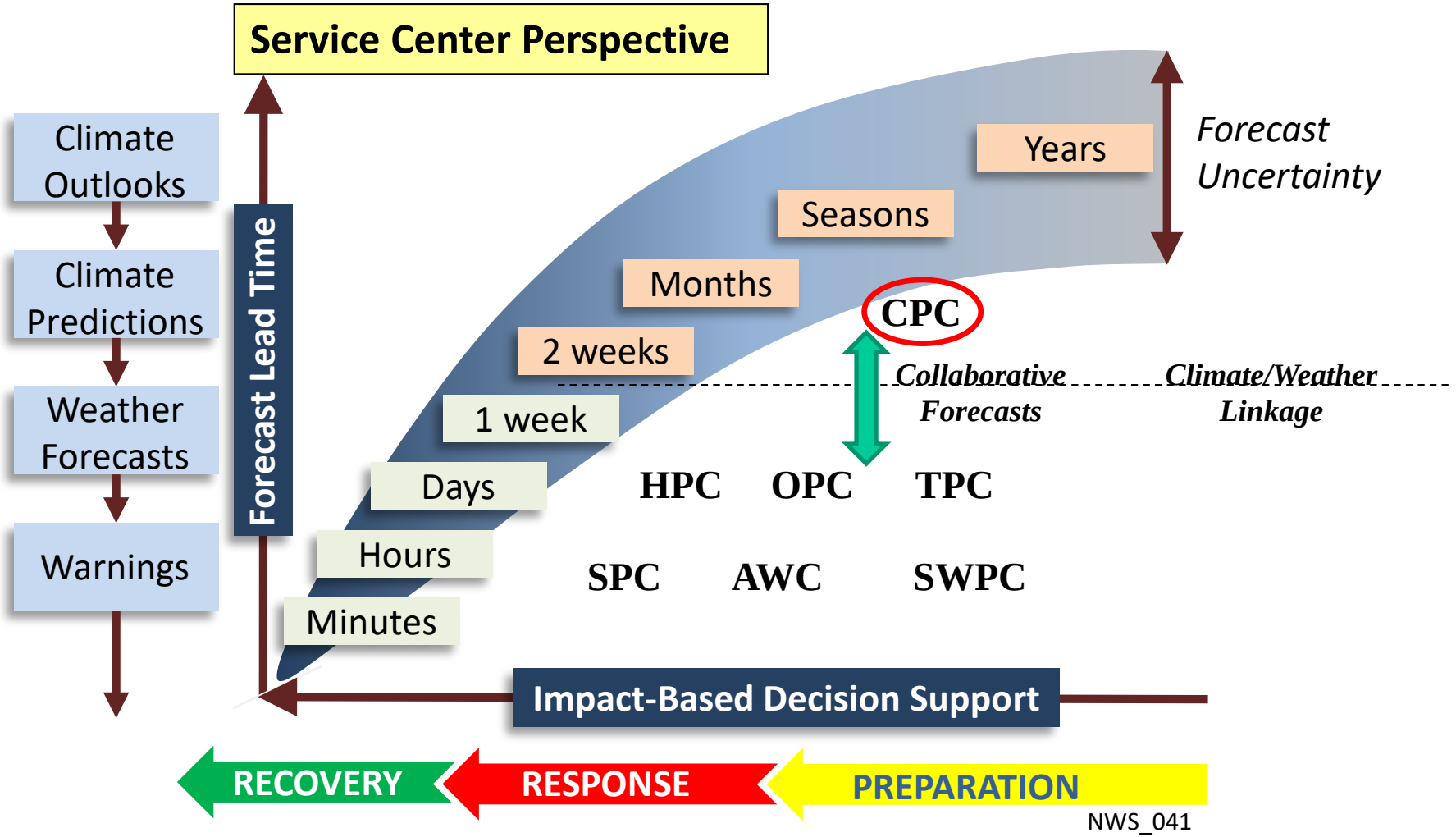
# “Short-Term Drought Forecasting: Process, Products, & Possible Future”

David Miskus

*NOAA/NWS/NCEP/Climate Prediction Center*

*Drought Task Force 3 Telecom*
*Friday, June 22, 2018*
*2:15-2:45 pm EDT*

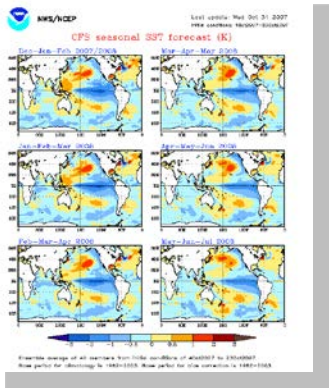
# NOAA Seamless Suite of Forecast Products Spanning Climate and Weather

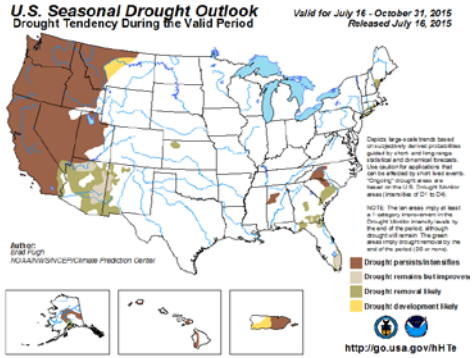


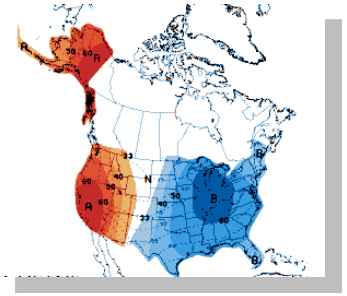

NWS_041

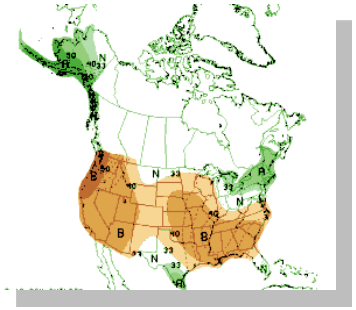
# Climate Prediction Products

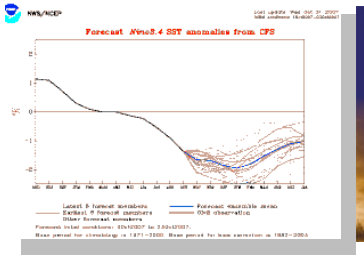
- **Focus on Week-2 to Seasonal-to-Interannual**
  - 6-10 Day & 8-14 Day [ERFs] Precipitation & Temperature Outlooks
  - Day 3-14 Hazards Outlooks (US [HAF], Global Tropics [MJO/GTH])
  - Monthly & Seasonal [LLFs] Precipitation & Temperature Outlooks
  - Monthly & Seasonal Drought Outlooks [DOs]
  - Seasonal Hurricane Outlooks (Atlantic and Eastern Pacific)
  - Monthly ENSO Prediction
  - Week 3-4 Temperature/ Precipitation
  - Week 2 Heat Outlook
  - Arctic Sea Ice Forecasts

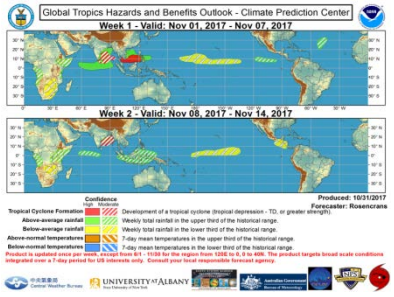


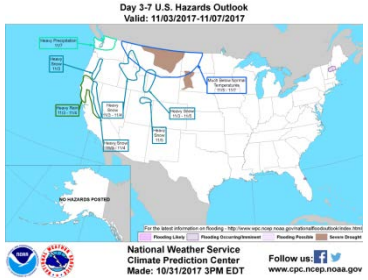



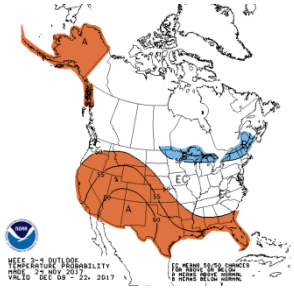










*** Dynamical Models**
- Climate Forecast System
- Global Forecast System
- ECMWF
- NMME

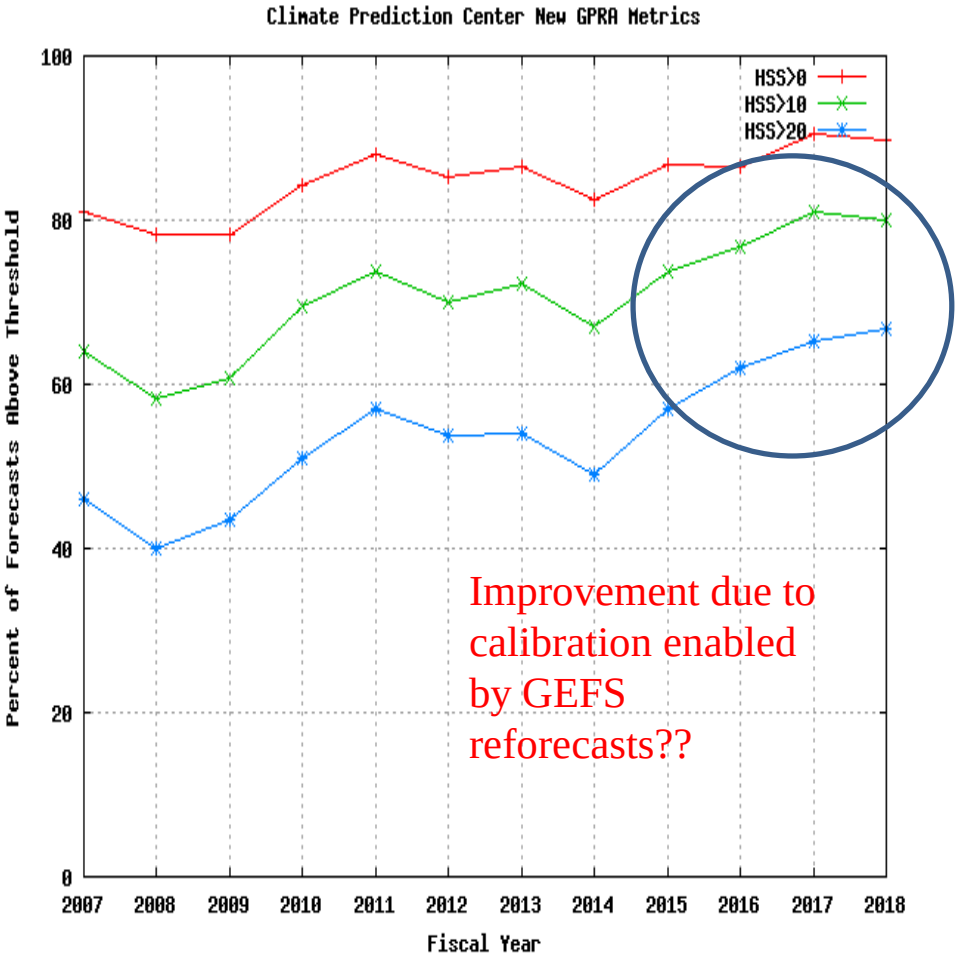
# CPC Comprehensive Skill Metric (CSM)

Comprehensive skill metric (CSM) based on all CPC extended range and long range outlooks.

CSM includes over 1000 product issuances per year.

Judged “successful” if its Heidke Skill Score exceeds a particular threshold.

CSM shows continuous, improvement of CPC products.



# Drought Outlook Presentation

- History of the Drought Outlook (DO);
- Preparation of the Operational DOs (Seasonal & Monthly);
- DO Verifications;
- Drought Outlook Challenges;
- Next Steps in Drought Forecasting (Future);

# US Drought Outlook History

- Originated in August 1999 (shortly after the US Drought Monitor became operational). USDM was originally a monitor & outlook, decided it was best to make 2 separate products. SDO went public in March 2000;

- Intent is to present a simple national picture of where droughts will improve (removed), persist, or develop (but not worsen);

- Original production schedule issued initial SDO on 3rd Thursday of month, with updated SDO (if required) on 1st Thursday of next month, by one of the 5 CPC forecasters rotating among other duties;

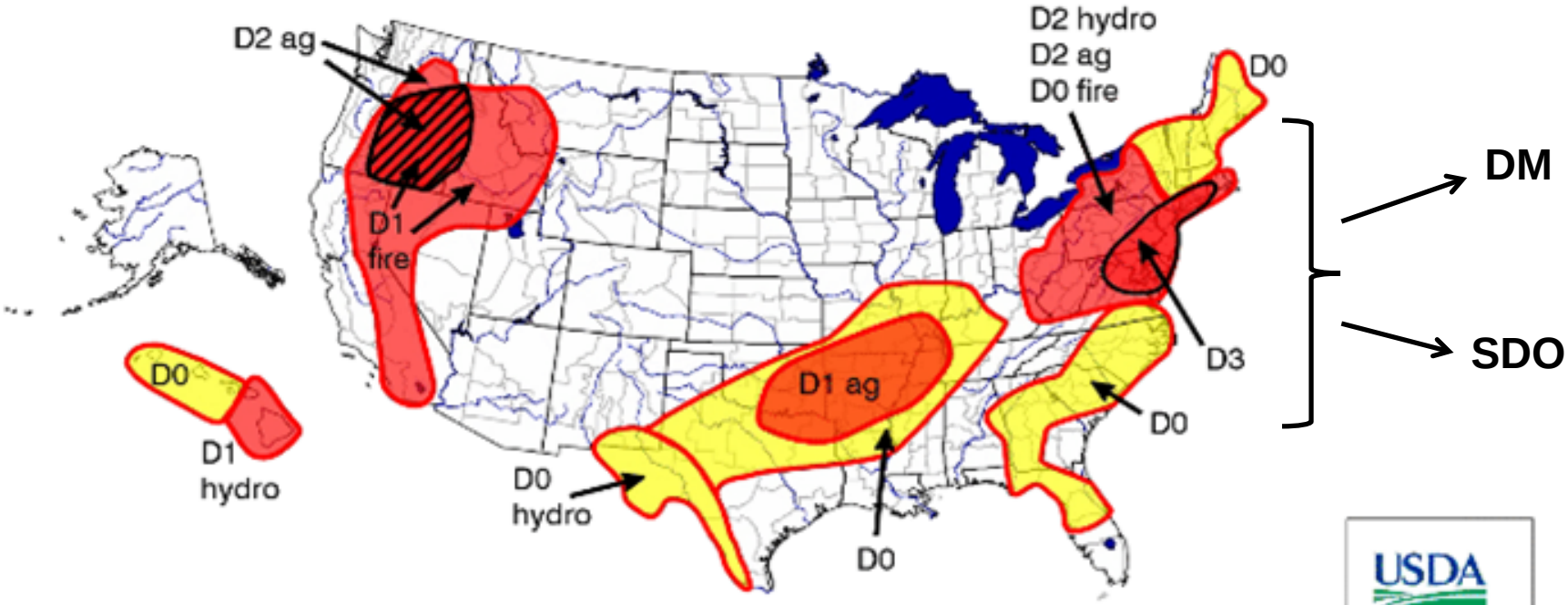
- Replaced updated SDO (released 1st Thursday of next month) with new MDO (released last day of month) starting July 2013;

- Color-blind compliant colors started in Jan 2014 in collaboration with climate.gov, along with removal of arrows & text (cleaner);

- Overlay most recent forecasts (tools) on SDO & MDO MXDs in May 2018, similar to the U.S. Drought Monitor GIS process.

August 3, 1999

# Experimental U.S. Drought Monitor




"Drought" means moisture shortages leading to damaged crops or pastures, high wildfire risk, or water shortages. The map is based on information from many sources, including both satellite and surface data, and it focuses on widespread drought. Local conditions may vary.

Yellow (D0) = Drought Watch Area (abnormally dry but not full drought status)

Red (D1–D4) = Current drought ranging in severity from standard (D1) to severe (D2–D3) to extreme (D4)

Crosshatching ( ) = Overlapping drought type areas

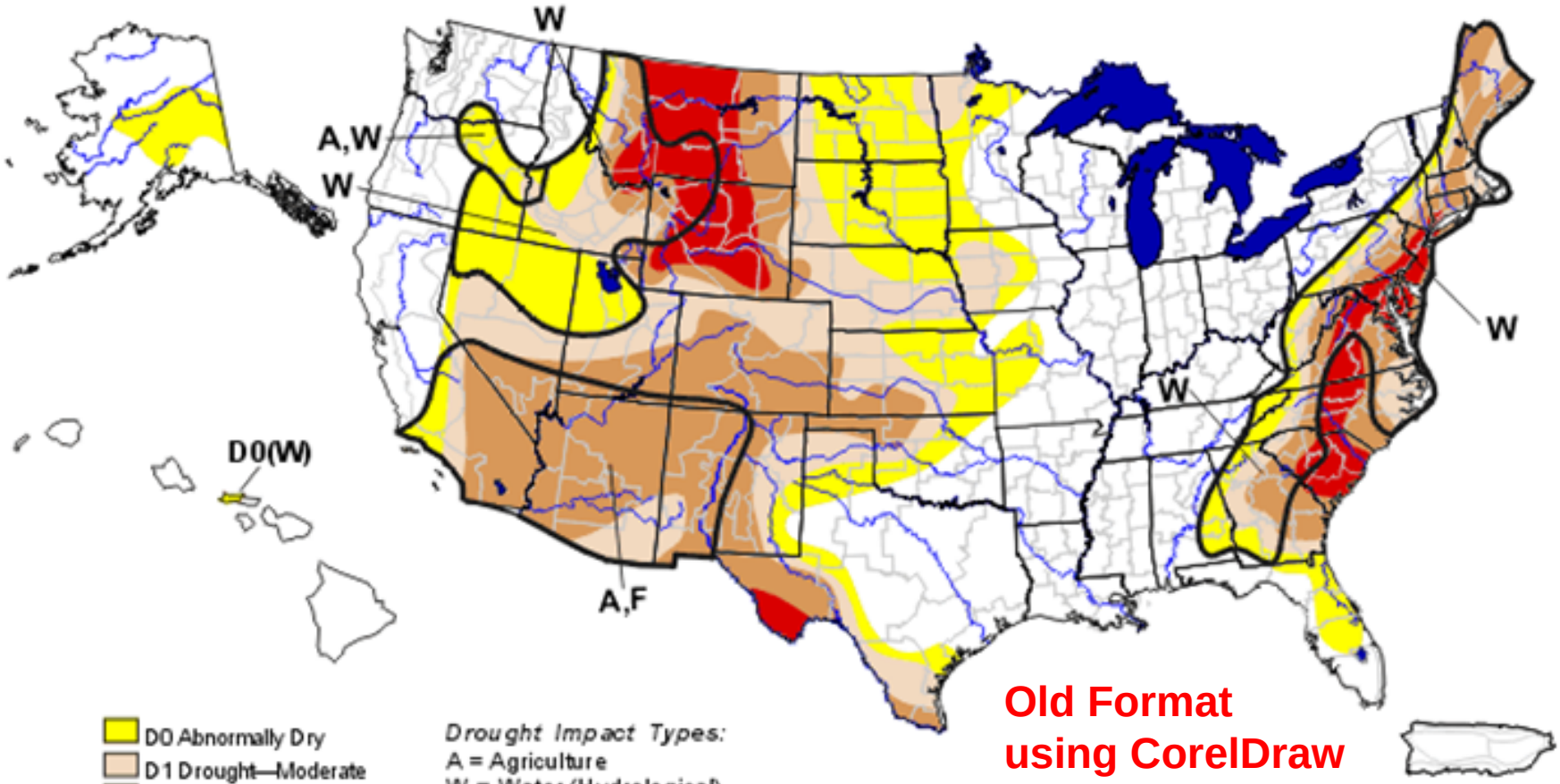
Drought type: Used when impacts differ
- Ag = agricultural (crops, grasslands)
- Fire = forestry (wildfire potential)
- Hydro = hydrological (rivers, wells, reservoirs)

**Drought Forecast** →

Plus (+) = Forecast to intensify
Minus (-) = Forecast to diminish

# U.S. Drought Monitor

**April 16, 2002**
Valid 8 a.m. EDT




**Old Format using CorelDraw**

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

*Drought Impact Types:*
A = Agriculture
W = Water (Hydrological)
F = Fire danger (Wildfires)
Delineates dominant impacts
(No type = All 3 impacts)

*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, April 18, 2002***

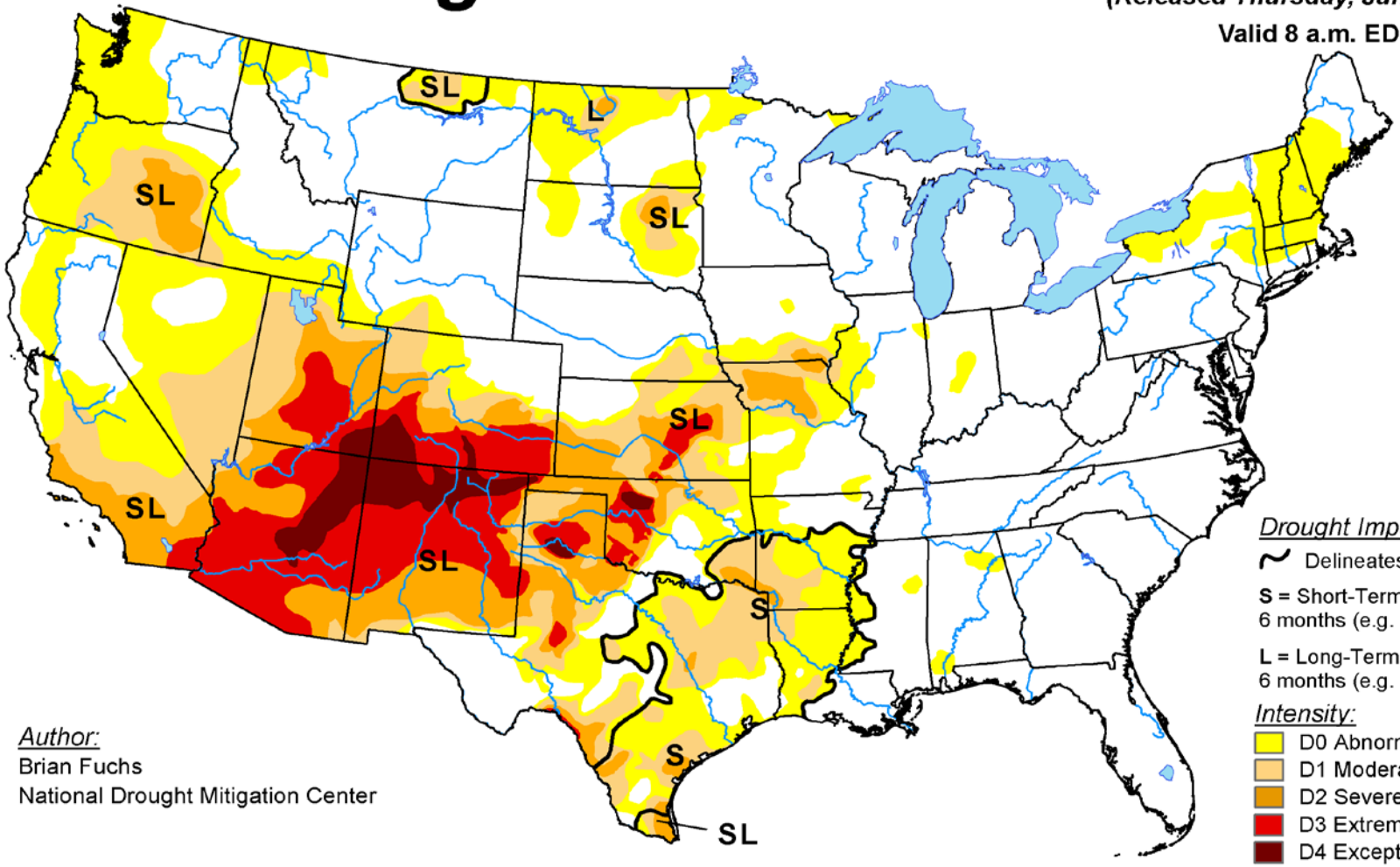
***Author:*** *David Miskus, JAWF/CPC/NOAA*

# U.S. Drought Monitor

**June 19, 2018**

***(Released Thursday, Jun. 21, 2018)***

**Valid 8 a.m. EDT**





*Author:*
Brian Fuchs
National Drought Mitigation Center


*Drought Impact Types:*

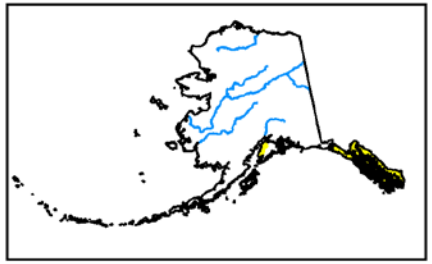
Delineates dominant impacts

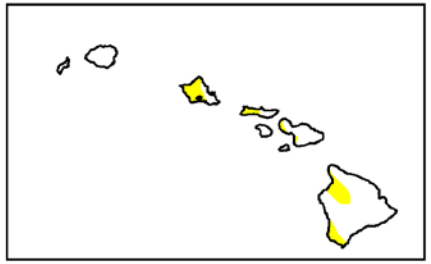
**S** = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

**L** = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

*Intensity:*

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





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

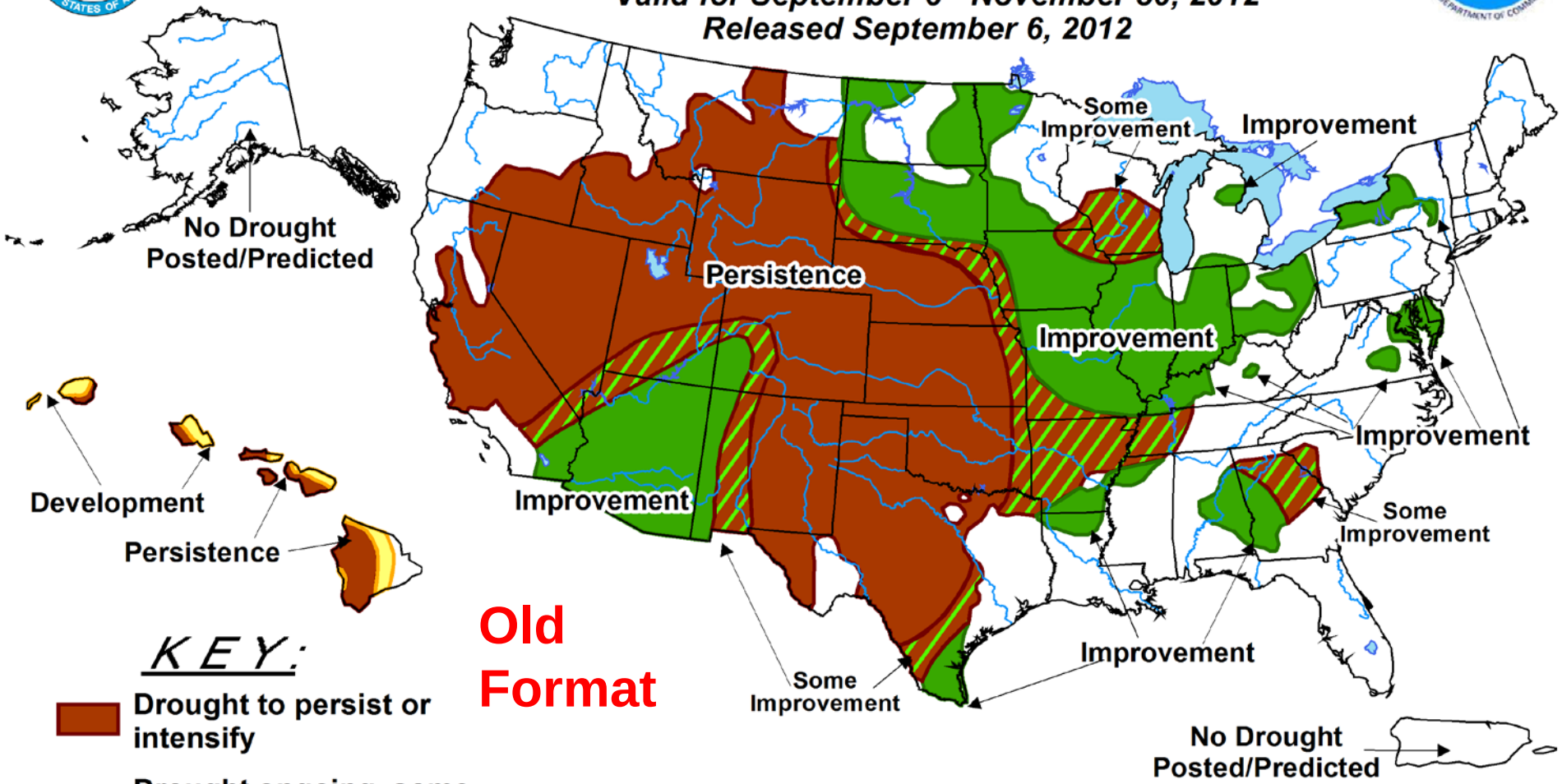
**http://droughtmonitor.unl.edu/**

# U.S. Seasonal Drought Outlook

## Drought Tendency During the Valid Period

***Valid for September 6 - November 30, 2012***

***Released September 6, 2012***




Old Format

***KEY:***

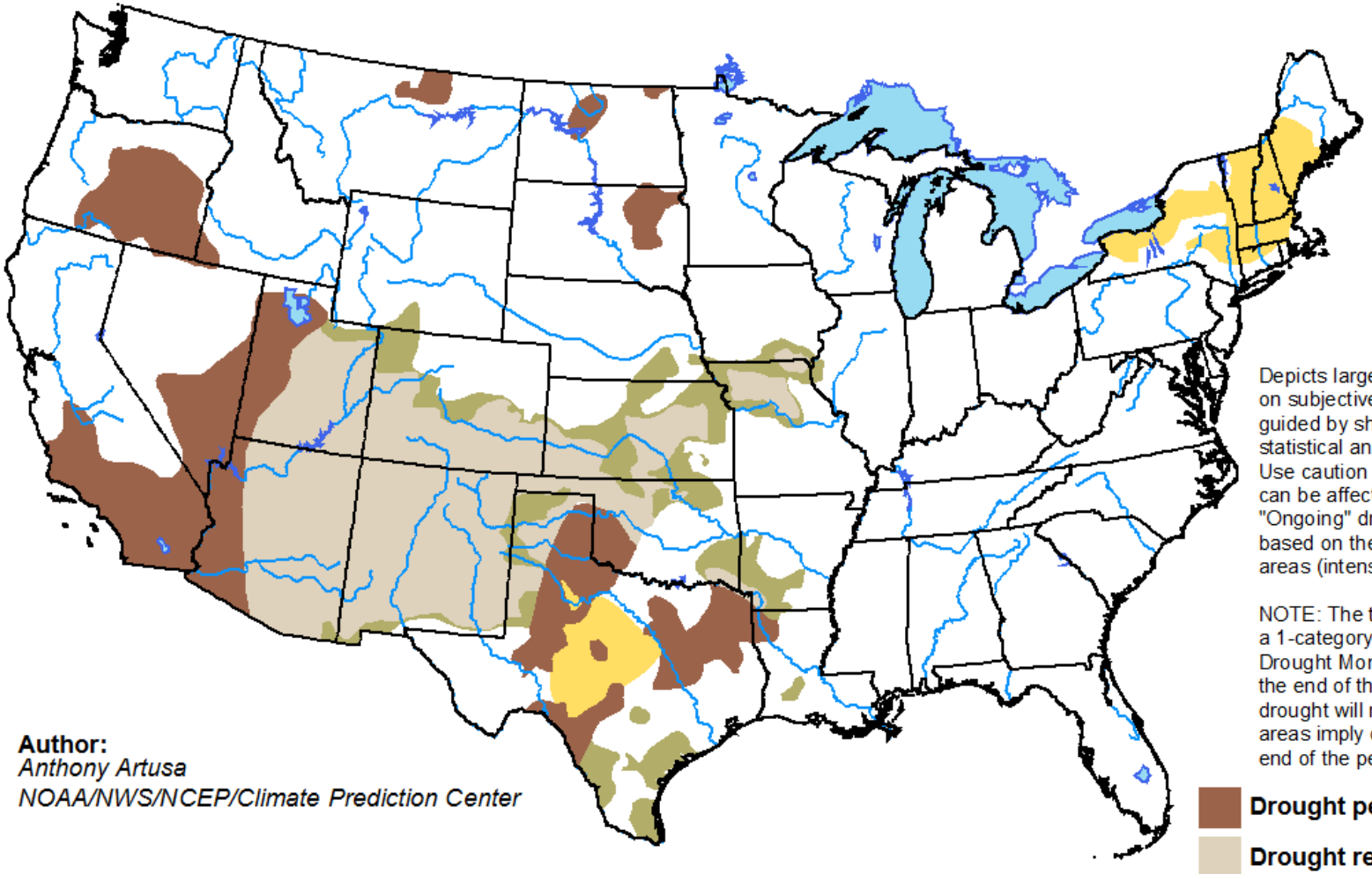
- Drought to persist or intensify
- Drought ongoing, some improvement
- Drought likely to improve, impacts ease
- Drought development likely

Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Short-term events -- such as individual storms -- cannot be accurately forecast more than a few days in advance. Use caution for applications -- such as crops -- that can be affected by such events. "Ongoing" drought areas are approximated from the Drought Monitor (D1 to D4 intensity). For weekly drought updates, see the latest U.S. Drought Monitor. NOTE: the green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.

# U.S. Seasonal Drought Outlook

## Drought Tendency During the Valid Period

***Valid for June 21 - September 30, 2018***
***Released June 21, 2018***

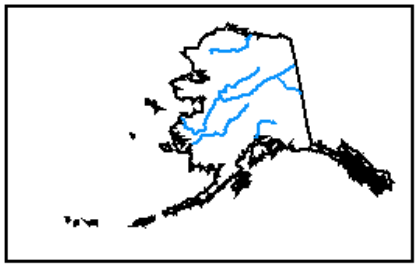


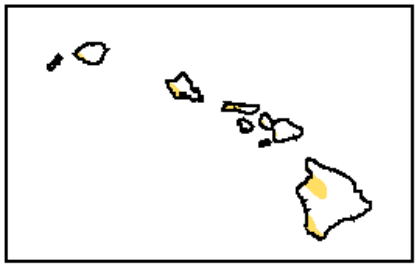
Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to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

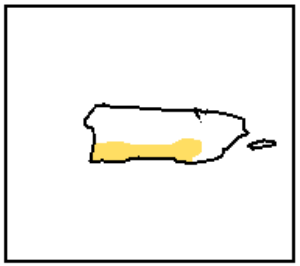
NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

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


**Author:**
*Anthony Artusa*
*NOAA/NWS/NCEP/Climate Prediction Center*

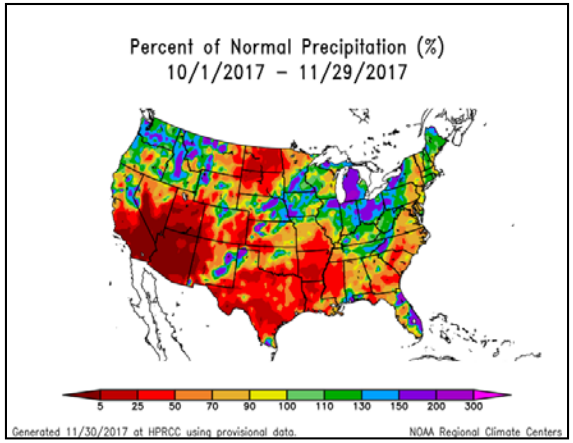



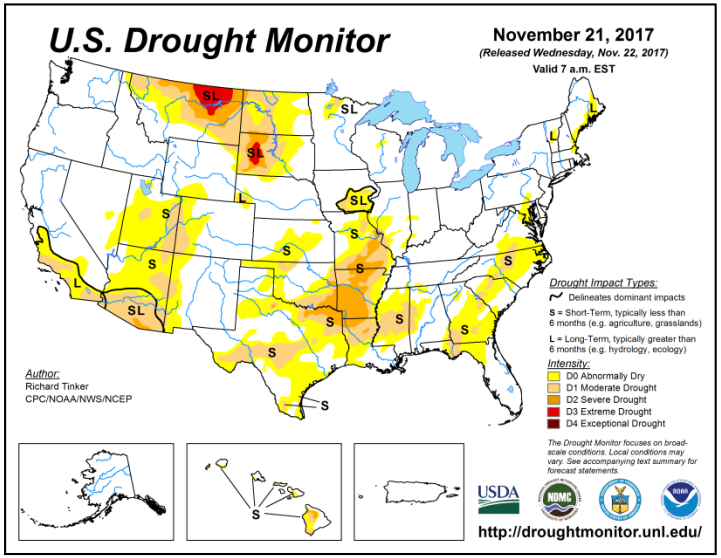


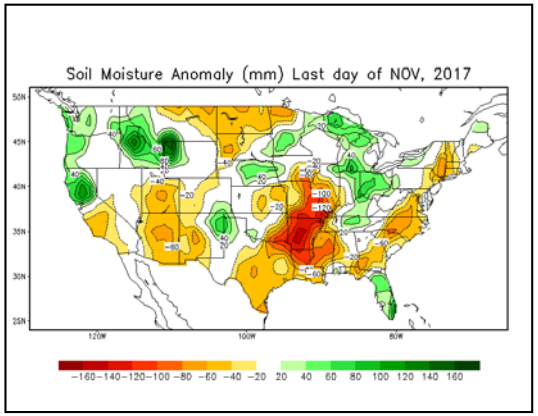


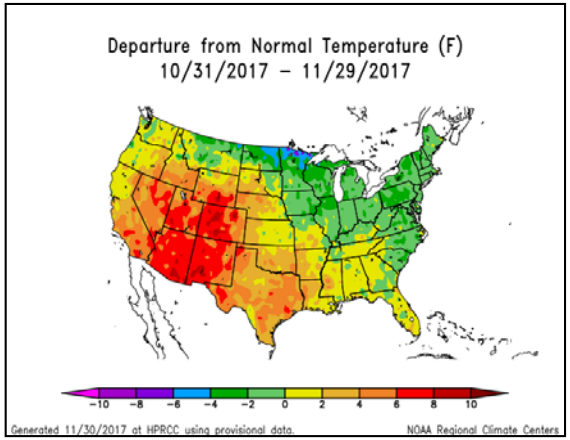
**http://go.usa.gov/3eZ73**

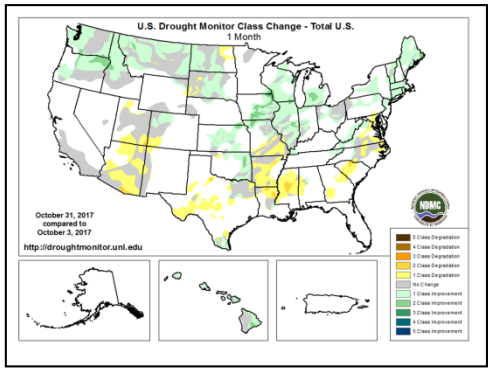
# Drought Outlook: Start with Current DM Conditions

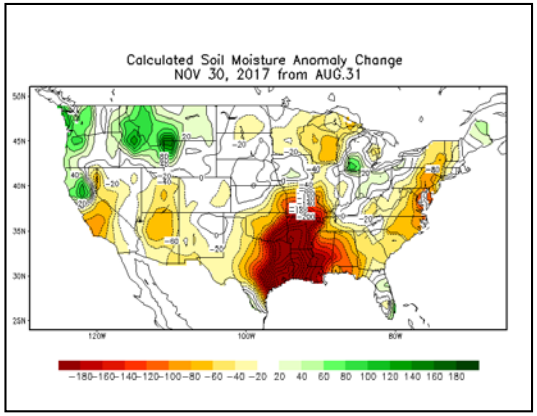


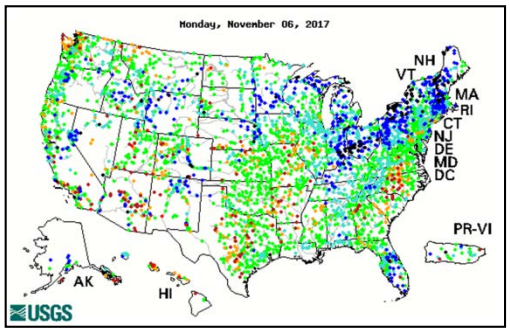



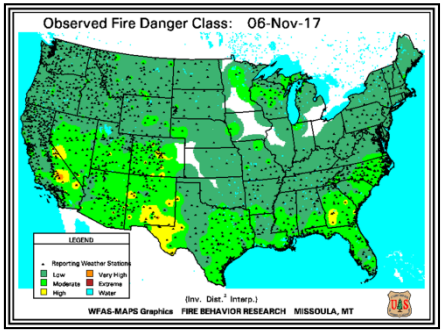



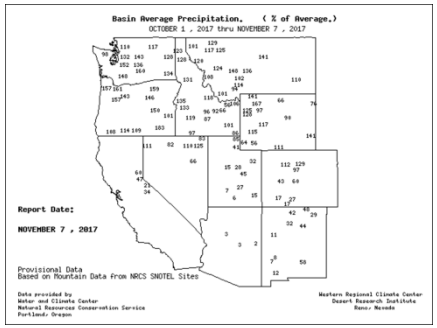



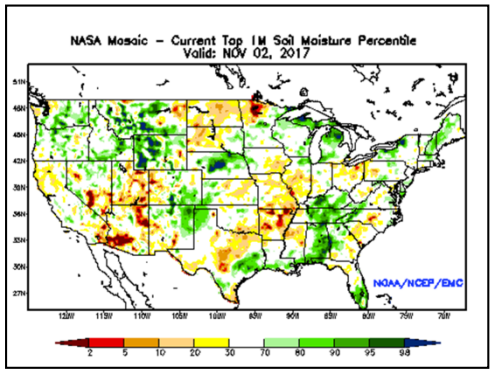



# *Drought Outlook Production*

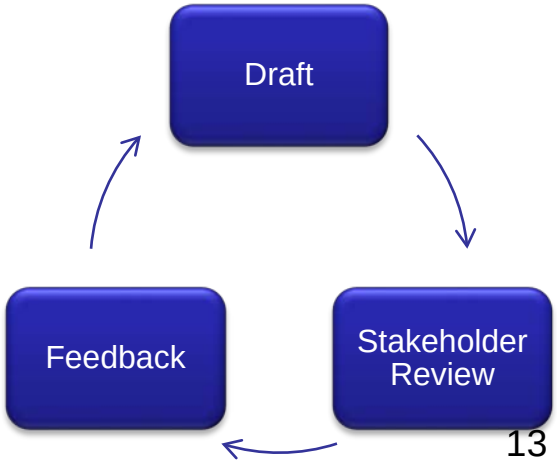
**Seasonal Drought Outlook (SDO): Produced in conjunction with the seasonal temperature and precipitation outlooks (released on third Thursday of month).**

**Monthly Drought Outlook (MDO): Produced in conjunction with the updated 1-Month forecast (released on the last day of the month).**

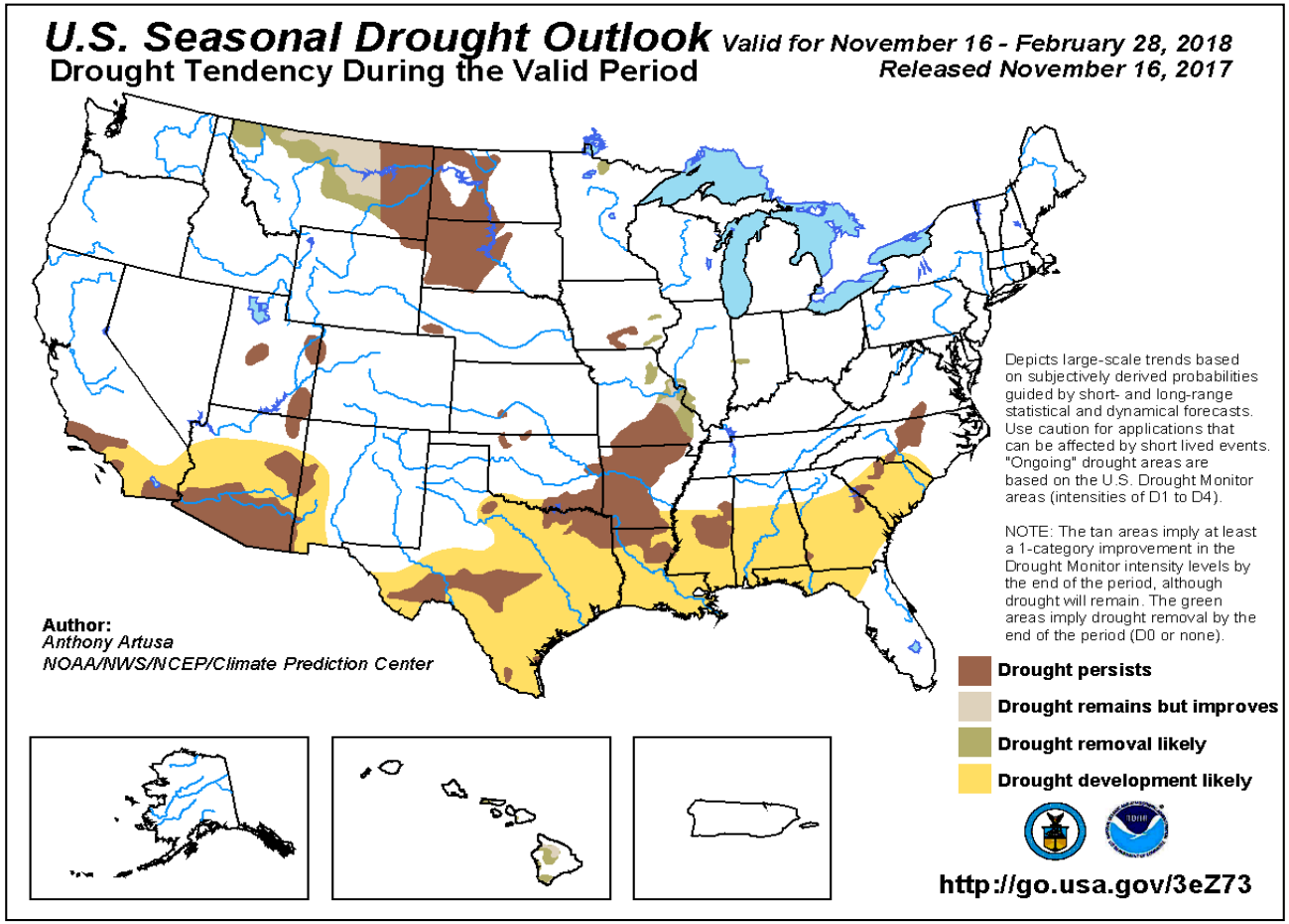
- ✓ **Most recent Drought Monitor is starting point for the Drought Outlooks.**

- ✓ **Drought Outlook forecaster consults with extended range (Week 2), Week 3-4, and long-lead (monthly and seasonal) forecasters and guidance to ensure continuity and consistency between the products. This is currently done *subjectively* by the forecaster and the process might be improved by making new objective tools that blend the extended-range and long-lead tools.**
- ✓ **Forecaster sends draft forecast to stakeholders for feedback. Typically, several dozen stakeholders will request changes to the forecast over 2-3 days.**

- ✓ **For example, requests were made from California during the very wet 2016-17 winter to reduce the amount of drought improvement in certain regions.**



# Drought Forecasting: Many Different Contributions (Tools)



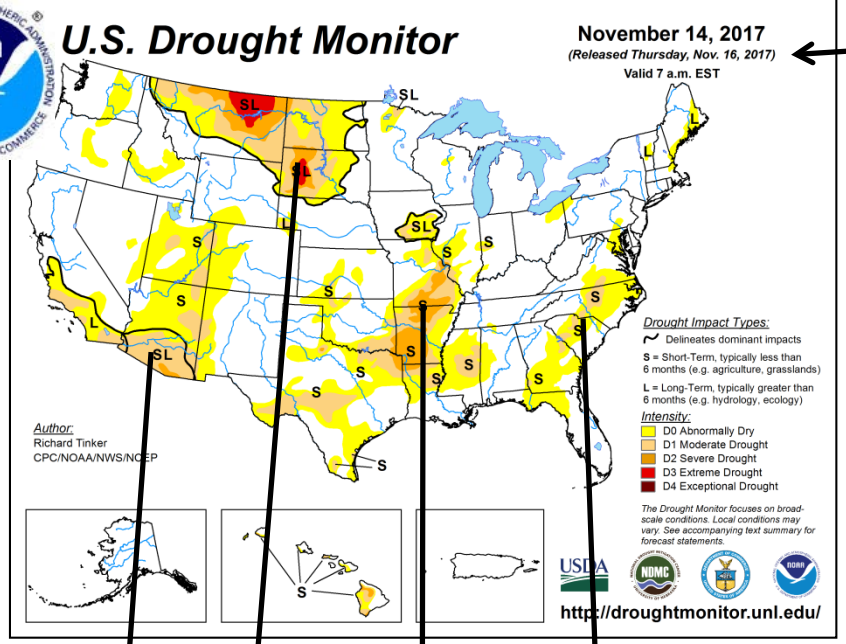

Start with latest U.S. Drought Monitor D1 areas

Short-Term Forecasts: (less than 1-Month)

Climatologies And Analogs

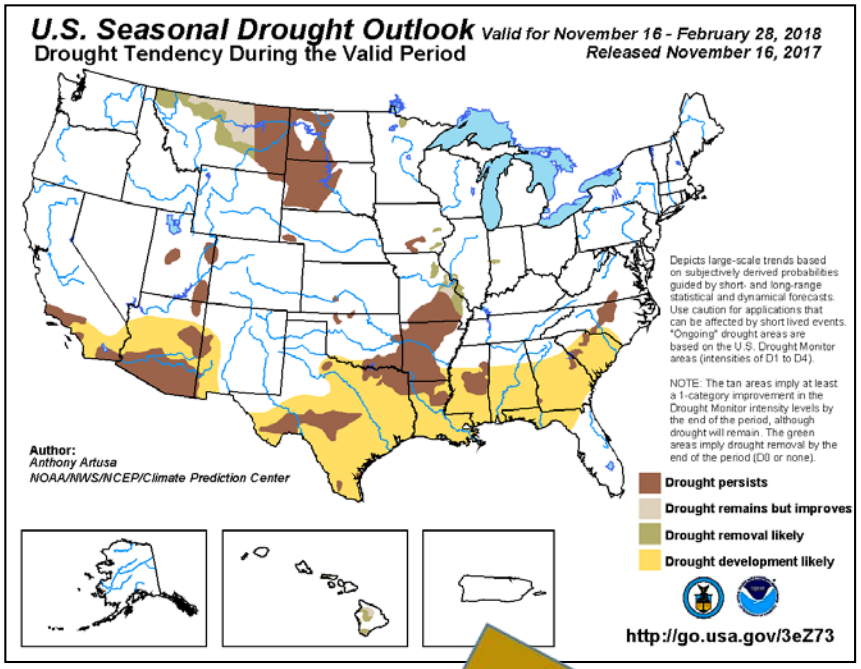
Long-Range Forecasts: (1- to 3-Months)

(Note ENSO Status & Other Atmospheric/Oceanic Indicators)

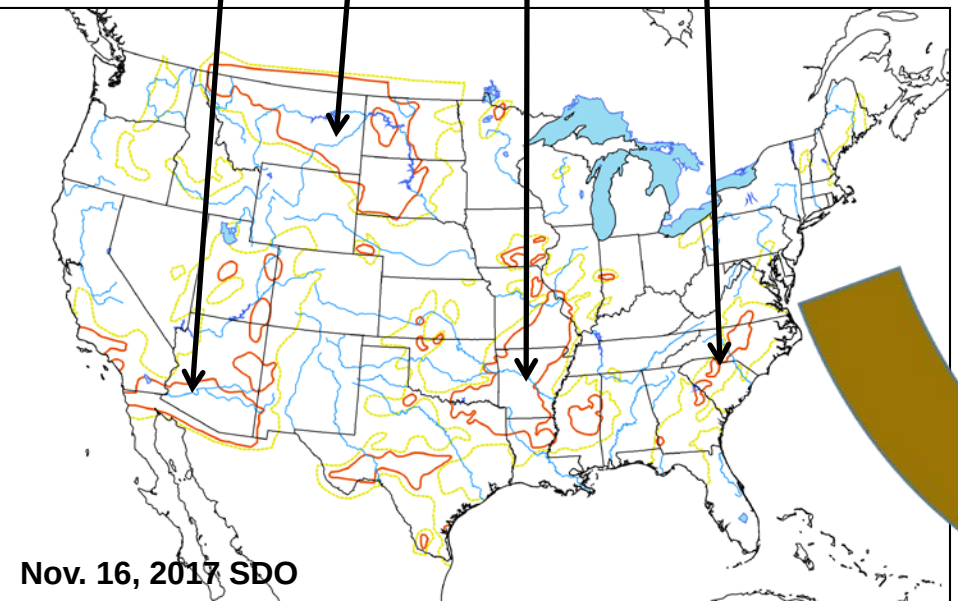



*Start with 11/14/17 US Drought Monitor*

Initial D17JF18
Seasonal Drought Outlook
(released Nov. 16)



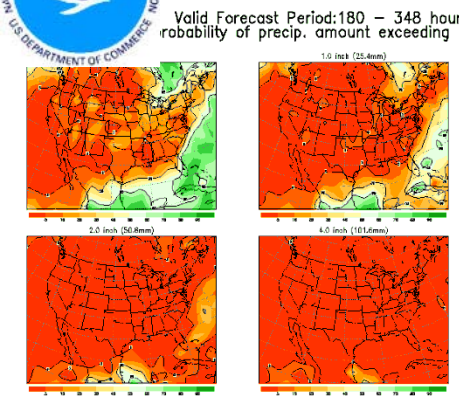

*Use the latest U.S. Drought Monitor*
***D0*** *&* ***D1*** *shape file areas*

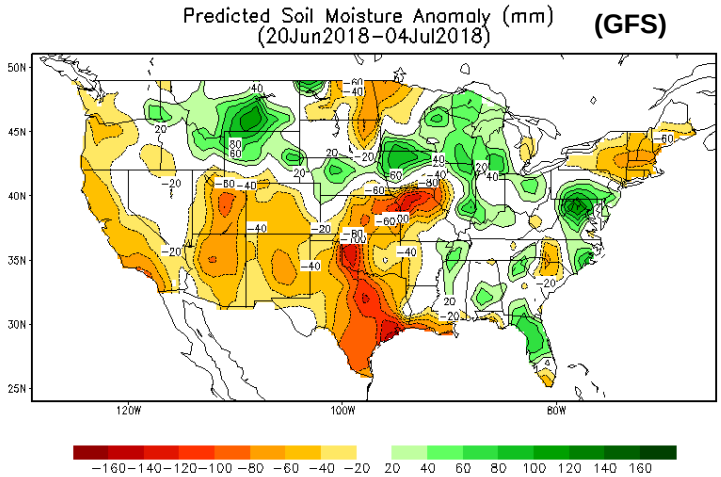


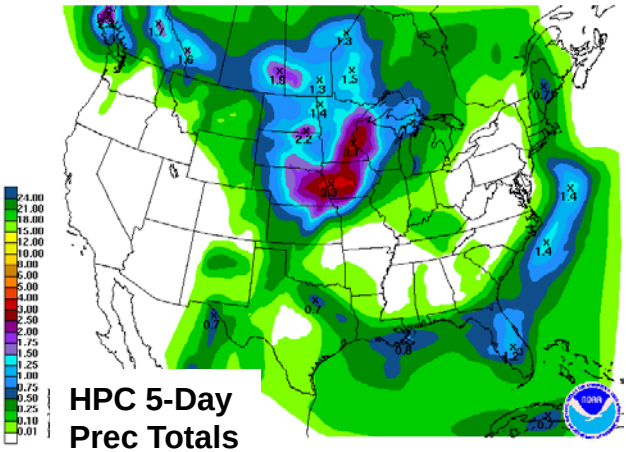
**Nov. 16, 2017 SDO**

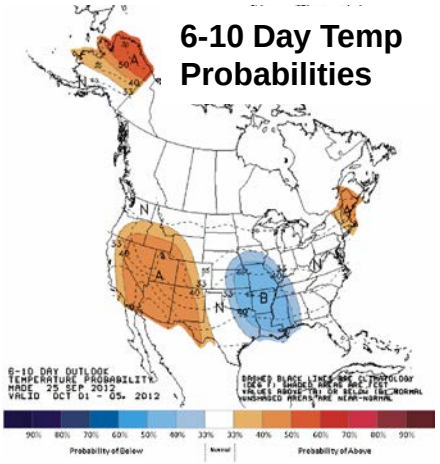
*From Tools - Determine if D1-D4 areas will:* ***Persist****,* ***Improve****, or be* ***Removed****;*
*and if D0 & normal areas will* ***Develop***

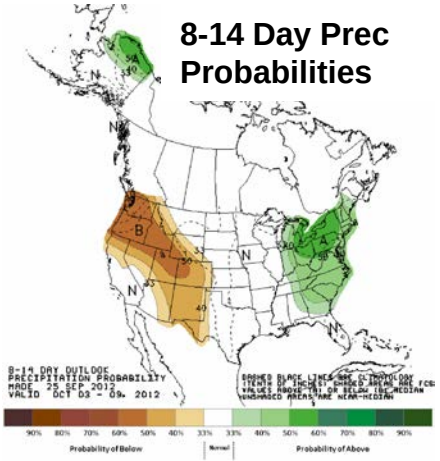
# Primary Drought Outlook Inputs – Short Term

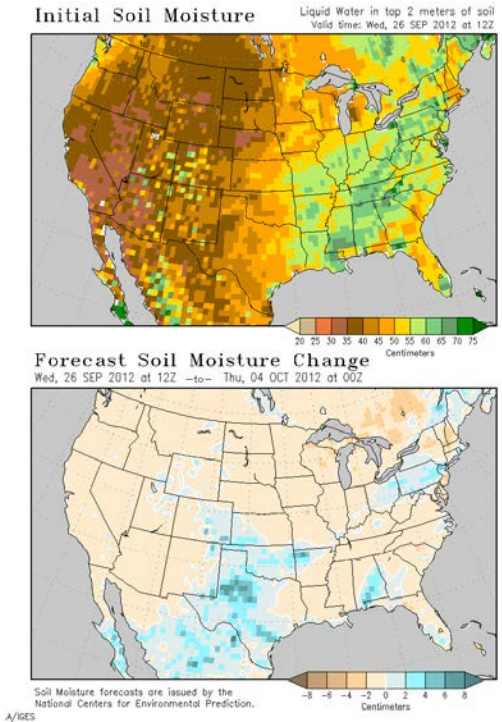


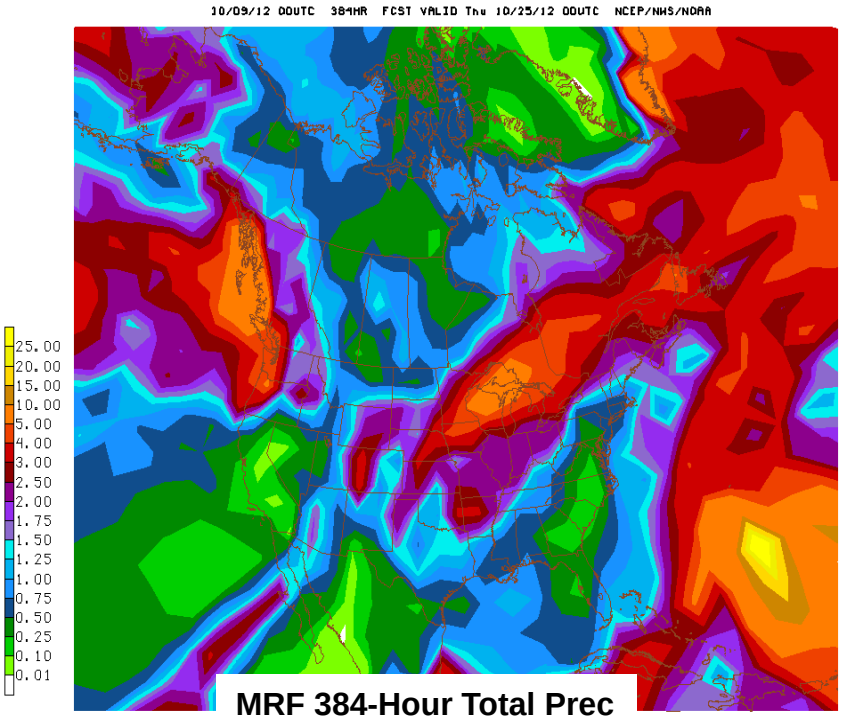



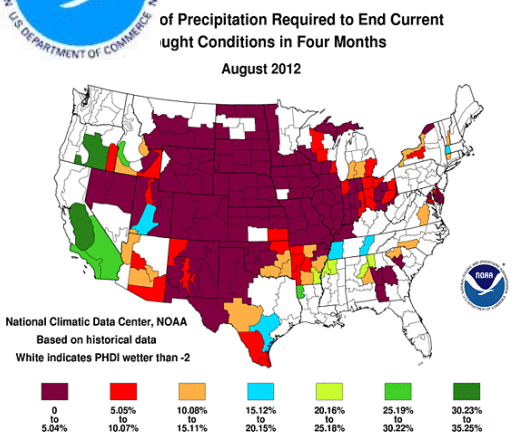



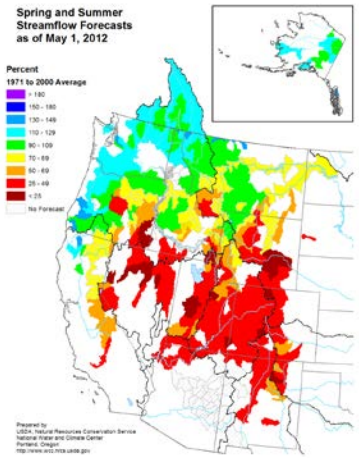



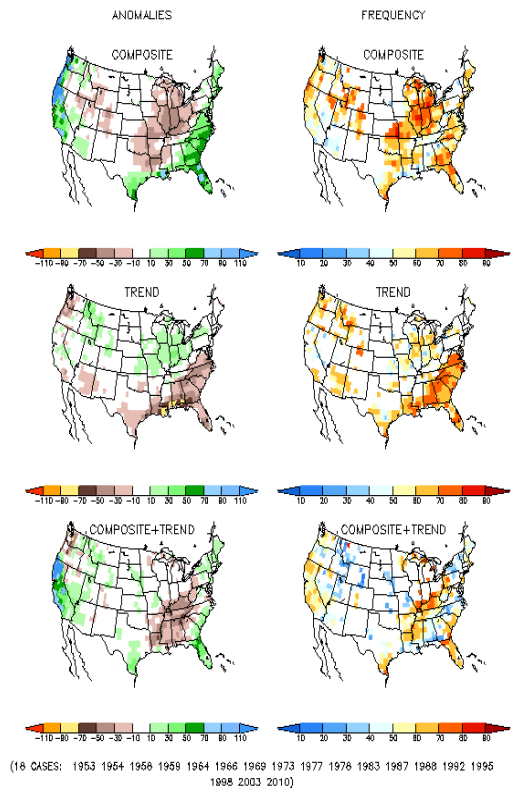



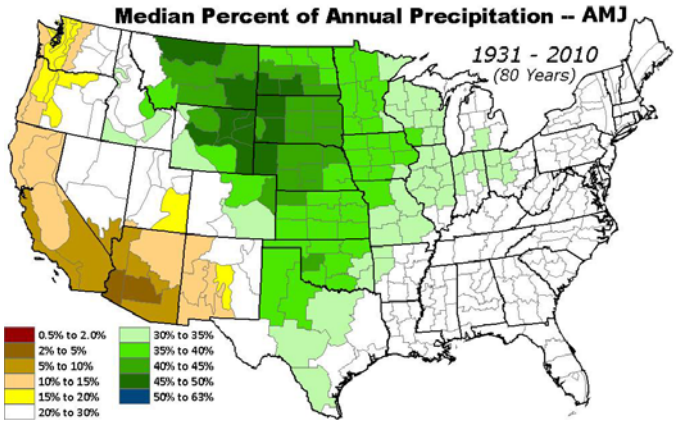



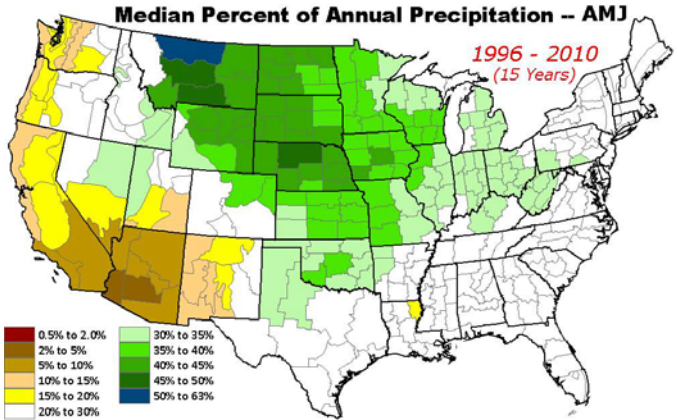
# Primary Drought Outlook Inputs – Climos & Analogs

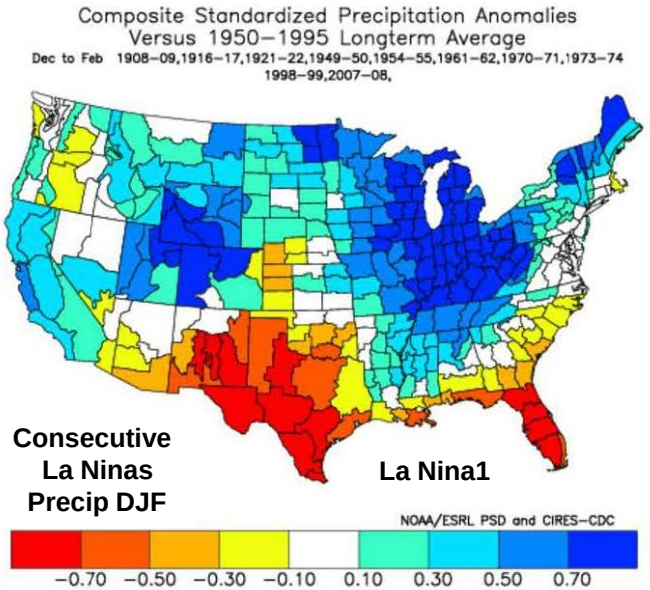


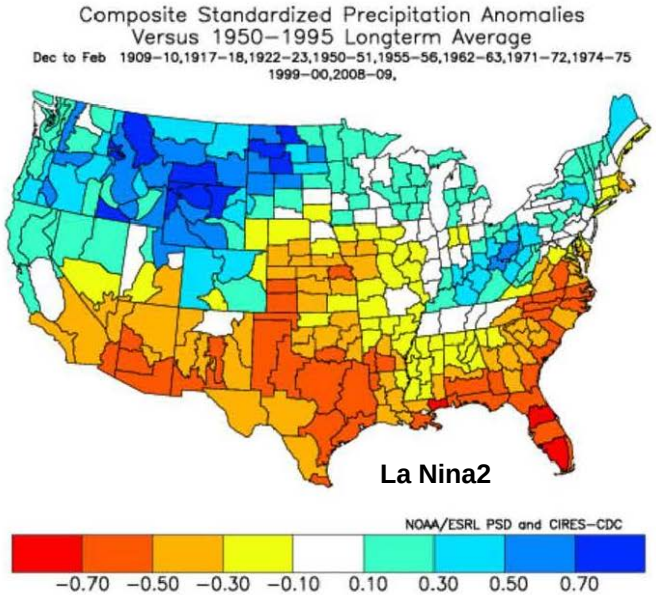



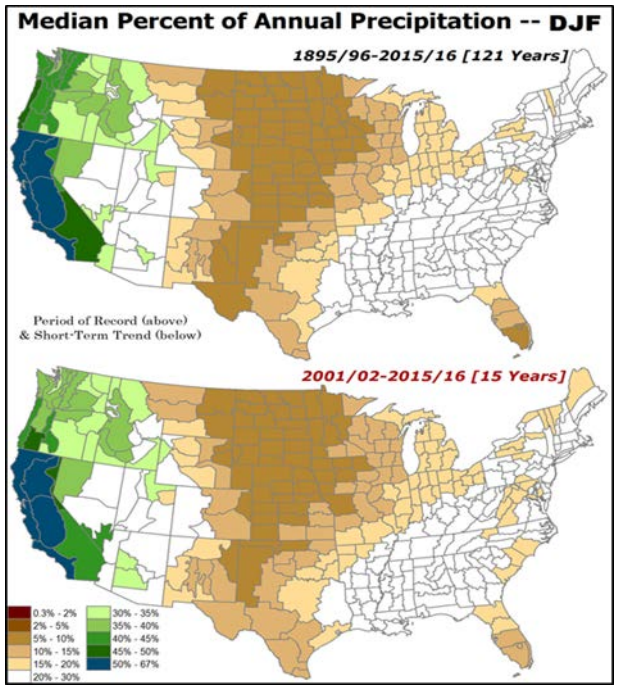



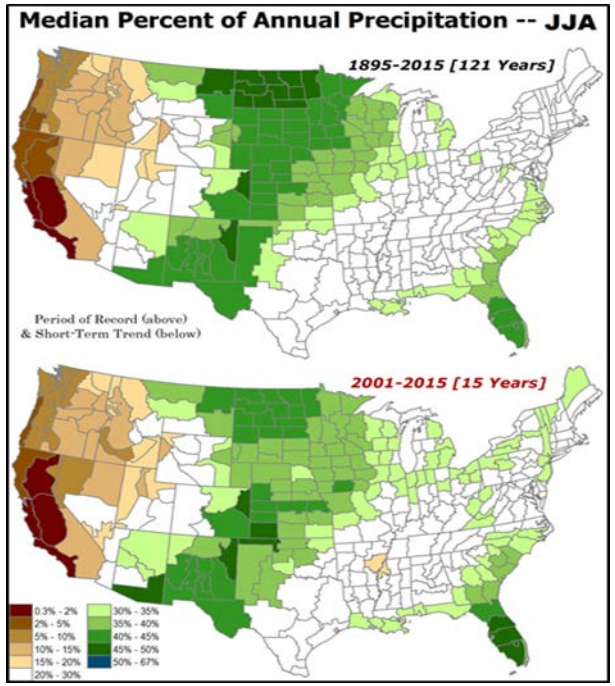



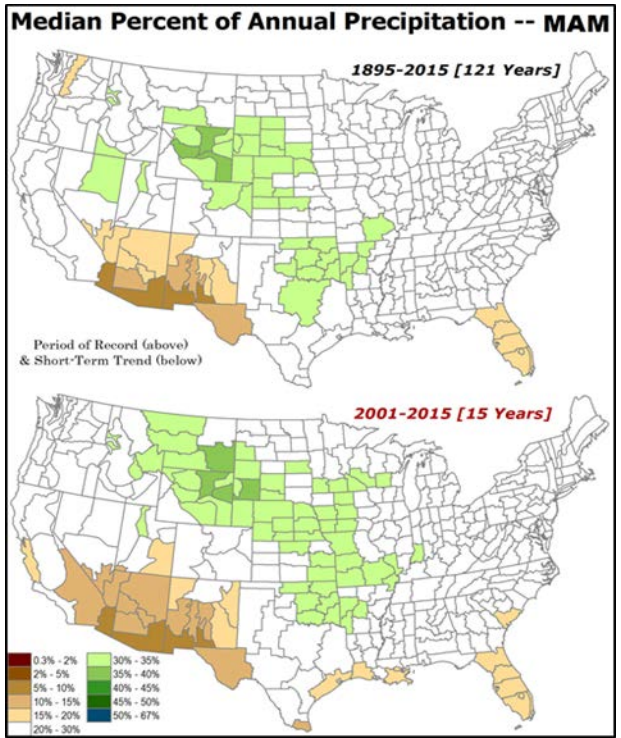
Winter
DJF

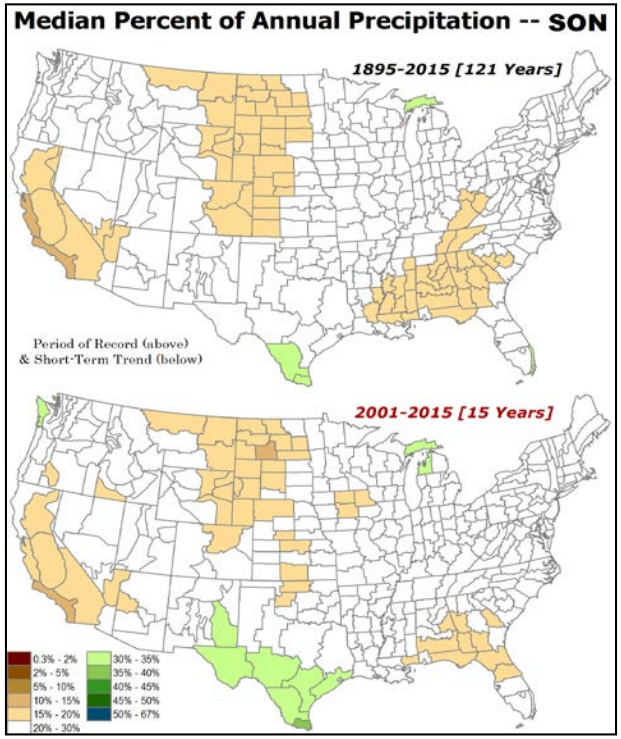



Summer
JJA

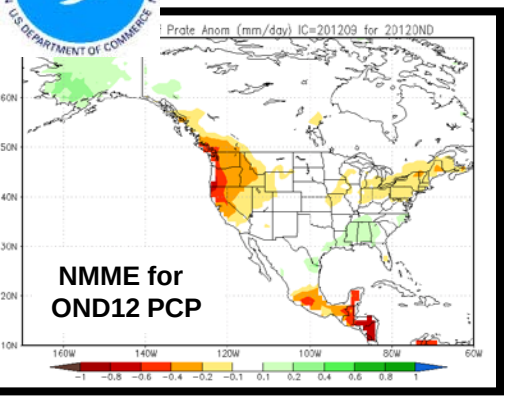
Spring
MAM



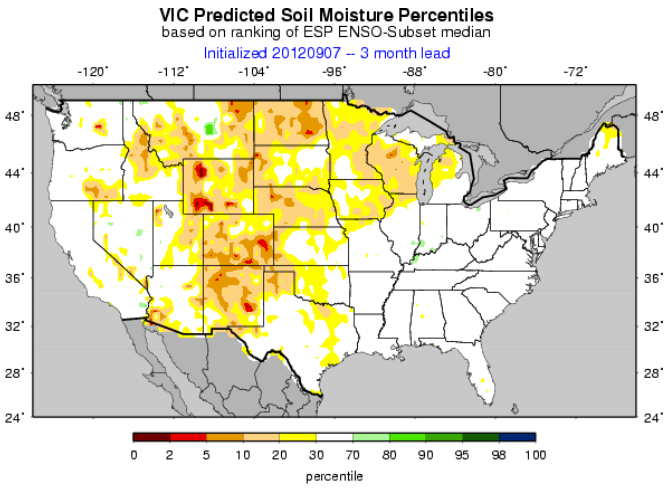



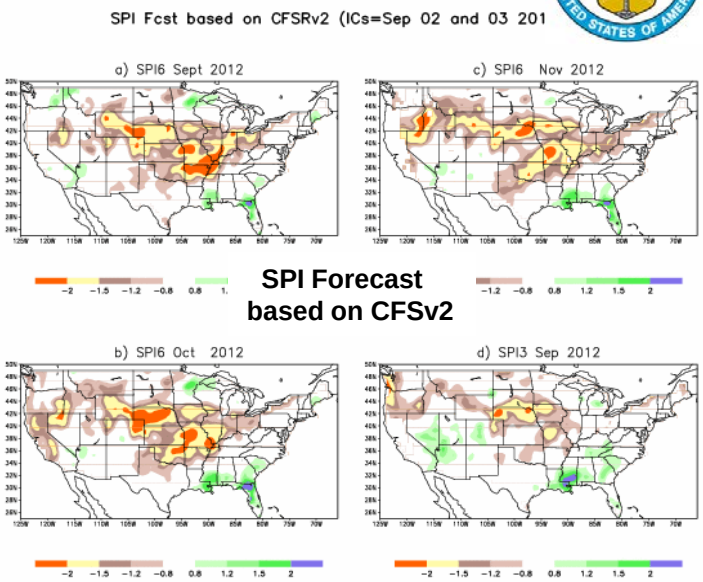

Fall
SON

# Primary Drought Outlook Inputs – Long Term

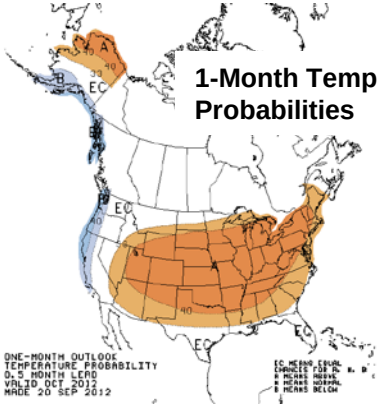



NMME for OND12 PCP

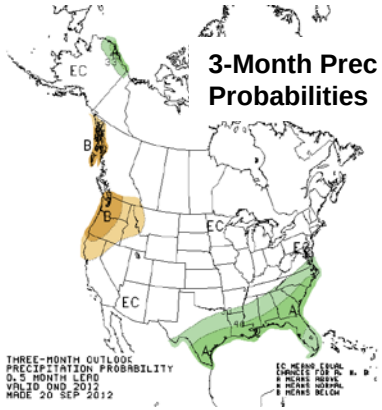


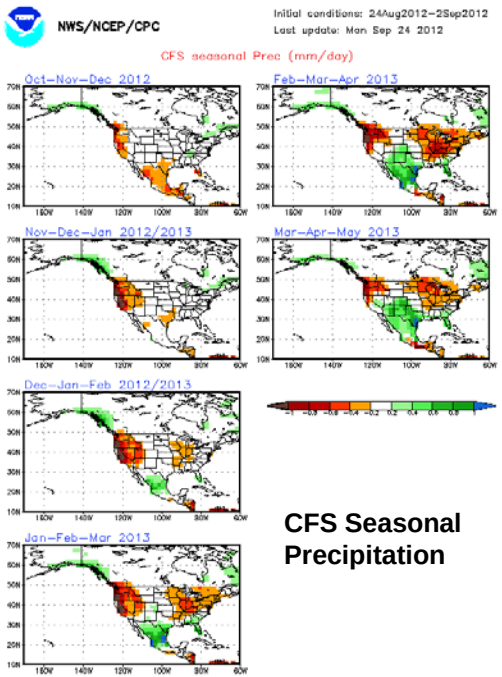

SPI Forecast based on CFSv2



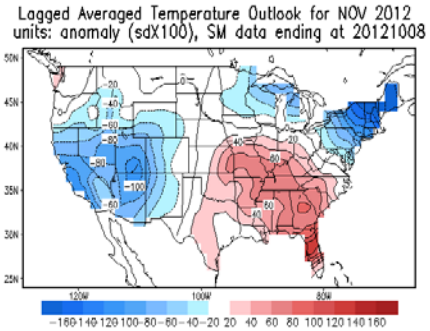

1-Month Temp Probabilities

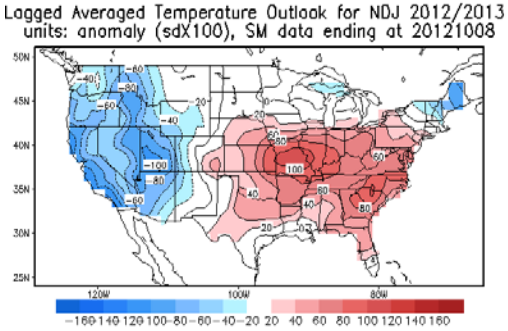


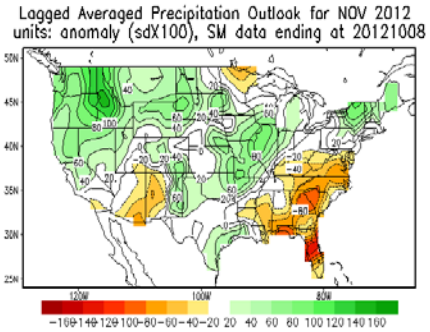

3-Month Prec Probabilities

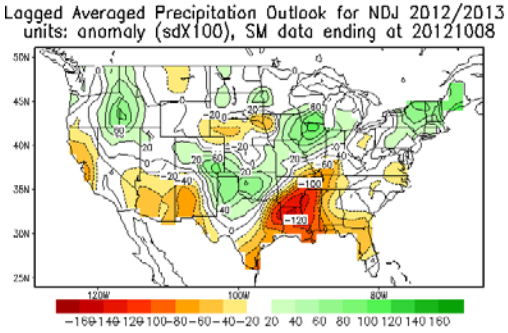



CFS Seasonal Precipitation



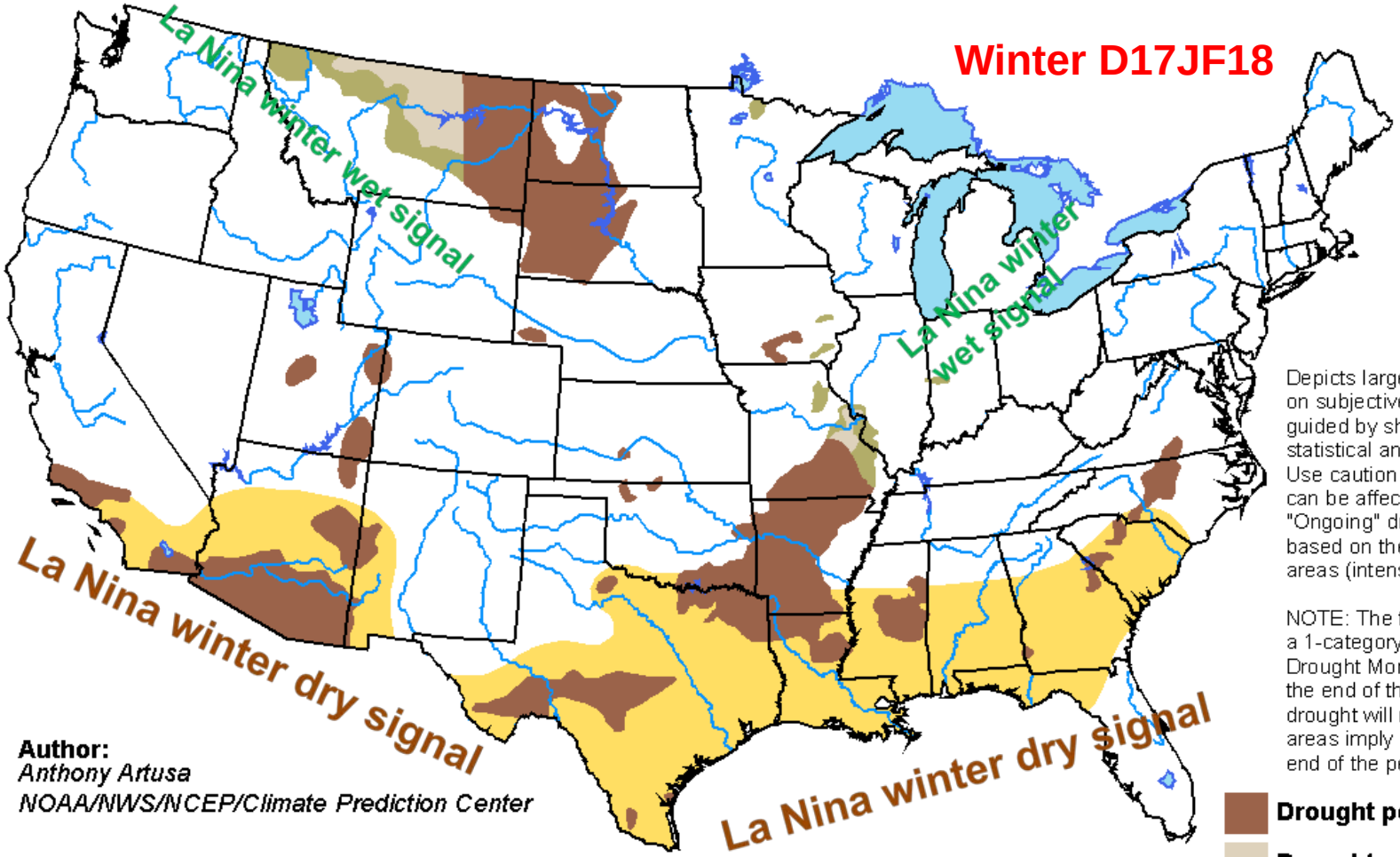



# U.S. Seasonal Drought Outlook *Valid for November 16 - February 28, 2018*

## Drought Tendency During the Valid Period

*Released November 16, 2017*

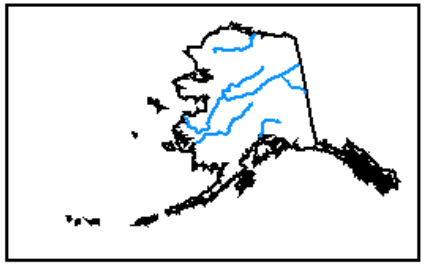


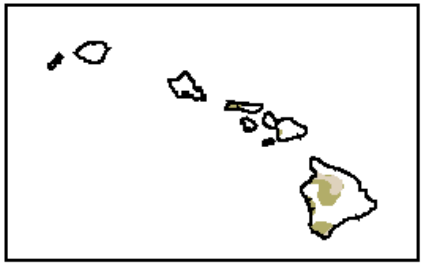

**Author:**
*Anthony Artusa*
*NOAA/NWS/NCEP/Climate Prediction Center*

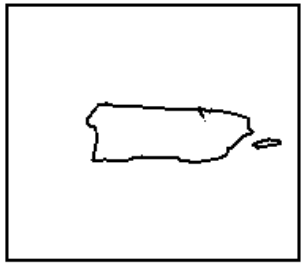
Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to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

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





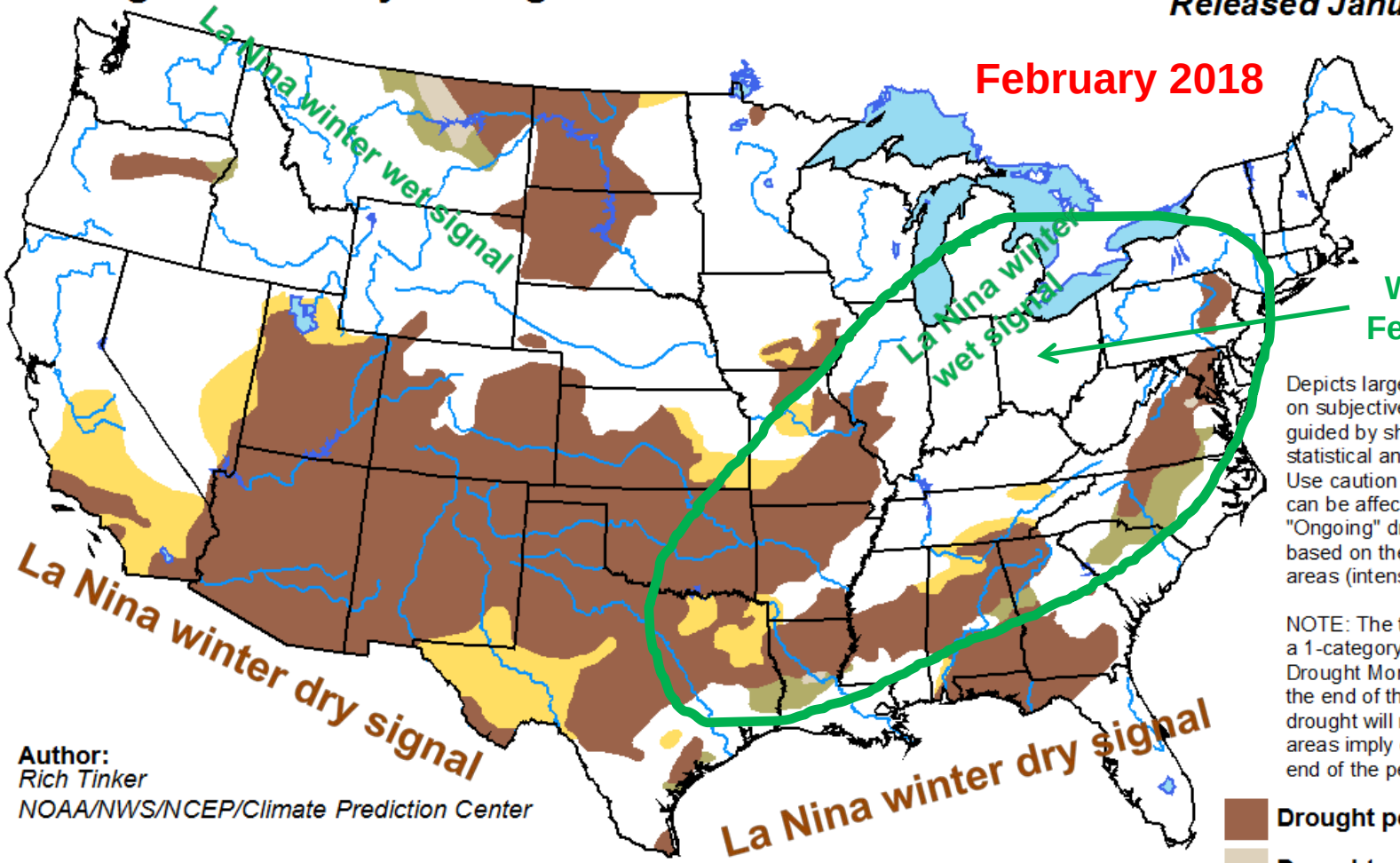


**http://go.usa.gov/3e273**

# U.S. Monthly Drought Outlook

## Drought Tendency During the Valid Period

*Valid for February 2018*
*Released January 31, 2018*

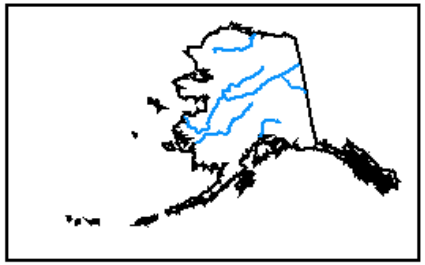


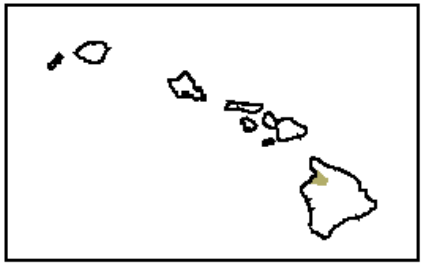

Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to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

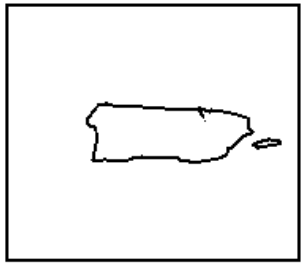
NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

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


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





http://go.usa.gov/3eZGd

# 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**

**Summary** - Short overall narrative.

## 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, 384-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 (DNP) 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.

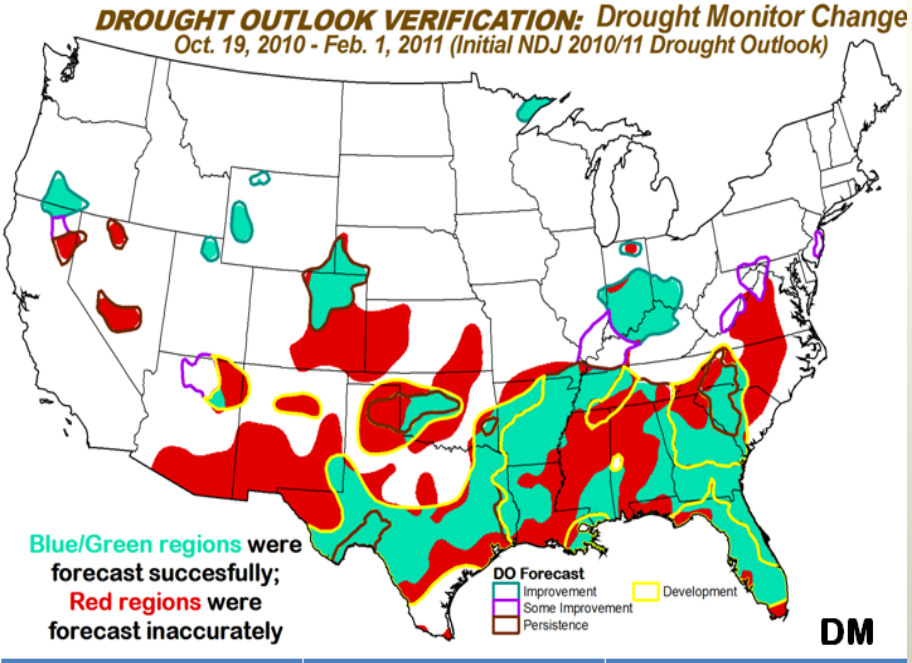
*Confidence for the Southeast is moderate to high.*

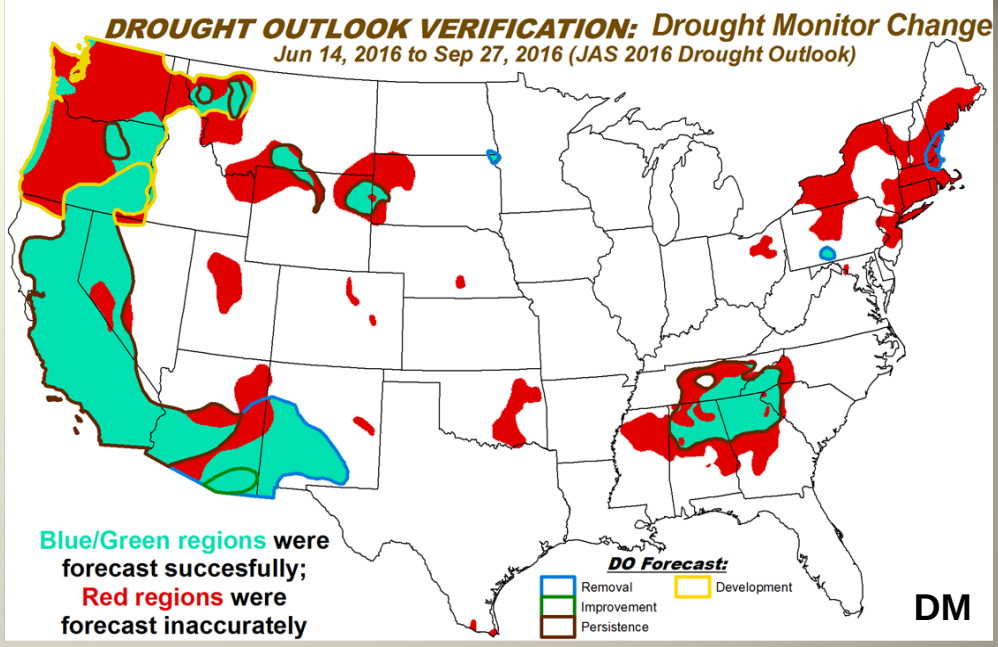
**Discussion** – Long, detailed narrative by region that includes reasoning & confidence rating.

(Both MDO & SDO have Summary & Discussion)

# How Are We Doing?

## Verifications….



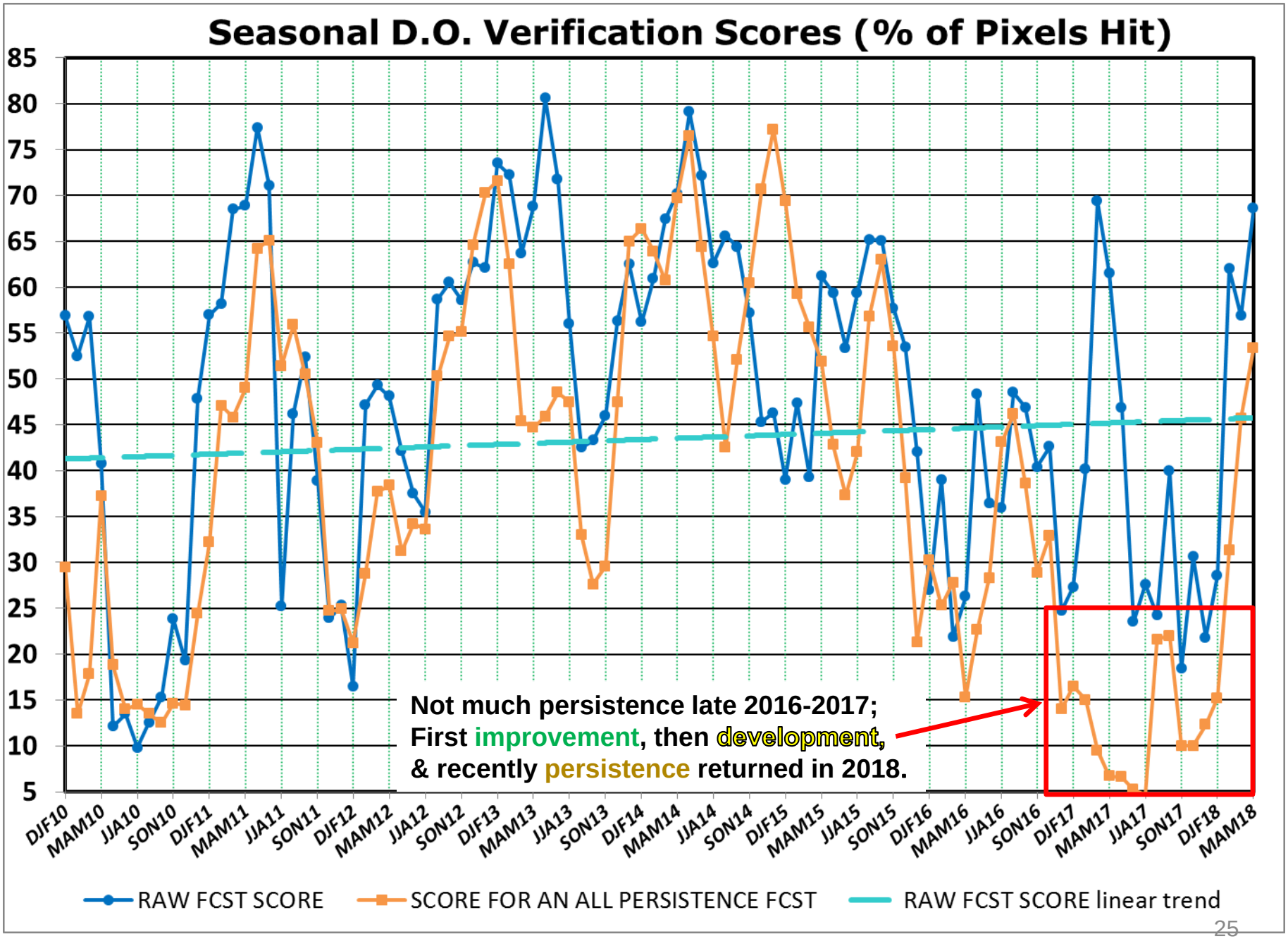



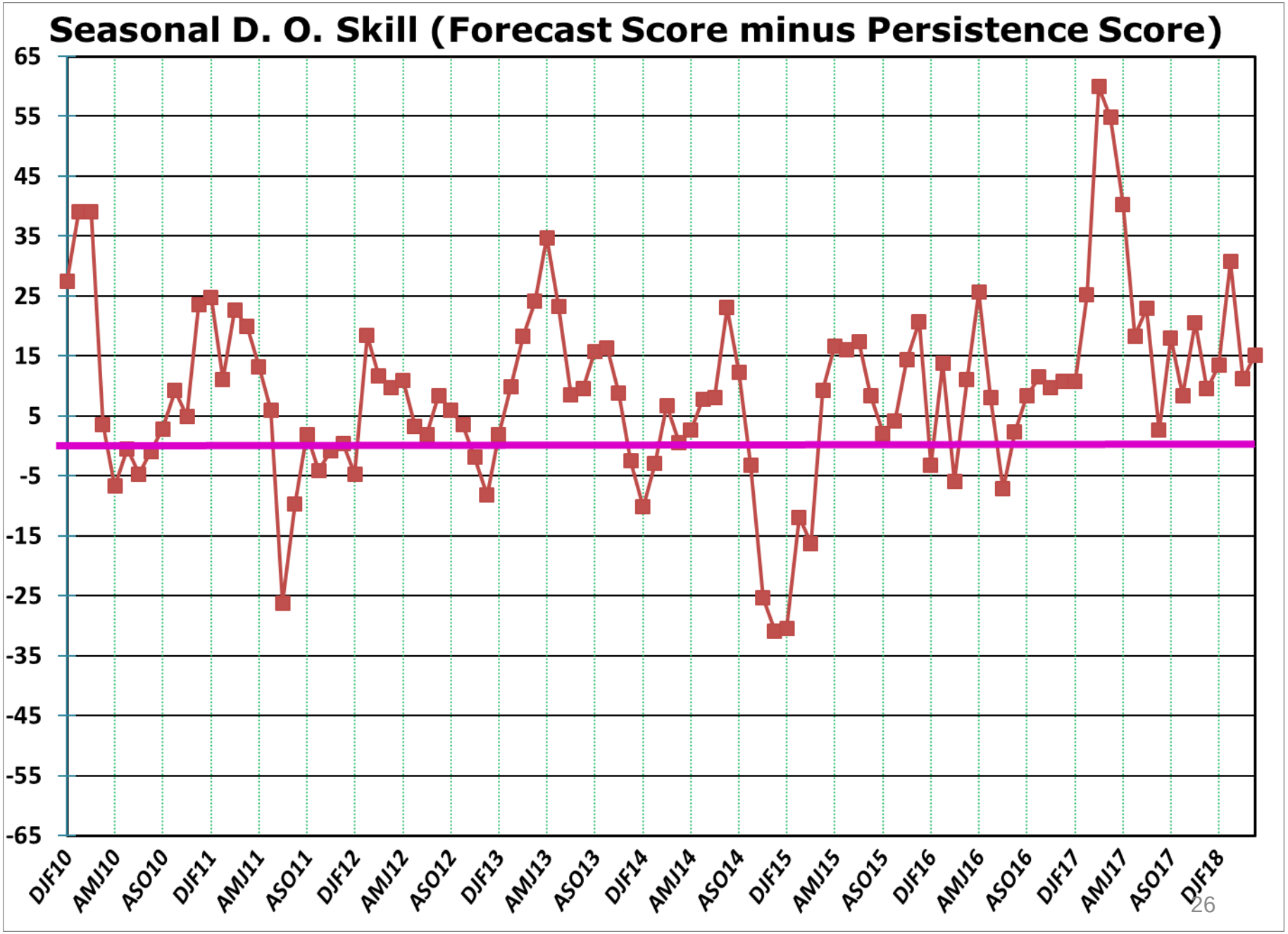

| FORECAST | HIT | MISS |
|---|---|---|
| Improvement | 8,759 | 437 |
| Persistence | 33,049 | 20,537 |
| Development | 30,686 | 58,999 |
| **TOTAL** | **73,494** | **79,973** |
| ***SCORE*** | ***47.9%*** | |
| PERSISTENCE FORECAST BASELINE | 35,039 | 108,616 |
| ***PERSISTENCE FORECAST SCORE*** | ***24.4%*** | |
| ***"SKILL"*** | *(forecast score) minus (persistence score)* | ***+23.5*** |

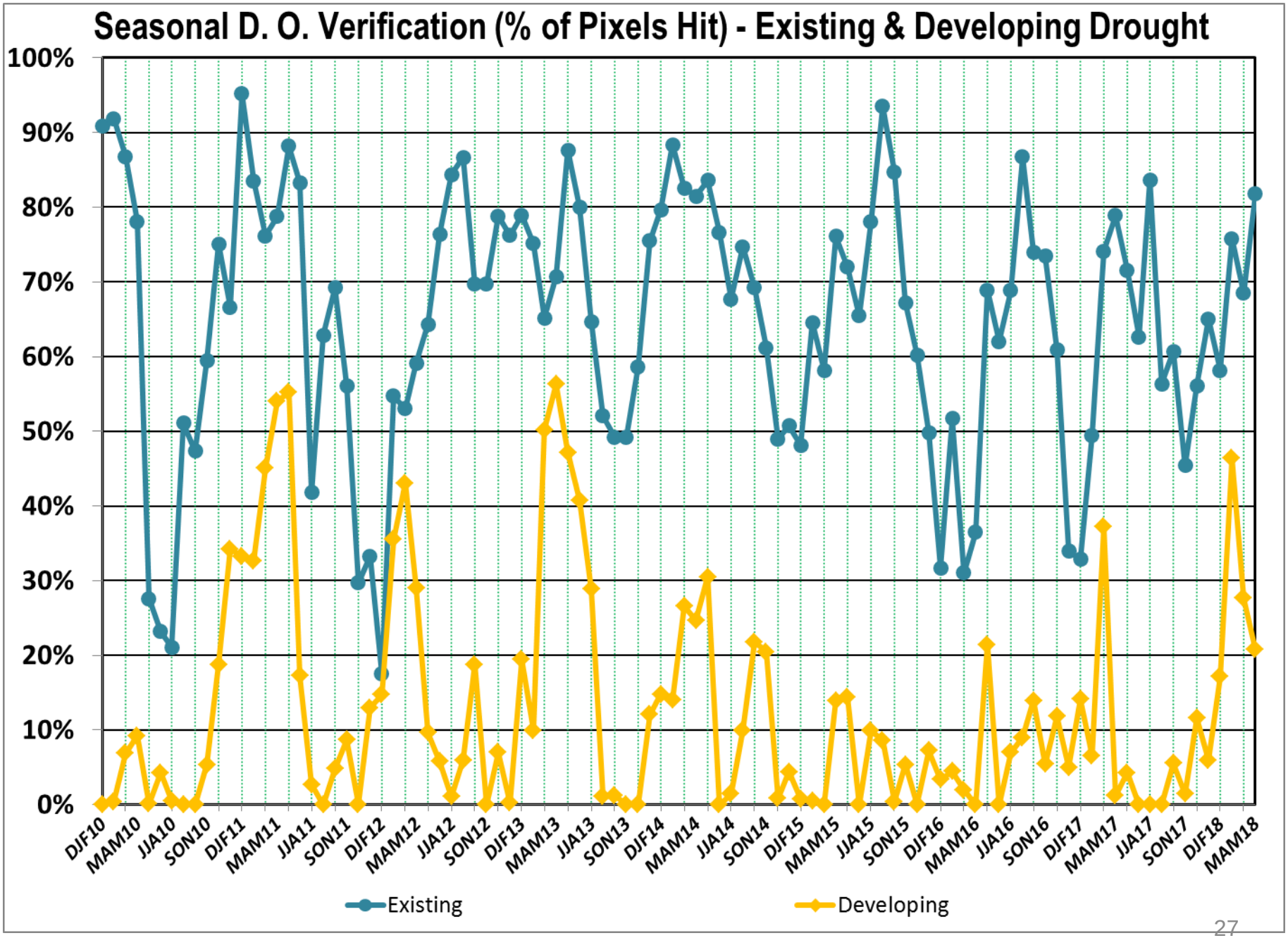
| FORECAST | HIT | MISS |
|---|---|---|
| Improvement/Removal | 10,162 | 3,358 |
| Persistence | 45,495 | 5,168 |
| Development | 5,577 | 56,468 |
| **TOTAL** | **61,234** | **64,994** |
| ***SCORE*** | ***48.5*** | |
| PERSISTENCE FORECAST BASELINE | 48,810 | 56,940 |
| ***PERSISTENCE FORECAST SCORE*** | ***46.2*** | |
| ***"SKILL"*** | *(forecast score) minus (persistence score)* | ***+2.3*** |

Good Skill during developing La Nina & El Nino

Mediocre Skill during ENSO Neutral & Summer


Seasonal D.O. Verification Scores (% of Pixels Hit)
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
DJF10
MAM10
JJA10
SON10
DJF11
MAM11
JJA11
SON11
DJF12
MAM12
JJA12
SON12
DJF13
MAM13
JJA13
SON13
DJF14
MAM14
JJA14
SON14
DJF15
MAM15
JJA15
SON15
DJF16
MAM16
JJA16
SON16
DJF17
MAM17
JJA17
SON17
DJF18
MAM18
Not much persistence late 2016-2017;
First improvement, then development,
& recently persistence returned in 2018.
RAW FCST SCORE
SCORE FOR AN ALL PERSISTENCE FCST
RAW FCST SCORE linear trend


Seasonal D. O. Skill (Forecast Score minus Persistence Score)
65
55
45
35
25
15
5
-5
-15
-25
-35
-45
-55
-65
DJF10
AMJ10
ASO10
DJF11
AMJ11
ASO11
DJF12
AMJ12
ASO12
DJF13
AMJ13
ASO13
DJF14
AMJ14
ASO14
DJF15
AMJ15
ASO15
DJF16
AMJ16
ASO16
DJF17
AMJ17
ASO17
DJF18


Seasonal D. O. Verification (% of Pixels Hit) - Existing & Developing Drought
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
DJF10
MAM10
JJA10
SON10
DJF11
MAM11
JJA11
SON11
DJF12
MAM12
JJA12
SON12
DJF13
MAM13
JJA13
SON13
DJF14
MAM14
JJA14
SON14
DJF15
MAM15
JJA15
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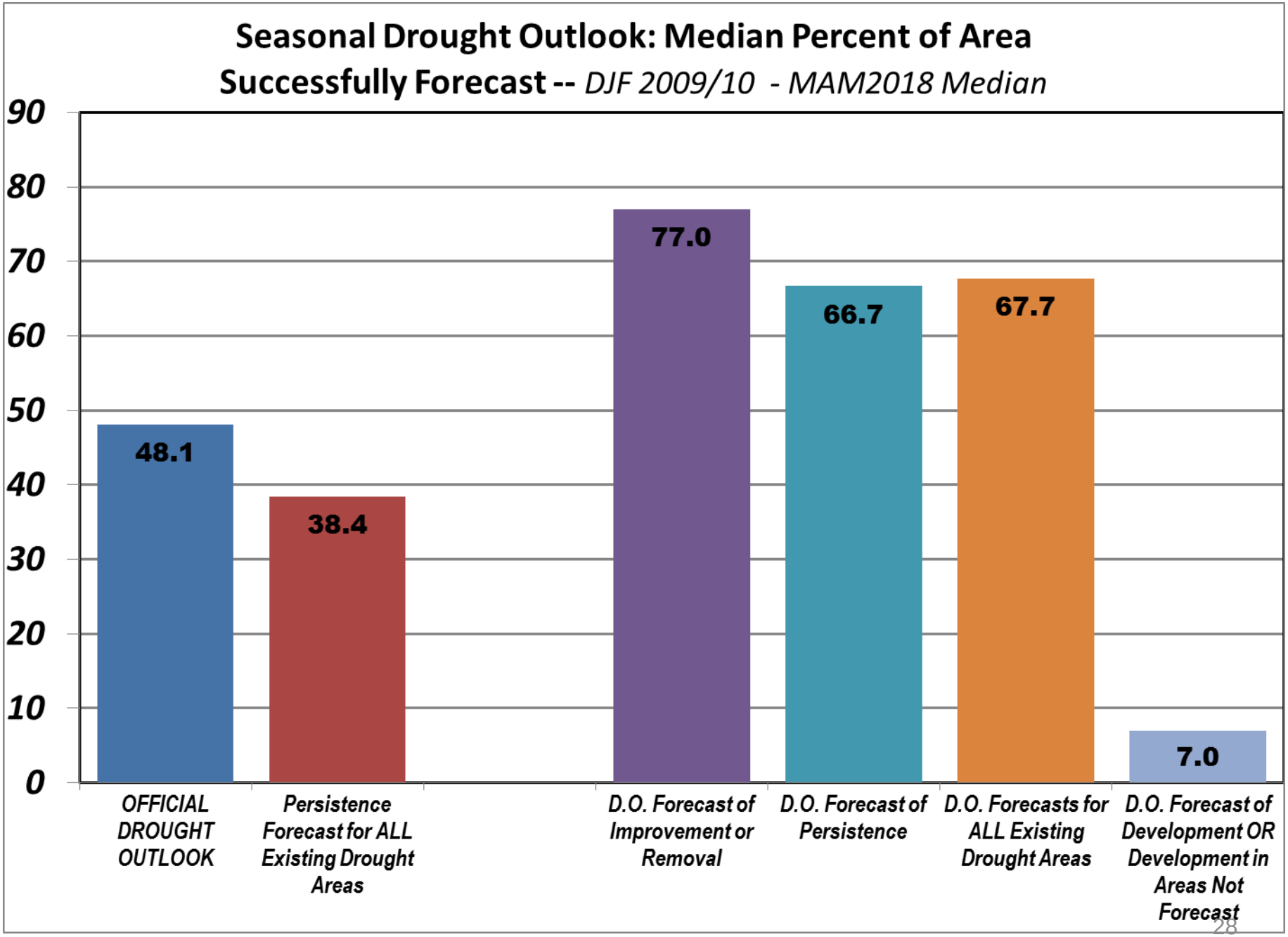
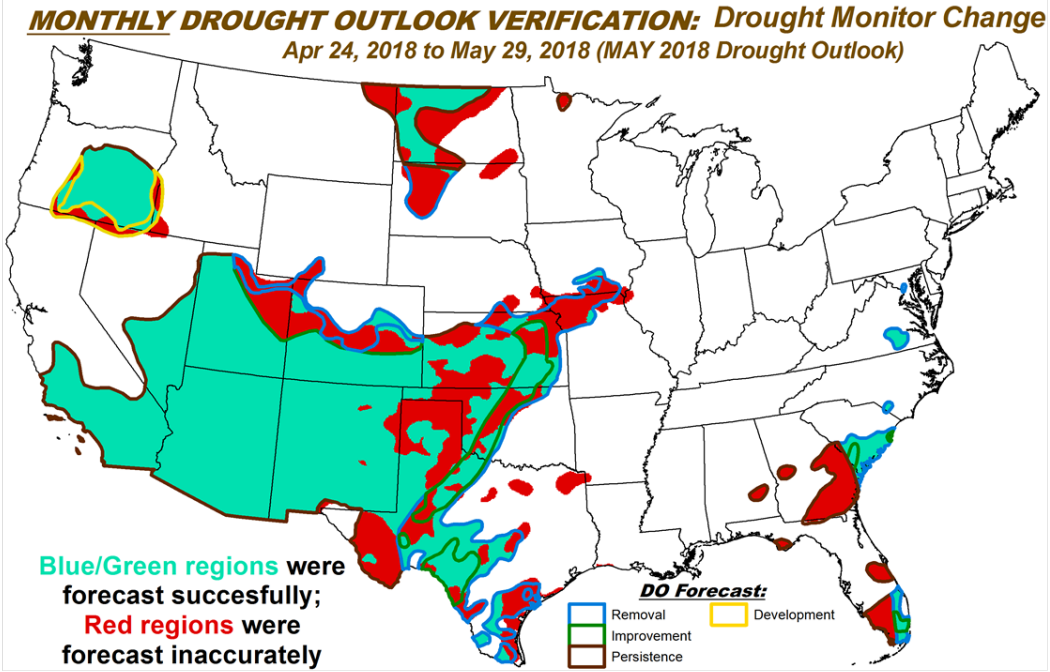
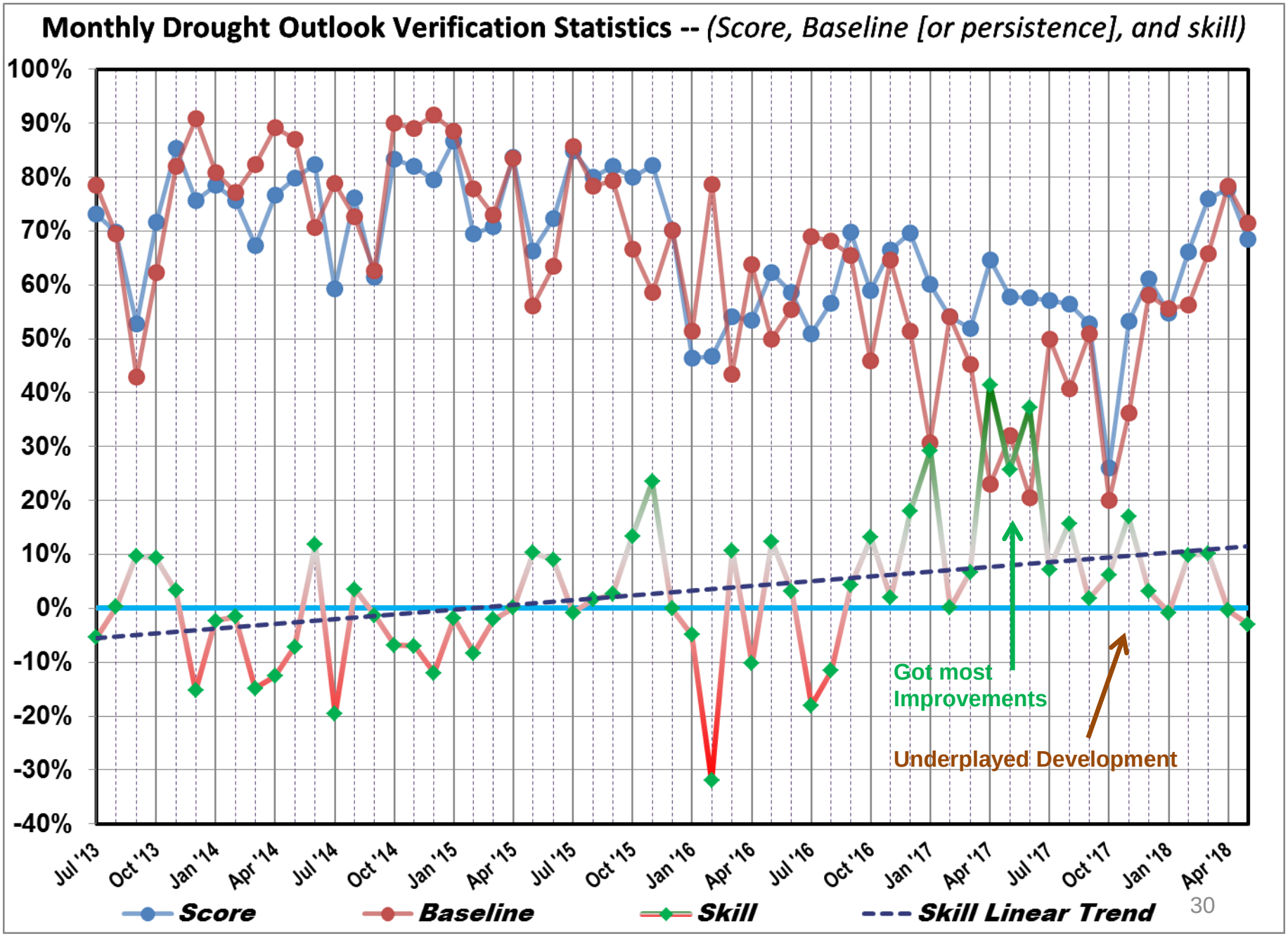
SON16
DJF17
MAM17
JJA17
SON17
DJF18
MAM18
Existing
Developing


Seasonal Drought Outlook: Median Percent of Area Successfully Forecast -- DJF 2009/10 - MAM2018 Median
90
80
70
60
50
40
30
20
10
0
48.1
38.4
77.0
66.7
67.7
7.0
OFFICIAL DROUGHT OUTLOOK
Persistence Forecast for ALL Existing Drought Areas
D.O. Forecast of Improvement or Removal
D.O. Forecast of Persistence
D.O. Forecasts for ALL Existing Drought Areas
D.O. Forecast of Development OR Development in Areas Not Forecast




| FORECAST | HIT | MISS |
|---|---|---|
| Improvement/Removal | 14,655 | 19,135 |
| Persistence | 87,384 | 18,690 |
| Development | 973 | 9,496 |
| **TOTAL** | **103,012** | **47,321** |
| ***SCORE*** | ***68.5*** | |
| PERSISTENCE FORECAST BASELINE | 95,100 | 37,941 |
| ***PERSISTENCE FORECAST SCORE*** | ***71.5*** | |
| ***"SKILL"*** | *(forecast score) minus (persistence score)* | ***-3.0*** |


Monthly Drought Outlook Verification Statistics -- (Score, Baseline [or persistence], and skill)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%
Jul '13
Oct '13
Jan '14
Apr '14
Jul '14
Oct '14
Jan '15
Apr '15
Jul '15
Oct '15
Jan '16
Apr '16
Jul '16
Oct '16
Jan '17
Apr '17
Jul '17
Oct '17
Jan '18
Apr '18
Got most Improvements
Underplayed Development
Score
Baseline
Skill
Skill Linear Trend

# Drought Outlook Challenges

- **Blending short-term forecasts (where most of the skill is) with seasonal (long-term) forecasts;**

- **Improving skill of forecasts (especially Precipitation & DO's Development) at all time ranges;**

- **Automation of production & verification *(getting there!);***

- **Although there are many quantitative & objective inputs into the Drought Outlook forecast generation, ultimately the forecast is produced subjectively using a human in the loop (6 different authors with varying decision styles) – although the DM is also produced this way;**

- ***Providing useful information for both the agricultural, hydrologic, & local government decision-makers.* CPC has not formally surveyed DO users yet, but from DO meetings, emails, etc. - Agriculture would like both short & long-term DOs for current season crops (e.g. MDO) & planning for next year. Hydrologic prefers accurate, regional, long-term DO for water management (store water if drought expected, release some if not). Both short and long-term drought affects local government decisions.**

- **Currently, stakeholder engagement & time-consuming climate model runs lead to long production time (*hence no weekly or bi-weekly updates [yet]*);**

- **Should we move to an objective and/or probabilistic Drought Outlook (at least start with tools for input)?;**

**In a meeting with Dr. Uccellini, a longer DO should be probabilistic.**

# Next Steps in Drought Forecasting

## Short-Term:

- **More GIS automation to objectify DO (like DM) - *ongoing;***

- **Real-Time DO Verification: Make more objective & automated; consider scoring persistence as "correct"; average weekly DM drought over forecast period since one anomalous week can completely make or break a DO forecast;**

- **Ongoing CPC Monthly Drought Working Group (DWG) brings operational (OPB) and R&D (OMB) staff together to learn from & communicate more to each other to improve operational drought forecasting (*better communication really does help*);**

## Long-Term:

- **Develop a R2O plan for long-term improvement of DO:**
  **Improvement of Precipitation forecasts in the models is highest priority;**
  **Integration of Temperatures, Precipitation, and Soil Moisture Forecasts ;**

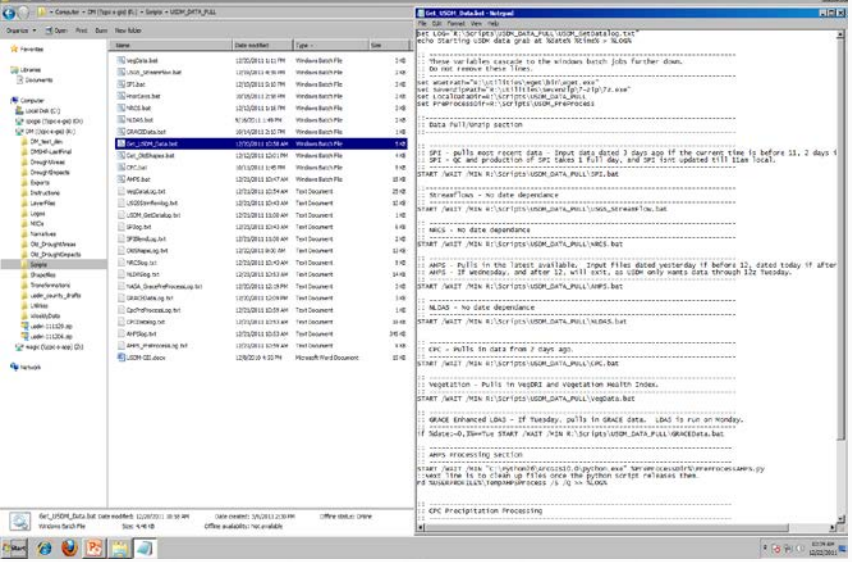
- **Engage the drought community for ideas on improving the DO (survey):**
  **Comparison of the (subjective) DO with objective ones, such as objective SPI or one based upon the PDI. What is customer preference?**

- **Continuation of the current manual forecast, with the objective forecasts used as input and run in parallel;**

- **Develop a 2-month DO (1- & 3-months now), or a bi-weekly MDO update on Fridays, or a 6-month DO (for water management/hydro users);**

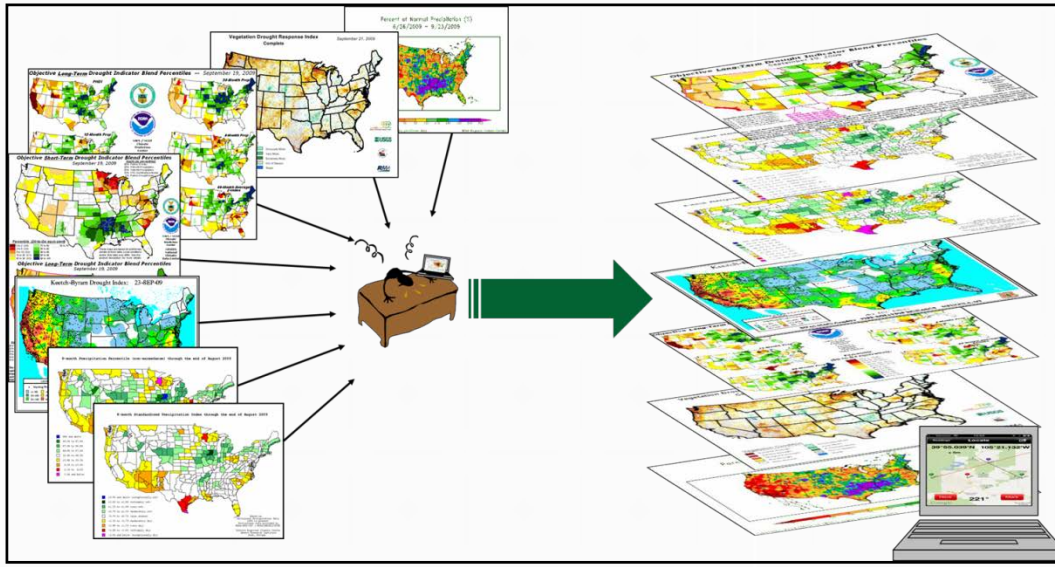
- ***Develop a probabilistic, objective DO (since other CPC forecasts are);***

# DOs: Attempting to Simulate the DM Production



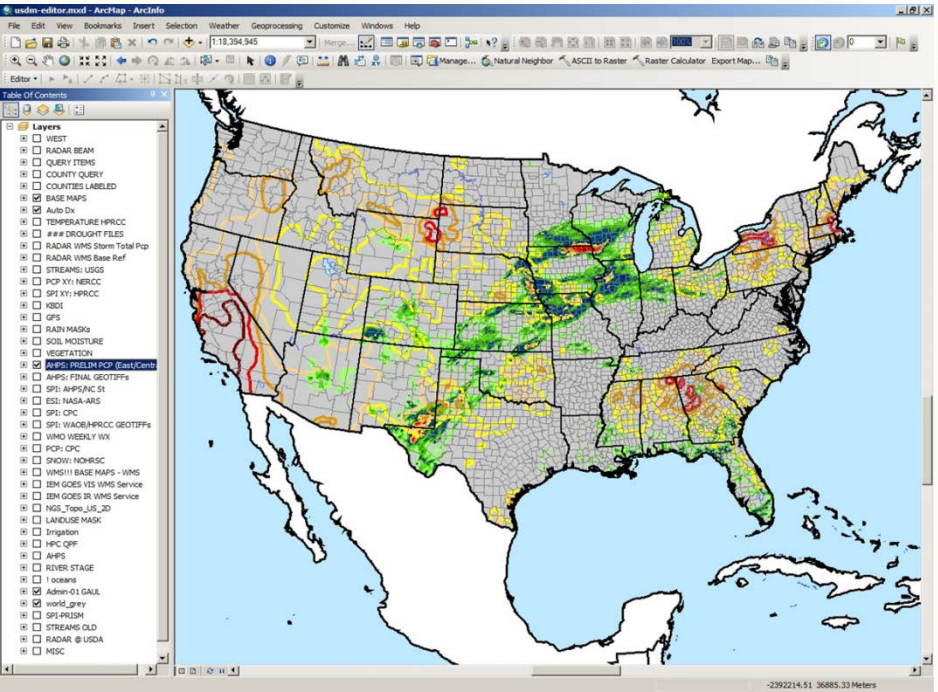
1) Scripts to get & download tools;

***Current Drought Monitor***

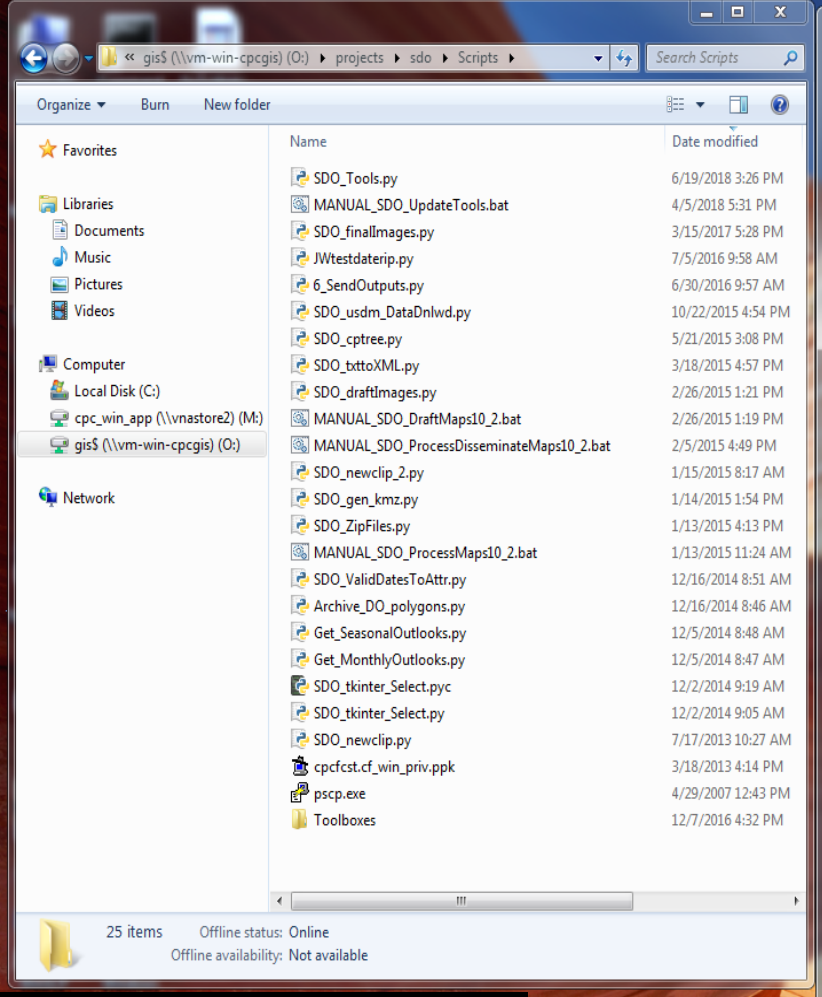


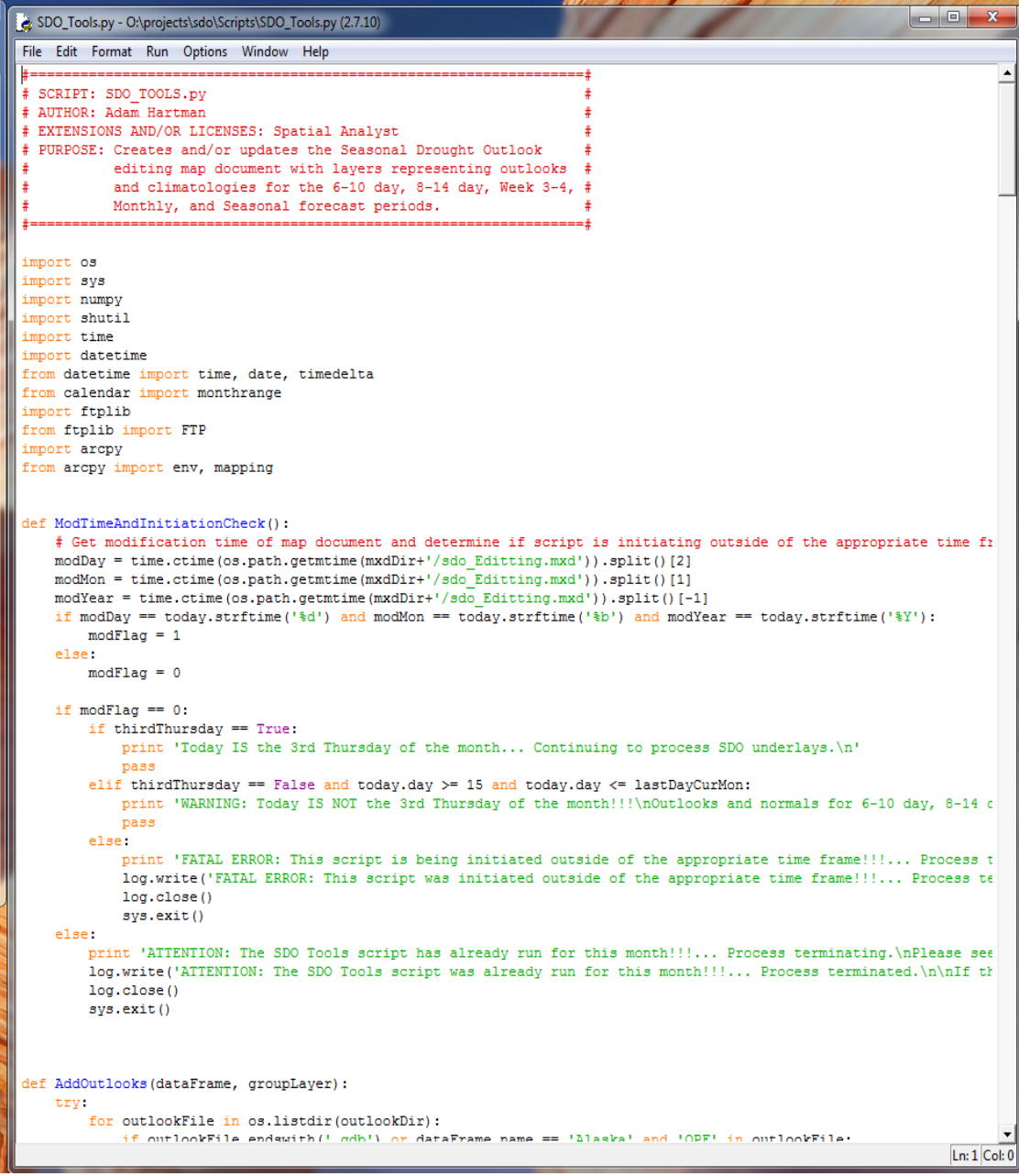
2) Multiple products/tools to review;

2a) Incorporate local expert input (e.g. DM Email list server, 450+);



3) GIS to overlay tools and create products, in this case the DM.

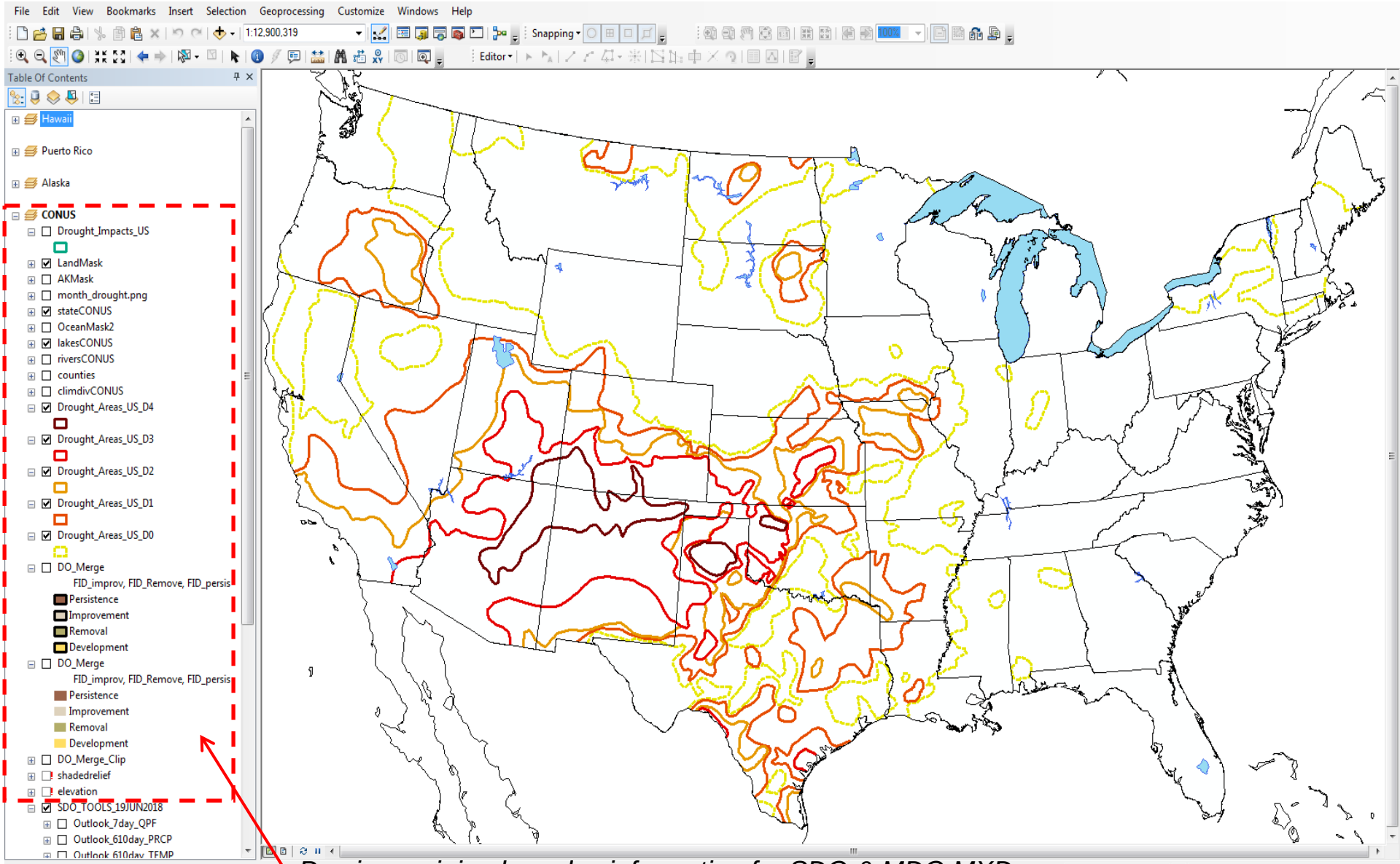



```
#==================================================================#
# SCRIPT: SDO_TOOLS.py                                             #
# AUTHOR: Adam Hartman                                             #
# EXTENSIONS AND/OR LICENSES: Spatial Analyst                      #
# PURPOSE: Creates and/or updates the Seasonal Drought Outlook     #
#          editing map document with layers representing outlooks  #
#          and climatologies for the 6-10 day, 8-14 day, Week 3-4, #
#          Monthly, and Seasonal forecast periods.                 #
#==================================================================#

import os
import sys
import numpy
import shutil
import time
import datetime
from datetime import time, date, timedelta
from calendar import monthrange
import ftplib
from ftplib import FTP
import arcpy
from arcpy import env, mapping


def ModTimeAndInitiationCheck():
    # Get modification time of map document and determine if script is initiating outside of the appropriate time fr
    modDay = time.ctime(os.path.getmtime(mxdDir+'/sdo_Editting.mxd')).split()[2]
    modMon = time.ctime(os.path.getmtime(mxdDir+'/sdo_Editting.mxd')).split()[1]
    modYear = time.ctime(os.path.getmtime(mxdDir+'/sdo_Editting.mxd')).split()[-1]
    if modDay == today.strftime('%d') and modMon == today.strftime('%b') and modYear == today.strftime('%Y'):
        modFlag = 1
    else:
        modFlag = 0

    if modFlag == 0:
        if thirdThursday == True:
            print 'Today IS the 3rd Thursday of the month... Continuing to process SDO underlays.\n'
            pass
        elif thirdThursday == False and today.day >= 15 and today.day <= lastDayCurMon:
            print 'WARNING: Today IS NOT the 3rd Thursday of the month!!!\nOutlooks and normals for 6-10 day, 8-14 c
            pass
        else:
            print 'FATAL ERROR: This script is being initiated outside of the appropriate time frame!!!... Process t
            log.write('FATAL ERROR: This script was initiated outside of the appropriate time frame!!!... Process te
            log.close()
            sys.exit()
    else:
        print 'ATTENTION: The SDO Tools script has already run for this month!!!... Process terminating.\nPlease see
        log.write('ATTENTION: The SDO Tools script was already run for this month!!!... Process terminated.\n\nIf th
        log.close()
        sys.exit()



def AddOutlooks(dataFrame, groupLayer):
    try:
        for outlookFile in os.listdir(outlookDir):
            if outlookFile.endswith('.gdb') or dataFrame.name == 'Alaska' and 'OPF' in outlookFile:
```

1) New SDO and MDO get, save, and download Python scripts for MXD.

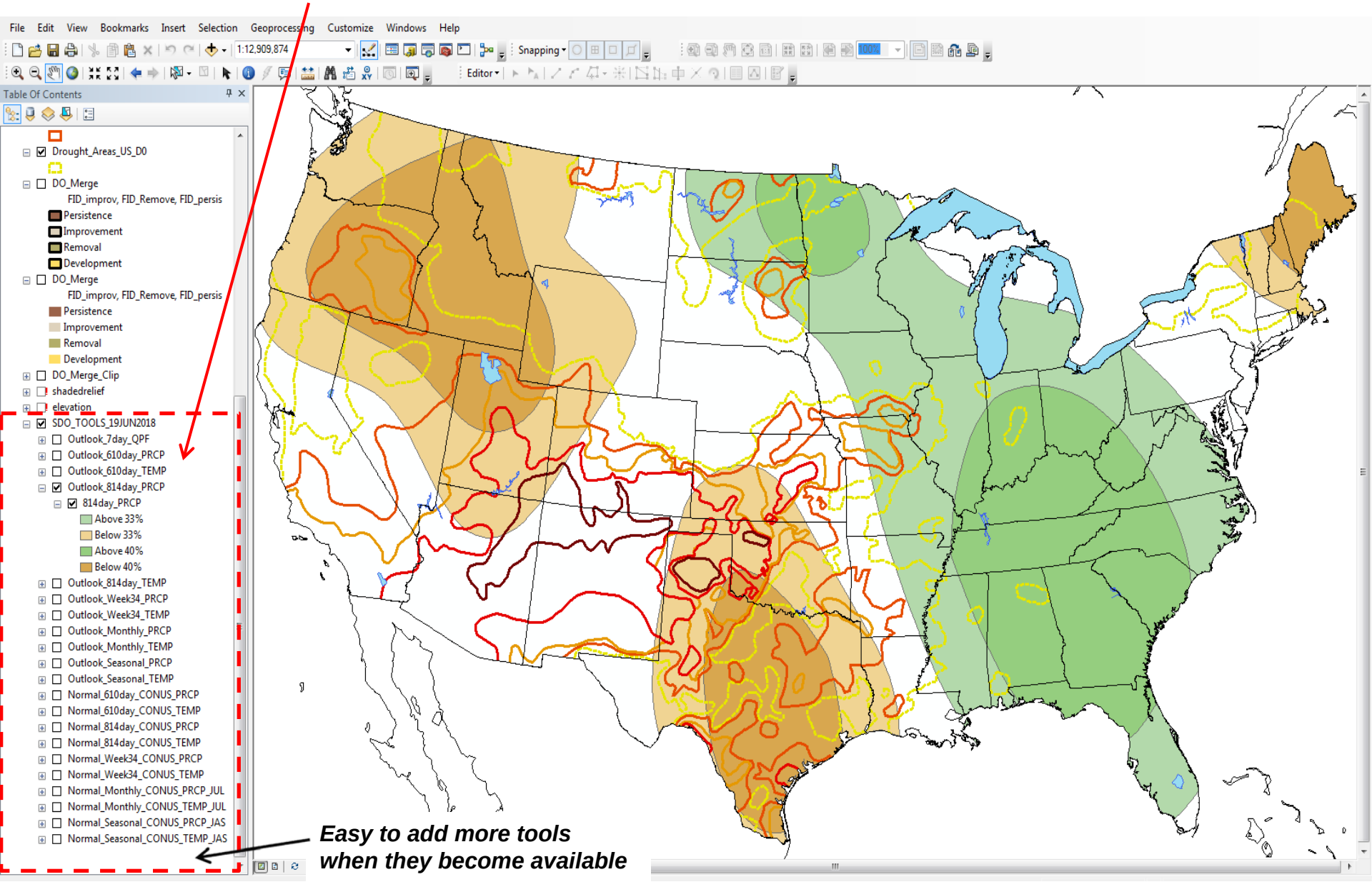
Saves time & assures latest forecasts overlaid on DO MXD




*Previous minimal overlay information for SDO & MDO MXDs.*

**2) Expert input from: a) Monthly Drought Briefing; b) Sanity Checks; c) DO Email list server (~25)**

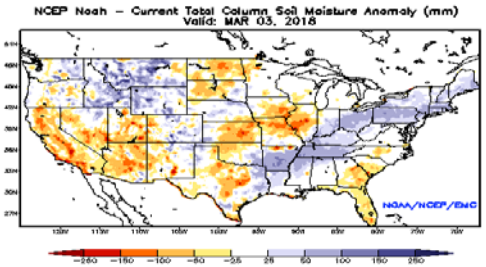
# 3) New Tool Overlays; DO Probabilities (instead of DM Percentiles) on MXD



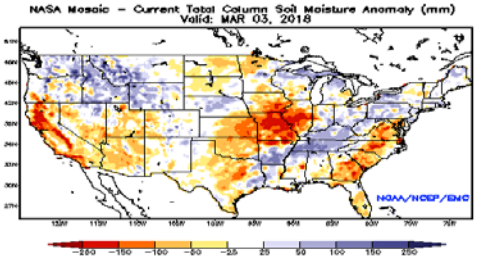

*This example has 8-14 Day ERF Precipitation Probabilities overlaid with D0-D4 drought layers*

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

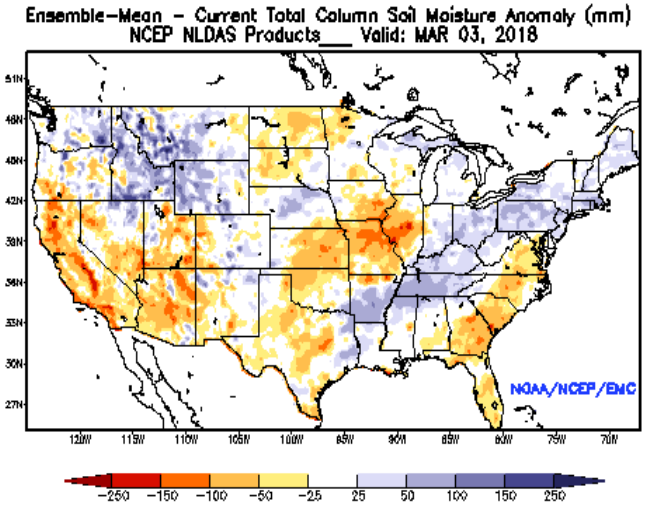
NOAH



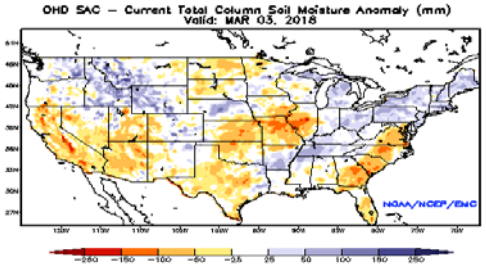

MOSAIC



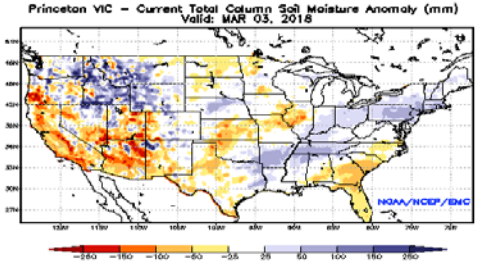

Ensemble Mean
Land Surface Model Output




SAC

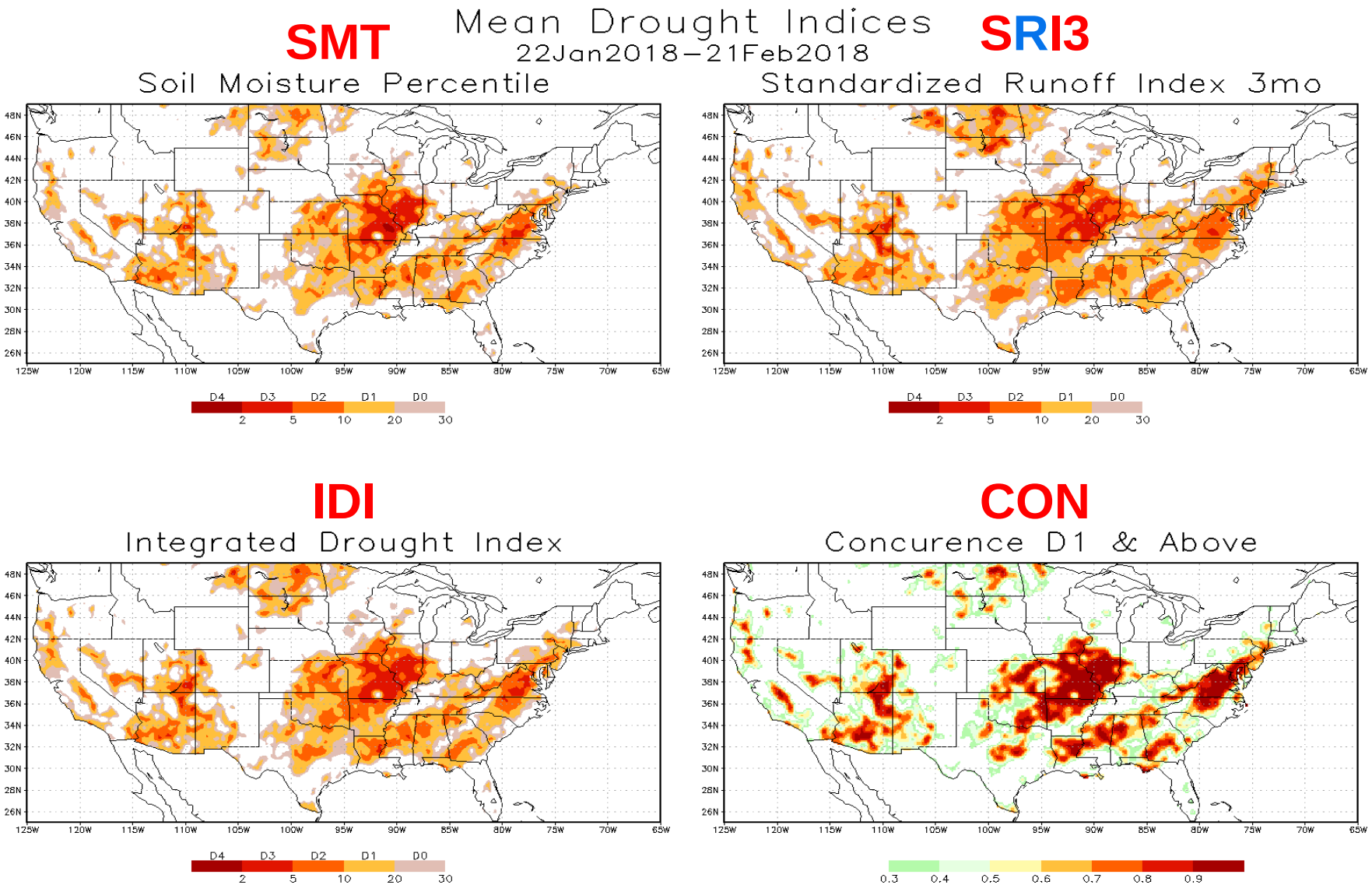



VIC




https:///ldas.gsfc.nasa.gov/nldas/NLDAS2model.php

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




**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 DO SPI6 only!

(Drs. Kingtse Mo & Li Xu at CPC)

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**NMME models:**

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

6 models * 10 members each = 60 ensemble members

* Use Model Precipitation to get respective **SPI6** forecasts

* Map onto a uniform distribution function (end up with values between 0 & 1) for Probs

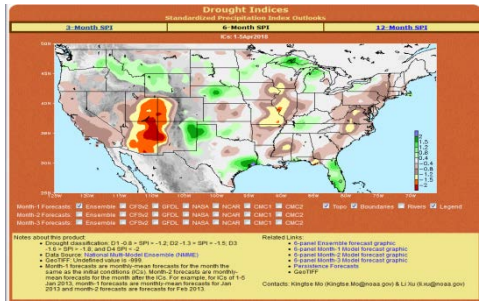
* For ex: at each grid point:

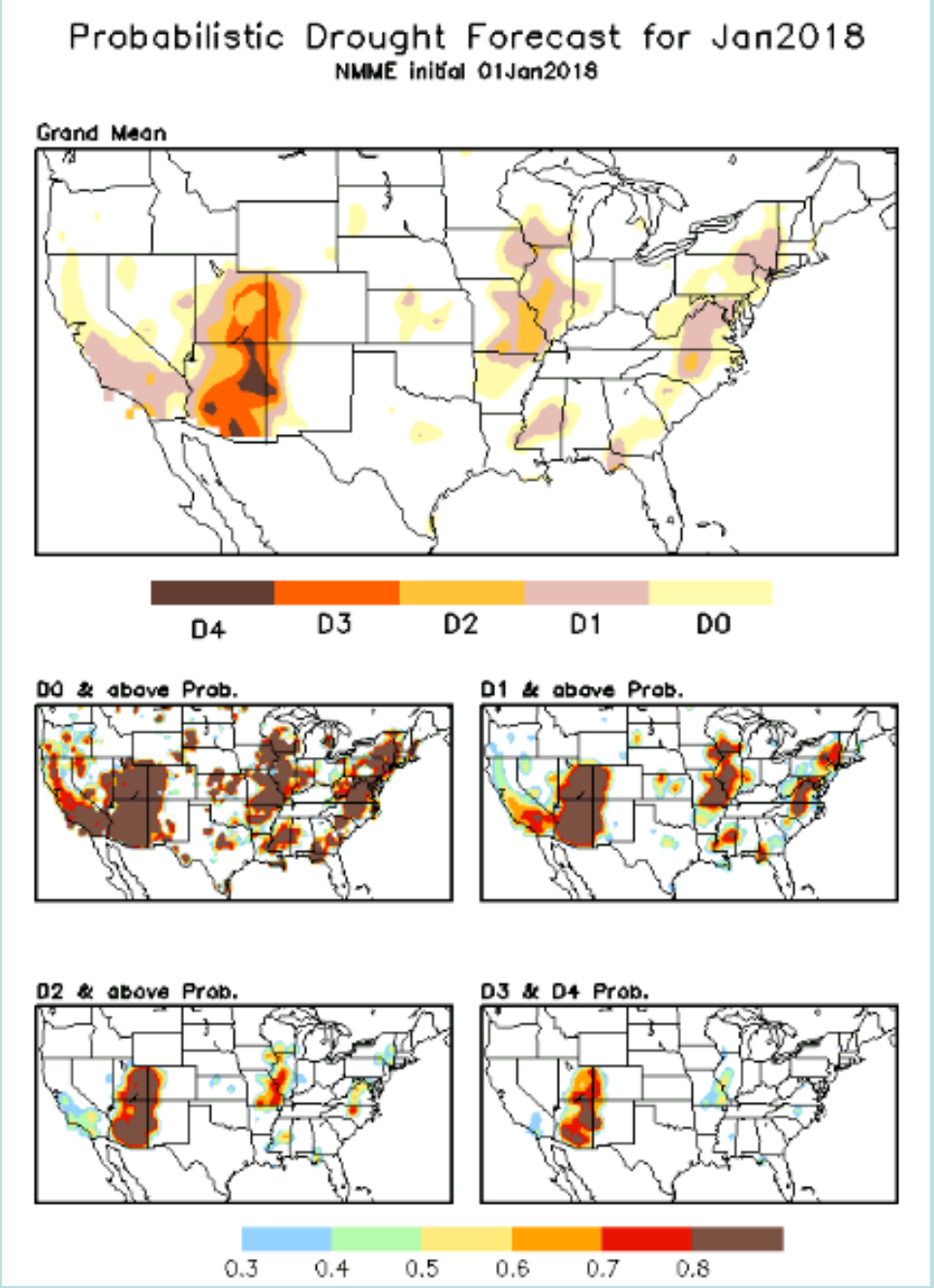
  - If all ensemble members agree – 100% probability
  - If only half of the members agree – 50% probability

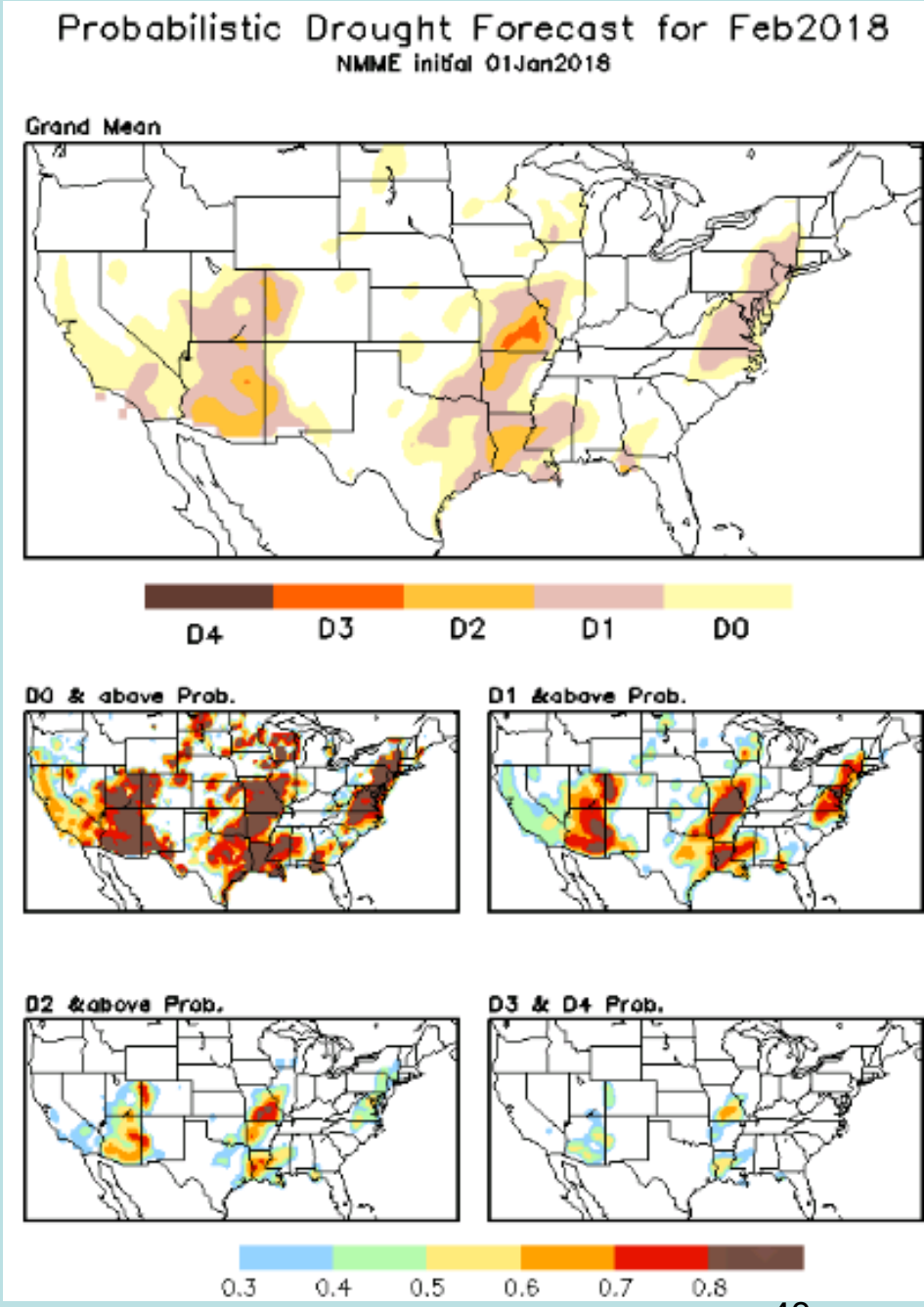
- Verification against CPC's Unified Precip Analysis (daily, gauge-based, CONUS, 0.25x0.25-deg)

---

D1: -0.8 > SPI > -1.2
D2: -1.3 > SPI > -1.5
D3: -1.6 > SPI > -1.8
D4: SPI < -2.0

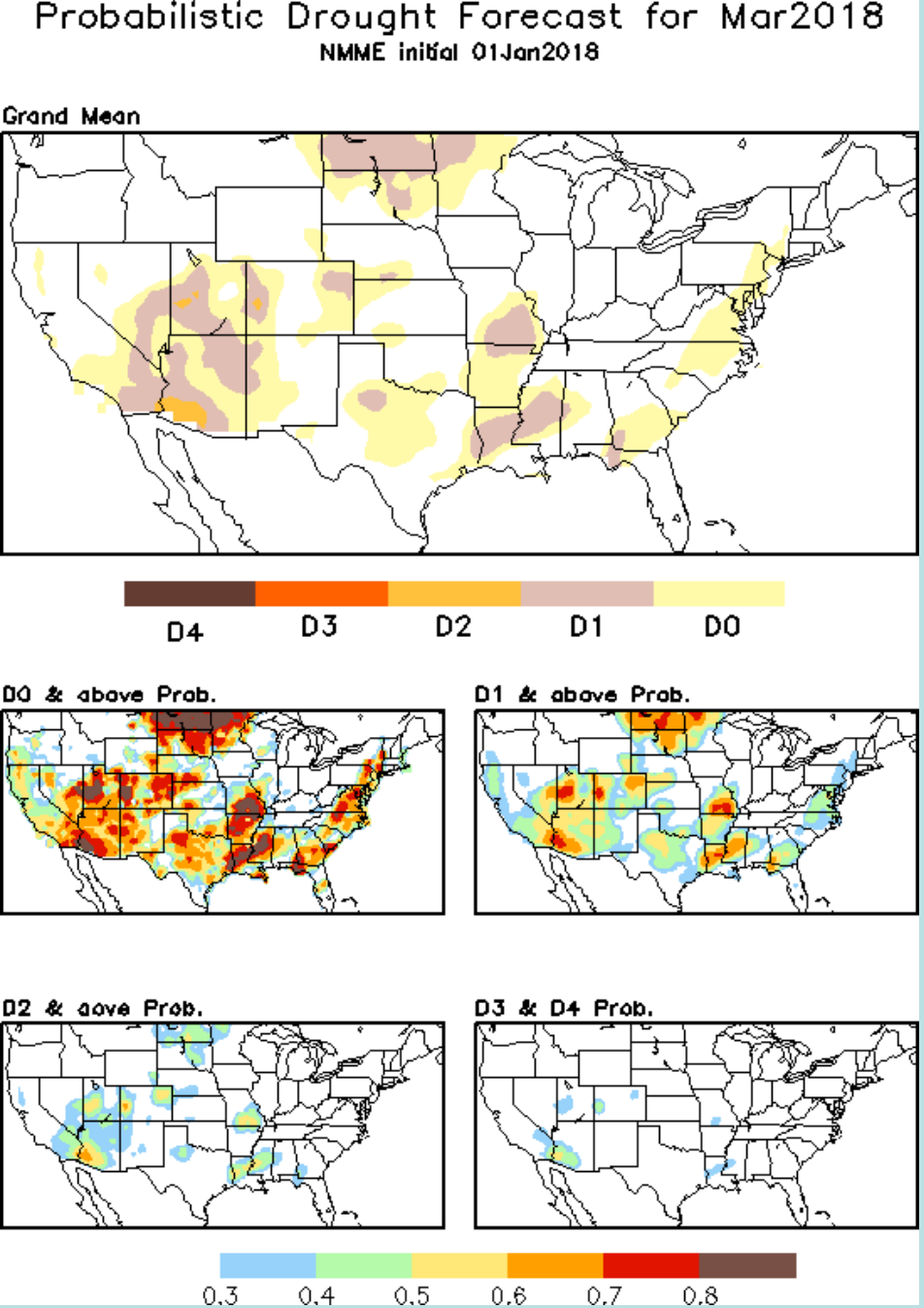


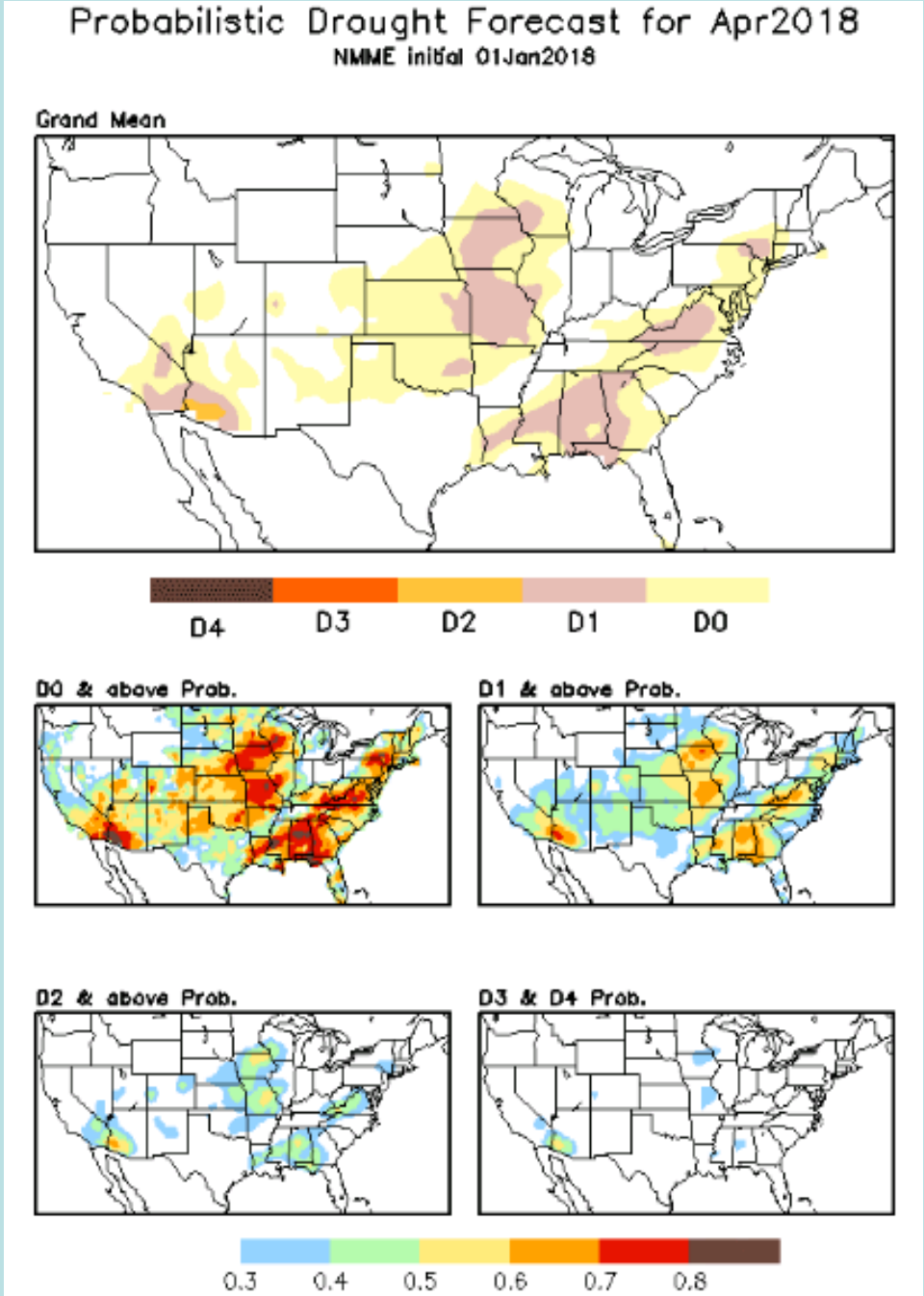


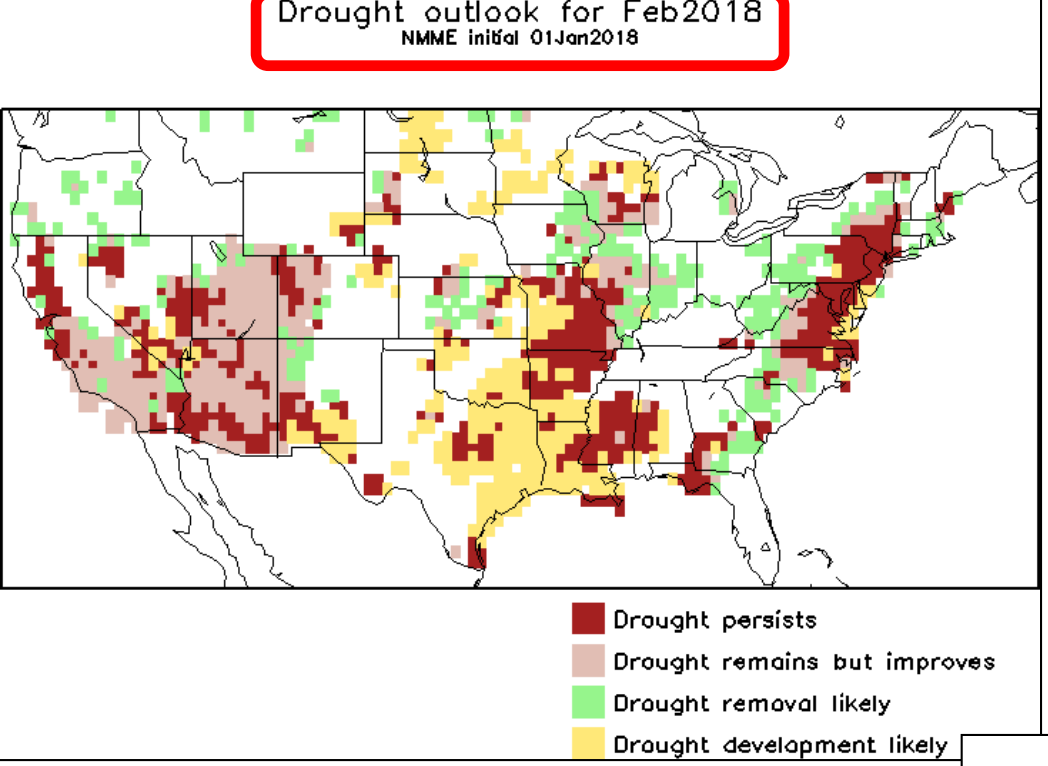



Likelihood of Drought & Intensity & longer time ranges for Decision Support Services



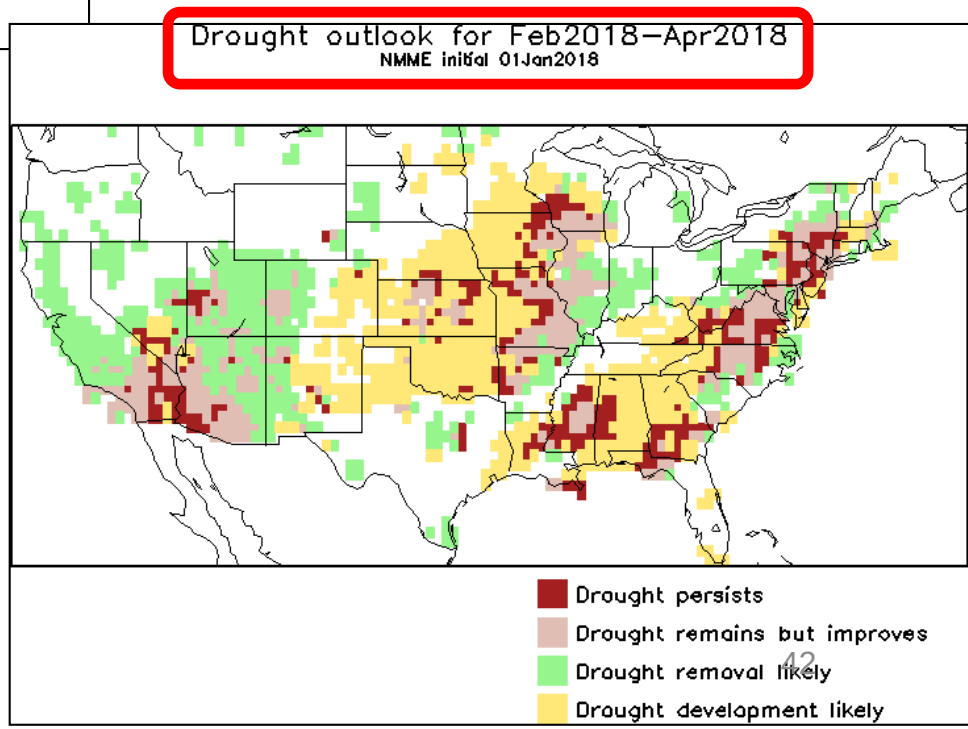




Likelihood of Drought & Intensity & longer time ranges for Decision Support Services

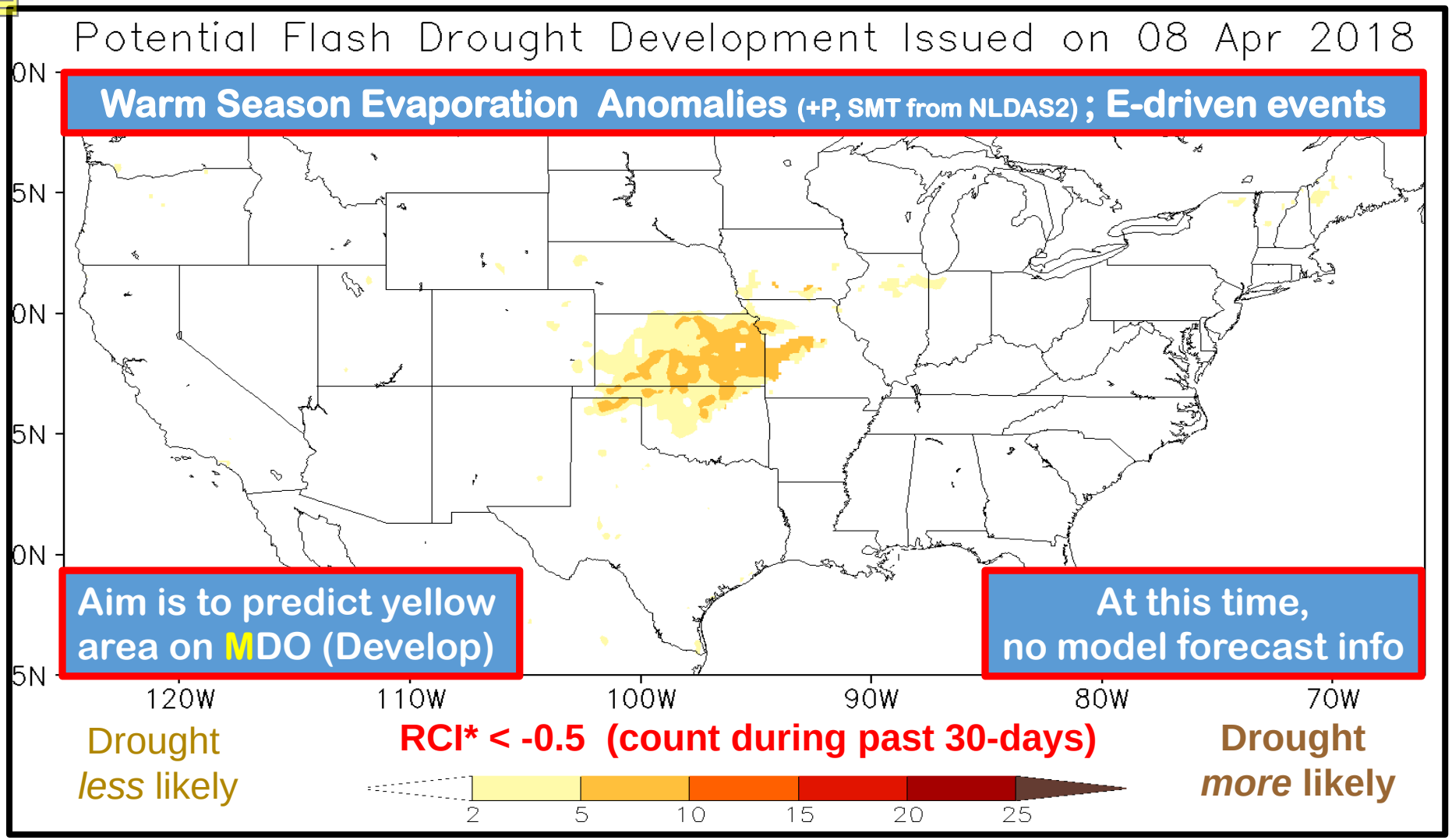



**Feb 2018**

**FMA 2018**



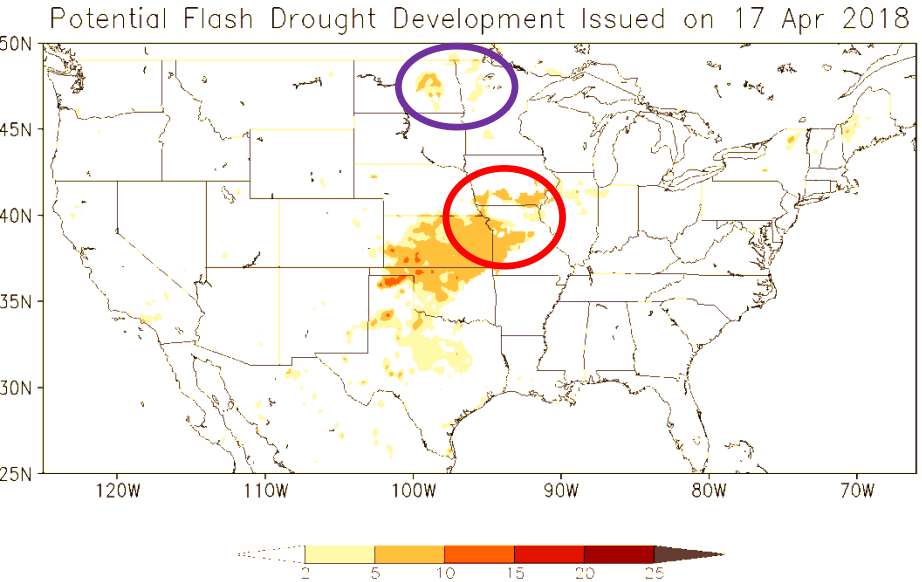

**In the official Drought Outlook Tendency Format!!**



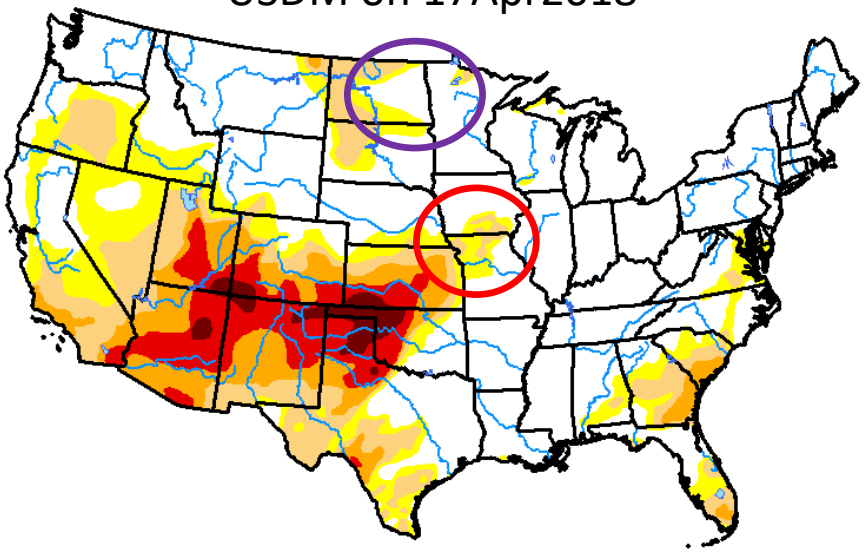

*Rapid Change Index is accumulated magnitude of moisture stress changes (standardized differences) occurring over multiple weeks (Otkin et al (2015))

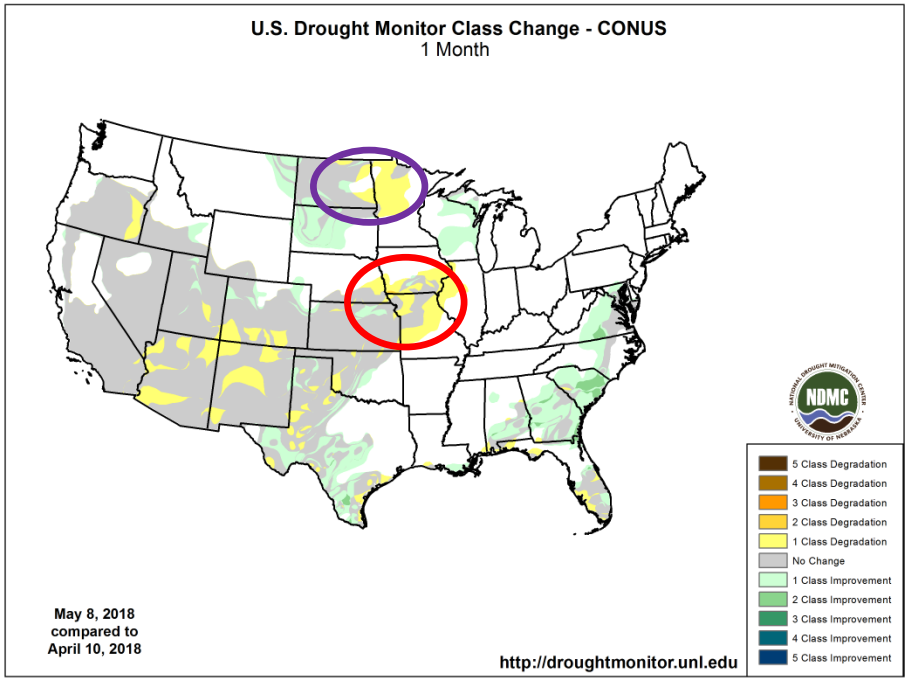


Dr. Gwen Chen

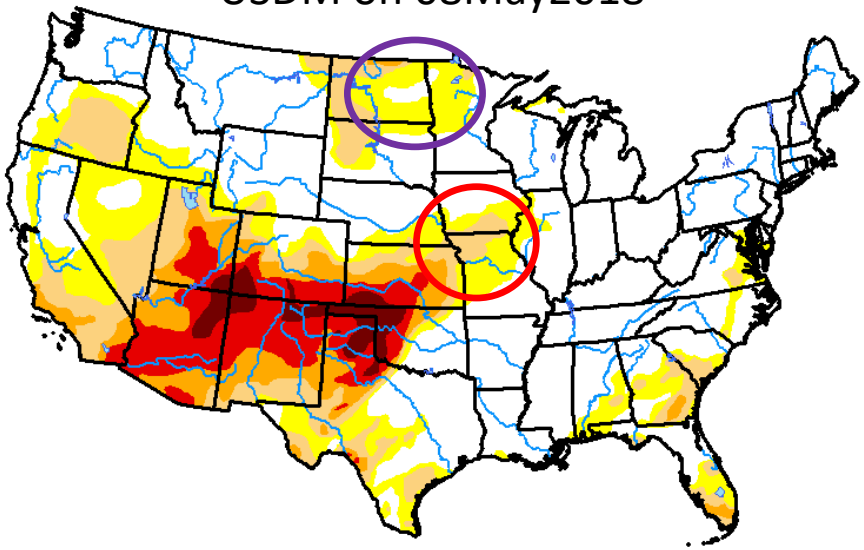



USDM on 17Apr2018

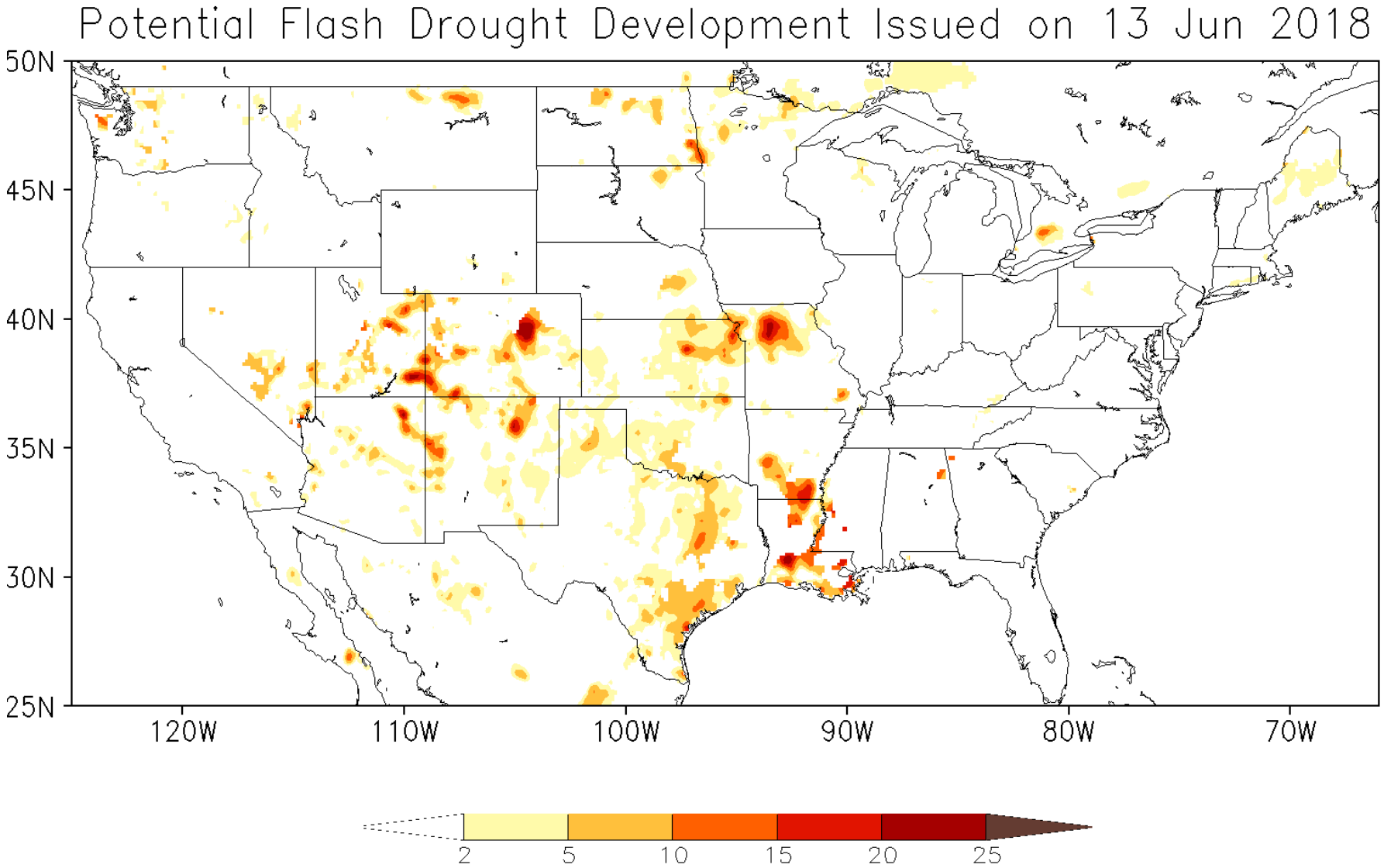





USDM on 08May2018




Gwen Chen




*Most recent Potential Flash Drought Index now being overlaid on the MDO MXD*

…and other drought forecast tools being developed & tested at CPC (to be continued)

# THANK YOU!

**Any Questions, contact:**

**David.Miskus@noaa.gov**
**(301) 683-3453**