

Ministry of Environment and Sustainable Development
Direction of Environment and Classified Establishment
Centre for Air Quality Management (CGQA)

**Regional Consutation on Air Quality, Clean Vehicles
and Sustainable Mobility Roadmap**
August 24 - 25, 2016, Nairobi

***Air Quality Monitoring
Air Quality Index System and forecasting model in Senegal***

Presented by

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Senegal overview

Senegal is bounded by:

- ✓ Atlantic ocean in west;
- ✓ Mauritania in north and east;
- ✓ Mali in east;
- ✓ Guinea and Guinea Bissau in south

Capital city is Dakar



Background and justification

Senegalese Government:

- ✓ being aware of the need to improve the quality of life of people;
- ✓ taking into account the impacts of air pollution on the human health and the environment (the health cost of air pollution is estimated at 65 billion in 2001 according to a study of the World Bank),



created in 2009 a Centre for Air Quality Management (CGQA).

Background and justification

The centre was funded by the Nordic Development Fund (NDF) and the Senegalese Government.

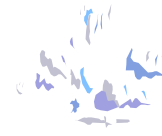
The setup was done through the fourth component of the PAMU (Urban Mobility Improvement Program) implemented by the ministry in charge of transport, through Executive Council of Dakar Urban Transport (CETUD) which consisted of the creation of:

1. Centre for Air Quality Management (Centre de Gestion de la Qualité de l'Air – CGQA);
2. Motor Vehicles Technical Control Centre (Centre de Contrôle Technique des Véhicules Automobiles – CCTVA)

Background and justification







- ✓ Due to its objectives of environment watch, the centre has been placed under the supervision of the Ministry of Environment and Sustainable Development
- ✓ It has five monitoring stations and a van mobile laboratory.

Objectives



- ✓ keep on watching the ambient air pollution,
- ✓ Inform the public on air quality and provide reports to the authorities for decision making,
- ✓ Advocate realistic measures for improving air quality,
- ✓ Promote the establishment of a committee on air quality.

Pollutants monitored by CGQA

Monitored pollutant	Source	Health effects
Nitrogen Oxides (NOx)	Transport, combustion plant,	Asthma, susceptibility of children to bronchial infections. 
Ozone (O ₃)	Transformation of NOx and hydrocarbons in the presence of sunlight.	Cough, eyes irritation, etc. 
Benzene Toluene Xylene (BTX)	Transport, industry, nature	Nervous system disorders, loss of consciousness 
Particulates matter PM2.5 and PM10	Transport, industry and nature (dust and sandstorm...)	Respiratory and cardiovascular diseases 
Carbon monoxide (CO)	Transport	Chronic intoxication, headaches, vertigos, cardiovascular problems 
Sulphur dioxide (SO ₂)	Fuel and coal combustion	Adult acute respiratory symptoms and children breathlessness. 

How we measure air quality?

❑ Continuous measurement

- Fixed monitoring stations with ambient air analyzers
- Mobile laboratory with analyzers which enable to measure in areas not covered by the fixed stations



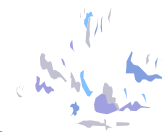
How we measure air quality?

Ambient air analyzers inside the station

- ❑ Continuous measurement
 - Gaz and particulates analyzers that determine pollutants concentrations
 - Real time data : instant alert possible
 - Measurement campaigns (mobile laboratory)



Location of the stations



Stations type and monitored pollutants per station

#	Site name	Coordinates		Station type
		N	W	
1	Bd Republique	14deg 40' 14"	17deg 26'11"	Urban roadside
2	Medina	14deg 41'14"	17deg 26'54"	Suburban roadside
3	HLM4	14deg 42'37"	17deg 27'09"	Urban background
4	BelAir	14deg 40'50"	17deg 25'58"	Urban industrial rd
5	Yoff	14deg 44'51"	17deg 27'35"	Regional background

	Site	Parameters							
		SO2	NOx	NO2	PM10	PM2,5	O3	CO	Benz
1	Bd.Republique	X	X	X	X	X	X	X	
2	Medina		X	X	X			X	
3	HLM4	X	X	X	X		X		
4	BelAir	X	X	X	X	X			X
5	Yoff		X	X	X		X		

Bd Republique



HLM4



Medina



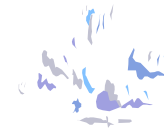
BelAir



Yoff



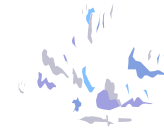
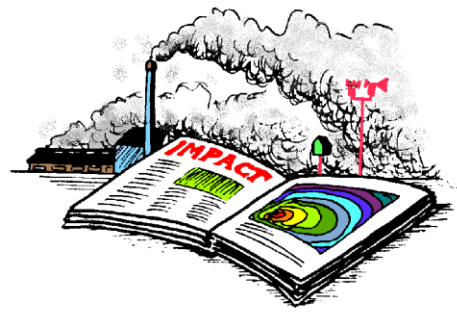
Location of the stations



Meteorological parameters are also measured at HLM station

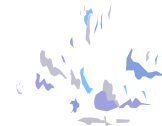
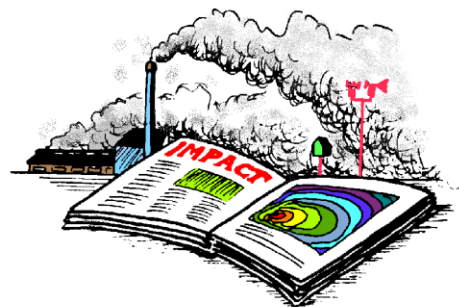
- ✓ Temperature
- ✓ Relative humidity
- ✓ Net radiation
- ✓ Pressure
- ✓ Wind speed
- ✓ Wind direction





Air Quality Index (AQI)

- ✓ Index for reporting daily air quality on the web www.air-dakar.org and www.denv.gouv.sn;
- ✓ Tells how clean or polluted the air is, and what associated health effects might be a concern;
- ✓ Five pollutants are used to calculate the AQI: O₃ (ozone), PM (particulate matter), CO (carbon monoxide), SO₂ (sulphur dioxide) and NO₂ (nitrogen dioxide).



Air Quality Index (AQI)

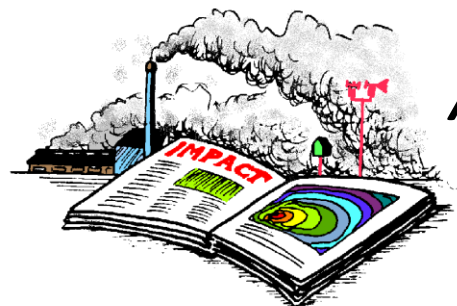
AQI = Air Quality Index

Air Quality Index (AQI) values...	Levels of Health Concern	Colors
When the AQI is in this range...	... air quality conditions are:	... as symbolized by this color:
0 – 50	Good	Green
51 - 100	Moderate	yellow
101 - 200	Unhealthy	Orange
> 200	Very Unhealthy	Red

The AQI = index for reporting daily air quality:

- how clean or polluted is the air,
- Indicate associated health concerns you should be aware of.

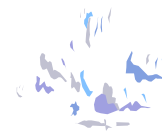
$$AQI = \frac{\text{Pollutant concentration}}{\text{Pollutant limit value}} \times 100$$



Air Quality Index (AQI)

Guidelines and limit values ($\mu\text{g}/\text{m}^3$) WHO & Senegal

Pollutant	Averaging time	Maximum Limit Value	
		WHO	Senegal
Sulphur Dioxide (SO_2)	1 hour	500 (10 min)	-
	24 hours	125	125
	Year	50	50
Nitrogen Dioxide (NO_2)	1 hour	200	200
	Year	40-50	40
Ozone (O_3)	1 hour	150-200	-
	8 hours	120	120
Carbon Monoxide (CO)	1 hour	30 000	-
	8 hours	10 000	30 000 (24h)
Particles $<10 \mu\text{m}$ (PM_{10})	24 hours	50 *	260
	Year	20 *	80
Lead (Pb)	Year	0.5-1,0	2



Other reports

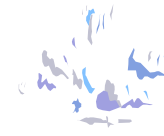
Reports on air quality

- **Monthly reports**
- **Quaterly reports**
- **Annual reports**

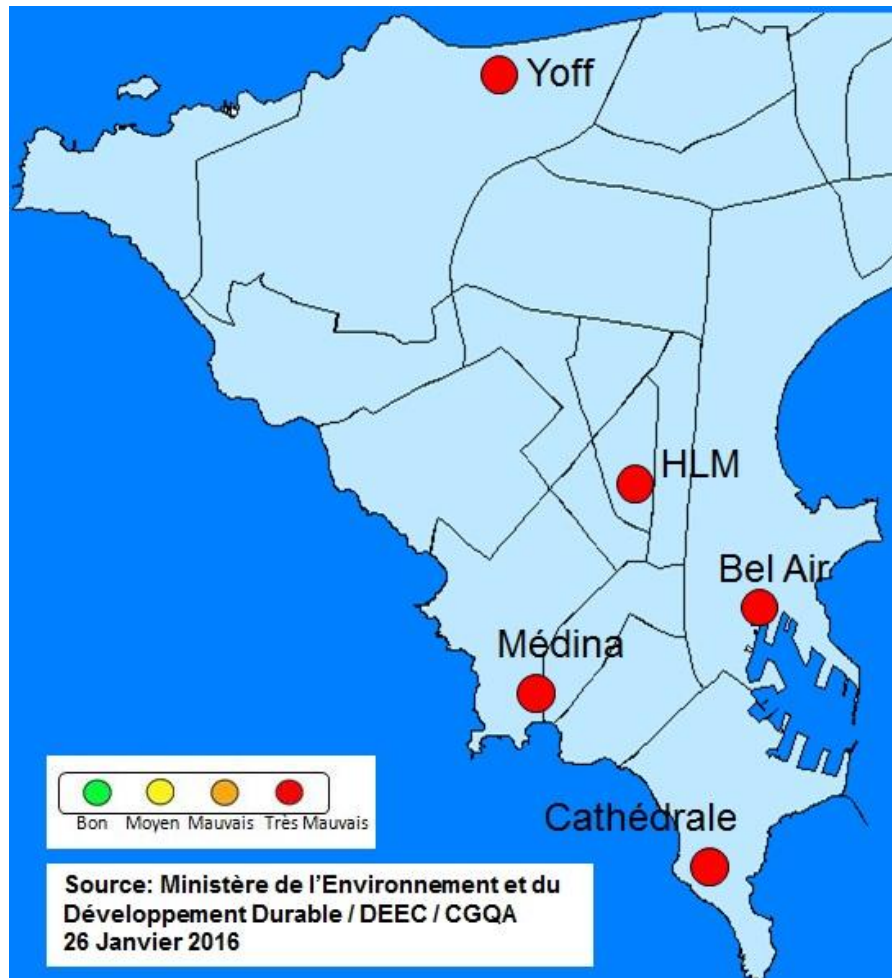
Available for download on the following website:

www.air-dakar.org

Air Quality Index (AQI)

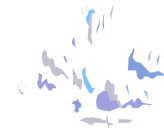


Air pollution episode on 26 – 31 January 2016



- High PM concentrations
- PM10 maximum values exceeded 700 micrograms per cubic meter in most of the measurement stations
 - Red AQI which means very unhealthy air quality
 - Everyone may experience health effects of air pollution

Air Quality Index (AQI)



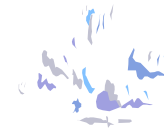
Air pollution episode started on january 26th 2016

**Alert
message was
sent to the
press and
hospitals
(pneumology
services)**



« The air quality for today is very unhealthy (Red Index). Deserts particulates concentrations started increasing yesterday. This situation could last for the next 72 hours. »

Air Quality Index (AQI)

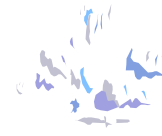


*Health warnings issued from ministry
in charge of health and doctors*

« The exposure of populations to these high particulates concentrations (PM10) presents a real danger, especially for people suffering from asthma and respiratory allergies.

Young children, sensitive people and elderly persons should avoid long exposure to ambient air »

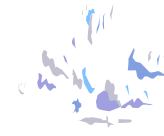
Air Quality Index (AQI)



*Health warnings issued from ministry
in charge of health and doctors*

- « - respect scrupulously any ongoing medical treatment
- ask a doctor if any suspicious symptom appears (cough, difficulty on breathing, eye or throat irritation)
- avoid intensive physical activity or sport (especially competition) increasing volume of air inhaled »

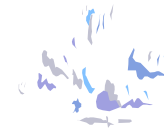
Air Quality Index (AQI)



*Health warnings issued from ministry
in charge of health and doctors*

« - Be careful not to aggravate the effect of this pollution with other respiratory tract irritating factors such as use of solvents, burning incense, and especially tobacco smoke. »

Air Quality Index (AQI)



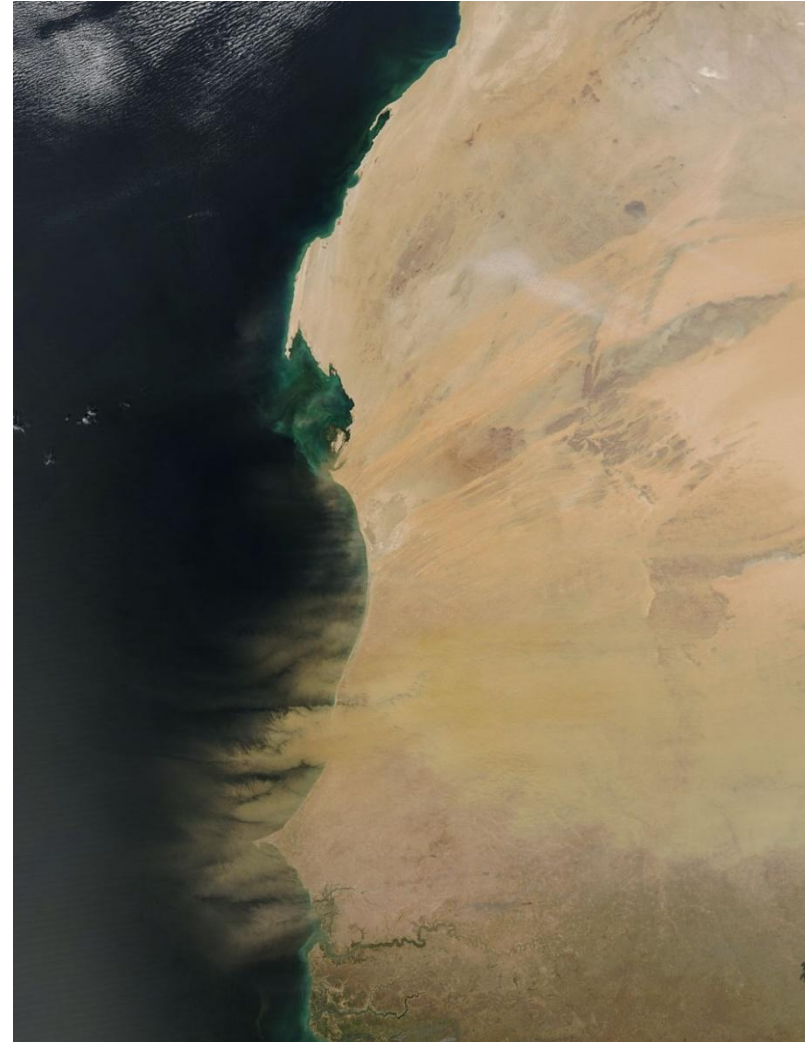
Air pollution episode on 26 January to 31 March 2016



The whole city (and even the country) has been covered by dust that caused a problem of visibility

Where the pollution comes from ?

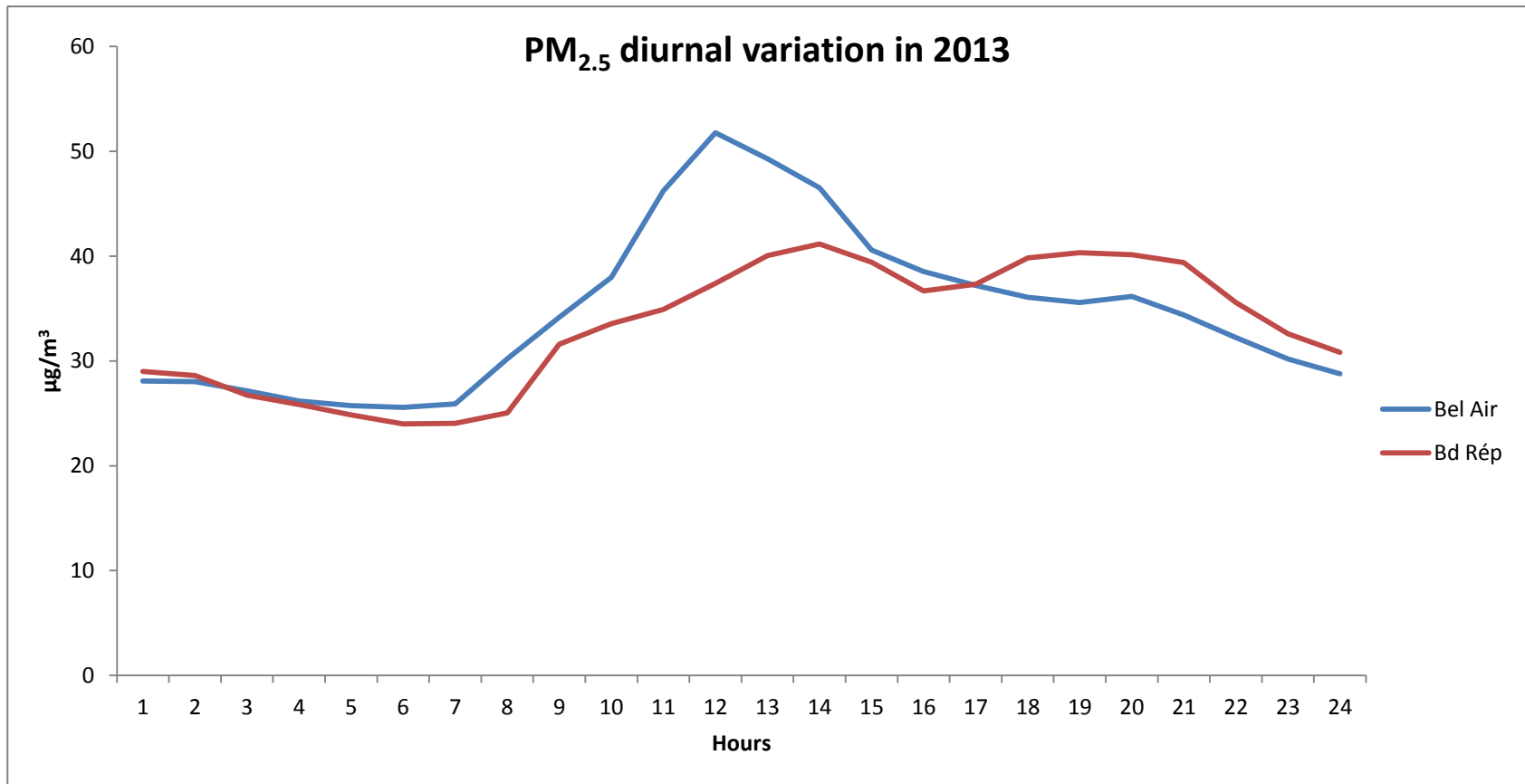
- ✓ Saharan dust is also correlated with episode of high PM concentrations
- ✓ Traffic congestion during these episodes become obviously another aggravating factor



Impact of traffic



Diurnal $PM_{2.5}$ evolution in 2013



Peak Concentrations during hours of traffic congestion

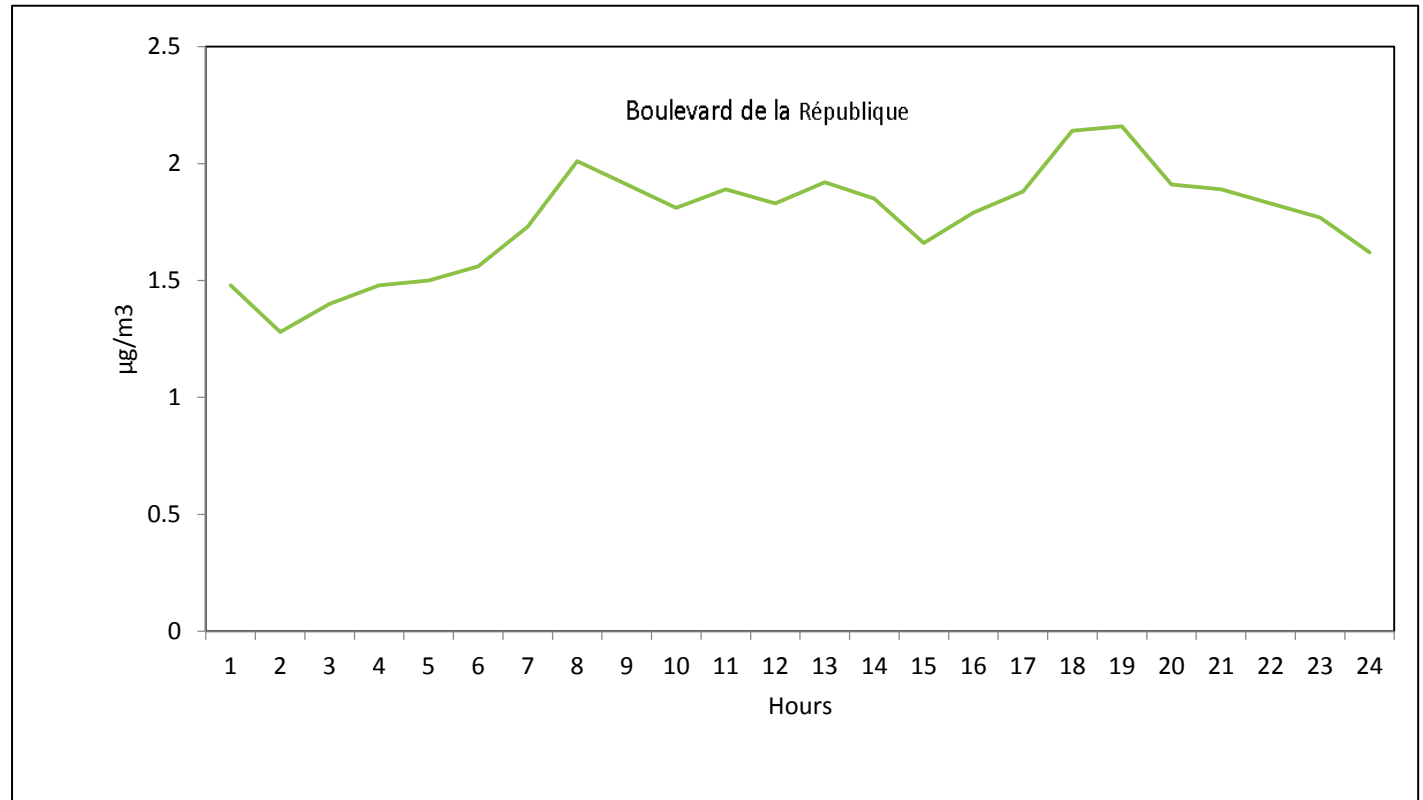
Impact of traffic



Diurnal variation of carbon monoxide

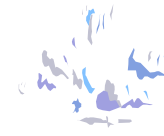
✓ traffic station located on the road side

✓ Maximum values observed during hours of traffic congestion

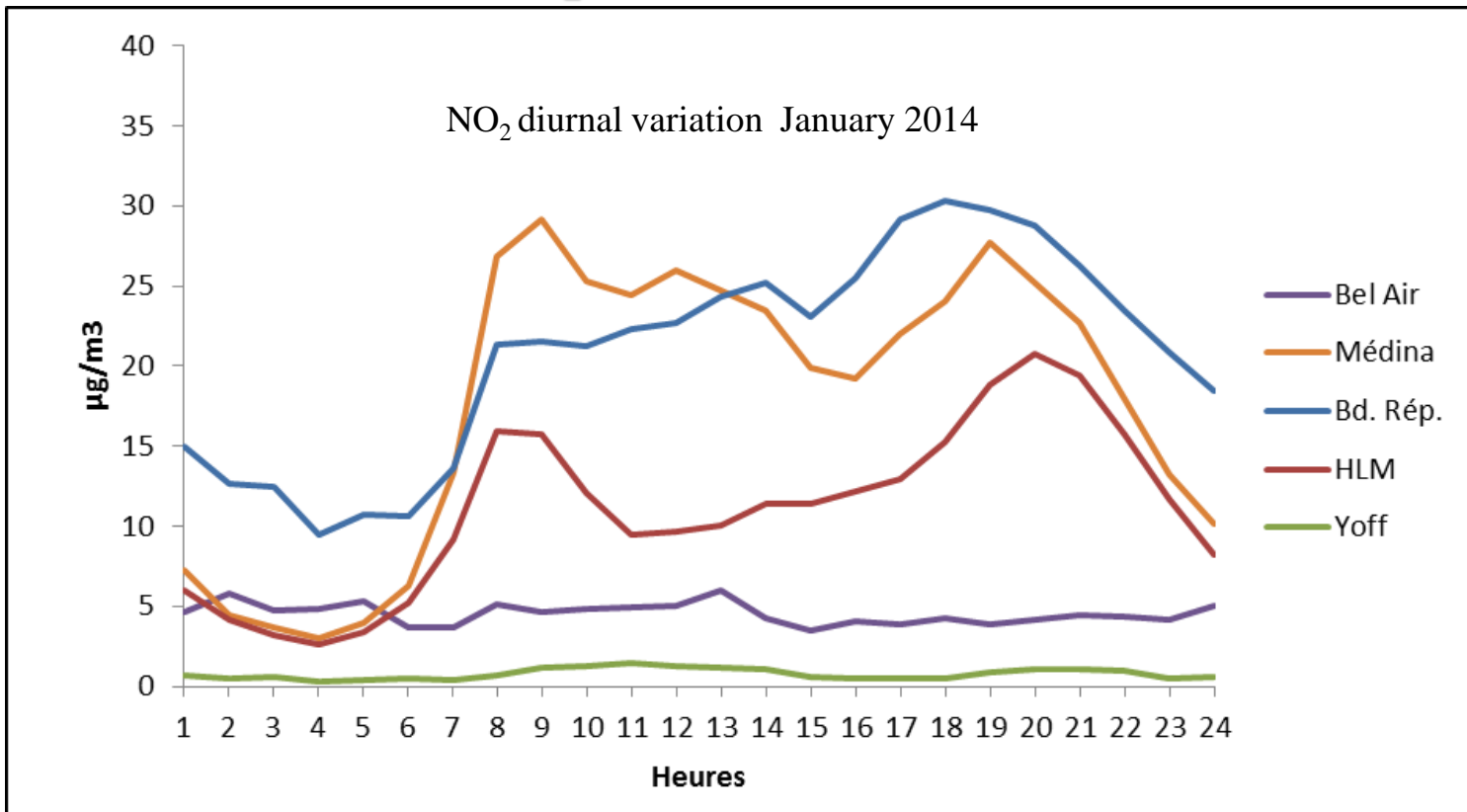


CO diurnal variation during 2013 first quarter

Impact of traffic

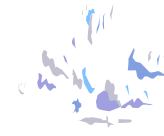


Nitrogen dioxide (NO_2) diurnal variation in January 2014



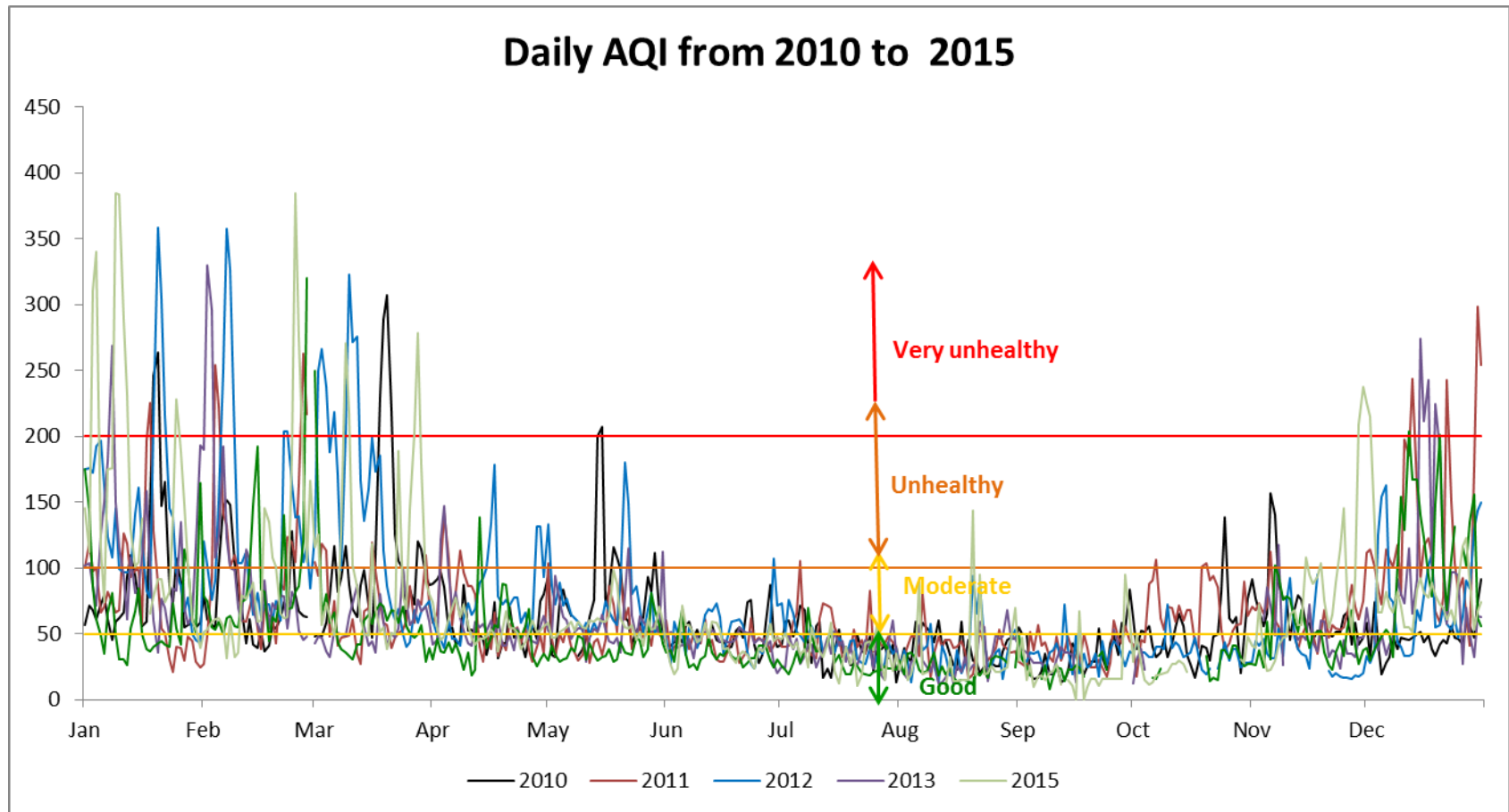
Peaks concentrations during hours of traffic congestion hours

AQI Prediction methods



Evolution of the AQI from 2010 to 2015

The trend shows 2 different seasons. A dry season with unhealthy to very unhealthy AQI and a rainy season with good AQI.



AQI Prediction methods



Composition of the time series

Estimation of the ARIMA model

$$Y_t = T_t + S_t + \varepsilon_t$$

VALIDATION of the model

ARIMA is written : ARIMA (p, d, q)

- *p=level of auto-regression
- *d= the order of integration
- *q= moving average calculation

Test Box Ljung (bruit blanc)

AQI Prediction methods



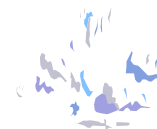
2^{ème} Model: Simple Linear regression

We can explained the variance of a dependante variable by an independant variable with an algebric equation: $Y_i = (B_0 + B_1X_1)$

Dry saison

Model	Non Standardised coefficients	Signification
	A	
Constant	3,464	0,00
PM10	0,395	0,00

AQI Prediction **methods**



AQI (Dry saison) = 3,464+ 0,395 (PM10)

$$Y = B_0 + B_1 (X_1)$$

Ex : Estimated the Air Quality Index by PM10

$$IQA=3,464+0,395*(PM10)$$

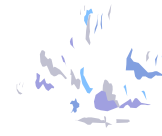
AQI (Rainny saison)= 11,084+ 0,339 (PM10)

$$Y = B_0 + B_1 (X_1)$$

Ex : Estimated the Air Quality Index by

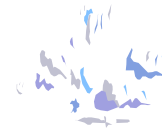
$$PM10 \quad IQA=11,084+0,339* (PM10)$$

Conclusion



For a better air quality assessment and abatement strategies

- The standards must be for all majeure pollutants coming from exhaust gas. Standards are for the CO, the smoke opacity and the hydrocarbons.
- Integrated the statistic model after testing it.
- Assessment of emissions from motorized vehicles and industrial facilities (ongoing).
- Linkage between epidemiological data (rate of hospital admissions, and the mortality from air pollution).



Thank you for your
attention