Preparation of RODOS System for the Accreditation Procedure for its Use in the Czech Republic

F I N A L V e r s i o n

RODOS REPORT

DECISION SUPPORT FOR NUCLEAR EMERGENCIES

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Preparation of RODOS system for the Accreditation Procedure for its use in the Czech Republic

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Management Summary

The report describes the reasons and requirements for RODOS accreditation in the Czech Republic, status of its internal quality assurance procedures and the local quality assurance activities performed during customisation process. Part of the results of calculations according to RODOS product are presented here for both obligatory validation tasks defined by the Czech Accreditation Board.

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1 Introduction

The Atomic Law accepted by the Czech government in 1997 year [1] strictly defines regulations related to utilisation of software in the field of nuclear safety. For the codes used for assessment of nuclear or radiation safety of nuclear facilities the State Office for Nuclear Safety (SONS) requires evaluation of these codes in compliance with the VDS 030 [3]. The guideline supersedes the former so-called „Standardisation“ process.

A committee on „Standardisation of computational programs for nuclear safety“ has been established by SONS and operates under SONS supervision. The accreditation commission team consists of experts from various institutions - State Office for Nuclear Safety, State Institute of Radiation Protection, Nuclear Research Institute Rez, SKODA Plzen, NPP Dukovany and Temelin, Energoprojekt Praha, Czech Technical University, etc.

The standards for evaluation of quality of computer codes for the assessment of nuclear safety are overviewed. The conditions and requirements for accreditation of a software package following the national governmental regulations are mentioned. Intrinsic Q/A features applied during the RODOS development are pointed out in the following paragraphs. Attention to the local quality assurance process applied during the further RODOS customisation for the Czech territory is described.

Local quality assurance process is realised in the three steps:

- Screening of the local data and its purification and verification during the first stage of data collection
- Processing of the data to the format required by the various RODOS modules including reconstruction of some important missing values or its recalculation to the fine spatial grid
- Running of the obligatory validation tasks defined by the Czech accreditation board, comparison of the results among other codes being validated by the similar way

2 Standards for Evaluation of Quality of Calculation Codes for the Assessment of Nuclear Safety

For definition of mandatory rules for quality evaluation in the Czech Republic the following standards are taken into account:

ISO 9001 - Quality assurance systems - Model of quality assurance of products during their design, production, operation and service

ISO/IEC 9126 - Information technology - Software product evaluation - Quality characteristics and guidelines for their use (1991). Czech equiv. standard: CSN 36 9020.

VDS 030 - Guidelines for the evaluation of the calculation codes for the nuclear safety assessment. *Guidelines of State Office for Nuclear Safety from 25.6.1996*

ISO/IEC 12119 - Information technology - „Software Packages - Quality Requirement and Testing“. Czech equiv. standard: CSN ISO / IEC 12119.

3 The accreditation process

For all codes used for assessment of nuclear or radiation safety of NPP the State Office for Nuclear Safety requires evaluation of these codes in compliance with the VDS 030 Guideline [3]. The evaluation process supersedes the former so-called „Standardisation“. Executive organ for the evaluation is accreditation commission team, which supervises the introduction of the defined obligatory regulations for the accreditation procedure, appoints reviewers for judgement and defines and approves validation tasks. The commission can make a decision on application of a shortened accreditation procedure for those foreign codes provided that an appropriate foreign state supervisor has already accepted the codes. For each particular case the commission states all types of necessary documents which must be submitted and tasks which must be done.

The main activities of the accreditation commission consist of:

- collection of up-to-date information about SW packages including foreign codes and maintain latest knowledge in the field
- selection of proper codes for evaluation procedures
- decision about type of procedure of evaluation (full or shortened for outstanding foreign codes being commonly accepted)
- check the completeness of delivered documentation
- appointment of reviewers
- realisation of the validation sessions
- elaboration of conclusions and recommendations
- delivery of all results of the procedure to the SONS

The codes standardised in the past will be re-evaluated or excluded from the system of evaluated codes (software packages). Inclusion of a code in the system of evaluated codes will be reviewed after 3 years.

By evaluating software packages by expert evaluation commissions the State Office for Nuclear Safety does not assume legal responsibility of the authorship organisation for code and its quality.

4 Conditions and requirements for submition of software packages for nuclear safety assessment to evaluating procedure

State Office for Nuclear Safety is governmental regulatory body, which is responsible for radiation protection of population. According to its philosophy corresponding regulations are declared, which are mandatory for each organisation dealing with nuclear research and engineering. SONS follows the standards [5, 6], which are used in their Czech modifications CSN 36 9020 and CSN ISO / IEC 12119. On the basis of the standards the SONS prepared the Guideline VDS030 [3] where all necessary procedures for SW packages used in the field of nuclear safety are defined. The following documents are required for the inclusion of foreign codes into the list of evaluated software packages:

1. Code abstract containing summary data about the code

2. Quality assurance document - declaration of the company that the presented software package complies with the Quality Assurance Program having been introduced in the company in accordance with the valid standards

3. Proof of legal obtaining of the code

4. Letter of the authorship organisation's agreement with the application for including the code into the list of evaluated software packages in the Czech Republic.

5. For the foreign code proof of permission issued by the supervisory body from the country of origin to use the package for nuclear safety assessment in case of „ the shortened procedure" of codes evaluation. A decision on the use of the shortened procedure for foreign codes is made by an expert's commission provided that these codes have already been accepted by an appropriate foreign state supervisor

6. Required documentation to be submitted will include the existing original documents (in Slovak, English or Russian) supplemented with:

- an annotation,
- letter of agreement of the supervisory body of the country of the adopted software package origin,
- checkout of test tasks and
- a possible specific application

7. Technical Report on the Software Package has to include:

- Introduction - overview and present state of solution of the given problems in the world with specifying particular relations to software packages and experiments; determination of the application area of the presented software package

- Physical Model - a detailed description of the physical model with specifying and discussing all applied assumptions and limitations

- Numerical Model - description of the used mathematical model with compatibility analysis and verification of numerical process convergence and stability

- Software Package
  - a short characterisation of SW package (computer requirements, computer type and configuration, programming language, structure, memory requirements, computing speed, etc.);
  - comparison of SW package with current notable codes;
  - indication of further possible SW development and adequate improvement

- Testing of code - computation results - a report containing results of SW package testing based on experimental, operational or other accepted referential data or a comparison with other SW packages of the same category

- Input data maintenance and actualisation

- Users Guide - instructions for the use of SW package.

5 Overall Quality Assurance process within the RODOS development

Quality assurance (QA) procedures have been introduced into RODOS in the same beginning of its development. Working group no. 1 relates directly to system development and quality assurance. QA procedures are to be inherently contained in all other working groups during process of RODOS development and its customisation. Professor Simon French such a working group leader (WGL5, WGL6) and his colleagues have exerted a great effort so that QA culture has permeated the project. All contractors have realised the significance of the QA process and they are adopting the inner QA RODOS instructions in spite of different culture in each institute and lack of manpower and time. The problem cannot be postponed until the end of the project.

RODOS QA team supervises the inclusion of quality assurance procedures into all parts of the project. It covers the wide range of activities from selection of the latest up-to-date methodology, model development, coding and code verification and its testing, model validation, to declaration of a proper unified housestyle of all RODOS documents. A survey of current QA practices has been performed on the basis of QA questionnaire followed up by individual personal discussion with the aim to pay more attention to QA process.

Quality procedures in the broader sense should hit process of development at all levels. Corresponding methods are selected on the basis of profound analysis of the latest state of knowledge. Advanced structure of the RODOS system provides support for different levels of accident having broad-range character from simple reports (regularly issued during monitoring of normal operation on decision level 0) and analysis and prediction of the current and future radiological situation (decision level 1) to a simulation of potential countermeasures (level 2) and detailed evaluation of the benefits and disadvantages of various countermeasure strategies in early and late stages of accident (level 3). RODOS consists of three types of subsystems:

- Analysing Subsystem: Processes incoming data and forecasts areas of contamination including temporal variations
- Countermeasure Subsystem: Suggests possible countermeasures, checks them for feasibility, and calculates their expected benefit
- Evaluation subsystem: Ranks countermeasures strategies according to their potential benefit and preference weights provided by the decision makers

The outstanding feature of the RODOS architecture is utilisation of data assimilation and uncertainty handling techniques. Each subsystem includes a certain number of data assimilation modules, which enable to reduce uncertainties of predictions. Model prediction is compared against online monitoring data and, therefore, a combination of model predictions and measurements lead to reduction of uncertainty in the final results. Both measurement and model predictions are complementary and their combination substantially increases the reliability of results.

Data assimilation techniques together with uncertainty handling have been introduced into all main parts of the system. In early stage of release the results from atmospheric dispersion modules are evaluated in the light of the incoming data and eventually modified or even replaced by direct measurements of air concentration of radionuclides (Atmospheric Monitoring Module). In the next step, predicted activity deposition to surfaces with different roughness is evaluated and improved using measurements of surface contamination and gamma dose rates (Deposition Monitoring Module). Then the model predictions of the radionuclides transfer through food chain is tested and improved by measurements of activity concentrations in foodstaffs and feedstuffs. The introduction of the data assimilation techniques into atmospheric, hydrological and food chain models are documented in particular RODOS reports (for example [ROD7 - ROD12]).

Significant application of the Bayesian approach to data assimilation and uncertainty handling for RIMPUFF (Lagrangian mesoscale atmospheric dispersion model) is described in [ROD7]. Its original deterministic version calculates prediction on the model parameters only, without taking into account any measurement. More recently, the model has incorporated Bayesian algorithms to update its predictions in the light of observations taken at certain detector points. The uncertainties associated with various model parameters (source term composition and time behaviour, deposition rates, weather conditions, measurement errors etc) enter into the model by assigning distributions to these parameters. The distributions are updated when new data arrives, so that more accurate forecasts can be made.

A great deal of uncertainty is inherent in managing a nuclear accident. Then, the design of RODOS is based upon the use of probabilistic methods to model uncertainty and Bayesian statistical methods to update these probabilities in the light of data. The same methodology is used for decision analysis, where the Bayesian methods provide a consistent approach resulted from combination of information from all sources (some inputs derived from expert judgement are just another source of data for decision).

When we return to the phase of coding the code have to be verified in order to produce not only correct results but also so that the coding culture ensured easy future upgrade and maintenance. Professor French [ROD3] has introduced specific meaning for phase of validation which is something more than only software verification. Code verification checks whether the system calculates and presents accurately what it was designed to do. Validation does more than that, it checks that something useful is done. Here are some questions raised in [ROD5], that are to be addressed in the validation process of RODOS:

- What outputs from RODOS the decision makers want?
- What outputs from RODOS should the decision makers want?
- Do the decision makers understand the outputs?
- How timely is the support?
- Is it possible to obtain the data?
- Do the decision makers trust the results of system?
- Is RODOS consistent, complete and flexible - to what tasks is it suited?

Each individual developer, although may not be able to address all the issues, follows the steps leading to a better decision support.

As for code verification, current approach of the procedure includes:

- preparing a set of guidelines on coding standards
- setting up procedures by which software may be submitted for checking and analysis
- suggesting schemes of program testing
- suggesting methods by which the different versions of model can be tracked and recorded

During static testing of the code its source form is tested. RODOS is setting up a service, known as QA Facility, whereby contractors can submit their software for static testing via Internet. Report [ROD2] summarises the results of use of QA Facility provided at Imperial College for RODOS project.

Version control means both tracking the development and controlling releases. When code is changed during its development, some records should be kept what was modifies and by whom. The modification records are documented. Version control keeps track of version capabilities and differences from previous releases.

Interim review of status of QA process within RODOS development was done in [ROD6]. All contractors were approached with a questionnaire about the status of their QA procedures and practices. The questions were grouped under four main target QA issues:

1. ***Model verification***: The intention is to produce code that is correct, tested, and maintainable, in that any programmer can look at the code and understand it without too much effort. Ideal recommended activity in this fields includes:

- Utilisation of the Imperial College QA Facility to check the code
- Full implementation of own in-house QA procedures in a particular contractor institute (ISO standards)
- Additional utilisation of source code control systems, such as SCCS or RCS
- Archivation of all released versions of programs for purposes of version recreation, if needed
- Code tests to destruction, i.e. with extreme, silly, or missing data

2. ***Model validation***: Purpose is to demonstrate that the models represent the real world, and to gain confidence in the output of the models. Attention should be concentrated to the following main issues:

- Input data sets should be quality-controlled at the time of collection. If sufficient data are available, scientific methods of calibration, followed by blind validation are used. Sparse data can be extended by simulation or reconstruction from other available primary databases. Sensitivity studies should be carry out in order to assess the effect of perturbation or inaccuracies in the input data
- Implemented models have to be reviewed by presentation or publication

- All contractors have cross - compared their results with other models, where possible. Many contractors have taken part in international exercises (BIOMOVS, VAMP, ...)

3. ***Usefulness to decision makers*** : The intention is to support a coherent decision making. The output from the models must be useful to the decision maker, trustworthy, and easy to understand. The developer of models should concentrate on the following topics:

- Possibility of running the model in real time. The goal should not be achieved as a result of unacceptable simplifications or by omitting data assimilation techniques. On the other hand it is more important (at least in the early stages of accident) to have timely output than over-detailed model. Decision maker will want crude but quick answer with guidance on the uncertainty, rather than precise answers to detailed questions resulting from time-consuming calculations.
- Robustness of models against inaccurate or missing data. Sensitivity studies should prove the fact, models have to be supplied by robust default data
- Model outputs have to be targeted to users needs. Usefulness of model output for decision maker should be proved on the basis of close contacts with decision makers (during decision conferences, emergency exercises, interactive demonstrations)

4. ***Documentation:*** The intention is to demonstrate a quality audit of the project, and to prevent ideas and information disappearing when people leave. The following documentation is required:

- Model description
- Functional specification
- Interface definitions
- Test plans and results
- Users manuals
- Programmers manuals

The RODOS documentation is submitted to quality assurance procedure too. General rules and recommendations are stated in

[ROD1]. Writing technical reports in a standard format ensures important aspects of establishing an audit trail. The standard format includes:

- A review process when at least one contractor not associated with the report has checked it for technical errors, clarity and fit with the project objectives
- A management summary which explains the purpose of the document to the project
- Document history which means that the pedigree of the document is known
- A report number which means that the co-ordinator has a simple way of keeping track of documentation

6 Main Activities Started for Preparation of the RODOS for Accreditation in the Czech Republic

Czech RODOS team utilises benefits and results of the internal QA process introduced into RODOS and described in the previous chapter 4. The RODOS QA procedure enables to fulfil the requirements declared in the chapter 3, which follow from the Czech obligatory regulations. From this point the local quality assurance (LQA) procedure have to be launched to address those parts of RODOS customisation process which is under responsibility of the local implementation team. The Czech team considers the following main issues for its LQA process:

1. Own contribution to the overall RODOS QA process. It means not only to keep the commonly accepted QA rules but also to improve quality of a certain algorithms
2. To bring evidence of high level of internal quality assurance of the RODOS system. The detailed review will be submitted to the Czech committee for standardisation in order to support its decision on a shortened accreditation procedure
3. Translation of RODOS panels into Czech language and its authorisation, check for obligatory Czech terminology
4. Assessment of the compliance of RODOS models and RODOS default data with the obligatory values explicitly referred in the Czech governmental regulations (isotope dependent FCM parameters and dose factors for defined age categories, values of intervention levels etc.)
5. Overall local input data quality assurance

6.1 Own contribution to the overall RODOS QA process

Keeping up commonly accepted rules of QA procedure introduced within framework of the RODOS development should be obligatory for each contractor. There is no need to discus the topic any more. We should like to mention activity in another field of QA process, which is improvement of some algorithms, particularly in the field of monitoring of radiation situation. The report [7] describes algorithms for predictive monitoring of one measuring unit of an Early Warning Network (EWN) based on predictive capabilities of Bayesian models.

The algorithms check natural background dose rate measurements with the aim to reveal unnatural increase in the measurements as quickly as possible. This information is vital for early warning as well as for shortening of delays for countermeasure applications during early stage of nuclear accident. Special models are used whose parameters are recursively updated according to Bayesian methodology, which enables to predict behaviour of the measurements. It means that for each measurement the prediction can be done and probability that the measurements will reach a threshold value in couple of measuring instants is provided. In this way a release of radionuclides can be detected earlier, before actually reaching a dose rate threshold values. Consequently, the corresponding preventive actions can be speeded up while a level of false alarms can be kept low.

Dose rate measurements analysed has been provided by National Radiation Protection Institute in the form of 10 minute measurements of Czech Early Warning Network, site Churanov (mountain measuring site with higher natural background). During tuning of the monitoring algorithm the forgetting factor and number of prediction steps needed for adjustment of the algorithm were found on the basis of simulation experiments. During stage of evaluation of the monitoring algorithm, two hypothesis were assumed resulted from the presumption about form of radioactive cloud and direction of its moving with regards to the detectors:

- Sudden increase of the dose rate measurements
- Linear increase of the measurements in several steps (trend analysis)

MATLB (MathWorks) tool was selected as experimental environment. Resulting software modules for prompt monitoring are available in the form of C-coded modules. The final aim of the activity is to include the algorithms into interface between online EWN measurements and automatic mode of RODOS operation.

6.2 Preparation of review of RODOS QA procedures to support decision on a shortened accreditation procedure

The requirements following the obligatory regulations declared in Atomic Law and particularly in the Guideline VDS 030 were compiled for purposes of RODOS accreditation and necessary activities have been started in the fields:

- Gathering information for the full system description including abstract of the product, quality assurance documents and proof of legal obtaining of the code
- Collection of documentation in the form of technical reports on the software package with a detailed description of the physical and numerical models, comparison with the present state of knowledge, a short characterisation of hardware and software requirements and delivery of the complete set of user manuals; precise housestyle of documents is expected
- preparation of the obligatory validation runs defined by the Czech Accreditation Commission (see validation runs in chapter 7.1) and their archivation within the frame of the software verification and scientific validation
- Compilation of some training material for precise interpretation of results at all levels, formulation of additional requirements for training of staff

The activity is in a halfway and mostly draft versions of model descriptions and technical reports are available. But the final versions are necessary and some delay can be expected.

Negotiations with the accreditation commission have been started and proper contacts are established. The shortened validation procedure is assumed. Two sets of validation tasks have been created and delivered to particular users including our Czech RODOS team.

6.3 Translation of RODOS panels into Czech language and its authorisation

Phrases and technical terms used in RODOS panels have been extracted from corresponding files and a dictionary has been created in order to facilitate and automate the process of translation to the native language. This makes easy the process of localisation of a new version of the product immediately after its installation.

The dictionary has been sent to authorisation. The National Radiation Protection Institute, which is responsible to governmental regulatory bodies, guarantees the process. The authorisation process also has to respond the new regulations and obligatory terminology introduced in Atomic Law, namely in its executive instructions [2] (Regulation No. 184). The process of authorisation is in progress.

6.4 Assessment of the compliance of RODOS models and RODOS default data with the obligatory values explicitly referred in the Czech governmental regulations

For all codes used in nuclear safety assessment the methodology must conform with the objectives explicitly defined in the corresponding native regulations. Clear definition of the origin of data should be declared, as well. The compliance with the latest state of investigation and knowledge and latest ICRP recommendations are expected. The analysis of the RODOS default input data has to confirm the expectations. There are some additional requirements issued by Czech national authorities, which have to be approved.

Above all are regulations [2], where categories for many variables are stated and their numerical values are explicitly defined and assumed as obligatory. The following variables and their categories (and many others) are mentioned here:

- Radiation and tissue weighting factors
- Obligatory definitions of the terms used in radiation protection (kinds of doses and committed doses and their names)
- Set of radionuclides which should be taken into account
- Splitting of population to 6 age groups (< 1 year, 1 - 2 , 2 - 7, 7 - 12, 12 - 17, > 17 years). On the other hand RODOS assumes 5 age categories (1 year, 5 , 10, 15, 20 years)
- Factors of conversion [Sv / Bq] for calculation of committed effective doses from radionuclides intake by inhalation and ingestion (for full set of radionuclides, six age categories). The problem is with corresponding factors for equivalent doses

- Directive values of intervene levels for case of nuclear accident

The comparison with corresponding RODOS environment have to be done and in some cases the default RODOS values will be substituted by the new ones. It relates not only for local data but also for redefinition of some physical-chemical constants.

An example of the comparison is presented in the supplement 1. Here the age-dependent dose conversion factors [Sv/Bq] are extracted from the obligatory Czech regulations [2] for all 64 nuclides used in the RODOS FDMT parameters. The values are compared with the corresponding values of the RODOS database which are consistent with publications ICRP-68, ICRP-72 and IAEA Bas. Saf. Standards.

6.5 Overall quality assurance of local input data

It is fully on responsibility of the customisation team to extend quality assurance process of the RODOS system to the customisation tasks, mainly:

1. Quality assurance procedure for local data including clear reference of its sources, screening them and cleaning from rubbish values, checking for correct sum values etc.
2. Stepwise improvement of complex model parameters related to Czech territory on the basis of co-operation with external expert teams
3. Acquisition of proper primary databases with miscellaneous relevant data and their check for mistakes and time inconsistencies
4. Reconstruction of the missing gridded data from various primary databases (selection, merge and recalculation of some important items on the basis of correlation with known associated values)
5. Transmission of the reconstruction software to QA Validation Facility operating within overall RODOS QA procedure - utilisation of the Imperial College QA Facility to check the code

The process of local RODOS data collection for Czech Republic was made difficult by several adverse facts:

- Lack of legislation, which should have to define for the information owners their duties to provide data to another national organisation (nor for data originally created with help of some supporting programme of EC - for example LandUse database CORINE)
- After 1990 some organisations stopped the data collection (reorganisation, lack of money)
- Incompatibility of data in civil and military sectors - different formats and systems of co-ordinates of collected data
- The RODOS project requires fine gridded data, which are not available at full extent. The required data have to be reconstructed from additional associated database(s)
- Some primary databases obtained from various external providers suffer from mutual time inconsistency
- Because of lack of financial resources there was not possible to buy data from commercial data companies. Then, the level of quality of really obtained data was not perfect and lot of additional work was spent for data checking, reparation and cleaning
- Some model parameters (mainly for the FDMT customisation - see [8]) have to be improved only on the basis of expert judgement, which seems to be long-term process. Co-operation with several teams has been established, further continuation depends on possibility to proceed in the project

Some aspects of the quality assurance of model parameters and other FDMT data are described in [8]. In the next text will be described the task of the local data collection and basic idea for its transformation into RODOS with regard to keep the quality of information.

At first, it should be stated that no data, which could be directly transported into RODOS, were obtained. For some particular items we have found commercial companies which have declared their capability to tailor data for RODOS purposes. But the prices of the services were far beyond our possibilities and moreover only a few data items could be obtained by this way. That is why the extensive data collection has been started on the basis of negotiations with many state institutions both from civil and military sectors and lot of more or less relevant data (in the following text is used the term „primary databases“) has been gathered. Unfortunately, some of the primary databases obtained represented a certain older working version of the data and there are still no laws to force the provider to release the latest one. This has required additional effort for the data cleaning, reparation and check.

Nevertheless, a certain results have been achieved and proper primary databases and other associated data structures have been made available for RODOS customisation purposes. The effort has been concentrated to two main parts of local data:

- model parameters
- gridded data

Some specific aspects related to definition of proper local values of the model parameters for purposes of FDMT is discussed in [8]. Co-operation with experts' teams has been started also in the field of atmospheric and hydrologic models. From the point of view of quality assurance two aspects have been declared as a rules for process of local data collection:

- Missing values of model parameters or substitution of their improper default values have to be defined only on the basis of co-operation with Czech expert teams from various institutes and organisations
- Definition of grid size for the whole Czech Republic should be optimum, but as fine as possible to prevent loss of information. The **grid size 1 x 1 km** has been selected. It could be assumed as sufficiently fine from the point of view of level of information and the small size comply with the future expected improvement of real measurements and more detailed statistics

6.5.1 Primary databases available for customisation purposes

Primary rough data more or less useful for RODOS customisation purposes for Czech Republic can be found in abroad or, mainly, at various institutions in CR:

a) international providers :

- either free of charge (http://edcwww.cr.usgs.gov/landdacc - elevation, land use- various projections)
- or partially free of charge : ISIS - Intelligent Sat. Inf. Syst. (ftp.dfd.dlr.de ---> pub/gisis; http://isis.dlr.de) ; SABE (borders of states, districts, ...) etc.

b) local providers :

There were several data providers both from civil and military sectors. Unfortunately, format of their data is mutually incompatible. Because of historical reasons the civil sector systematically prefers S-JTSK system of co-ordinates, which is specific only for territory of the former Czechoslovakia. Military databases accept S-42 system of co-ordinates. We have gained access to the following databases:

- State Statistical Office: district average data on :
  a) population - 5 or 6 age categories for each municipality (6242)
  b) agricultural production, no. of animals
- UIR - National Identification Register : ref. points in S-JTSK
- UHDP - for settlement units << district; no. of settlement units is about 14 000; for each unit available 42 characteristics (id. codes, agricultural production of various species, type of surface, ...)
- ARCDATA CR - OBCE : polygons of cadasters of municipalities
- BORDERS - database from TERPLAN, borders of districts in S-JTSK
- CORINE - land use (*urban and built-up areas , free country - non-agricultural , agricultural - arable areas, cropland , agricultural - lasting plants:gardens, vineyards, hop-gardens,... , grassland and pasture , mixed agricultural and shrubland , forests , water areas)* -----> polygons in S-JTSK
- SOIL - soil types (*light soil - sand , lighter middle textured soil , middle textured soil - loam , heavier middle textured soil , heavy soil - clay, peat , peaty - bogged, peaty- gleyed , built-up and water areas)* ---> polygons in S-JTSK
- DMU200 - vector map in S-42 (vector layers for: *drainage,built up areas, roads and railroads, util., borders, land covers*)
- DMR 1: elevations on the grid 1 x 1 km for the whole CR ; S-JTSK, S-42
- CRCR - Climatic Regionalisation of the Czech Republic (*useful for multiparametric definition of radioecological regions for Czech*

Republic) , could be available in any systems of co-ordinates including geographical co-ord.; possible access for RODOS is under negotiations

6.5.2 Intermediate results extracted from the primary databases

The primary databases represent a mixture of various data with different level of data quality, usually designed for a special purpose of their owners. Its direct utilisation for transfer into RODOS is not possible for many reasons, mainly due to:

- Necessity to check and sometimes repair data, because the original owner usually provided the data without sufficient guarantee; occurrence of mistakes; check for completeness - still missing data for a certain parts of CR territory
- Improper system of co-ordinates, different identification codes used for the same entities within various databases (then, a proper RODOS item has to be found on the basis of merging from two or more databases)
- Mutual time inconsistency between databases (each database is updated at a certain date, no mutual synchronisation is ensured); for example administrative changes are not included systematically

Because of this reasons an intermediate step in data transformation process has to be realised. It consists in prepocessing of the primary databases and extraction of RODOS relevant information together with simultaneous data check, correction and necessary modification. As a result of this intermediate step are:

A**)** **INTERMEDIATE GRID FILE** (IGF) for the whole Czech Republic

B) **VECTOR LAYERS** (sets of polygons for the whole country) for many important data items

As for IGF, a special attention has been devoted to the construction of gridded environmental data necessary for the radio-ecological and countermeasure calculations within RODOS. Data on population surface density according to particular age categories, agricultural production, numbers of animals, soil types and other items has been extracted from various primary databases into the intermediate gridded file. It consists of 82 138 records, each record stands for tile 1 x 1 km and comprises many items characterising various properties on the tile (co-ordinates of the tile centre in JTSK system, maximum altitude, identification of radioecological region, district number, average population according to age categories, surface and soil characteristics, agricultural production data on the tile etc.). The grid continuously covers the whole surface of the Czech Republic and after its final transformation to geographical co-ordinates it should be continuously linked to neighbouring countries. The intermediate file serves partly for automatic generation of a new data item (correlation with the existing entities in IGF expressed by selection rules), partly for the final transformation to the required RODOS format and finally will facilitate the data transition to European database.

A part of the intermediate S-JTSK grid file is demonstrated in the supplement 1 of [8]. Each of the 82 138 records stands for each tile 1 x 1 km. The structure of the record is the following:

did sx sy ele p1 p2 p3 p4 p5 p6 p7 pmax c1 c2 c3 c4 c5 c6 c7 c8 cmax a1 a2 a3 a4 a5 r1 r2 r3 **........*****r32 z1 z2 z3*** **...................** etc.

did ..... district id

sx, *sy* ... JTSK co-ordinates of the tile centre

ele ..... elevation : max. on the tile

p .... fraction of soil types on the tile [%] :

p1 = sandy;

p2 = loamy sand;

p3 = loam;

p4 = loamy clay;

p5 = clay;

p6 = peat;

p7 = built-up area, water, ...;

pmax = no. of prevalent category p (1 to 7) on the tile

c .... LandUse - fraction [%] on the tile:

c1 = built-up areas;

c2 = free non-agricultural areas;

c3 = agricultural - arable;

c4 = agricultural - fruit+wine+hop+;

c5 = grassland;

c6 = mixed agricultural near settlements;

c7 = forests;

c8 = drainage (rivers, lakes, reservoirs);

cmax = no. of prevalent c category (1 to 8) on the tile

a1,..... a5 .... number of habitants from different age roups leaving on the tile

r1, ... r32 .... production of various agricultural products (see [8]) on the tile

z1,......, zn .... number of animals living on the tile

others .... the file is expected to be extended by other items (sheltering factors, ...)

In the final stage, just before transition into RODOS or to European database, the transformation of the IGF from native JTSK co-ordinates to geographical co-ordinates will be done.

Second result of the primary databases pre-processing are vector layers represented by a complete set of polygons for the whole country for many important data items such as:

- *each soil type category p1 - p6*
- *isolines of agroclimatic region (based on multicriterial nalysis)- so far in negotiations*
- *several LandUse categories c1 - c7*
- *forests (DMU200)*
- *built-up areas (villages, towns)*
- *borders (country, districts, cadasters, executive municipality reas (fig. 3), ...)*

The vector layers include important spatial information which could be used in the process of reconstruction of the rough average values (for example district average agricultural production) to fine gridded data (see examples below).

6.5.3 Examples of reconstruction to fine gridded data

One of the main tasks in quality assurance of the local data is to prevent loss of information during their extraction, processing or reconstruction. Moreover, some sophisticated methods can be introduced so that the originally available rough average data bearing poor level of information could be reconstructed to fine gridded data with substantial improvement of information level. The improvement results from utilisation of some additional available information. Two different examples describe the process.

a) Gridded data on population

What is to be done:

Preparation of gridded data on population according to 5 age categories for the whole territory of the Czech Republic; grid size compatible with RODOS (0.02 x 0.02 degrees in geogr. co-ordinates);

Available primary database:

Population in 5 or 6 age categories for each municipality (6242 units) provided officially every year by Czech Statistical Office. The data were bought in machine readable form in *dbf* format. Part of listing of the data is described here in the supplement 2. The record contains 10 items starting with type of settlement, its name, code, inhabitants total and discrimination to 6 age categories (for RODOS purposes 2. and 3. categories are merged).

What is missing:

No location information is available. To overcome the problem, some additional information has to be found in other associated primary databases. Two kinds of information could be found here, each represents different level of information:

- At least one reference point (e. g. its co-ordinates) will be linked with the exclusive municipality code

- Borders of built-up areas (at least one closed polygon) will be found according to the municipality code

Provided that reference point (s) can be found, then statistical information relating to average population density could be used. This philosophy is suggested for RODOS, when average population density 2000 inhabitants/km^2 is used. Then, the equivalent circle borders can be determined and its intersection with the defined grid is calculated.

The second case represents more precise solution. It is clear that equivalent circle is not good approximation, mainly for elongated real built-up areas. On the other hand the solution based on calculation of intersections of the polygons representing real built-up areas is much more complicated.

How to assign location characteristic to a certain municipality code:

Additional primary databases were analysed for purposes of finding possible relation between municipality code and municipality spatial location. The following results have been reached and used:

1. ***Reference point (s)*** : The proper database is UIR - National Identification Register, where reference point(s) are given in S-JTSK system of co-ordinates. The database is distributed by Ministry of Regional Development of the Czech Republic

2. ***Polygons of built-up areas:*** The only source is database DMU200 provided by Topographic Service of the Czech Army. The database is a vector map in S-42 system of co-ordinates and its vector layer of *built-up areas* can be extracted.

Practical realisation of definition of all closed polygons for all 6242 municipalities was rather difficult. We were given the latest version of DMU200, but, unfortunately, the format of the database was improper for direct processing. The main reason was the fact, that the vector layer of built-up areas for the whole Czech Republic consists of 85 map pages what means 85 different text files. Polygons can start on one page and continue on another page. The structure is valid for various GIS systems, but not for RODOS purposes. We have spent a lot of time and money trying to check the database and resolve a certain time inconsistency between UIR and DMU200 what resulted to necessity to include information for remaining undefined 7 settlements „by hand“.

When trying to link of all 85 files to one, we have met the problem of „spaghetti data“ for polygons continuing on another page. We were faced to the task to develop some kind of data automation kit but the way was far beyond our possibilities. Many other inconsistencies and missing values were revealed. The report on the process is available.

Therefore, many institutes and companies dealing with the problem were contacted with regards to the latest version of DMU200, but nobody was able to merge all 85 files to one correct file. At the end we have bought the „nearly proper“ file for older version of DMU200 (1996). „Nearly proper“ means, that we had to add several settlements by hand and modify some differences (for example the capital Prague was defined in multiple form of its districts, built-up areas less then 4 ha (1 ha = 10000 m^2) were originally neglected and treated such a point objects etc.) in order to adjust correct total check sums. The co-ordinates of the polygons were again reprocessed (because of external provider possibilities) to S-JTSK system of co-ordinates.

Such a result, the vector layer for the whole Czech Republic consisting of polygons for all municipalities and corresponding database of reference points is now available. Part of the layer for near area of NPP Temelin with regard to SSE direction (about 22 km in this direction is situated large town Ceske Budejovice) is drawn in Fig. 1 (in JTSK co-ordinates).

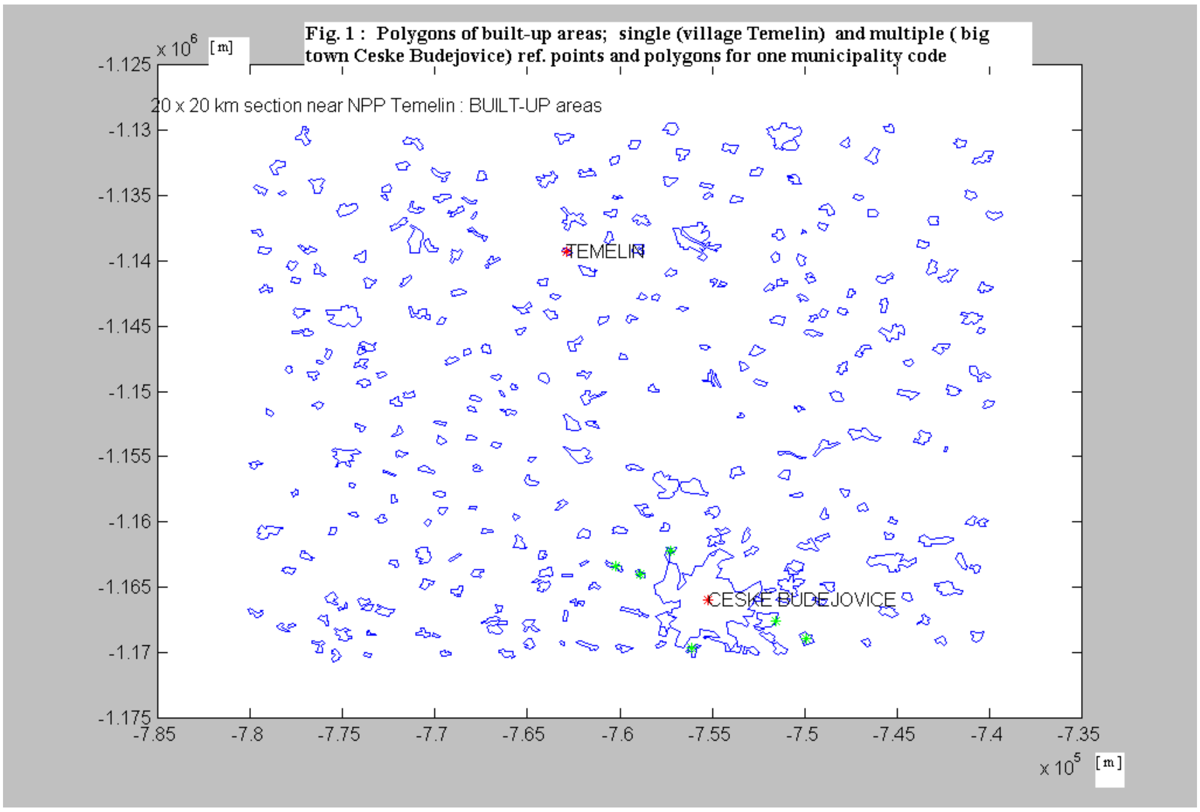
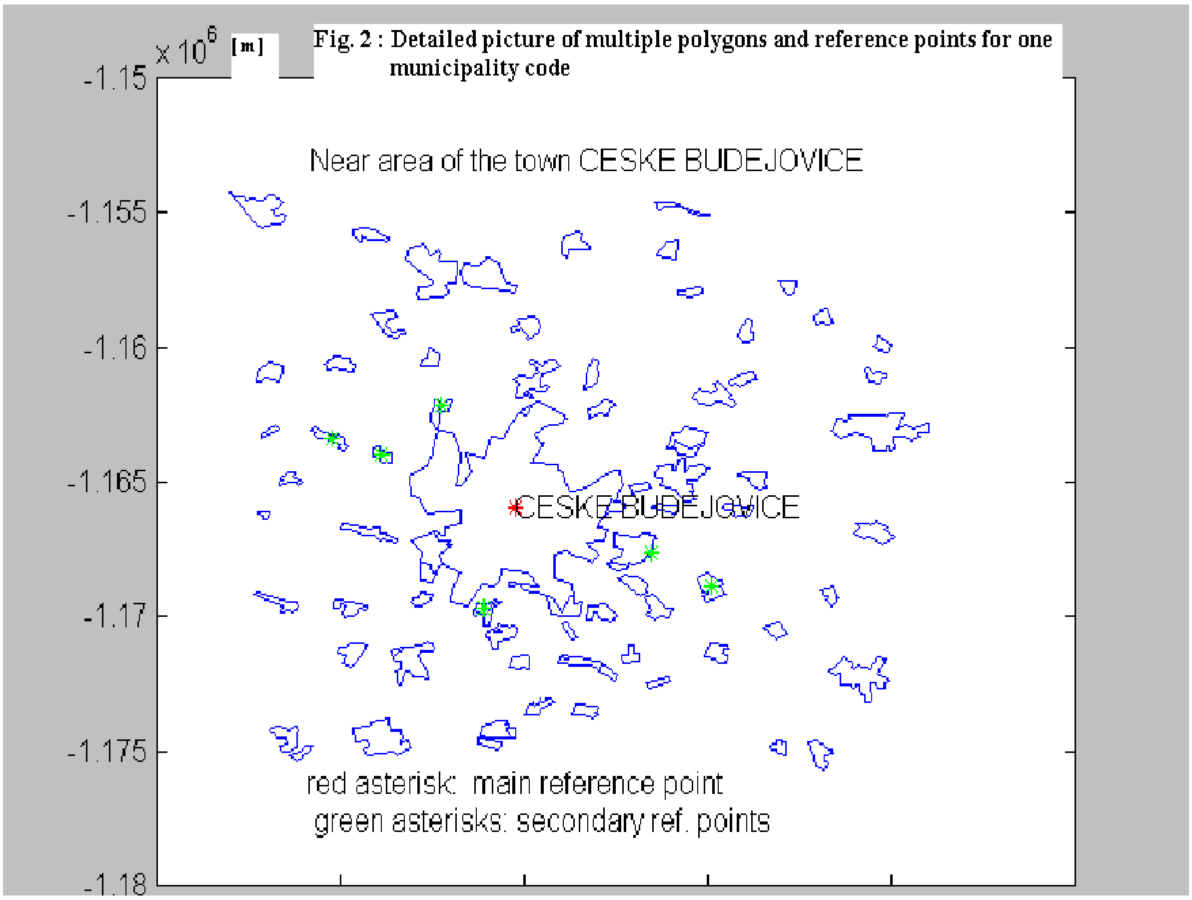


Fig. 1 : Polygons of built-up areas; single (village Temelin) and multiple (big town Ceske Budejovice) ref. points and polygons for one municipality code

Because of administrative reasons the following features should be emphasised:

1. At least one closed polygon exists for one municipality code. Then, the total built-up area for a certain municipality can consists of several closed polygons. On fig. 2 (some zoom of fig.1) is displayed near area of large town Ceske Budejovice together with the main and secondary closed polygons and their corresponding reference points
2. Maximum one reference point exists for one closed polygon. Polygons without reference point mean empty closed area inside another built-up area
3. Such a side-product of the activity we have bought also polygons of executive areas of the municipalities (see example of fig. 3, JTSK co-ordinates). It covers continuously the whole territory and it could be used for purposes of decision making

Fig. 2 : Detailed picture of multiple polygons and reference points for one municipality code



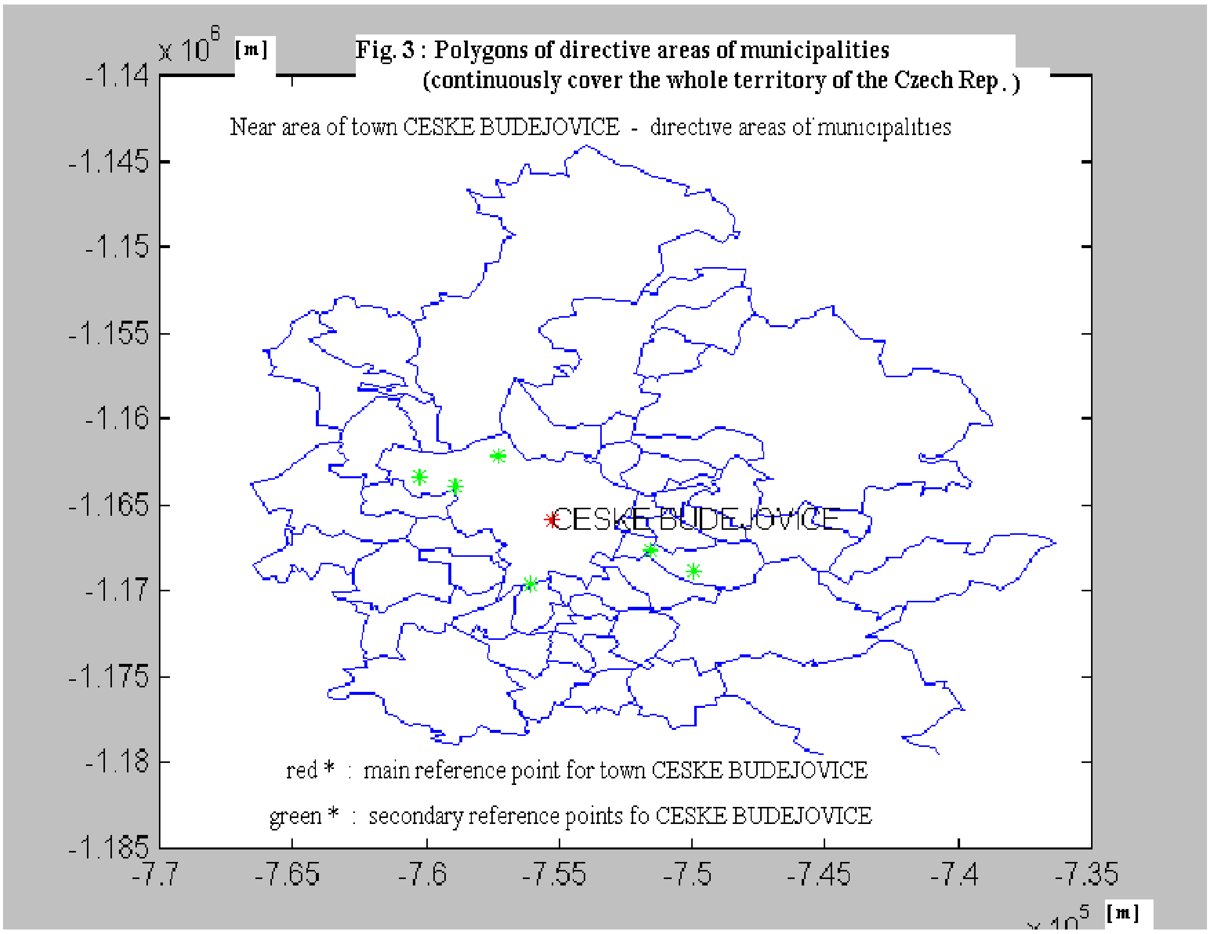


Fig. 3 : Polygons of directive areas of municipalities (continuously cover the whole territory of the Czech Rep.)

In the final step the coverage of the polygons with S-JTSK grid is computed and then rather precise values of age-dependant population density on the tiles can be found. So far the RODOS philosophy based on the equivalent circles (we have modified this to equivalent rectangles) is used for determination of the *a1*, ..., *a5* values from the IGF. More precise solution based on the real built-up areas is in progress.

b) Gridded data on agricultural production

<u>What is to be done</u>:

Preparation of gridded data on agricultural production for selected products (more detailed discussion is in [8]) on the grid covering the whole territory of the Czech Republic; grid size compatible with current and expected future RODOS requirements (size 1 x 1 km is assumed to be sufficient).

Available primary database:

District average values on agricultural production provided officially every year by Czech Statistical Office. The data were bought in machine-readable form in *dbf* format. The database stands for 82 products observed for CR and is described in [8] in supplement 3. For all 78 districts of CR each record contains district code, district name, district total area, district total population, and then 82 values of yield of observed products follows.

What is missing:

No location information is available. If we have on mind that the average area of district is about 30 km × 40 km, the average district values have very poor spatial information. The values for one district are the same on its entire grid tiles regardless of real surface coverage (forest, built-up areas, arable soil, ...).

Fortunately, we have some additional information which could be extracted from other associated primary databases and help us to overcome the problem. Especially, for this case of determination of basic spatial distribution of agricultural production an idea of dependency on a surface type on the grid tile is evident. Several proper vector layers derived mostly from the primary database CORINE are available. If there is forest, built-up area or water on the tile, then there should be zero agricultural production on the tile. From this point of view the most suitable seems to be the vector layer of arable soil, on the basis of which the variable c3 (percentage of arable soil on the tile) in IGF was determined for all tiles continuously covering territory of Czech Republic.

If the c3 vector layer is used for correlation of the district average values, then the correlated value of the yield of product $\underline{p}$ on the tile $\underline{j}$ of the district $\underline{o}$ can be recalculated according to scheme:

$$r_p^{o,j} = \frac{G_p^o}{A^o} \cdot \frac{c3^{o,j}}{100}$$

where

$r_p^{o,j}$ ...... yield of product $\underline{p}$ on the tile $\underline{j}$ of the district $\underline{o}$ [t / km^2]

G_p^o .... total production of product $\underline{p}$ for district $\underline{o}$ [t]

(primary input value)

A^o ...... total arable soil area for district o [km^2]

$c3^{o,j}$ ... percentage fraction of soil type „arable soil“ (see database IGD) on tile j from district o

Disadvantage of the method is fact, that all products are treated by the same manner, because we have not so far proper criteria for discrimination of the spatial distribution between particular products. On the other hand additional selection rules can be formulated on the basis of soil types on the tile or identification of the area as a special growing region (potatoes, cereals, sugar beet - this kind of information is in UHDP primary database, which could be useful).

From the fig. 4 we can observe the expected level of improvements of the yield values, which is represented by high degree of spatial variations. The figure relates to selected are of 40 km × 40 km around Dukovany NPP. Each tile is treated for contents of arable soil (variable c3 in IGF) on the tiles when three categories are assumed:

1. category - percentage of arable on the tile > 70%; black asterisk in the picture
2. category - percentage of arable on the tile ∈ <10%; 70%>; blue circle in the picture
3. category - percentage of arable on the tile <10%; green point in the picture

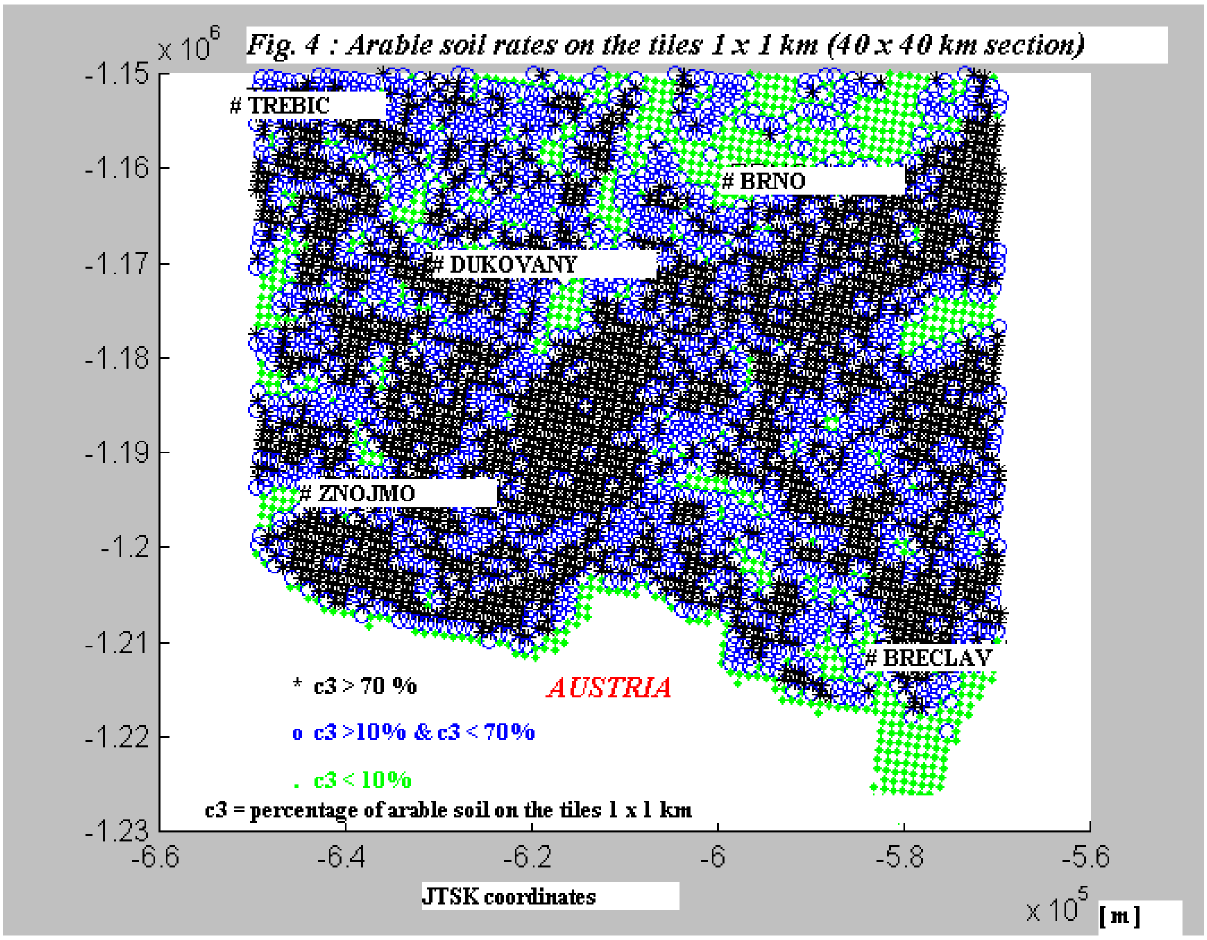


Fig. 4 : Arable soil rates on the tiles 1 x 1 km (40 x 40 km section)
x 10^6
-1.15
-1.16
-1.17
-1.18
-1.19
-1.2
-1.21
-1.22
-1.23
TREBIC
BRNO
DUKOVANY
ZNOJMO
BRECLAV
AUSTRIA
* c3 > 70 %
o c3 >10% & c3 < 70%
. c3 < 10%
c3 = percentage of arable soil on the tiles 1 x 1 km
-6.6
-6.4
-6.2
-6
-5.8
-5.6
JTSK coordinates
x 10^5
[m]

7 Utilisation of the RODOS algorithms for analysis of the obligatory validation tasks defined by the Czech Accreditation Board

Input data for two validation tasks were issued by the Czech Accreditation Board for software used in the field of nuclear safety. Each software package used in CR for analysis of the impact of accidental releases from NPP on population have to be submitted to the obligatory validation procedure.

7.1 Definition of the validation task 1: Simple case

Source characteristics:	single point
Atmospheric stability category: (according to Pasquill)	F
Wind speed at 10 m height:	1.0 $m.s^{-1}$
Orography:	flat terrain
Surface roughness:	0.1 m (uniform)
Release height:	45 m
Source heat capacity:	0 kW
Release vertical output speed:	0 $m.s^{-1}$
Near-standing building effect:	no
Temperature inversion occurrence:	no
Precipitation:	no

Source term:	Xe135	10 Bq . s^{-1}
	I131aerosol	10 Bq . s^{-1}
	I131org.	1 Bq . s^{-1}
	I135aerosol	10 Bq . s^{-1}
	I135org.	1 Bq . s^{-1}
	Cs137	10 Bq . s^{-1}

Duration of release 10 hours

Critical age category: adults

Task :

For one direction of windrose and the following receptor points at radial distances from the source of releases:

1, 3, 5, 10, 20, 50, 100 km

the following results should be generated:

1. Distribution of ground-level radionuclide concentration in air below plume axis at all receptor points
2. Distribution of deposited activities on the ground (at all receptor points below plume axis)
3. Distribution of effective dose [Sv/y] at all receptor points below plume axis with further discrimination to the particular pathways (irradiation from cloud, deposition, inhalation, ingestion)
4. Distribution of equivalent dose to thyroid [Sv/y] at all receptor points below plume axis

Removal processes of radionuclides from the surface can be neglected.

The following annotation should be enclosed:

- Give an explanation if some data have to be entered by different way
- Specify the model for calculation of dispersion coefficients
- Specify size of aerosol particles and describe the method for calculation of fallout.

- Declare the source of your input nuclide dependant data and its compliance with the Guideline [3]
- Describe the way how the effect of near-standing buildings can be assumed
- Bring any other information related to the way of your computation

Fig.5: *Validation task 1: Results of RODOS Prognoses calculations using* ATSTEP atmospheric dispersion module – case of low surface roughness (rural)

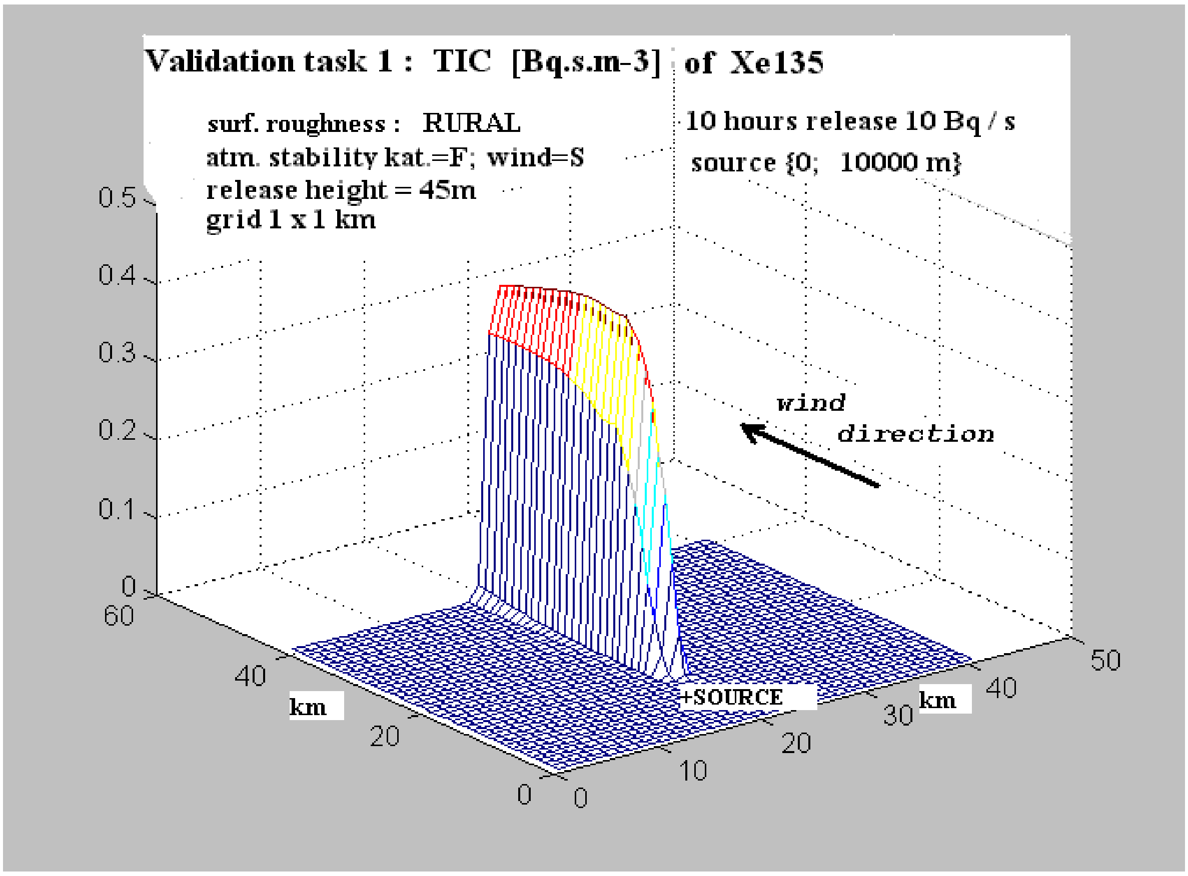
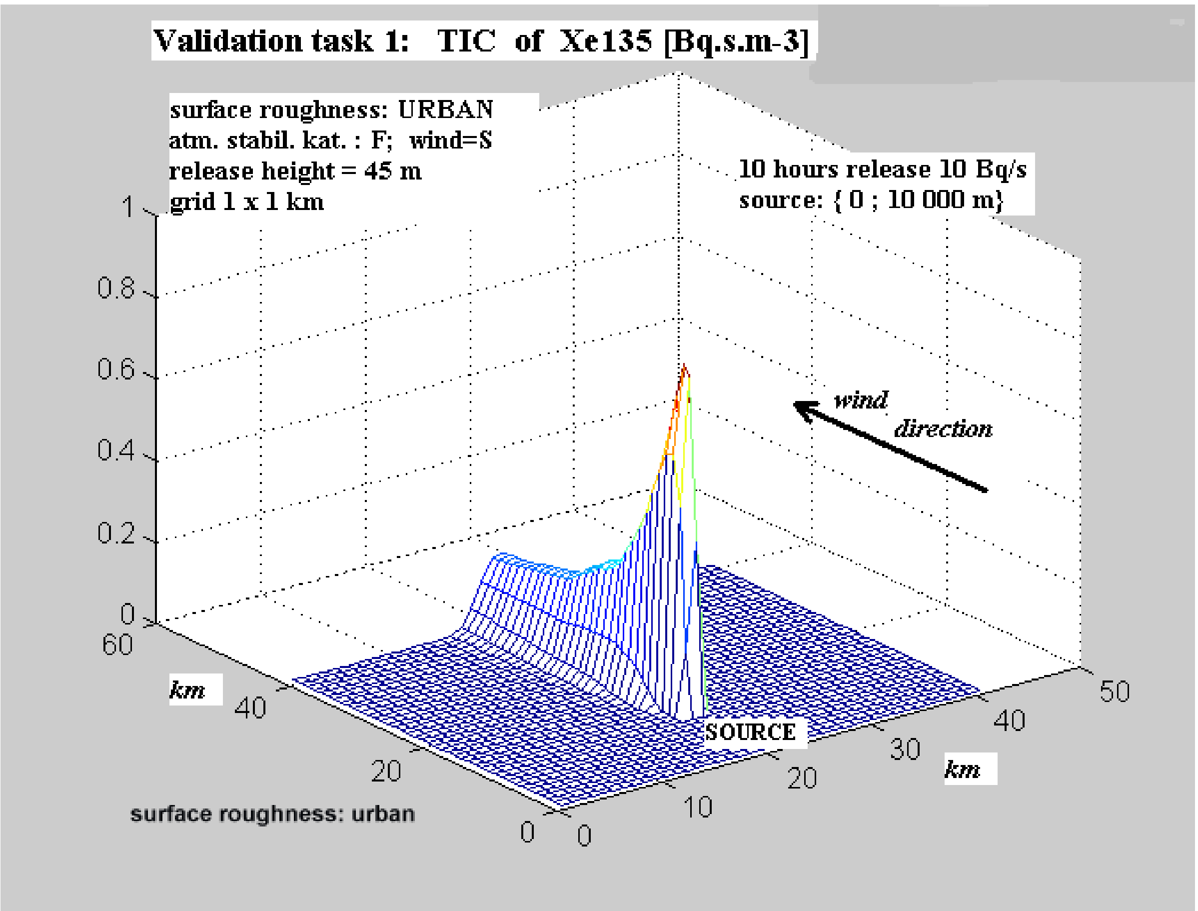


Fig.6: *Validation task 1: Results of RODOS Prognoses calculations using* ATSTEP atmospheric dispersion module – case of high surface roughness (urban)



7.2 Definition of the validation task 2: Run with precipitation, inversion and building wakes

Source characteristics:	single point
Atmospheric stability category: (according to Pasquill)	F
Wind speed at 10 m height:	1.0 $m.s^{-1}$
Orography:	flat terrain
Surface roughness:	0.1 m (uniform)
Release height:	45 m
Source heat capacity:	0 kW
Release vertical output speed:	0 $m.s^{-1}$
Near-standing building effect: height = 154 m, width = 190 m	cooling towers in the selected wind direction;
Temperature inversion occurrence:	height of lower inversion boundary = 200 m
Precipitation:	2 mm / hour (during all release)
Source term:	Xe135 10 $Bq . s^{-1}$
I131aerosol	10 $Bq . s^{-1}$
I131org.	1 $Bq . s^{-1}$
I135aerosol	10 $Bq . s^{-1}$
I135org.	1 $Bq . s^{-1}$

Cs137	10 Bq . s^{-1}
Critical age category:	adults

Task :

For one direction of windrose and the following receptor points at radial distances from the source of releases:

1, 3, 5, 10, 20, 50, 100 km

***the following results should be generated*:**

1. Distribution of ground-level radionuclide concentration in air below plume axis at all receptor points
2. Distribution of deposited activities on the ground (at all receptor points below plume axis)
3. Distribution of effective dose [Sv/y] at all receptor points below plume axis with further discrimination to the particular pathways (irradiation from cloud, deposition, inhalation, ingestion)
4. Distribution of equivalent dose to thyroid [Sv/y] at all receptor points below plume axis

Removal processes of radionuclides from surface are neglected.

The following annotation should be enclosed:

- Give an explanation if some data have to be entered by different way
- Specify size of aerosol particles and describe the method for calculation of fallout and washout.
- Describe the way how the effect of near-standing buildings is assumed
- Bring any other information related to the way of your computation

Fig. 7: ***Demonstration of the influence of precipitation on radionuclide depletion from the plume***

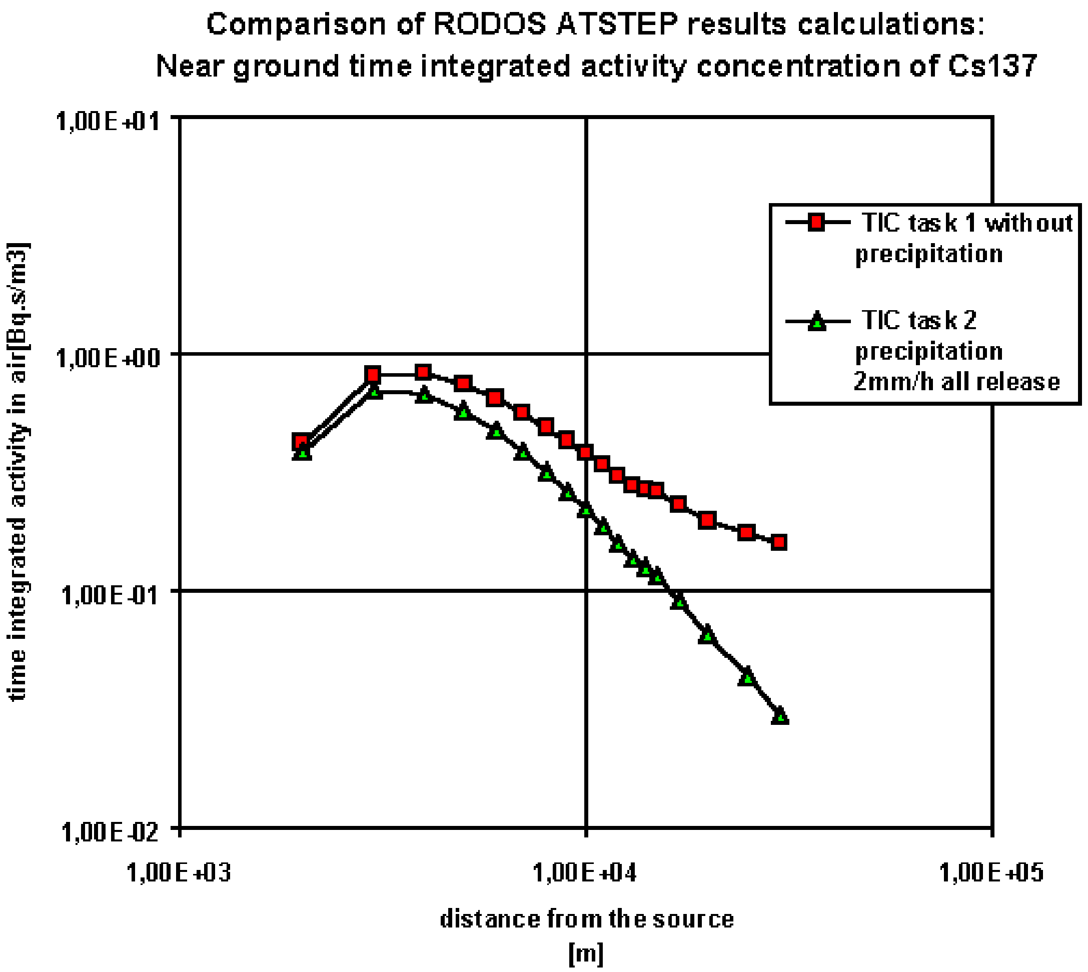


Fig. 8: ***Deposited activity of I131 fractions on the ground***

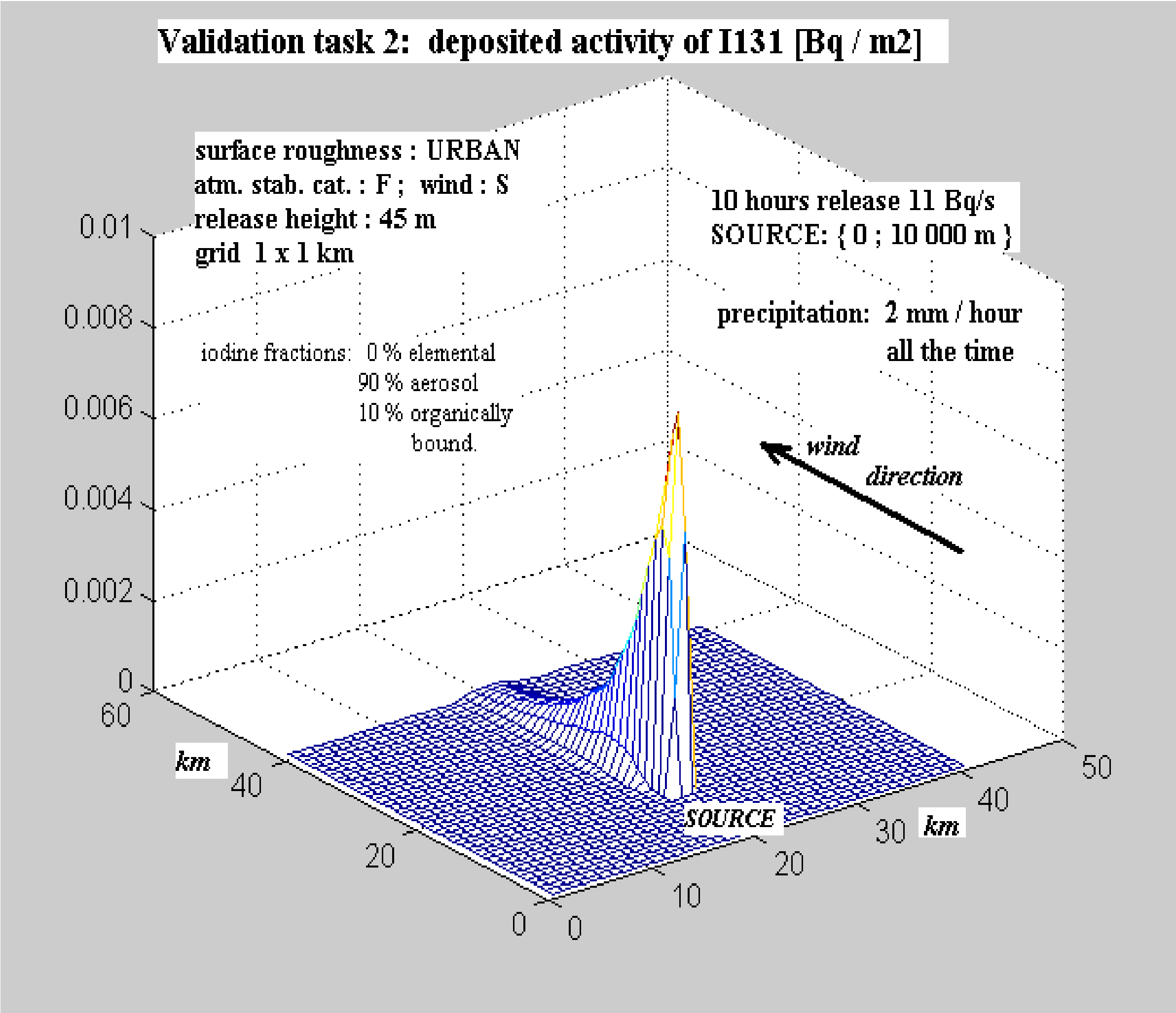
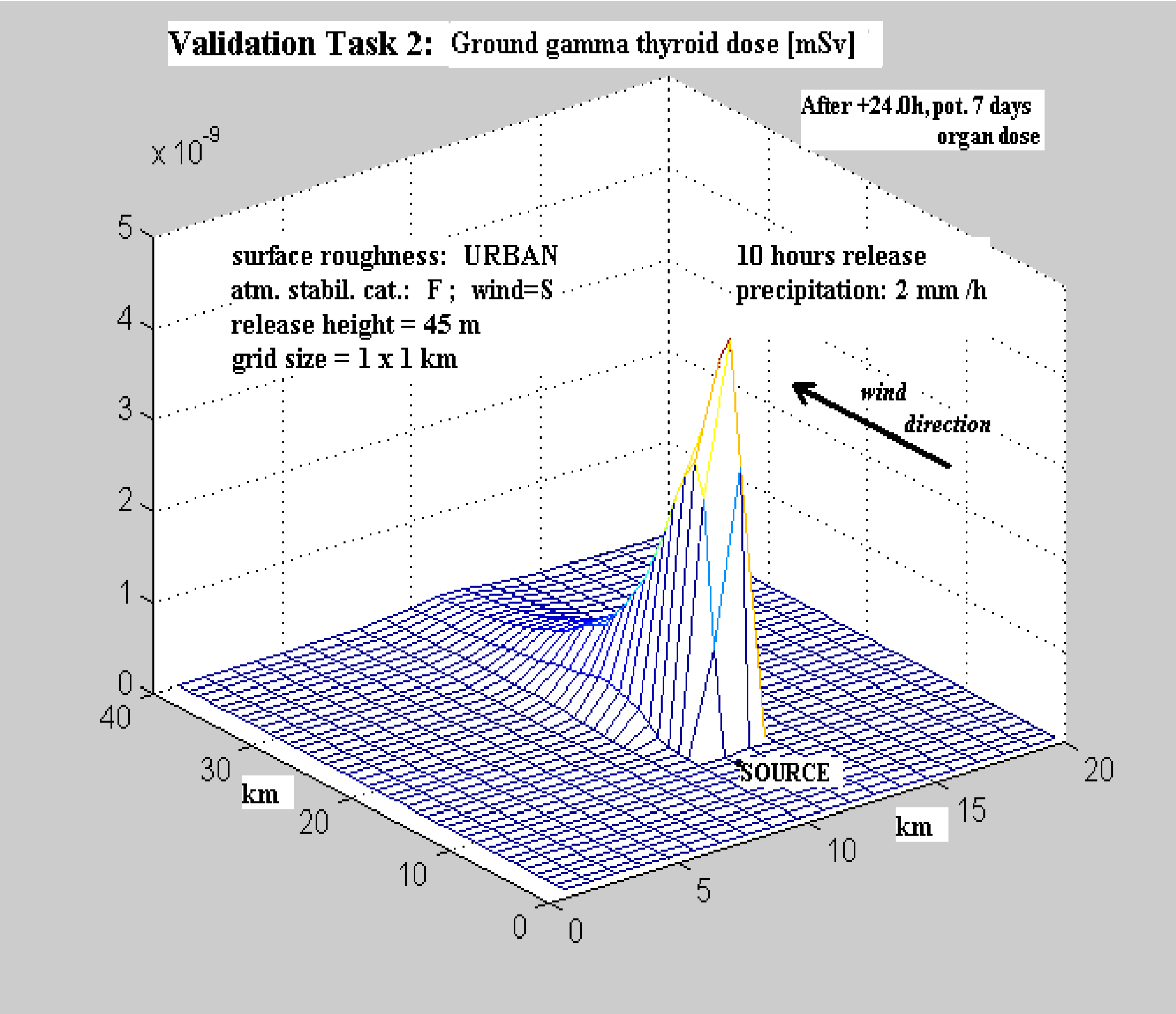


Fig. 9: ***An example of gamma doses calculation based on the ATSTEP atmospheric modelling – input data according to validation task 2***



The results selected above relates to the PROGNOSE ATSTEP calculations. Occurrence of inversion situations and building wake effect were not analysed during the ATSTEP calculations. Many other simulation runs were performed having character of sensitivity studies on influence of variation of some input model parameters. For example on the fig. 7 are compared results without and with precipitation. Initial inter-comparison of results with other codes has been started and good consent has been achieved. Some results of this comparison are presented also in [9] .

8 Conclusion

The local quality assurance process of RODOS system for its use in the Czech Republic is in progress. Four main points are treated as crucial:

- Confirmation of compliance of RODOS system with Czech regulations being obligatory for any code used in the field of nuclear safety assessment
- Determination of proper full set of local input data being verified for the territory of the Czech Republic with emphasis on its quality and information contents
- Running of validation tasks defined by the Czech Accreditation Board and inter-comparison with other respective codes
- Determination of the all model parameters for the RODOS modules including fine gridded environmental data with regards to their further import to the European databases. The determination should respect European Q/A standards.

The question related to local input data showed to be extremely complicated and time consuming. Both types of the environmental data (model parameters and gridded data) should be determined on the bases of close co-operation with the Czech experts' teams. Many useful relations have been established, but the future of the co-operation now is not clear because the RODOS project ends in September 1999.

As for gridded data a special subsystem for the primary rough data pre-processing is constructed. The way of selection of various data from different primary databases, its cleaning, checking and merging is used in the first step. Then, the transformation into intermediate gridded file (IGF) follows. Other modules enable extension of the IGF by the new entities on the basis of correlation of rough average data bearing originally poor information with secondary databases or vector layers. In the final step the conversion from the native JTSK system of co-ordinates to geographical and transformation into RODOS databases will follow.

Such an example of the final format of the environmental gridded data proper for import to the European database could serve the results of the FDMT customisation for CR [8]. The final step was accomplished so far for the geographical page e014n49 (NPP Temelin inside) for population and agricultural products (the rest is ongoing and dependant on available manpower). The area e014n49 (one degree of longitude by one degree of latitude) is divided into 100 x 100 cells.

The most of the modules from the data transformation subsystem are written in MATLAB 5 code. The rest of C++ programs were sent for verification to the Imperial College QA Facility. Some of the modules solve very special problems like for example intersection of the grid points with complicated vector layers. Two closed polygons – one rather simple and one extremely complicated - are displayed on fig. 10. Special algorithms are included in the subsystem, which enable to determine if a certain point is located inside or outside the polygon. We believe that the detailed analysis contribute to the quality assurance of the local data.

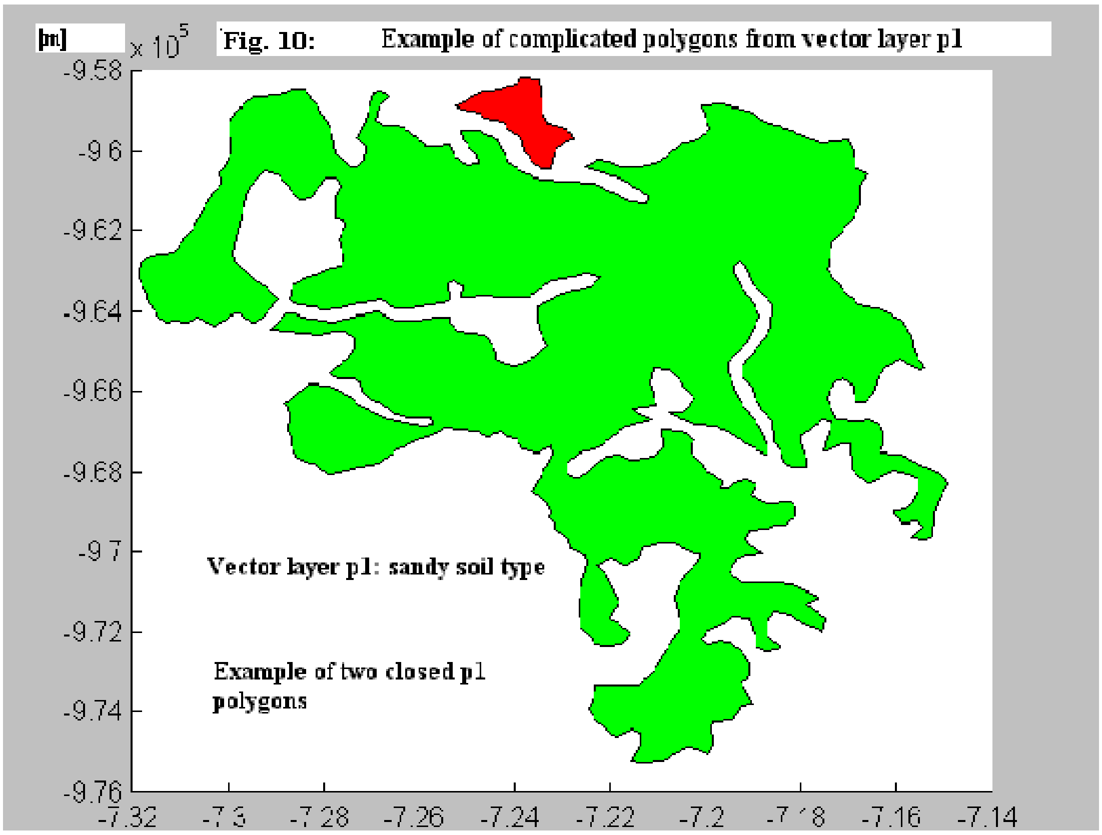


Fig. 10: Example of complicated polygons from vector layer p1

9 RODOS QA/Validation Reports:

[ROD1] S.French, and O.Schüle : Quality Assurance and Housestyle for RODOS. Technical Documents. RODOS(WG1)-TN(96)-02 , (1996)

[ROD2] S.Burne : Report on the Quality Assurance Questionnaire. RODOS(WG1)-RP(97)-01 , (1997)

[ROD3] S.French : Validation and Quality Assurance for RODOS. RODOS(WG1)-RP(98)-01 , (1998)

[ROD4] S.Burne : Report on the RODOS QA Facility. RODOS(WG1)-RP(98)-02, (1998)

[ROD5] S.French, and K.Politis : A Survey of Validation Plans for Modules in RODOS. RODOS(WG1)-TN(98)-04, (1998)

[ROD6] S.French, S. Burne : RODOS QA & Validation Review - Status at Trnava. Contractors' Meeting (Oct. 1998). RODOS(WG1)-TN(98)-04 , (1998)

[ROD7] K. Politis, J.B. Procter : BayesRIMPUFF User manual.
RODOS(WG5)-TN(97)08, Sept. 97

[ROD8] K. Politis : A Validation study for BayesRIMPUFF
RODOS(WG5)-TN(98)06, July 97

[ROD9] F. Gering, S. Huebner, H. Mueller : Information needed for modelling the data assimilation in the food and dose module. RODOS(WG5)-TN(97)09, Oct. 97

[ROD10] A. Faria, J. Smith, F. Gerning, S. Huebner : Bayes FDM model from contamination of plants. ODOS(WG5)-TN(97)10, Oct. 97

[ROD11] J.Q. Smith, S. French et al. : Probabilistic Data Assimilation within RODOS. RODOS(WG5)-RP(97)02

[ROD12] Xingzeng LIU (China Institute for Radiation Protection), Alain SOHIER and Carlos ROJAS-PALMA (MOL) : Parameter Uncertainty and Sensitivity Analysis for Gamma Dose Rate Calculations. RODOS(WG5)-TN(96)05

10 References

[1] Law of Czech Republic No. 18 / 1997 - Peace utilisation of nuclear energy and ionising radiation (Atomic Law).

[2] Regulation No. 184 / 1997 - Executive instructions of the Atomic Law. Instructions of the Czech State Office for Nuclear Safety relating to requirements of ensuring radiation protection (July 1997).

[3] Guideline VDS 030 for evaluation of calculation codes for the assessment of nuclear safety. Mandatory instructions of the Czech State Office for Nuclear Safety for accreditation process for software packages.

[4] ISO 9001 - Quality assurance systems - Model of quality assurance of products during their design, production, operation and service.

[5] ISO/IEC 9126 - Information technology - Software product evaluation - Quality characteristics and guidelines for their use (1991), Czech equiv. standard: CSN 36 9020.

[6] ISO/IEC 12119 / 1994 - Information technology - „Software Packages - Quality Requirements and Testing“. Czech equiv. standard: CSN ISO / IEC 12119.

[7] Nedoma P., Karny M. Pecha P. ... : Predictive Monitoring of Radiation Situation. RODOS (WG1) - TN(98) 27

[8] Pecha P., Nedoma P., Karny M. : FDMT Customization for its Use in the Czech Republic. RODOS (WG3) - TN(98) 14, final version Aug. 1999.

[9] Pecha P., Nedoma P., Pechova E.. : Modelling of Radionuclides Transport due to Atmospheric Releases Used in the Various Stages of Nuclear Power Plant Design. *6-th Int. Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Oct. 99, Rouen, France*

Supplement 1 : **Example of the new dose conversion factors [Sv/Bq] for inhalation pathway for RODOS nuclide group**

(the worst cases from point of view of retention categories were selected from [2])

NA24	2.30E-09	1.80E-09	5.70E-10	3.40E-10	2.70E-10
CO58	9.00E-09	7.50E-09	3.10E-09	2.60E-09	2.10E-09
CO60	9.20E-08	8.60E-08	4.00E-08	3.40E-08	3.10E-08
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB86	1.20E-08	7.70E-09	2.20E-09	1.10E-09	9.30E-10
RB88	1.90E-10	1.20E-10	3.20E-11	1.90E-11	1.60E-11
SR89	3.90E-08	3.00E-08	1.20E-08	9.30E-09	7.90E-09
SR90	4.20E-07	4.00E-07	1.80E-07	1.60E-07	1.60E-07
SR91	3.50E-09	2.50E-09	7.70E-10	4.90E-10	4.10E-10
SR92	2.20E-09	1.50E-09	4.50E-10	2.70E-10	2.30E-10
Y90	1.30E-08	8.80E-09	2.70E-09	1.80E-09	1.50E-09
Y91	4.30E-08	3.40E-08	1.30E-08	1.00E-08	8.90E-09
ZR95	2.40E-08	1.90E-08	8.30E-09	7.30E-09	5.90E-09
ZR97	8.20E-09	5.60E-09	1.90E-09	1.20E-09	8.90E-10
NB95	7.70E-09	5.90E-09	2.50E-09	2.20E-09	1.80E-09
MO99	6.90E-09	4.80E-09	1.70E-09	1.20E-09	9.90E-10
TC99M	1.30E-10	1.00E-10	3.50E-11	2.50E-11	2.00E-11
RU103	1.30E-08	1.00E-08	4.20E-09	3.70E-09	3.00E-09
RU105	1.40E-09	9.80E-10	3.20E-10	2.20E-10	1.80E-10
RU106	2.60E-07	2.30E-07	9.10E-08	7.10E-08	6.60E-08
RH105	2.40E-09	1.70E-09	5.60E-10	4.50E-10	3.50E-10
SB127	3.90E-08	3.10E-08	1.30E-08	1.00E-08	8.60E-09
SB129	4.20E-08	3.80E-08	1.60E-08	1.40E-08	1.20E-08
TE127M	4.10E-08	3.30E-08	1.40E-08	1.20E-08	9.80E-09
TE127	1.20E-09	7.90E-10	2.60E-10	1.70E-10	1.40E-10
TE129M	3.80E-08	2.90E-08	1.20E-08	9.60E-09	7.90E-09
TE129	3.50E-10	2.30E-10	6.90E-11	4.70E-11	3.90E-11
TE131M	8.70E-09	7.60E-09	2.00E-09	1.20E-09	8.60E-10
TE131	2.60E-10	1.70E-10	5.20E-11	3.50E-11	2.80E-11
TE132	2.20E-08	1.80E-08	4.20E-09	2.60E-09	1.80E-09
I129	7.20E-08	8.60E-08	6.70E-08	4.60E-08	3.60E-08
I131	7.20E-08	7.20E-08	1.90E-08	1.10E-08	7.40E-09
I132	9.90E-10	7.30E-10	2.20E-10	1.40E-10	1.10E-10
I133	1.90E-08	1.80E-08	3.80E-09	2.20E-09	1.50E-09
I134	4.80E-10	3.40E-10	1.10E-10	6.80E-11	5.50E-11
I135	4.10E-09	3.70E-09	7.90E-10	4.80E-10	3.20E-10
XE133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS134	7.00E-08	6.30E-08	2.80E-08	2.30E-08	2.00E-08
CS136	1.50E-08	1.10E-08	4.10E-09	3.50E-09	2.80E-09
CS137	1.10E-07	1.00E-07	4.80E-08	4.20E-08	3.90E-08
CS138	4.20E-10	2.80E-10	8.20E-11	5.10E-11	4.30E-11
BA140	2.90E-08	2.20E-08	8.60E-09	7.10E-09	5.80E-09
LA140	8.80E-09	6.30E-09	2.00E-09	1.30E-09	1.10E-09
CE141	1.60E-08	1.20E-08	5.00E-09	4.80E-09	3.80E-09
CE143	5.90E-09	4.10E-09	1.40E-09	1.00E-09	8.30E-10
CE144	3.60E-07	2.70E-07	7.80E-08	4.80E-08	4.00E-08

PR143	1.30E-08	9.20E-09	3.60E-09	3.00E-09	2.40E-09
ND147	1.20E-08	8.60E-09	3.50E-09	3.00E-09	2.40E-09
NP239	5.60E-09	4.00E-09	1.60E-09	1.30E-09	1.00E-09
PU238	2.00E-04	1.90E-04	1.10E-04	1.00E-04	1.10E-04
PU239	2.10E-04	2.00E-04	1.20E-04	1.10E-04	1.20E-04
PU240	2.10E-04	2.00E-04	1.20E-04	1.10E-04	1.20E-04
PU241	2.80E-06	2.90E-06	2.40E-06	2.20E-06	2.30E-06
AM241	1.80E-04	1.20E-04	1.00E-04	9.20E-05	9.60E-05
CM242	2.70E-05	2.10E-05	6.10E-06	4.00E-06	3.30E-06
CM244	6.20E-05	5.70E-05	6.10E-05	5.30E-05	1.30E-05

Dose conversion factors [Sv/Bq] for ingestion pathway for RODOS nuclide group

(the worst cases selected from [2] from point of view of gut transfer values)

NA24	3.50E-09	2.30E-09	7.70E-10	5.20E-10	4.30E-10
CO58	7.30E-09	4.40E-09	1.70E-09	1.10E-09	7.40E-10
CO60	5.40E-08	2.70E-08	1.10E-08	7.90E-09	3.40E-09
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB86	3.10E-08	2.80E-08	5,90E-09	3,50E-09	2.80E-09
RB88	1.10E-09	6.20E-10	1.70E-10	1.20E-10	9.00E-11
SR89	3.60E-08	1.80E-08	5.80E-09	4.00E-09	2.60E-09
SR90	2.30E-07	7.30E-08	6.00E-08	8.00E-08	2.80E-08
SR91	5.20E-09	4.00E-09	1.20E-09	7.40E-10	6.50E-10
SR92	3.40E-09	2.70E-09	8.20E-10	4.80E-10	4.30E-10
Y90	3.10E-08	2.00E-08	5.90E-09	3.30E-09	2.70E-09
Y91	2.80E-08	1.80E-08	5.20E-09	2.90E-09	2.40E-09
ZR95	8.50E-09	5.60E-09	1.90E-09	1.20E-09	9.50E-10
ZR97	2.20E-08	1.40E-08	4.40E-09	2.60E-09	2.10E-09
NB95	4.60E-09	3.20E-09	1.10E-09	7.40E-10	5.80E-10
MO99	5.50E-09	3.50E-09	1.10E-09	7.60E-10	6.00E-10
TC99M	2.00E-10	1.30E-10	4.30E-11	2.80E-11	2.20E-11
RU103	7.10E-09	4.60E-09	1.50E-09	9.20E-10	7.30E-10
RU105	2.70E-09	1.80E-09	5.50E-10	3.30E-10	2.60E-10
RU106	8.40E-08	4.90E-08	1.50E-08	8.60E-09	7.00E-09
RH105	4.00E-09	2.70E-09	8.00E-09	4.60E-10	3.70E-10
SB127	1.70E-08	1,20E-08	3,60E-09	2.10E-09	1.70E-09
SB129	4.30E-09	2.80E-09	8.80E-10	5.30E-10	4.20E-10
TE127M	4.10E-08	1.80E-08	5.20E-09	3.00E-09	2.30E-09
TE127	1.50E-09	1.20E-09	3.60E-10	2.10E-10	1.70E-10
TE129M	4.40E-08	2.40E-08	6.60E-09	3.90E-09	3.00E-09
TE129	7.50E-10	4.40E-10	1.20E-10	8.00E-11	6.30E-11
TE131M	2.00E-08	1.40E-08	4.30E-09	2.70E-09	1.90E-09
TE131	9.00E-10	6.60E-10	1.90E-10	1.20E-10	8.70E-11
TE132	4.80E-08	3.00E-08	8.30E-09	5.30E-09	3.80E-09
I129	1.80E-07	2.20E-07	1.90E-07	1.40E-07	1.10E-07
I131	1.80E-07	1.80E-07	5.20E-08	3.40E-08	2.20E-08
I132	3.00E-09	2.40E-09	6.20E-10	4.10E-10	2.90E-10
I133	4.90E-08	4.40E-08	1.00E-08	6.80E-09	4.30E-09
I134	1.10E-09	7.50E-10	2.10E-10	1.40E-10	1.10E-10
I135	1.10E-08	8.90E-09	2.20E-09	1.40E-09	9.30E-10

XE133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS134	2.60E-08	1.60E-08	1.40E-08	1.90E-08	1.90E-08
CS136	1.50E-08	9.50E-09	4.40E-09	3.40E-09	3.00E-09
CS137	2.10E-08	1.20E-08	1.00E-08	1.30E-08	1.30E-08
CS138	1.10E-09	5.90E-10	1.70E-10	1.20E-10	9.20E-11
BA140	3.20E-08	1.80E-08	5.80E-09	3.70E-09	2.60E-09
LA140	2.00E-08	1.30E-08	4.20E-09	2.50E-09	2.00E-09
CE141	8.10E-09	5.10E-09	1.50E-09	8.80E-10	7.10E-10
CE143	1.20E-08	8.00E-09	2.40E-09	1.40E-09	1.10E-09
CE144	6.60E-08	3.90E-08	1.10E-08	6.50E-09	5.20E-09
PR143	1.40E-08	8.70E-09	2.60E-09	1.50E-09	1.20E-09
ND147	1.20E-08	7.80E-09	2.30E-09	1.30E-09	1.10E-09
NP239	8.90E-09	5.70E-09	1.70E-09	1.00E-09	8.00E-10
PU238	4.00E-06	4.00E-07	2.40E-07	2.20E-07	2.30E-07
PU239	4.20E-06	4.20E-07	2.70E-07	2.40E-07	2.50E-07
PU240	4.20E-06	4.20e-07	2.70E-07	2.40E-07	2.50E-07
PU241	5.60E-08	5.70E-09	5.10E-09	4.80E-09	4.80E-09
AM241	3.70E-06	3.70E-07	2.20E-07	2.00E-07	2.00E-07
CM242	5.90E-07	7.60E-08	2.40E-08	1.50E-08	1.20E-08
CM244	2.90E-06	1.90E-07	1.40E-07	1.20E-07	1.20E-07

Supplement 2 : Primary database on population according to age categories(provided annually by Czech Statistical Office)

Type	Municipality name	Code	Population total	Popul. Age < 1	Popul. Age 1->2	Popul. Age 2->7	Popul. Age7->12	Popul. Age12->20	Popul. Age >19
3100	Hl.m. Praha	000000	1204953	8786	9290	70866	66062	114297	935652
3201	Benesov	529303	16067	139	158	1146	1109	1933	11582
3201	Bernartice	532568	260	0	4	21	20	23	192
3201	Bilkovice	530743	201	3	1	6	7	27	157
3201	Blazejovice	532380	107	0	1	7	4	11	84
3201	Borovnice	532096	112	1	2	5	3	13	88
3201	Bukovany	532924	588	8	8	48	38	51	435
3201	Bystrice	529451	3886	30	43	320	252	370	2871
3201	Ctibor	532690	106	1	0	8	6	13	78
3201	Cakov	529478	99	0	0	3	7	14	75
3201	Cechtice	529486	1305	17	18	83	85	121	981
3201	Cercany	529516	2547	17	22	160	173	284	1891
3201	Cerveny Ujezd	529532	259	0	2	8	9	44	196
3201	Cesky Sternberk	529541	124	1	2	9	7	10	95
3201	Ctyrkoly	529567	205	0	2	15	8	18	162
3201	Dekanovice	532746	80	1	2	8	6	9	54
3201	Divisov	529621	1352	8	13	106	91	132	1002
3201	Dolni Kralovice	529648	937	7	5	68	75	97	685
3201	Drahnovice	532151	58	2	3	2	1	0	50
3201	Dunice	532843	71	0	0	0	4	7	60
3201	Hermanicky	529702	667	4	9	27	36	62	529
3201	Hradiste	532932	38	0	0	0	0	2	36
3201	Hulice	529737	279	2	0	14	23	40	200
3201	Hvezdonice	529745	280	3	2	14	14	24	223
3201	Charovice	532886	162	1	1	5	14	10	131
3201	Chleby	532878	53	0	0	2	5	6	40
3201	Chlistov	532045	238	1	0	6	50	22	159
3201	Chlum	529770	136	0	4	8	6	16	102
3201	Chmelna	529788	119	1	3	12	7	19	77
3201	Chocerady	529796	967	16	9	55	52	98	737
3201	Choratice	532606	75	0	0	2	13	6	54
3201	Chotysany	529818	456	3	3	28	36	41	345
3201	Chrastany	532037	154	0	0	11	5	19	119
3201	Jankov	529842	925	9	10	57	62	79	708
3201	Javornik	529851	132	1	1	11	10	13	96
3201	Jesetice	532134	135	1	2	9	6	10	107
3201	Kamberk	531031	173	1	1	6	3	13	149
3201	Keblov	529907	210	2	1	18	9	12	168
3201	Kladruby	533084	191	2	3	13	11	21	141
3201	Kondrac	529931	412	4	3	25	37	55	288
3201	Kozmice	529940	209	4	5	14	10	18	158
3201	Krhanice	529958	752	7	10	54	48	70	563
3201	Krnany	529974	315	2	2	19	11	45	236
3201	Krecovice	529991	725	10	6	41	53	87	528
3201	Krivsoudov	530000	418	2	6	22	16	46	326
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……	…….	……	……	……	……	……	……	……	……

………………….. etc. for 6242 municipalities in total ……………………..

Document History

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