DIESEL LOCOMOTIVES CONTRIBUTION AROUND "GARE DE L'EST" STATION

Frédéric Mahé[1], *Fabrice Maury*[2], *Erwan Corfa*[2], *Armand Albergel*[2]

[1]AIRPARIF (Air Quality Monitoring Network for Paris and Ile-de France Region)

[2] ARIA Technologies SA , Boulogne-Billancourt, France

Summary

- **« Gare de l'Est » district modeling**
  - Context
  - Site modeling
  - Emission modeling
  - Choice of scenarios (emissions + meteorology)
- **Results**
  - District pollution levels, streets traffic only
  - District pollution levels including Diesel locomotive emissions
  - Contribution of Diesel locomotive
- **Conclusion**

Context

« Gare de l'Est » is the starting point of trains to Germany and to East (railways not all along electrified)

➔ Use of Diesel locomotives

Objectives of the study:

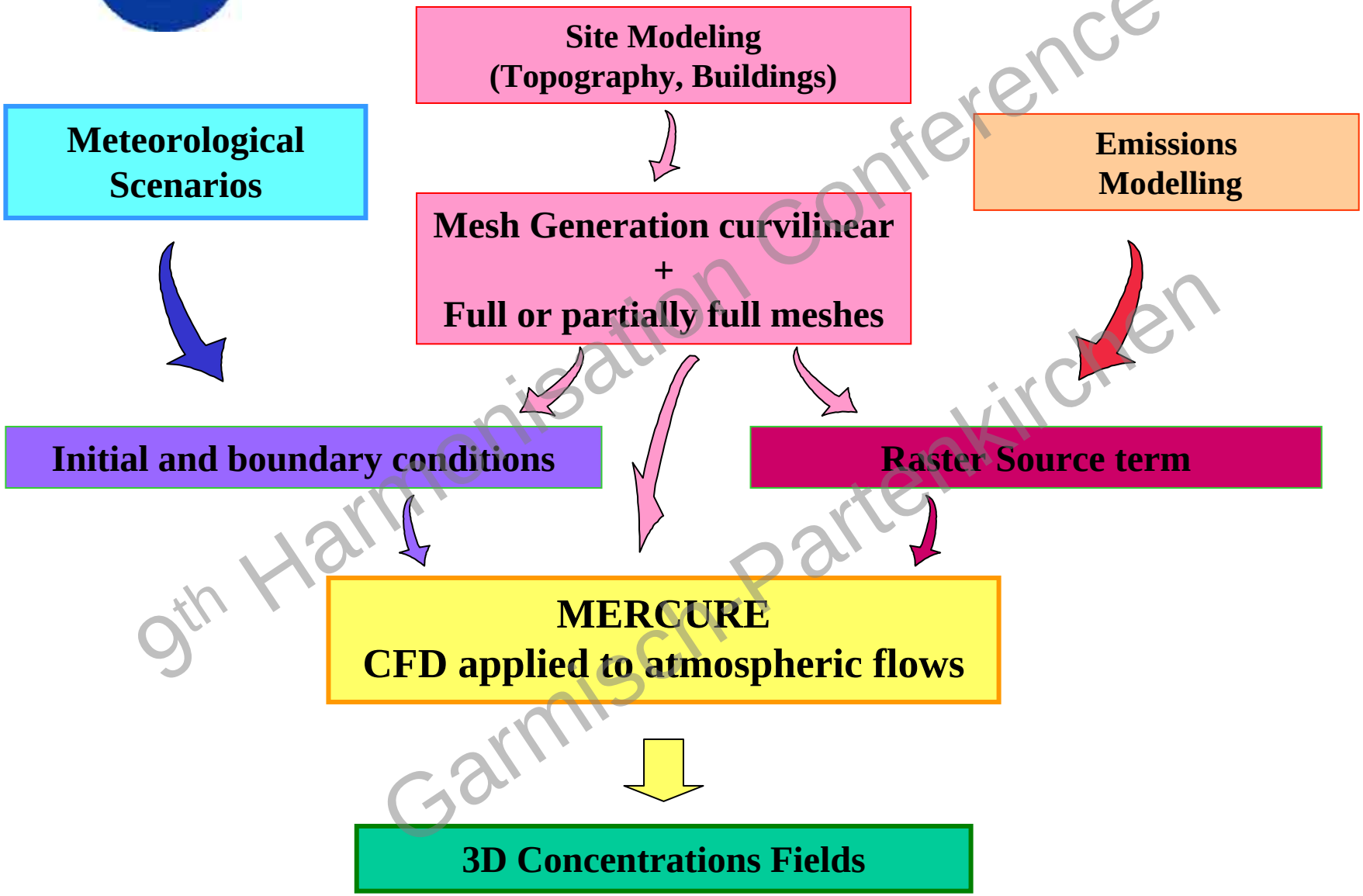
1) Quantify the contribution of the background and of local sources for the whole district area,

2) Quantify the impact of the Diesel locomotives for several running modes and for the selected meteorological conditions

3) Improvement due to new engine technology

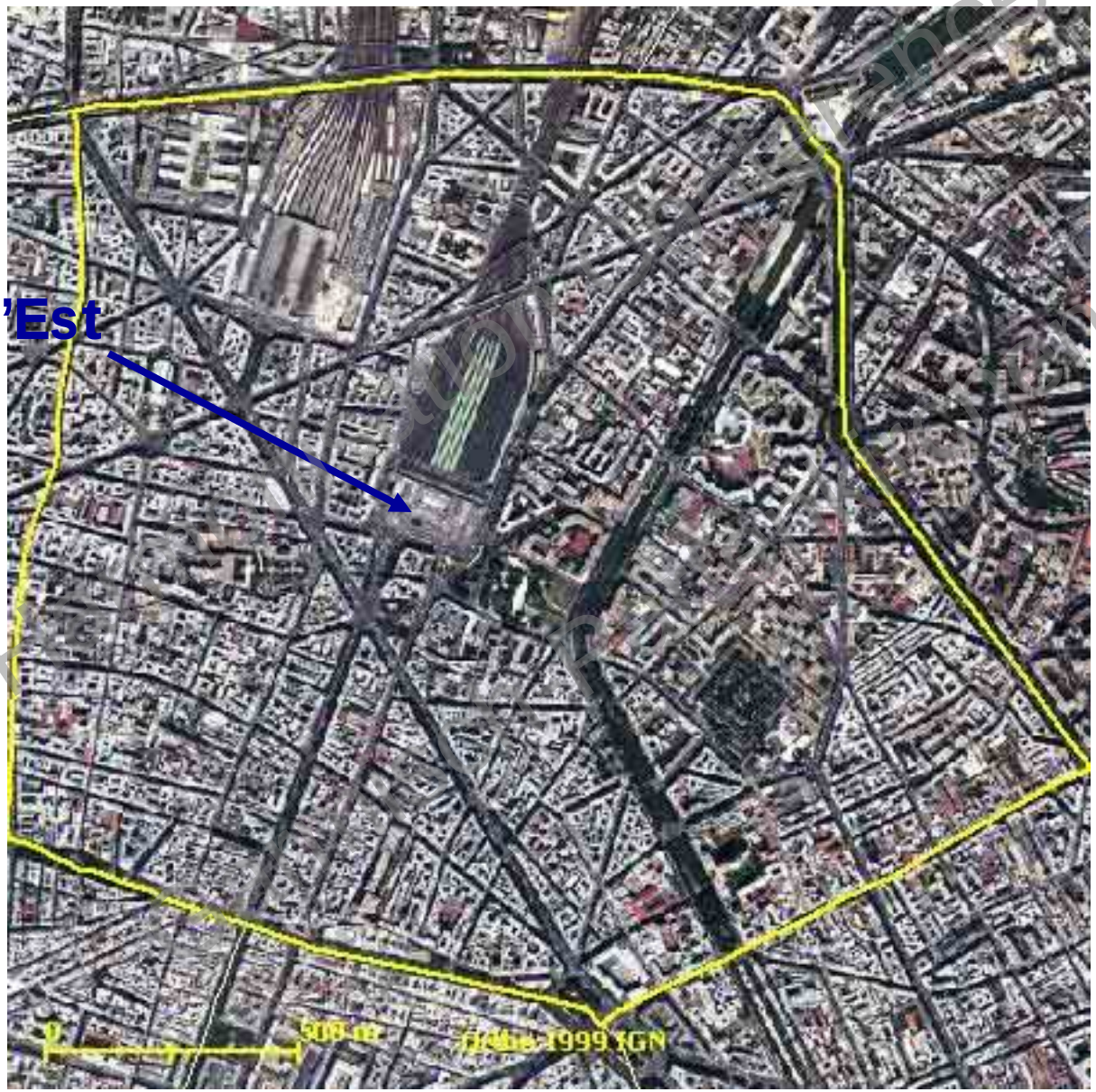
Study realized by AIRPARIF ordered by Conseil Régional Ile-de-France and the City of Paris

General flowchart ARIA LOCAL



The district…

Gare de l'Est



Difficulties

- High density of buildings
- Complex geometry

➔ Old Paris downtown

- High density and many kind of emission sources
  - Traffic (all types of vehicles)
  - Rail Station « Gare de l'Est »
  - Domestic and Tertiary emission
- Variability of the emissions in time and space
- High sensitivity to meteorological situation
- CPU Consuming : Up to 3 days per run

FIND THE « RIGHT » COMPROMISE

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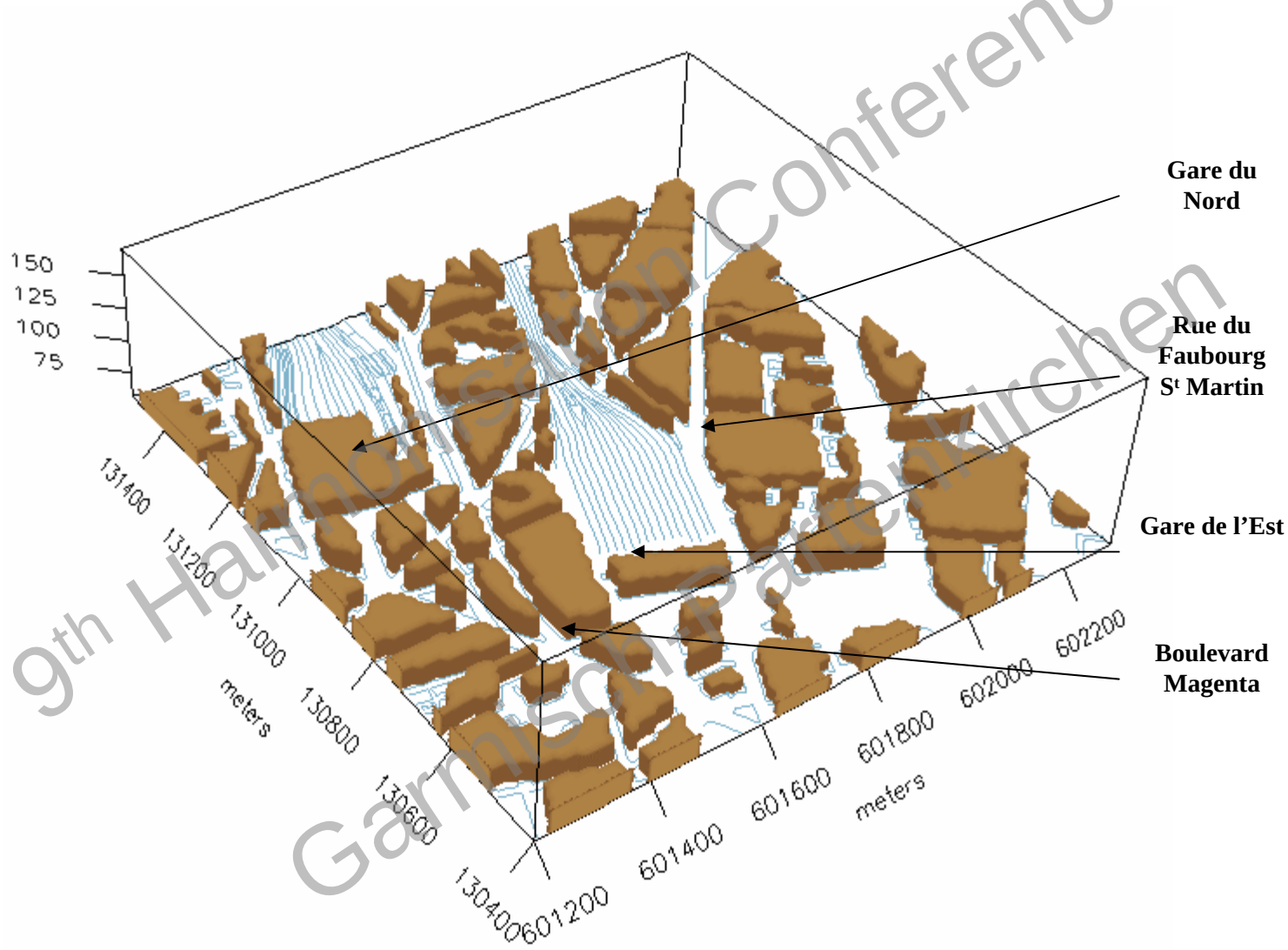
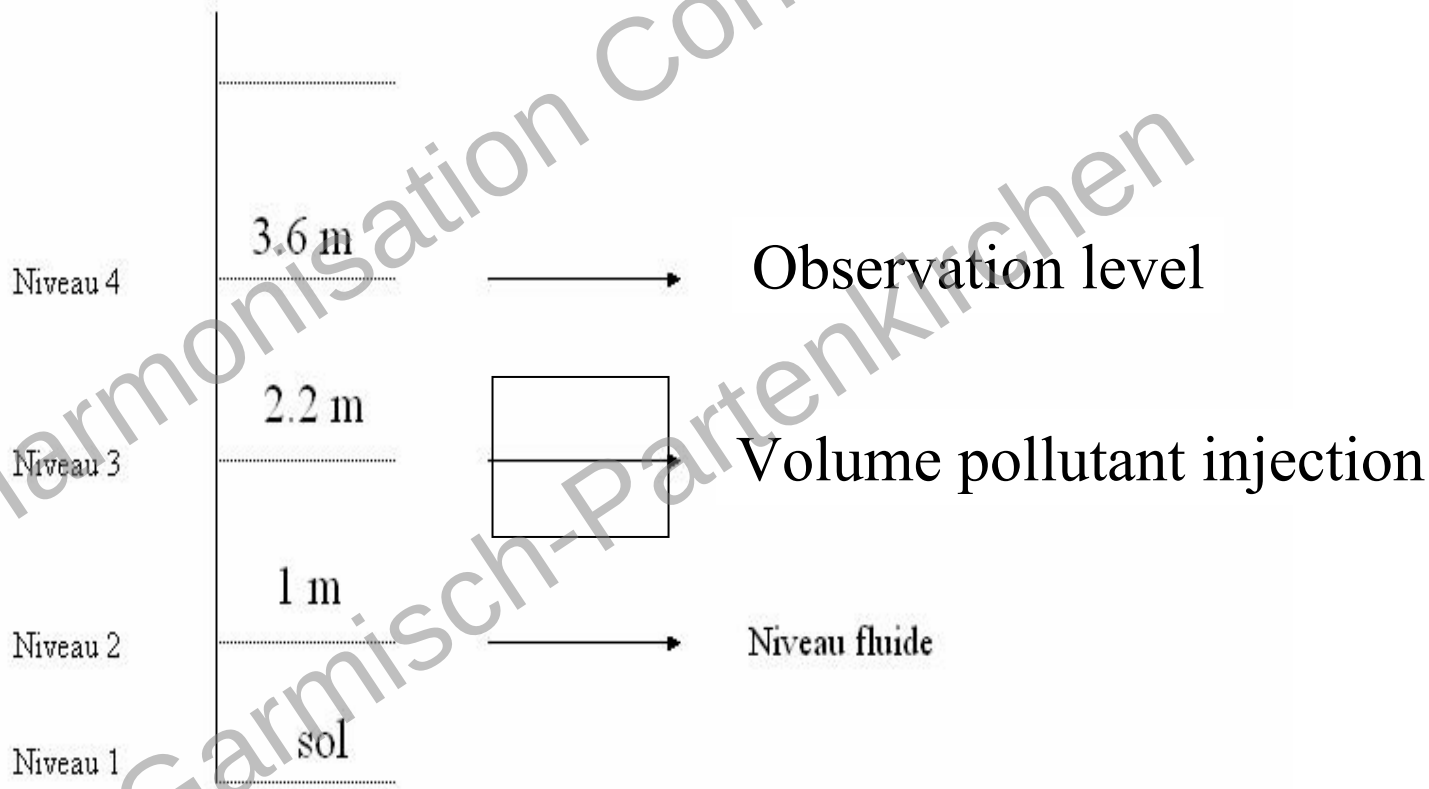
Final mesh and buildings as seen by the model



Vertical mesh



Vertical resolution : 1m at ground and 46m at the top (170m)

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Emission modeling

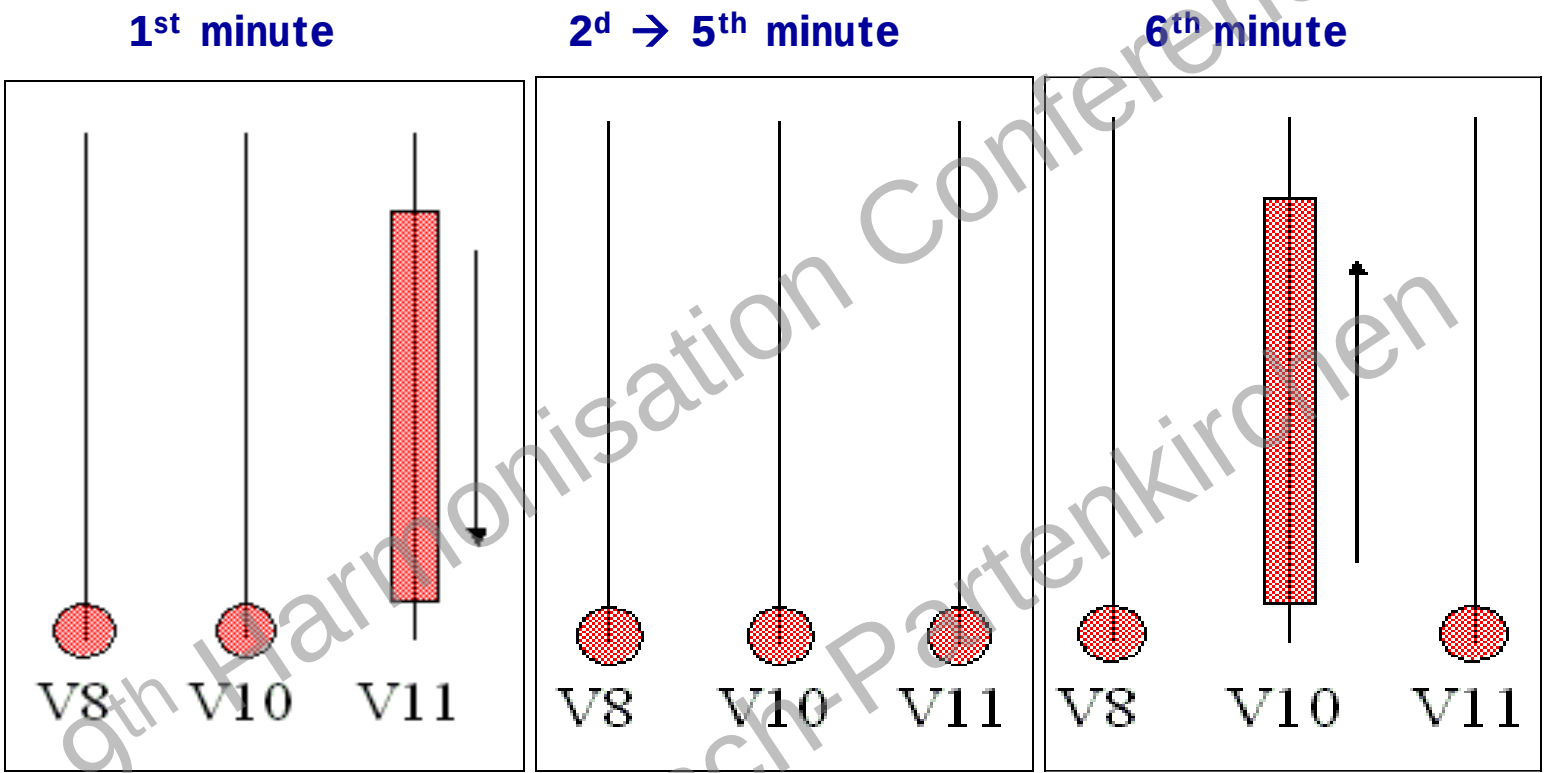
Street traffic emission :

- Significant data for the morning rush hours a weekly day (source : DREIF)
- National urban vehicle fleet for the year 2000 (source : ADEME/INRETS + Observatoire des déplacements)
- Emission factors **Copert III**

Diesel locomotives emissions :

- 6 minutes period (9h15-9h20) with 3 locomotives CC72000 on 3 near lines (source SNCF)
- Emission factors for 3 Engine speeds (idle/arriving, warming up, departure) (source : SNCF)

Diesel locomotives emissions localizations



V8, V10 et V11 are railways where the 3 locomotives are.

For the parked locomotive, two modes are considered :
-mode 1 : « Idle »
- mode 2 : « Warming up »

Emissions Factors for Diesel locomotives

Pollutant	idle/Arriving	Warming up	départure (1min)
CO	3103 g/h	1600 g/h	1480 g/h
NOx	577 g/h	7500 g/h	10420 g/h
Particules	259 g/h	350 g/h	425 g/h

Emissions data for CC72000 locomotive (source SNCF)

We generally consider that the emissions during the « idle phase » are the same than during the « arriving phase » : no traction effort in both cases

Comparison between streets and Gare de l'Est emissions (1)

Sources (6 minutes of loco presence)	CO	NOx	Particles
Street traffic	16 kg	1.8 kg	197 g
Locomotives, "warming up" mode for standing locomotives	628 g i.e. 3.9 % of street traffic	1.6 kg i.e. 88.9 % of street traffic	97 g i.e. 49.2 % of street traffic
Locomotives, "idle" mode for standing locomotives	904 g i.e 5.7 % of street traffic	337 g i.e. 18.7 % of street traffic	80 g i.e. 40.6 % of street traffic

During this 6 minutes periods, the « Gare de l'Est » emission are :

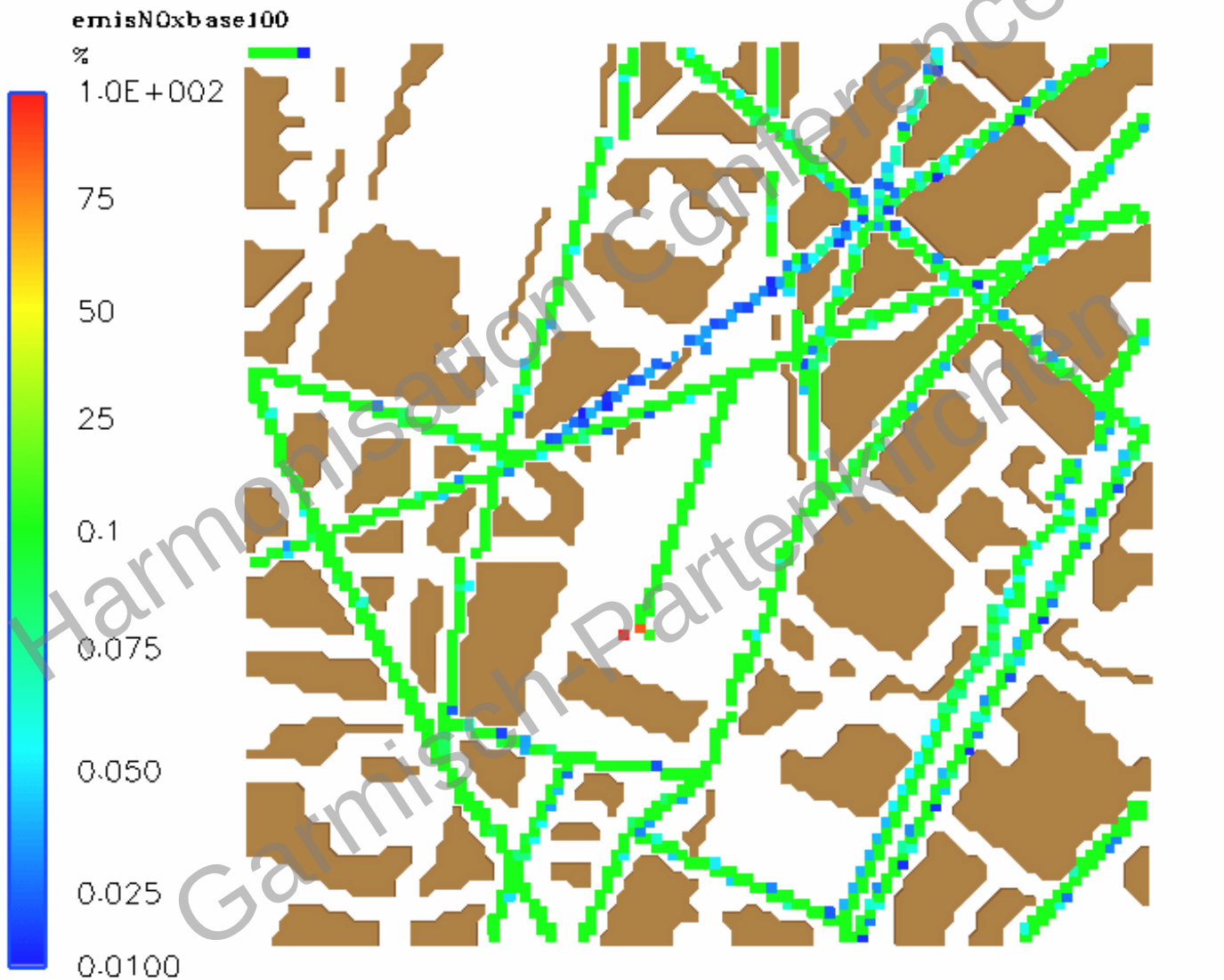
- ***very important for NOx***
- ***significant for particles***
- ***low for CO***

Comparison between streets and station emissions (2)

Sources Inside the domain	CO	NOx	Particles
Street traffic (weekly day)	**2400 kg/day**	**270 kg/day**	**29.6 kg/day**
Locomotives (Standard day source SNCF)	**21 kg/day**	**68 kg/day**	**3.4 kg/day**
Car Traffic emission for all the city of Paris (weekly day)	*191 tons/day*	*35 tons/day*	*3.3 tons/day*

Diesel locomotives give 20 % of the daily emissions for NOx et 10 % for particles over the whole district

Mapping of the NOx emissions



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Definition of scenarios

3 configurations for the emissions :

- Street traffic only (Reference case)
- Street traffic + 3 Diesel locomotives considering 2 Engines in « warming up » mode, (scenario « Loco 1 »)
- Street traffic + 3 Diesel locomotives considering 2 Engines in « Idle » mode, (scenario « Loco 2 »)

4 meteorological conditions :

Situation meteo	Stability	Wind Direction	Wind Speed
5D-SW	Neutral (D)	SW (220°)	5 m/s
2D-SW	Neutral (D)	SW (220°)	2 m/s
5D-NE	Neutral (D)	NE (22°)	5 m/s
2D-NE	Neutral (D)	NE (22°)	2 m/s

Configurations retenues

		Meteo			
		5D-SO	2D-SO	5D-NE	2D-NE
Configurations emissions	Reference	X (CO, NOx, PM)	X (CO, NOx, PM)	X (CO, NOx, PM)	X (CO, NOx, PM)
	Loco 1	X (CO, NOx, NOxrail, PM, PMrail)	X (NOx, NOxrail, PM)	X (NOx, NOxrail, PM)	X (NOx, NOxrail, PM)
	Loco 2	X (CO, NOx, NOxrail, PM)			

➔ Need of two virtual species (NOx_all and NOx_rail) to easily compute contribution of Gare de l'Est station (Idem for PM)

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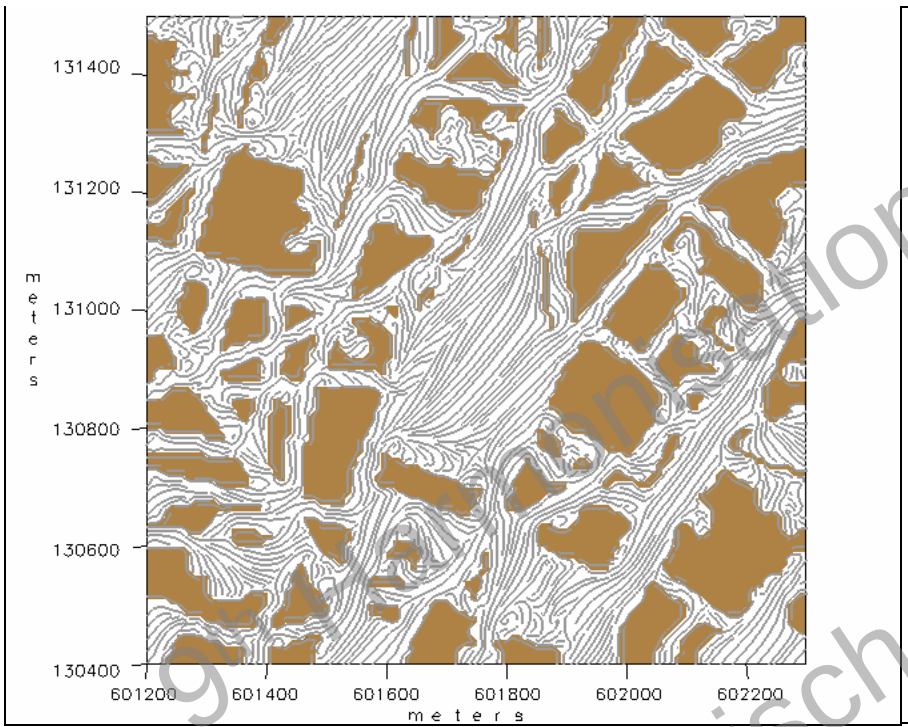
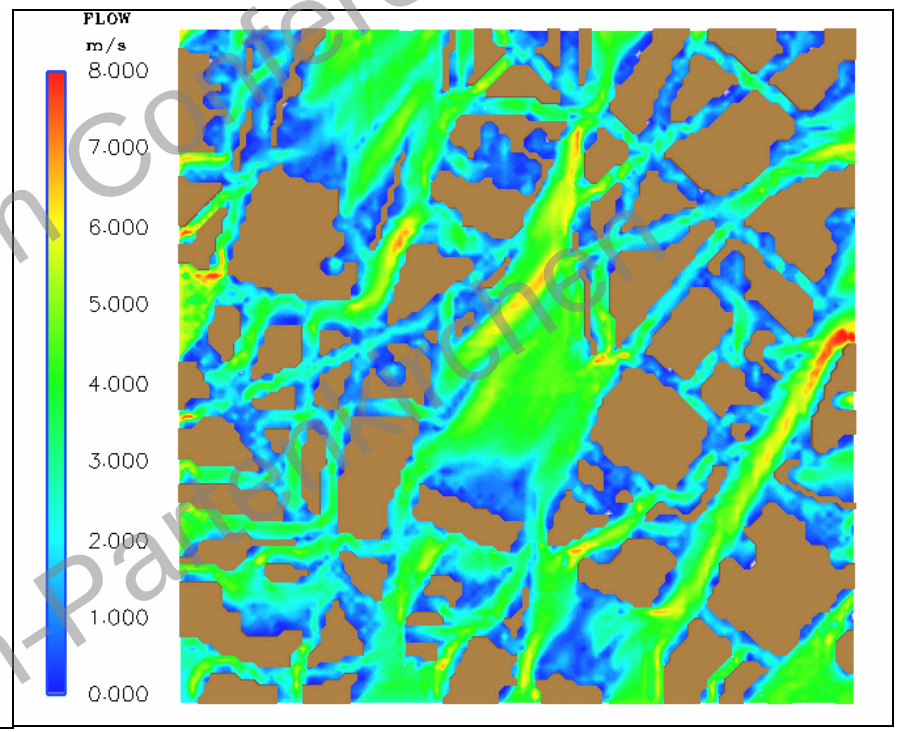
Run parameters

- Turbulence Closure: (k-ε Dyunkerke)
- Virtual potential temperature as thermal variable
- « Terrain following » for the curvilinear
- Advection➔ Semi-lagrangian methods for scalars : θ, CO, NOx_all, PM et NOx_rail
- Background : a time dependant profile
- Release : time dependant mesh injection mode

Flow visualization



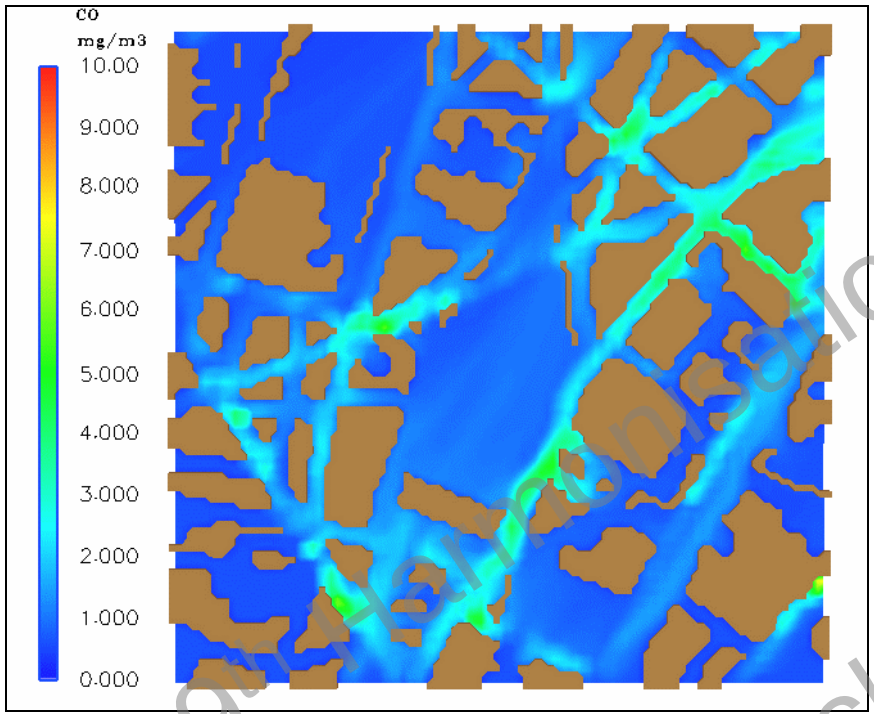
Streamlines



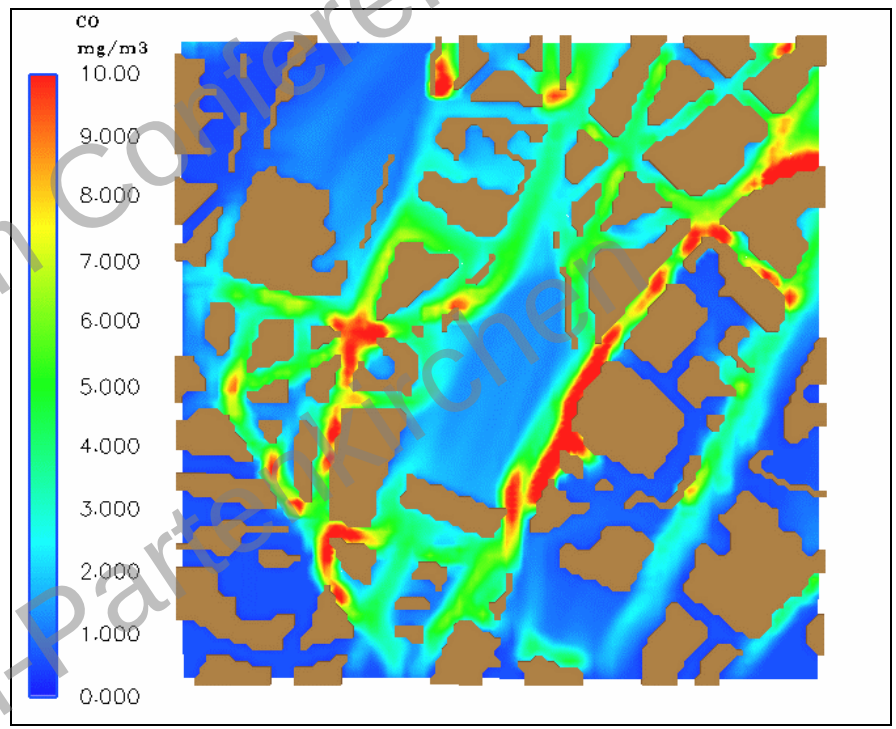
wind Speed

Flow 5D-SW (prevailing wind direction)

District pollution level
Street traffic only



CO, 5D-SW



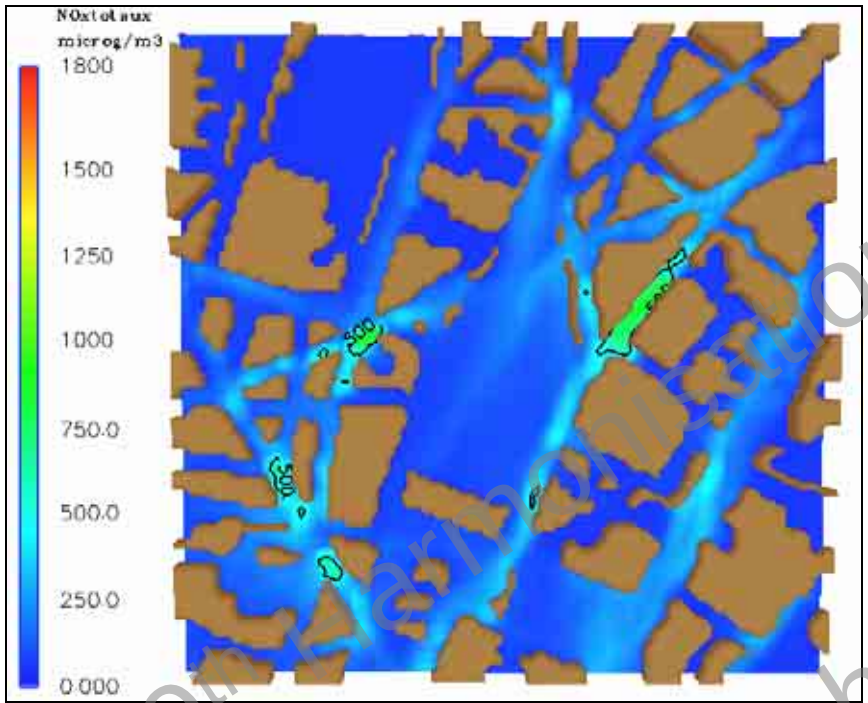
CO, 2D-SW

Pollutant : CO

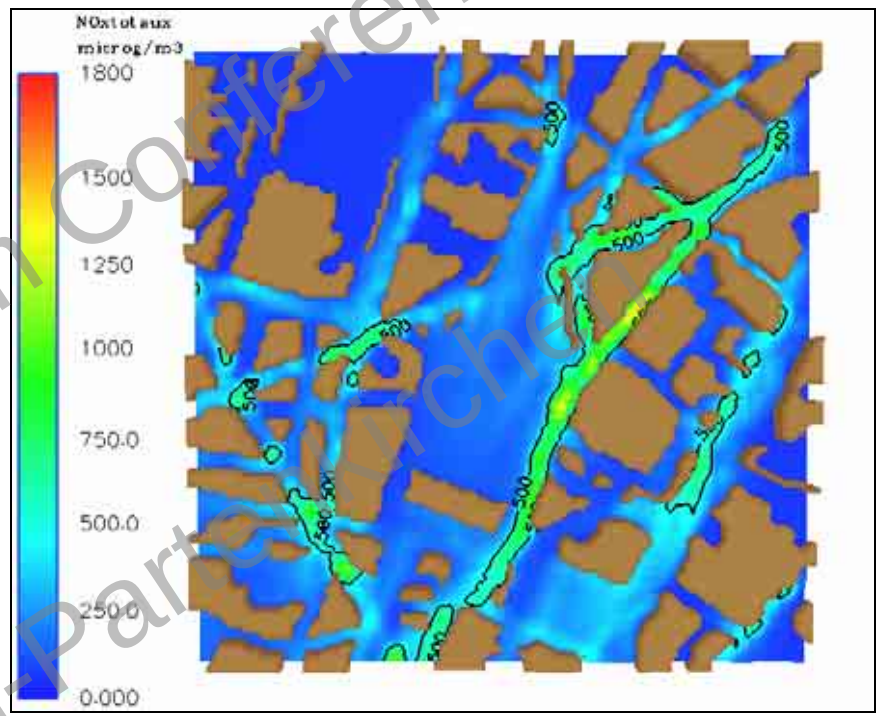
Background : 0.6 – 1 mg/m³

In streets : 1 – 10 mg/m³

District pollution level
Street traffic only



NOx, 5D-NE



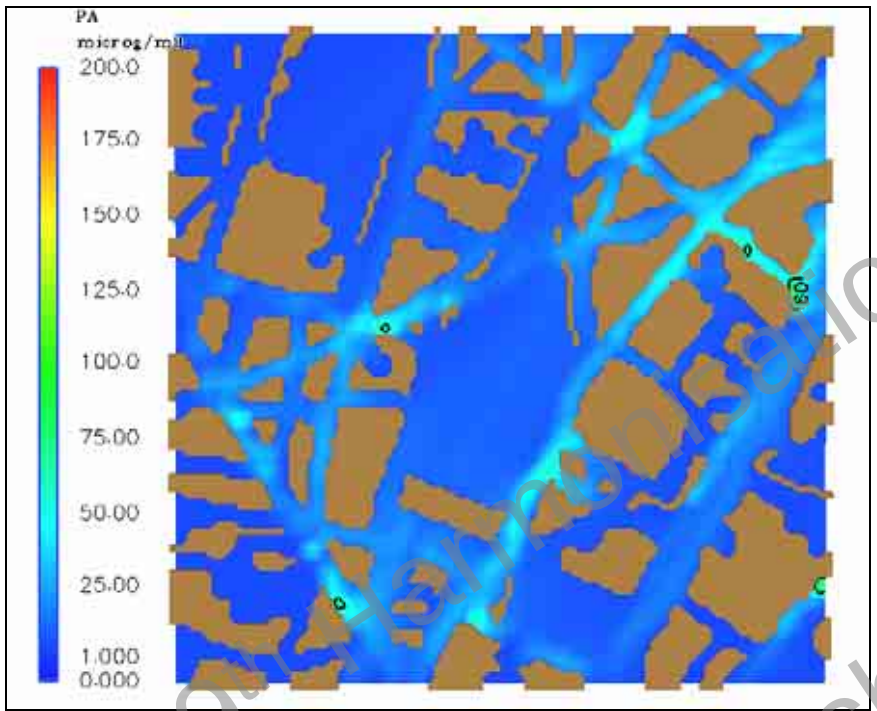
NOx, 2D-NE

Pollutant : NOx

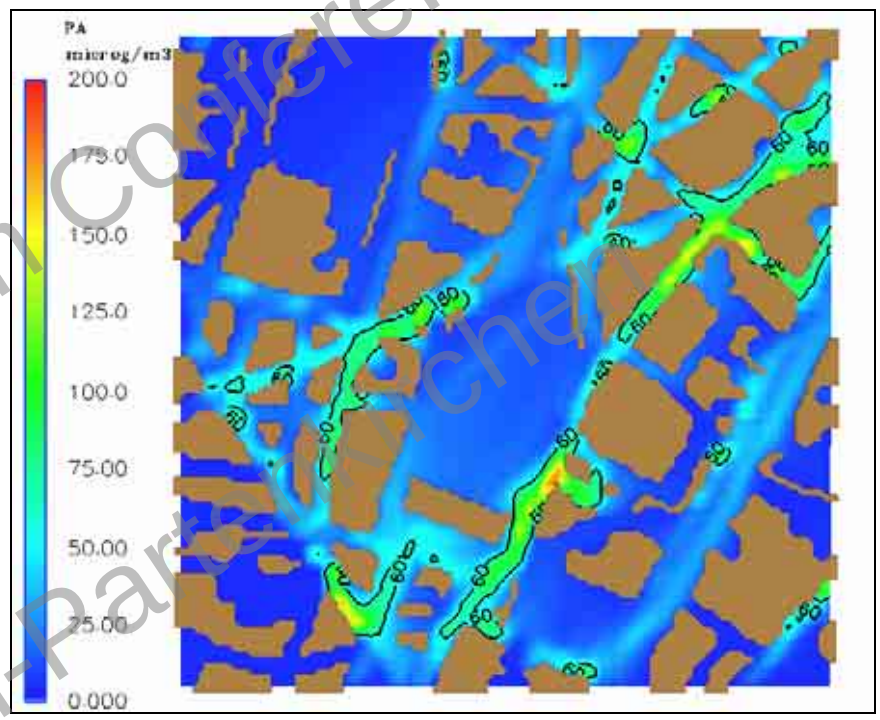
Background : 100 - 200 µg/m³

In streets : 400 – 1400 µg/m³

District pollution level
Street traffic only



PM, 5D-SW



PM, 2D-SW

Pollutant : PM

Background : 10 - 25 µg/m³

In streets : 40 – 150 µg/m³

District pollution level
Street traffic only

- Background concentrations are representative of dense urban district of Paris

- Computed street concentrations are close to measurements done in the district

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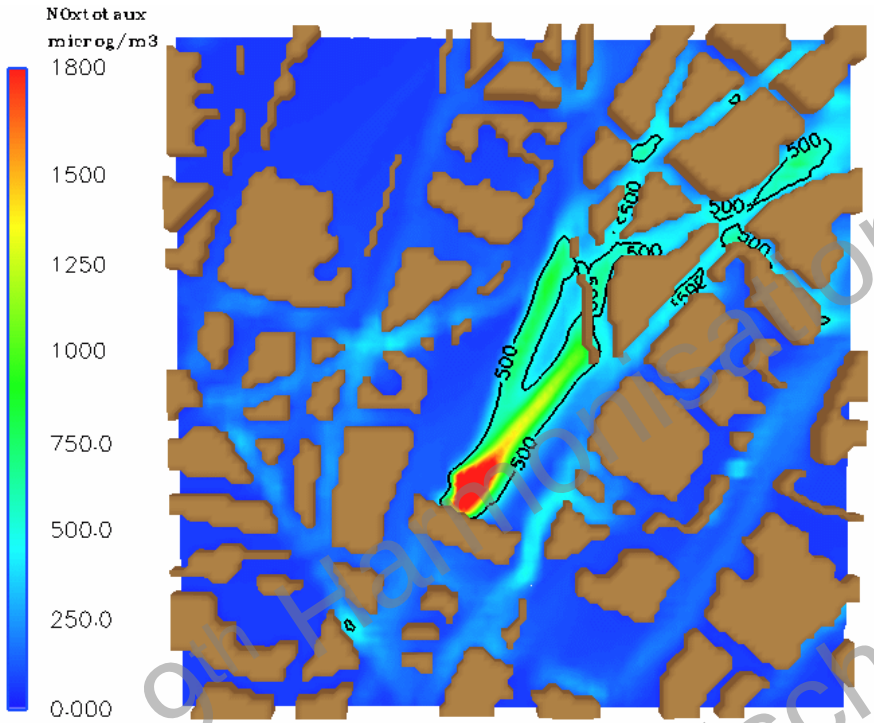
Dispersion Modeling results

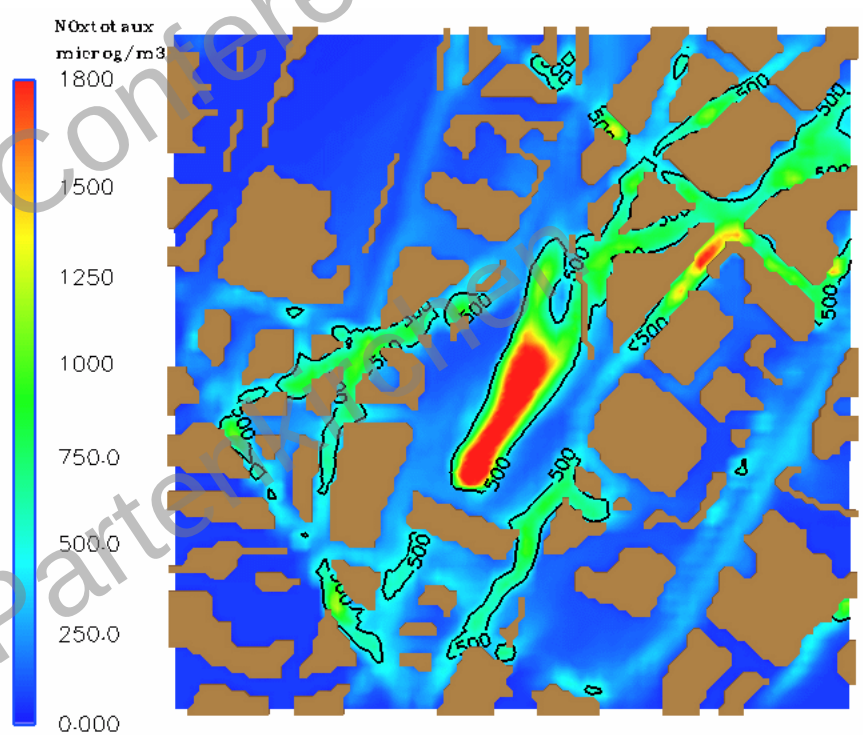
All results are given at t = 6 minutes including a cycle of:

- **1 arriving locomotive,**
- **2 or 3 parked locomotives**
- **1 departure**

District pollution level
Street traffic + Diesel locomotives



Loco 1, 5D-SW

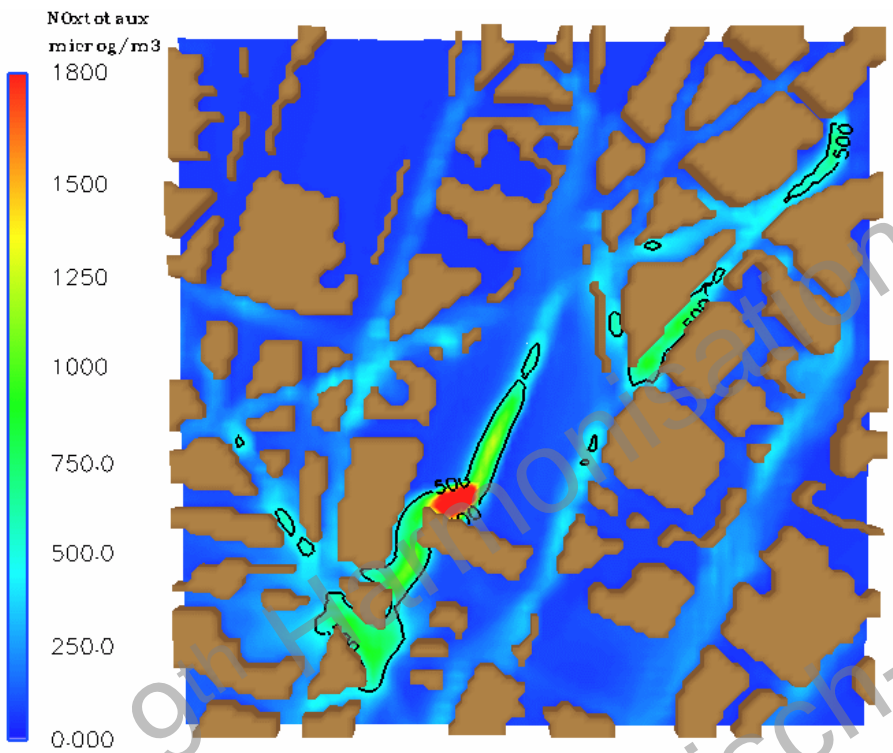


Loco 1, 2D-SW

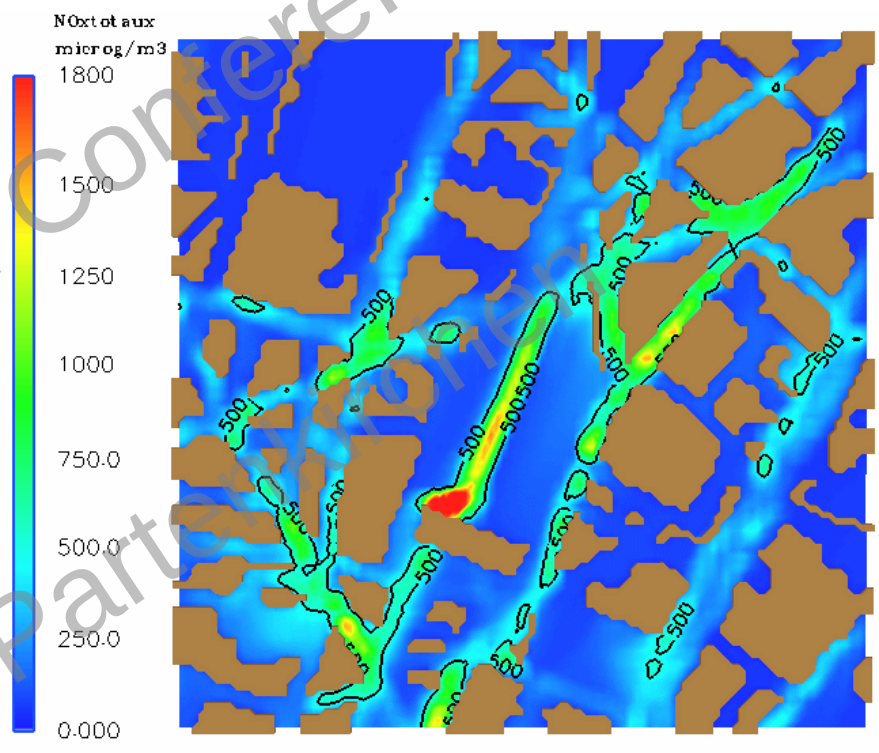
Pollutant : NOx, SW wind

Downwind concentration :
500 - 1000 µg/m³ (5m/s) et 750 – 1500 µg/m³ (2m/s)

District pollution level
Street traffic + Diesel locomotives



Loco 1, 5D-NE



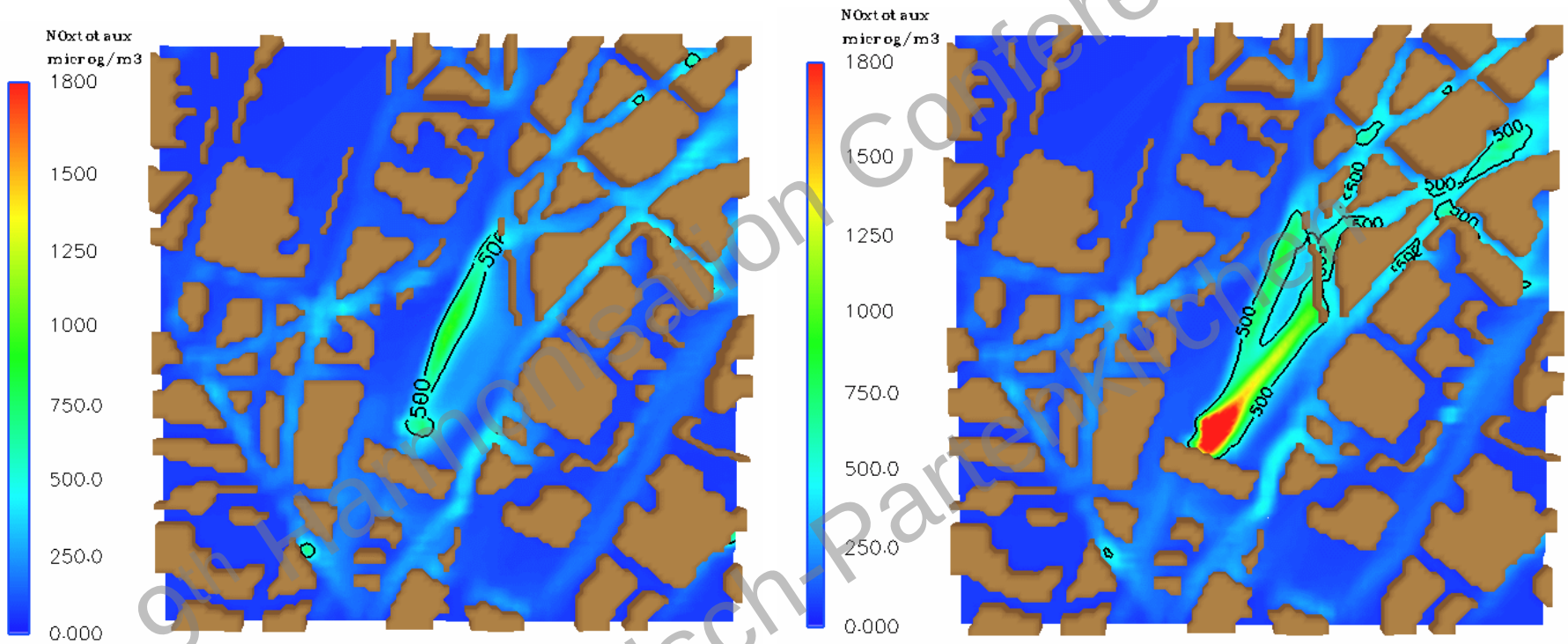
Loco 1, 2D-NE

Pollutant : NOx, NE Wind

Downwind concentration

500 - 1000 µg/m³ (5m/s) et 700 – 1200 µg/m³ (2m/s)

District pollution level
Street traffic + Diesel locomotives



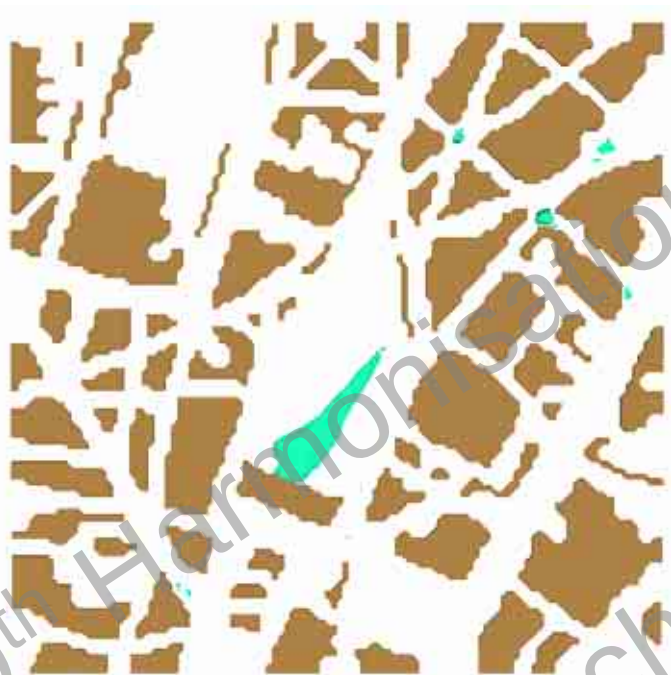
Loco 2, 5D-SW **Loco 1, 5D-SW**

Pollutant : NOx, Different running speed when parking

Loco 1 : Warming up the engines when parking
Loco2 : Engines already warm ➔ idle when parking

District pollution level
Street traffic + Diesel locomotives

Iso-surfaces concentrations of PM >= 60 µg/m3



Loco 1, 5D-SW

Loco 1, 2D-SW

Pollutant : PM, Wind SW

Downwind concentrations :
40-70 µg/m³ (5m/s) et 50-150 µg/m³ (2m/s)

District pollution level

Street traffic + Diesel locomotives

Iso-surfaces de concentrations en PM >= 60 µg/m3

Loco 1, 5D-NE

Loco 1, 2D-NE

Pollutant : PM, wind NE

Downwind Concentrations :

40-80 µg/m³ (5m/s) et 50-100 µg/m³ (2m/s)

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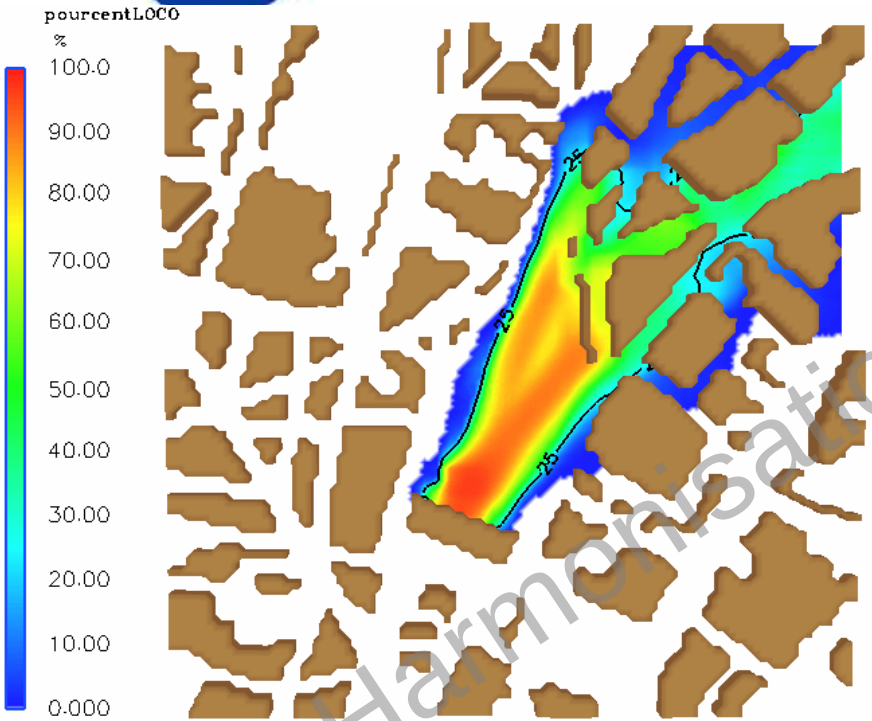
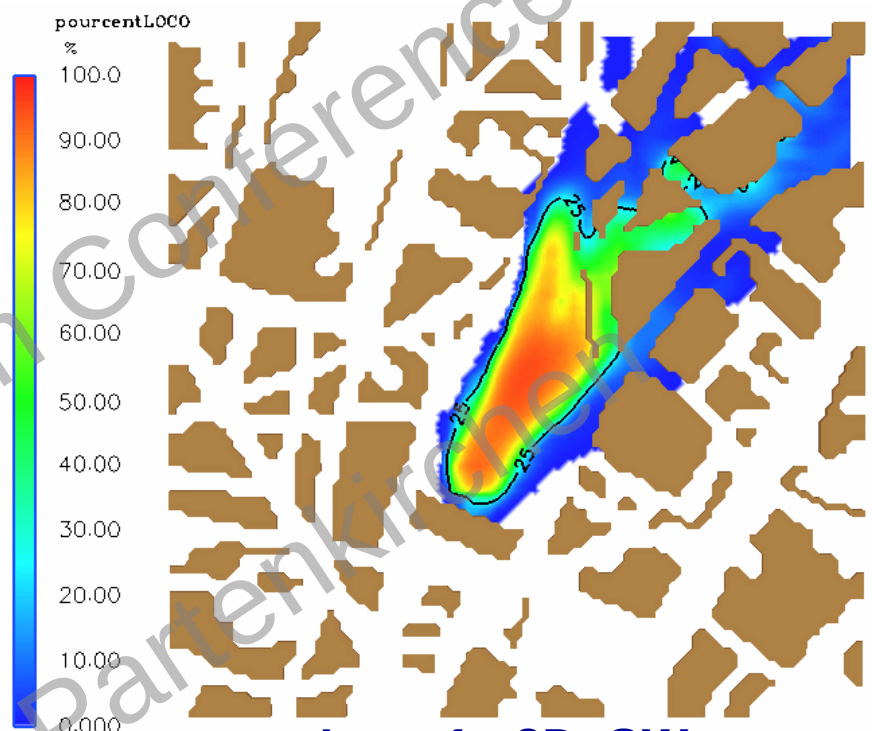
Contribution of Diesel locomotives ➔NOx



Loco 1, 5D-SW



Loco 1, 2D-SW

Pollutant : NOx, SW wind

Along railwails and in the station contribution up to 90 %

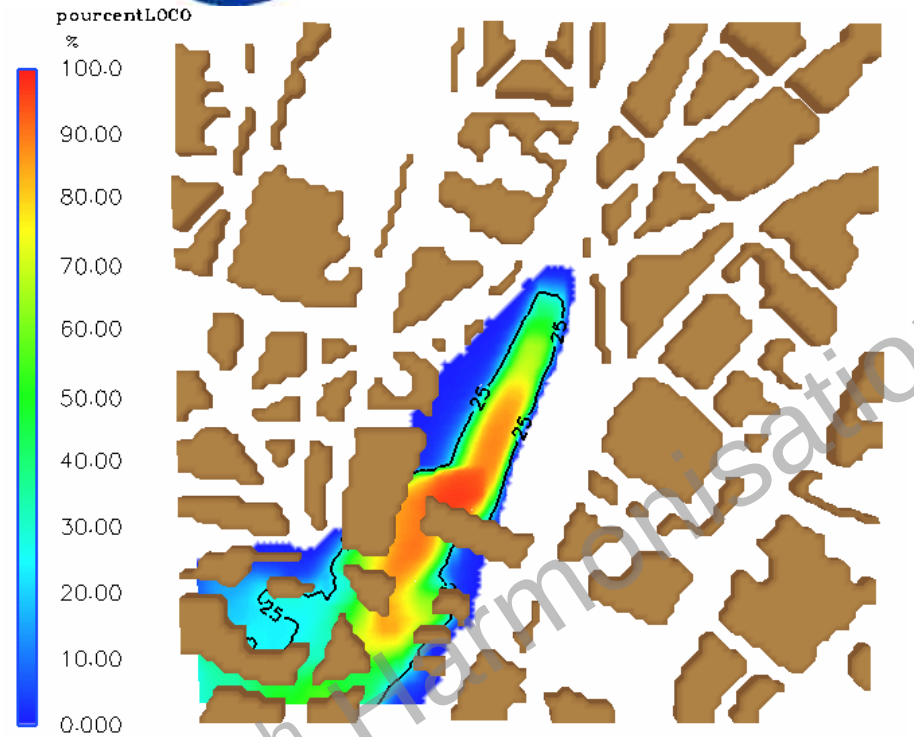
Downwind in the district : 60-70 %

Downwind domain where contributions > 25 % :

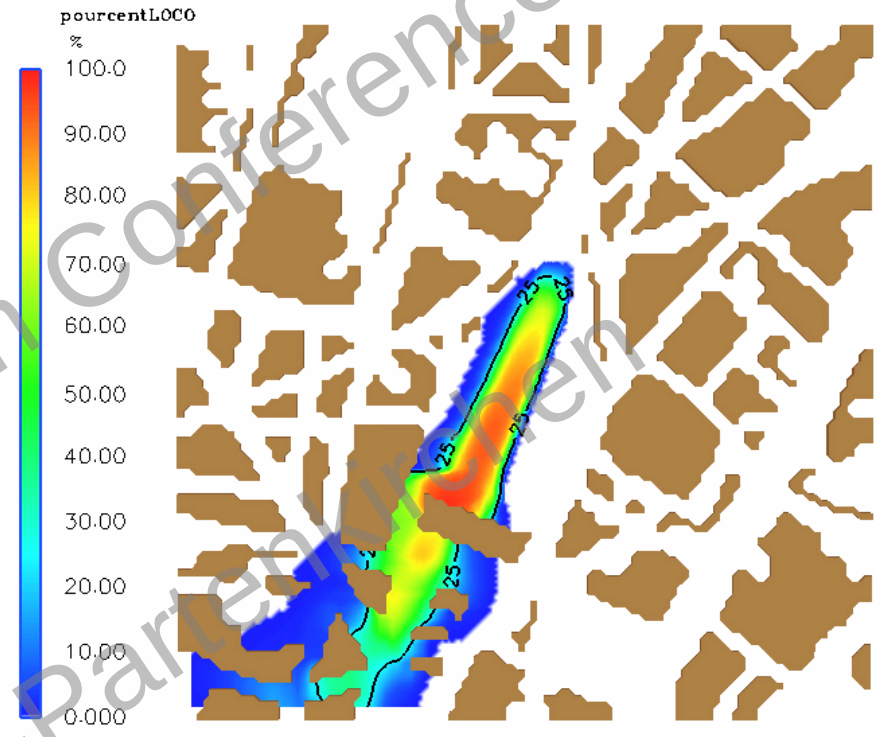
➔400 x 250m (5 m/s)

➔200 x 200 m (2 m/s)

Contribution of Diesel locomotives ➔ NOx



Loco 1, 5D-NE



Loco 1, 2D-NE

Pollutant : NOx, NE wind

In the station up to 90 %

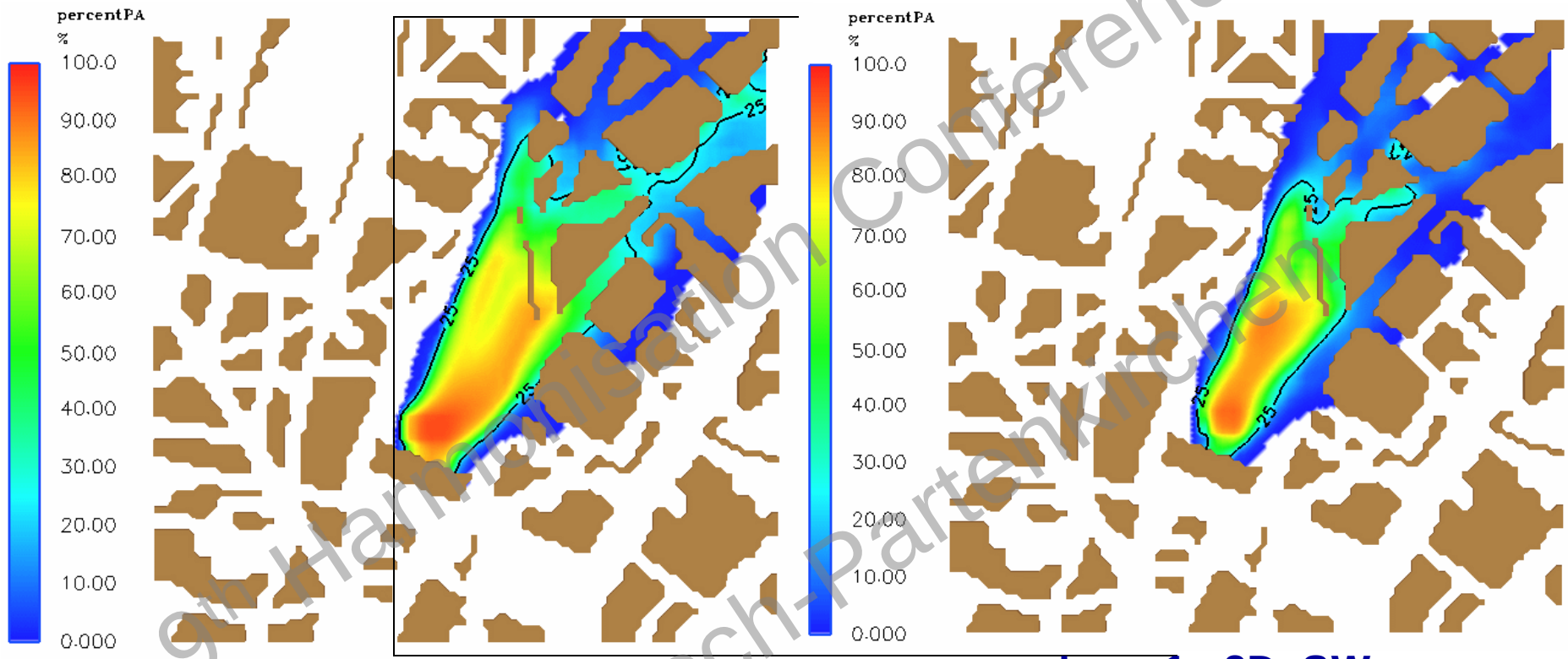
Downwind in the district : 60-85 %

Downwind domain where contributions > 25 % :

➔ 500 x 200m (5 m/s)

➔ 350 x 100m (2 m/s)

Contribution of Diesel locomotives ➔PM



Pollutant : PM, Wind SW

In the station up to 90 %

Downwind outside the station : max 60%

contribution Area > 25 % less important than NOx

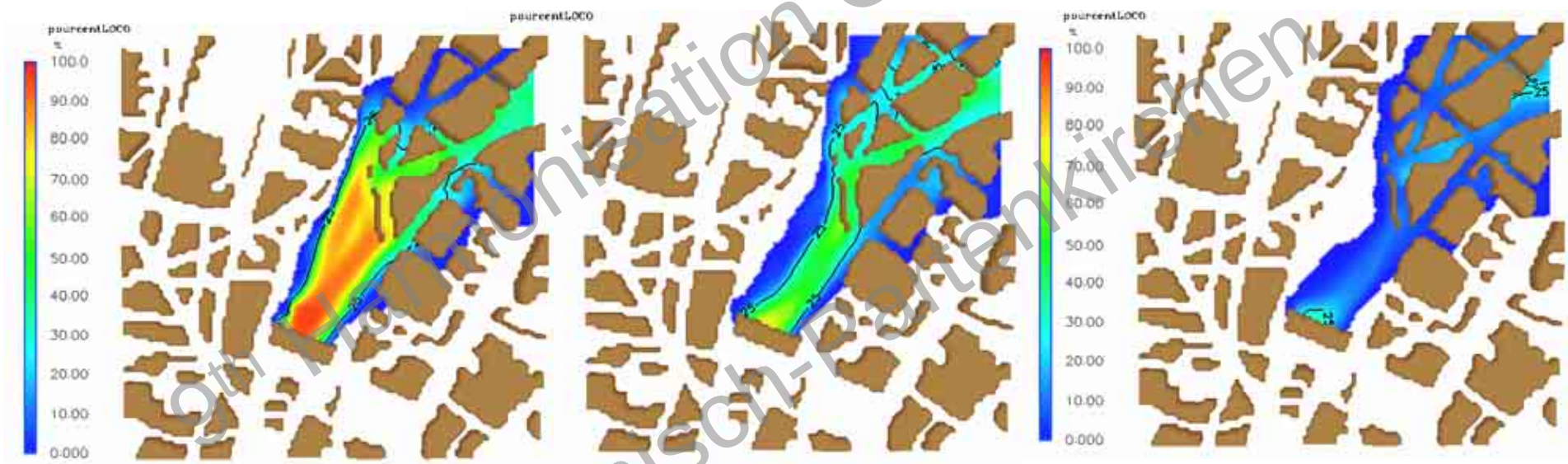
Persistence of the contribution of Diesel locomotives after the end of pollutant emissions

Persistence : contribution of the Diesel locomotives – wind SW, 5 m/s

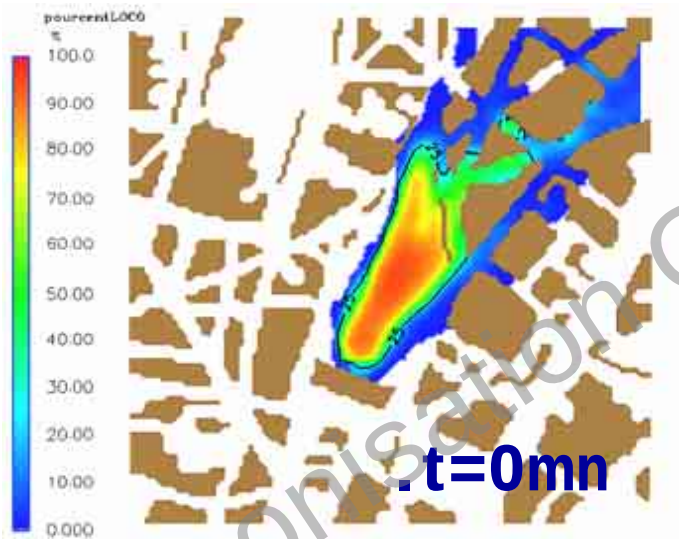
At t= 0 min after the end of locomotives emissions

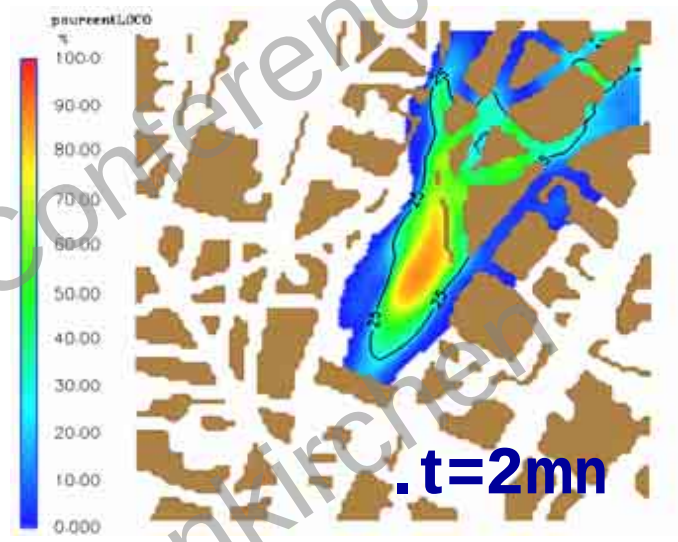
t = 2 min after

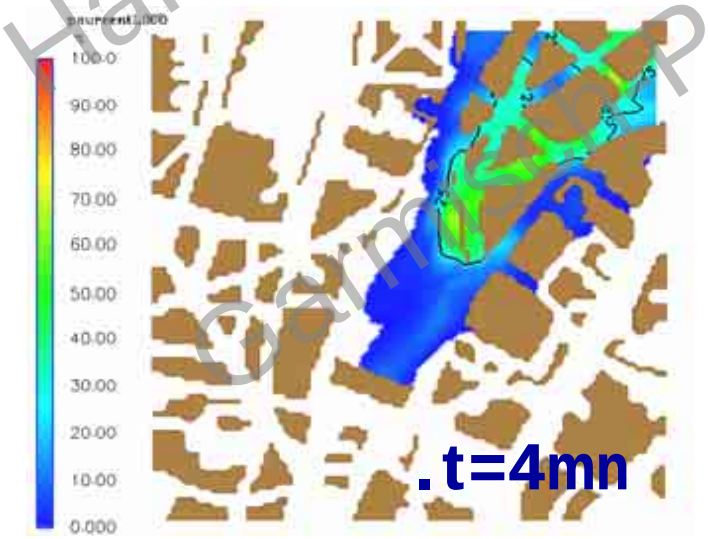
t = 4 min after



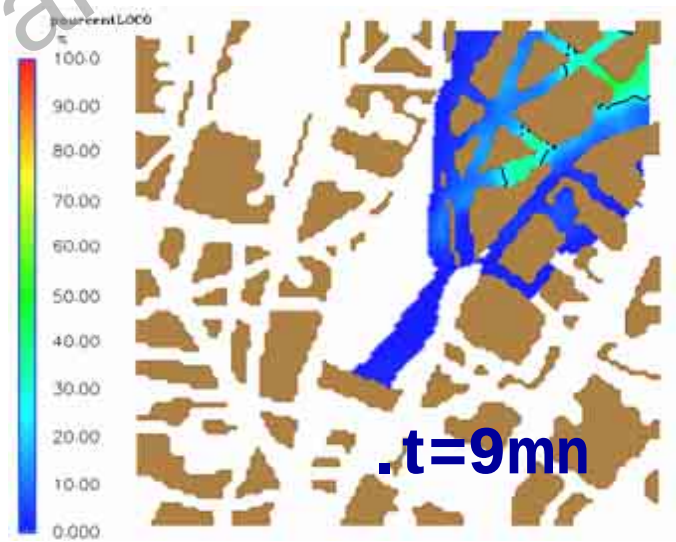
Persistence : contribution of the Diesel locomotives – wind SW, 2 m/s





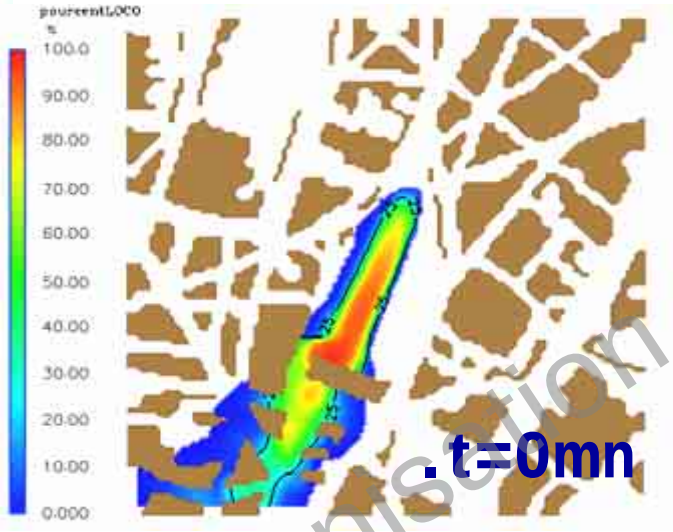


t = 4 min after the end of locomotives emissions

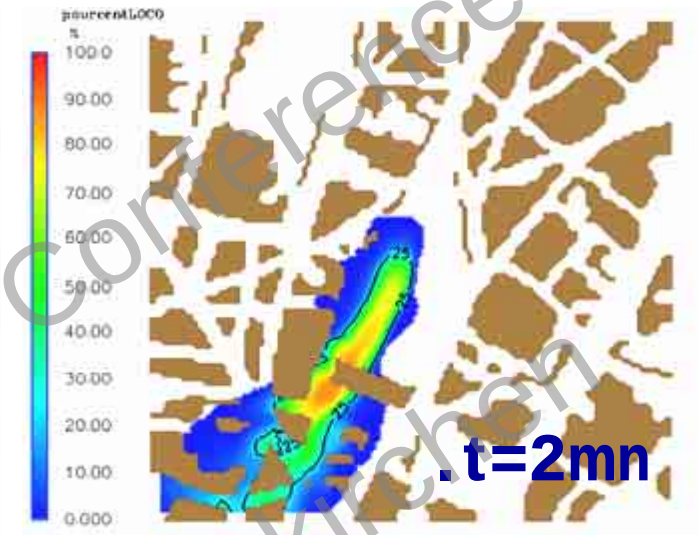


t = 9 min after the end of locomotives emissions

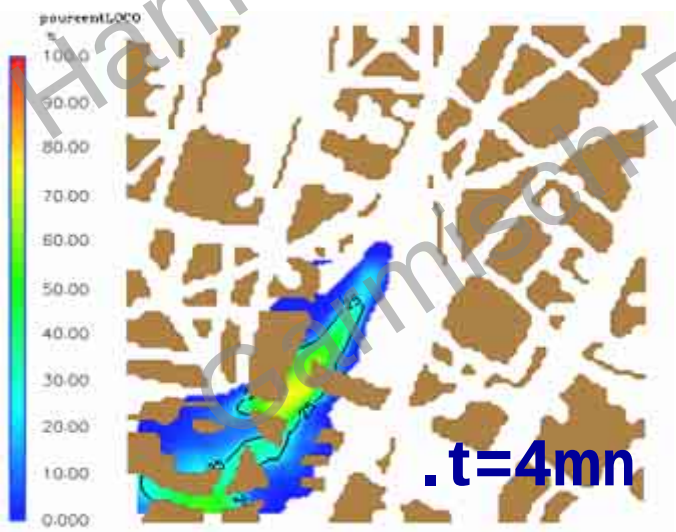
Persistence : contribution of the Diesel locomotives – wind NE , 2 m/s



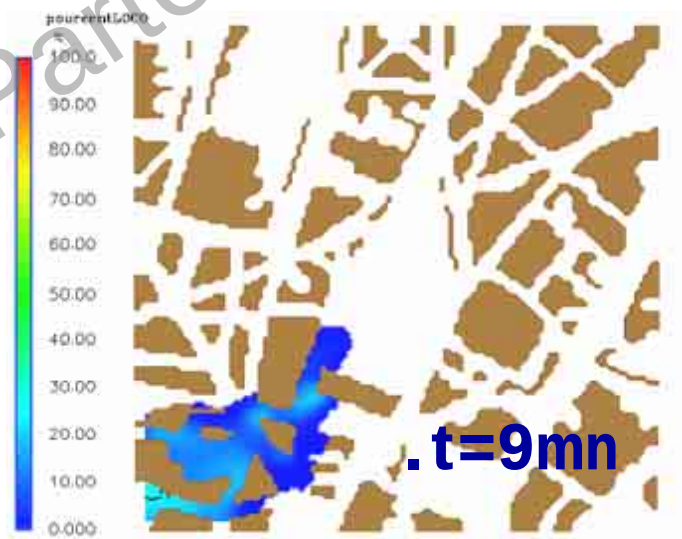
t = 0 min after the end of locomotives emissions



t = 2 min after the end of locomotives emissions



t = 4 min after the end of locomotives emissions



t = 9 after the end of locomotives emissions

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Conclusions (1)

Car traffic background and street concentration correctly computed and in agreement with:

- Specific terrain campaigns
- Similar areas in Paris downtown

Contribution of Diesel locomotives

- Sensitive to the engine running speed (idle or warming up) especially for NOx
- Negligible Impact for CO
- Important Impact for NOx and PM ➔ 60 % contribution and more in the vicinity of the station (inside and few hundred meters downwind
- Significant persistence up to 10 minutes after the end of locomotive emissions.

Conclusions (2)

Actions

- Situation Year 2000 and before : Warming up inside « Gare de l'Est »
- Situation Year 2002: idle mode when parking , the warming up already done in the « Ourq » marshalling yard.
- Situation 2004: CC72000 new engines

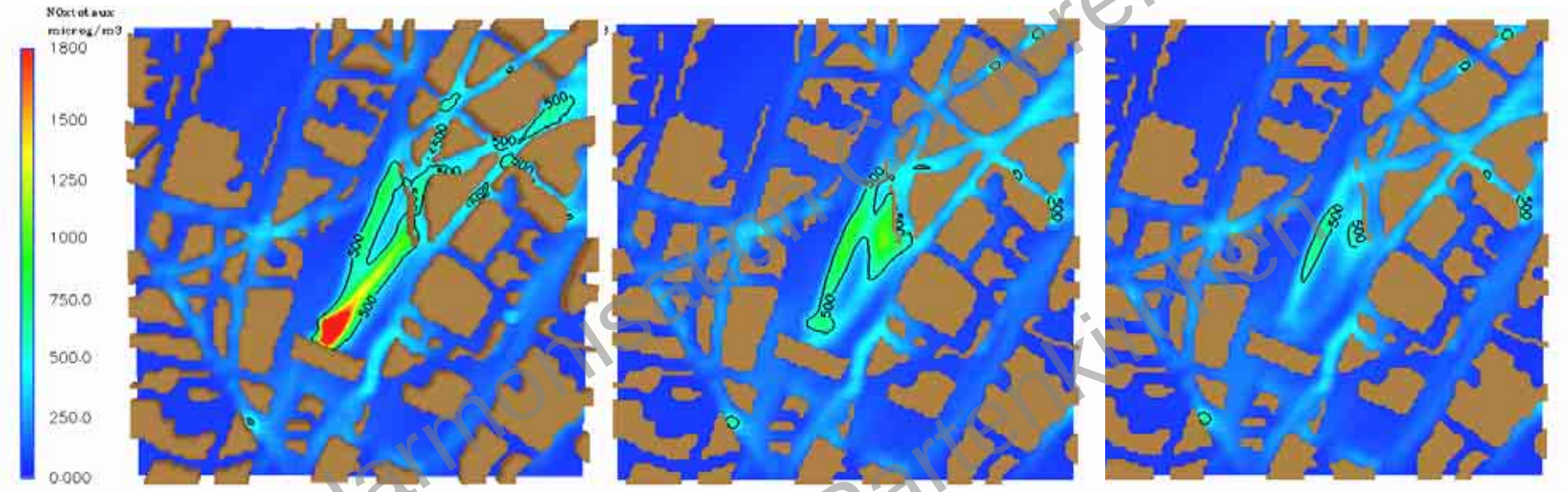
Emission reduction: CC72000 new motorization

Pollutant	Idle/Arriving	Warming up	Departure (1 min)
CO	1354 g/h 56 % Cut down	369 g/h 77 % cut down	545 g/h 63 % de
NOx	193 g/h 67 % cut down	3371 g/h 45 % cut down	7048 g/h soit 32 % de réduction
Particles	-	-	-

Data for a locomotive CC72000 with new engine (source SNCF)

Prospective : the evolution (5D-SW)

Year 2000 | **Year 2002** | **Future**



New protocol
(Warming up the engine strictly less than 2 min)

New protocol
+ New engines

(reduction ~ 50 % of the emissions)