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Towards a world hydrological cycle observing system

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Abstract 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.

A un système mondial d'observation du cycle hydrologique

Résumé Il est extrêmement difficile de pouvoir associer en temps réel des séries de données hydrologiques à l'échelle globale, données qui pourraient être utilisées pour décider des investissements pour le développement et la gestion des ressources en eau sur un base durable, pour la protection de l'environnement et l'étude du changement climatique à l'échelle mondiale. Plusieurs raisons existent pour expliquer ces difficultés, mais le fait beaucoup de pays ont récemment pratiqué des coupes sombres dans les réseaux hydrologiques et les services qui en ont la charge en est une nouvelle. Cela signifie que la connaissance des ressources en eau du globe décroît au moment où la demande en eau augmente dans tous les pays. Par contraste, météorologues et climatologues ont un accès aisé à un grande nombre de données mondiales, en temps réel pour beaucoup d'entre-elles, principalement grâce à la Veille Météorologique Mondiale (VMM) de l'OMM. On propose un Système Mondial d'Observation du Cycle Hydrologique (SMOCH) afin de faciliter d'accès aux données mondiales et d'aider les services hydrologiques qui le désirent. Un réseau mondial d'environ 1000 stations est prévu pour les cours d'eau les plus importants avec des banques de données associées et des produits adaptés aux besoins des utilisateurs. Le SMOCH sera tout d'abord mis en place en Afrique, avec un réseau d'une centaine de stations, puis étendu à d'autres régions du monde. C'est un outil nécessaire pour prévenir la crise montante des

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ressources en eau et essentiel pour atteindre le développement durable.

BACKGROUND

While the pace of development is accelerating in many parts of the world, there is also growing and widespread pressure for increased protection of the environment. To reconcile these differing thrusts and to satisfy a number of other aspirations, the United Nations Conference on Environment and Development (UNCED) was held in Rio de Janeiro in June 1992. UNCED produced a blueprint for the future of this planet, namely Agenda 21, which addresses the problems of today to prepare for the coming challenges.

Views of the Conference and of its success, or failure, differ widely. However, one matter which became clear was that a common and adequate knowledge base is lacking in many areas where judgement of priorities and far reaching decisions are needed. Amongst the most important of these is the area of fresh water.

In fact for many, fresh water encapsulates the environment/development dilemma. Water is needed for so many human activities: for drinking, sanitation, food, power, navigation and the like; and the demand is rising rapidly. Yet water is also a vital ingredient of the global environment, providing habitats and powering the natural movement of materials and energy about the globe by means of the hydrological cycle. Since history started, mankind has been manipulating the hydrological cycle through the construction of dams, canals, drainage works, irrigation schemes and similar means. Now these modifications are becoming more and more massive. To meet future demand, which well before 2050 AD is expected to be double that of today, even larger scale investments in water projects are needed.

NEED TO IMPROVE KNOWLEDGE OF THE HYDROLOGICAL CYCLE

Both the fresh water chapter (Chapter 18) of Agenda 21 and the Report of the International Conference on Water and the Environment (ICWE, 1992), on which it was based, recognize that knowledge of the hydrological cycle, in terms of both quantity and quality, is the essential basis for effective water management. These same sentiments are reflected in a number of other similar documents (Dooge *et al.*, 1992; IUCN, 1991). These reports indicate the need for monitoring systems, including data archives, for water resources assessment and for pollution protection and control. They identify the importance of communicating information on water to decision-makers and to the general public, information which would include the likely impact of climate change on water resources. However, Chapter 18 and the ICWE Report also recognize that the monitoring systems and the hydrological services that operate them are in need of much greater support. The situation is worst in Africa. There the country reports of the UNDP/World Bank Sub-Saharan Africa Hydrological Assessment Project show national instrument networks to be in decline. They show the absence of computer-based archives and the lack of qualified staff. A similar situation exists in most other parts of the world (WMO/UNESCO, 1991) largely because many governments have cut funding to hydrological services and those with allied missions. They have, of course, cut funds at the time when the demand for water is continuing to rise rapidly and when more money is being spent for the development and maintenance of water projects. There seems to be little recognition that the design and operation of such projects involve more risk the less hydrological data are applied to them.

It is a paradox that Governments and agencies are willing to invest many millions in projects with fragile hydrological foundations, ones which may not be sustainable, but they are unwilling to spend the very much smaller sums needed to ensure that data are collected and processed to meet current and future needs and to demonstrate the sustainability of projects. The argument usually is that there is no time for data collection. Rapid assessment methods have to be adopted as a consequence. However, this argument is an old one which has been used ever since water resources development started. At the present time circumstances are vastly different.

Due to the accelerating demand, water resources are now under great stress in many parts of the world, a stress which will intensify and spread as time goes on. Abstractions are increasing from surface water and groundwater sources, pollution is mounting and there are growing difficulties from salt water intrusion, salinization and similar problems of overuse and misuse. By the time the global demand has doubled, it is estimated that about one quarter of the total average flow of all the world's rivers will be in use. Foretastes of the future global water scenario are visible today in parts of the Middle East, the Sahel and particularly around the disappearing Aral Sea, areas where the demand for water has outstripped the available resource and negative impacts are apparent. In the next century, are we going to have a world where lack of water will exercise control over virtually every socio-economic activity and others besides?

PROVISION OF INFORMATION

There are countless rivers and streams draining the land surface and, in addition, subterranean discharges to the seas and oceans. They drain basins that vary in size from the Amazon to little more than a point. Some 200 of these rivers occupy international basins containing between 2 and 10 countries. Together the world's rivers are estimated to discharge on average about 40 000 km^3 of water per year to the seas and oceans and to transport a large suspended and bed load.

The world's 60 largest rivers are estimated to carry more than 50% of the total flow and probably about the same percentage of the transported material, although these estimates may be seriously in error, for the flow of many rivers is not measured at all, or not reliably measured. In other cases it is not measured at the tidal limit before the river enters the sea, nor where the rivers cross international boundaries. The same problems apply, but to an even greater extent, to measurements of the quantities of the materials being transported. Then there are many cases where the two sets of measurements (quantity and quality) are made at different sites, perhaps by different agencies.

These problems continue despite the international programmes promoted by WMO, UNESCO and other agencies such as ISO, to say nothing of IAHS. They also continue despite parallel regional and national initiatives, in many case initiatives stimulated by technical assistance programmes funded by donors.

Records of river flows from around the world are collected at the Global Runoff Data Centre (GRDC) in Koblenz, Germany. A similar collection of water quality records is carried out by the WHO Collaborating Centre on Surface and Ground Water Quality at Burlington, Ontario, Canada. The first of these centres comes under the aegis of WMO, with UNESCO cooperation, the second has UNEP, UNESCO, WHO and WMO involvement. However, neither of these centres has adequate coverage of the globe, in terms of the countries sampled, nor in terms of the duration of the data sets, and the data are of variable quality. For these reasons, it is extremely difficult to employ these data to assess comprehensively the world's water resources over the long term. To undertake this task for a particular decade, a year or a month is an impossibility. An entirely fresh approach is needed.

PROPOSAL

There may be several solutions to the availability of high quality up-to-date water resources data, but the one preferred here is to create a world-wide network of key stations linked by satellite with an associated quality controlled data base. This global network, of perhaps 1000 stations, and the data base, which would be distributed, would constitute the major part of the World Hydrological Cycle Observing System (WHYCOS). WHYCOS would employ existing measuring stations where these meet the specifications, upgraded stations and new ones. Likewise WHYCOS would supplement existing data bases where these are suitable, while new ones would be established where they do not exist. Geostationary satellites, such as Meteosat, would be used with Data Collection Platforms (DCPs) and ground receiving stations for data transmission, together with existing segments in the WMO Global Telecommunication System (GTS) of the World Weather Watch (WWW) where these are available. Ideally WHYCOS and its future derivatives would be maintained initially for 20 years.

Stations in the WHYCOS network would measure not only river flow and water quality variables, but also on-bank temperature, humidity, radiation, wind speed, barometric pressure, precipitation and several related variables (Table 1). The idea would be to make the measurements, and thus the WHYCOS products, as attractive and as cost effective as possible to a variety of user communities.

***Table 1** WHYCOS-Africa: data to be acquired and transmitted*

	Frequency of measurement per day
Environmental variable:	
Water level	1-6 (depending on size of river)
Water pH	1
Water conductivity	1
Water temperature	1
Dissolved oxygen	1
Turbidity	1
Air temperature	8 (synoptic hours)
Rainfall	24 plus daily total
Relative humidity	8
Wind speed	8
Net radiation	8
Housekeeping variable:	
Battery voltage	1
Solar panel voltage	1
Memory status	1
Temperature inside instrument housing	1

Particularly important would be to interest and involve the environmental community, as well as those concerned with development, in order to gain the financial support of funding institutions. It would also be important to integrate WHYCOS with ongoing allied activities, such as GEMS Water Quality, WWW and Global Climate Observing System (GCOS).

Because the situation in Africa is the most difficult, the plan is to focus attention, in the first place, on that continent. WHYCOS-Africa aims to build up a collection of high quality data for the main rivers and, at the same time, stimulate and support the hydrological services through their responsibilities for the management and maintenance of the network. External funds would be applied for training, for installation and maintenance of instruments and equipment, to facilitate data processing and exchange and to assist the flow of products to users. About 100 stations would be established for Africa initially, each recording 15 or more variables for transmission by DCPs and satellite to national and international centres. The use of modern techniques, external funding and long-term support are seen as the most effective means of encouraging the rehabilitation of national hydrological services.

A small team would be set up to run WHYCOS-Africa in collaboration with national hydrological services, river basin authorities and regional bodies. Stage 1 of WHYCOS-Africa would build on the experience of the existing satellite based data collection systems such as those on the Niger and the 10 similar systems in operation. Attention would be given to combining WHYCOS data and products with those from remotely sensed imagery for regionalization of point measurements. In Stage 2, the network could be expanded to bring in additional stations. Alongside the instrument network and the telecommunications system, data banks would be developed progressively and products produced for users. First the project team would establish the overall global data bank, then work would start to set up the regional and national equivalents. By Stage 2 each hydrological service would be equipped with the hardware and software to archive its own subset of the data, together with the additional data acquired from the remainder of the WHYCOS-Africa archive. Processing of the data and the development of products would be based on appropriate components of the WMO technology transfer system for hydrology known as HOMS. Stress would be placed on seeking national users for the products. On the international level for the first time, there would be continent-wide information available for decision-making on water resources and on environmental matters, to establish priorities and to guide investment.

PRINCIPLES

A number of important principles underlie the WHYCOS proposals:

(a) there must be committed national participation and recognition that WHYCOS complements existing national data collection, processing and product preparation;

(b) national hydrological services must obtain the full benefit of WHYCOS;

(c) there must be a long-term commitment to WHYCOS;

(d) WHYCOS must be sustainable and it must be capable of upgrading;

(e) free exchange of data must be agreed by all participants;

(f) monitoring sites are to be selected so that the data can meet the widest possible use; and

(g) participants are encouraged to contribute extra stations to WHYCOS.

CONCLUSIONS

Sustainable development and meaningful environmental protection are both dependent on effective water resources management, which in turn is dependent on data, particularly reliable hydrological data. Currently such data are not readily available globally, regionally and even nationally for a number of nations. The rapidly rising demand for water makes it imperative that the world's water resources are husbanded with greater care and concern now and in the next decades than previously. WHYCOS provides the key element of an effective strategy for combatting the coming water crisis, with attention focussed first on Africa and then on other regions, in order to build up a World Hydrological Cycle Observing System.

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