JRodos: An off-site emergency management system for nuclear accidents

1.1 Management Summary

For almost three decades, the European Commission has promoted and supported the development of a non-commercial computer-based decision support system for off-site emergency management and rehabilitation issues after nuclear accidents, RODOS, and it's Java based successor since 2010, JRodos.

The models in JRodos for assessing radiological and other consequences together with design features of the system allow real-time operation for off-site emergency management as well as applications as a tool for exercises, preparedness and planning.

A world-wide data base and the supported coupling to a set of globally applicable meteorological weather forecast data allows general application for any point on the globe. Inherent features and tools allow the adaptation of models, data bases, and the user interface to national conditions and user preferences.

There is an active user community that takes influence on further developments. In recent years, task-oriented needs and new ideas of users for applications in non-accident situations in combination with ever cheaper, faster, more powerful hard- and software lead to many innovations with respect to models, system features and tools, some of them as yet beyond the scope of a system intended for operational use.

The text at hand outlines the models contained in JRodos and their possible use to assist in the frame of emergency management, and summarises operational aspects.

Contents

1.1 Management Summary 2

2 Introduction 4

3 The JRodos simulation models 5
3.1 Aerial transport, terrestrial exposure pathways and countermeasures 5
3.1.1 Models for the early phase 6
3.1.2 Later phase models 7
3.2 Models for aquatic transport and aquatic exposure pathways 9

4 Operational aspects 11
4.1 The JRodos user community 11
4.2 Adaptation to user preferences and national and regional conditions 11
4.3 Required computational resources 12
4.4 Human resources required for JRodos in an operational emergency centre 12
4.5 Human resources required for applying the recovery phase models 13

5 An example application of the JRodos Emergency model chain 14

6 Getting more information about JRodos and related European projects 20

7 Summary 20

8 Acknowledgement 21

9 References 21

10 List of figures 21

11 List of acronyms and denotations 22

2 Introduction

The full implications of a serious radiation accident became apparent for the first time with the Chernobyl Accident in May 1986. Deficiencies were revealed in how to deal with an event of such magnitude. Inconsistent response from a variety of decision making bodies, regional, national and international, led to many problems of practical and political nature and to much confusion and poor or ineffective implementation of countermeasures. All of this had a profound impact on nuclear emergency preparedness and post-accident management worldwide and in particular in Europe.

As response, many 'Post Chernobyl' actions were initiated within the European Union's research and development programmes and related activities in regulation and monitoring, inducing much research to ensure that emergency management processes become better designed to meet future challenges. One of these programmes has led to the development of the non-commercial real-time on-line decision support system RODOS.

The general task of a decision support system for off-site nuclear emergency management is to provide consistent and comprehensive information at local, regional and national levels, during all phases of a real event and while preparing for a possible future event. Getting prepared requires the creation of plans through which communities intend to reduce vulnerability to and decrease the impact of future accidents. It also includes the creation of accident scenarios and background material for training and exercising the personnel and stakeholders that would be involved. In case of a real event, the system will house all relevant information on the release and the environmental contamination, and it will forecast health, agricultural, economic impacts with and without the application of countermeasures. It can also assist decision makers in evaluating different measures against a range of quantitative and qualitative criteria. A further objective of such a system was and is the promotion of a common emergency management frame aiming to move away from national solutions.

The RODOS system itself is a synthesis of many innovative methods and techniques [Ehr 00]. Forecasting modules predict how contamination would spread following atmospheric and aquatic releases of radiation. A set of models calculate the best estimate of the current and evolving radiological situation in contaminated inhabited and agricultural areas. Dose models predict the dose to individuals and communities for all exposure pathways not related to ingestion, both with and without the application of countermeasures. Special food chain models predict the contamination of terrestrial and aquatic food stuffs and the resulting dose to people. Additional decision aiding components can facilitate the ranking and selection of alternative options using decision analysis procedures. Inherent features and tools allow adapting models, data bases, and the user interface to national conditions and user preferences.

In the almost three decades that have passed since the beginning, hundreds of scientists and software engineers, emergency managers and stakeholders in many European countries were involved in the multitude of projects underpinning the engineering of the system. In recent years, application-oriented needs of operational users gained growing impact on the development, demanding a re-design that finally lead to the Java-based successor version of RODOS issued in 2009, JRodos [Iev 10]. The latter operates on modern information technology platforms, shows good performance and operational stability and is user friendly in operation and administration.

In 2017, JRodos is operationally applied for example in Austria, Finland, Germany, the Netherlands, Switzerland, Ukraine and Hong Kong. All in all, more than 20 institutions in 16 countries operate the system at national but also at local level.

The long-lasting legacy of the RODOS project is manifest in the international NERIS network (European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery), an expanding community of academics, researchers, emergency managers, public administrators and others concerned with emergency management that promotes coherent approaches to delivering nuclear or radiological emergency response and recovery across national boundaries (http://www.eu-neris.net/).

3 The JRodos simulation models

This chapter covers the models that are included in JRodos for typical terrestrial and aquatic exposure situations; there are further ones for special exposure situations not mentioned here.

3.1 Aerial transport, terrestrial exposure pathways and countermeasures

Figure 1 illustrates the atmospheric transport and deposition phenomena and the resulting terrestrial exposure pathways after an accidental release of radioactive material into the environment; the assumed origin is a nuclear reactor.

The released volumes of air follow the wind flow. With growing distance, the initial nuclide concentration is diluted because uncontaminated air gets mixed in and the cloud will spread until it reaches an inversion lid. The passing cloud causes external exposure by gamma irradiation and internal exposure by inhalation of radioactive air near ground. Dry and in particular wet deposition processes lead to a radioactive contamination of surfaces, causing external exposure by gamma irradiation. In addition, material deposited onto natural surfaces can finally end up in the human food chain and lead to internal exposure by ingestion of contaminated food products.

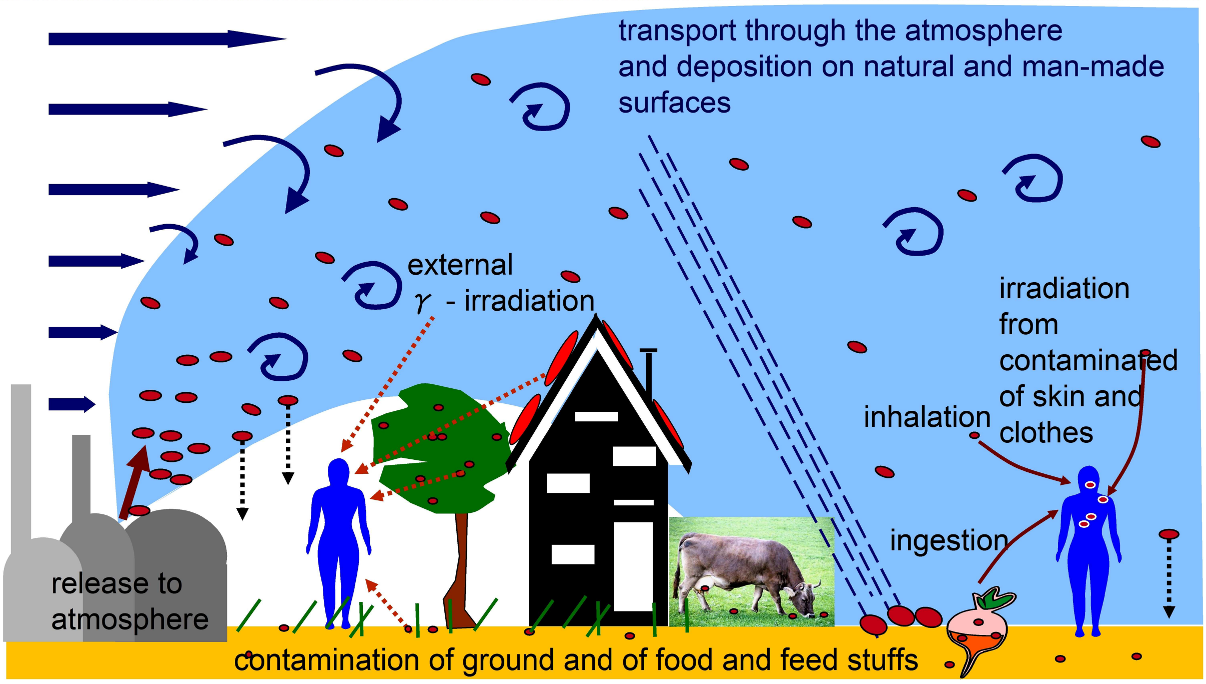

Figure 1: Atmospheric transport and deposition phenomena and terrestrial exposure pathways.

Figure 2 names the models or model chains in JRodos dealing with such effects and indicates which phases of an accident they cover. In this report we use the designation "threat phase", "release phase", and "recovery phase". The threat phase begins with the point in time when the possibility of a relevant release is realised and ends when the event is brought under control or with the onset of a major release in the wake of the event. The release phase ends when all significant releases have terminated and there is no more deposition of airborne material from the travelling radioactive cloud; the term early phase designates both phases together. The subsequent phase is referred to as recovery or late phase.

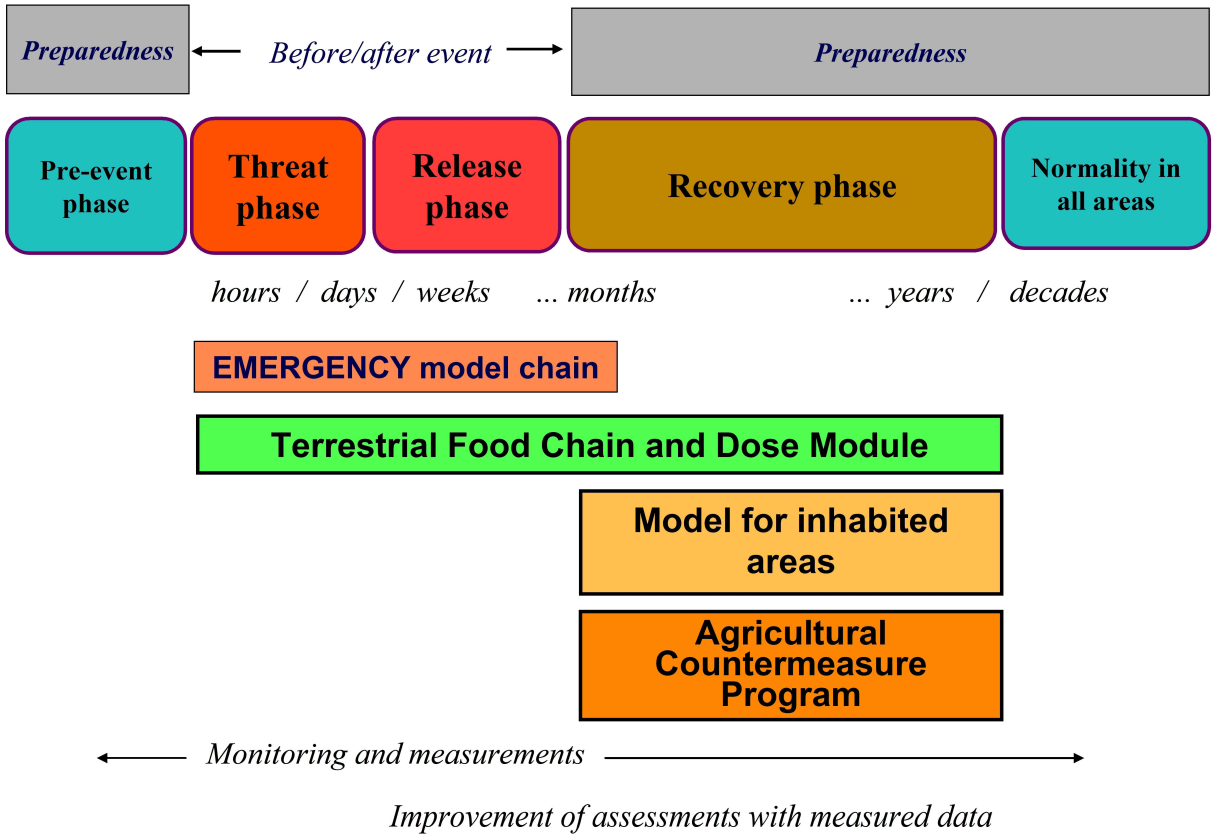

Figure 2: JRodos models and model chains and the phases they cover.

3.1.1 Models for the early phase

JRodos contains several Atmospheric Transport and Deposition Models, some applicable on the local scale in the order of one hundred km, others to distances of some thousand kilometres. With respect to meteorological information, data from national or global weather services can be used. For local scale applications, data like wind speed and direction can directly typed in by hand via the user interface.

The countermeasures for interrupting or mitigating the early phase exposure pathways are evacuation, sheltering and the intake of (stable) iodine tablets. The Emergency Action Simulation model of JRodos indicates areas where individual doses would exceed pre-defined intervention levels for the early phase actions, and simulates the effects their implementation would have on doses.

The transfer of radioactive material to food and subsequently to man is modelled in the Terrestrial Food Chain and Dose Module. For early phase applications, the model uses as input the radionuclide concentrations in the air near ground and information about the rainfall from the near or far range Atmospheric Dispersion and Deposition models.

The phenomena considered in the food chain part are illustrated in Figure 3. Airborne activity is deposited onto the ground and vegetation by dry and wet deposition processes (Figure 3a). As time goes on, a fraction of the deposited activity reaches the interior of the plants and is transported to other parts, while the activity remaining on the above-ground plant surfaces gets removed by weathering processes and will end up finally on the topmost soil layer (Figure 3b). The direct deposition onto plants and the processes following afterwards depend significantly on the seasonal development of the plant. This is the reason why the date of an accident plays a crucial role for the ingestion pathways in regions with pronounced seasonal variation of the climate. An uptake of activity by life stock via feed, watering and inhalation is followed by biological transport and excretion processes, leading to a contamination of animal food stuffs. (Figure 3c). Raw products get usually processed before consumption, changing the original activity concentration (Figure 3d). Processing includes simple washing or peeling, storage, and the conversion into a secondary form of product, such as grain to flour or bran.

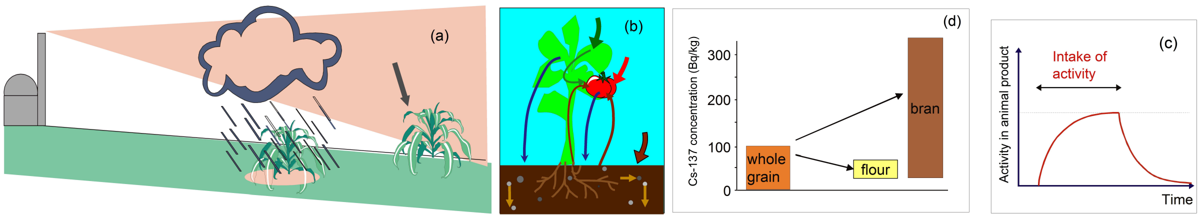

Figure 3: Phenomena considered in the terrestrial food chain model.
Deposition onto vegetation and soil (a), transfer of activity to/through/from plants (b) and animals (c), change of activity concentration by food processing (d).

The food chain model calculates the activity concentrations in the foodstuffs ready for consumption and indicates the areas where the concentrations are expected to exceed pre-defined levels, from the time of the accident until decades later.

The near range Atmospheric Transport and Deposition Models, the Emergency Action Simulation model and the Terrestrial Food Chain and Dose Module can be applied individually or combined in form of a so-called **Emergency model chain**. This chain is designed for quick and easy assessments of the radiological situation and the areas with a potential for early phase and food countermeasures for up to 800 km distance to the release point. The input of run conditions and the amount of presented results is reduced to a minimum. Chapter 5 illustrates how to work with the Emergency chain by means of an application example for a fictive accident.

3.1.2 Later phase models

Radioactive material deposited onto natural and man-made surfaces and the contamination of food can persist for months, years or even decades. The affected areas and food and feed stuffs require management and countermeasures with the final aim to bring back the living conditions to normality, if possible.

For assessing the time development of the activity concentrations in food in the later phases of an accident, the Terrestrial Food Chain and Dose Module can be used in connection with measurements (time integrated activity in air, activity in precipitation, amount of rainfall); data in EURDEP format[1] are supported.

[1] https://eurdep.jrc.ec.europa.eu

The Model for Inhabited Areas in JRodos is concerned with the phenomena involved in the contamination of urban surfaces and surroundings, and the possible countermeasures - bringing people out of the area, different options for the decontamination of contaminated surfaces, or the complete removal of such surfaces, see Figure 4.

Input to the model is the activity deposited on a reference surface in a user-defined area of interest. The deposition input can either come from a calculation with the near range Atmospheric Dispersion and Deposition model, or can be given by hand input. The user must provide a formalised description of the environment, and a list of one or more action combinations that shall be considered in the area.

From the initial deposition, the model calculates the distribution over the different components of the urban environment and the development with time. It then assesses the effects of actions on the contamination and dose levels, the required resources, the associated waste and costs, and the time span during which the contamination levels exceed given limits that would not allow return to normal living in the area.

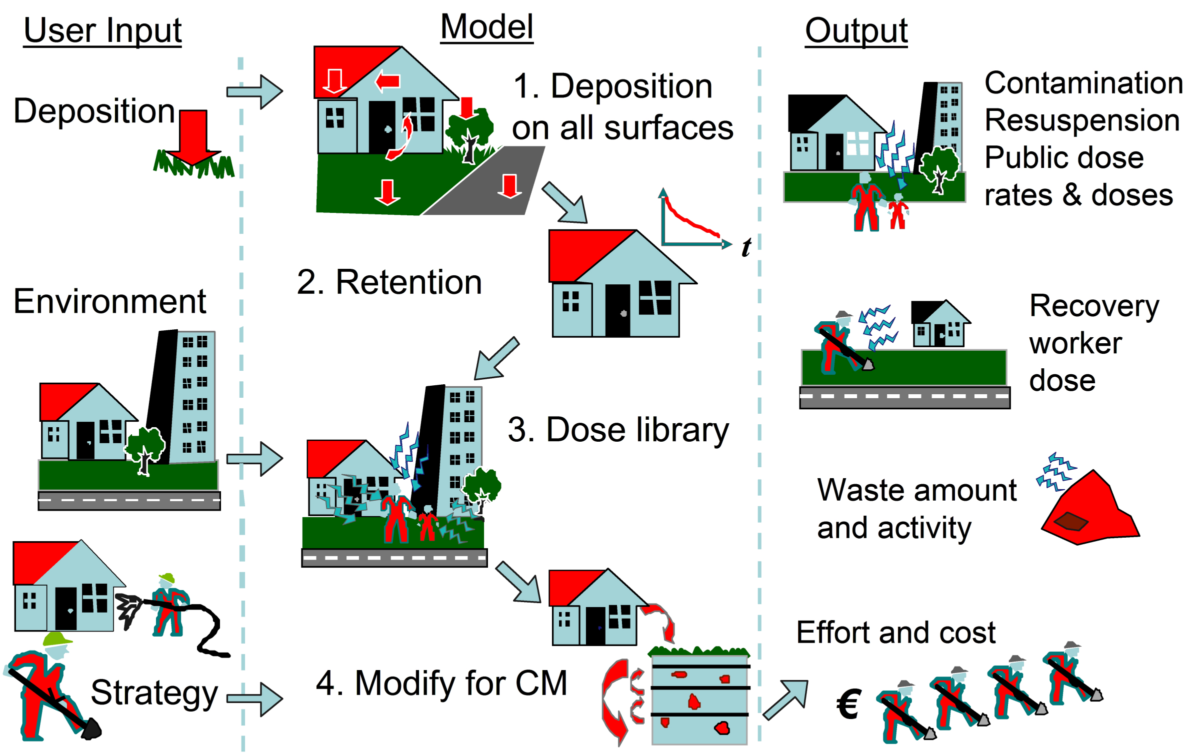

Figure 4: Overview of the Model for Inhabited Areas. "CM" designates a countermeasure strategy.

The corresponding Agricultural Countermeasure Program is concerned with the contamination of agricultural areas and food and feed stuffs. Here, the possible countermeasures range from restrictions in food marketing over removal or decontamination actions to changing agricultural practices. The model can use as input the radionuclide concentrations in the air near ground and information about the rainfall from the near or far range Atmospheric Dispersion and Deposition models, or it can work with point data about the time integrated activity in air, the activity in precipitation and the amount of rainfall from measurements in EURDEP format. The model assesses the effect of the action strategies on the food contamination and the resulting dose levels, the required resources, the associated waste and costs, and the time span during which pre-defined activity levels in food would be exceeded.

The output of both models is used to identify suitable and effective action strategies that fit with the available resources, and to optimise the timing of the actions, in a real situation as well as for planning. However, the number of possible recovery phase action strategies is usually large, and it can be difficult to identify the most suitable ones by using the results from the urban or agricultural area models alone.

For this purpose, JRodos contains an extra software package as add-on that allows to structure the problem by helping to identify, order and rank the factors that will influence the decision, see Figure 5. Objectively quantifiable factors will play a role, like "collective dose saved" or "working hours required". However, the method allows also to include subjective factors, such as the assumed public acceptance of a strategy. The factors will be given weights, such as "unimportant" or "very important". The model translates this into numbers and relations, and, by applying hierarchical decision criteria algorithms, finally produces a ranked list of the evaluated strategies.

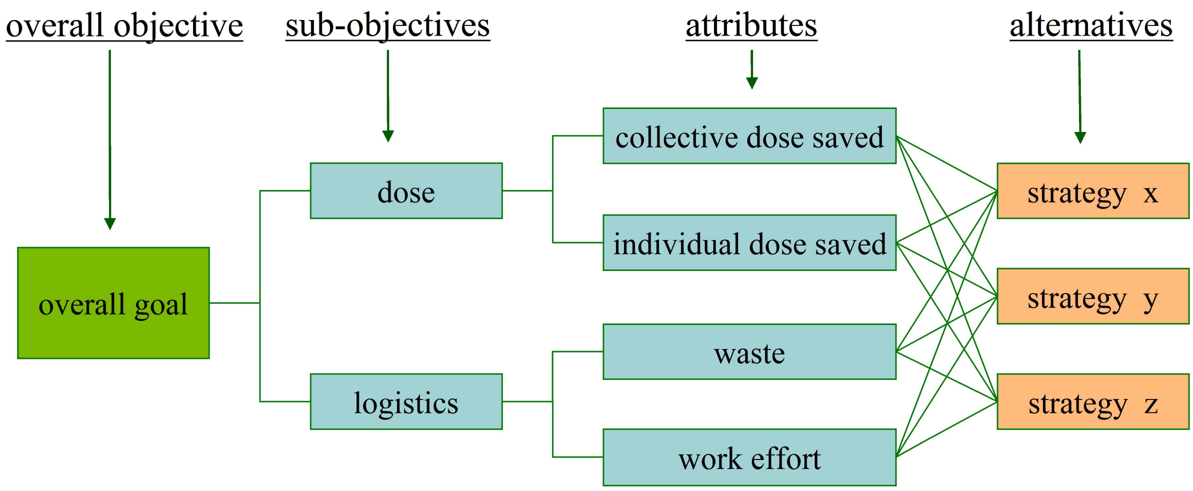

Figure 5: Evaluation of strategies: An example for a structured problem.

3.2 Models for aquatic transport and aquatic exposure pathways

The Fukushima accident demonstrated the importance of an adequate simulation capability for aquatic pathways. The JRodos package includes a comprehensive Hydrological Model Chain, see Figure 6.

The Hydrological Model Chain covers the dispersion of material released into and through most aquatic environments (rivers, reservoirs, lakes, estuaries, coastal waters, the open sea) and the transfer to various water bodies of material deposited from the atmosphere (for example, run-off from catchments). Aquatic Food Chain and Dose Models simulate the transfer of radionuclides from contaminated water and fish to man and the resulting radiation exposure. Also considered is the usage of contaminated water for drinking and watering life stock, and for irrigating crops. Recently, three models for long-term aquatic countermeasures in rivers, watersheds and lakes have been included, too.

From the models in the chain, the user can choose the ones appropriate for the environment and the radio-ecological issues at stake.

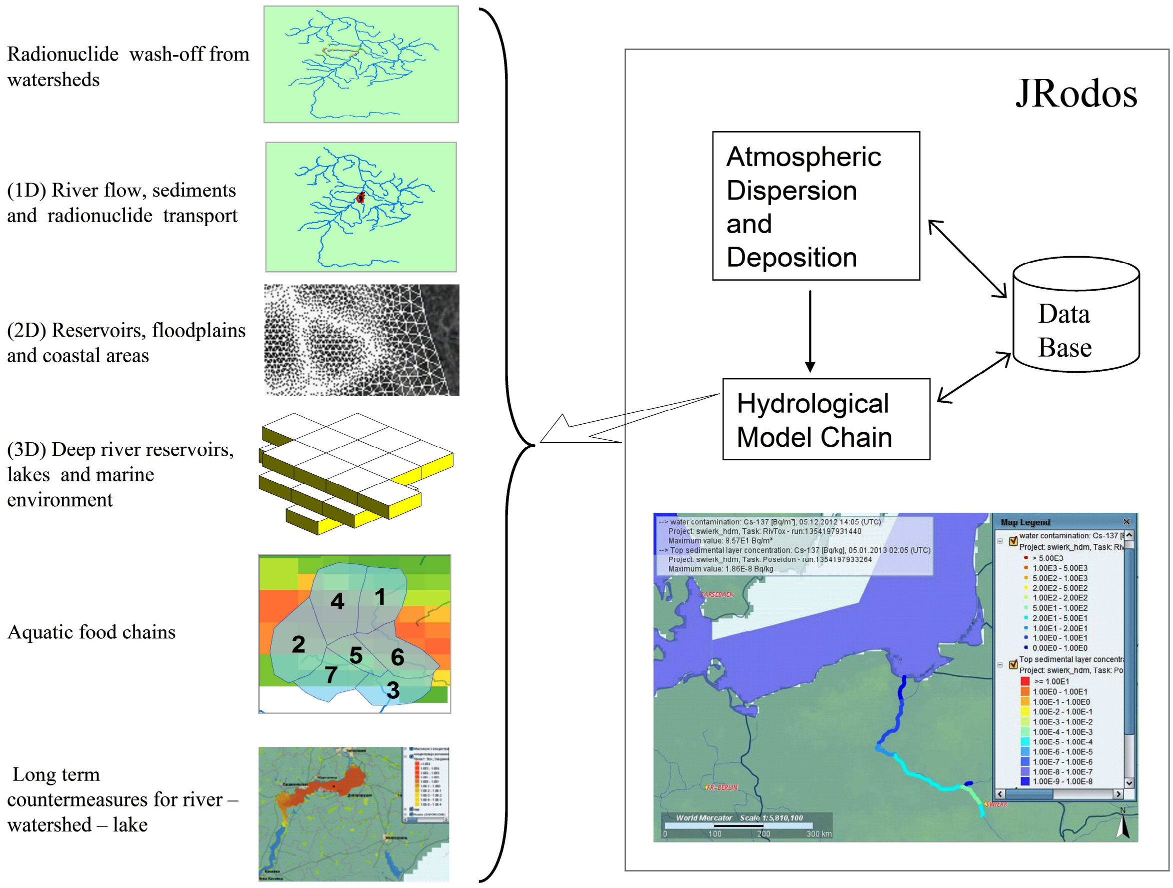

Figure 6: The JRodos hydrological model chain.

Input to the 1D, 2D, and 3D models and the Watershed model is the deposited activity calculated with the near or far range Atmospheric Dispersion and Deposition models. Data describing the discharge of contaminated water at specific locations can also be used.

The three-dimensional models for deep river reservoirs, lakes and marine environment can also use the American NOMADS[2] weather forecast data (wind, temperature etc.), and the hydrological forecast data from "MyOcean"[3] that only recently became available (currents, temperature, salinity etc.); both are publicly accessible and free of charge. This enables for the first time a combined prognosis of the atmospheric dispersion, the deposition onto land and water, and the further transport through water bodies of pollutants on the basis of forecasts from numerical models.

All aquatic models describe special environments and require customisation to the target regions for which they shall be applied. So far, selected models have been customised and applied for coastal water bodies around Fukushima in Japan, for the fresh water reservoirs around Chernobyl, the river system of the Dnieper in Ukraine, and for the Vistula river basin

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[2] www.ncep.noaa.gov
[3] http://marine.copernicus.eu/

in Poland [Zhe10]. The result example in Figure 6 shows the calculated contamination of the Vistula river after an assumed airborne release from a reactor in the region.

4 Operational aspects

4.1 The JRodos user community

JRodos is a non-commercial system and free of charge. Interested parties apply to the JRodos team at the Karlsruhe Institute of Technology (KIT).

For simply joining the community it suffices to sign a license agreement with KIT that regulates the terms of use. This grants access to the current installation package, future updates and new builds, and also supportive material like a basic training course.

A sustainable and operational application of the system may require individual support during the installation, adaptation or operation phase. This is subject of a general "RODOS Maintenance and Support Contract" between KIT and the respective user, to be signed on a year-to-year bases, from 5000 Euro upwards. The support covers help in all technical issues related to the usage of the system, the customisation and the adaptation to national conditions, including the coupling to existing external data, but not the acquisition of national data.

In 2016 there are 10 holders of such general support contract. In addition, there are a few customers with special contracts covering defined tasks and deliverables they individually order and pay for.

The RODOS User Group "RUG" promotes the use of the system. During the yearly meetings, the developers present new features and trends, users have the possibility to present their applications of and experiences with the system, and suggested modifications or extensions are discussed and ranked by the participants.

It is worth noting that within the JRodos User Group all improvements and new features become available for the whole community, even if initiated and paid for by the interest of individual users or groups.

4.2 Adaptation to user preferences and national and regional conditions

The system design supports national language customisation and offers tools to realise user preferences. Many users, for example, want to limit the visible amount of calculation results and to modify the presentation styles of calculation results and background maps.

With respect to numerical weather forecast data, several common formats are supported (e.g. GRIB1 and GRIB2, netCDF). The system foresees coupling to data from national weather services and supports the use of globally applicable weather data that are publicly available from the American NOMADS server[4].

With respect to measurements (meteorological data, source term monitor data, radiological data), currently the EURDEP format is supported[5]. The possibility to use the IRIX format[6]

[4] data from the Global Forecast Systems (GFS), cf. http://www.emc.ncep.noaa.gov/index.php?branch=GFS
[5] https://eurdep.jrc.ec.europa.eu
[6] wwwns.iaea.org/downloads/iec/info-brochures/13-27431-irix.pdf

supported by the IAEA will be developed in the frame of a recently launched European project "FAST Nuclear Emergency Tools" (FASTNET).

The default data outfit provided with the system is for use within Central Europe. A world-wide data base for general use outside Europe is also supplied. To customize the system to regional and national conditions, users can add data and maps covering their areas of interest in greater detail.

JRodos currently models 35 types of terrestrial foodstuff and 21 types of terrestrial feedstuff relevant for Europe. Recently, two varieties of rice with default parameters were included in frame of a EU supported JRodos installation in Mainland China that was completed in 2017.

Many of the radio-ecologically important factors which are expressed by parameters in the terrestrial Food Chain and Dose Model can vary significantly between different regions. Therefore, the model parameters may have to be adapted to the area for which the model will be applied. For this purpose the concept of radio-ecological regions has been introduced; they describe areas in which the model parameters are assumed to be constant. For each region the full set of parameters has to be defined for all food- and feedstuffs; the parameters are then applied for all locations within the region. The parameters encompass foodstuff related data like consumption rates or food processing factors, vegetation related data such as growing times of crops or the transfer factor soil-to-plant, and animal related data, for example typical feeding diets for domestic animals producing milk and meat. The definition of radiological regions and the acquisition of data for each region is in the responsibility of the user. Such task has been carried out e.g. for installations and applications in Ukraine, Russia, Sweden and Mainland China.

All hydrological models need individual customisation to the areas where they shall be applied; support by the development team can be given.

4.3 Required computational resources

Fully supported are the platforms Microsoft Windows and Linux, and partly Mac OS. For straightforward applications it is sufficient to use a quad core 64 bit laptop with 4 gigabyte RAM and 200 gigabyte hard drive; special applications can require more resources.

The system consists of a Server part for computations and system management, a Client part for interactions with the user, and a Data Base (PostgreSQL). The three components can reside together on one single laptop or distributed over separate machines; mixed operating systems are supported (e.g. Linux for the Server part, and Windows for the Clients).

4.4 Human resources required for JRodos in an operational emergency centre

In the following it is assumed that JRodos is operationally installed in some emergency centre, fully customised and with all data connections foreseen there.

One person, here referred to as "administrator", should be responsible for checking that the system, the computer hosts and all data transfer is up and well. The required general skill is the ability to handle computers under the operating system Windows or Linux, depending on the company policy. JRodos related tasks comprise the installation of a PostGres SQL engine and new JRodos releases or updates, and the carrying out of maintenance procedures. The administrator should have knowledge in operating JRodos that is sufficient to initiate appropriate steps for reporting system or model problems, to perform support tasks like installing a new user and taking care of user and user group settings, and to support users in

JRodos issues, in particular during customization-like tasks. All administration and maintenance tasks can be performed with the help of the system documentation and the support covered by the "RODOS Maintenance and Support Contract"; there is no necessity for dedicated courses for system administrators.

In case of an emergency, one person should be devoted to operating the basic models: the Emergency chain, the Far Range Dispersion Model and, if foreseen in the emergency centre, models in the Hydrological Model Chain. For general interaction with the JRodos user interface, the ability to work with Windows-like look and feel systems in combination with a few hours of training suffices. A basic course suitable for self-training without attending a special course can be downloaded by members of the JRodos community. Operators should train regularly by themselves to work with the models they attend to.

The operator should be complemented by a radiological expert. This person will advise the operator on the input for JRodos, interpret and comment the results produced by the system; eventually also acting as a mediator between the system and those involved in taking decisions.

In principle, the radiological advisor could also operate the system, but this is not recommendable during a real emergency. The reason is "too much stress put onto one person" on the one hand. On the other hand, part-time absence from the Centre could be required, in particular if the advisor also would act as a mediator.

An emergency centre must stay operative 24 hours a day, all year round. This means that one administrator and one operator/advisor must always be on call, be able to appear in the Emergency Centre and start working with the system within a defined time. For the German RODOS Central Installation, for example, the accepted time is 30 minutes during working hours, and 1.5 hours outside. The on-call-system and the response times have to be checked and exercised in regular intervals.

The Fukushima Daiichi accident showed that the emergency phase could last for days or weeks. This means that at least two persons per job must be available for covering 24 hours in two shifts. The people involved need to train regularly with the system to maintain their skills, but can otherwise be busy with other occupation.

4.5 Human resources required for applying the recovery phase models

The Terrestrial Food Chain and Dose Module in connection with measurements has a user interface different to the one in the Emergency model chain; however, operating that model does not require additional skills or scientific background.

The domain of the Model for Inhabited Areas and the Agricultural Countermeasure Program is the recovery phase of an accident; by design they shall assist in the analysis, planning and optimisation of late phase urban and agricultural countermeasures. They are operated interactively and iteratively to find answers to specific questions concerning how to deal with a given contamination in a specific area. Their application is not a task to be performed during an emergency. The same holds true for the software package for assisting decision makers in evaluating different measures against a range of quantitative and qualitative criteria.

Dependent on the country, separate departments may be responsible for recovery questions in urban and agricultural areas. One person each should become familiar with the topics covered by the model, and with operating the model.

5 An example application of the JRodos Emergency model chain

In the following, the JRodos user interface is illustrated by means of an example application of the so-called EmergencyLite chain that exercises the same models as the Emergency chain, but with less input possibilities.

Below, we describe a fictive Emergency Centre in the area of the German city Karlsruhe that is equipped with JRodos and takes part in an emergency exercise. The scenario assumes a hypothetical accident taking place at a (fictive) nuclear power plant, KIT-CN with location at the Karlsruhe Institute of Technology in Germany, on September 9, 2013.

For producing the screen shots, we used a general JRodos set-up for world wide applications, and re-analysis Grib2 NOMADS data that we have in our archives; they cover September 9 to 12 in 2013.

We assume that the JRodos operator has arrived at the working place and started the system. The User Interface is open, the operator just clicked on the "Create a new project" icon; the EmergencyLite chain project shall be named "DEMO", see Figure 7.

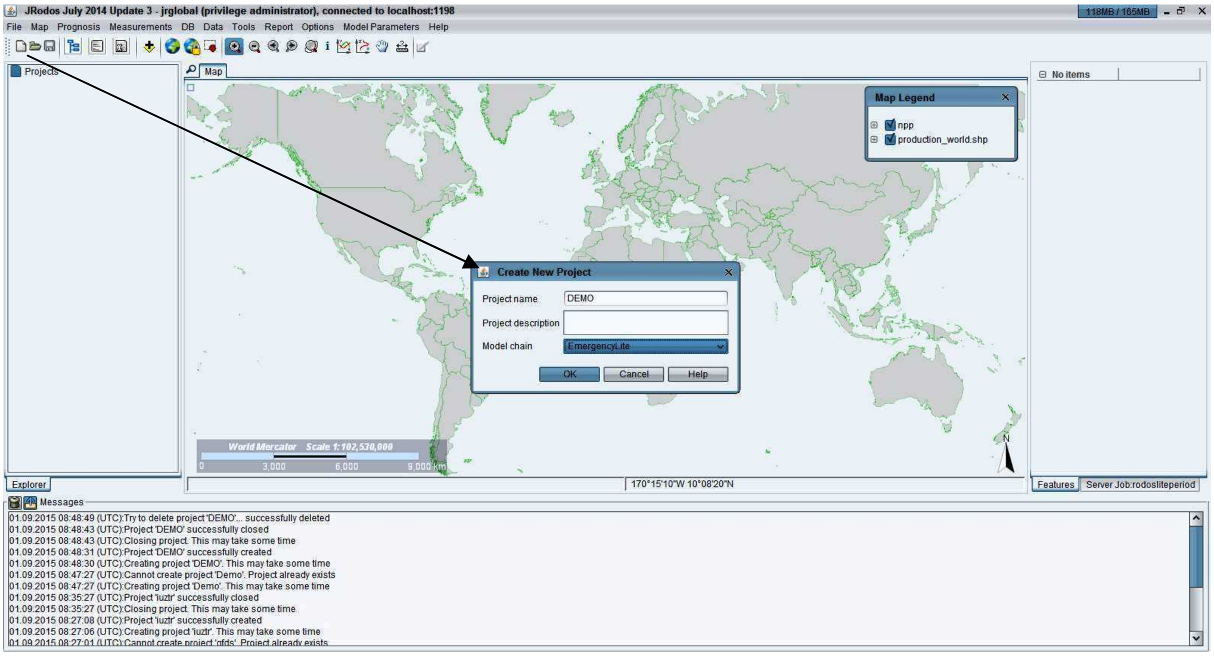

Figure 7: JRodos User Interface; creating an EmergencyLite project.

After clicking [OK], the RODOS-Lite Input Interface opens as a separate tab in the central window, and the operator must fill out a sequence of tabs before the calculation can be set on the way.

In RODOS-Lite tab "Site", the operator specifies that it is an accident in a nuclear power plant, selects from the list of countries "Germany", and then from the list of available reactors in Germany, "KIT-CN", the reactor for which the calculation shall be carried out, see Figure 8. Then, the operator clicks [OK] and is allowed to the next tab, "Source term", see Figure 9.

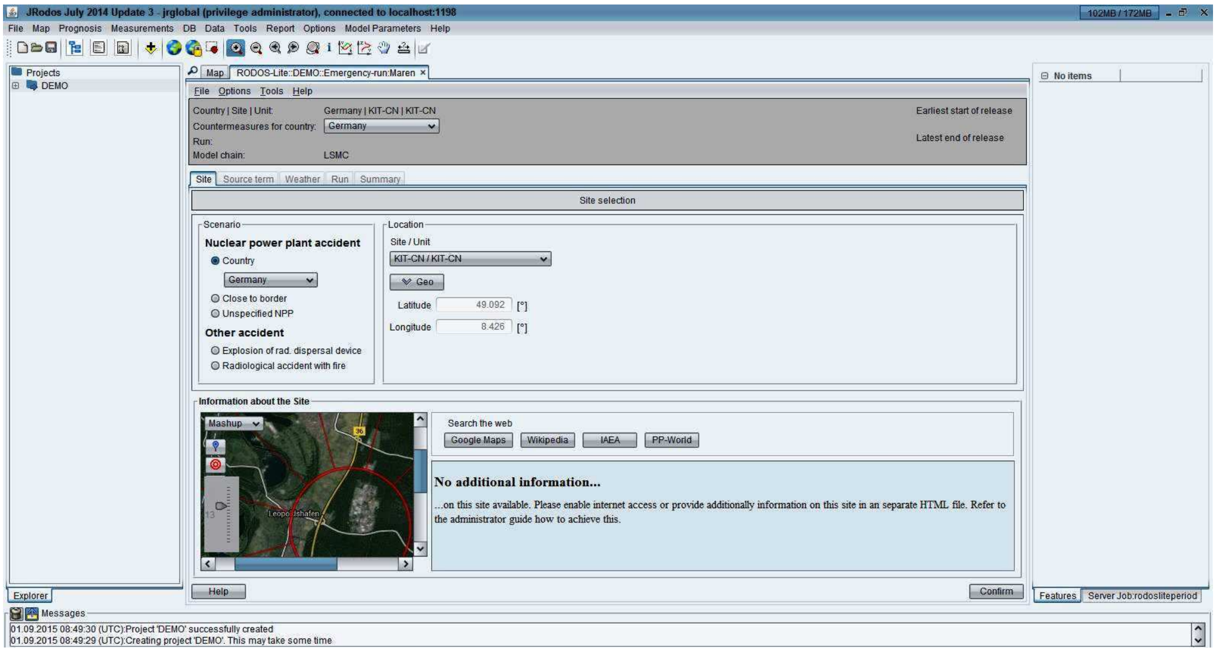

Figure 8: User input with RODOS-Lite; tab "Site".

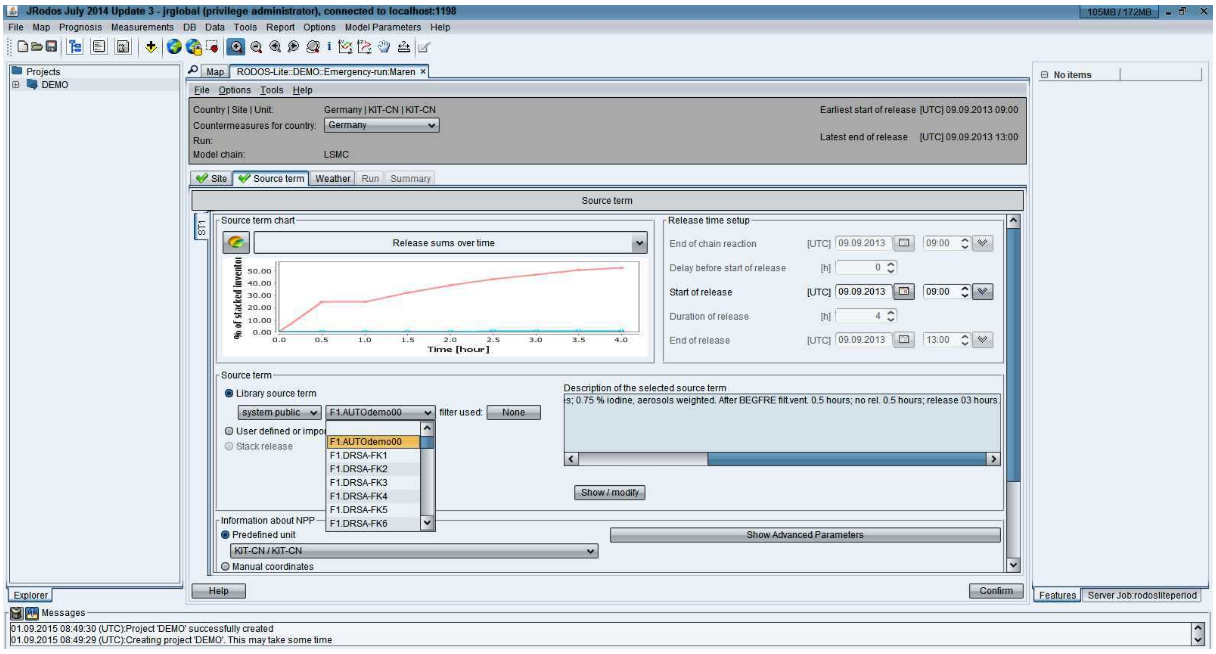

Figure 9: User input with RODOS-Lite; tab "Source term".

The radiological advisor informs the operator that - as far as the current knowledge goes - the release did start at 9:00 UTC and that the source term may resemble one contained in the JRodos "System public" source term library, "F1.AutoDemo00". In tab "Source term", the operator specifies the date and time and selects source term "F1.AutoDemo00". A descriptive text and a figure appear in the comment box and the "Source term chart" section, respectively. Then, the operator clicks [OK] and proceeds to the next tab, "Weather", Figure 10.

To give an example for the coupling to numerical weather forecast data, we assume that the Emergency Centre has installed a feature for automatically downloading NOMADS data to a suitable location accessible for the JRodos Server, because they want to be prepared to *perform atmospheric dispersion and deposition calculations for any point on the globe at any time. The JRodos system was pre-configured to use the NOMADS data during the customisation phase.*

The radiological advisor decides that for a first quick assessment it suffices to carry out a prognosis covering the first 24 hours after the begin of the release in one hour steps. In the "Weather" tab, the operator makes this specification in the "Prognosis time setup" section.

Because the system is pre-configured to use the NOMADS data, it recognises that data are present for the specified prognosis period and allows proceeding to the next tab "Run", Figure 11.

Please note, that by selecting "Measurement data", the system would start diagnostic calculations, but this would require the coupling to some on-line measurement system.

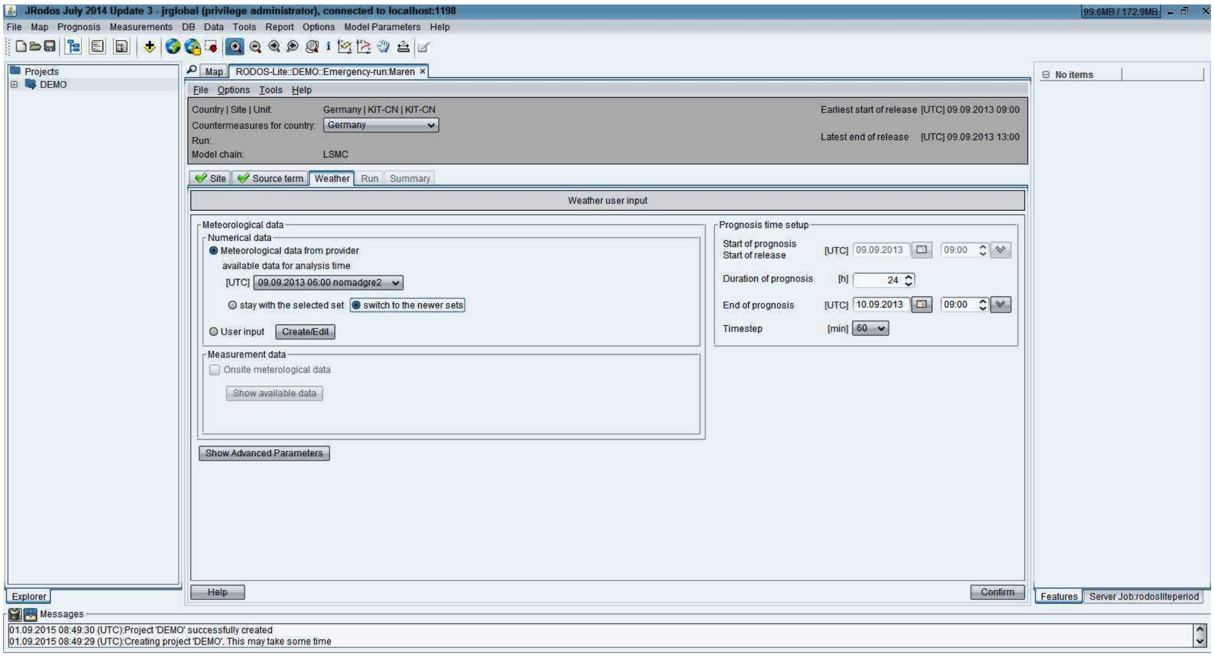

Figure 10: User input with RODOS-Lite; tab "Weather".

In the "Run" tab, the pre-setting is "Exercise", which applies here. In addition, one can select the grid type and the distance to which the calculation shall be performed. At this stage, the radiological advisor is only interested in the near range around the release point. The operator accepts the pre-configured default, "5 rings, 100 km", clicks [OK] and proceeds to the last tab, "Summary", Figure 12.

Tab "Summary", of which the screen dump shows only the uppermost part, gives a summary of the input. The operator studies the summary, and clicks on [Submit] to start the calculation.

Note 1: Before clicking [Submit], one can go back to any tab for inspection or corrections.

Note 2: All input made is saved and can be re-used for future projects.

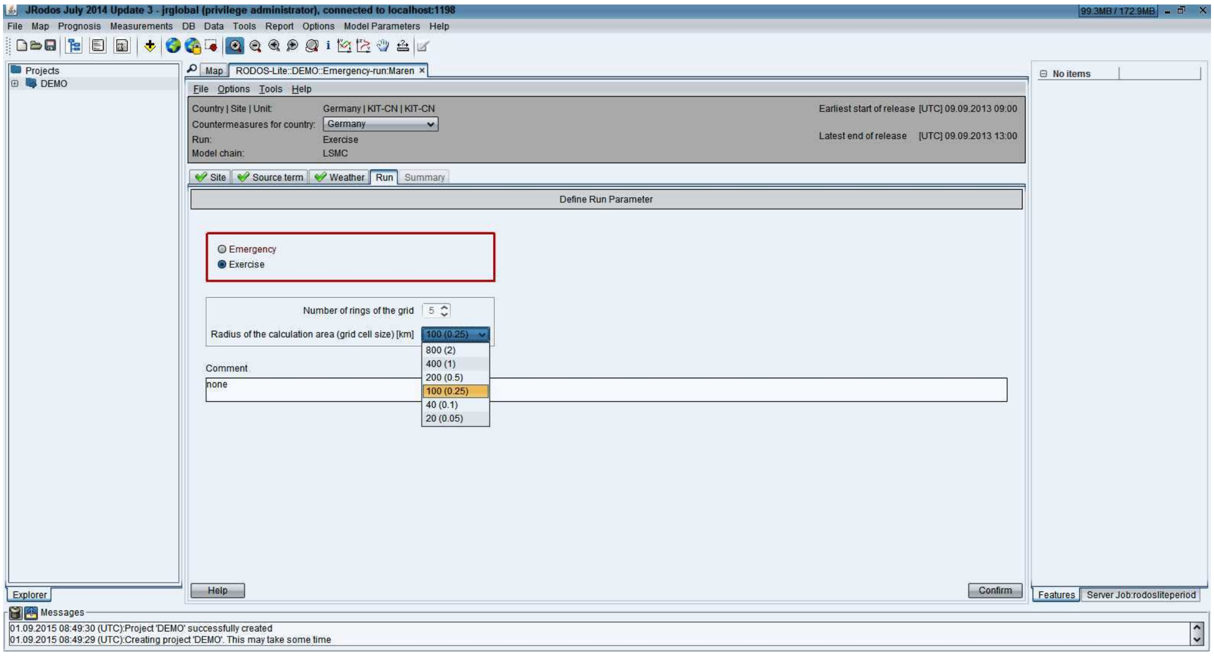

Figure 11: User input with RODOS-Lite; tab "Run".

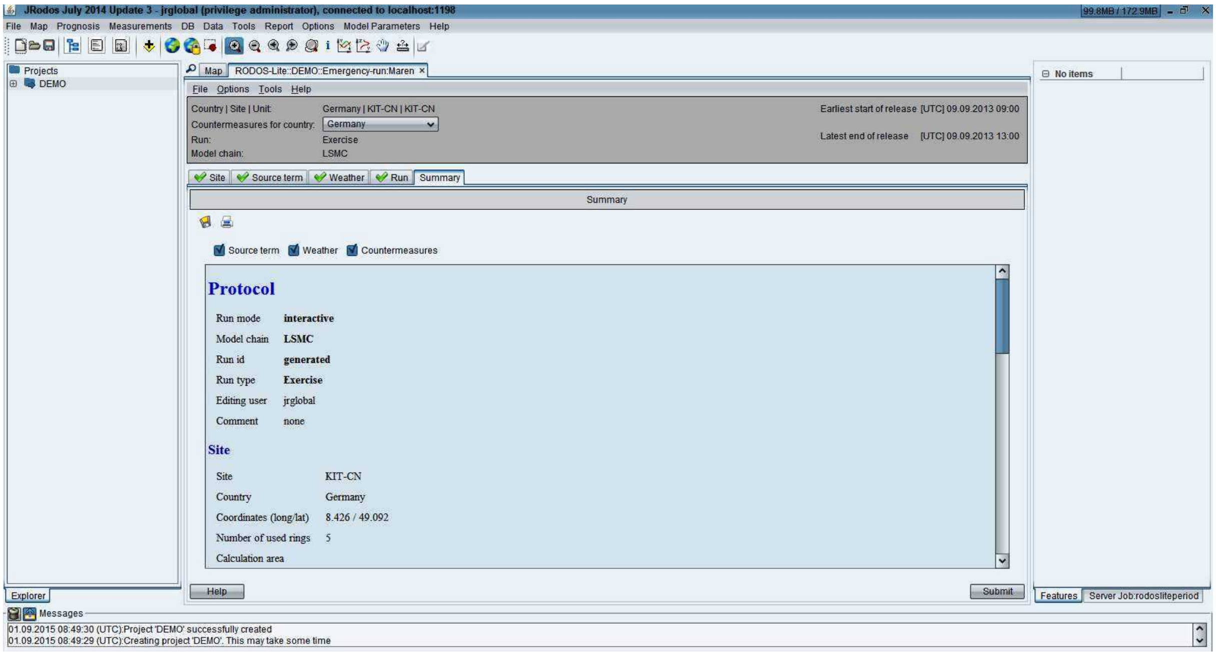

Figure 12: User input with RODOS-Lite; tab "Summary".

After submitting, prognostic calculations with the near range Atmospheric Transport and Deposition Model, the Emergency Action Simulation model and the Terrestrial Food Chain and Dose Module, are carried out one after the other, without further user interference. On the quad core notebook producing the demonstration screenshots, this took about 5 minutes.

Figure 13 shows the JRodos User Interface and illustrates the presentation of map-type results. The central "Map" tab in Figure 13 consists of one or more result and map layers. The list of all layers in the Map tab, the "Map Legend", is visible to the right. The available results are offered in form of a "Result Tree" in the "Projects" section of the user interface to the left of the Map tab.

On delivery the system contains a default set of simple maps; in addition, user-customized maps or map layers from the Internet can be used[7]. For creating Figure 13, "OpenStreetMaps" was used to provide a background - we do not have localized maps for the region.

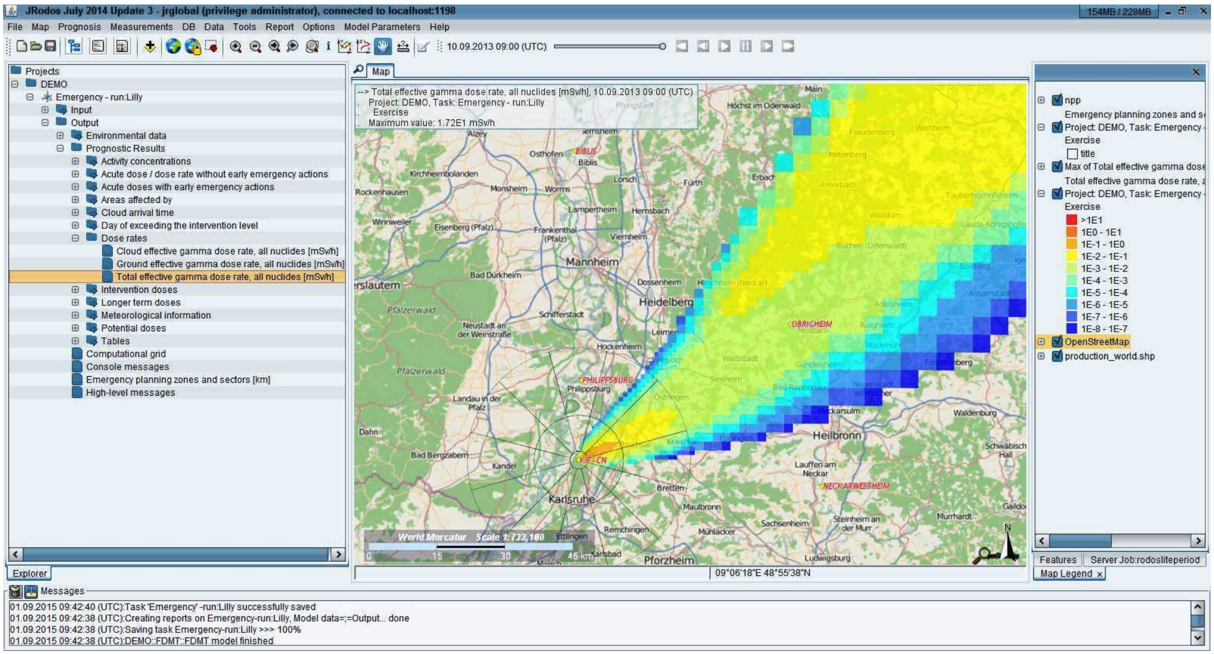

Figure 13: JRodos User Interface; presentation of a map-type result (on OpenStreetMap).

The radiological advisor usually will ask the operator to show selected results. The first one he or she may like to see is the prognosticated total effective gamma dose rate at the end of the 24 hour period.

From the "Result Tree", the operator selects "Dose rates, then "Total effective gamma doses rates, all nuclides [mSv/h]"; this is the result visible in the Map tab in Figure 13.

The "Total effective gamma doses rates" result is available for all 24 hour steps of the prognosis. The operator can use the time slider (Figure 14) to display the different time steps, step by step, or automatically like playing a video.

Figure 14: JRodos User Interface, time slider.

The JRodos Tool Bar offers - among others - several icons for functions like zooming, moving the picture, measuring distances; they are common for graphical user interfaces and not explained here.

[7] "ESRI shapefile" and "geotiff" geographic data formats is supported. Alternatively, one may use geodata from a PostGIS database or from the Web Map Service (WMS) server. The use of Google Maps (hybrid view) or OpenStreetMaps layers is also possible.

With the "Time plot builder" icon, one can construct a time graph in one or more grid points, see Figure 15.

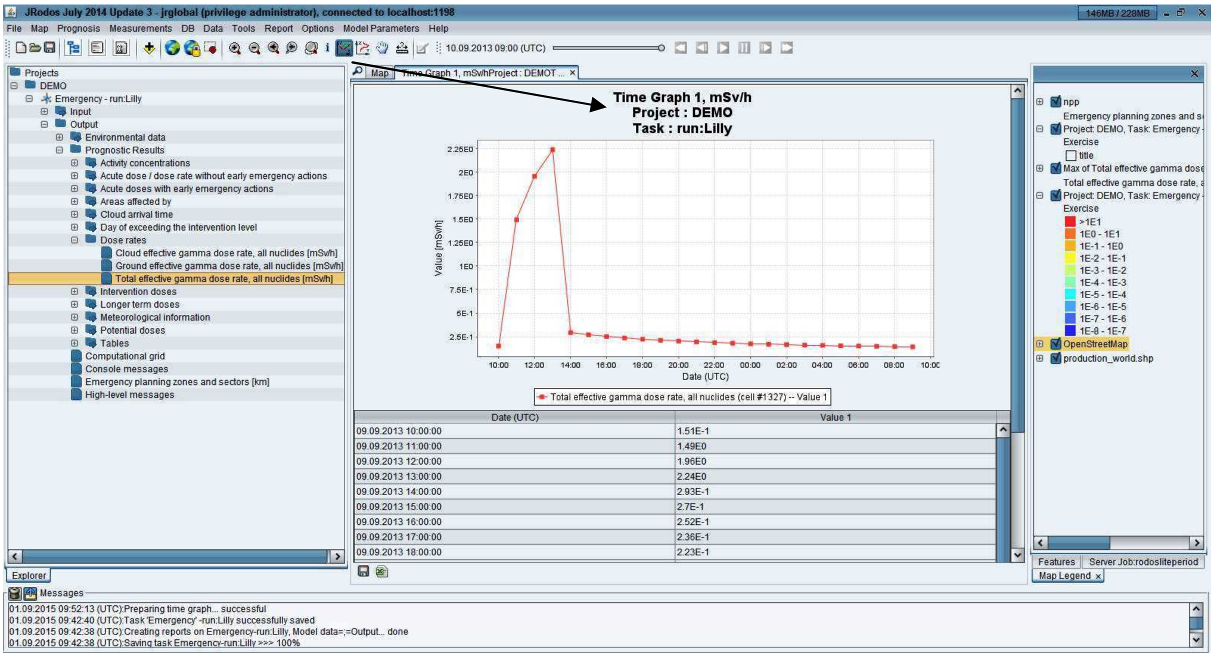

Figure 15: JRodos User Interface, time plot builder.

In a similar way, results can be displayed for all models, not only the ones in the Emergency chain. In addition, the weather data can be visualised. Figure 16 shows for example the wind field from the NOMADS data from 9.9.2013, 6:00 UTC, for the region of interest. It is also possible to visualise measurement data, if such data are implemented.

JRodos contains tools for saving the complete map view as image (static or as animated sequence for time dependent results) and for saving individual map layers as shape files. Also supported is the automatic generation of result reports, and accessing model results from a 3rd party GIS software.

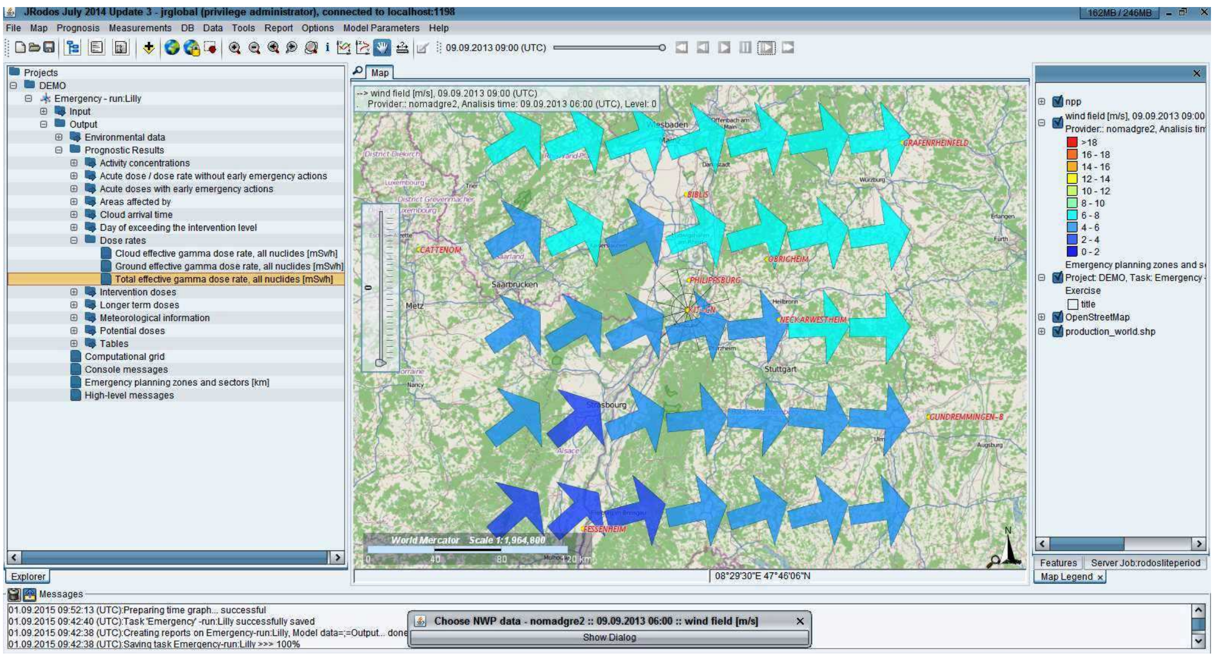

Figure 16: JRodos User Interface; displaying of prognostic wind field (on OpenStreetMap).

6 Getting more information about JRodos and related European projects

Reference [Ras10] summarizes the key results of the project "European Approach to Nuclear and Radiological Emergency Management and Rehabilitation Strategies" (EURANOS). A series of articles in this periodical are devoted to the further development of the RODOS models and system to JRodos, and one can find references to all models mentioned in the report at hand. There is free download access to all articles[8].

Reference [Dur13] presents the outcomes of the first workshop on the practical implementation of the new ICRP recommendations in frame of the "European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery" (NERIS). There is free download access to all articles[9].

References [Cla14] and [Cla16] are intended for non-experts in the field. [Cla14] describes relevant radiological phenomena, the fundamentals of radiological emergency management, the modelling of the radiological situation in computer programs in general and the JRodos models in particular. [Cla16] focuses on the current JRodos system and selected developments in the last years.

7 Summary

JRodos is a decision support system for off-site emergency management following releases of radioactive material into the environment. It contains detailed simulation models for predicting and analysing the resulting contamination, health and economic consequences. JRodos is a non-commercial system with an active user community that influences system extensions and development trends.

The default data outfit is for use in Central Europe. A world-wide data base and the supported coupling to a set of globally applicable meteorological weather forecast data allows general application for any point on the globe. Furthermore, inherent features and tools allow the adaptation of models, data bases, and the user interface to national conditions and user preferences.

The JRodos system is applied by its users in emergency centres or at national or local level as a support and training tool for emergency management including long-term rehabilitation and pre-planning, thus contributing to the improvement and harmonisation of many issues in these fields.

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8 http://www.radioprotection.org/index.php?option=com_toc&url=/articles/radiopro/abs/2010/05/contents/contents.html

9 http://www.radioprotection.org/component/solr/?task=results#!q=neris&sort=score%20desc&rows=10&e=radiopro&f=year%3A%222013%22

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10 List of figures

Figure 1: Atmospheric transport and deposition phenomena and terrestrial exposure pathways. 5

Figure 2: JRodos models and model chains and the phases they cover. 6

Figure 3: Phenomena considered in the terrestrial food chain model. 7

Figure 4: Overview of the Model for Inhabited Areas. 8

Figure 5: Evaluation of strategies: An example for a structured problem. 9

Figure 6: The JRodos hydrological model chain. 10

Figure 7: JRodos User Interface; creating an EmergencyLite project. 14

Figure 8: User input with RODOS-Lite; tab "Site". 15

Figure 9: User input with RODOS-Lite; tab "Source term". 15

Figure 10: User input with RODOS-Lite; tab "Weather". 16

Figure 11: User input with RODOS-Lite; tab "Run". 17

Figure 12: User input with RODOS-Lite; tab "Summary". 17

Figure 13: JRodos User Interface; presentation of a map-type result (on OpenStreetMap). ... 18
Figure 14: JRodos User Interface, time slider. ... 18
Figure 15: JRodos User Interface, time plot builder. ... 19
Figure 16: JRodos User Interface; displaying of prognostic wind field (on OpenStreetMap). 19

11 List of acronyms and denotations

Esri Shapefile	see shapefile -
EU	European Union
EURANOS	European Approach to Nuclear and Radiological Emergency Management and Rehabilitation Strategies
EURDEP	European Radiological Data Exchange Platform
FASTNET	FAST Nuclear Emergency Tools
geotiff	Public domain metadata standard which allows geo-referencing information to be embedded within a tagged image file format (tiff) File
GIS	Geographic Information System
GRIB	GRIdded Binary or General Regularly-distributed Information in Binary form, a concise data format commonly used in meteorology to store historical and forecast weather data
h	hour (physical unit)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IRIX	International Radiological Information Exchange
JRodos	Java Version of RODOS
KIT	Karlsruhe Institute of Technology
mSv	milli-Sievert (physical unit)
NERIS	European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery (http://www.eu-neris.net/)
NetCDF	Network Common Data Form, a set of machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data
NOMADS	National Oceanic and Atmospheric Administration (NOAA) Operational Model Archive and Distribution System (www.ncep.noaa.gov)
PostgreSQL	An object-relational database management system
RAM	Random Access Memory
RODOS	Real-time On-line Decision Support System
RUG	RODOS User Group
shapefile	The shapefile format is a digital vector storage format for storing geometric location and associated attribute information.
tab	Tabbed document interface ("tabbed browsing"), in a web browser, tabs divide open pages displayed in a single window
UTC	Coordinated Universal Time (Fr. Temps Universel Coordonné)
WMS	Web Map Service