



Jet Propulsion Laboratory
California Institute of Technology



The Regional Climate Model Evaluation System (RCMES): A Systematic Evaluation Of CORDEX Simulations Using Obs4MIPs

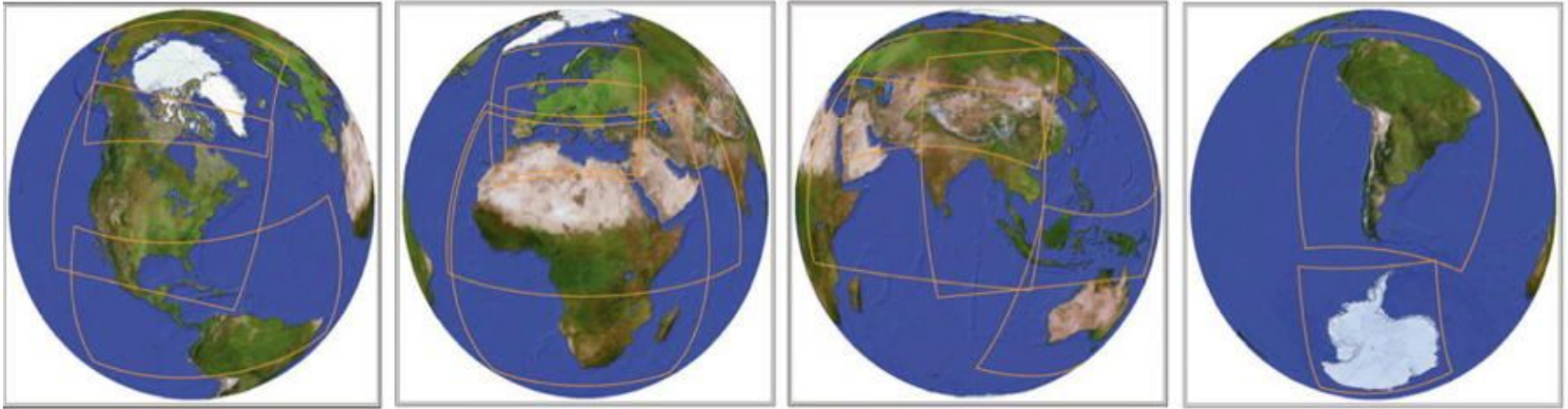
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Duane Waliser¹, and Huikyo Lee¹
Bill Gutowski²

¹: JPL, Caltech ²: Iowa State University

Acknowledgement: 14 CORDEX Domain Teams

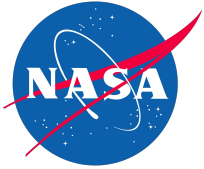
Introduction

CORDEX.org



- The Coordinated Regional Climate Downscaling Experiment (CORDEX) has helped paved the way for studying climate change at regional and local scales.
- Systematic model evaluation studies across the 14 domains (each with multiple simulations and many variables) have been limited, with differences in data publication requirements (e.g. ESGF vs local storage/ftp) and archiving standards (e.g. use of CF-compliant netCDF)

Project Goals



Leverage NASA-sponsored RCMES and NASA-co-sponsored obs4MIPs to benefit WCRP/CORDEX



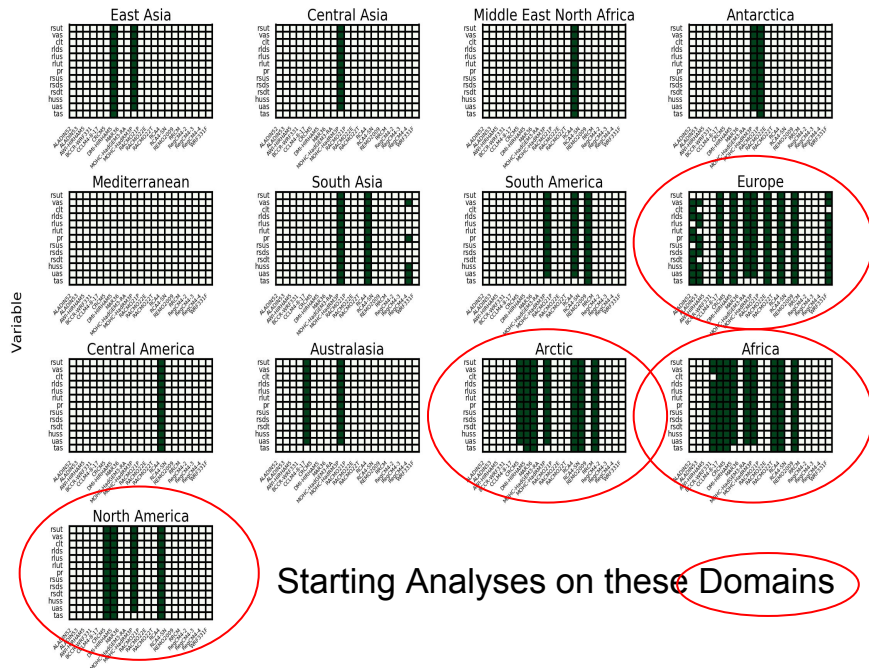
- I. Make it easy to perform systematic evaluations with CORDEX domains, models and variables
 - Utilize the Regional Climate Model Evaluation System (RCMES, <http://rcmes.jpl.nasa.gov>)
- II. Leverage NASA satellite observational datasets in evaluations
 - Utilize Obs4MIPs (<https://www.earthsystemcog.org/projects/obs4mips/>)
- III. Increase communication and collaboration between CORDEX domains

Reaching out to CORDEX domains (10/2016)

Domain	Name	Email	Indicated an interest in participating	Historical Model Simulations Completed	Number of Models	Models on ESGF (Reanalysis Driven)
Australasia	Jason Evans	jason.evans@unsw.edu.au	Y	Y	4	2
South Asia	J. Sanjay	sanjay@tropmet.res.in	Y	Y	3	3
Central Asia	Levent Kurnaz	levent.kurnaz@boun.edu.tr	Y	Y	3	1
Middle East North Africa		levent.kurnaz@boun.edu.tr	Y	Y	2	1
North America	Seth McGinnis	mcginnis@ucar.edu	Y	Y	6	4
South-East Asia	Fred Tangang	ftangang@gmail.com	Y	Y	0	0
East Asia	Hidetaka Sasaki	hsasaki@mri-jma.go.jp	Y	Y	6	2
Europe	Stefan Sobolowski	stefan.sobolowski@uni.no	Y	Y	10	10
Central America	Tereza Cavazos	tcavazos@cicese.mx	Y	Y	2	1
Africa	Chris Lennard	lennard@csag.uct.ac.za	Y	Y	10	9
Arctic	Annette Rinke	Annette.Rinke@awi.de	Y	Y	13	7
Antarctic	Andrew Orr	anmcr@bas.ac.uk	TBD	Y	2	2
Mediterranean	Samuel Somot	samuel.somot@meteo.fr	Y	Y	15	0
South America	Silvina Solman	solman@cima.fcen.uba.ar	Y	TBD	TBD	TBD

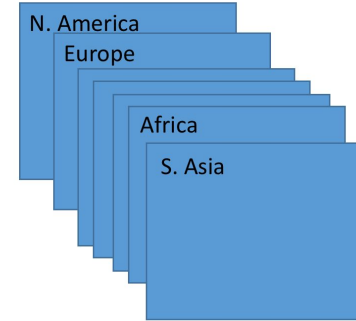
<https://docs.google.com/spreadsheets/d/14j1z-ltZphsgiJOyUkPGh1cvY6JGkDjlcP0ITnP5EM/edit#gid=0>

ERA-Interim Reanalyses Forced RCM simulations Available on ESGF

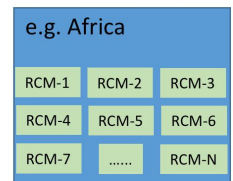


Schematic of Multi-Domain, Multi-Model and Multi-Variate CORDEX Model Evaluation with Obs4MIPs

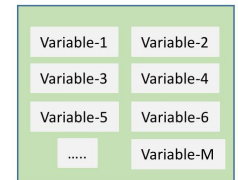
CORDEX has 14 Domains



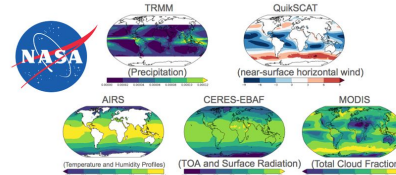
Each Domain has N RCMs



Each RCM has M Variables

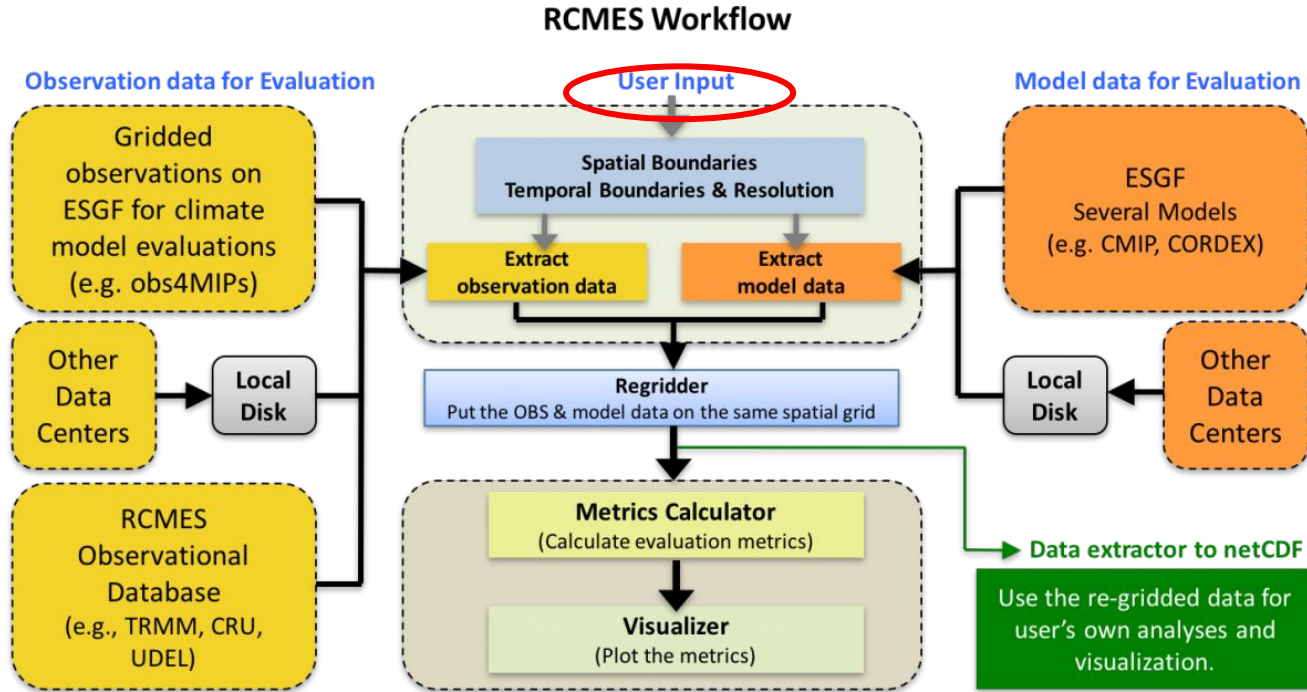


obs4MIPs – e.g. M Satellite Variables for Model Evaluation



RCMES
Model Evaluation
Multiple Metrics

More on RCMES [Lee et al. 2018, GMDD under review]



- RCMES was originally designed and funded by NASA for use in the National Climate Assessment (NCA)
- Software is open source and available through github (<https://github.com/apache/climate>)
- Website: <http://rcmes.jpl.nasa.gov>

```
workdir: /home/goodman/goodman_processing/CORDEX/analysis/NAM-44/CERES-EBAF/rlus/annual
output_netcdf_filename: rlus_CERES-EBAF_NAM-44_annual.nc

# (RCMES will temporarily subset data between month_start and month_end.
# If average_each_year is True (False), seasonal mean in each year is (not) calculated and used for metrics calcul
time:
  maximum_overlap_period: True
  temporal_resolution: monthly
  month_start: 1
  month_end: 12
  average_each_year: True

space:
  boundary_type: CORDEX_NAM

regrid:
  regrid_on_reference: True

datasets:
- loader_name: local_split
  name: CERES-EBAF
  file_path: /proj3/data/obs4mips/rlus_CERES-EBAF_L3B_Ed2-8_*.nc
  variable_name: rlus
- loader_name: local_split
  name: UQAM-CRCM5
  file_path: /proj3/data/CORDEX/NAM-44/rlus/rlus_NAM-44_ECMWF-ERAINT_evaluation_r1i1p1_UQAM-CRCM5_v1_mon_*.nc
  variable_name: rlus
  lat_name: lat
  lon_name: lon
- loader_name: local_split
  name: SMHI-RCA4
  file_path: /proj3/data/CORDEX/NAM-44/rlus/rlus_NAM-44_ECMWF-ERAINT_evaluation_r1i1p1_SMHI-RCA4_v1_mon_*.nc
  variable_name: rlus
  lat_name: lat
  lon_name: lon
- loader_name: local_split
  name: DMI-HIRHAM5
  file_path: /proj3/data/CORDEX/NAM-44/rlus/rlus_NAM-44_ECMWF-ERAINT_evaluation_r1i1p1_DMI-HIRHAM5_v1_mon_*.nc
  variable_name: rlus
  lat_name: lat
  lon_name: lon
- loader_name: local_split
  name: MOHC-HadRM3P
  file_path: /proj3/data/CORDEX/NAM-44/rlus/rlus_NAM-44_ECMWF-ERAINT_evaluation_r1i1p1_MOHC-HadRM3P_v1_mon_*.nc
  variable_name: rlus
  lat_name: lat
  lon_name: lon
```

Season

Domain

Observations

Models

Why we need “Systematic Evaluation”

- This Config file (namelist file) is necessary to run each evaluation combination (CORDEX Domain, Season and Variable), forming a large “evaluation matrix”.
- 14 variables x 13 domains x 3 seasons x ~10 models > 5000 evaluations
- Writing that many Config files manually would be cumbersome/prohibitive.

Solution: Extract metadata from input filenames

rlus_NAM-44_ECMWF-ERAINT_evaluation_r1i1p1_UQAM-CRCM5_v1_mon_*.nc

Variable Domain

Model

User Input:
Dataset Locations
(obs4mips, CORDEX)

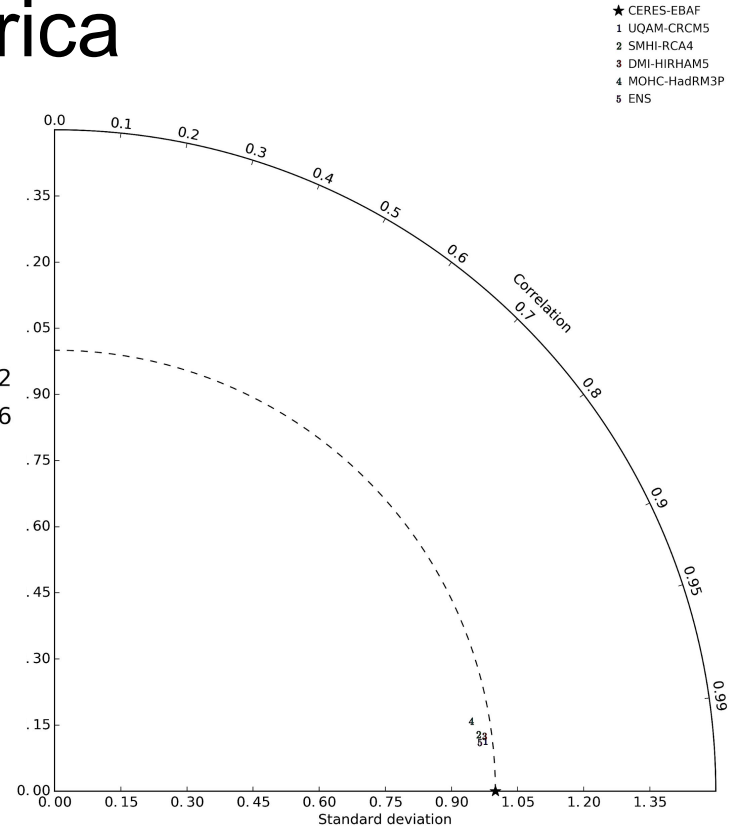
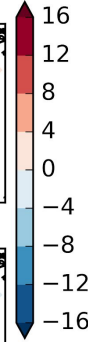
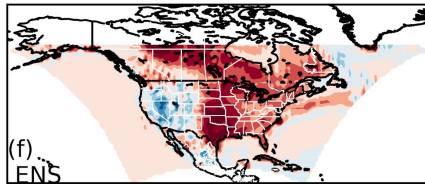
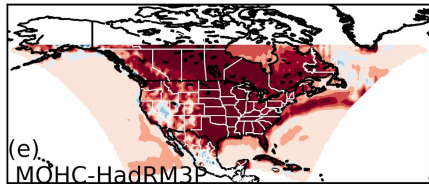
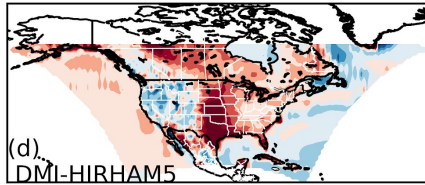
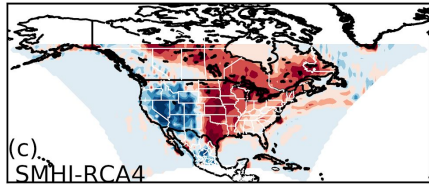
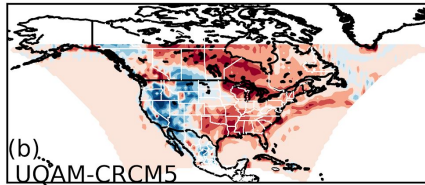
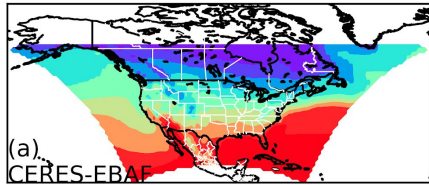
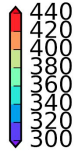
Evaluation Groups
(Season, Domain, Variable)

Config File

RCMES

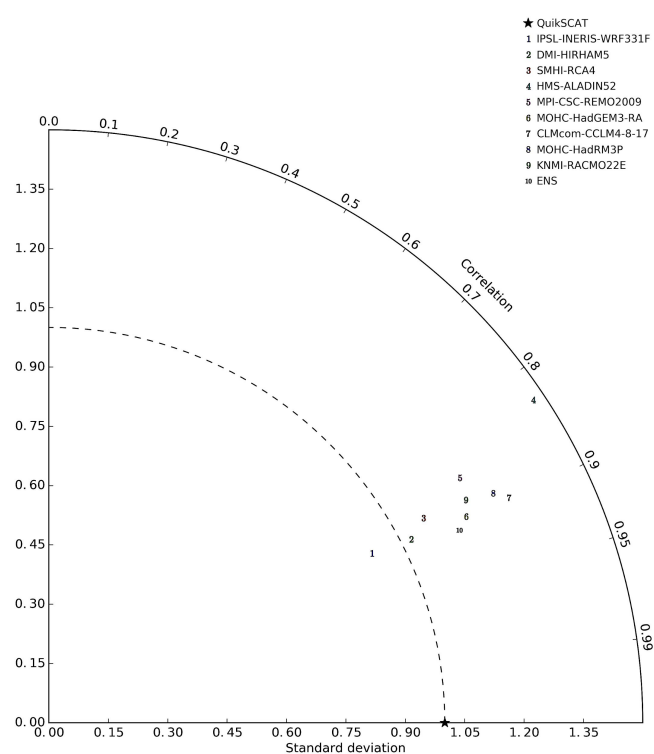
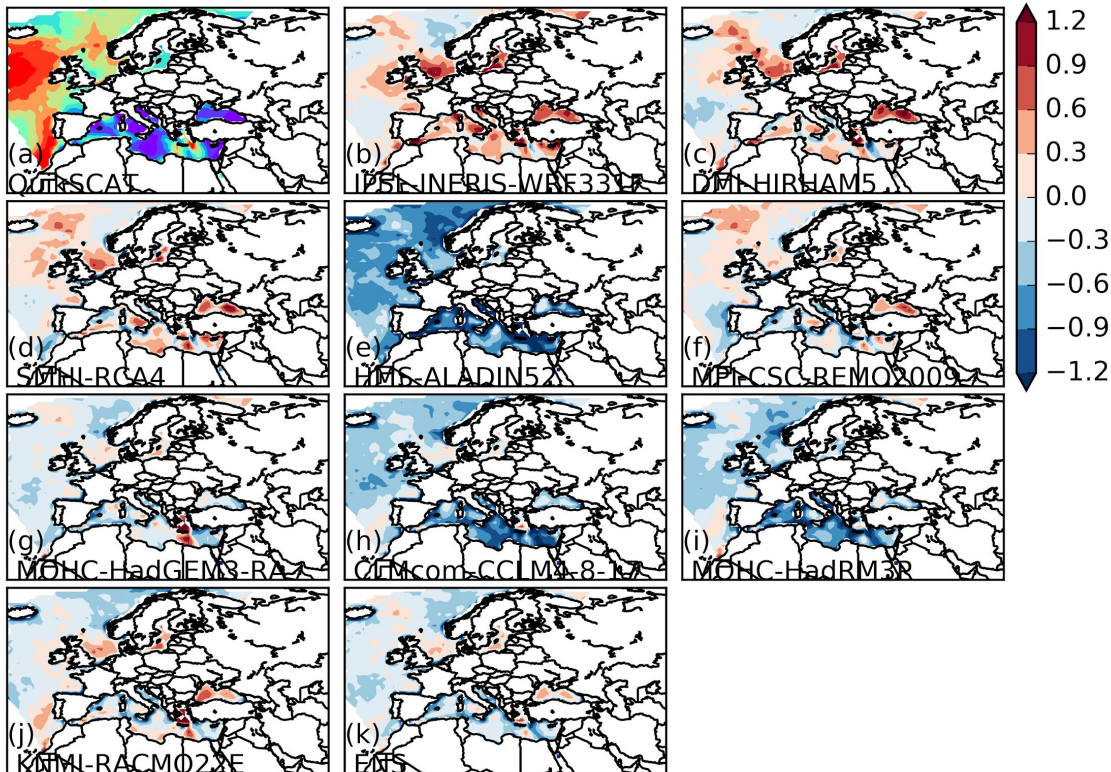
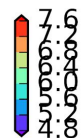
We can group all models and obs datasets together by common attributes (domain and variable) to form a unique evaluation, and therefore **automatically generate Config Files using only the dataset locations as user input.**

CERES Outgoing LW Surface Radiation (W/m^2) (annual) North America

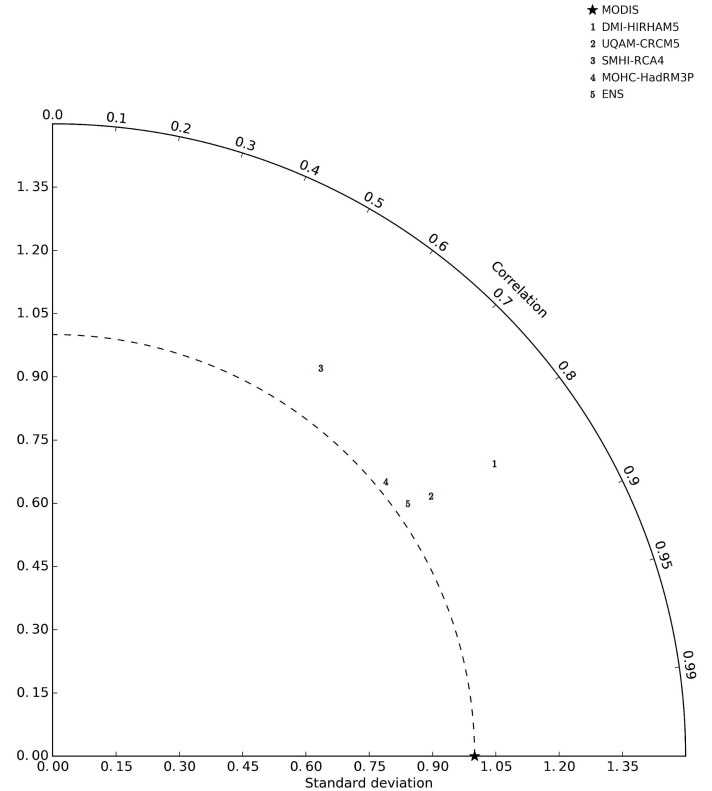
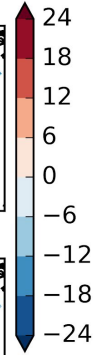
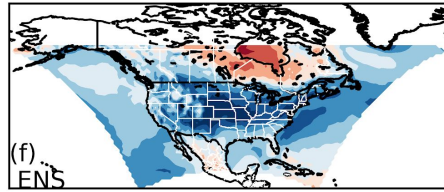
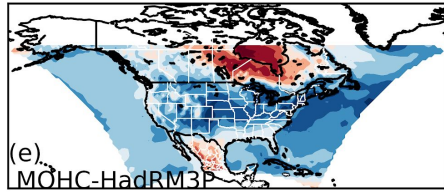
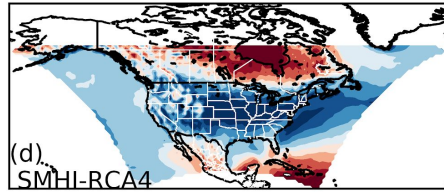
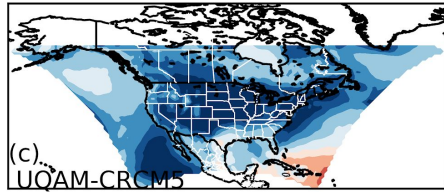
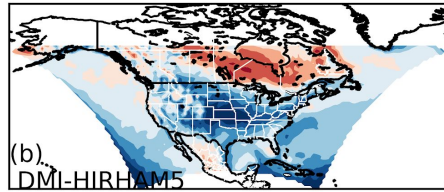
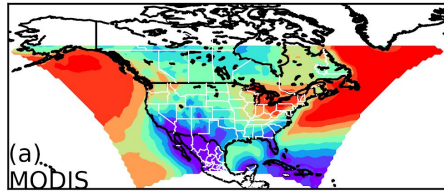
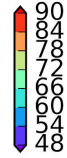


QuikSCAT Zonal Sea-Surface Wind (m/s) (summer)

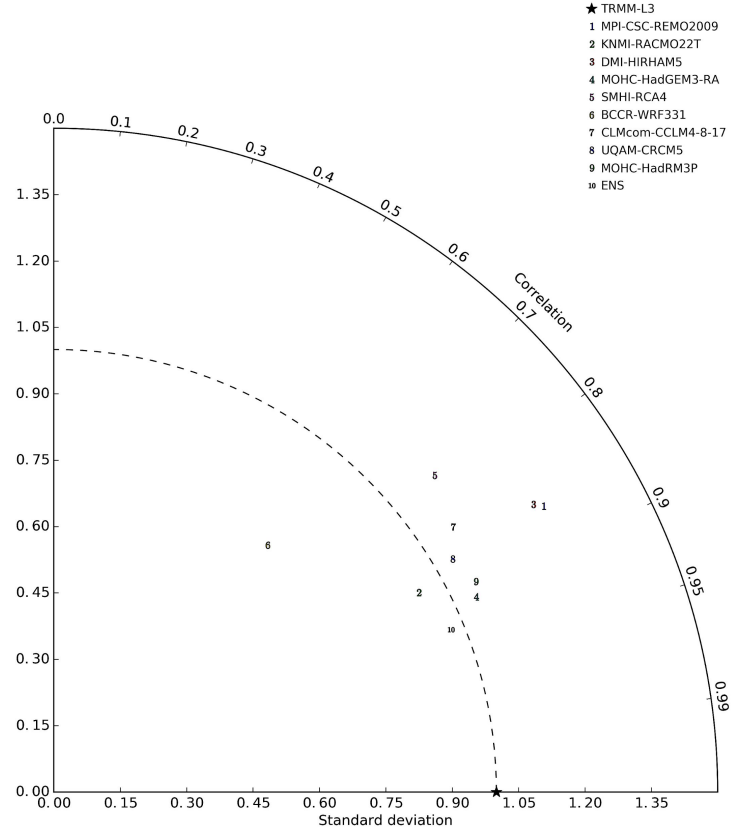
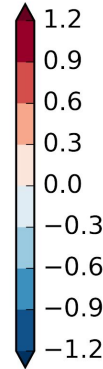
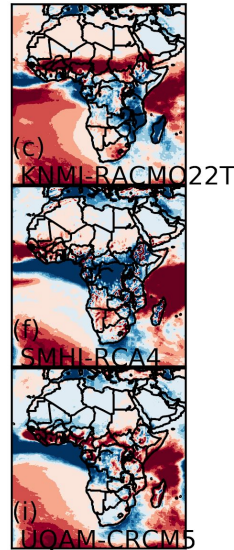
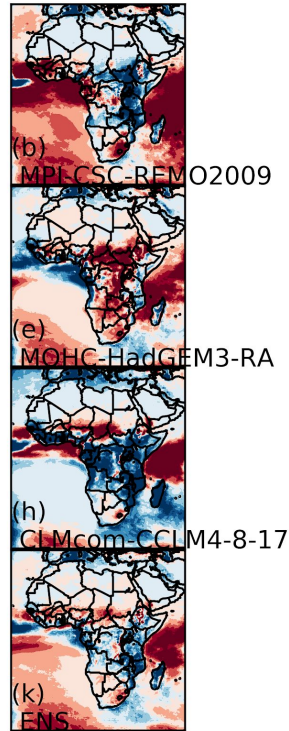
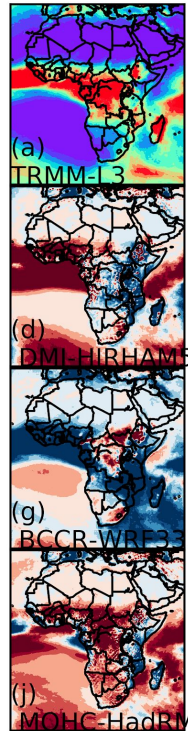
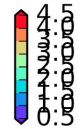
Europe



MODIS Total Cloud Fraction (%) (winter) North America

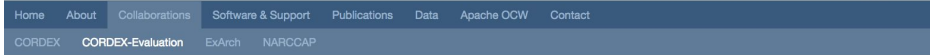


TRMM Precipitation (mm/month) (annual) Africa



Project Website (Results Index Page)

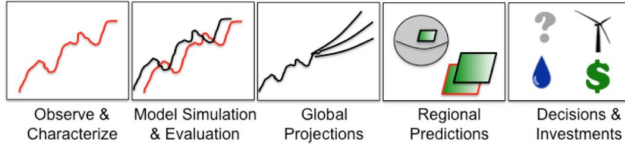
Regional Climate Model Evaluation System



CORDEX-Evaluation

Observation-Based Model Evaluations

A critical component of CORDEX are the regional climate models (RCMs) that are used to downscale the global climate model simulations and projections (e.g. typically from CMIP), and provide guidance for regional policy and decision support related to climate change (see schematic below; Whitehall et al. 2012; WMO Bulletin). Because of the potential role these RCMs (may) have, it is a high priority to bring as much observational scrutiny to them as possible. This requires the systematic application of observations; enabling such multi-variate evaluations is essential for advancing model development, and for performing quantitative model comparison and uncertainty analyses. Providing access to observations for such purposes is the objective of obs4MIPs, and performing such model-based evaluation is the objective of RCMES.

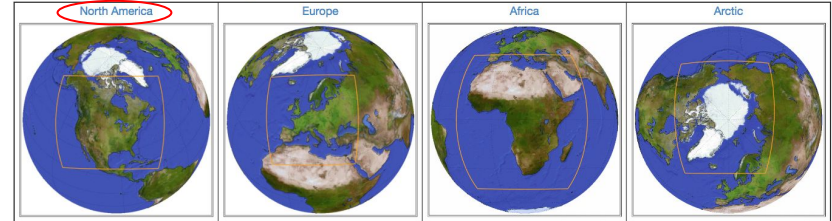


In concert with CORDEX leadership, RCMES via the support of NASA, is undertaking a multi-domain, multi-model and multi-variate observation based model evaluation. The objectives are to demonstrate the use of RCMES, including its access to obs4MIPs data and model evaluation functionality, for regional climate evaluation relevant to CORDEX. The goals of the project include: 1) fostering a cross-domain CORDEX community interaction, 2) demonstrate the utility of (NASA) earth observations - particularly from obs4MIPs, and 3) provide a uniform, albeit limited, assessment of model fidelity across multiple CORDEX domains.

The proposed evaluation consists of the bulleted elements given below. Analysis is underway on the CORDEX model output that have been made readily available (e.g. ESGF) to date. Preliminary results are provided via the Quick Navigation and Tables below. **Additional model output is welcome, and will be incorporated as it is received.** To provide additional model output that can be included in this comparison, please send an email to rcmes-team@jpl.nasa.gov.

- 16 Variables:
 - Precipitation from TRMM & GPCP
 - Net longwave & shortwave radiation at the surface and TOA from CERES
 - Temperature & water vapor at 850, 500 and 200 hPa from AIRS
 - 2m temperature, 850 & 200 hPa zonal and meridional wind, and sea level pressure from MERRA-2
- 5 Evaluation Metrics:
 - bias, centered RMS and Taylor plots for climatological annual and seasonal means
 - temporal correlation and centered RMS for 12-month annual cycle
- CORDEX Domains:
 - Include all domains and its models for which all or part of the above variables are accessible via ESGF or otherwise by CORDEX domain technical point of contact.
- CMIP5 GCMs:
 - Including a small number (~6) of select GCMs used for driving CORDEX RCMs.

Quick Navigation - Jump to Evaluations



Results

North America Evaluations

Reference Dataset	Variables	Results Page by Seasons		
CERES-EBAF	Downwelling Longwave Radiation (Surface) Upwelling Longwave Radiation (Surface) Downwelling Longwave Radiation (TOA) Downwelling Shortwave Radiation (Surface) Downwelling Shortwave Radiation (TOA) Upwelling Shortwave Radiation (Surface) Upwelling Shortwave Radiation (TOA)	Annual	Summer	Winter
		Annual	Summer	Winter
		Annual	Summer	Winter
		Annual	Summer	Winter
		Annual	Summer	Winter
		Annual	Summer	Winter
		Annual	Summer	Winter
MODIS	Total Cloud Fraction	Annual	Summer	Winter
QuikSCAT	Near-Surface Wind Speed Near-Surface Zonal Wind Near-Surface Meridional Wind	Annual	Summer	Winter
		Annual	Summer	Winter
		Annual	Summer	Winter
TRMM-L3	Precipitation	Annual	Summer	Winter

<https://rcmes.jpl.nasa.gov/content/cordex-evaluation>

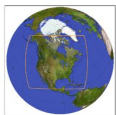
Project Website (Example Results Page)

North America CORDEX - DLR - Annual

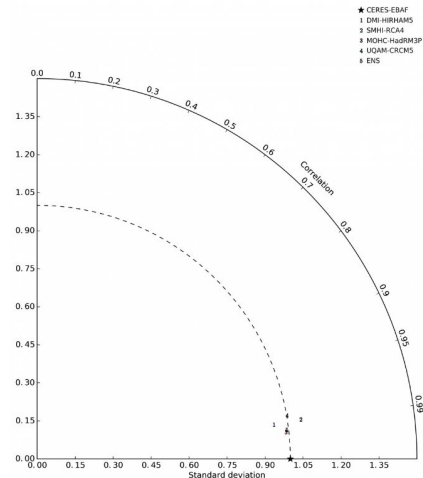
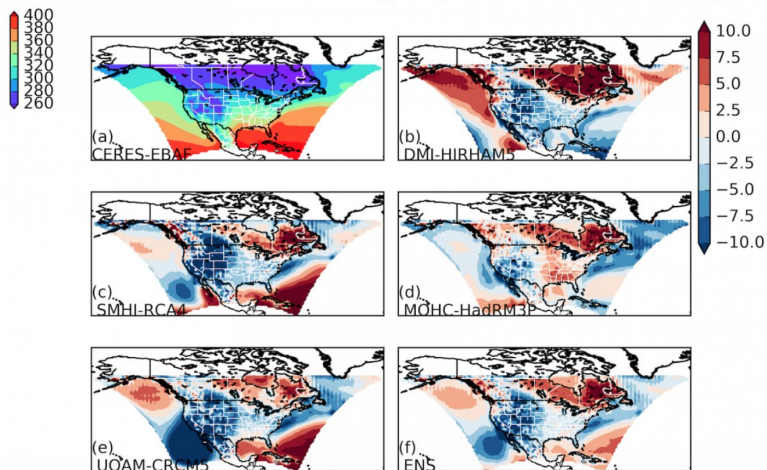
Downwelling Longwave Radiation - Annual

Quick Navigation

- Results
- Configuration Files



Results - CERES-EBAF Downwelling Longwave Radiation (W/m2) (annual)



Download Configuration Files

The following compressed file contains a configuration file (.yam) and dataset file (.nc) specific for annual downwelling longwave radiation in North America. It also contains two high resolution .png files of the two pictures above.

download:

[NAM-44_CERES-EBAF_rlds_annual.zip](#)

<https://rcmes.jpl.nasa.gov/content/nam44-ceres-rlds-annual>

Analysis Plan / Future Work

1. Initial Evaluations will focus on domains with the most simulations on the ESGF
 - a. Display these evaluations on RCMES website
 - b. Inform CORDEX coordinators of these results
2. Include analysis and configuration files for 3D Temperature and Humidity fields from AIRS.
3. Analyze and post remaining evaluations with simulations (not on ESGF but) made available to us (mid-late 2018)

CORDEX Central America and South America Training Workshop on Downscaling Techniques (<http://www.cima.fcen.uba.ar/cordex-2018/>)

Home Agenda Registration Information Logistic

WCRP CORDEX WCRP World Climate Research Programme SMHI CIMA CONICYT IFAECI UMI-3351

CORDEX Central America and South America
Training Workshop on Downscaling Techniques

La Paz, Bolivia, June 25-27 2018

Objectives of the Training Workshop:

The Workshop is intended for PhD students and early career researchers with a background in regional climate science. The main objectives are to build capacity in regional climate downscaling techniques and to coordinate future CORDEX activities in the domains over South and Central America/Latin America and the Caribbean.

- There will be a hands-on RCMES training session on June 27.
 - Introduction of the Regional Climate Model Evaluation System (RCMES) and NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP)
 - Generation of statistically downscaled datasets by applying simple delta methods and BCSD (<https://github.com/tjvandal/bcsd-python>) to climate model output using RCMES