Hydro Predict' 2008

Interdisciplinary Conference 'Predictions for Hydrology, Ecology, and Water Resources Management: Using Data and Models to Benefit Society'
(Prague, Czech Republic, 15-18 September 2008)

The “Summary, conclusions and recommendations” of the HydroPredict'2008 Conference given below was prepared by Professor H.-P. Nachtnebel of the Universität für Bodenkultur Wien (BOKU), University of Natural Resources and Applied Life Sciences, Vienna, Austria.

This short report gives first an overview of the papers presented at the conference, then some conclusions are derived which are complemented by recommendations addressing further research questions. As well as the presentation of 85 papers, 60 papers were exhibited as posters.

Summary

The conference covered the following topics:
Topic A: Catchment Modelling; ungauged basins (PUBS)
Topic B: Accounting for uncertainty
Topic C: Ecohydrology
Topic D: Linking atmospheric and hydrological processes
Topic E: Processes in the unsaturated zone
Topic F: Surface water quality, thermal load and sediments
Topic G: Coastal groundwater systems and groundwater quality
Topic H: Interaction between surface and groundwater systems; groundwater modelling
Topic X1: Predictions, flood forecasting
Topic X2: Predictions, runoff forecasting
Topic Y1: Climate change impacts
Topic Y2: Impacts of land se on water resources
Topic Y3: Management of groundwater and surface water

Comparing the session topics with the themes of the recent 7th IHP Programme overlaps can be clearly identified referring to
- Adapting to the impacts of global changes in river basins and aquifer systems
- Impacts of global changes in river basins and aquifer systems
- Ecohydrology for sustainability.

Furthermore, some cross cutting themes such as transboundary water management issues and conjunctive use of surface and groundwater systems (HELP), water management issues in semi-arid regions (G-WADI), role of extremes in water management (IFI) and sediment transport issues (ISI) were discussed during this conference.

The IAHS PUBS initiative has been explicitly addressed in session A.

In **session A** two papers dealt with catchments under extreme climatic conditions. One analysed and modelled hydrological processes in an Arctic environment, the second estimated the runoff in ungauged semi-arid catchments in Iran. Both papers are of high relevance due to already observed rapid climatic and subsequent hydrological changes and due to major deficits in data and in knowledge about relevant processes in such environments. The next two papers addressed scale issues in hydrological modelling. In the opening and keynote paper the various sources of uncertainties in hydrological modelling were discussed. It was mentioned that although most of the hydrological models are based on a state space approach more or less no data are available about the state. Most of the data refer to measurements of the output (discharge) and input (precipitation and temperature) where the latter is subjected to a high uncertainty due to a sparse gauging network which is additionally subjected to a large measurement error. Benefits are seen in integrating at least some data describing the state, such as soil moisture networks or groundwater observations. Further it was concluded that improved mapping of land cover by field surveys may assist in improved modelling. As an example an area indicated as a forested area may react completely different to rainfall dependent if it is an old forest, an intensively used monoculture or if it is a mixed forest stand with different vegetation layers. Such information could be easily obtained from a field survey.

In **topic B** the assessment of the uncertainty in parameter estimation was emphasized. One keynote paper addressed the value of integrating soft data in modelling ungauged catchments. It was shown under which circumstances soft data could help in improved parameter estimation. Another paper analysed the impact of spatial variability of the input on parameter estimation. It was shown that even with a highly variable input reliable parameter estimation is possible. In another paper a Kalman filtering approach was applied to predict model output. Interesting was also to learn about the consequences of uncertainties in model prediction on decision making, for instance on the award of water rights.

The ecohydrology **session (C)** included several papers dealing with functions of wetlands in different regions (Romania, Okavango Delta, Japan, Chile). The interaction between hydrological and biogeochemical processes was excellently described in several papers. Other papers analysed the role of land use on flows of water (surface runoff, groundwater recharge) and flows of nutrients and of other substances. The interaction between the different systems (abiotic-biotic; man made and natural systems) was carefully analysed. It can be concluded that real progress has been achieved in the last decades in this domain.

Topic D addressed the linkage between atmospheric and hydrological processes. Very often this interaction is seen only in direction from atmosphere to hydrology. But all of the atmospheric models require also vertical flows from the ground to the atmosphere and they parameterise this flow in a simplified way, although the hydrological models simulate also the losses. A coupling of these two models could at least lead to a unified approach and could reduce the noise incorporated in both models. Papers analysed the soil moisture response to atmospheric forcing, soil evaporation, the response of runoff to precipitation changes.

Directly related to this topic was also **session E** with the title «processes in the unsaturated zone». The benefits from remote sensing for monitoring soil moisture were demonstrated for a one kilometre grid. The joint modelling of water flow and movement of substances in the unsaturated zone, the role of the unsaturated zone on runoff formation in a hilly environment was demonstrated for several catchments under different climatic conditions. The results are impressive although the data base for the soil layer is rather poor in several case studies. To my opinion more emphasis should be put on soil mapping, soil classification, mapping of the land cover and sound a priori estimation of relevant hydrological parameters.

The topics in **session F** were surface water quality, thermal loads and sediments. Not all of the papers fitted well to these topics. Several papers analysed the benefits of water quality monitoring systems, the uncertainties in data and in modelling. It is appreciated that also the role of field experiments (tracers) is investigated in some of the papers. One paper addressed thermal loadings and under consideration of globally increasing water temperatures and increasing needs for cooling water this specific topic should gin more attention.

In « coastal groundwater systems and groundwater quality (**topic G**) » mostly the latter subject was presented in several papers. The role and fate of pollutants in the underground, the monitoring of pollutants by geophysical techniques and the dating of sediments by pollutants were discussed.

Topic H had the title « interaction between surface and groundwater systems, groundwater modelling ». Some papers worked on analysing the interaction at different scales, some dealt jointly with quantitative and qualitative aspects. It was interesting to learn that several papers referred to the benefits of additional field measurements and to remote sensing data to improve model applications. Also, the proposed concepts to model karst systems were appealing as well as the transient features of parameters in some modelling approaches. In one keynote the scale aspects in modelling the interaction between the different water bodies were deeply analysed.

Topics X1 and X2 were among the key topics of this conference « predictions and flood forecasting ». State of the art in operational flood forecasting is ensemble based flood forecasts from which confidence intervals or exceedance probabilities of a critical threshold level can be derived. Most of the papers concentrated on ensemble forecasts and investigated benefits and risks of such an approach. In one of the keynotes it was stated users are interested in a « most probable forecast » instead of having a range of possible outcomes. Tools were proposed to assist in a probabilistic assessment of ensembles and it was suggested to consider also the type of event in classifying uncertainties of the forecasts. The task related to reliable parameter estimation techniques was also approached by several papers recommending neural networks, data mining and inverse estimation techniques. Updating procedures and recursive parameter estimation techniques based on Kalman filters, Ensemble Kalman filters for non-linear systems were demonstrated in applications. Some papers presented real time operation systems which are a challenging task from the methodological side but very tricky from the viewpoint of responsibility, liability and accountability. In case of real time flood management how is going to pay if the operation of a system results in unexpected damages? The meteorological service providing the forecasts, the hydrologists who developed the hydrological model, the responsible operator? Good luck!

Climate change impacts were in the focus of **session Y1**. Not surprising that stochastic downscaling concepts are proposed by several authors because the spatial resolution of the global circulation models is still not sufficient for hydrological modelling tasks. Authors confirm that and state that the use of rainfall time series from global climate change model sis not recommendable, even not for the historic period from 1980 to 2005. Therefore downscaling approaches based on Hidden Markov model sis proposed by one group. Others use only the temperature from the GCM which is more reliable and study the impacts of climate change on the snowmelt processes in some catchments.

Besides climate change human interventions may have recently a stronger impact on the catchment hydrology, except from Polar Regions. So, land use impacts on water resources were discussed in **topic Y2**. Some paper deal with nutrient release from agricultural areas, others analyse the impact of land use on floods, and also the consequences of urbanisation for water resources are analysed.

The final **session Y3** has the emphasis on water management issues for both surface and groundwater. Several case studies throughout the world are presented; most of them concentrate on groundwater problems. Those who work on similar problems could benefit but it is difficult to draw specific conclusions from the papers. In one paper an unstructured GIS is presented which could be interesting for several hydrological and hydraulic problems when irregular boundaries or subunits are needed. Also a paper about the operation of a complex hydrothermal power system offered some interesting ideas.

Conclusions

A few subjective comments are made which came up during listening to presentations and during discussion with colleagues.

(1) The consideration of scales and the scale dependency in parameter estimation techniques have been widely recognised in different areas. Definitely this will contribute to an improved understanding of hydrological processes. A coherent methodology is still missing. In some approaches simulation techniques are used to generate typical structures at different scales while others apply non-linear relationships to describe parameters at different scales.

(2) The application of sophisticated mathematical techniques in forecasting systems such as Kalman filters, Ensemble Kalman filters, inverse state estimation, and particle filtering is quickly progressing. A few years ago ensemble forecasts were an interesting research domain, of course this is still the case, but in the mean time several systems based on this technique are already operational. On the other hand it is surprising that the improvement of monitoring systems is lacking. A lot of information could be gained by improved measurement techniques to provide at least some online information about system states. Especially in an alpine environment the data base is poor. The density of the monitoring system is low, the measurement error is quite high and radar and other remote sensing techniques don't work properly in such an environment.

(3) Meteorological processes drive hydrological processes but there is an important feedback that is not fully considered in the modelling approaches. Meteorologists run their atmospheric models in which

the land surface is simply parameterised and the soil moisture content is frequently estimated on the basis of an accounting scheme. In advanced hydrologic models the spatio-temporal soil moisture distribution is modelled in detail and this information could be used to improve the estimation of fluxes across the interface. One of the few hydrological variables which are probably monitored with a smaller error is the discharge. But this information is not often used in recalibrating atmospheric models although the runoff constitutes a spatio-temporally integrating variable.

(4) Distributed hydrological models and eco-hydrological models require many parameters which are dependent on the land cover, especially on the vegetation layer. Often, a simple classification into a few categories such as glaciers, bare rock, pastures, forests, agricultural land, vineyards, domestic areas are used. From a hydrological perspective it makes a large difference if a younger homogeneous spruce stand or an old mixed forest stand with several vegetation layers is modelled. This information would be rather easily available but it is not frequently considered in modelling applications.

(5) Coupling or integrating hydrological with biological models, for instance modelling the development of a plant community requires the estimation of parameters which characterise/define the fluxes among the subsystems, such as the abiotic and the biotic system. The seasonal cycles of plant development and the respective forcing on the hydrological system are considered by temporarily varying suction forces etc. But several other parameters describing the infiltration capacity, the surface roughness are also time dependent but are frequently considered only as soil class dependent parameters without considering impacts f biological activities in the soil and on its surface.

Overall, it was a quite interesting conference with several excellent contributions generating lively discussions.

Recommendations

A lot of information is now available at different scales, either from satellite data or included in national, regional GIS data base. Obviously, these data are of high value for hydrology and water resources but they are imprecise data and their information cannot be directly translated into hydrological information. Such information could substantially help to reduce the uncertainty in parameter estimation techniques in hydrological modelling. The benefits of such a methodology have been already demonstrated in some papers but it would be helpful to organise a meeting (workshop or conference) addressing exclusively this issue in different hydrological applications.

Hydrologists work mostly with state models formulated in the state space. Typical examples are spatially distributed models which model each element by a series of layers or storage schemes. Typical states refer to the snow water content of the snow layer, the amount of water stored in the interception layer, the sol moisture content in different soil layers and finally in the groundwater and in rivers. Which of these quantities is well monitored? To overcome this problem inverse modelling techniques are applied but it would be helpful to at least a handful of stations online available to improve the operational use of hydrological models. But in first step the benefits from including such data should be clearly demonstrated. Numerous distributed hydrological models were applied in case studies and groundwater observations should be available in most of the cases. Of course, such a hydrological model cannot be calibrated to the observed groundwater data but only fitting to runoff data is not attractive anymore. Such additional information could also help in narrowing the parameter space. By analysing qualitatively the deviations between models and some observations critical judgements about the model structure could be obtained.

Coupling of meteorological and hydrological models is seen as a challenging and promising approach to improve the logical structure of both components. Atmospheric models are mainly based on physical principles and are thus less conceptual then hydrological models. Hydrological models simulate the whole hydrological cycle and utilise land related information which are not considered in meteorological models. Therefore both sides could benefit from an integrated approach. Some case studies yielded promising results. Also in real time forecasting the coupling will help when precipitation patterns can be continuously updated by runoff data.