HYACINTS

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International Research School of Water Resources

Seminar on Uncertainties in Climate Change Impacts on Water Resources

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Abstracts

Uncertainty in hydrological modelling – terminology, methodologies and HYACINTS' contribution

Jens Christian Refsgaard, Geological Survey of Denmark and Greenland (GEUS)

The presentation gives a definition of uncertainty and how it can be characterised in terms of (a) type of uncertainty, i.e. statistical, scenario, qualitative, ignorance; (b) nature of uncertainty, i.e. reducible/non-reducible; and (c) sources of uncertainty. Furthermore an introduction is provided to how uncertainty can be dealt with in hydrological modelling and which methodologies exist for assessing various types of uncertainty. HYACINTS is a five years project (2008-2012) aiming at developing improved tools and methodologies for assessing the effects of climate change on water resources at both regional and local scales. HYACINTS will assess uncertainties related to prediction of climate change impacts with particular focus on uncertainty related to (i) selection of GCM and RCM; (ii) feed-back processes between atmosphere and land surface; (iii) geological conceptualisation; and (iv) downscaling from climate model grids to the much smaller local scale hydrological model grids.

Uncertainty and stochastic sensitivity analysis of the GeoPEARL pesticide leaching model

Gerard Heuvelink, Wageningen University and Research Centre, The Netherlands

GeoPEARL is a spatially distributed model describing the fate of pesticides in the soil-plant system. It calculates the drainage of pesticides into local surface waters and the leaching into the regional groundwater. GeoPEARL plays an important role in the evaluation of Dutch pesticide policy plans. In this study we analyzed how uncertainties in soil and pesticide properties propagate through GeoPEARL for three representative pesticides. The GeoPEARL output considered was the 90 percentile of the spatial distribution of the temporal median of the leaching concentration over a period of twenty years (P90). Results of the Monte Carlo uncertainty propagation analysis showed large uncertainties in P90, with interquartile ranges larger than the median for all three pesticides considered. Taking input uncertainty into account also leads to a systematic shift of the P90 towards greater values. Stochastic sensitivity analysis showed that the pesticide properties were the main sources of uncertainty and that uncertainty in soil organic matter contributed to a lesser extent.

Quantitative techniques for evaluating probability forecasts with observations, including examples from the U.S. National Weather Service

James Brown, Office of Hydrologic Development, NOAA/National Weather Service, United States of America / University Corporation for Atmospheric Research, United States of America

The River Forecast Centers (RFCs) of the U.S. National Weather Service (NWS) produce ensemble forecasts of temperature, precipitation and stream flow at discrete forecast locations for a variety of forecast lead times. There is a need to evaluate these predictions and to identify the factors responsible for forecast bias and skill in different modelling situations. This will lead to improved techniques for modelling and observing hydrologic systems and for generating reliable uncertainty information, which is needed for risk-based decision making. While quantitative methods for evaluating probability forecasts are widely used in the atmospheric sciences, they are rarely used in hydrology. Quantitative evaluation is concerned with the joint probability distribution of the observed and forecast variables, estimated from historic pairs of (ensemble) forecasts and observations. The joint distribution may be factorized in two ways to provide one marginal and one conditional distribution. These probability distributions convey several attributes of forecast quality, such as the reliability of the forecast probabilities, which can be measured with specific metrics, such as the reliability diagram. This presentation provides an overview of quantitative techniques for evaluating probability forecasts and presents some real examples from the NWS RFCs.

WATCH – Water and Global Change

Richard Harding, Centre for Ecology and Hydrology, Wallingford, UK

The Global Water Cycle is an integral part of the Earth System. It plays a central role in global atmospheric circulations, controlling the global energy cycle (through latent heat) as well as the carbon, nutrient and sediment cycles. Globally, the supply of freshwater far exceeds human requirements. However, by the end of the 21st century, these requirements begin to approach the total available water. Of course, regionally the water demand – for agriculture, and domestic and industrial use – already exceeds supply.

Increasing CO2 levels and temperature are intensifying the global hydrological cycle, with an overall net increase of rainfall, runoff and evapotranspiration, and will increasingly do so. The predictions of future rainfall regionally are fairly uncertain, there are, however, indications that the Mediterranean region will see reductions of rainfall and some equatorial regions, such as India and the Sahel, will see increases. The seasonality may also change, causing new, and sometimes unexpected, vulnerabilities. The intensification of the hydrological cycle is likely to mean an increase in extremes – floods and droughts. There are suggestions that inter-annual variability will increase – with an intensification of the El Ninõ and NAO cycles – leading to more droughts and large-scale flooding events. These cycles are global phenomena which will impact different regions simultaneously (although often in different ways).

The Integrated Project (WATCH), funded under the EU FP6, will bring together the hydrological, water resources and climate communities to analyse, quantify and predict the components of the current and future global water cycles and related water resources states, evaluate their uncertainties and clarify the overall vulnerability of global water resources related to the main societal and economic sectors.

Uncertainty Concepts Applied by the IPCC

Kirsten Halsnæs, DTU Climate Centre Risø, Denmark

The IPCC assessment reports have aimed at using a consistent set of concepts and guidelines for reporting uncertainties spanning climate change modelling, GHG emission scenarios, energy-economic modelling, impact and adaptation studies, and various other elements. The presentation introduces the IPCC uncertainty guidelines and discusses in this context, how the concepts have been used in relation to key conclusions in WGI, WGII, and WGIII.

Uncertainty has to be very different understood in climate models compared with for example economic models, and a number of insights are provided about uncertainties specifically can be understood in relation GHG emission projections, mitigation costs assessment, and in relation to economic valuation of climate change impacts. Some very basis methodological limitations surround economic valuation of climate change impacts due to long time horizons, intergenerational issues, and impacts on sectors and assets beyond the scope of economics. Recommendations are given about how economic analysis considering limitations can be used as an input to broader integrated assessments.

The role of uncertainty in adaptive water management

Hans Jørgen Henriksen, Geological Survey of Denmark and Greenland (GEUS)

The presentation introduces uncertainties in relation to adaptation and adaptive water management (AWM). A central contribution by AWM is that it provides added value through explicitly embracing uncertainty. Since water management and adaptation are hampered by a wide variety of uncertainties such as unpredictability, incomplete knowledge and ambiguities, AWM suggest capacity building through learning and adaptation, for responding flexibly and effectively to changing and unknown conditions. Fundamental here is the involvement of multiple actors, each with their own interests often being in conflict or mutually incompatible.

Decision makers not only have to learn how to deal with uncertainties related to climate predictions and modelling, they also have to deal with the conflicting views and ambiguity. This is important for identifying robust and efficient adaptation solutions suitable under different possible future scenarios. Ambiguity and multiple/ incompatible perspectives about a problem are caused by a diversity of different backgrounds (scientific, ideological), understandings (financial, legal, ethical) and social positions (cultural). Hence learning how to deal with differences require communication and dialogue in order to incorporate, exchange and mutually understand the various stakeholder beliefs, values and perceptions that might influence their problem understanding, framing, and search for adaptation strategies.

Methods for coping with ambiguity and multiple knowledge frame uncertainties can be applied by ‘negotiation’ (deal making), ‘dialogical learning’ (mutual interactive learning/social learning) and ‘making present’ (learning about system from roles).

The presentation gives an example of stakeholder engagement and dialogue regarding uncertainty analysis of adaptation strategies for the Guadiana water conflict by applying Bayesian belief networks in the Upper Guadiana river basin in Spain - one of seven NeWater case studies (www.newater.info). After the testing of the participatory process and the Bayesian belief network tool an evaluation was made based on stakeholder perceptions. The perspectives of incorporating stakeholder values and beliefs as part of AWM climate adaptation is briefly discussed and expanded by including lessons learning from other NeWater basins (Rhine, Elbe and Tisza).

Uncertainty in climate change impacts on freshwater ecosystems

Erik Jeppesen, NERI, University of Aarhus

Several simple and complex models have been developed with the purpose of predicting the effect of climate change on freshwater ecosystems. Typical these models are calibrated on the present-day situation, and in a few cases tested on an independent present-day dataset. The realism of the models for a future climate change situation is, however, debatable. Using space-for-time substation I will show that climate change will have profound effect on the ecosystem dynamics – dynamics that are not covered by any model today. Rather than using a lot of effort to gain insight into the uncertainties of existing models, focus should be on developing more realistic ecosystem models for prediction of climate change effects.

Uncertainty in climate change impacts on water resources in Denmark – sensitivity analysis

Lieke van Roosmalen, Geological Survey of Denmark and Greenland (GEUS)

A quantitative comparison of plausible climate and land use change impacts was performed to estimate the uncertainty related to the choice of climate scenario on the simulated impacts of climate change on the hydrology of an agricultural catchment in Denmark. An integrated, distributed hydrological model was used to simulate changes in the groundwater system and its discharge to rivers and drains for the IPCC A2 and B2 climate scenarios (2071–2100). The land use change effects included the doubling of the area with forest at the expense of grain and grass, changes in crop development dates, and a limited increase in potential evapotranspiration for crops in the scenario climate simulations. Annual groundwater recharges increased for both climate scenarios, giving higher groundwater heads and stream discharges and amplifying the seasonal dynamics significantly. A local sensitivity analysis of the model parameters showed that the hydrological response to the climate changes was only marginally affected by parameter value variations within the estimated parameter confidence intervals. Also, a comparison of two bias-correction methods, a delta change and direct method, showed that the choice of method only marginally affected the simulated hydrological impacts of climate change. This study has shown that climate change has the most substantial effect on the hydrology in this catchment, whereas other factors such as irrigation, CO2-effects on transpiration, and land use changes affect the water balance to a lesser extent.