Paris CO_2 network: observations & requirements

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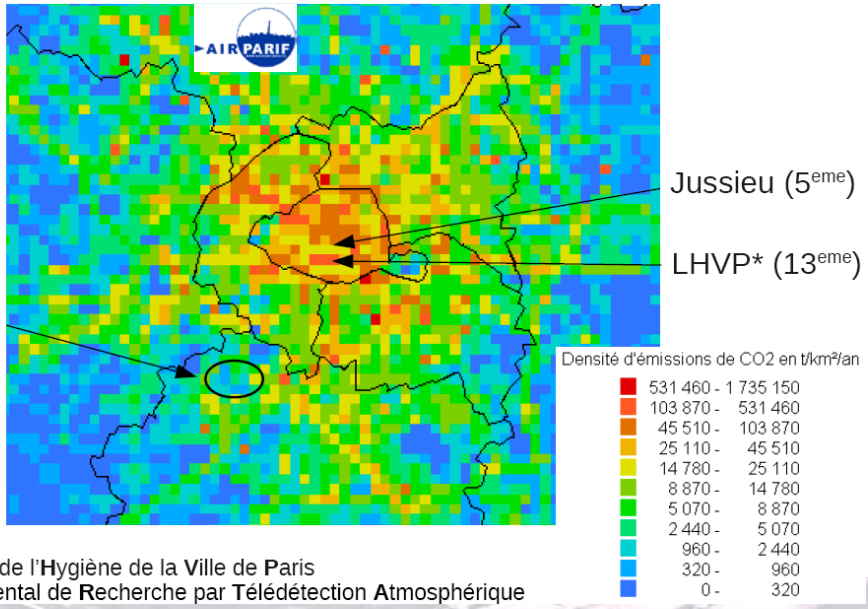
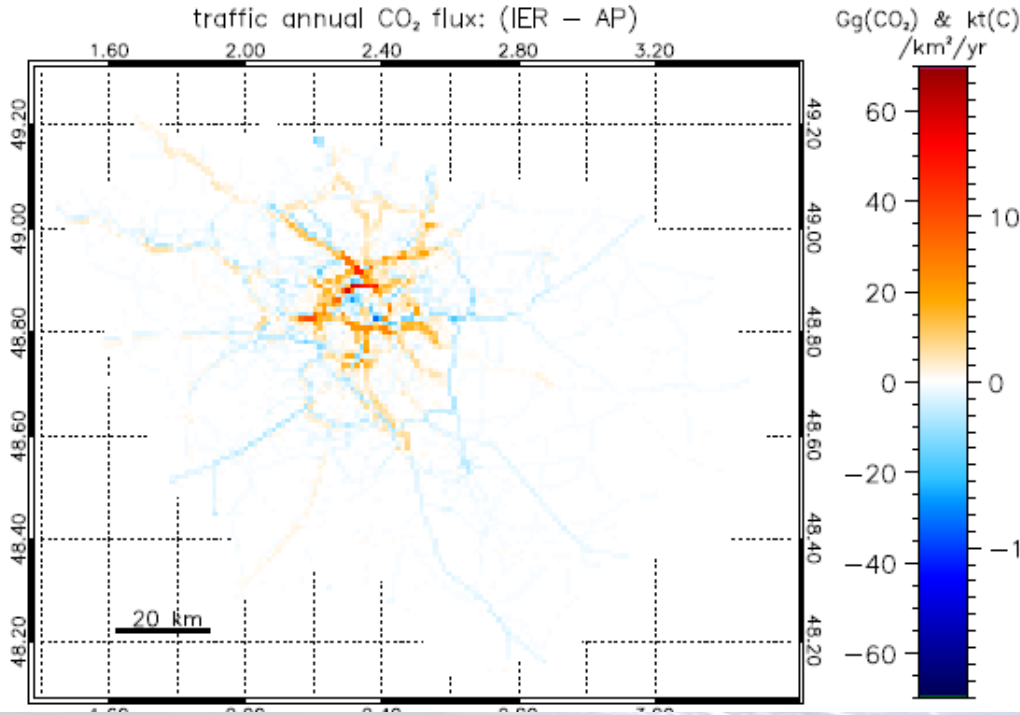
Variability and spatial differences between inventories: example for the traffic sector

A very large spatial variability



de l'**H**ygiène de la **V**ille de **P**aris
ental de **R**echerche par **T**élédétection **A**tmosphérique



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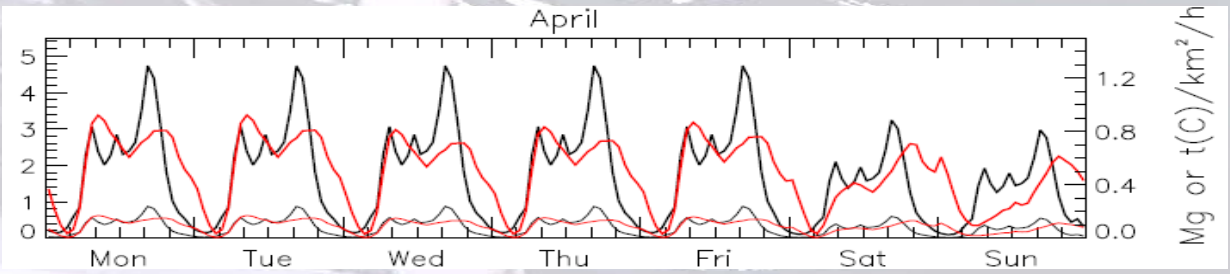
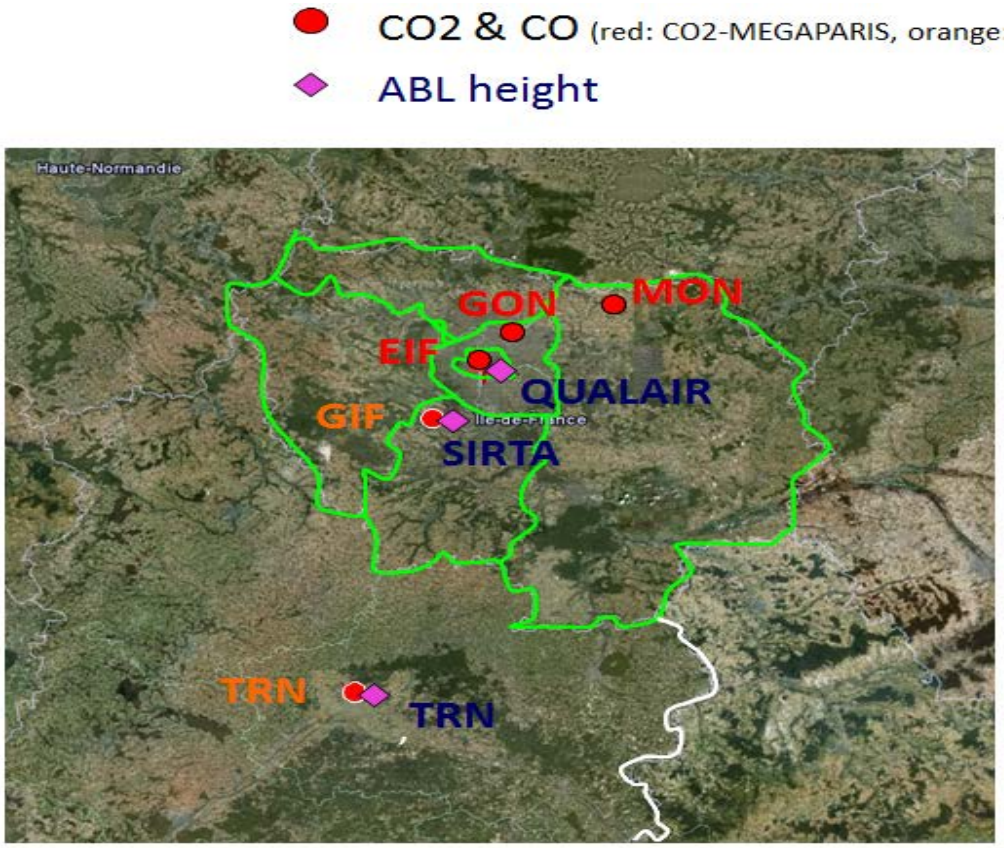
Temporal differences: example for the traffic sector



Season 1: the CO_2-Megaparis network



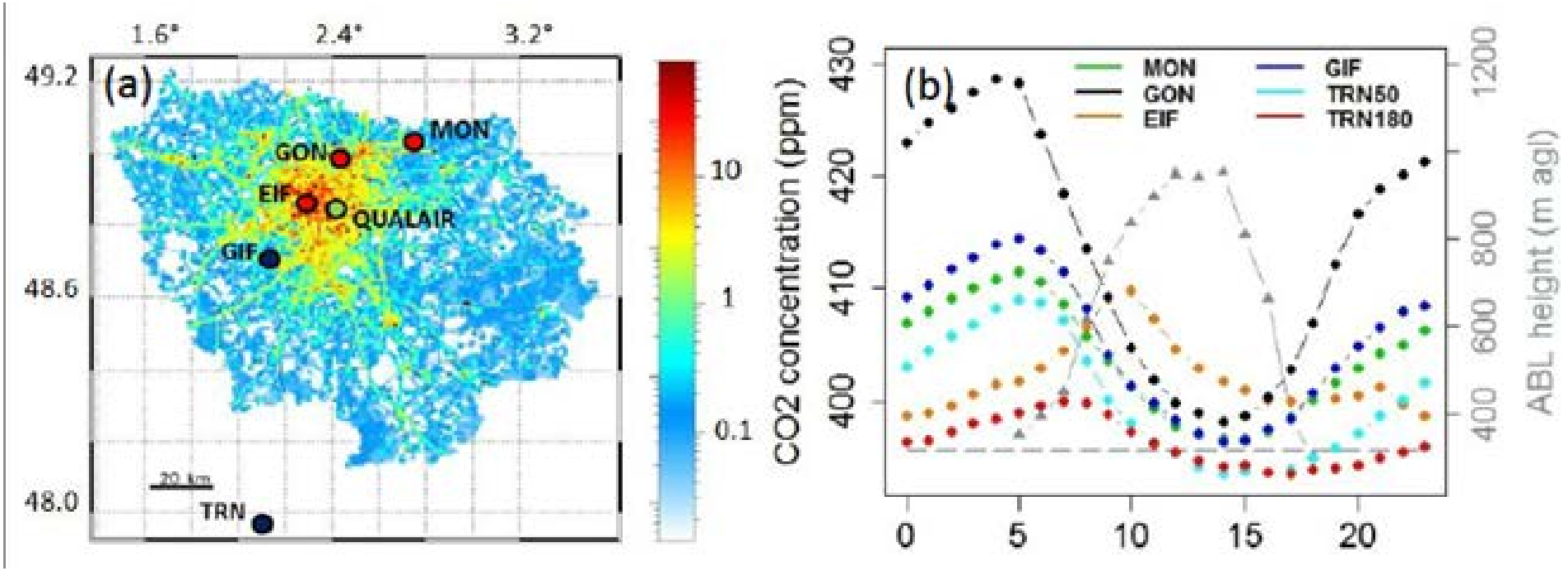
Model G1302 (CO_2/CO/H_2O)

Xueref-Remy et al, tbs

July 2010- August 2011	EIF	MON	GON	GIF	TRN
Accuracy CO_2	0.128ppm	-0.039 ppm	-0.071 ppm	GC = Reference	GC = Reference
Repeatability CO_2	0.382ppm	0.101 ppm	0.065 ppm	0.05 ppm	0.06 ppm

CO_2 diurnal cycle

- The strength of the signal increases with the urbanization level
- There is a strong coupling with the boundary layer cycle (especially at EIF)

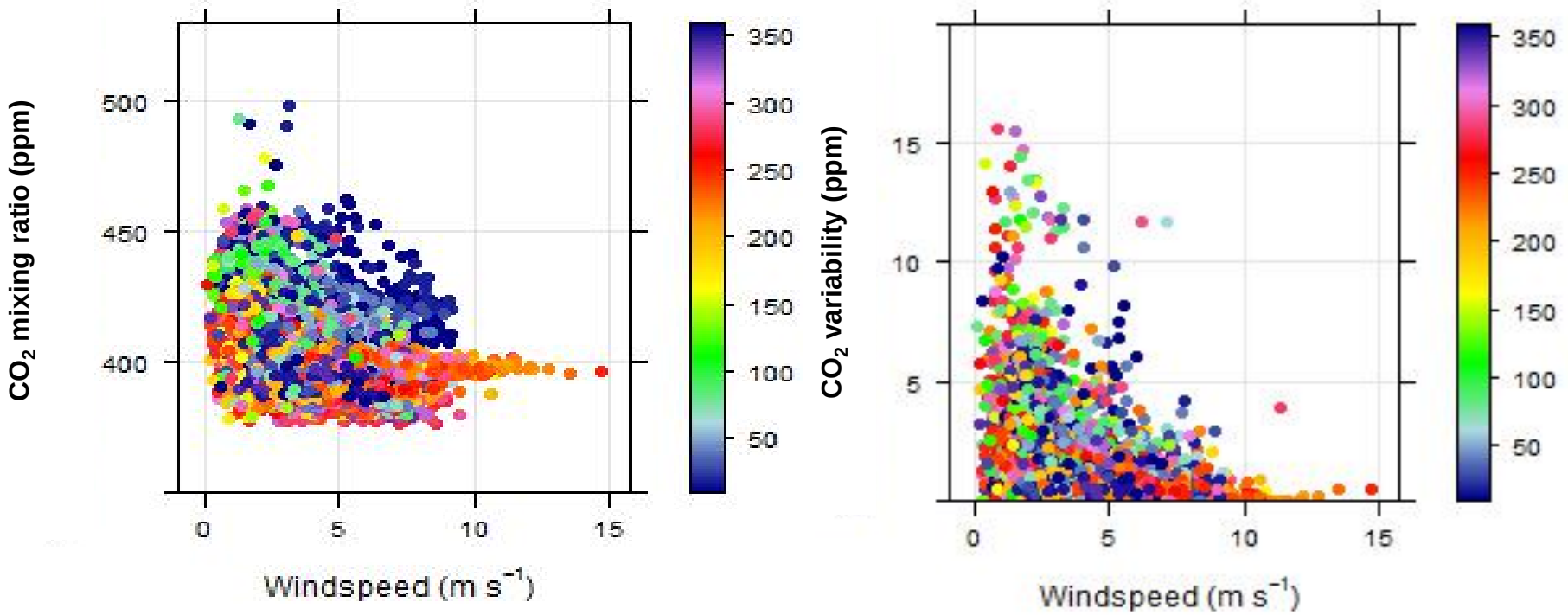


Xueref-Remy et al, tbs

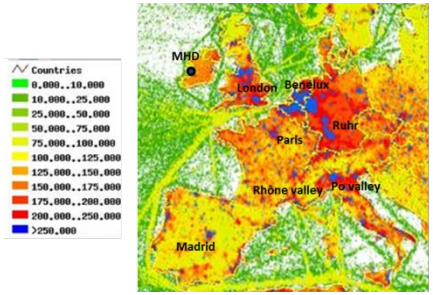
Windspeed as a key factor

- Dilution of the plume
- Decrease of the variability (this latter being mainly linked to the wind direction + urban emissions variability)

Example of GIF:



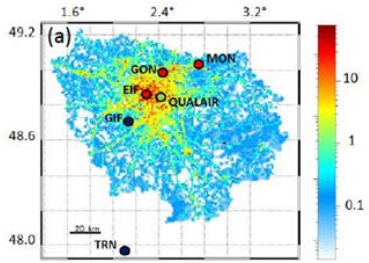
Xueref-Remy et al, tbs



Assessing the plume:

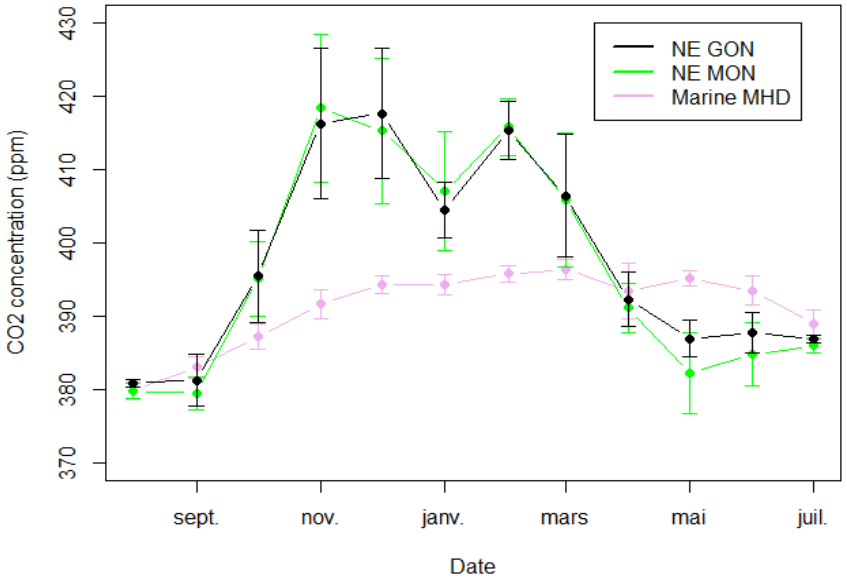
proper background choice

(ex. Turnbull et al, 2015)

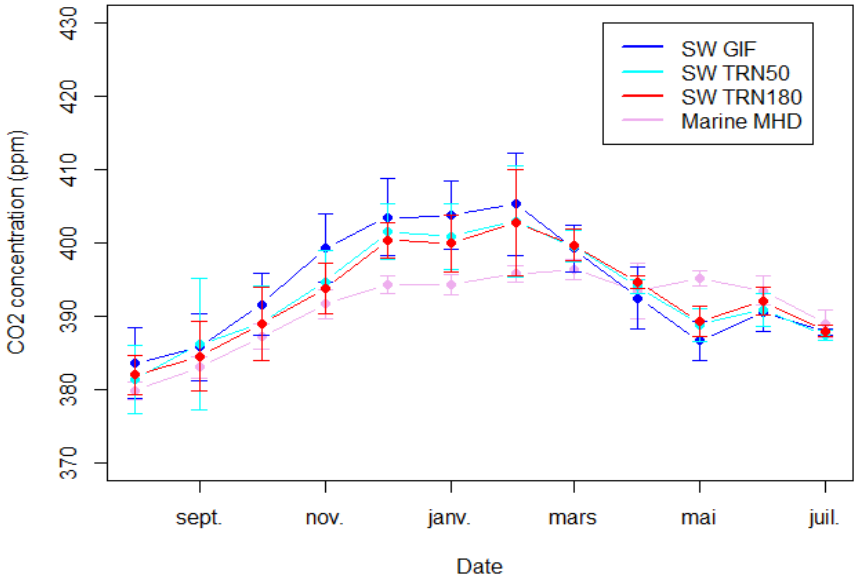


Xueref-Remy et al, tbs

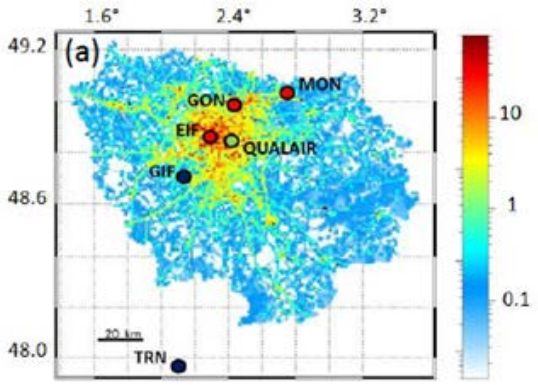
NE sector CO2 background, comparison to MHD marine sector



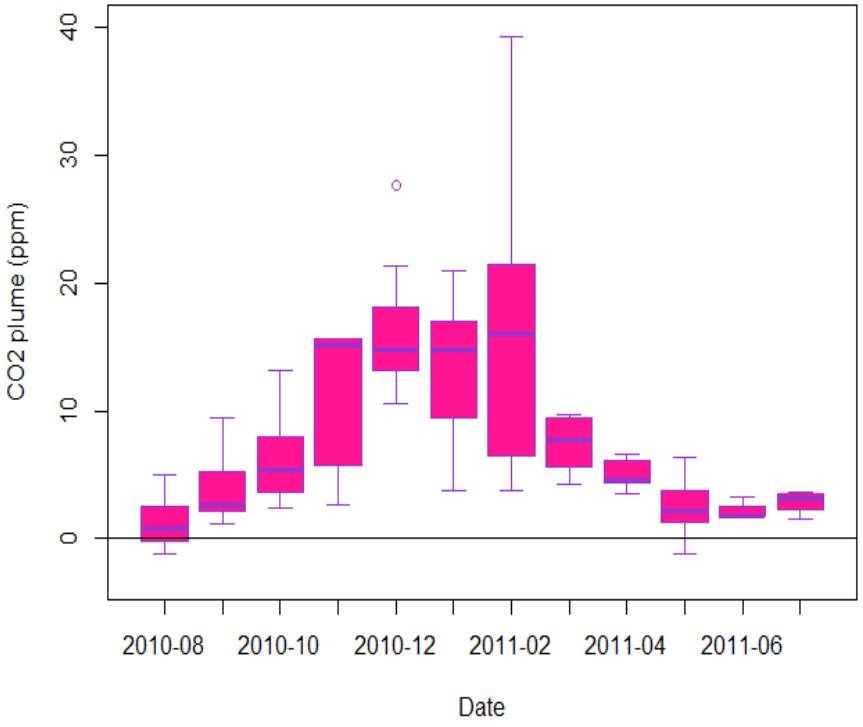
SW sector CO2 background, comparison to MHD marine sector



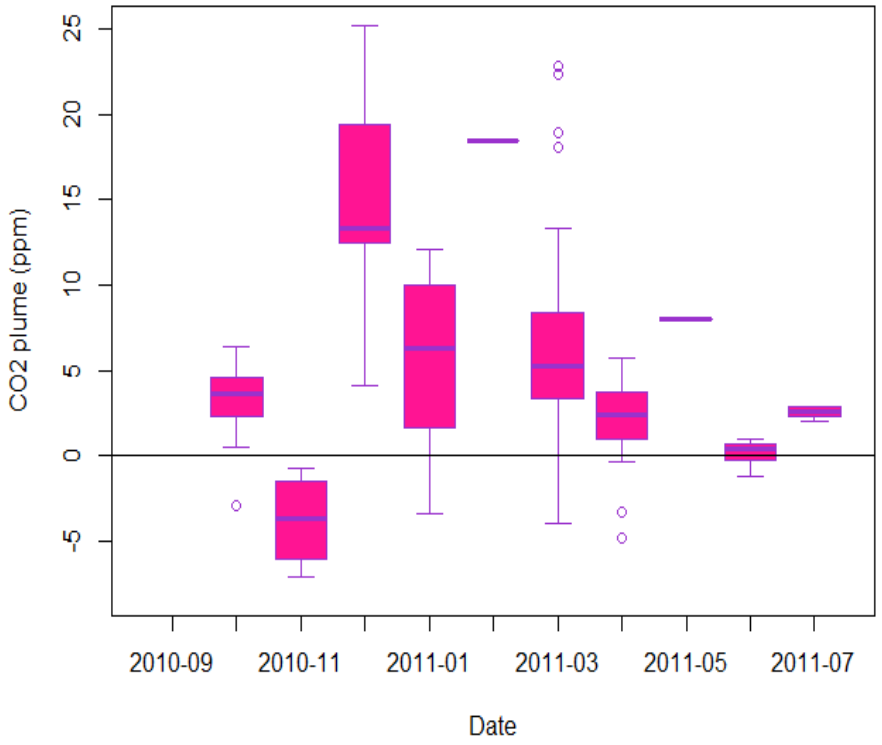
Paris megacity CO_2 plume



GIF to GON



GON to GIF

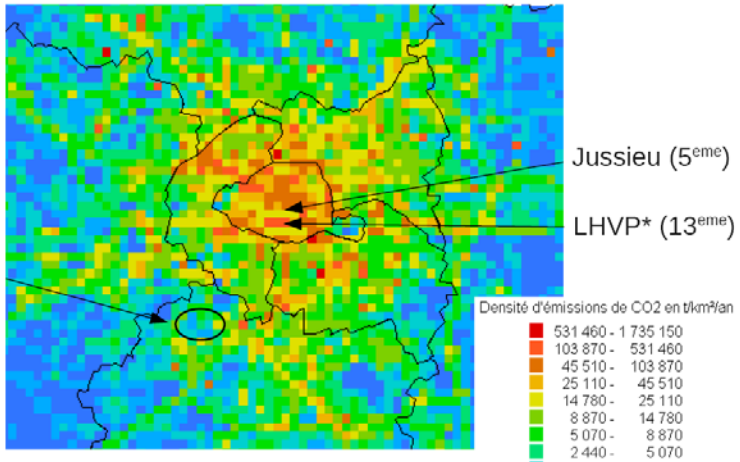


Xueref-Remy et al, tbs

Assessing the relative role of the different emission sectors

$^{14}CO_2$ Winter campaign in Feb 2010

(Lopez et al, ACP, 2013)

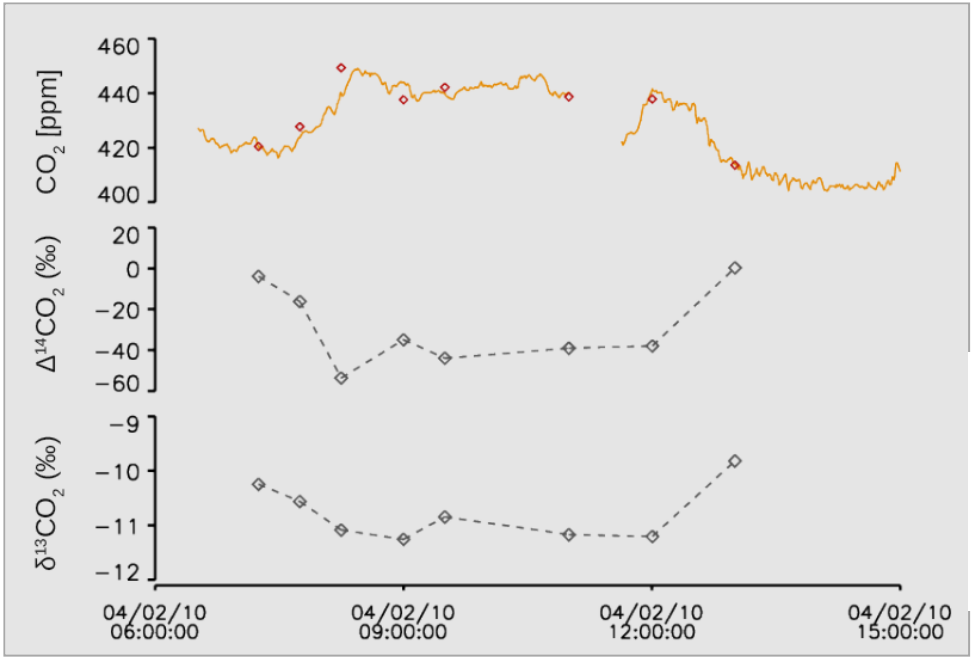


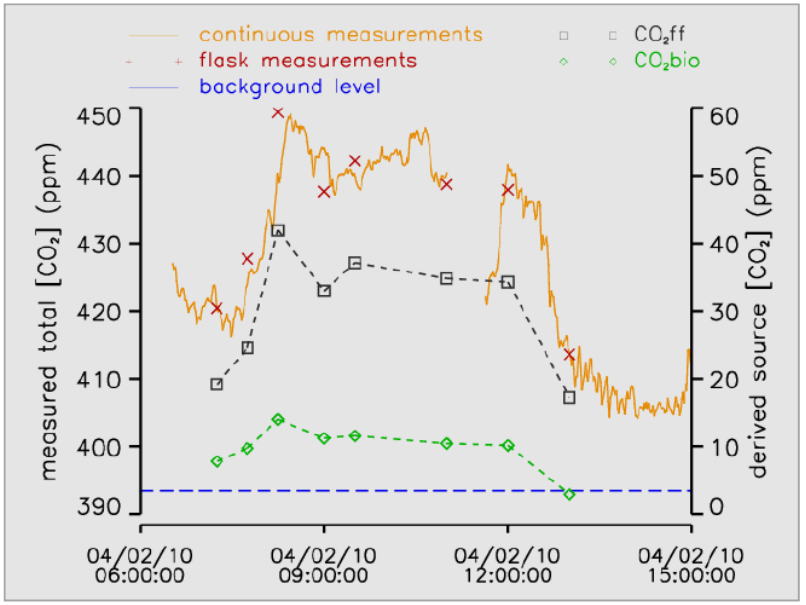
* LHVP : Laboratoire de l'Hygiène de la Ville de Paris
** SIRTA : Site Instrumental de Recherche par Télédétection Atmosphérique

$$CO_2ff = CO_2meas \cdot \frac{\Delta^{14}CO_2bg - \Delta^{14}CO_2meas}{\Delta^{14}CO_2bg + 1}$$

$$\Delta^{14}CO_2bio = \Delta^{14}CO_2bg$$

$$\Delta^{14}CO_2ff = -1$$





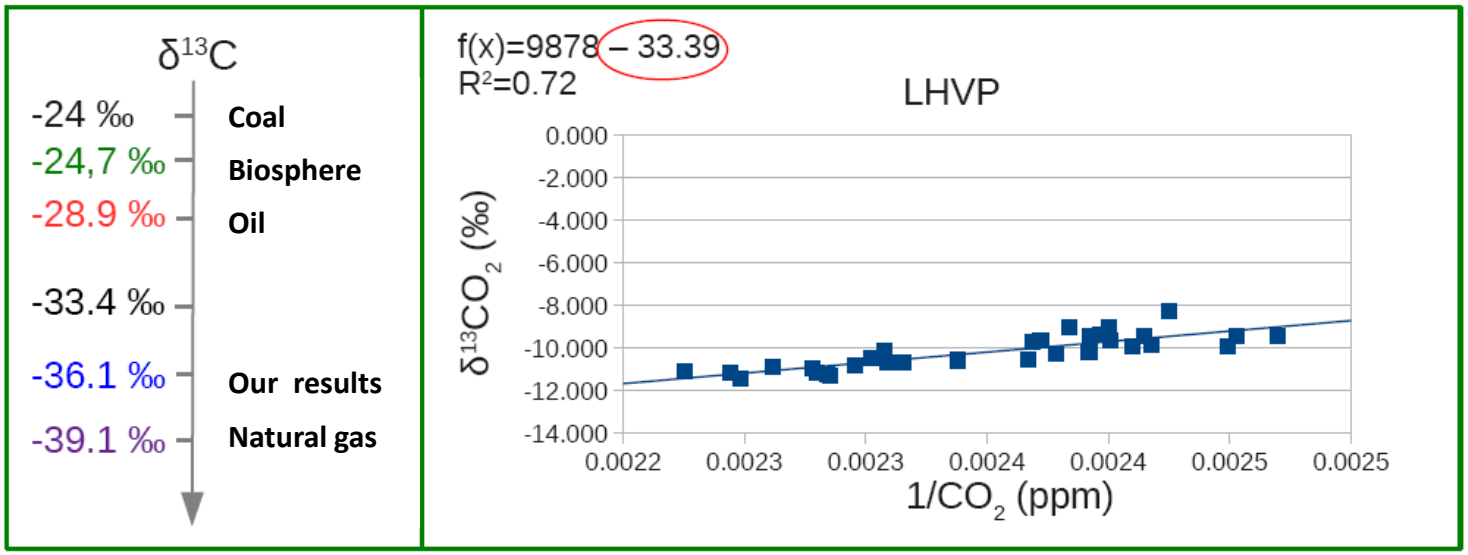
	LHVP (ppm / %)	Sources
CO_2 ff	30 ppm / 75 %	Natural gas and oil
CO_2 bio	10 ppm / 25 %	Human and biospheric respiration Biofuels

Assessing the role of the different emission sectors:

$^{13}CO_2$ Keeling plot

$$\delta^{13}CO_2 meas = \frac{CO_2 bg(\delta^{13}CO_2 bg - \delta^{13}CO_2 s)}{CO_2 meas} + \delta^{13}CO_2 s$$

Winter 2010 (Lopez et al, ACP 2013):



Correction to substract the biospheric contribution: $\delta^{13}Cbio = -24.7$ ‰

→ $\delta^{13}Cff = -36.1 \pm 2.7$ ‰

Gas: 70%

Residential and industrial sectors

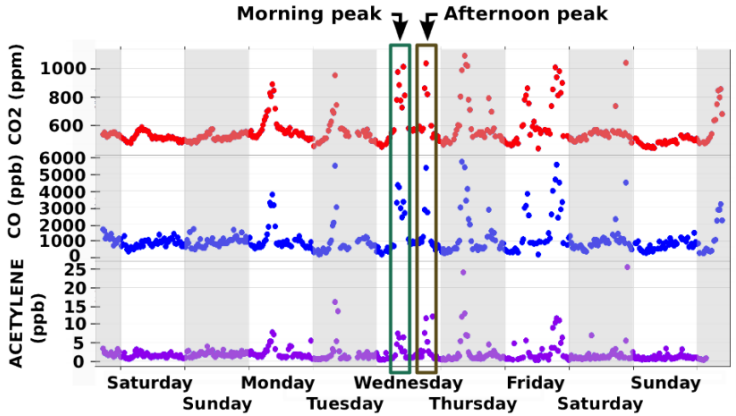
Oil: 70%

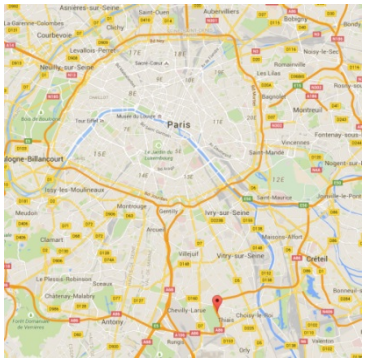
Traffic sector

Lopez et al, ACP, 2013

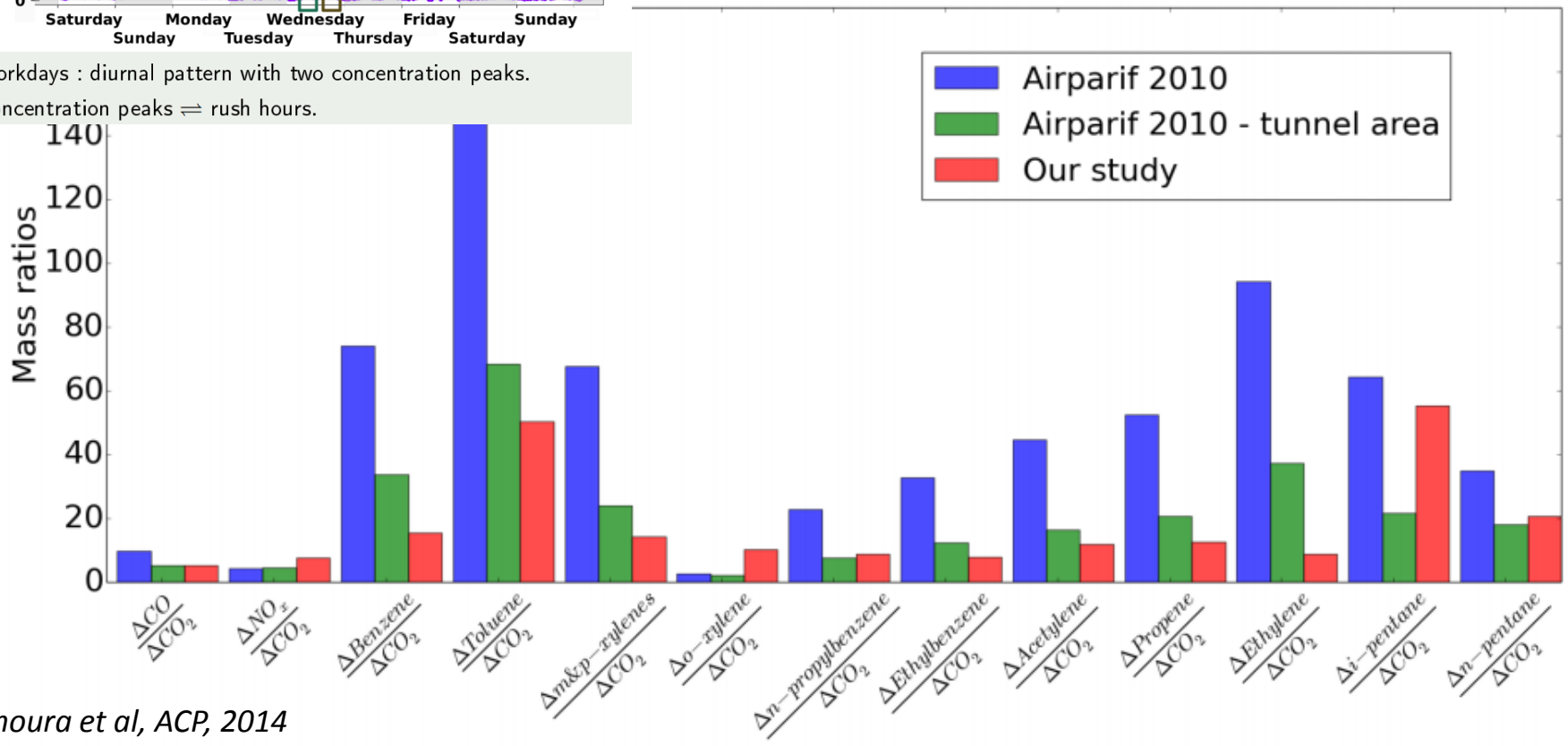
Tracers: CO & VOCs => assess emission ratios to CO_2

Ex: tunnel campaign (primequal-ZAPA project): traffic emission sector only





- Workdays : diurnal pattern with two concentration peaks.
- Concentration peaks ⇌ rush hours.



Ammoura et al, ACP, 2014

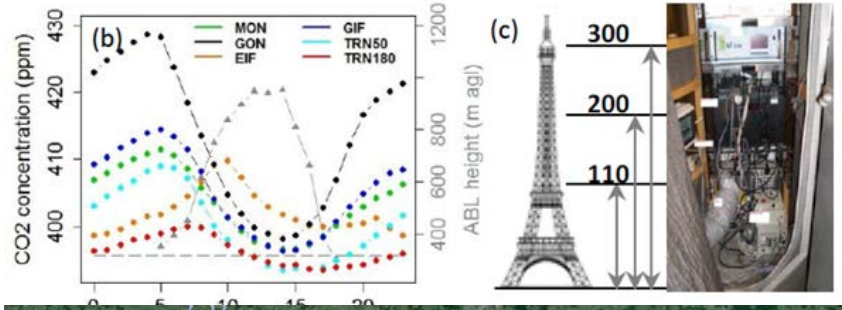
Conclusion and perspectives

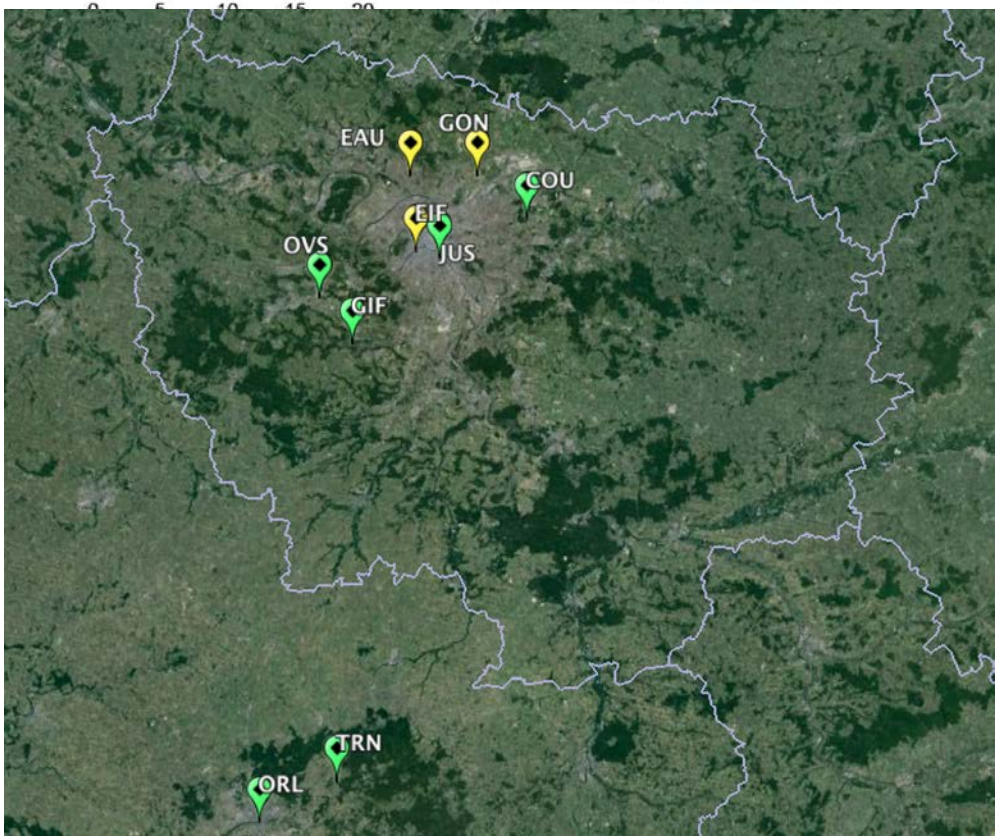
- Need a good background: get it regional and not continental
- Choice of the station elevation: strong coupling with ABL height dynamics=> + Need ceilometer/LIDAR…
- Need tracers of emissions: isotopes, CO, NOx, VOCs, black carbon…
- Need meteorological fields at the stations (ex. windspeed: regulates the intensity of the urban signal - from a dome to a plume)

Season 2: Carbocount-city / IPSL / Ville de Paris network

❑ **ABL height covariation:**

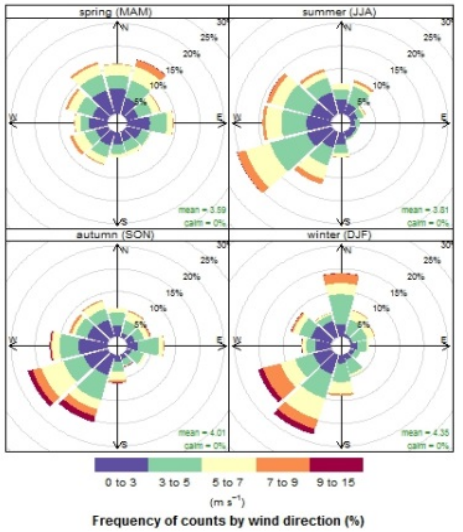
=> CO_2 profile at the Eiffel tower





❑ **Wind direction fluctuations :**

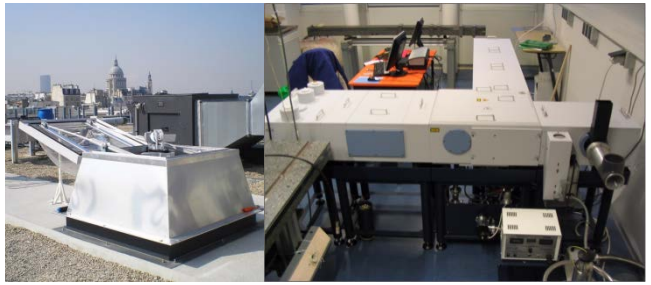
=> arches of circles on main wind paths



❑ **Link with satellite data:**

⇒ in-situ stations at TCCON sites & model

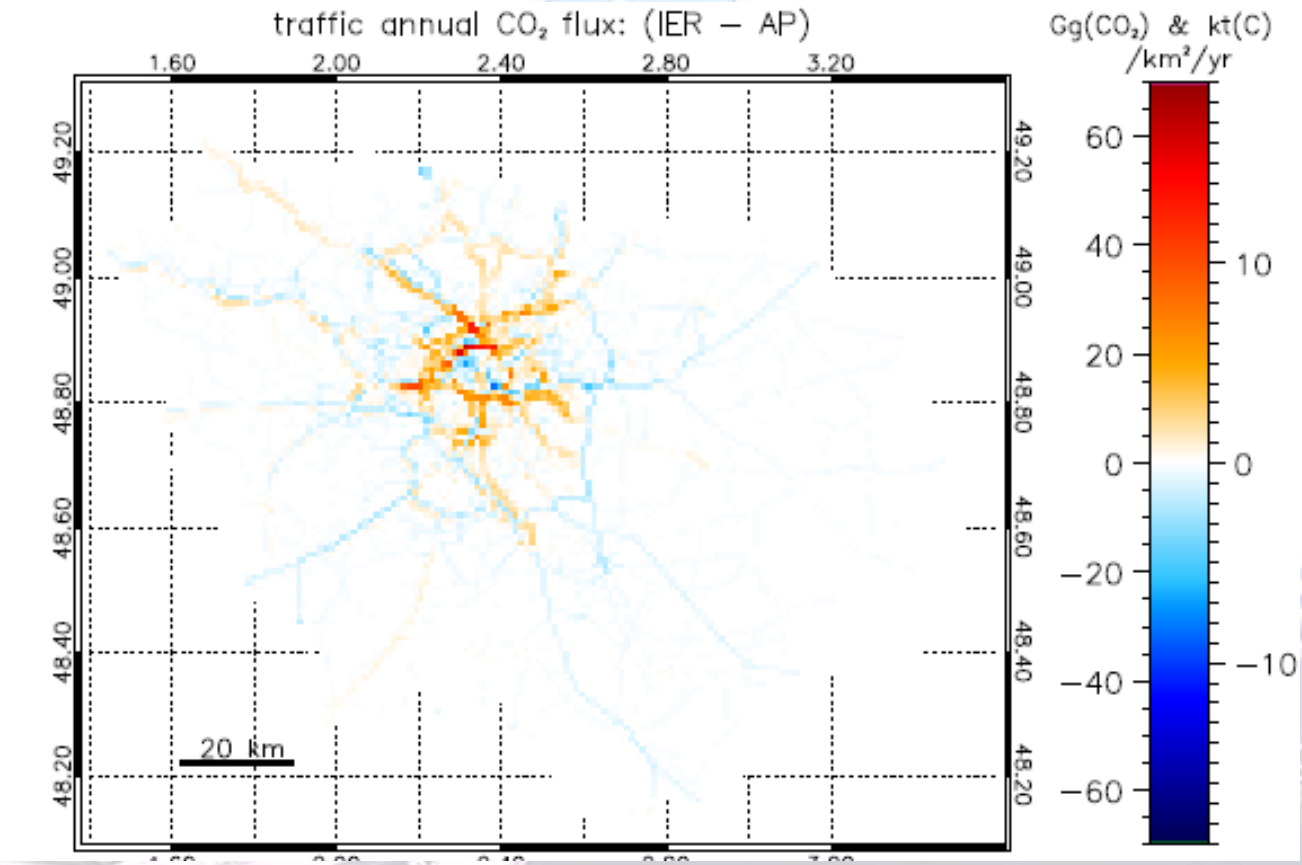
⇒ Regular tracers to come(14C…)



Topics of discussion

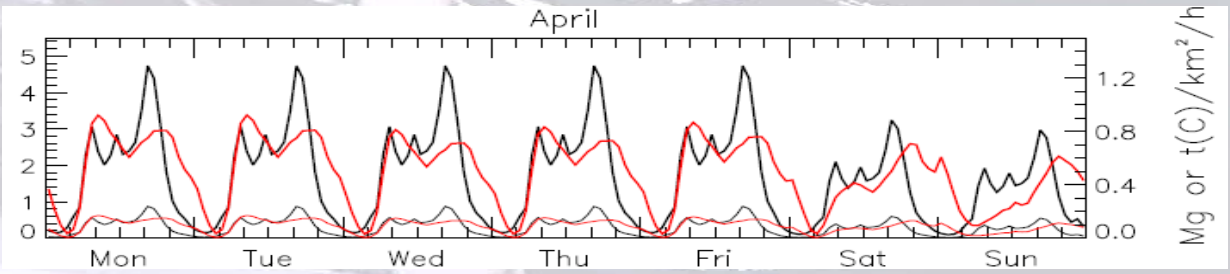
- Calibration standard supply
- Range of concentrations
- Calibration strategy (mobile vs fixed, air sample exchanges, cal round robin, link to national networks)
- Choice of meteorological instruments
- Height of sampling
- Strategy for regular tracers monitoring ($^{14}CO_2$, $^{13}CO_2$…)
- Link with the Air Quality community (ex. (CO), black carbon, NOx, VOCs…)

Spatial differences : example for the traffic sector

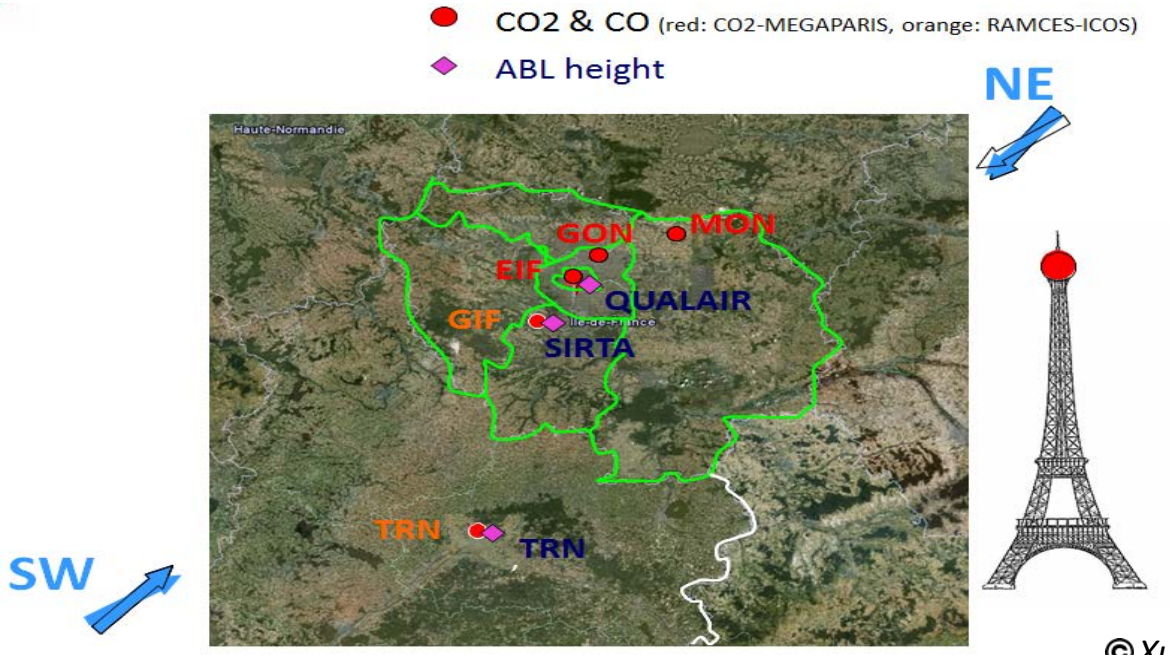


© *Dieudonné et al, 2013*

Temporal differences: example for the traffic sector



Season 1: CO_2-Megaparis (680k€)



Model G1302 (CO_2/CO/H_2O)

©*Xueref-Remy et al, tbs*

MON	GON	EIF	GIF	TRN
CO2-Megaparis	CO2-Megaparis	CO2-Megaparis	ICOS	ICOS
CRDS Picarro G1302	CRDS Picarro G1302	CRDS Picarro G1302	Gaz chromatography	Gaz chromatography
CO_2, CO	CO_2, CO	CO_2, CO	CO_2, CO and others!	CO_2, CO and others!
5s	5s	5s	5mn	5mn

+ 3 aerosols Lidars (355 nm, 15m, 5mn)

Data quality

- **1 calibration with 3 gases of known concentration every 2 weeks (3 months at EIF)**
- **1 target gas every day (15 days at EIF)**
- **The gas calibration tanks were calibrated on the WMO-X2007 reference scale for CO_2**
- **Data were filtered out for instrumental instability**
- **Data were eye-checked and cleaned for very short and local outliers**

=> Precision / accuracy :

CO2-Megaparis datasets:

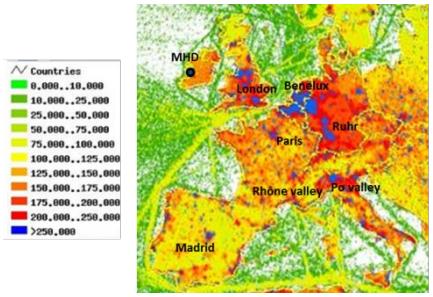
July 2010- August 2011	EIF	MON	GON
Accuracy CO_2	0.128ppm	-0.039 ppm	-0.071 ppm
Precision CO_2	0.382ppm	0.101 ppm	0.065 ppm

ICOS datasets (in Lopez et al, 2012)

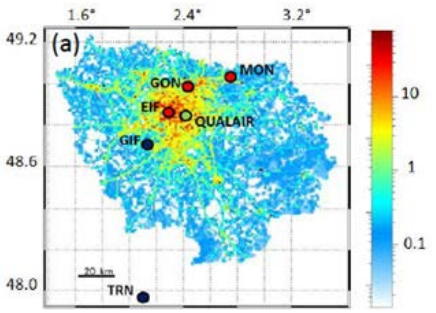
	GIF	TRN
Accuracy CO_2	GC = Reference	GC = Reference
Precision CO_2	0.05 ppm	0.06 ppm

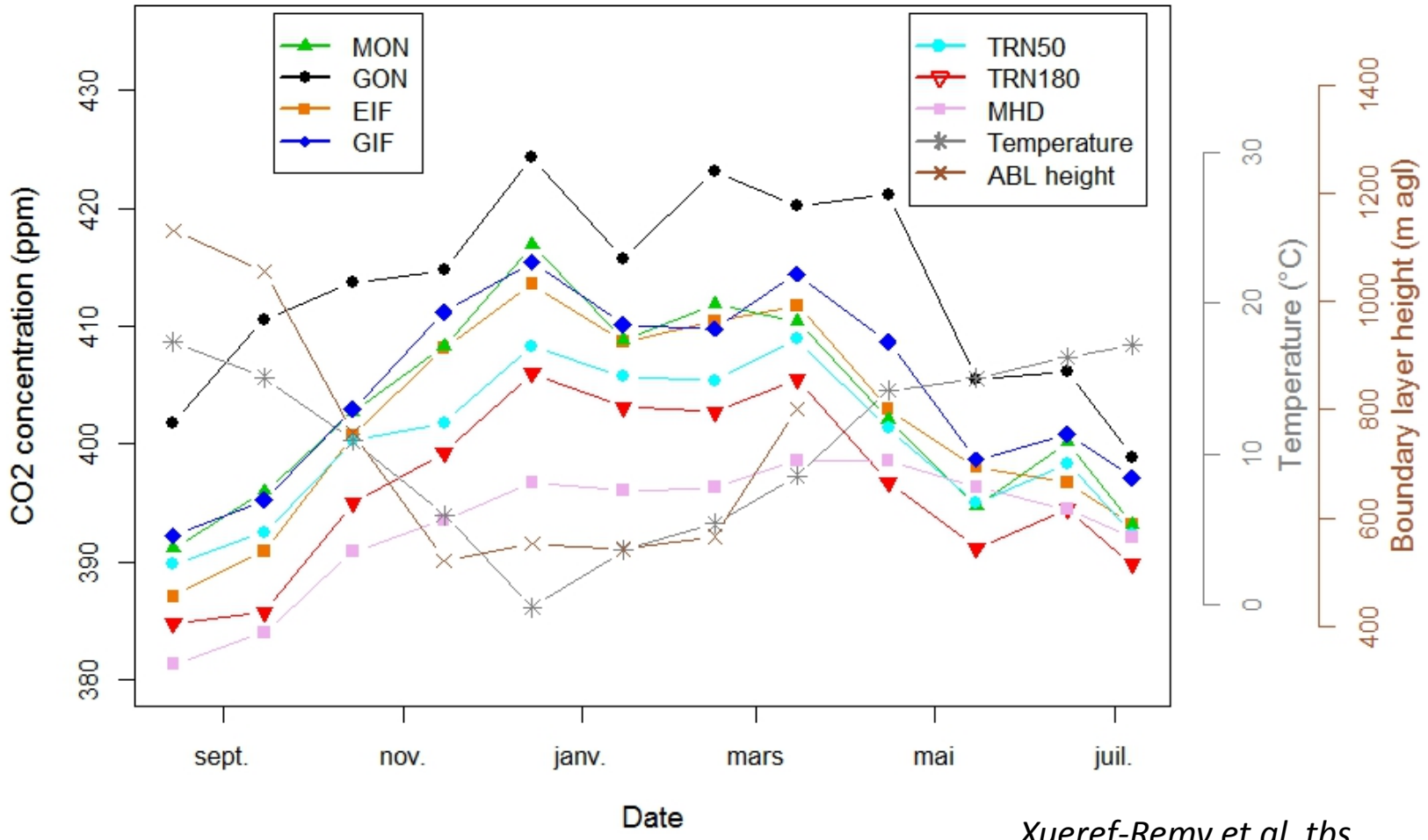
Objectives

- Assess Paris megacity CO_2 plume
- Assess/improve CO_2 emissions using inversion technics (see Philippe Ciais' talk)
- Use carbon isotopes to assess the role of the different emission sectors from observations / compare to inventories
- Develop other atmospheric methodologies for emission factors assessment



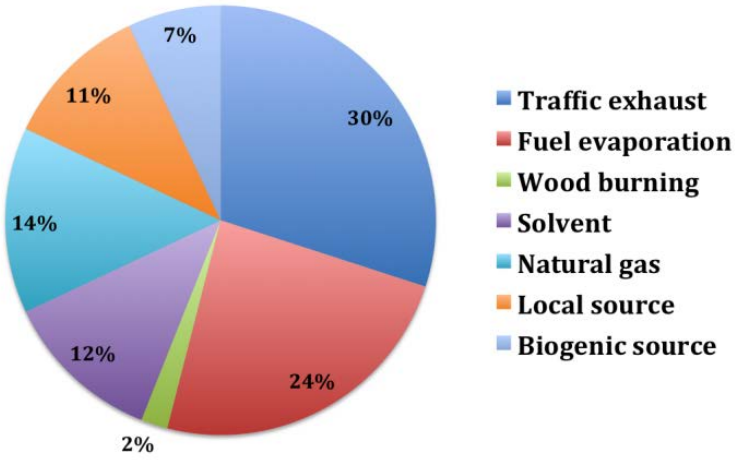
CO_2 seasonal cycle

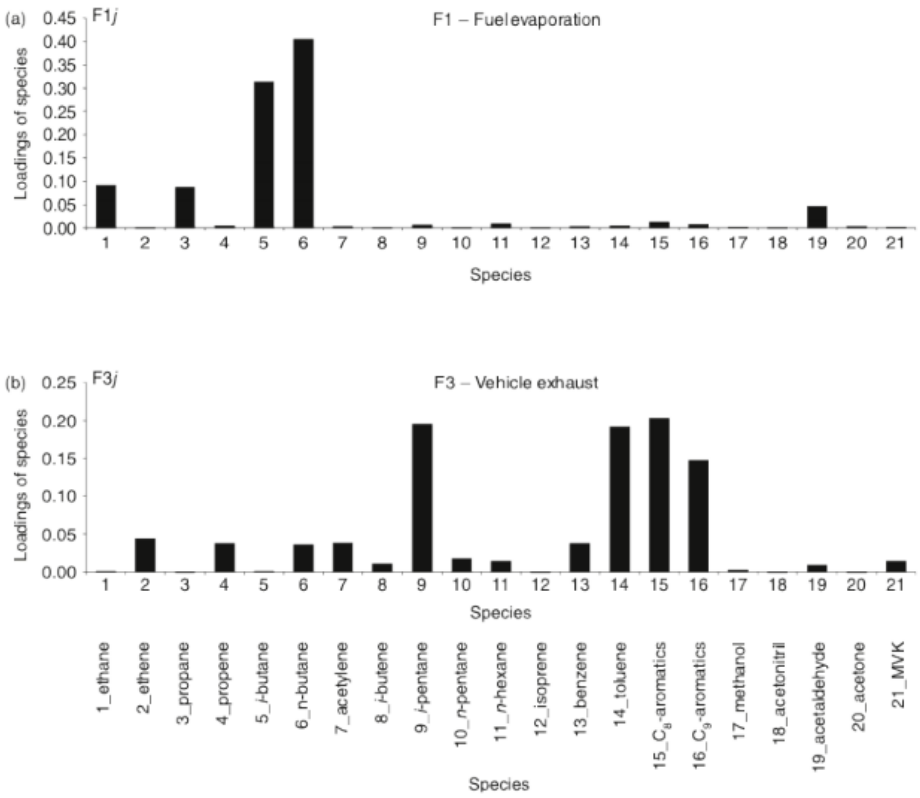




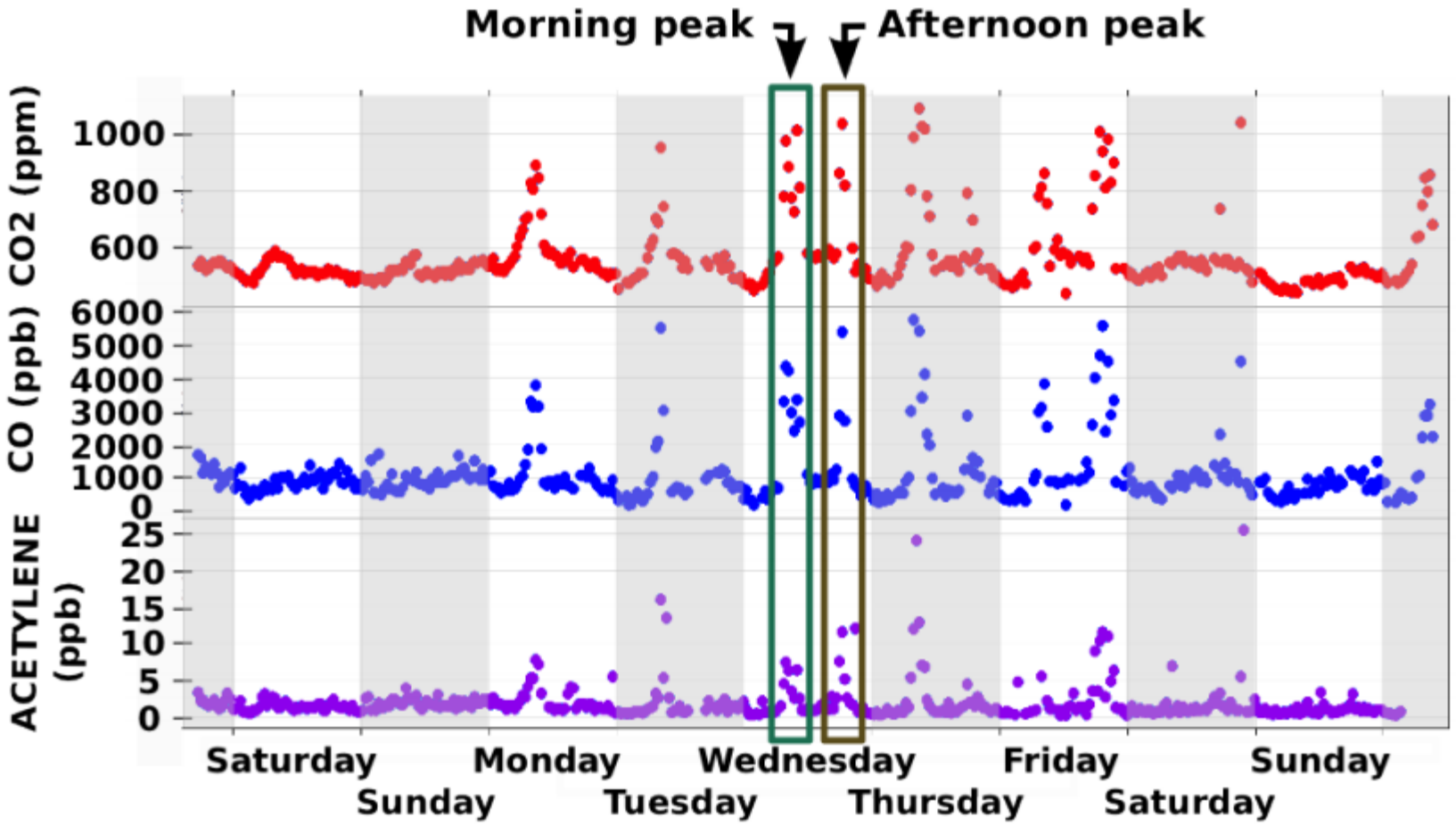
Xueref-Remy et al, tbs

VOC sources in Paris (Gaimoz et al., 2011)





Source : Gaimoz et al., 2011.



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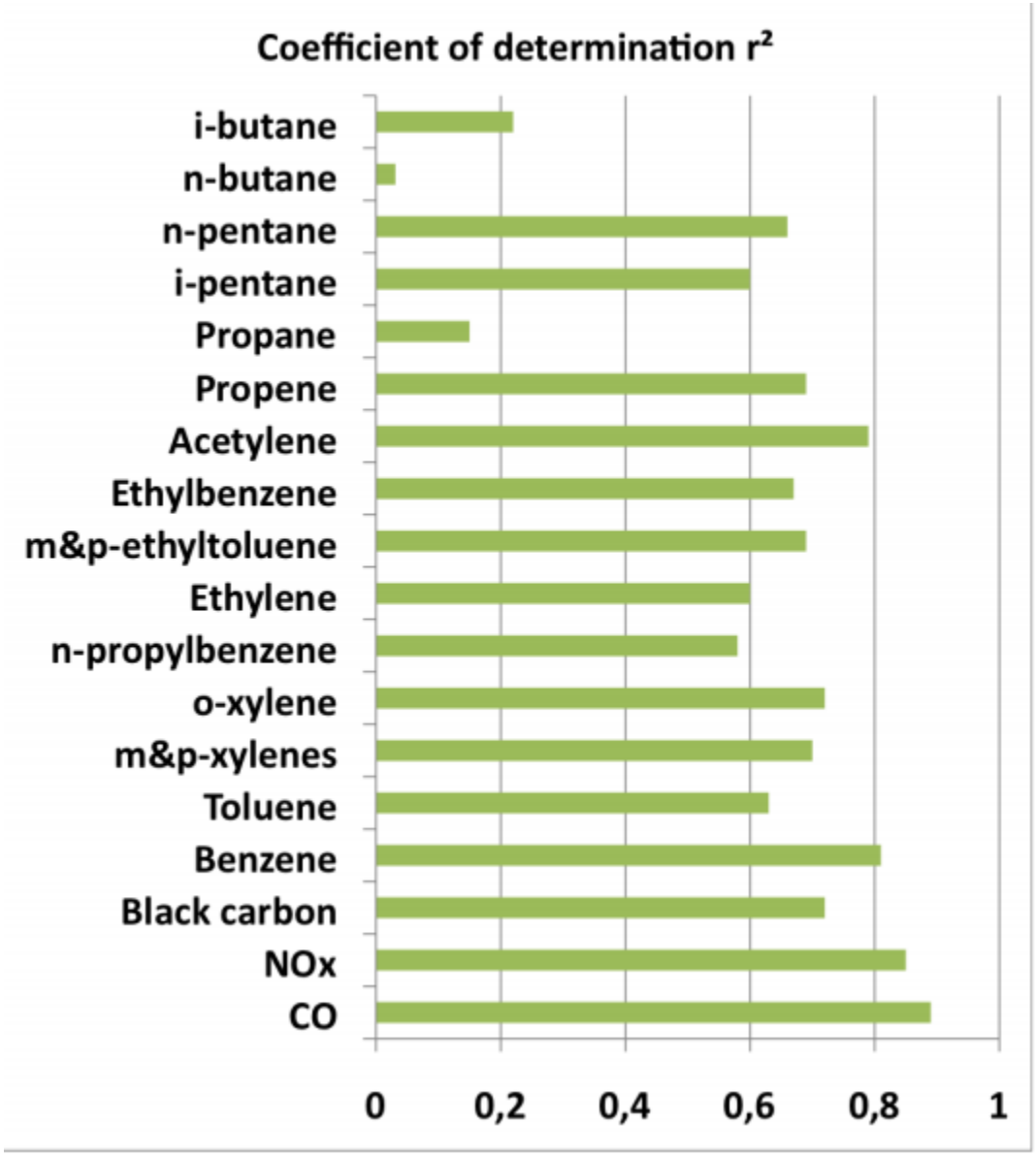


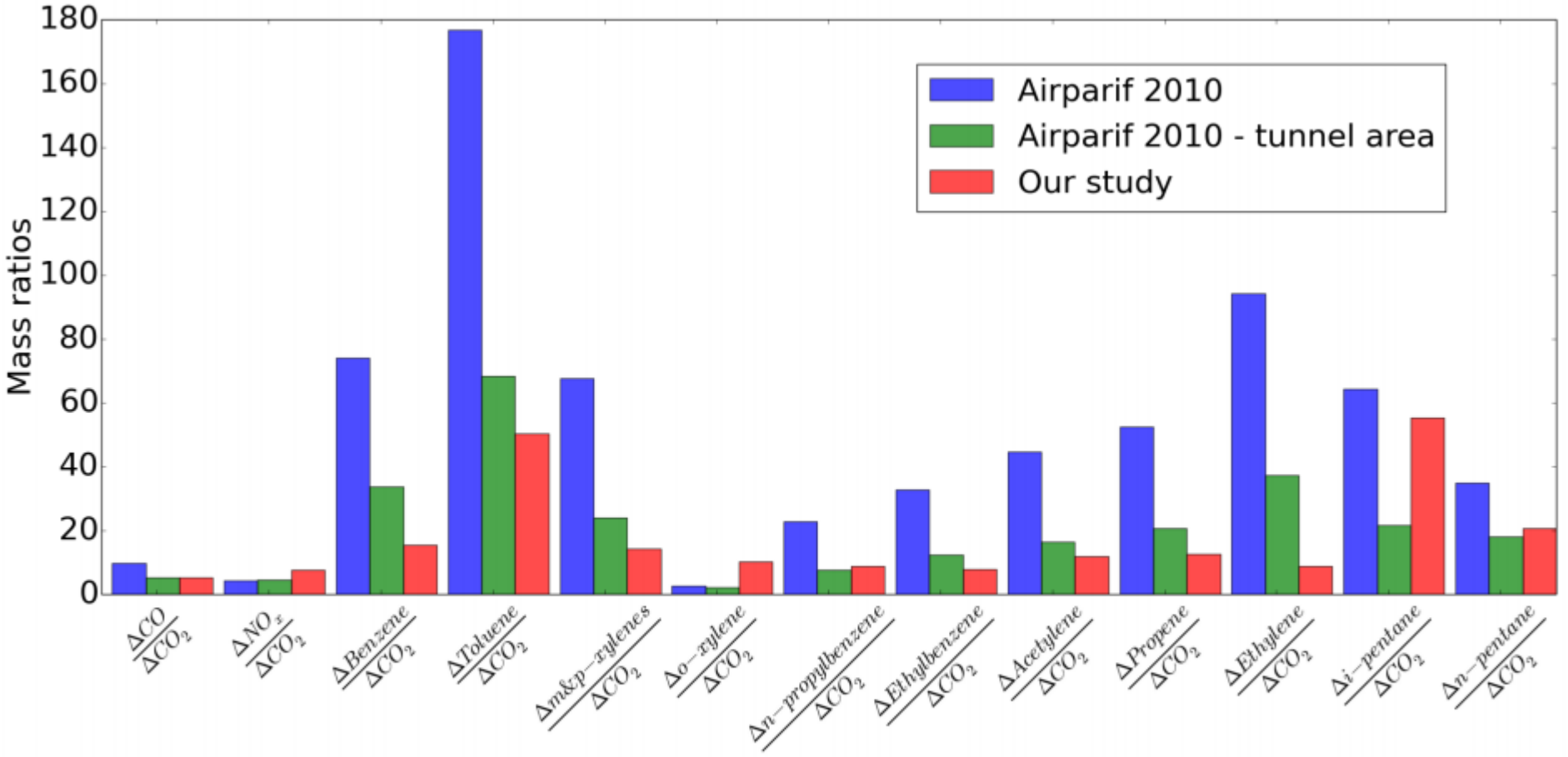
Identification of co-emitted species (Gaimoz et al., 2011).

p-value test

p-value < 0.001

Correlations

Strong correlations $\rightarrow$ similar source of emission (traffic activities).



Data from inventory : traffic only.

Intercomparaison of high resolved inventories

AIRPARIF Paris/ IER Stuttgart : 1x1 km², 1h (2008)

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Sector	$Mt(CO_2)/yr$ IER	AIR
All	62.86	52.07