WORLD CLIMATE PROGRAMME

APPLICATIONS and SERVICES

SIXTH PLANNING MEETING

ON

WORLD CLIMATE PROGRAMME - WATER

(WALLINGFORD, 1-5 MARCH 1993)

WCASP - 29

WMO/TD-No. 609

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UNITED NATIONS EDUCATIONAL
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ORGANIZATION

WORLD METEOROLOGICAL
ORGANIZATION

The WCP implemented by WMO in conjunction with other international organizations consists of four major components:

The World Climate Data and Monitoring Programme (WCDMP)
The World Climate Applications and Services Programme (WCASP)
The World Climate Impact Assessment and Response Strategies Programme (WCIRP)
The World Climate Research Programme (WCRP)

World Meteorological Organization
Case postale N° 2300
1211 Geneva
Switzerland

Telephone: (022) 730 81 11
Telefax: (022) 734 23 26
Telex: 41 41 99

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INTRODUCTION

1.1 The Sixth Planning Meeting on World Climate Programme-Water (WCP-Water) was held at Cosener's House, Abingdon and at the Institute of Hydrology, Wallingford from 1 to 5 March 1993. It was organized jointly by WMO and UNESCO with the support of the Institute of Hydrology, to review progress in the execution of the projects which constitute the list of activity areas and priority projects contained in Annex 4 of the report of the Fifth Planning Meeting. It was also to instigate new projects and to investigate a framework for future work.

1.2 At the opening, Mr Max Beran of the Institute of Hydrology welcomed participants to the meeting as did Dr John Rodda and Mr Mike Bonell, speaking on behalf of the Secretary General of WMO and the Director General of UNESCO respectively. In turn each of the speakers emphasized the importance of WCP-Water and how it provided a link into a number of other programmes, much as those of UNEP, FAO, IIASA and IAHS. Professor Brian Wilkinson (Director, IH) reflected the views of the earlier speakers, noting the relevance for the United Kingdom and for the Institute of the discussions that were to take place within the Planning Meeting.

1.3 It was recognized that WCP-Water had been endorsed by the different constituent bodies of WMO and UNESCO and most recently by the Commission for Hydrology during its ninth session. Previous planning meetings had been held in UNESCO, WMO and IIASA and it was very appropriate that the Sixth Meeting should be hosted by the Institute of Hydrology.

1.4 Several of the participants in the Sixth Planning Meeting (Annex 1) had attended a number of the previous sessions. The work accomplished had allowed inputs to other climate and climate related meetings and projects, for example to the Second World Climate Conference. It had been hoped that the 6th session could also make a useful contribution to the Inter Governmental Meeting on the World Climate Programme scheduled for 14 to 16 April 1993 but because of the need to prepare papers well in advance of that meeting it was recognized that it would be very difficult to achieve a written contribution.

1.5 Mr Max Beran was elected Chairman of the meeting. He thanked other participants for their confidence in his chairmanship. He also thanked them for their agreement to the agenda (Annex 2).

2. REVIEW OF RECOMMENDATIONS AND DECISIONS OF GOVERNING AND ADVISORY BODIES

World Climate Programme

2.1. The World Climate Programme (WCP) was first adopted by the Eighth WMO Congress (Cg-VIII) in 1979 as a major WMO Programme. The overall objectives of the WCP, as agreed by Cg-XI for inclusion in the Third WMO Long-term Plan, are:

(a) To facilitate the effective collection and management of climate data and the monitoring of the global climate system including the detection and assessment of climate variability and change;

(b) To foster the effective application of climate knowledge and information for the benefit of society and the provision of climate services including the prediction of significant climate variations both natural and as a result of human activity;

(c) To assess and advise governments on the impacts of climate variability and change that could markedly affect economic or social activities and to contribute to the development of a range of socio-economic response strategies that could be used by governments and the community;

(d) To improve the understanding of climate processes for determining the predictability of climate, including its variability and change, identifying the extent of human influence on climate and developing the capability for climate prediction.

2.2. Eleventh WMO Congress by its Resolution 12 (Cg-XI), recognized that the WCP was established to respond to the world's demand for enhanced information on climate and climate change and on methodologies of application of climate knowledge in various socio-economic areas and for assessments of climate impacts. Congress then decided that the WCP "should be reconstituted to provide an inter-agency inter-disciplinary framework to address the full range of climate and climate change issues including research into the economic and social consequences of climate and climate change". In view of this, Congress agreed that the WCP should now have the following structure:

- World Climate Data and Monitoring Programme (WCDMP) - implemented by WMO;
- World Climate Applications and Services Programme (WCASP) - implemented by WMO;
- World Climate Impact Assessment and Response Strategies Programme (WCIRP) - implemented by the United Nations Environment Programme (UNEP);

- World Climate Research Programme (WCRP) - implemented jointly by the International Council of Scientific Unions (ICSU) and WMO, with the possibility of the International Oceanographic Commission (IOC) of UNESCO becoming an additional co-sponsor in the near future.

2.3. WCP-co-ordination

The session was informed about the complex structure and co-ordination of WMO-related climate activities (see fig. 1). It was recognized that this would be discussed during the forthcoming IGM-WCP.

Second World Climate Conference

2.4. The results of the first decade of work under the WCP were discussed by the Second World Climate Conference (Geneva, October/November 1990). On specific issues concerning water, the SWCC noted that:

- Among the most important impacts of climate change will be its effects on the hydrological cycle and water management systems, and through these, on socio-economic systems. Increases in incidence of extremes, such as floods and droughts, would cause increased frequency and severity of disasters;

- The design of many costly structures to store and convey water, from large dams to small drainage facilities, is based on analyses of past records of climatic and hydrological parameters. Some of these structures are designed to last 50 to 100 years or even longer. Records of past climate and hydrological conditions may no longer be a reliable guide to the future. The design and management of both structural and non-structural water resource systems should allow for the possible effects of climate change;

- Data systems and research must be strengthened to predict water resources impacts, detect hydrological changes, and improve hydrological parameterization in global climate models;

- Existing and novel technologies, for more efficient use of water for irrigation, should be made available to developing countries in semi-arid zones.

WMO Eleventh Congress

2.5. Out of the Second World Climate Conference arose a major proposal for the development of a Global Climate Observing System (GCOS), which was subsequently endorsed by Cg-XI in its Resolution 9 (Cg-XI) - see Annex 5. To promote GCOS, a joint planning office has been established in WMO and several meetings have been held to define the programme. To this end, the Scientific and Technical Committee has met twice under the chairmanship of Sir John Houghton and there have been meetings of its subcommittees, the one on land surface discussing particularly the hydrological input to GCOS. It is anticipated that the international hydrological community will be called upon to play an important role in the development and implementation of the hydrological aspects of GCOS.

2.6. Cg-XI clearly recognized the important link between climate and hydrology and water resources. It requested CCl to increase its activities in support of climate data and monitoring, in co-operation with CHy and other technical commissions. One potential future link between CHy and CCl concerns scenarios of potential future climates for assessment of implications of potential climate change and increased variability. Congress has welcomed the emphasis on activities in the application of climate information in areas related to flood, drought and water and noted the close collaboration between WCP and the HWRP. It expressed appreciation for the relevant activities of CHy and welcomed the continued development of water-related activities within the WCP grouped under the heading WCP-Water and actively supported by a number of other international organizations in particular UNESCO, the International Association of Hydrological Sciences (IAHS), International Institute for Applied System Analysis (IIASA) and UNEP. Congress also indicated that the WMO Special Trust Fund for Climate and Atmospheric Environmental Activities might be used to support the collection of hydrological data for climate monitoring and work on climate-water projects in areas of marginal water supply.

2.7. Although the Global Energy and Water Cycle Experiment (GEWEX) and the GEWEX Continental Scale International Project (GCIP) are activities undertaken within the WCRP, they have great importance for the work of CHy. The "water" component of GEWEX requires the compilation of hydrological data and studies of the hydrological cycle. The original proposal for GCIP was developed by the IAHS/WMO Working Group on GEWEX and, from the very outset, the CHy Rapporteur on Hydrological Modelling for Climate Studies has been intimately involved. It is only appropriate, therefore, that Cg-XI called for a strengthening of links between WCRP and HWRP.

International Conference on Water and the Environment, Dublin and the United Nations Conference on Environment and Development (UNCED), Rio de Janeiro

2.8. During the lead up to UNCED, and at UNCED itself, considerable attention was directed towards climate and climate change. This culminated in the signing of the Convention on Climate Change and the adoption of Agenda 21. Both in the Dublin Report

and in Chapter 18 of Agenda 21 concern for the impact of climate change and variability on freshwater resources and on the hydrological cycle is evident. Recommendations for action are given which include the strengthening of data collection and research programmes, the detection of climate change and assessment of the likely socio-economic impacts.

2.9 One result from Rio of special relevance to WCP-Water was the UN General Assembly Resolution 47/88 of 22 September 1992 concerning the elaboration of an international convention to combat desertification. Since then a Secretariat has been established for the International Negotiating Committee on Desertification, INC-D and the first substantive session on these negotiations are set for May 1993 in Nairobi, Kenya.

Commission for Hydrology

2.10 The main aim of contributions by the WMO Commission for Hydrology to the WCP is to ensure an effective input from operational hydrology to water-related aspects of studies of climate and the use of climate information for water-resource activities. The objectives are concerned with the effective use of climate data and information in the planning and operation of water-resource systems and with the use of hydrological data in climate-related studies. In this, the Commission's principal input is to activities under WCP-Water, as described below. At its Ninth Session in January 1993 the Commission endorsed the continuation of WCP-Water and appointed a rapporteur (Mr. J. Schaake) on GEWEX and water and energy interactions at the land surface whose terms of reference include support to relevant WCP-Water projects. See Annex 6 for a description of the proposed World Hydrological Cycle Observing System (WHYCOS).

2.11 Mr Schaake is a Rapporteur in the Working Group on Operational Hydrology, Climate and the Environment with Mr M. Beran as the Chairman. This Group also contains three other rapporteurs with remits of relevance to WCP-Water; the first on GCIP and large scale hydrological studies (Mr A. Hall, Australia), the second on Hydrological data for observing climate and environmental change (Mr Z. Kaczmarek, Poland) and the third on Impacts of climate and environmental change on operational hydrology (Mr M.A. Roche, France).

2.12 It was decided in 1980 that, in order to take account of the special role of water in climate, all water-related activities within the WCP should be grouped under the heading World Climate Programme-Water (WCP-Water). UNESCO agreed to share with WMO the responsibility for co-ordinating these activities. Since 1981 a series of five planning meetings on WCP-Water have been held. These meetings have formulated and, as necessary, updated plans for implementation of various projects on climate and water.

Commission for Climatology

2.13 The Commission for Climatology held its Eleventh session in Havana, Cuba in February 1993. At the session CCl appointed a Rapporteur on Water Resources to serve as Liaison with CHy.

3. GENERAL REVIEW OF CURRENT AND PLANNED ACTIVITIES

3.1 Intergovernmental Panel on Climate Change (IPCC)

3.1.1 At its last plenary, held in Nairobi in November 1992, IPCC re-established its Working Group 2 concerned with impacts and responses. This group met in Geneva in February 1993 and considered hydrology and water resources within two of the four sub-groups which were established for the meeting. The meeting welcomed the fact that IPCC was giving more attention to hydrology and water resources than previously, recalling that the Second World Climate Conference had recognised that climate change could have far reaching effects on water resources. However there was concern that the effort on hydrology and water resources was split between two sub-groups.

3.1.2 Subsequent to the drafting and publication of the First IPCC Assessment in 1990, a substantial number of studies were undertaken that dealt with all aspects of climate change, including hydrological effects and water resources management impacts. As a result, all three Working Groups of the IPCC were directed to prepare supplements to their First Assessment findings. In this way, timely updates to the First Assessment would be provided prior to publication of the Second Assessment planned for 1995. Information on hydrology and water resources was included in a volume entitled Supplement to the IPCC Climate Change Impacts Assessment published in 1993.

3.1.3 One of the more important findings included in the hydrology and water resources supplement was that although the body of information on this topic is growing rapidly, especially case studies of hydrological impacts, few new insights have been offered by these studies particularly for water resources management impacts. This is due largely to the fact that most of the analyses are based on general circulation model (GCM) outputs which simply do not provide the information required for evaluating management-related impacts.

3.1.4 The hydrology and water resources supplement included two principal recommendations: (1) Increased variability of floods and droughts will require a re-examination of engineering design assumptions, operating rules, system optimization, and contingency planning for existing and planned water management systems; and (2) more studies on hydrological sensitivity and water resource management vulnerability need to be focused in arid and semi-arid regions and small island states.

3.2 International Negotiating Committee for the Framework Convention on Climate Change

The Framework Convention on Climate Change which was signed by some 160 nations at UNCED in Rio de Janeiro is at present being ratified. It is expected that the forthcoming activities under INC under the Convention will prove to be of significance to WCP-Water.

3.3 NATO Special Programme on the Science of Global Climate Change

3.3.1 The general objectives of the Programme are to promote research dealing with potential global changes within the Earth's environment system, using the means available to the NATO Science Committee. Those are essentially related with the funding of advanced level scientific meetings of two different kinds: the "Advanced Research Workshops", which are international meetings held for two to five days for 20 to 50 prominent scientists from NATO or other countries with the objective of assessing the state-of-the-art in a given scientific area and to formulate recommendations for future research; the "Advanced Study Institutes" which are two-week international schools at post-doctoral level gathering together typically 12 to 15 lecturers and 60 to 80 students, with the objectives of disseminating advanced knowledge not yet in university curricula and fostering scientific contacts between senior and young scientists.

3.3.2 The Special Programme on the Science of Global Climate Change was created in the beginning of 1990 and will extend its activities until the end of 1995. It will particularly aim at describing and understanding the interactive physical, chemical and biological processes that regulate the total Earth system. Its primary goal is to advance our capability to predict changes in the global environment, in particular those which are related to human impacts on climate. The increase in tropospheric concentrations of green-house gases with its future effects on climate, the depletion of stratospheric ozone and other global consequences of human activity including also deforestation and various land use changes, could indeed carry a threat to change global living conditions.

3.3.3 With the Special Programme entering its third year, a number of Workshops and Institutes have already been held of relevance to WCP-Water. One of the more important was the Workshop on **Opportunities in hydrological data for climate change studies** which took place in Lahnstein, Germany in 1991. For the future programme there were several workshops of interest to WCP-Water; with the Tucson workshop on the **Trials and Tribulations of Modelling and Measuring; Global Environmental Change and Land Surface Processes in Hydrology** being the most significant.

3.3.4 The Human Dimensions of Global Environmental Change Programme (HDP) is an international research programme whose aims relate to human interactions with the global environment. Potential areas of joint interest exist within HDP's projects that relate to land use and climatic change, and where policy sensitivities arise through problems of water supply and demand.

3.4 Agenda 21

Agenda 21 which was adopted and signed by most countries of the world at UNCED in Rio, 1992 includes several references to hydrology and water resource management. In particular Chapter 9 "Protection of the Atmosphere", Chapter 12 "Managing Fragile Ecosystems: Combating Desertification and Drought" and Chapter 18 "Protection of the Quality and Supply of Freshwater Resources" should be of direct relevance to WCP-Water.

3.5 FAO

3.5.1 FAO has taken several initiatives to intensify activities concerned with climate issues, including possible climate change. While all these initiatives are in the field of agriculture, forestry and fisheries, a number of them, particularly those related to agriculture are heavily involved with water aspects of the agricultural production, such as irrigated crops.

3.5.2 In addition to the FAO WCP-Water Project C.3 on the water potential for irrigation in Africa, two other FAO projects are included in WCP-Water, namely one on sensitivity to climate change (greenhouse effect) of irrigation water availability, including reservoirs, and a second on population support capacity of land, based on agro-ecological zones established according to climatic, among other characteristics. FAO therefore looks forward to continued co-operation with WCP in general and WCP-Water in particular.

3.6 United Nations Environment Programme (UNEP)

3.6.1 It was decided by the Advisory Working Group on Water Resources Programme of UNEP that research should be conducted especially on the possible shift of the climate belts and the effect of this on the pattern of water use, i.e. how to take climate change into consideration in design criteria for water management systems. It was recommended that research topics should be carefully selected to ensure they produce useful results which could be directly applicable.

3.6.2 UNEP's intellectual contribution to the ICSU's International Geosphere-Biosphere Programme (IGBP) will be to provide recommendations in all relevant fields.

3.6.3 Besides the specialized project on the global climate change related to IGBP, UNEP is also concerned with the climate change impacts on water resources development. Under its Programme for the Environmentally Sound Management of Inland Waters (EMINWA), attention is paid to the environmental aspects of the development of river basins. At present, Lake Chad and its deterioration is the major matter of concern. All possible causes of the lake's degradation are being analyzed and all plausible water supply alternatives for the basin under short, medium and long-term climate change impacts are being considered. Similar types of project are in preparation for Latin America and Asia.

3.7 UNESCO International Hydrological Programme, IHP, Implementation of the fourth phase of IHP (1990-1995)

3.7.1 At its ninth session in March 1990, the IHP Council adopted the detailed plan for the execution of the Programme for 1990-1995 (IHP-IV) entitled: "Hydrology and water resources for sustainable development in a changing environment". This programme is composed of three subprogrammes: (a) Hydrological research in a changing environment (Subprogramme H); (b) Management of water resources for sustainable development (Subprogramme M); (c) Education, training, transfer of knowledge and information (Subprogramme E). The three subprogrammes are broken down into 15 themes covering 44 projects, some of which are split into subprojects.

3.7.2 Member States have expressed considerable interest in such activities as the humid tropics programme (project H-5.1), small islands, hydrology of arid and semi-arid zones (project H-5.2), hydrology of snow and ice (project H-4.2), the FRIENDS project (project H-5.5). Several projects under Subprogramme H are administered jointly with other international organizations; in particular the role of the ICSU/IGBP core project on the biosphere aspects of the hydrological cycle. In relation to Subprogramme M, particular emphasis has been placed on problems related to urban hydrology, integrated water resources management, environment and socio-economic aspects of water management, and management of large lakes and international basins. In connection with Subprogramme E, the importance of the network of postgraduate courses has been strongly emphasised.

3.7.3 In connection with UNESCO's fourth Medium-Term Plan (1996-2001), a concept paper on forthcoming activities in hydrology and water resources has been prepared. It will form the basis of the plan for the fifth phase that is proposed to focus on "Hydrology and water resources development in a vulnerable environment". It takes into account recommendations made at ICSU's ASCEND 21 Conference, Vienna (November 1991) and the International Conference on Water and Environment (ICWE), Dublin (January 1992) and builds upon the UNCED recommendations.

3.7.4 The framework of the document is based on four concepts: the role of scales in hydrological processes, vulnerability of the environment, integrated water resources management, and education, training, and transfer of knowledge. The IHP-V programme is divided into eight themes: (1) Global hydrological and biochemical processes; (2) Eco-hydrological processes in the surficial environment; (3) Groundwater resources at risk; (4) Strategies for water resources assessment and management in emergency and conflicting situations; (5) Integrated water resources management in arid and semi-arid zones; (6) Humid tropics hydrology and water management; (7) Integrated urban water management; (8) Transfer of knowledge, information and technology.

3.7.5 At its tenth session (July 1992), the IHP Council endorsed the concept for IHP-V (1996-2001), and agreed in general to its content. The details of IHP-V are currently being considered by the IHP national committees and their suggestions will be incorporated into the final document to be presented to the UNESCO General Conference scheduled for November 1995.

3.8 IIASA studies on Climate Change, Water Resources and Socio-Economic Impacts

3.8.1 For the past decade much attention has been placed on assessing the impacts of climate change on the world's water resources. These assessments have focused on the hydrological impacts or the supply side. IIASA's Water Resources Project played a role in these international activities. The work proposed for 1994 takes a broader look: it also analyzes the joint impact of population growth, economic development and climate change on regional water resources and the social and economic systems that these water resources serve. Within the framework of Integrated Impact Assessment the research will focus on four major areas.

- regional vulnerability of water resources to climate change: impacts on water supply and demand;

- comparative assessment of hydro-climatological models;

- water resource management to mitigate climate change impacts

- integrated socio-economic assessment of climate change.

3.8.2 Vulnerability is assessed by examining a region's demand-supply balance. Two methodological issues are raised here: What is the appropriate scale on which to perform these analyses and how does one do a global assessment? This work will be based on the work on vulnerability by Kulshreshtha (World Water Resources and Regional Vulnerability: Impact of Future Changes, IIASA, RR-93-10, June 1993) carried out at IIASA. His data and results will represent the national scale and will be compared to global and river basin scale assessments of vulnerability.

3.8.3 Models to assess hydrological impacts of climate change scenarios have been applied to many basins, but little research has taken place on the appropriateness or repeatability of results when compared to other modelling techniques. This task proposes to examine four or five different rainfall-runoff models that have been used in climate change assessment and to apply them to a suite of catchments and river basins with consistent data sets. The preliminary set of models to be compared are: 1) The Kaczmarek Water Balance Model developed at IIASA, 2) The Strzepek-Yates Water Balance Model, 3) Urbiztondo Conceptual Rainfall-Runoff Model, and 4) Ozga-Zielinska Meso-Scale Model. The basins identified are the Upper Danube, the Warta in Poland, the Nile and Zambesi in Africa. These represent a wide range of hydro-climatic zones and should provide insights into the appropriateness of various modelling approaches to specific spatial (river basins) and temporal (crucial periods within the hydrological year) scales of the analyses

3.8.4 Water resources management is the task of controlling the natural hydrological resource into a managed resource to be applied by society to a variety of uses. The impact of climatic change on the natural hydrological resource has been relatively well studied. However, the impact on the water uses themselves has been less studied. Studies of alternative water management strategies alone or in combination with capital investments have been very few. The work of this proposed task is to study alternative water management strategies, at the local and river basin level on the following water uses: agriculture, thermal power plant cooling water, hydropower, industrial water use, municipal water supply and navigation. Case studies may incorporate the Danube, Nile, Warta, Vistula, and Zambesi River Basins.

3.8.5 Most assessments of Climate Change impacts have focused on the impact on a single economic sector or natural resource, even sometimes on only a single water use. These separate assessments do not accurately model the comprehensive or integrated impact of climate change. Since water is one of the major natural resources, whose supply is directly impacted by climatic change and that has a wide variety of uses in society and the economy, there is a need to perform integrated assessments of the impact of climate on the entire economy and society. IIASA will complete in 1994 such a study focusing on the Agricultural Sector of the Egyptian Economy jointly with FAP and the US Environmental Protection Agency. It is proposed to extend this study in 1994 and perhaps beyond to look more carefully at the entire Egyptian economy and expand the water resources to look not only at water quantity but also at quality.

3.9 IAHS

IAHS is involved in a number of activities relevant to WCP-Water. The main one is the GEWEX programme. In order to provide a relevant input from the international hydrology community, a joint IAHS/WMO - Working Group for GEWEX was founded in 1989. This group formulated four projects meant as contributions to GEWEX:

(a) GEWEX Continental Scale International Project (GCIP) (project leader: J. Schaake, USA)

(b) Meteorology of Precipitation Measurement (B. Sevruk, Switzerland);

(c) WMO Project on Evaluation of Measurements for Estimation of Areal Evapotranspiration (A. Askew, WMO);

(d) Global Runoff Data Centre (H. Liebscher, Germany).

The GEWEX programme which is a part of the WCRP is guided by a Scientific Steering Group including three hydrologists. The first project (GCIP) now forms one of the major GEWEX activities. The second project has been discussed at a number of symposia e.g. in Saint Moritz in 1991 and 1992. On the third topic a workshop was held in the Netherlands. The development of the last project is discussed under A5.

A number of further meetings are scheduled for the IAHS/IAMAP Scientific Assembly in Yokohama (July 1993) including a symposium on GEWEX-GCIP, a meeting of the joint IAHS/WMO Working Group on GEWEX and a workshop on the Use of old Hydrometeorological Data to Study Global Changes.

4. IMPLEMENTATION OF WCP-WATER PROJECTS UNDER THE SIX ACTIVITY AREAS

The meeting considered each of the current WCP-Water projects in some detail. It recorded its views and recommendations in the following paragraphs of the report. It also prepared up-dated and revised projects sheets for each project, taking account of these recommendations. These are presented in Annex 4.

A. Studies of hydrological data in the context of climate variability and change

A.1 Analyzing historical hydrological and related information

A.1.1 The meeting was pleased to learn that Mr. Pfister of Bern, Switzerland was working on the write up of the methodology and that IAHS planned to publish the text as a monograph later in 1993.

A.1.2 It was noted that the response to the questionnaire on availability of historical information had been somewhat disappointing, although some good support has been obtained from the Working Group on Hydrology of WMO Regional Association VI (Europe). It was furthermore noted that IHP project H.2.3 was related to A.1.

A.1.3 One continuing problem to be faced was that much of the relevant material was available only in the language of its compiler and this was often not one of the official languages of the UN. However, it was noted that the intention was primarily to identify sources and that only summaries or abstracts are necessary for this purpose.

A.1.4 The meeting was also informed that IAHS will consider "Use of Old Hydrometeorological Data to study Global Change" during the IAHS/IAMAP International meeting in Yokohama, Japan 11-23 July 1993.

A.2 Analyzing long time series of hydrological data and indices with respect to climate variability and change

A.2.1 The meeting was informed of progress with the project and of the results of the analyses of data which were summarised in the IIASA collaborative Paper No CP-92-05 "Occurrence of Climate Variability and Change within Hydrological Time Series - a

statistical approach" published in September 1992. The meeting also noted the background material prepared by Prof. G. Cavadias for the interpretation phase of the project "A survey of current approaches to modelling of hydrological time-series with respect to climate variability and change" and proposals for further implementation of the project made by the workshop held in the WMO Secretariat in November 1992. The meeting expressed its gratitude to the Polish Academy who had strongly supported the analysis through Dr Mitosek and was disappointed to learn that he would no longer be so closely concerned.

A.2.2 It was noted that it would be necessary to collect additional information on developments in the catchments affecting observations in order to distinguish between human impact and climate variability and change. The meeting stressed that the work should concentrate at first on both river discharge and lake level data, and urged WMO to advertise the availability of the data so that analysis could continue.

A.2.3 The updated status of the project is presented in Annex 4 to this report.

A.3 Distinguishing between the influence of man's activity and climate variability on the hydrological cycle

A.3.1 The meeting noted that the project has been idling since the publication of the report by Messrs J. C. Refsgaard, W. M. Alley and V. S. Vuglinsky ("Methodology for distinguishing between man's influence and climatic effects on the hydrological cycle", IHP-III Project 6.3. IHP Technical Document in Hydrology. UNESCO, Paris, 1989). It was recognised, however that the project may be reactivated through an initiative within the framework of the UNESCO IHP-IV H-5-1 Humid Tropics Programme in connection with Africa. There is a proposal to evaluate the combined impacts of climate (rainfall) variability and land-use changes, arising from population pressures on the water quality and quantity of selected drainage basins. The meeting noted that there is potential for collaboration with UNEP and with WMO through WHYCOS.

A.3.2 It was noted that CHy IX had appointed a Rapporteur on "Water-use" (A. Perks, Canada) whose work may contribute to further development of this project.

A.4 Monitoring of glacier fluctuations

A.4.1 This project is made up of two components: one concerning the World Glacier Inventory, and the second the study of the fluctuation of glaciers. Both are scientifically supervised by ICSI of IAHS. The World Glacier Inventory is an effort to make a snapshot image of the global glaciation for the time period of ca. 30 years from 1950s-1980s. In the inventory, main geometrical features of glaciers outside Greenland and Antarctica are considered.

A.4.2 The study of fluctuations of glaciers includes the records of changes in surface area, front position and mass balance of selected glaciers. The compiled results are currently published every five years. The sixth volume covering the five years 1986-1990 will be published during 1993. These series are accompanied by high quality glacier maps, for selected glaciers.

A.4.3 These activities are covered under two IHP H-4 projects which aim to study the relationship between snow, ice cover and ice sheet dynamics and global and regional precipitation patterns using global and mesoscale circulation models. The World Atlas of Snow and Ice Resources will also be completed and published within the framework of these projects.

A.4.4 The meeting recognized the importance and relevance of the current activities of glaciologists and urged that as much data on glaciers as possible are made available in computer compatible form for purposes of monitoring glacier changes and also for the modelling of land phase processes at the global scale.

A.4.5 The meeting noted furthermore that a review publication related to the project will be published during 1993 by UNEP.

A.4.6 An updated description of the project is included in Annex 4.

A.5 Collection of global runoff data sets

A.5.1 The meeting was informed that the Global Runoff Data Centre (GRDC) now has a permanent staff under the direction of Mr K. Wilke.

A.5.2 Mr Wilke reported on administrative arrangements and developments in this project. His proposal to extend the tasks of the Centre by basic statistical analyses was accepted. This includes regional and global trends in hydrological time series, calculation of balance components for large regions, desegregation of runoff, transfer to grid area values for validation of GCMs and maps of means of measured and gridded runoff.

A.5.3 Furthermore a Geographical Information System (GIS) will be generated for station and catchment related values, digital elevation model, vegetation and soil map, large lakes and dams.

A.5.4 The Centre was encouraged to maintain the co-operation with UNEP's GEMS/WATER and GRID and the Global Precipitation Climatology Centre (GPCC), and to explore links with World Data Centres.

A.5.5 The WMO Secretariat was encouraged to continue its efforts to obtain additional data for inclusion in the basic data set to get a more comprehensive coverage of the land surface of the world.

A.5.6 The meeting urged the establishment of the Steering Committee for GRDC as soon as possible. This Committee can also advise the griding activities referred to above which are a contribution to WCP-Water Project B.3

A.5.7 It was proposed that an international workshop on GRDC should be held every 3 years.

A.6 Transfer of hydrology information to grid point or grid area values

A.6.1 This project has been incorporated into project B.3.

A.7 Global Energy Balance Archive (GEBA)

A.7.1 Prof Ohmura reported that the GEBA presently possesses 150,000 station months of data for 1,600 locations. A major progress in assimilation of new data was reported in digitizing and inserting the global radiation and net radiation from the monthly reports at the World Radiation Data Centre in St Petersburg for the period 1964 to 1985. The occurrence frequency of the errors in monthly values in the WRDC data is 2%. Most errors are corrected by the GEBA assimilation. A new radiation balance for the earth's surface was calculated based on the GEBA data over land and ocean.

A.7.2 Future effort will be directed to update the data for the period 1986 to 1990. Areas of sparse coverage over the oceans and in polar regions remain. Attempts to separate UV radiation were abandoned for reason of poor data quality and lack of standardised measurements. A closer tie with the BSRN (Baseline Surface Radiation Network of the WCRP) will be established to improve the accuracy.

A.7.3 All data were publicly available and were already being provided on request to GCM modellers and others and there was considerable confidence that the new global atlas of energy balance would be completed by 1992.

A.7.4 The meeting congratulated Prof Ohmura and his colleagues on their excellent work and wished them every success with the final stages of their task.

A.7.5 The updated status of the project is presented in Annex 4.

A.8 Detecting Global and Regional Runoff Trends by Monitoring Discharges of Selected Rivers

A.8.1 Dr Wilke from GRDC presented a revised project proposal, which is included in Annex 4.

A.8.2 It was noted that stations to be used in the project had been selected based on catchment and discharge criteria.

A.8.3 The meeting recognized that this project would be of relevance to the activities planned under GCOS.

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

A.9.1 It was recognized that this project had to await the outcome of A.8. However, the meeting was concerned that funding and staffing cutbacks had resulted in this activity being curtailed and appealed for the project to be reactivated. UNESCO is investigating possibilities, subject to 1994/95 biennium funding.

B. Modelling of the hydrological cycle

B.1 Coupling of physically based climate and hydrological models

B.1.1 The meeting considered that the further development and improvement of physically-based mathematical models of the atmosphere would gain greatly from a better understanding of the effect of climate on hydrological processes and an upgrading of the manner in which such processes are incorporated into atmospheric general circulation models (GCMs). This would be aided by the coupling of climate and hydrological models.

B.1.2 It was recognized that the international hydrological community, both through the IAHS/WMO Working Group on GEWEX and CHy, had taken initiatives and played an active role in developing improvements in the land-phase descriptions in GCMs.

B.1.3 While encouraging their colleagues to continue this direct collaboration with GCM modellers, the meeting also emphasized the importance of pursuing the development of macro-scale hydrological models such as that proposed by Becker and Nemec in 1987.

B.1.4 The meeting noted that it was recommended by the Fifth Planning Meeting on WCP-Water, that a technical scientific meeting or series of meetings be convened in due course to bring together those who are involved in macro-scale hydrological modelling under WCP-Water, GEWEX, IGBP and other international programmes so as to exchange experience and encourage collaboration between the individual experts and between the programmes themselves. Such a meeting is currently being planned with the support of NATO in the first half of 1993.

B.3 Development of grid-related estimates of hydrological variables

B.3.1 This project was seen as being very closely linked with Projects A.5 and B.1 and the meeting was pleased to note their parallel development. A revised project description presented by Dr Wilke was discussed and adopted, see Annex 4.

B.3.2 It was noted that a workshop related to this project was planned for the autumn of 1993 and that sessions on related matters were planned during the IAHS/IAMAP Joint International Meeting, Yokohama Japan 11-23 July 1993.

B.3.3 Dr Wilke presented details of a project "Transformation of measured flow data to grid points", see (Annex 4) which was a contribution to this project. Other activities within the framework of the FRIEND project (IHP H-5-5) were also reported on by Dr Arnell (IH, UK).

B.4 Hydrological aspects of HAPEX

B.4.1 General information was provided on the latest developments as regards HAPEX. It was recognized that this comprised a loosely-knit series of national and regional projects with aims for parameterizing the water and energy exchanges over various biomes. The project title was adjusted accordingly. The role of IGBP-BAHC in future large scale experiments was noted.

B.5 Use of atmospheric moisture transport information for water balance computations

B.5.1 A knowledge of atmospheric moisture content is indispensable for the determination of water balances of large basins and areas. The meeting noted that within Project B.5 a report had been prepared and published as an IHP Technical Document in Hydrology ("Use of data on atmospheric moisture transport over continents and large river basins for the estimation of water balances and other purposes" by L.P. Kuznetsova, Project IHP-III 1.1, UNESCO, 1990 (SC/90/WS-36)).

B.5.2 This report deals with the analysis and generalization of the national research programme results of the last decade particularly with respect to reviewing new information on atmospheric water content and transport in connection with water balance computations. The report reviews water balances over the USSR, China, the Indian sub-continent and the Amazon basin. Case studies for water balance computations for the Parana, Volga, Ob and Irtys basins are also presented.

B.5.3 This completes Project B.5 for the present.

B.6 Preparation of monthly global gridded precipitation data sets

B.6.1 The activities of the WCRP Global Precipitation Climatology Project and its control element GPCC, which is established at the NMS of Germany, Deutscher Wetterdienst, were introduced by Mr Rudolf.

B.6.2 The meeting recognized that the products of the GPCC (time series of monthly precipitation totals on an area-grid) will be of special interest for climate related hydrological studies.

B.6.3 Mr Rudolf proposed to include the provision of these global precipitation analyses in the WCP-Water, which was endorsed by the meeting and included as project B.6, see Annex 4.

B.7 Comparison study of time series of areal mean monthly precipitation and streamflow of selected catchment areas.

Mr Rudolf introduced this new project proposal, which was endorsed by the meeting and included in WCP-Water as project B.7, see Annex 4.

C. Application of climate information in the planning, design and operation of water-resources systems

C.1 Application of climatological data and methods to water-resources projects

C.1.1 A report on this subject has been prepared by the Rapporteur to the WMO Commission for Hydrology, Dr Liebscher "Climatological Data and Climate Information for Water Resources Projects". The report will be completed and published in 1993.

C.1.2 The meeting recommended that the Rapporteurs on related matters appointed by CHy-IX and CCl-XI be asked to contribute to this project in their work.

C.2 Application of climate information for water projects in the Sahel

C.2.1 In association with the activities of the WMO/UNEP Inter-governmental Panel on Climate Change (IPCC), a report on the possible impact of climate change on water resources in the Sahel was prepared by J. Sircoulon in 1990. Being relevant to the WCP-Water Project C.2, the report was published as a contribution to this project.

C.2.2 It was felt to be important to maintain the project as an indication of the importance that WCP-Water put on the use of climate information in sensitive regions and as a basis for encouraging those with the resources to assist in such work in the region.

C.3 Application of climate information to irrigation water supply assessments in Africa using a digital geographic information system data base

C.3.1 A digital geographic information system (GIS) database has been prepared for Africa on a scale of 1:5,000,000 and published in 1987. This GIS is being used as a basis for developing a methodology for water supply assessment on a regional and continent-wide basis. A customized GIS has been developed for part of the Nile Basin. It supports the estimation of hydrological model parameters, drainage area determination, and the estimation of physical variables such as elevation, slope and length. This GIS will be used for water resource studies in the IGADD countries. A new methodology for the collection of data is under test.

C.4 Application of conditional climatological information to water supply forecasting in the USA

C.4.1 This project has been completed and a report published: A non-parametric framework for long-range streamflow forecasting, by J.A. Smith, G.N. Day and M.D. Kane, WCASP No. 17, 1991 (WMO/TD No. 428).

C.5 Re-analysis of hydrological observations in the Czech Republic

C.5.1 In view of recent changes concerning the status of former Czechoslovakia and the existence of the two new independent states, the input to the project by the Czech Hydrometeorological Institute in Prague is now limited to activities in the Czech Republic and a relevant change is proposed in the title of this project, to that used here.

C.5.2 A final report was submitted for the sub-project "Re-analysis of hydrometeorological characteristics" The report "Hydrological Design Data Estimation Techniques" gives an overview of results of analyses of hydrological data in a river network with the aim of extending hydrological information into ungauged sites of the network and has been published in the WCASP series of reports (WCASP-26, WMO/TD No. 554, May 1993).

C.5.3 Studies have been initiated for the two other parts of the project:

- analysis of long-term hydrometeorological series, and
- changes in water balance.

The aims of these studies are to assess and verify the evidence of the impact of climate change, variability and man-made changes on hydrological parameters.

C.5.4 The status of the project was updated as indicated in the revised project contained in Annex 4 to this report.

C.6 Teleconnexion of the El Niño phenomenon with extreme hydrological events in South America

C.6.1 This project continues to be implemented under the auspices of WMO Regional Association III (South America). A survey on hydrological aspects of the El Niño phenomenon was initiated by the WMO RA III Working Group on Hydrology. The relevant questionnaire was distributed among WMO RA III Members in 1989. The replies to this survey have been evaluated and a preliminary draft prepared, which was considered by the eleventh session of RA III. Additional information is currently being requested so as to increase the geographical coverage in RA III. In addition, RA IV has been invited to undertake a similar survey and analysis.

C.7 Development of Improved Climatic Scenarios for Water Resource Assessment

C.7.1 It was reported that since the Fifth Planning Meeting, when this project was agreed, a number of new approaches to deriving improved climatic scenarios have been developed. All make use of general circulation model output, and most make use of the model-simulated 700-mb height field. Specifically, four approaches were described: (1) a weather-pattern based stochastic temperature and precipitation model; (2) a linear model linking atmospheric circulation and precipitation (snowpack accumulation); (3) disaggregation of GCM output using a one-way nesting of models; and (4) canonical correlation of atmospheric circulation and regional streamflow patterns.

C.7.2 Details of each of these approaches have been published in international journals and it was suggested that enough information has been compiled to consider the preparation of a WMO report documenting these procedures for international distribution and use. A revised project description is included in Annex 4.

C.8 Verification of Probabilistic Streamflow Forecasts

C.8.1 The U.S. National Weather Service has reported that work is proceeding on this project, but unfortunately due to staffing problems it will be at least two years before any technical reports will be available.

C.9 The impact of the El Niño Southern Oscillation (ENSO) phenomenon on the hydrology of the South West Pacific

C.9.1 The meeting reviewed this project proposal and agreed that although there would be possibilities of merging it with ongoing projects it should be treated as an independent project, see Annex 4.

C.9.2 In particular the close relation between this project and C.6 was recognised as well as its obvious connection to the TOGA project.

D. Studies of the influence of climate change and variation on water resources

D.1 Sensitivity of water-resource systems to climate variability and change

D.1.1 This was seen as an umbrella project which provided a means of recording and following-up on any of a wide range of activities concerned with this very important topic. Specific tasks undertaken by clearly identifiable groups were presented as separate projects under Activity Area D.

D.1.2 The meeting agreed that this project should continue.

D.2 Use of climate data for the study, planning and management of water resources

D.2.1 The meeting noted with satisfaction that the UNESCO Source Book in Climatology for Hydrologists and Water Resource Engineers has been completed and edited by M. Sanderson. The volume published by UNESCO/IHP in 1990 contains chapters on the radiation and energy balances of the Earth's surface, water in the atmosphere, the water balance of the Earth's surface and climate classification, as well as a chapter on past and future climatic change.

D.2.2 The publication of this volume completes Project D.2 for the present.

D.3 Study of the impact of climatic variability and change on the occurrence of droughts

D.3.1 The publication of the drought aspects foreseen under items 4 and 6 was not carried out and no activities have been developed in IHP-IV. It was proposed to continue the project with a new target date for the publication being 1996.

D.3.2 However under item 3 "Past Activities" the following are relevant:

(i) Forum du Sahel: Séminaire sur l'état de l'art en hydrologie et en hydrogéologie dans les zones arides et semi-arides d'Afrique, Documents techniques en hydrologie, UNESCO, Paris 1990.

(ii) Approaches to Integrated Water Resources Management in Humid Tropical and Arid and semi-arid zones in Developing Countries, by M. M. Hufschmidt and J. Kindler, UNESCO, Paris 1991.

D.4 Study of the impact of climate variability and change on the occurrence of floods in urban areas

D.4.1 The meeting recognised that several activities relative to this project were ongoing especially various workshops were referred to:

- Technical Conference on "Tropical Urban Climates", TeCTUC, Dhaka, Bangladesh, 28 March - 2 April 1993

- HYDROPOLIS - International Workshop on the Role of Water in Urban Planning, Wageningen, the Netherlands, 29 March - 2 April 1993

- International Congress "Metropolitan Areas and Rivers", Rome, Italy, 5 - 8 December 1993

- International Workshop on "Integrated Water Resources Management in Urban and Surrounding Areas", Gelsenkirchen, Germany, 29 May - 2 June 1994

D.4.2 Under the auspices of UNESCO, the International Research and Training Centre on Urban Drainage (IRTCUD) had recently been established in Belgrade. As Project D.4 would logically fall under IHP-IV Project M-3-3 (Integrated Water Management in Urban Areas) to which IRTCUD would also contribute, IRTCUD would be approached to assess the feasibility of this project.

D.4.3 A revised project description is included in Annex 4.

D.5 Testing the transferability of hydrological simulation models

D.5.1 This project represented a call for applied research to be undertaken by national institutions. It was noted that several papers of relevance to D.5 had been published and that this project was of special concern to the CHy Working Group on Operational Hydrology, Climate and Environment.

D.6 Impact of CO_2 induced climate change on UK water-resources

D.6.1 The meeting was informed of the work undertaken under this national project by Dr Arnell. A report on the most recent study, to the UK Department of the Environment, was due to be issued soon.

D.6.2 The meeting concurred with Dr Arnell's view that with the completion of the study this WCP-Water project could be terminated. The report would be provided to WMO.

D.6.3 The project status is also reported in Annex 4.

D.7 Assessment of Impact of Possible Climate Change and/or Sensitivity of Irrigation Systems including Storage of Irrigation Water in Reservoirs

D.7.1 Work on this project has been undertaken by the Swiss Federal Institute of Technology, Zürich (ETH) under contract to FAO. The report is in the process of editorial revision.

D.8 Assessment of Climate Change Impact on Population Supporting Capacity of Land Based on AEZ (Agro-Ecological Zones)

D.8.1 The meeting noted that this project had moved into a more operational phase in the Sahel and expressed interest in learning in due course of the experience gained by FAO in this regard.

D.9 Impact of Climate Change on Thermal and Ice Regime of Rivers and Lakes

D.9.1 Updated information submitted by UNESCO is included in Annex 4.

D.10 Impact of Climate Change on Suspended Sediment and Water Quality

D.10.1 The IHP related activity (IHP-IV project H-1-2 Study of erosion, river bed deformation and sediment transport in river basins as related to natural and man-made changes) could be considered as a contribution to the above project, viz:

. Contribution to the organization of the 5th International Symposium on River Sedimentation (IRS) (Karlsruhe, 6-10 April 1992) with in particular the sponsorship of a special workshop on "Effects of Resuspension of River Sediments".

The proceedings of this workshop were published by UNESCO through the release of a limited number of copies by the organizer of the symposium entitled "Workshop on Sediment Quality" edited by P. Larsen and N. Elsenhauer, December 1992, 81 pp; UNESCO could develop this publication within its series: "Technical Documents in Hydrology". A UNESCO Technical Report on the topic is being prepared by a working group:

D.10.2 A working group will also meet during an International Symposium to be held in St. Petersburg (16-20 May 1994) on a related topic: "State of the Art in River Engineering: Methods and Design Philosophies", in order to finalize the technical report.

D.11 Sensitivity of Storage Systems to Climate Change

D.11.1 Updated information from IIASA is included in Annex 4.

D.12 Overview of Methods to assess the relations between climate variability/change and water resources

D.12.1 This project proposal was presented by Dr Arnell of IH, UK and was discussed and accepted by the meeting. As detailed in Annex 4 it relates to applications of impact studies by water managers, planners and decision makers. Phase I would be a project definition stage.

D.13 Climate Variation Impacts on Water Balance and Water Quality of Shallow Lakes

D.13.1 This proposal was presented by Dr Szilagyi from VITUKI, Hungary and was discussed and accepted by the meeting. As detailed in Annex 4, the project comprised studies of water quantity and quality sensitivity to climate in the catchment of Lake Balaton.

E. Impact of climate on society through water resources

E.1.1 The meeting discussed the lack of projects under area E and how to interest economists and social scientists in contributing. There were a number of difficulties but it was agreed that this was a matter worth pursuing. It was suggested that members of the planning meeting might make individual contacts and that a short article could be prepared on WCP-Water for journals read by those concerned with human dimensions. This article would summarise the work under WCP-Water and invite contributions within the topic: Impact of Climate on Society through Water Resources.

F. Influence of man's activities on climate

F.1.1 The hope was expressed that UNEP would soon find it possible to include one or more projects under this topic.

5. TERMINATION OF PROJECTS AND DEVELOPMENT OF NEW PROJECTS

5.1 During its review of current projects, as reported under section 4 above, the meeting recognized that certain of them had met their immediate objectives and might be considered "completed for the present". The use of this phrase was deliberate because it is always possible to do further work on any topic and under WCP-Water in particular it would be unwise to declare that a subject was ever closed. The projects identified in Annex 4 as completed could therefore be revived in the future when concrete proposals for further work are received.

5.2 With the provision noted above, the meeting noted that the following project could now be considered "completed for the present":

C.4 Application of conditional climatological information to water supply forecasting in the USA.

5.3 The following new projects were included in WCP-Water. Their descriptions are given in Annex 4.

B.6 Preparation of monthly gridded precipitation data sets.

B.7 Comparison study of time series of areal monthly precipitation and streamflow of selected catchment areas.

C.9 Impact of the El Niño southern oscillation phenomena on the hydrology of the South West Pacific.

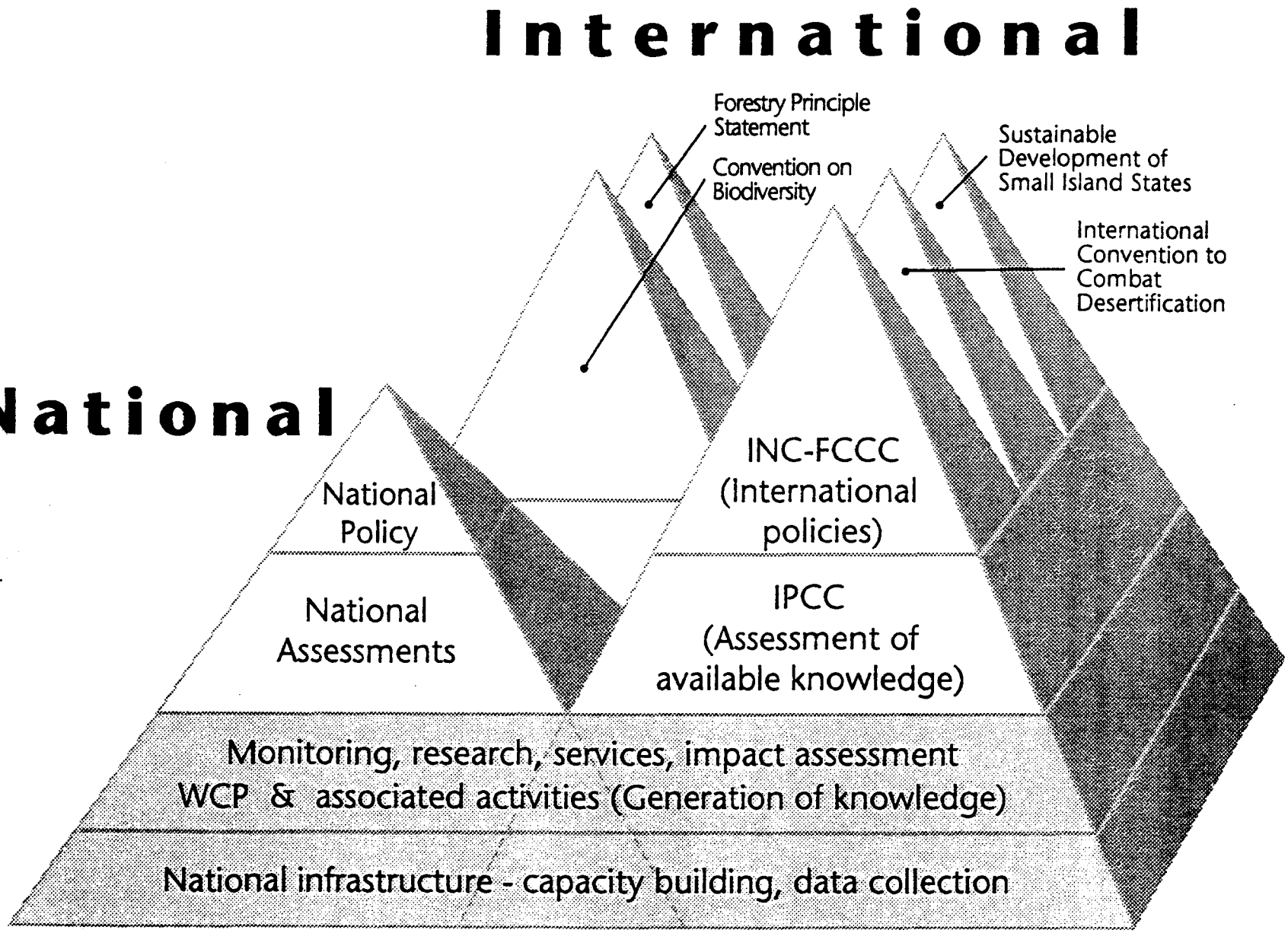
D.12 Overview of methods for assessing the implications of climate change and variability for water resources management.

6. FUTURE DEVELOPMENT AND MEDIUM TO LONG-TERM PLANS

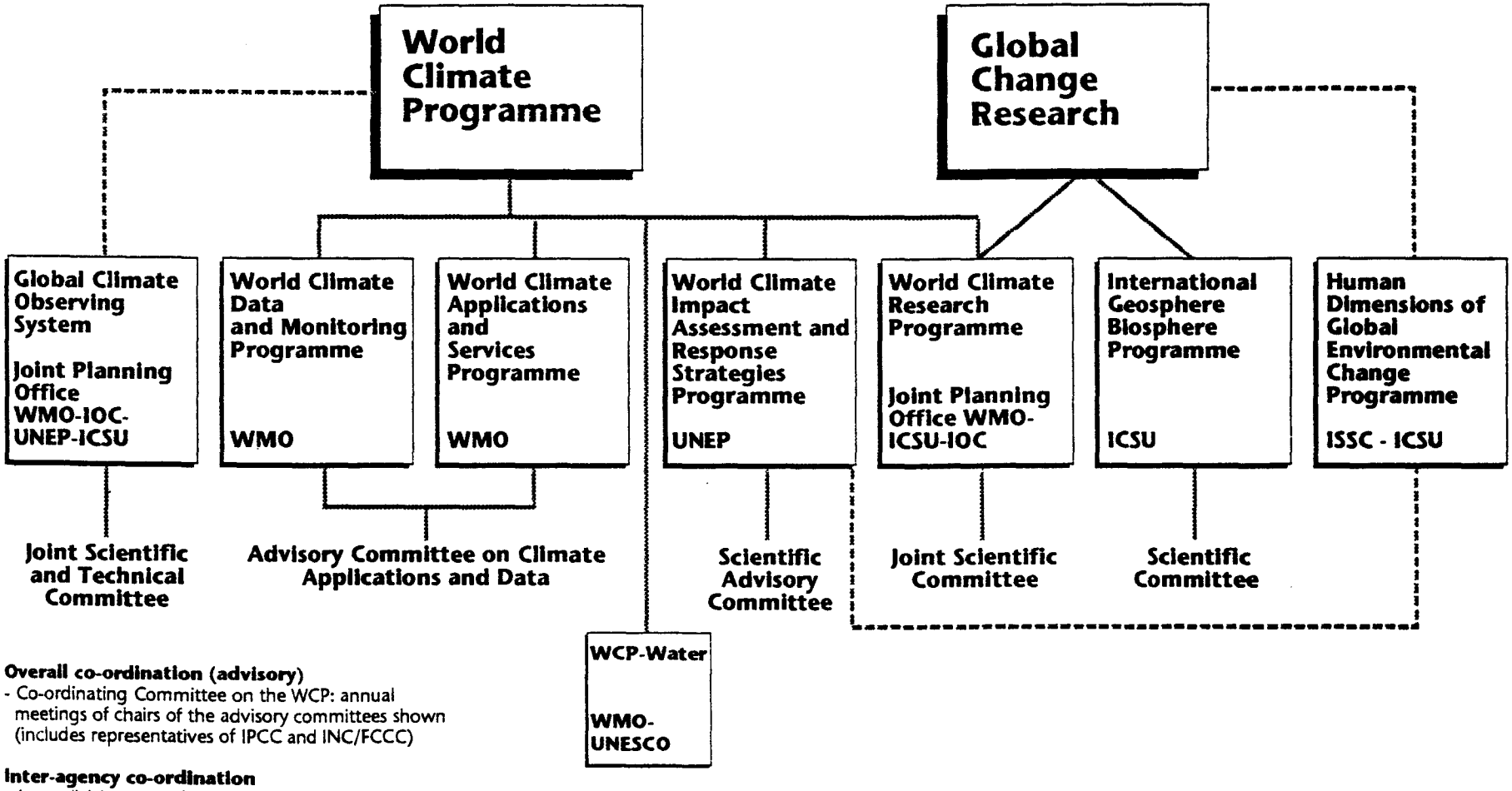
6.1 The meeting noted that this item has been adequately considered under item 3. General review of current and planned agency activities.

7. CLOSURE

7.1 The meeting reviewed and adopted a draft of the report of the meeting and requested the WMO Secretariat to complete the report with descriptions of the status of each project.



URE 1 - NATIONAL CLIMATE ACTIVITIES: THEIR RELATIONSHIP TO NATIONAL AND INTERNATIONAL ASSESSMENTS AND POLICIES



Overall co-ordination (advisory)
- Co-ordinating Committee on the WCP: annual meetings of chairs of the advisory committees shown (includes representatives of IPCC and INC/FCCC)

Inter-agency co-ordination
- (annual) Meetings of Executive Heads of all participating organizations, convened by the Secretary-General of WMO
- Senior Representatives of participating organizations meet at least annually

NOTE: Organizations indicated in boxes are lead agencies for programmes (others are also involved)

FIGURE 2 - INTERNATIONAL CLIMATE ACTIVITIES: EXISTING ORGANIZATIONAL AND CO-ORDINATION ARRANGEMENTS

ANNEX 1

Sixth Planning Meeting on World Climate Programme-Water

Wallingford, 1-5 March 1993

LIST OF PARTICIPANTS

Mr. Henny Colenbrander
IAHS
Rozendaalselaan 36
6881 LD VELP
The Netherlands

Tel: (31) 8564 6798
Fax: (31) 8562 9336

Dr. Klaus Wilke
Global Runoff Data Centre (GRDC)
Bundesanstalt für Gewässerkunde
Kaiserin-Augusta-Anlagen 15
D-5400 KOBLENZ
Germany

Tel: (261) 1306 307
Fax: (261) 1306 302

Mr. Bruno Rudolf
Global Precipitation Climatology Centre (GPCC)
Deutscher Wetterdienst
Postfach 10 04 65
D-6050 OFFENBACH
Germany

Fax: (4969) 8062 2993

Mr. Atsumu Ohmura
Department of Geography
Project A-5, ETH
Winterthurstrasse 190
8057 ZURICH
Switzerland

Tel: (1) 2575 220
Fax: (1) 3625 197
Tlx: 815813

Dr. Ferenc Szilágyi
VITUKI
P.O. Box 27
H-1453 BUDAPEST
Hungary

Tel: (361) 1142 617
Fax: (361) 1341 514

Mr. Vaclav Dvorak
Czech Hydrometeorological Institute
Na Sabatce 17
143 06 Praha 4
Czech Republic

Tel: (422) 4010 800
Tlx: 123335 CHMUC

Mr. Harry F. Lins
US Geological Survey
436 National Centre
Reston, VA 22092
USA

Tel: (703) 6485 712
Fax: (703) 6485 070
Tlx: 160443 usgsut

Mr. Max Beran
Institute of Hydrology
Maclean Building
Gifford
Wallingford, Oxon, OX10 8BB
United Kingdom

Tel: (44491) 388 00
Fax: (44 491) 380 97
Cable: Hycyle Crowmarsh Wallingford

Dr. N. Arnell
(same address as Mr. Beran)

Mr. Mike Bonnell
Division of Water Sciences
Department of Earth Sciences
1 rue Miollis
75 732 PARIS CEDEX 15
France

Tel: (331) 4568 4002
Fax: (331) 4306 1122
Tlx: 204461 paris

Dr. J. C. Rodda
WMO
Case postale No. 2300
CH-1211 GENEVE 2

Tel: (41 22) 730 8355
Fax: (41 22) 734 8250
Telex:41 41 99 OMM CH

Mr. L.E. Olsson
(same address as Dr. Rodda)

ANNEX 2

AGENDA

1. INTRODUCTION

2. REVIEW OF RECOMMENDATIONS AND DECISIONS OF GOVERNING AND ADVISORY BODIES

3. GENERAL REVIEW OF CURRENT AND PLANNED AGENCY ACTIVITIES

4. IMPLEMENTATION OF WCP-WATER PROJECTS UNDER THE SIX ACTIVITY AREAS:

   A. Studies of hydrological data in the context of climate variability and change
   B. Modelling of the hydrological cycle
   C. Application of climate information in the planning, design and operation of water-resource systems
   D. Studies of the influence of climate change and variation on water resources
   E. Impact of climate on society through water resources
   F. Influence of man's activities on climate

5. TERMINATION OF PROJECTS AND DEVELOPMENT OF NEW PROJECTS

6. FUTURE DEVELOPMENTS AND MEDIUM-TO LONG-TERM PLANS

7. CLOSURE

STATEMENT OF THE 6TH PLANNING MEETING ON WORLD CLIMATE PROGRAMME - WATER, WALLINGFORD, U.K. 1-5 MARCH 1993

Climate and water are inseparable, as are water and life. In the far distant past life on the planet started in water. And today, a reliable and wholesome supply of water is vital for drinking, growing food, human health, industry, energy production and transport. Put simply: without water, civilization would stop.

Demand for water continues to rise rapidly and is expected to double between now and the year 2050; it will then equal about one quarter of the total flow in the world's rivers. However the water resources of many parts of the world are now in a critical state. Climate changes and sea level rise are likely to make the situation even more difficult. Indeed it will be largely through the impact on the hydrological regime - i.e. rivers, aquifers, lakes and reservoirs - that the consequences to society of changes in precipitation and evaporation will be most acutely felt.

The World Climate Programme - Water (WCP-Water) addresses these present and future problems. As a component of the overall World Climate Programme it addresses all four of its major themes: data, applications and services, impacts and responses, and research. A set of some 30 priority projects have been developed based upon the global resource of hydrological information on river flow, precipitation, solar radiation and glacier fluctuations. Within WCP-Water the issues that are addressed span from the science of climate change through to practical problems of water management.

The science of climate change is represented by several projects which lead to better representations of hydrological processes in climate prediction models, to improved presentation of hydrological data in gridded form to assist with model validation, and to closer monitoring and detection of past changes. One example of this latter interest is the evidence of trend that has been established in a considerable fraction of the longest records held on the Global Runoff Data Centre's archive (itself a WCP-Water contribution).

WCP-Water also promotes the application of climate information for planning and operating water resource systems through case studies such as in the countries of the Sahel where a quite extraordinary level of past climatic variability has lead to disasters and human tragedy. Pioneering studies into the impacts of future climate change on the hydrological cycle and water resources feed into important processes such as IPCC and the negotiations for a Climate Convention.

WCP-Water is acutely aware of the central role of data and a significant proportion of its activities is devoted to underpinning projects concerning all four primary elements - runoff, precipitation, radiation and glaciers. Global coverage, long term recording, quality control, and adequate timeliness are all emphasised. Without these data, and the understandings that they provide, there is prospect of the future failure of water resource systems in many regions of the globe, just at the time when the demands for water for drinking, sanitation, agriculture and for energy will be rising to an all-time high.

ANNEX 4

WORLD CLIMATE PROGRAMME - WATER
(WCP-WATER)

ACTIVITY AREAS

AND

PRIORITY PROJECTS

As proposed by the Sixth Planning Meeting on WCP-Water
(Wallingford, 1-5 March 1993)

Summary Listing of Activity Areas and Priority Projects for WCP-Water as prepared by the Sixth Planning Meeting on WCP-Water (Wallingford, 1-5 March 1993)

A. STUDIES OF HYDROLOGICAL DATA IN THE CONTEXT OF CLIMATE VARIABILITY AND CHANGE

A.1 Analysing Historical Hydrological and Related Information

- IAHS with cooperation of UNESCO, WMO, ICSU, other interested international bodies and national institutions

A.2 Analysing Long Time Series of Hydrological Data and Indices with Respect to Climate Variability and Change

- WMO in cooperation with the Global Runoff Data Centre (GRDC), Polish Academy of Sciences, IIASA, and interested national bodies

(A.3 Distinguishing Between the Influence of Man's Activity and Climate Variability on the Hydrological Cycle)

- Project completed for the present

A.4 Monitoring of Glacier Fluctuations

- ICSI (IAHS) with the support of UNESCO and UNEP

A.5 Collection of Global Runoff Data Sets

- WMO and GRDC

(A.6 Transfer of Hydrology Information to Grid Point or Grid Area Values)

- incorporated into Project B.3

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* Projects in parentheses have either been completed or incorporated into others and are therefore no longer being implemented.

A.7 Global Energy Balance Archive (GEBA)

- Swiss Federal Institute of Technology, Zürich (ETH) with other national institutions and the World Radiation Data Centre, Leningrad.

A.8 Detecting Global and Regional Runoff Trends by Monitoring Discharge of Selected Rivers

- GRDC and WMO.

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

- UNESCO in cooperation with WMO, IIASA, GRDC and national institutions

B. MODELLING OF THE HYDROLOGICAL CYCLE

B.1 Coupling of Physically Based Climate and Hydrological Models

- WMO and national institutions

(B.2 Development and Application of Second Generation Grid-Oriented Hydrological Modelling Techniques)

- incorporated into Project B.1

B.3 Development of Grid-Related Estimates of Hydrological Variables

- WMO and UNESCO in collaboration with national institutions

B.4 Hydrological aspects of HAPEX

- National institutions, WMO and ICSU at international level

(B.5 Use of Atmospheric Moisture Transport Information for Water Balance Computations)

- Project completed for the present

B.6 Preparation of monthly global gridded precipitation data sets

- GPCC and national institutes

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* Projects in parentheses have either been completed or incorporated into others and are therefore no longer being implemented.

B.7 Comparison study of time series of areal mean monthly precipitation and streamflow of selected catchment areas

- GPCC and GRDC

C. APPLICATION OF CLIMATE INFORMATION IN THE PLANNING, DESIGN AND OPERATION OF WATER-RESOURCE SYSTEMS

C.1 Application of Climatological Data and Methods to Water-Resource Projects

- WMO

C.2 Application of Climate Information for Water Projects in the Sahel

- WMO, with participation of countries of the Sahel and in collaboration with UNSO, CIEH, AGRHYMET Centre and with the financial support of UNDP and other donors.

C.3 Application of Climate Information to Irrigation Water Supply Assessments in Africa Using a Digital Geography Information System Data Base

- FAO in cooperation with interested member countries.

(C.4 Application of Conditional Climatological Information to Water Supply Forecasting in the USA)

- Project completed

C.5 Reanalysis of Hydrological Observations in Czechoslovakia

- Czech Hydrometeorological Institute

C.6 Teleconnection of the El Niño Phenomenon with Extreme Hydrological Events in South America

- WMO - RA III Working Group on Hydrology

C.7 Development of Improved Climatic Scenarios for Water Resource Assessment

- National agencies and WMO with contributions from UNESCO, IIASA and IAHS.

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* Projects in parentheses have either been completed or incorporated into others and are therefore no longer being implemented.

C.8 Verification of Probabilistic Streamflow Forecasts

- US National Weather Service in cooperation with other national agencies

C.9 The impact of the El Niño southern oscillation phenomenon on the hydrology of the South West Pacific

- WMO - RA V Working Group on Hydrology

D. STUDIES OF THE INFLUENCE OF CLIMATE CHANGE AND VARIATION ON WATER RESOURCES

D.1 Sensitivity of Water Resource Systems to Climate Variability and Change

- National institutions and WMO with contributions from UNESCO, IIASA and IAHS

(D.2 Use of Climate Data for the Study, Planning and Management of Water Resources)

- Project completed for the present

D.3 Study of the Impact of Climate Variability and Change on the Occurrence of Droughts

- UNESCO in cooperation with WMO and IAHS

D.4 Study of the Impact of Climate Variability and Change on the Occurrence of Floods in Urban Areas

- National institutions, UNESCO and the International Research and Training Centre on Urban Drainage, in cooperation with WMO, IAHS and UATI

D.5 Testing the Transferability of Hydrological Simulation Models

- National institutions with international coordination by WMO

D.6 Impact of CO_2 Induced Climate Change on UK Water Resources

- Institute of Hydrology, UK, in cooperation with other national and regional bodies

D.7 Assessment of Impact of Possible Climate Change and/or Sensitivity of Irrigation Systems Including Storage of Irrigation Water in Reservoirs

- FAO in cooperation with FAO member countries

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* Projects in parentheses have either been completed or incorporated into others and are therefore no longer being implemented.

D.8 Assessment of Climate Change Impact on Population Supporting Capacity of Land Based on AEZ (Agro-Ecological-Zones)

- FAO

D.9 Impact of Climate Change on Thermal and Ice Regime of Rivers and Lakes

- UNESCO and WMO in collaboration with national institutions

D.10 Impact of Climate Change on Suspended Sediment and Water Quality

- UNESCO and WMO in collaboration with national institutions

D.11 Sensitivity of Storage Systems to Climate Change

- IIASA in cooperation with national research institutions

D.12 Overview of methods for assessing the implications of climate change and variability for water resources management

- WMO, UNESCO, UNEP and IPCC with input from other international and national agencies

D.13 Climate variation impacts on water balance and water quality of shallow lakes

- VITUKI

E. IMPACT OF CLIMATE ON SOCIETY THROUGH WATER RESOURCES

- No projects proposed at this stage

F. INFLUENCE OF MAN'S ACTIVITIES ON CLIMATE

(F.1 Influence on Water-Resource Projects of Climate)

- Project completed for the present

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*Projects in parentheses have either been completed or incorporated into others and are therefore no longer being implemented.

ACTIVITY AREA A

STUDIES OF HYDROLOGICAL DATA IN THE CONTEXT OF CLIMATE VARIABILITY AND CHANGE

An analysis of historical hydrological data and information, and in particular of long hydrological time series, is being undertaken in order to gain fuller knowledge of climate variability and a better understanding of the processes related to climate change, including the influence of man on climate.

Due to the close relationship between climate and hydrology, hydrological variables and water resources are very strongly influenced by variations in climate. In this respect, hydrological variables, such as surface runoff, can be considered as "climate variables" representing on a large scale in time and space the residual of precipitation and evaporation.

In addition, a continuing inventory of water resources, their supply, demands and their dynamics, is needed to provide hydrological data (precipitation, runoff, glacier fluctuations, etc.):

(a) to climate modellers for the validation of predictions;

(b) to researchers studying climate change and variability;

(c) to hydrologic modellers for validation of their models and methods and for use in sensitivity studies; and

(d) for the application to food, energy, economic and health problems.

In relation to (a) above, new methodologies should be developed to relate hydrological and physiographic data to grid points or areas so that they might be used in conjunction with atmospheric general circulation models (AGCMs).

Project A.1 Analysing Historical Hydrological and Related Information

1. Background

Historical hydrological and related information, concerning for example floods, low flow periods or river ice periods, is available in many countries in the form of direct information stored in archives or in the form of indirect information such as proxy-data (for example ice core data, dendrochronological data, sediment probes, historical records tied to climatological or hydrological parameters, etc.). This material has been used for specific studies but could be more broadly used to increase our knowledge of variations in hydrological regimes during past centuries and for analysing climate variability and change.

Several organizations, including some working within the framework of the WCP, have undertaken research in these fields. However, there is a need for more co-ordination between the individual research studies.

Research groups need information on existing inventories of historical hydrological data sources including proxy-data. Therefore, it would be necessary to compile information on existing data. Furthermore, a unified methodology is needed in the form of guidance material so that results of individual research groups can be compared.

2. Output

(a) Improvement of methodologies and as far as possible unification of them;

(b) Support for the work of, and provision of guidance and information to, research groups;

(c) Comparison of results using various approaches for specific climatological or hydrological variables and for specific periods;

(d) Increasing knowledge of variations in hydrological regimes during past centuries.

3. Past activities

Circular letters have been distributed by WMO and IAHS to collect information as a basis for a review of the availability of historical hydrological and related information in member countries. Information obtained has been stored in INFOCLIMA. Three rapporteurs of the WMO RA VI Working Group on Hydrology compiled relevant material available from Europe, published as "Studies and Models for Evaluating the Impact of Climate Variability and Change on Water Resources within WMO Regional Association VI (Europe)", WMO/TD-No. 463, 1992. One IAHS-Rapporteur compiled detailed material on the climate of Europe of the past 500 years.

4. Further implementation

The next stage of the project will be:

- Organization of the International Workshop on the Use of Old Hydrometeorological Data to Study Global Changes (Yokohama, Japan, 15 July 1993).

- Compiling additional sources of historical data and proxy-data including
  (i) acquisition of hydrological information from historical records and field data;
  (ii) extraction and processing of hydrological information into quantitative form;
  (iii) calibration of the quantitative data in order to allow comparisons with current data sets or experience;
  (iv) drawing conclusions from calibrated series concerning variability of the hydrological regime;

- Developing guidance material on the analysis of historical and proxy-data.

Detailed steps include:

(a) Contacting well known scientists active in this field to seek additional material;

(b) Continuation by the IAHS rapporteur of the preparation of guidance material on the analysis of hydrological information from historical records and field data;

(c) Coordination meeting between projects A.1, A.2, A.3 and A.4.

5. Organizations/bodies involved

IAHS responsible with co-operation from UNESCO, WMO, ICSU and other interested international bodies and national institutions.

6. Tentative time schedule

(a) to (c) Continuing activity.

7. Comments

This project involves the co-operation of many scientists from very different fields of research. This project started in 1983 and became operational only after several years. Liaison necessary with Projects A.2, A.3 and A.4.

Project A.2 Analyzing Long Time Series of Hydrological Data and Indices with Respect to Climate Variability and Change

1. Background

In many countries long hydrological time series are available from instrumental records (e.g. of precipitation, discharge, water levels of rivers, estuaries, lakes). From these hydrological variables and relevant meteorological variables (e.g. air temperature) sets of hydrological statistics (annual mean, monthly mean, minimum values, exceedance of thresholds or falling below thresholds based on daily values, etc.) and indices (drought-index, etc.) can be obtained. This material should be used for improving knowledge of climate variability by being analyzed in that respect. In some countries relevant investigations are currently being undertaken.

Research groups need information on existing long time series. Therefore, it will be necessary to compile information on such time series and their availability. Furthermore, a unified methodology is needed in the form of guidance material so that the results of individual research groups can be compared.

Long hydrological time series are often influenced by man's activities. These effects have to be identified and eliminated in the time series so as to isolate the influence of climate variability and change. A methodology for eliminating these effects was developed under Project A.3.

2. Output

Results of analyzing such long time series may give more detailed information on the variability of climate in time and space. The results will contribute to a better understanding of the physical processes behind climate variability and change.

3. Past activities

During the first phase of this project, a set of statistical tests and a computer program were developed, and a number of long time series of hydrological data were identified and collected for the study. In total, more than 200 time series of data were made available by Members of WMO and were subsequently analyzed by the Polish Academy of Sciences in co-operation with the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria. The length of the series varied from 30 to 200 years. The results of the analyses are summarized in the IIASA Collaborative Paper No. CP-92-05 "Occurrence of Climate Variability and Change within Hydrological Time Series - a Statistical Approach" which was published in September 1992.

In order to discuss and identify techniques and hypotheses for stochastic and time series modelling, as well as the principal statistics to be used in studying spatial variability of hydrological data, a workshop was held in the WMO Secretariat from 9-13 November 1992. Thirteen national expert from Africa, Asia, Australia and Europe participated in the workshop, reviewed the current state of the field and formulated proposals for further implementation of the project.

4. Further implementation

The phases of the project are:

Phase A - Compilation phase

(a) The data series as received from national institutions are entered into a computer and a WCP-Water Project A.2 data base is compiled at the Global Runoff Data Centre (GRDC) in Koblenz, FRG, with the aid of the system routinely used by Bundesanstalt für Gewasserkunde (BfG), Koblenz;

(b) This data base (Data Base A) is available to all interested institutions;

(c) Phase A will continue over an extended period so that all data received will be entered into Data Base A as and when received. The data base will therefore be up-dated from time to time and will need to be annotated as to the month and year of its latest update.

Phase B - Analysis phase

(a) All the results of analyses using the project methodology will be entered into Data Base B which will comprise: (i) the results of the analyses as provided by national institutions, where the results only, without corresponding data series, were submitted by suppliers, (ii) the results of independent analyses of data series agreed with the data supplier, where both the results and data were submitted; (iii) the results of independent analyses of the data series undertaken by the Polish Academy of Sciences, where the data only were submitted to the Secretariat;

(b) Entries in Data Base B will be annotated as to their origin and kept by the GRDC. Data Bases A and B can then be made available to all interested institutions either singly or together, including to Working Groups on Hydrology of the WMO Regional Associations;

(c) The length of time over which Phase B extends will correspond with the length of the period of Phase A.

Phase C - Interpretation phase

(a) In parallel with the implementation of Phases A and B, all participating institutions will be invited to develop proposals as to:

(i) techniques and hypotheses for stochastic and time series modelling for use in the interpretation of the apparent variability and change in respect to time;

(ii) the principal statistics to be used in studying variability and change with respect to space - it being recognized as infeasible to use the full set of results of Phase B for this purpose;

(iii) how the areal study might be conducted and how its result might be displayed;

(b) A report "A survey of current approaches to modelling of Hydrological time-series with respect to climate variability and change" WCASP-23, WMO/TD No. 534) which was prepared by Prof. G. Cavadias in November 1992 will serve as a background material for formulating proposals for the interpretation phase of the project.

(c) It is foreseen that regional analysis will play an important part in Phase C and that the Working Groups on Hydrology of the WMO Regional Associations will be involved in such work.

5. Organizations/bodies involved

The project is being executed by WMO in co-operation with GRDC, Polish Academy of Sciences and IIASA and with the participation of those Member countries which have available long hydrological time series.

6. Tentative time schedule

Based on 4 above:

Phase A	1990s
Phase B	1990s
Phase C	1991-1996

7. Comments

Liaison with Projects A.1, A.3, A.4, A.5 and A.10

Project A.4 Monitoring of Glacier Fluctuations

1. Background

In some alpine countries glacier fluctuations have been observed for more than a century and internationally coordinated glacier monitoring started in 1893. Since 1960 worldwide glacier observations have been standardized and published on a five-year basis by the Permanent Service on the Fluctuations of Glaciers (PSFG). Five volumes of "Fluctuations of Glaciers" have been published and the sixth volume ("Fluctuations of Glaciers 1985-90") is now in press.

Since 1976, the Temporary Technical Secretariat (TTS) for the World Glacier Inventory has assembled national or regional glacier inventories using a computerized data system. This project was completed by mid-1985, by which time a joint programme had been developed. This new programme, the World Glacier Monitoring Service, combines the TTS and the PSFG. In 1989 the "World Glacier Inventory - Status 1988" was published, giving an overview of the statistical data basis on the distribution of glaciers over the entire globe. Mass balances of about 50 glaciers are now being reported at two-years intervals with the new publication series "Glacier Mass Balance Bulletin" (No. 1 issued in 1991, No. 2 in press).

2. Output

(a) Records of long time series of glacier variations;

(b) Monitoring climate variations in all glaciated regions on the basis of mass-balance studies of reference glaciers.

3. Organizations/bodies involved

(a) ICSI of IAHS with the support of ICSU/FAGS, UNESCO/IHP and UNEP/GEMS;

(b) The ETH in Zurich, Switzerland, furnishes the infrastructure of the secretariat;

(c) National institutions as correspondents.

4. Tentative time schedule

1993 Publication of Volume VI of "Fluctuations of Glaciers" (1980-1995), of the "Glacier Mass Balance Bulletin No. 2) and of UNEP/GEMS Environment Library No. 9 "Glaciers and the Environment".

1994 Publication of Volume VI of "Fluctuations of Glaciers" (1980-1985)

1996 Publication of the World Atlas of Snow and Ice Resources (Vol. 1) and accompanying technical monograph (Vol. 2)

Project A.5 Collection of Global Runoff Data Sets

1. Background

An international data base of hydrological data is considered necessary for estimating land surface related hydrological inputs/outputs of general circulation models (GCM), for testing grid oriented estimation techniques for such inputs/outputs and validation of GCMs. These data sets are also needed for global or continental water balance studies, investigation of regional and global trends, regions studies, estimation of input of fresh water and other matter into the oceans and coupling of hydrological and meteorological models. Besides the collection of runoff values of small river basins (100 - 5,000 km^2), the Project A.5 provides a general service for the collection and storage of internationally available sets of hydrological data. This task is performed by the permanent Global Runoff Data Centre (GRDC) (see also appendix to this project description).

2. Output

(a) Global data base for surface water runoff from about 3100 selected stations; daily and and/or monthly values

(b) Support for the development of GCMs

(c) Service to other activities requiring such data

(d) Reports of GRDC

3. Past activities

(a) Collection of daily runoff data for years 1978-1982 and related catchment maps

(b) Setting up a permanent "Global Runoff Data Centre" (GRDC)

1983-1987 at the Institute for Bioclimatology and Applied Meteorology of the University of Munich, Germany

Since 1988 at the Federal Institute of Hydrology in Koblenz, Germany

(c) Inclusion in GRDC of the monthly data up to 1979 published by UNESCO in the "Discharges of Selected Rivers of the World"

(d) Inclusion in GRDC of data from other sources (year books, etc.)

(e) Requests for GRDC updates were circulated in May and June 1990

(f) Co-operation of the GRDC with other global data centres (e.g. GPCC)

(g) Second Workshop on the GRDC, 15-17 June 1992 at Koblenz, Germany

(h) Implementation of a PC-based data bank system (INFORMIX)

4. Further implementations

(a) Collection of runoff data (updating of stored data sets)

(b) Collection of additional runoff data to achieve better spatial distribution of stations

(c) Continuation of inclusion of additional data from other sources

(d) Compilation of information on stations

(e) Processing and storage of data in GRDC

(f) Homogeneity tests and basic statistical analyses

(g) Generation of a Geographical Information System (GIS)

(h) Mapping of station network and statistical analyses

(i) Disaggregation of runoff and transferring to grid area values

(j) Map of long term annual and monthly means of measured and gridded runoff

(k) Further co-operation with the GPCC and other relevant global data centres (e.g. GRID-UNEP)

5. Organizations/bodies involved

Based on (a) to (k) of 4 above:

(a) and (b): WMO Secretariat

(c) to (k): GRDC at Federal Institute of Hydrology, Koblenz, Germany

6. Tentative time schedule

Continuing activity

1993-1995 for project 4 (i)

7. Comments

Liaison necessary with Projects A.2, A.8 and with regard to the derivation of grid-based values with B.3.

Appendix to A.5

GLOBAL RUNOFF DATA CENTRE

1. Collection of runoff data at global scale

- Following UNESCO recommendations (alternatively)
  - large rivers with mean annual discharge greater than 100 m^3/s
  - basins with catchment areas greater than 1 000 000 km^2
  - basins with more than 1 000 000 inhabitants

- long series of runoff (WCP-Water Project A.2)

- runoff into the oceans (GEMS/Water, WCP-Water Project A.8, GCOS)

- undisturbed areas up to 5 000 km^2 (WCP-Water Project A.5)

Status of data bank on 23 November 1992:

- 3 081 stations from 131 countries

- 2 500 rivers

- 229 834 monthly data sets with daily runoffdata

- 37 441 yearly data sets with monthly runoff data

2. Transformation of measured flow data to grid points (BMFT - Project 07 KFT 96)

Since October 1992, a nationally funded research project has been undertaken in close connection with the GRDC at the Federal Institute of Hydrology in the context of the WMO WCP-Water Project B.3 (Development of Grid-related Estimates of Hydrological Variables):

Using the Weser catchment in Germany as a first pilot area, monthly runoff values for the period 1971 to 1980 have been computed on a grid net. The methods used are in line with the agreement reached on the Second Planning Meeting on Grid Estimation of Runoff Data, held in Warsaw, in April 1992. In accordance with user requirements, the grid size can be customized for projects in climatology and hydrology on regional and global scales. A Geographic Information System (GIS) is being used as a tool for the computation of these data. Data input to the GIS consists of image processed

data sets (soils, landuse, etc.) from international institutions as well as from a Digital Elevation Map of the Weser catchment.

The research undertaken in the Weser basin is a first step. The methods developed will be tested and applied in other geographical regions of the world. The purpose is to develop a set of methodological tools for the use of climatologists. As climatologists work with grids of various sizes, the geo-referenced gridding of runoff is a possibility for linking GCM outputs with runoff. Based on grids, the GCM outputs can be validated, using gridded runoff based on the same grid size.

Appendix to A.5

GLOBAL RUNOFF DATA CENTRE

Future Activities Under Consideration of Proposals of The Second Workshop on The Global Runoff Data Centre, Koblenz, 15 to 17 June 1992

- Complementation of data with emphasis on the calculation of continental discharge

- Documentation of data sets

    - extension of station catalogue (e.g. start of measurements, missing periods, measurement techniques, data quality, distance to mouth, subcatchment areas)

    - extended statistical analysis

Generation of a Geographical Information System

- location of stations
- river bed
- boundaries of catchment areas
- frontiers of countries
- Digital Elevation Model
- remote sensing and geomorphological data

Co-operation of GRDC with GPCC

- precipitation on a 2.5° grid

- comparison of grid-related estimated discharge (GPCC) with calculated discharge (GRDC)

Project A.7 Global Energy Balance Archive (GEBA)

1. Background

The amount and quality of direct measurements of energy balance components increased substantially after the International Geophysical Year. This development made it possible to re-evaluate the earth's energy balance, based on the observed values.4XTh6GCMs have recently been developed to the stage that the diabatic processes are taken into account. With such models it is especially important that the computed surface energy balance components are accurate. In regions with insufficient ground observations, and especially for the oceans, the satellite based observations of radiation, surface roughness length and wind offer a new possibility for energy balance evaluation. These methods, however, need ground based data of high quality for algorithm calibration and for verification.

The previously ignored flux of latent heat of melting should be taken into account in global energy balance. This component plays an important role for regions covered by seasonal snow cover and glaciers, not only in the energy balance but in the hydrological cycle. The latent heat of melting is the major heat sink during the summer on sea ice in polar regions.

Recently it has become known that the energy fluxes show secular variations similar to those of air and sea surface temperatures. This tendency has been found in global radiation and net radiation and is considered to be related to the hydrological balance. This means that the secular variations in the hydrological cycle should be considered together with variations in energy balance. These are new conditions and requirements for energy balance data. Therefore, the Department of Geography of the Swiss Federal Institute of Technology in Zurich has initiated the work of collecting directly measured energy balance fluxes and compiling them into a computerized archive.

2. Output

(a) Computerized global archive of monthly and annual values of global radiation, direct solar radiation, diffuse sky radiation, global radiation, short-wave reflected radiation or albedo, long-wave incoming and outgoing radiation, long-wave net radiation, net radiation, sensible heat flux and latent heat flux, subsurface heat flux, latent heat of melt.

(b) Time series of some of the above mentioned fluxes for selected stations.

(c) Ground truth for satellite-based estimations of energy balance fluxes on the earth's surface.

(d) Validation data for the GCMs

(e) A new global atlas of energy balance.

3. Past activities

Energy flux data have been extracted from 1500 publications and summarized as monthly means of energy balance components at 600 locations. The total data stored are about 250,000 station months. Among these there are 144 stations with more than one year period of measurement. The data base scheme has been designed and a data entry application program, including "physically possible" data quality control, has been released for routine data input. The fluxes are assimilated for the period from the beginning of the observations till 1985 (in publication). The quality control software has been completed. We abandoned the archiving of UV. This will be done within BSRN/WCRP.

4. Further implementation

(a) Collection and summarizing of energy flux data as monthly means and entry of monthly means into the data base, especially for the period after 1985.

(b) A new stress for the collection of data is placed on ocean surfaces and, especially for the Arctic Ocean.

(c) Sunshine duration hours, though not an energy flux, was made as an object for further collection.

(d) Completion of the new global atlas.

5. Organizations/bodies involved

Department of Geography, Swiss Federal Institute of Technology (ETH): Building and updating the archive from 1985 and continuing after 1990.

World Radiation Data Centre, St Petersburg

NASA Langley Research Centre, Hampton

BSRN/WCRP (Baseline Surface Radiation, Network/World Climate Research Programme)

Department of Geography and Department of Cartography, Swiss Federal Institute of Technology, Zürich (ETH): Cartographic representation of energy balance, 1989-1991.

6. Tentative time schedule

Based on (a) to (e) of 4 above:

(a) December 1993

(b) June 1994

(c) June 1994

(d) Dec 1994

7. Comments

Closely related to Projects A.3 and A.4. Expected to contribute to Projects C.1, C.3 and D.2.

Project A.8 Detecting Global and Regional Runoff Trends by Monitoring Discharges of Selected Rivers

1. Background

It is expected that changes in climate will affect the river runoff regime. Therefore it is important to review on a regular basis updated time series of runoff from selected rivers. For this reason runoff data should be collected from suitable stations on a routine basis soon after they are observed. Stations for this purpose were selected on the basis of the following criteria:

(a) Stations nearest the coast on the 15 largest rivers of the world to monitor the main inflow into the oceans, and the 20 largest basins

(b) 30 additional stations with long records and reliable data, equally distributed over the whole world, to monitor change.

2. Output

(a) Results will be published regularly

(b) Early recognition of possible changes to draw the attention of decision makers on the effects.

3. Past activities

(a) Project developed from past activities under Projects A.2, A.3 and A.5.

(b) Selection of suitable stations

4. Further implementation

(a) Routine collection of runoff data

(b) Inclusion of the runoff data in the GRDC

(c) Regular analysis of data to monitor inflow to the oceans and possible change

(d) Regular publication (report?)

5. Organizations/bodies involved

Based on (a) to (d) of 4 above:

(a) WMO Secretariat

(b) **GRDC**

(c) and (d) **GRDC with other institutions interested in the subject**

6. Tentative time schedule

(a) to (d) **Continuing activity**

7. Comments

Liaison with projects A.2 and A.5 and also with GCOS where this project would be an important component and also for the future WHYCOS.

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

1. Background

It is expected that as a result of the greenhouse effect the frequency and intensity of floods and droughts may change. Due to some very severe events in recent years the impression has been obtained that changes have already occurred. However up to now there has been no systematic approach to the collection of relevant data or their statistical analysis. Therefore this project aims 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 should 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 recognise the existence of non-stationarity.

2. Output

(a) Improvement of knowledge with respect to the effects of climate change on the statistical characteristics of hydrological events both as regards their magnitudes and their frequencies of occurrence.

(b) Early recognition of possible changes to allow decision makers to undertake appropriate steps.

3. Past activities

Publication of:

- Discharge of Selected Rivers of the World, Volumes I, II and III, Studies and Reports in Hydrology No. 5, UNESCO, 1971 et seq.

- World Catalogue of Maximum Observed Floods by J. Rodier and M. Roche, IAHS Publ. No. 143, 1984

- Hydrological Aspects of Drought by M. Beran and J. Rodier, Studies and Reports in Hydrology No. 39, UNESCO and WMO, 1985

- Methodology for Distinguishing between Man's Influence and Climatic Effects on the Hydrological Cycle by J. Refsgaard, W. Alley and V. Vuglinsky, Technical Documents in Hydrology, UNESCO, 1989.

4. Organization/bodies involved

(a) Compilation of relevant hydrological data; i.e. updating flood catalogue and creating equivalent information on droughts.

(b) Inclusion of data in GRDC

(c) Standardization of the material available

(d) Analysis of the data and interpretation of results

(e) Workshop to plan future statistical analyses

5. Organization/bodies involved

The project is to be executed by UNESCO within the framework of IHP-Project H-2.3 in cooperation with WMO, IIASA, GRDC and national institutions.

6. Tentative time schedule

The original time schedule was as shown below, but staffing and funding problems have caused it to be delayed.

(a) 1990-1991
(b) 1991-1992
(c) 1992-1993
(d) and (e) 1993

7. Comments

Liaison ith Projects A.2, A.3, A.5 and A.8.

ACTIVITY AREA B

MODELLING OF THE HYDROLOGICAL CYCLE WITH SPECIAL REGARD TO PROVIDING INPUTS FOR CLIMATE MODELS

The quantitative coupling of climate, hydrologic and water-resource systems can best be achieved within the framework of mathematical models of the hydrological cycle. However, nearly all existing hydrological models are river basin oriented and so are their atmospheric inputs and outputs (precipitation and evapotranspiration). This is one reason for the recent difficulties in coupling hydrological models with atmospheric general circulation models (AGCMs), the latter being generally grid oriented with standard grid scales of 1.5 to 2.5 degrees. Even when the hydrologic and climate models are not directly coupled but run in parallel, enormous difficulties exist in providing the required input data from one model to the other. For the same reason, it is impossible to make direct use of observed river discharges for climate studies over an area.

The most practical way of overcoming this difficulty would appear to be by developing and applying a second generation of grid-oriented hydrological modelling techniques which can take account of all land surface related moisture and heat fluxes. Outputs of these models are related primarily to grid areas. However, if one wished to use the outputs for flow components (overland flow, percolation, interflow, base flow, streamflow) in any river basin studies then these outputs must first be related to basin divides. For this reason they must be routed and superimposed with special regard to the storage and delay processes within the different hydrological subsystems of the river basin. This should be taken into account when using discharge records for such studies and, in particular, for validating AGCMs.

Thus, intensified research activities are required in the field of hydrological modelling in the framework of the projects listed below. It is quite obvious that for these projects causal physically-based models are preferred. The explanatory power of causal models makes them especially attractive to WCP-Water because they have the potential of making inferences about events and their impacts which are beyond the range of past observations, as well as about the consequences of man's influence on the natural processes involved.

While recognizing the legitimacy of many categories of models, special emphasis should be put on those which are based on the dynamics of the physical processes involved, including the feedbacks between the processes traditionally treated independently of each other. The inclusion of such feedbacks will call for innovative approaches and a re-examination of the traditional dividing lines.

Project B.1 Coupling of Physically Based Climate and Hydrological Models

1. Background

It is considered that the further development and improvement of physically-based mathematical models of the atmosphere would gain greatly from a better understanding of the effect on climate of hydrological processes and an upgrading of the manner in which such processes are incorporated into atmospheric general circulation models (AGCMs). This would be aided by the coupling of climate and hydrological models. This project is therefore seen as providing direct support to the WMO Global Energy and Water Cycle Experiment (GEWEX).

2. Output

Presentation of practical ways for bringing together results of physical climate and hydrological modelling in order to accommodate the physically based relationships (feed-backs) which are mostly being neglected in the current practice of modelling.

Specifications of input data requirements to be considered by:

- climate modellers;
- hydrologic and water-resource system modellers.

Improved methods (hydrological models) and computerized technologies for estimating water transfer at the land surface, in particular areal evapotranspiration, dependent upon climatic, physiographic and other characteristics (e.g. soil, land use, vegetation, geology).

3. Past activities

Progress continues to be made in improving the incorporation of hydrological processes in AGCMs.

The Co-ordination Meeting for Implementation of WCP-Water Projects, held in Geneva in November 1986, discussed this subject and its report (WCP Report No. 129, (WMO/TD No. 169)) provides useful information.

Partly as an outcome of that meetings, Messrs. Becker and Nemec developed a proposal for hydrological models which might be used to link with climate models. This is described in "Macroscale hydrological models in support to climate research" by A. Becker and J. Nemec, Proceedings of the International Symposium on the Influence of Climate Change and Climatic Variability on the Hydrologic Regime and Water Resources, Vancouver, August 1987, IAHS Publ. No. 168, 1987.

Proposals for work on macro-scale modelling in support of the Global Energy and Water Cycle Experiment (GEWEX) were developed by the IAHS/WMO Working Group for GEWEX (St. Moritz, December 1989).

These proposals subsequently became part of the GEWEX Continental Scale Study which is expected to be implemented first in the USA, centered on the Mississippi Basin.

The report entitled "Opportunities to Improve the Hydrology of Atmospheric Models" by J.C. Schaake was published in 1993 as Technical Report in Hydrology and Water Resources No. 37 (WMO/TD-No. 539).

4. Further implementation

(a) Publication of a report entitled "Land surface processes in large-scale hydrology" by CHy Rapporteurs on Hydrological Interactions of the Land Surface: J.D. Kalma and I.R. Calder.

(b) Further development of plans for GEWEX, in particular the GEWEX Continental-scale International Project (GCIP), and the implementation of these plans.

5. Organizations/bodies involved

WMO, as lead agency under GEWEX, the WMO Commission for Hydrology and national institutions.

6. Tentative time schedule

1994 for 4 (a) above
1994-2000 and beyond for 4 (b) above.

7. Comments

Liaison with A.5, A.7 and B.3.

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

1. Background

No widely accepted methodology exists for transferring information from hydrological stations to grid points or areas. Such a methodology is required, however, for making use of information on observed streamflow in the development and use of atmospheric general circulation models (AGCMs) (see WCP-Water Project A.5) 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).

2. Output

(a) A methodology and generalized procedure for the transfer of hydrological information, as well as physiographic and other characteristics to grid point or grid area values; (see appendix to this project description)

(b) One or more such methodologies for use in treating the data held by the WMO Global Runoff Data Centre (GRDC).

3. Past activities

(a) A state-of-the-art report on grid-point and grid-area estimates was prepared as a draft and reviewed at the Workshop on the Global Runoff Data Set and Grid Estimation (Koblenz, FRG, 10-15 November 1988) (WCRP Report No. 22 (WMO/TD-No. 302), 1989);

(b) Preliminary plans for the compilation of gridded sets of run off and related data were prepared at the second meeting of the IAHS/WMO Working Group for GEWEX (St. Moritz, December 1989);

(c) The plans were subsequently developed and became parts of two related, but separate projects:

(i) GEWEX Continental Scale Study (GCIP). This is focused on the Mississippi Basin.

(ii) Grid estimation of runoff for Central Europe. This project is co-ordinated by WMO and involves Austria, Czech Republic, Federal Republic of Germany, Hungary, Poland, Switzerland and the UNESCO FRIEND project

(d) Proposals for (c) (i) were adopted at the meeting of the Joint Scientific Committee for the WCRP (Tokyo, March 1990) for inclusion in the Scientific Plan for GEWEX;

(e) Plans for (c) (ii) were developed at the Planning Meeting on Grid Estimation of Runoff Data (Laxenburg, March 1990);

(f) The Second Planning Meeting on Grid Estimation of Runoff for Central Europe was held in Warsaw, April 6-9 1992

4. Further implementation

(a) Phase I of the project 3(c) (ii) was completed by April 1992. Phase II, which began in April 1992, involves the testing of methods for producing grid maps of runoff, using data from six pilot study areas (Weser, Elbe, Sajo, Upper Vistula, Upper Rhine and Upper Danube). A meeting of participating institutions is planned for late 1993.

Phase III of project 3(c)(ii) will involve the application of the selected methods to the entire study area in Central Europe (5-25°E, 45-55°N).

5. Organizations/bodies involved

WMO in collaboration with national institutions and IIASA. The UNESCO FRIEND project is also associated with the project.

6. Tentative time schedule

1990-2000 and beyond for project 3 (c) (i) GCIP

1992-1993 for project 3 (c) (ii) Phase II

1993-1995 for project 3 (c) (ii) Phase III

7. Comments

Liaison with Projects A.5, B.1, B.6 and B.7.

Project B.4 Hydrological aspects of HAPEX

1. Background

There is ample evidence of the sensitivity to climate changes of heat and moisture fluxes at the land surface. The purpose of the WCRP project for Hydrological-Atmospheric Pilot Experiments (HAPEX) is to improve our understanding of the processes involved and to provide a basis for developing and testing improved parametric formulations of these processes for use in atmospheric circulation models. HAPEX field studies will collect comprehensive sets of hydrological, atmospheric and related data for a number of specific sties.

2. Output

Sets of original and processed data from HAPEX field studies stored at a central repository or repositories.

3. Past activities

(a) HAPEX-MOBILHY, S.W. France, 1985-86;
(b) First ISLSCP Field Experiment (FIFE), Kansas, USA, 1987.
(c) HAPEX-Sahel, Niger, 1992.

4. Further implementation

(a) European Field Experiment in a Desertification Threatened Area (EFEDA), Spain, 1994 or 1995 (preliminary test 1991);
(b) Boreal Forest Interaction (BOREAS), Canada 1994
(c) Storm Central experiment, Central Great Plains, USA, 1990s;
(d) Land surface processes/hydrology experiments;
(e) Collation and storage of HAPEX data sets;
(f) Distribution of the data sets (FIFE data are available on CD-ROM).

5. Organizations/bodies involved

National institutions, individually or in multi-lateral co-operation. WMO/ICSU under WCRP at international level.

6. Tentative time schedule

Continuing, each experiment having its own time schedule.

7. Comments

Liaison with Projects B.1 and B.3.

Project B.6 Preparation of monthly global gridded precipitation data sets

1. Background

Global precipitation analyses are necessary for climatological and hydrological research, eg. to investigate the global hydrological cycle, for the verification of atmospheric general circulation models (GCMs) as well as for climate and climate change detection studies.

The purpose of the WCRP Global Precipitation Climatology Project (GPCP) is to derive global gridded data sets of monthly precipitation totals on a 2.5° grid as time series for the period 1986-1995 based on all available observation technologies. The Global Precipitation Climatology Centre (GPCC) is a central element of this project.

2. Output

(a) Analyses of gridded monthly precipitation data based on conventional measurements;

(b) Global data sets of gridded monthly precipitation combining the analyses based on conventional measurements with precipitation estimates based on satellite images and NWP model forecasts;

(c) Error range estimates for the gridded results, separately for sampling and systematic measuring errors;

(d) Statistical results on variability of precipitation in time (sub month) and space (sub-grid);

(e) Annual and quarterly status reports and input data availability;

(f) Service reports on gridded results to the World Data Centres for Meteorology, the other centres of the GPCP and climate research activities.

3. Past activities

(a) Setting up the Global Precipitation Climatology Centre at the Deutscher Wetterdienst, Offenbach, FRG, in August 1988;

(b) Collection of precipitation data from synoptic reports and monthly CLIMAT reports received via GTS and from other sources, based on bilateral contacts, by mail;

(c) Development of a precipitation point data bank including the time series of monthly precipitation totals from rain-gauges, as well as station meta-information, and climatological normals;

(d) Estimation of the rain-gauge data density required for the calculation of areal means on the grid;

(e) Development of procedures for processing and quality-control of synoptic and monthly precipitation data;

(f) Implementation of a method for the spatial objective analysis and calculation of areal mean monthly precipitation on a grid from rain-gauge measurements;

(g) Development of a data bank for gridded precipitation estimates of different sources (objective analysis results over land, estimates based on satellite images and accumulated results from NWP model forecasts);

(h) International Workshop on Analysis Methods of Precipitation on a Global Scale (5th GPCC Workshop, Koblenz, FRG, 14-17 September 1992;

(i) Investigation of the spatial sampling error of the areal mean monthly precipitation totals analysed from conventional measurements;

(j) Development of a blending scheme for merging the analyses based on gauge-measurements with precipitation estimates based on satellite images and NWP model results into global data sets;

(k) Publication of methods used at the GPCC in journals and workshop proceedings; publications of the first annual report of the GPCC "Monthly precipitation estimates based on gauge measurements on the continents for the year 1987 (preliminary results) and future requirements" by WRCP and DWD, August 1992

(l) operation on a trial basis since 1992

4. Further implementation

(a) Continuous collection of precipitation data (synoptic and monthly) received via GTS;

(b) Continued efforts to increase the number of precipitation data available at the GPCC through bilateral contacts;

(c) Including orographic/climatological relationships to improve the spatial objective analysis of monthly precipitation over land areas;

(d) Estimation of errors of monthly areal mean precipitation from the different sources;

(e) Implementation of an optimum-estimation technique to merge the results from different sources into a global data set.

(f) operation on a routine basis.

5. Organization/bodies involved

WCRP Global Precipitation Climatology Project (GPCP) and its centre (GPCC) operated by the Deutscher Wetterdienst.

National Weather Services and Hydrological Institutes contribute by providing conventionally measured precipitation data.

ESOC, JMA and NOAA are operating the geo-stationary satellites (Meteosat, GMS, GOES-East and West) and NASA is providing the microwave data of a polar orbiting satellite.

The satellite precipitation estimates are evaluated by the GSPDC and PSPDC (operated at CAC/NOAA and GSFC/NASA).

The NWP model results are provided by ECMWF.

6. Tentative time schedule

Until the end of 1993 preparation of preliminary global gridded precipitation analyses for the 36 months of 1987-1989 on a trial basis;

Permanent operation on a routine basis from 1994 onwards;

Development of advanced analysis methods in co-operation with research institutes, post 1995 higher resolution of the gridded products is planned.

7. Comments

Closely related to Project A.5 and links to projects A1, A2, B3 and B7.

Project B.7 Comparison study of time series of areal mean monthly precipitation and streamflow of selected catchment areas.

1. Background

The largest components of the water balance are precipitation and streamflow. Residuals are evaporation and storage changes. Since measuring methods of both precipitation and runoff have special uncertainties, the results have to be discussed in detail. The difference of precipitation and runoff have to be interpreted whether they represent residual components of the water balance or result from measuring errors.

2. Output

(a) time series of areal mean precipitation and surface runoff for selected catchment areas

(b) reports and publications.

3. Past activities

(a) collection and evaluation of precipitation data at GPCC

(b) collection and evaluation of runoff data at GRDC

(c) digitisation of catchment area boundaries at GRDC.

4. Further implementation

Phase I

(a) Selection of suitable catchment areas

(b) estimation of the errors of precipitation and runoff data separately

(c) comparison and discussion of the time series

Phase II

(d) analysis and interpretation of the differences

5. Organisations involved

GPCC and GRDC in Phase I

GPCC, GRDC and other (also national institutions) in Phase II

6. Tentative time schedule

(a) 1993 - 1994

(b) 1995 - 1997

7. Comments

Linked to projects A5, B3 and B6

ACTIVITY AREA C

APPLICATION OF CLIMATE INFORMATION IN THE PLANNING, DESIGN AND OPERATION OF WATER-RESOURCE SYSTEMS

Water-resource projects can sometimes be planned, designed and operated purely on the basis of hydrological data. When such data are not sufficient, use must be made of other data, particularly climatological data. Even when a reasonable to good set of hydrological data is available, the use of climatological data can greatly improve the planning and design. In many cases the only local data are climatological and these must be used to derive estimates of hydrological and water-resource parameters for the localities concerned.

Long-range weather outlooks for periods of one to three months hold great potential for the improved management of water resources through their use in deriving predictions of future water supply and demand. The current uncertainty in these predictions means that a probabilistic approach needs to be taken.

There is a need for studies and guidance as to what climate information can be used and how in the planning, design and operation of water-resource systems. Future improvements in long-range climate predictions should be followed with a view to their being used to enhance water-resource management practice.

Project C.1 Application of Climatological Data and Methods to Water-Resource Projects

1. Background

The planning, design and operation of many water-resource projects is based in large part on the analysis of climatological data. Current practice already demonstrates the value of this approach and can provide the basis for the development of guidance on the subject.

2. Output

Guidance on the application of climatological data and methods to water-resource projects.

3. Past activities

Literature search and review leading to a CHy Rapporteur's report "Climatological data and climate information for water resources projects" by H.J. Liebscher published as a WMO Technical Document (WMO/TD-No. 585, 1993).

4. Further implementation

Rapporteurs of CHy and CCl to contribute.

5. Organizations/bodies involved

WMO through the CHy and CCl Rapporteurs.

6. Tentative time schedule

CHy Rapporteur to report 1996, CCl Rapporteur 1997.

7. Comments

Liaison with Project D.2.

Project C.2 Application of Climate Information for Water Projects in the Sahel

1. Background

Nowhere has the impact of climate variability been more evident in recent years than in the Sahel. The central actor in all considerations of the droughts and desertification is the shortage and unreliability of water supplies. Of all regions, therefore, the Sahel is one where all available information should be used to ensure the best designed and most efficiently operated water projects. This includes the use of climate information in the planning, design and operation of such projects.

2. Output

(a) Guidance on the use of climate information in conjunction with hydrological data for the design and operation of water projects, in particular where such information and data are scarce;

(b) Contributions to studies of the impact on water systems of climate variability in the Sahel;

(c) Assistance in the practical application of climate information for water projects in the Sahel.

3. Past activities

(a) Report on the derivation of design floods for small basins in the Sahel was prepared by WMO in 1984 with the support of the United Nations Sahelian Office (UNSO);

(b) A mission visited Niger in 1985 and prepared a report entitled "Application of Climate Information and Hydrological Forecasts for the Sahel";

(c) A technical meeting on hydrological design criteria for use in the Sahel was held in Dakar in 1986 with the support of WMO, the Comité Inter-africain d'Etudes Hydrauliques (CIEH) and UNSO.

(d) Report by J. Sircoulon, Impact possible des changements climatiques à venir sur les ressources en eau des régions arides et semi-arides, WCAP-12, WMO/TD No. 380, June 1990.

4. Further Implementation

The above outputs will be achieved through a series of activities undertaken as the opportunity arises and as funds permit, principally in collaboration with other international and regional bodies.

The AGRHYMET Programme (including the AGRHYMET Centre in Niamey) provides an infrastructure, including a data base and computer facilities, and pursues a programme of activities closely related to the subject of this project.

The UNSO and the CIEH are both involved in related activities.

Certain activities of a technical assistance nature may be undertaken with the financial support of UNDP or WMO's Voluntary Co-operation Programme (VCP).

5. Organizations/bodies involved

WMO, with the participation of the countries of the Sahelian region and in collaboration with UNSO, CIEH and the AGRHYMET Centre and with the financial support of UNDP and other donors.

6. Tentative time schedule

Continuing activities similar to those recorded under 3. above, as and when the opportunity arises.

Project C.3 Application of Climate Information to Irrigation Water Supply Assessments in Africa using a Digital Geographic Information System Data Base

1. Background

A digital geographic information system (GIS) data base for Africa has been prepared by FAO with UNEP funding in connexion with a desertification study. Twenty-three maps have been digitized and processed at a scale of 1 to 5 million including political boundaries, soils (FAO soil map), geology (UNESCO map), watersheds, annual rainfall, river systems and physiography. Because of FAO's emphasis on Africa and the need for consistent information on water and irrigation potential, the Africa GIS is being used as a basis for developing a methodology for water supply assessment on a regional and continent-wide basis.

2. Output

Climate information (precipitation for different periods, temperature, evapotranspiration) combined with elementary water balance principles is used to develop an assessment of water supply for irrigation systems in Africa. More detailed assessments are being prepared for selected basins, first in the IGADD countries.

3. Past activities

The basic methodology was developed and water potential for irrigation in Africa, on a scale 1:5,000,000 was published in 1987. The publication is available on request. The digitized version of the FAO/UNESCO Soil Map of the World at 1:5,000,000 scale is now available. The data, in Geographic projection, is in ARC/INFO EXPORT format, arranged in seven continental areas and contained in 63 diskettes. The use of the spatial data set requires access to GIS software which can read the ARC/INFO EXPORT format.

A customized GIS was developed for part of the Nile Basin. It supports analysis to estimate hydrological model parameter type information including gridded flow path connectivity, drainage basin area definition for forecast locations, and physical variables such as elevation, slope and length. The GIS utilizes vector and gridded raster formats. The raw data files were manually digitized from 1:2,000,000 scale topographic maps produced by the US Defense Mapping Agency. A commercial GIS program (ARC/INFO) was used to digitize the basic GIS data sets which included streams, elevation contours, political boundaries, city names, and basin boundaries. The GIS is efficient and well designed for specific outputs, but it is not necessarily designed as a generalized GIS for any project.

4. Further implementation

A new methodology to be used in this project for collection of data has been tentatively developed and is currently in a pilot test phase.

The study will now be made on a larger scale (1:1,000,000) for selected IGADD countries (Nile Basin). A more sophisticated water balance model will be used.

5. Organizations/bodies involved

The Water Service in the FAO Land and Water Division is performing the work with the co-operation of countries in the Nile Basin belonging to IGADD.

6. Tentative time schedule

The first phase was terminated in 1987 and the second in 1991. Work is continuing on developing the new methodology.

Project C.5 Re-analysis of Hydrological Observations in the Czech Republic

1. Background

Hydrological and related climatological data have been collected and stored in Czechoslovakia for many decades. They have been analyzed as a basis for evaluating the country's water resources and for other purposes. From time to time such evaluations are revised to take account of new data that have become available and/or amendments to national water policy. Recent developments in our understanding of climate, its variability and its impact on available water resources may lead to new approaches in the assessment of water resources and call for a re-analysis of the existing hydrological records.

2. Output

(a) Review of international guidance in the field, in particular in association with Projects A.2 and D.1, and their pilot application within the framework of national activities.

(b) Re-analysis of certain hydrological and climatological observations;

(c) Proposals for further development and future application of methodologies at national and international levels.

3. Past activities

On the basis of a pilot study which was finalized in 1988, the work continued on the selection and application of suitable methodologies for evaluating hydrometeorological data and information for each of the following parts of the project:

(a) Analysis of long-term hydrometeorological series:

A technique for analysis of homogeneity of the series of hydrological and climatological observations was developed with the aim of identifying and assessing changes in time. The study included preparation of relevant software for consequent application in detecting changes in long series of observations;

(b) Re-analysis of hydrometeorological characteristics: (part completed)

A new method for evaluation of basic hydrological characteristics and hydrological design parameters in a system of sites of a river network was developed and subsequently applied for estimation of hydrological parameters at ungauged sites of the Elbe River basin. The report of the study: "Hydrological Design Data Estimation Techniques" has been published in the WCASP series of reports (WCASP-26, WMO/TD-No. 554).

(c) Changes in water balance:

Various techniques for water-balance studies were verified and the work continued on the preparation of input data and information. Methods for estimation of areal precipitation - the principal input element of the balance studies were verified and modified and the relevant water monthly balance model was developed.

4. Further implementation

The next phases of the project will include continuation of activities under items 3 (a) and 3 (b) above and publication of results.

5. Organizations/bodies involved

The Czech Hydrometeorological Institute, Prague.

6. Tentative time schedule

Based on (a) to (c) of (2) above:

(a) 1989-1994;

(b) started 1986 and continuing;

(c) 1994.

7. Comments

This project will be closely co-ordinated with Projects A.2 and D.1.

Project C.6 Teleconnection of the El Niño Phenomenon with Extreme Hydrological Events in South America

1. Background

The meteorological anomalies, in particular those relating to precipitation, which are associated with the El Niño phenomenon affect the hydrological regime in those regions of South America situated on the western side of the continent.

It is also felt that these anomalies may be at the origin of droughts and floods affecting the eastern side at distances of 2000 kilometres and more.

A better understanding of the situation, besides being of considerable scientific value, would lead to the very practical application of improving hydrological predictions for the sub-regions concerned.

2. Output

(a) Selection of catchments and methodologies to be applied and assembling of both meteorological (El Niño) and hydrological (catchment) data;

(b) Analysis (modelling, correlations, etc.);

(c) Reporting on the results of the study.

3. Past activities

A survey was initiated in 1989 among WMO Member countries of Regional Association III (South America). The survey sought information on hydrological aspects of the El Niño phenomenon, geared to the establishment of a common methodological base that would allow the evaluation of the hydrological repercussions of the phenomenon, with the aim of forecasting and mitigating its negative effects such as floods and droughts. The information collected was analyzed and a preliminary draft report submitted to the tenth session of RA III (1993).

4. Further implementation

Additional information is to be collected to improve geographical coverage and RA IV (North and Central America) has been invited to undertake a similar study.

5. Organizations/bodies involved

WMO through the RA III Working Group on Hydrology.

6. Tentative time schedule

Based on (a) to (c) under (2) above:

(a) 1990
(b) 1990-1995
(c) 1995

7. Comments

Liaison with Project C.9 and D.1.

Project C.7 Development of Improved Climatic Scenarios for Water-Resource Assessment

1. Background

Perhaps the single most significant of all the effects of global climate change is the effect on the availability of water. Water-resources managers need to have methods for assessing the sensitivity of the systems they manage to changes in climate, CO_2 concentrations, and sea level. Also of importance is the need for methods of evaluating the risk or uncertainty associated with such assessments. Many of the existing predictive tools (watershed models) are not sufficiently focused on the water and energy balance issues to provide the necessary answers. Virtually all techniques of hydrological analysis are based on the assumption of a stationary or unchanging climate. Present means of generating the meteorological forcing functions for hydrological models under assumptions of climatic change use simple adjustments to current climatic conditions. Development of methods which make full use of information from general circulation models (GCMs) and observational data to drive hydrological models is envisioned.

2. Output

(a) Transferrable methods for translating generalized, synoptic-scale climate model output into a hydrologically-relevant stream.

(b) Application and comparison of methods in terms of water-resource planning and policy making in order to assess the risk or uncertainty of assessments.

3. Past activities

Progress has been made on the development of transferrable methods for producing improved, hydrologically-relevant climatic scenarios from general circulation model output. Four distinct approaches have been devised: (1) a weather-pattern based stochastic temperature and precipitation model; (2) a regression-based model relating precipitation (snowpack accumulation) with atmospheric circulation; (3) a nested model approach; and (4) a canonical correlation based model relating regional streamflow with patterns of atmospheric circulation.

4. Further implementation

The four methods developed to date will be published as a WMO report.

5. Organizations/bodies involved

National agencies with international coordination by WMO, with contributions from Unesco, IIASA and IAHS. USGS is currently undertaking such studies as part of the US Global Change Research Program.

6. Tentative time schedule

Ongoing through 1990's

WMO report on approaches to scenario improvement to be issued by end of 1994

7. Comments

Liaison with Projects D.1, D.2 and B.1

Project C.8 Verification of Probabilistic Streamflow Forecasts

1. Background

Forecasts of future streamflow events are beginning to be made in terms of estimated conditional distributions of the events. These forecasts are most useful for the distant future where there is usually much uncertainty. Long-term forecasts of seasonal snowmelt runoff have been made since the 1930's using regression models. Since the mid 1970's, conceptual hydrological models have been used together with historical climatological data to make "Extended Streamflow Predictions", not only of the seasonal snowmelt runoff volume, but specific attributes such as maximum or minimum stages, durations of events, etc. Their application to low flow and reservoir inflow forecasting during droughts has emerged during the last 10 years.

This study will investigate how to judge the performance of these techniques. Are probabilistic forecasts from conceptual models likely to be biased? Is there actually more uncertainty than these models indicate? How well do these models perform as compared to simpler statistical methods? If conceptual models lead to biased probabilistic forecasts, can the biases be corrected while preserving the skill without introducing bias in the resulting probabilistic forecasts?

The proposed approach is to formulate a conceptual statistical framework which allows verification statistics to be defined and their distributions to be estimated by simulating forecasts during the historical period. These statistics would be used to address the questions raised above.

2. Output

Report on the subject of the project.

3. Past activities

This project evolved from activities being undertaken in conjunction with WCP-Water Project C.4.

4. Further implementation

National study by agencies concerned.

5. Organizations/bodies involved

US National Weather Service in cooperation with other water-related organizations in the USA.

6. Tentative time schedule

Report should be available in 1996.

Project C.9 The impact of the El Niño southern oscillation phenomenon on the hydrology of the South West Pacific

1. Background

The variability of precipitation in many countries in the South West Pacific has been shown to be associated with phases of the El Niño-Southern Oscillation (ENSO) Index. Project A.2 has identified deficiencies in the availability of good quality long-term hydrological records for the South West Pacific. However, it is expected that the amount and distribution of long-term rainfall records will provide a better indication of hydrological trends. As part of Project A.2, it is proposed to apply the computer program for trend detection to long-term time series precipitation data. These long-term precipitation time series will also provide an opportunity to analyse the impact of ENSO on the hydrology of the South West Pacific. Particular emphasis will be placed on the occurrence and frequency of extreme hydrological events (floods and droughts) and the relative phase of the ENSO Phenomenon.

2. Output

(a) Analysis of trends in precipitation data for the South West Pacific and comparison of this with available streamflow data.

(b) Maps of variability of precipitation and streamflow data and trends for the South West Pacific.

(c) Relationships between variations in the ENSO Index and variability of precipitation and streamflow.

(d) Methodologies aimed at providing a forecast of future hydrological conditions.

3. Past Activities

There has been considerable research into the relationship between ENSO and the climate of some of the individual countries within the South West Pacific. However, there have been no studies aimed at evaluating the overall impact and interrelationships. The analysis of streamflow data within Project A.2 is seen as an initial step for this project.

4. Further implementation

The data sets will be collected through a Rapporteur for the Regional Association V (South West Pacific) Working Group on Hydrology who will have the task of undertaking the associated analyses.

5. Organizations/bodies involved

WMO through the RA V Working Group on Hydrology.

6. Tentative time schedule

Based on (a) to (c) under (2) above:

(a) 1994
(b) 1994-95
(c) 1996-97
(d) 1996-97

7. Comments

Liaison with Project A.2, C.6, F.1 and GPCC.

ACTIVITY AREA D

STUDIES OF THE INFLUENCE OF CLIMATE CHANGE AND VARIATION ON WATER RESOURCES

The projects under this activity field are divided into groups each prompted by a major observation about climate's impact on water resources.

Perhaps the most important outcome of any study in this area is a statement of the effect on water-resource decision variables of changes in climate inputs, whether actual, predicted or presented only as possible future scenarios. This activity therefore includes all sensitivity analyses, whether on hydrological variables or on water-resource decision variables (Project D.1).

The second class of projects is inspired by the recent altered perspective on climate, i.e., that it is in continual motion. Movements which occur over a time scale of, say, 30 to 80 years are of particular importance as these are the planning horizons for current human activity in water-resource projects. Movements which occur over a 10-30 year time scale are important in that this is often the order of duration of our data base on which the scheme is designed. Within this time scale we conventionally ignore the possibility that part of the variation is due to movement and we tend to assign the total variability to the single cause of local fluctuation about a locally stable average value.

The final premise on which the projects in this activity field are founded is the idea that there is a distinction between hydrological variables (e.g. aquifer level, runoff volume, flood frequency distribution), and water-resource decision variables (e.g. reservoir volume, hundred year flood, crop water use). In some cases the difference is slight, but in general it can be stated that hydrological variables are directly measured or derived from measurements with little intervention. Water-resource decision variables tend to be derived quantities somewhat remote from the basic measurements. Thus it is often the case that the relationship is sufficiently obscured so that one cannot directly and simply estimate the effect of an alteration in the governing hydrological variables on the derived water-resource variable.

The question of establishing appropriate scenarios for climate change and variation to be expected within the planning period of important water-resource projects is covered under Activity Area B.

Project D.1 Sensitivity of Water-Resource Systems to Climate Variability and Change

1. Background

Hydrologists, water-resource planners and managers are increasingly alerted to the differences in the properties of climate and hydrological quantities as measured over different time periods. This realization, and the need to take action, exist independently of whether the differences are the product of sampling variability or intrinsic non-stationarity due to climate change. The problem is especially acute in arid and semi-arid regions where variability, for example in annual runoff, is already high so that stable water-resource schemes to compensate for the uncertainty and shortages of supplies are most vital. This project addresses directly the responsibility passed by the Villach Conference in 1985 to the scientific community to reduce the uncertainty in forecasting the impact of greenhouse gas induced change and in framing policies to meet the impact.

2. Output

(a) The enhancement of our understanding of the origin of interannual and seasonal variability and the persistence properties of salient hydrological variables;

(b) An increase in our appreciation of the performance of different hydrological modelling techniques in replicating the response to climate inputs;

(c) Estimates of the sensitivity of hydrological and water-resource qualitative and quantitative outputs due to possible changes in climate inputs using scenarios within the limits of climatological studies;

(d) Policy implications of climate change to water-resource management and planning.

3. Past activities

(a) International Symposium on the Influence of Climate Changes and Climatic Variability on the Hydrologic Regime and Water-Resources, Vancouver, August 1987, organized by IAHS with sponsorship of WMO and UNESCO. Proceedings: IAHS Publ. No. 168, 1987;

(b) Norwich meeting which reviewed procedures for developing scenarios and made future research recommendations across a broad spectrum of interest including Project D.1. Water Resources and Climate Change: Sensitivity of Water-Resource Systems to Climate Change and Variability - Report of a workshop held in Norwich, UK (March 1987), WMO/ESCAP Report No. 4, 1988;

(c) Material prepared in 1988 by the CHy Rapporteur on WCP-Water:

(i) bibliographic review of published literature on scenario development for hydrological and water-resource sensitivity;

(ii) reports on policy advice on climatic change for water-resource managers and planners;

(d) WMO Statement on the Hydrological and Water-Resource Impacts of Global Climate Change - adopted by CHy-VIII in November 1988, endorsed by WMO Executive Council in June 1989;

(e) Convening by WMO of the Conference on Climate and Water (Helsinki, September 1989) - proceedings published in 1989 and report in 1990.

4. Further implementation

It is felt that the larger part of the effort should be devoted to the problem of change in hydrological output expressed as a function of a given change in climate input (mainly precipitation). Large basins which illustrate different rainfall and temperature regimes should be selected. All forms of modelling and approaches should be encouraged ranging from simple water and energy balance formulations to conceptual models. However, more emphasis should be given to those models which successfully passed the tests suggested under Projects D.5.

A report on the subject is being prepared by the CHy Rapporteur on Impacts of Climate and Environmental Changes on Operational Hydrology.

5. Organizations/bodies involved

Research at national level.
WMO at international level, with contributions from UNESCO, IIASA and IAHS.

6. Tentative time schedule

Continuing long-term activity.

7. Comments

Closely linked with Project B.1 and with Projects D.2 and D.5. Future contacts with ICOLD, ICID, IWRA, IWSA with respect to policy response.

Project D.3 Study of the Impact of Climatic Variability and Change on the Occurrence of Droughts

1. Background

There is a need to provide hydrologists with advice on how to make better use of climatological information so as to improve understanding of the occurrence of hydrological droughts and associated climate events. The aim is to improve related risk assessment, planning and management for the prevention and mitigation of the consequences of the natural hazards concerned.

2. Anticipated output

(a) Promotion of national studies;
(b) Publication of a technical report.

3. Past activities

First draft of the report was presented and discussed during the IAHS Symposium on the Influence of Climate Changes and Climatic Variability on the Hydrological Regime and Water Resources, Vancouver, August 1987.

4. Further implementation

The technical report foreseen under UNESCO/IHP-III Project 3.4 was not prepared. However, a report on the drought aspects will be prepared.

5. Organizations/bodies involved

UNESCO in cooperation of WMO and IAHS.

6. Time schedule

Publication of the report by UNESCO in 1996.

7. Comments

Liaison with Projects D.2 and D.4.

Project D.4 Study of the Impact of Climate Variability and Change on the Occurrence of Floods in Urban Areas

1. Background

Current design practice for urban drainage systems takes no account of possible climate change due to the effects on climate of the urban area. There is evidence of changes in rainfall rates and the incidence of heavy rainstorms which can cause more severe flood problems than hitherto.

2. Output

Improved awareness amongst urban designers of possible greater vulnerability of current drainage systems to floods and the development of design modifications to overcome the hazard.

3. Past activities

None.

4. Further implementation

A related project is established under IHP-IV Project M-3-3 (Integrated water management in urban areas) under the auspices of the IHP National Committees of Netherlands and Germany.

5. Organizations/bodies involved

National institutions, e.g. University of Essen, UNESCO and the International Research and Training Centre on Urban Drainage (IRTCUD with its sub-centres) in cooperation with WMO, IAHS and UATI.

6. Tentative time schedule

Not yet established. A Workshop on "Integrated Water Resources Management in Urban and Surrounding Areas" is scheduled for 1994 under the auspices of Netherlands/Germany IHP National Committees.

7. Comments

Liaison with Projects D.2, D.3 and with the WMO programme of activities in urban climatology.

Project D.5 Testing the Transferability of Hydrological Simulation Models

1. Background

Remarkable progress has been achieved during the past period in the better understanding of problems related to the use of mathematical models of river basins for investigating changes in the hydrological regime due to climate variations (or changes) and/or other causes, such as land-use changes. Following this, consideration has turned to the usefulness, indeed the necessity, of testing more carefully the transferability of catchment models from gauged to ungauged basins or from given to changed conditions (climate or land-use changes, etc.), which is a prerequisite for the application of these models in studies of the effects of various changes in the physical conditions in a basin on its hydrological regime.

Moreover, it is felt that intensified activities in the development of hydrological models which meet the demands of physical soundness, geographic, climate and land-use transferability are most desirable and could contribute greatly to better solutions of the problems being considered within its activity area.

Long-term activities involving the testing of hydrological simulation models should continue. It is recognized that the testing of model transferability will require considerable research effort and that, even if specific activities would be initiated immediately, it would take some time before results could be obtained which would contribute directly to the objectives of the WCP and the Operational Hydrology Programme of WMO. Because of this, the recommendation for the above project should not be constructed as a recommendation to terminate studies of climate-impact assessment along the lines already pursued.

2. Output

Guidance and practical experience on the transferability of hydrological simulation models.

3. Past activities

(a) Publication by WMO in 1985 of WCP Report No. 98 - Sensitivity of Water Resource Systems to Climate Variability;

(b) Publications by the Danish Hydraulic Institute:
Danish Hydraulic Institute (1993): Validation of Hydrological Models, Phase II.
Refsgaard, J.C. (1993): Model and Data Requirements for Simulation of Runoff and Land Surface Processes in Relation to Global Circulation Models. Presented at the Nato Advance Research Workshop on Global Environmental Change and Land Surface Processes in Hydrology, Tucson, Arizona, 17-21 May 1993.

4. Further implementation

Further studies and testing of various hydrological models.

5. Organizations/bodies involved

National studies with international co-ordination by WMO.

6. Tentative time schedule

Continuous.

7. Comments

Liaison with Project D.1.

Project D.6 Impact of CO_2-induced climate change on UK water resources

1. Background

The UK, in common with other countries, may be considerably affected by global warming caused by the increasing concentration of greenhouse gases in the atmosphere. The Institute of Hydrology has therefore developed a climate change impact research programme, with funding from several agencies. Specific objectives of the programme are:

(a) to investigate the sensitivity of different catchment types to changes in climate inputs (rainfall and potential evaporation) and changes in catchment land use following climate change, using physically-based models of river flow generation.

(b) to determine the implication of a number of climate change scenarios for river flow regimes and surface water resources in the UK.

(c) to develop procedures for including information on climate change in water resources planning and assessment.

2. Output

The basic data analysed during the course of the project are simulated daily and monthly flows, produced by applying conceptual rainfall-runoff models to time series of rainfall, temperature and potential evaporation data perturbed according to a number of equilibrium and transient climate change scenarios.

The studies are published in reports to funding agencies and in the international refereed literature.

3. Past activities

Papers and reports have been published on potential changes in monthly flow regimes in different UK catchments, focusing on the effect of catchment characteristics on controlling the amount and type of change. A report has also been prepared reviewing the implications of climate change for the activities of the National Rivers Authority. Current work is focusing on (i) the development of scenarios for changes in potential evaporation in the UK, (ii) estimating the implications of a number of climate change scenarios produced by the Climatic Research Unit, University of East Anglia, and (iii) investigating the possible changes in river flow regimes between 1990 and 2050 using a number of transient climate change scenarios. A report describing these studies will be produced in 1993.

4. Further implementation

The project will be completed on the publication of the report.

Project D.7 Assessment of Impact of Possible Climate Change and/or Sensitivity of Irrigation Systems including Storage of Irrigation Water in Reservoirs

1. Background

Several continents, Asia in particular, depend on irrigated agricultural production for feeding their population. Several preliminary studies were made by individual researchers and FAO on the possible impact of climate change on the availability of water for irrigated food production.

2. Output

An estimation of the degree of decrease of availability of water for irrigation, including the impact on storage reservoirs. Advice to be given to FAO member countries.

3. Past activities

Methodological studies have been undertaken as described under 1. above.

A report "Climate Change Impact on Agricultural Water Management" was produced and is in the process of editorial revision.

4. Further implementation

Completion of the report.

5. Organizations/bodies involved

The Water Service in the FAO Land and Water Division, subcontractors, FAO Member countries, authorities involved in irrigation.

6. Tentative time schedule

1994 Publication of report

7. Comments

This project is being implemented in conjunction with Project C.3 and D.8.

Project D.8 Assessment of Climate Change Impact on Population Supporting Capacity of Land Based on AEZ (Agro-Ecological Zones)

1. Background

FAO has developed a methodology to ascertain the population supporting capacity of land, using as input climatic, soil and crop production characteristics, spatially grouped by AEZ. This methodology has been used with data available in the FAO Geographic Information System (including the FAO-UNESCO soil map) and projections of the food production in the developing countries of the world have been published. Climate change would no doubt alter these projections considerably.

2. Output

Projections of the population supporting capacity of land with different scenarios of a climate changed by the greenhouse effect.

3. Past activities

FAO's AEZ methodology was used in a study to estimate changes in potential population supporting capacities in the Sahel countries due to southward shifts in the length of growing period. The study covers the 1960-1985 period.

4. Further implementation

A case study proposal "Climate Change, Agroecological Potential and Agricultural Productive Capacity" has been prepared and is awaiting funding by UNEP.

5. Organizations/bodies involved

FAO Land and Water Division with subcontractors.

6. Tentative time schedule

Depends on funding.

7. Comments

This project is being undertaken in conjunction with Projects C.3 and D.7.

Project D.9 Impact of Climate Change on Thermal and Ice Regime of Rivers and Lakes

1. Background

Due to the change of the climatological regime, the thermal and ice regimes of rivers and lakes may change as a consequence of changes in the hydrology regime due to climate change. A proper understanding of the changes in the thermal and ice regime is also necessary for studies of water quality and of the impact on the aquatic environment. A study based on certain climate scenarios may help to derive some conclusions as regards the change in the thermal regime.

2. Output

(a) A methodology and generalized procedure for the assessment of changes in the thermal and ice regime of streams and lakes, including reservoirs.

(b) Case studies based on typical scenarios of the impact of climate change on thermal and ice regimes.

(c) Conclusions as to the order of magnitude of potential changes of water temperature, ice formation, duration of icy periods and ice thickness and on the general tendencies in these phenomena.

3. Past activities

Detailed studies on thermal and ice regimes of major rivers and lakes have been implemented, but no account has been taken of potential climatic change.

4. Further implementation

(a) Compilation of a fact finding report on the status of methodologies available for the impact studies

(b) Detailed plans for selected case studies to be implemented by methods selected on the basis of (a)

(c) Implementation of case studies

(d) Workshop based mostly on the case studies

(e) Final report on the conclusions related to the assessment of changes in thermal and ice regime.

5. Organizations involved

UNESCO and WMO in collaboration with interested national institutions, particularly for (c).

6. Tentative time schedule

1991-92 for (a) and (b)
1992-93 for (c)
1993 workshop (d)
1994 final report (e)

7. Comments

Liaison with Projects C.7, D.1 and D.10.

Project D.10 Impact of Climate Change on Suspended Sediment and Water Quality

1. Background

Any change in the hydrological regime may influence suspended sediment concentrations, the temperature of water and its hydrochemical and hydrological indices. A decrease in the minimum flow changes the dilution rate of pollutants and a change in flow velocity may influence sediment concentration. While some efforts have been successful in detecting changes in the water regime, almost no reference can be found on the potential change in sediment and water quality. Global warming may influence the thermal regime of rivers and lakes, which has an impact on aquatic life, including benthos and algae. A study based on certain climate scenarios may contribute to the understanding of potential influences on water quality.

2. Output

(a) A methodology and generalized procedure for the assessment of changes in the sediment and water quality regime of streams and lakes.

(b) Case studies based on typical scenarios of climatic change on suspended sediment and water quality regimes.

(c) Conclusions as to the order of magnitude of potential changes of major parameters and as to general tendencies.

3. Past activities

Relatively little consideration has been given to these secondary effects of climate change. Some information can be found in the papers of the WMO RA VI Conference on Climate and Water (Helsinki,11-15 September 1989), particularly in the papers by M. Beran and M. Falkenmark. In addition, the IHP-IV project H-1.2 (Study of erosion, river bed deformation and sediment transport in river basins as related to natural and man-made changes) assisted the organization of the 5th International Symposium on River Sedimentation (IRS), Karlsruhe, 6-10 April 1992. Some of the materials contributed to this Symposium could be considered as a contributor to this project. The Proceedings were published by UNESCO entitled "Workshop on Sediment Quality", P. Larsen and N. Elsenhauer, December 1992, 81 pp, which will be further developed into a UNESCO "Technical Document in Hydrology" in 1994.

4. Further implementation

(a) Compilation of a fact finding report on the status of methodologies available for the impact studies

(b) Detailed plans for selected case studies to be implemented by methods based on the report under (a)

(c) Implementation of case studies

(d) UNESCO Technical document in Hydrology based on Karlsruhe symposium

(e) Final report on the conclusions related to assessment of changes in sediment and water quality regimes.

Activities related to these problems are also likely to be undertaken as part of IGBP.

5. Organizations involved

UNESCO and WMO in collaboration with interested national institutions.

6. Tentative time schedule

1991-92 for (a) and (b)
1992-93 for (c)
1994 Technical Document in Hydrology (d)
1994 final report (e)

7. Comments

Liaison with Projects C.7, D.2 and D.9.

Project D.11 Sensitivity of Water Resource Systems to Climate Change

1. Background

In many cases alternative management may be an efficient tool for coping with hydrological variability and for ensuring the necessary reliability of meeting various water demands. Because of their cumulative effects on both natural and man-made storage systems, any changes in climatic and hydrological variables may be seriously magnified when they are transferred into changes of water demand and supply. Such changes might be reflected in the performance criteria of water-resource systems based on the operation and management of the system. This project addresses directly the possible impact of climatic and hydrological non stationarity on the design and operation of water resource systems. A strong focus on reservoirs and water storage systems is evident to reflect their importance in water resource management.

2. Output

(a) Methodology for evaluating possible consequences of climatic change on reliability, resilience and robustness of water storage, delivery, and supply;

(b) Methodology for estimating changes in water demand resulting from climatic change;

(c) Policy suggestions in the face of uncertainty linked with the estimation of future climatic conditions of water resource system behaviour.

3. Past activity

A number of scientific papers have been published in connection with the possible impact of climatic change and storage systems. However, no systematic and comprehensive review of the problem is available.

4. Further implementation

(a) Development of a general methodology that may be used by water-resource planners in dealing with the design and operation of water resource systems;

(b) Case studies and analyses for selected regions of the world;

(c) Workshop of water managers and policy makers.

5. Organization

IIASA's Water Resources project, in cooperation with interested national research institutions.

6. Tentative time schedule

1990-1993 Development of methodology and elaboration of one or two pilot case studies"

1993-1994 Other case studies and final report (monograph).

7. Comments

This project will be implemented in conjunction with D.1 and D.7.

Project D.12 Overview of methods for assessing the implications of climate change and variability for water resources management

1. Background

One of the most significant impacts of climate change due to the increased concentration of greenhouse gases is likely to be on river flows and groundwater, and hence on water resources. These changes may be felt over the next 20 or 30 years, which is well within the planning horizon for major water resources schemes.

There have been many individual studies into possible changes in water resources, and considerable experience is being accumulated in both potential impacts and appropriate methodologies. Little of this information or experience, however, is filtering through to operational water management agencies. There is therefore a need for an international project, coordinated by WMO, to ensure that water managers have access to the best possible data, results and methods. This project will both contribute to the IPCC Working Group 2 studies and provide a means by which the recommendations of Working Group 2 are disseminated to water managers.

2. Output

The overall objective of the project is to provide information on climate change and water resources in a form useful to water managers and policymakers. The specific outputs will be:

i) A summary of methods for estimating the implications of climate change for river flows and groundwater recharge.

ii) A summary of methods for estimating the potential impact of changes in river flows, water quality and groundwater resources on the human and water use systems.

iii) The development of procedures for incorporating information on climate change in water resources planning and assessment.

iv) Illustration of methods and procedures with a number of case studies.

3. Past activities

Not applicable.

4. Further implementation

There will be three components to the project:

i) Nationally-funded and bilateral projects, examining specific aspects of climate change and water resources: many such projects are already under way or in preparation.

ii) Frequent workshops (every year) to exchange results and experiences, and coordinate activities.

iii) A Working Group, established to encourage coordination and to produce a report giving advice to water managers and policymakers on how to allow for the effects of climate change in water resources planning and assessment. The report would be published and distributed through WMO.

5. Organisations/bodies involved

The project would need to be a joint effort between WMO, UNESCO, UNEP and IPCC, with significant input from WHO, UNDP, IAHS and IIASA, as well as national agencies.

6. Tentative time schedule

Phase I would be a feasibility study, assessing the need for a review and determining the resources required to conduct one. It would be completed by 1994. Phase II - in 1995 and 1996 - would involve the production of a report.

7. Comments

The project is closely linked with the other projects in Activity Area D, and with Project C.7.

Project D.13 Climate Variation Impacts on Water Balance and Water Quality of Shallow Lakes

1. Background

The water balance and the water quality of shallow lakes are strongly influenced by meteorological factors. The meteorological parameters can effect the water quality of shallow lakes:

(a) directly (global radiation, temperature, wind) or

(b) indirectly (surface runoff, precipitation, evaporation, and other hydrological factors).

The shallow lakes have a high surface/volume ratio so they are very sensitive to hydrometeorological changes. Moreover in eutrophic shallow lakes biological processes are not limited by nutrient deficiency, that is primary production is determined by meteorological parameters. Thus shallow eutrophic lakes are good subjects for the investigation of climatic variations on the hydrological regime and water quality of lakes.

The Lake Balaton is a large shallow lake situated in West Hungary. Its surface area is about 600 km^2, catchment area is 6000 km^2, and the average depth of the lake is around 3m. The western part of the lake is eutrophic and the eastern meso-trophic. Meteorological data have been collected regularly for over 100 years in this region. A long-term (over 70 years) time series of monthly water balance data and a shorter ones (over 20 years) of water quality data exist for the lake. Consequently this lake is a good test area for the investigations mentioned below. The aim of the project is to make a case study for Lake Balaton analysing the effects of climatic variations on the water balance and water quality parameters.

2. Output

(a) Preparation of a manual for statistical handling and analysis of meteorological, hydrological and water quality data together;

(b) Development of coupled hydrological, hydrodynamical and water quality models for the simulation of the effects of climatic changes on surface runoff and lake water quality;

(c) Preparation of proposals for implementation of the developed methodology for other lakes of the world.

3. Past activities

(a) Data collection for Lake Balaton for the last 72 years (monthly average meteorological, water balance and water quality data);

(b) Selection of the parameters which are included in the analyses;

(c) Development of hydrodynamic, rainfall-runoff and eutrophication models.

4. Further implementation

(a) Preparation of data base;

(b) Selection of statistical methods for mathematical analysis of the data;

(c) Statistical analysis of the data including two and multiple variable methods and trend analyses;

(d) Quantifying the meteorological effects on water balance and water quality;

(e) Implementation of the rainfall-runoff, hydrodynamic and eutrophication on models for the lake;

(f) Coupling of models including calibration and validation procedures;

(g) Simulations for different meteorological conditions and analysis of the effects on household water and water quality;

(h) Publication of the results

5. Organisation/bodies involved

Water Resources Research Centre (VITUKI) Budapest, Hungary

6. Tentative time schedule

Deadline of the activities: 1995

7. Comments

Closely linked with Project D.7, D.10, D.11 and E.2.

ACTIVITY AREA E

IMPACT OF CLIMATE ON SOCIETY THROUGH WATER RESOURCES

The impact of climate on society through water resources can be considered on several levels.

One is a simple statement of the type of impact that a climate change or variation has on the population of a given region either directly or through the projection of these water-regime changes into other areas of vital societal importance such as food, energy and health. It should be noted that the final impact might be positive or negative, not only as a function of the climate change or variation itself but also as a consequence of the effect of the change in hydrological characteristics on societal interests. For example, flooding in moderation can be beneficial to some societies and reduced variability in streamflow could be detrimental.

A higher level involves the study of the adaptability of the given population to such impacts. For example, with regard to the impact of droughts and floods, two major hypotheses have been posed. The first states that persistent and adaptative societies, through their technological and social organization, lessen the impacts upon the resident population of frequent climate fluctuations or climate related events. The second hypothesis states that success in insulating a society from relatively frequent events of climate origin, where the society is becoming increasingly complex both socially and technically, will increase the vulnerability of such a society to natural (climate-related) as well as to social perturbations that occur much less frequently.

ACTIVITY AREA F

INFLUENCE OF MAN'S ACTIVITIES ON CLIMATE

There is much interest in both scientific and more general circles as to whether man's activities are influencing or will influence the climate. It is proposed that such an influence might be exerted through changes in the hydrological regime. If such a proposition is to be seriously studied, there is need for an improvement of the representation of the climate forcing functions in the modelling of the hydrological cycle under man's intervention. Results of such studies would help to separate man-made changes in the hydrological cycle from natural variability and would also help to reconstruct non-influenced conditions.

RESOLUTION 9 (CG-XI) - GLOBAL CLIMATE OBSERVING SYSTEM

THE CONGRESS,

NOTING:

(1) The Ministerial Declaration at the Second World Climate Conference,

(2) The recommendations embodied in the statement of the Second World Climate Conference, concerning the establishment of a Global Climate Observing System,

(3) The concept for the Global Climate Observing System (see annex) proposed by an *ad hoc* group convened by the chairman of the Joint Scientific Committee for WCRP,

CONSIDERING:

(1) The importance and urgency of acquiring comprehensive information on the properties and evolution of the Earth's climate system, for detecting climate change, supporting climatological applications for economic development and developing cliamte science and predictions,

(2) That the required Global Climate Observing System must address a multi-disciplinary range of processes reaching beyond the current scope of existing operational meteorological, hydrological, oceanographic, cryospheric and biospheric observing programmes,

(3) The essential role of the World Weather Watch in providing basic observations and derived products describing the state of climate,

(4) Resolution XVI-8 of the IOC Assembly to undertake the development of a Global Ocean Observing System (GOOS) and the proposal, contained in that resolution, that the GOOS support office should provide the oceanographic component of the Planning Staff for the Global Climate Observing System,

RECOGNIZING the essential contribution to the knowledge of global climate processes made by experimental or research observing programmes, and the role played by scientific institutions and space agencies in supporting those programmes,

RECOGNIZING further that the Global Climate Observing System is intended to provide essential support to all programmes of the World Climate Programme,

DECIDES that a Global Climate Observing System shall be established, based on the co-ordination and association of existing or planned operational and research programmes for observing the global environment, and the further development of those programmes as required to ensure continuity of information over decades;

ENDORSES the establishment of:

(1) A Scientific and Technical Committee for the Global Climate Observing System, jointly by WMO, ICSU, IOC, after consultation with other relevant international organizations and participating space agencies;

(2) An inter-disciplinary planning office for the Global Climate Observing System, with staff seconded by the sponsoring organizations and participating agencies;

REQUESTS the Executive Council:

(1) To take all necessary actions to ensure that the Organizations provides effective leadership in the planning and development of the Global Climate Observing System, in co-operation with co-sponsoring organizations and participating agencies;

(2) To consider and, as necessary, approve the arrangements for the organization and management of the Global Climate Observing System;

REQUESTS the Secretary-General:

(1) To negotiate with co-sponsoring organizations, in consultation with other participating organizations and agencies, the arrangements under which the Global Climate Observing System would be established.

(2) To arrange, within available budgetary resources, for the participation of the Organization in the planning and development of the Global Climate Observing System, including support of the activities of the Scientific and Technical Committee and inter-disciplinary planning office.

Annex to Resolution 9 (Cg-XI)

Concept of the Global Climate Observing System

1. The goal of the Global Climate Observing System (GCOS) is to provide comprehensive information on the total climate system, involving a multi-disciplinary range of atmospheric, oceanic, hydrologic, cryospheric, and biotic properties and processes.

2. The GCOS is intended to meet the needs for:

(a) Climate system monitoring, climate change detection and monitoring of the response to climate change, especially in terrestrial ecosystems and mean sea-level;

(b) Data for application to national economic development;

(c) Research towards improved understanding, modelling and prediction of the climate system.

3. The GCOS will build, as far as possible, on existing operational and scientific observing, data management and information distribution systems, and further enhancement of those systems. The GCOS will be based upon:

(a) Improved World Weather Watch systems;

(b) The establishment of a global ocean observing system for physical, chemical and ecological measurements;

(c) The maintenance and enhancement of programmes monitoring other key components of the climate system, such as the distribution of important atmospheric constituents (including the Global Atmosphere Watch), changes in terrestrial ecosystems, clouds and the hydrological cycle, the Earth's radiation budget, ice sheets, and precipitation over the oceans.

THE WORLD HYDROLOGICAL CYCLE OBSERVING SYSTEM (WHYCOS)

There are considerable difficulties in assembling global hydrological data sets in near real time, data that might be used for deciding investment for sustainable water resources development and management, for environmental protection and for studying global change. Several reasons exist for these difficulties, a new one is that many countries have recently been cutting back on hydrological networks and the services that operate them. This means that knowledge of the World's water resources is getting worse when the global demand for water is accelerating. By way of contrast, meteorologists have ready access to large volumes of global data, much of it in real time, principally through WMO's World Weather Watch (WWW). A World Hydrological Cycle Observing System (WHYCOS) is proposed to facilitate access to global data and support hydrological services in need. A world-wide network of about 1000 stations is planned for the largest rivers, together with associated data bases and products to meet the needs of users. WHYCOS would start in Africa with a 100-station network and be expanded to other regions. It is a necessary tool for averting the coming water crisis and essential to the drive towards sustainable development.

REPORTS PUBLISHED IN THE WORLD CLIMATE APPLICATIONS PROGRAMME (WCAP)/ WORLD CLIMATE APPLICATIONS AND SERVICES PROGRAMME (WCASP) SERIES

WCAP - 1	CLIMATE AND HUMAN HEALTH. Proceedings of the Symposium in Leningrad, 22-26 September 1986, Volume I
WCAP - 2	CLIMATE AND HUMAN HEALTH. Proceedings of the Symposium in Leningrad, 22-26 September 1986, Volume II
WCAP - 3	ANALYZING LONG TIME SERIES OF HYDROLOGICAL DATA WITH RESPECT TO CLIMATE VARIABILITY - Project Description
WCAP - 4	WATER RESOURCES AND CLIMATIC CHANGE: SENSITIVITY OF WATER-RESOURCE SYSTEMS TO CLIMATE CHANGE AND VARIABILITY. Norwich, U.K., November 1987
WCAP - 5	FOURTH PLANNING MEETING ON WORLD CLIMATE PROGRAMME - WATER. Paris, 12-16 September 1988
WCAP - 6	CLIMATE APPLICATIONS: ON USER REQUIREMENTS AND NEED FOR DEVELOPMENT [Reports of the CCl rapporteurs on Users' Requirements and Publicity (F. Singleton) and New Approaches in Applications (D.W. Philips) to the tenth session of the Commission for Climatology, Lisbon, April 1989]
WCAP - 7	DROUGHT AND DESERTIFICATION. [Report of the CCl Rapporteur on Drought and Desertification in Warm Climates to the tenth session of the Commission for Climatology (Lisbon, April 1989) (L.J. Ogallo) and lectures presented at the training seminar in Muñoz, Philippines (14-24 November 1988) by N. Gbeckor-Kove]
WCAP - 8	REPORT OF THE FIRST SESSION OF THE CCl WORKING GROUP ON CLIMATE AND URBAN AREAS INCLUDING BUILDING AND OTHER ASPECTS AND SOME RELATED PAPERS by Professors E. Jauregui and Shen Jianzhu, Members of the Working Group
WCAP - 9	REPORT OF THE EXPERT MEETING ON CLICOM CLIMATE APPLICATIONS (INCLUDING CARS), Geneva, 6-10 November 1989
WCAP - 10	URBAN DESIGN IN DIFFERENT CLIMATES by B. Givoni, University of California, U.S.A.
WCAP - 11	FIFTH PLANNING MEETING ON WORLD CLIMATE PROGRAMME - WATER, Laxenburg, Austria, 30 April - 4 May 1990
WCAP - 12	IMPACT POSSIBLE DES CHANGEMENTS CLIMATIQUES A VENIR SUR LES RESSOURCES EN EAU DES REGIONS ARIDES ET SEMI-ARIDES, par Jacques Sircoulon, ORSTOM, Paris, France, June 1990
WCAP - 13	INFORMATION ON METEOROLOGICAL EXTREMES FOR THE DESIGN AND OPERATION OF ENERGY SYSTEMS by G.A. McKay, Consulting climatologist, Canada, September 1990
WCAP - 14	EXTREMES AND DESIGN VALUES IN CLIMATOLOGY by Tibor Faragó, Hungarian Meteorological Service, Budapest, Hungary and Richard W. Katz, National Center for Atmospheric Research, Boulder, U.S.A.

WCAP - 15 BIBLIOGRAPHY OF URBAN CLIMATE, 1981-1988. Prepared by Prof. T.R. Oke, Atmospheric Science Programme, Department of Geography, University of British Columbia, Vancouver, B.C., Canada

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Note: ***Following the change of the name of the World Climate Applications Programme (WCAP) to World Climate Applications and Services Programme (WCASP) by the Eleventh WMO Congress (May 1991), the subsequent reports in this series will be published as WCASP reports, the numbering being continued from No. 16 (the last "WCAP" report).***

WCASP - 17 A NONPARAMETRIC FRAMEWORK FOR LONG-RANGE STREAMFLOW FORECASTING by J.A. Smith, G.N. Day and M.D. Kane, Hydrologic Research Laboratory, National Weather Service, U.S.A.

WCASP - 18 REPORT OF THE FIRST SESSION OF THE ADVISORY COMMITTEE ON CLIMATE APPLICATIONS AND DATA (ACCAD), Geneva, 19-20 November 1991 (also appears as WCDMP-17)

WCASP - 19 URBAN CLIMATOLOGY IN AFRICA (Special issue of the journal "African Urban Quarterly"), Yinka R. Adebayo, guest editor, August 1992

WCASP - 20 OPERATIONAL CLIMATOLOGY - CLIMATE APPLICATIONS: ON OPERATIONAL CLIMATE SERVICES AND MARKETING, INFORMATION AND PUBLICITY. Reports to the eleventh session of the Commission for Climatology, Havana, February 1993 by the CCl rapporteurs on Operational Climatological Services (J.M. Nicholls) and Marketing, Information and Publicity (D.W. Phillips)

WCASP - 21 CLIMATE APPLICATIONS: ON USER REQUIREMENTS AND CLICOM APPLICATIONS. Reports to the eleventh session of the Commission for Climatology, Havana, February 1993 by the CCl rapporteurs on User Requirements (O. Moch) and CLICOM Applications (P. David and S. Roy)

Disponible en français: APPLICATIONS CLIMATOLOGIQUES: LES BESOINS DES USAGERS, LE CLICOM/APPLICATIONS. Rapports à la onzième session de la Commission de climatologie, La Havane, février 1993, par les rapporteurs de la CCl pour les besoins des usagers (O. Moch) et le CLICOM/Applications (P. David et S. Roy)

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