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RECENT DEVELOPMENTS OF DECISION SUPPORT SYSTEM RODOS. APPLICATION FOR FUKUSHIMA ACCIDENT

Ie. Ievdin*, D. Trybushnyi**, I. Kovalets*, S. Didkivska*, M. Zheleznyak*
*Institute of Mathematical Machine and System Problems NAS of Ukraine,
**Karlsruhe Institute of Technology, Germany
e-mail: Dmytro.Trybushnyi@kit.edu

INTRODUCTION

11th of March 2011 a disastrous 8.3 point earthquake hit Japan. Immediately after the main event the heaviest recorded tsunami crushed Japanese eastern coast, leaving Fukushima nuclear power plant without its cooling system. Due to this a partial fuel meltdown happened followed by a long release lasting at least for several weeks.

Within a week after the event, the redesigned European decision support system for nuclear emergencies JRodos [1-2] has been customized for the use in Japan. The system showed its high flexibility proving the effectiveness of the concept and implementation.

CUSTOMIZATION DETAILS

The JRodos system is designed to provide decision support when nuclear emergencies happen on different locations of the world not necessarily within Europe. For the first phase after the accident the atmospheric dispersion modelling and early countermeasures simulation are the most important runs giving an estimate on consequences. Two models integrated into JRodos system LSMC and EMERSIM are responsible for the calculation of nuclear release atmospheric dispersion with estimation of potential doses and early countermeasures effectiveness (evacuation, relocation, distribution of iodine tablets). These models require a set of geographical data and actual numerical weather prediction data, where the latter should be updated regularly.

Geographical input needed by the models was created from a free public data. This includes digital elevation map 1km*1km, landuse 1km*1km, soil data and population density from year 2000. All the four maps were created as uncompressed GeoTIFF files using ArcGIS 9.0 software [3] and uploaded to the JRodos system using the documented functionality.

The regularly updated numerical meteorological forecast data has been suggested by the two sources:

- Institute for Meteorology and Climate Research Atmospheric Environmental Research (IMK-IFU) – part of Karlsruhe Institue of Technology (KIT);
- Institute of Mathematical Machines and System Problems (IMMSP), Environmental Modelling Department.

Both organizations use mesoscale numerical weather prediction system WRF [4] as a Meteorological software, reading boundary and initial conditions data of Global Forecast Model from a US public ftp. The data is provided by National Centers for Environmental Prediction (NCEP) [5].

Setup of WRF model in IMMSP was done from scratch, using the default model parameters configuration. The model domain has been selected to cover Japan and adjacent areas: 1500km*1500km, latitude-longitude projection with a grid cell of a size 0.1*0.1 decimal degree. The WRF model from IMK has a domain 1500km*1000km.

Both sources provided prognosis data for duration of at least 72 hours with one hour time step and 6 hours update period between two analysis times.

Initially the 1.0 degree resolution initial and boundary conditions from the Global Forecast System (GFS) operated by US National Center for Environmental Prediction (NCEP) were used by WRF-IMMSP. At the same time WRF-IMK used 0.5 degree resolution also from

GFS. Later WRF-IMMSP also moved towards reading 0.5 degree data as this suggested more detailed starting meteorological fields.

A standard WRF model output is produced in the form of binary NetCDF files [6]. Before the accident only a special ASCII or GRIB1 data could be used as the source for numerical weather prediction data. Following the WRF demands a special parser has been created based on the open source NetCDF Java library [6]. Due to the extendable architecture of the JRodos system the creation of a NetCDF parser was the only required step to digest WRF output. Now the corresponding parsers digest the data transparently in ASCII, NetCDF or GRIB1 format and save the meteorological field information to the JRodos NWP database. Later the data is queried from the database and used in the calculations.

On Figure 1 a map representing wind field at 10 meters in Fukushima region is visualized. Data are queried from JRodos database, where it is parsed from NetCDF files earlier.

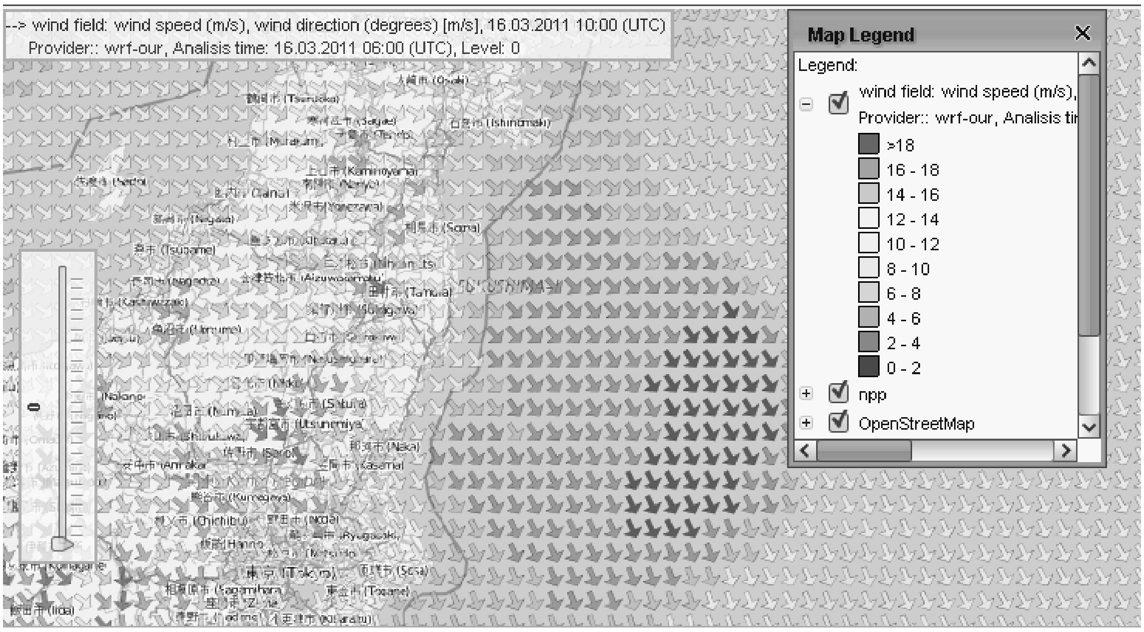

Figure 1. Visualization of numerical weather prediction data from WRF:
wind field at 10m near Fukushima

In order to provide fast and easy representation of the time dependent results for reports, meetings, or publishing on web pages, a functionality of creating animated GIF files was implemented on the client side of the JRodos system. A user can specify background map layers, zoom level and time-dependent field on the Map tab of the user interface (e.g. a calculated result of meteorological data). The GIF creator automatically moves the time slider and each step makes a snapshot of the Map. The advantage of such an approach is its WYSIWYG property (what you see is what you get).

The customized and updated version of the JRodos system was distributed among the interested users who then highly appreciated the improvements and new features. Karlsruhe Institute of Technology is using the improved JRodos customized for Japan for producing daily prognosis maps of a tracer source-term. The results are put on the web server [7] together with analysis of the models from JRodos system, update on the current state of the reactor, sourceterm estimation (if available) etc.

The map tab displaying one of the simulation results is presented on Figure 2.

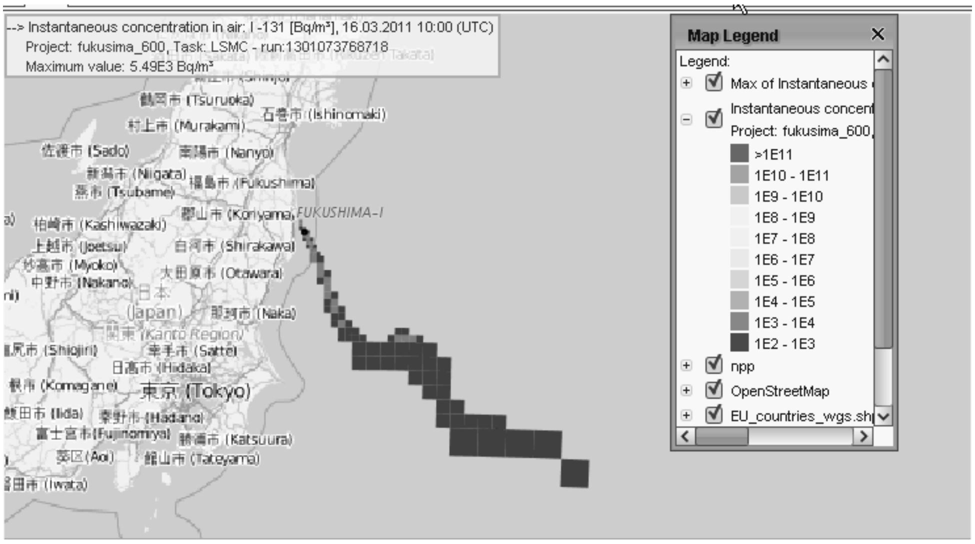

Figure 2. Map tab displaying instantaneous concentration of I-131 in air with OpenStreetMap background

RESULTS

As it usually appears during heavy nuclear accidents in early phase the uncertainty in source term dominates all other sources of uncertainties. Therefore it is very difficult to provide reliable forecasts of nuclear dispersion and fallout. In such a case the conservative estimates should be made on the basis of available information. Following expert estimates provided by some nuclear agencies (e.g. http://www.dw-world.de/dw/article/0,,14938445,00.html) the conservative estimates of the Fukushima source term was 20% of Chernobyl source term with respect to I-131 and 20 to 60% of the Chernobyl source term with respect to Cs-137. Those estimates are mostly related to the 16th of March and the following days when partial fuel meltdown occurred. Fortunately during those days the wind dispersed radioactivity mainly to the ocean (Figure 2). However due to high risk of the new accidents the same values of source term were used by many groups as to provide forecast of atmospheric dispersion following hypothetical accident. The same approach was used also with JRodos.

Figures 3 and 4 shows the consequences of such hypothetical release scenario of $3*10^{16}$ Bq of Cs-137 and $3*10^{17}$ Bq of I-131 during 1-3 April 2011. The wind transported a radioactive cloud to the south in direction of Tokyo (Figure 3). However the predicted countermeasure involved mainly iodine tablets for children (Figure 4) and those countermeasures didn't reach Tokyo. The region of iodine tablets for adults was much less (not shown) and spread up to 50 km from reactor to the south.

CONCLUSIONS

Modelling Fukushima nuclear release proved flexibility of the JRodos architecture and implementation, allowing fast customization to a new geographical location and creation of additional system components to support a new type of binary input data (NetCDF). The new features are highly appreciated by the JRodos Users community (e.g. CIEMAT, Spain; RIVM, the Netherlands; Umwelbundesamt, Austria).

Application of JRodos to Fukushima accident allowed providing conservative forecasts of atmospheric dispersion based on operational numerical weather prediction data. Even with conservative source term estimates the obtained countermeasures were mainly iodine tablets for children. The region of countermeasures didn't reach Tokyo for one of the worst meteorological scenarios of 1-3 April 2011 when wind was blowing to the south.

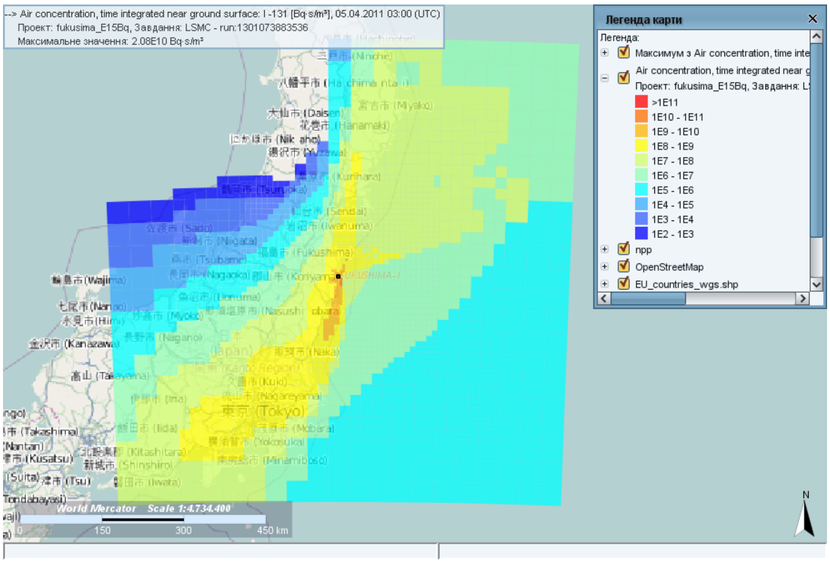

Figure 3. Time integral concentration near ground surface of I-131 following hypothetical release scenario and meteorological scenario of 1-3 April 2011

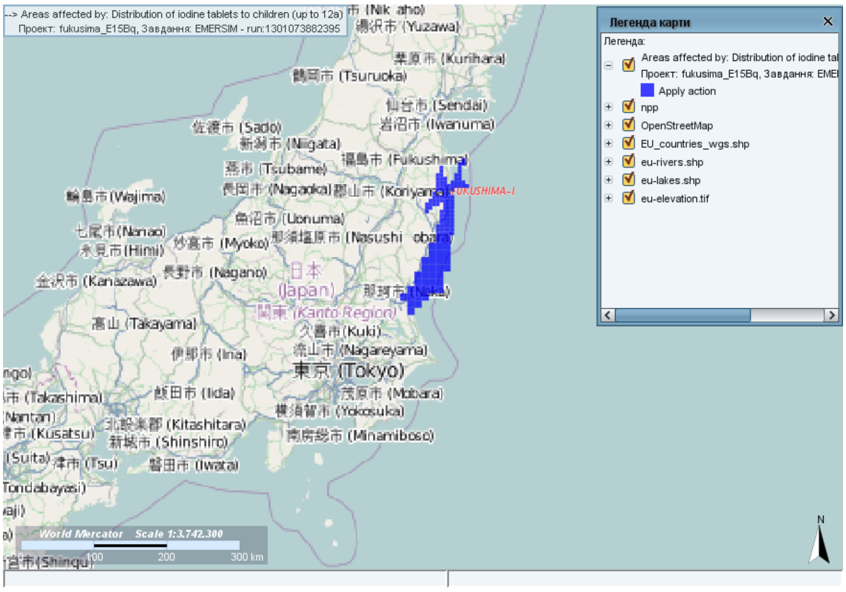

Figure 4. Region of iodine tablets application for children following hypothetical release scenario and meteorological scenario of 1-3 April 2011

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