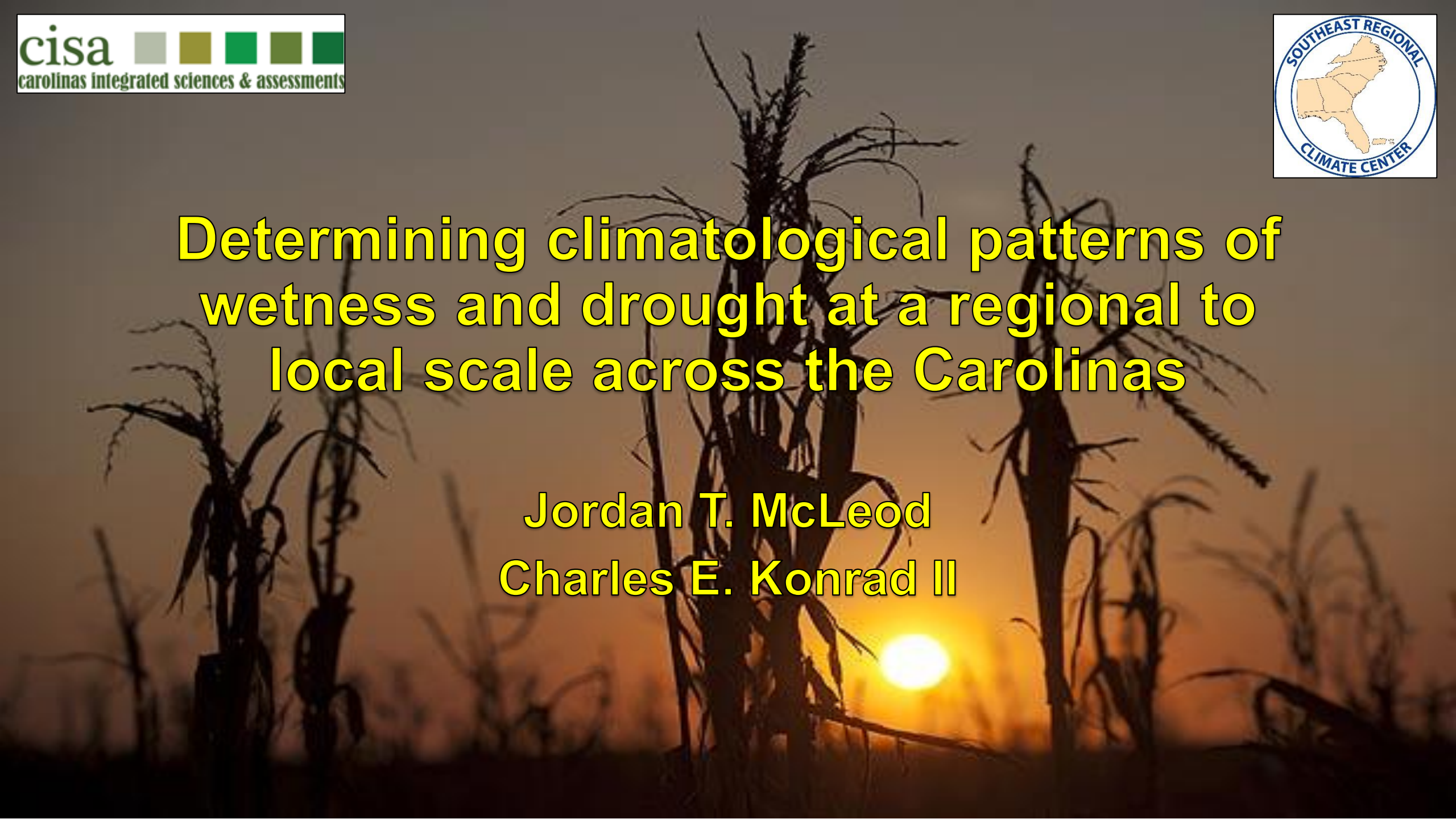
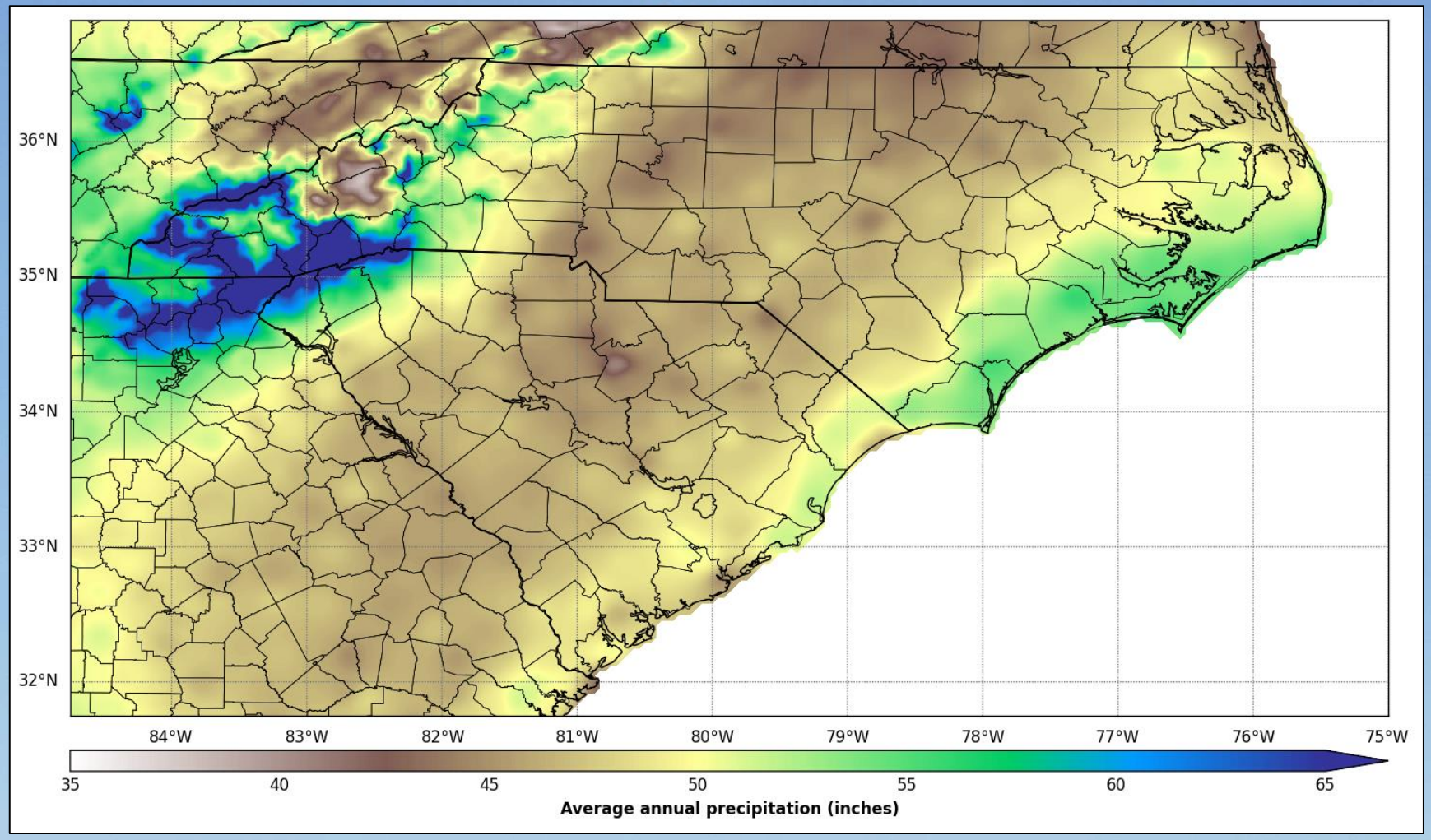


Determining climatological patterns of wetness and drought at a regional to local scale across the Carolinas

Jordan T. McLeod

Charles E. Konrad II

Background


36°N
35°N
34°N
33°N
32°N
84°W
83°W
82°W
81°W
80°W
79°W
78°W
77°W
76°W
75°W
35
40
45
50
55
60
65
Average annual precipitation (inches)

Goal: Develop a spatially detailed, long-term precipitation climatology of the Carolinas that provides users with a geographic visualization of the spatial and temporal variability of precipitation across the region.

Research Objectives:

1) Use recent high-resolution precipitation data to add regional to local scale detail to the precipitation climatology.

2) Identify spatially coherent patterns of long-term precipitation change and variability across the region.

3) Describe the seasonal evolution of exceptional drought across sub-regions within the Carolinas. *(current work)*

Data

- PRISM (Parameter-elevation Regressions on Independent Slopes Model) is a statistical model that interpolates precipitation from a relatively sparse network of station observations based on changes in elevation across space. Gridded output is available at a 4 x 4 km spatial resolution.
- The spatial detail of PRISM precipitation fields increases during the period of record spanning 1895 to present as the density of weather observing stations increases.
- The incorporation of radar-derived MPE data into the PRISM model beginning in 2002 has further enhanced the spatial detail of precipitation fields.

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Oregon State
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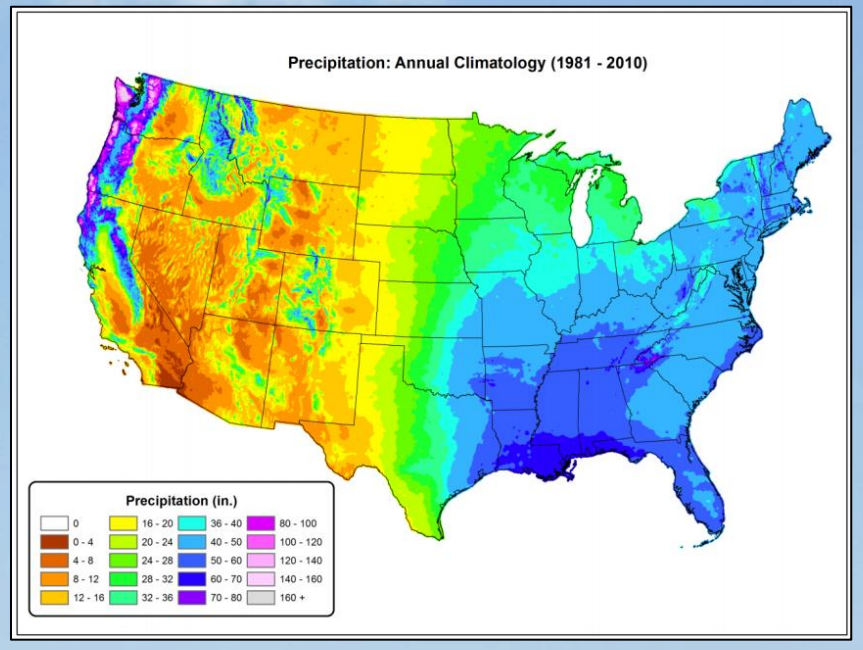
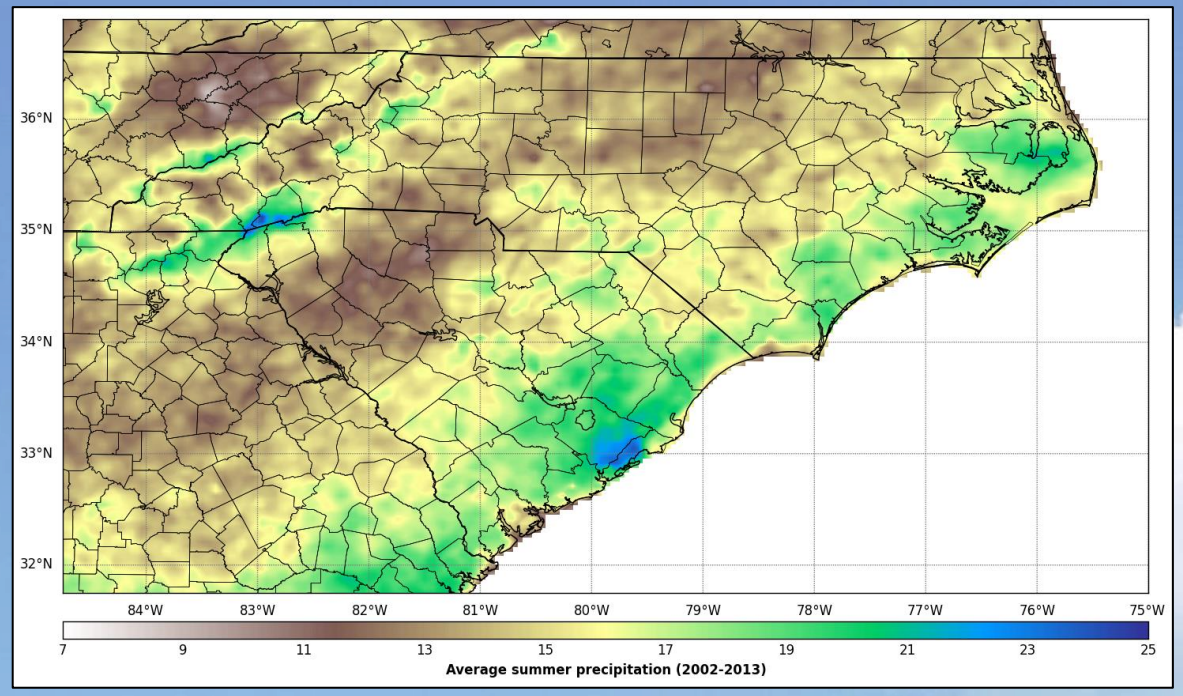
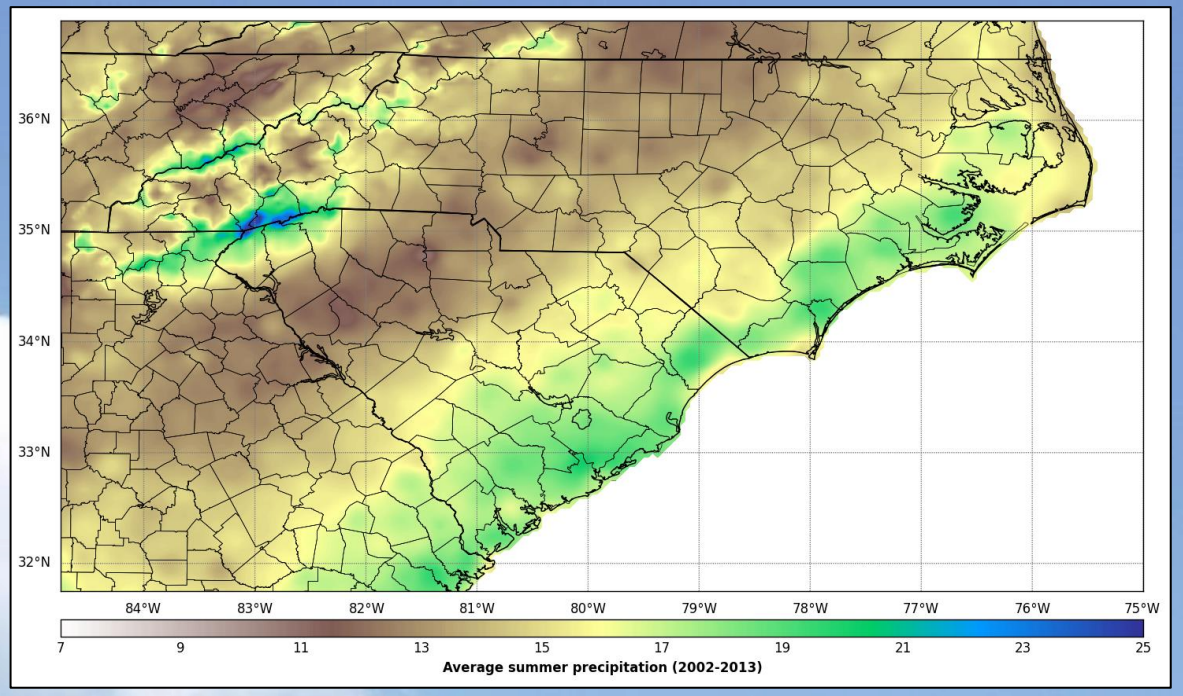


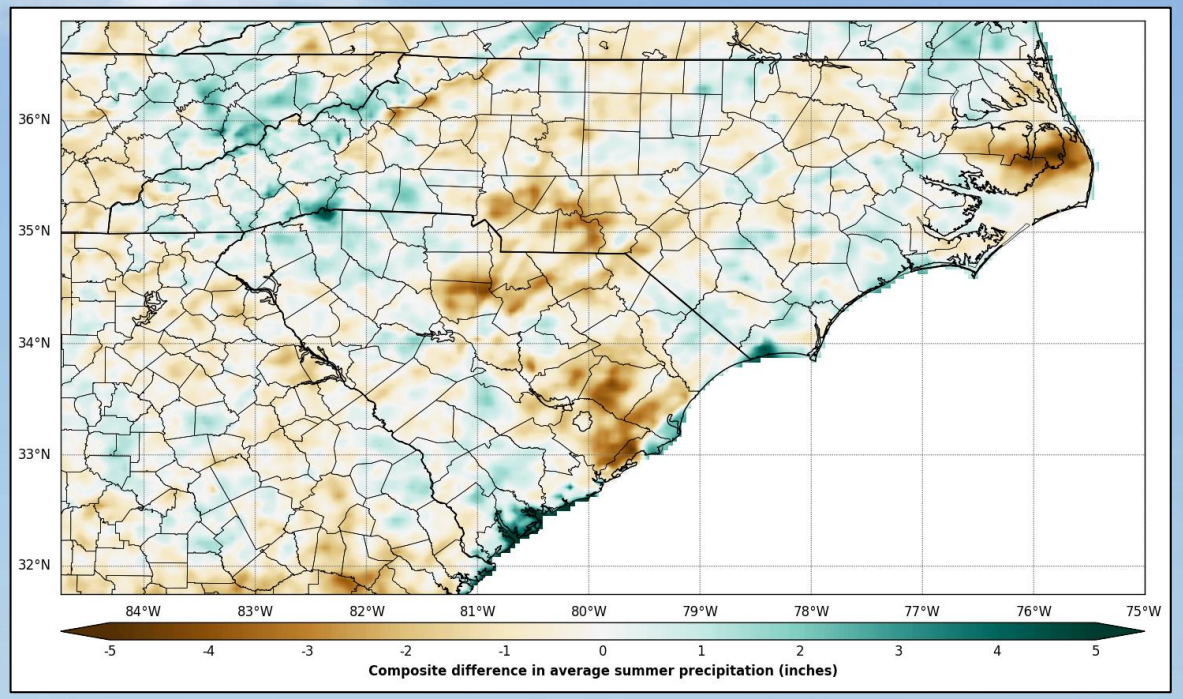
Results

Regional to local variations in precipitation climatology

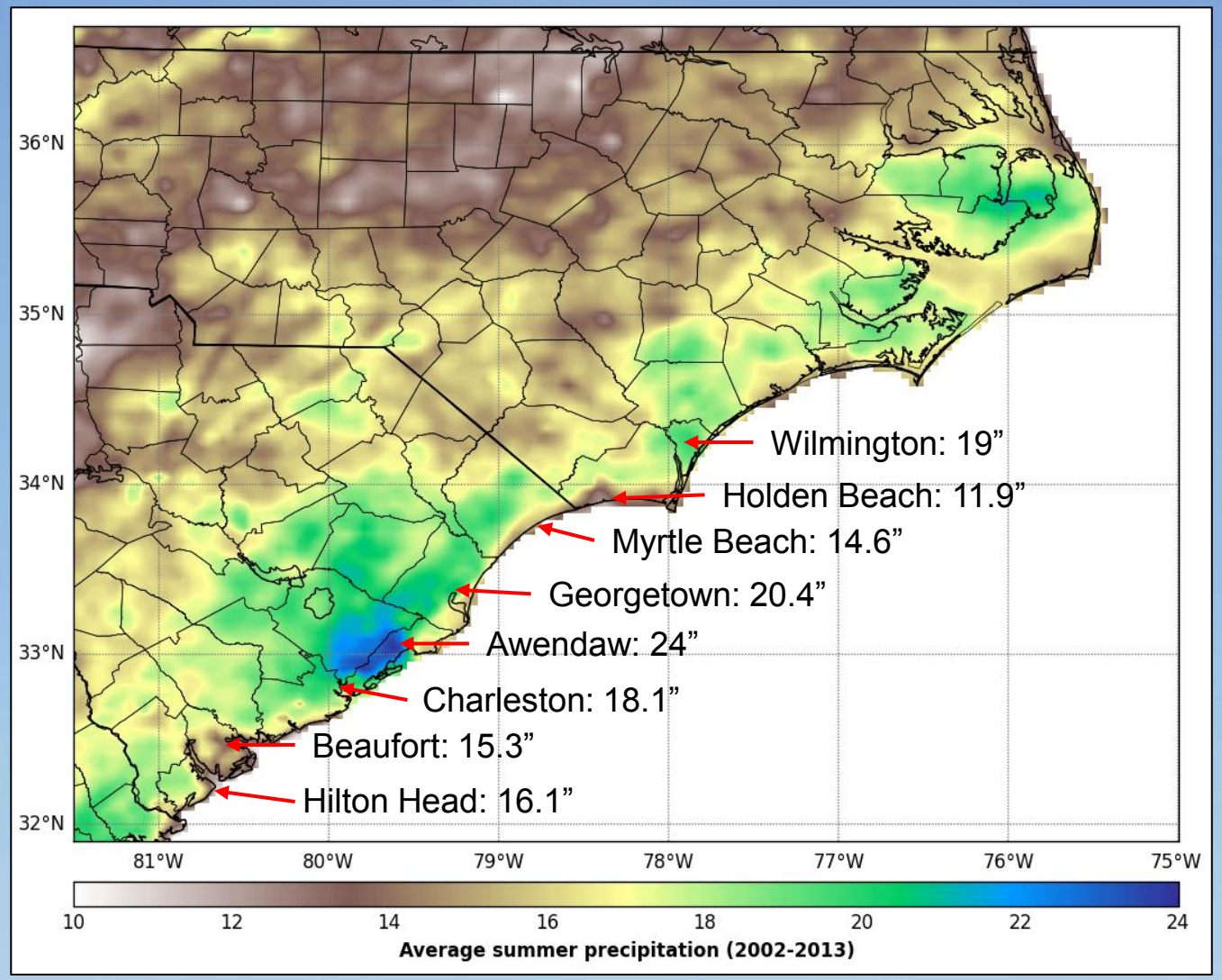




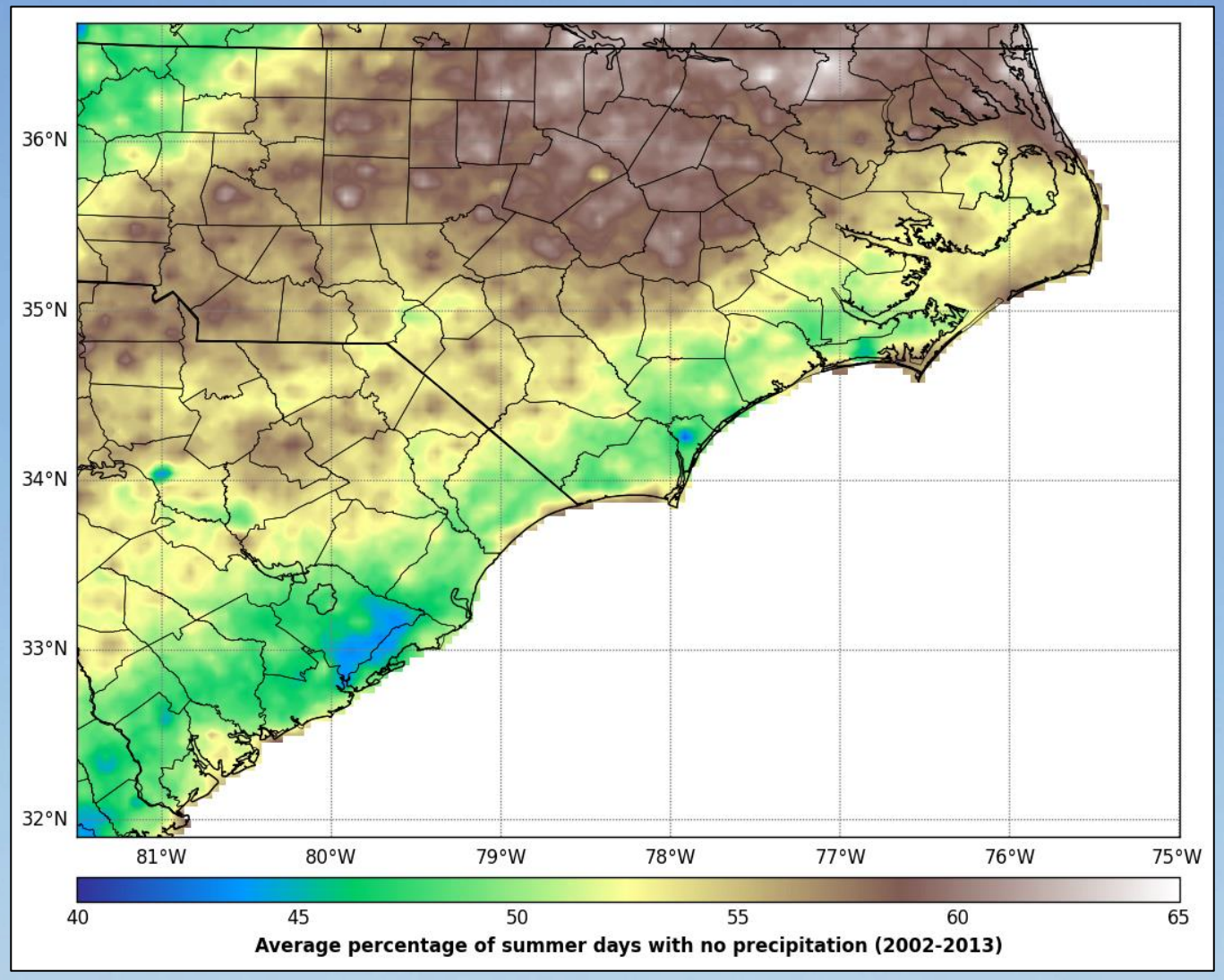
Average summer precipitation (inches) during 2002–2013 based on daily PRISM (top left) and monthly PRISM (top right) data. A composite difference map that subtracts the daily-scale data from the monthly-scale data is shown at bottom right.



Average summer precipitation (inches) over the Carolinas coastal plain during 2002–2013

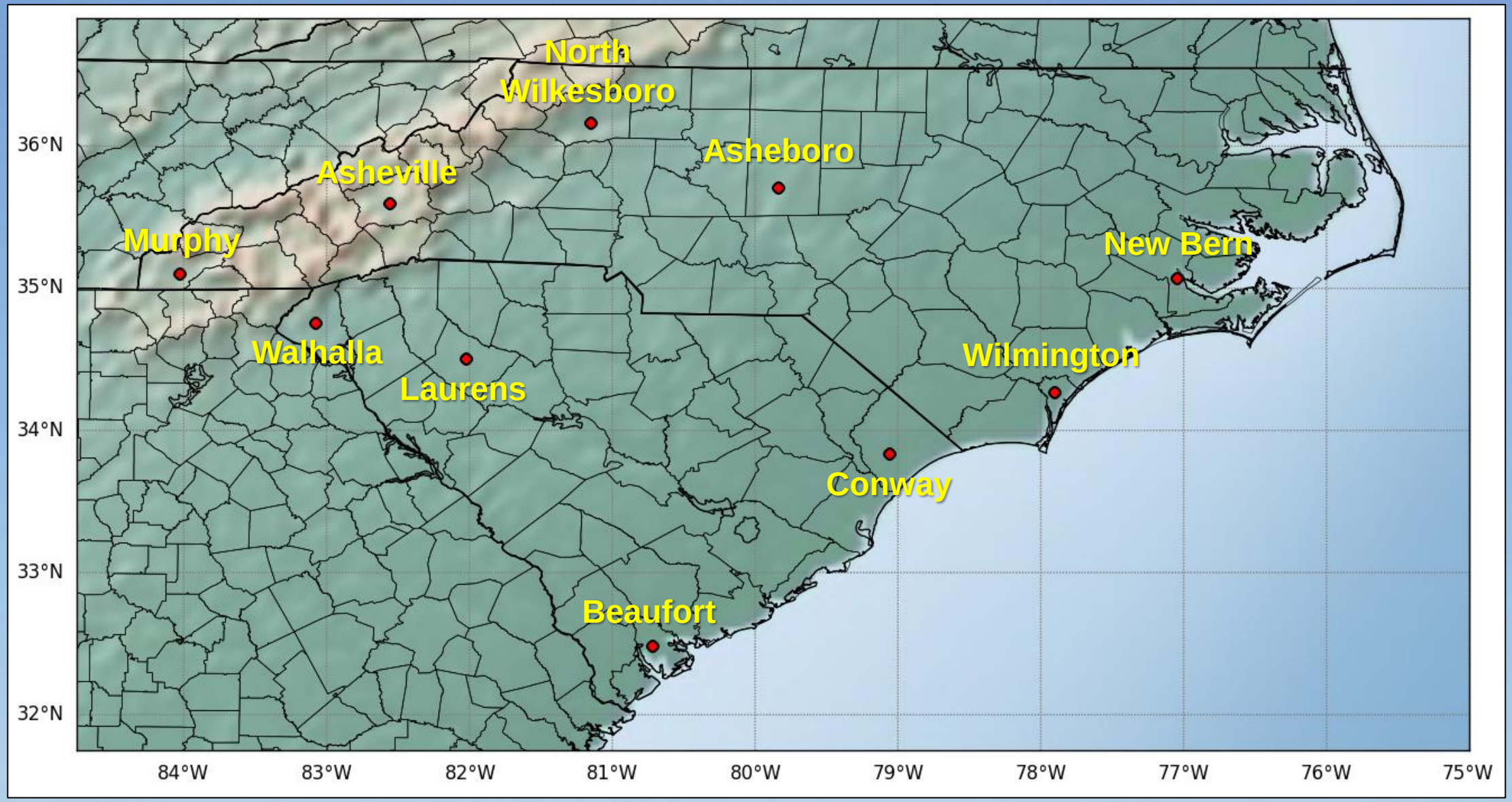


Average percentage of summer days with no precipitation over the Carolinas coastal plain during 2002–2013



Comparison of daily precipitation estimates from PRISM and station gauges across the Carolinas region from 1981–2013

Ten stations were selected for analysis based on the quality of their precipitation data record and their geographic location...



Comparison of the mean summer precipitation computed from station gauges versus daily PRISM

Mean Summer Precipitation (1981-2001)					
Station	*State*	*Station gauge*	*Daily PRISM*	*Raw difference*	*% difference*
Beaufort	SC	17.11	10.04	-7.07	-41.3
Wilmington Intl Arpt	NC	20.56	14.69	-5.87	-28.6
Conway	SC	19	14.06	-4.94	-26.0
New Bern Craven Cnty Arpt	NC	17.57	12.47	-5.1	-29.0
Asheboro	NC	12.02	9.6	-2.42	-20.1
Laurens	SC	11.18	8.85	-2.33	-20.8
North Wilkesboro	NC	13.43	12	-1.43	-10.6
Walhalla	SC	14.6	13.22	-1.38	-9.5
Asheville Downtown	NC	9.94	7.03	-2.91	-29.3
Murphy	NC	14.48	11.72	-2.76	-19.1

Mean Summer Precipitation (2002-2013)					
Station	*State*	*Station gauge*	*Daily PRISM*	*Raw difference*	*% difference*
Beaufort	SC	15.02	14.99	-0.03	-0.2
Wilmington Intl Arpt	NC	20.09	19.53	-0.56	-2.8
Conway	SC	19.47	20.17	0.7	3.6
New Bern Craven Cnty Arpt	NC	17.68	17.93	0.25	1.4
Asheboro	NC	13.09	12.3	-0.79	-6.0
Laurens	SC	13.58	12.73	-0.85	-6.3
North Wilkesboro	NC	13.6	13.46	-0.14	-1.0
Walhalla	SC	17.64	17.3	-0.34	-1.9
Asheville Downtown	NC	11.44	11.59	0.15	1.3
Murphy	NC	15.12	14.85	-0.27	-1.8

Difference values are displayed as PRISM minus station gauge estimates.

Results

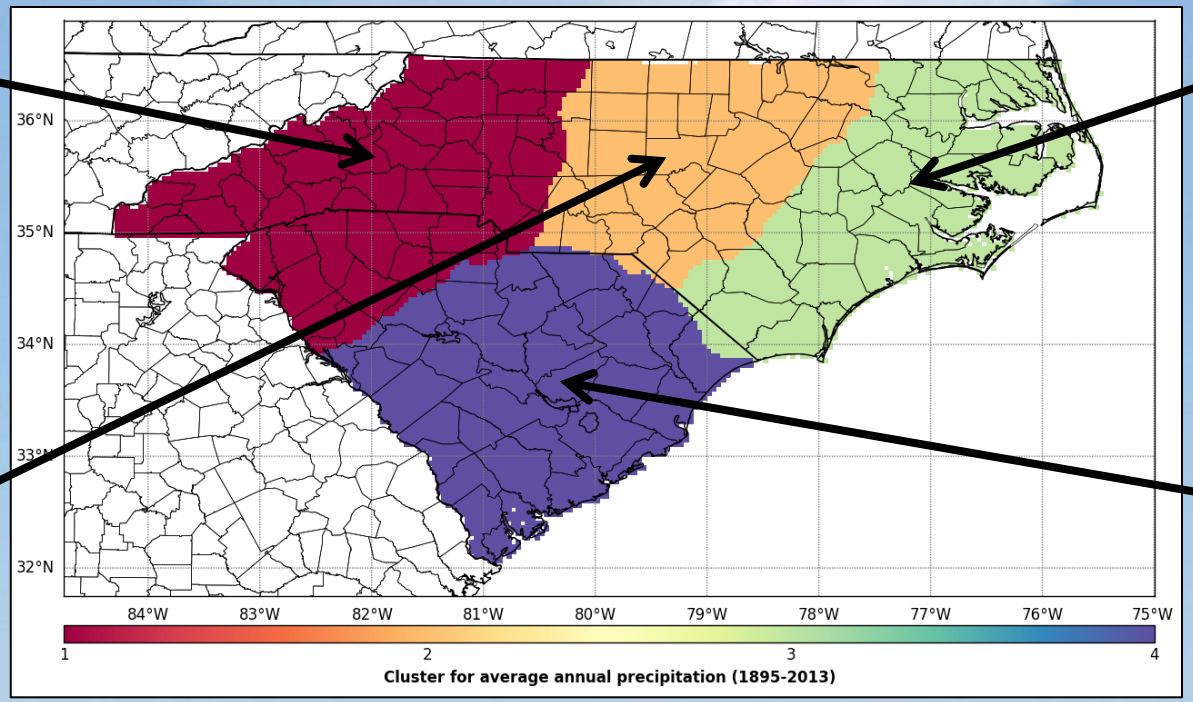
Spatial patterns of precipitation variability

Cluster analysis

- A clustering method that is most suitable for large gridded datasets, known as CLARA (Clustering Large Applications), was used to identify spatially coherent regions in which annual precipitation exhibits similar patterns.
- Average annual precipitation values for each 4 x 4 km pixel within the Carolinas domain were standardized relative to their baseline distribution from 1895–2013.
- For this type of clustering procedure, the user determines the most appropriate number of clusters. After testing for sensitivity, we chose 4 clusters (shown below) since this most closely matches the 4 principal geographic regions of the Carolinas.

(1) Carolina mountains

(2) NC piedmont



(3) NC coastal plain

(4) SC piedmont and coastal plain

Correlation matrices for average seasonal precipitation by cluster

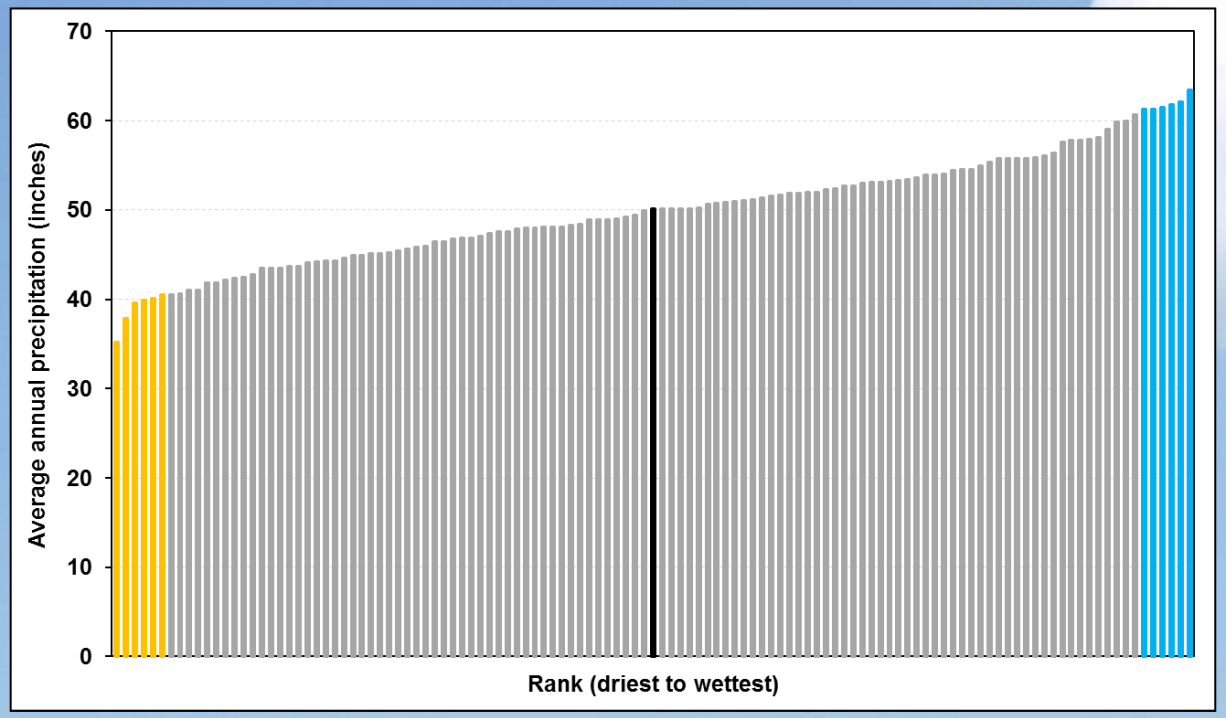
Winter (DJF)				
	Carolina mtns	*NC pdmnt*	*NC coast*	*SC pdmnt & coast*
Carolina mtns	1	0.84	0.67	0.64
NC pdmnt	0.84	1	0.91	0.81
NC coast	0.67	0.91	1	0.86
SC pdmnt & coast	0.64	0.81	0.86	1

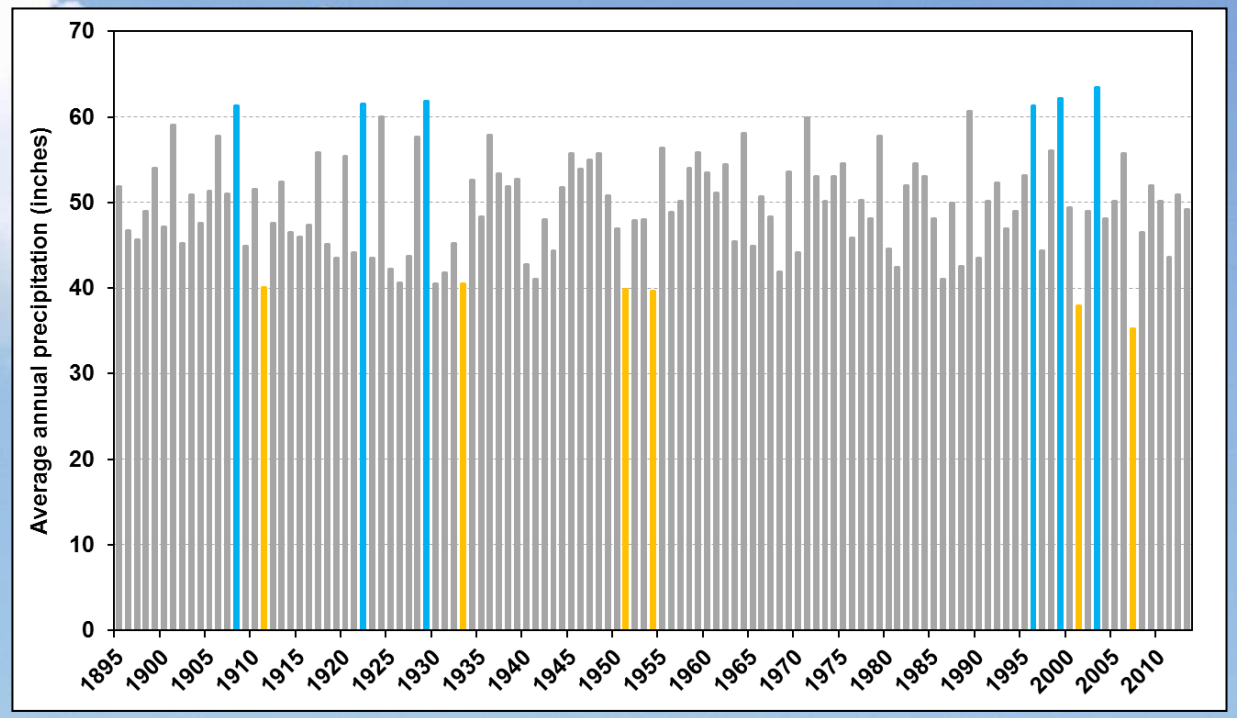
Spring (MAM)				
	Carolina mtns	*NC pdmnt*	*NC coast*	*SC pdmnt & coast*
Carolina mtns	1	0.80	0.63	0.77
NC pdmnt	0.80	1	0.88	0.75
NC coast	0.63	0.88	1	0.73
SC pdmnt & coast	0.77	0.75	0.73	1

Summer (JJA)				
	Carolina mtns	*NC pdmnt*	*NC coast*	*SC pdmnt & coast*
Carolina mtns	1	0.79	0.56	0.76
NC pdmnt	0.79	1	0.80	0.71
NC coast	0.56	0.80	1	0.62
SC pdmnt & coast	0.76	0.71	0.62	1

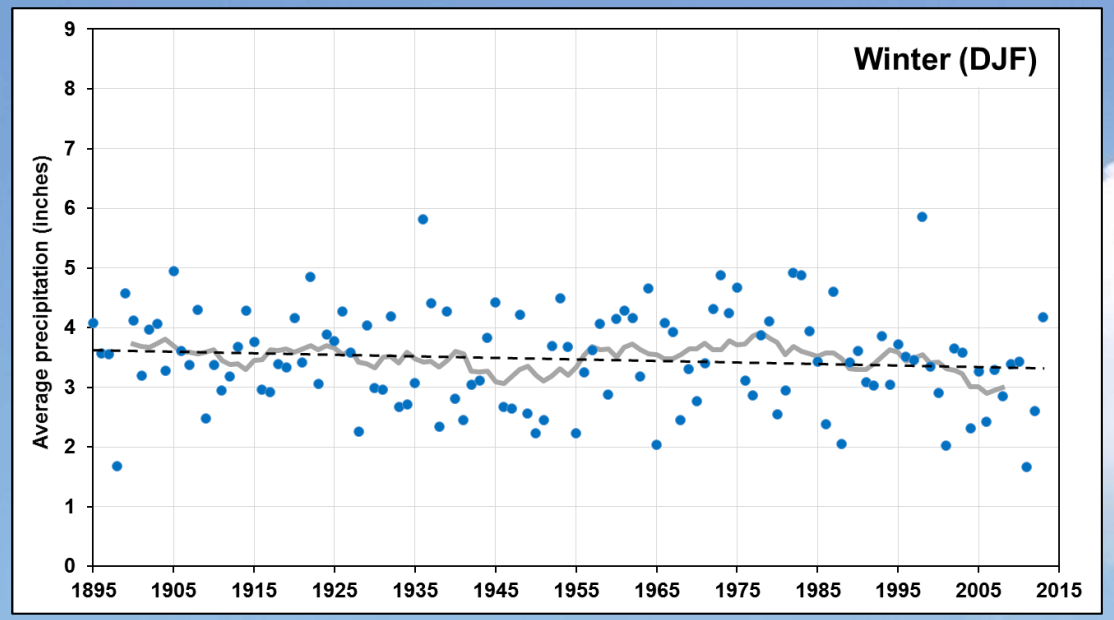
Autumn (SON)				
	Carolina mtns	*NC pdmnt*	*NC coast*	*SC pdmnt & coast*
Carolina mtns	1	0.76	0.53	0.75
NC pdmnt	0.76	1	0.86	0.79
NC coast	0.53	0.86	1	0.67
SC pdmnt & coast	0.75	0.79	0.67	1

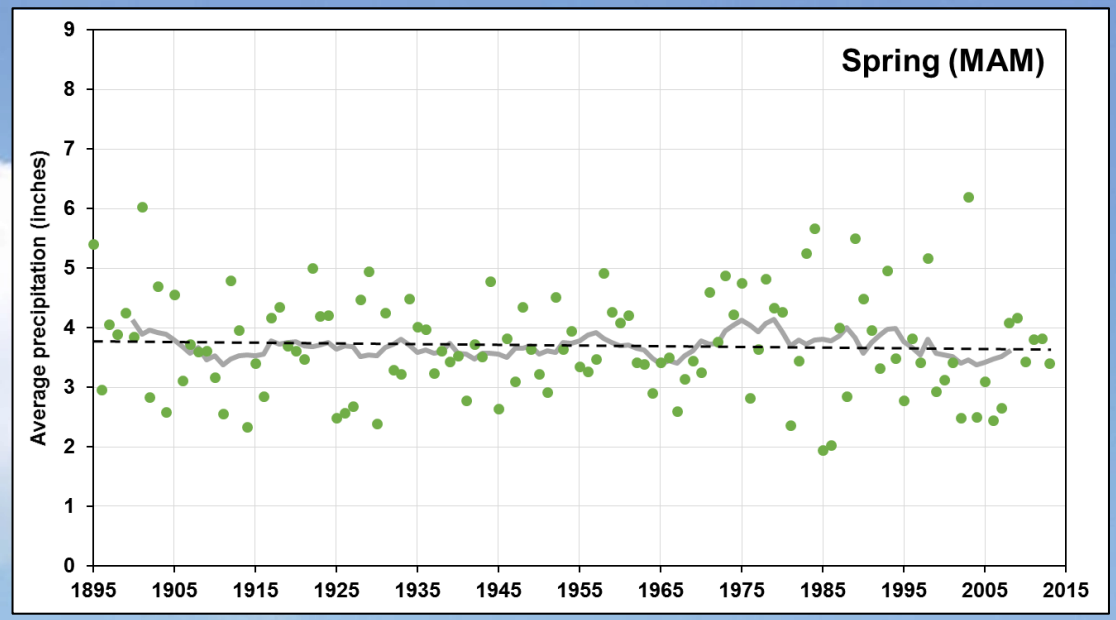
Distribution and time series of annual precipitation totals averaged across the NC coastal plain cluster (1895–2013)

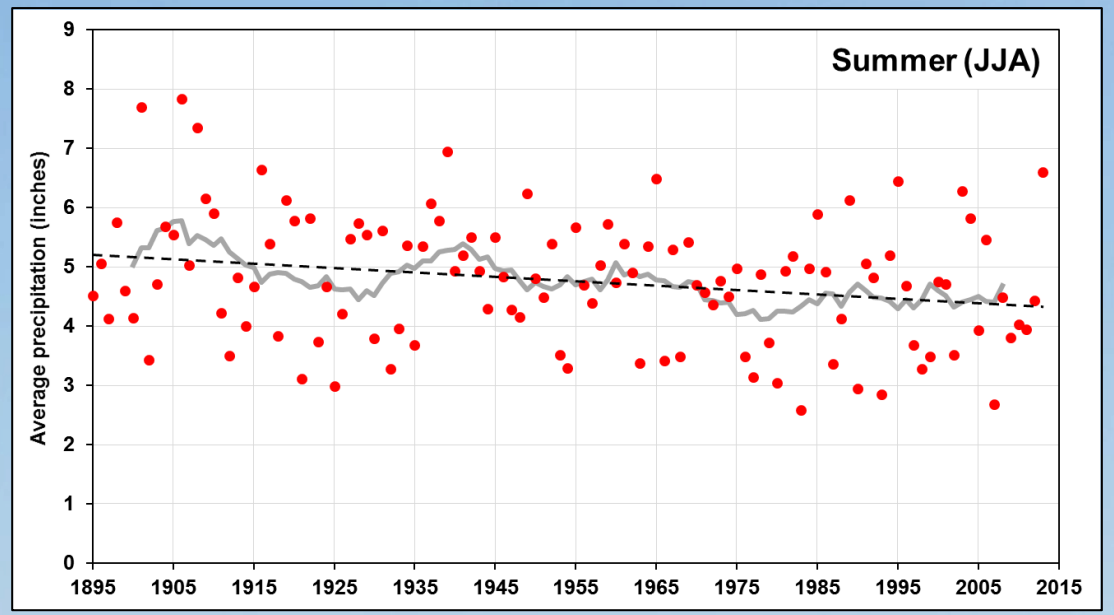


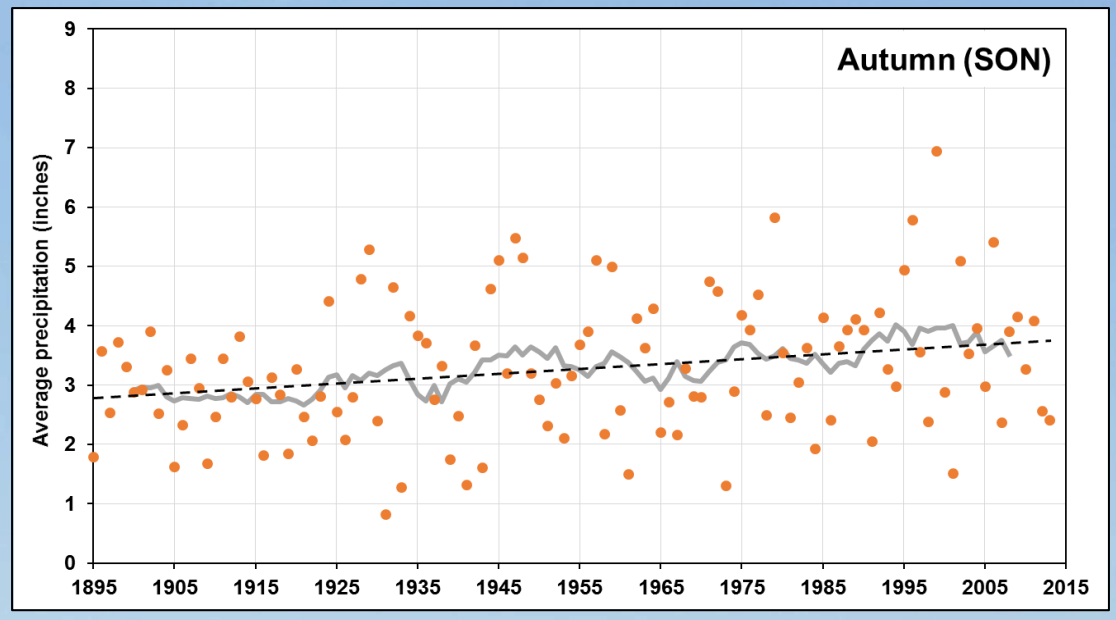


NC piedmont: Scatter plot with linear regression of average precipitation by season (1895–2013)



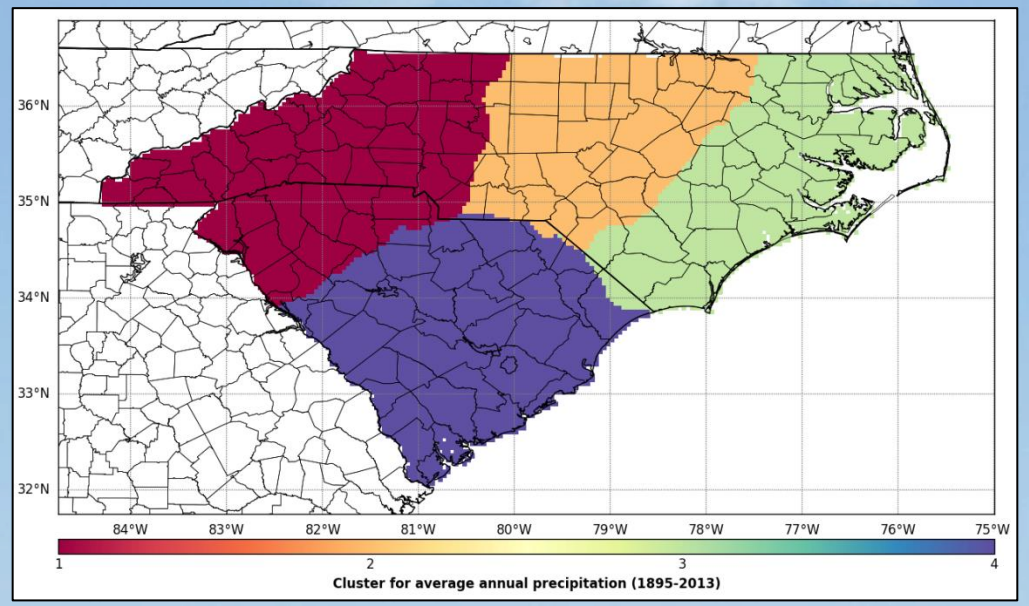






How does the percent change in average seasonal precipitation vary across the Carolinas from 1895–2013?

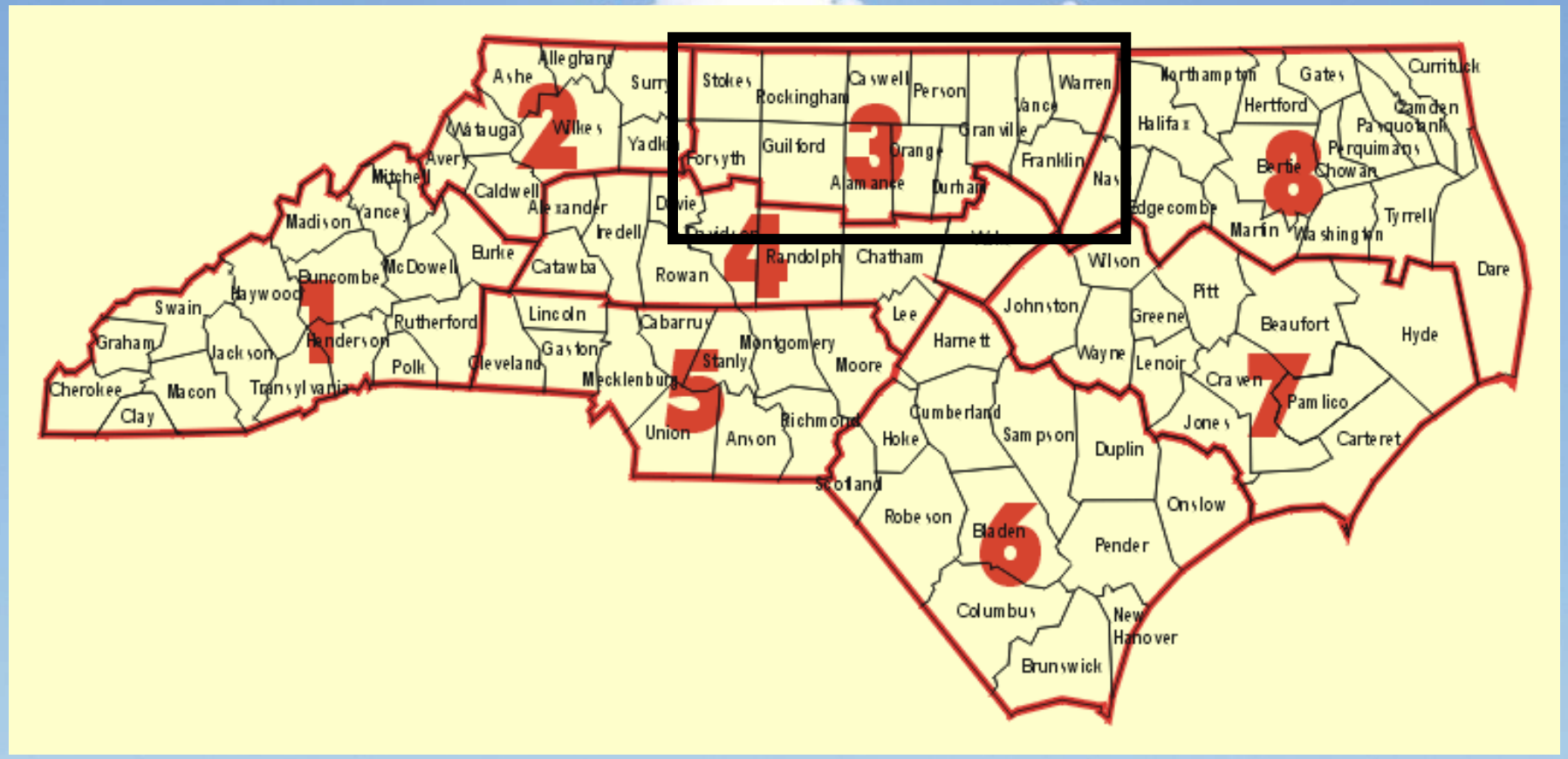
Percent Change in Average Precipitation by Season (1895–2013)				
Cluster	Winter	Spring	Summer	Autumn
Carolina mtns	-6%	1.4%	-18.9%	26.8%
NC pdmnt	-7.9%	-3.4%	-17.1%	34.2%
NC coast	-6.6%	-0.3%	-12.5%	37.8%
SC pdmnt & coast	-1.9%	2.3%	-9.8%	20.9%



Results

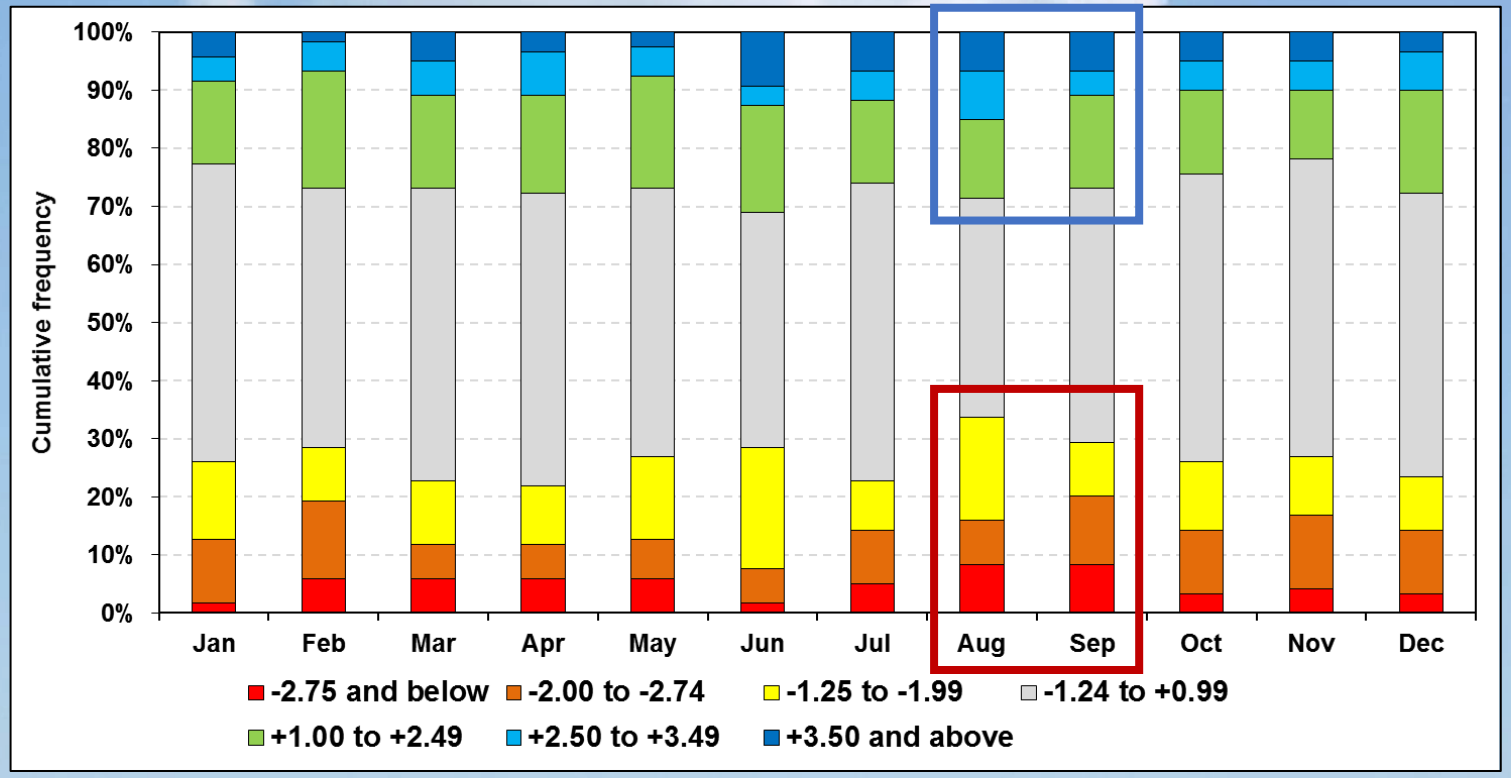
Seasonal evolution of exceptional drought across the Carolinas

Developing a seasonal climatology of the Palmer Z-Index and the Palmer Hydrological Drought Index for climate divisions across the Carolinas region (1895–2013)



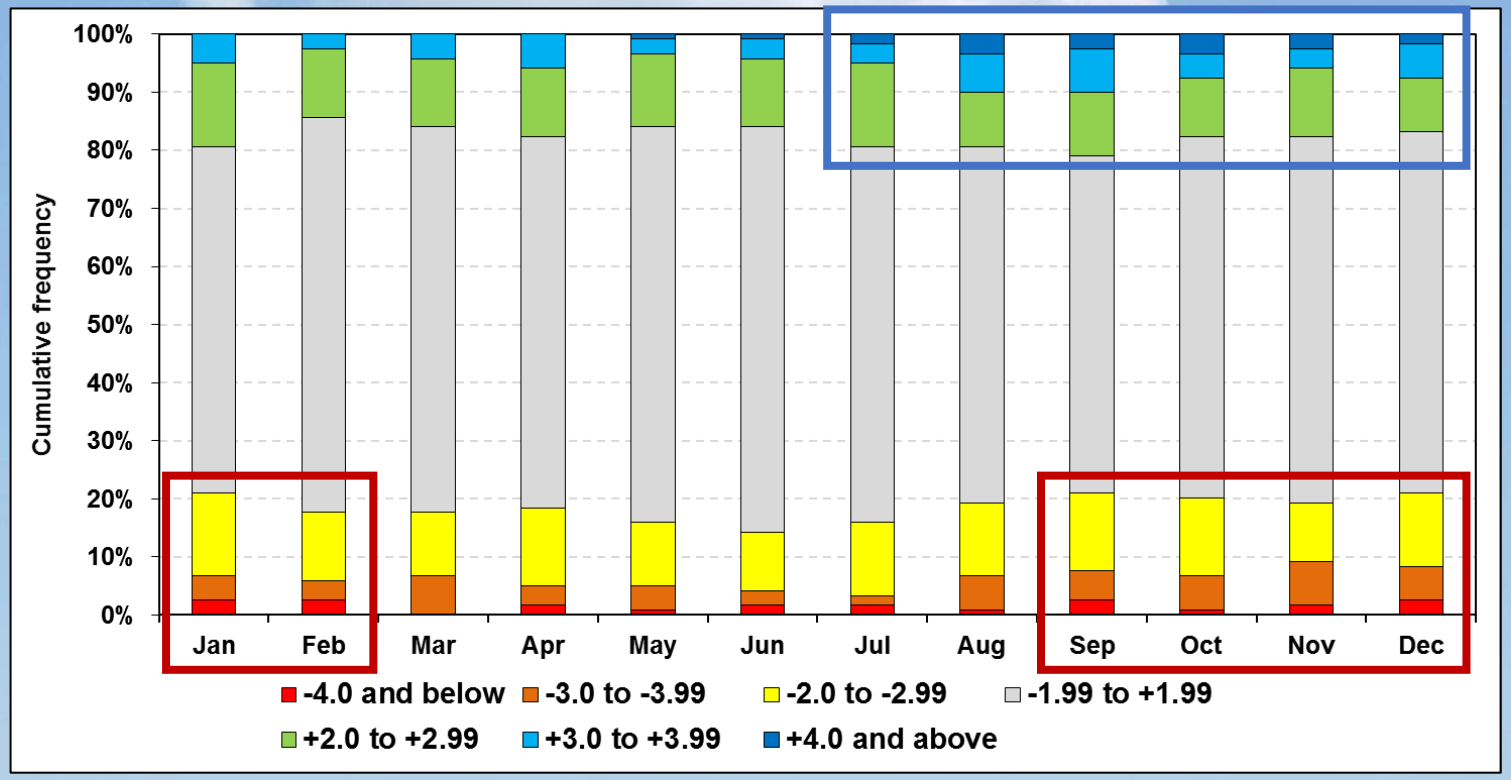
Frequency of short-term meteorological drought and wetness by month

Percentage of months within categories of the Palmer Z-Index during 1895–2013													
Index range	*Category*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
+3.50 and above	Extremely moist	4%	2%	5%	3%	3%	9%	7%	7%	7%	5%	5%	3%
+2.50 to +3.49	Very moist	4%	5%	6%	8%	5%	3%	5%	8%	4%	5%	5%	7%
+1.00 to +2.49	Moderately moist	14%	20%	16%	17%	19%	18%	14%	13%	16%	14%	12%	18%
-1.24 to +0.99	Neutral	51%	45%	50%	50%	46%	40%	51%	38%	44%	50%	51%	49%
-1.25 to -1.99	Moderate drought	13%	9%	11%	10%	14%	21%	8%	18%	9%	12%	10%	9%
-2.00 to -2.74	Severe drought	11%	13%	6%	6%	7%	6%	9%	8%	12%	11%	13%	11%
-2.75 and below	Extreme drought	2%	6%	6%	6%	6%	2%	5%	8%	8%	3%	4%	3%



Frequency of long-term hydrological drought and wetness by month

Percentage of months within categories of the Palmer Hydrological Drought Index during 1895–2013													
Index range	*Category*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
+4.0 and above	Extremely moist	0%	0%	0%	0%	1%	1%	2%	3%	3%	3%	3%	2%
+3.0 to +3.99	Very moist	5%	3%	4%	6%	3%	3%	3%	7%	8%	4%	3%	6%
+2.0 to +2.99	Moderately moist	14%	12%	12%	12%	13%	12%	14%	9%	11%	10%	12%	9%
-1.99 to +1.99	Neutral	60%	68%	66%	64%	68%	70%	65%	61%	58%	62%	63%	62%
-2.0 to -2.99	Moderate drought	14%	12%	11%	13%	11%	10%	13%	13%	13%	13%	10%	13%
-3.0 to -3.99	Severe drought	4%	3%	7%	3%	4%	3%	2%	6%	5%	6%	8%	6%
-4.0 and below	Extreme drought	3%	3%	0%	2%	1%	2%	2%	1%	3%	1%	2%	3%



Summary

- Based on station gauge verification, daily PRISM estimates are not reliable across the Carolinas region prior to 2002.
- PRISM data, especially during the MPE period, confirm that summer precipitation is somewhat less along the immediate Carolinas coastline due to the inland propagation of the sea breeze front.
- Based on the cluster analysis, average precipitation totals among the four sub-regions are more highly correlated (i.e. less spatial variability) during winter than any other season. Precipitation among the four sub-regions is least correlated (i.e. greater spatial variability) during summer and autumn.
- For the Carolinas region as a whole and each of the four sub-regions individually, average precipitation has decreased significantly during the summer and increased substantially during the autumn from 1895–2013. Winter precipitation has decreased slightly and spring precipitation has remained stable during this period of record.
- We are currently examining the seasonal evolution of the most exceptional droughts across the Carolinas. Are the patterns shown for the NC piedmont similar to those in other climate divisions?

Thanks!

Any questions?

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