Trends and uncertainty in long inflow predictions 🌷 for hydropower management

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Hydro Tasmania

Connected to National Electricity Market

Storages 1 hour – 3 years

30 hydropower stations and catchments

Rainfall driven (no snowpack)

Stochastic optimisation for long term water value
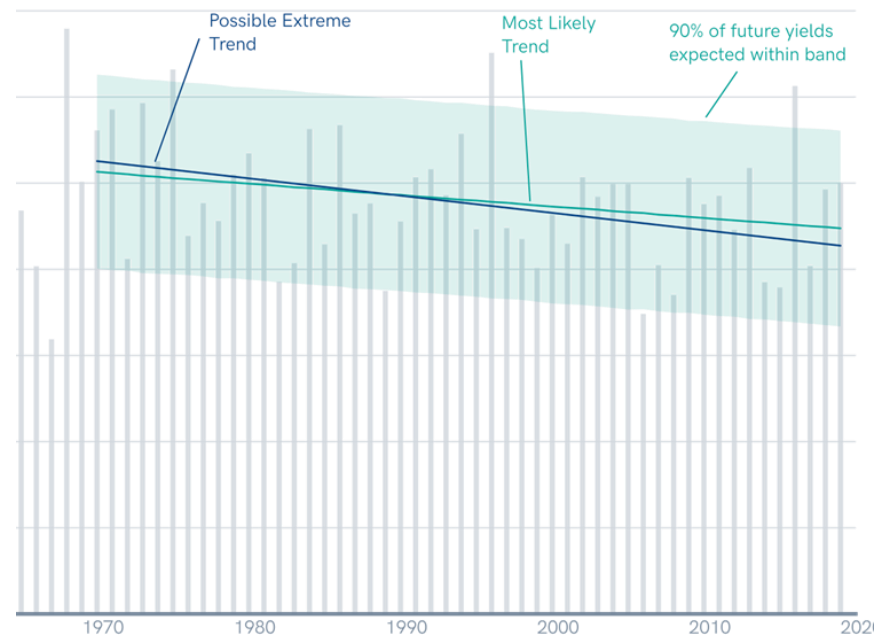
The Problem

Need long term stochastic inflow series at 30 sites

Current approach ('Allie Method')

Random resampling of post-1996 inflows

- – Spatial correlation preserved
- – No autocorrelation
- – No trend

The solution: <u>T</u>rend and <u>U</u>ncertainty in <u>L</u>ong <u>I</u>nflow Predictions ⚓

Censored multivariate normal (sinh-arcsinh transformation)

$$\mathbf{q}(t) = \begin{bmatrix} q_1(t) \\ q_2(t) \\ \vdots \\ q_N(t) \end{bmatrix} \sim \overline{\mathbf{mvsash}}(\boldsymbol{\mu}(t), \boldsymbol{\sigma}(t), \boldsymbol{\epsilon}(t), \boldsymbol{\delta}(t), \boldsymbol{\Sigma})$$

location (mean)   scale   skew   shape   covariance

Fourier series (seasonality)

Rev Thomas Bayes

$$\mu_i(t_j) = \mu_{i,0}(t_j) + \boxed{k_i(t_j)\, q_i(t_{j-1})} + \sum_{m=1}^{M} \mu_{i,m,0}(t)\sin(2\pi m t_j) + \underline{\mu_{i,m,1}}(t)\cos(2\pi m t_j)$$

Autoregressive term

Trend in Fourier coefficients

$$\mu_{i,m,n}(t) = \mu_{i,m,n,0} + \mu_{i,m,n,1} t$$

+ partial (spatial) pooling with Gaussian Process prior

Inputs

Inflows to Power Stations Historical *net* inflows **derived** observations from monthly water balance model

net local pickup = Δvolume + outflows - controlled inflows
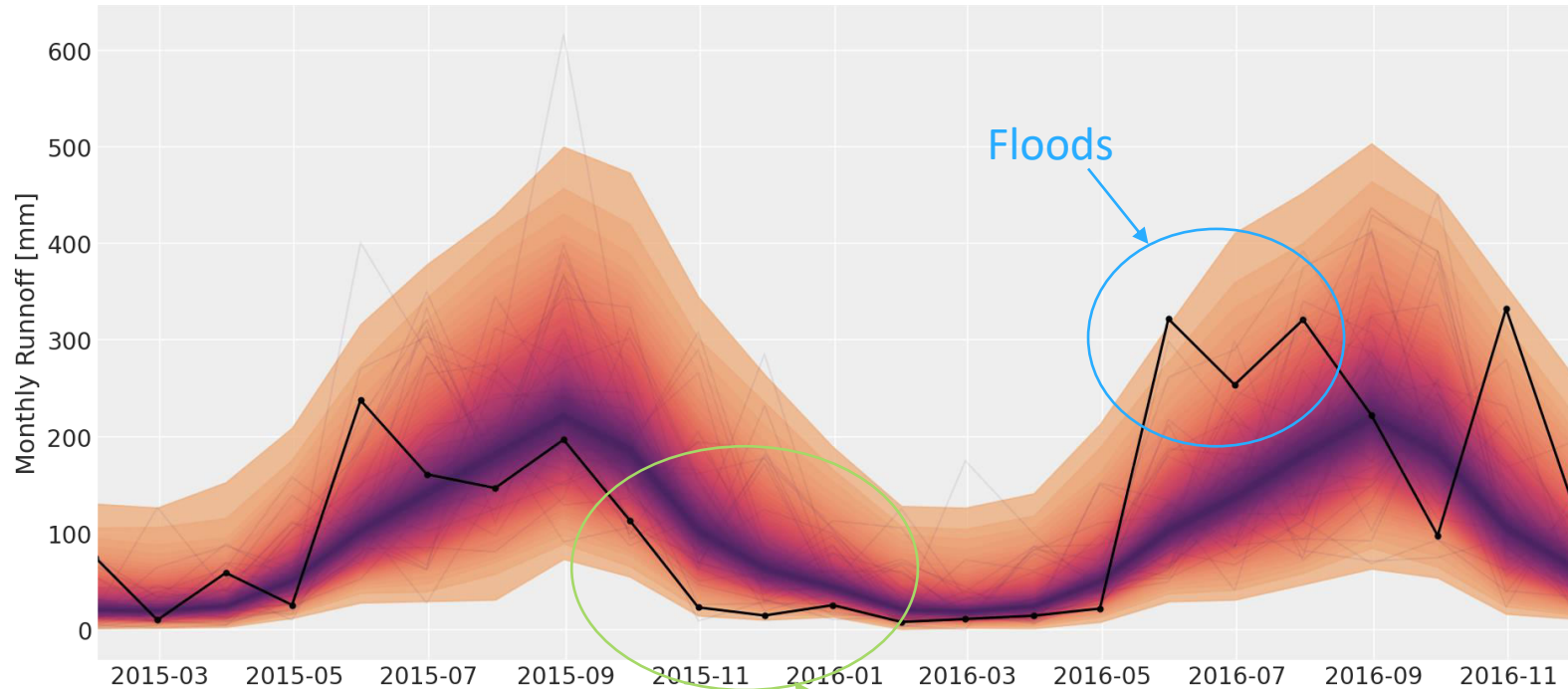
30 good quality sites post-1991

Australian Landscape Water Balance model (AWRA-L) evaporation + simple evaporation model to derive gross inflow

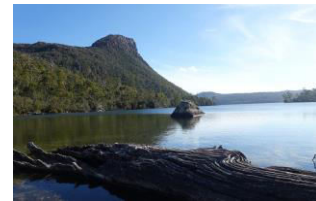**Streamflow gauge network** 25 natural flow sites with long record. Several with 100 years of near continuous record
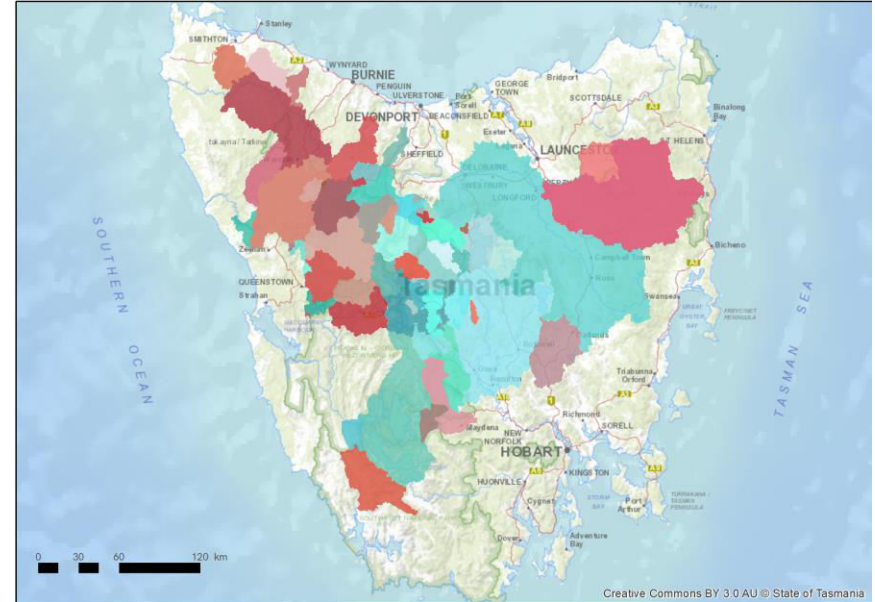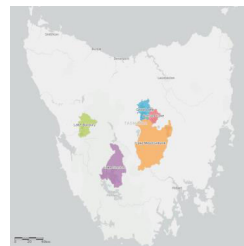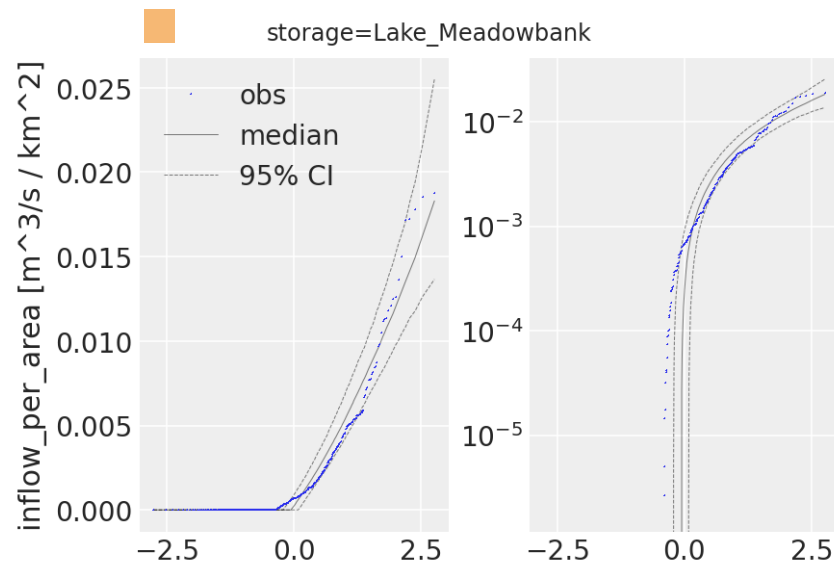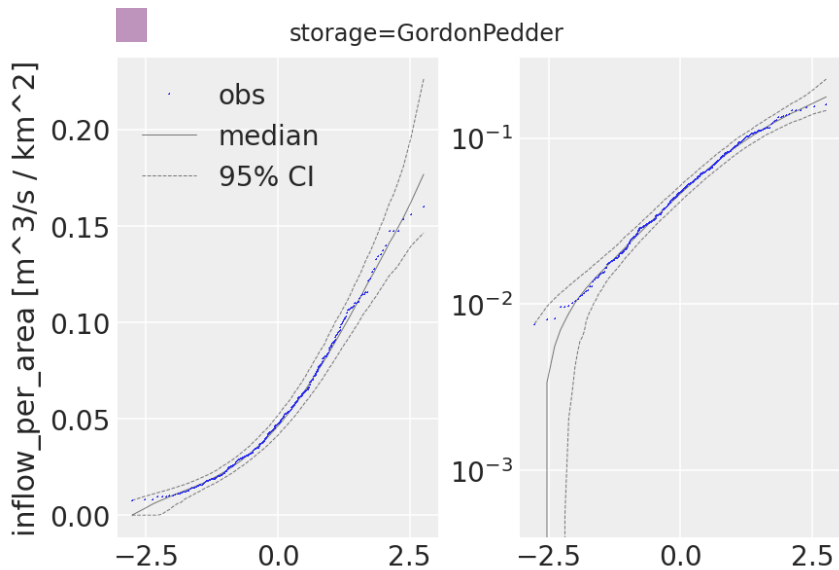
Simulations – Better extremes

Lake Rowallan

Floods

Flash drought

Observations
Ensemble member
Ensemble 98% HDI

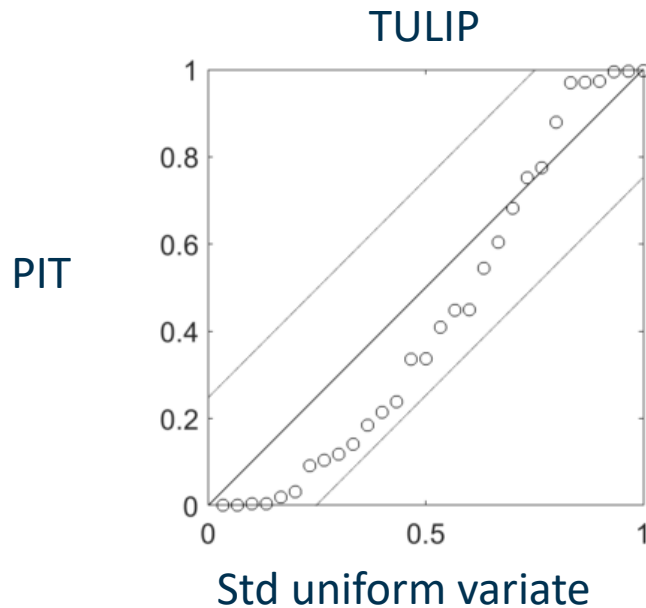# Marginal distributions

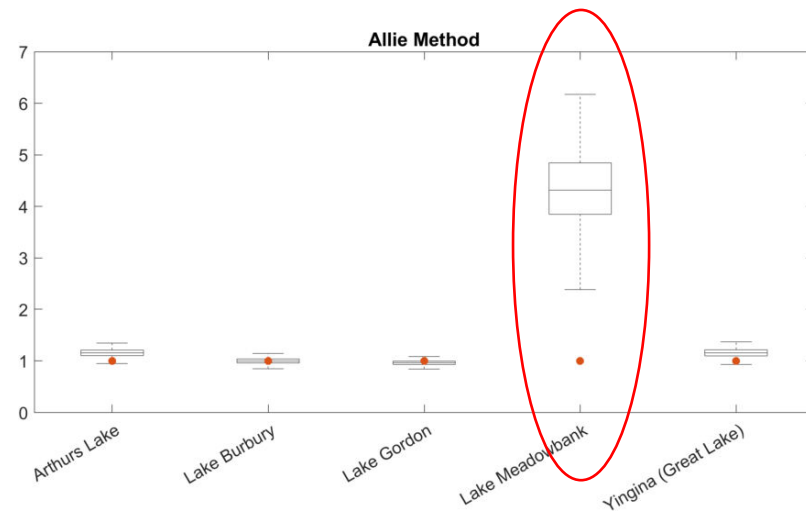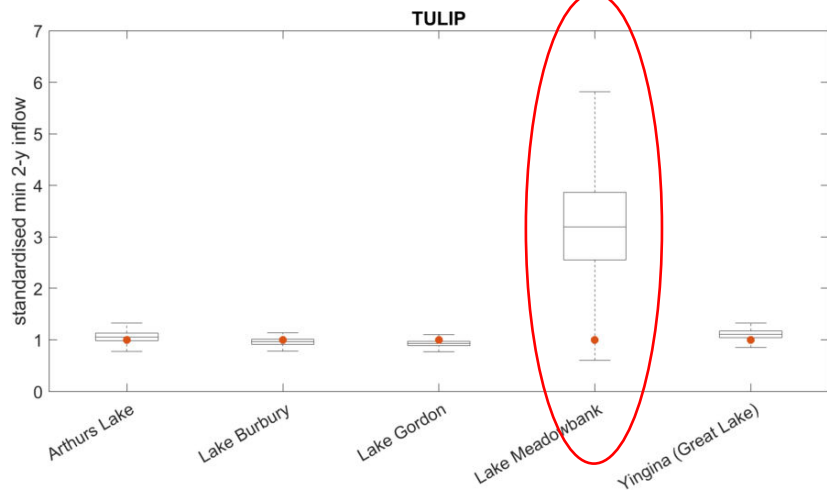# Autocorrelation

Lake Gordon
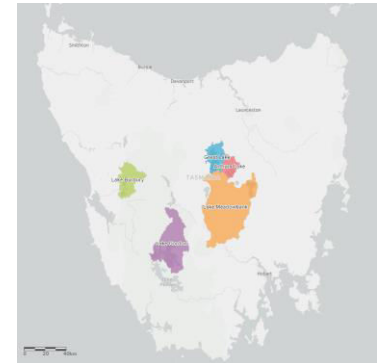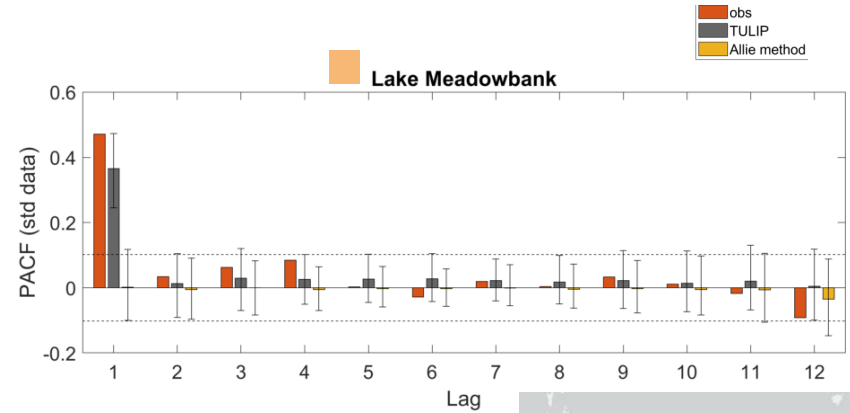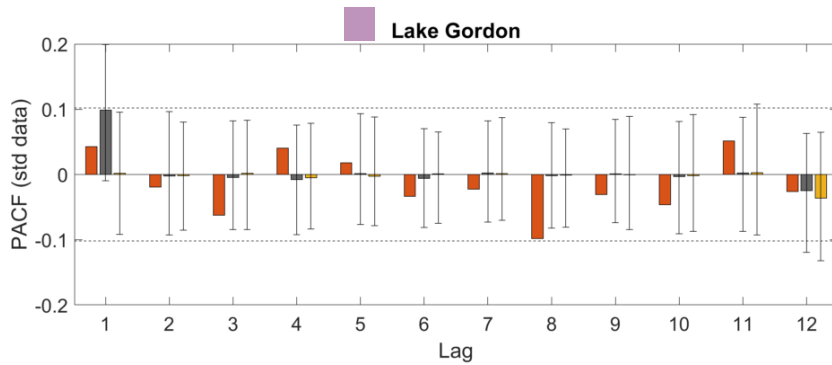
Lake Meadowbank

Reliability – Lake Meadowbank annual accumulations

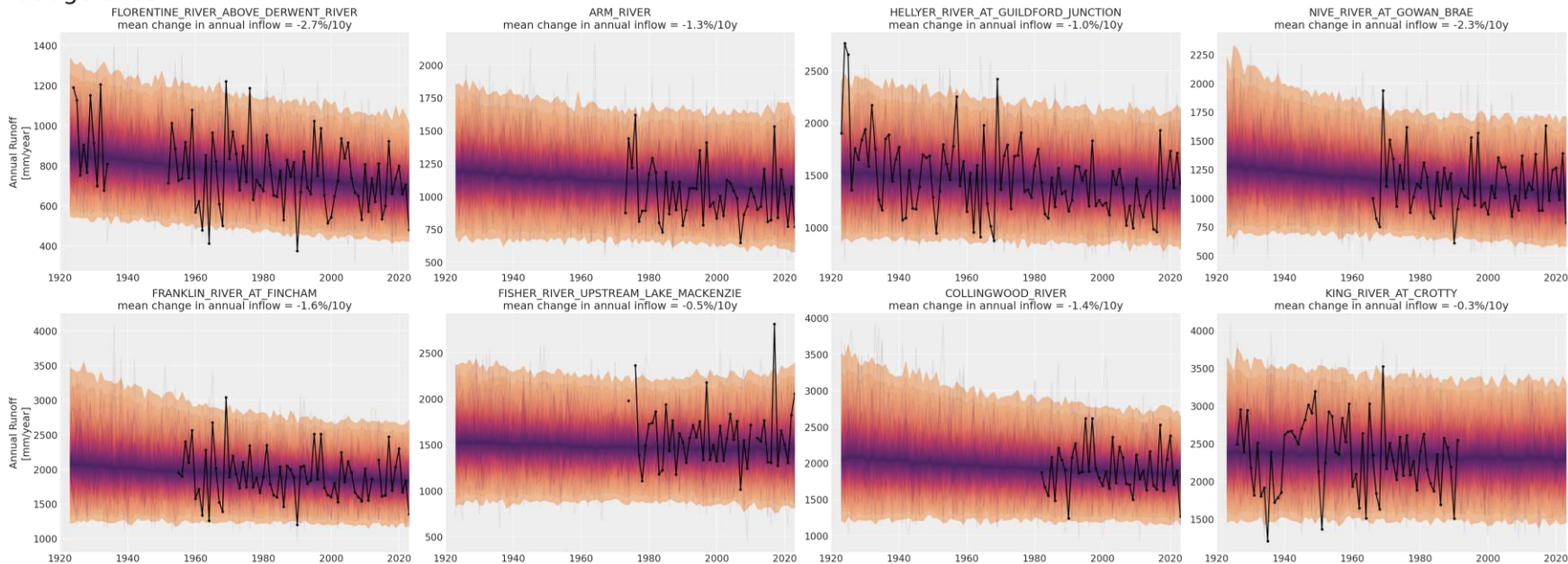
TULIP

Allie Method

PIT

Std uniform variate

Std uniform variate
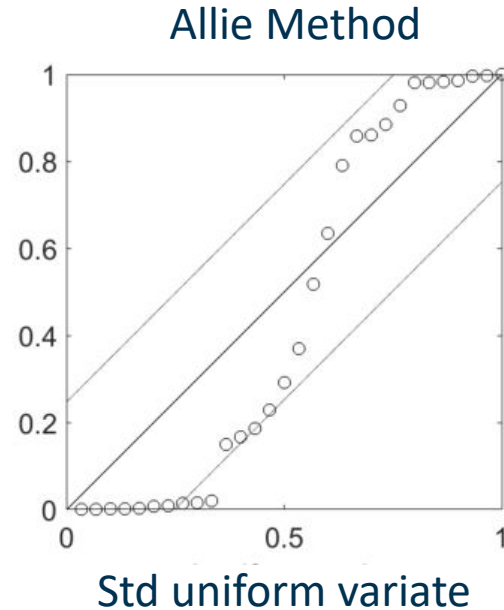
Drought – 2-year inflow minima

Trends

Gauge sites

Observations
Ensemble member
Ensemble 98% HDI

Longer record sites inform shorter

Further work

Climate-model-informed trend

Thank you!

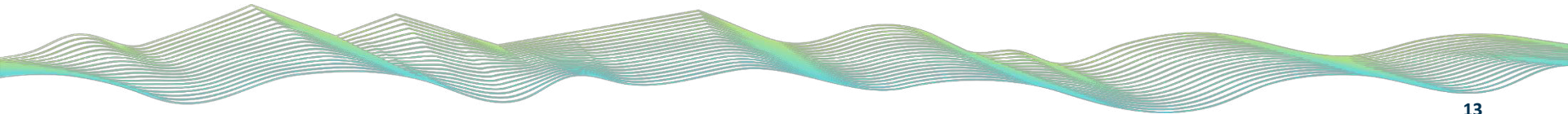**Dr David Horsley**
Hydro Tasmania
David.Horsley@hydro.com.au

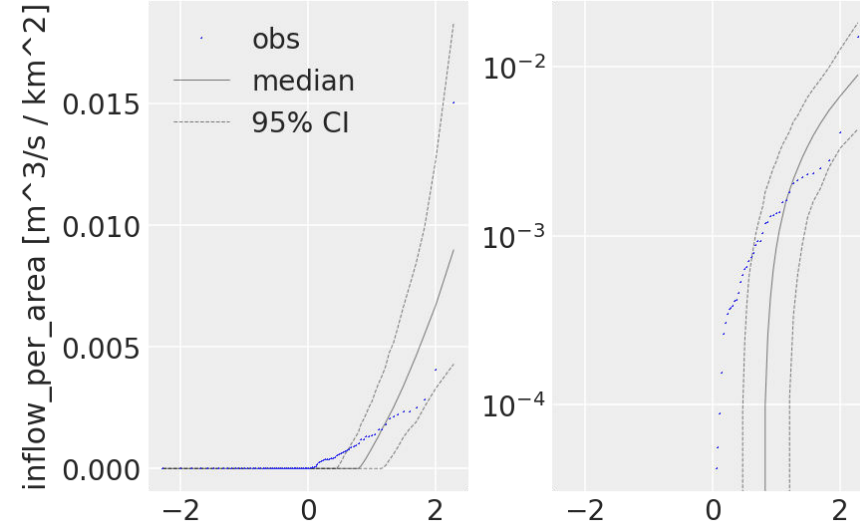**Dr James Bennett**
CSIRO Environment
james.bennett@csiro.au
https://people.csiro.au/B/J/James-Bennett
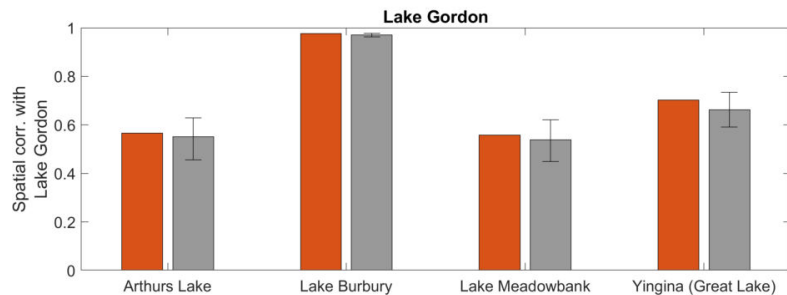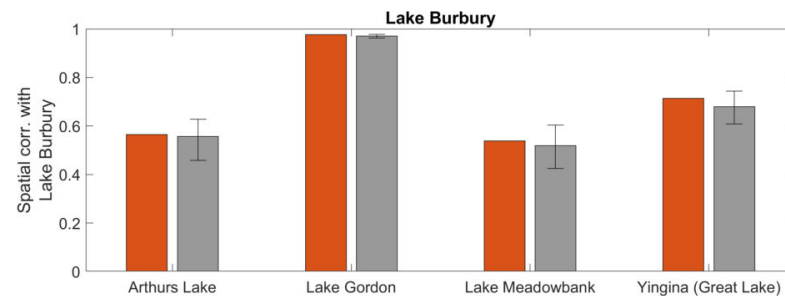
Supplemental slides

Marginal distributions – seasonal data
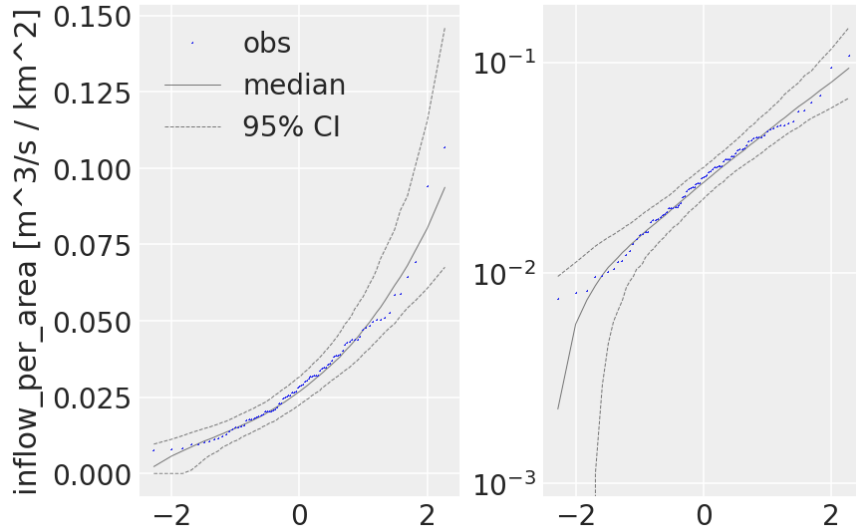
Spatial correlation
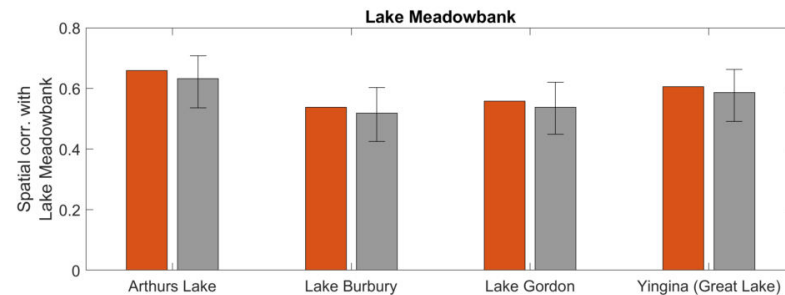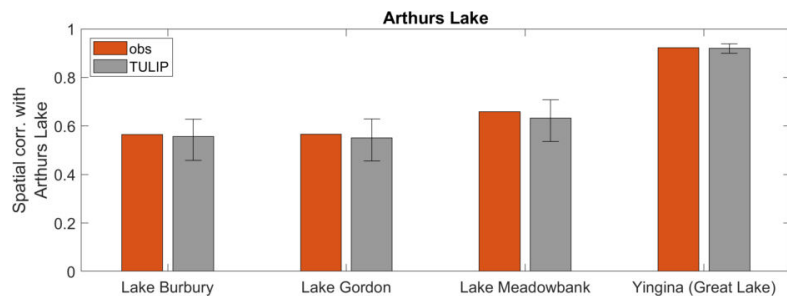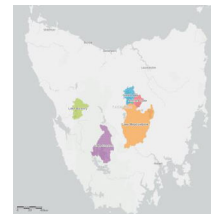
Spatial correlated parameters