# Impact of two wheel vehicles on African combustion aerosols emissions

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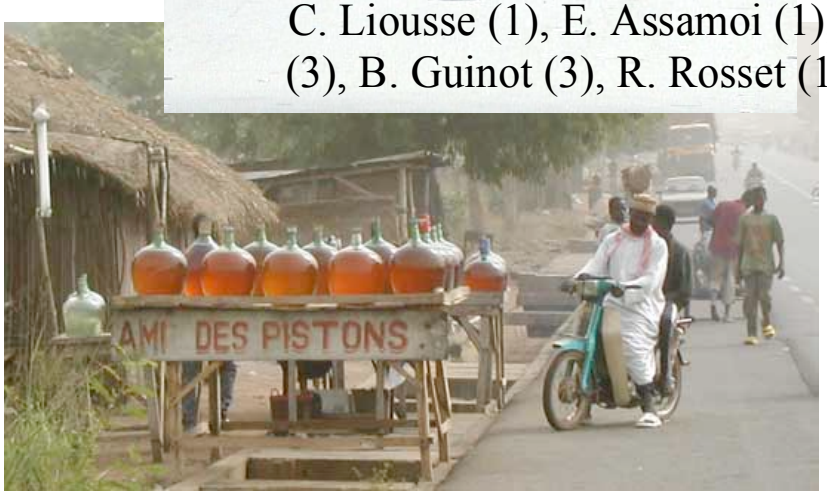


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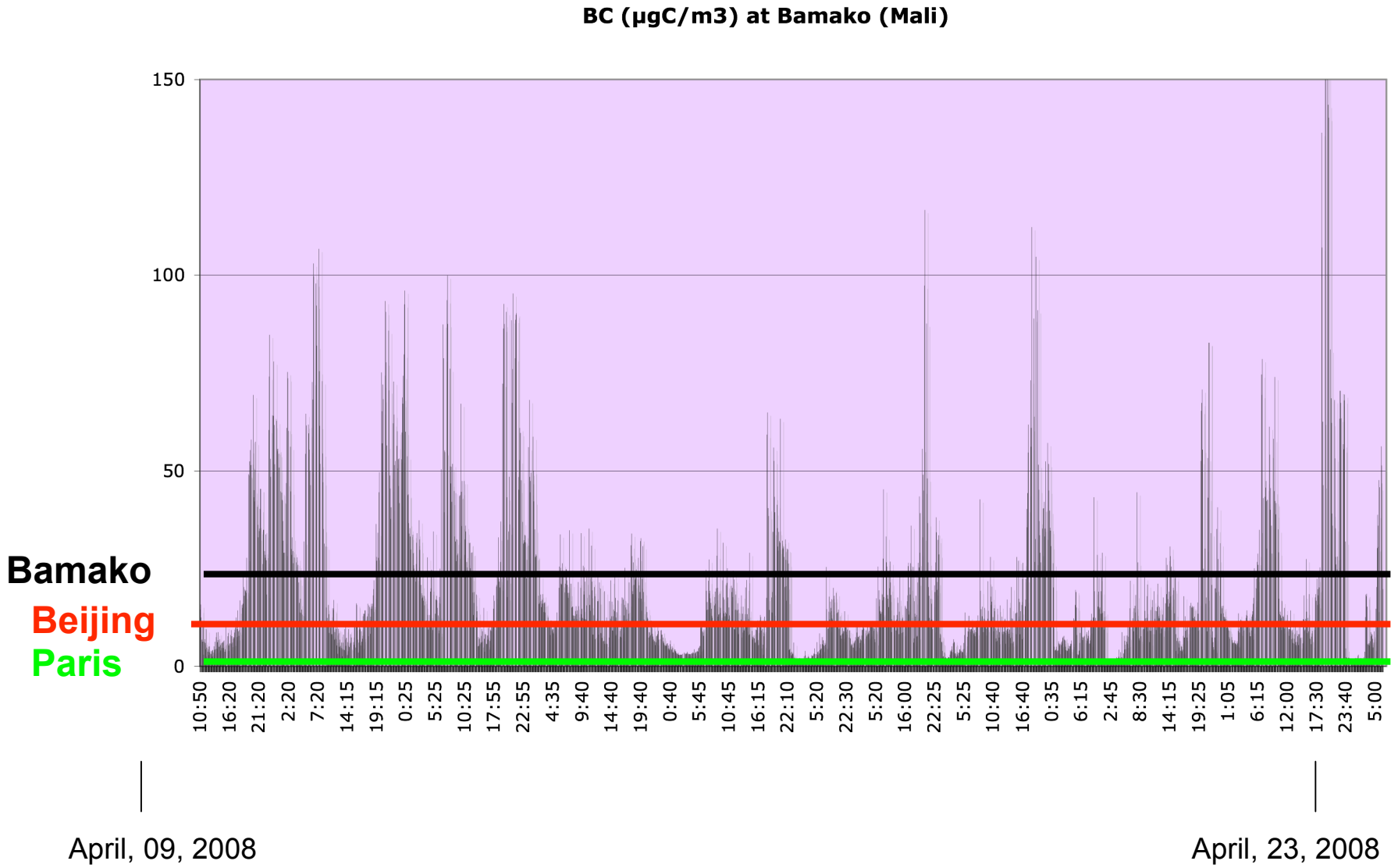
(5) Service d'Aéronomie, UMR 7620 CNRS/Paris 6, France and CIRES/NOAA/ESRL, Boulder, CO, USA

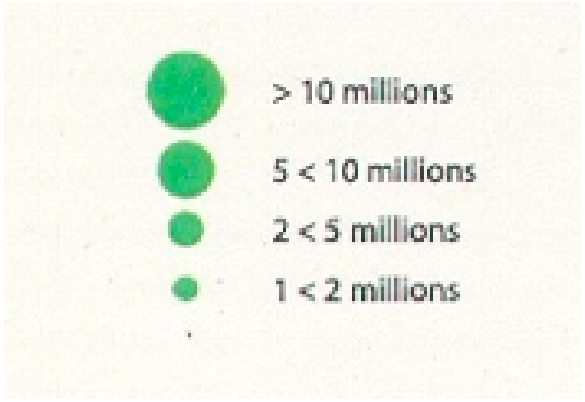
Anthropogenic pollution :
a real concern over West African megacities…

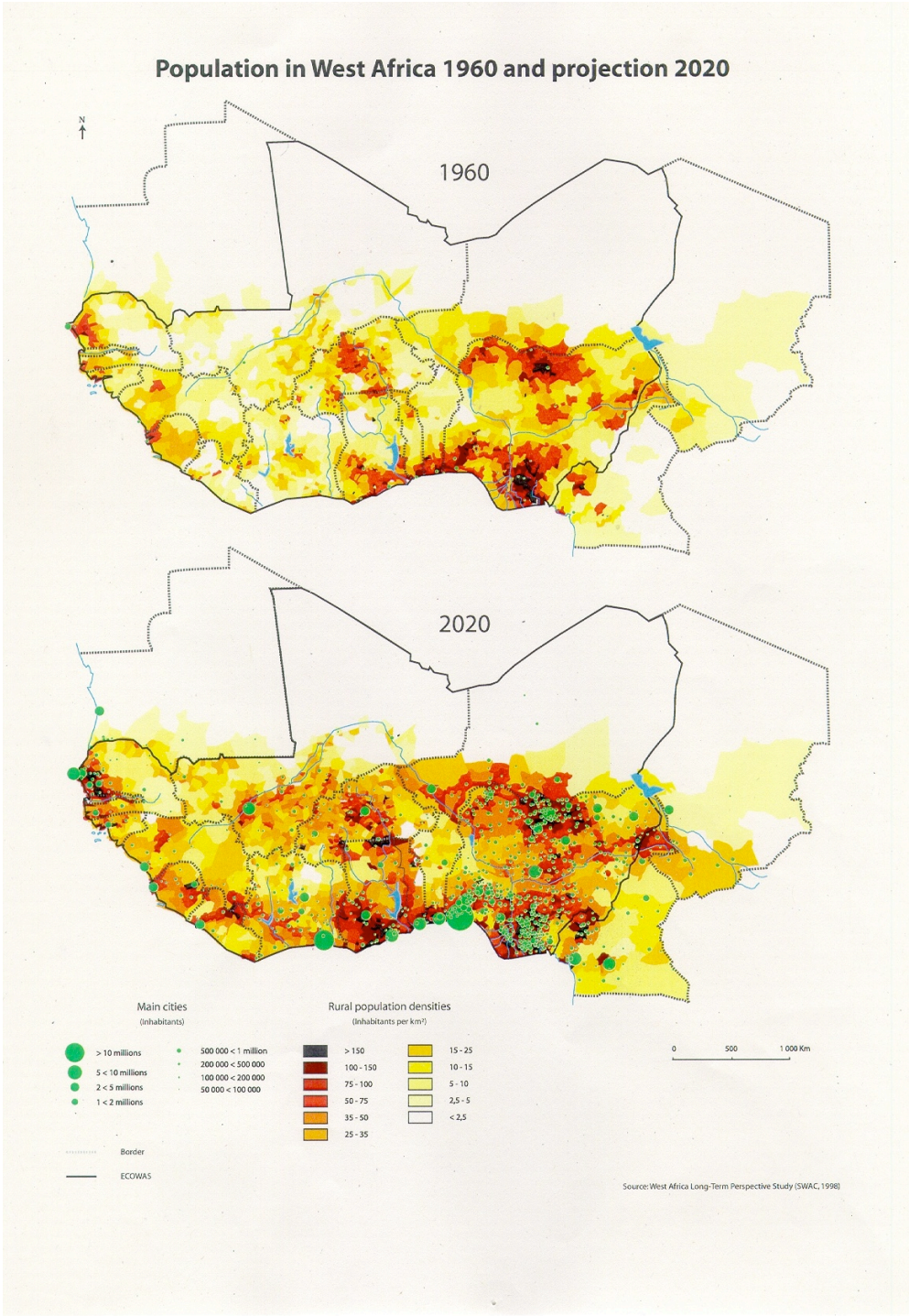
# Black carbon measurements : example of high concentrations at Bamako, Mali




From Liousse, Galy, Diop, Ndiaye et al., POLCA program

# Significant urban growth is expected over West Africa



## Emission inventories for aerosols from fossil fuel and biofuel combustion sources exist only for the global scale

*Africa data are extracted from global model of emissions*

**Example: from Junker and Liousse, Atmospheric Chemistry and Physics (ACP), 2008**

**African Emissions are provided country by country**
**Spatialization is done by using the GISS population map**

# A global bottom-up method (based on Junker and Liousse, ACP 2008)

**Methodology**

**- Use of the United Nations Energy database**
**- Provides fuel consumption data for:**
**185 countries; 33 different fuels**
**over 50 different usage/technology categories**

**Emissions are fuel-dependent, fuel usage-dependent and technology-dependent**

**- Emissions calculated for 3 sectors : Industrial/Domestic/Traffic**
**- Technology splitted following development level of each countries:**
**3 groups : Developed/Semi developed/Developing**

**- Emission factors for 3 country classifications, 8 different fuels and 3 usage categories**

**Population density within each country (population map) and emissions country/country => 1°X1° spatial distribution of emissions**

# Emission Factors values for Black carbon and primary organic carbon

**Emission factors are provided for 3 categories:**

- **Industrial**
- **Domestic**
- **Traffic**

**And for 8 different types of fuels:**

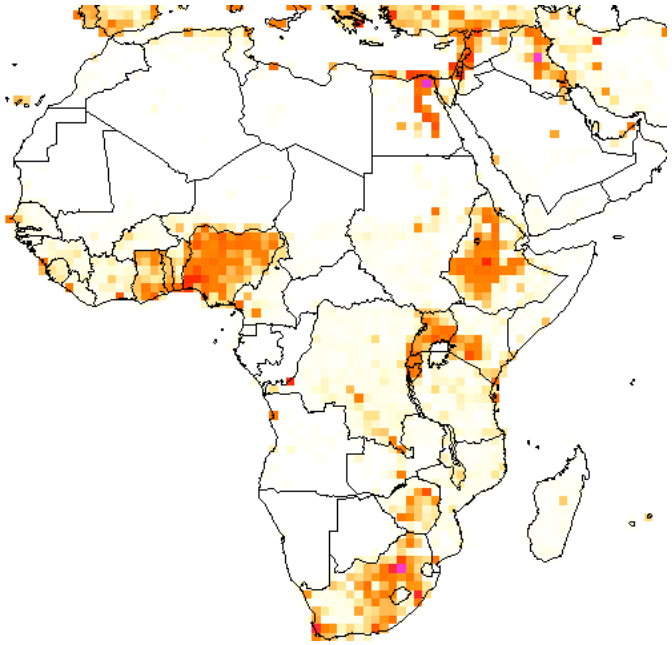
- **Solid fuel**
- **Fuelwood**
- **Charcoal**
- **Peat**
- **Aviation**
- **Diesel/Heavy fuel**
- **Motor Gasoline**
- **Gases (natural, GPL, etc.)**

**Emissions factors are taken from published literature or from results of observation campaigns**

# Year 2000 Africa

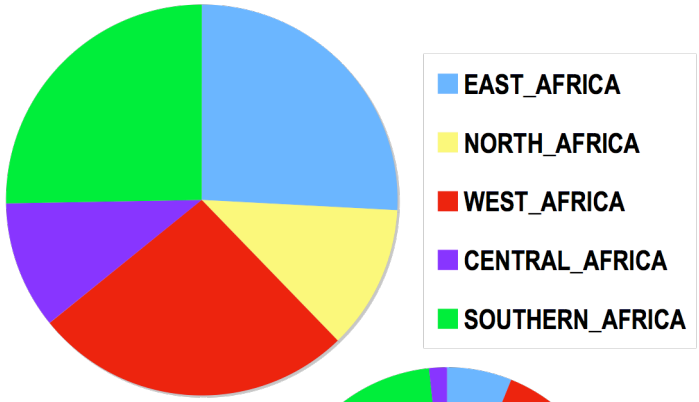
## Fossil fuel and biofuel combustions

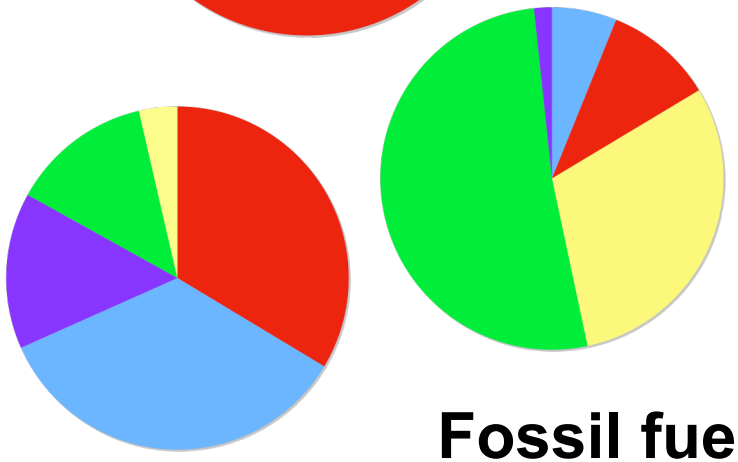
BC 0.64 Mt(BC)



BC (tons/1°x1°)


Total BC



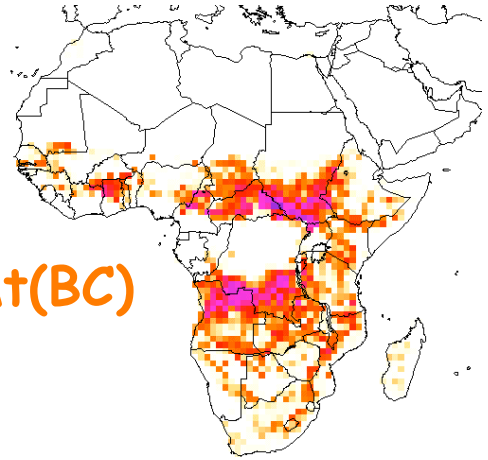



Biofuel BC

Fossil fuel BC

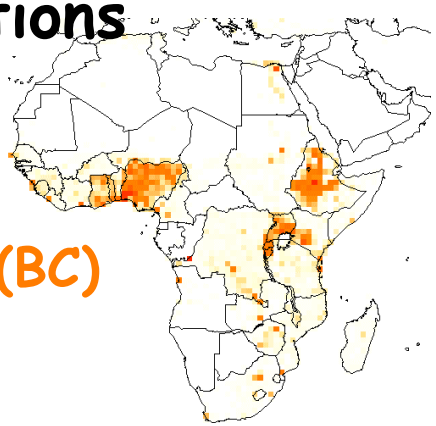
# African BC emissions by source types

Biomass burning



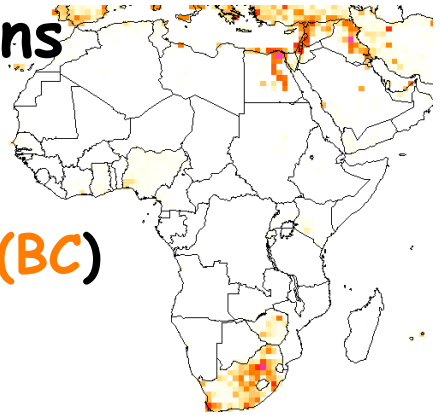
2.28 Mt(BC)

Biofuel combustions



0.44 Mt(BC)

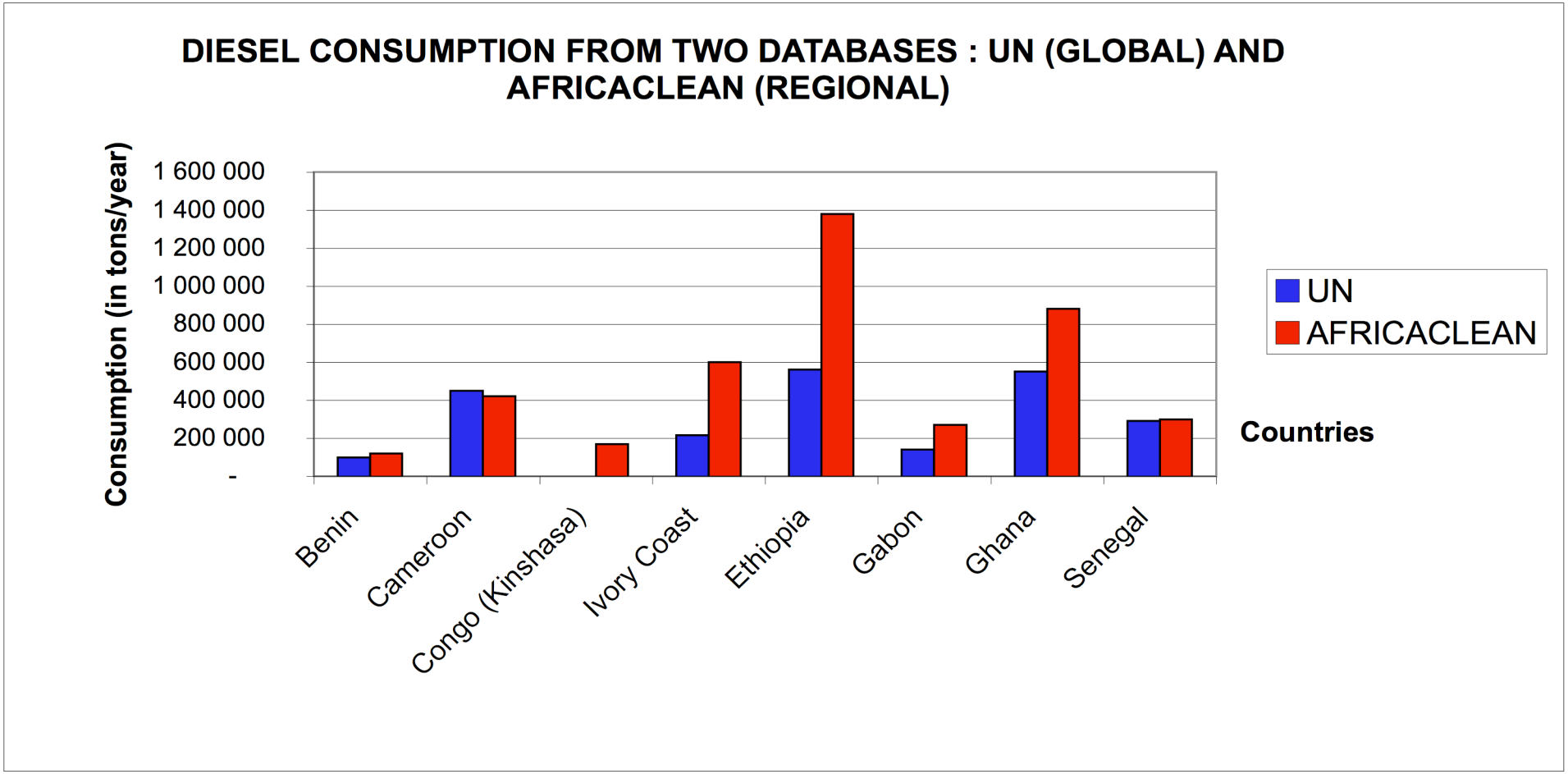
Fossil fuel combustions



0.20 Mt(BC)

BC (tons/1°x1°)

# Uncertainties on regional emissions in Africa : Example showing diesel consumption




*Large discrepancies between global inventory and regional zoom obtained with Africaclean database for the traffic emission inventory*

# Measurements of 2-wheel vehicles emissions : New emission factors

Measurements of **emission factors**

example for zem : $CO/CO2$ = 0.42
zem= Zemidjem ~ moto-taxi

EF(Black carbon) = 0.79 g/kgdm
EF(Organic carbon) =9.1 g/kgdm

***EF for traffic in developing countries :***
***0.15 for BC and 0.73 for OC***

Urban emission characterization at Cotonou - AMMA international campaign, May 2005
*AMMA = African Monsoon Multidisciplinary Analyses*

*Guinot et al., 2008*

# TWO-WHEEL VEHICLE EMISSIONS : NEW FUEL CONSUMPTION DATA

## *1- Count the number of 2-wheel vehicles per country*

| COUNTRIES | NUMBER OF TWO WHEELS |
|---|---|
| BENIN | 320 000 |
| BURKINA FASO | 120 000 |
| CAMEROON | 50 000 |
| CHAD | 5 500 |
| GHANA | 100 000 |
| GUINEA | 45 000 |
| GUINEA BISSAU | 2 500 |
| IVORY COAST | 80 000 |

| COUNTRIES | NUMBER OF TWO WHEELS |
|---|---|
| MALI | 300 000 |
| NIGER | 5 000 |
| NIGERIA | 1 300 000 |
| SENEGAL | 10 000 |
| SIERRA LEONE | 15 000 |
| TOGO | 90 000 |
| UGANDA | 70 000 |

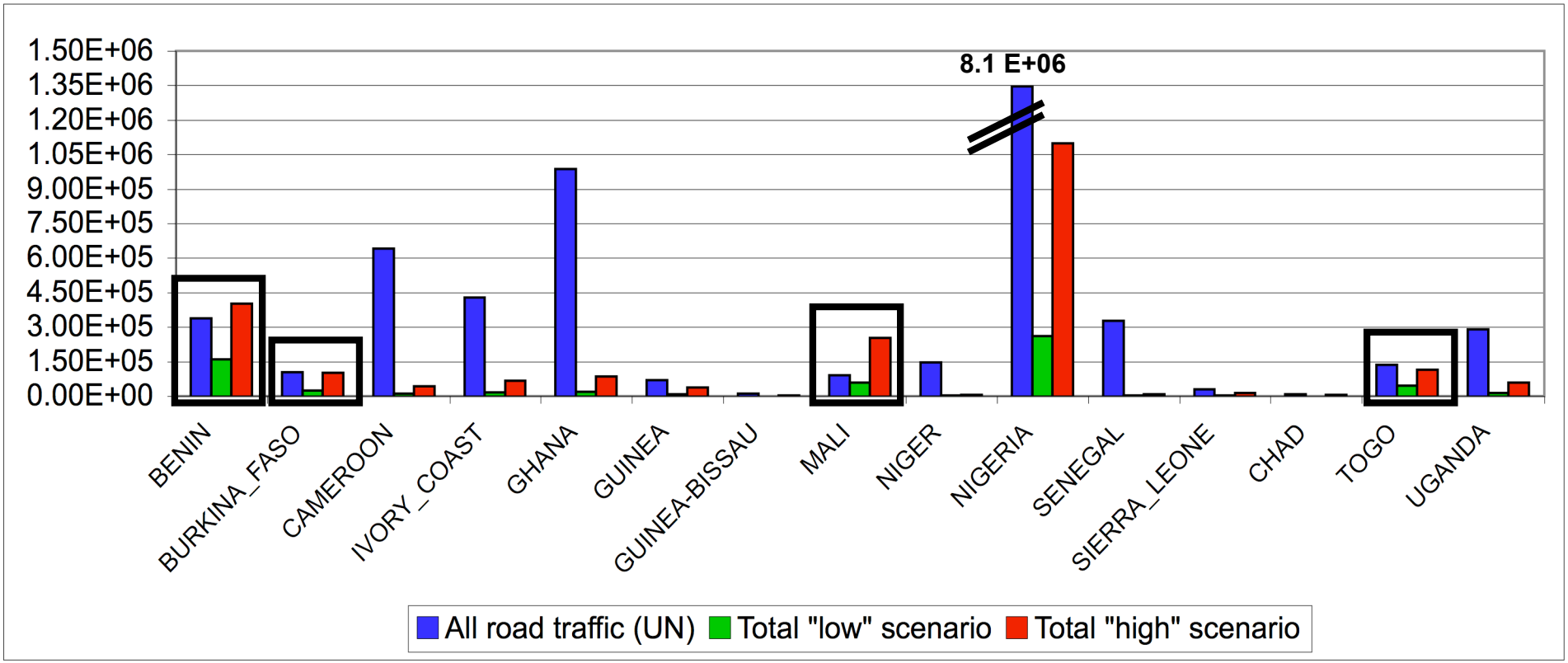
## *2) Asumptions for a "low" and a "high" scenario*

| | "low" scenario | | "high" scenario | |
|---|---|---|---|---|
| | "clean" two wheels | « zemidjans » | "clean" two wheels | « zemidjans » |
| **Number of days of usage** | **5 days per week** | | **7 days per week** | |
| **Daily consumption (liters)** | **1** | **4** | **3** | **6** |
| **Emission factors (g/kg)** | **BC = 0.55<br>OC = 2.55** | **BC = 0.79<br>OC = 9.10** | **BC = 0.79<br>OC = 9.10** | |
| **Fuel volumic mass ($kg/m^3$)** | **4% oil : $\rho$ = 754.2** | | **25% oil : $\rho$ = 776.25** | |

# IMPORTANCE OF FUEL CONSUMPTION VALUES (TONS PER YEAR) DUE TO TWO-WHEEL VEHICLES

***Comparison with data for total traffic (UN)***

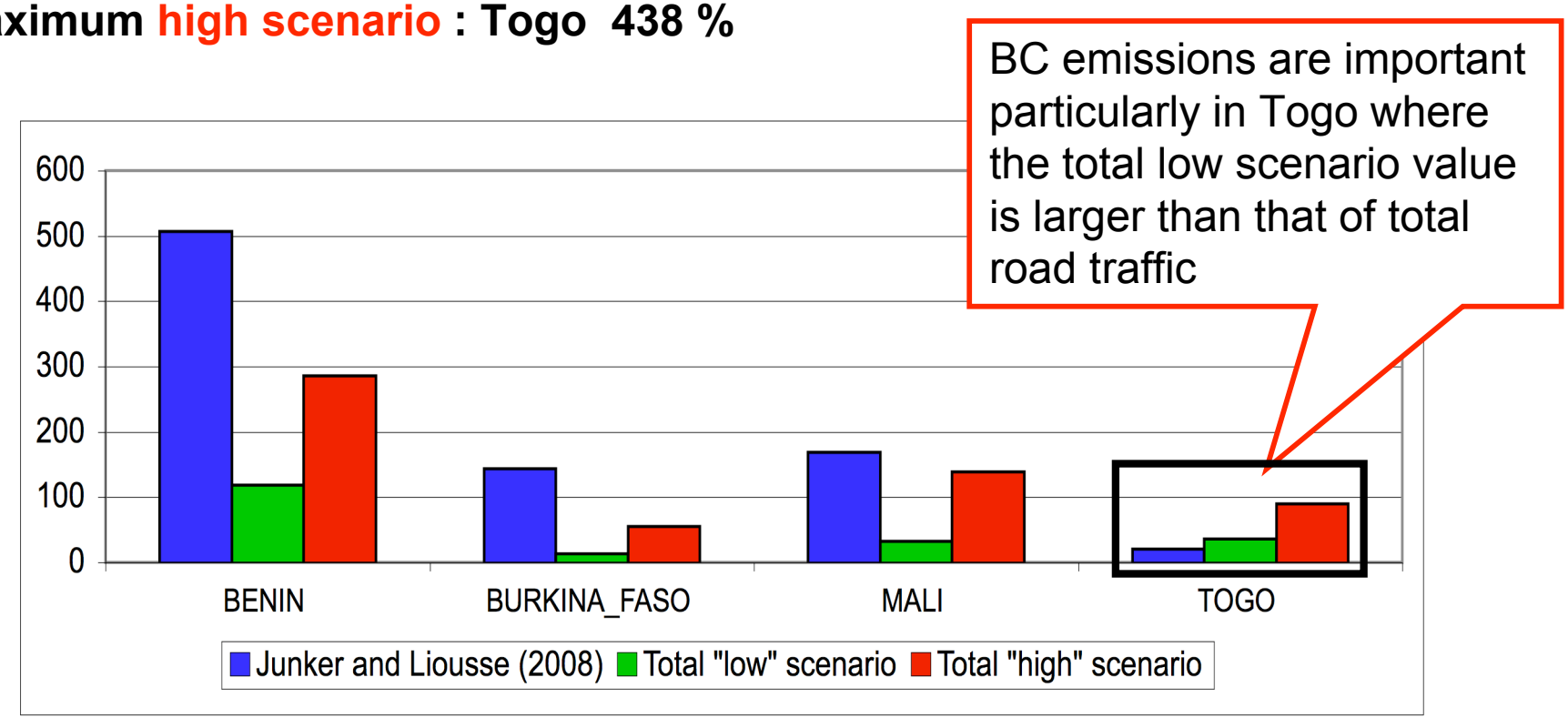
- **minimum low scenario : Senegal 0,6 %**
- **maximum low scenario : Mali 66 %**
- **minimum high scenario : Senegal 3 %**
- **maximum high scenario : Mali 279 %**



# IMPORTANCE OF BLACK CARBON EMISSIONS (TONS PER YEAR) DUE TO TWO-WHEEL VEHICLES

*(Comparison with global Junker and Liousse inventory for total trafffic)*

- **minimum low scenario : Burkina-Faso 9 %**
- **maximum low scenario : Togo 173 %**
- **minimum high scenario : Burkina-Faso 39 %**
- **maximum high scenario : Togo 438 %**

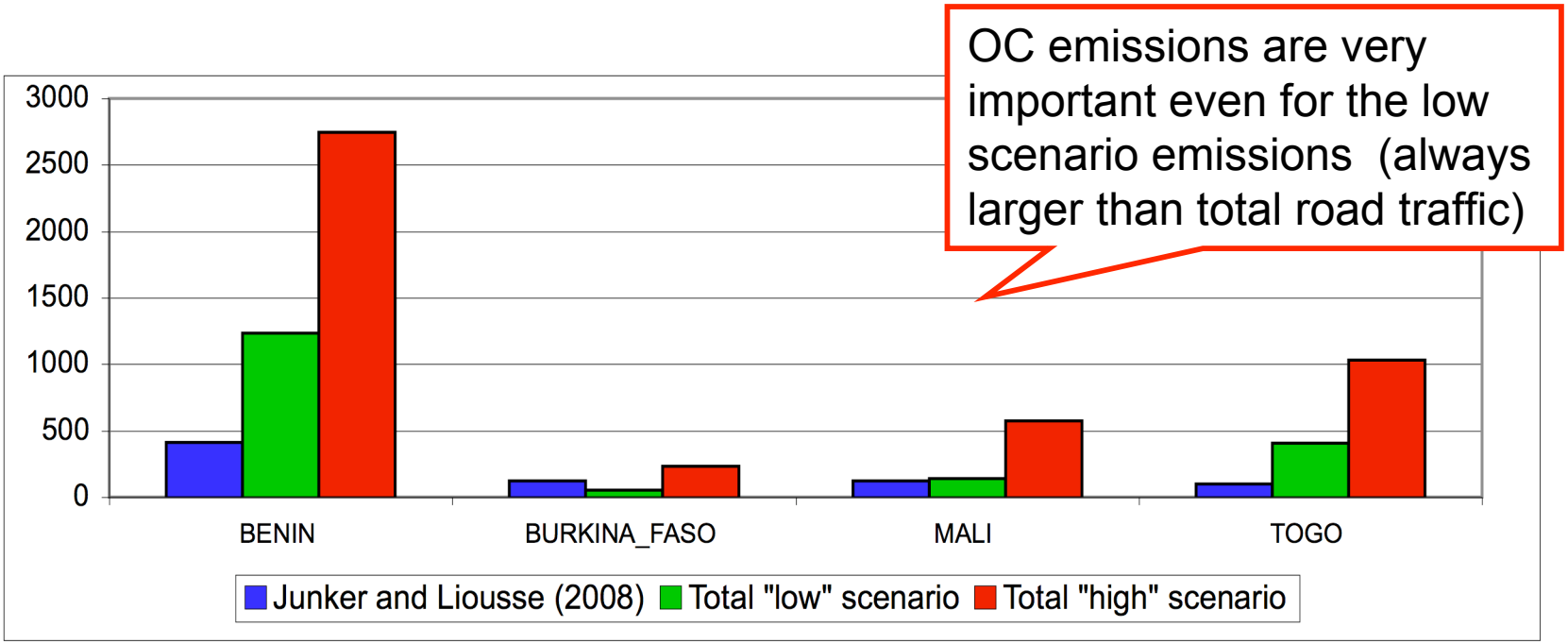



BC emissions are important particularly in Togo where the total low scenario value is larger than that of total road traffic

# IMPORTANCE OF ORGANIC CARBON EMISSIONS (IN TONS PER YEAR) DUE TO TWO WHEEL VEHICLES

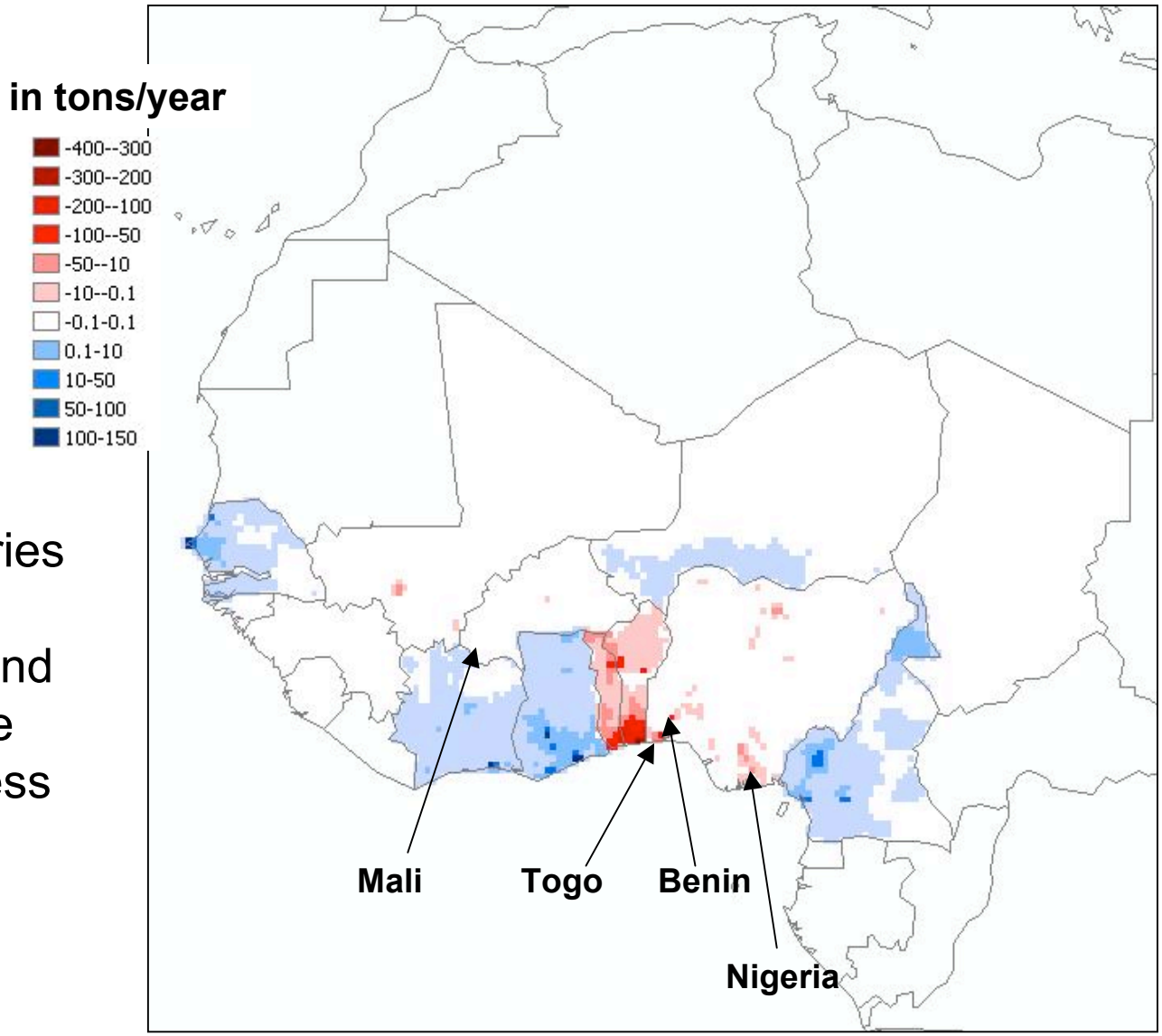
*(Comparison with global Junker and Liousse inventory for total traffic)*

- **minimum low scenario : Burkina-Faso 55 %**
- **maximum low scenario : Togo 411 %**
- **minimum high scenario : Burkina-Faso 188 %**
- **maximum high scenario : Togo 1037%**




→ **higher impact than BC (incomplete combustion of 2 stroke motorbike).**

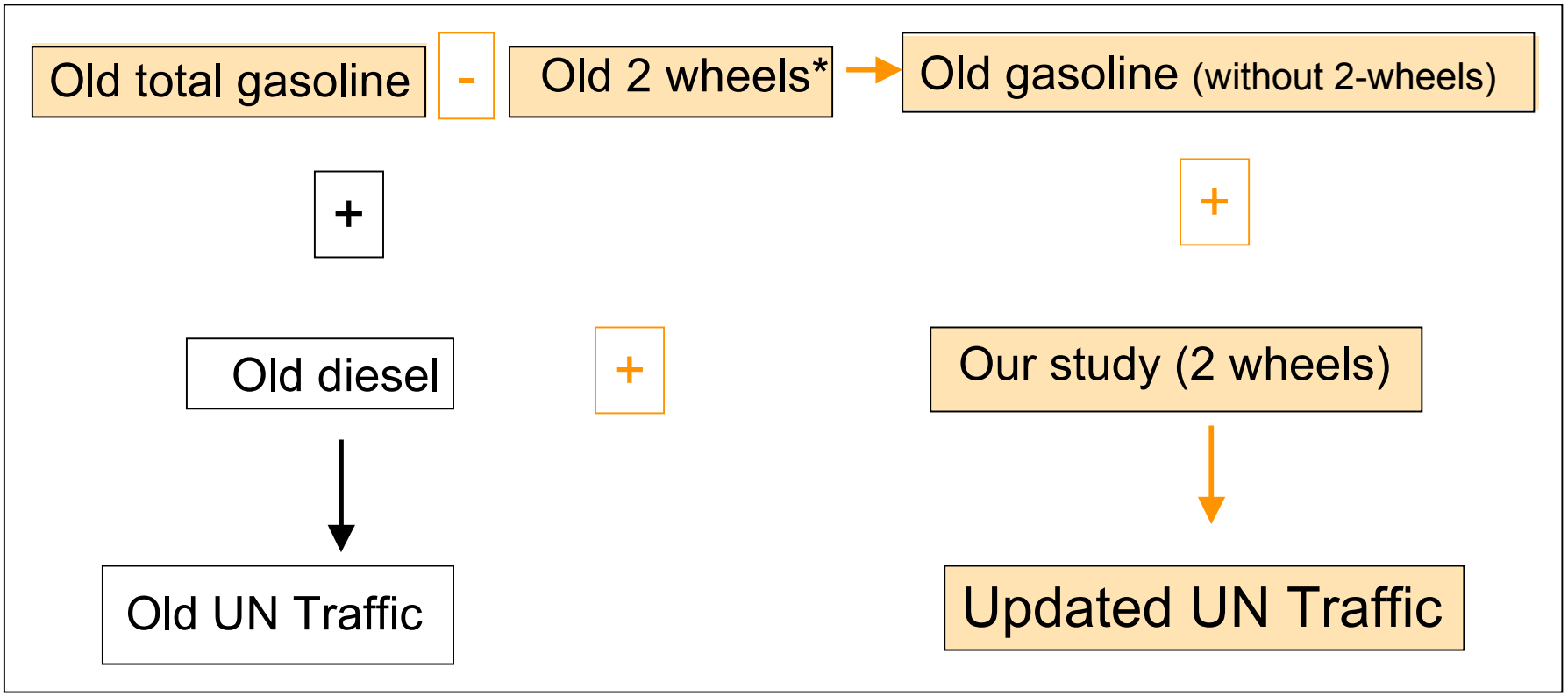
# OC Emissions differences between the Junker and Liousse (2008) inventory and the current study including 2-wheel vehicles




**Red** indicates countries where two-wheel vehicles dominate and **blue** countries where they are relatively less important.

→ **This work shows the importance of specific regional characteristics**

# Updated UN fuel consumption (by updating 2-wheel contribution)




*Old 2 wheels =
=>75% of old total gasoline for countries with 2 wheel impacts
=>10% of old total gasoline for countries without 2 wheel impacts

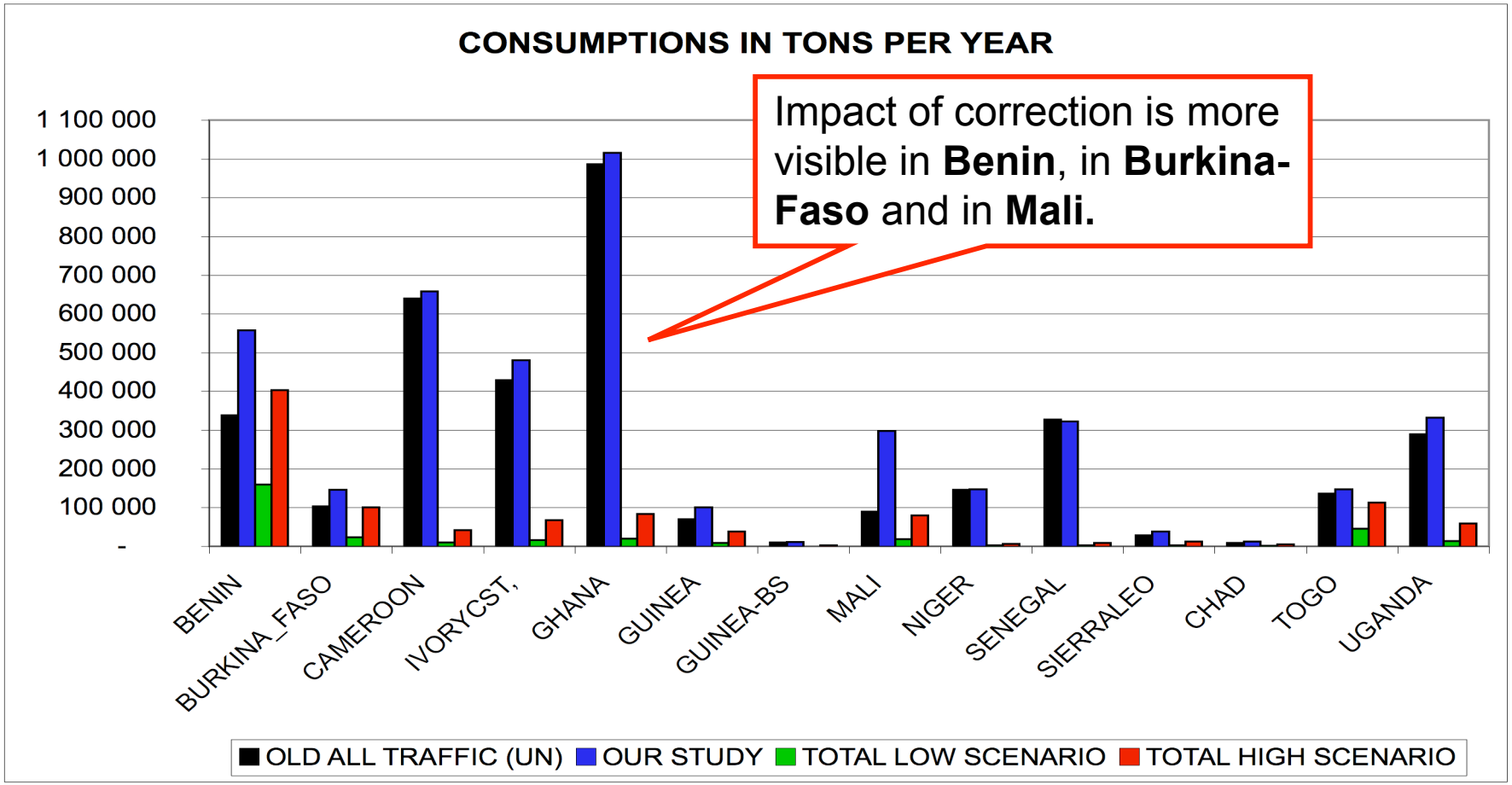
CONSUMPTION *

**Total old road traffic (UN)** : 3,600,345 tons/year

**Total new road traffic (our study)** : 4,265,250 tons/year

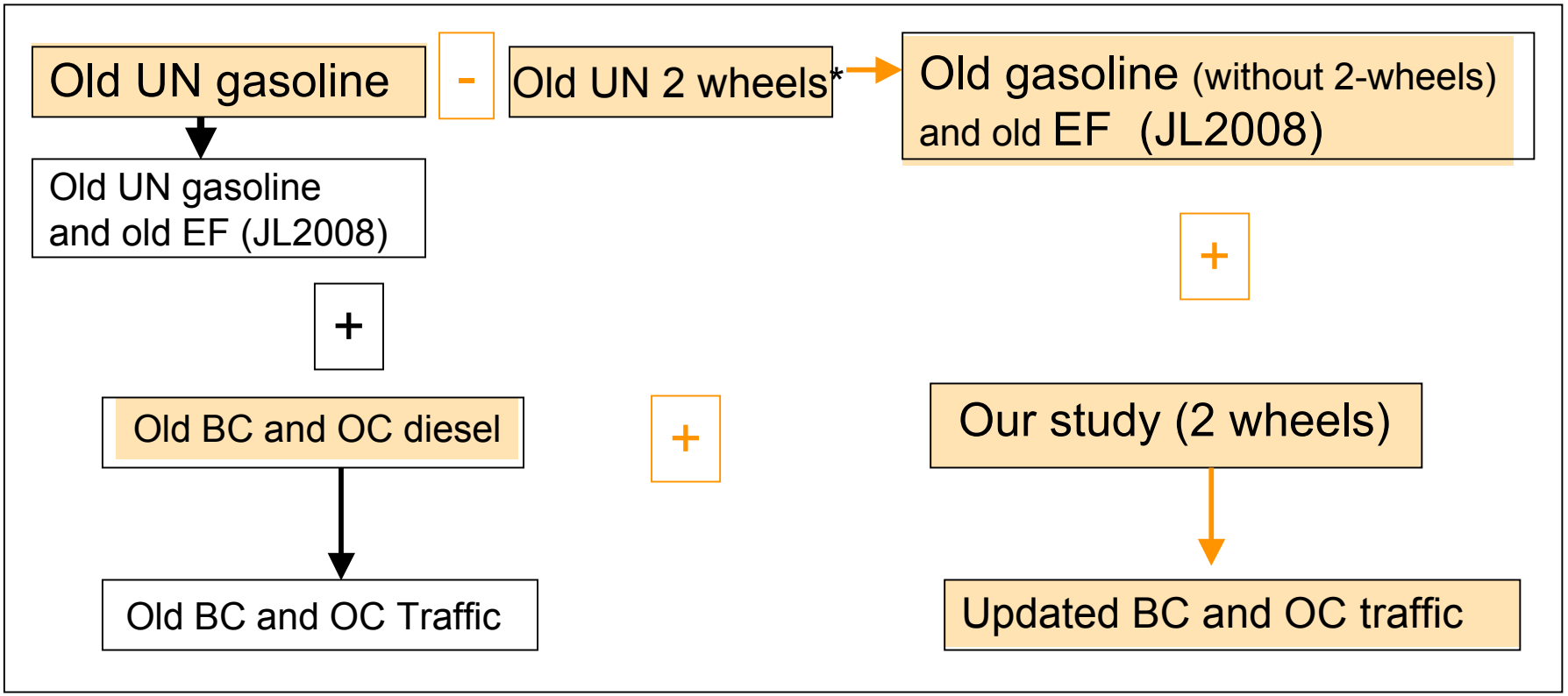
**Total low scenario (our study)** : 324,639 tons/year

**Total high scenario (our study)** : 1,018,979 tons/year




*** Without Nigeria**

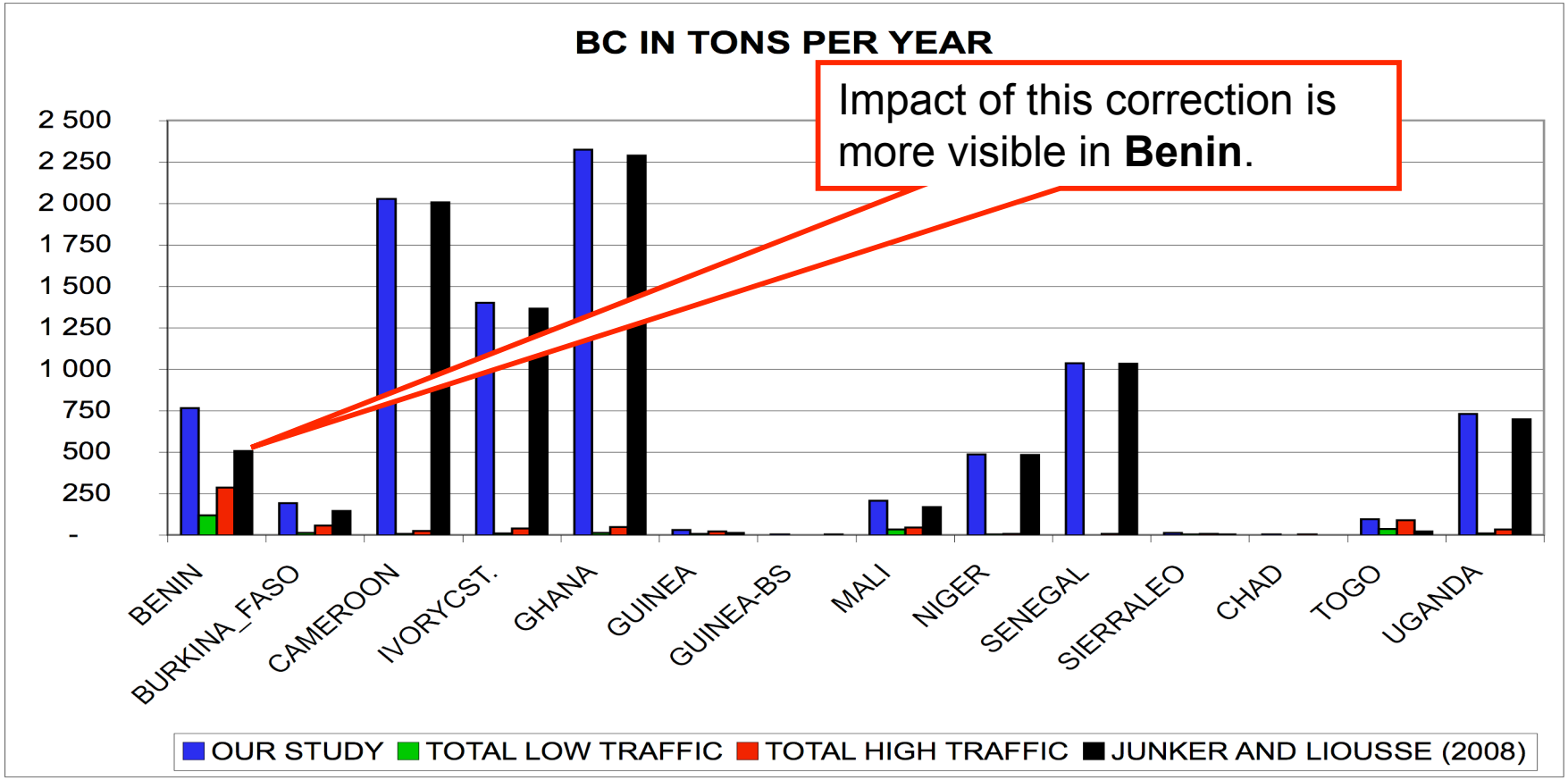
# Updated BC and OC inventory (by updating 2-wheel contribution)




*Old 2 wheels =
=>75% of old total gasoline for countries with 2 wheel impacts
=>10% of old total gasoline for countries without 2 wheel impacts

# BLACK CARBON (BC) *

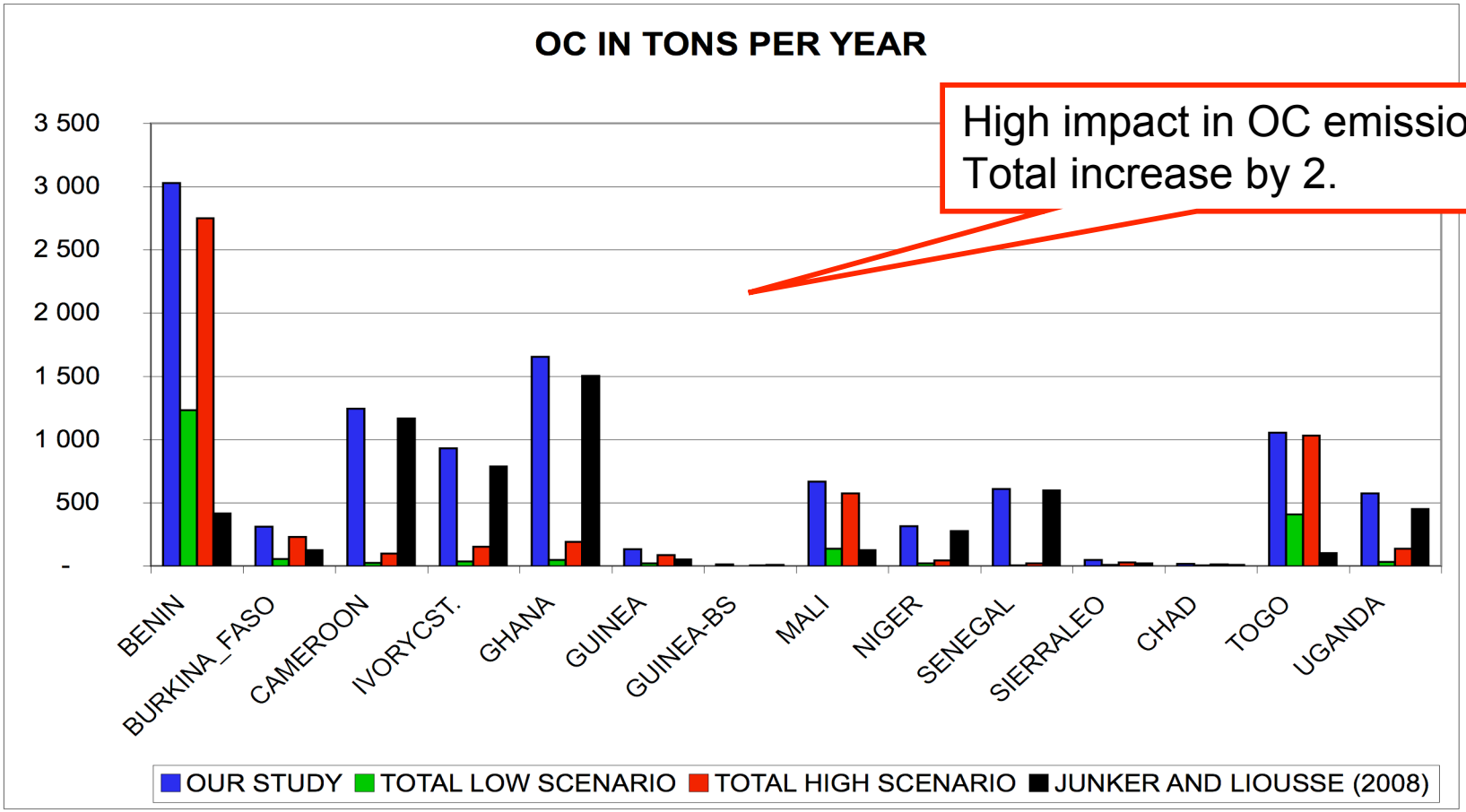
**Total old road traffic (JL08)** : 8 727 tons/year
**Total new road traffic (our study)** : 9 301 tons/year
**Total low scenario (our study)** : 243 tons/year
**Total high scenario (our study)** : 653 tons/year




*** Without Nigeria**

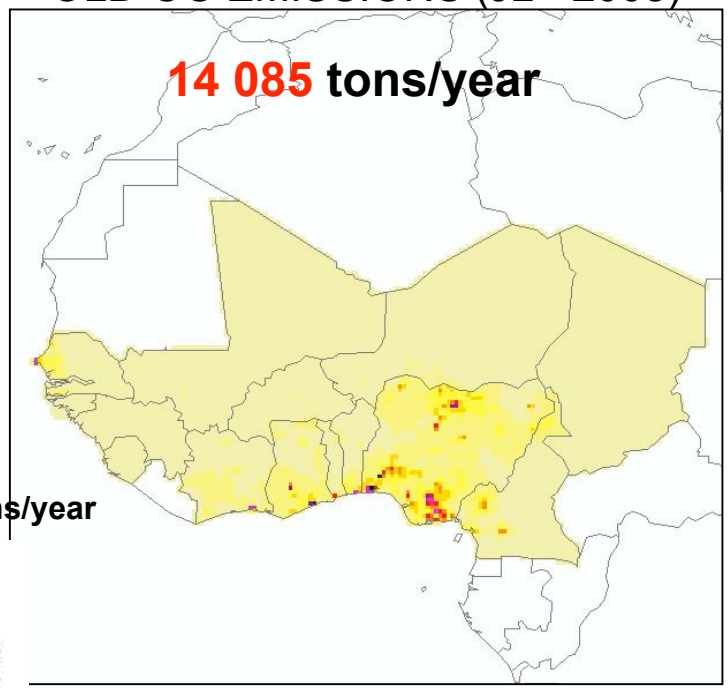
# ORGANIC CARBON (OC) *

**Total old road traffic (JL2008)** : 5616 tons/year
**Total new road traffic (our study)** : 10 577 tons/year
**Total low scenario (our study)** : 2 021 tons/year
**Total high scenario (our study)** : 5 345 tons/year



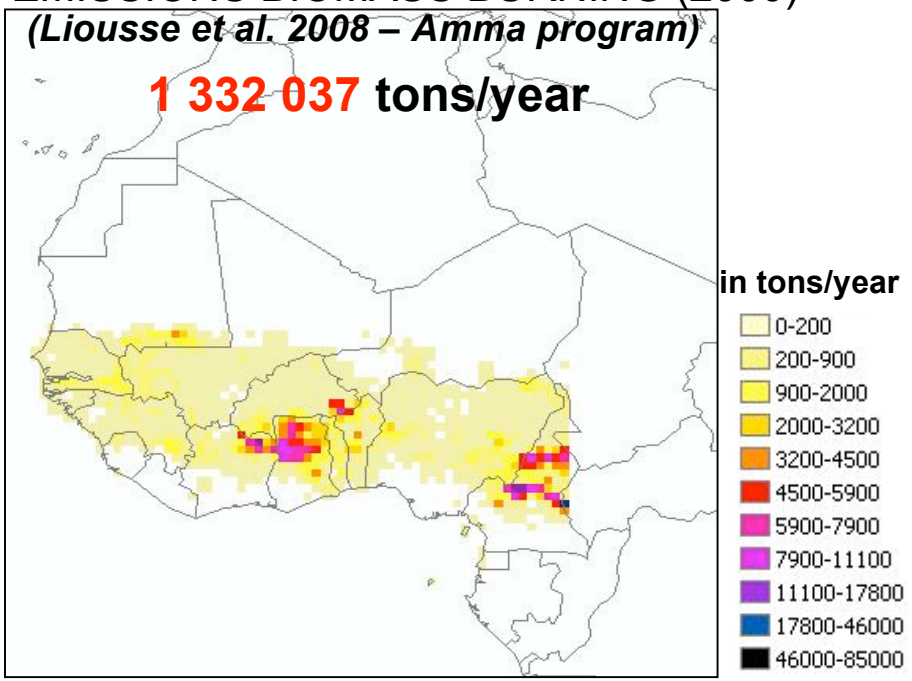

*** Without Nigeria**

OLD OC EMISSIONS (JL - 2008)

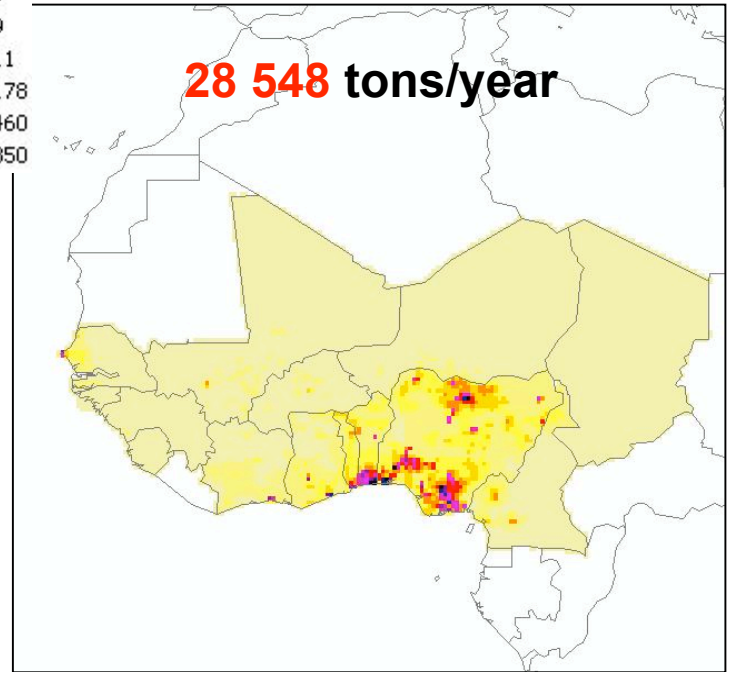



OC EMISSIONS BIOMASS BURNING (2000)

*(Liousse et al. 2008 – Amma program)*




NEW OC EMISSIONS CORRECTED (our study)




New corrected OC emissions are 2 times higher than old *(and 10 times smaller than the west african biomass burning emissions (instead of 20 before))*

**A new hot spot of anthropogenic emissions in the coast of Guinean Gulf and north of Nigeria appears.**

# CONCLUSIONS

❖ Large underestimates of fuel consumption in the West African region in the global database.

❖ This work focused on two-wheel emissions shows the need to integrate African specifities in BC and OC emissions (both on fuel consumption and emission factors).

❖ More generally all traffic emissions need to be updated → not only two-wheels but also for trucks and bus for Gasoline and also for Diesel.

❖ A new emission hub is shown centered on the coast of Guinean Gulf and north of Nigeria → this hub is expected to increase in future projections if no traffic regulation is taken.