

Enabling Regional Climate Model Evaluation: A Critical Use of Observations for Establishing Core NCA Capabilities

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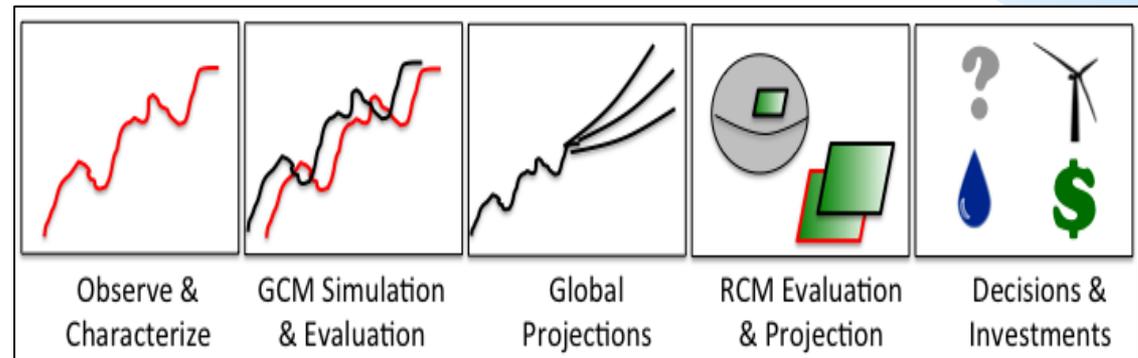
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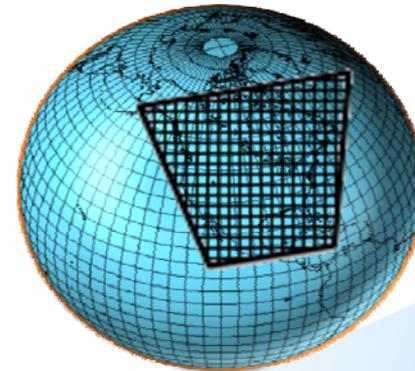
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Response to: NASA Center's Call for Proposals
To Support The National Climate Assessment

PI Telecon : February 24, 2012

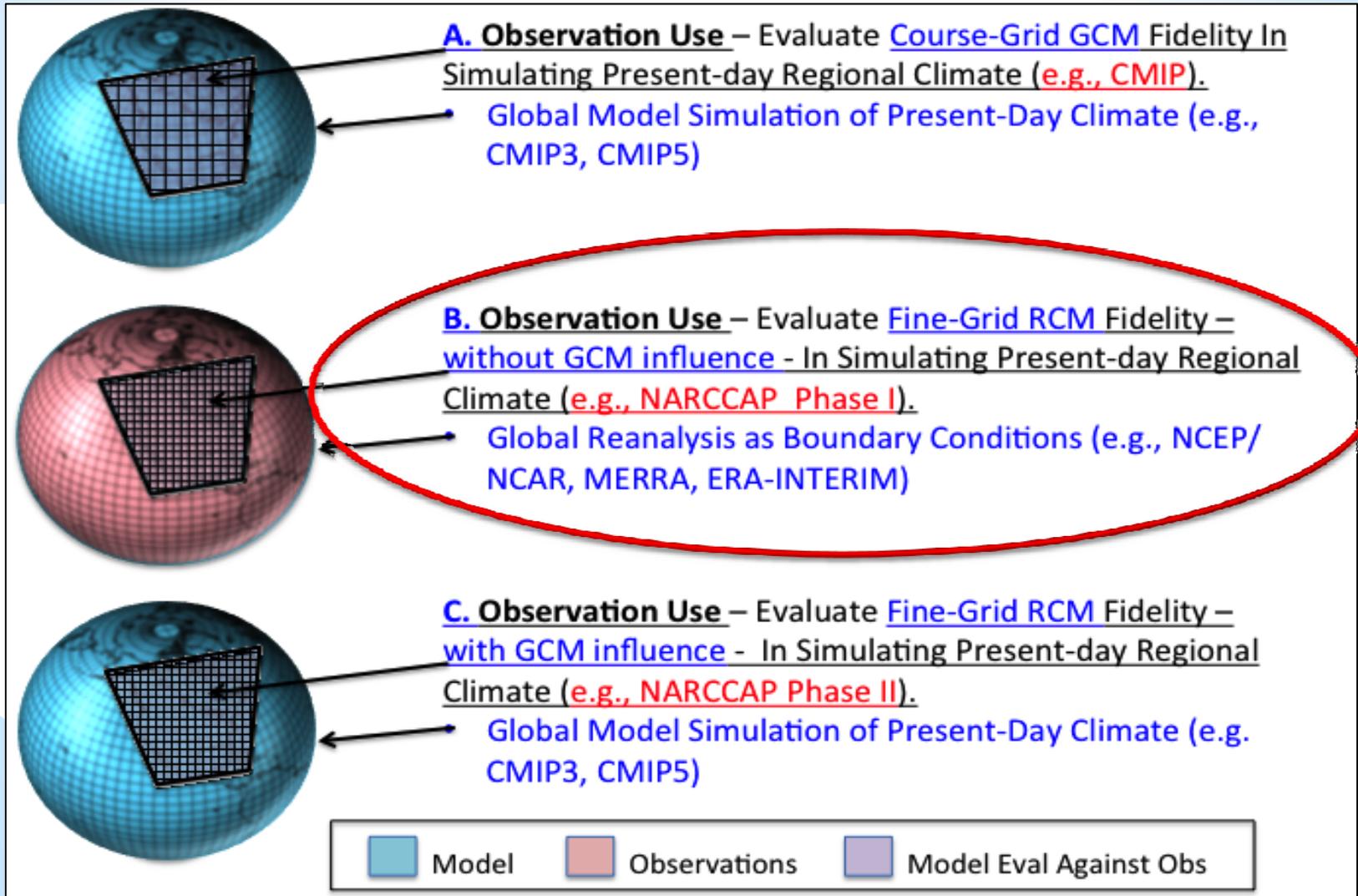


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- Global Climate Models (GCMs) provide the only quantitative, physically-based means for predicting climate change.
- Regional climate models (RCMs) are a key tool to downscale the global predictions for characterizing and quantifying climate change impacts on scales relevant to decision-support and climate assessment activities (e.g. NCA).
- It is imperative that GCMs and RCMs are evaluated against observations so that their strengths and weaknesses can be quantified and model shortcomings can be improved.
- Systematic evaluation studies of GCMs have been undertaken for some time (e.g., AMIP, CMIP, CFMIP), however there has been less attention/consideration made to systematic evaluation of RCMs.
- NASA can provide critical and unique observational resources and technological leadership to facilitate RCM evaluation and thus make key contributions to the NCA process.

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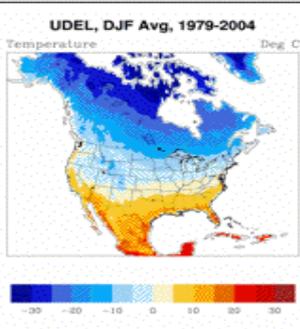
Using NASA Observations for model evaluation relevant to the NCA



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NARCCAP

North American Regional Climate Change Assessment Program



Regional Models

Model	Aliases	Modeling Group	Full Name
CRCM	MRCC	OURANOS / UQAM	Canadian Regional Climate Model / le Modèle Régional Canadien du Climat
ECPC	RSM	UC San Diego / Scripps	Experimental Climate Prediction Center Regional Spectral Model
HRM3	PRECIS, HadRM3	Hadley Centre	Hadley Regional Model 3 / Providing REgional Climates for Impact Studies
MM5I	MM5, MM5p*	Iowa State University	MM5 - PSU/NCAR mesoscale model
RCM3	RegCM3	UC Santa Cruz	Regional Climate Model version 3
WRFP	WRF	Pacific Northwest Nat'l Lab	Weather Research & Forecasting model

Drivers

Driver	Full Name	Ensemble Member Used
CCSM	Community Climate System Model	b30.030e (ctl), b30.042e (fut)
CGCM3	Third Generation Coupled Global Climate Model	CGCM #4
GFDL	Geophysical Fluid Dynamics Laboratory GCM	20C3M, run2; sresa2, run1
HadCM3	Hadley Centre Coupled Model, version 3	Custom run for NARCCAP
NCEP	NCEP/DOE AMIP-II Reanalysis	N/A

RCM / GCM combinations

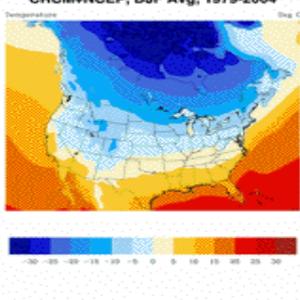
	Phase I		Phase II		
	NCEP	GFDL	CGCM3	HADCM3	CCSM
CRCM	X		1		2
ECPC	X	1		2	
HRM3	X	2		1	
MM5I	X			2	1
RCM3	X	1	2		
WRFP	X		2		1
timeslice		X			X

1: First pairing to be run
2: Second pairing to be run

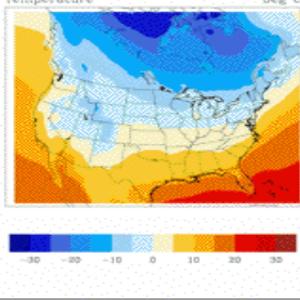
SPONSORS



CRCM+NCEP, DJF Avg, 1979-2004



ECPC+NCEP, DJF Avg, 1979-2004



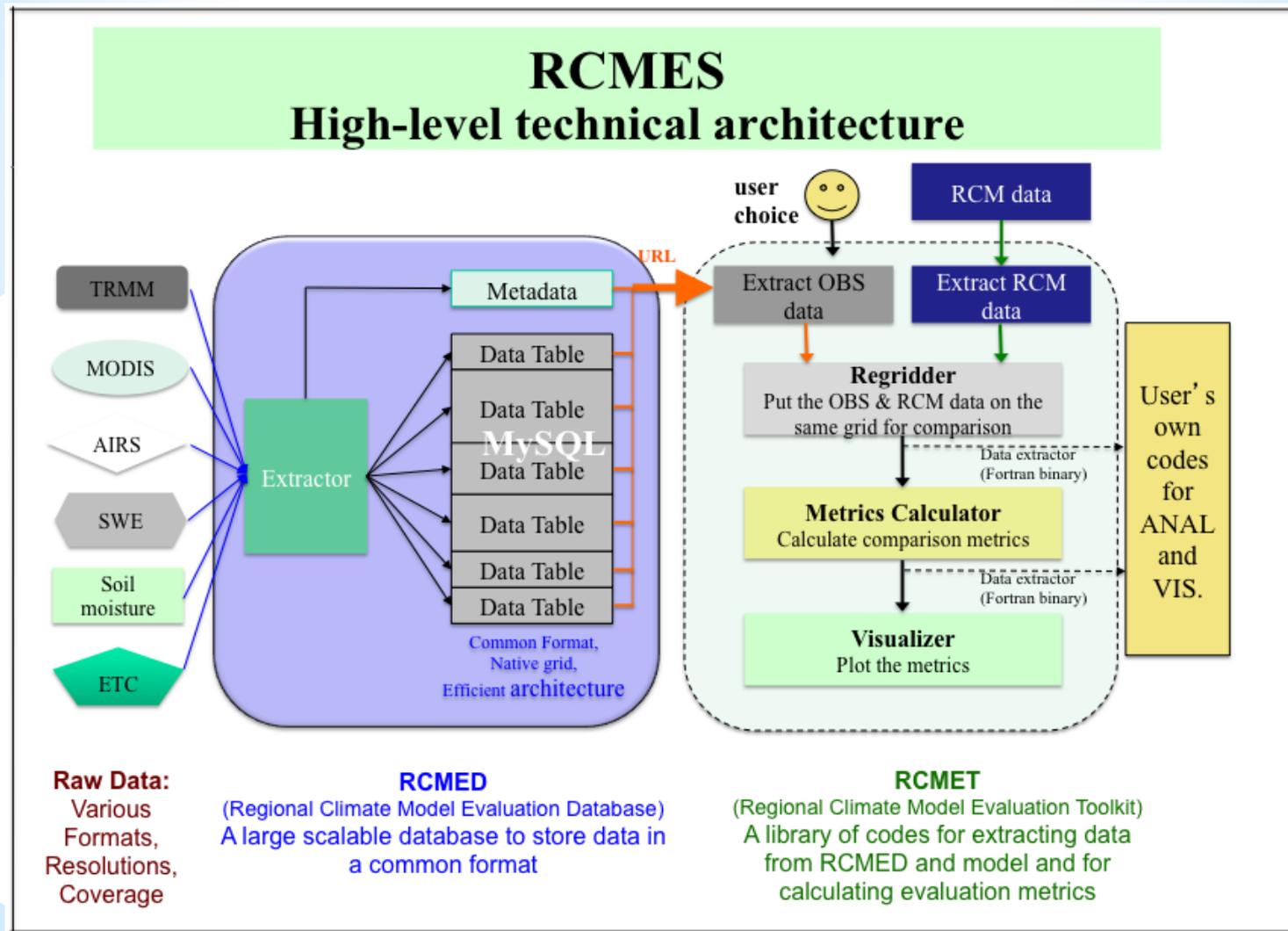
NARCCAP is the North America Regional Climate Change Assessment Program (PI: L. Mearns, NCAR).

Several RCMs downscaling future climate change projections from GCMs.

RCM performance needs to be characterized against observations using present-day simulations.

NARCCAP is the U.S./N.A. contribution to CORDEX.

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Ingest obs/models, re-gridding, calculate metrics (e.g, bias, RMSE, correlation, significance, PDFs), and visualize results (e.g., contour, time series, Taylor).

RCMES

High-level technical architecture

AVAILABLE

- AIRS gridded daily 3D temperature and water vapor
- TRMM 3B42 3-hourly gridded daily precipitation
- ERA-Interim 6-hourly surface temperature & dewpoint, 3D temperature & geopotential
- NCEP daily Unified Rain gauge Database (URD), 0.25° resolution
- Satellite-based Snow Water Equivalent (SWE) assimilation data
- MODIS daily Cloud fraction
- Climate Research Units (CRU) monthly precipitation and temperature (Tavg, Tmin, Tmax) at 0.5 ° resolution.
- MERRA-

FUTURE

- CERES radiation, CloudSat atmospheric ice and liquid, MODIS snow cover, ISCCP cloud fraction, MERRA, etc.

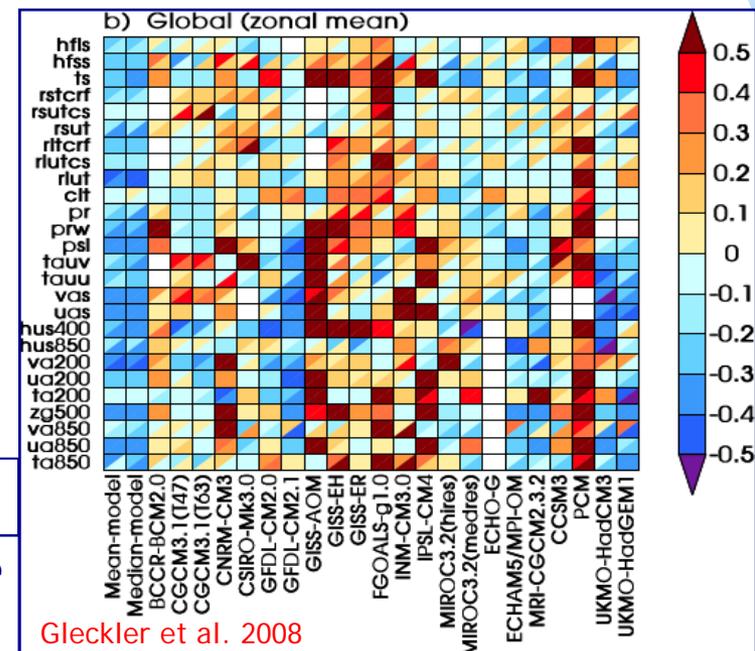
Ingest obs/models, re-gridding, calculate metrics (e.g, bias, RMSE, correlation, significance, PDFs), and visualize results (e.g., contour, time series, Taylor).

This activity includes three tasks:

- I) Tailoring RCMES for application to the NCA.
(e.g. data sets, metrics, visualization, GUI)
- II) Systematic application of observations to evaluate NARCCAP RCM and CMIP GCM simulations over the U.S./N. America.
- III) Overall incorporation of model evaluation/assessment results and RCMES infrastructure into the near- and long-term NCA process.

GOAL

Observation-based model performance metrics for modeling regional climate.



Progress Tailoring RCMES

* RCMES database/IT work

- * LDAS monthly hydrology
- * MERRA hydrology
- * MERRRA atmospheric data too (200m, 500m, 850m and surface)
- * NOHORS
- * JPL Evapotranspiration
- * Land surface temperature (Simon hook)
- * Exploring the use of MongoDB

* Public Portal Release

- * <http://rcmes.jpl.nasa.gov>
- * By March 2012 – CORDEX Arctic Meeting target

* RCMET tool

- * Metrics calculation: Bias, RMSE, Correlations in conjunction with
- * Visualization using contour maps, the Taylor diagram, and Portrait diagram
- * Constructed Virtual Box and VMWare images for easy deployment
- * Will enhance UI starting in April 2012 and deploy cloud version of tool

Dataset Name	Abbreviation	Description
Unified Rain-gauge Database Dataset	URD	Precipitation variable within the Unified Rain-gauge Database
AIRS L3 Standard daily product (AIRS/AMSU) Version 5	AIRS	L3 daily gridded standard retrieval product using AIRS IR and AMSU, without-HSB
Tropical Rainfall Measuring Mission Dataset	TRMM	The TRMM standard products include measurements from satellite and ground-based sensors and geophysical parameters derived from them. The sensor measurements include visible and infrared radiance, microwave brightness temperature, radar reflectivity, surface radar volume scans, and rain gauge and disdrometer data. The derived geophysical products include vertical rain and hydrometeor profiles, rain type, radar backscatter cross section, raindrop size distribution, rain gauge rain rates, and five-day and monthly average rain rates.
ECMWF Re-Analysis Dataset	ERA	European Centre for Medium range Weather Forecasting Re-Analysis dataset
Moderate Resolution Imaging Spectroradiometer	MODIS	MODIS (or Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites.
Climate Research Unit TS 3.0 Dataset	CRU	Climate Research Unit Description
Snow Water Equivalent (Sierra Nevada)	SWE	Sierra Nevada - Snow Water Equivalent (Blended)
Climate Research Unit TS 3.1 Dataset	CRU_TS_3.1	Climate Research Unit Description
MERRA DAS 3d analyzed state on pressure	MAI6NPANA	MERRA 3D analyzed state, meteorology, instantaneous, on pressure levels, at native resolution

SYNERGISTIC INTERACTIONS

- * North American Regional Climate Change Assessment Project (NARCCAP) = CORDEX N. America.
- * CORDEX-Africa
 - * In collaboration with University of Cape Town, Republic of South Africa, and Swedish Meteorological and Hydrological Institute (SMHI), Sweden.
- * EXPLORING USE OF RCMES with CORDEX ARCTIC and S.E. Asia.
- * Climate & Knowledge Development Network (CKDN;
<http://cdkn.org/>)
 - * Synergistic activities with Bruce Hewitson (PI) and University of Cape Town (UCT), and Roger Street (Oxford University)
 - * Evaluating RCMES and its use in climate training: 1st user lab in April 2012 in Dakar
- * Kim Whitehall – Howard University/Prof. G. Jenkins Advisor
 - * Incorporating RCMES into her PhD studies on regional Climate Modeling (Africa)
- * Melanie Cooke – University of Toronto/Prof. Paul Kushnir
 - * Incorporating RCMES into her PhD studies on regional Climate Modeling (Arctic)

NARCCAP Multi-decadal Hindcast Evaluation Results - Limited/Preliminary

Figure. The conterminous US domain. The boxes indicate the locations of the 14 subregions.

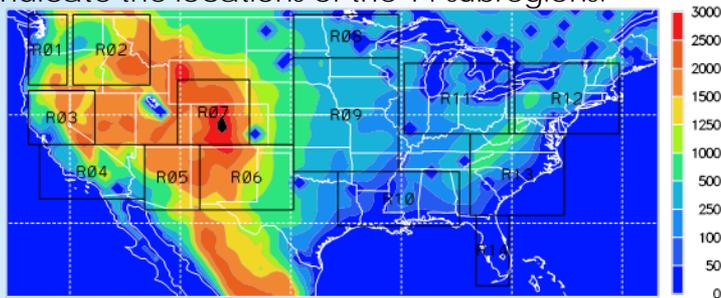


Table 1. The RCMs evaluated in this study.

Model ID	Model Name
M01	CRCM (Canadian Regional Climate Model)
M02	ECP2 (NCEP Regional Spectral Model)
M03	MM5I (MM5 – run by Iowa State Univ.)
M04	RCM3
M05	WRFG (WRF – run by PNNL)
ENS	Model Ensemble (Uniform weighting)

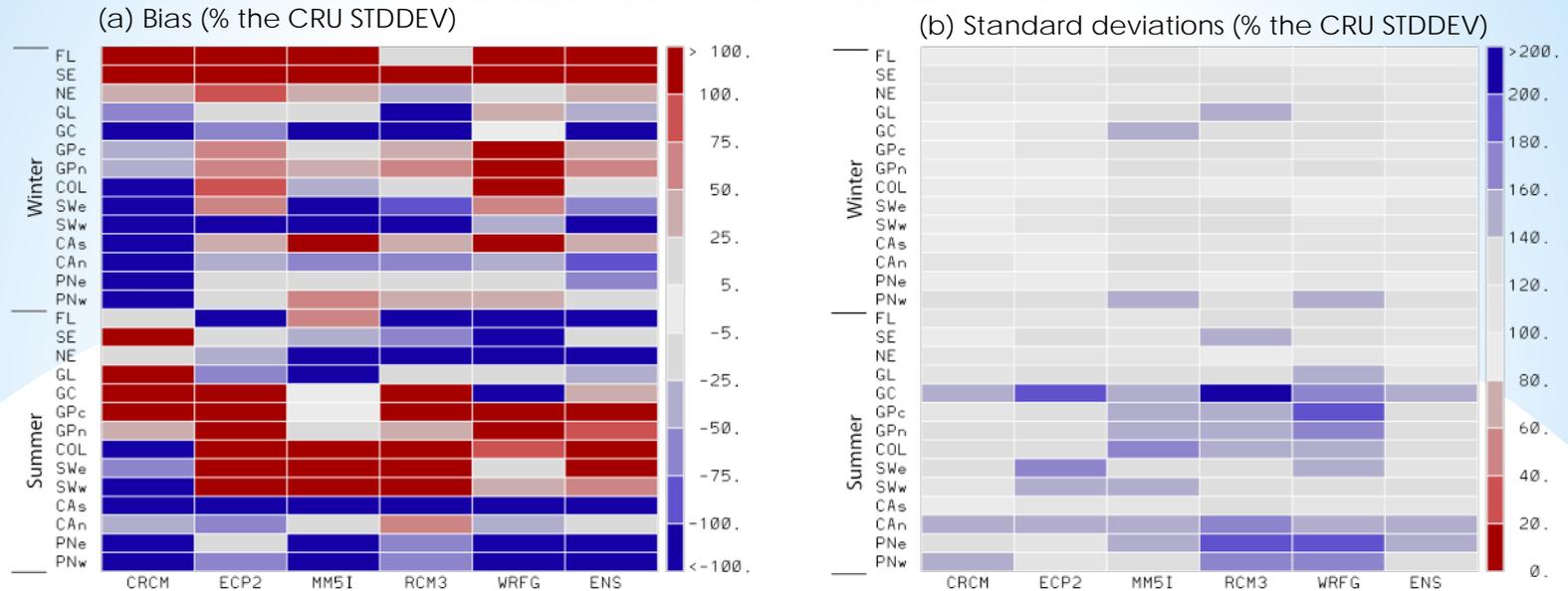
Table 2. The subregions within the conterminous US region.

ID	Region	Long Range	Lat Range	i Range	j Range
01	PNw (Pacific NW – west)	236.25-239.75	42.75-49.25	73-80	56-69
02	PNe (Pacific NW – east)	240.25-247.25	42.75-49.25	81-95	56-69
03	CAN (northern California)	236.25-242.25	37.25-42.25	73-85	45-55
04	CAs (southern California)	237.25-245.25	32.25-37.25	75-92	35-45
05	SWw (SWUS – west)	246.25-251.75	31.25-37.25	94-104	33-45
06	SWe (SWUS – east)	251.75-260.25	31.25-37.25	104-121	33-45
07	COL (Colorado)	249.75-256.25	37.25-43.25	100-113	45-57
08	GPn (nor. Great Plains)	260.25-269.75	45.25-49.25	121-140	61-69
09	GPc (central Great Plains)	260.25-269.75	34.75-45.25	121-140	40-61
10	GC (Gulf Coast)	264.25-275.25	29.75-34.75	129-151	30-40
11	GL (Great Lakes)	270.25-279.75	38.25-44.75	141-160	47-60
12	NE (NE US)	280.25-289.75	38.25-44.75	161-180	47-60
13	SE (SE US)	276.25-284.75	30.75-38.25	153-170	32-47
14	FL (Florida)	276.75-279.75	24.25-30.75	154-160	19-32

- The monthly-mean time series of the daily-mean **surface air temperatures and precipitation** over the conterminous US region from **five RCMs** (Table 1) that have participated in the **NARCCAP hindcast experiment** have been evaluated against the CRU data for the 24-year period 1980-2003.
- The RCM simulations, mostly at 50km horizontal resolutions, are interpolated onto a common grid nest of 0.5-deg horizontal resolution for analysis, evaluation, and inter-comparison (Figure).
- Fourteen sub-regions (as depicted in the figures and table) are selected for closer examinations of model performances in various regions of interests (Table 2).

Seasonal surface air temperature climatology

Bias and interannual variability



- The simulated summer (JJA) and winter (DJF) surface air temperatures in the 14 sub-regions are evaluated against the CRU analysis data.
 - Standard deviation is used as the indicator for the magnitude of interannual variability.
 - Model bias and standard deviation are normalized by the standard deviation of the CRU data.
- Mean biases vary, quite systematically, according to geography and season
 - Warm biases in the Great Plains area for both summer and winter
 - Cold biases in the Pacific, Gulf, and Atlantic coast regions in summer
 - Warm biases in the Atlantic coast (NE and SE), Florida (FL) and northern California (CAn) during winter.
- All models reasonably simulated the interannual variability of the winter temperatures in almost all regions.
 - The interannual variations in the summertime surface air temperature are generally overestimated by almost all models in almost all regions.
- The model ensemble is consistently among the best performers for all seasons, regions, and metrics.

Summary and Plans

- * RCMES development (IT team) – Improved Functionality, Web page/interface, etc.
- * NARCCAP hindcast evaluation
 - * The monthly-mean time series of the surface air temperature and precipitation from the NARCCAP hindcast experiment is being evaluated for the 24-year period from 1980 to 2003
- * It has been found that model performances show systematic variations according to seasons and geography
 - * All models except CRCM generate overestimate ([underestimate](#)) the annual mean temperature in the Great Plains ([Atlantic and Gulf of Mexico coastal](#)) regions.
 - * Warm biases in the Great Plains area for both summer and winter
 - * Cold biases in the Pacific, Gulf, and Atlantic coast regions in summer
 - * Warm biases in the Atlantic coast, Florida and northern California regions during winter
- * All models reasonably simulated the interannual variability of the winter temperatures in almost all regions.
- * The model ensemble is consistently among the best performers for all seasons, regions, and metrics.
- * Near-term plan
 - * Develop contribution to NCA report from the monthly-mean surface air temperature and precipitation evaluations.
 - * Evaluate additional surface variables (SWE and surface fluxes)
 - * Archive additional reference data for evaluation (MERRA surface fields, ET retrievals, radiation, clouds).
 - * Cultivate related CORDEX opportunities to gain insight into user and decision-support needs.