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Better accounting of droughts in long-range inflow predictions with TULIP

David Horsley [a], James C. Bennett [b], Andrew Schepen [c] and David E. Robertson [b]

[a] Hydro Tasmania, Hobart, Australia
[b] CSIRO Environment, Melbourne, Australia
[c] CSIRO Environment, Dutton Park, Australia
Email: james.bennett@csiro.au

Abstract: Many water management agencies rely on stochastic inflows scenarios to plan water operations. For example, Hydro Tasmania, Australia's largest hydropower generator and water manager, relies on 20+ year inflows scenarios to assess the long-range sustainability of their power generation system. A variety of methods are available for stochastic data generation, but many assume a stationary climate. In locations where inflow data have long-term trends, assuming a stationary climate in stochastic data generation is likely to underestimate future wet or dry extremes, in particular for sequences of dry or wet months or years. Assuming a non-stationary climate moves the generation of stochastic scenarios closer to the realm of forecasting: using initial conditions (in this case trend) to predict the future.

To address these issues, we have developed the Trend and Uncertainty in Long Inflow Predictions (TULIP) model. TULIP is a Bayesian model that generates long-range predictions of inflows at the monthly time step. TULIP accounts for:

- Heteroscedasticity and skew in inflow data by using data transformation with the sinh-arcsinh transformation, and zero values with censoring
- Spatial correlation between inflow sites
- Autocorrelation using a first-order autoregressive model
- Seasonal variation in properties (1)-(4), using Fourier series to control the parameters
- Linear trend in inflow, by inducing trends into the Fourier coefficients.

TULIP is being implemented operationally by Hydro Tasmania to replace its existing method of generating stochastic scenarios, which assumes a stationary climate. At sites with long-term trends in historical inflow, we show that TULIP produces more reliable long-range predictions than is possible if a stationary climate is assumed. This allows TULIP to produce sharper ensembles and more realistic projections of future drought, allowing Hydro Tasmania to better plan for the long-range sustainability of its system. In this presentation we describe the TULIP model and its performance. We discuss future plans to incorporate information on inflow trends from global and regional climate models into TULIP.

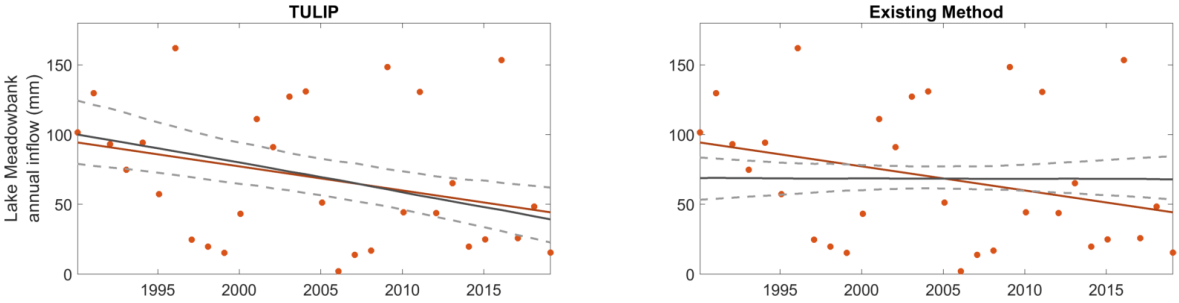

Figure 1. Representation of trends in inflows to Lake Meadowbank by TULIP (left) and the existing Hydro Tasmania method for generating stochastic series (right). Red points and trend lines show observations; black trends and confidence intervals show modelled trends

Keywords: *Ensemble prediction, drought, stochastic scenarios, hydropower generation*