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Numerical schemes of *fluidyn*-PANACHE  
for solution of 3D Wind field and pollutant dispersion  
over complex terrain

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Softwares in ...




Environment






Safety

Energy

## fluidyn-PANACHE

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- Atmospheric flow and pollutant dispersion
  - ➔ Using CFD equations
  - ➔ Tri-dimensional wind patterns
  - ➔ Solar radiation, soil nature, ground relief, vegetation cover, water bodies, urban areas ....
  - ➔ From very short to very long time periods



## fluidyn-PANACHE

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- Methodology
  - ➔ Modelling the terrain features
  - ➔ Body-fitted mesh (structured or unstructured)
  - ➔ Establish wind patterns (typical/anticyclonic)
  - ➔ Emission characterization
  - ➔ Pollution dispersion



## fluidyn-PANACHE

### Methodology

- Modelling the terrain features
- Body-fitted mesh (structured or unstructured)
- **Establish wind patterns (typical/anticyclonic)**
- Emission characterization
- Pollution dispersion



## Wind patterns : numerical schemes

- Measured wind (mass) interpolation
- Partial Donor Cell (PDC)
- Strongly Implicit Procedure (SIP)
- Implicit Unstructured (NT)
- Total Variation Diminishing (TVD)

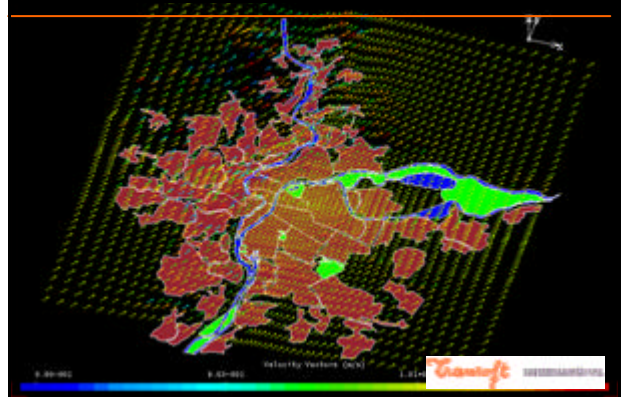


## Wind patterns : numerical schemes

- Measured wind (mass) interpolation**
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## Example : Wind fields over Lyon



## Wind patterns : numerical schemes

- Data interpolation
- **Partial Donor Cell (PDC)**
- Strongly Implicit Procedure (SIP)
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## Partial Donor Cell (PDC)

- Time variant scheme
- Implicit in space
- Explicit in time
- ➔ Accidental dispersion of pollutants  
Peak hour variation



## Example : A1 highway



Aménagements de l'autoroute A1 projetés par la D.D.E. de la Seine-Saint-Denis

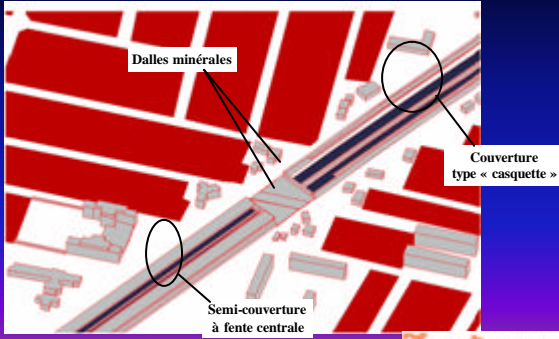


## Cases studied

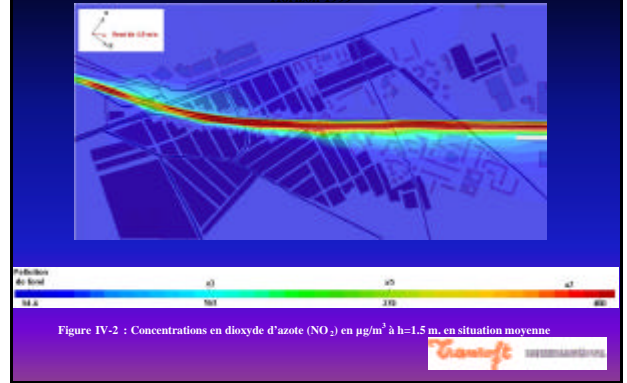
- Average situation
  - ➔ Average traffic
  - ➔ Most frequent weather data
  - ➔ Associated pollution
- Extremely adverse situation
  - ➔ Peak hour traffic
  - ➔ Adverse weather data
  - ➔ Associated pollution



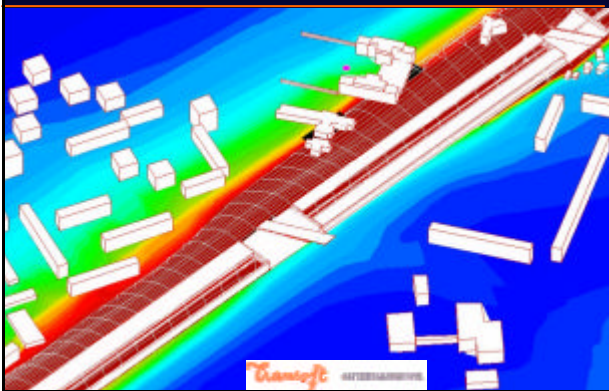
## Numerical model of terrain



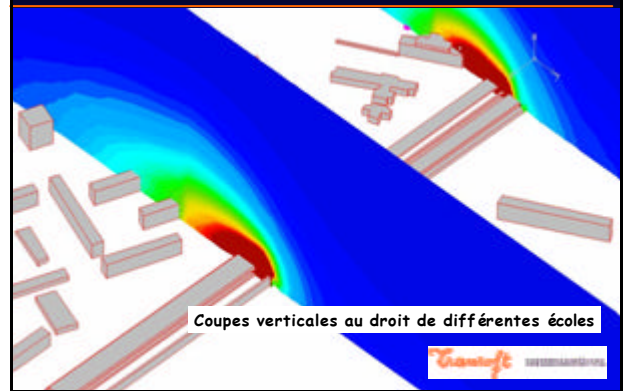
## Results



## Local results



## Local results



## Wind patterns : numerical schemes

- Data interpolation
- Partial Donor Cell (PDC)
- Strongly Implicit Procedure (SIP)**
- Implicit Unstructured (NT)
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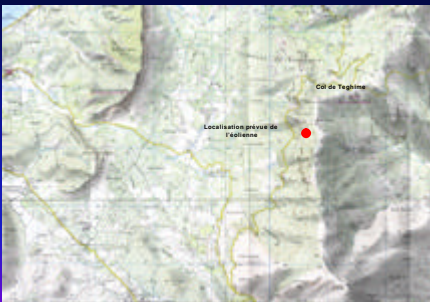


## Strongly Implicit Procedure (SIP)

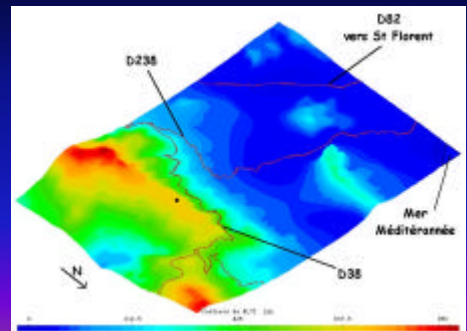
- NS equations are totally coupled  
Pressure, momentum and equation of state
- Implicit in time
- Implicit in space
- Stabilised airflow at low velocities
- ➔ Dispersion from continuous sources



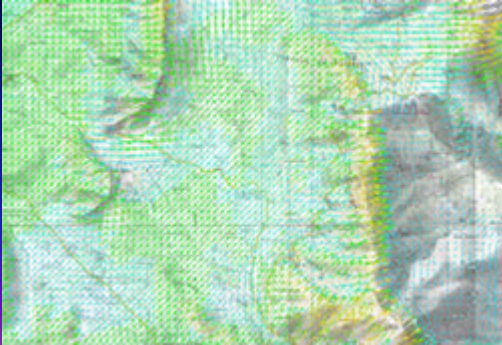
## Example : Wind fields over Corsica



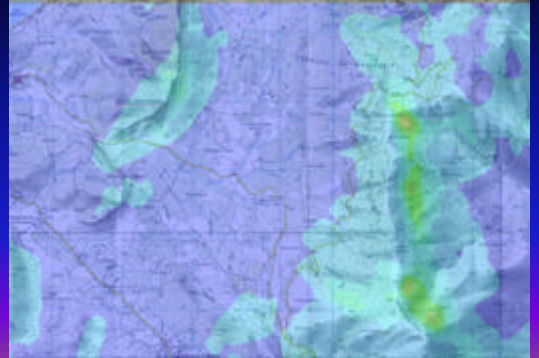
## Numerical model of terrain



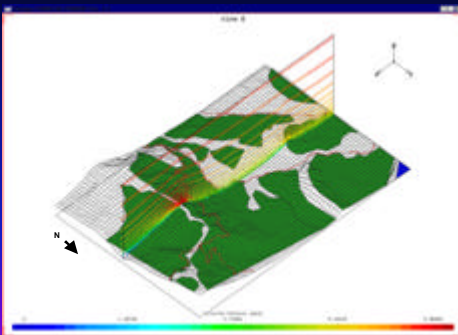
## Resulting wind fields



## Resulting turbulence levels



## Resulting vertical wind fields



## Wind patterns : numerical schemes

- Data interpolation
- Partial Donor Cell (PDC)
- Strongly Implicit Procedure (SIP)
- Implicit Unstructured (NT)**
- Total Variation Diminishing (TVD)

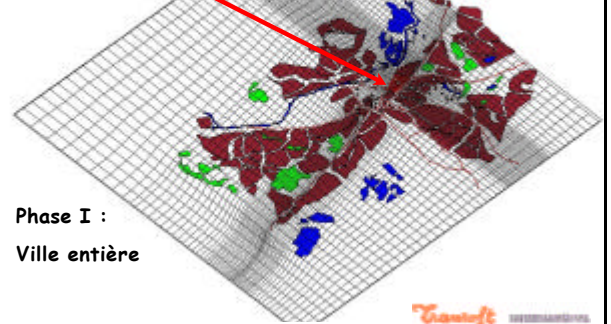
## Implicit unstructured (NT)

- Implicit monotonous scheme
  - Implicit in time
  - Implicit in space
  - Unstructured mesh
- High-density of odd-shaped buildings



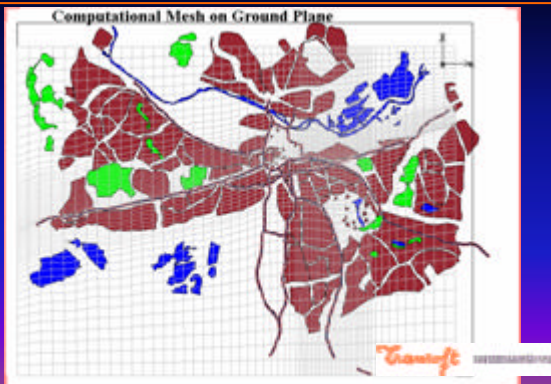
## Example : Reading (UK)

Maillage plus fin au niveau du centre ville

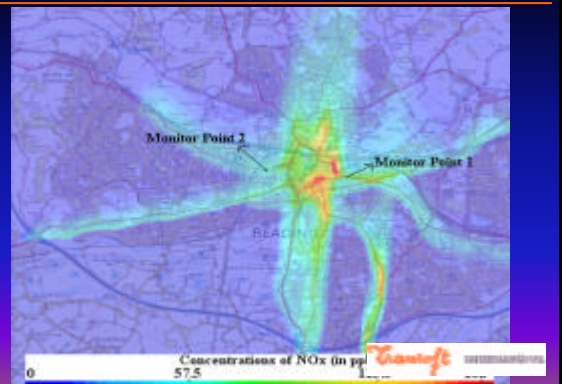


Maillage curviligne épousant la forme de la route

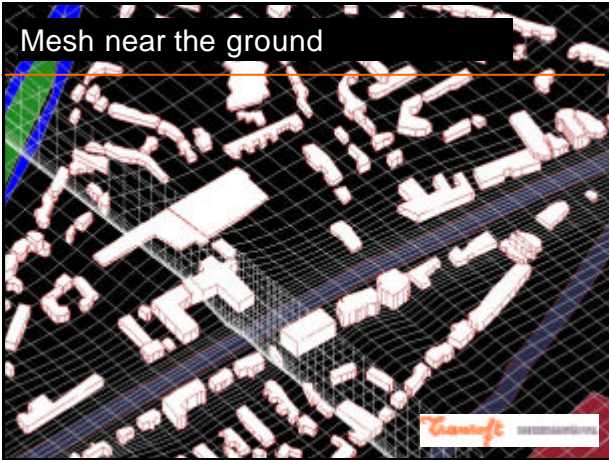
## Computational mesh



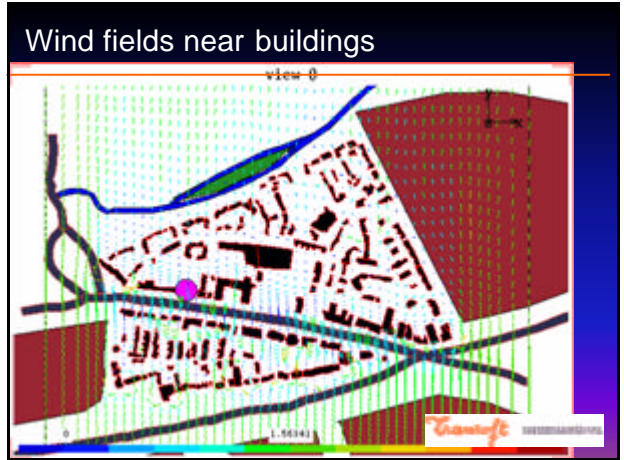
## Resulting pollution fields



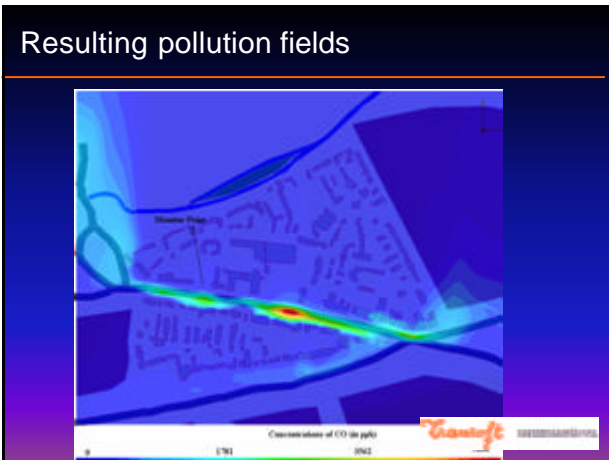
Mesh near the ground



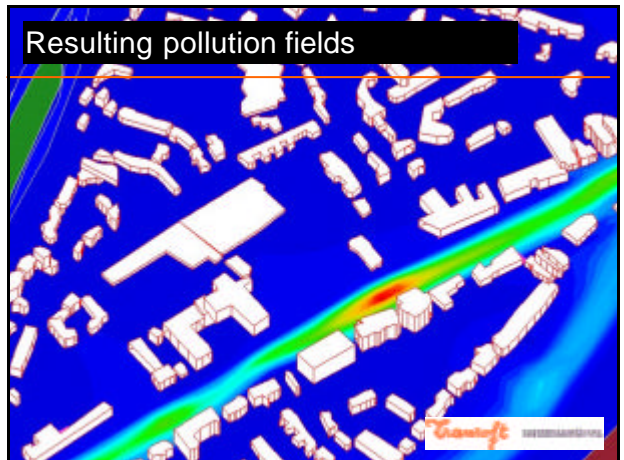
Wind fields near buildings



Resulting pollution fields



Resulting pollution fields



## Wind patterns : numerical schemes

- Data interpolation
- Partial Donor Cell (PDC)
- Strongly Implicit Procedure (SIP)
- Implicit Unstructured (NT)
- **Total Variation Diminishing (TVD)**



## Total Variation Diminishing (TVD)

- Density-based
- Explicit in time
- Explicit in space
- ➔ Fast transient flows (deflagration)



## Example : Toulouse



## Conclusion

- Fluidyn-PANACHE  
3D atmospheric flow and pollutant  
over complex terrain
- 5 schemes to calculate wind fields :
  - ➔ Data interpolation (solveur Lagrangien)
  - ➔ PDC
  - ➔ SIP
  - ➔ NT
  - ➔ TVD
- Chosen according to modelling requirements
- A simulation can use two solvers



# Conclusion

	Mesh	Time steps
Interpolation	Very crude	None
SIP	Regular	Large
NT	Any	Large
PDC	Regular	Small
TVD	Any	Very small

