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The Evolution and Status[1] of the 2017 Northern High Plains Drought and the Ongoing Southern Drought

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1. Introduction and background

Drought is a natural disaster occurring over land as a consequence of below normal rainfall over a period of time, affecting water supply, agriculture, livestock, and thus lives and economy. It may last from months to years. Last year, in 2017, over the United States, a drought emerged quickly in early May over the Northern Great Plains states of Montana, North and South Dakota. The losses are estimated to be in the few billion US dollars. This study is a follow up to the study/talk given at last year's Climate Diagnostics and Prediction Workshop meeting in Oklahoma entitled, "The sudden Onset of the current 2017 Northern High Plains Drought", plus now the added discussion on the status of, even a bigger, ongoing Drought in the Southern and Western United States.

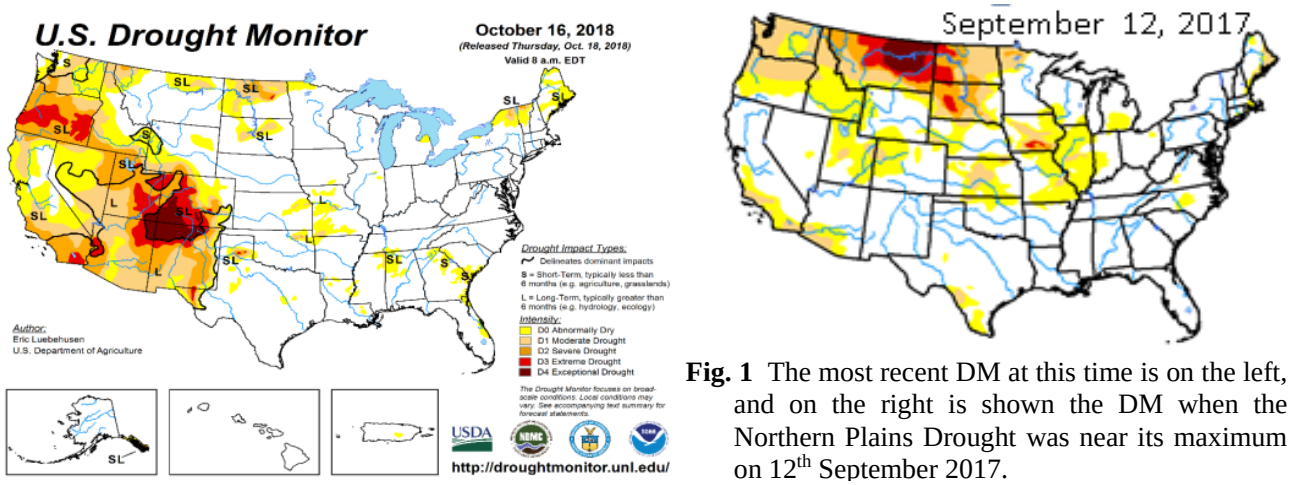

Fig. 1 The most recent DM at this time is on the left, and on the right is shown the DM when the Northern Plains Drought was near its maximum on 12th September 2017.

As regards to the 2017 Northern Plains Drought, on what happened and lessons learned, the following summary points from last year's study/talk were noted:

- Could the onset of the Drought have been addressed/caught by the Drought Monitor (DM) a bit early? - Yes!
- Was the accruing precipitation deficit in the Dakotas/Montana recognized a bit late? – Yes!
- Did we put too much trust on the model's/official rainfall forecast? – Yes!
- So, unlike flash floods, which can happen in a matte belowr of several hours or days, and can be forecast ahead of time to a certain extent, all droughts have to develop from week after week, month after month, precipitation deficit, accrued deficit of rainfall/ soil moisture conditions!
- That too depends on where? & when? Does the region have a limited-months-only rainfall season? Such as California/WA/OR/Northern Plains/Florida? Then the accrued rainfall deficit is critical, and must be watched carefully!

[1] as of this conference time, October 2018

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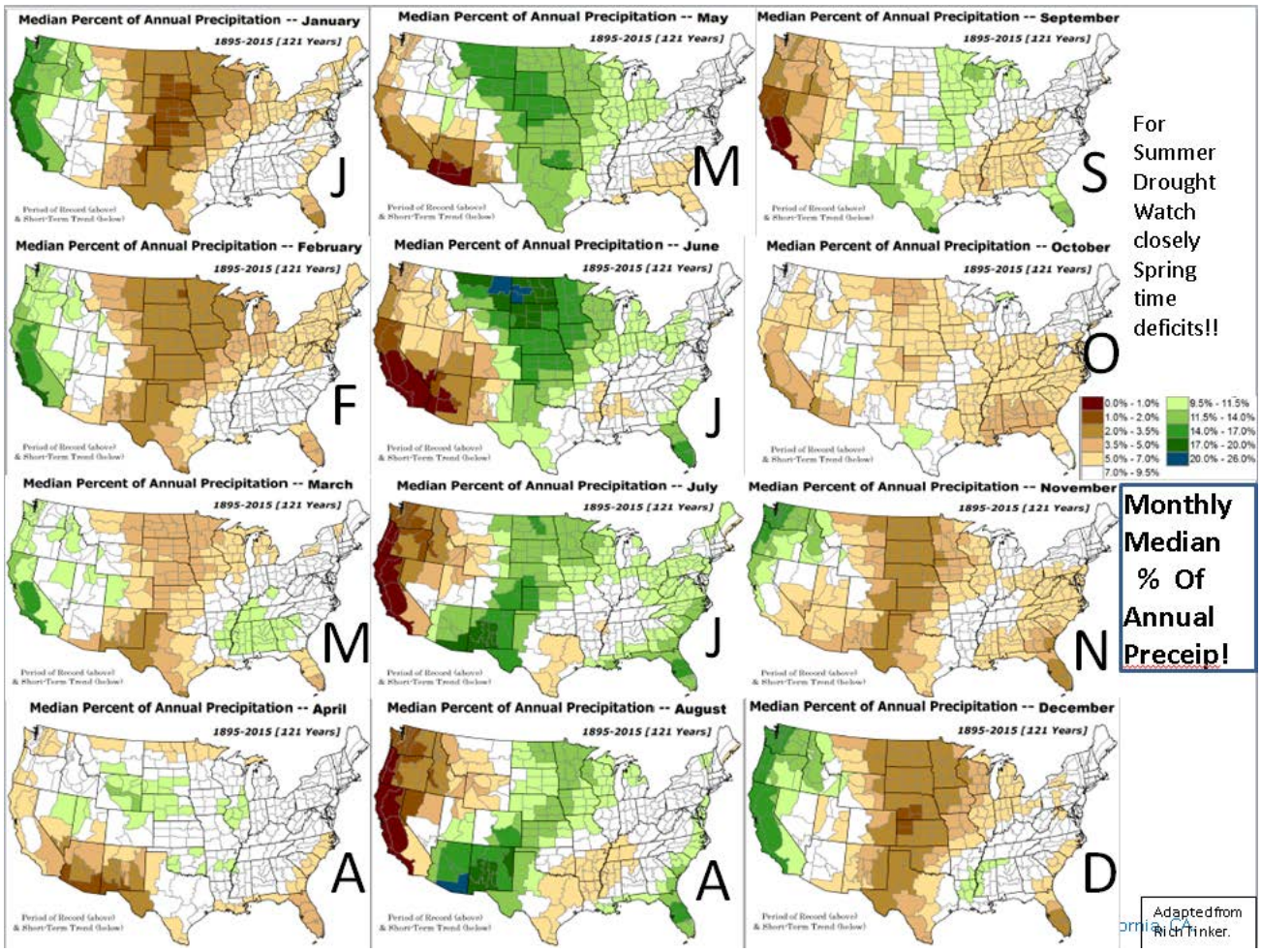

Fig. 2 Annual March of the climatological monthly median % of Annual Precipitation over the United States.

So, until such time our (models'/official) rainfall forecasts improve to be more reliable and useful, existing/accrued P/SM deficits combined with realistic/cautious evaluation of whatever precipitation probability outlook, taking into account the rainfall seasonality in the region, may give us the best possible guidance of drought outlooks; will we have to develop/issue drought development probability based on existing dryness (drought monitor) and future precipitation forecast probability!! The three main take-away points in being able to assign/declare drought in a region and be able to forecast are:

- Keep watching regularly (every week!) the accrued/Accumulated Precipitation deficit in a given region over a continuous period ranging from weeks/month/seasons.
- Put this deficit in the context of what the climatological rainfall season is, for that region!! Is it a limited few months of the year, or is it more or less spread through out the year? When Is the rainfall deficit occurring?
- Future Rainfall/Temperature/Soil moisture forecast and its skill!

2. The rainfall conditions preceding and the current status of the two droughts

To better understand the evolution of the conditions preceding the above two droughts, let us first look at the climatological annual march of the precipitation over the United States, shown as the monthly median percent of annual precipitation in Fig. 2 below. It is clear that the MJJA is the main rainfall season over the Northern Plains states which experienced drought in 2017.

Early in 2017 (Jan/Feb, see above in Fig. 3), the focus was still on the major drought that was coming to an end in California, and on the drought in the southeast. Little attention was paid to the Northern Plains and

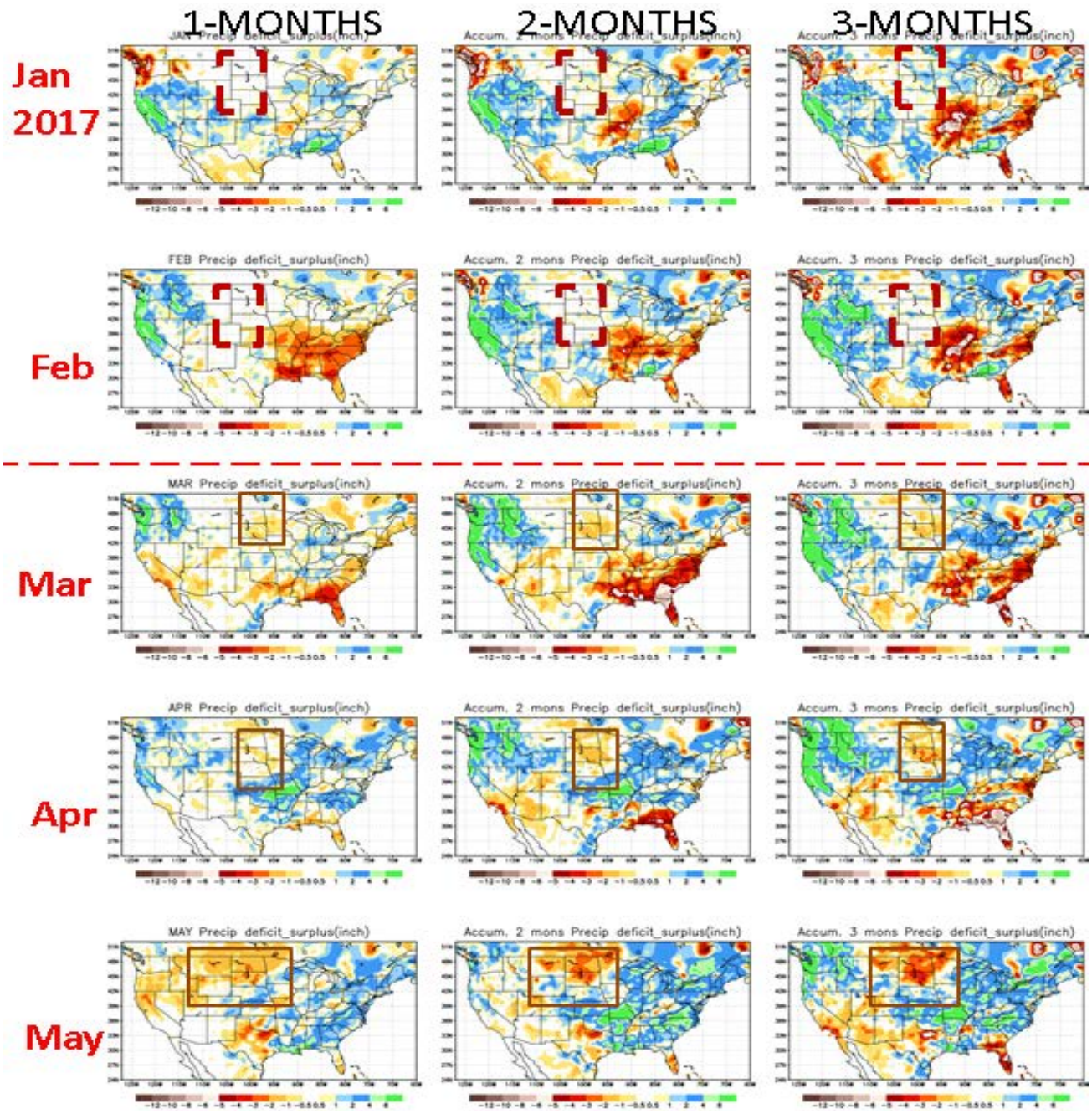

Fig. 3 Annual march of the previous 1-mon, 2-mon, 3- months actual accumulation of actual precipitation deficit/excess anomaly at month's end in January through May of 2017.

there were no signs of emerging drought there. Early signs of developing dryness/drought in the Northern Plains were beginning to emerge at the end of March (first in South Dakota), definitely in April, and firmly/fully established in May, after missing the expected rainfall in May, the first full month of the three month rainy season MJJ !

For regions with only a few months of main rainy season, say summer time in regions such as the Northern Plains, it is important to pay attention to the accruing rainfall deficits (from whatever little precipitation) in the months preceding the main rainy season. If rainfall deficits already exist in place in a region such as Montana/North and South Dakotas, leading up to the first month of the main rainy season, then to add to this

deficit, if the first month of the rainy season (say April/May) does not get the normal rainfall, then the drought is most likely to emerge there. That's exactly what happened in 2017 here in this region.

Figure 4 shows US drought monitor sampled every month from January 2017 through October 2018. The reason for the gradual increase in the drought area and intensity in the US south and west is the two back to back La Niñas (see Table 1) , which are generally associated with lack of precipitation and dryness in the South and Southwest (Fig. 5).

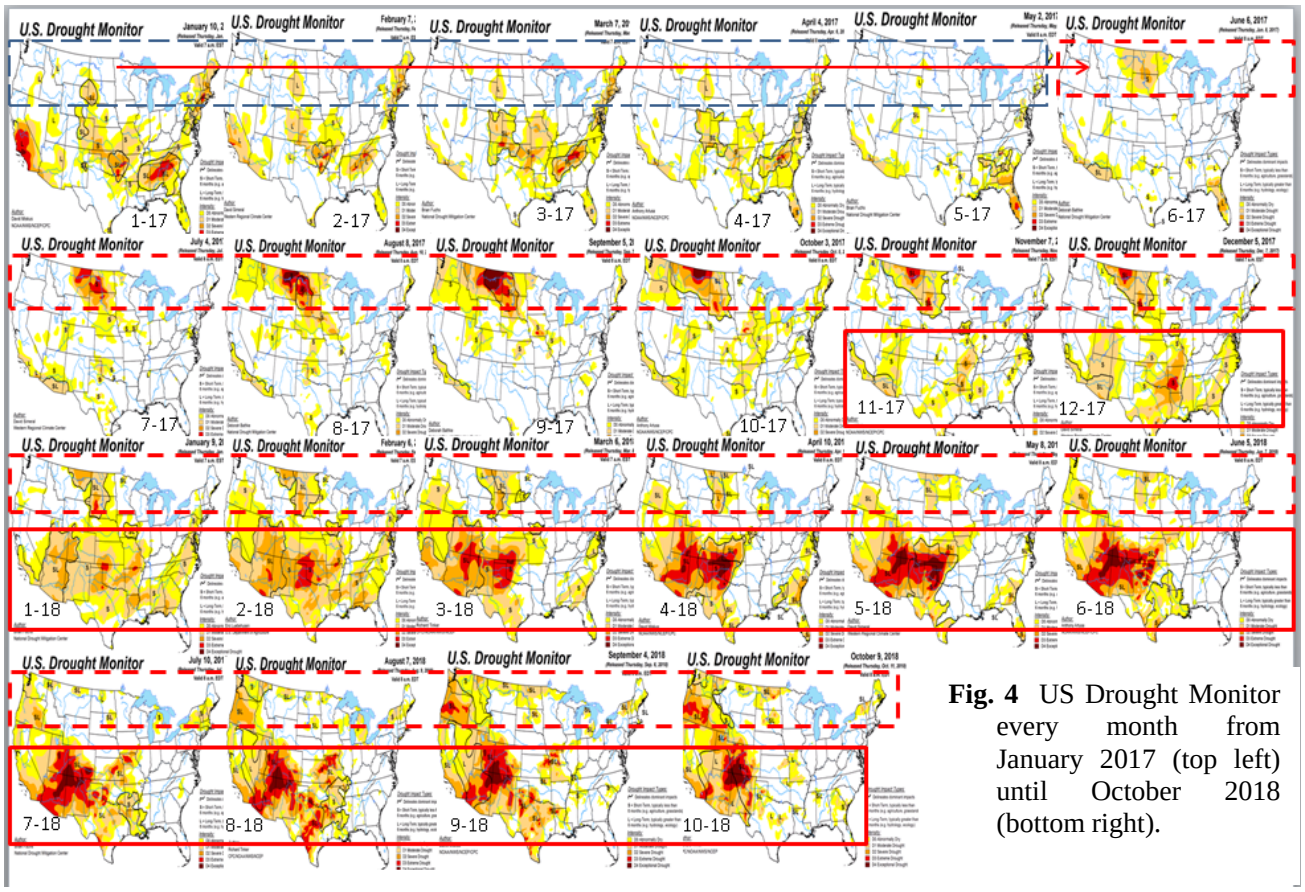

Fig. 4 US Drought Monitor every month from January 2017 (top left) until October 2018 (bottom right).

Table 1 2010-2018 cold and warm episodes by season.

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Historical El Nino / La Nina episodes (1950-present)

Cold & Warm Episodes by Season

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2010	1.5	1.3	0.9	0.4	-0.1	-0.6	-1.0	-1.4	-1.6	-1.7	-1.7	-1.6
2011	-1.4	-1.1	-0.8	-0.6	-0.5	-0.4	-0.5	-0.7	-0.9	-1.1	-1.1	-1.0
2012	-0.8	-0.6	-0.5	-0.4	-0.2	0.1	0.3	0.3	0.3	0.2	0.0	-0.2
2013	-0.4	-0.3	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.3	-0.2	-0.2	-0.3
2014	-0.4	-0.4	-0.2	0.1	0.3	0.2	0.1	0.0	0.2	0.4	0.6	0.7
2015	0.6	0.6	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.5	2.6
2016	2.5	2.2	1.7	1.0	0.5	0.0	-0.3	-0.6	-0.7	-0.7	-0.7	-0.6
2017	-0.3	-0.1	0.1	0.3	0.4	0.4	0.2	-0.1	-0.4	-0.7	-0.9	-1.0
2018	-0.9	-0.8	-0.6	-0.4	-0.1	0.1	0.1	0.1				

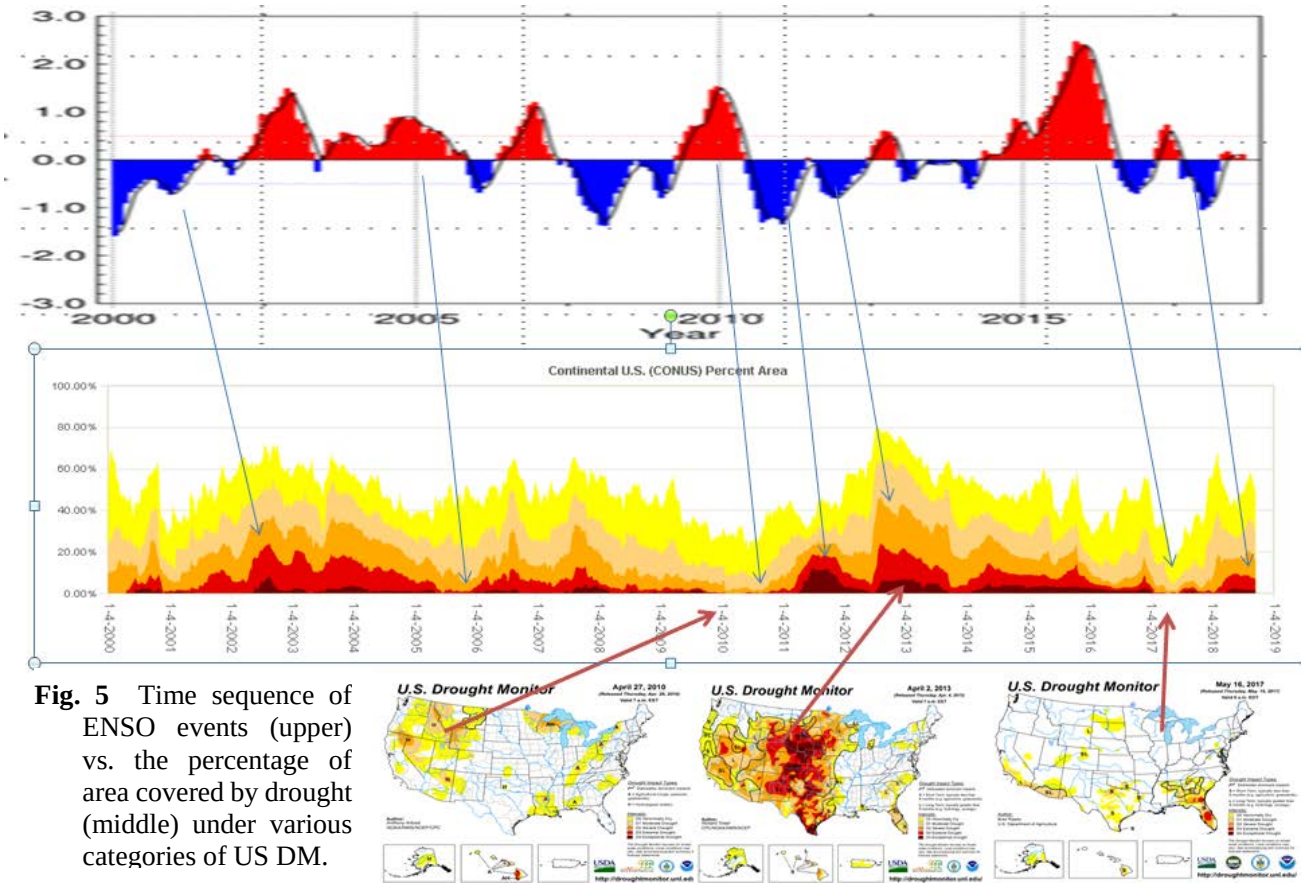

Fig. 5 Time sequence of ENSO events (upper) vs. the percentage of area covered by drought (middle) under various categories of US DM.

See also Fig. 5, which shows the time sequence of ENSO events vs. the percentage of area covered by drought under various categories (in the US Drought Monitor), following the various El Niño and La Niña events. The general El Niño/La Niña composites of US precipitation produced and shown in CPC web site (for example, not shown) also illustrates the general moistening (above normal precipitation) of US following an El Niño and the relative drying (below normal precipitation) of the country following a La Niña.

3. Summary

So, what is the status of the two droughts, the Northern High Plains Drought and the Southwest Drought? The 2017 Northern Plains Drought got a considerable reprieve from the 2018 rainfall season, is all but gone, and only very small parts of it still exist in a muted form in far northern North Dakota and vicinity. The drought in the southern or southwestern US, which also reflects the rainfall deficit from the two recent back to back La Niñas primarily in the four corners area states of AZ/NM/UT/CO, while it may likely improve with the upcoming El Nino rains, it is not clear if those rains will be sufficient to make up for these large earlier deficits.

It is very important to monitor the rainfall shortfalls on many time scales, ranging from weeks to at least a few years, and it is hard to represent these rainfall deficits at various time scales with just the S (short term) and L (long term) representation in the simple drought monitor, without precisely attributing what the S/L time scales correspond to.