Rejets accidentels en milieu urbain : le projet COST ES 1006

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COST Action ES1006: Evaluation, Improvement and Guidance for the Use of Local scale Emergency Prediction and Response Tools for Airborne Hazards in Built Environments

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and all COST contributors

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COST, c'est quoi ?

- Cadre intergouvernemental européen pour la **CO**operation en **S**cience et **T**echnologie
- Soutient le développement des compétences en reliant différentes communautés scientifiques
- Crée un réseau européen
- Relie la recherche et les applications

source: ARIANET

source: ABC news

source: EWTL - UHH

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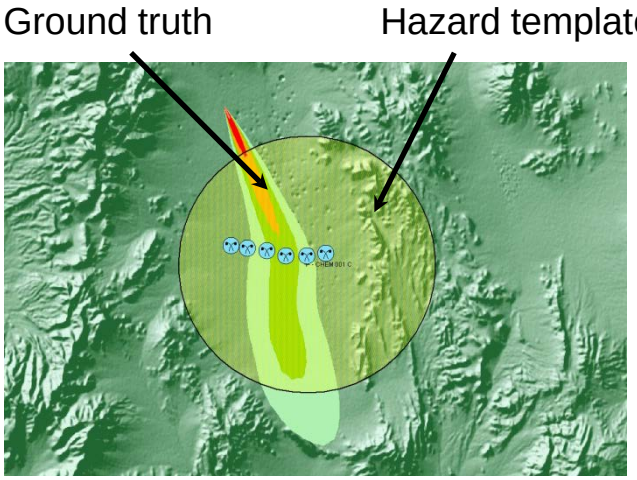
Les heureux contributeurs

Pourquoi des modèles plus avancés?

Abaques et tables

- Simple means of displaying potential hazard area on map very quickly, without resorting to complex calculations;

Pros	Cons
Simple and quick to use	Large uncertainties, limited information and poor resolution.
Simple meteorological inputs.	Primarily developed for open terrain, not well-suited to local-scale urban areas.



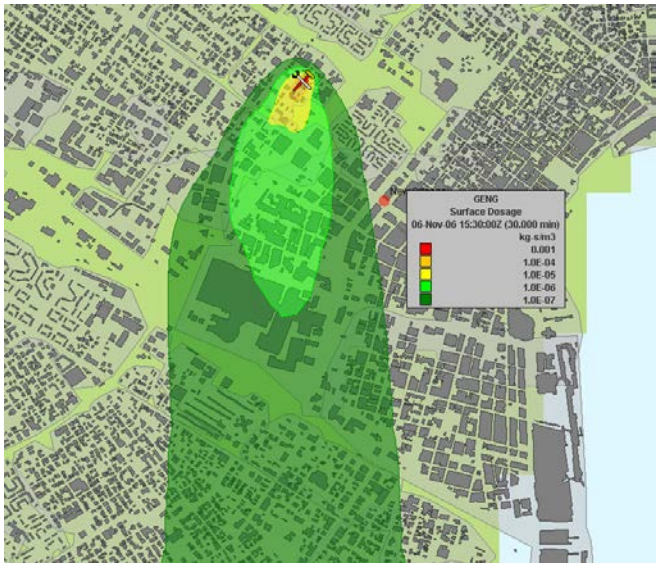
ATP-45 chemical template (Courtesy: Dstl)

- Examples: Emergency Response Guidelines and NATO ATP-45 templates;
- NOT considered by Action.

Semi-empirical Methods (Type 1 Models)

- Models that combine theoretical methods and data from field trials to predict dispersion;
- Vary greatly in complexity and sophistication.

Pros	Cons
Simple inputs, rapid execution on PCs and laptops.	May not resolve important details close to source.
Provide acceptable results for wide range of releases.	Limited capability for resolving spatial and temporal variations in concentrations.



Solution from UDM and SCIPUFF (Courtesy: Dstl)

- Examples: ALOHA, ADMS, AERMOD, UDM, SCIPUFF.

Full Flow Field Calculations (Type 2/3 Models)

- Methods that calculate the 3-D wind field throughout the area of interest to predict the dispersion of material in detail.

Pros	Cons
Provide detailed spatial and temporal predictions of hazard.	Computational time and resources may be large compared to simpler methods.
Can handle all types of release.	Complexity of process.

Solution from PMSS (Courtesy: P. Armand, CEA).

- Examples: Microswift/Spray, Large Eddy Simulation methods.

BEST PRACTICE GUIDANCE

A document on ADMs in ERTs for practitioners

COST ES1006
Best Practice Guidelines
for the use of Atmospheric Dispersion Models in Emergency Response Tools at local-scale in case of hazmat releases into the air

Presented for all co-authors
By Patrick ARMAND

France Atomic and alternative Energies Commission

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30 March 2015

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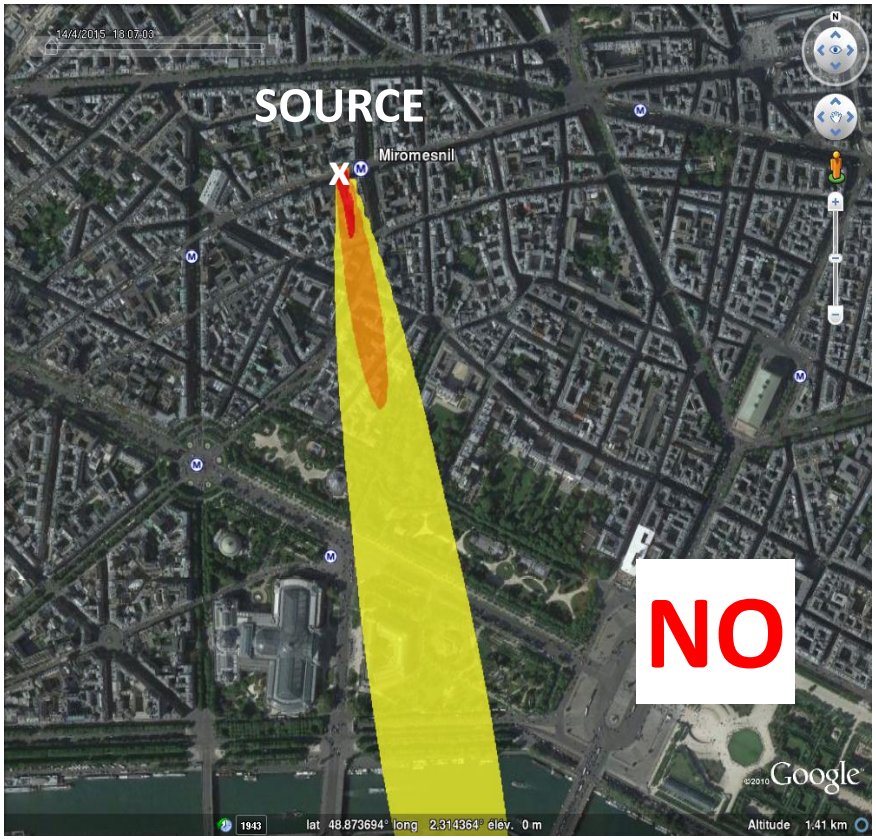
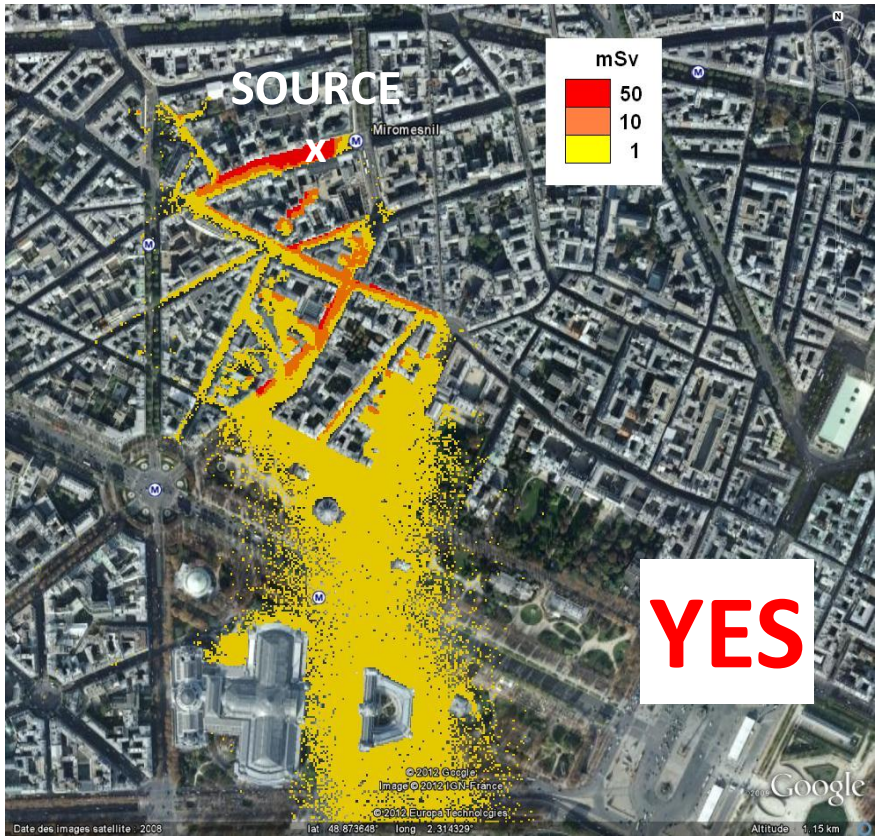
Exercise with the Paris Fire Brigade

Fictitious explosion of a “dirty bomb“

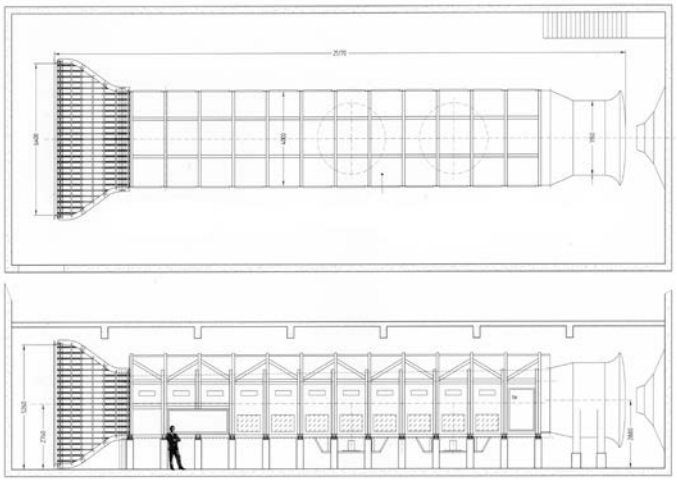




Cobalt-60 dispersion and dose evaluated using type I (left) and II (right) models

(wind from the North – source term due to the explosion from the ground to 20 m – 10 TBq)

WT data for model evaluation



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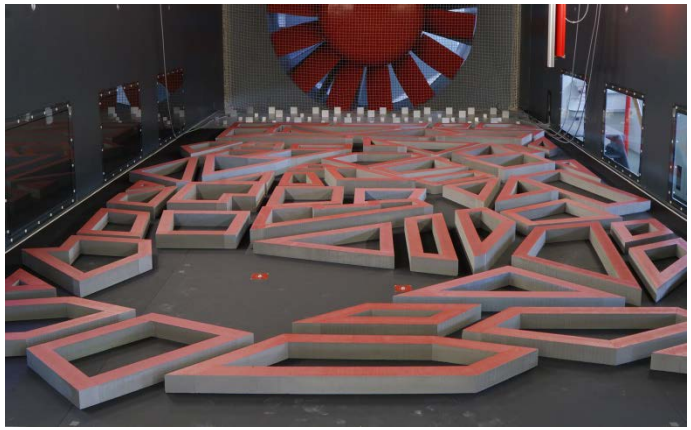
1st data set

Michelstadt:

- virtual town
- aspect ratios typical for central European cities
- roof type: flat roofs
- building height: 15 m, 18 m, 24 m
- building width: 15 m
- street width: 18 m, 24 m
- idealized urban roughness in the scale 1:225

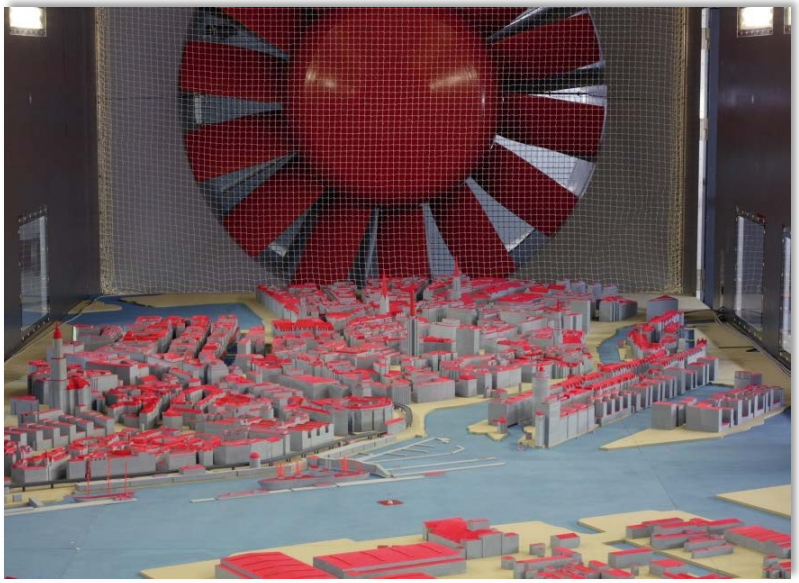
Vienna



2nd data set

Complex urban terrain experiment (Cute):

- wind tunnel measurements
  - model scale 1:350
  - 1.4km x 3.7km
  - wind direction 235°
  - puff and continuous releases
  - three source locations
- field measurements
  - 45 minute release
  - source on a boat
  - 20 measurement locations



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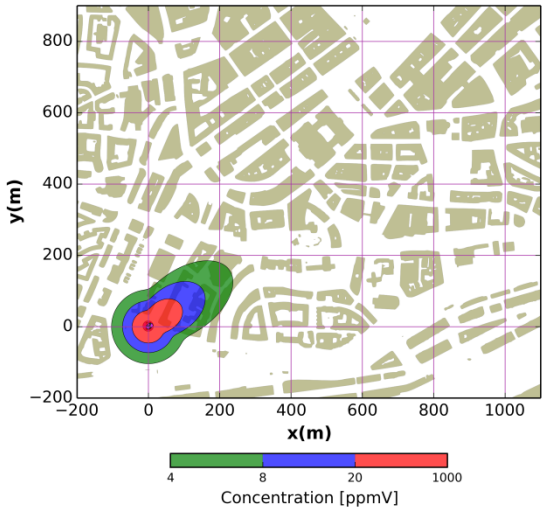
Results of the model evaluation exercises

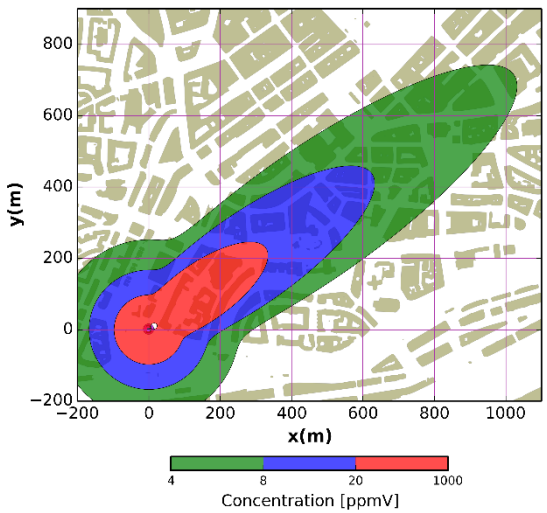
Python Package with validation metrics

An ad-hoc tool for comparing physical measurements and results of numerical simulations was developed

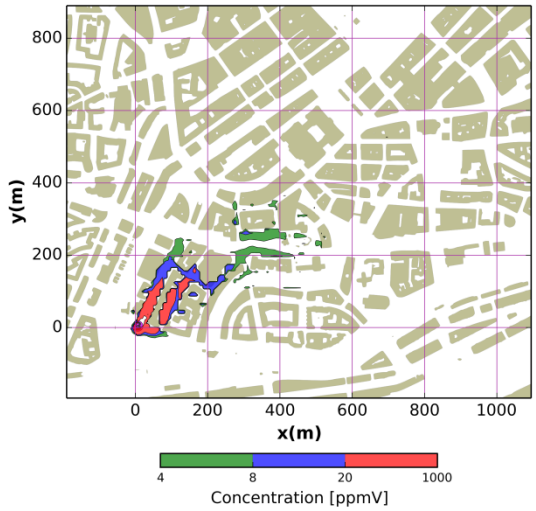
CUTE – blind test, continuous release

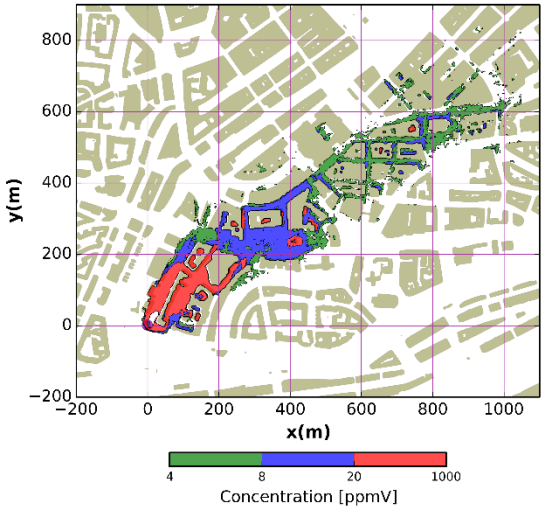
Type I



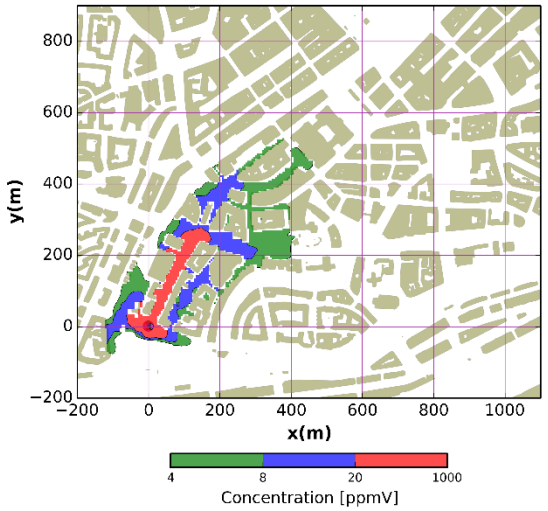


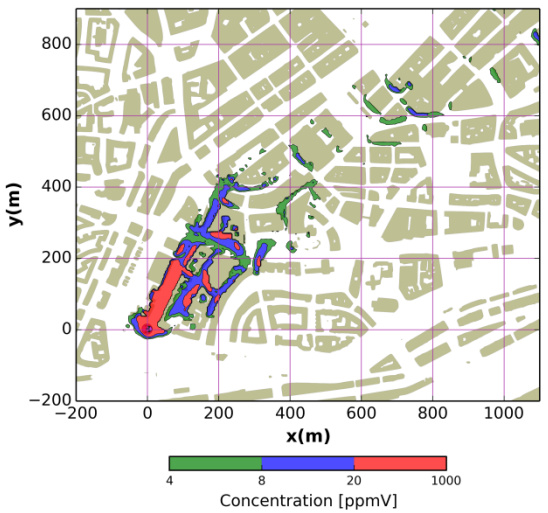
Type II





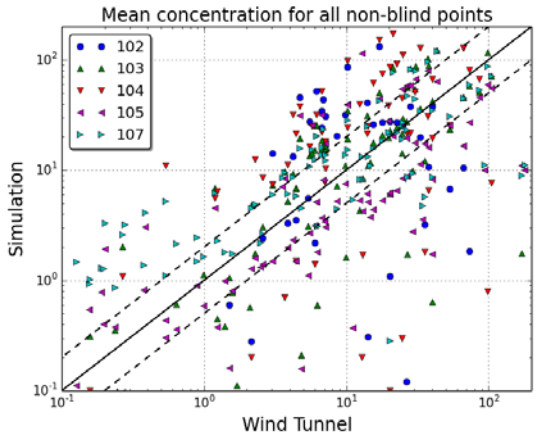
Type III



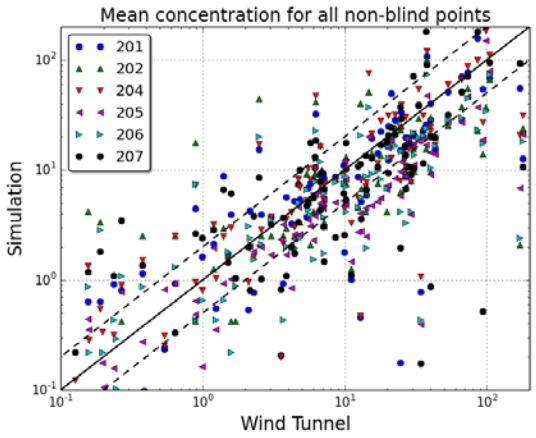


Michelstadt – **non-blind** test, continuous release

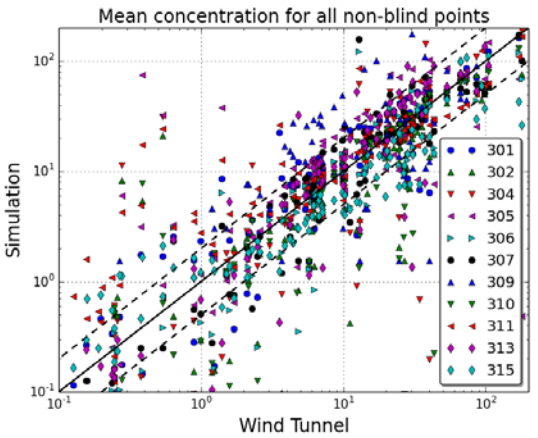
Type I



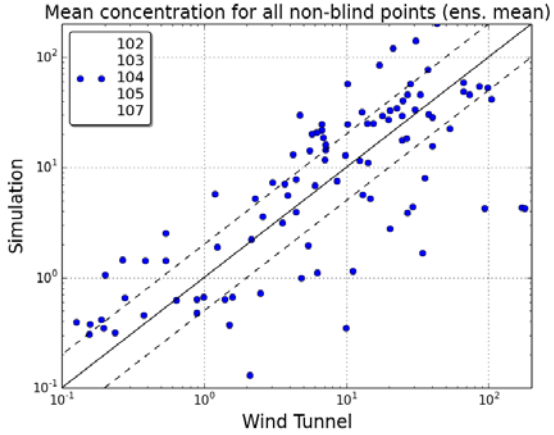
Type II

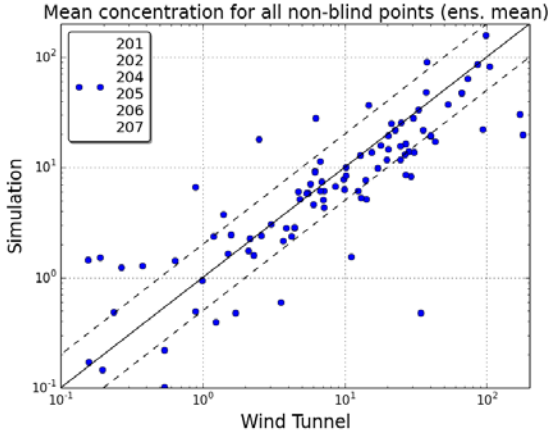


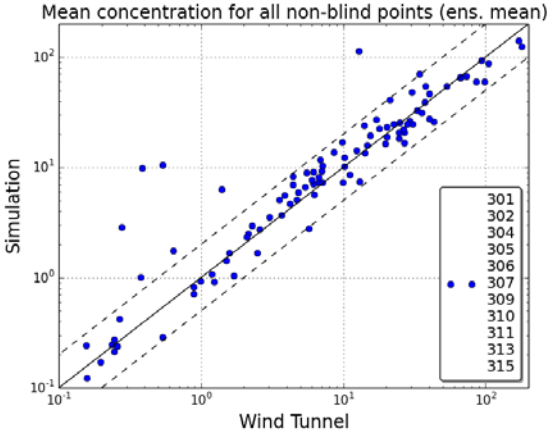
Type III



Mean concentration, all points







Mean concentration, ensemble average

What we have learnt:

- the model performance is influenced significantly by the location of sources and receptor points, *due to the complexity of the geometry*
- metrics are within the acceptance values for most models
- the model performance increases with increasing model complexity
- difference was observed between the blind and non-blind tests, *but not systematic*
- consistency of results increases with model complexity, *for more advanced type, results of different models look more similar*

WT experiments – sensitivity analysis

Type I

- sensitivity studies varying surface friction velocities, surface roughness and approach flow directions

Type II

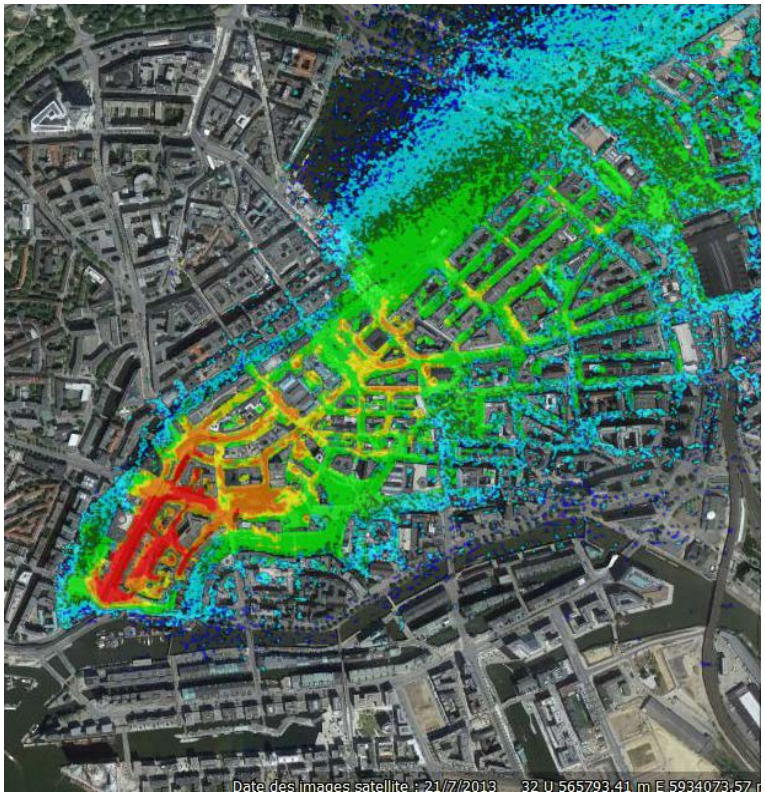
- model runs with the same model in different configuration by different users
- different elaboration of available inputs: turbulent kinetic energy, mean wind

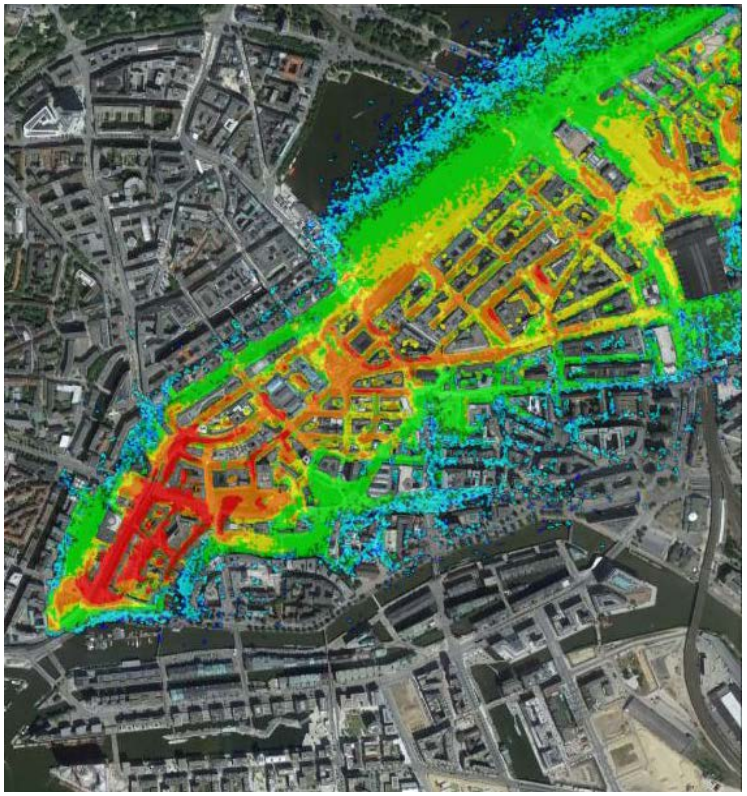
Type III

- model runs with different spatial resolution of the simulation
- evaluation of the variability of puff releases with the most complex LES-based models

Main outcomes: the importance of (1) having access to appropriate meteorological input data for achieving more reliable simulations of accidental releases (2) having the option to assess observations and predictions uncertainties (3) characterizing as well as possible the source term

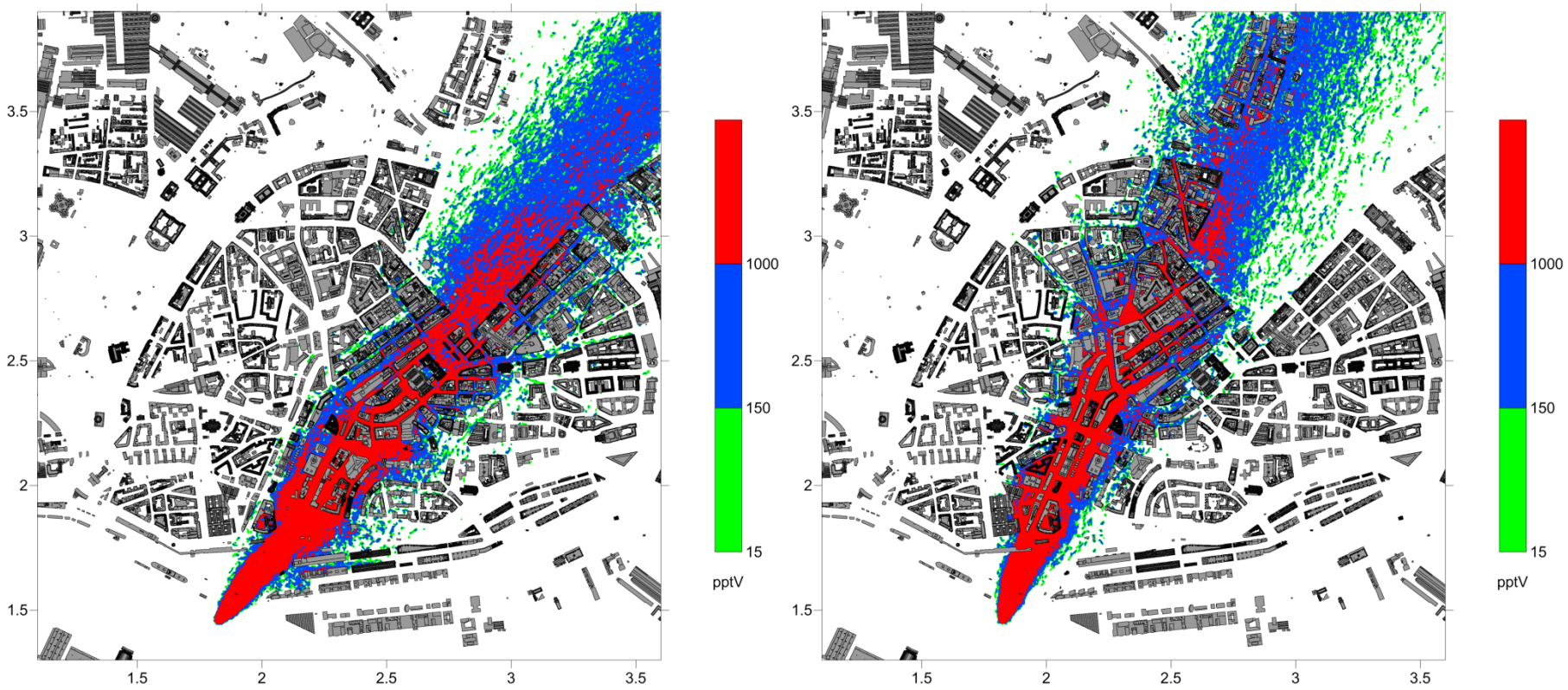
A field test – CUTE 1





Comparison of concentration field with two turbulence inlet profiles, Type II models

A field test – CUTE 1



Model 206a, left: vertical wind profile from the mast available measurement **only** at 175m, the direction is homogenous in vertical

Model 206b, right: wind profile having directions that vary in the vertical, made from **all** available data from the weather mast

Type II models. Comparison of concentration field with two wind inlet profiles

A field test – CUTE 1

What we have learnt:

- the intrinsic variability of atmospheric motions makes the comparison more critical
- sensitivity to input data: non-representative reference measurements may heavily affect the performance and response of the models
- …….. real life is turbulent and difficult …..

Conclusions

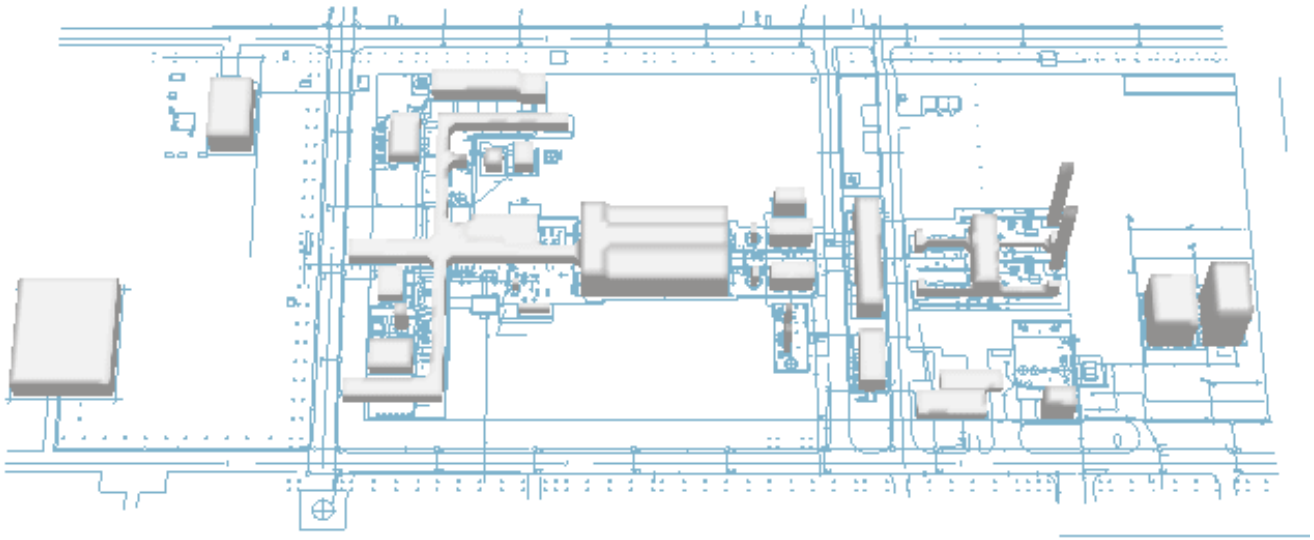
- despite uncertainties, models represent a valid tool to better support handling of emergency situations
- a higher level of physical description in a model is worthwhile to achieve higher simulation accuracy, also in difficult scenarios like emergency response
- choice of model/modelling approach is always a compromise between performance, reliability and response time
- different modelling approaches are used in the different phases of the response process
- more reliable results from complex models facilitate better emergency response

Conclusions - I

- *most advanced models (Type III) still need long computation and preparation time and might not be applicable directly in the emergency response phase, where a fast simulation result is required;*
- *for puff/complex environment … simplest models (Type I) show a tendency to underestimate, this being a relevant issue for emergency response management, where a conservative approach is usually preferred;*
- *'intermediate models' (Type II) are more physically-based and have better performances than simpler ones, still offering a relatively fast response*

Accident Gas RElEase - *AGREE*

A database for the simulation of a Real Accident



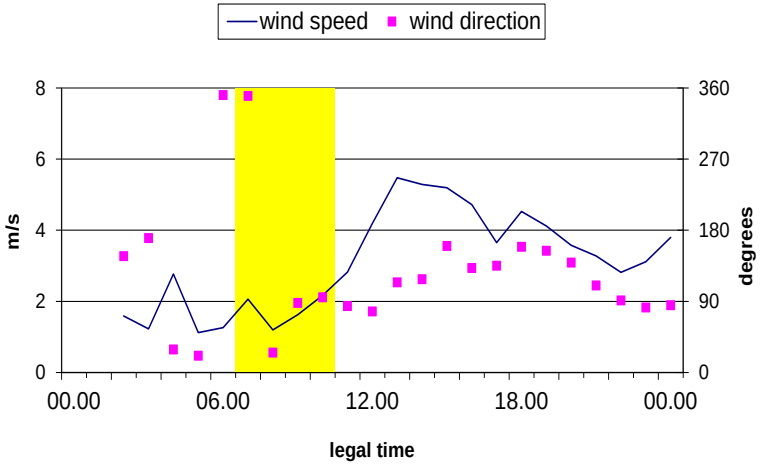
Brief description of the accident

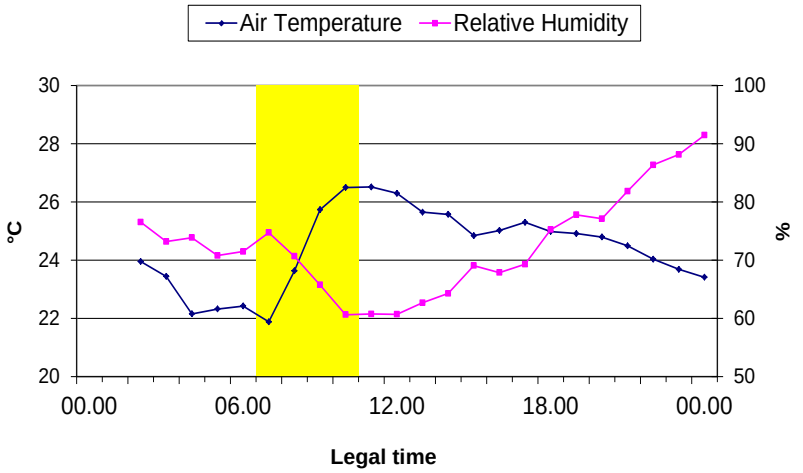
An accidental leaking of Vynil Chloride Monomer, an highly toxic industrial chemical used to produce the polymer PolyVinyl Chloride (PVC) took place in a chemical facility.

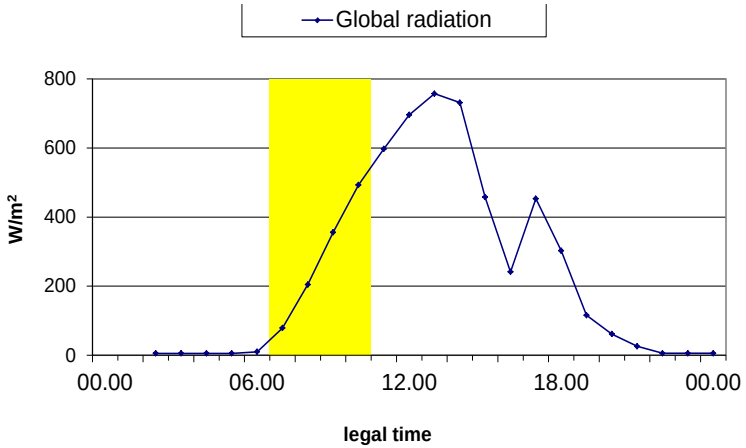
The substance was released inside a partially open building in a liquid state and partially evaporated causing high concentration in air outside the building, measured by the local VCM automatic monitoring network installed around the plant, causing an alarm state and the intervention of Firemen.

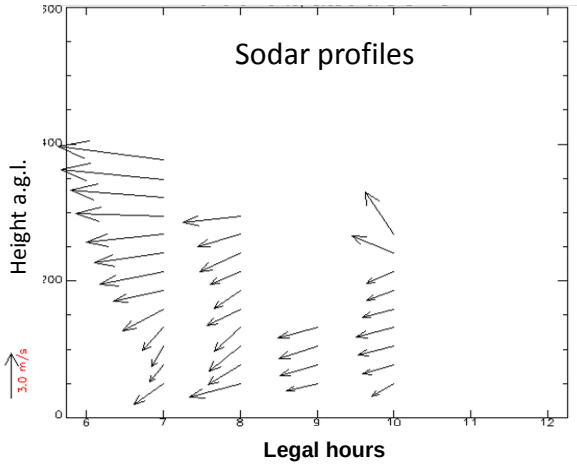
The accident was managed by both internal and external emergency teams and closed after about 50 minutes

Example of meteo data





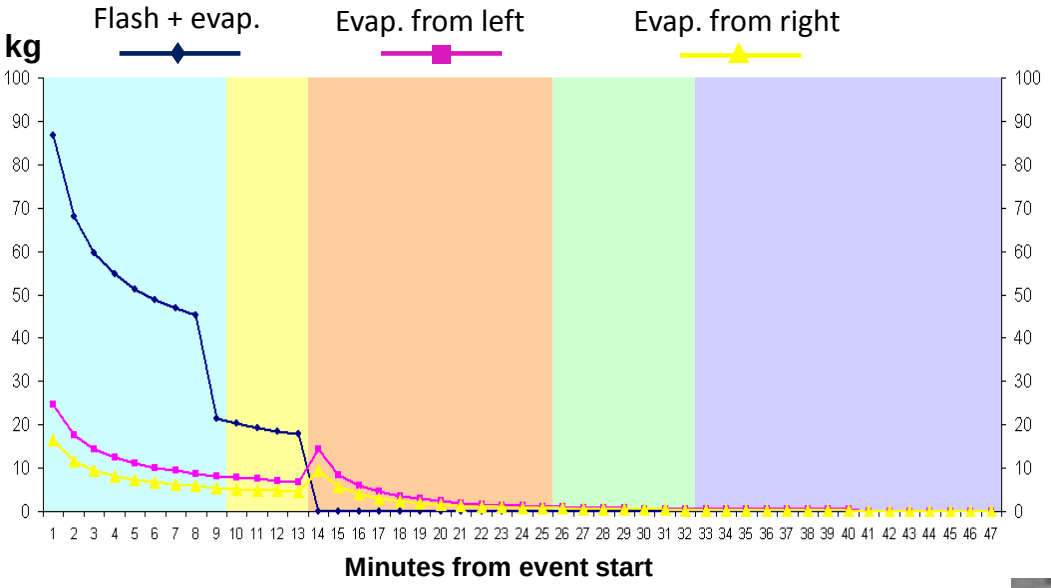




…. but there are 4 different meteo stations available, model users were left free to make their choices ….

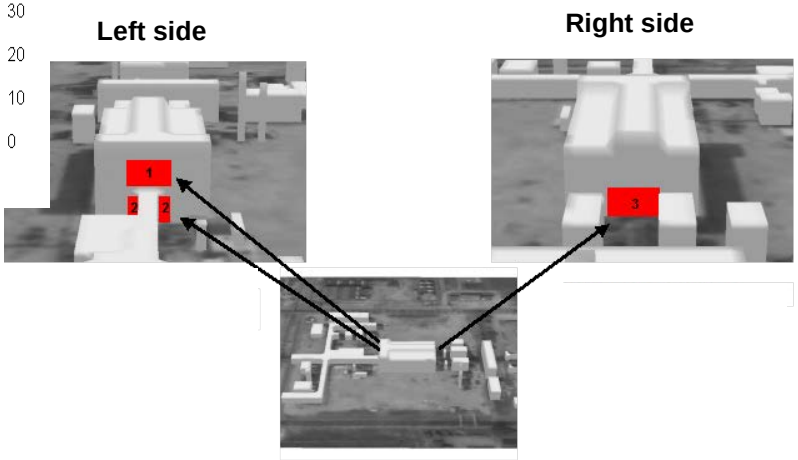
Emission scenario

A relatively detailed estimation of a time-dependent behavior of the emission was calculated and is available for modelers. The release can be treated as a neutral gas



This represents a 'first guess' scenario based on the information available just after the event

Time dependent emissions



Emission regions

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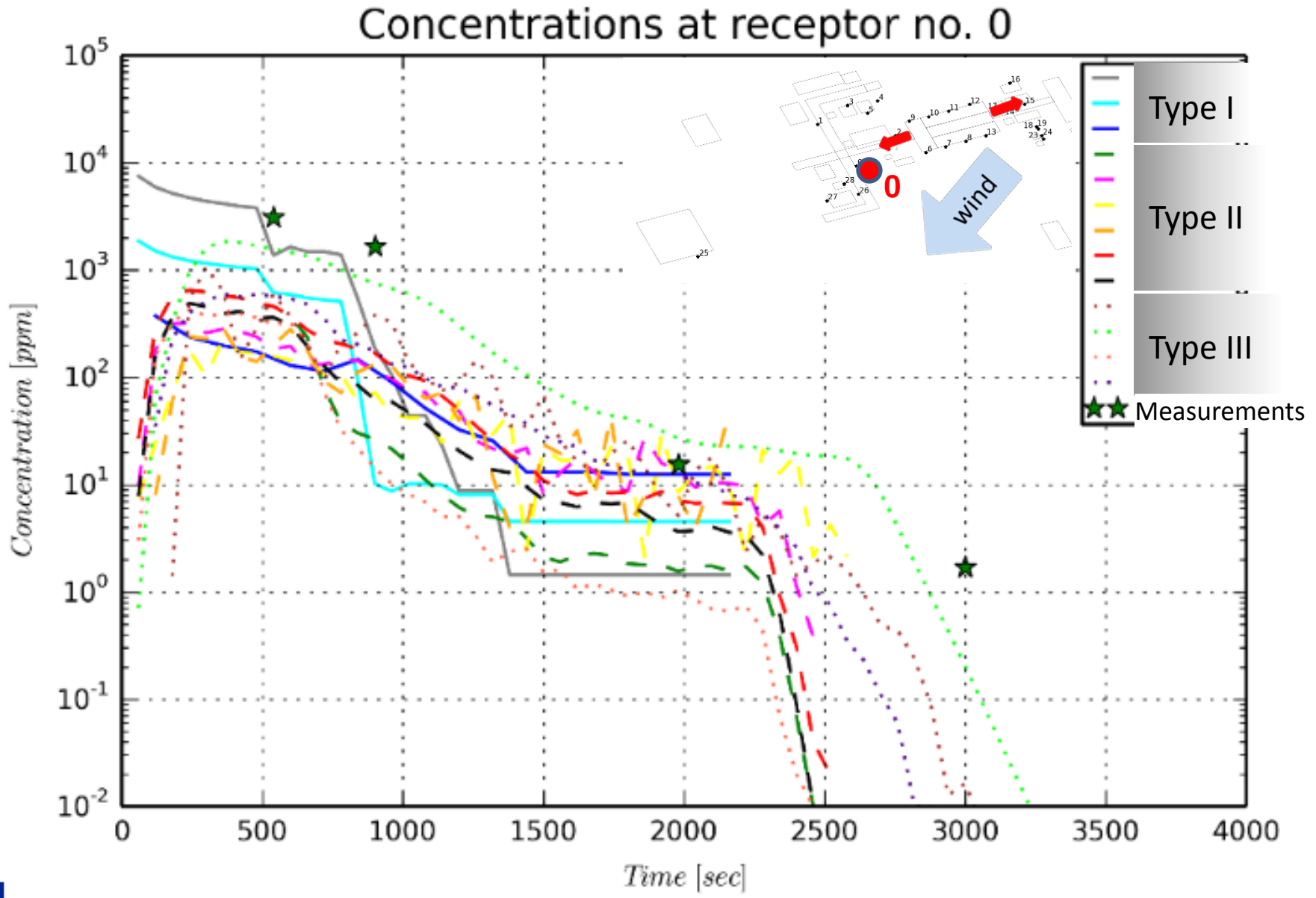
Compare models/measurements



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Summary

- AGREE is NOT an evaluation data set.
  Large input uncertainties
  BUT: it is a valuable test case from a typical industrial site
- Close to the source, Type I models fail in predicting the spread of the plume influenced by the buildings.
- All models tend to underestimate the measured concentrations in this case. Results might be improved with an improved source term estimation.
- Concentrations time-series from most Type II and Type III models are in good agreement with measurements.
- Type II and Type III models predicted a wide lateral spread of the plume. This was confirmed by the measurements.
- Representative meteorological measurements with higher temporal resolution than hourly data are recommended.