Severe Hail over the United States and its Relationship to the Climate System

John Allen (1), Michael Tippett (2,3), Adam Sobel (2,4)

(1) International Research Institute for Climate and Society Columbia University, NY, United States (JohnTerrAllen@gmail.com), (2) Department of Applied Physics and Applied Mathematics, Columbia University, New York, New York, USA, (3) Center of Excellence for Climate Change Research, Department of Meteorology, King Abdulaziz University, Saudi Arabia, (4) Lamont Doherty Earth Observatory, Columbia University, Palisades, NY, USA.

Relating hail occurrence to the climate system is an essential step on the road to seasonal and sub-seasonal forecasts of severe thunderstorm activity for the United States (U.S.). Each year over the U.S., large hail produces in excess of one billion dollars of insured losses. Despite this impact and the risk of locally incredible damage, hail generally receives less attention in severe storms research. Part of this inattention stems from the quality limitations of hail reports in the national dataset, which provide considerable challenges in obtaining statistically robust relationships between observed hail, its environment and the climate system. While environmental conditions that produce hail are reasonably well understood, these relationships have seen little application to the climatic system.

A relationship between environmental characteristics and large hail occurrence has been developed to estimate the monthly frequency of hail occurrence. These relationships imply that indices for other severe phenomena (e.g. tornadoes) may not be representative of the appropriate set of ingredients. Using observations from the National Climatic Data Center's Storm Data, hail indices that describe the probability of occurrence of events given objective fitting of a Poisson distribution to pre-defined convective variables is derived. These indices describe the monthly climatological likelihood is based on environmental data from the North American Regional Reanalysis (NARR) over the continental United States for the period 1979-2012.

Applying these relationships, the strength of using both carefully controlled observations and environmentally derived frequency to identify links between the climate system and severe thunderstorms will be illustrated using the El Niño Southern Oscillation (ENSO). The phase of ENSO has long been hypothesized to influence severe thunderstorm occurrence over the U.S. However, limitations in the severe thunderstorm observation record, combined with large year-to-year variability have made demonstrating such a relationship difficult, particularly during spring, the peak hail season. We show that fewer hail events occur over the central United States during El Niño and conversely more occur during La Niña. These changes in hail events are reflected in large-scale environmental indices that are correlated with the occurrences of hail climatologically. Based on this relationship, we will present evidence of seasonal predictability for spring severe thunderstorms based on the winter ENSO phase, which is particularly effective for moderate to strong ENSO events.