# COST

Domain Committee "ESSEM"

# COST Action *732*

**Start Date** *29/03/2005*
**End Date** *28/03/2009*

*Quality Assurance and Improvement of Microscale Meteorological Models*

# FINAL EVALUATION REPORT

This Report stems from the relevant Domain Committee.
It contains four parts:

***I. Management Report*** *prepared by the COST Office/Grant Holder*
***II. Scientific Report*** *prepared by the Chair of the Management Committee of the Action.*
***III. Evaluation Report*** *prepared by the "ad hoc" Evaluation Panel, established by the Domain Committee, and edited by the COST Office.*
***IV. DC General Assessment*** *prepared by the Domain Committee*

**Appendices:**

Confidentiality: the documents will be made available to the public via the COST Action web page except for chapter *II.D. Self evaluation* and *IV. DC General Assessment.*


**Executive summary of the Scientific Report (max.250 words):**

The main objective of the Action was to improve and assure the quality of micro-scale meteorological models that are applied for predicting flow and transport processes in urban or industrial environments.

The action worked for 4 years and produced several reports and a guideline for the evaluation of such models.

The results were disseminated in special sessions of conferences and in numerous publications. They can be downloaded from the action's homepage under

http://www.mi.uni-hamburg.de/Home.484.0.html

***I. Management Report*** *prepared by the COST Office/Grant Holder*
*(same layout as in the Monitoring Progress Report)*

***I. Management Report*** *prepared by the COST Office/Grant Holder*

### *I.A. COST Action Fact Sheet*

- **COST Action** *732- Quality Assurance and Improvement of Microscale Meteorological Models*
- **Domain** *Earth System Science and Environmental Management "ESSEM"*

- **Action details:**

| Details | |
|---|---|
| This Action has stopped running in the 6 last months. | |
| Draft Mou: 333/04 | Mou: 228/05 |
| Start of Action: 29/03/2005 | Entry into force: 16/02/2005 |
| End of Action: 28/03/2009 | CSO approval date: 01/12/2004 |

- **Objectives** *(from DB as in About COST)*

*The main objective of the Action is to improve and assure the quality of micro-scale meteorological models that are applied for predicting flow and transport processes in urban or industrial environments.*

- **Parties:** *list of countries and date of acceptance*

**Parties: list of countries and date of acceptance**

| Country | Date | Country | Date | Country | Date | Country | Date |
|---|---|---|---|---|---|---|---|
| Austria | 18/03/2005 | Belgium | 09/01/2008 | Bulgaria | 17/02/2005 | Cyprus | 10/02/2005 |
| Czech Republic | 27/06/2005 | Denmark | 16/02/2005 | Finland | 18/03/2005 | France | 16/02/2005 |
| Germany | 16/02/2005 | Greece | 17/02/2005 | Hungary | 25/05/2005 | Italy | 18/10/2005 |
| Netherlands | 10/02/2005 | Poland | 16/02/2005 | Portugal | 02/05/2005 | Romania | 15/02/2005 |
| Slovakia | 03/03/2005 | Spain | 14/04/2005 | Sweden | 20/10/2006 | Switzerland | 31/03/2008 |
| United Kingdom | 16/02/2005 | | | | | | |
| Total: | 21 | | | | | | |

**Intentions to accept: list of countries and date**

| Country | Date | Country | Date | Country | Date | Country | Date |
|---|---|---|---|---|---|---|---|
| Israel | 06/03/2007 | | | | | | |
| Total: | 1 | | | | | | |

**Other participants**

WMO observer Liisa JALKANEN (permanent guest)

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### *I.C. Overview activities and expenditure*

**Action 732 - budget from 29-Mar-2005 to 26-May-2009**

Generated on 26-May-2009

**Meetings**

| Meeting Type | Date | Place | Paid part | Cost | Status | Total |
|---|---|---|---|---|---|---|
| Management Committee | 29-Mar-2005 | Valencia (ES) | 20 | 19041.68 | Paid | |
| In conjunction with Work | 28-Jul-2005 | Hamburg (DE) | 16 | 11563.36 | Paid | |
| Management Committee | 09-Nov-2005 | Chatoux (FR) | 20 | 13416.62 | Paid | |
| Joint Management Comm | 22-Mar-2006 | Bratislava (SK) | 23 | 16335.4 | Paid | |
| Joint Management Comm | 04-Jul-2006 | Copenhagen (DK) | 13 | 8822.85 | Paid | |
| Working Group | 19-Oct-2006 | Athens (GR) | 25 | 19161.12 | Paid | |
| Working Group | 11-Jan-2007 | Hamburg (DE) | 14 | 10718.71 | Paid | |
| Management Committee | 22-Feb-2007 | Brussels (BE) | 27 | 17907.06 | Paid | |
| Management Committee | 31-May-2007 | Vienna (AT) | 25 | 17147.41 | Paid | |
| Joint Management Comm | 15-Oct-2007 | Lecce (IT) | 20 | 18449.2 | Paid | |
| Working Group | 10-Dec-2007 | Vienna (AT) | 15 | 10207.37 | Paid | |
| Joint Management Comm | 18-Feb-2008 | Prague (CZ) | 24 | 15755.21 | Paid | |
| Management Committee | 13-May-2008 | Thessaloniki (GR) | 25 | 20169.48 | Paid | |
| Joint Management Comm | 11-Sep-2008 | Torino (IT) | 25 | 19876.78 | Paid | |
| Management Committee | 04-Dec-2008 | Madrid (ES) | 26 | 18191.39 | Paid | |
| Working Group | 16-Feb-2009 | Chatou (FR) | 8 | 5243.16 | Paid | |
| | | | | | | **242006.8** |

**STSM**

| Beneficiary | Date | From | To | Cost | Status | Total |
|---|---|---|---|---|---|---|
| Ms Jana Matejovicova | 29-Jul-2006 | 833 15 Bratislava (SK | Sofia (BG) | 925 | Paid | |
| Dr Athanasios Sfetsos | 29-Jul-2006 | Kozani (GR) | Sofia (BG) | 970 | Paid | |
| Mr RICCARDO BUCCOL | 29-Jul-2006 | Lecce (IT) | Sofia (BG) | 932 | Paid | |
| Ms Klara Bezpalcova | 13-Nov-2006 | Prague (CZ) | Hamburg (DE) | 700 | Paid | |
| Mr Fotios Barmpas | 25-Nov-2006 | Thessaloniki (GR) | Hamburg (DE) | 1536 | Paid | |
| Dr Silvana Di Sabatino | 18-Nov-2007 | Lecce (IT) | ROSKILDE (DK) | 1050 | Paid | |
| Ms Catherine Gorle | 21-Jan-2008 | B-1640 sint-Genesius | D-20146 Hamburg (DE) | 722 | Paid | |
| Mr GEORGE EFTHYMIC | 30-Mar-2008 | Kozani (GR) | TORINO (IT) | 960 | Paid | |
| | | | | | | **7,795** |

| **Workshops** | | | | | | |
|---|---|---|---|---|---|---|
| Title | Date | Place | | Cost | Status | Total |
| Opening workshop on Qu | 28-Jul-2005 | Hamburg (DE) | | 3,000 | Paid | |
| COST732 Internal Works | 22-Mar-2006 | Bratislava (SK) | | 2,950 | Paid | |
| COST732 MC + Internal | 04-Jul-2006 | Copenhagen (DK) | | 1,500 | Paid | |
| Internal Workshop | 19-Oct-2006 | Athens (GR) | | 3,000 | Paid | |
| 8th COST 732 MC and W | 31-May-2007 | Vienna (AT) | | 2,200 | Paid | |
| MC 9 + WG | 15-Oct-2007 | Lecce (IT) | | 2,400 | Paid | |
| COST 732 Expert Meetir | 10-Dec-2007 | Vienna (AT) | | 1,500 | Paid | |
| MC 10 | 18-Feb-2008 | Prague (CZ) | | 2,000 | Paid | |
| COST 732 MC and WG I | 13-May-2008 | Thessaloniki (GR) | | 2,990 | Paid | |
| COST 732 Management | 11-Sep-2008 | Torino (IT) | | 2,784 | Paid | |
| MC 13 | 04-Dec-2008 | Madrid (ES) | | 3,000 | TBR | |
| Expert Meeting | 16-Feb-2009 | Chatou (FR) | | 2,986 | TBR | |
| | | | | | | **30,310** |

| **General Support Grants** | | | | | | |
|---|---|---|---|---|---|---|
| Title | Date | | | Cost | Status | Total |
| Website Development | 06-Jul-2005 | | | 1,920 | Paid | |
| General | 01-Jul-2006 | | | 2,000 | Paid | |
| General | 20-Mar-2007 | | | 2,000 | Paid | |
| Website | 01-Jan-2008 | | | 2,000 | Paid | |
| | | | | | | **7,920** |

| **Schools** | | | | | | |
|---|---|---|---|---|---|---|
| Type | Date | Place | title | Cost | Status | Total |
| | | | | | | **0** |

| **Honoraria** | | | | | | |
|---|---|---|---|---|---|---|
| Title | Date | Expert | | Cost | Status | Total |
| Ending Action 732 on 28 | 28-Mar-2009 | PALMGREN FINN | | 500 | TBR | |
| | | | | | | **500** |

| **Grant** | | | | | | |
|---|---|---|---|---|---|---|
| Grant Holder | Date | | | Cost | Status | Total |
| | | | | | | **0** |

| **Dissemination** | | | | | | |
|---|---|---|---|---|---|---|
| Title | Date | | | Cost | Status | Total |
| | | | | | | **0** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | **Action Total** | **288531.8** |

***II. Scientific Report*** *prepared by the Chair of the Management Committee of the Action, describing results achieved during the Action operation in this period, in no more than 3 pages (the report is "cumulative"). All items listed in Sections A, B, and C, below, must be addressed.*

*Additional documentation such as extended scientific reports, proceedings of workshops, seminars or conferences may be provided separately as an annex to this report, and should be referenced in the report.*

## *II.A. Innovative networking*

### *II.A.1 Innovative knowledge resulting from COST networking through the Action*

The main objective of the Action was to improve and assure the quality of micro-scale meteorological models that are applied for predicting flow and transport processes in urban or industrial environments.

In particular it was intended

- to develop a coherent and structured quality assurance procedure for these type of models which gives clear guidance to developers and users of such models as to how to properly assure their quality and their proper application,
- to provide a systematically compiled set of appropriate and sufficiently detailed data for model validation work in a convenient and generally accessible form (www data bank),
- to invite from all participating states scientists and users to apply the procedure and to prove its serviceability,
- to build a consensus within the community of micro-scale model developers and users regarding the usefulness of the procedure,
- to stimulate a widespread application of the procedure and the preparation of quality assurance protocols which prove the 'fitness for purpose' of all micro-scale meteorological models participating in this activity,
- to contribute to the proper use of models by disseminating information on the range of applicability, the potential and the limitations of such models,
- to identify the current weaknesses of the models and data bases,
- to give recommendations for focussed experimental programmes in order to improve the data base and
- to give recommendations for the improvement of present models and, if necessary, for new model parameterisations or even new model developments.

The action was successful. All items were addressed, the last two only partly due to a lack of time. A number of reports were written and the expertise gained was disseminated at special sessions of several conferences, in talks and in publications. Both, the WMO and the European Environment Agency (EEA) took notice of the action's results. Members of the action were asked to participate in the new EEA Forum for Air Quality Modelling (FAIRMODE, http://fairmode.ew.eea.europa.eu) which is tasked to translate the scientific results into administrative regulations.

COST 732 started with a joint ESF/COST 732 Exploratory Workshop on 'Quality Assurance of Micro-Scale Meteorological Models' on July 28/29, 2005 in Hamburg, Germany. A state-of-the-art report was published in late 2005 (Schatzmann and Britter, 2005, 150 pages). In addition to an overview on present and past quality assurance initiatives this report contains the recommendations for action 732 which were given by the about 45 participating scientists from Europe and the US (the number of participants was limited in order to allow ample discussions). These recommendations which were presented in a first COST 732 report

- **Proceedings, International Workshop on Quality Assurance of Microscale Meteorological Models**

formed the basis for the subsequent work.

Since autumn 2005 eleven further Management Committee meetings were held at Chatou (France), Bratislava (Slovak Rep.), Risoe (Denmark), Athens (Greece), Brussels (Belgium), Vienna (Austria), Lecce (Italy), Prague(Czech Republik) and Thessaloniki (Greece), Torino (Italy) and Madrid (Spain).

The MC together with the WGs drafted the following two background documents:

- **Background and Justification Document to Support the Model Evaluation Guidance and Protocol Document**
- **Best Practice Guideline for the CFD Simulation of Flows in the Urban Environment**

Both documents are rather voluminous (50 to 100 pages). There role is to explain and justify the recommendations given in a third document, the

- **Model Evaluation Guidance and Protocol Document**

This much shorter document gives step-by-step guidance to model developers and users on how to assure the quality of a micro-scale meteorological model. The guidance and protocol document comes along with recommendations for particularly selected data sets which should be used during the validation work.

In its final stage of preparation is a fifth document

- **COST 732 Model Evaluation Case Studies: Approach and Results**

which reports on the requirements the action has set for validation data, the use of the data in the evaluation process and finally the experiences made and lessons learned when applying the procedure.

The first four of the documents have been printed and made publicly available. They can be downloaded from the homepage of the action under http://www.mi.uni-hamburg.de/Home.484.0.html . The fifth document will hopefully be available at the final event of the action which will take place in form of an International Workshop from June 3-5, 2009 in Hamburg (see programme on the homepage).

It can be concluded that action COST 732 delivered what was promised in the proposal and in the Memorandum of Understanding.

### *II.A.2 Significant scientific breakthroughs as part of the COST Action*

Only one example will be given here which concerns a not yet widely recognised problem: the data requirements for urban model validation purposes.

COST action 732 dealt mainly with Urban RANS (Reynolds-Averaged Navier-Stokes) CFD and Non-CFD (Computational Fluid Dynamics) models since these types of models are presently most widely used in the COST member states. Both model types apply steady boundary conditions, i.e. they deliver one solution for one specific meteorological situation. The variability of atmospheric situations is indirectly accounted for by repeating the runs for different wind directions, stabilities etc., each of those runs being steady state again.

Steady state models require validation data from experiments which were taken under steady state atmospheric conditions, and here the problem begins. The atmosphere is intrinsically time dependent and never steady state. The weather is continuously changing; both due to the atmospheric circulation and due to the diurnal cycle. The fluctuations and gusts in the incoming wind couple with equally important vortex shedding from buildings to control the local flow fields and the dispersion of pollutants. To overcome this problem quasi-steady situations are usually defined which are composed of mean values averaged over e.g. 20 min or 30 min. However, as was shown in Schatzmann et al. (2009) at the example of a detailed analysis of data from urban field experiments, the time scale of the naturally occurring turbulent structures significantly exceeds such short averaging periods. As a consequence, the commonly determined short-time mean values measured inside the urban canopy layer have the character of random samples, i.e. snapshots, only. Depending on the wind direction, the variability between seemingly identical cases can be large. To simply increase the sampling time would not solve but worsen the problem since over periods longer than 30 min a systematic trend in meteorological conditions due to the diurnal cycle has to be expected. Wind tunnel and Large Eddy Simulation models show likewise that many hours of constant weather conditions would be needed until

the time series become ergodic and deliver always the same mean values. In view of this it has to be concluded that episodic field measurements cannot be representative at locations with highly fluctuating flow properties.

A second problem caused by the naturally occurring atmospheric variability concerns the determination of representative input conditions for the model runs. In most field experiments only one reference station exists that can be used to characterise the meteorological situation and the model input. Fortunately, however, there are a few exceptions, most prominent among them the Joint Urban 2003 experiment in Oklahoma City (Allwine et al., 2004). In this experiment the wind vector was measured with high temporal resolution at multiple locations in parallel. Hertwig (2008) compared for several periods the wind velocities and directions which were measured simultaneously at different stations at undisturbed positions upwind from the business district. Not very surprising, the results deviate significantly from each other, the differences clearly exceeding the uncertainty of the instruments. Although not the raw data but already 5 min mean values were compared, the data did not vary in synchrony with each other which indicates that there are large scale low frequency structures superimposed to the mean flow.

Assumed that 20 min averages would be used to determine the input for a model run, it became very obvious that the models would predict quite distinct flow and, above all, concentration fields, depending on from which measurement site the input data were chosen. In the Oklahoma field experiment more than 100 anemometers, Sodars etc. were deployed and measured in parallel. The data of many of them would likewise be suitable to be used as reference velocities. All of them deliver different model inputs, and the differences are typically much larger than the instrument uncertainty. A model user could select the input which leads to the best fit. To regard such a test as a serious proof for model quality would certainly not be justified.

The ambiguity in the right choice of input data for model simulations concerns every field data set, not only those in which the model input can be selected from several meteorological towers. In experiments with one reference station only it simply remains unknown how representative this particular tower measurement really is. The large turbulent elements embedded in the mean flow create changes from location to location and from averaging interval to averaging interval which could be determined only if the mean weather remained constant and a sufficiently large ensemble of short time means could be collected and statistically analysed.

A third difficulty which has been encountered in the search for reliable validation data sets originates from the fact that resources are limited and field measurements usually are made at a few selected points only. A CFD model, on the other hand, requires at the inflow boundary a complete data array, and this not only for the mean velocity but also for more complex properties like the turbulent kinetic energy or the dissipation rate. Provided the measurement was made with a high-resolution instrument that delivered a velocity time series (which is usually not the case in older field data sets) this information is available for the measurement position only. It needs to be extrapolated laterally and vertically which requires additional assumptions to be employed (e.g. assessment of a roughness length, a logarithmic wind profile in the surface layer, horizontal homogeneity of the flow etc.). In view of what was explained before, all these assumptions are most likely not justified over short averaging intervals but presume the existence of long periods of constant weather, the existence of a boundary layer in equilibrium with the underlying surface etc. As a consequence, the model is fed with input which most likely does not sufficiently correspond to the flow or concentration measurements which are used in the validation process to check the accuracy of the model output.

Since it is unfair to blame a model for “flaws” contained in the data and which originate from the inherent variability of the atmosphere, and since all models which were tested by the action were run in steady state mode, action COST 732 came, after lengthy discussion, to the conclusion to base the validation work predominantly on wind tunnel data since here the weather can be carefully controlled and kept constant for many hours. Furthermore it was decided to request that the wind tunnel boundary layer characteristics were fully known and documented in sufficient detail. In order to provide the chance to compare the wind tunnel data with reality, it was decided to accept only data from laboratory experiments in which a real field situation was

replicated. This data philosophy was finally the backbone for most of the validation work carried out by the action, and it was reflected in the validation examples which are presented in the fifth document.

### *II.A.3 Tangible medium term socio-economic impacts achieved or expected.*

Urban emissions occur mainly within or shortly above the canopy layer i.e. within a zone where the atmospheric flow is heavily disturbed by buildings and other obstacles. It is well-known that buildings can deflect plumes and care for sometimes increased, sometimes decreased dilution, depending on the density, height and shape of the obstacle array. In comparison to unobstructed terrain, local concentrations can change by more than an order of magnitude. As a consequence, it is inappropriate to consider buildings within a surface roughness parameterisation only, particularly if predictions on the scale of a few streets or city blocks are being made. These facts, in conjunction with increasing computer power, have promoted the development of obstacle-resolving or accommodating prognostic and diagnostic models, subsequently called micro-scale meteorological models. Nowadays these models are commercially available and widely used in environmental impact studies.

The increasing use of these models is paralleled by a growing awareness that the majority of these models have not been the subject of rigorous evaluation. Consequently, there is a lack of confidence in the modelled results. To cast doubt on the results is justified, as was shown by systematic studies in which applications of the same model by different modellers to a given problem and applications of different models by either the same or different modellers to the same problem revealed significant differences. Nevertheless, these models are used in the preparation of decisions with profound economic and political consequences.

This Action will lead to a substantial improvement of the culture within which models are developed and applied. With validated models more reliable predictions will be made. Making a conservative estimate that, per year, 100 detailed environmental assessment studies with predictions for air pollution levels within built-up environments are required under national or EU-directives in each of the 25 participating countries, and that the savings as a result of more realistic model predictions would amount to only 10 000 € per case, the total annual saving would be already about 100 times larger than the overall costs for the whole COST Action 732.

### *II.A.4 Spin off of new EC RTD Framework Programme proposals/projects*

As was already pointed out under II.A.1 the results of this Action will be reflected in the EEA-initiative FAIRMODE. The methodology will be taken over and applied in the new European research project WAUDIT (Wind Resource Assessment Audit and Standardization). Furthermore the methodology developed in the action forms the basis for a proposal of a new COST action with emphasis on quality assurance for Large Eddy Simulation Models. More proposals which are based on the actions results will be submitted as soon as appropriate calls are being made.

### *II.A.5 Spin off of new National Programme proposals/projects.*

There is no complete list of national projects in the field of quality assurance presently available.

The German Science Foundation established a focussed research programme in which mathematicians, engineers in fluid dynamics and meteorologists work together on the improvement of models for geophysical applications (MetStroem).

## *II.B. Inter-disciplinary networking*

### *II.B.1 Additional knowledge obtained from working with other disciplines within the COST framework*

COST 732 offered a frame for close cooperation between engineers and micro-meteorologists, scientist and administrators. This mix proved to be very fruitful and led to a successful cooperation.

### *II.B.2 Evaluation of whether the level of inter-disciplinarity is sufficient to potentially provide scientific impacts*

The level of inter-disciplinarity in COST 732 was appropriate.

### *II.B.3 Evaluation of whether the level of inter-disciplinarity is sufficient to potentially provide socio-economic impacts. (Specific examples)*

The tasks COST 732 had to fulfil were predominantly of technical nature. The results will induce socio-economic impact as was pointed out under II.A.3.

### *II.C. New networking*

- ***Additional new members joining the Action during its life.***

  The action started with about 10 countries, all other members joined shortly after the start. The COST office should be able to deliver the exact dates.

- ***Total number of individual participants involved in the Action work. (Number of participants. Give % of female and of Early Stage Researcher participants)***

  The action consisted of 35 MC members (8 female, 10 early stage researchers). Every MC member was a member of a Working Group as well. In addition the action asked 8 external experts (3 female, 5 early stage researchers) to strengthen the WG teams.

- ***Involvement of Early Stage Researchers in the Action, in particular with respect to STSMs, networking activities, and Training Schools. In addition, justification should be provided if less than 4 STSMs were carried out during the year.***

  All but 1 STSMs were carried out by early stage researchers. Both the financial conditions of the action and the tasks which had to be worked on suggested, however, to apply this instrument somewhat restrictive.

- ***Involvement of researchers from outside of COST Countries. (Number of participants from non-COST Countries approved by the CSO. Give % of such participants from countries with reciprocal agreements. Specify their contribution)***

  The action had 1 participant from Israel and 1 permanent observer from the World Meteorological Organisation.

- ***Advancement and promotion of scientific knowledge through publications and other outreach activities. (Number of publications and other outreach activities that resulted from COST networking through the Action. Complete list should be given in an annex)***

  Publication activities are still ongoing. Up to now about 50 publications or conference contributions can be attributed to COST 732.

- ***Activities and projects with COST network colleagues.***

  Many of the publications are joint publications from several COST 732 members. Some of the members prepared joint proposals and carry out joint research work.

- ***The capacity of the Action members to raise research funds.***

  The members of the action are at least partly experienced senior researchers with a long record of research projects. A statistic of individual research funds of the COST 732 members has not been compiled.

***III. Previous scientific report(s)***

Part II of past periods' reports are to be found here.
►***Previous Scientific Report***

▪ ***Results achieved during the period 16 February 2005 to 31 May 2008***

**1. Objectives of the Action:**

The main objective of the Action is to improve and assure the quality of micro-scale meteorological models that are applied for predicting flow and transport processes in urban or industrial environments.

**2. Tasks:**

In particular it is intended
- to develop a coherent and structured quality assurance procedure for these type of models which gives clear guidance to developers and users of such models as to how to properly assure their quality and their proper application,
- to provide a systematically compiled set of appropriate and sufficiently detailed data for model validation work in a convenient and generally accessible form (www data bank),
- to invite from all participating states scientists and users to apply the procedure and to prove its serviceability,
- to build a consensus within the community of micro-scale model developers and users regarding the usefulness of the procedure,
- to stimulate a widespread application of the procedure and the preparation of quality assurance protocols which prove the 'fitness for purpose' of all micro-scale meteorological models participating in this activity,
- to contribute to the proper use of models by disseminating information on the range of applicability, the potential and the limitations of such models,
- to identify the current weaknesses of the models and data bases,
- to give recommendations for focussed experimental programmes in order to improve the data base and
- to give recommendations for the improvement of present models and, if necessary, for new model parameterisations or even new model developments.

**3. Status:**

Cost Action 732 started with the 1st MC Meeting in March 2005 in Valencia, Spain. Presently 21 countries plus the World Meteorological Organization joined the action and nominated experts for the Management Committee and the Working Groups. Up to now 11 MC/WG meetings plus 4 workshops have been carried out.

**4. Progress:**

The action started with a joint ESF/COST 732 Exploratory Workshop on 'Quality Assurance of Micro-Scale Meteorological Models' on July 28/29, 2005 in Hamburg, Germany. A state-of-the-art report was published in late 2005 (Schatzmann and Britter, 2005, 150 pages). In addition to an overview on present and past quality assurance initiatives this report contains the recommendations for action 732 which were given by the about 45 participating scientists from Europe and the US (the number of participants was limited in order to allow ample discussions). These recommendations which were presented in a previous COST 732 progress report form the basis for our present work.
Since autumn 2005 nine further Management Committee meetings were held at Chatou (France), Bratislava (Slovak Rep.), Risoe (Denmark), Athens (Greece), Brussels (Belgium), Vienna (Austria), Lecce (Italy), Prague(Czech Republik) and Thessaloniki (Greece). The MC together with the WGs drafted the following two background documents:

- Background and justification document to support the model evaluation guidance and protocol document
- Best practice guideline for the CFD simulation of flows in the urban environment

Both documents are rather voluminous (50 to 100 pages). There role is to explain and justify the recommendations given in a third document, the

- Model evaluation guidance and protocol document

This much shorter document gives step-by-step guidance to model developers and users on how to assure the quality of a micro-scale meteorological model. The guidance and protocol document comes along with recommendations for particularly selected data sets which should be used during the validation work.

The content and the recommendations given in the documents are presently tested by the action itself. The Mock-Up Urban Setting (MUST) data set which comprises field and wind tunnel experiments from flow and dispersion experiments carried out within and above an urban building array made up by 256 ship containers was selected and brought into a usable form. 11 groups of numerical modellers (9 CFD and 2 non-CFD) started to simulate the MUST case thereby following the evaluation guideline. At the next step the results of the modelling exercise were presented and compared and the differences were discussed. Different evaluation metrics were tested, recommendations for fair comparisons were given, conclusions from the MUST exercise were drawn and tools for comparing the different results from the models were developed.

The documents were printed and sent around to model developers and users in the participating countries. In order to receive feedback from the community of micro-scale meteorological modellers a special COST 732 session was organized at the 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes which took place in Cambridge, UK, from July 2nd to 5th, 2007. This conference was used to disseminate the actions results and to form a consensus within the scientific community about the most effective ways to evaluate numerical models.

Presently the action is busy with testing the guideline and the recommendations given in the documents with additional data from the Joint Urban 2003 experiment. This experiment is regarded to be the largest and most complex urban dispersion experiment. It took place 2003 in Oklahoma City. Data from field and corresponding wind tunnel experiments are prepared, numerical grids are generated etc. First results will be presented in October at the 12th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes in Cavtat, Croatia.

## 5. STSMs:

The action sponsored three STSMs in July 2006. Young scientists from Greece, Italy and the Slovak Rep. were given the opportunity to attend a training school in Bulgaria which dealt with the application and validation of the US EPA regulatory models. Further 2 STSMs were necessary in 2006/2007 in order to analyse the MUST data (Silvana Sabattini at Neri) and to bring them into a form the numerical modellers can use (Photios Barmpas in Hamburg). Early in 2008 George Efthimiou carried out calculations in Torino and Catherine Gorle prepared the gridding of the geometry for the Oklahoma City business district which will be modelled next. All STSMs sponsored young researchers and were successfully carried out.

## 6. Synergetic activities:

Action 732 is related to action 728 which, instead of the micro scale, works on the meso scale. Certain activities (model inventory, validation strategies) are done in close cooperation, partly

by the same persons.

The action has established some contact with action P20 “Large-Eddy Simulation for Advanced Industrial Design (LES-AID)”. However, the fields of application of the two action is quite different (Development of large-eddy simulation strategies for turbulent flows in industrial applications involving combustion, external/internal flows and multi-phase fluids), there is limited overlap only and not much room for co-operation.
The first COST732 workshop was a joint ESF/COST activity.

The action coordinates work of it members which is co-sponsored by numerous national or European projects (e.g. ACCENT).

▪ ***Dissemination of results***

The activities of the action concerning the dissemination of results on conferences have been reported already under section 4. In addition, papers were published and distributed.

- ***Action related Publications and Reports***

Schatzmann, M. (2005) Quality assurance and improvement of micro-scale meteorological models – A proposed new COST action. Proceedings 5th International Urban Air Quality Conference, March 29-31, 2005, Valencia, Spain.

Schatzmann, M., and Britter, R. (Eds.) (2005): Proceedings from the International Workshop on ‘Quality assurance of microscale meteorological models’. European Science Foundation, ISBN 3-00-018312-4.

Britter, R., and Schatzmann, M. (Eds.) (2007): Background and justification document to support the model evaluation guidance and protocol document. COST Office Brussels, ISBN 3-00-018312-4.

Franke, J., Hellsten, A., Schlünzen, H., and Carissimo, B. (Eds.) (2007) Best Practice Guideline for the CFD simulation of flows in the urban environment. COST Office Brussels, ISBN 3-00-018312-4.

Britter, R., and Schatzmann, M. (Eds.) (2007): Model evaluation guidance and protocol document. COST Office Brussels, ISBN 3-00-018312-4.

Trini Castelli, S., and T. G. Reisin (2007) Application of a modified version of RAMS model to simulate the flow and turbulence in presence of buildings: The MUST COST732 experience. Proceedings, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK.

Trini Castelli, S., T. G. Reisin and G. Tinarelli (2007) Development and Application of MicroRMS Modelling System to Simulate the Flow, Turbulence and Dispersion in the Presence of Buildings. Proceedings, 29th International Technical Meeting on Air Pollution Modelling and its Application, Aveiro, Portugal.

Bartzis, J.G., A. Sfetsos, G. Efthimiou, S. Andronopoulos, A. Venetsanos (2007) Validation exercise utilizing ADREA and STAR-CD codes in urban scale, the MUST Experiment. Proceedings, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK.

Franke, J. (2007) Validierung von CFD Ergebnissen im Windingenieurwesen. In U. Peil (Edt.) Praktische Anwendungen in der Windingenieurtechnik - 10. Dreiländertagung D-A-CH, WtG-Berichte, pages 127-136, Braunschweig, ISBN 3-928909-09-6.

Franke, J, A. Hellsten, H. Schlünzen, and B. Carissimo (2007) The COST 732 best practice guideline for CFD simulation of flows in the urban environment – A summary. International Journal of Environment and Pollution (submitted).

Goricsan, I, Balczko, M, Czader, K, Rakai, A, Tonko, C.S. (2007) Simulation of Flow in an Idealised City Using Various CFD Codes. Proc., 11th International Conference on Harmonisation within At-

mospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK., ISBN 978-1-873702-03-1.

Regert, T, Goricsan, I., Balczo, M, Czader, K, Lajos, T (2007) Use of Detection of Coherent Flow Structures for Better Understanding of 3D Flow Fields in Urban Environment, Proc., PHYSMOD 2007, International Workshop on Physical Modelling of Flow and Dispersion Phenomena, Orleans, France, ISBN 2-913454-32-1.

Leitl, B., Bezpalcova, K and Harms, F. (2007) Wind tunnel modelling of the MUST experiment. Proceedings, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK.

Buccolieri, R., and Di Sabatino, S. (2007) Flow and pollutant dispersion in urban arrays for the standardization of CFD modelling practice. Proceedings, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK.

Santiago, J.L., and Martilli, A. (2007) Simulation of MUST experiment using RANS k-epsilon model. Validation against wind tunnel measurements and analysis of spatial average properties. Proceedings, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK.

Saloranta, J. and Hellsten, A. (2007) Evaluation of a general CFD-solver for a micro-scale urban flow. Proceedings, 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK.

Di Sabatino, S. and Buccolieri, R., (2007) MUST experiment simulations using CFD and integral models. International Journal of Environment and Pollution (submitted).

Trini Castelli S. and Reisin T.G., (2008) Application of a modified version of RAMS model to simulate the flow and turbulence in presence of buildings: the MUST COST732 exercise. International Journal of Environment and Pollution (submitted).

Goricsán, I., Balczó, M., Balogh, M., Czáder, K. Rákai, A., Tonkó C. (2008) Simulation of flow in an idealised city using various CFD codes. Int. J. of Environment and Pollution (submitted).

Efthimiou, G.C., John G. Bartzis and Spyros Andronopoulos (2008) Modelling the concentration fluctuation and individual exposure in complex urban environments. Proceedings, 12th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cavtat, Croatia (submitted).

Leitl, B., and Schatzmann, M. (2008) Quality assurance of urban flow and dispersion models - new challenges and data requirements. Invited Lecture, 3rd International Symposium on Wind Effects on Buildings and Urban Environment (ISWE3), Tokyo, March 4-5.

Nuterman R.B., A.V. Starchenko and A.A. Baklanov (2007) Microscale model for urban environment (M2UE). In: Enviro-RISKS: Man-induced Environmental Risks: Monitoring, Management and Remediation of Man-made Changes in Siberia. Baklanov, A. (Ed.), EC 6FP CA Enviro-RISKS Project Report: Overview and Progress Reports by Partners. DMI Scientific Report 07-04, ISBN: 978-87-7478-550-7, pp. 47-52.

Nuterman, R. and A. Baklanov (2007) Overview and Application of Obstacle Resolved Models for Air Flow and Pollution Transport Simulations. DMI Scientific Report 07-03, ISBN: 978-87-7478-549-1, 36 p.

Olesen, H, and Berkowicz, R. (2008) Guide to Excel sheets for MUST exercise. Internet publication, http://www2.dmu.dk/atmosphericenvironment/Docs/SpreadsheetInfo.pdf.

Piringer, M., K. Baumann-Stanzer, E. Polreich, M. Hirtl, G. Rau, 2008: Selected results of two model validation exercises. EMS Annual Meeting, Amsterdam (accepted).

Di Sabatino S., Olesen H., Berkowicz R., Franke J, Schatzmann M., Britter R., Schlünzen H., Martilli A., Carissimo B., 2008. A model evaluation protocol for urban scale flow and dispersion models. Proc. 12th Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cavtat, Croatia (accepted).

Piringer, M., K. Baumann-Stanzer, E. Polreich, M. Hirtl, 2008: User experience with model validation exercises. 12th Int. Conf. on Harmonisation, Cavtat, Croatia (accepted).

Di Sabatino, S, R. Buccolieri, H. Olesen, M. Ketzel, R. Berkowicz, J. Franke, M. Schatzmann, H. Schlünzen, B. Leitl, R. Britter, C. Borrego, A. M. Costa, S. Trini- Castelli, T. Reisin, A. Hellsten, J. Saloranta, N. Moussiopoulos, F. Barmpas, K. Brzozowski, I. Goricsan, M. Balczò, J. Bartzis, G. Efthimiou, J. L. Santiago, A. Martilli, M. Piringer, M. Hirtl, A. Baklanov, R. Nuterman, A. Starchenko (2008) COST 732 in practice: the MUST model evaluation exercise. Int. J. of Environment and Pollution (submitted).

Schatzmann, M., and Britter, R. (2008) Quality assurance and improvement of micro-scale meteorological models. Int. J. of Environment and Pollution (submitted).

- ***Conferences and Workshops***

Three workshops were organized by the Action:

- ESF/COST 732 Exploratory Workshop on 'Quality assurance of microscale meteorological models'. Hamburg/Germany, July 28/29, 2005
- COST732 Expert Meeting 'First results of the MUST validation exercise', Hamburg/Germany, January 11/12, 2007
- COST732 Expert Meeting 'Finalisation of the MUST wind tunnel validation exercise', Hamburg/Germany, January 11/12, 2007
- Special COST732 Session during the 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes which took place in Cambridge, UK, from July 2nd to 5th, 2007.

- ***Web site***

A COST 732 homepage has been developed and is permanently kept up-to-date. It can be found under
http://www.mi.uni-hamburg.de/Home.484.0.html

In addition, the action has prepared a COST 732 poster and a flyer, both are available at the homepage of the action.

- ***Scientific and Technical Cooperation***

COST 732 and COST 728 operate a joint web-based inventory of meso- and micro-scale meteorological models, see under
http://www.mi.uni-hamburg.de/Model-Inventory.5554.0.html

- ***Transfer of results***

The idea that drives the action and its activities was disseminated within the community by a talk of the chairman at the 5th International Urban Air Quality Conference in Valencia, at the International Workshop on Physical Modelling of Flow and Dispersion Phenomena in London, Ontario, at the ACCENT workshop in Thessaloniki and at two meetings with a corresponding Japanese/Korean quality assurance initiative in Tokyo (2007) and in Seoul (2008).

The general COST validation strategy was presented at the 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK, and during the summer School for PhD students "Atmospheric Boundary Layer Flows in Air Pollution Modelling" at van Karman Institute in Brussels.

A COST 732 poster has been prepared which was displayed by the secretary or members of the action at several conferences and other pertinent occasions.

The COST 732 documents (see http://www.mi.uni-hamburg.de/Official-Documents.5849.0.html ) were distributed through the national representatives to a large number of engineers and meteorologists who work in our field. In addition they were distributed to the participants of the 6th International Conference on Urban Climate in Gothenburg, the 28thNATO/CCMS International Technical Meeting on Air Pollution Modeling and its Application in Leipzig, the 10th Annual GMU Conference on Atmospheric Transport and Dispersion Modeling in Fairfax, USA, and the 11th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Cambridge, UK.

- ***Contacts in the ERA***

Members of the Action launched (or participate/participated in) projects within the scope of the European Frame Work Programmes. Especially the European NoE ACCENT on Atmospheric Composition Change and the FUMAPEX project (Integrated Systems for Forecasting Urban Meteorology, Air Pollution and Population Exposure) should be mentioned here. COST732 members initiated and actively contributed to FUMAPEX and organized the ACCENT workshop on Model Benchmarking and Quality Assurance (QA) which was held in Thessaloniki/Greece, on 29/30 May 2006.