Letter from the EGU President

The global water crisis and the emergence of socio-hydrology

In his quarterly message, the EGU President emphasises the need to work in an interdisciplinary way to understand the long-term interplay between the natural water system and the human water system, which is needed to address both local and global water issues.

The European Geosciences Union deals with many subjects that are of enormous relevance to society. Mineral resources, climate and natural hazards, to name a few, are high on the political agenda. It is clear that a better understanding of the underlying processes may lead to more informed and more efficient decision making. Water, hailed as one of the grand challenges facing humans in the modern era, is among the hot topics in the 21st century. What is referred to as the global water crisis summaries an issue people have to face in many parts of the world at the local scale. Globally, 1.1 billion people lack access to an improved water supply and 2.4 billion lack improved sanitation, with more than 3 million people dying per year as a result.

While drinking water and water for household consumption and industry are very often a local and regional problem, it is irrigation that dominates water use at the global scale. Still, on a global average, much more water is available than is actually consumed: about 6400 m³/yr/capita runs off in the water catchments of the world, with only a fraction of that being used by humans. However, this is just an average. The actual values of available water vary considerably in space and time: over the high and low runoff regions of the world, and through the high and low runoff seasons.

When water demand is greater than the available resource, as is the case in some areas of north-west India, China, northern Africa, and the southern United States, water scarcity prevails. If the consumption, measured as the water volume per year that is extracted from rivers and groundwater, exceeds the annual replenishment, the water use is unsustainable, leading to falling ground water tables and reduced streamflow. These trends may be exacerbated by population dynamics – increasing population translating in increases in water demand – and life-style changes. For example, in China the per capita meat consumption has increased almost threefold in the past three decades which has resulted in exponential increases in water demand.

Local and global water issues are naturally monitored by water managers, who have a portfolio of options to address them:

- Technical approaches, including more efficient irrigation methods (e.g. drip irrigation instead of sprinklers), water storage and water transfers (to balance the temporal and spatial variability of water availability), and sanitation measures.
- Organisational approaches of integrated water resource management, using only renewable resources (i.e. sustainable water use), cross-sectorial management strategies (e.g. agriculture, industry, households), and demand management (e.g. providing incentives to users to use less water).
- Economic approaches, such as water pricing, trading water permits and strengthening the economy. The latter is particularly relevant in areas where water scarcity is not due to a lack of freshwater resources but to an inability to use these resources efficiently due to economic reasons (such as in much of subsaharan Africa and parts of northern India).
- Political, legal and social approaches, where the focus is on setting up an appropriate governance structure to support integrated water resource management, strengthening the role of water management within relevant sectors, raising awareness of the role of water resources, and improving education.

In all of these approaches, the physical aspects of freshwater are only one component of the entire problem. They are closely intertwined with the human components associated with the technical, organisational, economic, political, legal and social facets of the issue.

Traditionally, the scenario approach has underpinned the decision making process in water management. Here, the term scenario is

Men and children withdraw water for irrigation in the Dogon plateau (Mali) during a sandstorm day. Ensuring the population has safe and sustainable access to water is one of the major challenges in the region. (Credit: Velio Coviello, distributed via imaggeo.egu.eu)

Historically, windmills have been used for keeping the water levels down in polders in the Netherlands. (Credit: Anna Nadolna, distributed via imaggeo.egu.eu)

used in the geoscientific sense: as a synonym for a forecast, or a number of alternative forecasts or projections each of which includes (rather than excludes) the main uncertainties. This kind of scenario approach is often used in water management with certain assumption on water demand, water availability, and their space-time distribution. On the basis of these scenarios (and other factors such as politics) decisions are taken to manage the water resources in some optimum way.

While the scenario approach has served us well for decades, there is now growing awareness that it may not embrace the full spectrum of the possible futures of the water system. Importantly, the human factors (technical, organisational, economic, political, legal and social aspects) are almost always prescribed as a boundary condition, i.e. as an external forcing. This does not allow for long-term, dynamic feedbacks between the natural water system and the human water system to be captured. However, in a planet where humans have changed almost all aspects of the world, these feedbacks may, in fact, be the main control on how the system evolves. We are living in the Anthropocene, the era when the human footprint is omnipresent, so treating humans as mere boundary conditions may be anachronistic and may not lead to desirable decisions. Natural scientists cannot continue to ignore the human factor.

Therefore, to understand water cycle dynamics over long timescales, we need to take into account the interactions and feedbacks with human systems. This new way of thinking, of treating humans as part of the system rather than as an external factor, has given rise to the emergence of 'socio-hydrology', a science aimed at understanding the dynamics and co-evolution of coupled human-water systems.

The defining characteristics of socio-hydrology over the traditional way of dealing with people and water are the following:

- Capturing feedbacks of the human-natural water system in a dynamic way, going beyond the traditional practice of prescribing human factors as external. The essence of socio-hydrology is the co-evolution of humans and water. A co-evolutionary system includes a general process of generating a 'new variation', with new variations or 'emergent behaviour' being brought about by feedbacks between processes at a range of scales. This may lead to exceedance of 'tipping points', which may result in systems evolving into new, potentially unobserved, states.
- Quantifying system dynamics in a generalisable way. The traditional scenario approach has always been context dependent and tailor made to the local conditions. While for the immediate decision making this is undoubtedly essential, for a more long-term view of the scientific approach one would hope to learn from other cases, to abstract a more uniform knowledge base. This knowledge base should be quantitative to go beyond the traditional practice of dealing with the human factors in a qualitative way. In fact, there have already been a few early attempts of proposing coupled differential equations to represent the system dynamics, including the social system.
- Not necessarily predictive. The coupled human-nature system is inherently non-linear and this non-linearity may prohibit full predictability. Lack of predictability doesn't come as a surprise if one looks at the history of humankind, so predictability should not, in fact, be expected. However, the socio-hydrologic approach may still be predictive in a statistical sense, as are other non-linear systems researched in the geosciences. Perhaps even more importantly, the emergent behaviour, the possible futures that would not easily be predicted by traditional forecasts, may prove extremely important for decision making, and very interesting from a scientific perspective in its own right.

Socio-hydrology may pursue a number of lines of enquiry. An historical perspective would be to learn from reconstructing and studying the past, while in comparative socio-hydrology one learns from the similarities and differences between catchments in different places. Process socio-hydrology, on the other hand, focuses on studying a small number of real human-water systems in detail to gain more fundamental insights into causal relationships.

The 21st century water problems are complex, involving feedbacks across multiple scales, sectors and agents. Addressing these complicated issues requires radical new ways of thinking and it is fundamental to focus on co-evolution and emergent patterns, without forgetting the unexpected. Socio-hydrology implies a change in the way we research and teach as humans begin to play a much bigger role in water cycle dynamics. To generate viable solutions to the water challenges we face today, it is fundamental to carry out such joint efforts.

Socio-hydrology embraces processes beyond the purely physical, chemical and biological relationships, shifting the science towards more holistic descriptions, with process interactions becoming increasingly important. In fact, there may be a lesson learned here for other geosciences beyond hydrology. The human imprint is certainly not limited to freshwater, it is omnipresent. Other areas of the geosciences within the EGU may face similar challenges. We need to work in an interdisciplinary way to understand the long-term interplay of humans and geoprocesses, which are needed to address a plethora of both local and global management issues. It may no longer suffice to treat humans as boundary conditions in an isolated way but as an integral part of the coupled human-nature system when advancing Earth system sciences in the Anthropocene.

Günter Blöschl
EGU President

Division reports

News brought to you from four EGU divisions

In each edition of GeoQ division presidents or deputy presidents contribute reports that update EGU members with news from their divisions. Issue 11 gives voice to Gerrit de Rooij (Hydrological Sciences), Shaun Lovejoy (Nonlinear Processes in Geosciences), Johan van der Molen (Ocean Sciences) and Özgür Karatekin (Planetary and Solar System Sciences).

HS Hydrological Sciences

For the first time, the 2014 General Assembly had a theme: The Face of the Earth. Hydrological processes clearly play their part in shaping this face but, nevertheless, much of the terrestrial water resides underground. The terrestrial hydrological cycle, including its subsurface components was beautifully illustrated by a demonstration model (a miniature hillslope and river valley with forests, pastures and crop lands) built and brought to Vienna by the Leibniz Centre for Agricultural Landscape Research in Müncheberg, Germany. In the model one could trace water raining down on 'the face of the Earth' as it infiltrated the soil, moved back to the atmosphere through plant root, stems and leaves, or percolated further downwards to reach the groundwater where it slowly flowed horizontally towards a river. Even a drinking water well was represented, illustrating the importance of groundwater as a source of high-quality drinking water.

The model illustrated many but not all facets of the Hydrological Sciences. These are impossible to cover by a single individual. The HS Division therefore has ten subdivisions, each headed by a subdivision chair who is responsible for the programme for the corresponding segment of hydrology. These men and women spend a lot of their free time shaping the programme but are less visible to many attendants than the convenors or the division president, and for that reason I would like to highlight their importance for generating the scientific backbone of the General Assembly experience.

The various disciplines in hydrology are looking to the future, and the start of 2013–2022 Hydrological Decade, initiated by the International Association of Hydrological Sciences was marked by a dedicated session entitled 'Panta Rhei: a vision and an agenda for the next 10 years of hydrological research in support of society'. The following is a report by the current Chair of Panta Rhei, Alberto Montanari, who proposed and organised the session.

"Panta Rhei is dedicated to research activities on change in hydrology and society. The purpose of Panta Rhei is to reach an improved interpretation of the processes governing the water cycle by focusing on their changing dynamics in connection with rapidly changing human systems. The practical aim of Panta Rhei is to improve our capability to make predictions of water-resource dynamics to support sustainable societal development in a changing environment. The concept implies a focus on the hydrological system as a changing interface between environment and society, whose dynamics

Model of the terrestrial hydrological cycle at the EGU 2014 General Assembly, by the Leibniz Centre for Agricultural Landscape Research. (Credit:Stephanie McClellan/EGU)

are essential to determine water security, human safety and development, and to set priorities for environmental management.

The session was very well attended and included six carefully selected speakers covering the breadth of hydrology: Hubert Savenije, Demetris Koutsoyiannis, Upmanu Lall, Berit Arheimer, Efi Foufoula-Georgiou, and Stefania Tamea. Their presentations were insightful and triggered vigorous discussions after each talk that the chairmen could hardly stop. The powerpoint slides of each talk can be downloaded from the Panta Rhei web site (www.iahs.info/pantarhei). The visionary session definitely contributed to set the basis for future research activities to address societal challenges related to water."

Gerrit de Rooij
HS Division President

NP Nonlinear Processes in Geosciences

Thanks to all your efforts, the Nonlinear Processes (NP) Division had a good year: the 2014 General Assembly featured 416 NP abstracts (a 10% increase from 2013) in 22 NP sessions with 7 more sessions co-organised with other divisions. In addition, two NP short courses were organised: 'Scale, scaling and multifractals in complex geosystems' by S. Lovejoy and D. Schertzer, and 'Complex systems methods for data analysis and modelling in geosciences' by R. Donner and J. Donges. NP notably benefited fom an exceptionally high success rate (52%) for General Assembly travel grants. The conference also honoured NP's Outstanding Student Poster awardee Hyeyum Hailey Shind, and the recipient of the 2014 Lewis Fry Richardson Medal, Olivier Talagrand.

I would like to especially recognise the help of the science officers (Stefano Pierini, François Schmitt, Reik Donner, Olivier Talagrand, Jose Redondo, Philippe Fraunie, Valerio Lucarini), and other

members of the NP executive Daniel Schertzer (Publications), Isabel de Lima (Scientific Affairs), Henk Djikstra (Division Affairs) August Gires (Webmaster and new Young Scientist Representative), Catherine Nicolis (Richardson Award Committee), Gaci Said (Developing Countries Programme).

This was the first year that the Assembly had an official theme: The Face of the Earth. Although this theme certainly had some NP relevance, next year's theme, A Voyage Through Scales, was proposed by the NP division, and I hope will allow for direct NP involvement in the organisation of special activities. Although it is not yet clear exactly what this will entail, possibilities include theme-inspired exhibits, books and documentary films.

I'm looking forward to seeing you all in Vienna in 2015!

Shaun Lovejoy
NP Division President

OS Ocean Sciences

As the Ocean Sciences (OS) Division President Peter Brandt was unable to attend the 2014 General Assembly because of a research cruise, he asked me to represent the division during the conference. I have attended several assemblies in the past, as a participant prior to 2008, as convener since 2008, and as OS division officer since 2009. I was confirmed as the OS deputy president at the division business meeting during the conference.

The OS programme at the EGU 2014 General Assembly included over 250 oral and nearly 600 poster presentations. A highlight was surely the lecture of the Fridtjof Nansen medallist Stephen Griffies, who presented a lively overview of advances in the modelling of ocean circulation and processes, illustrated with stunning computer animations. In 2013 we started with the PICO presentations, which combine short oral presentations with in-depth discussion using large touch-screen displays. Unfortunately, in 2014, we could not convince our conveners to opt for such a session. Nonetheless, we will continue to promote this type of presentations, as they represent a stimulating way for scientific discussions and direct interactions among scientists.

At this point I want to thank the whole OS Division team, including the Nansen Medal committee who contributed significantly to the development of the division and also helped me in my functions during the Assembly. Special thanks go to former OS Division President Bernard Barnier, whose solid presence during the meeting was a great help.

One of the main pillars of the activities of the division is the open access Ocean Science journal. During the last few years, the number of submitted abstracts and accepted papers increased considerably; this is visible in the increased impact of this publication among the scientific community. Submissions peaked in 2012 owing to a large number of special issues and have plateaued in 2013. This success can be traced back to the great work of the team

Ocean Science is one of EGU's 16 open access journals.

of editors and reviewers, who have contributed to make the journal more and more attractive for readers and authors.

With the General Assembly, the Ocean Science journal, and the outreach and education activities, OS aims to further develop into a productive environment for scientists from Europe and all over the world to gain progress in the various ocean science disciplines and have beneficial interactions with other fields of the geosciences. It provides the platform for, in particular, young scientists to present their results, to network within the research community, and to play an active role in developing the future of the EGU and its Ocean Sciences Division.

On behalf of the OS Division President Peter Brandt,

Johan van der Molen
OS Division Deputy President

PS Planetary and Solar System Sciences

At the EGU 2014 General Assembly, the Planetary and Solar System Sciences (PS) Division had more than 750 abstracts in the programme, distributed over 24 sessions including co-organised sessions. There were 14 PS-led sessions with 420 submitted abstracts, representing roughly a 10% increase with respect to 2013. In 2014, oral and poster presentation constituted about 40% and 53%, respectively, of the total presentations, with the remaining 7% provided by the three PS PICO sessions, which generally received very positive feedback. The most popular PS-led sessions were related

to Mars science and exploration, and to outer planets, icy satellites and rings.

During the EGU 2014, the PS Division 2014 David Bates Medal was awarded to François Forget for his leadership in planetary climate modelling, his contributions to improving global climate models and for establishing the first quantitative framework for comparative planetology. The 2014 Division Outstanding Young Scientists Award was awarded to Christina Plainaki for fundamental studies on cosmic ray physics and on the interaction of icy moons surfaces with planetary magnetospheres. Congratulations to the awardees!

Several press conferences took place during the EGU 2014 promoting the diversity of planetary sciences. These included 'Fingerprints of life: from the early Earth to outer space' on habitability, 'The new face of the moon: science and exploration' on lunar exploration, 'Cassini and Saturn: the 10th anniversary and new results' on Saturn exploration, and 'Sights and sounds: volcanoes on Earth and mars', which included a presentation about supervolcanoes on Mars.

This year's General Assembly theme was The Face of the Earth. As part of the theme, the EGU organised an exhibit on the topic Space and the Earth with focus on comparative planetology. Jim Head from Brown University delivered the Face of the Earth Keynote Lecture on Space and the Earth. This exceptional lecture, as well as the press conferences, are available on demand after the conference. Next year's General Assembly theme will be A Voyage Through Scales, which, again, can prove very interesting for the PS community.

During the EGU 2014, a number of young scientists from the PS division volunteered to help at different domains including the programme, publications and outreach activities. Thanks to their initiatives it is now possible to follow the news and updates from the EGU

Space and the Earth exhibition area at the EGU 2014 General Assembly (Credit: Stephanie McClellan/EGU)

PS Division on Twitter and Facebook. They will also contribute in organising several short courses aimed for young scientists at next year's General Assembly. Future contributions from early-career researchers will also be greatly appreciated.

The preparation of the next EGU Assembly has already started with the announcement of the skeleton programme based on this year's successful sessions. All scientists, young and less young, are encouraged to be active within the PS Division. We are looking forward to receiving your proposals and suggestions to make the next General Assembly in Vienna another successful gathering.

Özgür Karatekin
PS Division President