A23D-2396: Causes of Cool Season Precipitation Bias in the East South Central U.S.

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DISCUSSION

A climatological maximum in cool-season precipitation, secondary to that in the Pacific Northwest, exists in the East South Central U.S. region (ESC). Many regional climate simulations have difficulty reproducing this maximum, whether forced with a reanalysis or global climate model (GCM). This problem exists in some, but not all, of the simulations completed for the North American component of CORDEX (Coordinated Regional Downscaling Experiment) and NARCCAP (North American Regional Climate Change Assessment Program). We use both of these ensembles of regional climate model (RCM) simulations to examine precipitation and some of the factors that govern its climatology in this region to develop a better understanding of why some simulations perform better than others. In the future, we plan to evolve our analysis and additional analyses into a suite of different climatological metrics that will be useful in many regions for diagnosing similar problems in other simulations.

The ESC roughly encompasses the Lower Mississippi, western South Atlantic, southern Ohio and Tennessee hydrologic regions. Cool-season precipitation (November-April) in the ESC is often convective in nature and strongly forced. Some of the potential causes of the climatological precipitation bias for this region we will examine, but may not be included here yet, are bias in: sea-surface temperatures (SSTs), moisture flux, El Nino-Southern Oscillation teleconnections, and the climatology of extratropical cyclones. We will also examine simulation configurations to identify any common threads between the simulations that perform better and those that perform worse.

MODELS & METHODS

NARCCAP (www.narccap.ucar.edu)

50km RCMs forced with the NCEP-DOE Reanalysis 2 (NCEP) and the 4 CMIP3-era GCMs listed in Table 1.

NA-CORDEX (https://na-cordex.org)

50km, 25km, and 12km RCMs forced with the ERA-Interim Reanalysis (ERA-Int) and the 5 CMIP5-era GCMs listed in Table 2.

Table 1: NARCCAP

RCMs	Model Info
CRCM	Canadian RCM v.4.2.0
ECP2	ECPC's version of the Regional Spectral Model (RSM)
HRM3	Hadley Center RCM v3 (HadRM3P)
MM5I	5th Gen. Mesoscale Model (MM5)
RCM3	RegCM3
WRFG	Weather Research and Forecasting Model v2.0.1, modified
GCMs	**Model Info**
CCSM	Community Climate System Model v3
CGCM	Canadian Coupled GCM v3
GFDL	GFDL Climate Model v2.0
HADCM	Hadley Center Coupled Model v3

Table 2: NA-CORDEX

RCMs	GCMs
CRCM5	EC-EARTH
CanRCM4	CanESM2
HIRHAM	GFDL-ESM2M
RCA4	HadGEM2-ES
RegCM4	MPI-ESM-LR
WRF (v3.5.1)	

OBSERVATIONALLY-BASED DATASETS

Several reanalyses and gridded, observation-based datasets are used for comparison.

LIVNEH: 1/16° daily, gridded observations
(Livneh et al. 2013, doi: 10.1175/JCLI-D-12-00508.1)

UDEL: University of Delaware 1/2° monthly mean, gridded observations
(Willmott and Matsuura 1995, doi:10.1175/1520-0450(1995)034<2577:SIOAAA>2.0.CO;2)

NARR: 32km resolution North American Regional Reanalysis
(Mesinger et al. 2006, doi: 10.1175/BAMS-87-3-343)

HadISST: Hadley Centre Global SST, monthly, 1° interpolation of observations
(Rayner et al. 2003, doi: 10.1029/2002JD002670)

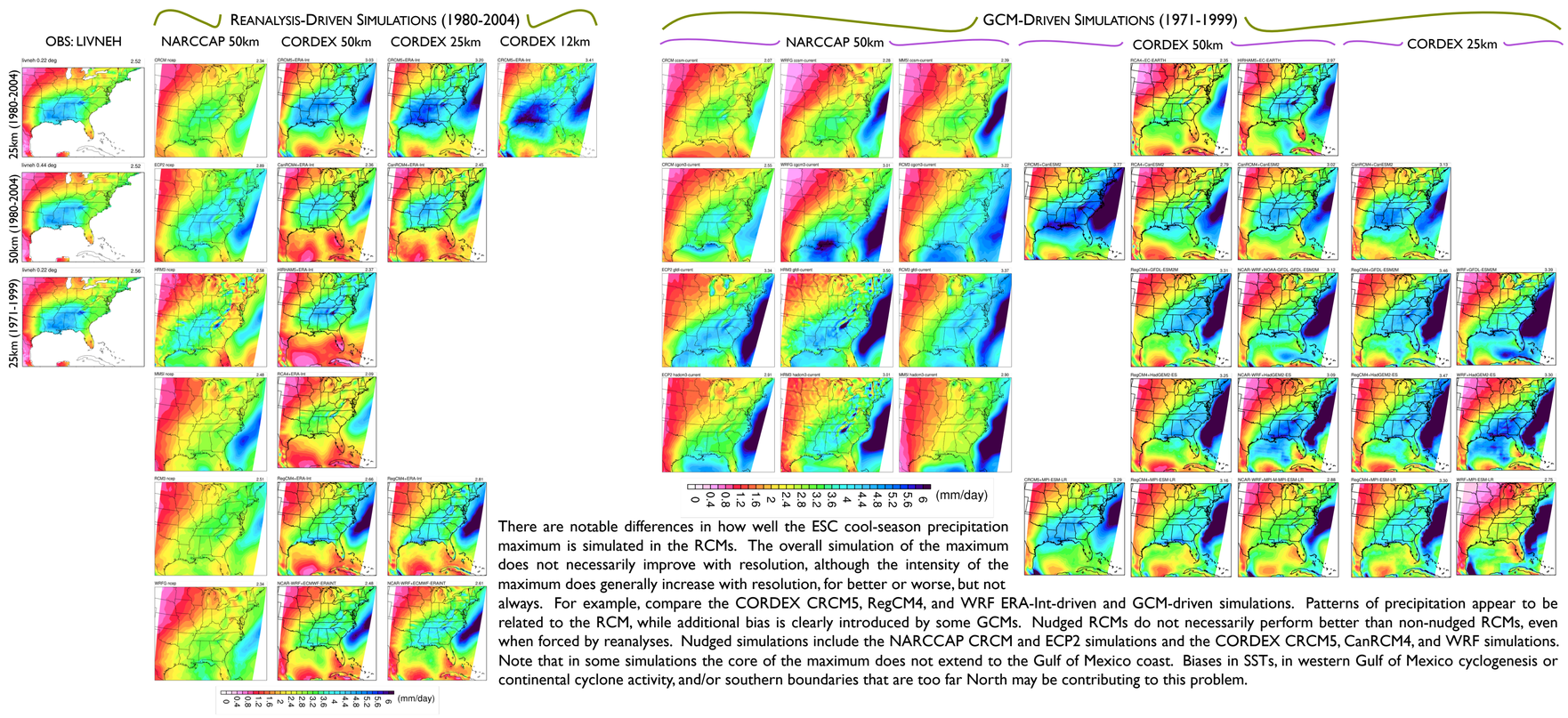
CYCLONE ANALYSIS: Pvar

We have modified the technique used by Wallace et al. (1988, doi: 10.1175/1520-0469(1988)045<0439:RBCTAT>2.0.CO;2) to examine the climatology of extratropical cyclone activity (ETC) including: average activity, intensity and frequency. Pvar is the 24h difference filtered mean sea-level pressure field, modified to only capture low-pressure passage. We will use Pvar in the future to create metrics related to the intensity and frequency of cyclones, and relationships of the biases and changes therein to biases and changes in precipitation.

ENSO TELECONNECTIONS

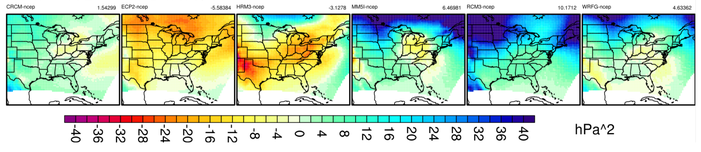
The precipitation response to drivers of interannual climate variability, such as El Niño Southern Oscillation (ENSO), is a challenge for climate models to capture. To explore this issue, we have started by implementing the techniques used in Langenbrunner and Neelin (2013, doi: 10.1175/JCLI-D-12-00542.1) to develop a metric to evaluate the ability of climate models to capture ENSO precipitation teleconnections over the US.

November – March Average Precipitation from the NARCCAP and NA-CORDEX Simulations



There are notable differences in how well the ESC cool-season precipitation maximum is simulated in the RCMs. The overall simulation of the maximum does not necessarily improve with resolution, although the intensity of the maximum does generally increase with resolution, for better or worse, but not always. For example, compare the CORDEX CRCM5, RegCM4, and WRF ERA-Int-driven and GCM-driven simulations. Patterns of precipitation appear to be related to the RCM, while additional bias is clearly introduced by some GCMs. Nudged RCMs do not necessarily perform better than non-nudged RCMs, even when forced by reanalyses. Nudged simulations include the NARCCAP CRCM and ECP2 simulations and the CORDEX CRCM5, CanRCM4, and WRF simulations. Note that in some simulations the core of the maximum does not extend to the Gulf of Mexico coast. Biases in SSTs, in western Gulf of Mexico cyclogenesis or continental cyclone activity, and/or southern boundaries that are too far North may be contributing to this problem.

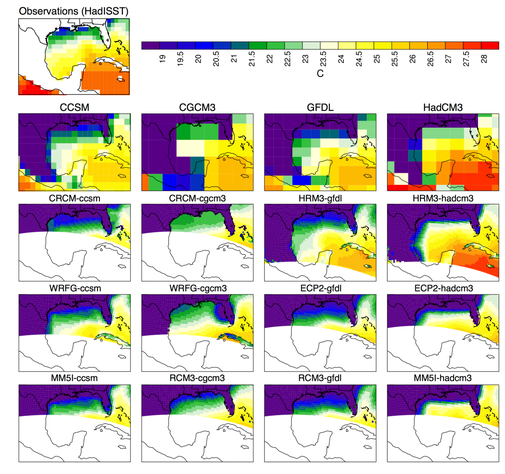
ETC Bias



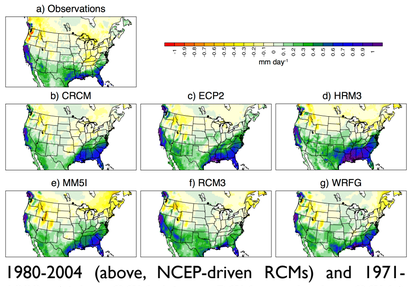
1980-2004 November – March average Pvar difference between the NARCCAP NCEP-driven RCMs and their driver. Negative values indicate that the RCM produced ETCs that were too infrequent and/or too weak, and vice-versa, compared to NCEP.

SST Bias

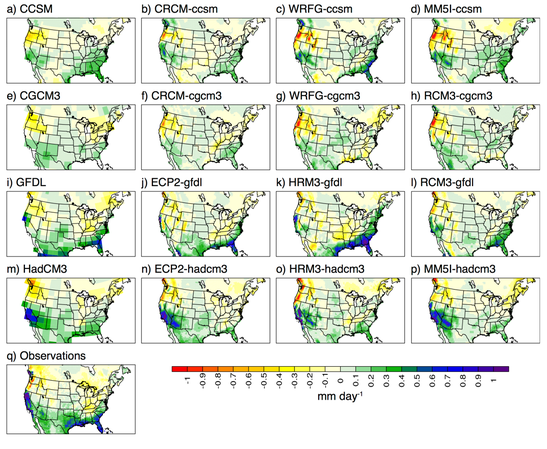
1971-1999 November – April average SST. In the GCM-driven NARCCAP RCM simulations, biases in Gulf of Mexico (GOM) SSTs are clearly inherited from the GCMs. Also, the method in which the RCMs interpolate GCM SSTs to the higher-resolution coastlines of the RCMs has lead to many models having very cold SST biases in the Gulf. Continued work is being done to determine what role the biases play in our region, but they likely contribute to less precipitation, particularly near the coast. This plot also illustrates where the southern boundaries of the RCMs lie relative to the coast. Limited spatial spin-up before the coast in some of the RCMs may also be a factor in the performance of the RCMs in the ESC.



ENSO Teleconnections



1980-2004 (above, NCEP-driven RCMs) and 1971-1999 (right, GCM-driven RCMs and the GCMs) December – February precipitation teleconnections. Teleconnections calculated by linear regression analysis of precipitation (UDEL) against the Niño 3.4 SST index. I.e., the change in precipitation rate per degree change of SSTs in the Niño-3.4 region. El Niño, corresponds with wetter than normal winter conditions over much of the southern portion of the U.S. and drier conditions over the Ohio River Basin. When forced by the reanalysis, RCMs capture the broad patterns of winter ENSO precipitation teleconnections; however, the intensity of the precipitation response varies across the models. For example, HRM3 dramatically overestimates the wet response over the Southeastern US while CRCM underestimates the drying over the Ohio River Basin. In the GCM-driven simulations, it is clear that the RCMs follow the teleconnection patterns from their drivers. Generally, the amplitude of the teleconnections is too low in all but the HRM3-gfdl. Also, in the WRFG- and RCM3-cgcm3 the correlation is reversed in the ESC.



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