Preface

The atmosphere is the primary driving force for all hydrological processes, yet the availability of spatially and temporally reliable hydrometeorological information remains a critical issue in many hydrological studies. Tools to derive reliable spatially-distributed long-term meteorological information are needed for hydrological assessment, particularly in developing countries where observation networks are extremely coarse and the vulnerability to droughts and extreme hydrological events is large. The problem is made more urgent by the suggestion that a warmer climate will lead to an intensification of the hydrological cycle, and particularly to an increase in the frequency of extreme events, i.e. heavy precipitation and droughts. In order to accurately represent and understand the impact of climate dynamics on the development of freshwater resources, water management tools that account for the coupled land–atmosphere system are needed. Indeed, the derivation of spatially and temporally representative hydrometeorological data and their accurate representation in water management tools is important to predict the current and future developments in freshwater resources, which are influenced by changing climate and land surface patterns due to intensified human activities.

In order to address the issue of climate variability and its representation in water management tools, the symposium *Quantification and Reduction of Predictive Uncertainty for Sustainable Water Resources Management* was conducted to provide a joint forum for meteorologists and hydrologists during the International Union of Geodesy and Geophysics (IUGG) XXIV General Assembly in Perugia, Italy, in July 2007. The symposium was organized by the IAHS International Commission on Coupled Land–Atmosphere Systems (ICCLAS) and the joint IAHS/WMO Working Group on GEWEX, and supported by the IAMAS International Commission on Climate (ICCL), the IAHS commissions ICWRS (International Commission on Water Resources Systems) and ICRS (International Commission on Remote Sensing) and the IAHS PUB (Predictions in Ungauged Basins) working group. In total, 86 abstracts were presented at the symposium.

This publication comprises the proceedings of the symposium. It contains 54 peer-reviewed papers which reflect the multidisciplinary aim of the symposium: to view the uncertainties in the end-to-end prediction of hydrological variables, beginning with the atmospheric driving and ending with the hydrological calculations for scientifically-sound decisions in sustainable water management. Consequently, the book is organized in two main parts; the first part addresses the *Quantification and reduction of predictive uncertainty in hydrometeorological forcing* and the second part includes studies aiming at *Minimizing risks in water management decisions by improving the understanding and spatial representation of the coupled land–atmosphere system.* Part 1 comprises the following four sections:

1.1 Meteorological prediction and uncertainty

1.2 Spatial climate data and uncertainty

1.3 Hydrological predictions using integrated climate–hydrological modelling
1.4 Uncertainty in hydrological forecasting

The section on *Meteorological prediction and uncertainty* addresses the identification and estimation of the long-term meteorological information which is required for hydrological modelling. In this section, the relevance and utility of multiple climate model products for purposes such as extreme flow predictions and long-term climate change impact studies are discussed. It is also shown that regional climate forecast information for hydrological modelling can be derived by interpreting meteorological data using knowledge of larger-scale weather systems, such as those governed by monsoon and ENSO dynamics. Finally, the incorporation of satellite image time series to improve understanding of the formation of weather events is also addressed.

The second section, on *Spatial climate data and uncertainty*, focuses on the specific problem of deriving spatial climate information. Indeed, input data uncertainty caused by spatial variations in precipitation and solar radiation within a catchment is a significant problem in hydrological modelling. To address this problem, satellite remote sensing data, ground-based radar data and geo-statistical interpolation of conventional meteorological data are used to quantify spatial climate data, and associated uncertainties are assessed. Error propagation caused by scarce climate data availability in hydrological modelling is also investigated.

The third section focuses on *Hydrological predictions using integrated climate–hydrological modelling*. This section is introduced by a summary of GEWEX (Global Energy and Water Cycle Experiment) activities and indicates the hydrological focus of the project over the next five years. Experiences with the use of global and regional climate model products for hydrological prediction and forecasting are then presented for a variety of different climate zones, i.e. Russia (Northern Europe), Jordan (Middle East), Ghana (West Africa) and Brazil.

The fourth section, *Uncertainty in hydrological forecasting*, aims at understanding the multiple causes of uncertainty in hydrological modelling (i.e. input data, model parameters, model structure) and discusses methods for uncertainty quantification in hydrological forecasting. For this purpose, ensemble or Monte Carlo predictions are particularly useful to produce hydrological probabilistic forecasts expressing climate and hydrological uncertainties.

The second part of the book, *Minimizing risks in water management decisions by improving the understanding and spatial representation of the coupled land–atmosphere system*, consists of four sub-sections:

2.1 Hydrological predictions using spatial data and integrated land surface–atmosphere–hydrology modelling
2.2 Geographical transferability of methods and predictions in ungauged basins
2.3 Meteorological predictions and data assimilation for flood risk management
2.4 Integrated water management systems for sustainable water management

In the section on *Hydrological predictions using spatial data and integrated land surface–atmosphere–hydrology modelling*, the use of spatial data and land surface–

atmosphere modelling aims to provide a better understanding of both meteorological and hydrological processes in order to improve water resource predictions. The section is introduced by summarizing the AMMA (African Monsoon Multidisciplinary Analysis) project where multi-scale data and land-surface modelling are employed to achieve better understanding of the attendant processes. The impact of using uncoupled or coupled atmospheric–hydrological modelling is also investigated, and a methodology for upscaling and assimilating point soil measurements in land surface modelling of mean spatial moisture fields is presented. Furthermore, the capabilities of land surface models and hydrological models for simulating streamflow are evaluated and compared, and methods for evapotranspiration estimation are presented and discussed in relation to perspectives for improved water resource management.

The second section, *Geographical transferability of methods and predictions in ungauged basins*, elaborates on the use of geographical information to parameterize hydrological models. Information on physical catchment characteristics is particularly important to estimate and transfer model parameters to ungauged catchments where hydrological measurements for model parameter calibration are not available. The utility of physical catchment properties, catchment similarity indices and clustering techniques for water resource predictions in ungauged basins is investigated.

Sections 2.3 and 2.4 focus on the development of water management tools for flood risk management and sustainable water resource management, respectively. In 2.3, *Meteorological predictions and data assimilation for flood risk management*, the adoption of ensemble weather predictions and real-time data assimilation techniques to improve flood forecasting confidence are shown, and the implementation of these methodologies in a flood management decision support system is presented. For ungauged catchments, different methods based on focused pooling approaches are evaluated in terms of flood forecasting perspectives, and the use of geomorphic characteristics and event antecedent moisture condition in operational flood forecasting systems are discussed.

In the final section on *Integrated water management systems for sustainable water management*, integrated climate–hydrology forecasting and reservoir management systems designed for operational implementation are presented. The overall aim of these control and management systems is to optimize rates of water supply to meet water demands. For this purpose, it is important to understand and quantify the way uncertainty influences the systems, i.e. impacts of uncertainties related to meteorological input data, water availability and water demands should be adequately addressed and communicated to decision makers.

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