18th International Conference on
Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes
9-12 October 2017, Bologna, Italy

JRODOS FOR NUCLEAR EMERGENCIES: IMPLEMENTATION IN SWITZERLAND AND FURTHER DEVELOPMENTS

Cyrill von Arx[1] and Markus Oberle[1]

[1] Swiss Federal Nuclear Safety Inspectorate (ENSI), Industriestrasse 19, CH-5200 Brugg, Switzerland

Abstract: JRODOS is a modular decision support system intended for use in radiological emergency protection. Switzerland has implemented this software as primary prognosis tool for the impact assessment of radiological emergencies at nuclear installations. Here we present the current status of the software, the implementation in Switzerland, and give an outlook on further developments.

Key words: *JRODOS, decision support system, radiological emergency, radiological impact assessment, atmospheric dispersion modelling, dose calculation.*

INTRODUCTION

JRODOS stands for Java Real-time Online DecisiOn Support system and is a modular programme intended for use in radiological emergency protection. Switzerland has implemented this software as primary prognosis tool for the impact assessment of radiological emergencies at nuclear installations. As a result, Switzerland has become a major promoter of this system and has been instrumental in furthering its development. The aim of our contribution to the 18th HARMO Conference is to present the current status of the software, its implementation in Switzerland, and to give an outlook on future developments.

Karlsruhe Institute of Technology (KIT) released a new version of JRODOS in February 2017, based upon the RODOS User Group decisions on the direction of development, our advanced requirements, and requests from other users. In May 2017, the ‘Update 1’ was released to remedy some minor bugs. The current version is thus called ‘2017 February Update 1’. ENSI implemented this version on both its operational and test systems and it has become the operational service model on 1 June 2017.

IMPROVEMENTS AND NEW FEATURES

One of the central improvements of the new version is the update to modern dose conversion factors (based on ICRP 109 database vol. 3.0 and Petoussi-Henss *et. al.*, Phys. Med. Biol. 2012; 57: 5679-5713). This update required a change in the treatment of daughter nuclides: up to now, the dose conversion factor (DCF) of a mother nuclide included the contribution from daughter nuclides, permitting an atmospheric dispersion model (ADM) calculation restricted to mother nuclides. With the update, daughter nuclides are treated separately and in detail in the ADM for both air concentration and ground deposition as well as in the dose calculation. Furthermore, nuclide-dependent results are only available for the nuclides selected in the source term and therefore previous versions were unable to provide these results for daughter nuclides unless they were included in the source term in the first place. To lift this restriction for the most important mother-daughter pairs, the source term’s nuclide list is completed if one nuclide of the following pairs is present: Kr-88/Rb-88, Sr-90/Y-90, Mo-99/Tc-99m, Rh-106/Ru-106, I-132/Te-132, Ba-137m/Cs-137, Ba-140/La-140, and Ce-144/Pr-144m. Additionally, the three chemical forms of Iodine are now treated separately during dose calculation; in previous versions, they were accounted for during dispersion but dose calculation only used the DCF of aerosol Iodine.

The pre-processor for meteorological data has been crucially improved, a major bug in the wind field interpolation was fixed, and the GRIB parsing process was accelerated. Specifically for the ADM model LASAT, the rain interpolation procedure was modified to use only spatial (but no longer temporal) interpolation; this change provides a physically more sensible result. For LASAT only, the time-dependent airborne nuclide concentration on the vertical calculation levels is now available in the result list. The three ADM models RIMPUFF, DIPCOT, and LASAT are now able to consider a user-defined particle size distribution. With the model EmerSim, early emergency actions and their impact on doses are now possible up to 48 hrs. The maximum number of possible radio-ecological regions in the terrestrial food and dose module FDMT has been increased significantly to 25, from originally 5.

On the GUI part, the changes include a compact presentation of available nuclides for nuclide-specific results including sorting functionality and percentage of each nuclide's contribution, better support for WMS server, and improved performance when rendering big grids. Both calculation kernel and GUI have been expanded to allow source terms and meteorological input data to have up to 1008 intervals (equalling seven days with 24 hrs of six ten-minute intervals each). The feature of multiple parallel source terms, which was until now restricted to LASAT, has been extended to include RIMPUFF and DIPCOT. Concerning user administration, the concept of user groups has been introduced as well as the possibility to transfer a set of start-up settings to any number of users or user groups.

A further important development is the Web Client, which permits access to the JRODOS database via web browser. Since this is not in service in Switzerland, it will not be further discussed here.

IMPLEMENTATION IN SWITZERLAND

Switzerland has decided to switch to the JRODOS software in 2014 as replacement for its ADPIC system. Adaptation to country-specific requirements lead to the implementation of the Swiss coordinate system and the improvement of the calculation engine to use 10 min meteorological data. Furthermore, KIT developed the so-called 'ENSI grid', consisting of five rings with around 30'000 grid cells each. With this grid, the user is able to specify both the number of rings and the innermost grid cell horizontal resolution in metres; starting from the innermost ring outwards, each consecutive ring has half the resolution of the previous one. The vertical resolution is derived from the meteorological input data and cannot be modified by the user. This grid permits simulations with reasonable resolution near the source and at the same time up to rather large downwind distances, all within acceptable calculation time.

A further development of JRODOS focusses on the parallelisation of LASAT and LOPGAM inside JRODOS. LASAT is the ADM of choice for ENSI and LOPGAM is a submersion model to calculate the external cloud dose. Both models are parallelised to a large degree themselves, and JRODOS builds on this feature. Inside JRODOS, each time step requires three calculation steps: wind field interpolation, dispersion calculation, and dose calculation. These three steps are running on separate threads and are stacked, with wind field interpolation always working three time steps ahead. The current configuration assigns 10 calculation threads to the LASAT call within the dispersion calculation and the LOPGAM call within the dose calculation.

Within the ENSI emergency response organisation's software portfolio, JRODOS is linked via WMS to MADUK, the management and visualisation software for ENSI's fixed dose rate measurement rings around Swiss NPPs. This permits the overlay of the current dispersion situation with the current measurement values. Furthermore, the export of our dose prognoses to emergency response partners is achieved via MADUK. Hourly dispersion simulations with a unit source for all nuclear installations in Switzerland (except the zero-power research reactor in Lausanne) monitor system availability. These calculations are transferred to MADUK to produce the current dispersion situation GIS layer; in case of an emergency, they further serve as a first basis for assessing the geographical area where emergency protection measures may have to be implemented. The source term prognosis tool ADAM STEP, which estimates the potential release for heavy accident scenarios based on PSA level 2 analyses, has been modified to produce source terms in XML format as a direct input to JRODOS.

Concerning hardware, ENSI has three separate server systems: two operational systems and one test system. All systems are identical in build and configuration, but have separate databases and map servers. This increases system availability – which is essential for an emergency response organisation (ERO) – while at the same time reducing interdependencies and administrational overhead. Meteorological data is sent from

MeteoSwiss via two separate paths and arrives at ENSI on two distinct servers, with failover capability. Again, this increases system availability. Since 1 June 2017, ENSI uses Lenovo x3850 X6 Servers with 4 Intel Xeon E7-8890 v3 sockets of 18 cores at 2.5 GHz each, a total of 256 GB RAM, and approx. 4 TB memory. With 'hyperthreading' enabled, each server consists of 144 logical cores, in principle permitting 144 parallel threads. Although this is quite different from the IBM Power5 system used for its predecessor ADPIC, the calculation power available ensures acceptable calculation times. What is considered acceptable for ENSI derives from the staff meeting rhythm of the ERO: typically, these meetings take place every hour, leaving about 20 min for input and calculation of a new simulation.

To test and trim JRODOS's performance on our hardware, we defined a 'benchmark' scenario: 24 hrs simulation time with 10 min time step, 1 ring of the 'ENSI grid' with 250 m resolution, a source term with two parallel emissions of 2 hrs and 140 nuclides each (i. e., all available nuclides). The new release leads to runtimes of about 50 minutes for this benchmark case; using the 'old' JRODOS standard set of only 29 nuclides, the runtime reduces to about 15 min. For comparison, a typical simulation in an emergency case would consist of 8 hrs simulation time and use the set of 29 nuclides in the source term (the other parameters being identical). Such an input leads to a runtime of about 6 min, which lies well within the time frame required in our ERO.

CONCLUSION AND FURTHER DEVELOPMENTS

With the release 'February 2017 Update 1' JRODOS has reached a stable, reliable, and mature state. Its modular structure and intuitive GUI, combined with the underlying models' sophistication and versatility, make it an application uniquely suited for use in an emergency protection context and satisfying high availability requirements.

Whilst the current state and the simulation times presented above are sufficient for the application within our emergency organisation, we envision further developments to permit speedier and more versatile calculations. Thread allocation to processor cores and further parallelisation of the calculation are central objects of development. On one hand, we intend to experiment with the parallelisation capabilities within JRODOS, optimising runtime and use the hardware's parallelisation potential. On the other hand, performing the wind field interpolation for a number of typical grid configurations right after the meteo data arrives at ENSI could save precious time during an emergency. This, however, would require the complete decoupling of the meteorological pre-processor from JRODOS.