INTER-COMPARISON OF REAL-TIME DISPERSION MODEL RESULTS, SUPPORTING DECISION-MAKING IN CASE OF NUCLEAR ACCIDENTS AND FOCUSING ON QUANTIFICATION OF UNCERTAINTY

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INTRODUCTION

In Norway, the decision making body for handling nuclear accidents is 'Kriseutvalget' - consisting of an assembly of national authorities: Radiation Protection, Health, Police, Military, Civil Defence, etc. Kriseutvalget is supported by a number of institutions, giving expert advice on questions of relevance. Similar preparedness organisations exist in most European countries. An important adviser to Kriseutvalget is the Norwegian Meteorological Institute (met.no), giving Kriseutvalget meteorological and dispersion forecasts, and advice/information on such topics. The most important tool for the meteorologists on duty is a real-time dispersion model, SNAP (Severe Nuclear Accident Program), specially designed to model long-range atmospheric transport of the radioactive debris released during nuclear accidents (*Saltbones et al.,* 1995; *Bartnicki et al.,* 2001). The question then naturally arises: What is the uncertainty of dispersion model forecasts?

To get a measure of the inherent model uncertainty in such forecasts, National Meteorological Services (NMS) in Europe have pooled their resources together in the EU-project 'ENSEMBLE' (*Galmarini et al.,* 2002). The project is strictly internet oriented and its main ideas are:

- to develop software for statistical treatment of dispersion model results,
- to develop, refine and harmonize the output from operational dispersion models,
- the NMS will run their dispersion models in joint exercises, using input from the most updated numerical meteorological model results available,
- the dispersion model results should be sent on internet to a common website for statistical treatment,
- the results from all models will be available to all participants on internet,
- project participants can compare model results with any other model or a chosen combination of models,
- project participants will be able to display the out-layers, the mainstream results and quantify model uncertainty.

The aim of the project is to develop a new internet based decision support system for operational use by the national decision makers - in real accidents. Selected results from project exercises, seen from Norwegian perspective, will be presented on-line using already developed internet tools.

ENSEMBLE WEB PAGE

Ensemble is a web system located on a server at Joint Research Centre (JRC) in Ispra, Italy. An important part of the project consists of real-time exercises, which involve 21 models from different institutions in Europe, USA and Canada. All together, 10 exercises simulating nuclear accident are planned during the project duration in the period 2001 - 2003. Already six of these exercises have been completed. Results of each exercise are sent and then analysed using a dedicated web page (Figure 1).

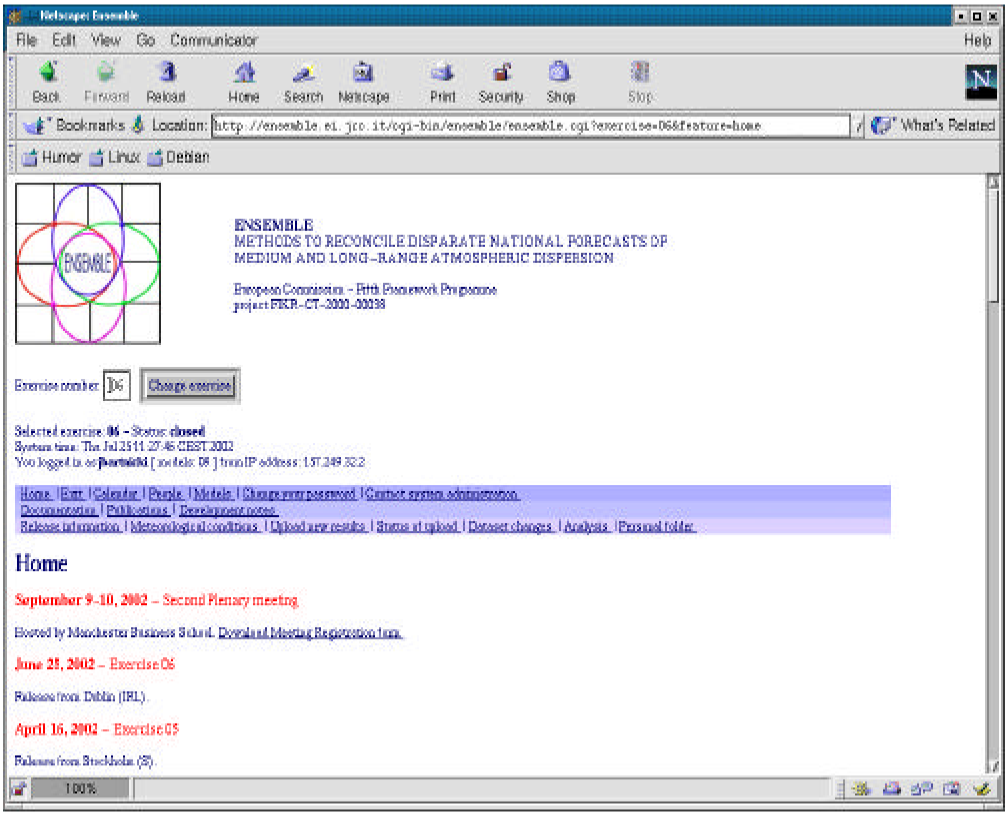

Figure 1. Home page of the ENSEMBLE project.

This page includes also general information about the project, its documentation, calendar of events, publications and list of people involved. Topic "Development notes" gives updated information about latest tools and eventually corrected errors in these tools. Topic "Models" presents a list of meteorological and dispersion models for each participating institute.

Warning about each exercise is sent to all participants by fax and e-mail. In addition, all details about the source term for each exercise can be found under topic "Release conditions".

When participants receive such a warning, they run a dispersion model. Than, they compress the results using a specially developed FORTRAN program. Transfer of results to JRC is performed by a tool, which can be found under the topic "Upload results". Topic "Status of upload" can be used to check if the transfer of data was successful.

If the transfer was successful, each participant can check the results using a large number of tools grouped under topic "Analysis". Computed concentrations (at five vertical levels), time integrated concentrations, wet depositions, dry depositions and precipitation amount can be checked and compared among different models, as well as, displayed using specialized graphics. Based on our experience, as one of the participants, we have found these tools extremely useful, easy to use, fast end effective. For example, comparing our results with other models, we could discover very quickly simple errors (e.g. resulting form wrong typing of emission rate etc.) and correct them at once.

When the errors in the results are discovered, the submitted file can be deleted form JRC database, new model run performed and corrected results transferred to JRC once again. In such a case, participants write a short note to JRC explaining the reason for deleting the file, which can be found under the topic "Dataset changes".

Once the simulation is completed and all results transferred to JRC, an extensive analysis can be performed by each participant. Many figures can be created as a result of the analysis. These figures can be stored by each participant in his (her) "Personal folder" available on the web page.

Details about the ENSEMBLE web page will be presented on-line during the meeting.

Exercise-05: SNAP results

From six exercises performed in the framework of the ENSEMBLE project up to now, exercise-05 was especially interesting from the Norwegian perspective, because in this case, radioactive cloud covered a part of Norway. Therefore, in our presentation we will focus on this event.

The aim of the exercise-05 was a simulation of the artificial nuclear accident, which happened in Stockholm, Sweden, on 16 April 2002. During the accident, a leakage of Cs137 occurred at the height of 2 m, which lasted for 10 hours. Temporal pattern of emission was quite complicated with the rate order of 10^{15} Bq/hour. Participants were asked to send a real-time dispersion forecast for the next three days.

The results of the SNAP model are presented in Figure 2, as grid plot for time-integrated concentration. Radioactive cloud is reaching south of Norway, but the red line with highest concentration is located slightly below the Norwegian coast. This picture gives important information about the area affected by the radioactive cloud but there is no hint about the uncertainty of results.

Exercise-05: ENSEMBLE results

Concerning uncertainty, there is some improvement when the results of the ensemble forecast are presentd.

As an example, greement on threshold level (10^{-5} Bqh/m^3) for time-integrated concentration among 10 selected models is shown in Figure 3. This figure can be inerpretted in the following way. All 10 models have predicted the arrival of Cs137 in the grids located in the middle of the cloud, whereas at the borders of the cloud, only one of the models predicted the presense of Cs137. Figure 3 indicates that the south of Norway is very likely (100% agreement among models) to be affected by the radioactive cloud. On the other hand, only one or two models (but not SNAP) have predicted the arrival of Cs137 to the Central part of Norway. Finaly, none of the models has shown any influance of the accident on the Northern part of Norway.

Such an information is very useful for the decison maker and we have got a very positive response for this kind of the analysis from the Norwegian Radiation Protection Authority.

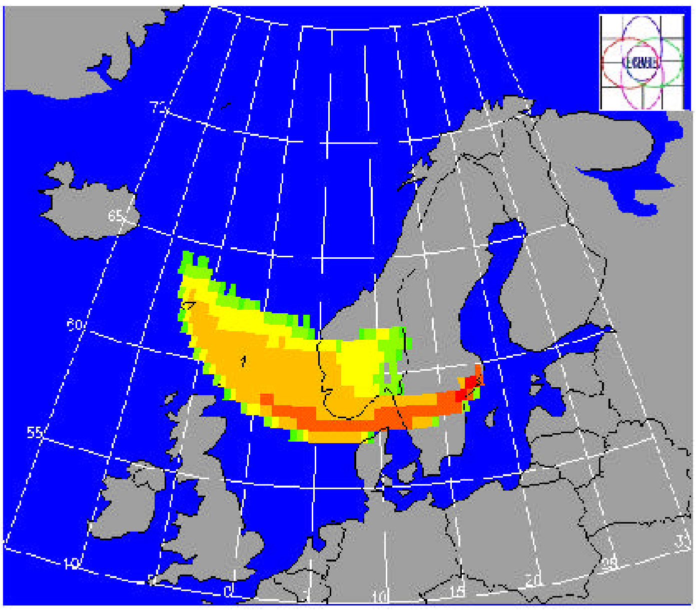

Figure 2. Grid plot for time-integrated concntration computed with the SNAP model.

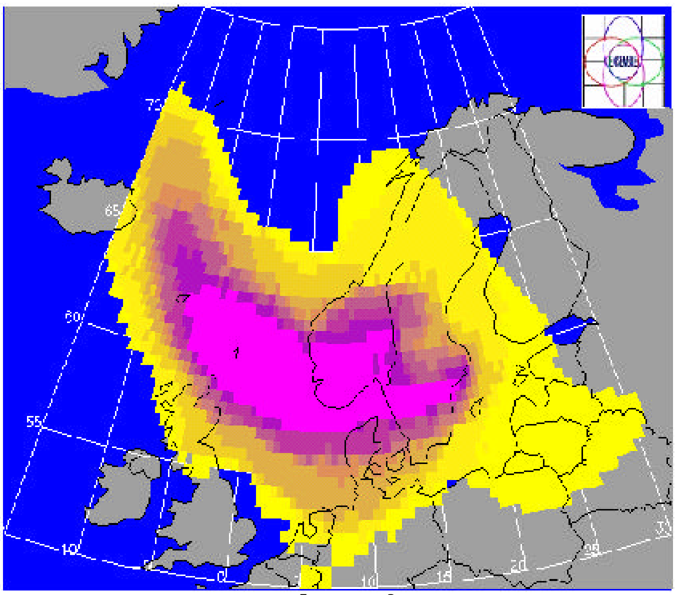

Figure 3. Agreement on threshold level (10^{-5} Bqh/m^3) for time-integrated concentration among 10 selected models.

Additional and very important advantage of the ensemble forecast is a posibility of reciving prediction even in the case when our SNAP model for some reason can not be used operationaly (e.g. problems with local meteorological data).

CONCLUSIONS

In the middle of its duration, the ENSEMBLE project has already developed a very useful internet tool for operational dispersion models used in case of nuclear accident. This tool has been tested by us and other project participants in six exercises and it proved to be very convenient and efficient for presentation and analysis of results. From the Norwegian perspective its main advantages are:

- robust, user friendly and fast in application,
- simple in operation but can be used for sophisticated analysis,
- can be used for comparison and integration of many models results (21 at present),
- can be used for different types of uncertainty analysis,
- significantly increases exchange of information among modellers resulting in improvements and harmonisation of national models,
- this tool can be used in case of a real accident already now,
- is well received by Norwegian National Authority responsible for radiation protection.

In summary, our main conclusion can be formulated in the following way: although not finished yet, the ENSEMBLE project is already very successful in harmonizing 21 different operational dispersion models developed for the case of nuclear accident.

ACKNOWLEDGEMENTS

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