FUTURE RADIOLOGICAL DISPERSION CALCULATIONS IN SWITZERLAND WITH JRODOS AND LASAT

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Abstract: Atmospheric dispersion and dose calculations play an essential role in the assessment of a nuclear emergency situation, especially if they are used to decide upon appropriate off-site emergency response measures. From the point of view of a national regulatory body, a system providing such calculations has to satisfy highest requirements on quality of results as well as on reliability and availability. It is clear, however, that any numerical calculation suffers from uncertainties as well as modelling constraints, which put limits on the informative value of the results (e.g. radiological dose prognosis).

In 2010, the Swiss Federal Nuclear Safety Inspectorate ENSI launched a project to replace the current atmospheric dispersion calculation system ADPIC by 2015. The goal is to provide high-quality dispersion calculations on an Intel-based, high-performance computing platform. In collaboration with the developers of JRODOS and LASAT, ENSI is currently implementing a new atmospheric dispersion system for a range of up to 250 km from the site, based on the requirements of the Swiss concept for emergency preparedness in case of radiological accidents in nuclear power plants. Additionally, the system design shall be chosen based on known limitations of input data and optimised regarding general simulation parameters, in order to permit fast and reliable dose prognoses.

Key words: *ADPIC, JRODOS, LASAT, ENSI, atmospheric dispersion calculation, emergency preparedness*

INTRODUCTION

Although the current system ADPIC (Atmospheric Diffusion Particle-In-Cell, version 5.0) performs well in terms of quality and availability, over the years it has become difficult to keep up with modern visualisation tools. Furthermore, since ADPIC runs on expensive (but very reliable!) UNIX machines, it must compete with systems running on Intel-based platforms. Within the present overview we would like to present our efforts and challenges to replace the current atmospheric dispersion calculation system ADPIC by 2015.

The Swiss concept for emergency preparedness in case of accidents in nuclear power plants requires amongst others an assessment of the radiological situation and eventually a forecast assessing the future potential off-site consequences with a high quality atmospheric dispersion and dose model. Besides the source term, the most important requirements for such a calculation are:

- a validated state-of-the-art model to simulate the transport of gases and aerosols in the atmosphere,
- wind fields, which on the one hand rely on high quality numerical weather predictions (NWP) and on the other hand (especially in the vicinity of the release point) account sufficiently for orographic aspects and
- a user-friendly computer infrastructure, which can be customized to fulfil the procedures of emergency preparedness at the Swiss Federal Nuclear Safety Inspectorate ENSI.

Furthermore the Swiss concept sets requirements on the assessment of a radiological situation, which implies a limitation of the available time for computation (~ 12 to 15 minutes), and on the availability and reliability of the atmospheric dispersion calculation system (>99%, see below).

SETUP AND CHALLENGES

LASAT is a Lagrange particle dispersion model (Janicke 2007), which has been chosen by ENSI to replace ADPIC by 2015. The program simulates dispersion and transport of a representative sample of tracer particles utilizing a random walk process and complies with the German guideline VDI 3945 Part 3. Since the program is widely used and accepted by national authorities in Germany, ENSI has focussed its attention more on the computational performance of the code than on the quality of its calculation results.
As a first step in 2012 ENSI financed collaboration between the developer of LASAT, Janicke Consulting, and the Ingolstadt University of Applied Sciences in order to analyse the performance of the code on a dedicated IBM server (Meyer 2012). This machine has the following specifications:

- IBM server X3850 X5
- 8 Intel Xeon E7-8870 processor units (10 dual-threaded processors each)
- 512 GB RAM and 4.8 TB SAS-hard disks
- Windows Server 2008 R2 Enterprise 64 Bit

The investigation carried out by Janicke Consulting and the Ingolstadt University of Applied Sciences showed that although multi-threading routines (OpenMP) are implemented in LASAT, the calculation time strongly depends on the type of problem and on the type of computer architecture. Furthermore, a dispersion calculation consists of a sequence of parallel and serial parts. In January 2013 Janicke Consulting presented an updated version of the code, with improved performance. According to a reference test example, the calculation time could be reduced by more than a factor of 4. Finally, it must be mentioned, that because of the NUMA-architecture of the IBM server used, the scalability of the performance drops significantly if more than one processor (socket) is in use. Saturation in performance was already observed with 2 processors (20 cores in total).

COSMO-2 is a NWP model operated by MeteoSwiss (Calpini 2011). As with the current system ADPIC, it is planned to use forecast data derived from this model also in future to generate suitable wind fields for the dispersion calculation at ENSI. The key specifications are:

- 24 hour forecasts computed every 3 hours and delivered to ENSI and the National Emergency Operations Centre NEOC
- Time resolution 10 minutes
- Covered area at least 500x500 km^2 around the Swiss NPPs (Fig. 1)
- Horizontal spatial resolution of NWP 2.2 km, (1 km after 2016)
- Horizontal spatial resolution of the wind fields of the dispersion calculation 250 m at minimum in the vicinity of the release point

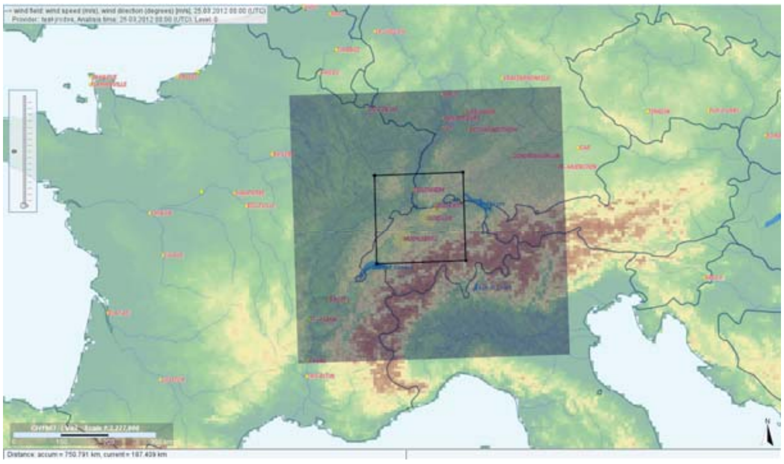

Figure 1. Snapshot of the JRODOS system showing the orography of Switzerland and of the surrounding states. The inner square shows the area currently covered by the data of NWP at ENSI. With the replacement of ADPIC the covered area will be extended to the larger grey shaded square.

JRODOS is a Java-based Real-time online decision support system (Ievdin 2010), whose development and distribution is in the overall control of the Karlsruhe Institute of Technology (KIT). The program offers the capability to choose from different atmospheric dispersion models and already includes dose calculation modules. It also features user-friendly visualisation and control tools. Due to the requirement of ENSI to perform the atmospheric calculation with LASAT as a module inside JRODOS and due to other desired enhancements, JRODOS is currently being further developed with the following requirements:

- Increase of the amount of points of the calculation grid
- Capability of a 5-fold nesting for the dispersion calculation with LASAT
- Processing of the COSMO-2 data of MeteoSwiss with a time resolution of 10 minutes
- 2 simultaneous sources with variable release rate
- Implementation of the program LOPGAM of Janicke Consulting in order to account for gamma submersion
- Fully parallelised wind field processor
- Fully parallelised post processor to generate the graphical output

The availability of the dispersion calculation system for emergency preparedness is set at >99%. From this it follows that for maintenance and because of possible failure of hardware or software no more than 3.6 days a year is allowed for service interruption. In order to comply with this requirement, the strategy of ENSI and the NEOC is to install a fully redundant system at their respective locations in Brugg and Zurich. Of course, both systems will be on backup power supply and both institutions have full remote access to the partner’s system.

CONCLUSION

JRODOS in combination with the established dispersion calculation program LASAT presents a good replacement for ADPIC, which allows ENSI to keep up to date with developments in technology for the next decade. In the frame of the installation process, the new system will be continuously compared with ADPIC and other models to assure that the current standards are met and the projects provides a sustainable basis for the future.

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