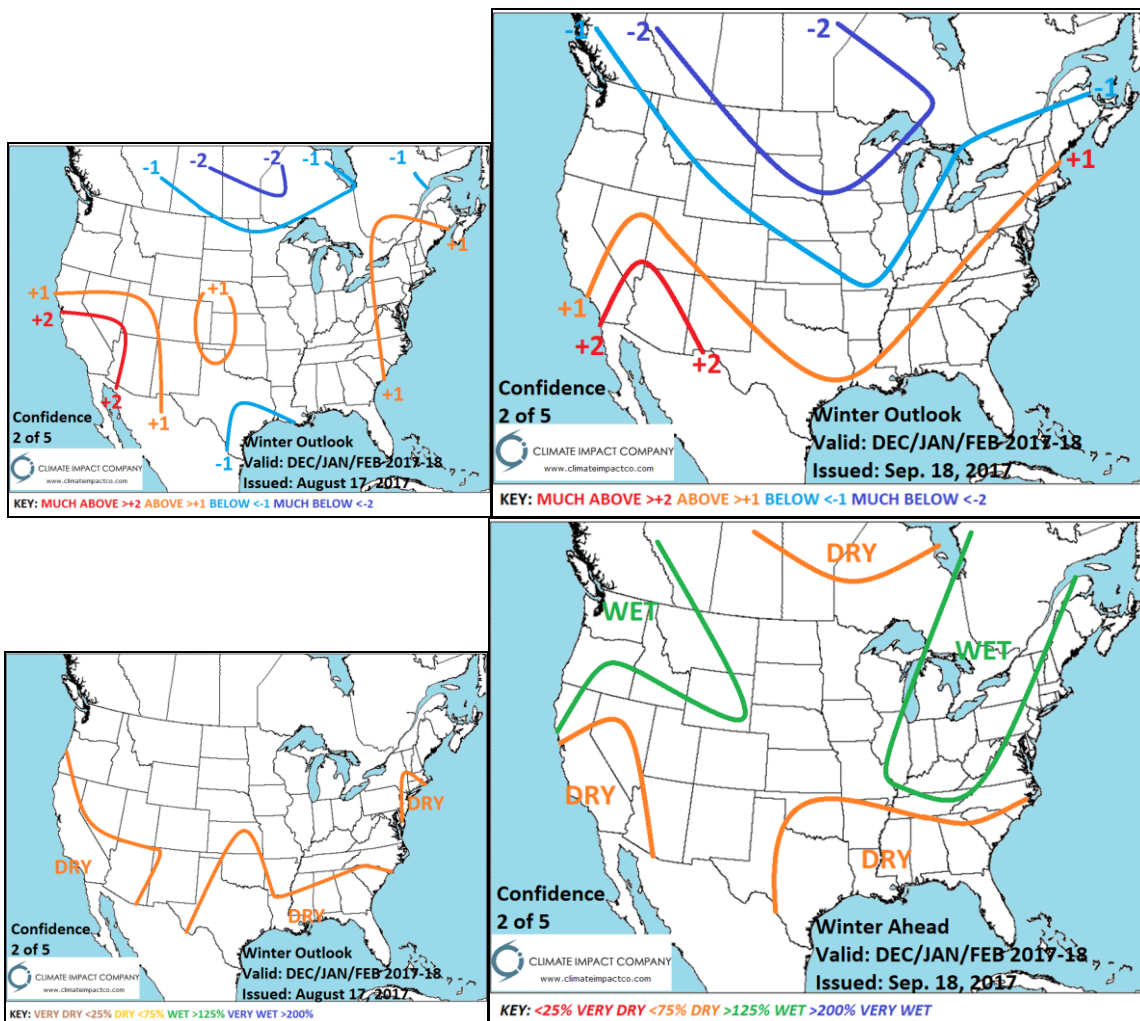


## Climate Impact Company Season 1-3 Ahead Outlook for North America

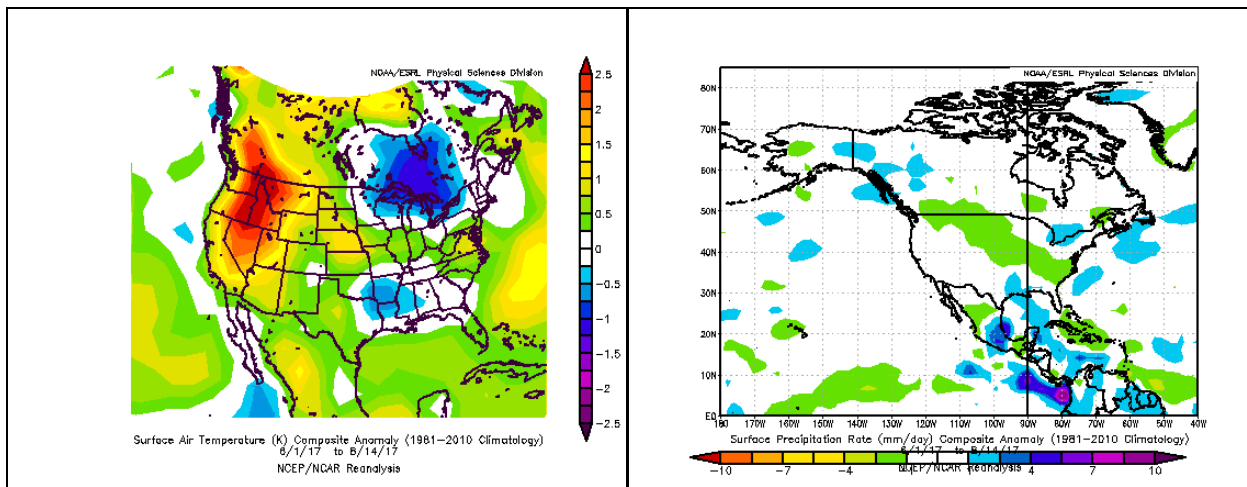
Issued: Monday, September 18, 2017

**Executive Summary:** The Climate Impact Company cold season outlook across North America is based on a constructed analog and considers NCEP CFS V2 and ECMWF (models) and the NMME probabilistic forecast (model). Results point toward a colder than previously indicated winter 2017-18 pattern across North America mainly central portions.

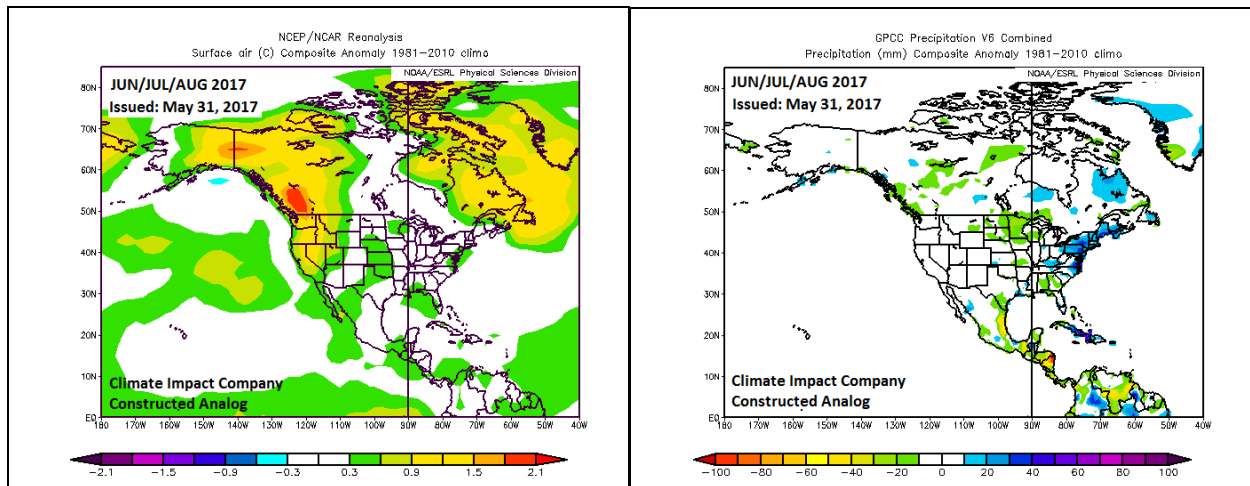
### Meteorological Winter Outlook for North America (previous left)



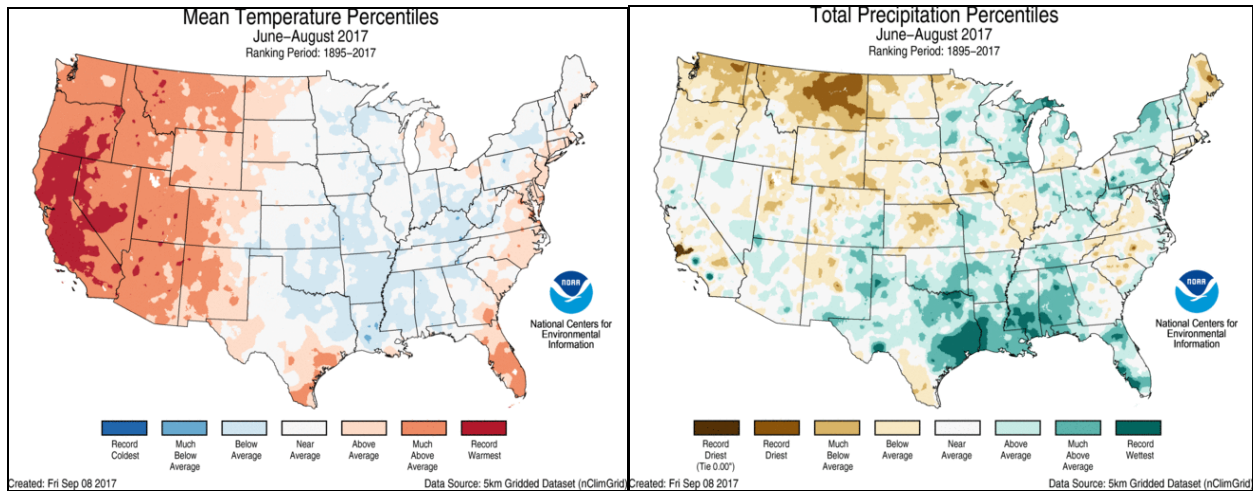
**Summer 2017 review:** An unexpected cool anomaly appeared in the Great Lakes and Ontario (region(s) during the just-ended meteorological summer season (*Fig. 1*). Anomalous heat was intense across the West/West-Central U.S. with marginal heat in the Mid-Atlantic States. Dryness dominated the North-Central to Mid-Atlantic States while wet weather emerged in the Gulf region (*Fig. 2*). The Climate Impact JUN/JUL/AUG 2017 climate forecast correctly predicted the warmth in the West but was not cool enough in parts of the East-Central U.S. (*Fig. 3*). The rainfall outlook was correct with North-Central dryness but not wet enough in the Gulf region (*Fig. 4*). U.S. temperature and precipitation ranking analysis more clearly define the summer 2017 character as hot West and wet South-Central (*Fig. 5-6*).



*Fig. 1-2: North America temperature and precipitation anomalies for summer 2017.*



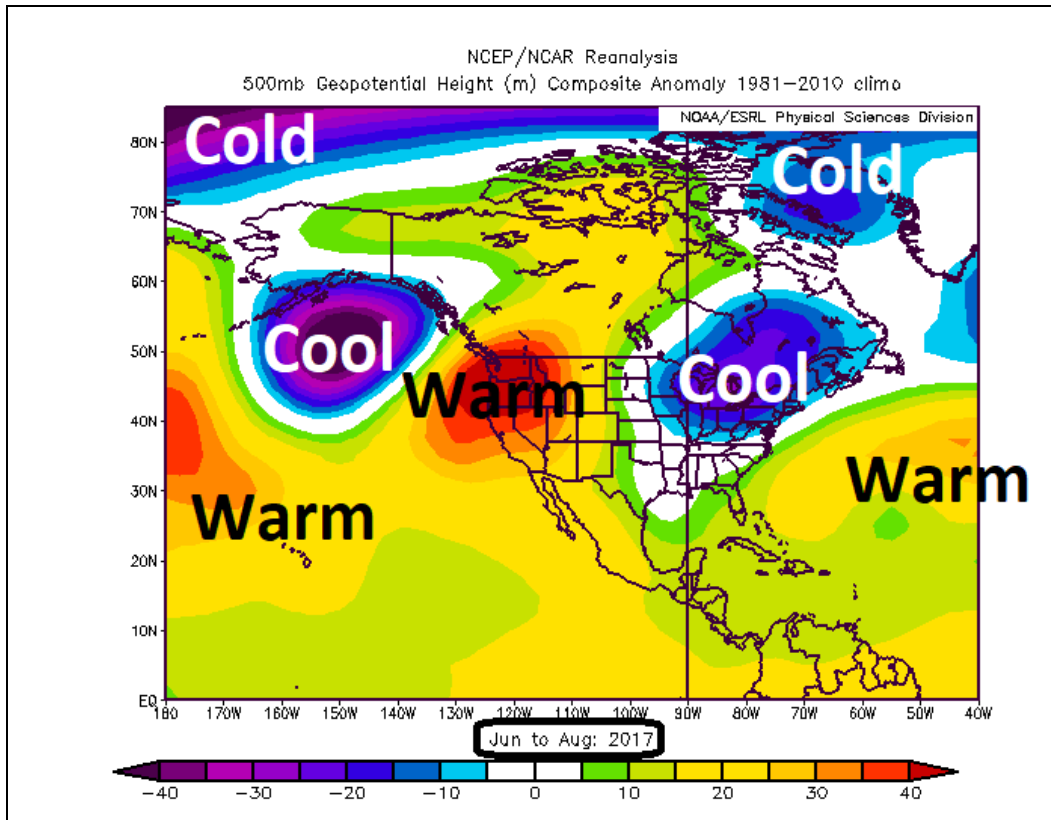
*Fig. 3-4: The Climate Impact JUN/JUL/AUG 2017 temperature and precipitation forecast.*



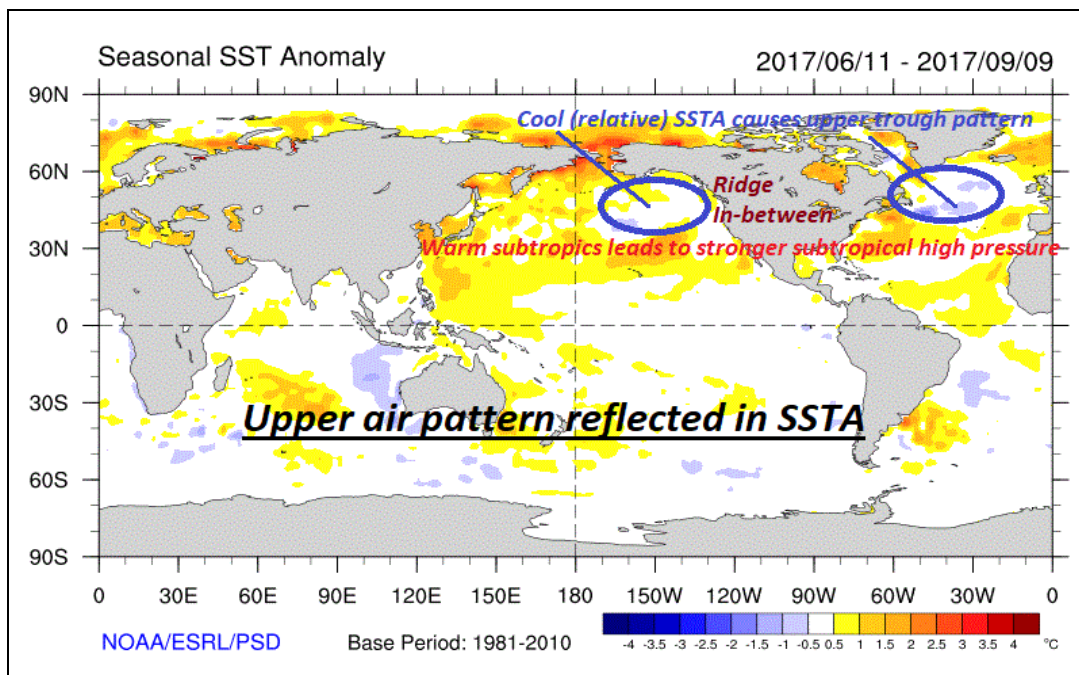
*Fig. 5-6: NOAA analysis of U.S. temperature and precipitation ranks for summer 2017.*

**Forecast methodology for North America cold season 2017-18:** The Climate Impact Company contribution to the 2017-18 cold season climate outlook is based on a constructed analog. The analog tries to approximate the JUN/JUL/AUG 2017 500 MB anomaly pattern across North America and then carried forward a historical precedent for what follows for upcoming winter and next spring.

The JUN/JUL/AUG 2017 500 MB anomaly pattern across North America indicates several interesting features (*Fig. 7*). First, note the below normal 500 MB anomalies in the polar region indicating the middle atmosphere of the polar region is colder than normal implying sea ice is a bit more widespread for mid-year versus normal. There is susceptibility of the polar vortex to extend southward a cold trough and that happens in eastern Canada to south of Greenland during summer 2017. The northern Pacific cools and a 500 MB trough is generated in the Gulf of Alaska. In-between the GOA low and Northeast U.S. low an upper warm ridge crests over western North America. Finally warm SSTA in the subtropical region (*Fig. 8*) supports a stronger than normal southeast Pacific high pressure and Bermuda High in the North Atlantic.



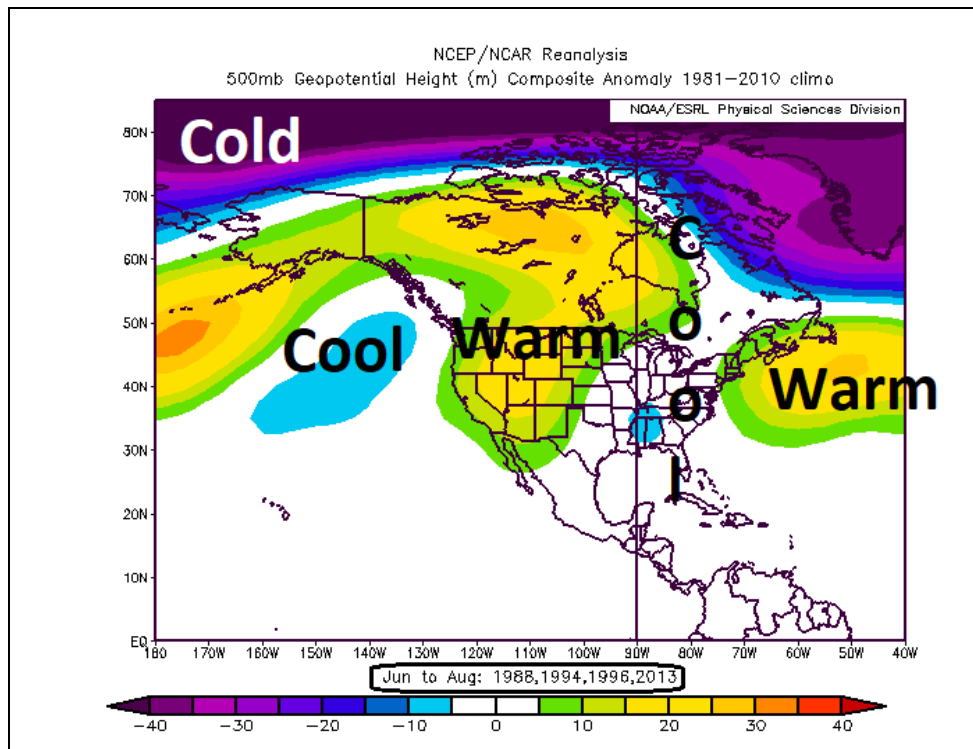
*Fig. 7: The 500 MB anomaly pattern for JUN/JUL/AUG 2017 across North America.*



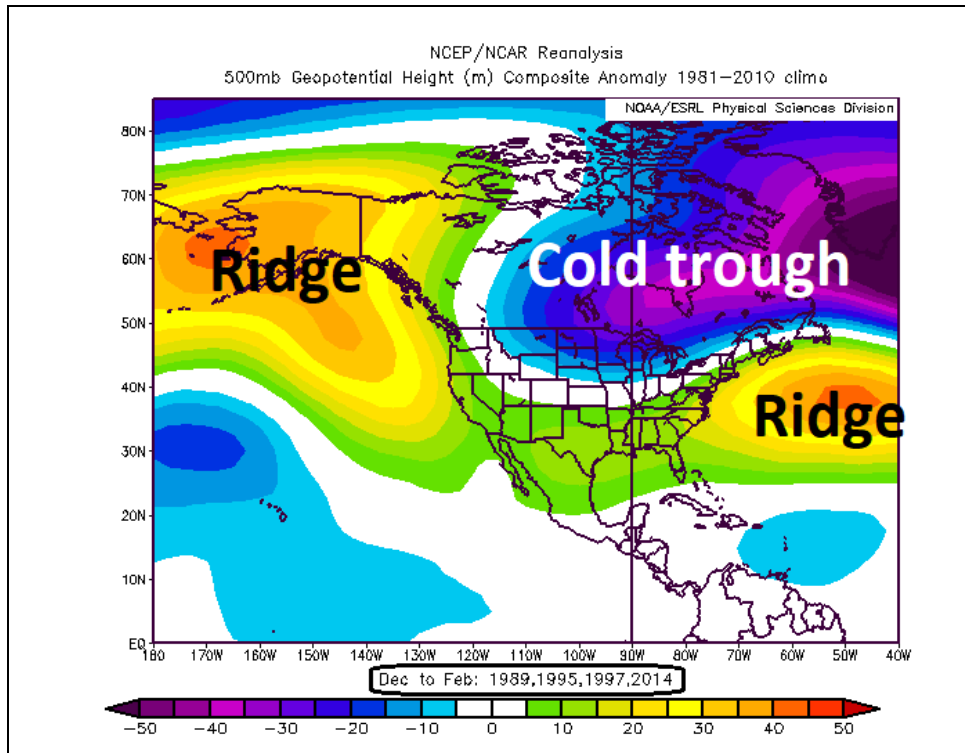
*Fig. 8: The generally strong subtropical ridging in both the North Pacific and North Atlantic correlates to warm SSTA in those regions. Cool upper trough(s) reside in the Gulf of Alaska where SSTA is relatively cool and south of Greenland where cool SSTA is present.*

The 500 MB anomaly pattern across North America is approximated by analog years 1988, 1994, 1996 and 2013 (**Fig. 9**). All years from 1950-2016 were reviewed. The analog match is not perfect. However, there are key matches particularly the cold 500 MB anomalies in the polar region which is unusual in the generally warmer climate of the past 2-3 decades. The JUN/JUL/AUG 2017 500 MB pattern in the middle latitudes is approximated with a weaker trough in the Gulf of Alaska and Interior East and a strong ridge in-between over the western U.S.

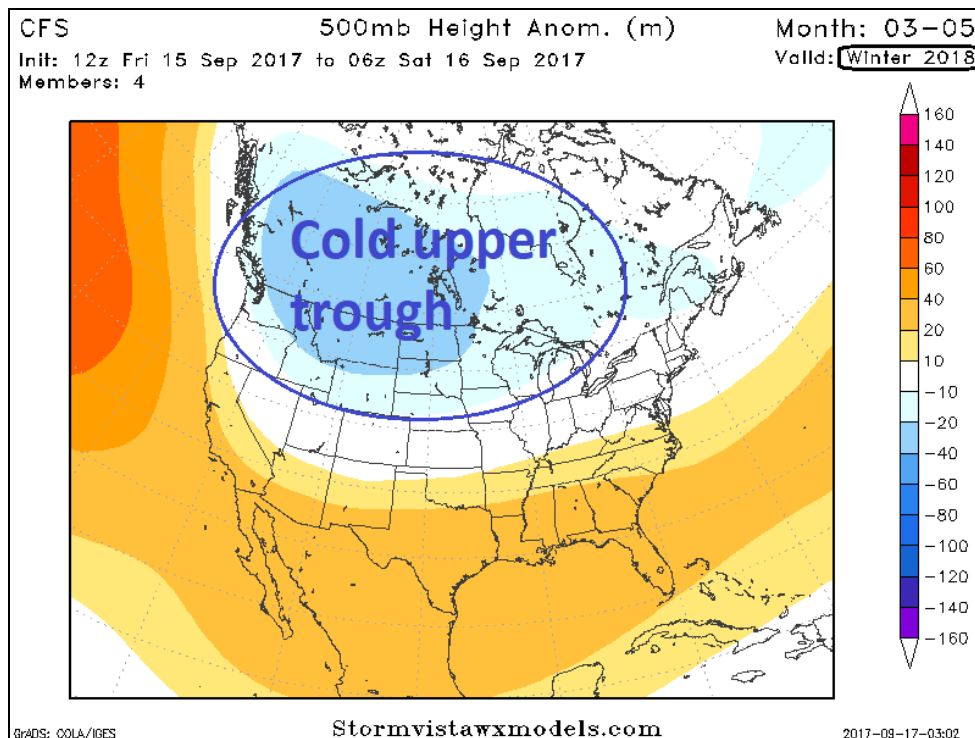
Using the analog years for winter 2017-18 the 500 MB anomaly pattern indicates a stronger than normal polar vortex centered on Greenland to south-central Canada with a warm upper ridge off the U.S. West Coast and Southeast U.S. (**Fig. 10**). Implied is a cold and snowy winter in the Central U.S. The NCEP CFS V2 500 MB anomaly forecast for winter also indicates a cold trough although farther west for DEC/JAN/FEB 2017-18. This outlook supports evolution of an arctic air mass over west and south portions of Canada with arctic outbreak implications for the U.S. (**Fig. 11**). Interestingly, the temperature probability forecast from the International Research Institute for Climate and Society also indicates increasing cold risk for western Canada to the Ohio Valley for winter ahead (**Fig. 12**). Evidence for a colder winter is gaining and presented in the updated outlook.



**Fig. 9:** The most representative analog years of JUN/JUL/AUG 2017 chosen from the 1950-2016 climatology of 500 MB anomalies is the combination of 1988, 1994, 1996 and 2013.



*Fig. 10: Using the analog years the projected 500 MB anomaly pattern across North America for winter 2017-18 is indicated.*



*Fig. 11: Current North Atlantic SSTA regimes having an influence on North America climate.*

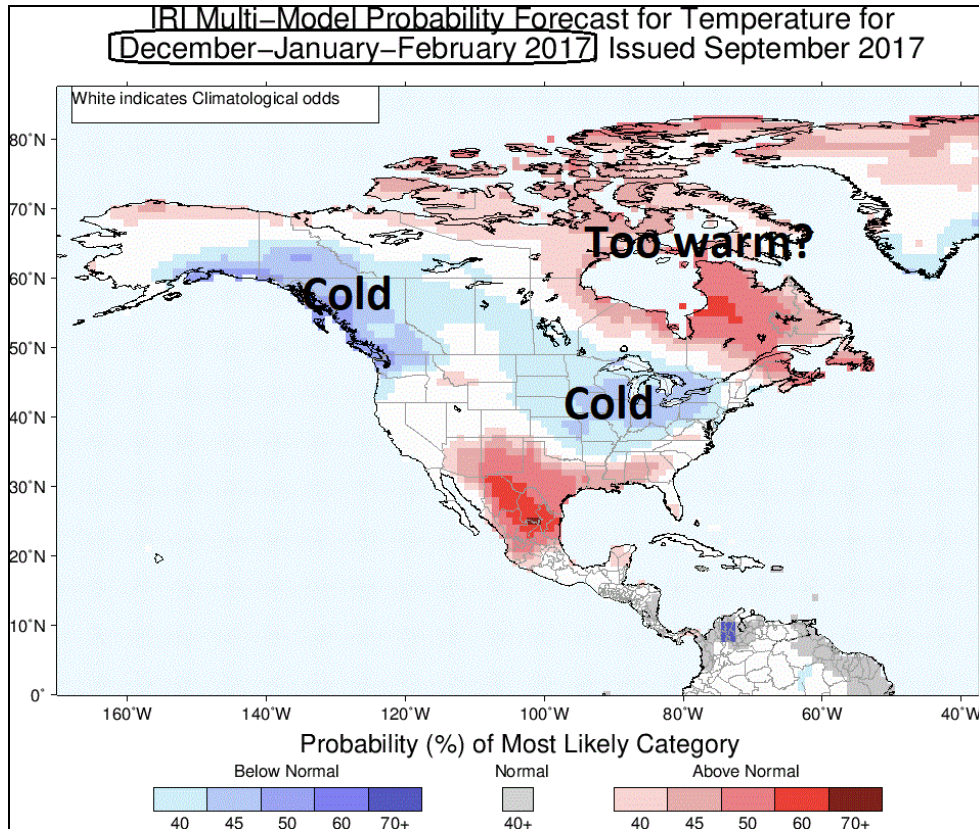


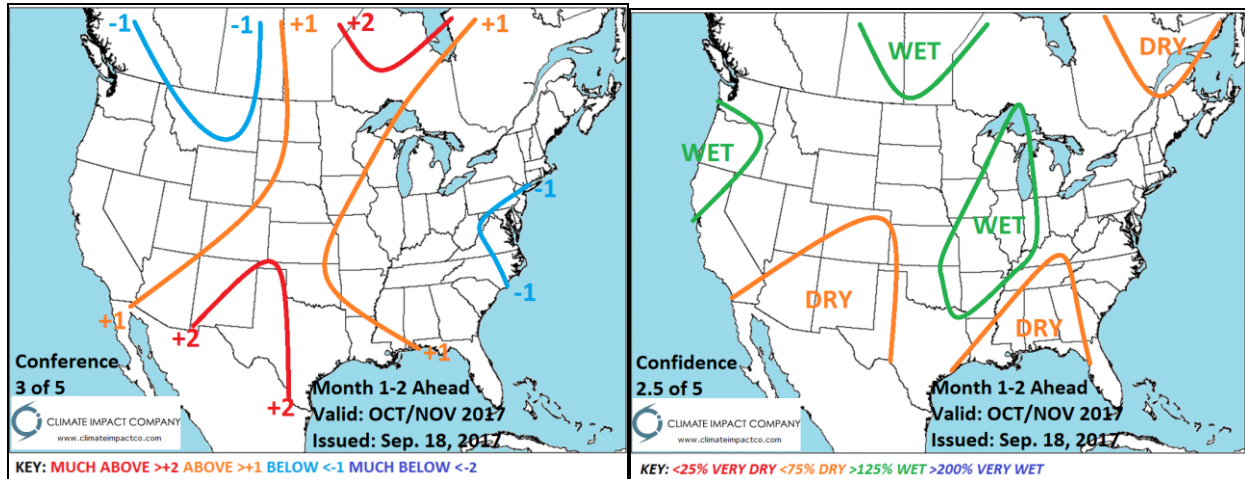
Fig. 12: The IRI probability forecast of temperature for DEC/JAN/FEB 2017-18.

**Climate forecast:** The outlooks are based on the analog years coupled with input from CFS V2, IRI and ECMWF. The winter outlook trends colder than previously indicated. The SSTA regimes expected are marginal La Nina, weak cool Pacific decadal oscillation (-PDO) and marginal to moderate warm Atlantic multi-decadal oscillation (+AMO). The North Atlantic oscillation is generally in the positive phase (based on analog years) supporting warmth in the East. However, snow cover may act independently as a cold air producer given the expected evolution of an arctic air source region in the lee of the Canadian Rockies. Arctic air flow can act independently of the prevailing upper air pattern as suggested by the NAO regime.

Analog year	NOV	DEC	JAN	FEB	MAR
1988-89	<b>BELOW</b>	<b>BELOW</b>	<b>BELOW</b>	<b>ABOVE</b>	NORMAL
1994-95	<b>ABOVE</b>	NORMAL	NORMAL	<b>BELOW</b>	<b>BELOW</b>
1996-97	<b>ABOVE</b>	NORMAL	NORMAL	NORMAL	<b>ABOVE</b>
2013-14	<b>ABOVE</b>	<b>ABOVE</b>	NORMAL	<b>ABOVE</b>	<b>ABOVE</b>
Consensus	<b>ABOVE</b>	NORMAL	NORMAL	<b>NML-ABV</b>	<b>NML-ABV</b>

Table 1: North America snow cover for the analog years on a monthly basis through the cold season is indicated.

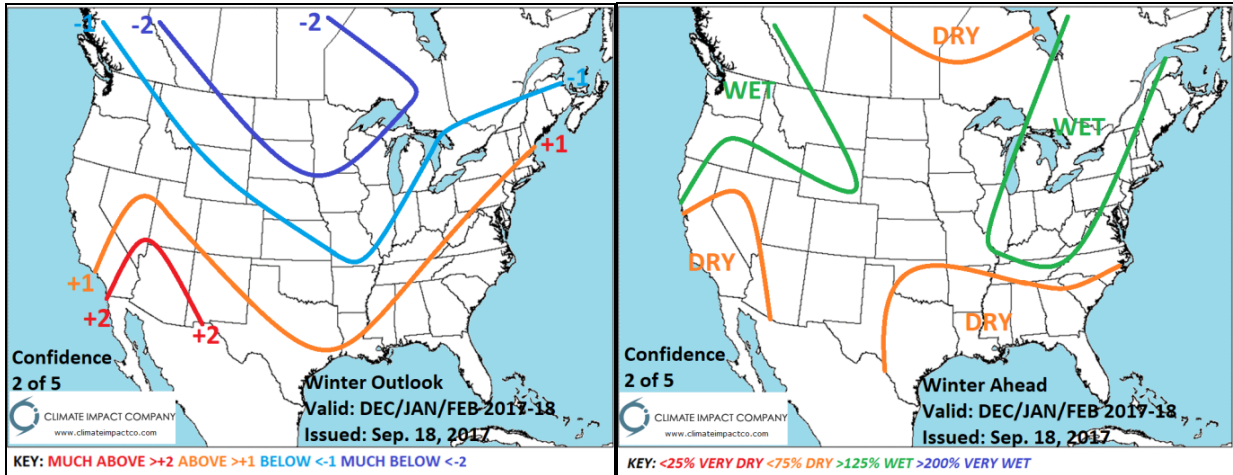
**OCT/NOV 2017:** The forecast trend is cooler. Based on the analog(s) early season snow cover develops across the northern U.S. in November. The likely catalyst is increasing support for an elongating polar vortex across central/east-central Canada enhanced by early season snowfall across the northern U.S. Additionally, early season arctic air may gather in the lee of the Canadian Rockies possibly surging south into the U.S. in November. Anomalous warmth is strongest in central/northeast Canada (although the trend is less warm) and also Texas.



*Fig. 13-14: The Climate Impact Company SEP/OCT/NOV 2017 temperature and precipitation anomaly forecast for North America*

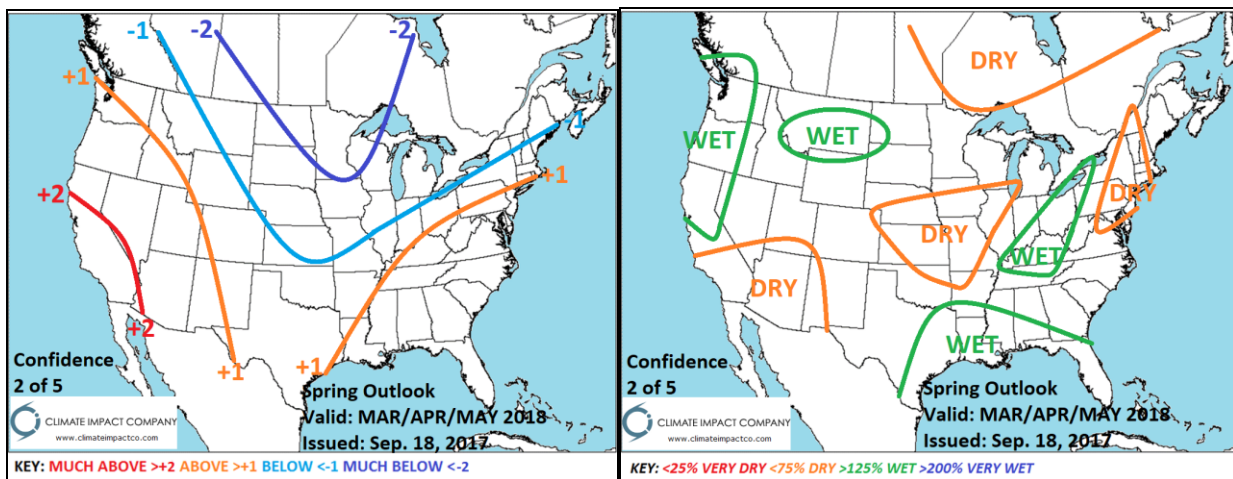
**DEC/JAN/FEB 2017-18:** The winter outlook is flipping colder. Analogs and some dynamic models are indicating cold risk for central North America. Producing the cold risk is increasing risk of an arctic air reservoir stretching from Alaska to south-central Canada and possibly the northern U.S. Snow cover is likely near normal for winter trending toward above normal by February. Most of the snow cover is across the North-Central U.S. acting as a carpet for incoming cold from Canada. The warm risk remains in the Southwest U.S. to southern Texas plus the Gulf region with a highly volatile thermal pattern in the East averaging slightly above normal. The precipitation outlook for winter is above normal in the Ohio Valley northeastward to Quebec. There may be heavy amounts in the Midwest. Above normal precipitation is also forecast for the Northwest States while southern areas tend to be the dry zones.





*Fig. 15-16: The Climate Impact Company DEC/JAN/FEB 2017-18 temperature and precipitation anomaly forecast for North America.*

**MAR/APR/MAY 2018:** The winter thermal pattern is expected to hold-on during next spring with late season snow and cold for the North-Central U.S. A warmer than normal spring is forecast in the West and Southeast U.S. Wet weather emerges in the Gulf region and lingers in the Northwest U.S.



*Fig. 17-18: The Climate Impact Company MAR/APR/MAY 2018 temperature and precipitation anomaly forecast for North America.*