ACQWA

Assessing Climate impacts on the Quantity and quality of WAter

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1. Foreword by the Project Co-ordinator and Director

The ACQWA Project has now completed one-third of its mandate, 20 months after it began on October 1, 2008. As reflected in the pages of this Newsletter, there has been significant progress in the research accomplished by the partners involved, and it is good to note that there have been no major delays or changes in the work programme. It is also noteworthy to highlight the fact that the first annual report of the ACQWA project was delivered to the European Commission in December 2009. This process will be repeated by March 2011 and should prove to be facilitated with the implementation of a new software package designed for scientific and financial reporting.

Over the past few months, climate-related news has unfortunately taken a turn for the worse. The Copenhagen Conference of the Parties to the UN Framework Convention on Climate Change (FCCC/COP-15, December, 2009), that raised high expectations from a wide scientific and public community that we were on the verge of a new global awareness of our environment and the need to protect it, did not lead to any binding agreement. This has been considered by many to be a step backwards from the Kyoto Protocol which, despite its numerous failings, nevertheless had the merit of setting a calendar for emission abatements. The disappointing conclusion of COP-15 also paved the way for the attacks against the Intergovernmental Panel on Climate Change (IPCC). While some of the errors that were raised in the Fourth Assessment Report were indeed legitimate, and while the IPCC could be criticized for its inadequate handling of the affair in terms of public relations, the fact remains that climatic change remains a very real issue. Addressing climatic change and its impacts requires urgent policy attention now in view of the long inertia of the climate system and the fact that in general, the greater the amplitude of global warming, the more severe the impacts are likely to be for many sectors and in many countries.

It is thus in this new and difficult situation, where there has been a possible undermining of public and political confidence in climate science, that projects like ACQWA need to be keenly aware of the need for cutting-edge research, the publication of results in leading journals, and the translation of these results into a form that is both comprehensible and useful for policy with the EU and the non-EU partner countries. At a recent meeting on the European Water Framework Directive held in Lille, France, the Science Officer in charge of the ACQWA project stated that “policy makers will not read scientific papers published in Nature, Science or the Journal of Hydrology. They need to have at their disposal research results that they can use to decide on a range of possible options as climate change unfolds”. While this statement may surprise many “pure scientists”, it is appropriate for the European Commission to remind the research community that the primary goal of EU projects is indeed to provide new findings designed to guide EU policy. These findings are of course only possible if ACQWA maintains the momentum of quality that it has strived to attain from the very start of the project.

We wish you pleasure in reading through these pages and look forward to communicating with you through future edition of these newsletters.

Martin Beniston, Project Coordinator and Markus Stoffel, Project Director

2. Climate Scenarios for Climate Change Impact Analysis in the Alpine Region

(A. Gobiet, M. Themeßl, A. Leuprecht, Wegener Center for Climate and Global Change, University of Graz, Austria)

ACQWA WP3 – Task 3.1

The basis for the assessment of climate change impact on the quality and quantity of water in ACQWA are regional climate simulations from the EU FP6 project ENSEMBLES (see ACQWA newsletter 2). Though the ENSEMBLES simulations currently represent the highest standard of quality in regional climate modeling, their direct application in hydrological modeling (or climate change impact research in general) is not advisable due to remaining model errors and the scale gap between climate models (grid spacing 25 km, effective resolution about 100 km) and most hydrological models (operating at grid-scales of a few 100 meters). Therefore, ACQWA has a strong focus on further downscaling and error correction of regional climate simulations.

In a first step, the two main regional climate simulations used in ACQWA (see ACQWA newsletter 2) have been post-processed using an empirical-statistical technique (quantile mapping (QM), Themeßl et al., 2010) to remove errors of the mean and variability from daily temperature and precipitation time series. Figure 1 illustrates the QM method. It is capable to remove model biases and to adjust the variability without removing the climate change signal in variability. In addition, QM proved to be very robust over a wide range of applications and to perform equally or superior to methods like the analog method, local scaling, or multiple linear regression (Themeßl et al., 2010).

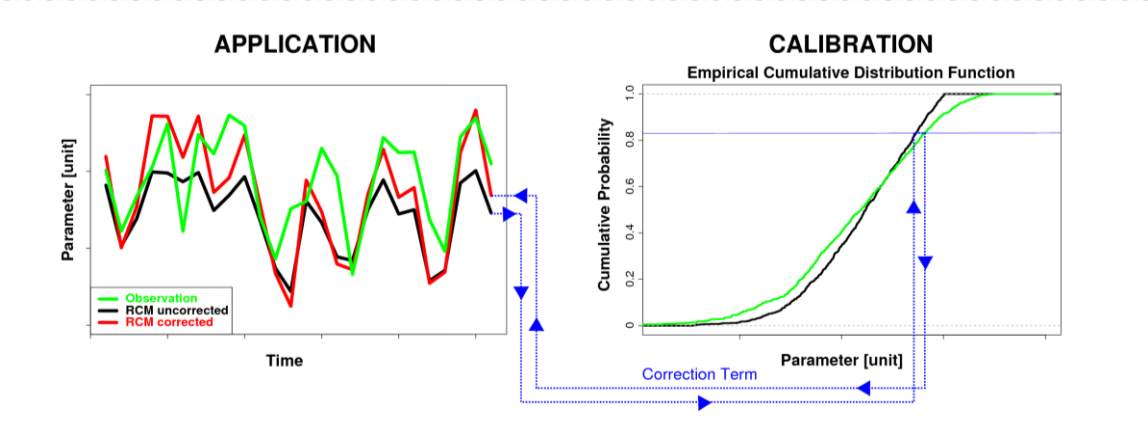

Figure 1. Quantile mapping: Modeled cumulative frequency distributions are mapped to observed distributions (right panel). The mean and variability of modeled time series are adjusted, but temporal correlation with observations is only slightly improved (left panel). Applied to climate scenarios, this drawback is irrelevant, but advantages remain and changes in not only in mean climate, but also in variability and extremes can still be studied after applying the correction.

In ACQWA, QM is implemented in a way that it properly accounts for spatially and seasonally varying model errors. Figure 2 demonstrates the performance of QM over the Alpine region. As observational basis, the E-OBS dataset (v2) has been used (Haylock et al., 2008) and the results are available on a 25 km grid. Two examples of uncorrected (left panels) and corrected (right panels) summer temperatures from RegCM3 (upper panels) and precipitation

from REMO (lower panels) are shown. Seasonal mean errors are be reduced by at least half an order of magnitude.

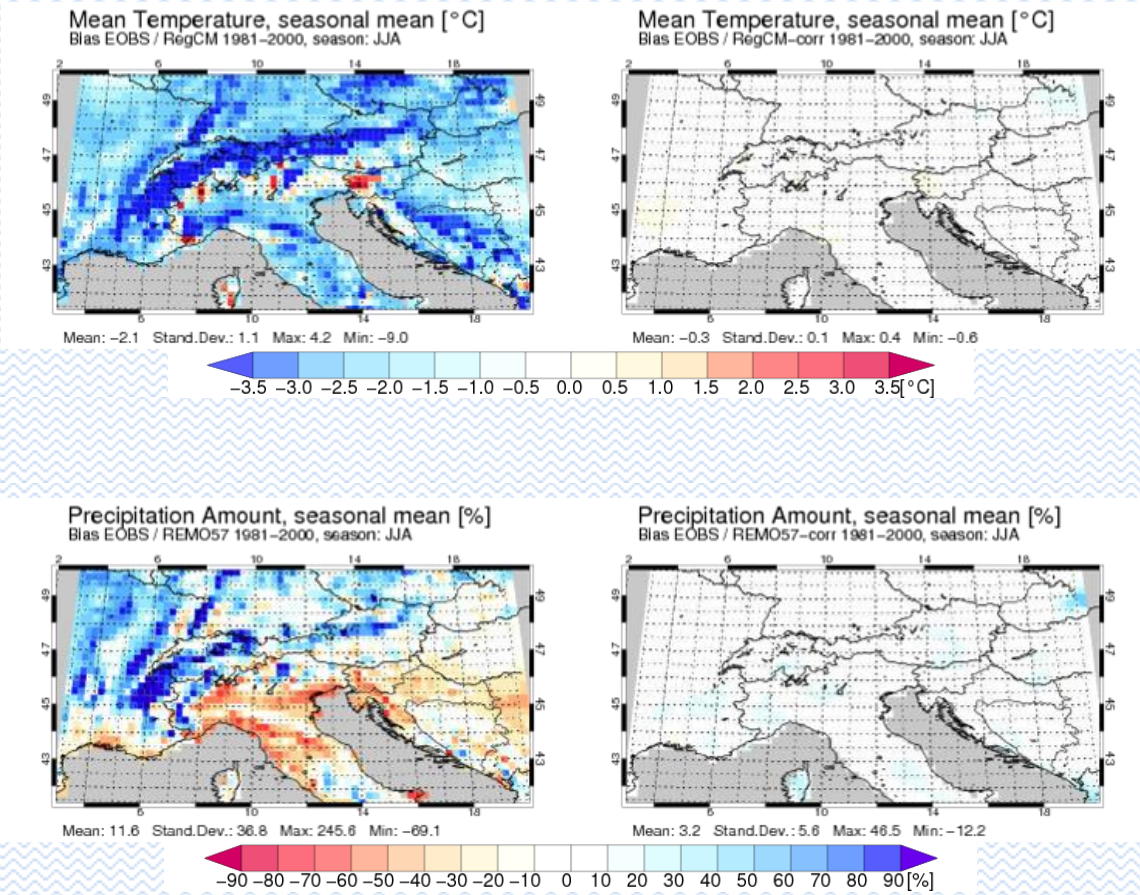

Figure 2. Seasonal errors in regional climate models before (left panels) and after empirical-statistical correction (right panels): RegCM3 summer temperature (upper panels) and REMO summer precipitation (lower panels). Training period for the empirical-statistical correction: 1961 – 1990; evaluation period: 1981 – 2000.

The simulations shown in Figure 2 (extended until 2050) will be the basis for larger scale climate change impact investigations in ACQWA. In order to satisfy the need for local scale climate information, daily and three hourly climate scenarios at the location of meteorological stations are produced in addition. The station-scenarios include further parameters like radiation, humidity and wind speed (depending on data availability and user request) and will be the basis for most local scale climate change impact simulations in ACQWA.

In addition to these two fundamental ACQWA climate scenario datasets, a high resolution gridded product (1 km grid spacing) is currently under development and various other downscaling techniques are investigated (including higher resolution dynamical simulations and direct statistical downscaling from global climate models). This will allow estimating the reliability or uncertainty of climate downscaling techniques in an unprecedented manner and will add to a comprehensive estimation uncertainty of high resolution climate scenarios in the Alpine region at a later stage of the project.

References

Haylock M.R., N. Hofstra, A.M.G. Klein Tank, E.J. Klok, P.D. Jones, M. New, 2008, A European daily high-resolution gridded dataset of surface temperature and precipitation for 1950–2006. J. Geophys. Research, 113, doi:10.1029/2008JD010201.

Themeßl, M., A. Gobiet and A. Leuprecht, 2010, Empirical-statistical downscaling and error correction of daily precipitation from regional climate models, Int. J. Climatol, accepted.

Acknowledgements

The ENSEMBLES data used in this work was funded by the EU-FP6 Integrated Project ENSEMBLES (Contract number 505539) whose support is gratefully acknowledged.

3. ACQWA New Data Warehouse

(Gregory Giuliani and Anthony Lehmann, University of Geneva, Switzerland)

ACQWA WP2 – Task 2.5

A large FTP disk has been setup to allow the ACQWA partners to share and exchange their relevant data sets (upload and download) for the entire duration of the project. There are three possibilities to connect to the ACQWA Data Warehouse: through a SFTP account, through the web or through a network drive. The best option is to access ACQWA data sharing space using SFTP but in the case you want to access it through the web or through a network drive, you have to request a personal account by contacting Gregory Giuliani (gregory.giuliani@unepgrid.ch).

The repository is structured either by types of scenarios (e. g., climatic, hydrologic and socio-economic scenarios) and by geographical area (Rhone, Po, Aconcagua, Kyrgyzstan, etc.). For each region several sub-folders are available to access hydrologic, meteorological, remote sensing, topographic, land-use, soil and socio-economic data.

For instance, different data sets are already available especially at the global and European scales:

- Climate Research Unit (CRU) Climate data (http://csi.cgiar.org/)
- Global Climate data (http://www.worldclim.org/)
- European Soils database (http://eusoils.jrc.ec.europa.eu/)
- Landscape of Europe (http://www.alterra.wur.nl/UK/research/Specialisation+Geo-Information/Projects/lanmap2)
- SRTM DEM (http://srtm.csi.cgiar.org/)

Each data set comes with a metadata documentation file describing in detail the data content. In addition, base layers from the canton of Valais are also available and our ACQWA partners from the University of Graz have made available different results from their climate simulations.

We also wish to bring your attention to the fact that ACQWA has become an official task in the Global Earth Observation System of Systems (GEOSS) Workplan 2009-2011 and as such all the significant outputs in terms of data (climatology, hydrology, environment, socio-economics) must be made available through the GEOSS GEOPortal. In consequence, all the services developed to feed the ACQWA portal (currently under development, http://acqwa.grid.unep.ch/) will be registered into GEOSS and will thus enhance the visibility of the ACQWA project and its major outputs for the benefit of the scientific community and decision makers.

4. Developing methods to calibrate physically-based hydrological models in areas with limited data availability

(David Finger and Paolo Burlando, ETHZ, Switzerland)

ACQWA WP3 – Task 3.2

Introduction

A key task of the ACQWA project is the prediction of glacier and snow melt runoff in the headwaters of mountainous regions. Such predictions rely on adequate meteorological forecasts [ACQWA, 2008] and also on satisfactory calibration of hydrological models. Model calibration is especially difficult when data availability is rare, as is the case in the remote areas of interest in Central Asia (e.g. the ACQWA study site in Kirgizstan) and South America (e.g. Aconcagua study site). Indeed, data availability in such remote areas is frequently limited to conventional discharge observations and satellite remote sensing observations. Recently the use of satellite remote sensing observations to drive and calibrate hydrological models has become increasingly important in hydrological modeling [e.g. Immerzeel et al., 2009; Wagner et al., 2009; Zhang et al., 2009]. However, research in this respect has not yet fully achieved a consensus about the suitability and the value of remote sensing data to calibrate physically based hydrological models, such as TOPKAPI [Ciarapica and Todini, 2002; Todini and Ciarapica, 2001].

During the first year of the ACQWA project, HWRM investigated the value of conventional discharge data (Q), extensive glacier mass balance (MB) and easily obtainable satellite snow cover images (SC) on model calibration. By the means of comprehensive Monte Carlo simulations we assessed the value of the three data sets in calibrating a modified version of TOPKAPI [Finger et al., 2010], which accounts for snow and ice related hydrologic components. The results indicate that satellite snow cover images combined with conventional discharge data lead to higher overall model performance, suggesting first that the modified version of TOPKAPI is suitable to be applied in areas where only these two datasets are available, and second that the use of these data for calibration produces an improved internal consistency of the model.

Method

In the context of the ACQWA investigations the modified version of TOPKAPI was applied to a small glacierized catchment (Rhone glacier in Switzerland) and validated against Q, recorded by the Swiss Federal Office of Environment (FOEN), MB as determined by Huss et al. [2008], and SC retrieved for a 8 year time period, from 2000 to 2008 from MODIS satellite

data [Hall et al., 2002]. Each of these observational data sets was used individually and in combination with the other data sets to determine the best 100 runs of the 10'000 Monte Carlo runs performed with model parameter sets generated randomly within a constrained range. Further details on the model setup and on the Monte Carlo simulation strategy are given in Finger et al. [2010].

Results

The best 100 runs of the Monte Carlo simulations revealed reasonable overall model results (Figure 1). Results of daily SC simulation indicate that during wintertime, when the entire catchment is covered by snow, the model parameters are obviously insensitive to SC data and the agreement between observed and computed SC remains above 98%. In fall, when the first snow fall occurs, and late spring and summer, when snow melt leads to snow free areas, the computed SC is more sensitive to the choice of model parameters (Figure 1a). The winter snow accumulation and the summer snow- and icemelt ablation show a fairly good agreement with the reference accumulation and ablation values, being these in most cases within the error band of the TOPKAPI computed values (Figure 1b). Discharge drops to minimal rates of 0.2 m3 s-1 during winter period and reaches maximal values of 30 m3 s-1 when warmer air temperatures lead to snow- and ice melt (Figure 1c). Discrepancies between modeled discharge and observed occur in particular in spring and during heavy precipitation events, thus denoting the critical role played by the rainfall input. The model shows, however, a good capability to follow the ablation dynamics dependent runoff variability.

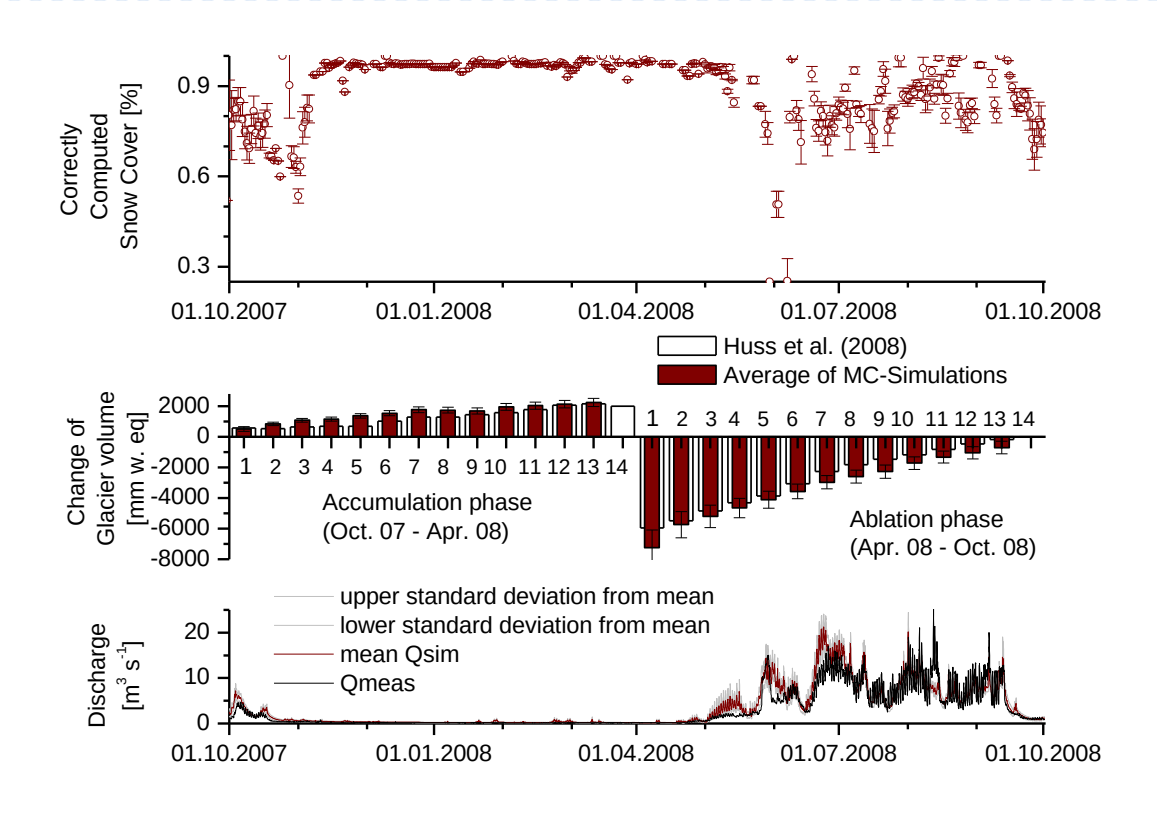

Fig. 1: Model performance of the 100 MC simulations with the best overall model performance. Panel a) depicts the mean fraction of correctly predicted daily snow cover. In panel b) the mean mass balance for 14 altitude bands are compared to mass balances determined by Huss et al. (2008). Panel c) illustrates the hydrographs of the 100 selected runs.

The role played by the variables used for calibration is better illustrated by Figure 2. The figure compares the overall model performance (defined by the product of the probability to be the best run in regard to discharge, snow cover and mass balances – see Finger et al. [2010] for details) of the best 100 Monte Carlo runs selected according to individual data sets and combination of the available data sets (Figure 2). While the use of all data sets combined provides, as intuitively expected, the highest overall model performance, the use of one or two variables only for the calibration of the model generally provides a poor performance. An exception is given by the combined use of discharge and satellite snow cover images, which is capable of constraining the model parameters significantly, thus leading to an overall model performance comparable to that obtained using all the available variables (Figure 2). This is an interesting and promising result, as it allows a good calibration of the model on the basis of non conventional data sets that are increasingly available. The associated improvement of the internal consistency of the calibrated model is particularly important, because it increases the suitability to simulate basin responses to future climatic conditions.

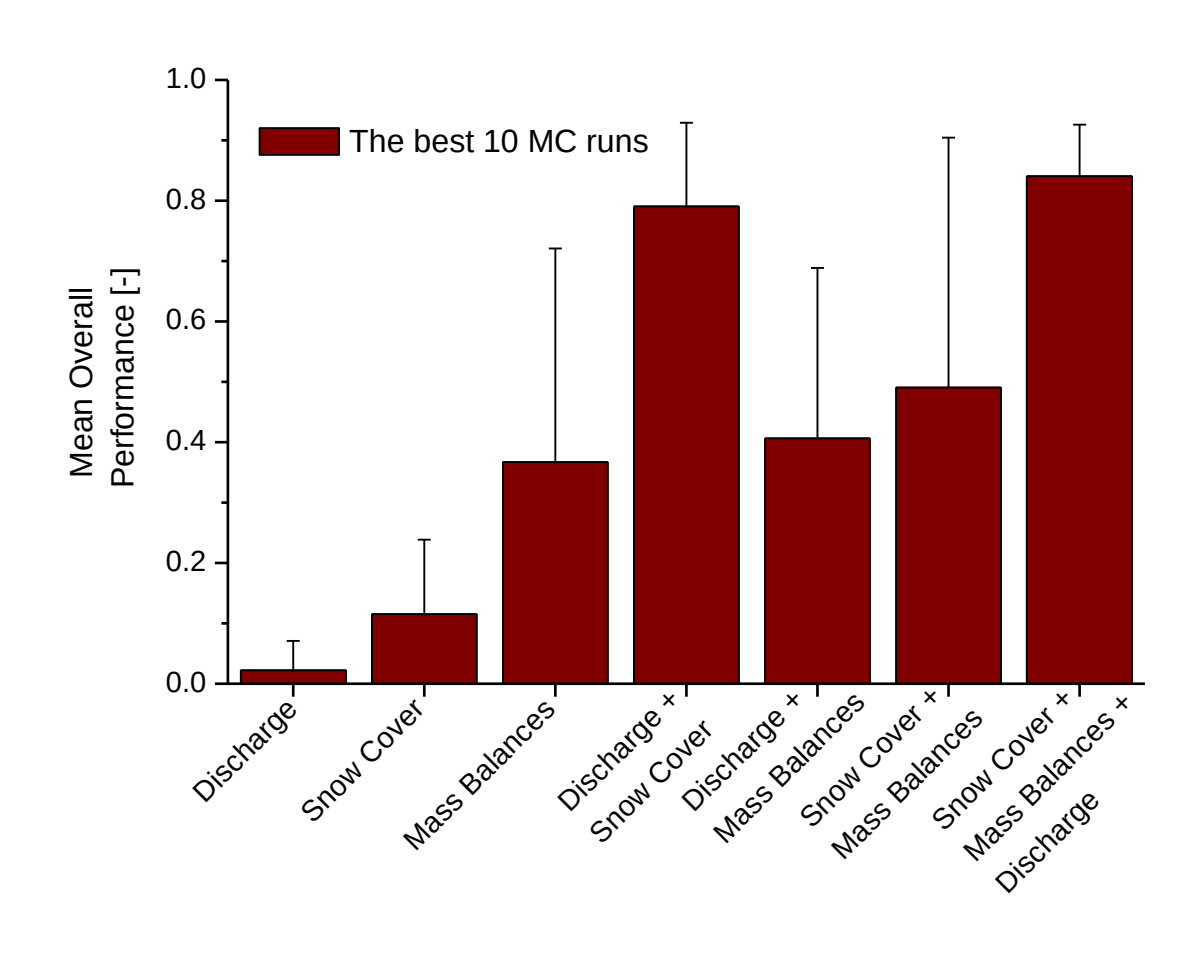

Fig. 2: Mean overall performance (defined by the good agreement of simulated discharge, snow cover and mass balances with measurements) of the 100 best runs selected with the observational dataset indicated on the X-axis. The error bars illustrate the standard deviation from the mean.

Conclusion

In summary, the preliminary studies carried out within ACQWA could demonstrate that the modified TOPKAPI, as one of the model chosen to simulate the effect of climate change on

the hydrologic response to future climates, is a suitable model for the purpose, particularly in mountainous regions. In particular, the calibration technique using MODIS snow cover maps and discharge recordings allows a proper calibration of the model also in remote and data poor regions. In fact, discharge data constrain the model with respect to temporal scales and volume information, whereas satellite binary snow cover images provide the necessary spatial information to constrain the model distributed response properly.

References

ACQWA (2008), Assessing Climatic change and impacts on the Quantity and quality of Water, University of Geneva, Geneva.

Ciarapica, L., and E. Todini (2002), TOPKAPI: a model for the representation of the rainfall-runoff process at different scales, Hydrol. Process., 16, 207-229.

Finger, D., F. Pellicciotti, M. Konz, S. Rimkus, and P. Burlando (2010), The value of glacier mass balances, satellite snow cover images and hourly discharge on calibration of a physically based, fully distributed hydrological model, submitted to WRR.

Hall, D. K., G. A. Riggs, V. V. Salomonson, N. E. DiGirolamo, and K. J. Bayr (2002), MODIS snow-cover products, Remote Sens. Environ., 83(1-2), 181-194.

Huss, M., A. Bauder, M. Funk, and R. Hock (2008), Determination of the seasonal mass balance of four Alpine glaciers since 1865, Journal of Geophysical Research-Earth Surface, 113(F1).

Immerzeel, W. W., P. Droogers, S. M. de Jong, and M. F. P. Bierkens (2009), Large-scale monitoring of snow cover and runoff simulation in Himalayan river basins using remote sensing, Remote Sens. Environ., 113(1), 40-49.

Todini, E., and L. Ciarapica (2001), The TOPKAPI model, in Mathematical models of large watershed hydrology, edited by V. P. Singh, Water Resources Publications, Littleton, Colorado, USA.

Wagner, W., N. E. C. Verhoest, R. Ludwig, and M. Tedesco (2009), Editorial 'Remote sensing in hydrological sciences', Hydrology and Earth System Sciences, 13(6), 813-817.

Zhang, Y. Q., F. H. S. Chiew, L. Zhang, and H. X. Li (2009), Use of Remotely Sensed Actual Evapotranspiration to Improve Rainfall-Runoff Modeling in Southeast Australia, J. Hydrometeorol., 10(4), 969-980.

5. The ACQWA Project in the Gran Paradiso National Park

(Rocco Tiberti, Dipartimento di Biologia Animale, Università di Pavia, Italy & Alpine Wildlife Research Centre, Gran Paradiso National Park, Italy; Antonello Provenzale, Istituto di Scienze dell'Atmosfera e del Clima, ISAC-CNR, Torino, Italy; Achaz von Hardenberg, Alpine Wildlife Research Centre, Gran Paradiso National Park, Italy)

ACQWA WP4 – Task 4.1

Alpine lakes are especially sensitive to global anthropogenic impacts: the hydrochemistry of mountain lakes is severely influenced by the chemical composition of atmospheric depositions and by climatic conditions. For this reason, remote lakes are considered "early response" indicators of climate change, atmospheric deposition and air pollution. In addition, high altitude alpine lakes are affected mainly by regional threats rather than by local ones, and can thus be used as laboratories for studying the effect of regional and global changes on freshwater ecosystems.

The Gran Paradiso National Park (GPNP) and the Institute of Atmospheric Sciences and Climate of the Italian National Research Council (ISAC-CNR) are working together on these assumptions to investigate how climate and environmental changes may alter the biota of high altitude alpine lakes.

Within this project, we are modelling the functioning of the ecosystem of 20 alpine lakes in the GPNP for which physical, chemical and biological data are collected in the field on each summer since 2006. The zooplankton and phytoplankton communities and the bacterial abundance have been quantified in all the lakes included in our study, enabling us to assess the impact of the presence of alien fish species (Salvelinus fontinalis) and to describe the seasonal dynamics of the lakes, using both empirical data and mathematical models. The exhaustive study of the hydrochemistry and morphology of these lakes enabled us to assess the factors influencing their physical and chemical features: preliminary results show that the effects of the long-range transport of atmospheric pollutants in the high mountain lakes at GPNP (located in the Western Alps) is by far less significant than in Alpine lakes in the Central Alps. The low impact of human activities in the GPNP lakes make them important reference sites for comparing their relatively undisturbed biota with those of the lakes in other Alpine districts, as well as for studying the long term evolution of Alpine lakes in response to long-range pollutant transport, to climate change and to other global threats.

Photo credits: all photos by Antonello Provenzale

6. Employing Extreme Events to Assess Adaptive Capacity to Climate Change in Water Governance Arrangements

(Margot Hill, University of Geneva, Switzerland)

ACQWA WP4 – Task 4.3

As part of a doctoral research to better understand adaptive capacity to climate change across two contrasting water governance arrangements (Rhone, Switzerland and Aconcagua, Chile), an initial water governance assessment in the context of Integrated Water Resources Management of the Swiss Canton of Valais took place in 2009. Results from the governance assessment in the Swiss case area showed that despite the water governance system scoring well under the 3 indicators (accountability, transparency, participation), serious concerns were raised about its ability to cope and adjust to a changing climate and rising competition on water use, mainly through the lack of integration across different geographies and users. Issues also arose in interviews which suggested that a correlation between 'participation' and 'decentralisation' and greater adaptive capacity should not be taken as a normative assumption.

Key problematic areas identified by the assessment can be grouped as follows: lack of resources at commune level; sectoral institutional approach; conflicts between the concept of the 'lowest appropriate level' and that of 'subsidiarity'; complexity of water sovereignty at different levels of government; conflicts on the horizon regarding artificial snow generation, climate change, long term hydropower concessions, and the growth of micro-hydropower. Ongoing work is using extreme events as an effective illustration of one type of climate uncertainty, in which to explore and assess the plasticity and adaptive capacity of the governance system through further stakeholder interviews. Key questions to be answered through field work this year are: What key components of adaptive capacity can be empirically observed in the case areas in the responses to extreme events? How does the mobilisation of these components vary across the different sectors/uses/locales?

For more information on the results of the governance assessment, and ongoing work, please refer to:

Hill, M. (2009) Converging Threats: Assessing socio-economic and climate impacts on water governance, Climate 2009 Conference, 2-6 November 2009, Available at: www.klima2009.net/en/pap.

Hill, M. (2010) Converging Threats: Assessing socio-economic and climate impacts on water governance, International Journal of Climate Change Management and Strategies. Accepted.

Hill, M. (2010) Swiss Water Governance Assessment: Full Report, Working Paper, Institute of Environmental Science, University of Geneva, Switzerland.