# High-Resolution Regional Reanalysis for the Southeast United States: Seasonal, Sub-Seasonal and Diurnal Variability of Precipitation

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## Introduction

We present an analysis of the seasonal, sub-seasonal and diurnal variability of rainfall from the COAPS Land-Atmosphere Regional Reanalysis for the Southeast at 10 km resolution (CLARReS10).

We have used the NCEP-Scripps Regional Spectral Model (RSM) (Juang and Kanamitsu, 1994) to downscale both the NCEP DOE Reanalysis II (R2) and the ECMWF ERA-40 for the period 1979-2001. Dynamical downscaling of coarser reanalysis has been used successfully in a similar integration over California (Kanamitsu and Kanamaru 2007). This approach provides a computationally efficient regional reanalysis without the need for regional data assimilation of observations (von Storch, 2000). It has been shown by Lim et al (2010) that a downscaling of R2 with RSM at 20 km over the Southeast resulted in a reduced wet bias and a more realistic spatial pattern of summer precipitation, with improved spatial and temporal correlation of rainfall, and reduced mean square error.

## Domain and Model Configuration

### 1. Domain

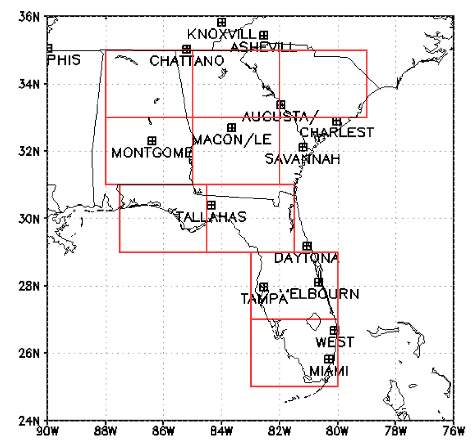


Fig. 1: Model domain

The CLARReS10 regional model domain is shown in Fig. 1. The regional model, NCEP/Scripps RSM uses the winds, temperature, humidity and surface pressure of the global reanalyses (either R2 or ERA40, at 6-hourly intervals, as lateral boundary conditions.

### 2. Model Configuration

| | Feature | Reference |
|---|---|---|
| 1 | Dynamics: hydrostatic primitive equations transformed into Fourier basis functions | Juang and Kanamitsu (1994) |
| 2 | 10-km horizontal resolution; 28 vertical layers; 4-min resolution orography | Kanamitsu and Kanamaru (2007) |
| 3 | Planetary boundary layer process | Hong and Pan (1996) |
| 4 | Shortwave and longwave radiation | Chou and Lee (1996); Chou and Suarez (1994) |
| 3 | Shallow convection | Tiedtke (1983) |
| 4 | Deep convection: Simplified Arakawa Schubert Scheme | Pan and Wu (1995) |
| 5 | Boundary forcing: scale selective bias correction | Kanamitsu and Kanamaru (2007) |
| 6 | Land surface: Noah; four soil layers | Ek et al. (2003) |

Table 1: Regional model configuration and features

## Validation Data

1. Hourly: precipitation from surface weather observation stations (ASOS/AWOS) from NCDC.
2. Daily precipitation:
   a) CPCDaily US Unified Precipitation, resolution 0.25° (1979-1998);
   b) Community Collaborative Rain Hail and Snow (CoCoRaHS) Network (2008-2010).
3. Monthly:
   a) PRISM Climate Group, resolution 4km , Oregon State University, http://www.prismclimate.org, created 10 Jun 2002;
   b) NCDC station climatology (1971-2000).

## Results: Seasonal Cycle

### 1. Regional averages

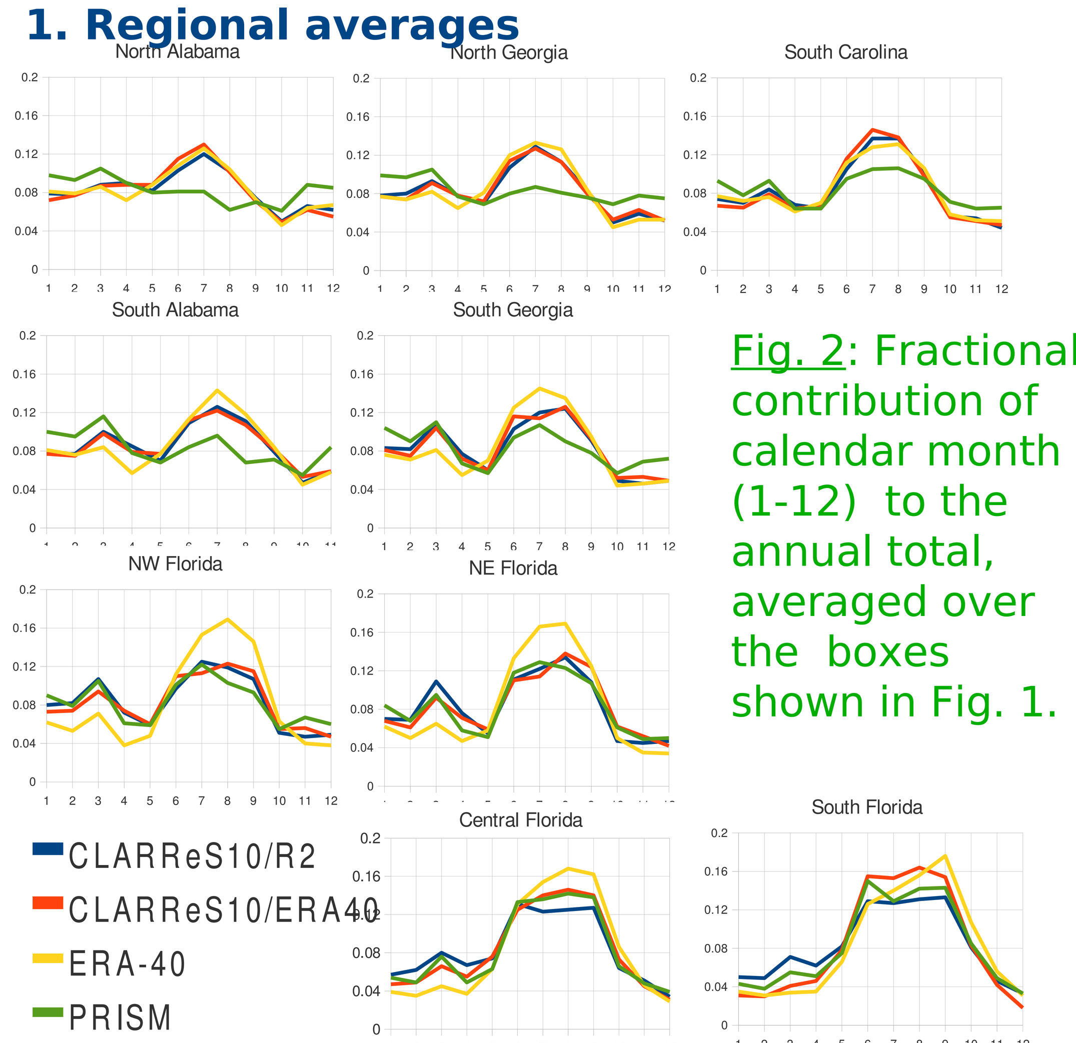


Fig. 2: Fractional contribution of calendar month (1-12) to the annual total, averaged over the boxes shown in Fig. 1.

▶ The global reanalysis overestimates the contribution of summer precipitation and underestimates the contribution of spring precipitation to the annual mean in all regions of the domain except for South Florida.

▶ Both regional reanalyses ameliorate this bias in Florida and South Georgia but not in northern portion of the domain.

### 2. Representative Florida stations

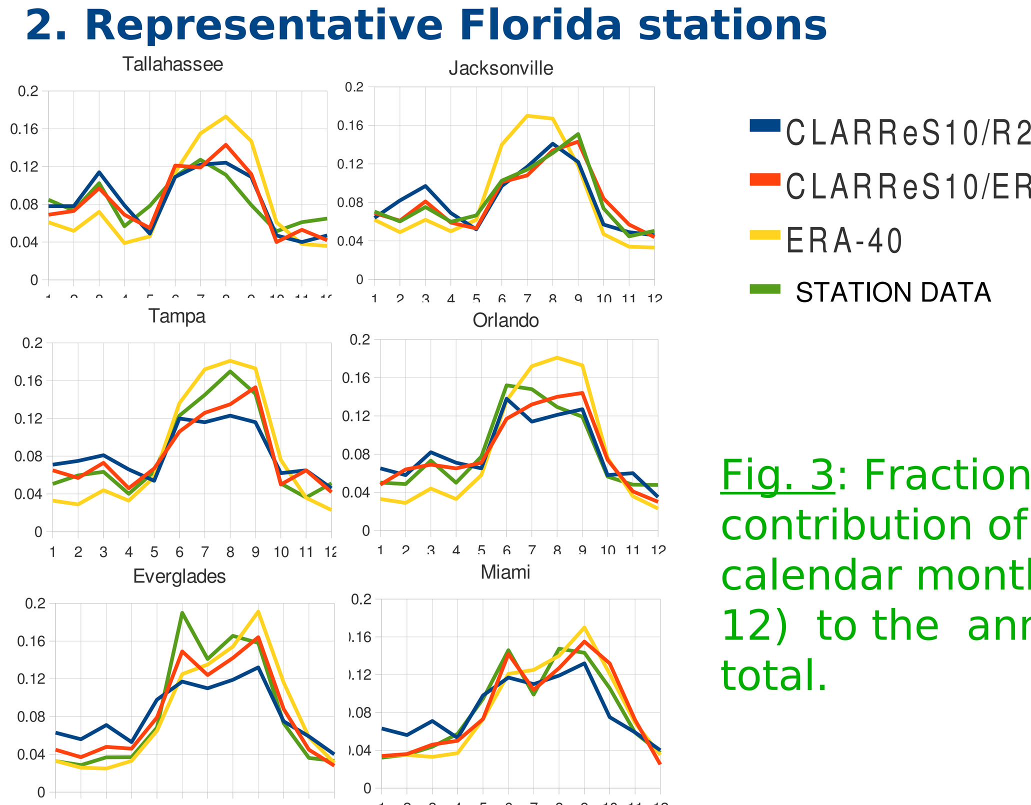


Fig. 3: Fractional contribution of calendar month (1-12) to the annual total.

▶ Regional reanalyses have better climatology of the seasonal cycle of precipitation; some indication that CLARReS10/ERA40 outperforms CLARReS10/R2.

## Results: JJA mean and variance

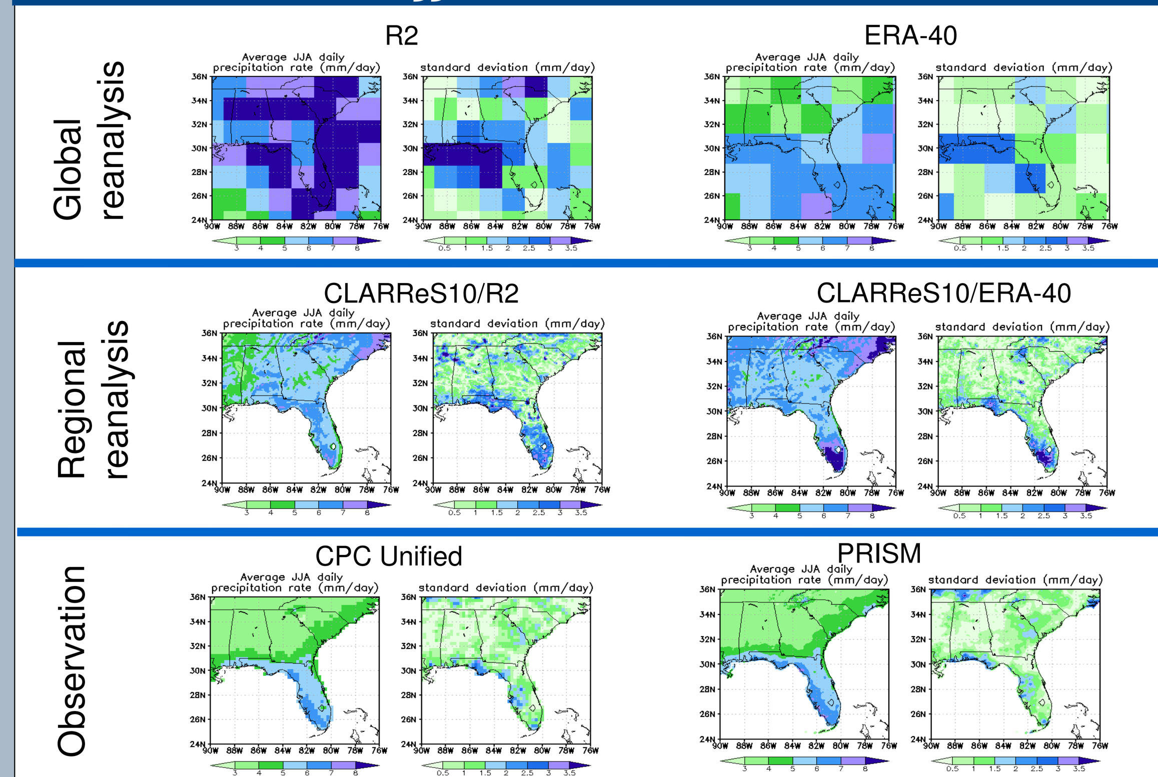


Fig. 4: Reanalysis and Obs. average summer rainfall (mm/day)

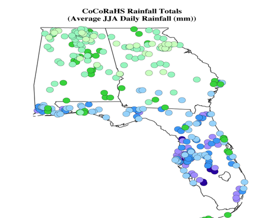

Fig. 5: CoCoRaH network observed average JJA rainfall (mm/day) for 2008-2010. Note the relatively smaller values at the coast.

▶ CLARReS10 reduces the wet bias of R2, but introduces a wet bias to ERA40. The interannual variance range, however, is simulated well.

▶ CLARReS10 accurately reproduces the relatively smaller rainfall values at the coastline.

## Results: JJA Precipitation Frequency

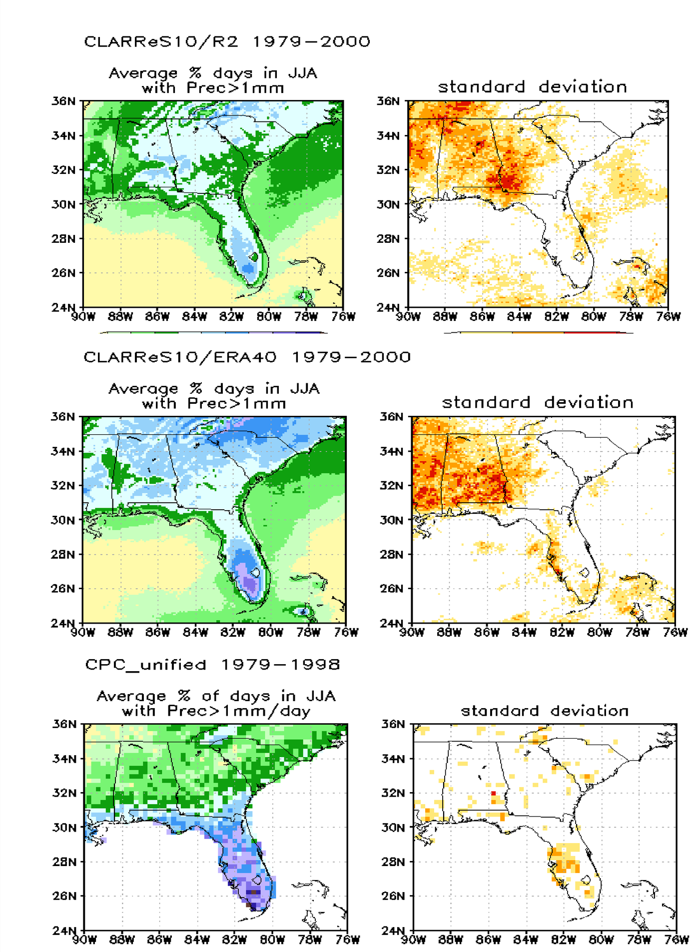


Fig. 6:

a) Average percentage of days in JJA with precipitation rate exceeding 1mm/day (right) for CLARReS10/R2, CLARReS10/ERA40 and observations (CPC Unified)
b) Standard deviation (left)

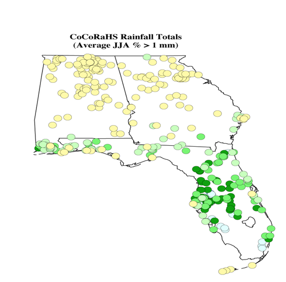

Fig. 7: CoCoRaH network average percentage of days in JJA with precipitation rate exceeding 1mm/day for 2008-2010. Note the relatively smaller values at the coast.

▶ Outside of Florida, both versions of CLARReS10 overestimate both the average summertime frequency of rainy days, and the variance of that frequency. In Florida, the frequency tends to be underestimated, particularly in CLARReS10/R2.

▶ CLARReS10 accurately reproduces the relatively smaller rainfall frequency at the coastline.

## Results: Diurnal Cycle

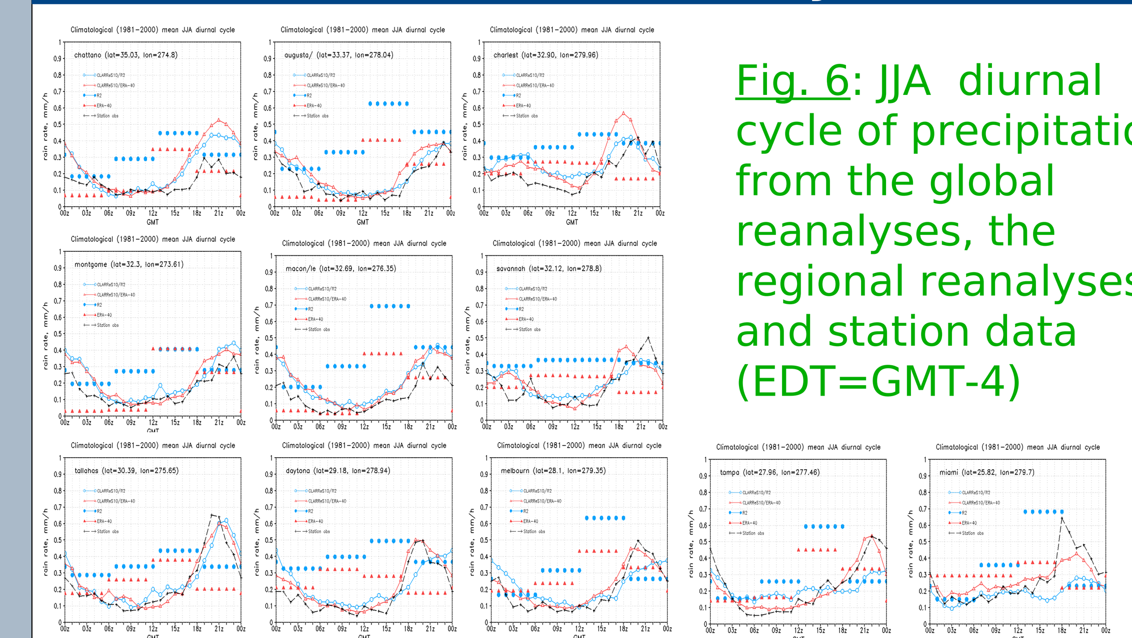

Fig. 6: JJA diurnal cycle of precipitation from the global reanalyses, the regional reanalyses, and station data (EDT=GMT-4)

| Station | CLARReS10/R2 | CLARReS10/ERA40 |
|---|---|---|
| Augusta | **0.96** | **0.91** |
| Charleston | 0.67 | 0.66 |
| Daytona | 0.80 | **0.97** |
| Macon | **0.93** | **0.92** |
| Melbourne | 0.82 | **0.95** |
| Miami | 0.73 | 0.88 |
| Montgomery | **0.93** | **0.92** |
| Tampa | **0.95** | **0.90** |
| West Palm Beach | 0.54 | 0.83 |
| Tallahassee | **0.91** | **0.95** |
| Savannah | 0.83 | 0.76 |

Table 2: Correlation of diurnal cycle between regional reanalyses and station data

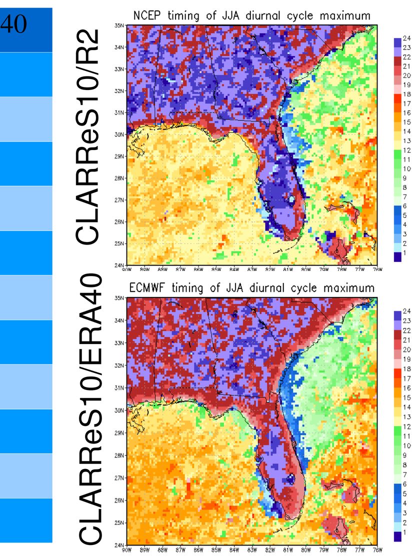


Fig. 7: Average timing of JJA diurnal maximum (GMT)

▶ The diurnal cycle in CLARReS10 is in very good agreement with station observations, particularly in Florida, and an improvement over both R2 and ERA 40.

▶ There are subtle differences between the two downscalings in the timing of the diurnal maximum.

## Summary

▶ The downscaled reanalyses show good agreement with observations in terms of relative seasonal distribution and diurnal structure of precipitation.

▶ The distribution of precipitation is simulated well over Florida, but has a wet bias over Georgia, Alabama and South Carolina.

▶ There are important differences between the two simulations (CLARReS10/ERA40 tends to be wetter than CLARReS10/R2, and to have the diurnal precipitation maximum earlier in the day).

▶ A comparison of the CLARReS10 downscaling with MERRA and CFSR is currently underway.

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• PRISM monthly precipitation was provided by the PRISM Climate Group at Oregon State University from their website at http:www.prism.oregonstate.edu ;
ECMWF-ERA40 Reanalysis data were provided by the ECMWF, from their data server at http://data.ecmwf.int/data/ ;
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