RTMOD: Real-Time MODel evaluation

Graziani, G.; Galmarini, S.; Mikkelsen, Torben Krogh

Publication date:
2000

Document Version
Publisher's PDF, also known as Version of record

Risø-R-1174(EN)

RTMOD: Real-Time MODel Evaluation

Giovanni Graziani and Stefano Galmarini
JRC - Ispra, Italy

and

Torben Mikkelsen
Risø National Laboratory, Denmark

Risø National Laboratory, Roskilde
January 2000

Abstract. The 1998 - 1999 RTMOD project is a system based on an automated statistical evaluation for the inter-comparison of real-time forecasts produced by long-range atmospheric dispersion models for national nuclear emergency predictions of cross-boundary consequences.

The background of RTMOD was the 1994 ETEX project that involved about 50 models run in several Institutes around the world to simulate two real tracer releases involving a large part of the European territory. In the preliminary phase of ETEX, three dry runs (i.e. simulations in real-time of fictitious releases) were carried out. At that time, the World Wide Web was not available to all the exercise participants, and plume predictions were therefore submitted to JRC-Ispra by fax and regular mail for subsequent processing.

The rapid development of the World Wide Web in the second half of the nineties, together with the experience gained during the ETEX exercises suggested the development of this project. RTMOD featured a web-based user-friendly interface for data submission and an interactive program module for displaying, intercomparison and analysis of the forecasts.

RTMOD has focussed on model intercomparison of concentration predictions at the nodes of a regular grid with 0.5 degrees of resolution both in latitude and in longitude, the domain grid extending from 5W to 40E, and 40N to 65N.

Hypothetical releases were notified around the world to the 28 model forecasters via the web on a one-day warning in advance. They then accessed the RTMOD web page for detailed information on the actual release, and as soon as possible they then uploaded their predictions to the RTMOD server and could soon after start their inter-comparison analysis with other modellers. When additional forecast data arrived, already existing statistical results would be recalculated to include the influence by all available predictions.

The new web-based RTMOD concept has proven useful as a practical decision-making tool for real-time communication between dispersion modellers around the World and for fast and standardised information exchange on the most probably contaminated areas.

The project was conducted as a Concerted Action project with support from the European Commissions Nuclear Energy-Radiation Protection Research Program, under Contract No. FI4P-CT97-0068

ISBN 87-550-2682-6
ISBN 87-550-2687-7 (Internet)
ISSN 0106-2840

Information Service Department, Risø, 2000

Contents

1 Introduction

RTMOD (Real Time MODel evaluation) is an Interned-based system suited to analyse in real-time the predictions of several mathematical models applied to simulate the atmospheric dispersion of harmful materials, as radioactive pollutants. RTMOD is structured as a website interfacing the modeller on the client side, and the statistical analysis system on the server. The modellers participating to the RTMOD exercises are informed by fax and e-mail when a dry run (a fictitious release) takes place, and they access a web page where the release information is stored, starting the simulation using their meteorological data and long-range dispersion models. The simulation domain fixed for the first two exercises (and maintained for the fourth) as the European region encompassing 5° W to 40°E in longitude and 40°N to 65° N in latitude, has been made variable to host the simulation for the Algeciras accident and any eventual future exercise.

After the completion of the simulation, the modeller can upload to the RTMOD site the results obtained, in a standardised format. RTMOD processes the new results arrived, by comparing them with the results of other models available at the moment. When new model results arrive, the statistical inter-comparison is updated.

The statistical analyses in RTMOD are carried out on air concentration and dry and wet deposition at ground, three variables particularly important for radiation protection management.

The statistical analysis package implemented in RTMOD is presented and discussed in depth elsewhere (Mosca et al., 1998). In RTMOD only the Confidence in Contamination level (CCL) has been added to the statistics used in ETEX. The CCL is a two-dimensional matrix with each cell corresponding to a node of the calculation grid. The value in each cell is the fraction of available models that predict above a fixed threshold value. If all the models participating in the study are reliable, a high CCL value at a given time in a point indicates a not negligible risk to exceed dangerous concentrations. The RTMOD system produces CCL maps at the same times of FMS.

Here a brief overview of the statistics is given. Details and definitions can be found also on the Webpage. Three main types of analyses are performed:

Time analysis, where the concentrations at a fixed location are considered for the whole duration of the simulation. This analysis can give insight on discrepancies between predictions from different models that may arise due to time shifting.

Space analysis, where the concentrations at a fixed time are considered all over the domain. This analysis is useful to evince space shifting between different model predictions.

Global analysis, where all the concentration values at any time and location are considered. For this analysis the distribution of the values is important, as well as the overall tendency of a model to underestimate or overestimate concentrations with respect to the other models.

These analyses produce results in numerical and graphical format, as shown in this Report by some examples.

2 System Organisation

Thi home page of the RTMOD system is accessible through Internet. Some of the web pages, containing the general information about the system, and examples of the exercises performed are accessible to everyone, while the access to other pages is restricted only to the modellers participating to the exercise.

Each RTMOD experiment starts with pre-alert (24 hours before) and alert messages sent via e-mail and fax by the project manager at JRC Ispra. Information about the fictitious release (source location, exit speed, exit temperature, dry deposition velocity, …) are available to the participants on the Internet. The simulations are produced in real-time. At the end of it, each participant sends a model output file in standard format to the JRC. The send procedure is a simple browse of the file on the local hard disk or , as an alternative, via the ftp protocol.

When at least two model results arrive to the RTMOD server, the statistical comparison initiates. The results of each model are compared against the other available results. After this phase, new web pages containing the results are automatically built and published on the Internet. Hence each modeller can access these pages and see the performances of his model against those of all the others. When new model results arrive, the procedure of statistical comparison starts again and all the models already present are analysed with respect to the newly arrived models.

The website of the RTMOD system allows also the participants to establish a discussion group about different topics that may arise during the exercise. Archives of the different experiments and of the minutes of meetings are also accessible via the Internet.

3 Structure of the Program

The RTMOD system is installed on a dual-Pentium PRO200 personal computer, running Linux as operating system. The system is fully portable across platforms since it is based on PERL and IDL (Interactive Data Language, by Research Systems, Inc.), that are both platform-independent. The following Figure shows the main flow chart of the RTMOD system. The project manager at JRC can insert the data concerning a new exercise in an apposite form. At time due, by simple clicking a button, this form is automatically published on the Internet and the modellers are informed via email that a new experiment has started. At the same time a PERL language procedure (PROC1) builds the template-input file for the IDL program. This template input file changes at each exercise since some of the analyses are carried out at locations, specific of the exercise, as for the time analysis. These initialisation actions must be done only once for each dry run. Instead, a shell script driving PERL and IDL procedures runs at user-defined frequency until all the model results have arrived and have been processed.

When at least two model results have arrived at the JRC, the shell script starts the module PROC2 , written in PERL, that performs two main operations. First it determines which are the new model results and checks that their format agree with the specified requests, and that the values it contains are appropriate (e.g. data are referred to the correct simulation domain, they are inside the correct temporal window, etc.) Second, for all the correct data files PROC2 calculates the concentration percentiles, updates the status of each model from -1 to 0, and rewrites the concentration values as required by the IDL program STAT. Three different numbers are used to represent the processing status of each model:

-1 for model results not yet arrived
0 for model results arrived but not processed
+1 model results arrived and processed

After PROC2, the shell script drives the IDL program STAT that processes the results of models with status equal to 0 and changes their status to +1 if the processing was successful. The processing consists in calculating all the statistical indices previously described and in producing the GIF (Graphics Interchange Format) images resulting from the graphical inter-comparison. The input file for the IDL program contains the following information:

- exercise number
- set number (two different sets of data are taken into account, corresponding to predicted and analysed meteorology)
- source location co-ordinates and emission rate
- location of the RTMOD system base directory
- total number of models participating in current experiment
- co-ordinates of points where the FMT indices must be calculated
- concentration level and times for calculating the FMS

- threshold concentration value for calculating the CCL index
- concentration values corresponding to the percentiles to be shown by the box plots
- status of each model

In a separate file concentration values predicted by each model at each grid cell and at each time are stored in a tabular format.

When the images are ready and the statistical indices are calculated, a third PERL program, PROC3, runs to build the HTML page containing the results. At termination, the shell script checks if all the model results have been processed (i.e. if the status of all models is +1). If the check is positive, the system terminates the analyses for the current experiment, otherwise it checks if new results have arrived during the processing. If this second check is positive, then the whole procedure starts again, otherwise the system waits until new model results arrive. Finally, when the first results for a model are ready on the Internet, the corresponding modeller is notified by email.

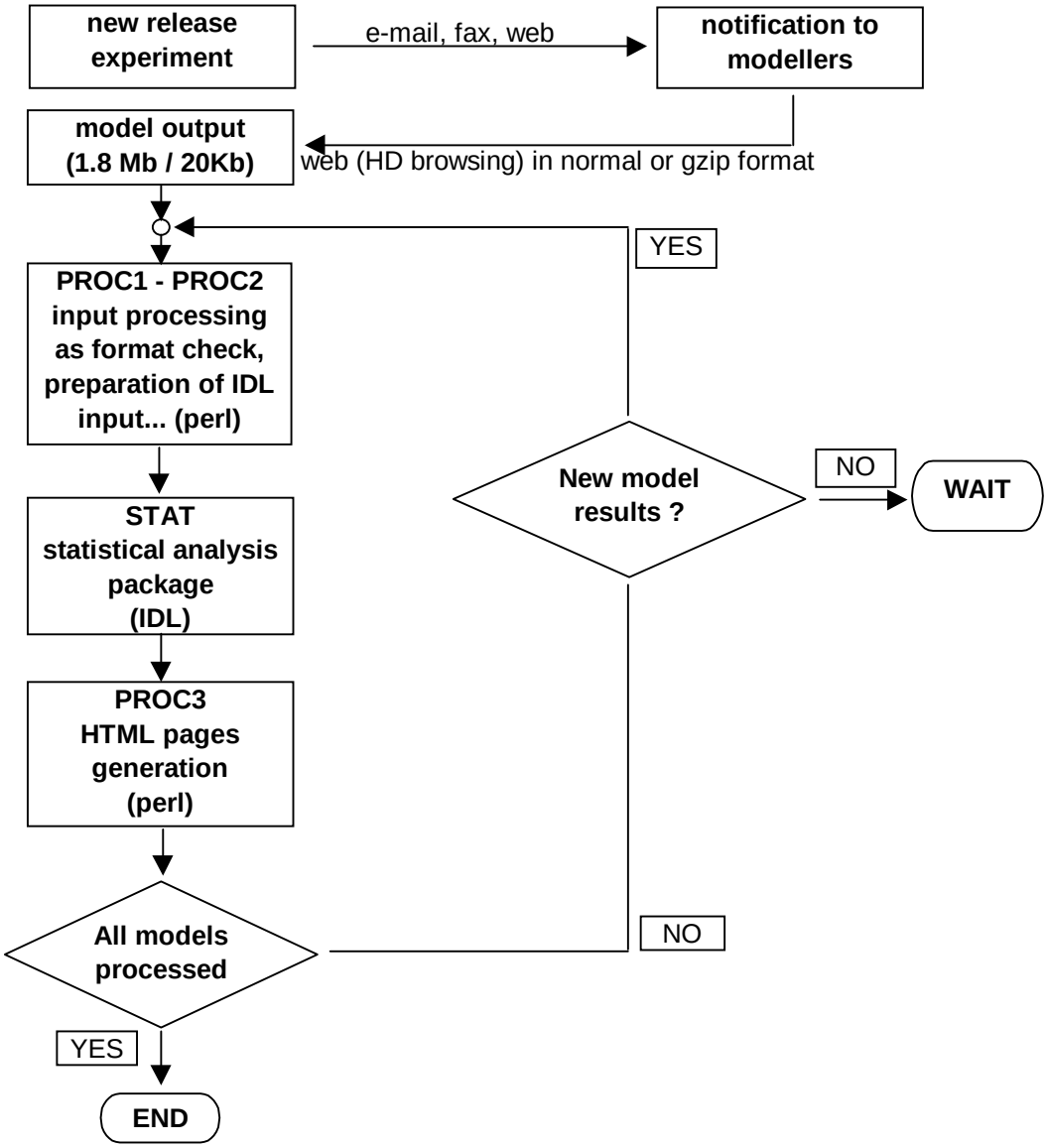


Figure 1. Structure of the program

4 Participating Countries and Institutions

Country	Institute
Austria	CIMG
Belgium	KMI
Bulgaria	NIMH
Canada	Centre Meteorol. Canadien
Denmark	RISOE, DMI, NERI
Finland	Metoffice
France	MeteoFrance
Germany	DWD
Italy	ANPA
Japan	JAERI
Norway	Met Office
Russia	SPA Thyphoon
Sweden	Metoffice
The Netherlands	KNMI, RIVM
U.K.	Met Office
U.S.A.	SR Wh., LLNL

Exercises performed

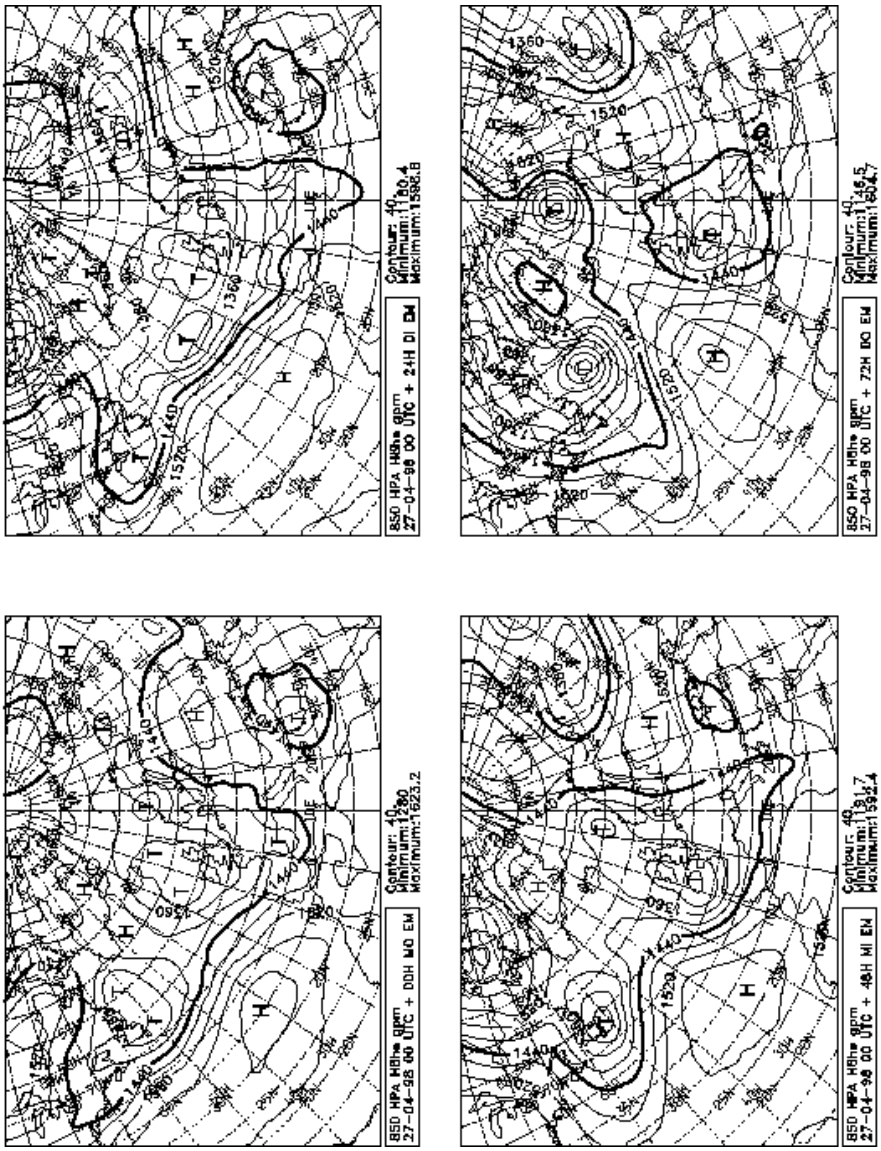
Four exercises were carried on in the period of the Contract, characterised as follows:

Emission location	Date	Time horizon
Chernobyl (Russia)	28/04/98	60 h
North-London (UK)	09/06/98	60 h
Algeciras (Spain)	30/05/99	144h
Edinburgh (UK)	10/06/99	60 h

Three out of four of these exercises were executed in real-time. For each of them, during the following days model comparison was also executed with results obtained with analysed meteorological fields. The third case from Algeciras that was also included in RTMOD was not a real-time exercise. This was a real accidental release that took place on May 30 1998 from a steel-mill in southern Spain where accidentally radioactive metals were melt down. An unknown amount of contaminated air left the location, was dispersed over the western coast of Spain and travelled all the way North reaching the Southern coast of France and Northern Italy two to three days after the release, where it was detected by the existing monitoring network. This release was simulated as a post factum event using ECMWF analysed meteorological fields for the period. Differently from the two previous cases, in this exercise wet and dry deposition were also taken into account. The measurements from the monitoring network were used to estimate the source term and evaluate the model performance as shown in the following.

5 Experiment 1

RTMOD - Experiment 01 - Synoptic weather maps



On the 28 April 1998 the synoptic pattern over Eastern Europe resembled to a large degree to the weather situation which was observed at the time of the Chernobyl accident (starting the release on the 26 April 1986).

A large high pressure area was observed on the 28.04.1998 with a central pressure >1025 hPa over Russia, Bielorussia, Ukraine and extending ridges to the Baltic States and Eastern Poland. A small low pressure area (<1000 hPa) extended from the Western Baltic Sea to Northern Italy. The surface winds were in the Chernobyl area from the SE and again similar to the 1986 situation. The 850 hPa surface showed the high pressure area > 1520 gpm extending from Novaya Zemlya to Eastern Europe. A pronounced upper air low with a centre value < 1320 gpm was located over central France.

The general weather pattern did not change much during the next two days.

Results

20 modellers took part to the real-time exercise and only 9 to the model inter-comparison using analysed data.

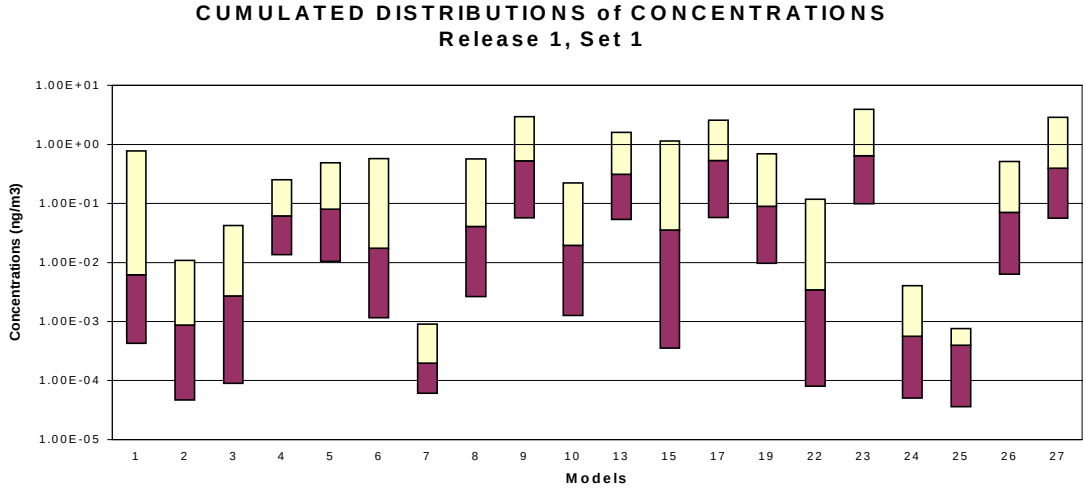
The results of the study are presented here in terms of the two box plots drawn on the global results, as a comparison of the concentration evolution at two sites (time analysis) and of the FMS at two time intervals for the real-time case (space analysis).

Large differences can be observed in the distribution of global results, which indicate that even the mean order of magnitude is often matter of disagreement.

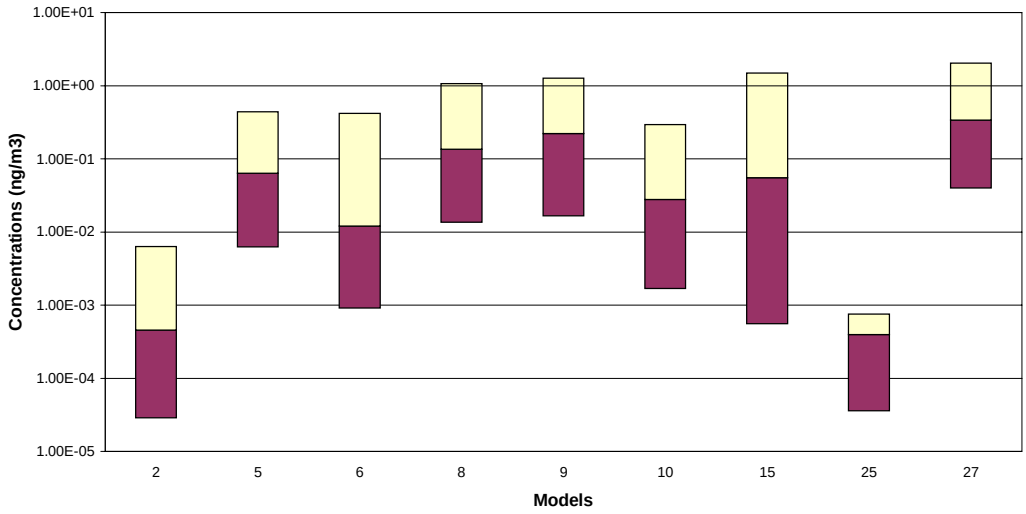
For the time-analysis, the first figure shows the sites selected for the exercise (11), whilst the other three show the concentration versus time for two participants. These indicate that evolution of the concentration at the sites also presents large variation, as the time of arrival, peak value and duration are concerned.

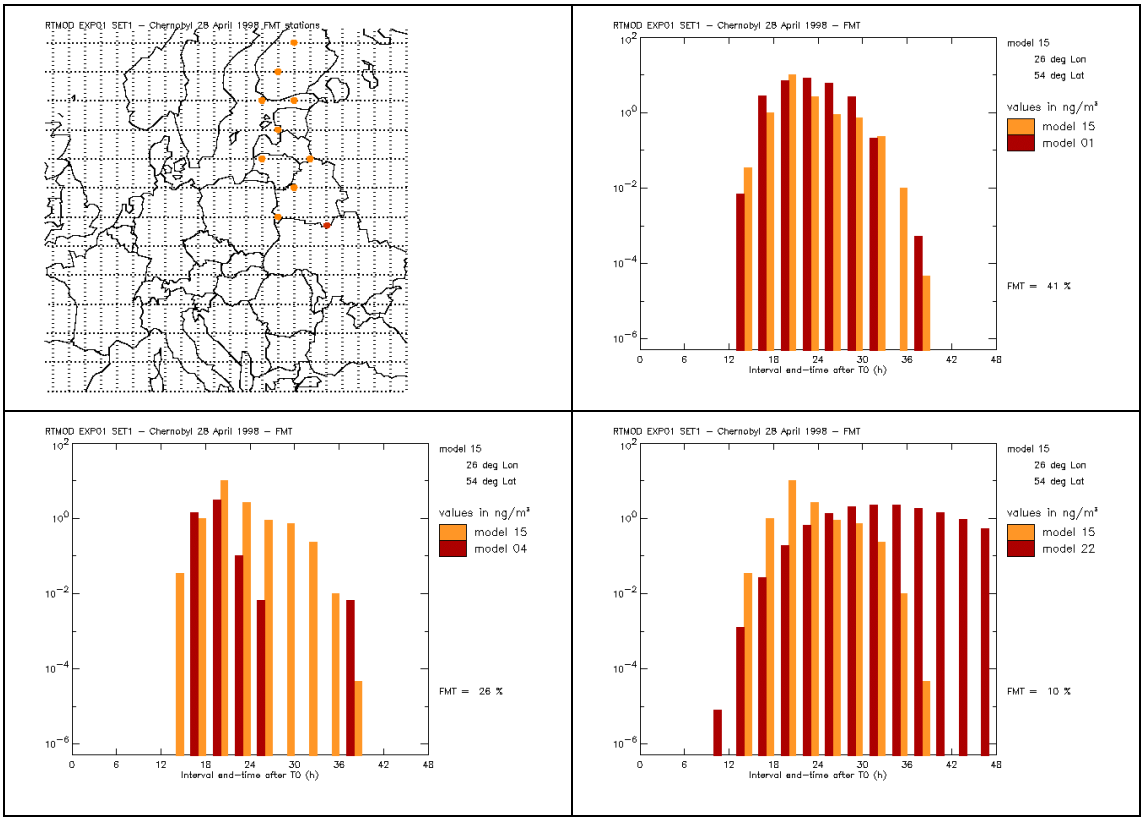
For what concerns the space analysis, two comparisons are reported at two time intervals. They indicate how small differences in trajectories and in horizontal dispersion can increase with time and produce very different projection at ground.

The CCL at the four intervals of 12, 24, 36 and 48 h are also reported. It can be instructive to compare these results with the CCL (as defines above), that summarises the differences among the 20 participants.

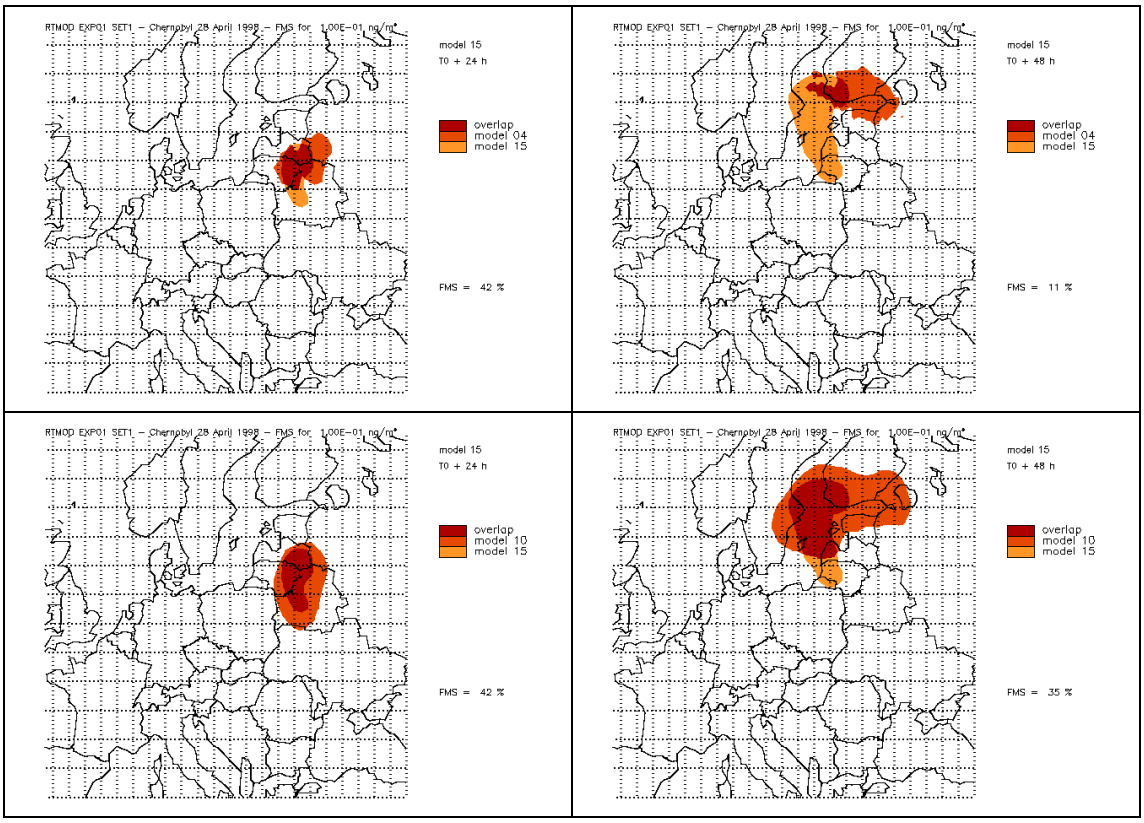


CUMULATED DISTRIBUTIONS of CONCENTRATIONS
Release 1, Set 6

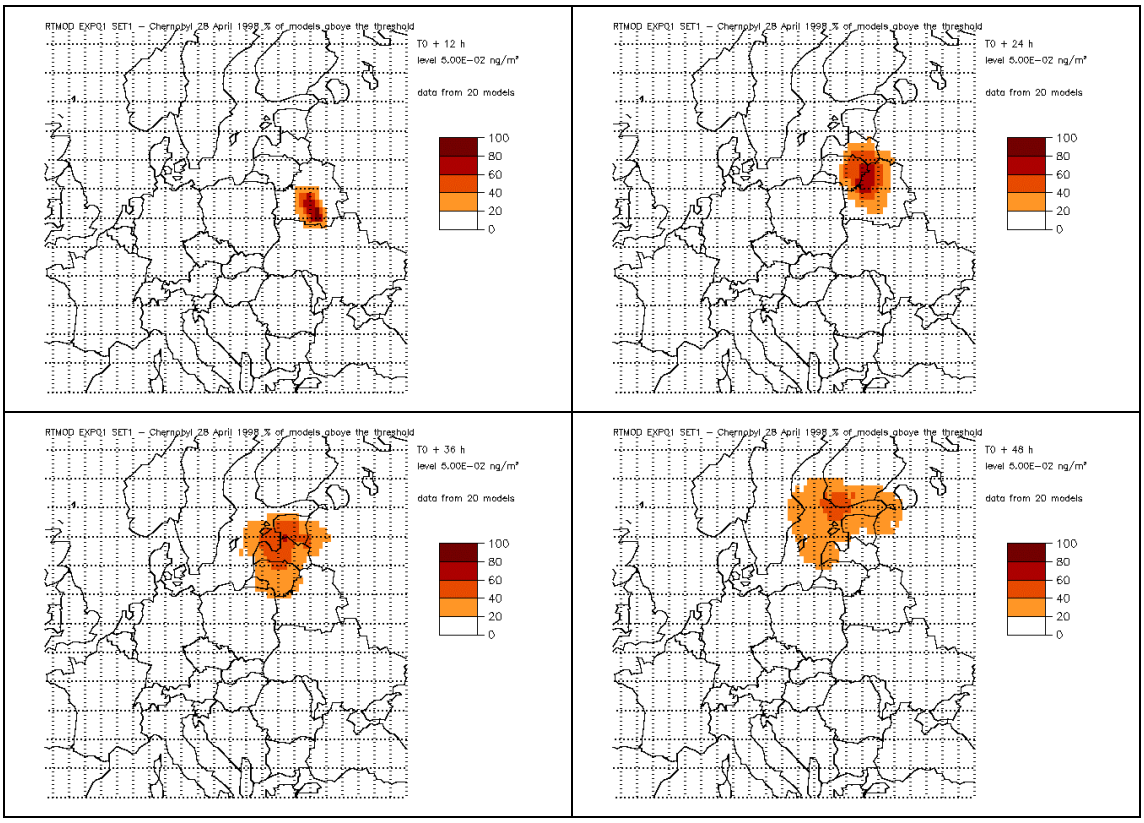




Experiment 1: selection of the sites for the time-analysis and three examples of model inter-comparisons



Experiment 1: FMS at 24 and 48 hrs



Experiment 1: CCL at 12, 24, 36 and 48 hrs

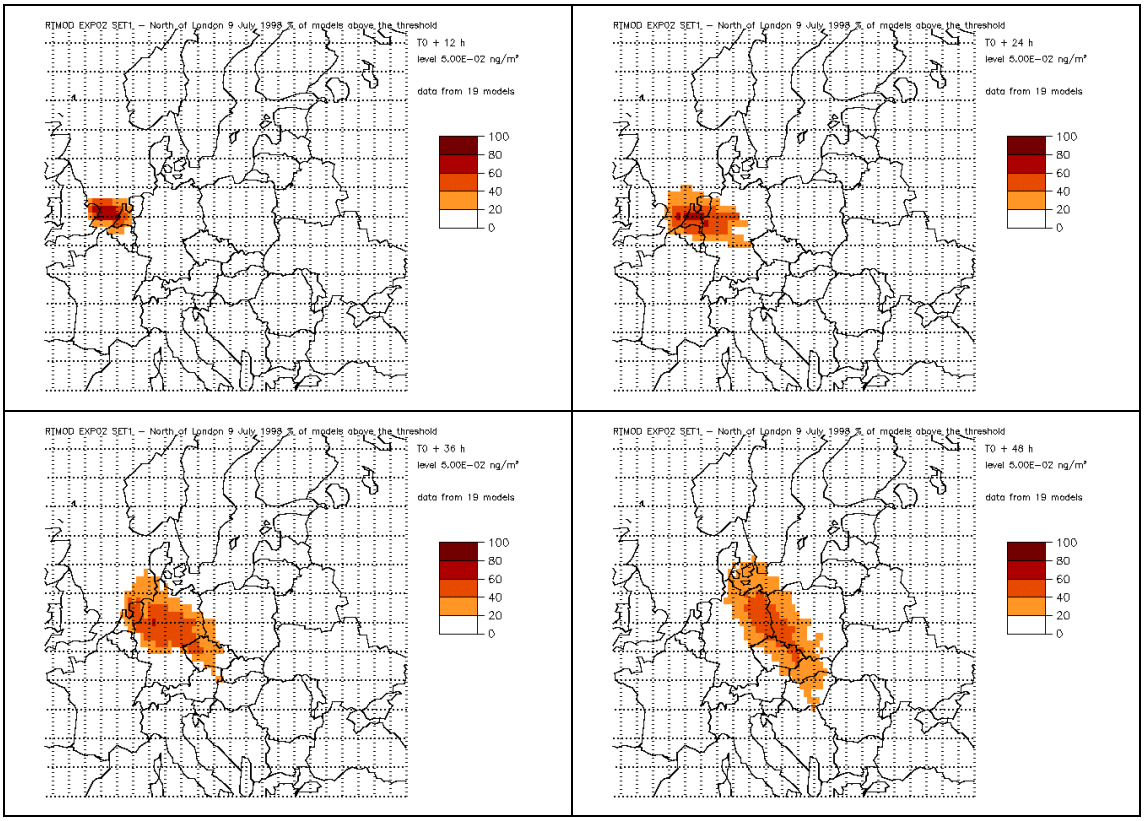
Experiment 2

Synoptic Situation on the 09. July 1998 00 UTC.

The synoptic situation on the 9th July 1998 was considerably different from the one in April. A low with central pressure < 985 hPa was situated close to Jan Mayen island and extended a frontal system to the South with a warm front across Southern Norway and the Eastern North Sea. The cold front belonging to the same system lay over the Northern North Sea and extended into Ireland. A strong anticyclone with central pressure > 1030 hPa over the Azores extended a ridge with 1015 hPa into Central Europe. The atmospheric flow was therefore between those two pressure systems from Northwest behind the cold front and more westerly in the warm sector. The 850 hPa surface showed the same features. The release took place after the cold front had passed the release location. The weather pattern did not change significantly during the following 48 hours.

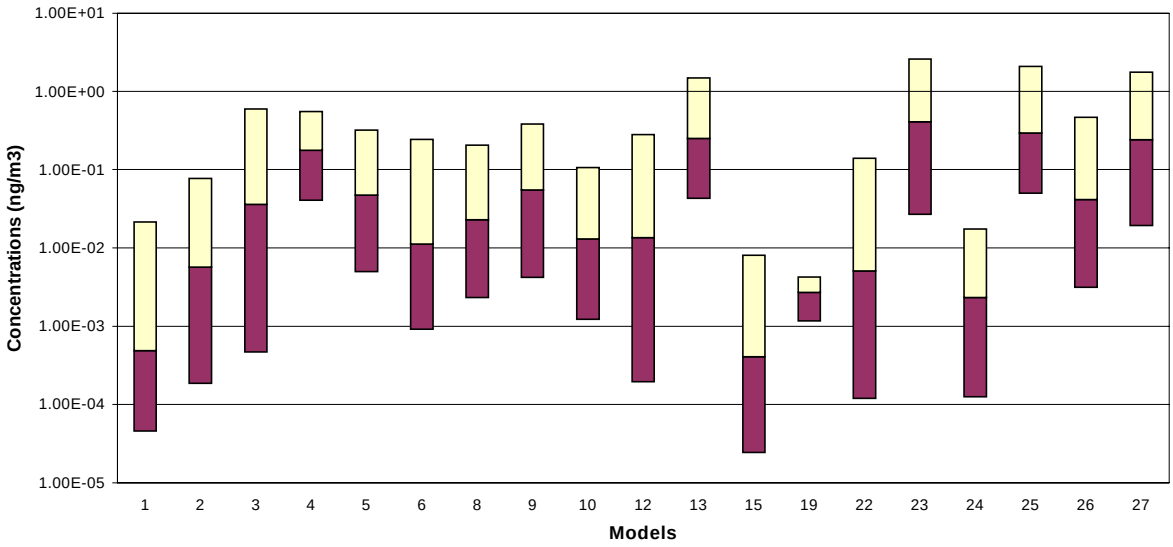
Results

19 participants took part to the real-time experiment and 16 to the analysed inter-comparison. Already in the reply to the alert it was possible to notice a net improvement: a few hours after the alert already 5 participants could compare their results on the web in terms of time evolution and spatial distribution of the ground concentration. The results for the real-time are reported in the following in terms of CCL at 12, 24, 36 and 48 hr after the beginning of the release. One can notice the net improvement in the comparison that is also possible to see in the cumulated distribution. This may be due to the fact that long range dispersion due to a westerly wind situation is possibly easy to reproduce. The change from the forecasted to the analysed meteorology however does not seem to alter considerably the pattern.

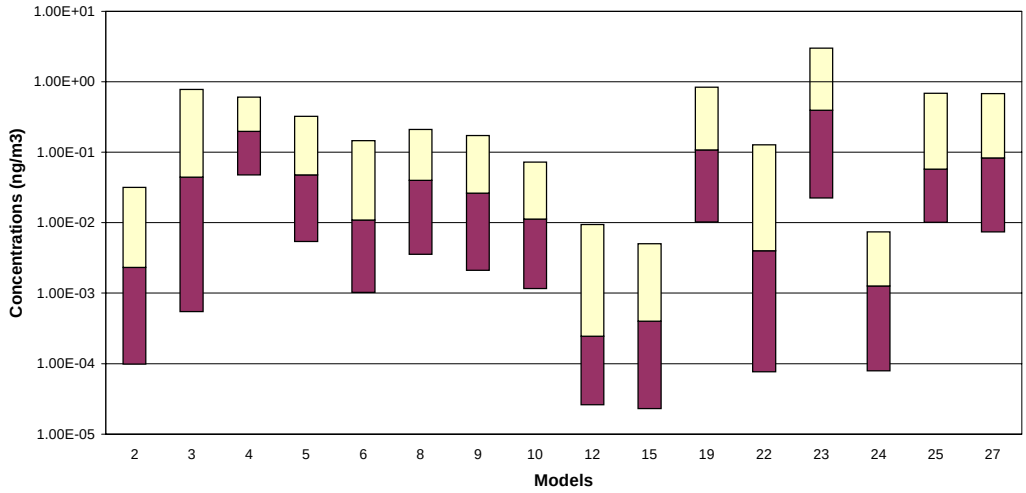


Experiment 2: CCL at 12, 24, 36 and 48 hr after the release start

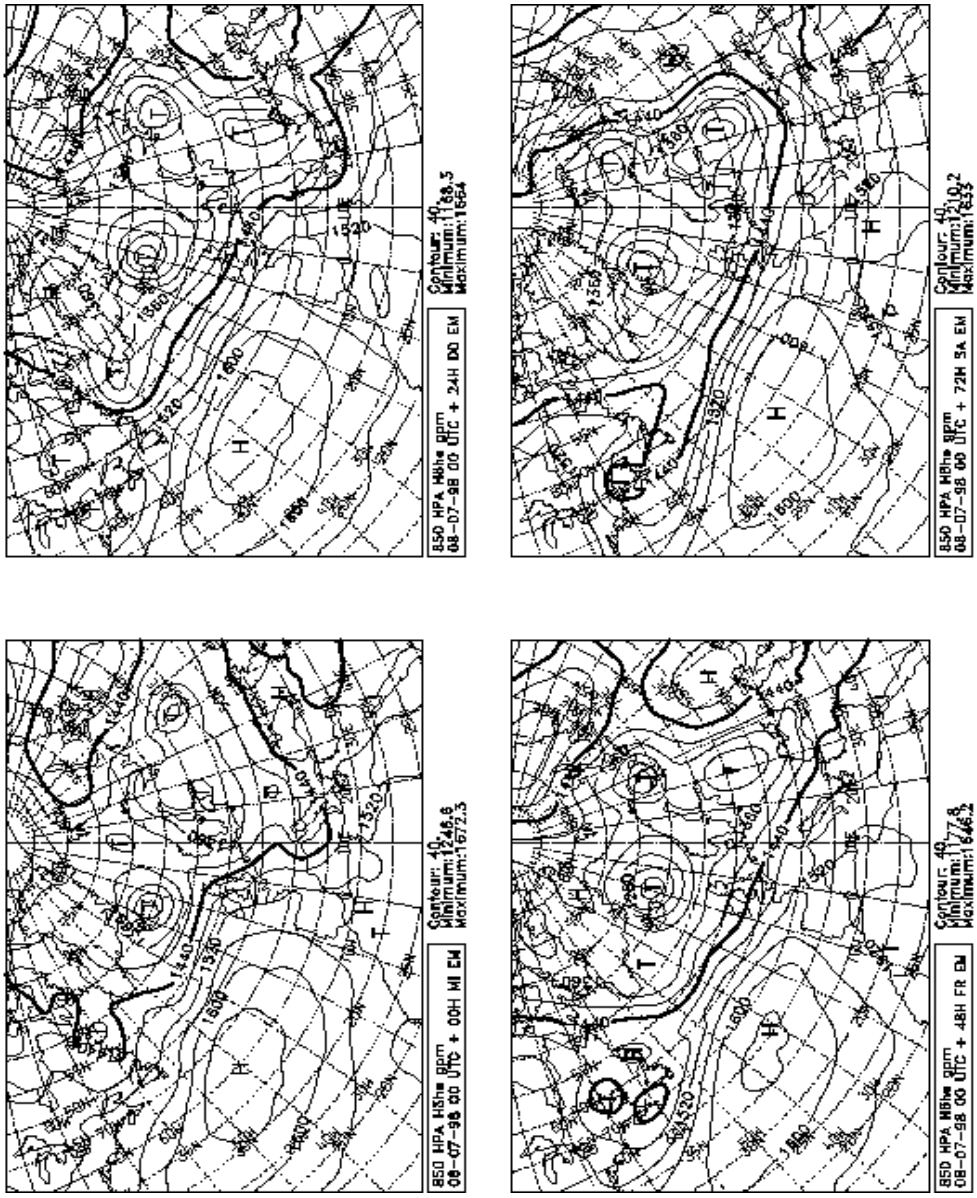
CUMULATED DISTRIBUTIONS of CONCENTRATIONS
Release 2, Set 1



CUMULATED DISTRIBUTIONS of CONCENTRATIONS
Release 2, Set 6



RTMOD - Experiment 02 - Synoptic weather maps



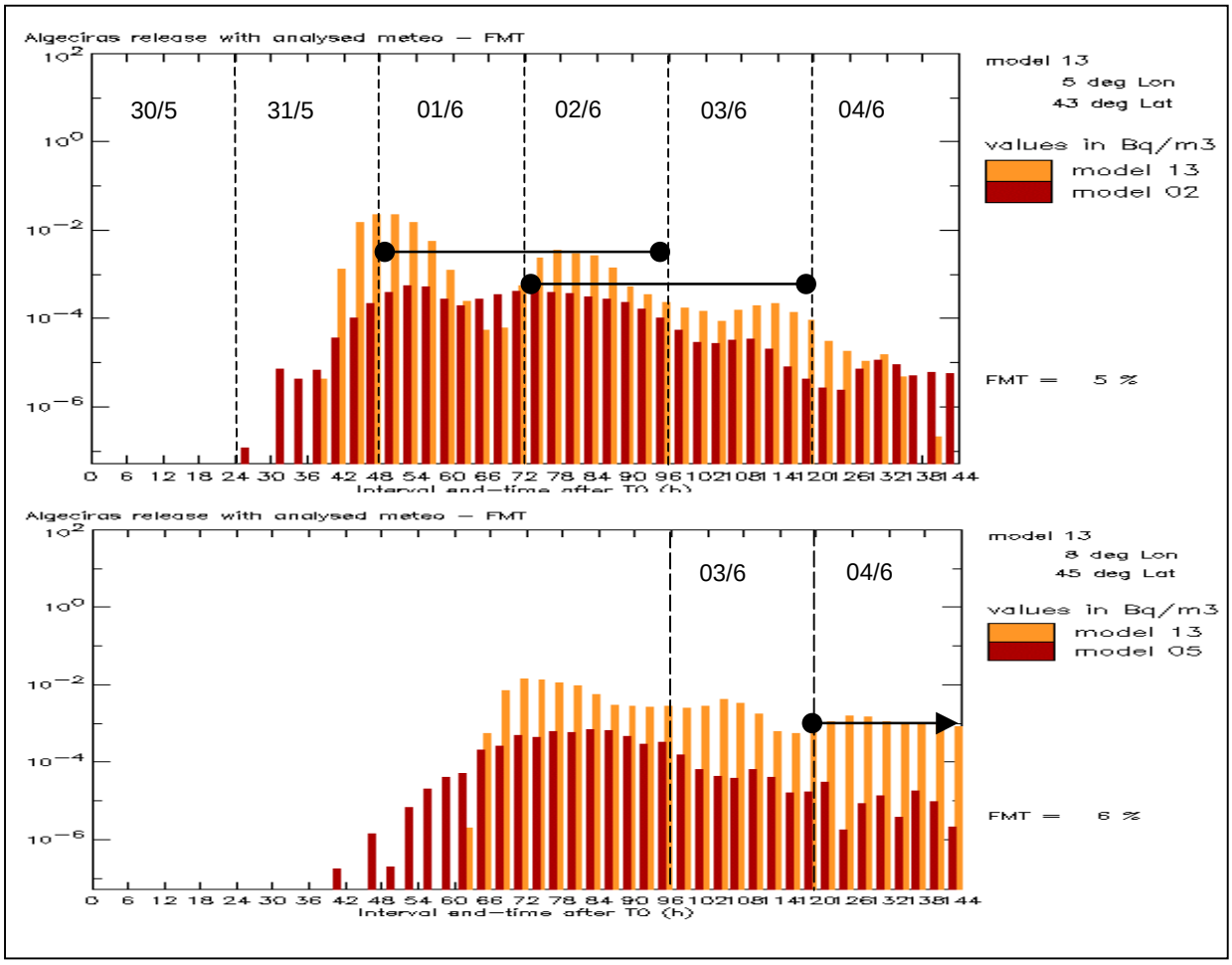
Experiment 3: Algeciras Accident

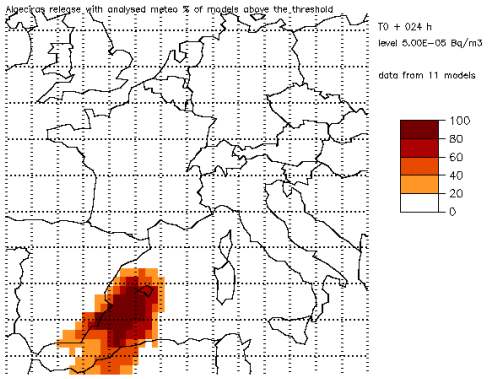
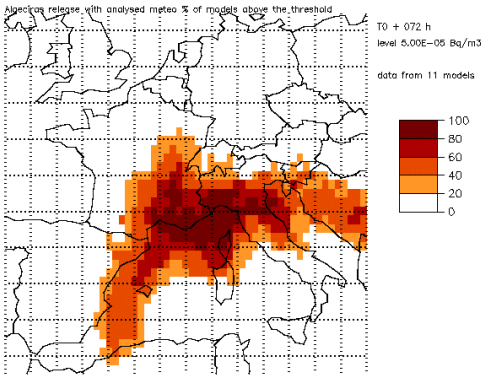
During the second RTMOD meeting, it was envisaged to use the established network of modellers to perform an exercise of inter-comparison based on the accidental release from Algeciras. The fact that at that time the source was reconstructed allowed to experience how many participants were able to simulate the post-factum event, and how their results compare each other and few the gathered monitoring data.

To perform this inter-comparison however, it was necessary to modify substantially the software due to the different units of the release (Bq instead of grams), due to the enlargement of the domain, due to the necessity to account for dry and wet deposition. All these modifications were already planned in the frame of the exercise for the last release.

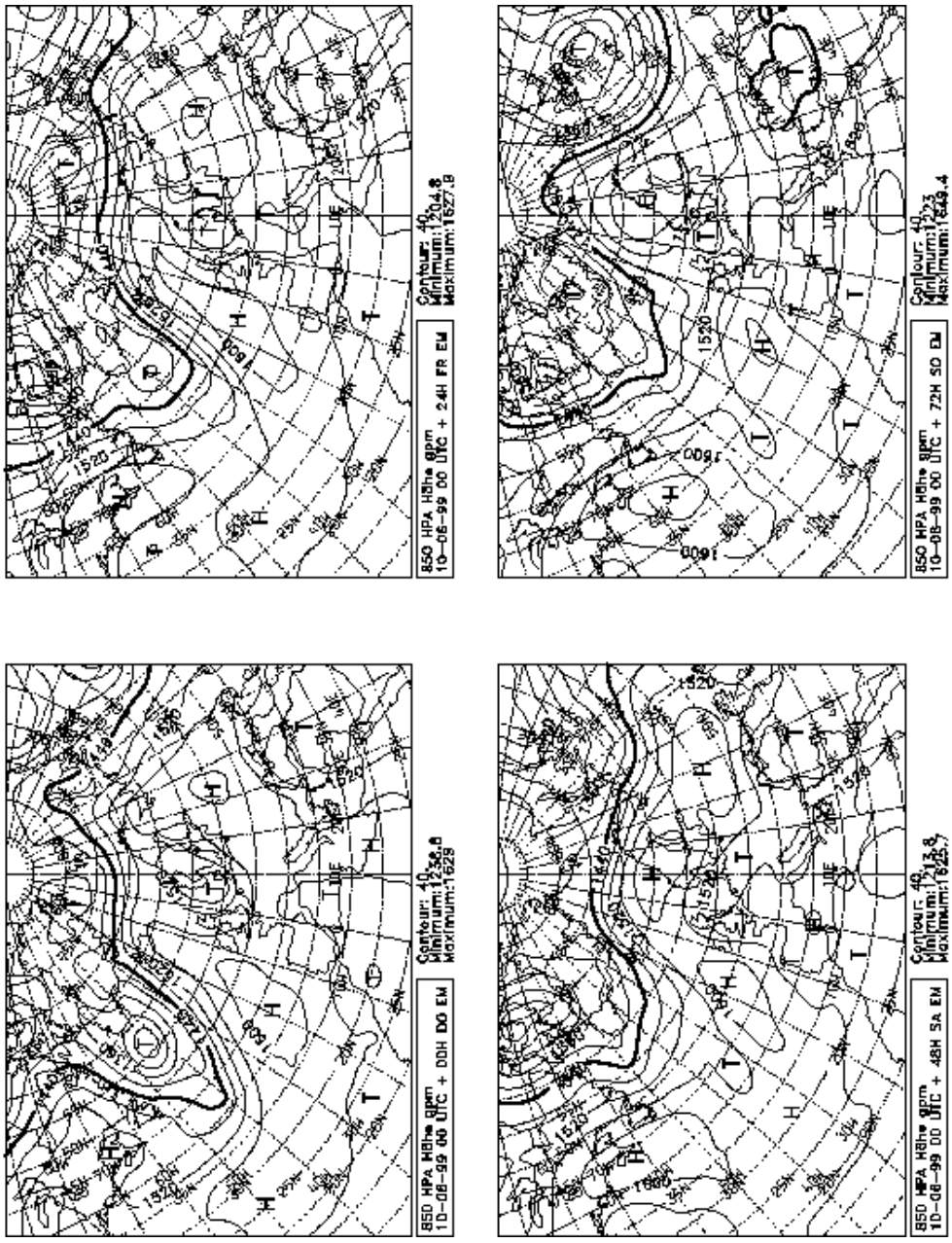
The results are presented here in terms of time evolution (note the agreement with observations) and in terms of CCL after one and three days.

Experiment 3 (Algeciras): Cs-137 concentration evolution at two stations, comparison with observations



	
Experiment 3: CCL at 24hrs after the release start	*Experiment 3: CCL at 72hrs after the release start*

RTMOD - Experiment 04 - Synoptic weather maps



Experiment 4

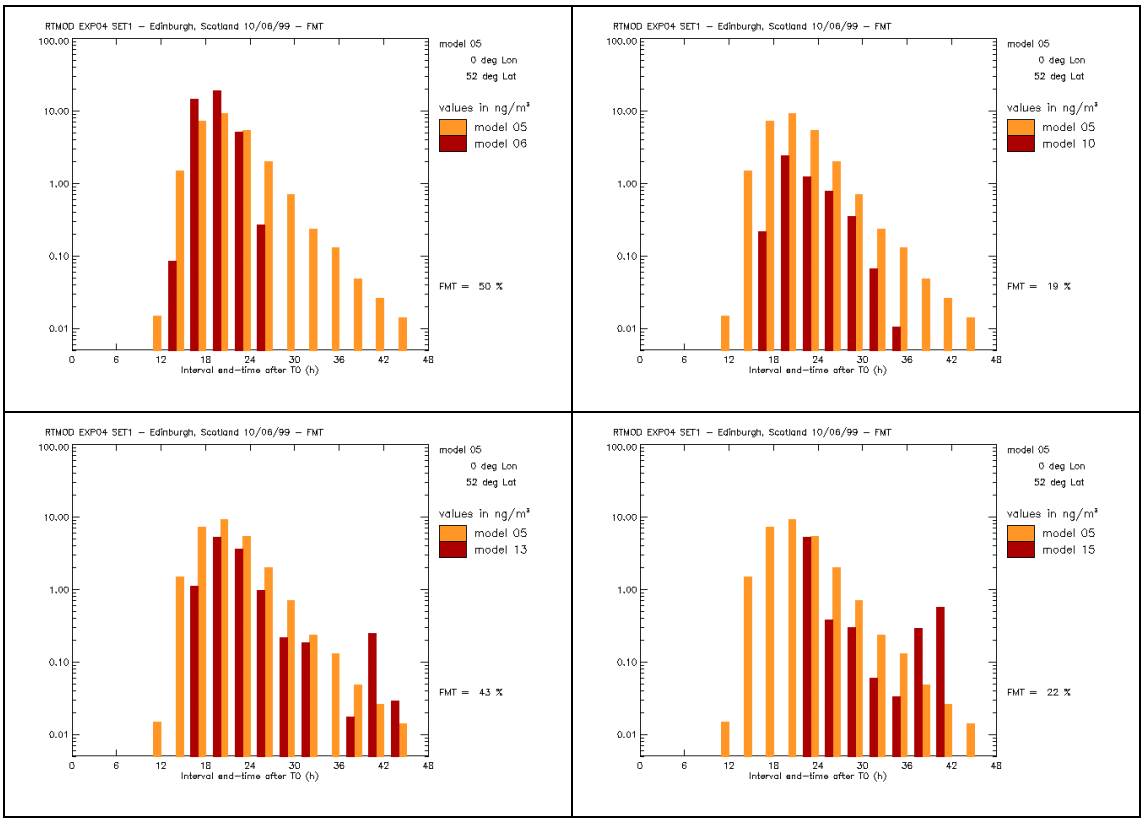
Synoptic Situation on the 10. June 1999 00 UTC

On the 10. 06.1999 the synoptic weather pattern in Europe was characterised by a low pressure area over the North Sea and Southern Norway. The corresponding high was situated over the Urals. On the western side of the mentioned low a northerly flow carried relatively cold air to the South. This situation was suitable for a simulated transport of air pollutants from Scotland over England and the Channel to Northern France. The forecasted trajectories showed a similar behaviour for the next two days, although the pressure gradient weakened. The only doubt, which remained when the final go-message was given to the RTMOD participants, was that the flow might change into one with a north-easterly component which would carry the material outside the computational area. Fortunately enough, this did not happen.

Results

13 modellers took part to the real-time exercise and 12 to the inter-comparison.

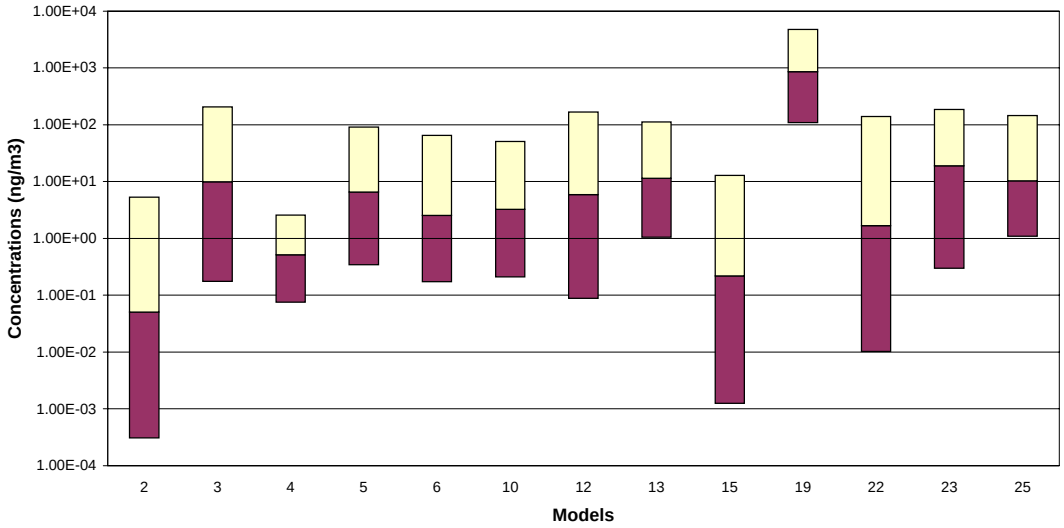
The coherence among the real-time results was enhanced in comparison with the previous exercises. Nonetheless some differences still exist, as shown by the following evolutions, in the time-of-arrival, duration and peak value of the concentration at a given location.

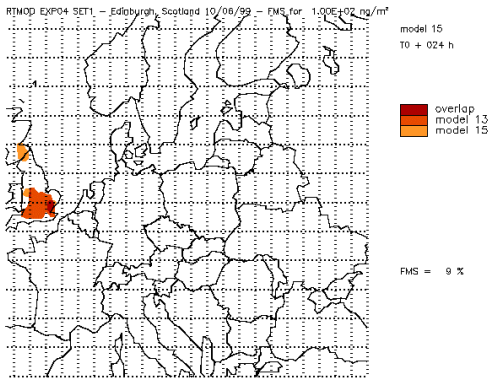


Experiment 4: Concentration evolution calculated by two models at four sites

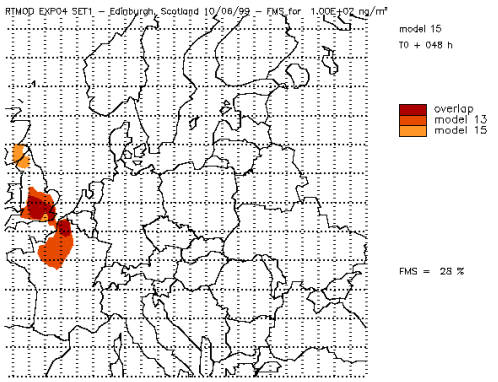
The differences in concentrations are nonetheless reduced when compared to the differences in deposition. The following Figures show the FMS for two couples of models at 24hr and 48hr after the release start. It is evident that the sparse character of precipitation enhances the differences in the calculated deposition.

CUMULATED DISTRIBUTIONS of CONCENTRATIONS
Release 4, Set 1

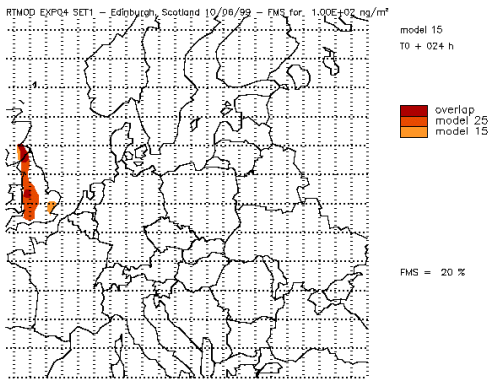




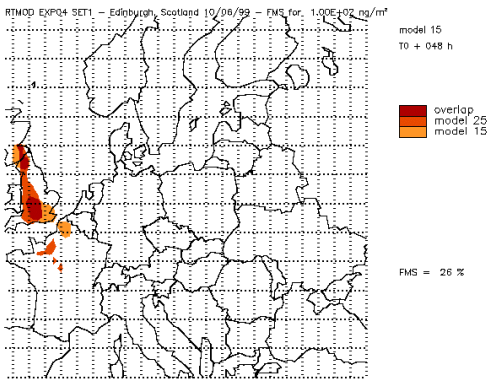
Experiment 4: FMS of the wet deposition 24 hrs after the release start



Experiment 4: FMS of the wet deposition 48 hrs after the release start



Experiment 4: FMS of wet deposition 24 hrs after the release start



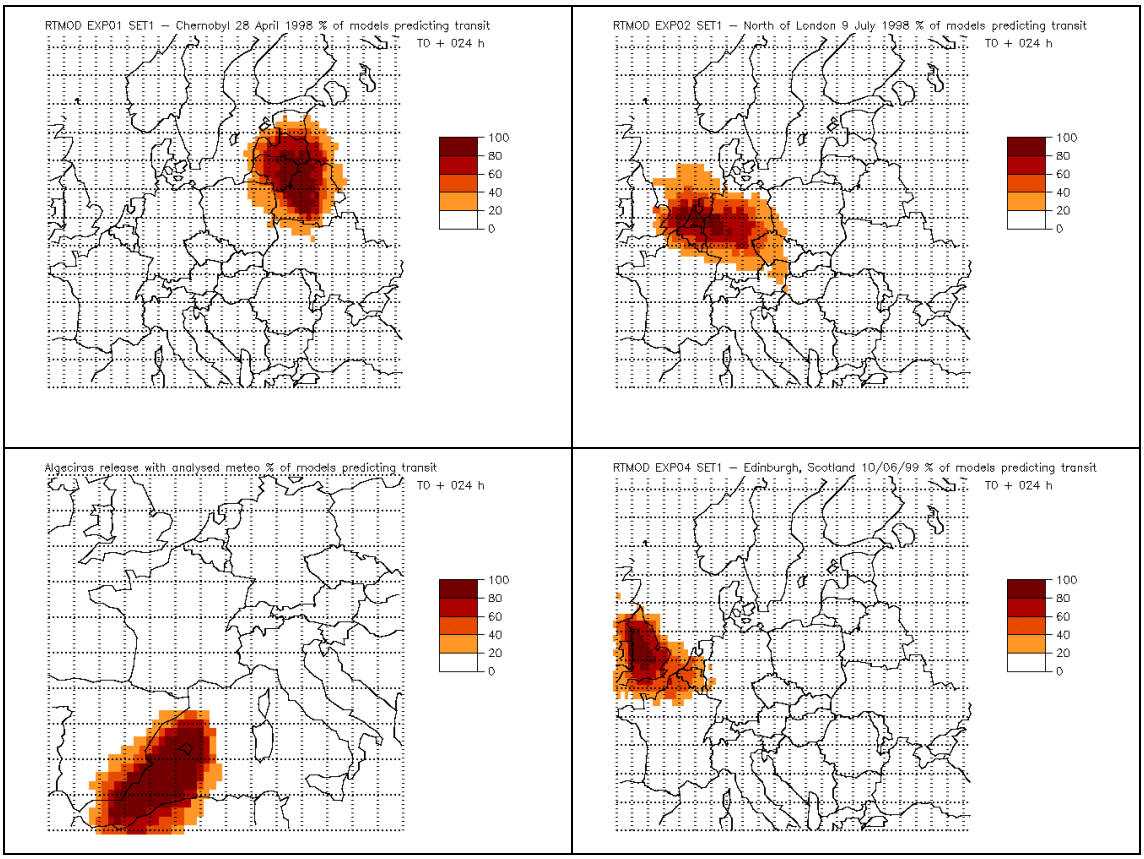
Experiment 4: FMS of wet deposition 48 hrs after the release start

Conclusion

The development and application of the RTMOD has gone beyond the initial planning. The participation was not limited to EU Member Countries but was enriched by the collaboration with American, Russian and Japanese Institutions. The real.-time exercises were backed up by the model intercomparison, using analysed meteorology. The improvement in the software during the Project allows presently to evaluate model-to-model results on different space and temporal domains, using the concentrations as well as the deposition results. The web-page has been enriched with a Forum and with an Overview page of some of the results for external users. Statistical analysis procedure has improved with the implementation of CCL.

New statistical tools that could be used in real-time were also envisaged.

One of these, tested during RTMOD, is defined as where the models are indicating contamination up to a given prescribed level, within which a certain time-limit (Confidence in Time of Arrival, CTA). In the following, examples for the four exercises are given for the same time-limit of 24 hr. The dark region indicates that more models are forecasting the same CTA. The graphs are only indicative since the levels and even the units are different. In case of an accident, it could be however interesting from the decision-maker point of view to have the information on the region where it is highly probable to take counter-measures.



Confidence in Time-of-Arrival (CTA): Results of the 4 cases for 24 hrs

The discussion during the three meeting has produced fruitful ideas and constructive criticisms.

To the end of the project, it is worth to finish with a comment of one of the users: “The web page, statistical analysis package and graphics output alone were a fine achievement, quite apart from the increased insights we have all gained on the nature of dispersion over long range, and the intricacies of the modelling problem. The evolution of the group over a number of years to become the strong team

it is today is a substantial achievement, and every effort should be made to prevent this advance being lost. We have progressed over the years from a rather solicitous view of the various national models to an appreciation of the ingenuity and the many different techniques used by others, and a conviction of the value of collaboration".

Appendix I. Model Number and Participants

MODEL No.	*Participant (Institute)*
mod28	*Joergen BRANDT (National Environmental Research)*
mod27	*Connee FOSTER (ARAC-3, Lawrence Livermore Nat. Lab)*
mod26	*Ulrike PECHINGER (Central Institute for Meteorology and Geodynamics)*
mod25	*Ilkka VALKAMA / Pilvi Siljamo (Finnish Meteorological Institute Air Quality Research)*
mod24	*Ludo VAN DER AUWERA (Institut Royal Météorologique de Belgique)*
mod23	*Thomas HANTKE, Harry SLAPER, Freek ALDENKAMP (Laboratory of Radiation Research)*
mod22	*Dimiter SYRAKOV/Maria PRODANOVA (National Institute of Meteorology and Hydrology)*
mod21	*Roland DRAXLER (NOAA AIR Resources Laboratory)*
mod20	*Stefan SKULEC (Slovak Hydrometeorological Institute)*
mod19	*V. SHERSHAKOV (SPA)*
mod18	*Daniel SCHNEITER / Felix SCHACHER (Institut Suisse de Météorologie Section de l'environnement)*
mod17	*Jorgen SALTBONES (Norwegian Meteorological Institute)*
mod16	*Ion SANDU (National Institute of Meteorology and Hydrology)*
mod15	*Jens Havskov Sorensen and Alexander BAKLANOV (Danish Meteorological Institute Meteo.&Oceanographic Research)*
mod14	*Marguerite MONFORT (CEA - IPSN/DAS/STAS)*
mod13	*Roy H. MARYON, Derrick RYALL (Meteorological Office)*
mod12	*Joakim LANGNER (Swedish Meteorological and Hydrological Institute)*
mod11	*Roman ZELAZNY (Institute of Atomic Energy)*
mod10	*Hubert GLAAB (Deutchen Wetterdienst German Weather Service (DWD))*
mod09	*Gertie T. GEERTSEMA (Royal Netherlands Meteorological Institut (KNMI))*
mod08	*Mike BRADLEY (ARAC-2, Lawrence Livermore Nat. Lab.)*
mod07	*Jan MACOUN (Czech Hydrometeorological Institute)*
mod06	*Réal D'AMOURS (Centre Météorologique Canadien)*
mod05	*Hiromi YAMAZAWA / Masamichi CHINO (Department of Environmental Safety Research Japan Atomic Energy Research Institute (JAEARI))*
mod04	*Dan GRIGGS (Westinghouse Savannah River Co.)*
mod03	*Franco DESIATO (ANPA)*
mod02	*François BOMPAY (METEO-FRANCE)*
mod01	*Torben MIKKELSEN (Risø National Laboratory-Department of Meteorology and Wind Energy)*

Appendix II. 1. Meeting at RISØ on January 20. 1998

Minutes of the

First RTMOD Plenum meeting

H.H. Koch Auditorium

January 20. 1998, Risø National Laboratory, Denmark

Participants

Dr. Giovanni Graziani - Joint Research Center, ISPRA
Dr. Stefano Galmarin - Joint Research Center, ISPRA
Dr. Francois Bompay - METEO-FRANCE, Toulouse
Dr. Gertie T. Geertsema - Royal Netherlands Meteorological Institute (KNMI)
Dr. Hurbert Glaab - Deutchen Wetterdienst (DWD),
Dr. Lennart Robertsson [1)] - Swedish Meteorological and Hydrological Institute (SMHI)
Dr. R.H. Maryon - Meteorological Office, Bracknell, U.K.
Dr. Marguerite Monfort - CEA - Fontenay-aux-roses, France
Dr. Alix Rasmussen - Danish Meteorological Institute (DMI)
Dr. Jens Havskov Sørensen - Danish Meteorological Institute (DMI)
Dr. Thomas Hantke - RIVM, Bilthoven, The Netherlands
Dr. Ludo Van der Auwera - Institut Royal Meteorologique de Belgique
Dr. Ilkka Valkama - Finnish Meteorological Institute (FMI)
Prof. Werner Klug, - Uni- Darmstadt, Germany
Dr. Jørgen Saltbones- DNMI

Attending from Risø National Laboratory:
Torben Mikkelsen
Søren Thykier-Nielsen
Poul Astrup
Sven-Erik Gryning
Jørgen Brandt
Ulla Riis (Secretary)

CC to:
Dr. Daniel Schneiter, SMA, Switzerland
Dr. John Pace, Lawrence Livermore Nat'l, USA
Dr. Real D'Amours, DOE, Canada
Dr. Robert Addis, Savanna River Nat'l., USA
Dr. D. Syrakov, Bulgary
Dr. M. Chino, JAERI, Japan
Dr. Vjacheslav Shershakov, SPA-TYPHOON; Russia
Dr. Roland Draxler, NOAA Air Resources lab. USA
Dr. Neale Kelly, European Commission, DG XII, Nuclear Fission Safety.

Apologizes for absence: Dr. Franco Desiato - ENEA-ANPA
[1)] Substituted for Joachim Langner-SMHI

Agenda: January 20. 1998 Risø National Laboratory

9:00	Welcome to the participants, description of the main goals of RTMOD
9:30	Discussion on the number of releases and time schedule
10:00	Presentation of the Technical Specification Document: the alert procedure, the real-time replies, the format of the data, the statistical analysis, the results of the comparison
10:30	Coffee break
11:00	Reactions from the participants
12:30	Lunch
14:00	Definition of the most suited meteorological conditions and consequently the time window for the first release
15:00	Discussions and time planning for the next meeting
15:30	Departure to Copenhagen airport from Risø by bus

Minutes

The meeting was opened by the introduction of the projects administrative co-ordinator Torben Mikkelsen, who shortly described the contractual lay-out for the coming RTMOD exercises and the economical and administrative conditions for participation as provided by EU-DG XII in the Concerted Action (CA) contract between Risø and the Commission, and in the meanwhile distributed Associated Contracts to be closed between Risø and the 12 other CA-participating Institutes.

Dr. Giovanni Graziani then illustrated the technical reasons for RTMOD, which are mainly:

- to maintain the connections established during ETEX among the real-rime long-range dispersion modelling community;
- to increase the number of inter-comparison exercises, thereby improving the statistical estimation of the uncertainties of model results;
- to better understand the relationships between weather conditions and model discrepancies;
- to prepare for participation in any future full-scale long-range release experiment's.

Real-Time Model Inter-comparison

Dr. Stefano Galmarini next presented the plan and general lay-out for the coming model inter-comparisons. To facilitate this in an easy way for all participants, a new automated statistical evaluation package based on Web (Internet)-technology is presently being developed at Ispra for on-line inter-comparison of the various national long-range models participating in the RTMOD CA. The basic statistical packages have been carried over from the previous ETEX project, in which context many of the participating long-range dispersion models earlier simulated the two real tracer releases ETEX-I and ETEX-II.

During the days of ETEX (Oct. 1994) the Web (Internet) was not so easily accessible as it is nowadays via browsers from any location in the world. Thus, during ETEX, predicted model data had to be sent to JRC-Ispra by fax and regular mail for subsequently processing. The vivid development of the World Wide Web, and the experience gained during ETEX, suggested the development of an on-line tool based on this new technology that includes a friendly user-interface for data submission, and which provides some real-time program modules running on the host server (at Ispra), producing and displaying the results of the statistical analyses on-line, and in real time, to the user.

The new on-line web tool can be used for a wide class of models in many different contexts. The currently developed RTMOD tool analyses the predictions of air concentration fields at grid points (on

a regular 0.5 degrees by 0.5-degree resolution in both latitude and longitude). The grid extends from 5W to 40E in longitude, and 40N to 65N in latitude.

Exercises

Hypothetical releases are to be notified to the participating modelling groups, which beyond the 13 CA RTMOD participants also include Japan (JAERI), USA (Lawrence Livermore Nat. Lab, and Savanna River Nat. Lab), Canada (DOE), Switzerland (SMA), and Norway (DNMI).

Once notified of an up-coming RTMOD release, participants themselves must first access the RTMOD Web pages to gain further information, and here also return their predictions within the time windows as specified below.

JRC will then manage (within a time frame of a few days) the inter-comparison analysis with other models. As participants predictions arrive at Ispra, existing statistical results will be updated on the fly. This new "live" RTMOD Web-site can in a way be considered as a real-time decision-making support tool, since the performances of several models (to be considered an ENSEMBLE, say) in this way can be simultaneously used to provide real-time realistic information on the most probably contaminated areas in Europe (for the chosen source strength). The new RTMOD Web site is expected to be up and running around the end of February '98. Thereafter, a "zero test" will immediately be performed with all participants to check the Web-product in all its aspects (end of March).

Reactions from the participants

Comments from the participants were first related to the RTMOD Web presentation:

It was mentioned that the Internet-technology does not always ensure a prompt transfer of the information directly to the RTMOD participant. For instance have some institutes (in France, e.g.) nowadays adopted security filters to screen out what might be irrelevant incoming e-mails (sic!). It was therefore decided that notification of the fictitious accidents to the modellers should be sent out by Ispra in a duplicated way, both via Web and by fax.

Similarly, the participants were requested to back-up their Web-submissions to Ispra by also faxing the concentration contours of their 24 Hrs forecast concentration field (for version control only).

The time windows (deadline) for submission of real-time concentration forecasts (out to + 48 hours if possible) was agreed to be within 6 hours from the notification of the release. The participants agreed to identify themselves with a "transparent" rather than with an "anonymous" model identity template (the latter was the case during ETEX), and furthermore requested a possibility for downloading any other participants model results from the Web, in order to perform further statistics at "home" on their own.

The time window to transfer the analysed model predictions on the Web site was set to 1 week. In principle the model results cannot be changed subsequently, except in some special cases, that should be notified within a 2 weeks period following the release and with the agreement of Ispra. Participants should notice that errors in the data format for the model outputs will impair the uploading on the RTMOD Web site.

According to requests from the participants, it was furthermore agreed - as specified above - that each Institute could submit the results of two different calculation sets, the first performed with forecasted, and the second with analysed, meteorological fields. The first data set favours tests of real-time decision support ENSEMBLE prediction strategies, whereas the latter eliminates the differences in the numerical predicted weather forecasts themselves, and therefore favour dispersion model intercomparison.

Intercomparison of the results based on forecasts vs. analysed fields will furthermore reveal whether the rather consistent results as obtained during ETEX applies to other weather conditions. The Web-based automated procedure and on-line format control should ease the submission efforts and the model evaluation for all parties. With this outlook it was decided to increase the RTMOD number of exercises so that:

- at least two exercises will be performed before the summer '98 period (20 April - end of June).

Two different weather conditions will be considered, one with Westerly, and another one with Easterly winds, their sequence depending on meteorological occurrence in the considered time window. The release location will be changed accordingly.

For the two first RTMOD releases, it was decided to limit the evaluation to non-buoyant and non-depositing emissions. The duration of the release will in both cases be fixed to be 6 Hrs , the start of the release will be at 0900 UTC. It was also decide to stick to maximum +48 hours of concentration predictions, both for the forecasted and for the analysed data sets. In order not to smooth the differences that may occur in model results, it was also agreed that participants should produce and submit 1-hour averaged concentration fields every 3 hours (i.e., a total of 16 1-hour averaged fields should be submitted for each of the two modes: forecasted and analysed).

The alert to the modellers should be given one day before at noon. For the two spring '98 RTMOD exercises, only working days will be selected, with the exception of Friday.

Lengthy discussions followed whether to include a comparison for dry and wet deposition. It was decided to postpone this side of the exercise until after the next interim meeting will take place, mainly at Ispra on the 22-23 September 1998. In the meantime, the possibility of cumulated deposition comparison and concentration data assimilation will be thoroughly examined.

Towards the end of the meeting there evolved an informal round-table discussion about post-ETEX developments and improvements regarding long-range atmospheric dispersion models by all the participants. Other topics up for discussion were the ETEX -2 release and the latest understandings hereof. On this matter, Sven-Erik Gryning presented his micro-meteorological measurements from the source location during the release as obtained from a sonic anemometer, and he also showed some interesting non-zero vertical wind velocities over the release site in connection with the frontal passage. These Boundary Layer wind data were measured by a co-located French sodar system.

Towards the end of the meeting, a short presentation was given by Torben Mikkelsen of the atmospheric model chains now integrated in the RODOS real-time European decision support system, and which also are scheduled for real-time participates in the RTMOD exercises.

Torben Mikkelsen also mentioned a new Russian (SPA-Typhoon, Obninsk) "ISTC-initiative" for possible future joint East-West ETEX-type long-range experiment's, with release points inside Russia and the newly independent East European states e.g., Belarus and Ukraine.

Appendix III. 2. Meeting at Ispra 1998 Sep. 22-23

Minutes of the Second RTMOD Meeting,

Ispra 22-23 September 1998

Attachments: Agenda, List of participants

1. Presentation of the main features of the system and of results of the two exercises performed

RTMOD is structured as a website interfacing the modeler on the client side, and the statistical analysis system on the server, at JRC Ispra. The modelers participating to the RTMOD exercises are informed by fax when a dry run (a fictitious release) takes place, and they access a web page where the release information is stored, starting the simulation using their meteorological data (forecast and analyzed) and long-range dispersion models.

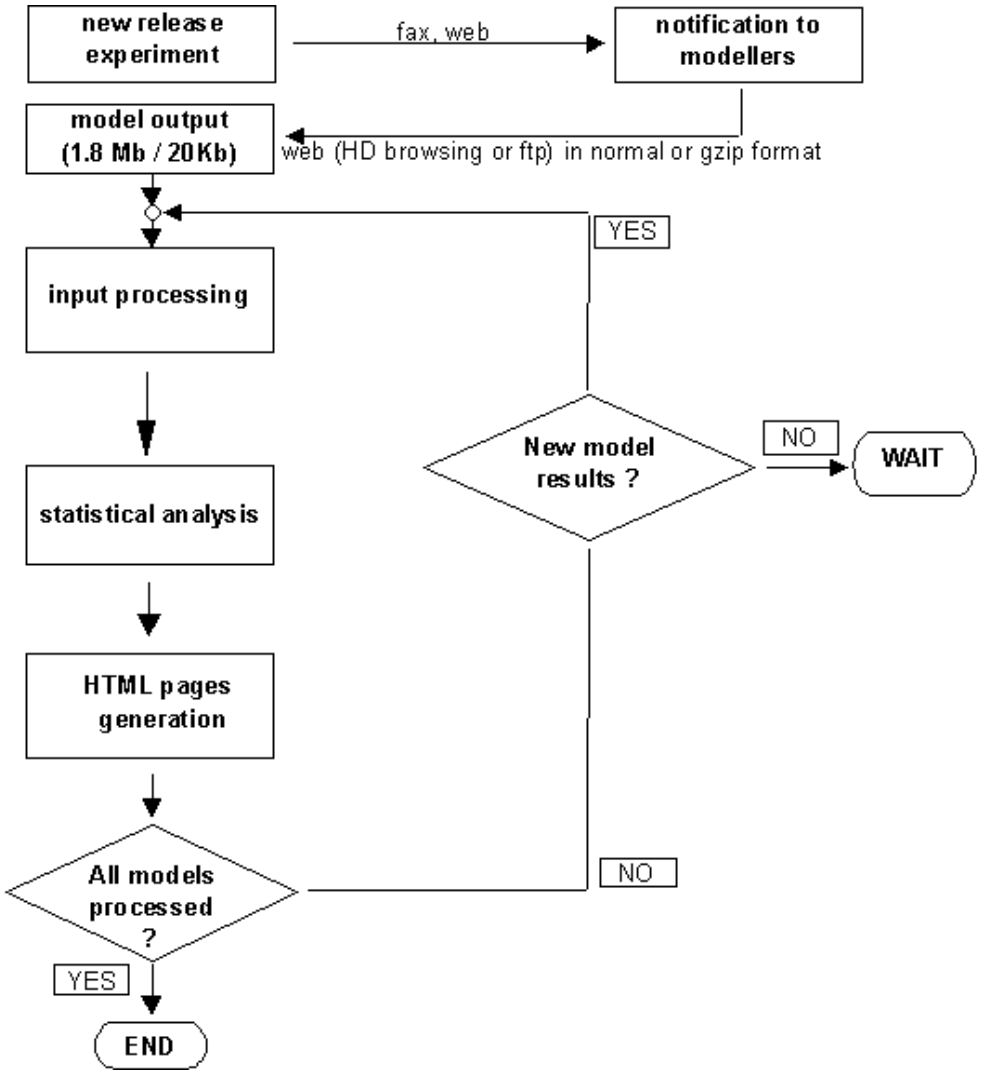


Figure 1. Main structure of the RTMOD system for the intercomparison of long-range dispersion models.

The simulation domain of these fictitious accidental releases into the atmosphere is currently the European region encompassing 5° W to 40°E in longitude and 40°N to 65° N in latitude. After the completion of the simulation, the modeler can upload the results obtained to the RTMOD site, in a standard format. RTMOD processes the new results arrived, by comparing them with the results of other models available at the moment. When new model results arrive, the statistical intercomparison is updated where needed.

Three main types of analyses are performed:
Time analysis, where the concentrations at a fixed location are considered for the whole duration of the simulation.
Space analysis, where the concentrations at a fixed time are considered all over the domain.
Global analysis, where all the concentration values at any time and location are considered.
These analyses produce results in numerical and graphical format (Table 1).
Table 1 lists the numerical analyses carried out in RTMOD.

Table 1. The numerical analyses performed by RTMOD statistical module.

Time analysis	• FMT • Pearson's correlation coefficient • bias and NMSE • time of arrival and duration • time of peak and peak value • integrated concentration
Space analysis	• FMS • Confidence in Contamination Level
Global analysis	• FA2, FA5, FOEX • parameters of data distributions (percentiles, Kolmogorov-Smirnov, Cramer-VonMises-Smirnov, chi-square) • Pearson's correlation coefficient • bias and NMSE, geom. mean bias, geom. mean variance

Also, a number of graphical analyses and representations are produced by RTMOD when comparing any two models. A list is given in the following Table 2.

Table 2. The graphical analyses performed by RTMOD statistical module.

Time analysis	• plot of time-series • integrated concentration plot
Space analysis	• contour maps • Confidence in Contamination Level (CCL) maps
Global analysis	• scatter diagrams • box plots

Most of these statistical parameters provide a comparison between any two models. However, a few parameters were computed aiming at determining the average prediction of all the models, to be used by decision-makers in case of an emergency. For instance, the Confidence in Contamination Level

map (CCL) determines for any domain location the percentage of models that predict concentrations above a certain threshold. This allows to scrutiny the areas that are most probably involved by high concentrations.

Following the interest of the modeling community after the first meeting held at Risoe (Denmark) in January 1998, the participation in RTMOD was enlarged to non-EU participants, from other European and non-European countries such as Japan, USA and Canada. A total of 28 participants was finally reached (Table 3).

Table 3. RTMOD participants by country.

Austria	CMG	Japan	JAERI
Belgium	IAMB	Norway	NMI
Bulgaria	NIMH	Poland	IAE
Canada	CMC	Rumania	NIMH
Czech Republic	CHI	Russia	SPA
Denmark	DMI NERI RISOE	Slovak Republic	SHI
		Sweden	SMHI
		Switzerland	ISM
Finland	FMI	The Netherlands	KNMI RIVM
France	CEA-IPSN MeteoFrance	United Kingdom	Meteorological Office
		USA	LLNL/ARAC-2 LLNL/ARAC-3 NOAA Westinghouse S.R. Co.
Germany	DWD		
Italy	ANPA		

The following paragraph presents some results obtained in the first two RTMOD experiments performed up to July 1998. Details are given on the timing of the experiments and on the functioning of the hardware and software components of the system.

1.1. The first fictitious release at Chernobyl

The first hypothetical release, aimed at simulating a nuclear accident, was performed on the 28th of April 1998 from the location of Chernobyl (Ukraine). The release started at 0900 UTC and lasted 6 hours with constant emission rate of 10 g/s. At the same time the release start was notified to modelers by fax and e-mail.

The choice of the location was made on the basis of the meteorological circulation of that day, and to commemorate the 12th anniversary of the Chernobyl accident.

This first experiment was mainly planned to test the system, and to check the transmission protocols and the procedures. It was planned to receive the earliest replies from participating modelers as faxed maps showing the prediction of cloud location 24 hours after the release start time. At the same time the upload of the data files to be processed by the statistical analysis module of RTMOD were expected.

Eighteen models sent their results by fax to JRC Ispra, within a short time (Table 4) from the release beginning.

Table 4. Time of participants' response by fax in experiment 1 (Chernobyl). Release notification at 0900 UTC.

Participant	Fax date and time (UTC)	Participant	Fax date and time (UTC)
ANPA (I)	28-04-98 – 0954	LLNL/ARAC3 (USA)	(*)
CMC (CDN)	28-04-98 – 1330	Meteorological.Office (UK)	28-04-98 – 1058
CHMI (CR)	28-04-98 – 1449	MeteoFrance (F)	28-04-98 – 1014
DMI (DK)	28-04-98 – 1209	NIMH (BG)	28-04-98 – 1127
DNMI (DK)	28-04-98 – 1400	RHMI (RO)	29-04-98 – 0745
DWD (D)	28-04-98 – 1127	RISOE (DK)	(*)
ISM (CH)	28-04-98 – 1134	RIVM (NL)	29-04-98 – 1556
JAERI (J)	28-04-98 – 0904	SMHI (S)	28-04-98 – 0930
KNMI (NL)	28-04-98 – 1305	SPA (RU)	28-04-98 – 1100
LLNL/ARAC2 (USA)	28-04-98 – 1132	Westinghouse S.R.Co (USA)	28-04-98 – 1607
(*) results sent only on file			

The transmission of files and their format showed some problems. Five output files arrived in the correct format within few hours from the release start. Other three correct files arrived the day after. The processing of the remaining models was delayed due to errors and necessary resubmission. Figure 2 shows the Confidence in Contamination Level (CCL) at 12 and 48 hours after the release start. This is defined as the area contaminated above a certain level for a given fraction of the participating models: the higher is the consensus, the darker is the area on the map.

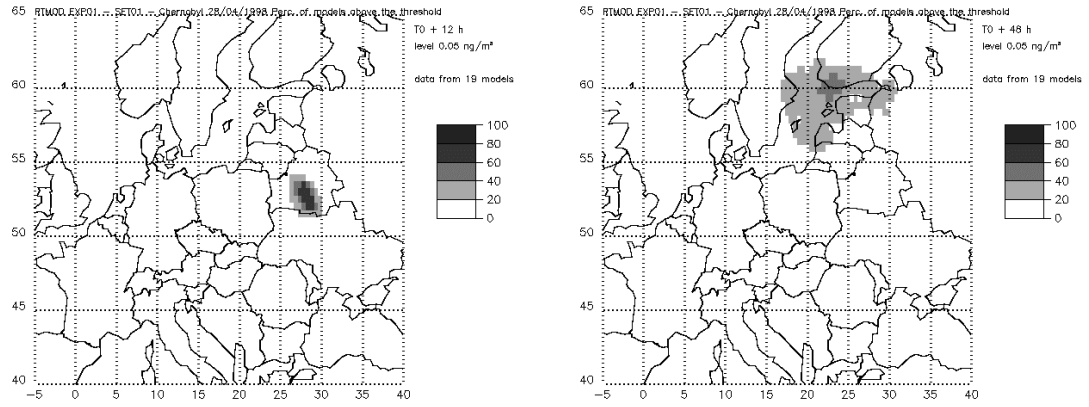


Figure 2. Experiment 1 (Chernobyl). Confidence on Contamination Level (CCL) maps at 12, and 48 hours after the release start. Dark areas have the highest confidence.

Figure 2 indicates that the general consensus on the contaminated area reduces with time. It seems however that there is a small group of participants whose forecasts were similar. Even for those, however, differences in concentration evolution at a given location can be relatively large, as it can be seen in Figure 3.

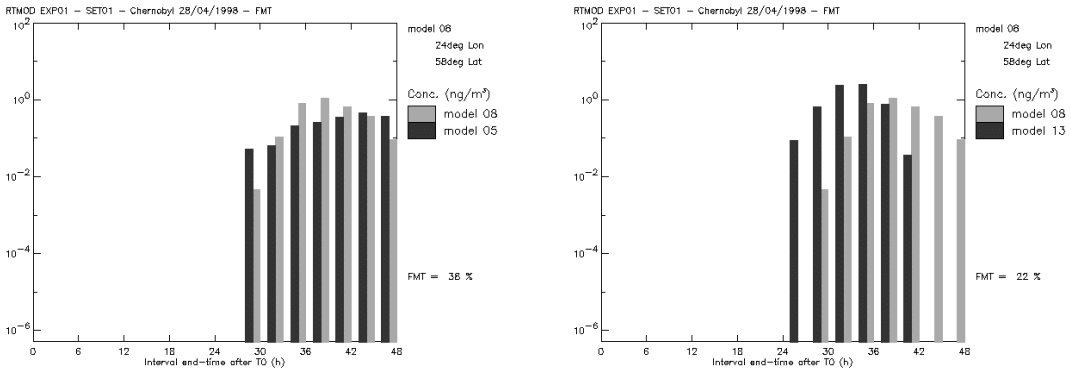


Figure 3. Experiment 1 (Chernobyl). Time series plot at (24E;58N). Left: agreement in time and concentration values. Right: agreement in concentration values but shift in time.

1.2. The Release in England

The second experiment was performed the 9th of July 1998. The fictitious release happened somewhere north to London (UK) at 0900 UTC. Again, a release of 10 g/s intensity and lasting 6 hours was decided. 21 modelers sent the plots of their predictions by fax (Table 5).

Table 5. Time of participants' response by fax in experiment 2 (England). Release notification at 0900 UTC.

Participant	Fax date and time (UTC)	Participant	Fax date and time (UTC)
ANPA (I)	09-07-98 – 0957	KNMI (NL)	09-07-98 – 1206
CEA (F)	09-07-98 – 1240	LLNL-ARAC2 (USA)	09-07-98 – 2233
CMC (CDN)	09-07-98 – 1039	LLNL-ARAC3 (USA)	09-07-98 – 1749
CMG (A)	09-07-98 – 1314	Meteorological.Office (UK)	09-07-98 – 0958
DMI (DK)	09-07-98 – 1008	Meteo-France (F)	09-07-98 – 0935
DNMI (DK)	09-07-98 – 1108	NIMH (BG)	09-07-98 – 1034
DWD (D)	09-07-98 – 1117	RIVM (NL)	09-07-98 – 1057
FMI (FIN)	09-07-98 – 1127	SMHI (S)	09-07-98 – 1001
ISM (CH)	09-07-98 – 1022	SPA (RU)	09-07-98 – 1120
JAERI (J)	09-07-98 – 1028	Westinghouse S.R.Co (USA)	09-07-98 – 1246
KMI (B)	09-07-98 – 1305		

This time all the procedures went smooth, thanks to the testing and experience gained with the first preliminary experiment. No major problems were noticed in the transmission of output files and in the

processing and publication of the results on the web, that was completed immediately after the data reception.

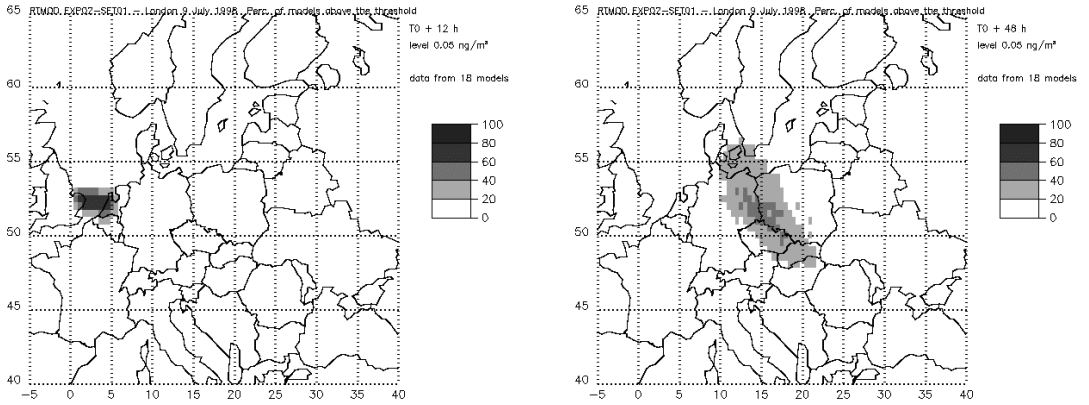


Figure 4. Experiment 2 (England). Confidence on Contamination Level (CCL) maps at 12 and 48 hours after the release start. Dark areas have the highest confidence.

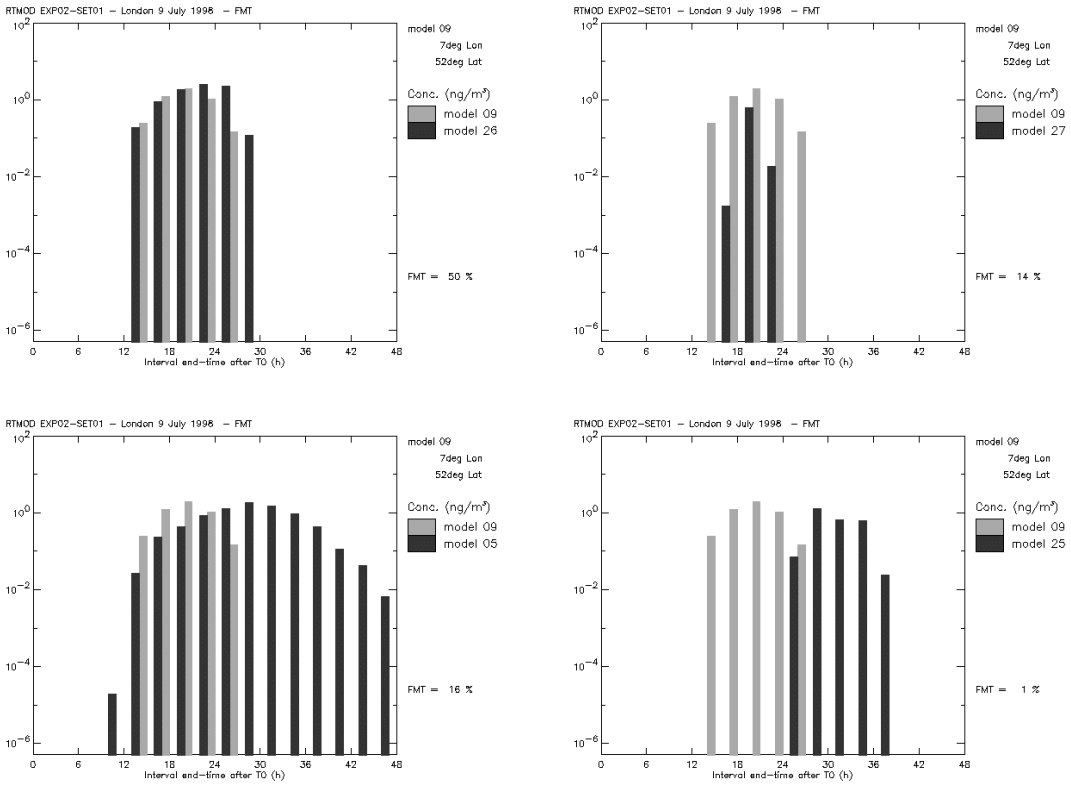


Figure 5. Experiment 2 (England). Time series plot at (7E;52N). Upper left: agreement in time and concentration values. Upper right: disagreement in concentration values. Lower left: disagreement in duration. Lower right: shift in time.

In this experiment, the selected threshold contour level of the CCL map (Figure 4), is narrow at 12 hours and does not show significant changes in the transport direction even after hours. On the con-

trary, the contour stretches in the direction normal to the transport. This indicates that discrepancies in transport direction, more than on transport velocity, influence the predictions. The time series plots for this release (Figure 5) are typical examples of how the over- or under-prediction of concentration values and/or of duration and the time shift can influence the performance of model predictions in the time analysis (FMT index).

1.3. Improvements demanded

The participants demanded various improvements to the system. Some of them would not be executed during the present time frame of the project. They are however a good indication of the participants' interest to the exercise.

IMPROVEMENTS TO BE TAKEN WITHIN THE PROJECT

1. Creation of a HTML page with the statistical methodology, and links to this page.
2. Addition of some blinking image to the modeller's page indicating unread messages in the forum
3. Tables with model characteristics and links to the modeller' identification number
4. Statistical analysis results for deposition (dry and wet)

IMPROVEMENTS/CHANGES IN POSSIBLE FUTURE PROJECT

1. Allowance of access to modellers to the results of other modellers
2. Model output files downloadable by all modellers
3. Dynamic personalised clustering of models for creating a "reference" model
4. Intercomparison of the model itself for predicted and analysed meteorology
5. Concentration vertical profiles analysis (on some locations)

2. Presentation of the calculations performed by some of the participants on the Algesiras release

Calculation aiming at the re-construction of the source intensity, time and duration of the Algesiras emission of Cs-137 were presented by a number of participants, H. Yamazawa (Japan), B. Pobanz (LLNL, USA), F. Bompay (Meteo-France), F. Desiato (ANPA, Italy), G. Geertsema (KNMI, NL), T Mikkelsen (Risoe, DK), J. Sorensen (DMI; DK), L. Robertson (SMHI, Sweden).

The source intensity obtained was estimated by the majority of the modellers to be in the range of 50-100 Ci released during the early hours of the 30th of May 1998. Information received later by the Spanish authorities helped to identify the release time between 000 and 300 UTC of that day. The list of the measurements gathered by LLNL and used for the calculations will be further enlarged by some extra information that can be provided by the Commission, either directly or via member Countries such as Italy or France.

The large interest created by the results obtained up to now suggested using the RTMOD network to run an inter-comparison exercise using the estimated emission. To this aim, the people at Ispra will work out a Technical Specification Document with the characteristics of the source and the description of the expected model outputs.

3. The East-to West ETEX: State of the art

Presentation of the studies aiming at having another ETEX release from Obninsk meteorological tower, were presented and discussed during the meeting.

Description of the tower and of the surrounding facilities was presented. Description of the chaff characteristics was also given. After the meeting, the Russian participants were invited at the Ispra laboratories to examine in detail the various samplers and the tubes.

4. The next two fictitious releases. Comparison of deposition fields

Discussion on the future RTMOD real-time releases concerned the necessity to include deposition (both dry and wet). The possibility to compare only dry deposition was excluded since it would have

consisted in a comparison of a quantity proportional to the concentration integrated over the interested period. In was agreed to compare not only cumulated deposition but also the precipitation fields used and the values of the boundary layer depth at 0000 and 1200 UTC. The two next releases will be one in winter and the next in spring, from Obninsk

5. Future of RTMOD in connection to emergency response

It was also proposed to link more closely the project to the data bank of monitoring data. In this respect the interest demonstrated by all participants on the Algeciras measurements is indicative of the importance to establish such a link. It was proposed that a future development of the present emergency response exercises could be realised by changing drastically the approach and make the conditions a modeller much more similar to what he would face in a real emergency situation. Rather than distributing to the modellers the information concerning the occurrence of a release, the coordinates of the source, the time of the release and the source term, they will be notified that accident has occurred sometime in the past and that an hypothetical monitoring network has detected specific levels of contamination in time and space. Starting from these facts the modellers are asked to provide information about the source and the future development of the cloud. In the absence of real data collected from a monitoring network, JRC will ask one of the modellers to produce a dispersion forecast given certain conditions and at a specific time. This field will then be distributed as virtual monitoring network detection. This type of exercise will then "force" the modellers to use a more realistic and reduced set of information and to develop techniques to produce a reliable forecast. Despite an exercise of this type will make the modellers face evident difficulties, the RTMOD community reacted enthusiastically to the proposal, which will thus be taken into consideration for the future in an appropriate administrative and financial framework. This type of exercise establishes the necessary prerequisites within the modelling community to make use of the real time monitoring data for modelling porpuses.

Actions to be taken

A short report on the meteorological situation during the various releases (W. Klug)
A short model description (Modellers)
Creation of a HTML page with the statistical methodology, and links to this page (JRC).
Addition of some blinking image to the modeller's page indicating unread messages in the forum (JRC)
A table on the web site that reveals the identity of the modellers (JRC)
Redefine and redistribute the Algeciras release. Meteorological data may be made available by some of the participants (JRC)
Statistical analysis results for dry and wet deposition (JRC)

Attachments: List of Participants

R. Addis, Savannah River Technology Centre, USA
P. Astrup, T. Mikkelsen, Risø National Lab, DK
A.Balkanov, J. Havskov Sorensen, Danish Meteor. Inst., DK
R. Bellasio, R. Bianconi, S. Mosca, Enviroware, Italy
F. Bompay. Meteo- France
M. Bradley, B. Pobanz, Lawrence Livermore Nat. Lab., USA
R. D'Amours, Environment Canada
F. Desiato, ANPA; Italy
G. Geertsema. Netherlands Meteor. Inst., NL
H. Glaab, D.W.D., Germany
T. Hantke, RIVM, NL
A. Jourtchak, A. Korenev, SPA Typhoon, Russia
W. Klug, Tech, Univ. Darmstadt, Germany
R. Maryon, Met. Office, UK
U. Pechinger, Central Inst. for Meteorology and Geodynamics, Austria

M. Prodanova-Bojadjieva, D. Syrakov, Inst of Meteor. & Hydrology, Bulgaria
L. Robertson, E. Roos, SMHI, Sweden
J. Saltbones, Meteor. Inst. Norway
I.Valkama, Meteor. Inst. Finland
L. Van der Auwera, Meteor. Inst., Belgium
H. Yamazawa, JAERI, Japan
S. Vadé, DG XI C1, European Commission, Luxembourg
M. De Cort, S. Galmarini, G. Graziani, JRC of European Commission, Ispra, Italy

Agenda

22 September
MORNING SESSION 900-1230 (chairman G. Graziani)

- Welcome by P. Part, Head of the Unit Environmental Impact Assessment of Environment Institute
- Generalities on the two releases (by W. Klug)
- The main results and comments on the zero and first releases (R. Bianconi)
- Open discussion

AFTERNOON SESSION 1400- 1730 (chairman W. Klug)

- Discussion of the monitoring data from Algeciras accident
- Simulations of Algeciras release (JAERI, KNMI,SMHI, ANPA, Meteofrance, LLNL and others)
- General discussion on Algeciras results and implication for RTMOD participants

23 September
MORNING SESSION 900-1230 (chairman G. Graziani)

- ETEX-3 present situation and development
- Future development of RTMOD: wet and dry deposition and eventual modifications in statistical comparison parameters
- Future of RTMOD in connection with the emergency capabilities

Appendix IV. 3. Meeting at Ispra 1999 Sep. 01-02

Minutes of the 3rd RTMOD meeting (Ispra, 1/9 – 2/9 1999)

On September 1 and 2 1999, the final RTMOD workshop was held at JRC Ispra. During the meeting the following subject were discussed:

Day 1 morning:
Summary of the RTMOD project, the JRC perspective
Results characteristics as a function of the weather situation
Spreading of the model results
Possible improvements

Day 1 afternoon:
The RTMOD experience, the participants perspective (presentation by participants, approx. 5 min each with neither model nor result presentations)
Open discussion: criticisms and achievements
Conclusive remarks and recommendations

Day 2 Morning
Discussion of the Share-Cost Action
Conclusion of the meeting

Follows a summary of the discussion for each of the subjects.

Summary of the RTMOD project, the JRC perspective

A summary of the project was presented by G. Graziani who identified the original scope of the project and the goals set at its start.

After an overview of the activities performed during the project, the fulfilment of the original goals was verified.

Originally, RTMOD intended to set up a system for the acquisition and communication of model results from a community of modellers spread around the world and to perform a series of dry runs during which the model results would be acquired and compared in real time.

A web-based system for real-time statistical evaluation of long-range dispersion models was developed (http://rtmod.ei.jrc.it/rtmod)

According to the project, the following requests were planned:

- Required exercises: 3 real-time dry runs in different meteorological conditions
- Participation: 11, from EU Member Countries
- Statistical analysis procedure: as for ETEX
- Web page: limited access to participants
- variables to be compared: atmospheric concentration
- Temporal and spatial domain: fixed

RTMOD is structured as a website interfacing the modeller on the client side, and the statistical analysis system on the server, at JRC Ispra.

The modellers participating to the RTMOD exercises are informed by fax when a dry run (a fictitious release) takes place, and they access a web page where the release information is stored, starting

the simulation using their meteorological data (forecast and analysed) and long-range dispersion models (see Fig.1).

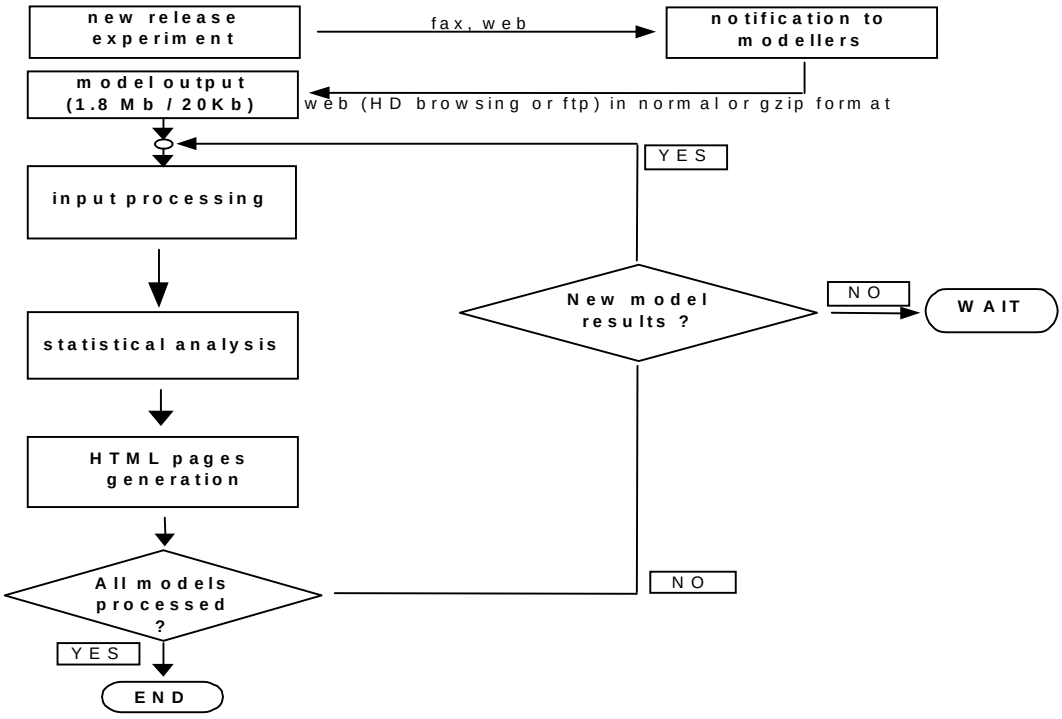
The simulation domain of these fictitious accidental releases into the atmosphere was planned to be the European region encompassing 5° W to 40°E in longitude and 40°N to 65° N in latitude. Nonetheless, in the course of the project , domain of variable sizes and origin can be accepted.

After the completion of the simulation, the modeller can upload the results obtained to the RTMOD site, in a standard format. RTMOD processes the new results arrived, by comparing them with the results of other models available at the moment. When new model results arrive, the statistical intercomparison is updated where needed.

The statistical analyses produce results in numerical and graphical format.

Following the interest demonstrated by the modelling community, the participation to RTMOD was enlarged to non-EU participants, from other European and non-European countries such as Japan, USA and Canada. A total of 28 participants was finally reached.

All together four RTMOD experiments were done, and they are presented in the following paragraph, including some examples of the results obtained.



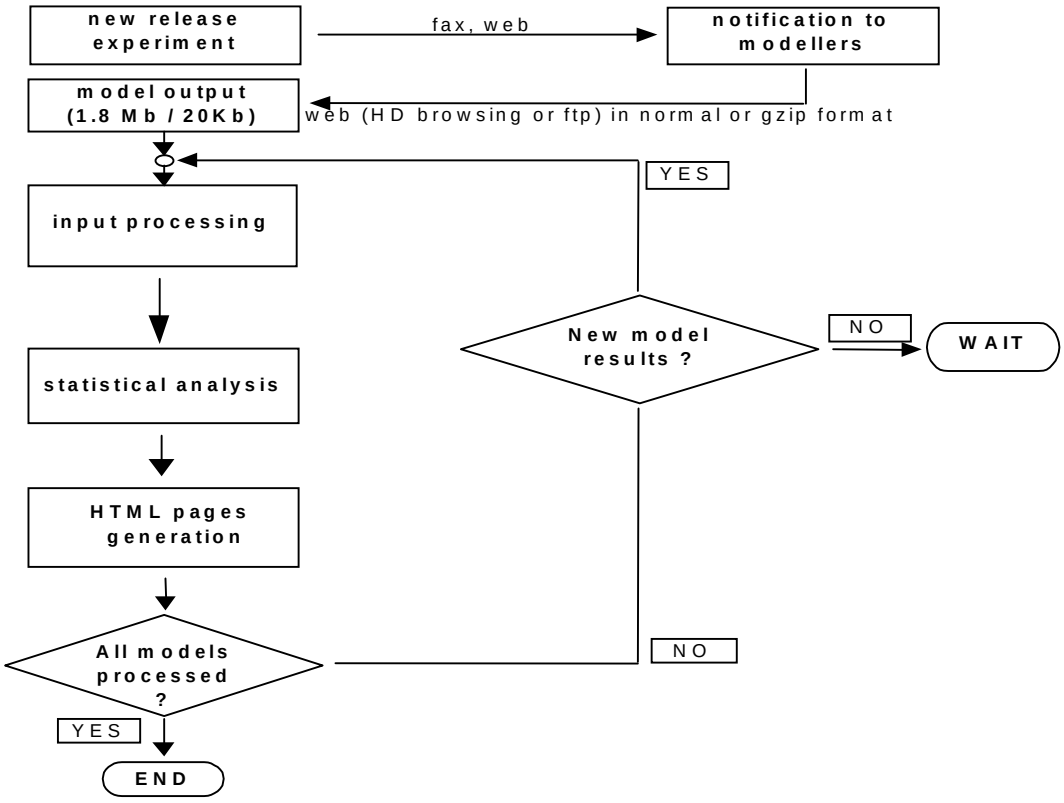


Figure 1. Main RTMOD structure for long-range dispersion models inter-comparison.

Within the two-year of the project the following exercises were performed:

Chernobyl release

The first hypothetical release, aimed at simulating a nuclear accident, was performed on the 28th of April 1998 from the location of Chernobyl (Ukraine). The release started at 0900 UTC and lasted 6 hours with constant emission rate of 10 g/s. At the same time the release start was notified to modellers by fax and e-mail. The choice of the location was made on the basis of the meteorological circulation of that day, and to commemorate the 12th anniversary of the Chernobyl accident. Earliest replies from participating modellers were foreseen to be in the form of faxed maps showing their prediction of cloud location 24 hours after the release start time. At the same time the upload of the data files to the RTMOD website was expected.

This first experiment was mainly planned to test the system, and to check the transmission protocols and the procedures. Eighteen models sent their results by fax to JRC Ispra, within a short time from the release beginning.

A release North of London

The second experiment was performed the 9th of July 1998. The fictitious release happened in London (UK) at 0900 UTC. Again, a release of 10 g/s intensity and lasting 6 hours was decided. This time all the procedures went smooth, thanks to the testing and experience gained with the first preliminary experiment. No major problems were noticed, in the transmission of output files, and in the processing and publication of the results on the web. This time 21 modellers sent the plots of their predictions by fax in a few hours from the alert.

A release at Edinburgh

The third real-time experiment was performed the 10th of June 1999. The fictitious release happened in Edinburgh (UK) at 01200 UTC. A release of 80 g/s intensity was assumed to produce non-negligible values for dry and wet deposition, for a duration of 3 hours. This time all the procedures went smooth, thanks to the testing and experience gained with the first preliminary experiment. No major problems were noticed, in the transmission of output files, and in the processing and publication of the results on the web. This time 21 modellers sent the plots of their predictions by fax in a few hours from the alert, in spite of the fact that dry and wet deposition results had to be produced.

Between the second and third release the evaluation of the Algeciras event was carried on,in spite of the fact that this was not a real-time evaluation. Nonetheless, it was considered that RTMOD constituted a good platform for model validation, similar to ATMES. Algeciras case served also to test and tune the deposition part of RTMOD that was not considered during the first two real-time releases.

The activities performed during the exercise are therefore:

- Development of the RTMOD web site and system
- Performed exercises: 3 real-time dry runs + 4 analyses (including Algeciras)
- Participation: from and outside EU Member Countries, generally > 11
- Statistical analysis procedure: extended with respect to ETEX
- Web page: re-built and extended with a Forum and Demo for non-participants.
- Evaluation system: generalized to allow the use on any pre-defined grid
- Variables to be compared: concentrations + dry and wet deposition. Variable spatial & temporal domain
- Reception and analysis of faxed maps.

The characteristics of the releases are presented in the table below. Set 1 and Set 6 represent the results obtained using on-line meteorological forecast or analysed meteorological fields respectively.

date: location:	Experiment 01 28 April 1998 Chernobyl (Ukraine)		Experiment 02 9 July 1998 North of London (England)		Experiment 03 30 May 1999 Algeciras (Spain)		Experiment 04 10 June 1999 Edinburgh (Scotland)	
lon:	30.1 E		0		-5.27 E		-3.283 E	
lat:	51.4 N		53 N		36.08 N		56 N	
rate:	10 g/s		10 g/s		5.14E+08 Bq		80 g/s	
start (UTC):	0900		0900		0000		1200	
duration:	6 hours		6 hours				3 hours	
conc units:	ng/m3		ng/m3		Bq/m3		ng/m3	
MODEL	Set 01	Set 06	Set 01	Set 06		Set 06	Set 01	Set 06
1	Y		Y					
2	Y	Y	Y	Y		Y	Y	Y
3	Y		Y	Y			Y	
4	Y		Y	Y		Y	Y	Y
5	Y	Y	Y	Y		Y	Y	Y
6	Y	Y	Y	Y		Y	Y	Y
7	Y							
8	Y	Y	Y	Y		Y		
9	Y	Y	Y	Y				
10	Y	Y	Y	Y		Y	Y	Y
11								
12			Y	Y		Y	Y	Y
13	Y		Y			Y	Y	Y
14								
15	Y	Y	Y	Y		Y	Y	Y
16								
17	Y							
18								
19	Y		Y	Y			Y	Y
20								
21								
22	Y		Y	Y			Y	Y
23	Y		Y	Y			Y	Y
24	Y		Y	Y		Y	Y	Y
25	Y	Y	Y	Y			Y	
26	Y		Y	Y		Y (no WD)	Y	
27	Y	Y	Y	Y				
28								

Results characteristics as a function of the weather situation

The various cases analysed show an overall similar behaviour of the models with the expected increasing variability dependent on the duration of the simulation. No specific correlation with the weather pattern was observed.

Spreading of the model results and Possible improvements

A preliminary analysis of the way to treat the model results has been performed. Aim of the analysis presented was to determine how the model results could be represented in order to obtain information to be used on the emergency response. The results gather and homogenised as far as space and time representation are concerned can in fact be used to determine the uncertainty of the prediction which is a useful information from decision making purposes. The analysis conducted and presented during the meeting aimed at grouping the models according to and outlier analysis of some of the statistical parameters adopted for the model evaluation. These are the global distribution and the space and time figure of merit. Though preliminary and limited in potential this analysis shows how a series of information can be extracted from the ensemble of models and reproduced in a limited number of parameters easy to use and interpreted in case for emergency response.

During RTMOD new parameters were developed for this purpose such as the Confidence in Contamination Level in space and time, the maximum concentration, the distribution of the arrival time and the model envelope. These parameters show a great potential for emergency response application and will be analysed in detail in the future.

The RTMOD experience, the participants perspective

During this section every participant presented his perspective on the exercise. In general very positive comments were presented and the exercise was very considered as an essential activity for both model improvement and exercising emergency response activities. Suggestions were proposed as far as small technicalities are concerned such as for example maintaining and revising the fax procedure for the alert and more extensive use of the on-line forum also during the alert. Below a more detailed list of the suggestions is presented.

Summary of some observations

A. AUSTRIA

RTMOD experiments have provided a good opportunity to inter-compare the behaviour of different long-range emergency response models.

Open question: Which models are more reliable than the others. Are the results from the WMO-RSMC´s (Toulouse and Bracknell) more reliable than the national emergency response model? Can the time lag, until the results come to the NMC´s be decreased?

Comment: Why have national models: because results need to be produced quickly. Reliability of networks is not always guaranteed.

→ Need RSMC + national modelling system

Suggestion: Also inter-compare results as they are distributed by the RSMC´s (time integrated concentrations, etc) more detailed analysis on differences in model results should be provided for individual analysis: more information on model physics and model specifications should be provided . This would give support to further model development.

The forum should be introduced to improve national models: e.g. support should be provided from RSMC´s or other scientific centres to improve national models operator performance within RTMOD:

RTMOD is not an operational application of modelling system at the moment. A protocol needs to be developed.

In Austria, the wish of national decision-makers exists to get a quick survey on international model results: e.g. CCL charts or other ensemble forecasts.

B. GERMAN WEATHER SERVICE (DWD)

There is still a large spread in the model results as it was apparent in the former model evaluation studies (ETEX, ATMES).

There exists a group of models (not necessarily the same for different experiments) with relative consistent model results.

A convergence of the results of the different models can be found, if analysed meteorological data is used instead of forecast data.

The comparison of dry resp. wet deposition results is a step forward for a better understanding of differences between the model results.

Also a consistency check between concentration and deposition values can be executed.

If concentration measurements are available (as for the Algeciras case), there is the possibility to improve model results by adapting model parameters or employing data assimilation techniques.

Remarks and proposals

The approach to calculated ensemble values of a group of dispersion model results by statistical methods is an interesting new aspect in the field of model evaluation with a high potential to reduce the uncertainties of concentration forecasts.

There can be a tendency to check especially, whether the model results are in the "main stream" of the ensemble of the available models (e.g. CCL presentation). But this can be misleading, because these scores depend on the quality of the participating models.

From the modeller's point of view, it would be an advantage to have also averaged statistical values of a specific model compared to the ensemble results.

With the advent of models with higher time and space resolution, it should be discussed whether the grid resolution of the model output could be adapted for future studies.

The RTMOD project was a very useful study for the further improvement of the real-time long-range dispersion models.

C. KNMI

1. the last alert period was not clearly indicated
2. the pre-alert and alert message must contain all the relevant information: not only the source information but also what is required as response. For example it is requested to fax a concentration plot for T0+24 hours.
Also the fax number to fax this plot to has to be part of the message.
3. Ideally the layout of the message is always the same, and the same layout is used for the email and the fax.

Discussion of the Shared-Cost Action

Given the success of the present activity, during the second day of the meeting a new project was presented meant as continuation and extension of the present one. The new activity foresees a much deeper strengthening of the emergency response potential of the RTMOD system and the its transformation in an operative system to be used in case of real emergency.

Conclusions

Feasibility of the system has been demonstrated
Modeler's network has been maintained and extended
Concision in statistical comparison has to be extended, making use of the experience gained.

The participation at the last RTMOD meeting is presented in the following

Table 1

Name	Organisation
Robert ADDIS	**Savannah River Site, USA**
Poul ASTRUP	RISØ NATIONAL LABORATORY
Alexander BAKLANOV	Danish Meteorological Institute
Roberto BIANCONI	ENVIROWARE SRL
François BOMPAY	METEO-FRANCE
Mieczyslaw BORYSIEWICZ	Polish Org. Institute of Atomic Energy
Gerhard DE VRIES	JRC - Environment Institute
Franco DESIATO	ANPA, Italy
George FRASER	DG XI/C/1
Simon FRENCH	Univ. of Manchester
Stefano GALMARINI	JRC Environment Institute
Gerda GEERTSEMA	K. N. M. I.
Hubert GLAAB	DWD
Giovanni GRAZIANI	JRC- Environment Institute
Thomas HANTKE	RIVM
Werner KLUG	DARMSTADT
Roy MARYON	U.K. Meteorological Office
Torben MIKKELSEN	RISØ NATIONAL LABORATORY
Sonia MOSCA	ENVIROWARE SRL
Ulrike PECHINGER	Central Institute for Meteorology (A)
Christer PERSSON	SMHI
Patrick PETIT	JRC Environment Institute
Alain PINAULT	METEO-FRANCE
Jørgen SALTBONES	Norwegian Meteorological Institute
Anne Grete STRAUME	KNMI
llkka VALKAMA	Finnish Meteorological Institute
Ludo VAN DER AUWERA	KMI
Hiromi YAMAZAWA	JAERI
Roman ZELAZNY	Polish Org. Institute of Atomic Energy

In the Project the following contact points were established

Name and lab.
Torben MIKKELSEN Risø National Laboratory-Department of Meteorology and Wind Energy
François BOMPAY METEO-FRANCE
Franco DESIATO ANPA
Dan GRIGGS Westinghouse Savannah River Co.
Hiromi YAMAZAWA / Masamichi CHINO Department of Environmental Safety Research Japan Atomic Energy Research Institute JAEARI
Réal D'AMOURS Centre Météorologique Canadien
Jan MACOUN Czech Hydrometeorological Institute
Mike BRADLEY ARAC-2, Lawrence Livermore Nat. Lab.
Gertie T. GEERTSEMA Royal Netherlands Meteorological Institut (KNMI)
Hubert GLAAB Deutchen Wetterdienst German Weather Service (DWD)
Roman ZELAZNY Institute of Atomic Energy
Joakim LANGNER Swedish Meteorological and Hydrological Institute
Roy H. MARYON, Derrick RYALL Meteorological Office
Marguerite MONFORT CEA - IPSN/DAS/STAS
Jens Havskov Sorensen and Alexander BAKLANOV Danish Meteorological Institute Meteo.&Oceanographic Research
Ion SANDU National Institute of Meteorology and Hydrology
Jorgen SALTBONES Norwegian Meteorological Institute
Daniel SCHNEITER / Felix SCHACHER Institut Suisse de Météorologie Section de l'environnement
V. SHERSHAKOV SPA
Stefan SKULEC Slovak Hydrometeorological Institute
Roland DRAXLER NOAA AIR Resources Laboratory

Dimiter SYRAKOV/Maria PRODANOVA National Institute of Meteorology and Hydrology
Thomas HANTKE, Harry SLAPER, Freek ALDENKAMP (Laboratory of Radiation Research
Ludo VAN DER AUWERA Institut Royal Météorologique de Belgique
Ilkka VALKAMA / Pilvi Siljamo Finnish Meteorological Institute Air Quality Research
Ulrike PECHINGER Central Institute for Meteorology and Geodynamics
Connee FOSTER ARAC-3, Lawrence Livermore Nat. Lab
Joergen BRANDT National Environmental Research

References

Bellasio R., Bianconi R., Graziani G. and Mosca S. (1999) RTMOD: An Internet based system to analyse the predictions of long-range atmospheric dispersion models. Computers & Geosciences.

Bellasio R., Bianconi R., Graziani G. and Mosca S. (2000) RTMOD: A Web-based real-time statistical evaluation package for long-range dispersion models. In: *Air Pollution modeling and its Application XIII*, Eds. S.-E. Gryning and E. Batchvarova; Kluwer-Plenum, pp. 321-328.

Internet based system to analyse the predictions of long-range atmospheric dispersion models. Computers & Geosciences.

Mosca S., Graziani G., Klug W., Bellasio R. and Bianconi R. (1998) A statistical methodology for the evaluation of long-range dispersion models: an application to the ETEX exercise. Atmospheric Environment. vol. 32, n. 20.

Girardi F., G. Graziani, D. van Velzen, S. Galmarini, S. Mosca, R. Bianconi, R. Bellasio, W. Klug and G. Fraser (1998) *ETEX - The European tracer experiment.* EUR 18143 EN, Office for Official Publications of the European Communities, Luxembourg, ISBN 92-828-5007-2, 108 pp.

Mosca S., R. Bianconi, R. Bellasio, G. Graziani and W. Klug (1998) *ATMES II - Evaluation of long-range dispersion models using data of the 1st ETEX release.* EUR 17756 EN, Office for Official Publications of the European Communities, Luxembourg, ISBN 92-828-3655-X, 458 pp.

Bibliographic Data Sheet **Risø-R-1174(EN)**

Title and authors

RTMOD: Real-Time MODel Evaluation

Giovanni Graziani and Stefano Galmarini
JRC - Ispra, Italy
and
Torben Mikkelsen
Risø National Laboratory, Denmark

ISBN	ISSN
87-550-2682-6 87-550-2687-7 (Internet)	0106-2840

Department or group	Date
Wind Energy and Atmospheric Physics Department	January 2000

Groups own reg. number(s)	Project/contract No(s)
	FI4P-CT97-0068

Pages	Tables	Illustrations	References
47	6	6	4

Abstract (max. 2000 characters)

The 1998 - 1999 RTMOD project is a system based on an automated statistical evaluation for the inter-comparison of real-time forecasts produced by long-range atmospheric dispersion models for national nuclear emergency predictions of cross-boundary consequences.

The background of RTMOD was the 1994 ETEX project that involved about 50 models run in several Institutes around the world to simulate two real tracer releases involving a large part of the European territory. In the preliminary phase of ETEX, three dry runs (i.e. simulations in real-time of fictitious releases) were carried out. At that time, the World Wide Web was not available to all the exercise participants, and plume predictions were therefore submitted to JRC-Ispra by fax and regular mail for subsequent processing.

The rapid development of the World Wide Web in the second half of the nineties, together with the experience gained during the ETEX exercises suggested the development of this project. RTMOD featured a web-based user-friendly interface for data submission and an interactive program module for displaying, intercomparison and analysis of the forecasts.

RTMOD has focussed on model intercomparison of concentration predictions at the nodes of a regular grid with 0.5 degrees of resolution both in latitude and in longitude, the domain grid extending from 5W to 40E, and 40N to 65N.

Hypothetical releases were notified around the world to the 28 model forecasters via the web on a one-day warning in advance. They then accessed the RTMOD web page for detailed information on the actual release, and as soon as possible they then uploaded their predictions to the RTMOD server and could soon after start their inter-comparison analysis with other modellers. When additional forecast data arrived, already existing statistical results would be recalculated to include the influence by all available predictions.

The new web-based RTMOD concept has proven useful as a practical decision-making tool for real-time communication between dispersion modellers around the World and for fast and standardised information exchange on the most probably contaminated areas.

Descriptors

ACCIDENTAL AND RADIOACTIVE RELEASES; DECISION MAKING SUPPORT; RISK ANALYSIS; LONG-RANGE ATMOSPHERIC DISPERSION MODELS; MODELS INTER-COMPARISON; REAL-TIME; ON-LINE; EXERCISES; STATISTICAL ANALYSIS; FORECASTS; AIR POLLUTION; NUCLEAR ACCIDENTS; CHERNOBYL

Available on request from Information Service Department, Risø National Laboratory,
(Afdelingen for Informationsservice, Forskningscenter Risø), P.O.Box 49, DK-4000 Roskilde, Denmark.
Telephone +45 4677 4004, Telefax +45 4677 4013