

Implementing an Enhanced Flash Flood Climatology for Central North Carolina

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National Weather Service, Raleigh, NC

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The need for a climatology

Flash flood impacts can vary in scale and severity - *where are the hot spots?*

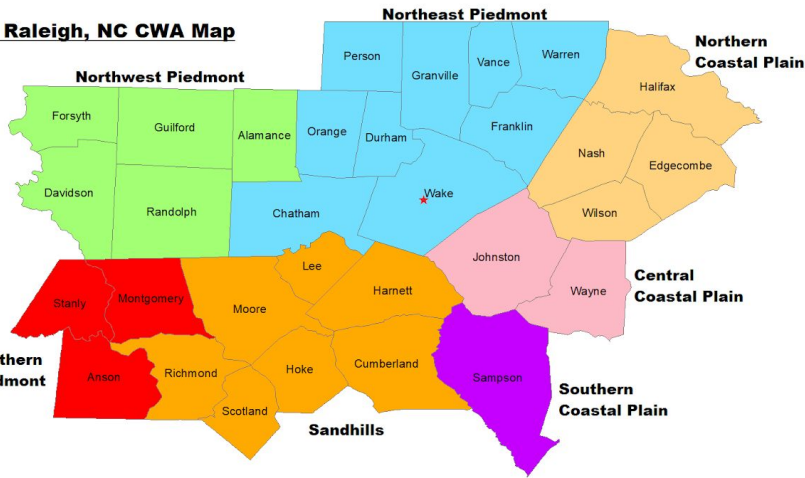
Reducing the size of Flash Flood Warnings is difficult - *can we provide greater detail of flood prone areas in Flash Flood Warnings?*

Synoptic and mesoscale weather patterns for flash flooding are well known - *how do they apply to central North Carolina?*

Project Goal: Improve the accuracy of flash flood warnings and efficiency of warning operations

Improving our products

*NWS Raleigh, NC CWA Map



Flash Flood Warning

Valid Until
2:15 PM EST Thursday
November 12, 2020

Safety Information

- Avoid walking or driving through flood waters!
- Move immediately to higher ground!

Potential Exposure

| | |
|--|-----------------------|
| | Population: 1,992,888 |
| | Schools: 392 |
| | Hospitals: 21 |

@NWSRaleigh



Improving our products

The current state of Flash Flood Warnings provides limited actionable information

Generic list of impacted locations

The National Weather Service in Raleigh has issued a

* Flash Flood Warning for...
Forsyth County in central North Carolina...
Northwestern Guilford County in central North Carolina...

* Until 200 AM EDT.

* At 1100 PM EDT, Doppler radar indicated thunderstorms producing heavy rain across the warned area. Around 1 inch of rain has fallen since 1015 PM. Additional rainfall amounts of 1 to 2 inches are possible in the warned area. Flash flooding is ongoing or expected to begin shortly.

HAZARD...Life threatening flash flooding. Thunderstorms producing flash flooding.

SOURCE...Radar.

IMPACT...Life threatening flash flooding of creeks and streams, urban areas, highways, streets and underpasses.

* Some locations that will experience flash flooding include...
Winston-Salem, Kernersville, Clemmons, Huntsville, Lewisville, Summerfield, Stokesdale, Walkertown, Rural Hall, Stanleyville, Pfafftown, Sedge Garden, Belews Creek, Colfax, Belews Lake and Donaha.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

Turn around, don't drown when encountering flooded roads. Most flood deaths occur in vehicles.



Improving our products

Generic list of impacted locations

The National Weather Service in Raleigh has issued a

* Flash Flood Warning for...

Eastern Person County in central North Carolina...

Nash County in central North Carolina...

Warren County in central North Carolina...

Vance County in central North Carolina...

Granville County in central North Carolina...

Northwestern Halifax County in central North Carolina...

Franklin County in central North Carolina...

* Until 1215 PM EDT.

* At 820 AM EDT, Doppler radar and automated gauges indicated showers and thunderstorms producing heavy rain across the warned area. Up to three inches of rain has already fallen since 600 AM. Flash flooding is ongoing or expected to begin shortly.

HAZARD...Heavy rain producing life threatening flash flooding.

SOURCE...Radar and automated gauges.

IMPACT...Life threatening flash flooding of creeks and streams, urban areas, highways, streets and underpasses.

* Some locations that will experience flooding include...

Rocky Mount, Henderson, Oxford, Roxboro, Nashville, Creedmoor, Louisburg, Warrenton, Butner and Franklinton.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

Turn around, don't drown when encountering flooded roads. Most flood deaths occur in vehicles.

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Improving our products

Added value but must be entered manually

The National Weather Service in Raleigh has issued a

* Flash Flood Warning for...
Southeastern Forsyth County in central North Carolina...
Northeastern Davidson County in central North Carolina...
Northwestern Guilford County in central North Carolina...

* Until 100 AM EDT

* At 959 PM EDT, Doppler radar and automated rain gauges indicated heavy rain falling across the warned area. Up to two inches of rain has already fallen. Piedmont Triad International Airport has received 1.73 inches in the past two hours. Brush Creek at Muirfield Road is also rapidly rising and is approaching flood stage quickly. Flash flooding is expected to begin shortly.

* Some locations that will experience flooding include...
Greensboro, High Point, Lexington, Thomasville, Kernersville,
Summerfield, Haw River State Park, Lake Jeanette Marina, Oak Hollow Marina and Lake Townsend.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

Turn around, don't drown when encountering flooded roads. Most flood deaths occur in vehicles.

Be especially cautious at night when it is harder to recognize the dangers of flooding.

National Weather Service - Raleigh, NC



The Process For Identifying Flood Prone Areas

- Review Hot Spots provided by emergency managers in early 2000s
- Rigorous review of all flash flood reports from 2008 - 2020 via StormData (~750 in total)
 - Quality control reduced the storm reports to 570
 - Reports were cross-referenced and attributed to individual weather events that resulted in flash floods in order to study meteorological features
 - Reports were also plotted (ArcGIS) and analyzed (eg, heat maps) to identify areas with recurring flood events
- Re-surveyed emergency managers for their local knowledge of flood prone areas



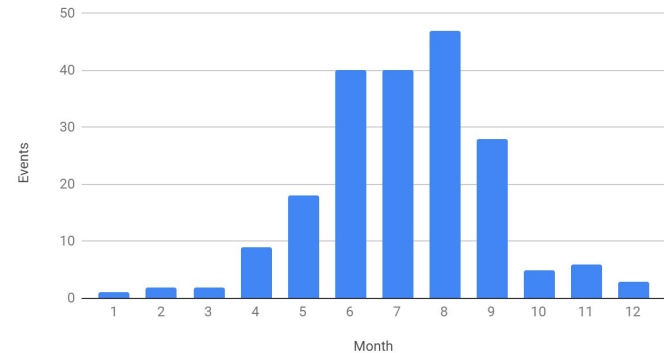
The Process For Composite Analysis

- Used the same database of 2008-2020 flash flood reports
- The North American Regional Reanalysis (NARR) was used to analyze the individual cases
- Each case analyzed using traditional surface and upper-level parameters starting 24 hours prior to flash flooding reports
- Composites maps for case subsets were created, starting with monthly/seasonal categories
 - Focus on non-tropical cases as a starting point

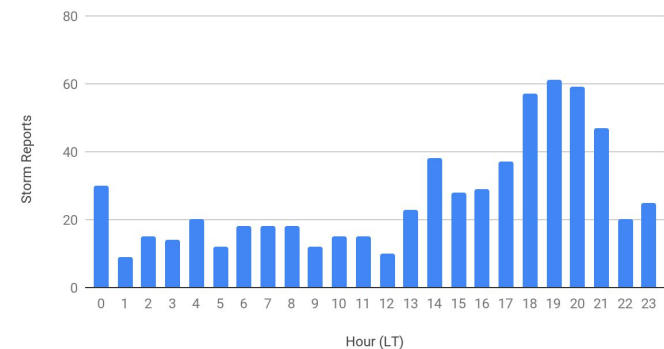
Analyzing Flash Flood Events

- Most flash flood events occur in June, July, August
- Peak in flash flooding and storm reports during the evening hours

Flash Flood Events by Month (2008-2020)

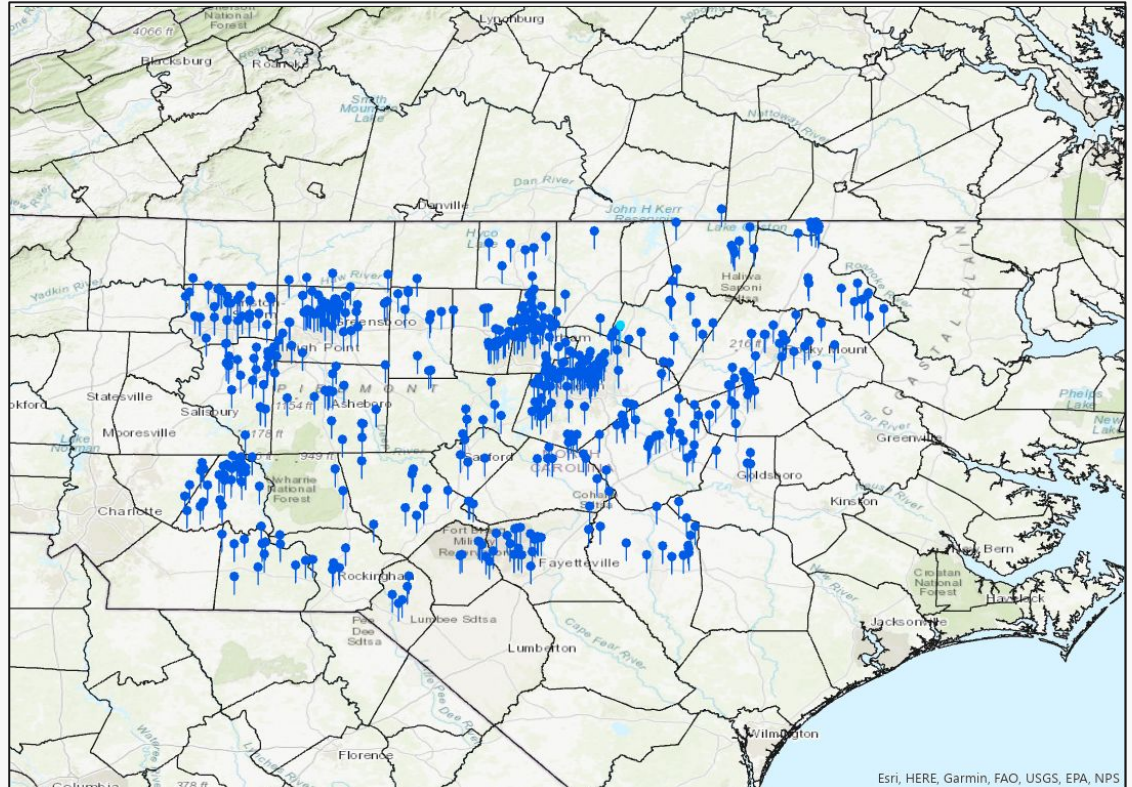


Local Storm Reports by Hour (2008 - 2020)



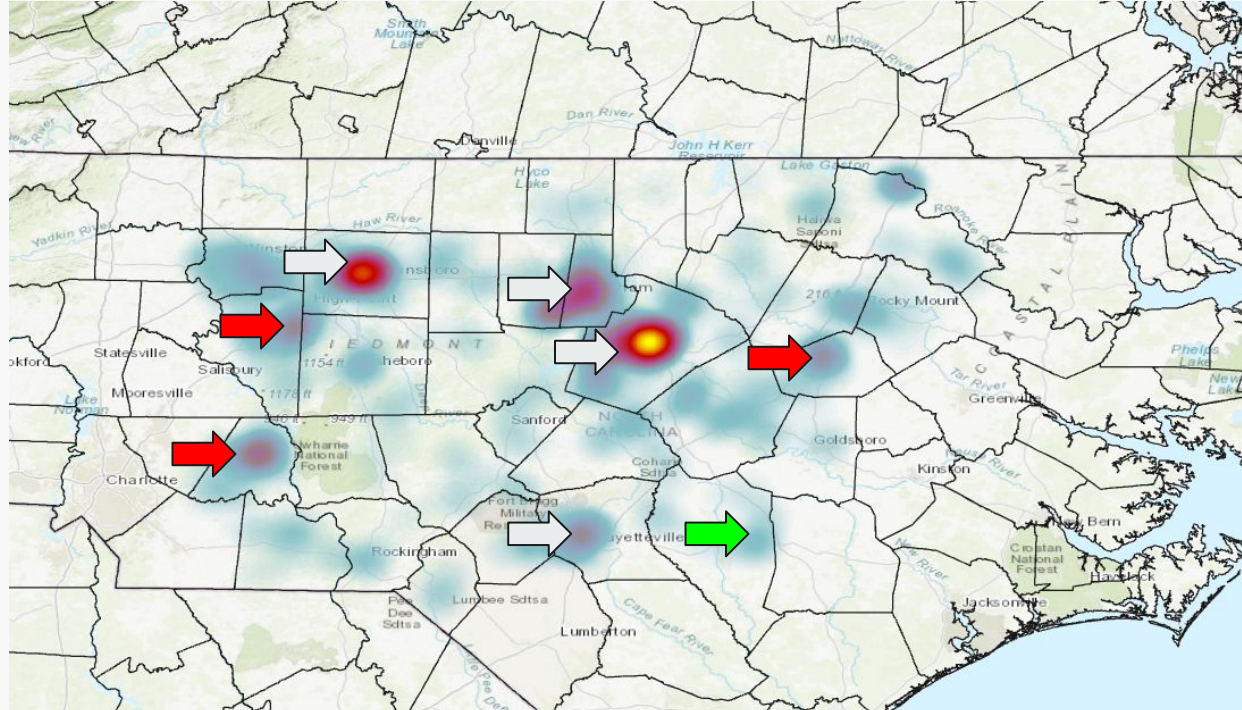
Mapping Flood Reports

- Mapped all flash flood LSR's from 2008-2020
- Filtered reports:
 - At least two separate events
 - Within one mile of each other
 - Have some similar verbiage (intersection, creek, landmark)
- 570 reports reduced to 168



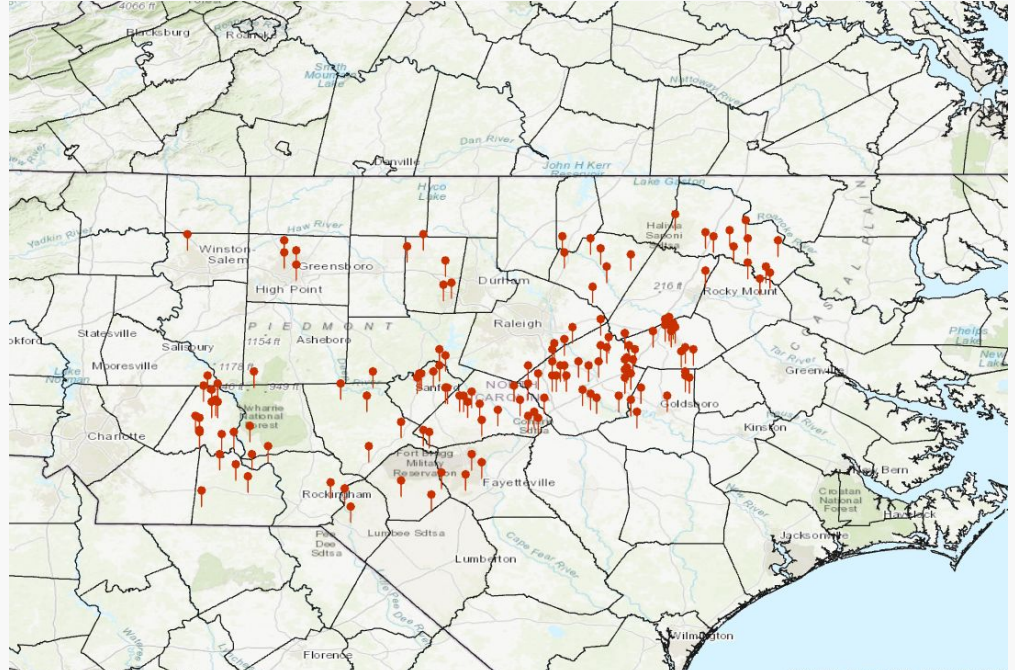
Mapping Flood Reports

- Hot spot analysis
 - Well known urban areas
 - Raleigh-Durham
 - Greensboro
 - Fayetteville
 - Some other urban areas highlight
 - Albemarle
 - Wilson
 - Thomasville
 - Some other areas also stand out
 - Ex: Eastern Sampson Co



Engaging our core partners

- In the early 2000s, NWS Raleigh worked with county officials in 18 counties to identify flood prone areas (hot spots)
- Test files and primitive GIS maps were available for forecasters to reference - outside of AWIPS
- Eventually shapefiles were created for AWIPS and warning operators could overlay with radar and qpe.





Engaging our core partners

- Survey request sent to 31 Emergency Managers requesting locations of flood prone areas.
- COVID-19 protocols precluded any face to face outreach.
- Seven counties have responded to the survey - more outreach needed (opportunity!)

NWS Raleigh Flood Hot Spot Survey

Dear valued NWS Core Partner,

The National Weather Service in Raleigh is requesting your valued input and assistance in identifying flood prone areas within your designated County. Over many years, flood prone areas, or hot spots, have been identified through forecaster experience of the local area and anecdotal evidence, as well as feedback from our partners. It has been many years since we last executed a comprehensive survey. Having the ability to pinpoint where hotspots are located, as well as knowing the amount of rainfall that can cause significant flash flooding in these locations, is extremely valuable when issuing Flash Flood Warnings for the protection of life and property.

Having this awareness of flood prone hot spots, forecasters will be able to:

- Provide more detailed, targeted and actionable information in flood warnings
- Potentially reduce the areal size of flood warnings.
- Provide better communication with emergency managers and other decision makers for the protection of life and property.

Please use this Google Form survey to provide up to 10 hot spots in your County. Intersections or water crossings are very helpful. Any additional information you can provide about each hot spot (ie; type and severity of flooding, impacts to roads, residences, or business, etc.) is greatly appreciated and can also be provided on the form. If you have are aware of more than 10 hot spots, please email our Hydrologist Barrett Smith (barrett.smith@noaa.gov) and we can arrange a means for providing additional locations.

We respectfully request this survey be completed by February 16th, 2022. However, if you require additional time, please let us know in advance so we can plan accordingly. Thank you very much!

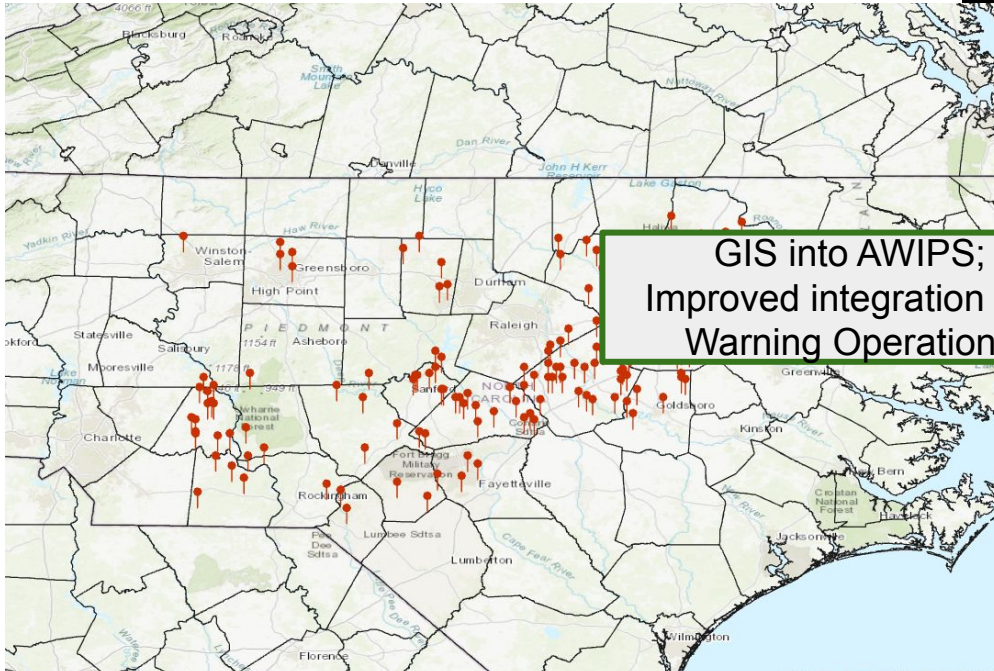


Engaging our core partners

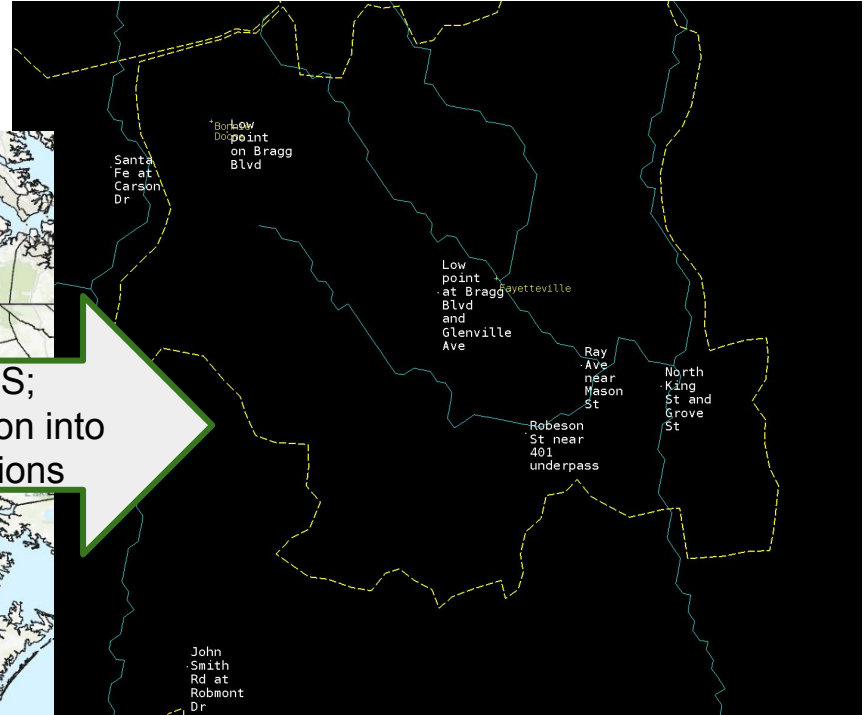
- All potential hot spots have been compiled into one list:
 - Original hot spots from early 2000s
 - Locations of multiple flood reports
 - New locations provided by EMs in 2022

| County | Name | LAT | LON |
|--------|--|-------------|--------------|
| Lee | Hwy 501, at Deep River and Patterson Creek | 35.57301725 | -79.1928801 |
| Lee | North Plank Road at the Deep River | 35.55480986 | -79.28724073 |
| Lee | Lower River Road | 35.57 | -79.06 |
| Lee | River Birch Shopping Center, 1065 Spring Lane, Sanford, NC 27330 | 35.48618954 | -79.20241603 |
| Anson | High-Rock Crusher Rd at Lanes Creek between NC 742 N and Ansonville-Polkton Rd | 35.08 | -80.18 |
| Anson | George Wright Rd at Richardson Creek | 35.15337383 | -80.24697681 |
| Anson | Cribbs Creek Rd between Race Track Rd and Rocky River Church Rd | 35.12656645 | -80.20740981 |
| Anson | Webb Rd between Beck Rd and Deep Creek Church Rd | 34.85740195 | -80.15549231 |
| Anson | Pleasant Grove Church Rd between NC 109 N and Dennis Rd | 35.05164584 | -80.06671744 |
| Anson | German Hill Rd between Caudle Rd and Gold Mine Ext | 35.00479496 | -80.27868326 |
| Anson | Lockhart Rd between US 52 N and Brown Creek Rd | 35.02546201 | -80.10469049 |
| Anson | Brown Creek Church Rd between US 52 N and Coppedge Eddins Rd | 35.01945396 | -80.10573926 |
| Anson | Robinson Bridge Rd between Teal Hall Rd and Crawford Pond | 34.86785223 | -80.04892559 |
| Anson | Randall Rd between Wightman Church Rd and Lee Rd | 35.13229925 | -80.20443203 |
| Anson | Mills Rd between Poplar Hill Rd and Prison Camp Rd | 34.96695842 | -80.18857069 |
| Anson | Grassy Island Rd between NC 109 and Stanback Ferry SR | 35.07321713 | -79.98768712 |
| Anson | Dennis Rd between Pleasant Grove Church Rd and 109 N | 35.06414624 | -80.02550009 |
| Anson | McAllister Farm Rd between Stanback Ferry Rd and Smith Ferry Rd | 35.09628066 | -79.95460248 |
| Anson | Okey High Rd between Tice Rd and Union County line | 34.86800176 | -80.3114689 |

Mapping flood reports



GIS into AWIPS;
Improved integration into
Warning Operations



Using Hot Spots in Warnings

The National Weather Service in Raleigh has issued a

* Flash Flood Warning for...
Southeastern Johnston County in central North Carolina...

* Until 415 PM EDT.

* At 101 PM EDT, Doppler radar indicated thunderstorms producing heavy rain across the warned area. Flash flooding is ongoing or expected to begin shortly.

HAZARD...Life threatening flash flooding. Thunderstorms producing flash flooding.

SOURCE...Radar.

IMPACT...Life threatening flash flooding of creeks and streams, urban areas, highways, streets and underpasses.

* Some locations that will experience flash flooding include...
Smithfield, Micro, Selma, Pine Level, Kenly and Princeton.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

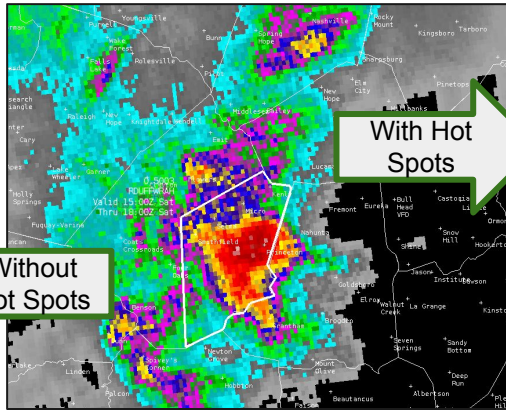
Turn around, don't drown when encountering flooded roads. Most flood deaths occur in vehicles.

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LAT...LON 3526 7843 3557 7835 3567 7815 3560 7813
3559 7806 3542 7815 3539 7815 3539 7814
3537 7816 3535 7815 3534 7822 3532 7824
3532 7827 3532 7829 3529 7830 3526 7841

FLASH FLOOD...RADAR INDICATED
FLASH FLOOD DAMAGE THREAT...CONSIDERABLE

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The National Weather Service in Raleigh has issued a

* Flash Flood Warning for...
Eastern Johnston County in central North Carolina...

* Until 345 PM EDT.

* At 1247 PM EDT, Doppler radar indicated thunderstorms producing heavy rain across the warned area. Flash flooding is ongoing or expected to begin shortly.

HAZARD...Life threatening flash flooding. Thunderstorms producing flash flooding.

SOURCE...Radar.

IMPACT...Life threatening flash flooding of creeks and streams, urban areas, highways, streets and underpasses.

* Some locations that will experience flash flooding include...
Smithfield, Micro, Selma, Pine Level, Kenly, Princeton and Buckhorn Reservoir.

This includes the following flood prone areas...

Weaver Rd at Little River, Little Rd along Spring Branch, Richardson Bridge Rd along Bawdy Creek, Devil's Racetrack Rd and Rt. 39 & Buffalo Creek

PRECAUTIONARY/PREPAREDNESS ACTIONS...

Turn around, don't drown when encountering flooded roads. Most flood deaths occur in vehicles.

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LAT...LON 3526 7848 3555 7834 3573 7820 3573 7818
3571 7816 3560 7813 3559 7806 3542 7815
3539 7814 3536 7816 3534 7822 3532 7824
3532 7827 3529 7830 3526 7841

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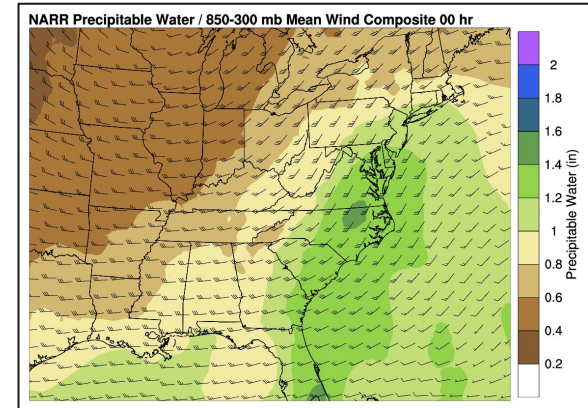
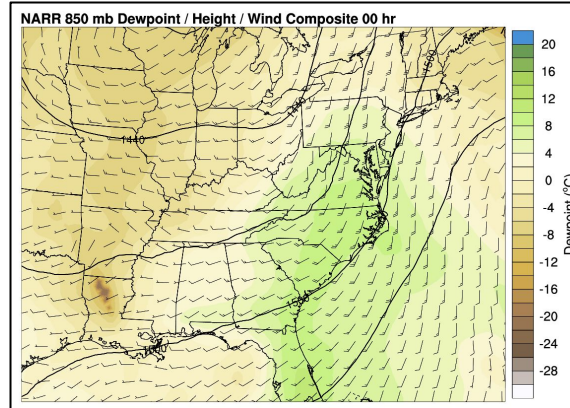
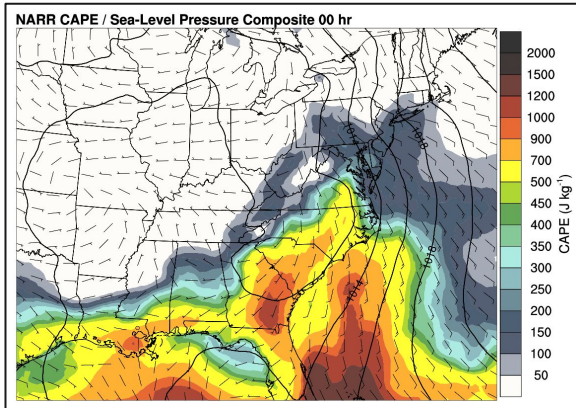
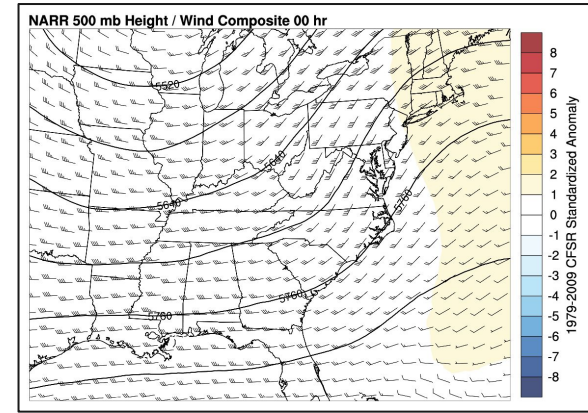
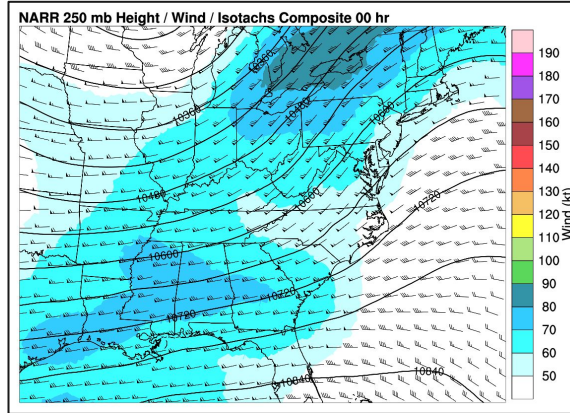
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Ingredients for Flash Flooding

- Maddox et al. (1979)
 - Convective storms, high dewpoints, moist through a deep layer, weak to moderate cloud layer wind shear, training, weak shortwave forcing, near the mid-tropospheric ridge, nighttime hours (Plains states mostly).
- Other studies have found similar environmental ingredients
 - very high PW and PW anomalies in excess of +2 SDs above normal, interaction with quasi north-south frontal zones, etc (Grumm 2007).
 - High 850-700mb temperatures and dewpoints, frontal interactions, weak, southerly tropospheric flow (Gaffin and Hotz 2000).

Pattern Composites (April example)



Note: This study does not yet include antecedent soil moisture conditions



Conclusions and Next Steps

Expand composite analysis to each season, including summertime convective regimes, and also identify diurnal peaks in flash flooding

Continue to coordinate with emergency management across central NC to confirm and refine flooding hotspots derived from the catalog of reports

Continue to integrate into AWIPS (Hazard Services) for use in Flash Flood Warnings



Acknowledgements

NWS Raleigh Hydrology Team

Luke Friedman & Malcolm Byron - NCSU students - data entry