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On application of the “hot-run” version of the ENSEMBLE system to the ECURIE Level 3

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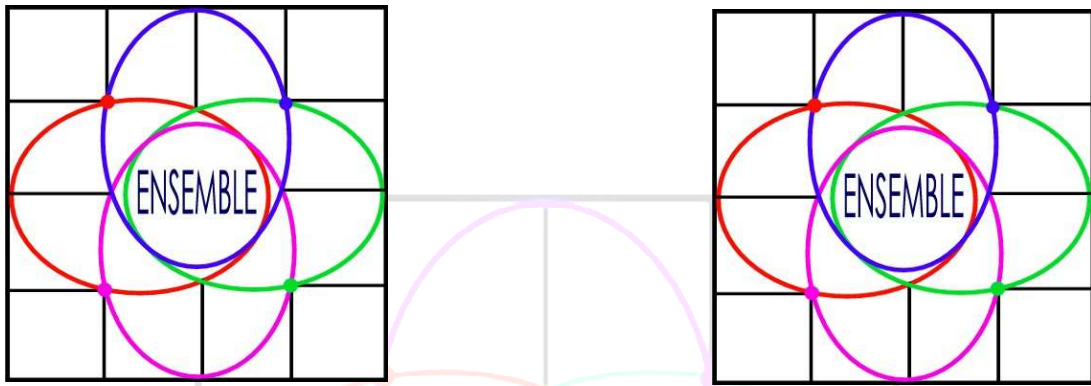
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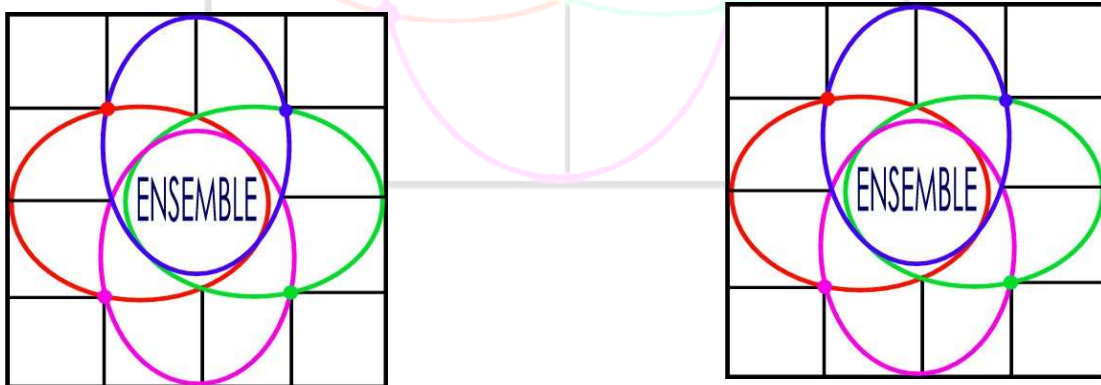
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Institute for Environment and Sustainability

2008

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INTRODUCTION

The ENSEMBLE system has been created with the primary aim of harmonizing the information coming from the various countries and to work out a reconciled European long range atmospheric dispersion ensemble forecast. The concept of multi-model ensemble dispersion forecast consists of the qualitative and quantitative analysis of the results produced by several modeling tools on the same case, to produce a composite picture that includes all contributions from the various simulations. This analysis has the advantage of taking into account all possible forecasted scenarios and to determine the level of consensus among the various modeling tools. Within ENSEMBLE the differences in atmospheric dispersion prediction become an asset as they are used to determine the forecast reliability.

Recently the ENSEMBLE system has been linked to the European radiological database (EURDEP) and the early warning information exchange system (ECURIE). The first one is a common European platform for the real time exchange of real time monitoring data on gamma dose and it includes more than 4000 individual sampling points distributed on the European territory and western Russia. In particular the coupling of EURDEP with ENSEMBLE enables real time model validation. ECURIE is the official European alert system in case of nuclear emergencies. The information produced by ECURIE provides a first hand mean for a prompt alert of the ENSEMBLE modeling community. All the information relevant to atmospheric modeling can be filtered and delivered to the modeling community through the ENSEMBLE web interface.

On 12th December 2007 an ECURIE Level 3 exercise was organized. The ENSEMBLE was activated to perform assessment of the situation after hypothetical release. This report gives details on the contribution of ENSEMBLE to ECURIE exercise with particular emphasis on the so called “hot-run” version of the ENSEMBLE system. 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 “hot-run” version of the system for presenting the results of the simulations performed during the

exercise; in Section 4 a summary is provided on the ENSEMBLE community response to the notification and on the dispersion forecasts produced during the exercise; in Section 5 few additional results are presented available in the system and finally the conclusions are included in Section 6.

1. ORGANISATION OF THE EXERCISE AND ACTIVATION OF THE ENSEMBLE SYSTEM

The exercise was organized by the TREN H.4 Luxembourg jointly with Irish authorities. According to normal procedures notification was sent to EC (ECURIE arrangements). The total number of ECURIE messages was about 20; their information content limited, but nevertheless sufficient to satisfy Council Decision 87/600/Euratom requirements at an early stage of the emergency. During the exercise all the messages were sent via CoDecS network.

The TREN H.4 emergency team collected the incoming information and used the available emergency tools 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. The internal system of the EU ARGUS (Rapid alert and crisis management system) was used during the exercise for exchanging messages between different organizations involved in the exercise. All the messages from ECURIE system were also directed to ARGUS.

2. THE SCENARIO OF THE EXERCISE

According to the information received via ECURIE system the release happened at 3.00 on 12th December 2007 due to the fire on submarine ship. No detailed data on source term was sent to the ECURIE system however there was information from the EURDEP system that the increased gamma dose rates were observed at few Irish measurement stations located at the west coast (Rosslare, Clonshagh, Killough and later on Dundalk).

In the new version of the ENSEMBLE system it is possible to use an automatic connection between ECURIE and ENSEMBLE systems enabling:

- receive the ECURIE messages in ENSEMBLE,
- parse the content of the messages to identify relevant information for modeling,
- create a new case or an additional case within a new or existing sequence on ENSEMBLE,
- notify the event and transfer the source term to ENSEMBLE users.

In principle the following information relevant for the ENSEMBLE system can be extracted from the ECURIE message:

- Whether it is a release notification or release info update
- Release starting time
- Release ending time (optional)
- Release composition and rates (optional)
- Source location
- Source coordinates
- Nature of the accident (optional)

As there was no detailed data on source term only data on the location and the time of the release could be extracted from ECURIE message. Other values had to be defined by the ENSEMBLE administrator resulting in the message shown below (Table 1).

Release Location	CELTIC SEA
Longitude	6.52 W
Latitude	51.93 N
Release Time	2007-12-12 03:00
Release rates [Bq/s]	1.0E+15; 1.0E+15
Release Duration [h]	60 h
Release Height[m]	2 m
Release Type	submarine accident
Nuclides	I-131; Cs-137
Forecast horizon	2007-12-14 15:00

Table 1 Source term (first notification)

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

```

Enform version          $ 1.00
Random key              $ STS9MKX
Sequence number        $ 11
Case number            $ 1
Creation date (UTC)    $ 200712121217
Title                  $ first notification
Location               $ celtic sea
Xsource (deg E or m)  $ -6.5200
Ysource (deg N or m)  $ 51.9300
Release start (UTC)   $ 200712120300
First output (UTC)    $ 200712120600
Time horizon of forecast (UTC) $ 200712141500
Nature of release      $ submarine accident
#
#
Standard domain        $ Y
Coordinates            $ LL
UTM zone               $ 0
Hemisphere            $ N
Xmin (deg E or m)     $ -15.0000
Ymin (deg E or m)     $ 30.0000
Nx                    $ 151
Ny                    $ 91
Dx (deg or m)         $ 0.5000
Dy (deg or m)         $ 0.5000
Vertical levels (m agl) $ 0. 200. 500. 1300. 3000.
#
#
Number of outputs      $ 20
Dt_out, Dt_start, Dt_end (min) $ 180 120 180
#
Number of substances  $ 2
#
Substance              $ CS-137
Code                   $ 01
Release units          $ Bq s-1
Emission periods       $ 1
Start time, End time (UTC) $ 200712120300 200712151500
Emission vertical levels $ 1
Rate, Hmin (m), Hmax (m) $ 1.0000E+15 2. 2.
#
Substance              $ I-131
Code                   $ 02
Release units          $ Bq s-1
Emission periods       $ 1
Start time, End time (UTC) $ 200712120300 200712151500
Emission vertical levels $ 1
Rate, Hmin (m), Hmax (m) $ 1.0000E+15 2. 2.
#
Comments follow        $ N

```

Table 2 Example of notification file

Later on, during the exercise, the source term was corrected by adjusting the release rate (Table 3).

Release Location	CELTIC SEA
Longitude	6.52 W

Latitude	51.93 N
Release Time	2007-12-12 03:00
Release rates [Bq/s]	1.0E+6; 1.0E+6
Release Duration [h]	60 h
Release Height[m]	2 m
Release Type	submarine accident
Nuclides	I-131; Cs-137
Forecast horizon	2007-12-14 15:00

Table 3 Source term (second notification)

The meteorological situation during the exercise was quite stable as there was a high pressure system located centrally in Europe and in consequence the main wind flow at the location of the release was from South direction towards North.

3. THE “HOT-RUN” VERSION OF THE ENSEMBLE

During the years, it has become clear the necessity to provide users with a so-called “hot-run” version of the ENSEMBLE system. A series of needs were in fact identified by users also during other international exercises (Potempski, Galmarini 2007), mainly:

- Need for a quick overview of the current status of a developing situation
- Need for an aggregated view to evince space evolution in time
- Need to reduce time to prepare plots

Also, producing a large set of plots may become a repetitive task when plot parameters are defined. These hot-run features are useful at two different levels: system and user ones.

At system level it is in fact necessary to have available an overview that can be a common reference for all system users, including those that cannot make analyses. At user level it is instead useful for the single users to set specific parameters that may vary due to their different interests.

The following ENSEMBLE elements have been identified for the hot run:

- Variables

- Types of plot
- Models
- Plot levels
- Frequency of representation
- Frequency of regeneration of hot run analysis

The variables that were included in the hot run are:

- Time-integrated concentration [Bqh/m³]
- Surface concentration [Bq/m³]

The types of plots that are generated are:

- Agreement in percentile threshold (APT)
- Agreement in threshold level
- Grid plot

The choice of models is different for the system wide hot-run and the user hot-run. At system level, models are selected according one of the two following criteria:

- Models using the most recent meteorological input
- The predictions of any model based on its most recent meteorological input

At user level the choice is more refined, and users can select what models to include in the analysis, selecting members from the list of models.

The system “hot-run” feature was extensively used by the users during the exercise. The main screen of the Web site containing “hot-run” version of the system is shown on Fig. 1. All the produced results are directly available from this page, so the interface is very easy and fast – there are no embedded additional pages. This is in fact “one click” interface – to get the results desired really one click is needed only.

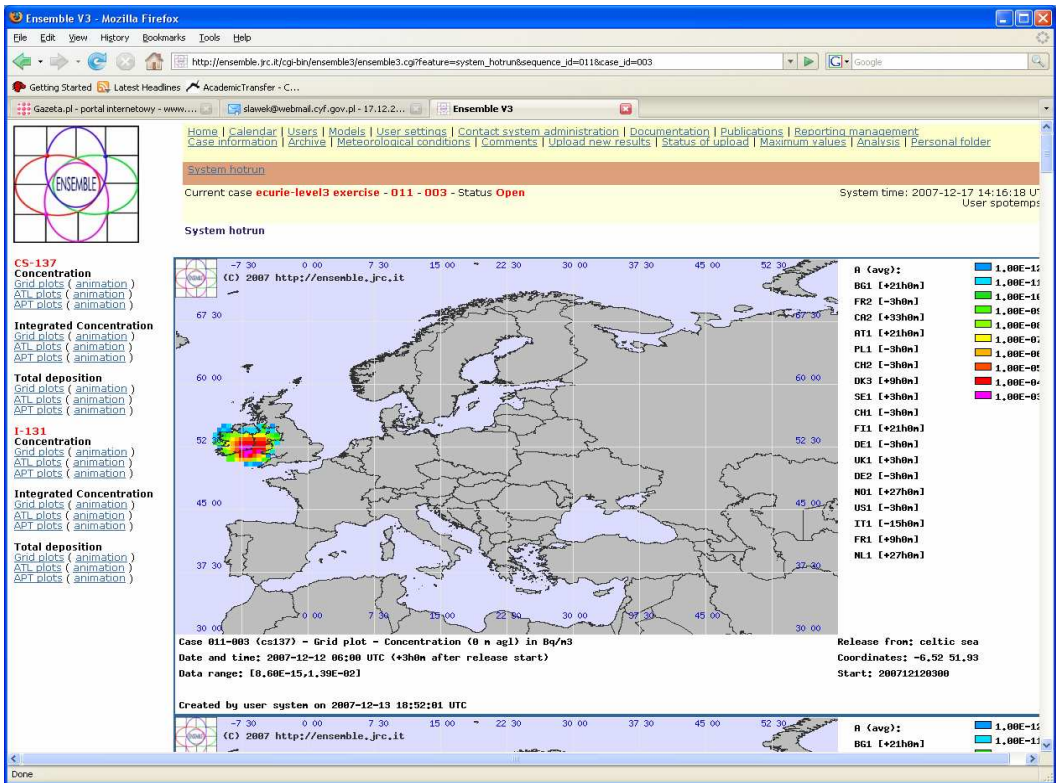


Fig. 1 System hot-run page of Ensemble

On Figs. 2-6 an average concentration of ENSEMBLE simulations for Cs-137 is shown for the following time steps: 12, 24, 36, 48 and 60 hours after the beginning of the case release (for updated source term).

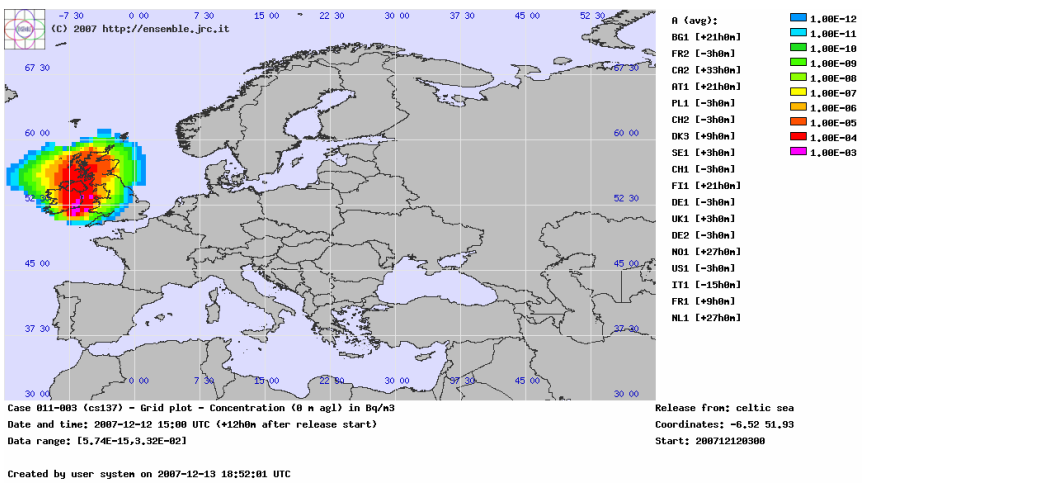


Fig. 2 Concentration field for Cs-137 12 hours after the start of the release

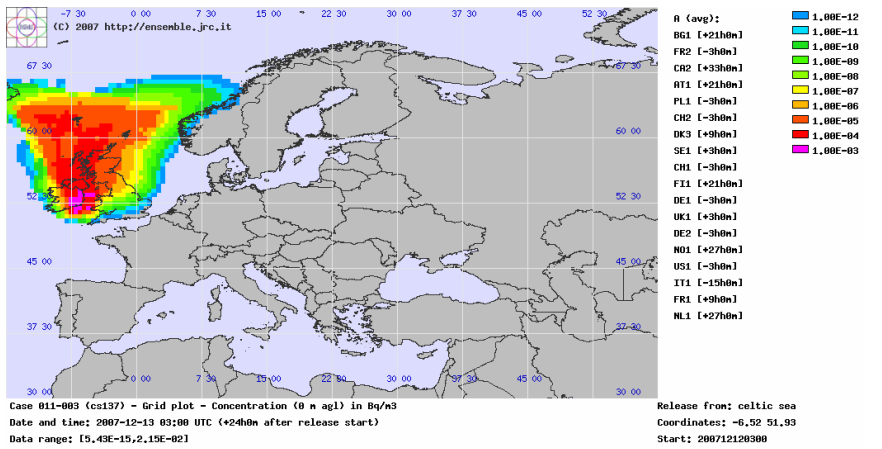


Fig. 3 Concentration field for Cs-137 24 hours after the start of the release

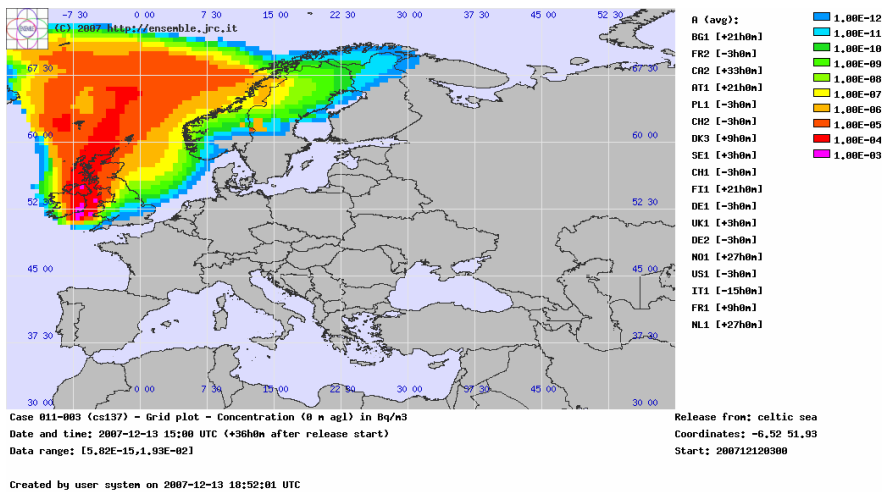


Fig. 4 Concentration field for Cs-137 36 hours after the start of the release

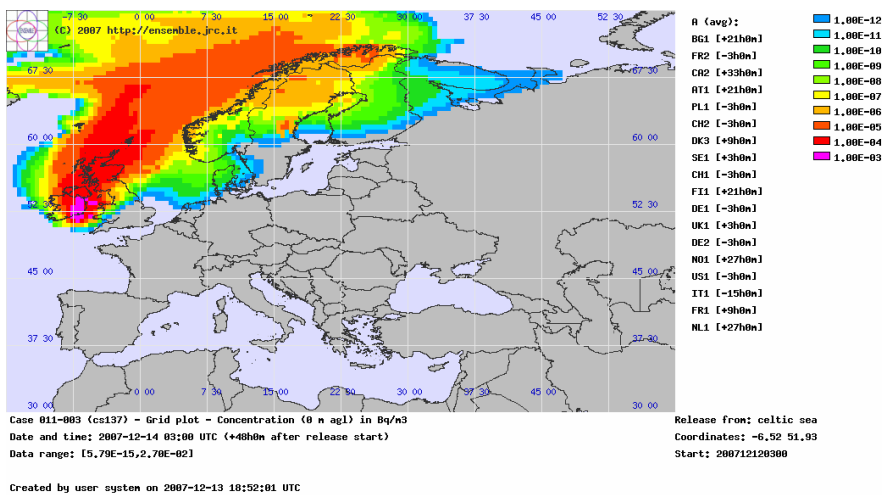


Fig. 5 Concentration field for Cs-137 48 hours after the start of the release

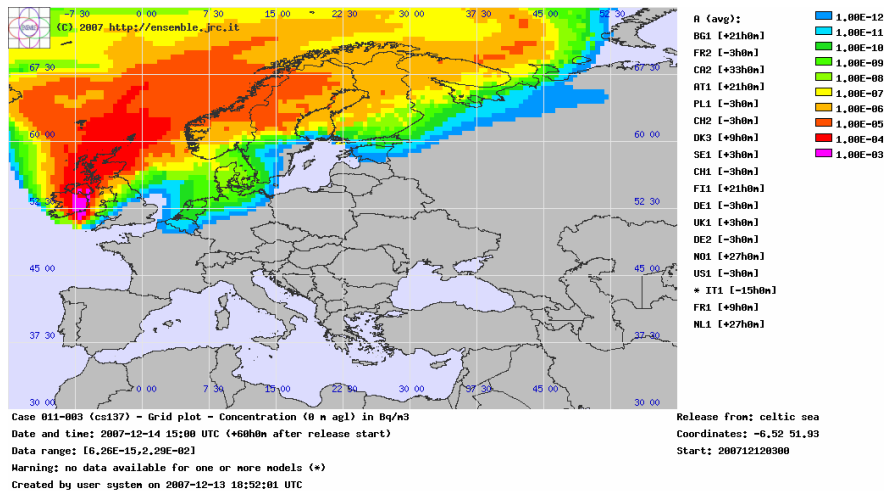


Fig. 6 Concentration field for Cs-137 60 hours after the start of the release

As one can observe with the lapse of time the cloud was becoming wider but still distributed towards North. Starting from 36 hour of the simulation period a part of the cloud was turning along Scandinavia and north regions of Russia. The hot-run version of the ENSEMBLE system automatically produced the maps for following variables:

1. Surface concentration [Bq/m³]
2. Time-integrated concentration [Bqh/m³]
3. Cumulated total deposition (dry + wet) [Bq/m²]

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

1. Grid plot: Given N model predictions for one of the variables above listed the plot shows the average of the N models' predicted values.
2. Agreement in Threshold level (ATL): 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.
3. Agreement in Percentile level (APL): Given N model predictions for one of the variables above listed and a given percentile value (50% in this case) the plot shows the space distribution of the variable corresponding to the percentile value of distribution of the models' predictions. For example for 50% it corresponds to the Median model (i.e. at each point

in space and time this is the value of the field such that half of the models produced the lower and half of them the higher value).

As presented elsewhere (Galmarini et al. 2004a-c) the combined consultation of ATL and APL 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. In this exercise the 50th percentile was used in hot-run version. On Figs. 7-11 APL is shown for time integrated concentration for Cs-137 at hours: 12, 24, 36, 48 and 60 after the beginning of the release.

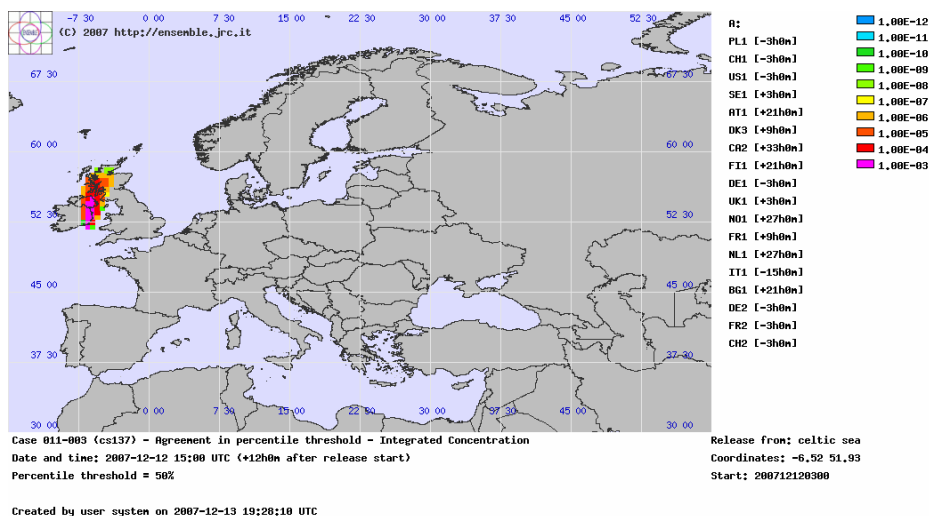


Fig. 7 APL (50%) for time integrated concentration for Cs-137: 12 hour

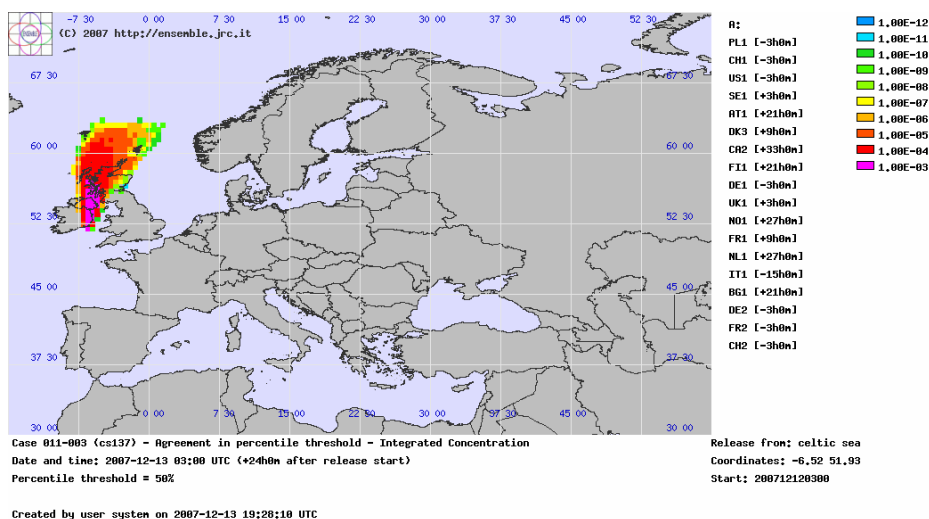


Fig. 8 APL (50%) for time integrated concentration for Cs-137: 24 hour

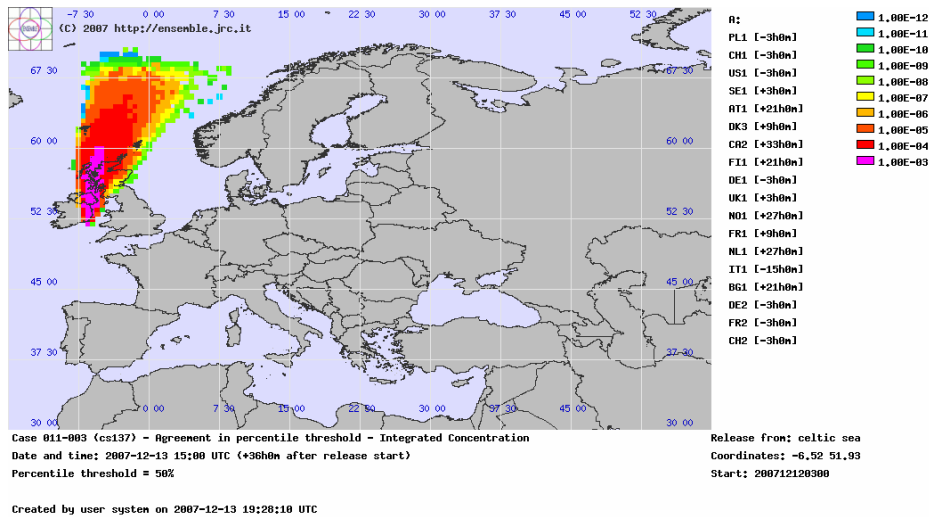


Fig. 9 APL (50%) for time integrated concentration for Cs-137: 36 hour

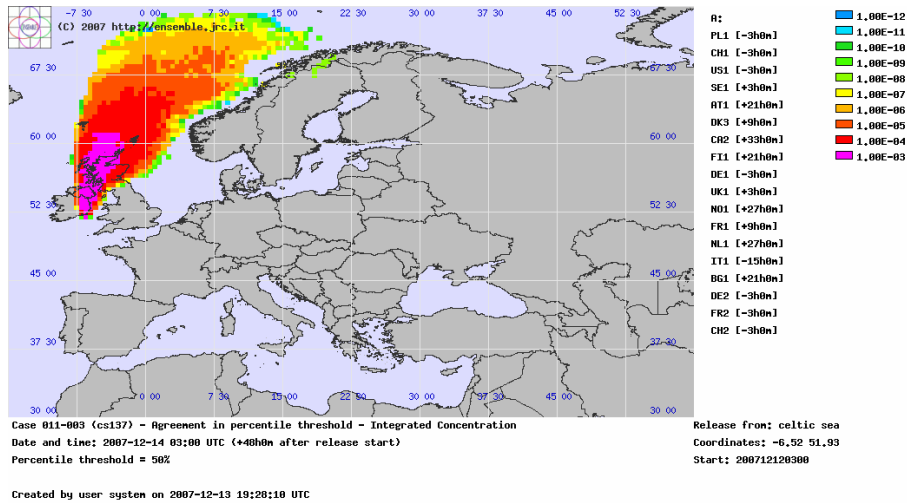


Fig. 10 APL (50%) for time integrated concentration for Cs-137: 48 hour

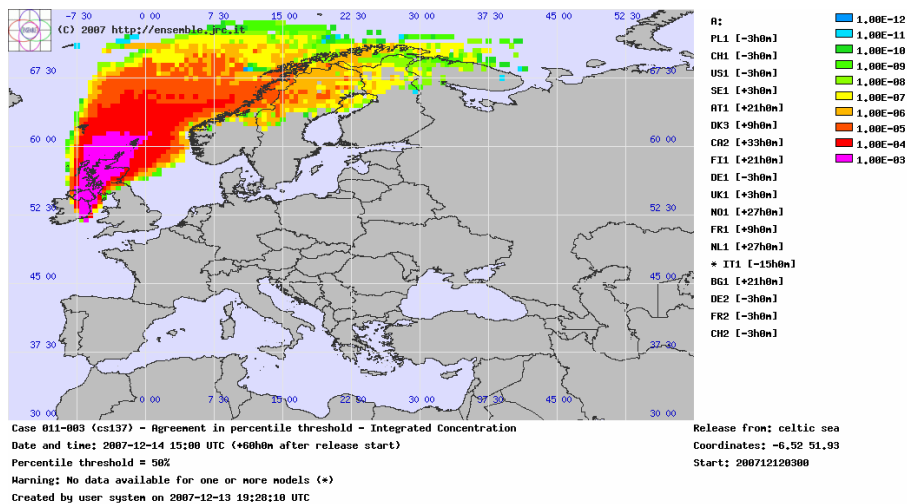


Fig. 11 APL (50%) for time integrated concentration for Cs-137: 60 hour

From these pictures one can observe that there is relatively good agreement among models, particularly for higher concentration values, however the cloud is not as widely spread as the average of the ensemble shown on Figs. 2-6. It seems that information on the median is more practical than the average because:

- models' predicted values are not taken into calculation (so "strange" values have no impact on the results),
- the median says about something which is in the middle among the results of the simulations and thus reflects better the "central point" of the whole ensemble.

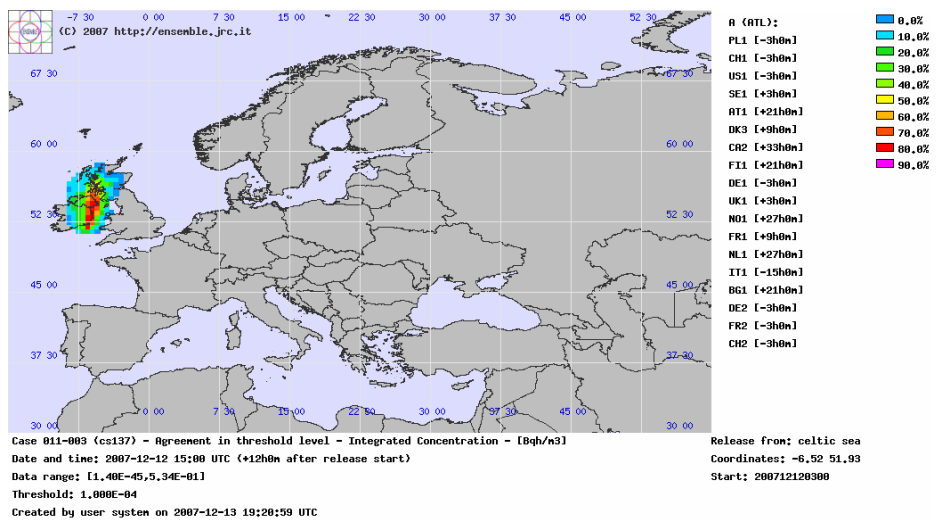


Fig. 12 ATL (threshold: 1.0e-4 Bq/m³) for Cs-137 time integrated concentration: 12 hour

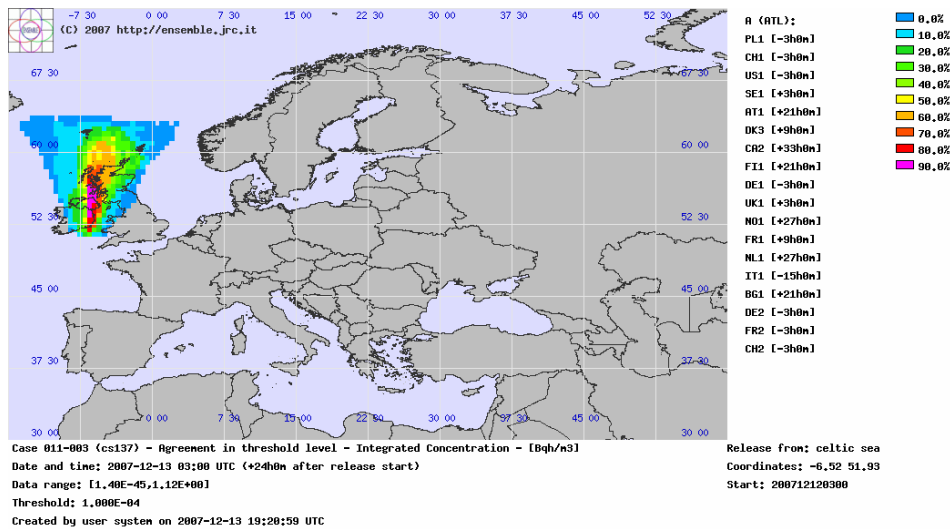


Fig. 13 ATL (threshold: 1.0e-4 Bq/m³) for Cs-137 time integrated concentration: 24 hour

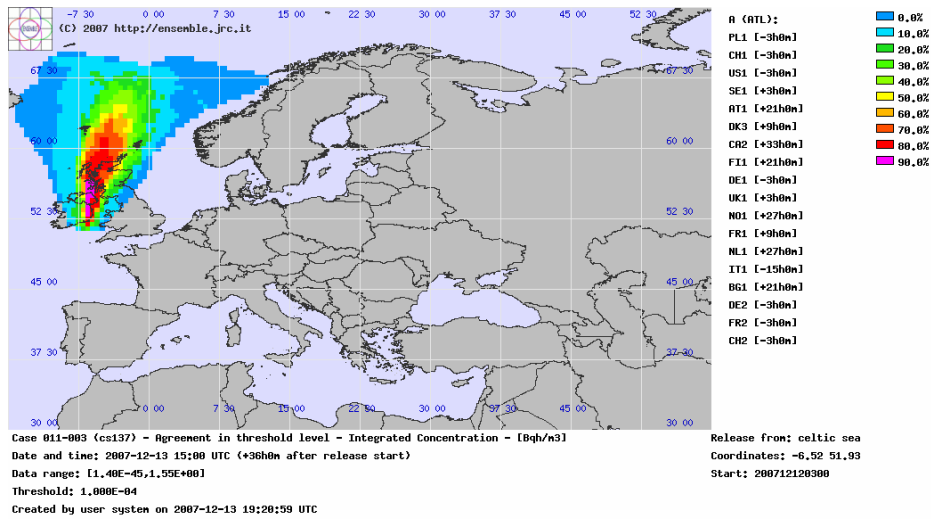


Fig. 14 ATL (threshold: 1.0e-4 Bqh/m³) for Cs-137 time integrated concentration: 36 hour

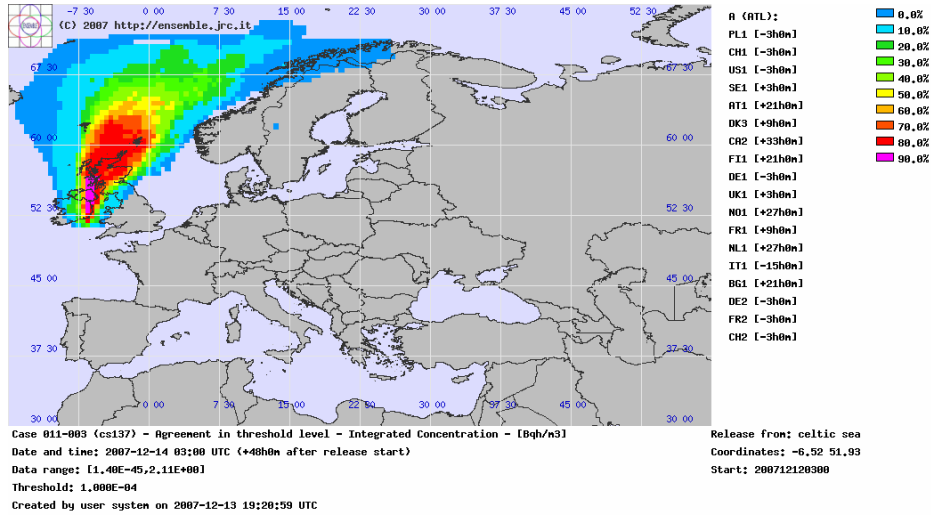


Fig. 15 ATL (threshold: 1.0e-4 Bqh/m³) for Cs-137 time integrated concentration: 48 hour

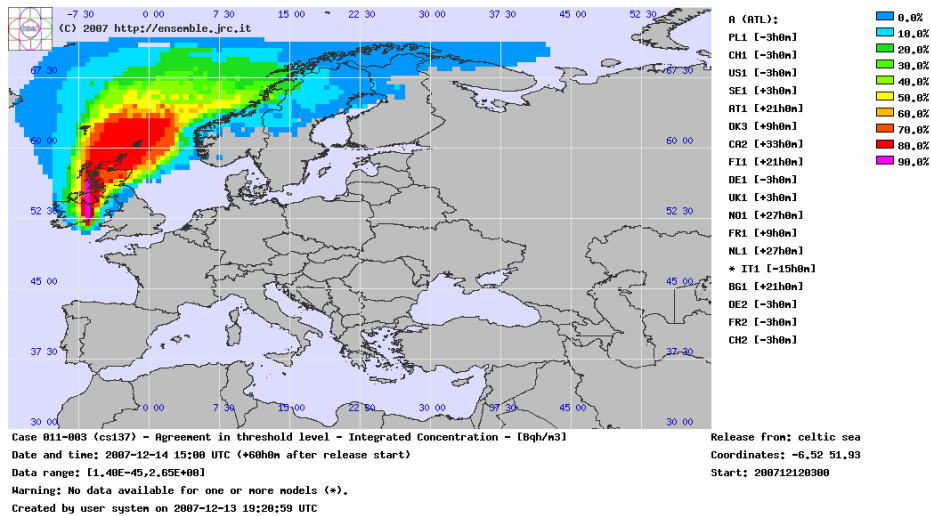


Fig. 16 ATL (threshold: 1.0e-4 Bqh/m³) for Cs-137 time integrated concentration: 60 hour

This also confirmed by the ATL pictures shown on Figs. 12-16. Less than 20% models predicted values higher than the threshold across large domain (blue areas on the pictures). More than 70% predicted exceedance of the threshold for compact red area on the picture and probably only green areas produced the highest uncertainty (20-40% models' predictions). Taking into account the fact that due to meteorological conditions causing the cloud was moving to polar region this higher uncertainty is understandable as frequently this region is located close to the boundaries of the domain used in numerical models of weather forecast systems.

Very similar pictures can be presented for iodine. On Figs. 17 and 18 respectively are shown:

- APL (50%) for I-131 time integrated concentration, at hour 60
- ATL (threshold: $1.0e-4$ Bq/m³) for I-131 time integrated concentration, at hour 60

As one can observe the differences in comparison with analogous figures for cesium are small and related rather to the different values (higher for iodine) than to the shape of the cloud.

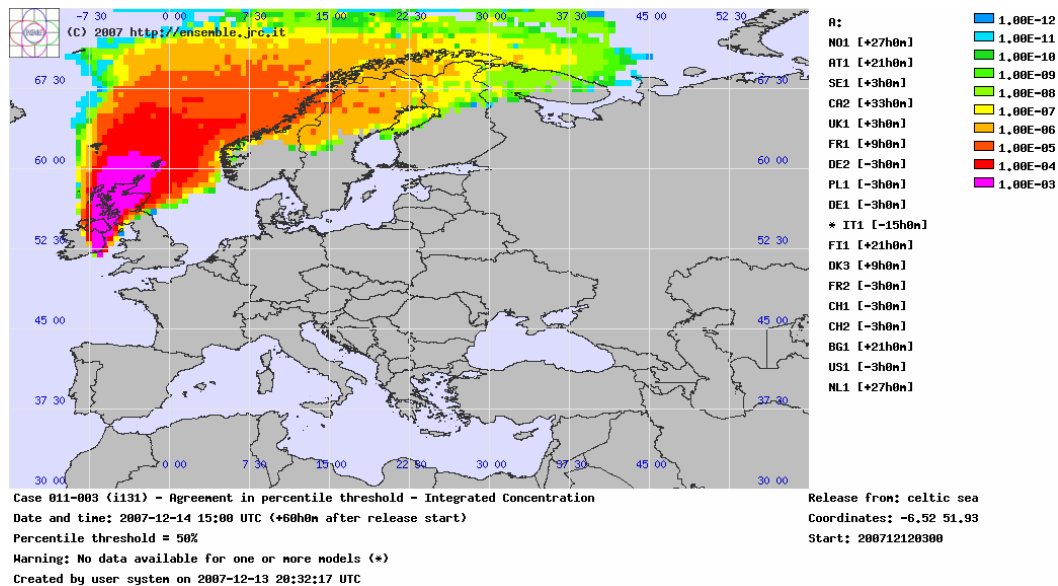


Fig. 17 APL (50%) for time integrated concentration for I-131: 60 hour

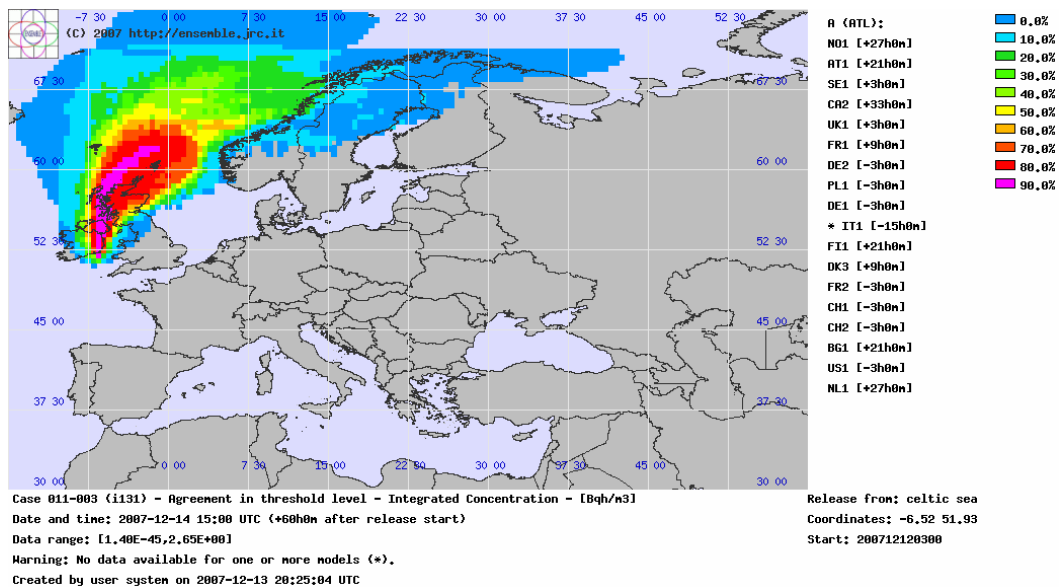


Fig. 18 ATL (threshold: 1.0×10^{-4} Bq/m³) for I-131 time integrated concentration: 60 hour

The other nice feature of the “hot-run” version of ENSEMBLE (and particularly appreciated by the users) is automatically generated animation files available directly from the main page (Fig. 1). These animation files are produced for the same variables as the plots mentioned above.

In fact one of the animation files was transferred to EU internal communication and crisis management system ARGUS to present development of the situation to all EU organizations engaged in the exercise.

4. ENSEMBLE NETWORK RESPONSE TO NOTIFICATIONS

The following notification to the ENSEMBLE community took place:

- at 09:58 UTC general information on possible release without any detailed data on source term,
- at 11:29 UTC first message containing possible source term (Table 1),
- at 14:52 UTC second message containing updated source term file (Table 3).

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

Figures 19 and 20 give the time evolution of forecast submission to the ENSEMBLE web sites by the modelling community for the first and second simulation runs. After the first notification 6 first simulation results reached ENSEMBLE Web site within 2 hours from the time when the message on source term was sent (among them one in the first 30 minutes) and additional 12 results during next 6 hours. Total number of the prognoses received was 21, which were coming from 20 different atmospheric dispersion models. After the second notification (with adjusted source term) 8 results reached ENSEMBLE system within first 2 hours (among them two in the first 30 minutes) and 9 results during 9 hours. Total number of the prognoses delivered was 24 also coming from 20 models. Some of the results were submitted in the following days as due to internal reasons a number of participants could not take part to the exercise in real time. However, it is remarkable that most of them sent their simulation 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.

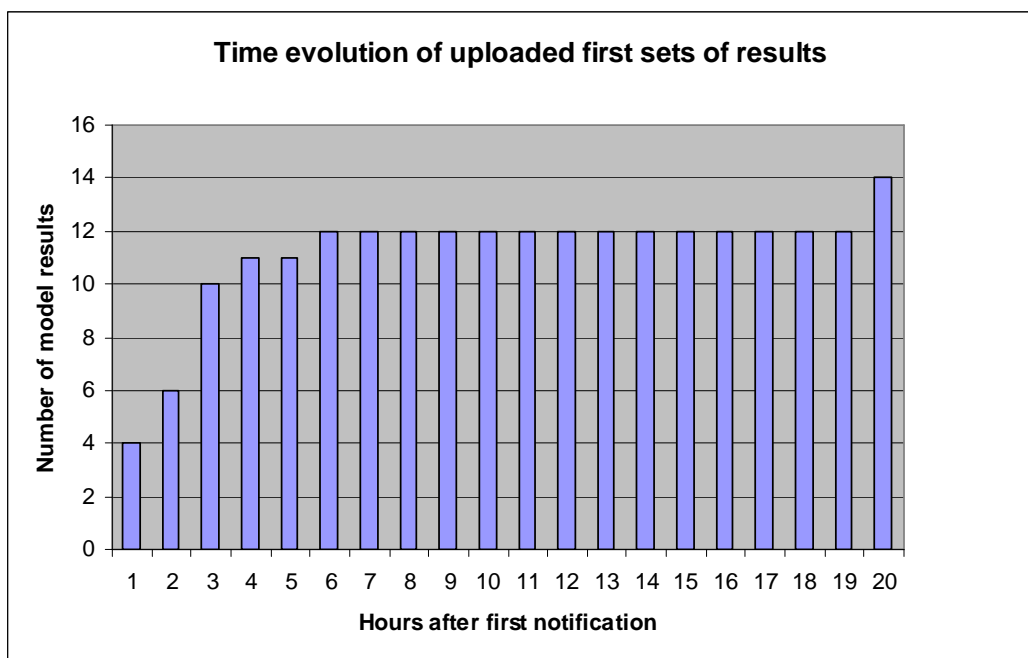


Fig. 19 Time evolution of the upload of model results on the ENSEMBLE web site during the exercise – first simulation

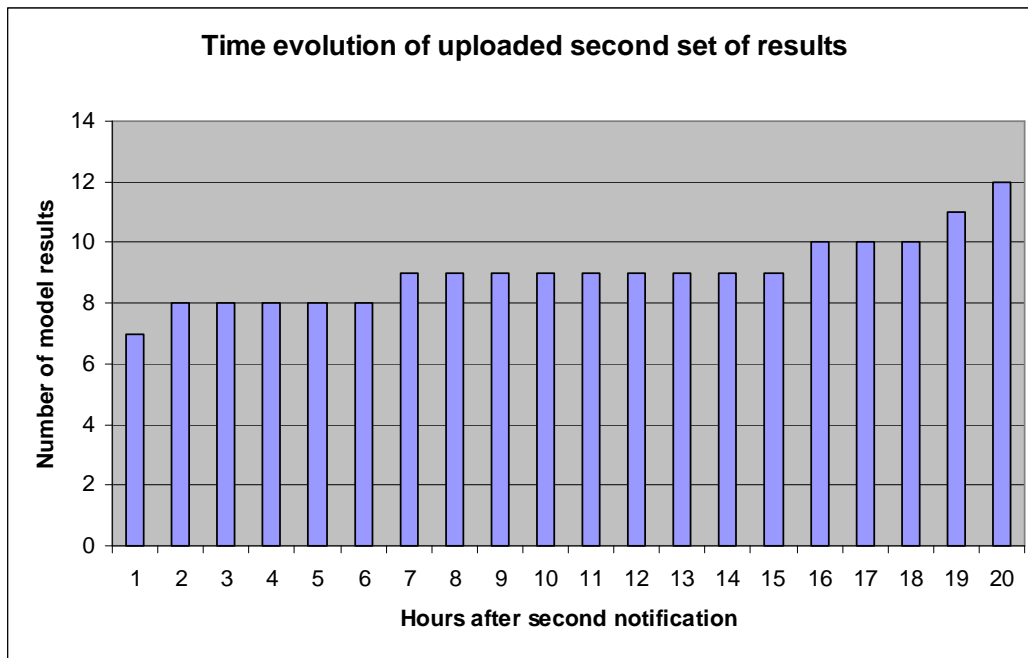


Fig. 19 Time evolution of the upload of model results on the ENSEMBLE web site during the exercise – second simulation

5. ADDITIONAL RESULTS FROM THE ENSEMBLE SYSTEM

More detailed analysis of the situation can be made in the normal full version of the system. Looking at the figures 17 and 18 one for example could be interested in the information if the plume would reach Iceland or not. To check behaviour of the models at this location an appropriate time series can be produced (Fig. 20) for example for two sets of ensemble simulations: one data set (blue on the picture) is the average of models' results created by applying meteorological data from the time 0.00 UTC (i.e. 3 hours before the beginning of the release) and the second set (red on the picture) is the average of models' results obtained from new meteorological data. We can observe essential difference between these two ensemble sets. Much higher concentrations for a long period were predicted by applying new meteorological data. This example shows how important is updating continuously the results of dispersion simulations when new weather forecast becomes available. Similar analysis can be made for any other location.

Case 011-003 (cs137) - Time overlap - Integrated Concentration in Bq/m³
 Date and time: from 2007-12-12 06:00 to 2007-12-14 12:00 UTC - Iceland
 Ensemble A maximum: 2.99E-04 - Ensemble B maximum: 1.29E-07
 Warning: No data available for one or more models (*).

Release from: celtic sea
 Coordinates: -6.52 51.93
 Start: 200712120300

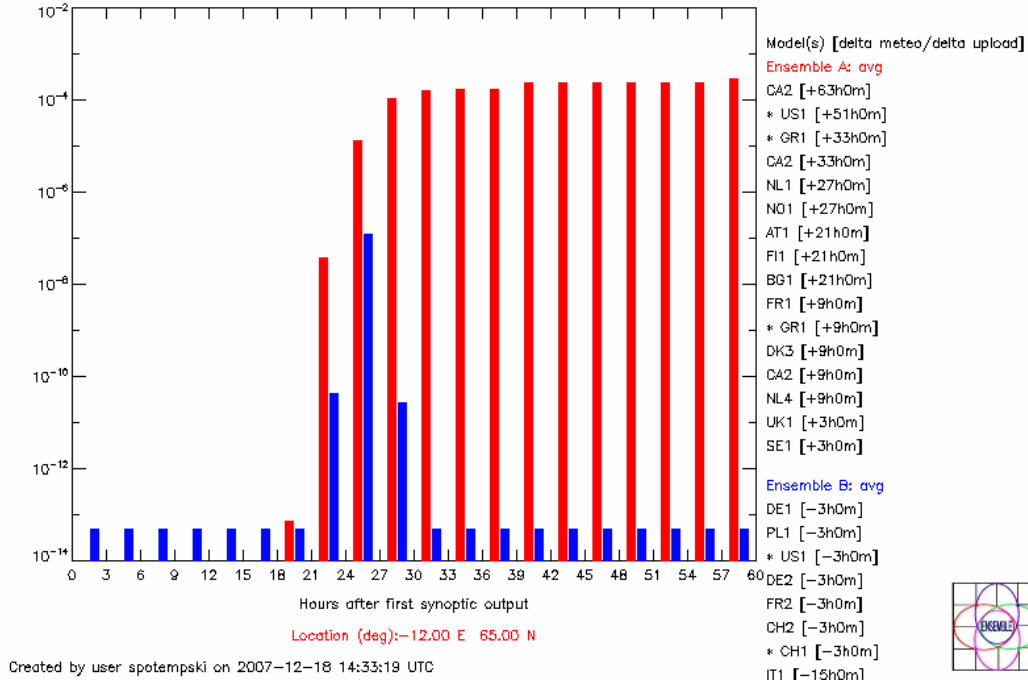


Fig. 20 Time series for the location (12.0 W, 65.0 N) near Iceland for two ensembles

To illustrate the difference between prognosis based on older and newer meteorological data one can visualize space overlap on precipitation – Figs. 21 and 22 (with the threshold corresponding to shower).

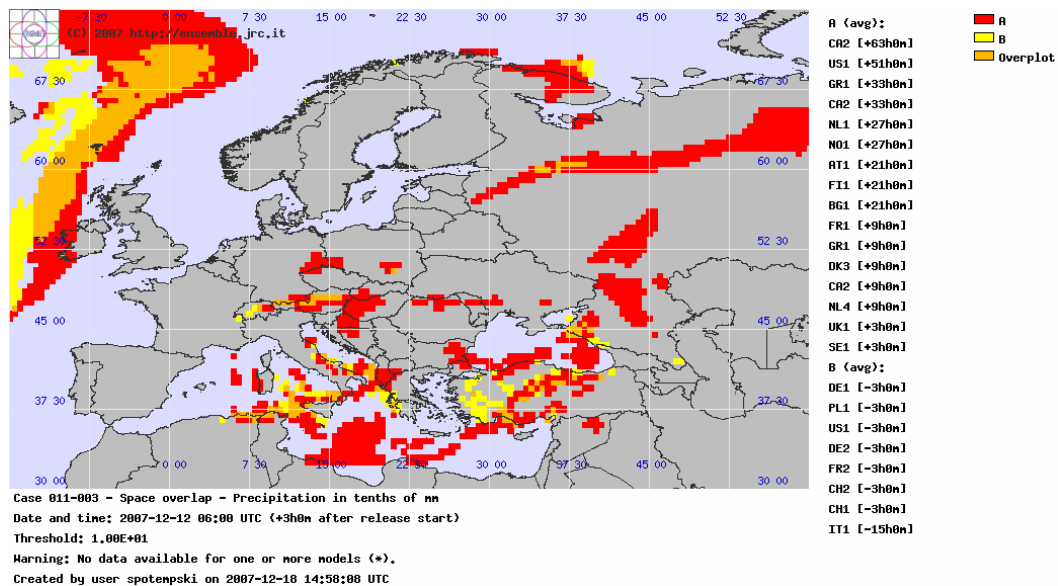


Fig. 21 Space overlap for precipitation 3 hours after the release for two ensembles

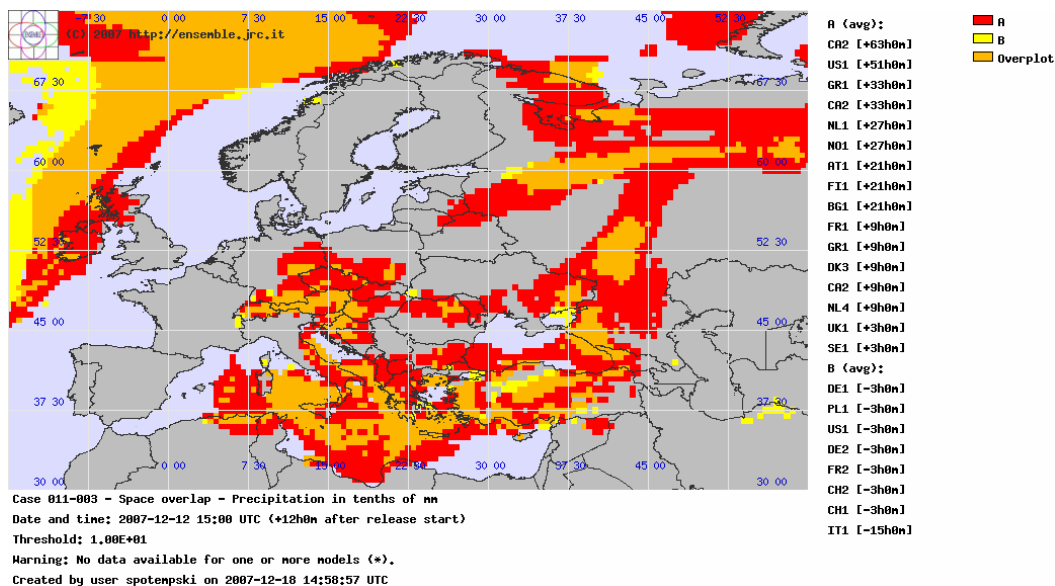


Fig. 22 Space overlap for precipitation 12 hours after the release for two ensembles

It can be noticed that new simulation predicted higher precipitation (red areas) than older ones (yellow), however there are also big areas covered by both ensembles (orange). In particular it is important that new predictions produced higher values for precipitation close to the location of the release or maybe predicted that the precipitation can happen earlier. Of course precipitation plays an important role for calculating deposition fields.

To observe whether there is the difference in wet deposition we selected two EURDEP station (Rosslare – closer to the release point and Dundalk located far away) and produced time series of the I-131 deposition for these locations shown on Figs.23 and 24 for the same two ensemble datasets. For the station closer to the release point (Rosslare) the wet depositions obtained from the new simulations are higher by about 50% in comparison to the wet deposition received for older simulations. For far located station (Dundalk) starting from 6th hour we can observe that there is a good agreement between the results generated for these two ensembles, however the deposition is much lower than the one calculated for the first station. For the first hours however there is an essential difference in the results but this can be also an effect of the prediction of stronger wind in the new simulations.

Case 011-003 (I131) - Time overlap - Wet deposition in Bq/m²
 Date and time: from 2007-12-12 06:00 to 2007-12-14 12:00 UTC - Rosslare
 Ensemble A maximum: 4.50E-01 - Ensemble B maximum: 8.43E-02
 Warning: No data available for one or more models (*).

Release from: celtic sea
 Coordinates: -6.52 51.93
 Start: 200712120300

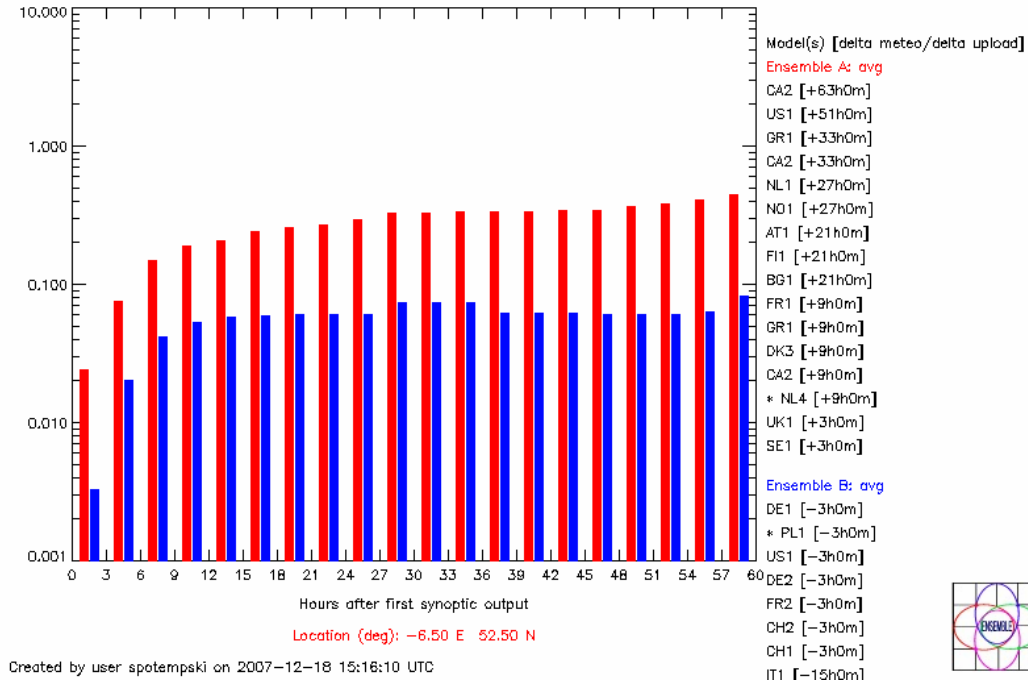


Fig. 23 Time series for I-131 deposition – Rosslare station

Case 011-003 (I131) - Time overlap - Wet deposition in Bq/m²
 Date and time: from 2007-12-12 06:00 to 2007-12-14 12:00 UTC - Dundalk
 Ensemble A maximum: 9.43E-02 - Ensemble B maximum: 4.94E-02
 Warning: No data available for one or more models (*).

Release from: celtic sea
 Coordinates: -6.52 51.93
 Start: 200712120300

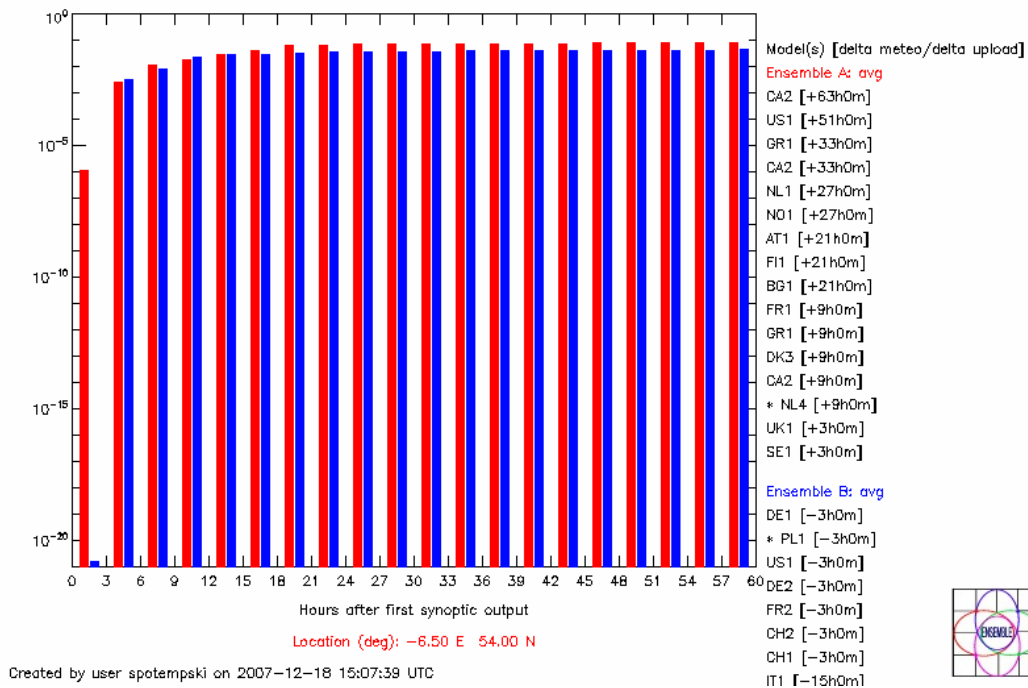


Fig. 24 Time series for I-131 deposition – Dundalk station

The information from EURDEP station can be very useful for verification of the prognosis however there are some difficulties related to the following facts:

- no data on concentration field is available on the measurement stations,
- necessity of transferring models' predicted concentration into doses (available in EURDEP) what can be a source of high uncertainty due to:
 - o no good information on source term,
 - o usage of dose model which should be applied to make this transfer.

Nevertheless some qualitative information from measurement stations can be also very useful – even binary – like such that the threshold for gamma dose rate has been exceeded at his location, but not exceeded in the other one. Incorporating this type of information into the system demands however more investigation.

6. CONCLUSIONS

In the report the application of the latest version of the ENSEMBLE system, in particular the “hot-run” version, to the ECURIE Level 3 exercise was described. The “hot-run” version enables fast and easy presentation of the available results in the ENSEMBLE system but it should be seen as one of the elements of the continuous development of the system.

The latest changes of the ENSEMBLE system are related to the addition of several important features and coupling with other systems for nuclear emergency response operated by the European Commission. It concerns the European Community Urgent Radiological Information Exchange and the European Radiological Data Exchange Platform. The ECURIE system serves for providing the States information on the current and predicted situation related to the nuclear or radiological event, meteorological conditions, national countermeasures undertaken, and other data. Then coupling the ENSEMBLE system with ECURIE enables automatic activation of the users of ENSEMBLE modeling community, so they can perform appropriate simulations and upload their results into the system. The developed “hot-run” version of the system

supports automation of the whole process. Once the results of users' simulations are uploaded a number of various plots are created by the system and the users can have quick overview of the situation. It also enables finding possible discrepancies between the results which can be caused still by simple mistakes. Then the verification of the simulation results is much easier and faster.

On the other hand the ENSEMBLE system has been already linked to EURDEP database, which means that in real case the simulation results can be validated against measurement data. It should be underlined that EURDEP database operates in real-time, so it enables the fastest exchange of information between monitoring network and modeling community.

In such a way three EC systems: ECURIE, EURDEP and ENSEMBLE have been connected in one logical chain. Starting from notification of the radiological or nuclear event, through the multi-model simulation to comparison of the predicted concentrations with the measured data one can get the full picture of the developing situation in almost automatic way. The "hot-run" version of the system completes this chain by providing necessary tools for making automatic visualization of the results of the simulations.

It should be added that some information available in these systems has rather only qualitative meaning and therefore there is a need for further development in order to utilize effectively all available data in these systems.

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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)

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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 application of the “hot-run” 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 possible exchange of information between ECURIE, ENSEMBLE and EURDEP systems operated at JRC.

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