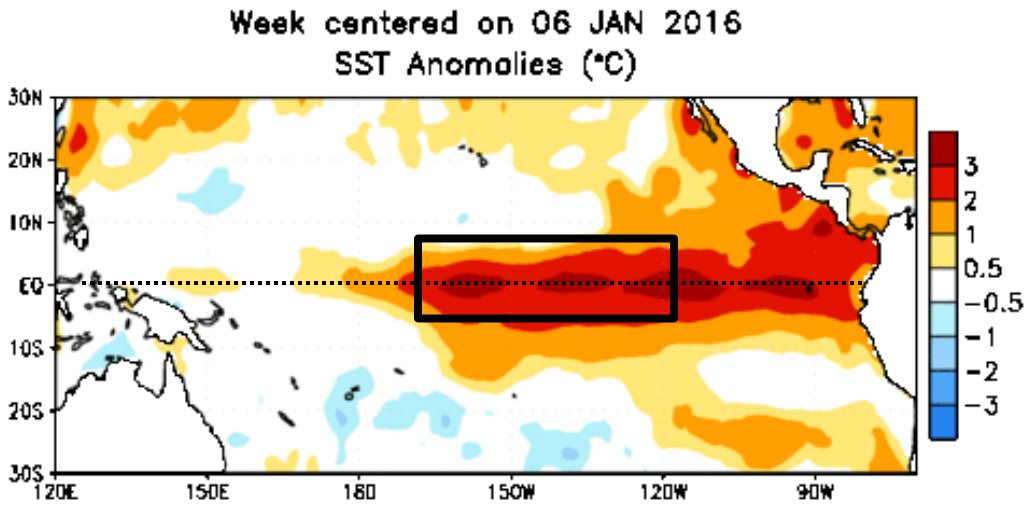
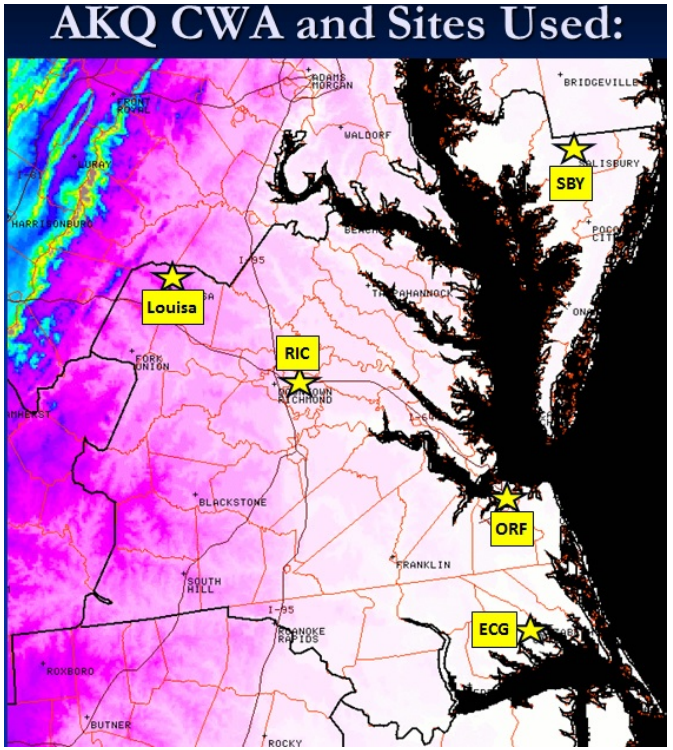
El Nino in the Mid-Atlantic: What does it mean for us?

El Nino conditions have developed and are expected to persist into the upcoming winter and last through the spring of 2016. The term “El Nino” refers to a local warming of the tropical Pacific Ocean. The most studied location to determine the strength of an El Nino event is along the equator between 170 W and 120 W longitude, an area commonly referred to as the “Nino 3.4 region” (see black rectangle in figure below). El Nino is actually just one phase of the El Niño/Southern Oscillation, often called by the acronym *ENSO*. *ENSO* has two phases: a ***warm phase*** we call **El Nino** and a ***cool phase*** called **La Nina**. These alternate at irregular intervals of 1 to 4 years. This particular El Nino is expected to remain strong through this winter, meaning that the tropical Pacific within the Nino 3.4 region will have sea surface temperature (SST) anomalies averaging at least 1.5 C above normal for 5 months. Looking back since 1950 there have been six strong El Nino events that this upcoming winter season will have as analogs from which we can base a winter outlook on. These strong events occurred during the winters of **1957-1958**, **1965-1966**, **1972-1973**, **1982-1983**, **1991-1992**, and **1997-1998**. We will examine 5 stations within the Wakefield County Warning Area (CWA).





Precipitation: Generally Favors Wetter than Average Conditions

During strong El Nino events, above-normal precipitation typically extends across much of the southern United States and this includes the Wakefield CWA (see bottom right image). Large thunderstorm complexes tend to become more numerous during strong El Nino events due to the unusually-warm waters over the tropical eastern Pacific Ocean. Abundant amounts of moisture get lifted into the atmosphere and powerful subtropical jet streams efficiently transport this moisture across the southern United States. This brings frequent occurrences of moderate to heavy rain or occasional snowstorms to much of the region.

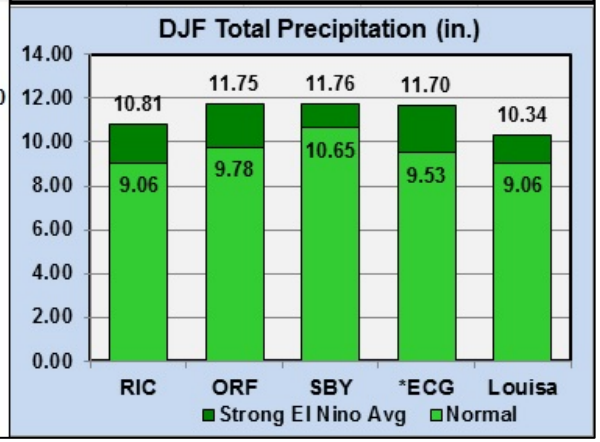
However the values only slightly favor wetter than average conditions, indicative of the many other factors that influence winter conditions across the mid-Atlantic region. The chart and graph below (at left) shows the observed winter (Dec-Feb) precipitation amounts and anomalies averaged across the last six strong El Niño events at five sites within the Wakefield CWA. Note that total precipitation averages above normal at all sites, with the greatest anomalies occurring at Norfolk in southeast VA and in northeast NC at Elizabeth City. However, also take note of the variability between individual seasons; 1997-98 being very wet at all locations while 1982-83 was wet at Norfolk and Elizabeth City but drier than normal at Richmond, Salisbury, and Louisa. ***Overall though, odds favor a normal to wetter than normal winter with a dry winter rather unlikely.***

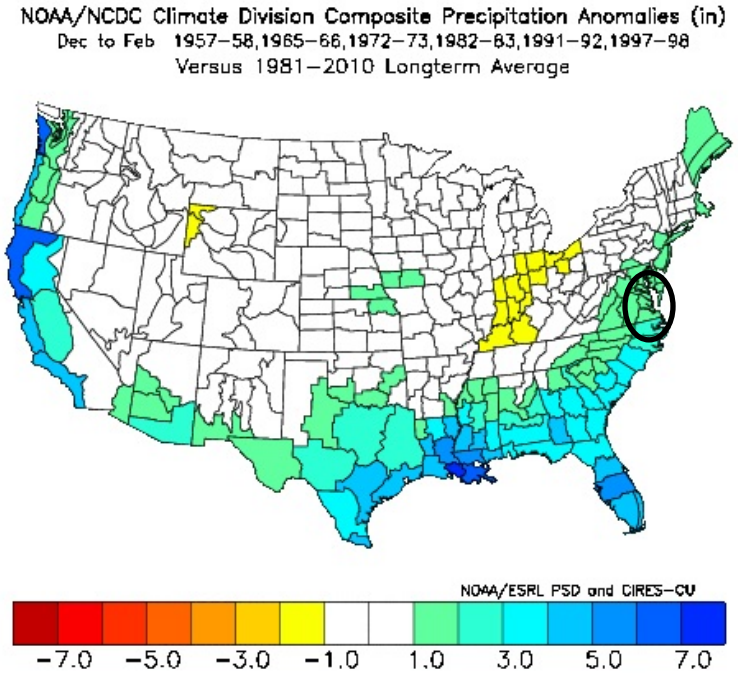
	DJF Precipitation				
Season	RIC	ORF	SBY	*ECG	Louisa
1957-58	14.22	12.24	13.87	11.68	12.78
1965-66	9.10	9.77	7.64	11.43	9.74
1972-73	8.68	9.87	11.11	10.25	9.28
1982-83	8.91	12.74	9.26	11.93	4.95
1991-92	8.99	8.98	10.38	9.69	9.13
1997-98	14.97	16.87	18.28	15.19	16.16
Avg	10.81	11.75	11.76	11.70	10.34
Normal	9.06	9.78	10.65	9.53	9.06

"Avg" of 6 Str El Nino cases

"Normal" based on 1981-2010

RIC= Richmond, VA
ORF= Norfolk, VA
SBY= Salisbury, MD
*ECG= Elizabeth City, NC
Louisa= Louisa, VA (co-op)



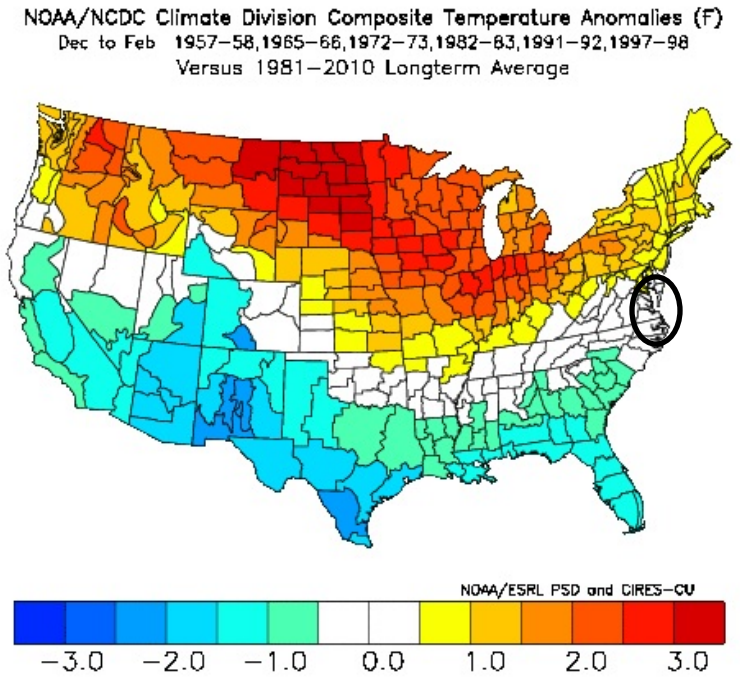


Temperature: No Clear Signal for Warm or Cold

During strong El Nino events, average winter temperature favors warmer than normal conditions across the northern tier of most of the nation and colder than normal conditions over most of the southern states (see image bottom right). However, the mid-Atlantic region south into North Carolina shows too much variability among the cases to provide a clear signal with some events being cold and others warm. The strong El Nino winters of 1957-58 and 1965-66 were cold, averaging several degrees below normal at all 5 stations, while 1991-92 and 1997-98 were rather warm and averaged 2-3 F above normal (see table at bottom left). The average of the 6 strong El Nino winters shows that the warm and cold cases tend to cancel each other out making for near normal temperatures as a whole (i.e. Richmond's "Normal" or long term mean temperature is 39.9 F and the 6 strong El Nino case "Avg." is nearly identical at 40.1 F).

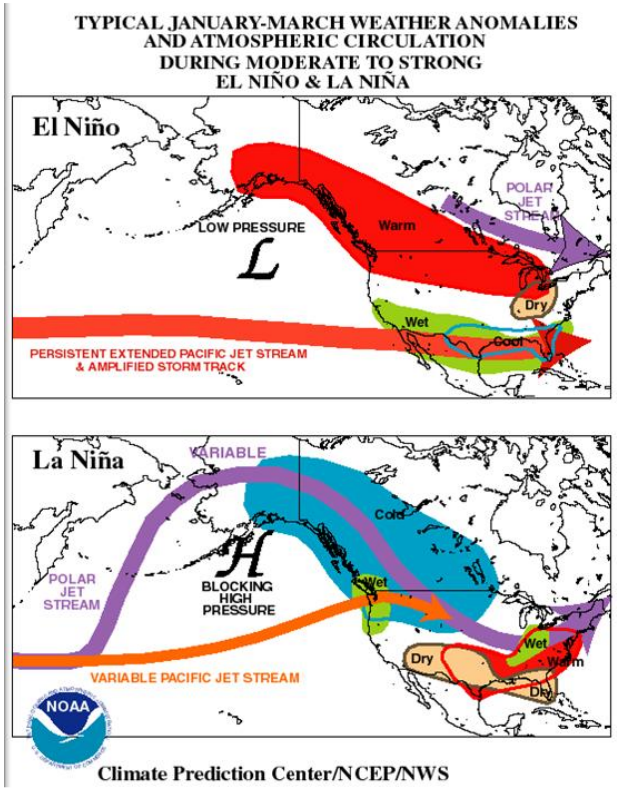
Overall odds do not favor a cold or warm winter, but as the 6 cases show this does not mean that a near normal winter is favored either.

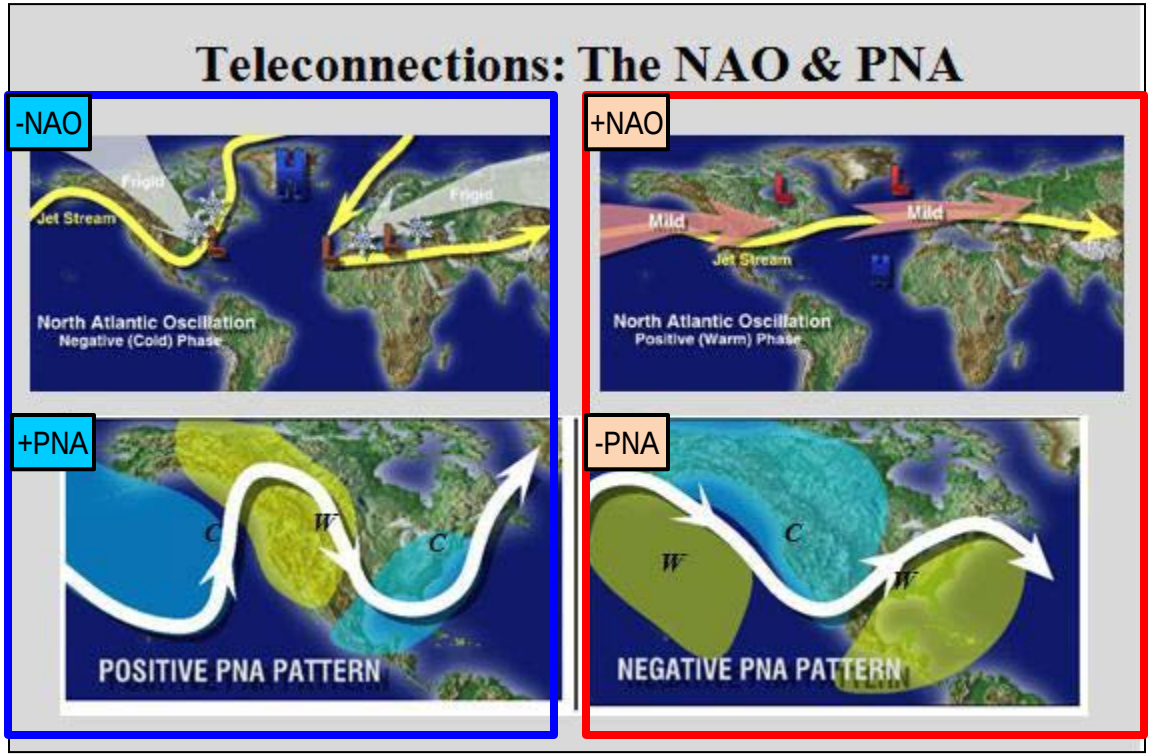
	DJF Avg Temperature				
Season	RIC	ORF	SBY	*ECG	Louisa
1957-58	37.1	40.1	35.3	40.5	34.9
1965-66	36.7	39.3	36.1	41.6	35.9
1972-73	40.6	43.1	40.3	44.0	39.3
1982-83	41.0	43.2	39.5	45.0	39.2
1991-92	42.5	45.0	39.4	46.3	39.7
1997-98	42.4	45.7	42.5	45.3	38.5
Avg	40.1	42.7	38.9	43.8	37.9
Normal	39.9	42.8	37.6	44.0	37.0



Temperature: No Clear Signal for Warm or Cold

So, what does this mean and is there anything else that we can consider? The image at bottom left shows "typical" mid and upper level flow through the atmosphere during El Nino and La Nina winters. In the El Nino case, note that there is the presence of a "persistent" Pacific jet stream through the southern US, while the "polar jet" tends to be locked up over northern and eastern Canada. The 4-panel image at bottom right shows 2 "teleconnection" patterns that vary on timescales of a few weeks to months and occur independent of El Nino or La Nina. When particular "phases" of each of these become dominant during most of a winter season, the results can be significant. The positive phase of the North Atlantic oscillation (NAO) features a persistent jet across the US and tends to keep arctic air masses locked up to our north across the far northern tier of the US or Canada, typically resulting in warmer than normal temperatures over the mid-Atlantic region. The opposite is true of the negative phase of the NAO and in this case, the jet stream becomes highly amplified with a deep trough diving into the southern and southeast US. The result often brings much below normal temperatures to the mid-Atlantic states, along with increased probability for snow across the Wakefield CWA. The Pacific North American pattern (PNA) is somewhat different in that the "negative" phase brings the relative warmth to the mid-Atlantic while the positive phase brings the cold.



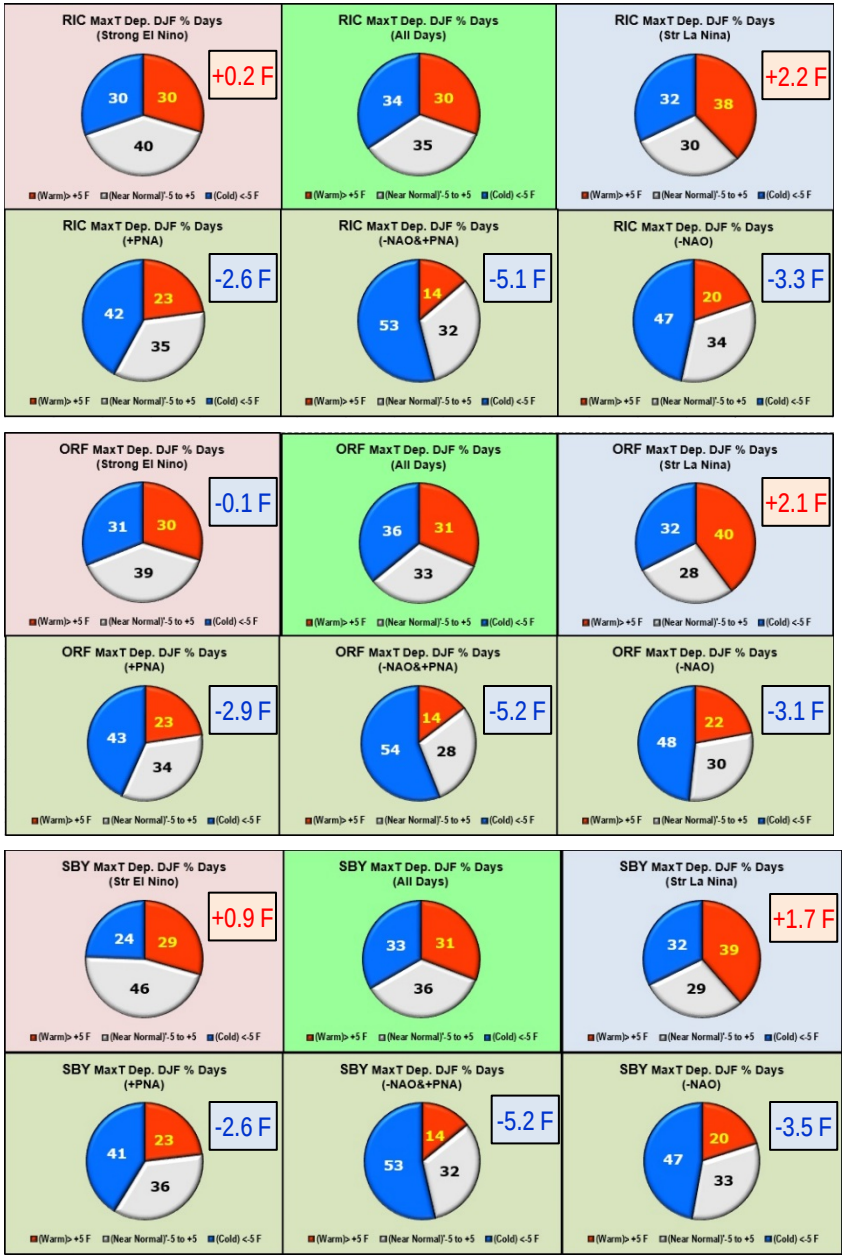


Temperature: (continued)

The series of charts to the right show how much affect a strong El Nino, strong La Nina, and the cold phases of the NAO and PNA have on winter temperature at Richmond, Norfolk, and Salisbury. The pie charts break out the daily high temperature into 3 categories: ***near normal*** (5 F either side of normal), ***cold*** (more than 5 F below normal), and ***warm*** (more than 5 F above normal). Taking RIC as an example, the 6 strong El Nino winters average near-normal temperatures 40% of the time, cold temperatures ***30%*** of the time, and warm temperatures ***30%*** of the time. In a given DJF/winter season of 90 days, this would yield roughly 36 days near normal, 27 days cold, and 27 warm.

When the NAO is in its cold or negative phase, note how much the conditions are altered, now having nearly a 50% probability **(47%)** that a given day will be more than 5 degrees below normal and only a ***20%*** chance that a given day will be 5 F above normal. Totaled up, days with the –NAO prevailing average ***3.3 F*** colder than normal. When both the PNA and NAO are in their respective cold phases at the same time (-NAO and +PNA), the effects are even more impressive, a ***53%*** chance for cold and just a ***14%*** chance for warm and an average high temperature ***5.1 F*** colder than normal. The results are fairly similar at Norfolk and Salisbury.

Unfortunately, these phases of the NAO and PNA are rather unpredictable beyond a period of a few weeks and hence the difficulty at making a winter forecast several months in advance.



Temperature: (continued)

Revisiting the average temperature by season for each of the strong El Nino cases, and now adding what the average value of the NAO was during each case, we find a decent correlation between temperature. Except for the 1997-98 winter, the temperature for each winter season matched the phase of the NAO (negative NAO matches with cold temperatures).

	DJF Avg Temperature					
Season	RIC	ORF	SBY	*ECG	Louisa	NAO
1957-58	37.1	40.1	35.3	40.5	34.9	-0.49
1965-66	36.7	39.3	36.1	41.6	35.9	-0.59
1972-73	40.6	43.1	40.3	44.0	39.3	0.36
1982-83	41.0	43.2	39.5	45.0	39.2	0.95
1991-92	42.5	45.0	39.4	46.3	39.7	0.47
1997-98	42.4	45.7	42.5	45.3	38.5	-0.23
Avg	40.1	42.7	38.9	43.8	37.9	
Normal	39.9	42.8	37.6	44.0	37.0	

Some other miscellaneous temperature data is listed in the table below. One thing to note is that temperatures tend to be moderated during strong El Nino winters, owing to the Pacific-dominated flow. On average, strong El Nino winters have less very warm days (highs of 70 F or greater) as well as less very cold days (highs of 32 F or colder) when compared to the long-term normals.

	DJF Coldest Daily Temperature (Min)					DJF Days Tmax <= 32 F					DJF Days Tmax >= 70 F				
Season	RIC	ORF	SBY	*ECG	Louisa	RIC	ORF	SBY	*ECG	Louisa	RIC	ORF	SBY	*ECG	Louisa
1957-58	4	11	-2	10	4	6	7	14	6	11	0	1	0	2	0
1965-66	3	10	-6	13	0	9	5	11	1	8	1	4	0	4	1
1972-73	5	12	10	10	5	6	8	7	5	5	3	3	2	4	1
1982-83	15	20	9	17	7	3	2	4	1	4	7	7	4	7	3
1991-92	16	19	7	16	8	1	0	2	0	2	5	8	1	7	2
1997-98	16	25	18	21	6	0	0	0	0	1	2	5	1	5	0
Str El Nino AVG	10	16	6	15	5	4	4	6	2	5	3	5	1	5	1
Normal	8	16	5	13	0	6	3	8		6	5	7	2	8	3

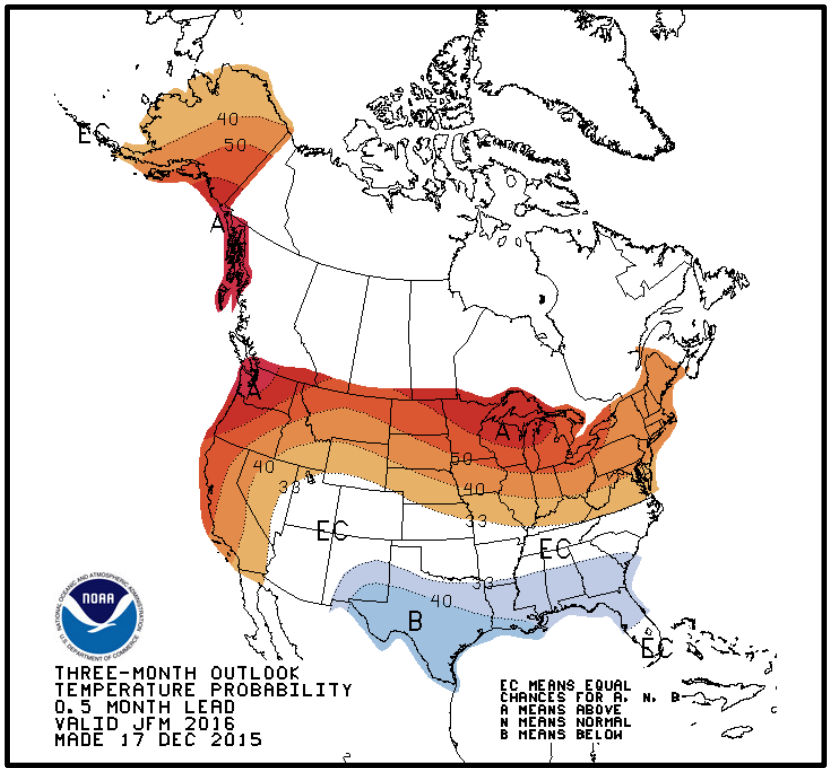
Snowfall: Above Average overall but Highly Variable

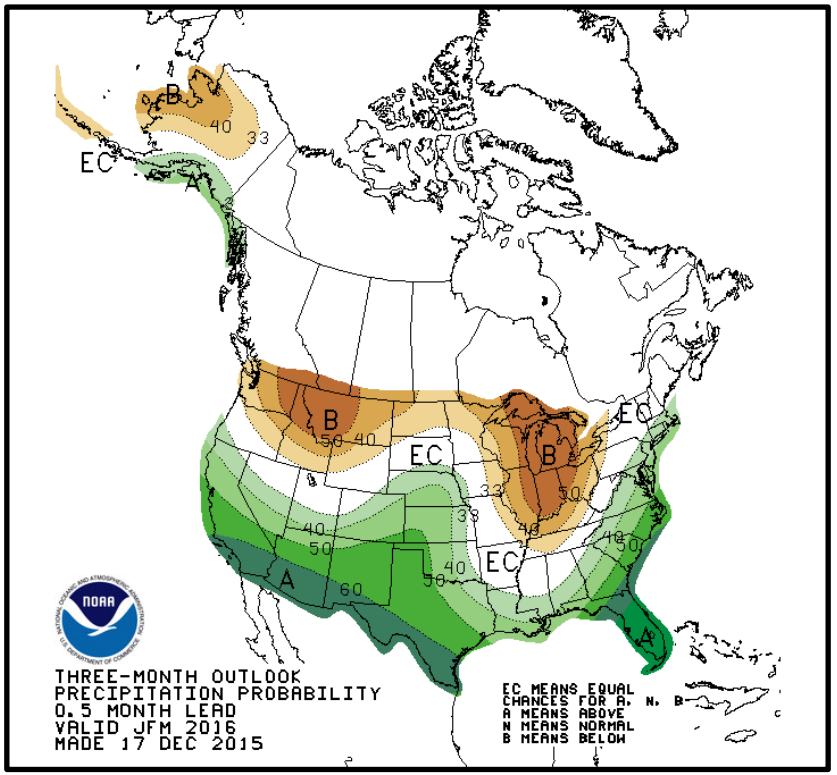
During strong El Nino events, average snowfall has been highly variable but averages slightly above to above normal except at Salisbury. A closer look shows that a few anomalous large snowstorms (February 1983 for example) bring up the average and may not be representative of the winter as a whole. As with temperature, the negative NAO and positive PNA to a lesser extent tend to favor more snow and appear to be a stronger signal than the ENSO phase alone.

	Seasonal Snowfall				
Season	RIC	ORF	SBY	*ECG	Louisa
1957-58	20.5	4.5	18.3	0.0	38.5
1965-66	29.2	14.7	20.4	9.2	39.7
1972-73	6.7	13.8	2.2	20.2	8.0
1982-83	29.4	3.4	11.2	7.0	19.7
1991-92	0.9	0.0	0.0	0.0	3.5
1997-98	1.2	0.0	1.0	0.0	7.0
Str El Nino AVG	14.7	6.1	8.9	6.1	19.4
Normal	10.3	5.8	9.9	4.5	17.1

The latest CPC 30 Day Outlook for Jan/Feb/Mar

Generally matching with all of the data mentioned so far, the most recent CPC outlook favors increased chances for cooler and wetter than average conditions across most of the southern United States. For precipitation, the Wakefield CWA shows increased chances for a wetter than average winter season especially over far southeast VA and northeast NC), while temperatures show equal chances for above, below, or near normal values.





Online resources for the 2015-2016 El Nino

NOAA/Climate Prediction Center: [El Niño/Southern Oscillation (ENSO)]

Daily NAO and PNA Index Values: [http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/teleconnections.shtml]

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