Projection Results from the CORDEX Africa Domain

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Based on presentations by
Grigory Nikulin and Erik Kjellström
ARB-44 is synchronized to AFR-44: the same grid boxes. Resolution of 0.44 deg corresponds to approximately 50 km.
ARB-44 simulations with RCA4

Boundary conditions using:

Reanalysis:
ERA-Interim (ECMWF) reanalysis (1979-2010) is done
ARB-44 simulations with RCA4

Boundary conditions using:

Reanalysis:
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- For a reanalysis a weather forecast model is ran for a long period. Meanwhile, any available observations are used to correct the forecast each 6th hour continually during the simulation (data assimilation).
- Observations can be based on satellite, radio sonde, aircraft, ground based,…
- A few variables are closely connected to the observations, like T2m, surface air pressure, temp and wind in atmosphere.
- Many variables are purely model products, like precipitation, radiation, energy fluxes, although they still depend on the assimilated variables.
- A reanalysis represents the best available consistent atmospheric state each 6th hour.
ARB-44 simulations with RCA4

Boundary conditions using:

Reanalysis:
ERA-Interim (ECMWF) reanalysis (1979-2010) is done

GCM historical (1950-2100):
EC-Earth (Europe) started
CNRM-CM5 (France) started
GFDL-ESM2M (USA) started

GCM projections (2006-2100):
EC-Earth (Europe) RCPs 45 & 85 to be done
CNRM-CM5 (France) RCPs (45) & 85 to be done
GFDL-ESM2M (USA) RCPs (45) & 85 to be done
HadGEM (UK) RCPs (45) & (85) to be done
Computer resources with RCA4

Africa CORDEX domain

Domain description:
222x222x40 grid boxes with 0.4deg resolution, time step 15 min

Examples on SMHI computer cost per 1 year simulation:
Linux cluster ekman: 10.6 hours (100 parallel processors)
Linux cluster gimle: 5.4 hours (100 parallel processors)
---> 140 years takes 1 month on gimle
Africa CORDEX domain

Domain description:
222x222x40 grid boxes with 0.4deg resolution, time step 15 min

Examples on SMHI computer cost per 1 year simulation:
Linux cluster ekman: 10.6 hours (100 parallel processors)
Linux cluster gimle: 5.4 hours (100 parallel processors)
--> 140 years takes 1 month on gimle

Domain description:
646x648x40 grid boxes with 0.15deg resolution, time step 10 min

Examples on SMHI computer cost per 1 year simulation:
Linux cluster gimle: 4.8 days (100 parallel processors)
--> 140 years takes 1 year and 10 month on gimle

Thus, resolution increases 3 times and computer time increases 21 times.

RCA4 can be setup on a Linux laptop for less expensive process studies!
All input data here are global. Thus, we can set up RCA over any regional domain and run.

Physiography (orography/terrain, vegetation, soil): 1.5 TB

Atmospheric boundary data for input (wind, temp, humidity) + SST and ice each 6th hour:

ERA-Interim (1979-2011): 2.6 TB
GFDL-ESM2M (1950-2100): 1.8 TB
EC-Earth (1950-2100): 8.1 TB
--> ~16 TB for 8 GCMs

CORDEX output from RCA: 1.8 TB
--> 23 TB for CORDEX Africa 0.44 at Rossby Centre (8 GCMs)
RCA4 code management

RCA4 (and most other climate models) is written in Fortran and C++ code languages.

100,000 lines of code.

We are using a version control system (subversion) to organize code development.

You need to be experienced in Linux/Unix systems to run the model and you need to be an experienced computer programmer in Fortran and C++ to understand and develop the code.
ARB-44 RCA4 ERA-Interim

Atlas Mountain

East Mediterranean land

Arabian Peninsula

RCA

ERA-Int

CRU

Udel

GPCC6
AFR-44 simulations in CORDEX

Arctic

Antarctic
Uncertainties in observed prec

Precipitation bias relative to GPCP (JFM, 1998-2008)

- Large difference between GPCP and TRMM (adjusted to different gauge products)
- ERA-Interim has the largest biases (precipitation is not assimilated with obs.)
too few or no gauge stations for all months over large regions
quality of gridded gauge based precipitation ??????
CMIP5 boundary conditions at RC

All rcp45 and 85 (CMIP5):

- EC-Earth (Europe)
- CanESM (Canada)
- CNRM-CM5 (France)
- HadGEM2-ES (UK)
- NorESM1-M (Norway)
- MIROC5 (Japan)
- GFDL-ESM2M (USA)
- MPI-ESM-LR (Germany)
- IPSL-CM5A (France)
- CSIRO-MK3 (Australia)

RC CORDEX domains:
Africa, Europe, Arctic, Arab, South America, South Asia
<table>
<thead>
<tr>
<th>GCM CMIP5</th>
<th>Historical 1950-2005</th>
<th>RCP8.5 2006-2100</th>
<th>RCP4.5 2006-2100</th>
<th>RCP2.6 2006-2100</th>
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</table>

✓ Completed  ✓ Running  ✓ Planned
Projected temperature changes

RCA4(6GCMs) ensemble mean (annual)

2m Temperature (tas) | ANN | RCA4(GCMs)

CTL | SCN1 - CTL | SCN2 - CTL | SCN3 - CTL

RCP45

RCP85

°C SCN - CTL

°C
Projected temperature changes

RCA4(6GCMs) ensemble mean (seasonal)

Temperature
RCP 8.5
2071-2100 vs 1971-2000

°C SCN - CTL
Projected temperature trends

2m Temperature anomalies wrt 1970-2000 | 31-yr. mov. mean | (tas) | ANN | Africa (AFR) 20W-50E 40S-35N | land

- RCA4 (CanESM2)
- RCA4 (CNRM-CM5)
- RCA4 (NorESM1-M)
- RCA4 (EC-EARTH)
- RCA4 (MIROC5)
- RCA4 (HadGEM2-ES)
- ENS. MEAN

°C

Year

1980 2000 2020 2040 2060 2080

0 1 2 3 4 5 6

0 1 2 3 4 5

AFRICA DOMAIN (CORDEX), 1°x1°, 0.44 deg, 504 km
Projected precipitation changes

RCA4(6GCMs) ensemble mean (annual)

Precipitation (pr) | ANN | RCA4(GCMs)
Projected precipitation changes

RCA4(6GCMs) ensemble mean (seasonal)

Precipitation
RCP 8.5
2071-2100 vs 1971-2000
Thank you!

شكرًا لاهتمامكم

THANKS!