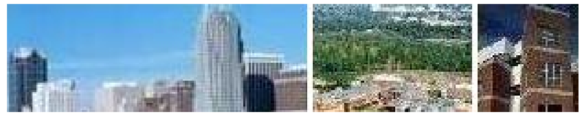
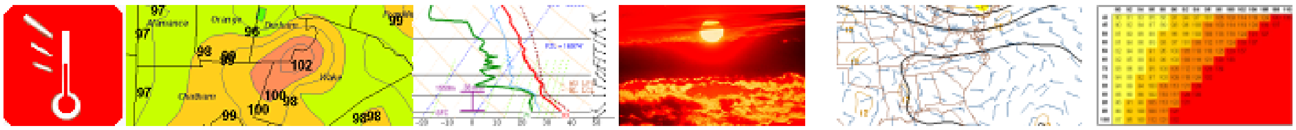
Event Summary
National Weather Service, Raleigh NC



July 23-25, 2010 Heat Wave Event

Note that this is a PDF version of the event summary and that some links, media or resources may not be avaiable in this format.



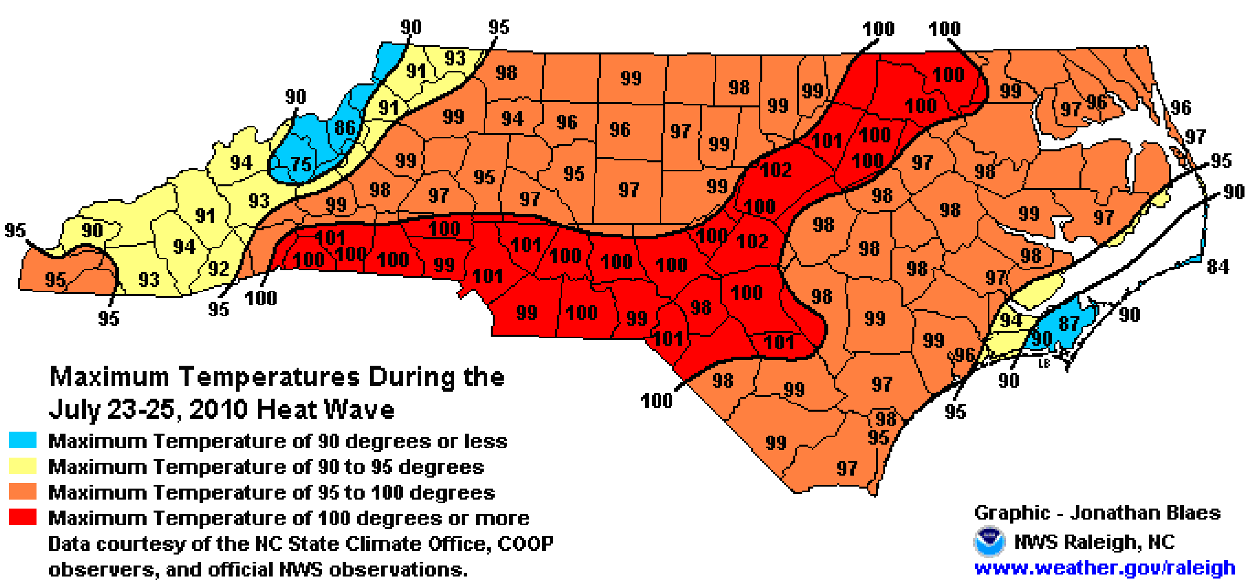
Event Headlines

...A strong subtropical ridge dominated the southeastern United States from 23-25 July 2010 with record breaking temperatures and very humid conditions...
...A classic upper air pattern for a heat wave over the Southeast was present with a closed 5940m contour at 500 hPa, 700 hPa heights greater than 3210m, and 850 hPa temperatures over 21C...
...The hottest day was on Sunday July 25th when high temperatures across most of central North Carolina ranged between 96 and 102 degrees (text listing | map of high temperatures - for the 24 hour period ending at 800 AM on July 26)...
...Afternoon surface dew points in the lower to mid 70s combined with temperatures between 95 and 102 resulted in heat index values of 105 to 118 degrees...
...A combined thirteen temperature records were set at the Raleigh-Durham and Piedmont Triad International Airports...
...The synoptic pattern associated with this hot and very humid heat wave differed from another heat wave with negligible heat indices that occurred two weeks earlier...

Event Overview

Central North Carolina experienced a three day period of excessively hot and humid conditions during 23-25 July, 2010. Numerous temperature records were set at the Raleigh-Durham and Piedmont Triad International Airports during the period. A strong subtropical ridge dominated the southeastern United States from 23 to 25 July 2010. The event featured a classic upper air pattern for a heat wave over the Southeast with a closed 5940m contour at 500 hPa, 700 hPa heights greater than 3210m, and 850 hPa temperatures over 21C. In addition, surface dew points in the lower to mid 70s along with precipitable water values ranging between 1.75 and 2.25 inches at KGSO led to very high heat index values and a fair amount of convection for a period of record heat. This event was interesting in that the atmosphere was very moist and surface dew point temperatures did not mix out much during the afternoon resulting in very high heat index values.

Maximum Temperatures During the Heat Wave

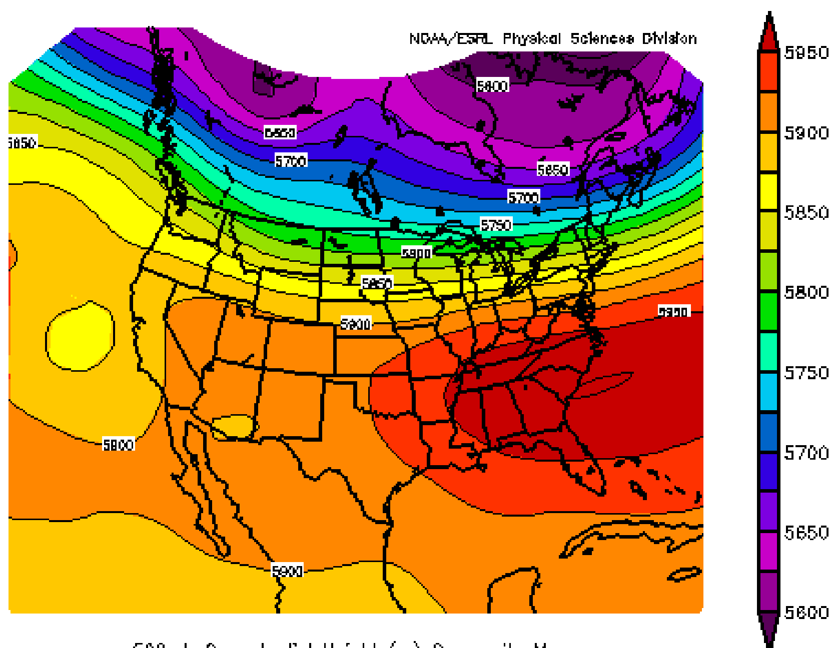


Event Details

There is no official definition of a heat wave but varying definitions have been used (Robinson, 2001) and the term is generally relative to the area or location in which the hot weather occurs. Several definitions require the duration of above normal conditions to last for 2-3 days. Others focus on high temperatures of approximately 2 standard deviations above normal for about 2 days over a region rather than single stations. The definition recommended by the World Meteorological Organization is when the daily maximum temperature of more than five consecutive days exceeds the maximum temperature normal by 5C (9F). The definition from the American Meteorological Society Glossary of Meteorology is a period of abnormally and uncomfortably hot and unusually humid weather. To be considered a heat wave, such a period should last at least one day, but conventionally it lasts from several days to several weeks. In the United States definitions often vary by region, however, a heat wave is frequently defined as a period of at least three consecutive days above 90F. The National Weather Service criterion for the issuance of a Heat Advisory in central North Carolina is when the heat index is expected to reach 105F for three hours. An Excessive Heat Warning is issued in central North Carolina when the maximum heat index is expected to exceed 110F.

A broad ridge of high pressure aloft was established for several days across the southern CONUS before the event with temperatures well above normal. The main ridge was centered across the southwestern U.S. and a smaller center was located off the southeast U.S. coast on July 18th. A short wave trough associated with a 50-60 kt jet at 500 hPa moved across the northern Plains on 20 July, the Great Lakes on 21 July and into the New England on 22 July. As this system moved off the coast, the upper level ridge became established over the Southeast with the ridge extending from 300 hPa, downward to 500 hPa. The ridge at 700 hPa was centered over central Alabama with warmest temperatures at this level located just west of the Appalachians while a light, mainly westerly to southwesterly flow was noted at 850 hPa. The heat wave was focused from 23 July though 25 July with the hottest air temperatures observed during the afternoon of 25 July while the hottest heat index values were observed during the afternoons of 24 and 25 July. By the morning of 25 July, the 12 UTC upper air pattern featured a ridge aloft at 300 hPa and 500 hPa that was located just east of central North Carolina with very warm 500 hPa temperatures around -2C. At 700 hPa the heights had fallen slightly and the thermal ridge axis had shifted into the Mid Atlantic and Northeast with the flow becoming more northwesterly and containing a downsloping component at 850 hPa. The heat wave came to an end on 26 July as a cold front moved through central North Carolina and the associated trough at 700 hPa and 850 hPa brought cooler temperatures to the lower troposphere. High temperatures on 26 July were several degrees cooler then the 25th and by 27 July, high temperatures were below normal.

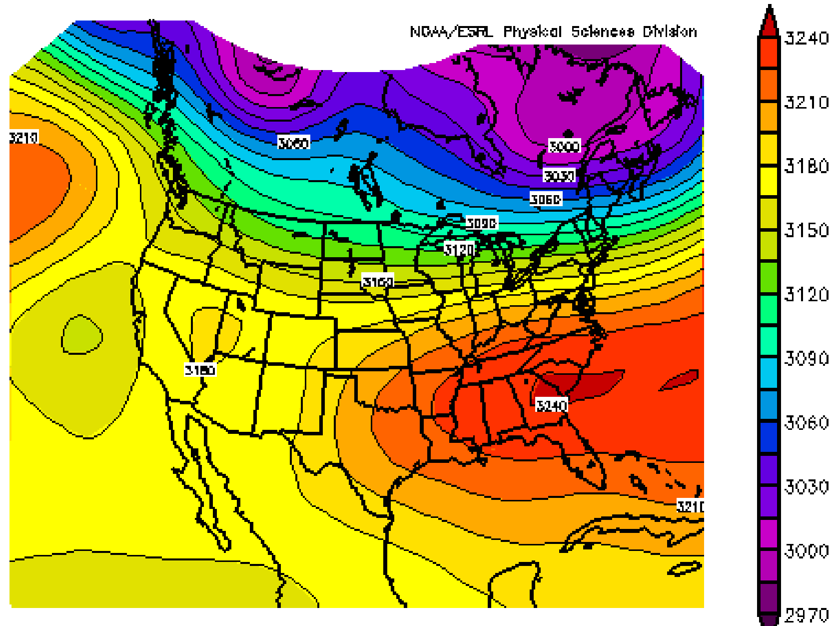
The maps to the right and below are provided from the Earth System Research Laboratory's Daily Mean Composites page



500mb Geopotential Height (m) Composite Mean
7/23/10 to 7/26/10
NCEP/NCAR Reanalysis

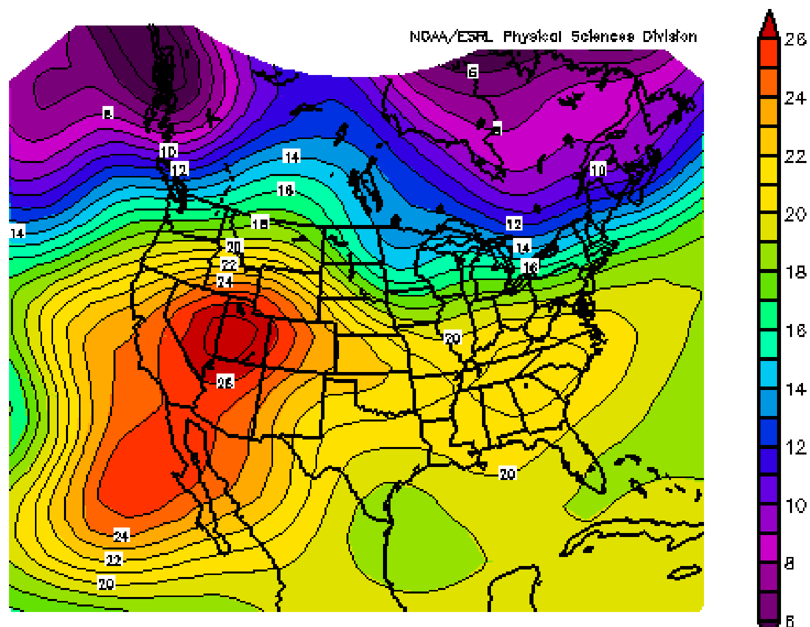
(http://www.esrl.noaa.gov/psd/data/composites/day/) which can provide multiday composites of various meteorological fields. The potential for a heat wave can be initially identified by examining the upper air pattern. In particular, forecasters can determine if the pattern is a significant anomaly and compare it to past events with a historical database. Examining this event in this context shows that this event featured a large high pressure ridge across the southern U.S. The ridge was of fairly significant amplitude, with 3 day mean heights in excess of 5950 meters. The climatological average of 500 hPa heights for 23 July through 26 July during the period of 1968 to 1996 shows that the there is typically a ridge of high pressure extending from the southwestern U.S. eastward to the southeast U.S. and east into the subtropical Atlantic. A broad, low amplitude trough is present across the northeastern U.S. and southern Canada with maximum heights in the ridge around 5900 meters. Comparing the observed mean over the 23 July through 26 July period with the climatological normals from 1968 to 1996 yields an objective anomaly chart which shows that the 500 hPa heights were 60 to 70 meters above normal across the Carolinas and southern Appalachians. An anomaly of 60 to 70 meters is certainly very significant as these values are generally in the 2 to 3 standard deviation range.

This event also featured a large high pressure ridge across the southeastern U.S. at 700 hPa. An informal study at the NWS Raleigh noted that the location and intensity of the maximum 700 hPa height contour had a good correlation with periods of excessive heat. The study noted that 700 hPa heights in excess of 3210 and especially 3240 meters to the south and southwest of central North Carolina (especially centered over Atlanta GA and Birmingham AL) were most commonly associated with excessive heat in central North Carolina. The ridge during the 23 July through 26 July period was of fairly significant amplitude, with 3 day mean heights in excess of 3225 meters. The climatological average of 700 hPa heights for 23 July through 26 July during the period of 1968 to 1996 shows that the there is typically a ridge of high pressure extending west from the subtropical Atlantic into the southeastern U.S. and far southern Plains with heights in the ridge ranging from around 3180 to 3210 meters. Comparing the observed mean over the 23 July through 26 July period with the climatological normals from 1968 to 1996 yields an objective anomaly chart which shows that the 700 hPa heights were 30 to 70 meters above normal across the Carolinas and southern Appalachians which is significant and in a favorable location.



700mb Geopotential Height (m) Composite Mean
7/23/10 to 7/26/10
NCEP/NCAR Reanalysis

Examining the temperatures at 850 hPa can provide another signal of the potential for extreme heat, although the presence of warm temperatures at 850 hPa does not always portend a heat wave. A long used technique to forecast the maximum surface temperatures is to use the observed 850 hPa temperature from a 12 UTC morning sounding and warm it dry adiabatically to the surface. The technique has various assumptions and limitations including that it is most applicable near sea level, in generally fair weather (cloud free with limited wind), and flat topography. But the implication here is that the 850 hPa temperature can be used as a surrogate for the surface temperature when the skies and weather are fair. During this event you can see that there was a large area of very warm temperatures in the southwestern U.S. and another maximum of warm temperatures over the southeastern U.S. where the 3 day mean value from 23 July through 26 July was in excess of 21 degrees C. The climatological average of 850 hPa temperatures for 23 July through 26 July during the period of 1968 to 1996 shows that the 850 hPa temperatures typically range in the 16 to 18 degree C range. Comparing the observed mean over the 23 July through 26 July period with the climatological normals from 1968 to 1996 yields an objective anomaly chart which shows that the 850 hPa temperatures were a rather significant 3 to 4 degrees C above normal.



850mb Air Temperature (C) Composite Mean
7/23/10 to 7/26/10
NCEP/NCAR Reanalysis

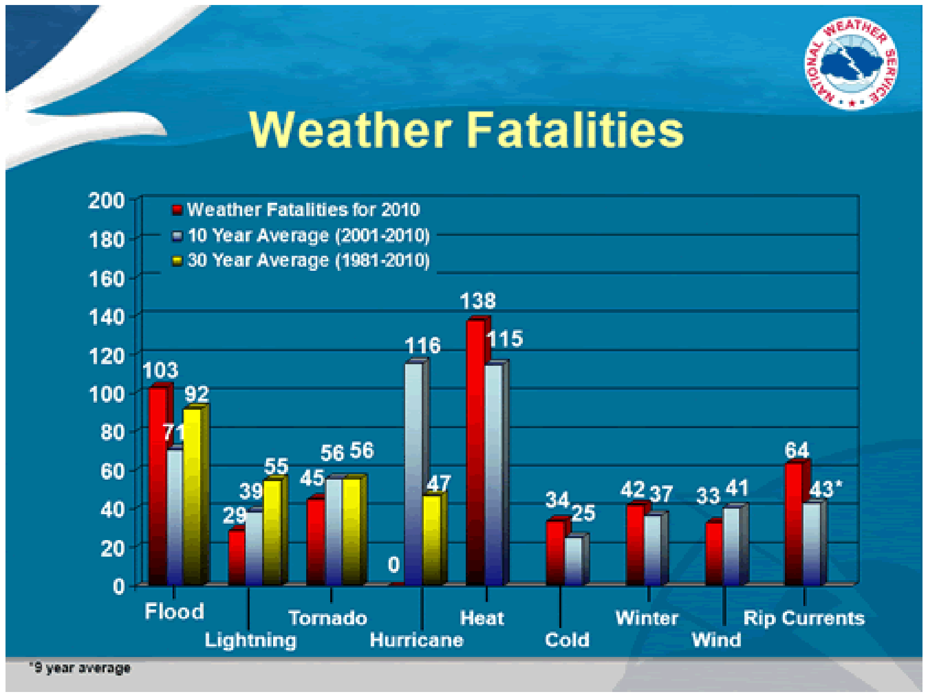
Once the heat wave gets underway, it can become self-sustaining. High pressure ridges generally produce sinking air or downward vertical motion which inhibits the formation of clouds and precipitation. When air is forced to descend, it is compressed which results in warming. During this kind of pattern, the upper level ridge builds, the lower levels of the atmosphere warm, and the surface temperatures typically rise a degree or two each day.

Table of Temperature and Precipitation Data from 20-28 July, 2010

The temperature and precipitation data below are for the Raleigh-Durham International Airport (KRDU), the Piedmont Triad International Airport (KGSO), and the Fayetteville Regional Airport (KFAY).

KRDU	Max T	Min T	Avg T	Precip	KGSO	Max T	Min T	Avg T	Precip	KFAY	Max T	Min T	Avg T	Precip
7/20	98	73	85.5	0.64	7/20	93	74	83.5	T	7/20	96	77	86.5	0
7/21	97	75	86	T	7/21	95	74	84.5	0	7/21	97	77	87	T
7/22	97	75	86	0	7/22	94	76	85	0	7/22	99	74	86.5	0
7/23	100	76	88	T	7/23	96	78	87	T	7/23	99	78	88.5	0
7/24	100	79	89.5	0	7/24	96	78	87	0	7/24	98	78	88	0
7/25	102	80	91	0	7/25	96	78	87	0	7/25	100	77	88.5	0.01
7/26	94	77	85.5	0	7/26	92	75	83.5	0	7/26	98	75	86.5	0
7/27	83	72	77.5	0.32	7/27	85	72	78.5	1.14	7/27	82	75	78.5	0.33

Heat Wave Impact and Risk



Severe heat waves have produced significant agricultural damage, power outages due to increased use of electricity for air conditioning, as well as injuries and deaths. Typically many heat related deaths go unreported, but heat waves are responsible for more deaths annually than other larger natural disasters such as lightning, floods, hurricanes, and tornadoes. The 10-year average (2001-2010) for heat related deaths in the U.S. is 115 (NWS 2010). The National Weather Service estimated that between 1936 and 1975, approximately 20,000 U.S. residents died of heat related causes. In North Carolina, there were four reported heat related deaths in 2008, one in 2007, two in 2005, and one in 2001.

The image to the right shows the average number of annual fatalities for various weather phenomena across the United States and its territories on a 10 or 30 year basis through 2010 (NWS 2010). The statistics in the image are compiled by the Office of Services and the National Climatic Data Center from information contained in Storm Data, a report comprising data from NWS forecast offices in the 50 states, Puerto Rico, Guam and the Virgin Islands.

More information on heat waves, their impact, and how to protect yourself is available on our Heat Awareness and Safety web page. Additional information on heat hazards, how fast the sun can heat a car, heat safety, and heat disorder symptoms are available on the National Weather Service Heat Safety web page.

The Heat Index

The heat index is an index that combines the air temperature and relative humidity in an attempt to determine the human-perceived equivalent temperature, essentially how hot it feels. The human body normally cools itself by perspiration, which evaporates and carries heat away from the body. However, when the relative humidity is high, the evaporation rate is reduced, so heat is removed from the body at a lower rate, causing it to retain more heat than it would in dry air.

The heat index is derived from work carried out by Robert G. Steadman which was published in 1979 in the Journal of Applied Meteorology titled, “The Assessment of Sultriness Part I and Part II.” The heat index contains assumptions about the human body mass and height, clothing, amount of physical activity, thickness of blood, sunlight and ultraviolet radiation exposure, and the wind speed. Significant deviations from these will result in heat index values which do not accurately reflect the perceived temperature. It is important to note that there is no “official” formula to calculate heat index exactly and that heat index values are derived from a collection of equations that comprise a model. The heat index table located to the right is from table 4 in section 7.12.1 of the National Weather Service Instruction (NWSI) 10-1605.

The Heat Index (or apparent temperature) is the result of extensive biometeorological studies. The parameters involved in its calculation are shown below (from Steadman, 1979). Each of these parameters can be described by an equation but they are given assumed magnitudes (in parentheses) in order to simplify the model.

- Vapor pressure. Ambient vapor pressure of the atmosphere. (1.6 kPa)

- Dimensions of a human. Determines the skin's surface area. (5' 7" tall, 147 pounds)
- Effective radiation area of skin. A ratio that depends upon skin surface area. (0.80)
- Significant diameter of a human. Based on the body's volume and density. (15.3 cm)
- Clothing cover. Long trousers and short-sleeved shirt is assumed. (84% coverage)
- Core temperature. Internal body temperature. (98.6°F)
- Core vapor pressure. Depends upon body's core temperature and salinity. (5.65 kPa)
- Surface temperatures and vapor pressures of skin and clothing. Affects heat transfer from the skin's surface either by radiation or convection. These values are determined by an iterative process.
- Activity. Determines metabolic output. (180 W m-2 of skin area for the model person walking outdoors at a speed of 3.1 mph)
- Effective wind speed. Vector sum of the body's movement and an average wind speed. Angle between vectors influences convection from skin surface (below). (5 kts)
- Clothing resistance to heat transfer. The magnitude of this value is based on the assumption that the clothing is 20% fiber and 80% air.
- Clothing resistance to moisture transfer. Since clothing is mostly air, pure vapor diffusion is used here.
- Radiation from the surface of the skin. Actually, a radiative heat-transfer coefficient determined from previous studies.
- Convection from the surface of the skin. A convection coefficient also determined from previous studies. Influenced by kinematic viscosity of air and angle of wind.
- Sweating rate. Assumes that sweat is uniform and not dripping from the body.
- Ventilation rate. The amount of heat lost via exhaling. (2-12%, depending upon humidity)
- Skin resistance to heat transfer. A function of activity, skin temperature, among others.
- Skin resistance to moisture transfer. A function of the vapor-pressure difference across the skin (and, therefore, relative humidity). It decreases with increasing activity.
- Surface resistance to heat transfer. As radiation and convection from the skin increases, this value decreases.
- Surface resistance to moisture transfer. Similar to heat transfer resistance but also depends upon conditions in the boundary layer just above skin's surface.

Heat Index Table

HEAT INDEX VALUES
DEWPOINTS (F)

T(F)	35	40	45	50	55	60	65	70	75	80	85
75	76	77	77	78	78	79	78	77	75		
80	79	79	79	80	80	81	82	83	85	87	
85	82	82	82	83	84	85	87	90	93	99	107
90	86	86	86	87	88	90	92	96	100	107	117
95	90	91	91	92	93	95	97	101	107	115	126
100	95	95	96	97	98	101	104	108	114	121	132
105	99	100	101	102	104	106	109	114	120	129	140
110	104	104	105	107	109	112	115	120	126	134	145
115	107	108	110	112	114	117	121	126	133	141	152
120	111	112	113	116	118	122	125	132	138	146	156
125	114	115	117	120	123	127	130	136	142	151	163
130	116	117	119	123	125	130	134	141	149	156	168

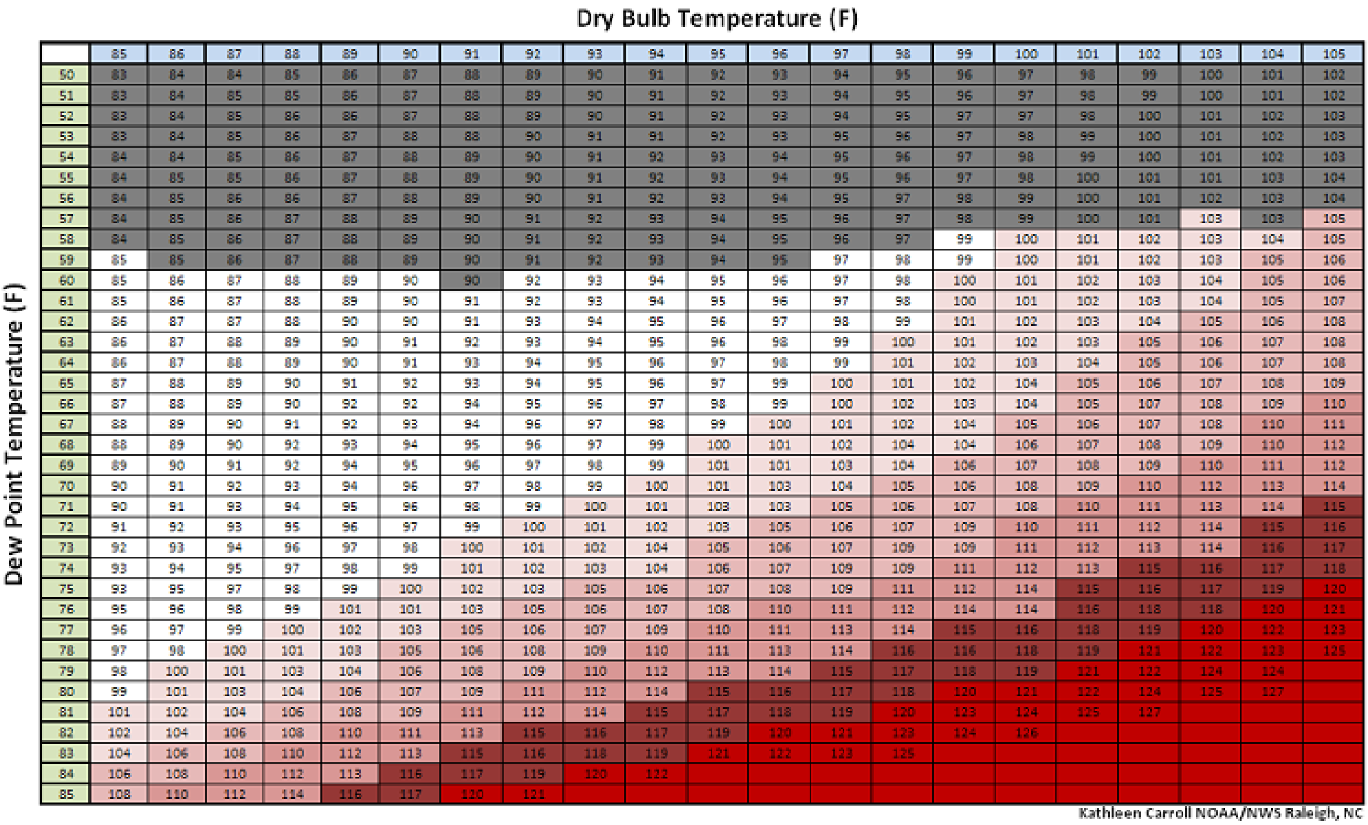
HEAT INDEX VALUES
RELATIVE HUMIDITY (%)

T(F)	20	30	35	40	45	50	55	60	70	80	90
75	71	72	73	73	74	74	75	75	76	77	78
80	79	79	80	80	80	81	81	82	83	84	86
85	82	83	84	84	85	87	88	89	93	97	102
90	86	88	89	91	93	95	97	100	106	113	122
95	92	94	97	99	102	105	109	113	123	134	147
100	98	102	106	109	114	118	124	130	143	158	
105	104	112	116	122	127	134	141	149	166		
110	112	122	129	136	143	152	161	171			
115	121	135	143	152	162	173	184				
120	130	148	159	170	182	196					
125	140	163	176	190	205						
130	151	179	195	212							

from (NWSI) 10-1605

These last five variables are used explicitly to derive the apparent temperature. By an iterative procedure which relies on the assumptions in the first list, the model is reduced to a relationship between dry bulb temperature (at different humidities) and the skin's resistance to heat and moisture transfer. Since these resistances are directly related to skin temperature, there is a relationship between ambient temperature and relative humidity versus skin (or apparent) temperature. As a result of this procedure, there is a base relative humidity at which an apparent temperature (e.g., 90°F) "feels" like the same air temperature (90°F). Increasing (decreasing) humidity and temperature result in increasing (decreasing) apparent temperature, and, the apparent temperature can be lower than the air temperature.

The heat index chart shown to the right was locally produced by the NWS Raleigh for this project (click on the image to enlarge). This chart provides the heat index for a given temperature and dew point at one degree intervals. Note the area of heat index values highlighted in gray, these heat index values are actually lower (cooler) than the air temperature. In general, when the dew point temperature is below 60 degrees F, the heat index will be equal to or cooler than the dry bulb temperature.



Dew Point Temperature (F) \ Dry Bulb Temperature (F)	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
50	83	84	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
51	83	84	85	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
52	83	84	85	86	86	87	88	89	90	91	92	93	94	95	97	97	98	100	101	102	103
53	83	84	85	86	87	88	88	90	91	91	92	93	95	96	97	98	99	100	101	102	103
54	84	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
55	84	85	85	86	87	88	89	90	91	92	93	94	95	96	97	98	100	101	101	103	104
56	84	85	86	86	87	88	89	90	91	92	93	94	95	97	98	99	100	101	102	103	104
57	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	103	103	105
58	84	85	86	87	88	89	90	91	92	93	94	95	96	97	99	100	101	102	103	104	105
59	85	85	86	87	88	89	90	91	92	93	94	95	97	98	99	100	101	102	103	105	106
60	85	86	87	88	89	90	90	92	93	94	95	96	97	98	100	101	102	103	104	105	106
61	85	86	87	88	89	90	91	92	93	94	95	96	97	98	100	101	102	103	104	105	107
62	86	87	87	88	90	90	91	93	94	95	96	97	98	99	101	102	103	104	105	106	108
63	86	87	88	89	90	91	92	93	94	95	96	98	99	100	101	102	103	105	106	107	108
64	86	87	88	89	90	91	93	94	95	96	97	98	99	101	102	103	104	105	106	107	108
65	87	88	89	90	91	92	93	94	95	96	97	99	100	101	102	104	105	106	107	108	109
66	87	88	89	90	92	92	94	95	96	97	98	99	100	102	103	104	105	107	108	109	110
67	88	89	90	91	92	93	94	96	97	98	99	100	101	102	104	105	106	107	108	110	111
68	88	89	90	92	93	94	95	96	97	99	100	101	102	104	104	106	107	108	109	110	112
69	89	90	91	92	94	95	96	97	98	99	101	101	103	104	106	107	108	109	110	111	112
70	90	91	92	93	94	96	97	98	99	100	101	103	104	105	106	108	109	110	112	113	114
71	90	91	93	94	95	96	98	99	100	101	103	103	105	106	107	108	110	111	113	114	115
72	91	92	93	95	96	97	99	100	101	102	103	105	106	107	109	110	111	112	114	115	116
73	92	93	94	96	97	98	100	101	102	104	105	106	107	109	109	111	112	113	114	116	117
74	93	94	95	97	98	99	101	102	103	104	106	107	109	109	111	112	113	115	116	117	118
75	93	95	97	98	99	100	102	103	105	106	107	108	109	111	112	114	115	116	117	119	120
76	95	96	98	99	101	101	103	105	106	107	108	110	111	112	114	114	116	118	118	120	121
77	96	97	99	100	102	103	105	106	107	109	110	111	113	114	115	116	118	119	120	122	123
78	97	98	100	101	103	105	106	108	109	110	111	113	114	116	116	118	119	121	122	123	125
79	98	100	101	103	104	106	108	109	110	112	113	114	115	117	118	119	121	122	124	124	
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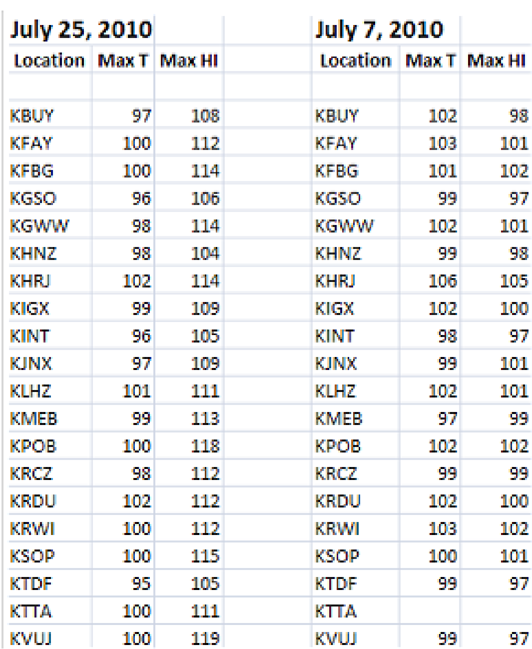
81	101	102	104	106	108	109	111	112	114	115	117	118	119	120	123	124	125	127			
82	102	104	106	108	110	111	113	115	116	117	119	120	121	123	124	126					
83	104	106	108	110	112	113	115	116	118	119	121	122	123	125							
84	106	108	110	112	113	116	117	119	120	122											
85	108	110	112	114	116	117	120	121													

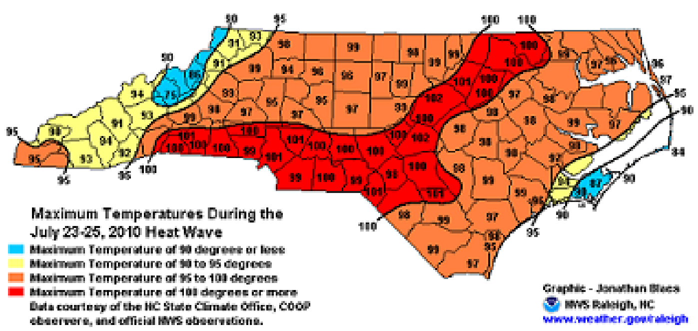
Kathleen Carroll NOAA/NWS Raleigh, NC

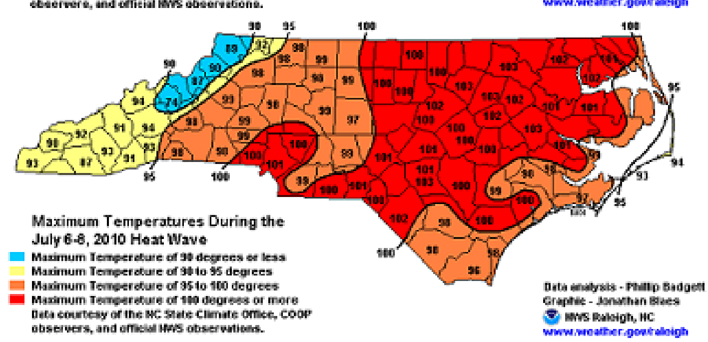
Comparison of this Event with a Similar Event with Lower Heat Indices

Earlier in July 2010, a 3-day period of excessive heat occurred from 6-8 July which generally resulted in higher maximum temperatures across central North Carolina then the 23-25 July heat wave. It is interesting to note that the heat index values across central North Carolina for that event were considerably lower and that in general; conditions did not reach heat advisory criteria despite highs in excess of 100 degrees.

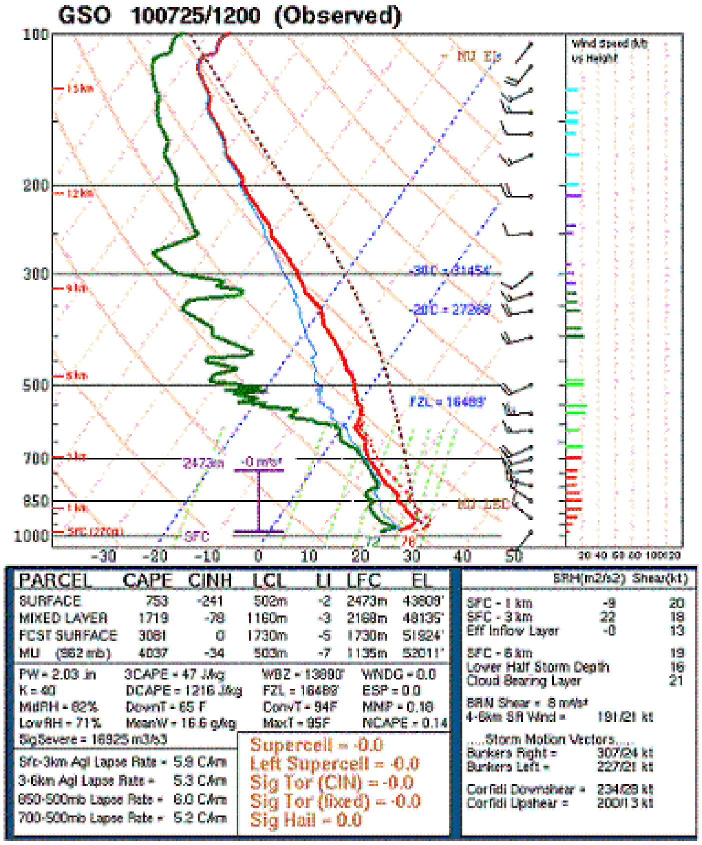


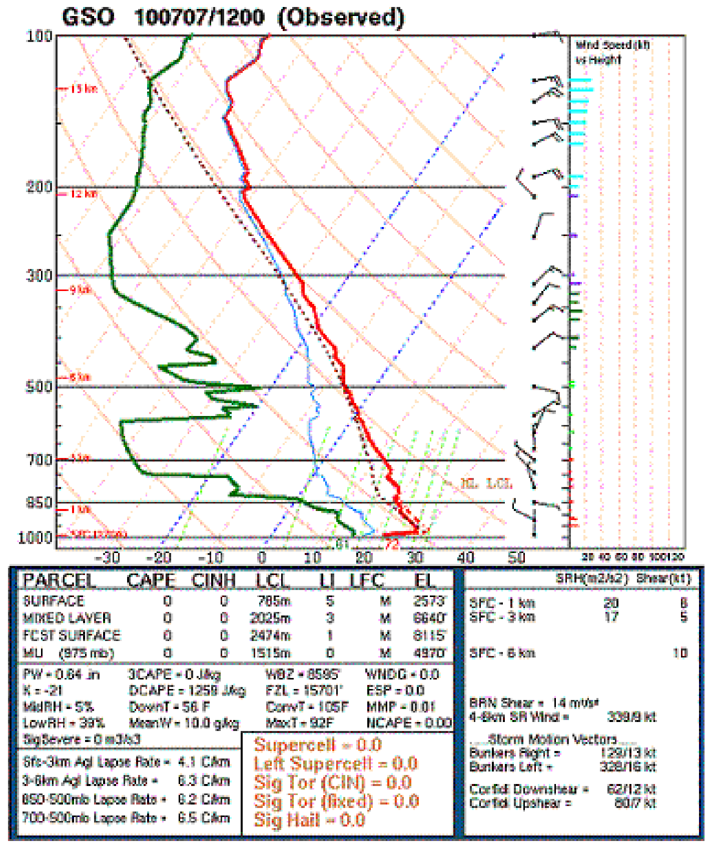
July 25, 2010				July 7, 2010		
Location	Max T	Max HI		Location	Max T	Max HI
KBUY	97	108		KBUY	102	98
KFAY	100	112		KFAY	103	101
KFBG	100	114		KFBG	101	102
KGSO	96	106		KGSO	99	97
KGWW	98	114		KGWW	102	101
KHNZ	98	104		KHNZ	99	98
KHRJ	102	114		KHRJ	106	105
KIGX	99	109		KIGX	102	100
KINT	96	105		KINT	98	97
KJNX	97	109		KJNX	99	101
KLHZ	101	111		KLHZ	102	101
KMEB	99	113		KMEB	97	99
KPOB	100	118		KPOB	102	102
KRCZ	98	112		KRCZ	99	99
KRDU	102	112		KRDU	102	100
KRWI	100	112		KRWI	103	102
KSOP	100	115		KSOP	100	101
KTDF	95	105		KTDF	99	97
KTTA	100	111		KTTA		
KVUJ	100	119		KVUJ	99	97





Precipitable water values generally ranged between 1.75 and 2.25 inches at KGSO from 23-26 July (1.87" on 23/00 UTC, 2.29" on 23/12 UTC, 2.00" on 24/00 UTC, 1.88" on 24/12 UTC, 1.57" on 25/00 UTC, 2.03" on 25/12 UTC, and 2.21" on 26/00 UTC) which all exceeded the 75th percentile for KGSO. In fact, a precipitable water value of around 2.00 inches for mid to late July is around two standard deviations from normal. On 7 July, the precipitable water values were less than 0.75 inches across much of central NC.

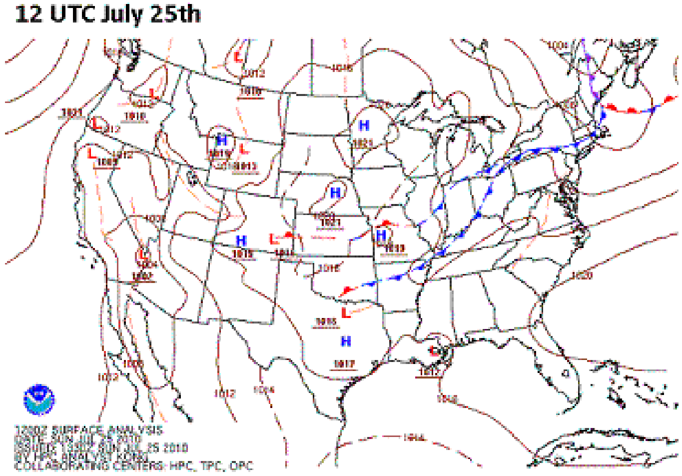




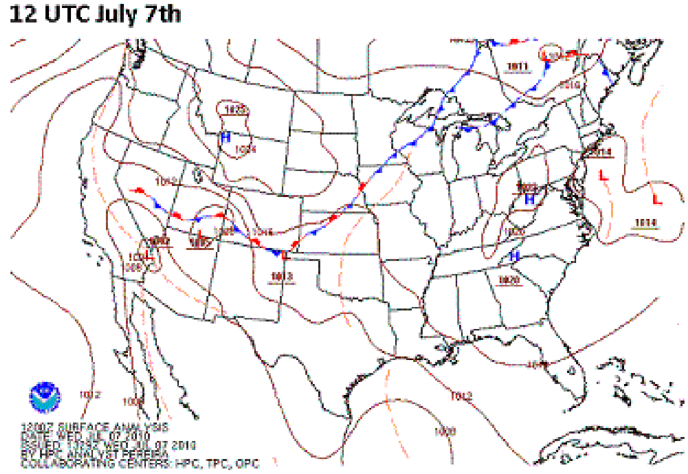
When comparing the surface and upper air charts from the two different time periods (6-8 July and 23-25 July), a few hypotheses can be drawn as to why the 6-8 July event was hot and relatively dry while the 23-25 July event was hot and very humid with relatively higher heat indices. The main difference between the two cases is the location and orientation of the high pressure ridge across the eastern U.S. and the associated flow around it. The hot and dry case had the mid and upper level ridge axis centered over the central Appalachians with the ridge axis extending south to north and the upper level jet across the Northern Plains. In contrast, the hot and humid case had a broad, flat, high pressure ridge that extended from west to east across the southeastern U.S. with the upper level jet located over the Great Lakes and New England.

Similar patterns are present in the lower troposphere with the ridge at 700 hPa and 850 hPa located over the southern Appalachians for the dry case and an west to east ridge axis located over the southeast Atlantic coast for the humid case. The flow around this low level ridge off the Southeast coast allowed warm moist air from the Gulf of Mexico to be transported across the lower Mississippi Valley and into the Tennessee Valley and the Carolinas. The surface high was centered well off the Southeast U.S. coast, in a "Bermuda High" type pattern with a ridge extending west into eastern Florida. The surface pattern for the less humid case featured a surface high over the southern Appalachians that extend along a north-south axis with a light, mainly northerly flow in the Carolinas.

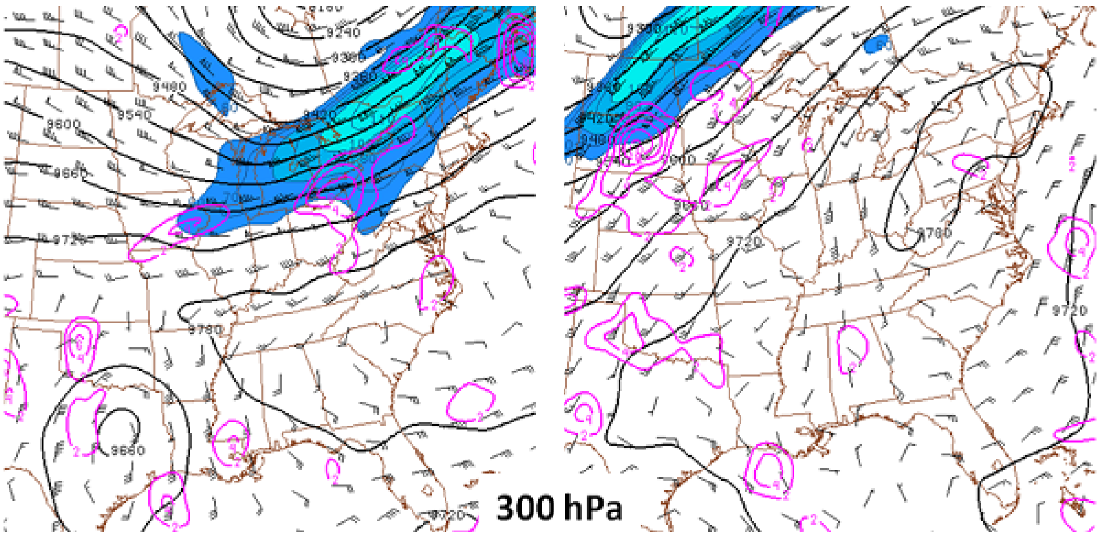
12 UTC July 25th



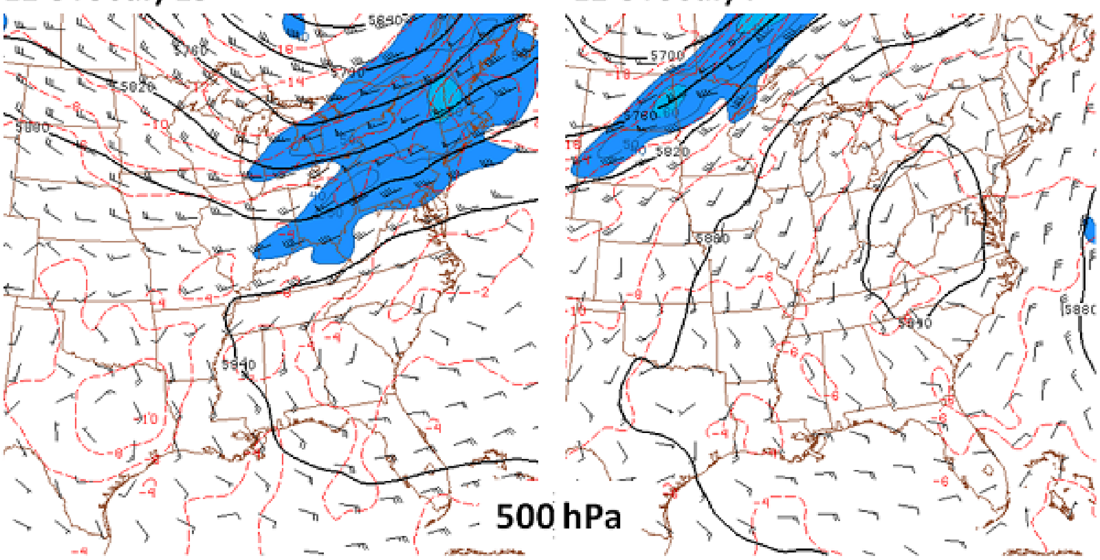
12 UTC July 7th



12 UTC July 25th | 12 UTC July 7th

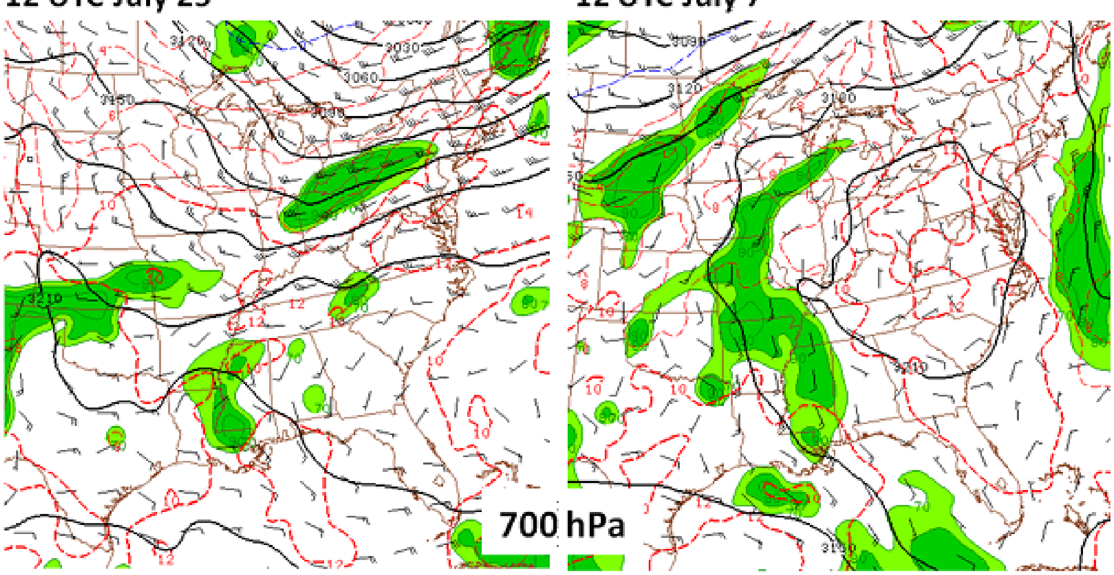


12 UTC July 25th | 12 UTC July 7th

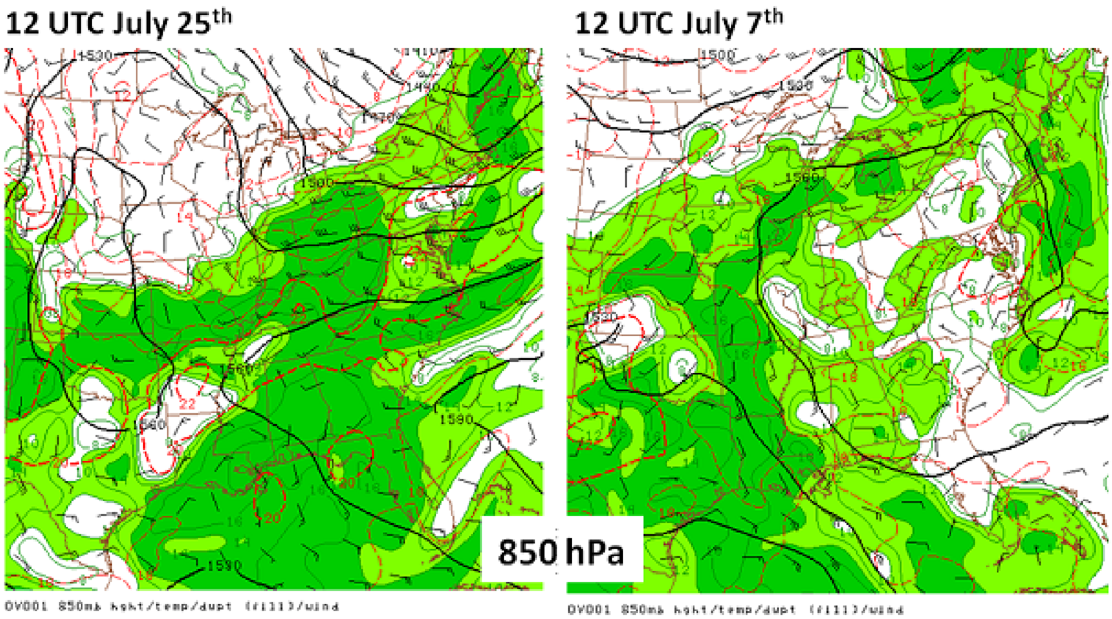


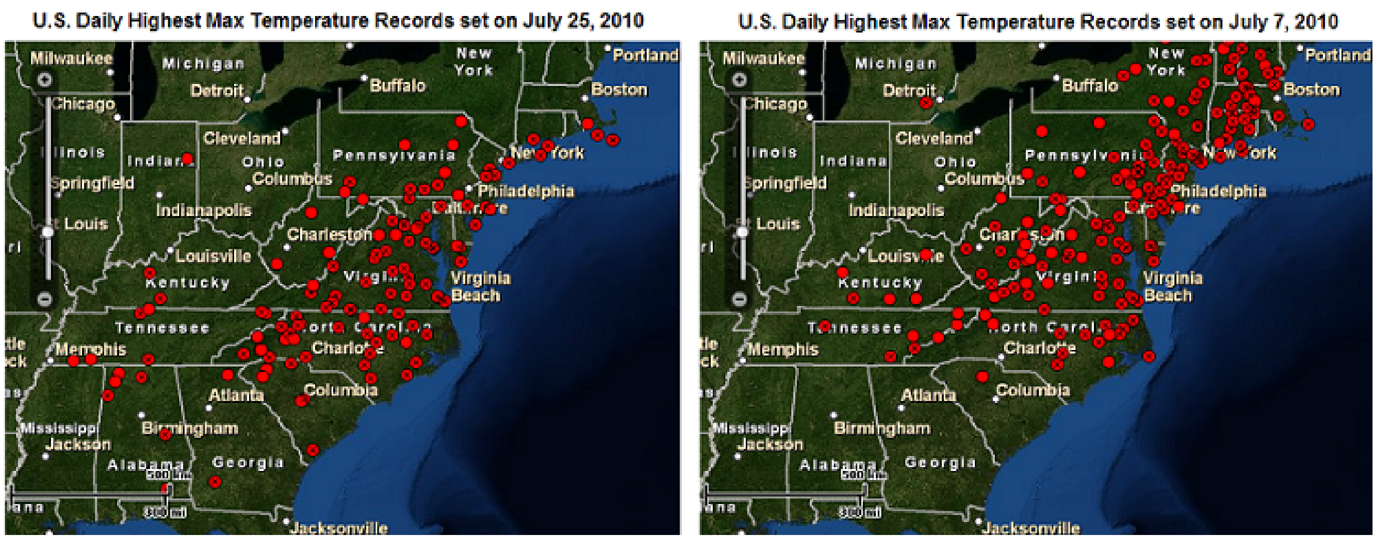
25/1200V001 500mb hght/temp/wind | 07/1200V001 500mb hght/temp/wind

12 UTC July 25th | 12 UTC July 7th



700mb hght/wind/temp/700-500mb mean RH (fill) | 700mb hght/wind/temp/700-500mb mean RH (fill)





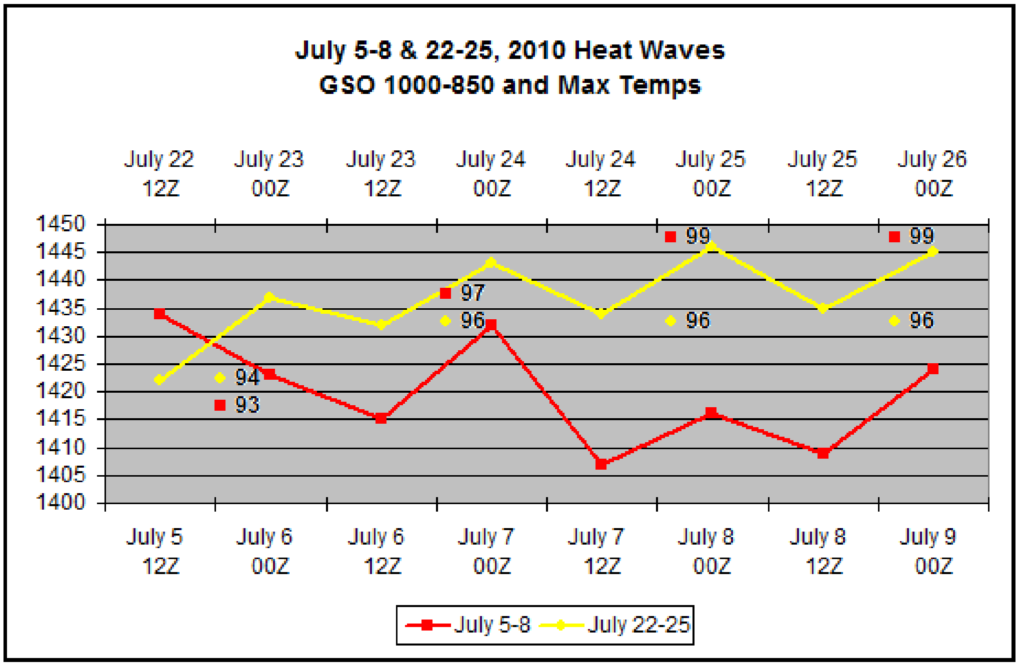
The image above compares the locations of record high temperatures on 7 July and 25 July 2010. The image is from the National Climatic Data Center which has a nice records look up website (http://www.ncdc.noaa.gov/extremes/records/) that allows users to search for various temperature, precipitation, and snow record. Note that the data may be preliminary and has the potential to include some errors but it is a helpful web site.

The low level thicknesses in the 1000 hPa - 850 hPa layer in the 23-25 July humid case (shown in yellow) were much greater than those for the 6-8 July dry case (shown in red) in the chart to the right. This is interesting since the maximum temperatures during the dry case (shown in red squares) were several degrees warmer than the maximum temperatures during the humid event (shown in yellow diamonds), even with thickness values 10-30m lower than the humid case.

Keep in mind that on a humid day, the low level thickness values should be greater due to the presence of additional water vapor and the impact on the virtual temperature. On a less humid or drier day, the reduced amount of water vapor would lead to lower thicknesses. For example, on a hot and humid day, the difference between the low level dry bulb temperature (T) and the virtual temperature (Tv) can be up to 3 degrees C (nearly 6 degrees F). For an extreme case, comparing an extremely dry air mass with a very humid environment, a 5-degree C difference between T and Tv would give about 23 meters of difference in the 1000-850 hPa thickness (Lackmann, 2010). This would likely be the upper limit of that effect given the comparison between the two extremes. More typical values would likely range on the order of 5 to 10 meters.

While the amount of water vapor in the lower troposphere would alter the low level thicknesses directly through changes in the virtual temperature, the changes in moisture would also impact surface temperatures by altering the amount of cloudiness. The additional moisture would likely lead to enhanced cloudiness and reducing the amount of insolation, this would work to cool surface temperatures. While on a dry day, the reduced moisture should lead to less cloudiness and more insolation.

There are several other factors that impact maximum temperatures in addition to the low level thickness values. These include the amount of cloudiness and insolation, the amount of moisture in the soil which influences how much short wave radiation is converted to sensible heating, horizontal thermal advection, the amount of wind and turbulence, and more. So when comparing heat waves or maximum temperatures, the amount of moisture in the low levels that alters the low level thicknesses is one of many sources of uncertainty.



Significant Event and a Hot Summer

Raleigh-Durham International Airport records during the 23-26 July, 2010 period

- The low temperature at the Raleigh-Durham International Airport on July 23rd was 76 degrees. This breaks the old record high min of 75 set in 1991 and 1978.

- The low temperature at the Raleigh-Durham International Airport on July 24th was 79 degrees. This breaks the old record high min of 75 set in 1987.

- The high temperature at the Raleigh-Durham International Airport on July 24th was 100 degrees. This ties the old record originally set in 1999 and 1976.

- The low temperature at the Raleigh-Durham International Airport on July 25th was 80 degrees. This breaks the old record high min of 74 set in 1986 and 1981.

- The low temperature of 80 degrees on the 25th is the all-time record high minimum temperature ever at the Raleigh-Durham International Airport. The old all-time record high minimum was 78 degrees and was held on four separate days, July 8th 1986, July 13th 1981, August 9th 2007, and August 14th 1995.

- The high temperature at the Raleigh-Durham International Airport on July 25th was 102 degrees. This breaks the old record of 98 originally set in 1949.

- The low temperature at the Raleigh-Durham International Airport on July 26th was 77 degrees. This breaks the old record high min of 73 set in 2005, 2004, 1991, and 1987.

Piedmont Triad International Airport records during the 23-26 July, 2010 period

- The low temperature at the Piedmont Triad International Airport on July 23rd was 78 degrees. This breaks the old record high min of 76 set in 1999, 1991, and 1934.

- The low temperature at the Piedmont Triad International Airport on July 24th was 78 degrees. This breaks the old record high min of 75 set in 1934.

- The high temperature at the Piedmont Triad International Airport on July 24th was 96 degrees. This ties the old record originally set in 1995, 1976, and 1972.

- The low temperature at the Piedmont Triad International Airport on July 25th was 78 degrees. This breaks the old record high min of 74 set in 1969 and 1934.

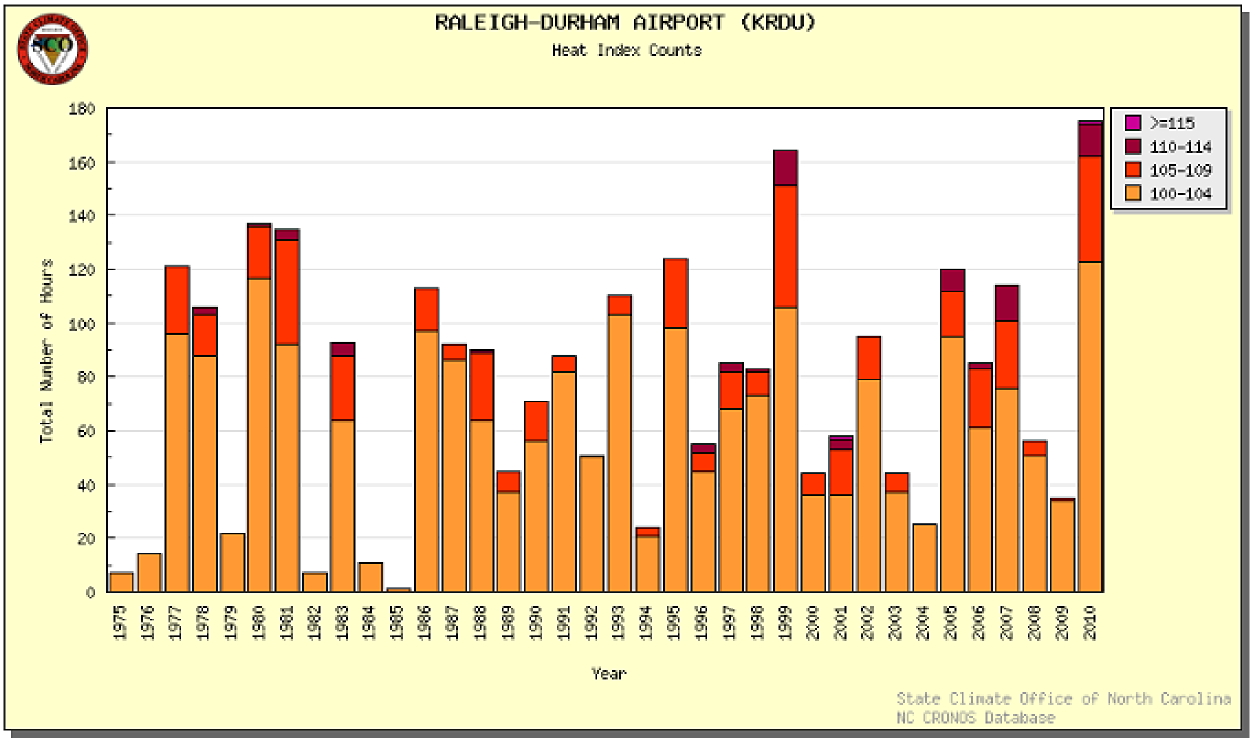
- The minimum temperature of 78 degrees on the 23rd, 24th, and 25th is the record high minimum for July at the piedmont Triad International Airport. This breaks the old record high minimum for July of 77 degrees set on July 1st 1970, July 10th 1981, and July 14th

1981.

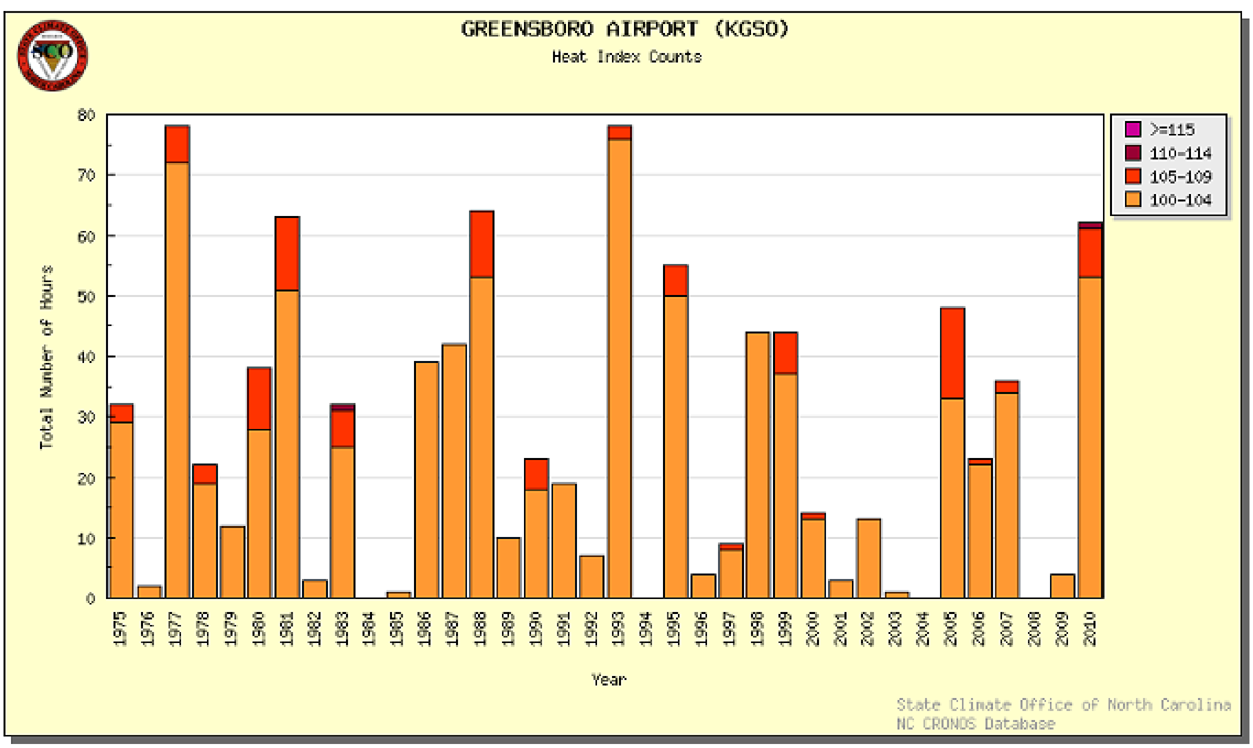
- The low temperature at the Piedmont Triad International Airport on July 26th was 75 degrees. This breaks the old record high min of 74 set in 2005.

The State Climate Office of North Carolina put together a Heat Index Climatology. The Heat index was devised as a way to determine how warm the outside temperature feels when relative humidity is factored in. The graphs below show the number of hours that the heat index exceeds specific thresholds at Raleigh-Durham and Greensboro.

Graph of the number of hours of specific heat levels at Raleigh-Durham, NC from 1975 through November 30, 2010



Graph of the number of hours of specific heat levels at Greensboro, NC from 1975 through November 30, 2010



Final Thoughts

The event featured a classic upper air pattern for a heat wave in the Southeast with a closed 5940m contour at 500 hPa, 700 hPa heights greater than 3210m, and 850 hPa temperatures over 21C. In addition, surface dew points in the lower to mid 70s led to very high heat index values and a fair amount of convection for a period of record heat.

A heat index chart was locally produced at the NWS Raleigh NC office for this project. This chart provides the heat index for a given temperature and dew point at one degree intervals. Note the area of heat index values highlighted in gray below, these heat index values are actually lower (cooler) than the air temperature. In general, when the dry bulb temperature is below 60 degrees F, the heat index will be equal to or cooler than the dry bulb temperature.

Two heat episodes were compared, the 6-8 July, 2010 (hot and not very humid) and the 23-25 July, 2010 (hot and very humid) to note any differences in the overall pattern that could discriminate between heat episodes that are either humid or not very humid. The main difference between the two cases is the location and orientation of the high pressure ridge across the eastern U.S. and the associated flow around it. The hot and dry case had the mid and upper level ridge axis centered over the central Appalachians with the ridge axis extending south to north and the upper level jet well removed and located across the Northern Plains with an associated frontal system. In contrast, the hot and humid case had a broad, flat, high pressure ridge that extended from west to east across the southeastern U.S. with the upper level jet located over the Great Lakes and an approaching frontal system.

The National Climatic Data Center has a nice records look up website (http://www.ncdc.noaa.gov/extremes/records/) that allows users to search for various temperature, precipitation, and snow record. Note that the data may be preliminary and has the potential to include some errors but it is a helpful web site.

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Acknowledgements

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Case Study Team

Kathleen Carroll
Jonathan Blaes