Prob.



D2 & above Prob.



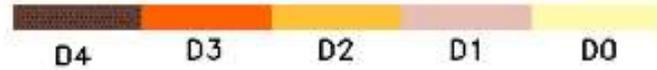
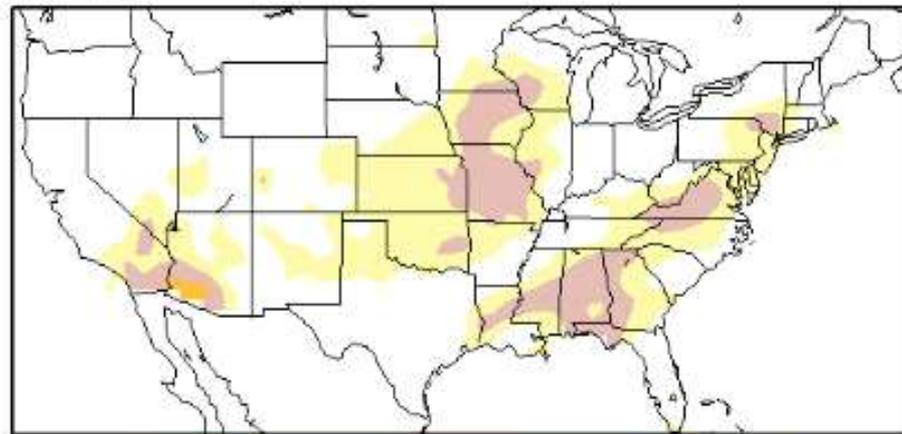
D3 & D4 Prob.



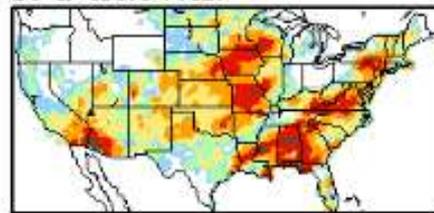
Probabilistic Drought Forecast for Apr2018

NMME initial 01Jan2018

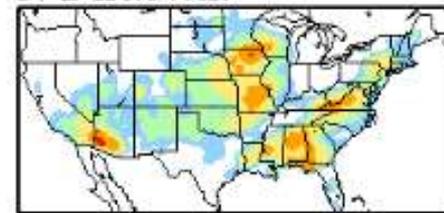
Grand Mean



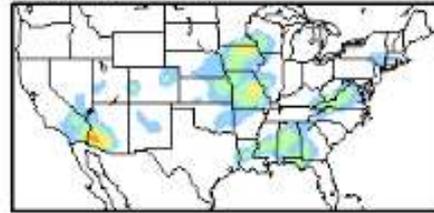
D0 & above Prob.



D1 & above Prob.



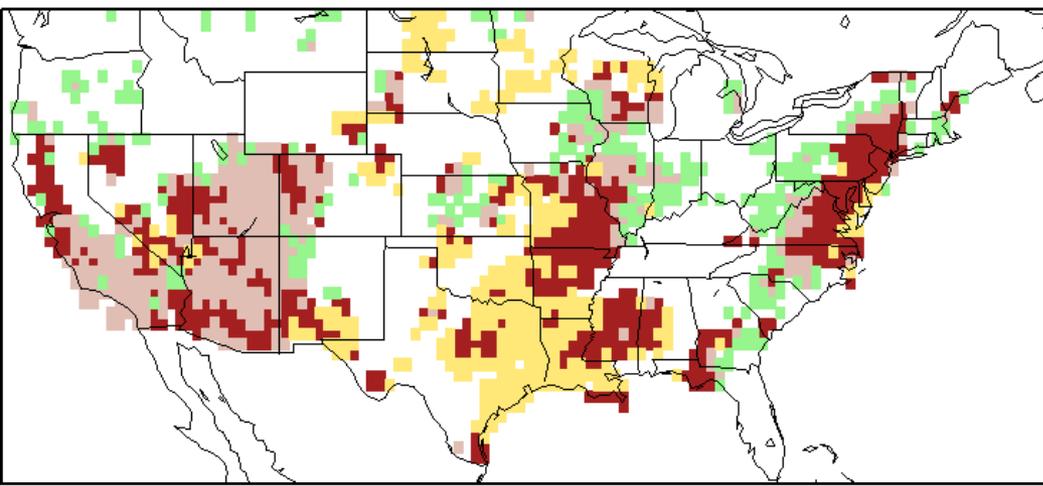
D2 & above Prob.



D3 & D4 Prob.



Drought outlook for Feb2018
NMME initial 01Jan2018

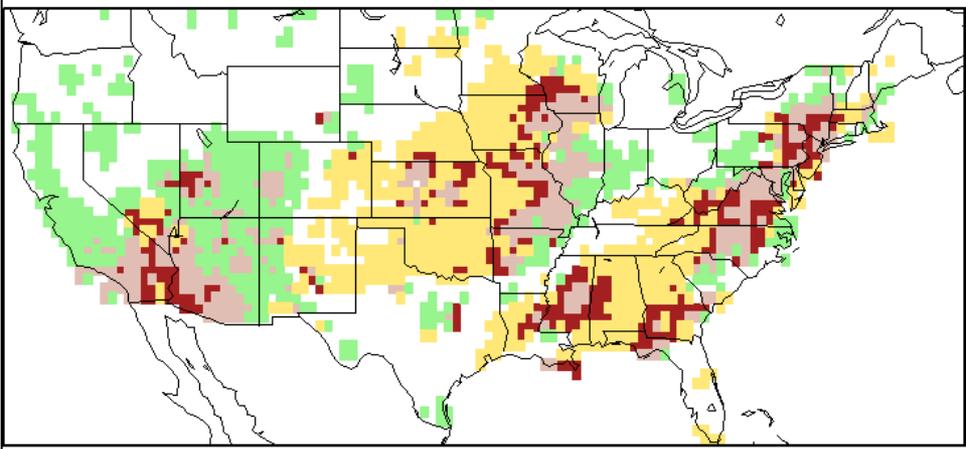


Feb 2018

- Drought persists
- Drought remains but improves
- Drought removal likely
- Drought development likely

FMA 2018

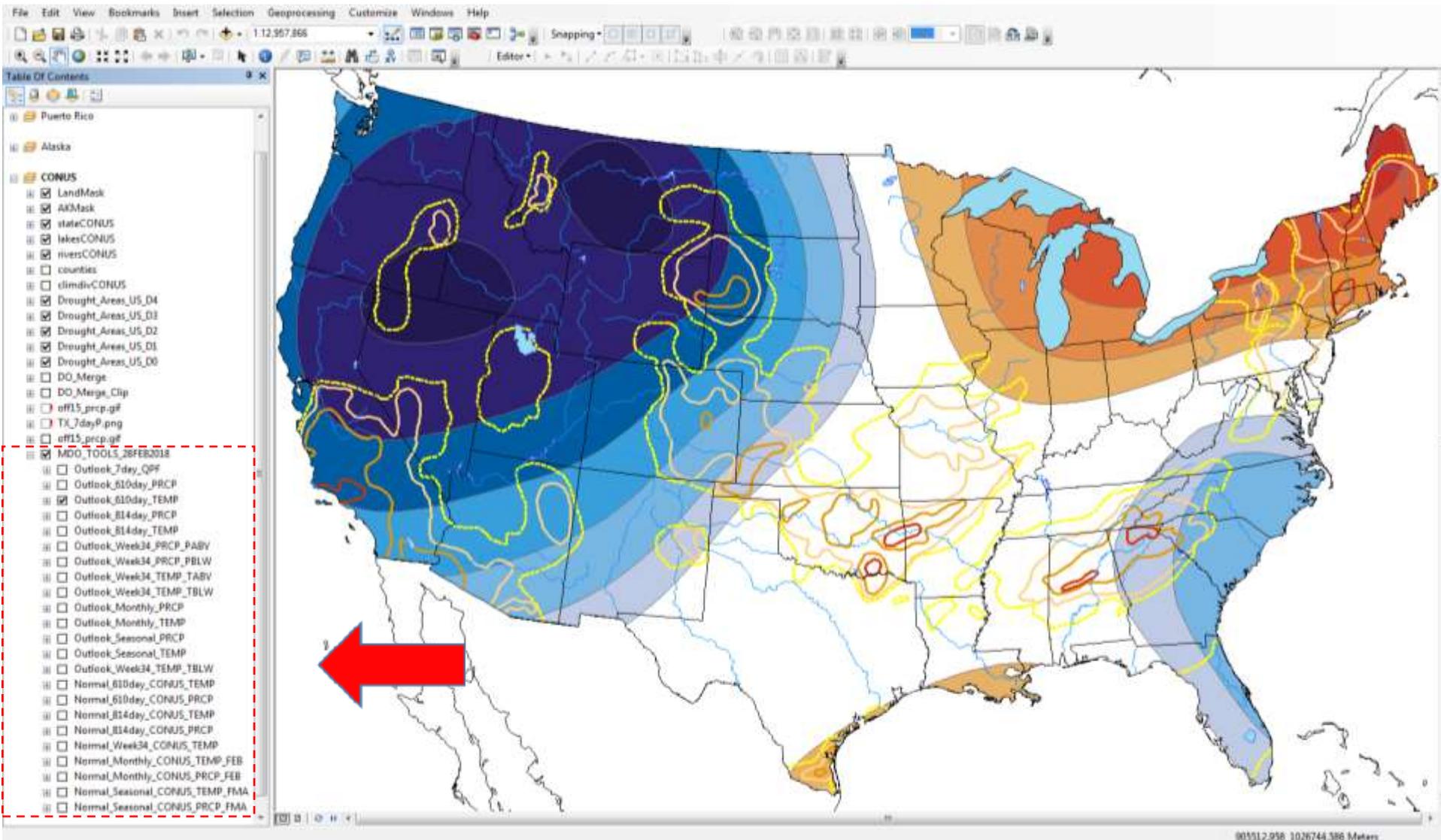
Drought outlook for Feb2018–Apr2018
NMME initial 01Jan2018



- Drought persists
- Drought remains but improves
- Drought removal likely
- Drought development likely

In the official
Drought Outlook
Tendency
Format!!

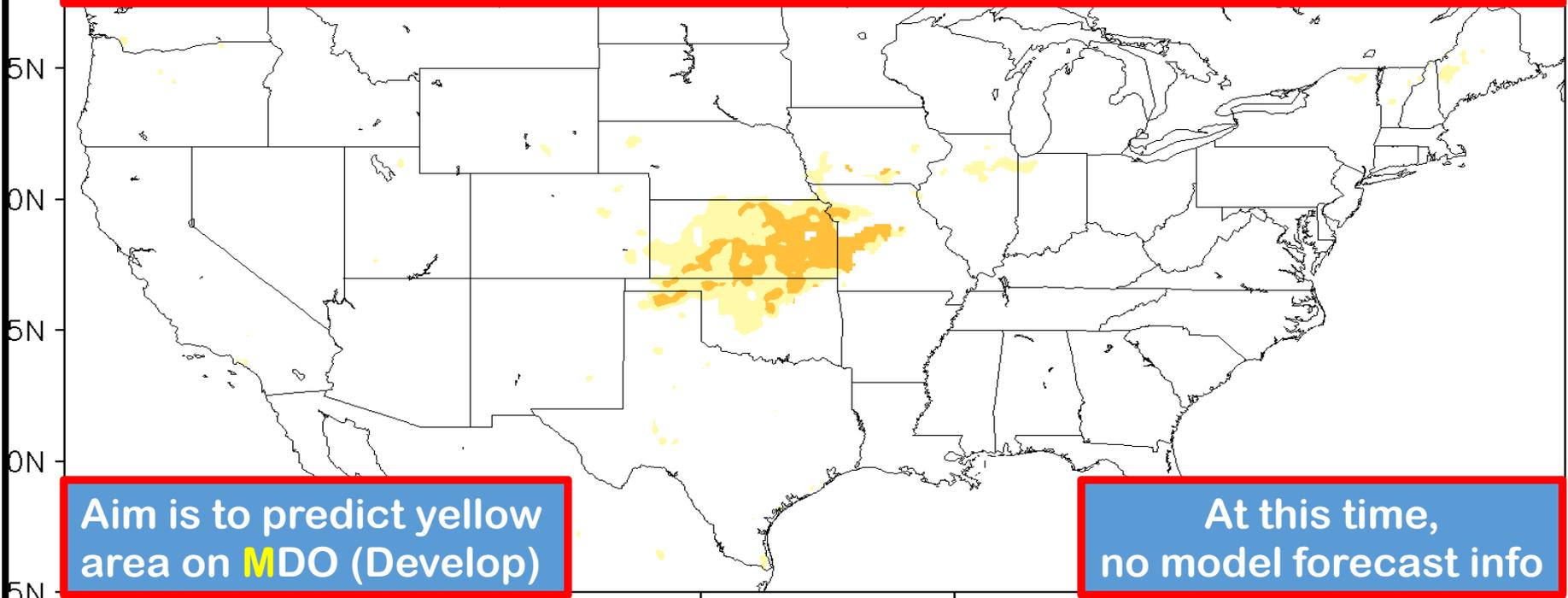
Prototype for Overlaying DO Tools on MXD



This example has 6-10 Day ERF Temperature Probabilities overlaid with D0-D4 drought layers

Potential Flash Drought Development Issued on 08 Apr 2018

Warm Season Evaporation Anomalies (+P, SMT from NLDAS2) ; E-driven events



Aim is to predict yellow area on MDO (Develop)

At this time, no model forecast info

Drought less likely

RCI* < -0.5 (count during past 30-days)

Drought more likely



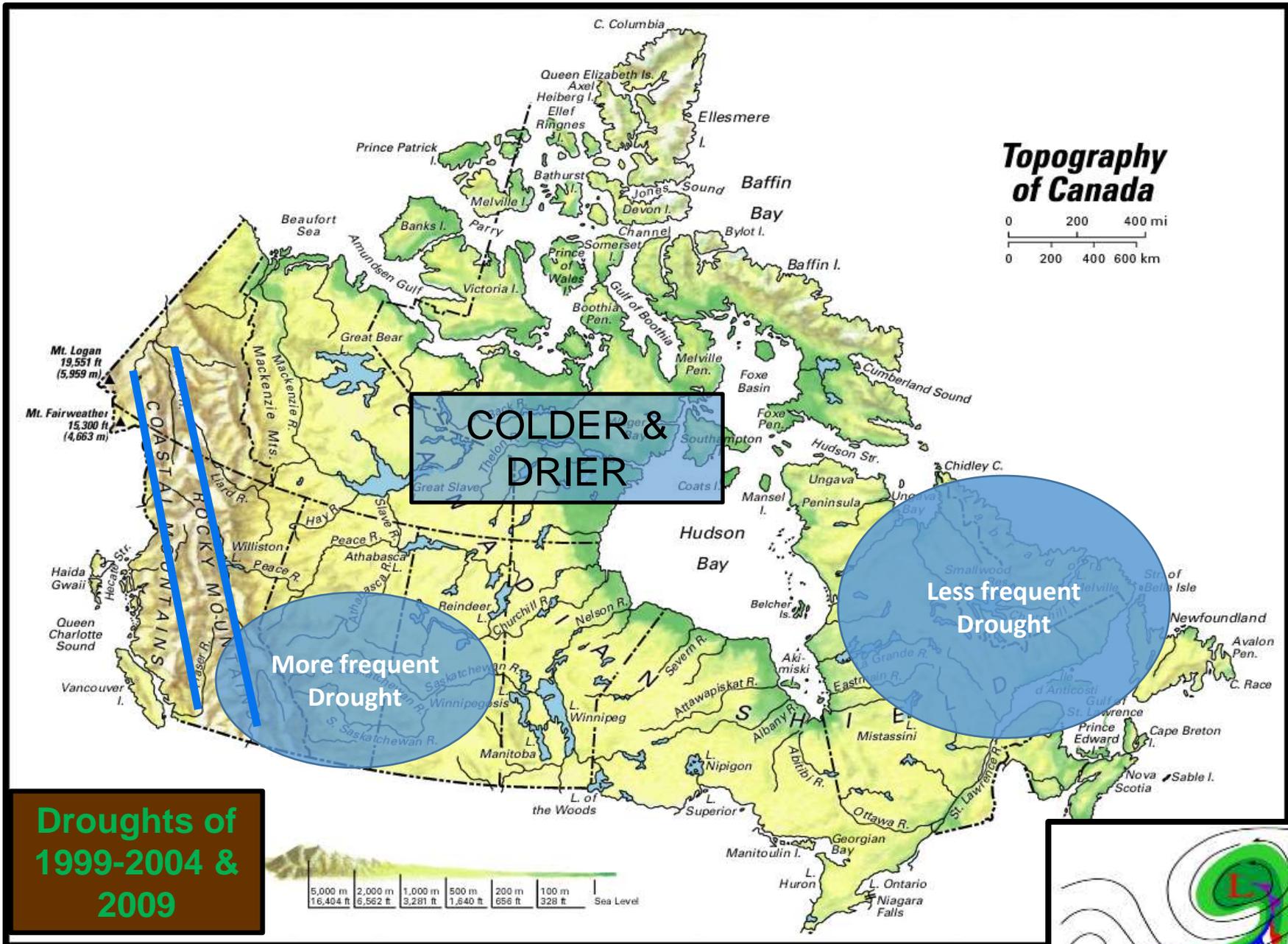
*Rapid Change Index is accumulated magnitude of moisture stress changes (standardized differences) occurring over multiple weeks (Otkin et al (2015))

Future Work

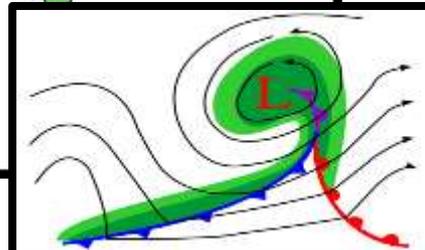
- Monitor performance of new tool in real time.
- Evaluate the drought susceptibility metrics using historical data and refine the metrics based on the evaluation.
- Produce drought **probability maps** instead of deterministic maps.
- Next phase will incorporate **CFSv2 forecast data into the tool to predict P-driven drought events**, provide drought improvement information, and reduce false alarm.

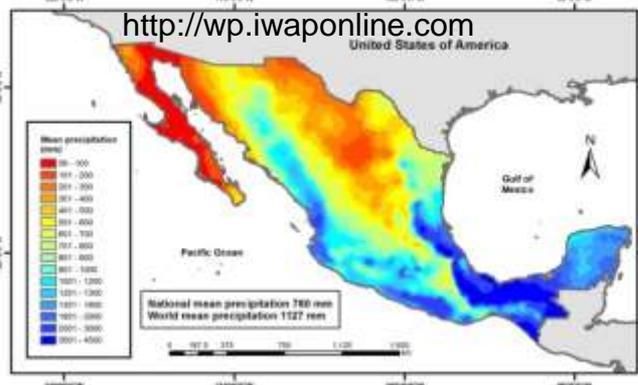
4. Some issues specific to Canada and Mexico



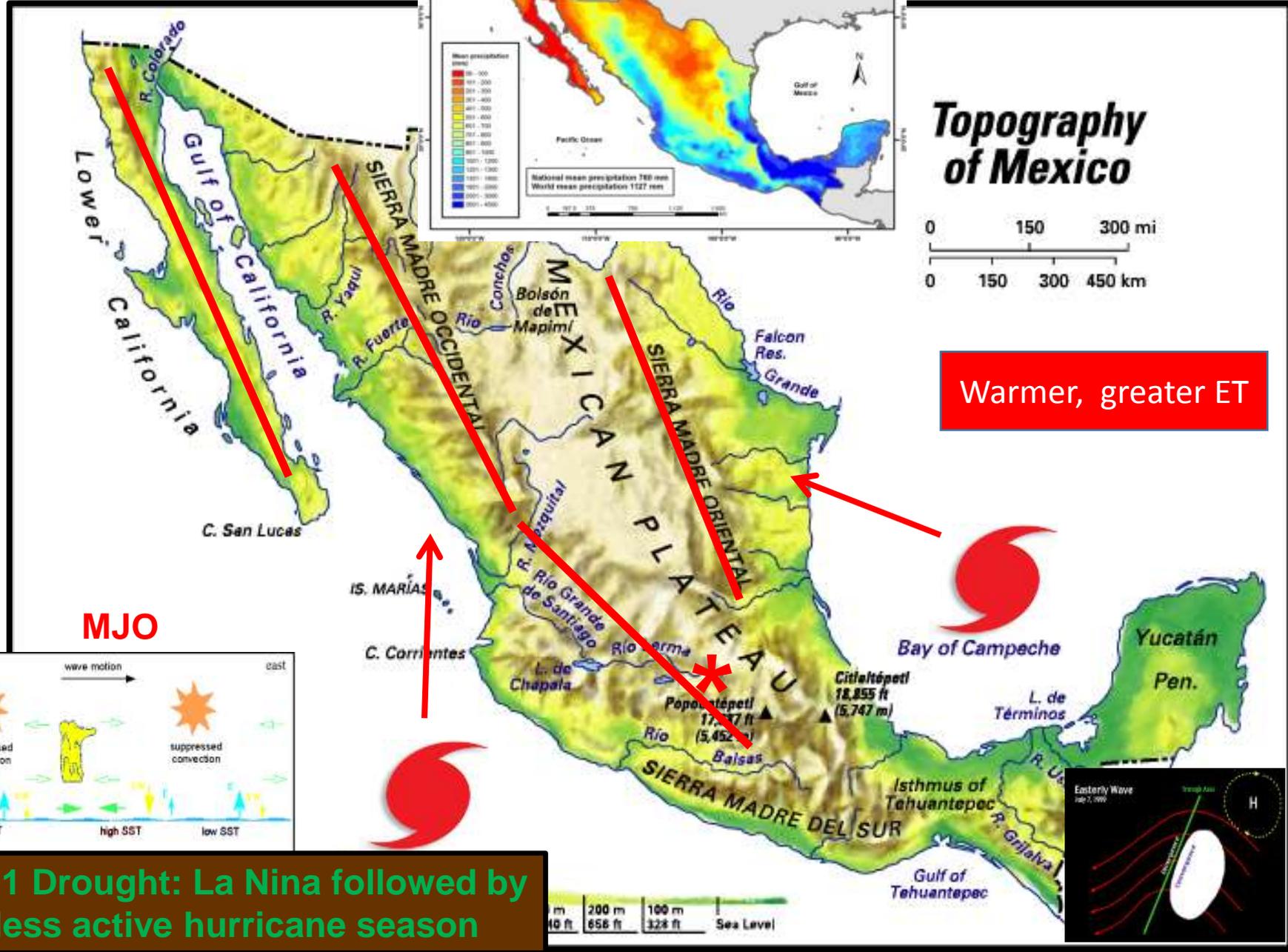
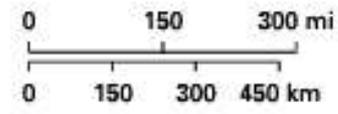


Map Source: Britannica



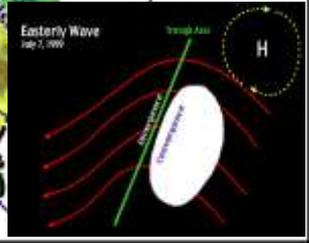
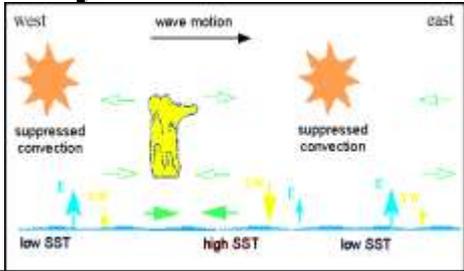


Topography of Mexico



Warmer, greater ET

MJO



2011 Drought: La Nina followed by less active hurricane season

North American Monthly/Seasonal Drought Outlook Tool Checklist



Climatology/Trends			
SST Anomaly			
AHPS/ACIS DNPs			
AHPS/ACIS PNPs			
AHPS/ACIS Temp DN			
Drought Monitor			
Soil Moisture			
Stream flows			
Snow Water Content			
Reservoirs			
Palmer Drought Index			
SPI			
ENSO Composites			
Analogs			
<u>Prcp 2 end Dx</u>		Consolidation	
Evapotranspiration			
Runoff			
<u>WPC 1-7 day Prcp</u>			
<u>CPC 8-14 day Prcp</u>			
<u>CPC Weeks 3,4 Prcp</u>			
<u>30/90 day Temp Otlk</u>			
<u>30/90 day Prcp Otlk</u>			
MJO			
CAS			
CFS			
NMME			

Special thanks :

Trevor Hadwen & Dwayne Chobanik (Agri-Feed)

David Miskus & Dr. Lin Xu (CPC)

Dr. Kingtse Mo & Dr. David DeWitt (CPC)

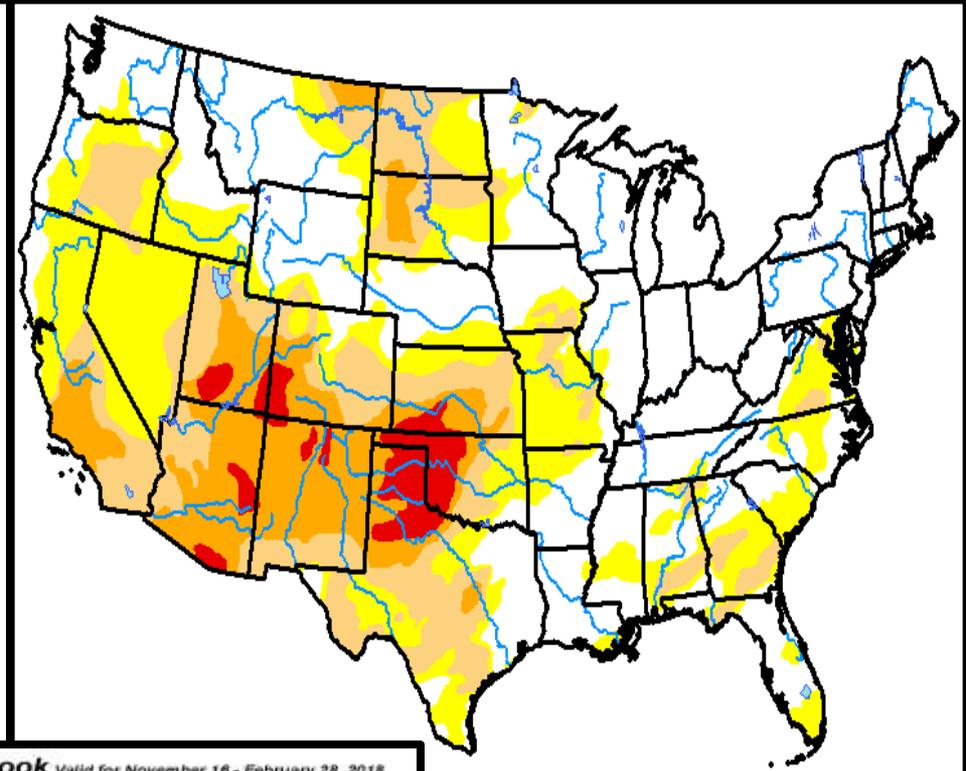
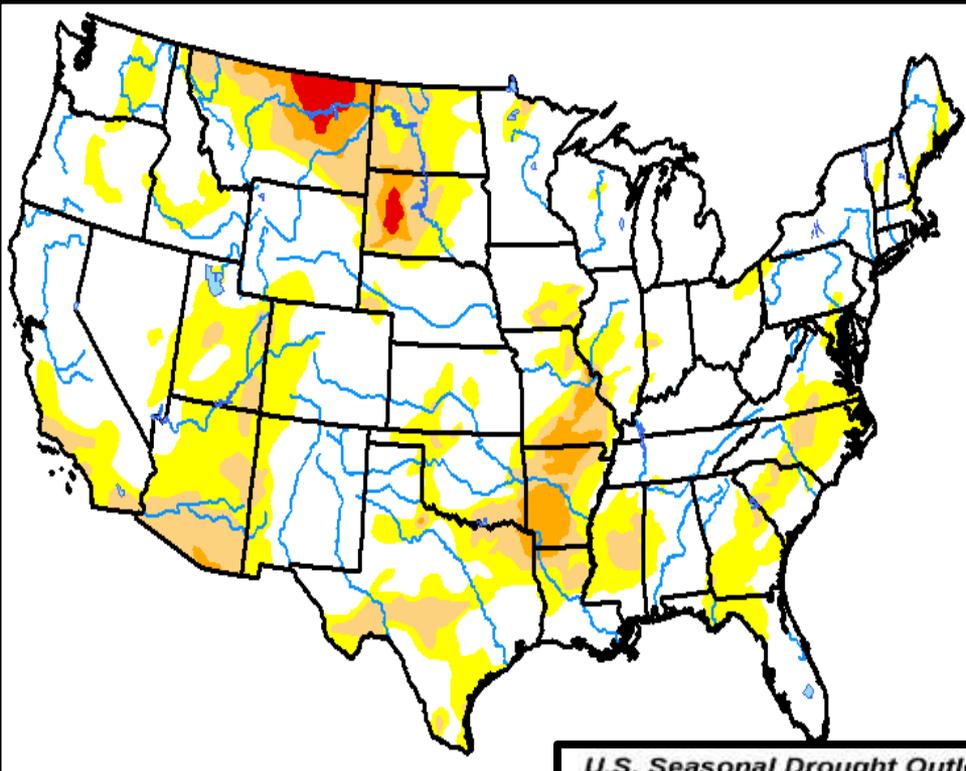
Dr. Gwen Chen & Jon Gottschalck (CPC)



Washington, D.C. cherry blossoms

Begin (11/14/2017)

End (2/27/2018)



U.S. Seasonal Drought Outlook Valid for November 16 - February 28, 2018
Drought Tendency During the Valid Period
Released November 16, 2017

Author:
Anthony Araya
NOAA/NWS/NCEP/Climate Prediction Center

Drought large-scale trends based on statistically derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that are for affected by short-lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor area (probability of 0.1 to 0.4).

NOTE: The dry areas imply at least a 1-category improvement in the Drought Monitor category leads to the end of the period, although, drought will remain. The green areas imply drought removal by the end of the period (0.5 or more).

- Drought persists
- Drought remains but improves
- Drought removal likely
- Drought development likely

<http://go.usa.gov/3eZ73>

**Valid:
11/16/17 - 2/28/18**