EUROPEAN COMMISSION
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ENSEMBLE for ECURIE

Contribution of ENSEMBLE v. 2 to the ECURIE Level 3 Exercise

S. Potempski, S. Galmarini

Institute for Environment and Sustainability

2007

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Content

INTRODUCTION

This report summarises the contribution of the ENSEMBLE activity to the ECURIE Level 3 exercise.

The ECURIE Competent Authorities Meeting in February 2006 decided, in response to a proposal by the European Commission, that the Swedish FALKEN nuclear emergency exercise would also be the ECURIE main level 3 exercise in 2006. The FALKEN exercise was carried out on 4 October 2006. Sweden played the role of an accident country. The scenario for use in the exercise was chosen in such a way that a serious emergency happened at the Ringhals NPP Unit 1 (BWR).

The exercise involved the new version of the ENSEMBLE long-range atmospheric dispersion forecast system, managed at the JRC Ispra. It was the first application of version 2 of the system in such international exercise.

The ENSEMBLE activity, which is part of the Joint Research Centre (JRC) institutional support activity to DG-TREN, is described in detail in Galmarini et al. (2001), Galmarini et al. (2004a, b and c). It consists of a network of 19 countries and 22 institutions (mainly from Europe but also from US and Canada – see Appendix for the list) operating 24 long range atmospheric transport and dispersion models. The dispersion models used by the various institutions differ in terms of concept and numerical code and make use of weather forecasts produced by different Global Circulation Models or Limited Area Models. Once the network is alerted, the model predictions produced by the various institutions are collected on the ENSEMBLE system located at the EC/Joint Research Centre in Ispra. A web facility allows the remote users to consultant in real-time and independently the model results present on the system. In this way every participating institution has the possibility of comparing in-house model predictions with those produced by others and of assessing the reliability of model forecasts. Most of the institutes that constitute the ENSEMBLE network normally act as national scientific and technical advisors to decision makers in case of emergency. All the services provided by the ENSEMBLE system are in real-time. ENSEMBLE was already used successfully during other international exercises such as CONVEX exercise in 2005, other ECURIE exercise in 2002, DSSNET exercise in 2003 and 16 periodic exercises performed since 2001. A dedicated site was created specifically for this exercise, where a synthesis of the various model results were presented to the outside world namely National Competent Authorities and advisors to decision makers that are presently not part of the ENSEMBLE activity and that have no access to the restricted site.

This report gives details on the contribution of ENSEMBLE to ECURIE exercise. Section 1 describes the organisation of the exercise events timeline, the notification procedure to the ENSEMBLE community, Section 2 contains information about the scenario and the source terms used for the simulation; Section 3 describes the public web site where the results of the ENSEMBLE analysis produced at JRC during the exercise were published in real-time; in Section 4 a summary is provided on the ENSEMBLE community response to the notification and on the dispersion forecasts produced during the exercise; Section 5 presents for each of the releases considered the results produced within ENSEMBLE which were not published on the public web site; and finally the conclusions are included in Section 6.

1. Organisation of the exercise and activation of the ENSEMBLE system

As mentioned above in the ECURIE exercise Sweden played the role of accident state with Ringhals NPP as a localization of major radiological event.

According to agreed procedures on notification first, Sweden sent accident information to IAEA (ENATOM arrangements) and EC (ECURIE arrangements). The number of messages was fairly low and their information content limited, but nevertheless sufficient to satisfy Council Decision 87/600/Euratom requirements at an early stage of the emergency.

The first alert was received at the Commission security office in Brussels, which notified the TREN H.4 ECURIE duty officer in Luxembourg. Then the

ECURIE duty officer activated the ECURIE communication room in Luxembourg and forwarded the message to all official stations in the CoDecS network and additionally by fax to all ECURIE contact points.

The TREN H.4 emergency team collected the incoming information and used the available emergency tools (IAEA ENAC, EURDEP, ENSEMBLE and RESPEC) in order to assess the situation and provide information to TREN hierarchy and other Commission emergency services.

JRC REM group (JRC H.4) activated the ENSEMBLE system and maintained the website tool for displaying atmospheric dispersion forecasts produced by the system. Access info for this site was sent to all ECURIE States through the ECURIE network in order to provide all States access to long-range atmospheric dispersion results.

2. The scenario of the exercise

The exercise scenario was a partial loss of reactor cooling at the Ringhals NPP Unit 1. The event sequence started with a containment leakage and partial failure of reactor shutdown (incomplete control rod insertion and boron injection) with insufficient core cooling. The accident resulted in a radioactive release to the atmosphere due to loss of containment isolation a few hours after the initial event.

The actual weather situation resulted in a release trajectory through southern Sweden towards Latvia and Estonia, with a possibility of rain showers in the release path.

Practically during the whole exercise there was no precise information about possible source term. Therefore the first simulations were provided under the assumption that hypothetical release of I-131 occurred at the height at least as the NPP stack (Table 1).

Release Location	RINGHALS (SWEDEN)
Longitude	12.11 E
Latitude	57.25 N
Release Time	2006-10-04 04:00

Release rate [Bq/h]	1.5E+15
Release Duration [h]	6 h
Release Height[m]	100 m
Release Type	unknown
Nuclide	I-131
Forecast horizon	2006-10-06 15:00

Table 1 Source term of hypothetical release early morning 4th October, 2006

The information about source term was sent to the ENSEMBLE community in a text file with specific format (Table 2), allowing in principle for automation of the simulation process.

```
Enform version                    $ 20060127
Random key                        $ R3Y2C5Q
Case number                       $ 021-001
Creation date (UTC)               $ 200610040400
Title                             $ ECURIE_L3 2006
Location                          $ RINGHALS exercise
Xsource (deg E)                   $ 12.11
Ysource (deg N)                   $ 57.25
Release start (UTC)               $ 200610040400
Duration                          $ 6 h
Time horizon of forecast (UTC)    $ 200610061500
Nature of release                 $ unknown
#
Standard domain                   $ Y
Coordinates                       $ LL
Xmin                              $ -15
Ymin                              $ 30
Nx                                $ 151
Ny                                $ 91
Dx                                $ 0.5
Dy                                $ 0.5
Vertical levels (m)               $ 0 200 500 1300 3000
#
Number of outputs                 $ 20
Dt (hours)                        $ 3
#
Nuclide                           $ I131
Code                              $ 01
Release units                     $ Bq/h
Start time, End time (UTC)        $ 200610040400 200610041000
Rate, Hmin (m), Hmax (m)          $  1.50000E+15    100    100
```

Table 2 Example of notification file

Later on, during the exercise, this source term was corrected by adjusting the proper time of the release and by adding two additional isotopes (Table 3).

Release Location	RINGHALS (SWEDEN)
Longitude	12.11 E
Latitude	57.25 N
Release Time	2006-10-04 11:30
Release rate 1 [Bq/h]	1.5E+15
Release rate 2 [Bq/h]	1.5E+15
Release rate 3 [Bq/h]	1.5E+15
Release Duration [h]	8.5 h
Release Height[m]	100 m
Release Type	Unknown
Nuclide 1	Cs-137
Nuclide 2	I-131
Nuclide 3	Sr-90
Forecast horizon	2006-10-06 21:00

Table 3 Source term of the release during the day

3. THE ENSEMBLE FOR ECURIE PUBLIC WEB SITE

Access to the ENSEMBLE system is normally restricted to the institutions that contribute by submitting model predictions and that act as advisors to decision makers in their respective countries. In order to allow a wide spread dissemination of model predictions that could be used by all the community participating to the exercise, additional web site was developed for public access. The results of the ENSEMBLE analysis produced at JRC/IES/REM were available under the web address: *http://ensemble.jrc.it/ensemble4ecurie/*. The information about web site was disseminated to all the community participating to the exercise in the form of ECURIE message. All the model predictions were published on the public web site in terms of ensembles (i.e. composite results produced in order to estimate the overall dispersion forecast reliability; Galmarini et al., 2004a). Such an approach was chosen in order to exploit the main assets of the ensemble representations i.e. the possibility of making synthesis of several model predictions that also include the level of prediction reliability and to reduce the amount of information available for consultation thus facilitating the task of the end user.

It should be also clarified that this facility is neither official nor permanent but developed specifically for the ECURIE exercise. The Competent Authorities are expected to access ENSEMBLE page if they want to.

Figure 1 gives a screen shot of the home page of the public web site. The page contained variable message stripes with continuous updates on the situation evolution and information about the simulations available on the site; links to the predictions corresponding to specific radio nuclide emissions; a short text explaining the variables analyzed and the type of treatment performed in terms of ensemble analysis; a link to a sample plot with explanations of the various plot legends.

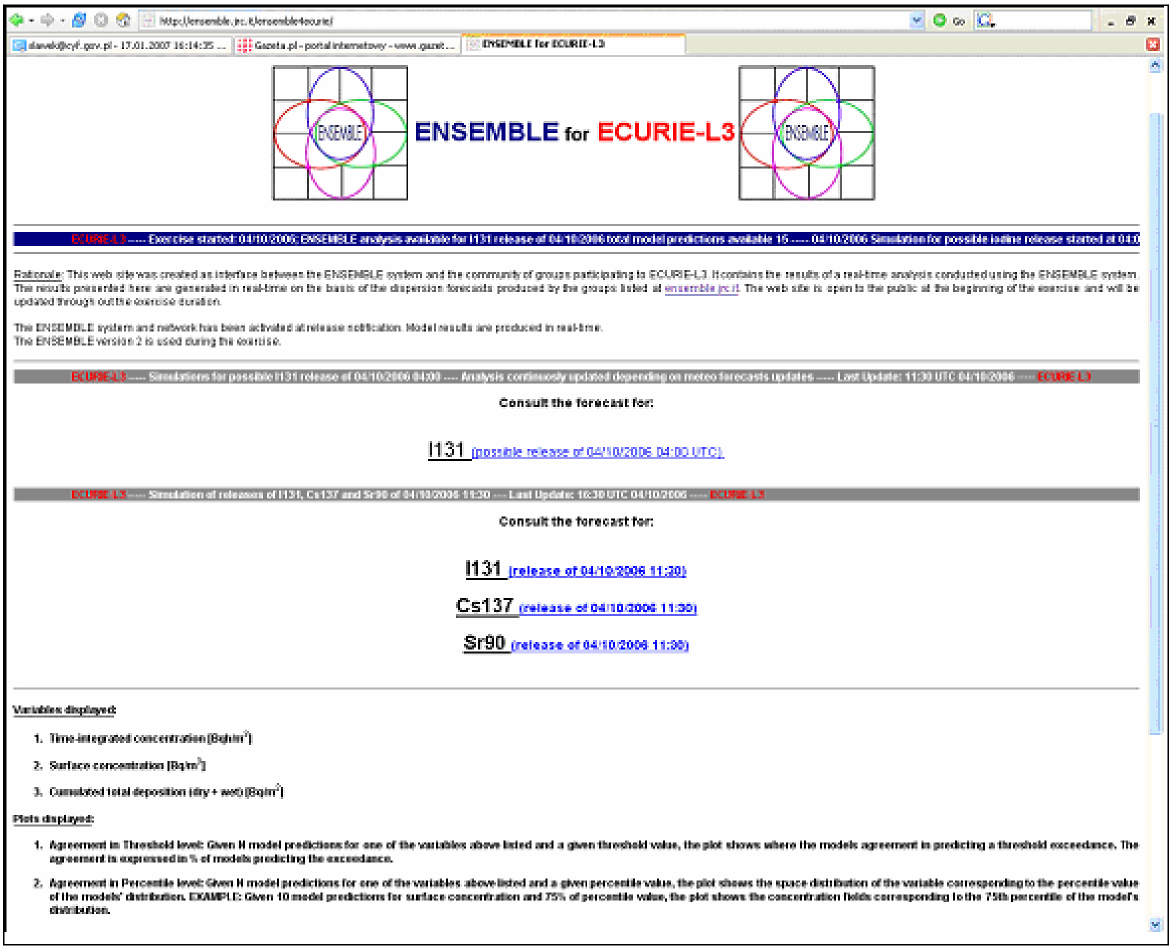

Fig. 1 Home page of Ensemble for ECURIE Web site

The links for the various nuclide dispersion forecasts are connected to a page where the source term used was displayed and the results of the ENSEMBLE analysis for the different variables listed below were given with interval of 6 hours. Figure 2 gives an example of the page where the results for ^{131}I where provided. The thumbnail pictures contained in the table can be consulted individually or composed into an animation just by one-click option. In spite of the fact that within ENSEMBLE model predictions are provided with time resolution of 3 hours, 6 hours was chosen for the public web site in order to reduce the amount of information available and for easier consultation.

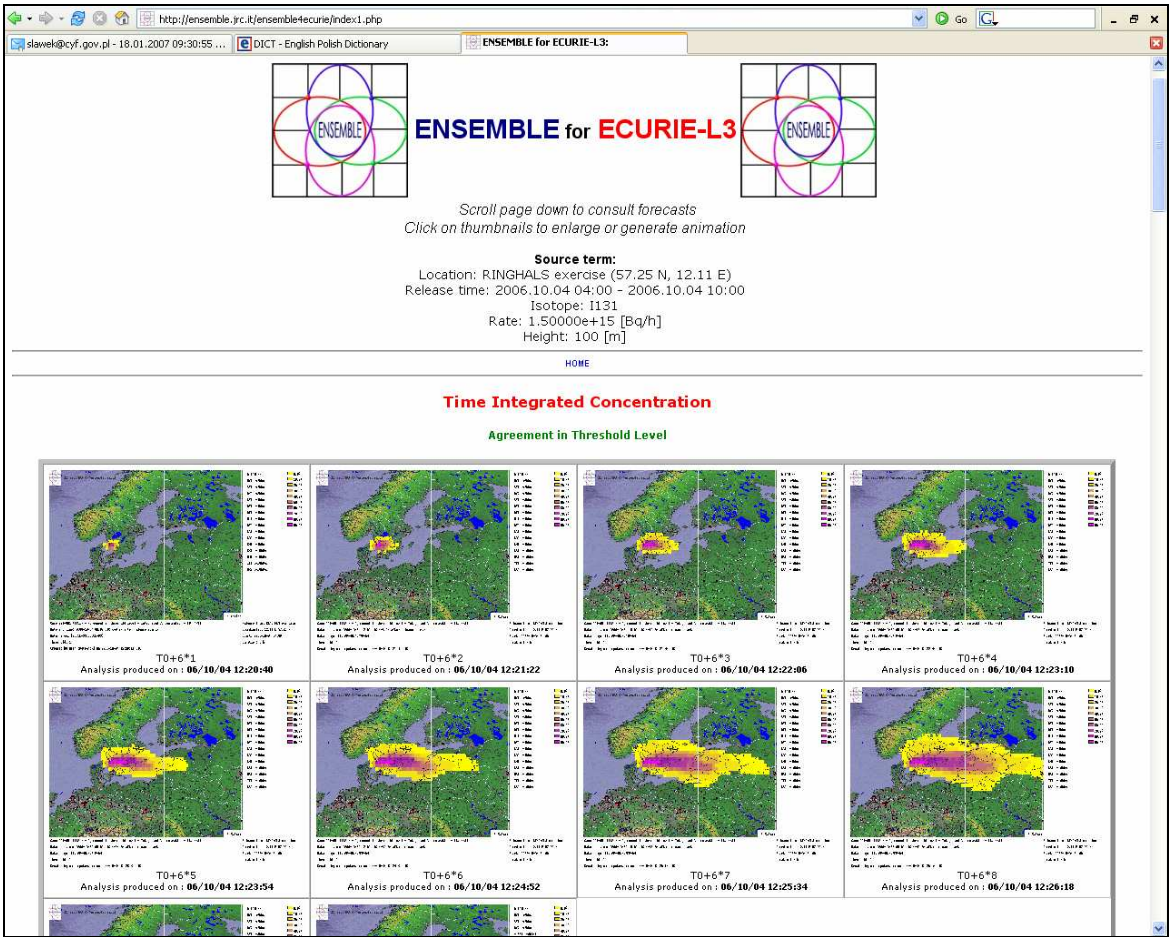

Fig. 2 Presentation of the results on ECURIE Web site

The maps for following variables were presented:

1. Time-integrated concentration [Bqh/m^3]
2. Surface concentration [Bq/m^3]

3. Cumulated total deposition (dry + wet) [Bq/m^2]

These results were displayed as one of the following two possible plots:

1. Agreement in Threshold level: Given N model predictions for one of the variables above listed and a given threshold value, the plot shows where the models agreement in predicting an exceedance of a threshold. The agreement is expressed in % of models predicting the exceedance.
2. Agreement in Percentile level: Given N model predictions for one of the variables above listed and a given percentile value, the plot shows the space distribution of the variable corresponding to the percentile value of the models' distribution. EXAMPLE: Given 10 model predictions for surface concentration and 75% of percentile value, the plot shows the concentration fields corresponding to the 75th percentile of the model's distribution.

As presented elsewhere (Galmarini et al. 2004a-c) the combined consultation of these two parameters allows to know where and when a threshold value will be exceeded and how many models predict the exceedance; furthermore one can determine the value of the variables in every point of the domain that is predicted by at least the specified percentage of models. For this exercise the 50^{th} percentile was selected. An example on the use of the two parameters for the ECURIE ^{131}I simulations is given in Figure 3. The upper panel gives the ATL with a threshold value of 1 Bqh/m^3 for time integrated concentration 54 hours after the release. The low threshold value is chosen in order to obtain a confident estimate on the spatial coverage. The plot shows that there is large agreement among the models (13) in predicting the plume passage over the Baltic Sea towards East.

The bottom panel gives the actual time integrated concentration field produced by at least 50 percent of the models. From the plot one can determine the actual time integrated concentration values knowing that 50% percent of the models produce those results. The consultation of the two plots provides estimates on model agreement and actual values produced by a large portion of the model forecasts available.

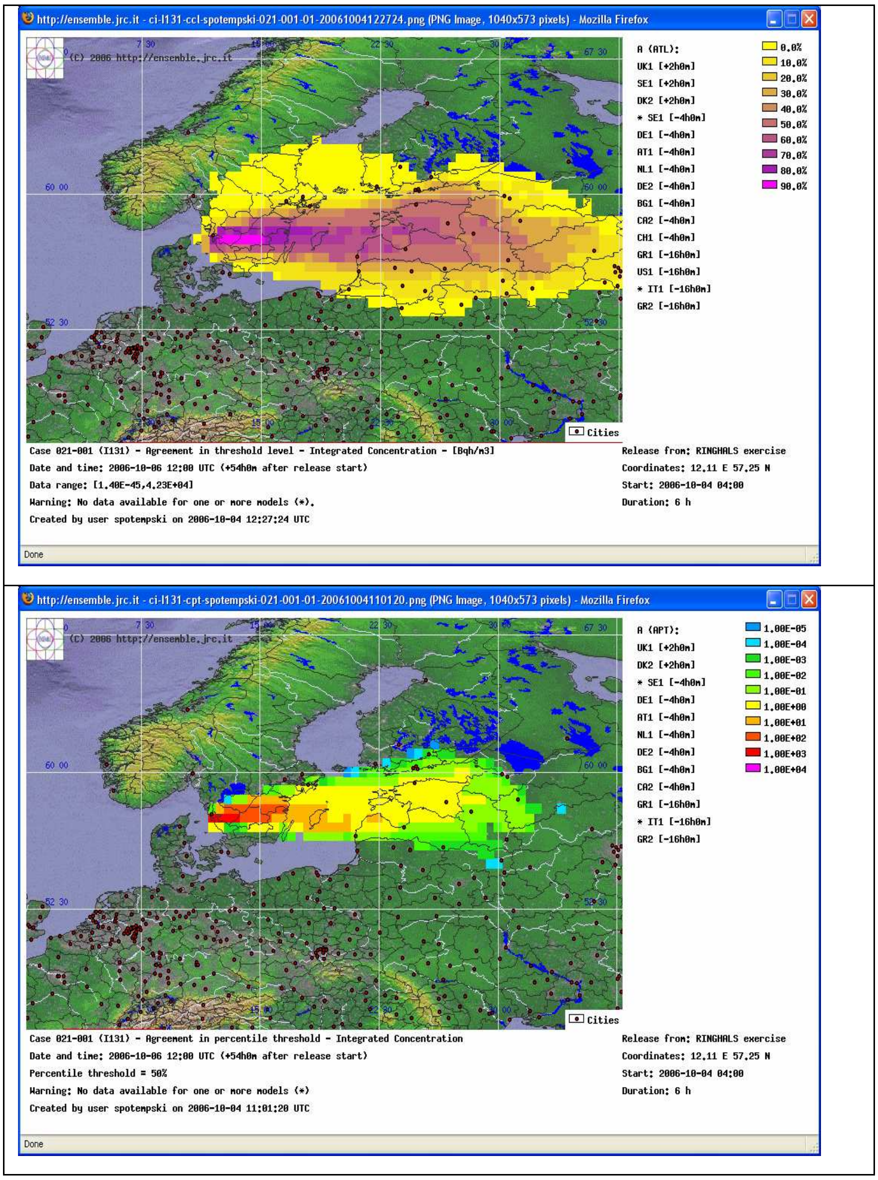

Figure 3 Examples of the ENSEMBLE analysis published on the public web site during the exercise (ATL and APL for time integrated concentration).

The web site was updated continuously during the exercise.

The updates depended on:

1. New model predictions were produced
2. Update of model predictions due to new meteorological forecast
3. New information was provided by the organisation on the source term

All these information were provided by either the web page or the plots.

4. ENSEMBLE NETWORK RESPONSE TO NOTIFICATIONS

The following notification to the ENSEMBLE community took place:

- at 07:22 UTC on the hypothetical ^{131}I release,
- at 13:02 UTC updated information about the current situation,
- at 14:32 UTC for the release of ^{131}I, ^{137}Cs and ^{90}Sr, that started at 11:30 UTC.

One can notice there was an essential time difference between obtaining the information about the release and actual start of the release.

Figures 4 and 5 give the time evolution of forecast submission to the ENSEMBLE web sites by the modelling community for the first and second simulation runs. For both simulations 10 first results reached ENSEMBLE Web site within 2 hours from the notification, while the first 5 results 80 minutes for the first runs and 40 minutes for the second simulation. A total number of 26 forecasts were submitted for both cases - some of them in the following days as due to internal reasons a number of participants could not take part to the exercise. However, it is remarkable that most of them sent their results later. The continuous update of dispersion forecast based on new weather predictions provided a considerable amount of information that could be used for real-time model inter-comparison and scenario assessment.

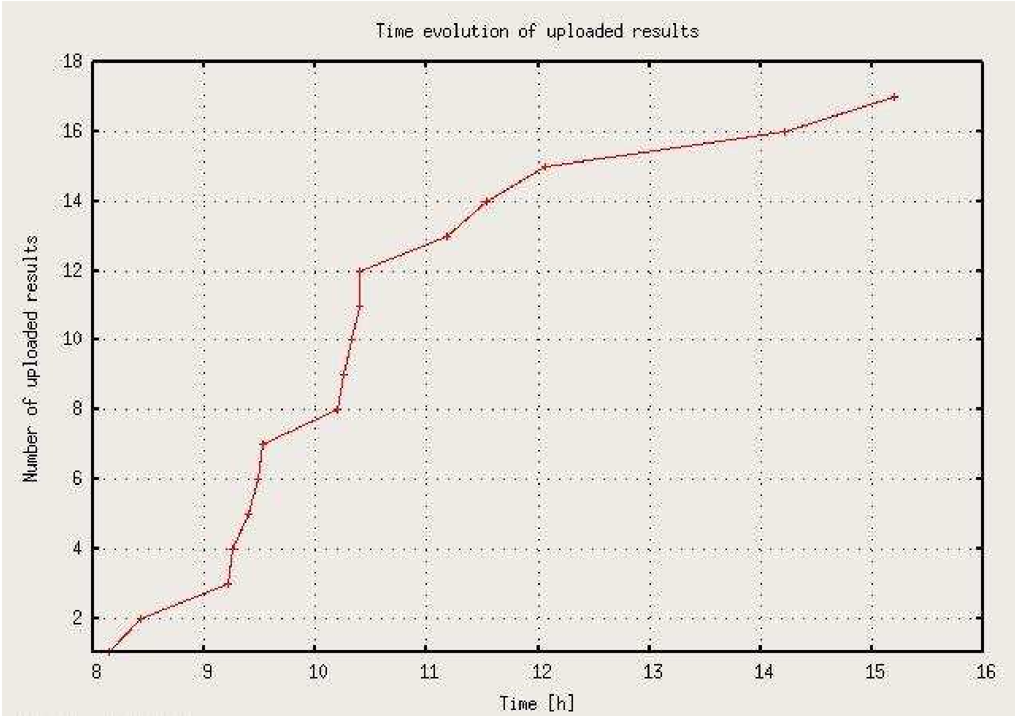

Fig. 4 Time evolution of the upload of model results on the ENSEMBLE web site during the exercise – first simulation (x-axis: time, y-axis: number of uploaded results)

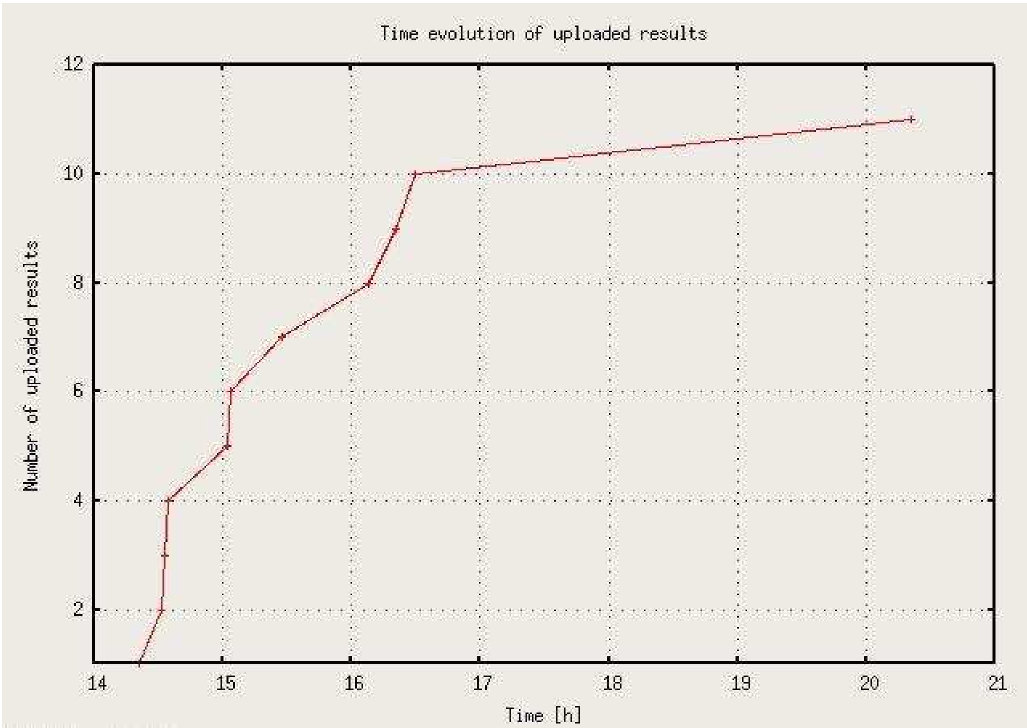

Fig. 5 Time evolution of the upload of model results on the ENSEMBLE web site during the exercise – second simulation (x-axis: time, y-axis: number of uploaded results)

5. ADDITIONAL RESULTS FROM THE ENSEMBLE SYSTEM

This section summarises some results obtained with ENSEMBLE for the ECURIE exercise. It includes standard products that can be produced in real-time and that are useful to assess the reliability of the dispersion forecast as well as the models agreement. Most of the results presented here were not published on the public web site as mainly dedicated to meteorologists or atmospheric dispersion community. The results are presented for two simulations performed and will mostly relate to the forecasts for the third day after the release.

In comparison with the version 1 of the ENSEMBLE system, in version 2 there are new capabilities for visualization of the results, which were utilised during the exercise. First of all, the results of the simulations are presented on numerical digital map. The user can switch on or off the following geographical layers: regions, cities (with or without their names), topography, major rivers, major lakes and nuclear sites. The map is scalable, so new elements appear when the resolution is becoming higher. Secondly some manipulations on the map are also possible like: zooming, panning, querying the results on the map and fitting the considered case into the domain. Some examples are presented later in this section. In the new version also structure of the simulation cases has been changed – now multiple isotopes (or species) can be considered within one case. Additionally the graphical user interface has been improved as operating on one screen one can easily fast move between all the time steps and switch which models should be taken into ensemble and how this ensemble is to be defined (by maximum value or the mean). The user can also store graphical results in his personal folder for later use. Some simple configuration of the colour palette related to the user defined scale is possible as well. This configuration can be saved as default setting.

As mentioned earlier, model predictions are submitted with time resolution of three hours and results of that kind shown hereafter for intermediate time intervals between release start and +60h can also be produced.

<u>October 4th, ^{131}I release, 4.00:</u>

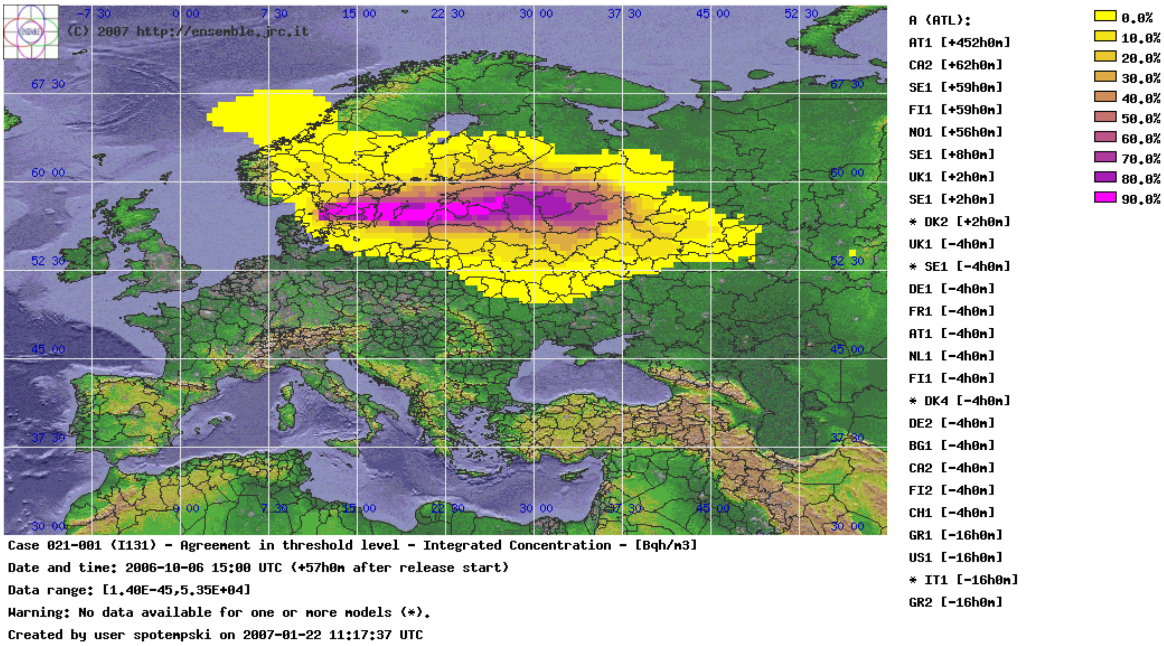

Fig. 6 ATL plot. Forecast for TIC 59h after ^{131}I release of 4.00. . Threshold= 0.1 Bqh/m^3

Figure 6 shows the Agreement in Threshold Level obtained with 22 model predictions. The model results differ for the weather forecast used (produced before or after the release date and time).

The threshold level used for time-integrated concentration is 0.01 Bqh/m^3. The picture relates to the situation 59h after the beginning of the release. The concentration has become lower at long range therefore a low threshold value allows identifying the spatial coverage of the cloud as produced by all models and the agreement level among them. From the figure one can see that a large area of agreement (coloured in magenta) can be identified and that the plume extends from west part of the Baltic Sea directly towards east. The yellow area shows the domain of disagreement among the models caused by typical variations of the results of numerical weather prediction systems used.

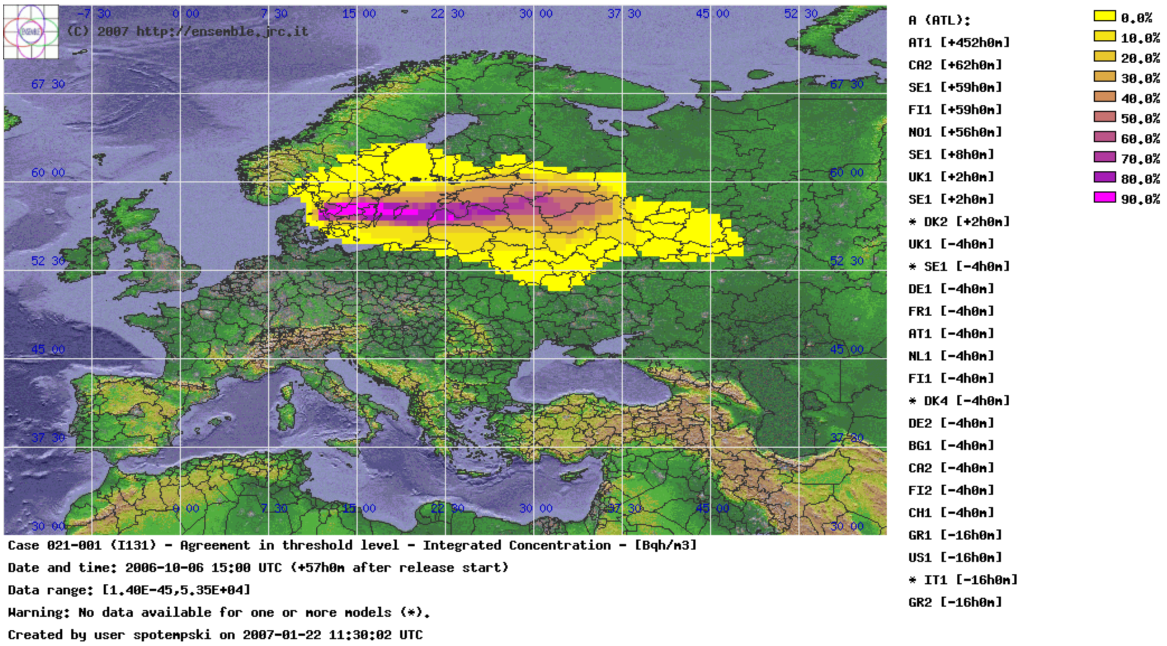

Figure 7. ATL plot. Forecast for TIC 59h after ^{131}I release of 4.00. Threshold= 1 Bqh/m^3

On the Fig. 7 the same plot is shown for the threshold 1 Bqh/m^3. From both pictures one can observe relatively small area of low or even medium agreement (colours between yellow and magenta). This indicates that generally there is a good agreement in the main direction of the cloud transport and higher uncertainties observed are related rather to low time-integrated concentration values. This is probably caused by stable weather conditions, hence no particular hot-spots can be expected.

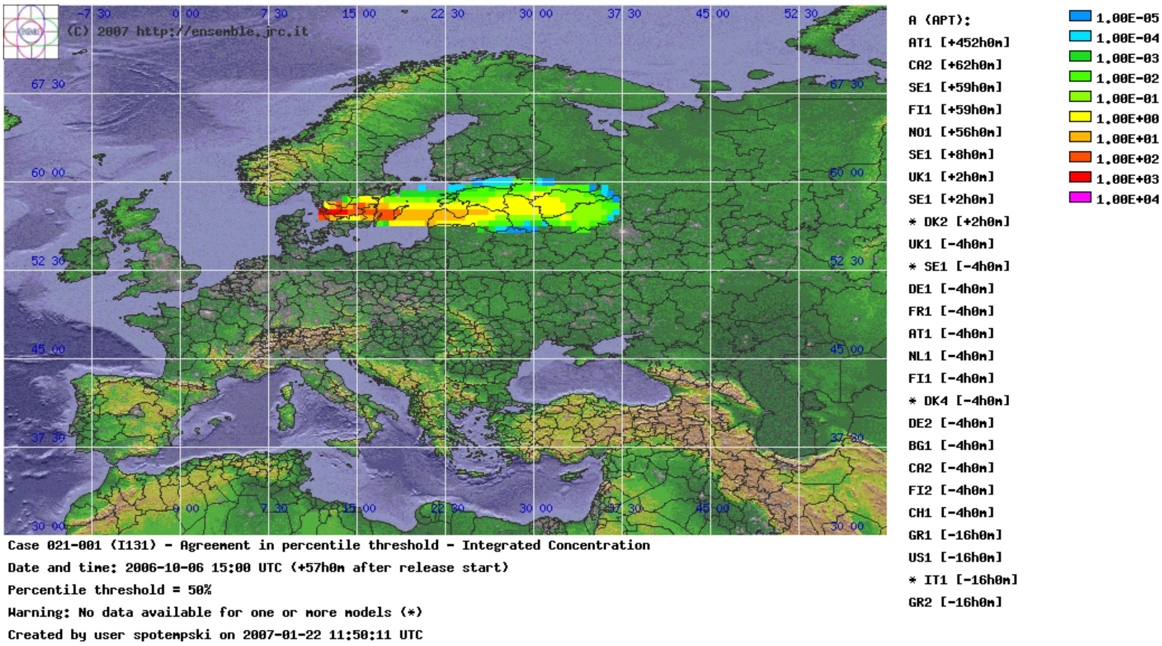

Figure 8. APL plot. Forecast for TIC 59h after ^{131}I release of 4.00; 50th percentile

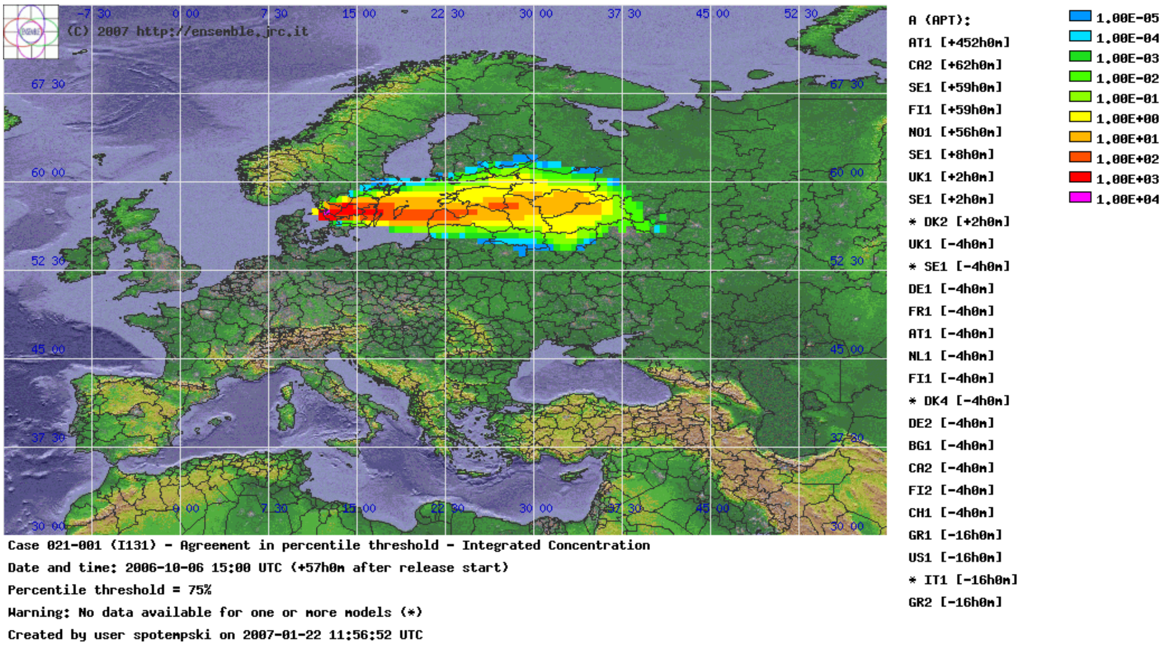

Figure 9. APL plot. Forecast for TIC 59h after ^{131}I release of 4.00; 75th percentile

Figures 8 and 9 give the agreement in percentile threshold calculated with 50 and 75 has percentile value respectively of 22 model predictions distribution 59 h after release. From the plots one can determine the actual levels of time integrated concentration predicted respectively by 50 and 75% of the models. By combining these results with the ones shown on Figure 6 and 7 one has a strong indication on forecasts reliability and severity of the forecasted scenarios.

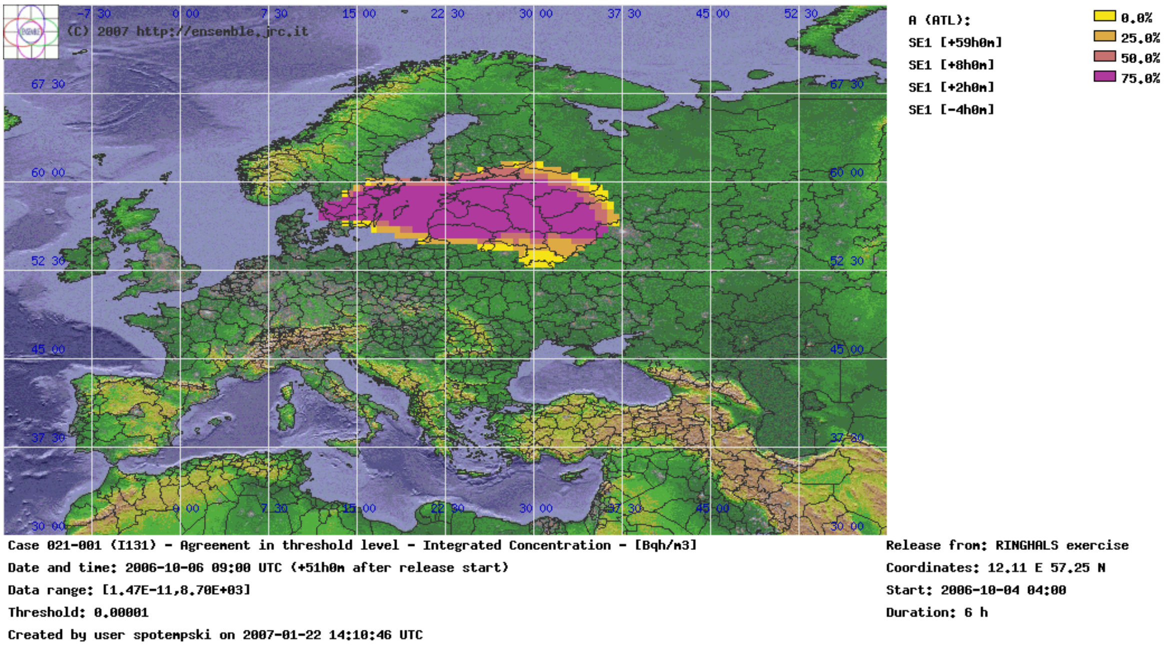

Figure 10. ATL plot. Forecast for TIC 53h after ^{131}I release of 4.00; Threshold=1.e-05 Bqh/m^3, one model, updated numerical weather forecast

In order to verify the impact of meteorological forecasts on the dispersion for one model on Fig. 10 shown is agreement on the level threshold=1.0e-05 1 Bqh/m^3 for simulations based on updated meteorological fields. One can easily found that this impact was small, which was caused by very stable weather conditions.

On Fig. 11 a similar plot is presented but with the models using similar source of weather numerical prediction system. Dispersion of the result is, of course, bigger than the one shown on Fig. 10, but still agreement of the results is high.

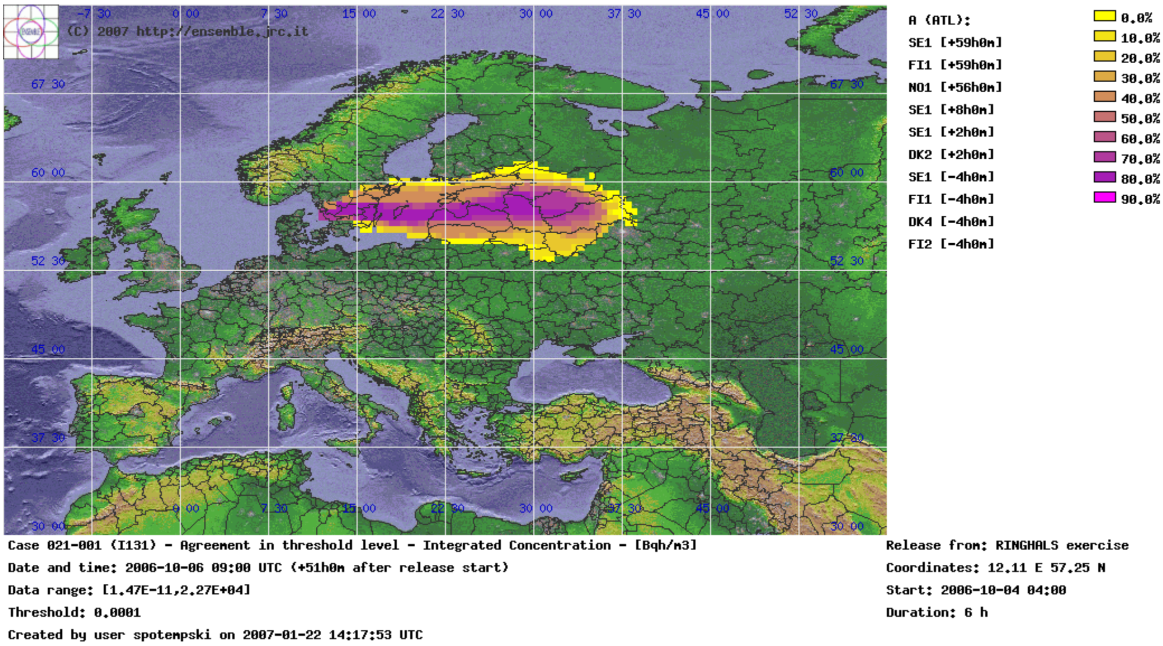

Figure 11. ATL plot. Forecast for TIC 53h after ^{131}I release of 4.00; Threshold=1.e-05 Bqh/m^3, different models, same source of weather prediction system

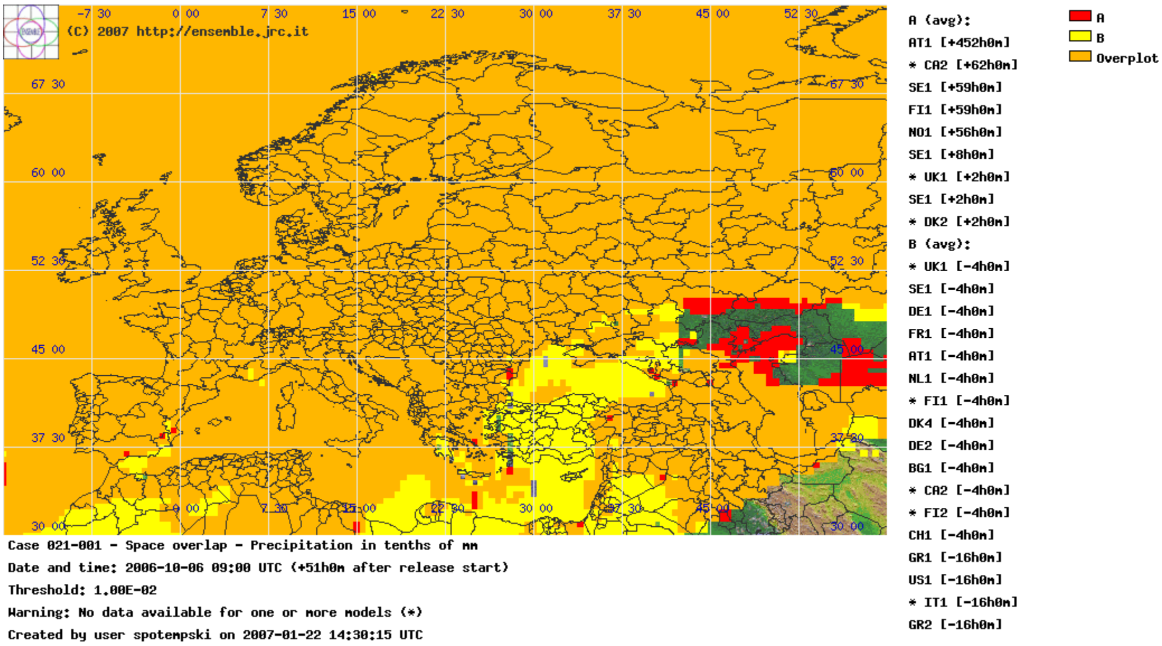

Figure 12. Space overlap for precipitation. Forecast for TIC 53h after ^{131}I release of 4.00; Threshold=1.e-02 mm

On Fig. 12 space overlap on precipitation is shown: weather forecast based on analyses before the start of release (ensemble A) against weather forecast based on analyses after the start of release (ensemble B). The agreement is very good (orange area), in particular for the area with passing cloud.

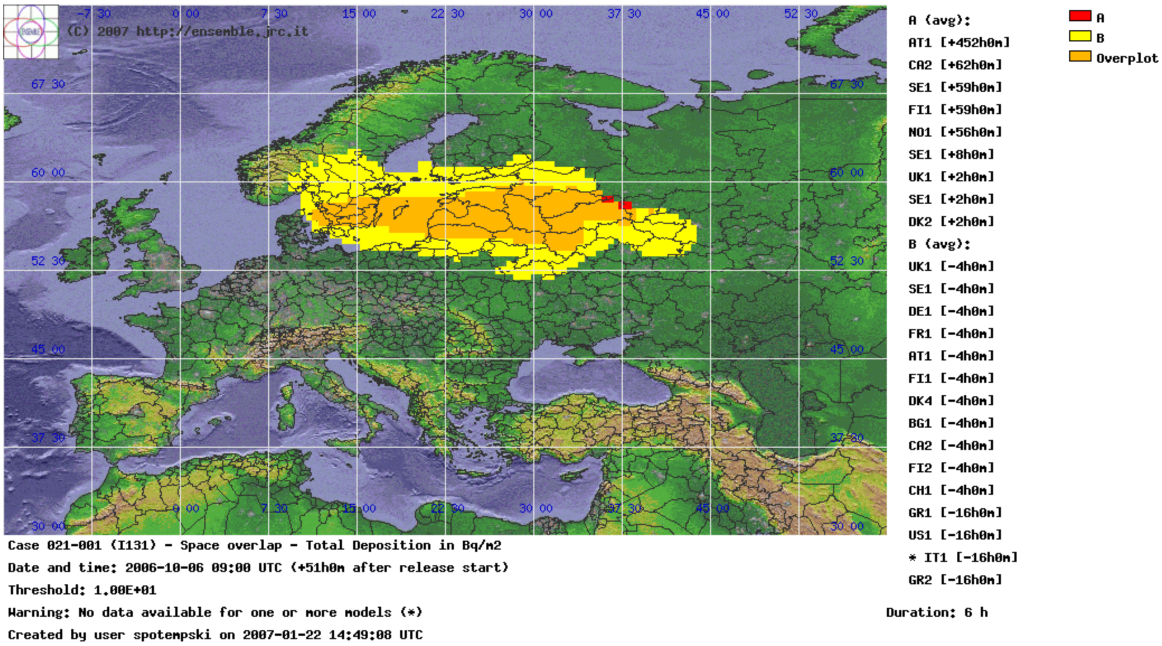

Figure 13. Space overlap for total deposition. Forecast for TIC 53h after ^{131}I release of 4.00; Threshold=10 Bq

Then on Fig. 13 space overlap for total deposition is presented using the same ensembles. One can observe that models using weather forecasts available after the start of the release predict wider dispersion than models using weather forecast based on the earlier analyses.

<u>October 4th, release of ^{131}I, ^{137}Cs, ^{90}Sr at 11.30:</u>

On Fig. 14 space overlap for time integrated concentration is presented with two ensembles: A – based on weather forecast produced before the time of release and B – based on later weather forecasts. On this picture one can see that the results of dispersion models using newer meteorological prognoses are less spread than the ones using earlier forecasts. This suggests that meteorological conditions became more stable and in consequence the uncertainty of the results was smaller.

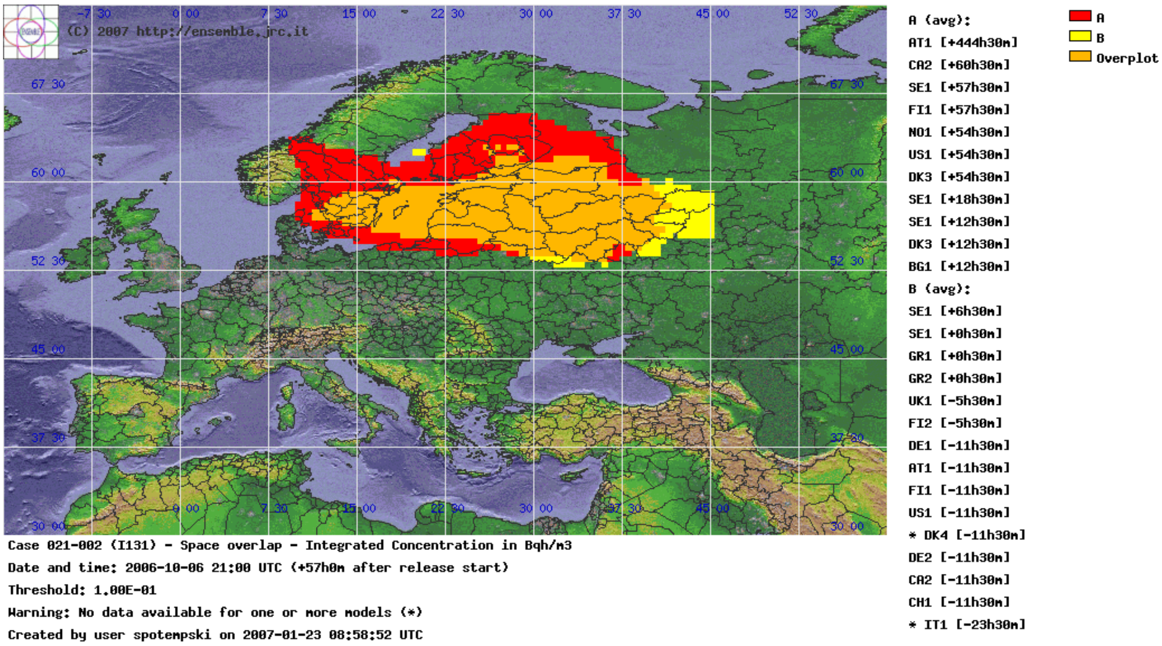

Figure 14. Space overlap for TIC. Forecast for TIC 57h after ^{131}I release of 11.30; Threshold=0.1 Bqh/m^3

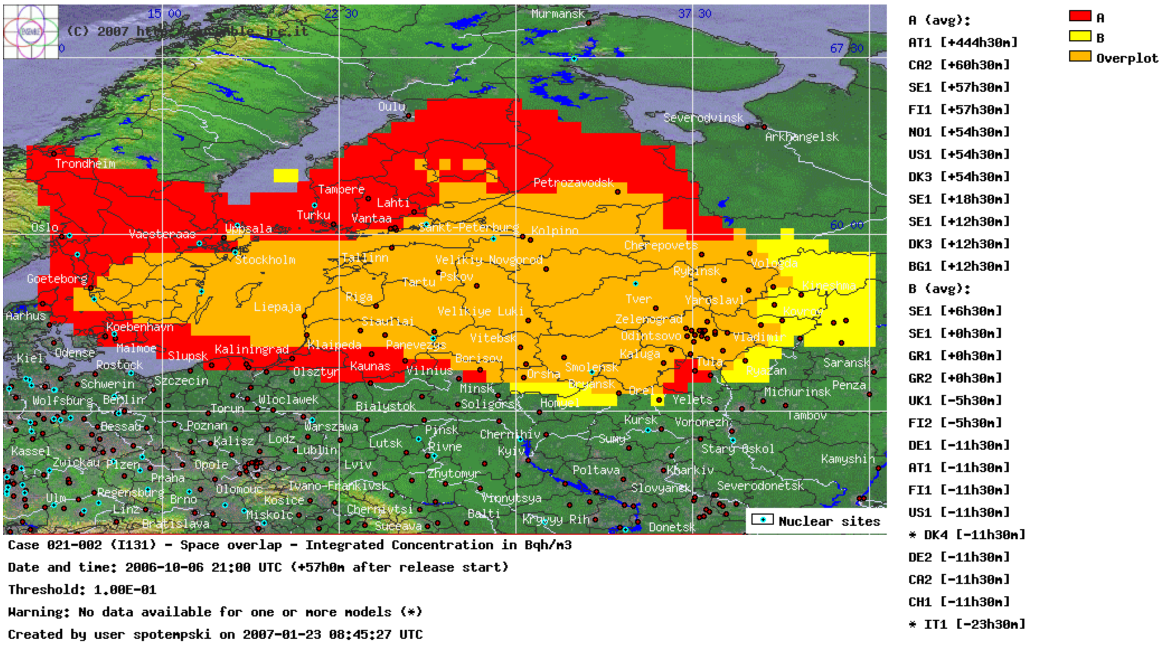

Figure 15. Space overlap for TIC. Forecast for TIC 57h after ^{131}I release of 11.30; Threshold=0.1 Bqh/m^3 – zoomed picture, all the layers included

To illustrate new features of the presentation of the results available in Ensemble version 2 system on Fig. 15, the same picture is shown but zoomed and with additional layer included (major rivers and lakes, cities and nuclear sites). In contrast with the previous version the current system uses numerical digital maps with geographical database and in consequence some operations on the maps like zooming or panning are possible as mentioned earlier.

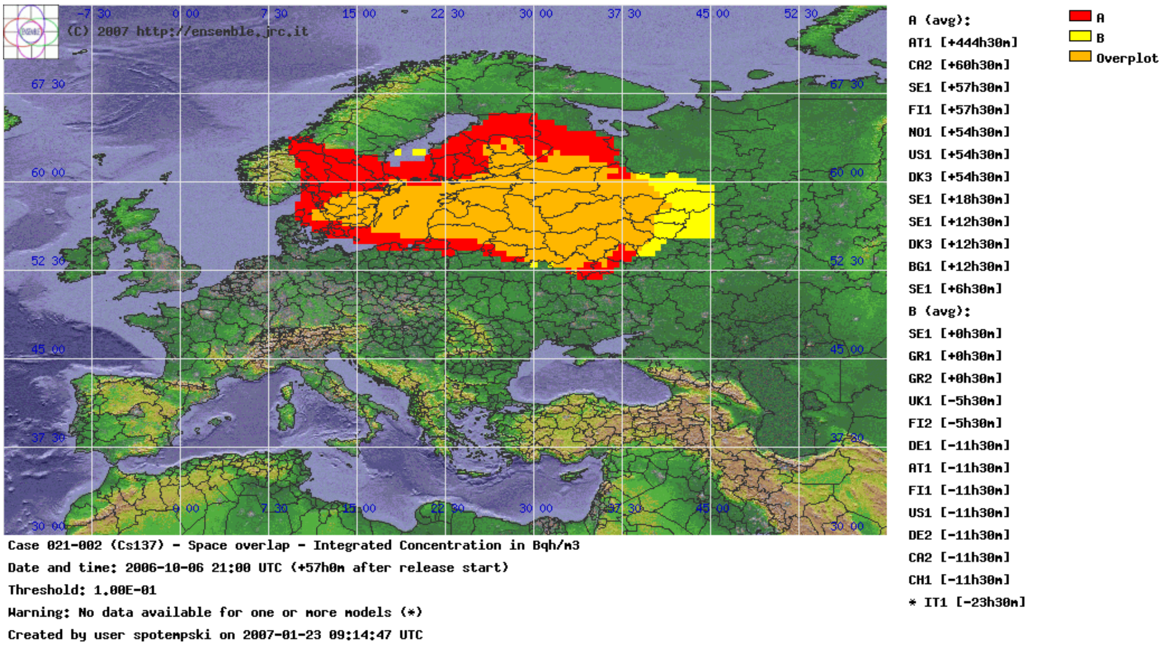

Figure 16. Space overlap for TIC. Forecast for TIC 57h after ^{137}Cs release of 11.30; Threshold=0.1 Bqh/m^3

Fig. 16 shows space overlap of time integrated concentration for caesium and is practically the same as for iodine (Fig. 14).

Another type of possible presentation of the results is shown on Fig. 17, where time evolution of dry deposition for ^{90}Sr is plotted. Two ensembles are visualized: A – only Scandinavian models, which use the same weather forecast system (red), B – non Scandinavian ones (blue). Only small differences can be noted as the values of B ensemble in hours 14 to 17 can be practically considered as zero. It is interesting, that such very good agreement can be observed in later hours.

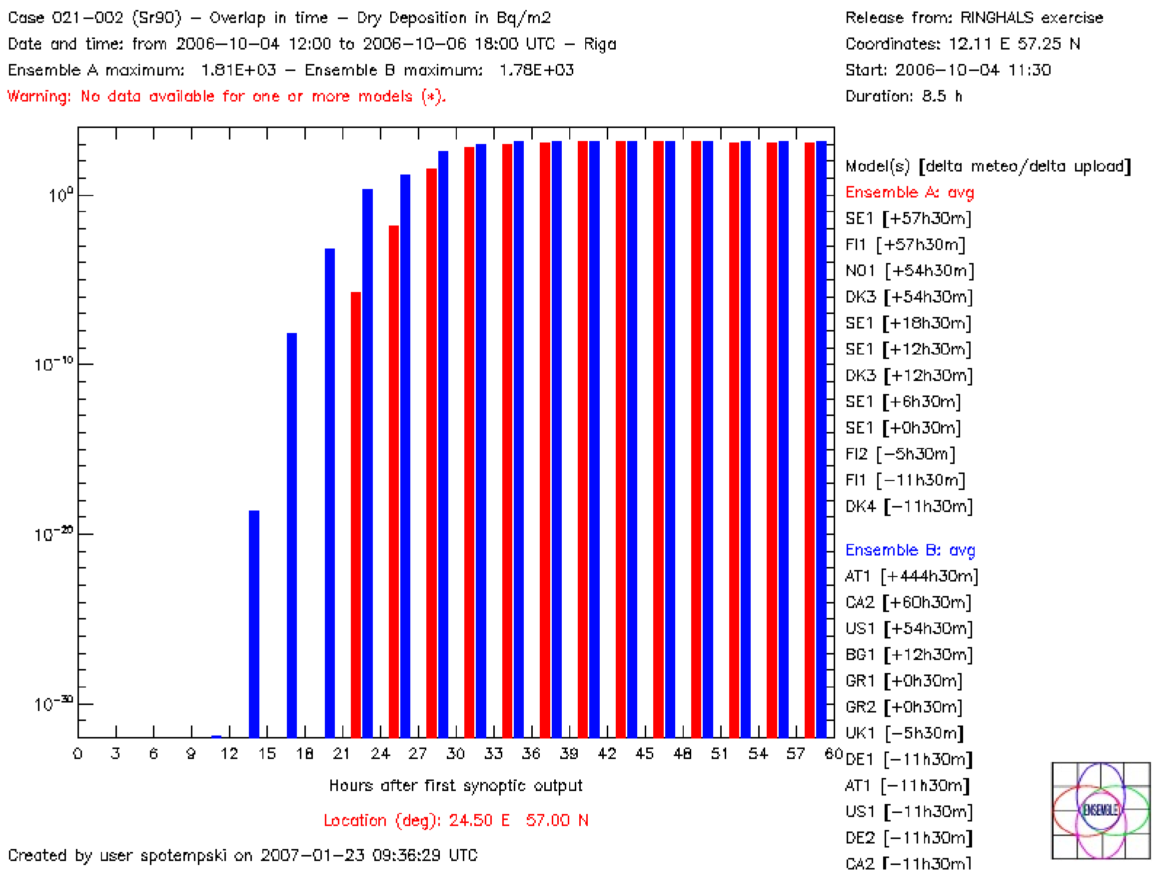

Figure 17: Time series of dry deposition of ^{90}Sr calculated for Riga. Results from two ensembles: Ensemble A average of Scandinavian model; Ensemble B average of non Scandinavian model results.

The other possible results are concentrations on five vertical levels: 0m, 200m, 500m, 13000m and 3000m. On Fig. 18 grid plot of caesium concentration is displayed on the ground level. Having marked “Query” option by clicking on the map one can get the actual values for a chosen point of interest. In Table 4 such concentrations on different vertical levels for Riga localization are collected for the time 30 hours after the release. From the table one can observe that except of few values the differences are typically of factor 2. It can be also seen that most of the radioactive material is at the heights below one thousand meters.

Similar operations can be made for other variables. Of course grid plots can be produced for individual models as well (for example Fig. 19).

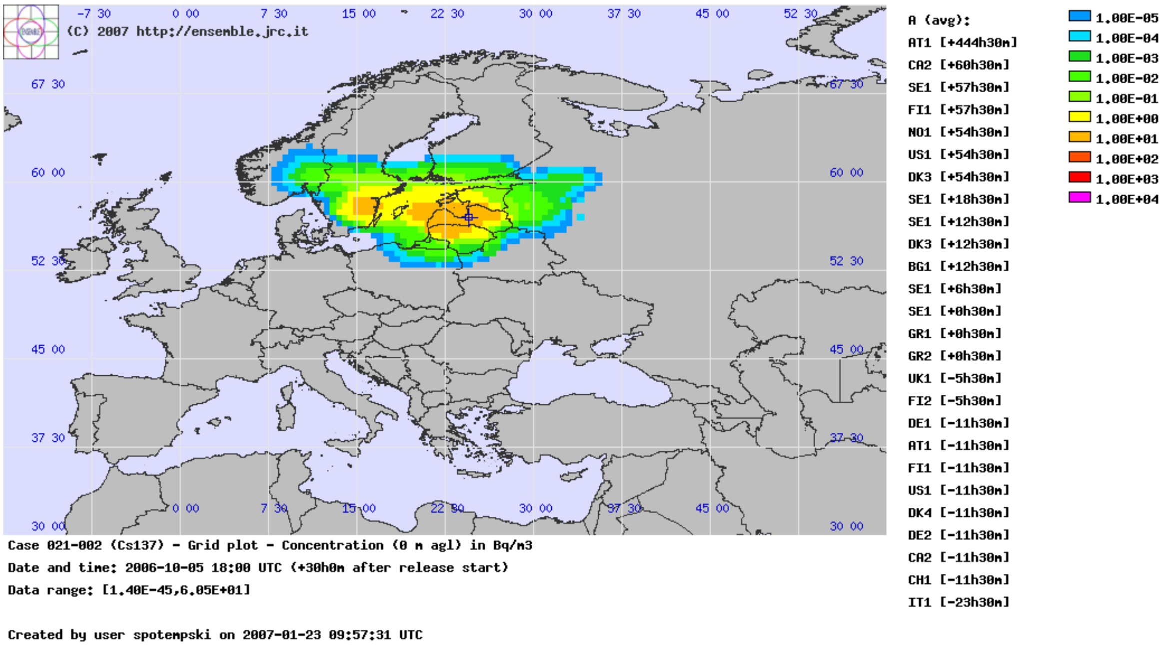

Figure 18: Concentration on level 0m of ^{137}Cs, 30 hours after release: average over all the models.

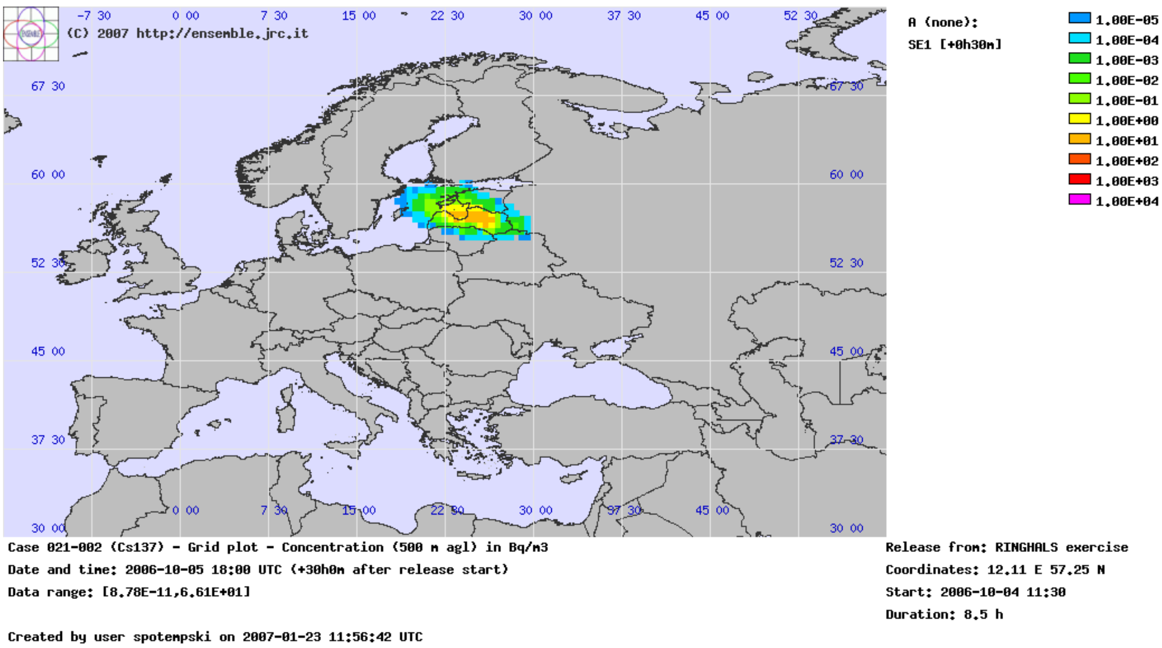

Figure 19: Concentration on level 500m of ^{137}Cs, 30 hours after release - one model result.

Location: 57.0 N,24.5 E	0 m	200 m	500 m	1300 m	3000 m
Average	5.140e+01	5.005e+01	5.169e+01	2.196e+01	4.215e+00
AT1 [+444h30m]	2.375e+01	4.521e+01	8.083e+01	5.841e+01	0.000e+00
CA2 [+60h30m]	5.122e+01	5.748e+01	6.001e+01	1.261e+01	0.000e+00
SE1 [+57h30m]	1.904e+00	1.425e+00	5.235e+00	6.173e-01	0.000e+00
FI1 [+57h30m]	4.808e+01	5.649e+01	7.712e+01	4.967e+01	9.271e-01
NO1 [+54h30m]	1.401e+02	1.742e+02	1.387e+02	8.494e+01	3.365e+00
US1 [+54h30m]	1.049e+02	7.846e+01	1.044e+02	5.498e+01	0.000e+00
DK3 [+54h30m]	7.774e+01	8.330e+01	4.200e+01	1.060e+01	3.749e-05
SE1 [+18h30m]	6.003e+00	6.145e+00	1.671e+01	3.290e+00	0.000e+00
SE1 [+12h30m]	9.319e+00	7.070e+00	1.119e+01	1.521e+00	0.000e+00
DK3 [+12h30m]	5.877e+01	6.064e+01	5.663e+01	2.298e+00	2.206e-08
BG1 [+12h30m]	1.449e+01	2.135e+01	2.528e+01	3.302e+00	1.419e-04
SE1 [+6h30m]	2.735e+01	1.081e+01	6.316e+00	2.573e-01	0.000e+00
SE1 [+0h30m]	3.735e+01	1.844e+01	1.220e+01	1.423e-01	0.000e+00
GR1 [+0h30m]	5.463e+01	5.457e+01	5.426e+01	5.217e+01	4.300e+01
GR2 [+0h30m]	2.016e-02	2.015e-02	2.013e-02	1.997e-02	1.914e-02
UK1 [-5h30m]	5.087e+01	8.422e+01	5.237e+01	1.182e+00	0.000e+00
FI2 [-5h30m]	1.472e+02	7.700e+01	5.219e+01	2.938e+01	5.910e-01
DE1 [-11h30m]	6.623e+00	5.347e+00	1.295e+00	1.366e+01	1.846e+00
AT1 [-11h30m]	0.000e+00	0.000e+00	0.000e+00	0.000e+00	0.000e+00
FI1 [-11h30m]	7.498e+01	7.941e+01	1.009e+02	4.172e+01	2.406e-01
US1 [-11h30m]	3.926e+01	3.790e+01	4.161e+01	3.860e+01	5.415e-01
DK4 [-11h30m]	0.000e+00	0.000e+00	0.000e+00	0.000e+00	0.000e+00
DE2 [-11h30m]	1.522e+02	1.352e+02	1.882e+02	1.558e+01	5.320e-02
CA2 [-11h30m]	3.974e+00	6.416e+00	9.660e+00	8.144e+00	0.000e+00

Table 43 Concentration of ^{137}Cs on vertical levels (30 hours after release)

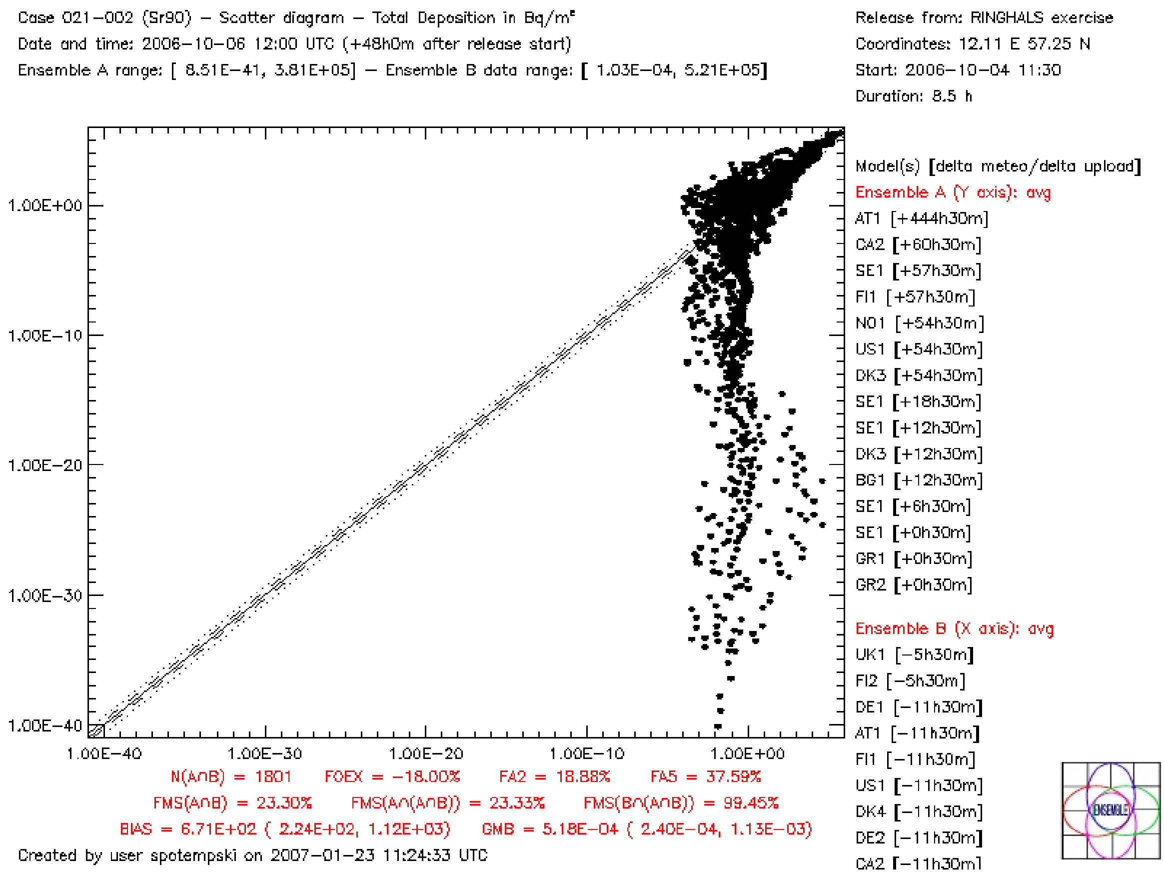

Figure 20: Scatter diagram of total deposition for ^{90}Sr, 48 hours after release.

Yet another type of results – a scatter diagram is presented on Fig. 20. Two ensemble datasets are compared: A – model results based on weather forecasts prior to the release, B – model results based on weather forecasts posterior to the release. Except of very small values given by ensemble A (10^{-40} to 10^{-5} Bq/m^2) the distribution of values is rather well balanced. This can be easily observed after changing the lower limit to 10^{-5} Bq/m^2 (Fig. 21). On the other hand it also means that at some grid points ensemble B gives values about 1 Bq/m^2, while ensemble A gives practically zero. This is consistent with space overlap shown on Fig. 14.

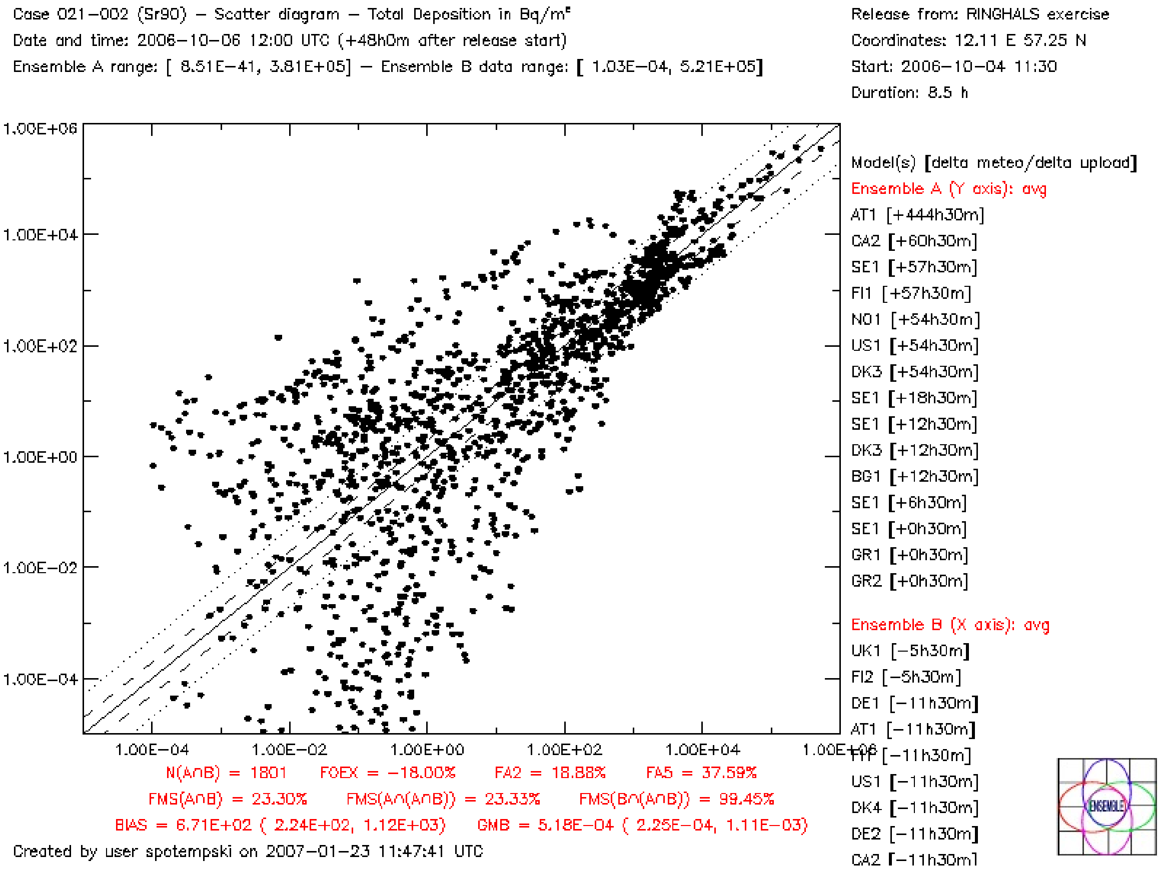

Figure 21: Scatter diagram of total deposition for ^{90}Sr, 48 hours after release, lower limit 1.0e-5 Bq/m^2.

6. Conclusions

This report summarizes the ENSEMBLE contribution to the ECURIE Level 3 international emergency response exercise held on 4th October 2006. According to the agreement made during the ECURIE Competent Authorities meeting the Swedish FALKEN nuclear emergency exercise became the main ECURIE exercise. The ENSEMBLE community took part to the exercise by providing long range atmospheric transport and dispersion predictions during the exercise for two cases: the hypothetical and the actual release. It was the first usage of the new version 2 of the system during international exercise. The ENSEMBLE activities were coordinated by the Joint Research Centre in Ispra from which the release notifications and the information on the release specifications were distributed to the community of 22 Institutions that are part of the ENSEMBLE network. For the cases appropriate scenarios were simulated: dispersions of only ^{131}I (first case), and of ^{131}I, ^{90}Sr, ^{137}Cs (second case). The model predictions produced by the ENSEMBLE network which are normally accessible only to the ENSEMBLE network, were made public to the wider emergency response community taking part to the exercise by means of a dedicated web site whose address was distributed by means of an official ECURIE notification. The web site contained ensemble analysis of all model results submitted in real time after the notification and was continuously updated through out the exercise. The results of model predictions, in spite of being produced by independent models using also independent weather forecasts, were very much consistent with each other and provided a coherent picture on the evolution of the dispersion. The treatment of the model results by means of the ENSEMBLE parameters and indicators proved a good assessment of the forecasts homogeneity and consistency as well as of its high reliability level.

The new version of the ENSEMBLE system was applied during the exercise. The most important features of this version appreciated by the users are:

- presentation of the model predictions on numerical maps, allowing for typical operations like zooming or selection of layers to be displayed,
- in comparison with the previous version there is more flexible organisation of the visualization of the results,
- information on source term is sent to the user in a unified form (in principle allowing for the automation of the simulation process),
- within one case several subcases can be included for example for different isotopes or with different characteristics of source term.

It should be also added that for public web page the results of the model predictions were presented in an animated form, which was nicely welcome by the participants of the exercise.

During the emergency the ENSEMBLE results will be typically accessed by institutions in charge of atmospheric dispersion predictions as well as by radiation protections institutions that act as advisors to decision makers. As it was the very first application of the new ENSEMBLE system during an international event, more exercises should be organized to get a necessary feed back from the users for further improvement of the ENSEMBLE system and its products. Nevertheless migration from the version 1 to version 2 of the system was smooth and an essential progress of the improvement of the ensemble methodology can be observed.

REFERENCES

ECURIE Level 3 Exercise, Management Summary Report

Galmarini S., R. Bianconi, W. Klug, T. Mikkelsen, R. Addis, S. Andronopoulos, P. Astrup, A. Baklanov, J. Bartniki, J. C. Bartzis, R. Bellasio, F. Bompay, R. Buckley, M. Bouzom, H. Champion, R. D'Amours, E. Davakis, H. Eleveld, G. T. Geertsema, H. Glaab, M. Kollax, M. Ilvonen, A. Manning, U. Pechinger, C. Persson, E. Polreich, S. Potemski, M. Prodanova, J. Saltbones, H. Slaper, M. A. Sofiev, D. Syrakov, J. H. Sørensen, L. Van der Auwera, I. Valkama, R. Zelazny, 2004a, Ensemble dispersion forecasting, Part 1: Concept, approach and indicators, *Atmos. Environ.*, **38**, 28, 4607-4617

Galmarini S., R. Bianconi, R.Addis, S. Andronopoulos, P. Astrup, J. C. Bartzis, R. Bellasio, R. Buckley, H. Champion, M. Chino, R. D'Amours, E. Davakis, H. Eleveld, H. Glaab, A. Manning, T. Mikkelsen, U. Pechinger, E. Polreich, M. Prodanova, H. Slaper, D. Syrakov, H. Terada, L. Van der Auwera 2004b Ensemble dispersion forecasting, Part II: Application and evaluation, *Atmos. Environ.*, **38**, 28, 4619-4632

Galmarini S., R. Bianconi, R. Bellasio, G.Graziani, Forecasting consequences of accidental releases from ensemble dispersion modelling. *Journal of Environmental Radioactivity*, 57, 203-219, 2001

Galmarini S., R. Bianconi, W. Klug, T. Mikkelsen, R. Addis, S. Andronopoulos, P. Astrup, A. Baklanov, J. Bartniki, J. C. Bartzis, R. Bellasio, F. Bompay, R. Buckley, M. Bouzom, H. Champion, R. D'Amours, E. Davakis, H. Eleveld, G. T. Geertsema, H. Glaab, M. Kollax, M. Ilvonen, A. Manning, U. Pechinger, C. Persson, E. Polreich, S. Potemski, M. Prodanova, J. Saltbones, H. Slaper, M. A. Sofiev, D. Syrakov, J. H. Sørensen, L. Van der Auwera, I. Valkama, R. Zelazny, 2004c: Can the Confidence in Long Range Atmospheric Transport Models be increased? The Pan European experience of *ENSEMBLE, Radiation Protection Dosimetry*, **109**, 1-2, 19-24

APPENDIX

Below the Institutions that constitute the ENSEMBLE network and that take part to the ENSEMBLE activities:

- Agenzia per la protezione dell'ambiente e servizi tecnici (IT)
- Austrian Meteorological and Geophysical Office (AT)
- Bulgarian Hydrometeorological Institute (BG)
- Danish Meteorological Institute (DK)
- Environment Canada (CA)
- Finnish Meteorological Institute (FI)
- German Weather Service (DE)
- Greece National Research Centre "Demokritos" (GR)
- Meteo-France (FR)
- Meteorological Office (UK)
- National Institute of Public Health and Environmental Protection (NL)
- National Institute for Physics and Nuclear Engineering (RO)
- Norwegian Meteorological Institute (NO)
- Polish Atomic Energy Institute (PL)
- Risø National Laboratory (DK)
- Royal Meteorological Institute Belgium (BE)
- Royal Netherlands Meteorological Institute (NL)
- Savannah River Site (USA)
- Swedish Meteorological and Hydrological Institute (SE)
- VUJE Trnava, Inc. (SK)

European Commission

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Abstract

The ENSEMBLE activity is a part of the Joint Research Centre institutional support activity to DG-TREN. It consists of a network of 22 institutions operating 24 long range atmospheric transport and dispersion models, which differ in terms of concept and numerical code and make use of various numerical weather forecasts. The model predictions produced by these institutions are collected on the ENSEMBLE system located at Joint Research Centre in Ispra. A web facility allows the remote users to consultant in real-time and independently the model results present on the system. The report is devoted to the first application of the new version of the ENSEMBLE system in an international event – the ECURIE exercise. It contains the description of the simulation results provided during the exercise with particular emphasis on the new features of the ENSEMBLE system. The model predictions were presented on dedicated, specially established web site for the ECURIE Competent Authorities.

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