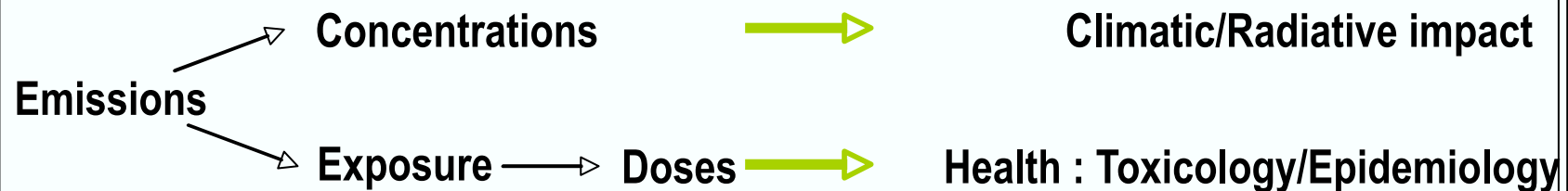


Emissions/Health and climatic impact of african urban aerosols

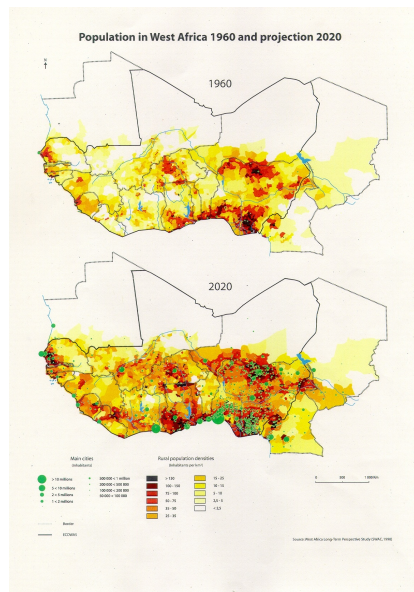
C. Liousse, Doumbia T., Assamoi E., Galy-Lacaux C., Gardrat E., Castéra P., Zouiten C., Pont V., Léon J.F., Mallet M., Uzu G., Guinot B., Rosset R., Baeza A., Penner J.E., Val S., Cachier H., Marchand N., Xu L., Criqui P, Annesi Maesano I., Granier C., Yoboué V., Diop B., Koita O., Ndiaye A., Ouafo M., Gueye P., Diouf A., L. Sigha, A. Konaré, K. Pienaar, A. Didier.



Focus on urban aerosols/Multidisciplinary approach
In situ measurements/modeling/satellite

Why such a study in Africa?

- intense photochemistry
- source mixing
- unexpected urban air pollution*
- increase of urban population



Dust

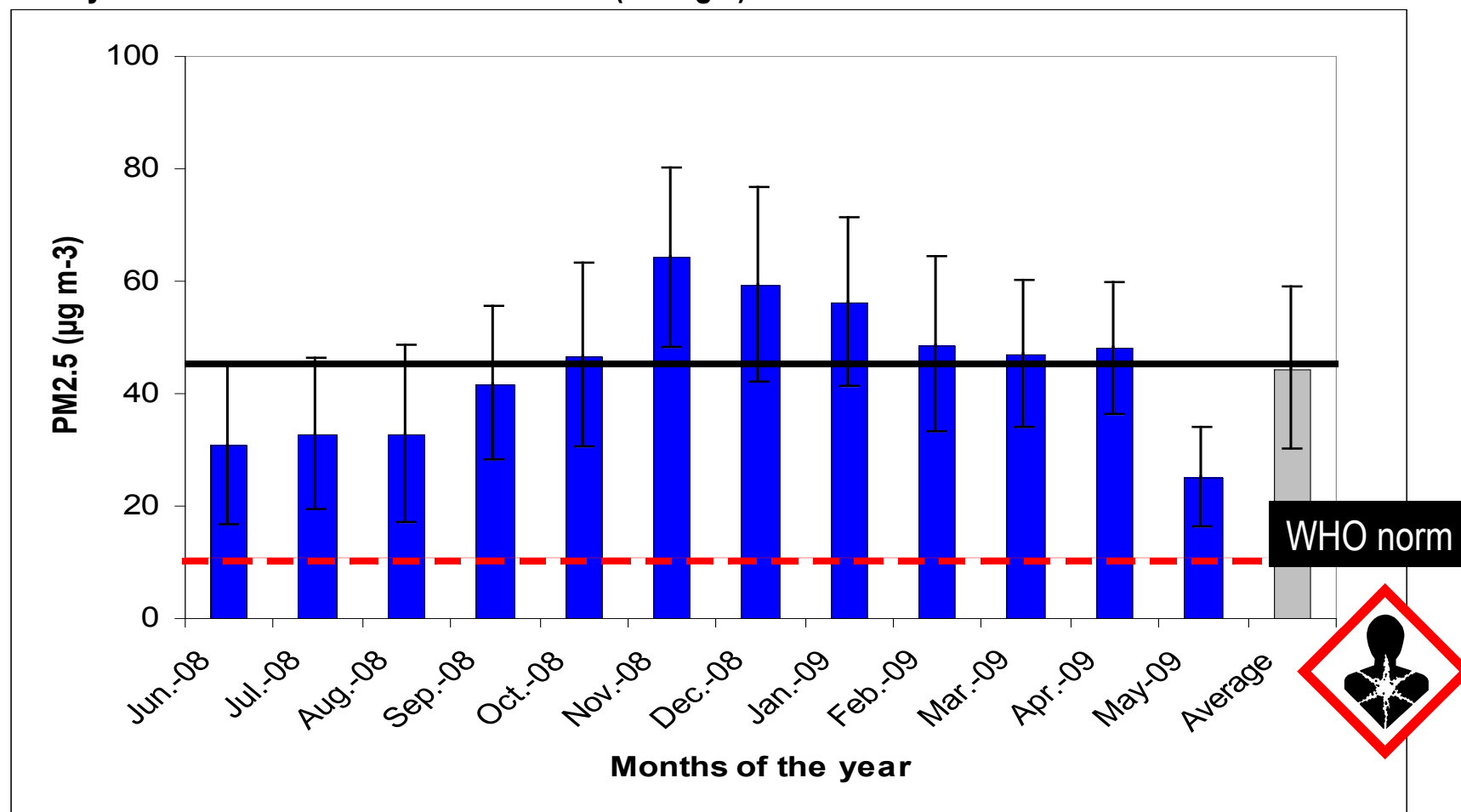
Savanna fires

Industries

Savanna fires : Lioussé et al. 2010
Dust : Marticoréna et al.

Unexpected pollution : focus on a traffic site in Dakar (Senegal)

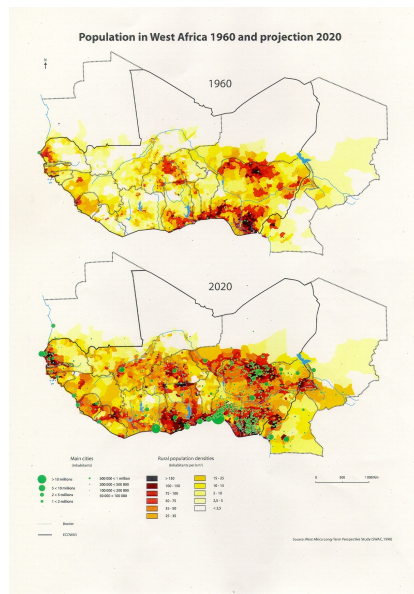
Monthly PM25 mass concentration in Dakar (Sénégal)



Doumbia et al., 2012

Why such a study in Africa?

- intense photochemistry
- source mixing
- unexpected urban air pollution
- increase of urban population



1960

Population

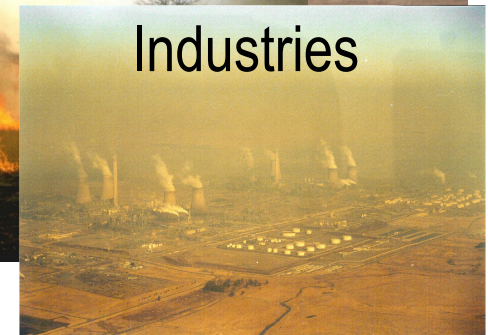
2020

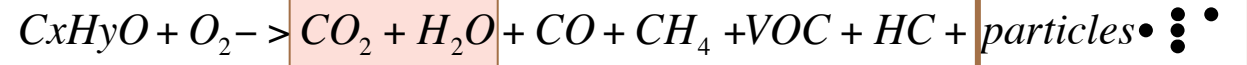


Dust



Industries





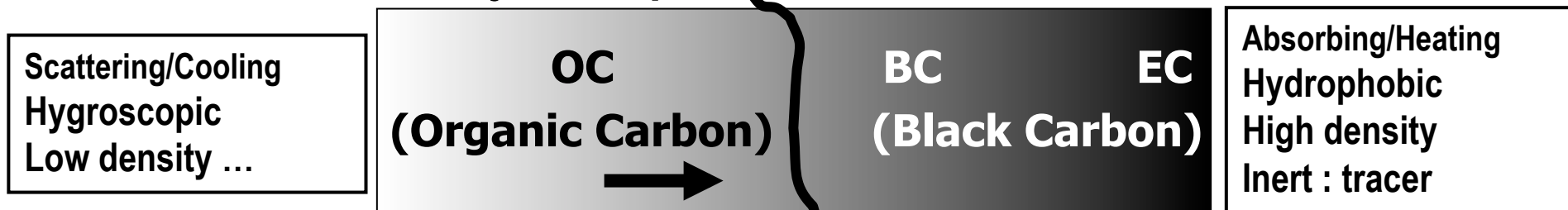
Different Combustion Aerosols are produced

- with different chemistry
- with different optical properties

Combustion quality Influence
(temperature, oxygen supply)
Influence of fuel nature
=> BC/OC variability



Major components :



BC and OC definition method-dependent

African fossil fuel and biofuel inventories : focus on black carbon and organic carbon (see Assamoi et al., session 6C)

Present (2005) : A regional bottom up inventory (0.25°x0.25°) :

Data consumption and activities :

United Nations database
International Energy Agency data for power plants
Brocard (1996) for fuelwood and charcoal
Assamoi & Liousse (2010) for two-wheel inventory
Local inquiries (11 answers/26 african countries)

Emission factors :

Junker and Liousse 2008/Bond et al. 2007
Campaigns (AMMA, POLCA)
=> African specificities (2-stroke, truck, charcoal, AW..)

Futur (2030) : based on 2005 inventories and POLES model for

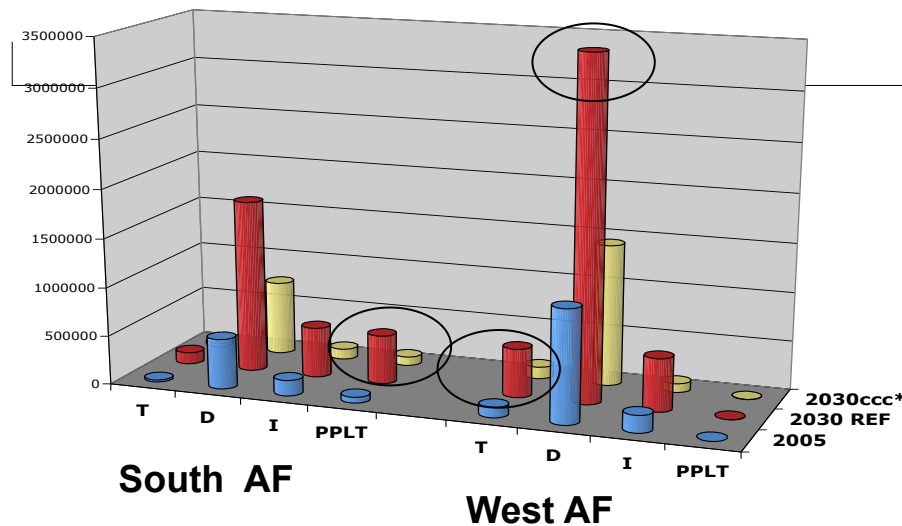
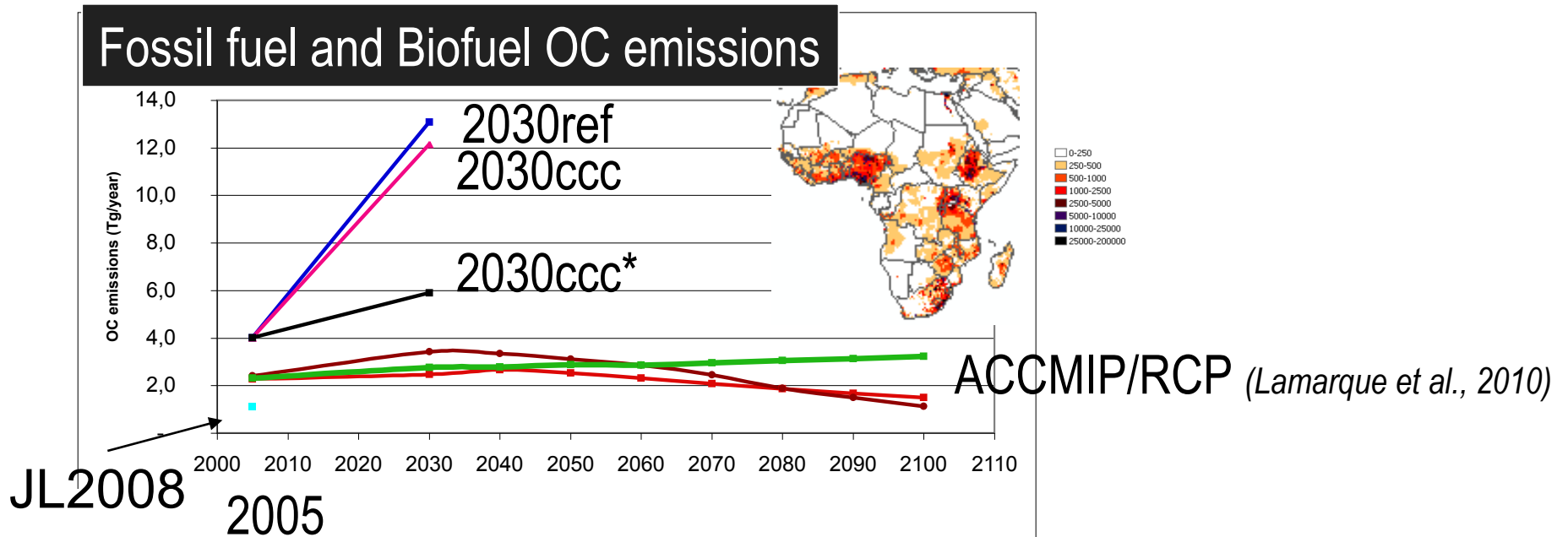
Reference scenario : Reflect the state of the world as environmental policy objectives (2000)

CCC scenario : Introduction of carbon penalties (Kyoto) for 2010 and a reduction of 37 Gt of CO₂ in 2030.

CCC* scenario :CCC +

- West Africa : two stroke replaced by four stroke vehicles
- South Africa as a semi developed country for fuel consumption future estimate
- Emission factor of animal waste burning : low part of the range

Specific african emission inventories for the Present and the Future.



Importance of domestic fires
West Africa : + traffic
South Africa : + industries

Assamoi, PhD 2011, Liousse et al., 2012

ORISAM-TM5 Model description => BC and OC concentration fields

❖ TM5 standard version

- $6^\circ \times 4^\circ$ global, $3^\circ \times 2^\circ$ and $1^\circ \times 1^\circ$ over Africa
- 25 vertical levels : 1010 hPa to 0.47 hPa
- Off-line meteorology (ECMWF)
- Wet deposition by stratiform/convective precipitation

❖ Augmented with ORISAM (traceur mode : Guillaume et al., 2007)

- 6 size bin distribution of aerosol mass concentrations in a sectional aerosol model
- 4 aerosol species : BC hydrophilic; BC hydrophobic; OC hydrophilic; OC hydrophobic

❖ Global and regional BC and OC emissions

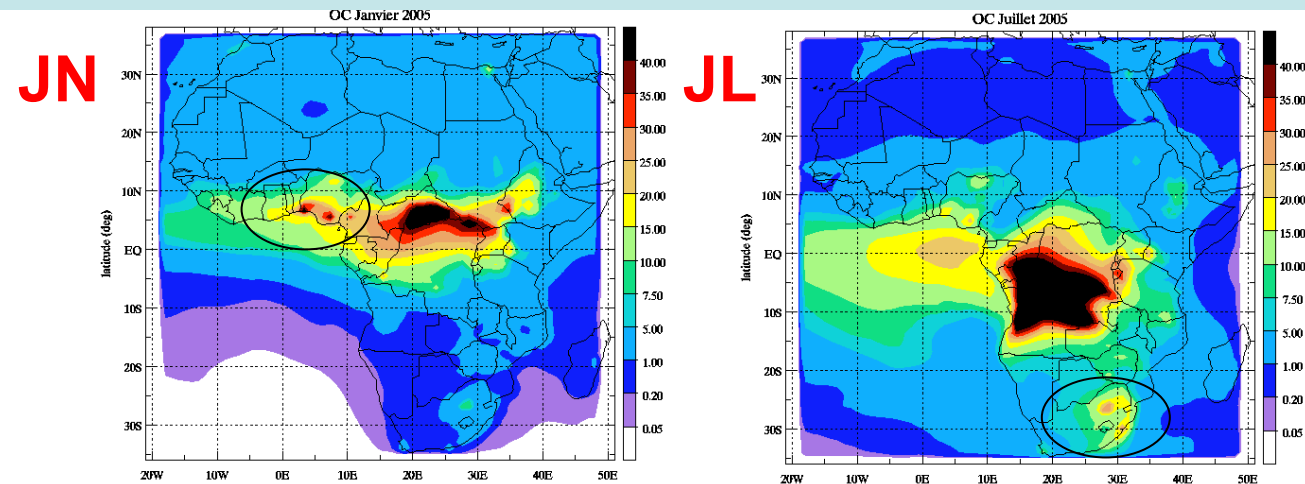
- Biomass burning AMMABB (Lioussé et al., 2010)
- Fossil fuel and biofuel (Assamoi and Lioussé, 2010, Lioussé et al (2011) for 2005, 2030ref and 2030ccc*, Junker and Lioussé 2008)

Off-line model (Wang and Penner, 2009) => AOD, Aerosol Direct Effect (ADE)

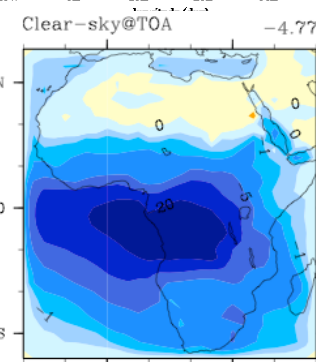
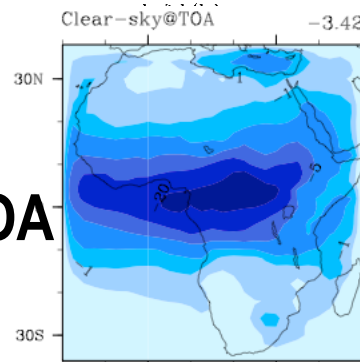
- Externally mixed of BC and OM emitted from biomass burning over Africa
- Hydrophobic BC with hygroscopicity fact. $bbc = 5.e-7$
- OM contains 30% hygroscopic materials as ammonium sulfate with $bom = 0.14$
- $\rho_{BC} = 1.8 \text{ kg/m}^3$; $\rho_{OM} = 1.0 \text{ kg/m}^3$;
- BC size dist.: Mallet et al., 2003 ($r_g = 0.028 \mu\text{m}$; $\sigma_g = 1.94$)
- OM size dist.: Zhang et al., 2005(JGR) ($r_g = 0.077 \mu\text{m}$; $\sigma_g = 1.0$)
- BC => $1.76-0.46i$ (Bond and Bergstrom), 2006; OM => $1.53-0.03i$ (Kirchstetter et al., 2004)

Concentration fields and radiative impact : focus on carbonaceous aerosols

OC ($\mu\text{g}/\text{m}^3$)

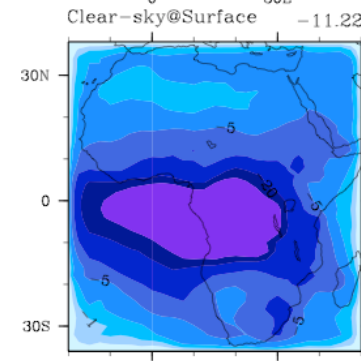
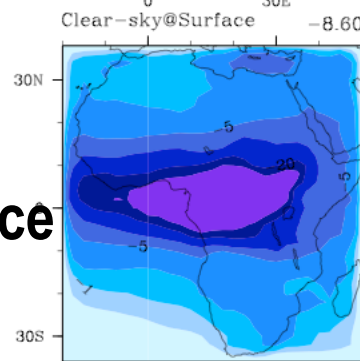


TOA



ADE (W/m^2)

Surface



In agreement with RegCM3 studies
on biomass burning (Malavelle et al., Tummon et al.)

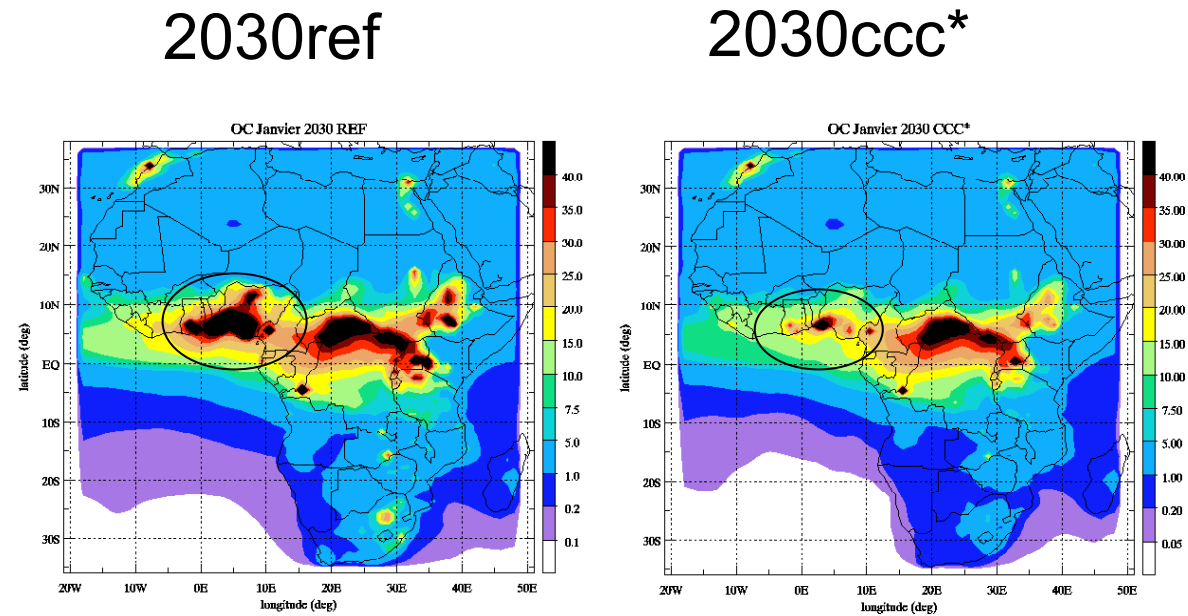


Assamoi, PhD 2011

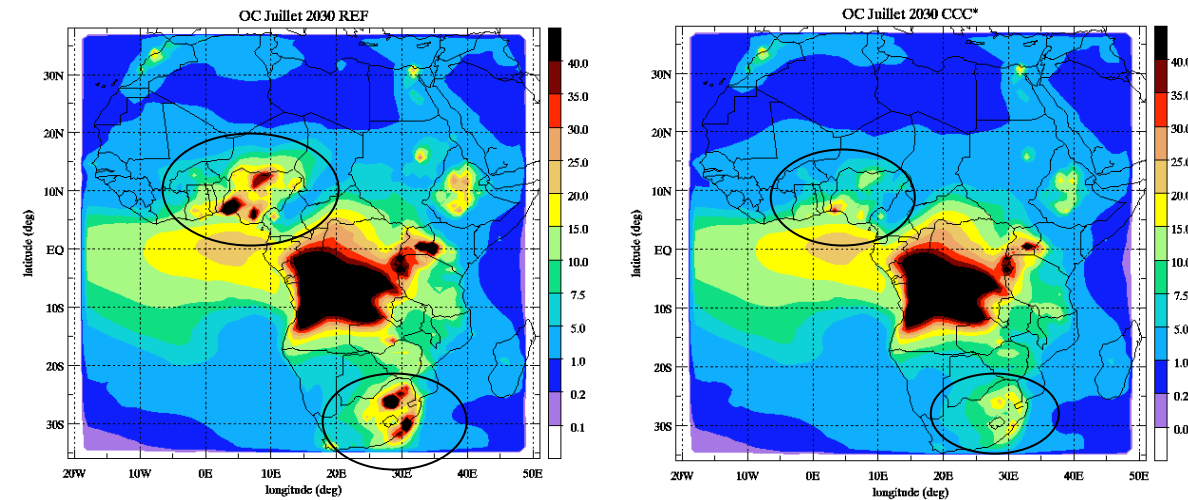
Concentration fields and radiative impact : focus on carbonaceous aerosols

OC ($\mu\text{g}/\text{m}^3$)

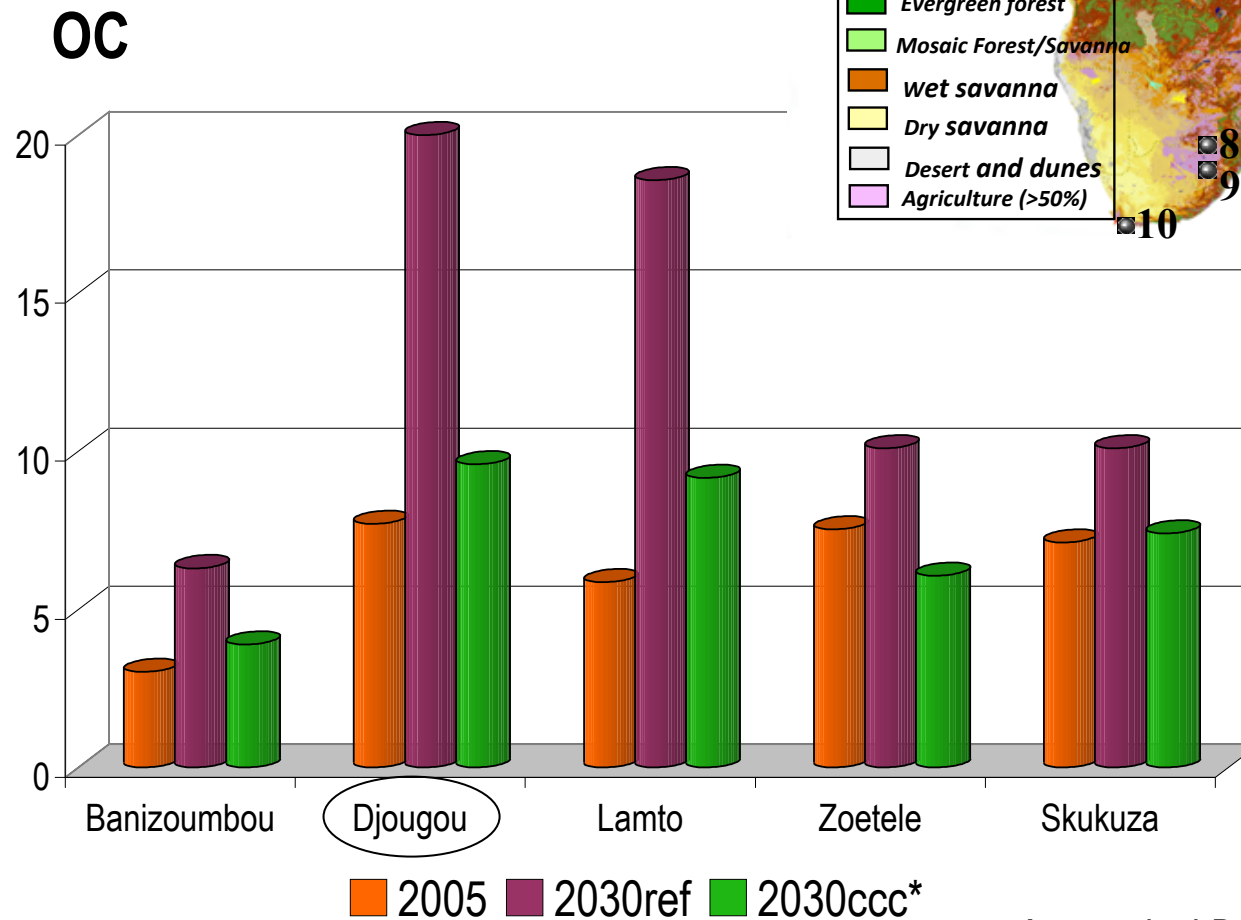
Jn



Jl

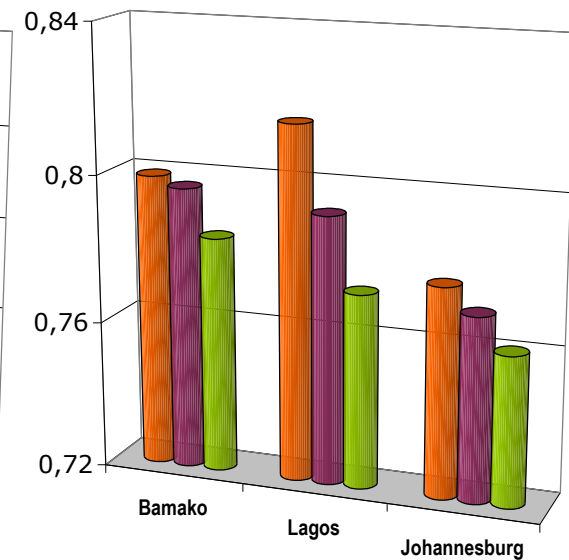
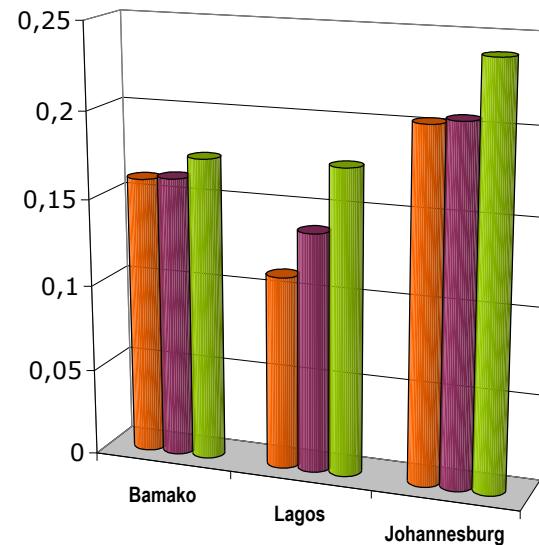
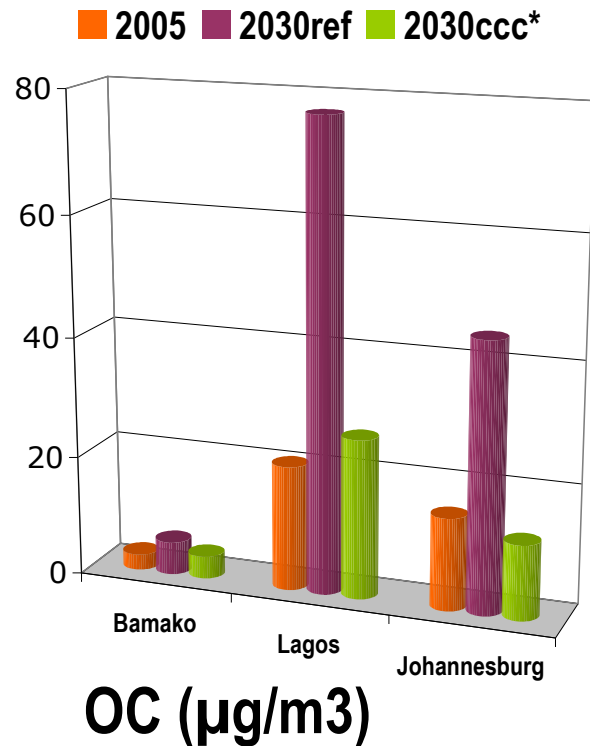


IDAF rural sites : are they affected?



Concentration fields and radiative impact : focus on carbonaceous aerosols

Urban sites : how are they affected? ...



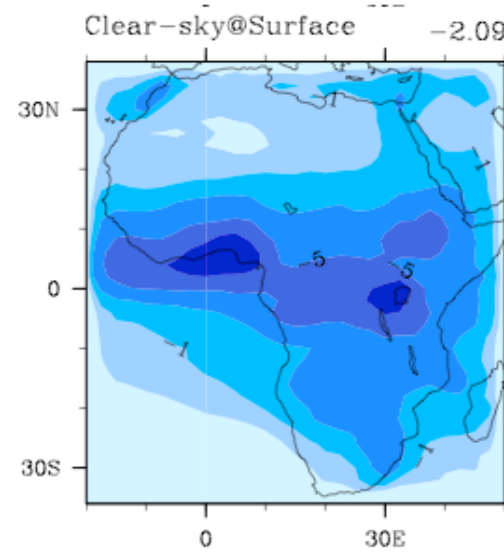
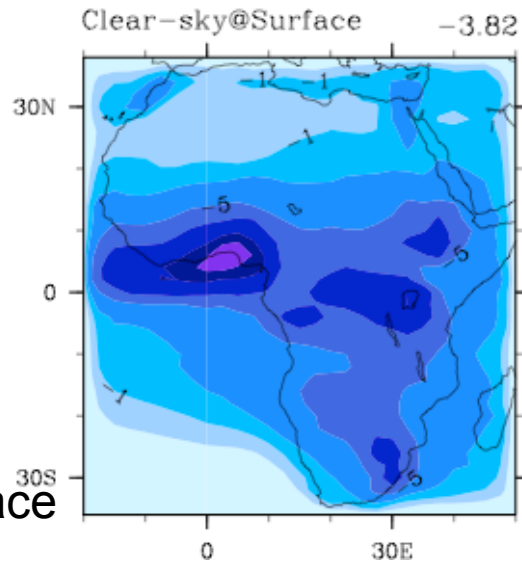
More BC/OC, Less SSA => More Absorption

2030ref

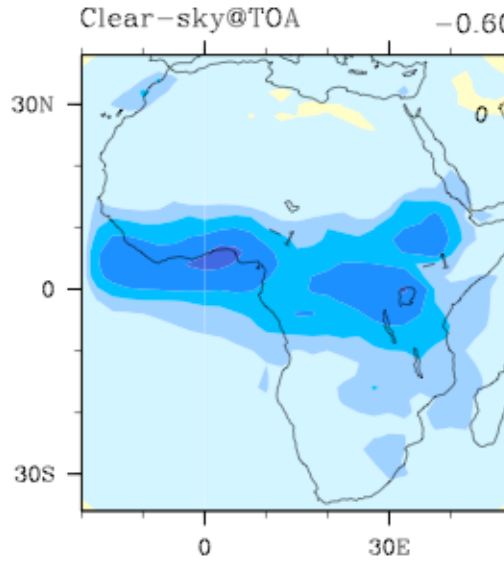
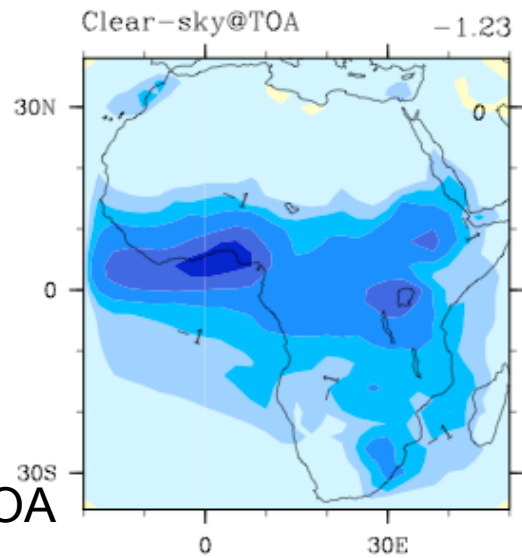
2030ccc*

**SW forcing
Fossil
Fuel only**

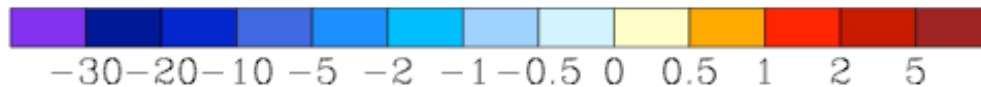
Surface



TOA



More heating in 2030ccc*!



July 2030ref

July 2030ccc*

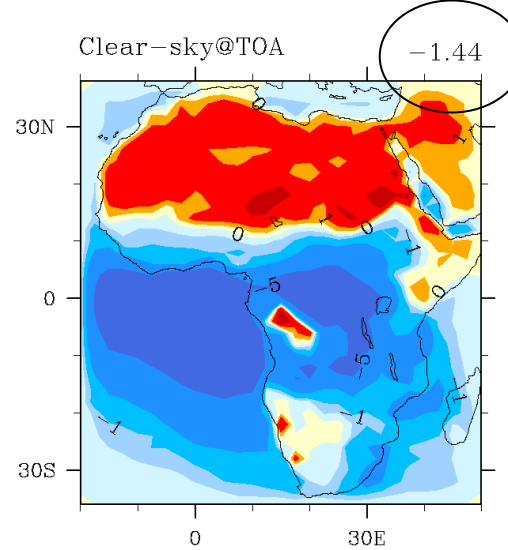
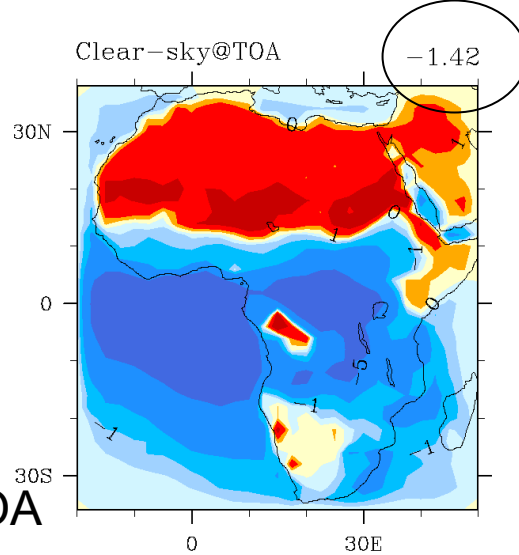
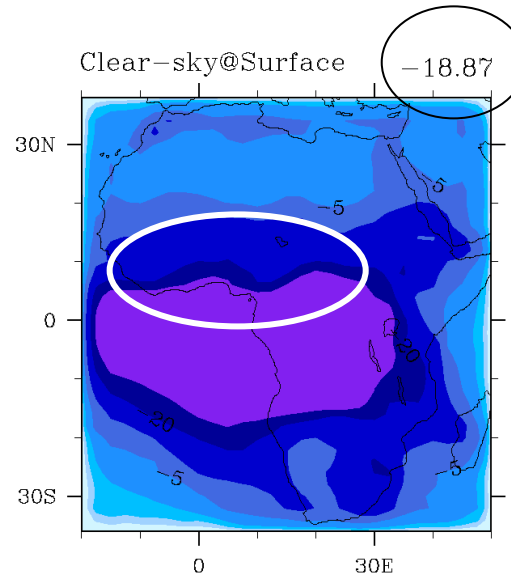
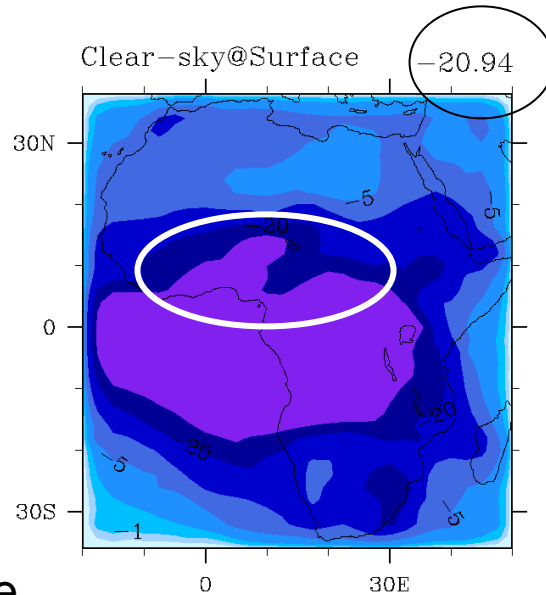
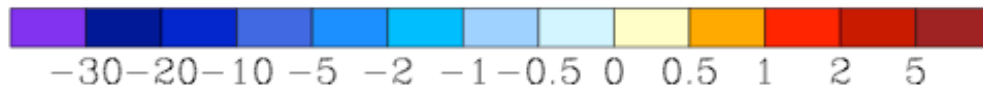
**SW forcing
FF + BB**

**More surface heating
in 2030ccc*!**

**TOA of the same order
in 2030ccc*!**

Surface

TOA



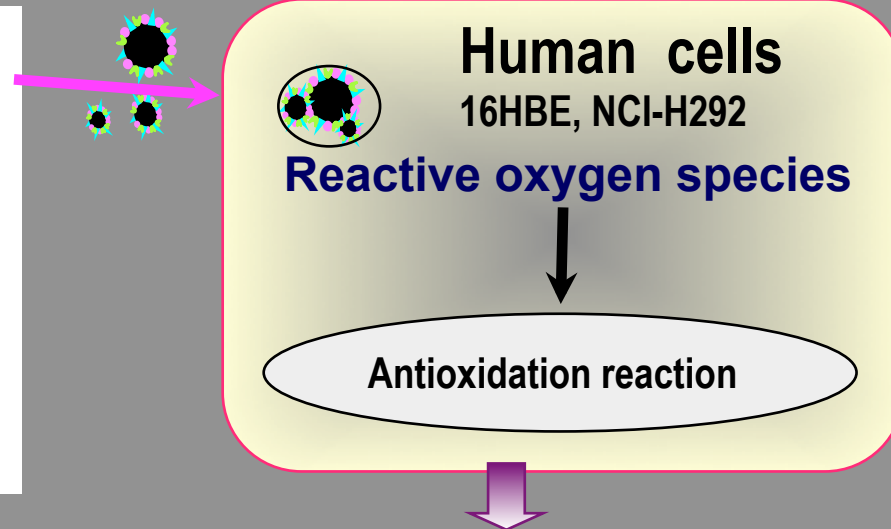
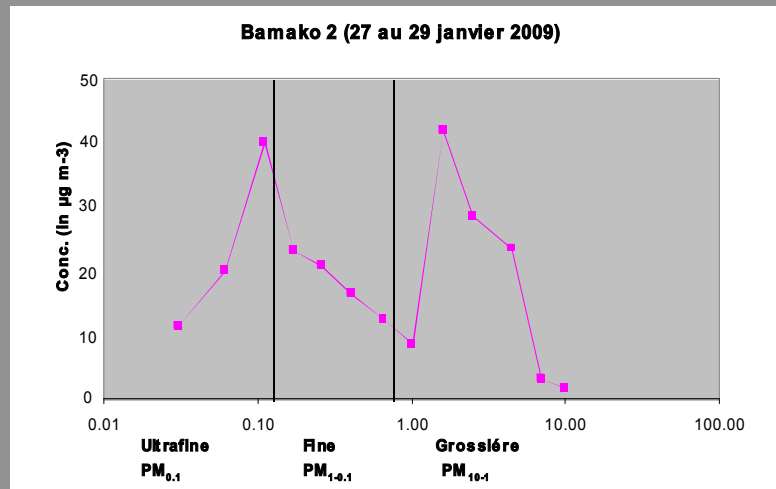
CCC* : a relative increase of BC particles

=> More heating ...

CCC* : a relative decrease of OC particles

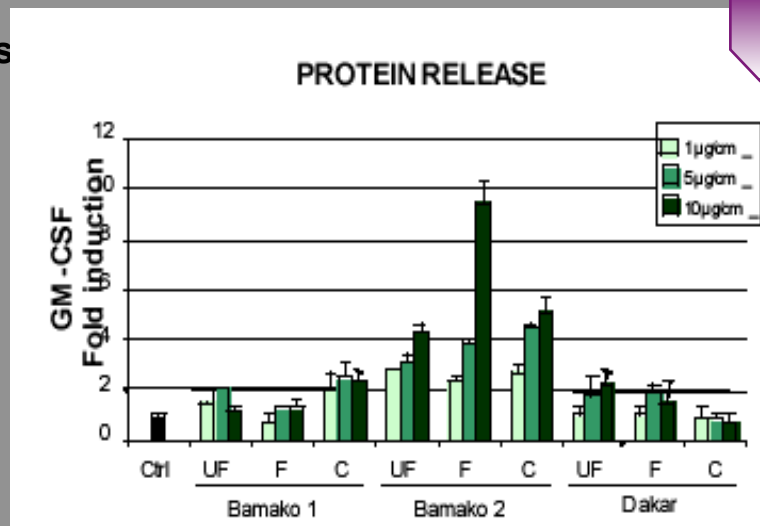
=> Improve of air quality/health

POLCA program: focus on traffic sites in Bamako (Mali) and Dakar (Sénégal)



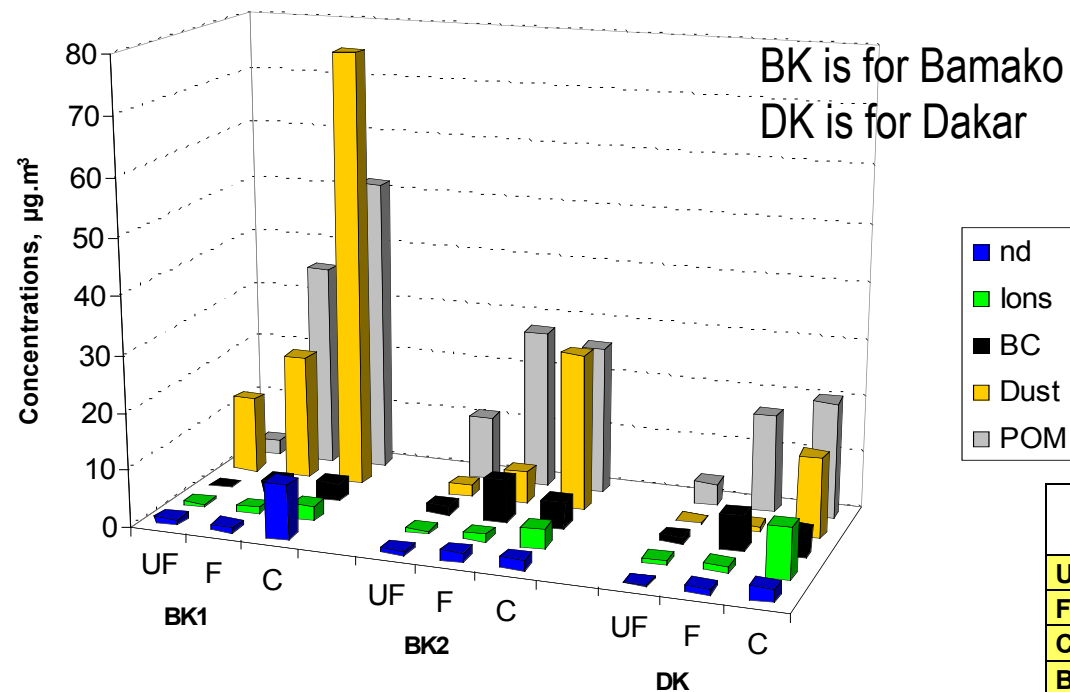
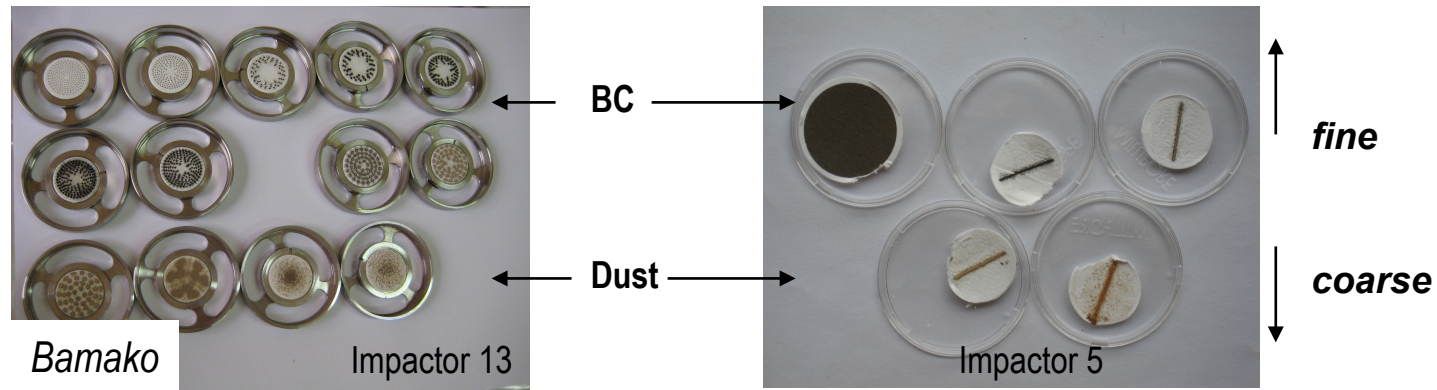
pro-inflammatory response with
Cytokines secretion (GM-CSF, IL-8...)

Biomarkers



3 situations : more impact for Bamako 2

Focus on POLCA studies : air pollution in traffic sites in Bamako and in Dakar



	BK1	BK2	DK
	BC/OC		
UF	0.17	0.18	0.49
F	0.09	0.35	0.54
C	0.11	0.34	0.36
Bulk	0.10	0.31	0.45

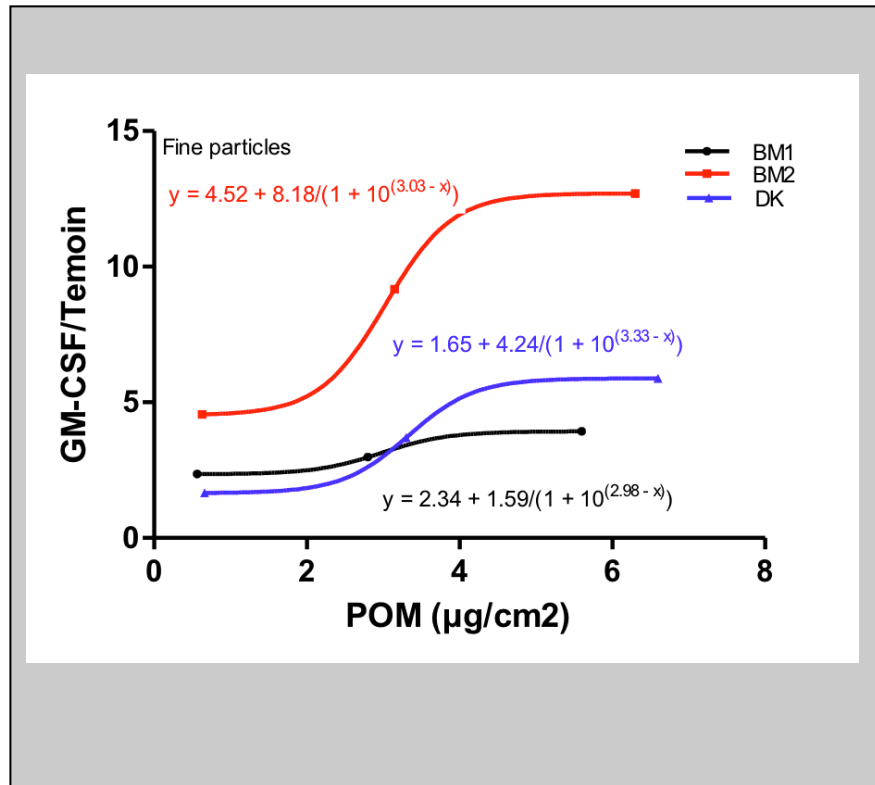
Val et al. , 2012, Doumbia, PhD 2012

Focus on POLCA studies : air pollution in traffic sites in Bamako and in Dakar

- UV absorption more important in Bamako than in Dakar (more WSOC% also)
- Bamako dominated by domestic fires and 2 wheel vehicles (incomplete combustion) whereas Dakar by diesel emissions

	Bamako	Dakar
WSOC/OC	0.8	0.25
UV BC/IR BC	1	0.75

Focus on POLCA studies : Inflammatory Impacts/Source emissions



Better correlation between GM-CSF and carbonaceous aerosols than for other aerosols

Better correlation for BK2 than for DK : BK2 aerosol more biologically active (higher OC%, abs. OC, WSOC ..) than DK aerosol.

No correlation for BK1 (dust events)

Negative Role of incomplete combustion of domestic fires and traffic in Bamako in contrast to diesel DK emissions

A tentative coupling between the impacts : Mitigation?

First results :

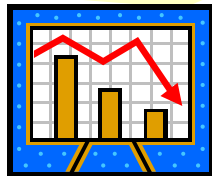
« the best scenario (2030ccc*) » $\Rightarrow$ OC decrease, BC/OC increase

Recalling what is best scenario = 4 stroke into 2 stroke, EF decrease for domestic fires



for air quality : More OC $\Rightarrow$ more «biologically reactive» particles

ccc* : health improve



for climate change : relative increase of heating !!

- $\Rightarrow$ Importance of combustion emission characterization (present/future)
- $\Rightarrow$ Multidisciplinary approach (energy/emission/pollution/climate/health)
- $\Rightarrow$ Need to focus on developing countries (choice of energy for heating, traffic, industries, power plant) : help for decision makers

Conclusion and perspectives

A real multidisciplinary collaboration is set up to estimate Pollution/Health Risks :

- Integrated modeling chain**
- Crossed Short/long-term measurements/satellite on pollution and health**
- Socio-economical aspects (emissions, costs)**
- link with climate studies**

On going:

-Modeling chain: in construction

-AP characterization : gases/aerosols including health relevant species : black carbon, organics, PAH, soluble particles and trace elements; need new bioavailability measurements

-Inflammatory impact of aerosols : new measurements of redox capacity (an interesting tool to follow up lung inflammation risks without human cell experiments)

-Satellite data : new tools (HR data/proxis determination)

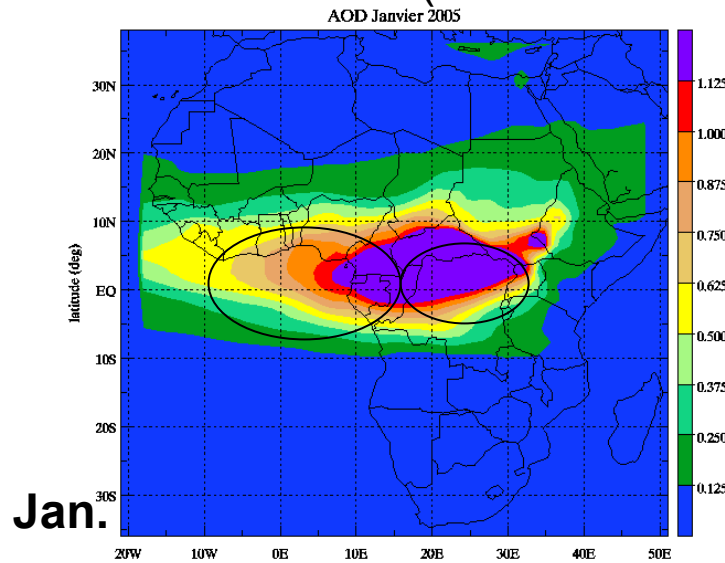
**Need : long-term crossed measurements in Africa
(Environnement/Health observatory) (not yet funded)**



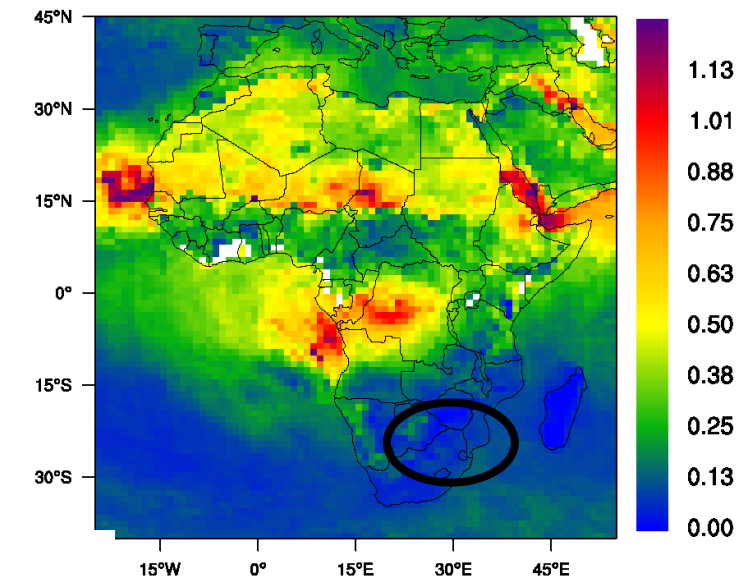
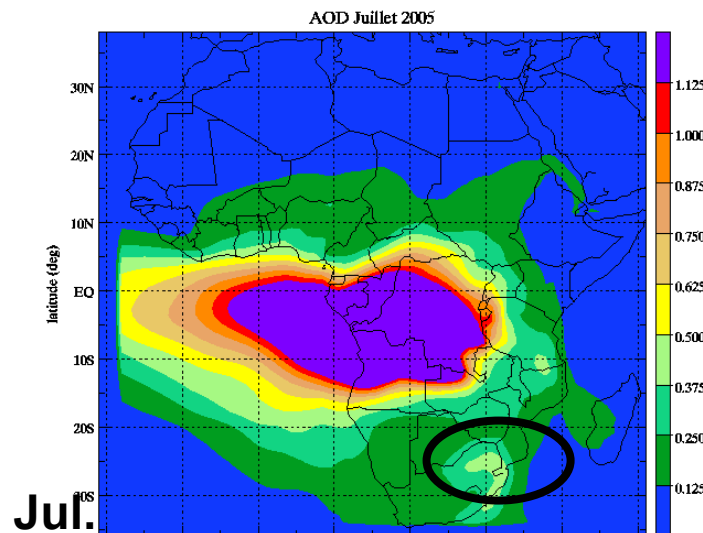
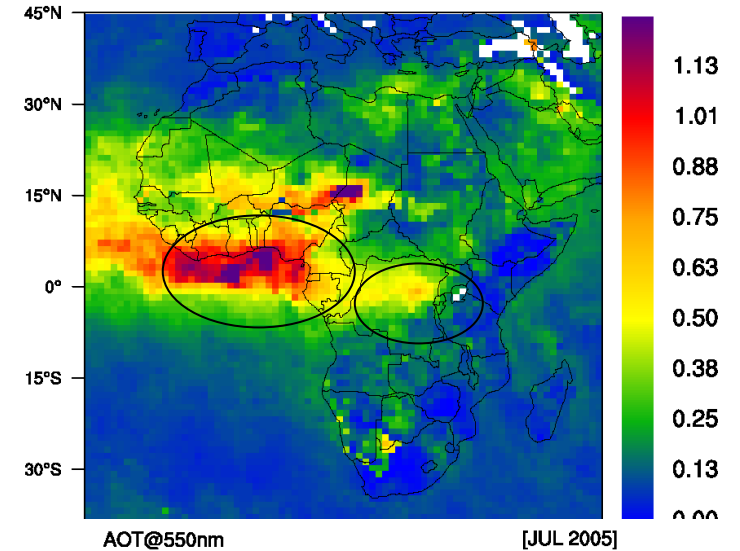
Thank you for your attention!!

Comparison with satellite data (AOD 550 nm) for 2005 ...

TM5 Model (no-dust version)



MODIS



In agreement with RegCM3 studies
on BB (Malavelle et al., Tummon et al.)