SIEREM: an environmental information system for water resources

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Abstract The joint research unit "HydroSciences Montpellier" (HSM) aims to study hydrological variability on the African continent. SIEREM, an environmental information system for water resources, has been developed at HSM. The POLLEN method was used to design and achieve this successful system. This method is adapted from the OMT (Object Modelling Technique) method, which is specific to the design of environmental information systems. The main part of the analysis technique consists of modelling the data, i.e. identifying the objects of the system, defining their structure and describing their relationships. The information system is then described according to the different services it has to fulfil. This permits one to define the processes asked for by the users and to provide a description of the functions and algorithms. The system is thus divided into sub-systems. Each one is described according to its interface, the piece of software implemented, the managed object classes and the services provided, and the relationships with the other sub-systems. The final result of this information system is a package of different software products. Depending on their rights and needs, the users get specific accesses to information. Each information type, such as a GIS layer or a rainfall chronicle, is managed in every different product of the system. The public can get metadata through the web site, a researcher in the laboratory can work with the data using the Orion software, etc.

Key words GIS application; DBMS; web interface; environmental base of knowledge; water resources; hydrological modelling; West and Central Africa

INTRODUCTION

SIEREM was developed as a tool to help rainfall–runoff models. The area on which these models are used is West and Central Africa. It was required to also be useful for explaining, *a posteriori*, possible variations in this area of the world. And finally, another objective of SIEREM is to provide data inventory and software tools to help the end users to manage, select and handle the information.

The development of SIEREM started in 1999 with two simultaneous phases: data collection and the system analysis and design. The challenge was to build a system with both chronological data and spatialized information (such as soil, vegetation and DEM layers). HydroSciences Montpellier formed a team of engineers to start three tasks: collection of hydro-meteorological data and metadata, collection and building-up of geographical information, and the required data homogenization and integration into an environmental system built using a specific method of system analysis and design.

THE SYSTEM ANALYSIS AND DESIGN METHOD

The method used is POLLEN (Gayte *et al*., 1997) adapted from the OMT method (Rumbaugh *et al.*, 1991). This method is based on two simple principles: graphical representation and respect of the logical steps in the software life cycle such as: the conceptual modelling of data (object diagram, dictionary), process modelling (functional model, function dictionary) and system, sub-system and reservoir identification (system diagram, dictionaries, etc.).

CHRONOLOGICAL DATA CONCEPTUAL MODELLING

The chronological data are measurements done at one time in one place. All the object modelling which describes such type of data is described and the description of the place, the date of the measurement, the person who measured out, and the owner of the data. Figure 1 shows how the modelling of the chronological series in SIEREM operates.

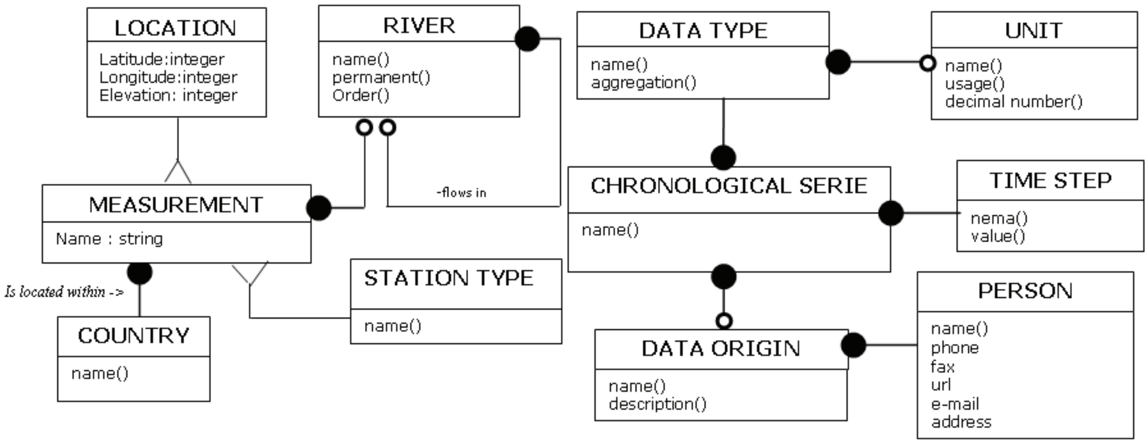


Fig. 1 The conceptual modelling of chronological data.

SPATIAL DATA MODELLING

POLLEN provides special classes called "abstract classes", for designing the basic spatial objects. There are three abstract classes: **point**, **line** and **polygon**. Using these classes, it is easy to build derived classes with point, line and polygon geometric structures. Those derived classes will design surface areas with geometric and topological properties. Figure 2 displays an example of the use of the abstract classes to build a conceptual model of a basin and a river.

Another type of class provided by the method is the opaque class. This type permits modelling free of the GIS internal structure and consideration of only the function provided by the class. The DEM object is a good example of an opaque class and, with this facility, can be integrated into the design diagram.

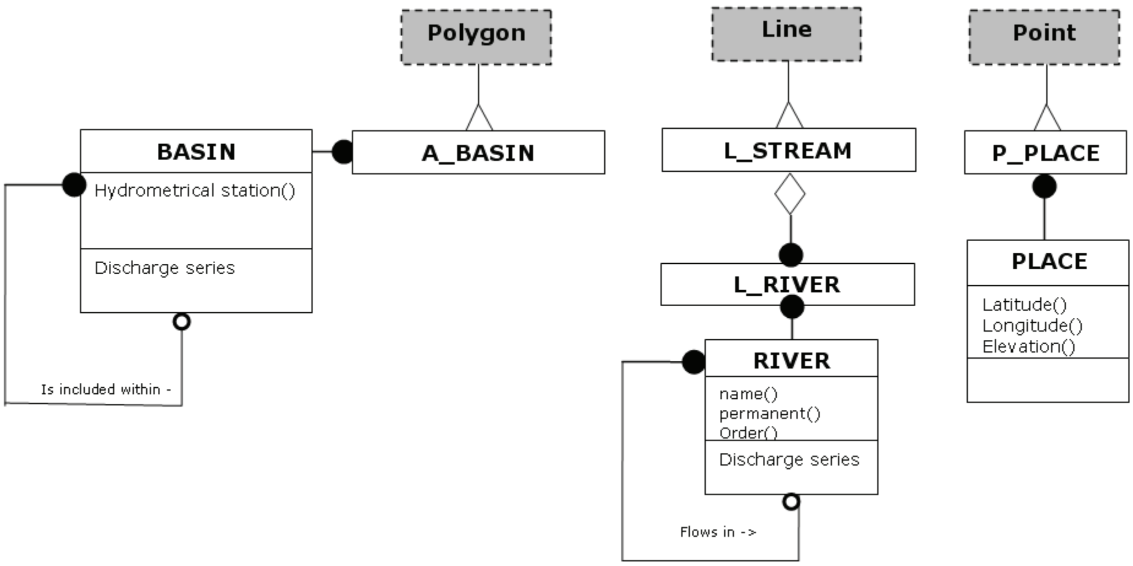


Fig. 2 Part of the conceptual modelling of spatial data.

FUNCTION MODELLING

The function model is another part of the POLLEN method. The aim is to identify the different functions provided by the system, such as the chronological series management which allows one to create and to exploit personal sets of series, and the website, which displays GIS layers and station metadata to the public.

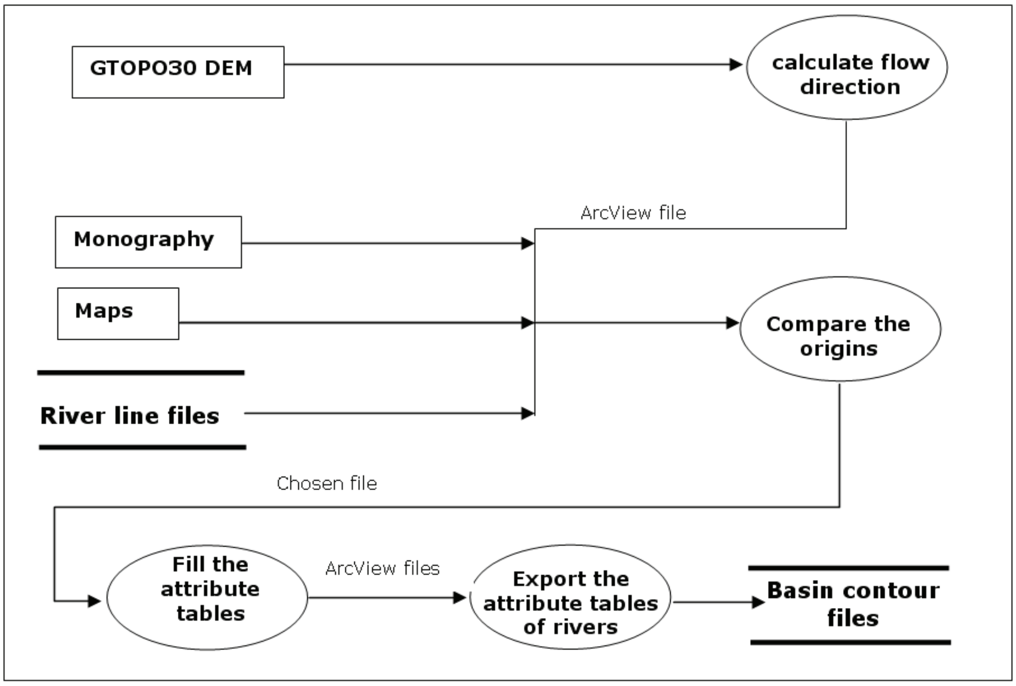


Fig. 3 Example of a functional model. Data flow diagram for the processing of basin contours.

The answer is the accurate identification of data used by the functions and the flow of information that the system has to manage. Figure 3 displays the data flow diagram for the processing of basin contours. At this step of the analysis, there is a good knowledge of what are the devices and the information needed to create the information set called "basin contour".

SYSTEM CONCEPTION DIAGRAM

The system conception step is the description of the system in an architecture closer to the final system. Figure 4 displays the system diagram with the nodes representing sub-systems and lines representing the links between them. Two principal tasks are required at this step of the achievement of the system design: the sub-system identification, which allows separation into sub-systems corresponding more or less to the future pieces of software of the system, and the reservoir identification which points out the sub-system dedicated exclusively or not, to the data storage.

SUB-SYSTEM INDENTIFICATION

The data warehouse sub-systems are drawn with a bold frame on Fig. 4. The users of the different sub-systems are represented with the two different levels. The first level is the technician who is the information system builder, updating data with appropriate criteria and scale. The second level is either the hydrologist or the researcher. This type of user is considered as a final user of the system using the information as an entry for another piece of software such as a GIS application or hydrological modelling software.

For example, the sub system *Chronological data management* operates the data entry, update, extraction and inventory for the hydrometeorological data. The sub-system *DBMS*, provides data and metadata management, etc.

DATA RESERVOIR IDENTIFICATION

This task is quite simple but it is very important to identify it properly in order to be sure that the data reservoir structure fits with the data classes stored. In the SIEREM case, there are three

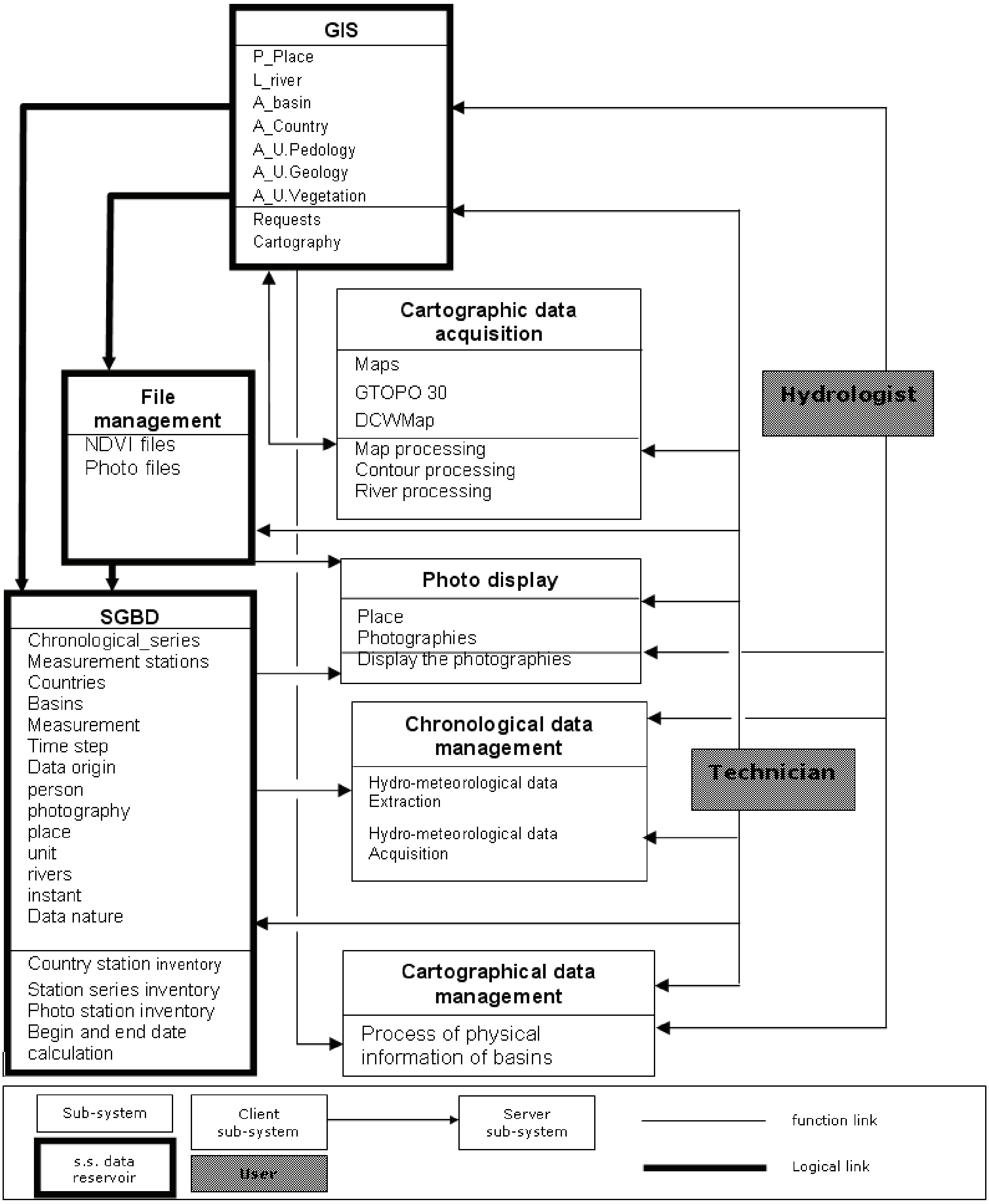


Fig. 4 SIEREM system diagram.

reservoirs: the *DBMS* to store the chronological data and metadata, the *files system management* to store logically picture files, NDVI files, and photography files and the *GIS* to store spatial information.

Integrity links exist between these three systems because all information refers to the metadata managed by the DBMS. The implementation and the checking of these integrity links are assumed to be conducted by the technician.

THE DEVELOPED PROCESSES

There are mainly five client applications using the SIEREM resources. First of all HydroSciences Montpellier implemented a stand-alone piece of software called "ORION" which is the main tool for researchers to build most of the hydrometeorological data set for their modelling session. The second part is the web site that allows the publication of the systems content and result products. The third client of SIEREM is made of some pieces of software implemented by HydroSciences Montpellier and called "Plateform". This set brings together model algorithms and puts the results interpretation procedures at the researchers' disposal. The fourth client is the software ArcGIS which provides all GIS functions for using and working with the spatial data layers and linking them with the chronological data sets. The fifth client is the set of all applications which came with the DBMS MS SQL Server for the administration of the database. Database administration mainly means all the tasks linked to the security management of the system and all the automatic backup functions. The first two clients are detailed below.

THE ORION SOFTWARE

This stand-alone piece of software is the toolbox used by the researchers on their own computers to choose, select and extract their data set to use either for statistical calculation or for running models. Of course, the data access criteria are targeted at hydrological parameters, i.e. basin, type of measurement station, origin of data, data consistency, etc. Therefore, Orion also provides a large format of extracted data and some tools to present and publish inventory or data yearbooks.

SIEREM WEB SITE http://www.hydrosciences.fr/sierem

The aim of the SIEREM web site is to provide to the scientific community with the metadata of all the environmental information managed in the project and the major scientific results produced. First of all, the web site displays through various ways of selection, the metadata on the hydro-meteorological set used by HydroSciences Montpellier to carry out their research. In this way, the web site tries to list the contacts of all national departments in Africa in order to permit everyone to ask for data. Figure 5 displays the sequence of screens in order to obtain information about chronological data.

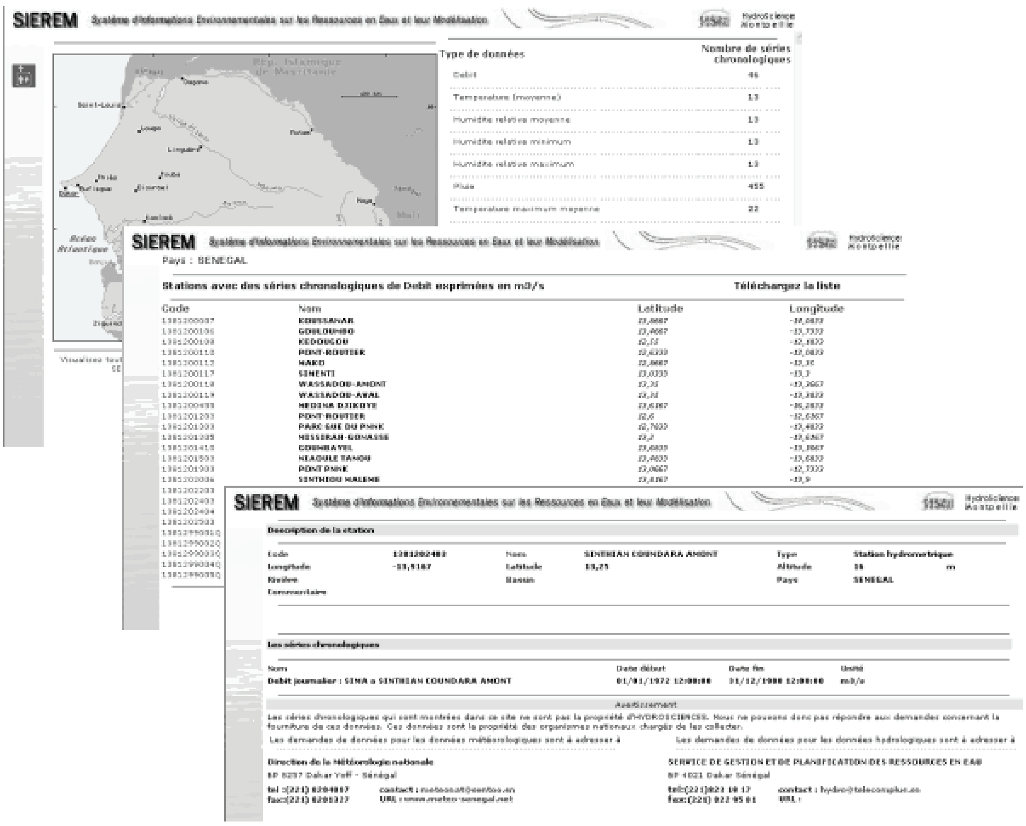


Fig. 5 Series of web site windows concerning the metadata on hydrometeorological chronological series.

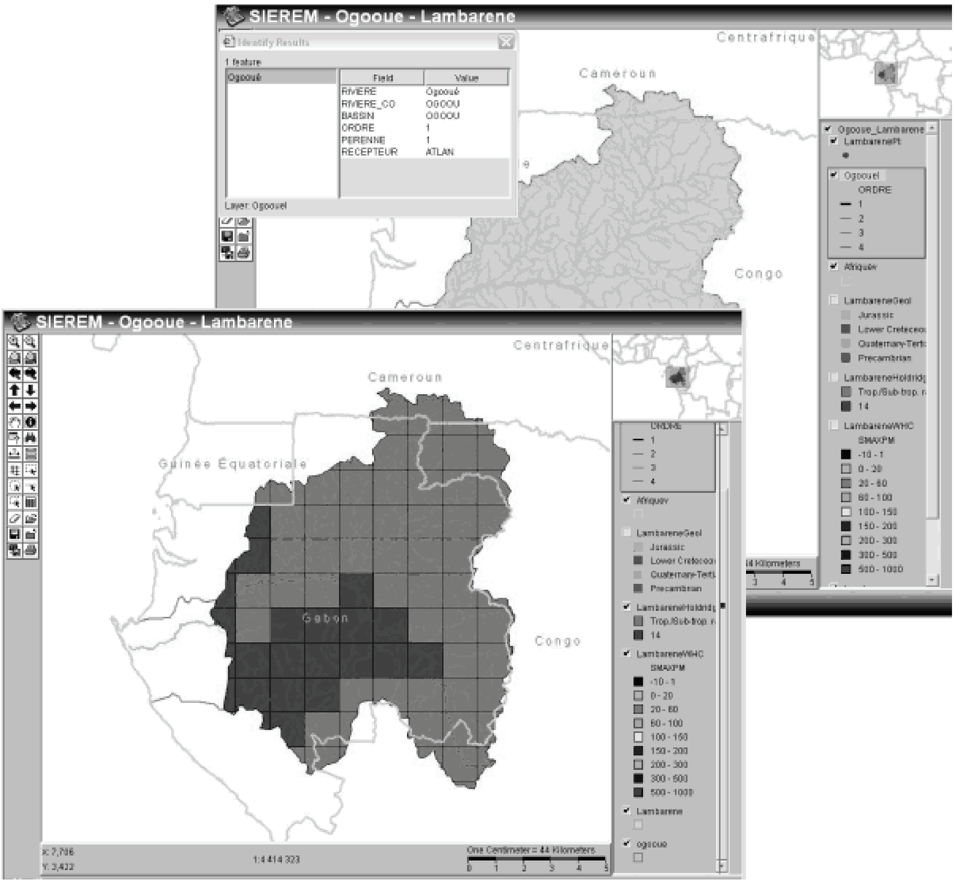


Fig. 6 SIEREM Web GIS application: the Ogoowe basin example.

Another important part of the website is the GIS application. This function runs under an ARCIMS software and provides GIS layers implemented by HydroSciences Montpellier. This application gives users several GIS tools to work with the SIEREM spatial information. It also provides the possibility of creating personal work sessions by adding and processing one's own GIS layers into the application. Figure 6 shows the web GIS application for the Ogoowe basin.

There are two other important sections in the web site. First, the landscape pictures section which is an attempt to build a significant base of African landscapes in terms of soil and vegetation cover information as well as a (not exhaustive) catalogue of the principal hydraulic installations. The second part is the product section. This allows HydroSciences Montpellier to provide for download several hydrological and research products, e.g. the entire data grid used by the team for their modelling session.

There is also free access to download the metadata of the hydrometeorological series, all basin boundaries and all basin hydrographic network data. This part of the website is specially built in order to enhance the knowledge of the scientific community in Africa and to assist the African national services in their efforts to provide good environmental data.

Therefore, SIEREM provides a large set of tools with which to access the information. The system was built in order to distinguish between some classes of users and this is carried out by the piece of software every user is allowed to use.

For example, everybody can check the runoff series metadata for the Ogoowe basin through the web site. Also, everybody can also download the GIS layers for the Ogoowe basin, such as the hydrographic network or the Water Holding capacity grid, and so on. Using Orion, all researchers and students working on the HydroSciences Montpellier network can choose a set of runoff series on the basin. Orion provides functions to extract the time series in several formats, to copy and aggregate them to other time steps. With other SIEREM tools the researchers can calculate their own mean rainfall grid from a chronological series data set built with Orion. And at last, they can run their modelling session with this information package.

CONCLUSION

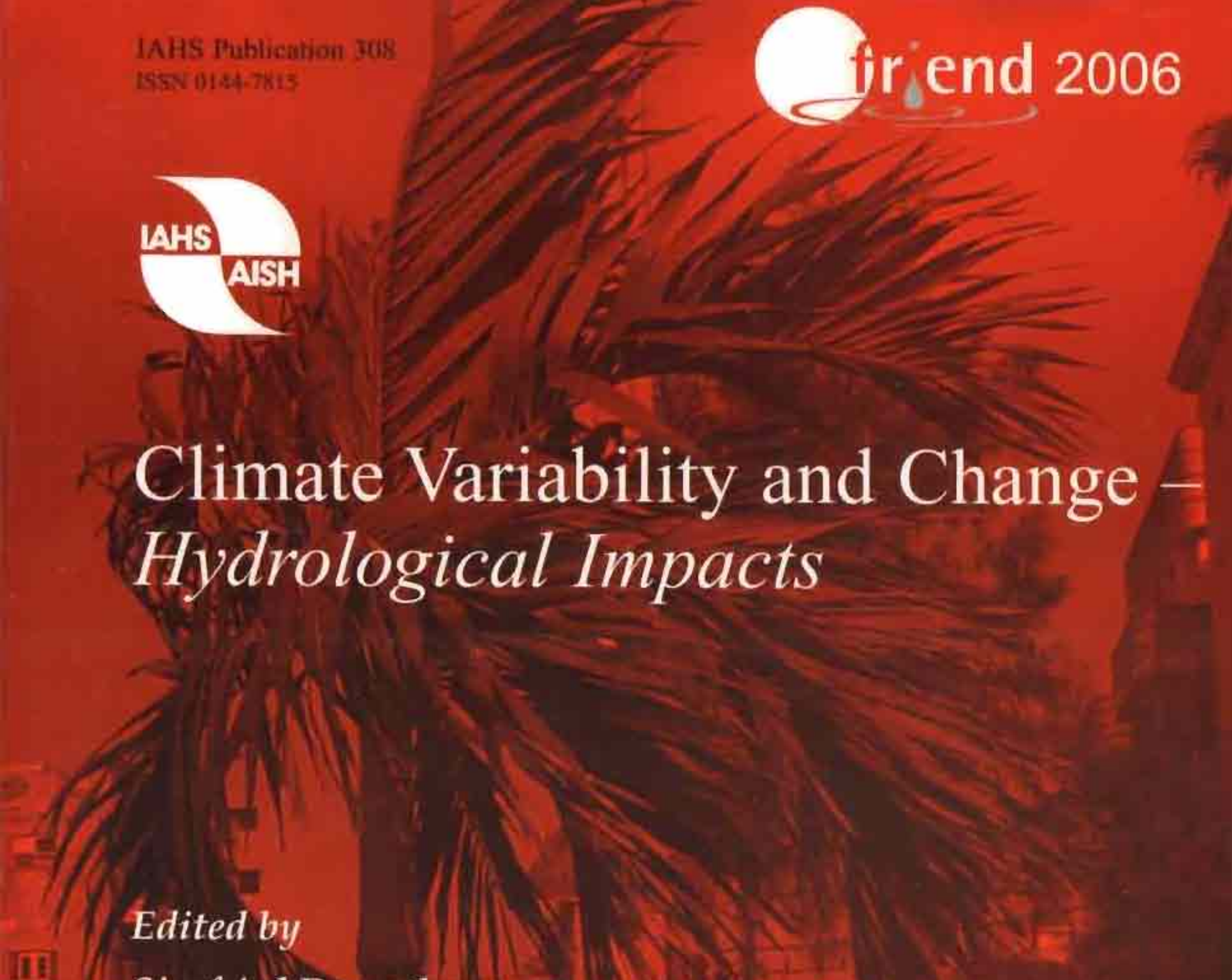
Computer science has an important role in the management of the very heterogeneous sets of data involved in the development of environmental information systems. The problems posed to computer scientists are of many kinds: information must be located, information must be dated, information are heterogeneous and metadata must be linked to the information.

Given the importance of such systems, which are now used systematically in every large-scale project, the analysis methods must be homogenized too. In this context, POLLEN brings an attempt to define the design and the analysis. A big effort must be made by the project managers of such systems to carry and to adapt old systems to the ISO 19115 metadata norm. SIEREM is totally compatible with this norm.

REFERENCES

Rumbaugh *et al.* (1991) *Object-Oriented Modeling and Design*. Prentice Hall, Englewood Cliffs, New Jersey, USA.

Gayte, O., Libourel, T. *et al.* (1997) Conception des systèmes d'informations sur l'environnement—HERMES. Collection Géomatique.



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