Data management in multidisciplinary research projects with the River Basin information System

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Abstract

For the development of strategies for sustainable land management various different tools from different disciplines are needed. Especially there should be tools to deal with the data management and presentation. A tool in the field of environmental data which focuses on this goal is the River Basin Information System (RBIS) which has been developed at the Department of Geoinformatics at the Friedrich Schiller University of Jena. RBIS is a web-based, modular structured platform for environmental data management and data sharing and addresses the management, analysis, visualization and presentation of different types of data in the context of multidisciplinary environmental planning (http://www.rbis.uni-jena.de). The system is used in several inter-/multi-/ and transdisciplinary research projects e.g. “TFO - The Future Okavango” (www.future-okavango.org) or “LUCCI” (www.lucci-vietnam.info) and is based on open source software (e.g. MapServer, PostgreSQL, …) ensuring a cost-efficient deployment and operation. A main focus of RBIS lies in the maintenance of metadata to ensure that information about data provenance, genesis and responsibility are not lost during processing steps applied by external tools or internal functionalities. The corresponding RBIS module stores meta-information about different data types (e.g. time series data) and offers flexible user interfaces for their visualization and manipulation. Since the origin of the system lies in the field of environmental modeling one main module deals with the management of measured and simulated time series data. Beside user-friendly import and export routines and interfaces for analysis and visualization, it provides functionalities for gap detection, rule-based gap filling and statistical analyses. Another main RBIS module allows the management and visualization of vector and gridded geo-data together with associated meta-information according to the ISO 19115 standard. Moreover all datasets (e.g. station, soil, vegetation, observations, …) described by coordinates or an area can be automatically displayed and linked to a map. Moreover, RBIS features additional modules to maintain input and output data for environmental simulation models and store documents. Due to special linkage functionality, data from different RBIS modules can be associated with each other to form problem-tailored views for environmental managers and other users. RBIS is also a standalone part of the Integrated Landscape Management System (ILMS) (http://ilms.uni-jena.de), which is a modular software integrating different steps of environmental system analysis and planning in a flexible and user-friendly workflow. Therefore RBIS provides different interfaces to access and insert data from external tools. Latest developments are mainly in the field of the user and permission management, introduction of Multilanguage support (current available languages are English, German, Vietnamese, Portuguese and Spanish) and the development of new modules related to new data types (e.g. water management infrastructure). We will give an overview about the system, latest developments and current applications.

1. Introduction

The need for a detailed understanding of environmental systems and strategies, for their adequate management, is gaining more and more importance as we face complex problems arising from global climate change, population growth and socio-economic development. In order to create strategies for the sustainable use and management of such systems and to assess the complex interactions of their underlying processes, a variety of data coming from different sources and disciplines, e.g. remote sensing, hydrology, biology, soil science or socio-economic sciences, have to be managed and integrated. To tackle this chal-

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lenge, flexible data management and information systems are needed. In order to provide meaningful information for decision makers and environmental scientists, these systems should not only support the mere storage of environmental data, but also their description with comprehensive and standardized metadata.

To address the above mentioned needs the River Basin Information System (RBIS), as a web-based platform for environmental data management and data sharing, was developed at the Department of Geoinformatics at the Friedrich Schiller University of Jena.

2. The origin development and purpose of RBIS

The development of RBIS started more than 10 years ago. Over the time the system has been continuously developed and enhanced. The following section will give a short overview of the genesis and purpose of RBIS as well as an overview about the system layout, main modules and functions.

2.1. The predecessors of RBIS

A first version of RBIS was implemented and tested in the EU-project ‘Tisza River’ which was launched within the 5th EU-Framework program in 2002. The project was assessing the water quantity and quality of the river Tisza. One objective of the project was to establish a management oriented exchange of data and information among the countries sharing the Tisza basin. This was achieved by the developing of the web-based Tisza River Information system (TRIS) (Flügel et al. 2005). During the same time period another web-based river basin information system (Saale RIS) has been developed in the Saale-Project3. The Saale RIS was designed and developed as a homogeneous database for integrated modelling (Bongartz et al. 2003).

Based on the experiences and developments of the two systems the technical base and basic set of functionalities and modules of the current version was set within the ILMS project4 (http://ilms.uni-jena.de). The developed ILMS system provides an integrated modular software platform and covers different steps of environmental systems analysis and planning in a flexible and user-friendly workflow (Kralisch et al. 2012). RBIS is a standalone part of ILMS and serves as central data store. Therefore RBIS provides different interfaces to access and insert data from external tools.

With the development of the core modules and functions of RBIS in the ILMS project the approaches from the TRIS (data sharing) and Saale RIS (homogeneous database for integrated modelling) have been joined.

2.2. Core system

In order to achieve the given technical and economical requirements defined by ILMS and other research projects (see more under section…) the core system was built under the following conditions and decisions:

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3 Saale-project: Integrated River Basin Management of the Saale River was funded from 2001 until 2004 by the BMBF
4 ILMS: Integrated Land Management System for Water Management, Local and Regional Planning was funded from 2006 until 2011 in the context of "Unternehmen Region" ("regional business"), the BMBF innovation initiative for the new federal states (http://ilms.uni-jena.de)
Cost-efficient deployment and operation
In order to ensure a cost-efficient deployment and operation, RBIS is completely based on open source software and built in a modular way. The common layout of RBIS follows a 3-tier architecture. On the server side, the system is implemented using a standard Linux web stack with Apache web server, PHP programming language, PostgreSQL database management system (http://www.postgresql.org) and PostGIS extension (http://www.postgis.org) for spatial data support. To manage and visualize spatial data the UMN MapServer is used to create maps and the OpenLayers library for a user friendly display of map data in a web browser. In case of no or slow internet connectivity, and for an easy distribution, RBIS may also be operated in a virtual server environment using the VirtualBox (http://www.virtualbox.org) software package.

Flexible and easy to extend
To build a system which is flexible and easy to extend according to actual requirements XML-files are used as description layers. Based on the description in the XML-files (e.g. underlying database schema, data type, default values, display order, group and field title, general permissions and allowed actions, dataset and map linkage, document association) different forms to view, search, create, edit and interlink datasets are generated. Therefore it is very flexible and new modules can be added easily (for more detail see Kralisch et al., 2009).

Platform for data and information sharing
Since RBIS is a web-based system the access to stored data is controlled by a user and permission management. It is based on permission groups, actions (view, edit, delete) and data types (e.g. time series data or geodata). Furthermore information about data manipulation activities (activity, new data, time, IP and user) and occurred errors are logged in order to ensure transparency, simplify the processing of support requests and allow the generation of activity reports. To reduce the effort to add and upload new data, especially if datasets differs only slightly, all RBIS forms can be saved as a template for later use. Stored datasets can be searched via attribute values or, if there is a spatial reference, via map (Zander et al. 2011).

2.3. Main RBIS modules
A main focus of RBIS lies in the maintenance of metadata to ensure that information about data provenance, genesis and responsibility are not lost during processing steps applied by external tools or internal functionalities. The corresponding RBIS module (RBISmeta) stores meta-information about different data types (e.g. time series data) and offers flexible user interfaces for their visualization and manipulation. Uploaded vector and raster datasets is described by metadata according to the ISO 19115 (ISO 2003) standard for geographic information metadata and visualized in a user friendly, feature-rich frontend taking advantage of OpenLayers (RBISmap). Furthermore all datasets with a given location (e.g. measurement station, soil, vegetation) can be automatically linked to a map and back which opens the possibility to search for datasets not only by metadata but also by their spatial location in a map. An example is the link between a measurement station and the corresponding point on a layer/map, which will be automatically created during station creation based on type and location information. With the module RBISdoc documents and their metadata (e.g. project related PDF documents) can be stored or associate to other dataset in RBIS (e.g. images associated to a measurement station). Beside the management of geodata the management of time series data is needed to support environmental modelling. The module RBISsts handles the management, analysis, statistical processing, gap filling and visualization of measured and simulated time series data. To make sure information about data provenance and genesis are not lost during data processing, RBISsts provides functions for describing time series data and their processing by detailed metadata
As it lies in the origin of raw and original time series data the format always differs. Therefore several of different import routines including pre-processing steps (e.g. to adjust time intervals or delete doubled entries) have been developed. To reduce the maintenance and data import effort a mass import and continues import of time series data. These functions for example are used to import simulated climate data or to continuously update data measured in the field. A more detailed description of functions can be found at Zander et al., 2011.

3. The deployment, maintenance and enhancement of RBIS

RBIS was and is applied in more than 15 research projects of different sizes (http://www.rbis.uni-jena.de). The covered regions are mainly related to catchments, located in Asia, Africa and South America and somehow related to research projects dealing with integrated water resources management or in general climate change topics. According to the demands raised in several research projects additional modules and functions has been developed. Selected ones will be described in section 3.2.

3.1. Applications

The different scales of application can be grouped as follows. The named examples reflect the current use and not a fixed grouping.

- **Single research topics**
  RBIS installation related to small projects (e.g. PhD thesis) with a small amount of registered users. The main focus lies mainly on meteorological and hydrological data management, pre-processing, analyses, access and preservation of time series data.
  
  **KosiRBIS**: Data collected in the Kosi catchment within the PhD research Evaluating Upstream-Downstream Linkages of Hydrological Dynamics in the Himalayan Region.
  
  **JakartaRBIS**: is a part of PhD research supported by Directorate General of Higher Education, Ministry of National Education and Republic of Indonesia under the Debt Swap Indonesian-German Doctoral Scholarship (IGDS) program.

- **Researcher group focused on a single field of research**
  RBIS installations set up within project cooperation for data exchange and management at institutional level for staff members and cooperating project partners with the focus on meteorological and hydrological data management, pre-processing, analyses and access.

  **DrysalRBIS**: Geo- and environmental data in the BMBF-funded project Dryland salinity (Multi-scale analyses of dryland salinity impacts and adaptive Integrated Water Resources Management (IWRM) strategies for salinity mitigation in the Berg River basin, Western Cape Province, South Africa (2005-2008))

  **SeyhanRBIS**: Time series data collected and measured in the Seyhan River basin during the project GIRMASEM (GIS supported Integrated Water Resources Management System (IWRMS) for the Eastern Mediterranean: A regional clean water action plan for the Seyhan River (GIRMASEM)(2006 – 2009))

- **Researcher groups and stakeholder focused on multi-disciplinary research**
  RBIS installations set up for basic and result data management, sharing, exchange and presentation for all project members and local stakeholder within an inter-/multi-/transdisciplinary environmental research project.
BrahmaRBIS and DanubeRBIS: environmental data from the Brahmaputra and Upper Danube river basins collected within the EC project BRAHMATWINN (Twinning European and South Asian river basins to enhance capacity and implement adaptive integrated water resources management approaches – http://www.brahmatwinn.uni-jena.de)(2006-2010).

OBIS*: the Okavango Basin Information System stores environmental information from the Okavango basin for the BMBF-funded project The Future Okavango (http://www.future-okavango.org).

Vu Gia Thu Bon RBIS*: environmental data from the Vu Gia Thu Bon River Basin from the BMBF-funded LUCCI project (Land Use and Climate Change interactions in the Vu Gia Thu Bon River Basin/Central Vietnam - http://www.lucci-vietnam.info).

3.2. Additional functions and modules

Since RBIS was applied in inter-/multi-/transdisciplinary research projects a lot of new functions and modules have been developed based on the demands raised during project runtime. In order to integrate and link datasets belonging to different disciplines the location of all study sites and areas (e.g. soil samples, water quality samples, test sites, survey areas/sites, biodiversity sampling plots, …) can be managed and automatically displayed in a map in the module RBISobserv. The described locations can be used in a general observation description or in all discipline dependent or independent additional RBIS modules (for example RBISsoil to manage taken soil sample analyses). The link to official soil information with respect to the project / catchment region can be realized either by just import main information (location, soil type) and link to an existing database or if there is no database, import interesting parts of the data directly and link to corresponding documents or excel files. At the end there’s a nice overview about all available soil data information in the region and plans based on that new sampling site can be made or used e.g. for model parameterization.

The example shows the necessity to take care about the different permissions and restrictions arising from different data sources. Measured data within a research project may be free for all either before or after publications of related theses. Bought datasets may only accessible within the project consortium or just for parts of them. Meta- and location data should be provided to all users or at least registered users to provide information about existing data and the opportunity to ask for access permission. To address these requirements the permission management of RBIS have been redesigned and extended to a strategy focusing more on single dataset restriction, permissions and owner rights.

The involvement of local stakeholder, dissemination and capacity building is an important task in research projects funded by the BMBF. Therefore tools and products should be also available in the local language to reach people who are not familiar with English. In order to meet these demands internationalization support for RBIS has been introduced on the level of the application (menu, system messages and field titles) and partly on the level of the data language (selected selection lists). Currently the languages Vietnamese, Portuguese, German and Spanish are available beside the main language English.

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5 Project under the research program “sustainable land management” in module A which is founded by the BMBF. The program deals with interactions between land management, climate change and ecosystem services with the aim to develop technologies, system solution and policy strategies in regions severely affected by climate and structural-demographic changes (http://nachhaltiges-landmanagement.de/en/).
3.3. Outlook

Current developments are primarily driven by demands arising in the two BMBF funded transdisciplinary projects TFO and LUCCi. Each corresponding RBIS installation is used as a project database to share and exchange basic time series data, geodata and documents within the project consortium and preliminary and final results will be available within the project consortium and working groups (e.g. derived land use maps, field measurements …). The migration to the new developed permission management should significantly contribute to the willingness and possibility (in case of license and copyright constraints) of data sharing at least within the project consortium.

One new module will be for example a module to store information about water management infrastructure (weirs, reservoirs, pumps …) or a web-based execution of JAMS\(^6\) model runs based on time series data stored in RBIS and a module to manage models, model runs, parameter sets and model result data. Result data in the form of indicators will be stored in the existing module RBISind, which will be adjusted and enhanced regarding to the produced data.

To motivate and qualify potential user and data provider RBIS training courses have been and will be offered to project members and local stakeholders. Moreover it is intended to install RBIS with all the collected data somewhere at one or more institutions in the study area in the end phase of a project to make sure all collected data stays somehow in the region and is accessible for the locals. The preservation of as much as possible data related to a research project could serve as baseline of following projects in the same region which could save time in the data collection phase at the beginning. Beside planned and arose developments during project runtime, one focus lies on the implementation of standards (e.g. Sensor Observation Service) to open RBIS interfaces to a wider range of applications and tools.

4. Conclusion

It was shown that RBIS is a useful tool for different sizes of environmental research projects. Based on its over 10 years of history the system has been improved and gathered experiences and knowledge influenced the developments and enhancements. Therefor RBIS has become a powerful tool to support on the one hand scientists in time series and geodata management and presentation and on the other hand data sharing and management within environmental research projects. The maintenance, deployment and enhancement effort is easy manageable due to its modular, flexible structure and the usage of open source software. With the integration of data from different disciplines and the web-based execution of model runs based on e.g. land use change and climate scenarios and the presentation (e.g. visualization) of result data and findings RBIS will more capable to support decision makers and serve as information platform for local stakeholder.

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