GLOBAL PALEOENVIRONMENTAL DATA

A report from the workshop sponsored by Past Global Changes (PAGES) August, 1993

Organized by J.T. Overpeck and J. Pilcher

Edited by D.M. Anderson

PAGES WORKSHOP
REPORT SERIES 95-2

PAGES
PAST GLOBAL CHANGES
A CORE PROJECT OF
THE INTERNATIONAL
GEOSPHERE-BIOSPHERE
PROGRAMME **IGBP**

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PAST GLOBAL CHANGES (PAGES) is the International Geosphere-Biosphere Programme (IGBP) Core Project charged with providing a quantitative understanding of the Earth's past environment and defining the envelope of natural environmental variability within which we can assess anthropogenic impact on the Earth's biosphere, geosphere and atmosphere.

In order to evaluate their effectiveness, models intended to predict future environmental changes must be capable of accurately reproducing conditions known to have occurred in the past. Through the organization of coordinated national and international scientific efforts, PAGES seeks to obtain and interpret a variety of paleoclimatic records and to provide the data essential for the evaluation of predictive climatic models. PAGES seeks the integration and intercomparison of ice, ocean and terrestrial paleorecords and encourages the creation of consistent analytical and data-base methodologies within the paleosciences.

The PAGES Project focuses on specific sets of questions and issues:

- *How has global climate and the Earth's natural environment changed in the past? What facts are responsible for these changes and how does this knowledge enable us to understand future climated and environmental change?*
- *To what extent have the activities of man modified climated and the global environment? How can we disentangle anthropogentic-induced change from natural response to external forcing mechanisms and internal system dynamics? What were the initial conditions of the Earth system prior to human intervention?*
- *What are the limits of natural greenhouse gas variation and what are the natural feedbacks to the global climate system? In what sequence, in the course of environmental variation, do changes in greenhouse gases, surface climated, and ecological systems occur?*
- *What are the important foring factors that produce climated change on societal time scales? What are the causes for abrupt climatic and environmental events and the rapid transitions between quasi-stable climatic states which occur on decadal to century time scales?*

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SPECIAL NOTICE TO ALL READERS:

Many of the ideas, descriptions, and guidelines presented in this report are likely to evolve as PAGES science activities mature. In this sense, this report is a living document. PAGES and the WDC-A for Paleoclimatology (the PAGES data coordination center) update these activities in their newsletters, and in documents distributed via the Internet. Readers of this report are encouraged to contact the PAGES and WDC-A centers to be placed on their mailing list, and to regularly check the Internet home page of the WDC-A for new information, including Internet links to new data efforts. The URL address is http:/www.ngdc.noaa.gov/paleo/paleo.html.

WORKSHOP SUMMARY

In August 1993, participants from 13 countries met in Bern, Switzerland, to discuss the management of paleoclimate data relevant to the goals of the IGBP Past Global Changes (PAGES) Project. Reports from participants described many of the efforts currently underway to archive and distribute paleoclimate data, and identified protocols currently in place for the management of paleoclimate data. Following the reports from participants, working groups met separately to identify priorities and establish guidelines for several different data categories, including tree-ring data, and historical documentary data, paleoceanographic data, modeling data, climate reconstruction data, and ice core data. The group met in plenary session to examine the findings of each working group, and develop recommendations that form the basis for the PAGES Data Management Guide.

Reports from participants described 29 different national and international efforts currently underway to collect, archive, and distribute paleoclimate data. The types of data discussed were extremely diverse, ranging from historical documents to sea level and lake level data spanning the late Quaternary to gridded fields derived from climate model simulations. In many cases, protocols for the collection and distribution of the data are now in place, and the participants noted that this makes a logical step in the development of comprehensive data management guidelines. In many cases, these data are being assimilated in order to satisfy specific goals, scientific foci, or national objectives that are distinct from the PAGES scientific foci. Workshop participants agreed that to meet the PAGES objective to develop a multi-proxy three-dimensional record of climate extending backwards in time, a set of common guidelines for PAGES data are required.

Following the reports from participants, working groups met separately to develop guidelines for specific data categories. In many cases, the working groups recognized protocols already in place, for example the International Tree-Ring Data Bank file formats and protocols. Additional recommendations were established to ensure that the data collected could be used to address the PAGES scientific foci. For relatively new categories of data, and categories lacking existing protocols, experts within the working groups identified key data management issues.

Guidelines for the collection of paleoclimate data were developed by the individual working groups, and discussed by all workshop participants. The group recognized that paleoclimate data are extremely diverse, and often collected for different scientific foci. Thus, guidelines need to be created or fine-tuned as the paleoclimate research community moves to create an international public domain database from heterogeneous sources. Guidelines are a useful way to ensure that these data can be used to address the scientific objectives of PAGES. The Guidelines can be summarized by the following general principles, in addition to the more specific recommendations that appear in the section PAGES Data Management Guide.

- Data should be freely distributed and available without restriction
- Data archived should include both reconstructed climate and the raw data from which the reconstructions are derived. Raw data should be sufficiently detailed so that reconstructions can be reproduced or evaluated using different calibration data, and for uncertainty to be evaluated.
- Metadata (data that describe the measurements, including site location, units of measure) are as important as the individual data themselves. Every effort should be made to include sufficient metadata so that the measurements can be fully utilized.

The World Data Center-A for Paleoclimatology in Boulder, Colorado, USA, serves as the data coordination center for IGBP PAGES, and will be committed to providing regular updates on the rapidly expanding paleoenvironmental data activities that result from the Bern Workshop.

ROLE OF PALEOENVIRONMENTAL DATA IN GLOBAL CHANGE

In efforts to understand the natural variability of the Earth climate system and the potential for future climate change, paleoclimate data play a key role by extending the long-term baseline of observations of past climate change. The instrumental record that spans the last century is simply too short to establish the baseline of natural variability, or to evaluate the slowly-changing components of the climate system such as ice sheets and deep ocean circulation. The window on the past provided by paleoclimate data provides our only means to investigate how the climate system operated under boundary conditions (e.g., atmospheric trace gas concentrations, insolation) substantially different from today. For this reason, the WDC-A and other data efforts also support climate model validation using the paleoclimate record. Paleoclimate data include quantitative estimates of past climates and environmental changes derived from natural recorders such as ice cores, tree-rings, ocean and lake sediments, cave speleothems, corals, and macrofossil deposits. In addition to their obvious role in the realm of observations, paleoenvironmental data also play a role in process studies that seek to understand the processes responsible for natural seassonal to millenial-scale climate variability, and determine how well these processes can be simulated by models.

GOALS OF THE IGBP PAGES PROGRAM

The goal of the IGBP is "To describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human activities"—from IGBP Report 28: IGBP in Action.

PAGES is a Core Project of the International Geosphere-Biosphere Program. Through the organization of coordinated national and international scientific efforts, PAGES seeks to obtain and interpret a variety of paleoclimatic records and to provide the data essential for the validation of predictive climate models. The PAGES project is designed to increase our understanding of the natural physical processes that control the earth's environmental systems, their temporal and spatial variability, their rates of change, and the linkages that operate between environmental and ecological systems. PAGES builds on existing national programmes by providing the international framework needed to accomplish scientific endeavors which are beyond the capacity of any single nation. In the years since the establishment of the PAGES Core Project Office in Bern in 1992, the scope of the PAGES effort has expanded dramatically, and now encompasses five scientific foci, Global Paleoclimate and Environmental Variability (the PANASH Project), Paleoclimate and Environmental Variability in Polar Regions, Human Interactions in Past Environmental Changes, Climate Sensitivity and Modeling, and Cross-Project Analytical and Interpretative Activities (PAGES news, 1993&1994). More information can be obtained from the PAGES Core Project Office, Bärenplatz 2, CH-3011 Bern, Switzerland.

RELATIONSHIP TO THE IGBP

The International Geosphere Biosphere Program was established in 1986 by the International Council of Scientific Unions to address challenges of global change, recognizing that the complexity and importance of this topic required an international approach, with emphasis on a soundly based framework for research planning, implementation, and synthesis (from Report 28: IGBP In Action).

PAGES coordinates its activities with other IGBP Core Projects in several ways. Workshops and planning meetings are co-sponsored by Core Project Offices so that scientific programs can be supported in a coordinated way. Data management activities and requirements are developed in cooperation with the IGBP Data and Information System (DIS) that seeks to coordinate the data-related activities of all the Core Projects. PAGES and the World Data Center-A for Paleoclimatology are committed to working with all Core Projects of the IGBP and with other scientific programs to generate paleoenvironmental data sets and products.

THE WORLD DATA CENTER-A FOR PALEOCLIMATOLOGY

The World Data Center-A for Paleoclimatology plays a key role in the PAGES science plan. The WDC-A is the primary data coordination center for data generated as part of PAGES initiatives, and assists PAGES by making sure that data is compatible across each of the PAGES science initiatives (Fig. 1). In addition, it serves as the hub for data exchange between PAGES, national and international paleoclimate data archives, and data archives associated with other core projects of the IGBP. Within this structure, specialized data sets are organized by extramural data cooperatives that operate outside of the WDC-A. Guidance for the data cooperatives is provided by advisory panels composed of scientific experts. This structure keeps the decisions in the hands of scientists and the individuals who know the data best. Once the data are submitted to the WDC-A, the data sets are archived and prepared for distribution via magnetic media and on-line (Internet) access, in formats that are compatible with DOS, Macintosh, and UNIX computers.

The principles for scientific data management and exchange and the responsibilities of the World Data Centers have been carefully developed by the International Council of Scientific Unions.

The WDCs are operated and supported by national organizations, which agree to observe the following ICSU WDC principles:

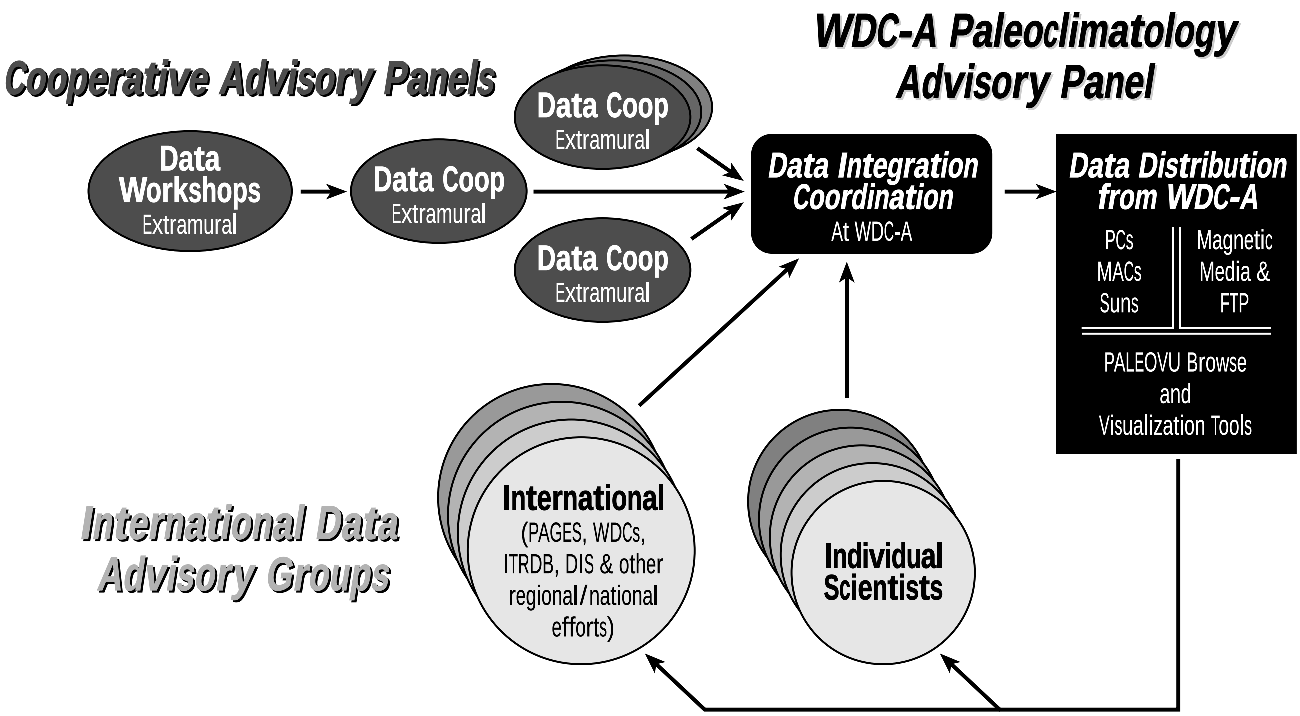

Figure 1
World Data Center-A for Paleoclimatology: Pathways for sharing data.

i) The WDCs shall operate on a long-term basis. If for any reason they must be terminated, the data holdings will be transferred to another appropriate WDC.
ii) The WDCs will exchange data among themselves, as mutually agreed, so that data availability and processing for higher data products will be facilitated.
iii) Data will be provided to any scientist, in general, on an exchange basis or, at most, at a cost not to exceed cost of copying.
iv) WDCs will accept any scientist as a visitor to work on site with the data holdings.
v) WDCs will prepare and publish catalogs of data holdings.
vi) WDCs will, insofar as practical, help a scientist locate and access related data not held in the WDC system.

In addition to its role as a coordination center for PAGES and its commitment to the preservation of all types of paleoenvironmental data, the WDC-A also has a special focus on data relevant to the goals of the US Global Change Research Program and the NOAA Climate and Global

TABLE 1

Status of data guidelines for different types of paleoenvironmental information archived by the WDC-A for Paleoclimatology.

Data Category	Suggested guidelines appear in data-specific section of Guide	Suggested guidelines appear in Reports	Suggested guidelines appear in general section of Guide
Cave and spring calcite	x		
Corals	x		
Eolian deposits		x	
Fluvial deposits			x
Fossil insects			x
Fossil pollen	x		
Glacier mass balance		x	
Historical documents	x		
Ice cores	x		
Ice wedge/periglacial features		x	
Lake level variations		x	
Loess		x	
Long instrumental records		x	
Molluscs			x
Noble gases in ground water		x	
Ocean sediments	x		
Packrat middens		x	
Paleolimnological data	x		
Paleosols			x
Plant macrofossils		x	
Sea level variations		x	
Tree ring data	x		
Treeline movement data		x	

Change Program. In this capacity, the WDC-A receives data from individual scientists funded by science agencies of the US and other countries. Ideally, data produced by these scientists are archived and made available by the WDC-A at the same time that the data are published in the open peer-reviewed literature. Coordinated projects are focused on producing or assembling paleoclimate data from data-poor regions and on calibrating new proxies for paleoclimate data, and augment the efforts of the entire paleoclimate research community to produce the needed paleoclimate perspective. The size and breadth of the WDC-A archive is rapidly expanding, fueled by data submitted from these multiple pathways. Many of these data categories already have established protocols, or have protocols that were developed during this workshop (Table 1). Additional information regarding the NOAA Paleoclimatology Program and the World Data Center-A for Paleoclimatology (program descriptions, data catalogs) can be obtained from the NOAA Paleoclimatology Program, 325 Broadway, Boulder, CO, USA, 80303, email paleo@ngdc.noaa.gov; World Wide Web URL: http://www.ngdc.noaa.gov).

THE PURPOSE OF THE WORKSHOP AND THIS REPORT

In August 1993 PAGES brought together scientists and data management experts from around the world to assess where we are, and where the international scientific community is going with regard to data management in the rapidly evolving field of paleoclimatology. The scientific goals outlined by PAGES require coordinated efforts among regional and national data centers. These individual centers have goals and responsibilities that are unique. PAGES seeks to identify the aspects of these efforts that are relevant to the PAGES goals, and to develop a coordinated data management plan that 1) takes advantage of scientific expertise and experience of the individual centers in compiling PAGES-related data, and 2) assists individual centers with data sharing and distribution on a global basis.

To accomplish these goals, the workshop was organized around a series of presentations that describe national and regional data efforts, and a series of working group sessions, each focused on a different category of paleoenvironmental data. Results of the working group discussions are described in the World Data Center/ PAGES Data Management Guide, and the catalog of individual data efforts appears in Reports by Participants. We have annotated the Reports section with icons to describe pathways used by each data effort for data distribution (includes pathways planned and in effect, revised in March, 1995). In some cases, the working group reports outline protocols and data efforts already in place and well-established. In other areas, the discussions are more preliminary, and describe what the participants would like to see in terms of data management, along with some general guidelines. The workshop and this report are viewed as an important first step in an evolutionary process that will fuel the international research community with the paleoenvironmental data that they need to understand how the Earth system works, and how the behavior of Earth system processes can be predicted.

WORKSHOP RECOMMENDATIONS

Throughout the workshop, science-driven data management emerged as a unifying theme. In this context, most participants endorsed the concept that data guidelines be developed around scientific objectives and goals. In several instances data efforts have been established by scientific initiatives such as CLIVAR, GOALS, PMIP, and others, and are tightly focused around the goals of the initiative. In these cases protocols and recommendations for data management are often determined by project participants after consideration of the scientific problems addressed by the program. For example, in the case of CLIVAR, highest priority is placed on seasonally to annually resolved paleoenvironmental data, as opposed to records with only millenial-scale resolution. In the case of PMIP, the development of paleoclimate data that can be used to create time-slice reconstructions of climate are paramount. To make full use of the spectrum of paleoclimate data, it is essential that data managers and coordinating scientists are aware of the priorities and protocols of individual, focused data efforts.

At the workshop, a framework for interaction among individual data efforts and centers was discussed that includes both regional and centralized archives. The World Data Center-A serves as a primary data coordination center for all types of data relevant to the PAGES scientific foci. The WDC-A will make all data holdings available to all scientists without restriction. The WDC-A is also committed to the long-term archive and distribution requirements for these data. With regard to data formats and data content, the WDC-A works closely with PAGES scientists and project leaders to make sure that the data are archived in a consistent and easy-to-use format.

Regional and national data efforts are generally more focused than the WDCs, and are not always able to meet the ICSU guidelines for data distribution. Thus some data holdings from these centers may not be freely available. Also, because of the focused nature of some regional data efforts, some of the data holdings are not relevant or appropriate for use by the general paleoclimate and global change communities. In the case where these data are relevant and can be shared, the WDC-A will assist in data archive and distribution. The WDC-A will serve as conduit for data distribution to the broad IGBP community by serving as a node in a distributed data archive network, and also by maintaining and distributing data for the individual centers where appropriate. In many cases the WDCs will continue to rely on the scientific expertise and experience of the regional centers in compiling or evaluating individual categories of data.

The need to recognize the effort of individual scientists who produce, analyze, and publish the data was a concern stated throughout the workshop. Unless the individual scientist receives satisfactory credit, there is little incentive for scientists to contribute data. In some cases, anonymous, un-acknowledged distribution of data can threaten the scientific enterprise. The solution of how to properly credit scientists is complicated because it varies between countries and scientific disciplines. Although no consensus was reached at the workshop, the recommendations of R. Webb and L. Mayer to create a contribution series were sanctioned at a subsequent PAGES Scientific Steering Committee Meeting (see next section). The value of this to scientists will vary individually. Procedures at the WDC-A have always encouraged contributions of published data as opposed to unpublished data, to reinforce the credit received from publishing data, and also to maintain a level of peer review for all archived data.

GUIDELINES FOR IGBP PAGES / WORLD DATA CENTER FOR PALEOCLIMATOLOGY DATA CONTRIBUTION SERIES

1. The purpose of the Data Contribution Series is to provide a mechanism that:
   - Gives scientists citation credit for their data contributions
   - Ensures that digital datasets are archived in their complete form, including the descriptive information that is needed to make the archived data most useful. Due to space limitations, published datasets are often presented in summary or figure form only
   - Ensures that post-publication modifications, corrections or additions to datasets are available in the public domain
   - Keeps track of data contributions made as part of IGBP PAGES
   - Gets more data into the public domain in a timely fashion
2. The form of an IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series citation:

Examples:

Maher, L. (1995). Lake Wobegon pollen record. IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series #2001. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

Maher, L. (1996). An improved.....record. IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series #4321. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA.

In a manuscript, authors would usually cite the original (i.e., peer-reviewed) publication containing the dataset (if the data are published), and a statement like the following (where Maher, 1994 is a peer-reviewed paper containing a summary pollen diagram from Lake Wobegon):

"The data used are those published in Maher (1994), and available from the World Data Center for Paleoclimatology (Maher, 1995)."

or

"The data used are those published in Maher (1994), and updated in the form archived at the World Data Center for Paleoclimatology (Maher, 1995)."

Note that datasets that are associated with a given publication will be left intact, and updated/improved datasets will be given new numbers. In this way data users will know exactly which data were used to obtain specific results.

3. The process for submitting data and obtaining a IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series contribution number is as follows:
   a. data are submitted to the IGBP PAGES/World Data Center for Paleoclimatology in Boulder, in digital form, and with required descriptive information ("metadata")—see below to find out what metadata are required
   b. acknowledgment of data sets received is made, if requested, via the Internet

c. once the dataset has required metadata, and is ready for distribution, a contribution series number is assigned, and the dataset can be checked on the Internet

d. a formal letter of appreciation is mailed with full citation—on PAGES/WDC letterhead

The WDC-A has established formal relationships with the journals such as the American Geophysical Union journal *Paleoceanography* and the *Journal of Paleolimnology* so that lengthy, data-intensive papers can be published in journal articles, with data available from the WDC-A. In these cases the scientists receive publication credit, data are peer-reviewed in the open literature, can be identified via well-known literature searching tools, and are also available in an easy-to-access electronic format. In all cases where data is used, individual scientists and their publications should be cited, in addition to a reference to the data center where the data were obtained.

GENERAL

Meeting participants enthusiastically endorsed the Data Policy Statement distributed by the International Council of Scientific Unions (see below). Workshop participants identifed some guidelines relavant to all paleoclimate data, and working groups developed additional guidelines for specific data categories. In several cases, the working groups approved specific protocols already in use by other data efforts, and these are noted in the sections below.

DATA POLICY STATEMENT

Relying on the ICSU and WDC principles the following more detailed IGBP data policy principles and their implementation based on the statement in IGBP Report No. 12 were proposed and accepted at the IGBP-SC in Australia in December 1994.

- The IGBP requires and early and continuing commitment to the establishment, maintenance, validation, description, accessibility, and distribution of high-quality, long-term data sets.
- Full and open sharing of the full suite of global data sets for all global change researchers is a fundamental objective.
- Preservation of all data needed for long-term global change research is required. For each and every global change data parameter, there should be at least one explicitly designated archive. Procedures and criteria for setting priorities for data acquisition, retention, and purging should be developed by participating agencies, both nationally and internationally. A clearing-house process should be established to prevent the purging and loss of important data sets.
- Data archives must include easily accessible information about the data holdings, including quality assessments, supporting ancillary information, and guidance and aids for locating and obtaining the data.
- International and where appropriate suitable national standards should be used to the greatest extent possible for media and for processing and communication of global data sets.
- Data should be provided at the lowest possible cost to global change researchers in the interest of full and open access to data. This cost should, as a first principle, be no more than the marginal cost of filling a specific user request. Agencies hould act to streamline administrative arrangements for exchanging data among researchers.

- For those programs in which selected principal investigators have initial periods of exclusive data use, data should be made openly available as soon as they become widely usefu. In each case the funding agency should explicitly define the duration of any exclusive use period.

HOW TO SUBMIT AND ACCESS DATA AT THE WORLD DATA CENTER-A FOR PALEOCLIMATOLOGY

The PAGES Data Management Guide contained in this report provides a useful starting point for anyone wishing to submit data to the World Data Center so that it can be shared by the international community. In general, all data generated or used in a PAGES-related effort should be submitted to a recognized PAGES data management center within 3 years of generation or at the time of publication, whichever comes first. Data can be submitted on diskette or other electronic medium, or via the Internet using anonymous FTP. Write access is provided to the /pub subdirectory at the anonymous FTP site ngdc1.ngdc.noaa.gov. Data on paper are also accepted, although not preferred. Wherever possible, contributors should follow the guidelines already developed for specific categories such as tree-rings or sea-levels. Where no specific guidelines exist, contributors should follow the general guidelines listed below. For questions about how to submit data, or specific data formats to use, contact the Center via mail, email, FAX, or phone. (World Data Center-A for Paleoclimatology, 325 Broadway, Code E/GC, Boulder, CO, 80303-3328, USA; email: paleo@ngdc.noaa.gov; FAX: 1-303-497-6513; phone: 1-303-497-6280). It is anticipated that the guidelines for data submission will be modified to respond to the needs of the scientific community, and updated versions of the data guide will always be available from the center.

CHECKLIST FOR SUBMITTING DATA TO THE WORLD DATA CENTER-A FOR PALEOCLIMATOLOGY

- ✔ Contact the Center for the most up-to-date Data Guidelines. Where appropriate, obtain software from the Center to make data submission easy. Forms and software currently exist for tree-ring data, pollen data, and ocean sediments data.
- ✔ Submit your data on diskettes or via the Internet using FTP. Printed reports are also accepted.
- ✔ Receive your acknowledgement from the Center and review your data set to make sure everything is correct.

Accessing data at the WDC-A for Paleoclimatology is easy. Data are distributed via the Internet, and are also available on diskettes for the cost of reproduction (data catalogs and order forms are available). One advantage of Internet access is that the data are distributed free of charge. On the Internet, one can use FTP (anonymous FTP address: ngdc1.ngdc.noaa.gov), gopher (Gopher address: gopher.ngdc.noaa.gov), or one of the World Wide Web browsers such as Mosaic or Netscape (WWW address: http://www.ngdc.noaa.gov). In 1995, the Center introduced a search capability for World Wide Web users that allows the user to search for datasets that meet criteria that the user specifies on a form. In addition, hypertext links to other World Wide Web sites provide a connection to other data efforts and data archives on the World Wide Web. Thus, the Center serves as a convenient starting point for paleoclimatologists looking for other types of data.

GENERAL GUIDELINES FOR ALL PALEOENVIRONMENTAL DATA

- All datasets should include both metadata (information that describes the data, including site information, latitude, longitude) and sample measurements.
- Data descriptions must include references to be cited when data is used.
- Both raw data and paleoenvironmental reconstructions should be archived. Raw data should be sufficiently detailed that analyses can be reproduced or revised using alternate calibration files or methodologies, and so that uncertainty (of both age and independent variables) can be evaluated. In particular, the raw age measurements should be included and sufficiently detailed that alternate corrections can be made, for example between radiocarbon ages and calendar age.
- Data sets should be archived in such a way that they can be readily distributed on different media (Internet, diskette, tape) for use on different computer operating systems (DOS, Macintosh, UNIX).
- Data sets should be archived in such a way that they can be updated as new data become available, or existing data are revised.

A. Metadata. Should include:

- Dataset name.
- Core identification number where appropriate.
- Description of dataset and variables.
- Latitude, in decimal degrees, or degrees, minutes, and seconds. South latitudes can be described by negative numbers.
- Longitude, in decimal degrees, or degrees, minutes, and seconds. West longitudes can be described by negative numbers.
- Elevation of site, or depth of site (e.g., for marine sediment cores).
- Contributors, including contact information.
- References. Identify references that should be cited when data are used. Include references that describe methods used.
- Relationship to other versions of the data set (e.g., this data include updates to our 1981 publication).

B. Description of age model and sample ages.

- In general, ages should be included for each sample depth, and also provided as a seperate table that consists of age measurements (e.g., from radiocarbon, oxygen isotope events). The description of the age model should clearly and explicitly state how the ages for each depth were derived, describe any corrections made (such as a conversion from radiocarbon to calendar years) and how the ages are reported (in years B.C., years A.D., years B.P., or thousands of years B.P. If years B.P. are reported, present must be specified (e.g., 1950 A.D.). Actual age measurements should be treated as an independent variable (see below), and listed separately as a table containing sample depth, age, uncertainty, and other relevant parameters. Radiocarbon age measurements should be calculated using the guidelines in Stuiver and Polach (1977), using the "old" half life 5568 years, with present defined as 1950 A.D. (departures from these suggested conventions should be described). Sufficient information should be provided so that alternate age models can be constructed. Alternate age models can be submitted as an additional independent variable.

C. Sample measurements. All measurements should include:

- Depth or depth interval of sample. Centimeters or meters should be used.
- Sample age, determined from the age model described in the metadata section. If unknown, or not determined, a missing data flag should be included.
- Variable names. Non-standard variables should be completely described.
- Units of each variable.
- Precision of each variable.
- Format of each variable.
- In the case of derived or corrected variables, the raw measurements should also be included and sufficiently detailed so that alternate corrections can be made.
- Methods should be described where appropriate, and references to methods should be included as metadata.

D. Other measurements.

- Calibration data should be included where appropriate. For example, data used in the calibration of proxy data, transfer functions, and modern calibration data sets should be included where possible.

GUIDELINES FOR SPECIFIC DATA CATEGORIES (FROM WORKING GROUPS)

Paleoceanographic Data

Working Group: D. Anderson, J. Cole, J. Coyne, W. Curry, M. Diepenbroek, L. Labeyrie, R. Merrill, and H-P. Plag

Several independent projects are underway to archive paleoceanographic data. These include the Ocean Drilling Project, the Delphi Project, and RESPONSE, a sea level database. Each of these projects has an established protocol for archiving data. Based in part on these existing data management efforts, the group identified several aspects of data management common to all paleoceanographic archives.

A. Metadata.

- Information should include where the cores are stored, what samples have been removed from the cores, and when possible, a list of publications related to those samples.

B. Description of age model and sample ages.

- See general guidelines.

C. Sample measurements.

- All sample information should be referenced to depth in core.
- Measurements include magnetic properties, gamma, p-wave, GRAPE, water content, bulk density, textural features, and varve thickness, and image data (color or grey-scale). Geochemical analyses include calcium carbonate, organic carbon and nitrogen, opal, trace metals including Cd and Ba, and stable isotope and radiogenic isotope (e.g., ^{14}C) measurements. Data on analytical technique and precision, (including the machine used, and the sediment fraction analyzed (e.g., foraminifer species and size class measured) should be included. The issue of whether a table of additional calibration data (e.g., isotopic standards used, blank values, reference to standard intercalibrations if available) should be supplied was unresolved.
- The group recongized that difficulties exist comparing stable isotope measurements between laboratories, and encouraged an intercalibration working group or workshop be convened to improve the ability to use and compare measurements made in different laboratories.

C. Other measurements.

- The data may include counts of planktonic and benthic foraminifers, radiolarians, diatoms, coccolithophorids or other microfossil-producing organisms. The variables are quantitatively-derived raw counts of individual taxa. The data may be from individual sediment cores, sediment traps (time series), from plankton tows, or from a synoptic array of sediment samples. Deep sea sediment samples should include information on sample depth in core, original sample weight, sample split, size fraction, bulk density, state of dissolution, age documentation. Sediment trap or plankton tow samples should include deployment logistics, dates of collection, sample split, diameter of sediment trap or plankton net aperture, synchronous hydrographic data, and taxonomic nomenclature.
- Data sets consisting of micropaleontological data from deep sea sediments already exist at the WDC-A for Paleoclimatology which may prove useful for guiding future submissions. These include the CLIMAP 18k, COHMAP, and SPECMAP data sets. New data sets will provide maximum benefits to the users if they are submitted in a format similar to these existing data sets.

Sea Level Data

The group approved the guidelines described by H. Plag for the RESPONSE database (see Database Reports).

Coral Data

The following guidelines for submitting coral data to the WDC-A were developed at the International Workshop on Coral Records of Ocean-Atmosphere Variability, La Parguera, Puerto Rico, Nov. 5-8, 1992. These guidelines have been adopted by the NOAA Paleoclimatology Program and PAGES, to provide global change investigators with ready access to published paleoclimatic records and reconstructions. All data are listed with their original references, which users of these records must cite. Guidelines for submission require that sufficient information is included so that database users can test alternate interpretations or apply the data to questions other than those addressed by the original investigator. WDC-A encourages submission not only of coral measurements but also of X-radiography images, relevant calibration datasets, and quantitative climate reconstructions from coral data. Preferred data formats are ASCII text tables for data, JPEG files for images.

A. Metadata

- Site information should include coral species, and description of the environment when deemed relevant by the investigator (e.g., fore-reef vs. lagoon sites, and water characteristics).

B. Description of age model and sample ages.

- Contributors should describe the assumptions used to create the age model, or reference a paper where the assumptions are stated.
- Contributors are encouraged to include images of x-radiographs, or other images that aid in the interpretation of the age model, using jpeg, gif, tiff, or other standard image formats.
- For additional information on age models, see general guidelines.

C. Sample measurements.

- Geochemical data may include minimal corrections (e.g. machine corrections, for standards, etc.) at the investigators' discretion.
- No secondary manipulations should be performed on the measurements (e.g. detrending, normalizing, smoothing).
- Duplicate measurements may be included at the investigators' discretion.
- Reconstructions (e.g., climate indices) should include a description of how they were constructed.

D. Other measurements.

- Calibration data, if appropriate (e.g., a local sea surface temperature or salinity record, or ocean chemistry measurements). Cite original reference or source of data.

Terrestrial Sediment Data

Working Group: O. Borisova, J. Branson, J. L. deBeaulieu, E. Grimm, Z. Guo, S. Harrison, H. J. Jette, I. Lentner, L. Maher, P. Markwick, R. Thompson

A very diverse range of data types were described, and the notes below refer principally to plant macrofossil and pollen data. Guidelines for ice-wedge, loess, and paleontological data are provided by Borisova, Guo, and Graham, respectively, in the Database Reports. Specialized data-entry software has been developed for pollen and macrofossil data (Tilia), but data may be submitted in virtually any computerized format (e.g. ASCII, Lotus spreadsheet).

A. Metadata.

- Dataset description for middens usually includes sample number, midden name, etc. For wet sediment samples, usually core, depth in core, etc.
- Site description should include aspect (for middens), substrate, local modern vegetation, extralocal vegetation, physiography. For wet sediment samples this category should include surface area of site, water depth, within-site location. Site description should also include country, secondary and tertiary political divisions (e.g. state or province, county), site description (e.g. type of lake or fen).

B. Description of age model.

- See general guidelines.

C. Sample measurements.

- Data are counts, occurrences, and/or qualitative assessments of abundance of plant macrofossils. The quantification scheme should be described—raw counts, presence/absence, vs. 6-point scale, etc. Assemblages of such fossils are preserved in environments ranging from urine-cemented *Neotoma* middens to lacustrine and wetland sediments. Although plant macrofossils are the primary data source in these assemblages, additional information may be available in the form of vertebrate, insect, and isotopic data.
- Sample size, usually in grams or kilograms (for middens) or volume (in cubic centimeters for wet sediment samples).
- Sampling, laboratory processing, and analytical information: seive sizes used, which taxa were looked for (and, if applicable, which not), method of identification (published keys, comparative collection, etc.). For midden samples—were samples disaggregated in water (and all possible specimens identified), or were only the fossils visible on the surface identified?
- Pollen data should include complete pollen counts and sample depths. Percentage data are accepted only if the original counts are no longer available. All data necessary to calculate pollen concentration for each sample (e.g. sample volume or mass, quantity of spike added, concentration of exotic in spike, count of spike) should also be included.

Tree Ring, Historical Documentary, and Ice Core Data

Working Group: H. Fritts, G. Hunt, T. Mikami, C. Pfister, J. Pilcher, J. White

Within this working group, separate recommendations were identified for tree-ring data, historical documentary data, and ice core data, each based on procedures already in place. Specialized data entry and manipulation software are available for tree-ring data; these require the use of specific file formats noted below.

Tree Ring Data

Specific guidelines for tree-ring data have been established by the International Tree-Ring Data Bank (ITRDB), and computer programs have been written that use specific data formats (described below). In general, the data should meet the following standard for data quality: All measurements must be dendrochronologically cross-dated. Ring width and density measurements must include information from a minimum of 10 trees with a common chronology that is 100 years or more in length.

A. Metadata

The following named variables are included in the metadata description. Capitalized words refer to formal variable names.

- NAME OF THE DATA SET.
- STATE or COUNTRY: Country where this collection was made. For the United States, enter the name of the state.
- SITE NAME: Name of the site given by the collectors or principal investigators.
- SITE CODE: Three-character site code.
- ELEVATION: Elevation of the collection site in meters.
- LATITUDE: Latitude (degrees and minutes) of the site where the trees were collected.
- LONGITUDE: Longitude (degrees and minutes).
- SPECIES CODE: This four-letter code is obtained from the species list supplied with the ITRDB Program Library.
- COMMON NAME: Common name for the species. This can also be obtained from the species list supplied with the ITRDB Program Library.
- MEASUREMENT TYPE: Type of measurements used to establish this chronology, (e.g. total ring width, latewood width, maximum latewood density).
- CHRONOLOGY TYPE: Type of indices developed.
- FIRST and LAST YEAR: First and last years for the chronology.
- NAMES AND ADDRESSES of the Principal Investigators and/or data contributor.
- Other information such as statistics of the chronology, references to publications, special characteristics of samples, revision version (if more than one standardized chronology), maps of data site, type of sample collected, local site.

B. Description of age model and sample ages.

- See general guidelines.

C. Sample measurements.

- Include Ring Width—total, earlywood and latewood widths; Wood density—maximum, minimum, average earlywood and average latewood; Other data types include isotopic concentrations, chemical composition.

File formats for specific measurements and variables are described below.

Ring Width Data (ASCII files, with file extension .RWL)

- These are measurements in units of .01mm of the thickness of tree-ring width for each year. Each file consists of all the measurements for a given site. As many as 50 Core ID numbers and 50 data series may comprise one (site) file (Table 1). Missing value code is 999 or blanks. The 10 values following the decade are the 10 annual measurements for the 10 years of that decade.

TABLE 1
FORMAT FOR RING-WIDTH DATA FILES:

Column number	Variable
1-6	Core ID Number
9-12	Decade
13-72	Data Values, FORTRAN format 10(I6)
74-78	Site ID Number

Site Chronologies (ASCII files, with file extension .CRN)
These are the normalized averages from a stand of trees, representing percentage of mean growth observed for each year over the entire stand. Site Chronologies are used in climate analysis, and it is these values which are displayed by the ITRDB software. Data are stored as 4-digit numbers, with a value of 1000 representing mean growth and 900 representing 90% of mean growth, etc. There is only one time series per file (Table 2), in contrast to the raw data files. Missing value code is 9990. Site information is stored in the first 3 records of the file.

TABLE 2
FORMAT FOR CHRONOLOGY HEADER RECORDS
(3 HEADER RECORDS PER FILE).

Record #	Column	Variable
1		
	1-6	Site ID
	10-61	Site Name
	62-65	Species Code, optional ID#'s
2		
	1-6	Site ID
	10-22	State or Country
	23-30	Species
	41-45	Elevation
	48-57	Lat-Long
	68-76	1st & last Year
3		
	1-6	Site ID
	10-72	Lead Investigator
	73-80	completion date
4-??		
	1-6	Site ID
	7-10	Decade
	11-14	Annual Value
	15-18	# of samples
	82-88	TRL ID(optional)
	74-77	(repeated 10x)
	78-80	(repeated 10x)

D. Other measurements.

- Standardized Indices (averaged by year from original measurements).

Documentary Data

The following guidelines are based on the experience obtained from managing the EURO-CLIMHIST (EU) and the Japanese Historical Weather (J) data-base. Notes specific to one data set are prefixed by EU or J. For EU, detailed coding and formatting instructions are contained in Schüle & Pfister, Coding Climate Proxy Information for the EURO-CLIMHIST database (revised version in Frenzel B., Pfister C., Glaeser, eds. 1994). Stuttgart (in preparation). For J, coding instructions will be published.

A. Metadata

- Detailed source identification (archive, library, publication), and time of creation of source.
- Time of observation (year, month, day, hour), style (Julian, Gregorian, Japanese, Chinese, Islamic, other).
- name and lifetime of observer.
- EU: owner of record (initials, personal source number). J: Project member name.

- data quality indications (contemporary or non contemporary observation, uncertainty in time, place or observation). Calibration depending of the type of observation.
- content of observations: numerical code and / or full text.
- secondary data (diaries): EU+J: monthly frequencies of rainy, snowy, cloudy and sunny days, wind directions (EU).
- secondary data (indices): EU: monthly, seasonal and yearly temperature and precipitation indices.
- secondary data (weather charts): EU: monthly, seasonal; J: daily, monthly.

B. Description of age model and sample ages.

- See general guidelines.

C. Sample measurements.

- Measured temperature, precipitation, atmospheric pressure (early instrumental diaries).
- State of sky, thermic conditions, precipitation (number of rainy and snowy days), wind direction and speed (mainly non-instrumental diaries, ship's logs etc., EU).
- General character of atmospheric conditions for several days, weeks and months as well as biological, phenological, hydrological data (water levels, snow and ice features etc.) on anomalies and hazards (mainly chronicles, annals etc., EU).

D. Other measurements.

The following reconstructed variables are included.

- Impacts on the biosphere, the hydrosphere and the anthroposphere which are contained in historical documents.
- Early instrumental measurements carried out prior to the creation of national weather services.

Ice Core Data

[The following guidelines were submitted by participants of the Ice Core Data Workshop convened by J. White that met immediately following the PAGES Data Management Workshop.]

The group recommended the formation of the Ice Core Data Bank (ICDB) and encourages all scientists working in the field to contribute their data. A single data center, WDC-A Paleoclimatology, has been identified as the archival point for paloeclimate data from ice cores. Glaciological data from surface collections and shallow cores, as well as possibly some deep cores, should also be submitted to WDC-A for Glaciology. The World Data Center-A for Paleoclimatology will provide a list of alternative data centers to which this data may also be submitted. A hierarchy of data types is suggested: published, ancillary and unpublished. Submission of data should be linked to publication of papers; published data should be in the data bank. Researchers are also encouraged to submit unpublished and ancillary data to the ICDB if such data are of good quality and would not otherwise be available. To ensure quality, data should be checked thoroughly for errors after submission. The Data Advisory Panel (DAP) of PAGES should be used to help solve problems with data centers, including slow response to requests for data, lax advertising, and insufficient efforts to make data easily accessible.

Several independent efforts are currently underway to create or expand centralized and distributed ice core data archives. The group made the following recommendations that apply to each of these efforts.

- Updating of archived data (e.g. new age models, additions to existing records) is encouraged. Updates will be kept separate from the earlier file(s) and both data sets will be annotated to note the update.
- Data centers should also interact with journals to encourage submission of data.
- The data center should actively advertise for and recruit data.
- Easy access to the data was more important to the group than security and knowing who is getting the data. Anonymous FTP access and release of data is encouraged to make data easily accessible.
- The data centers should inform data submittors of the existence of appropriate, alternative data centers for parallel submission of data. (e.g. WDC-A Glaciology).
- Data centers should keep track of requests for data and make a list of such requests available to the contributor.
- Provisions should be made for archiving some surface and shallow core collections as a set, e.g. a traverse line or a field as opposed to a single point.
- Data already published in tables should be incorporated into the ICDB. In general, this may be done by a courtesy letter asking the first author for permission to add the data to the ICDB.

A. Metadata.

- Data on cores should be reported versus depth and also, where applicable, versus age.
- Data should be identified by location (latitude and longitude, as well as geographical name if so desired), core name, and data type.
- Comments on the data submitted with the data are essential and should be incorporated into the presentation seen by those requesting data. These comments should include how to cite the data (capability for more than one publication citation is necessary), comments on quality and potential pitfalls, and a contact person in the event of questions.

B. Description of age model and sample ages.

- All sample measurements should report depth in core, in addition to sample age.
- For additional information, see general guidelines.

C. Sample measurements.

- Data should be checked for errors before and after submission.
- Types of submissions include raw data, averages or curve fits of raw data, and inferred paleoenvironmental information from data. Every effort should be made to archive raw data as well as reconstructions and other variables.
- Depths in cores should be reported in meters or centimeters from the surface when the core was drilled.

D. Other measurements.

- Calibration data sets (e.g., surface collections, meteorological data, etc.) are also important and should be archived.

PALEOENVIRONMENTAL RECONSTRUCTIONS AND MODEL OUTPUT

Working Group: S. Evans, J. Guiot, W. R. Peltier, P. Schweitzer, and R. Webb

The user must be able to judge the quality of the reconstructions provided. In particular, one should have access to the main characteristics of the reference data set; full descriptions of key assumptions employed and methods used to develop paleoenvironmental reconstructions must be included. It should be noted that reconstructions using several types of original data will likely be more accurate than those based on a single type of observation. Whenever possible, original data, including modern calibration data sets, should accompany paleoenvironmental reconstructions, unless those data are publically archived. Reconstructions should also contain supporting information that is specific to the type of primary observations used.

A. Metadata.

- grid cell size, position, registration, and spatial coverage
- method of interpolation or extrapolation to grid cells
- date the reconstruction or simulation was created
- units of measure
- time depicted by the reconstruction and the associated age model
- estimated errors of the individual grid cell values
- details of the file format, including the layout and format of numerical and character data (source code of programs used to create the data files will usually suffice)
- information on the origin of the data, including date of original papers, and method of digitization if the original source was not digital.

B. Description of age model and sample ages.

- See general guidelines.

C. Other measurements.

- Reconstructions based on biological indicators should include a listing of taxa and number of individuals on which percentages are based, and actual counts of specimens if possible; taxonomy by which specimens were identified; the number of reference samples and map locations of the samples; chronostratigraphic control of the original samples.
- Reconstructions based on geochemical indicators should include: a listing of the samples analyzed, their locations, sample size, and the types of analyses that were made; details of the measurement, including instrumentation used, precision, detection limits, calibration and standards, and chronostratigraphic control of the original samples.
- Reconstructions from geophysical indicators should include a listing of geophysical observations, their locations, accuracy, and precision.

Following the workshop, specific recommendations for numerical climate model output have been drafted and reviewed. The following section was submitted by R. Webb and M. Chandler.

The following is a preliminary and slightly modified list of outputs fields that PMIP has proposed as useful for model-model and/or model-data comparisons and basic information (model characteristics) that the Model Evaluation Consortium for Climate Assessment (MECCA) group has identified as necessary documentation of the model/experiment (Table 1). The PMIP list is derived from the recommended diagnostics for Atmosphere Modeling Intercomparison Project (AMIP) and input from PMIP members. The MECCA list was compiled by the Analysis Team Project Manager, W. Howe. Monthly, seasonal, and annual values for most variables should be archived for each grid node, north and south hemisphere averages, global averages, and when appropriate meridional-vertical zonal means.

Information Required to Describe and Compare Climate Model Simulations, proposed by PMIP.

Category	Fields	Units
Basic Information	Published or unpublished reference describing the model and the control run	
	Published or unpublished reference describing experiment	
	Version of model run and approximate date run to help track model development	
	Time step(s) for model and sub modules	minutes/hours
	Time interval used to store results	
	(sampled, averaged, accumulated)	hourly, daily, monthly
	Vertical resolution	resolution and distribution
	Seasonal cycle activated	yes/no
	Diurnal cycle activated	yes/no
	Interactive surface ocean model (what type)	yes/no
	Length of model experiment	yr
	Number of years in average	yr
	Solar constant	W/m^2
	Orbital parameters	
	Eccentricity:	
	Obliquity:	degrees
	Longitude of perihelion (w):	relative to the moving vernal equinox minus 180 degrees
Trace Gas Concentrations	CO_2 concentration	ppm
	CH_4 concentration	ppm
	N_2O	ppm
	Dust	size and distribution
Model Fields	Grid description/spatial resolution	resolution and distribution
	Surface elevation	m
	Surface type/characteristics and fraction (albedo, masking depth, rooting depth)	
	Soil type and fraction	
	Specified fields (e.g., sea surface temperatures, clouds, sea ice)	
	Initial conditions (there may situations where extreme initial conditions, relative to modern, may have a significant effect on the simulation)	

Category	Fields	Units
Energy Budget, Top of the Atmosphere	Incoming short-wave	W/m^2
	Reflected short-wave	W/m^2
	Outgoing long-wave	W/m^2
	Net radiation	W/m^2
	Planetary albedo	%
Energy Budget, Surface	Incident short-wave	W/m^2
	Reflected short-wave	W/m^2
	Net long-wave	W/m^2
	Sensible heat	W/m^2
	Latent heat	W/m^2
	Net radiation	W/m^2
Hydrological Cycle Variables	Soil moisture/layer & total	kg/m^2
	Snow depth	m
	Snow coverage	%
	Snow mass	kg/m^2
	Soil ice/layer & total	kg/m^2
	Liquid precipitation, both large-scale and convective	mm/day
	Snow precipitation, both large-scale and convective	mm/day
	Evaporation and sublimation	mm/day
	Runoff	mm/day
	Total precipitable water	kg/m^2
	Surface air temperature	°C
	Ground temperature	°C
	Sea-level pressure	hPa
	Surface winds	m/s
	Wind stress components	N/m^2
	Relative humidity	%
	Ocean ice cover	%
	Ocean heat transport	W/m^2 Northward
Tropospheric Variables	500hPa geopotential height	m

Category	Fields	Units
At 850hPa and 200hPa	850hPa and 200hPa temperature	°C
	850hPa and 200hPa zonal and meridional winds	m/s
	850hPa and 200hPa specific humidity	g/kg
	Streamfunction	m^2/s
	Velocity potential	m^2/s
	Geopotential height	m
Clouds and Radiation	Total cloudiness	%
	Clear-sky outgoing long-wave radiation	
	Top of the atmosphere clear-sky reflected short-wave radiation	W/m^2
	Surface net clear-sky short-wave radiation	W/m^2
	Surface net clear-sky long-wave radiation	W/m^2
	Cloud liquid water	g/m^2
Meridional-Vertical Zonal Means	At standard pressure levels 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10	hPa
	Zonal and meridonal winds	m/s
	Temperature	Celsius
	Specific humidity	g/kg
	Relative humidity	%
	Cloudiness	%
	Meridional streamfunction	kg/s

This section includes short reports that describe current national and international data collection efforts and data archives. In most cases these reports summarize presentations given at the workshop. The reports were updated by the contributors in April, 1995 to reflect the most up-to-date information. Throughout this section, reports that describe available data are annotated with icons to identify whether data are or will be available in the form of

- printed reports
- diskettes
- CD-ROMS
- FTP
- Internet/World Wide Web.

1. DATA MANAGEMENT PERSPECTIVES

H. C. Fritts

Introduction

The International Tree Ring Data Bank (ITRDB) is a paleoenvironmental data set housed and managed at the National Geophysical Data Center in Boulder, CO, USA. The University of Arizona has been involved in a small contract to develop an outreach program for ITRDB. In the first year of this effort we have directed our attention at the data contributor (i.e. forest and tree-ring scientists such as dendrochronologists). In the future we will focus on the data user as well as the data contributor.

What is included in the ITRDB?

The ITRDB collections now include 3,000 tree-ring chronologies from at least 28 countries, including 103 species, as well as the basic ring measurements representing more than 8 million dated values.

Outreach Objectives.

The objectives of the outreach program were to interact with the scientific community, obtain existing chronologies, and assure quality control. To reach these objectives it was necessary to bridge the gap between a large data base and the individual data provider, to facilitate the transfer of data, motivate scientists to contribute not only for the present, but for the future as well.

Solutions

1. It was necessary to convince scientists that their contribution would be fully acknowledged. This was done not only by messages to that effect but by giving the scientist a free copy of the ITRDB disks in which names of contributors are displayed prominently with all data sets.

2. We established an E-MAIL bulletin board called the International Tree-Ring Data Bank Forum. This facilitated discussion of scientific questions, allowed us to obtain new ideas, provided a channel for information about the ITRDB and generated a feeling of community associated with the presence of the ITRDB. We asked the forum “What are the apparent obstacles to ITRDB contributions?” The most common concerns were: Where to contribute? Who was in charge? How to convert formats? Do my data meet the requirements? What is needed for quality control? Why take the time? Isn't it just an added burden? How do I benefit? Why share data with competitors?

3. Some tangible benefit was needed to generate a feeling of cooperation and sharing. Thus we assembled a computer disk with the needed information, addresses of active scientists, a list of known useful tree species, and the best available programs, manual and help files needed to date, standardize, process, and submit data. Nothing like this had

been done before and the effort has been received enthusiastically. The disk was prepared and sent free to all scientists agreeing to donate their data. The disk greatly facilitated the development of chronologies and their submission to the ITRDB by providing for measurement, format conversion, quality control for crossdating, chronology standardization and development and the transfer of required data into the proper ITRDB format.

4. We have recently initiated a program of data quality control, checking all contributed measurements with the ultimate objective of developing a process for screening future contributions to assure that all will be adequately dated and measured.

Results

Around 200 potential contributors have received free disks. Worker efficiency has increased. The rate of submission has increased. The Library has been acclaimed universally as a significant scientific contribution to the field of dendrochronology. Most important - a great deal of good will has been generated and a closer working relationship established with the data provider and the ITRDB.

Conclusions

Modest support of grassroots outreach programs can be cost effective and yield high returns in (1) the numbers of donations, (2) enhanced support from data providers as well as well as data consumers, (3) greater productivity in scientific work, and (4) increased availability and use of paleoenvironmental information, and (5) improved data quality control.

2. RECONSTRUCTING SPATIO- TEMPORAL PATTERNS OF CLIMATIC SITUATIONS FROM MULTI-PROXY MAPS

C. Pfister

The following paper briefly presents a project which is called Euro-Climhist (Frenzel, Pfister & Glaeser, 1994). It is part of the Programme "European Paleoclimate and Man since the Last Glaciation" set up by European Science Foundation (ESF) in 1989. Euro-Climhist aims at multi proxy mapping all kinds of high resolution paleoclimatic data for the period of the last 1000 years in order to reconstruct spatio- temporal patterns of past climatic situations. These are used as indicators of past changes in atmospheric circulation and compared to corresponding results of General Circulation Models.

Applications

It is thought that the Euro- Climhist data-base might be used in three different ways:

- To investigate the causes of climatic variations on two fundamental time scales: decadal and century.
- To investigate the relationship between climatic variability and changes in the frequency and severity of anomalies.
- To assess impacts of climatic changes upon pre- industrial economies and societies both in the short and in the long term.

The project has succeeded in coordinating many ongoing efforts on reconstruction of regional paleoclimates in such a way that both the local data, which were needed for the reconstructions, as well as their results could be integrated into a coherent data structure. This procedure hinged on the readiness of regional partners to prepare their data according to agreed standards and to submit them to the main data-base. It was assured that the "owner" of a regional data-set gets the exclusive right for a regional interpretation of his or her data by a written legal agreement that defines the rights and duties of both parties and which offers advantages for both of them. At present the research group cooperating with Euro-Climhist involves geographers, historians, meteorologists and dendrochronologists from 20 European nations, East and West.

Standardizing Data

Standardization of data between researchers of different countries is less a problem for data which are already described in quantitative terms (e.g. tree-rings or ice-cores) than for qualitative descriptions of past weather patterns. The task of assessing the reliability of this information and extracting the inherent "objective" data is most economically done within regional reconstructions by scholars who are:

- native speakers of the language in which the sources are written
- trained to distinguish between reliable contemporary and unreliable non-contemporary information

- familiar with the economic and natural properties of the particular natural, social and institutional environment, in which the documents were created.

As sources from different regions of Europe are written in manifold languages, the members of the scientific community involved must agree on certain rules for translating and standardizing this information.

There is a frequent assumption that descriptive weather comments are not only imprecise, but also inaccurate. Again, not always justifiably it is also believed that the degree of reliability is likely to vary directly with the time one goes back before the adoption of standard recording procedures. So far as descriptive entries are concerned such assumptions are not necessarily valid. It turned out that a spatial picture of the climatic situation in a particular month or season may be derived from a framework of a limited number of verified observations if those are well distributed across the continent. When groups of entries are available from the major parts of Europe, an agreement between them becomes apparent.

In the majority of cases the individual entries were in accord with the weather information plotted from other data sources in the sense, that the entire picture was “meteorological”, i.e. consistent with the physical laws of the atmosphere. The charts themselves provided a check on particular entries. Inconsistencies, that point to sources of error in the data, could be readily discovered in this way.

It needs to be stressed that a multi proxy and direct weather map yields climatic information which is area-covering and not just limited to the regions and places from which the observations were drawn. Moreover, it can be downscaled to intermediate areas, from which no data are available. Of course, this applies rather for temperature than for precipitation which is mainly controlled by regional factors; but compared to the frequent situation of absolute data gaps with which climate history is plagued, the inference of some probable state of climate from a tentative European weather situation brings a tremendous advantage.

Pilot Project—The Maunder Minimum

In a pilot project focusing upon the period of the late Maunder Minimum (1675-1715) a full set of seasonal and monthly weather data charts was produced. The charts for winter and spring over the 30 year period 1675-1704 were interpreted in terms of tentative synoptic situations by a team of meteorologists from Iceland, U.K., Denmark, Norway, Switzerland and Czechia (Wanner et. al., 1994).

The maps of these months are compared to the mean pressure between 1949 and 1980. In the 1949-80 situation there is a depression SW of Iceland during these six months. From December 1694 to May 1695 Northern Europe was mainly dominated by anticyclonic situations. This lead to a steady flow of cold air from NE or E to Central Europe in the winter months and to a cold air advection from the N Sea during the spring months. The full set of 180 weather charts is contained in Frenzel, Pfister & Glaeser (1994).

Further ongoing studies will reconstruct the synoptic situation in the remaining months of the year from June to November. Moreover the statistical analysis of weather situations in the late Maunder Minimum will be compared to the results of GCM model runs. Finally the significance of forcing factors (solar, changes in the thermohaline circulation of the North Atlantic) will be discussed (Wanner et. al., in press). In a later stage other time slices (early 19th century, 16th century, 14th century will be investigated in this way.

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Editor's note: A limited number of European historical documentary time series are available from the World Data Center-A for Paleoclimatology.

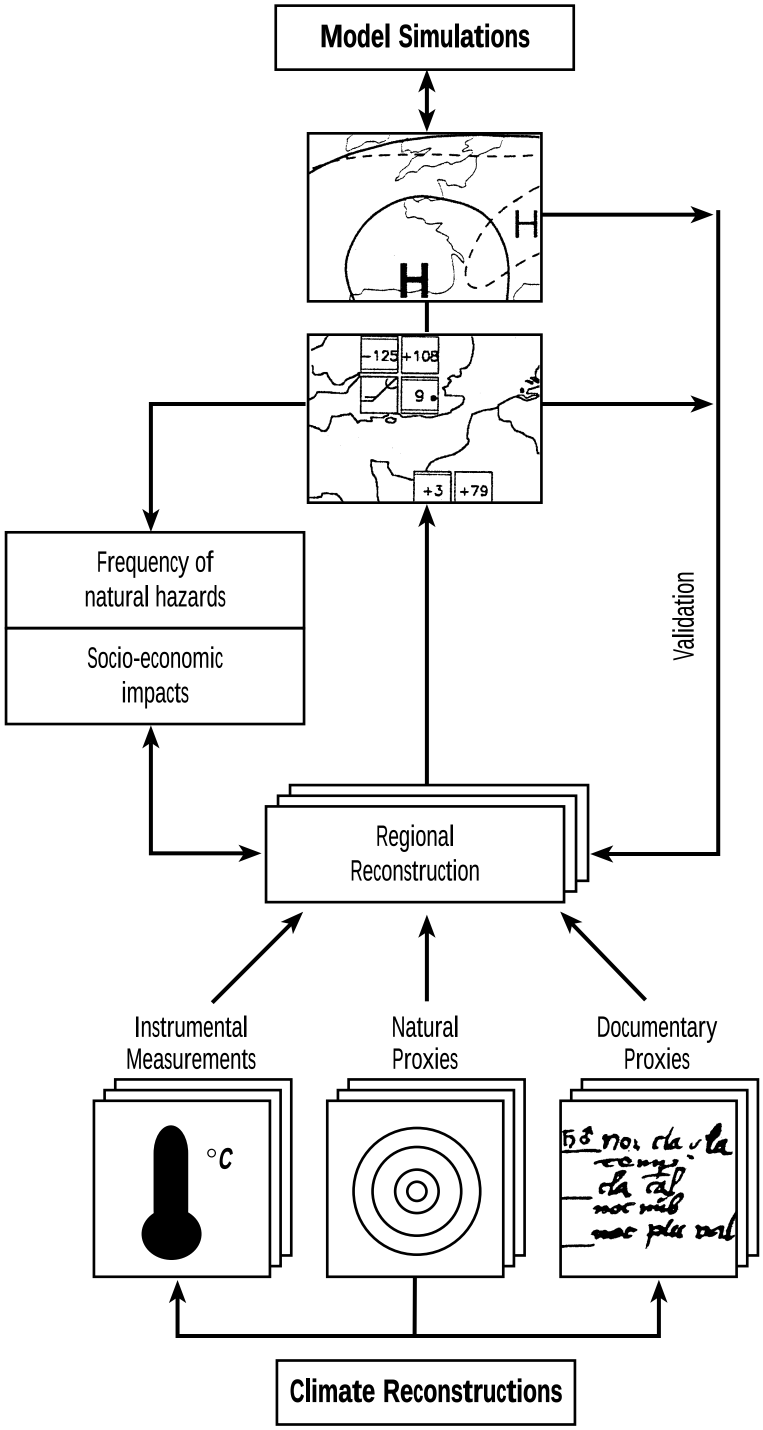

Figure 1

The five steps which were taken from the written source in the archive to the reconstruction of circulation patterns: 1.) Analysis of local data, 2.) Reconstruction of regional climatic variations, 3.) Reconstruction of climatic variations at the European level, 4.) Reconstruction of tentative circulation patterns, and 5.) Confrontation of the results to the results of model simulations.

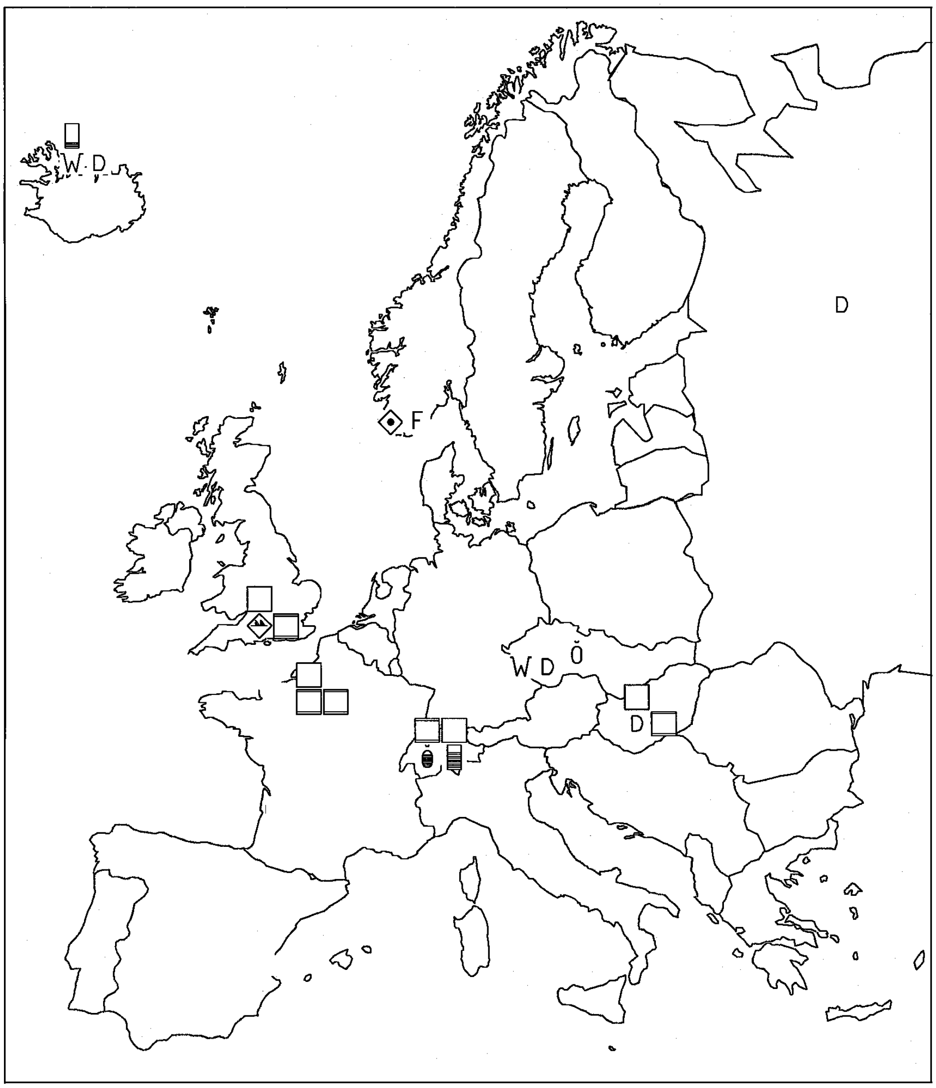

Figure 2
Reconstruction for Summer, 1704: The information contained in the squares contains quantitative or semi- quantitative information on temperature (simple squares) and on precipitation (squares with double margins). The icons display qualitative information, the plus and minus values after a D are the mean temperatures estimated from dendroclimatic evidence. In the warm season of 1704, Central and Eastern Europe were once more dominated by anticyclonic situations after two decades of cloudy or rainy summers. Norway suffered from cold and rainy weather, and temperatures in Northern Scandinavia were far below average according to tree-ring information, whereas Iceland, situated more to the West, was rather warm and dry. The synoptic interpretation suggests, that the steering depression was centered over Western Norway and that the Azores High frequently extended over Central and Eastern Europe. Low temperatures in central Italy, which are indicated from dendro-climatic data, are hard to comply with this situation. Source: Pfister et. al. in Frenzel, Pfister, Glaeser, 1994.

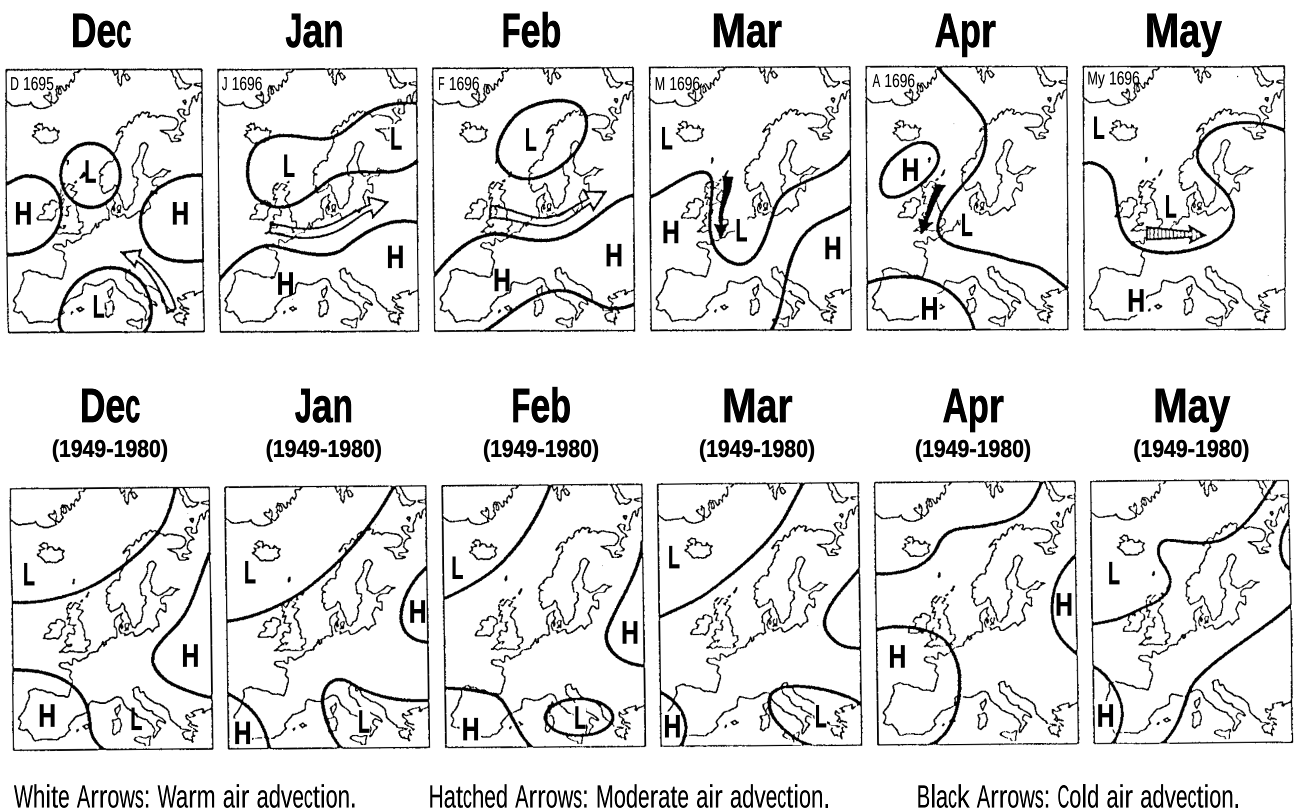

Figure 3
Reconstruction of mean sea-level pressure distribution from Euro-Climhist data for winter and spring months 1694/95 in comparison with the average for 1949-1980 (Brazdil and Stekl, 1986). Source: Wanner et al. in Frenzel, Pfister & Glaeser (1994).

3. HISTORICAL WEATHER DATABASE IN JAPAN

T. Mikami

Weather records in old diaries

In Japan, there are a large number of old diaries which include daily weather records, such as “fine all day”, “snowy and cold in the morning” and so on, since the 17th century. Most of these are official diaries such as diaries of feudal clans and temples, and are now kept in local museums and libraries. Thus we made an attempt to collect these weather records from all over Japan for the purpose of making a unique database which is named Historical Weather Database in Japan.

Daily Historical Weather Database

We have made a daily historical weather database for 35 stations as of December 1994. Various kind of weather conditions, weather changes in a day and additional weather phenomena were represented by the combination of numerical codes in one line such as “38 B 40 0 0 0 0” which means that it was cloudy in the morning, becoming rain in the afternoon and was cool. All the data are digitized and stored in magnetic tapes and optical disks.

Monthly Historical Weather Database

Among 35 daily historical weather databases, 13 stations were selected for monthly historical weather database in which the total number of days with each weather condition are expressed in terms of weather codes. As an example of monthly historical weather database, we show digitized records of January in 1812 - 1822 at Yokohama (Table 1) and a list of 13 stations (Table 2).

Monthly historical weather databases are open for public use. Direct access to data archived at the World Data Center-A for Paleoclimatology through Internet is available from all over the world.

Table 1
Digitized Records for Yokohama

Year	Mn	Location	T1	T2	T3	T4	T5	T6	T7	T8	T9	TA	TB	TC	TD	Z-	S4-
1812	01	YOKOHAMA	25	0	4	0	0	0	0	1	0	0	0	0	1	0	31
1813	01	YOKOHAMA	26	0	1	1	0	0	0	0	0	1	0	2	0	0	31
1814	01	YOKOHAMA	24	0	2	0	0	0	0	2	0	0	0	1	2	0	31
1815	01	YOKOHAMA	20	1	5	1	0	0	0	1	0	0	0	2	1	0	31
1816	01	YOKOHAMA	24	2	1	0	0	0	0	0	0	0	0	1	3	0	31
1817	01	YOKOHAMA	25	0	2	0	0	0	1	2	0	1	0	0	1	0	31
1818	01	YOKOHAMA	23	2	1	0	0	0	0	0	0	1	0	0	4	0	31
1819	01	YOKOHAMA	18	2	7	0	0	0	0	2	0	0	0	2	1	0	31
1820	01	YOKOHAMA	24	3	1	0	0	0	0	3	0	0	0	0	1	0	31
1821	01	YOKOHAMA	20	0	4	0	1	0	0	0	0	0	0	0	4	0	29
1822	01	YOKOHAMA	24	0	2	0	0	0	1	0	0	0	0	1	2	0	31

T1:fine T2:partly cloudy T3:cloudy T4:shower T5:thunderstorm T6:heavy thunderstorm T7:little rain T8:rain
T9:heavy rain TA:hail TB:snow shower TC:little snow TD:snow

Table 2
Location and data period of 13 stations.

No.	City Name	File Name	Location		Period	Document
1	Hirosaki	HIROSK.DBF	40.6N	140.5E	1661-1867	Official diary
2	Morioka	MORIOK.DBF	39.7N	141.2E	1660-1840	Official Diary
3	Kawanishi	KAWANS.DBF	38.0N	140.0E	1830-1889	Private Diary
4	Nikko	NIKKOU.DBF	36.7N	139.6E	1685-1871	Official Diary
5	Hachioji	HATIOJ.DBF	35.7N	139.3E	1720-1885	Farmhouse Diary
6	Yokohama	YOKOHAM.DBF	35.5N	139.6E	1806-1899	Private Diary
7	Sabae	SABA.DBF	36.0N	136.1E	1729-1870	Official Diary
8	Ise	ISE.DBF	34.5N	136.7E	1683-1889	Official Diary
9	Ikeda	IKEDA.DBF	34.8N	135.5E	1714-1889	Official Diary
10	Tanabe	TANABE.DBF	33.7N	135.4E	1814-1869	Private Diary
11	Hagi	HAGI.DBF	34.4N	131.4E	1736-1867	Official Diary
12	Usuki	USUKI.DBF	33.2N	131.8E	1674-1868	Official Diary
13	Nagasaki	NAGASKI.DBF	32.7N	130.0E	1700-1872	Official Diary

Editor's note: A limited number of Japanese historical documentary time series are available from the World Data Center-A for Paleoclimatology.

4. ICE CORE DATA

J. White

Ice cores are one of our best archives for paleoenvironmental information. The list of potential properties which can be measured is extensive. These measurements yield key information both about past changes in climate, for example, from stable isotope ratios in the ice, as well as changes in climate forcing factors, such as the past levels of atmospheric CO_2 and CH_4. Cores in high accumulation areas yield detailed pictures of past environments, with annual to sub-annual resolution that can be tied to historical observations. Cores in lower accumulation areas yield long records of environmental and climatic change on the time scale of glacial/interglacial cycles. Ice cores have been recovered from the major polar ice sheets, as well as polar, mid latitude and tropical latitude ice caps. Currently, the number of deep ice cores which have been collected is relatively small, less than ten, yet their impact on our understanding of past climates is substantial. Significantly more shallow cores (less than 200 m) have been collected and analyzed.

Current Research

Deep coring efforts have recently focused on Greenland: the GRIP and GISP2 cores. At the present time, deep and shallow coring is planned for ice sheets and ice caps around the world by the U.S., the Japanese, the Canadians, a European collaboration (French, Danes, Swiss, Germans and English), the Australians, the Canadians and the Chinese. This is an unprecedented push for new deep and shallow ice cores. A considerable amount of data is already available, although only a small amount of it has been collected in one data center. Considerably more measurements will be made in the future, as data on the GRIP and GISP2 cores are completed and new coring efforts yield ice, and eventually data .

At the Ice Core workshop, the following sites were identified for which data are available and could be submitted to the Ice Core Data Bank: Byrd, Little America, Ross Ice Shelf, Law Dome, GRIP, GISP2, Dye-3, Camp Century, Renland, Milcent, Crete, North Central, North Site, Dye-2, South Dome, Mizuho, Dunde, Tanggula, EUROCORE, Dome C, D10, D15, D57, Caroline, Dome B, Komosolaka, Lambert Glacier Basin.

Formation of an Ice Core Data Bank

Representatives of the ice core scientific community met in Bern, Switzerland on August 26 and 27, 1993 to discuss the current status and availability of data from ice cores, and to consider the formation of an Ice Core Data Bank (ICDB). In addition to the guidelines for ice core data that appear in this report, the group also identified the following guiding principles for the formation and operation of an Ice Core Data Bank.

A single data center, WDC-A Paleoclimatology, has been identified as the initial contact point for paleoclimate data from ice cores. Glaciological data from surface collections and shallow cores, as well as possibly some deep cores, should be submitted to the WDC-A for Glaciology.

- A hierarchy of data types is suggested: published, ancillary and unpublished.
- The ice coring community is international, with active groups in Denmark, France, England, Germany, Switzerland, Australia, Japan, China, Canada as well as many Universities and research institutes in the United States. In order for an Ice Core Data Bank (ICDB) to be successful, it must be sensitive to the different situations which exist in the different countries. In many cases outside of the U.S., ice core research is concentrated at one national laboratory where all, or nearly all, of the key parameters are measured. This makes it easier to identify who has data and is active, but it also means that the fate of these labs rises and falls with the level of each individual government's enthusiasm and funding for ice cores. The competition for research money can be fierce, and so the results generated by each national group become extremely valuable. In order for the ICDB to be successful, it must be sensitive to this situation and provide for proper credit to be given. It must also join the scientific community in actively promoting ice coring and ensuring that ice core data is readily available to the broader scientific community as well as the public. In the United States, proper crediting of data producers is equally important. The situation is helped by the fact that most funding agencies require that data eventually be publicly accessible.

PALEOCEANOGRAPHY DATABASE EFFORTS

1. DATA MANAGEMENT IN THE OCEAN DRILLING PROGRAM

J. Coyne

Introduction

The Ocean Drilling Program (ODP) is a basic scientific research program bringing together an international partnership of scientists from 20 nations. The program's primary objective is to explore Earth's history by retrieving and analyzing core samples from beneath the floors of the world's ocean basins. The sediment and hard rock samples are collected during cruises aboard the drilling vessel JOIDES Resolution. The retrieved core samples are described and analyzed by scientists in the shipboard laboratories. Samples are further distributed for shorebased measurements.

The ODP Database Group is responsible for archiving both the data generated from core samples and the geophysical data collected by ODP; this includes data collected onboard the JOIDES Resolution during each cruise, as well as data generated from ODP core samples by investigators working in their home laboratories. The Database Group is also responsible for archiving the computerized data from ODP's predecessor, the Deep Sea Drilling Project (DSDP), which operated from 1968-1983.

Each cruise of the JOIDES Resolution, approximately two months in duration, sails with a international scientific crew and technical support staff of about 50 people. It is assigned a Leg number to identify each cruise. A 12,000 sq. ft., seven-story shipboard laboratory facility contains state-of-the-art scientific equipment. The laboratories include sedimentology, paleomagnetics, physical properties, petrology, thin section, paleontology, chemistry, X-ray diffraction and fluorescence, downhole logging and underway geophysics, as well as modern facilities for photography, electronics, and refrigerated core storage. VAX, SUN, Macintosh, PCs, and Masscomp computers onboard assist with data collection and data retrieval as well as scientific bookkeeping and routine clerical work. For an overview of the drilling program, including science planning procedures, drilling vessel capabilities, shipboard laboratories, engineering development activities, logging, etc., the reader is referred to ODP Technical Note #11 (1).

Data collection on paper forms is often incomplete, illegible, and incorrectly filled out. This is a problem especially in descriptive data collection, such as sedimentologic and paleontologic descriptions where scientists from varied backgrounds and expertise describe the data in variable detail, quality, and emphasis. To overcome these problems, standardized data collection procedures are being implemented. Computerized data entry forms with standard error and range checks are being developed for shipboard data collection. These checks include sample identification, restrictions on values entered, and checks on missing values. For descriptive data collection, online lists from which the scientists may choose items for entry into the database fields greatly reduces data entry errors.

This paper describes the data sources and organization of the ODP database, discusses existing data collection and quality control procedures used by ODP, and highlights future directions for database development.

Sources of ODP scientific data onboard ship

The ODP database contains shipboard data generated from over 90 kilometers of core collected by ODP on Legs 101-present (currently Leg 151). Three methods are used to collect data onboard ship:

1. Handwrite data onto paper forms

2. Keypunch data using computerized screen forms and spreadsheets

3. Direct capture of machine-generated data into computer files

In addition, the ODP database also includes computerized data files of data collected during DSDP Legs 1-96 and data generated in shorebased labs from samples taken from cores collected by both DSDP and ODP. The ODP database is currently composed of over 2,600,000 records, with the DSDP computerized data files comprising 1,100,00 of these records. The database is growing at an increasing rate, about 200 megabytes every two months, due in part to the increasing ability to retrieve cores.

Collecting data on paper forms onboard ship and then keypunching the data onshore is time-consuming and potentially reduces the quality of the data through keypunching errors and possible omissions of important data. Currently, only paleontologic determinations require onshore keypunching of data after the cruise. Plans are being formulated to develop software to enter these data directly into the computer.

Computerized screen forms and spreadsheets with built-in edit and range checks are increasingly used on the ship to enter data immediately into the database. This eliminates many errors and allows the scientist to utilize the computer facilities to create plots, charts, and graphs for immediate interpretation and publication.

Direct data capture by the computer is possible for a number of datasets. For these files, sample identifiers are keypunched by shipboard personnel and then the results of the analyses are captured from laboratory instruments by the computer. This method is mostly used in laboratories which product large amounts of data per core, such as chemistry and paleomagnetics data.

ODP database organization and quality control

The ODP database is currently stored in System 1032 (System 1032 is a trademark of CompuServe), an online, relational, general-purpose database management system that runs on the VAX family of computers.

Searches can be performed on any field in the data files. A standardized sample identifier is part of each record in the database, this facilitates searches and retrieval from a single dataset and allows cross referencing of all the datasets. Figure 1 shows an overview of the organization and content of the ODP database.

Quality control providing database integrity is an important aspect for providing useful data to the international scientific community. To ensure quality data, the Database Group performs routine checks on data entry and after the data are computerized. Edit checks are built into the computerized screen forms to immediately detect any errors for a given data field, such as:

1. Type and range checks to ensure the data are within a given range and are the expected data type (e.g., decimal, text, etc.)

2. Internal cross-checking to compare values in different fields for a given record (e.g., some data files require values in several fields to add up to 100% percent)

3. Cross data file verification to check a record's sample identifier against a master dataset of the samples that actually exist

Additional computer programs have also been developed to perform specific quality checks on datasets following the cruise.

Future directions

An ongoing activity of the Database Group is to computerize as much of the data collection process onboard ship as possible. ODP is currently requesting proposals for work to upgrade the database/computer system both on the ship and shore. The new system will be UNIX based and utilize client/server technology. The project is expect to take about two years.

Obtaining data

In 1989 a 2 disk CD-Rom set containing DSDP data was published by the National Geophysical Data Center (NGDC). A CD-Rom set of ODP data for Legs 101 through 122 was completed in March 1992; it contains software to allow the user to search and display multiple datasets.

Data collected by ODP are restricted in distribution to the members of the appropriate shipboard scientific party for 12 months following the completion of a leg. Thereafter all the data are available to the public. Most requests can be answered quickly and free of charge.

To obtain data from the ODP database, direct requests to:

Data Librarian, Database Group, Ocean Drilling Program, Texas A&M Research Park, 1000 Discovery Drive, College Station, Texas 77845, U.S.A.; Phone: (409)-845-8495; Internet: DATABASE@Neslon.tamu.edu; Easylink Number: 62760290

Editor's Note: The World Data Center-A for Marine Geology and Geophysics at the National Geophysical Data Center also archives and distributes data from the Ocean Drilling Program. For more information, contact World Data Center-A for Marine Geology and Geophysics, 325 Broadway, Code E/GC, Boulder, CO USA (http:\\www.ngdc.noaa.gov\mgg\mggd.html).

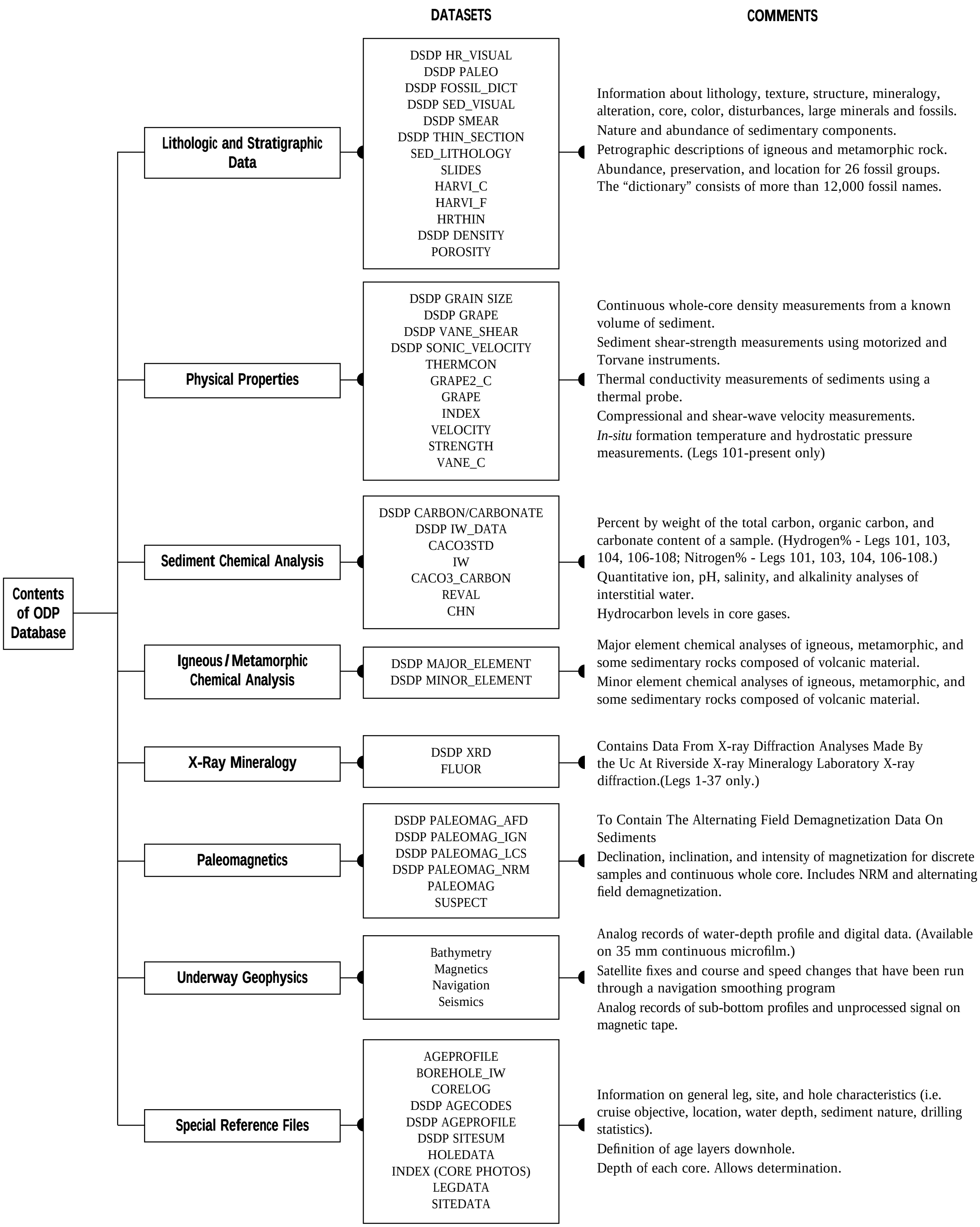

Figure 1
The organization and content of the Ocean Drilling Program database

2. RELATIVE SEA-LEVEL DATA STORED IN RESPONSE

H. P. Plag

Introduction

The study group *Global Geodynamics* at the University of Kiel primarily aims at modeling the rheology of the Earth's mantle in a broad period band ranging from seismic periods at the short end up to several kiloyears (kyrs) at the long end. However, designing such a broad-band rheological model requires a large amount of data pertaining to different time scales in order to constitute sufficient constraints which may eventually help to assess the validity of different models. Therefore, a substantial fraction of the group's activities is devoted to the collection and analysis of appropriate data.

Relevant constraints for the mantle rheology first of all come from experimental data obtained under high pressure and temperature conditions. From such laboratory experiments, constitutive relations may be derived, which are the basis for any modeling. However, to determine both the frequency dependence of the rheology and the depth-dependent structure of the viscoelastic properties of the mantle, additional observations are required.

Of great importance in this respect are any observations being related to exogenic deformation of the Earth. Unfortunately, in most of the observations of deformational signals are biased by, and partly linked to, other processes, which are mainly due to the interactions of atmosphere, hydrosphere, cryosphere, and the solid Earth. Thus, understanding the global interactions of these spheres is a prerequisite for using deformational observations in modeling the viscoelastic properties of the Earth.

According to these requirements, in 1987 the study group decided to build up a database of observations related to deformations of the Earth, and the database was named RESPONSE. Right from the beginning, RESPONSE was designed to accommodate an amount of information sufficient:

- To access the quality of the data, both concerning the measurements and the expressiveness in respect to the deformations of the Earth.
- To analyze the non-deformational part of the data.
- To contribute as much as possible to an understanding of the dynamics of the atmosphere-ocean-cryosphere-solid Earth system.

Among the observations pertaining to relatively long time scales, the Holocene relative sea-level(RSL) is of particular importance. Within the last decades, Holocene sea-level has continuously been studied as part of the International Geological Correlation Programme (IGCP). The IGCP Project 61 resulted in an Atlas of sea level curves (Bloom, 1982), while the IGCP Project 200 ('Late Quaternary Sea-Level Changes: Measurements, Correlations and Future Applications') is summarized in van der Plassche (1986), Devoy (1987), Tooley and Shennan (1987) and Scott et al. (1989). The World Atlas of Holocene Sea-Levels produced by Pirazzoli (1991) is part of IGCP Project 200. This atlas presents 500 relative sea-level curves, and regional plates provide a global overview of Holocene sea-level trends.

An early digitized database of globally distributed radiocarbon-dated water-level indicators was compiled by W.S. Newman, and the quality of the data is thoroughly discussed in Pardi and Newman (1987). Unfortunately, the amount of information stored for each sample is very limited and in many cases too scanty to assess the quality of individual samples. More elaborated national or regional databases have been compiled within the last five to ten years in several countries.

RSL data have extensively been used to constrain the Earth's mantle rheology in studies of post-glacial rebound (see e.g. Peltier, 1984; Tushingham and Peltier, 1991, 1992, for summaries). These studies of rebound and the concurrent sea-level changes mainly aim at the determination of the long-term mantle viscosity, which is a crucial parameter in modeling mantle convection.

Since RSL data provide a set of weighty constraints, the IAG Special Study Group 5.121 *Causes and mechanisms of post-glacial uplift* (1988) strongly supported the compilation of global RSL databases, and recommended that this work should be done in cooperation between the University of Lund, where an initiative had taken place to compile the Fennoscandia RSL data, and the University of Kiel, where a compilation of global RSL data had started. Currently, this work has resulted in a large and globally distributed data set of nearly 7000 different samples. Newly published or submitted RSL data are continuously added to RESPONSE. It is this set of RSL samples that will be considered here.

Past RSL, of course, is not directly observable but rather has to be derived from indicators of former sea-level positions. In using the RSL data, the particular characteristics of the water level indicators and the derived RSL sample points cause a number of problems which are due to the fact of that RSL is a relative quantity that is not directly observable. Interpretations are often inconsistent, and care must be taken in combining different sea level estimates. The problems related to the collection and interpretation of RSL samples are fully discussed in van der Plassche (1986). Examples of erroneous geophysical applications of RSL data are given in Plag and Rautenberg (1993).

SCHEDULE FOR RESPONSE

1987 First design of RESPONSE

1988 Start of data collection

1989 Cooperation with University of Lund, Department of Quaternary Geology

1990 Incorporation of Newman's data

1991 First final design of the RSL data structure

1993 Transfer to **Ingres,** On-line version of RESPONSE

1994 Updates, consistency checks, data analyses

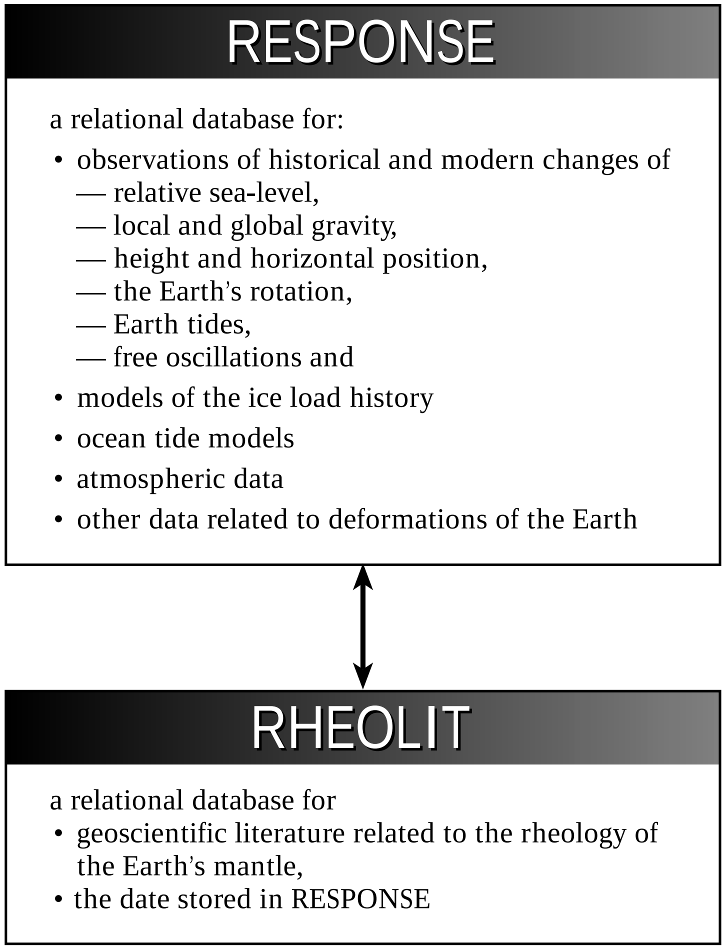

Figure 1
Contents of RESPONSE and RHEOLIT

The Structure of RESPONSE

Right from the start of our activities directed towards a database, it was not only our aim to make available as much high quality data as possible, but also to collect and summarize publications related to geophysical studies of the above mentioned kind (see schedule in inset box). Therefore, the references to the sources of the data are kept in a second separate database called RHEOLIT, which accommodates a large number of references to studies of the rheology of the Earth's mantle and related studies as well as the sources of the data stored in RESPONSE.

The overall structure of the two databases RESPONSE and RHEOLIT is shown in Fig. 1. RESPONSE compiles observations of historical and modern changes of relative sea-level, temporal changes of local and global gravity, and changes in the Earth's rotation. In addition to the deformation-related observations, information about the exogenic forces such as ice load models or the astronomical tidal potential are also stored in RESPONSE.

The data entries in RESPONSE are arranged in groups of samples. A group is characterized by the information given in a main group table, which identifies each group and the type of data in this group.

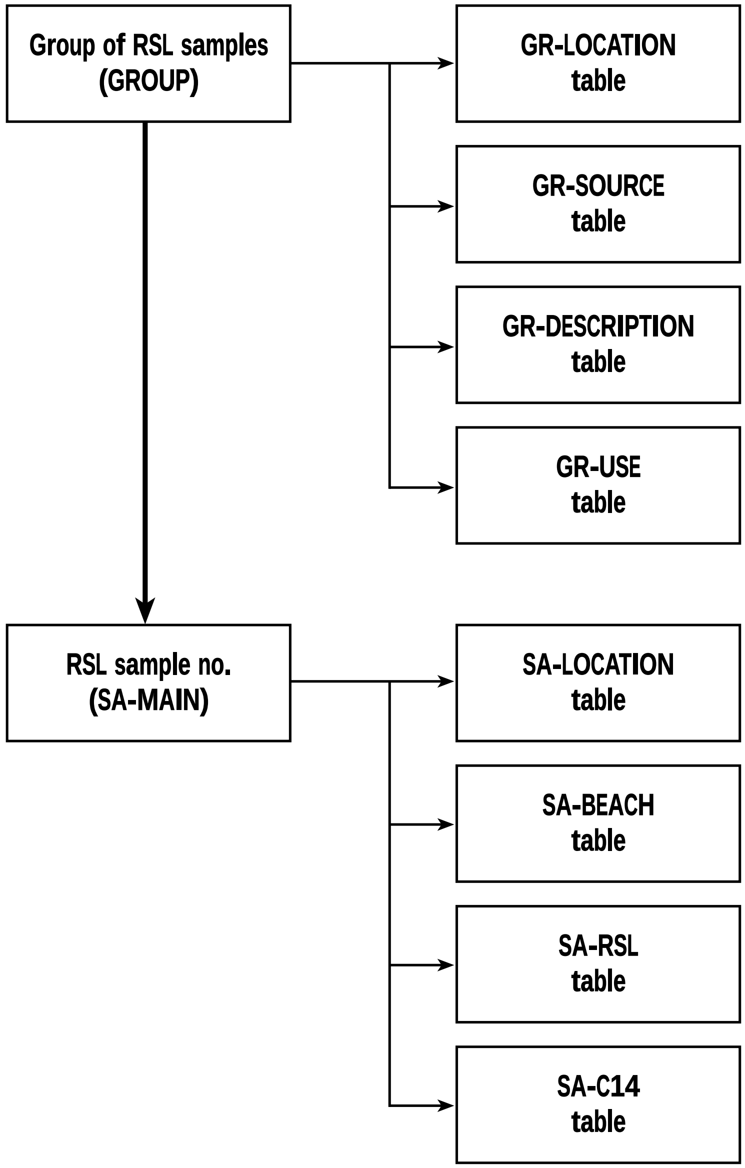

Figure 2
Structure of the RSL data sets

Structure of the RSL Data Sets

For a RSL data set, there are four group-related and four sample-related tables (Fig. 2), excluding the main group table mentioned in the previous section.

The first group table (GR-LOCATION) contains the information often used in the data searches, such as geographical coordinates of the site, time interval covered and the average quality of the sample. GR-SOURCE contains the reference(s) to the data source. There may be several entries for a given group. The description of geology and tectonics of the site or region are stored in GR-DESCRIPT together with other comments applying to all samples in the group. Finally, GR-USE contains references to papers, where the data have been used in scientific studies. This table may also hold short summaries of results obtained by using the data.

The main sample table (SA-MAIN) holds the identifications of the samples and it furnishes room for commentary information concerning a sample's location, age, method of age determination, height and material used. For some methods of age determination, additional detailed information is stored in specific tables such as SA-C14.

All quantitative information about the location of a sample is stored in SA-LOCATION, including the geographical coordinates, the height of the sample with respect to a reference datum, and the material of the sample. The qualitative and quantitative description of the beach environment around the sampling location may be accommodated in SA-BEACH. The derivation of the former position of the sea-level often involves a number of assumptions. In order to distinguish between the actually measured data and the derived quantities, the sea-level positions are complied in the separate SA-RSL table. It is this table, which will be the one most frequently consulted.

The age determination of a sample requires special consideration. For ages of several kyrs, radiocarbon dating is most frequently used, and the SA-C14 may hold additional information concerning the age determination using this method. It is anticipated that provision will be made for further tables for other age determination methods as they are more frequently used.

RSL Data Sources and Quality Checks

The RSL data currently stored in RESPONSE may be separated into three distinct parts:

- Samples collected by the late Prof. W.S. Newman, who established a large database of samples published mainly in Radiocarbon (Pardi and Newman, 1987). However, these samples of times and heights of former sea-level come with only a limited amount of auxiliary information. Therefore, it is necessary to rescan the respective publications to extract more information about age determination, geology, error sources, etc.
- The samples extracted from literature by the author and his coworkers. These samples come with all information available in the respective publications, and the entries have been cross checked by at least two independent individuals. Most of these samples are radiocarbon-dated. However, corrections for different radiocarbon time scales still have to be introduced and carefully checked.
- Samples compiled at the University of Lund. These samples are currently carefully checked and will be included in the on-line version of RESPONSE.

Currently, the data are further assessed by a consistency analysis being based on collocation of the samples to produce smoothed RSL topographies. Inconsistent samples should be detectable in the residuals of the topography. However, inconsistent samples are not, necessarily due to errors in the entries, but may be caused by large tectonic movements, or they may be due to misinterpretation of the relationship between an individual sample and the RSL. Nevertheless, samples detected as being inconsistent with the surrounding sea-level topography will be flagged accordingly.

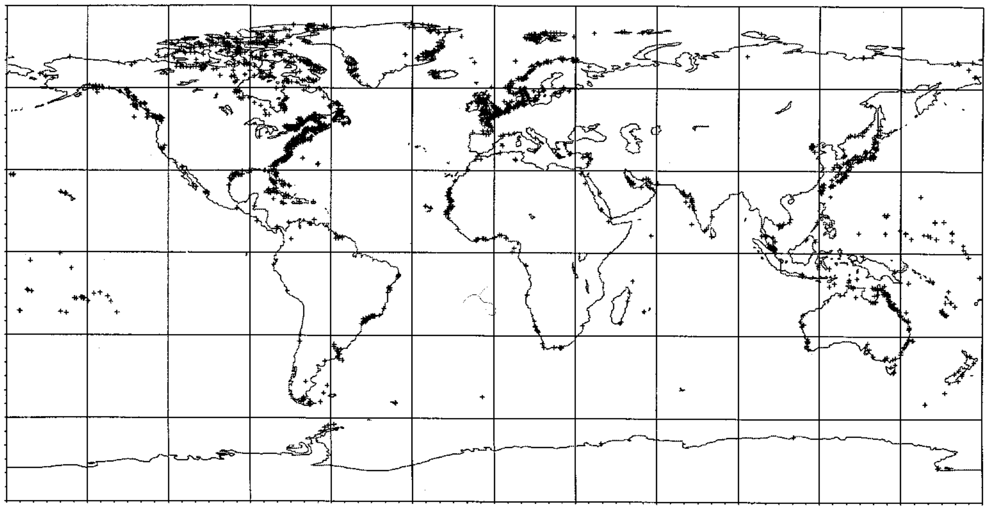

Figure 3

Geographical distribution of the RSL-samples stored in RESPONSE. Note that each cross may represent between 1 and 60 samples, depending on the number of samples in a group. From Plag and Rautenberg (1993).

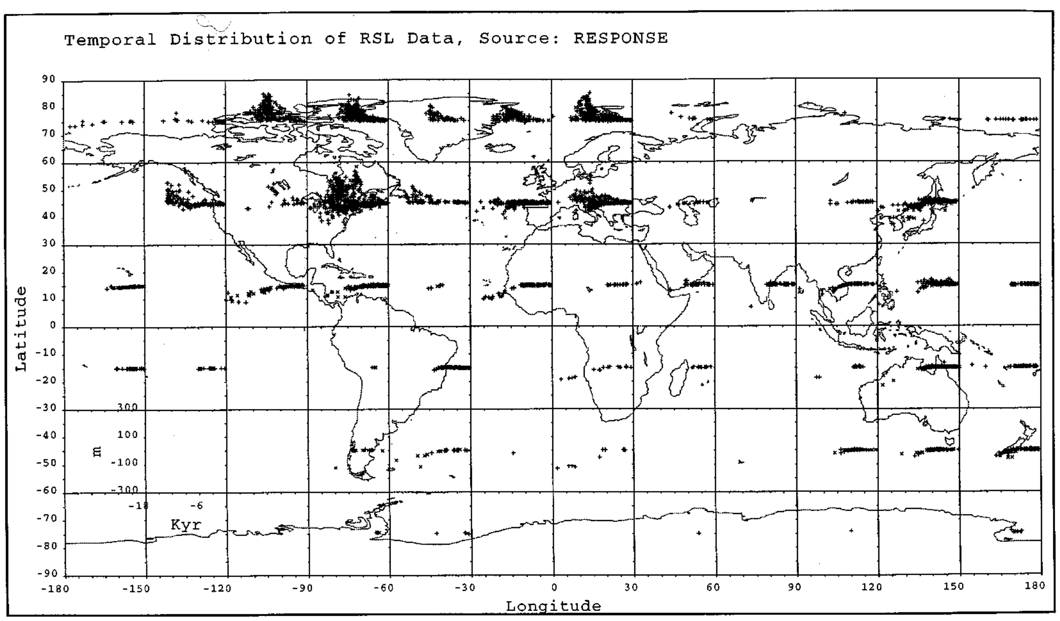

Figure 4

Distribution of the RSL database in time and space. The RSL data of each 30° x 30° grid area are plotted in a diagram with sea level height versus time, and with each diagram located in the respective grid. A sample diagram including the scales is given in the grid with the origin at 150°W, 60°S. From Plag and Rautenberg (1993).

The RSL data

The geographical distribution of the RSL samples currently stored in RESPONSE is illustrated in Fig. 3. The coverage of the global coast lines is fairly good. However, especially at the coasts of Antarctica and Siberia the amount of data is almost negligible. Considering the largely uncertain history of the Antarctic ice sheet and of the ice cover in parts of Siberia (Denton and Hughes, 1981), this lack of data is a severe drawback in modeling the Earth's response to glacial loading. Additional data is needed for the eastern coast of Africa, parts of the Asiatic coasts and the western coast of South America.

Visualizing the space-time distribution of the RSL data is not simple. However, Fig. 4 provides an impression of the space-time variability of the RSL by plotting the data of each 30° x 30° grid area into a diagram located in the respective area. Each diagram depicts the RSL heights as a function of time. The diagrams over the Southern hemisphere all show an increase of sea-level over the last 18 kyrs, while most diagrams north of about 60° N have a decreasing sea-level tendency. The diagrams located between 30° N and 60° show both tendencies, which is due to the combined effects of gravitation and deformation close to the ice boundary. This spatially highly variable pattern of the sea-level changes emphasizes the problems inherent in the concept of global eustacy. The separation of isostatic movements, geoidal variations and eustatic sea-level changes may only be achieved by utilizing a complex, gravitationally consistent theory as first derived by Farrell and Clark (1976). It should also be noted that the current sea-level changes exhibit a similar spatial variability. Thus, assigning the global average trend to the eustatic (climate-related) signal may be misleading (see e.g. Emery and Aubrey, 1991; Groger and Plag, 1993; Plag, 1993, for more detailed discussion).

Access to RESPONSE

RESPONSE is currently being transported from a simple collection of data files to the relational database structure described in the previous sections. The database software used is Ingres, and RESPONSE is being implemented on a Sun workstation. On-line access to RESPONSE is scheduled for December 1993.

Responsibility for maintaining RESPONSE currently rests with the Institute of Geophysics of the University Kiel, Germany. Access to the on-line version of the database will be free for all scientific purposes. It is planned, however to transfer RESPONSE as soon as possible to an agency providing better prospects for continuity of maintenance than those prevailing at a University institute.

To get access to RESPONSE, it will be necessary to establish an user account. Inquiries should be send to the author via fax or email. If required, the author will send more information in response to the inquiry, and this information is preferably distribute as either a LATEX or a PostScript file via email. The information distributed embraces a technical description of RESPONSE and RHEOLIT; a user manual for RESPONSE and RHEOLIT (file only); a (selected) bibliography of RHEOLIT (file only); a catalog of the RSL data (PostScript file only); a copy of Plag and Rautenberg (1993) (PostScript file only).

If an agreement is reached, an user account will be established either for searching all or selected areas of RESPONSE and/or RHEOLIT or for adding data to RESPONSE. However, the right to add data will only be granted exceptionally, and data should preferably be submitted by sending emails to the author with the contents being in accord with the guidelines for RSL data submission.

Acknowledgments

The work on RESPONSE and RHEOLIT was initially carried out with grants of the Deutsche Forschungsgemeinschaft (grants Zs-4/6-1,2). The design of the tables to accommodate the RSL data has been developed in close cooperation with N.-O. Svensson and S. Bjork. The RSL data was compiled by W.S. Newman and kindly supplied by V. Gornitz.

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TERRESTRIAL SEDIMENT DATABASE EFFORTS

1. NORTH AMERICAN POLLEN DATABASE

E. C. Grimm

The North American Pollen Database (NAPD) is established at the Illinois State Museum with funding from the Climate and Global Change Program of the U.S. National Oceanic and Atmospheric Administration (NOAA). The objective of the database is to create a relational database for fossil pollen and modern surface samples from North America that will be readily available to the scientific research community. The database is intended to be both an archive of pollen and associated data as well as an important research tool for studies in paleoclimatology and paleoecology. The database software is Paradox® from Borland International, which runs on IBM PC or compatible computers. From it inception, NAPD has worked closely with the European Pollen Database (EPD) to produce compatible database structure. As a result, the two databases have identical table structure and have produced a common database manual.

The database has a coordinator (Eric C. Grimm), a systems designer, and an advisory board of palynologists from the U.S. and Canada. The role of the Board is to provide advice on the kinds of data to incorporate into the database, set database protocols, set priorities for data acquisition, and encourage other palynologists to submit their data.

Initially, the Database concentrated on incorporating the existing COHMAP (Cooperative Holocene Mapping Project) data into the Paradox tables. Having a large set of data already in electronic form facilitated development of the database structure. However, the COHMAP data were very much a research tool, and the research aims of COHMAP sometimes compromised the archival protocols of NAPD. Consequently, much time has been devoted to supplementing and correcting the COHMAP data. In addition, many new sites have been added.

Originally, the master NAPD tables resided at the Illinois State Museum; however, NAPD is now a subset of the Global Pollen Database (GPD), which is housed at the NOAA National Geophysical Data Center (NGDC) in Boulder, Colorado, which is also the World Data Center-A for Paleoclimatology and the PAGES data coordination center. The Global Pollen Database currently contains data from North America, Latin America, and Siberia.

All data are freely available over the Internet from NGDC by anonymous FTP and the World Wide Web (WWW). The pollen database is accessible from the NOAA Paleoclimatology Pollen Page:

http://www.ngdc.noaa.gov/paleo/pollen.html

A “What’s new” link leads to a table listing new and updated data sets. This table is updated at least monthly, and new data sets are available immediately. The files available for sites having various geographic or temporal criteria can be located with a search engine

accessible from the NOAA Paleoclimatology Home Page:
http://www.ngdc.noaa.gov/paleo/paleo.html

The data are also obtainable from the NGDC anonymous FTP server (ftp.ngdc.noaa.gov, directory /paleo/pollen). The data are available in several formats, including the full database tables and various ASCII and spreadsheet formats. SiteSeer, a popular Microsoft® Windows® program for perusing the data is also available from the above WWW and FTP sites.

The database contains archival tables, which contain the basic data, such as the pollen counts and uncalibrated radiocarbon dates, and research tables, which contain interpretive data necessary for actually using the database. Examples of research tables are those that contain age models and the taxonomic hierarchy. A default age model is constructed for each data time-series using radiocarbon dates, published and unpublished criteria of the data contributors, and regional stratigraphic correlation made possible with the database itself. The structure of the database provides for storage of alternative age models based on other criteria (e.g. calendar years instead of radiocarbon years) or for archival purposes (e.g. the widely used COHMAP age models). A taxonomic hierarchy is created to allow extraction of data at any taxonomic level. Typically, the raw data from individual sites have a finer taxonomic resolution than required for regional to global studies. The hierarchy permits the database to retain the maximum taxonomic resolution provided by the original investigators while providing for easy extraction at various higher taxonomic levels.

Good database design favors a larger number of tables with a few fields each, rather than a smaller number of tables each with many fields. This design follows the principle of “one fact in exactly one place.” The central unit of the database is the *pollen bearing entity*, which might be a core, section, or surface sample. Examples of data associated with pollen bearing entities are site information, pollen counts, geochronology, workers, and publications. Separate tables exist for each kind of these data. The Database now contains ~60 tables with ~150 unique fields of data. Total database size is about 20 MB. Although such numbers may at first seem daunting, understanding the database is simplified by an awareness of the relationships between the different categories of tables and the realization that the core data are stored in a relatively small number of tables.

The database has five categories of tables. Archival tables store the original data that are not expected to change, except to correct errors or add missing information. Examples are the SITELOC table (Table 1), which stores locational information such as latitude and longitude, and the P_COUNTS table (Table 2), which stores the original pollen counts. Research tables store data that are derived by manipulation of the archival tables or are of an interpretive or subjective nature. Such data are likely to change or to be supplemented. Examples are the tables used to establish age models for pollen sequences: table AGEBASIS stores the age-depth points used to establish a chronology; table CHRON describes the age model used (e.g. linear interpolation); and table P_AGEDPT stores the age for each pollen sample. Whereas radiocarbon dates reported by the radiocarbon laboratory are stored in the C14 archival table, adjusted dates are stored in the AGEBASIS table. Users should not alter the archival tables (although they should notify the database administrators of any mistakes!), but could add to or change the research tables for their own purposes. Users may also add new research tables. Look-up tables contain codes for repeatedly used items and save space and reduce errors in the database by storing such information in only one place. System tables are used by application programs to help maintain the integrity of the database. They store the description of the structure of the database, including the names of all tables and fields, and the composition of primary, alternate, and foreign keys. Views contain information derived from other existing tables or views, making certain combinations of data more convenient to access. For example, the P_VARIS table stores the taxonomic hierarchy of variables in the archival P_VARS table.

Table 1

The SITELOC table, which is an archival table storing site-location data. The political divisions (PolDiv1, PolDiv2, PolDiv3) are codes: 3 letters for country and numbers for state/province and county. Country names follow ISO Standard 3166. State/province and county codes follow U.S. Department of Commerce FIPS PUB 10-3. This table also contains fields for latitude, longitude, elevation, and site area.

SiteName	SiteCode	SiteExists	PolDiv1	PolDiv2	PolDiv3	LatDeg	LatMin	LatSec
Alderdale Bog	CAN-ON000-ALDE		CAN	8	0	46	3	0
Alexander Lake	CAN-NF000-ALEX	Y1972	CAN	5	0	53	20	0
Alexis Lake	CAN-NF000-AXIS	Y1977	CAN	5	0	52	31	0
Alfies Lake	CAN-ON000-ALFI	Y1972	CAN	8	0	47	53	0
Aliuk Pond	CAN-NF000-ALIU	Y1972	CAN	5	0	54	35	0
Allenberg Bog	USA-NY009-ALLE	Y1968	USA	36	9	42	15	4
Anderson Pond	USA-TN185-ANDE		USA	47	185	36	2	0
Antoine Lake	CAN-ON000-ANTO	Y1972	CAN	8	0	47	44	0
Lac des Atocas	CAN-PQ057-ATO	Y1979	CAN	10	57	45	32	35
Attawapiskat Lake	CAN-ON000-ATTA		CAN	8	0	53	0	0
Lac à l'Ange	CAN-PQ016-ANGE	Y1977	CAN	10	16	47	28	54
Balsam Lake	USA-NY111-BALS		USA	36	111	42	30	0
Ballycroy Bog	CAN-ON000-BALL		CAN	8	0	43	57	15

Table 2

The P_COUNTS table, which is an archival table containing the original pollen counts. All fields are codes. E# = entity number, Sample# = sample number, Var# = variable number, and Count = the pollen count. the first line indicates a count of 15 pollen grains of Var# 16 (Ambrosia-type) in Sample# 1 (16 cm) in entity# 47 (Chatsworth Bog).

P_COUNTS	E#	Sample#	Var#	Count
50168	47	1	16	15
50169	47	1	25	1
50170	47	1	29	1
50171	47	1	44	3
50172	47	1	72	2
50173	47	1	74	65
50174	47	1	95	277
50175	47	1	182	1
50176	47	1	210	1
50177	47	1	222	6
50178	47	1	251	85
50179	47	1	270	4
50180	47	1	271	2
50181	47	1	293	8

2. EUROPEAN POLLEN DATABASE

R. Cheddadi and J. L. de Beaulieu

Introduction

Pollen analysis is a time consuming activity. Pollen-analytical data are thus a valuable scientific resource that should be permanently archived for future generations of researchers. We are living in the 'information revolution' with an ever-increasing availability of powerful personal computers, with the development of computer-based databases and data-retrieval systems, and with the enormous expansion of the primary scientific literature. It is against this background that a European Pollen Database (EPD) is now being developed to provide for all palynologists a permanent archive of the basic data generated by pollen analysts in Europe, a tool for further research on palaeoecological and biogeographical problems at a variety of temporal and spatial scales, and a primary data-source for furthering our understanding of past environmental history at a time when research on Global Change is becoming important (excerpt from the EPD 1st Newsletter, January 1991).

History, Origin and financing of the EPD

For participants to the closing session of the IGCP 158 project in June 1989 in Cracow it was obvious that a European Pollen Database be initiated during that meeting. It was agreed that in order to develop joint research programs it is necessary to set up a homogeneous pollen database which gathers available information from regional working groups.

Obviously, such a European project concerns a wider community of palynologists than participants to the IGCP project, mostly those who wish to develop "cooperating investigations on earth history particularly in the context of the IGBP Global Change program and related initiatives" (initial proposal for Database Workshop, by G.L. Jacobson, B.E. Berglund, B. Huntley, E.C. Grimm, J. Guiot). That is why between 1988 and 1991 a series of meetings (May, August 1989 at Frostavallen, 1989 at le Puy, September 1990 at Wilhelshaven, January 1991 at Arles) allowed a great number of specialists to discuss the project, make decisions concerning the database, its technical structure, its housing (Arles, France), coopt the members of an executive committee and of an advisory board and establish a protocol ruling the database.

In 1991, funds obtained from the European Community within the EPOCH Paleoclimate program allowed the employment of a post-doc as a database manager and the launching of the EPD.

Structure of the EPD

An important characteristic of the EPD is that its structure is completely compatible with the North American Pollen Database. This perfect coordination between the two databases represents the base of a future development of pollen databases in other continents.

Besides the pollen data, it was necessary to include in such database a variety of information related to the sites and to the corings. This information is necessary for the understanding and the interpretation of the pollen data.

A. The EPD Management System

The software used to set up the structure of the EPD is Paradox from Borland. A technical structure for the North American Pollen Database (NAPD) and the EPD was proposed by Eric Grimm and John Keltner and then adopted for both databases.

The data that is being compiled and stored in the EPD extends far beyond the pollen counts. It includes precise details of the site location, the present vegetation surrounding the site, the sediment lithology, the chronology, the loss-on-ignition, all bibliographic details relating to published accounts of the site, and the name(s) and address(s) of the worker(s) who collected the coring and analyzed the pollen samples.

The EPD is divided into many separate tables, each having relatively few fields. These tables are then linked together by key fields. Within the database as a whole, each table contains a different type of data. Four main types of tables can be distinguished:

1. Archive tables: they contain the reported data from each site. These data are the fundamental archive for future use and are not expected to change after they have been added to the database.
2. Look-up tables: they contain lists of items that will be referred to repeatedly elsewhere by means of short alphabetic or numeric codes. These lists (e.g. workers, sites etc.) allow the full name of coded items to be looked up as required.
3. Research tables: they contain information that is either derived by manipulation of the data in the archive tables (e.g. pollen percentage values for selected taxa calculated by the database user from the raw pollen counts stored in the archive tables, estimated ages for samples in a profile calculated by the database user from the radiocarbon or other age determinations stored in the archive tables, etc.) or else is of subjective or interpretative character (e.g. age assignments for a profile that are based upon stratigraphic correlation with one or more separate dated profile(s)). Users are likely to develop a variety of research tables, apart from those initially provided for, according to the requirements of their projects.
4. System tables: they store a description of the entire database structure in four tables. This information includes the names and general categories (archival, lookup etc.) of all the EPD tables; the names and fields types of each field (or column) in each table; and documents how the database is indexed with key fields.

Beside Paradox the EPD uses the Tilia software written by E. Grimm, to enter pollen data and to draw the pollen diagrams.

B. The handling software (SiteSeer, GrafSite)

SiteSeer and Grafsite are two software packages available for NAPD and EPD respectively. They allow the display of a map of North America/Europe with all the sites available in the database, according to their geographical coordinates, then with a mouse the user can visualize (and if needed print) the pollen diagram. Their use is very simple since all the functions are interactive with a mouse through icons. Several other options are also available.

The main difference between SiteSeer and GrafSite is that when the European pollen data compilation started there was no centrally-developed research tables comparable to those containing age models developed by Thompson Webb and associated with the COHMAP database that formed the initial start of the NAPD. GrafSite now allows interpolations of ^{14}C dates, and correlations between well-dated sites and closely non-dated sites. The age models obtained are then stored in a research table.

Both SiteSeer and Grafsite run under Windows and are freely distributed.

C. Data compilation

1. Network for data compilation. A rather heavy questionnaire was proposed in a first attempt to the contributors. This questionnaire was aimed at obtaining the information concerning the site which should be archived in the Paradox tables. This first attempt failed as very few contributors filled in and returned the questionnaire. The new strategy, which brings more results, was to ask the contributors:
   - to fill in a very simple questionnaire
   - to send the raw pollen data as it is available (diskettes or paper)
   - to send the publications when available.

   After a first compilation in the database, precise questions regarding the necessary information to be archived and which is not accessible in the publication are requested from the author.

   Data compilation is a consuming effort and requires a lot more time than expected because most of the data have not been entered into the computer. Moreover, some key articles are written in languages which are not accessible for the database centre. This last point lead us to develop regional centers to deal with local (national) contributors.
2. Systematics and pollen nomenclature. The principle of the EPD is to collect data that are directly derived from field and laboratory observation. This is why it has been decided from the outset that pollen counts would be introduced in the database under the terminology adopted by the authors. However, the authors often use different nomenclature keys and thus the same pollen type may be identified with different terminologies. Moreover, changes may occur as a result of progress in determination, so that there are inconstancies in the raw data that are offered to the EPD. In order to make the database exploitable, the list of taxa provided by the authors had therefore to be turned into a common language.

   A group of experts in pollen morphology accepted the enormous task which consists of establishing a type-list of taxa on the basis of simple nomenclature rules (according to H. J. B. Birks) and referring either to published determination keys or to the experience of the experts. Three lists are now available for 1) medio- and north-European regions, 2) southern Europe and in circum-Mediterranean regions, other pollen taxa exist, and pollen types described in northern regions may correspond to larger groups of species, and 3) eastern European countries. In addition to these type-lists aiming to preserve the taxonomic level of raw data, the information concerning the higher taxa has been added to the database in order to make easier syntheses at a small scale. The activities of the working group in charge of pollen morphology and nomenclature were not given many means nor advertising. However, they represent a fundamental approach which should be a basis for discussions about regional structures and lead to a common language.

Obtaining the pollen Data from the Centre National Universitaire Sud de Calcul (CNUSC) by Anonymous FTP.

The data that have been collected during the last three years from the palynologists who wished to collaborate are now freely available to the users. As mentioned in the EPD protocol (see Newsletter number 1), there are restricted and unrestricted sites in the EPD. The Advisory board agreed on that, for the time being, the unrestricted data can be available to anyone with access to FTP and that the restricted data should be distributed from the EPD centre upon written request from the user.

Conclusion

Despite the efforts expended to date, and the enormous progress that has been achieved, one should note that the 501 pollen diagrams available from 334 sites in the EPD do represent only about 30% of the high quality palynological sequences studied throughout Europe.

One should mention that the number of contributions is much higher than at the beginning of the EPD project. Our target is to reach 900 pollen diagrams within three years and mostly to fill the spatial gaps on the European map if we succeed in obtaining funds from the EC.

Editor's note: Data for the unrestricted EPD sites are also available from the World Data Center-A for Paleoclimatology.

3. GLOBAL LAKE LEVEL (STATUS) DATABASE

S. P. Harrison

Description of Project

Regionally-synchronous changes in lake level or relative water depth, which are both surrogates for lake volume, can be used to provide information about changes in regional water budgets during the Late Quaternary. There are four extant lake-level or lake status data bases: the Oxford Lake-Level Data Base, the Chinese Lake-Level Data Base, the European Lake-Level Data Base and the Former Soviet Union and Mongolia Lake-Level Data Base. The Oxford Lake-Level Data Base contains information on closed-basin lakes and is global in coverage. However, because of the restriction to closed-basin lakes it contains little information from many temperate regions and, since it was completed in 1989, its coverage of other areas is now out of date. The other three data bases include information from both closed and overflowing lakes and are ongoing projects. A data cooperative for *Late Quaternary Lake-Level Data* was initiated in September 1992, with support from the NOAA-NGDC Paleoclimate Program, with the aims of combining the existing data bases into a new global data base and providing a mechanism to include new data for other regions as they become available. The co-ordinators of this data cooperative are Marge Winkler (Madison, USA) and Sandy P. Harrison (Lund, Sweden).

Description of data

The data base contains assessments of lake level or relative water depth (lake status) through time based on a consensus interpretation of the available physical, chemical and biological data from cores or exposed sections. Descriptions of the primary data on which the assessments of lake status are based is also included in the data base, as is information on the dating control.

Structure of Data Base

The data base consists of individual documentation files for each lake basin, containing descriptions of the primary data and its interpretation, a continuous assessment of lake status through time, information on dating control and background information about the site. These documentation files are linked to summary data files, giving information on all the basins.

List of Variables Archived

Location Data: basin name, country, latitude, longitude, elevation
Background Site Data: basin type, basin origin, catchment geology, basin area (total area including lake area), lake area, mire area (if lake now overgrown), mean depth, maximum depth, presence of surface inflows and outflows, hydrological type (e.g. spring-fed, groundwater

inflow/discharge, closed/open), limnological information if available (e.g. productivity, water chemistry), description of aquatic vegetation and surrounding mire vegetation (if applicable), description of modern climate

Dating information: sources of dating (e.g. radiocarbon, tephrachronology, counting of annual laminations, pollen correlation with nearby radiocarbon-dated site), number of radiocarbon dates, length of record coded, listing of radiocarbon dates including lab. number, standard error, material dated, depth in core or elevation in section, possible dating problems (i.e. age too young, contamination, sample too small) and whether used in status coding, listing of tephra dates (code name, depth in core or elevation in section, assigned age, source of assigned age)

Summary of data sources used for coding (e.g. lithology, sedimentation rates, depositional (as opposed to coring) hiatuses, aquatic pollen and macrofossils, diatoms, molluscs, ostracodes, geochemistry, geomorphology, archaeology, other.

Primary data and interpretation: description of primary data for each data source used, indication of potential explanation of these data, consensus interpretation of the data in terms of either changes in lake level or changes in relative water depth.

Status coding: pseudo-continuous coding for length of extant or codable record. The summary files only contain assessments at 500 yr. intervals back to 30,000 yr. BP (or length of extant or codable record)

Primary references (i.e. those references used to derive coding, including unpublished data)

Secondary references (i.e. those references used to provide background data or which only repeat data given in the primary references)

Coding information: indication of who coded the data and when the final coding version was archived.

Data Submission

Scientists wishing to contribute data to the new global lake-level (status) data base are asked to contact Sandy P. Harrison or Marge Winkler for information about and assistance with data submission.

Editor's note: Data for the Oxford, European, and Former Soviet Union and Mongolia Lake Level Databases are available from the World Data Center-A for Paleoclimatology.

4. GLOCOPH (GLOBAL CONTINENTAL PALAEOHYDROLOGY) DATABASE

J. Branson

The GLOCOPH Project

An INQUA Commission, known as GLOCOPH (Global Continental Palaeohydrology Project) has been established to study global changes in the fluvial regime during the last 20,000 years. The main objectives of the commission are to:

1) determine the main changes that have occurred in the water balance of the major environmental zones in the last 20,000 years and to quantify these changes;

2) reconstruct the major trends and sequences of river flows for selected rivers in each region;

3) relate changes in hydrology to causative factors (e.g. climate, human activity);

4) establish the degree to which changes in water balance correlate from one area to another;

5) develop global palaeohydrological models based upon field investigations and data interpretation.

The GLOCOPH Database

A database is currently being developed to facilitate the collation and distribution of fluvial palaeohydrological data collected prior to and during the GLOCOPH project, and to act as a continuing resource. The database development has been funded by the Leverhulme Trust, and is being undertaken at the GeoData Institute, University of Southampton, U.K.

The GLOCOPH database aims to provide a resource to facilitate the study of long-term palaeohydrological change by providing access to datasets of primary and secondary environmental parameters which are of interest for the modeling of fluvial palaeohydrological processes and controls. These data include details of channel morphology, catchment characteristics, sedimentology, and calculations of hydrologic and hydraulic parameters including discharge, velocity, sediment yield, groundwater etc. which were derived from the primary data. Through the consolidation of data from different sources it is possible to undertake regional studies that are not restricted by physical or disciplinary boundaries. It will allow, for example, determination of past runoff regimes at different spatial and temporal scales, and the analysis of the factors that influence the hydrological cycle to determine their controlling influence on changes in the water balance. New hypotheses can therefore be tested or existing models validated.

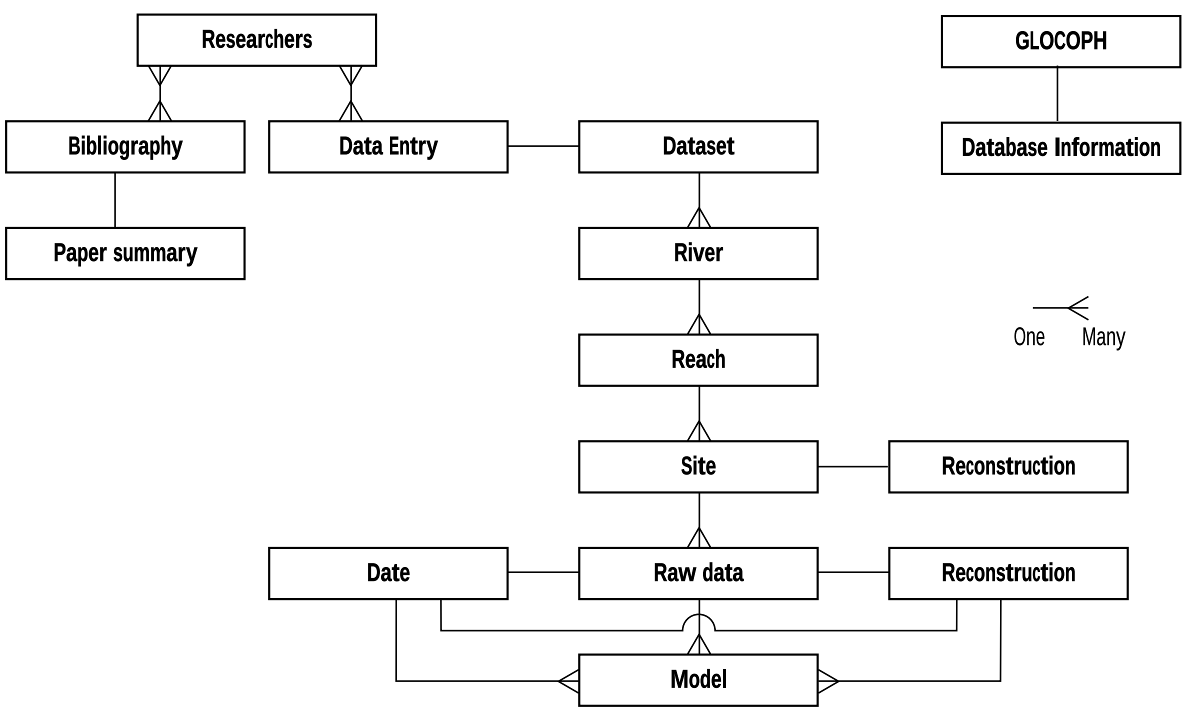
Database Structure

The database is being developed using the ORACLE relational database system from the ORACLE Corporation. A simplified version of the data structure is shown in Figure 1, and further details of the tables are given below.

Within the relational structure the data have been stored in a hierarchy and are first grouped into individual datasets. A dataset represents an individual donation of data from a researcher or data from related publications by the same author(s). The dataset table gives information of the spatial and temporal coverage of the data within the individual datasets, the techniques used during data collection and a brief description of each dataset and associated keywords.

The source of the data is denoted by an identifier in the data entry table. Most data have been obtained from publications, unpublished reports or directly from the data collector. This table also shows who entered the data into the database, the date of entry and the status of the entry, i.e. whether it is a new entry or has been changed. This table is linked to the researchers table, which gives details of the name and address of the person who collected the data, the person who contributed the data to the database and who should be contacted regarding the dataset. The bibliography table gives a full reference of both the papers or report from which the data were obtained and details of any other papers which discuss the particular dataset. Summaries of the papers, including keywords are given in the paper summary table.

Figure 1
Simplified structure of the GLOCOPH database showing main tables and linkages.



Data from each dataset are first grouped by river or by climatic or geographic region and are then subdivided into reaches and then sites. A site may represent, for example, an individual cross section of the river, a gravel pit, peat core or slackwater deposit. Wherever possible, the data are spatially referenced by latitude and longitude at the site level. The lowest level of classification is the record; this represents measurements at a particular level within a core or boulder deposit, for example.

Data for each record are held within three groups of tables which present the raw data, reconstruction and date associated with each record. A high level of standardisation is required if the data collected by different researchers are to be directly comparable, and thus all data have been standardized to International Standard measurements. The original data are also held in the database but will not be accessible to users unless specifically requested. The equations used to format the data are available within the database, however, so that it is possible to recover the original measurements.

The raw data tables contain the primary field data and the reconstruction table the derived data (of the types shown in Table 1). The date tables hold the date of the sample and, where appropriate, details of the dating method and laboratory, description of errors associated with the date and the upper and lower error margins of the date. Ideally there should be a date for each record but there should be at least a rough chronology for each site.

Table 1: Types of data in the database (guidelines only)

Data Type	Category	Variables
Raw Data	Bed sediments	particle size, facies descriptions, dune height, channel roughness indicator
	Cross sections	width, cross sectional area, depth, palaeostage, height, radius
	Planform	stream length, channel slope, meander geometry, braiding index
	Drainage basin	basin area, drainage density, valley
Reconstruction		velocity, discharge, bed shear stress, stream power, flood frequency, flood recurrence interval, sediment yield, channel deepening

Modeling and analysis of the data can be performed using the model table, within this table there are routines available to apply various hydrological models to the data, with which to calculate discharge, velocity etc. using the primary data. Alternatively, routines are available to format the required data so that it can be imported into a spreadsheet or similar package and analysis undertaken external to the database.

In addition to the data tables the database contains metadata and information and look-up tables. The metadata are particularly important within a multidisciplinary dataset such as the GLOCOPH database as they enable the user to make full use of the data without complete knowledge of the particular discipline in which the data were collected. The information tables give information on the GLOCOPH project (the GLOCOPH table), recent additions to the database and how to use the database (the database information table). There will also be information about meetings, conferences and recent publications of relevance to the palaeohydrology research community. Look-up tables contain codes for frequently used parameters (e.g., for country names, site types, etc.).

Access to the GLOCOPH database

Access to output from the database is currently being made available via the Internet (URL location http://www.geodata.soton.ac.uk/glocoph/glocoph.html), and ASCII files of particular datasets will be shortly available through anonymous ftp. Personal searches are available on request from the database administrator and the results can be output on computer disc, tape or paper printout as preferred.

On-line access to the database will also be available to allow interactive searching of the database tables. Once logged into the database, users access the data from custom-built forms using a menu system. Searches can be made to obtain data from studies concerning, for example, an individual country, river, site, a particular time frame or technique or within a given geographical region. The strength of the database is that it is possible to combine the results of several studies to enable reconstructions of runoff globally or for particular geographic regions or environments.

At present there is no graphical component within the database although this is being developed to allow site photographs to be included and to facilitate the production of maps and graphs of the data. Currently there are routines in the database, however, to export site location data in formats that can be directly imported into public domain map viewing packages.

Protocols outlining the conditions under which data are accepted for the database and how they are to be used are distributed to data contributors and users. It is critically important, for example, that anyone who uses the data obtained from the database in a publication should reference both publications regarding the original data by the data contributor (details of which are given in the source table, see above) and the database. Guidelines for submission of data to the database are outlined in Table 2.

Table 2
Information that should be included when submitting data to the GLOCOPH database

Data Type	Category	Examples of variables
Personnel information	Contributors	Name, organization, address, e-mail of principal investigator, names of other investigators involved with data collection
	Contact address	Name, organization, address, e-mail of the person who should be contacted regarding the dataset
	General information	Location: Country/countries, river or region
	Reach description	Drainage basin/catchment size, length of reach, brief description
	Site description	Type of site (e.g. flood deposits, cross section, terrace), latitude and longitude
	Documentation	Details of published and non-published references written about the site and dataset
	Data collection techniques	date of collection, sampling devices, sampling strategy, number of samples
Data	Type of data	sediment core, flood occurrence record, flow data
	Location	depth in core
	Raw data	sediment size, slope angle
	Reconstruction/interpretation	velocity, discharge, flood frequency (can be numerical or text, include details of method/model used, errors, measure of distribution)
	Age of record	radiocarbon, absolute or relative
	Dating	method of dating, location/number of laboratory, calibration curve used, errors

Data Submission

Data can be submitted in printed format, as text files on DOS or UNIX discs or spreadsheet or database files. Discs or pre-printed forms can be provided if required.

Further information

Further information about the GLOCOPH project and the database may be obtained from Julia Branson at the GeoData Institute, University of Southampton, Southampton, SO17 1BJ, U.K.; e-mail geodata@soton.ac.uk

5. DATABASES FOR THE WESTERN UNITED STATES

R. S. Thompson and K. H. Anderson

We are compiling the available pollen and packrat midden data for the United States west of 95° W. (and immediately adjacent portions of Canada and Mexico). The pollen data will be submitted to the North America Pollen Database (NAPD) and both the pollen and midden data will be available as Paradox™ and ASCII files. These database compilation efforts are described in greater detail below.

Modern Surface Pollen Samples.

Modern pollen samples, coupled with modern climate data, are being compiled to provide the basis for quantitative paleoclimatic reconstructions from fossil pollen assemblages. We have compiled a list of 1537 modern pollen surface samples, and core-top samples from fossil sites from the western United States that we may be able to include in the modern calibration database. We have raw counts or percentage data for 707 of these. Through collaborative research with scientists at the University of Oregon (P. J. Bartlein and B. Lipsitz) we have generated a 25km grid of modern climatic data for North America. The modern climatic estimates for each surface sample will be distributed with the modern pollen data.

Fossil Pollen Samples.

We have identified 128 fossil pollen sites in the western United States (Fig. 2), and we have data from 42 of these localities. We are now soliciting data on western fossil pollen sites, and are searching the literature for additional sites and collaborators.

Packrat Middens.

Taxonomically diverse plant macrofossil assemblages are preserved in the urine-cemented "middens" of ancient *Neotoma* spp. in arid western North America. Each radiocarbon-dated assemblage provides a wealth of floristic detail, but only (it is generally believed) for a discrete point in time. Thus far we have compiled information on 811 samples for the packrat midden database, and we plan to contact the 22 identified researchers in this field to request additional data. Major compilation of the dataset will be done in 1994-1995, and all data will be submitted to the World Data Center-A for Paleoclimatology for distribution.

CELIA/LIGA Data Effort

L. J. Maher

Project CELIA (Climate and Environment of the Last Interglacial in Arctic and Subarctic North America) was originally established by the Boreal Institute of Northern Studies at the University of Alberta 1990. CELIA Board Members include J. Brigham-Grette, M. Edwards, S. Funder, J. Kutzbach, L. Maher, J. Matthews, G. Miller, A. Morgan, N. Rutter, C. Schweger, C. Tarnocai, J-S. Vincent, and A. de Vernal.

A NATO Advanced Workshop on Last Interglacial in the Arctic and Subarctic was held in Hanstholm, Denmark in October 1990. Project LIGA (Last Interglacial in the Arctic and Subarctic) was formed at this time, and project members included: P. Anderson, J.-L. de Beaulieu, O. Borisova, J. Eiriksson, S. Funder, P. Gibbard, T. Hamilton, S.P. Harrison, M. Houmark-Nielsen, B. Huntley, K.L. Knudsen, E. Larsen, L.J. Maher, J.V. Matthews, Jr., G. Miller, A. Raukas, N. Reeh, A.-M.Robertsson, N. Rutter, C.E. Schweger, H.-P. Sejrup, A. Sher, A. Telka, C. Turner, A. Velichko, A. de Vernal, and B. Ward.

A LIGA Meeting was held in Quebec, Canada, during May 1993, with the following attendees: Pat Anderson, Jacques-Louis de Beaulieu, Weston Blake Jr, Julie Brigham-Grette, Peter Clark, Jon Eiriksson, M.E. “Ted” Evans, Joël Guiot, Philippe Gachon, Tom Hamilton, Sandy Harrison, Claude Hillaire-Marcel, William Hyde, Sigfus J. Johnsen, Karen Luise Knudsen, John Kutzbach, Eiliv Larsen, Stein Erik Lauritzen, Marin Geologi, Lynda Levesque, Louis Maher, John Matthews, Gifford Miller, Alan Morgan, Thomas Pedersen, Richard Peltier, Leonid Polyak, Ann-Marie Robertsson, André Rochon, Nat Rutter, Charles Schweger, Marit-Solveig Seidenkrantz, Hans-Pettr Sejrup, Alice Telka, Anne de Vernal.

The data are organized around individual sites, and a summary site listing is available from the author. Site descriptions are found in the files listed in the Sites subdirectory of the database. These are self-extracting compressed (zipped) files, each of which contains a number of separate files dealing with that site. The filename conventions for these files are listed in Table 1. LIGA data and information are available over the Internet (FTP address: geology.wisc.edu, subdirectory pub/liga; URL address ftp://geology.wisc.edu/pub/liga).

Table 1
File Conventions Used in the LIGA Project.

Filename	Contents
Site.ref	Site Name, Name(s) and address(es) of Contributor(s)
	Site location (latitude, longitude, other geographical description)
	Site description, stratigraphy, types of data, geochronology
	Published references
Site.tif or Site.gif	a standard graphics file of strat diagram, map, etc.
Site.pal	palynology
Site.mag	magnetic stratigraphy
Site.dia	diatoms
Site.tim	timing (chronology)
Site.for	foraminifera
Site.ice	ice core data
Site.mac	macrofossils
Site.ins	insects

MULTI-PROXY DATABASE EFFORTS

1. INTERNATIONAL PALEOCLIMATE DATABANK (PKDB)

I. Lentner

The International Paleoclimate Databank (PKDB) was initiated in 1985 on request of the Climate Research Program of the German Federal Government. The head of this databank and of the research project "Terrestrial Paleoclimatology" is Prof. Dr. H.C.B. Frenzel. He developed the scientific goals of the databank in connection with the requirements of the other research groups of this national program. The above mentioned databank is located at the Botanical Institute of the Stuttgart-Hohenheim University.

From the very beginning of its existence, it was clear that the databank should not be a mere compilation of paleoclimate data, but that at first all the data stored must be critically analyzed. The reason for this is that paleoclimate data originate in a wealth of disciplines, thus they are not always compatible with each other. On the other hand they were obtained during a long time of research. This means that the state of scientific knowledge is not always the same. Last but not least, already published paleoclimate data is strongly influenced by general assumptions and by the mode of thinking during various times.

All this taken together creates a strong heterogeneity of the originally published data. This is even true for accurate databases, which are so indispensable in paleoclimatology. On the other hand the amount of data available is enormous and stimulating. In view of these facts Prof. Frenzel hesitated at first to follow the request of the German Climate Research Program to create a paleoclimate databank. But while he was preparing the "Atlas of Paleoclimates and Paleoenvironments of the Northern Hemisphere", together with Prof. Pécsi, Budapest, and Prof. Velichko, Moscow, he finally agreed to follow the wishes of the peers of the Climate Research Program.

Contents of the Database

The databank only relies on already published data. This strongly reduces juristic problems. On the other hand, all disciplines that contribute directly or indirectly to our paleoclimatological knowledge are taken into consideration. For example, contributing disciplines range from the philologies, via geology, geomorphology, pedology, physics, paleontology, paleobotany to biology.

There exists an agreement that the written historical data will be stored in the databank EURO-CLIMHIST, even if they were attained within the framework of the "Terrestrial Paleoclimatology" research.

Marine paleoclimate data will be stored at the databank in Bremen. Data on vegetation history is handed to the European Pollen database in Arles. Data on pollen flora of surface samples, in relation to vegetation and present-day climates, which are so important for the reconstruction of past climates, are stored at the PKDB. The same holds true for data on present-day and former above- and below-ground terrestrial biomass. The reason for this is that we try to quantify paleoclimates, where this was not done by the authors of the various papers studied.

Approximately 26,000 titles of papers and books, written in 15 different languages, are included into our databank. Besides this, we are constantly including original and critically analyzed data from all contributing disciplines. In this respect it should be noted that from each paper studied the original data is included, always together with the critical analyses, so that both these types of datasets are available and of course we do not wish to suppress the original data.

At the moment, besides Prof. Frenzel, 4 biologists, two students of biology and one foreign language secretary are involved in the work of the databank. Within this group I am responsible for programming and data management.

The critical analyses mentioned are being done at first by Prof. Frenzel, who has tried to learn as many regions of the globe as possible from practical experience, in order to better understand shortcomings, pitfalls and errors in paleoclimatological reconstructions.

These critically analyzed and - if necessary - corrected data is then used for drawing paleoclimatological maps and for performing some time series analyses. Both of them are eventually discussed by all members of the "Terrestrial" and "Marine Paleoclimatology" research group, who have joint meetings twice a year at the Mainz Academy of Sciences and Literature. These meetings usually include the members of 15-18 of the institutes. Thus a huge degree of criticism of the original data, as well as of those which were analyzed by Prof. Frenzel, is obtained. This is a constantly operating process, into which long discussions about the quality of dating the past in the field and in the laboratory are included.

Technical Notes

From the very beginning this databank worked as a multi-user system. That means it exists only as a unique, but always actualized version of the databank. The operating system was at the beginning XENIX on an Intel 386 computer. In 1992 we changed to AIX based on an IBM-RISC computer. Since 1992 we have been integrated into the campus network, and as a result of this the PKDB team has direct access to the services of the INTERNET.

We use the EMPRESS databank program, a product of Canada, which is becoming more and more common in the field of meteorological databanks. With its newest version it offers now the possibility of distributed databases. This will open new opportunities for cooperation with other institutions using Empress on whatever operating system.

Regarding the present-day storage capacities we have attached to our computers hard disks with 6 GB capacity and an EXABYTE- stacker with a maximum capacity of 250 GB.

The work with the Geographical Information System (GIS) ARC/INFO has recently begun. This system should enable us to generate climate maps of several time slices as detailed as possible, in order to minimize the work done by hand.

The International Paleoclimate Databank is already technically connected with the DKRZ (German Climate Modeling Center) in Hamburg, in order to intensify the joint scientific work in progress. We are aiming at opening the databank to other users too. Yet, in this respect we depend on the Ministry for Research and Technology, which at first has to solve various jurisdical and financial problems.

2. SEDAN—THE GERMAN PALEOCLIMATE DATA CENTER FOR MARINE AND LACUSTRINE SEDIMENTS

M. Diepenbroek

At the Alfred Wegener Institute for Marine and Polar Research (AWI), a paleoclimate data center for marine and lacustrine sediments (SEDAN) will be set up within the next few years at the request of those scientists in Germany who work in the marine part of PAGES. The project is funded by the Federal Ministry for Research and Technology (BMFT). In Germany about 25 institutions are sampling and analysing marine and lacustrine sediments. With the foundation of new institutes, the organization of special research programmes, new or reconstructed research vessels, the amount of existing samples and data has remarkably increased. At present about 50 km of sediment cores exist. The datacenter will guarantee the consistent and long-term storage of data derived from these samples and will make them available for the scientific community, especially for modeling groups working on paleoclimate.

Characteristics

Figure 1 shows the attributes found to be essential for the characterization of the datacenter and that were recognized during the conception phase. The first aspect in the data domain is the availability of data. Both historically important data sets and recent data sets should be available. Data quality, a crucial aspect in the data domain, can be estimated. The quality information is parameter dependant. In general, it might be sufficient to specify the method of measurement and calibration, the precision of the data, and—if possible—to give citations on data sets. In many cases however, additional and more specific information is needed. Problems in the data domain are caused by the variety of possible analyses, interpretations, and calibrations and the alterations in these fields.

The first crucial aspect in the structural domain that must be addressed is the usability of the system. Low entry requirements, simple handling and high responsiveness will contribute to the effectiveness of the system. To cope with the growing requirements of users and with future developments in information technology, the system must be adaptable through improvements and enlargements. Problems in this field arise from the spatial distance between institutes and working groups and the different hard- and software environments. Legal aspects have also to be recognized. Copyright and similar questions always led to controversial discussions. The copyright question has to be solved in accordance with the users. Finally, there must be some benefit for the data producers to be motivated to store their data in the datacenter.

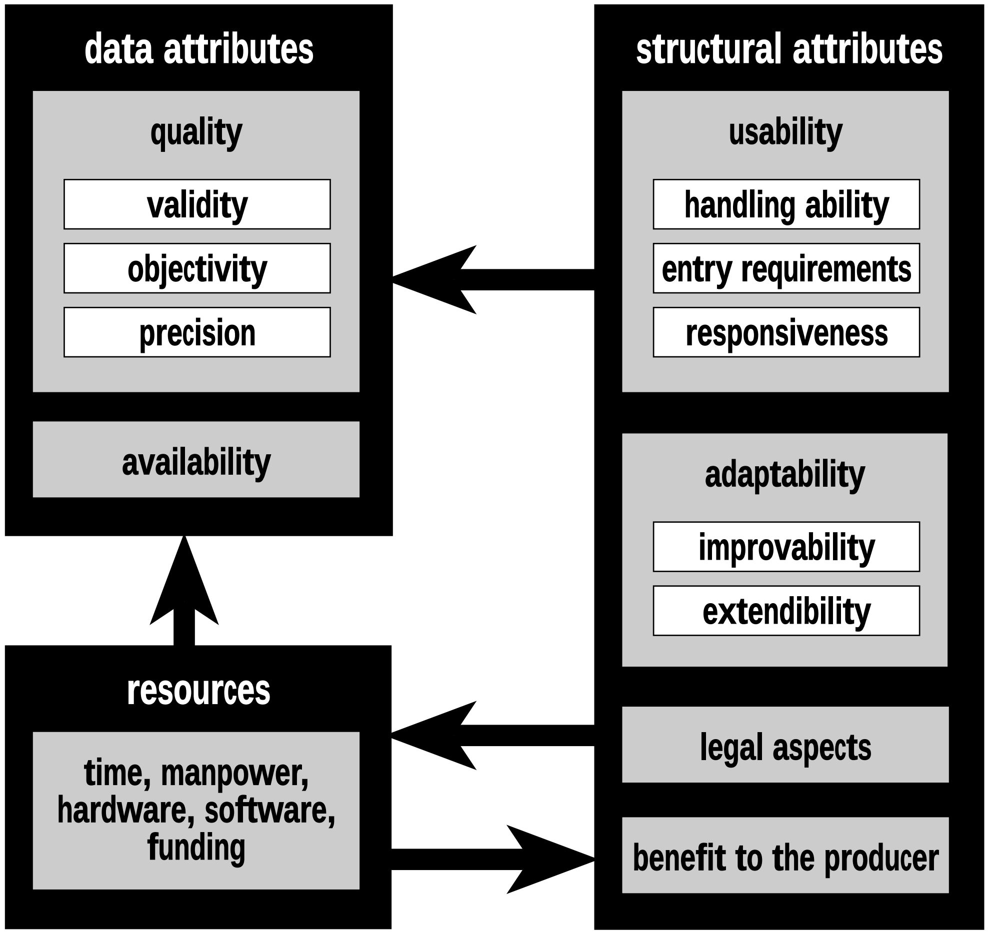


Figure 1
Critical aspects of the projected system

Specifications

From the previously mentioned aspects and problems it is apparent that a flexible data model is needed that meets the requirements of a heterogeneous and dynamic scientific environment. Further requirements are the realization of a data quality check and detailed data security. The users should be connected on-line to the database. Access should be done through high level front ends (geographical browser - retrieval, import, and export). At the same time the system will be tied into the international data exchange (e.g. with the NGDC or the WDC A via ftp or mail). The motivation of users to deliver their data to the data center can be viewed under different aspects. On one hand the user receives a powerful tool for storing and managing his data. On the other hand he is responsible for "his" data pool and should be able—in a progressive state—to manage his pool independently. Accordingly, the data sets are related to the name of the producer. Moreover, the data will be made citable through publishing an abstract of the data description in the "Reports for Polar Research". This will solve the copyright question

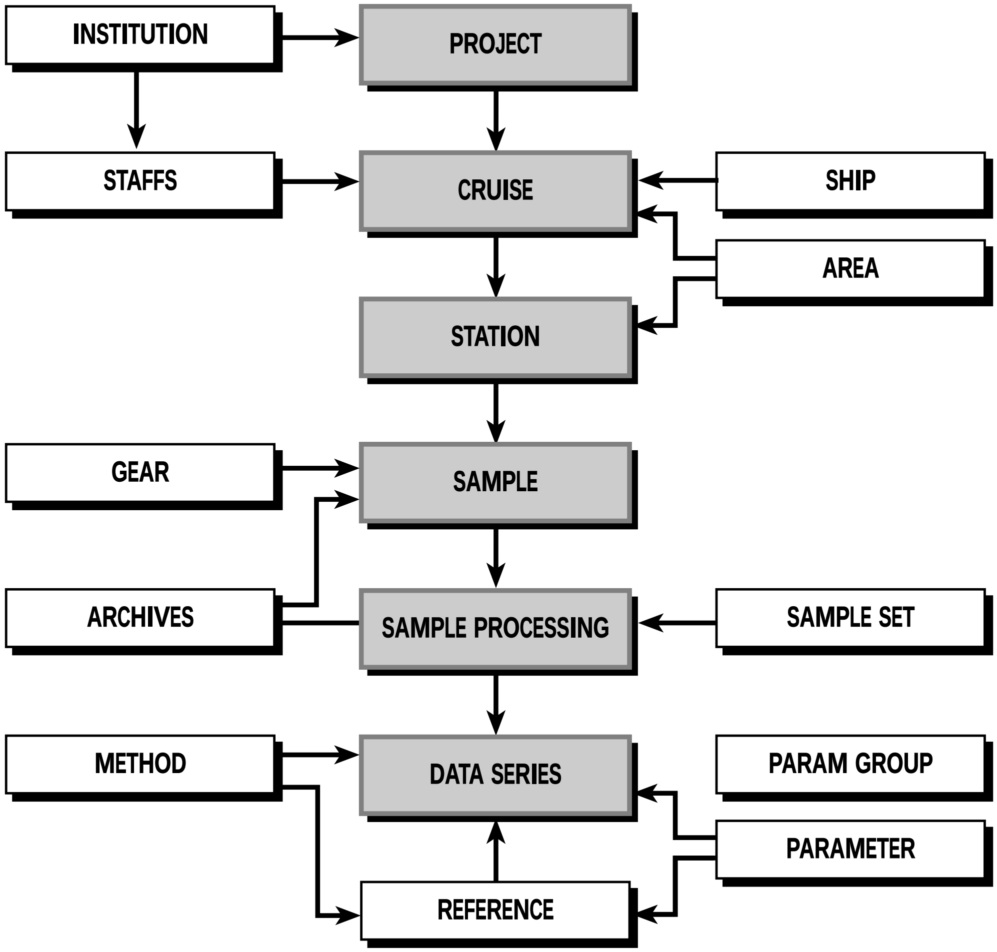


Figure 2
Data model

and has a positive influence on the availability and quality of data. Proposals coming from several quarters have also suggested that all paleoclimate projects financed by the national funding organizations are obligated to deposit their results in the data center after publication of the data at the lastest (similar to the practice of the NSF).

The data model and the network concept are currently in use in the sediment core database of the AWI. The data model (Figure 2) shows a hierarchical order of the meta information, beginning with the projects, which are often bound to an institution, then the cruises, the stations, and the samples. The sample processing and the data series description form the lower levels. Other objects supplement the information in these tables, as the gear list or a list of all citations connected with the data. The essential part of this model is formed by the combination of data series, parameter, and method, which guarantees that the system can also be easily adapted to individual and changing requirements. Novice users simply add their specific parameters and methods (if not yet present) to be able to store all desired data types.

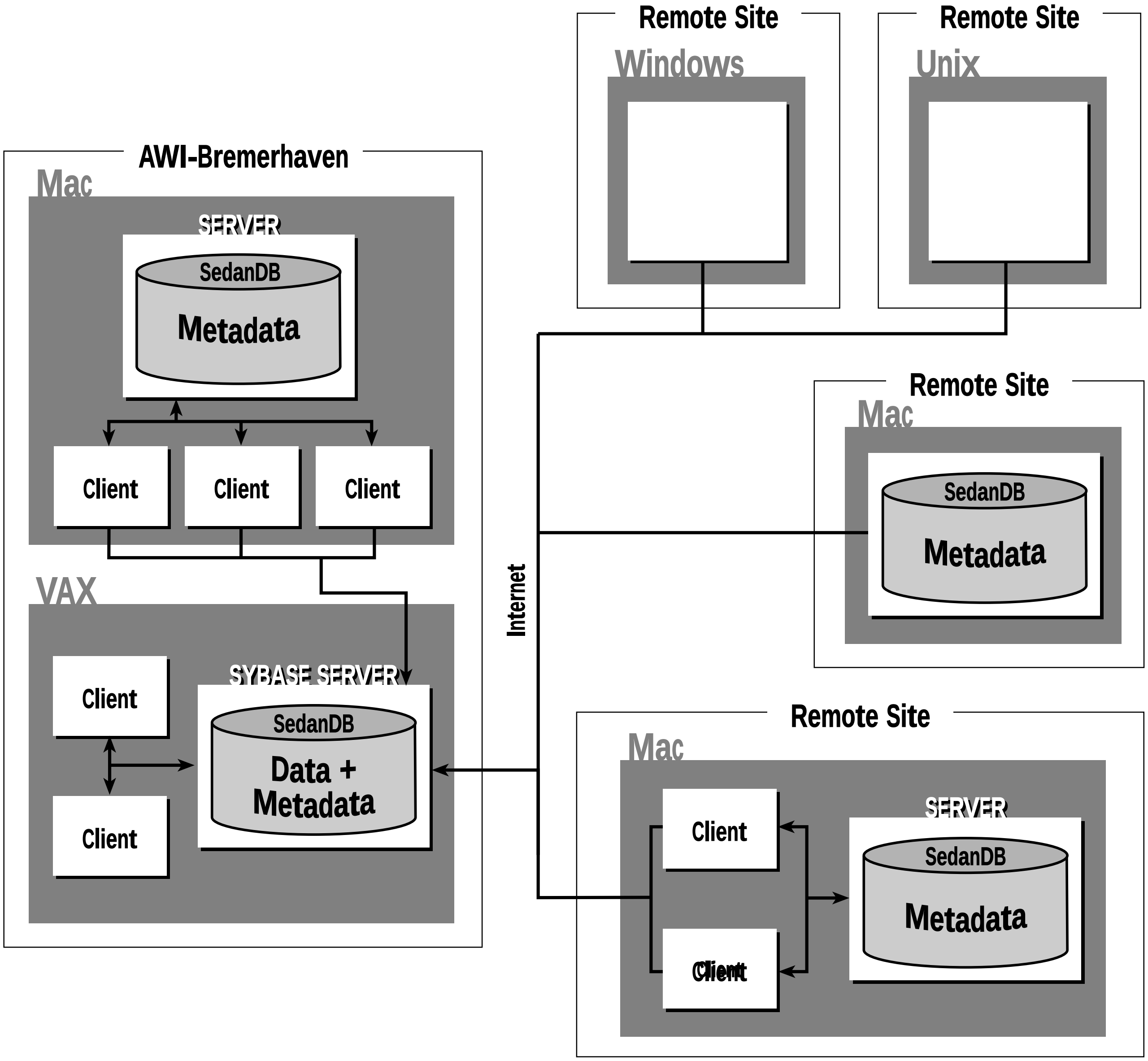


Figure 3
Network concept

The network concept (Figure 3) is based on the client/server-principle. The database server runs on a VAX 6610. Remote users outside Bremerhaven will have access to the server via Internet. To improve the access speed the meta information is mirrored on local servers. The mutual update of meta information is running in the background. The initial phase of the project (3 years) will be financed by the Federal Ministry for Research and Technology (BMFT) (essentially the employment of a scientist and a programmer). The necessary hard- and software as well as basic services (network, system management, communication, backup) are available through the AWI. In 1995 a first status report and an evaluation of the project will be prepared.

3. RUSSIAN PALEO DATA EFFORTS

A. A. Velichko [O. Borisova, Presenter]

A considerable amount of paleoenvironmental data has been collected in the Laboratory of Evolutionary Geography and other leading laboratories in Russia by now. We are interested in making the data available to global change scientists.

The main types of paleodata include: terrestrial biota (vegetation, fauna); soil cover and loesses; permafrost and periglacial events; glaciation dynamics; limnic paleo- ecology.

It is necessary to discuss, what key data sets must be included in the PAGES database, and what variables should be archived for each of the above-mentioned types of information. For some of them special submission guidelines should be worked out. Our laboratory could take part in this work for such types of data as loess and soil sequences, permafrost and periglacial events and continental ice sheets history.

As an example of the guidelines for the data on the ice-wedge casts we can propose this draft:

1. Site location: latitude, longitude, country, state/province, elevation;
2. Geomorphological position of section with wedge casts;
3. Lithology and stratigraphy of the host material;
4. Paleontological data on the host sediments palynology, mammal fauna, molluscs;
5. The height of wedges;
6. Angle between the fissure strike and the section front;
7. The wedge top width;
8. Diameter of wedge polygons;
9. Presence or absence of the upper kettle layer of the wedges;
10. Lithology of the wedge fill (from the top downward);
11. The fabric of the wedge fill;
12. Description of the lateral contacts of wedges with the host material;
13. Estimated depth of the ancient active layer.

Our current efforts in data management include collecting of pollen data on the Holocene, Late Glacial and the Last Interglaciation, which were produced by specialists of the Laboratory of Evolutionary Geography and other main laboratories in Russia. At present there are pollen data on about 50 sections on the Russian Plain and Siberia which can be shared for the PAGES database.

At present the most urgent problem is to develop the submission guidelines for the principal data types. The draft “PAGES Data Management Guide” should be discussed in regional working groups to improve sharing of each data type. The final data management guidelines should be distributed around the world to build an international system of paleoenvironmental data management.

Editor's note: Pollen data from a number of Russian sites are available from the World Data Center-A for Paleoclimatology.

4. AN AUSTRALIAN QUATERNARY CLIMATE DATABASE

G. R. Hunt

Australia's federal geoscientific body, the Australian Geological Survey Organisation (AGSO), aims to provide an integrated geoscience data storehouse through database development. Recently AGSO has placed an increasing emphasis on environmental geoscience issues leading to greater Quaternary research. The Australian Quaternary Climate Database forms a part of AGSO's database development. Funding for the project is partly derived from a National Greenhouse Advisory Committee grant. Staff consist of one full-time researcher, temporary students and computer support.

The database is intended to centralize and standardize data (both primary and interpreted) derived from the Quaternary literature. The stored climatic interpretations will provide a basis for producing palaeoclimatic maps of Australia at selected time periods. These maps and the supporting data will be used to test palaeoclimatic models. A further goal is to input new and presently unpublished raw data including data related to newly published material. The database would then form a central data repository for Quaternary palaeoclimatic research. Free and remote access to the database via a medium such as the World Wide Web would be the most desirable option (cost-recovery constraints are still being debated).

Database Description

The database will be composed of tables containing entry fields. The present (1995) structure is shown on the accompanying diagram (Figure 1). It will utilize information contained in the published Quaternary literature. Eight main tables are planned; sites (location information), geochemistry, geochronology, geomorphology, palaeomagnetism, palaeontology, palaeobotany and conclusions (climatic inferences). Also included are look-up tables (containing lists of terms with abbreviations) for faster and more reliable data entry. On the diagram the look-up tables have bold borders and are found on the right-hand side of the page.

The bibliography BMR Record 1991/104 (Bleys et al., 1991) which contains 1500 references provides the source of references. A pilot project is now on our corporate mainframe running on ORACLE the relational database management program. Six tables have been set up to test the structure. They are the sites, geochemistry, geochronology, palaeobotany, palaeontology and conclusions tables. The fields in these tables are shown on the diagram. The SITES table contains the locality and current environmental conditions of the site. The GEOCHEM table for geochemical results has been divided into three parts. The first indicates where in the site the sample is from and what it and the surrounding material is composed of. The second is for the chemical analyses. The third is for amino acid racemisation results. The GEOCHRON table contains information relating to dating including the location and nature of the sample in the site. The three-part

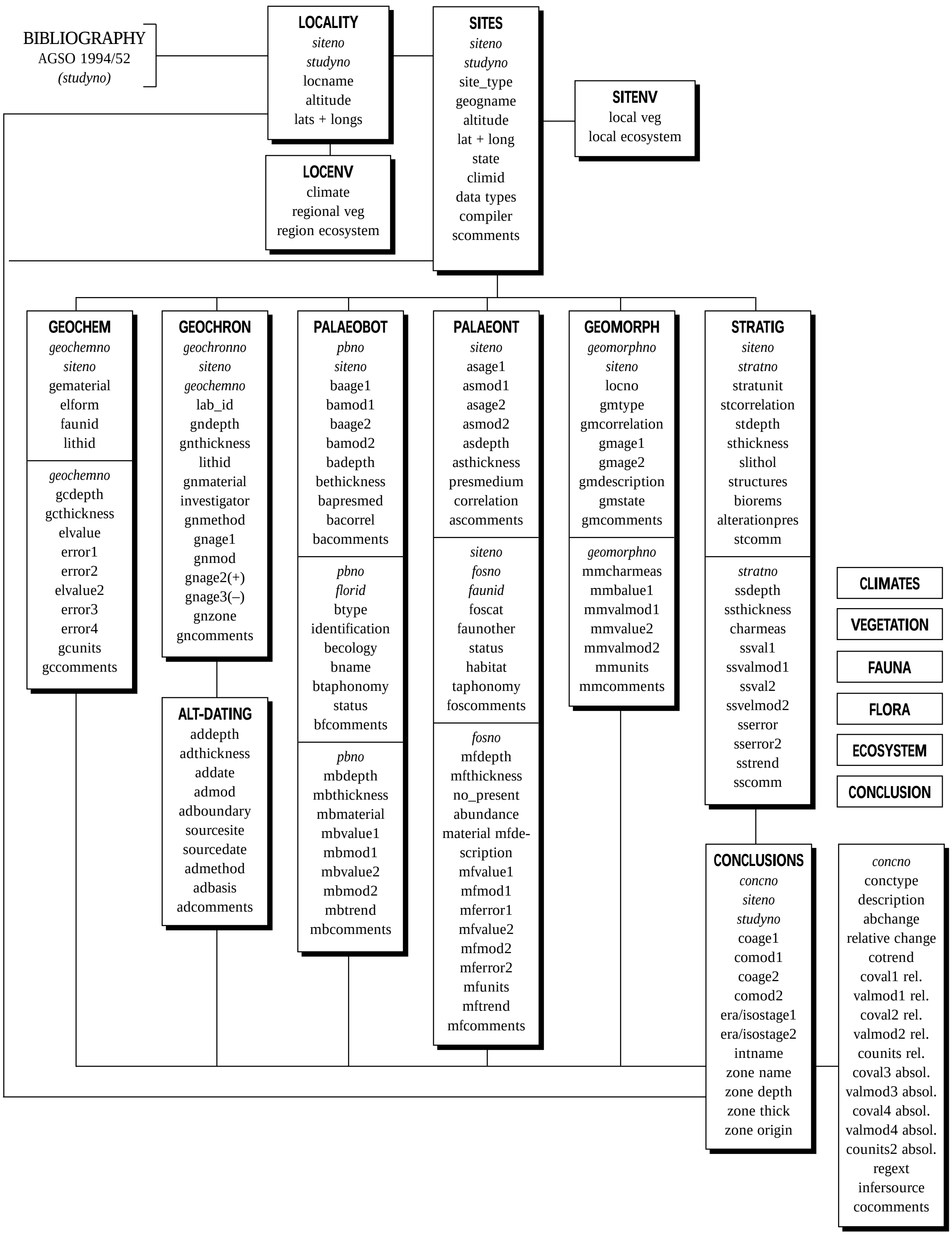


Figure 1

Australian Quaternary Climate Database structure with tables delimited by shadowed boxes and lookup tables named on right. Underlined fields contain numbers to link tables. Lines between tables indicate linkages.

PALAEOBOTANY table is for fossil flora information. The first part provides extra information on the site (such as preservation of material and method of analysis). The second contains information on the floral-zones in the site. The third holds the plant species and other related material present in the zone. The PALAEONTOLOGY table on the fossil fauna has five parts with information on; (i) the faunal-zones in the site, (ii) faunal-assemblages within the zone, (iii) measured values on the assemblage, (iv) fossil species within the assemblage, and (v) measured values on the individual species. The two part CONCLUSIONS table contains the palaeoenvironmental conclusions of the author. The first part indicates the origin of the conclusion in terms of the site, study and discipline (e.g. geochemical). The second part holds the actual conclusions and exists in two versions. The early form simply contains single fields to describe the type of conclusion (precipitation, temperature, etc.) and the information available for the site. The updated version has a more complex set of fields. These describe the age and nature of the conclusion (including trends and regional extent). Currently one hundred sites from over forty studies have been entered.

Challenges

Certain challenges are being encountered during the design phase. The range and variety of climatic information causes difficulty in designing appropriate fields. The reliability of data may be in question. Caution must be paid to misprints in the manuscript. Of more significance are conclusions or data discredited or questioned by other work. There may need to be some form of index of reliability. The data and conclusions will still be entered as further work may resurrect the conclusions. The presentation of the literature varies. The data can be in forms such as graphs and diagrams which cause a loss numerical accuracy. Other information may not be reported or incomplete. Relating data and conclusions to their original source needs to be considered. Many papers have conclusions or results which are derived from other papers. Entering data twice in different studies will tend to emphasize it and give it more authority than it may merit. This could be avoided by linking papers together by referring back to the original source paper, but this would create a more complex structure and other problems.

Overall there is little collaboration between Quaternarists regarding the development of such a database. Attempts to gain inputs from researchers regarding the structure of the database have evoked little response. Some researchers (particularly from the palynological field) are already creating individual databases of their own or a wider range of material.

1995 Update

Many changes have been made since the meeting in 1993. An updated bibliography, AGSO Record 1994/52 (Bleys et al., 1994), containing 2000 references now provides the source of references. The database has moved from being a pilot project to a relatively stable structure containing a rapidly increasing quantity of data. There are now around 1000 sites from 250 studies stored. Of the eight main ‘tables’ originally conceived (sites, geochemistry, geochronology, geomorphology, palaeomagnetism, palaeontology, palaeobotany and conclusions) only palaeomagnetism has not been developed. In addition, stratigraphy and alternative dating (correlation and other indirect methods) table structures now exist and most of the existing tables are revised versions (in some cases extensively). The revised structure is shown in Figure 1 (compare and contrast it with the 1993 description above).

Links are being established with other database groups to increase cooperation and limit the duplication of data entry. The database will act as a secondary or mirror storage site for pre-existing datasets (such as the pollen database) for the convenience of local users. Access for external users of AGSO's databases through World Wide Web is being rapidly developed with a home page and textural information about projects already available. Once a future goal, the storage of primary data derived from the researcher is now a reality. Data has been obtained for the oceanographic realm and terrestrial data should follow in short order. The use of directly supplied data will solve many of the problems listed in 1993 derived from literature extraction.

Bleys, E., Hunt, G.R. and Truscott, M. 1991. Quaternary climate in Australia: a bibliography. Bureau of Mineral Resources, Geology and Geophysics Record. 1991/104: 292 pp.

Bleys, E., Hunt, G.R. and Truscott, M. 1994. Quaternary climate in Australia: a bibliography. Second edition. Australian Geological Survey Organisation Record. 1994/52: 2 vols, 418 pp.

5. QUATERNARY PALEOENVIRONMENTAL DATA MANAGEMENT IN CHINA

Z. Guo

Data management of paleoenvironmental research in China has a short history of just several years. Up to date, there exist only a limited number of small databases, mostly centered on specific topics (e.g. palynology, historical records of climate) for personal or collective use. Further studies, especially the efforts of paleoclimatic modeling need urgently a synthetic and comprehensive database for the paleoenvironment in China, which can be used by the related scientists.

For this purpose, the Natural Scientific Foundation of China has launched in 1992 a five-years great research program (*Dynamic Processes of Paleoenvironmental Changes in the Arid and Semiarid regions in Northern China over the Past 150 ka*) directed by Professor Liu Tungsheng. This program will be finished in 1996 and one of the core projects is to construct the *Database of Quaternary Paleoenvironment in China* in the Institute of Geology, Chinese Academy of Sciences.

Description of Research Program

Presently, the effort is still at the beginning stage and the plan is to collect the following data:

(1) Modern environmental data: including the modern climate, natural vegetation, soils, desert, sea surface temperature and other related modern data covering the Chinese territory and the adjacent regions. These calibration data sets will be used as the basis for interpreting the paleodata and to convert the paleodata into quantitative estimates of past climate. The problems with data sources are expected to be resolved in unifying the existing databases on specific topics through cooperation.

(2) Classical paleodata: which are primarily the frequently used data sets related to paleoenvironment of China (such as the dust flux in Pacific) and those of known/hypothesized forcing factors influencing the paleoclimate in China (such as the orbital parameters and solar insolation values, deep-sea isotope records, selected data from polar ice cores, etc).

(3) Existing paleodata in China: which are the large amount of paleodata obtained through research projects in China during the past thirty years, including those from loess, paleolake, deserts and adjacent oceans. Because some of the data, especially those obtained in early years have potential problems of accuracy, these data will be rigorously examined to ensure the quality.

(4) New data obtained through the five year program and other ongoing research programs: the program *Dynamic Processes of Paleoenvironmental Changes in the Arid and Semiarid Regions in Northern China over the Past 150 ka* contains seven projects: (a) *high resolution times series of paleoclimate*, project centered on absolute dating of various records; (b) *geochemical and isotopic indications of the interactions between continents and the atmosphere*, focused on geochemical and isotope indicators of climate; (c) *response of vegetable biomass to changes of climate*, project centered on palynological studies; (d) *loess deposition and atmospheric circulations*, focused on the information of eastern Asian paleomonsoon recorded in the Chinese loess-paleosol sequence; (e) *impact of land-ocean interactions to aridification*, focused on ocean changes and the climatic effects; (f) aridification and paleohydrology, project centered on paleolake and paleodeserts; and (g) *database of Quaternary paleoenvironments in China and paleoclimatic modeling*. The first six projects are expected to provide a considerable amount of new paleoenvironmental data. These results, in addition to the existing paleodata, will be used to produce a series of paleoenvironmental maps for selected time slices.

Loess Data

Among the data to be collected, those obtained from the loess-paleosol sequence represent the most important, because the Chinese loess-paleosol sequence is among the most complete and continuous continental records of paleoclimate. Research on loess in China has so far been the most conspicuous part in the study of paleoenvironment. Up to date, at least twenty sections located in different climatic regions have been studied in detail and large amounts of high quality data have been obtained. Enclosed here is a draft scheme for loess data management. Because the most complete loess sequence in China contains more than fifty paleosols which represent a cumulative time of about one million years, and thus contain nearly half part of the paleoenvironmental information of the Quaternary, the database for loess should take into account the morphological features which are the basis for interpreting the paleosols as well as the physical and chemical data.

The following Draft Protocol for Loess data management has been proposed by: Liu Tungsheng and Guo Zhengtang, Institute of Geology, Chinese Academy of Sciences, Yu Zhiwei Geology Department, University of Mines of China.

Draft Protocol for Loess Data

1. Data Type Description

   Data relevant to paleoclimatic reconstruction obtained from loess-paleosol sequence, including the stratigraphic controls, morphological description, biological fossils, physical and chemical measurements and paleoenvironmental interpretation.

2. List of variables archived [this list is not exclusive]

   A. Stratigraphy

      1. *Lithostratigraphy:*
         - depth of the upper boundary
         - lithostratigraphic unit label (e.g. L1, S1, Sangamonian soil, Eemian soil, etc.)
         - length of the boundary transition (cm)

      2. *Magnetostratigraphy:*
         - depth
         - boundary of magnetic chron and subchron (Matuyama upper boundary)

3. *Magnetic secular variation*
   - depth
   - susceptibility
   - natural remnant magnetization (NRM) intensity
   - viscous remnant magnetization (VRM) intensity
   - inclination
   - declination
4. *Absolute Datings Control:*
   - depth
   - age
   - dating method
   - material for dating (e.g. humus for ^{14}C; quartz for TL; volcanic ash for K/Ar method)
   - estimated accuracy
   - data source (laboratory, reference)

B. Lithology

5. *Macromorphology:*
   - depth of the upper boundary
   - horizon order number
   - transition type of the lower boundary (regular, ondulated, irregular)
   - length of the boundary transition (cm)
   - Munsell color code
   - humidity condition for description
   - estimated texture (sandy, silty etc.)
   - structure
   - substructure
   - HCl effervescence
   - Munsell color code for clay coating
   - estimated clay coating abundance
   - type of secondary carbonate feature (pseudomycelia, nodule etc.)
   - size of secondary carbonate feature (cm)
   - abundance of secondary carbonate feature
   - type of Fe-Al feature
   - size of Fe-Al feature
   - abundance of Fe-Al feature
   - soil horizon nomenclature (E, Bt, K, etc)
   - other specific aspects

   Note: The systems in Soil Taxonomy (soil survey staff, 1974) can be used for standardizing the nomenclature in the macromorphological description.

6. *Micromorphology:*
   - depth
   - micromorphological features

   A computer compatible recording form has been proposed by Bullock et al. (1985) and can be used for micromorphological data management for soil-loess sequences.
7. *Mineralogy:*
   - sample depth
   - mineral types (quartz, hornblend, etc.)
   - abundance (%)
8. *Clay mineralogy*
   - sample depth
   - mineral species
   - estimated abundance (%)

C. Biological Data

9. *Macrofossil*
   - depth
   - fossil species
   - abundance
10. *Meso- or/and Microfossil*
    - depth
    - fossil species
    - abundance
11. *Palynology*
    - depth
    - pollen types
    - original pollen counts

D. Physical Data

12. *Magnetic susceptibility*
    - depth
    - susceptibility value
13. *Grain size*
    - depth
    - percentage of the fractions of <2 µm, 2-5 µm, 5-10 µm, 10-25 µm, 25-50 µm, 50-100 µm, 100-200 µm and >200 µm
14. *Bulk Density*
    - depth
    - bulk density

E. Chemical Data

15. *Total Chemical Measurement*
    - depth
    - elements expressed in the forms of oxides (SiO_2, Al_2O_3, etc).
    - abundance

16. Microchemical Analysis

- depth
- measured elements
- abundance

17. Rare Earth Element (REE)

- depth
- elements
- abundance

18. Cation Exchangeable Capacity (CEC) and Exchangeable Cations

- depth
- CEC
- exchangeable cations
- abundance (cmolc/kg)

19. Amino-acid Measurements

- depth
- types of amino-acid
- abundance

20. Other Chemical Data

pH, content of organic matter, carbonate content, contents of soluble salt, oxygen isotope, carbon isotope, ^{10}Be, Free iron content, total iron content, etc.

These data can be stored in terms of depth and measured values and should be stored in separated data files.

F. Secondary Data (developed from the primary or “raw” data)

1. Depth-Age Transformation (time scale)

- depth
- age

2. Paleosol

- name of the soil unit
- classification

3. Specific indexes

Indices derived from the primary data, which are used as proxy of paleoclimate (e.g. ratio of stable/unstable minerals, crystallinity of illites, median and skewness of the grain size). These data can be stored in terms of depth and calculated values.

4. Quantitative Reconstruction of Paleoclimate

- depth
- paleoprecipitation
- paleotemperature

3. Basic Information for the Site
   - site location: latitude, longitude, country, state/province, elevation
   - contributor: name, address, source of data
   - site description: physiography, modern climate (and source)
   - a stratigraphical sketch
   - number of samples
   - taxonomic nomenclature followed (reference)
   - sample resolution
   - laboratory analysis information: name of the laboratory, methods (short description, e.g. CBD method for free iron content, and reference)
   - other methods (those used to generate secondary data and quantitative estimates of past climate)
   - documentation: published/unpublished, references
   - preferred dataset formats for submission.

6. THE CANADIAN DATABASE EFFORT

H. Jetté

Man has had a profound influence over the landscape and the vegetation in the southern part of Canada, where the highest density of the population is found, but in more northern areas the vegetation is still in agreement with the environment. These vast areas, covered by a mixture of boreal forest, woodland, shrub and herb tundra are important to research oriented toward past environments since they provide reference material to calibrate modern environments. This advantage, somewhat linked with the size of the country is also a disadvantage because some remote areas are still poorly documented. This report presents the Canadian database effort, the emphasis toward the study of past environments, and the concerted effort to obtain a comprehensive story from the study of different proxy-data. It covers the fossil records from marine, ice and terrestrial environments.

The Marine Record

Two large databases cover the marine record in Canada. One results from the work of Anne de Vernal and collaborators. It consists of 265 sites located in Hudson Bay, St. Lawrence River, Labrador Sea, Baffin Bay, Norwegian Sea, Barentz Sea and throughout the North Atlantic. Of these sites, 30 have been analyzed for their fossil records and all surface samples have been used for transfer functions calibration. The other database has been compiled by the Atlantic Geoscience Centre (AGC), a Division of the Geological Survey of Canada. Peta Mudie is in charge of this database which covers eastern Canada, the Beaufort and Black Seas. Transfer functions to infer salinity and sea surface temperatures have been developed for both databases. Sediment content has been analyzed for palynomorphs, dinoflagellates and foraminifera.

The Ice Core record

This database has been compiled from the analysis of ice cores collected on Meighen Island (1 core), Devon Island Ice Cap (3 cores) and the Agassiz Ice Cap (6 cores) in the Canadian Arctic. The variables measured are $\delta^{18}O$, dust, conductivity, major ions, pollen, ice layers and physical properties of the ice and the bore hole. The $\delta^{18}O$ reveals a history of annual temperatures and the major ions reflect volcanism, sea ice cover and source area changes. Regional pollen shows regional recolonisation of plants after the ice age and exotic pollen gives information about changes in sources, productivity and wind transport. The summer melt record of the Agassiz Ice Cap spans the entire Holocene and has become one of the major summer proxies for the Northern latitudes. David Fisher is responsible for this database.

The Terrestrial Record

Some of the Canadian terrestrial data has been compiled by the Geological Survey of Canada under a paleoecological database. This comprises information on pollen, diatom and macrofossil (plants, arthropods, mosses) generated by the Survey's scientists since 1960. We are now in the process of editing our pollen files for accuracy as they are merged with the NAPD project. In addition, a dated fossil-wood database has been compiled from literature. The author is in charge of this information. A companion database related to paleoenvironments is the GSC ^{14}C database which compiles more than 5000 Canadian radiocarbon dates on marine and terrestrial material. Roger McNeely is in charge of this database. Other Canadian terrestrial databases comprise pollen and macrofossils from the province of Quebec, managed by Pierre Richard, also in the process of being merged with the NAPD, and various other regional pollen databases which are also being merged with the NAPD project. A dendrochronological database has been compiled from literature by Bryan Luckman. Other databases include the paleolimnology database (John Smol), comprising data on diatoms, chironomids and chrysophyta. This database comprises mostly modern reference material but some fossil sequences are available.

A carbon/carbonates content database has been created to indicate the nature of sediment and areas prone to contamination by hard-water effect (H. Jetté).

Another database relevant to paleoenvironments is the geothermal database (Alan Taylor). Ground temperature has been measured at 88 exploratory wells owned by oil companies mainly in the Arctic and Subarctic regions of Canada. Results from the top parts of the cores are interpreted by scientists as the warming following the Little Ice Age.

Under development is a lake level database in collaboration with NOAA. Bob Vance, GSC, is in charge of this database. So far, areas targeted for inclusion into the database have been identified.

New Orientation

Lately, a lot of effort has been put into the calibration of reference material to modern environmental conditions. Reference material is collected in collaborative effort. Surface samples are collected with a gravity corer designed by John Glew. Only the top 1 centimetre is kept as surface samples. Many holes are sampled in order to get enough material for diatoms, chironomids, chrysophyta and pollen. Conductivity, pH, and temperature of the water are measured. A water sample is collected, filtered within 24 hours, and submitted for geochemical analysis. Depth of water and the area of the lakes sampled are noted. The shortest distance from treeline is measured and the vegetation type surrounding the lake is identified. All these measures insure that all parameters necessary for the calibration of different types of proxy-data, such as pollen, diatoms, chironomids and chrysophyta to modern conditions are quantified. Different proxy-data can provide, in addition to the climatic history, information to complement paleoenvironmental reconstructions. For example, diatoms will provide information on paleo-lake levels, on lake evolution and on pollution.

Nodes approach

There is a concerted effort, between Canadian scientists, to combine information derived from various proxy-data to reconstruct past environments. Different proxy-data are identified at each level and worked out independently. For example, palynologists and diatomists, working in collaboration, develop transfer functions to infer past climate from their respective proxy-data. Results from these transfer functions are compared to complement information derived by each proxy-data. Study sites are chosen in transition areas where the vegetation is more sensitive to climatic changes and nodes have been identified across Canada to concentrate on this multidisciplinary approach. Lately, a multidisciplinary project has been developed in collaboration with the Canadian Climate Centre to provide the GCM modelers with the best possible paleoenvironmental reconstruction of Canada 6000 years ago. This project encourages scientists to search and gather all pertinent information related to that time frame and to share data.

Addresses of database managers listed in the text.

Hélène Jetté, David Fisher, Roger McNeely, Alan Taylor, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada, K1A 0E8

Peta Mudie, Geological Survey of Canada, P.O. Box 1006, Dartmouth, Nova Scotia, Canada, B2Y 4A2

Bob Vance, Geological Survey of Canada, 3303 - 33rd Street N.W., Calgary, Alberta, Canada, T2L 2A7

Anne de Vernal, GEOTOP, Université du Québec à Montréal, C.P. 8888, Succursale A, Montréal, Québec, Canada, H3C 3P8

Pierre Richard, Université de Montréal, C.P. 6128, Succursale A, Montréal, Québec, Canada, H3C 3J7

Bryan Luckman, University of Western Ontario, London, Ontario, N6A 5C2, Canada

John Smoll, John Glew, Queens University, PISCES Laboratory, Kingston, Ontario, K7L 3N6

CLIMATE MODEL OUTPUT, CLIMATE FORCING, AND MODERN CALIBRATION DATA

1. THE PALEOCLIMATE MODELLING INTERCOMPARISON PROJECT (PMIP)

S. Joussaume, R. S. Webb, K. Taylor

Introduction

Paleoclimate modeling is increasingly being used as a tool to help validate the GCMs used to study future climate change. Model resolution and the parameterization of physical processes are continuously being improved and updated in General Circulation Models (GCMs). As model development proceeds, the climate models must continue to be tested to see if modifications yield improved simulations for the modern as well as for the very different boundary conditions of the past. Modeling groups are planning to run an increasing number of paleoclimate simulations, both new and revisiting old experiments to see how new parameterizations effect model results.

The Paleoclimate Modelling Intercomparison Project (PMIP) developed out of a NATO Advanced Research Workshop on “Paleoclimate Modeling” organized in Saclay (27-31 May 1991) organized by J. Jouzel and S. Joussaume. PMIP involves the voluntary participation of twelve groups working with atmospheric general circulation models (AGCMs) from about a half dozen different countries (Table 1).

Table 1
Modeling Groups Participating in PMIP
(not all modelers/groups will run all simulations).

Groups/Institutions	Investigators
Moscow University	A. Kislov
Bureau of Meteorology Research Centre	B. McAvaney
Canadian Climate Center, GCM 6&7	N. McFarlane, D. Verseghy
CSIRO Division of Atmospheric Research, 9-Level R21	J. Syktus
French Climate Community Model	H. Le Treut
GFDL Climate Model	A. Broccoli, S. Manabe
Laboratiore de Modelisation du Climate et de l’Environnement (SECHIBA)	S. Joussaume, N. Ducoudre, G. Ramstein
NASA/GISS Model 2’	D. Rind, R. Webb, J. Overpeck
NCAR CCM 1&2; GENESIS Models	J. Kutzbach, R. Oglesby, K.Taylor, L. Sloan, S. Thompson, T. Crowley, S. Schneider
Max Plank Institute for Meteorology, ECHAM3/ LSG/T42	M. Lautenschlager, L. Bengtsson, K. Herterich

Meteorological Research Institute, Tsukuba	A. Kitoh
UGAMP Version 2	P. Valdes, N. Hall
UKMO Hadley Centre	J. Mitchell, C. Hewitt
Mexico University	J. Adam
University of Illinois Model	M. Schlesinger
University of Melbourne Climate Model	B. Budd
Yonsei University (Korea)	J. Oh

Primary goals of PMIP are: 1) to run GCMs from different modeling groups using the exact same forcing/boundary conditions to simulate past climate conditions, 2) to compare simulated climates of the GCMs to each other to see how the different models perform under boundary conditions that are distinctly different from modern, and 3) to compare simulated climates of the GCMs to the geologic record to see which models best resolve the observed record of past climate conditions. Some of the fields to be compared are listed in Table 2. Two specific time- periods have been chosen for initial investigation: 6 K yr and 21 K yr B.P.

Equilibrium simulations of past climates by AGCMs can be useful for investigating the physical mechanisms of climate change. These model experiments can be used to test the sensitivity of the atmospheric circulation of known forcing of past climates such as variations in solar radiation, ice sheet extent or CO_2 concentration. Paleoclimate simulations also allow us to test the simulated climate sensitivity. AGCM parameterizations are developed and validated using present-day observations and there is no guarantee these parameterizations produce a correct sensitivity of the climate under different forcing. Paleoclimates offer a unique opportunity to test model sensitivities when sufficiently quantitative and globally distributed paleo-data are available and the causes of the changes are deterministic and easily quantified.

At present, several simulations of past climates have been performed by various AGCMs. Although some simulated features have been well corroborated by paleoenvironmental data, other features have not. It is important to understand which results are model-dependent. Very few model-model comparisons have been conducted. Moreover, experiments for the same time periods have not been performed with exactly the same boundary conditions, which limits the model-model comparisons. Model-model and model-data comparisons are now underway for the modern climate conditions (e.g. the Atmosphere Model Intercomparisons Project -AMIP). The goal of PMIP is to apply this same strategy (AMIP) in paleoclimate experiments. PMIP has identified two well define numerical experiments that will promote both model-model and model-data comparisons. Models have evolved since the experiments mentioned above, the data coverage and quality have improved, and many modeling groups are planning to redo their paleoclimate simulations.

Climate Forcing, Model Boundary Conditions, Validation Datasets

A problem common to paleoclimate modeling efforts arises when changes simulated by a model fail to match evidence from the geologic record. The source of data/model mismatches is often difficult to identify and can be the result of either poor model performance, incorrect or misinterpreted geologic evidence, or incorrect specification of model boundary conditions. In addition, the range of possible values specified for past boundary conditions may overshadow differences in model sensitivity to these changes and complicate direct comparisons between simulations by different modeling groups. Successful use of paleoclimate simulations for model validation, paleoclimate hypothesis testing, and model development requires that a concerted effort be made to advance our knowledge of past conditions used to specify boundary conditions. As part of this effort two workshops were held at Lamont Doherty Earth Observatory to begin the synthesis of the next generation of boundary conditions used in climate models: ice sheet height, ice sheet area, sea surface temperatures, sea ice distribution, land surface conditions, and atmospheric composition. The goal of these workshops was to bring members from the geologic and climate modeling communities together 1) to focus on defining the relative importance of different boundary conditions, 2) to identify which are well-constrained and which are poorly constrained boundary conditions and their relative uncertainties, and 3) to indicate where further boundary-condition work is necessary and the types of climate-model simulations that can be used as sensitivity tests. The two LDEO workshops represent a first step in a collaborative effort of atmospheric scientists, paleo-oceanographers, geologists, and glaciologists to specify more up-to-date climate boundary conditions for paleoclimate modeling.

Why 6,000 and 21,000 years BP?

The time periods 6,000 and 21,000 year BP were selected because they are among two of the best documented periods of the past from the stand point of paleoclimatic/ environmental data coverage, and the large number of on-going and previously existing climate simulations availabe to help guide the PMIP experimental design. The 6,000 year BP climate represents a time of sizable changes in the seasonal distribution of the solar forcing with only a minimal Laurentide ice sheet (insignificant globally). At 6,000 year BP, the Northern Hemisphere extratropical latitudes receive larger incoming solar radiation during the summer season than at present, allowing for a warming of the continents, whereas winter insolation was less than present, resulting in increased seasonality 6,000 year BP. Sea surface temperatures were indistinguishable if not identical to modern. The terrestrial data coverage is plentiful and often accurately dated (e.g. COHMAP data) and will permit a relatively detailed comparison with the data of the models' response over the continents to the well known changes in the insolation pattern. In particular, the 6,000 year BP experiment should be useful in evaluating ground hydrology parameterizations which strongly influence summer continental climates in the Northern Hemisphere.

The Last Glacial Maximum (21,000 year BP) climate represents full glacial conditions. This experiment involves large changes in the surface boundary conditions: ice sheet extent and height, changes in SSTs, albedo, sea-level and CO_2, but only minor changes in insolation patterns. This period is important for understanding how ice sheets influence climate. Though not as abundant as for 6K yr BP, paleoclimatic/ environmental data are relatively plentiful for this period (e.g., CLIMAP, 1981; COHMAP, 1989) Over the oceans, SSTs have been reconstructed from microfossil transfer functions and $\delta^{18}0$ stratigraphies (e.g., CLIMAP). Data for both boundary conditions and model verification are therefore relatively widely available for this period, whereas for earlier periods they are less plentiful and of poorer quality.

Experiment Design

The Last Glacial Maximum experiment (LGM, 18,000 year BP radiocarbon years) will be run using 21,000 calendar yr BP orbital forcing, reduced greenhouse trace gas concentrations, and large terrestrial ice sheets. The primary LGM experiment will be run using modern day ocean heat transports ("q-flux", the way most GCMs are now run in 2 x CO_2 simulations of future climate change). A second optional LGM experiment will be run by some groups using fixed sea surface temperatures from a revision of CLIMAP and land surface conditions reconstructed for the LGM. The Mid-Holocene (MH, ca. 5,300 year BP radiocarbon years) will be run using 6000 calendar year BP orbital forcing and reduced greenhouse trace-gas concentrations. The primary MH experiment will be run using sea surface temperatures fixed at modern day values. A second optional MH experiment will be run by some groups using modern day ocean heat transports and 6,000 year BP land surface conditions slightly altered from modern (e.g., vegetated North Africa). This suite of paleoclimate experiments using modern land surface conditions and ocean heat transport allow PMIP to use the geologic record as independent estimates of past conditions in the data/model comparisons.

Project scientific objectives

The scientific purposes of PMIP include:

Comparison of results from different AGCM simulations of paleoclimates to determine why the simulated climates agree in some respects and differ in others. The intercomparison of models under extremely different conditions that can be verified with the paleoclimate/environmental data will complement the results of other GCM inter comparison projects. (e.g., AMIP in which many of these same models are being run with other boundary conditions). It is hoped that the intercomparison will lead to an improvement of the models' physics parameterizations and eventually a better representation of the physical mechanisms.

- Reduction in the uncertainty of current estimates of climate sensitivity.
- Determination of the spatial distribution of paleoclimatic changes that are consistent with the imposed boundary conditions (prescribed

from paleoclimate reconstructions) for use in driving other component models of the paleoclimate system (e.g. oceans or vegetation) and for use in interpreting paleoclimate data.

- Comparison of the model simulations with paleoclimate data to identify and understand the consistencies and inconsistencies that are required by models designed to simulate the evolution of climate on time-scales of 1000 years or longer.

Project structure / organization / schedule

The coordinators of PMIP are Sylvie Joussaume, who works at the Laboratoire de Modelisation du Climat et de l'Environnement (Saclay) in France; Karl Taylor, who works at the Lawrence Livermore National Laboratory (PCMDI) in the United States of America. Robert Webb from NOAA/NGDC Paleoclimatology Program (USA) is working closely with PMIP to ensure the availability of paleoclimate boundary conditions that can be used in the model experiments and paleoclimate reconstructions that can be used in assessing the simulations. Current plans within PMIP include a second NATO Advance Study Institute upon the completion of the modeling effort for presentations of model/model and data/model intercomparisons. An October 1995 workshop, co-funded by the NOAA Paleoclimatology Program and Commission of the European Communities, was held to implement the first modeling intercomparison within PMIP and a vehicle for interaction among climate modelers.

Table 2
PMIP Output Fields

Category	Fields	Units
Model	Grid description	
	Surface elevation	m
	Surface type and fraction	
Energy Budget	Incoming shortwave (top of atmosphere)	W/m2
	Reflected shortwave (top of atmosphere)	
	Outgoing longwave (top of atmosphere)	
	Incident shortwave (surface)	
	Reflected shortwave (surface)	
	Net longwave (surface)	
	Sensible heat (surface)	
	Latent heat (surface)	
Hydrologic Cycle	Soil moisture	kg/m2
	Snow mass	kg/m2
	Liquid precipitation, both largescale and convective	mm/day
	Snow precipitation, largescale and convective	mm/day
	Evaporation and sublimation	mm/day
	Runoff	mm/day
	Total precipitable water	kg/m2
Surface Circulation	Surface air temperature	Celsius
	Ground temperature	Celsius
	Sea-level pressure	hPa
	Surface winds	m/s
	Wind stress components	N/m2
	Relative humidity	%
Tropospheric Circulation	500hPa geopotential height	m
	Temperature (850hPa, 200hPa)	°C
	Zonal and meridional winds (850hPa, 200hPa)	m/s
	Specific humidity (850hPa, 200hPa)	g/kg
	Streamfunction (850hPa, 200hPa)	m2/s
	Velocity potential (850hPa, 200hPa)	m2/s
	Geopotential height (850hPa, 200hPa)	m
Clouds, Radiation	Total cloudiness	
	Clear-sky outgoing long-wave radiation	W/m2
	Top of the atmosphere clear-sky reflected short-wave radiation	W/m2
	Surface net clear-sky short-wave radiation	W/m2
	Surface net clear-sky long-wave radiation	W/m2
	Cloud liquid water (if possible)	g/m2
Meridional Circulation-Vertical Distribution of Zonal Mean Values	Zonal and meridonal winds	m/s
	Temperature	C
	Specific humidity	g/kg
	Relative humidity	%
	Cloudiness	%
	Meridional streamfunction	kg/s

2. QUANTITATIVE PALEOENVIRONMENTAL RECONSTRUCTIONS USING BIOLOGICAL PROXY DATA: RECOMMENDATIONS

J. Guiot

Fauna and flora now respond, and have responded in the past, to a more or less complex combination of environmental changes. A good knowledge of their modern ecology coupled to adequate mathematical methods permits a quantitative approach to reconstructing these changes from biological proxy data. Such reconstruction methods are often called “transfer functions”, but this name must be taken in a large context as they are no longer based on the calibration of a function. These transfer functions may convert two types of proxies into environmental information: either assemblages (i.e. the relative abundance of a great number of species or simpler their presence/absence), or parameters related to the growth of selected individuals of a given species (e.g. tree-ring width, density, isotopic content, etc.). That type of approach needs a reference dataset containing the same type of proxies as in the fossil data associated with the environmental variables assumed to be the most useful.

Key Issues: Problems

Problem 1. This quantitative approach implies that the biological proxy response has not significantly changed in the past, which limits the time span of the approach. Moreover the use of these proxy data requires the existence of modern analogues for these proxies. In some extreme climates or during rapid transition, this is not always the case.

Problem 2. When the reference dataset is too limited, misinterpretations of the relationship between environment and proxies are possible, e.g., an absence of both dry and cold samples in the reference dataset will lead to the reconstruction of systematically dry and warm conditions for glacial periods. More generally, if two climatic parameters are too strongly correlated in the reference dataset, the same correlation will be obtained in the reconstructions.

Problem 3. The reference dataset has often been built from various authors source and is heterogeneous. This is the price to pay for a sufficiently diversified modern dataset. This heterogenity can come from the chemical preparation of the samples, from the taxon identification (some are not recognized, some are misinterpreted), or from the number of individuals counted.

Problem 4. In long-settled regions, the distribution of some proxy data has been modified by humans. This can be reflected in a modification of the assemblages or/and a modification of the growth of the individuals. Consequently, the statistical relationship between proxies and environment is disturbed, providing spurious reconstructions.

Problem 5. Biological data are often influenced by a complex combination of numerous biotic and abiotic variables, making the deconvolution of the different signals of interest really difficult. Taking climatic factors as an example, the presence of a species or the efficient growth of individuals is submitted to the combined effects of temperature, water availability, sunlight, in a quantitative way or through the occurrence of extremes (frost, drought, etc.).

Problem 6. Some species are ubiquitous or have a large environmental tolerance. Frequently, the species are not differentiated by the analyst, so that a taxon covers several species with very different ecological behaviour. All that restricts the potential of the reconstructions. Nevertheless the assemblage itself sometimes permits an indirect access to the species.

Problem 7. The low-resolution reconstructions are based on environmental "normals" calculated for example on 30 years. The variability around these normals is sometimes high and illustrates the ability of the biological organisms studied to adapt to a more or less large range. This variability is certainly a lower limit to the error bar associated with these reconstructions.

Problem 8. All the proxies have a more or less high inertia. Usually they integrate the environmental conditions over an interval of time. That appears in the proxy time-series by statistical autocorrelation. Sometimes that inertia is too long to permit adequate reconstruction during a rapid transition phase.

Problem 9. As in all paleoenvironmental studies, the time scale is crucial. Dating techniques are now rapidly evolving. Results which are presented in a time scale (sometimes with no precise indications on the age model used) may be nearly worthless when the time scale itself is revised.

Key Issues: Some solutions

Qualitative methods may solve some of these problems, because they involve more intuition and are not constrained to use a predefined shape for the relationship proxy-environment. It can qualitatively manage the problems of thresholds. The counterpart is that a non-constrained intuition has not always reasonable limits and hardly convinces the user of the results (e.g. the climate modeller). Quantitative information, even when associated with large error bars, is much more useful, as such a large error bar reflects the limits of what can be extracted from the data. The same limits also affect the qualitative results, but they are often hidden.

The recent developments of the quantitative techniques enable us to pass beyond the former limits, by combining several signals and in particular by integrating quantitative and qualitative information, and by using more flexible mathematical methods. The regional and global databases which are now emerging are another tool to solve a part of those problems. Problems 1 and 2 are linked to the diversity of the modern dataset. They can be solved by gathering all the modern samples available and then by collaboration between scientists. There remains the problem of heterogeneity of the dataset (problem 3) which can be solved by carefully checking the data. Some authors prefer to use only their own data or data only analyzed using the same protocol. The consequence can be the loss of diversity. Statistical methods exist to smooth the samples according to the environmental variables to be reconstructed (e.g., the response surface method). Another solution to the heterogeneity is the actual effort in favor of the databases carrying along a better collaboration between scientists with the opportunity of technical and taxonomical discussions. Some types of method are more affected by the biases present in the modern data set. They are regression-type methods or extrapolative methods. Coefficients are calibrated on the modern data and can be strongly influenced by biases. This type of method is generally practicable for extrapolation back to recent time (the last millennia) and particularly for tree-ring data. When they are applied to older fossil data possibly in no-analog situations, the predictions can be really unrealistic. I prefer interpolative methods, based on the research of analogues (others such as neural networks or fuzzy logic seem promising), which are unable to provide non- existing environmental estimates but in consequence can provide underestimated predictions. The extrapolative methods, amplifying the defects of the reference data, will often be unable to deconvolute two strongly correlated signals (problem 2), while the interpolative ones are able to take profit of the few samples inconsistent with the general trend. The surface samples strongly disturbed by humans (problem 4) are easily recognized and discarded. When this disturbance is weaker, a statistical analysis can be used to smooth out the human action from the modern samples. All calibration on modern data can be then biased by this disturbance: a way to avoid that is to use an inverse step: environmental information present is extracted from the paleodata and interpreted by comparison to the modern data.

A major point in all reconstruction ventures is to give a clear idea of the errors associated with the results. For high-resolution data, such as tree-rings, it is often possible to keep a test-sample for independent verifications. Jackknife or bootstrap methods are appropriate tools to evaluate the errors bars. More recent methods based on the “fuzzy logic” account for the uncertainty associated to the data. Nevertheless, this verification is not sufficient for low-resolution data for which the analogues are frequently taken in distant geographical regions. Only a large number of diversified reconstructions using several types of proxies will definitely validate the results. We do need then large databases and particularly multi-proxy databases.

In recent decades, proxy data have been converted in conventional climatic variables such temperature or precipitation, to facilitate the comparison with the model outputs. Now ecological models are available at the global scale or at a more regional or even local scale to use these outputs and produce more biological entities. They are the results of a complex combination of environmental variables and can be more directly compared to the proxy data. This more fairly natural “forward approach” solves the problems of signal deconvolution (problem 5). Examples are comparison of pollen data with the biomes issued from the biome model of Prentice, comparison of the well dated pollen diagram with the predicted vegetation succession (as predicted by a gap model of Shugart-type), or comparison of tree-ring data with tree-growth predicted by a cambial model (of Vaganov-Fritts type). A great effort must now be done on the most appropriate way to produce proxy data compatible with the biological models output, e.g. to convert pollen data into biomes.

The recent use of the forward approach is not a brutal rejection of the former "inverse approach". On the contrary, we have a new tool to enhance the environmental signal present in the proxy data. The key to the method is the constraint derived from using a qualitative or quantitative independent variable. The advantage of proxies like pollen, tree-rings or foraminifers is that widespread measurements are available, but the environmental signal is sometimes difficult to isolate: the constraint is in fact a decoder. The method is the following: given a fossil assemblage, all the modern analogues of a fossil assemblage are determined at a certain degree of similarity, but finally only those satisfying a particular condition are kept. The conditions can be brought by an indicator coming from the same proxy dataset (e.g. rare taxa) or from other proxies (multiproxy approach).

The following are examples: (1) often modern pollen analogues for glacial periods come from tundra, cool or even warm steppes: if some rare taxon proves the incompatibility of steppes, only tundra analogues are kept; (2) absolute frequencies showing a low pollen productivity: only analogues with extreme climate can be taken; (3) modern analogues come from a large variety of locations: we may restrict the choice to those having a close value of a given geochemical parameter (carbon content, $\delta^{18}O$, etc.); (4) lake-level data can be used to select modern pollen analogues indicating precipitation values compatible with those of nearby closed lakes; (5) in periods of rapid climatic transitions, biological organisms with a rapid response (insects) are useful to correct results coming from slower organisms (vegetation); (6) discontinuous historical documents can be also used to precise the climatic signal driving tree-rings.

The rapid evolution of the dating systems impose some caution. All the environmental reconstruction techniques based on time-series do not need any precise time scale. It is then possible to obtain the reconstructions as a function of depth. The conventional ^{14}C time-scale can be associated at the end of the process, permitting later a calibration according the latest calibration. The problem is different for time-slice reconstructions. for which it is necessary to adopt a ^{14}C age model, but also to use the stratigraphic correlation of close sites. However, there is the danger of audacious hypotheses on the synchronism of some minor events over large geographical regions.

Conclusions

In conclusion, the development of regional and global databases must be based on original data from the authors and must cover all the proxy data useful for our knowledge of the past climatic changes. The authors of global paleoclimatic syntheses have to be as transparent as possible concerning the data used, the method and the errors bars, so the data user will be able to judge the quality of the reconstructions that he wants to use. In particular, he should have access to the main characteristics of the reference dataset, the chronostratigraphy, the age model, the reconstruction method, and the estimation of the error. If the method is based on analogues, he must know the type of distance used, minimum distance for the closest analogue of each fossil sample; if the method is of regression-type, he must know correlation between observations and estimates both on the calibration data and on the independent verification data.

Multi-proxy reconstructions are able to provide solutions to most of the quoted problems. The databases must also be used in a forward way for comparison with biological objects produced by ecological models coupled to climatic models.

3. MODEL BOUNDARY CONDITIONS AND TIME SERIES OF CLIMATE FORCING

W. R. Peltier

A description of the data set of Time Dependent Topography Through the Glacial Cycle

Source:	Prof W.R. Peltier, Dept of Physics, University of Toronto
Date:	May 1993
Data resolution:	1 degree latitude/longitude grid data starting at (-179.5,+89.5) 180 rows of (360 points along a line of constant latitude).
Time Period:	21KBP to the present
Data 1:	topographical heights at 1 Kyr intervals since the last glacial maximum.
Units:	metres. However in order to present a dataset in positive integer format, 10000 has been added. i.e if the data in this dataset is called itopog then true_topog = itopog - 10000 true_topog has values within the range [-9300,7200] metres.
Data 2:	Ice-cover data at 1 Kyr intervals since the last glacial maximum.
Values:	1 if there is ice, 0 otherwise.
Files:	Either tar files TOP.tar and ICE.tar; or top.n for n=0,1,…,21 and is_ice.n for n=0,1,…,21

There is also an ascii version of top.21 called TOP.21.ascii,which can be used to check interpretation of the binary files.

The tar files were created on an SGI machine, you may need to use dd to swap bytes on other machines (eg Suns): dd if=TOP.tar conv=swab | tar xvof -

Logical Data Structure: 16 bit binary unsigned integers, least significant byte first.

Note: In some areas, the ice-cover data indicates that there is ice while the topographic height is negative indicating that the region is below sealevel. In these cases, it should be assumed that the area is ice-covered. Either the region is not inundated or the ice is floating.

Editor's note: These data are available from the World Data Center-A for Paleoclimalotogy.

4. MODERN CALIBRATION DATA FOR PALEOCEANOGRAPHY

D. M. Anderson

Modern calibration data provide paleoclimatologists with two key tools: A reference point by which departures from the present can be measured, and a means to quantify (in terms of climate variables such as temperature and precipitation) the magnitude of change observed in the geologic past. As quantitative estimates of past climate improve, the choice of modern calibration data sets will no doubt become more important because of their influence on climate reconstructions. These notes provide examples of the ways that modern calibration data are used in paleoclimatology, and an introduction to some of the sources of digital calibration data that are available from distributed and centralized data archives.

Calibrating the signal

Calibrating fossil plankton abundance using modern biogeography

One example of the role that modern climate data play lies in calibrating changes in fossil plankton with modern biogeographic patterns. The multivariate transfer functions used by the CLIMAP Project are one example. Another example can be found in the north Atlantic. Counting the ratio of left-coiling *Neogloboquadrina pachyderma* to other foraminifer plankton shells in a sediment core from the North Atlantic at the end of the last glacial maximum, Lehman and Keigwin (1992) found evidence of abrupt changes in species abundance indicative of rapid shifts between warmer and colder water in the surface north Atlantic (Fig. 1). Without reference to modern species distributions, the magnitude of temperature change indicated by these shifts would be uncertain, and quantitative comparisons with other proxies would be at best qualitative. By analyzing the modern biogeographic pattern of *N. pachyderma* abundance with respect to temperature however, we are able to estimate the amount of temperature change associated with the faunal abundance patterns. In this example, the selection of the calibration data set (and its characteristics) have a direct influence on the environmental reconstruction.

Measuring departures from the present

Because paleoclimatologists are concerned with changes from the present, the choice of a modern reference value is of key importance. Subtle differences between modern reference points, and the consistency between different modern data sets, will become even more important as the search for more accurate estimates continues. With regard to the calibration of the coretop foraminifer abundance (Fig. 1), different results might be obtained if a different sea surface temperature dataset were used. Each of the sea surface temperature climatologies now available has different attributes that make them suitable for different scientific objectives. These differences (in resolution, in the time interval used to construct climatological means) provide different estimates of the modern climate that need to be considered when calibrating paleoclimate data.

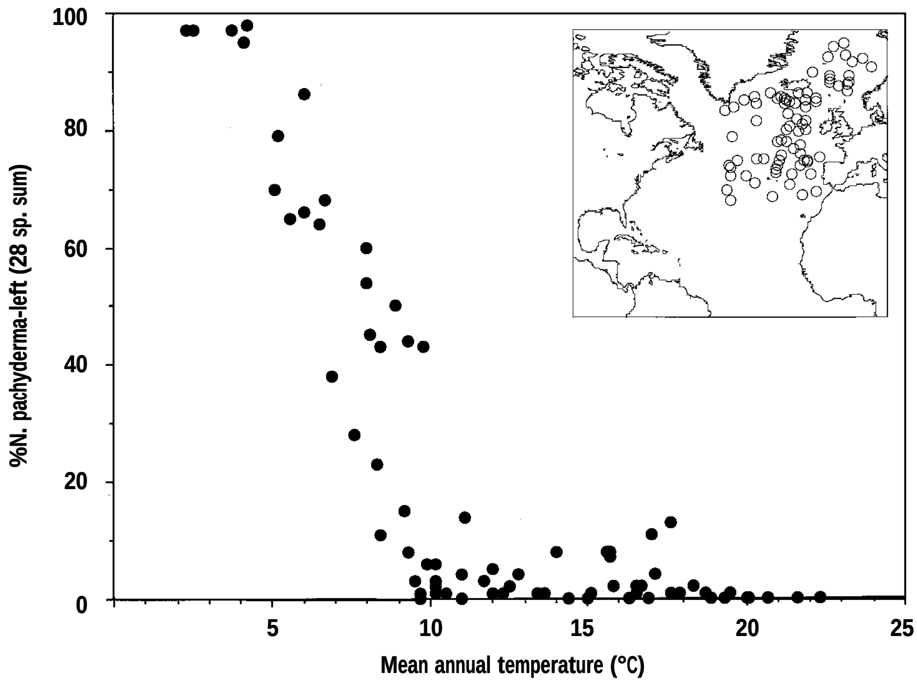


Figure 1
Calibrating the magnitude of temperature change associated with the change from 0 to 100% left-coiling Neoglogoquadrina pachyderma in coretop sediments from the north Atlantic.

Sources of modern calibration data

The volume and number of sources of available climate data are increasing at an explosive rate. Prior to the Bern workshop, centralized archives, such as the data archive at the National Center for Atmospheric Research in Boulder, and the National Climate Data Center, were among the most useful sources of climate data. CD-ROMS produced by these centralized archives, often containing several different climate data sets, have been and remain a popular source of modern calibration data (Table 1). In the two years since the Bern Workshop, the rapid growth of the Internet has led to the rapid evolution of a distributed data archive consisting of a number of different sites, each containing different types of data. Finding the data in this distributed maze can be a challenge. Using the World Wide Web and a few starting points (Table 2) one can begin to identify sources of relevant data.

Other valuable compendiums of data sources include the excellent summary of Internet (FTP, Gopher, WWW) and CD-ROM sources of meteorological data by Stern (1994), and books such as The Internet Navigator (Gilster, 1994). Gilster (1994) also provides an excellent introduction on how to use the Internet from networked machines, and also using modems.

Table 1
Popular CD-ROMS Providing Modern Calibration Data

Title	Contents	Contact Information
TOGA CD-ROM	COADS ocean temperature and meteorological data, PMEL moored buoy data, GEOSAT sea surface height, FSU gridded windfields, ISCCP Cloud data	NASA Physical Oceanography Distributed Active Archive Center, 4800 Oak Grove Drive, Pasadena, CA, 91109, USA; 818-354-0906; ral@shrimp.jpl.nasa.gov
Monthly-mean distributions of satellite-derived sea surface temperature and pigment concentration	NOAA AVHRR MCSST and Nimbus-7 CZCS Pigment Concentration	NASA Physical Oceanography Distributed Active Archive Center, 4800 Oak Grove Drive, Pasadena, CA, 91109, USA; 818-354-0906; ral@shrimp.jpl.nasa.gov
World Weatherdisc	World Airfield Summaries, WMO Station Data, some COADS data, other meteorological data	Weatherdisc Associates, Inc., 4584 NE 89th, Seattle, WA, 9811, USA; 206-524-4314
World Ocean Atlas 1994	Objectively analyzed temperature, salinity, and nutrient fields, includes profile data	National Oceanographic Data Center, 1825 Connecticut Ave, Washington, DC, USA; 202-606-4549; services@nodc.noaa.gov
Global Relief CD-ROM	Gridded topography and bathymetry data, and vector coastline files including the world vector shorelines, and MicroWorld Database II.	National Geophysical Data Center, 325 Broadway, Boulder, CO, USA; 303-497-6215; info@ngdc.noaa.gov

Table 2
World Wide Web Sites Providing Modern Calibration Data

Site	Contents	Universal Resource Locator (URL)
NASA Global Change Master Directory	Meteorological data, satellite-derived data sets	http://gcmd.gsfc.nasa.gov
National Climate Data Center	Climate Data, primarily US	http://ncdc.noaa.gov
National Oceanographic Data Center	Oceanographic data	http://www.nodc.noaa.gov
National Center for Atmospheric Research	Diverse set of climate data, pointers to other datasets, data relevant to climate modeling	ftp://ftp.ucar.edu
National Center for Supercomputing Applications	Mosaic, FTP, and other software used to access the Internet	http://www.ncsa.uiuc.edu/General/NCSAHome.html

REFERENCES

Gilster, P. 1994. *The Internet Navigator.* John Wiley and Sons, N.Y.

Lehman, S. J., and Keigwin, L., 1992. Sudden changes in North Atlantic circulation during the last deglaciation. *Nature*, 356:757-762.

Stern, 1994. File weather/data/part1, on the anonymous ftp server rtfm.mit.edu (subdirectory/pub/usenet/news.answers).

ADDITIONAL CONTRIBUTIONS

1. FAUNMAP: AN ELECTRONIC DATABASE DOCUMENTING LATE QUATERNARY DISTRIBUTIONS OF MAMMAL SPECIES

R. W. Graham

FAUNMAP is an electronic database documenting the late Quaternary distribution of mammal species in the United States. It has been developed at the Illinois State Museum (ISM) with support from the National Science Foundation. The project is co-directed by Drs. Russell Graham of ISM and Ernest L. Lundelius, Jr. from the University of Texas at Austin. The primary purpose of this database is to investigate the evolution of mammalian communities. Specifically, with statistical techniques and mapping capabilities of a Geographic Information System (GIS), changes in the distributions of individual species and their effects upon mammal community composition can be documented for the late Quaternary. Understanding these processes will also facilitate interpretations of human exploitation of mammalian resources. However, this database has many other applications as discussed later.

Project Description

For the past four years, data have been captured from paleontological and archaeological sites that contain mammalian remains. There are currently encoded data from about 3000 sites. FAUNMAP focuses on sites in the contiguous 48 states during the last 40,000 years, essentially the limits of radiocarbon dating. Selection criteria for incorporation of sites into the database include the following: 1) known geographic location (at least county level); 2) chronologic controls (stratigraphic, biostratigraphic, cultural affiliation, radiometric dates, etc.); and 3) voucher specimens (actual specimen, cast, or photograph) in a public institution. A network of 14 regional collaborators from throughout the United States and Canada are assisting with data selection, validation, and analysis.

Data are derived from the scientific literature, including selected theses, dissertations, and contract reports. Information on site name, location, relative and absolute chronologies (including cultural associations), stratigraphy, depositional systems, taphonomic attributes, and mammal species are recorded for each site. The structure of the database allows for differentiation of the smallest unit of a site, Analysis Unit (microstratigraphy, biostratigraphic zone, cultural component, etc.), as defined by the original author. This information is linked and cross referenced with an electronic bibliography documenting data sources.

Data are entered electronically on IBM compatible PC computers with a commercial relational database software, PARADOX. This approach has several advantages. By using PCs, the GIS workstation is not tied up with data entry. By having the database on a PC platform with a commercially available database manager, it is also easy to distribute the database to anyone with this or a similarly compatible system. In other words, one does not need a sophisticated GIS workstation to use the attribute files of the database.

Data files can be stored in a relational environment selecting for any combination of attributes desired, e.g., one species from a certain age range and specific site type. This information is then transported via ETHERNET to an IBM 6000 GIS workstation in order to generate temporal maps of changing distributions. By using latitude and longitude as the site locators, the database can be manipulated on any GIS system.

The real power of a GIS as an interdisciplinary tool is its ability to easily overlay maps of different types. For FAUNMAP, maps of modern mammal species distributions and Laurentide Ice Sheet boundaries have been digitized with ARC/INFO and can be overlain on the paleontological and archaeological site maps for different species at various time intervals. Likewise, the FAUNMAP database can be overlain on other types of maps, e.g., paleovegetation or paleolandscape.

Analyses have involved the production of distribution maps for individual species at selected time intervals, e.g., >20, 15-20, 10-15, 8-10, 4-8, and 0.5-4 ka. Various techniques of spatial analysis, (e.g., clustering, ordination,k TWINSPAN, and lacunarity) will be used to investigate changes in species associations, provinciality, and patchiness. Results of these investigations will be published as scientific reports. In addition, the time series maps, bibliography, and database will be published in hard copy and electronic forms by the Illinois State Museum. Publication of the database is anticipated in the summer, 1994.

Other Applications of the FAUNMAP Database

The FAUNMAP database has many other paleobiological, archaeological, and paleoenvironmental applications (e.g., paleoenvironmental and paleoclimatic reconstructions, extinction modeling, human subsistence studies, interactive exhibits, etc.). FAUNMAP has already been used to document changes in the distributions of two carnivores, American marten (*Martes americana*) and fisher (*Martes pennanti*) throughout the late Quaternary. Time series maps for these two boreal forest species demonstrated that the marten migrated north with climatic warming at the end of the Pleistocene period while the fisher remained in the southern Appalachians until historic times. Such zoogeographic patterns are valuable to various wildlife managers who, for example, might consider reintroducing the fisher into the southern Appalachians. The FAUNMAP database is currently being used with modern climate data and quantitative techniques for late Quaternary paleoclimatic reconstructions along the central Mississippi River Valley.

Related Databases

Other electronic mammalian databases are being developed. Dr. E. L. Lundelius is currently assembling, in the FAUNMAP format and with the assistance of the ISM staff, an electronic database for late Quaternary mammals of Australia. The FAUNMAP database structure is also being used for the construction of a database on late Quaternary mammals of

Europe that is being directed by Dr. Wighart Von Koenigswald (Institut fur Paleontologie, Bonn, Germany). Dr. Joaquin Arroyo-Cabrales (Laboratorio de Paleozoologica, Mexico City, Mexico) has started planning for a Mexican database that will also incorporate the FAUNMAP structure.

For Additional Information

For further information on the FAUNMAP database contact Dr. Russell W. Graham, Research and Collections Center, Illinois State Museum, 1011 East Ash, Springfield, Il, 62703, USA; telephone 217-785-4844; FAX: 217-785-2857; Internet email rgraham@museum.state.il.us or faunmap@museum.state.il.us.

The World Wide Web address is: http://www.museum.state.il.us (see research programs).

The FAUNMAP database has been published in hard copy with an ASCII disk by the Illinois State Museum: FAUNMAP Working Group 1994. FAUNMAP-A Database Documenting Late Quaternary Distributions of Mammal Species in the United States. Illinois State Museum Scientific Papers nos. 1 and 2. Available from the Illinois State Museum Society, Springfield, Il., 62706, USA.

2. U. S. GEOLOGICAL SURVEY GLOBAL CHANGE AND CLIMATE HISTORY PROGRAM

P. N. Schweitzer

U.S. Department of the Interior U.S. Geological Survey Global Change Research Program

A primary goal of the U.S. Global Change Research Program (USGCRP) is to provide reliable predictions of future climate changes and their effects. The USGS Global Change Research Program contributes to the USGCRP by documenting the character of environments in the past and present, and by documenting the geological, hydrological, geochemical, and geophysical processes involved in environmental change.

Research carried out by the program falls into two general categories: (1) studies of past conditions designed to distinguish anthropogenic change from natural climate variability and to improve and evaluate computer-based general circulation models (GCMs), and (2) studies of environmental processes directed towards understanding how modern processes interact with global change. Research projects of the program are organized around seven thematic elements, as follows:

- Biogeochemical Exchanges between Terrestrial Systems and the Atmosphere and Oceans. Research on the cycling of carbon and key nutrients, including volcano emissions, through terrestrial and coastal marine systems and on past changes in these processes.
- Arid and Semiarid Regions. Research Monitoring conditions and processes in arid and semi-arid regions, and research to understand the mechanisms and history of changes in these environments.
- Cold Regions Research. Monitoring of conditions and processes in cold regions, and research to understand the mechanisms and history of changes in these environments.
- Interaction of Climate and Hydrologic Systems
- Land Characterization and Land Data Management. Mapping and monitoring the land surface with remotely sensed data, preserving digital land surface data for use in change detection, and distributing global change data.
- Paleoclimate Research. Documentation of the rates, frequencies, and consequences of past climate changes and the effects of changes on the biosphere, research to determine the causes and mechanisms of climate change, and improving and testing global and regional climate models.
- Sensitivity of Water Resources

A detailed overview of the program and a list of published papers are available from the Program Coordinator, Dr. Michael D. Carr, Mail Stop 104, U.S. Geological Survey, Reston, VA 22092, Tel: (703) 648-4450, FAX: (703) 648-5470, email: mdcarr@isdmnl.wr.usgs.gov.

Paleoclimate Research

The USGS conducts interdisciplinary research on paleoclimates, paleohydrology, paleoecology, and paleoceanography. USGS is focusing this interdisciplinary expertise on paleoclimatology upon aspects of Earth System History that are of particular relevance to understanding global change. Understanding how the global climate system changed in the past, how rapidly those changes occurred, and how the environment responded to past climate changes have important application to current concerns about the prospect of future global-scale warming of significant magnitude, and how such a warming may influence life on Earth.

USGS paleoclimate research is designed to document the record of natural variability of climate on all time scales; determine past rates of climate change, and when climate changes occurred; understand the consequences of climate change upon the environment, especially in sensitive areas such as polar regions; improve general circulation models with testing and comparison with paleoclimate data sets.

Current research projects

USGS studies are designed to document the variability of past climate and environmental change at a time resolution ranging from decadal to Milankovitch cycles. Studies are conducted in both continental and marine settings. Larger-scale efforts are focused on developing continental to global scale environmental reconstructions for incorporation in climate modeling studies. These records are required to document the rates and magnitudes of natural variability, reveal links between different components of the climate systems, and delineate interactions between past environmental change and ecosystems. Many of these studies provide important insights into key processes that operate within the climate systems and can be used to identify feedbacks and forcing.

Records of past change include:

- Paleoclimatology and paleolimnology of Lake Baikal, southeastern Siberia
- Climate history of the Amerasia Basin of the Arctic Ocean
- Paleoclimate reconstructions from ice core records
- Marine and terrestrial climate change in the western U.S.
- Owens Lake climate record
- Late Cenozoic climates of Alaska and Yukon
- Deep ocean circulation and climate change
- High-resolution sea-surface temperature record from corals
- Paleohydrology and climate change
- Proxy records of tropical Pacific paleohydrology and paleoclimate from banded corals
- Response of fluvial systems to climatic variability
- Interface of paleoclimatology and aquifer geochemistry
- Global reconstructions of past climate states

- Pliocene Research, Interpretation, and Synoptic Mapping (PRISM) Last Interglacial: Timing and Environments (LITE)
- Technique development and refinement
- Lakes, climate, and ostracods, tephrochronology and climate change

For Additional Information

More information on paleoclimate datasets is available from Peter Schweitzer, M.S. 955, U.S. Geological Survey, Reston, VA 22092

3. TEPHRA DATABASES

Valerie A. Hall

Introduction

Tephra studies are now one of the most dynamic sciences in Quaternary Studies. Recent researches into tephra distribution has shown that, until recently, the geographical extent of volcanic ash distribution has been constantly and seriously underestimated. Advances in analytical techniques now allows geochemically confirmed site linkage over extensive areas,in some cases comparative hemispheric and global volcanic studies.Tephra studies contribute to research on volcanism and volcanic processes as well as to past environmental investigations.

Databases for tephra are now under construction. The databases seek to include data on present and past volcanism and will eventually include quantitative and qualitative information. No doubt there will be a major expansion in the scope and number of databases for this expanding research area in the next few years.

Current Databases

Presently there are two databases containing a wide range of information on volcanism, explosivity indices, location of specific volcanoes and tephra geochemistry. A third is under development. The larger of the two, known as CATALOG is managed by Koji Okumura and Hiroshi Machida.

CATALOG—"Catalogue of widespread tephra layers in the world" aims to compile a catalogue of widespread Quaternary tephra layers over the world. Such a catalogue will include data on marker-tephra layers such as source vent, type of explosive volcanism, age, distribution, petrographic nature of constituent material and hence should be useful in the world-wide and regional correlation of Quaternary sequences. Okumura and Machida are working on data input but have difficulty in that the amount and quality of data are uneven on a global scale. More information from tropical and developing countries is required. CATALOG is complementary to the work of Tom Simkin and Lee Siebert (Global Volcanism Program, Smithsonian Institute, Washington). Late in 1993 they distributed a datafile of all Holocene eruptions with known Volcanic Explosivity Index (VEI) greater than 4 (and lava volumes greater than 1km^3) prior to publication of the second edition of Volcanoes of the World. An interesting interpretation of some of the data was published as "Terrestrial volcanism in space and time" in Annual Reviews Earth and Planetary Science 21, 427-452 (1993).

The status of CATALOG in December 1994 was published in the INQUA Commission on Tephrochronology Newsletter as follows:

World largest tephra (VEI greater than &) list: most information has been collected. Japanese major tephra (VEI greater than 4): data input is almost finished except for the reference list. A publication of the world tephra catalogue is planned for late 1996.

Guidelines and data input forms may be obtained from:

Koji Okumura
Geological Survey of Japan
1-1-3 Higashi, Tsukuba, Ibaraki 305, Japan
Phone: +81-298-543694
Fax: +81-298-523461, 543533
Email: kojiok@gsj.go.jp

TEPHRABASE is currently being developed in the Department of Geography at the University of Edinburgh. The pages accessed will enable complex searches of the database to be carried out. Both published and unpublished data on tephra deposits and their source volcanoes will be available when the database is completed. At present only data on tephra layers derived from Icelandic volcanoes will be stored.

Further information can be obtained from:

Anthony J. Newton
Department of Geography
Drummond Street
EDINBURGH
Email: AJN@geovax.ed.ac.uk
Tephrabase: Netscape Home Page
http://www.geo.ed.ac.uk/tephra/tbasehom.html

Databases Under Construction

The International Comission on Volcanism and Chemistry of the Earth's Interior is expanding is database on major eruptions of the last two hundred years. Further information on this database may be obtained from:

Dr Steven Self
Dept. of Geology and Geophysics
University of Hawaii at Manoa
Honolulu HI 96822
USA
Phone: +1-808-956-5996
Fax: +1-808-956-2538
Email: self@lani.soest.hawaii.edu

The INQUA Commission of Tephra Studies has a number of working groups including databases. Further particulars may be obtained from:

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PAGES PUBLICATION LIST

IGBP Reports:

No. 6 Global Changes of the Past. Edited by H. Oeschger and J.A. Eddy

No. 12 The International Geosphere-Biosphere Programme: A Study of Global Change; The Initial Core Projects, Chapter 7, Past Global Changes (PAGES).

No. 19 Past Global Changes Project: Proposed Implementation Plans for Research Activities. Edited by J.A. Eddy.

Pages Workshop Reports:

93-1 High Resolution Record of Past Climate from Monsoon Asia: The last 2000 Years and Beyond.
Edited by Raymond Bradley; September 1993

93-2 An International Decade for the East African Lakes (IDEAL).
Edited by Thomas C. Johnson, July 1993

94-1 Research Protocols for PALE (Paleoclimates of Arctic Lakes and Estuaries).
Issued by PALE Steering Committee, June 1993

94-2 INQUA/PAGES Workshop; Paleomonsoons in Africa and surrounding oceans: the last 200,000 years.
Edited by Stefan Kroepelin, 1994

PAGES-START Workshop, Past Global Changes in Africa.
Edited by Eric Onyango Odada, 1994

94-3 International Marine Global Change Study (IMAGES): Science and Implementation Plan
Issued by: IMAGES Planning Committee, 1994

95-1 The PANASH Project, Paleoclimates of the Northern and Southern Hemisphere
Edited by the PANASH Project Leaders

Occasional Publications

1. Pages Project Status and Work Plan (1994-1998)

AGCM	Atmosphere General Circulation Model
ARTS	Annual Records of Tropical Systems
BAHC	Biospheric Aspects of the Hydrological Cycle (IGBP)
BDP	Baikal Drilling Project
CAPE	CircumArctic Paleo Environments (formerly PALE)
CLIVAR	Climate Variability and Predictability (WCRP)
COHMAP	Cooperative Holocene Mapping Project
DIS	Data and Information System (IGBP, HDP)
ELDP	European Lake Drilling Project
ENSO	El Niño/Southern Oscillation
EPC	European Paleoclimate and Man Project
EPICA	European Programme for Ice Coring in Antarctica
EPOCH	European Programme for Climatology and Natural Hazards
GAIM	Global Analysis, Interpretation and Modelling (IGBP)
GCTE	Global Change and Terrestrial Ecosystems (IGBP)
GISP 2	Greenland Ice Sheet Project—Two
GOALS	Global Ocean-Atmosphere-Land System Program
GRIP	Greenland Icecore Project
HIPP	Himalayan Interdisciplinary Paleoclimate Project
IAEA	International Atomic Energy Agency
IAI	Inter-American Institute for Global Change Research
ICDB	Ice Core Data Bank
ICDP	International Continental Drilling Program
ICSU	International Council of Scientific Unions
IDEAL	International Decade of East African Lakes
IGBP	International Geosphere - Biosphere Programme
IGCP	International Geological Correlation Programme
IMAGES	International Marine Global Change Study
INQUA	International Union for Quaternary Research (ICSU)
ITASE	International Trans-Antarctic Scientific Expedition
ITRDB	International Tree-Ring Data Bank
LGM	Last Glacial Maximum
LOICZ	Land-Ocean Interactions in the Coastal Zone (IGBP)
NAD	Nansen Arctic Drilling Project
NOAA	National Oceanic and Atmospheric Administration (USA)
ODP	Ocean Drilling Project
PAGES	Past Global Changes (IGBP)
PALE	Paleoclimates from Arctic Lakes and Estuaries
PANASH	Paleoclimates of the Northern and Southern Hemispheres
PEP	Pole–Equator–Pole
PMAP	Paleoenvironmental Multiproxy Analysis and Mapping Project
PMIP	Paleoclimate Modelling Intercomparison Project
SCAR	Scientific Committee on Antarctic Research (ICSU)
SCOR	Scientific Committee on Ocean Research (ICSU)
SST	Sea Surface Temperature
START	System for Analysis, Research and Training (WCRP, IGBP, HDP)
TIGER	Terrestrial Initiative in Global Environmental Research
WAIS	West Antarctic Ice Sheet Project
WCRP	World Climate Research Programme
WDC-A	World Data Center-A for Paleoclimatology
WGNE	Working Group on Numerical Experimentation