IAHS AISH

International Association of Hydrological Sciences

Association Internationale des Sciences Hydrologiques

Celebrating 90 years of international scientific cooperation and activity

Delft, October 2012

Index

www.iahs.info

Information about all aspects of IAHS is available from the IAHS web site or:

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Cover photo: *Reflections, Delft*. 13 February 2009
By sublime_79 on Flickr (flickr-3280112104),

Metaphor of IAHS Activities

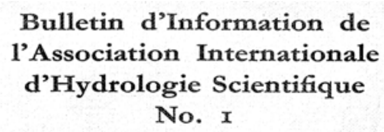
90 years of catalysing and structuring the development and flow of hydrological sciences, with IAHS assemblies as milestones, based on a worldwide scope and community, and leading to the consolidation of knowledge through time.

Graphical display (Tagxedo©) of occurrences of geographic and thematic references in the corpus of all IAHS Publications' titles, available at www.iahs.info

Hydrolandscape: Hraunfossar, Iceland (waterfalls from the lava) and symbolizing hydrology as an Earth science: a glacial river emerges from a groundwater path under a lava field.
Christophe Cudennec

Hydrology is the science which deals with the waters of the Earth, their occurrence, circulation and distribution on the planet, their physical and chemical properties and their interactions with the physical and biological environment, including their responses to human activity.

(UNESCO, 1964)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No. 1

1922–1952


INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES
ASSOCIATION INTERNATIONALE DES SCIENCES HYDROLOGIQUES
PRESIDENT: MARK F. MEIER
SECRETARY GENERAL: JOHN C RODDA
NEWSLETTER
No 1
March 1980

1952-1982

1982–2012

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www.iahs.info

Gothenburg 2013
Initiative 2013–2022
Prague 2015

IAHS celebrates 90 years

Landmarks in the world of water — memorable attributes and events that are noted and quoted — often tend to focus on large physical features like the River Amazon and Niagara Falls. Alternatively they feature extremes such as the Pakistan floods of 2010 and the successive droughts in the Horn of Africa. But there are others that are less immediately recognizable, which do not often hit the headlines, e.g. the start of international initiatives, like the International Hydrological Programme (IHP) in 1975 and the Millennium Development Goals in 2000. Pre-dating these happenings was the launch of the International Branch (or Section) of Scientific Hydrology at the Rome General Assembly of the *International Union of Geodesy and Geophysics* (IUGG) in 1922, later to become the *International Association of Scientific Hydrology* (IASH). This brochure commemorates the 90 years since that event. It highlights some of the main achievements of what is now the *International Association of Hydrological Sciences* (IAHS) — the foremost international learned society dealing with the pressing problems of water resources, floods, droughts, water pollution, erosion, etc., together with the science and technology to address them.

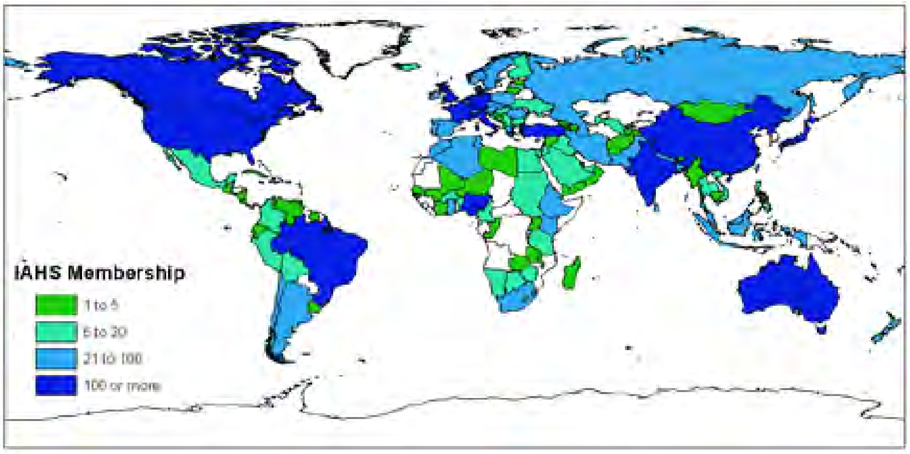
Today, the Association is a lively non-profit making international non-governmental scientific organization. It started from small beginnings in 1922 as a gathering of a few scientists and engineers from about half a dozen European countries — probably none of those present would have called themselves a hydrologist — and now has 5400 individual members, 10 commissions and two working groups. What was in the minds of these delegates when they established the Hydrology Branch of IUGG and in the thoughts of those who made it into the Association in 1930 is not recorded in the proceedings. However, there is little doubt that they would be amazed at the extent and depth of the Association's activities as the 21st century unfolds. Then the Association's assemblies attracted fewer than 100 participants, with little happening in the years intervening. Now, IAHS is a vibrant international community of hydrologists. Furthermore the Association shares activities in a number of fields: with several IUGG Commissions, with some of the other seven Associations in the IUGG family, and also with a number of associations outside the IUGG, including the International Association of Hydrogeologists (IAH) and the International Association of Hydro-Environment Engineering and Research (IAHR). These linkages demonstrate that IAHS has a broad base for its science activities. In addition, there is the intergovernmental world where IAHS has interests in common with several UN bodies, particularly with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Meteorological Organization (WMO) and the International Atomic Energy Agency (IAEA), and also with UN Water. Indeed IAHS, through the efforts of Professor L. J. Tison (Secretary General 1948–1971), helped launch the UNESCO and WMO programmes in hydrology. Professor Tison is recognized as one of the three "fathers" of the International Hydrological Decade (IHD) which preceded the International Hydrological Programme (IHP), and he was very influential in establishing the WMO Commission on Hydrological Meteorology, the forerunner of today's Commission on Hydrology. These and other facts and figures are captured on the Association's website www.iahs.info, together with a wealth of information about its current activities.

started in 1922 as a gathering of a few scientists and engineers — now has 5400 members

There have been so many changes over the 90 years of the Association's existence to facilitate its business, we tend to forget them. The ease of travel nowadays allows meetings to take place virtually anywhere on the planet, whereas they were all in Europe during the early years. Over the last decade, IAHS and its Commissions have convened 6–8 conferences a year on specific topics, in addition to the Scientific Assemblies and General Assemblies within IUGG Assemblies. The tradition of publishing Proceedings and Reports of IAHS (Red Books), which commenced in 1924 at the Madrid General Assembly, has continued to the present, with IAHS Publication 356 being the most recent. Sediment dynamics, land subsidence, forest hydrology, isotopes and groundwater management are amongst the themes of recent proceedings. In addition there are the Special Publications Series (Blue Books), Benchmark Series and the *Hydrological Sciences Journal* (*HSJ*). *HSJ* was originally published three times a year from 1953 as the *Bulletin of IASH*; it became *HSJ* in 1982 and now has eight issues a year, with more than 1000 pages per volume. These publications can be ordered at the Association's online bookshop, while members in poorer countries have free online access to *HSJ*. The IAHS Press was established at Wallingford, UK, in 1972 and its four staff probably produce more scientific publications dealing with hydrology and water resources than any other publisher. None of the other IUGG associations have such an extensive publications programme.

The different forums offer the means for discussion, review, publication and dissemination of the results of research and they help to direct efforts to areas where problems are proving more intractable. They stimulate educational outreach and the transfer of knowledge which can be applied in

The worldwide distribution of IAHS members.



planning, development and management of water resources, particularly through the IAHS Task Force for Developing Countries (TFDC). TFDC manages the programme for the free distribution of *HSJ*, Red Books and other publications to more than 50 libraries in developing countries, and has been underway since 1991. IAHS has also been very successful in obtaining funds from a considerable number of donors to support the attendance of members from these countries at IAHS gatherings.

To recognize outstanding contributions to the science and to international hydrology, along with UNESCO and WMO, IAHS awards the *International Hydrology Prize* annually, and also the *Tison Award* to young scientists for recording their innovative research in one of the Association's publications.

Peering into the past through the prism of the science to predict and forecast future events has a well established methodology in hydrology, whereas the means for predicting the path of the science itself remain rudimentary. Nevertheless the Association has, on several occasions, taken a glimpse at what the coming years may hold. For example, at Rome in 1987 the *Water for the Future* symposium looked at the *Thrust of Thought in Contemporary Hydrology and New Techniques in Data Capture*. Twice since 1982 the minds of a selection of the younger members of IAHS have been exercised to consider the future of hydrology. Most recently, the *Hydrology 2020 Working Group* reported its findings in 2006 (*Hydrology 2020: An Integrating Science to Meet World Water Challenges*, ed. by T. Oki, C. Valeo & K. Heal, IAHS Publ. 300). In a similar way, the 10-year *Predictions in Ungauged Basins* (PUB) initiative, which kicked off in 2002, was aimed at a future where the *ultimate goal* in hydrology would be achieved — the hydrological prediction of ungauged basins and reduction of the associated uncertainty. Now the results of the PUB Decade are being examined and evaluated, and a new call announced searching for an innovative science initiative that will take the Association forward. Discussions are taking place on possible themes at the Delft Symposium and some of these are being presented in the: *Visionary session on the next hydrological decade.* This initiative will lead the Association to its centenary in 2022.

John C. Rodda

IAHS outreach

Task Force for Developing Countries

IAHS has always recognized the need to encourage participation in the activities of the Association by educational and research institutions in developing countries that frequently do not have sufficient financial resources to maintain comprehensive libraries of hydrological publications. To increase the dissemination of hydrological research publications, IAHS offers members from financially-disadvantaged countries* 80% discount on all IAHS books produced before the current year. In addition, the IAHS Task Force for Developing Countries (TFDC), established in 1991, distributes all IAHS publications free of charge to a number of key institutions. The objective is to disseminate IAHS literature to scientists in countries in need and includes the *Hydrological Sciences Journal* (*HSJ*), conference proceedings (Red Books) and the *Benchmark Papers in Hydrology* series. The TFDC has also been instrumental in obtaining funding for scientists from developing countries to attend some of the Association's scientific meetings.

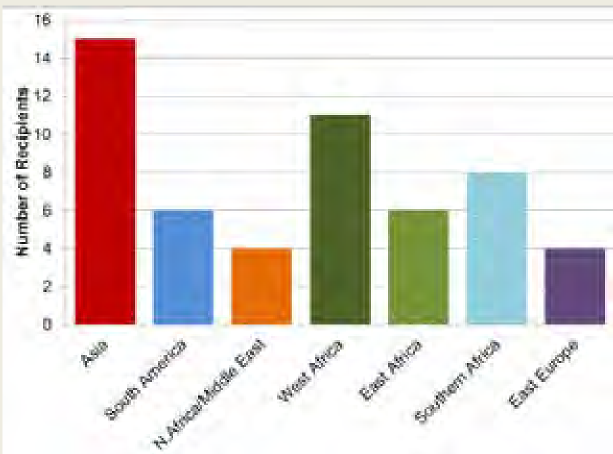
During 2009 the list of countries and institutions was revised based on a survey to determine where the dissemination process would achieve the most effective results. There are currently 55 recipients and their geographic distribution is illustrated in the graph below. Africa has the largest number of recipients (a total of 25) spread across the sub-regions of the continent. Asia has the second largest number and of these, India has the most (5). The institutions receiving the publications include University libraries, academic and research departments, national research laboratories and state hydrological agencies.

The objective of the TFDC programme is to ensure that the IAHS publications are accessible to as wide a group of research scientists and post-graduate students as possible. The recipient institutions are therefore obligated to make the publications available to as many other individuals and groups within their geographic area.

During the 2009 survey the TFDC also ensured that the recipient institutions were aware of the *United Nations Development Programme's Open Access to Research in the Environment* (OARE www.oaresciences.org) initiative, which provides eligible institutions with online access to more than 2990 scientific journals covering an enormous range of environmental and related topics, including hydrology, oceanography, environmental pollution and conservation policy. Organizations in the poorest countries get free access, while those in poor countries get access to all the journals for a single basic annual fee of US$1000. Some institutions were not aware of this opportunity to access scientific literature at affordable rates.

The 2009 survey revealed that many libraries in developing countries have cut back on their journal subscriptions and, therefore, initiatives such as the IAHS TFDC and OARE are critical to ensure that scientists are able to gain access to international scientific publications to support both their research and educational development. A number of the recipients indicated that the IAHS publications distributed through the TFDC programme are widely used by individuals within the institution as well as by visitors and through local inter-library loan services.

The future should see improved



*see list on page 4.

integration of the TFDC programme with other IAHS activities, particularly the Working Group on Education and the new Science Initiative for the forthcoming decade (2013–2022) that will replace PUB. IAHS is committed to enabling the development of new scientists, as well as encouraging the full participation of developing countries in international hydrological research activities. Many societal problems associated with water are experienced by developing countries and appropriate solutions can often be best developed by local researchers who are familiar with the problems. It is very important therefore that these researchers are able to keep abreast of international developments in hydrological sciences so that they are able to develop their own science, as well as apply it in practice. It is evident that the TFDC has contributed to achieving this objective during the more than 20 years that it has been in existence.

Denis Hughes

IAHS members from the following countries are eligible for free access to *Hydrological Sciences Journal* and 80% discount on book prices, subject to the minimum price restriction:

Albania, Algeria, Angola, Armenia, Azerbaijan, Bangladesh, Belarus, Benin, Bhutan, Bolivia, Bosnia-Herzegovina, Bulgaria, Burkina Faso, Cambodia, Cameroon, Cape Verde, Central African Republic, China, Colombia, Côte d'Ivoire, Cuba, Democratic Republic of Congo (Zaire), Djibouti, Ecuador, Egypt, El Salvador, Ethiopia, Gambia, Georgia, Ghana, Guatemala, Guyana, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kenya, Korea (DPR), Lesotho, Liberia, Macedonia, Madagascar, Malawi, Mali, Micronesia, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Senegal, Serbia, South Africa, Sri Lanka, Sudan, Suriname, Swaziland, Syria, Tadzhikistan, Tanzania, Thailand, The Palestine Authority, Togo, Tonga, Tunisia, Uganda, Ukraine, Uzbekistan, Vietnam, Western Samoa, Yemen, Zambia, Zimbabwe.

This list is subject to revision.

Needs and opportunities for hydrology education in a changing world

Working Group on Education

Protection from hydrological extremes and the sustainable supply of hydrological services in the presence of climate change, improving lifestyle and increasing population pressure are the defining societal challenges for hydrology in the 21st century. These challenges require new approaches to solving hydrological problems, which in turn demand changes to the way we educate the current and future generations of hydrologists. Recent surveys of the current educational basis for hydrology demonstrate that hydrology education is not yet prepared to deal with these challenges.

It is therefore not just the practice of hydrological science that must advance, but also our approach to the primary and continuing education of hydrologists. The educational system that supports the teaching of hydrology must undergo a paradigm shift away from the current practice of imparting a narrow set of basic concepts and a disciplinary set of skills to engineers and scientists. Given the great complexity of the problems facing a changing world, the teaching of hydrology must adopt a greater emphasis on learning from observations and from collective experiences in dealing with the environment around us in the context of societal needs.

Hydrologists have to be well equipped with practical experience in observing and measuring hydrological variables, with in-depth process understanding and with the knowledge of how to translate this insight into quantitative theory and models. Training such a holistic "renaissance" hydrologist requires a coherent and comprehensive scientific basis. Hydrology does not yet present itself in such a coherent way, leading to hydrologists with a restricted or uneven background, e.g. biased to their science or engineering home department. Even if such a coherent image could be found at this time, the increasing impact of climate change (largely propagated to society through the hydrological cycle) and the deepening footprint of human activity challenge the suitability of many of our methods, while also creating an exceptional opportunity to advance the education of hydrologists.

Rural water resources, Brazil (A. Bronstert).

A significant step forward can, in our opinion, only be achieved through a concerted community-driven effort. The IAHS Working Group on Education represents such a community effort. We are exerting a leadership role in developing a global network of hydrology educators as a necessary basis for capacity building in the area of hydrology education. Activities include the organization of workshops, the development of databases with information about hydrology education throughout the world, and the support of community efforts such as the Modular Curriculum for Hydrologic Advancement (MOCHA), www.mocha.psu.edu.

Thorsten Wagener

Undergraduate engineering students on a hydrology course at the Pennsylvania State University.

Tracers in hydrology

International Commission on Tracers (ICT)

The International Commission on Tracers (ICT) was established at the IUGG Assembly in Vienna in 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 early 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 the ICT. Since then the use of environmental (naturally occurring) and artificial (intentionally injected) tracers has permeated the various sub-fields of hydrological sciences.

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 promoting use of these methods within the hydrological sciences. ICT supports the integration of tracer approaches throughout hydrology by technology transfer from academia to practice.

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 transport processes, determining flow, transport and rock parameters, tracing water phase changes (evaporation, condensation, sublimation) and controls on water quality. Tracer techniques are helpful in arid and semi-arid regions for quantifying groundwater and vadose zone water fluxes. Tracer methods have become a major calibration and validation tool in modelling of mass transport in groundwater, in catchment modelling, and in the identification of runoff generation processes. Tracer approaches can be extremely useful in assessment of surface water–groundwater interactions, dating of water (estimation of transit times and their time-distributions), quantifying water–rock interactions, and in evaluation of water resources and their vulnerability to pollution.

The use of natural tracers has considerably changed the understanding of runoff generation processes that are among the most important processes in catchment hydrology. Understanding pathways of precipitation through the catchment, residence times of water and chemical species, and subsurface flow paths is crucial for catchment modelling and for quantification of solute and contaminant transport. Tracer methods, combined with hydrometric measurements, have proved to be effective for identifying runoff generation mechanisms in headwater catchments and in the modelling of catchment processes.


Water sampling for environmental tracers in the Chad Basin, Nigeria, 2004.

Recently, tracers have been used increasingly in various research settings to understand solute transport phenomena in karst aquifers, fractured rock aquifers and heterogeneous porous media. Tracers are indispensable to understand and quantify water flow paths in these types of aquifers by their combined use with mathematical models, as well as for calibration of numerical flow and transport models. Currently, isotopes are finding their use in understanding of biodegradation processes underground. The characteristic isotopic signature of many pollutants and the changes in isotopic composition during specific biological, chemical and physical processes may yield unique information on the origin of pollutants and on their fate in soil and groundwater. In particular, isotope analysis can provide essential information in natural attenuation studies. Conservative and reactive tracers can greatly aid in the design and evaluation of enhanced bioremediation strategies by providing a reliable way to measure *in situ* contaminant decay, oxide-reduction process rates, and zones of influence.

ICT also discharges its responsibilities through extensive cooperation with the other IAHS Commissions, and with other organizations, such as the International Atomic Energy Agency (IAEA), UNESCO/IHP, the International Association of Hydrogeologists (IAH), and other groups within the hydrological community. During the last 20 years, ICT has organized or co-sponsored more than 30 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.

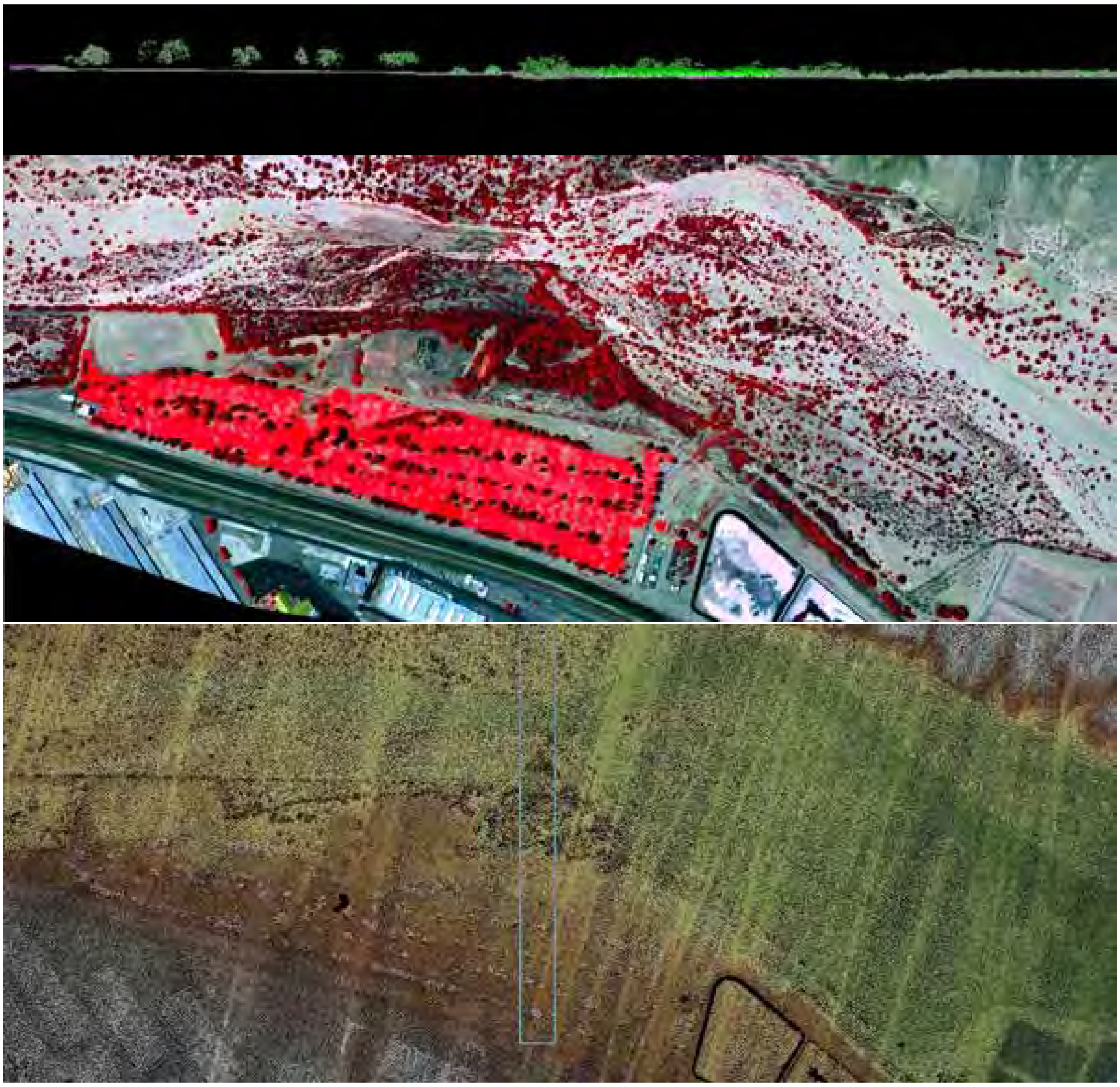
Piotr Maloszewski

Remote sensing and hydrology

International Commission on Remote Sensing and Hydrology (ICRS)

Remote sensing technology has evolved into an integral research tool for the natural sciences. Disciplines such as climatology, hydrology, and studies of the terrestrial biosphere have all developed a strong remote sensing analysis component. Moreover, remote sensing has facilitated our understanding of the environment and its many processes over a broad range of spatial and temporal scales. This is an important part of hydrological research, especially in water resources management, environmental monitoring and prediction, and the detection of environmental change. Likewise, spatial database management software tools such as geographical information systems have facilitated the modelling and interaction of spatial data. ICRS strives to promote the use of these technologies in state-of-the-art applications in hydrology, water and environmental resources.

Since the launch of the first remote sensing satellite in 1971, hydrologists and other scientists have developed algorithms to extract hydrological information from remotely-sensed data, developing and/or adapting existing hydrological methods capable of making efficient use of this new information. Numerous remote sensing instruments have been launched on satellite and airborne platforms, which, along with advancements in computer and software technology, have made it possible to evaluate and quantify large numbers of drainage basin physical characteristics and state variables related to hydrological modelling. Over the years, research and applications of remote sensing and GIS within hydrology have been developed to cover a variety of topics, including the monitoring of snow-pack properties, permafrost and ice, determination of soil moisture, flood mapping and wetland detection, monitoring of water quality, bathymetry and suspended sediment concentrations, estimation of evapotranspiration of natural and agricultural vegetation, estimation of irrigation water demand of crops, mapping of natural vegetation



LiDAR point cloud profile (top) shown on a section of LiDAR map (middle) and corresponding multispectral image (bottom) of a portion of the Mojave River floodplain in southern California, USA. Data and imagery were used to estimate the evapotranspiration rate of the riparian zone vegetation species.

and invasive species, as well as the estimation of the energy balance over these surfaces. A combination of satellite and airborne instruments has been used to retrieve some of these hydrological parameters that, when coupled with new techniques such as airborne and ground-based LiDAR, and recently developed methods of surface energy balance flux measurements such as scintillometers and eddy covariance systems, have resulted in the advancement of applications and modelling of surface terrain features and the hydrological cycle.

The IAHS specific interest in remote sensing began with a committee at the Canberra Assembly in 1979, with the first meeting occurring in 1981 in Denver, Colorado. It became the ICRS in 1998. The mission of this Commission is to advance the use of remote sensing, data transmission and geographic information systems in applications related to the hydrological sciences. It defines and facilitates needed research and stimulates technology transfer from the researcher to the user. ICRS activities cut across all activities of IAHS and it liaises with other international organizations such as COSPAR, WMO, UNESCO, UNEP and IUGG to facilitate research cooperation. The ICRS commission currently has two sections or divisions, Remote Sensing and Geographic Information Systems (GIS).

ICRS sponsors workshops and symposia at IAHS Scientific Assemblies and at International Union of Geodesy Geophysics (IUGG) General Assemblies sometimes co-sponsored with other commissions. In addition, ICRS has organized specialized symposia on *Remote Sensing and Hydrology*. The first was held in April 2000 in Santa Fe, New Mexico and the second was recently held in Jackson Hole, Wyoming in September 2010. These symposia have been very well attended, resulting in IAHS publications such as *Remote Sensing and Hydrology 2000* (IAHS Publ. 267) and *Remote Sensing and Hydrology 2010*, a compendium of papers from the Jackson Hole symposium (IAHS Publ. 352). Other examples of publications resulting from symposia sponsored by ICRS at IAHS Scientific Assemblies include *Hydroinformatics in Hydrology, Hydrogeology and Water Resources* in 2009 and *Remote Sensing for Environmental Change Detection* published in 2007 (IAHS Publs 331 and 316, respectively).

Christopher Neale

Precipitation

IAHS Working Group on Precipitation

This intriguing "Starry Night" by van Gogh illustrates the complexity of the processes involved in precipitation, which challenge the advance of hydrological sciences.

Vincent van Gogh (1853–1890) The Starry Night (1889) Oil on canvas, 29 × 36¼", Museum of Modern Art, New York, acquired through the Lillie P. Bliss bequest. Digital image ©2012 The Museum of Modern Art /Scala, Florence.

Why a Precipitation Working Group?

The intermittent nature of precipitation is a striking phenomenon. Heavy rainfalls occur in very short fractions of time and space, but can have dramatic impacts. These events challenge classical approaches in hydrology, because they contaminate other hydrological fields through balance equations, e.g. generating various types of floods. Indeed they generate strongly non-Gaussian statistics (not taught in classical text books) with more frequent extremes than expected, sensitive scale dependency of the observables that therefore cannot be defined point-wise, in contrast to what classical text books assume. These fundamental problems have huge, practical implications for both *in situ* and remotely-sensed measurements, and modelling of precipitation. Without this strange behaviour of precipitation, downscaling and upscaling of hydrological fields would be straightforward! Unfortunately, they are not, and this is a fundamental problem for climate projections.

Not only is precipitation a complex phenomenon, but its research framework is complex. Firstly, precipitation is at the interface of hydrological and meteorological sciences and therefore precipitation research is interdisciplinary by nature. This already raises delicate questions, including who assumes the responsibility of measuring, developing measurement and recording devices, investing for research and development, etc. But solving the aforementioned problems requires a much larger interdisciplinarity; in particular it should include statistical and stochastic physics, and many branches of mathematics (e.g. stochastic processes, measure theory). Fortunately, there have been numerous, outstanding inputs by the precipitation community in nonlinear sciences.

The above explains why IAHS formerly had an International Commission on Precipitation and why its closure years ago was unfortunate. In 2007, the decision was taken to create a new IAHS Working Group on Precipitation to foster contributions by hydrologists in precipitation research, as well as to provide the hydrological community with better access to the most advanced developments in precipitation research and technology. The Working Group will help develop these activities within and out of IAHS.

Future activities

The first years of the Group were mainly devoted to setting up activities, such as the organization of conference sessions on precipitation in various frameworks, and developing networks with similar groups to mutualize efforts. As well as the International Precipitation Conferences (IPC), closer collaboration has been established with e.g. the International Commission on Clouds and Precipitation (ICCP) of IAMAS (International Association of Meteorological and Atmospheric Sciences).

The Group is currently preparing a precipitation roadmap for IAHS, building on the numerous discussions regarding the fundamental deadlocks of precipitation research and technology, ranging from new measurement technologies to theoretical problems, as well their lack of applications in all hydrological domains.

Daniel Schertzer

Snow and ice hydrology

International Commission for Snow and Ice Hydrology (ICSIH)

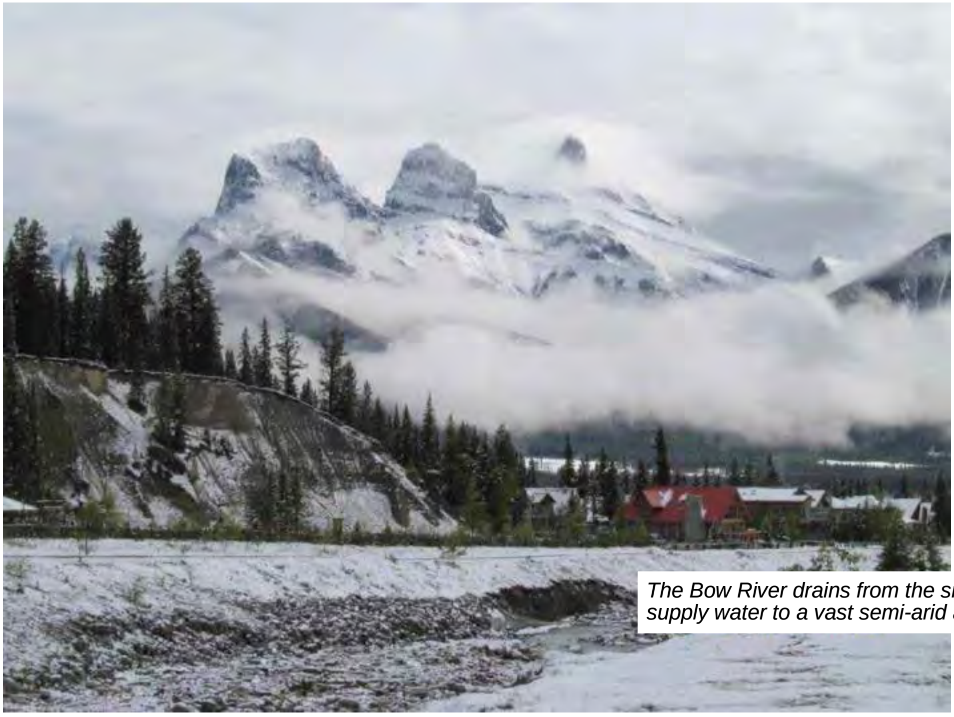
Snow and ice have been studied as core components of hydrology since its inception as a science, and their dynamics are key to hydrological functioning for much of the world. Water stored as snow and ice is a critical contributor to the world's available freshwater supply and is essential for the sustenance of natural ecosystems, agriculture and human societies. The formation, vaporization and melting of snow, ice and soil frost are important and dynamic components of the hydrological cycle and hold an inordinately important role in runoff formation and streamflow generation. Snowmelt water and soil frost play major roles in runoff generation and soil moisture replenishment for both cold regions and uplands, and river flow from these source regions is extremely important to more temperate and often more arid downstream areas. River and lake ice affect water flow and may result in catastrophic flooding. Due to global warming, the cryosphere is experiencing rapid changes. Changing climate has resulted in altered patterns of snowfall and snowmelt, the conversion of snowfall to rainfall, loss of glaciated area and the thawing of permafrost.

The goal of ICSIH is to promote the scientific study of the processes of snow and ice dynamics and the influence of snow and ice on the environment, runoff generation, rivers and lakes, with an emphasis on the seasons and regions where the solid phase of water and its subsequent runoff are prevalent.

ICSIH was approved to begin its functions with a provisional bureau at the IAHS Bureau meeting in Foz do Iguaçu, Brazil in 2005, and then voted into existence by the IAHS General Assembly at IUGG in Perugia, Italy, in 2007, when the former IAHS *International Commission on Snow and Ice* (ICSI) became the *International Association of Cryospheric Sciences* (IACS) of IUGG. ICSIH has fruitful connections with IACS.

Regine Hock

Braided river runoff from the Drangajokull ice cap, Iceland.



The Bow River drains from the snow and glacier-clad Canadian Rockies to supply water to a vast semi-arid agricultural region. Photo, May Guan.

Statistical hydrology

International Commission on Statistical Hydrology (ICSH)

Statistical methods for hydrological analyses have a long history and continue to be an intense research focus. Such tools have proved to be pivotal in numerous applications and procedures. The success of statistical descriptions of hydrological processes underlines the enormous complexity of hydrological systems, which makes a purely deterministic description ineffective.

Recently, the number of available tools, approaches and procedures in several statistical sub-topics has increased faster than before. The correct application of new and old updated methods is fundamental for hydrological studies. There are more than 100 international journals on statistics, and more than 40 that now accept contributions on statistical hydrology. Many software and routines are available in several languages (S, R, C++, Fortran, etc.) either commercially or as freeware. For any specific hydrological problem many potential statistical approaches are available.

Starting from these premises, during the IUGG General Assembly in 2007, a working group (named STAHY – Statistics in Hydrology) was proposed and approved by the IAHS Bureau. This working group operated in collaboration with ICWRS to collect people interested in this topic and create a virtual common space to coordinate, optimize and concentrate information. The aim was to offer a focal point for statisticians wishing to understand the hydrological applications, and for hydrologists who need to use a statistical tool and would like to easily understand what is the right approach, and so that statistical hydrologists can easily update on recent developments in their research field.

The STAHY family fast became a rich group of young scientists that enthusiastically collaborated in developing several initiatives and the STAHY portal (www.stahy.org). Significant effort was devoted to reporting on all the organized initiatives and collecting information, pictures and presentations at the website.

During the 2011 IUGG General Assembly the STAHY-WG was transformed into the International Commission on Statistical Hydrology (ICSH) in order to give weight to its contribution to the scientific community. This memorable event further encouraged the group.

Nowadays, ICSH counts 118 participants from 42 countries, while since January 2010 the website has registered more than 15 000 visits from 135 countries.

ICSH has several active initiatives: including:

– organization of sessions at all the main scientific assemblies: IAHS, IUGG, EGU, AGU;
– an annual topic workshop (the first was in Taormina, Italy, 2010 as a STAHY-WG and the first one as ICSH was in Tunis, Tunisia, 2012);
– short courses on the main statistical topics promoted by ICSH. Two courses were organized on the Copula function and the third will be held in Hannover, Germany, in 2013;
– monthly reference collection initiative. Every month, at the website, lists of references on specific statistical topics are updated by the initiative coordinator. The success of this initiative is confirmed by several citations to the website in journal papers. Currently five topics are active: *Copula function* coordinated by Jing Li, University of Adelaide, Australia; *Non-stationarity* coordinated by Ebru Eris, Istanbul Technical University, Turkey; *Regional frequency analysis* coordinated by Emna Gargouri, Institut Supérieur des Etudes Technologiques de Radès, Tunisia; *Entropy function in hydrology* coordinated by Simon Michael Papalexiou, National Technical University of Athens, Greece, and by Federico Lombardo, Università degli Studi di Roma 3, Italy; *Long memory and parametric models in environmental time series*, coordinated by Marcella Corduas, Università degli Studi di Napoli Federico II, Italy.

For the future, ICSH plans to continue and extend these initiatives, and proposes to set up an ICSH library of "R" codes of the main statistical methods useful for hydrological applications. "R" is a freeware software with a large library well known by the scientific community. The selection and validation of the most useful routines in our field would be a valuable service for statistical hydrologists.

Salvatore Grimaldi

The STAHY Group at the Taormina Workshop 2010.

Surface water

International Commission on Surface Water (ICSW)

ICSW is responsible for promoting research into surface water hydrology and its interaction with other aspects of the hydrological cycle. The primary focus 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. Core activities, including flood and drought prediction, mitigation and forecasting, continue within ICSW; however, a higher priority is given to interdisciplinary research including socio-economic aspects. This covers instream ecology, wetland ecology, poverty reduction, hydrology and health and knowledge building to reduce international conflict in water.

Like other IAHS commissions, ICSW is involved in one of the major current scientific topics: climate variability and change and its impacts on the hydrological cycle and water resources. This includes many issues of concern to ICSW, such as detection of change in observed hydrological records, studies of the effects of climate change on hydrology, elaboration of adequate scenarios, and large-scale hydrology. But there are two particular foci to this important cross-cutting ICSW research: (i) large-scale hydrology and (ii) low flows and drought.

Large-scale hydrology

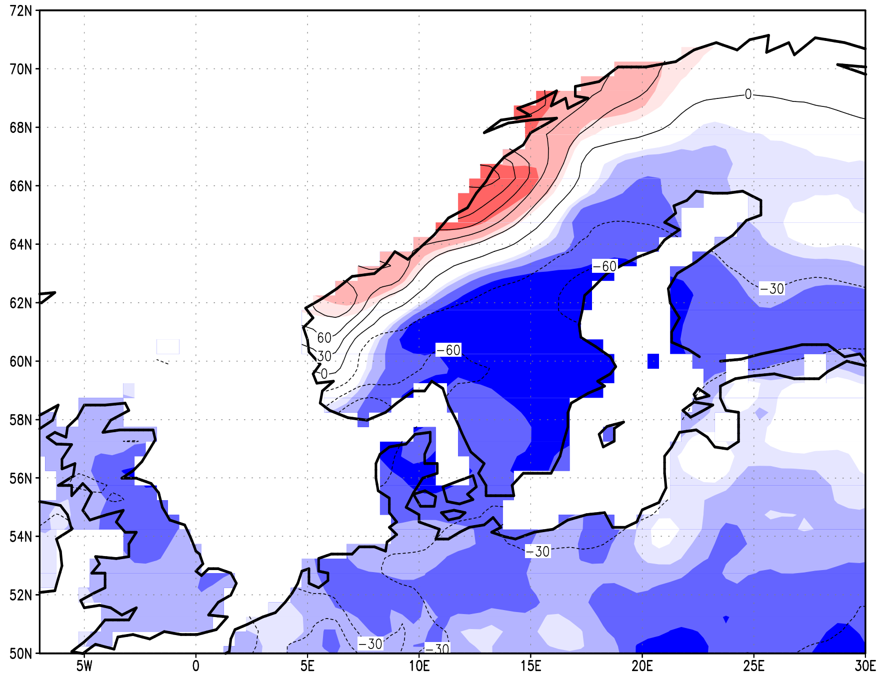
The United Nations has identified better understanding of large-scale water cycle processes as essential to socio-economic development and global water/food/energy security. Large-scale hydrological research (i.e. beyond the individual river basin scale) is essential for the detection of hydrological change in space and time, attribution of causes, identification of processes and their interactions and prediction at ungauged sites.

Recent research linked to ICSW has made significant contributions to advancing knowledge of: flow regimes and climate–hydrology interactions across northern Europe (figure below), the North Atlantic, the UK and other parts of the world, including the Mediterranean Basin and West and Central Africa; the role of river basin properties in modifying hydrological response; trends in low flows and drought across Europe; and links between large-scale weather patterns and hydrological extremes. ICSW researchers have highlighted the importance of large-scale river flow archives for evidence-based assessment of past hydrological variability, and for supporting hydrological modelling of future changes. Much of this research has been conducted in the context of the UNESCO International Hydrological Programme cross-cutting theme FRIEND-Water (Flow Regimes from International Experimental and Network Data).

We believe the breadth of ICSW contributions and findings demonstrates a move towards a more interdisciplinary and joined-up approach (including combining empirically-based and modelling studies) to understanding hydrology at large scales that will underpin major future research advances.

Low flows and drought

For many years ICSW has contributed to increased knowledge on the subject of low flow and drought through publications covering topics such as the definition of drought, low flow estimation at the ungauged site, extreme value analysis of drought, developing methods to assess drought characteristics and study of how drought propagates through the hydrological cycle, studies of changes in low flow and drought over time in Europe, climate change effects on drought and the relationship between weather types and drought. These topics are also covered in a textbook on hydrological droughts (Tallaksen, L. M. & van Lanen, H. A. J. (eds), 2004) to which ICSW members made a significant contribution, and training courses have been organized. ICSW has also actively contributed to the establishment of the European Drought



Composite precipitation anomaly between November high- minus low-river flow years (1968–1997) for rivers in NW Norway, which is indicative of the inverse correlation of river flow between NW and SE Scandinavia (FRIEND Report 2006–-2009, Euro-FRIEND Project 3: Large-scale hydrological variations).

South Morocco. In these dry areas, every drop of water is used for crop production.

Centre (EDC: www.geo.uio.no\edc), a virtual centre including European drought research and drought management organizations to promote collaboration and capacity building between scientists and the user community.

ICSW and the United Nations agencies

A large part of ICSW activities has been and will be achieved through joint activities with other commissions and agencies outside of IAHS. The Commission has developed close links with the UNESCO and WMO programmes: HELP (Hydrology, Life Environment and Policy), WHYCOS (World Hydrological Cycle Observing System), but it is mainly through its many interactions with the global FRIEND-Water that ICSW brings support to UNESCO IHP. It is also partly through these collaborations and interactions that the Commission will endeavour to support capacity building in developing countries by increasing activities in these regions.

Eric Servat

Land–atmosphere systems

International Commission on the Coupled Land–Atmosphere System (ICCLAS)

Land surface hydrological processes interact with the atmosphere as an integrated coupled system. Atmospheric conditions (direct and diffuse solar radiation, humidity, wind speed and temperature) influence the surface energy balance and partitioning of net radiation into evapotranspiration and surface heating. In turn, hydrological moisture availability, soil types, vegetation parameters and the subsequent evapotranspiration at the land surface affect atmospheric conditions, especially in terms of the evolution of temperature and humidity, and the development of the convective boundary layer.

Evaporated moisture feeds atmospheric conditions influencing 'downstream' rainfall. For instance, moisture may be cycled through the land surface–atmosphere system several times over large continental scales, e.g. through the Amazonian rainforest. Understanding the complex features of heterogeneous land surfaces and their hydrological processes provides improved insight to day-to-day meteorological forecasts, as well as the evolution of hydrological extremes such as drought.

In addition to the basic mechanics of the coupled land–atmosphere system, there is growing concern over the possibility of anthropogenic climate change caused by emissions of carbon dioxide and other 'greenhouse gases'. The science of projecting future changes in climate is complex and interdisciplinary. Consequently, ICCLAS aims to provide high quality science on the interface between climate and hydrology. The objective is to facilitate research, scientific exchange and knowledge transfer with respect to these issues through the organization of symposia and workshops, and through the publication of edited volumes that summarize the current 'state of the art'.

ICCLAS has been a partner in a several key research topics including:

Modelling and measuring the role of land surface to atmosphere fluxes of energy and water

The land surface exchanges water and energy with the overlying atmosphere. Such exchanges are intrinsically important for hydrology but are also important for the evolution of day-to-day weather systems. For instance, during hydrological drought, moisture is limited at the land surface and thus much of the incoming solar radiation is partitioned into heating of the near surface atmosphere. This results in more elevated maximum day-time temperatures than would otherwise occur. Similarly, during hydrological drought, the atmosphere has higher evaporative demand due to reduced evapotranspiration, leading to increased evaporation rates from reservoirs and other water bodies. Robust characterization of these processes is hampered by their significant spatial variability due to the variability of soils and vegetation. Increasingly, remote sensing is used to characterize this spatial and temporal variability of hydrological processes with the aim of improving their representation.

Downscaling atmospheric and climate models for assessment of hydrological variability and extremes

A key research area is the interpretation of Global Climate Model (GCM) output at temporal and spatial scales commensurate with hydrological processes. This active area of research seeks to develop robust methodologies for interpreting spatially-coarse GCM output to provide hydrologically-meaningful forcing variables such as rainfall.

Assessing the predictability of hydrological variability utilizing known modes of climate variability

In addition to possible future climate change, many parts of the globe are significantly affected by known natural modes of climate variability. These operate on a range of time scales. The El Niño Southern Oscillation (ENSO) impacts tend to provide seasonal to inter-annual variability in hydrologic regimes, whereas the Pacific Decadal Oscillation (PDO) and Atlantic Multi-decadal Oscillation (AMO) operate on time scales of decades and beyond. To understand how future climate and hence hydrological regimes may change, it is critical to characterize the impact of such naturally-occurring climate modes on hydrologic regimes. As these modes are increasingly well understood, good predictability of expected hydrological regimes may result for a variety of areas impacted.

Stewart Franks

Groundwater

International Commission on Groundwater (ICGW)

A fundamental hydrological science and a vital resource for humanity

Groundwater makes up nearly 70% of the world's freshwater resources; only 0.2% is found in lakes or rivers and 30% is bound as snow and ice in mountains and in the polar regions. Groundwater plays an important role in our environment and economies. The storage capacity of groundwater reservoirs combines with small flow rates to provide large, extensively distributed sources of water supply. Groundwater also supports rivers, lakes and wetlands, especially through drier months when there is little direct input from rainfall. In fact, most of the water we use for agriculture, industry and drinking water either is groundwater or was groundwater before discharging into surface water bodies.

Studying groundwater processes is challenging as the subsurface systems where it occurs are inaccessible and highly heterogeneous. Traditionally, groundwater research focused on understanding the nature of subsurface flow and characterizing the parameters that control groundwater flow and contaminant transport in different rock types and systems. More recently, the development of models that represent groundwater systems has demonstrated the importance of detailed characterizations and also the pressing need for new approaches to solve the complex problems encountered in the field. This has led to the development of a wide range of different models and modelling approaches, including deterministic and stochastic methods. An example of detailed field characterization that has led to development of novel modelling approaches is illustrated.

Groundwater–surface water/ seawater interactions

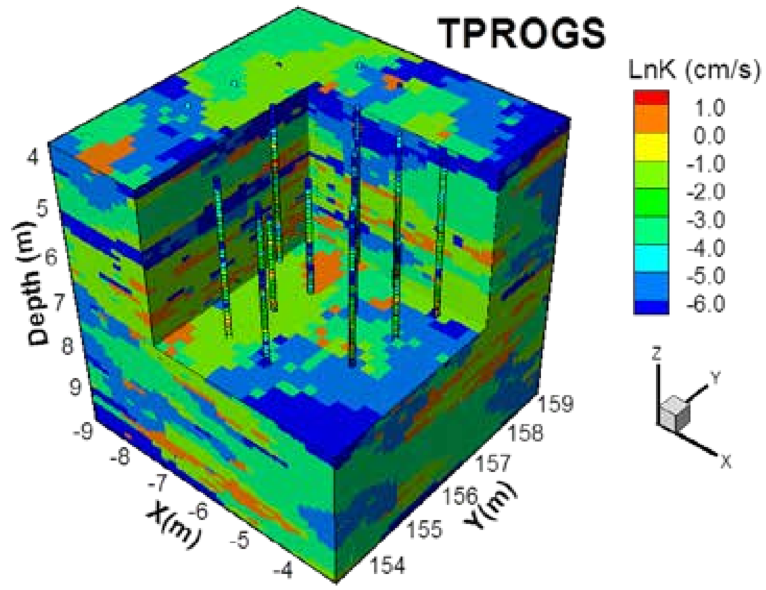
While this work of characterizing and modelling groundwater systems is far from complete, the scope of groundwater research has expanded immensely during the last decade. Growing understanding of groundwater systems and the recognition that processes in them are interconnected with the processes in freshwater systems and in the oceans has ignited new areas of research including, for example, the study of groundwater–seawater interactions and groundwater–surface water interactions that are critical to ecological communities and to wise stewardship of our water resources. Research over the last decade has investigated many aspects of groundwater–surface water interactions, and has succeeded in identifying and understanding many underlying processes and factors, such as the dynamics of flow, sediment transport, contaminant transport and chemical reactions in river beds and flood plains, and how processes at different spatial scales interact. Advances have been made through field, laboratory and modelling investigations. Improved computer power continues to expand the possible types of evaluations.

Groundwater and water resources management

Throughout the world, regions and nations rely on groundwater for drinking, irrigation and industrial water supplies. Many important aquifers, however, are on a fundamentally unsustainable path. Large pumping-induced declines in water levels have called into question the viability of these aquifers to serve as a continuing resource for those areas. A classic example of unsustainable groundwater development is the North China Plain, where factors, including climate change, high population density, and rapid economic development, present a compelling case of groundwater resources in peril. Managing the groundwater supplies in these aquifers in a more sustainable fashion requires an integrated approach that recognizes the role of all components of the hydrological cycle. Over the last two decades, considerable attention has been given to identifying and quantifying the key components of an aquifer's water balance and the linkage with ecological processes. Important advances have been achieved through new data collection and interpretation approaches, development of integrated hydrological and ecological models, and a more multidisciplinary focus.

Groundwater in food and energy security

Groundwater plays a central role in ensuring food and energy security for many nations. In the USA and China, groundwater provides over 60% of the water used for agricultural irrigation. Thus grain production and food output heavily depend on availability of groundwater. The water–energy nexus has been a topic of considerable interest and importance over the last decade. For example, in Canada hydrogeologists are increasingly being called upon to assess the impact of the exploitation of



One realization of the hydraulic conductivity field generated from a well-known groundwater tracer experiment site (MADE site). The field is generated using the geostatistical program TPROG conditioned to hydraulic conductivity values estimated from grain-size data at 1741 points. Such detail in the subsurface is often critical for transport model predictions.

From Bianchi, M.C. Zheng, C. Wilson, G.R. Tick, G. Liu & S.M. Gorelick. 2011. Spatial connectivity in a highly heterogeneous aquifer: From cores to preferential flow paths. Water Resources Research 47, W05524. This figure is reproduced/modified by permission of the American Geophysical Union.

Eco-environmental consequences of groundwater depletion in the North China Plain: (clockwise from top left) a bridge over a dried-up river; former riverbed used for farming; wastewater flowing in a river; and a disappearing wetland (photos, Chunmiao Zheng).

conventional and unconventional energy on groundwater quantity and quality. In the USA, the exploitation of shale gas has fundamentally altered the energy landscape, but there remain many concerns about the environmental consequences and water resource implications of hydraulic fracturing or fracking, an essential technology for shale gas production. Nuclear waste disposal is another topic that will not be going away. There are similar concerns about energy in Australia, China and Europe, so it is a global topic. The (ground)water–energy nexus is a topic in which groundwater hydrologists will play a vital role.

ICGW's role and activities

ICGW is responsible for the advancement of groundwater sciences by supporting the distribution of new technologies, methodologies and scientific findings through the organization of workshops and symposia and by collaborating with other IAHS commissions and scientific organizations such as the American Geophysical Union (AGU), the International Association of Hydrogeologists (IAH) and the National Ground Water Association (NGWA; USA).

The main achievements of ICGW during the last decade include:

- continuation and expansion of the well-known and successful GQ (Groundwater Quality) and ModelCARE conference series;
- establishment of two new conference series, HydroPredict and HydroEco, and
- organization of topical workshops and symposia including:
  (1) groundwater–surface water interactions
  (2) groundwater–seawater interactions
  (3) sustainability of groundwater in highly stressed aquifers
  (4) transboundary water management

Another important role of ICGW is to facilitate and promote communication between researchers from different subject areas and different geographical areas, and to provide opportunities for young researchers to discuss their research questions with groundwater experts.

During the last decade, ICGW has made great efforts to realize this role and has established a mentorship programme which runs at the ICGW-organized conferences (e.g. ModelCARE, GQ, HydroPredict and HydroEco). Conference attendees have the opportunity to attend Mentorship Lunches with members of the conference Scientific Advisory Committee (SAC) and/or invited speakers. These lunches provide an informal way for conference attendees to talk to the SAC members, and students are very welcome. ICGW also manages an internet-based discussion group using the internet facility LinkedIn. The group now has over 600 members and provides a forum for the discussion of relevant (groundwater-related) topics for all who have an interest in groundwater-related science.

Chunmiao Zheng

Erosion and sediment

International Commission of Continental Erosion (ICCE)

Environmental problems associated with land erosion, sediment redistribution and transport, sediment-associated transport of nutrients and contaminants, the role of fine sediment in degrading aquatic ecosystems and related issues have assumed increasing importance in recent years. Whereas formerly interest in erosion and sediment transport focused primarily on those areas of the world with high rates of soil erosion and high sediment yields, sediment problems have been shown to be equally important in other regions where erosion rates and sediment yields are relatively low. These regions are frequently more sensitive to human impact and related shifts in sediment response, and even small changes in sediment mobilization and transfer can result in significant impacts on aquatic habitats. At the global scale, land-use change and climate change are exerting an important influence on the sediment loads of the world's rivers, which are also being increasingly impacted by the construction of large dams. Rivers are a key source of sediment supply to deltas and the coastal seas, and changes in their sediment loads can have wide-ranging implications. More generally, human impact on erosion and sediment transport is clearly evident across a range of scales, and the role of fine sediment in diffuse source pollution has resulted in it being described as the world's greatest pollutant, recently and historically. These problems are central to the interests of the International Commission on Continental Erosion (ICCE) and the work of the Commission has therefore gained increasing relevance in recent years. The Commission has responded by directing its attention to these key issues.

The recent work of ICCE has focused on a number of areas, aimed at emphasizing the sensitivity of erosion and sediment transfer to human impact and global change, and improving our understanding of sediment-related problems. The first links to the need to develop a better understanding of the mobilization, transfer and redistribution of sediment within the landscape and within river basins of different scales. This has highlighted the importance of establishing sediment budgets, which link erosion and sediment mobilization to sediment transfer and storage, and ultimately sediment output at the outlet of a river basin. Particular emphasis is placed on identifying sediment sources and sinks. Sediment sources are a key influence on sediment quality and sediment sinks can exert an important control on sediment fluxes, since much of the sediment mobilized from the surface of a catchment may be deposited and stored in such sinks, with only a small proportion reaching the basin outlet. Sediment budgets are increasingly seen as a key tool in sediment management and ICCE was ahead of its time in directing attention to this theme and organizing a symposium on *Sediment Budgets* in 1988 in Porto Alegre, Brazil. This was followed up by the Moscow symposium on *Sediment Transfer through the Fluvial System* in 2004 and a second symposium on *Sediment Budgets* held in Foz do Iguacu, Brazil in 2005.

The development of improved measurement techniques has also been an important focus for ICCE activity in recent years. This reflects both the need to obtain more reliable information on river sediment loads and the need to develop the new techniques required to quantify the various components of sediment budgets. A major symposium on *Sediment Transport Monitoring in River Basins* held in Oslo, Norway in 1992, was followed up by the Oslo workshop on *Erosion and Sediment Transport in Rivers – Technical and Methodological Advances* in 2002 and a specialized workshop on *Sediment Tracing* held in Melbourne, Australia, in 2011.

The importance of human impact on erosion and sediment transport is a recurring theme for ICCE, with the symposia on *Sediment Dynamics in Changing Environments* held in Christchurch, New Zealand in 2008 and on *Sediment Dynamics for a Changing Future* held in Warsaw, Poland in 2010 and the upcoming symposium on *Erosion and Sediment Yields in the Changing Environment* to be held in Chengdu, China in October 2012.

Wildfires are seen as an increasing threat to many of the world's forests and can cause greatly increased sediment mobilization and transport, and so both extensive damage within the area and major problems in rivers and reservoirs downstream due to growth in sediment loads. In June 2012 ICCE organized a Symposium on *Wildfire and Water Quality: Process Impacts and Challenges*, held in Banff, Alberta, Canada, to address this important issue.

A gully developing in an irrigated area in the Dangara region of central Tajikistan.

The River Pyandz with active bank erosion, Pamir Mountain.

The Fukushima disaster in Japan in 2011 has undoubted parallels with the Chernobyl disaster of 1986, and has again directed attention to the importance of erosion and sediment transport in controlling the redistribution and fate of radionuclide contamination. This topic will be the focus of a workshop to be held at the IAHS Scientific Assembly in Gothenburg, Sweden, in July 2013.

The many detrimental impacts of sediment within river basins, which include degradation of aquatic habitats and siltation of reservoirs and other infrastructure for water resource development, highlight the need for sediment management strategies and ICCE addressed this theme through a workshop on *Sediment Problems and Sediment Management in Asian River Basins* at the IAHS Hyderabad Scientific Assembly in 2009, and earlier during the Dundee symposium organized by ICCE in 2006. Together, these ICCE symposia and workshops have generated a valuable set of IAHS Publications which are an important resource for those working in the field.

ICCE actively collaborates with other international bodies. These include the UNESCO International Sediment Initiative (ISI), the World Association for Sedimentation and Erosion Research (WASER), the International Research and Training Centre in Erosion and Sedimentation (IRTCES) 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 Atomic Energy Agency (IAEA). ICCE has been an active participant in UNESCO's International Hydrological Programme for many years, and this involvement has increased through its contributions to the UNESCO ISI. Several ICCE members have played an active role in Collaborative Research Projects organized by IAEA, where the application of new isotopic and radionuclide tracer techniques for documenting erosion and sediment redistribution rates and fingerprinting sediment sources has been significantly advanced. ICCE has also been a major contributor to the Global Geochemical Mapping programme coordinated by Norwegian scientists, which aims to exploit the sediment archives provided by river floodplains and deltas to document both global patterns of sediment geochemistry and recent changes associated with human impacts in the upstream river basin.

Valentin Golosov & Des E. Walling

Water quality

International Commission on Water Quality (ICWQ)

General objective and activities

The International Commission on Water Quality (ICWQ) is responsible for promoting the advancement of research on the water quality of hydrological systems, including assessment, modelling and management. This goal is accomplished informally through the research of the Commission officers and through organized technology transfer activities such as symposia and workshops on topical issues at which scientists present and discuss their results and publish in accompanying Red Books or journal special issues.

Since 2000, ICWQ has convened or contributed to the organization of 28 workshops and symposia at IAHS and IUGG assemblies, and many other national and international events, including, in 2010 co-convening the seminar on *Water Quality in Capacity Development: Policy Options and Practical Solutions in the National and Transboundary Context* at the 2010 Stockholm Water Week.

Commission membership

At the ICWQ plenary meeting in Melbourne in 2011 it was agreed to establish a "membership" of ICWQ so that interested scientists could become members of the Commission and be able to support ICWQ activities. There are now 62 ICWQ members, some of whom are already involved in the organization of symposia and workshops at the IAHS-IAPSO-IASEI Assembly in Gothenburg in July 2013.

Three main topics for current and future activities

Three main topics are the present focus of future ICWQ activities:

– Understanding freshwater quality problems in a changing world
– How can models help to solve water quality problems?
– How to benefit from new monitoring technology?

Sessions related to these are planned for the 2013 Assembly in Gothenburg.

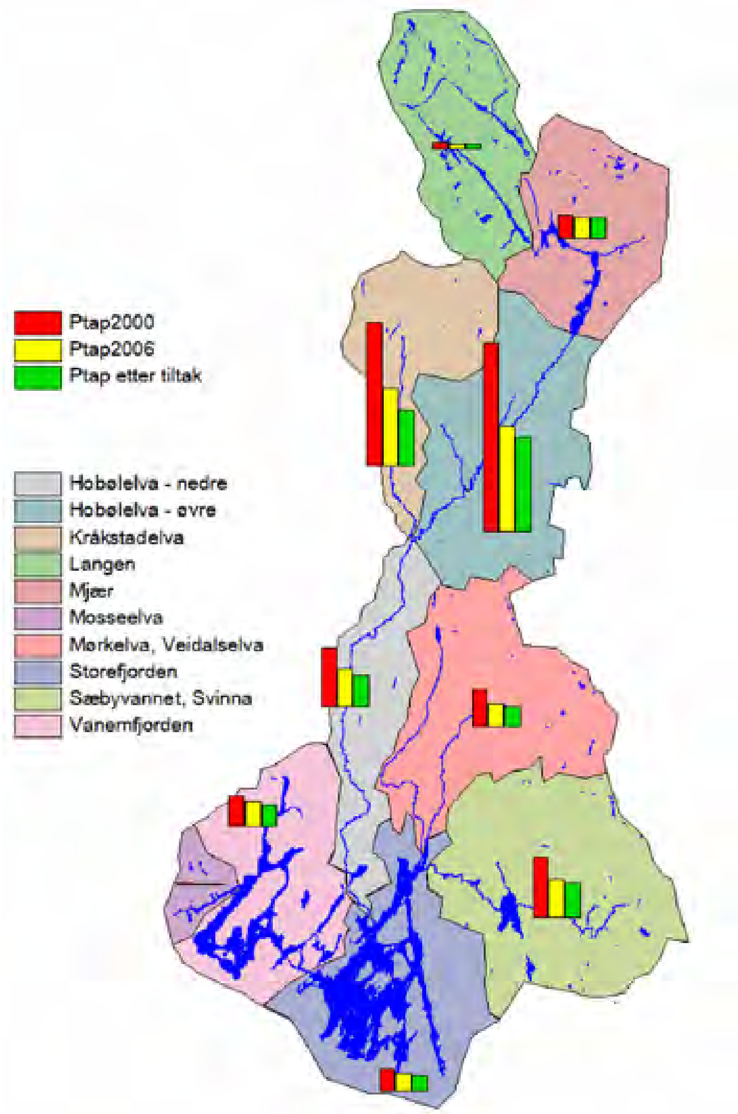
Garbage in water, Borneo.

Understanding freshwater quality problems in a changing world

Both the nature of, and solutions to, water quality problems differ between regions, reflecting various environmental and societal conditions. The world is undergoing accelerated changes in climate, land use and society, which will also influence water resources. There is an urgent need for better overall knowledge of the water quality situation worldwide, as well as a deeper understanding of processes involved in water quality degradation and improvement. More efficient water management and implementation of remedial measures to improve the situation have to be based on scientific knowledge. Scientific questions are: How to understand and describe the behaviour of changing hydrological systems and impacts on freshwater quality in different regions? How can the typical time scale of change be identified? How can we effectively bring together theoretical hydrology, experimental hydrology and new measurement techniques to advance our knowledge of water quality processes? How to estimate and project the development and patterns of freshwater quality with uncertainty estimates to support risk assessment?

How can models help to solve water quality problems?

Despite all the uncertainties involved in water quality modelling with limited input data, water quality models are important and irreplaceable tools that support water managers' and policy makers' work. It is practically impossible to evaluate the effectiveness of land management measures, and assess impacts of changes in land use and climate on water availability and quality without using modelling tools. Dynamic catchment models driven by climate conditions and land use could provide functional and useful support for creating river basin management plans in view of changing conditions. However, models do not always find their way to real-case applications. Our intention is to discuss with researchers and experts in water management the applicability of modelling tools for solving real water quality problems by summarizing the success stories and analysing the obstacles and barriers considering the following questions: What are the conditions for success in model application to real problems? How and to what extent can results of water quality modelling be generally applicable for solving distinct water quality problems in certain conditions (e.g. diffuse-source pollution)? What are the obstacles and barriers preventing successful application of water quality models to real water management? What actions are needed from modellers and from stakeholders to improve the situation?



Modelling phosphorus losses after mitigation measures in Norway.

Monitoring river flow and water quality in the UK.

How to benefit from new monitoring technology?

Data for water quantity and quality investigations are vital for all areas of hydrology, from monitoring and assessing water resources and understanding their response to environmental change, to model calibration and testing. There is currently a high demand for evaluation of water quality monitoring strategies to meet the requirements of legislation and to assess the effectiveness of remediation measures and the future prospects for highly stressed hydrological systems. The development and deployment of novel low-cost and continuously monitoring sensors for water quantity and quality is increasing, e.g. smart sensor networks, "labs-on-a-chip", and distributed temperature sensing technology. The widespread adoption and use of such monitoring and investigative techniques requires their validation relative to existing methods. Advances in data processing and assimilation methods may also be required to manage, process and assimilate the large volumes of data generated by widespread deployment of continuously-monitoring sensors and application of the new generation of high-resolution characterization approaches. ICWQ will promote the sharing of good practice and experience of novel characterization techniques for water quantity and quality investigations.

Valentina Krysanova

Water resources systems

International Commission on Water Resources Systems (ICWRS)

The International Commission on Water Resources Systems (ICWRS) promotes research on the integration of all phases of water resource protection, planning, design, development, management, operation and utilization. The range of scientific interests represented by ICWRS is especially related to the term "system" in its name. A system describes a regularly interacting or interdependent group of items forming a unified whole. Specifically, it is recognized that natural and human elements interact closely and need to be analysed in an integrated fashion. Integration of physical and social domains is the reason why ICWRS covers a wide range of scientific interests with Integrated Water Resources Management (IWRM) as a central theme.

What does IWRM mean?

The term "integrated water resources management" was originally defined during the Dublin conference in 1992. It emphasized the complexity of WRM, which should integrate over:

1. all the water occurrences and interactions in the hydrological cycle;
2. all the different uses that society has of water and the interactions and feedback with the hydrological cycle;
3. the different temporal and spatial scales of the water resources and its use;
4. the full range of objectives (interests) and constraints of water resources utilization;
5. the sustainability of water resources development and use;
6. the process of implementation and the representation of stakeholders in the decision process.

Mostly as a result of the efforts undertaken by the Global Water Partnership, the focus of IWRM shifted towards the process of implementation (item 6), in recognition that in the past stakeholder involvement and participation had not received adequate attention. Also, in the years before Dublin, much attention was given to so-called "policy analysis", which included the interactions between the water resources system, the water users system, and the economic system (items 1–5), but which did not pay much attention to item 6. As a consequence, in recent years IWRM has been equated with the process, whereby the physical, technical and economic intricacies of changing boundary conditions, human interventions and the feedbacks that these interventions have on the different system elements, have often been neglected.

From a research strategy perspective, ICWRS is an organization that stresses the importance of quantitative scientific approaches within IWRM. The main contribution that the commission strives to make within the hydrological sciences is to make full use of technological advances in measurements and computation within IWRM. As a result, we often see cooperation between ICWRS and remote sensing (ICRS), because satellite data are important for fact-based development of water resources at the catchment scale. Similarly, there are close contacts with statistical hydrologists (ICSH), because of the relevance of statistics for the management of water systems such as dams and reservoirs. Lately, measurement and control within water resources

Cahora Bassa Dam, Mozambique.

systems has been a focus and is expected to play a central role in ICWRS for the coming years.

The activities of ICWRS are dedicated to new approaches in order to find a balance between society's demand for water and the restoration of waters as part of the conservation of nature in the 21st century. Here, the integration challenge consists of 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 economic/social development, water supply and water conservation, and urban and rural water users.

Practically speaking, the ICWRS activities consist of organizing and sponsoring conferences and workshops and associated publications. At each IAHS Assembly, ICWRS convenes symposia and workshops. For example, at IUGG in Perugia in 2007, ICWRS organized the symposium *Changes in Water Resources Systems: Methodologies to Maintain Water Security and Ensure Integrated Management* resulting in IAHS Publ. 315, and in 2009, in Hyderabad, ICWRS organized, together with ICWQ, ICRS and IAH, the symposium *Improving Integrated Surface and Ground-water Resources Management in a Vulnerable and Changing World*, published as IAHS Publ. 330. In years during which no central IAHS Assembly takes place, ICWRS endeavours to organize an independent event. For example, in 2006, the very successful 3rd International Symposium on *Integrated Water Resources Management: Reducing the Vulnerability of Societies Against Water Related Risks at the Basin Scale*, held in Bochum, Germany, attracted the submission of 679 abstracts. And, in 2010, the 5th International Symposium on *Integrated Water Resources Management* was held in Nanjing, China. For all workshops and symposia, the abstracts represent a wide geographical range.

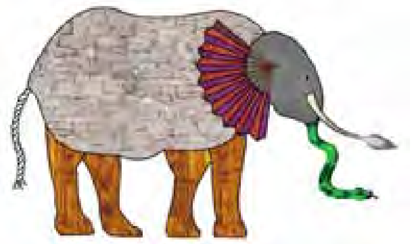
Relatively speaking, ICWRS meetings tend to attract good participation from less developed countries. This bias reflects the interest of ICWRS for the integrated development of water resources as well as the great need for IWRM in these countries.

Nick van de Giesen

Small-scale irrigation of onions in northern Ghana.

Chamarel Waterfall, Mauritius.

Prediction in ungauged basins (PUB)



The PUB Initiative 2003–2012

PUB has been IAHS's major research initiative during the 2003–2012 decade, and comes to a close at the Delft conference in October 2012. This initiative has been agenda setting for the entire hydrological community worldwide and has led to significant international and regional initiatives to further the science of hydrology for the benefit of society.

The rationale for the PUB decade

Sustainable management of river basins requires a variety of predictive tools that can generate runoff predictions, over a range of time and space scales. The most widely used predictive tools for runoff predictions are essentially data-driven, i.e. they are estimated from gauged data. Unfortunately, in most catchments around the world runoff is not gauged. In any given region, in any part of the world, only a small proportion of the catchments possess a streamgauge where runoff is measured. All other catchments have no streamgauge, and are therefore ungauged, and yet runoff information is needed almost everywhere people live for a multitude of management purposes.

The lack of universal theories or equations applicable directly at the catchment scale has led to a plethora of models being developed and used for predicting runoff. These models differ markedly in their model concepts and structure, their parameters, and the inputs they use. They also differ in terms of which dominant processes they represent, and the scales at which they make predictions. Most models are developed by different people with different disciplinary backgrounds, while benefiting from local observations, experiences and practices that are influenced by local climate conditions and catchment characteristics. Consequently, they tend to have unique features not applicable in other places: every hydrological research group around the world seemingly studies a different object, their local catchment. The net result has been considerable fragmentation, "a cacophony" and a dissipation of effort that is not conducive to further advances.

The Decade on Predictions in Ungauged Basins (PUB) launched by the International Association of Hydrological Sciences (IAHS) in 2003 was aimed at achieving major advances in the capacity to make predictions in ungauged basins, through harnessing improved understanding of climatic and landscape controls on hydrological processes. The vision of PUB was to help a transformation "from cacophony to a harmonious melody". One of the clear tasks that the PUB initiative set out to achieve was to address the fragmentation of modelling approaches through *comparative evaluation*: "Classify model performances in terms of time and space scales, climate, data requirements and type of application, and explore reasons for the model performances in terms of hydrological insights and climate-soil-vegetation-topography controls."

The societal relevance of PUB

However, PUB also had a higher ambition. It was felt that focusing on a grand problem such as PUB, that had to draw heavily on new fundamental and theoretical advances in hydrology and associated Earth system sciences to address the immediate problem-solving needs of society, had the potential benefit of enabling hydrology to meet both its scientific and societal obligations. In other words, PUB was also seen as the vehicle to advance and revitalize the science of hydrology. Indeed, over the past decade, the PUB community has made huge strides in advancing both predictive capability and fundamental understanding of hydrological processes by working together in a concerted and coordinated manner. The PUB effort has helped to challenge long-held assumptions and to question common paradigms, and has increased the constructive dialogue between different sub-disciplines and schools of thought.

The synthesis report

An important output of the PUB decade is the synthesis report coordinated by Günter Blöschl. The book started as a PUB benchmark report, but over time metamorphosed into a synthesis, mainly building on a comparative assessment of thousands of studies from around the world, with predictive uncertainty assessed along the axes of processes, places and scales, and interpreted hydrologically. The literature on the current state of the art of runoff predictions, in terms of the various signatures, was reviewed by over 150 contributing authors, and organized into several chapters. The painstaking task of comparative assessment was carried out by several able assistants in Vienna, who toiled hard to do the analyses and generate new insights from them, with the support of several of the book contributors as well as the cooperation of scores of the original study authors, who provided the data sources needed for the assessment. Every chapter went through numerous revisions by the contributors themselves, and then by the editors, as part of the overall synthesis effort.

The contents of this book, in a sense, reflect the lessons learned from the diversity offered by nature's own experiments, as expressed through the thousands of studies surveyed in this book. Through its comparative performance assessment of methods across processes, places and scales, the book takes an approach to generalization through learning from the differences and similarities between catchments around the world. It throws light on the status of PUB at the present and can serve as a benchmark against which future progress can be judged. Along the way the book has generated a new scientific framework that potentially can guide future efforts aimed at improving runoff predictions in ungauged basins and advancing the science of hydrology. This proposed new framework centres on a higher-level synthesis of what we can learn from individual places with generalized understanding gained from comparing the differences between different places, thus benefiting from the legacies of co-evolution.

PUB closure

During the Delft conference (October 2012) the book will be presented, as well as the PUB manual coordinated by John Pomeroy and containing practical guidelines on how to "put PUB into practice". With these two books a very successful decade, vibrant with new initiatives and enthusiasm, has come to a close. The decade strongly established hydrology as an integrated Earth science with high societal relevance and it brought much new energy to the hydrological community as a whole. We look forward to the new research initiative of IAHS for the following decade and hope that it will be as stimulating to the next generation of hydrologists as the previous decade has been.

Hubert Savenije
PUB Chair 2011–2012

Run-off Prediction in Ungauged Basins:
Synthesis across Processes, Places and Scales
Edited by: G. Blöschl, M. Sivapalan, T. Wagener, A. Viglione & H. Savenije.
Available April 2013 from Cambridge University Press, ISBN 9781107028180

Putting PUB into Practice
Edited by J. Pomeroy *et al.* (in preparation). to be published by CWRA with IAHS.

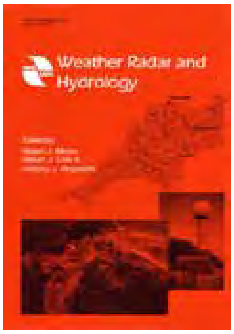
IAHS Press

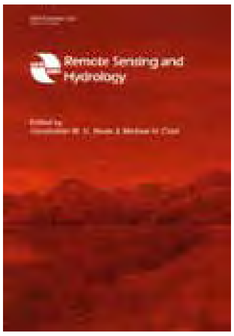
Three book series, Red Books (*Proceedings and Reports*), Blue Books (*Special Publications*) and *IAHS Benchmark Papers in Hydrology*, are published by IAHS Press, in addition to *Hydrological Sciences Journal* (*HSJ*). Up to now 356, ten and eight volumes of Red, Blue and Benchmark books have been published, respectively. The standing and audience of *HSJ*, grew when it first went online in 2005, but have increased considerably again since 2010 when the publishing partnership with Taylor & Francis (T&F) commenced. (Enquiries regarding library/ institutional access to *HSJ* should be directed to T&F.)

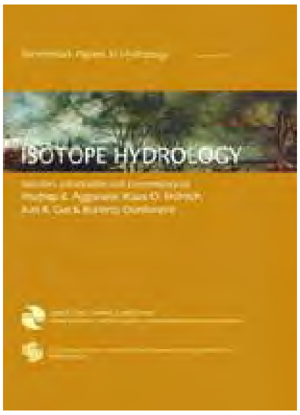
The IAHS Press office at CEH Wallingford, UK, consists of four staff who manage the editorial work for *HSJ*, as well as book production, enquiries, marketing, sales and distribution, and IAHS Press representation at relevant conferences worldwide. The IAHS Newsletter, also produced by IAHS Press, is circulated to all registered members three times a year via an eNews facility. Members also receive alerts about new books, conferences/meetings and other relevant information from third parties. The online IAHS bookshop was developed recently. In addition, customers in North America now have the option to order IAHS publications via www.amazon.com. A new IAHS web site is currently in development and this will incorporate many new features, including the online bookshop.

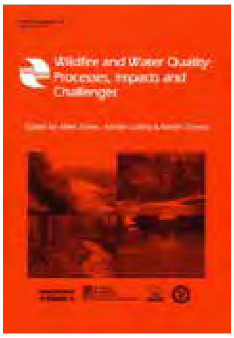
All older publications (i.e. published between 1924 and 2004) in the Red Book and the Blue Book series are available to view/download as pdfs at the IAHS website. Abstracts of all papers in newer volumes are also available.

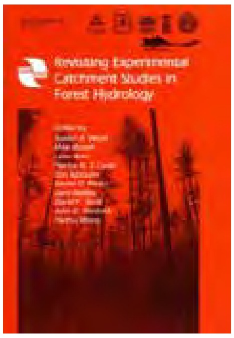
The IAHS Benchmark Papers in Hydrology Series published its eighth title *Isotope Hydrology*, in 2012. This, and the earlier volumes are unique in that each brings together the seminal papers that chartered the development of a specific topic in hydrology — some papers published over 100 years ago — with commentaries explaining their significance.











Clockwise from top: *HSJ*, IAHS Special Publ. 10, IAHS Publs 351, 352, 353, 354, IAHS Benchmark 8.

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