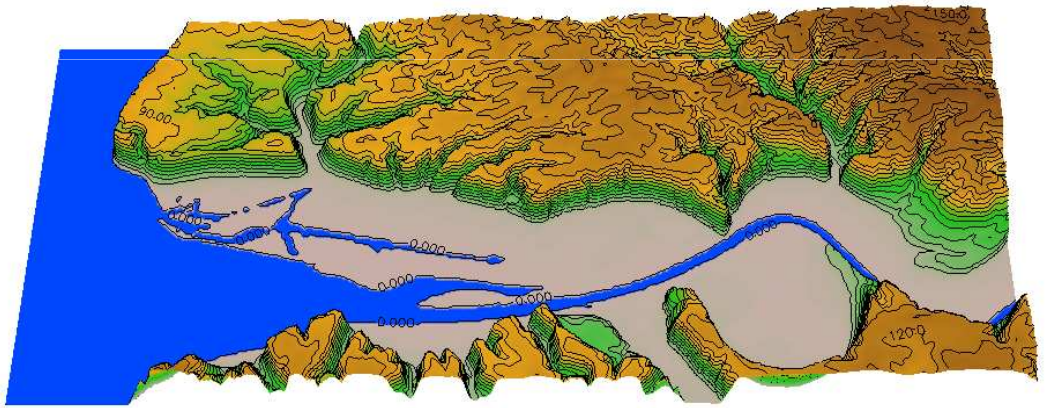
SIMULATION OF SO_2 EPISODES EXCEEDING EU REGULATIONS IN THE INDUSTRIAL AREA OF LE HAVRE WITH THE MM5, SWIFT AND SPRAY MODELS



Sylvie Perdriel – sperdriel@cairn-dev.fr, Jacques Moussafir – jmoussafir@aria.fr,
Claude Derognat – cderognat@aria.fr, Jérôme Cortinovis - jerome.cortinovis@airnormand.fr

CAIRN Développement SARL
26, Avenue Brezin – 92380 Garches – France
Telephone: +33 (6 08 49 46 54 – Fax: +33 (0)9 59 51 54 05
E-mail: info@cairn-dev.fr.fr – http:/ /www.cairn-dev.fr

Summary

- Context and Goal
- Input Data
  - ✓ Topography
  - ✓ Meteorological data
  - ✓ Emission data
- Modelisation scheme
- Model validation
- Validation of the emission mitigation measures
- Conclusion

SO2 Peaks Study – Le Havre area

Context and Goal

- European regulations for SO_2:
  - ✓Daily concentration averages:
    - C_m < 125 µg/m³
    - Maximum number of exceedance / year : 3
  - ✓Hourly concentration averages:
    - C_h < 350 µg/m³
    - Maximum number of exceedance / year : 24
- 2007 measurements: Number of exceedance per industrial zone

Industrial Zone	C_m	C_h
Le Havre	18	37
Port Jérôme	5	18

SO2 Peaks Study – Le Havre area

Context and Goal

European commission ask French Government to respect the european regulations

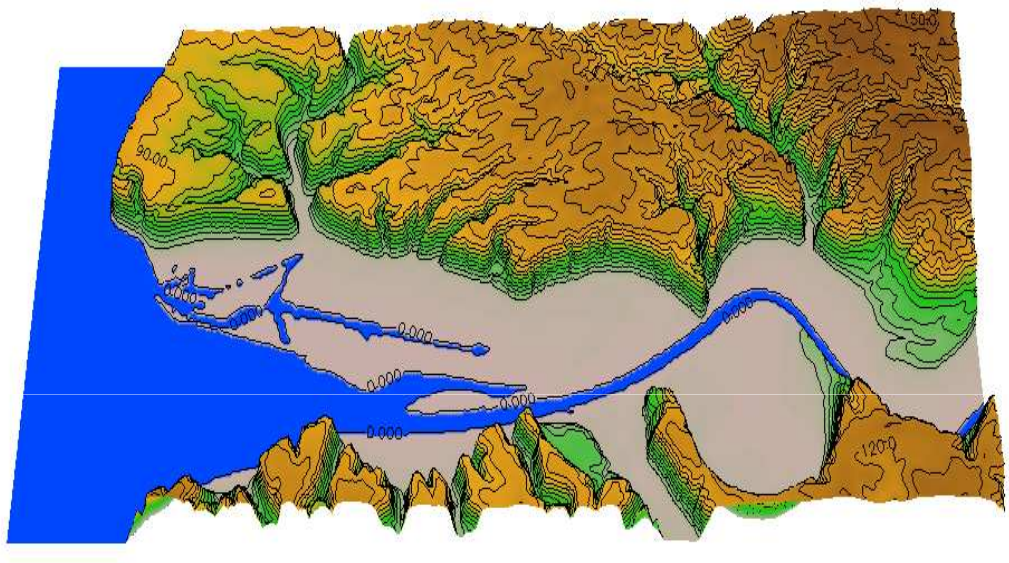
➔The local industry manager DREAL had to validate emission mitigation measures asked to the industrial plants

➔Choice of air dispersion modeling has been made for this validation in a two step study :

- The model validation over the 2007 peak episodes for 5 sensors
- The modeling of the mitigation reductions over these episodes and comparisons with the EU regulations

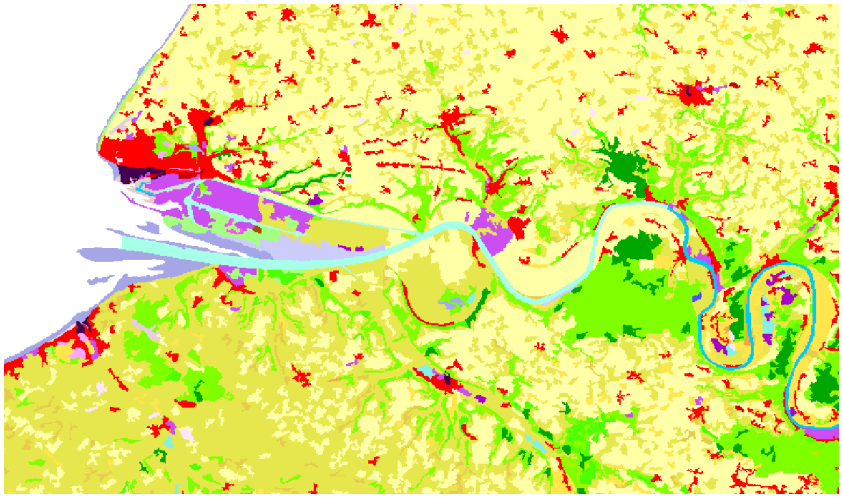
SO2 Peaks Study – Le Havre area

Site description



- ✓ Sea shore site: WideEstuary extended by the Seine river
- ✓ High cliff : 100 m along the northern border of the estuary

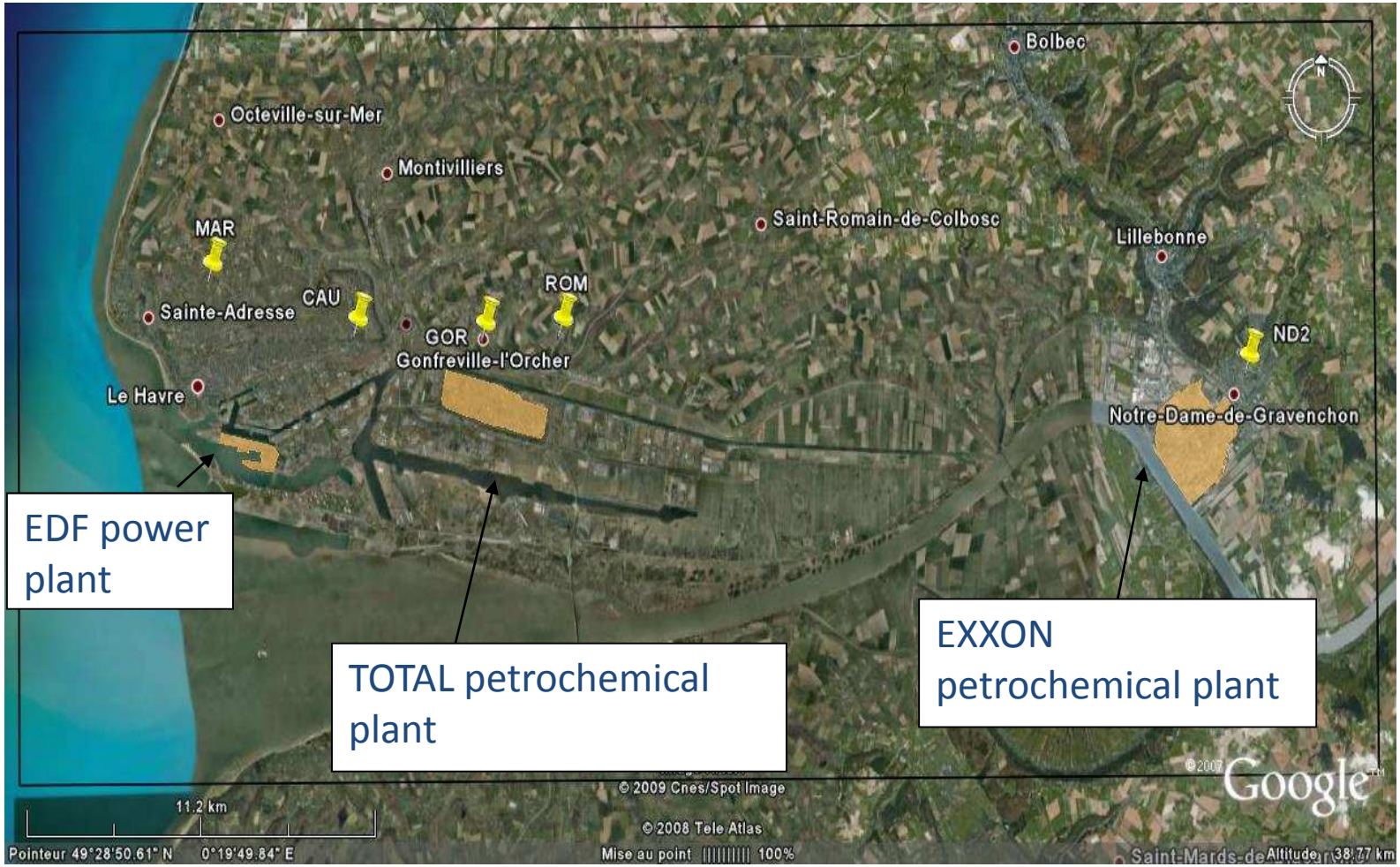
Land Cover map
Purple ➔ Industrial zones
Red ➔ towns



Données topographiques : IGN – 100m)

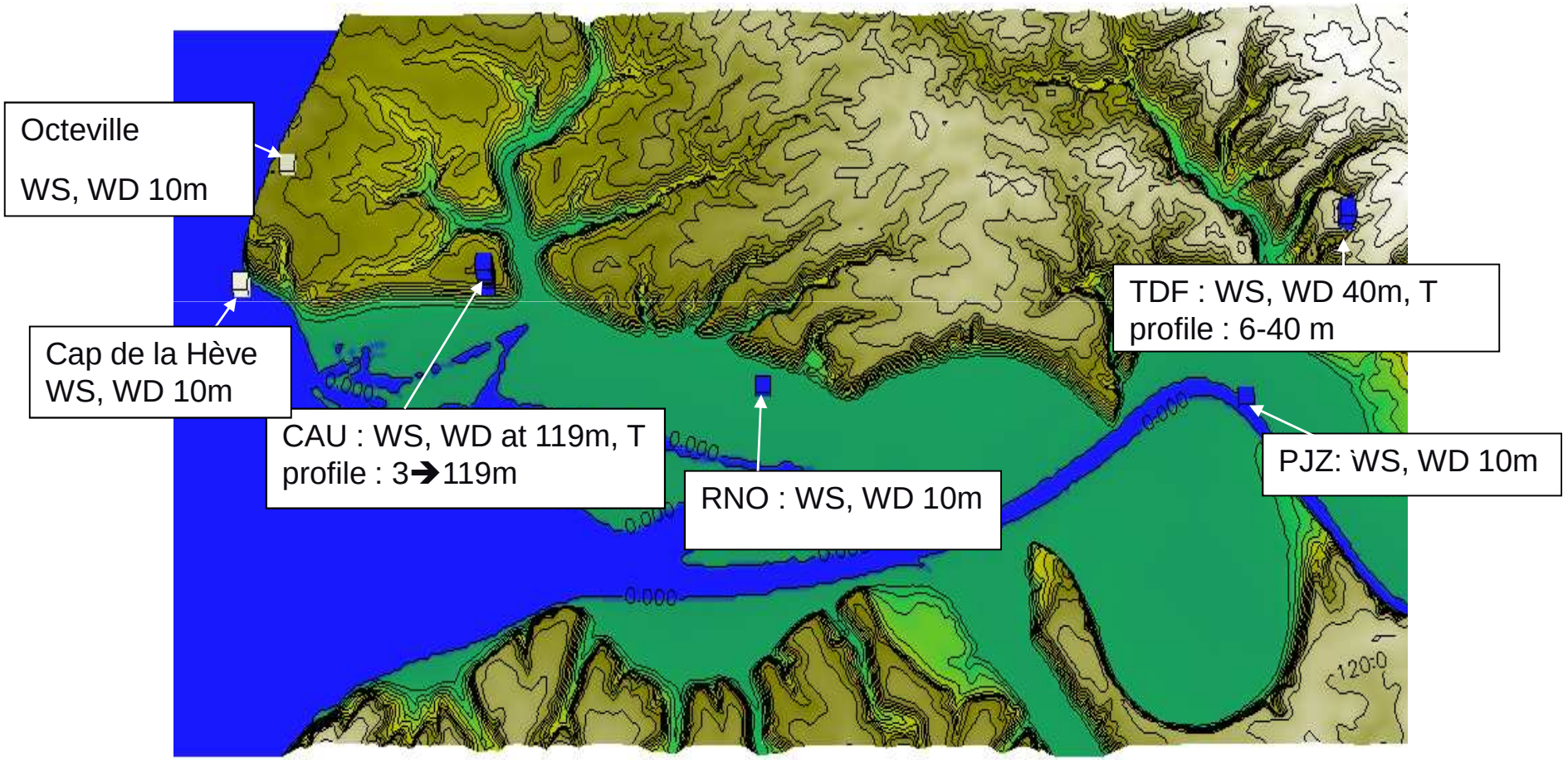
SO2 Peaks Study – Le Havre area

Concentration sensors



SO2 Peaks Study – Le Havre area

Meteorological data



SO2 Peaks Study – Le Havre area Stacks

- Plant :
  - ✓ EDF : 3 stacks– H: 240m each
  - ✓ TOTAL : 18 stacks – H: 25 to 110m
  - ✓ EXXON MOBIL : 16 stacks – H: 38 to 140m
  - ➢ ➔ takes into account 90% of SO2 releases for Le Havre area and 95% for Port Jérôme area

- SO2 emission rates ➔ Given by the Industrials on an hourly basis

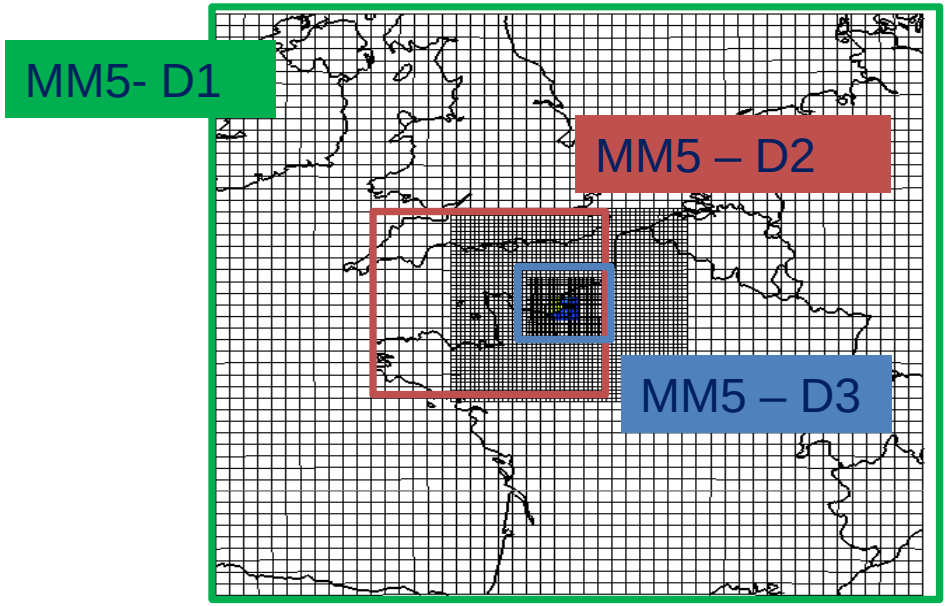
SO2 Peaks Study – Le Havre area

Wind Modeling

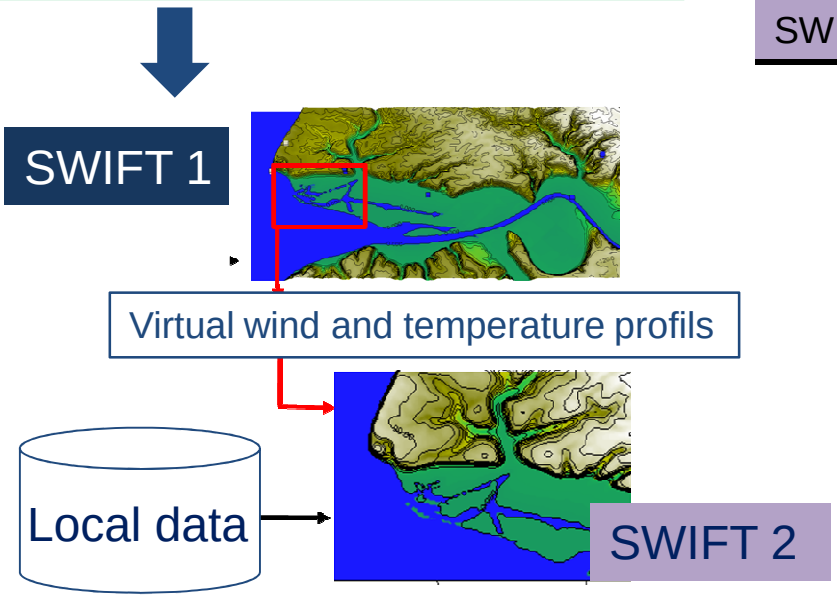
- Two different approaches
  - ✓ Using only local meteorological data :
    ➔ SWIFT model using all local meteorological stations : 100m resolution
  - ✓ A classical nested approach from continental scale to regionalm scale ➔ MM5+ SWIFT
    - MM5 :
      - 3D pour prévision ou analyse à échelle régionale
      - Imbrication de plusieurs domaines ➔ résolution finale 3km
      - Initialisation à partir des données NCEP (ex GFS)
    - Adaptation à l'échelle du site : SWIFT
      - Assimilation des verticales mMM5 à des mesures virtuelles
      - Assimilations de toutes les mesures du site
      - Utilisation des données du site à petite échelle

SO2 Peaks Study – Le Havre area

Wind Modeling : nesting approach



Domain	Resolution
MM5 - D1	27 Km
MM5 - D2	9 Km
MM5 - D3	3 Km
SWIFT 1	400 m
SWIFT 2	100m

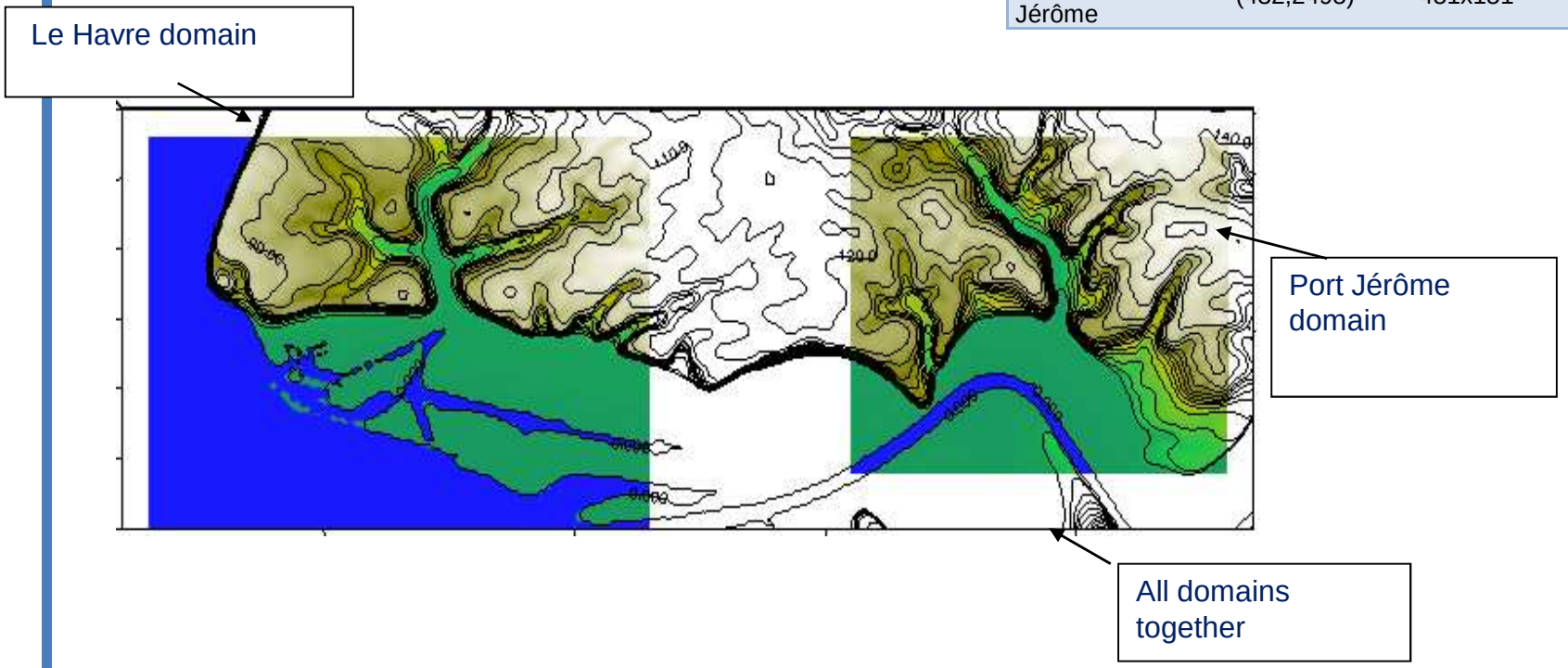


SO2 Peaks Study – Le Havre area

Local scale domains

- To improve simulation time ➔ 3 simulation domains have been considered

Domain	SW point	Number of points	Size in Km
Le Havre	(433,2495)	201x141	20.1x14.1
Port Jérome	(461,2497)	151x121	15.1x12.1
Le Havre+Port Jérôme	(432,2495)	451x151	45.1x15.1

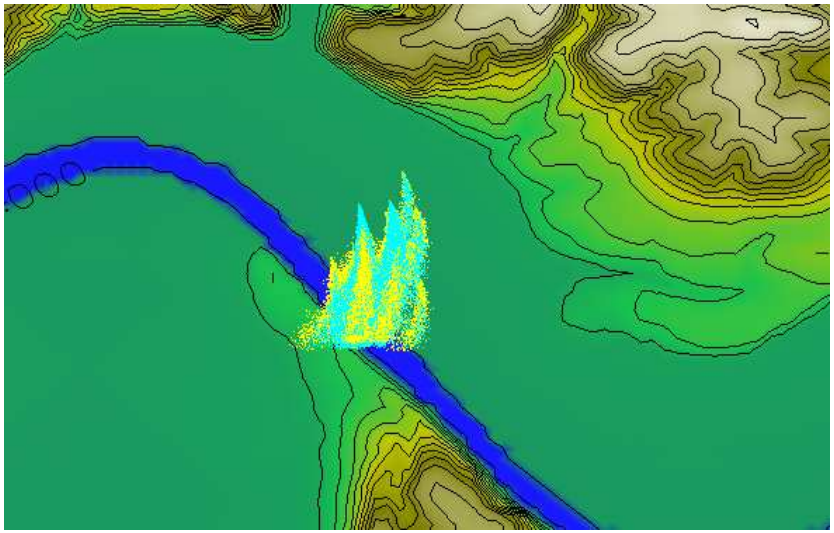


SO2 Peaks Study – Le Havre area

Dispersion Modeling :Spray

- ❑ Non steady state lagrangian dispersion model
- ❑ Wind and turbulence fields coming for SWIFT
- ❑ Well adapted to complex topography
- ❑ High number of particle release

➔accuracy :1µg/m3



SO2 Peaks Study – Le Havre area
Model Validation

❑ Choice of the validation point

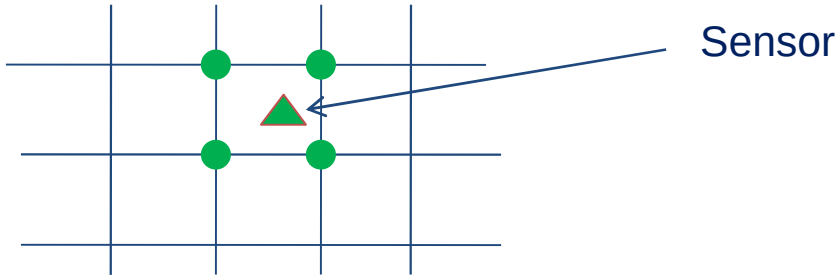
✓ Wind speed sensor precision : +/-0.5 m/s

➔ At 2km, possible delay of 15mn on the plume transport

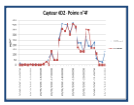
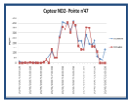
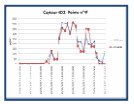
✓ Wind direction sensor precision : +/-5 °

➔At 2km, possible error of 180m for the plume center line

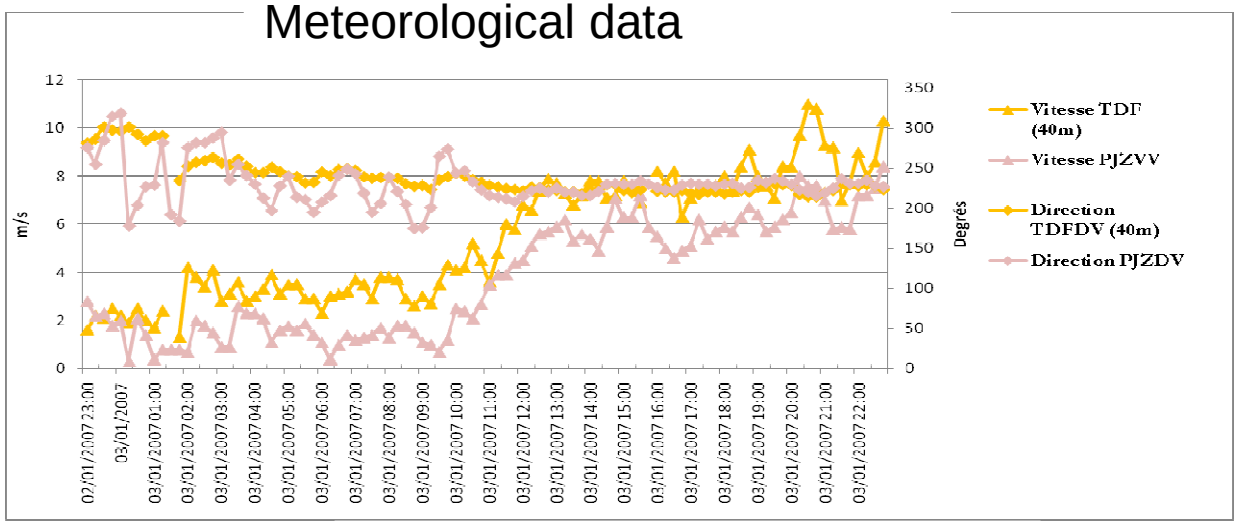
➔ We choose to take the Best 4 calculated values at t-dt t, t+dt with dt=1/4h



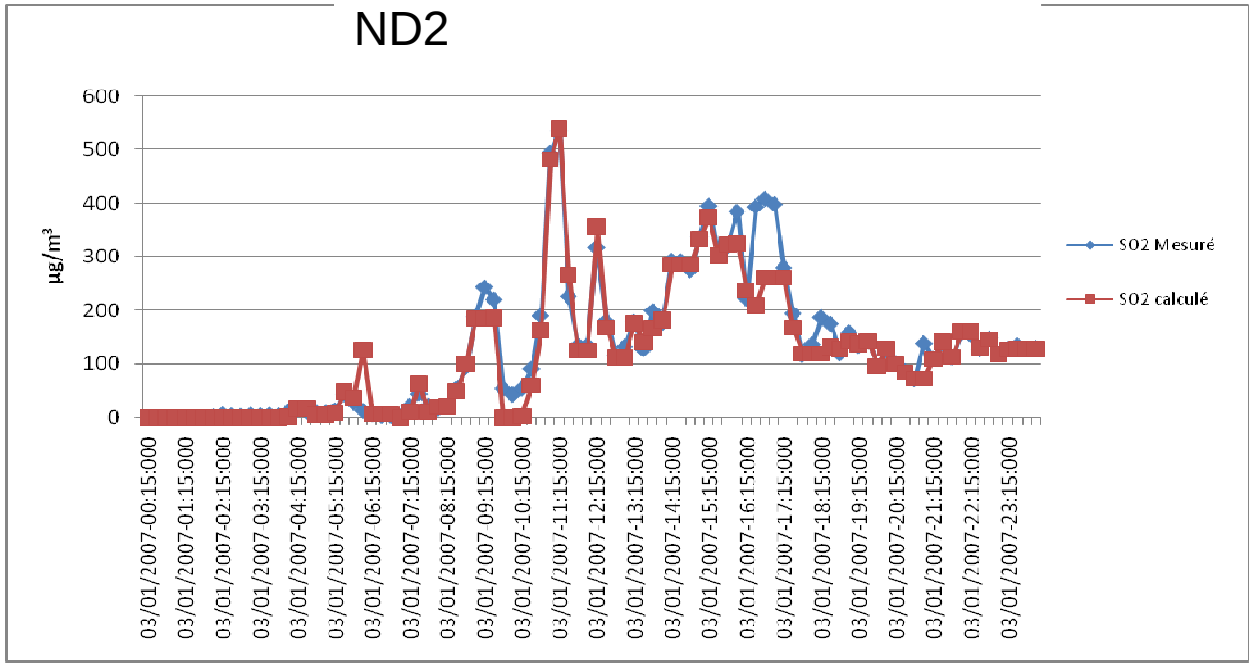
SO2 Peaks Study – Le Havre area
Model Validation Results

- Caractéristiques des pointes :
  - ✓58 simulations :
    - 14 dealing with hourly concentration averages
    - 36 dealing with dailyconcentration averages
    - 8 dealing with both hourly and daily concentration averages
  - ✓
- Results:
  - ✓ 32 good simulations :
    ex : Port Jérôme  , Le Havre 
  - ✓26 not so good simulations :
    ex : Port Jérôme  , Le Havre 

SO2 Peaks Study – Le Havre area
Simulation n°1 – Port Jérôme

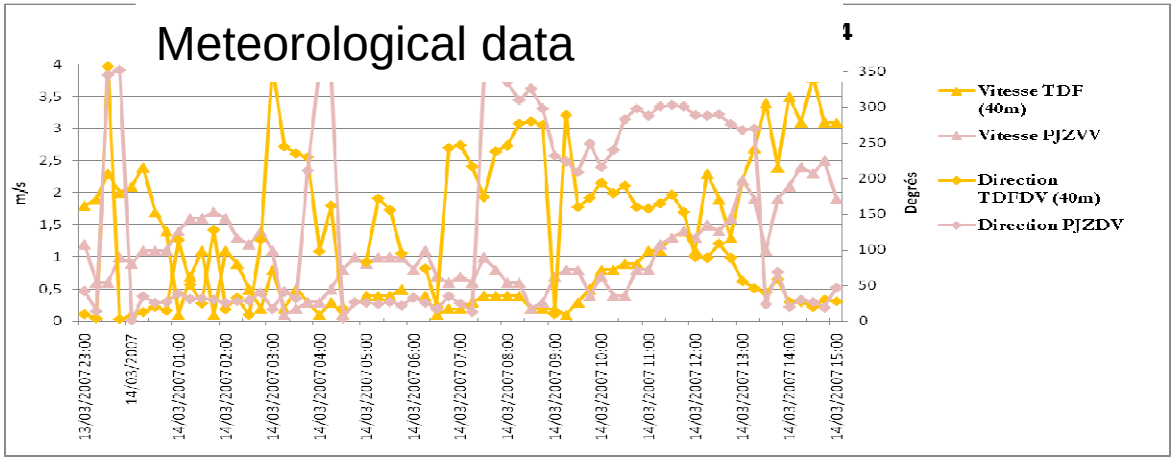


Well correlated wind speeds and directions

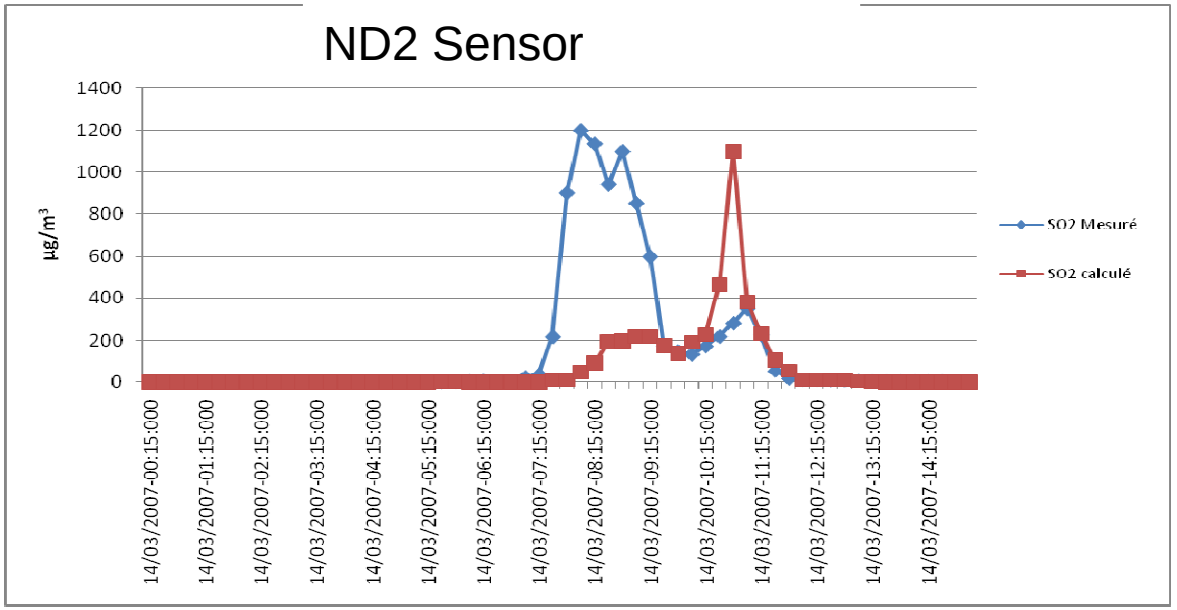


Good results !

SO2 Peaks Study – Le Havre area
Simulation n°24 – Port Jérôme



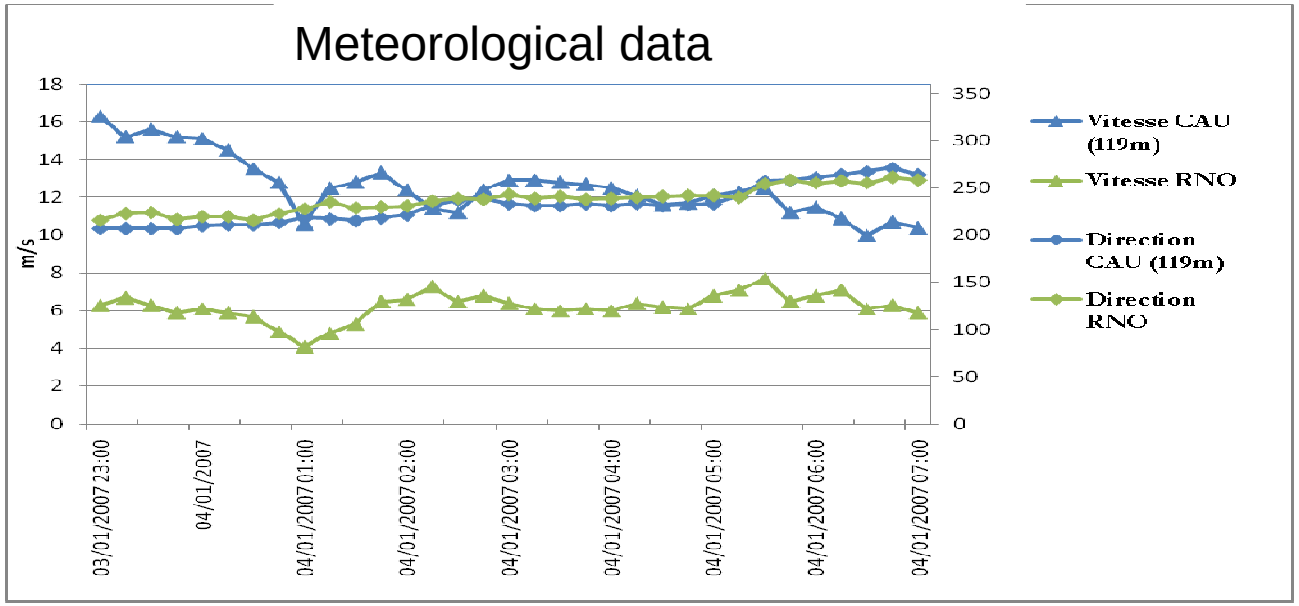
Low and uncorrelated winds– Fluctuant wind directions



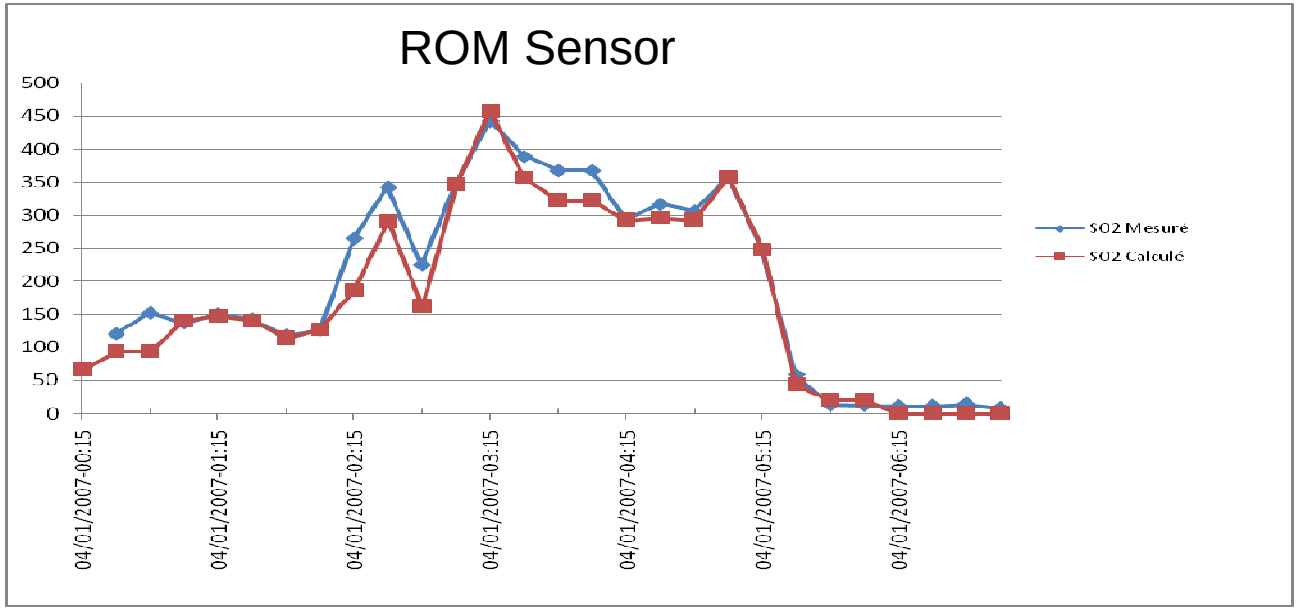
Poor results !

SO2 Peaks Study – Le Havre area

Simulation n°24 – Le Havre



Well correlated wind speeds and directions

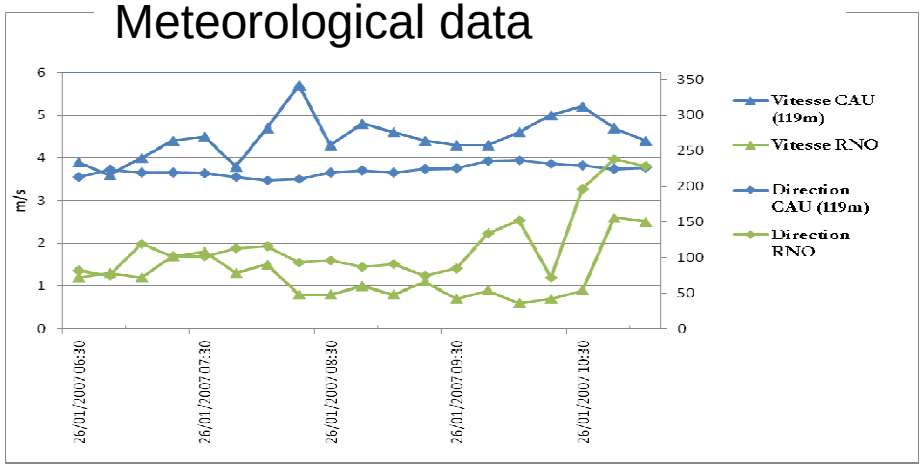


Good results !

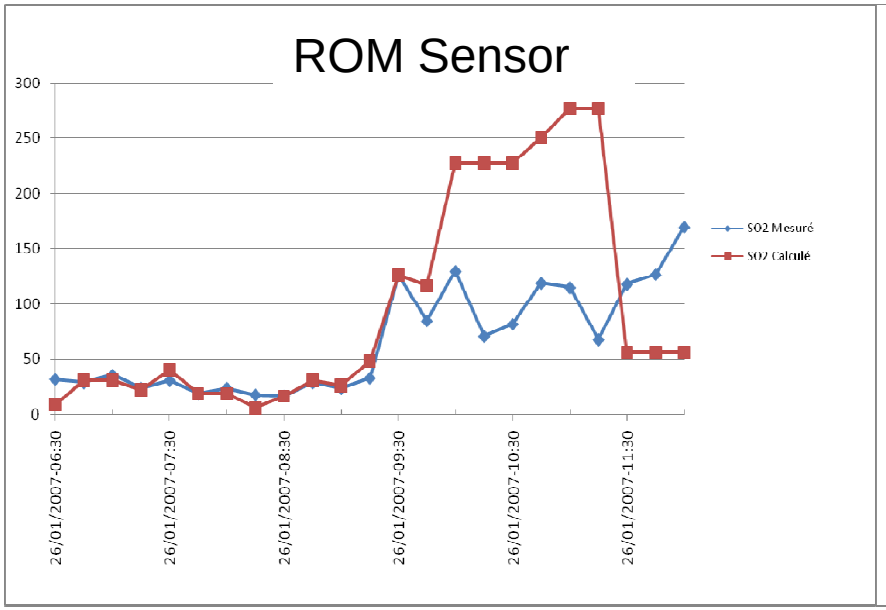
SO2 Peaks Study – Le Havre area

Simulation n°11 – Le Havre

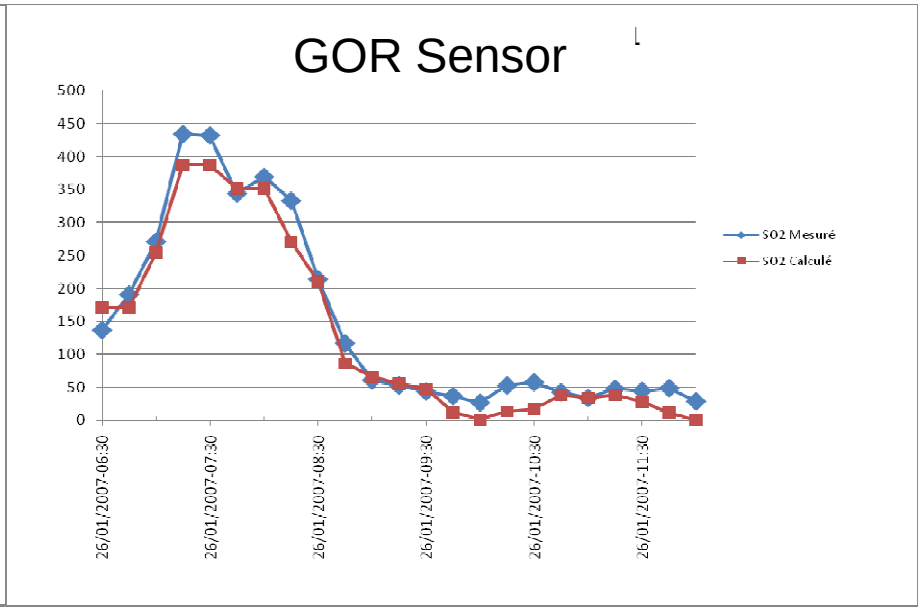
Meteorological data



ROM Sensor



GOR Sensor



SO2 Peaks Study – Le Havre area
Statistical results

- Port Jérôme : Good results

	ND2 sensor
Correlation	0.56
Fractional Biais	-0.12
Mean geometric Biais	0.9
FAC2	0.91

- Le Havre: Ok for the GOR and ROG sensors – Not ok for CAU

	GOR	ROM	CAU
Correlation	0.59	0.52	0.27
Fractional Biais	0.05	0.05	-1.11
Mean geometric Biais	1.	1.	0.5
FAC2	0.86	0.68	0.31

- Both sites at the same time : OK for moderate to high wind speeds, not OK for low wind speeds ➔ most of the situations

	ND2	GOR	ROM	CAU
Correlation	-0.24	0.34	-0.06	0.03
Fractional Biais	-0.71	-0.15	-0.68	-1.5
Mean geometric Biais	0.5	0.7	0.7	0.2
FAC2	70%	58%	48%	13%

SO2 Peaks Study – Le Havre area
Model validation conclusion

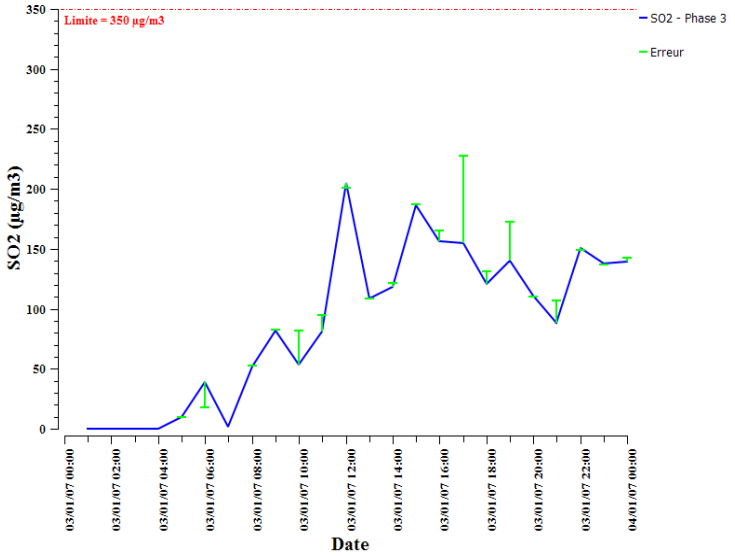
- Two categories of meteorological situations :
  - ✓ Moderate to high wind speeds with good correlation between the ground stations and profiles ➔ good or acceptable results
  - ✓ Low and fluctuant winds ➔ poor results
- An exceptional meteorological situation : christmas 2007 with a very stable situation, very low wind speeds during 4 days ➔ poor results
- Further work on models to improve this low wind situations :
  - ➔ Enhance turbulence scheme
  - ➔ Try to use ECMWF results instead of GFS
  - ➔ Have a real vertical profile in the estuary to measure vertical gradients at stack heights

SO2 Peaks Study – Le Havre area

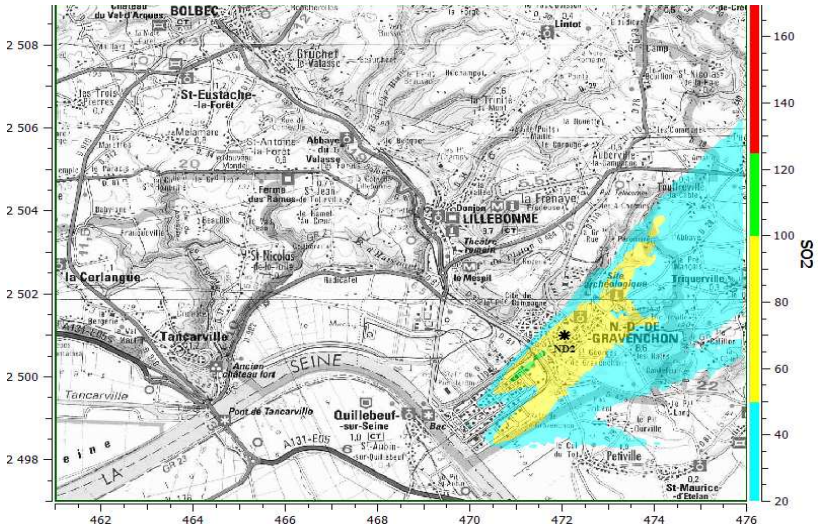
Validation of the mitigation measures

- The well represented peaks have been kept to validate the mitigation measures
- A new sets of simulation have been performed taking into account emission mitigations
- In each case, results have been presented taking into account the modeling errors from the model validation

Simulation 1 – Hourly concentration averages



Simulation 1 – Daily concentration



➔ Only one situation still shows SO2 concentration exeeding EU regulations

Thank You for your attention