flexRISK

Flexible Tools for Assessment of Nuclear Risk in Europe – Report 2010

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1 Introduction

After a long break in the construction of new nuclear power plants in most countries, since a few years, licensing procedures for new plants have been started in several European countries, and also some developing countries increase their efforts to embark on a nuclear energy path. Also, many aging plants continue to operate, often with life-time extensions up to 60 years and power uprating. Severe accidents, releasing substantial fractions of the core inventory into the environment, continue to carry the potential for widespread contamination. It is therefore desirable to provide risk studies, based on the latest scientific findings and methods, to the decision makers and also the public to assess possible environmental and health consequences, to see the geographical regions that may be affected at significant levels from plants at different locations, or to compare the risks of different pathways of development of the nuclear energy development.

Considering this context, the project flexRISK aims at creating a flexible tool for the evaluation of geographical distribution of the risk in Europe due to severe and most likely accidents in nuclear facilities for the present situation as well as foreseeable developments. It also aims at contributing to improve the knowledge related to nuclear risks of different target groups. To achieve this, characteristic source terms and accident frequencies for different reactors or at least reactor types are identified. Together with large-scale atmospheric dispersion modelling, using the state-of-the-art transport and dispersion model FLEXPART, contamination patterns of the ground and near-ground concentrations of relevant radionuclides are calculated for a large set of representative meteorological situations. The FLEXPART calculations for this project were carried out on the VSC.

2 Model and setup

The transport and dispersion calculations were performed with an Version 8.1 of the Lagrangian particle dispersion model FLEXPART (`http://transport.nilu.no/flexpart`, Stohl et al. 2005) with some adaptations. FLEXPART is written in `Fortran` (the version used is mainly `Fortran` 77 with some parts in `Fortran 90/95`). It is a scalar programme, but due to the large number of runs to be performed, the VSC infrastructure was needed and could also be used efficiently.

The comptutational costs of each run depends, inter alia, on the number of computational particles used, the length of the simulation, the number of species, and the output grid. Some key parameters of the set-up used are:

- Number of particles per run: 150.000
- Length of the simulation: 15 days, terminated before if all species fall below a threshold
- Number of species: 2 (inert tracer for noble gases, aerosol tracer for aerosol-bound species and iodine)
- Coarse output grid: concentration output in one layer (0-150 m), 63 × 44 grid cells
- Fine output grid: concentration output in one layer (0-150 m), 330 × 280 grid cells

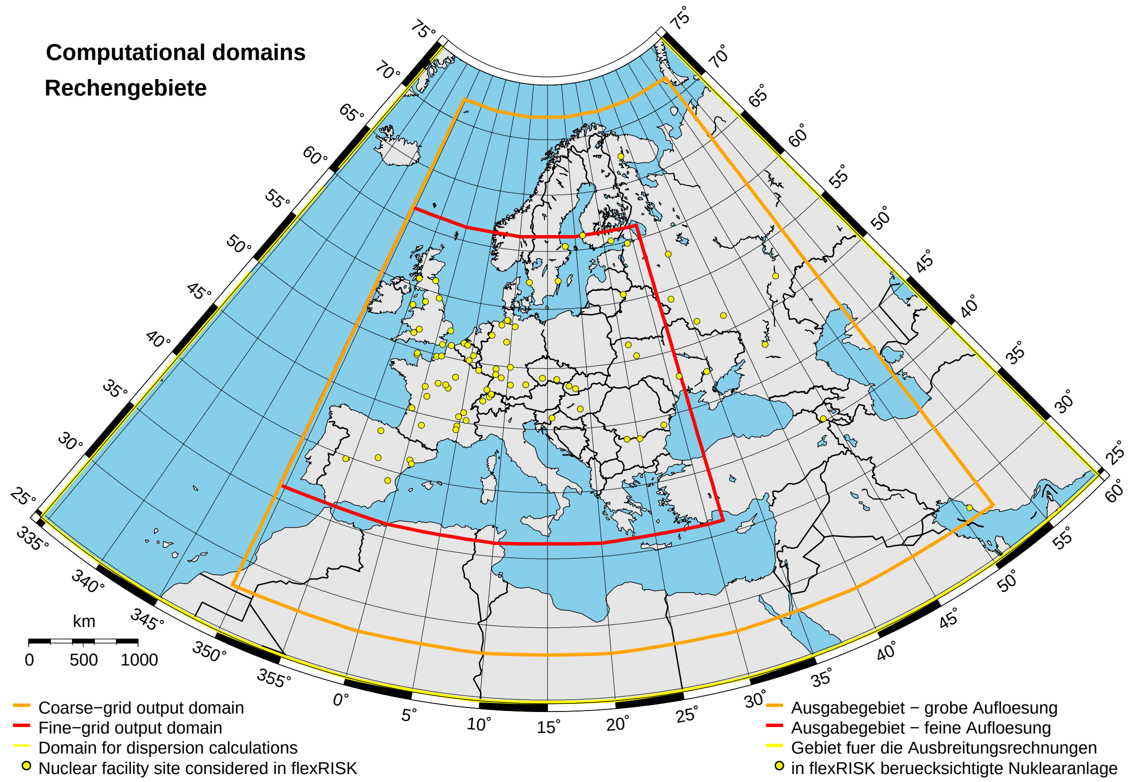

Figure 1: Computational domains. Yellow line: transport and dispersion simulation domain. Output was generated for two nested domains, a coarse (1° resolution, orange) and a fine one (10 km resolution, red). Yellow dots mark the approximately 90 nuclear facilities considered in the project.

- Output parameters: deposition, time-integrated concentration
- Output frequency: 3 hours

The domains and the nuclear sites considered (mainly nuclear power plants) are shown in Figure 1.

Runs were carried out for about 90 sites. Another important preparation concerned the selection of the dates for each of the simulations. Two important conditions should be fulfilled: the temporal distance between the runs should not vary too much (thus ensuring also equal sampling of all the seasons), and the releases should equally cover all times of the day, as this influences the dispersion conditions. This latter conditions should be fulfilled over not too long periods of time, at least for each season. This condition lead us to use 272 different start times for each calendar year, giving over the 10 years studied (2000-2009) 2720 times, more than initially anticipated. In addition, 88 (90) dates from the year 1995 that were simulated in the predecessor project RISKMAP project (`http://www.umweltbundesamt.at/umwelt/kernenergie/akw/riskmap/`, Andreev et al. (1998)) were included.

As in some sites different reactor types exist, and in some reactors also different accident sequences with different temporal release shapes had to be considered, the total number of runs is even larger.

Meteorological input fields were the so-called ERA-Interim reanalysis data from the European Centre for Medium Range Weather Forecasting (ECWMF). They have a horizontal resolution of 0.75° and were used with 42 vertical layers. These data are stored in `GRIB`, a moderately efficient binary format used by the meteorological community. The library needed to read the `GRIB` files was kindly installed by the VSC staff. The 11 years of data represent 110 GB.

```
...
1995112701 [new: 1,3-6][sub: ~][run: ~][suc: 2,7-9][cra: ~][err: ~]
1995120103 [new: 1-93][sub: ~][run: ~][suc: ~][cra: ~][err: ~]
1995120504 [new: 1-93][sub: ~][run: ~][suc: ~][cra: ~][err: ~]
1995120906 [new: 1-93][sub: ~][run: ~][suc: ~][cra: ~][err: ~]
1995121307 [new: 1-93][sub: ~][run: ~][suc: ~][cra: ~][err: ~]
1995121709 [new: 1-93][sub: ~][run: ~][suc: ~][cra: ~][err: ~]
1995122110 [new: 1-93][sub: ~][run: ~][suc: ~][cra: ~][err: ~]
...
#
#     7782  (new)         (not submitted yet)
#        0  (sub)mitted   (job queued via ./submit.sh)
#        0  (run)ning     (job started)
#      402  (suc)cessful  ('CONGRATULATIONS' message found)
#        0  (cra)shed     (status 'running' but not visible in qstat)
#        0  (err)or       (no 'CONGRATULATIONS' message)
#     8184  total
```

Figure 2: Example of the output from the python monitoring script `status.py`

3 Production runs

From the set-up described above, a total of about 520,000 single core jobs resulted for which the input data structure had to be created and runs had to be submitted.

For the creation of the input data, a `python` script has been written that assignes the runs to a tree-like structure and then creates the required directories and input data. In order to save disk space and time for the creation, all the files were that are common for all the runs were kept in a separate directory and referenced by links created by the script. Thanks to the different modules available, `python` worked very well for this task.

A strategy to submit and monitor the jobs in a comprehensive way was also needed. We are very grateful for the VSC staff who provided some shell scripts for the sequential submission of the jobs. A set of 50 VSC nodes was reserved for the flexRISK production runs. Monitoring the large amount of simulations was also challenging. The VSC staff created a `python` script which provided overview information on the runs submitted, running, successfully finished, and crashed (see Figure 2 for a sample output). This information was also used to automatically rerun crashed jobs and fill in the submission queue. Apart from some minor problems, the production phase went smoothly. It consumed about 185,000 core-hours and produced about 2.5 TB of output data. The data transfer between VSC and BOKU-Met was accomplished with `rsync` over the internet.

The production runs have finished and we have started the evaluation of the results. Figure 3 shows an example of the deposition output of one single run (source in Mochovce, Slovakia).

4 Outlook

Once the runs are checked, the FLEXPART simulations will be post-processed to obtain the radiation doses so that they can be compared with dose levels, such as for example limits of the Austrian intervention regulations, or other indicators of health risks. The probability of exceedance of such levels and other parameters will be evaluated as a risk / hazard indicators and displayed in the form of maps and tables.

It is planned to publish a comprehensive subset of results on the project web site. For this purpose, a python/genshi framework is under development. So far, it has been used to create basic information on the nuclear facilities considered.

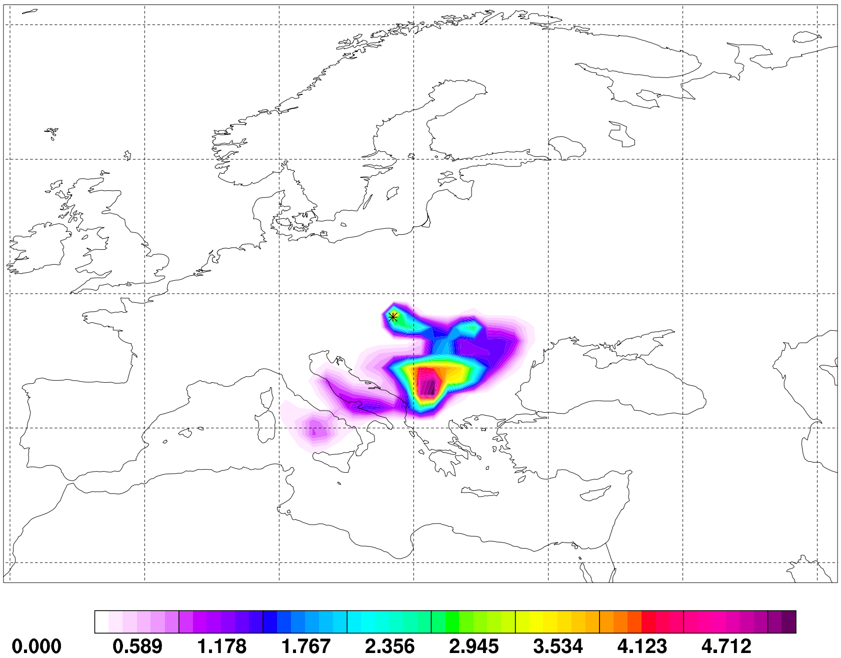

Figure 3: Example of the simulated deposition field at the end of a run for a source at Mochovce, Slovakia (relative units).

5 Further information

Additional information can be found on the project web site `http://flexrisk.boku.ac.at/`. An overview of this project has been presented in the 31st NATO/SPS International Technical Meeting on Air Pollution Modelling and its Application, 27 Sept – 1 Oct 2010 in Torino (Italy) in the form of a poster with title *flexRISK – Flexible tools for assessment of nuclear RISK in Europe*.

Acknowledgement

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References

Andreev, I., Hittenberger, M., Hofer, P., Kromp-Kolb, H., Kromp, W., Seibert, P., Wotawa, G. (1998): Risks due to beyond design base accidents of nuclear power plants in Europe? The methodology of Riskmap. *J. Hazardous Materials*, 61, 257-262.

Stohl, A., Forster, C., Frank, A., Seibert, P., and Wotawa, G. (2005): Technical note: The Lagrangian particle dispersion model FLEXPART version 6.2., *Atmos. Chem. Phys.*, 5, 2461–2474, `http://www.atmos-chem-phys.net/5/2461/2005/`.