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16th International Conference on
Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes
8-11 September 2014, Varna, Bulgaria

COST ACTION ES1006
Evaluation, improvement and guidance for the use of local-scale emergency prediction and response tools for airborne hazards in built environments.

presented by Silvia Trini Castelli for COST ES1006
CNR – ISAC, Torino, Italy

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The motivation

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Accidental or deliberate releases of hazardous materials in populated areas induce a growing concern in the society.

Instantaneous accidental releases from ……

- Industrial sites
- Energy facilities
- Transportation of hazardous materials
- Terrorist attacks

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Accidental or deliberate releases of hazardous materials in populated areas induce a growing concern in the society

Instantaneous accidental releases from….

- industrial sites,
- energy facilities,
- transportation of hazardous materials
- or even a CBRN (Chemical-Biological-Radiological-Nuclear) terrorist attack

…. can lead to catastrophic consequences in terms of population casualties and damage to ecosystems and infrastructures.

Dealing with such releases is complicated by the need for a fast and at the same time sufficiently accurate emergency response tool.

The Emergency Response Tools…

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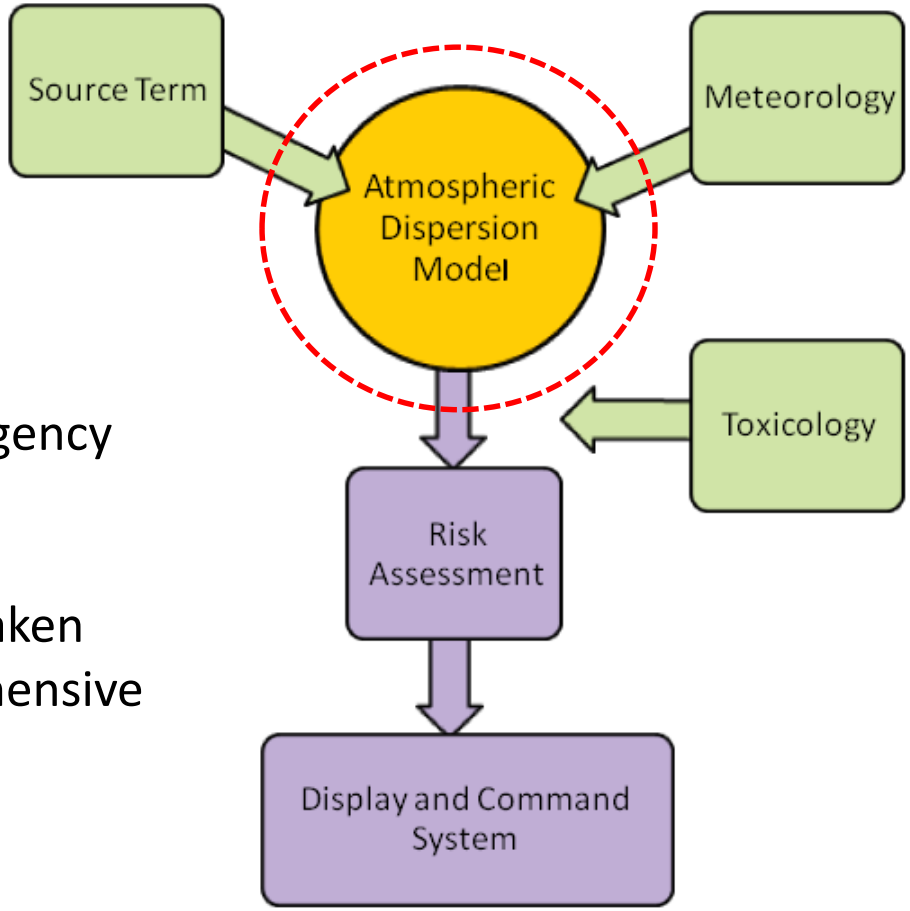
Emergency response tools take the form of fully integrated management systems, or modular concepts that have interfaces between the individual components.



They all have to provide the means to:

- Characterise potential hazards;
- Manage the logistical aspects of emergency incident response;
- Account for different types of release;
- Document the decisions and actions taken during an incident, to facilitate comprehensive post-incident analysis.

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… and the dispersion models

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A crucial part of a state-of-the-art emergency response management tool is represented by the **airborne hazards dispersion models**

these, combined with sensors that detect and measure hazardous material concentrations are the backbone for any comprehensive emergency management system.

One of the biggest scientific challenges in local-scale emergency response remains the prediction of airborne hazards dispersion from accidental or deliberate releases at the very local scale, especially within complex environments.

If dispersion of agents and resulting threats are unknown, all subsequent steps of modern emergency response and management quickly become questionable, inefficient and maybe even threatening for first responders.

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The keywords: accidental, local scale, built environments

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Due to its unexpected nature, an **accidental release** is a complex phenomenon and a challenging situation to handle.

*.... A highly **problematic** scenario unfolding in an **uncertain** frame.*

At the **local scale**, the situation is typically complicated by the following factors:

- the duration of the release is often very short
- the emission characteristics of the source are only partially known
- the local meteorological conditions are not readily available at the desired level of accuracy, and are subject to constant change
- the response time in which to mitigate the effects of a release is short
- the release occurs in a complex industrial or urban environment

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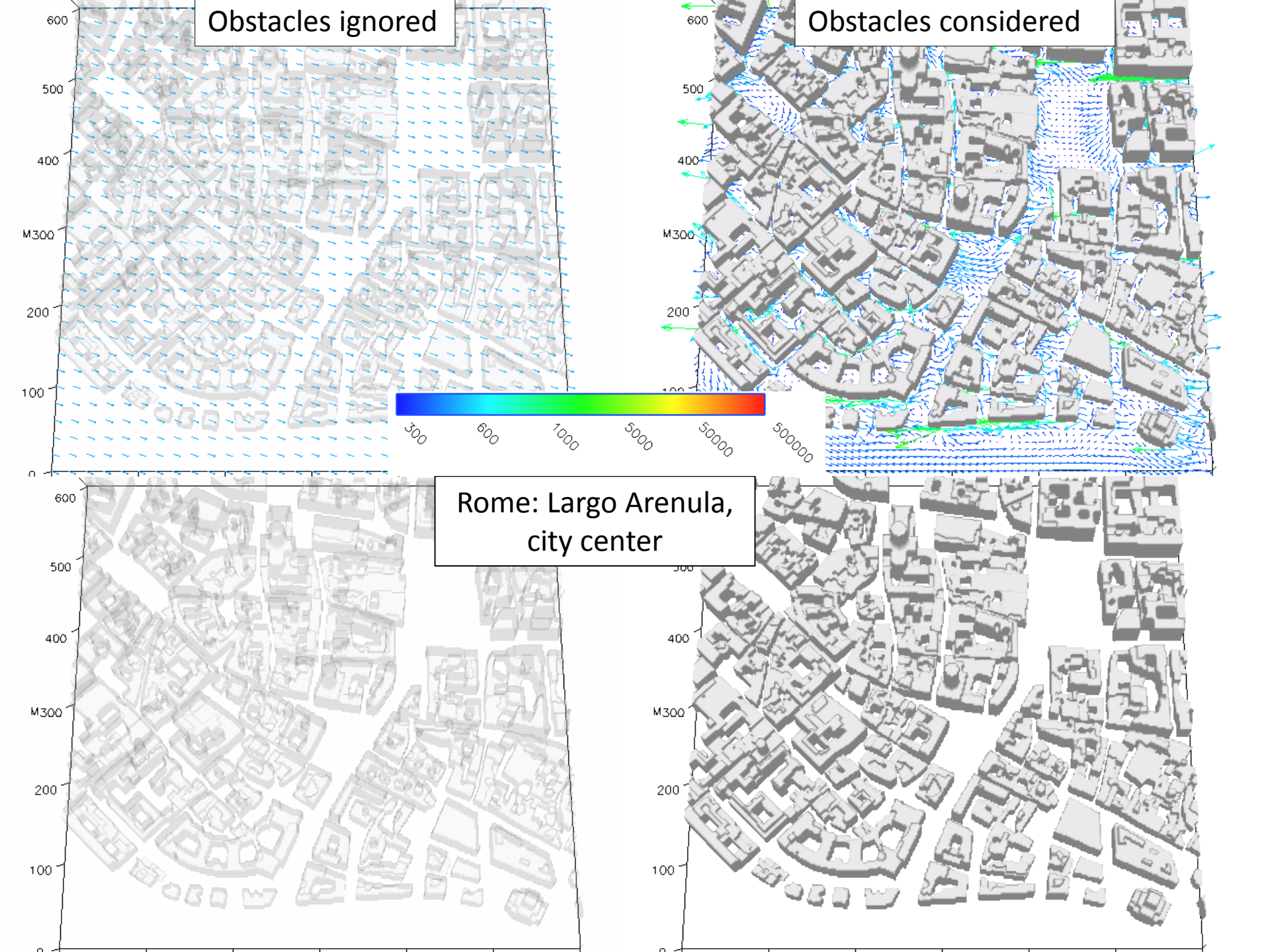
Obstacles ignored
Obstacles considered
600
500
400
M300
200
100
0
300
600
1000
5000
50000
500000
Rome: Largo Arenula, city center

The focus and aims in practice

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The **main focus** of COST Action ES1006 is **to improve the quality and robustness** of local-scale predictions of airborne hazard dispersion from accidental or deliberate releases in complex urban and industrial environments.

The Action **aims** at establishing a **HARMONIZED** scientific and methodological reference for local-scale airborne hazard modelling for the **three response phases**: (1) pre-accidental analysis and planning (2) actual emergency response; (3) post-accidental analysis , through:

✓Improving the scientific basis behind local-scale dispersion modelling;

✓Developing an inventory of models and modelling systems;

✓Developing comprehensive practical guidance for using models to track and predict the dispersion of airborne hazards.

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The **Background document** is.....

- Identifying and illustrating the present and future threats and the challenges related to their handling

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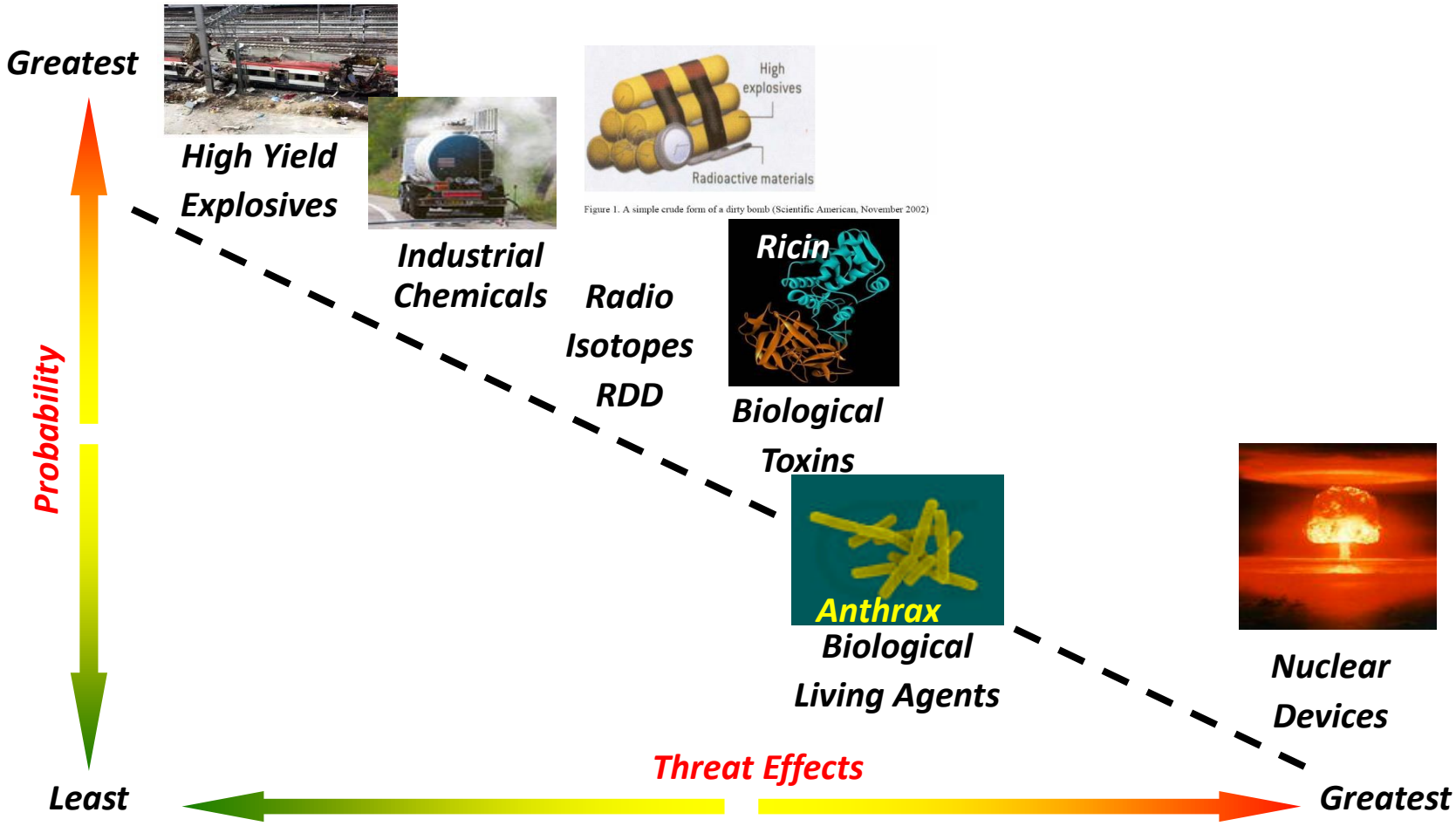

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The **Background document** is.....

- Identifying and illustrating the present and future threats and of the challenges related to their handling
- Introducing, reviewing and discussing the different modelling approaches and tools currently in use or under development

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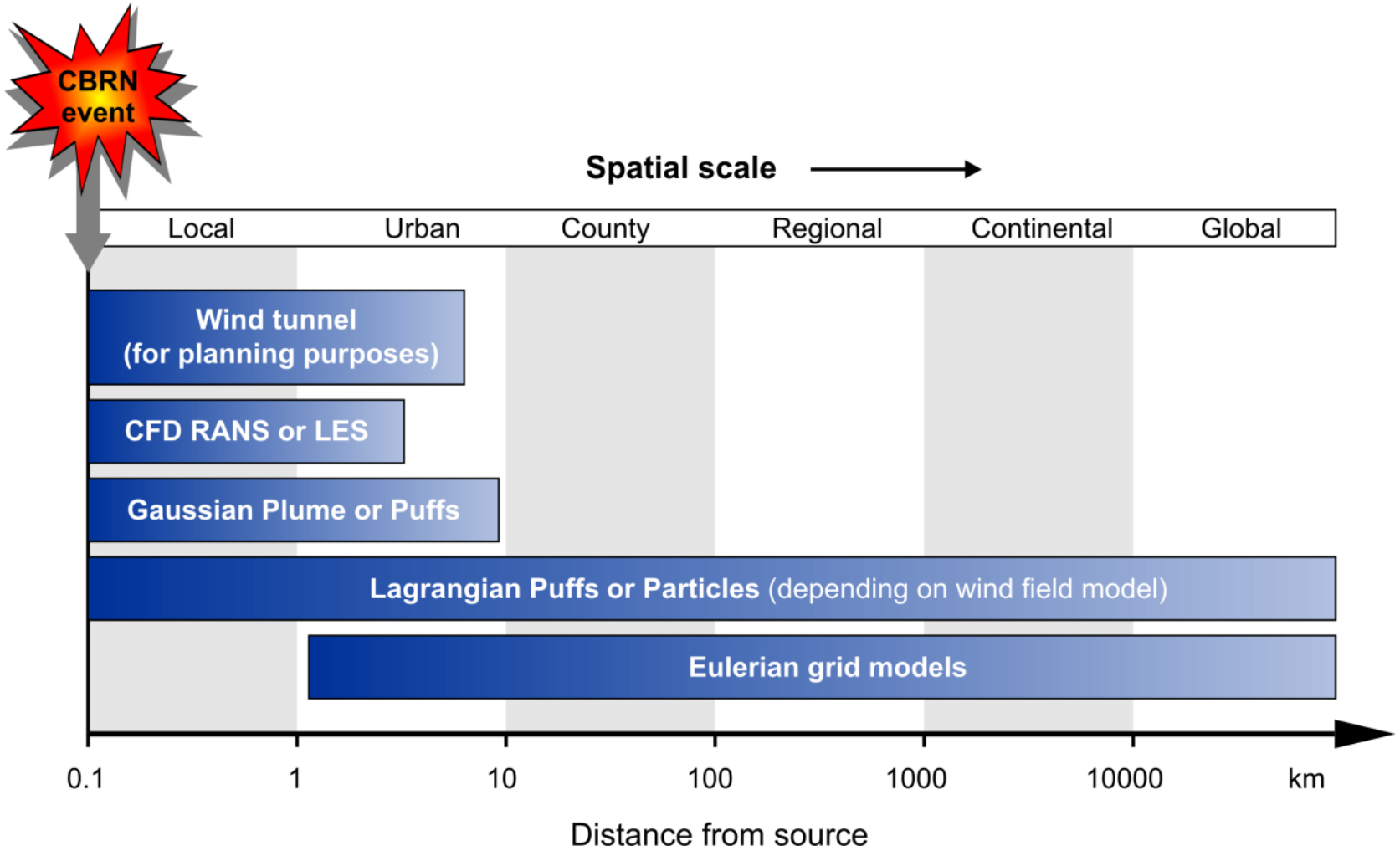

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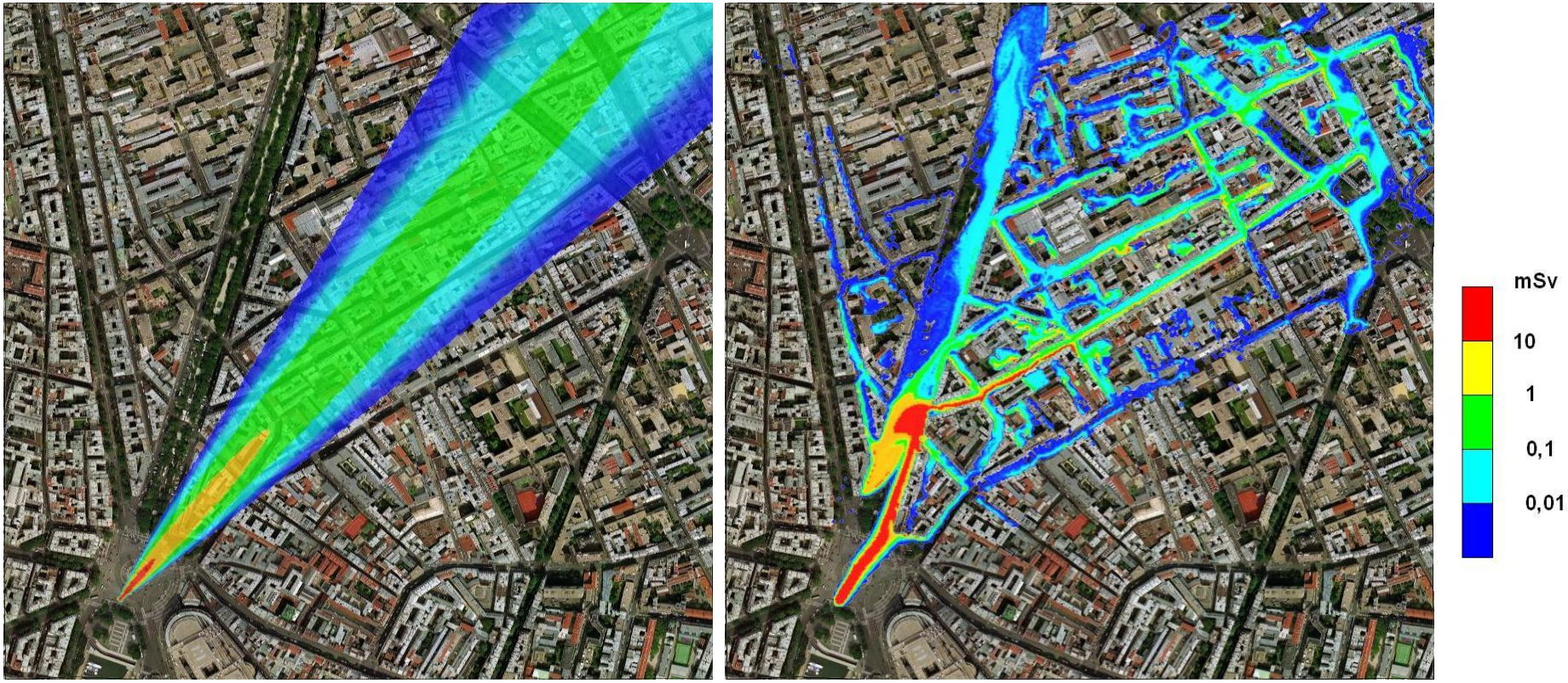

Total Effective Dose Equivalent (in mSv) resulting from the atmospheric dispersion of a radiological threat agent (3 TBq of ^{137}Cs) as seen by a simple Gaussian model and by a Lagrangian Particle Dispersion Model taking the buildings into account

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The **Background document** is.....

- Identifying and illustrating the present and future threats and of the challenges related to their handling
- Introducing and reviewing the different modelling approaches and tools currently in use or under development
- Exporting the analysis to specific problems related to the dispersion modelling for emergency planning and response

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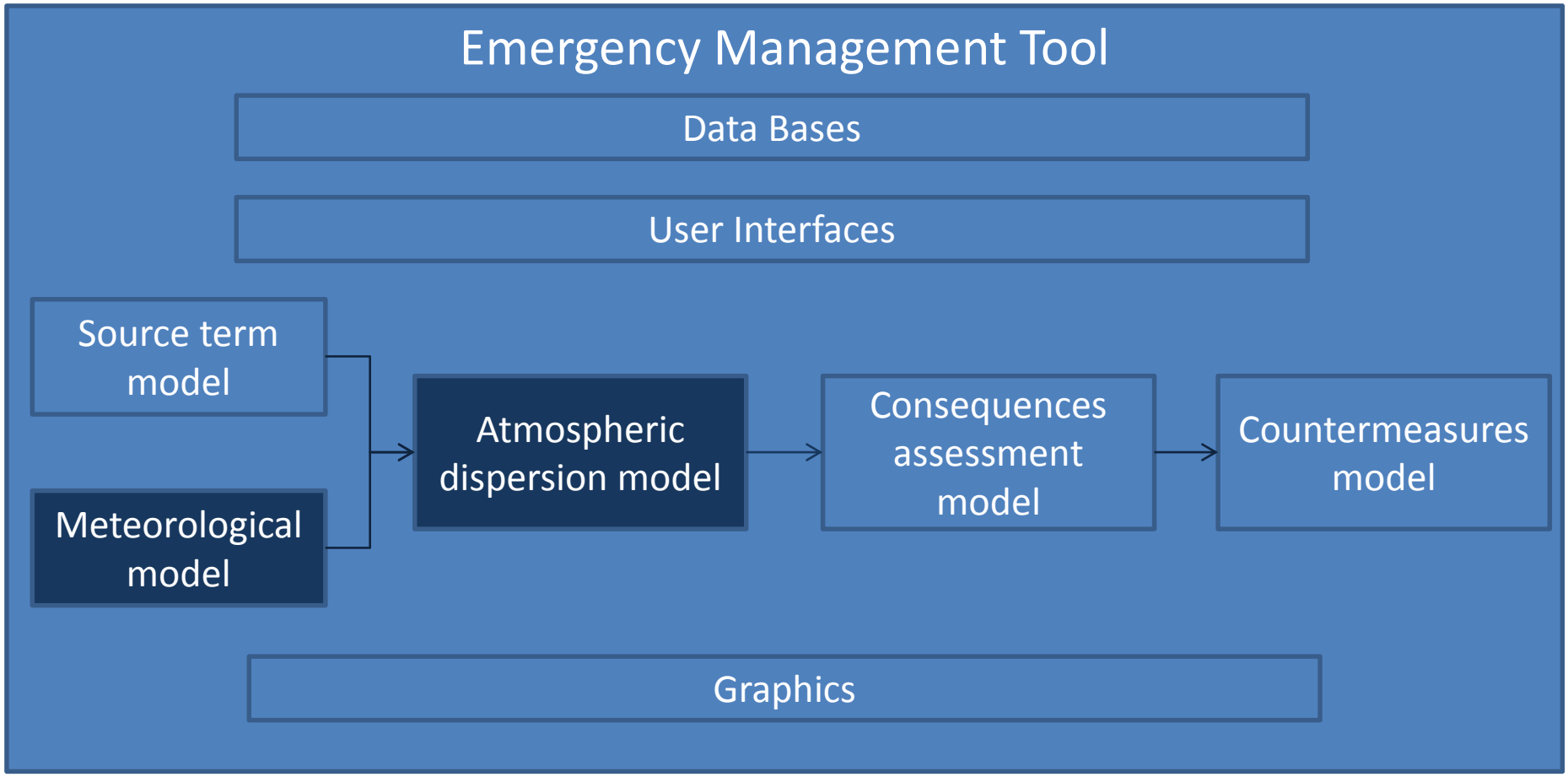

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The **Background document** is.....

- Identifying and illustrating the present and future threats and of the challenges related to their handling
- Introducing and reviewing the different modelling approaches and tools currently in use or under development
- Exporting the analysis to specific problems related to the dispersion modelling for emergency planning and response
- Addressing the uncertainties related to the application of modelling systems in emergency response framework

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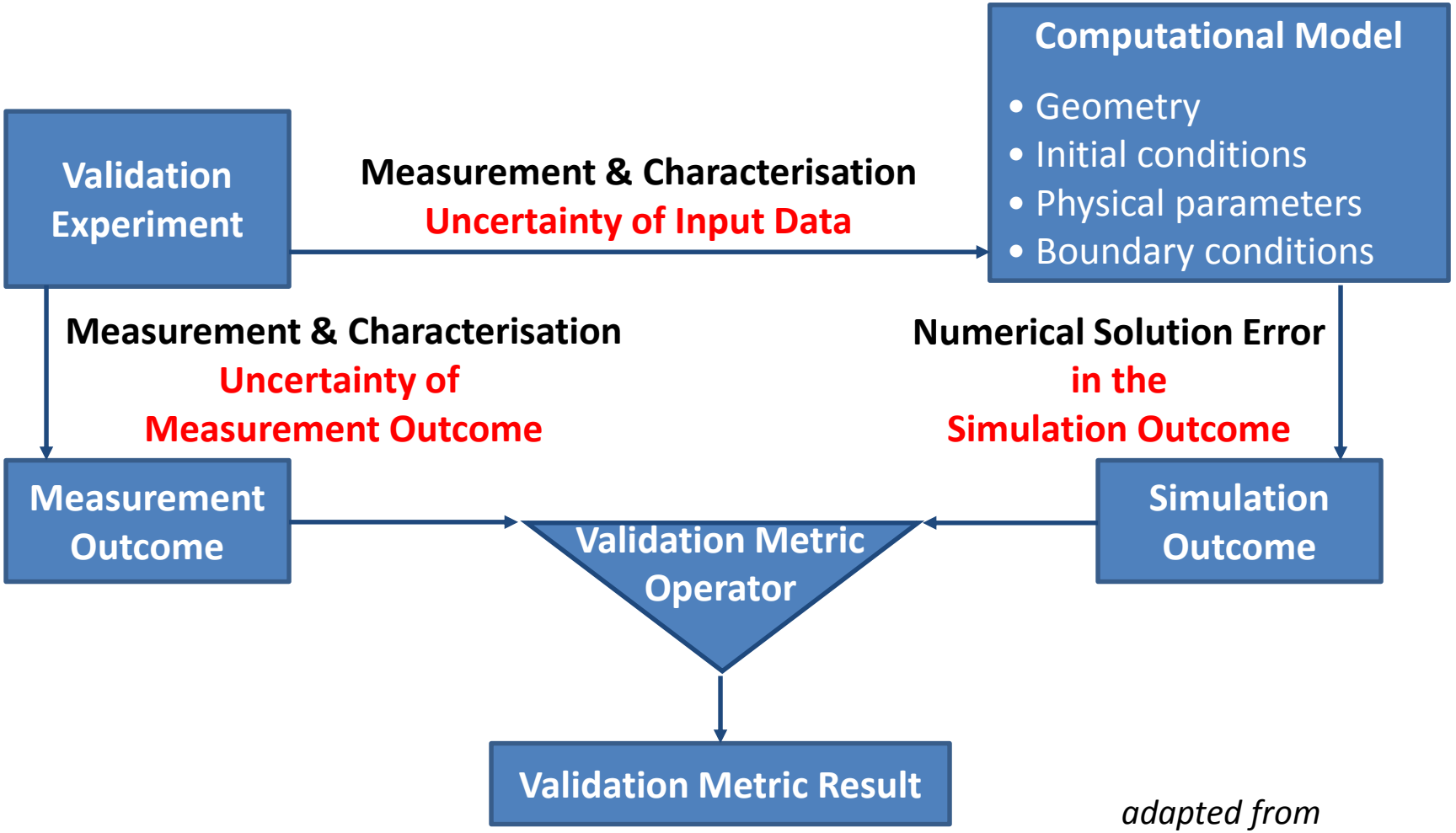

adapted from
Oberkampf and Roy (2010)

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The **Background document** is.....

- Identifying and illustrating the present and future threats and of the challenges related to their handling
- Introducing and reviewing the different modelling approaches and tools currently in use or under development
- Exporting the analysis to specific problems related to the dispersion modelling for emergency planning and response
- Addressing the uncertainties related to the application of modelling systems in emergency response framework
- Outlining the practical constraints, regulations and legal issues and the framework for their implementation

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The **End-users and stakeholders questionnaires**

Objectives:

- To inventory models, tools and methodologies **currently applied** in the context of emergency management and local-scale threat reduction

- To identify the **practical problems** encountered by first responders, personnel of civil protection, security management and other stakeholders when confronted with output from modelling tools

  - Who uses hazmat models?
  - Which models/tools?
  - Planning? Emergency? Training?
  - Experiences?
  - Data for model evaluation?
  - Requirements for further development?

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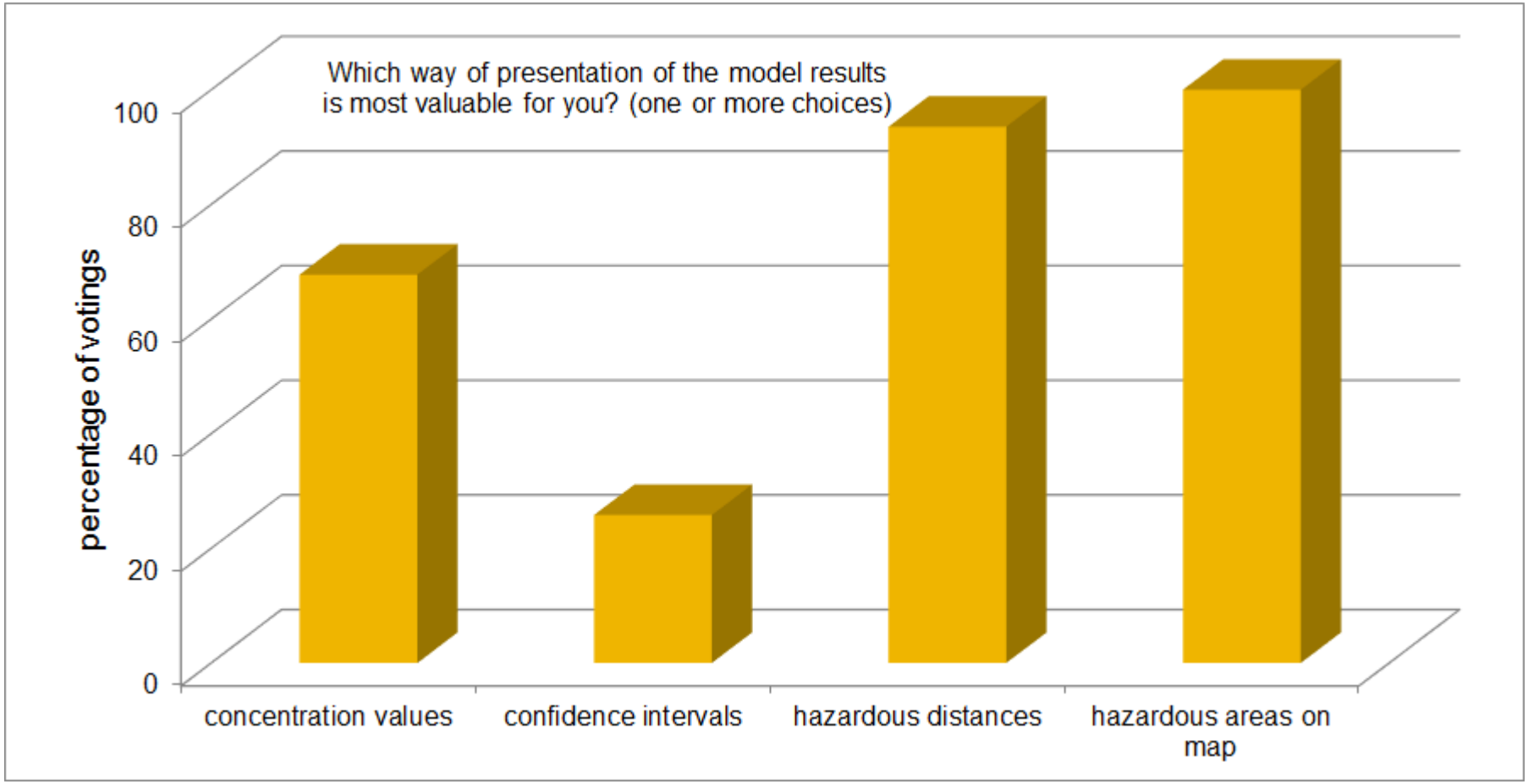
The End-users and stakeholders questionnaires



"Emergency models have to be simple, robust and fast, user-friendly interface with on-line help, potential damage zones on google map"

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The Inventory of emergency response tools and dispersion models

ERMIDT

the Emergency Response Models and Tools Inventory Database Tool

- A dedicated model inventory was established after a catalogue of the state-of-the-art of emergency response tools for airborne hazards from accidental/deliberate releases in complex urban and industrial areas was compiled

- The inventory is elaborated inside an user-friendly excel file

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Emergency Response Modelling Tools Inventory Database Tool (ERMIDT)

Read this first:

The **Emergency Response Modelling Tools Inventory Database Tool** (**ERMIDT**) was developed in the frame of the COST Action ES1006 and aims listing the different emergency computational tools and models (**ECT&M**) currently available and applied to support Emergency Response and Planning in case of accidental or deliberated release and dispersion of hazardous gases in built-up areas.

Taking into account the wide variety of existing ECT&M and modelling approaches, the ERMIDT includes both a short and long description of each type of Models and Tools.

The ERMIDT integrates the following data-sheets:

1 – ***Info*** – General ERMIDT Information
2 – ***DS*** – Database Summary of Compiled ERCT&M
3 – ***ERCTD*** – Emergency Response Computational Tools Database
4 – ***MMD*** – Meteorological Models Database
5 – ***STMD*** – Source Term Models Database
6 – ***DMD*** – Dispersion Models Database
7 – ***CRMD*** – Consequences and Risk Models Database
8 – ***Comments***

ECT&M developers and users are invited to fill the information regarding their models to be integrated in the ERMIDT and send it to the COST Action

Examples and supplementary comments are indicated in italics.

ES1006 contact person for questions & information:
Richard Tavares (richard.tavares@ec-nantes.fr / tavaresram@gmail.com)

The results achieved today - IV

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The **Inventory of observational databases**

- **Elaboration** of an inventory of the available databases from experimental campaigns: *discussion and identification of useful ones for emergency response, addressing…*
  - ✓ *How to test hazmat dispersion model?*
  - ✓ *How to choose validation data set?*
  - ✓ *Which additional data are required for the validation of an emergency response model?*

➢ *the best is to produce own dedicated data set → Michelstadt*

➢ *the second best is to choose well documented experiments/accidents*

- **Selection** of case studies for the modelling exercise in COST ES1006 Action
  - ✓ *Test case 1: idealized European city, Michelstadt case*
  - ✓ *Test case 2: real European city*
  - ✓ *Test case 3: industrial site – real accident AGREE*

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The Package with validation metrics

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

Main features of the tool are:

1. "User friendly" as well as "Advanced user" program;
2. as general and flexible as possible, applicable to flow and dispersion models of any complexity, with different outputs (object oriented programming);
3. built in order to easily include more developments, such as additional metrics, additional plots etc;
4. developed to be used both under Linux and Windows;
5. including all modules necessary to produce the results (metrics, plots).

Already applied for Michelstadt case study !

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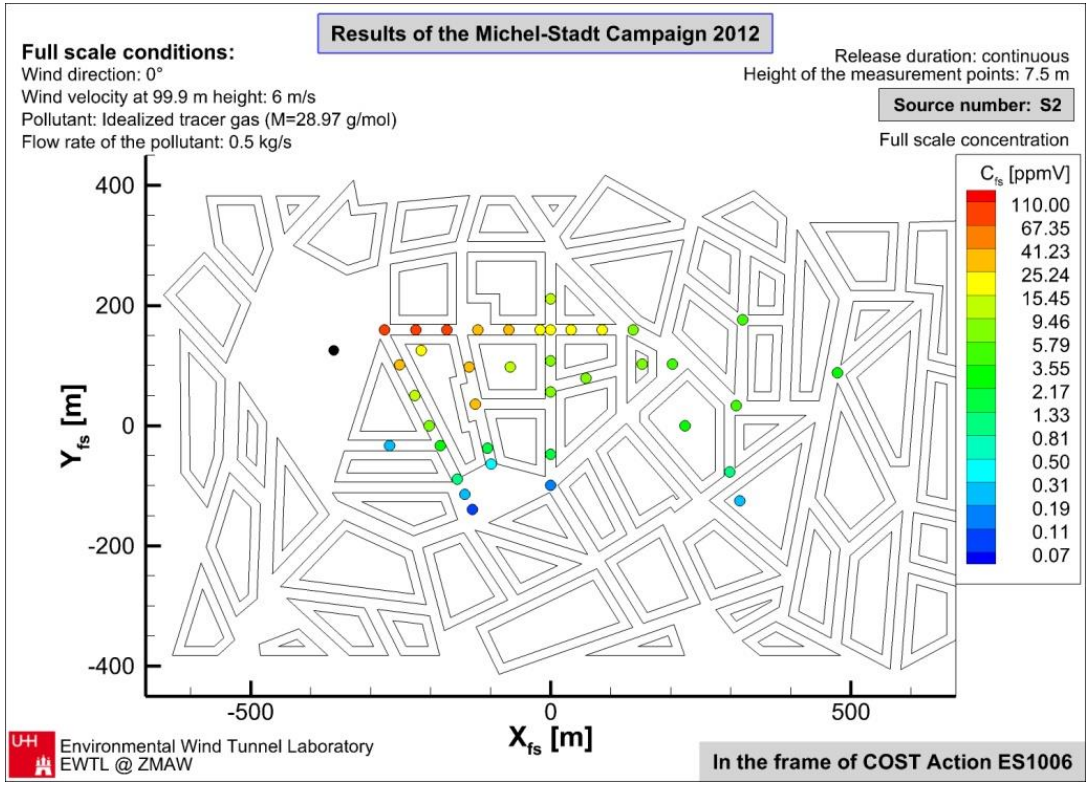
The Michelstadt exercise - Model intercomparison and validation



✓Data gathered during a wind-tunnel flow and dispersion experiment (Hamburg University) – several **continuous/puff releases** in different locations; **non-blind** and **blind** tests

✓A typical **European urban site** is reproduced, designed to include potential inhomogeneities, characterising the neighbourhood-scale urban areas across Europe

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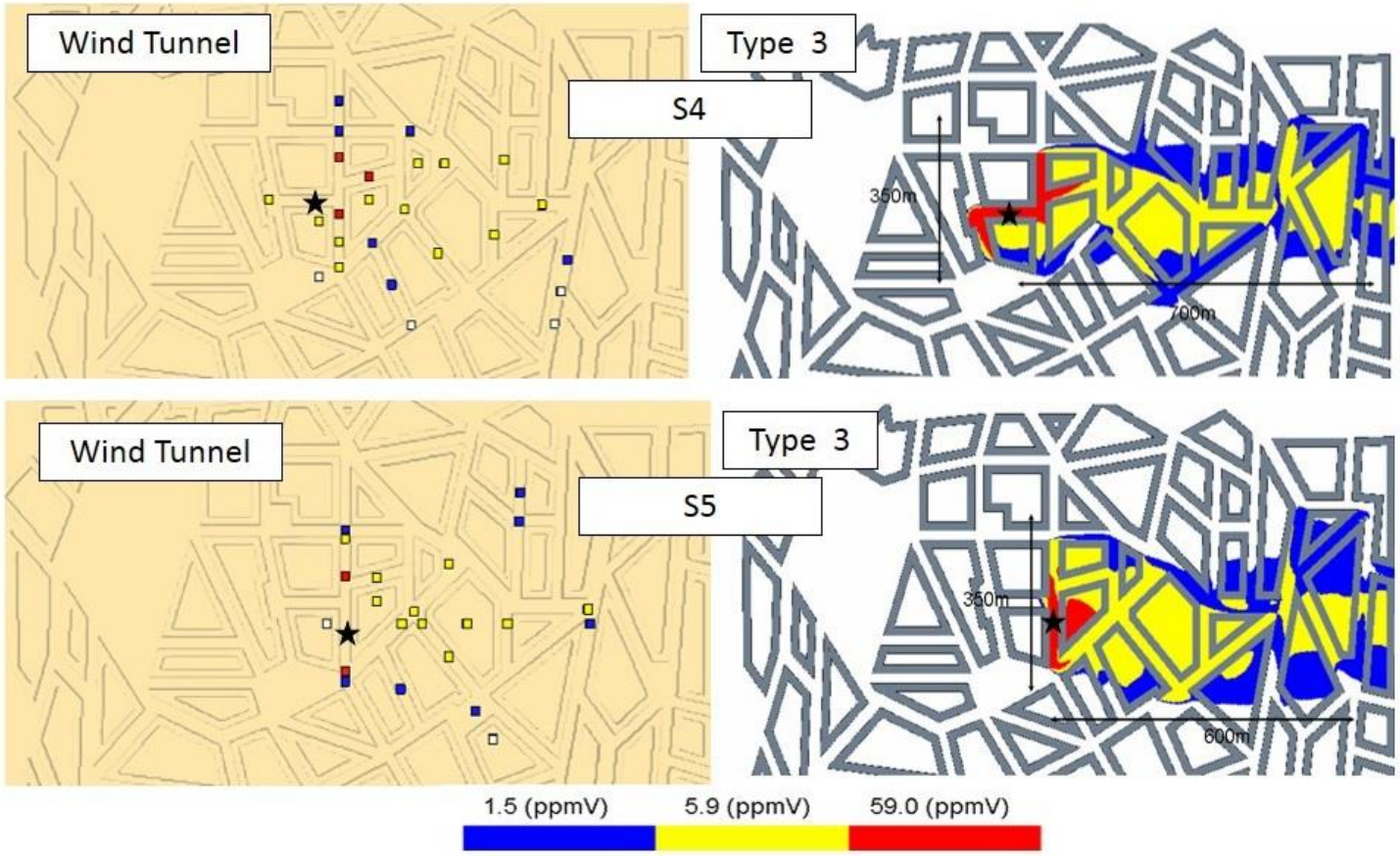
The Michelstadt exercise - Model intercomparison and validation

Modeling approach	Number of models	Dispersion modelling method	Computational time
Type 1	7	Gaussian (2 with building parameterization)	1 -5 min
Type 2	5	Lagrangian	2 min – 5 hrs
Type 3	10 (6 models)	CFD (8 RANS; 3 LES; 1 RANS-Lagrangian)	2 hrs – 4 days



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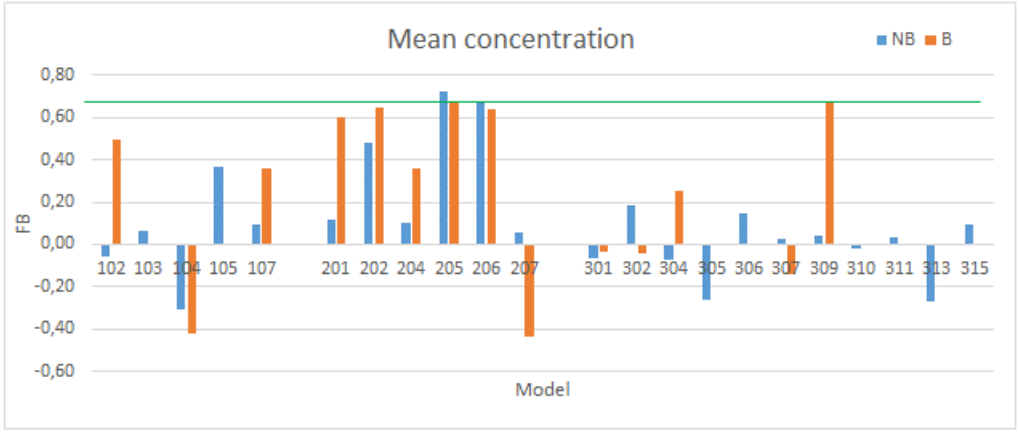
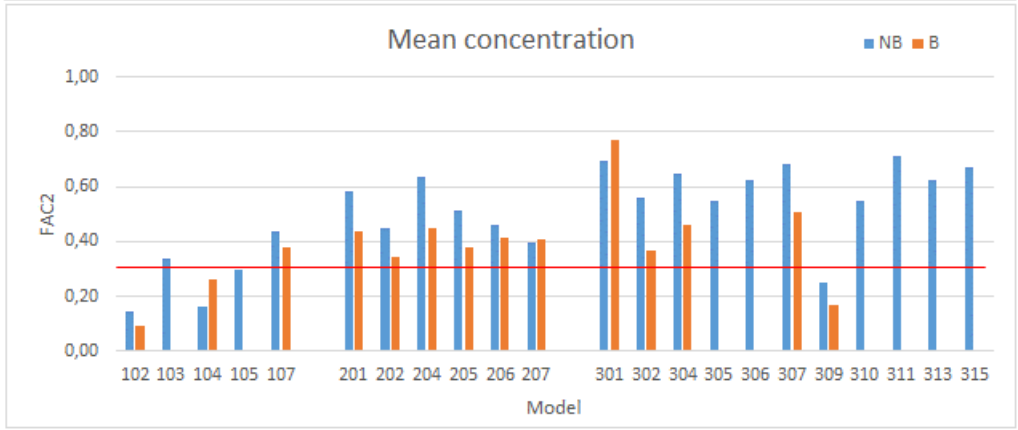
Continuous release





Acceptance values:
FB < 0.67
FAC2 > 0.3

Hanna S. and Chang J., 2013, *Meteorology and Atmospheric Physics*, 116, 133-146

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Modeling approach	Number of models	Dispersion modelling method	Computational time
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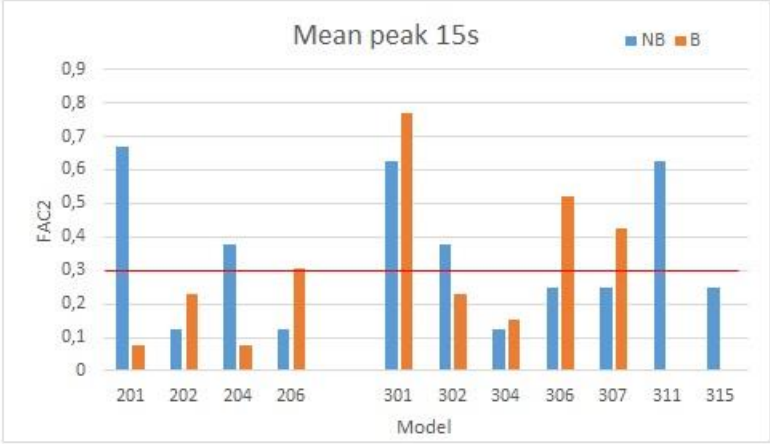
Puffs release



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Hanna S. and Chang J., 2013, *Meteorology and Atmospheric Physics*, 116, 133-146

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The ongoing activity - I

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The Catalogue of Threats and Challenges

A document collecting, documenting and characterizing typical and relevant local-scale threats from releases of toxics in populated areas.

Goal: to guide the model development towards the present and future needs of emergency response management.

What is in:

a description of the conditions and development of potential events, involving releases of the hazardous materials having properties that can lead to negative health and safety effects to the humans being exposed.

Main topics on consequences analysis:

(i) categories of the relevant hazardous properties of chemicals / materials;
(ii) types of the hazardous phenomena likely to occur in the course of the accidental events;
(iii) emission situations leading to releases of the hazardous materials
(iv) sources to be considered in the dispersion modelling and consequence assessment.

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The ongoing activity - II

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The **Best Practice Guideline**

A document providing guidance in how to apply emergency response dispersion models in order to lower the unavoidable uncertainty in simulation results.

Motivation:

to highlight the supporting information provided by ADM in an emergency and to propose practical guidelines tailored to the needs of the emergency responders and decision makers.

General features:

✓dedicated to professionals (first responders, decision makers...) who might have to handle emergency situations involving hazmat atmospheric releases.

✓providing recommendations on how to use ADM / ERT in the preparedness, emergency, and post-accidental phases of release events.

✓formulated in a concise and practical way

✓focusing on complex built environments and local scale dispersion.

✓considering various threats to humans beings and environment according to:

- the type of released agents: C, B, or R-N
- the cause of the event: accidental or deliberate.

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The **Best Practice Guideline**

Main topics addressed:

- ✓ Explanation about the people for whom BPG are proposed (BPG audience)
- ✓ Brief presentation of ADM categories and the relation between ADM and ERT
- ✓ Comment on ADM and ERT results which can distributed to emergency responders (how dispersion results are processed to estimate health consequences…)
- ✓ Identification of the people involved in ADM / ERT development and / or use

(done)

- ➢ Provision of guidelines on ADM use, supported by the Action modelling exercises and reference threat scenarios, classified according to the phase of the emergency response
- ➢ Discussion on modelling aspects like: (i) the ADM results space and time accuracy; (ii) the models performances versus the computational needs…
- ➢ Discussion on critical or open issues like: (i) the uncertainties on the input data, (ii) the use of in-field measurements in combination with ADM, etc.
- ➢ Proposal of response-practice procedures integrating ADM in the emergency phases

(in process)

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The ongoing activity - III

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The Model Evaluation Protocol

*A **task-oriented** model evaluation protocol introducing an evaluation procedure that could be applicable during all three distinct phases of models application in emergency response: (1)* pre-accidental analysis and planning (a priori predictions); *(2)* predictions during an actual emergency; *(3)* post-accidental analysis (a posteriori simulations).

General features :

Model Evaluation Protocol

(1) Model description
(2) Experimental data base description
(3) Scientific evaluation
(4) Code Verification
(5) User-oriented evaluation
(6) Model validation
(7) Uncertainty and sensitivity analysis

Application / feasibility of the MEP: Problems, Critical Discussion, Recommendations

Open issues and required future work

The ongoing activity - IV

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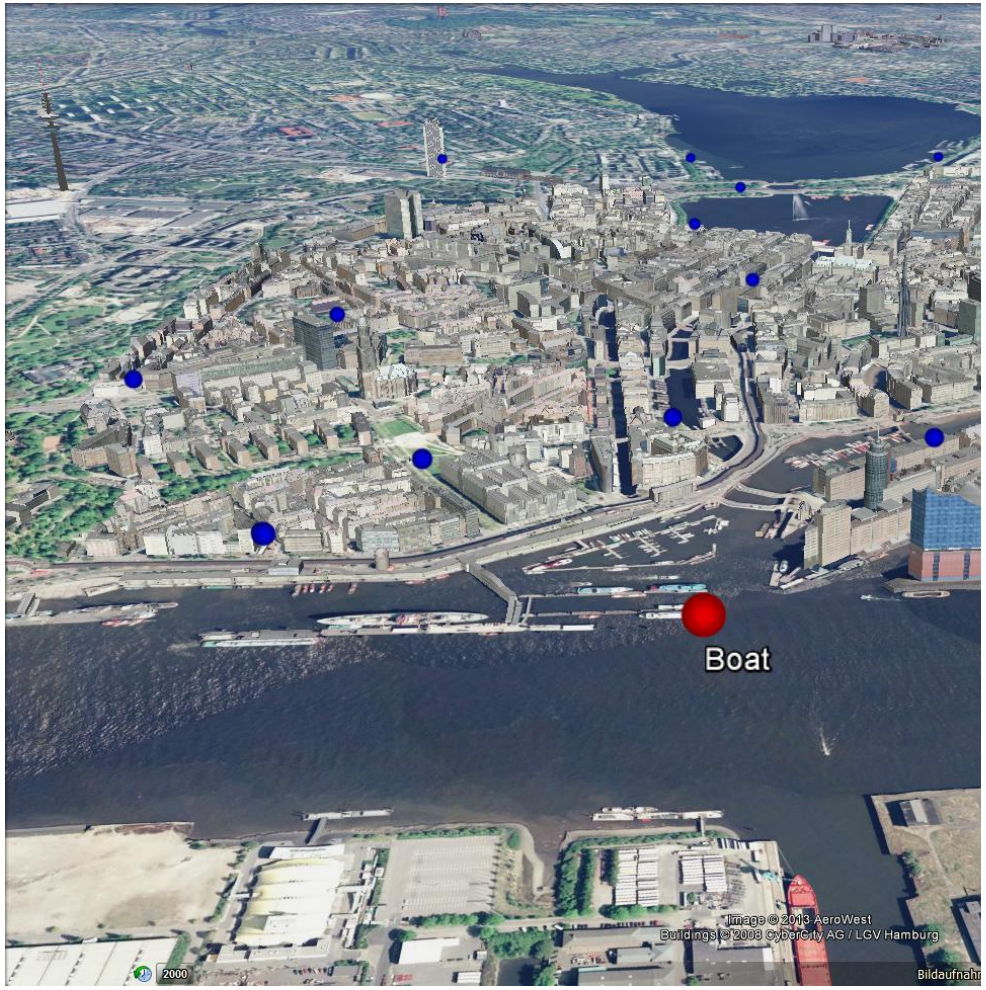
The real city and real accident modelling exercises



Continuous 45-minutes release of SF6 with a flow rate of 2 g/s, from the boat towards the harbor area.

The concentration was detected by 20 measurement stations located at different positions.

Each measurement station has 9 bag samplers. Each bag was filled for 10 minutes => 10-minute average values.

Wind tunnel experiment available.

Test Case 2: real European city – to be modelled within the Action

COST is supported by the EU RTD Framework Programme

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The ongoing activity - IV

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The real city and real accident modelling exercises

Accident Gas RElEase ***AGREE:*** a database for the simulation of a Real Accident

The substance (Vynil Chloride Monomer) was accidentally released inside a building in a liquid state and partially evaporated causing high concentrations in air outside the building, measured by the local VCM automatic monitoring network (more than 50 samplers) installed around the plant, causing an alarm state and the intervention of Firemen. The accident was managed and closed after about 50 minutes

Test Case 3: industrial site – to be modelled within the Action

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More on Thursday, 9-11

14:30-15:50

SPECIAL COSTES1006 SESSION

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