The Fourth International Meeting on Global Continental Palaeohydrology GLOCOPH 2000

HYDROLOGICAL CONSIQUENCES OF GLOBAL CLIMATE CHANGES
GEOLOGIC AND HISTORIC ANALOGS OF FUTURE CONDITIONS

Jointly with Symposium on
Glaciation and Reorganization of Asia's Network of Drainage

CONFERENCE PAPERS AND ABSTRACTS

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Moscow and Central Part of Russian Plain
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Historical flood archive and its analysis using GIS (Tagus river, Central Spain)

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The Tagus is the longest river of the Iberian Peninsula (1200 km) and the third largest in catchment area (81,947 km^2) passing both through Spanish (54,769 km^2) and Portuguese (27,178 km^2) territory. The river regime is influenced by Atlantic fronts crossing the Iberian Peninsula mostly during winter. Eastern and northeastern tributaries are of a mixed hydrological regime and are affected by snowmelt and rain water from the Iberian and eastern Central Range areas, while southern and northwestern tributaries are dominated by rain water. General discharge characteristics are: (1) maximum discharge from February to March; (2) minimum discharge in August; (3) a peak in December; and (4) reduced discharge in January.

The historical information available on the past flooding of the Tagus basin dates back to AD 849, although more continuous and reliable data start to emerge in the year AD 1100. Historical archives including flood information are scattered along the entire river, the largest being Aranjuez, Toledo, Talavera de la Reina and Alcántara. Other cities located at the main tributaries of the Tagus which boast extensive historical records are Madrid (Manzanares river) and Alcalá de Henares (Henares river). Over 375 historical flood entries are included in the database.

Database structure

One of the main shortcomings of preexisting databases is a lack of geographic referencing of information which will permit the later handling of data using geographic information systems (GIS). The database created for the Tagus basin "PaleoTagus" is of the relational type and is backed up by a standardized, compatible database management system which not only permits the storage of information, but also its quantitative and qualitative analysis through a GIS. The GIS includes graphical covers and applications plus the necessary tools for numerical analysis. In the PaleoTagus database, the *primary table* is denoted "historical" and contains information corresponding to a flood event in coded format and the *secondary tables* serve to define the meaning of these codes. In the "historical" data table, each flood event is assigned a registry code or event identifier which is made up of the combination of date+reach+location of the flood. This registry number, and therefore event number, is unique in the database. Identification codes used are those established by other administrative bodies. For streams, the arcs encoded by the decimal river code (DRC) by the Water Authorities were used. For the municipal districts, the codes of the Spanish national statistics organization were used. For example, a flood occurring on December 20th 1168 (11681220), in the Tagus river (030100000000) as it passes through Toledo (0845168) would be assigned the code: 116812200301000000000845168.

In the primary table, numerical information mainly consists of hydraulic flood data such as water level, estimated discharge, flow velocity etc. Alphanumerical data correspond to fields such as causes and damages, encoded according to the pre-established groups. The descriptions obtained from historical documents are included as fields of text. Associated with this table are the code-relating, or secondary tables which comprise two fields: code and definition or name. Others define the causes leading to the flood (rain, snow, hail, rain+snow, etc.) and the damages produced: human losses, damage to infrastructure (communication, water or urban structures), damage to agricultural land and industries (irrigation and drainage networks, farmland, industrial areas) and geomorphological changes in river channels and floodplains. These damages are assigned codes corresponding to: no damage, minor damage and major damage or destruction.

Database implementation

An important feature of Paleotagus is the PaleoTagus Program Manager which aids in the consultation and handling of the database, providing visual results (graphs and maps), text (tables and reports) and simple data analysis. The software was created using the Avenue programming language (directed at objects) based on the GIS ArcView 3.0a program which is widely used worldwide. Using this language, small programs (scripts) were developed which permit the creation of windows, menus, tools, dialogue windows etc. acting as intermediaries between the end-user and the GIS (Figure 1).

The program manager consists of a main menu from which windows with the following query options or submenus may be accessed (Figure 1): a) date; b) stream; c) site; d) cause; e) damages: human, material (communication, water and urban networks), to agriculture and industry (irrigation and drainage networks, farming areas, industrial zones), to natural channels.

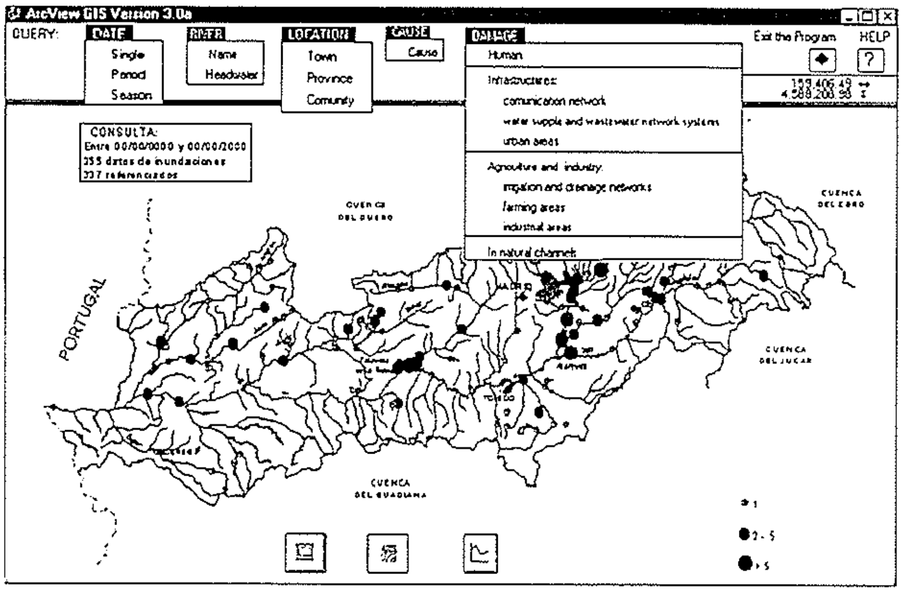

Fig. 1. Main menu of the PalaeoTagus program manager and graphical output of a search comprising all the historical floods in the Tagus Basin.

Database query results

In the most elementary type of search, information is obtained on the distribution and frequency of past floods occurring in the Tagus basin. In this search, four periods corresponding to those showing the greatest frequency of extreme flood events are identified: AD 1150-1290, 1550-1600, 1730-1850 and 1850-1910. Apart from general searches, queries which center on specific channel reaches or sites may be made. Here, more detailed information on each documented record consisting of photographs, topographical maps, hydraulic modeling data and estimated peak discharges using HECRAS computer program. A detail analysis of this type of information in Toledo show a period of extreme flooding between AD 1100 and 1200 (AD 1113, 1168, 1178 and 1181) presenting discharges from 4000 to 5000 m^3sec^{-1}. These floods are considerably greater than those recorded in recent historical times such as those occurring in AD 1876 and 1947, which present peak discharges of 3000 to 3100 m^3sec^{-1}. Other past flood events of relevance such as those of AD 1211 and 1258 have estimated peak discharges *c.* 3000 m^3sec^{-1}, and those occurring in AD 1158, 1200, 1565 and 1942 are estimated at *c.* 2000 m^3sec^{-1}. Peak discharges below those corresponding to these past floods are provided by the Toledo gauging station instrumental data record (from 1972 to the present), which quotes values under 1100 m^3sec^{-1}. Two important features emerge from these findings. On the one hand, it seems clear that the historical flood record substantially completes the information on extreme floods with recurrence periods beyond gauging station time records. And on the other, the data obtained from the historical record reflect the non-stationary nature of the floods when considering time periods of sufficient length. Annual flood series used in flood frequency analyses are assumed to be stationary in time (all floods are randomly generated from a single probability distribution with stable moments). This assumption is a significant limitation to be kept in mind in the evaluation of hydrological hazards by purely statistical methods.