QUALIFIED DATASETS FOR BENCHMARKING LOCAL-SCALE EMERGENCY RESPONSE MODELS FOR THE PURPOSE OF DISASTER MANAGEMENT

Vasiliki K. Tsiouri[1], Silvia Trini Castelli[2], Spyros Andronopoulos[1]

[1]National Centre for Scientific Research "DEMOKRITOS", Institute of Nuclear and Radiological Sciences and Technology, Energy and Safety, Environmental Research Laboratory,
Athens, Greece
[2]National Research Council, Institute of Atmospheric Sciences and Climate,
Torino, Italy

COST
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

DEMOKRITOS
NATIONAL CENTER FOR SCIENTIFIC RESEARCH

ISAC

15th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes,
6-9 May 2013, Madrid, Spain

- The objective

To identify **Qualified Data** to maintain quality assurance when extensively evaluating emergency response systems, characterized by sufficiently reliable dispersion information

- In this respect as part of the Action **COST ES1006** *"Evaluation, improvement and guidance for the use of local-scale emergency prediction and response tools for airborne hazards in built environments"*

↓

- Collection of available datasets based on previous and ongoing research work for the evaluation of **local-scale accidental release modeling**

Three Main Questions:

Q1. which are the main sources of data?

Q2. what is needed to test and validate a dispersion model to be integrated into an emergency response tool?

Q3. which are the distinctive characteristics needed from a dataset for this specific type of validation?

DEMOKRITOS
NATIONAL CENTER FOR SCIENTIFIC RESEARCH

ISAC

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Specific datasets suited for emergency response models are rare !

- Therefore datasets originally gathered in atmospheric dispersion experiments were mainly considered
- Definition of possible limitations related to their use when validating models in the frame of emergency response assessment
- Special attention to data relevant to the dispersion of a pollutant in built up areas and near/within/above the urban environment

DEMOKRITOS
NATIONAL CENTER FOR SCIENTIFIC RESEARCH

ISAC

cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

POSSIBLE SOURCES OF DATASETS FOR EVALUATION OF MODELS USED IN EMERGENCY RESPONSE MANAGEMENT SYSTEMS

Three main groups of sources

1. Field experiments
2. Laboratory experiments –(Wind tunnel / rotating tanks experiments)
3. Real accidents, where data could be collected, even if sparsely

Classification drawn on the basis both of COST Action ES 1006 main goals and of the specific needs for model evaluation and validation

the guiding lines are:

- **Accidental** (even when intentional) releases and
- **Built-up** environments

A parent classification – GROUPS

include datasets that can bring a contribution to the understanding of important processes and the following improvements of models beyond the stringent criterion of considering built environments

I. Experiments in built-up areas and urban environments
II. Experiments from radiological studies for emergency preparedness and response
III. Experiments concerning dense/light gas releases
IV. Real accidents

A parent classification – GROUPS

II. Experiments from radiological studies provide a better quantification of the amount of airborne radiation released from the power plant accidents – source term estimation algorithms

- ✓ *It is therefore important to investigate these aspects even when the related experiments did not take place in complex geometries*

A parent classification – GROUPS

III. Negatively or positively buoyant gas emissions aimed at improving the description of the source term and the characterization of the emission

- ✓ *a correct description of the source is fundamental to obtain a reliable performance of the models, being the source term one of the core aspects from where uncertainties and errors may be generated*

A parent classification – GROUPS

IV. Real accidents

In these cases numerical modelling experiments and model intercomparisons become the main approach to study the accidents and to infer useful information on the model performance

Basic dataset characteristics for emergency response models validation (Hanna et al., 1991)

1. Meteorological data should be concurrently available at sensors located close to the release site
2. Measurements of concentrations should be available at more than one distance downwind: a sufficient lateral resolution should be also assured in order to document the spatial structure of the plume/cloud
3. High time frequency of the concentration measurements should be available

Hanna et al. (1991), Report Nos. 4545, 4546, and 4547, 338 pp.

These three main criteria can be accompanied by more stringent requirements:

- a wide range of meteorological conditions should be documented in the dataset
- both instantaneous and continuous releases should be described
- both passive and buoyant (positively or negatively) gas releases should be included

COST ES1006

the proper datasets for the validation of hazardous material dispersion models should be specifically prepared for the different phases of emergency response, as well as for pre- and post-accident analysis

The inventory and the classification provided in this presentation want to be the first basis on which to build a consensus in COST ES1006 Action on:

(1) which data are important for the validation of hazardous material dispersion models

(2) in which form they are most useful

A qualified dataset for model testing and demonstration of model performance in emergency response in built environments should:

- be representative of an accidental release, both if data are a product of a real accident or of an experiment
- represent a case with presence of obstacles or it should address some important aspect or issue affecting the dispersion modelling reliability
- provide concurrent meteorological and concentration measured data, a high-quality experimental data set and high-quality meteorological observational data including high temporal and special resolution as well as high-quality tracer sampling data has to characterize the dataset
- describe a variety of meteorological conditions, such as different atmospheric stratifications and it has to be prepared in a harmonized form, to be easily used for testing purposes

GROUP I EXPERIMENTS IN BUILT-UP AREAS AND URBAN ENVIRONMENTS

Experiment (date)	Dataset Description. (F-field experiment, L-Lab experiment, O-Obstucted, U-Unobstructed	References
Birmingham (1999/2000)	F, O, real city, eleveted plateau, complex configuration of buildings	Cooke et al. (2000) Technical Paper CUED/A-AERO/TR.27, Department of Engineering, Cambridge University.
URBAN 2000_Salt Lake City (2000)	F, O, real city, complex terrain, major urban tracer and meteorological field campaign (part of the DOE's Chemical and Biological National Security Program	Allwine et al. (2002), *Bull. Am. Meteorol. Soc. 83, 521-536.* Chang et al. (2005), *J Appl Meteorol., Vol. 44 (4): 485-501*
Los Angeles (2001)	F, O, real city, satisfactory data, tall buildings	Rappolt (2001), Report number 1322, prepared for STI, Bel Air, MD, by Tracer Environ. Sci. and Tech., San Marcos, CA 92071. 33 pp. Hanna et al. (2003), Atmospheric Environment, Vol. 37: 5069-5082.
Barrio Logan (2001)	F, O, real city, single storey residences, Limitied information on the experimental details appears to be available.	Venkatram et al. (2002), 4th AMS Symposium on the Urban Environment, Norfolk, VA. Venkatram et al. (2004), Atmos. Environ., 38, 3647-3659.
London: DAPPLE programme (2003)	F, O, real city	Hanna and Chang (2012), Meteorol. Atmos. Phys. Britter, R.E. (2005), http://www.dapple.org.uk
Joint Urban 2003 Oklahoma City experiment: (2003)	F, O, real city, avilable archived data set that has been quality-controlled and consistency-checked based on a detailed data management plan.	DPG (2005), https://ju2003- dpg.dpg.army.mil Hanna and Chang (2012) Meteorol. Atmos. Phys.
Nantes field (1999)	F, Real city	Vachon et al (1999), 6th Int. Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes.
Kit Fox (1995)	F, O, artificial structures, Dense gas (CO_2) was released at nearly constant rate	Hanna and Chang (2001), Atmospheric Environment, Vol. 35, 2231-2242. Hanna et al. (1999) Hanna Consultants Report No. P011F for the American Petroleum Institute, Washington, DC, 110pp.

GROUP I EXPERIMENTS IN BUILT-UP AREAS AND URBAN ENVIRONMENTS

Experiment (date)	Dataset Description. (F-field experiment, L-Lab experiment, O-Obstucted, U-Unobstructed	References
Cardighton (1993)	F, O, artificial structures, The paper does not provide a clear database of the measurements.	Davidson et al. (1995), Atmospheric Environment, Vol. 29, 3245-3256.
UMIST ETC (1995)	F, O, artificial structures, conducted on a flat test, gas tracer of pure-grade propylene (C3H6) was released	Macdonald (1997), Report to DSTL on Agreement 2044/014/CBDE. Environmental Technology Centre, UMIST, UK
Dugway (2001)	F, O, artificial structures, not enough basic data are provided in this reference to allow effective use to be made of the experiment.	Venkatram et al. (2002), 4th AMS Symposium on the Urban Environment, Norfolk, VA, May 2002.
MUST (2001)	F, O, artificial structures, flat open terrain, variety of wind and stability conditions, concentrations available	Biltoft C.A. (2001), Customer report for Mock Urban Setting Test, DPG Document No. WDTC-FR-01-121 Yee and Biltoft (2004) Boundary Layer Meteor, Vol. 111, pp.363–415.
Nantes (1999)	L, O, real city	Kastner-Klein et al. (2000), In Proceedings of 14th AMS Symposium on Boundary Layers and Turbulence, 2000.
Joint URBAN 2003 Oklahoma City experiment: (2003)	L, O, real city	Leitl et al. (2003), Final Report Phase I 08-2003, & Leitl and Schatzmann (2005), Final Report Phase II 07-2005, Kastner-Klein et al. (2003), AMS Symp. on Urban Zone, Seattle, WA.
MUST (2001)	L, O, artificial structures	Bezpalcova, K. and Harms, F. (2005), EWTL Data Report
Cardighton WT (1993)	L, O, artificial structures	Macdonald et al. (1998), Atmospheric Environment 32, 3845-3862.
Porton Down WT	L, O, artificial structures	Macdonald et al. (1998) Atmospheric Environment 32, 3845-3862.

DEMOKRITOS
NATIONAL CENTER FOR SCIENTIFIC RESEARCH

ISAC

cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

GROUP II EXPERIMENTS FROM RADIOLOGICAL STUDIES FOR EMERGENCY PREPAREDNESS AND RESPONSE

Experiment (date)	Dataset Description. (F-field experiment, L-Lab experiment, O-Obstucted, U-Unobstructed	References
MOL (2001)	F, U, flat terrain, Ar^{41} release, complete data information	Drews et al. (2002), Report of NKS project NKS/BOK-1 , ISBN 87-7893-109-6. Available from the NKS Secretariat,www.nks.org. Tsiouri et al. (2012a), Radiation Protection Dosimetry, Vol. 148 (1), 34-44.
ANSTO (2002-2003)	F, U, Complex terrain, radioactive noble gas Ar^{41}, release data along with concurrent meteorological measurements, valuable tool for evaluating emergency response models of radiological dispersion.	Dyer and Pascoe (2008), 12th Int. Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Tsiouri et al. (2012b), International Journal of Environment and Pollution 50 (1-4) , pp. 386-395

GROUP III EXPERIMENTS CONCERNING DENSE- LIGHT GAS RELEASES

Experiment (date)	Dataset Description. (F-field experiment, L-Lab experiment, O-Obstucted, U-Unobstructed	References
Burro and Coyote	F, U, dense gas (LNG) pool, Release quasi-continuous. lateral and temporal resolution: good	Koopman et al (1982), Burro series data report. LLNL/NWC 1980 LNG Spill Tests, UCID-19075 Goldwire et al. (1983), LLNL/NWC 1981 LNG phase transition, UCID-199953
Maplin Sands	F, U, dense gas(LNG,LPG), surface: water, Release: Both instantenous and continuous, release: boiling liquid, lateral resolution: marginal & temporal resolution: good	Puttock et al. (1984) TNER.84.046, Shell Research Ltd., Thornton Research Centre, Combustion Division.
Thorney Island	F, U, dense gas	Anfossi et al. (2010), Atmospheric Environment, 44 (6), 753-762. Nielsen and Ott (1996), Riso Report 845(EN), Risö National Laboratory Report 845 (EN)
Desert Tortoise and Goldfish	dense gas, 2-phase jet, flat area	Goldwire et al. (1985), Desert Tortoise series data report: UCID-20562, Lawrence Livermore National Laboratory, Livermore, CA, 1985
Hanford Kr85	F, U, radioactive, neutral cloud	Nickola et al. (1970), A volume of atmospheric diffusion data, BNWL-1272, UC-53, Battelle Pacific Northwest Laboratories
Prairie Grass	F, U, dense-gas release but neutral cloud	Barad (1958), Vol. I. AFCRC-TR-58-235 (I), AD 152572. AFGL, Hanscom AFB, MA 01731. Hanna et al. (1991), Report Nos. 4545, 4546, and 4547, 338 pp.
NASA_HySafe SBEP	F, U, Light gas, 2-Phase jet (Large LH2 release on flat ground with small circular ground fence around the spill dike)	Witcofski RD, Chirivella JE. (1984), Int J Hydrogen Energy 1984;9(5):425–35. Venetsanos and Bartzis (2007), Int. J. of Hydrogen Energy, 32 (13), 2171-2177
BAM	large-scale LH2 spill tests adjacent to buildings, accidental spills of cryogenic hydrogen in a residential area.	Marinescu-Pasoi and Sturm (1994), Reports R-68.202 and R-68.264; Venetsanos and Bartzis (2007), Int. J. of Hydrogen Energy, 32 (13), 2171-2177

GROUP IV REAL ACCIDENTS

Accidents (date)	Description. (F-field experiment, L-Lab experiment, O-Obstucted, U-Unobstructed	References
FESTUS (2002)	F, O, dense gas. Chlorine accident at a chemical processing plant in Festus, Missouri (took place while a railcar was offloading chlorine at a chemical processing facility).	Hanna S.R (2007), Report Number P082, prepared for RFHEEE, Arlington, VA, 58 pp. Hanna et al. (2009), Atmos Environ. 43, 262-270.
Macdona (2004)	F, U, dense gas. A filled 90-ton chlorine railcar was breached releasing 60 tons of chlorine as of three days after the accident.	Hanna S.R (2007), Report Number P082, prepared for RFHEEE, Arlington, VA, 58 pp.
Graniteville (2005)	F, O, dense gas. The collision derailed both locomotives and 16 of the 42 freight cars of train 192. Among the derailed cars from train 192 were three tank cars containing chlorine, one of which was breached, releasing chlorine gas.	Railroad Accident Report NTSB/RAR-05/04. Washington, DC. Hanna et al. (2009), Atmos Environ. 43, 262-270.
Stockholm (1983)	F, O, light gas. Hydrogen gas explosion	Venetsanos et al (2003), Journal of Hazardous Materials 105 (1-3) , pp. 1-25

First screening of possible candidates to enter a 'primary group' of experiments

For urban-scale and building-scale:

URBAN 2000 provides a dataset that resolves interacting scales of motion from the individual building up through the regional scale under the same meteorological conditions

Joint Urban 2003 tracer and meteorological data, a web site is openly accessible and provides an archived data set that has been quality-controlled and consistency-checked based on a detailed data management plan.

Valuable dataset for evaluation and improvement of existing dispersion models

Radiological studies for emergency preparedness and response:

ANSTO Experiment Routine airborne release data from nuclear research reactor of the radioactive noble gas Ar41 provides a valuable tool for evaluating emergency response models of radiological dispersion and evaluation of data assimilation algorithms for estimating the unknown emission rate of radionuclides in the atmosphere

DEMOKRITOS
NATIONAL CENTER FOR SCIENTIFIC RESEARCH

ISAC

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

CONCLUSIONS

- data-sets that shall be used for the validation of hazmat dispersion models specifically prepared for different phases of emergency response, as well as for pre- and post-accident analysis were proposed
- a parent classification that include all datasets that can bring a contribution to the understanding of important processes and the following improvements of models, going beyond the stringent criterion of considering built environments was elaborated
- 'primary' groups of datasets were particularised

key element for the prediction of danger zones and health effects: The dispersion models implemented in emergency response systems

absolutely necessary: quality assurance of the dispersion models' predictive capabilities

High quality experiment dataset for emergency-response applications should be promoted with high priority

Thank you for your attention!

We welcome your questions, suggestions, comments!

EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY