Seasonal Forecasting: Process and Products

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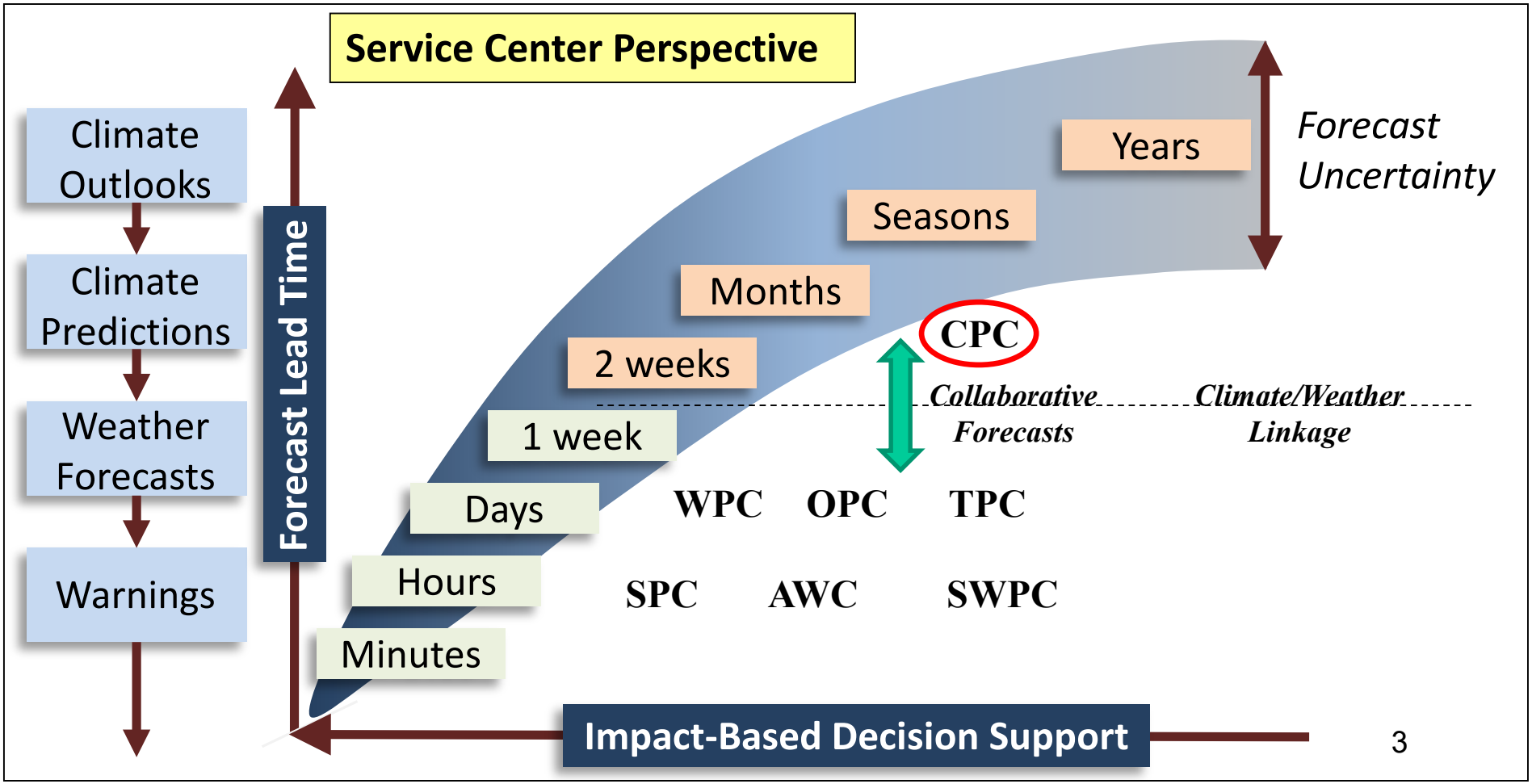
NOAA/NWS/Western Region Headquarters

Ogden Drought Workshop
Wednesday, October 24, 2018

Drought Outlooks Presentation

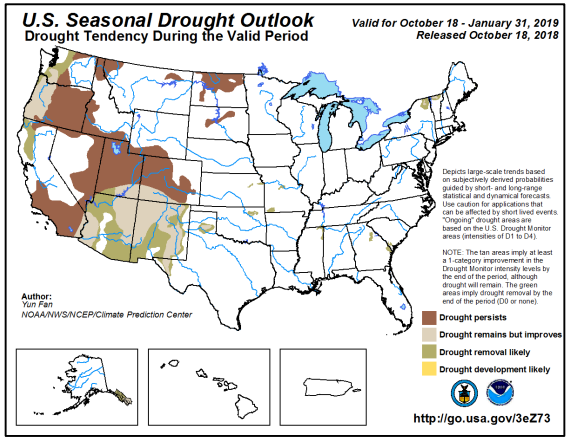
- Overview of CPC's Climate and Drought Outlooks;
- History of the Drought Outlooks;
- Preparation of the Operational Drought Outlooks;
- Verification;
- Drought Outlook Challenges and Next Steps;
- Current Outlooks

NOAA Seamless Suite of Forecast Products Spanning Climate and Weather



Climate Prediction Products

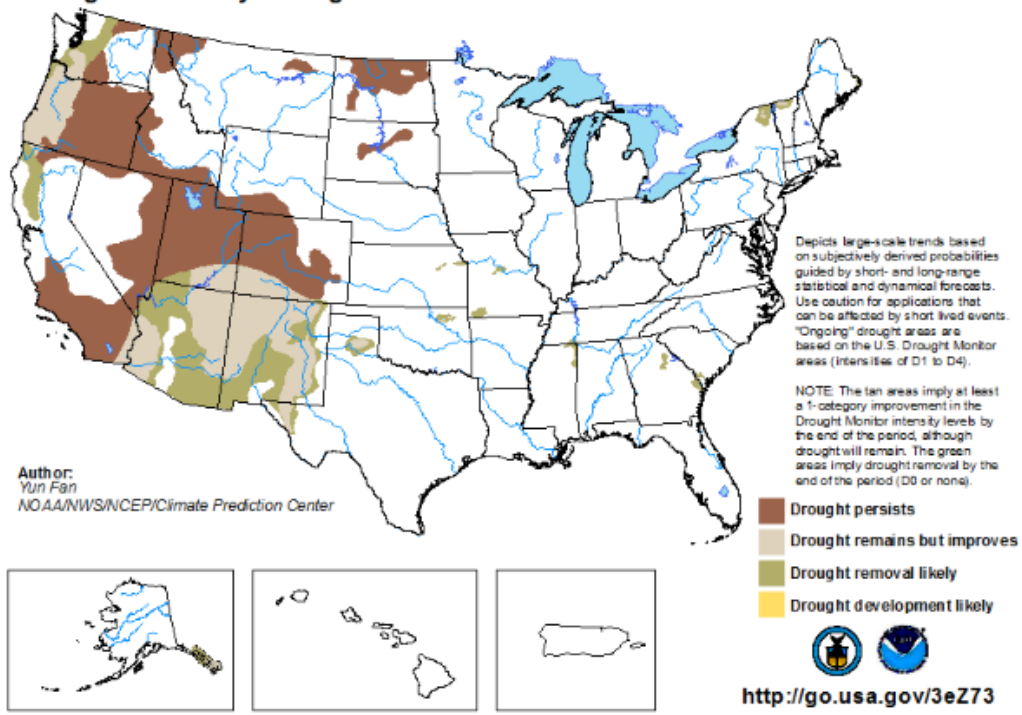
- **Focus on Week-2 to Seasonal-to-Interannual**
  - 6-10 Day & 8-14 Day (Extended Range Forecasts) Precipitation & Temperature Outlooks
  - Day 3-14 Hazards Outlooks (US Hazards, Global Tropics [MJO/GTH])
  - Monthly & Seasonal (Long Lead Forecasts) Precipitation & Temperature Outlooks
  - Monthly &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



Climate Prediction Products

Click on product title to go to product page. Move cursor over product parameter name to display the graphic -- click to enlarge. Links to these same products are also available below.

6-10 Day Outlook (Interactive) Temperature Precipitation	One Month Outlook (Interactive) Temperature Precipitation
8-14 Day Outlook (Interactive) Temperature Precipitation	Three Month Outlook (Interactive) Temperature Precipitation
Week 3-4 Outlooks Temperature Exp. Precipitation	U.S. Hazards Outlook 3-7 Day 8-14 Day 8-14 Day Temps
U.S. Drought Information Monitor Monthly Outlook Seasonal Outlook	Global Tropics Hazards Outlook Weeks 1 and 2



www.cpc.ncep.noaa.gov

Production Schedule

Extended Range Forecasts	Daily
Hazards Analysis Forecasts	Mon-Fri
Global Tropical Hazards	every Tue
Weeks 3&4	every Fri
Monthly Long Lead Forecast - 2 per month	3rd Thu & updated last day of month
Seasonal Long Lead Forecast - monthly	3rd Thu
Seasonal Drought Outlook - monthly	3rd Thu
Monthly Drought Outlook - monthly	last day of month
ENSO Weekly Update	every Mon
ENSO Monthly Discussion	2nd Thu
Hurricane Outlook - Yearly + update	May + August

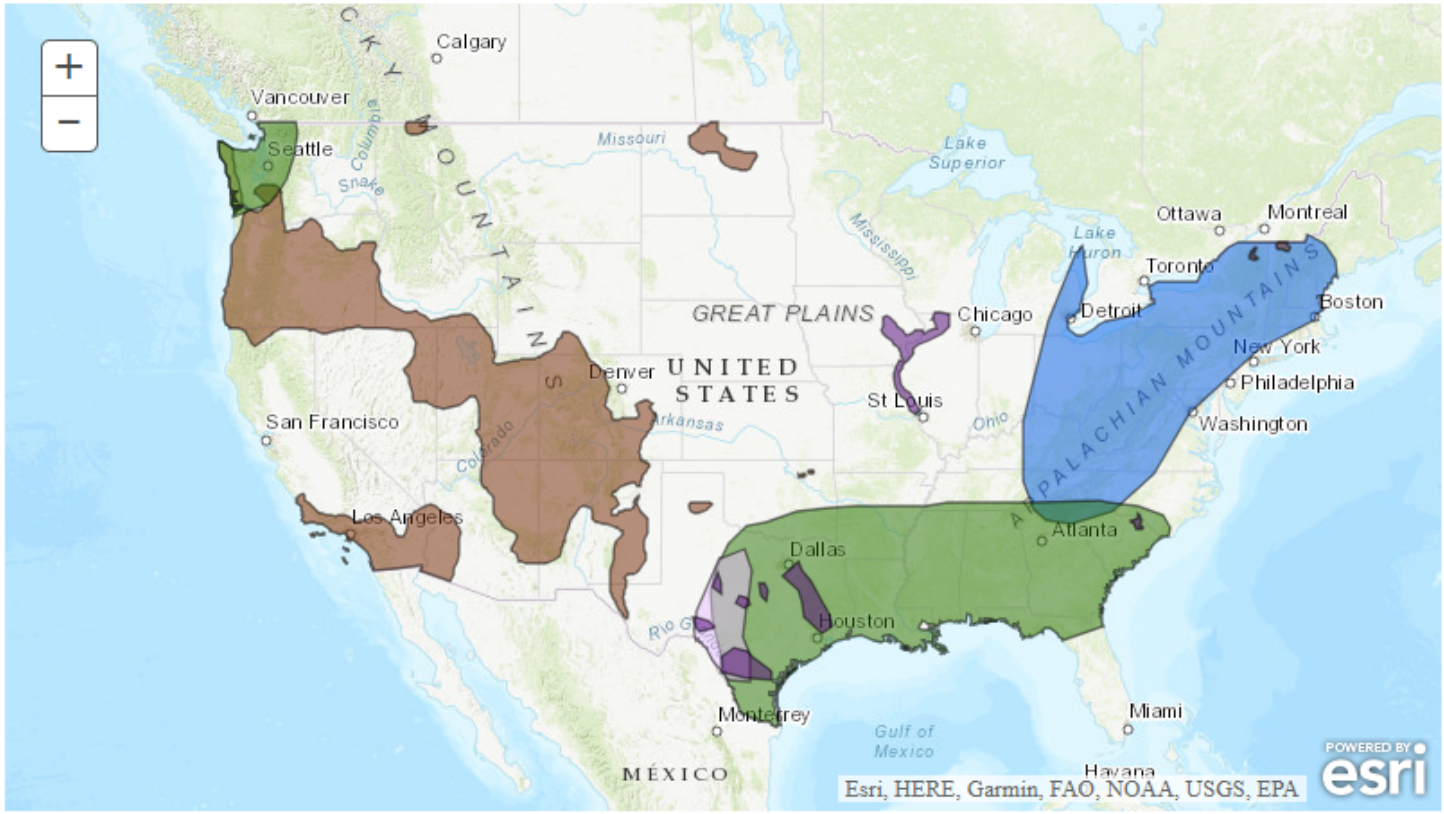
U.S. Hazards Outlook - Made October 19, 2018

	Days 3-7	Days 8-14	Probabilistic Days 8-14
Precipitation	✔		
Temperature	✔	No Hazards	
Soils	✔	No Hazards	Not Available EH>

NOTE: Dynamic map may be delayed in updating graphics. See static maps below this for the most up to date graphics.

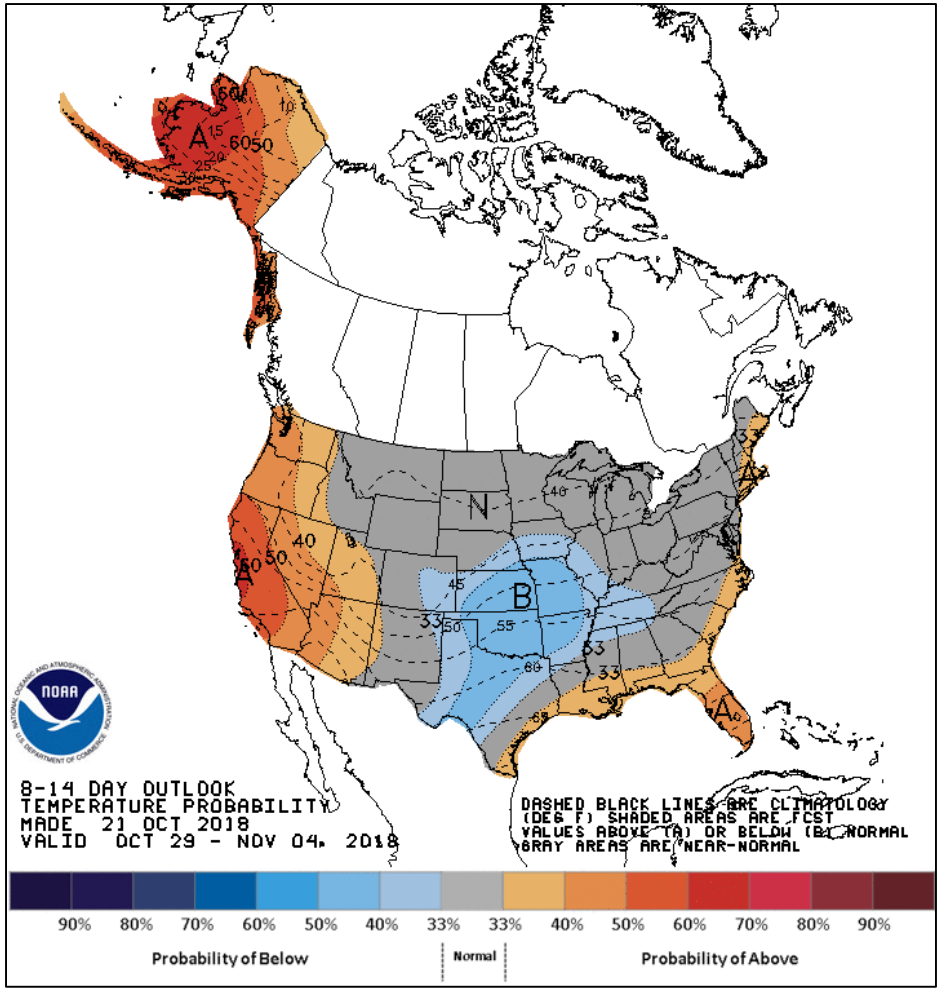
Legend

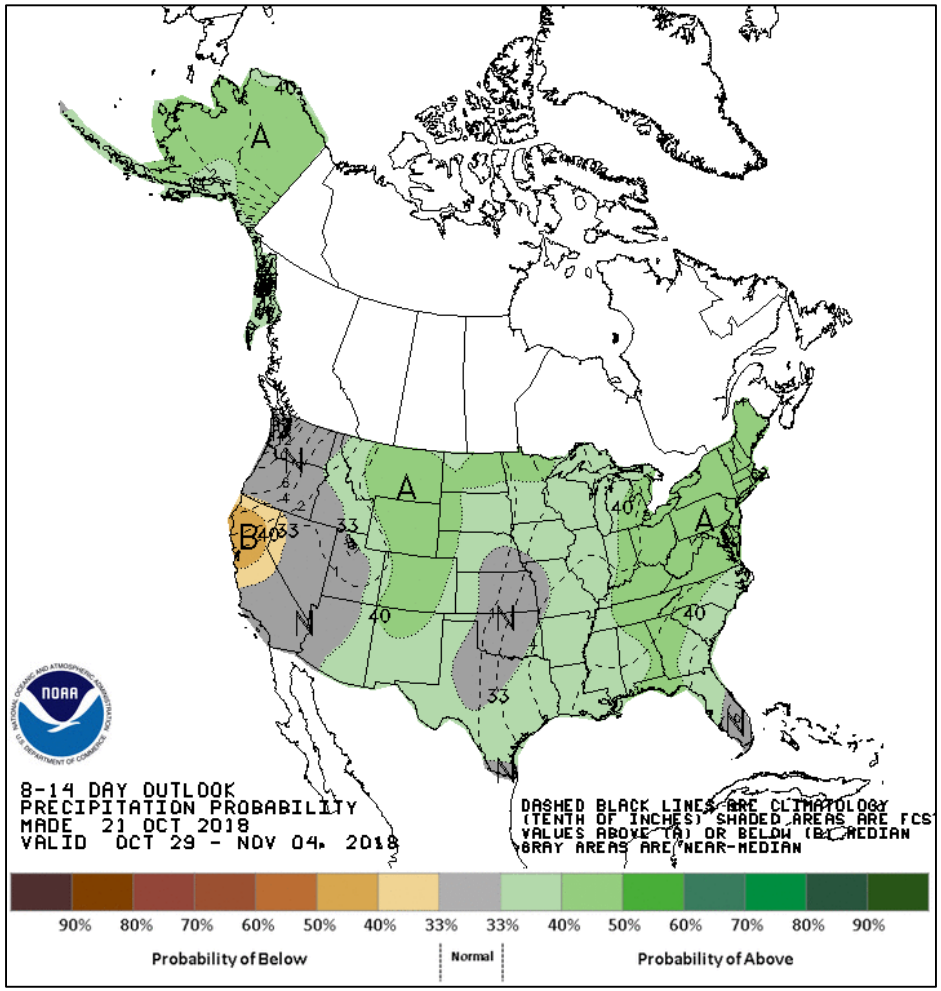
- Flooding Likely
- Flooding Occurring or Imminent
- Flooding Possible
- Freezing Rain
- Heavy Ice
- Heavy Precipitation
- Heavy Rain
- Heavy Snow
- Severe Weather
- Excessive Heat
- High Winds
- Much Above Normal Temperatures
- Much Below Normal Temperatures
- Significant Waves
- Enhanced Wildfire Risk
- Severe Drought



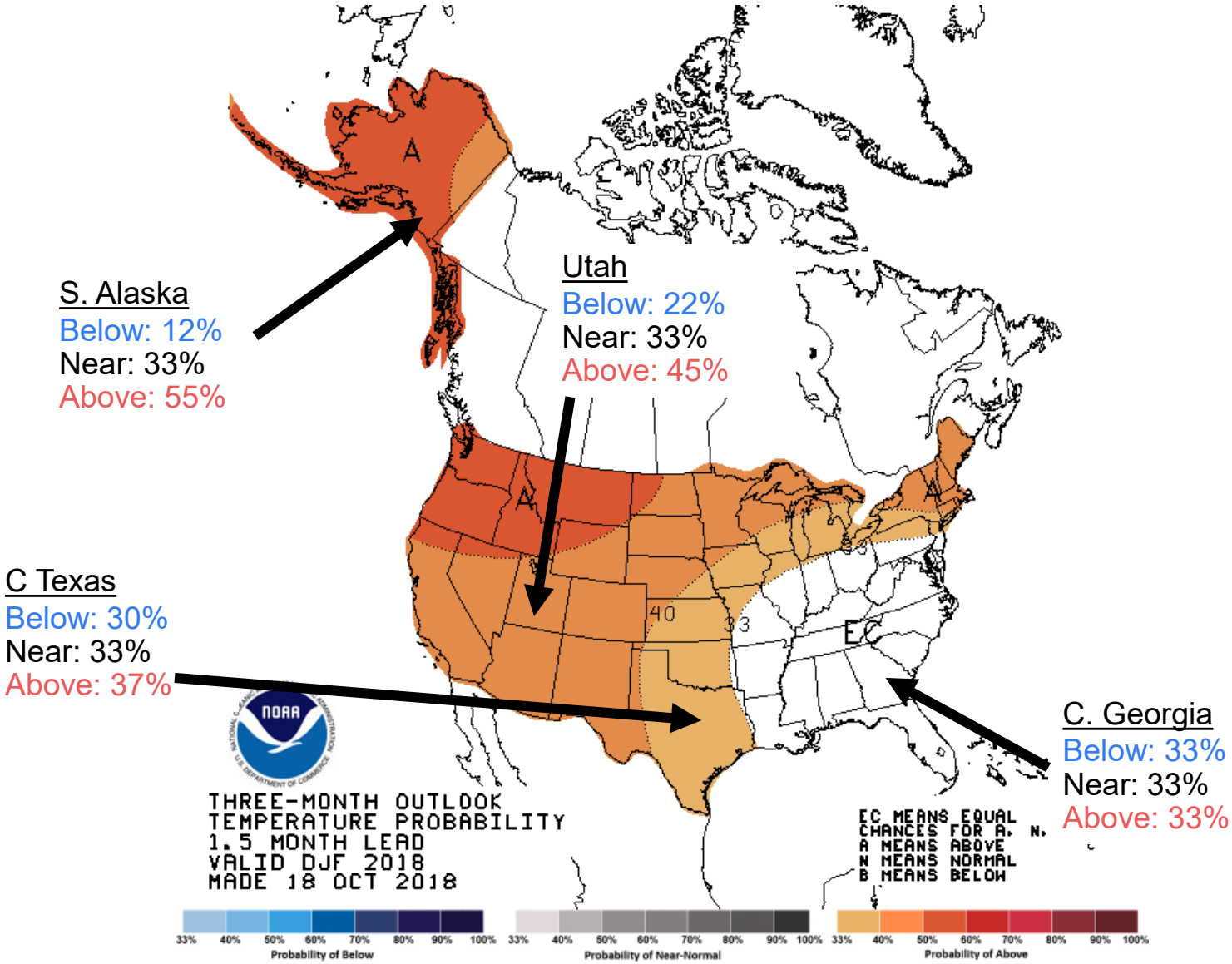
Categorical Outlooks	Experimental Probabilistic Outlooks (Information)
Day 3-7 Day 8-14	Temperature Hazards Precipitation Hazards

8-14 Day Outlooks





What is the Seasonal Outlook Telling Me?



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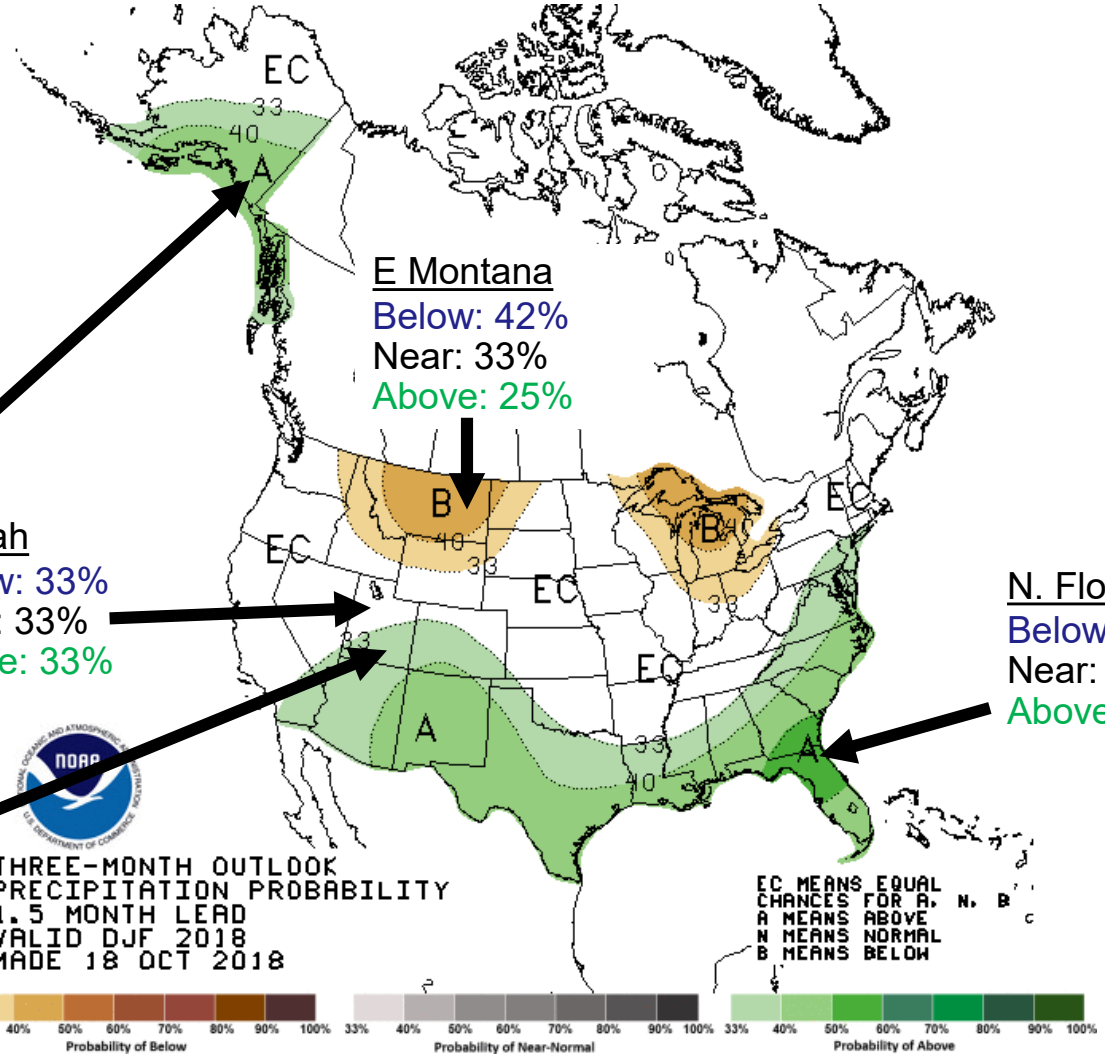


S. Alaska
Below: 22%
Near: 33%
Above: 45%

E Montana
Below: 42%
Near: 33%
Above: 25%

N Utah
Below: 33%
Near: 33%
Above: 33%

N. Florida
Below: 15%
Near: 33%
Above: 52%

S Utah
Below: 30%
Near: 33%
Above: 37%

Odds slightly favor above average precipitation for southern UT this winter.

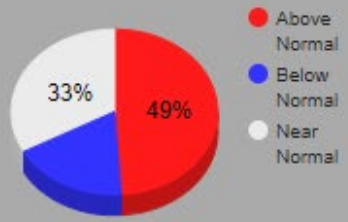
What is the Seasonal Outlook Telling Me?

INTERACTIVE DISPLAY - UPDATED: 18 OCT 2018

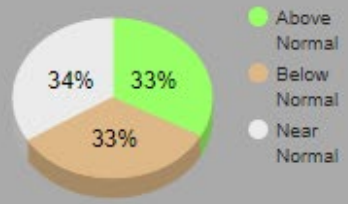
Ogden, UT, USA

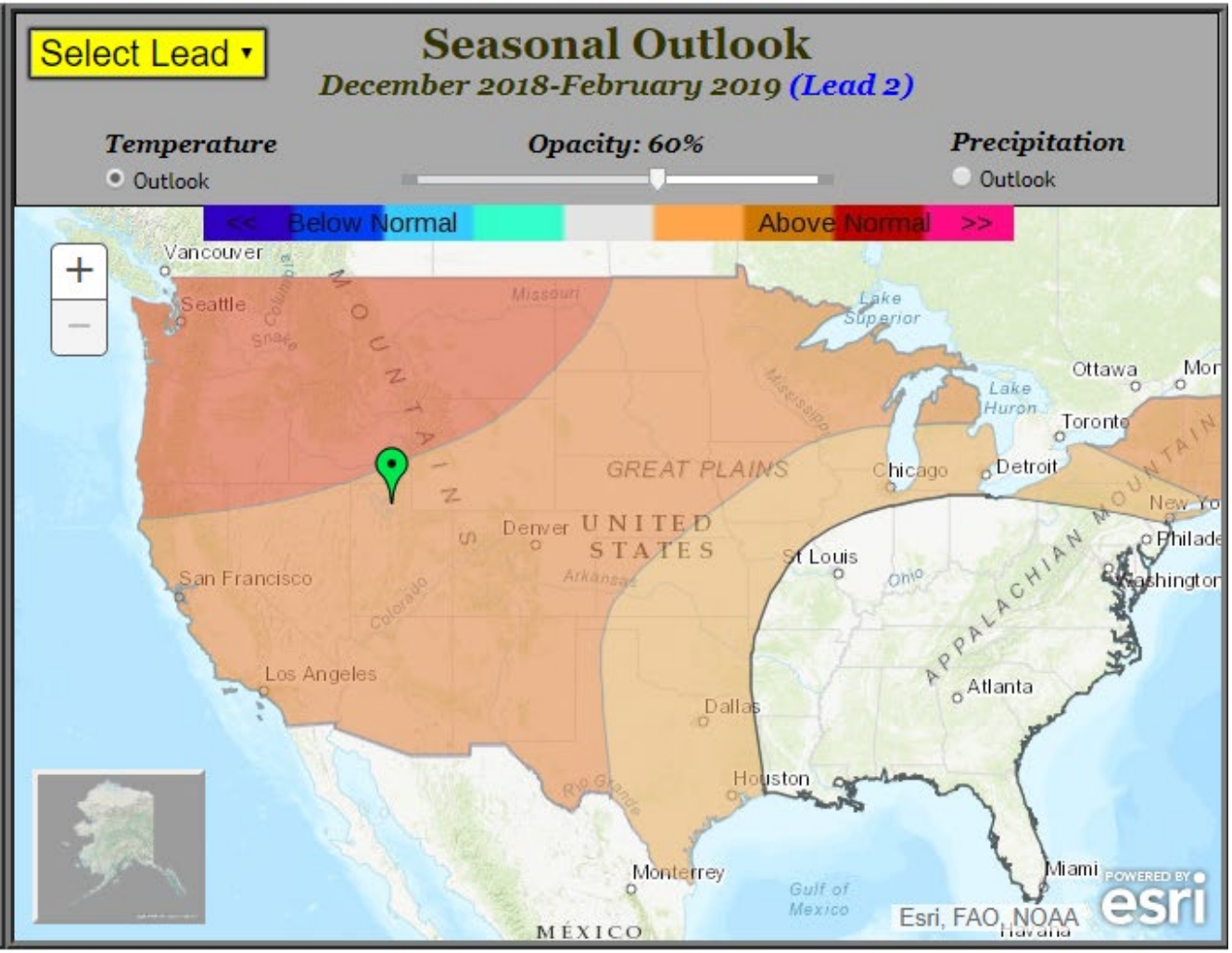
7 Day Forecast for Ogden, Utah

Three Category Temperature Outlook
Normal Maximum Temperature: **37**
Normal Minimum Temperature: **19**

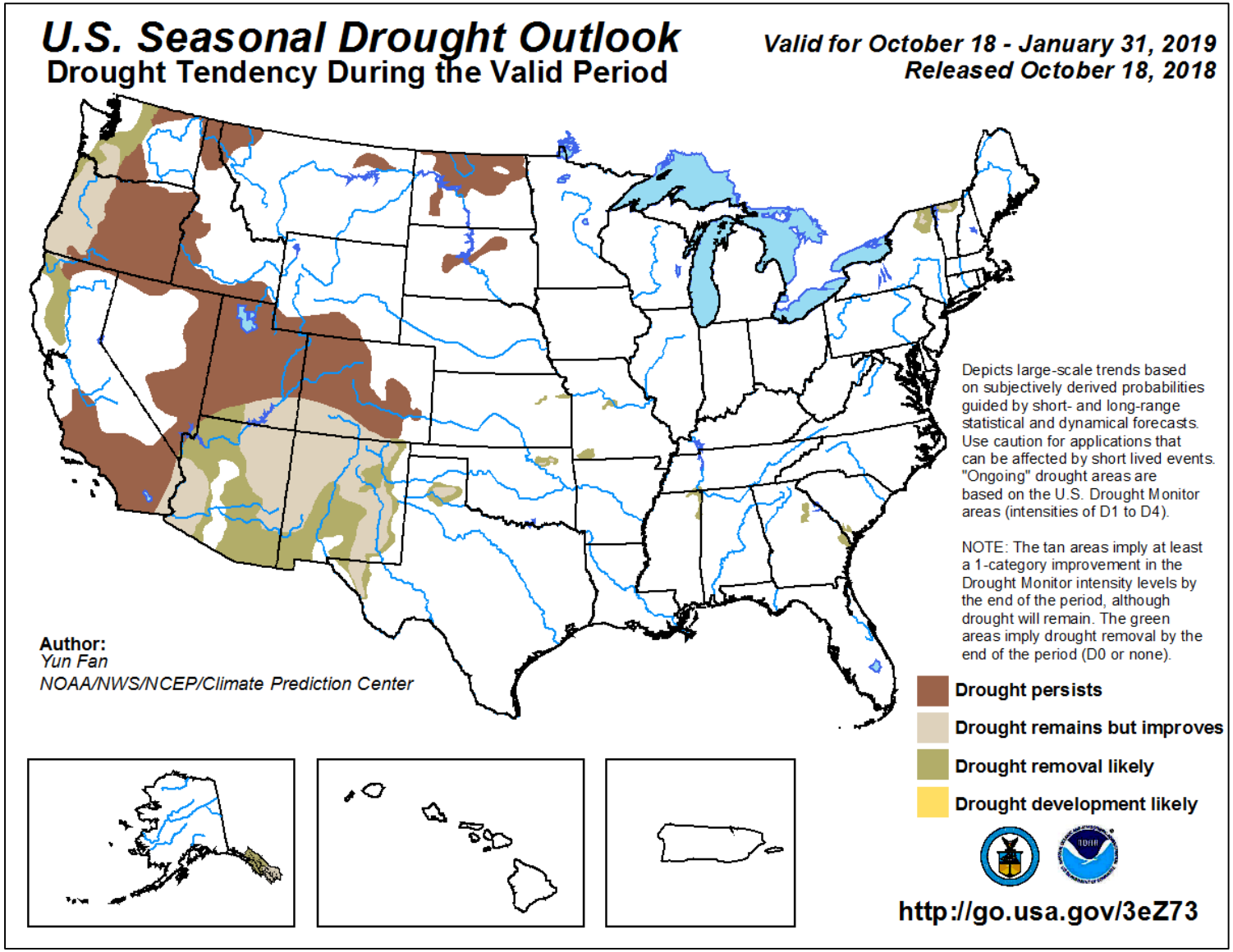


Three Category Precipitation Outlook
Normal Precipitation: **9.37**





What is the Seasonal Drought Outlook Telling Me?



Forecast tools

DYNAMICAL MODELS

- Global Forecast System (GFS) and ensembles
- European Centre for Medium-range Weather Forecasts (ECMWF) ensembles
- Canadian ensembles

STATISTICAL TOOLS (Downscaling)

- GEFS/ECWMF T, P – bias corrected/calibrated, using reforecasts
- NAEFS – Bias-corrected ensemble forecasts – T, P
- Consolidation – GEFS and ECMWF – Dynamic weighting of calib models
- GFS P, T – Dynamical model output– calibrated P, T
- Analog composites – Average T, P for the 10 best 500-hPa analogs
- Klein T – screening regression
- Tele-connections – Simultaneous, significant temporal correlations for two or more widely separated locations.

http://www.cpc.ncep.noaa.gov/products/predictions/90day/tools.html

Where does seasonal predictability come from?

- *Persistent or recurring atmospheric circulation patterns* associated with anomalies in
  - the initial state of the climate system, or
  - boundary conditions

- *El Niño and La Niña*: anomalous climate states whose development, persistence and evolution are somewhat understood

- Potentially persistent or recurring atmospheric circulation patterns that are less well understood: AO, NAO, PNA, AAO

- *Unidentified persistent atmospheric patterns* may arise from the initial state of the climate system or from boundary forcing

- *Decadal variability or trends*:
  1. Climate Change
  2. Anomalies in the large scale ocean circulation can vary over decadal timescales

     e.g. Atlantic Meridional Overturning (AMOC)

Factors Influencing a Climate Forecast

- **Climate Change - trends**

- **Natural Climate Variability – "organizes" weather**
  El Niño-Southern Oscillation (ENSO)
  Mid-latitude Oscillation modes (NAO, AO, PNA, …)
  Land Surface Processes (Soil moisture, Snow cover, …)

- **Atmospheric Noise -** unpredictable "climate" signals produced by chance through cumulative effects of weather. This is large in middle latitudes, small in the Tropics. Major cause of *"uncertainty"* in forecasts, and especially true during ENSO-neutral conditions and Northern Hemisphere summer (convection, tropical systems).

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;

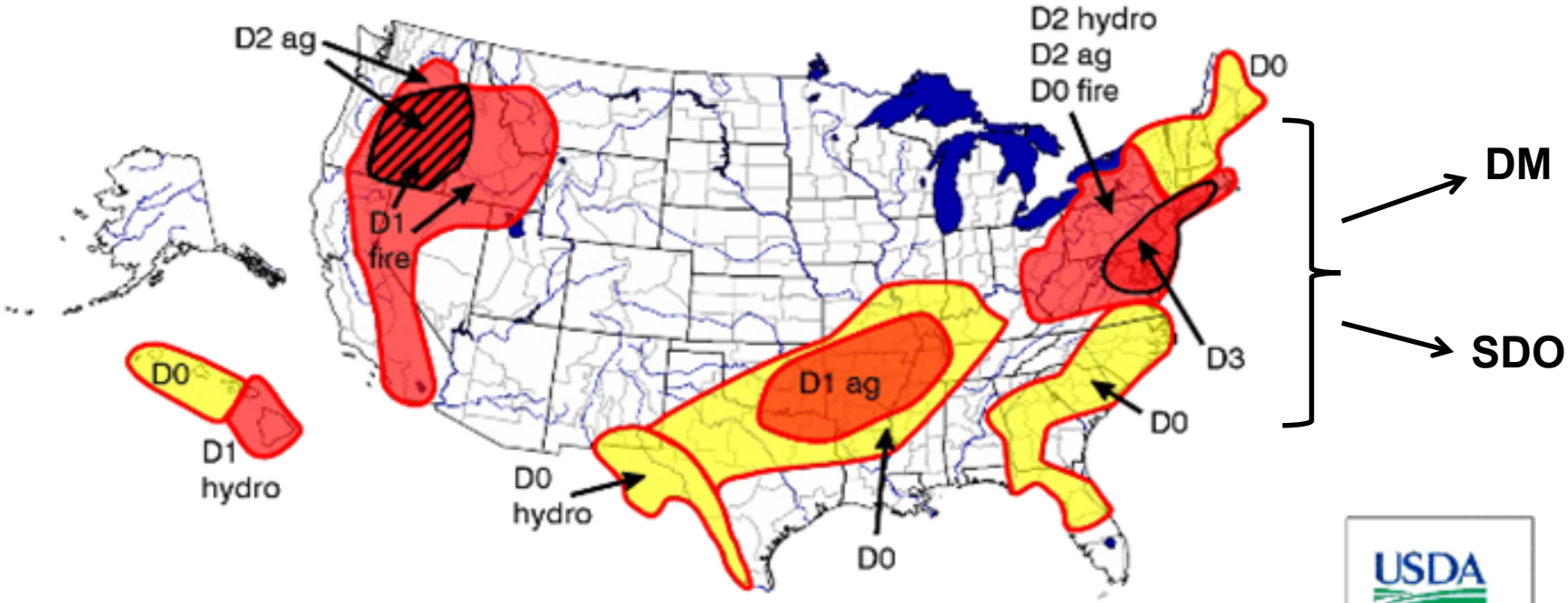
- Replaced updated SDO (released 1st Thursday of next month) with new MDO (released last day of month) starting July 2013;

- 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

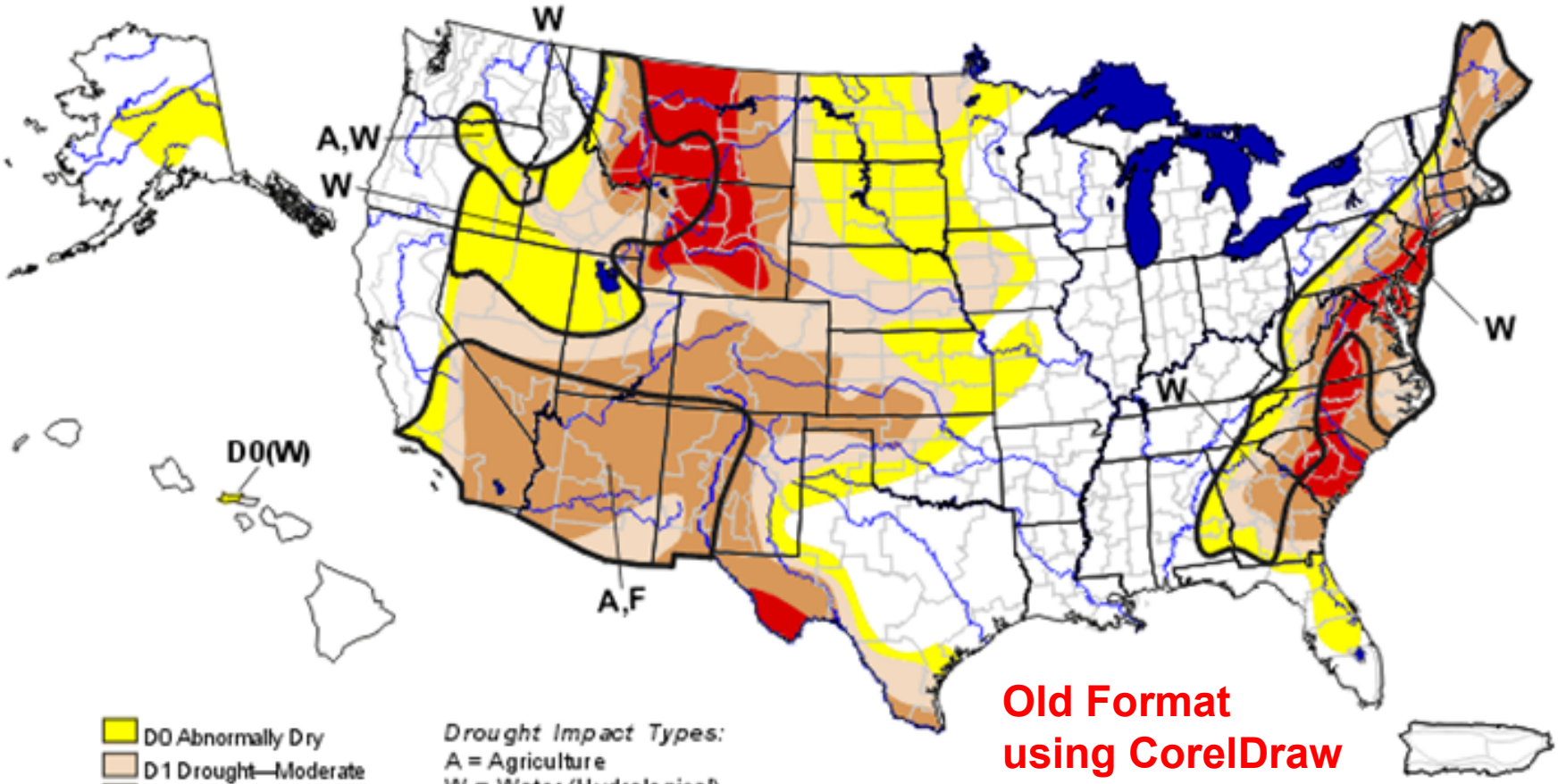
Drought type: Used when impacts differ
- Ag = agricultural (crops, grasslands)
- Fire = forestry (wildfire potential)
- Hydro = hydrological (rivers, wells, reservoirs)

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

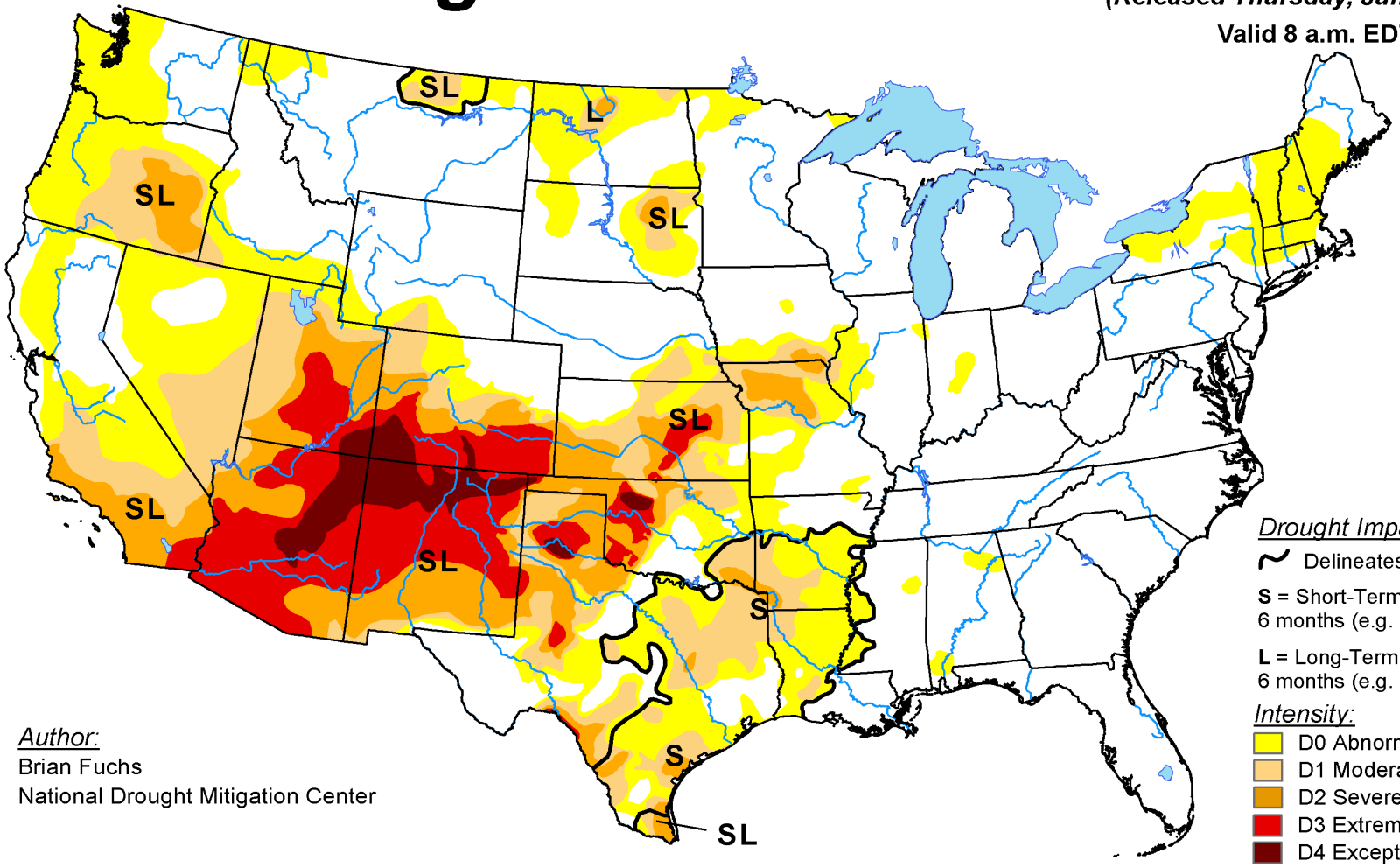
Author: *David Miskus, JAWF/CPC/NOAA*

U.S. Drought Monitor

June 19, 2018

(Released Thursday, Jun. 21, 2018)

Valid 8 a.m. EDT



Drought Impact Types:

Delineates dominant impacts

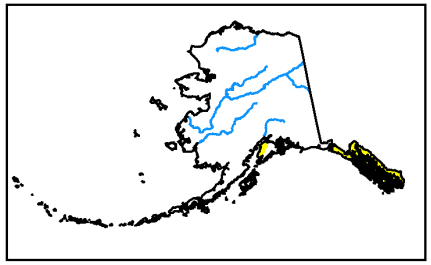
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

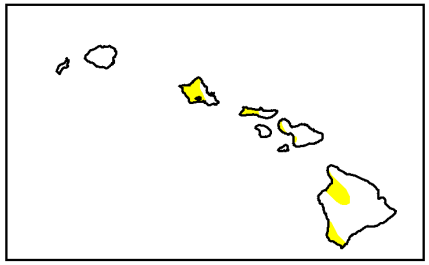
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

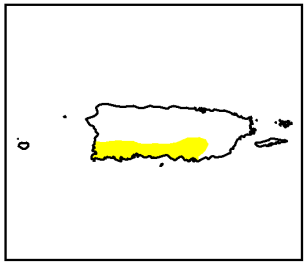
Intensity:

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

Author:
Brian Fuchs
National Drought Mitigation Center







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

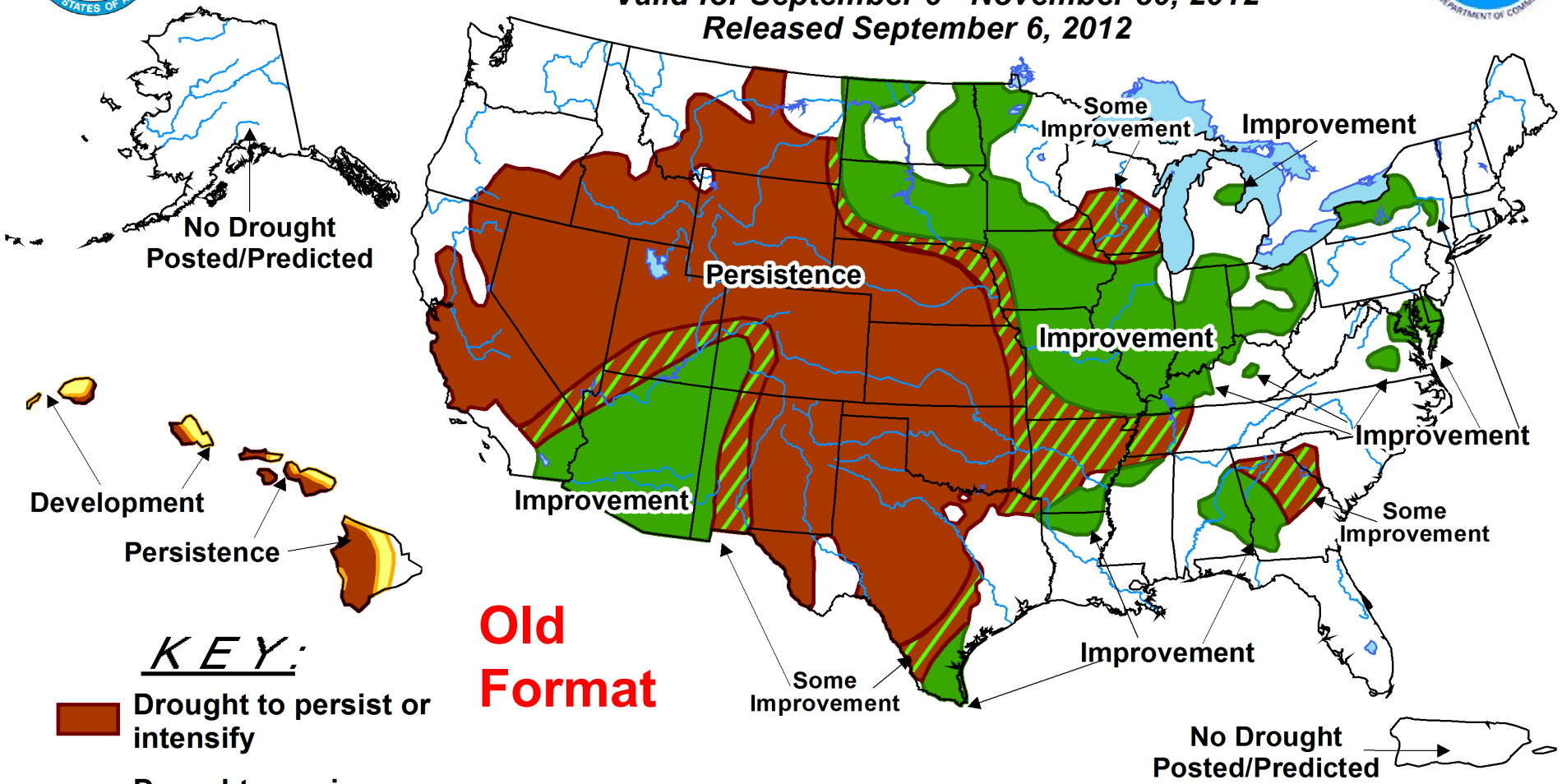
http://droughtmonitor.unl.edu/

U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid for September 6 - November 30, 2012

Released September 6, 2012



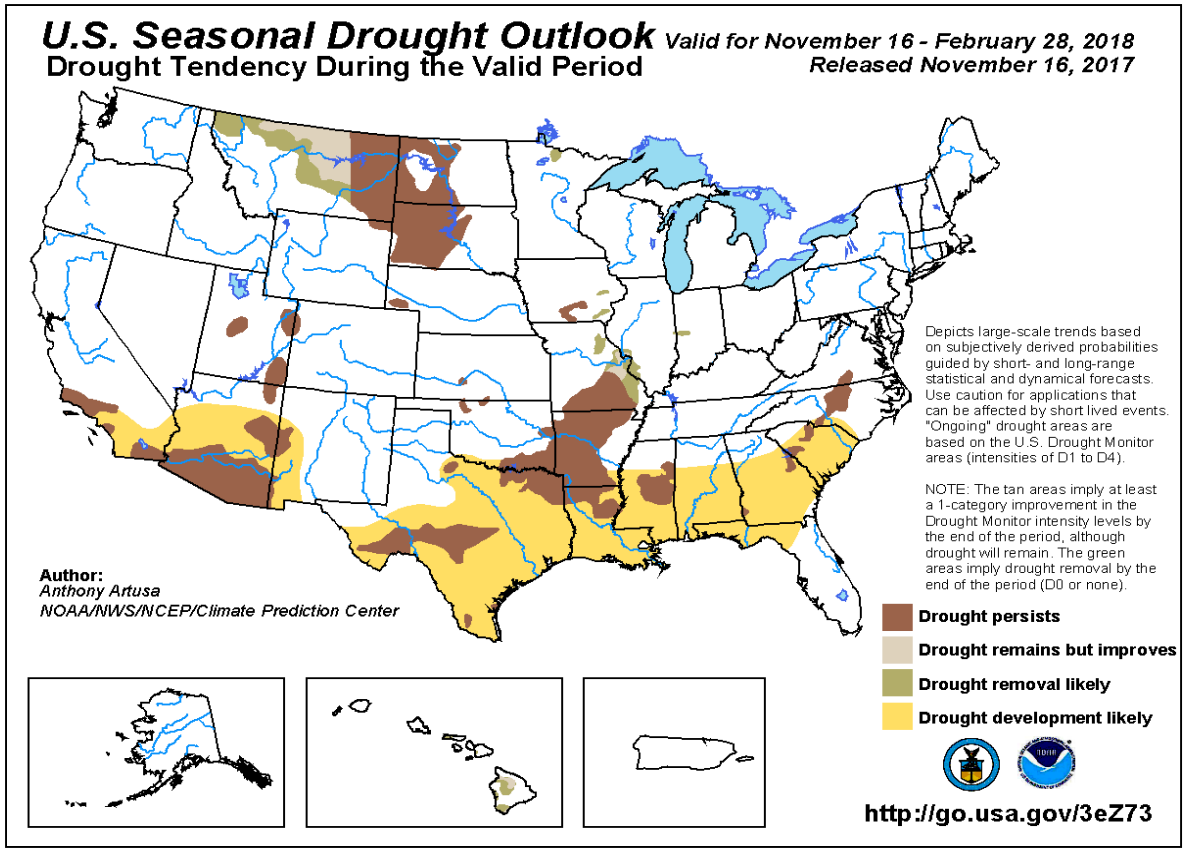
Old Format

KEY:

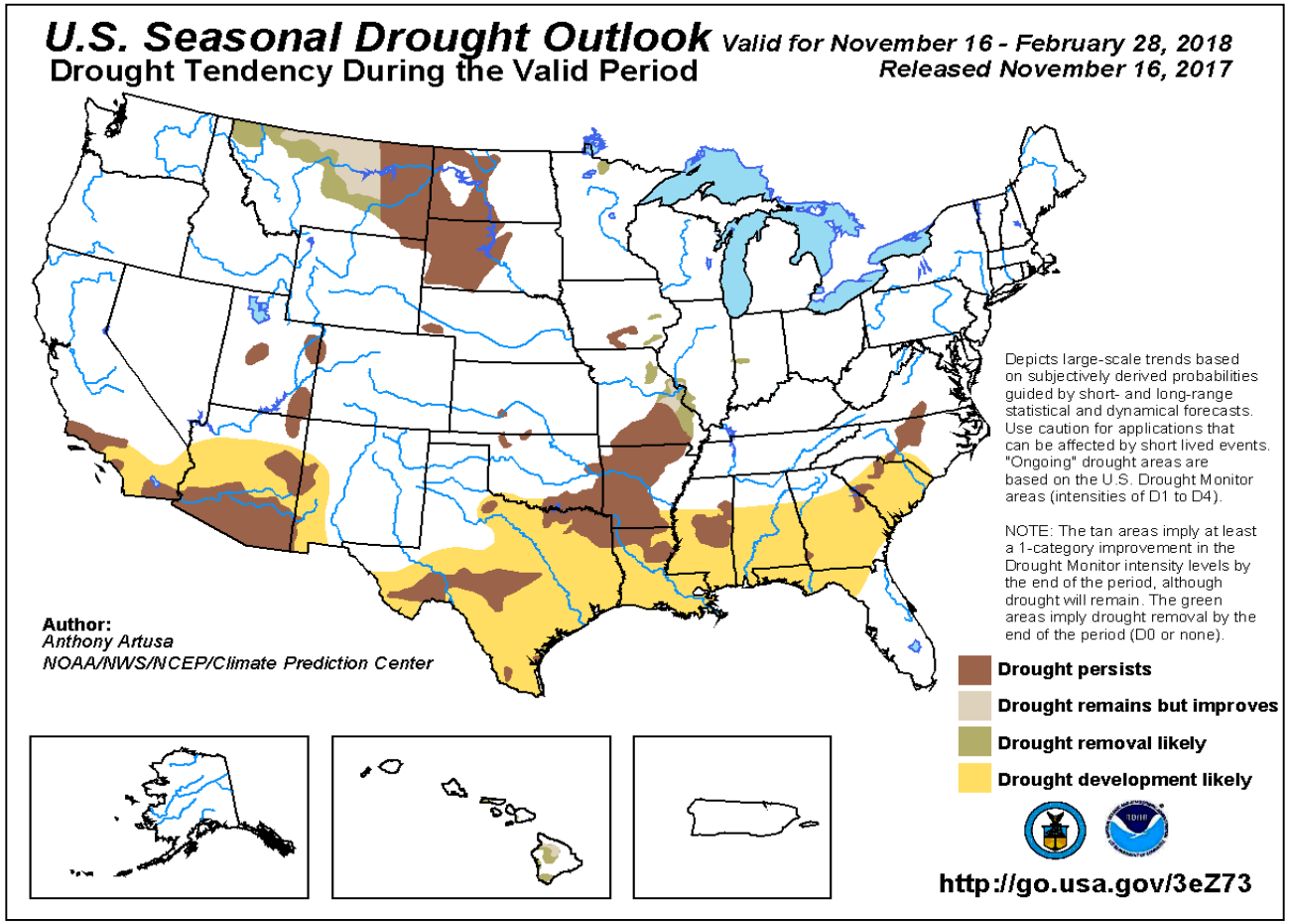
- Drought to persist or intensify
- Drought ongoing, some improvement
- Drought likely to improve, impacts ease
- Drought development likely

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.

Drought Outlook Process



Drought Forecasting: Many Different Contributions (Tools)



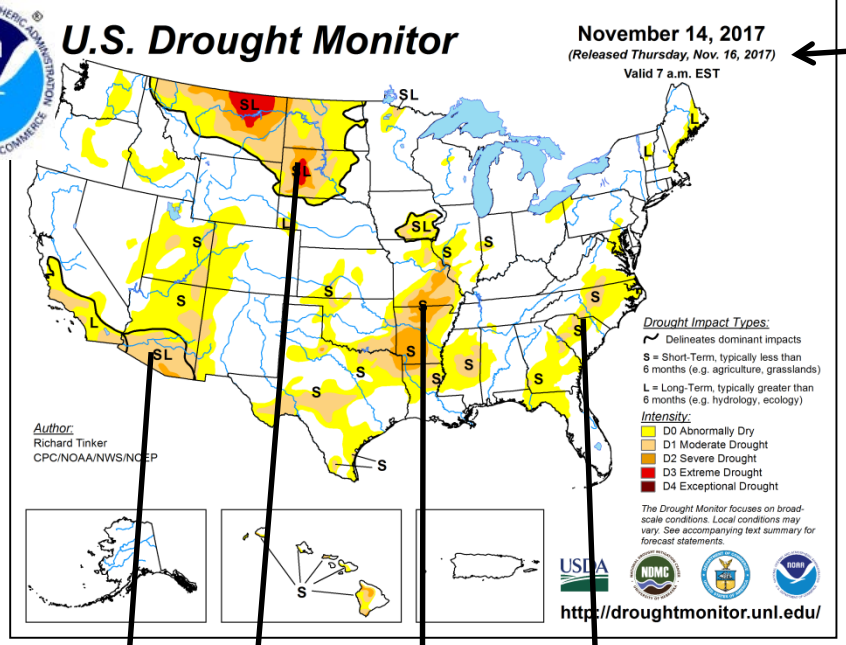
Start with latest U.S. Drought Monitor D1 areas

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

Climatologies And Analogs

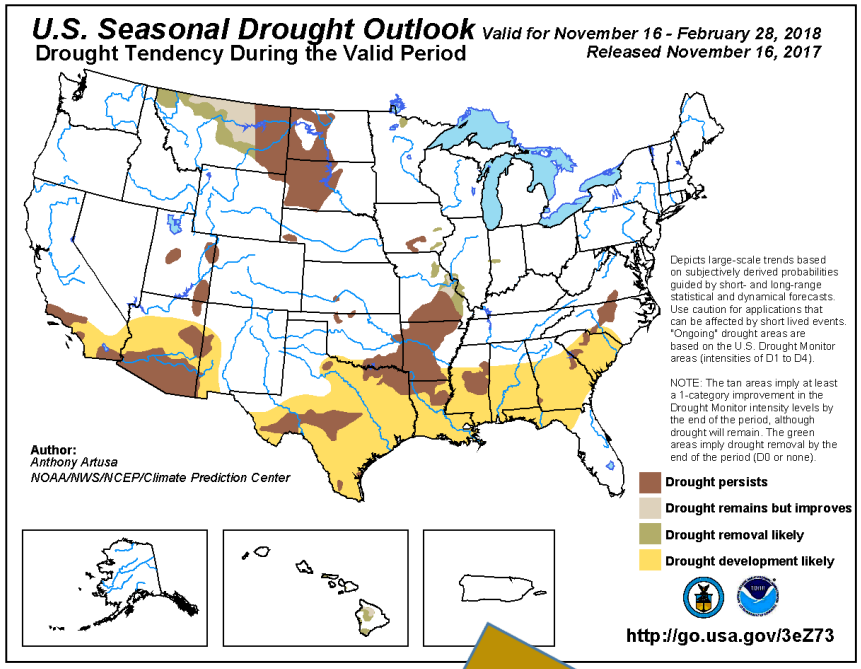
Long-Range Forecasts: (1- to 3-Months)

(Note ENSO Status & Other Atmospheric/Oceanic Indicators)

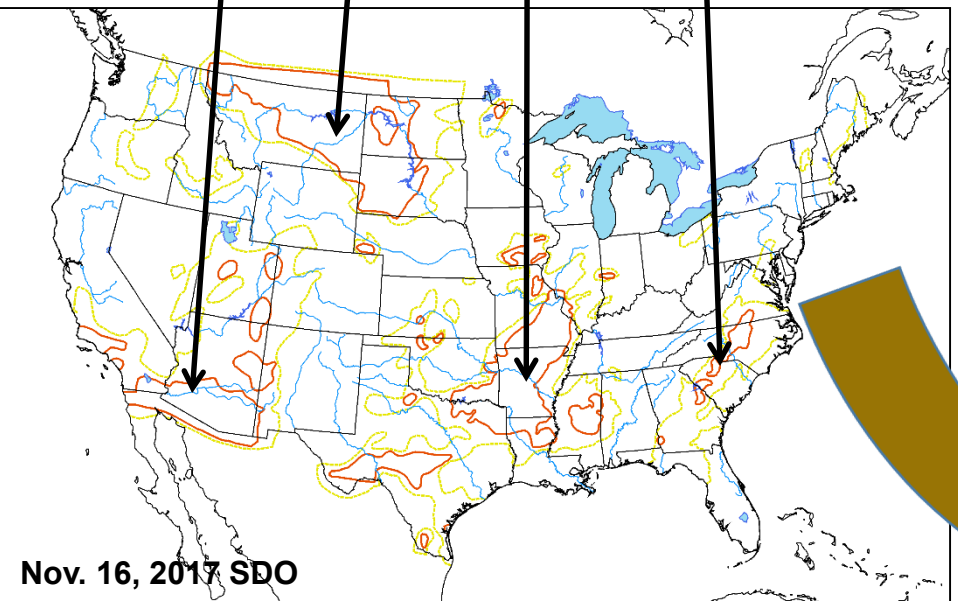


Start with 11/14/17 US Drought Monitor

Initial D17JF18
Seasonal Drought Outlook
(released Nov. 16)



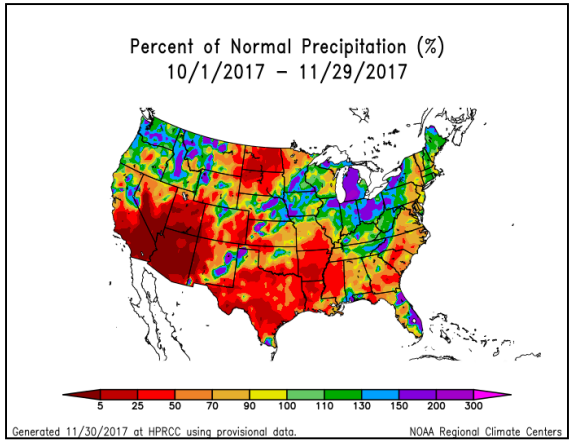
Use the latest U.S. Drought Monitor
D0 *&* ***D1*** *shape file areas*

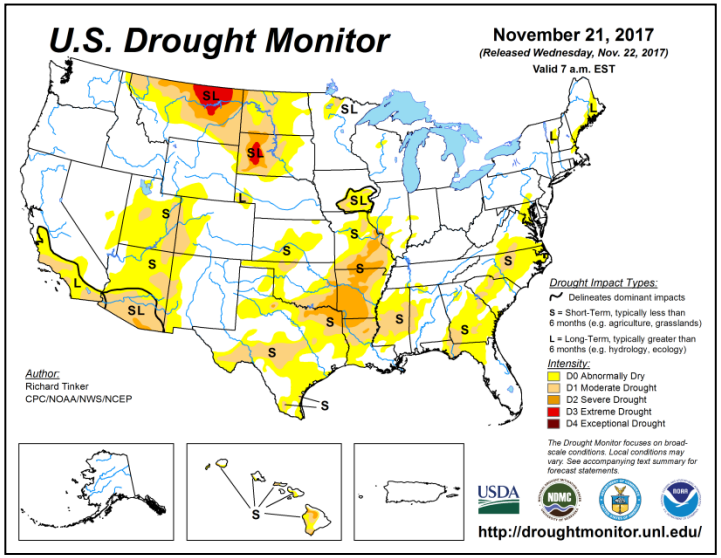


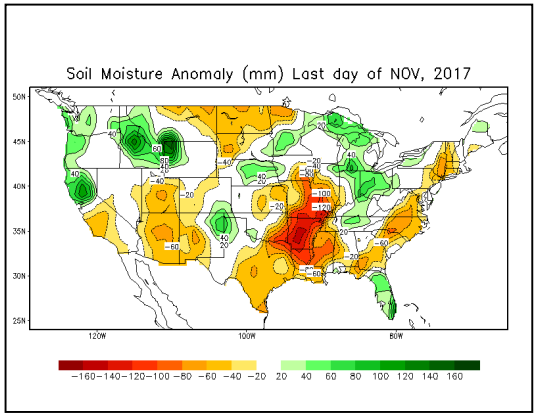
Nov. 16, 2017 SDO

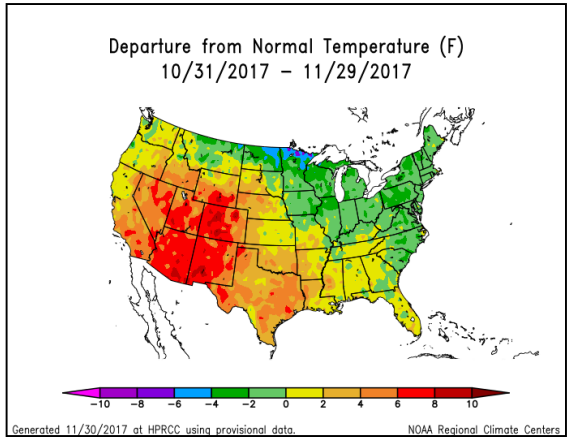
From Tools - Determine if D1-D4 areas will: ***Persist****,* ***Improve****, or be* ***Removed****;*
and if D0 & normal areas will ***Develop***

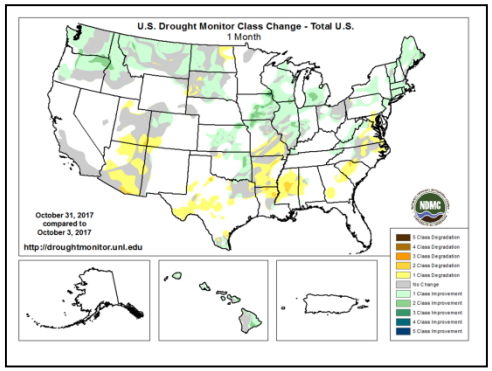
Drought Outlook: Start with Current DM Conditions

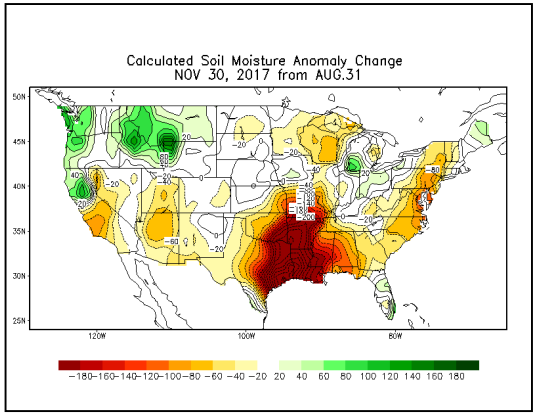


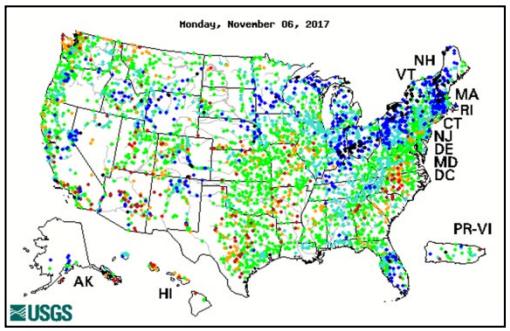


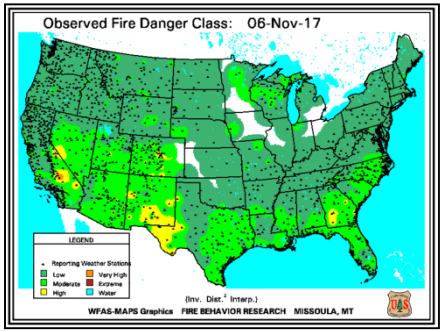


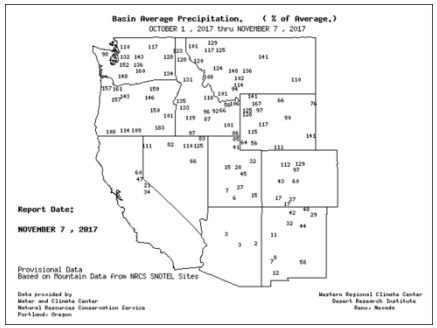


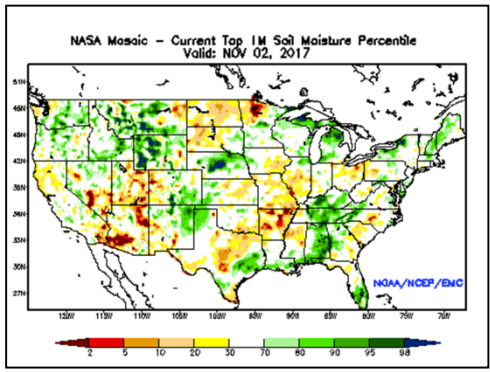




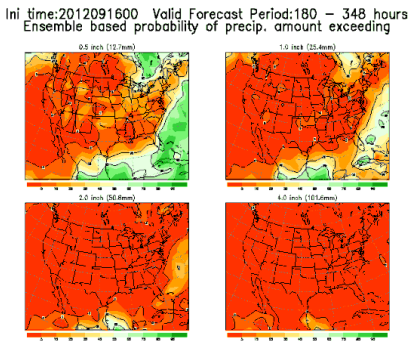


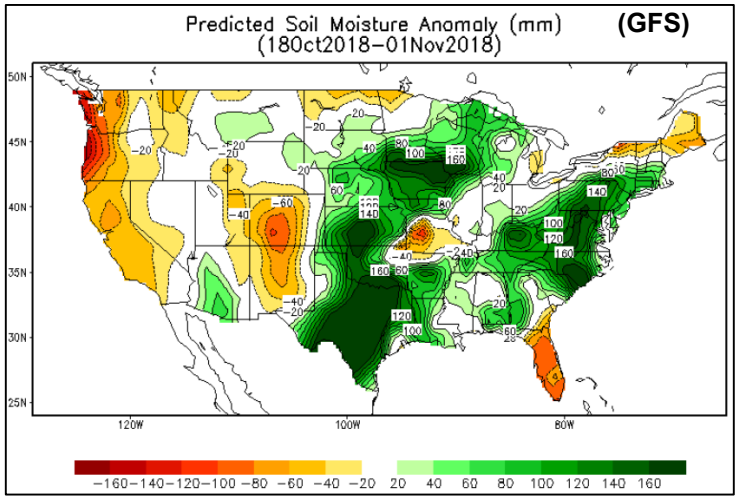


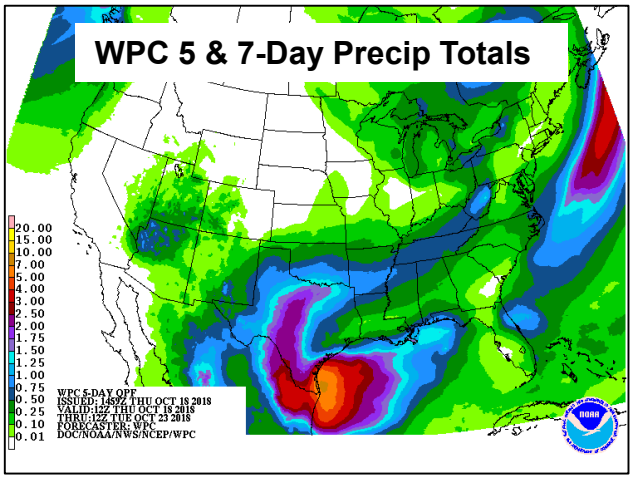


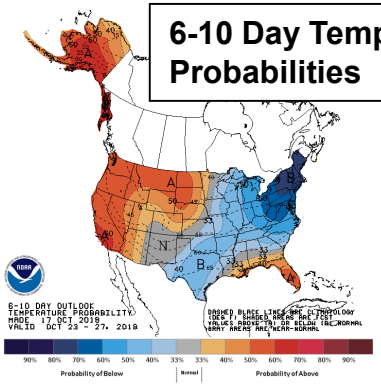


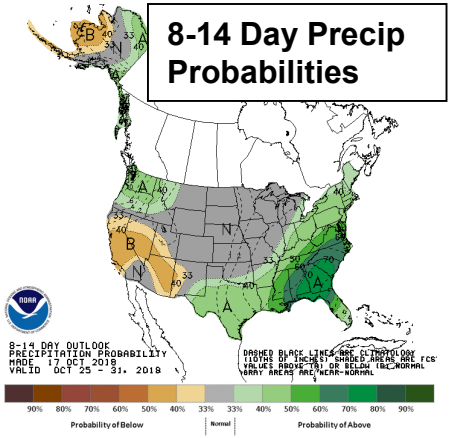
Primary Drought Outlook Inputs – Short Term

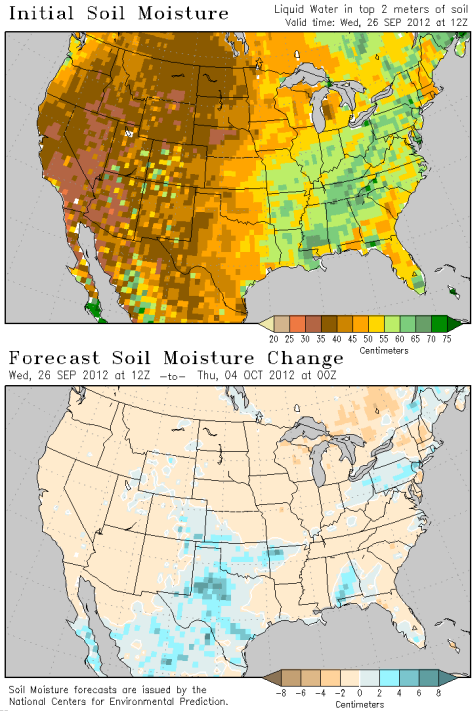


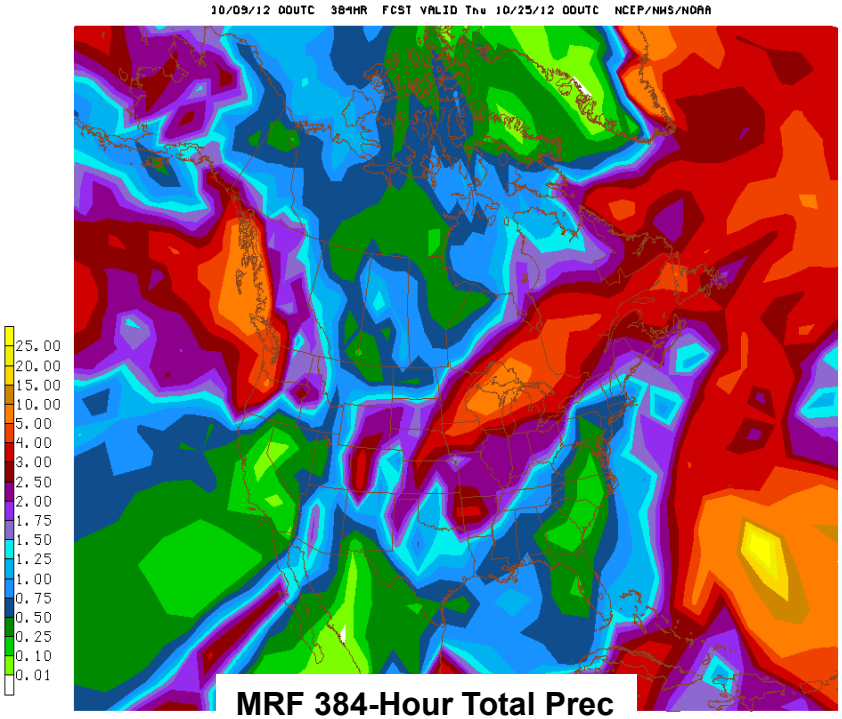




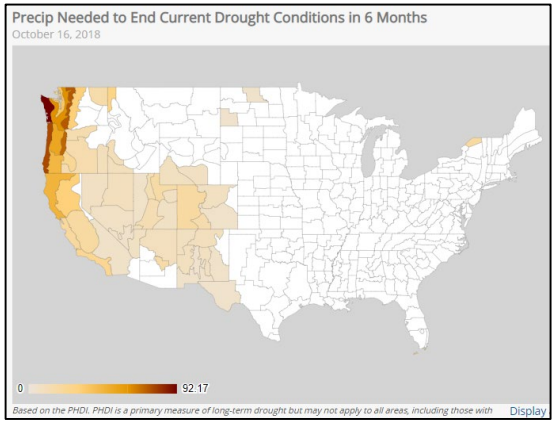


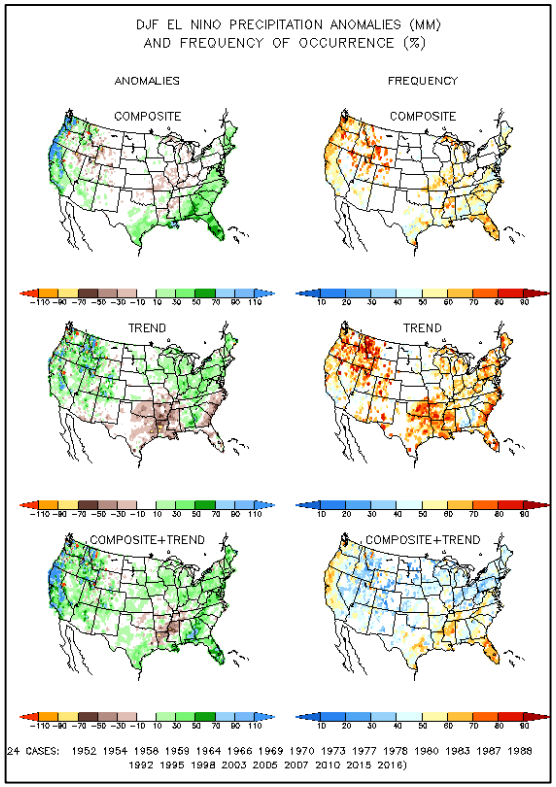


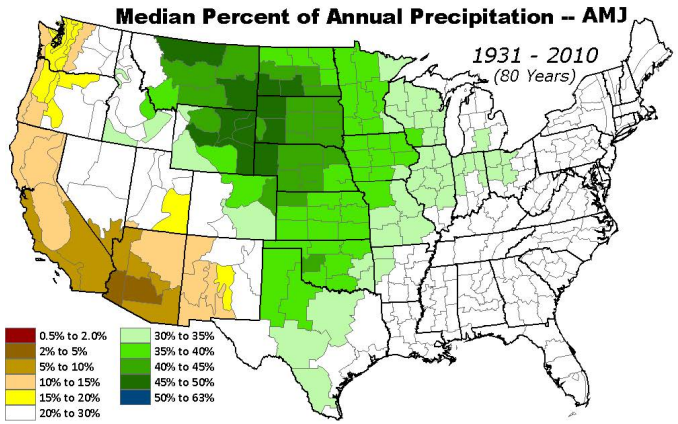


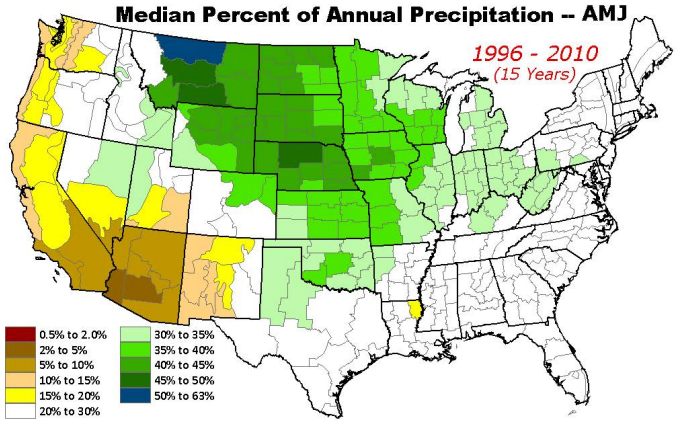


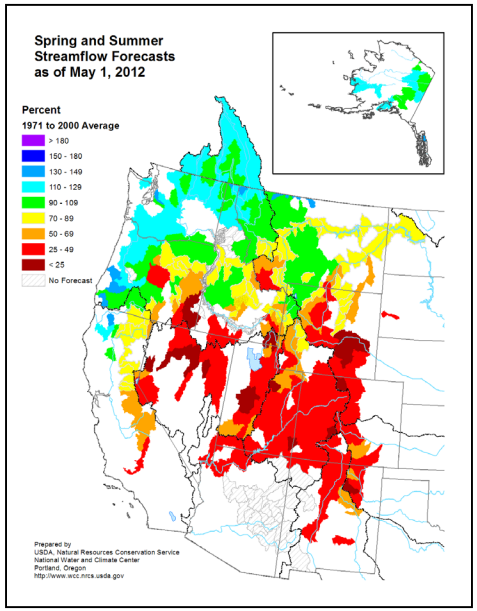
Primary Drought Outlook Inputs – Climatology & Analogs



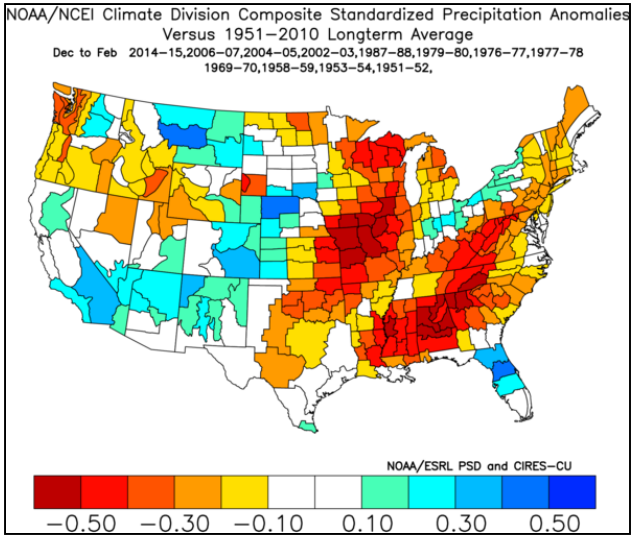




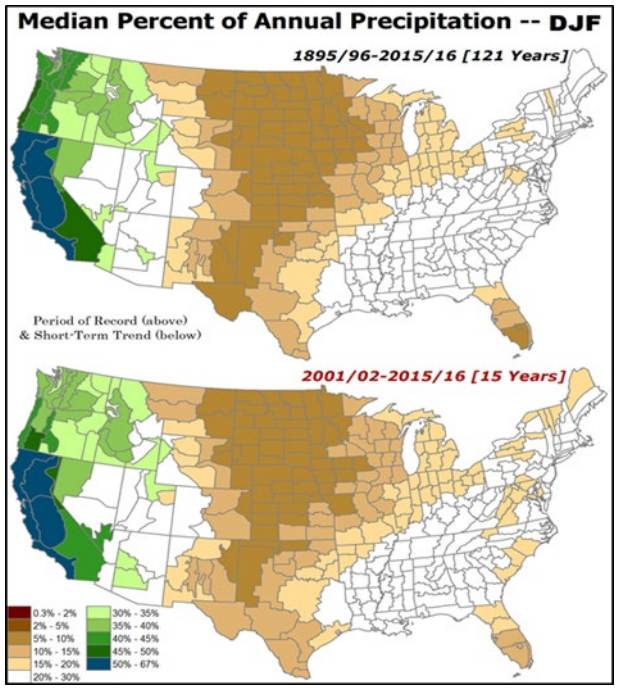


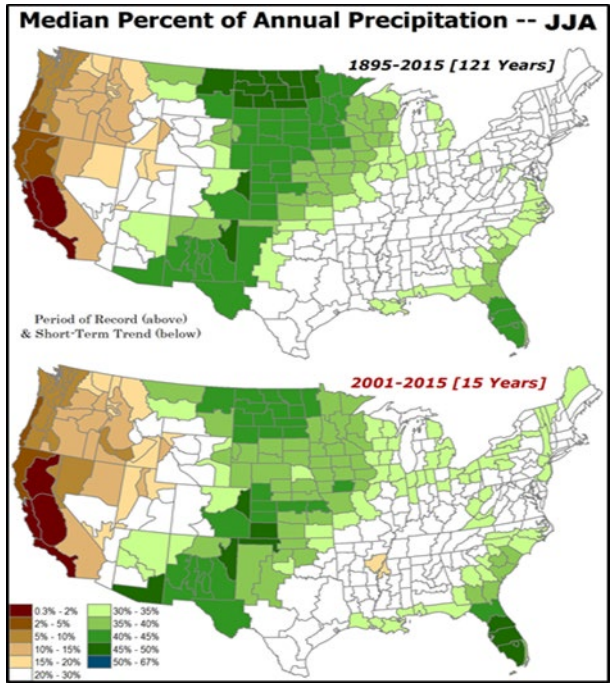


Weak El Nino Cases
1950-2010 Base Period



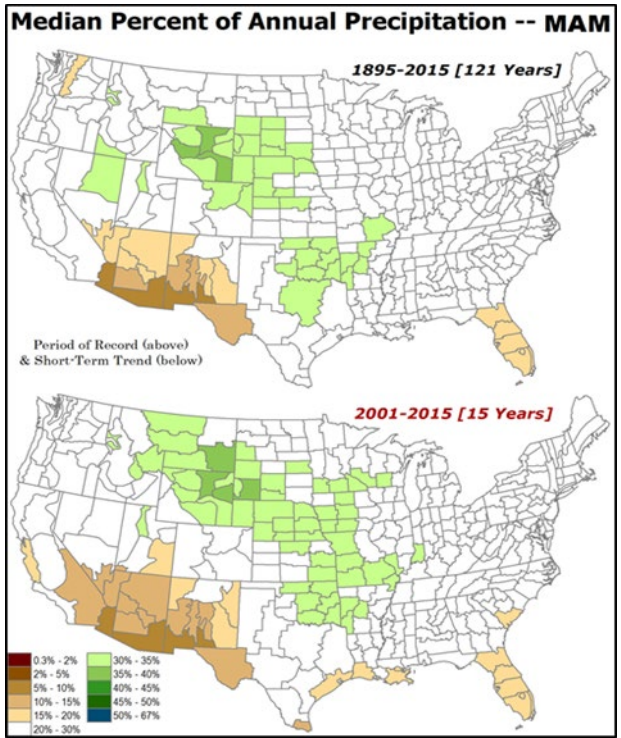
Winter
DJF

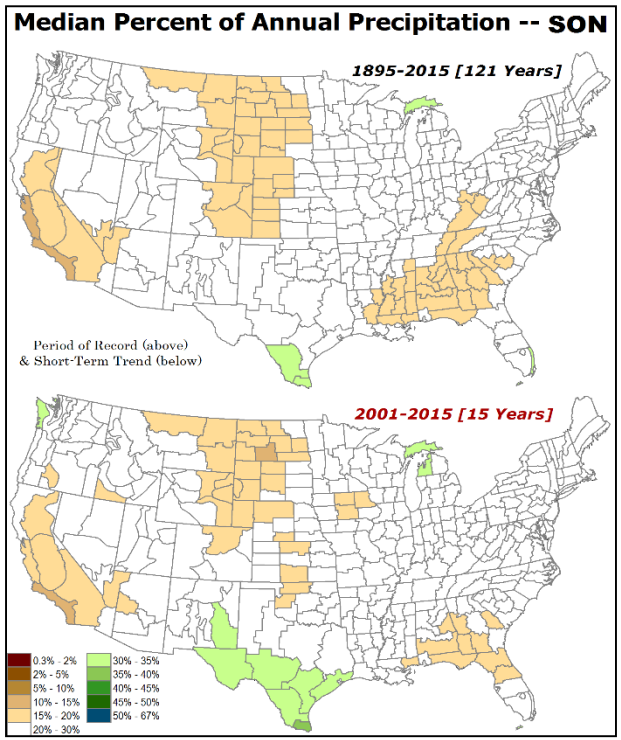




Summer
JJA

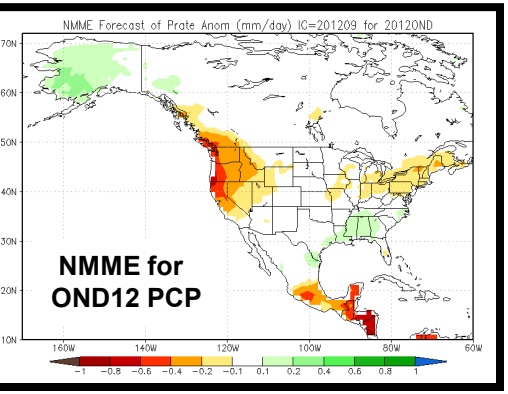
Spring
MAM

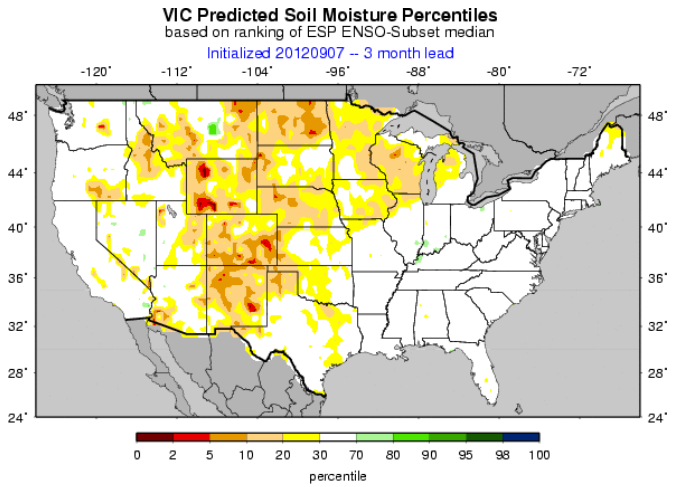


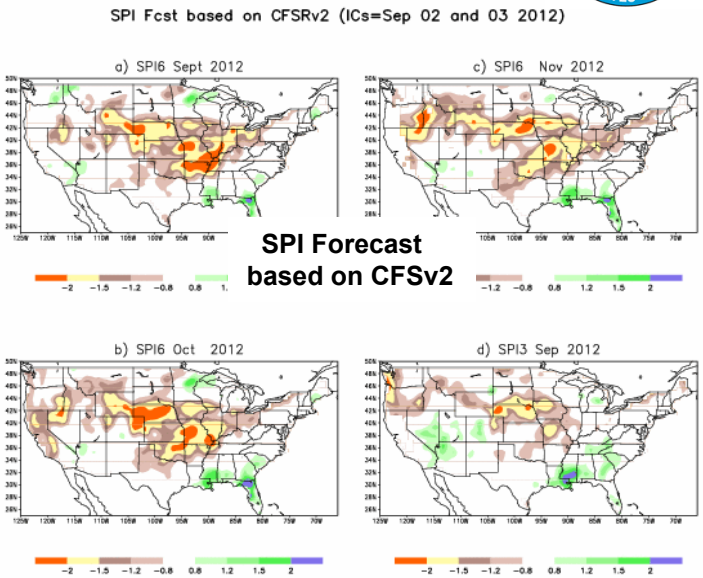


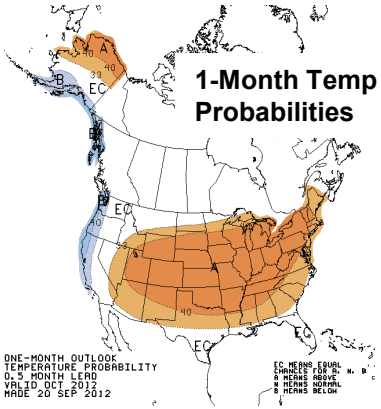
Fall
SON

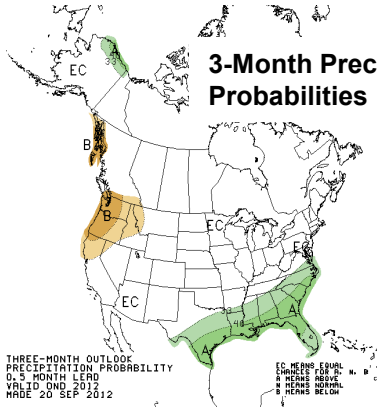
Primary Drought Outlook Inputs – Long Term

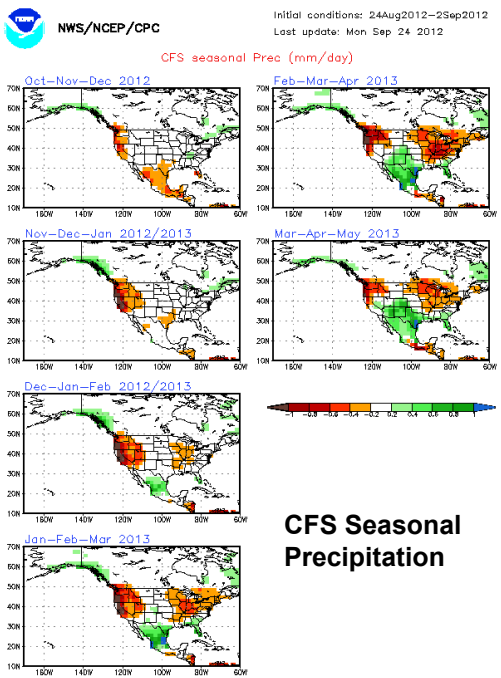


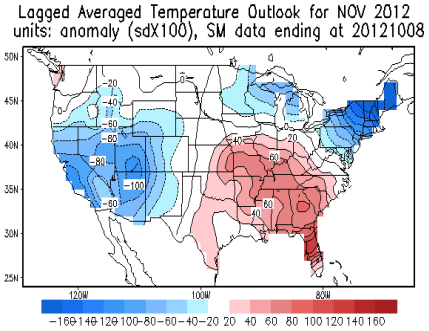


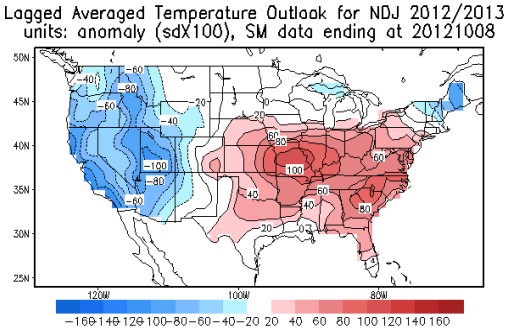


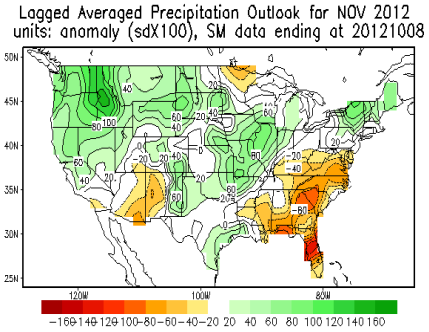


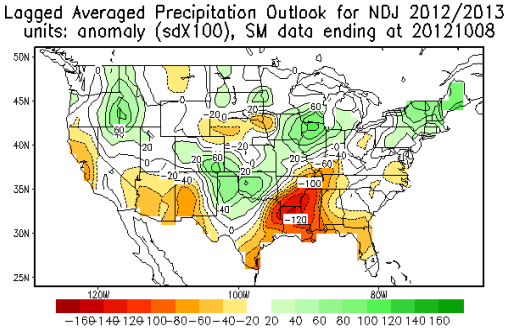












Drought Outlook Production

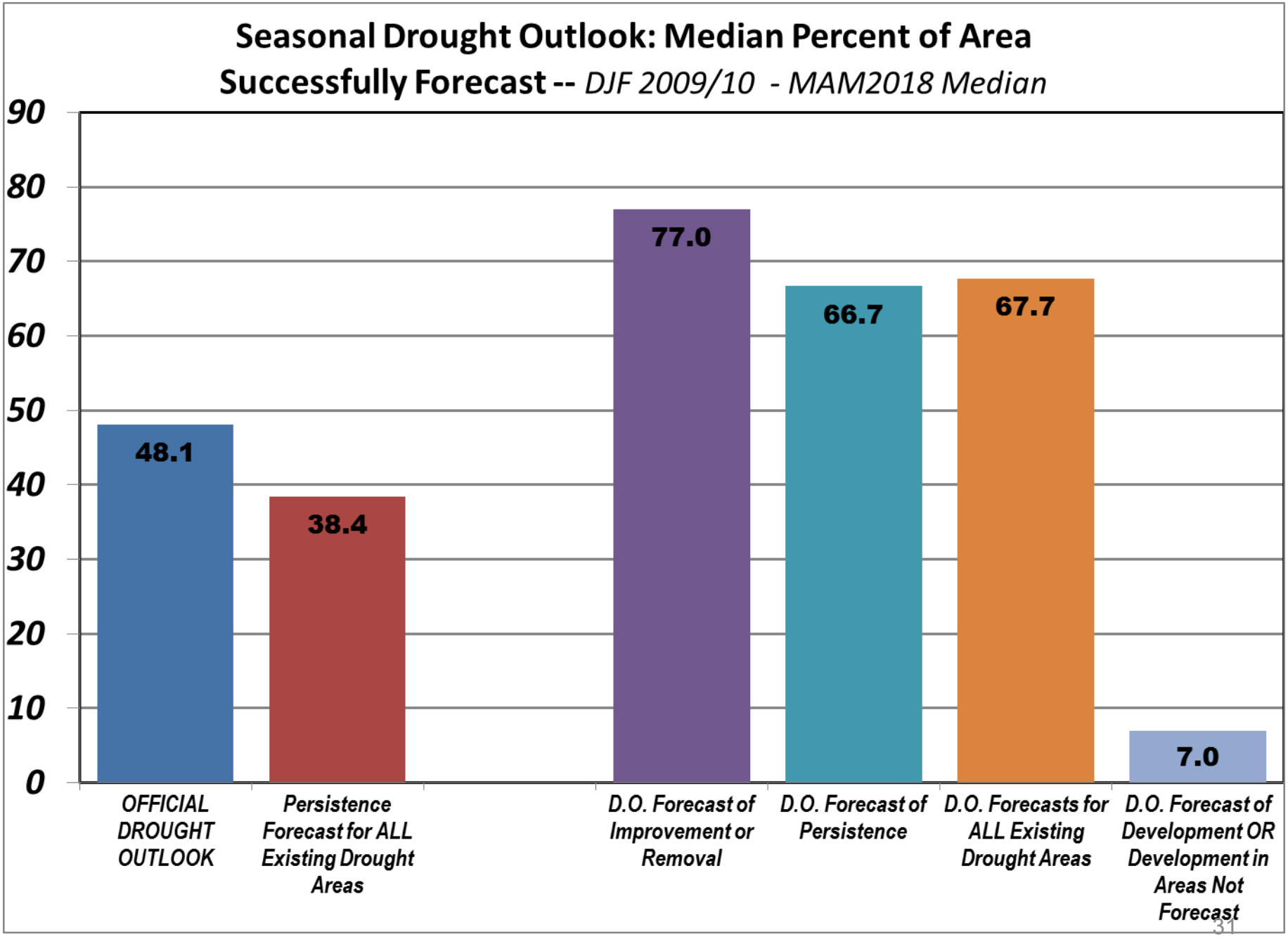
Seasonal Drought Outlook (SDO): Produced in conjunction with seasonal temperature and precipitation outlooks (released 3rd Thursday of month).

Monthly Drought Outlook (MDO): Produced in conjunction with updated 1-Month forecast (released 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 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 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.**

How Are We Doing?

Verifications….

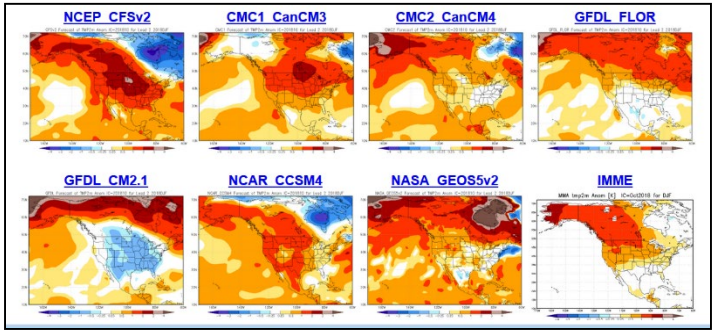

Seasonal Drought Outlook: Median Percent of Area Successfully Forecast -- DJF 2009/10 - MAM2018 Median
90
80
70
60
50
40
30
20
10
0
48.1
38.4
77.0
66.7
67.7
7.0
OFFICIAL DROUGHT OUTLOOK
Persistence Forecast for ALL Existing Drought Areas
D.O. Forecast of Improvement or Removal
D.O. Forecast of Persistence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

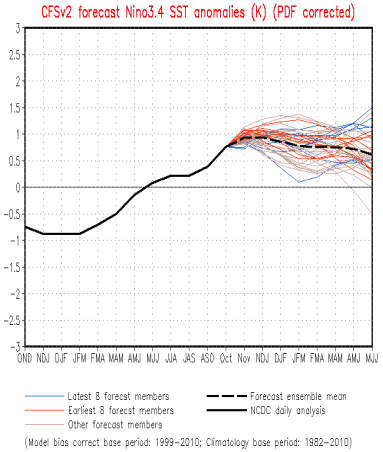
Skill of the Outlooks

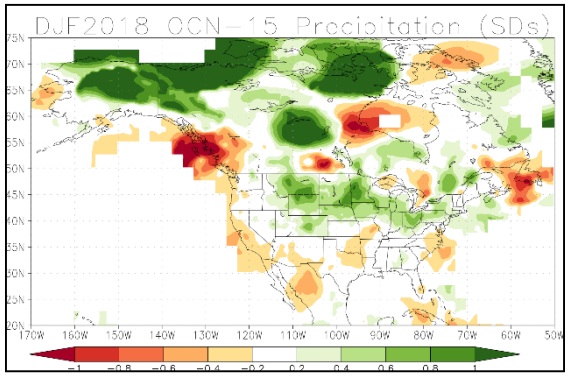
- **Skill in the outlooks comes from:**
  - **The Trend**
  - **Opportunities like El Nino/La Nina**
  - **Shorter term forecasts (Monthly outlooks)**

- **Skill is better in the winter seasons - not as good in the summer**

- **Models and Tools continue to improve!**







Drought Outlook Challenges

- **Blending short-term forecasts (most skillful) with seasonal forecasts;**
- **Improving outlook skill (especially precipitation) at all time ranges;**
- **Automating production & verification *(getting there!);***
- **Although there are many quantitative & objective inputs into the Drought Outlook process, ultimately the forecast is produced subjectively by humans with varying decision styles – similar to DM;**
- ***Providing decision makers with the information they need.* CPC has not formally surveyed DO users yet, but from DO meetings, emails, etc.**
  - **Agriculture community would like both short & long-term DOs for current season crops (e.g. MDO) & planning for next year.**
  - **Hydrology community 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 = 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)?;**

Next Steps in Drought Forecasting

Short-Term:

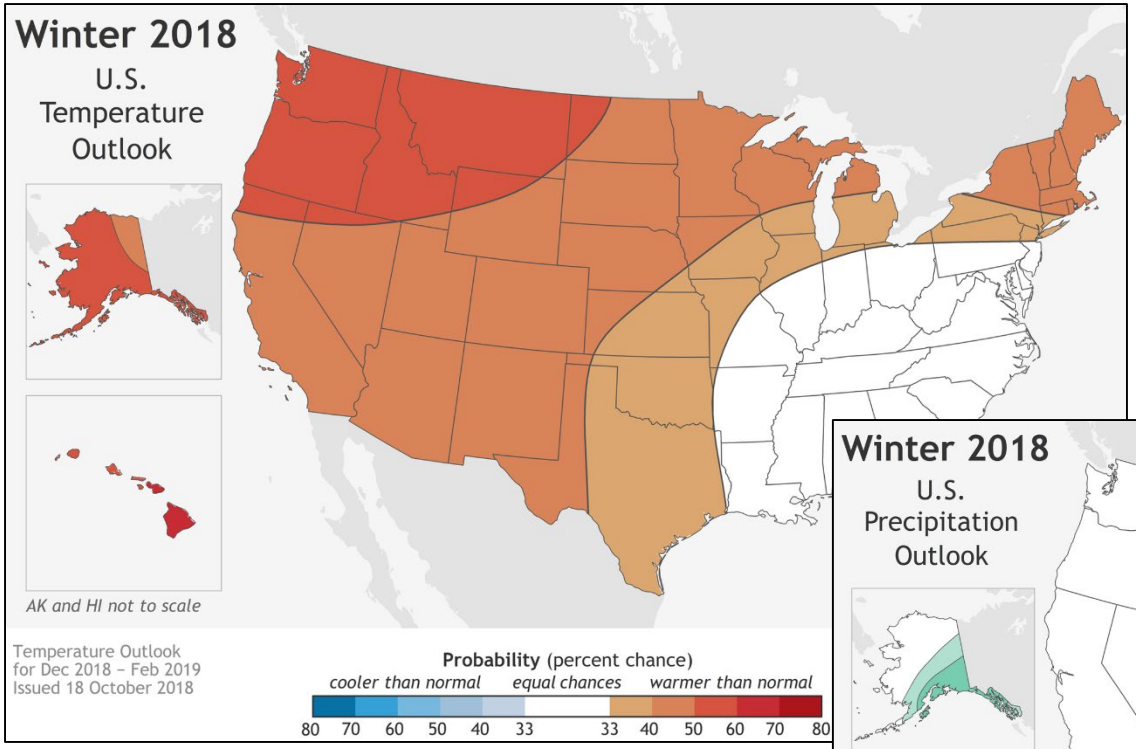
- **More GIS automation to objectify DO (like DM) - *ongoing;***
- **Real-Time DO Verification: Make more objective & automated; consider scoring persistence as "correct"; average weekly DM drought over forecast period since one anomalous week can completely make or break a DO forecast;**
- **Ongoing CPC Monthly Drought Working Group (DWG) brings operational (OPB) and R&D (OMB) staff together to learn from & communicate more with each other to improve operational drought forecasting (*better communication really does help*);**

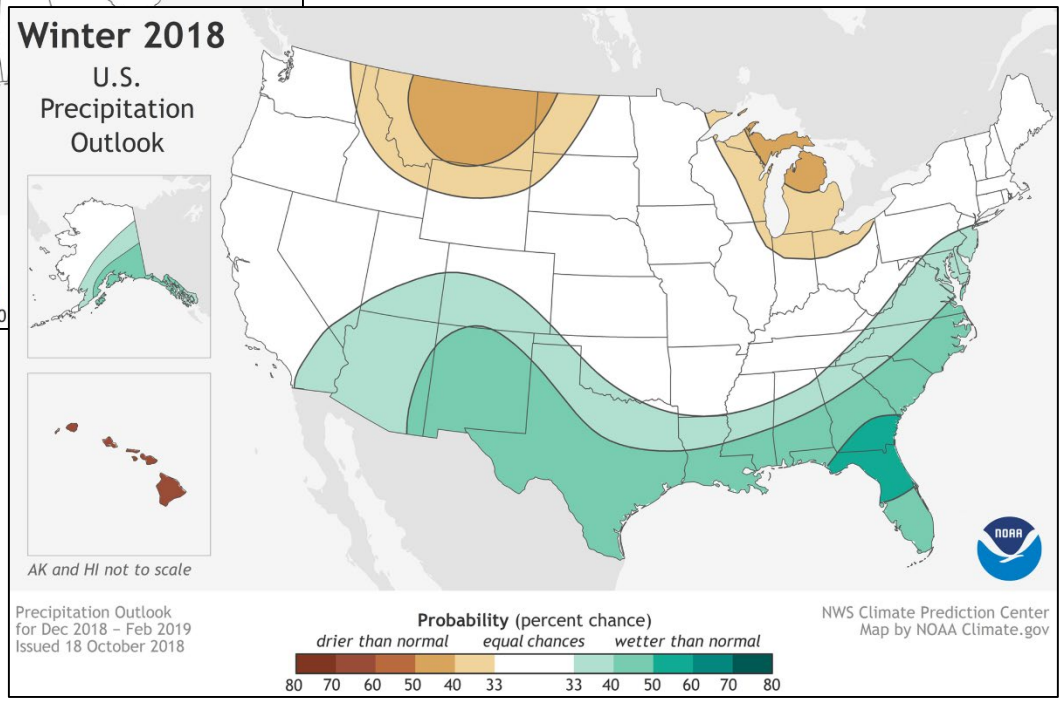
Long-Term:

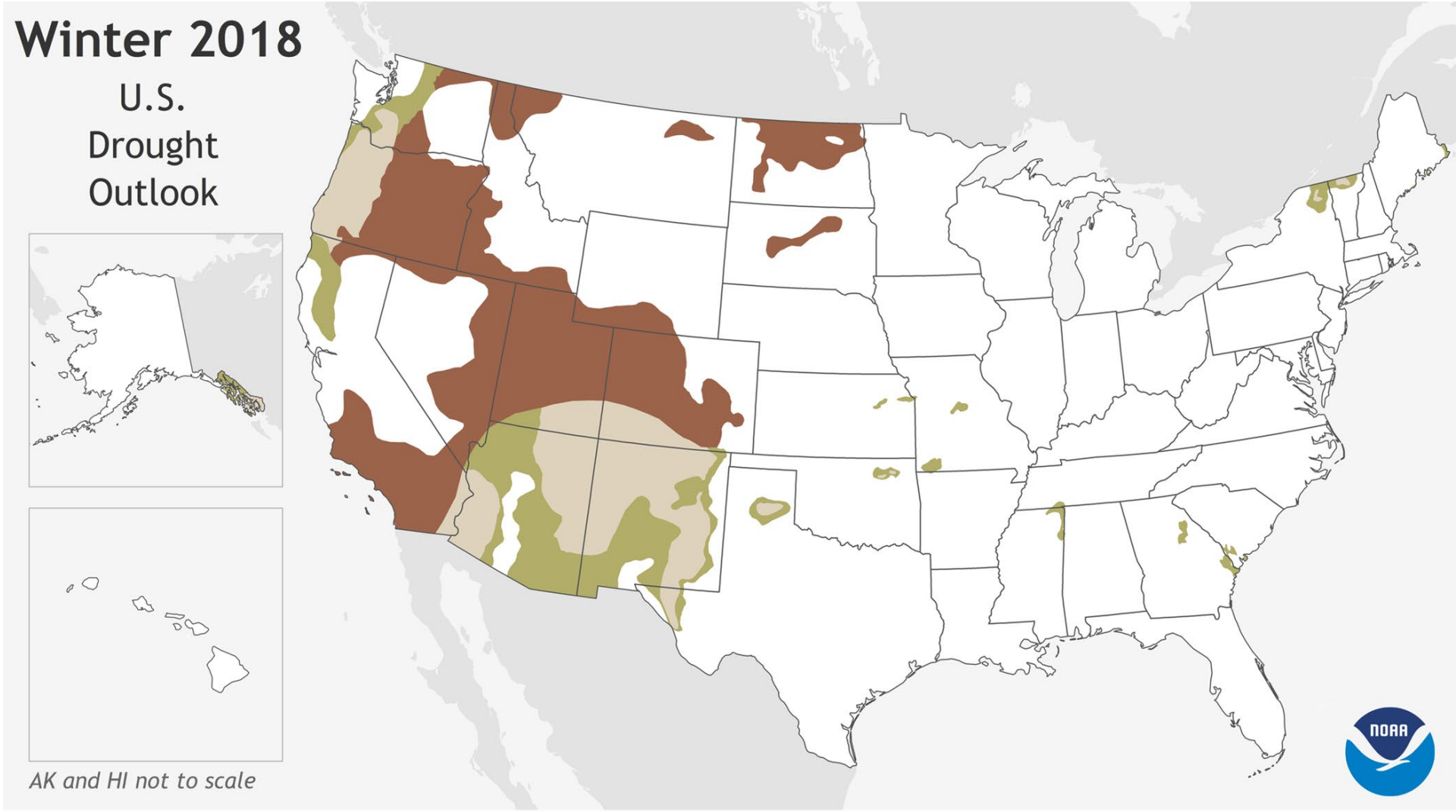
- **Develop a R2O plan for long-term improvement of DO: Improvement of Precipitation forecasts in the models is highest priority; Integration of Temperatures, Precipitation, and Soil Moisture Forecasts ;**
- **Engage the drought community for ideas on improving the DO (survey): Comparison of the (subjective) 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 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);***

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Current Outlooks







Drought Outlook
valid through Jan 2019
Issued 18 Oct 2018

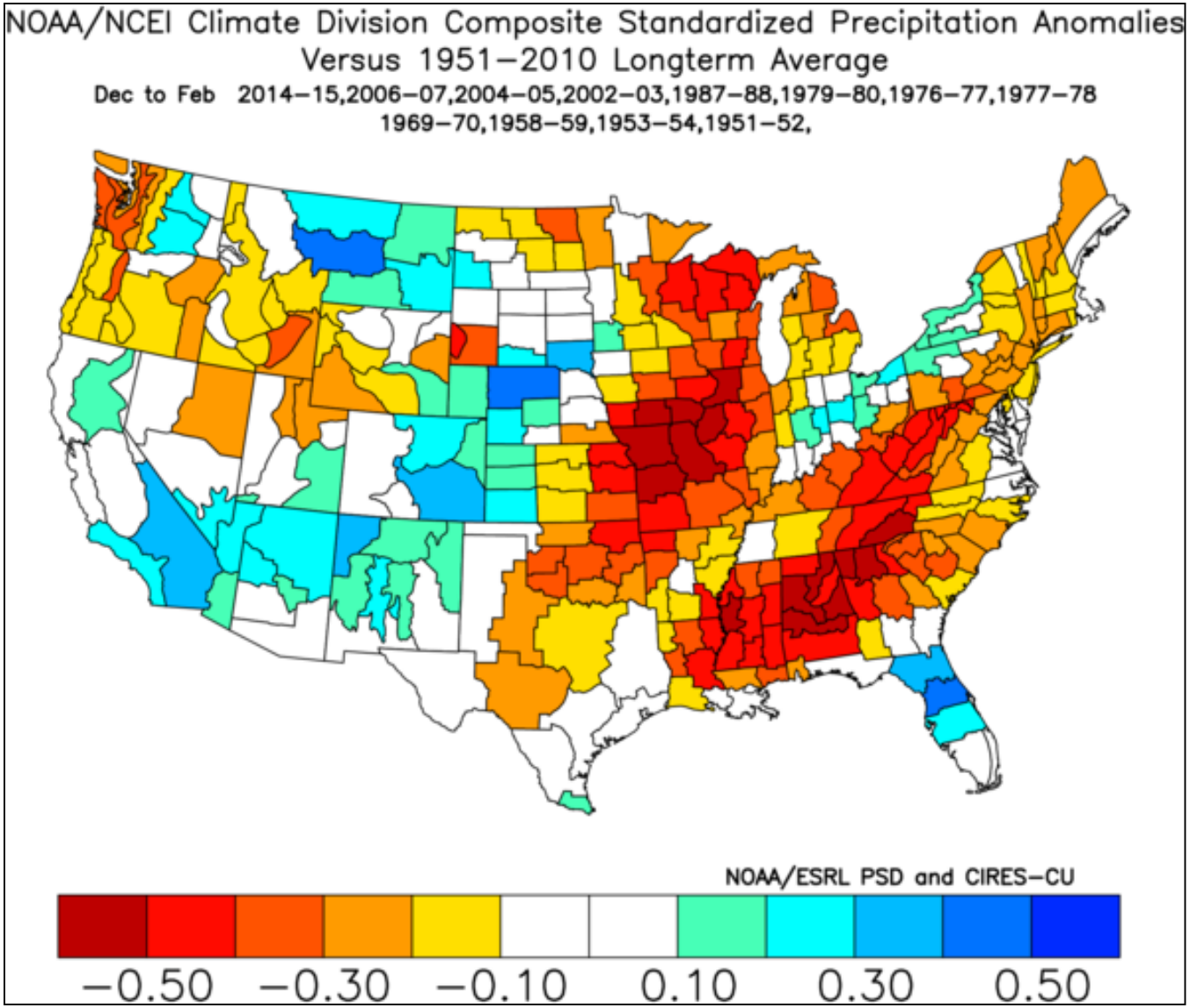
Drought Tendency

None | Develop | Continue or Worsen | Improve | End

Climate.gov
Data: CPC

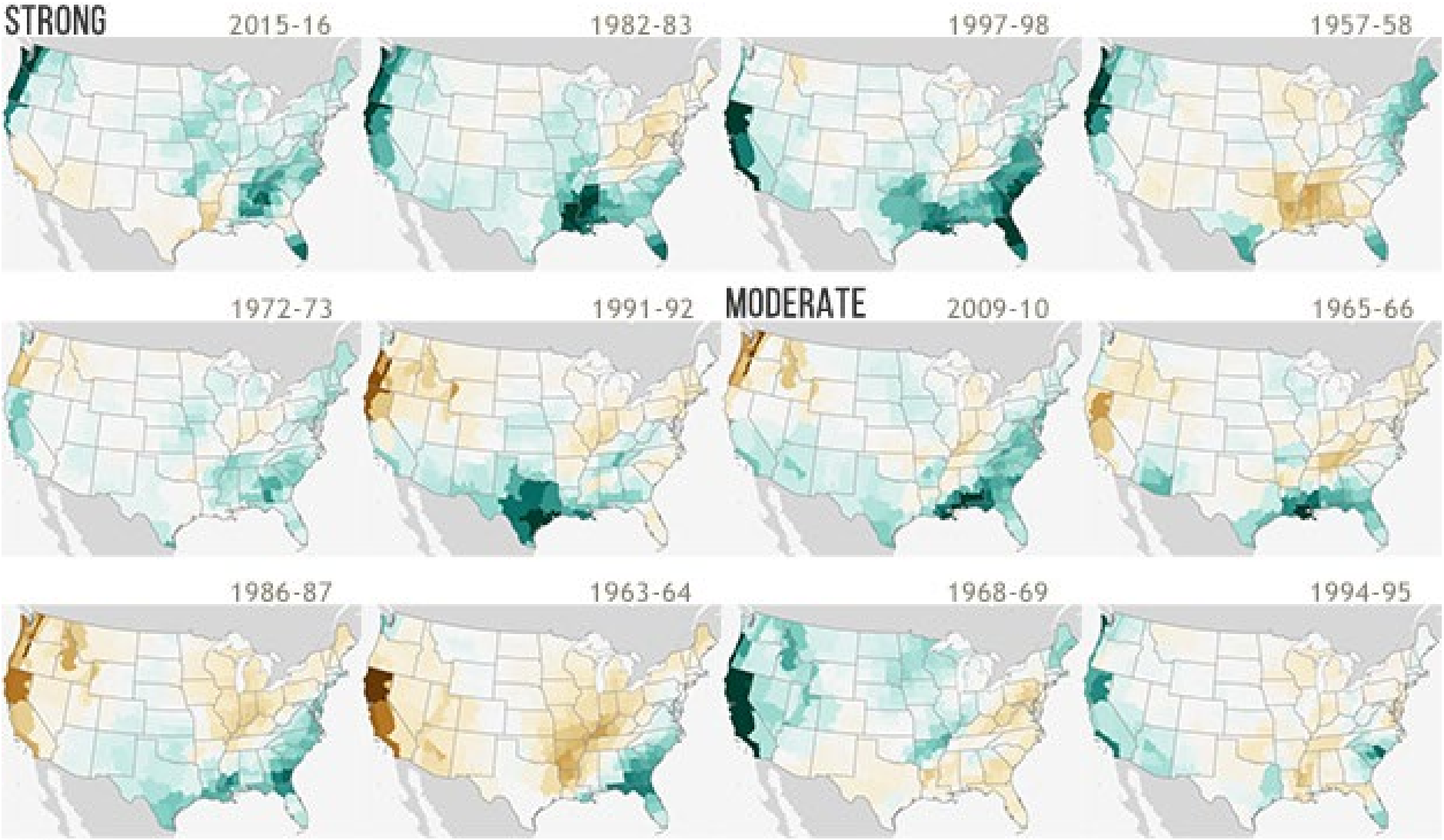
Weak El Niño Cases

1950-2010 Base Period

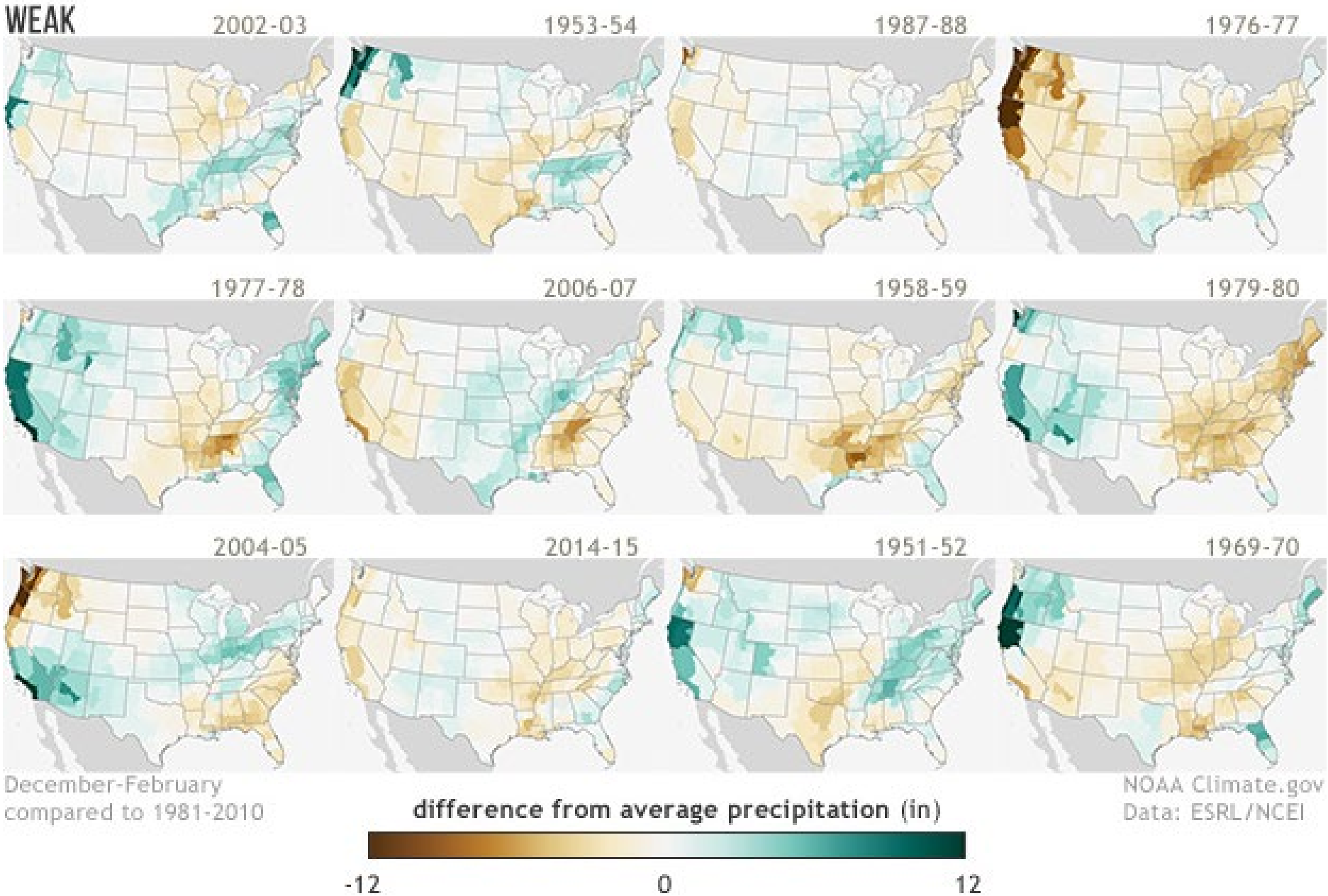


NOT a forecast, but a range of possibilities – what has happened before

Precipitation Anomalies: Strong / Moderate El Niño

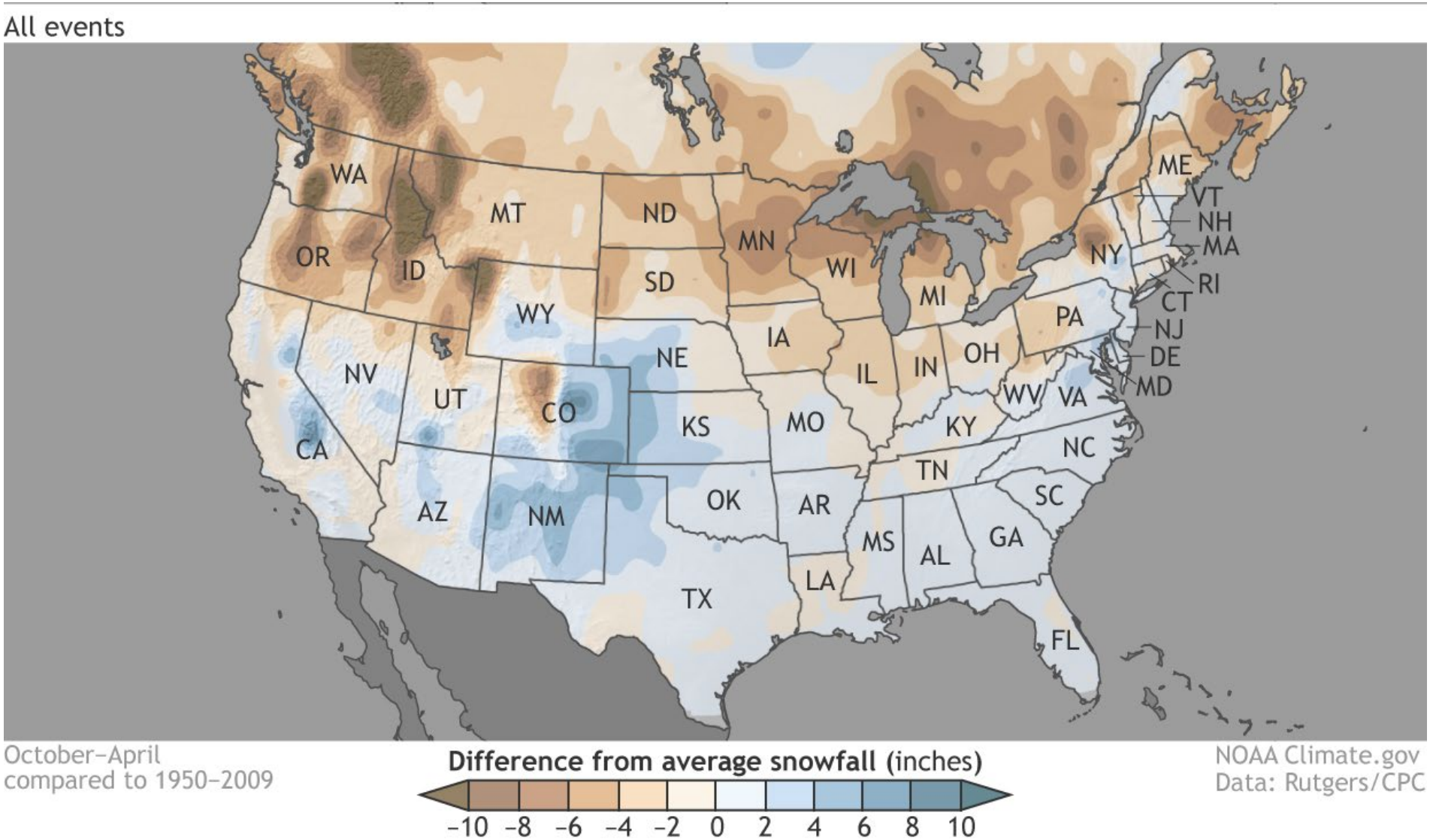


Precipitation Anomalies: Weak El Niño



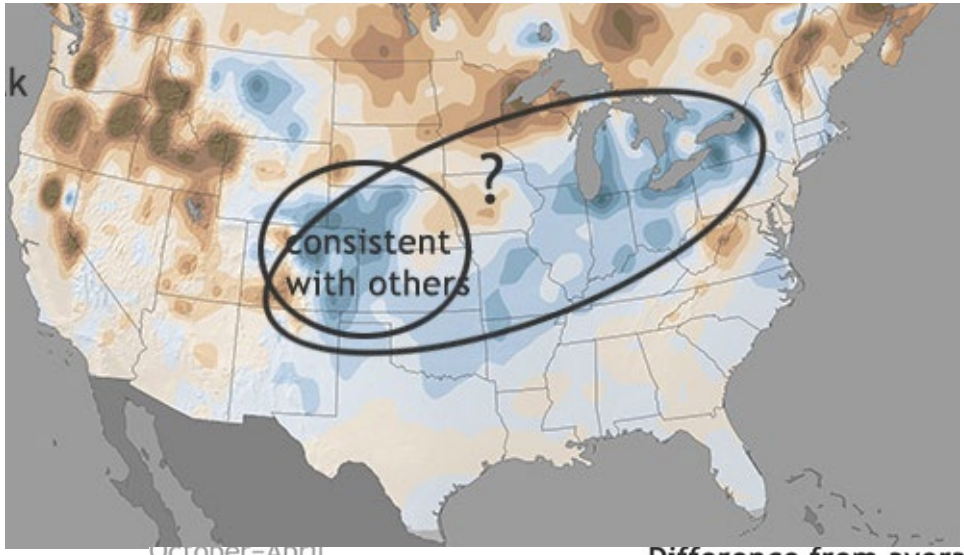
Snowfall Anomalies: El Niño years

All (21) years



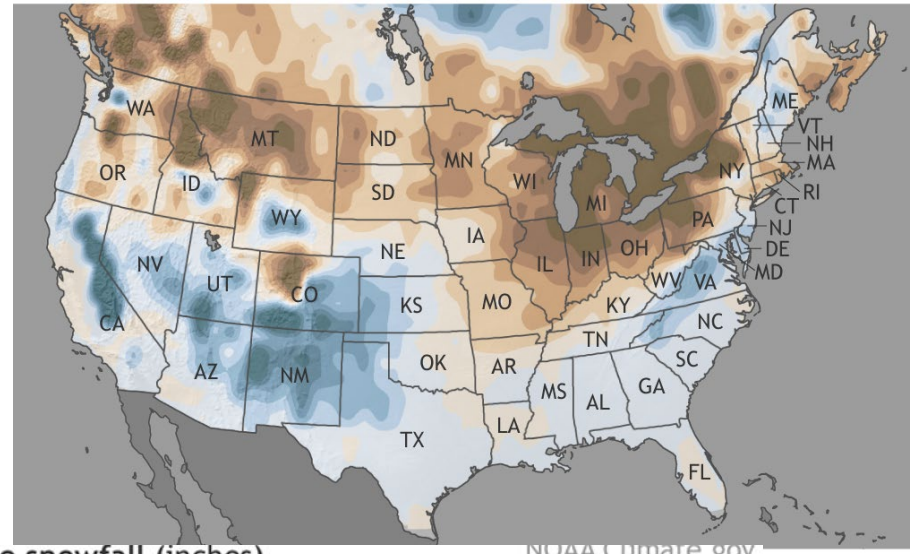
Snowfall Anomalies: El Niño years

Weak (10) years



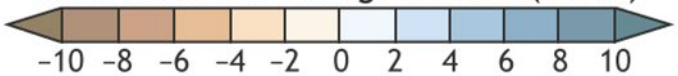
October–April
compared to 1950–2009

Strong (10) years



NOAA Climate.gov
Data: Rutgers/CPC

Difference from average snowfall (inches)



THANK YOU!

Any Questions, contact:

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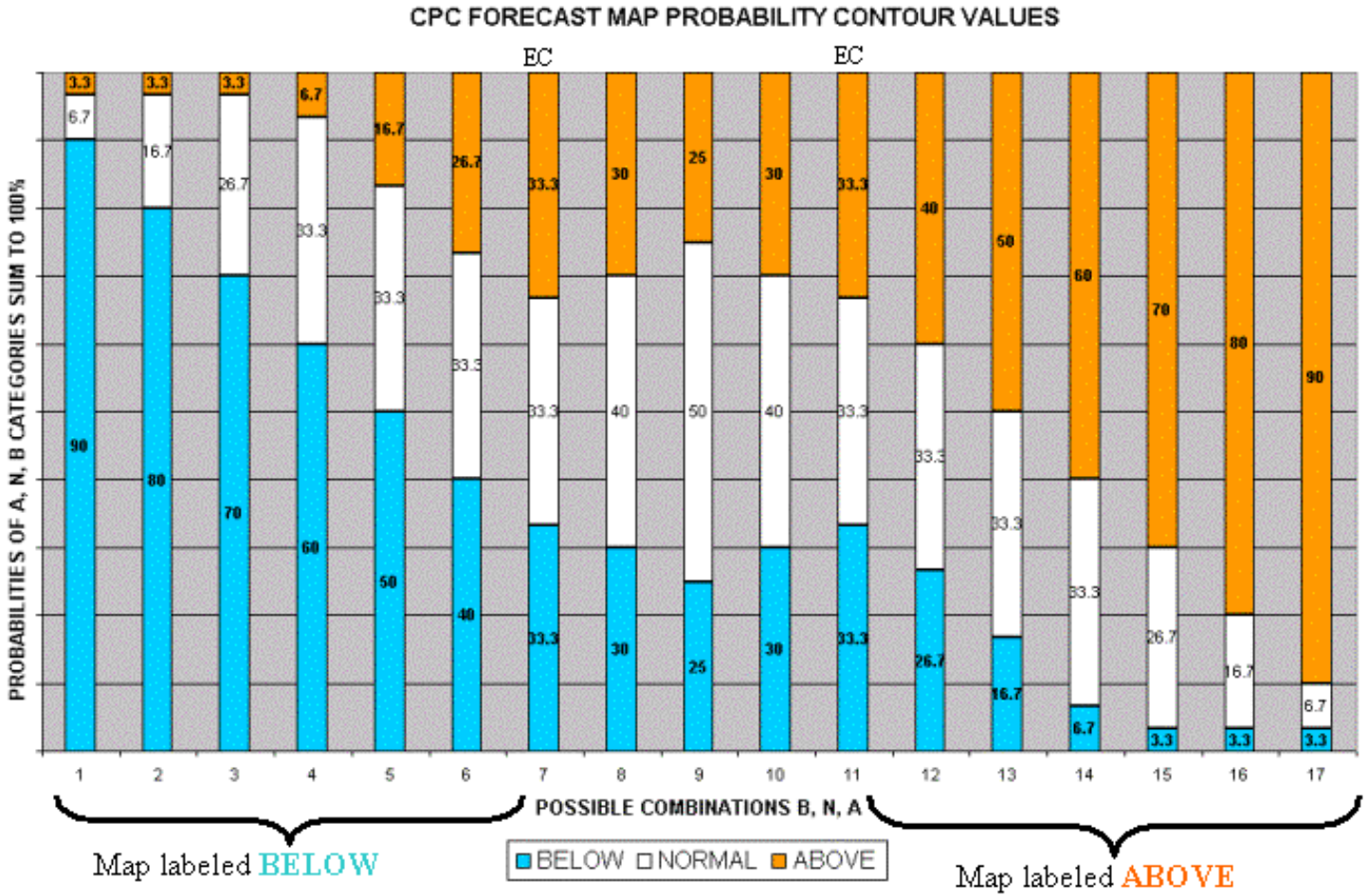
(801)524-5137 ext. 285

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

Extended Range Forecasts

Possible combinations of A, N, B for probability lines on CPC forecast maps.
Combinations 8, 9, 10 are rarely used.



Terciles