North Atlantic Subtropical High effects on Summertime Precipitation Organization in the Southeast US

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INTRODUCTION

The North Atlantic Subtropical High (NASH) has significant impacts on both sides of the Atlantic on timescales ranging from diurnal to multi-decadal. In particular, the western side of the NASH, known as the *NASH western ridge (NASH WR),* controls seasonal moisture transport, vertical motion and precipitation in the southeastern United States (SE US) and Caribbean. The NASH affects SE US precipitation via the location of the NASH WR and its control on low-level flow, sea level pressure and vertical motion.

Rickenbach *et al. (*2015, R15) used a high-resolution radar-based precipitation dataset available from 2009-2012, to study the organization of precipitation over the SE US. Their framework revealed significant differences between the diurnal and seasonal variability of IPF and MPF: 1) the more thermally forced IPF have a strong diurnal and seasonal cycle, whereas the more dynamically forced MPF do not; 2) the springtime transition to the summer IPF season in the SE US shares some similarities with monsoonal climates (Rickenbach *et al.* 2019); and 3) about 60% of all extreme summertime precipitation pixels were associated with MPF (Rickenbach (2018).

OBJECTIVES

The objective of this study is to **understand how the daily variability of the position of the NASH WR influences the organization of daily summertime precipitation in the SE US. This may provide insight on the role of the NASH on the onset of the IPF rainy season in the SE US.**

METHODOLOGY

This study uses the June-August 2009-2012 daily R15 radar-based precipitation organization dataset, TRMM satellite derived precipitation, and the NARR reanalysis.

R15 classified precipitation features based on their size (Fig. 1) as either isolated precipitation features (IPF) that are smaller than 100 km or as larger, mesoscale precipitation features (MPF).

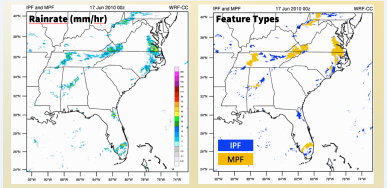

Figure 1: 17 June 2010 00Z R15 radar based precipitation total (left panel) and the split into IPF and MPF precipitation categories (right panel).

The daily position of the NASH WR is defined as the westernmost point of the 1,560 m geopotential height contour at 850 hPa. An example is shown in Fig. 2.

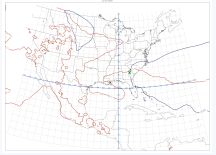

Figure 2: June 3 2009 (NASH-NE) location of the NASH western ridge (green 'x') defined using the westernmost point on the 850 hPa 1,560 m geopotential contour (black). Blue lines separate the quadrants.

The average 2009-2012 summertime position of the NASH WR was determined and the domain was divided into four quadrants based on this location. Each day was labeled according to the quadrant where the NASH WR was located. Composite maps of total, IPF and MPF precipitation, SLP, and synoptic scale circulation fields were created to analyze the typical precipitation and synoptic-scale conditions associated with each NASH western ridge category

RESULTS

1. Variability of the position of the NASH

The average position of the NASH WR in JJA 2009-2012 was 86°W, 28°N, similar to previous studies (Fig. 2). The NASH WR was most often (75% of the days) located in the NASH-NW and NASH-SE (Table1) and tended to stay in these quadrants for a few days at a time. Over the seasonal cycle, the NASH WR shifted westward in early summer and back eastward in late summer.

	NW	SW	NE	SE	Total
June	27	10	7	63	107
July	76	22	7	17	122
August	36	23	20	39	118
Total	139	55	34	119	347

Table 1: Frequency of NASH WR position during JJA 2009-2012.

2. NASH WR and Synoptic Scale Circulation

The NASH WR modulates the strength and position of Low Level Jets (LLJs) and moisture fluxes, to influence regional precipitation patterns:

a. Great Plains LLJ (GPLLJ, Fig. 3) and moisture fluxes (Fig. 4) were about 40% stronger in the western than in the eastern composites.
b. *NASH-NW:* GPLLJ funnels moisture around the SE US and toward the Great Lakes (Figure 4a), leaving the SE US generally drier (Figure 3a). Since NASH-NW periods often lasted 5 days and longer, this means that portions of the SE US can experience prolonged dry spells during NASH-NW events.
c. *NASH-SW*: GPLLJ funnels moisture into the SE US thereby fueling precipitation (Figure 3c).
c. *NASH-NE*: strongest precipitation occurs offshore along a LLJ on the western side of the NASH (Figure 3b).
d. *NASH-SE:* strongest precipitation stretches northeastward from the eastern Gulf of Mexico, through Florida and into the North Atlantic, along the western side of the NASH (Figure 3d).

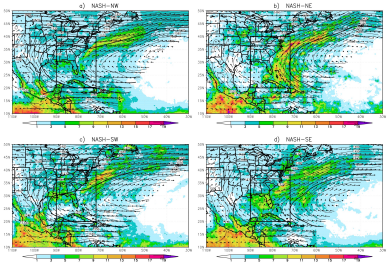

Figure 3: Composites of TRMM precipitation, and 850 mb NARR winds and geopotential for each NASH WR quadrant.

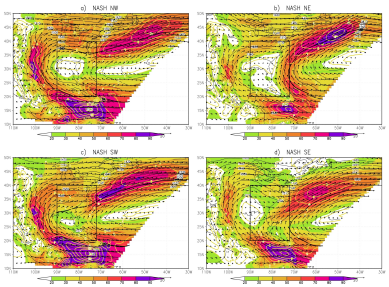

Figure 4: Composites of 850 hPa moisture flux along with the geopotential height for each NASH western ridge quadrant.

3. NASH WR and Precipitation Organization

Tropospheric circulation differences between NASH WR composites affected precipitation organization in the SE US. Table 2 shows that:

a. *NASH-NW:* driest composite mainly due to a deficit in MPF.
b. *NASH-SE:* lowest values of IPF precipitation.
c. *NASH-SW:* rainiest composite due in large part to MPF, but also IPF. Largest IPF precipitation amount of all composites.

	NASH-NW	NASH-NE	NASH-SW	NASH-SE	All-Days
IPF	1.23 (+0.01)	1.24 (+0.02)	1.31 (+0.09)	1.16 (-0.06)	1.22
MPF	2.00 (-0.26)	2.46(+0.18)	2.46 (+0.19)	2.47 (+0.20)	2.27
Total	3.23 (-0.27)	3.70 (+0.20)	3.77 (+0.28)	3.63 (0.14)	3.49

Table 2: Domain averaged precipitation for each NASH WR composite during JJA 2009-2012.

d. Distinct regionality associated with the synoptic circulation patterns occurred (Fig. 5).
e. MPF precipitation was enhanced in regions where dynamical features like LLJs were present, particularly in MPF for NASH–NW, and NASH-SE, and NASH-SW (Fig. 5).

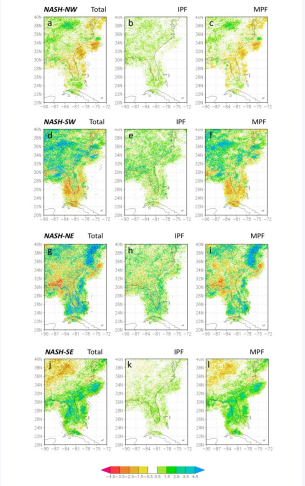

Figure 5: Composites of Total, IPF and MPF precipitation for each NASH WR composite.

CONCLUSIONS

This study extends our current understanding of the influence of the summertime NASH western ridge on SE US precipitation to include its influence on daily precipitation variability and organization.

a. Differences in domain averaged precipitation between composites were relatively modest, but a distinct regionality associated with the synoptic circulation patterns was present.
b. For each composite MPF precipitation was enhanced in regions where dynamical features like LLJs were present.
c. A dipole pattern with wetter inland/dryer coastal (NASH-NW) and dryer inland/wetter coastal (NASH-SE) conditions is an important feature of the SE US summertime climate.

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