1. Beneath the surface of global change: Impacts of climate change on groundwater
5 August 2011
Timothy R. Green | Makoto Taniguchi | Henk Kooi | Jason J. Gurdak | Diana M. Allen | Kevin M. Hiscock | Holger Treidel | Alice Aureli

Summary: Global change encompasses changes in the characteristics of inter-related climate variables in space and time, and derived changes in terrestrial processes, including human activities that affect the environment. As such, projected global change includes groundwater systems. Here, groundwater is defined as all subsurface water including soil water, deeper vadose zone water, and unconfined and confined aquifer waters. Potential effects of climate change combined with land and water management on surface waters have been studied in some detail. Equivalent studies of groundwater systems have lagged behind these advances, but research and broader interest in projected climate effects on groundwater have been accelerating in recent years. In this paper, we provide an overview and synthesis of the key aspects of subsurface hydrology, including water quantity and quality, related to global change. Adaptation to global change must include prudent management of groundwater as a renewable, but slow-feedback resource in most cases. Groundwater storage is already over-tapped in many regions, yet available subsurface storage may be a key to meeting the combined demands of agriculture, industry, municipal and domestic water supply, and ecosystems during times of shortage. The future intensity and frequency of dry periods combined with warming trends need to be addressed in the context of groundwater resources, even though projections in space and time are fraught with uncertainty. Finally, potential impacts of groundwater on the global climate system are largely unknown. Research to improve our understanding of the joint behaviors of climate and groundwater is needed, and spin-off benefits on each discipline are likely.

2. A review of drought concepts
14 September 2010
Ashok K. Mishra | Vijay P. Singh

Summary: Owing to the rise in water demand and looming climate change, recent years have witnessed much focus on global drought scenarios. As a natural hazard, drought is best characterized by multiple climatological and hydrological parameters. An understanding of the relationships between these two sets of parameters is necessary to develop measures for mitigating the impacts of droughts. Beginning with a discussion of drought definitions, this paper attempts to provide a review of fundamental concepts of drought, classification of droughts, drought indices, historical droughts using paleoclimatic studies, and the relation between droughts and large scale climate indices. Conclusions are drawn where gaps exist and more research needs to be focussed.

3. Drought modeling – A review
6 June 2011
Ashok K. Mishra | Vijay P. Singh

Summary: In recent years droughts have been occurring frequently, and their impacts are being aggravated by the rise in water demand and the variability in hydro-meteorological variables due to climate change. As a result, drought hydrology has been receiving much attention. A variety of concepts have been applied to modeling droughts, ranging from simplistic approaches to more complex models. It is important to understand different modeling approaches as well as their advantages and limitations. This paper, supplementing the previous paper (Mishra and Singh, 2010) where different concepts of droughts were highlighted, reviews different methodologies used for drought modeling, which include drought forecasting, probability based modeling, spatio-temporal analysis, use of Global Climate Models (GCMs) for drought scenarios, land data assimilation systems for drought modeling, and drought planning. It is found that there have been significant improvements in modeling droughts over the past three decades. Hybrid models, incorporating large scale climate indices, seem to be promising for long lead-time drought forecasting. Further research
described. Prediction within this methodology is a process of ensemble forecasting using a sample of parameter sets from the behavioural model space, with each sample weighted according to its likelihood measure to estimate prediction quantiles. This allows that different models may contribute to the ensemble prediction interval at different time steps and that the distributional form of the predictions may change over time. Any effects of model nonlinearity, covariation of parameter values and errors in model structure, input data or observed variables, with which the simulations are compared, are handled implicitly within this procedure. GLUE involves a number of choices that must be made explicit and can be therefore subjected to scrutiny and discussion. These include ways of combining information from different types of model evaluation or from different periods in a data assimilation context. An example application to rainfall-runoff modelling is used to illustrate the methodology, including the updating of likelihood measures.

17. Trends in precipitation and temperature in Florida, USA
25 July 2012
Christopher J. Martinez | Jerome J. Maleski | Martin F. Miller

Summary: Annual, seasonal, and monthly trends in precipitation, mean temperature, maximum temperature, minimum temperature, and temperature range were evaluated using stations from the United States Historical Climatology Network (USHCN) for the time periods 1895–2009 and 1970–2009 for the state of Florida. The significance and magnitude of station trends were determined using the non-parametric Mann–Kendall test and Sen’s slope, respectively. The collective, field significance of trends were evaluated using a Monte Carlo permutation procedure. Field significant trends in seasonal precipitation were found in only the June–August and March–May seasons for the 1895–2009 and 1970–2009 time periods, respectively. Significant decreasing trends in monthly precipitation were found in the months of October and May for the 1895–2009 and 1970–2009 time periods, respectively. Field significant trends were found for all temperature variables for both time periods, with the largest number of stations with significant trends occurring in the summer and autumn months. Trends in mean, maximum, and minimum temperature were generally positive with a higher proportion of positive trends in the 1970–2009 period. The spatial coherence of trends in temperature range was generally less compared to other temperature variables, with a larger proportion of stations showing negative trends in the summer and positive trends at other times of the year and more negative trends found in the 1970–2009 period. Significant differences in temperature trends based on the surrounding land use were found for minimum temperature and temperature range in the 1970–2009 period indicating that data homogenization of the USHCN temperature data did not fully remove this influence. The evaluation of trends based on station exposure ratings shows significant differences in temperature variables in both the 1895–2009 and 1970–2009 time periods. Systematic changes in trends can be seen in the 1980s, the period of widespread conversion from liquid-in-glass to electronic measurement, indicating that some of the differences found may be due to uncorrected inhomogeneities. Since notable differences were found between differently rated stations pre-1940, a time which the present-day rating should have little to no influence, attribution of differences based on station rating should be done with caution.

18. Temporal variability in stage–discharge relationships
26 June 2012
José-Luis Guerrero | Ida K. Westerberg | Sven Halldin | Chong-Yu Xu | Lars-Christer Lundin

Summary: Although discharge estimations are central for water management and hydropower, there are few studies on the variability and uncertainty of their basis; deriving discharge from stage heights through the use of a rating curve that depends on riverbed geometry. A large fraction of the world’s river–discharge stations are presumably located in alluvial channels where riverbed characteristics may change over time because of erosion and sedimentation. This study was conducted to analyse and quantify the dynamic relationship between stage and discharge and to determine to what degree currently used methods are able to account for such variability. The study was carried out for six hydrometric stations in the upper Choluteca River basin, Honduras, where a set of unusually frequent stage–discharge data are available. The temporal variability and the uncertainty of the rating curve and its parameters were analysed through a Monte Carlo (MC) analysis on a moving window of data using the Generalised Likelihood Uncertainty Estimation (GLUE) methodology. Acceptable ranges for the values of the rating-curve parameters were determined from riverbed surveys at the six stations, and the sampling space was constrained according to
distributed erosion and sediment transport model was used to evaluate the effectiveness of the ISWM project. The model was calibrated against long-term measured suspended sediments at the watershed outlet. Land use and conservation measures were mapped and analyzed for 1995 and 2005, paying particular attention to quantification of changes in soil erosion and sediment delivery due to ISWM. The results showed that a combination of decreased soil loss (from 18.5\(\text{tha}^{-1}\text{y}^{-1}\) in 1995 to 13.2\(\text{tha}^{-1}\text{y}^{-1}\) in 2005) and increased sediment deposition (from 7.7 to 12.4\(\text{tha}^{-1}\text{y}^{-1}\)) has led to a strong decrease in sediment yield (from 8.4 to 3.9\(\text{tha}^{-1}\text{y}^{-1}\)) and the sediment delivery ratio (from 0.454 to 0.295). The results of scenario analysis showed that soil conservation measures taken in fields effectively reduce on-site soil loss and sediment yield. However, off-site sediment control measures appear to be much less effective at reducing sediment yield. This diachronic comparison of soil erosion and sediment delivery revealed that ISWM is quite effective and efficient; therefore, it is the appropriate method to combat soil erosion in the TGA and similar areas.

24. Evaluation of 1D and 2D numerical models for predicting river flood inundation
1 November 2002
M.S. Horritt | P.D. Bates

Abstract: 1D and 2D models of flood hydraulics (HEC-RAS, LISFLOOD-FP and TELEMAC-2D) are tested on a 60km reach of the river Severn, UK. Synoptic views of flood extent from radar remote sensing satellites have been acquired for flood events in 1998 and 2000. The three models are calibrated, using floodplain and channel friction as free parameters, against both the observed inundated area and records of downstream discharge. The predictive power of the models calibrated against inundation extent or discharge for one event can thus be measured using independent validation data for the second. The results show that for this reach both the HEC-RAS and TELEMAC-2D models can be calibrated against discharge or inundated area data and give good predictions of inundated area, whereas the LISFLOOD-FP needs to be calibrated against independent inundated area data to produce acceptable results. The different predictive performances of the models stem from their different responses to changes in friction parameterisation.

25. Comparison and evaluation of multiple GCMs, statistical downscaling and hydrological models in the study of climate change impacts on runoff
20 April 2012
Hua Chen | Chong-Yu Xu | Shenglian Guo

Summary: In this study a rigorous evaluation and comparison of the difference in water balance simulations resulted from using different downscaling techniques, GCMs and hydrological models is performed in upper Hanjiang basin in China. The study consists of the following steps: (1) the NCEP/NCAR reanalysis data for the period 1961–2000 are used to calibrate and validate the statistical downscaling techniques, i.e. SSVM (Smooth Support Vector Machine) and SDSM (Statistical Downscaling Model); (2) the A2 emission scenarios from CGCM3 and HadCM3 for the same period are used as input to the statistical downscaling models; and (3) the downscaled local scale climate scenarios are then used as the input to the Xin-anjiang and HBV hydrological models. The results show that: (1) for the same GCM, the simulated runoffs vary greatly when using rainfall provided by different statistical downscaling techniques as the input to the hydrological models; (2) although most widely used statistics in the literature for evaluation of statistical downscaling methods show SDSM has better performance than SSVM in downsampling rainfall except the Nash–Sutcliffe efficiency (NSC) and root mean square error-observations standard deviation ratio (RSR), the runoff simulation efficiency driven by SDSM rainfall is far lower than by SSVM; and (3) by comparing different statistics in rainfall and runoff simulation, it can be concluded that NSC and RSR between simulated and observed rainfall can be used as key statistics to evaluate the statistical downscaling models’ performance when downscaled precipitation scenarios are used as input for hydrological models.