C27-W108A

Evaluation of the multiple-model CORDEX-Africa hindcast experiment using the RCMES

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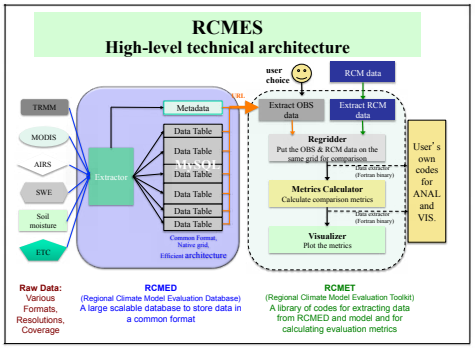
Background:
- Climate models play a crucial role in developing plans to mitigate and adapt to climate variations and change for sustainable developments.
- Model evaluation is an important step in linking climate simulation quality to projection uncertainty and then to climate change impact assessments.
  - Uncertainties propagate according to model hierarchy
  - Bias correction is based on model evaluation
  - Determination of the weights in multi-model ensemble



Regional Climate Model Evaluation System (RCMES):
- Provide a fast, flexible, comprehensive system to allow easy comparison of climate models with observations.
- Enable researchers to handle a large volume of data and reduce time taken for model evaluation studies from weeks to hours.
- Help model developers with cutting-edge observations and diagnostics to evaluate and improve their models.
- Help end-users understand the uncertainties in climate projections for the regions of interest.
- RCMES is:
  - *Efficient*: Fast access to reference data and toolkit
  - *User Friendly*: Intuitive and transferrable GUI
  - *Flexible*: Cloud-based architecture
  - *Expandable*:
    - *Easy to add new data/analysis tool*
    - *Scalable storage solution*

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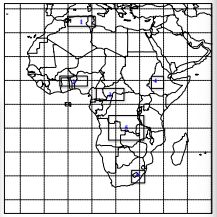
CORDEX-Africa multi-model hindcast
- Collaboration between JPL, UCLA, UCT & Rossby Centre
- Monthly data from 11 RCM 20-year hindcast.
  - Models with incomplete/missing data are excluded
  - Evaluation period are limited by the REF data period.
- Evaluations are performed for:
  - Precipitation, T2, T2Min, T2Max, Cloudiness
- REF data:
  - Precipitation: TRMM.v6 (1998-2010), CRU (1901-2006)
  - T2, T2Min, T2Max: CRU (1901-2006)
  - Cloudiness: MODIS (2001-2008; mod 06 in http://mcst.gsfc.nasa.gov/)

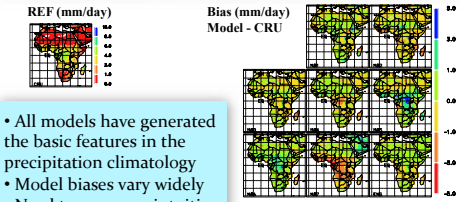
Institution	Model / Variable	PRECIP	T_{MEAN}	T_{MIN}	T_{MAX}	Cloudiness
CNRM	ARPEGE5.1	X	X	X	X	X
DMI	HIRHIM					X
ICTP	RegCM3					
IES	CCLM	X	X	X	X	X
KNMI	RACMO2.2b	X	X	X	X	X
MPI	REMO					
SMHI	RCA35	X	X	X	X	X
UCT	PRECIS	X	X	X	X	
UC	WRF311	X	X	X	X	
UM	MM5	X	X	X	X	
UQAM	CRCM5					
n/a	ENS	X	X	X	X	X

Table. Models and variables incorporated in this evaluation study



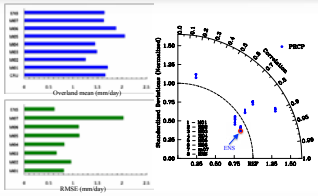
CORDEX-Africa domain
- 0.44°-resoln analysis domain
  - Model data are interpolated onto the analysis domain
- 6 sub-regions:
  1. Western Mediterranean
  2. Western sub-Sahara
  3. Central sub-Sahara
  4. Upper Nile
  5. South-central sub-Sahara
  6. Eastern RSA

Precipitation Climatology: Overland only, 1989-2006 [Limited by CRU]

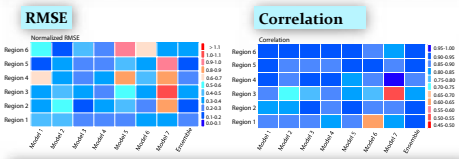


- All models have generated the basic features in the precipitation climatology
- Model biases vary widely
- Need to use more intuitive visualization of model performance.

Precipitation spatial variation: Taylor diagram

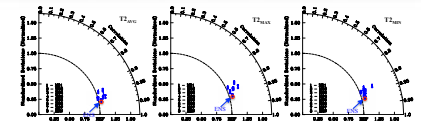


Precip annual cycle in sub-regions: Portrait diagram



- Most models generate spatial distribution reasonably
  - spatial correlation coefficients between 0.8 and 0.9
- Model performance in simulating the annual cycle vary according to regions as well as models
- *Model ensemble is consistently among the best in simulating precipitation climatology measured in terms of RMSE, bias, and pattern correlation.*

2-m Air Temperature Climatology: Overland only, 1989-2006 [Limited by CRU]

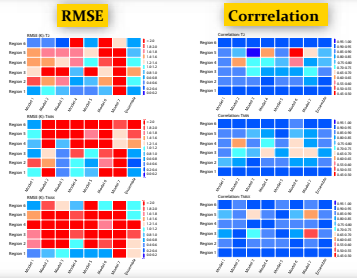


Overland-means (K)

Data	$T2_{AVG}$	$T2_{MIN}$	$T2_{MAX}$
CRU	297	290	303
M01	296	290	303
M02	297	292	303
M03	296	290	302
M04	297	291	304
M05	296	290	303
M06	298	293	304
M07	293	288	298
ENS	296	290	302

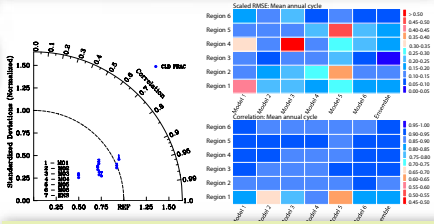
- Spatial patterns of the all three 2-m temperature fields agree closely with the CRU analysis
  - Spatial pattern correlation is generally higher than precip.

2-m Air Temperature Climatology: Annual Cycle in sub-regions



- All models generate spatial patterns of the observed 2-m air temperatures reasonably
- Model performance in simulating 2-m temperatures also vary according to regions.
- *Performance of model ensemble is consistently among the best terms of RMSE, bias, and pattern correlation.*

Cloudiness (2001-2008)



- All models also generate spatial patterns of the observed cloudiness reasonably
- *Like for precipitation and 2-m air temperatures, performance of model ensemble is consistently among the best in terms of RMSE, bias, and pattern correlation.*

Summary
1. Multi-RCM preliminary CORDEX-Africa hindcast data are evaluated against available REF data using RCMES
2. Most RCMs simulate the observed characteristics in precipitation, 2-m air temperatures and cloudiness.
3. Model performance varies according to regions
4. Intuitive presentation schema is useful for visualizing model performance.
5. ***The model ensemble consistently performs among the in terms of RMSE, bias, and pattern correlation***
6. ***More rigorous evaluation of a larger set of model variables & variable-weight model ensemble will be performed & applied to obtain ensemble climate change signals for the CORDEX-Africa region.***