Ten years of Harmonisation activities: Past, present and future

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1 Introduction

In this introductory address to the 7th conference on *Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes* I will take a look at the history of the "Harmonisation initiative", and examine its connection to the world that surrounds it. We, in the community of modellers and model users, are living in a landscape of models and science where many things function far less ideal than they could. I will here point to things we can do about it – both individually and as a group – and ask questions to be discussed during the conference.

I consider these Harmonisation conferences to be the ideal forum for a debate on how we can increase the usefulness of the work that we all do. It is my hope that at this conference and after it, we can further develop actions as well as educate ourselves, so that our work is put to better use.

One of my main points of emphasis will be that in the community of modellers, as well as in the community of model users, we should build upon the experiences of each other.

As a group, we should construct common tools (such as databases and software tools and tools for information exchange) and promote the use of them.

Individually, as modellers we shall do whatever we can in order to make our own work accessible to our colleagues. Often this aspect is neglected, because the emphasis is being given to providing the sponsors with the immediate answers that they want – rather than building up durable, well-documented and generally accessible methodologies.

There is a tendency too often to start from scratch with modelling work, and as a result many of us fight with the same problems and repeat the same mistakes.

The paper contains three main sections: The first takes a historical perspective. It outlines the background of the Harmonisation activity and discusses what has happened to a number of recommendations set forth at the first kick-off workshop in 1992. The second part of the paper inspects some features of the "landscape of modelling" and identifies various "good questions". And finally, the third main section gives some suggestions for the future. The paper is meant to be both a resource of information on activities (via the reference list) and an introduction to debate at the conference.

2 Historical overview

In June 1991, a meeting with about 20 European scientists as participants was held at the Joint Research Centre in Ispra. The meeting considered the topic “European Harmonisation in Atmospheric Modelling Systems”. The concern was primarily dispersion models for short ranges, i.e. models for regulatory use and as real-time tools. This meeting led to the formation of a steering committee, which subsequently has organised the Harmonisation workshops and conferences from 1992 until today.

The initiative leading to the meeting in 1991 was taken primarily because it was recognised that in Europe, the state of dispersion modelling left much to be desired in several respects. I would like to mention two issues:

- There was (and still is) a great number of regulatory models in use within Europe.
- Generally, the models applied were not scientifically up-to-date.

As to the first issue, the existence of a multitude of models poses several problems. The fact that different models may produce differing results for the same scenario is inconvenient from an

administrative point of view. Further, it is difficult to compare the different models and their merits. Is model A to be preferred compared to model B for a certain purpose?
It was recognised that there was a lack of basic standards and tools that would make it feasible to make statements on model merits in a satisfactory way. The steering committee wished to improve upon this situation.
As to the second issue – that models were not up-to-date – a lot of knowledge and experience is documented in the scientific literature. The role of models is to generalise this information into sets of rules and procedures that can be used in practice. Thus, it can be regarded as the primary purpose of modelling to ensure that *the greatest possible amount of available knowledge is incorporated into the decision-making process*. However, new scientific developments did not seem to be transferred to the user community as efficiently as they could be; this was seen as a severe problem when the initiative started. A resolution, which was passed at the first workshop in 1992, stated:
The practical atmospheric dispersion models, which are presently used for regulatory purposes, are based on 25-year old research (Pasquill-Gifford type stability classes, simple Gaussian dispersion schemes, i.a.). During the past 25 years, research in atmospheric dispersion has progressed substantially, thus rendering the presently used regulatory models outdated. Consequently, there is now a need for development and practical implementation of computer codes based on our present knowledge of atmospheric dispersion.
The resolution describes well the state of regulatory modelling in the early nineties. Since then, a number of more modern models have made their way into regulatory modelling.
In the next subsections, I will recapitulate some of the work that has been done since our first kick-off workshop in Denmark in 1992. These sections may serve to you as a catalogue of useful information.

2.1 Workshop On Objectives For Models, May '92

When the European initiative on *Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes* was launched in 1991 the purpose was to achieve increased co-operation on and standardisation within regulatory models. The first workshop – *"Objectives for Next Generation of Practical Short-Range Atmospheric Dispersion Models"* – was held in May 1992 in Denmark, and set the scene for much of the further work (Olesen and Mikkelsen, 1992). The focus of the workshop was on the *management of model development* and the *definition of model objectives*, rather than on detailed model contents. It was the intention to identify actions to be taken in order to improve the development and use of atmospheric dispersion models.
A number of recommendations for the improvement of "modelling culture" were suggested (Berkowicz and van Ulden, 1992; Olesen and Kretzschmar, 1992; Graziani et al., 1992). Most of these are stated below and will be discussed in the following:

- *There should be systematic comparisons of model predictions versus existing data sets from experiments. Further, future experiments needed to fill out knowledge gaps should be pointed out.*
- *Review of regulatory use of models. Which models are actually used in the EC member states? What guidance or requirements do the different countries have?*
- *Comparison of output from different models for a single case (in the style of a product review in a journal).*
- *Model users should be aware of the uncertainties inherent in model calculations. Work should be undertaken on how to determine model uncertainties and how to present them to the model users.*
- *There should be an action for setting up guidelines for model development and documentation. The aim is to promote more correct use of models.*
- *There should be an action for harmonisation of meteorological input for "next-generation models".*
- *One or more electronic Bulletin Board Services (BBS) or similar services should be established to help the co-ordination of model development and management.*

It is interesting to see what has happened concerning the activities proposed in 1992. The Harmonisation initiative has always done its work on a voluntary basis, and it never had funds to

carry out work on its own. Nevertheless, I think that the workshop in 1992 gave a push and stimulated many activities, which have taken place in the subsequent decade. Some of these activities will be described in the following sections.

2.2 Recommendation: Systematic comparisons of model predictions versus data

The recommendation that there should be systematic comparisons of model predictions versus existing data sets from experiments has certainly been implemented. The basis for much of this work has been the so-called Model Validation Kit. The kit addresses the classic problem where a single stack emits a non-reactive gas.

A preliminary version of the "Model Validation Kit" appeared for the workshop in Manno, Switzerland, in 1993. The subsequent year, for the workshop in Mol, the kit was streamlined, and it has retained essentially this form since then. It has been a useful point of reference for a lot of studies at subsequent conferences, but it does have recognised limitations. One weakness of the methodology used in the Model Validation Kit is that its results should be interpreted with great care, because it does not explicitly address the question of stochastic nature of observed concentrations. In order to cope with this type of problems John Irwin proposed an approach, which was discussed and further developed at several Harmonisation conferences (e.g. Irwin 1999, 2000). The methodology is not as simple as that of the Model Validation Kit methodology, but addresses some of its shortcomings in a relevant way. Irwin's work recently acquired a more official status: the American standards organisation ASTM published it as an ASTM standard guide (ASTM 2000). I will address this line of work in more detail in a separate paper (Olesen 2001).

At the Harmonisation conferences there have been many enlightening papers on the intricacies and pitfalls of model evaluation. Thus, a train of activities has been initiated which would hardly have been carried out without the initiative.

The model evaluation activities have gradually been broadened in scope from the single stack problem to other classes of problems, such as street canyon modelling.

Concerning the original recommendation to identify needed experiments, the Harmonisation initiative was less successful. It was pointed out that a comprehensive, baseline dispersion experiment with a stack of moderate height – say 50 meters – was never carried out in Europe. However, the attempts to raise funding for such an experiment were not successful – other types of experiments have received higher priority from funding agencies.

2.3 Recommendation: Review of regulatory models in EC.

The recommendation to review regulatory use of models has been responded to by including "country reviews"' as a major topic for the harmonisation conferences. Thus, in the course of years, a valuable resource of information about practices in the various countries has accumulated in the conference proceedings. Through the web page of the Harmonisation initiative (specifically: URL 1) a list of all presentations at the harmonisation conferences is available.

2.4 Recommendation: Comparison of output from different models

A number of studies where models have been intercompared have been conducted and reported at the harmonisation conferences.

Probably the most comprehensive was the one by Cosemans et al. (1994). 12 European modelling teams calculated the impact of a 600 MW power plant using one of their national models. Large differences between the results of the models were observed. These differences were reduced when the meteorological input for the models was normalised, but there were still differences between models of a factor of 3.

Another quite comprehensive study, which was reported at the conference in Rouen and finished since then (Hall et al. 2000a) is particularly interesting because it defines a protocol for model intercomparisons, which can be used in future work. I believe that the conclusions from the study are symptomatic for the situation. In their report for the UK Environment Agency the authors state:

...However, in searching for consistent differences in behaviour between the three models, one of the conclusions of the study was that there did not seem to be many... ... It appears that the advanced models and their meteorological preprocessors are still in a state of scientific development which has not yet converged to a consensus view of how they should behave...
and they give as a recommendation:
That it be recognised that atmospheric dispersion models are imperfect and, for the 'advanced' models especially, still subject to scientific uncertainty and further development. In particular, different models and versions of models may produce markedly different results in regulatory studies. The Agency will need to understand these differences, the ways in which they arise and to take account of the uncertainties associated with this type of calculation in its regulatory decisions.

2.5 Work on uncertainties

One of the recommendations from the first workshop was that all users should be aware of the uncertainties inherent in model calculations. This issue is still a weakness, and it will be a topic for discussion later, by myself as well as others.

2.6 Guidelines for model development and documentation

At the workshop in 1992 it was recommended to start an action for setting up guidelines for model development and documentation. The initiative itself has not produced any such guidelines, but it has tried to stimulate and inspire related work by other bodies. Modellers seeking guidance can now find help in a number of documents: At the first workshop in 1992, a "Dutch standard on the description of air pollution models" was presented (Noordijk, 1992). In 1994, the "Model Evaluation Group" funded by the European Commission (as part of a programme on Major Industrial Hazards) produced several leaflets with guidance for model developers (Model Evaluation Group 1994a; 1994b). The German VDI has produced various guidelines, and in 1995, the British Royal Meteorological Society issued a policy statement with "Guidelines on the justification of choice and use of models, and the communication and reporting of results" (Royal Meteorological Society, 1995).

2.7 Meteorological input

As it was envisaged during the first workshop, work on meteorological pre-processors was started within the framework of the COST action 710: “Harmonisation in the pre-processing of meteorological data for dispersion models”. This action took place during the period 1994-97. It produced a final report (Fisher et al., 1998) which can serve as a useful standard reference describing the state of art within meteorological pre-processing. The book contains a number of recommendations on how to perform pre-processing, but also identifies problem areas where current methods are insufficient and should be improved. Part of the book is available through the COST 710 home page (URL 2).

2.8 Electronic services

At the first workshop in 1992, I gave a presentation entitled “Electronic information exchange in the field of atmospheric dispersion models” (Olesen, 1992), where I advocated for the use of Bulletin Board Services and similar electronic services as a potentially useful tool for the modelling community. It is interesting to look back at that paper now, in the light of the dramatic changes in the use of the Internet that have taken place since then. Actually, what I advocated has to a large extent happened. Electronic information exchange is now a part of everyday life, but in the modelling community we could make better use of our possibilities. I will return to this point later.
One of the things I had in mind in 1992 was a model catalogue. In 1995, when the technical possibilities arose, I assisted the European Topic Centre on Air Quality of the EEA in producing a prototype of a Model Documentation System for use on the web. The system is now a well-established service running in the framework of the ETC/AQ (URL 3). An "electronic service"

which deserves mentioning here is the web site of the “Harmonisation...” initiative. It was established in 1995 and contains plenty of information on work related to the initiative (URL 4).

3 The landscape of dispersion modelling

In this second main part of the paper, let us look at "the landscape of modelling" and analyse some of the features we can observe. These observations can be useful to keep in mind when we consider what we can expect to achieve in future with respect to harmonisation. I have been inspired by some papers from previous harmonisation conferences to raise a number of problematic issues.

3.1 Duplication of effort

My first point is that there is an abundance of scientific literature within dispersion modelling. There is also an abundance of models, and an abundance of scientific conferences. The amount of information is overwhelming, but it is under-used. Despite all the work that is being done, we (modellers) still have difficulties in finding answers to the questions that users come with.

I believe that a widespread duplication of effort takes place, and that a lot of our work is to some extent wasted. We ought to build upon the experiences of each other -– and we do – but not enough.

At the conference in Rhodes in 1998, R. Schulze presented a paper (Schulze, 1998) which contained a number of very rational suggestions. Schulze outlined how we could establish a framework for model development, which would serve society better than the present (dis-) organisation. Schulze pointed to the advantages of an approach, which we have *not* taken so far: He suggested that the development effort of various institutions should be focused on *individual algorithms* – not on complete models. Schulze listed around twenty processes and issues, which an all-round regulatory model should be able to handle. If the work of creating the algorithms were distributed among several groups, then the tremendous job of creating an all-round model would stand a better chance of success. Schulze compared the situation with that of a symphony orchestra, where the individual musicians can be gifted, but a successful result nevertheless depends on the presence of a conductor. Schulze noted:

The approach outlined will enable an individual research organisation to really probe deeply in a rather narrow area rather than single-handedly trying to develop a comprehensive model to address, at least crudely, all the issues. If 10 or 15 research organizations each chose specific areas to study, I believe that more progress would be made in developing a comprehensive up-to-date model for use in Europe as well as elsewhere.

The idea expressed by Schulze is appealing, and it may serve as an inspiration in our work. However, looking at the "landscape" of dispersion modelling, the idea does not seem to be practicable to its full extent. In Europe, there is not only one, rationally behaving, source of funding for modelling work. Instead, each group receives its funding from some sponsor who is interested in getting a certain, limited job done – not in funding a comprehensive, long-term research activity. One might imagine that the research programmes of the European Union could be a framework to carry out co-ordinated research, distributed over a large number of groups. However, over the years our experience has been that model development is *not* one of the areas, which receive a high priority. The EU has channelled some funds into *co-ordination* (e.g. through COST actions), but *model development* as such has been left to be financed by ad hoc sponsors. As a result, we see the present landscape with scattered groups, each nursing its own model. Having said this, I am *not* saying that things cannot improve. On the contrary: I am advocating an approach where we use each other's work better. But, in order to be realistic, I see no signs for a dramatic change of the funding situation.

So, we are faced with the question: Which steps can we take to encourage re-use of our work? Later in the paper, I will give some suggestions.

3.2 Uncertainty in model results

Looking at the "landscape of modelling", it is widely recognised among modellers that there are large uncertainties in model results. Because of the stochastic nature of atmospheric turbulence these uncertainties cannot be eliminated and will remain large, even if we have a perfect model.
As modellers, we feel an obligation to convey this information to model users. But it is very difficult to quantify these uncertainties. Many papers have been written which are concerned with this aspect, but there is no simple answer to be given when a user asks: "How accurate is your model?"
I will return to this subject in another presentation during this conference, but I think it should be a central theme for discussion.

3.3 The regulator's dilemma: Different models yield different results

In a recent report prepared for the UK Environment Agency (Hall et al., 2000b), the authors state:
"From a regulatory point of view, the differences in predictions between models and between different versions of the same model are of equal, if not greater, importance than their absolute reliability. These differences are often of significant scale and can directly affect regulatory decisions."
For a decision-maker, it would be most convenient with just *one* model being prescribed for a given situation. But when different models give different results, this often reflects that there is a scientific uncertainty. This uncertainty should not be hidden. At previous conferences we have discussed what harmonisation implies, and there are varying points of view. But I think there is consensus that some form of harmonisation – harmonisation *within* modelling – has a lot of benefits to offer. Such harmonisation aims at use of common tools wherever reasonable, and at re-using each other's work in many senses.
But it remains a "good question" how we best can provide regulators with guidance.

3.4 User requirements

At the previous conferences the majority of presentations has been from model developers, and only a minor part from model users. Still, the voices of model users have been heard and they have posed "good questions". Some of the needs of model users tend to be overlooked by model developers. M. Tasker has raised several such questions in papers. One of his central points was (Tasker, 1997):
As gas dispersion models become more complex, the need to provide clear, unambiguous guidance for their use becomes increasingly important.
Tasker illustrates this need with several instructive examples from his experience. I think that Tasker makes a good point: Guidance is often insufficient to avoid erroneous use of models.
Another concern of users is expressed by Tasker (2000):
Often gas dispersion practitioners have to use inappropriate models for non-standard gas dispersion applications simply because no better techniques are available. Serious errors could arise as a result. For example, using a flat ground model for dense gas dispersion over a hill in stable atmospheric conditions will inevitably give incorrect results. It is important that sufficient effort is directed towards developing new models to quantify problems which cannot, at present, be adequately dealt with.

4 The future – what can we do?

In this third major section, let us consider what we can do in the future to improve matters. I have a few suggestions, but this conference is an obvious opportunity for all of us to come with input and discuss this. There are things we can do as individuals, and there are actions which we can take as a community.

4.1 Individual actions

If we first look at the individual aspect, we can all pay more attention to how we make our work easily accessible to others. There are many facets of this:

- Think of your audience when you write
- Make software user-friendly
- Make code well documented and freely accessible
- Rely on standards or on other recognised common tools wherever this makes sense.
- Report not only on success, but also on failures and pitfalls.
- Make work accessible through the Internet

These "commandments for good behaviour" are frequently not adhered to. An obvious obstacle is time and resource constraints: It takes extra time to care for the rules outlined above, so quality is often sacrificed in order to keep deadlines. But each of us can do something in this respect.

4.2 Actions as a community

An important obstacle to the use of common tools and guidelines can be that we are unaware of their existence. The ultimate obstacle is of course that *there are no* relevant common tools.
In both of these situations, the present conference has a mission: we should create common tools and make them accessible on the web. This conference is a proper place to disseminate information on common tools, standards and guidelines and inspire further developments.

4.3 Is there a future for FAQ-like structures?

I wish to bring forward for discussion some thoughts I have on how we can improve communication within the modelling community. In the Internet age, the concept of FAQ lists has been established. FAQ stands for "Frequently Asked Question" and the concept is used especially in conjunction with Internet "newsgroups" (discussion groups). In discussion groups, questions can be asked openly, and anybody can give a response. Some questions are asked repeatedly, and in order to handle such questions in a rational manner, it is common for newsgroups to compile lists of frequently asked questions and their answers.
Within the subject of atmospheric dispersion, there are to my knowledge no FAQ lists. It is my belief that in the modelling community we could benefit from some kinds of FAQ-like structures, although there may be better alternatives than traditional FAQ lists.
Compared to many other fields, the domain of atmospheric dispersion is complicated, and the questions which are asked are more complex that those in, e.g. a computer-related FAQ. Further, traditional FAQ's are often maintained by a single, enthusiastic person. Maintenance of a FAQ-like document for dispersion modelling requires more expertise and time than you can expect from a single volunteer. So, there are reasons to consider whether other FAQ-like structures could be established, possibly as a supplement to traditional FAQ's.
In this context it can be noted that the concept of FAQs to some extent serves the same purpose as traditional review articles in scientific journals. One might imagine review articles being published on the Internet, so that they could serve as FAQs.
Another "FAQ-like structure" is the access to archives of newsgroup postings. Such archives are literally mines of useful information within certain subject areas. Their usefulness can be illustrated with the following example:
If I am confronted with a computer-related problem, where a computer exhibits a weird behaviour, I first try to search in the documentation from the manufacturer of the particular piece of hardware or software, which I suspect to be cause of the problem. However, very often such a search gives no useful result. Nevertheless, I can be almost sure that I am not the only person who has experienced this problem. So the next step, which has worked for me dozens of times, is to search through an archive of newsgroup postings. There is a service (formerly deja.com, now groups.google.com; URL 5) which maintains an archive of millions of postings in newsgroups going back to 1996. These newsgroups concern almost every topic. The subject area of computer-related problems is particularly well covered: almost every conceivable problem has been brought up and responded to. So, if I am able to characterise my problem by a few well-chosen terms, I will most likely find my problem described and resolved in

the archives of newsgroup discussions. These newsgroups represent an amazingly comprehensive mine of information.
To the best of my knowledge, there is yet no discussion forum on the Internet where the topic of atmospheric dispersion modelling has received any really profound treatment with input from model users and model developers. I would like to see such a forum to develop over the years to come. If one or more forums for discussions became widely used, they could over the years generate a comprehensive body of information.
There is an existing distribution list on atmospheric dispersion of chemicals, which was originally called GT-ATMDC, but recently changed name to AtmosphericDispersion (URL 6). This list has existed since 1993, but has only been slightly used. There are no other well-focused lists or Usenet newsgroups, which I have been able to find. Therefore, the AtmosphericDispersion list is a convenient rallying point for the modelling community, and I think that use of it should be promoted. The list maintains an archive of all items covered in the past, but it does not yet represent any profound source of knowledge.
I wish to encourage you at this conference to discuss ideas on how we can accelerate the establishment of FAQ-like structures.

5 Conclusions

The first part of this paper recapitulates previous work related to the harmonisation initiative; it can serve as a catalogue of useful information. In the second part, the "landscape of modelling" is inspected, resulting in some "good questions" to the modelling community. Here, a striking observation is the amount of duplication of effort, which takes place. The third part of this paper is directed towards the future and mainly deals with steps that we can take in order to reduce duplication of effort. One particular idea is discussed in some detail: the establishment of FAQ-like structures.
Finally, let me recapitulate a number of questions, which it seems relevant to deal with during the present conference:
How can we pool experiences?

- In general: Which steps can we take to encourage re-use of our work?
- Specifically: How can we accelerate the development of FAQ-like structures? Can we promote publishing of review papers on the web?

"Good questions":

- How can we quantify model uncertainties?
- How can regulators be assisted in their choice of models?
- How can we best provide users with guidance on model use?

In general, we should use this conference to promote harmonisation. The conference can be used to

- Advertise tools of common interest.
- Give suggestions and recommendations for further work.

6 References

6.1 References to printed publications

ASTM (2000), 'Standard Guide for Statistical Evaluation of Atmospheric Dispersion Model Performance', D6589. American Society for Testing and Materials (available through www.astm.org).
Berkowicz, R. and van Ulden, A.P, (1992),' Scientific basis for next-generation models; summary of discussions in Work Group I', *in:* Proceedings of the workshop on *"Objectives for Next Generation of Practical Short-Range Atmospheric Dispersion Models"*, pp. 9-16, Risø, Denmark. Eds. Olesen and Mikkelsen (see below).
Cosemans, G., Kretzschmar, J., Janssen, L. and G. Maes (1997): The Third Workshop's environmental impact assessment model intercomparison exercise. Int. J. Environment and Pollution, Vol. 5, Nos. 4-6, pp. 785-798.
Fisher, B.E.A., J.J. Erbrink, S. Finardi, P. Jeannet, S. Joffre, M.G. Morselli, U. Pechinger, P. Seibert and D.J. Thomson (eds., 1998), 'COST Action 710 – Final report. Harmonisation of the pre-processing of

meteorological data for atmospheric dispersion models', EUR 18195, Luxembourg: Office for Official Publications of the European Communities. ISBN 92-828-3302-X.
Graziani, G., Sartori, E. and Klug, W. (1992), 'Data bases and principles for model evaluation; summary of discussions in Work Group III', *in:* Proceedings of the workshop on *"Objectives for Next Generation of Practical Short-Range Atmospheric Dispersion Models"*, pp. 25-29, Risø, Denmark. Eds. Olesen and Mikkelsen (see below).
Hall, D.J., A. M. Spanton, F. Dunkerley, M. Bennett and R.F. Griffiths (2000a), 'An inter-comparison of the AERMOD, ADMS and ISC dispersion models for regulatory applications'. TR P362. ISBN 1 85705 340 0. Environment Agency, Bristol, UK.
Hall, D.J., A.M. Spanton, F. Dunkerley, M. Bennett and R.F. Griffiths (2000b), 'A review of dispersion model inter-comparison studies using ISC, R91, AERMOD and ADMS', TR P353, ISBN 1 85705 276 5. Environment Agency, Bristol, UK.
Irwin, J.S. (1999), 'Effects of concentration fluctuations on statistical evaluations of centerline concentration estimates by atmospheric dispersion models', 6th international conference.on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Rouen, France, October 11-14, 1999.
Irwin, J.S. (2000), 'Statistical Evaluation of Atmospheric Dispersion Models', Int. J. Environment and Pollution, Vol. 14, Nos. 1-6, pp. 28-38.
Model Evaluation Group (1994a): 'Guidelines for model developers'. Can be requested from DG XII/D1, Rue de la Loi 200, B-1049 Brussels, Belgium. Fax +32 2 296 3024.
Model Evaluation Group (1994b): 'Model evaluation protocol'. Can be requested from DG XII/D1, Rue de la Loi 200, B-1049 Brussels, Belgium. Fax +32 2 296 3024.
Noordijk, H. (1992), 'Quality criteria for air pollution models, standardisation and model development in the Netherlands', *in:* Proceedings of the workshop on *"Objectives for Next Generation of Practical Short-Range Atmospheric Dispersion Models"*, pp. 131-138, Risø, Denmark. Eds. Olesen and Mikkelsen (see below). Refers to 'The Dutch standard on the description of air pollution models' which is reprinted in the proceedings, pp. 203-207.
Olesen, H.R. (1992), 'Electronic information exchange in the field of atmospheric dispersion modelling', *in:* Proceedings of the workshop on *"Objectives for Next Generation of Practical Short-Range Atmospheric Dispersion Models"*, pp. 95-98, Risø, Denmark. Eds. Olesen and Mikkelsen (see below).
Olesen, H.R. and Kretzschmar, J. (1992), Requirements concerning model capabilities and model output; summary of discussions in Work Group II, *in:* Proceedings of the workshop on *"Objectives for Next Generation of Practical Short-Range Atmospheric Dispersion Models"*, pp. 17-25, Risø, Denmark. Eds. Olesen and Mikkelsen (see below).
Olesen, H.R., and Mikkelsen, T. (1992), Proceedings of the workshop on *"Objectives for Next Generation of Practical Short-Range Atmospheric Dispersion Models"*, Risø, Denmark. Available at National Environmental Research Institute, P.O. Box 358, DK-4000 Roskilde, Denmark. Parts of the proceedings are available through http://www.dmu.dk/atmosphericenvironment/Harmoni/1_w_shop.htm
Olesen, H.R. (2001), 'A platform for model evaluation'. 7th international conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Belgirate, Italy, May 28-31, 2001.
Royal Meteorological Society (1995), 'Atmospheric Dispersion Modelling: Guidelines On the Justification of Choice and Use of Models, and the Commmunication and Reporting of Results'. 104 Oxford Road, Reading RG1 7LJ, England.
Schulze, R. (1998), 'Creating harmony from dissonance in model development – a business approach', 5th international conference.on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, May 18-21, 1998, Rodos, Greece.
Tasker, M. (1997), 'Gas dispersion modelling harmonization: an industrial viewpoint', *Int. J. Environment and Pollution*, Vol. 8, Nos. 3-6, pp. 241-249.
Tasker M. (2000), 'The harmonization of gas dispersion modelling for industrial applications: a few thoughts for the future', *Int. J. Environment and Pollution*, Vol. 14, Nos. 1-6, pp. 1-9.

6.2 References to web resources

URL 1: http://www.dmu.dk/atmosphericenvironment/Harmoni/ProcIntr.htm, 'Overview: Proceedings of the Harmonisation workshops and conferences Harmonisation initiative'. Visited March 2001.
URL 2: http://www.dmu.dk/atmosphericenvironment/cost_710.htm. 'Harmonization in the pre-processing of meteorological data for dispersion models'. Visited March 2001.

URL 3: http://www.etcaq.rivm.nl/databases/mds.html. 'European Topic Centre on Air Quality'. Visited March 2001.
URL 4: http://www.dmu.dk/atmosphericenvironment/harmoni.htm. 'Initiative on Harmonisation...'. Visited March 2001.
URL 5: http://groups.google.com. 'Google groups'. Visited March 2001.
URL 6: http://listserv.surfnet.nl/archives/atmosphericdispersion.html. ' AtmosphericDispersion'. Visited March 2001.