The Great Hail Outbreak of March 2011

On the last weekend of March 2011 (March 26-27), South Alabama and South Georgia were impacted by a significant severe weather outbreak. The majority of this event consisted of unusually large hail (for this part of the country), but there were also a few weak tornadoes and damaging wind gusts. The consistently large hail size (including many stones of golf ball size or greater), large quantity of storms, and long event duration made this one of the most prolific large hail outbreaks for this region.

Unlike many of the past local severe weather events (e.g. The March 1, 2007 and February 13-14, 2000 tornado outbreaks), the upper level winds were fairly zonal (i.e. flowing fast from west to east with no major troughs or ridges) across the southern half of the country. Fig. 1 below shows the 500 MB height field over the Deep South on Saturday morning, a few hours before the event began. The height contours are rather flat over the Southeast U.S., except for a few subtle "ripples". It is unclear what (if any) role any of these "ripples" aloft played in the event.

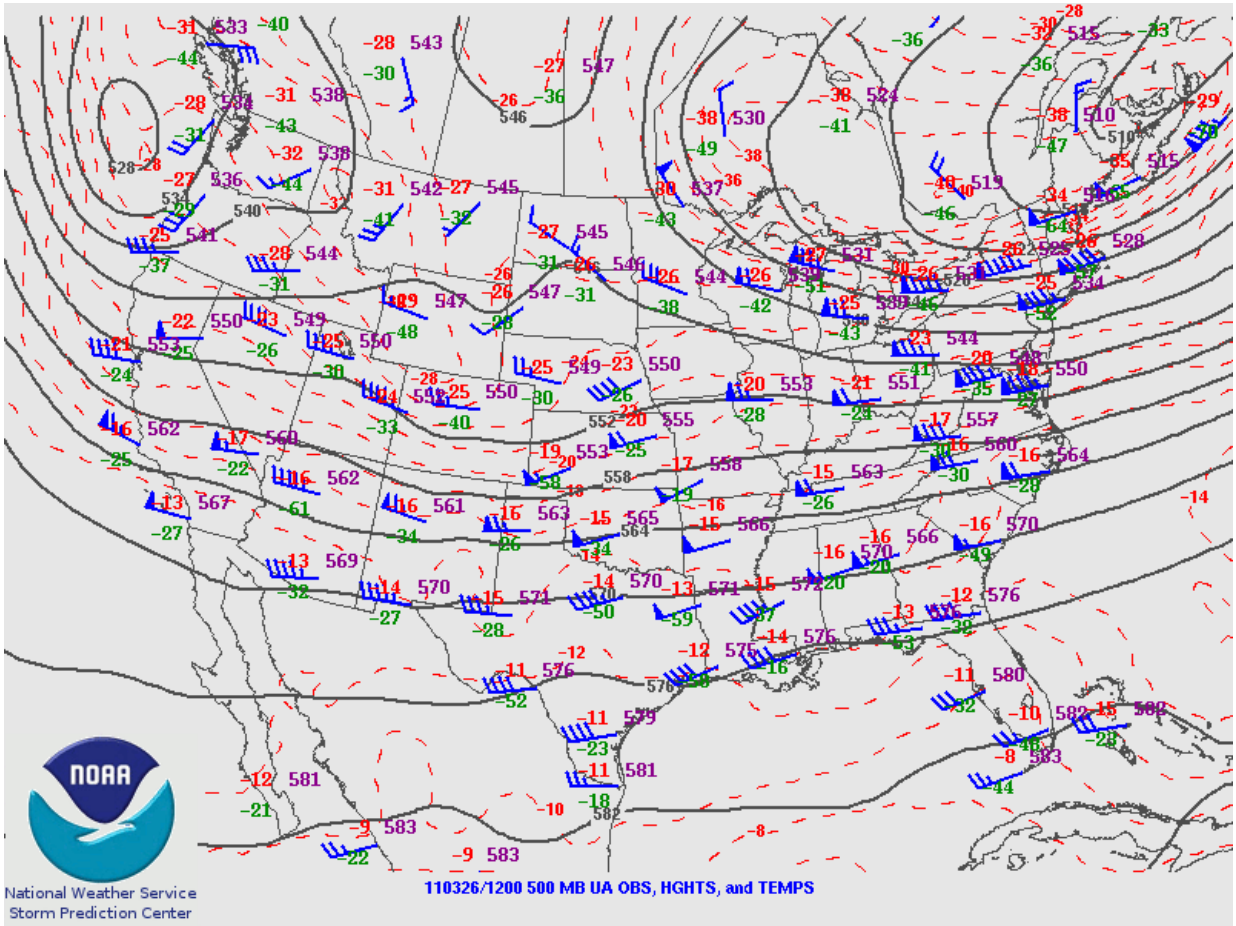

Fig. 1. 500 MB Station plots with objectively analyzed geopotential heights (solid black lines; decameters) and temperatures (dashed red lines; Celsius) 8 AM EDT, March 26, 2011

The Saturday morning surface analysis (fig. 2 below) shows a quasi-stationary frontal system well north of the region, and a "sub-synoptic scale" warm front bisecting the Florida Panhandle; separating dry, modified Continental Polar air (brought down from a cold front a few days before) to the north and east from warm, moist Maritime Tropical air to the west and south. Although the moisture gradient with this feature shows up well in the dewpoint contours, this feature lacks a well-defined wind shift and/or pressure trough that is characteristic of most synoptic-scale fronts.

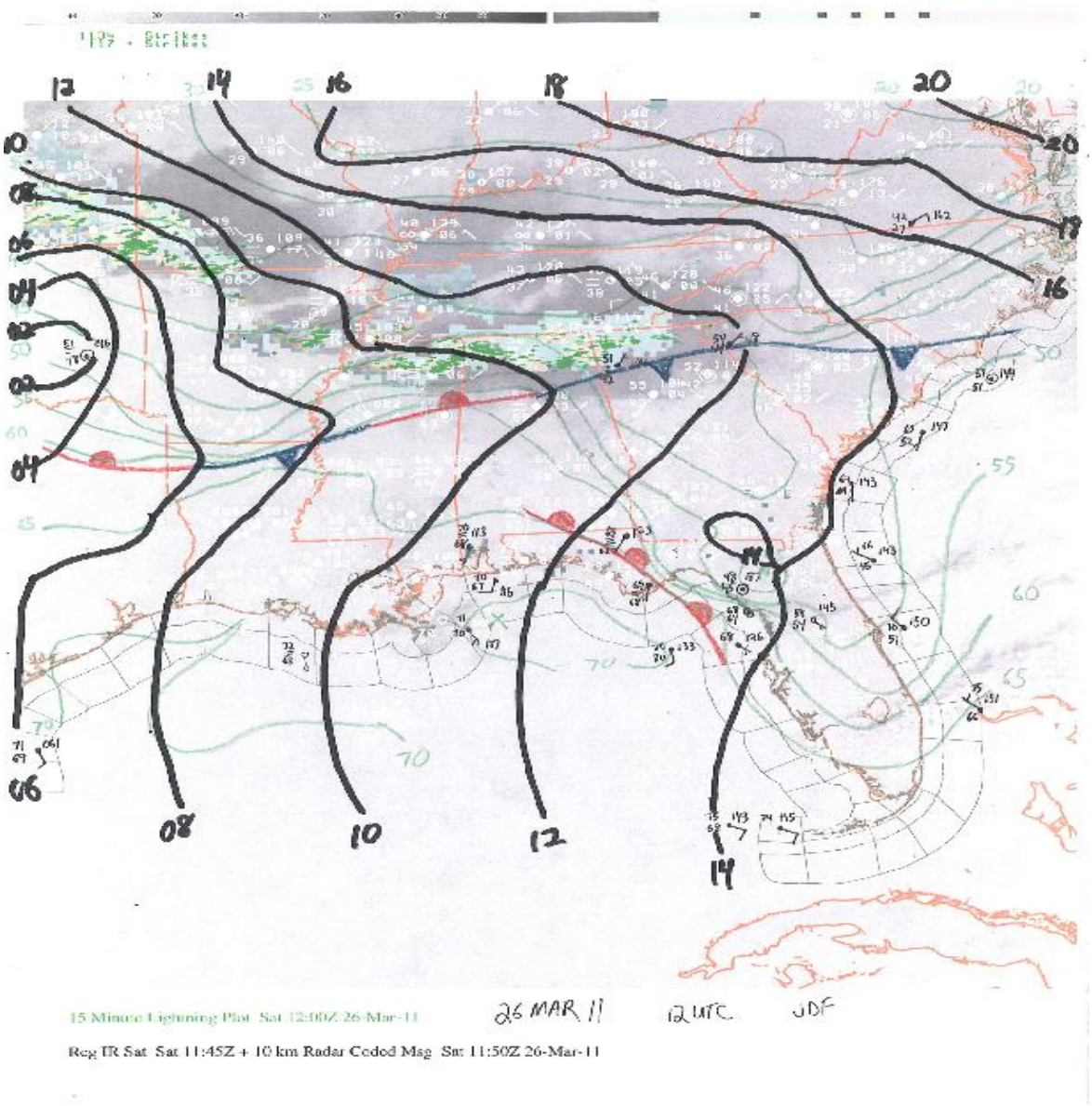

Fig. 2. Surface Station plots (black or white), IR Satellite image (shaded gray), CG lightning (green dashes), and 10km Radar composite (color image) with subjectively analyzed Mean Sea Level Pressure (solid black lines, MB), dewpoint temperatures (solid green lines, Farenheit), & frontal analysis 8 AM EDT, March 26, 2011

South of the frontal system, much of the Gulf Coast was in a low-level warm air advection pattern, as low layer winds transported warmth and moisture northward from the warm Gulf of Mexico waters. Not only did this help to destabilize the atmosphere (a prerequisite for thunderstorm development), but warm air advection is also associated with rising motion (albeit broad and weak). While it is clear that the frontal system to the north served as a focus for shower and thunderstorm development (see the composite radar image on fig. 2), it is not necessarily clear what triggered the intense thunderstorms Saturday afternoon across extreme South Georgia and South Alabama, as this region was well away from the main frontal system.

As surface temperatures reached the 80s F early Saturday afternoon, thunderstorms were able to tap into abundant potential energy. Meteorologists refer to this type of potential energy as CAPE (**C**onvective **A**vailable **P**otential **E**nergy), and it can help indicate how strong thunderstorm updrafts can get. Strong updrafts are crucial for the production of large hail, and CAPE values were generally between 1000 and 2000 J/kg Saturday afternoon. These values are usually enough to support strong updrafts.

Even though there was not much curvature to the upper level wind field, the west winds aloft were unusually strong for this time of year and so far to the south. The large difference between these winds and the lighter south winds at the surface produced vertical wind shear values of 45 to 50 knots. Such shear over a deep layer helps to organize storms and can keep them active for hours (as opposed to the "pulse" type storms in the Deep South during the summer, which develop and dissipate within an hour or so). Strong vertical wind shear can also cause thunderstorm updrafts to rotate, which can further sustain storms and lead to the development of "super cell" thunderstorms, capable of producing large hail, damaging wind gusts, and even tornadoes.

Adding to the overall favorable environment was an unusually large "lapse rate" in the mid troposphere (between 10 thousand and 18 thousand feet). A lapse rate is the temperature difference within a layer, and large lapse rates tend to strengthen updrafts and enhance hail growth. Normally the lapse rate over the Gulf Coast region is about 6 degrees Celsius per kilometer, but during this event it was 7 to 7.5 degrees Celsius per kilometer. This may not sound like a big difference, but lapse rate differences of only half a degree Celsius or so can make a significant difference in thunderstorm updraft speeds. The combination of ample low-level moisture, potential energy (strong daytime heating coupled with cold air aloft), and strong winds aloft, made conditions favorable for the growth of large hail.

There were two distinct rounds of severe storms. The first was Saturday afternoon through early evening, as several super cell thunderstorms developed and moved east across South Georgia and South Alabama. Most of these storms produced large hail, often up to golf ball size. Closer to the main frontal system to the north, the vertical wind shear was a little stronger. This may have helped in the generation of 3 brief and relatively weak tornadoes in Georgia late Saturday afternoon and early evening. With the loss of daytime heating (potential energy), round one of the severe storms finished soon after sunset on Saturday.

The large scale weather pattern did not change much on Sunday. The winds aloft were still fast and zonal (fig. 3 below), contributing to deep layer vertical wind shear values of around 40 knots. At the surface, the frontal system that was well north of the region on Saturday had begun to approach South Georgia and South Alabama as a cold front (fig. 4). Rising motion ahead of this front helped generate another round of thunderstorms beginning early Sunday afternoon.

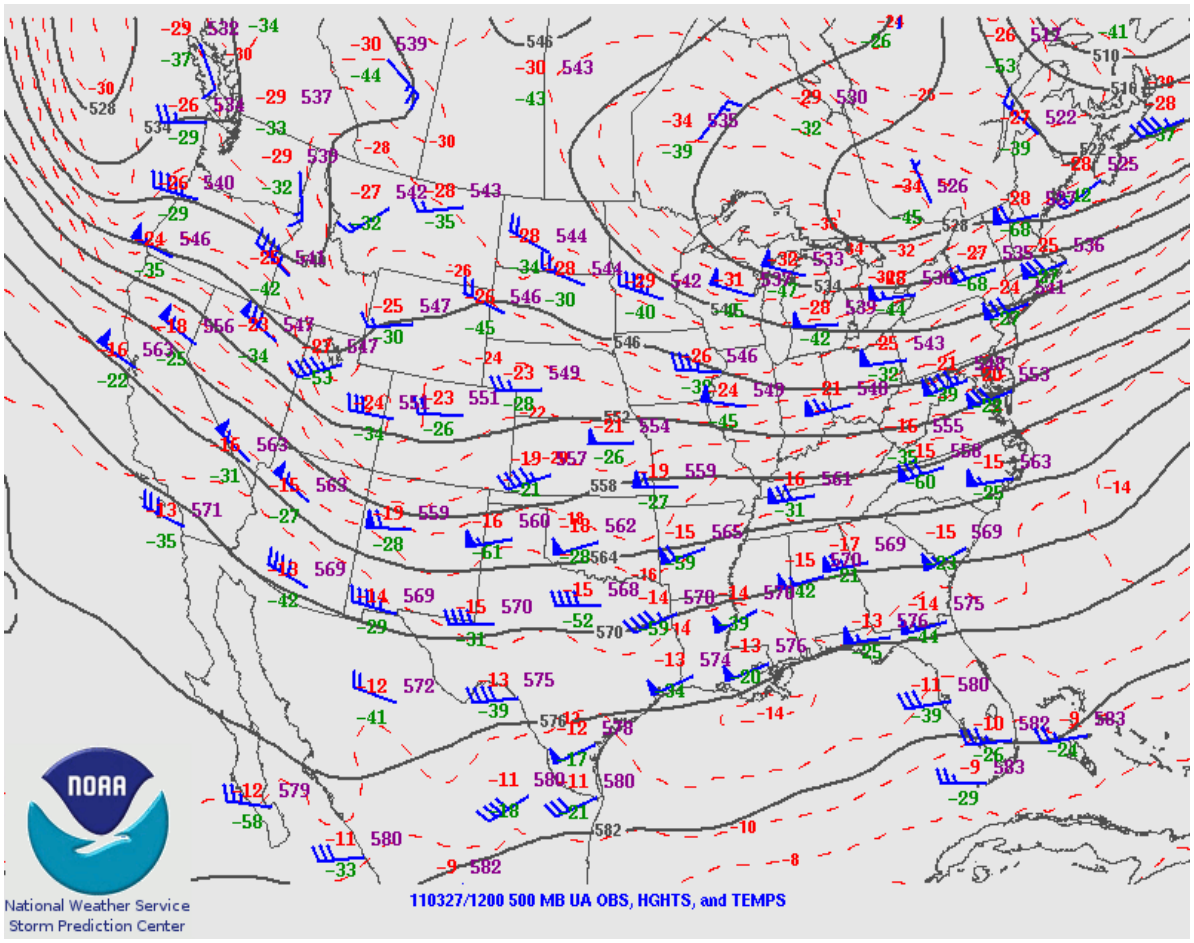

Fig. 3. As in *Fig. 1* except 8 AM, March27, 2011

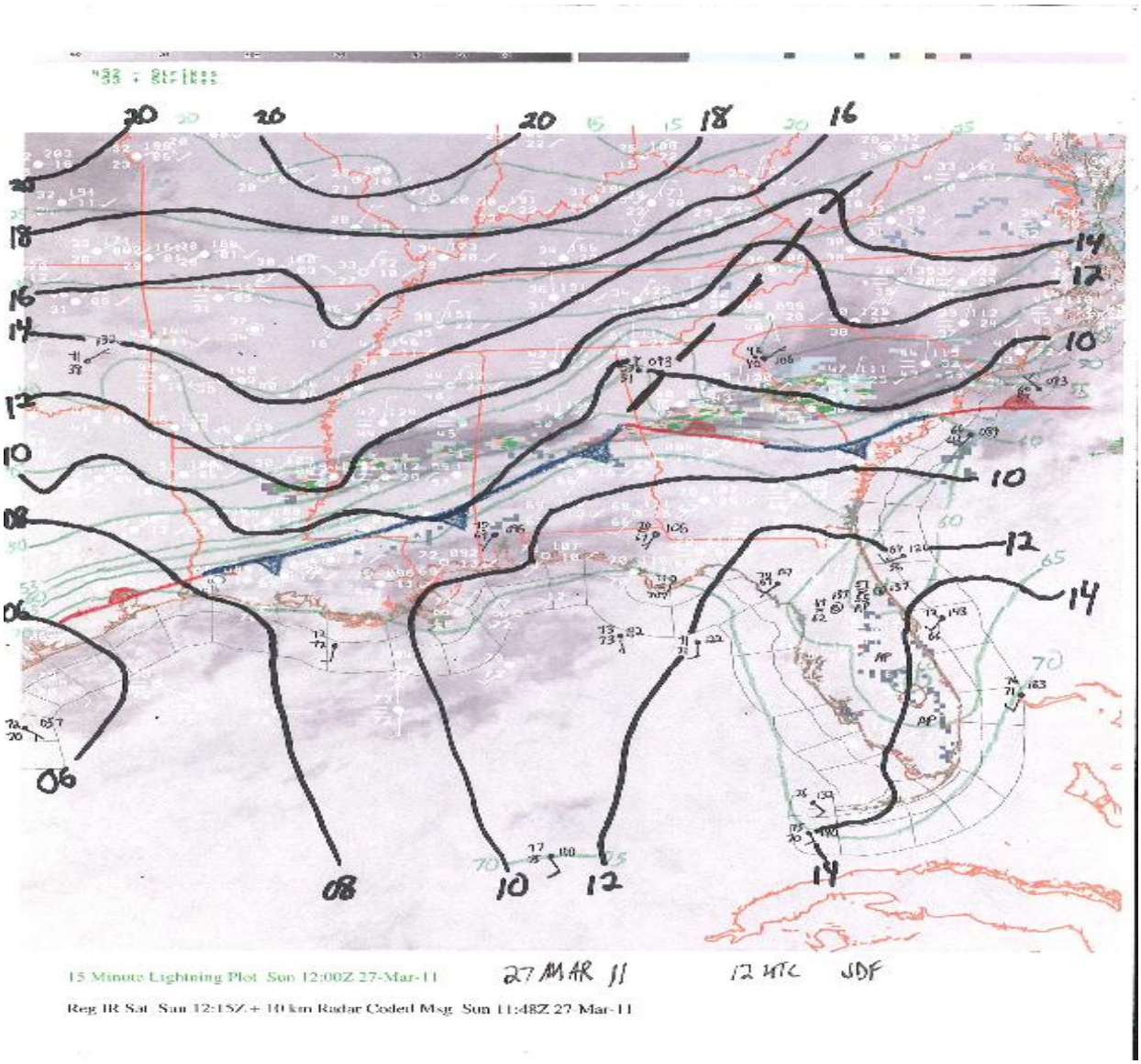

Fig. 4. As in *Fig. 2* except 8 AM, March27, 2011

Despite slightly weaker vertical wind shear magnitudes than what were observed on Saturday (40 knots instead of 50 knots), numerous super cell thunderstorms developed in the moderately unstable airmass Sunday afternoon. Once again, surface-based CAPE values were between 1000 and 2000 J/kg and mid level lapse rates were between 7 and 7.5 degrees Celsius per kilometer. While not very favorable for tornado development, the combination of shear and instability was once again more than sufficient for super cell thunderstorms producing large hail. Once again, numerous reports of golf ball sized hail were received until the event ended early Sunday evening. There was one report of tennis ball size hail in Southeast Alabama.