

### **Jan 2015 SW Climate Podcast: 2014 Year in Review, and Stuck in El Limbo**

In the January Southwest Climate Podcast, Zack Guido is back and joins Mike Crimmins to discuss the state of the climate in 2014, including the record year for Arizona and the near record year for New Mexico. They also talk about weather systems that affected our most recent temperature and precipitation patterns, the ongoing uncertainty with El Niño, or as some have started referring to it, "El Limbo", and the state of precipitation and drought in the southwest. They wrap things up looking at the seasonal outlooks and the projected trends for the coming year.

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Zack: We do have a lot of things to talk about; it has been a busy month climate and weather wise. First we will summarize where we are and how we got here in the last couple of months. That will inevitably turn our attention to, as always, to El Nino. Some people have been calling this a limbo. According to some it is here, according to others, it is not. According to some it will come. According to others it will not. 01:06

Mike: What did we say last time? I am afraid we have boxed ourselves in our own forecast. I am pretty sure I declared the El Nino in the last podcast. 01:11

Zack: You declared the El Nino last year! 01:24

Zack: So the big climate story of 2014 has been the temperatures. It went down in the record books as the warmest year since 1880, when wide spread record keeping began. We will talk a bit about that. 01:53

Zack: So I will start with a brief summary of where we are. So the current conditions if you look at precipitation, in terms of percent of average in the last 60 days, Four Corners region in Arizona and New Mexico have experienced above average precipitation, upwards of 150 percent of average. The Tucson area has experienced above average precipitation. Then in Arizona, in the valleys outside of the Mogollon region, it has been drier than average. And most of New Mexico has been drier than average. If you look at the last 30 days, that pattern has been the same. The Four Corners region above average, Tucson has the bull's-eye of precipitation and dry else where. Also, California received a lot of rain in December and it has been really dry since the end of December. 02:56

Mike: They made the news with a couple of storms but it has not been keeping pace. 03:01-0

Zack: There was a big atmospheric river that struck California and parts of Arizona. Snow pack conditions in the Mogollon Rim region, in the mountains of Flagstaff are running at below average for this time of year, less than 70 percent of average. Which is surprising since it has been wetter than average in those parts, but that may reflect that warm weather that we have had. In New Mexico it is similar. Most of the basins there where snow pack gets measured are running at below 80 percent of average. That includes the upper Rio Grande river basin that touches into Southern Colorado. That is sort of bad news for the Rio Grande because that river has been running at below average stream flow for a long time now. It is in need of hefty dose of wintertime precipitation. Elsewhere in Colorado and in the Colorado River Basin, it is about average. So that is playing out in terms of the early stream flow forecasts at about average stream flow conditions. That is where we stand in terms of precipitation, which I think is what most people care about in the winter. How did we get there? What has been the atmosphere pattern that has set up, that has delivered above

average conditions in the Four Corners regions and Tucson, but drier elsewhere? 04:27

Mike: We were going over some of the data and maps over the last couple of months and there is no single culprit. This has been the winter of weather. We have had a mixed bag of all sorts of stuff since the fall. I kind of lump October into our discussion because that is technically the beginning of the water year. In the very beginning of October we were still having some tropical storm activity. So if we look at some of our drought indices going back there, we had a wet October and we march forward here. It is important to lump the fall in here because most of Arizona saw 0 precipitation in November and that looked like bad news, but it was tempered from the fact that we came off of a wet monsoon and then those interesting events in October. Then we move into a fairly busy pattern in December with some storms dropping out of the North. It has been a mixed bag over the last couple of months. 05:39

Zack: December brought us 4 relatively precipitation events in Tucson and January has been another 3. 05:48

Mike: It has been busy. They have been weak storms that have dropped out of the Northwest. They have had some extra ingredients we just haven't seen in the last couple of years. Which is this subtropical moisture off of the coast of Mexico. I got a call from a reporter this morning and he is getting pressure from his readers to talk about drought here in Arizona. It stuck me that, I think our expectations for winter precipitation are so low that it only needs to rain once or twice and the drought is over. The last couple of winters we were getting an event and then waiting and then getting another event. Here we are getting 3 or 4 in a month and it is starting to look very wet. Again, if you back up from that climate perspective, most areas across the Southwest, even with this pace of storms, are not keeping pace. This is kind of interesting. Even to hit pace and keep average, we need to do better than we are doing right now. Again like you mentioned, it is a patchwork of patterns. The Four Corners have done well and thank goodness that they have because the Four Corners got left behind in the monsoon and they got left behind last winter. The drought is really deep in that area. 07:21

Zack: That being said though, December was pretty good for us. 07:32

Mike: It was pretty isolated even over Eastern Pima County. It was good for Tucson, the storms pick up and bull's-eye on us. A couple of strange events poured out some showers here and there; even on days it wasn't supposed to rain. 08:12

Zack: Some people we were talking offline about in Cochise County, it has been dry. 08:10

Mike: Yeah again, they had 7 inches of rain in a couple of days with those tropical storms and then it has shut down since then. The thinking is, there is a lot of (?) moisture just below the surface, but the surface is drying out. It has also been warm over the last couple of months. We have had those cold snaps, but overall the overnight temps have been high and we have pushed up into warm temperatures pretty regularly over the last couple of months. 08:43

Zack: Temperature wise in the last 30 days, California has been above average and the Four Corners region has been slightly above average. Elsewhere it has been slightly below average, but if you go back to last 60 days, it has basically been average from half of New Mexico, westward. If you look at the broader scale jet stream pattern, which leads up into our discussion of is there any smoking gun behind making any sense of this stuff, is on average the jet stream has had a ridge over the west coast a bit. We can't call this a ridiculously resilient ridge because it has been moving around, it has been breaking down, but overall it has allowed that cold air to spill in on the east side of the ridge over the Northern Great Plains, but what you expect with that is that underneath that ridge is where you are going to have that warm air. If we don't have that ridge break down and you don't see it much, then you are not going to have much of an opportunity to move cold air into here. It is interesting because the couple of cold events that we have seen, such as the New Years Eve event. That cold air came from that Great Plains and worked its way back towards the

Southwest. So it didn't drop straight out of the Northwest or the North as it typically does, it was what we call a digging trough on that front side of the ridge, which actually backed the air into Arizona. At the same time there was moisture down in the East Pacific that it had to work with. So it had those two great components to work with, which was that cold air and then the moisture to make it a pretty decent storm. That was probably one of our better storms of the whole season. It is tough to make that happen again with all of those ingredients coming together. 10:37

Zack: I think you mentioned that a lot of these storms were relatively weak. That is probably contributing to the meager snow pack conditions that we have seen so far. Even though we have had six precipitation events in the six weeks or so, they haven't produced a lot of snow. Or has the snow since melted? 11:00

Mike: I think if you look at the traces of snow, water equivalent, we haven't lost a lot yet. A lot of that accumulation has come recently. We are at that make or break point, where today we are back up in the 70's and there is a weak ridge building over us which will move the storms away and it will warm up. So we could start losing that again if we don't start picking up those storms and cooling off again. But to your point about the strength of them, given this pattern here, some of it has been a split jet stream. That is where we get these closed or cut off lows underneath the broader scale ridge. Those are typically of subtropical origin. They are coming in from the East Pacific and bringing some moisture with them. But they are very warm storms and they don't have a lot of dynamics. They are sloppy, they have a very high snow level, they move around and they are not organized in the way they put the rainfall down. To get really good bomber precip and snow levels, you want to have the whole jet stream involved, pulling down cold air with it and parking over us and putting together a really deep storm. We haven't had a lot of that this season. To not be too pessimistic, it is only January. January, February and March is our good season. 12:27

Zack: Right, so in terms of snow pack, our eyes are paying attention and we are not going to be too pessimistic. Even though some of the areas like the upper Rio Grande headwaters aren't living up to what we had hoped. 12:37

Mike: I got a chance to talk to some of the water managers in Arizona over the last couple of weeks and the forecasts that they are putting out here in Arizona are not pessimistic at all. Where they are at right now, snow pack is not great but there is still some hope that there will be some additional accumulation. 12:55

Zack: Well hope and optimism is also contained in the seasonal climate forecast! Which still suggests for the next three months that there are slightly increased chances for above average precipitation. Before we get there I want to go back because you said something interesting, this year it has been weather. What you mean by that I think is that there is not a lot of underlying conditions that are really forcing persistence in a particular condition. 13:23

Mike: Exactly, we haven't seen any particular mode of the atmosphere take over or something that would set up a particular jet stream that would park anywhere. We had this discussion prior to the podcast and going through the different indices and trying to look to see if you could pin point what you have seen this winter on a specific pattern. You can't really. You see a lot of noodling. The jet stream being progressive, kind of moving around. What this actually connects back to; is us declaring that El Nino is here. I like this idea of El Limbo, it is half there. So the sea surface temperature pattern is fine and dandy, but if it doesn't do anything to the atmosphere, no one cares. The atmosphere matters. The sea surface temperature patterns sure looks like El Nino but the fact that it hasn't connected to the atmosphere, doesn't really matter to us at this point. We can't really pin it back on El Nino, is what I am saying. But if you take it the other way, I don't care. It has been raining, what is causing it is just a mix. 15:02

Zack: There may be a climate part of that and that is, the warmer water is off the west coast. 15:12

Mike: Yes, we have been kicking this idea around for months now, looking at the sea surface temperatures in

the East Pacific. We are not talking equatorial now; we are sort of outside of the El Nino zone. But up along the coast of North America, especially over the coast of Baja Mexico and Southern Mexico, they have been really warm. It appears that is related to the ridiculously resilient ridge. The jet stream pattern the last couple of years have limited the upwelling you would normally see there. The simple way of thinking of it has allowed a lot of that warm water to pool there and it is still there. If you look at some of the metrics of moisture over the Southwest and the East Pacific, they are all connected to each other. So when we get a storm that wanders by us, it seems to be able to tap in and drag that moisture in. If you look at the last five years, it has been mostly cold there, which would mean less access to moisture. So when storms would wander down by us, they wouldn't have much moisture to tap into and they would wander by. They would get a little bit cooler, we would see some high clouds and that is about it. We get a storm wandering by now, it is actually able to make precip. Not real well and organized. I think it is a nice ingredient we can look forward to. 16:35

Zack: Have you read anything on why that ridge set up so persistently in that last two or three years. 16:44

Mike: What I have seen and it is kind of in the blogosphere, I think what people are really centering on is that we have a La Nina like pattern across the Equatorial Pacific, lots and lots of convection over the West Pacific, very warm water building up over a lot of years because of that La Nina Pattern, driving lots and lots of tropical convection. When you have that very persistent area of just exhausting tons and tons of heat in the atmosphere, it sets up a wave pattern in the jet stream in the northern hemisphere. What that happens to look like is just like the ridge pattern we had over the last... I think this is where you will see some attribution studies and you already have. Some controversial attribution studies have come out in the last couple of months where people are saying this just a lock in of a motive natural climate variability, it looks very La Nina like that the atmosphere just can do. So we need to look out for these things. 17:48

Zack: It is important to point out that sort of the official definitions over the last couple of years have been neutral. 18:04

Mike: That is why some people in the community are arguing that our El Nino, La Nina definitions are too simple. Too boxy. That is not to argue that we don't, you do need to have some objective definition but we are getting into these strange flavors. We may be getting too obsessed with crossing thresholds. Which is why I think you have seen some of the agencies internationally say, El Nino enough. 18:28

Zack: Japan has done that. CPC, NOAA has not. They have held back and are not declaring it, even though the sea surface temperatures in a particular region have been above the threshold since a little bit before November. Although they are declining in temperatures now and there is some indication that this event is waning in terms of sea surface temperatures. But what has been missing is, that tropical convection has not been vigorous in this central, slightly eastern part of the Pacific Ocean. It has remained over Indonesia. When you don't have that precipitation moving eastward, you are not pulling the atmospheric strings as much as you would during a traditional El Nino event. 19:19

Mike: Exactly, and again I think we are going to be studying this one for a while. It is a good humbling event because I think it is going to push the science in a good direction. You don't see the gradient sea surface temperatures across the Equatorial Pacific that you expect, we never had the cool down to help sort of drive the oscillation pattern and maybe help reorganize the convection in the right spots. The interesting thing though is that we have had trouble pin pointing where this thing was going to go at every step and if you look at the modeling...well first off, if you just look at the cross section of temperatures across the Equatorial Pacific, there is the warm water coming to the surface in the Eastern Pacific, some cooler than average water below it, but there is still a lot of warm water in the Western Pacific and it sure seems like another Kelvin wave is possible. The models are still converging on warmer than average temperatures all the way through next summer. So it is not crashing, it is not the typical situation where we did it, we exhausted it and we are going back to neutral conditions. The models are still really confused with whether or not this thing is going

to hang on and maybe give us a chance at a second year coming on. I am still scratching my head and I think we are going to continue watching this thing for the next couple of months. 20:40

Zack: In terms of El Nino's impact on precipitation, it is worth pointing out that its mostly felt in the winter time. So even if there is an El Nino chugging along during the summer, there is some influence it has on the monsoon. It is not as clear-cut as it is on winter precipitation. 21:00

Mike: I think that maybe to be clear too, there doesn't seem to be any indication that much of any of our weather patterns this winter have been driven by the El Nino pattern. 21:11

Zack: That is your point that it has been weather dominated. 21:12

Mike: What I mean by that is, there isn't any sort of remote forcing anywhere causing the weather to organize around it, it is the typical free for all in the atmosphere. The flip side of it would be, say that the El Nino sea surface temperature pattern, which we certainly have, did coordinate with the atmosphere you would have this big area of thunderstorm activity in the Central Pacific, being a big rock in the stream or a big energy source. You would see the weather organize around that and start to persist. We haven't seen that. 21:51

Zack: El Nino has put its fingerprint on 2014, in terms of the warmest year on record. So that is related to it. 21:56

Mike: Yes and we knew that this year was probably going to turn out at as one of the warmest, if not the warmest, because of the shift towards warm temperatures across the Pacific. 22:09

Zack: So those that want some numbers, the global average temperature was .69 degrees Celsius or 1.24 degrees Fahrenheit, above the 20th century average. That 20th century average was 57 degrees Fahrenheit. It beat the previous record warmth of 2010 and 2005 by .04 degrees Celsius or almost .1 degree Fahrenheit. So regionally it was also the warmest here in the Southwest. By Southwest I mean Arizona, Nevada and California. They all experience the warmest year on record and there are 120 years to draw from. Then most of the West is much above average. The East was not. It was this opposite. It was below average in the East, which then if you average the U.S. as a whole together, the U.S. hasn't experienced its warmest year on record. But when sea surface temperatures are warmer than average during El Nino conditions, part of that heat then releases to the atmosphere and warms up the temperatures. 23:35

Zack: So I think this is the climate change fingerprint that people respond to. If you look at the 12 warmest years on record, they have all been since 1998, with 1998 being the really big El Nino year that pumped a lot of heat into the atmosphere. So it is also worth pointing out that this has an influence on precipitation, temperature sort of ramps up the evaporation and transpiration as well. There was this interesting paper that recently came out that asked the question, how unusual is the 2012-2014 California drought. This is a paper by Dan Griffin, who actually was a CLIMAS graduate student not too long ago and is now at the University of Minnesota. So it is trying to use tree ring records to put this drought into a long term, 1,200 years or so, perspective. What they found is, if you just look at precipitation, it is not unprecedented. There has been maybe a three-year period in the historical record that has been as dry. But then when you couple that with temperature, given that it has been really warm and you use some sort of imperfect, but none the less drought indicators, this drought has been the driest in California in the last 1,200 years. 25:03

Mike: There is that subtle part of that story thought that we don't spend enough time on and that is the dryness; the lack of precipitation is not unprecedented. This is the story that we miss is these kind of droughts are in our back pocket and at the ready. When they come along we should expect them and not freak out that they are unprecedented. The temperature component absolutely drives it in a new direction. But just the frequency of the drought is not 0. These intense multi year droughts, if not decade long droughts are completely part of the natural climate variability down here. 25:59

Zack: Yeah to your point, there was another report released just before this paper that just looked at precipitation. It just looked at the atmospheric patterns that set up and produce dry conditions like what we experienced. That ridge is a percent feature. 26:29

Mike: Again, it is not taking climate change out of the equation; it is saying that under natural variability and natural circumstances, this is a completely probable situation. To me this indicates this idea of needing to put these into planning perspectives and use them as probable scenarios for us to act around. 26:48

Zack: So back to El Nino, if that El Nino does sort of persist, we probably would expect another very warm, if not record breaking year. Although record breaking may be difficult given how warm the sea surface temperatures were earlier this year. 27:08-0

Mike: It will be a warm year. Then you go down to the region and what is going to drive Arizona in a warm year is this pattern. If you look back at why California, Arizona and Nevada go really warm, at least for Arizona you can look at this map that we are looking at, which is warm in the West and cool in the Midwest and the East. You can map the jet stream pattern around that, the ridge is to the north over the Western U.S. and there is big, this is where you go polar vortex. That blue in those very cold temperatures in the upper Midwest are because of the jet stream pattern over the Eastern U.S. That jet stream is going north of the U.S. on the western side and then dipping down to the Midwest. So in the West, that warm air from the tropics is coming up, where on the Eastern portion, it is that cold air from the Arctic. So to get us to do this again this year, we need to be under the ridge. We are kind of there right now. We are still chugging along pretty warm. Another thing that drove the temperatures here in Arizona, we had very high over night temperatures from last spring through the summer and fall. It was humidity. That again points back to the East Pacific, warmer than average moisture source right at our doorstep. If you go back and you look at the over night temps through the summer and fall, it is 6 months of the year that were way warmer then they have been. You usually start to see temperatures crash in September and October as things dry out, it never did. I think that helped push us over the top with temperatures. 28:59

Zack: Just to hit upon the seasonal climate forecasts, which are again largely ENSO influenced, they are calling for the next three months to have increased odds for above average precipitation. Any thoughts for what they are clueing into? 29:18

Mike: I am not sure. They sure look like an El Nino pattern, even if we don't get that lucky. I wonder if all the models are struggling with, we have all of these sea surface temperatures that look like El Nino. If you look at the forecast models all the way up through April, they have got enhanced chance of above average precip here across the Southwest every month. If you back over time, that above average precip forecast has been in play for almost a year now. There are a lot of positive signs here moving forward that we are not going to just fall off a cliff and have everything shut down. But again, how much of this is driven by El Nino really showing up, I am not sure. 30:09

Zack: Some of those above average chances for wetter conditions do fall over Colorado too. So that could help the snow pack conditions. Before ending, I did want to mention the snow pack conditions in California. They did receive a lot of rain and there was some flooding. In California all three if the Sierra's are running at 40 percent of the January 2015 percent of average and below. Those events, while helping our precip scenario, they are still looing pretty bleak.