The Fall Line Forecast

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The Hatteras Low, Bombogenesis and You

The central Virginia fall line area with Spotsylvania, King George and Caroline to the East and Culpeper and Orange to the west, presents many challenging weather forecasting opportunities. Not the least of these is the regional snowfall forecast resulting from the creation of the Hatteras Low.

For many Virginians, the Outer Banks of North Carolina have provided family vacation memories across many generations. Teaching my children and their children the joys of surf fishing as the waves washed over their feet and the warm sand eroded underneath is a treasured experience I will continue again this summer with my youngest grandson. But as I stand near the surf and teach him about leader knots, flounder rigs and casting techniques, my mind will wander off to the years I spent studying the winter monster that frequently haunts the coast of the Outer Banks.

There was considerable talk in the printed press, on television, and at your local grocery store regarding the failure of the snow depth forecasts for the mid March, 2017, snowstorm. The impacts on regional, state, national decision makers and you are a professional concern for every meteorologist charged with providing actionable information to the public and government officials that have a responsibility to keep commercial, transportation and government emergency services as viable as possible during these potentially dangerous winter storms. The cardinal rule every weather forecasting student learns is to "never cry wolf "or over forecast a dangerous weather event , as you will potentially lose your audience for the next life threatening storm. With the impacts being costly and dangerous, the east coast cold air damming Hatteras low nor'easter is the most worrisome winter forecast for Virginia and North Carolina meteorologists.

In the winter of 1986, atmospheric and ocean scientists from universities and government agencies across the United States and Canada converged on the almost deserted Outer Banks of North Carolina to study the sudden development of exploding winter storms climatologically occurring from January 15 through March 15 with the resulting potential to cause the halt of coastal daily life from North Carolina through Maine. It was widely understood by east coast forecasters that the twelve hour snowfall predictions impacting the coastal and inland cities from Norfolk and Richmond to Boston and Cape Cod lacked the required skill to adequately support decision makers and protect the public. Many of the scientists and graduate students that joined us from the US west coast were not even familiar with the phenomenon we call a nor'easter. The experiment was called GALE for the Genesis of Atlantic Lows Experiment.

As a graduate student at North Carolina State University living in the shadow of the lighthouse on Hatteras Island during this experiment, I was surprised to learn from locals, mostly over beers, seafood and hush puppies, that the "Hatteras Low" was legendary in their culture. World renowned scientists and meteorology graduate students listened with cyclone physics equations swirling in their heads as engaging "bankers"

told us stories of going to bed at night thinking that tomorrow would be windy and cold. It was not unusual to wake the next morning to gale force northeast winds, thunder snow and ocean water overriding the beach into the streets of Buxton. As meteorology students, we were taught to always spend time with local agriculturists and watermen to learn their practical historical perspective on the weather phenomenon we were about to study. These were valuable and cordial bi-directional out of classroom lessons that served us well as we designed our experimental procedures.

The Hatteras Low is the result of a process known to meteorologists as cyclogenesis or the creation of a cyclone or low pressure system. Cyclogenesis in this case develops along a stationary front typically stretching from offshore of Virginia Beach, through Diamond Shoals and terminating near Savannah. This coastal front separates cold air to the west from warm air to the east. The cold air to the west develops when a strong high pressure system over New England vigorously pumps cold dry air into the coastal plains and piedmonts of Virginia and North Carolina. The heavy dense cold air becomes "dammed" against the eastern slopes of the Blue Ridge and the meandering western edge of the Gulf Stream with close proximity to Cape Hatteras.

Frontogenesis or a coastal front develops between the cold air from New England and the warm air over the significantly warmer waters of the Gulf Stream. Thus the breeding ground for the Hatteras Low is formed. As the cold air ventures over the warmer Gulf Stream, thermal instability at the surface, similar to a pot of cold water over a hot burner, causes air to rise and surrounding air rushes in to fill the near surface void. Due to the rotation of the earth, the horizontal influx of air takes on a counter clockwise or cyclonic flow. This is cyclogenesis. But for the Hatteras Low to intensify into a powerful nor'easter, this surface based cyclone must connect to the upper troposphere some 5 to 10 kilometers above the surface. If the timing is right, an upper level storm moving from west to east will create and area of upper level divergence or spreading of air thus inviting the air at the surface to rush vertically to fill the upper level void. This is often referred to by meteorologists as "bombogenesis" or the creation of an atmospheric bomb where the central surface pressure drops rapidly, the winds intensify, clouds and high precipitation rates develop in the rising air and the storm generally begins to travel along the jet stream through the northeast coastal corridor. The location of the resulting snow line following bombogenesis depends on the location of the originating Hatteras Low and the northeastern position of the jet stream. An 80 kilometer error in forecasting the location of the Hatteras Low formation or the path of the nor'easter can easily invalidate the twelve hour snow forecast for the east coast. GALE was designed to document a season of Hatteras Low events and discover potential paths to improved skill in the twelve hour forecast.

Operationally, weather balloons are launched from Wallops Island, Sterling, Blacksburg, Greensboro and Morehead City every twelve hours with an approximately 300 kilometer spacing between the sites. During GALE, weather balloons were launched every three hours from these locations and special upper air measurements were made at locations between these operational sites in Virginia and North Carolina. A major conclusion of the GALE research was that improved temporal and spatial density of vertical upper air soundings beyond current operational practices could significantly improve the twelve hour Hatteras Low snowfall forecast.

But the cost of launching weather balloons more frequently and adding new operational balloon launching sites was cost prohibitive. The labor of two trained technicians is required for each launch as well as helium, balloons and expendable weather instrumentation packages. In the late 1980's, The National Oceanographic and Atmospheric Administration (NOAA) began testing various ground based radio frequency vertically pointing technologies to recover much of the same weather data provided by weather balloons. These are stand-alone unmanned systems that provide continual vertical soundings of the atmosphere and were successful in improving twelve hour forecasts in the Midwest United States. Unfortunately, due to rapidly changing radio frequency technologies and competition for funding needed for weather satellites, the ground based profiler systems were not widely deployed throughout the United States. Thus a major conclusion of the multi-million dollar GALE campaign for improving the twelve hour Hatteras Low snowfall forecast was not addressed with an operational solution.

Even though modern day numerical weather prediction computer models benefit from exponentially increasing computing power, without the enhanced spatial and temporal sounding data recommended by GALE scientists, the state of the art for predicting the location of the formation of the Hatteras Low remains at approximately 80 kilometers. As we witnessed last March, we are still dealing with the consequences of this lack of consistent ability to forecast location specific snowfall depths associated with the Hatteras Low. In a future article, we will explore how enhanced computing power attempts to address forecasting all the complex components of the Hatteras Low and bombogenesis with a technique called ensemble forecasting that leads to a probability of a specific snow depth for your location instead of a specific snowfall total.

Most of the time, forecasters are reasonably accurate about the location, path and snowfall of the Hatteras Low. There are times, such as last March, when we are embarrassed by prediction errors with serious consequences to the public. Meteorologists take personally the threats to citizens in their forecast area and this is why the east coast winter bombogenesis forecasting continues to be an important challenge for well intentioned forecasters. But most of all, they fear the loss of your attention to the next east coast cold air damming Hatteras Low nor'easter and the resulting consequences to you and your family.