Use of large datasets to support drought management planning and climate change assessments

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Advantages and application of large stochastic and climate change datasets to drought and water supply management planning.

Background

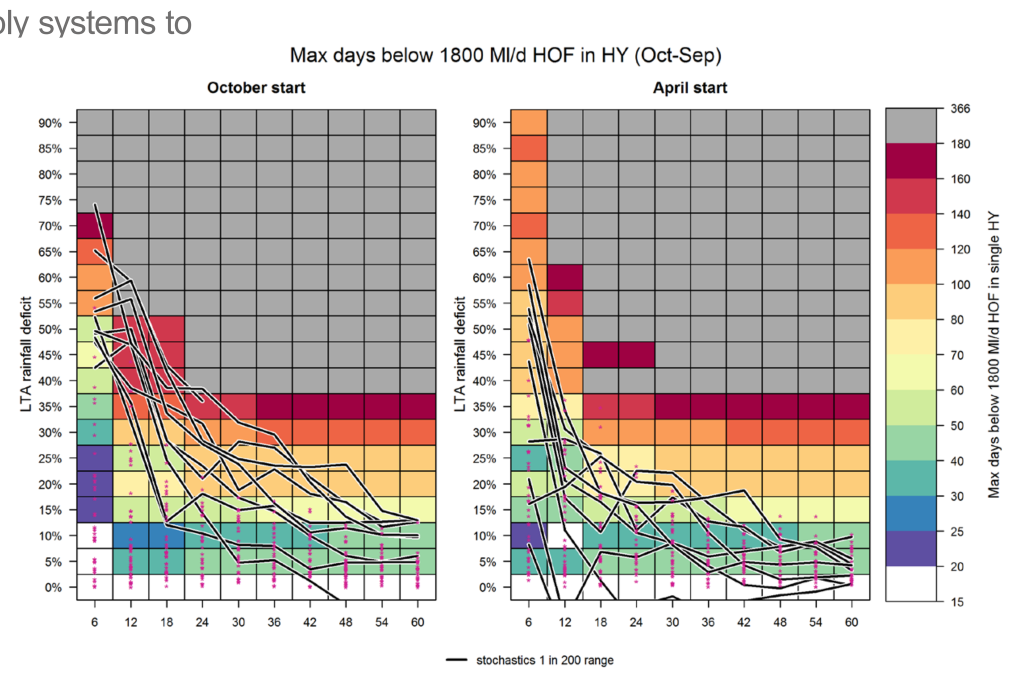
Water is considered to be one of the main mechanisms through which people will experience climate change. As a consequence of climate change and population growth, the number of people estimated to become exposed to water scarcity is projected to increase sharply in the future. Concerns regarding the potential implications of extreme, previously not experienced, droughts are also increasing.

Water supply planning in the UK has begun to move beyond using only the historic record to plan investments to maintain secure supplies. The UK has adopted the use of stochastically generated droughts to provide a more comprehensive understanding of resilience across a broad range of plausible drought events. Recent advancements in climate modelling captured within the latest UK Climate Projections 2018 could potentially begin to address the need for physically-based, plausible datasets that combine both natural climate variability and a changing climate in representing droughts of the future.

This poster focusses on applications and advantages of stochastic and climate change datasets, and discusses some of the potential issues associated with their use. Solutions to these issues are also discussed.

Stochastic datasets

Spatially coherent weather datasets are used in UK water supply planning to provide plausible drought events, representative of current climate, in addition to the droughts present in the historic record. These are used to test the current resilience of water supply systems to diverse range of droughts and provide an estimate as to their potential likelihood (noting that given these are statistical models, trained on historic data, such estimates should be used with caution). The outputs are then used to develop a Drought Response Surface [1] to visualise and communicate drought resilience to stakeholders and consider potential investment options. Given their spatial coherence, these can be used at the regional and national scale [2] to assess potential resilience benefits offered to different stakeholders by different regional scale solutions such as large reservoirs and inter-basin transfers [3].



Climate change datasets

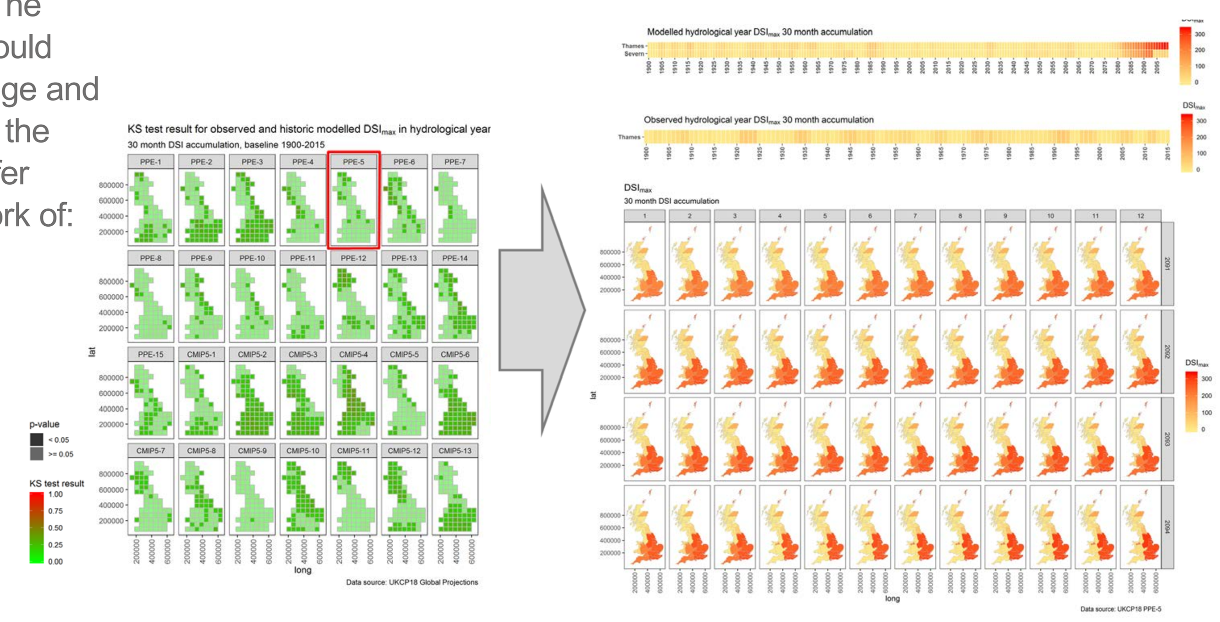
Significant challenges remain in making appropriate use of outputs from climate change models for impacts modelling and adaptation planning [4]. Methods for assessing future climate change impacts on water supplies in the UK have been based on the use of change factors (delta-change approach downscaling) due to these existing challenges including the representation of droughts in climate models and with bias correction, particularly with regards to extremes. The ability to use transient climate change datasets in confidence would represent a significant evolution in the approach to climate change and droughts adopted by planners. Recently published outputs from the latest UK Met Office's General Circulation Model, which may offer improvements in this regard, were examined through a framework of:

> Application of the Drought Severity Index (DSI) [5] to provide a "quick-look" at drought events without bias correction;

> Comparison of distributions of DSI (for different durations) between observed and modelled historic periods using Kolmogorov-Smirnov test to determine model skill in representing historic period; and

> Identification of severe drought events in model outputs and comparison with the observed record.

Where climate models can be shown to adequately replicate the distribution of observed historic drought events, these could then be bias corrected and used as inputs to water supply simulation models. The droughts within these outputs from physically based climate models would reflect both natural variability and the climate change signal and indicate how drought characteristics (frequency, duration, timing and seasonality) may evolve into the future to inform appropriate adaptation planning.



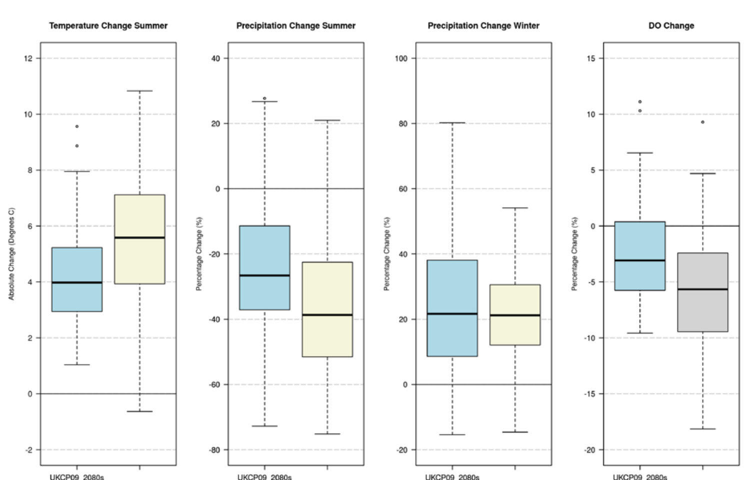
Water supply system implications

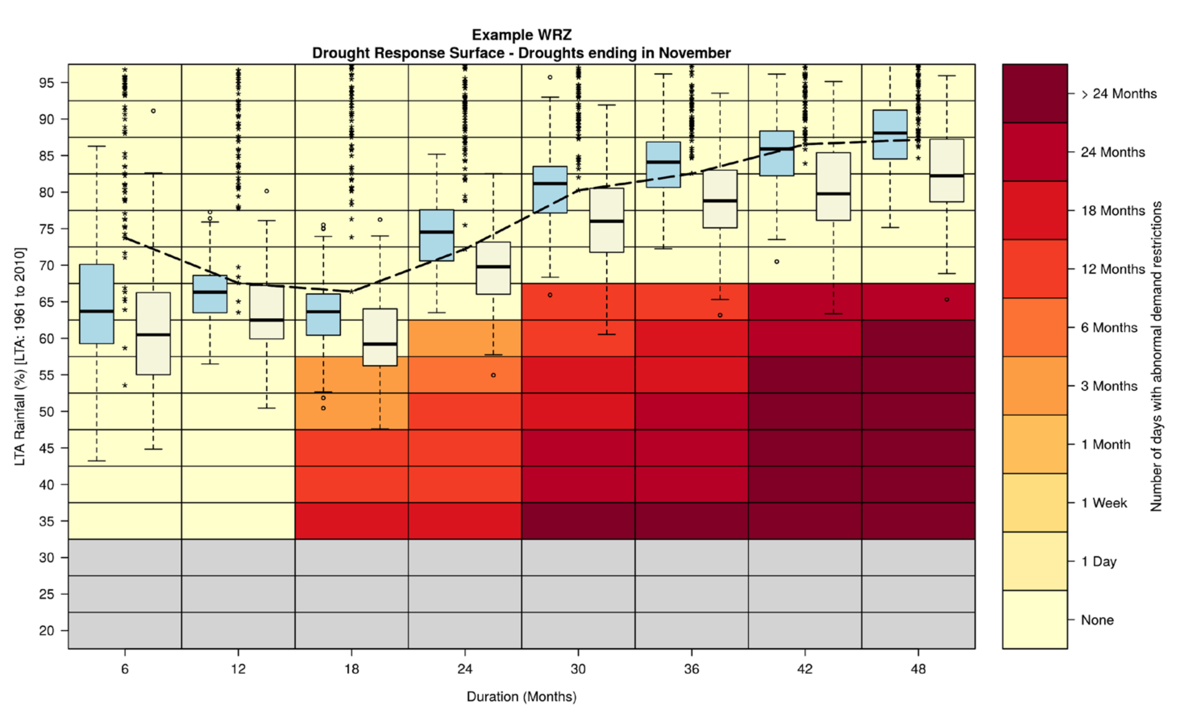
Large datasets can result in significant increases in water supply model run-times. There are two possible solutions to this issue:

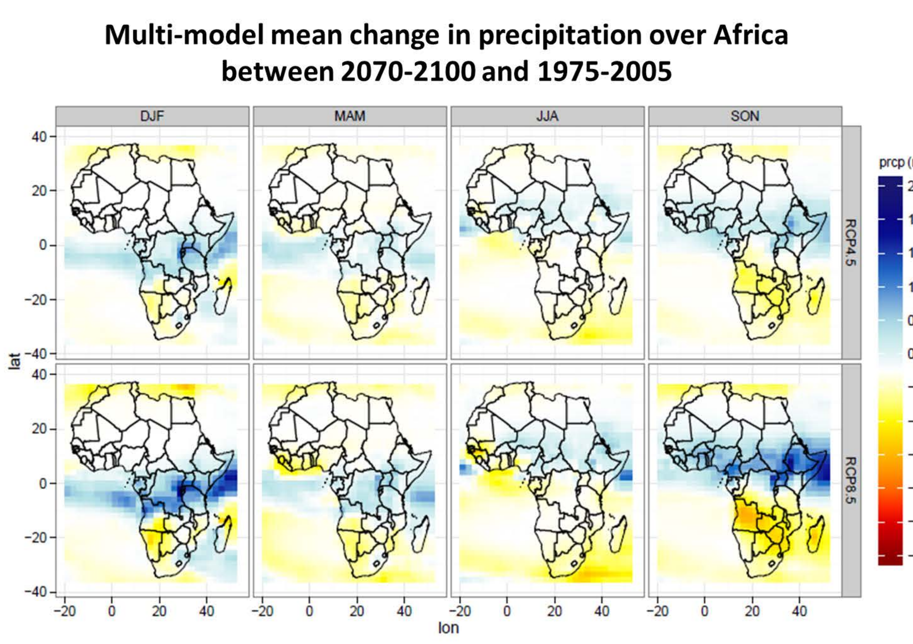
> Reduce the size of the dataset (screening tools); or

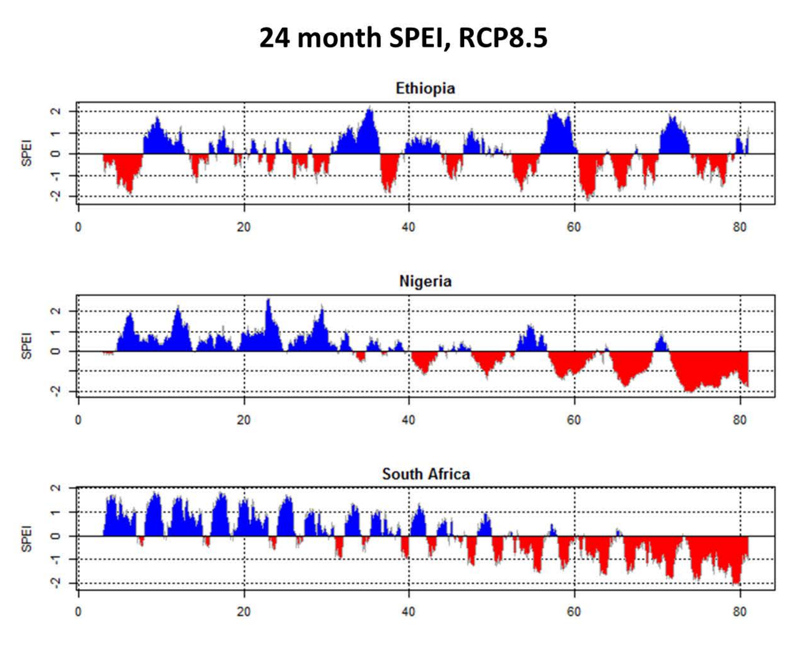
> Reduce the complexity of the model (emulators).

Screening tools have been used within the Drought Response Surface framework [6] to determine whether new stochastic or climate change data contain drought events more severe than those used previously. This ensures that additional simulation modelling is only undertaken for scenarios significantly different to those previously considered and reducing the requirement for repetition of simulation modelling that may provide no meaningfully different evidence to planners [7].



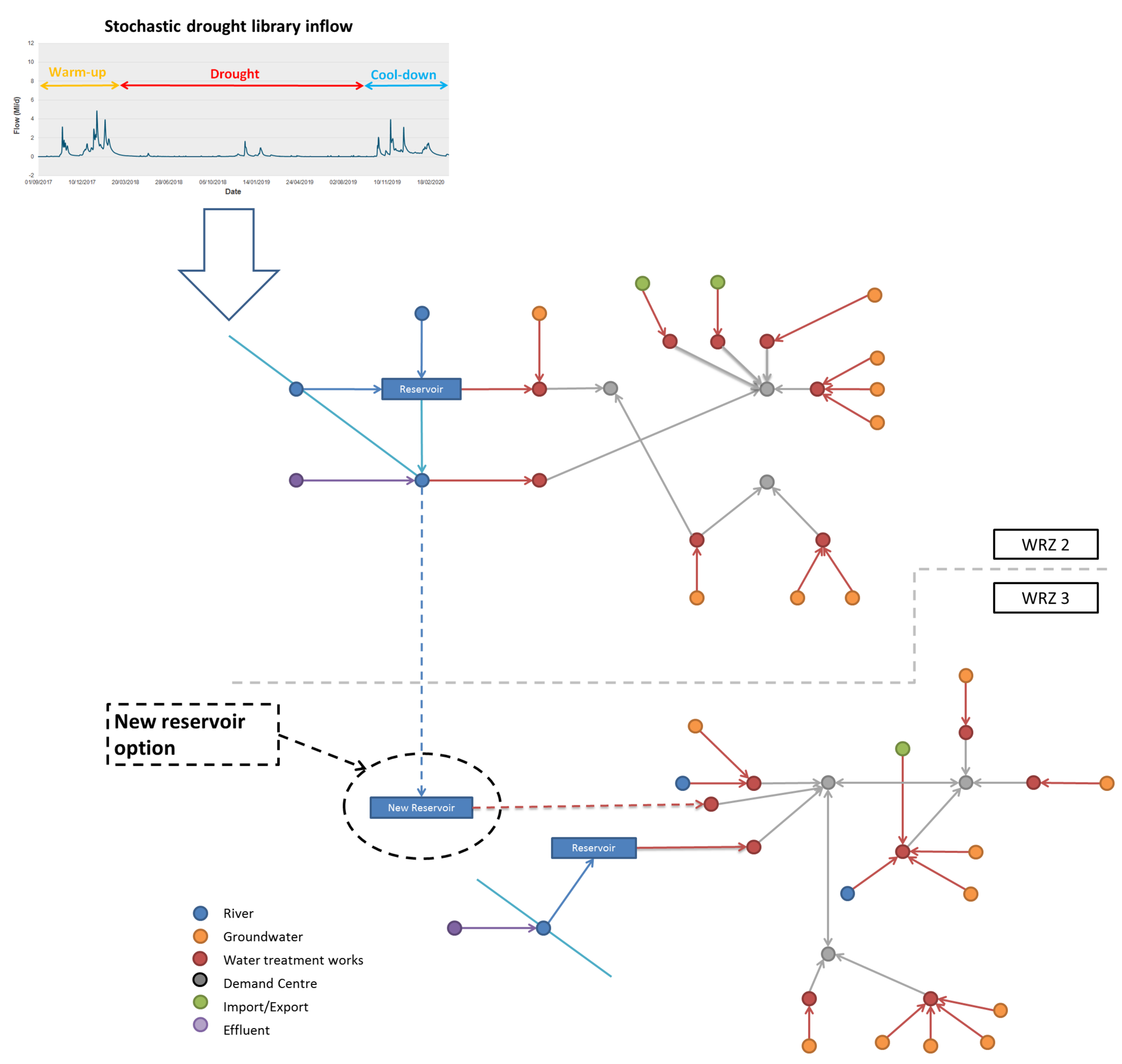






The resilience of water supply systems can also be influenced by seasonal changes in water availability (e.g. trend towards longer summers and delayed recharge in autumn / winter). The interrogation of large climate datasets using seasonal changes along with drought indicators can help identify locations where droughts are more prevalent within a dataset, and how severe these might be. The use of such a framework can be a valuable, rapid screening tool for identifying dataset trends and spatial characteristics.

Emulators, such as our Kestrel-WRM, allow for rapid simulation of water supply systems to determine current drought vulnerabilities, as well as model implications on system yield from new investment options. These emulators have allowed large datasets to be efficiently used to test water supply systems to droughts outside the historic record and develop "drought libraries" (sequences of successive, droughts with different characteristics with suitable warm-up and cool-down periods in between) to rapidly compare alternative investment portfolios and assess the different levels of drought resilience they may offer.



Summary

Large datasets, such as outputs from stochastic weather generators and climate models, can provide significant benefits including testing systems to a diverse and challenging range of conditions and through their spatial coherence, allow for the assessment of coincident drought in linked watersheds and improved understanding of system resilience to severe droughts not experienced in the observed historic record. However, such large datasets should be used with caution to ensure they are being used appropriately and efficiently. This poster has presented a rapid framework for determining potentially plausible droughts within climate models, highlighting the requirement for testing of climate model outputs before use, as well as tools to help understand water supply system vulnerability to new large climate datasets. Further work is required to understand drought representation in climate models, which could include production of stochastic future climate to increase the number of plausible climate change futures.

References

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