Extended Abstract

The merits and limitations of using ENSO phase as a winter forecasting tool in the Northeastern United States

Richard Grimaldi and Richard Jaworski SUNY Oneonta

A 64-year climatological record for the cold season in Syracuse, New York is analyzed for temperature, liquid equivalent precipitation, and snowfall. Evidence suggests that El Nino winters are characterized by warmer temperatures and below normal snowfall during the first month of winter followed by colder temperatures and above normal snowfall for the second month of winter. Analysis of the liquid equivalent precipitation to snowfall ratio reveals a corresponding trend of low ratios during the first month and high ratios during the second month of winter. While La Nina winters differed little from climatology during the first month, the second month of winter yielded anomalously low ratios, suggesting the likelihood of warmer temperatures accompanying precipitation events. Major snow events were more than five times more likely to occur for El Nino winters compared to climatology. It is suggested that the greater frequency of heavy snowfalls is during El Nino winters is related to an invigorated sub tropical jet stream providing for more phasing opportunities with the polar jet which are known to be associated with major east coast winter storms.

While the La Nina winter of 2008-2009 followed this general trend, the first month of the 2009-2010 El Nino winter did not follow suit, defying expectations of observing a warm period during the first month of winter. Upon reanalysis, it becomes clear that the observed negative phase of the North Atlantic Oscillation (NAO) was “locked in” from early December through March. This extended period of a negative NAO phase is known to yield synoptic scale troughs over the Eastern United States allowing for cold polar air to infiltrate the east coast. This created a situation which counteracted the expected early winter season warming that previous winters experiencing an El Nino signature contained.

The inter-relationship between ENSO and NAO phases can be explained as follows. Sea surface temperature forcing in the equatorial Pacific preferentially excites planetary wave number 1 (2) during an El Nino (La Nina) event. The energy contained within these waves is able to propagate vertically. Upon breaking in the very stable, upper reaches of the stratosphere, local and vigorous turbulent mixing occurs so that the westerly flowing airstream (near 50 degrees N at 10mb) sees such turbulence as friction, thus slowing its westerly momentum. Recalling that the atmosphere constantly adjusts its mean state to maintain thermal wind balance (implying a matching of the westerly momentum with the north to south temperature contrast) any slowing of the westerly momentum must be accompanied by a weakening of the north-south thermal contrast. This is at first realized by a warming of the upper reaches of the polar stratosphere. As planetary waves continue to propagate and break during November and December, the effects of the aforementioned warming in the upper-stratosphere are amplified and translate downwards to the lower-stratosphere and eventually the upper-troposphere by mid to late January. The warmed atmosphere is accompanied by an increase in heights near

Greenland. Such a height tendency is consistent with a weakening of the North Atlantic jet stream and is consistent with the loading pattern of the negative phase of the North Atlantic Oscillation. Due to the fact that El Nino events tend to produce longer, more energetic planetary waves (wave number 1), upon breaking, these long waves are very efficient at spinning down the stratospheric circumpolar vortex and projecting favorably upon the negative phase of the NAO by mid-winter.

A histogram showing relative frequency of NAO index ranked according to ENSO phase from Jan 22 to Feb 23 clearly indicates a bias towards negative NAO phase during El Nino years and conversely a bias toward positive NAO index during La Nina years. This is in agreement with the Syracuse temperature observations and also serves to explain why major east coast winter storms tend to occur with much greater frequency during El Nino years.