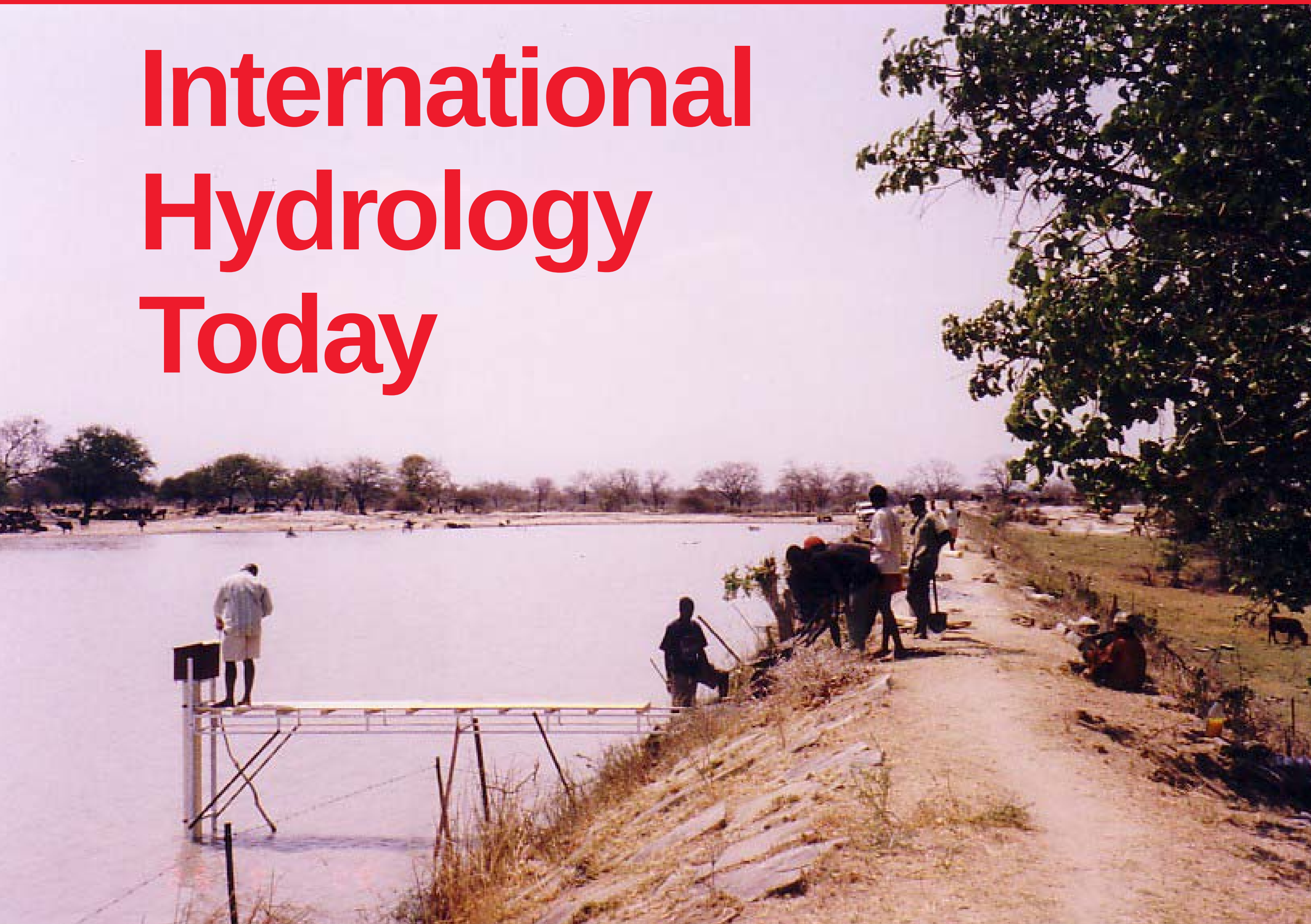
IAHS AISH

International Association of Hydrological Sciences
Association International des Sciences Hydrologiques

International Hydrology Today



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Fluvial deposition associated with the Teesta River crossing the Ganga-Brahmaputra Plain, India

Interrogating a water level recorder using a laptop PC, Zimbabwe

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Front cover picture:

Water level measurements of a reservoir constructed to store seasonal rainfall for domestic use, animal watering and small-scale irrigation, Zimbabwe

International Hydrology Today

In 2002, the International Association of Hydrological Sciences (IAHS) reached the 80th anniversary of its founding in 1922, in Rome, as the then International Section of Hydrology of the International Union of Geodesy and Geophysics (IUGG).

This publication celebrates these 80 years of international endeavour in hydrology. It provides a review of the Association's activities today and focuses on the hydrological sciences and their applications in which the IAHS Scientific Commissions are currently involved.

The Association is open to everyone worldwide with an interest in the research and practice of hydrology and water resources management. Membership is free of charge. You are most welcome to join any of our activities and contribute to the continuation of international cooperation in water sciences.

Kuniyoshi Takeuchi (President IAHS, 2001–2005)

Tributes to IAHS

from the Director-General of UNESCO

the United Nations Educational, Cultural and Scientific Organization

It gives me great pleasure to contribute to this 80th anniversary brochure of the International Association of Hydrological Sciences (IAHS), which has been a close partner of UNESCO since 1945. This partnership was further strengthened with the launching of the UNESCO International Hydrological Decade, during which several IAHS symposia and associated IAHS publications (now known as 'the Red Books') were devoted to various activities within the global network of International Hydrological Programme (IHP) Representative Basins.

Since 1975, the IAHS has continued to work in close partnership with the IHP by dedicating IAHS symposia and workshops to hydrological and water resources management topics approved by the IHP Intergovernmental Council from the first to fifth phases of the Programme.

During this time, water has progressively emerged to become one of the most pressing international issues of our time on the environment, development and even the peace agendas. Water is also one of UNESCO's highest priority areas. Since 2000, UNESCO has taken the lead in hosting the Secretariat of the inter-agency World Water Assessment Programme (WWAP), whose first World Water Development Report (WWDR) I myself will present at the forthcoming 3rd World Water Forum to be held in Kyoto, Japan, in March 2003. In addition, UNESCO and UNDESA (the UN Department of Economic and Social Affairs) are the lead agencies on behalf of the UN system for developing activities for the International Year of Freshwater 2003.

These developments aim to highlight where the major research gaps in hydrological science exist. The most urgent water policy and management issues are within the areas of climate variability and change, environment and human health, and food security. In response, the International Hydrological Programme will continue to reinforce its close collaboration with the IAHS to address critical research needs such as groundwater, the impact of extreme events (floods, droughts) and water quality processes. This collaboration will contribute towards providing better access to safe drinking water to fulfil human needs.

Koïchiro Matsuura
January 2003

from the Director-General of IAEA

the International Atomic Energy Agency

INTERNATIONAL ATOMIC ENERGY AGENCY

Sustainable water resources management: forty years of cooperation between IAEA and IAHS

The recently concluded World Summit on Sustainable Development recognised the need to improve the scientific understanding of the water cycle and to improve the availability of hydrological information as a means for sustainable management of water resources.

Since its inception in 1957, the International Atomic Energy Agency (IAEA) has played a critical role in developing isotope applications for hydrology, with a particular focus on understanding the earth's water cycle. A global network of isotopes in precipitation (GNIP) has been operational for about the last 40 years, providing critical data to understand the origin and variability of precipitation. A network of isotope monitoring stations for rivers is being designed to maximise and broaden the precipitation isotope data.

Through an active technical cooperation programme, with a funding of nearly $8M per biennium, we assist our developing Member States in using isotope techniques for the assessment and monitoring of water resources, in particular groundwater resources. In addition, substantial human resources and institutional capacity are being built through the provision of training and appropriate equipment for monitoring.

Isotope techniques have been particularly effective when used as an integral part of hydrological practices in the water sector. To this end, the IAEA strives to work in partnership with national and international organisations. We have a long-standing collaboration with the International Association of Hydrological Sciences (IAHS), which in 1963 was a co-sponsor of the first IAEA symposium on nuclear techniques in hydrology. Since then, the partnership has increased in many different areas. Presently, the IAHS Commission on Tracers has been closely involved with our programmes to increase the use and integration of isotope techniques in hydrology.

I congratulate IAHS on its many proud accomplishments in its 80-year history and wish great success in its activities in the years to come. I look forward to further strengthening our cooperation to continue to help improve education and research in, and practice of, hydrological sciences worldwide.

Dr Mohamed ElBaradei
January 2003

from the Secretary-General of WMO
the World Meteorological Organization

The International Association of Hydrological Sciences (IAHS), one of the oldest international Non-Governmental Organisations (NGOs), has made substantial contributions over the past 80 years to our understanding of hydrological processes and to improving the management of the world's water resources.

Both the International Meteorological Organization (IMO), founded as an NGO in 1873, and WMO, which was created in 1950 as IMO's successor, have enjoyed a special relationship with IAHS. In 1954, the United Nations Economic and Social Council proposed that WMO should take responsibility for operational hydrology in collaboration with National Hydrological Services and IAHS. This recommendation was supported by the Council of IAHS and its parent body, the International Union of Geodesy and Geophysics. In 1955, a panel of seven experts, including an IAHS representative, prepared a draft WMO programme that defined WMO's activities in the field of hydrology and water resources.

WMO's participation in the inter-agency International Hydrological Decade (1965–1974), proposed by IAHS, led to the establishment of WMO's Hydrology and Water Resources Programme in 1974. IAHS is the only NGO regularly invited to sessions of the Advisory Working Group of WMO's Commission for Hydrology. Likewise, WMO is invited to sessions of the Association's Bureau.

On behalf of the World Meteorological Organization, the world's hydrological and meteorological communities and myself, I am pleased to convey our best wishes to one of our oldest, closest and most outstanding non-governmental partners. I wish to pay tribute to the founding fathers of IAHS and to the successive generations of officers and members of the Association for their foresight and commitment for the advancement of their profession and the science of hydrology. On this auspicious occasion, I also wish the IAHS many more years of productive service for the benefit of humankind.

Professor G. O. P. Obasi
January 2003

Introducing IAHS

The International Association of Hydrological Sciences

Starting point

From its launch in 1922, the activities of the International Association of Hydrological Sciences have helped to solve the pressing problems of water resources existing in many parts of the world. This Association — the oldest and most distinguished international learned society in the water field — serves the needs of humanity through the promotion of science and the stimulation of its applications. IAHS has accomplished this by acting as a catalyst for international cooperation and sound management in the development and use of water resources.

Basic to these endeavours is the pursuit of the science of hydrology. This is the science which *"deals with the waters above and below the land surfaces of the Earth, their occurrence, circulation and distribution, both in space and time, their biological, chemical and physical properties, their reaction with the environment, including their relations to living things"*.

The forums of the Association provide for discussion, comparison and publication of the results of research, and initiate, facilitate and coordinate research into those hydrological problems that require international cooperation. They offer a firm scientific basis for the optimal use of water resources systems. This includes educational outreach and the transfer of knowledge on planning, engineering, management and the economic aspects of applied hydrology and water resources.

In a changing world, where diminishing water resources and the hazards of floods, droughts and pollution play an ever increasing role, what could be more important than to improve and disseminate knowledge and understanding of these fields through the science of hydrology?

IAHS today

IAHS is a nonprofit-making non-governmental scientific organisation dedicated to the improvement of the well-being of every man, woman and child on this planet through the motivation of the community of scientists and engineers involved in the study and application of hydrology and water resources. The Association is widely known for the vitality of its activities, particularly for its scientific meetings — assemblies, symposia and workshops — and for its publications and research projects. It now has a membership of over 3700 globally, drawn from 129 countries. As there is no membership fee (unlike most other scientific bodies), the Association is accessible to any professionally-interested person worldwide, including many in developing countries and in those countries where the economy is in transition. But IAHS is not a rich organisation: it has no dedicated benefactors. Its main source of income comes from the sales of its publications: *Hydrological Sciences Journal*, the proceedings of symposia, and special publications, to libraries, IAHS members and other interested parties, worldwide.

Governance

The Association is run for its members by its members. Every four years there are elections at the General Assembly for the honorary officers of the Association, elections which are conducted in a fair and open fashion, in accordance with its Statutes and Bylaws. The President, Secretary General, Treasurer, Editor and other officers of the Association form the Bureau, which manages the affairs of IAHS between General Assemblies.

IAHS is one of seven autonomous bodies that together make up the International Union of Geodesy and Geophysics (IUGG) founded in 1919. IUGG is one of the members of the International Council for Science (formerly ICSU) with its secretariat in Paris. The Association is a leading member of the International Water Associations Liaison Committee, the committee established to bring together the dozen or so water-orientated international non-governmental organisations. IAHS is an elected member of the World Water Council Board of Governors and collaborates closely with UNESCO, WMO and IAEA through their respective programmes in water. This collaboration, in the case of UNESCO, WMO and IAEA, dates back to the 1960s: IAHS was one of the founders of the International Hydrological Decade (1965–1974) that led to the current International Hydrological Programme in UNESCO. These different links provide a wider stage over which the Association operates, the links to the agencies of the United Nations being particularly important.

Scientific Commissions

The activities of the Association are initiated primarily by its nine Scientific Commissions, which deal either with specific aspects of hydrology or with themes that cut across several or all aspects of

A nonprofit making nongovernmental organisation

Promoting the study and application of hydrology and water resources for the benefit of all people and the environment

Run by hydrologists for hydrologists

More than 3700 members drawn from 129 countries

Membership free of charge

Supported by sales of IAHS publications and donations from various organisations

Working closely with IUGG, ICS, IWA, WWC, UNESCO, WMO and IAEA

Nine scientific commissions on Surface Water, Groundwater, Continental Erosion, Snow and Ice, Water Quality, Water Resources Systems, Remote sensing, Atmosphere–Soil–Vegetation Relations and Tracers

Current projects including: Hydrology 2020 and Prediction in Ungauged Basins (PUB)

Disseminating research results and practice via meetings, training courses, publications and the IAHS web site: **http://www.cig.ensmp.fr/~iahs**

Providing publications free to libraries in financially disadvantaged countries and supporting scientists from these countries attending meetings

hydrology. They are the International Commissions on:

Surface Water, ICSW
Groundwater, ICGW
Continental Erosion, ICCE
Snow and Ice, ICSI
Water Quality, ICWQ
Water Resources Systems, ICWRS
Remote Sensing, ICRS
Atmosphere–Soil–Vegetation Relations, ICASVR
Tracers, ICT

The officers of each Commission are elected from the IAHS membership, by the members, every four years. Each Commission has contributed a review of their activities and current work in their field for this publication.

Programme

The Association's activities span a four-year cycle between General Assemblies. Recent Assemblies have been at Birmingham, UK, 1999, and Boulder, USA, 1995; the next will be in Sapporo, Japan, in July 2003. Each year the Association and its Commissions organise symposia and workshops in different parts of the world, often in cooperation with UNESCO and WMO. For example, in 2003 the Association is organising and co-sponsoring meetings at Stellenbosch, South Africa; Valdivia, Chile; Montpellier, France; Vienna, Austria; Tallinn, Estonia; Davos, Switzerland; Visakhapatnam, India, and Rome, Italy: each will address a single topic.

Halfway between General Assemblies, the Association organises its Scientific Assemblies. The most recent was held in Maastricht, The Netherlands, in July 2001, and the previous one was in Rabat, Morocco, in 1997. The next is planned for Iguacu, Brazil, in 2005. During the week of a General or Scientific Assembly, there are up to six symposia and ten workshops covering a large number of topics.

For example, at Rabat in 1997, six symposia addressed: Sustainability of Water Resources Under Increasing Uncertainty; Hard Rock Hydrosystems; Remote Sensing and Geographic Information Systems for the Design and Operation of Water Resources Systems; Freshwater Contamination; Hydrochemistry; and Human Impact on Erosion and Sedimentation. This Assembly had 455 participants, from 53 countries.

Projects

The Association undertakes and promotes research projects; for example during the period 1993–1998 much effort was devoted to a sustainable reservoir development and management project. A number of IAHS projects have contributed to the International Hydrological Programme. The International FRIEND Project is worth a special mention, as this has advanced cooperation, hydrological understanding and capacity building regionally, such as in the Southern Africa Development Community (SADC) countries, in West Africa and in the Hindu Kush Himalayan Region.

A new IAHS project has been launched on Prediction in Ungauged Basins (PUB), addressing one of the crucial difficulties in the hydrological sciences. As many ungauged basins are located in less developed countries, which cannot afford costly monitoring programmes, establishing an efficient methodology is of vast practical importance for assessment of water resources and building preparedness systems against water-related disasters. The kick-off meeting of the PUB project, held in November 2002 in Brasilia, raised considerable interest amongst many individuals and several supporting bodies worldwide.

Following the success of the IAHS Hydrology 2000 Working Group (which reported in 1987), the Association set up the Hydrology 2020 Working Group in 2001, composed of a dozen hydrologists, aged 35 or less, each from a different country. The aim of the Group is to predict what the science will be like some 15 years ahead when they report in 2005. *The Hydrology 2000 Report* (IAHS Publ. no. 171) makes very interesting reading today!

Publications

The IAHS publications programme started in 1924 with the production of the proceedings of symposia organised by the Association. This series, known as the “Red Books” because of their distinctive red covers, reached IAHS Publication no. 100 in 1970 and no. 276 by 2002. The Association’s scientific journal was started in 1956. Now called the *Hydrological Sciences Journal*, it is published bi-monthly with about ten papers in English or French in each issue. From time to time a special issue is produced: the most recent (vol. 47(5), 2002) contains invited papers on Ecohydrology. Over the last two years the Journal has risen sharply up the list of 50 water journals in the ISI Journals Citation Index: currently it is ranked fifth with an impact factor of 1.22 (ISI Journals Citation Report, 2001).

A series of Special Publications was started in 1989. The most recent deal with the hydrology and water resources of the River Nile (Special Publ. 5, 1999) and the ecohydrology of South American rivers and wetlands (Special Publ. 6, 2002). A series on snow and ice has been published jointly by IAHS and UNESCO, while UNESCO’s International Hydrology Series was published by IAHS. In the early 1980s, an informal newsletter was started by the then Secretary General to keep members abreast of IAHS activities. This newsletter has developed into a 24+ page publication, which appears three times a year in 4500 copies.

The IAHS website *http://www.cig.ensmp.fr/~iahs* contains information, articles and abstracts of scientific papers from these different publications.

Outreach

IAHS involves its members as readers of publications, participants in scientific meetings and users of results of research projects, and more actively as authors of articles in IAHS publications, contributors to scientific meetings and to research projects. The benefits derived from these activities and their practical applications at grassroots level are very difficult to quantify, a problem faced by IAHS and all similar bodies.

The IAHS Task Force for Developing Countries (TFDC) helps less developed countries to contribute to hydrological research, improve understanding of their water resources and manage them more effectively. It has accomplished this since 1991 by distributing the Journal and other publications to more than 70 libraries and institutes in some 50 countries free of charge. The aim is to provide scientists and engineers in these countries access to the most recent hydrological literature, so long as this literature is made widely available inside and outside the recipient organisation. The TFDC has also been successful in obtaining funds from outside bodies to support the attendance of members from developing countries at IAHS symposia and assemblies. These funds have been generously donated since 1991 by UNESCO, WMO, UNEP, IAEA, Rotary International, IUGG and ICSU, as well as by a number of private trusts and organisations and by government agencies, including those in Canada, France, Germany, Italy, Japan, The Netherlands, Norway, Sweden, Switzerland, the UK and the USA. The UK’s Department for International Development (DFID) has been very supportive of the Association for a number of years.

The future

The six billion or more people on this planet now depend on the world’s finite supply of freshwater, but before 2050 there will be two or three million more with even greater needs. Water for drinking, food production, sanitation, power, navigation and a host of other purposes is the basis of civilisation. But at present more than one billion only have water unsafe to drink, and over two billion lack proper sanitation. Hundreds of millions live in places where water is very scarce, a contested resource and where the recurring dangers of floods and droughts may be exacerbated by climate change.

The equitable and sustainable allocation of water resources and the prediction and mitigation of the impacts of extreme events must be based on the comprehensive understanding of these resources gained through cooperation amongst hydrologists and others professionally involved, and through cooperation and solidarity amongst nations. IAHS is a prime medium for maintaining this cooperation.

Surface Water

ICSW, International Commission on Surface Water

IAHS can contribute to a number of key challenges in the 21st century. These are severest and most urgent in developing countries, where 1.2 billion people lack access to safe drinking water, 2.9 billion lack adequate sanitation and 4 million children die each year from water-related diseases. Demographic trends indicate continued population growth from 5 billion in 1990 to more than 8 billion in 2025. In addition to providing water supplies and sanitation, there is a need to mitigate the impact of natural disasters, particularly floods and droughts, by improved design and forecasting. In developed countries, hydrological issues continue to be critical in the sustainable development of river basins. High priority issues are the allocation of water between direct uses (for example: irrigation, water and power supply) and for the maintenance of ecosystems, and the reduction of the economic and social costs associated with floods and droughts.

Wetland monitoring in Mauritania, West Africa

ICSW is responsible for promoting research in surface water hydrology and its interaction with other aspects of the hydrological cycle. The primary focus of activities is to advance knowledge of the dynamics and statistics of surface water hydrology and to encourage the transfer of this knowledge to the international scientific hydrological community and the water industry to improve the design and operation of hydrological systems. Historically, our core activities have been flood and drought prediction, mitigation and forecasting. However, a higher priority is now given to interdisciplinary research. This includes instream ecology, wetland ecology, poverty reduction, hydrology and health, and knowledge building to reduce international conflict in water. The Commission maintains close links with the International Hydrological Programme of UNESCO and with WMO programmes, for example in supporting the global FRIEND (Flow Regimes from International Experimental and Network Data), HELP (Hydrology, Life Environment and Policy) and WHYCOS (World Hydrological Cycle Observing System) programmes.

ICSW addresses a number of key questions, including:

– How can we reduce the uncertainty of estimating extremes at ungauged sites?
– Is there any evidence for an increase or decrease in the frequency of floods and droughts?
– Can we predict the impact of climate and land-use change on the peak and volume of flood response and the duration and magnitude of low river flows?
– Can we predict, over timescales of 5–100 years, the impact of deglaciation on the water resources 10–2000 km downstream from major glaciers?
– How do we ensure that river flows are both accurately measured, quality controlled and archived to support operational hydrology and hydrological research by this and future generations?
– How can we use remote sensing to advance understanding and prediction of extremes, e.g. using weather radar to forecast flood peaks?
– How can we make use of global relationships between the atmosphere, oceans and land surface

Low river flow and habitat loss caused by a prolonged period with little rainfall and sustained groundwater pumping from the Cretaceous Chalk aquifer, southern England

River Vltava, Prague, August 2002 (Source: Czech Hydrometeorological Institute)

to make medium range forecasts of water resource availability?

– How do we ensure that the benefits of flood inundation for agriculture, fisheries and biodiversity are maintained whilst the adverse damage to life and our economy are minimised?
– Can we develop predictive models for assessing the impact of changing flow regimes on instream macrophytes, invertebrates and fish?
– How do we balance the demands for surface water, for irrigation and water supply, with the environmental demands to maintain a healthy ecosystem?
– How do we improve our understanding of the hydrological functions of wetland ecosystems?
– Can advances in hydrology be used to understand vectors for waterborne disease and thereby reduce infant mortality?
– How do we transfer our knowledge to environmental protection agencies and water utilities?

The present decade marks a new landmark in hydrology. It is a decade when both the hydrological challenges to improve the well-being of society and our access to data, hydrological models and process understanding have never been greater. The environmental challenges provide an outstanding opportunity for young researchers to use their scientific knowledge to address these issues of global importance.

Recent ICSW-linked publications include:

Hydro-ecology: Linking Hydrology and Aquatic Ecology (IAHS Publ. no. 266, 2001).

FRIEND 2002 — Regional Hydrology: Bridging the Gap between Research and Practice (IAHS Publ. no. 274, 2002).

FRIEND — a global perspective 1998–2002, Centre for Ecology and Hydrology, Wallingford, UK (2002).

Groundwater

ICGW, International Commission on Groundwater

Only a small percentage of the world's total water resource is available to human beings as freshwater, and more than 98% of the available freshwater is groundwater. The storage capacity of groundwater reservoirs combines with small flow rates to provide large, extensively distributed sources of water supply. Hence, groundwater plays an important role in the development and management of water resources.

However, in order to solve the management problem, we must be able to predict the response of the system to any proposed operation policy, to contamination hazards, and to developments such as climate change and population growth. Prediction of groundwater flow and contaminant transport is therefore a prerequisite to properly addressing the management and sustainable use of groundwater.

Groundwater hydrology

Understanding the factors that control the flow of water through soils has led to the development of one of the most important fields in the earth sciences: groundwater hydrology. Over the years an impressive body of theory and practice has been developed. It is recognised that the nature of underground flow and contaminant transport must be understood in order to develop meaningful solutions to groundwater problems. This is not an easy task because the complexities of the geological processes cause many variations in natural flow systems. Groundwater systems often display complex patterns, manifested in the spatial variability of controlling parameters and boundary conditions at all scales of practical significance.

The study of groundwater requires new approaches and solutions and must face the continuing difficulties in developing models that represent groundwater systems. These are among the most difficult of earth system models because the systems are inaccessible and (as shown in the figure) very heterogeneous. Yet to properly manage such systems, detailed characterisation is required. Numerical solutions to groundwater problems are often necessary to solve complex problems encountered in the field. Furthermore, hydrological variables are usually affected by uncertainty, and both deterministic and stochastic methods of investigation are considered in groundwater studies. For any given groundwater system, some features are known relatively well and it is most advantageous to represent them in a model deterministically. Other features are less clearly known, or known very little, and it is important to represent them using stochastic methods in order to provide risk-qualified evaluations and decisions.

Activities

ICGW is responsible for the advancement of the science of groundwater hydrology, including the scientific basis for groundwater resource assessment and groundwater management. It also helps to bridge the gap between science and practice. A primary objective is to give greater exposure to valuable new technologies and methodologies that are useful in groundwater resource and water quality studies. This is accomplished through organised technology transfer activities and publications. ICGW discharges its responsibilities in three ways:

First, it organises significant international symposia, such as the well-known and successful GQ (Groundwater Quality) and ModelCARE conference series, and sponsors occasional regional symposia.

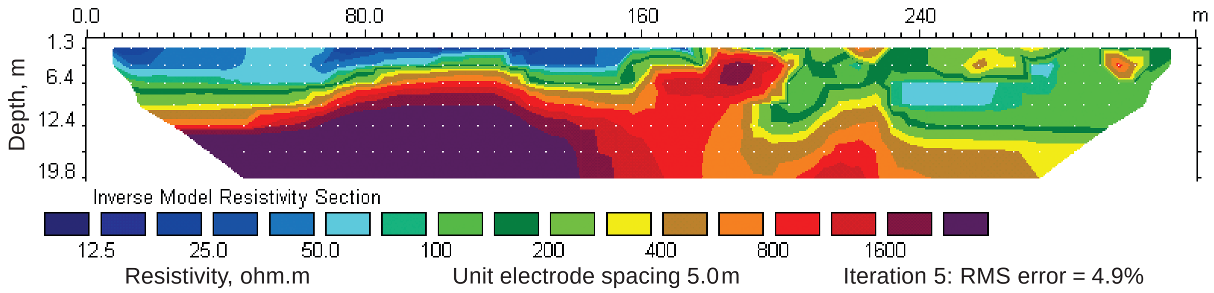
Second, it collaborates with other IAHS commissions and with other scientific organisations, including the American Geophysical Union (AGU), the International Association of Hydrogeologists (IAH) and the International Ground Water Modelling Center (IGWMC).

Third, it organises working groups to develop reports that focus on new and important aspects of hydrogeology. These activities are frequently coordinated with the International Hydrological Programme (IHP) of UNESCO.

Current research themes

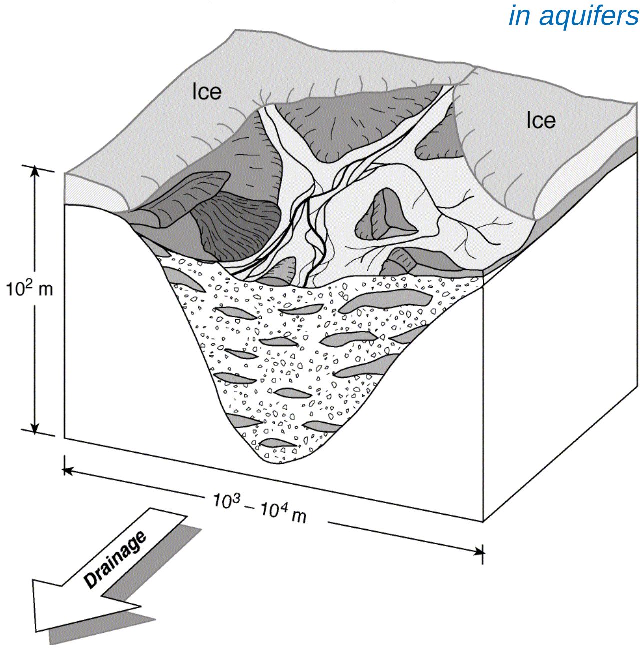
Examples of areas in which the Commission has traditionally been active and new areas that are being developed currently are:

– Groundwater quality, devoted to studying the movement of miscible (inert, reactive) and immiscible solutes in complex groundwater systems, as a result of the various contamination sources that may be present in the water cycle.



Electrical imaging of a variably weathered granite bedrock overlain by clay in places (India). Greens are more permeable weathered granite; blues show the presence of clay and reduced permeability. Image provided by Ron Barker, University of Birmingham, UK

Depositional environments in the creation of buried valley aquifers, showing some of the heterogeneities and challenges often met in characterising and modelling flow and transport in aquifers



– Environmental risk assessment, where the available tools for predicting pollutant migration are applied to evaluate the level of risk associated with groundwater contamination.
– Numerical modelling, devoted to accurate analysis and addressing the high level of complexity exhibited by both the natural aquifer systems and the physical processes that take place.
– Innovative field and laboratory measurement techniques, which are important for understanding the processes acting in groundwater and for acquiring the data necessary for model calibration and analysis.
– Advanced field data interpretation methods, where all the most recent theories and tools are applied to understand the fundamental processes acting in natural aquifers.
– Characterisation of heterogeneous media, including hydrogeological and hydrogeochemical aquifer properties. This element is fundamental to the study of flow and solute transport in natural aquifers, which typically exhibit spatially variable hydraulic properties.
– Management of groundwater resources under uncertainty, where groundwater problems are formulated in probabilistic terms, and innovative techniques are developed to overdesign cost-effectively groundwater management schemes in order to accommodate our predictive uncertainty.
– Effects of global change on groundwater, in terms of recharge, especially in arid and semiarid regions, in relation to water resources management, and in terms of responses of aquifers to extreme hydrological events, with respect to both quantitative and qualitative aspects.
– Analysing the effects of population growth on groundwater resources and available drinking water using large-scale groundwater models, as well as analysing mitigation.

This list could easily be extended, given the number of groundwater problems arising in water management and water use. The areas of interest listed emphasise that groundwater hydrology is heavily based on an interdisciplinary approach, involving different fields such as physics, chemistry, geology and other earth science related disciplines. Towards this goal, the role of ICGW is also to promote exchanges between researchers working in different fields, in order to analyse groundwater problems from various perspectives and cooperate in the solution of the theoretical and practical problems of groundwater hydrology.

Besides the promotion of the science of groundwater hydrology, ICGW commits itself to promote the development of methodologies for enhancing communication between hydrogeologists, decision makers and communities to strengthen public participation in groundwater analysis and protection. Such ambitious tasks will go far towards a better understanding of groundwater problems by different groups of stakeholders, and help to integrate and balance the needs of the social groups.

Continental Erosion

ICCE, International Commission on Continental Erosion

ICCE is dedicated to the advancement of research in erosion, sediment transport and sedimentation processes in relation to hydrology and fluvial geomorphology. It is also involved in the study of global patterns of erosion and sediment yield, and their controls, and of the role of particulate matter in the transport of contaminants within fluvial systems. In some areas, sediment-associated nutrients and contaminants cause serious pollution problems. Recognition of the important role of sediment in the transport of contaminants has given rise to a need for improved understanding of the routing of sediment through the fluvial system of drainage basins of different scales and of the dynamics of the sinks involved.

At the global scale, soil erosion is one of the major contemporary environmental issues. In many areas of the world, erosion rates have increased dramatically as a result of forest clearance and land-use change, and this accelerated erosion is commonly paralleled by marked increases in sediment yield. Both increased on-site soil loss and increased suspended sediment loads can give rise to serious economic and environmental problems: reduced soil productivity, reservoir sedimentation, disruption of water supply infrastructure and degradation of freshwater habitats. Soil erosion has an immediate impact on the long-term productivity of soil.

The continuing global population growth will result in an increasing demand for food. Soil erosion and associated land degradation threaten the world's capacity to produce the required food. Thus, more research is needed on soil erosion processes and their control, and better data must be provided on rates of soil loss and depletion of the soil resource in different areas of the world.

Studies of soil erosion at the landscape scale using classical methods are difficult, time consuming and expensive. Over the past 35 years, researchers have investigated the potential of using environmental and man-made radioisotopes (^{210}Pb, ^{7}Be and ^{137}Cs) to study soil erosion, sediment source and sedimentation. Although the use of radiometric methods to document rates and patterns of soil loss is attractive in its simplicity, it is founded on several key assumptions. A number of the potential limitations of using fallout radionuclides to estimate erosion are no greater than those associated with other techniques used by soil scientists and geomorphologists.

The need to investigate the sediment budgets of catchments in a variety of environments introduces an important methodological problem in documenting the movement and storage of sediment within large basins. In many, the source of sediment transported from the basin may be uncertain and there is clearly a need for further research to develop techniques for establishing sediment sources and for tracing the movement of the associated sediment through the fluvial system. Studies of fallout radionuclides and their redistribution within a drainage basin provide one possible approach to this problem.

The growing demand for water will inevitably lead to construction of many new dams. Although reservoir sedimentation problems are now well recognised, there is still a need to develop better methods of predicting basin sediment yields in regions where such data are absent and to devise improved strategies for basin management to reduce sediment inflows. River sediment loads represent a key component of the transfer of material from the land surface to the oceans, and thus of the global geochemical cycle. Lack of data on sediment loads for many rivers of the world hampers attempts to quantify these fluxes and to assess their sensitivity to global change. There is a need to promote both the development of sediment monitoring networks on the world's rivers and the standardisation of associated monitoring programmes to address these important global questions.

To address some of these problems, ICCE has recently established two Task Forces: on New Methods for Measuring Erosion and Sediment Transport, and on Standardisation and Comparison of Methods Used for Evaluation of Sediment Transport Crossing International Borders.

Activities

ICCE effectively straddles the divide between hydrology, geomorphology, civil engineering, agricultural engineering, sedimentology and geochemistry. The Commission regularly organises symposia and workshops, but also actively

Erosion on steep slopes of the Sikkim Himalaya (India) and coarse sedimentation in the valley immediately downstream

Extensive fine sediment deposition associated with the Teesta River as it crosses the Ganga-Brahmaputra Plain, India

collaborates with the other IAHS commissions, and with other international groups and bodies, regarding multidisciplinary approaches to hydrological problems and bridging the gap between research and practice through technology transfer to developing countries. These include the International Geosphere-Biosphere Programme (IGBP), the International Geographical Union (IGU), the International Coordinating Committee on Reservoir Sedimentation (ICCORES), the International Commission on Large Dams (ICOLD), the International Association of Sediment–Water Science (IASWS), the International Soil Conservation Organization (ISCO), and the International Research and Training Centre in Erosion and Sedimentation (IRTCS). ICCE has played an active role for many years to implement those aspects of UNESCO's International Hydrological Programme concerned with erosion and sediment yields.

ICCE is currently involved in the symposium on Erosion Prediction in Ungauged Basins (PUB): Integrating Methods and Techniques at the XXII IUGG General Assembly (Sapporo, 2003), part of the new IAHS initiative on PUB. The objective is to review recent developments in a wide range of methods and techniques that can be used to characterise runoff and erosion in ungauged basins, and to evaluate how to integrate the information obtained using remote sensing, GIS, modelling and other methods into a coherent view of the ungauged basins (IAHS Publ. no. 279, 2003).

Recent ICCE publications include:

Modelling Soil Erosion, Sediment Transport and Closely Related Hydrological Processes (IAHS Publ. no. 249, 1998).

The Role of Erosion and Sediment Transfer in Nutrient and Contaminant Transfer (IAHS Publ. no. 263, 2000).

The Structure, Function and Management Implications of Fluvial Sedimentary Systems (IAHS Publ. no. 276, 2002).

Snow and Ice

ICSI, International Commission on Snow and Ice

ICSI actually predates IAHS (founded in 1922) by over a quarter of a century: it was founded as the *Commission internationale des glaciers* (CIG) in 1894. The objectives of the CIG were to promote historical and scientific studies on glaciers throughout the world and to gather and disseminate the data through periodic publications and annual reports.

Research interests and publications

Originally, the CIG was mainly concerned with glacier movement and variations in their physical dimensions with fluctuations in climates. In 1939 the CIG merged with the Commission of Snow, founded in 1936, and the newly-named commission (ICSI) broadened its interests in 1948 to include all aspects of the science of snow and ice. Since then the Commission has continued to explore innovative research in the physical, geochemical and biological dynamics of the cryosphere. Through the efforts of working groups (WG), significant works have been (and continue to be) published in such different fields as snow mechanics, glacier mass balance techniques, isotope chemistry, nutrient dynamics of snow, hydrology of river and lake ice and ecology of snow fields. ICSI also continues the original objectives of glacier inventory and recording changes through the World Glacier Monitoring Service (WGMS), part of the Federation of Astronomical and Geophysical Services (FAGS) under ICSI's responsibility.

Current research and technology transfer

Today, ICSI not only undertakes activities of a purely scientific exploratory nature, but also transfers and applies scientific knowledge to the practical management and use of natural cryospheric resources. The pure science includes studying the relationship between snow and climate, the interactions between snow and vegetation, and snowmelt modelling, which are all related to the increasing interest in improving cryospheric representations in climate and hydrological models. Other subjects of interest are the dynamics of tropical glaciers, debris-covered glaciers, extraterrestrial ice, and runoff processes in cold regions. Scientific knowledge is transferred and applied through training courses in mass balance measurements of glaciers and through setting up glacier monitoring networks. These current topics are outlined briefly in the following paragraphs.

Snow and climate

Snow cover is a part of the cryosphere, which is an integral part of the global climate system with important linkages and feedbacks generated through its influence on surface energy and moisture fluxes, precipitation, hydrology and atmospheric and oceanic circulation. Because of its specific radiative and thermal properties, snow cover plays a major role in the climate system. The study of snow and climate is a rapidly evolving science, with new demands for detailed representations of snow processes to provide an up-to-date understanding of snow physics and to support modelling of climate change scenarios. An ICSI WG on Snow and Climate is writing a state-of-the-science work on interactions between climate and snow. Subjects include new techniques for studying snow–climate relationships by monitoring the extent of snow cover at continental and hemispheric scales, and recent advances in snow modelling physics to represent snow cover and parameterisation of snow processes in Global Climate Models (GCMs).

Snow and vegetation

Recent inter-comparisons of snow models for open and vegetated environments have shown widely divergent results, because current parameterisations do not include the full range and dynamics of snow processes. This is important because the interactions between snow and vegetation are increasingly recognised as an extremely important factor in regulating global climate and water supply. The studies of the ICSI WG on Snow and Vegetation are developing a more consistent and comprehensive approach to representing snow–vegetation interactions in various biomes, including the Arctic Tundra and sub-Arctic Boreal Forests, Mountains and Grasslands. The subject matter includes blowing snow processes, shrub-tundra snowmelt energetics, the dynamics of intercepted snow and snowmelt under forest canopies, and the impacts of ecosystem stress in the guise of climatic fluctuations, deforestation, land-use change and land-use management.

Tropical glaciers may provide almost the only water for fast developing societies during the dry seasons: Huaraz and Nevado Huascarán, Peru

Snow model inter-comparison

There is widespread use of many different types of snow models in various applications, such as hydrological forecasting, the structuring of global circulation models and avalanche prediction. The degree of complexity of these models varies greatly, from simple index methods to multi-layer models that simulate snow cover layering and texture. This variability makes it possible to investigate the relative importance of the different processes that can be taken into account and parameterised in a snow model. ICSI's WG on Snow Model Inter-comparison uses a two-tiered approach, based on off-line inter-comparison of snow models forced by meteorological data, and representing internal processes in the different snow models (e.g. layering, melting-freezing, compaction). Defining a common methodology to achieve the parameterisation of internal processes is a particular challenge, but a successful outcome will provide a substantial tool to optimise snow cover representation in climate models.

Tropical glaciers

Tropical glaciers are very sensitive indicators of low latitude global climate change as well as vulnerable resources of water supply in highly populated regions. The setting of homogeneous thermal conditions, where seasonality is dominated by variations in air humidity and moisture, leads to a particular interaction of climate and tropical glaciers. A major challenge for water management in low latitude, high mountain regions is that, although the 20th century glacier retreat has contributed to an abundant water supply, it has also diminished the resource capacity to support future increases in social activities. In this context, two ICSI WGs (on Himalayan and South American Glaciers) have studied glacier dynamics in these two regions, and have designed training courses on glacier mass balance measurements in the Himalayas (see inside back cover) and the Andes. ICSI also initiated and supported the publication of the book *Tropical Glaciers* as an issue of the International Hydrological Series (UNESCO and Cambridge University Press, 2001).

The majority of glaciers in many mountain ranges, as in the Himalayas, are debris-covered. When they retreat, they generate huge dammed lakes, which are very fragile to basin erosion and seismic tremors. These lakes represent tremendous hazards in many populated valleys of the Andes and Himalayas, but their relationships to glacier evolution are poorly understood. ICSI is evaluating the studies of debris-covered glaciers, and an ICSI-supported workshop in Seattle, USA, in 2000 comprehensively reviewed the present status of knowledge, generating *Debris-Covered Glaciers* (IAHS Publ. no. 264, 2000).

Application of scientific knowledge

Training programmes for monitoring glacier mass balance have been held in the Himalayas by ICSI Training Contingents, incorporated into teams of regional government organisations and university researchers, through UNESCO, who also supported publication of a training manual. A similar exercise will take place in South America in 2003/4. Training local technical personnel and establishing glacier monitoring networks are both essential to developing data acquisition systems, on which local management will have to rely in optimising use of snow and ice resources in high-mountain regions.

Water Quality

ICWQ, International Commission on Water Quality

ICWQ is responsible for promoting the scientific advancement of the water quality of hydrological systems, including their assessment and management. Water quality is a vast and complex topic. It embraces all phases of the hydrological cycle from precipitation inputs, through terrestrial surface water and groundwater systems, to the marine environment into which freshwater runoff ultimately discharges. Water quality can be defined by numerous physical, chemical and biological variables, and shows complex variations in space and time. Although not exclusively the result of human impacts, very many of the water quality problems in the world today have arisen through the use of water for domestic, agricultural and industrial purposes. As a consequence, surface, ground- and coastal waters have become polluted with a wide range of contaminants, including organic materials, nutrients, salts, acidifying compounds, heavy metals, organic micropollutants, radioactivity and sediments.

Activities

ICWQ organises and sponsors significant international and regional symposia and workshops, and collaborates with other groups, such as the other IAHS commissions, national and international scientific organisations, on subjects of joint interest. The topics covered in meetings include:

- Effects of scale on interpretation and management of sediment and water quality,
- Biogeochemistry of seasonally snow-covered catchments,
- Freshwater contamination,
- Hydro-ecology: riverine ecological response to changes in hydrological regime, sediment transport and nutrient loading,
- Optimisation of monitoring strategies for groundwater quantity and quality.

From time to time, ICWQ sets up working groups to focus attention on specific issues. In recent years they have addressed nutrient cycling and management, and urban water quality. This work has culminated in ICWQ-sponsored symposia generating several IAHS publications (*Impact of Land-Use Change on Nutrient Loads from Diffuse Sources*, 1999; *Impacts of Urban Growth on Surface Water and Groundwater Quality*, 1999; *Agricultural Effects on Ground and Surface Waters: Research at the Edge of Science and Society*, 2002: IAHS Publ. nos 257, 259 and 273 respectively).

ICWQ contributes to major international programmes in hydrology, such as the IHP, including HELP (Hydrology for Environment, Life and Policy), and addresses topics relevant to key global issues, such as those identified by the World Summit on Sustainable Development (Johannesburg, 2002) and the Third World Water Forum (Kyoto, 2003).

The World Water Vision states that deterioration of surface water and groundwater quality and the impact on ecosystems and biodiversity will be central issues for sustainable water resources development and management in the coming decades. It also states that there has been insufficient investment in water quality protection for urban and rural needs. Consequently considerable effort by NGOs, national and international scientific, management and policy agencies/organisations will go towards understanding and resolving water quality issues during the next decade.

ICWQ can serve these organisations by identifying experts to provide knowledge on water quality problems and by promoting research into critical issues that are not yet properly understood. It has identified the following key water-quality issues needing further research and assessment.

ICWQ's role as the 21st century unfolds will be to ensure that proper attention is given to key issues, such as these, and to provide a forum for discussing the key science involved and how to apply it to the best effect.

Effect of water quality on human health

Freshwater, both surface water and groundwater, is an important medium for the transport of toxins, viral and bacterial diseases and parasitic infections. Each year, waterborne bacterial infections account for half of the estimated 3–5 billion episodes of diarrhoea and the resulting 3 million deaths, mostly among children. Water quality impacts on human health are exacerbated in areas of high water stress, where the water withdrawn annually for human use is more than 40% of the water available. We need to understand better the relationships between water quality and quantity and their effects on human health.

Industrial garbage polluting water in Latvia. Photo by Curt Carnemark, 1993. © World Bank Photo Library

Contaminant transformation and transport

The processes by which contaminants enter watercourses and are transported, ultimately to the sea, are highly complex. In the journey of pollutants from source to sink there may be many stages and transformations, including interactions between dissolved and particulate phases involving physical, chemical and biological processes. Furthering our knowledge of freshwater contamination therefore requires an interdisciplinary approach.

Improving water quality monitoring

Approaches to collecting water quality data need refining to ensure that the information gathered is relevant to management issues, as well as scientific understanding, and that its benefits clearly outweigh the costs of data collection. As the need to assess water quality globally increases, it is appropriate to develop international standards of monitoring and assessment, but at the same time to ensure that protocols apply in and to developing countries.

Regional water quality problems / solutions

Considerable progress has been made in tackling national water quality issues, particularly in the developed world. In The Netherlands, the detrimental accumulation of nutrients in shallow lakes (eutrophication) has been alleviated during the last 20–30 years by improving agricultural practice (reducing nutrient leaching), effluent treatment, fish stock manipulation and cooperation between scientists and land/water managers. However, transboundary water quality problems have not usually received the same attention. Exceptions include the eutrophication of the Great Lakes in North America and the Baltic Sea, where nutrient outputs from point and non-point sources have been reduced and water quality has started to improve. Lake Victoria in eastern Africa, Lake Malawi in southern Africa, and the Aral Sea in Central Asia are placees where transboundary water quality is still a major problem.

Water quality and global change

Unnaturally high rates of change are likely in the 21st century as a consequence of human impact on, for example, global warming and land-use modification. Global change will influence hydrology and ecosystems, which in turn will affect water quality. In parts of the globe, hydrological extremes may become more acute as the climate warms. More severe flooding may mobilise and transport more fine sediment into watercourses, along with nutrients and contaminants. More acute droughts may lead to a rise in river temperatures, lower oxygen levels and change fish habitats. There is a pressing need to understand and model how water quality will respond, to predict potential harm to aquatic environments and then ameliorate them by appropriate management.

Application of new technologies

On-going developments in tracers, remote sensing and other technologies will provide new tools with which to advance our scientific understanding of the natural and anthropogenic factors influencing water quality, and also to improve our ability to manage and control this aspect of water resources.

Support for training in developing countries

Water quality problems are particularly severe in developing countries. In Latin America less than 2% of sewage is treated, while in Mexico 90% of wastewater treatment plants do not work. Many politicians view water problems in terms of quantity rather than quality, and in many developing countries there is a need to strengthen both institutions and policies in water quality management, regulation and protection. Attention needs to be focused on the best ways to promote capacity building in the water quality sector.

Water Resources Systems

ICWRS, International Commission on Water Resources Systems

Its title differentiates ICWRS from the other IAHS Commissions, which are named after parts of the hydrological cycle, specific characteristics of its components or to methodologies. A “resource” is defined as a source of supply or support, and water is an essential natural source of life and health for humankind and the environment. Resulting from this holistic understanding of the term “resource”, ICWRS promotes research and development on the integration of all phases of water resource protection, planning, design, management, operation and utilisation.

The range of scientific interests represented by ICWRS also relates to the term “system” in its name. A system is a regularly interacting or interdependent group of items forming a unified whole. Water resources are a distinguished example of interacting bodies under the influence of related forces. Again the approach needed is a holistic one. Responsibility for a system is shared among its components. Resulting from this double integration, ICWRS topics today cover a wide range of scientific interests with a common focal point that can be described as Integrated Water Resources Management (IWRM).

Integrated Water Resources Management

The modern concept of Integrated Water Resources Management considers two basic categories:

- the natural system, which is of critical importance for resource availability and quality, and
- the human system, which fundamentally determines the resource use, waste production and pollution of the resource.

An integrated approach must balance consideration of both categories and their interdependencies, and the different internal relationships within each category.

Example of interdependence

Land and water management provides an important link between natural and human systems. Here an integrated approach is needed that considers land-use developments and the role played by vegetation cover (including crop selection) in influencing the physical distribution and quality of water. Land-use development has to be considered as part of the overall planning and management of water resources, as it has a strong influence on the natural system.

Examples of the internal relationships

Examples of particular interest in water management include the following:

- Relationships between surface water and groundwater are essential for water management, as large proportions of the world’s population depend on groundwater for water supply. Widespread use of agro-chemicals and pollution from other non-point sources, strongly interlinked with infiltration, pose significant threats to groundwater quality. Water managers are forced to consider links between surface water and groundwater to ensure sustainable use of groundwater resources.
- Human demand entails the development of appropriate quantities of water of suitable quality.
- Consideration of quantity and quality in water resources management is essential in IWRM. The relationships between water quality and water quantity cannot be neglected, since non-point pollution is related to water fluxes. It is often necessary to consider pollution of surface and ground waters as originating from human activities and transported by runoff and groundwater recharge into our water resources.
- Within the human system, relationships and interlinkages are caused mainly by multi-site and multi-objective water utilisation. The economic demand for water by single user groups usually has to be harmonised with the needs of the whole society. Transboundary water resources add a spatial component within the human system of water resource utilisation, and different upstream and downstream water-related interests cause significant problems.

This list of necessities for integrated approaches within the water management could easily be extended. Clearly, a new approach is needed in order to find a balance between society’s demand for water and the restoration of waters as part of nature conservation in the new century.

ICWRS is dedicated to this task and the integration challenge is interpreted very widely, linking water quantity and quality, atmospheric/surface water and groundwater, land-use and water management, small-scale sub-catchments and large-scale main river basin systems, ecosystems and

The Möhne Dam, in the Ruhr region of Germany. Photograph by Ruhrverband, Essen, Germany (archive Ruhrverband)

economic/social development, water supply and water conservation, urban and rural water users, poor communities and better-off users, bio-physical and socio-economic information, statutory water governance and participation by catchment stake-holders, routine management and responses to hydrological extremes, technology application and capacity-building/advocacy.

Hydrological sciences have to consider the four characteristics of a water resource jointly:

– quantity,
– quality,
– condition of the aquatic habitat, and
– condition of the aquatic biota.

The ICWRS builds on, and bridges, the separate disciplines, promotes opportunities for cross-fertilisation among them and challenges them on matters of internal focus and priority in the sustainability/systems context of modern water management concepts.

Since water management depends on the human as well as on the natural system, ICWRS pays special attention to the human factor. Here the Commission considers the social context of water: balancing food production, human health and social development with resource protection; understanding and using the links between water and energy, water and policy, and water and civilisation; engaging public perceptions of sustainability; exploring links between hydrological extremes and their impacts on human communities and *vice versa*.

Integrating outputs from different disciplines relevant to the sustainability/systems approach requires a technological and conceptual ability to bridge the gaps between disciplines, in order to make the different types and scales of information and data inter-operable and to reinterpret information that lies in the overlap between the abiotic and the biotic sub-domains of hydrology and water resources.

IWRM is not only an engineering task based on interdisciplinary planning. It also starts with new thinking about the role of water as the most essential component in the natural and human system, about the ecological, economic and social effects of water management, the needs of today, the sustainability of our proposed solutions and the efforts of future generations to cope with inherited water problems.

This new understanding of water management must be transmitted in appropriate structural and non-structural solutions, which will have to integrate and balance the needs of many different groups of stake-holders. By devoting itself to this scientific task, ICWRS will ensure that the important role played by IAHS over the past 80 years will continue.

Recent publications from symposia organised by ICWRS are:

Regional Management of Water Resources (IAHS Publ. no. 268, 2001).

Integrated Water Resources Management (IAHS Publ. no. 272, 2001).

Remote Sensing

ICRS, International Commission on Remote Sensing

Remote sensing has been defined as the science and art of obtaining information about an object, area or phenomenon through the analyses of data acquired by a sensor that is not in direct contact with the target of investigation. ICRS recognises that the science of hydrology is data-limited and that the understanding of hydrological processes may benefit greatly from remotely sensed data and from improved spatial data organisation through the use of GIS (geographical information systems).

The applications of remote sensing and GIS in hydrology are becoming more important, and these techniques have the ability (a) to measure or manage spatial, spectral, and temporal information, and (b) to provide data on the state of the Earth's surface. Future advances in hydrological remote sensing and GIS are likely to depend heavily on improved technological and scientific capabilities.

The state of the science of remote sensing in hydrology was presented at an ICRS symposium on *Remote Sensing and Hydrology 2000* in Santa Fe, USA (IAHS Publ. no. 267, 2001). More recently, ICRS activities have resulted in a series of co-sponsored workshops and articles in a special issue of *Hydrological Processes* (2002).

Use of Remote Sensing

The potential of remote sensing for providing information to hydrologists and water resources practitioners has been recognised since the launch of the first ERTS-1 satellite in 1972. Since that time, hydrologists and other scientists have developed algorithms to extract hydrological information from remotely sensed data and to develop new, or adapt existing, hydrological methods capable of making efficient use of this new information. The increasing number of satellite and airborne platforms along with advancements in computer and software technology make it possible to evaluate and quantify large numbers of drainage basin physical characteristics and state variables.

The rapid growth of population in many countries, together with a generally increasing standard of living, is increasing demands on water for irrigation, industry and urban water supply and decreasing the quantity and the quality of available water. It is now well understood that positive benefit/cost ratios can be realised in using remotely sensed data in hydrology and water resources management. These estimates rely on savings derived from flood prevention and improved planning of irrigation and hydroelectric production.

In most cases, remote sensing data are used to assess the hydrological state of a basin or region by estimating various hydrological state variables (in the liquid, solid or gas phase) and/or hydrologically significant physiographic variables that can influence hydrological processes or responses. The simplest of these is the use of remote sensing imagery to identify items such as snow-covered areas, surface water extent or sediment plumes.

The second class involves obtaining data such as land cover, geological features or other hydrological variables and parameters through interpretation and classification of remotely sensed data. The third class involves the use of digital data to estimate hydrological state parameters directly. This is normally achieved through correlation of known hydrometric data with remotely sensed data or application of electro-optical models. In most remote sensing studies pertaining to hydrology, land-use data (class 2) are primarily used in conjunction with hydrological models.

Developments

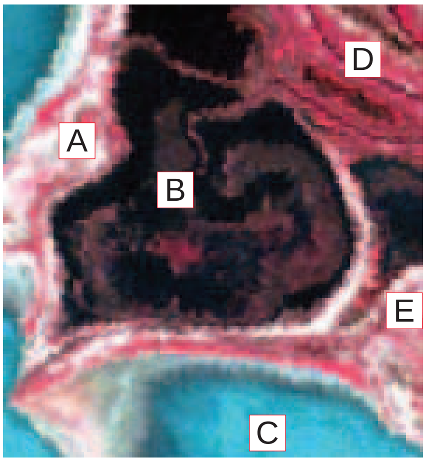
Over the years, research and applications of remote sensing within hydrology have embraced a variety of topics, from snow, permafrost and ice to soil moisture, flood mapping and wetland detection, as well as numerous studies examining water quality, bathymetry and suspended sediment concentrations.

Despite their promise, the use remote sensing techniques is still not exploited to the full by practising hydrologists: this represents a challenge for scientists and engineers. Research in the application of remote sensing in hydrology will continue as more uses of imagery are realised and as more satellite platforms and sensors are added to the existing complement. Changes in sensor characteristics and resolutions will afford new opportunities to hydrologists. In the short term, significant advances in hydrological sciences and real-time water management are likely as a result of the recent implementation of the Earth Observing System (EOS).

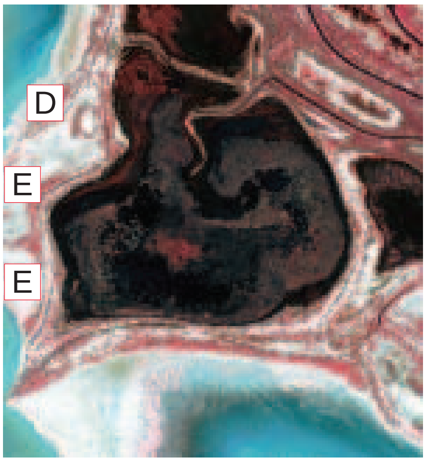
The recent launch of the EOS AM-1 satellite holds special promise for hydrologists, since it contains an array of sensors that will permit simultaneous measurements of various atmospheric and surface components of the hydrological cycle. It started collecting imagery in January 2000. Successors to the AM-1 are to be launched so that scientists will be able to access a continuous data set for at least an 18-year period. The recent successful launch of the European Envisat satellite will also provide a unique view of the water cycle from space.

As well as the expansion of the type and combination of sensors, spatial resolution of the imagery will continue to improve. DigitalGlobe's QuickBird commercial satellite now offers the highest publicly available resolution with 0.61 m panchromatic and 2.4 m multiband images. The vast potential of such high resolution "imagery" remains largely untapped. As seen in the figure, remote and inaccessible sites can be monitored with a number of satellites highlighting different spectral response (Landsat and IKONOS), as well as texture and dielectric response (Radarsat) for surface water delineation, vegetation and soil moisture estimates. Elevation information is also now derived remotely using airborne platforms such as LiDAR.

If remote sensing is truly to be effective in water management and hydrological applications, advancement in understanding of the electro-magnetic interaction with the hydrosphere and crysophere is a critical factor. The hydrologist's view of the world is as a complex nonlinear system, and only remote sensing offers repeatable, global and continuous observations of the state of the Earth. The use of remote sensing in solving previously daunting hydrological problems, such as flow prediction from ungauged basins (PUB), is now a very real possibility. ICRS is committed to this geo-spatial view of the water cycle and encourages research and development in this field of study.



Landsat



IKONOS

Radarsat S2

LiDAR

A wetland basin in the Peace-Athabasca Delta, Canada, illustrating a multi-sensor approach for hydrology. The wetland has been captured with Landsat TM (30 m resolution), IKONOS (4 m resolution) and Radarsat S2 (30 m resolution), and by airborne scanning LiDAR (gridded into 4 m cells). The image subset shows the reflectance and backscatter over:
(A) dry land covered by vegetation, (B) standing water beneath willows (no leaves), (C) open water, (D) willows (dry), and (E) grasses and sedges (dry). Only the near-infrared channel is shown for the Landsat and IKONOS images. Image texture, wetness and vegetation type, and elevation from LiDAR, are readily available for hydrological analysis.

Atmosphere–Soil–Vegetation

ICASVR, International Commission on Atmosphere–Soil–Vegetation Relations

As its name implies, the International Committee on Atmosphere–Soil–Vegetation Relations (ICASVR) concerns itself with the linkages of the land surface of the earth and its interactions with the atmosphere. There are several continuing challenges in securing a more comprehensive assessment of these couplings, addressing the so-called "vertical flux question".

The period from the late 1980s into the 1990s was an important benchmark in the development of realistic land surface atmospheric simulations. With the advent of increasingly sophisticated atmospheric models (for numerical weather prediction, climate simulation, and transport research) as well as major land surface experiments (e.g. FIFE, HAPEX) came the need to better understand, parameterise and model the linkages joining the dynamics of the land surface and of the atmosphere. At the same time, hydrological simulations were rapidly gaining in sophistication, making extensive use of spatially-distributed data sets (e.g. high resolution digital elevation and remote sensing imagery) and more accurately depicting the dynamics of soil water and plant canopies, either through deterministic or statistical approaches.

At about this time, a general recognition emerged within IAHS that, although activities related to the specialised sub-disciplines of the water sciences were being coordinated well through the Association, coordination across closely allied fields was lacking. One particularly important research arena, where coordination would be of obvious advantage, had to do with soil–vegetation–atmosphere interactions. Indeed, a proposal made to the IAHS Bureau (Vancouver, 1987) initiated a new commission, ICASVR. In some sense ICASVR joined a brotherhood of scientific organisations, with committees conceived at more-or-less the same time.

These resided in the International Geosphere–Biosphere Programmes of Biospheric Aspects of the Hydrological Cycle (BAHC), and in the International Satellite Land Surface Climatology Project (ISLSCP) of the World Climate Research Programme. Collaborations of various sorts developed between these groups, including participation in joint field explorations, development of models and data sets, and publication of mutually relevant results.

Research interests

From the start, the interests of ICASVR have spanned several areas that continue to develop rapidly today:

- Scaling hydrological behaviour from point to larger domains;
- Development of spatial aggregation rules;
- Interpretation of remote sensing data to derive land surface properties and parameters, and to quantify land–atmosphere water and energy fluxes;
- Quantification of the role that spatial heterogeneity in soil wetness and vegetative cover plays in prompting feedbacks with the atmosphere;
- Identification of the role of dynamic vegetation, either in the short term (e.g. crop growth and senescence) or longer term (e.g. greenhouse warming–vegetation feedbacks);
- Development and analysis of the behaviour of linked SVAT–atmosphere models, either within GCM and/or mesoscale models;
- Testing land surface schemes for consistency in a broader context (i.e. large-scale drainage basins).

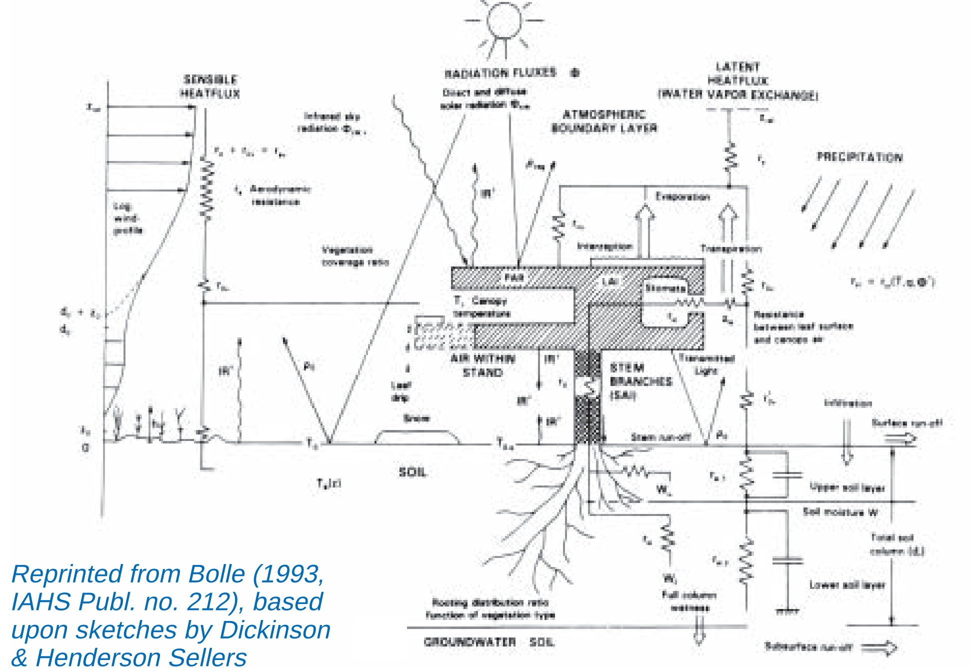
Contributions

ICASVR's first major contribution was convening a symposium at the XXth IUGG General Assembly (Vienna, 1991), with subsequent publication of *Hydrological Interactions between Atmosphere, Soil and Vegetation* (IAHS Publ. no. 204, 1991). In 1993 it joined with IGBP-BAHC to produce IAHS Publ. no. 212, *Exchange Processes at the Land Surface for a Range of Space and Time Scales*, a wide-ranging volume encompassing nearly all of the ICASVR thematic issues. At the IUGG General Assembly in Birmingham (1999), ICASVR developed a communiqué on the documented decline of water sciences data sets, released to 40 000 geophysicists as the publication *Eos-AGU Transactions* 82(5), 54–58. The latest volume *Soil–Vegetation–Atmosphere Transfer Schemes and Large-Scale Hydrological Models* (IAHS Publ. no. 270, 2001) was produced for a symposium at Maastricht.

This most recent volume, while indicative of its core interests in SVATs, is also emblematic of the direction that ICASVR may ultimately take in future.

From this ...

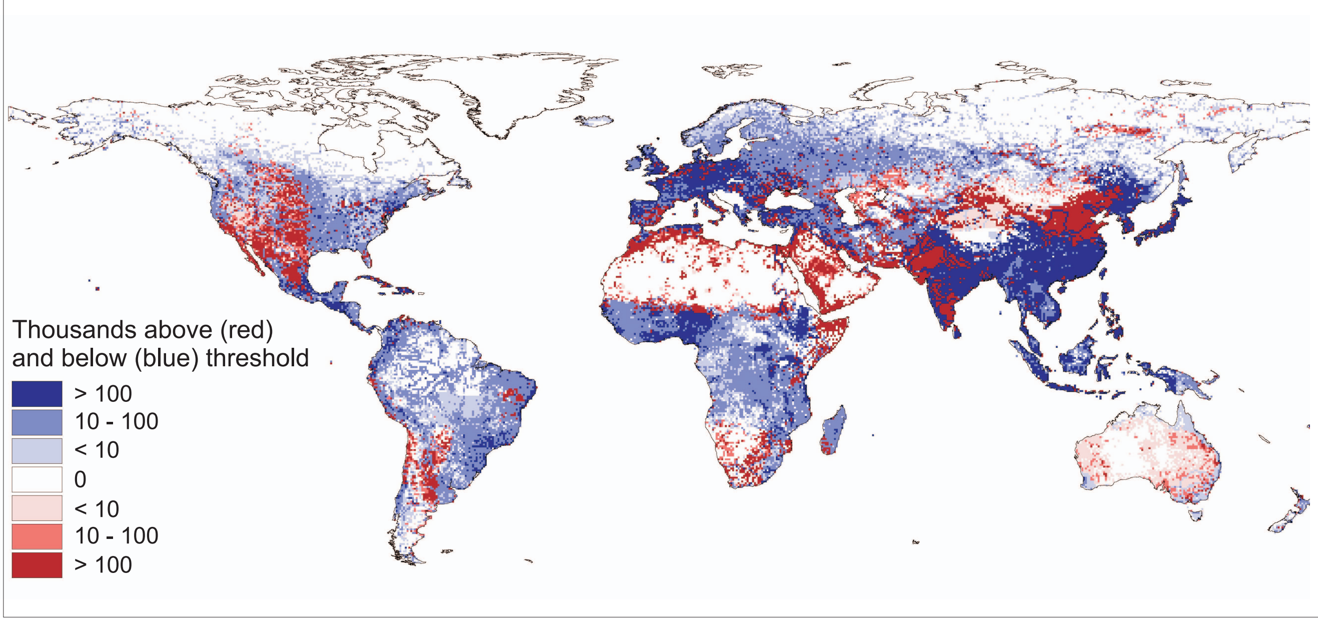
Components of a Soil Vegetation Atmosphere Transfer (SVAT) Model



Reprinted from Bolle (1993, IAHS Publ. no. 212), based upon sketches by Dickinson & Henderson Sellers

to this ...

Contemporary Population Relative to Water Stress Threshold



High resolution mapping of global water availability and use. Reprinted with permission from Vörösmarty et al. (2000), Science 289, 284–288. © 2000 American Association for the Advancement of Science

It specifically explores the application of the land–atmosphere schemes in a much broader setting, including their use in rainfall–runoff modelling, data assimilation, applications of remote sensing, links to runoff routing schemes, and parameter estimation of large-scale hydrological simulations.

Work remains to be done to link water and energy to the constituent cycles, as for sediment, carbon and biogeochemistry. These issues are increasingly integrative in their perspective, and it is worthwhile to postulate that the effort will expand further into integrated river basin management, water resource assessments, and other applications more directly relevant to society. In particular, it is not hard to imagine the conjunctive use of state-of-the-art SVATs in improved weather prediction, impact studies associated with extreme rainfall (flooding and drought), and high resolution mapping of sustained and episodic water stress.

These are the challenges ahead.

Tracers

ICT, International Commission on Tracers

The International Commission on Tracers (ICT) is one of the youngest commissions within IAHS. It was established at the IUGG Assembly in Vienna 1991. Unlike commissions established earlier, ICT is a methodologically based commission that cuts across all other commissions.

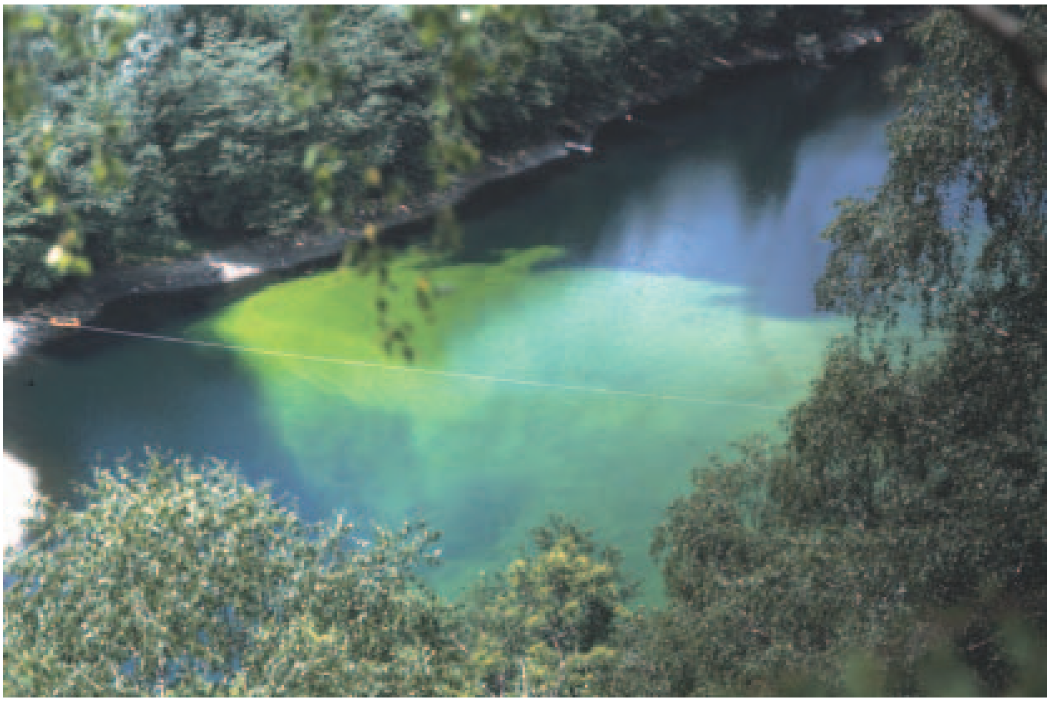
Before the 1950s, applications of tracers were rare in all disciplines of science. Then, step by step, researchers discovered the potential of this method, which nature had found long before: e.g. dogs use their own tracers to mark their territory and insects use pheromones with great success. By the end of the 1980s hydrologists had found various tracer substances and tools for analysis and interpretation, but still the number of researchers dealing seriously with tracers was rather limited. Hence there was a need to promote the dissemination of tracer methods amongst the entire hydrological community, which led to the foundation of ICT.

Since then the use of environmental (naturally occurring) and artificial (intentionally injected) tracers has permeated the various sub-fields of hydrological sciences. The number and quality of publications has increased remarkably, and so has the use of tracers as tools for water resources assessment. ICT seeks to promote tracers further for basic and applied research.

ICT is responsible for the advancement and application of artificial and natural tracers in hydrology, for developing and improving the methodological framework of tracer techniques and for extending these methods within the hydrological sciences. ICT supports the integration of tracer approaches throughout hydrology by technology transfer from research to operational use.

The particular usefulness of water tracing techniques is due to the fact that the tracing of water allows a direct insight into the dynamics of surface and subsurface water flux. Tracer techniques are a useful tool in understanding the transport processes, phase changes (evaporation, condensation, sublimation) and the genesis of water quality. Tracer techniques are particularly useful in arid and semiarid regions for quantifying groundwater and vadose zone water movement. Tracer methods have become a major calibration and validation tool in catchment

Injection of an artificial tracer into a river to study the dispersion processes during inflow to a lake



Use of a fluorescent tracer to study dispersion processes in a mountain lake

modelling and in the definition of runoff generation processes. Tracer approaches can be extremely useful in assessment of groundwater–surface water interactions, dating of waters, quantifying water–rock interactions and evaluating water resource vulnerability.

The use of tracers has considerably changed the identification of the different runoff components. Runoff generation processes are among the most important processes in catchment hydrology, and modelling them is improving considerably thanks to tracer methods. Understanding where water goes when it rains, water and chemical species residence times and subsurface flow paths is crucial for catchment modelling and the quantification of solute and contaminant transport. In recent years, tracer methods, combined with hydrometric measurements, have proved to be effective for identifying runoff generation mechanisms in headwater catchments.

ICT also discharges its responsibilities through extensive cooperation with the other IAHS Commissions, and with other organisations, such as the International Atomic Energy Association (IAEA), UNESCO/IHP, the International Association of Tracer Hydrology, the International Association of Hydro-geologists (IAH), and other groups within the hydrological community. In the relatively short time since it began in 1991, ICT has organised or co-sponsored more than 15 international and regional symposia and workshops that have disseminated results and the state-of-the-art of research findings to the hydrological science community. ICT participated in the development of the IAEA/UNESCO long-term inter-agency Joint International Isotopes in Hydrology Programme (JIIHP). It has also been a leading IAHS Commission in the development of the IAHS initiative Prediction in Ungauged Basins (PUB).

These related programmes and the ICT philosophy instilled into each of them are considered to be among the chief successes of the Commission over the past decade.

Recent publications from symposia organised by ICT include:

Tracer Technologies for Hydrological Systems (IAHS Publ. no. 229, 1995).

Application of Tracers in Arid Zone Hydrology (IAHS Publ. no. 232, 1995).

Integrated Methods in Catchment Hydrology—Tracer, Remote Sensing and New Hydrometric Techniques (IAHS Publ. no. 258, 1999).

Tracers and Modelling in Hydrogeology (IAHS Publ. no. 262, 2000).

The new IAHS initiative — PUB

Prediction in Ungauged Basins

Welcome to PUB!

PUB (Prediction in Ungauged Basins) is a unique scientific endeavour that IAHS has conceived, initiated and is implementing as its focus for the present decade. PUB invites participation by everyone interested in and/or in need of PUB sciences and products. The overall aim of PUB is to develop the hydrological sciences so that basin hydrology can be predicted using the limited information available for any basin, and to reduce the uncertainty associated with such prediction. At the same time PUB has a societal mission to provide the necessary hydrological information, especially discharge data, for ungauged or poorly gauged basins where those data are urgently needed.

The first aim will be addressed in a long-term perspective by accumulating the necessary science through observational experiments, theoretical analyses and syntheses, and model developments. The second aim will be approached in a short-term framework by assembling all the available knowledge and technology to meet the urgent needs.

How did it start?

The idea of PUB emerged from an IAHS Strategic Science Discussion conducted over the Internet during September–November 2000 and May–June 2001, which involved many hydrologists with no previous association with IAHS. PUB was one of many topics proposed during the discussion. However, as soon as the idea of focusing on ungauged basins emerged, many people supported it enthusiastically: there was a remarkable convergence in opinions. PUB was then formally proposed as an IAHS initiative at the IAHS Bureau meeting in July 2001 and was accepted unanimously. In March 2002, a preparatory PUB Workshop was held in Kofu, Japan. The draft science plan of PUB was compiled and endorsed by the IAHS Bureau in June 2002, leading to the PUB Kick-off Workshop held in Brasilia in November 2002.

Organisation of PUB

At the Brasilia kick-off meeting, the PUB Scientific Steering Group (SSG) was formed and it was agreed to set up a PUB Strategic Advisory Group (SAG). The SSG is now developing the complete PUB science plan around the themes listed below. The SAG is currently being formed. Its responsibility is to review and advise the activities of the SSG and to develop the overall PUB strategy, especially links with related programmes. The societal mission, including capacity building, is also a SAG responsibility.

Links with related programmes

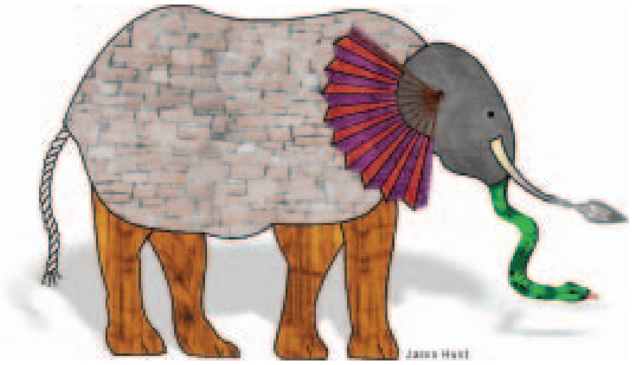
Some encouraging links are developing with the leading hydrological programmes. The 15th Inter-Governmental Council of the UNESCO International Hydrological Programme (IHP) passed a resolution in June 2002 welcoming the PUB initiative. The Council agreed to invite the national IHP committees to take part in PUB activities and to "recommend the IHP-VI, FRIEND, JIIHP, HELP (Hydrology, Environment, Life and Policy Programme), WWAP and other IHP-related programmes to cooperate closely with the IAHS PUB initiative in jointly organising scientific meetings, executing capacity building programmes and utilising the developed technology in the implementation of the respective programmes". PUB is going to establish PUB-HELP basins as part of the collaboration between these two programmes.

At the 26th GEWEX (Global Energy and Water Cycle Experiments Program) SSG held in Bangkok, Thailand in January 2003, IAHS PUB was invited to take part in GEWEX WRAP (Water Resources Application Programme) tasks to transform the GEWEX research products into water resources management information.

PUB will also collaborate with, and contribute to, the Coordinated Enhanced Observing Period (CEOP), the Model Parameter Estimation Experiment (MOPEX) and the Hydrology and Water Resources Programme (HWRP) of WMO, among others.

Why is PUB happening now?

The hydrological prediction of ungauged basins has been an ultimate goal of hydrology since it began. If satisfactory hydrological prediction in ungauged basins became possible, it would mean that hydrology was complete in that area of the science and that no further research would be necessary. Why then are we addressing the challenge of PUB now?

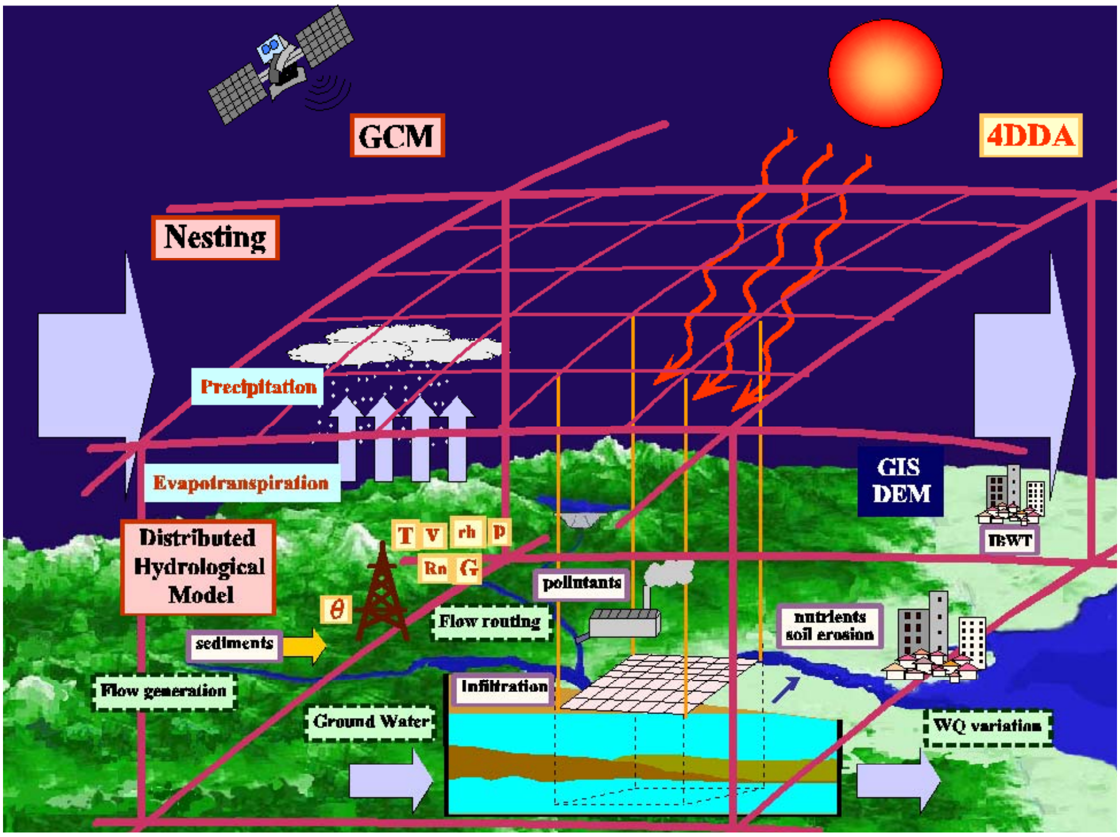


The Elephant, as described by blind men in the well-known Indian legend, has been adopted as the PUB symbol because PUB means different things to different people. However, only the integration of all aspects of hydrological science will provide a solution to PUB. Illustration reproduced by permission of Jason Hunt ©1999

There are two good reasons: needs and readiness. We are faced with a major water crisis that has emerged as a result of population growth, increase in water demand, environmental degradation and climate change. Increasing water shortages, intensifying flood hazards, and unseen but progressive groundwater contamination, are examples of the problems. Developmental and efficient water management needs are pressing all over the world. However, there are many basins worldwide where hydrological data (the basis of any water management) is lacking. There are numerous ungauged or poorly gauged basins. This is especially true in developing countries where data are urgently needed to enable water resources to be developed and managed. It is the societal mission of hydrologists to provide them with the data: we have to demonstrate what hydrological sciences can do for society.

At the same time, we are now equipped with wide-ranging knowledge and a suite of technologies to provide the data. We have advanced understanding of the various components of hydrological processes, modelling techniques and advanced observing technologies, including various remote sensing devices. It is time to integrate them to provide the data required and to address the challenge of further development of hydrological understanding.

It is not an objective of PUB to replace ground observations. PUB is a scientific project aiming to reduce the uncertainty in the estimates based on the available information. It is regrettable that hydrological networks are declining all over the world, as summarised in the often-repeated remark that "hydrological data are a newly endangered



The seamless merger of hydrology with meteorology and water resources. Reprinted from Takeuchi (2000), Hydrol. Sci. J. 46(6), p. 880.

species”. PUB emphasises just how valuable ground observation is for the purpose of reducing prediction uncertainty.

Objectives

PUB is a policy-relevant hydrological science activity with the following broad community objectives:

– To advance our ability to predict with confidence the fluxes of water out of drainage basins worldwide in areas of societal and ecological relevance, in different biomes and hydro-climatic regions, and to verify predictions with data from selected basins;
– To advance the scientific foundations of hydrology, including understanding the climatic and landscape controls on the natural variability of hydrological processes, and the impacts of human-induced alterations to climate and landscape;
– To increase the awareness of the value of data, especially of the measurement of hydrological variables, for the management of water resources around the world, and to demonstrate the importance of existing gauging systems and the need for targeted gauging to enhance currently inadequate, or nonexistent, data sources;
– To advance technological capability around the world, so that predictions in ungauged basins are firmly based on local knowledge of the climatic and landscape controls on hydrological processes, along with access to the latest data sources;
– Actively to promote capacity building activities in the development of appropriate scientific knowledge and technology for areas and communities where they are needed.

The central themes of the PUB initiative are heterogeneity and predictive uncertainty. PUB is geared towards developing methodologies and systems for assessing the uncertainty in predictions of hydrological variables at ungauged river sites, which arise from uncertainties in model parameters and data (climatic, physiographic, land-use, etc.), choice of model structure, information transfer (from gauged to ungauged catchments) mechanisms, and targeted methods to constrain and reduce the uncertainties.

PUB science agenda

The science agenda of PUB is currently under discussion but it is very likely that it will be organised around the following scientific activities:

1. Exploration of ways to characterise the heterogeneity of landscape properties and climatic inputs;
2. Development of a general model framework for heterogeneity and predictive uncertainty;
3. Conducting model inter-comparisons in selected gauged basins (PUB-HELP basins) to investigate uncertainty resulting from the choice of model structure;
4. Investigation of methods for efficient assimilation of gauged and/or remotely sensed data in order to constrain predictive uncertainty;
5. Promotion of process studies and field experiments to advance process understanding and conceptualisations with the aim of reducing predictive uncertainty;
6. Advancing our understanding and predictions of the effects of hydroclimatological variability and change;
7. Transforming the available global research products into hydrological information useful for local and regional water resources management.

The PUB Scientific Steering Group comprises 12 young hydrologists: Stewart Franks, Harouna Karambiri, Venkat Lakshmi, Xu Liang, Jeff McDonnell, Mario Mendiondo, Taikan Oki, John Pomeroy, Daniel Schertzer, Stefan Uhlenbrook and Murugesu Sivapalan (chair).

The Strategic Advisory Group’s initial membership is Pierre Hubert, Jim Wallace, Lars Gottschalk, Jim Shuttleworth and Kuniyoshi Takeuchi (chair).

Visit **http://www.cig.ensmp.fr/~iahs** for more information about PUB.

IAHS Publications

Part of the IAHS mission is to disseminate the results of hydrological research and practice worldwide. IAHS Press, the publishing arm of the Association, facilitates this by producing and distributing publications including *Hydrological Sciences Journal* (*HSJ*), the series of Proceedings and Reports (Red Books) and the Special Publications series. Brief descriptions of several of these are provided here. Details of all IAHS publications are provided in the 2003 Catalogue of Publications, available from IAHS Press and at the web site **http://www.cig.ensmp.fr/~iahs**. Abstracts of papers in all volumes (*HSJ* and books) published since 1999 are available on the web site.

IAHS members in financially disadvantaged countries receive 80% discount on books and *HSJ* subscriptions. All other members receive 25% discount on purchases. Discounts are subject to the minimum order charge of £10.00.

After covering production costs, revenues raised by IAHS Press are used to support IAHS activities, including distribution of IAHS publications on behalf of the Task Force for Developing Countries.

Books and subscriptions to *HSJ* are available for purchase only from IAHS Press. Please contact Frances Watkins *(frances@iahs.demon.co.uk)* about *HSJ* and Jill Gash *(jilly@iahs.demon.co.uk)* for books, at IAHS Press, Centre for Ecology and Hydrology, Wallingford, Oxfordshire, OX10 8BB, UK.

Hydrological Sciences Journal (*HSJ*)

***Editor**: Zbigniew W. Kundzewicz*

HSJ is the official journal of the Association and is one of the oldest and the most international of all the water-related journals. It currently ranks fifth in the Water Resources section (50 journals) of the ISI Journals Citation Index, with an impact factor of 1.22 (ISI Citations Index, 2001). Examples of recent papers published in *HSJ* are:

Global ENSO–streamflow teleconnection, streamflow forecasting and interannual variability. *F. H. S. Chiew & T. A. McMahon* **47**(3), 505–522 (2002).

The Hurst phenomenon and fractional Gaussian noise made easy. *D. Koutsoyiannis* **47**(4), 573–595 (2002).

Ecohydrology—a challenging multidisciplinary research perspective. *A. Porporato & I. Rodriguez-Iturbe* **47**(5), 811–822 (2002).

Canadian streamflow trend detection: impacts of serial and cross-correlation. *Sheng Yue, P. Pilon & R. Phinney* **48**(1), 51–64 (2003).

Ancient dams, settlement archaeology and Buddhist propagation in central India: the hydrological background. *J. Shaw & J. V. Sutcliffe* **48**(2), (2003).

The most recent special issue of *HSJ* is:

Towards Integrated Water Resources Management for Sustainable Development

Guest Editor: Bhupendra Soni

The eight papers assembled in this Special Issue of *HSJ* illustrate a multitude of water-related problems that are representative of those in developing countries. The papers were selected from presentations at the International Conference on Integrated Water Resources Management for Sustainable Development (New Delhi, 2000).

***HSJ* 47 Special Issue** (*2002*) ISBN 1-901502-91-0; 108+iv pp; £28.00

IAHS Books

Hydro-ecology: Linking Hydrology and Aquatic Ecology

edited by M. C. Acreman

Hydro-ecology brings together hydrological, hydraulic, geomorphic and biological/ecological knowledge to understand and predict the response of freshwater biota and ecosystems to variation of abiotic factors such as flows and water quality. IAHS held its first hydro-ecology workshop—*Riverine Ecological Response to Changes in Hydrological Regime, Sediment Transport and Nutrient Loading*—in Birmingham, UK, and this volume contains a selection of the work presented there.

Publ. no. 266 (*2001*) ISBN 1-901502-41-4; 162+xiv pp; £33.00

The Extremes of the Extremes: Extraordinary Floods

edited by Á. Snorrason, H. P. Finnsdóttir & M. E. Moss

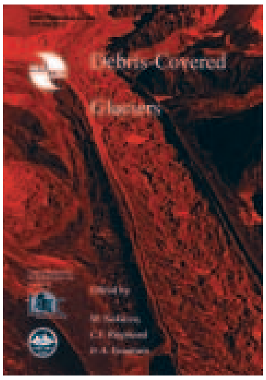
Extreme floods are among the most destructive forces of nature, and there is a perception that they are occurring with higher frequency now than in the past which is cause for international concern and calls for an understanding of the circumstances that might generate such disastrous events, and was the motive for the Reykjavík symposium on extraordinary floods, *The Extremes of the Extremes*. This publication is an outcome of that meeting.

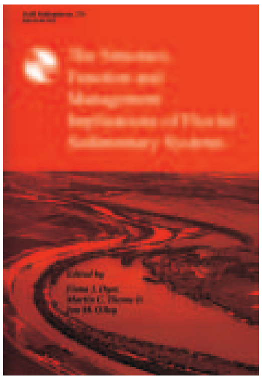
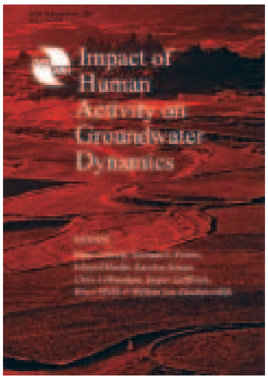
Publ. no. 271 (*2002*) ISBN 1-901502-66-X; 394+xiv pp; £60.00

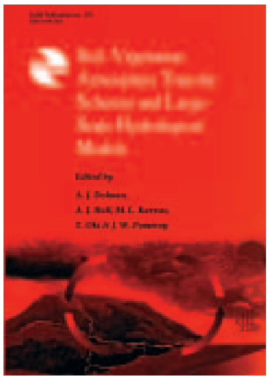
Impact of Human Activity on Groundwater Dynamics

edited by H. Gehrels, N. E. Peters, E. Hoehn, K. Jensen, C. Leibundgut, J. Griffioen, B. Webb & W. J. Zaadnoordijk

Human activities are intricately linked to the evolution and dynamics of groundwater quantity and quality. Given the alarming rate of land-use change globally, it is important to



understand the linkages between land-use change and groundwater dynamics. The impact on groundwater dynamics and resources of human activities (including urbanisation, land-use change and groundwater contamination) is evaluated. Techniques of adequate impact assessment are investigated, such as methods for quantifying recharge, for geochemical characterisation of aquifers, and for modelling contamination transport.

Publ. no. 269 (*2001*) ISBN 1-901502-56-2; 369+x pp; £59.50

Groundwater Quality: Natural and Enhanced Restoration of Groundwater Pollution

edited by S. F. Thornton & S. E. Oswald

The international GQ2001 conference (Sheffield, UK), provided a forum for discussion of the newest advances in research on natural and enhanced restoration of pollutants in soils and groundwater. Particular themes covered in this volume are site characterisation and remediation strategies using state-of-the-art techniques, field-scale demonstration of treatment technologies, fundamental understanding of natural attenuation processes in the subsurface and their application in remediation design, reactive barrier design and performance, and reactive transport modelling of natural attenuation processes.

Publ. no. 275 (*2002*) ISBN 1-901502-86-4; 604+xii pp; £82.50

Agricultural Effects on Ground and Surface Waters: Research at the Edge of Science and Society

edited by J. Steenvoorden, F. Claessen & J. Willems

This volume includes the Wageningen Statement, agreed by the participants at the international conference of the same name in The Netherlands, which contains recommendations to governments and international organisations. The themes – risk assessment by monitoring, model development, and decision support studies – are considered at levels where policy development and water management take place: the agricultural production unit, the regional and the national level. Attention is given to alternative approaches to policy making and communication between the parties: farmers, policy makers, interest groups in society, and scientists.

Publ. no. 273 (*2002*) ISBN 1-901502-76-7; 414+x pp; £63.50

Integrated Water Resources Management

edited by M. A. Mariño & S. P. Simonovic

As this volume shows, a new framework is emerging for water resources management based on the principle of integrated watershed management, described as “a form of coordinated management of land and water resources within a region, with the objectives of preventing land degradation, protecting the quality of the freshwater resource, protecting biodiversity, and continuing sustainable use, within a context which includes genuine community/government partnerships and recognition of socio-economic objectives”.

Publ. no. 272 *(2001)* ISBN 1-901502-71-6; 442+xiv pp; £65.00

The Structure, Function and Management Implications of Fluvial Sedimentary Systems

edited by F. J. Dyer, M. C. Thoms & J. M. Olley

This volume contains the proceedings of a symposium at Alice Springs, Australia, as a contribution to the UNESCO IHP-V Project 2.1: Vegetation, Land Use and Erosion. The papers cover a wide range of topics pertaining to fluvial sedimentary systems, recognising their role and how they are managed for the health of riverine systems. Balancing the needs of humans with those of riverine ecosystems requires information about how fluvial sedimentary systems impact on riverine ecology. Floodplains have a crucial role as temporary storages of water, sediment and nutrients, and any ecological management must address this.

Publ. no. 276 (*2002*) ISBN 1-901502-96-1; 484+xii pp; £72.00

Debris-Covered Glaciers

edited by M. Nakawo, C. F. Raymond & A. Fountain

The *Workshop on Debris-Covered Glaciers* (Seattle), aimed at synthesising current understanding about debris-covered glaciers and rock glaciers. Despite being relatively common, debris-covered glaciers have not been well studied, yet the melt rate of the ice under the debris is a fundamental variable that is crucial for mass balance calculations, response to climatic variations and for water runoff. Current debate on the origin of rock glaciers and their possible genetic connection to debris-covered glaciers highlights fundamental issues concerning debris transport and energy balances.

Publ. no. 264 *(2000)* ISBN 1-901502-31-7; 288+viii pp; £44.00

Interactions between the Cryosphere, Climate and Greenhouse Gases

edited by M. Tranter, R. Armstrong, E. Brun, G. Jones, M. Sharp & M. Williams

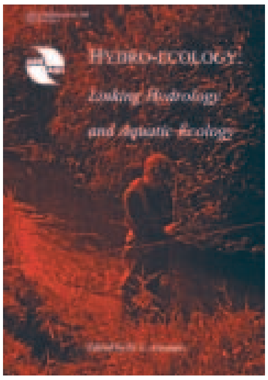
Snow cover distribution on both continental and hemispheric scales, and the feedback mechanisms between snow distribution, recent trends in climatic variation and major climatic events such as El Niño are considered. Advances in the modelling of snow-cover evolution and snowmelt, based on knowledge of processes for snow redistribution, energy exchange and snow metamorphism, are presented. How changes in snow- and ice-cover distribution may impact on chemical weathering reactions and perturb atmospheric CO_2 concentrations, and the isotope chemistry ($\delta^{18}O$) of present and past precipitation and the role of snow cover in the emissions of N_2O from soil are also discussed.

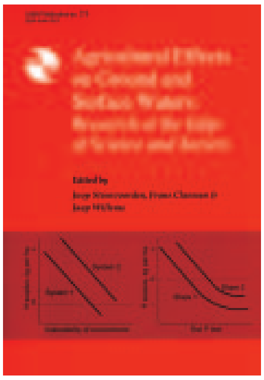
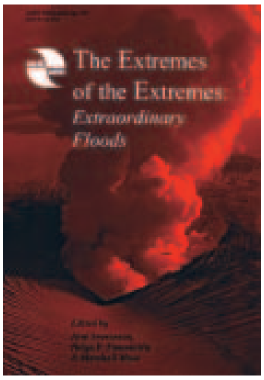
Publ. no. 256 *(1999)* ISBN 1-901502-90-2; 282+x pp; £42.50

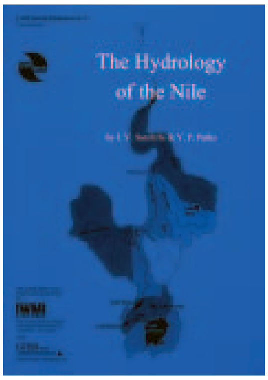
Soil–Vegetation–Atmosphere Transfer Schemes and Large-Scale Hydrological Models

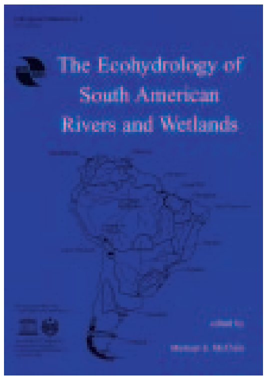
edited by A. J. Dolman, A. J. Hall, M. L. Kavvas, T. Oki & J. W. Pomeroy

Several key issues in soil–vegetation–atmosphere transfer (SVAT) models are poorly parameterised or not well enough







understood. Current SVAT schemes include complex descriptions of the physical mechanisms governing land surface processes requiring large numbers of parameters controlling the vertical fluxes. The rationale is that improved process representation will result in parameters which are easier to measure or estimate, and in improved model performance and robustness, but this is not necessarily so. The papers in this volume address these issues.

Publ. no. 270 *(2001)* ISBN 1-901502-61-9; 372+x pp; £59.50

Remote Sensing and Hydrology 2000

edited by M. Owe, K. Brubaker, J. Ritchie & A. Rango

The proceedings of this international symposium in Santa Fe, USA, represent the state of the science at the beginning of the 21st century: 125 papers detail many operational applications as well as attempts to exploit more varied parts of the electro-magnetic spectrum. They cover remote sensing aspects of: precipitation, snow and ice, large area experiments, evapo-transpiration, radar applications, microwave soil moisture, GIS, general hydrology, wetlands and hydrological modelling.

Publ. no. 267 (*2001*) ISBN 1-901502-46-5; 610+xiv pp; £80.00

Integrated Methods in Catchment Hydrology—Tracer, Remote Sensing and New Hydrometric Techniques

edited by C. Leibundgut, J. McDonnell & G. Schultz

Tracer techniques and remote sensing are important tools in catchment hydrology: while remote sensing is mainly used to address surface parameters, tracers are useful for quantifying sources of streamflow, groundwater residence times and surface and subsurface flow paths. However, little integration of tracer techniques with remote sensing and advanced hydrometric techniques has been attempted. This volume is the edited proceedings of a symposium (at IUGG 99, Birmingham, UK) which tackled this theme.

Publ. no. 258 *(1999)* ISBN 1-901502-01-5; 284+xii pp; £43.00

Tracers and Modelling in Hydrogeology

edited by A. Dassargues

This overview shows how tracer techniques contribute to the understanding, quantification and modelling of flow and transport processes in complex hydrogeological systems, and how they are used practically to assess groundwater quality, protection methods, solutions to contamination problems, and waste disposal impact studies, at different temporal and spatial scales. The papers arise from *TraM'2000*, in Liège, at which specialists from different branches of hydrology met together with numerical and geostatistical specialists.

Publ. no. 262 *(2000)* **ISBN** 1-901502-21-X; 572+xii pp; £74.00

The Hydrology of the Nile

by J. V. Sutcliffe & Y. P. Parks

The Nile is a set of very different tributaries, which came together by geological accident. Nevertheless, evidence from one part of the basin often throws light on a different area. Recent changes are discussed, in particular the dramatic change of regime of Lake Victoria and other lakes which occurred after 1961. The important wetlands of the White Nile basin are considered, including the effect of increased lake outflows. The authors draw on the extensive records collected throughout the basin to provide a detailed account of the hydrology of the whole Nile basin.

Sponsored by the International Water Management Institute (IWMI), Colombo, Sri Lanka, and Gibb Water, Reading, UK.

Special Publ. no. 5 *(1999)* ISBN 1-901502-75-9; 180+xii pp; £34.00

The Ecohydrology of South American Rivers and Wetlands

edited by M. E. McClain

An overview of ecohydrological processes operating in South America's most important aquatic systems. River reaches ranging from pristine to heavily impacted, and processes operating in channels, wetlands, and riparian environments are considered. The Amazon, Orinoco and Paraná receive the greatest attention, but the condition of the Piracicaba (São Paulo) and the Paraíba do Sul (Rio de Janeiro) are also evaluated. The natural attenuation processes in these ecosystems stand to aid South America in achieving its goal of sustainable use of its resources.

Sponsored financially by the UNESCO Regional Bureau for Science in Europe (ROSTE).

Special Publ. no. 6 (*2002*) ISBN 1-901502-02-3; 210+xiv pp; £39.50

Forthcoming IAHS Publications

Calibration and Reliability in Groundwater Modelling: A Few Steps Closer to Reality

edited by K. Kovar & Z. Hrkal

Proceedings of ModelCARE 2002, a conference held at Prague, Czech Republic, in June 2002

Publ. no. 277 *(in press)* ISBN 1-901502-07-4

Hydrology in the Mediterranean and Semiarid Regions

edited by E. Servat, W. Najem, C. Leduc & A. Shakeel

Proceedings of a symposium held at Montpellier in April 2003

Publ. no. 278 *(in press)* ISBN 1-901502-12-0

IAHS Press

disseminating the results of hydrological research and practice

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http://www.cig.ensmp.fr/~iahs

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For information about IAHS International Commissions contact their Secretaries:

ICSW, Surface Water

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ICGW, Groundwater

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ICCE, Continental Erosion

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ICSI, Snow and Ice

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ICWQ, Water Quality

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ICWRS, Water Resources Systems

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ICRS, Remote Sensing

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ICASVR, Atmosphere–Soil–Vegetation Relations

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ICT, Tracers

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Using a fluorescent tracer to study dispersion processes in a mountain glacier

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