Xth Kovacs Colloquium /
Xième Colloque Kovacs
Paris 2-3 July / *Juillet* 2010

The Tenth IHP/IAHS George Kovacs Colloquium preceding the 19th Session of the Intergovernmental Council of the International Hydrological Programme of UNESCO, will be held at UNESCO, Paris from 2-3 July 2010. This Colloquium is the continuation of a series of biannual international scientific meetings organised jointly by the International Hydrological Programme (IHP) of UNESCO and the International Association of Hydrological Sciences (IAHS) in the most challenging fields of water resources research. These meetings commemorate the late George Kovacs, an established authority on hydrology, who served as Chairman of the Intergovernmental Council of IHP and as Secretary General and President of IAHS.

The theme of the forthcoming Colloquium will be :

Hydrocomplexity: New Tools for Solving Wicked Water Problems

Internationally it is recognized that the human activities have become major drivers of change in the Earth's biosphere. The resulting deterioration of water quality, overexploitation of freshwater resources, adverse effects of hydrological hazards and landscape degradation, as well as sectoral management solutions, pose serious risks to human health and development. The same activities also affect the functioning of ecosystems and their ability to provide goods and services, on which human well-being depends. There is a need for community based trans-disciplinary management tools to provide a better understanding of water as both an abiotic resource and as a service delivered by ecosystems. This colloquium aims to exemplify emerging tools to solve complex water issues in variety of ecosystems and climatic zones using examples from a number of countries. There are three key objectives of this colloquium:

- Synthesize complex water systems in different geographical settings.
- Show how tools describing interrelationships between the hydrological cycle, livelihoods and ecosystems can contribute to more cost-effective and environmental-friendly water management.
- Highlight systems solutions and technology transfer opportunities through North-South and South-South linkages.

Invited speakers will deliver presentations on the state-of-the-art of aspects of the hydrocomplexity and tools which identify areas where gaps exist and outline areas for future research and application. Open discussions will then take place. In addition to the technically water-orientated contributions, the programme will include more general methodological presentations of the underlying concepts from policy and water management perspectives. Such perspectives will be the basis for establishing the practical questions to be addressed by water management tools and to explore new horizons in trans-disciplinary water sciences.

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Lotta Andersson is a research hydrologist at the Hydrological Division of Research and Development, Swedish Meteorological and Hydrological Institute and professor at the Department of Water and Environmental Studies, Linköping University. She achieved a PhD in 1989 with the thesis "*"Ecohydrological Water Flow Analysis of a Swedish Landscape in a 100 Year Perspective",* and became reader in 2001. Her fields of interest include catchment modeling of water flow and nutrients due to natural variability and human impact, with emphasis on the use of models as facilitators in stakeholder dialogues. At SMHI she is also responsible for national cooperation related to the EU WFD. She has a long experience in project management, with emphasis on projects in Sweden in the field of eutrophication and in Southern Africa in the field of water and climate change. She has published approximately 30 publications in peer-reviewed journals, 30 reviewed conference proceeding contributions, and 25 contributions to reports and books. She has also been active in national, as well as international scientific evaluations. Since 2002 she has been responsible for the secretariat of the Swedish IHP committee, and active in the UNESCO HELP programme.

Use of participatory scenario modelling as platforms in stakeholder dialogues

Lotta Andersson

The relationship between science and society has been widely debated in recent years. Related to environmental challenges, such as climate change and eutrophication, the use of models as a scenario tool for local planning of mitigation and adaptation is still more an exception than a rule. It has been suggested that modelling only will assist in environmental planning if the validity of used assumptions and presented results are tested and ratified by local actors. In this paper, experiences from two participatory research projects are discussed. In the first project, the aim was to assess how hydrological models can be used in stakeholder dialogues with emphasis on reduction of nitrogen and phosphorus loads in local lakes and the coastal zone. The second project aimed to assess how various stakeholders perceive climate induced risks on water allocation, farming and the environment, and with what means adaptation to such risks can be met. Following the experiences of these projects, attention is paid to how participatory processes related to environmental challenges can be organised. In both projects hydrological models have been used as a platform for communication among different stakeholder groups and scientists. Model facilitated dialogues, as defined in this paper, implies modelling *with* people, in contrast to agent based modelling which is based on modelling *of* peoples' behaviour and its consequences. Firstly, it is asked *why* stakeholder groups should be involved in matters of hydrological modelling. In the second section we make use of examples from the two projects to discuss *how* these theoretical imperatives can be translated into practice. Finally, it is asked *when* participatory modelling makes sense.

Fabrizio Fenicia is currently working as a senior researcher at the Gabriel Lippman Research Center (Luxembourg) in the field of environmental modelling. He studied Environmental Engineering at the University “La Sapienza” in Rome, where he graduated with distinction. He started specializing in hydrology during his master thesis, which was conducted at the University of Bodenkultur in Vienna. After graduation he studied for a Ph.D. in collaboration with the Technical University in Delft (TU Delft) and the Gabriel Lippmann Institute in Luxembourg. He graduated with distinction in 2008 with a thesis entitled ‘Understanding catchment behaviour through model concept improvement’. He was visiting scholar at the Forest Engineering department of the Oregon State University in USA, where he worked on conceptual aspects of the modelling process. He published several papers in peer reviewed journals and participated at several international conferences, including EGU, AGU and IAHS assemblies. He is also involved in education, contributing to the course of Hydrological Modelling at TU Delft. He received several acknowledgments including a best student paper award at the AGU assembly in 2006 and a best master thesis award in environmental engineering in 2001.

How to match accuracy and predictive capability in hydrological model development

F. Fenicia (1), H.H.G. Savenije (2), D. Kavetski (3)
(1) CRP – Gabriel Lippmann, Luxembourg
(2) Delft University of Technology, the Netherlands
(3) University of Newcastle, Australia

Hydrological models need to satisfy several requirements in order to be useful in scientific and practical applications. These conditions concern the identifiably of model parameters, accuracy of model predictions, and model realism. Each case study is often unique in respect of data availability, study area, and purpose of the model application. As a consequence, models that may work well for a given condition may not be appropriate for others. In order to face this problem, we here present a flexible approach for model development and testing. This approach provides unlimited flexibility to the development of different model configurations, allowing the user to test and compare different hypotheses of system behavior. In the specific case, we show how this approach, combined with several diagnostic tools, allows matching desired level of accuracy, and desired conditions of parameter identifiability. This balance, together with an assessment of model realism, is crucial for the development of models that, besides representing past catchment behavior, can be useful in prediction.

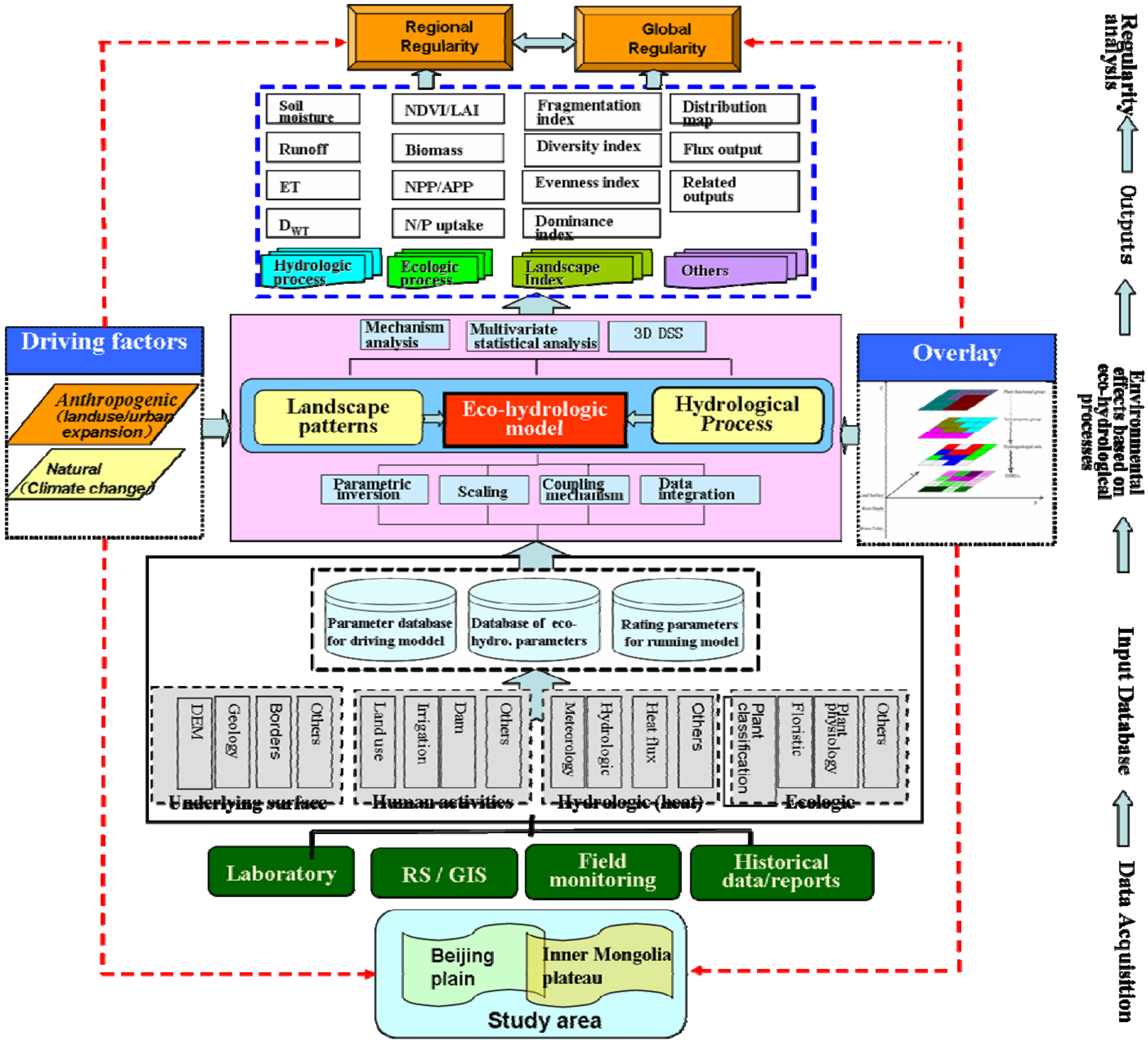
Huili Gong is the Vice President of the Capital Normal University China, Academician of the Russian Engineering Academy, member of the international steering committee of the eco-hydrology programme in the 7th Phase of the International Hydrological Program of UNESCO (UNESCO, IHP Ⅶ). He received his Ph.D. in hydrogeology from Jilin University in 1996. During 1996-1998, he worked as a postdoctoral at the institute of Remote Sensing in Peking University. As the principal investigator in a number of projects, Prof. Gong is responsible for the integrated system design, coupled model set-up and integration design of multi-technology of remote sensing. As an advanced visiting scholar, he went to Western Washington University, United States in 2001. He was a key member of groundwater survey and numerical simulation work in Changchun, Beijing, Zhengzhou and other places in China. In recent years, Prof. Gong has carried out a number of water ecology and wetland studies in the Beijing area, with support of a variety of remote sensing and geo-information technology. He is a key Chinese researcher with academic and scientific experience in the area of numerical groundwater model, eco-hydrology system interaction and model establishment in response to quantitative analysis. Prof. Gong has undertaken and completed a number of major research projects, such as the National Natural Science Foundation of China (NSFC), National Basic Research Program of China (973 Program), National High Technology Research and Development Program of China (863 Program) supported by the National Science Fund Committee, Ministry of Science and Technology, Chinese Academy of Sciences respectively. With good academic reputation, he has published over 120 research papers (including 21 SCI/EI indexed papers) in high academic level journals overseas. Professor Gong has won many scientific and technological prizes at the national, provincial and ministerial levels.

Eco-hydrology of the North China- the integrated monitoring & modelling challenges

Huili Gong, Jing Zhang, Yun Pan

The driving factors such as natural and human disturbances (e.g. urban expansion) are changing ecosystem responses dramatically on years to decades timescales. Especially in recent years, eco-hydrological systems in North China (including Inner Mongolia and area around Beijing) has been facing several key issues such as wetland shrinking, water table decline, degrading water quality, grassland deterioiration, urban heat island effect, etc.. These issues make it essential to consider dual stresses, including not only the interactive processes of hydrology and ecology, but also the social dependence. Thus, the interdisciplinary or trans-disciplinary challenge requires an integration of various information, knowledge and techniques for making ecohydrology-based development strategy. In this study, the current conditions and problems of eco-hydrology in Northern China are reviewed. An interdisciplinary framework is proposed for future research, which is incorporating three systems (RS, GIS and GPS) to extract hydro-ecological environment information. It is also facilitating coupling of eco-hydrological models with different scale and resolution to simulate the regional environmental change over years under impacts of climate, agricultural, and ecology. Also, the remote sensing monitoring and spatial data acquisition and application of geo-information techniques of resources and eco-environment around Beijing area are introduced. It will mainly focus on how to acquire spatial-temporal eco-hydrological information and represent it in three-dimensional manner. It is expected to provide a visible and digital support for integrated and interactive watershed management. The spatial interactive characteristics enable it to be used for eco-hydrological education for public, which will greatly improve public's understanding of eco-hydrology. The aims of proposed research plan are to reveal the process and mechanism of regional hydrological changes over long-term scale in the suburbs and metropolitan area, and determine the functionality and correlation between the process of water circle under controlled environment and the response of vegetation growth. The framework (Figure-1) provides an advanced research plan for hydrology and ecology, as well as integration with modern information technology. It is of great significance to establish a regional sustainable development pattern to balance regional development and protection of aquatic natural resources.

Keywords- Ecosystems; RS; GIS; Eco-Hydrological Model; Human Disturbance


Regional Regularity
Global Regularity
Soil moisture
Runoff
ET
D_{WT}
NDVI/LAI
Biomass
NPP/APP
N/P uptake
Fragmentation index
Diversity index
Evenness index
Dominance index
Distribution map
Flux output
Related outputs
Hydrologic process
Ecologic process
Landscape Index
Others
Driving factors
Anthropogenic (landuse/urban expansion)
Natural (Climate change)
Mechanism analysis
Multivariate statistical analysis
3D DSS
Landscape patterns
Eco-hydrologic model
Hydrological Process
Parametric inversion
Scaling
Coupling mechanism
Data integration
Overlay
Parameter database for driving moddel
Database of eco-hydro. parameters
Rating parameters for running model
DEM
Geology
Borders
Others
Underlying surface
Land use
Irrigation
Dam
Others
Human activities
Meteorology
Hydrologic
Heat flux
Others
Hydrologic (heat)
Plant classification
Floristic
Plant physiology
Others
Ecologic
Laboratory
RS / GIS
Field monitoring
Historical data/reports
Beijing plain
Inner Mongolia plateau
Study area
Regularity analysis
Outputs
Environmental effects based on eco-hydrological processes
Input Database
Data Acquisition

Hector Malano has 35 years of experience in water resources education and research. His main areas of research expertise and interest lie in river basin management, water cycle management (urban & rural) water allocation and operation of water resources systems and management and operation of irrigation systems. He has taught undergraduate and post-graduate subjects in water resources development and management, irrigation systems design, management, operation and maintenance of irrigation schemes. He has supervised over 60 post-graduate students. He has led several major research projects in Australia and overseas involving large teams of interdisciplinary researchers in the areas of water allocation and economic modelling, computer assisted operation modelling and water cycle modelling of rural and urban catchments. Prof Malano has authored and co-authored over 150 papers and is a past Vice-President of International Commission on Irrigation and Drainage and has carried out a number of domestic and international technical advisory assignments for overseas including the Australian Centre for International Agricultural Research (ACIAR), the Agency for International Development (USA), the World Bank (USA), the Food and Agriculture Organisation of the UN (FAO) in countries including Morocco, Thailand, China, USA, Vietnam, Sri Lanka & India. He is currently the Head of the Department of Civil and Environmental Engineering at the University of Melbourne, Australia.

Integrating Modelling and Decision Making in Water Resource Management

Hector M Malano

Growing water diversions for economic uses are increasingly stressing many river basins, compromising the integrity of aquatic ecosystems by depriving them of the minimum sustainable flow and increasing risk of water shortages and water security for economic activities. At present, irrigated agriculture consumes a large percentage of water diversions with about 280 million hectares of irrigated land. Sixty percent of these diversions are used consumptively while the rest become return flow downstream. Other economic uses including potable, municipal, industrial, hydropower generation and recreation account globally for about 30% of the total diversions although t the consumptive portion is rather small as most of these diversions are returned to water bodies often with lower quality than when diverted.

A large amount of effort has been made in the past to better understand surface and groundwater hydrologic processes. However, very little of this immense fount of knowledge is incorporated by planners and managers into the process of managing water resources.

Water resource managers must make water management decisions to satisfy three main objectives – Environmental, Economic & Social – Very often, a single discipline addresses one of these objectives in isolation and often in competition with the others. Addressing these three objectives conjointly requires an integrated-multidisciplinary approach to analysing alternative management options (scenarios). The use of scenarios as predicting planning tools must form an essential part of the decision support framework to inform water management decisions. Scenario development entails constructing an explicit story about how the future may unfold. Water management scenarios must be defined through an interactive process that usually involves modellers and stakeholders. Scenario planning requires strong and committed stakeholders to decide which alternatives appear more plausible. This paper posits that the main stumbling block for improved adoption lies in the lack of integration between scientific disciplines and between scientists and stakeholders.

In this paper, an integrated-interdisciplinary framework for modelling decision support including biophysical, environmental (ecologic) and social aspects is discussed. The proposed integrative framework centres around the integration of the modelling components with decision making stakeholders in a “scenario planning’ context. The role of the emerging discipline of implementation and integration science is also discussed. The paper will also discuss case studies involving the application of this framework in Australia and India.

Yasuro Nakajo is the Executive Vice President of the Japan Water Agency. He has played a key role in water management in a number of positions as highlighted below:

Career: 1974: Graduate, Faculty of Agriculture, The University of Tokyo
1974: Central Government Officer, Ministry of Agriculture, Forestry and Fisheries (MAFF)
1983: Director, First Construction Works Division,
Oyodogawa Agricultural Water Utilization Office,
Kyushu Regional Agricultural Administration Office, MAFF
1984: Land Improvement Engineering Office,
Kanto Regional Agricultural Administration Office, MAFF
1985: Senior Investigator for Land Improvement District, Administrative Division,
Agricultural Policy Department, Agricultural Structure Improvement Bureau, MAFF
1985: First Secretary, Embassy of Japan, Philippines
1988: Deputy Director (Administration Group), Administration Division,
Agricultural Structure Improvement Bureau, MAFF
1990: Director, Farmland Division, Farmland and Forest Department, Toyama Prefecture
1992: Counselor, Farmland and Forest Department, Toyama Prefecture
1993: Director, Design Division, Construction Department,
Kinki Regional Agricultural Administration Office, MAFF
1995: Senior Investigator for Government Enterprise, Water Utilization Division,
Construction Department, Agricultural Structure Improvement Bureau, MAFF
1997: Senior Investigator for Engineering, Design Division, Construction Department,
Agricultural Structure Improvement Bureau, MAFF
1998: Chief Deputy Director for Agricultural Engineering, Design Division,
Construction Department, Agricultural Structure Improvement Bureau, MAFF
1999: Director, Water Utilization Division, Construction Department,
Agricultural Structure Improvement Bureau, MAFF
2000: Director, Design Division, Construction Department,
Agricultural Structure Improvement Bureau, MAFF
2002: Director General, Rural Infrastructure Department, Rural Development Bureau, MAFF
2004: Deputy Director General, Rural Development Bureau, MAFF
2007: Director General, Rural Development Bureau, MAFF
2009: Executive Vice President, Incorporated Administrative Agency, Japan Water Agency

Spiral approach to IWRM - IWRM Guidelines at River Basin Level

Yasuro Nakajo

This presentation will focus on the application of IWRM at the river basin level. It will introduce Integrated River Basin Management (IWRM) Guidelines at River Basin Level which were launched the third United Nations World Water Development Report (WWDR-3) at the Fifth World Water Forum in March 2009 in Istanbul, Turkey. The purpose of developing these Guidelines is to raise awareness on the importance of integrated approach of water resources management at the river basin level and to address the practical implementation of IWRM. These Guidelines provide the necessary information to help practitioners implement IWRM in line with their own set of own circumstances. They consist of the fundamental concepts of IWRM as well as provide insights into the perspectives of various stakeholders with regard to water issues, keys for success for overcoming problems, and good examples where such keys for success were applied. Think of it is an instruction manual that synthesizes practical methodologies for IWRM to help implement IWRM at the river basin level. IWRM is essentially a user-friendly and cooperative approach that is an alternative to the activities previously carried out by individual water sectors acting in their own interests, with very little interaction with one another. The Guidelines invite each sector to fruitfully participate and cooperate in IWRM, with a practical road map so as to contribute to achieving both private and public benefits in a sustainable manner. A river basin approach in the implementation of IWRM is being recognized as a comprehensive basis for managing water resources more sustainably and will thus lead to social, economic, and environmental benefits. However, actual progress towards implementing IWRM varies enormously and depends on the area, capacity, political will, and the understanding of IWRM concepts and their implementation. Hence, the Guidelines have been split up into seperate stand-alone parts. They have been designed to enable readers to go to specific sections of the publications depending on their specific needs and circumstances without necessarily having to read the entire document

This presentation will introduce the ‘Spiral model’ and ‘Keys for success’ which are the key features of the IWRM Guidelines at the River Basin Level. The evolutionary, adaptive implementation of the IWRM process is illustrated by ‘Spiral model’. And ‘Keys for success’ can be used for overcoming difficult situations at each step in the practical process that begins with ‘Recognizing/Identifying’ pressing issues or needs, then ‘Conceptualizing’ the problem itself and formulating possible solutions, ‘Coordination and Planning’ among stakeholders in order to reach an agreement, and ‘Implementing/Monitoring/Evaluating’ the plan and its outcomes. This paper is an introduction of the Guidelines and a report of the progressing related activities for capacity development.

Saket Pande is a hydrologist and a resource economist at the Center for World Food Studies (SOW-VU) at VU University Amsterdam. He has advanced education in both Hydrology and Economics, and has expertise in the fundamentals of Hydrology, Applied Probability Theory, Economic Theory, and their intersections in real-world applications.

In recent years Saket has been extensively researching on how fundamentals of applied probability can explain the issues underlying calibration uncertainty in water systems, especially in basin scale hydrology. He has shown that control on hydrologic model complexity can lead to robust prediction performance in applications ranging from short term canal management to stream flow prediction for multiple river basins. He has also been studying the impacts of hydrologic uncertainty on economic systems. Using his advanced training in economics, Saket has also researched into temporal dynamics of individual decision-making as well as into the fundamentals of welfare economics.

Saket has extensive experience in working in multidisciplinary teams on topics such as uncertainty implications of climate change on water availability, food production and human wellbeing in developing countries like Benin and Ethiopia. Saket has been involved in development of innovative statistical and GIS tools for integrating data of different kinds, be it by resolution or source, into a unified modeling framework. Most recently Saket has been involved in mathematically conceptualizing basin level decentralized water management for arid areas in India and consequently has developed parsimonious conceptual models at monthly time step that conceptualizes relevant dominant processes. Saket's overarching aim is to use his diverse training to solve real-world problems that are interdisciplinary in nature.

A parsimonious model approach for water management in dryland areas

S Pande

This presentation deals with development of parsimonious models for water management in dry land areas. One major motivation for such an approach is data scarcity in many dryland areas of the world, inhabited by mostly vulnerable population. Such an approach can therefore prove valuable in devising water management strategies for poverty alleviation and human development. The approach will be to capture dominant processes of dryland areas in a model that can then mimick moisture evolution reliably. A delicate balance has to be maintained between model representation of dominant process and minimal data availability. This is achieved by process conceptualization that has minimal set of parameters but sufficient to represent the dominant processes while avoiding over-parameterization given small amount of data available.

Two processes, evaporation and subsurface flows, which are generally dominant in dryland areas are modeled at monthly time steps for two states of Gujarat and Rajasthan in western India. These two states are delineated into basins (that further comprise of interconnected subbasins) using a Digital Elevation Model. The interconnected sub-basins are then represented by interconnected linear (in storage-discharge relationship) reservoirs, and each reservoir is parameterized to represent the two fluxes. These parameters are then estimated based on GRACE (terrestrial storage change) and MERRA2D (evaporation flux) data simultaneously. These two data sets allow orthogonalization of information on the two fluxes, thereby controlling for parameter interactions (and hence identifiability). Finally, parsimony in parameters of the overall model of interconnected linear reservoirs is achieved by regionalizing recession parameters in terms of soil characteristics of the study area.

This study elicits an approach to model water balance at monthly scale in dryland areas with minimal data needs and based on satellite derived data sets. The approach utilizes simplicity in representing dryland areas at monthly time steps. Such an approach is urgently needed given livelihood of many poor depends on agriculture in such areas and when water scarcity and poverty alleviation remain one of the biggest challenges of this millennium.

Sandhya Samarasinghe is an Associate Professor at the Department of Environmental Management and a Founding Member of the Centre for Advanced Computational Solutions (C-fACS) at Lincoln University in New Zealand. She was awarded a scholarship to do an MSc Degree in Mechanical Engineering which she completed with Honours at the Patrice Lumumba International Friendship University in Moscow, former Soviet Union, where she also received the best student of the year award several years. Soon after, she won another scholarship to pursue a Masters Degree in Wood Engineering and Mechanics at the Department of Wood Science at Virginia Tech, USA. As part of her research, she developed a computer simulation model of the structural performance of wood pallets which is still in use in the pallet industry in the USA. The success of her Masters degree led to the award of a PhD scholarship by Virginia Tech, during which she was invited to the membership of the Virginia Tech Civil Engineering Honor Society based on outstanding grades. After completion of her PhD, she was offered a Postdoctoral position at the Centre for Computing and Biometrics at Lincoln University, New Zealand, to pursue research on Expert Systems and Artificial Intelligence. Through this research, she was awarded the largest ever research grant given by a New Zealand Company to a university by Transpower NZ Ltd. for intelligent automation of the control, fault diagnosis and restoration of the New Zealand power transmission network, spanning 11 years through her academic career as a Lecturer and Senior Lecturer in the Department of Natural Resources Engineering at Lincoln University in New Zealand. This work featured on TV and 33 other national and international media. She developed her expertise in theory and application of Neural Networks and Soft Systems in Natural Resources Engineering (land, water, environment) and Applied Sciences that culminated in the award of a book contract and the publication of her book entitled: Neural Networks for Applied Sciences and Engineering: From fundamentals to Complex Pattern Recognition (570 pages), by Taylor and Francis Inc. (USA) in 2006. She has published widely in many areas of engineering and sciences, served on Editorial Boards of many conferences, chaired conference sessions, won best conference paper awards, attracted large research grants, has spent 6-month sabbatical visits at Stanford University, USA, Princeton University, USA and Oxford University in the UK and maintains active international collaborations in Systems Modelling. She is cited in Who’s Who in the World and Who’s Who of Women in the World.

Neural networks for water systems analysis: From fundamentals to complex pattern recognition

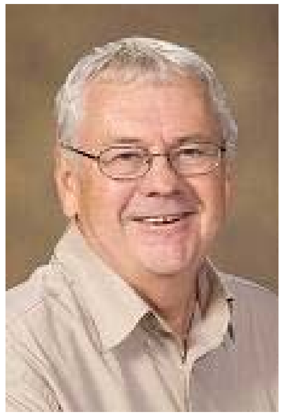
Sandhya Samarasinghe

Hydrological processes are characterised by high complexity, dynamism, and non-linear multiple-variable interactions in both spatial and temporal scales. Lack of physical understanding of the complexity of these processes has hampered the development of efficient models to study their behaviour and manage water resources effectively. Last decade has seen an increasing number of applications world-wide of Artificial Neural Networks (ANN) in modelling hydrological processes and water resources management. In 2001, for example, a group of Italian researchers proposed to the Italian Government and got funded a Neural Networks Initiative for Environmental Data Processing with one of the objectives being the development of powerful prediction tools for water resources management. Clearly, ANN has emerged as a promising approach to address some of the complex issues in water resources. This is mainly due to their ability to nonlinearly relate input and output variables in complex dynamical systems and their ability to capture and retain past memory of the system behaviour without needing a detailed understanding of the physics of the processes involved.

Broad categories of areas of successful applications of ANN in water resources include (i) forecasting- river flows, snowmelt runoff, rainfall, and lake level fluctuations; (ii) flood forecasting and management; (iii) hydrologic regionalisation; (iv) groundwater level forecasting, aquifer parameter estimation, and the effect of ground water over-exploitation; (iv) optimal operation of reservoirs and reservoir networks; (v) drought management, water demand forecasting and evaporation estimation; (vi) river salinity forecasting, water quality assessment and monitoring; and (vi) impact of climate change on water supplies.

A neural network consists of a number of computational units called neurons capable of local linear or nonlinear information processing. These are organised in layers in a highly parallel network in such a way that inputs flowing through the network can interact nonlinearly developing complex input-output mapping functions to any desired degree of accuracy. Three major types of networks used widely in water resources are multiple layer perceptrons (MLP), recurrent networks (RNN), and self organising maps (SOM); along with hybridisation of these as well as their variants. MLP is a powerful multivariate nonlinear regressor; RNN automatically embeds time (memory) into a network and are useful for time-series forecasting with or without exogenous variables; and SOM is a nonlinear unsupervised clustering approach that reveals clusters in the data while preserving the proximity (relationships) of the clusters. In this paper, an overview of these networks along with current modelling issues are presented followed by a case study of an ANN application to hydrologic regionalisation (HR), incorporating Geographic Information Systems (GIS), for estimating flows in an ungauged river in a 6-river basin catchment in New Zealand.

Accurate river flow estimation is difficult but is essential for optimal management of water resources. Problem is exacerbated when some rivers in a catchment are not gauged. HR can be used for estimating flows in ungauged rivers. In the past, a 2-step process involving regression has been used where models relating hydrologic variables to flows are developed for the gauged rivers in the first step, and the model parameters are related to the geomorphological characteristics in the second step in order to obtain accurate parameters for the ungauged rivers. Recently, a single step model involving ANN using both hydrologic and geomorphological variables together has been shown to be superior to both one step and two-step regression. In our study, one-step ANN with model refinement using genetic optimisation and SOM-based network pruning has been used to further simplify model structure and improve generalisation. Results show that accurate and parsimonious ANN models can be developed for flow estimation based on HR using efficient model refinement methods.



Jim Shuttleworth's major research interests are in physical processes in hydrology, with emphasis on evaporation and hydrometerology as applied to environment change at local, regional. and gloal scales, the application of remote sensing methods within hydrology, improving weather and climate prediction, and the micrometerology of natural and agricultural vegetation, including improving estimates of irrigated crop water requirements. Dr. Shuttleworth, who is a Regents' Professor in both the Department of Hydrology and Water Resources and the Atmospheric Sciences Department, has served on numerous national and international scientific advisory committees, including the National Research Council, the International Council of Scientific Unions, the international Hydrology Programme, the International Geosphere-Biosphere Programme, and the World Climate Research Programme. He is a Fellow of American Geophysical Union, the american Meteorological Society, and Royal Meteorological Society and is a lifetime member of the British Hydrological Society and the European Geophysical Society. Dr. Shuttlleworth holds a Ph.D. in High Energy Nuclear Physics and a D.Sc. from Manchester University in the UK. In 201 Dr. Shuttleworth was awared the AGU Hydrology Prize for "Outstanding contributions to the science of hydrology" and in 2006 IAHS, UNESCO and WMO jointly awarded Dr. Shuttleworth the prestigious International Hydrology Prize in recognition of his "innovative, international leadership over more than thirty years, contributing to the growth of hydrology into a major discipline of earth system science."

Back to Basics: On relating pan to reference crop evaporation rates

W. James Shuttleworth

When not all the weather variables needed to calculate reference crop evaporation rate are available, an estimate may have to be made by scaling down the measured evaporation loss from an evaporation pan by a “pan factor”. In the past the value of this factor has been defined empirically but recent research into the basic physics which controls evaporation from the Class A evaporation pan results in a physically-based equation describing pan evaporation in terms of ambient climate variables. This equation has been verified experimentally and is, like that for reference crop evaporation, an implementation of the Penman-Monteith Equation. Combining the equations describing reference crop and pan evaporation yields a new theoretical definition of the pan factor. This paper uses the resulting expression for pan factor to investigate theoretically how ancillary measurements (or estimates) of wind speed and temperature that may be made at an evaporation pan site can be used to improve the accuracy of a pan-based estimate of reference crop evaporation. The universality of the theoretical description of pan factor and the value of ancillary measurements is then explored in the context of long term pan evaporation measurements made at seven sites in Australia where ancillary weather data are available. Recommendations are made regarding how best to use any available ancillary weather data to improve the accuracy of pan-based estimates of reference crop evaporation.

Eugene Z. Stakhiv is currently appointed as US Co-Director, International Joint Commission (IJC) Upper Great Lakes Study, a five year (2006-2012, $15M study) that will look for more sustainable ways of operating the Great Lakes under various climate scenarios. He is also Technical Director of the recently approved UNESCO International Center for Integrated Water Resources Management (ICIWaRM).

Dr. Stakhiv also recently completed a 5-year study, as Co-Director of the Lake Ontario-St. Lawrence Study for the International Joint Commission (2000-2006, $20M study with Canada) .He has been at the Corps of Engineers Institute for Water Resources (IWR) for 30 years, and is Senior International Water Advisor. He has also served as Scientific Attache to US UNESCO Ambassador in Paris (May – Aug, 2004). Dr. Stakhiv also served as Senior Advisor to Iraq's Ministry of Irrigation from April 13-Sep 20, 2003.

Before that, he was Chief, Planning, Policy and Special Studies Division, Institute for Water Resources (1990-2004). The division helps in formulating practical policies and procedures that the Corps needs to respond to legislation, Administration initiatives and scientific advances. Most of the Corps' national studies of the past decade, such as the National Wetlands Mitigation Study, National Drought Management Study, Federal Infrastructure Strategy and Corps' Shore Protection Study, and currently the National Shoreline Management Study have been conducted by his Division. He served as first Co-chair for IPCC-I Water Resources and Hydrology Committee, and as Lead Author for IPCC-II and IPCC-III. Dr. Stakhiv has extensive international experience, primarily with the World Bank, serving as senior advisor to the water Ministries of Bangladesh, Ukraine, Armenia, Iraq and the Aral Sea Basin countries. Eugene Stakhiv has spent his entire professional career of 40 years with the Corps, and has served as study manager for several large comprehensive river basin studies and metropolitan water supply studies, including Washington, DC and New York City. He has a doctorate in water resources systems engineering from Johns Hopkins University, and author of nearly 70 published papers and 150 technical reports.

Practical Approaches to Water Management Under Climate Change Uncertainty.

Eugene Z. Stakhiv

Water resources management is in a lengthy and difficult transition phase in attempting to accommodate the large uncertainties associated with climate change. Water is the principal medium through which most of the projected impacts of global warming will be felt and ameliorated – reflected through changes in, and requirements for improved management of aquatic ecosystems which supply such basic societal services as hydroelectric power, municipal and industrial water supply, agricultural irrigation, commercial navigation and water based recreation, as well as indirect uses such as nutrient recycling, climate regulation and flood and drought mitigation. There has been a significant amount of research and many studies addressed to overcoming the challenges of a variable and changing climate. However, many of the standard water management practices, based on assumptions of a stationary climate and variability, can be effectively extended to accommodate some aspects of climate uncertainty. Adaptations of various strategies developed by the water management profession to cope with contemporary uncertainties and climate variability can also be effectively employed during this transition period, as a new family of hydrological tools and better climate change models are developed.

Adaptive management and the 'precautionary principle', as practiced by water managers, which historically relied on a 'standards-based' approach rather than on economic optimization, are key concepts that are central to the management of the vast network of existing water infrastructure, including ecosystem infrastructure. The same principles hold for the large proportion of water management demands subject to rainfed agriculture. The keystone of adaptive management is much improved meteorological and hydrologic data networks. These must be coupled with substantial improvements in climate models, especially regional circulation models that can provide more reliable 30-, 60- and 90-day forecasts. These initiatives would considerably improve water management capabilities in dealing with extreme climate impacts (especially floods and droughts).

Better adaptation to flood and drought and contingency preparedness and recovery operations is essential, for these are the leading edge of any adaptive management strategy that is inherently geared to dealing with uncertainty of climate variability and change, and inherently dependent on better forecasting and real-time data collection and analysis. Improvements in seasonal and intra-annual forecasts would offer the greatest positive changes to a broad array of water management functions – especially for agricultural irrigation, which uses approximately 80% of the freshwater resources of the globe, together with rainfed agriculture, and is essential to sustaining most economies of the developing world.

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He cooperated with the National Institute of Standards and Technology in the area of testing and mixed signal fault diagnosis for eight years. He has been a visiting professor at University of Florence, Italy, and at Nanyang Technological University in Singapore. He has been a technical advisor and Senior Scientist at Magnolia Broadband Inc. He has been a consultant to Magnetek Corp. and Anteon Corporation, a General Dynamics Company. For several summers he was a visiting faculty at Wright Labs - Advanced Systems Research Group and at Redstone Arsenal - U.S. Army Test, Measurement, and Diagnostic Activity. For one year he held the position of an IPA fellow at Wright Research Labs, Automatic Target Recognition Group. He was a visiting researcher at ATT Bell Laboratories - VLSI Systems Research Group and Sarnoff Research Labs. - Mixed Signal VLSI Design Group.

His current research includes embodied machine intelligence, motivated goal driven learning, self-organizing associative spatio-temporal memories, active learning of sensory-motor interactions, machine consciousness, as well as applications of machine learning to autonomous robots and avatars.

Motivated Machine Learning for Water Resource Management

Janusz Starzyk

Water resources planning and management require problem resolution as well as optimized use of resources. It involves many decision makers and stakeholders and it affects economic development, quality of life, health and safety. Since many objectives in water management are conflicting, it is hard to devise one optimum strategy. Water resource management tools include simulation, optimization and multi-objective analysis. The question is how to design a simulation tools to support water decision making satisfying multiplicity of goals including multi-objective decisions.

The main objective of this paper is to suggest an integrated modeling framework that may assist with the time consuming and difficult tasks of decision making by water management practitioners and to harmonize economic uses of water resources. Integrated and effective machine learning platform may help to build effective partnerships between modelers and practitioners in the development and application of water management models and observe them in handling simulated crisis situations. Motivated machine learning that provides seamless support for intelligent decision making process in dynamically changing environment could be applied to consider alternative water management policies. It may be able to incorporate socio-cultural, political, economic and institutional elements that influence decision making, addressing non-dominated solutions.

In the motivated learning (ML) systems, different types of data received from the environment are associated and represented to build knowledge and the environmental model. This representation is validated through active interaction with the environment. Learning in such systems is incremental, with constant prediction of the input associations based on the emerging models and only new information is registered in the system memory. Knowledge is not entered into such systems, but rather is a result of their successful use in a given environment. ML provides natural support for multiple objective decision making, focusing on the most pressing issues in active search for balance between conflicting situations and adverse environmental conditions.

It is suggested to further extend ML approach and apply to practical and theoretical aspects of water management in changing environments where the existing methods fail or work with difficulty. For instance, using classical machine learning to predict the future for physical processes works only under the assumption that same processes will repeat. However, if a process changes beyond certain limits, the prediction will not be correct. The expectation is that ML systems may overcome this difficulty and that such systems can be trained to advice humans.

It is expected that this natural learning will lead to more accurate models for water related policies and actions, and trough active interaction with human expert will use the provided input data identifying factors that most contribute to water supply, use, contamination or policy making decisions. A case study of machine learning water management decisions will be presented in this paper to demonstrate the application of EI in facilitating the humans with modeling and water related decision making process. Technological challenges and promises of building machine-level intelligence will be discussed.

Richard Taylor is a Reader in Hydrogeology in the Department of Geography, University College London and, since 2002, has held an adjunct faculty position in the Department of Geology of Makerere University (Uganda). He graduated with a BSc in environmental chemistry from Queen's University (Canada) which was followed by PhD research at the University of Toronto examining the relationship between long-term environmental change and groundwater in Uganda. Since 1991, Richard Taylor has worked collaboratively with government ministries, non-governmental organisations (NGOs), and research institutions to improve water supply and sanitation facilities under a wide variety of conditions that include rebel insurgency in northern Uganda (1994 - 1995) and genocide in Rwanda (1994). His research interests revolve around the impact of climate variability and change on freshwater resources with a particular focus on the potential of groundwater to improve food security and to meet the demand for safe water in the context of rapid population growth and climate change in sub-Saharan Africa. He has led large, multidisciplinary hydrogeological and hydrological investigations in Africa and United Kingdom and been awarded contracts and fellowships for his research by the Department for International Development (UK), UK Research Councils, National Science Foundation (US), Natural Sciences and Engineering Research Council of Canada, The Royal Society (UK), Royal Geographical Society (UK), and International Development Research Centre (Canada). He is Co-Chair of the IAH Commission on Groundwater and Climate Change and a member of the panel of experts coordinating the global UNESCO-IHP GRAPHIC (Groundwater Resources Assessment under the Pressures of Humanity and Climate Change) Programme. He recently initiated, led and organised the international conference, Groundwater & Climate in Africa, held in Kampala (Uganda) in June 2008 that featured more than 300 participants from 36 countries including 24 countries in Africa. In all of his work, he has trained a large number of personnel from governments, NGOs and universities in low-income countries and the UK. The results of his diverse and interdisciplinary work have been published in leading international scientific journals and the popular press.

Groundwater and global hydrological change

Richard Taylor

As the world's largest accessible store of freshwater, groundwater plays a critical role in enabling communities to adapt to freshwater shortages derived from low or variable precipitation and high freshwater demand. As highlighted by the IPCC in 2001 (TAR) and 2007 (AR4), our knowledge of how groundwater systems respond to changes in climate and abstraction remains profoundly limited. Although new diagnostic tools such as the global aquifer map (WHYMAP) and satellite monitoring of changes in total water storage under the Gravity Recovery and Climate Experiment (GRACE) have recently been developed, their deployment is greatly constrained by a dearth of reliable and sustained observations of groundwater systems. Land-surface models (LSMs) embedded in General Circulation Models and offline macro-scale hydrological models (MacPDM, WaterGAP, VIC) continue to employ erroneously simplistic characterisations of groundwater systems due, in part, to the fact that there are no global or continental-scale datasets to test or tune these models. Structural modelling challenges such as long response times of some groundwater systems to hydrological change and substantial uncertainty in projections of precipitation and evapotranspiration persist. New insight regarding the relationship between global hydrological change and groundwater systems including the impacts of (1) changing rainfall intensity and snowmelt regimes on groundwater recharge, (2) sea-level rise on groundwater levels in coastal aquifers, and (3) intensive abstraction for irrigation on groundwater storage have recently been developed from basin-scale studies where reliable groundwater observations exist. These studies provide a compelling case for the expansion of groundwater monitoring networks and compilation of a global groundwater archive, comparable to that to other components of the hydrological system (e.g., WMO, GRDC, WGMS), to improve understanding and management of the groundwater system under global hydrological change.