Changes to the North Atlantic Subtropical High and Its Impact on Summer Droughts/Floods in the Southeastern US

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1. Introduction

In recent decades, the Southeast United States (SE US) has experienced multiple severe droughts and floods. Given rapid increase of the population in the US, the need for understanding of the mechanism of the droughts/floods and an explanation of its predictability is becoming increasingly urgent for water resource management.

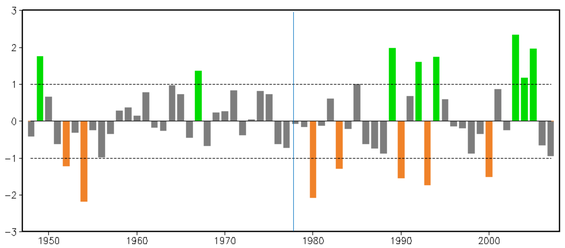

Figure 1. Normalized JJA Precipitation Anomaly

	1st 30 years 1948–1977	2nd 30 years 1978–2007
Wet and Dry (> 1 Stdv)	4	11
Contribution to Precipitation Variance	32%	68%

x^2 test: change is significant

What are the major factors influencing summer rainfall over the SE US?

- ***Sea Surface Temperatures (SSTs) and associated atmospheric circulation anomalies*** (Wang and Enfield, 2001; Seager et al., 2003; Schubert et al., 2009; Kushnir et al., 2010; Wang et al 2010),
- ***Hurricane activities*** (Elsner and Tsonis, 1993; Chan and Misra 2010),
- ***Soil moisture*** (Koster et al. 2004, Wu et al., 2007).
- ***The North Atlantic subtropical high (Bermuda high)*** (Henderson and Vega 1996; Katz et al., 2003). **One of the most important contributors suggested by our partial correlation analysis.**

Scientific Questions:
What is the impact of the NASH on recent summer droughts /floods over the SE US?

2. Data and Method

Atmospheric geopotential height (850hPa), wind and humidity fields from NCEP and ERA-40 reanalysis

Precipitation data *NOAA Climate Prediction Center (CPC) U.S. Unified Precipitation for 1948–98 and the realtime U.S. Daily Precipitation Analysis for 1999–2007*

Climate models: ***CMIP3*** ***(PICNTRL, 20C3M, A1B)***

Attribution analysis: *Following Santer et al (2007) and Li et al (2008), a large ensemble of multiple climate models simulation can provide the statistic distribution of trends.*

3. What happened for the NASH during the last 60-year?

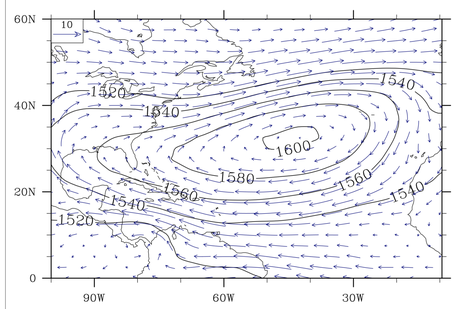

Figure 2. Climatological mean of the NASH at 850hPa

NASH intensified during the last 60-year (1948-2007) at a rate 0.9 gpm/decade (90% confidence level)

Ridge moved westward at the averaged speed: 1.22degree/decade

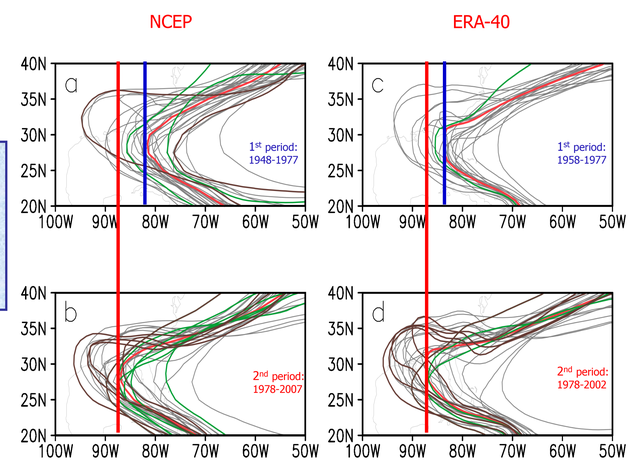

Figure 3. Interannual variations of 1560-gpm contour line at 850hPa during JJA in both NCEP and ERA-40 reanalysis data for the two periods considered. a). NCEP 1st period 1948-1977; b) NCEP 2nd period 1978-2007; c) ERA-40 1st period 1958-1977; and d) ERA-40 2nd period 1978-2002. Red thick curves represent the mean location of the NASH in JJA for the two periods; Green and brown lines represent the NASH in wet and dry years respectively.

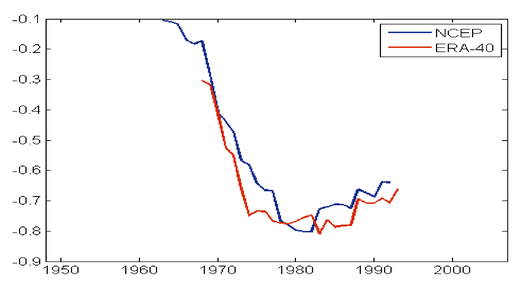

Figure 4. 30-yr (20-yr) moving correlation between the Normalized Precipitation Index (NPI) and the latitude of the NASH west ridge endpoint in the NCEP (ERA-40) data

1) Increased impacts of the Bermuda High on the summer rainfall in the SE US from the 1st to the 2nd period
2) The variance of N-S movement of the western ridge in the 2nd period increased by 47% (25%) relative to the 1st period using NCEP (ERA-40) reanalysis;

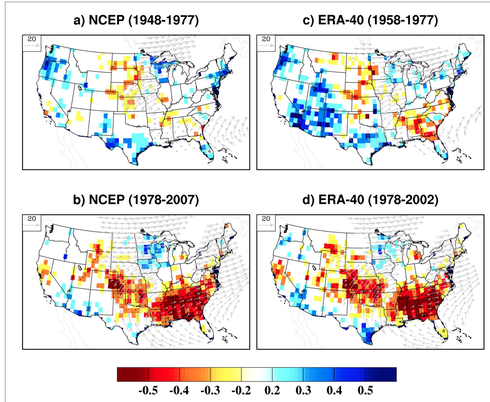

Figure 5. Linear regression of precipitation (shaded, mm/day) and moisture flux (vectors, Kg/m/s, only grid points passing 95% confidence level are plotted) against the latitude of the NASH western ridge.

- ***Increased impacts of the NASH on precipitation***
- ***When the western ridge moves to the north, rainfall tends to decrease in the SE US***
- ***When the NASH shifts southward, rainfall tends to increase***

4. Are the changes of the Bermuda High due to natural variation or anthropogenic forcing?

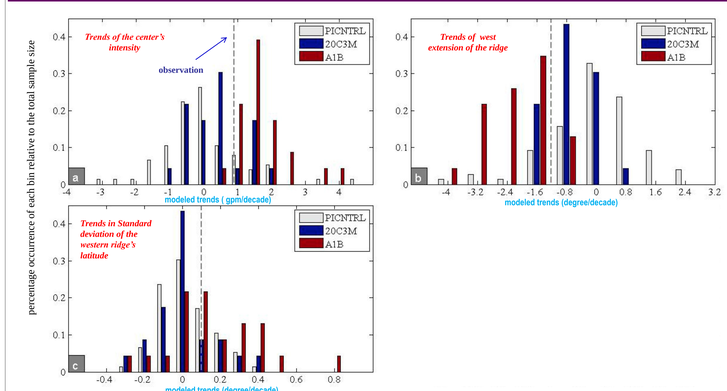

Figure 6. Distributions of a) the trend of the NASH center's intensity (unit: gpm/decade), b) the trend of westward extension of the NASH western ridge (unit: degree/decade), c) the trend of the standard deviation of the western ridge's latitude (unit: degree/decade) in the 21st century simulation (A1B, black) compared to those of the 20th century (20C3M, grey) and Pre-industry simulations (PICNTRL, white).

Observed trend is more likely explained by the 20th century run for example, models with anthropogenic forcing about 58% of models show an increase of the NASH center's intensity compared to the distribution (20%) in the PICNTRL simulations

5. Conclusions

- ***The enhanced variability of the SE US summer precipitation observed in recent decades is closely related to the changes of the NASH.***
- ***Bermuda High intensified, and extended westward. Its impact on the SE US rainfall increases through the enhanced meridional movement of its western ridge.***
- ***Such changes are more likely due to the increase of GHGs***

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