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UPDATES ON 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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Abstract: Updates on the results from COST Action ES1006 activity are presented and discussed. The main focus of the ES1006 Action is the evaluation of the airborne pollutant dispersion models, when applied for accidental or intentional releases in complex built environments, urban or industrial. The main achieved outcomes are introduced and briefly illustrated. More detailed and focused presentations go along with this general one, in order to discuss the most scientific and applicative results of the ES1006 COST Action.

Key words: *air pollution, models, accidental releases, emergency response.*

INTRODUCTION

The atmospheric dispersion models (ADM) represent a crucial part of local-scale emergency response tools (ERT) for tracking and predicting airborne hazards from accidental or deliberate releases. A major challenge is their application in complex topography and geometry. Various modelling approaches are applied, from simple parametric models and Gaussian methods to Lagrangian dispersion models and advanced CFD-based modelling suites. The different methodologies have specific advantages and disadvantages, when considering their efficiency, quality and the reliability of the results. For any accidental release scenario, depending on what simulation tools are used, a variety of answers can thus be given to the emergency responders.

The COST Action ES1006 was established with the main goals of evaluating the application of the ADM in built environments, that is urban or industrial sites, and of assessing their integration in emergency response systems. The focus is on short-term and small-scale threats, which the emergency services are most often called to face. The Action activity is mainly aimed at: (i) elaborating a complete inventory of local threat scenarios and related modelling systems presently used, which could be of reference for local-scale airborne hazards modelling; (ii) setting up a dedicated comprehensive, flexible and structured inventory of models applicable to local-scale accidental releases; (iii) investigating the main gaps, deficiencies and limitations in presently available knowledge and models, identifying the directives for their improvement; (iv) addressing the integration of airborne hazards modelling tools in the emergency response systems for urban/industrial applications; (v) evaluating available models with an application-oriented approach, through comparison against observations from qualified field and laboratory experiments and model inter-comparison; (vi) classifying the existing test data with respect to the present purpose and identifying desirable test scenarios for which data may be collected in the future. Here we present and discuss the main results achieved at present and the ongoing activity.

THE ACHIEVED RESULTS

The analyses performed so far are documented in scientific reports available on the Action's website: http:\\www.elizas.eu. A short description of the main outcomes and some illustrative results are presented hereafter. Other detailed and focused contributions are presented in this volume.

The Background Document.

The first outcome of the Action was a state-of-the-art report (COST ES1006, 2012), the main topics of which are listed hereafter. Starting from the general analysis, the specific problems related to dispersion modelling for emergency planning and response are addressed.

(i) Analysis and assessment of the applicability of the ADM into the ERT, of the specific needs and possible improvements connected to the expected timely response, and of the reliability of current local scale modelling techniques; (ii) definition of the concept of threats, description of threat scenarios, source terms of concern, critical and challenging situations for the different communities involved in local-scale emergency response; (iii) review of the different modelling approaches and tools and addressing of the limitations of both simple and advanced models and of emergency response systems from a current perspective; (iv) discussion of the particular challenges for contaminant dispersion modelling applied to the local scale and of the needs for future model development; (v) analysis of the present evaluation process for local-scale dispersion models, in particular when dealing with the uncertainties related to the application of models in emergency response; (vi) discussion of the specific requirements and datasets to pursue the quality assurance of local-scale models and of the related evaluation methodologies, including the first guidelines; (vii) discussion of the importance of the interaction between scientists and model developers with end users and decision makers; (viii) outline of practical constraints, regulations and legal issues.

The Inventory of Available Datasets.

A first database classifying the existing datasets on the basis of their completeness and usefulness was elaborated for the purpose of validating dispersion models specifically for emergency response systems (Tsiouri et al., 2013). Datasets gathered in atmospheric dispersion experiments are mostly described because sets suited for emergency response models are rare. The classification of databases is based on the Action's main goals, which refer to (1) Accidental (even when intentional) releases, and (2) Built-up environments. The possible limitations when using data to validate models in emergency response assessment are discussed. In a second time, some datasets that could better fit these two required specific points were selected. Among them, three were chosen as case studies for the Action modelling and evaluation activity: the Michelstadt exercise, presented in the following, a real-field campaign with continuous and puff releases carried out in a European harbour and a real industrial accident occurred in a European Country. The model evaluation and intercomparison will be completed within the year 2014.

The Inventory of Emergency Modelling Tools.

A catalogue of the state-of-the-art of emergency response tools and a dedicated model inventory for airborne hazards from accidental/deliberate releases in complex urban and industrial areas was elaborated (Tavares et al., 2014): the Emergency Response Models and Tools Inventory Database Tool (ERMIDT). It collects detailed information on existing models and ERT currently applied in the context of the Action, developed for local-scale incident scenarios. The structure of the catalogue enables an efficient access to the required information: type of application, type of computational approaches and models integrated, aspects of hazards and incident scenarios addressed, physical background, input data demands, model outputs, computational demands and information on model application/use, verification or related performance measures. The inventory is intended to support model-specific guidance regarding an efficient and reliable use of different models and tools.

The Data Comparison Tool.

An ad-hoc tool for comparing physical measurements and results of numerical simulations was developed in Python and it has been already applied to the Michelstadt modelling exercise (Milliez et al., 2014) . The main features of the tool are: (1) "User friendly" as well as "Advanced user" program; (2) as general and flexible as possible, applicable to 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). On the basis of the first test, further statistics and graphical processing that can be useful specifically for model evaluation in continuous or puff releases were identified and are being implemented in the tool to be used in next Action's modelling exercises.

The End-users and Stakeholders Questionnaires.

A questionnaire surveying the present tools used by end-users and stakeholders was elaborated and distributed, to investigate their needs and requirements related to the modelling suites. It was highlighted that most of the responsible agencies use simple approaches with minimal meteorological input and no consideration of buildings; also, few more sophisticated models are used combined with mesoscale meteorological model. The opinion of stakeholders towards uncertainties in the modelling approach were also analysed. In Figure 1, a plot representative of the preferences expressed for the type of model outputs is reported. The stakeholders' expectation from the use of ADM can be shortly summarized as: emergency models have to be simple, robust and fast, they should provide user-friendly interface with on-line help and supply potential damage zones on google maps as output.

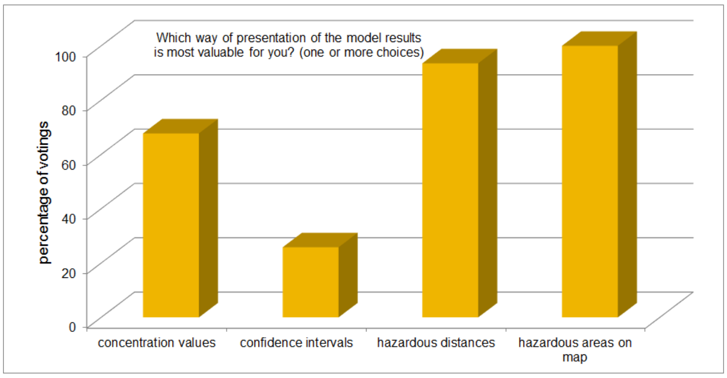

Figure 1. Summary of the preferred model simulation outputs as expected by stakeholders

As a follow-up, more focused interviews were proposed and analysed (Gariazzo et al., 2014). The general opinion expressed about the usefulness of ERT goes from 'good' to 'essential'. The potential limits in using more complex tools in emergency and the expectations when using these tools were analyzed and discussed. Documenting the limitations of different local-scale emergency response methodologies by assessing the actual uncertainty of model results is recognized as an important issue.

The 'Michelstadt' Modelling Exercise.

The first modelling exercise, "Michelstadt", is based on data gathered in a wind-tunnel flow and dispersion experiment performed in the WOTAN atmospheric boundary layer wind tunnel at the Environmental Wind Tunnel Laboratory in Hamburg (Fischer et al., 2010). The measurements were carried out in an idealized Central-European urban environment model, named as Michelstadt. Five point sources were used non-simultaneously in continuous and short-term release mode, and two wind directions were investigated. Model simulations and an intercomparison for continuous and puff releases were performed, aiming at identifying the key aspects and possible problems arising in applications to the emergency response frame. The different modelling approaches are summarized in Table 1.

Table 1. Types of models applied to simulate Michelstadt test case

Modeling approach	Number of models	Dispersion modeling 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

Flow and concentration data were released in a first non-blind test case for the modelling exercise, while in the blind test only the minimum flow information is provided to the modellers. In Figure 2 a sketch of the Michelstadt configuration is given for a continuous release source, S5, together with an illustrative output from model simulations run. Examples of scatter plots between observed and predicted mean concentration for a continuous release and mean dosage for the puff releases are given in Figure 3.

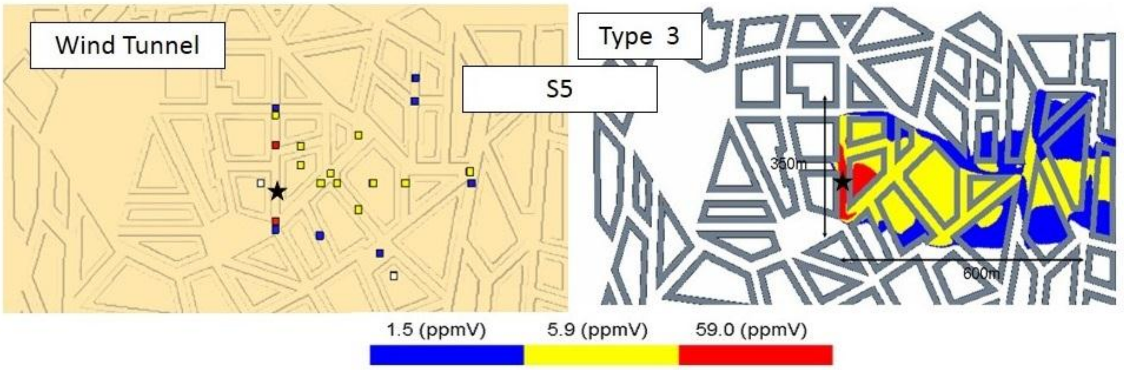

Figure 2. Sketch of the Michelstadt continuous release configurations (left) and examples of concentration contours simulated by one model from type 3 (right) as in Table 1, for source S5.

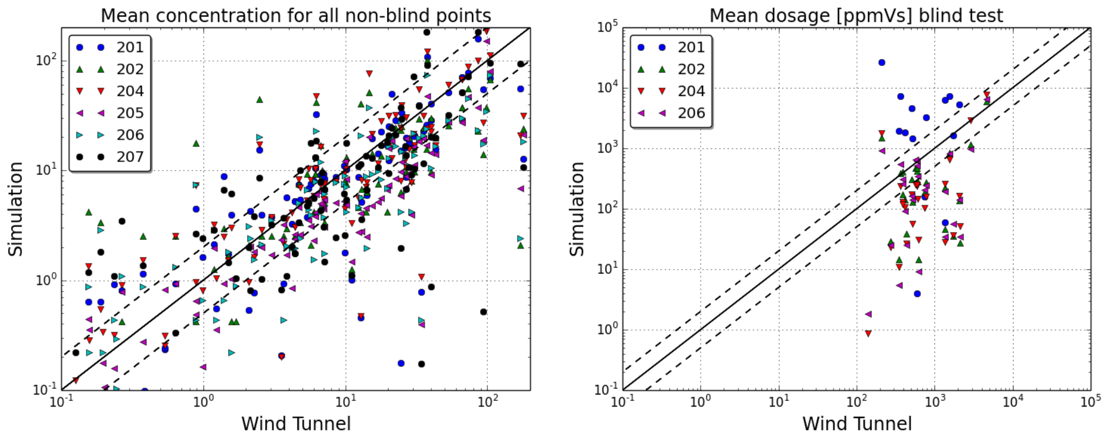

Figure 3. Michelstadt case, scatter plots for continuous release (mean concentration, left) and puff release (mean dosage, right), Type II models.

A statistical analysis of the results was performed (Baumann-Stanzer et al., 2014): as examples, in Figure 3 the normalized mean squared error (NMSE) is plot for the mean concentration for the continuous release and for the mean dosage for puff releases, both in the non-blind and blind test cases. The acceptance criterion in built environment requires that NMSE < 6 (Hanna and Chang, 2013). Most models give performances within the acceptance limit for the non-blind case while there is a worsening for the blind case; a certain variability in the performances of different models and different groups is shown. The actual results and comprehensive analysis will be presented and discussed with a specific attention to the computational aspects and their application in the emergency response context.

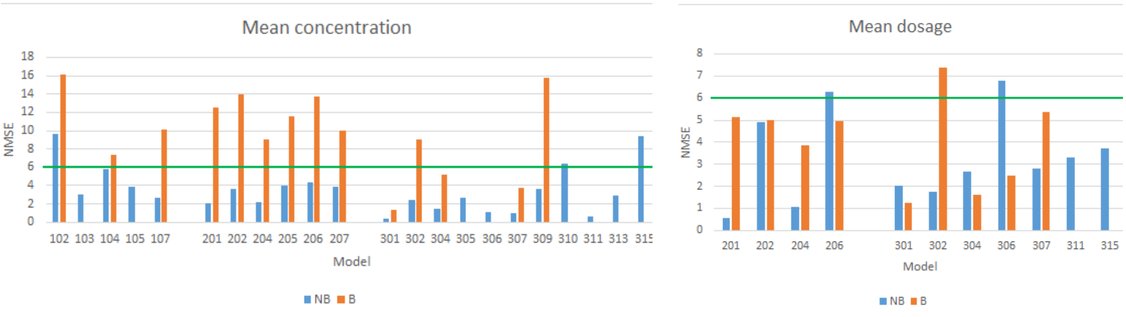

Figure 4. Michelstadt case, NMSE for continuous (mean concentration, left) and puff (mean dosage, right) release

THE ONGOING ACTIVITY

The Catalogue of Threats and Challenges: collecting, documenting and characterizing typical and relevant local-scale threats from releases of toxics in populated areas. The goal of the catalogue is to guide the model development towards the present and future needs of emergency response management. The document provides a description of the conditions and development of potential events, involving releases of the hazardous materials having certain properties that can lead to negative health and safety effects to the humans being exposed. Then, main topics pertinent to the consequences analysis are treated.

The Model Evaluation Protocol: reviewing the developments in model evaluation procedures for the validation of dispersion models, which can potentially be applied in cases of accidental or deliberate releases of airborne hazards in urban areas. A task-oriented model evaluation protocol is proposed, starting from the need of introducing an evaluation procedure that could be applicable during all three distinct phases of models application in emergency response, pre-accidental analysis and planning; predictions during an actual emergency; post-accidental analysis. The protocol is adopted and tested and further improved in the course of the modelling exercises planned in the Action.

The Best Practice Guideline: providing guidance in how to apply ADM in emergency response in order to lower the unavoidable uncertainty in simulation results. The document is expected to supplement the user manual of a typical model by information on the usability, the pros and cons as well as challenges and limitations of different modelling approaches. It is discussing the location of the ADM within the chain of assessment of an ERT, and identifies the model results that can be used in an operational approach. Possible approaches to deal with models in typical emergency events, to manage them in case of lack of input data, to use in-field measurements for improving the predictions, are presented and discussed and recommendations on Best Practices are provided for the different phases of emergency.

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