WORKSHOP REPORT:
SCIENCE AND DATA GAPS IN EU WATER-RELATED PROJECTS
A meeting organized by the EU-FP7 ACQWA Project

Riederalp, Switzerland, January 12-15, 2011

Rationale for the meeting

Following discussions with the European Commission in 2009 and 2010, it became apparent that it could be useful to hold a workshop between the coordinators and a limited number of key scientists working within European FP6 and FP7 projects that are broadly related to water and climate. The aim of this meeting was to identify key strengths and weaknesses in the different projects, and to assess whether some of the weaknesses (methodologies, models, data) could be possibly overcome through:

- collaborative action with other projects;
- initiation of new projects that could help bridge identified gaps;
- suggestion of future call topics under FP7 and looking towards FP8.

The Workshop, organized at the initiative of the EU-FP7 "ACQWA" project took place over a 3-day period from January 12-15, 2011 in Riederalp, Switzerland. Over 30 participants attended the meeting and included over 25 coordinators of EU-FP6 and FP7 projects related to climate and water (the list of participants is provided in Appendix 1 of this document.

The meeting began with brief overviews of each of the projects represented at the meeting, with identification of missing data and information that may have been an obstacle to progress in the projects and their successful outcome. A brief summary of the projects represented at the Riederalp Workshop are outlined below.

Discussions included the upstream as well as the downstream issues of water quantity, quality, use and governance. The projects each broadly represented one or more of the following key issues:

- Floods and droughts;
- Water quality;
- Adaptation in the water sector;
- Integrated management of climate change impacts;
- Multi-risk evaluation, prevention, and preparedness;
- Spatial Data Infrastructure, data handling, analysis, and exchange

Prior to the start of the Workshop, questionnaires were circulated to the participants to prepare for the breakout sessions aimed focusing on the principal issues that the Riederalp Workshop was addressing. These sessions focused on the following areas:

- Integrated Water Resource Managements (IWRM)
- Floods and Extreme Events;
- Water Scarcity and Droughts;
- Freshwater Ecosystems;
- Water Quality
- Spatial Data Infrastructure.

Overview of the projects represented at the Workshop

***Please note** that while an attempt was made to group the projects into broad thematic areas, many projects presented at the Riederalp meeting would fit into several generic themes.*

Projects on IWRM and river basin management

ACQWA – Martin Beniston
www.acqwa.ch
martin.beniston@unige.ch
Large integrating FP7 project, 37 partners, 6.5 mEuro, 5-years (10/2008 – 09/2013 > input to WFD RBMP 2015 update). Focuses on CC-impacts on water quantity up-downstream linkages in river basins. Case studies included: Po, Rhone in EU and river in Chile (as example for EU in future) and river in Kyrgyzstan. Focus also on conflict mediation in case of water resources use through (improved) governance. Aims to establish a data warehouse which is freely accessible once you requested a login via UNIGE / Anthony Lehmann. Main problems encountered with data: amount and compatibility of socio-economic data; data confidentiality (IWRM sensitive data); access to hydrological & meteorological data; lack of groundwater data.

CLIMB – Ralf Ludwig
www.climb-fp7.eu
r.ludwig@lmu.de
FP7 project, 48 months, 01/2010 – 12/2013, 19 partners and only 5 from EU. Focus on changes in precipitation patterns. Aims to develop a conceptual framework and looking at: hydrological budgets; extremes; quantification of uncertainty and uncertainty reduction. Focus on small to meso-scale catchments. Will produce a centralized & harmonized data structure. Encountered thus far: fragmented hydrometeorological network; scattered information; information on socio-economic data not accessible. Possible solutions could be that: the EC provides grants to 'buy' data 8 and an EC/EU data warehouse. Topics that could be addressed in the future in better ways: scales & scaling and spatially explicit socio-economic data modeling.

ClimWatAdapt – Cornelius Laser & Natasha Marinova
www.climwatadapt.eu
cornelius.laser@ecologic.eu and natasha.marinova@wur.nl
EC DG Environment commissioned project (service contract, 20 months) looking at vulnerability indicators (transport, energy, agriculture, economy, general). Executed by: CESR, Alterra, Ecologica, …. Project aims to come to an international assessment framework for (1) identification of the vulnerable area's to climate change and (2) evaluation of adaptation options and thus also identification of measures that could be promoted at EU-level. The inventory already resulted in > 100 adaptation measures, from technical (e.g. dykes) to supporting (e.g. land-use planning). They build upon, use scenarios developed in projects/initiatives etc. like: ENSEMBLES, SCENES etc.). Also makes use of MCA decision methods like Mulino-DSS. Project will also produce a map of EU, high resolution data, indicating the vulnerable area's in EU. Integrating all possible data: physical, economic, social changes. Also wants to be a clearing house. Help asked from all (projects etc.) to fill

in/provide data. And are looking for case studies that assess/demonstrate the effectiveness of CC adaptation measures.

EPI-WATER – Jaroslav Mysiak
http://www.feem.it/getpage.aspx?id=3635&sez=Research&padre=18&sub=70&idsub=86&pj=Ongoing
jaroslav.mysiak@feem.it
Project aims to evaluate Economic Policy Instruments (EPI) and wants to deliver as final product a guidance document in this area for use of EPI in the WFD implementation. Project just started (January 2011) and continues till December 2013 and partners are a.o. Acteon, Ecologic, WUR etc.. Case studies from all over Europe and beyond are analyzed and they established a 'policy think tank'. As spin off they also want to achieve a research network. It is foreseen that this network will organize a 'resilience' conference.

HIGH-NOON – Eddy Moors
www.eu-highnoon.org
eddy.moors@wur.nl
Focuses on the Ganges basin in India where they want to identify CC-adaptation measures a.o. through involvement of local stakeholders. Uncertainties here are (1) glacier/snow melt in the Himalayas and (2) changing monsoon pattern. Both will likely impact quantity of water (too much or too less) as well as lead to socioeconomic impacts. A further complicating big issue in the basin is also the ever increasing population density. The climate models applied to this basin demonstrate contradictory results. They disagree on the future rain fall patterns and other factors. Also the estimated retreating of glaciers in the basin by 20-22 m a year is uncertain. Gaps/lacks are: scarcity of precipitation stations; availability of data (for political reason – trans-boundary – and data not in/of desired quality); how will all continue after lifetime of project.

MIRAGE – Wouter Wolters
www.mirage-project.eu
wouter.wolters@wur.nl
Project focuses on Mediterranean Intermittent River Management. It aims to help to establish GES and to link to WFD POM for temporary streams, i.e. stream with no continuous flow of water. Groundwater withdrawal is a major issues in such streams. Questions asked (and solved?) in the project are how to deal with dynamics and how about tipping points. They focus on 'study basins' and 'mirror basins'.

WASSERMED – Roberto Roson
www.cliwasec.eu
roson@unive.it
Project (January 2010 – December 2012) focusing on climate change impacts in the Mediterranean and hereby focus on participatory processes. Mr. Roson is economist. Together with projects CLICO and CLIMB they form the CLIWASEC cluster.

WATCH – Richard Harding
www.eu-watch.org
rjh@ceh.ac.uk
Integrated project aimed to quantify and predict the current (20th century) and future (21st century) global water cycle. Finding is that on this scale the current models don't work very well for groundwater. Products of the project are: an 'extremes data-set (trends 1962 – 2005); a 20th century 'drought catalogue' and observed 'floods catalogue'. Project compared global hydrological models, land-surface hydrological models; vegetation models and river basin models. The study basins included Rhine, Danube, Volga from the EU and a couple of basins form > Europe. A same set of 'forcing data' was used when applying the different models. This exercise revealed huge differences in model outcomes.

NRP61 – Ulrich Bundi
www.nfp61.ch
bundi@eawag.ch
NRP stands for (Swiss) National Research Project. It is a project focusing on providing of knowledge to solve future water management issues. Project seems to work very much a long the three core-principles of RISKBASE (see RISKBASE). Furthermore, (another analogy with RISKBASE) it focuses on the 'use system', which is positioned between the natural system (i.e. ecosystem) and the social system. (PS: not mentioned explicitly: but noticed a lot of parallel with ecosystem services approach and 'resilience thing' as promoted by the Resilience Alliance and Stockholm Resilience Centre). The project has a strong focus on practical usefulness and starts from policy questions. There is a strong focus in the project on communication and implementation of the project results. It started in 2010 and ends in 2013.

Projects on water quality

DOCTRENDS – Estelle Baures
Website not avaible
estelle.baures@ehesp.fr
Project focuses on one detailed aspect, i.e. on climate drivers of Dissolved Organic Carbon (DOC) release. Project looks a.o. at annual changes in DOC in raw water. Partners are a.o. NERC, ANSES and VROM. A partner from Utrecht focuses on sorption of contaminants to DOC.

EAU4FOOD – Wouter Wolters
Website: not available yet
wouter.wolters@wur.nl
Project is under negotiation and focuses on the revitalization of natural regenerative capacity of agricultural soils. It aims that stakeholders and researchers will adapt to a trans-disciplinary innovation process. Co-design is another focus in the project. It is a cooperation project between EU and the African Union and it completely focuses on cases in Africa (Tunisia, Ethiopia, South Africa and Mali). The project also relates to NEPAD: New Partnership for Africa's Development.

NORMAN – David Schwesig
www.norman-network.net
d.schwesig@iww-online.de
This is the European network on monitoring and bio-monitoring of emerging pollutants. The network was kicked-off as FP6 project with the same name and is now a fully self supporting network. Its mission is to be a one step facility for issues of emerging pollutants. It aims to contribute to the prioritization of emerging pollutants and to – together with the JRC – harmonize methods and surveys. NORMAN produced and maintains three d-bases: EMPOMASS (d-base with mass spectra and info on occurrence of emerging pollutants); EMPODAT (key-players and experts in the field); EMPOMAP (important projects/initiatives in the field, such as: MODELKEY, SEDNET, …).

Projects on droughts

CIRCE – Elena Xoplaki
www.circeproject.eu
xoplaki@giub.unibe.ch
This was an FP6 Integrated Project focusing on regional assessment of CC impact in the Mediterranean Environment. Important product is their ECA&D d-base.

AQUASTRESS – Michele Vurro
www.aquastress.net
michele.vurro@ba.irsa.cnr.it

This project was an FP6 IP focussing on the mitigation of water stress through new approaches. The efforts not only gave to the water actors scientific results related to different technical, social and economic disciplines, but scientific teams disciplines with different conceptual frameworks, languages, working styles, and research ambitions face the challenge of overcoming these differences in order to function effectively. Collaborative activities among researchers and community members include an even more different array of goals, educational backgrounds and motivations than partnerships comprised of scientists only. Case Studies enabled the use of a common framework for the analysis of water stress and mitigation options, based on a participatory process that integrates stakeholder perception, increases their awareness on water stress issues, enhances the objectivity of scientific results, can facilitate the integration of results in developing EU-relevant policy recommendations.

XEROCHORE – Jaroslav Mysiak
www.feem-project.net/xerochore/
jaroslav.mysiak@feem.it
This project finished April 2010. It was a Coordination Action in which an exercise (synthesis) was performed to assess the research needs (roadmap/RTD-agenda) and policy choices in areas of drought. It aimed to inform drought management plans, WFD and the EU drought policy. Products: four guidance documents (available from their website) and five science-policy briefs (in five different languages) addressing respectively the following articles of the WFD: article 5, 8, 9, 11 and 13.

Projects on freshwater ecosystems and ecology

BIOFRESH – Klement Tockner
www.freshwaterbiodiversity.eu
tockner@igb-berlin.de
Ecosystems: status, trends, pressures and conservation priorities. Biggest project on biodiversity ever funded. Lasts until 2014. JRC, IUCN, etc. are involved. Freshwater contains >10% of all animal species. 1/3 of all vertebrate species. Build fresh water info platform. Predict responses FW biodiversity and Ecosystem Services to multiple pressures & scales. Increase awareness. Three scales: global, EU, basin (Danube, Elbe & Ebro). Book: rivers of Europe (Tockner et al.). CC-shifts. 12 Key products: FW biodiversity portal Interactive biodiversity atlas Outreach activity products Guidelines for future biodiversity management Networking: connecting to other international biodiversity initiatives/networks: a.o DIVERSITAS which has close link to IPBES www.freshwaterbiodiversity.eu www.riverscience.eu (SMART science for river basin management)

EFI+ – Stefan Schmutz
http://efi-plus.boku.ac.at/
stefan.schmutz@boku.ac.at
Follow up FAME (both FP6). Index of Biotic Integrity (IBI) is core. Focus on fish community. Impact human pressures on IBI. Pressure: hydrology, morphology, continuum (for migration) & water quality (several variables). Lot of lacking info on water quality pressures. NO standard on water quality data available in EU. BOD etc. not commonly available. FAME & EFI+ have similar d-base. Harmonized & standardized EU data is problem. Output: European Fish Index (EFI). Connecting/feed into WFD. Need: standardization, up-scaling from case studies to continental scale, transfer data across disciplinary boundaries, sustaining of life of dbases beyond lifespan of projects, need for EU (world) d-base warehouse (funding?). WISE is not enough.

EURO-LIMPACS – Martin Kernan
http://www.refresh.ucl.ac.uk/eurolimpacs
m.kernan@ucl.ac.uk
IP to evaluate the impacts of global change on EU FW ecosystems. Aims: - establish how to respond to CC direct & indirect - how can systems be better managed in relation to WFD Lot of data collected. Mesocosm experiments. Space for time substitutions, climate – acidification interactions. Climate-toxic substances interactions. Accumulation/remobilization legacy pollutants. Management response: modeling, indictors etc. Indicators of ecosystem health: large d-base/distribution pattern. WISER project updates the d-base. Main gap: integration of CC-indicators. Reference conditions. RTD priorities: maintain long-term experimental projects, improve statistical dynamic models, centralized info system. EU wide network of monitored catchments! In order to be able to improve effectiveness of measures. And many more recommendations. Impact on ecosystem goods and services. Book (Wiley) available.

REFRESH – Martin Kernan
www.refresh.ucl.ac.uk
m.kernan@ucl.ac.uk
Follow up to Euro-limpacs. Adaptive strategies to mitigate impacts of CC. System that will enable water mangers to cost-effectively do this. Center project is process based evaluation of specific measures. Focus on rivers, lakes and wetlands. Stakeholder engagement is an issue/key-part of the project. Workshops have already taken place. In March another one. 2010-2060 scenarios. Controlling ecosystem functioning is at the heart of adaptive management! Thresholds, indicators etc. Develops a new set of system indicators etc. Integrate ecosystem models. Chaining of models. Demonstration catchments. Storylines/scenarios. Missing: more sites with high quality data available.

Projects on glacier melt and runoff change

PACC – Nadine Salzmann
http://www.adaptationlearning.net/project/climate-change-adaptation-programmepacc-peru
nadine.salzmann@geo.uzh.ch
CC adaptation in Peru. Non EU project. Swiss funded. Reduce peoples vulnerability to CC impacts. Focus on local people and their needs. Coherent CC adaptation policy for the locals, that is what it is aimed at. Scenariaros, data etc. Needs/gaps: long term climate observations, data access, data reliability. Good personal contacts (local) is also a key to success. Adaptation measures. Common language is needed.

Projects on extremes

CORFU – Slobodan Djordjevic
www.corfu-fp7.eu
s.djordjevic@exeter.ac.uk
Collaborative research on flood resilience in urban areas. FP7, 4/2010 – 3/2014. 10 partners EU and 5+2 from Asia. 3.5 M Euro. Dura Vermeer is involved as partner from NL. Also social scientists included. Resilience = capacity to adapt. Adapt to hazards: resisting, …, responding, recovering, reflecting (5-R's). Europe/Asia: learn from each other! Running scenarios an assessing impacts and come to response. Aim CORFU: Quantify cost-effectiveness of different resilience measures and flood management strategies. Case studies EU: Hamburg, Nice and Barcelona. Asia: Dhaka, Beijing and Mumbai and … Lots of data gaps/needs. And big variance between cases. Many shades of gray in terms of data availability.

CRUE ERA-net – Wouter Vanneuville
www.crue-eranet.net
wouter.vanneuville@mow.vlaanderen.be
Flooding network. EC funding ended 2009 (FP6). Improve coordination between national flood research projects. Second call is ongoing. RTD agenda is on website, will be updated this year. Link to implementation of Flood Directive. CRUISE: primary link to info on flood related research across Europe. CRUISE is not updated recently… A bit outdated. But will be improved. Yearly CRUE snapshot. Results of the common projects + ongoing other main

events. ‘Flood resilient communities’ is latest Snapshot. Linking research & RTD in flood risk management. Who reads the documents/project reports? Nobody … So made a synthesis report. Less then 20 pages. Readable in less then 1 hour. Final conference September 2011: “Flood resilient communities – managing the consequences of flooding”= outcome 2nd CRUE funding initiative. Will also come a synthesis report for second call + papers in journal. D-base (CRUISE) probably be hosted at ‘NETWATCH’ (initiative JRC Seville) after end of CRUE.

FLOODSITE – Paul Samuels
www.floodsite.net
p.samuels@hrwallingford.co.uk
Flood damages are increasing: flood risks arise from human activity (because people get in the way. Floods are natural phenomenon). Floods appear more often, don’t respect boarders, public intolerance. Looks at flash floods, flooding in estuaries, wave overtopping etc. Storm surge will have largest risk to loss in lives (1953 event NL). Flash floods are most frequent cause of death: about 50% from people in vehicles! Greatest economic damage: major cities? (e.g. London: 200 billon pound of assets at risk). Large scale evacuation: major river basin floods. Lot of social science was done. Explored scenarios for specific cases (Germany, NL, UK). Task also on uncertainty in decision making. Statistics in extremes. Hundreds of publications resulted from the project (650). 400 documents available at website, will stay there the next 20 years (guaranteed by HR Wallingford). Gaps in science (some from FLOODsite reporting): decadal time scale prediction of extremes; detection and attribution of change; surge contributions to coastal extremes; impact of long-term CC on flood defence performance; performance of flood defences during future meteorological extremes. Gaps in data: measurements of flood flows are scarce (technical difficult + dangerous); long-term flood records are scarce; compilation of consistent EU d-base/set; consistent damage date (loss of life, injuries & health impacts); access to public data (a problem in UK); intermittent observation (project driven). Opportunities: make more use of national CC impact studies; national RTD projects; FLOODRISK 2012 conference (Deltares, Rotterdam). Barriers: lack of consistency in data, data policy of public bodies.

HYDRATE – Marco Borga
www.hydrate.tesaf.unipd.it
marco.borga@unipd.it
Hydro-meteorological data resources and technologies for effective flash flood forecasting. FP6. Several cases studied in project. Aimed to improve scientific basis for forecasting. Re-analyzed past cases, etc. Harmonizing observation methodologies/strategies. Towards a EU Flash Flood Data Archive. Finding: for most events, response time is less then 6 hours! Thus a serious physical constraint to the event-risk management strategy. Developed a flash-flood guidance tool. Needs: focus on hydro-meteorological predictions at small scales & multi-hazard an multi risk framework building; observations, Mediterranean focus.

RISKBASE – Jos Brils
www.riskbase.info
jos.brils@deltares.nl
As the pressures from both anthropogenic and natural causes on environmental systems increase, it is no longer effective or efficient to deal with one issue at a time, since solving a singular problem often causes damaging impacts on other environmental compartments or in

other places. We must consider the consequences of our actions on all parts of the environment in an integrated way and configure these actions to cope with an uncertain future. These challenges demand a different approach in order to achieve actual improvement of the ecological quality of our river basins, and thus sustain the goods and services they provide for the well-being of society. Risk-based management is this new approach. It involves the integrated application of three key-principles: be well informed, manage adaptively and take a participatory approach. Be well informed: This implies that a sound understanding of the functioning of ecosystems and their interaction with the social systems is the basis to their management. Manage adaptively: This implies that we have to learn-by-doing as social/ecological systems are complex and dynamic and can respond in non-linear and unexpected ways. Take a participatory approach: This implies the involvement of stakeholders in management, which enables them to exchange their views and opinions on problems and bring their knowledge to the table. By learning together to understand ecosystems in a better way, we will find better solutions. This process of social learning requires a common language. The developing ecosystem services approach may provide that language. A common understanding of the value of the goods and services that a healthy ecosystem can provide, and how their present poor status due to our actions can be improved, is the key to a new approach to ecosystem management. More to be read in the 'synthesis' booklet, which is free of charge downloadable from the 1st page of the RISKBASE website (www.riskbase.info).

Environmental data and the European Environment Agency EEA –André Wehrli
www.eea.europa.eu
andre.wehrli@eea.europa.eu
Clients EEA: EC, 32 Member countries, NGO's and public. Partnership network. State of the Environment and outlook report (last SOER 2010) is a key report every 5 year: synthesis booklet goes with it. EEA collects information and reports regularly on many topics. European water data center (WISE (Water Information System for Europe)) and climate change data centers are accessible through the EEA website (the latter including links to national adaptation strategies). The EU Adaptation Clearing House for Europe (ACE) is being developed by the European Commission as follow-up to the White Paper on climate change adaptation and will be managed and maintained by EEA from early 2012 onwards. Users: initially governments. Key EU policy processes with (CC) information needs: Water, Nature protection, Marine strategy, agriculture (CAP), forestry Green Paper. Other ongoing EEA activities: GMES (GIO Land) – DG Enterprise – and GISC, BISE,(biodiversity information system for Europe), flood impact d-base (under development), Core Set of Indicators (CSI, regularly updated). In the week of the workshop a EEA report on hazards was published, please see:
http://www.eea.europa.eu/highlights/natural-hazards-andtechnological-accidents

SDI / ENVIROGRIDS – Anthony Lehmann
www.envirogrids.net
anthony.lehmann@unige.ch
SDI: Spatial Data Infrastructure. FP7 project aims to explore the past, present and future Black Sea. Aims to build capacity of decision makers. Main drives of change: demography, land cover and climate. SWAT d-base & model used/developed. How can we share spatially explicit data and meta data: INSPIRE and GEOS initiatives. ENVIROGRIDS feeds as one task in GEOS. Links to World Meteorological Organization (WMO). How can we better

manage shared water resources? How can we fill the information gap? End-users: Black Sea Commission and ICPDR. D-base URM: Unified Resource Management. Link to *Google Earth*.. Delft April 2011 next conference at UNESCO-IHE in Delft.

Breakout session reports

Integrated Water Resource Management"

The session identified a number of gaps in knowledge, models, data and approaches.

First, the need for a more integrated and comprehensive approach was highlighted. Beyond the conventional water basin management perspective, there is a need to consider other socio-economic aspects and the interaction between water and other policies. For example, is water policy consistent with energy, agriculture, and other industrial policies, especially at the European level? Equally the link between water and the whole range of ecosystem services is not always made.

Are policy makers able/willing to exploit all available information produced by the scientific community? There is still a big gap between science available and its use in policy – how do we improve the flow of information?

The problems highlighted above are also due to the partial inconsistency between physical and socio-economic data and models. For example, data on water uses may not be available at the temporal and spatial detail required by hydrologic models. Hydrological information is often based on basins whereas economic (and social) data is administration regions. On the other hand, consumptive uses of water may not be available with industrial classification adopted in national economic accounts. Thus economic and physical data are often incompatible, because collected by different entities for different purposes. Future research should address the issues of building compatible data sets and the conversion process between different data formats, as well as the development of toolboxes for upscaling, downscaling and bias correcting data.

Other data gaps are found in groundwater data and exceptional events. More generally, there is a need to make available information available to new research projects, for example through a data repository. There are also important opportunities provided by the increasing availability of gridded data sets across Europe, including those based on Earth Observation. There may need to be more research on the barriers to the free exchange of data (physical and economic).

It is noted that socio-economic research related to water resources is quite limited. Most water related research projects are lead by physical scientists, and may be somehow biased in scope. Furthermore, the use of water in production processes is often not mediated by the market. The use of economic flexibility mechanisms in the allocation of water resources is quite rare, despite their potential in improving the efficiency of water resources allocation. More research and policy initiatives in this direction are necessary.

Extreme events, floods

In the discussion on extremes it was recognized that although the intention was to concentrate on high flow extremes within water systems, many of the concepts and principles are similar for low flow extremes. Both can pose practical difficulties to society, both cause degradation to the aquatic environments, both flow extremes cause difficulties in measurement and both extremes can be influenced by climate and other environmental changes. It is important to understand that extremes are not necessarily entirely negative, for some environmental processes and eco-system services to human society, extremes are positive in their impact.

Extremes are, by definition, experienced infrequently and thus the question arises to what extent should there be an attempt to control the extreme and to what degree physical and social infrastructure should be designed as adaptable and resilient to extreme conditions. A particular difficulty is that the typical time-scale between extremes and their effects may be two or more generations and thus the impacts lie outside the scope of life-time memory of much of society. Moreover, natural process that are responses to these extremes (for example morphological adjustment of rivers) may undergo step changes in response to an extreme upsetting an apparent benign appearance of static equilibrium to which the public has become accustomed.

Important gaps in information on extremes exist for one or more reasons which may arise from lack of technology, organizational deficiency or novelty of application. Floods are comparatively infrequent and during an event the concentration of public resource is usually on responding to the emergency rather than collecting information; this issue was one of the factors that led to the commissioning of HYDRATE in FP6. Primary measurements of total discharge (time variation or peak) and particularly of flood velocity across the river and flood plain in extreme events are rare. The HYDRATE project however developed methods for recovering estimates of peak discharge from evidence gathered through intensive post-event field campaigns.

Water quality information from floods is sparse be it on dissolved substances, sediments (bed load and suspended) or biota (pathogens and parasites). The remobilization of historic polluted sediments in extreme floods is an important mechanism in contaminant transport downstream.

In urban areas flood movement is controlled by the topography and connectivity of the road network, open land and sub-surface sewerage system and flooding into properties depends upon the location and dimension of potential entry points. This high density of data is not generally available to support research studies.

There is also inconsistency or lack of information on methodology of collection (and criteria for inclusion in databases about extreme events) particularly in some socio-economic data sets which makes difficult inter-comparison and combination of data sets. The workshop participants urged action on ensuring consistency of information, particularly related to uncertainties in the data collected and methodology used.

Flood flow measurement is difficult, and can be dangerous during a major flood; any research which improved the techniques and technology available for flood monitoring will have impact in reduction in uncertainty across flood risk management activities (risk assessment, economic assessment, forecasting and warning, provision of mitigation measures). Technological development is needed to improve rainfall data in mountainous and urban areas for use in forecasting and warning of extreme floods. Technological development is needed to distinguish better between glacial melt and snow melt contributions to runoff in mountainous catchments; this will inform research on climate sensitivities in water resources.

There is much flood risk management infrastructure in place across Europe; records of construction techniques and materials for ancient banks usually do not exist. Moreover, data on the condition of flood defence infrastructure (whether historic or not) is difficult to source in many situations. Technological advances are still needed for non-intrusive measurement of defence condition, and particularly variation in condition (with warning of dangerous weakening) during an extreme event.

Whilst new technological developments mostly mean more advanced or more widely spread hi-tech solutions, low-tech measurement techniques will remain very useful.

As in on other sectorial discussions at the Workshop, the participants expressed concerns about knowledge of and access to data sets as the documentation of data held both from public bodies and previous research is fragmented, making the data existence and availability difficult to identify. In addition there is a need to harmonize data structures to facilitate and promote access.

The participants discussed issues that posed barriers to action on the data gaps discussed above. There are many institutional barriers and increasing financial barriers to data access, including recharging for data and information already collected (sometimes with public resources) and licence conditions on the use of the data and publication of results. In some cases the monitoring or the research content may be a highly political, which we as scientists cannot influence. In some cases data is collected for compliance issues or legal enforcement, once compliance is established the data may be discarded and full value of the data collection is not achieved for research where long-term trends and developments are critical. For hydrological extremes high frequency data are often needed for research and technological development rather than aggregated daily values (e.g. daily rainfall depth or mean daily discharge). There may be a barrier at DG Research in funding data collection for irregular events, where the occurrence of random, extremes cannot be guaranteed within the specific time frames of a research project, it was suggested in discussion that NATO might provide support for such data collection. A similar issue is the acquisition of remote sensing data during an extreme, having priority access at short notice to sensors, irrespective of who pays, the urgency to gather information in an extreme event should have the priority; perhaps the civil protection institutions at country level should take on responsibility for data collection strategy in extreme events.

The discussion of the science gaps also took account of some of the policy drivers for research. In line with the objectives of the UN ISDR Hyogo Framework for Action, research should reduce the chances that a hydro-meteorological extreme turns into a disaster for the

communities affected. Furthermore, public communication on issues about extremes needs care in the use of language, avoiding specialist terminology that does not have common usage or where common usage differs from the professional use of the same language. In the professional dialogue should we throw out the idea of the worst case as this is misleading since we cannot know the full scope of the natural phenomena?

Criteria for selection a prioritization of the research on the science gaps needs discussion to generate some form of consensus, possibly through national representatives on the relevant programme committees. In the prioritization of research, the science community needs to give clear messages on the feasibility and potential for innovation to consider alongside political and practical criteria.

The discussion at the workshop generated several areas where further research effort could usefully provide advances in knowledge and understanding of extremes and the mitigation of their impacts on society. After the workshop these have been grouped into three categories:

- Characterization of extremes
- Analysis of extremes
- Impacts of extremes

In the broadest view, extremes are not entirely negative in their impacts. Thus research should also consider what benefits we get from extremes. This may require another way of thinking outside a typical reductionist approach to give an understanding of the role of extremes in natural systems.

Three issues arose on the characterization of extremes, particularly in the context of climate change. Whereas national and international policy development must take account of multi-generational timescales (say to 2100 or beyond), investment decisions are often taken on generational (decadal) timescales. Thus there is urgent need to improve understanding and reduce uncertainty on the decadal timescale changes to the incidence and intensity of water-related extremes and their impacts. This may involve different approaches that those used to develop climate, environment and social storylines at the century timescale. A related issue is the need for generation of climate projections for short-duration extremes (e.g. sub-daily intense storm precipitation, or storm surge movement) which are of relevance in risk assessment and management of impacts of the extreme on society.

Research is also needed to understand the degree that perceived changes in the frequency and intensity of hydro-meteorological extremes can be attributed to natural variability or to the anthropogenic influence on the global climate. Current research suggests that climatic signal in the trend in hydrological response may be discernable from natural variability within one or two decades.

In addition further scientific research is necessary on processes that are coupled to the water flow in hydro-meteorological extreme, such as water quality, sediments and substances transported during extreme events, pathogens and pollutants, all of which augment the potential for damage and risk to life and property.

Research on extremes is needed set in a multi-hazard framework for several risk sources, which may be coincidental, conjoint or cascading, taking a “whole systems” approach to the

physical, environmental, ecological and social systems, and their interdependencies and interconnectivities. Economic and social development of infrastructure (physical, governance, institutional, social, etc.) has become so complex that the occurrence of an extreme produces a shock to the ambient state leading to unforeseen consequences and impacts are problems. The analysis of extremes could usefully apply concepts and methods from complexity theory to generate a greater and richer understanding of the range of potential impacts of an extreme in one or more hydro-meteorological driver. If the ambient state of the system is close to a tipping point, the extremes may cause transition through a tipping point to reach a new and different (dynamically) stable state. The result of non-linear processes and complex interactions can produce non-intuitive behaviour and the science will need careful communication to non-specialists.

A specific example where past research has produced substantial technological advance is in the estimation of precipitation through weather radar systems. This science at national and European level has brought real practical benefit through flood warning. However, there are still many issues to address in sensing at small (urban) scale and in complex topography and on integrating weather radar data and numerical weather prediction systems for improved flood forecasting of intense flash floods.

The discussion covered some example impacts of extremes but these should not be viewed as the totality of the range of possibilities. Power generation plants (fossil fuel and nuclear) need access to cooling water; they are affected by both extreme low flows (thermal pollution and water availability) and floods (inundation, ingress of sediment and blockage of intake structures). Overall impacts of changes in extremes need integrated research to assess all factors and consequential impacts of lack of security or restriction of power availability in the extreme event, both on the local scale (e.g. flooded or clogged installations) and on a wider scale (e.g. longer term impact on a national power grid following reduced production due to insufficient cooling water). There is inadequate knowledge of the effectiveness of measures taken to mitigate the impacts of extremes and ex-post investigation could yield valuable understanding. Advancing knowledge could also further policy implementation through assessment of intangible impacts of extremes on long-term human health and well-being, ecological function, and water-body status, set in an appropriate multi-factor analytical framework.

Freshwater Ecosystems

The members of the session identified major deficits in establishing synergies among various EU Directives (WFD, HD, FD, ED), which often are treated in isolation (e.g., flood control, biodiversity conservation, water quality improvement). Furthermore, very few projects explicitly focus on coupling hydrological and ecological processes. For instance, to understand the role of hydrology in determining ecosystem services is still in its infancy (e.g., in IWRM context). The lack of a common language between different disciplines is considered as one reason that undermines collaboration (e.g. terms such as resilience or adaptation are used differently in ecology, hydrology, and economy). The members of the session also expressed their concern about the case study character of many funded projects. Case studies, often of short duration, provide an important empirical base for

formulating research questions and hypotheses but do mostly not allow advancing basic science, as a prerequisite for sustainable ecosystem management.

The members of the session identified the following research directions/activities:

- Establishment of an international Think Tank (a “Synthesis Center” for water science) for the integration of the knowledge generated through EC funded projects is considered as crucial for future innovation in the water sector (e.g. 5 % of project resources could be allocated to this center) .
- Establishment and maintenance of a network of large experimental (catchment) sites to study long-term interactions and feedbacks between hydrological and ecological processes (e.g. using decommissioned dams to examine flow-ecology relationships).
- How much water, in which quality, is required to maintain ecosystem processes and dependent services? A key challenge remains to disentangle the complex feedback mechanisms between hydrology and ecology in freshwater ecosystems (e.g. role of water level fluctuations in ground waters, wetlands, lakes and rivers in controlling ecosystem processes and biodiversity).
- Of particular interest is to understand ecological processes during and the consequences of extreme hydrological events (e.g. identify refugia for biodiversity).
- Similarly, our understanding of the synergistic, antagonistic or additive consequences of multiple drivers - including water stress, hydrogeomorphic pressures, pollution, climate change, and socioeconomic alterations - on ecosystem processes and services remains a challenge.
- Finally, we need solid indicators to monitor the water system from both a hydrological and an ecological point of view.

<u>Water quality</u>

To start, the discussion of this group allowed to define the topic “water quality” which these 3 words:

- Chemical quality
- Microbiological quality
- Ecological quality (biodiversity etc.)

Next, the group made a summary of the morning session “water quality” and specified different and important observations:

- There are weak links among the projects
- Many projects looking for the same data
- Mechanistic understanding of links between water quality and quantity is often missing
- There is ever increasing number of case studies and some of them are left too early. There is no follow-up after and new projects look for new case studies

And for these last observations we made some propositions/questions:

- Limited number of test sites?
- Prolong active phase of case study by linking with a central database unit that takes over after the project.

Climate change impact on water quality is not yet very high on the EU research agenda

- Lot of work focused on impacts on water quantity
- Some work on nutrients, major compounds, sum parameters
- Far less research on trace compounds, pollutants

Opportunities to improve water quality by controlled hydrological manipulation are not sufficiently exploited

- Gaps in both fundamental knowledge AND implementation
- Example Spöl River (CH): artificial flood releases to improve ecological conditions

Combine technical systems and natural ecosystems for improving water quality

- From emission to immision perspective

Trade-off between different ecosystem services is neglected. Management options should consider optimization not only one aspect but e.g.,

- pollutant removal
- groundwater recharge
- regeneration of riparian vegetation
- recreational value;

Develop integrated fingerprint indicators for effects / pressures by multiple-stressors

- Including indicators when a system is shifting towards a threshold / tipping point beyond which no (full) recovery is possible

Tools to enable a differentiation of trends from single events

- Close link between quantity & quality is needed

Impact of climate change on water-borne diseases

- Effect on input, mobility and proliferation of pathogens

Development of a disaster assessment system

- What happens during the disaster is often unclear
- Existing alarm monitoring systems are focused on human health / drinking water safety.
- Ecological effects are not systematically covered

Innovative standards for assessing environmental flow requirements

- How much water, of which quality, does an ecosystem need?

Improved techniques for sampling and *in-situ* monitoring

- In particular for ecology/biodiversity etc.

Water scarcity and droughts[1]

This breakout group decided in its initial discussions that the scope of the breakout-session 'Droughts' should be expanded to also address the priority topic 'Water Scarcity'. The group clarified the differences between these two terms and concluded that while water may be available in its physical sense, an imbalance between water availability and demand may enforce water deficiency from a socio-economic perspective, leading to a convergence of process impacts, i.e. water shortage. It was thus agreed that the two issues could not be addressed without independently of each e other.

The group furthermore discussed along the lines of two major objectives:

1. to formulate recommendations for improving the flow of information, data, and access to models across projects
2. to suggest what kind of projects could be envisaged in the future to improve the situation

It was generally agreed that the current data situation for projects is often difficult due to a number of frequently-recurring reasons. In particular, incomplete and un-standardized time series of data (e.g., climate, hydrology) are a major drawback for many projects, as the collection and harmonization of data is costly, time-consuming and often redundant. The main reason for the latter is an abundance of widespread, yet unknown or inaccessible data sources. This means that data is available in principle, but end-users and scientists are simply not aware of their existence or are unable to find the legal or financial means to access them. Another problem was identified in the different national regulations and/or legal characteristics that hinder a uniform provision of organized information. Finally, the high cost of some data (such as remote sensing imagery from private providers) often calls for work-around or waiving of beneficial information.

The group members identified harmonized time series of hydro/meteorological data as a pre-requisite to improve the data situation and information between projects. Further, it was highlighted that there is a huge lack of reliable information and knowledge about the impacts of drought or water scarcity on the environment and socio-economic systems across all spatio-temporal scales of possible scientific applications, from the continental to the catchment scale.

In order to make best use of available (infra-)structures, it was strongly advocated to promote, strengthen and proactively support the activities of the European Drought Observatory at the Joint Research Center (JRC in Ispra). One generally-acknowledged suggestion for improvement is to establish a clearinghouse of relevant and structured data,

[1] ***Definitions:***

Water Scarcity: The (long-term) imbalance between availability and demand for water. Water scarcity should not be viewed exclusively as a quantity problem: the degradation of groundwater and surface water quality, intersectoral competition, interregional and international conflicts, all contributes to water scarcity. Water Scarcity often has its roots in water shortage (drought), combined with population growth and economic development.

Drought: The term drought is used to define a temporary decrease in water availability due for instance to rainfall deficiency. Drought is an indistinct event, of water deficiency, that results from the combination of many complex factors and neither the beginning northe end can be precisely defined.

including meta-data, which hosts not only data from public and other services but explicitly asks for a comprehensive collection of relevant data produced by projects. The access of such a clearinghouse would be assured by means of a signed 'Memorandum of Understanding' between the European Commission and respective projects, that data used to generate results and those elaborated during the lifetime of a project, must be made available to initiatives and projects that follow on into the future. As an extension, and to reduce redundancy, all new FP-project proposals should contain a dedicated section on knowledge related to data sources, their availability and utilization within the project. It was agreed that it will be of utmost importance to demonstrate the benefit of an improved database for policy making and to attempt to involve policy makers in supporting the idea of a European Data and Information clearinghouse. Ultimately, the implementation of guidelines, maybe even an EU Directive, on the good governance of data (sharing) is envisaged as a possible framework, providing advice and general rules on data formats and standards, data storage following the completion of projects or the general terms of access. The European Environment Agency (EEA) is considered as a good potential co-ordinator of such efforts.

The group furthermore discussed several project ideas which could be implemented in the future to contribute to a closure of existing scientific and data gaps.

- Global change impacts on water scarcity; trying to isolate, evaluate and rate the different contributions to water scarcity (in a given region or scale)
- Propagation of drought impacts on water resources and its implications on good resources management
- Scales of droughts and drought impacts (including the development of drought impact models)
- Development of integrative methods for drought observation and modelling across scales

Further items of discussion

In the concluding parts of the Riederalp Worskhop, the following items were discussed and agreed upon:

- A follow-up workshop within 2 years to assess progress on the issues discussed at the meeting and to interact with stakeholders who may need research results for policy guidance;
- A policy-oriented paper to highlight the problems raised throughout the Workshop, possibly in *Environmental Science and Policy* (Elsevier Publishers);
- A possible Special Issue of a journal to point to ways and means of alleviating problems related to science and data gaps in major networked projects (possibly in *Journal of Hydrology*).

Furthermore, the issue of a "clearinghouse" for data from the numerous EU projects was discussed, in order to simplify the search for data that may already be in the possession of certain projects. The initiative of the European Environment Agency (EEA) for establishing such a data platform may be one way forward.

Report compiled in February, 2011, by:
Martin Beniston and Markus Stoffel (ACQWA project)
with inputs from:
Estelle Baurès, Jos Brils; Ulrich Bundi, Slobodan Djordjevic, Richard Harding, Martin Kernan, Ralf Ludwig, Roberto Roson, Paul Samuels, David Schwesig, Klement Tockner, Mladen Todorovic, Michele Vurro, André Wehrli, Florian Wimmer, Wouter Wolters

APPENDIX 1: WORKSHOP PARTICIPANTS

Surname	Name	e-mail	Affiliation	Project
Ammerl	Thomas	ammerl@bayfor.org	Bavarian Research Alliance	CLIMB
Baures	Estelle	Estelle.Baures@ehesp.fr	French School of Public Health	DOCTrends, ERA-EnvHealth
Beniston	Martin	martin.beniston@unige.ch	University of Geneva	ACQWA
Borga	Marco	marco.borga@unipd.it	University of Padova	HYDRATE
Brils	Jos	jos.brils@deltares.nl	Deltares	RISKBASE
Bundi	Ulrich	bundi@eawag.ch	Swiss National Science Foundation	NRP61
Djordjevic	Slobodan	s.djordjevic@exeter.ac.uk	University of Exeter	CORFU
Harding	Richard	rjh@ceh.ac.uk	CEH	WATCH
Kernan	Martin	m.kernan@ucl.ac.uk	University College London	Euro-limpacs, REFRESH
Kuriger	Jeanine	janine.kuriger@deza.admin.ch	Swiss Development Agency (SDA)	Global Programme CC
Laaser	Cornelius	cornelius.laaser@ecologic.eu	Ecologic Institute	ClimWatAdapt
Lehmann	Anthony	anthony.lehmann@unige.ch	University of Geneva	enviroGRIDS
Ludwig	Ralf	r.ludwig@lmu.de	Ludwig-Maximilians-Universität München	CLIMB
Marinova	Natasha	natasha.marinova@wur.nl	Alterra, Wageningen UR	ClimWatAdapt
Moors	Eddy	eddy.moors@wur.nl	University of Wageningen	High Noon
Mysiak	Jaroslav	jaroslav.mysiak@feem.it	Fondazione Eni Enrico Mattei	Xerochore, EPI-WATER
Pflieger	Géraldine	geraldine.pflieger@unige.ch	University of Geneva	ACQWA
Roson	Roberto	roson@unive.it	Foscari University, Venice	WASSERMed
Salzmann	Nadine	nadine.salzmann@geo.uzh.ch	University of Zurich	PACC
Samuels	Paul	p.samuels@hrwallingford.co.uk	H R Wallingford Ltd	FLOODsite
Sartori	Martina	martina.sartori@unimi.it	University of Milan	WASSERMed
Schmutz	Stefan	stefan.schmutz@boku.ac.at	Inst. of Hydrobiology and Aquatic Ecosystem Management	EFI+
Schwesig	David	d.schwesig@iww-online.de	IWW Water Centre Germany	NORMAN association
Stoffel	Markus	markus.stoffel@unige.ch	University of Geneva	ACQWA
Thiery	Dominique	d.thiery@brgm.fr	BRGM	N/A
Tockner	Klement	tockner@igb-berlin.de	IGB Berlin	BIOFRESH
Todorovic	Mladen	mladen@iamb.it	Mediterranean Agronomic Institute of Bari	WasserMed
Vanneuville	Wouter	wouter.vanneuville@mow.vlaanderen.be	Flanders Hydraulics Research	CRUE ERA-Net
Vurro	Michele	michele.vurro@ba.irsa.cnr.it	CNR-IRSA	AquaStress
Wehrli	André	andre.wehrli@eea.europa.eu	European Environment Agency (EEA)	N/A
Wimmer	Florian	wimmer@usf.uni-kassel.de	University of Kassel, Germany	ClimWatAdapt
Wolters	Wouter	wouter.wolters@wur.nl	Alterra	Mirage, Eau 4 Food
Xoplaki	Elena	xoplaki@giub.unibe.ch	University of Berne	CIRCE