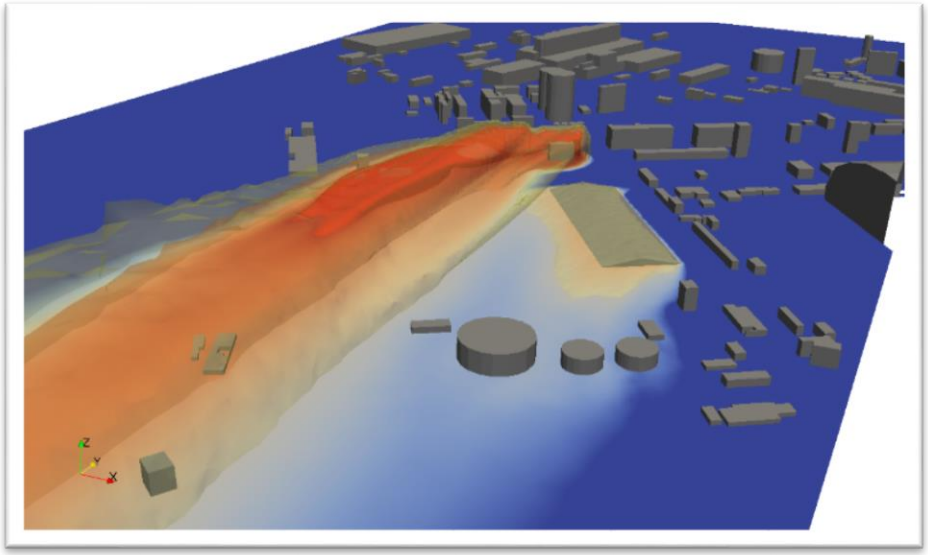
Code_Saturne Users Meeting

5th April 2018

Atmospheric case studies with Code_Saturne



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Contents

Methods, pictures but no quantified results (confidentiality…)

- Co-development of atmospheric features with Code_Saturne dev. team

  Atmospheric radiative transfer properties model (Code_Saturne V5.X)

- Projects and Studies using Code_Saturne

  Atmospheric study of mitigation potential of windbreak barriers / meshes in a industrial site – X

  Atmospheric dispersion study of pollutants emitted by a workshop in an dense urban area – X

- Formation and Support on Code_Saturne

  Ventilation system to reduce pollutant concentration in a warehouse - EGIS

- What's next

ARIA Technologies

- **ARIA Technologies SA**
  - Founded in 1990 by researchers from EDF R&D (1990)
- **SME with international network**
  - Headquarter in Boulogne-Billancourt
  - Offices in Grenoble, Toulouse and Brest
  - Subsidiary company in Milan (Italy) since 2000: ARIANET
  - Subsidiary company in Turin (Italy) since 2010: SIMULARIA
  - Subsidiary company in Rio (Brazil) since 2010 : ARIA do Brasil
- **One single focus: the atmospheric environment**
  - Software and systems
  - Study and consults
  - R&D collaboration with large universities/lab (IPSL CNRS) and research center (US-NCAR)

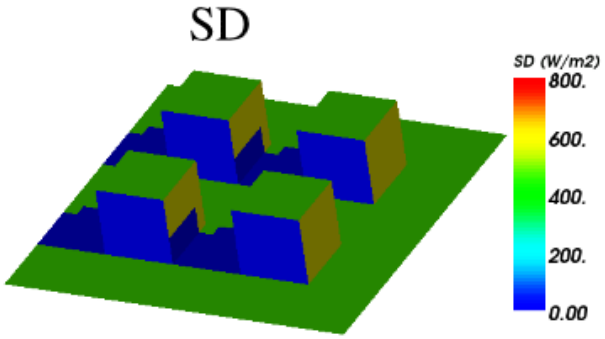


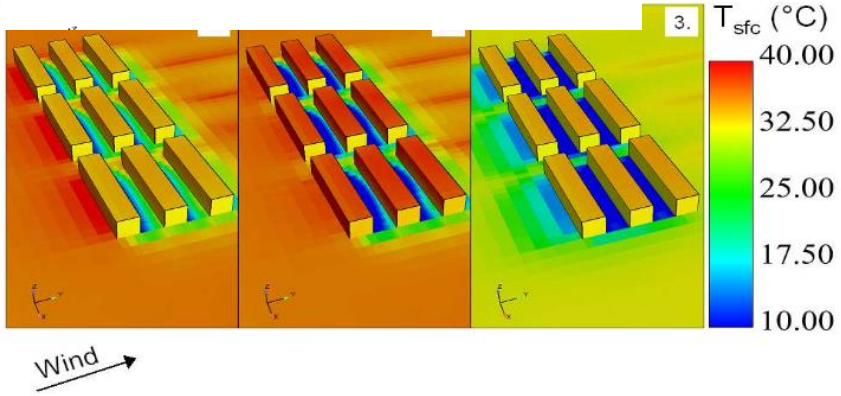


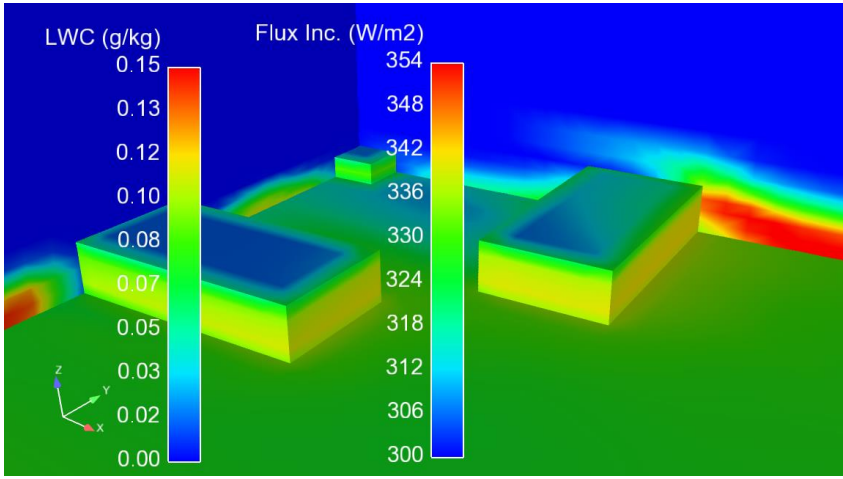
Co-development of atmospheric features with Code_Saturne dev. team : Atmospheric radiative transfer properties model (Code_Saturne V5.X)

Context and Objectives

- 3-D Radiative Transfer module developed by Douce and Mechitoua (2004)
- 3-D Atmospheric RT model developed by Milliez (2006) in **Mercure** (ancestor of CS) , Qu (2011) in CS **V2**, Makke (2015) with CS **V3** and Maanane (2016) with CS **V3**
- **Upgrade CS V5** with developments on 3-D RT model.







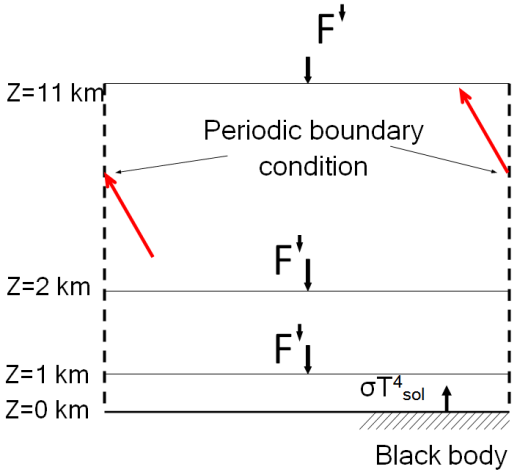
Cerea
Centre d'Enseignement et de Recherche en Environnement Atmosphérique

CODE SATURNE

Co-development of atmospheric features with Code_Saturne dev. team : Atmospheric radiative transfer properties model (Code_Saturne V5.X)

Road map of migration to Code_Saturne V5.X

- New atmospheric validation test case in Code_Saturne
- New boundary conditions developed to reproduce cyclic boundary conditions on radiative quantities only.
- Tested and validated on a single-column mesh



What's next

- Test on 3-D realistic mesh (in progress)
- 3-D solar radiative transfer model to be integrated
- Test cases to be set up with Code_Saturne V5 :
  - PARISFOG
  - MUST
  - CAPITOUL
- Publications …

Many thanks to Martin Ferrand, Yvan Fournier, Bertrand Carissimo, Yassine Maanane (PhD at CETHIL - INSA LYON) and Luc Musson-Genon (retired but still searching) !

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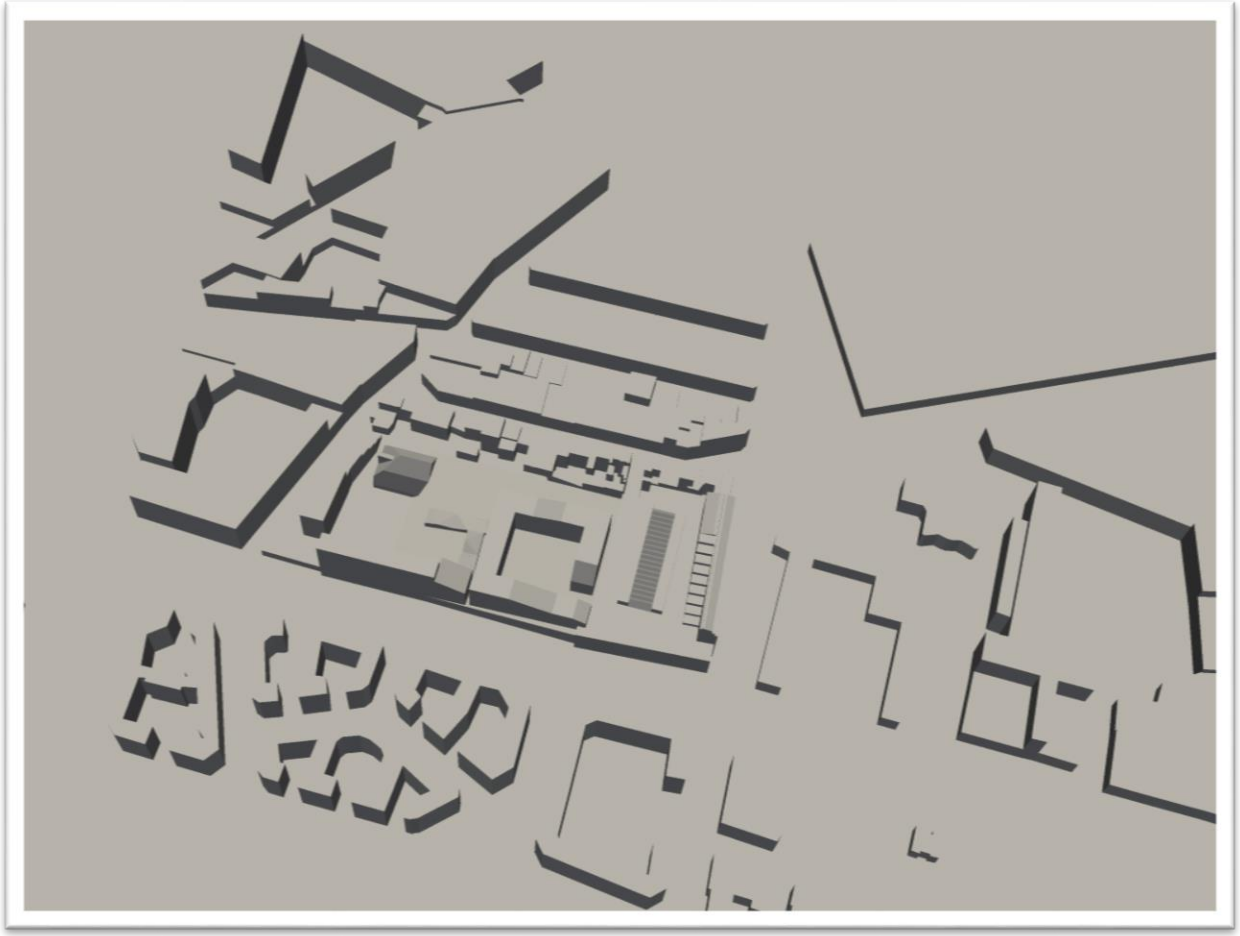
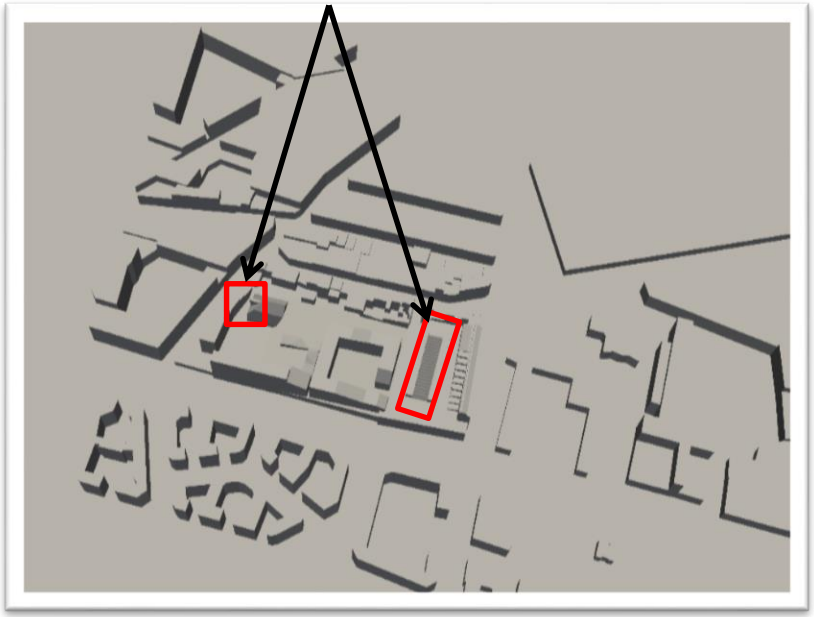
Context and objective (2017)

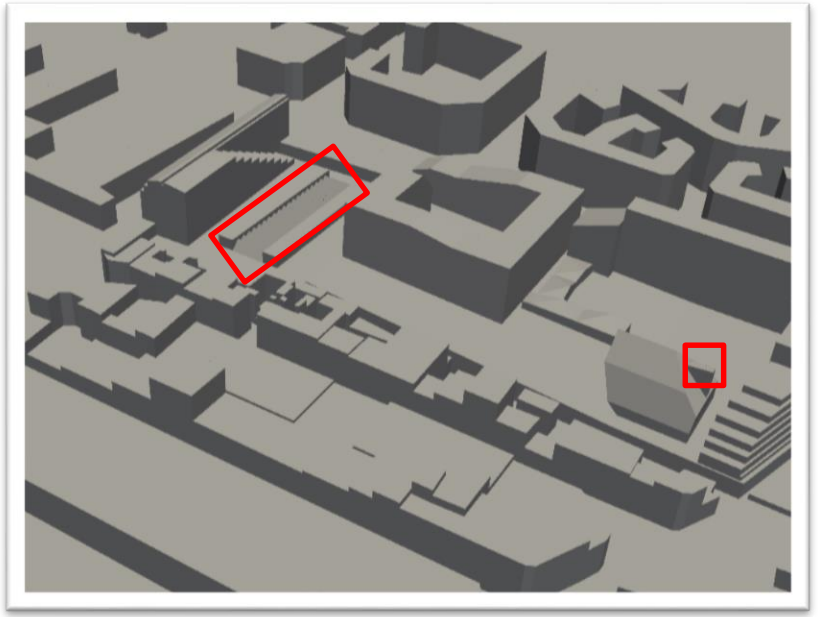
- Workshop build in dense residential urban area



Context and objective (2017)

- Workshop build in dense residential urban area
  - **Two sources of pollution : NOX, PM10, CO and COV release**

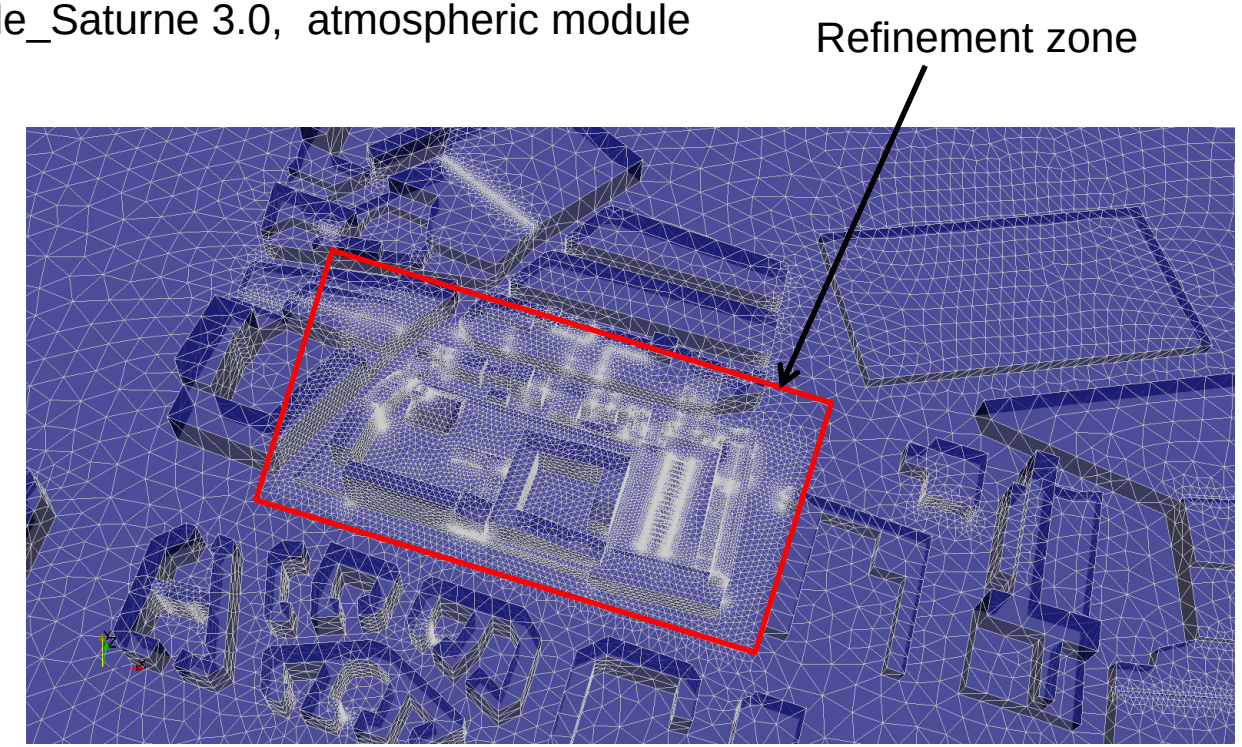




  - **Regulatory level of concentrations reached?**

Modeling with Code_Saturne

- CAD and mesh performed with SALOME 1,5 Millions cells (length scale between 0,5m and 20 m)
- Code_Saturne 3.0, atmospheric module

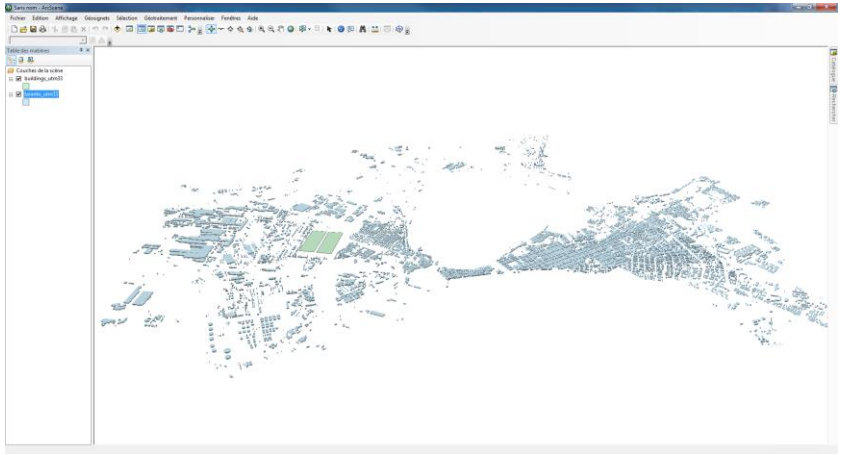


Meshed geometry with SALOME

Digital mock-up : GIS & CAD

The geometry is built with Salome software (open source, developed by CEA-EDF and OpenCASCADE , http://www.salome-platform.org/).

Building database is imported from a standard GIS format (shape file, LOD1).



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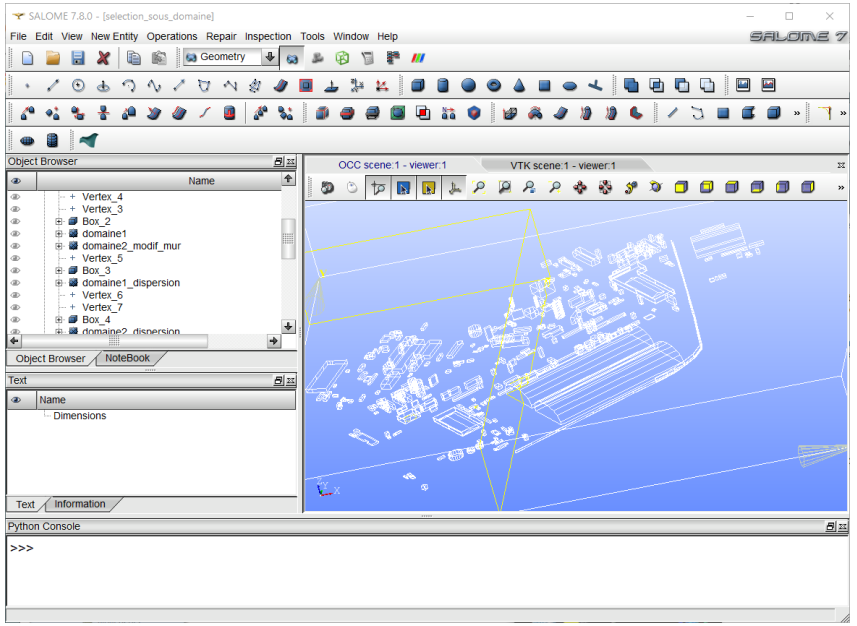
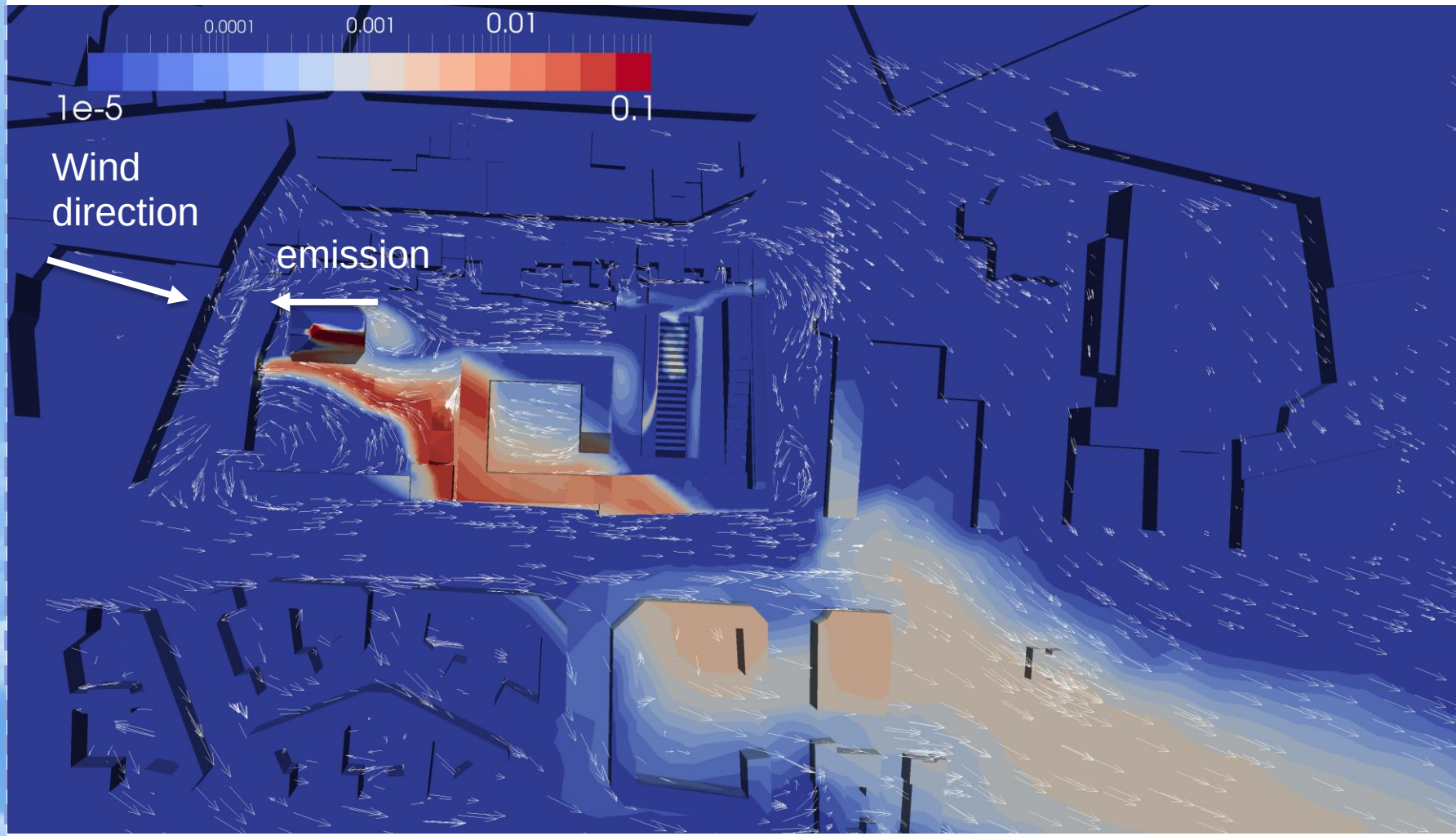


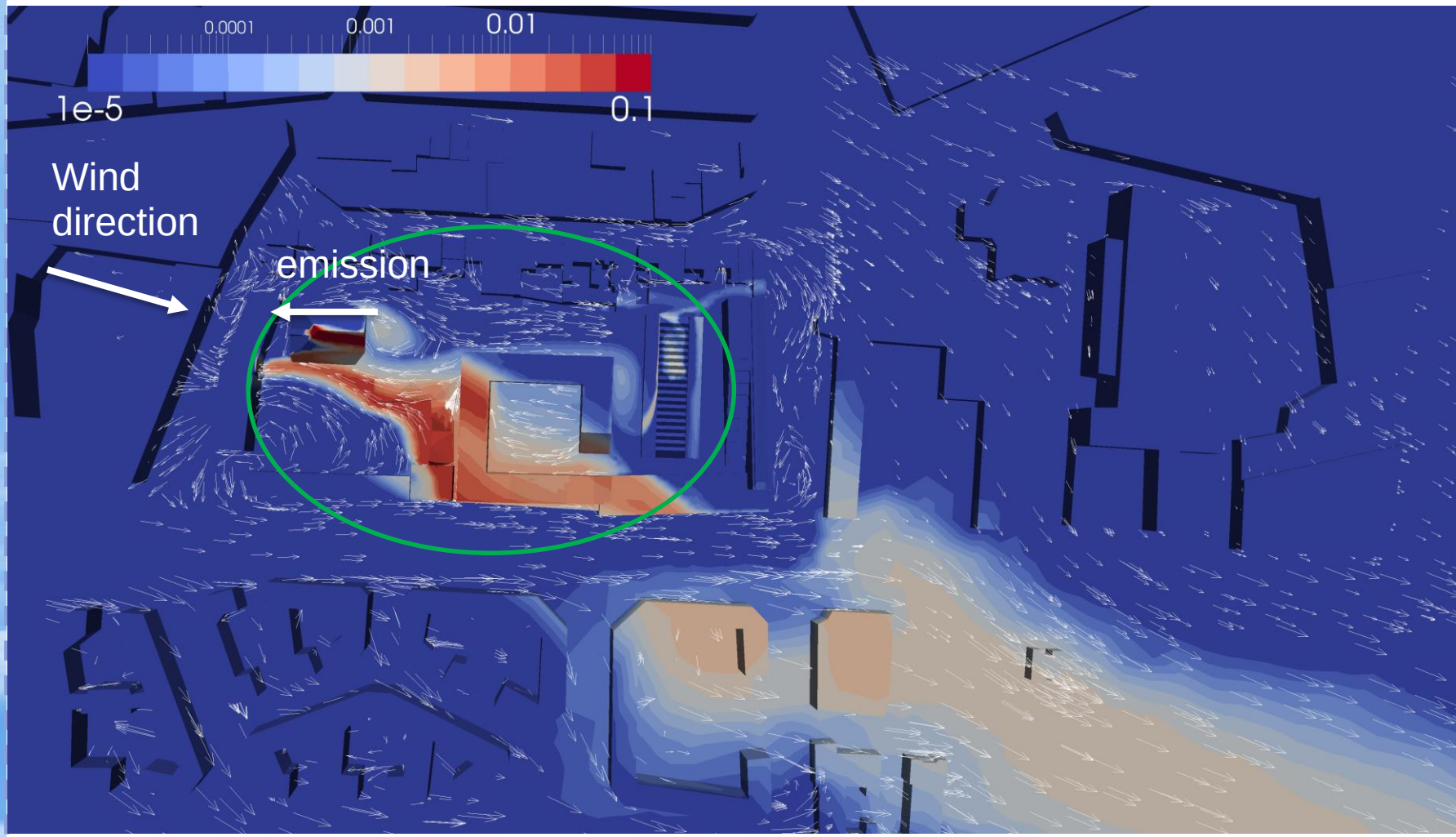
Salomé platform

Impact of wakes zone on concentration



Concentration field near the ground and near the walls of buildings – Velocity vectors field projected at z = 12m

Impact of wakes zone on concentration



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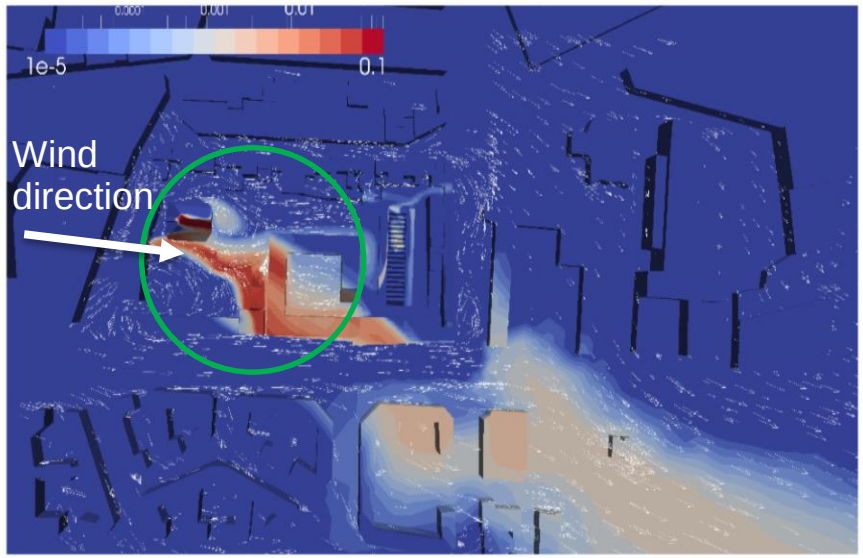
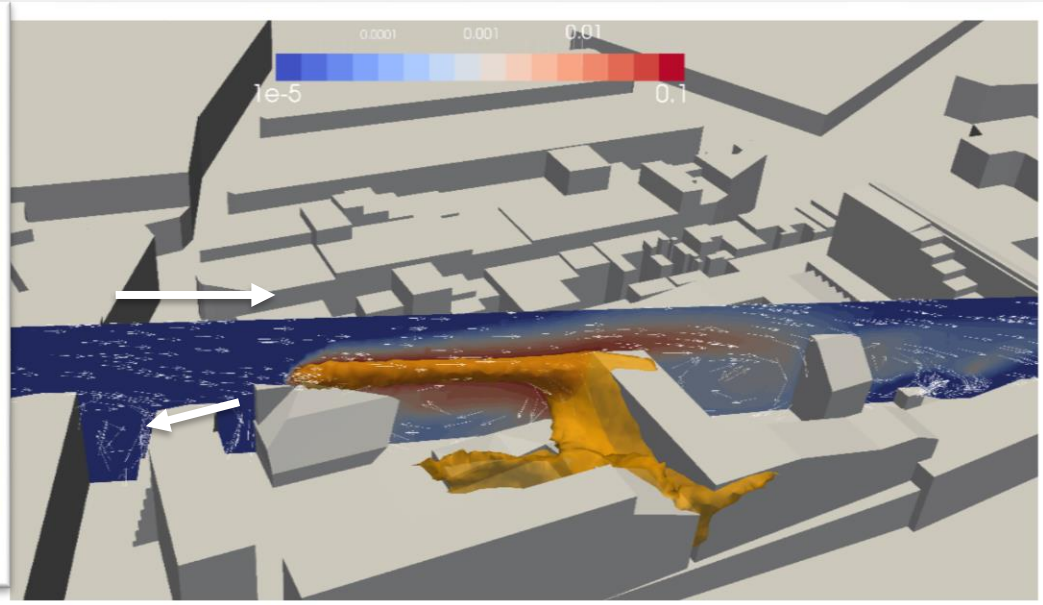
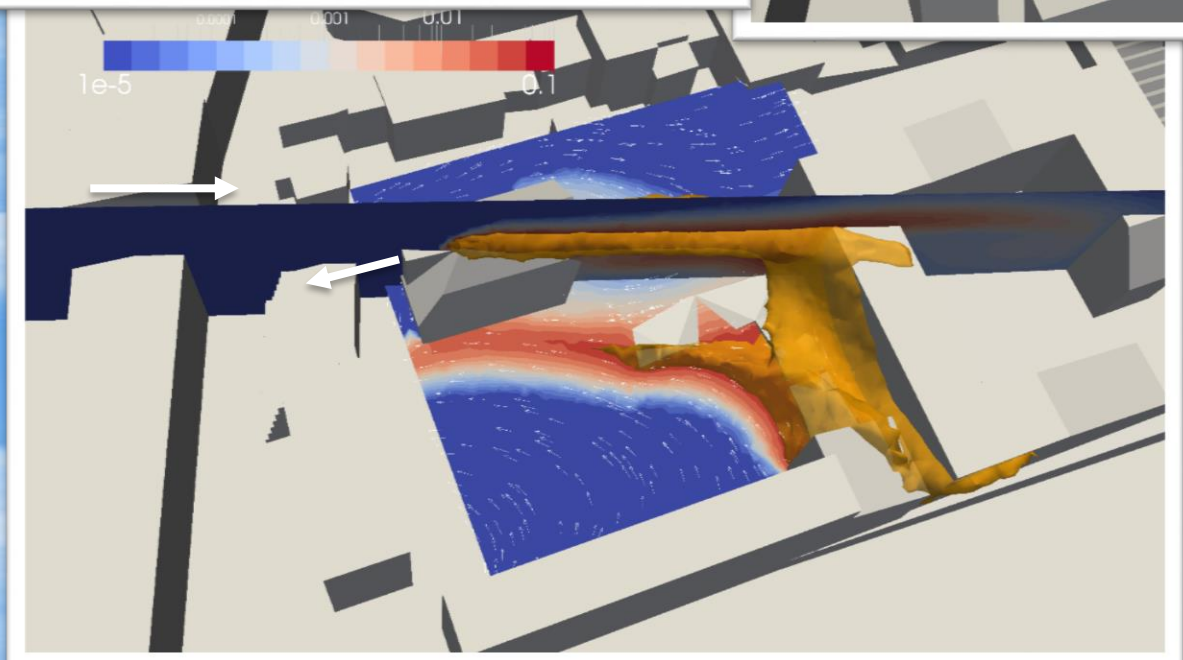






Atmospheric study of mitigation potential of windbreak barriers / meshes in a industrial site

→ limitation of the dust emission in industrial site

Main piles will be protected by new buildings. Secondary piles **could** be protected by nets. The purpose of this study is to quantify the **efficiency** of these **nets** on air quality impact, especially designed to reduced dust emission.

The modeling system has to take into account :

- building effects in 3D
- **Wind barrier** effect of the nets through their permeability
- **Particle barrier** effect of the nets through deposition on the surface

for keywords written in **red** ⟶ a CFD is needed !!!

Atmospheric study of mitigation potential of windbreak barriers / meshes in a industrial site

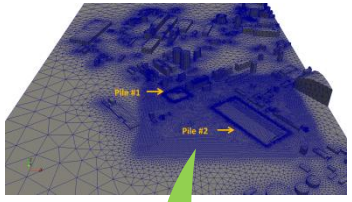
The calculation domains are chosen with the following constrains:

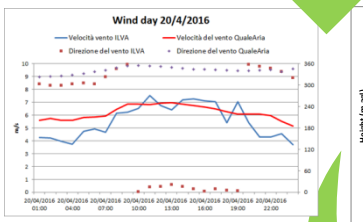
- Include the emissions
- Include the upwind obstacle that could have an effect on incoming wind
- Include sensitive zone outside (downwind) of the site
- Too large domain will lead to large CPU time

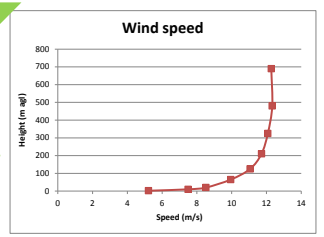
→ 2 sub-domains (1,2 km x 2,5 km and 1,7km x 2,9km)

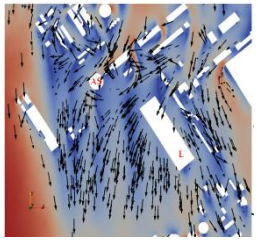
Method

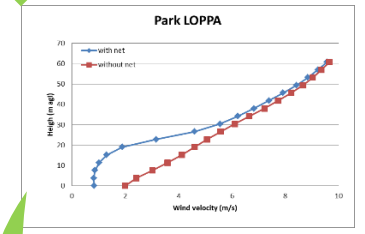
1. Setup of the domain(s), obstacles
2. Choose of the meteo situation(s) – a CFD is very time demanding tool. This represents the condition at boundaries given to the model. A critical wind-day is chosen
3. Meteo simulations, with and without the barriers, steady solutions obtained representing the equilibrium given by the N.S. equations with the local conditions (obstacles, physical effects of the barriers).
4. Emission estimation from dust piles for 5 different diameters (from PM2.5 to PM30) of particulate matter (EPA AP42 13.2.4 “Aggregate Handling and Storage Piles”; EPA AP-42 13.2.5 “Industrial Wind Erosion”; EPA AP42 13.2.2 “Unpaved Roads”)
5. Dispersion simulations, with and without nets, comparison of the two scenarios, estimation of the efficiency

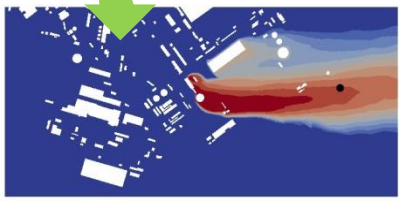












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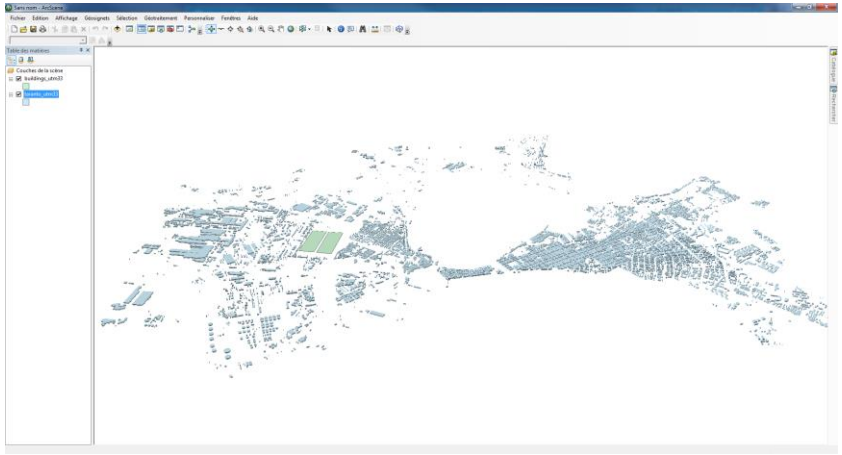

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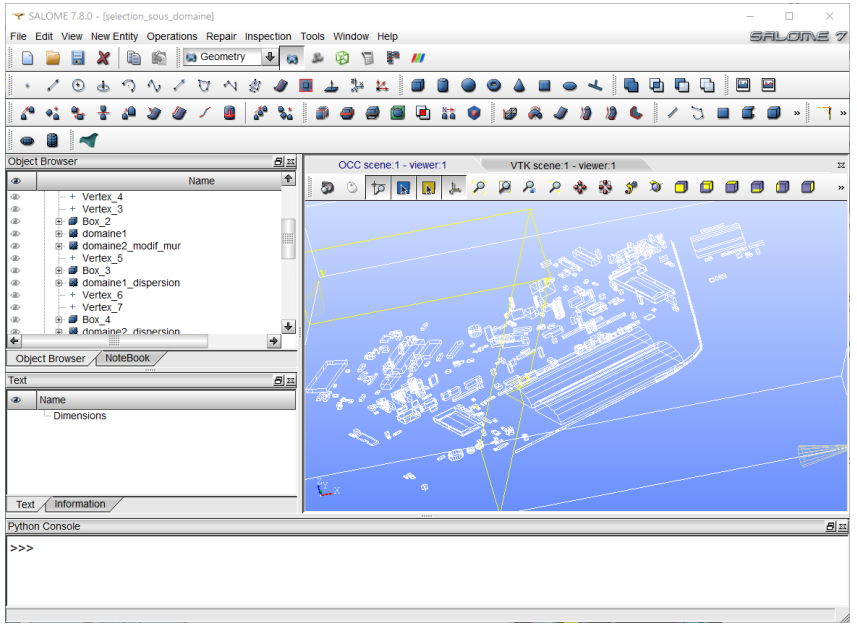
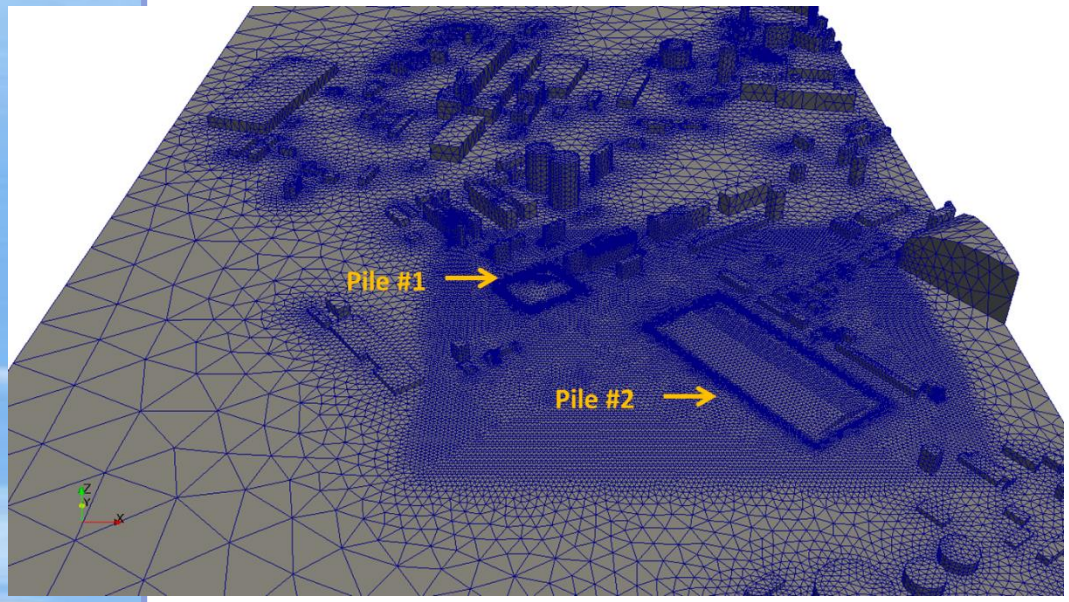


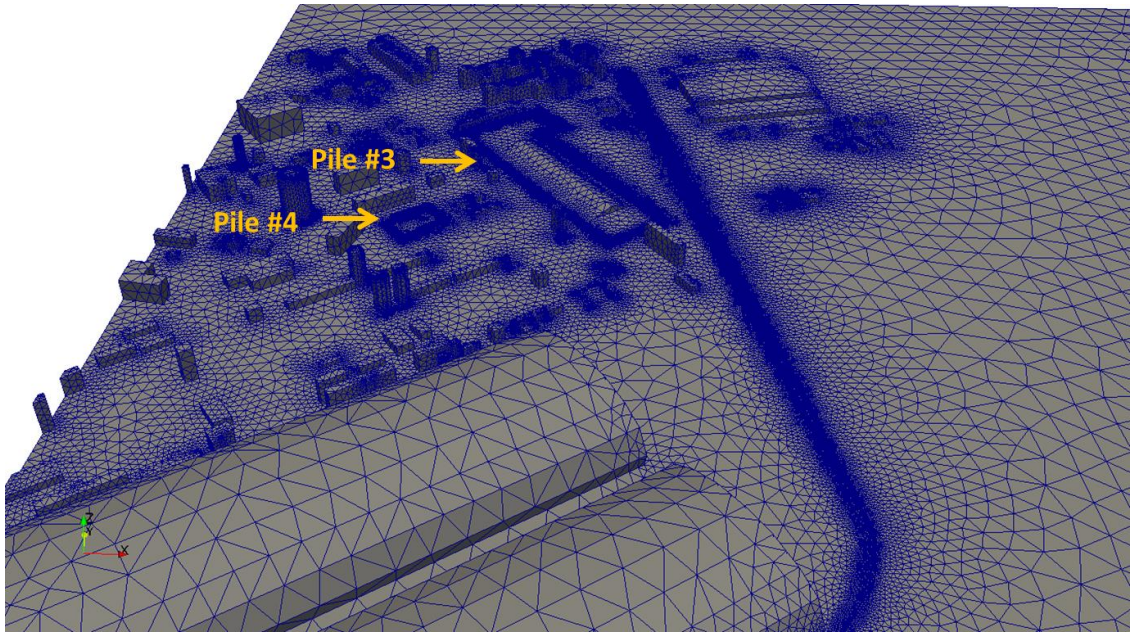
Salomé platform

Meshes

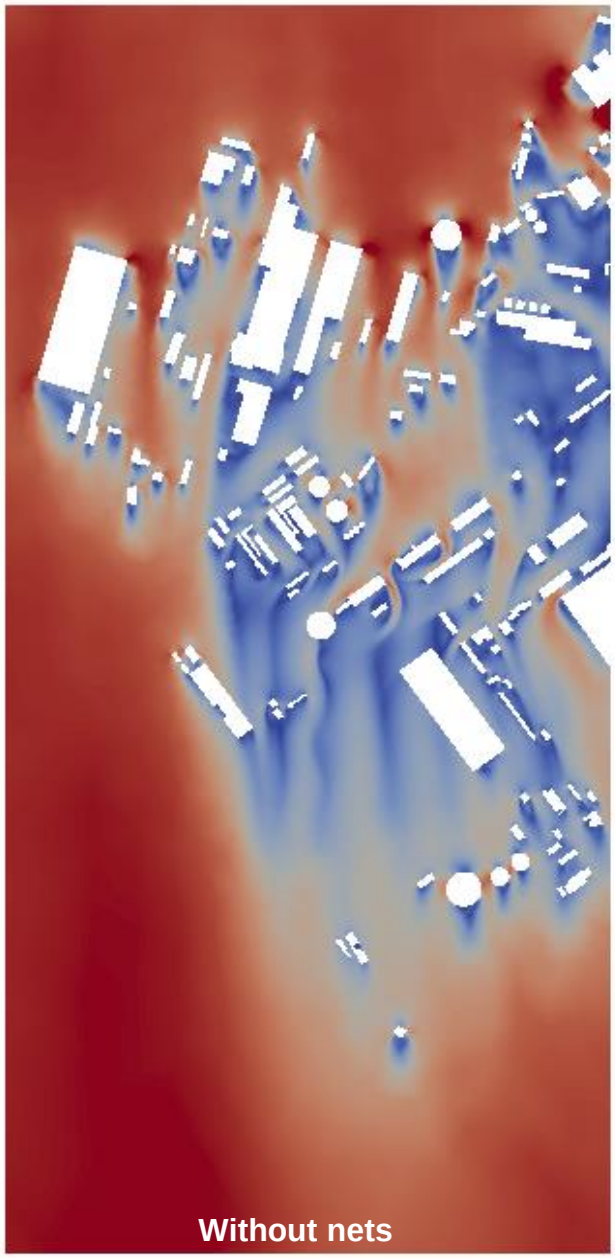


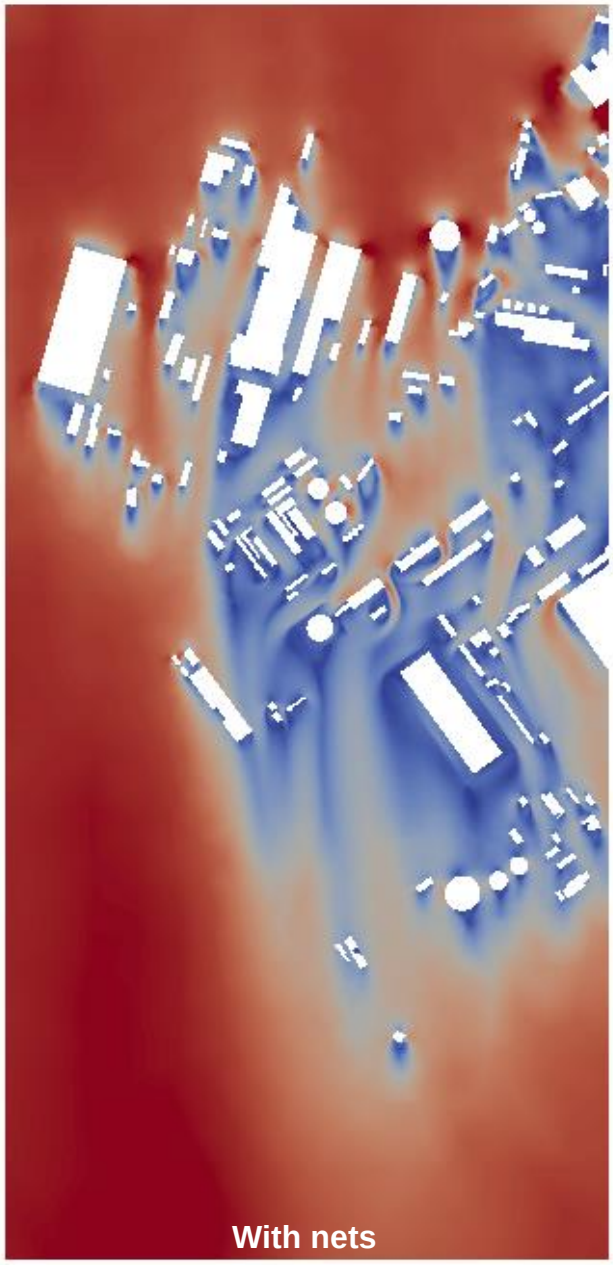
The meshes are also computed with Salome using tetrahedron elements and 2 zones for refinement.

About 3 millions cells – Resolution between 1m and 100m.

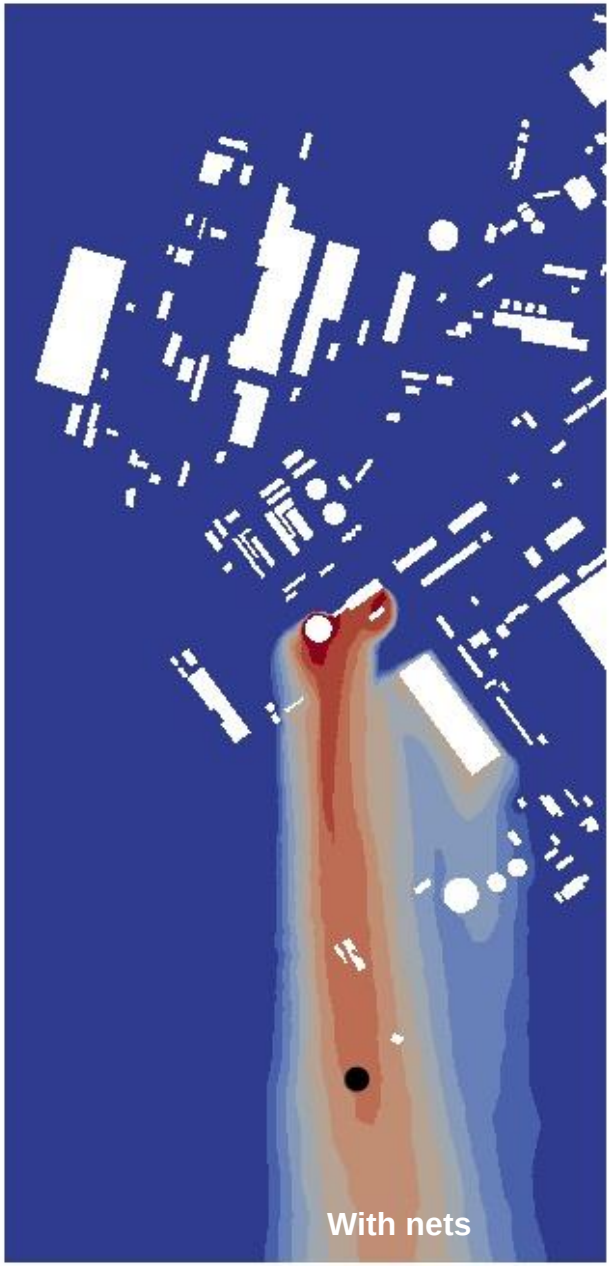


Some results - Wind fields

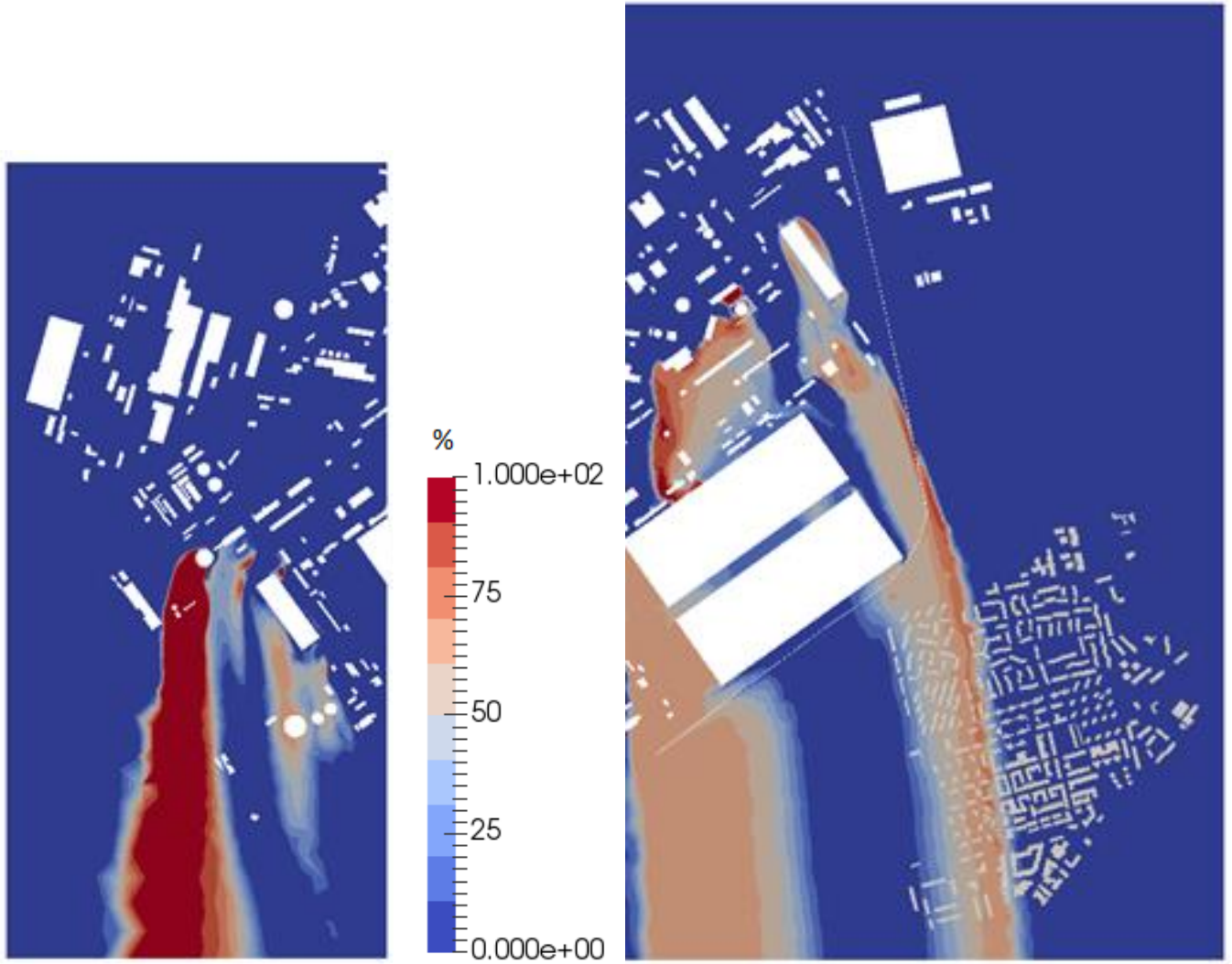




Some results - concentration fields



Some results - Mitigation



Relative reduction (%)

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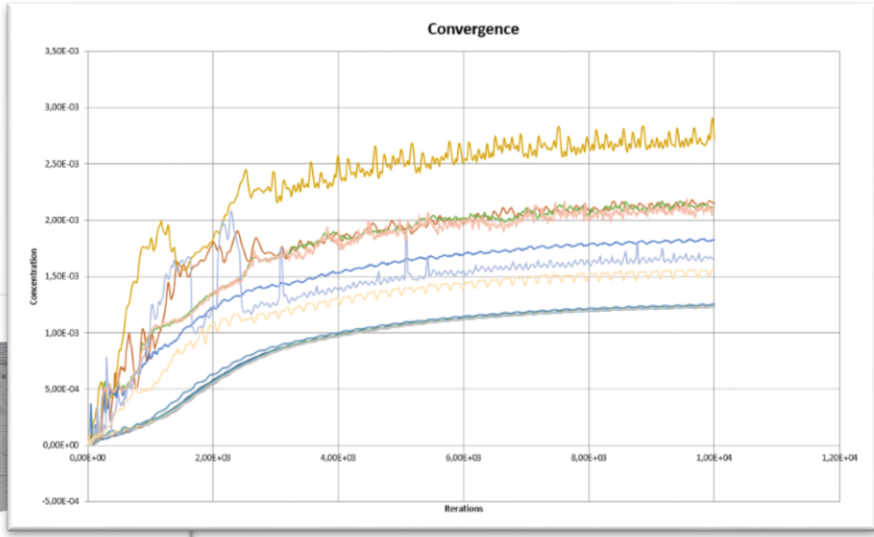
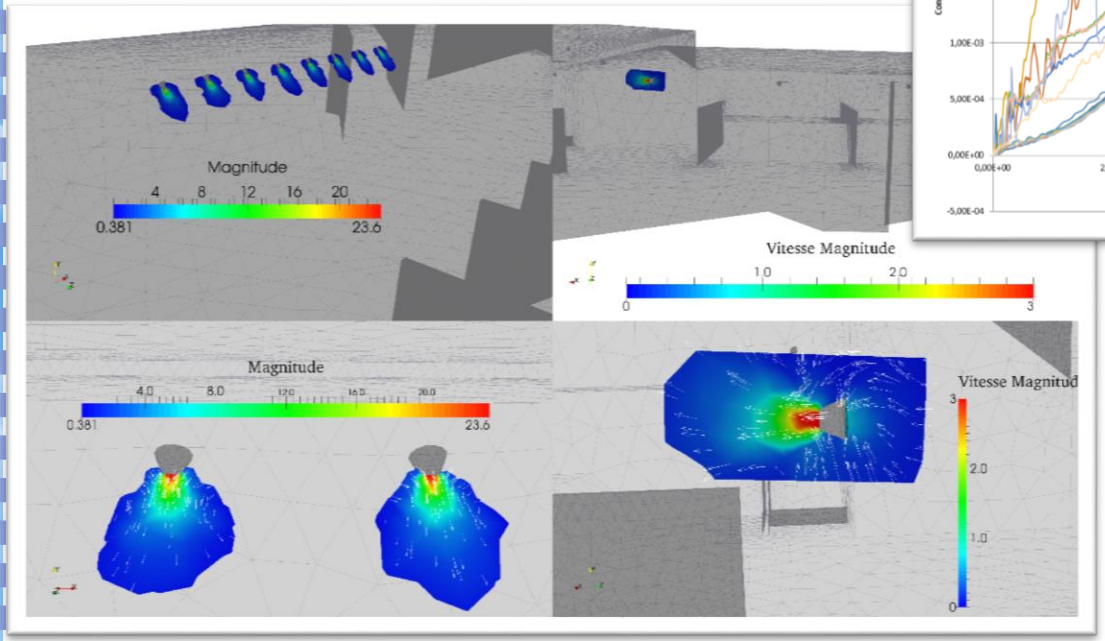
Formation and support

Formation and Support on SALOME/Code_Saturne :

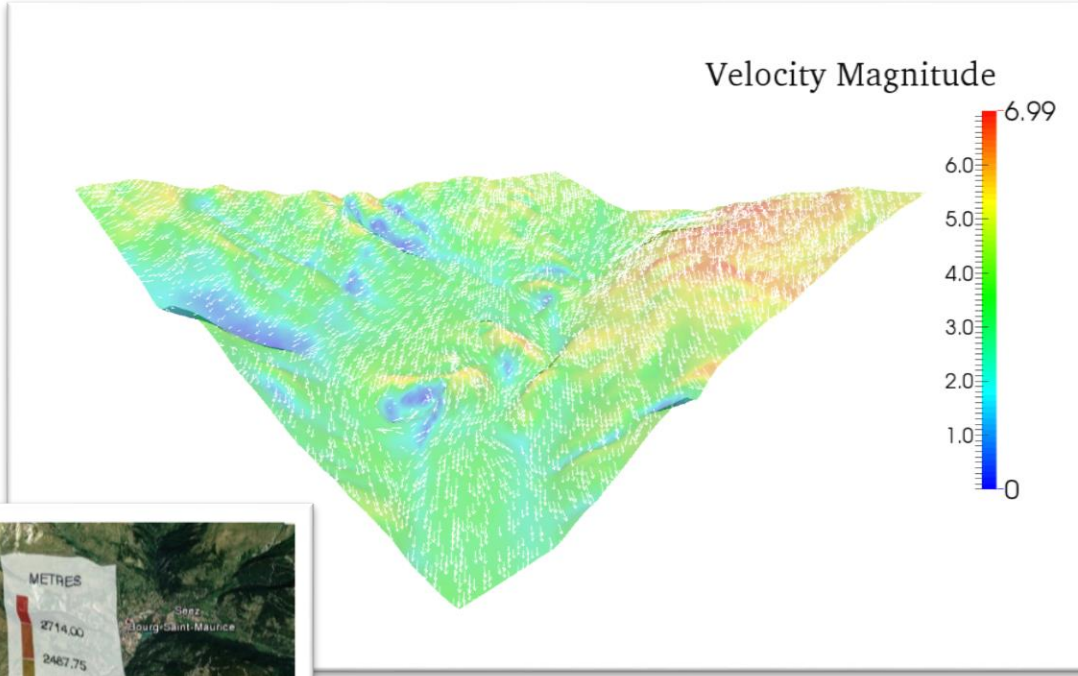
- Tutorials dedicated to customer application
- Support on study : (poster of V. Michaud) set up BCs, control convergency, set up injection of momentum or pollutant

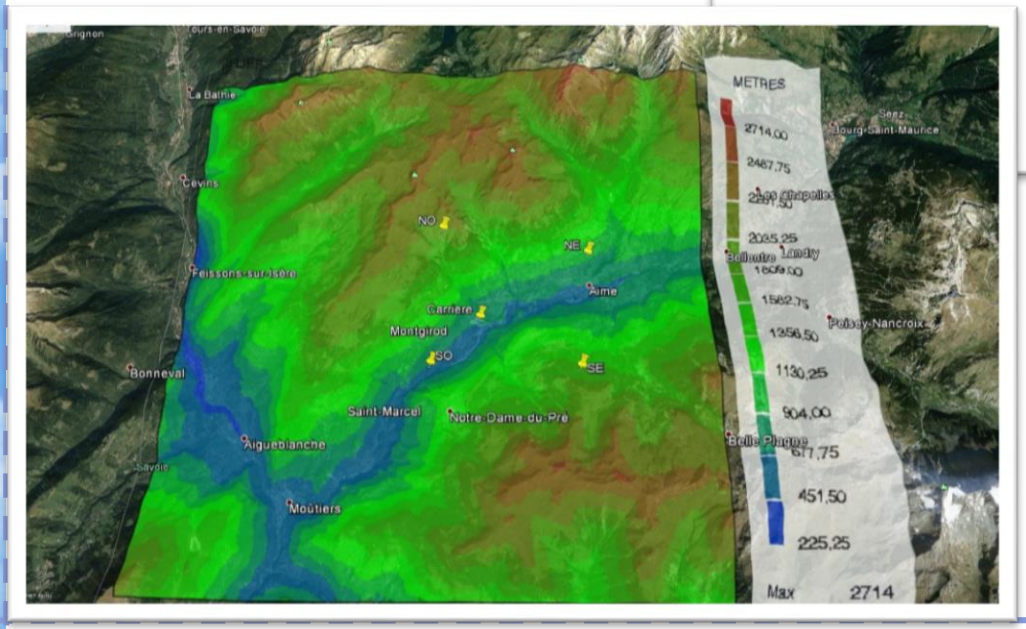




What's Next

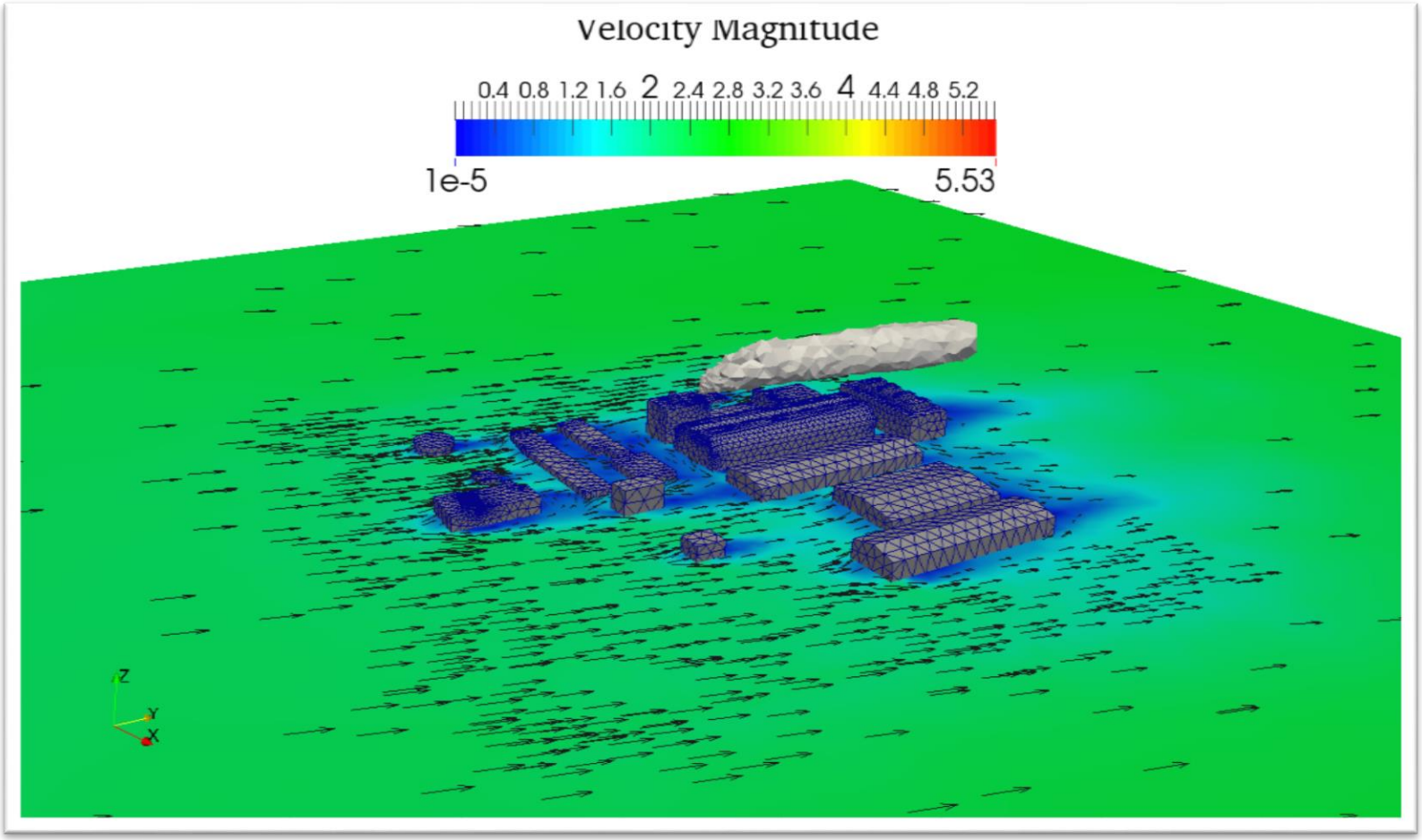
- **Dust dispersion study with very (very ?) complex topography (In progress)**





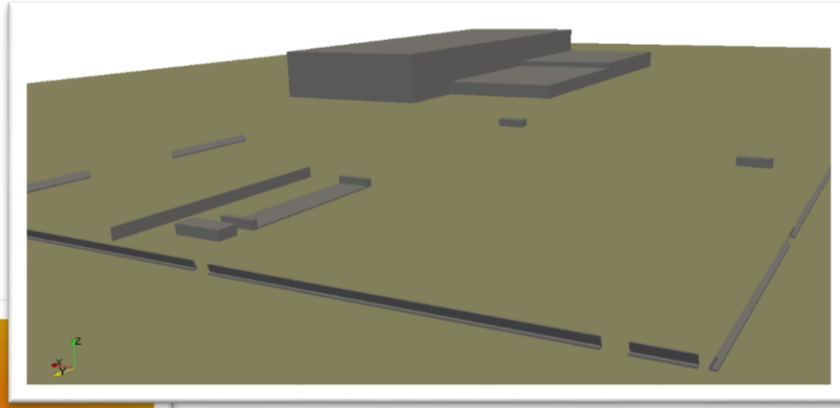
What's Next

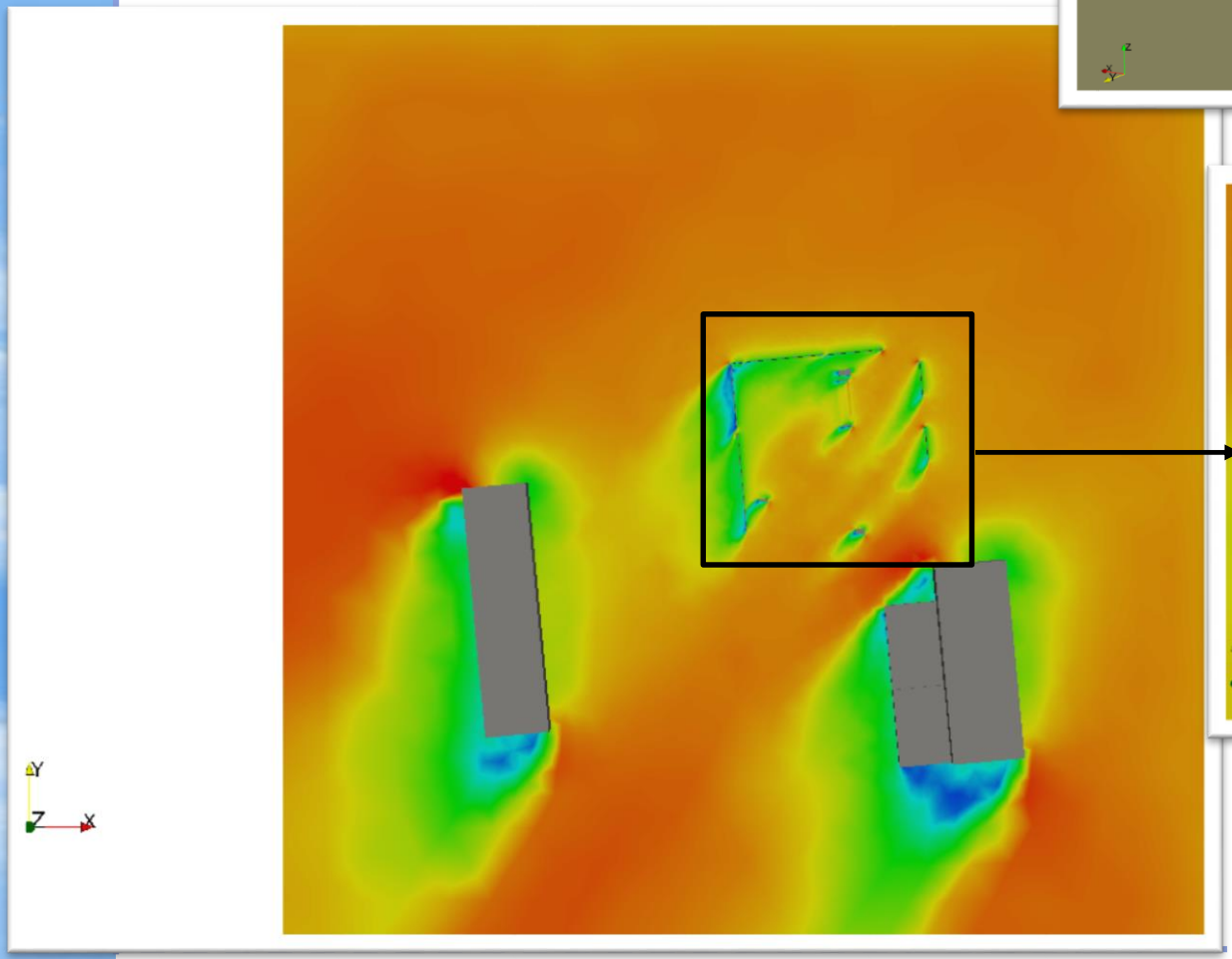
- **Wet plume dispersion study (In progress)**

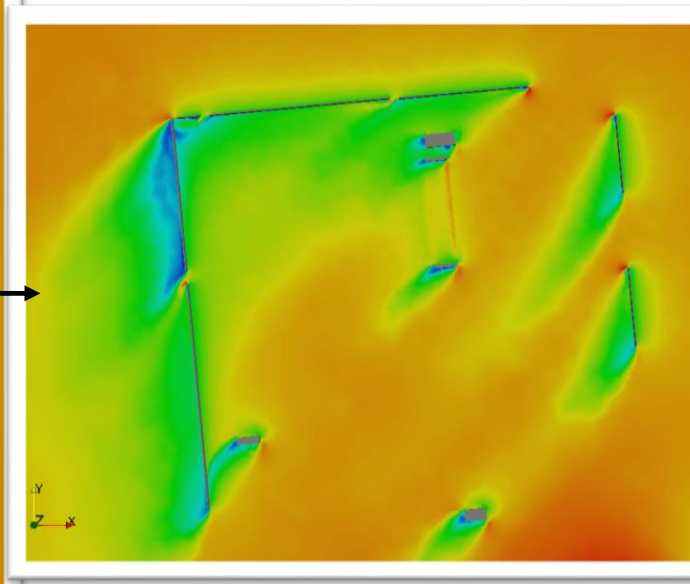


What's Next

- **Wind field study (In progress)**







Thanks for your attention