Project no. GOCE-CT-2003-505539

Project acronym: ENSEMBLES

Project title: ENSEMBLE-based Predictions of Climate Changes and their Impacts

Instrument: Integrated Project

Thematic Priority: Global Change and Ecosystems

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

Due date of deliverable: February 2008
Actual submission date: March 2008

Start date of project: 1 September 2004 Duration: 60 Months

Organisation name of lead contractor for this deliverable: SMHI/ICTP

Revision [Final]

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)

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.

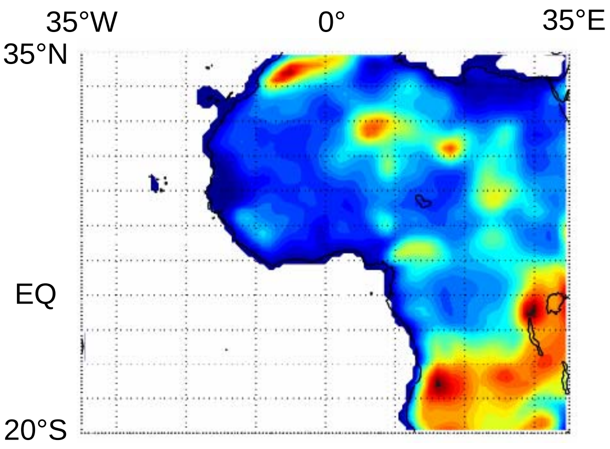
Both of these streams of RCM runs are done using 50 km grid spacing. The evaluation of the RCM runs is co-ordinated with other projects, such as EU-AMMA and WAMME. The 10 RCM groups in the table below contribute to the runs.

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.

[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 21st 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_hunidity
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**		If field capacity cannot be stored in mass related form, use volume fraction.		soil_moisture_content_at_field_capacity
Field capacity (volume fraction)	vfwsofc	1	**f**				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