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NA-CORDEX Archive Development
Regional Modeling for Climate Impacts

NA-CORDEX

ABSTRACT

For use in analysis of climate impacts, we are creating an archive of output from the NA-CORDEX regional climate simulations for North America.

The archive will include model output and derived data products from 34 different simulations, exploring the important of global model, regional model, future scenario, and spatial resolution.

To date, we have published data from available simulations for the essential variables in the collection (precipitation, surface temperature, and daily minimum and maximum temperature) through NCAR's Climate Data Gateway data portal. This archive features a custom search UI and subsetting capabilities to increase its usability.

We have also created a website that documents the contents of the archive and provides instructions on accessing the data.

We will apply the KDDM bias correction to the data and are developing an R package implementing the technique. We have completed a preliminary bias correction of several simulations using this method, and are developing and evaluating refinements to the technique based on these results.

We have begun regional pilot analyses to establish the relative credibility and usability of these simulations. We have also initiated the NCAR-NOAA collaboration to evaluate statistical downscaling methods using the Perfect Model evaluation framework.

The CORDEX Program

CORDEX (the *CO*ordinated *R*egional *D*ownscaling *EX*periment) is an international program to dynamically downscale climate simulations from CMIP5 by using them to drive regional climate models (RCMs) at high resolution over various regions worldwide.

The North American component of CORDEX features:
- 7 different RCMs
- 6 different GCMs (plus ERA-Int reanalysis)
- 2 future scenarios: RCP 4.5 & RCP 8.5
- 2 spatial resolutions: 50-km & 25-km
- 150-year simulations: 1950-2100 full transient)

The full set of simulations that we are archiving are shown in the table below.

The North American CORDEX simulation domain (50-km / 0.44° resolution)

NA-CORDEX Simulations

	CRCM5 (UQAM)	CRCM5 (OURANOS)	RCA4	RegCM4	WRF	CanRCM4	HIRHAM5	RCP	ECS (°C)
ERA-Int	0.44* 0.22* 0.11*	0.44*	0.44*	50km 25km	50km 25km	0.44* 0.22*	0.44*		
HadGEM2-ES								4.5	4.6
				50km 25km	50km 25km			8.5	
CanESM2	0.44*		0.44*			0.44* 0.22*		4.5	3.7
	0.44*	0.22*	0.44*			0.44* 0.22*		8.5	
MPI-ESM-LR	0.44*							4.5	3.6
	0.44* 0.22*	0.22*		50km* 25km*	50km 25km			8.5	
MPI-ESM-MR								4.5	3.4
	0.44*							8.5	
EC-EARTH†			0.44*					2.6	~3.3
			0.44*				0.44*	4.5	
			0.44*				0.44*	8.5	
GFDL-ESM2M				50km 25km	50km 25km			4.5	2.4
		0.22*						8.5	
Access	PoC	PoC	ESGF	PoC	PoC	CCCma	ESGF		
Institution	UQAM	OURANOS	SMHI	Iowa State *NCAR	U Arizona	CCCma	DMI		
Modeler	K. Winger	S. Biner	G. Nikulin	R. Arritt *M. Bukovsky	C. Castro, H-I Chang	J. Scinocca	O. Christensen		

WCRP CORDEX More information: http://cordex.org

Personnel

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Funding

ESTCP

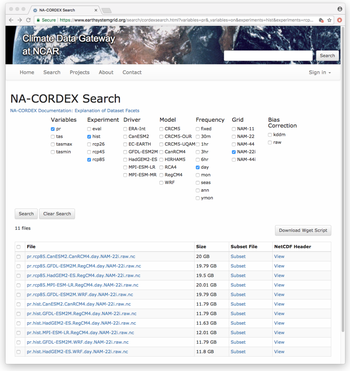
NCAR DATA ARCHIVE

The NA-CORDEX archive at NCAR is a collection of important impacts-relevant variables from the CORDEX RCM simulations for North America. We have archived this data in a standards-compliant format (CF-compliant NetCDF) at daily, monthly, and seasonal timescales on the native model grid as well as regridded to common lat-lon grids.

ARCHIVED VARIABLES

Variable	Long Name	Variable	Long Name
	ESSENTIAL		**ASPIRATIONAL**
pr	Precipitation	clt	Total Cloud Fraction
tas	Near-Surface Air Temperature	evspsbl	Evaporation
tasmax	Daily Maximum Near-Surface Air Temperature	evspsblpot	Potential Evapotranspiration
tasmin	Daily Minimum Near-Surface Air Temperature	huss	Near-Surface Specific Humidity
	HIGH PRIORITY	mrro	Total Runoff
hurs	Near-Surface Relative Humidity	mrros	Surface Runoff
prhmax	Daily Maximum Hourly Precipitation Rate	mrso	Total Soil Moisture Content
rsds	Surface Downwelling Shortwave Radiation	ps	Surface Air Pressure
uas	Eastward Near-Surface Wind Velocity	psl	Sea Level Pressure
vas	Northward Near-Surface Wind Velocity	rsus	Surface Upwelling Shortwave Radiation
	FIXED	sfcWind	Near-Surface Wind Speed
orog	Surface Altitude	snc	Snow Area Fraction
sftlf	Land Area Fraction	snm	Surface Snow Melt
		snw	Snow Amount
		sund	Duration Of Sunshine

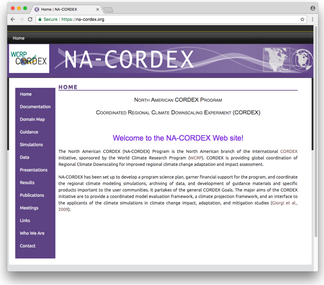
We are publishing the data through NCAR's Climate Data Gateway data portal. which provides a powerful search interface allowing users to find whatever combinations of data features are relevant to them. The ESG interface also supports server-side spatial and temporal subsetting to reduce download time and volume.



Website

The NA-CORDEX website will provide information about the data and guidance on how to access and make use of it.

In addition to overviews of relevant topics and documentation of model and simulation details, the website will provide general guidance on best practices for using the data in impacts analysis and decision making.

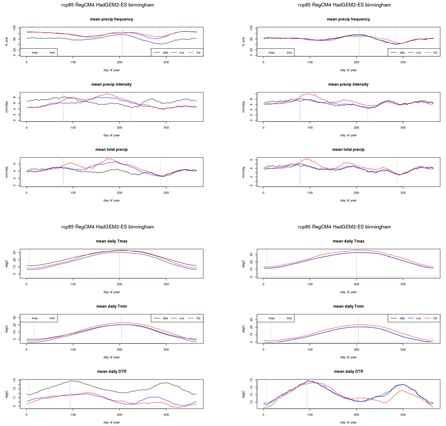


http://na-cordex.org

Bias Correction

Climate model outputs often exhibit systematic biases. To add value to the NA-CORDEX archive, we apply the KDDM (Kernel Density Distribution Mapping) bias correction technique to adjust the model outputs to match the statistics of observations from the Livneh et al. gridded observational data product.

The figures below show the effects of bias correction on the annual cycles of daily precipitation and temperature for Birmingham, Alabama, for one of the NA-CORDEX simulations.



REGIONAL EVALUATION

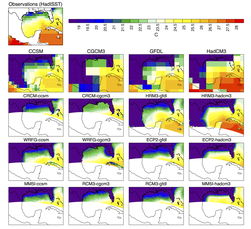
This project includes detailed statistical and process-level analysis in two regions of importance to DoD military installations to establish the relative credibility and usability of climate model simulations. These regional pilot analyses will contribute to guidance materials on use of climate simulations in these regions.

Process-Level Influences on Winter Precipitation in the Southeast U.S.

These figures show a regional analysis for the Southeast U.S. using data from NARCCAP, the predecessor to NA-CORDEX. This analysis focuses on the relationship between sea surface temperatures (SSTs) and winter precipitation in this region, and demonstrates how process analysis leads into an evaluation of the credibility of climate simulations in this context.

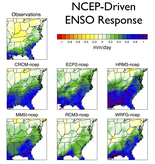
SST Anomalies

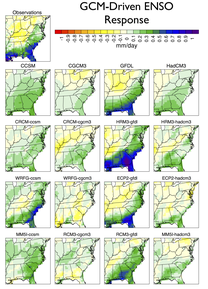
Winter precipitation in this region is strongly influenced by SSTs in the Gulf of Mexico. This figure shows November-April SSTs for the four driving GCMs and 12 downscaling RCM simulations in NARCCAP. Most of these models show a strong cold bias in SST near the northern coastline, which will suppresses storm activity in the region.



ENSO Precipitation Teleconnections

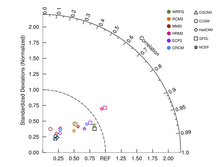
The El Niño Southern Oscillation (ENSO) has strong teleconnections to precipitation in this region. These figures show the winter precipitation response to the positive phase of the Oceanic Nino Index (ONI) for RCMs driven with NCEP reanalysis (below) and with GCM boundary conditions (right). The NCEP-driven RCMs show a significant precipitation response, but the GCMs other than GFDL have difficulty capturing the teleconnections to ENSO and exhibit a weak response.





Model Performance

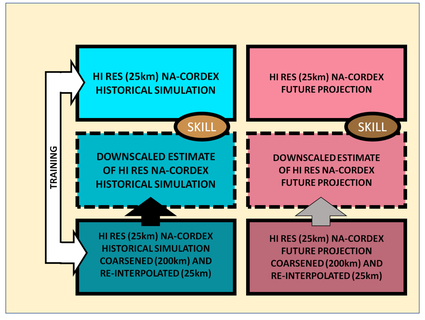
In the figure below, a Taylor diagram demonstrates how well the NARCCAP simulations capture the observed relationship between ENSO and DJF precipitation over the Southeast. The angular axis shows the spatial correlation between modeled and observed teleconnections; the radial axes show the spatial standard deviation of the teleconnections normalized against the observations. Models that have a negative spatial correlation with the observations are not shown (RCM3-cgcm3; WRFG-cgcm3).



STATISTICAL DOWNSCALING EVALUATION

Because climate models have coarse resolution (25 km) relative to impacts studies, statistical downscaling (SD) methods are frequently applied to add value and make model outputs more useful. This study includes the evaluation of SD methods using the "Perfect Model" framework.

Research Questions:
- Do different statistics for a given variable present different spatial patterns of errors? (E.g., changes in mean seasonal climate vs. extreme metrics based on daily statistics.)
- How does spatial interpolation contribute to error in statistical downscaling? Assessed by comparing historical climatologies.
- How well does the stationarity assumption of statistical downscaling hold? Assessed by comparing error in the historical period to errors in the future period.



The "Perfect Model" Framework

To evaluate statistical downscaling and bias correction, we apply the methods to coarsened model output, then compare them to the original model output. This allows us to evaluate the performance of these methods in the future as well as in the baseline period.

Preliminary Perfect Model Evaluation Results

Project collaborators at NOAA-GFDL have applied the perfect model comparison to NA-CORDEX data using the KDDM bias correction. These figures show the resulting seasonal average errors in tasmax for the historical period (1950-2005, left) and the future period (2076-2095, right) for the WRF RCM driven by the GFDL-ESM2M GCM under the RCP 8.5 emissions scenario. Large errors indicate locations where the statistical downscaling method of spatial interpolation plus KDDM has difficulties accurately reproducing the high-resolution climate. Differences between the two columns show locations where the assumption of stationarity in the bias correction may not hold.