Project No:603502

DACCIWA

"Dynamics-aerosol-chemistry-cloud interactions in West Africa"

Deliverable

D 2.2 Model Development

Due date of deliverable:	31/03/2017
Completion date of deliverable:	03/08/2017
Start date of DACCIWAproject:	1st December 2013 **Project duration:** 60 months
Version:	[V1.0]
File name:	[D_2.2_Model_Development_DACCIWA_v1.0.pdf]
Work Package Number:	**2**
Task Number:	**2**
Responsible partner for deliverable:	**UPS**
Contributing partners:	**UoY**
Project coordinator name:	Prof.Dr. Peter Knippertz
Project coordinatororganisationname:	Karlsruher Institut für Technologie

The DACCIWA Project is funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 603502.

Dissemination level		
PU	Public	**x**
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)	

Nature of Deliverable		
R	Report	**x**
P	Prototype	
D	Demonstrator	
O	Other	

Copyright

This Document has been created within the FP7 project DACCIWA. The utilization and release of this document is subject to the conditions of the contract within the 7th EU Framework Programme. Project reference is FP7-ENV-2013-603502.

DOCUMENT INFO

Authors

Author	Beneficiary Short Name	E-Mail
Cathy LIOUSSE	UPS	Catherine.Liousse@aero.obs-mip.fr
N'Datchoh Evelyne TOURE	UPS/UFHB	ndatchoheve@yahoo.fr
Laurent ROBLOU	UPS	laurent.roblou@aero.obs-mip.fr

Changes with respect to the DoW

Issue	Comments
Deley of deliverable	Due to some unexpected technical problems with the simulation. Delay was communicated to and approved by the PO (Ares(2017)3093496)

Dissemination and uptake

Target group addressed	Project internal / external
Scientific	Internal and external

Document Control

Document version #	Date	Changes Made/Comments
0.1	21.02.2017	Template with first structure
1.0	03.08.2017	Final version

Table of Contents

Introduction

The Regional Climate Model version 4 (RegCM4) from International Centre for Theoretical Physics has been used to conduct this research work. RegCM4 is a hydrostatic model with compressible sigma-p vertical coordinates that uses the dynamic core of Mesoscale Meteorological Model version 5 (MM5) from the National Centre of Atmospheric/Pennsylvania state University (NCAR/PSU's MM5; Grell et al., 1994). The Regional Climate Model (RegCM) has been widely used in Africa for several studies on climate variability, aerosols and their impact with good performance (Sylla et al., 2009; Konare et al., 2008; Solmon et al., 2008, 2012; Zakey et al., 2006, Tummon et al., 2010, Malavelle et al., 2011). Its accessibility and large community support contribute to its wide usage in several research teams on the African continent and overseas. These works are generally performed at quite coarse spatial resolution of 30 – 50 km with focus on dust, carbonaceous and sulphate aerosols using simple to complex chemistry (Solmon et al., 2006; Konare et al., 2008; Touré et al., 2012; Shalaby et al., 2012) options. In the DACCIWA WP2 work, the purpose was to adapt RegCM4 to be used for air pollution and health impact studies in West Africa. Therefore, one challenge assigned in this task was first to setup the finer resolution possible with a hydrostatic model like RegCM4 for PM2.5 calculation. Also, in the current version of RegCM4, the secondary organic carbon aerosol (SOC) portion is obtained by multiplying the primary organic carbon (OC) output by a constant factor of 1.4. Thus, our aim is to improve this parameterization by considering SOC formation as a function of OC sources. Finally, two options are now proposed in RegCM4 model to derive inorganic aerosols: (1) a simple parameterization transforming SO2 into SO4 (called AERO) and (2) a more complete option (DCCB) including all the inorganic species from thermodynamical calculations. These options will be compared over Africa in terms of performances and simulation time. In this report, we will present all sensitivity tests and model setup, performed for the year 2005. A validation run will be then proposed for the year 2015, with our best configuration choices and with the first results of DACCIWA-WP2 in terms of emissions (Task 2.1) and experimental results (task 2.3).

1 Sensitivity tests

The following configurations for RegCM4 and forcing emissions data were used for the sensitivity tests performed for the year 2005.

Year	2005
Spatial resolutions	15 km x 15 km and 25 km x 25 km
Land surface	Biosphere-Atmosphere Transfer Scheme (BATS, Dickinson et al., 1993).
Convection scheme	Tiedtke, (1989)
Vertical levels	23 levels
Large scale precipitation	scheme from Sundqvist et al., (1989)
Emissions	GFASv1.0 (not multiply at the source) and anthropogenic emissions including traffic, domestic fires, industries, power plant and charcoal making, from Liousse et al., (2014).
Chemistry option	AERO (Aerosol) and full chemistry (DCCB of ISORROPIA).
Dust module	4 bins dust module (Zakey et al., 2006).
Sea Salt module	2 bins sea salt (Zakey et al., 2008)
SST	Weekly Optimum Interpolation SST
Meteorological field forcing	EIN15

1.1 Sensitivity tests on spatial resolution

Several tests were conducted to define the optimal configuration to study air pollution and health impact at the regional level in Africa. Therefore, a big domain comprising the whole African continent at 25km x 25km and a small domain focusing on Western Africa only at 15km x 15km were first selected. Comparisons of these two situations (not shown here) have underlined that the smallest domain presents non-realistic particulate matter spatial distribution due to boundary condition problems and an incorrect transport of southern African area to the smallest study domain. The solution was then to define another big domain but at 15km x 15km and covering the whole Africa and to compare model scores between the two African domains; one at 25 km x 25km and the other at 15km x 15km spatial resolution.

Figure 1 shows how the spatial resolution impacts on AOD values in West Africa, for the dry season 2005. A relative difference of 20 to 40% in AOD values is observed between 15 km x 15km and 25km x 25km spatial resolution which is not negligible. Even if computation time is higher in the 15km x 15km configuration than

in the 25km x 25km configuration (22h versus 10h for one month respectively), our interest in air pollution of West African cities leads us to choose the 15km x 15km configuration for the following tests.

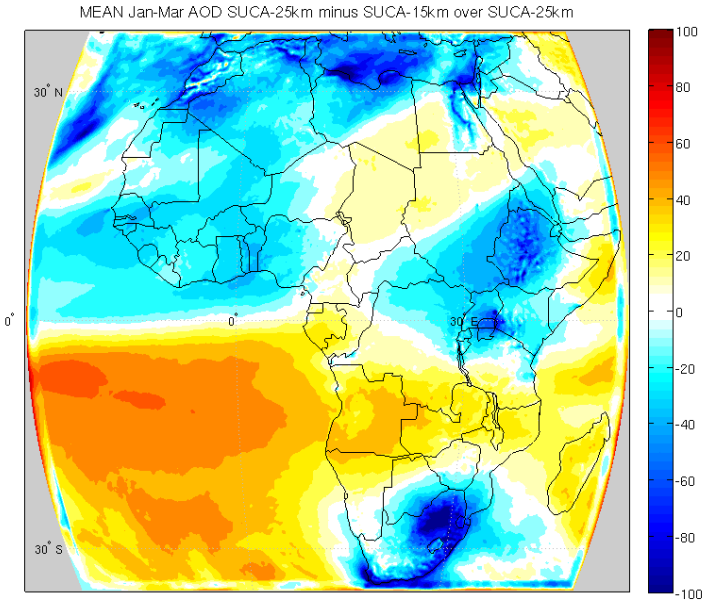

Figure 1: Resolution contribution in percentage to AOD during January to March 2005. The cold colours mean 15km x 15km is higher than 25km x 25km and hot colours means the opposite

1.2 Aerosol chemistry

Our interest is to correctly model carbonaceous particles (BC, OC), sulfate (SO4), fine particles of dust and sea salt in the purpose to obtain spatial distribution of PM2.5 surface concentration at a regional level.

RegCM4 includes a simple aerosol module called AERO taking into account carbonaceous aerosol particles (black and organic carbon) in the hydrophobic and hydrophilic state (Solmon et al., 2006), sulfate (SO2 and SO4, Quian et al., 2001) with an on-line dust (Zakey et al., 2006) and sea salt (Zakey et al., 2008) modules. Both dust and sea salt particles are emitted on-line, while carbonaceous and sulfate particles are coming from emission inventories: they are mainly injected in the first vertical layer near the surface. It is important to note that primary OC output is multiplied by 1.4 off-line to consider the secondary aerosol formation and deliver total organic carbon concentrations (Solmon et al., 2006). The model resolves the transport and interaction of 12 aerosols species with solar and infra-red spectra equations, using a radiation scheme when all aerosols particles are activated. Otherwise, RegCM4 has a gas phase parameterization (Shalaby et al., 2012) using CBMZ mechanism (Zaveri and Peters, 1999). This option includes 52 species and 24 prognostic tracers. For this parameterization, photolysis is calculated using meteorological and chemical variables such as altitude, zenith angle, ozone density, sulfate and nitrogen dioxide, surface albedo, cloud and aerosols optical properties from RegCM4. Also, in this parameterization inorganic aerosol are calculated using ISORROPIA model (Nenes et al., 1998a, b; Foutounkis and Nenes, 2007). This option called DCCB option allows to obtain 35 gases (H2SO4, HNO2, NH3, NO2, CH4, and so on ...) and 12 aerosols (BC and OC in hydrophobic and hydrophilic forms, Dust, sea salt). Carbonaceous, dust and sea salt aerosols are treated such as in the simple AERO module. In RegCM4, fine PM2.5 surface concentration (which is considered to be the sum of fine BC, POM, WS, Dust and Sea-salt) is then calculated by using the following equation (Liousse et al., 2016):

$$[PM2.5] = [BC] + 75\%[0C]\,x1.7\,x1.4 + 90\%[SO_4]\,x(1/0.43) + \left[PM2.5|_{dust}\right] + \left[PM2.5|_{seasalts}\right] \quad (1)$$

Fine BC is directly given by the model.

Fine water soluble is obtained by multiplying respectively sulphate given by the model in the AERO option by 0.90 (to consider only fine WS particles) and by 1/0.43 (to convert sulphate into water soluble particles).

Fine POM is obtained by multiplying primary OC given by the model by 0.75, 1.4 and 1.7 (to respectively consider fine particle, secondary organic aerosol formation and to convert OC into POM).

These coefficients used for the POM and the water soluble particles are sources of uncertainties and they will be investigated in the following sensitivity tests.

1.2.1 Water soluble formation: AERO / DCCB modules

Tests were conducted using AERO and DCCB parameterizations. The purpose of this work was to determine an acceptable configuration with low cost in terms of simulation hours and better model response. This allows assessing the add-value of DCCB compared to AERO parameterization. A contribution of 0 – 30 % in AOD values is observed between AERO and DCCB (figure 2) corresponding to 0 – 20% in fine particles matter (not shown here) for the whole year 2005 (Figure 2). In terms of simulation hours, the DCCB parameterization costs 3.3 times more than the AERO configuration. Therefore, the configuration AERO configuration at 15km x 15km spatial resolution with 23 vertical layers was retained for the 2015 simulations.

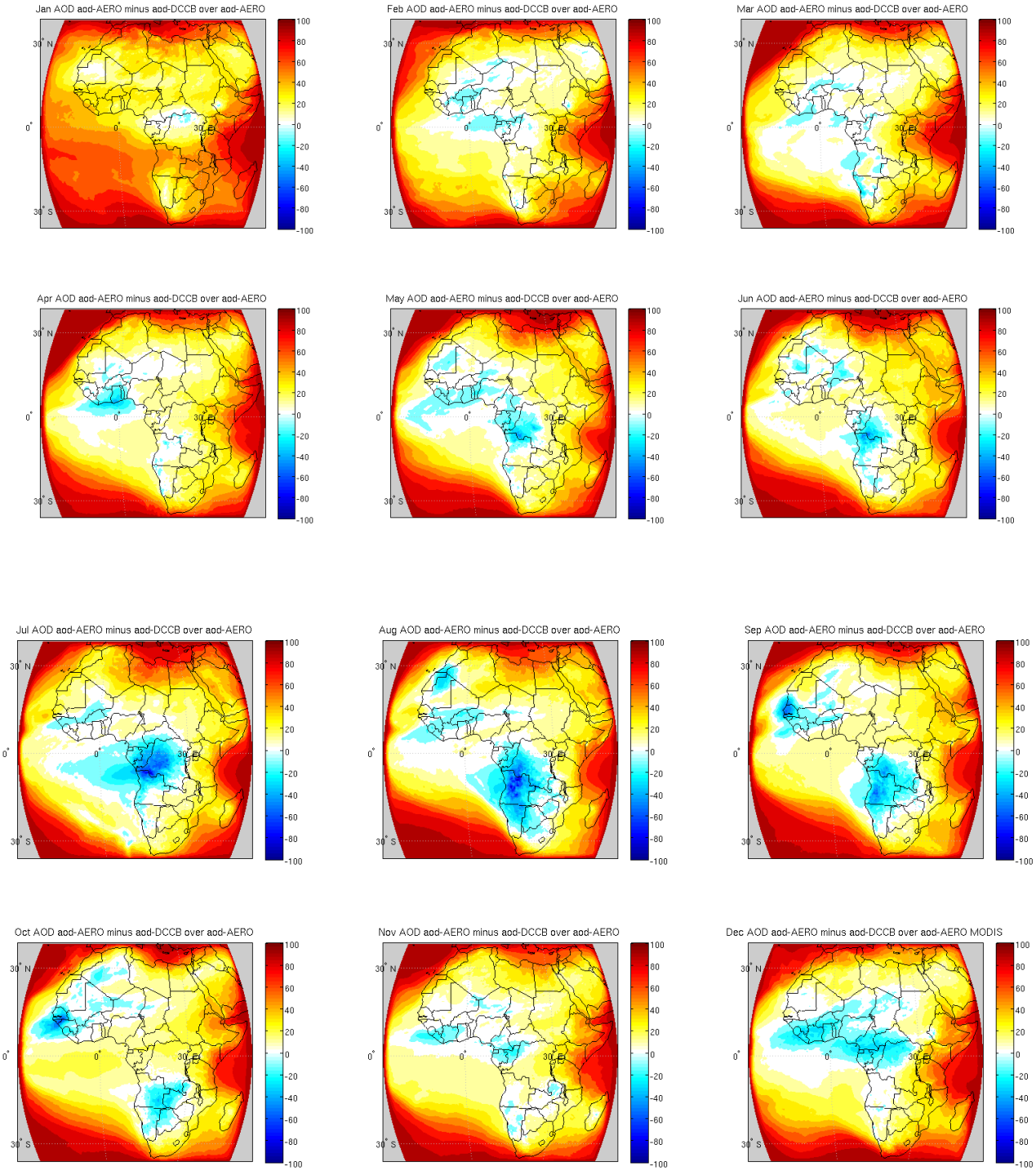

Figure 2: DCCB configuration contribution to monthly AOD compared to AERO configuration in percentage

1.2.2 Secondary Organic Aerosol formation

As previously mentioned, simulated primary OC are multiplied by 1.4 to obtain total organic carbon by including SOA formation. According to the different recent experiments measured at the sources; primary and secondary organic carbon, an exhaustive literature review was conducted. Table 1, 2 and 3 summarize $OC_{primary}/OC_{total}$ values obtained for urban/sub-urban areas (Table 1), rural/biomass burning/ biofuel (Table 2) and only biomass burning/biofuel sites (Table 3). From this compilation, the coefficients (table 4) are applied on primary OC emission sources to finally transport total OC

particles. This will allow better representation of SOC formation in the 2015 simulations. Consequently, the new PM2.5 calculation will be conducted with the following relationship:

$$[PM2.5] = [BC] + 75\%[0C] \times 1.7 + 90\%[SO_4] \times (1/0.43) + [PM2.5|_{dust}] + [PM2.5|_{seasalts}] \quad (2)$$

Table 1: OC_{prim}/ OC_{tot} for urban and traffic sources

OCp/OC	Reference	Location
0.63 (OC/EC = 1.93) (OCp/EC=1.27; mod: 1.40)	Yu et al., 2004	Urban site, Summer, North Birmingham, USA (biogenic and anthropogenic sources)
0.84 (OC/EC = 3.13) (OCp/EC=2.82; mod: 3.82)	Yu et al., 2004	Urban site, summer, Gulf-port, USA (biogenic and anthropogenic sources)
0.34 (OC/EC = 2.49) (OCp/EC=0.80; mod: 0.83)	Yu et al., 2004	Urban site, summer, Jefferson street, USA (biogenic and anthropogenic sources)
0.67 (OC/EC = 3.06) (OCp/EC=2.16; mod: 2.44)	Yu et al., 2004	Urban site Downtown Pensacola, USA (biogenic and anthropogenic sources)
0.49 (OC/EC = 3.64) (OCp/EC=1.85; mod: 1.80)	Yu et al., 2004	Suburban site Pensacola, USA (biogenic and anthropogenic sources)
0.23	Yu et al., 2004	Northeast region in USA based on IMPROVE sites and rural SEARCH sites (mixture of sources)
0.40	Yu et al., 2004	Southeast region in USA based on IMPROVE sites and rural SEARCH sites (mixture of sources)
0.34	Yu et al., 2004	Central region in USA based on IMPROVE sites and rural SEARCH sites (mixture of sources)
0.52	Yu et al., 2004	West region in USA based on IMPROVE sites and rural SEARCH sites (mixture of sources)
0.47	Yu et al., 2004	West Pacific region in USA based on IMPROVE sites and rural SEARCH sites (mixture of sources)
0.44	Yu et al., 2004	Average over USA IMPROVE sites
0.51 (OC/EC = 5.40)	Cheng et al., 2013	Central urban area in Beijing, China during Spring
0.58 (OC/EC = 3.48)	Cheng et al., 2013	Central urban area in Beijing, China during Summer
0.50 (OC/EC = 7.36)	Cheng et al., 2013	Central urban area in Beijing, China during Autumn
0.62 (OC/EC = 7.39)	Cheng et al., 2013	Central urban area in Beijing, China Winter Spring
0.30 – 0.90	Michel, 2005	8th July 1998 Paris, France
0.34 – 1.00	Michel, 2005	28th July 1998 Paris, France
0.61 – 1.00	Michel, 2005	25 January 2000 Paris, France
0.77 – 0.86	Michel, 2005	RH at 80% during winter Paris, France
0.78 – 0.86	Michel, 2005	RH at 50% during winter Paris, France
0.70 – 0.79	Michel, 2005	RH at 50% during summer Paris, France
0.73 – 0.78	Michel, 2005	RH at 80% during summer Paris, France
0.31 – 0.34	Zhang et al., 2005	September 2002 in Pittsburg, California, USA, industrialised site

0.20 – 0.31	Lanz et al., 2008	Fossil particles in urban background site in Zurich, Switzerland, January 2006
0.31	Cleverland et al., 2012	Urban site university of Houston, Texas, USA 15th August – 28th September 2006
0.61	Kondo et al., 2007	Winter, urban Center Tokyo, Japan
0.80 (SOC/OC) => 0.20	Kondo et al., 2007	Summer, urban Center Tokyo, Japan
0.52	Ng et al., 2011	Primary traffic emission, Queen College place, New York. High populated residential place
0.73	Michel, 2005	Pekin, China urban pollution
0.77 – 0.99	Michel, 2005	Gosan urban site influenced by China pollution located in southern Korea
0.35 – 1	Guillaume et al., 2007	Global average
0.45	Guillaume et al., 2007	Global average during Winter
0.55	Guillaume et al., 2007	Global average during Summer
< 0.4	Guillaume et al., 2007	Summer, in North America, Africa south of ITCZ, and over ocean
0.8	Guillaume et al., 2007	Northern hemisphere especially over Europe
0.24 – 0.5	Minguilla et al., 2016	Fossil Fuel source in Barcelona
0.31 – 0.37	Minguilla et al., 2016	Mixture of fossil fuel and cooking in Barcelona
Mean: 0.54		
Median: 0.52		
Standard deviation: 0.19		
Min: 0.2		
Max: 0.88		

Table 2: OCprim/ OCtot for rural, biomass burning and biofuel sources

OCp/OC	Reference	Location
0.64 (OC/EC = 5.40) (OCp/EC=3.45; mod: 3.66)	Yu et al., 2004	Rural site, Summer, Centreville, USA (biogenic and anthropogenic sources)
0.76 (OC/EC = 4.95) (OCp/EC=3.82; mod: 4.33)	Yu et al., 2004	Rural site, summer, Oak Grove, USA (biogenic and anthropogenic sources)
0.39 (OC/EC = 4.62) (OCp/EC=1.71; mod: 1.78)	Yu et al., 2004	Rural site, summer, Yorkville USA (biogenic and anthropogenic sources)
0.69	Lanz et al., 2008	Wood particles in urban background site in Zurich, Switzerland, January 2006
0.21 – 0.45	Dall'Osto et al., 2015	Rural site in Po Valley between montainsmountains range, northern Italy during summer, distant of about 10 to 50km from pollution sources
0.38 – 0.42	Dall'Osto et al., 2015	Cooking source in rural site in Po Valley between montainsmountains range, northern Italy during summer, distant of about 10 to 50km from pollution sources
0.3 – 0.4 (SOA/OCt) => 0.6 – 0.7 (OCp/OCt)	Aiken et al., 2008	Biomass burning, laboratory-produced primary biomass burning
0.97 – 0.99	Michel, 2005	Mandchourie characterised by biomass burning ABBI-feux
0.8	Guillaume et al., 2007	In August southern hemisphere due to savannas, forest fire
0.16	Ng et al., 2011	Night time in Queens College residential area from July 13th to August 4th, New york
0.51	Ng et al., 2011	Daytime in Queens College residential area from July 13th to August 4th, New york
0.34 – 0.42	Minguilla et al., 2016	Cooking source in Barcelona
0.31 – 0.37	Minguilla et al., 2016	Mixture of fossil fuel and cooking in Barcelona
0.63 – 0.74	Cheng et al., 2013	Biomass burning in Beijing China
0.69	Fine et al., 2002	Fireplace combustion of wood in southern USA
Mean: 0.6		
Median: 0.5		
Standard deviation: 0.20		
Min: 0.16		
Max: 0.98		

Table 3: OC_{prim}/ OC_{tot} for biomass burning and biofuel sources

OCp/OC	Reference and methodology	Location
0.69	Lanz et al., 2008	Wood particles in urban background site in Zurich, Switzerland, January 2006
0.3 – 0.4 (SOA/OCt) => 0.6 – 0.7 (OCp/OCt)	Aiken et al., 2008	Biomass burning, laboratory-produced primary biomass burning
0.97 – 0.99	Michel, 2005	Mandchourie characterised by biomass burning ABBI-feux
0.8	Guillaume et al., 2007	In August southern hemisphere due to savannas, forest fire
0.63 – 0.74	Cheng et al., 2013	Biomass burning in Beijing China
0.69	Fine et al., 2002	Fireplace combustion of wood in southern USA
Mean: 0.75		
Median: 0.69		
Standard deviation: 0.12		
Min: 0.65		
Max: 0.98		

Table 4: OC_{prim}/ OC_{tot} for the main sources in Africa.

$OC_{primary}/OC_{tot}$ Traffic: 0.52
$OC_{primary}/OC_{tot}$ Flairing: 0.52
$OC_{primary}/OC_{tot}$ Biomass burning: 0.75
$OC_{primary}/OC_{tot}$ wood burning: 0.75
$OC_{primary}/OC_{tot}$ waste burning:0.52

2 Validation tests

2.1 Configuration of 2015 simulations

The following RegCM4 configuration and forcing emission data were retained for 2015 simulations. Tests of validations were done with DACCIWA-WP2 field measurements.

It is important to note that aerosol optical depth measurements are particularly adapted for these tests since AOD measurements are coherent with model spatial resolution. This is not the case for BC, OC and PM2.5 concentrations which are obtained at Abidjan and Cotonou closed to the sources. However, such a comparison is necessary to control if modelled/measured concentrations are of the same order of magnitude.

Year	2015
Spatial resolution	15 km x 15 km
Land surface	Biosphere-Atmosphere Transfer Scheme (BATS, Dickinson et al., 1993).
Convection scheme	Tiedtke, (1989)
Vertical levels	23 levels
Large scale precipitation	scheme from Sundqvist et al. (1989)
Emissions	Biomass burning: corrected GFASv1.2 (multiplied by 3.4 as suggested by Kaiser et al., 2012) Anthropogenic emissions including traffic, cooking, charcoal making, waste burning, industries, power plant, flaring (see the deliverable D2.1 on Emission inventories of WP2 (Keita et al))
Chemistry option	AERO (Aerosol)
Dust module	4 bins dust module (Zakey et al., 2006).
Sea Salt module	2 bins sea salt (Zakey et al., 2008)
SST	Weekly Optimum Interpolation SST (OIWK)
Meteorological field forcing	NNRP2 (not available 2015 EIN15 data)

2.2 Results

2.2.1 Aerosols Optical Depth

Monthly modelled AOD spatial distribution was compared with MISR (Figure 3) and OMI (Figure 4) satellite data. It may be seen that the present simulation overestimates Aerosol optical Depth (AOD) over the land, especially over biomass burning sources while underestimating over the coastal region especially in the Gulf of Guinean during dry season. However these biases decrease and become positive during the wet season underlining a quite good representation of anthropogenic emissions sources and suitable transport of southern biomass burning sources to coastal region.

Let us note that the high AOD modelled values over biomass burning region may be attributed to biomass burning emissions, globally increased by 3.4 as suggested by Kaiser et al. (2012). This AOD biases will be improved by adapting this coefficient following ongoing works dealing with biomass burning comparisons (N'Datchoh et al., 2016 poster IGAC-2016). Also, late biomass fires (between March and April), observed over Guinea, Sierra Leone and Senegal (N'Datchoh et al., 2015) are well reproduced with RegCM4 but not by MISR and OMI observations (Figure 3 and 4). Moreover, the big AOD differences occurring during July and August over Namibian coasts between RegCM4 model and MISR or OMI might be related to model overestimation of the biomass burning and dust outflow in this area.

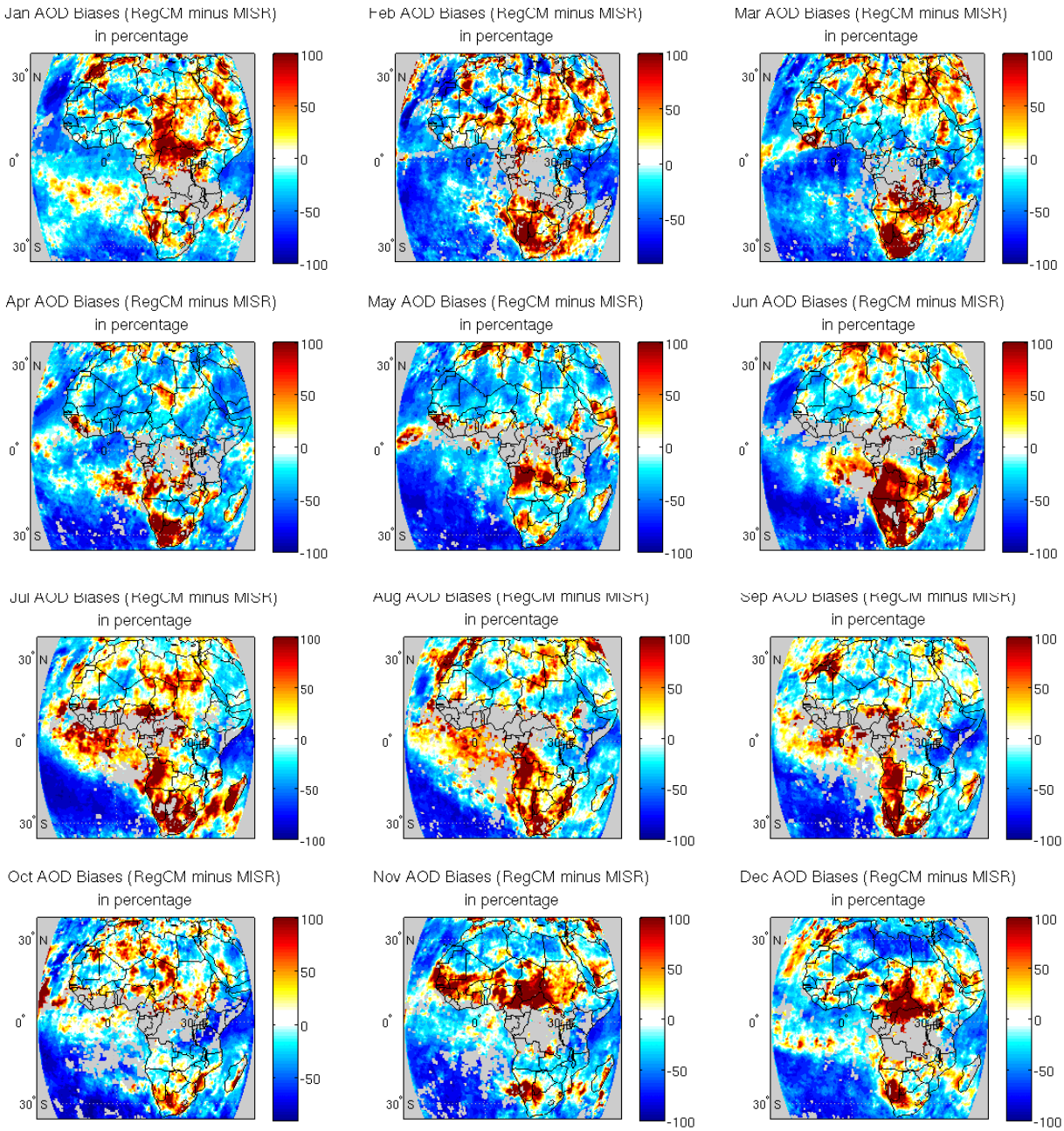

Figure 3: AOD biases in percentage of RegCM4 compared to MISR (cold colours shows RegCM underestimates while overestimates are represented by hot colours).

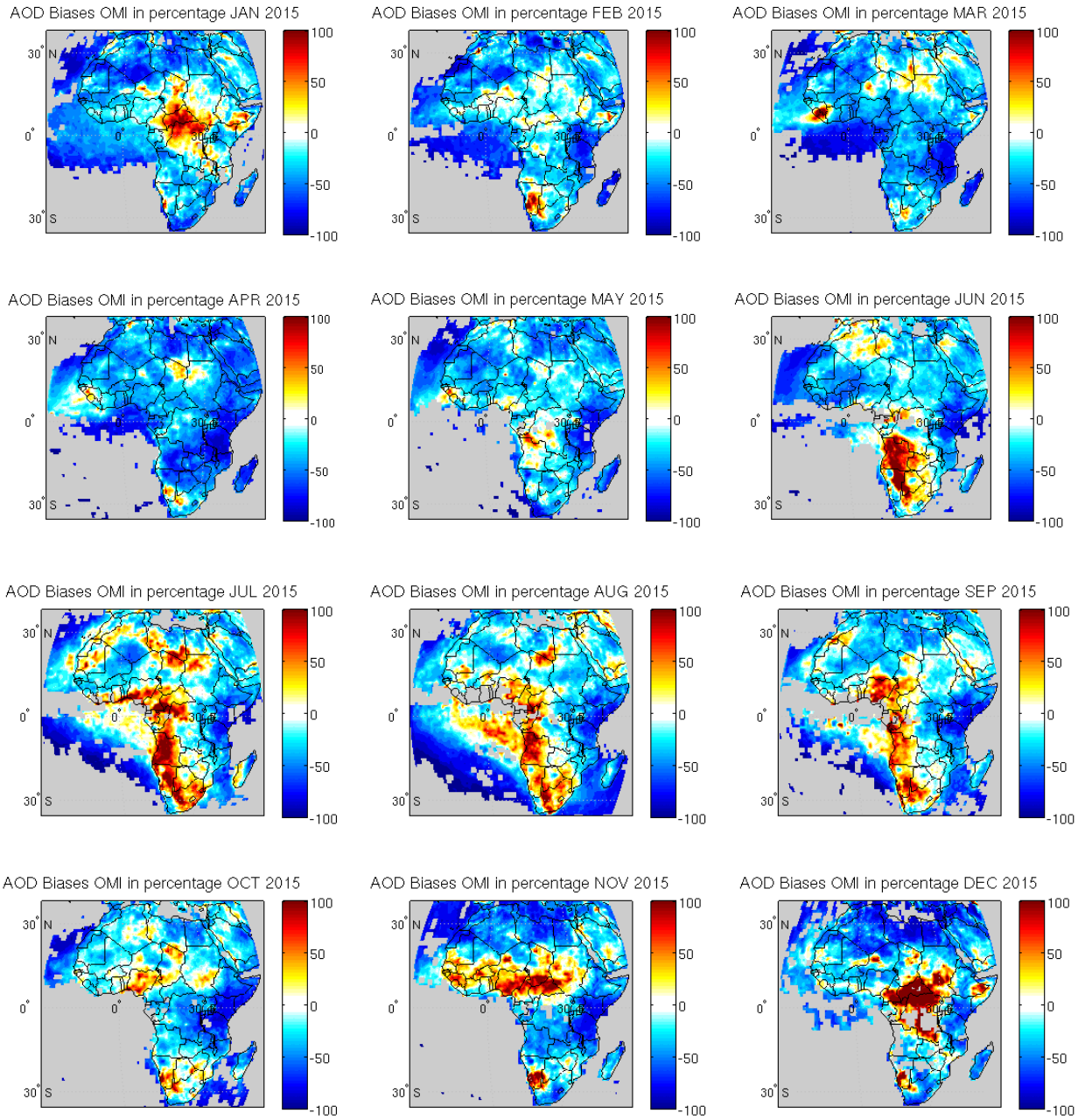

Figure 4: AOD biases in percentage of RegCM4 compared to OMI (cold colours shows RegCM underestimates while overestimates are represented by hot colours).

Finally it is interesting to note that OMI and MISR comparison with the model is much suitable over West Africa.

At Cotonou and Abidjan, where DACCIWA WP2 field measurements took place, observed AOD data (Djossou et al., 2017) were compared to RegCM4 simulated AOD (Figure 5). Positive AOD biases (overestimation of RegCM compared to observations) may be noticed during the dry season (December to May) while they become negative during the wet season (from July to November). In rural areas (Lamto in central Ivory Coast and Save in Northern Benin, Djossou et al., 2017), a different pattern of AOD biases is observed. Biases are negative during the dry season (from January to June and December) and mainly positive during the wet season (from July to October). This different

pattern between urban and rural AOD biases may be related to the impact of biomass burning fires which is more pronounced in rural areas than in urban areas influenced by anthropogenic sources. Also, AOD seasonal variability is better captured in rural areas due to a good representation of biomass burning seasonality. While AOD seasonal variability is also well reproduced by the model in Abidjan, this is less evident for Cotonou: this is perhaps due to an overestimation of the Nigerian flaring source impact in the model. Finally, AOD biases vary between -40% to 40 % in Abidjan (except in August (approximately 60%)), whereas about ± 50% in Cotonou (except in October where biases can be above 100%). In rural sites, biases vary between -60% to 60% in Lamto and -50% to 50% in Save (except in August with approximately 98%).

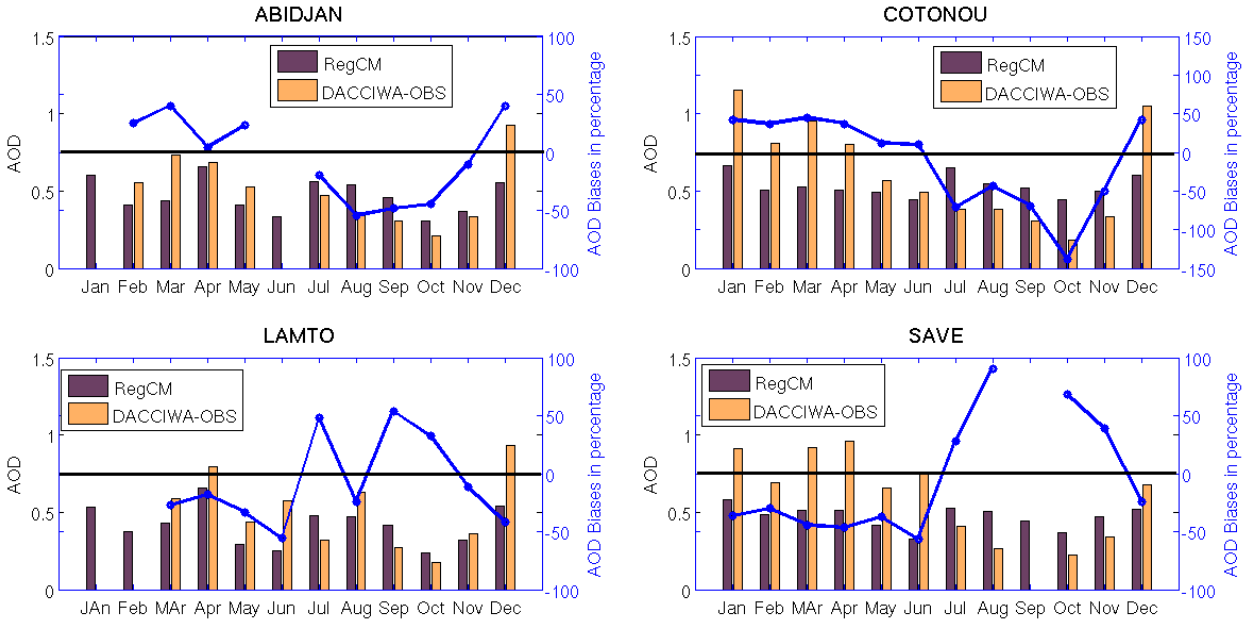

Figure 5: Simulated monthly AOD comparison to measured AOD in DACCIWA WP2 urban areas in Abidjan (top left) Cotonou (top right) and rural area in Lamto (down left) and Save (down right).

2.2.2 Carbonaceous particles (BC and OC)

BC and OC concentrations measured at the sources (Djossou et al., 2017) are compared to the simulated ones (Figures 6 and 7 respectively), for three sites in Abidjan (Fuel Wood, Traffic and Waste Burning sites) and one site in Cotonou (traffic site). Results show that in Abidjan waste burning site, there is a good agreement between modelled and measured BC concentrations. This comparison is also suitable in Abidjan traffic site except for May, June, November and December with higher measured BC values than modelled ones. As expected, due to the characteristics of the domestic fire site very closed to the sources, there are bigger differences between modelled and measured BC results at this site, especially during the wet season. In Cotonou, BC concentrations are of the same order except from march to September with modelled values higher than measured ones. These comparisons allow testing the model performance since the modelled values are globally of the same

order of magnitude than the measured ones. A different tendency is observed with OC at the different sites. Modelled values are much higher than measured values in Abidjan and Cotonou traffic site, whereas they are comparable in Abidjan domestic fire sites except for August, September and October which are of higher measured OC values.

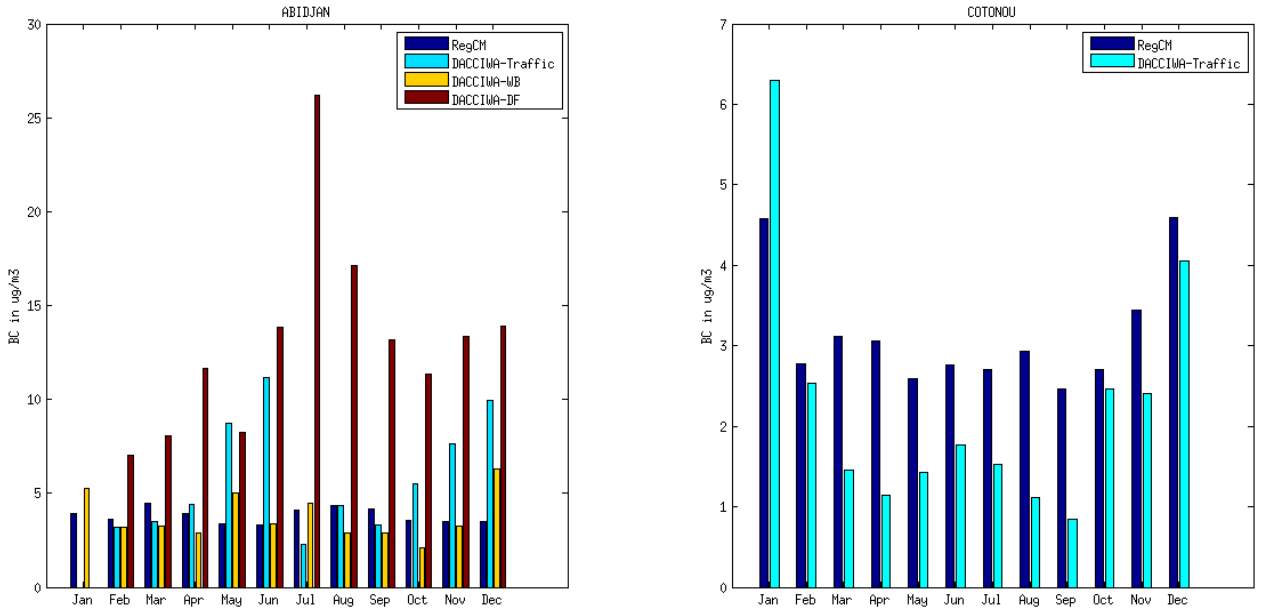

Figure 6: Simulated BC comparison with DACCIWA WP2 measurements in Abidjan and Cotonou.

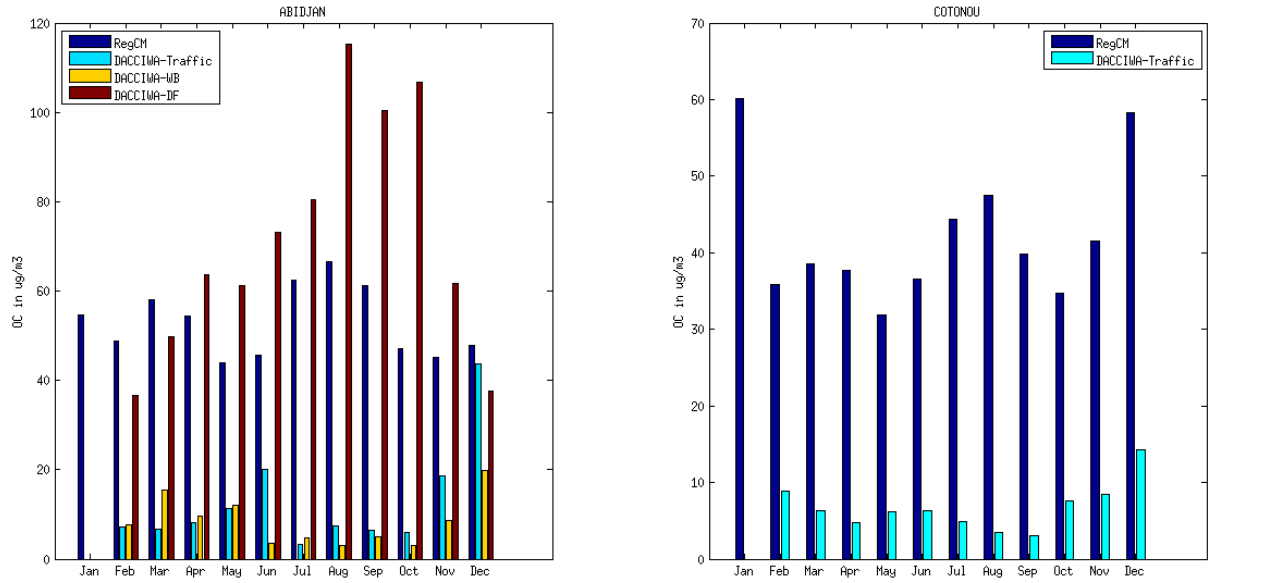

Figure 7: Simulated OC comparison with DACCIWA WP2 measurements in Abidjan and Cotonou.

2.2.3 PM2.5

The PM2.5 spatial distribution (Figure 8) shows that dust constitutes a large part of PM2.5 in the north hemisphere of Africa especially in Sahel. Biomass burning impact may be underlined in central and southern Africa. Anthropogenic sources have an important contribution in the coastal zone especially in the cities along the Gulf of Guinea.

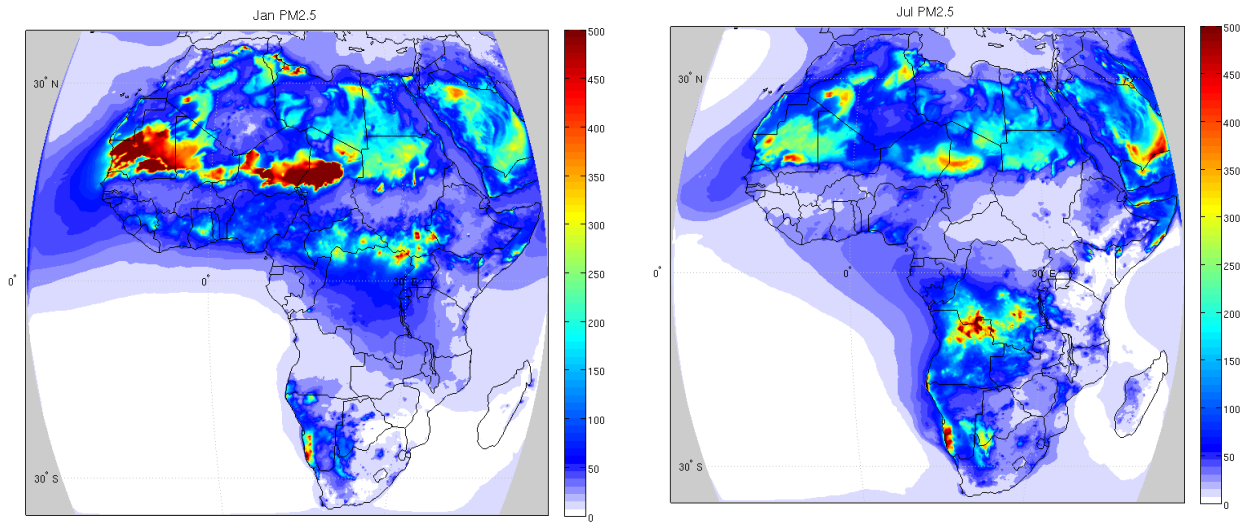

Figure 8: Simulated PM2.5 surface concentration in (ug/m3) spatial distribution in Africa during January and July 2015

Comparison between simulated PM2.5 and DACCIWA measurements reveal that the modelled PM2.5 is of the same order of magnitude for traffic and waste burning sites during the dry season whereas modelled PM2.5 is much higher during the wet season (Figure 9). This difference is less pronounced for Abidjan domestic fire site. This observation is in agreement with OC comparisons. It may suggest that the bigger values given by the model during the wet season can be due to problems of deposition parameterizations.

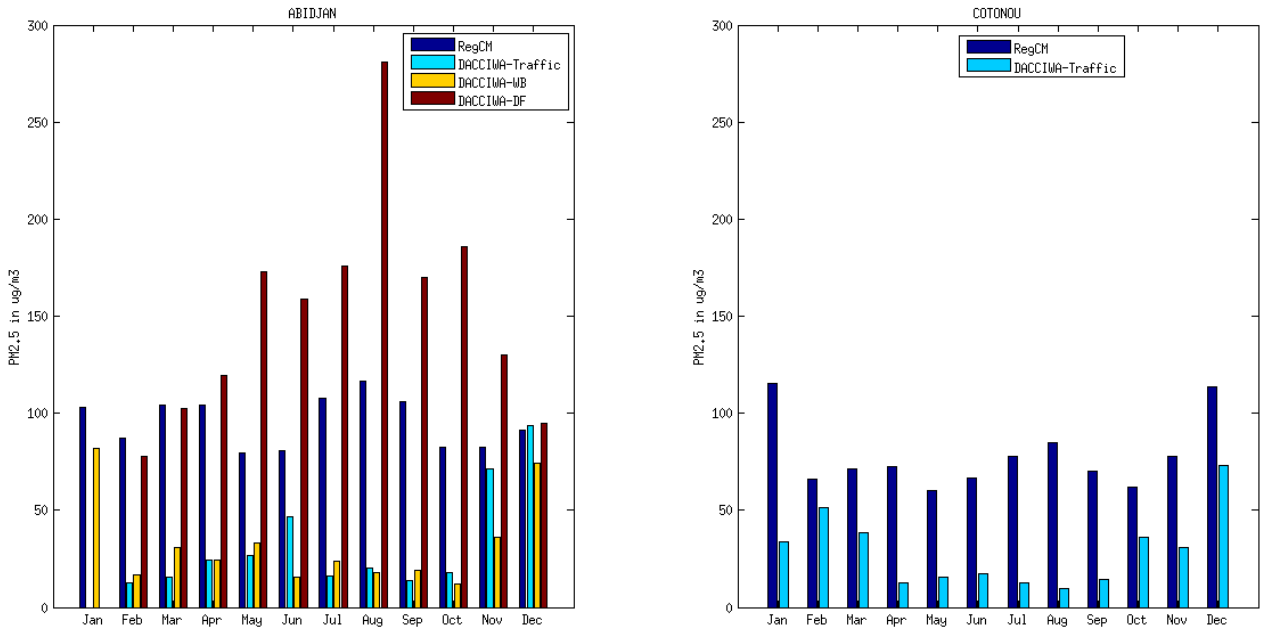

Figure 9: Simulated PM2.5 comparison with DACCIWA WP2 measurements in Abidjan and Cotonou.

FA sensitivity test on PM2.5 calculation was conducted by replacing the constant ratio between SO4 and water-soluble particles in the equation (2) by monthly ratio values given by DCCB parameterization for the year 2005 at each grid point of the model. In the Figure 10, it may be seen that such a change implies a decrease of 2 to 10% of PM2.5 concentrations over the biomass burning areas with DCCB values in January 2015 and in July 2015.

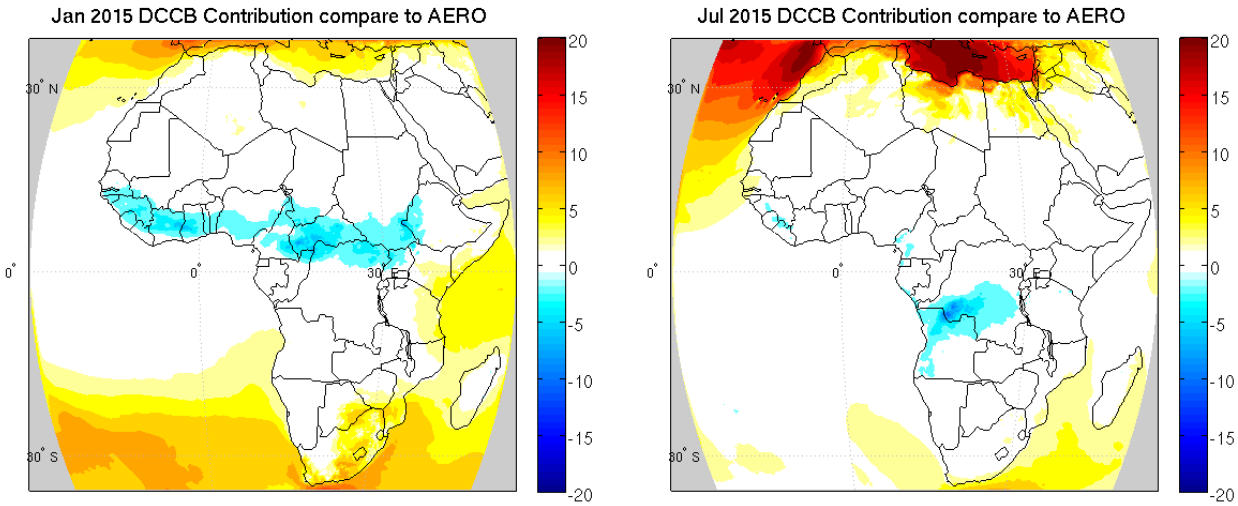

Figure 10: Spatial distribution of the PM2.5 differences due to different parameterization of water soluble particles for January and July 2015 (cold colours means that DCCB parameterization is higher than AERO and hot colours, that AERO is higher than DCCB).

3 Conclusion

The modelling activity in DACCIWA WP 2 framework has allowed us to define and setup RegCM4 configuration at the resolution of 15 x15 km over Africa. It has also contributed to updating PM2.5 calculations by improving total organic carbon and inorganic particle parameterizations. First validation tests have shown results comparable with measurements conducted over West African area. Such a work will be directly used in the task 2.5 when calculating PM2.5 health impact source by source. We note that the health modules (not described here) permit to calculate PM2.5 in the respiratory tract from RegCM4 PM2.5 results and allowing deriving associated diseases are also ready to be used.

4 References

Aiken, A. C., DeCarlo, P. F., Kroll, J. H., Worsnop, D. R., Huffman, J. A., Docherty, K. S., Ulbrich, I. M., Mohr, C., Kimmel, J. R., Sueper, D., Sun, Y., Zhang, Q., Trimborn, A., Northway, M., Ziemann, P. J., Canagaratna, M. R., Onasch, T. B., Alfarra, M. R., Prevot, A. S. H., Dommen, J., Duplissy, J., Metzger, A., Baltensperger, U., and Jimenez, J. L., (2008): O / C and OM / OC ratios of primary, secondary, and ambient organic aerosols with high-resolution time-of-flight aerosol mass spectrometry, Environ. Sci. Technol., 42, 4478–4485, doi:10.1021/es703009q.

Cheng, S., Lang, J., Zhou, Y., Han, L., Wang, G., and Chen, D. (2013). A new monitoring-simulation-source apportionment approach for investigating the vehicular emission contribution to the PM 2.5 pollution in Beijing, China. *Atmospheric environment*, *79*, 308-316.

Cleveland, M. J., Ziemba, L. D., Griffin, R. J., Dibb, J. E., Anderson, C. H., Lefer, B., & Rappenglück, B. (2012). Characterization of urban aerosol using aerosol mass spectrometry and proton nuclear magnetic resonance spectroscopy. *Atmospheric environment*, *54*, 511-518.

Dall'Osto, M., Paglione, M., Decesari, S., Facchini, M. C., O'Dowd, C., Plass-Duellmer, C., and Harrison, R. M., (2015) On the Origin of AMS "Cooking Organic Aerosol" at a Rural Site, Environ. Sci. Technol., 49, 13964–13972, doi:10.1021/acs.est.5b02922, 2015.

Dickinson RE, Henderson-Sellers A, Kennedy PJ (1993) Biosphere – atmosphere transfer scheme (BATS) version 1 as coupled to the NCAR Community Climate Model. NCAR Tech. Note NCAR=TN-3871STR, National Center for Atmospheric Research, Boulder, CO, 72 pp

Djossou et al., 2017

Fine, P.M., Cass, G.R., Simoneit, B.R.T., 2002. Chemical characterization of fine particle emissions from the fireplace combustion of woods grown in the southern United States. Env. Sci. Technol. 36, 1442e1451.

Fountoukis, C. and Nenes, A.: ISORROPIA II: a computationally efficient thermodynamic equilibrium model for K^+–Ca^{2+}–Mg^{2+}–NH_4^+–Na^+–SO_4^{2-}–NO_3^-–Cl^-–H_2O aerosols, Atmos. Chem. Phys., 7, 4639-4659, doi:10.5194/acp-7-4639-2007, 2007.

Grell, G. A., Dudhia, J. and Stauffer, D.R., (1994), A description of the fifth-generation Penn State/NCAR mesoscale model version 5 (MM5), Technical note TN-398+IA, Technical Report, Natl. Cent. for Atmos. Res. Boulder, Colorado.

Guillaume, B., Liousse, C., Rosset, R., Cachier, H., Van Velthoven, P., Bessagnet, B., & Poisson, N. (2007). ORISAM-TM4: a new global sectional multi-component aerosol model including SOA formation-Focus on carbonaceous BC and OC aerosols. *Tellus B*, *59*(2), 283-302.

Kaiser, J. W., Heil, A., Andreae, M. O., Benedetti, A., Chubarova, N., Jones, L., ... and Van Der Werf, G. R. (2012). Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power. *Biogeosciences*, *9*(1), 527.

Konaré, A., Zakey, A. S., Solmon, F., Giorgi, F., Rauscher, S., Ibrah, S. and Bi, X., (2008), A regional climate modeling study of the effect of desert dust on the West African monsoon, Journal of Geophysical Research: Atmosphere, 113, D12.

Kondo, Y., Miyazaki, Y., Takegawa, N., Miyakawa, T., Weber, R.J., Jimenez, J.L., Zhang, Q., Worsnop, D.R., 2007. Oxygenated and water-soluble organic aerosols in Tokyo. J. Geophys. Res. 111, D22212 http://dx.doi.org/10.1029/2006JD00740

Lanz, V. A., Hueglin, C., Buchmann, B., Hill, M., Locher, R., Staehelin, J., & Reimann, S. (2008). Receptor modeling of C 2–C 7 hydrocarbon sources at an urban background site in Zurich, Switzerland: changes between 1993–1994 and 2005–2006. *Atmospheric Chemistry and Physics*, *8*(9), 2313-2332.

Liousse et al., 2016

Liousse, C., Assamoi, E., Criqui, P., Granier, C., and Rosset, R. (2014). Explosive growth in African combustion emissions from 2005 to 2030. *Environmental Research Letters*, *9*(3), 035003.

Malavelle, F., Pont, V., Mallet, M., Solmon, F., Johnson, B., Leon, J. and Liousse, C., (2011), Simulation of aerosol radiative effects over West Africa during DABEX and AMMA SOP-0, Journal of Geophysical Research, 116(D8).

Michel, 2005 L'aérosol de combustion dans une région en grande mutation, l'Asie. Océan, Atmosphère. Université Paul Sabatier - Toulouse III, 2005. Français. <tel-00069797>

N'Datchoh E. T., Liousse C., Roblou L., Konaré A., van Der Werf G., N'Dri A. and Kaiser J. W., poster IGAC 2016: Biomass burning emission inventories over Africa: AMMABB and GFED uncertainties investigations.

N'Datchoh, E. T., Konaré, A., Diedhiou, A., Quansah, E. and Assamoi, P., (2015), Effects of climate variability on Savannah fire regimes in West Africa, Earth System Dynamics, 6, 161 –174, doi:10.5194/esd-6-161-2015.

Nenes A, Pandis SN, Pilinis C (1998a). ISORROPIA: A new thermodynamic equilibrium model for multiphase multicomponent inorganic aerosols, Aquat.Geoch., 4, 123-152.

Nenes A., Pilinis C., and Pandis S.N. (1998b) Continued Development and Testing of a New Thermodynamic Aerosol Module for Urban and Regional Air Quality Models, Atmos. Env., 33, 1553-1560 .

Ng, N. L., Herndon, S. C., Trimborn, A., Canagaratna, M. R., Croteau, P. L., Onasch, T. B., ... & Jayne, J. T. (2011). An Aerosol Chemical Speciation Monitor (ACSM) for routine monitoring of the composition and mass concentrations of ambient aerosol. *Aerosol Science and Technology*, *45*(7), 780-794.

Qian, Y., Giorgi, F., Huang, Y., Chameides, W. and Luo, C., (2001), Regional simulation of anthropogenic sulfur over east asia and its sensitivity to model parameters, Tellus B, 53(2), 171 191. Shalaby, A., Zakey, A. S., Tawfik, A. B., Solmon, F., Giorgi, F., Stordal, F., Sillman, S., Zaveri, R. A., and Steiner, A. L.: Implementation and evaluation of online gas-phase chemistry within a regional climate model (RegCM-CHEM4), Geosci. Model Dev., 5, 741-760, doi:10.5194/gmd-5-741-2012, 2012.

Solmon et al., 2008, Solmon, F., Elguindi, N. and Mallet, M., (2012), Radiative and climate effects of dust over West Africa, as simulated by a regional model, Climate Research, 52 97–113.

Solmon, F., Giorgi, F. and Liousse C., (2006), Aerosol modelling for regional climate studies: application to anthropogenic particles and evaluation over a European/African domain, Tellus B, 58(1), 51–72.

Solmon, F., Mallet, M., Elguindi, N., Giorgi, F., A. Zakey, and A. Konaré (2008), Dust aerosol impact on regional precipitation over western africa, mechanisms and sensitivity to absorption properties, Geophysical Research Letters, 35(24).

Sundqvist, H., Berge, E., and Kristjánsson, J. E. (1989). Condensation and cloud parameterization studies with a mesoscale numerical weather prediction model. *Monthly Weather Review*, *117*(8), 1641-1657.

Sylla, M. B., Gaye, A. T., Pal, J. S., Jenkins, G. S. and Bi, X. Q., (2009), High resolution simulations of West Africa climate using Regional Climate Model (RegCM3) with different lateral boundary conditions, Theoretical and Applied Climatology, 98 (3-4): 293-314, doi:s00704-009-0110-4.

Tiedtke M (1989) A comprehensive mass-flux scheme for cumulus parameterization in large-scale models. Mon Weather Rev 117:1779–1800

TOURE, N. E., Konaré, A. and Silué, S., (2012), Intercontinental Transport and Climatic Impact of Saharan and Sahelian Dust, Advances in Meteorology 2012.

Tummon, F., Solmon, F., Liousse, C. and Tadross, M., (2010), Simulation of the direct and semi-direct aerosol effects on the southern Africa regional climate during the biomass burning season, Journal of Geophysical Research, 115(D19).

Yu, S., Dennis, R. L., Bhave, P. V., and Eder, B. K. (2004). Primary and secondary organic aerosols over the United States: estimates on the basis of observed organic carbon (OC) and elemental carbon (EC), and air quality modeled primary OC/EC ratios. *Atmospheric Environment*, *38*(31), 5257-5268.

Zakey, A. S., F. Giorgi, and X. Bi (2008), Modeling of sea salt in a regional climate model: Fluxes and radiative forcing, J. Geophys. Res., 113, D14221, doi:10.1029/2007JD009209.

Zakey, A. S., Solmon, F. and Giorgi, F., (2006), Implementation and testing of a desert dust module in a regional climate model, Atmospheric Chemistry and Physics, 6, 12, 4687–4704.

Zaveri, R. A., and L. K. Peters (1999), A new lumped structure photochemical mechanism for large-scale applications, J. Geophys. Res., 104(D23), 30387–30415, doi:10.1029/1999JD900876.

Zhang, Q., Worsnop, D. R., Canagaratna, M. R., and Jimenez, J. L. (2005). Hydrocarbon-like and oxygenated organic aerosols in Pittsburgh: insights into sources and processes of organic aerosols. *Atmospheric Chemistry and Physics*, *5*(12), 3289-3311.