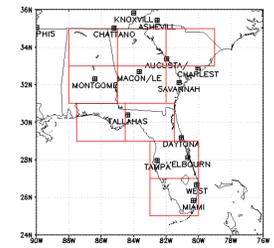


Introduction

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



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

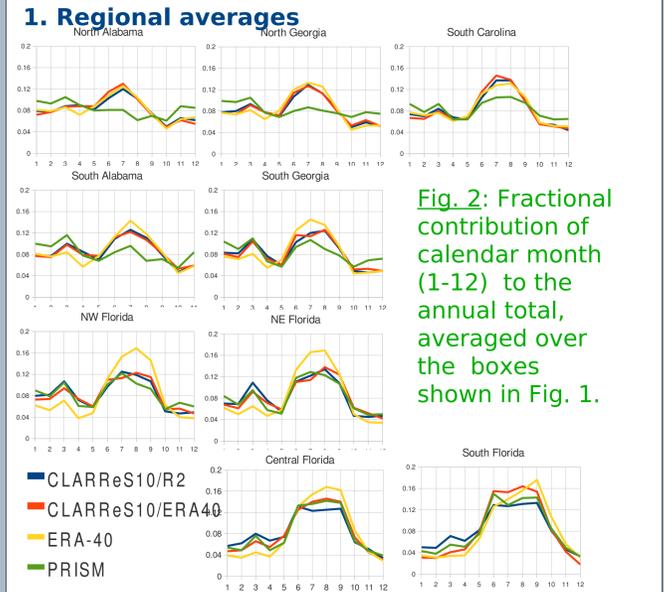
Feature	Reference
1 Dynamics: hydrostatic primitive equations transformed into Fourier basis functions	Juang and Kanamitsu (1994)
2 10-km horizontal resolution; 28 vertical layers; 4-min resolution orography	Kanamitsu and Kanamaru (2007)
3 Planetary boundary layer process	Hong and Pan (1996)
4 Shortwave 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

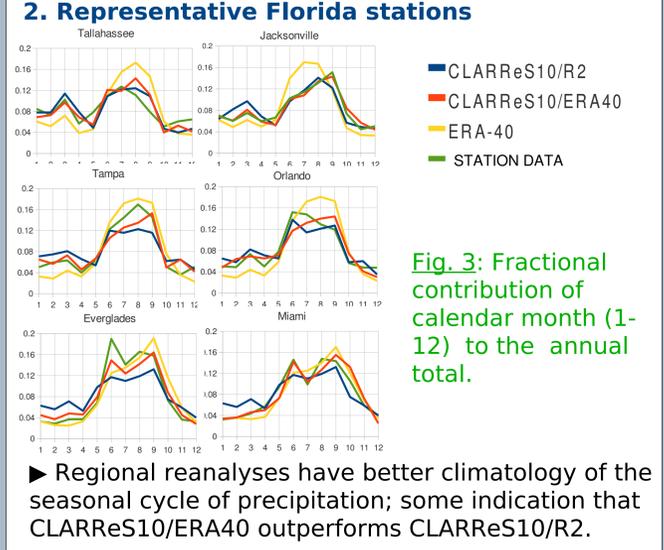
Validation Data

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

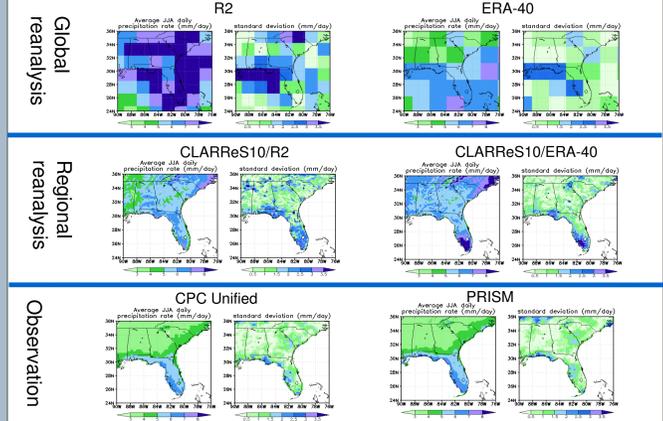
Results: Seasonal Cycle



► 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.

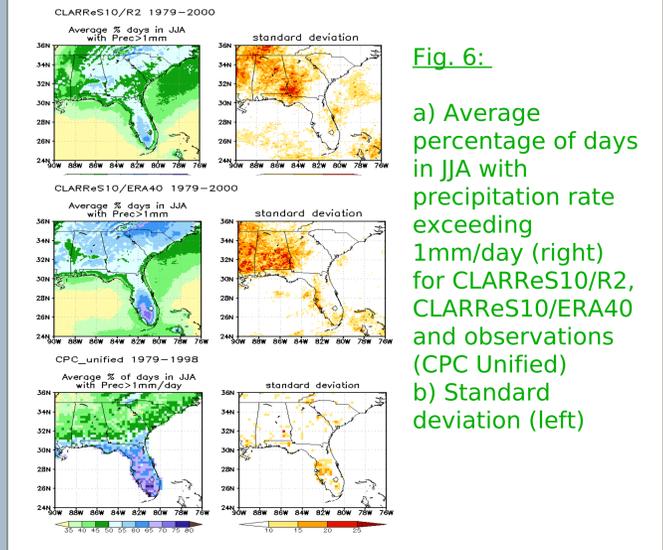


Results: JJA mean and variance



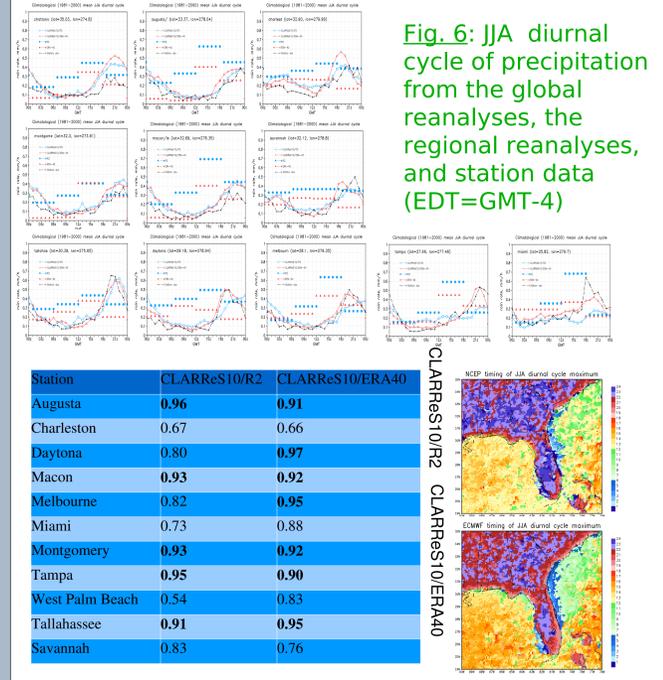
► CLARReS10 reduces the wet bias of R2, but introduces a wet bias to ERA40. The interannual variance range, however, is simulated well. ► CLARReS10 accurately reproduces the relatively smaller rainfall values at the coastline.

Results: JJA Precipitation Frequency



► 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



► 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.

Acknowledgements

• The University of Delaware monthly precipitation, CPC daily US Unified precipitation, and NCEP-DOE Reanalysis II data were provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their web site at <http://climate.geog.udel.edu/>; • PRISM monthly precipitation was provided by the PRISM Climate Group at Oregon State University from their website at <http://www.prismclimate.org/>; • ECMWF-ERA40 Reanalysis data were provided by the ECMWF, from their data server at <http://data.ecmwf.int/data/>; • Thanks to Dr. Kei Yoshimura for his assistance with the RSM model; • Funding for this project is provided by USDA Grant # 05900520024744 and USGS Grant #00590520026892.

References

Chou, M.D. and M. J. Suarez, 1994: An efficient thermal infrared radiation parameterization for use in General Circulation Models. Technical Report Series on Global Modeling and Data Assimilation, National Aeronautics and Space Administration/1994-104606, 3, 85 pp.

Chou, M.D., and C.T. Liu, 1996: Parameterizations for the absorption of solar radiation by water vapor and ozone. *J. Atmos. Sci.*, **53**, 1203-1208.

Ek, M. B., K. E. Mitchell, Y. Lin, E. Rogers, P. Grunmann, V. Koren, G. Gayno, and J. D. Tarpley (2003), Implementation of Noah land surface model advances in the National Centers for Environmental Prediction operational mesoscale Eta model. *J. Geophys. Res.*, **108**, 4230, doi:10.1029/2002JD002966.

Higgins, R. W., J. E. Janowiak, and Y.-P. Yao, 1996: A gridded hourly precipitation data base for the United States (1963-1993). NCEP/Climate Prediction Center Atlas 3, National Centers for Environmental Prediction, 46pp.

Hong, S. Y., and J. L. Pan, 1996: Nonlocal Boundary Layer Vertical Diffusion in a Medium-Range Forecast Model. *Mon. Wea. Rev.*, **124**, 2322-2339.

Juang, H. H., and H. Kanamitsu, 1994: The NMC Medium-Range Spectral Model. *Mon. Wea. Rev.*, **122**, 3-28.

Kanamitsu, M. and H. Kanamaru, 2007: Fifty-seven year reanalysis downscaled at 10km (CRDR10). Part I: System detail and validation with observations. *J. Climate*, **20**, 5553-5571.

Lim, Y. K., L. B. Stefanova, S. C. Chan, S. D. Schubert, and J. O'Brien, 2010: High-resolution subseasonal summer precipitation derived from dynamical downscaling of the NCEP/DOE reanalysis: How much small-scale information is added by a regional model? *Clim. Dyn.*, doi: 10.1007/s00382-010-0893-2.

Pan, H. L., and J. Mahrt, 1987: Interactions between soil hydrology and boundary layer developments. *Boundary-Layer Meteorol.*, **38**, 185-202.

Pan, H. L., and W. S. Wu, 1994: Implementing a mass flux convective parameterization package for the NMC Medium Range Forecast Model. Preprints, 10th Conf. on Numerical Weather Prediction, Portland, OR, Amer. Meteor. Soc., 96-98.

von Storch, Hans, Heiko Langenberg, Frauke Feser, 2000: A Spectral Nudging Technique for Dynamical Downscaling Purposes. *Mon. Wea. Rev.*, **128**, 3664-3673.

Tiedtke, M., 1983: The sensitivity of the time-scale flow to cumulus convection in the ECMWF model. Proceedings of the ECMWF Workshop on Convection in Large-Scale Models, 28 November-1 December 1983, European Centre for Medium-Range Weather Forecasts, Reading, England, 297-316.

Wilmut, C. J., and K. Matsuno, 2000: Terrestrial air temperature and precipitation: Monthly and annual time series (1950-1996), v. 1.01. Online at http://climate.geog.udel.edu/~climate/html_pages/README_globe_ts.html