UFIS – a database of ecological models

M. Knorrenschild*, R. Lenz, E. Forster, C. Herderich

GSF – Forschungszentrum für Umwelt und Gesundheit, Neuherberg,
P. O. Box 1129, 85758 Oberschleissheim, Germany, e-mail: ufis@gsf.de

Abstract

The concept of UFIS, an information system on ecological models, is presented. Its goal is to support worldwide interchange of models and modelling know-how. A standardized model documentation scheme has been developed which will serve as the basis of UFIS. The particulars of a model documentation within UFIS include general information, mathematical formulations and technical requirements. Data questions are also dealt with. UFIS will be accessible via worldwide computer networks and allow online retrievals.

Key words: information system; data base

1. Introduction

Due to increasing activities in ecological modelling over the past decades, it has become difficult for the individual ecologist to stay informed about the state of the art. While modellers usually are in touch with others working on the same subject, there is often lack of knowledge outside their own specialty. This is a severe drawback in establishing models in ecosystems where interdisciplinary work is essential. There is also the problem of data relevant to models: input data required by modellers are not necessarily the data that are acquired by field ecologists. The scientific community is already familiar with databases that offer information and access to various kinds of data on climate, weather, vegetation, and data of a geographical nature, e. g. the Australian ERIN – system (for information on ERIN point your WWW-client to http://kaos.erin.gov.au/). However, we are not aware of a database on models that allows various applications while at the same time giving detailed information, e. g. on process formulation.

It is obvious that a database of ecological models would contribute greatly to an efficient modelling process. Moreover, such a database is crucial to

*Corresponding author.

international coordination of modelling activities. Due to increasing ecological problems on a global scale, coordination has become a key issue to the scientific community and has led e. g. to the formation of the International Geosphere-Biosphere Program (IGBP). Model comparisons and questions of model coupling have been defined as key goals in many IGBP activities (see e. g. IGBP, 1994). It is the mission of UFIS to establish such an information system (UFIS is the German acronym for environmental research information system). Work on the UFIS project started in fall 1992 at the GSF Research Centre for Environment and Health and is being funded by the German Federal Minister of Research and Technology. UFIS is designed to offer information on ecological models and their data requirements to a degree of detail required to evaluate the quality of a model in several respects. In view of IGBP – relevance UFIS will consequently focus in particular on ecosystem models (while not neglecting models on lower levels of organization, see section 3.2.). In this paper the main features of UFIS and its organization will be presented.

2. Users of UFIS

Individual scientists of various backgrounds will take advantage of UFIS. With the help of UFIS, field ecologists will be able to identify present gaps in available data that prevent full use of state-of-the-art models. On the other hand, modellers will be able to obtain an overview of models available at other institutions in order to avoid duplication of efforts. Typical inquiries may be asking for a list of all models that simulate the water balance within an agricultural ecosystem, or for models that yield the biomass of an individual as an output variable. Modellers will also be able to extract process formulations from models in order to combine them with their own. The information provided will carry particulars about the temporal and spatial range in which models yield valid results. This is particular important to scientists with a different specialty who may not be able to judge if some model meets their goals. The amount of detailed information on the models stored in UFIS ensures that models can be compared to each other in view of different formulation of processes, different data requirements, and so on. This makes UFIS a valuable tool for project managers in international modelling activities like IGBP. Another group that will welcome UFIS is managers of ecological research in governmental institutions. They will be able to identify gaps in the current state-of-the-art of ecological modelling and adjust their funding policies adequately.

3. What kind of information is stored in UFIS?

A first concept of a documentation scheme for ecological models has already been proposed by Asshoff of the Ecosystem Research Centre at the University of Kiel (Asshoff, 1991). In joint work with Asshoff as well as Benz (see Benz, 1994) of the University of Kassel, we have developed a complete documentation scheme which we will briefly discuss now. The information contained in this scheme on a particular model is threefold: general information, description of processes within the model, and technical information.

3.1. General information

The aim of this section is to provide information for the user who is not interested in details of the model. Besides the obvious items like name and address of the modeller, a brief summary of the aim of the model and its basic ideas valuable information regarding the range of applications is given. This includes references to other models that could possibly be coupled with the one under consideration. The suitability of the model for purposes other than the original one can, to a certain extent, be judged from reports on calibrations and validations performed (and the data used), as well as spatial and temporal scales. References to user manuals and on a detailed model documentation are also available. A flow diagram of the model structure will provide the UFIS user with an idea of the organization of the model and its submodels.

3.2. Description of processes within the model

The basic idea is that each model is composed of a number of hierarchically ordered processes. The processes are described mathematically by equations. Here "equations" is used in a wide, abstract sense, including e. g. tables. The hierarchy among the set of processes of the model is naturally given by the coupling between these equations via variables. Information is stored for each process separately, referring to underlying subprocesses via pointers. This information includes: brief description, mathematical formulation, possible constraints, initial/boundary conditions, spatial and temporal resolution, references to the literature and embedded subprocesses. A set of keywords regarding the type of process and type of equation enables an efficient search within UFIS. Quantities used in the mathematical formulation will be classified as input and output for each process, indicating also which quantities are input and output of the full model. For each of the quantities a brief description, values used, range of values possible is given and also the source of the data (where applicable). It is also reported on sensitivity analyses performed by the modeller. In case the mathematical description of a model cannot be split into different processes, there is an option to describe the model verbally. However, we designed the structure of the scheme in a very general way, such that this case is considered the exception rather than the rule. For a detailed description of the mathematical documentation, we refer to Benz (1994) (for information on Benz' project ECOBAS, point your WWW-client to http://dino.wiz.uni-kassel.de/).

For each single process, a table of environmental conditions contains a description of its real world setting. Entries in this table describe the physical environment in which the underlying process formulation is valid. One of the items asked is the "level of organization" (Miller, 1975; Lenz, 1994) which the process takes place and a more specific characterization (e. g. which type of ecosystem, which species). Checking lists for these specifics are supplied; in particular, a comprehensive thesaurus for types of ecosystems has been developed. Further items sought are geographic location, type of climate, and type of soil. The particulars are to be given as general as possible without violating the validity of the process formulation. Where meaningful and available, information will (also) be given by means of commonly used classification schemes (like e. g. the FAO scheme for soil types).

3.3. Technical information on a model

This part deals with the computer implementation of the model. It is divided in software- and hardware- related information. Under the topic "software", it is mentioned which libraries are needed to run the model (if any), programming language used and where to obtain a complete program documentation. For the goal of UFIS as outlined above, the data question is of particular importance. The UFIS user will find here detailed description of the input files needed and also where to obtain them. Of course, sources of the program code itself, demo input, and sample output files are also given. Hardware requirements are given in the second part of this section, i. e. which operating systems versions of the model code are available, as well as disk space required.

4. Technical realization of UFIS

In view of the amount of paperwork required by the modeller who wants (or is forced) to provide the full documentation of his/her model, a computerized version of the questionnaire is in progress. This program will guide the modeller through all the questions being asked, and will accept answers on screen. In particular, it will provide access to thesauri. It will also run a few simple consistency checks on the input it is fed, such that obviously erroneous input will be rejected immediately. Entries accepted will be saved to a file which is then sent to the UFIS managers where it will be double-checked for completeness, unique use of terms and so on and finally stored in the central UFIS database. UFIS will be implemented using the $INGRES^{TM}$ relational database management system and will be maintained on a CONVEX computer at the GSF research centre. It will be accessible to the scientific community via Internet and WWW (http://www.gsf.de/UFIS/ufis) in order to enable queries via remote login to the database server and to yield immediate search responses. For technical reasons, flow diagrams of models will not be accessible in the database itself but via a separate server. Some technical details remain to be resolved but it is our goal to create a simple-to-use interface that will work for a number of widely used computing platforms like UNIX workstations, as well as PCs.

5. Concluding remarks

The UFIS questionnaire described above is available (in English or German) from the authors upon request. It comes with detailed instructions on how it is to be filled out as well as a completed sample questionnaire. We are currently in the process of feeding completed questionnaires into the database. Throughout the design period of UFIS, we will remain in touch with possible users in order to satisfy their requirements towards UFIS. Clearly, documentation is not the most attractive part of the modelling process, particularly if it requires much detailed information. However, we believe that it is well worth the effort and it is our goal to design UFIS user-friendly in both directions. There does not yet seem to be an internationally standardized model documentation available elsewhere, and it is hoped that UFIS will fill this gap.

References

IGBP, 1994. Global Modelling and Data Activities 1994-1998. IGBP Report 30, Stockholm.

Asshoff, M., 1991. Konzept einer Modelldokumentation. Interne Mitteilungen No. 5, Ecosystem Research Centre, University of Kiel.

Benz, J., 1994. ECOBAS – documentation of mathematical descriptions of ecological processes (in German). In: H. B. Keller, R. Grützner, J. Benz (Editors), Proc. of the 3th meeting of the working group “Werkzeuge für Simulation und Modellbildung in Umweltanwendungen”. Nuclear Research Centre Karlsruhe (KfK) Report no. 5310, pp. 55-63.

Miller, G. T., 1975. Living in the Environment – Concepts, Problems, and Alternatives. Wadsworth Publ..

Lenz, R., 1994. Ecosystem classification by budget of material; the example of forest ecosystems classified as proton budget types. In: F. Klijn (Editor), Ecosystem classification for environmental management, pp. 117–137, Kluwer.