Geophysical Research Abstracts
Vol. 18, EGU2016-16224, 2016
EGU General Assembly 2016

From drought indicators to impacts: developing improved tools for monitoring and early warning with decision-makers in mind

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Droughts pose a threat to water security in most climate zones and water use sectors. With projections suggesting that droughts will intensify in many parts of the globe, the magnitude of this threat is likely to increase in the future and thus vulnerability of society to drought must be reduced through better preparedness. While the occurrence of drought cannot be prevented in the short term, a number of actions can be taken to reduce vulnerability. Monitoring and early warning (M&EW) systems are often central to drought management strategies aimed at reducing vulnerability, but they are generally less developed than for other hazards. There are many drought indicators available for characterising the hazard but they have only rarely been tested for their ability to capture observed impacts on society or the environment. There is a pressing need to better integrate the physical and social vulnerability elements of drought to improve M&EW systems. The Belmont Forum project DrIVER (Drought Impacts: Vulnerability thresholds in monitoring and Early-warning Research, 2014 - 2016) aims to fill this gap by strengthening the link between natural (hydrometeorological) drought characterisation and ecological and socio-economic impacts on three continents (North America, Europe and Australia). The UK is a key DrIVER case study area. The UK has a well-developed hydrological monitoring programme, but there is currently no national drought focused M&EW system; different actors (water companies, regulators, farmers or industry) typically conduct M&EW for their own particular purposes. In this paper we present the early outcomes of an extensive programme of research designed to provide a scientific foundation for improved M&EW systems for the UK in future. The UK is used here as an example, and the findings could prove useful for other localities seeking to develop M&EW systems. Firstly, we present the results of stakeholder engagement exercises designed to ascertain current use of M&EW and future aspirations. Different stakeholders clearly have different goals for M&EW, but there are a number of common themes, including a desire to better understand the links between the outputs of large-scale M&EW systems (rainfall, river flow, etc), localised triggers used by decision-makers during drought episodes, and actual impacts of drought. Secondly, we present analyses designed to test the utility of a wide range of drought indicators for their use in UK applications. We demonstrate the suitability of standardised indicators (like the SPI) for use in the UK, addressing the suitability of statistical distributions and using these indicators for drought severity quantification and for understanding propagation from meteorological to hydrological drought; all of which are currently poorly understood aspects that are vital for future monitoring. We then address the extent to which these indicators can be used to predict drought impacts, focusing on several sectors (water supply, agriculture and ecosystems). These analyses test which indicators perform best at predicting drought impacts, and seek to identify indicator thresholds that trigger impact occurrence. Unsurprisingly, we found that no single indicator best predicts impacts, and results are domain, sector and season specific. However, we reveal important linkages between indicators and impacts that could enhance the design and delivery of monitoring and forecasting information and its uptake by decision-makers concerned with drought.