Weltdatenzentrum Abfluß
Bundesanstalt für Gewässerkunde
Koblenz, Deutschland

Global Runoff Data Centre
Federal Institute of Hydrology
Koblenz, Germany

Report No.1

Second Workshop on the GLOBAL RUNOFF DATA CENTRE

Koblenz, Germany, 15 - 17 June, 1992

Organized by
Hydrology and Water Resources Department;
World Meteorological Organization, Geneva
and
Federal Institute of Hydrology, Koblenz

GRDC

May 1993

56068 Koblenz, Kaiserin-Augusta-Anlagen 15-17, Phone (0261)1306-0, Fax (0261) 1306-302
Germany

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PREFACE

For the second time, a workshop on the Global Runoff Data Centre (GRDC) was held up at the Federal Institute of Hydrology (Bundesanstalt für Gewässerkunde/BfG) in Koblenz, Germany.
The workshop was coordinated by the staff of the GRDC in co-operation with the internal advisory group of the BfG and the Hydrology and Water Resources Department of the World Meteorological Organization (WMO).

The purpose of the meeting was to review the activities of the GRDC since its inauguration in 1988 as well as the future plans of the Centre which include the facilities for the gridding of hydrological data for use in validating global climate models.

Experts involved in the relevant international programmes and projects had been invited to take part in this workshop (see list of participants in Appendix A) to introduce their programmes and/or projects and to develop potential links to the GRDC.

Two working groups were established by the workshop. The first discussed major aspects of data collection and storage by the GRDC (Working Group A), the second working group considered problems of gridding of hydrological data (Working Group B). In this way many views could be exchanged so that the major points could be recorded in the final report.

The main part of this report includes basic information about the current and future activities of the GRDC. The sequence of the topics does not correspond the agenda of the workshop but it is structured according to the discussion points of the Working Group A.

The Appendix H includes most of the reports on the projects and programmes introduced by the participants at the workshop.

Once more we would like to thank all the participants for their kind co-operation and their active discussion in this workshop.

1 OPENING OF THE WORKSHOP

The workshop on the Global Runoff Data Centre (GRDC) was opened on 15 June 1992 at the Federal Institute of Hydrology (Bundesanstalt für Gewässerkunde) in Koblenz, Germany.

The Director of the Federal Institute of Hydrology, Prof. V. Wetzel and Dr. J. Rodda, Director of the Hydrology and Water Resources Department of the World Meteorological Organization (WMO) welcomed the participants.

1.1 Introductory Remarks

Prof. Dr. H.-J. Liebscher informed the workshop about development, relationships and future plans of the GRDC.

He explained that for the implementation of WMO/ICSU's Global Atmospheric Research Programme (GARP) and its First Global GARP Experiment (FGGE) it had been decided to collect flow data on a global scale. The selection process was made to meet the needs of FGGE (see Appendix C "Historical development of the GRDC"). The strategy was not set to suit the development of hydrological models but primarily to test atmospheric General Circulation Models (GCM). It was believed that the data that were of value to GARP were still of value to post-GARP research. Therefore, having established contacts with data suppliers at national level, it was decided to collect data for subsequent years in order to obtain longer series of data which are generally considered to be of greater interest than shorter records. This programme has been continued within the WMO World Climate Programme (WCP).

In 1981, at the first planning meeting on WCP-Water, the project A.5 "Collection of Global Runoff Data Sets" was developed. A data base was designed to meet the needs of the World Climate Research Programme (WCRP) which has always been the main aim of the project.

A procedure was developed to collect the relevant data sets. The first request for data was circulated by the WMO Secretariat to the Members of WMO in August 1982. The data sets were processed by the University of Munich. Later, WMO contacted the Federal Institute of Hydrology at Koblenz with a proposal addressed to their representatives to take charge of the database. During a period of 18 months only, the databank was established in Koblenz and the GRDC was officially inaugurated in November 1988. At the same time, an agreement between WMO and Germany was concluded in which the responsibilities and the functions of the GRDC were specified. The WCP-Water Project A.5 ist being implemented by operating the GRDC.

However, Prof. Dr. Liebscher explained later on, the GRDC activities were not limited to this project; it had served simply as the original basis for its establishment. The Centre had also entered UNESCO discharge data sets of major rivers of the world into the database. It is also responsible for entering the data and results of WCP-Water Project A.2 on the analysis of long time series of hydrological data. Additional data sets have been included into the database originated from other sources or projects as, for example, the Flow Regime of International Experimental and Network Data (FRIEND) or the data sets compiled by MacMahon.

The Centre is ready to accept and convert any set of hydrological data into computerized form which are not only of national interest.

The co-operation between the GRDC and other national/international institutions has been pursued through the last years and it is expected that much more data could be collected by the GRDC.

Recent developments may be of particular interest. In October 1990, an agreement was reached that the GRDC collaborate with UNEP in complementing to GEMS water quality data by the GRDC river discharge data. The actual need of flow data will be guided by the GEMS/WATER requirements. Separately, the GRDC proposed that it would also collect data for WCP-Water project A.8 (WMO 1990a).

Again, the aim is to monitor selected major rivers. This proposal was first made in May 1990, but the project certainly corresponds well with the aims of the Global Climate Observing System (GCOS) which was established just recently. It is intended that the GRDC also supports other relevant ongoing international programmes as the IHP of UNESCO, the Global Energy and Water Experiment (GEWEX), the International Geosphere and Biosphere Programme (IGBP) as well as the International Decade for Natural Disaster Reduction (IDNDR).

The links of the GRDC to other organizations are represented by Figure 1.

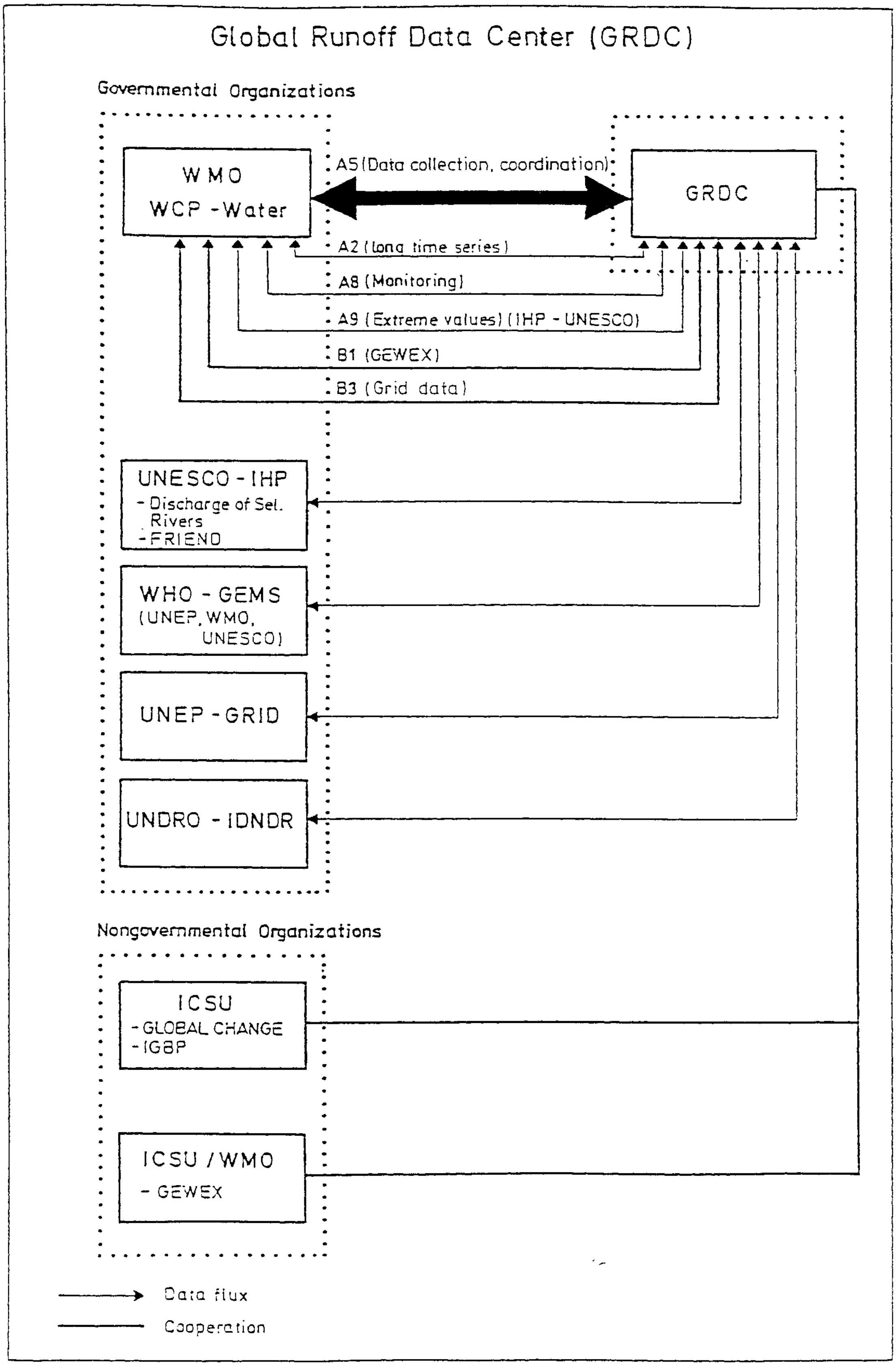
Global Runoff Data Center (GRDC)
Governmental Organizations
WMO
WCP -Water
A5 (Data collection, coordination)
GRDC
A2 (Long time series)
A8 (Monitoring)
A9 (Extreme values) (IHP - UNESCO)
B1 (GEWEX)
B3 (Grid data)
UNESCO - IHP
- Discharge of Sel. Rivers
- FRIEND
WHO - GEMS
(UNEP, WMO, UNESCO)
UNEP - GRID
UNDRO - IDNDR
Nongovernmental Organizations
ICSU
- GLOBAL CHANGE
- IGBP
ICSU / WMO
- GEWEX
Data flux
Cooperation

Figure 1

2 THE GLOBAL RUNOFF DATA CENTRE

2.1 General

The overall goal of the GRDC is to encourage national agencies to collect and manage information about their national water resources as well to provide international scientific communities and, in particular, the specific WMO projects with world-wide runoff data and related information.

The availability of world-wide data from an international data base is vital for estimating land surface related hydrological inputs/outputs of atmospheric general circulation models (GCM's), for testing grid oriented estimation techniques for such inputs/-outputs and for the validation of GCM's. Such data sets are also of great value for a number of other purposes, in particular in the context of the increasing interest in large-scale, even global, studies of hydrological processes.

The tasks of the GRDC can be summarized as follows:

(i) Collection, processing, archiving and dissemination of hydrological data and information;

(ii) Maintaining information about respective river basins;

(iii) Provision of hydrological data and other information to the relevant international programmes;

(iv) Transfer of hydrological observation/information to grid point or grid area values (This activity will be executed by the Department M2, Federal Institute of Hydrology with the support of the GRDC);

(v) Publication of reports;

(vi) Responding to inquiries of national/international institutes and interested individuals;

(vii) Co-operation with the Global Precipitation Climatological Centre (GPCC).

2.2 Status of the GRDC

The GRDC operates under the support of WMO for the benefit of members and the international scientific community and it receives data through WMO and from many other sources. It provides a means for the international exchange of data pertaining to river flow and surface-water runoff on a long-term basis. All data held by the GRDC are available to any legally user, upon written request or personal visit. Where every attempt is made to ensure a reasonable standard of data quality and related documentation, the ultimate responsibility in respect lies with the contributor and not with the GRDC.

In June 1992 the GRDC data bank consisted of discharge data of 2930 stations from 131 countries. Daily flow data are available for 1478 stations, and monthly flows for 1266 stations. For 186 stations daily flow data as well as monthly flow data are available (see Figures 1 to 7, Appendix G).

The Centre was etablished within the Department of Information Technology within the Federal Institute of Hydrology (BfG) at Koblenz. An internal advisory group coordinates the activities of the Centre. The databank follows the practice and experience in operating the national database for German rivers, comprising data on water levels, flows and water quality.

2.3 Structure and administrative arrangements

The internal structure and management of the Centre and the establishment of external links are the responsibilities of the GRDC. The GRDC is embedded in the Federal Institute of Hydrology with one regular staff member assisted by other Departments of the Institute. Because of the amount of international data exchange it is intended to increase the staff of the GRDC .
Plans are existing to establish a steering committee for the GRDC, similar to that of the GPCC, considered to be a very appropriate mechanism for reviewing the Centre's activities and advising on its future plans.

The GRDC is using national facilities for maintaining the global data base. In view of its potential links with international communities, possibilities should be examined of the availability to the GRDC of on-line connections with users and suppliers through the main international computer telecommunication networks. For checking and analysis of data by graphical or statistical methods the GRDC can use the facilities of the BfG.

The facilities of the GRDC are as follows:

- Data Base Management System (DBMS);
- Facilities for outside access to the data base;
- Conformity with international standards for computer equipment, operating system, DBMS, programming languages, data exchange and the remote access;
- Computer equipment and software which include PCs 486, SCO UNIX, INFORMIX, ROSI-SQL.

3 DATA

Hydrological data are needed for various purposes, such as global and continental water balance studies, regional studies, estimation of the loads of materials transported by rivers to the oceans, verification and initialisation of GCM's and coupling of hydrological and meteorological models. Principal purpose of the collection of data should be to provide background information to international programmes and projects such as:

- Analyzing long-time series of hydrological data and indices with respect to climate variability and change (WCP-Water Project A.2).

- Detecting global and regional runoff trends by monitoring discharge of selected rivers (WCP-Water Project A.8).

- Monitoring changes in the characteristics of extreme hydrological events i.e. floods and droughts (WCP-Water Projekt A.9).

- Global Climate Observing System (GCOS).

- Global Environmental Monitoring System (GEMS/WATER).

- Global Environmental Facility (GEF).

- UNEP/GRID.

- International Hydrological Programme (IHP) of UNESCO.

After data are received by the GRDC, they are checked, processed and stored within a special database. The programme consists of a menu-driven easy-to-use retrieval system where the user is able to select several options. The programme was developed with the aim of allowing future potential users, which are linked to the computer system of the GRDC, using the system in a on-line status.

The retrieval system offer the following possibilities (see Figures 8 - 13, Appendix G for examples):

- summary of available data;
- data listings;
- printout of hydrograph/flow duration curves;
- output of data on diskette/magnetic tape;
- access to station and catchment information.

It is also planned to include catchment boundaries as well as gridded runoff values to the data base. The GRDC is continuously developing new techniques for improving the collection, retrieval system and the transfer of data.
Figures 14 and 15 within Appendix G illustrate requests reached by the GRDC until June 1992.

3.1 Coverage

The data are collected from various sources:
- from WMO Members through the WMO Secretariat;
- the UNESCO publication "Discharges of Selected Rivers of the World" (until to 1984);
- hydrological yearbooks, monographs and reports;
- through direct contacts between the GRDC and other institutes and organizations (e.g. ORSTOM - Institut français de recherche scientifique pour le développement en coopération);
- the collection of long-term monthly series within the WCP-Water Project A.2;
- the MacMahon set of flow data;
- the FRIEND project.

Additional sources may include data sets listed within the INFOCLIMA-catalogue.

Possibilities for real-time data collection should be examined. In view of the purpose to which the data bank is established, future efforts should be made in collecting more data concentrated on a good areal coverage as well of data covering major rivers of the world rather than just collecting data from many countries as possible.

3.2 Procedures

In order to make the collection of data more systematic and capable, the GRDC should establish a procedure which would ensure a direct supply of data to the GRDC at regular intervals. For this purpose the GRDC will maintain a list of contributors and contact them directly. This procedure may include visits by the GRDC staff to countries which did not provide any records. The WMO Secretariat should continue establishing initial contacts with new contributors and relevant international or national programmes.

Additionally, the GRDC would ask any user of the GRDC databank for supplementary sources of new data. Published data should only be considered as an additional source of information as they represent data which are available prior to the time of publication within the GRDC databank. Additionally there is no possibility of revision of these data, as there is often a considerable time-lag between measurement and publication of the data.

3.3 Types of data

When discussing types of data to be collected by the GRDC, it was recommended that no historical, irregular or experimental data should be considered. Main focus of the GRDC is the collection of daily and monthly data. However, the GRDC should also collect other supplementary data and information such as extreme values, water levels rating curves, catchment boundaries, elevation, land uses, soil types, etc.

The GRDC should concentrate on possessing a good areal coverage by obtaining data from baseline stations, trend stations, and global flux stations and/or stations near the oceans (GEMS, WHO, WMO, UNESCO).

It was also suggested that data should be collected for:

- all large rivers with mean annual discharge greater than 100 m^3/s including major tributaries;
- basins with catchment areas greater than 1,000,000 km^2;
- basins with more than 1,000,000 inhabitants;
- stations characterizing flow into the oceans (GEMS, WCP-Water Project A.8, GCOS, i.e. collecting monthly discharge data for major rivers and making estimates of monthly continental discharge from the collected data and estimates of discharge from the ungauged areas of the continents for the period from 1950 to present);
- undisturbed areas ($\sim$ 5,000 km^2 and/or 1,000 km^2 - 10,000 km^2);
- selected catchments with natural flow.

4 OTHER INFORMATION

The GRDC should collect and retain information on the rivers, observing stations and the catchments concerned, i.e. on the elevation, distance from the river mouth, climate data, physiographic data, landuse data, irrigation and use of water as well as other information important for the assessment and use of flow data series.

Parallel to the flow data, maps of the catchments were also collected within the WCP-Water Project A.5. These maps can be used for digitizing catchment boundaries and river channels. In the past, some catchment boundaries were digitized by the Institute of Bioclimatology and Applied Meteorology, University of Munich. In the future, facilities of the BfG will be used for this task. It should also be considered using already digitized data from other agencies.

In the Department of Information Technology within the BfG, a computer program for digitizing maps and plotting maps (THEMAK) is already in use and it is intended to make it available also for the GRDC. First steps were undertaken in digitizing maps of regions with large rivers e.g. Africa, (see Figure 16, Appendix G).

The participants discussed strategies to be developed in order to encourage countries to provide their data to the GRDC. The following steps should be pursued:
- Initiation of institutional and personal contacts.
- Clear definition of the needs of the GRDC related to the use of the data.
- Participation in international projects.
- Invitation of national experts to the GRDC workshops.
- Establishment of permanent links with contributors of data.
- Regular presentation of posters at international conferences and conventions.
- Distribution of leaflets of the GRDC and its products at international conferences.
- Publication of regular information of the GRDC for contributors of data, exchange data, and provide other GRDC products; regularly exchange and provision of the database on diskformat.

- Regular reports of the GRDC within WMO Bulletins.
- Annually Status Reports of the GRDC to WMO.

5 CO-OPERATION

Co-operation with other data centres should help to enlarge the GRDC database. On the one hand those data already being collected can be made available to users, on the other hand the distribution of these data can play an important role in the assistance of collecting new data. It also seems possible to apply to other Centre's systems for the management and application of data. The co-ordination is necessary in selecting other stations which monitor discharge, water quality and precipitation in the same area of interest.

6 TRANSFORMATION OF FLOW DATA TO GRID POINTS

A pilot project was proposed for the purpose of constructing data sets over certain dense river flow networks, which could be used in currently available techniques for estimating runoff over grid-cells. The areas should be fairly homogenous from both climatic and hydrologic viewpoints. Daily river flow measurements for each catchment and for the years 1978 to 1990 should be obtained. Where this is not possible, monthly values should be taken instead.

The pilot area covers the basins of the rivers Rhine, Weser, Elbe, Oder and Weichsel within Germany, Czechoslovakia and Poland. The core area is:
48° - 55° N latitude, 7° - 15° E longitude - for the whole pilot area: 45° - 55° N latitude, 5° - 25° E longitude.

This activity is to be undertaken by the GRDC in co-operation with the Department M2 of the Federal Institute of Hydrology (BfG) and with the WMO, IIASA and other appropriate National Institutions.

When gridded runoff data are computed, they will be formated by the GRDC and made available to all users, together with the original data sets of dis-charges at specific gauging station. These data can be delivered together with other data sets and maps of the river basins if needed for other modeling purposes.
A number of data mentioned above may be extracted from existing GIS´s (for example GRID of UNEP). Therefore a decision will have to be made if a specialized GIS for the pilot data set should be developed.

Further arrangements are proposed by the WMO for provision of precipitation data in gridded format together with the gridded runoff values. These data should be within the same time step, period and grid resolution. They are supplied by the Global Precipitation Climatology Centre (GPCC) in Offenbach, Germany.
Preliminary selections of models indicate that these should mainly be based on measured runoff values in order to ensure that these time series are free of influences e.g. caused by precipitation data. In each case, however, the availability of input data and the need for hydrological accuracy will have to be taken into consideration for the final selection of a model. Thus it is assumed that testing several models, preferably one on the same data sets but simulating under different conditions (high elevations, hills, flatlands etc.) will be beneficial for the project. Therefore, it would be helpful if subroutines used for data management are the same or similar to all participating institutions (countries). This would ensure that the transfer of data and the results could be facilitated (See also the contribution "Principles and State of the Art", APPENDIX H).

General assistance to the project was provided by Dr. John Schaake. He noted that runoff produced by atmospheric models should be verified by the method of routing the runoff from several grid points to a stream gauge. He further commented to compare simulated discharge with observed discharge and the gauges to be used for this purpose must be essentially unaffected by upstream regulation or diversion.
Most of the continental discharge gauges are influenced by regulation or diversion and are therefore no good choices for those verification purposes (except based on an annual or climatological basis).

Water resource impacts of climate variability and change occur at much shorter time scales than within one month (e.g. high and low flows). Therefore, a number of additional specific locations are needed and a close co-operation between GRDC and GPCC should be assured.

On the ability of atmospheric models representing the surface water budget Dr. Schaake commented that this is depending on both local and large scale processes. To understand how to improve limitations indicated in model validations at specific stream gauges additional information on a larger spatial scale is fundamental. In particular, gridded fields of monthly runoff are needed. Ideally, these grid cells should cover all of the continents, but it is even more important for these estimates being well established at single locations rather than on an overall distribution. Furthermore, the comparison of runoff derived by atmospheric models and grid point runoff does not imply sufficient verification of the atmospheric model, because this requires runoff from discharge data being estimated at individual grid points.

Dr. Schaake made the following suggestions to develop diagnostic information for atmospheric modelers:

- To continue to identify specific regions where runoff grids will be produced and to set up a schedule to produce these data over the next few years.

- To collect daily and monthly discharge data for specific gauges for the period 1950 to the present in support of the gridding project.

- To produce monthly gridded fields (on a 30 minute grid) and to update them annually. Finally they should be combined with climatological programmes.

- To produce a data product together with the GPCC containing these grids, the stream gauge data, and related precipitation information.

Hydrologic modelers tend to focus their activities on data that are available within in their own countries. However, the needs of global hydrologic modeling require data from many countries.
The general state of the art in hydrologic modeling would advance substantially if quantity data are available for a wider range of climates. It would then be possible to acquire streamflow data of specific locations for limited periods as well other data required for hydrologic modeling which are needed for producing digital data products (e.g. basin boundaries).

7 ACTION PLAN

Future activities of the GRDC will be to complete together with the Secretariat of WMO existing data sets within the needed time steps and spacial resolutions. In order to motivate WMO Member States to provide additional data to the GRDC, WMO Members are being informed about the present status of the GRDC by a leaflet which is regularly updated. In CHy sessions of working groups and expert meetings of WMO, new ideas and as a result additional requests for data will probably arise. Then the GRDC will play a major role within the international exchange of data. Therefore, the Centre should strenghten its activities in the collection of data and all countries are asked to support the GRDC providing them with their runoff data sets.

An action plan was developed to continue the work which had already been accomplished and it can be seen from Appendix E.

8 CLOSURE

The workshop was closed at 13.00 p.m., June 17, 1992.

APPENDIX

LIST OF PARTICIPANTS APPENDIX A

Dr. Nigel Arnell
Institute of Hydrology
Maclean Building
Crowmarsh Gifford
Wallingford
Oxfordshire OX10 8BB
United Kingdom

Mr. Benedict
Department for WCRP
World Meteorological Organization
Case postale No. 2300
CH-1211 Geneve 2
Switzerland

Dipl.-Ing. Heiner Benking
c/o Project Consult
Isestr. 63
W-2000 Hamburg 13
Germany

Dr. Lydia Dümenil
Max-Planck-Institut für Meteorologie
Bundesstr. 55
W-2000 Hamburg 13
Germany

Mr. Vaclav Dvořak
Hydrology and Water Resources Department
World Meteorological Organization
Case postale No. 2300
CH-1211 Geneve
Switzerland

Mr. K. David Harvey
Surveys and Information Systems Branch, ESED
Environment Canada
8th floor, Place Vincent Massey
Ottawa, Ontario K1A OH3
Canada

Dr. Roy Jenne
National Center of Atmospheric Research
P.O. Box 3000
Boulder, Colorado 80307
USA

Prof. Zdzislaw Kaczmarek
Institute of Geophysics
Polish Academy of Sciences
ul. Ksiecia Janusza 64
PL-01452 Warsaw
Poland

Dr. Ephrat Lahmer-Naim
Institut für Meteorologie
Freie Universität Berlin
Dietrich-Schäfer-Weg 6 - 10
W-1000 Berlin 41
Germany

Prof. Jaromir Nemec
92 Route de Valauran
CH-1294 Genthod

Prof. Peter Peterson
U.N. Environment Programme/GEMS, and
Monitoring and Assessment Research Centre
The Old Coach House
Campden Hill
London W8 7AD
United Kingdom

Dr. John C. Rodda
Hydrology and Water Resources Department
World Meteorological Organization
Case postale No. 2300
CH-1211 Geneve 2
Switzerland

Prof. Dr. R. Roth
Institut für Meteorologie und Klimatologie
Universität Hannover
Herrenhäuser Str. 2
W-3000 Hannover 21
Germany

Mr. Bruno Rudolf
Global Precipitation Climatology Centre
Deutscher Wetterdienst, Zentralamt
Postfach 10 04 65
W-6050 Offenbach
Germany

Dr. John C. Schaake
National Oceanic and Atmospheric Administration
National Weather Service
1325 East West Highway
Silver Spring MD 20910
USA

Prof. Dr. Gert A. Schultz
Lehrstuhl für Hydrologie, Wasserwirtschaft und Umwelttechnik
Ruhr-Universität Bochum
Postfach 10 21 48
W-4630 Bochum 1
Germany

Prof. Igor A. Shiklomanov
State Hydrological Institute
23 Second Line
St. Petersburg 19 90 53
Russian Federation

Dr. Gabriele Wollenweber
Königsberger Str. 39
W-5560 Wittlich
Germany

<u>Federal Institute of Hydrology</u>

Bundesanstalt für Gewässerkunde
Kaiserin-Augusta-Anlagen 15-17
56068 Koblenz
Germany

Prof. Dr. Karl Hofius
Dipl.-Geogr. Klaus Isele
Dipl.-Met. Peter Krahe
Prof. Dr. Hans-Jürgen Liebscher
Dipl.-Geogr. Brigitte Malm
Dipl.-Geogr. Albert Predeek
Dr. Manfred Schumacher
Dipl.-Met. Ulrich Schröder
Professor und Direktor Volkhardt Wetzel
Dr. Klaus Wilke

WORKSHOP ON THE GLOBAL RUNOFF DATA CENTRE

Koblenz, Germany, 15 - 17 June 1992

Opening by representatives of the Federal Institute of Hydrology/Germany and the WMO	V. Wetzel J. Rodda
Introduction Development, relationships and future plans of the GRDC, aims of the Workshop	H.-J. Liebscher M. Schumacher

Session 1: RELATIONSHIP TO OTHER DATACENTRES OR INSTITUTIONS

Global Precipitation Climatology Centre (Offenbach, Germany)	B. Rudolf
State Hydrological Institute (St. Petersburg, Russian Federation)	I. Shiklomanov
Institute of Hydrology (Wallingford, U.K.)	N. Arnell
National Water Research Institute (Burlington, Canada)	K. D. Harvey
National Center of Atmospheric Research (Boulder, USA)	R. Jenne

Session 2:
THE GLOBAL RUNOFF DATA CENTRE

Review and future plans	M. Schumacher
- Current status	K. Isele
- Current techniques and administrative arrangements	A. Predeek
- Data storage, checking and analysis	
- Requests for and input of new data	
- Digitizing of catchment boundaries	
- Supply of data to users	
- Future plans	

Session 3:
DEVELOPMENT OF GRID-RELATED ESTIMATES OF HYDROLOGICAL VARIABLES

Introduction (WCP-Water B.3)	V. Dvořak
Principles and state of art	G. Wollenweber
Application of global runoff data in GCM with a report about BALTEX	L. Dümenil
Application in hydrological models	J. Nemec

Session 4:
CONTRIBUTION TO INTERNATIONAL PROGRAMMES

WCP-Water A.2	Z. Kaczmarek
WCP-Water A.8 & GCOS	V. Dvořak
GEMS	P. Peterson
	U. Schröder
GEF	S. E. Benedict
UNEP	
IHP	W. Gilbrich
WCP-Water A.9 & IDNDR	
GEWEX	J. C. Schaake
	G. A. Schultz
IGBP	E. Lahmer-Naim

Session 5:
RECOMMENDATION OF FUTURE ACTIVITIES

CLOSURE

1980:	First planning meeting on WCP-Water in Geneva, Projects A.2 (Analyzing long time series of hydrological data and indices with respect to climate variability and change) and A.5 (Collection of global runoff data sets) were established.
1982:	Data request of FGGE-data by WMO for the years 1978-1980
1982:	Second planning meeting on WCP-Water in Paris
1984:	Start of data-collection at the Lehrstuhl für Bioklimatologie und angewandte Meteorologie der Universität München
1984:	Request of data for the years 1981-1983 (1985) by WMO
1985:	Third planning meeting on WCP-Water in Geneva
May 1987:	The Federal Institute of Hydrology (BfG) begins to take over data sets; processing of the data for 1981-1983
Sept. 1988:	Fourth planning meeting on WCP-Water in Paris
14 Nov. 1988:	Official inauguration of the GRDC at the BfG
10 - 15 Nov. 1988:	Workshop "Global Runoff Data Set and Grid Estimation" in Koblenz
May 1990:	Fifth planning meeting on WCP-Water in Laxenburg, Projects A.8 (Detecting global and regional runoff trends by monitoring discharges of selected rivers) and A.9 (Monitoring changes in the characteristics of extreme hydrological events) were established
June 1990:	Request of data for years 1984-1988 by WMO
15 - 17 June 1992:	Workshop "Global Runoff Data Centre" in Koblenz

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WMO (1990b): Global Runoff Data Centre, WCP Newsletter No. 11, p.6, Geneva

WMO-PROJECTS AND OTHER INTERNATIONAL PROJECTS AND PROGRAMMES

APPENDIX D

WCP-Water Project A.2 - Analyzing Long-time Series of Hydrological Data and Indices with Respect to Climate Variability and Change

The major activity within this project is to undertake a comparative analysis of long-time series of hydrological and related data with respect to variability in time and in space. In accordance with the priorities specified in WCAP Report No. 3 work will be concentrated at first on river discharge and lake level data. The report describes the statistical parameters to be obtained and methodology to be used in the initial phase of the project.

To date, a total of nearly 230 time series of hydrological data or results of analyses have been submitted by WMO Members, entered into a computer and compiled into a project data base with the aid of the system used by the Global Runoff Data Centre (GRDC) in Koblenz, Germany. These data are being analyzed by the Polish Academy of Sciences. A summary and a review of results of these analysis will be published in an IIASA series report by June/July 1992

WCP-Water Project A.8 - Detecting Global and Regional Runoff Trends by Monitoring Discharge of Selected Rivers

This new project was proposed in order to enable early recognition of possible changes in river runoff due to expected change in climate. The project would be based on continuous monitoring of the limited number of selected large rivers of the world and a regular analysis of the data available. Responsibility for the project is with GRDC and the WMO Secretariat. The project has close reference to GEMS/WATER, GCOS and GEF projects.

An initial selection of approximately 40 stations was prepared by GRDC in 1990. The selection should be reviewed with other international organizations in the light of other international programmes. The next steps in the implementation of this project should include establishing a procedure for routine collection of specified data and preparing a suitable technology for regular analysis.

Stations for this purpose should be selected on the basis of the following criteria:

1. Stations of rivers with the largest flows near to the ocean (15 stations)

2. Stations with long records and reliable data (additional 30 stations)

WCP-Water Project A.9 - Monitoring Changes in the Characteristics of Extreme Hydrological Events (Floods and Droughts)

This project which is to be exhausted by UNESCO within the framework of IHP-Project H-2-3 has close relevance to the WCP-Water Project A.2 in its aim to develop approaches to the problem of detecting changes in the statistical characteristics of extreme hydrological events.

In the first step of the project available data on floods and droughts are to be collected, updated and unified. The initial analysis should be made by existing simple empirical methods. Later on in the project the necessary methods for statistical analysis for comprehensive studies should be developed which recognize the existence of non-stationarity.

WCP-Water Project B.3 - Development of Grid-related Estimates of Hydrological Variables

The project aims to develop a methodology for transfering information from hydrological stations to grid points or areas. Such a methodology is required for making use of information on observed streamflow in the development and use of General Circulation Models (GCMs) and for developing grid-based hydrological models (see WCP-Water Project B.1). The use and integration of remote sensing information also needs to be considered in this context. This project is seen as providing direct support to the WMO Global Energy and Water Cycle Experiment (GEWEX).

A project to calculate grid-related estimates of runoff over Central Europe is to be undertaken in three phases. In Phase I, each participating institution applied the methodology to data from their own country and prepared a technical which included:

- the experiences in applying the methodology;
- comments on the methodology; and
- proposals for improvements or for alternative methodologies.

In order to discuss the results, a meeting was held in April 1992. In this meeting it was proposed to use an approach with three stages in Phase II:

(i) use of only observed runoff data;
(ii) use of emperical-statistical relationships between physiographic characteristics (such as elevation) and runoff;
(iii) use of (ii) and hydrometeorological characteristics.

This approach should be applied for initial basins selected by each participating institution. Phase III will be the application of the finally agreed methodology throughout the whole project region.

GEMS/WATER

GRDC has agreed to participate in GEMS/WATER by providing selected flow data from its data base to the GEMS/WATER global data bank held at the WHO Collaborating Centre for Surface and Ground Water Quality in Canada.
The collaboration process calls for GRDC to provide GEMS/WATER with a synopsis of data records for use during the current GEMS/WATER country missions (1991-92). These missions are being organized by WHO with the aim of introducing Phase Two of the programme to participating countries and to discuss the planning and implementation of the expanded GEMS/WATER monitoring network. The countries were to be requested to make available their water quality data to the GEMS/WATER data base and water quantity data to GRDC.

The collaborations has been formalized by the signing of a letter of agreement between WHO and GRDC.

Other international projects and programmes

At the international level, it is relevant to quote the call made by the International Conference on Water and the Environment (Dublin, January 1992) for the exchange of data on the hydrological cycle on global scale and to take note of the relevant outcome of the UN Conference on Environment and Development (Rio de Janeiro, June 1992).
Within Europe, reference may be made to the European Environmental Agency, now being established by the European Community, and to its potential interest in the compilation and analysis of hydrological data from the European region.

Global Environment Facility

The Global Environment Facility (GEF) is a three-year pilot programme providing grants and low interest loans to developing countries to help them carry out programmes to relieve pressures on global ecosystems. The billion-dollar-plus fund supports internaional environmental management and the transfer of environmental technologies. The facility is a co-operative venture among national governments, the World Bank, the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

The GEF was established by representatives of a group of industrialized and developing countries in Paris in November 1990. The first projects are set to begin in mid-1991.

The goals which the GEF is established to address are all critical to the management of emerging planetary problems. They include:

- Reducing and limiting emission of greenhouse gases which cause global warming;

- Preserving the earth's biological diversity and maintaining natural habitats;
- Arresting the pollution of international waters;
- Protecting the ozone layer from further depletion.

UNEP/GRID

Following the initial contact made in October 1989 by GRDC with UNEP/GRID, the co-operation which was suggested between the two centres has been encouraged in October 1990 by the UNEP Office of the Environment Programme in Nairobi.

The exchange of flow data and of relevant digitized catchment boundaries is the main interest of the two centres. The detailed specific programme of the exchange of such information should be initiated by the centres concerned.

International Hydrological Programme of UNESCO

GRDC included in its database monthly data up to 1984 which were published by UNESCO in the "Discharge of Selected Rivers of the World". Co-operation with UNESCO's Division of Water Sciences was established during the past years.

In 1991 special efforts were made for preparation of a catalogue of flows for African rivers. In addition, the data for the period 1965-1984 were prepared for publishing in one volume.

Schedule of Future Activities
(as proposed by the Second Workshop on the Global Runoff Data Centre, 15 - 17 June 1992, Koblenz, Germany)

Activity	Responsible	Target date
1 ANNOUNCEMENT OF GRDC		
1.1 Update of leaflet	GRDC	December 1992
1.2 Report of the Workshop	GRDC	End of July 1992 (first draft)
1.3 Annual Status Report	GRDC	Annualy in December
2 GLOBAL DATA SET		
2.1 Letter to donor countries with report of the workshop	GRDC	End of October 1992
3 GLOBAL RUNOFF GRID CELL DATA		
3.1 Collection of additional data	GRDC/WMO	December 1992
3.2 Annual progress report		Annualy in December
4 GRDC PLANNING AND MANAGEMENT		
4.1 Regular review of GRDC activities and plans to international organizations and supports	GRDC	Annualy in December
4.2 Workshop to review and advise on GRDC activities	WMO/GRDC	Every 3 or 4 years (next workshop in 1995/1996)
4.3 Steering Committee for GRDC	WMO/GRDC	1993

LIST OF ABBREVIATIONS

BAHC	-	Biospheric Aspects of the Hydrological Cycle
BALTEX	-	Baltic Sea Experiment
FAO	-	Food and Agriculture Organization of the United Nations
FGGE	-	First GARP Global Experiment
FRIEND	-	Flow Regimes of International Experimental and Network Data
GARP	-	Global Atmospheric Research Programme
GCM	-	General Circulation Model
GCOS	-	Global Climate Observing System
GEF	-	Global Environment Facility
GEMS	-	Global Environmental Monitoring System
GEWEX	-	Global Energy and Water Cycle Experiment
GIS		Geographic Information System
GPCC	-	Global Precipitation Climatology Centre
GRDC	-	Global Runoff Data Centre
GRID	-	Global Resource Information Database
HAPEX	-	Hydrological-Atmospheric Pilot Experiment
HWR	-	Hydrology and Water Resources Department (WMO)
ICSU	-	International Council of Scientific Unions
IDNDR	-	International Decade of Nature Desaster Reduction
IGBP	-	International Geosphere and Biosphere Programme
IHP		International Hydrological Programme
IIASA	-	International Institute for Applied Systems Analysis
LfBAM	-	Lehrstuhl für Bioklimatologie und Angewandte Meteorologie, Universität München
NCAR	-	National Center of Atmospheric Research, Boulder, USA
NWRI	-	National Water Research Institute, Burlington, Canada
OHP	-	Operational Hydrological Programme
ORSTOM	-	Office de la Recherche Scientifique et Technique Outre-Mèr (Institut français de Recherche Scientifique de développment en coopération)
RAISON	-	Regional Analysis by Intelligent Systems on a Microcomputer
UNDP	-	United Nations Development Programme
UNEP	-	United Nations Environment Programme
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
WCP	-	World Climate Programme
WCRP	-	World Climate Research Programme
WHO	-	World Health Organization
WMO	-	World Meteorological Organization

FIGURES

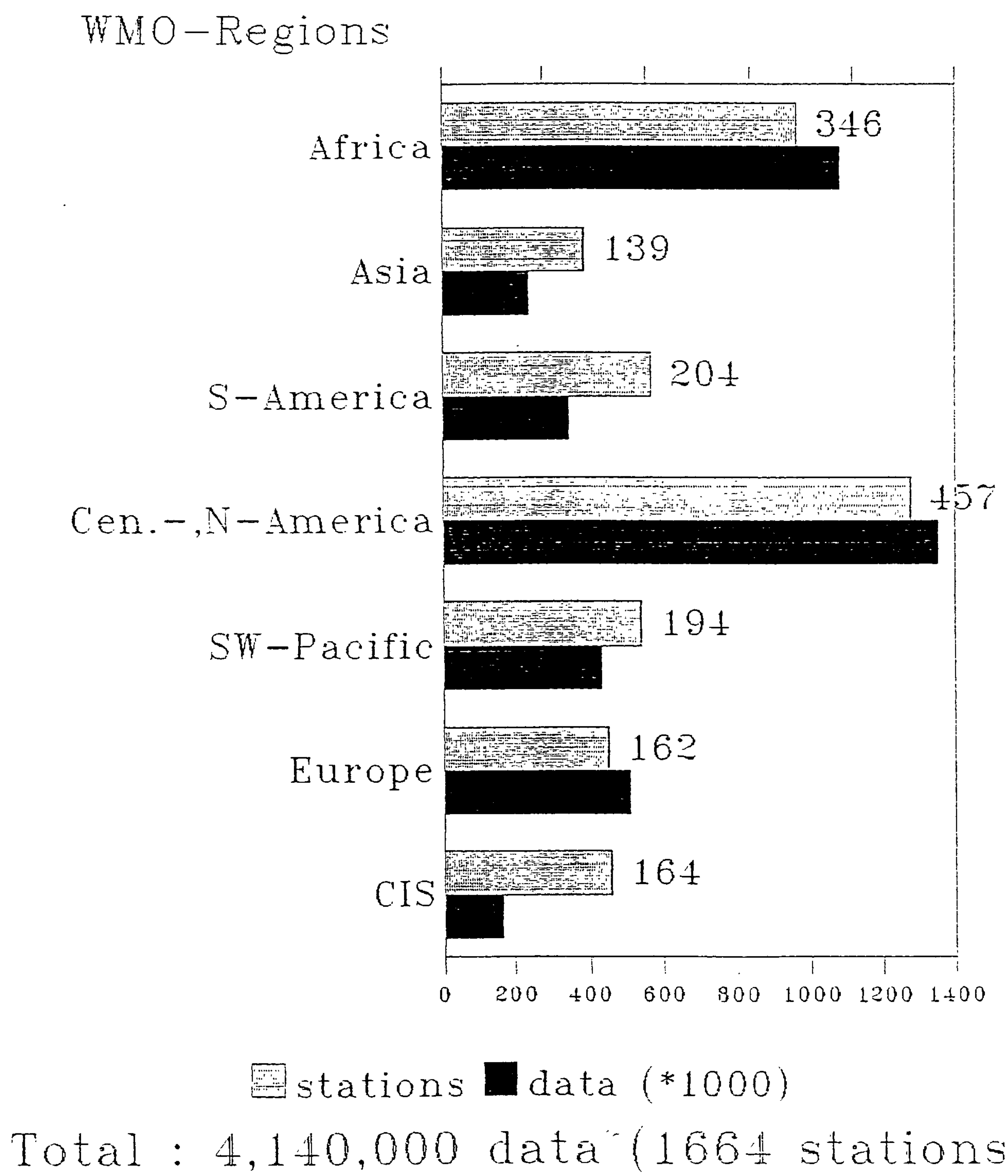

Figure 1: Data by WMO - Regions (daily)

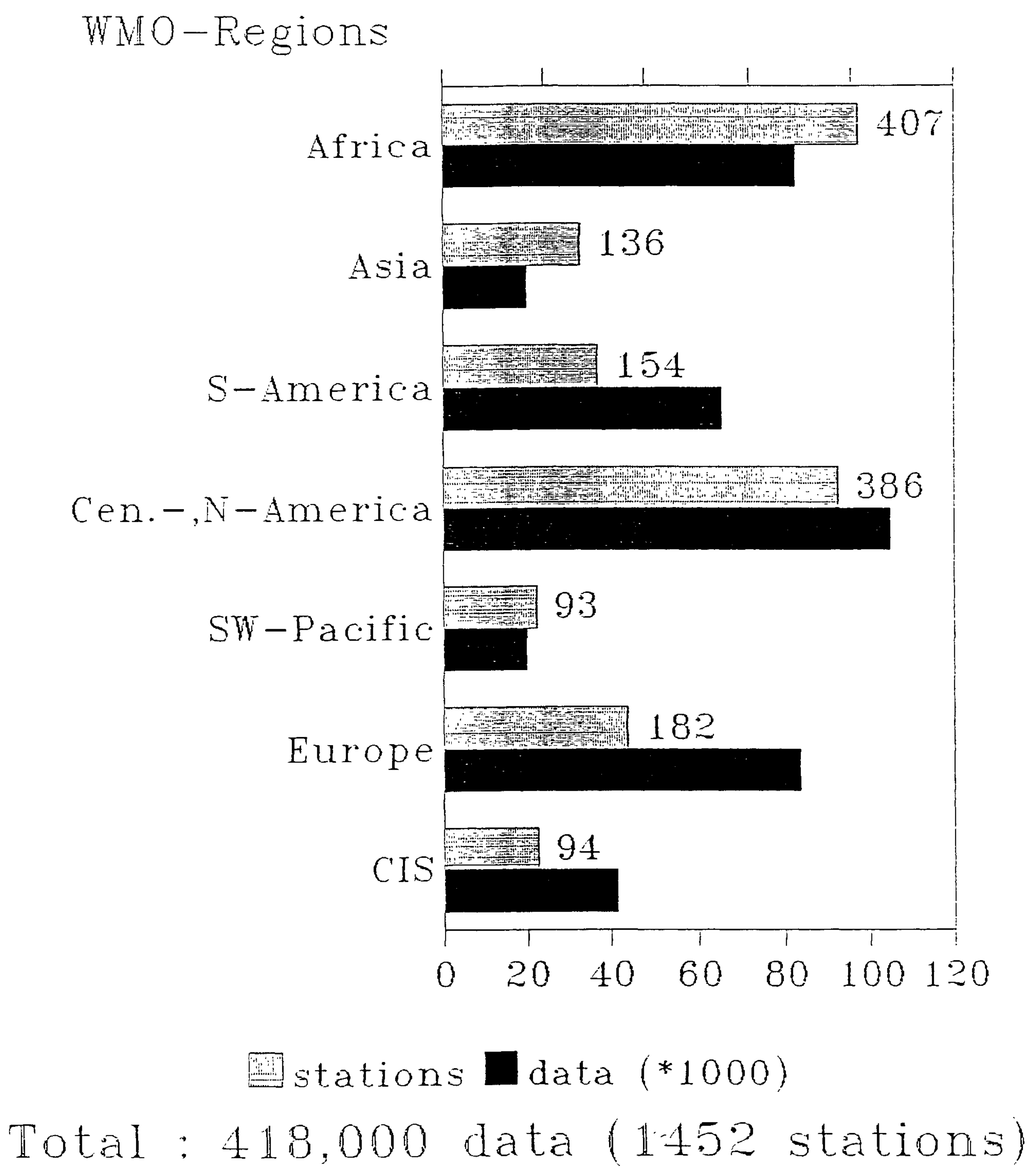

Figure 2: Data by WMO - Regions (monthly)

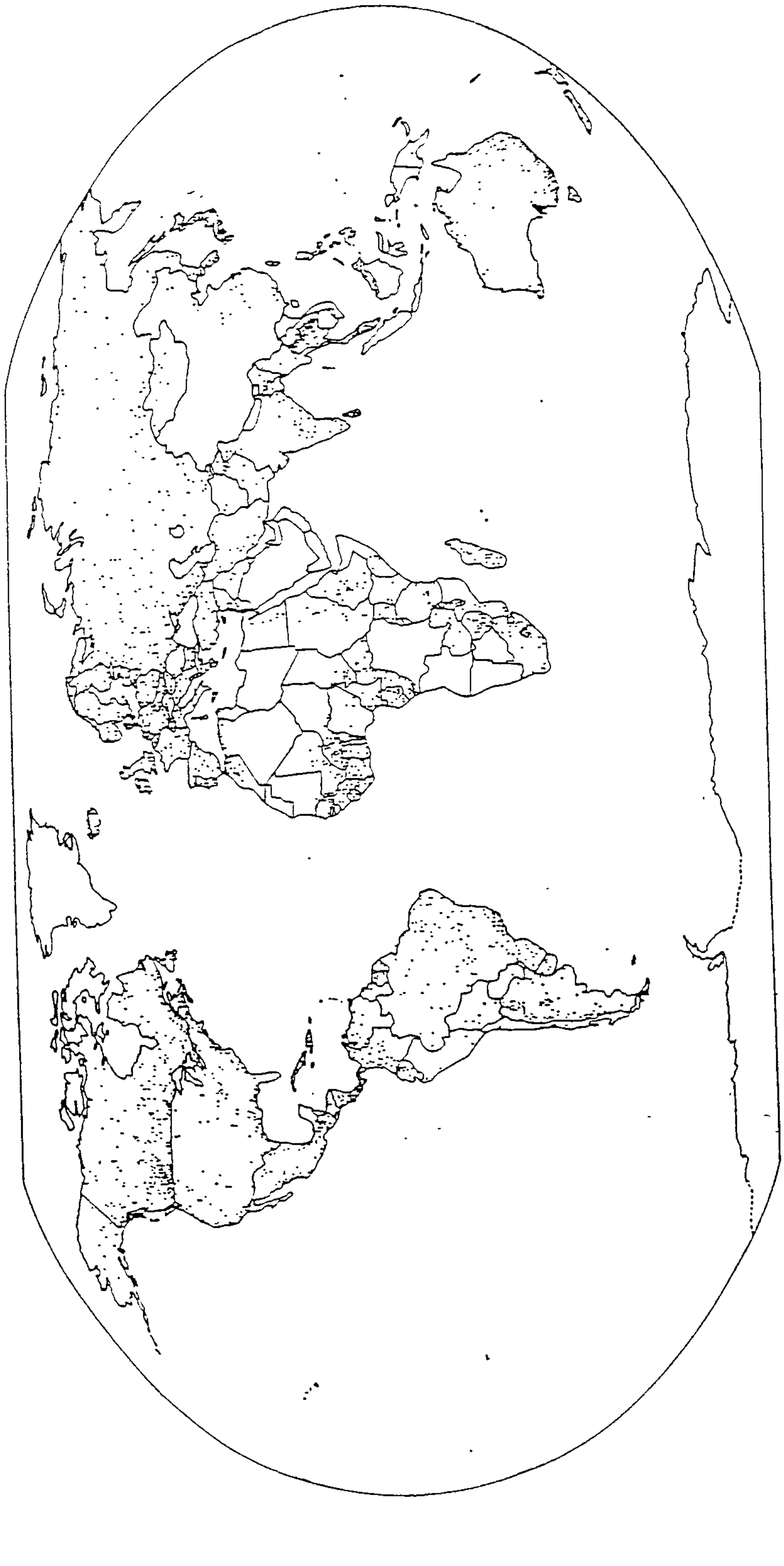

Figure 3: Network of Stations 1991

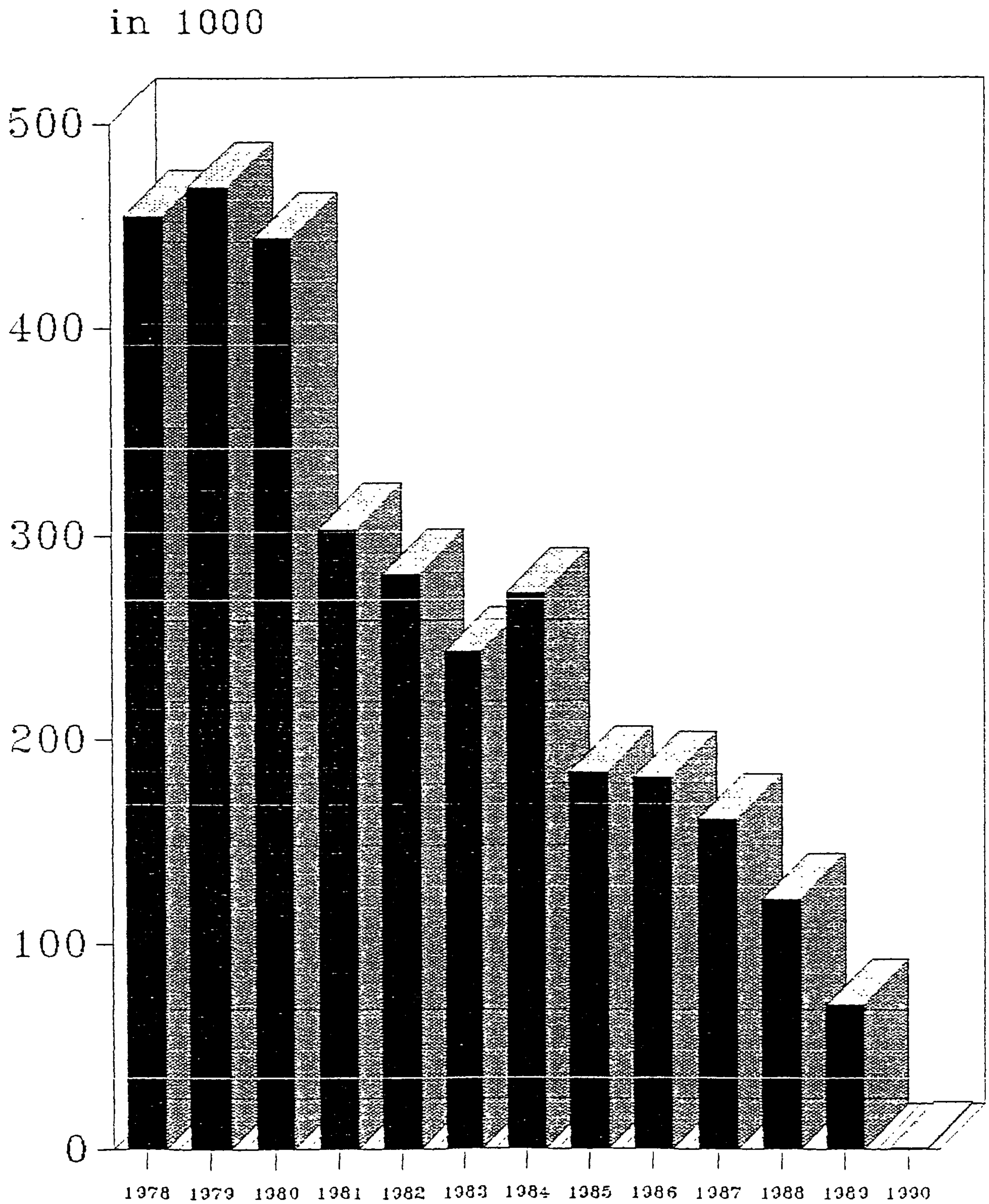

Figure 4: Data for Period 1978 - 1990 (daily)

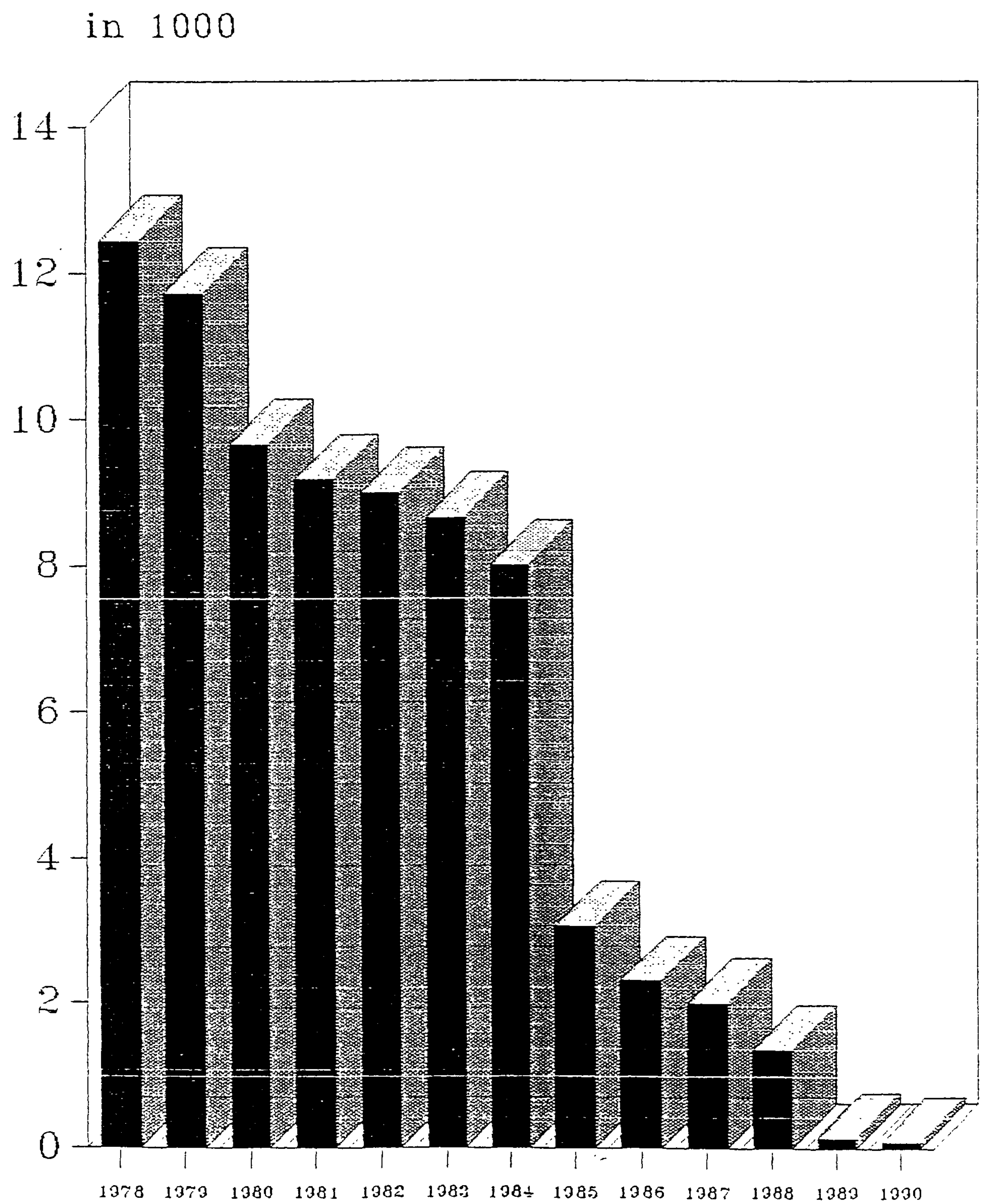

Figure 5: Data for Period 1978 - 1990 (monthly)

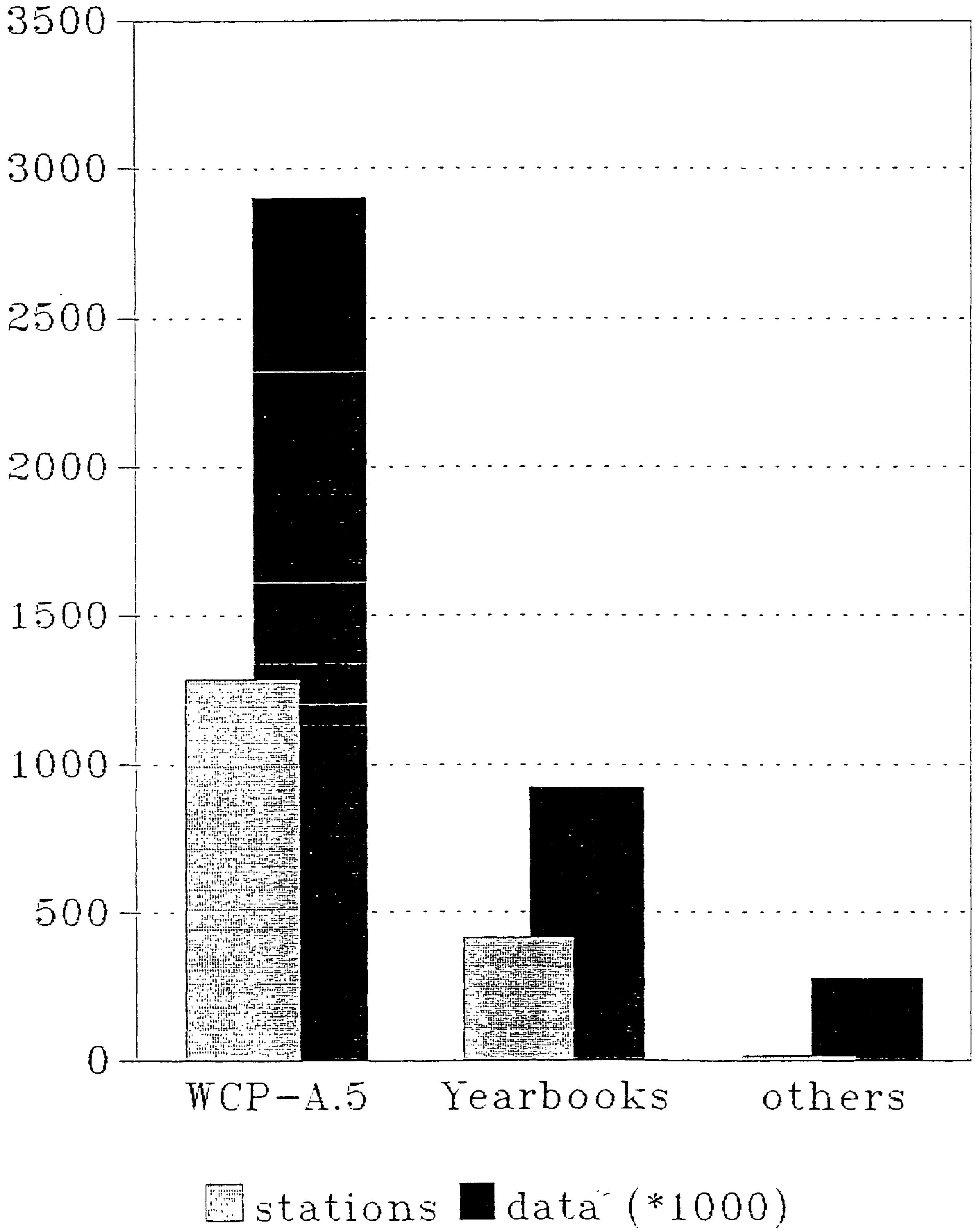

Figure 6: Data Sources (daily)

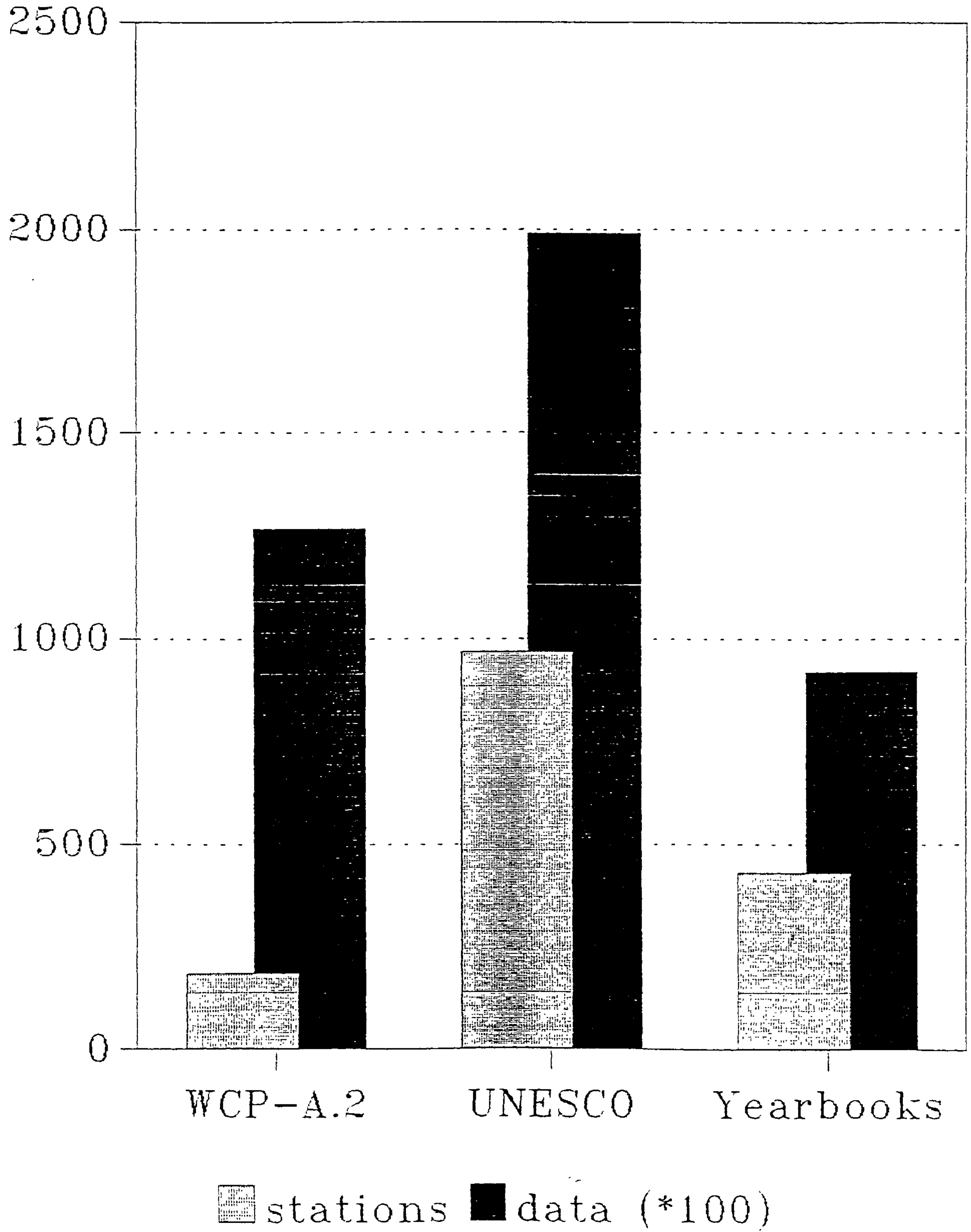

Figure 7: Data Sources (monthly)

GLOBAL RUNOFF DATA CENTRE (GRDC) - CATALOGUE

1. Africa (Region)

01 Medjerda (Subregion)

A	B	C	D	E	F	G	H	I	K	L
1201100	Medjerda	Ghardimaou	TS	3627N	843E	1480	1 1976	12 1979	M	1
1201150	Mellegue	KJ3	TS	3612N	850E	9000	1 1976	12 1979	M	1
1201500	Medjerda	Sloughia	TS	3658N	952E	20895	1 1976	12 1979	M	1
02	Chott Melhir, Chott Rharsa									
03	Chott Djerid									
04	Mediterranean Sea Coast (Western Part)									
1104150	Cheliff	Sidi Belatar	AL	3602N	027E	43750	1 1976	8 1978	M	1
1104200	Mina	Oued El-Abtal	AL	3550N	068E	6635	1 1976	8 1978	M	1
1104300	Rhiou	Ammi Moussa	AL	3587N	112E	2398	1 1976	12 1979	M	1
1104450	Mazafran	Fer a Cheval	AL	3667N	282E	1912	1 1976	8 1979	M	1
1104480	Boudouaou	Keddara	AL	3665N	342E	829	1 1976	8 1979	M	1
1104500	Isser	Lakhdaria	AL	3662N	358E	4149	1 1976	8 1979	M	1
1104530	Sebaou	Baghlia	AL	3680N	387E	2501	1 1976	12 1979	M	1
1104600	Bouselam	Sidi Yahia	AL	3642N	460E	4309	1 1976	8 1978	M	1
1104700	Rhumel	Oued Athmania	AL	3623N	630E	1220	1 1976	8 1978	M	1
1104800	Melah	Bouchegouf	AL	3645N	772E	552	1 1976	8 1978	M	1
1204900	Joumine	Djebel Antra	TS	3695N	947E	235	1 1976	12 1979	M	1
1304100	Emsa	Emsa	MC	3552N	530W	110	4 1971	2 1988	D	1
1304800	Kert	Dar Driouch	MC	3490N	329W	1353	6 1969	9 1987	D	1

COMMENT

A = GRDC-Code
B = River
C = Station
D = Code of country
E = Latitude
F = Longitude
G = Catchment area (km2)
H = Begin of observation data
I = End of observation data
K = Kind of data (M = Monthly data, D = Daily data)
L = Code of measurement

Figure 8

GLOBAL RUNOFF DATA CENTRE (GRDC)

River : DYLE
Station : SINT-JORIS-WEERT
Country : BELGIUM

Catchment Area : 645.0 km**2
Geographic location : 50 80 N 4 63 E
WMO Basin No :

1981 RUNOFF (M**3/S) 1981

Day	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.28	7.03	6.89	5.44	5.27	8.14	4.50	5.34	3.38	3.85	7.13	15.3
2	5.81	6.92	5.09	5.35	5.05	10.4	4.83	7.47	3.19	3.84	6.55	8.90
3	12.6	8.32	5.05	5.27	5.19	12.6	5.09	4.88	3.74	4.45	5.94	7.14
4	10.5	9.80	5.63	4.85	5.40	14.5	5.21	4.06	3.34	4.08	5.55	8.84
5	8.11	9.43	4.76	4.34	5.53	7.63	5.16	3.98	3.35	3.78	5.37	13.0
6	8.55	8.53	4.66	3.91	5.27	5.54	5.09	3.81	3.25	4.88	5.26	11.7
7	9.04	7.83	4.95	4.24	4.94	5.18	5.03	4.81	3.23	7.22	4.71	11.4
8	8.03	7.59	4.85	4.79	5.10	4.79	4.95	4.11	3.35	4.80	4.79	14.5
9	7.41	7.32	6.40	4.77	6.86	4.43	4.93	3.83	3.58	4.49	4.42	14.3
10	10.2	7.11	15.2	4.65	6.71	4.09	4.93	4.00	3.47	5.18	4.64	9.88
11	7.45	6.98	11.7	4.56	6.19	3.81	4.88	4.17	3.35	6.32	4.89	11.2
12	6.21	6.89	7.57	4.57	5.69	3.79	4.88	3.79	3.54	5.28	4.98	11.7
13	6.62	6.83	6.50	4.57	5.17	3.77	4.80	3.87	3.93	5.61	4.77	8.52
14	8.36	6.69	10.4	4.57	4.66	3.71	4.74	3.66	4.56	4.64	4.66	9.47
15	21.6	6.50	8.44	4.57	4.43	3.62	4.74	3.72	5.05	5.24	4.66	15.4
16	18.2	6.32	6.40	4.39	4.32	3.26	4.30	3.59	4.39	5.27	4.56	10.1
17	14.2	6.27	6.40	4.21	4.28	2.86	3.80	3.61	3.80	4.47	4.82	7.43
18	11.5	6.22	6.21	4.08	4.21	2.46	3.79	3.54	3.79	6.84	4.71	6.60
19	9.82	6.15	6.60	4.11	4.28	2.62	3.76	3.48	4.44	5.21	7.92	6.17
20	9.30	6.11	5.24	4.19	4.27	2.96	3.73	5.30	7.16	9.80	6.04	5.81
21	8.85	6.05	4.85	4.27	4.37	3.31	3.75	4.61	8.77	9.43	6.34	6.06
22	8.69	5.96	4.85	4.35	5.72	3.50	3.78	3.75	6.25	6.29	6.31	6.21
23	8.64	6.02	5.05	4.34	5.53	3.45	3.70	3.65	5.21	8.33	5.59	6.31
24	8.60	5.92	5.13	4.60	5.53	3.42	3.67	3.41	4.35	6.11	5.69	6.21
25	8.49	5.92	5.17	5.67	5.24	3.41	3.94	3.64	4.20	5.74	5.05	6.12
26	8.24	5.92	5.21	6.80	5.14	3.46	3.78	3.57	4.12	8.15	4.83	5.88
27	8.68	5.92	5.22	7.62	4.74	3.65	3.77	3.46	4.02	7.62	6.76	5.74
28	8.73	6.02	5.23	6.96	4.65	3.67	3.76	3.53	3.81	5.82	11.4	5.57
29	8.21		5.32	6.10	4.57	3.83	3.73	3.50	3.81	8.41	11.2	6.90
30	7.65		5.33	5.63	4.50	4.15	3.62	3.42	3.82	8.77	11.0	7.90
31	7.21		5.39		5.86		3.73	3.36		7.98		13.2
Mean	9.38	6.88	6.31	4.93	5.12	4.87	4.33	4.03	4.21	6.06	6.02	9.14

Mean	Jan.-June	6.25	July-Dec.	5.64	Year	5.94

Figure 9

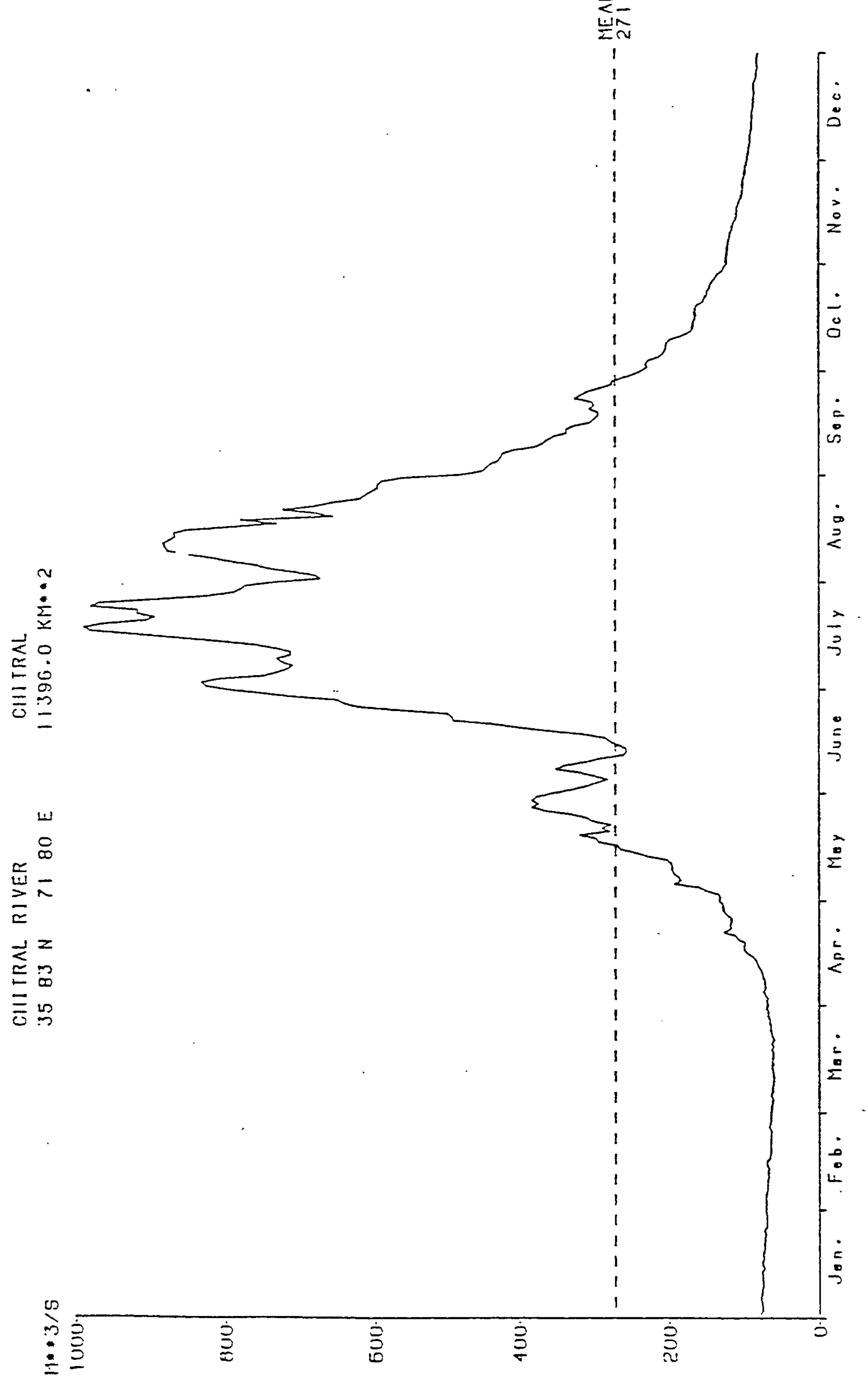

Figure 10: Mean Daily Discharge 1981

GLOBAL RUNOFF DATA CENTRE (GRDC)

River : DYLE
Station : SINT-JORIS-WEERT
Country : BELGIUM

Catchment Area : 645.0 km**2
Geographic Location : 50 80 N 4 63 E
WMO Basin No :

MEAN FLOW (M**3/S)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	J-J	J-D	Year
1978	4.08	4.14	4.43	3.67	5.30	3.46	3.49	2.75	2.67	2.88	2.96	4.23	4.18	3.16	3.67
1979	4.29	5.34	6.16	4.29	3.93	3.35	2.63	3.14	2.82	3.18	4.59	5.82	4.56	3.70	4.13
1980	5.06	5.42	4.56	4.90	4.10	3.69	7.52	3.56	3.23	3.95	4.15	5.63	4.62	4.67	4.65
1981	9.38	6.88	6.31	4.93	5.12	4.87	4.33	4.03	4.21	6.06	6.02	9.14	6.25	5.63	5.94
1982	M	5.61	6.38	5.42	5.42	4.99	3.99	4.17	3.96	6.48	5.54	7.01	M	5.19	M
1978-1982	M	5.48	5.57	4.64	4.77	4.07	4.39	3.53	3.36	4.51	4.65	6.37	M	4.47	M

Figure 11

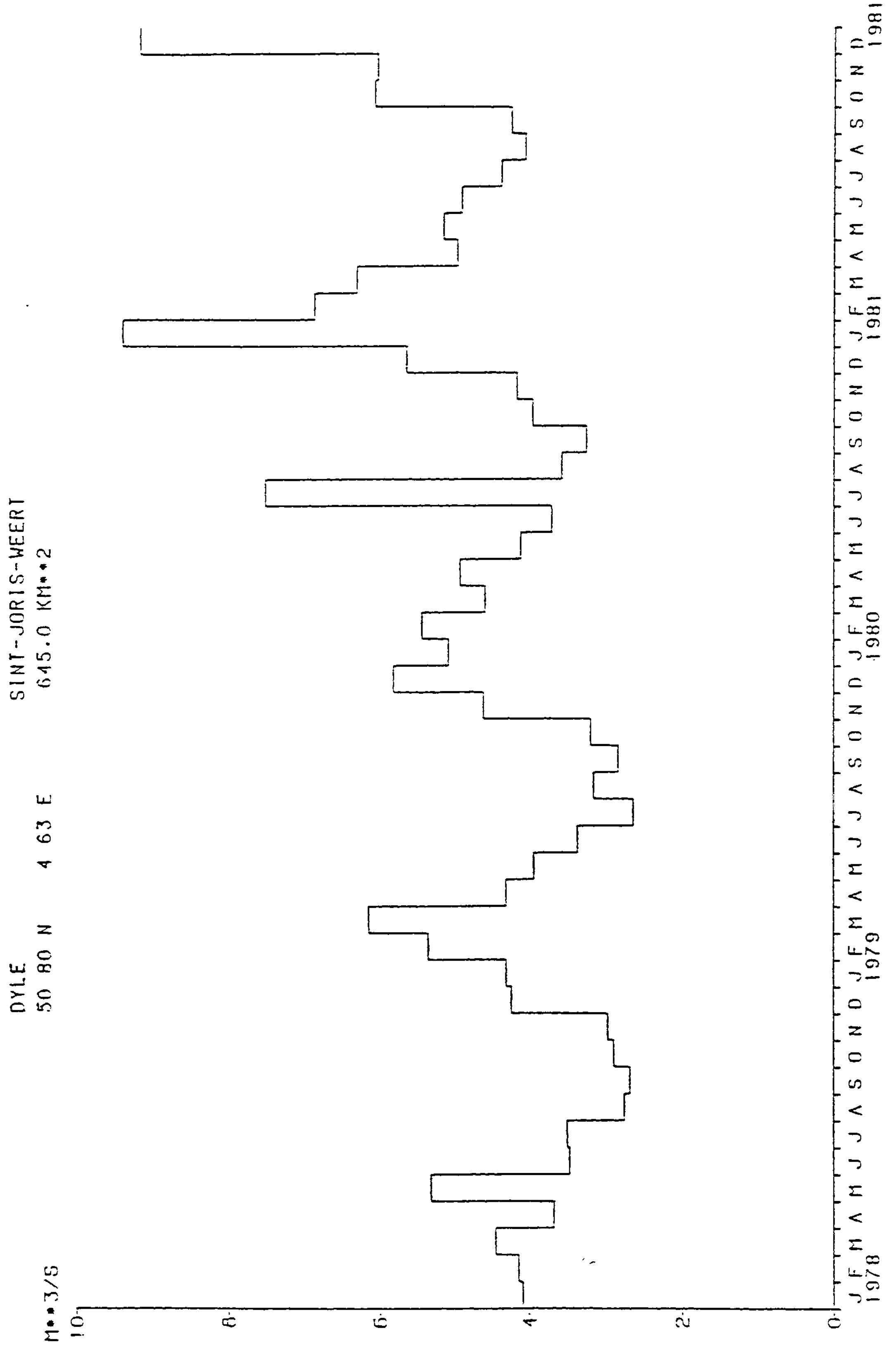

Figure 12: Mean Monthly Discharge 1978 / 81

GLOBAL RUNOFF DATA CENTRE (GRDC)

River : DYLE
Station : SINT-JORIS-WEERT
Country : BELGIUM

Catchment Area : 645.0 km**2
Geographic Location : 50 80 N 4 63 E
WMO Basin No :

FLOW DURATION TABLE 1981/1983

(1 DAY MEAN FLOW IN M**3/S FOR GIVEN PERCENTAGE OF TIME)

	0	1	2	3	4	5	6	7	8	9
0		3.33	3.43	3.50	3.55	3.61	3.65	3.69	3.72	3.75
10	3.78	3.81	3.84	3.88	3.91	3.95	[illegible]	4.03	4.06	4.10
20	4.14	4.19	4.22	4.25	4.27	4.30	[illegible]	4.37	4.40	4.44
30	4.49	4.52	4.55	4.58	4.61	4.65	4.69	4.73	4.76	4.80
40	4.83	4.85	4.88	4.91	4.95	4.99	5.02	5.05	5.09	5.13
50	5.17	5.21	5.24	5.27	5.30	5.35	5.40	5.45	5.50	5.54
60	5.59	5.63	5.66	5.70	5.76	5.82	5.87	5.92	5.96	6.01
70	6.06	6.11	6.15	6.19	6.24	6.30	6.37	6.49	6.61	6.68
80	6.76	6.85	6.97	7.07	7.17	7.31	7.47	7.62	7.77	7.94
90	8.16	8.33	8.55	8.77	8.97	9.45	9.92	10.4	11.6	14.3

NUMBER OF VALUES USED : 1095

FIRST MONTH USED: 1

Figure 13

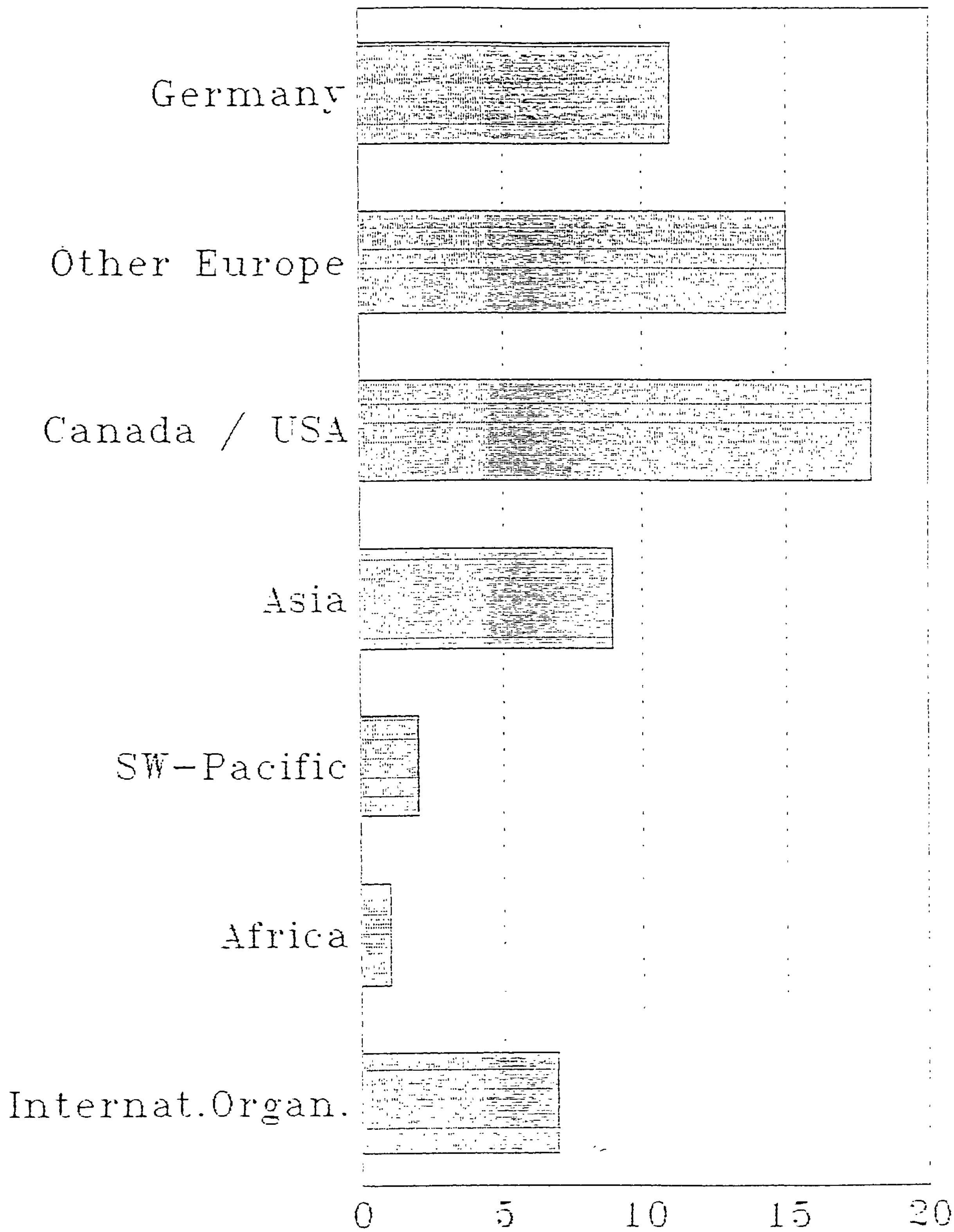

Figure 14: Origin of Data Requests

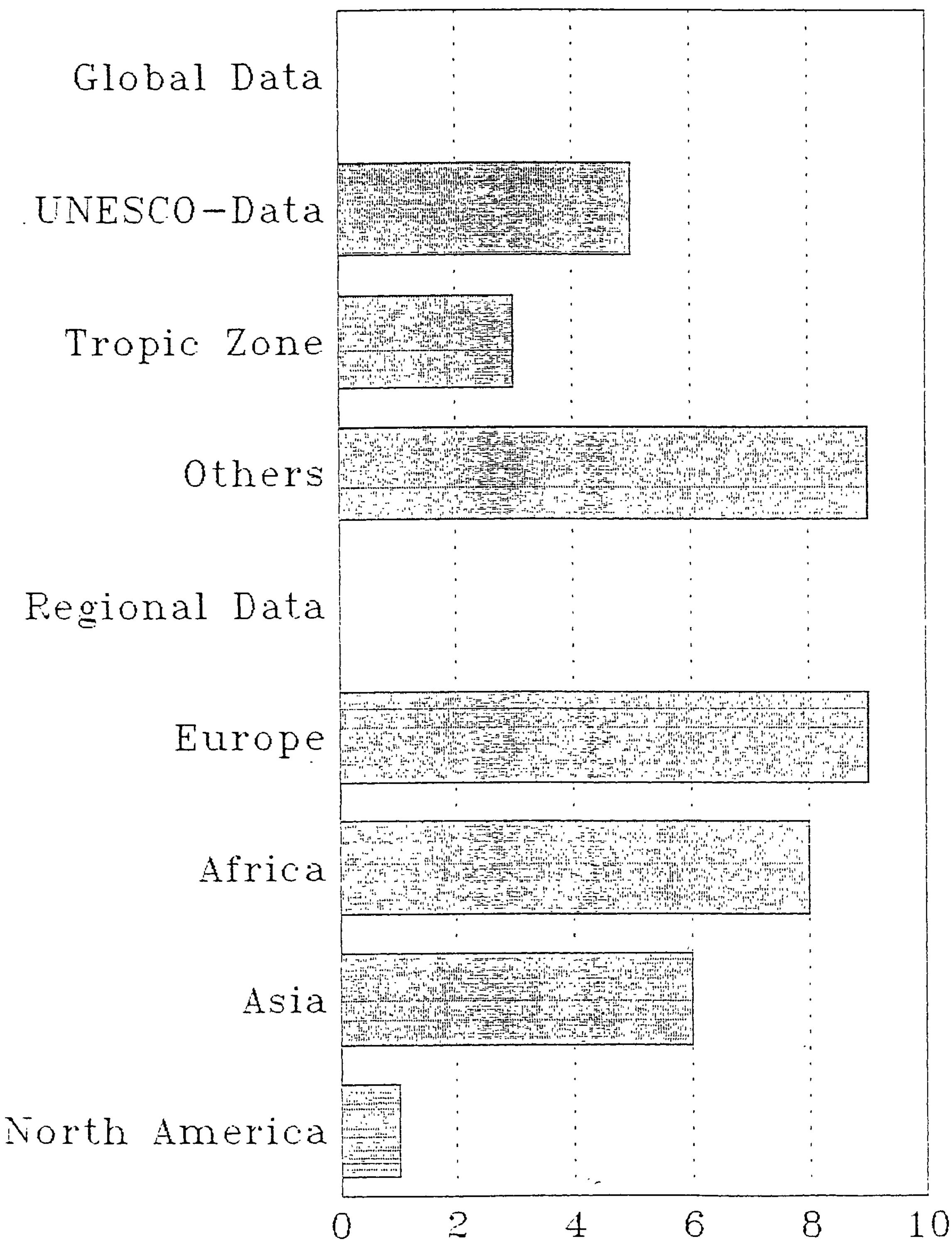

Figure 15: Origin of Requested Data

Figure 16: WMO-Region I Africa. Distribution of river and lake basins

REPORTS BY THE WORKSHOP PARTICIPANTS APPENDIX H

1. Principles and State of the Art
   G. C. Wollenweber

2. Runoff Data Sets at State Hydrological Institute
   I. A. Shiklomanov

3. The FRIEND Project
   Nigel Arnell

4. Data Available from National Center of Atmospheric Research (NCAR)
   Roy Jenne

5. The Global Precipitation Climatology Centre (GPCC) - Status June 1992
   Bruno Rudolf

6. Review of the GEMS/RAISON Software
   Ulrich Schröder

7. The BAHC Project - An Established Core Project of the IGBP
   E. Lahmer-Naim

8. Overview of WCRP with an Emphasis on GEWEX
   S. Benedict

Principles and State of the Art

by G.C. Wollenweber

I Introduction

The components of the water cycle are important links in the climate system between atmosphere, ocean and land surfaces. If they are not well described in General Circulation Models (GCM), the effect of global warming may be calculated not adequately. Flohn (1992) estimates an error of about 20% in atmospheric parameters because of poor modelling of the water cycle. For validation of GCM, of macro- and mesoscale models, for water management problems and for comparison with interpolated precipitation data especially in mountainous areas grid based runoff data have to be known. Techniques have to be developed to transfer hydrological data from gauging stations to regions without data. To suite different models two grid sizes will be used. A $0.5^{o}*0.5^{o}$ grid for fine mesh models and a $2.5^{o} * 2.5^{o}$ degree grid for coarse resolution models.

A comparison of grid based runoff data with the results of models leads to the question of accuracy. Are the differences mainly produced by the interpolation procedure or by the model itself. In GCM runoff is calculated on a global scale. Effects of time-lag between rainfall and runoff in different catchment areas can not be included. In addition the area covered by the grid boxes of models features in many cases a lot of heterogeneity and topographical differences. On the other hand the important evapotranspiration depends on meteorological parameters, vegetation, land use, soil water content,.. So, can such a variability be included in the gridding procedures?

Variabilities in density of runoff values, in data quality, in human activities and its influence on runoff production or even in the scales of problems to be solved ask for different methods. The results of these techniques have be compared with one another and with data not included in the development of the methods. If runoff data will be used for validation purposes of GCM models, it should be differentiated between methods with and without climatological data.

This contribution will concentrate on three algorithms for calculating grid based runoff data.

- weighted average,
  * with weights depending on the size of drainage area and of grid cell
  * which is based on point measurements
- multiple regression
- modelling the water balance

First a description and some applications of Liebscher´s proposal (1990) will be given. The algorithm is a weighted average, with weights based on the size of grid cell and parts of the drainage area. Some techniques, which are founded on point measurements, as e.g. Kriging and Quadrant were tested by Schwarzmaier et al. (1991). Empirical relations between runoff and characteristics of the drainage area and climatological parameters are discussed in Chapter II.3. In this multiple regression technique parameters modifying runoff can be included as independent parameters. The last chapter includes a description of water balance models with increasing degree of accuracy. Only in this algorithm, physical processes of runoff production can be considered explicitly. The influence of changes of land use, vegetation and / or irrigation can be included. Climatological parameters as e.g. precipitation and temperature have to be known. Up to now Arnell (1991) and Schwarzmaier et al. (1991) compared the results of some methods. A comparison between point- and area-related techniques is missing.

II Methods of runoff evaluation

II.1 Weighted averages

In contrast to rainfall or evapotranspiration, runoff represents an area integrated value and not a point measurement. Liebscher (1990) proposed the calculation of runoff on grid points by means of weighted averages. Two categories are to be distinguished. First, it is assumed, that at least one entire catchment area (A_{ci}) is within the grid cell (A_{Gj}) (Fig. 1). The estimated grid based runoff (Q_{Gj}) can be calculated from all measured runoff (Q_{ci}) values situated in the grid cell as a weighted average. The weighting factor a_i describes the influence of basin A_{ci} on the grid cell.

$$Q_{Gj} = \frac{1}{A_{Gj}} * \sum_{i=1}^{n} a_i * A_{ci} * Q_{ci}$$

$$A_{Gj} = \sum_{i=1}^{n} a_i * A_{ci}$$

In the second case one catchment covers more than one grid cell (Fig. 2). A disaggregation of the catchment based runoff has to be made. The grid based runoff (Q_{Gj}) is found by the interpolation of runoff of one catchment and the ratio of grid area to the relevant catchment area.

$$Q_{Gj} = a_j * \frac{A_{Gj}}{A_{ci}} * Q_{ci}$$

In almost homogeneous flatland areas the weighting factor a_j can be assumed to be 1. In mountainous areas a_j should be estimated from runoff studies of small drainage areas in comparison with downstream measurements on larger water courses. The main problem is to find realistic weights for each single grid cell. Since runoff measurements for each single grid cell are not available in most cases, a weighting scheme solely based on runoff data can not consider the real variability of runoff. Further information about grid cell characteristics has to be added to the algorithm. In case that parameters like rainfall, temperature or evapotranspiration are included the results will provide data for the validation of GCM, which are dependent on climatological parameters.

Predeek and Isele (1992) calculated runoff for the lowland river Aller and the mountain river Isar. They divided the area of the grid cell according to the size of the catchments included. Assuming a constant runoff value over each entire subgrid area the grid based runoff was calculated as weighted average. A comparison of the sum of all grid cell runoffs belonging to the same catchment with measurements at each river's mouth showed that calculations underestimated measurements. For the Aller annual differences deviated by less then 7%. The differences for the Isar showed an underestimation of about 8% at the average. If the subcatchments of the Isar are included, the error yielded to a lower annual value (1% - 2%).

Schädler (1992) calculated daily runoff for those parts of Switzerland, belonging to the Rhine catchment. Since most of his data were collected in the mountains, he divided the grid cell and the catchments into classes which covered a predetermined altitude range. The relative size of the horizontal area of a each elevation class determined the interpolation weight. Cross-validation was done for grid cells covering several catchments. Even in the case of a good agreement between the altitude distribution of the grid cell and the catchments the results overestimated the measurements within most cases. An average difference between measurements and calculations was not derived.

Gilyén-Hofer (1992) explicitly considered drainage areas with missing measurements in the algorithm. The calculations were done for annual averages of runoff of the Northern Mountains of Hungary. Starting with the case that one catchment coverd several grid cells, the grid based flow was determined by a first guess of runoff formulated in terms of a linear three term regression, multiplied by the grid area and by the ratio of observed and assessed total catchment runoff. For the case, that one grid cell coverd several catchments, the grid area was divided into three contributions:

- at least one drainage basin belonged entirely to one grid cell
- drainage areas belonging to several grid cells
- drainage area with missing runoff data.

Runoff of areas with missing measurements was determined by a three term linear regression, assuming a constant ratio between measured and calculated values of runoff for catchments belonging entirely to the same grid cell. This contribution had to be added to the runoff of the other drainage areas belonging at least partly to the grid cell under consideration.

Arnell (1992) used measured or interpolated values of rainfall to disaggregate runoff of large basins to grid cells. The weight was determined by the precipitation of the grid cell and of the catchment. The method included the assumption of a constant ratio of average runoff to rainfall across the entire basin and the whole year. This is an oversimplification. Especially in dry regions with high evapotranspiration a large error has to be expected. A weight representing an effective rainfall (i.e. rainfall - actual evapotranspiration) will give better results. Calculations with FRIEND data showed that the results strongly depend on the calculations of evaporation or on the ratio of rainfall to runoff.

Ozga-Zielinska recommended to determine the weight as a linear average of three components which characterize the grid cell for the case of disaggregation. The weight was a function of:

- precipitation in the grid cell
- altitude above sea level of grid the cell
- non forested area in the grid cell

During the Second Planning Meeting on Grid Estimation of Runoff Data in Warsaw (1992), a three level interpolation algorithm was recommended. For each level runoff can be determined as weighted average of the values of each single subarea. In the beginning (level I) a constant value of runoff is assumed for each subarea. In the case of a good resolution of the grid system and a high ratio of catchment size to grid size runoff will remain constant in subareas close by. If further information as physio-geographic (level II) and/or climatological data (level III) will be added, a higher resolution of runoff results will be found.

The last three methods - including level III of the proposal of Warsaw - considered precipitation and evapotranspiration as independent parameters. The other papers, which were published in Warsaw, followed the restrictions not using climatological data especially for GCM validation. Only Predeek and Isele (1992) calculated the relative error between measurements close by the mouth of the rivers and model results. Schädler demonstrated graphs of daily values of measured and calculated runoff. To judge the quality of different methods calculations have be done for the same test area and the results have to be compared with one another and with measurements, that were not included in the calculation process. Another problem is the amount of drainage areas distributed in a grid cell and the number of grids covered by a catchment. How does the accuracy of the results depends on it? Is there an additional influence of physio-geographical or climatological parameters on accuracy?

Up to now all algorithms mentioned are based on area weights as proposed by Liebscher (1990). A summery of interpolation techniques (Wollenweber, 1992), which rely on point measurements, showed that Kriging is used to consider spatial variability of data. The increasing popularity of Kriging is related to its advantages over other interpolation techniques. It considers the spatial structure of measurements. The weights of this technique depend on the variance of measurements. If the semivariogramm is described well Kriging estimates are in agreement with measured values at points where measurements are available. In addition to this Kriging provides an estimate of interpolation error which is mainly determined by the distance of measurement points. The error increases for grid points situated at the edge of data points and for poor spatial data density, especially in case of heterogeneous data. Consequently Kriging requires a high data density with homogeneous measurements. Schwarzmaier et al.(1991) realized the need of at least 6 values to find a good approximation to the semivariogram. Up to now a relation between the heterogeneity of data, the distance of measurement points and the number of data points for adapting a theoretical curve to the semivariogramm is unknown. Schwarzmaier et al. (1991) used simple Kriging to calculate grid based runoff for the northern part of the USA. The results were compared with those obtained by the Quadrant methods, a simple averaging procedure. Both methods considered horizontal distances. Vertical changes of runoff could not be included in the interpolation techniques. During May cross validation with measurements, not included in the calculation, showed a mean quadratic error of 42.7% for Kriging and of 42.6% for the Quadrant method. During January the mean error was 23.6% for both methods. But there were several months with high variances of the semivariogram values. The Kriging technique could not be applied to all data sets.

II.2 Empirical relations between runoff and characteristics of drainage area and climatological parameters.

In many cases runoff is described in terms of physio-geographical and climatological parameters as for example temperature, rainfall and evapotranspiration. The number of independent parameters which are significant and which are considered to be part of an regression analysis depend on time scale, size of catchment and grid area, topography, landuse, landcover, soil properties, density of fluvial system, temperature,... Factor analysis can be employed to find the important parameters. Bruijmzeel et al.(1983) calculated runoff, which was caused by a storm, as function of rainfall in case of a small catchment, situated in the tropics. Kinosita (1983) determined a peak flow in a channel, belonging to an other catchment of the tropics as product of rainfall and catchment area. Copp (1991) found a linear relation between monthly runoff, annual runoff, latitude, height and size of the catchment. Schwarzmaier et al. (1991) described monthly runoff for homogeneous areas (concerning runoff) of the northern parts of the USA. They started with a basic climatological data net at 0.5^o * 0.5^o grid. The regression was calculated as function of precipitation, temperature, relief energy, density of fluvial system, relative area of lakes, a factor, describing the form of the catchment and the latitude and longitude of the central point of the catchment. The coefficients changed with seasons and vegetation. For a larger area with varying flow characteristics a grid of 1^o * 1^o was chosen. The results showed a simple linear regression with vegetation types, monthly means of temperature and precipitation as independent parameters. The coefficients changed with seasons too. Solomon et al. (1968) were under the first to determine annual runoff based on a square grid with a distance of dx = 10 km. They started with a linear relation between temperature and parameters characterizing catchment and measurement points. The evapotranspiration was determined according to Turc and runoff by water balance. At the end of an iteration algorithm to reduce errors runoff was described by a linear regression. Cross validation showed an underestimation of measurements. The error increased for smaller catchments. Runoff calculation for the Northern Mountains of Hungary, a relatively homogeneous geographical region (Gilyen-Hofer, 1992) led to a simple linear regression for annual runoff as function of

- relative relief energy
- fraction of forested area
- infiltration coefficients.

The calculations showed that the correlation of specific runoff to relative relief height was larger than to the fraction of forested area and the infiltration coefficient. The total correlation coefficient slightly increased in case of using a three term linear regression instead of just considering relative relief energy.

Arnell (1992) compared a linear relation between annual runoff, precipitation and potential evapotranspiration with FRIEND data. The results were very sensitive on the calculation algorithm for evapotranspiration.

II.3 Water balance models

In section II.2 empirical relations between runoff and climatological and physio--geographical parameters were discussed. Even in case of multi regression techniques runoff production processes are not explicitly modelled. In this section a more sophisticated approach will be considered. Water balance models will be applied with grid based climatic input. According to time- and area-scale of the problem some terms of the water balance equation can be simplified. There are different levels of model calculations to choose from. These include changing numbers of physical processes in as much as interpolation techniques. To find grid based runoff, the catchment may be subdivided in homogeneous areas. Runoff can be estimated for each individual subarea by water balance. A weighted average of these runoff values leads to the grid based parameter. A more sophisticated application of water balance models requires a fine grid mesh, which covers the grid area and the catchments belonging to it. An additional water transport model describes the flow transport along the hill and rivers. Most of water balance models describe hydrological conditions of small catchments. For applications to other drainage areas with distinctive surface-, soil- and climatological features, the models have to be adapted to new surface conditions. For all model types precipitation is an important input. The quality of model results strongly depends on its spatial and time resolution. Since rainfall measurements are done more or less far away from the position of the grid points an interpolation procedure has be used, which leads to an additional error. In most cases evapotranspiration is unknown. Relations between potential and actual evapotranspiration which can consider plant relevant parameters as soil moisture, field capacity, stomatal resistance,... are published by Dyck et al. (1980). The influence of plant growth may be included by defining representative days, which are related to typical plant developments (Löpmeier, 1991). More complicated models include at least one dimensional submodels, which explicitly describe various processes of water vapor transfer out of plants and out of different soil levels (Sopholeous and Mc Allister, 1987). Monthly or annual runoff of large rivers, as e.g. Amazon, can be calculated by a combination of a water balance and water transport model (Vörösmarty et al., 1989). On a basis of a 0.5^o * 0.5^o grid soil moisture was calculated knowing precipitation, potential evapotranspiration and maximum field capacity. Runoff was found when rainfall and melting of snow prevails potential evapotranspiration. The water transport models connects the results of water balance belonging to different grid points with the fluvial system and the rate of water transfer. The relative error increased in case of a large ratio between grid size and catchment size.

Considering the enormous amount of various catchment characteristics reflections should be done to find simple physical models of runoff production based on hydrologic similarity. A first attempt could be found for storm runoff production. A simple conceptual model which was based on catchment topography, spatial variability of soil and rainfall, Hortan and Dunne type infiltration excess was developed (Sivapalan et al., 1987). The model equations were transformed into a dimensionless form with five similarity parameters and three dimensionless variables. The similarity parameters included two scaled hydraulic conductivity, two scaled soil moisture and one scaled soil-topography parameter. The three auxiliary parameters included initial conditions and storm characteristics. A comparison with measurements is missing to judge the quality of the model.

III Conclusions

The global varying density of water gauging stations, the variety of physio-geographical conditions of catchments and grid cells, the different influence of man on rivers and lakes and its surrounding lead to the need of several techniques to estimate grid based runoff. In section II methods like weighted averages, regression analysis and water balance models were discussed. Only if area related values were included in the algorithm the integrated characteristics of runoff was considered in the interpolation technique. In contrast to the first two techniques physical processes of runoff production were explicitly considered in water balance modelling. To judge the quality of different algorithms calculations have be done for catchments with varying characteristics. Comparing model results with measurements will demonstrate problems and advantages of different techniques. An other problem is the minimum number of interpolation points needed to keep the error below certain limits.

Figures:

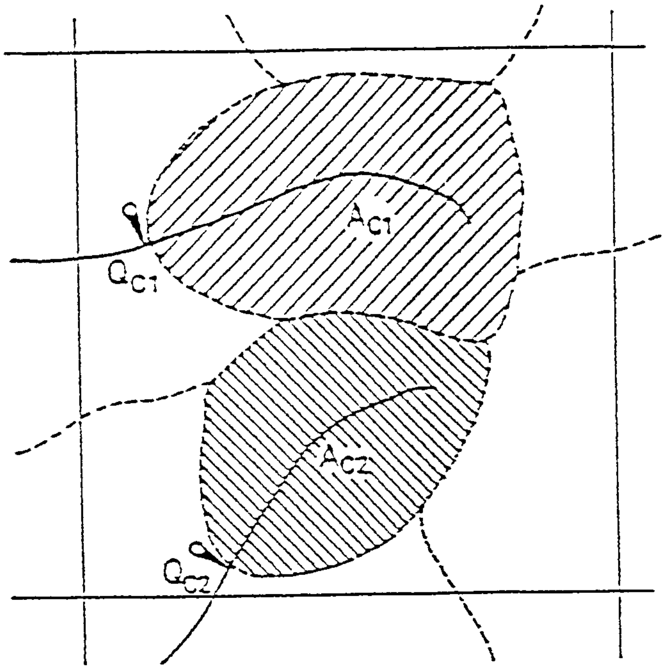

Figure 1: At least one subcatchment lies within the grid cell

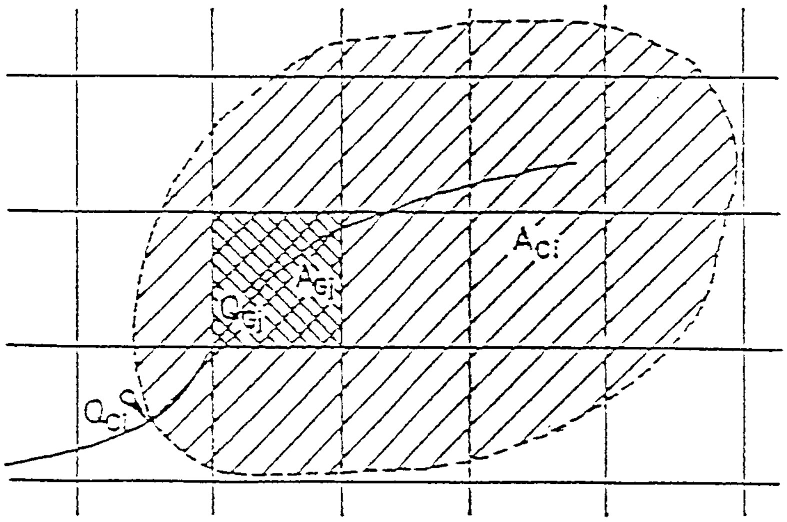

Figure 2: One subcatchment covers more than one grid cell

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Runoff Data Sets at State Hydrological Institute

by I. A. Shiklomanov

During last year the State Hydrological Institute (SHI) has closed cooperation with GRDC. We use widely the runoff-data of GRDC for our investigations of global water resources problems. In particular one of the most important theme of SHI is global generalisation of world water resources and their use. In result we must prepare the monograph "World Water resources at the beginning of XXI century".

It is one of the IHP-IV UNESCO project for 1990 - 1995. Russian NC (National Committee) for IHP is responsible for preparation of this monograph and I was appointed as coordinator of this project.

First stage of this work is the collection of global runoff data. For this purpose we have received information from GRDC, from different countries and international organisations.

Now we have in our data bank following monthly river runoff information:

Table 1:

Runoff Data Sets at SHI

(excluding the data of former USSR)

Continent	Number of Hydrological Stations	Number of Year/Stations
Europe	302	9230
North America	194	6820
Asia	394	8700
South America	240	3600
Africa	232	5200
Australia and Oceania	178	5500

The data are not sufficient for the preparation of a monograph and we ontinue our work. After this we collect data for water use and water consumption of different countries and water users and water quality data. After preparation the monograph we plan to give all hydrological data to GRDC.

The FRIEND Project

by Nigel Arnell

FRIEND (Flow Regimes for International Experimental and Network Data) is a contribution to IHP IV, and is concerned with international, regional hydrological analysis. Four FRIEND projects are operating. The first project began in 1986 in northern and western Europe, a second initiative (AMHY, concentrating on Alpine and Mediterranean Europe) began in 1990. The two further projects are planned in West and in South Africa.

The "northern and western European" FRIEND project has four scientific themes: regional low flow studies, the characterisation of large scale variations in regime (including gridding), flood and extreme rainfall studies and flow studies in a regional context.

The database contained, at the end of the first phase of FRIEND in 1989, daily flow data from 1350 catchments in 13 countries in northern and western Europe (UK, Ireland, France, Belgium, Netherlands, Luxembourg, Switzerland, Austria, Denmark, Norway, Sweden and Finland). All the catchments have an area of less than 500 km^2, have "good" records and are relatively free from artificial influences. The mean record length (in 1989) was just over 20 years. In the current phase of the FRIEND project the data set is being enhanced in two ways. Firstly, additional data are being collected from the original study region, to extend records and to fill in some gaps. Secondly, flow data are being acquired for Czechoslovakia, Poland and Russia, which officially joined the FRIEND project in 1992. By September 1992 the datebase may contain nearly 2000 catchments.

The FRIEND database is available for researchers involved in the FRIEND project. Limited amounts of data can be released to other researchers as long as permission is obtained from the original measuring authority.

Data Available from National Center of Atmospheric Research (NCAR)

by Roy Jenne

After NCAR was established in the early 1960s, it was recognised that the various research areas need assistance in obtaining access to data. The data effort was started in 1965 with two staff members. From 1978 - 90 there were usually 5 to 7 staff members. The purpose is to support research at NCAR and also to make it easier for the 60 to 100 member universities to obtain data. The archives include both basic observed data and many analyses and other products. The main priorities for data are:

- Data for meteorological research
- Data for physical oceanography
- Boundary conditions such as elevation, depth, land cover, soils, etc.
- Data to varify climate models
- Climate model data to support assessment studies

There are about 390 datasets at NCAR with a total volume of about 3000 gigabytes. Much of the volume is in several satellite datasets, but some high-resolution model data also has a significant volume.

What information about the data is available? We try to maintain information about every dataset in 2 or 3 levels of detail. One level is very brief: only one or two lines per dataset. In addition there should be at least a paragraph about each set. There are also some short papers that describe the information that is available according to subject area (data for hydrological studies, data from climate models, etc.)

Some datasets contain data for several thousand stations. In this case, users need an inventory to determine the data available from each station. About 25 inventories are available from NCAR. They may be obtained free of charge from an on-line file.

A major NMC/NCAR project to reanalyze the whole atmosphere started in 1991. The goal is to analyze the atmosphere every 6-hours for 1958-1992, using modern data assimilation methods. The project is described by Kalnay and Jenne in the December 1991 issue of the Bulletin of the American Meteorological Society.

The data support group at NCAR is preparing the data that are necessary for this project. This overall staff has been increased to 10 in order to make this work possible. The output of the global analyses will include the normal variables such as temparature and wind. It will also include diagnostic fields from the assimilation model-precipitation, surface radiation, heat fluxes, etc. We hope that the analyses can start about July 1993.

NCAR also maintains a collection of data from selected climate models that can be used for assessment studies of climate change. These studies include the effect of climate change on crop yields, water resources and forests.

A brief list of the data at NCAR is available on only a few pages of paper.

The Global Precipitation Climatology Centre (GPCC) - Status June 1992

Bruno Rudolf, Deutscher Wetterdienst, Offenbach a. M., FRG

1 Background

Water is the fundamental source for all life on the earth. Precipitation is the only input quantity in the water balance of the earth's surface, whereas evaporation and runoff represent the main losses. Besides, precipitation plays an important role in the energy cycle of the atmosphere due to the release of latent heat associated with the condensation of water vapour during its formation. It is also a highly sensitive indicator of global climate change. Finally, the hydrological cycle is of importance for the large-scale transport of pollutants.

Therefore global precipitation analyses are necessary for climatological and hydrological research, e.g. to investigate the global water balance, or for the verification of climate and general circulation models.

2 Establishment of the GPCC

The GPCC has been initiated by the World Meteorological Organization (WMO). It is a central element of the Global Precipitation Climatology Project, which was established by the World Climate Research Programme (WCRP), to provide global monthly precipitation totals on a grid of 2.5° latitude and longitude. The GPCC is operated by the Deutscher Wetterdienst (German Weather Service) and is a contribution of the Federal Republic of Germany to the WCRP. The tasks of the GPCC are defined in the WMO Technical Document WMO/TD-No. 367. All national Meteorological Services have been informed about the initiation of the GPCC by a letter of WMO distributed in October 1988.

3 Present data base (conventional measurements)

At the GPCC, monthly precipitation totals based on conventional measurements are available from CLIMAT reports or can be calculated from SYNOP reports disseminated via the World Weather Watch GTS (Global Telecommunication System) for about 4000 stations world-wide. However, the resulting station density over many parts of the continents is insufficient for a reliable calculation of the areal mean monthly precipitation.

Several countries (up to date Australia, C.I.S., Ghana, Great Britain, the Netherlands, New Zealand, and U.S.A.) have supplied additional monthly precipitation data, partly from very dense networks (cf. Table 1).

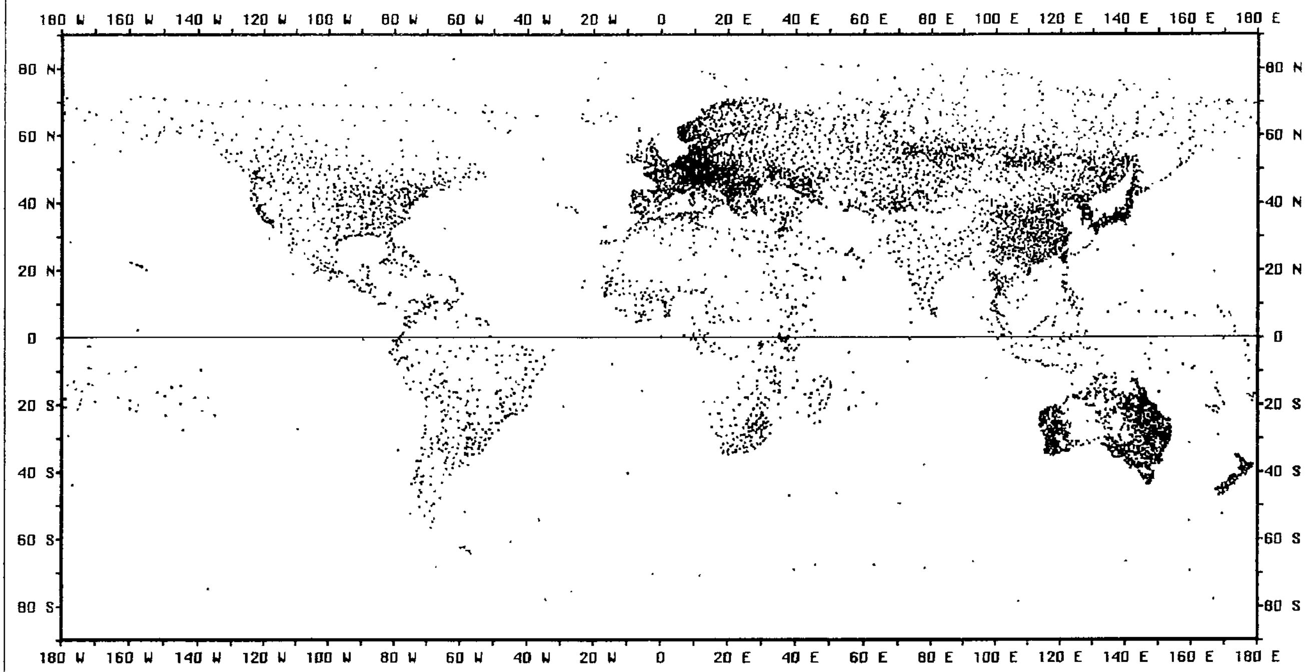

Fig. 1: Locations of stations, for which gauge-measured monthly precipitation totals are used for objective SPHEREMAP analysis for August 1987; data received via GTS (CLIMAT and SYNOP reports), Australia and New Zealand complemented by bilateral data exchange.

Some of those additional data have been included in the global data set being used for preliminary studies, the number of stations has been increased to approximately 6600 stations. The station sites can be obtained from figure 1.

The GPCC has calculated spatial precipitation analyses based on this preliminary data set for all months of the year 1987 and the year (cf. fig. 2), and is going on to evaluate the 1988 data. These results are calculated by an objective method using the code SPHEREMAP (from Willmott et al. based on Shepard's interpolation scheme) and discussed in WCRP/DWD (1992).

GPCC also is preparing intercomparisons of analyses based on conventional measurements, estimates derived from satellite images, and results from numerical weather forecast models. The methods used and some intercomparisons are described in Rudolf et al. (1991 and 1992).

Table 2 gives an overview for the gridded data available from GPCC at present. Besides the continuous monthly data also the climatological means from Jaeger (1976), Legates (1987), Hulme (1991) and WMO/UNESCO-Atlas are stored on a grid.

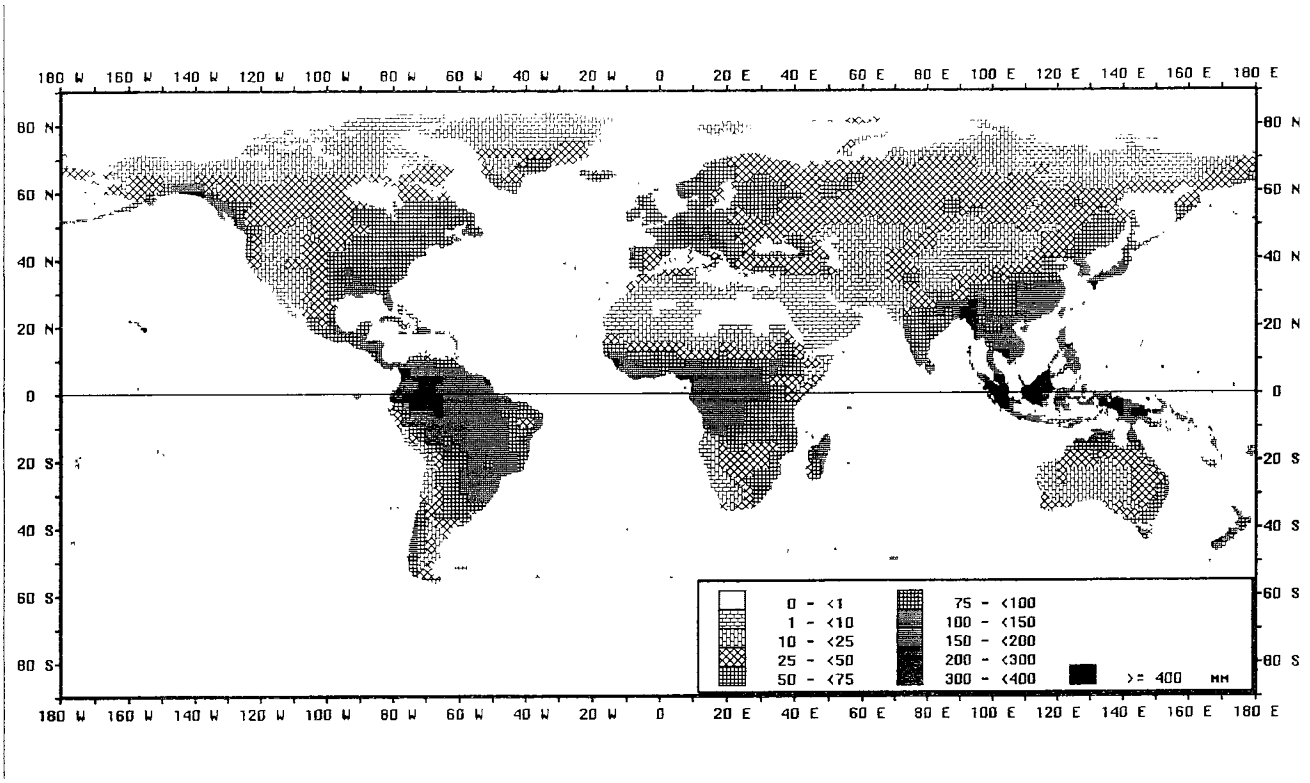

Fig. 2: Mean monthly precipitation (mm) totals for the year 1987 on a 2.5° grid calculated using the SPHEREMAP analysis code (based on gauge measurement of about 6600 stations).

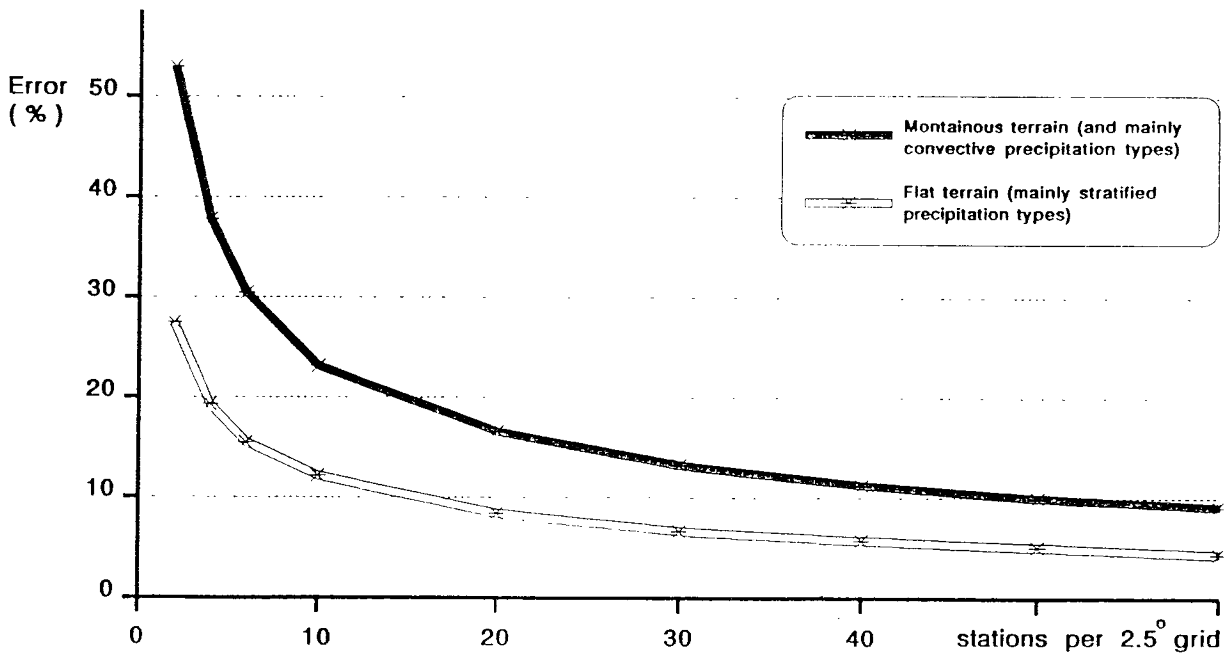

Fig. 3: Estimated relative error at the 95% confidence level for area-mean precipitation in a 2.5° square, over flat and mountainous terrain respectively (based on studies using data from Northern and Southern Germany).

4 Data requirements

The station density needed lies, according to investigations of the WMO and the GPCC (cf. Fig. 3), between at least 10 and 40 stations per 2.5° grid, corresponding to between 2 and 8 stations per 10.000 km^2, depending on orographical structure and climatic conditions in the grid.

Therefore GPCC is doing all efforts to obtain additional data from all countries by bilateral exchange. All national Meteorological Services are asked by the WMO to provide monthly data of the required volumn to the GPCC. Data delivering countries will receive the GPCC products free of any costs.

5 Availability of the GPCC products

The products according to the international tasks of the GPCC (areal mean monthly precipitation data on the 2.5° grid worldwide) will be published and disseminated on diskettes to the ICSU World Data Centres for Meteorology. The GPCC products will be:

- a periodic (yearly for twelve or half yearly for six months) publication including gridded precipitation maps of monthly totals and anomalies,

- data sets of monthly areal mean precipitation on the 2.5° grid for the continents based on gauge measurements, the GPCP precipitation estimates from satellites and accumulated weather forecasts results, the complete global data set merged from the different estimates, estimated error values giving the reliability of the precipitation estimates on the grid depending on the amount and quality of the input data (all results on the 2.5° grid, provided by floppy diskettes or tape),

- on request, evaluations on a 0.5° grid for continental areas with a sufficient station density.

The published report on the GPCC results, as well as the data sets on diskettes, will be available directly from the GPCC at no cost to institutions providing data.

The products can be ordered from the ICSU World Data Centres for Meteorology or from GPCC. In this case only the marginal costs of reproduction and distribution or filling a specific users request will be required. The data itself is free of charge.

Acknowledgement: The scientific work in GPCC is done by H. Hauschild, M. Reiss, W. Rüth and U. Schneider, the programming by P. Finger.

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Table 1: The GPCC data basis of gauge measured monthly precipitation depths (number of stations), status June 1992

	stored at GPCC	used for analysis	
Global data sets			
CLIMAT reports quality controlled	1,500	1,450	
SYNOP reports temporal coverage ≥ 70% quality controlled	3,500	2,300	
CAC			
Monthly Climatic Data of the World	4,900	2,000	
	1,200	50	
National data sets			
Argentina			
Atoll Islands			
Australia	(2,000)	---	More additional data systematically selected from the supplied national data sets will be used, when the GPCC data bank will have been developed (April 1992).
Brazil (Sao Paulo)	88	---	
Brazil (total)	7,000	720	
C.I.S.	355	---	
Germany	(2,000)	---	
Ghana	500	---	
Netherlands	3,000	---	
New Zealand	22	---	
Switzerland	90	---	
U.K.	260	80	
U.S.A.	(130)	---	
	400	---	
	8,000	---	
sum of data used for analysis		6,600	

( ) expected

Table 2: **GPCC data basis, status June 1992**

Monthly areal mean precipitation estimates on a grid

(x available o in preparation - not available)

Time series	1986		1987		1988		1989		1990	
	JFMAMJ	JASOND	JFMAMJ	JASOND	JFMAMJ	JASOND	JFMAMJ	JASOND	JFMAMJ	JASOND
Gauge measured data (over land, 2.5°)										
objective analysis			xxxxxx	xxxxxx	ooooox	xxoooo				
manual analysis			x x x	x x x						
Satellites estimates										
IR (geo+NOAA, 2.5°)	xxxxxx	xxxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxx
DMSP-SSMI (5.0°)	------	-------	-----x	xxxx-x	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxx
Forcast model results										
ECMWF (0-24h, 1.0°)	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx	x

Climatic means	JFMAMJ	JASOND	
UNESCO/WMO-atlases (digitized, 0.5°)	xxxxxx	xxxxxx	(over land only)
Legates (0.5°)	xxxxxx	xxxxxx	(based on gauge data as measured and on systematic error corrected data)
Jaeger (5.0°)	xxxxxx	xxxxxx	
Hulme (5.0°)	xxxxxx	xxxxxx	(over land only, time series of monthly results for 1951-1980 available)

Review of the GEMS/RAISON Software

by Ulrich Schröder

Background to RAISON -

RAISON originated some six years ago in response to a need for an integrated information management, GIS and prediction capability for Canada's acid rain programme. The package that has become RAISON/GEMS was largely developed over the following four years so that it included database and spreadsheet capabilities, sufficient capability in GIS that it could manipulate, store and display georeferenced data, and an analytical capability for examining the data base.

RAISON/GEMS is the "low-end" component of the RAISON family of software. It is primarily adapted to low-end machine capabilities that are typically found in developing countries. RAISON was adapted to the GEMS programme in order to respond to information management, analysis and interpretive needs.

RAISON ist primarily a numerical tool with sufficient GIS capability to permit effective use of geo-referenced information. RAISON is fully compatible with most commercial GIS systems such as ARC-INFO and SPANS and with spreadsheet systems such as Lotus.

RAISON is currently made available, under licence, in two forms. One, the RAISON/GEMS package, is the low-end version which cannot be used for modelling. This is designed for 386/486-based PC's with 4 Mb RAM. A stripped-down version is available for 286, 1 Mb machines. The second form is a full modelling version which includes the RAISON Programming Language (RPL) which permits the user to customize the software for virtually any type of application. RPL is our answer for flexibility while maintaining the integrity of the source code.

RAISON is an ongoing R&D programme of the National Water Research Institute in response to Environment Canada's needs for improved information technologies. The RAISON software ist owned by the Government of Canada.

The acronym RAISON stands for Regional Analysis by Intelligent System ON a microcomputer. The objectives of RAISON are:

1. Regional analysis of environmental data
2. Intelligent application of expert systems and models

The approach to the task of data combination was the RAISON approach which aimed to build an integrated system with all essential features of GIS, database, spreadsheet and statistics (Figure 1).

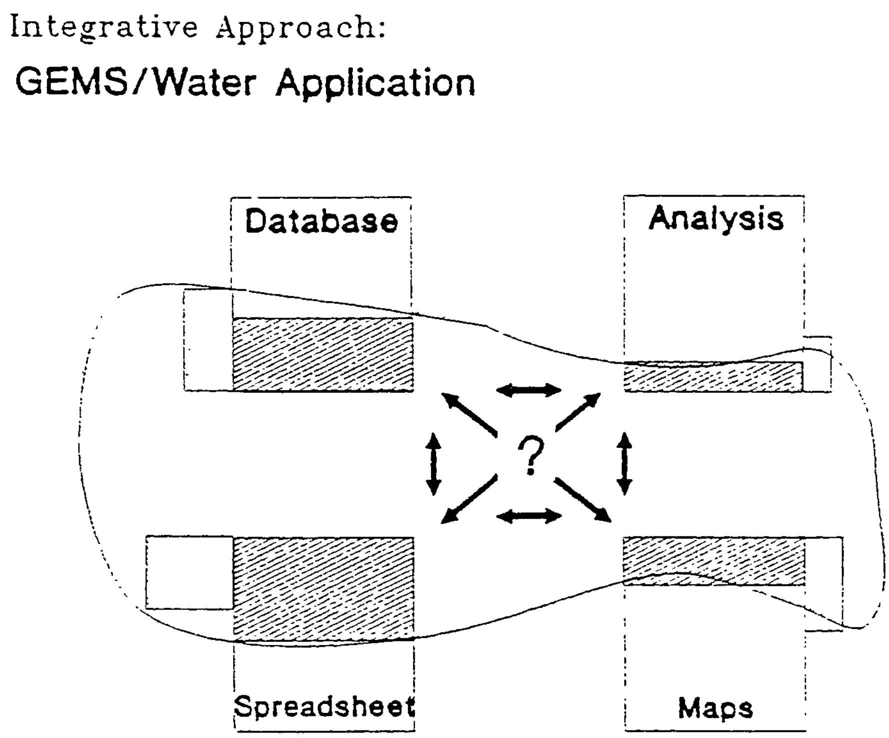


Figure 1:

The advantages of RAISON as it has been developed are as follows:

1. it employs micro-computer technology, requiring an IBM-compatible 386/486 machine (minimum 386/20 MHz with math co-processor), DOS 3.1 or newer, hard disk 10 Mb or above, 1.44 Mb 3.5" diskette drive and VGA graphics (640 x 480, 16 colour)
2. it is relatively inexpensive
3. it integrates a number of different software functions

4. it is compatible with popular software
5. it is flexible and user friendly
6. it can be customised to adapt to new problems or requirements
7. it is backed by experience in maintenance and training (now through a licencing system)

Beyond the basic version of RAISON/GEMS, with its four elements of database, analysis, spreadsheet and mapping, RAISON extends successively to special applications, expert systems and models and the RAISON programming language (RPL) (Figure 2)

Hierarchy of RAISON Programmes

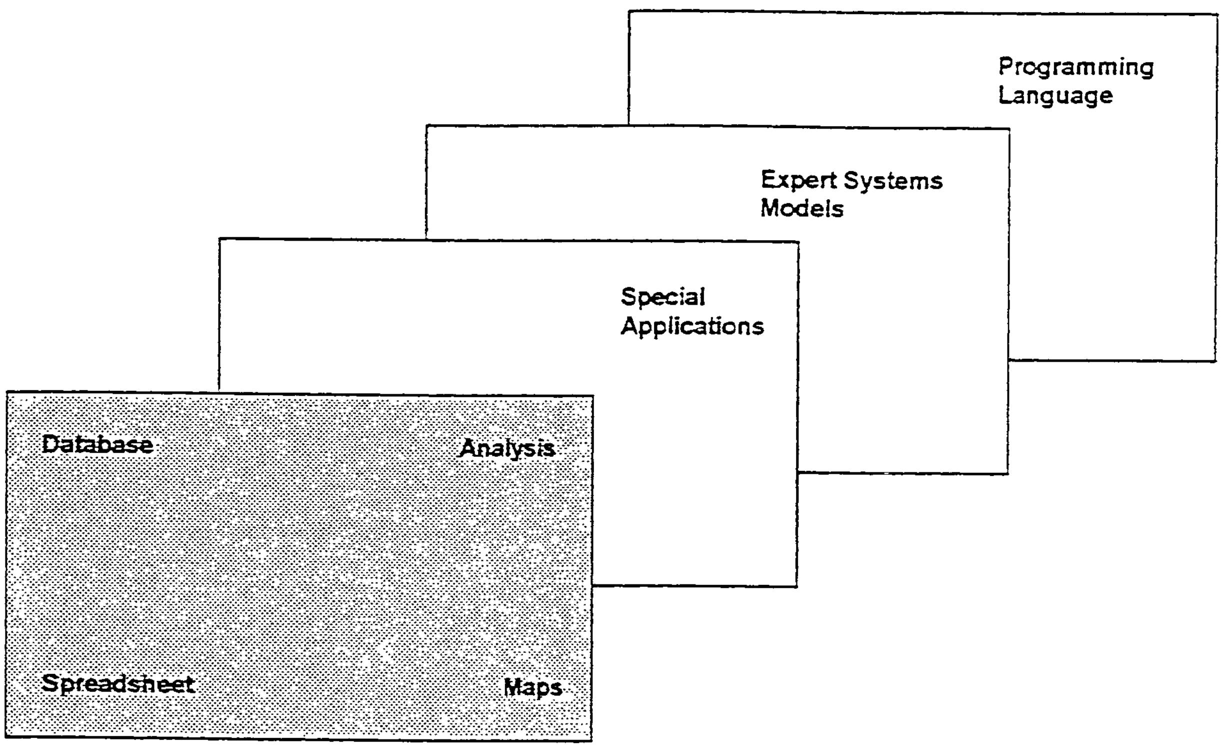


Figure 2

Example

Figure 3 shows the general way how to work with RAISON/GEMS

Data Retrieval within a Polygon

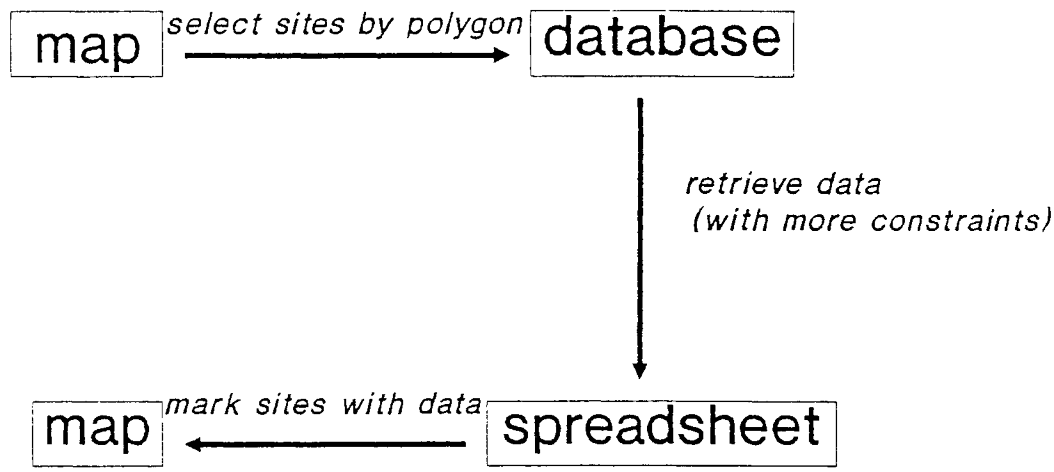
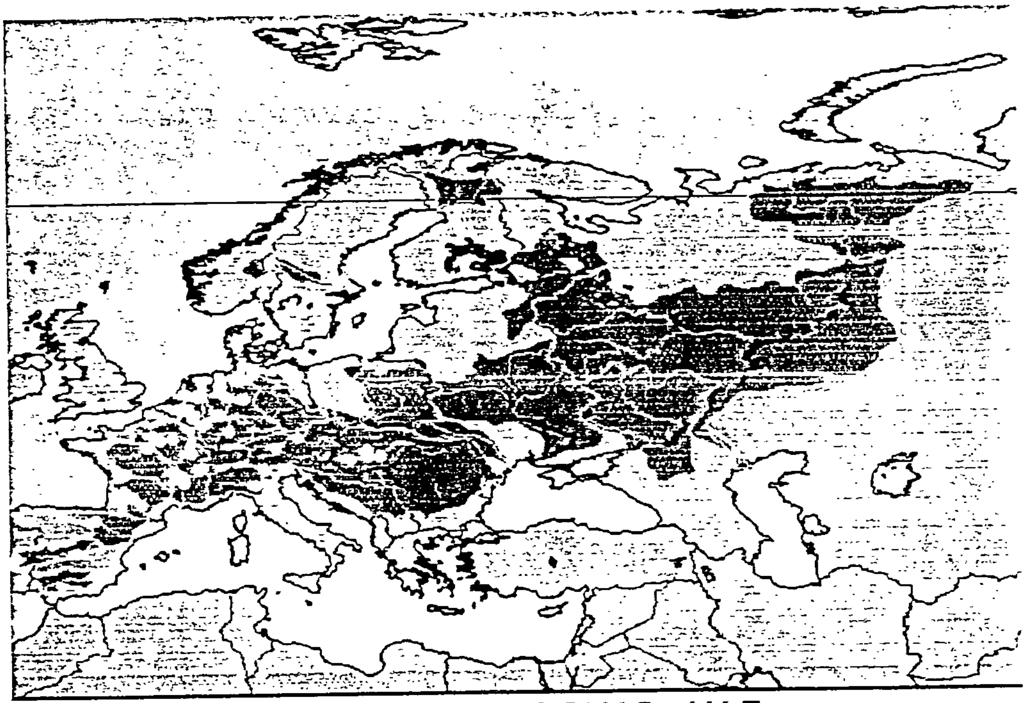


Figure 3

The following four pictures are demonstrating a concrete case study



RAISON REGIONAL MAP

EUROPE WATERSHEDS AND SAMPLING STATIONS

ENVIRONMENT CANADA 1992)

Figure 4

F1 Help   F10 Quit

STATION:disch19   DATE:88/02/01

WATERSHED:Rhine

DISCHARGE:4640

File rhindis.srf   Marked? No   Record 14 of 72

RAISON DATABASE

Discharge Data for Station 19

(ENVIRONMENT CANADA 1992)

Figure 5

A1: ^Station

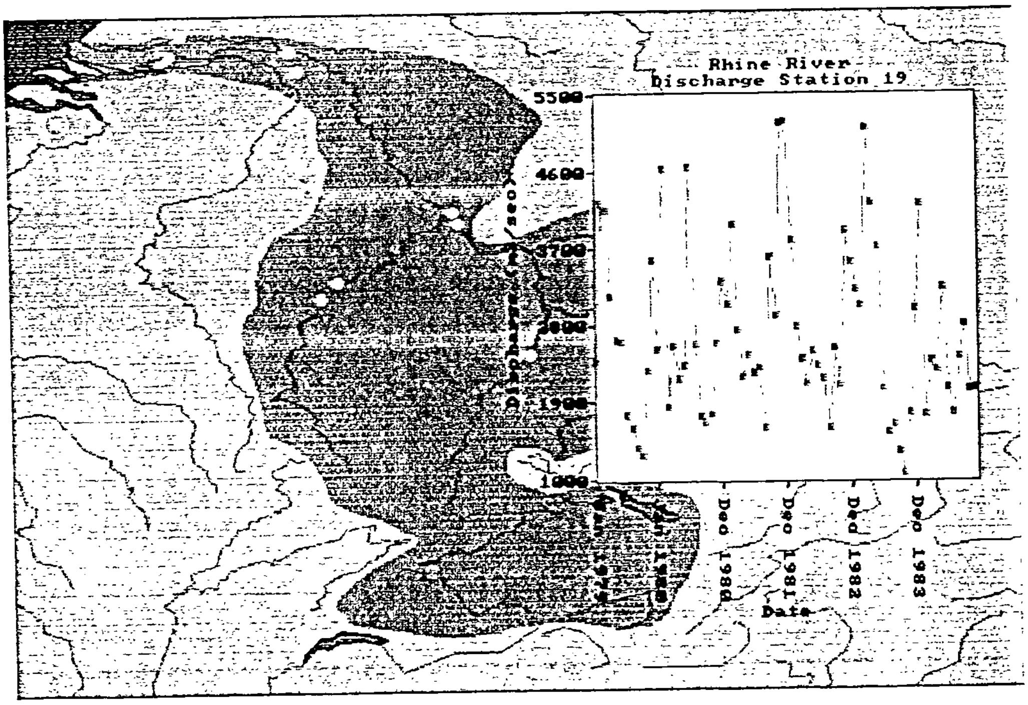
RAISON SPREADSHEET

GEMS WATER QUALITY STATIONS AND DATA

(ENVIRONMENT CANADA 1992)

	A	B	C	D	E
1		Date	Elec_Cond	Temp	O2_D
2	016001	79/01/10	370	1.8	13.8
3	016001	79/02/05	310	2.8	12.8
4	016001	79/03/06	250	4.1	11.2
5	016001	79/04/04	300	6.6	10
6	016001	79/05/03	400	*	10
7	016001	79/06/05	355	17.6	8.2
8	016001	79/07/02	600	16.2	10.9
9	016001	79/08/09	650	18.8	9.4
10	016001	79/09/04	620	17	8.9
11	016001	79/10/03	750	13.5	9.9
12	016001	79/11/05	600	8.6	9.8
13	016001	79/12/03	490	7.2	11.5
14	016001	80/01/03	420	3.2	12.6
15	016001	80/01/30	450	3.5	10.9
16	016001	80/02/26	440	6	10.7
17	016001	80/03/27	490	8.5	10.6
18	016001	80/04/23	470	8.8	10.2
19	016001	80/05/21	530	15.8	11.1
20	016001	80/06/15	530	16.2	7.8
21	016001	80/07/21	340	*	8.1
22	016001	80/08/18	380	17	9.4
23	016001	80/09/09	610	16.5	8.8
24	016001	80/10/09	550	14	8.6
25	016001	80/11/05	530	3	11.8
26	016001	80/12/04	460	2	11.4
27	046001	79/01/02	685	0	8.6
28	046001	79/01/11	820	2.3	11.1
29	046001	79/01/17	1010	2	10
30	046001	79/01/25	1130	3.4	9.6
31	046001	79/01/31	1170	5.5	9.2
32	046001	79/02/06	695	3.9	10.3
33	046001	79/02/19	580	4.2	10.9
34	046001	79/02/26	850	4.5	10.3
35	046001	79/03/05	910	6.3	9.1
36	046001	79/03/12	675	6.5	9.9
37	046001	79/03/20	525	8.2	9.8
38	046001	79/03/28	720	9	9.1
39	046001	80/01/04	800	4.6	10.5
40	046001	80/01/09	710	4.5	10.1
41	046001	80/01/19	950	2.4	10.7
42	046001	80/01/23	1050	4.7	10.4

Figure 6



RAISON GRAPHING AND DISPLAY

ENVIRONMENT CANADA 1992)

Figure 7

The BAHC Project - an Established Core Project of the IGBP

by E. Lahmer-Naim

Background

Vegetation and soils play a major role in affect the fate of rainfall and in regulating water transport to the atmosphere.

However, the regional and global importance of these processes and their climatic and environmental significance, are not well understood.

The IGBP Project Biospheric Aspects of the Hydrological Cycle (BAHC) will adress these problems and will quantify the role of terrestrial ecosystems on the exchanges of water, carbon and energy between land and air.

These issues are to be addressed over the full range of spatial scales relevant to the interactions between the land surface and the global water cycle.

The movement and storage of water around the world are intimately linked to the dynamics of the atmosphere and the global energy budget.

Water is also essential for life. In terrestrial ecosystems rainfall is the dominant factor determining the productivity of natural and managed ecosystems. However, patterns of precipitation across the world are highly variable, both spatially and in times.
In the event of global warming, regional alterations in rainfall regimes are likely to be of far greater ecological and socio-economic importance than the direct consequences of changes in other climate characteristics as, for instance, a rise in annual mean temperature of a few degrees.

The "water gap" in climate models

Despite their importance, hydrological processes and the role of the biosphere are not well described in large scale models, including General Circulation Models (GCMs) for climate simulation.

Particular problems result from the large GCM-grid mesh size (500 km); fine-scale effects caused by local topography and other land surface features, are neglected. It is therefore not surprising that GCMs representations of contemporary patterns of rainfall and river runoff do not adequatelly match observations at the regional level. This seriously limits their predictive use with different climate or land-use scenarios.

Assessments of changes in land surface properties

To improve the realism of GCMs by a better simulation of land-air water exchange an ameliorate understanding of near-ground dynamics of the water cycle, and its links to energy transfer - as affected by the composition and distribution of vegetation, land relief, soils, and other landscape features is need.

The BAHC project addresses these issues, through experimental studies, modelling and remote sensing. The emphasis is on biologically-mediated effects, with a structured progression from intensive studies of key processes at the patch scale to those layer scales (regional, continental and global).

Why plants matter

Vegetation affects water and energy exchanges in many ways.

Leaves and needles decrease wind strength, alter the absorption of solar radiation, and increase the surface area for evaporation. More importantly, higher plants carry moisture from different soil horizons to the atmosphere, by a complex and dynamic root system, water - conducting "tubes" and leaf and needle stomata. In addition, root dynamic and the decomposition of dead plant organic matter (e.g. roots, leaves etc.) by soil organisms modify soil texture and structure considerably, affecting water infiltration, seepage penetration and drainage.

From tropics to tundra

One region of particular concern is the Amazon Basin, supporting around 30 % of the Earth's remaining tropical forests. What would be the hydrological consequences ot their complete removal, and replacement by shrub and grassland? Such a scenario has recently been investigated using GCMs; however, similarly constructed models give very different results.

Semi-arid regions are also highly sensitive to environmental change. In the northern hemisphere ecosystems which affected by winter snow cover or permafrost will be greatly altered by global change especially carbon content in soils and carbon dynamic.

Patches, regions and continents

To assess effects of global change on the global scale, studies must cover the full range of natural and managed vegetation types. So the BAHC Core Project will investigate water, carbon and energy exchanges at various spatial scales. In patch scale studies all the factors affecting the water cycle will be studied. This information is needed to develop, test and evaluate models of soil-vegetation-atmosphere transfer (SVATs) for different biomes.
The BAHC Project will then develop larger scale descriptions of water transfer through the soil-vegetation-atmosphere system.

Cooperations with other IGBP core Projects and landsurface projects

Close links have been established between BAHC and the IGBP Core Project Global Change and Terrestrial Ecosystems (GCTE), which shared sites for many of the experimental ecosystem studies in the patch scale level. Meso- and macroscales studies will be carried out in close collaboration with the Global Energy and Water Cycle Experiment (GEWEX) of the World Climate Research Programme.

Generating model weather

BAHC researches need the best available information on meteorological conditions at their sites of interest, and how the local climate might change in the future. Since General Circulation Models (GCMs) do not yet provide output at sufficiently fine resolution to meet these needs, a weather generator project is being developed.

BAHC: Biospheric Aspects of the Hydrological Cycle
An established Core Project of the IGBP

During the 2nd SSC meeting in Berlin (27 - 30 April 1992) further development of the BAHC Science and Implementation Plan was made.
In accord with other IGBP Projects, BAHC adopted the same division into a three tier structure of Foci:

Research Foci:

Focus 1: **Studies of Water, Energy and Carbon Transfer between Soil, Vegetation and the Atmosphere at Patch Scales.**

Focus 2: **Regional Scale Studies of Land-Surface Properties: Experiments, Interpretation and Modelling**

Focus 3: **Interactions among the Biosphere, Water Resources, and Climate - Regional to Continental Scale**

Focus 4: **The Weather Generator Project**

Overview of WCRP with an Emphasis on GEWEX

by S. Benedict

The aim of the presentation was to document the role of WCRP (World Climate Research Programme), an international programme directed by the WMO/ICSU/IOC.

There are several research projects within WCRP but the emphasis was on the representation of GEWEX, Global Energy and Water Cycle Experiment (see fig. 1).

The objectives were as follows:

* Reduction of uncertainties in geographic and temporal distribution of the water budget.

* Measurement, prediction and modeling of responses of the hydrologic cycle and energy fluxes related to environmental changes.

* Acquisition of river discharge data as well of groundwater data as these data are fundamental to hydrological quantities and processes within the water cycle.

A request was made in respect to discharge data addressed to the GRDC as well to groundwater data as these data are needed for future determination of the water budget over continents and over the oceans (see fig. 2 and 3).
A further requirement for the proposed research project was set on the completion of basic hydrological data sets (soil moisture, vegetation characteristics etc.) to develop and validate coupled macro-scale atmospheric hydrological models.

It was pointed out that WCRP supports the goal within GRDC of gridding runoff data to accomodate macroscale hydrological as well climatological modeling.

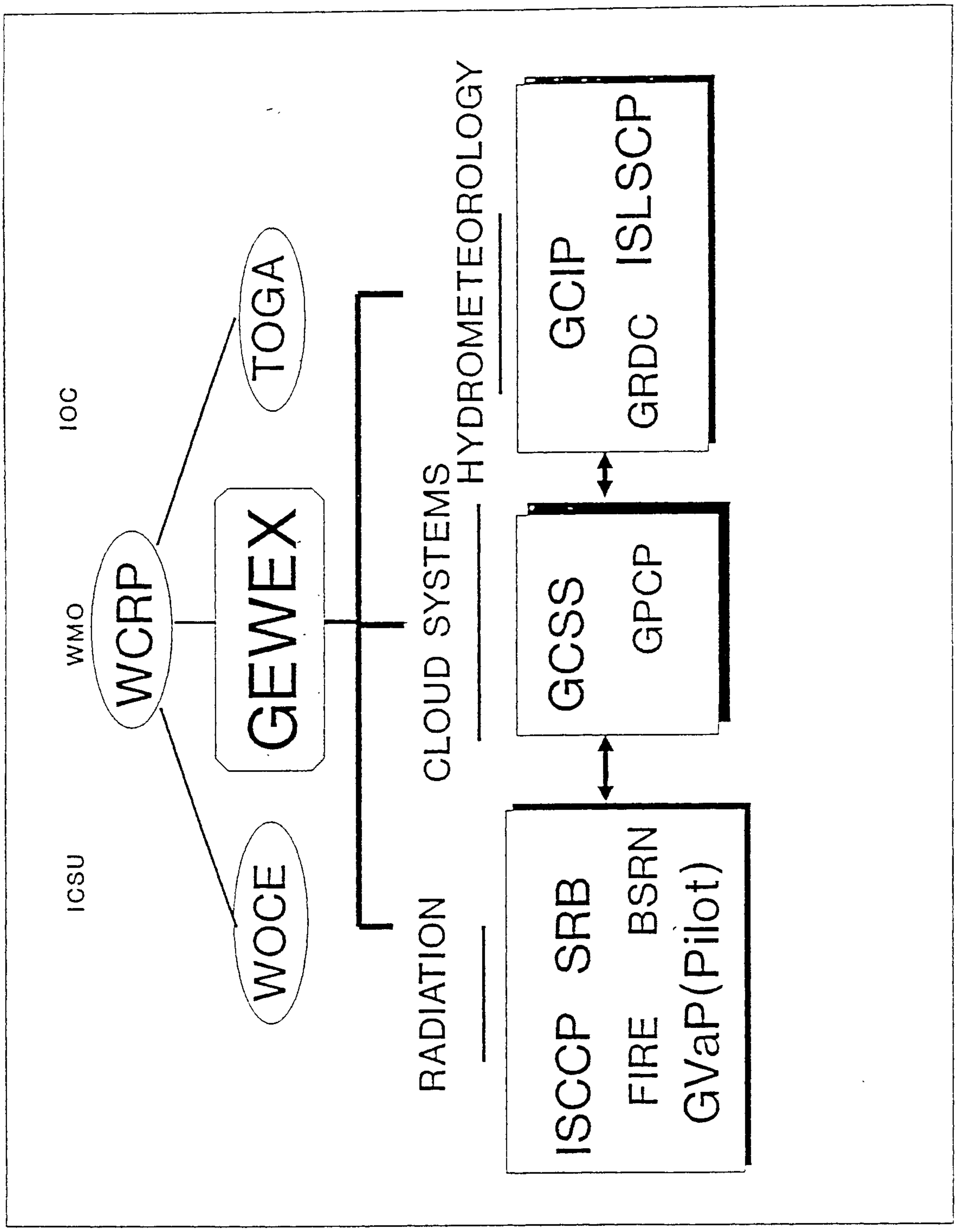

ICSU
WMO
IOC
WCRP
WOCE
TOGA
GEWEX
RADIATION
CLOUD SYSTEMS
HYDROMETEOROLOGY
ISCCP SRB
FIRE BSRN
GVaP(Pilot)
GCSS
GPCP
GCIP
GRDC ISLSCP

Figure 1

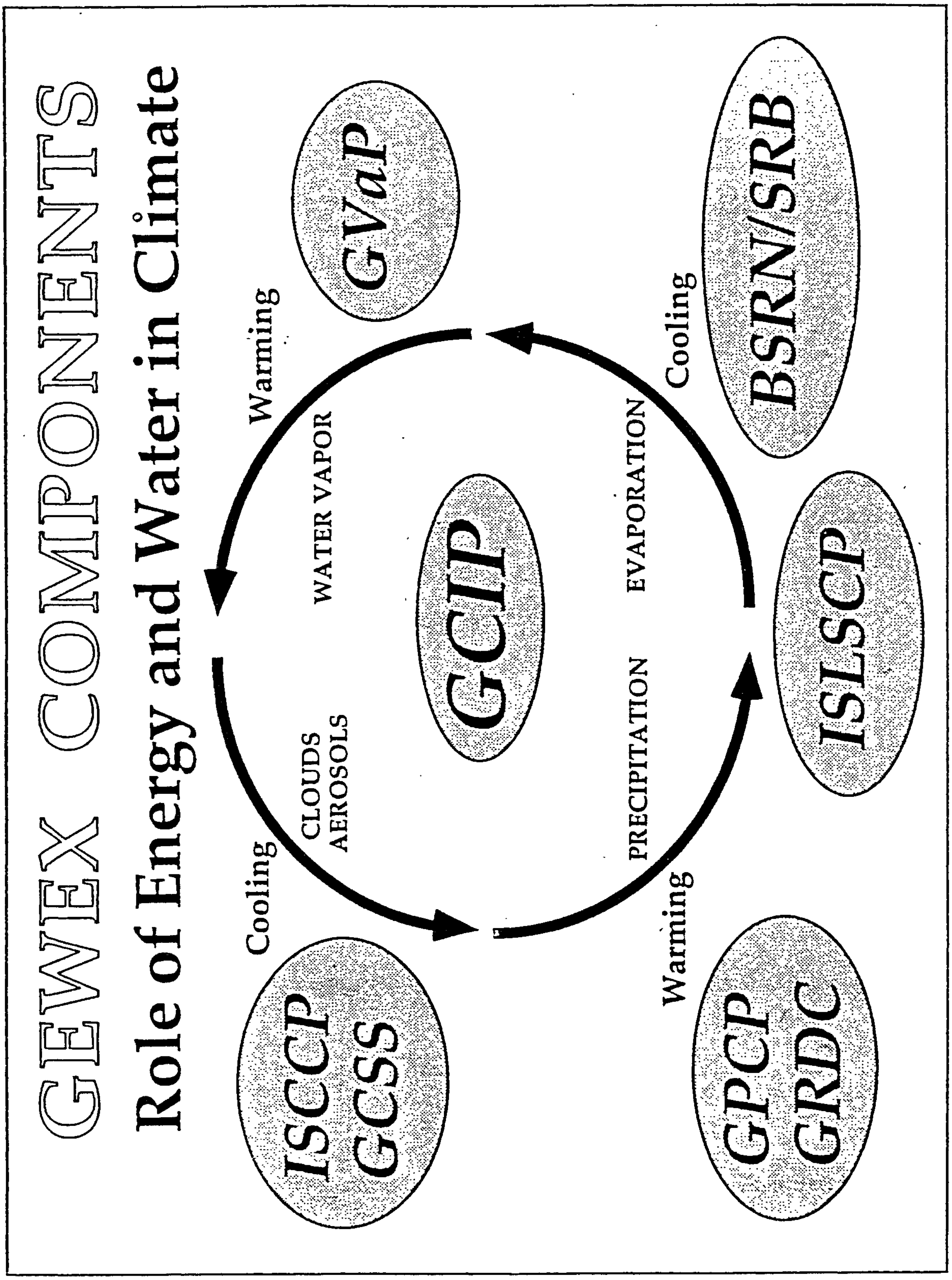

GEWEX COMPONENTS
Role of Energy and Water in Climate
ISCCP
GCSS
Cooling
CLOUDS
AEROSOLS
Warming
WATER VAPOR
GVaP
GCIP
PRECIPITATION
EVAPORATION
Warming
Cooling
GPCP
GRDC
ISLSCP
BSRN/SRB

Figure 2

GEWEX PROJECTS

- RADIATION

ISCCP - International Satellite Cloud Climatology Project
SRB - Surface Radiation Budget Project
BSRN - Baseline Surface Radiation Network
GVaP - GEWEX Water Vapour Project

- CLOUD SYSTEMS and ATMOSPHERIC DYNAMICS

GCSS - GEWEX Cloud System Studies
GPCP - Global Precipitation Climatology Project

- HYDROMETEOROLOGY

GCIP - GEWEX Continental-Scale International Project
GRDC - Global Runoff Data Center
ISLSCP - International Satellite Land Surface Climatology

Figure 3

Reference of GRDC-Reports

Report No. 1 May 1993 — **Second Workshop on the Global Runoff Data Centre, Koblenz, Germany, 15 - 17 June, 1992.**

In preparation :

Report No. 2 May 1993 — **Dokumentation bestehender Algorithmen zur Übertragung von Abflußwerten auf Gitternetze.**(Incl.abstract in English by GRDC: Documentation of existing algorithms for transformation of runoff data to grid cells).
G.C. Wollenweber

Report No. 3 June 1993 — **GRDC - Status Report 1992.**