Changing Precipitation, Temperature, and Stream Flow Conditions: Part 1

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David DuBois has been the New Mexico State Climatologist since February 2010 and located in Las Cruces. Although he is a native of New Mexico, he grew up on a farm in rural southern New Jersey. He is the director of the New Mexico Climate Center based out of the Plant and Environmental Sciences Department at NMSU. As State Climatologist, Dave teaches and trains students at NMSU as well as providing climate information and education to the public. He maintains an active research program in air quality and climate, participating in studies to understand the nature and origins of atmospheric particulates that we breathe. He is also the New Mexico Community Collaborative Rain, Hail and Snow (CoCoRaHS) state coordinator and looking for more volunteers from all corners of New Mexico to join. Dave holds physics degrees from Rutgers and NMSU, and a doctorate in atmospheric sciences from the University of Nevada Reno.

Editor's Note: The following paper represents a transcription of the speaker's remarks made at the conference. Remarks were edited for publication by the editor. The speaker did not review this version of his presentation and the editor is responsible for an errors.

Greg Pederson and I will work like a tag team this morning. We will talk about what is going on with our climate, water resources, snowpack, and so on. The first part of the presentation is going to be on the short-term perspective starting with last month and going back a few years to look at how our drought changes over time. Then Greg will talk about the longer term to put the short-term into perspective.

I like to work with visualizations and will describe each of my slides. Figure 1 shows September 2013 precipitation, which was an amazing month. A great storm came through New Mexico and we said if we have more months like September, we will be in pretty good shape. It was one of those events where everything came into place just right. The blue indicates 200-300% of what is normal for a long-term average and most of the state benefitted from this event. It was only one event, and it was rainfall, not snowpack. But coming after several years of drought, it was very welcomed. Only most of Lea and Hidalgo counties missed out on the rain.

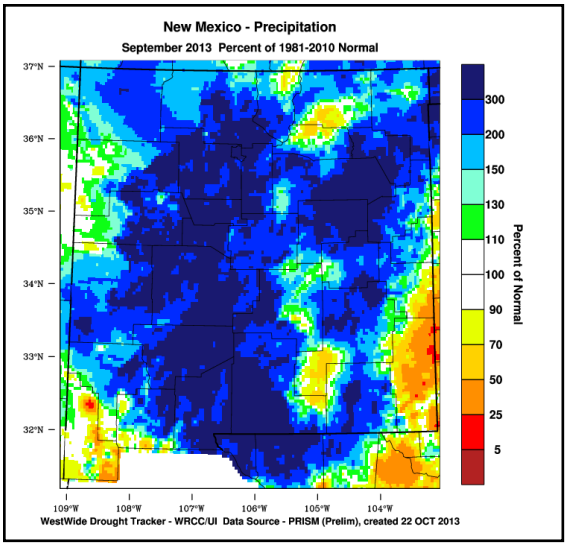


Figure 1. New Mexico - Precipitation

Figure 2 shows the monsoon for the months of July, August, and September. I chose a few of the stations and looked at the percent of average precipitation over those three months. You can see the green dots represent precipitation at more than 150% of normal, and yellow dots at 50-100%. A few places show more than 200% of the long-term average. Everywhere, except in Lea County, did really well over this monsoon. The monsoon is one of the hardest times to predict and we were very happy with the outcome.

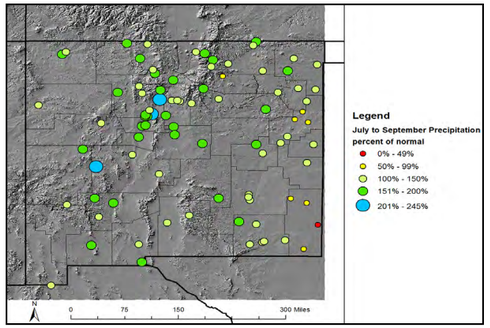


Figure 2. "The Monsoon", July-September precipitation percent of average

For at the long-term, if you look at precipitation for the first ten months of the year, from January through October of 2013, it's not too bad, but you start to see the effects of our drought. (Fig 3) Even with that really wet September, we continue to see this longer period of drought hanging over us. Only the middle of the state along the central valleys are they still in the near-average. Sierra County, Valencia County, Utero County, and a few other areas are still way over 100% of average. But anywhere that is yellow and orange represents drought lingering in the 75, 60, and 50% of average rainfall.

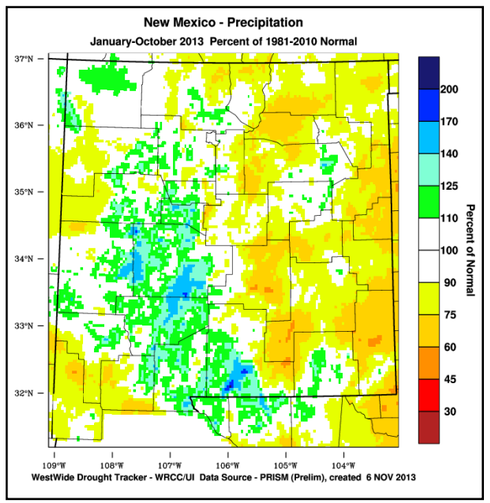


Figure 3. January to October 2013 percent of long term average - State-wide average 94%

So what about November? I plotted a graphic on the 18th. Figure 4 is already old news because we are looking outside this morning and are very optimistic about what the storm will produce. Hopefully everybody who was in the drought areas will be impacted by this storm. It does look like the storm is going to miss all those red areas again. The areas that are already doing well are going to be getting more rain, and the areas that have not been doing so well are going to be missing out on some of this storm's precipitation, but they will get some.

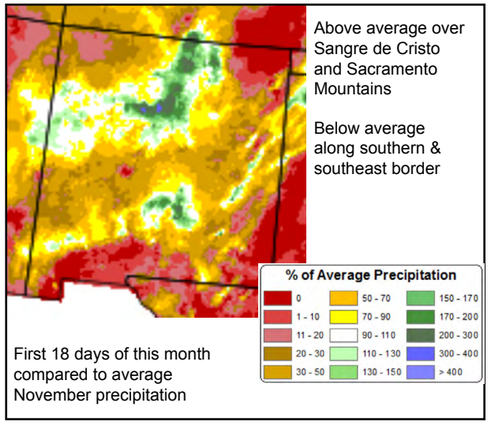


Figure 4. January to October 2013 percent of long-term average - Statewide average 94%

What about soil moisture? We look at what is coming down from the sky, how it actually infiltrates, and there is a new product I am very excited about. I have been working with the guys at NASA to produce a satellite-based model that looks at soil moisture. From two moving satellites, they can estimate how much soil moisture is below based on how much gravity is below them. Soil moisture will be calculated and put into models like this one on Figure 5. We are looking specifically at the first few centimeters of soil, and it pretty much matches what we suspected. The wetness percentiles are relative to the period from 1948 to 2009. In areas that enjoyed heavy precipitation from the September event, such as in the northern mountains, the soil moisture is continuing to look pretty good. But the areas that missed out, like in the Southeast corner, are not doing so well; they are in the 2 to 5 percentile range for that 61 year period.

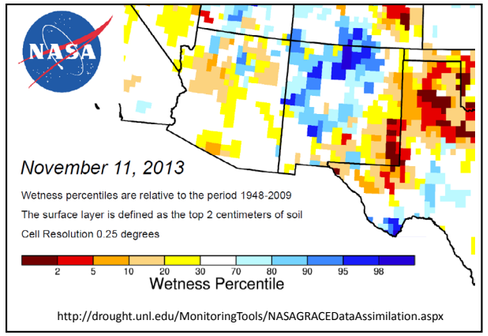


Figure 5. What about soil moisture?

How do we rate in terms of the period of record, which is about 118 years for the whole state of New Mexico? Figure 6 presents a table with the first green line representing the last two months of September and October. How does that rate in terms of all the September and October months going back to 1895? It registered as the ninth wettest on record. Since 1895, the wettest year was in 1941. The table is color-coated by how wet the year was. If the period is in green, then it is in the top ten wettest years. If it is in brown, it is in the bottom third driest in terms of precipitation. If we look at the last twelve months (average going back to 1895), we were right at about average. What about if you look back further? At two years, three years, and four years back, you can see the brown representing the effects of our long-term drought. The last three years have been the fourth driest. The four-year period has been the thirteenth driest. You can see the effects even with the large amount of rain we had in September. We are still in drought.

- The last 2 months have been the 9th wettest on record
- Past 3-yrs have been the 4th driest

Driest | ≤1/10 | ≤1/3 | Normal | ≥1/3 | ≥1/10 | Wettest

Period	Amount	20th Century Average	Departure	Rank (out of 119 years)	Record	Wettest/Driest Since
Sep - Oct 2013 2-month period	4.49" (114.05 mm)	2.73" (69.34 mm)	1.76" (44.71 mm)	111th Driest	1956	Driest since: 2012
				9th Wettest	1941	Wettest since: 1985
Nov 2012 - Oct 2013 12-month period	13.66" (346.96 mm)	13.51" (343.15 mm)	0.15" (3.81 mm)	68th Driest	1956	Driest since: 2012
				51st Wettest	1941	Wettest since: 2010
	Ties: 1995					
Nov 2011 - Oct 2013 24-month period	23.02" (584.71 mm)	27.03" (686.56 mm)	-4.01" (-101.85 mm)	24th Driest	2012	Driest since: 2012
				94th Wettest	1942	Wettest since: 2011
Nov 2010 - Oct 2013 36-month period	31.04" (788.42 mm)	40.50" (1,028.70 mm)	-9.46" (-240.28 mm)	4th Driest	1953	Driest since: 1956
				113th Wettest	1942	Wettest since: 2012
Nov 2009 - Oct 2013 48-month period	46.54" (1,182.12 mm)	53.94" (1,370.08 mm)	-7.40" (-187.96 mm)	13th Driest	1956	Driest since: 2012
				103rd Wettest	1988	Wettest since: 2011

Figure 6. Statewide precipitation rankings

Figure 7 is a nice visualization called the Standardized Precipitation Index, or SPI. It is widely used by climatologists to evaluate drought over many time scales. It goes from negative three to positive three with negatives being drought, and wherever it is positive, it is wetter. Zero represents the average. It is somewhat like a standard deviation with how much you are above or below the mean. Brown areas represent extended drought. The x-axis is time from the 1980s to the present. The y-axis is length of time and assesses drought from one month to five years. It is basically what the extent of drought is as it goes along in time. Green areas represent wet periods. You can see the 1985 wet period and again in the 1990s. You can see when drought comes up in this negative SPI. You have another one around 2002. It was wet around 2006–you might remember that we had a really wet period right after the summer, and you can see its effect here. This is for all counties in New Mexico. You can see that it is the darkest it has been in terms of this index going back all the way to the 1980s. You can see we exceeded this time period in the 2000s, so it is both a short-term and long-term drought. If it were a short-term drought, you would only see it in the bottom of this plot. You can see it is extended all the way in the darker three-year period. That is how we track from a perspective of the current few months, and the perspective of the last five; we then put it all the way back into the last thirty years.

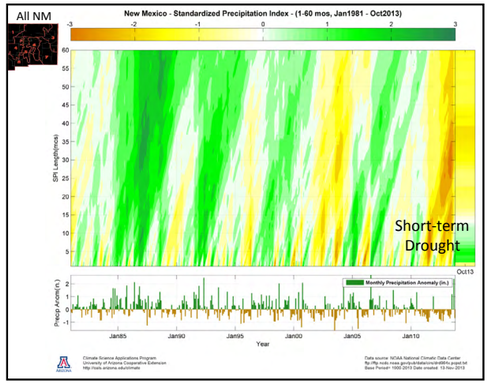


Figure 7. Standardized Precipitation Index (SPI)

Figure 7 was for the entire state and Figure 8 is for Climate Division 2. As climatologists, we like to group things. We like to separate things and find patterns. Climate Division 2 is in the northern mountains of New Mexico. Where there are high elevations in New Mexico, we like to look at what is going on with our snowpack. In Figure 8, you can see a fairly dry period in the 2000s, and we are seeing another dry period. This is actually much worse than in the last thirty years.

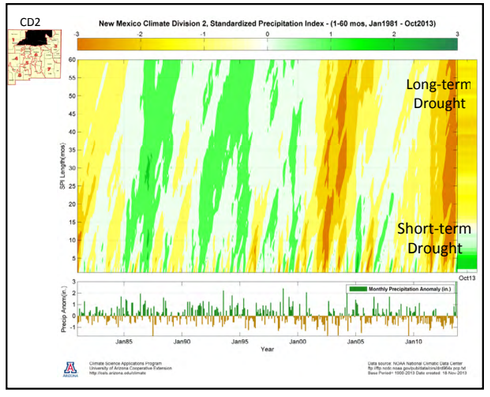


Figure 8. Climate Division 2

Now let's look at temperature. We see lots of plots like the one in Figure 9 that follows annual statewide temperatures back to the period of record in the 1890s to the present. The dots are an average yearly temperature. We can see some long trends: it was very warm in the 1950s and you see the corresponding bump; we have been slowly climbing since the 1970s or so. Then we have in 2012, the highest annual temperature in the period of record. Think of the impacts of a continuously warming state. I have been looking at all of the stations in New Mexico, and a lot of the warming we are seeing is from rising morning temperatures. It isn't in the urban areas, it is in rural areas. I kept looking at landscape changes and how that affects temperature, and how it looks compared to the entire western U.S. That is one of the questions we need to look at to solve some of our problems. Also, how and what does that impact in terms of agriculture? Snowpack is another big concern: we are seeing temperatures in higher elevations warming as well.

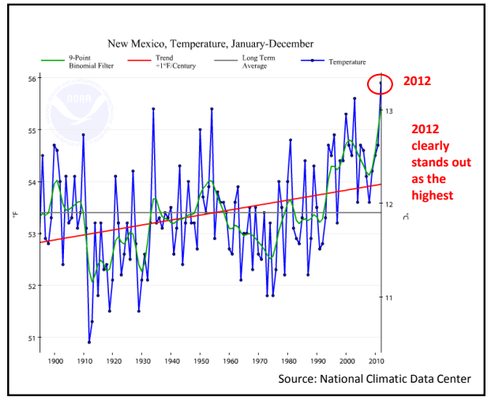


Figure 9. Annual Statewide Temperatures since 1895

Climatologists look at the drought monitor (Fig.10). It goes from a scale of zero to four with zero being normally dry and four being exceptionally dry. The return frequency probabilities as indicated on the figure start all the way back at 50-100 years.

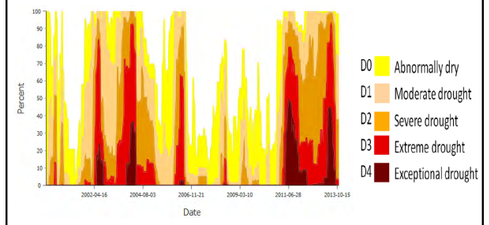
Drought classification puts drought in historical perspective

DM Level	Name	Frequency
D0	Abnormally dry	3-5 years
D1	Moderate drought	5-10 yrs
D2	Severe drought	10-20 yrs
D3	Extreme drought	20-50 yrs
D4	Exceptional drought	50-100 yrs

Figure 10. U.S. Drought Monitor

Looking at New Mexico as a whole from around 2000, Figure 11 shows the last thirteen years. It shows percent of land area within each drought category. A lot of the D4 category came in 2003, and again in 2011, 2012, and 2013. There hasn't been any time over this period that we haven't had one area that wasn't in drought in New Mexico. That is a telling statement about our state, our climate, and the variability. You can see intense periods that come and go and predicting these deviations is hard. We are at the mercy of other cycles like the El Niño Southern Oscillation that dries our precipitation in the winter time.

- Over past 13 years some or all of NM has been in some level of drought



Graph shows percent of land area within each drought category

Figure 11. State-wide NM Drought Monitor

Figure 12 and 13 show the drought monitor before and after the summer monsoon. In the latest drought monitor graph, we still have a few of the D3 areas over here in Lincoln County and around central New Mexico. In effect, we are still in drought even with that big summer 2013 monsoon.

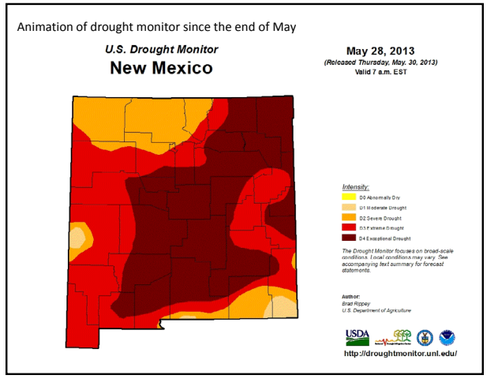


Figure 12. U.S. Drought Monitor, NM, May 2013

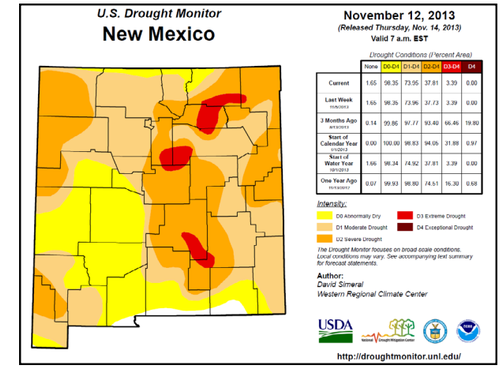


Figure 13. U.S. Drought Monitor, NM, Nov. 12, 2013

What are some of the impacts of drought? I could do a whole seminar series on drought impacts. I want to pick just one that is interesting to me. One of the questions of feedback systems in climate change as how does the landscape change affect the water cycle? I am particularly interested in the dust effects on snowpack. Figure 14 is a satellite image of an event north of Gallup in 2010. This is an event that made the snow brown up in the San Juan Mountains. Much has been written about the change of the melt cycle of snowpack in the San Juan Mountains. We are looking at the long-term effects and how it changes the overall hydrologic cycle when things melt much quicker.

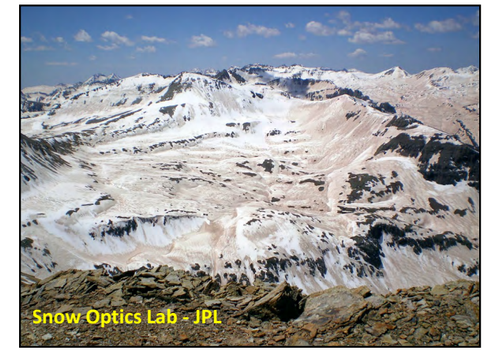


Figure 14. Dust on Snow 2009 May 19. San Juan Mtns. Source from NE AZ and NW NM

Figure 15 shows current capacity at Elephant Butte. We are just shy of 10%. Last time I looked, earlier this week, we were at 216,000 acre-feet out of 2.1 million acre-feet capacity. Storage bottomed out this summer at 60,000 acre-feet. This is one of the effects of our drought.

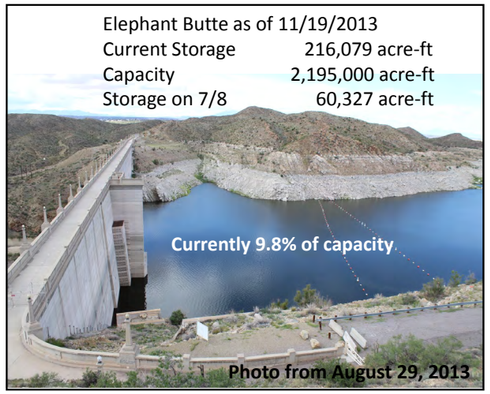


Figure 15. Capacity at Elephant Butte

Figure 16 is a picture from satellites just two days ago. The snow is represented in turquoise and I will show you the measurements of snow as indicated by the little snowflakes. Figure 17 is a plot of the amount of our snowpack as of a couple days ago. The blue line at the far left corner is our overall median from the stations in northern New Mexico and southern Colorado. The little red circle shows us where we are right now. We are just a little above the long-term median for the last thirty years, which is a positive thing, but it doesn't say how it will look this coming snow season. The green line represents 2013; it is a miserable line and hopefully we won't repeat it.

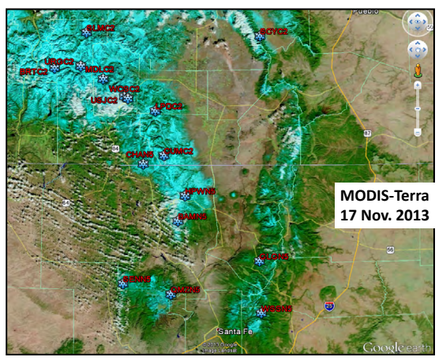


Figure 16. Satellite image of snow

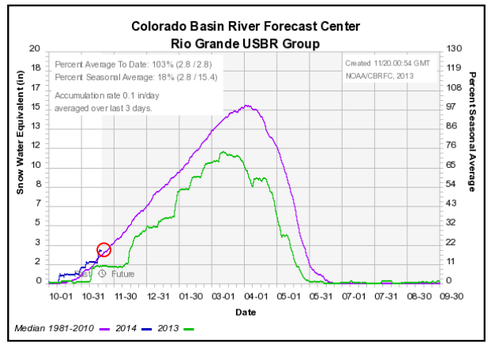


Figure 17. Rio Grande Basin + snow observations

Next are stream flow figures. The first is on the Rio Grande at the Otowi guage and shows percentiles (Fig. 18). The black line is the actual 28-day average flow in cubic feet per second. Even though we all know this is a well-managed system, you can still see the effects of drought on these wet periods. Looking at last year, 2012, you can see that we are very much down in the lower percentiles compared to other years. Compared to the Pecos (Fig. 19), you can see the real effects of flow from the Pecos before it goes into Santa Rosa Lake. We had some very low periods in 2003 and 2004, and then did fairly well until 2012. We were off the charts in terms of percentiles and were probably at record low amounts of flow. This speaks to variability. I want to impress upon you the amount of variability and how things can change very quickly in this system. We went from 1 cfs to highs of a couple orders of magnitude in a matter of weeks.

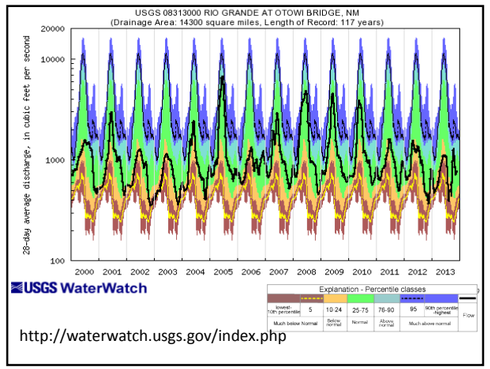


Figure 18. Stream flow on the Rio Grande at Otowi Gauge, Otowi bridge at highway 502; 28-day average flow in cubic feet per second

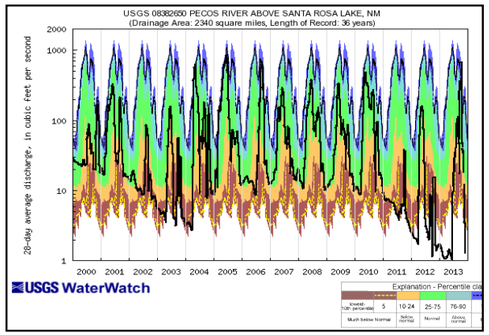


Figure 19. Stream flow on Pecos River above Santa Rosa Lake; 28-day average flow in cubic feet per second

What is the outlook? In terms of sea surface temperature, specifically in the Pacific, we are looking at what we have been calling La Niña, which is something between El Niño and La Niña. The forecast has been showing that we are probably going to be staying in that situation for a while (Fig 20). There isn't much predictability in where we are going, which doesn't help us climatologists–we are just scratching our heads. Figure 21 shows green for the probabilities that this to continue.

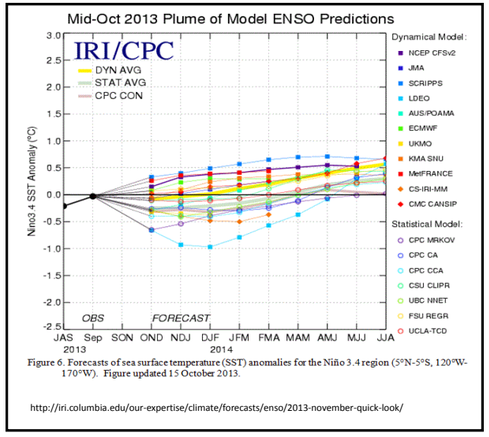


Figure 20. Forecast - ENSO-neutral is expected through Spring 2014. Seasonal predictions: Many models predict a gradual increase from slightly cooler than average to warmer conditions as the spring appropaches.

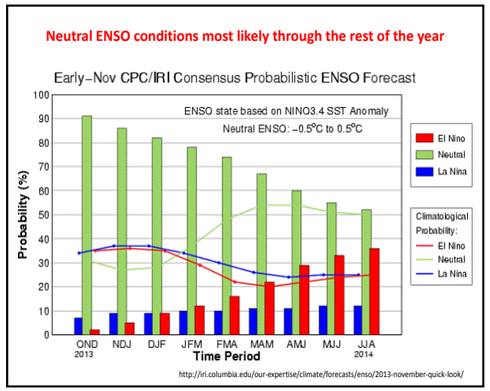


Figure 21. Seasonal Forecast

Figure 22 is the precipitation outlook for November through January. We haven't been able to predict what will happen in the wintertime, but we do have some guidance from the Climate Prediction Center. We see increased probabilities for below average precipitation and above average temperatures (Fig. 23). A good message is that it looks like the Colorado upstream will not be affected.

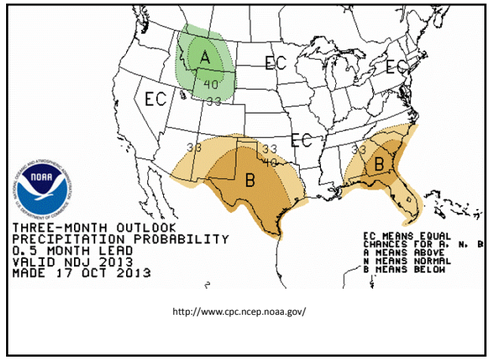


Figure 22. Nov. – Jan. Precipitation Outlook

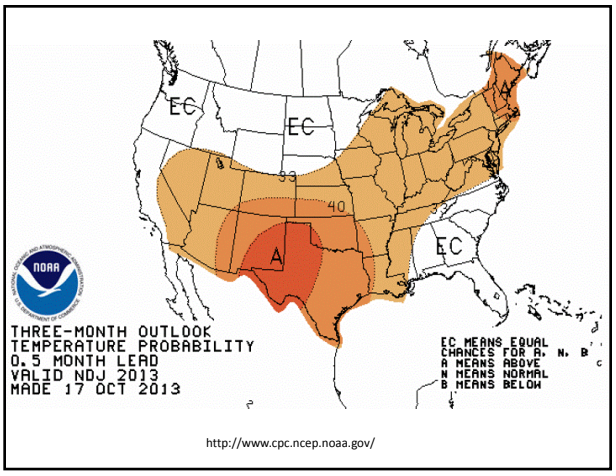


Figure 23. Nov. – Jan. Temperature Outlook

Figure 24 is the drought outlook through January 31, 2014. The brown chocolate color indicates that drought either persists or intensifies, and the lighter brown shows where drought development is likely. It is not too surprising, but as my message here is that we still have white in areas where we think drought will not intensify or appear, which is good. The bad thing is that most of the Rio Grande Basin is covered by brown.

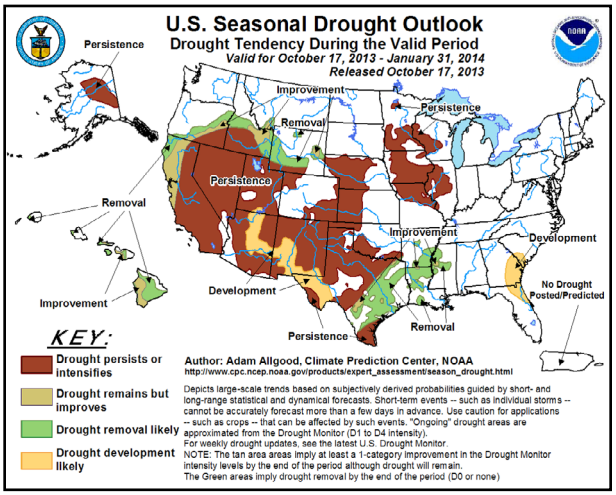


Figure 24. U.S. Seasonal Drought Outlook

Lastly, I want to plug the volunteer assisted CoCoRaHS network (Fig. 25). If you are interested in volunteering, please see me. It is one of the ways we gauge climate and drought in the state of New Mexico and across the country including Canada. It is very helpful and everybody can take part.

Figure 25. CoCoRaHS

I want to leave you with a peaceful photo from the mountains where hopefully we will be getting some snow soon (Fig. 26). My contact information is included.

Thank you.

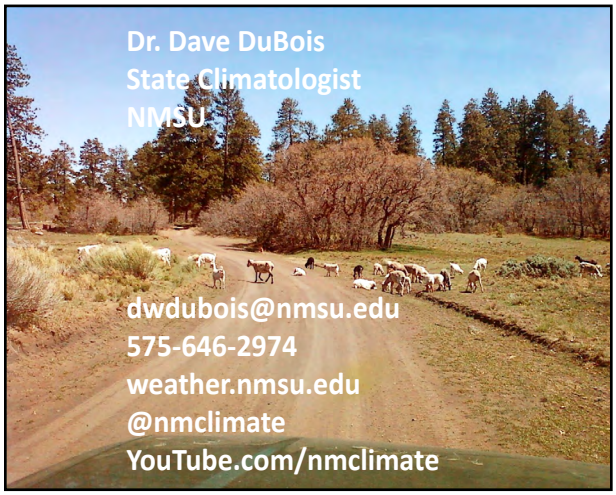


Figure 26. Contact information