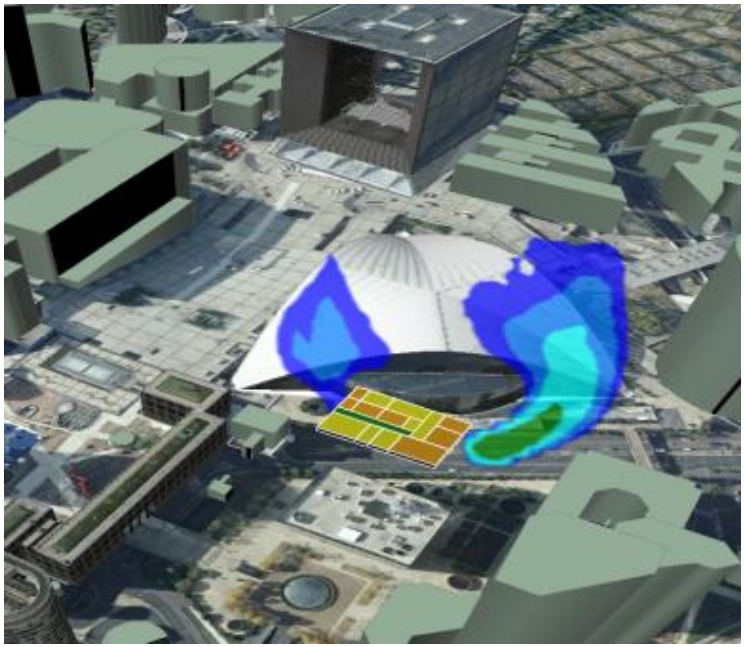

I
HARMO


I
HARMO

Coupling between PMSS and CONTAM: The indoor / outdoor contaminant transfer of a hazardous release



Cyril Bonan[1], Patrick Armand[2], Christophe Duchenne (duchenne@cea.fr), Armand Albergel[1](aalbergel@aria.fr), Christophe Olry[1](colry@aria.fr,) Maxime Nibart[1](mnibart@aria.fr),

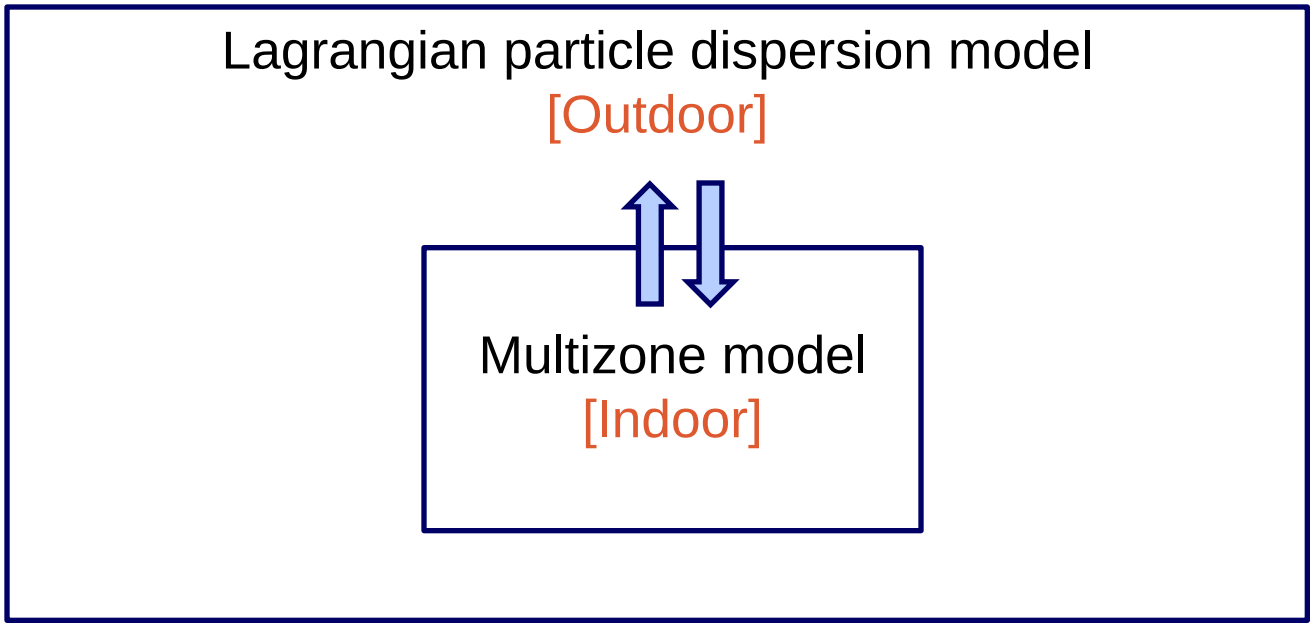
[1] ARIA Technologies, F-92100 Boulogne-Billancourt, France
[2]CEA, DAM, DIF, F-91297 Arpajon, France

ARIA Technologies SA
8-10, rue de la Ferme – 92100 Boulogne Billancourt – France
Telephone: +33 (0)1 46 08 68 60 – Fax: +33 (0)1 41 41 93 17
E-mail: info@aria.fr – http:/ /www.aria.fr

General context

- Study of dispersion of hazardous release in urban area
- Careful modelization of the population exposure to contaminant by taking into account outdoor and indoor air.

Necessity to couple two different scale models for a complete prediction



Objective

The main objective is to predict the ways outdoor air impacts on indoor air, and conversely, including the influence of atmospheric conditions and the building ventilation system

Models choosen

- OUTDOOR: **PMSS (Parallel Micro-Swift-Spray).**

Lagrangian particle dispersion model developed by ARIA Technologies, ARIANET, MOKILI, and CEA

- INDOOR: **CONTAM.**

A multi-zone airflow and contaminant transport analysis software developed by the NIST

PMSS

PMSS is the **parallel** version of the **MSS** tool, combining:

- a mass-consistent diagnostic model (**Micro SWIFT**)
- coupled to a Lagrangian particle dispersion model (**Micro SPRAY**)

PMSS is designed to model urban or industrial micro-scale dispersion phenomena with CPU times significantly shorter than the full CFD solutions.

Typical PMSS applications:

- Domain size: 1 to 10 km dimension / Cell size: 1 to 10 meters
- Single PC processor CPU time about 1/10th of real simulated time
- Response time: few minutes

MSS is included into the HPAC 5 suite of models

- Coupled to SWIFT meteorological assimilation model
- Coupled to SCIPUFF (Particle to Puff conversion and handoff)

CONTAM

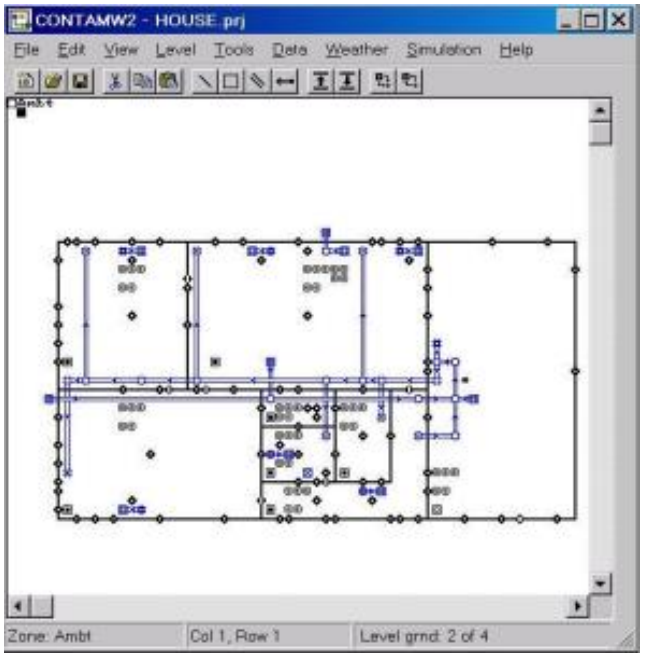
Multizone indoor air quality and ventilation analysis computer program.

Airflows :

- Room to room airflows driven by mechanical flow vent;
- Buoyancy effects inducing by temperature difference;
- Wind pressures acting on the exterior of the building.

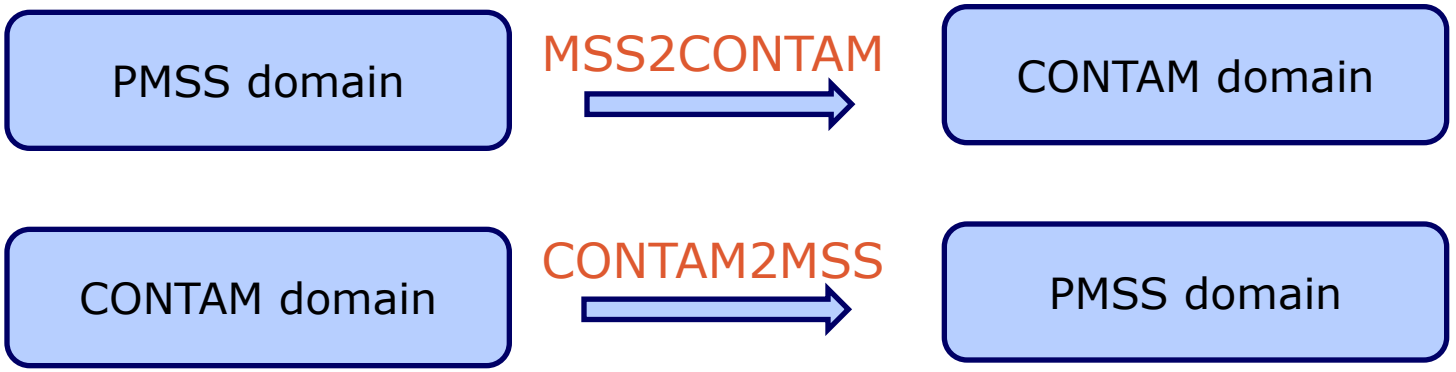
Contaminant concentrations

- Dispersal airborne contaminants transported by airflows;
- Chemical and radio-chemical transformations;
- Adsorption, desorption to building materials;
- Filtration;
- Personal exposure module.



Couplings

- One-way coupling
  - ❖ *Two tools developped:*

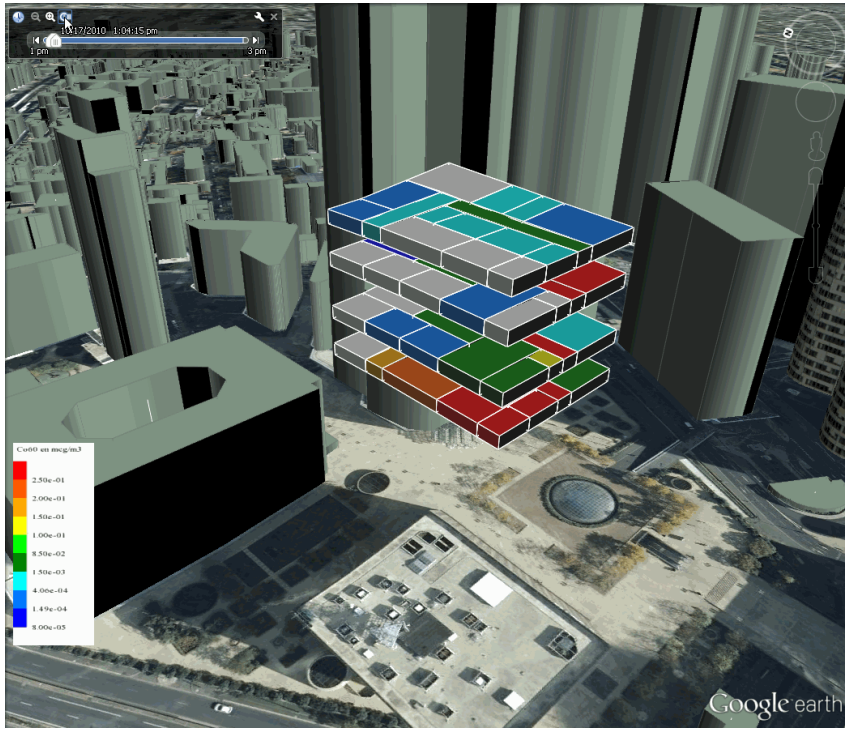


- Two-Way coupling non iterative
  - ❖ *Association of the two One-way tool:*

KML creation tool for CONTAM results

CONTAM2KML : **CONTAM** results can be visualized in space and time via Google Earth (kml format).

- Possibility to choose the level or the compartiment.
- Require a user geometry file of the building
- Georeferencing is taking into acount

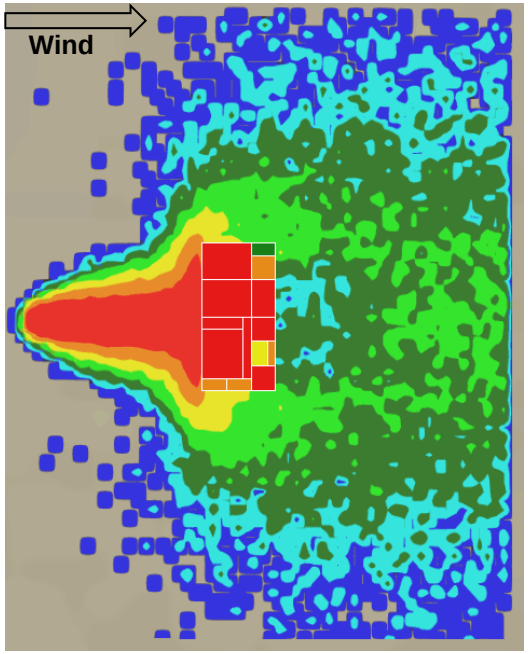


Visualisation example

OneWay coupling : PMSS2CONTAM

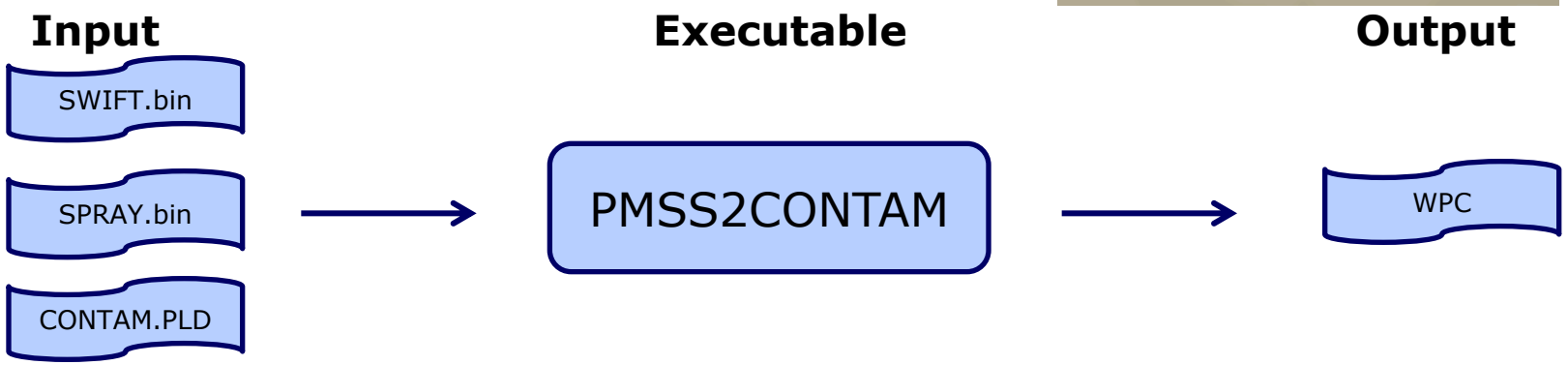
Functioning:

- Outdoor dispersion is executed by **PMSS**;
- Chronological results of **PMSS** are post-treated in order to create a time series boundaries conditions at outdoor/indoor paths to **CONTAM**
- Execution of **CONTAM**



Physical quantities provided to CONTAM :

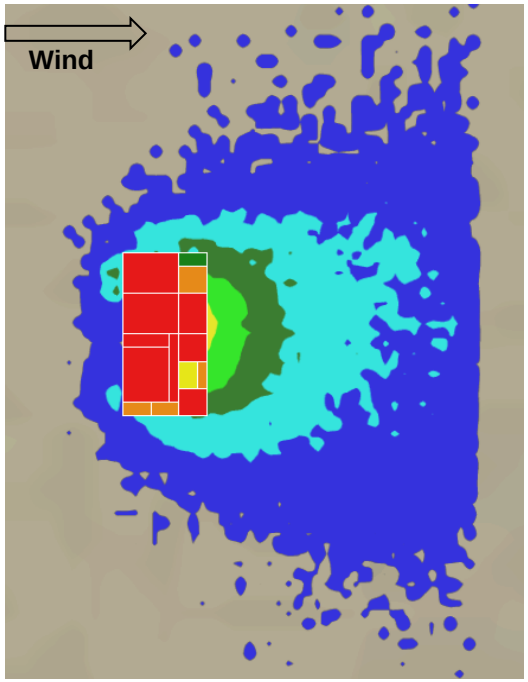
- Contaminant concentrations in kg/kg;
- Pressure differences in Pascal.



OneWay coupling : CONTAM2PMSS

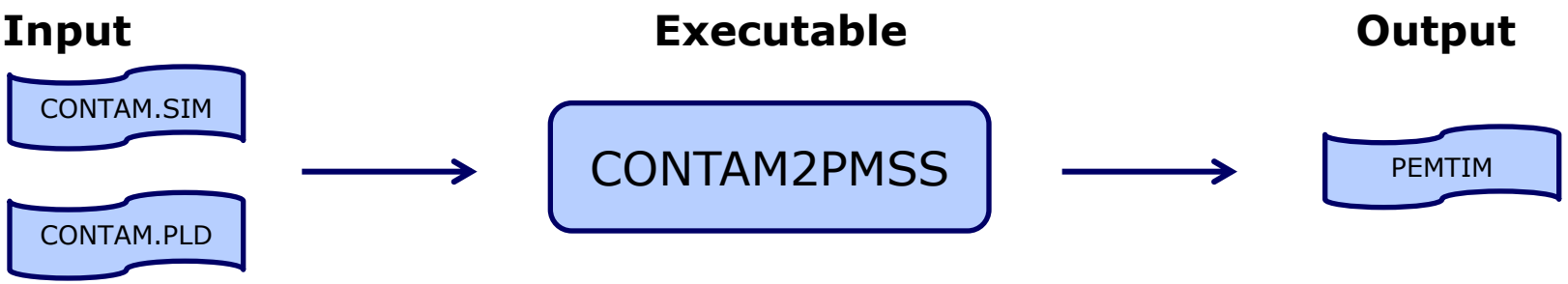
Functioning:

- Dispersion inside building computed by **CONTAM**;
- Chronological results of **CONTAM** are post-treated in order to create a time series of sources release file used by **PMSS**;
- Execution of **PMSS**



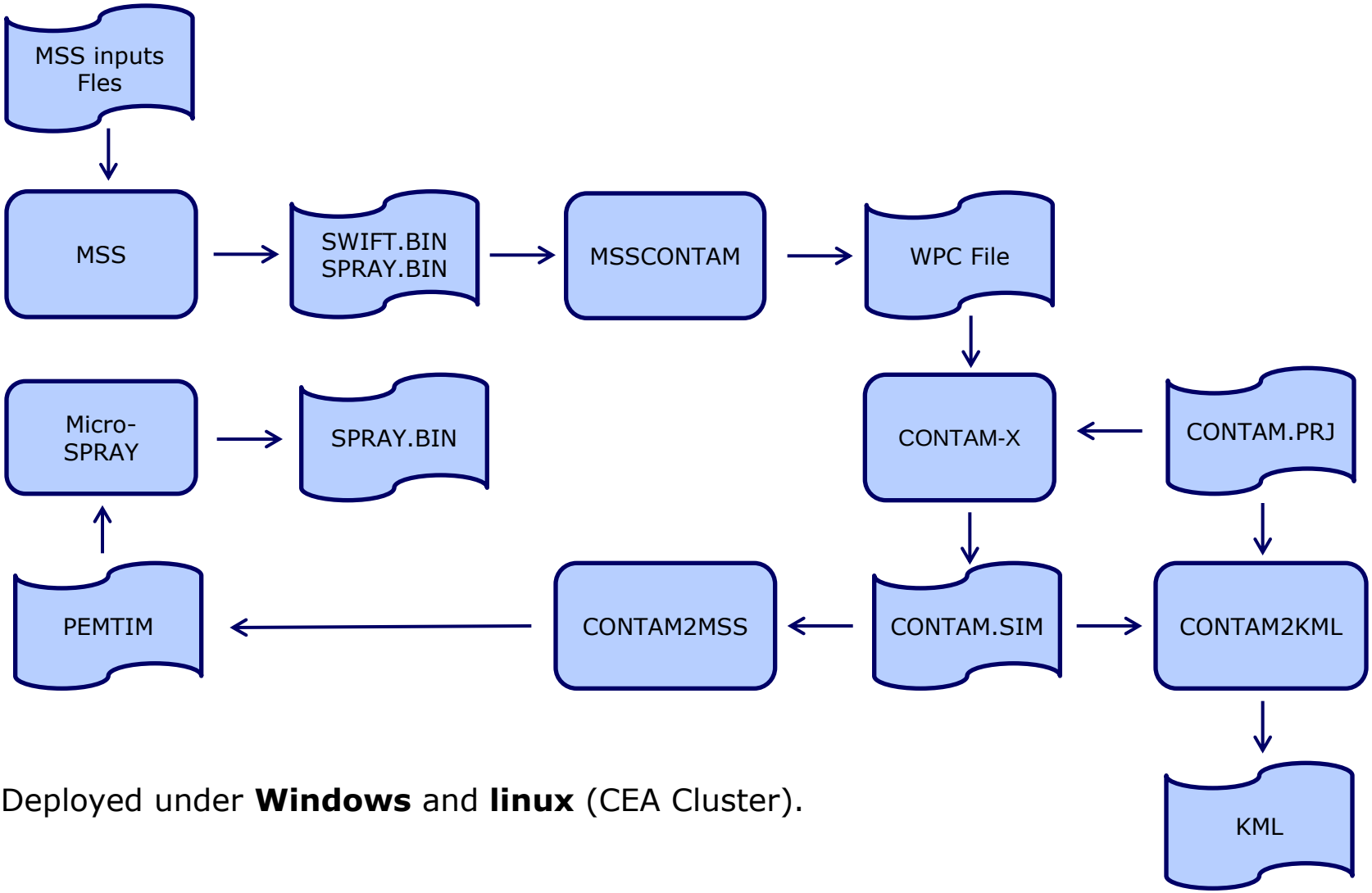
Physical quantities provided to PMSS:

- Sources rejection position;
- Contaminant debit in kg/h;
- Height and diameter of sources.



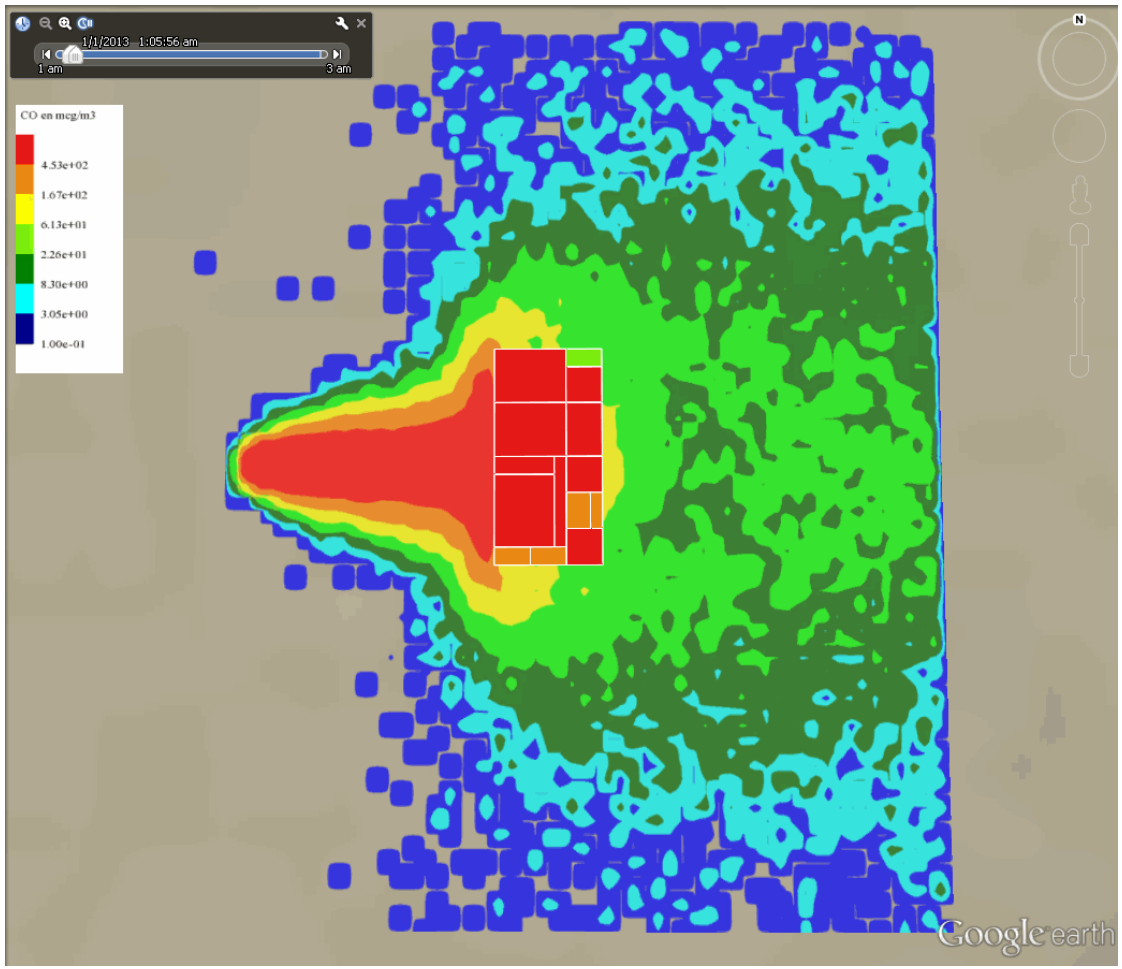
Two-Way non iterative coupling (1)

Calculation chain using script shell which sequently calls Python executables and encapsulating the coupling tools.



Deployed under **Windows** and **linux** (CEA Cluster).

Two-Way non iterative coupling (2)



Google Earth visualization results of CO concentrations (mcg/m³)

Validation : ALOHA Standart case (1)

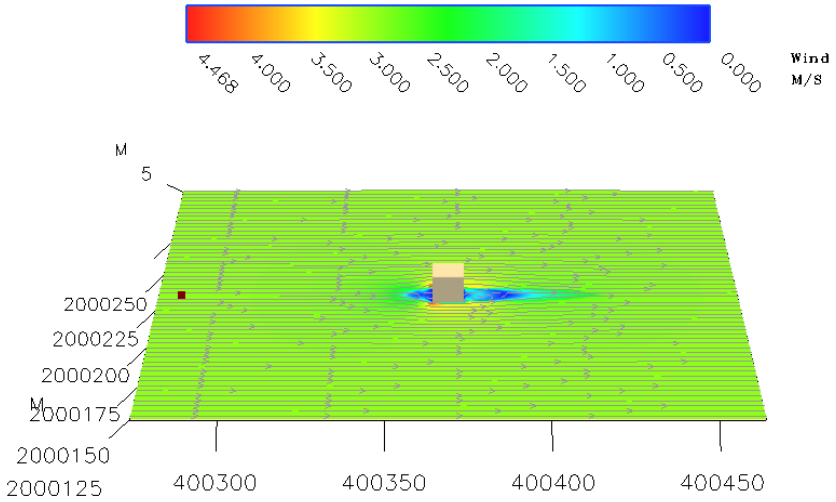
Case spécifications:

- Building dimensions : 10x10x10 m;
- Release : 4 kg of CO, 10 min, placed at 100 m from the building;
- Meteo : Neutral; West wind of 3.34 m/s speed (2m height); 15° C
- Building Air exchange rate (ALOHA) : 60 s

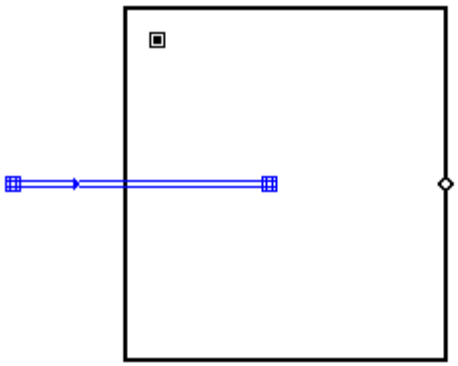
CONTAM project:

- Cube with aeration duct and opening to outdoor 2 m²
- Debit derivate from the Air exchange rate τ and the volume V

  → Airflow imposed in entry by $Q = \frac{V}{\tau}$;



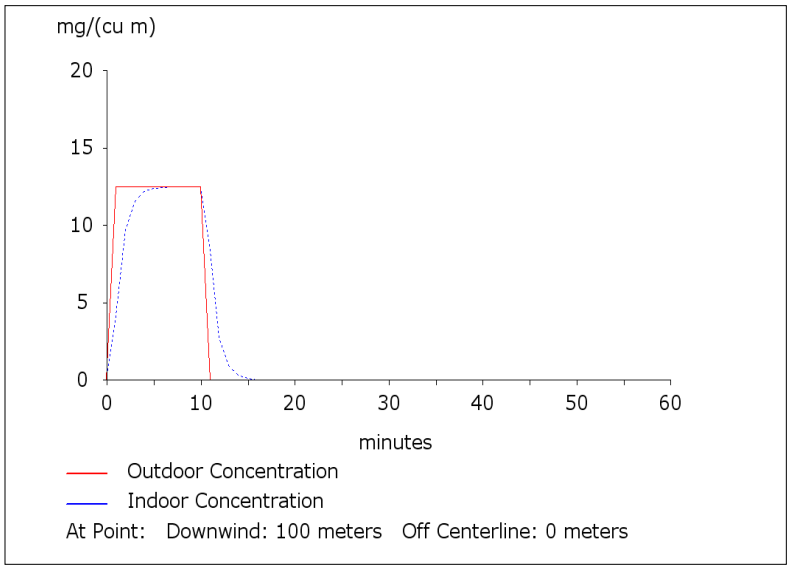
Source and obstacle location



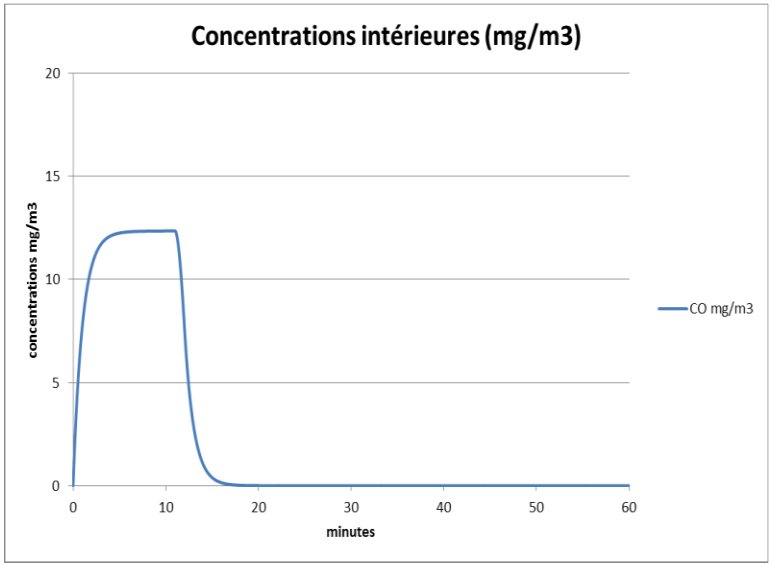
Projet CONTAM capture

Validation : ALOHA standard case (2)

- Validation of the concentrations coupling



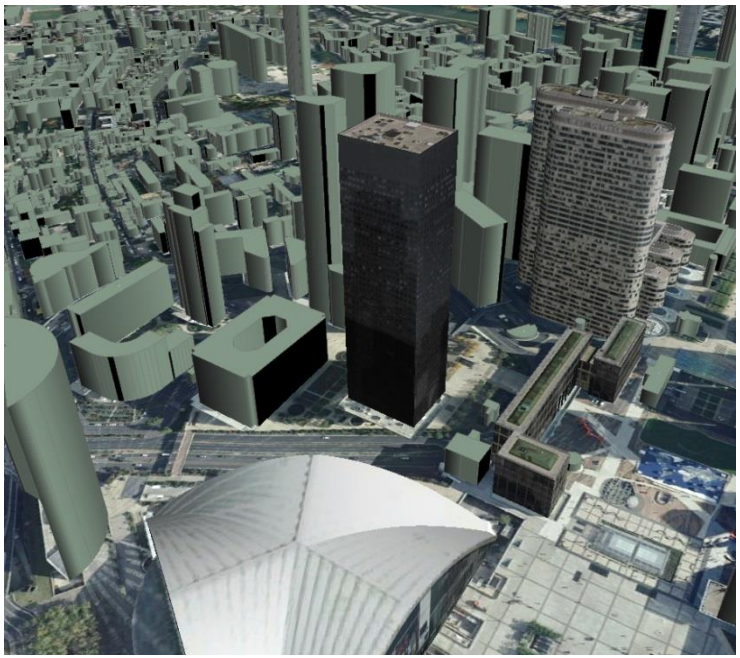
ALOHA results : concentrations in mg/m³

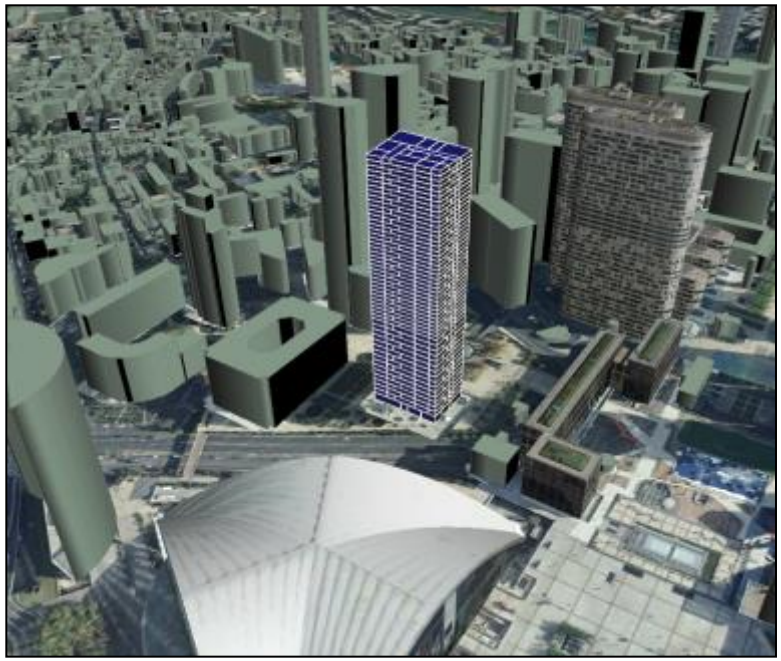


CONTAM results : concentrations in mg/m³

Good correlation between results ALOHA/CONTAM

Application : Business district of Paris (1)



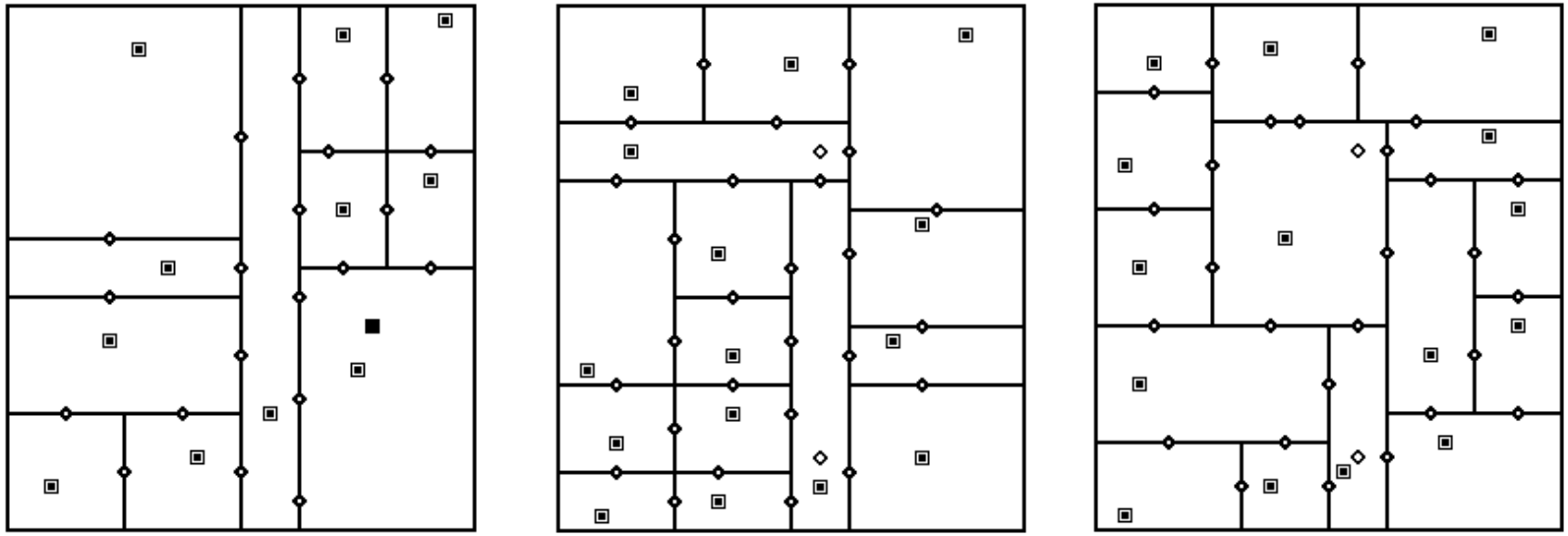


Google Earth aerial view : to the left, SketchUp model of the skyscraper tower,
To the right, kml representation of CONTAM

Application : Business district of Paris (2)

CONTAM Project:

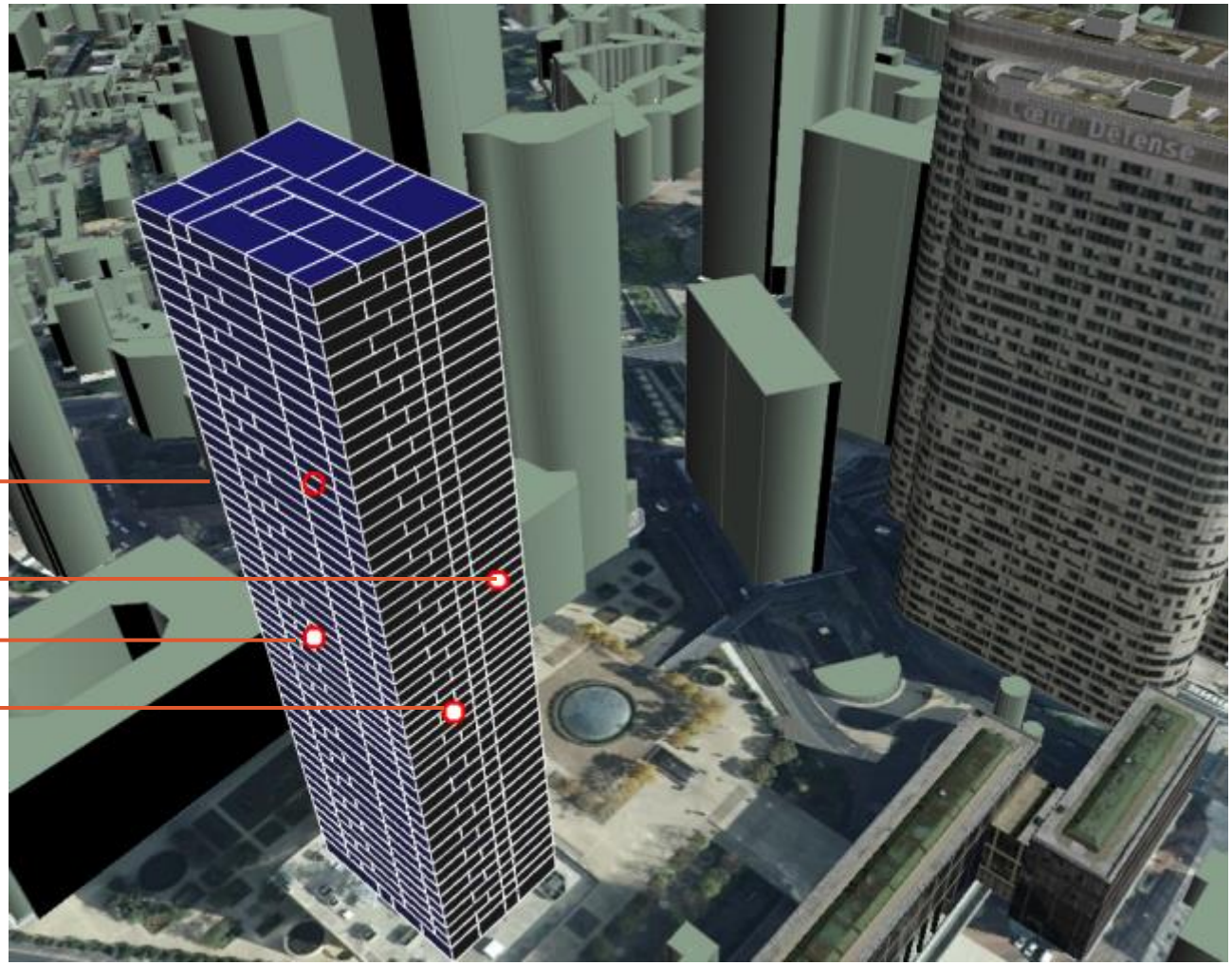
- Building dimension : 33.5 x 48.3 x 174 m
- 3 types of level, 52 levels in total
- Vertical and horizontal communication flow path between zones
- 1 second of calculation time step; 2h of duration.



Types of level for the CONTAM project

Application : Business district of Paris (3)

Level	Altitude
30	106 m
27	96 m
23	85 m
20	75 m



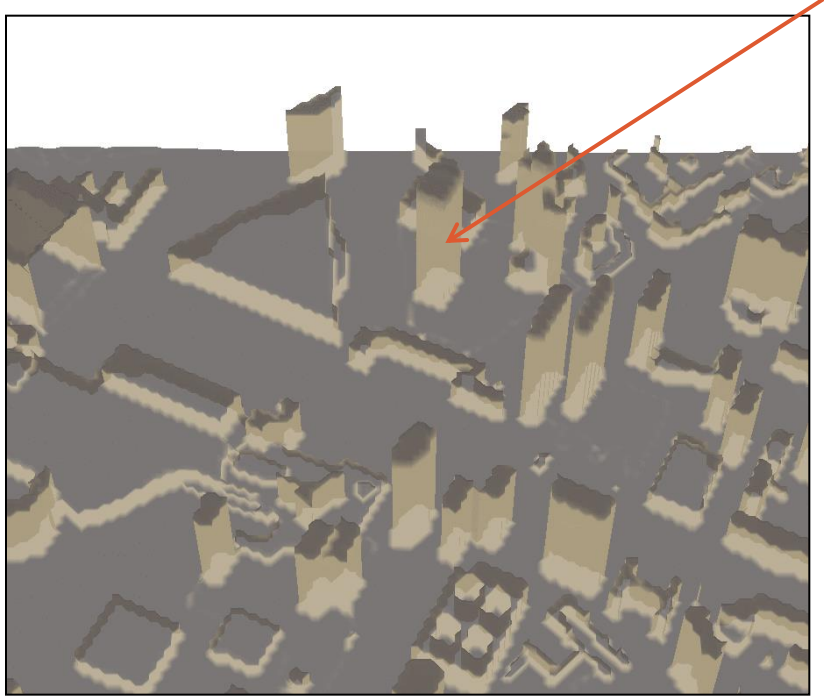
Google Earth view of the CONTAM tower

Application : Business district of Paris (4)

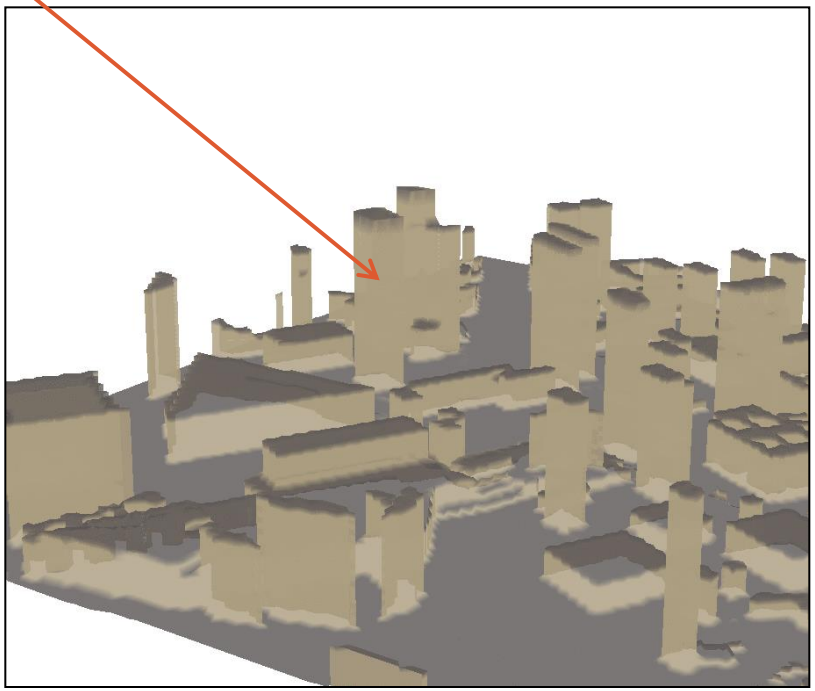
Contaminant release:

- Volumic release beginning at 12h00 . Duration: 5 minutes.
- Specie: Cobalt 60 (Co60); number of particles : 5000 per second
- Output concentrations: 1 minute

Building of interest



Top view of the plume (Savi3D)



Side view of the plume (Savi3D)

1 minute step

Application : Business district of Paris (5)

Calculation domain of PMSS :

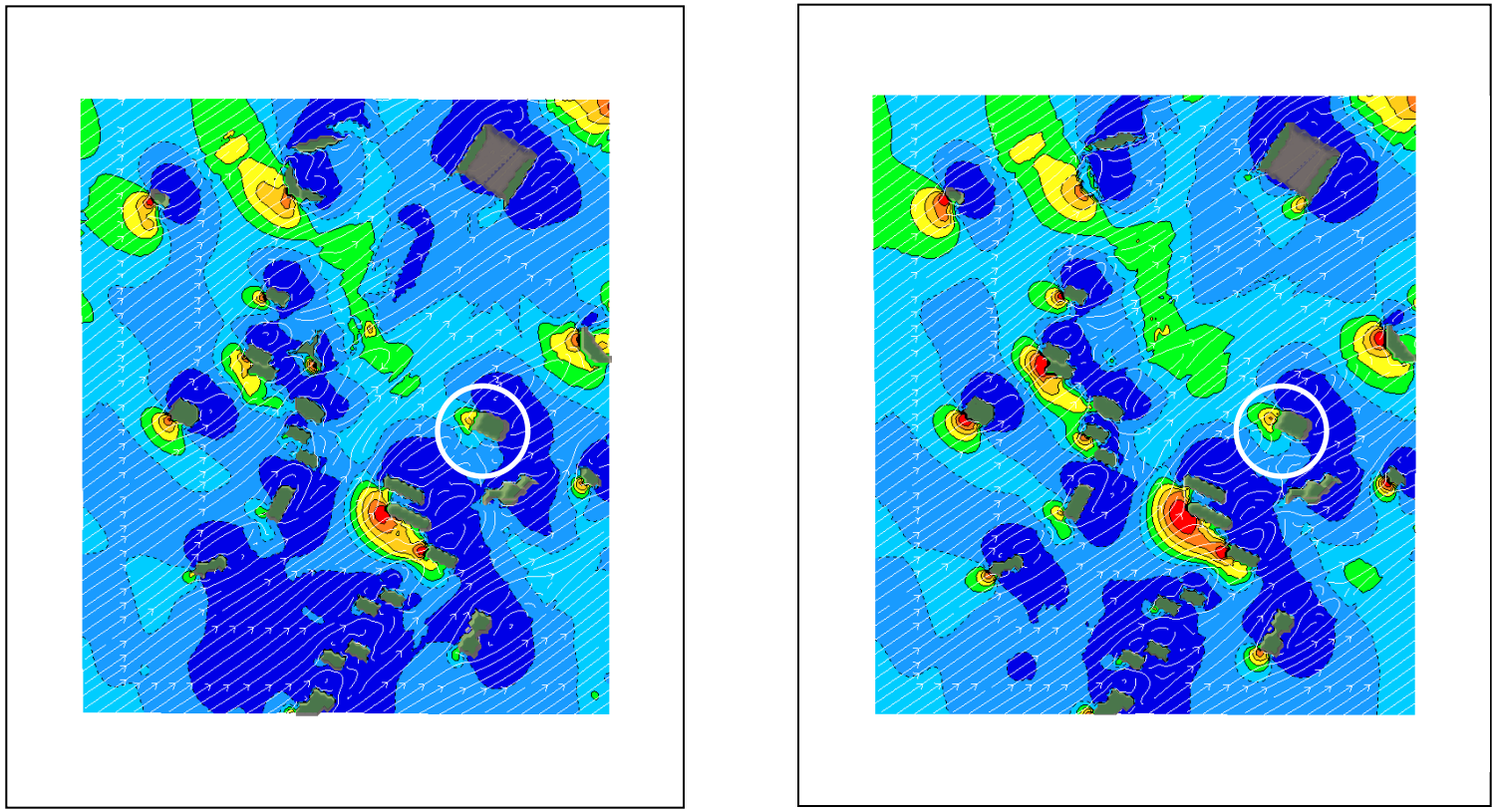
Lx (m)	1050
Ly (m)	900
Lz (m)	500
Horizontal resolution (m)	6
Vertical resolution (m)	2.5 at ground
Vertical levels (P-SWIFT et P-SPRAY)	40
Topography	yes
Bati	Complex

Meteo evolution (5 steps)

Time	Direction (degrees)	Speed (m/s)	Height (m)	Stability
12h 00min	145	2	10	Neutral
12h 05min	145	2	10	Neutral
12h 15min	145	2	10	Neutral
12h 30min	120	2	10	Neutral
14h 00min	90	2	10	Neutral

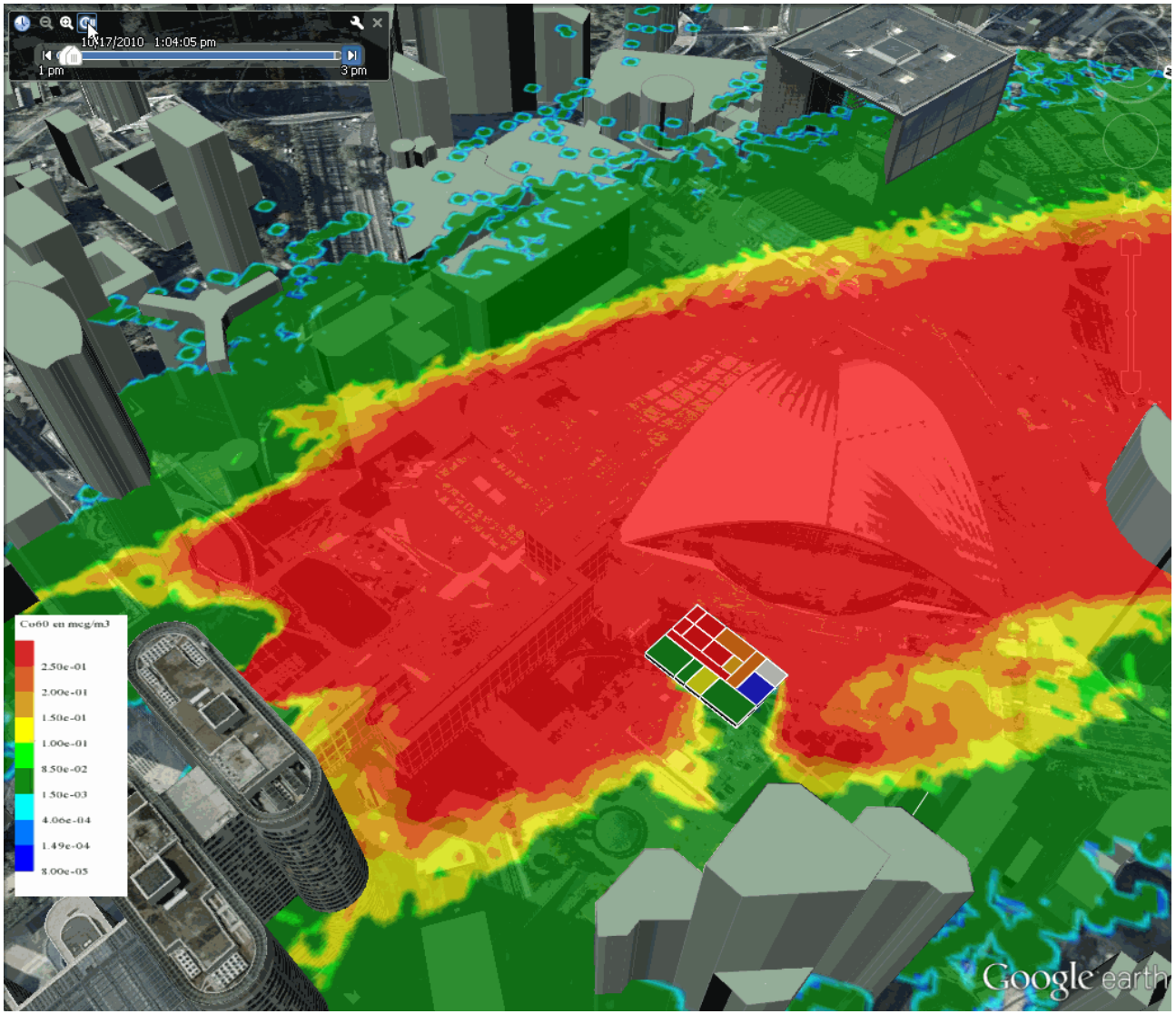
Application : Business district of Paris (5)

10/17/2010 12:00:0.00



2D Delta Pressure fileds and current line at the 20th level (left) and at the 27th level (right)

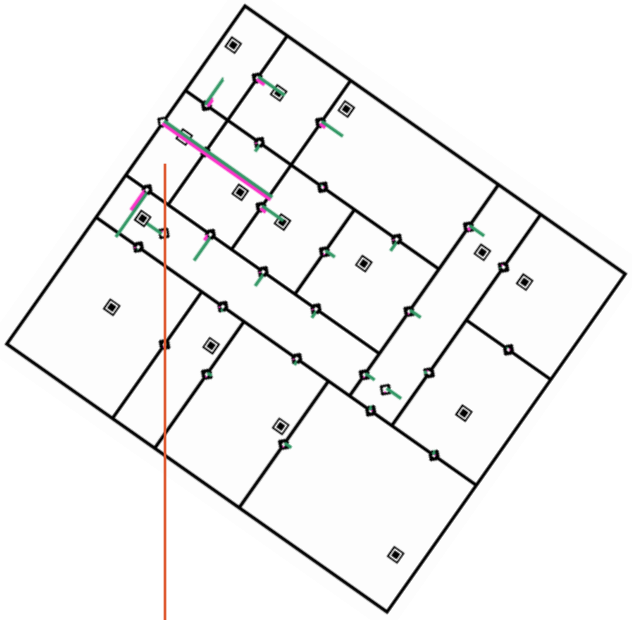
Application : Business district of Paris (6)

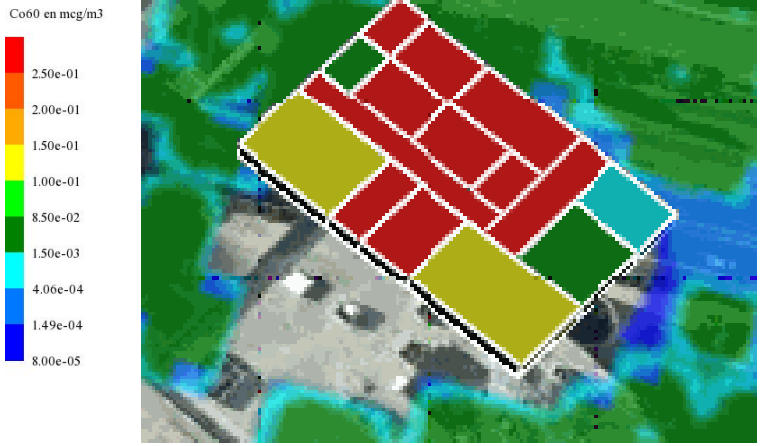


Google Earth view of CONTAM and PMSS results superposed for the 20th level

Application : Business district of Paris (7)

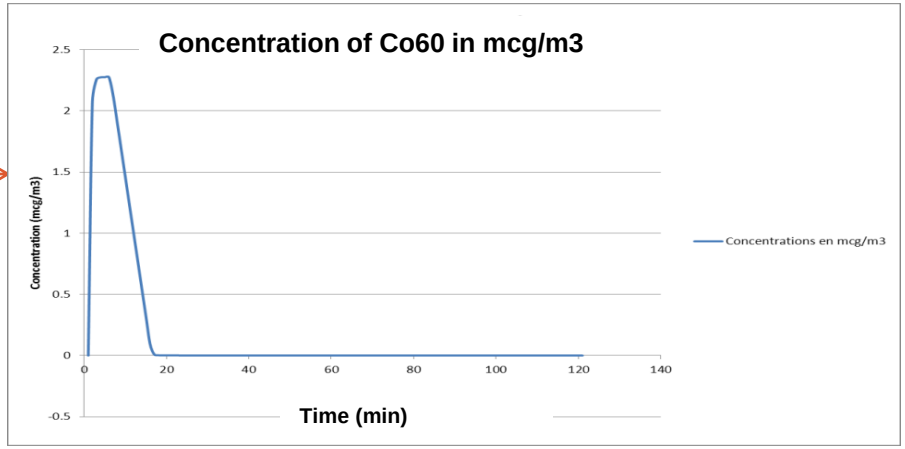
*CONTAM results of the **20th level** , 1st time step*





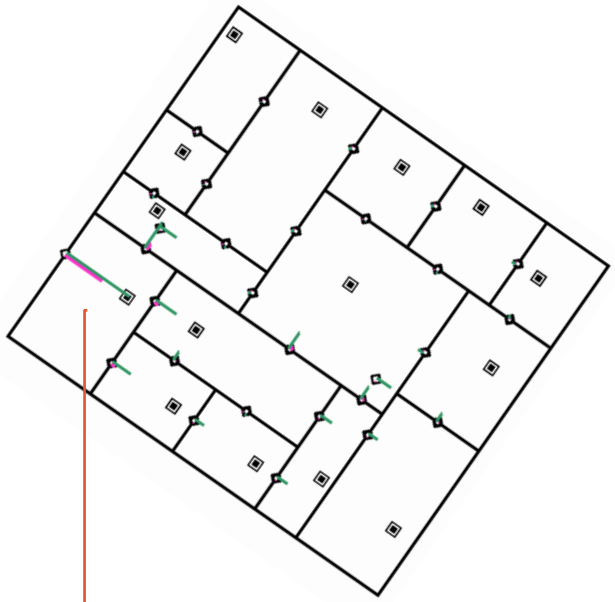
Zoom level 20

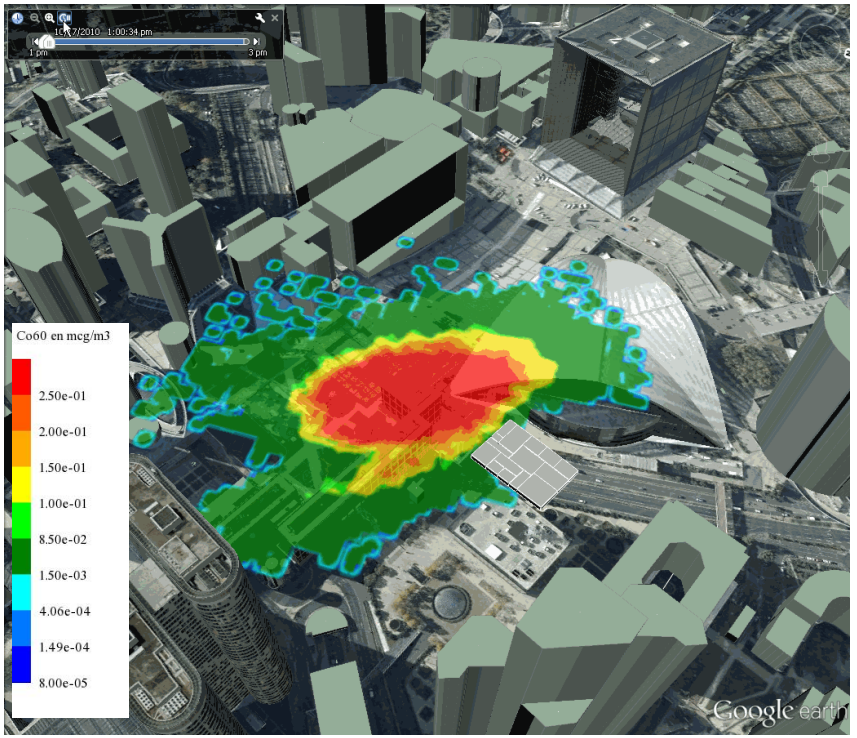
In pink a representation of delta P,
in green of airflow

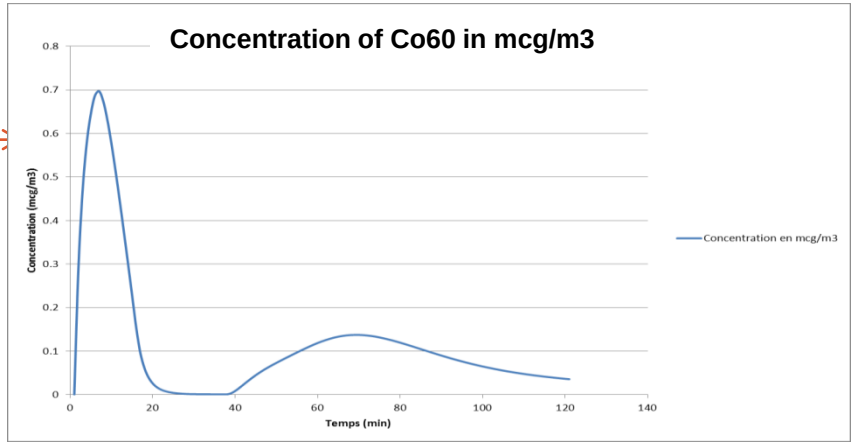


Application : Business district of Paris (8)

*CONTAM results of the **27th level** , 1st time step*



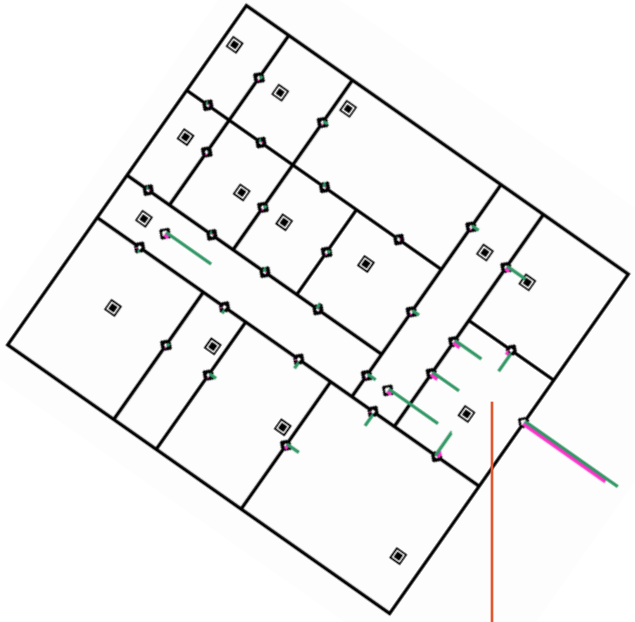


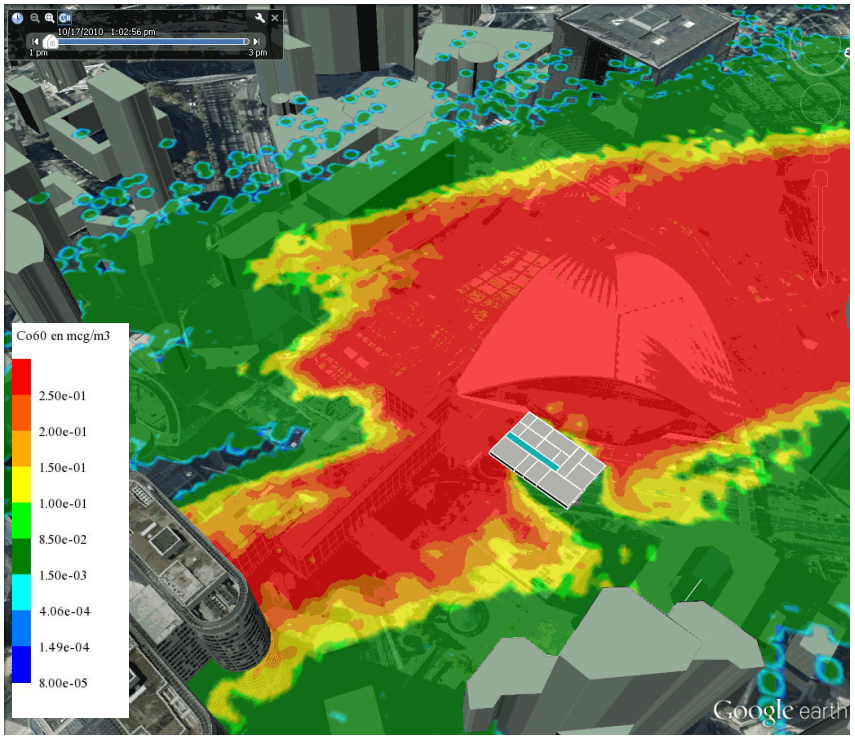


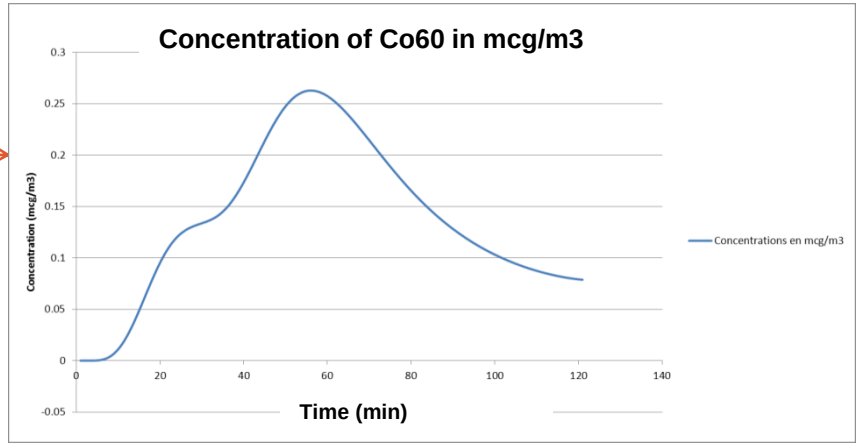
In pink a representation of delta P,
in green of airflow

Application : Business district of Paris (9)

*CONTAM results of the **30th level** , 1st time step*







In pink a representation of delta P,
in green of airflow

Conclusion and perspectives

- Development of a coupling PMSS/CONTAM taking into account the influence of atmospheric conditions and the building ventilation system;
- Comparison of concentration results of COUPLING MODEL and ALOHA and an application to a simple representation of skyscraper in Paris business district.

- Application to a real case, a public establishment for exemple;
- Integration of CONTAM on three scales chain such as WRF/PMSS/CONTAM;
- Iterative coupling.

Acknowledgements

Coupling PMSS and CONTAM development have been funded by CEA-DAM (Patrick ARMAND)

Mokili

ARIANET

Thank you for your attention.