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**D3.5.1 RCM simulation plan (RT3/WP3.5, AMMA region)**

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|---|---|---|
| **Dissemination Level** | | |
| **PU** | Public | √ |
| **PP** | Restricted to other programme participants (including the Commission Services) | |
| **RE** | Restricted to a group specified by the consortium (including the Commission Services) | |
| **CO** | Confidential, only for members of the Consortium (including the Commission Services) | |

# Simulation plan for the RT3 non-European region

As previously reported (M3.6), and following a dialogue with the EU-AMMA project, the RT3/WP3.5 regional climate model simulations for the non-European region target the region of Western Africa. This specification of the simulations enables a co-ordinated RT3-effort in WP3.5, and is also used to inform external collaborations.

These RT3/WP3.5 efforts include two modelling and evaluation streams:

S1) 10 RCM "evaluation" simulations (based on ERAINTERIM to the degree possible, complemented with ERA-40 or ECMWF analyses so as to cover the period of 1988-2007[1]).

S2) 10 scenario simulations (for 1990-2050 and A1B), using boundary conditions from a sub-set of the ENSEMBLES GCMs.

Both of these streams of RCM runs are done using 50 km grid spacing. The evaluation of the RCM runs is co-ordinated with other projects, such as EU-AMMA and WAMME. The 10 RCM groups in the table below contribute to the runs.

**Participating groups/RCMs**

| Institution | Model |
|-------------|-------|
| DMI | HIRHAM |
| SMHI | RCA3 |
| KNMI | RACMO2 |
| ICTP | RegCM |
| METO-HC | HadRM |
| MPIMET | REMO |
| UCLM | PROMES |
| INM | RCA3 |
| Met.no | HIRHAM |
| CHMI/CUNI | ALADIN CY28T3 |

**Model domain**

The RT3/WP3.5 RCM model domains will cover the area of 35°W-35°E, 20°S-35°N. (Shown in the figure below. The colour scale follows the surface geopotential, i.e. the orography.)
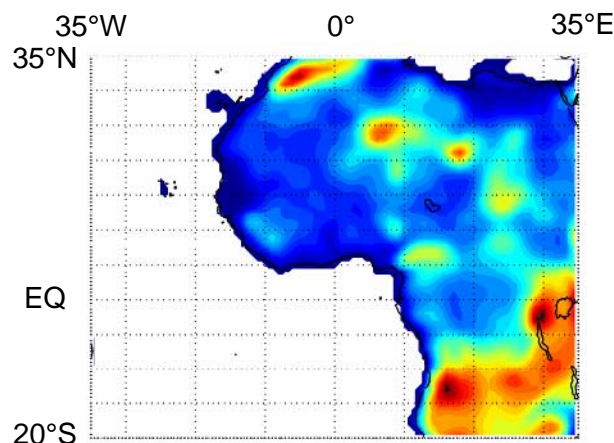


Identical grid specifications (perfect overlap for the RCMs with rotated lat/lon grids, and as perfect overlap as possible for the other RCMs) are applied.

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[1]The focus will be on the period since 2000 (cf. AMMA data availability), but it is nevertheless preferred to start in 1990 so as to obtain longer evaluation runs and a better overlap with the transient scenario runs.

As in RT3/WP3.1, this domain is the common "minimum domain" for the RCMs. Groups are free to choose a larger domain, as long as it covers the minimum domain with an overlapping grid as meant above.

**Period**

S1) the "evaluation" simulations will cover the period 1989-2007). A three-year spin-up should be carried out prior to these years. The start in 1989 is the starting year of the ERAINTERIM data. Consequently, alternative data can be used for the spin-up (e.g. ERA40 or a three-year perpetual simulation of 1989). Also, groups are free to opt for 1988-2007, i.e. achieve a full two decades of effective simulations. As above, this of course necessitates complementing ERAINTERIM with ERA40.

S2) the scenario runs will cover the period 1990-2050, partially overlapping that used in RT2B for Europe. Boundary conditions are chosen from a suitable ENSEMBLES GCM, or GCMs, and the A1B SRES emission scenario. Preferable GCMs are ECHAM5 and HadCM3. Other GCMs can be considered by the participating groups in case of technical reasons. In this case, preferably the same GCM as used for the European domain by the group in question should be chosen.

Again, there should be three year spin-up, before simulation of the year 1990.

**Output/diagnostics**

Each RCM should provide the common minimum output, conforming to the RT3/WP3.1 common minimum output (copied below. However, see the RT3 home page for possible updates). After finished simulations, the groups submit their data to the ENSEMBLES RCM database at DMI. Optional/additional fields are stored locally.

The dialog with EU-AMMA in late 2007/early 2008 was based on the above-mentioned RT3/WP3.1 common minimum output list and the specific impact study needs of EU-AMMA. Their collated response is contained in the table below.

| Meteorology | | Resolution | Coverage |
|---|---|---|---|
| **Output** | **Requested by WP** | **Temporal** | **Temporal** |
| Maximum Temp (in °C) | 3.1;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Minimum Temp (in °C) | 3.1;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Average Temp (in °C) | 3.1;3.2;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Maximum humidity (%) | 3.1;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Minimum humidity (%) | 3.1;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Average humidity (%) | 3.1;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Wind at 2 meter (m/s) | 3.1;3.2;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Global radiation (MJ/m²/day) | 3.1;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Daily Insolation (decimal hour) | 3.1;3.3;3.4 | Daily - or sub-daily | 1986-2050 |
| Potential evapotranspiration | 3.1;3.3;3.4;5.2 | Daily - or sub-daily | 1986-2050 |
| Daily Precipitation (mm) | 3.1;3.2;3.3;3.4;5.2 | Daily - or sub-daily | 1986-2050 |

It can be noted that compared to the requested variables, the RCM simulation specifications differ in few respects, for technical and other practical reasons:

- the RCM output will cover 1989-2050

- the RCM output has wind at 10 m altitude, rather than at 2 m

- relevant radiation output is provided as downward and net shortwave and longwave radiation components at the surface, complemented with sunshine hours

- evaporation is provided by all RCMs, whereas evapotranspiration and, in particular, potential evapotranspiration is an optional one (not modelled in all RCMs; when modelled, the definition might vary).

The alternative to using the actual evaporation as simulated by an RCM, or the RCM-calculated potential evapotranspiration when available, is to use formula based on temperature etc. A few such are available. One is of course the Thornthwaite water balance method (Thornthwaite 1948). However, as it has been found in some applications to lead to excessive impact estimates under climate change scenarios, Hargreave's equation, a temperature-based estimates of potential evaporation might be an option. (See Hargreaves, G.H., Allen, R.G. 2003. History and evaluation of Hargreaves evapotranspiration equation. *J. Irrig. Drain. Eng. 129,* 53-63.)

The Penman-Monteith formula is commonly used in many impact models. As some of the output that would be needed is not available from the RCMs, an alternative formulation of the formula would need to be used here. FAO provides guidance on this (Christian Baron, CIRAD-Bios, personal communication).

RT3/WP3.5 will have a dialogue with the EU-AMMA users of the RCM output on how to match the available RCM simulation results with the needed input to impact models.

**External forcings**

The choice of which external forcings are used in each RCM (e.g. GHG concentration, land-use types) is left unspecified, but they need to be documented. Each RCM applies its own land surface fields. The temporal evolution of greenhouse gas concentrations should be accounted for in each RCM in both modelling streams (S1, S2). Additional external forcings that may be applied include a variable solar constant, estimates of aerosol forcing and land use change. Chosen external forcings should in (S1) conform to actual ones.

The future climate simulations (S2) will focus on the early decades of the 21$^{st}$ century, until 2050. The external GHG forcing will conform to the SRES A1B.

**Model evaluation and analysis focus**

The focus of the RCM evaluation will be on the model skill in simulating the main features of the West African Monsoon and the value added by RCMs compared to the driving GCMs. Evaluation will consider "basic" climate variables (temperature, precipitation), selected key physical climate processes and selected variables in focus in impact studies. Systematic biases in climate model simulations for the region are expected to be identified.

Evaluation data available by EU-AMMA will be used. Indeed, the RCM simulations will be evaluated in dialogue with EU-AMMA, in particular when focusing on climate features of relevance for impact applications. A special focus will be given to the model analysis against data available for the AMMA special observing system.

The emphasis of the analysis of the scenario simulations (S2) will be on the possibility of applying the same probabilistic approach developed under WP3.3. Since this region is characterized by a wide range of GCM responses to GHG forcing, it will be critical to assess the uncertainty associated to the simulated changes as well as how this uncertainty is increased or reduced by the use of a set of RCMs.

**Timetable**

- WP3.5 RCM test simulations start after the finalisation of this specication, i.e. April 2008.

- All WP3.5 RCM runs (S1, S2) should be finalised and submitted to the ENSEMBLES RCM database at DMI, so that they are available by Month 54 (February 2009, *cf.* D3.5.2).

- The ENSEMBLES RCM evaluation should be completed by the end of the project (August 2009, *cf.* D3.5.3).

# APPENDIX 1

| Symbol | 1h/3h/6h/ 12h | X-hourly instantaneous output |
| | 1hc/3hc/6hc | output averaged/accumulated/min/max over X hours |
| | d | instantaneous daily output |
| | dc | averaged/accumulated/min/max daily output as average over all time steps |
| | dci | averaged/accumulated/min/max daily output as average over hourly/3-hourly instantaneous values |
| | m | monthly mean |
| | f | fixed fields |

| Field name | short name (PCMDI + extensions) | MKS Units CF Standard | RT3 (to be submitted to the data server) | Optional | Remarks | Cell_methods | CF stdname |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **1) Near-surface data** | | | | | | | |
| 2-meter temperature | tas | K | **dci** | **1h/3h** | | time: mean | air_temperature |
| Daily maximum 2-m temperature | tasmax | K | **dc** | | | time: maximum | air_temperature |
| Daily minimum 2-m temperature | tasmin | K | **dc** | | | time: minimum | air_temperature |
| Max Surface temperature (soil) | tsosmax | K | **dc** | **1h/3h** | | time: maximum | soil_temperature |
| Min Surface temperature (soil) | tsosmin | K | **dc** | | | time: minimum | soil_temperature |
| Surface temperature | ts | K | **dci** | **1h/3h** | | time:mean | surface_temperature |
| Sea surface temperature | sst | K | **d at 0 UTC** | | | | sea_surface_temperature |
| 10-meter U wind | uas | m s-1 | **dci** | **1h/3h** | | time: mean | eastward_wind 1) |
| 10-meter V wind | vas | m s-1 | **dci** | **1h/3h** | | time: mean | northward_wind 1) |
| 10-meter wind speed | wss | m s-1 | **dci** | **1h/3h** | | time: mean | wind_speed |
| 10-meter daily max. wind speed, without gust | wssmax | m s-1 | **dc** | | | time: maximum | wind_speed |
| 10-meter daily max. wind speed incl. gust | wsgsmax | m s-1 | **dc** | | | time: maximum | wind_speed_of_gust |
| 2-meter specific humidity | huss | kg kg-1 | **dci** | **1h/3h** | | time: mean | specific_humidity |
| 2-meter relative humidity | hurs | 1 | **dci** | **1h/3h** | | time: mean | relative_humidity |
| Daily maximum 2-m relative humidity | hursmax | 1 | **dc** | | | time: maximum | relative_humidity |
| Daily minimum 2-m relative humidity | hursmin | 1 | **dc** | | | time: minimum | relative_humidity |
| 2-meter dew point temperature | tdps | K | **dci** | **1h/3h** | | time: mean | dew_point_temperature |
| Mean sea level pressure | psl | Pa | **dci** | **1h/3h** | | time: mean | air_pressure_at_sea_level |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Surface pressure | ps | Pa | dci | 1h/3h | | time:mean | surface_air_pressure |
| Surface pressure | ps | Pa | 6h | | | | surface_air_pressure |
| | | | | | | | |
| Precipitation | pr | kg m-2 s-1 | dc | 1hc | | time: mean | precipitation_flux |
| Max hourly precipitation rate | prhmax | kg m-2 s-1 | dc | | Defined as the precip rate averaged over the whole hour with the highest precip amount | time: mean within hours time: maximum over hours | precipitation_flux |
| Large-scale precipitation | prls | kg m-2 s-1 | dc | | | time: mean | large_scale_precipitation_flux |
| Convective precipitation | prc | kg m-2 s-1 | dc | | | time: mean | convective_precipitation_flux |
| Column water vapour content | prw | kg m-2 | dc | | | time: mean | atmospher_water_vapor_content |
| Column condensed water content (liquid+ice) | clwvi | kg m-2 | dc | | | time: mean | atmosphere_cloud_condensed_water_content |
| Column cloud ice content | clivi | kg m-2 | dc | | | time: mean | atmospher_cloud_ice_content |
| Snowfall | prsn | kg m-2 s-1 | dc | | | time: mean | snowfall_flux |
| Large-scale snowfall | prsnls | kg m-2 s-1 | dc | | | time: mean | large_scale_snowfall_flux |
| Convective snowfall | prsnc | kg m-2 s-1 | dc | | | time: mean | convective_snowfall_flux |
| Evaporation | evspsbl | kg m-2 s-1 | dc | 1hc/3hc | | time: mean | water_evaporation_flux |
| Potential evapotranspiration | evspsblpot | kg m-2 s-1 | | dc | If available, provide a definition | time:mean | water_potential_evaporation_flux |
| Total cloudiness (Fraction) | clt | 1 | dc | | | time:mean | cloud_area_fraction |
| Upward sensible heat flux at surface | hfss | W m-2 | dc | 1hc/3hc | | time: mean | surface_upward_sensible_heat_flux |
| Upward latent heat flux at surface | hfls | W m-2 | dc | 1hc/3hc | | time: mean | surface_upward_latent_heat_flux |
| Momentum flux in U-direction | tauu | Pa | dc | 1hc/3hc | | time: mean | surface_downward_eastward_stress 1) |
| Momentum flux in V-direction | tauv | Pa | dc | 1hc/3hc | | time: mean | surface_downward_northward_stress 1) |
| Soil heat flux | hfso | W m-2 | dc | 1hc/3hc | | time: mean | downward_heat_flux_in_soil |
| Net SW surface radiation | rss | W m-2 | dc | 1hc/3hc | | time:mean | surface_net_downward_shortwave_flux |
| Downward SW surface radiation | rsds | W m-2 | dc | 1hc/3hc | | time: mean | surface_downwelling_shortwave_flux_in_air |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Net LW surface radiation | rls | W m-2 | **dc** | **1hc/3hc** | | time: mean | surface_net_downward_longwave_flux |
| Downward LW surface radiation | rlds | W m-2 | **dc** | **1hc/3hc** | | time: mean | surface_downwelling_longwave_flux_in_air |
| Top net SW | rst | W m-2 | **dc** | **1hc/3hc** | | time: mean | toa_net_downward_shortwave_flux |
| Top downward SW radiation | rsdt | W m-2 | **dc** | **1hc/3hc** | | time: mean | toa_incoming_shortwave_flux |
| Top net LW | rlut | W m-2 | **dc** | **1hc/3hc** | | time: mean | toa_outgoing_longwave_flux |
| Sunshine duration | sund | s | **dc** | | Time with above 120 W m-2 direct sunlight on surface perpendicular to sun beam | time: sum | duration_of_sunshine |
| Moisture of upper 0.1 m soil layer | mrsos | kg m-2 | **dc** | | | time: mean | moisture_content_of_soil_layer |
| Total soil moisture content | mrso | kg m-2 | **d at 0 UTC** | | | soil_layers: sum | soil_moisture_content |
| Surface snow amount | snw | kg m-2 | **d at 0 UTC** | | | | surface_snow_amount |
| Fractional snow cover | snc | 1 | **dc** | | | time: mean | surface_snow_area_fraction |
| Total runoff | mrro | kg m-2 s-1 | **dc** | | No need to store if equal to the sum of "Surface runoff" and "Drainage" | time: mean | runoff_flux |
| Surface runoff | mrros | kg m-2 s-1 | **dc** | **1hc/3hc** | | time: mean | surface_runoff_flux |
| Drainage (deep runoff) | mross | kg m-2 s-1 | **dc** | **1hc/3hc** | | time: mean | subsurface_runoff_flux |
| Surface albedo | as | 1 | **dc** | | | time: mean | surface_albedo |
| Sea ice fraction | sic | 1 | **d at 0 UTC** | | | | sea_ice_area_fraction |
| **2) Atmosphere, 3-D fields** | | | | | | | |
| **2.1) Variables** | | | | | | | |
| T | ta | K | | | | | air_temperature |
| U | ua | m s-1 | | | | | eastward_wind 1) |
| V | va | m s-1 | | | | | northward_wind 1) |
| Omega | wap | Pa s-1 | | | | | lagrangian_tendency_of_air_pressure |
| Z | zg | m | | | | | geopotential_height |
| Q | hus | kg kg-1 | | | | | specific_humidity |
| Cloud condensed water (liquid + ice) | clwi | kg kg-1 | | | Note change! Now includes | | mass_fraction_of_condensed_water_in_air |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | ice. | | |
| Cloud ice | cli | kg kg-1 | | | | | mass_fraction_of_cloud_ice_in_air |
| Relative humidity RH | hur | 1 | | | | | relative_humidity |
| Cloud area fraction in atmosphere layer | cl | 1 | | | May not be relevant when interpolated to pressure levels | | cloud_area_fraction_in_atmosphere_layer |
| | | | | | | | |
| **2.2) On all model levels** | | | | **6h/12h** | | | |
| | | | | | | | |
| **2.3) On interpolated pressure levels** | | | | | | | |
| 10 hPa | | | | | | | |
| 20 hPa | | | | | | | |
| 30 hPa | | | | | | | |
| 50 hPa | | | | | | | |
| 70 hPa | | | | | | | |
| 100 hPa | | | **d at 0 UTC** | **6h** | If 6h data is stored on model levels, the optional storing of the same 6h data at pressure levels might not be needed | | |
| 150 hPa | | | | | | | |
| 200 hPa | | | | | | | |
| 250 hPa | | | | | | | |
| 300 hPa | | | **d at 0 UTC** | **6h** | See above | | |
| 350 hPa | | | | | | | |
| 400 hPa | | | | | | | |
| 500 hPa | | | **d at 0 UTC except: Z 6h** | **6h** | See above | | |
| 600 hPa | | | | | | | |
| 700 hPa | | | **d at 0 UTC except: RH 6h (*) U,V 12h** | **6h** | See above | | |
| 800 hPa | | | | | | | |
| 850 hPa | | | **d at 0 UTC except: RH 6h (*) U,V 12h** | **6h** | See above | | |
| 900 hPa | | | | | | | |
| 925 hPa | | | **d at 0 UTC except: RH 6h (*)** | **6h** | See above | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 950 hPa | | | | | | |
| 1000 hPa | | | **d at 0 UTC except: Z, RH 6h (*)** | **6h** | See above | |
| | | | | | | |

| **ISCCP Cloudiness OR full cloud cover profile** | | | | | | |
|---|---|---|---|---|---|---|
| Low (recommendation: Psurfq – 0.8*Psurf) | clisccp | | **dc** | | 2) | clev: sum(asssuming ISCCP cloud cover definition) time: mean | isccp_cloud_area_fraction_in_atmosphere_layer |
| Medium (recommendation: 0.8*Psurf – 0.45*Psurf) | | | **dc** | | 2) | | |
| High (recommendation: 0.45*Psurf – 0 hPa) | | | **dc** | | 2) | | |

| **3) Soil/Ice (3-D)** | | | | | | |
|---|---|---|---|---|---|---|
| Soil temperature (profile on model levels) | tso | K | **d at 0 UTC** | **1h/3h** | | soil_temperature |
| Soil moisture (profile on model levels) | mrsos | kg m-2 | **d at 0 UTC** | | | moisture_content_of_soil_layer |
| Sea ice temperature profile | tsi | K | **d at 0 UTC** | | | sea_ice_temperature |

| **4) Fixed Fields** | | | | | | |
|---|---|---|---|---|---|---|
| Land area fraction of grid cell | sftls | 1 | **f** | | | land_area_fraction |
| Orography | orog | m | **f** | | | surface_altitude |
| Land use fields | lco | 1 | **f** | | | land_cover |
| Field capacity (mass related) | mrsofc | kg m-2 | **f** | | | soil_moisture_content_at_field_capacity |
| Field capacity (volume fraction) | vfwsofc | 1 | **f** | | If field capacity cannot be stored in mass related form, use volume fraction. | volume_fraction_of_water_in_soil_at_field_capacity |
| Wilting point | vfwsowp | 1 | **f** | | | volume_fraction_of_water_in_soil_at_wilting_point |
| Porosity | ptso | 1 | **f** | | | soil_porosity |

| **Dynamical output data** | | | | | | |
|---|---|---|---|---|---|---|
| UGEO at 850 and 500 hPa | ugeo | m s-1 | | **dc** | | geostrophic_eastward_wind |
| VGEO at 850 and 500 hPa | vgeo | m s-1 | | **dc** | | geostrophic_northward_wind |
| Potential vorticity at 315, 330, 350, 380 and 405 K | vorpot | K m2 kg-1 s-1 | | **dc** | | ertel_potential_vorticity |
| UQ | mpuqa | m s-1 | | **dc** | | product_of_eastward_wind_and_specific_humidity 1) |

| | | | | | | |
|---|---|---|---|---|---|---|
| VQ | mpvqa | m s-1 | | **dc** | | product_of_northward_wind_and_specific_humdity 1) |
| UT | mputa | K m s-1 | | **dc** | | product_of_eastward_wind_and_air_temperature 1) |
| VT | mpvta | K m s-1 | | **dc** | | product_of_northward_wind_and_air_temperature 1) |
| **Coordinates** | | | | | | |
| Rotated longitude, 1D | rlon | degrees | | | | grid_longitude 3) |
| Rotated latitude, 1D | rlat | degrees | | | | grid_latitude |
| Actual longitude, 2D | lon | degrees | | | | longitude |
| Actual latitude, 2D | lat | degrees | | | | latitude |
| Time | time | days since 1950-01-01 OR months since 1950-01 | | | | Julian day OR month 3) |

1) These winds are not rotated to the RCM grid, but are real north- and eastward winds!

2) Collect into one file with 3 height levels. Definition of variable isccp_cc(clev,rlat,rlon)
dimension clev=3; float clev(clev) (units= 1) the field clev takes the values 0.225, 0.625, 0.9
(centers). Clev: bounds="clev_bounds"; clev: comment="sigma level".
Need also a dimension bounds=2; float clev_bounds (clev,bounds) with values
((0,0.45),(0.45,0.8), (0.8,1.0)).. Remember to do the time averaging
after the participation of clouds into the 3 levels, since Psurf is time dependent…

3) Also remember the attribute section rotated_pole, which e.g. for the standard
50km grid is something like: char rotated_pole;  grid_mapping_name
= "rotated_latitude_longitude"; grid_north_pole_latitude = 39.25f; grid_north_pole_longitude
= -162.0f

4) For all temporally averaged fields there needs to be (2,ntimes) array time_bnds
that contain bounds for the averaging in the same units as time. Then the time
variable needs an attribute time: bounds = time_bnds