Short to Long range Ensemble Inflow Predictions Project (SLEIP)

Presenter: Kim Robinson

Presentation Overview

- Hydrologic forecasting at Hydro
- The problem
- SLEIP
  - Short Term Forecasting
  - Outlook Forecasting
  - Operationalisation

Why – Commercial stakeholder

Inform daily power station operation

- Keep the lights on.
- Maximise revenue from each mega litre.
- Avoid spill.
- Operate in a volatile electricity market where spot prices can vary from -$1,000 to $15,000 megawatt hour.

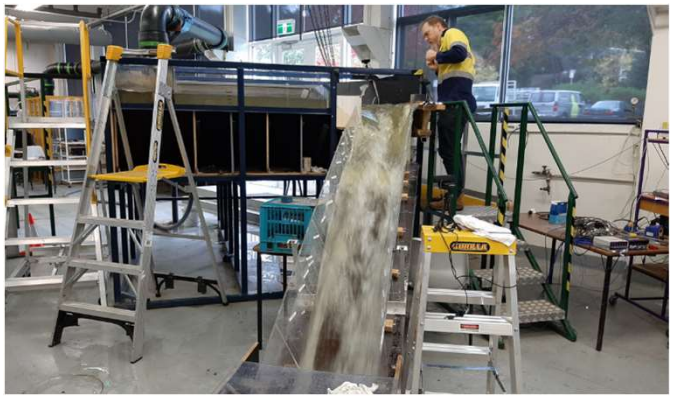
Why – Assets & Infrastructure stakeholders

- Dam Safety: Provide forewarning of flood loading on major dams.

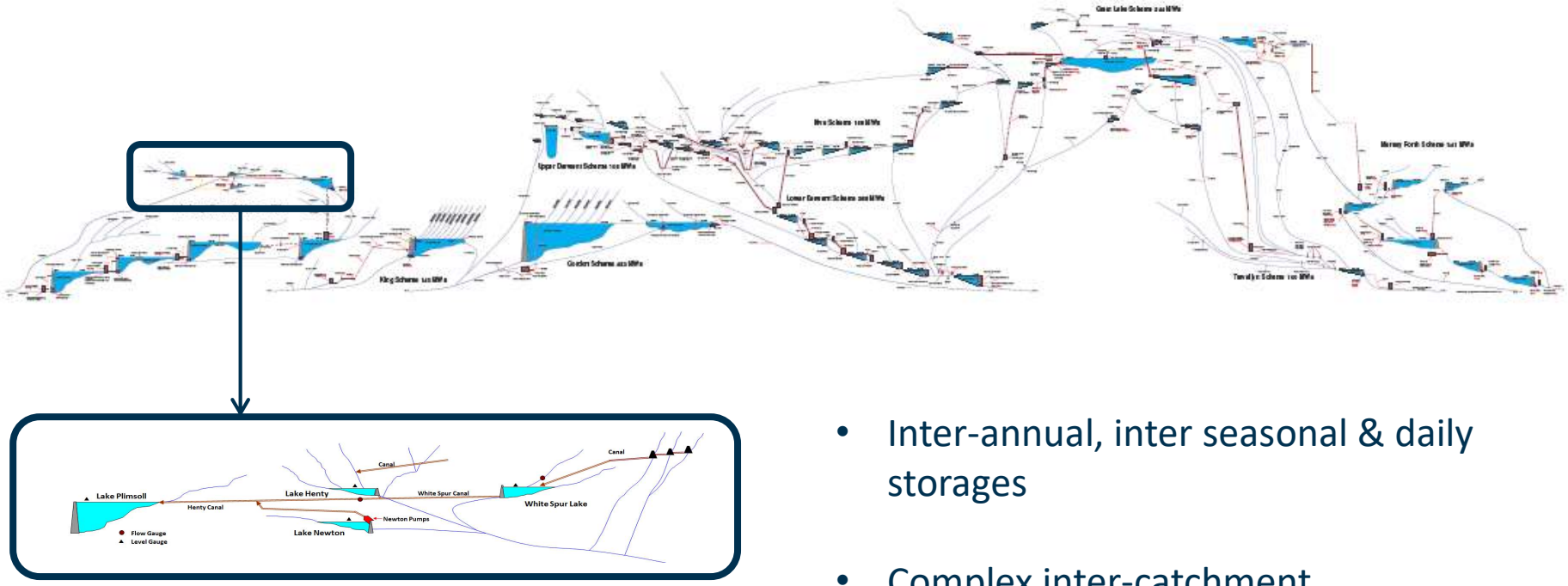
- Forecasting to manage construction flood risk
  - 24/7 forecasting system to enable safe construction during a dam upgrades.

- Best practise hydrology is part of being a responsible dam owner.

(2015) Engineers Australia



Hydro System



- Inter-annual, inter seasonal & daily storages
- Complex inter-catchment infrastructure

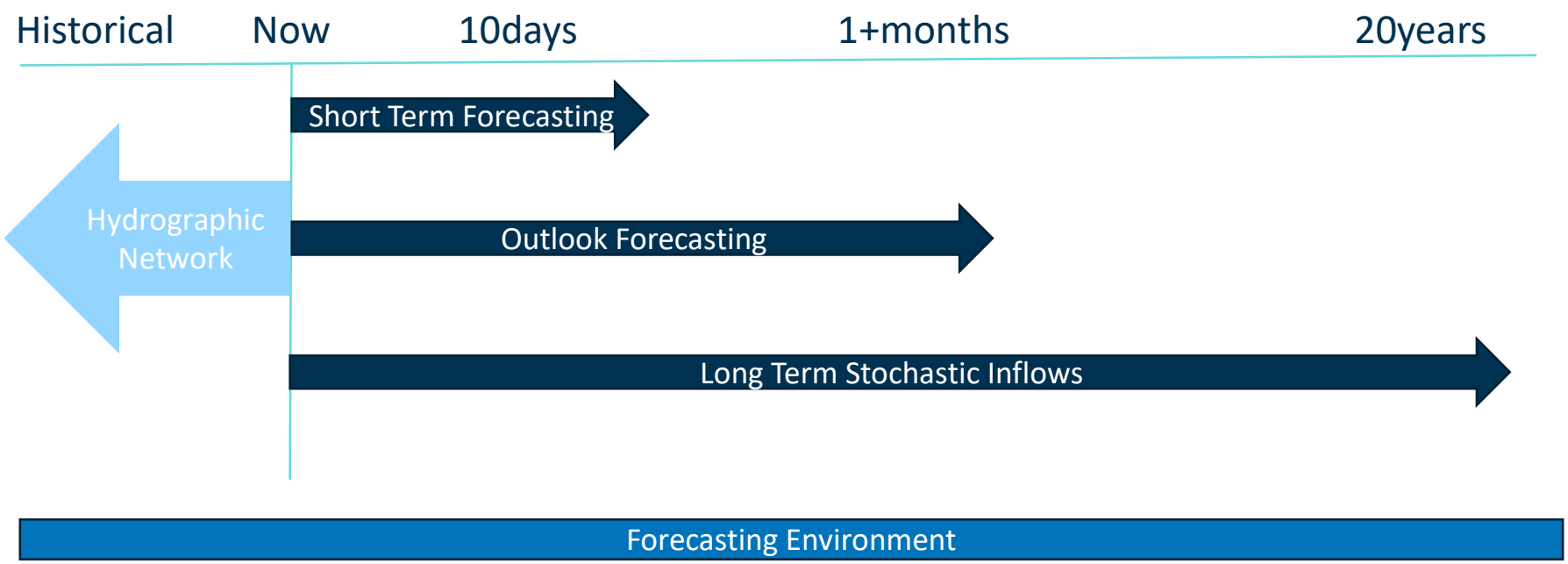
The Problem

- Very good deterministic forecasts cannot support a risk-based decision making framework and are difficult to assess against other variables (price, likelihood of spill, etc).

- After day 7 we need a better predictor of the future than climatology based on stochastic sampling of historical inflows.

The Solution (part of)

Short – Long Range Ensemble Inflow Predictions



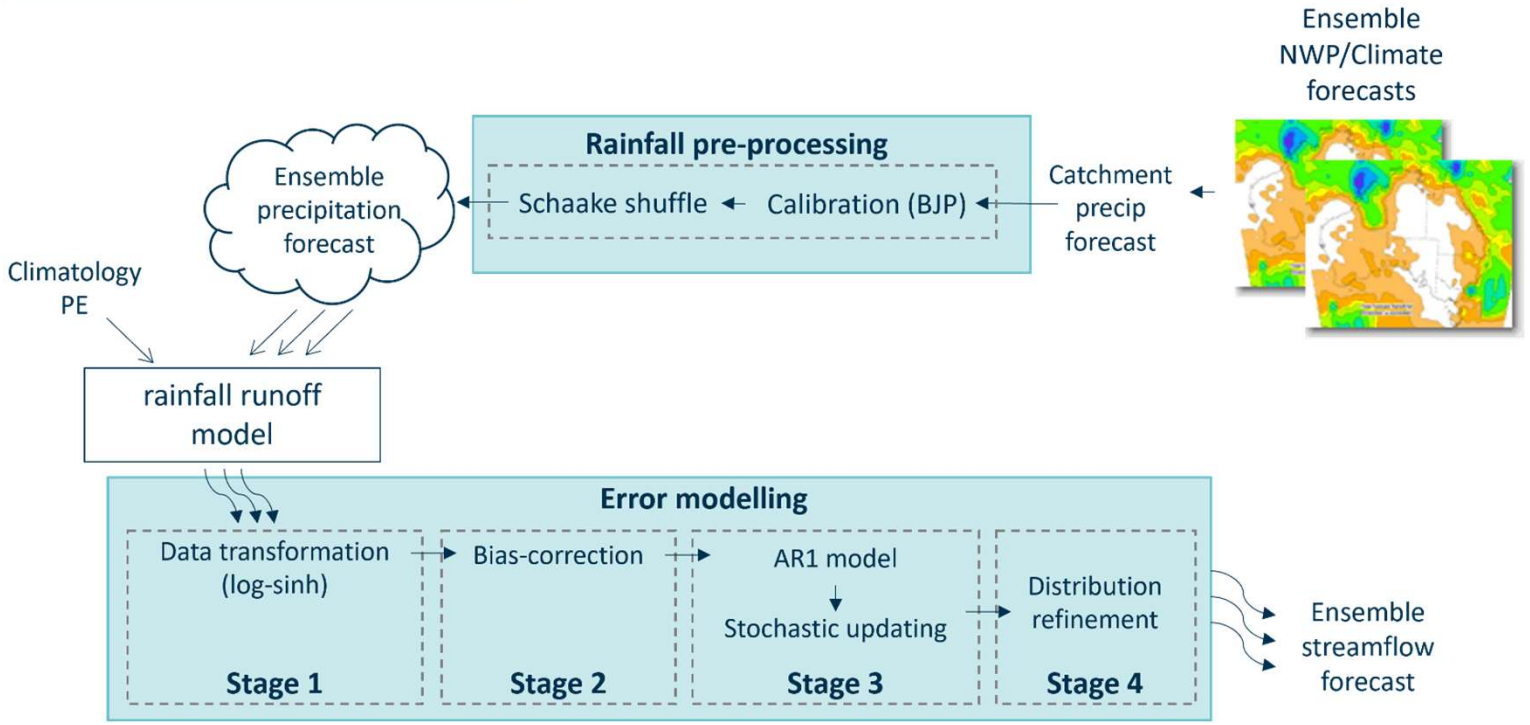
Overview

What is being developed

System	*Current*	Future
Short-term inflows (0-10 days)	• 7 day best estimate forecast (deterministic forecast)	• 10 day forecast with uncertainty quantified (ensemble forecasts driven by NWP)
Outlook inflows (1+ months)	• Random resampling of historical inflows	• 1+ months forecast with uncertainty quantified (ensemble forecasts driven by climate model)
Long-term inflows (20 years)		• Stochastic inflow sequence with historical and future trends, uncertainty, wet/dry sequences and extremes captured.

Short-Term Forecasting

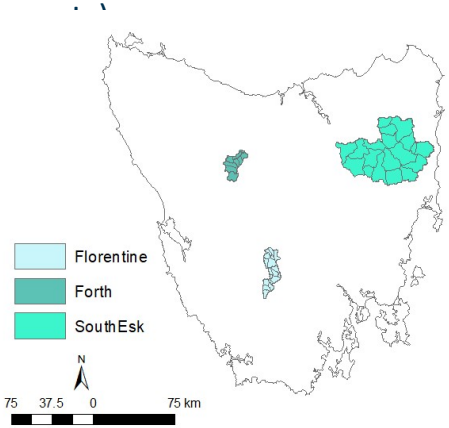
Modelling Method - Research Design - Findings



Short-Term Forecasting

Modelling Method - Research Design - Findings

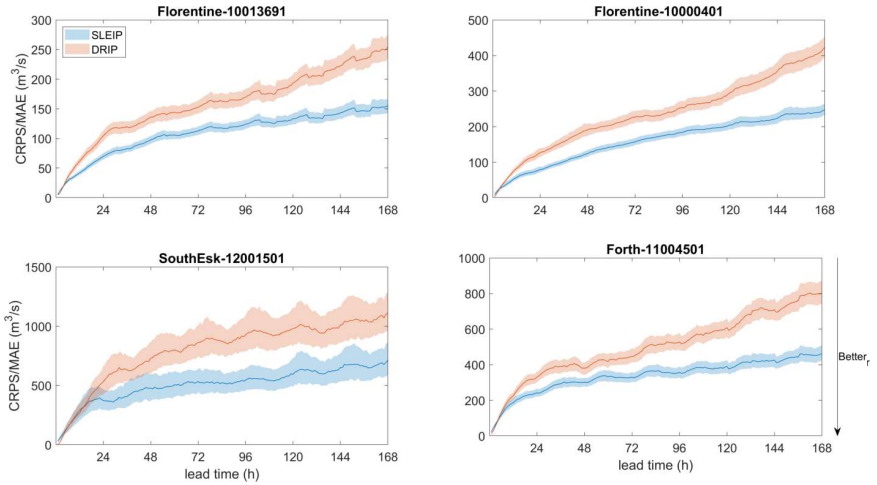
- Rainfall forecast analysis
- Rainfall forecast calibration methods
- Rainfall runoff model, routing and error model
- Retrospective forecasts
  - Short-term: Jul 2019 – Jun 2021 (699 f
  - Strict cross-validation
  - 200 ensemble members
- 7 gauges in 3 catchments

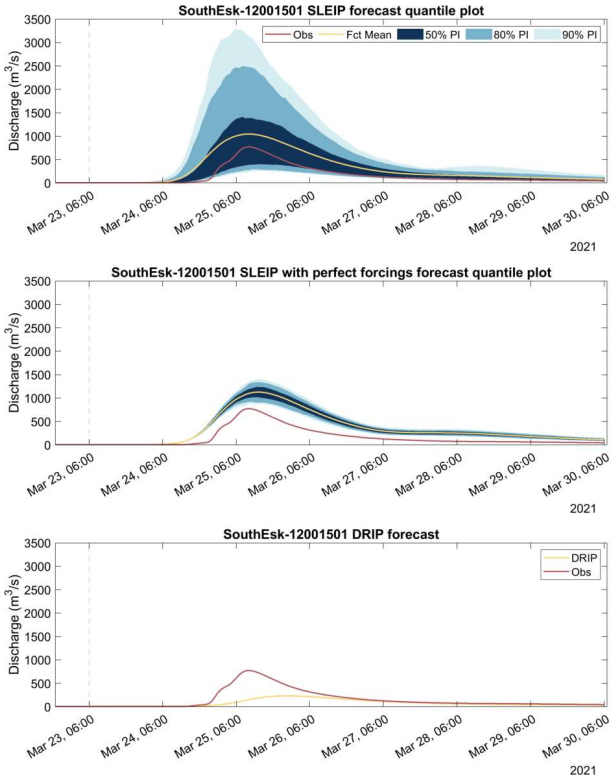


Short-Term Forecasting

Modelling Method - Research Design - Findings

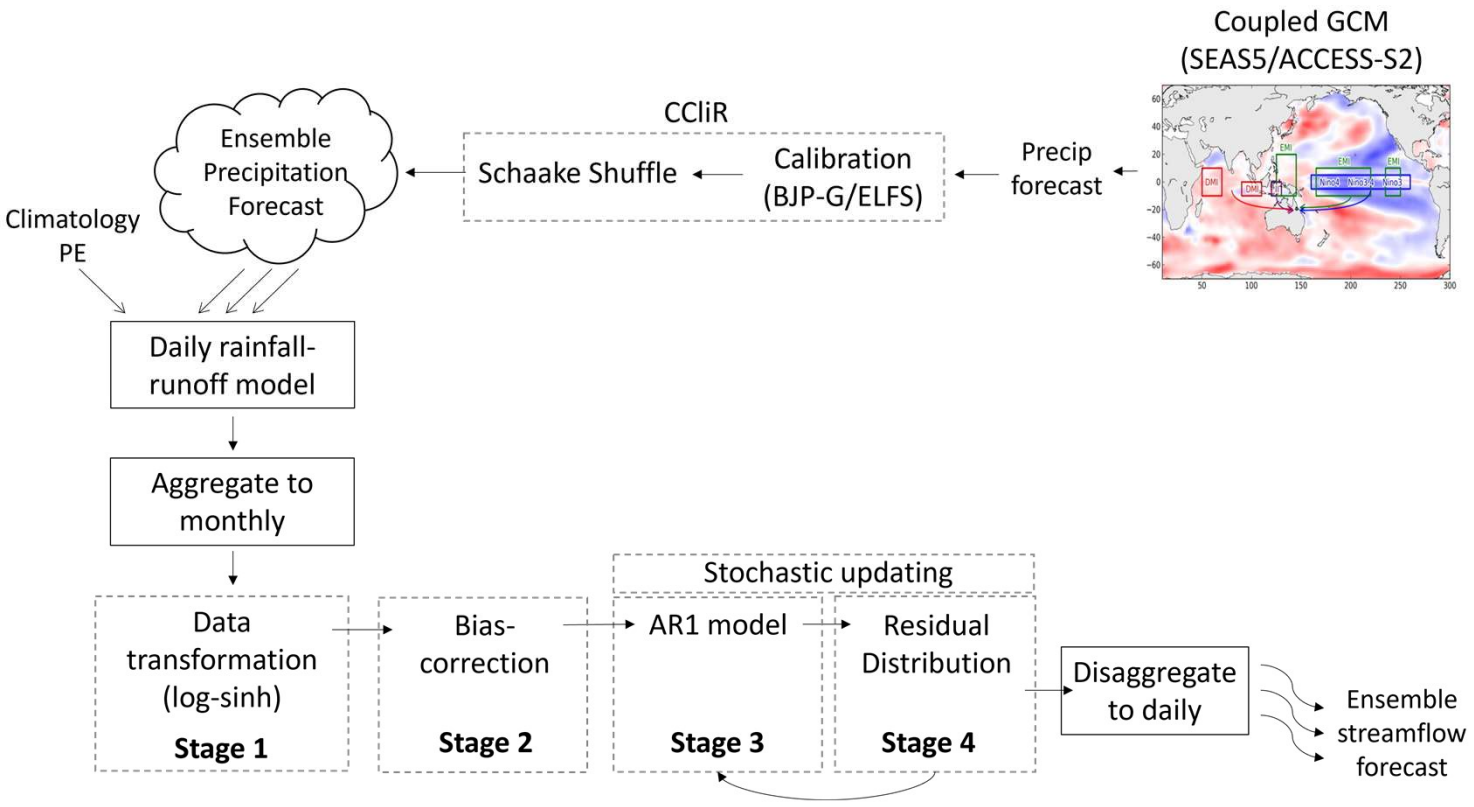
Forecasting methods demonstrated to have equivalent or better performance than the existing deterministic forecast with the additional benefits of quantifying uncertainty, better prediction of peak flows, and extending to 10 days.





Outlook Forecasting

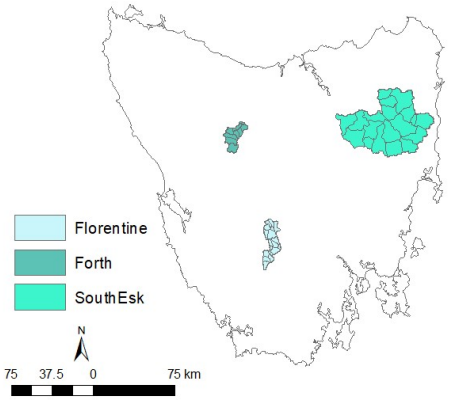
Modelling Method - Research Design - Findings



Outlook Forecasting

Modelling Method - **Research Design** - Findings

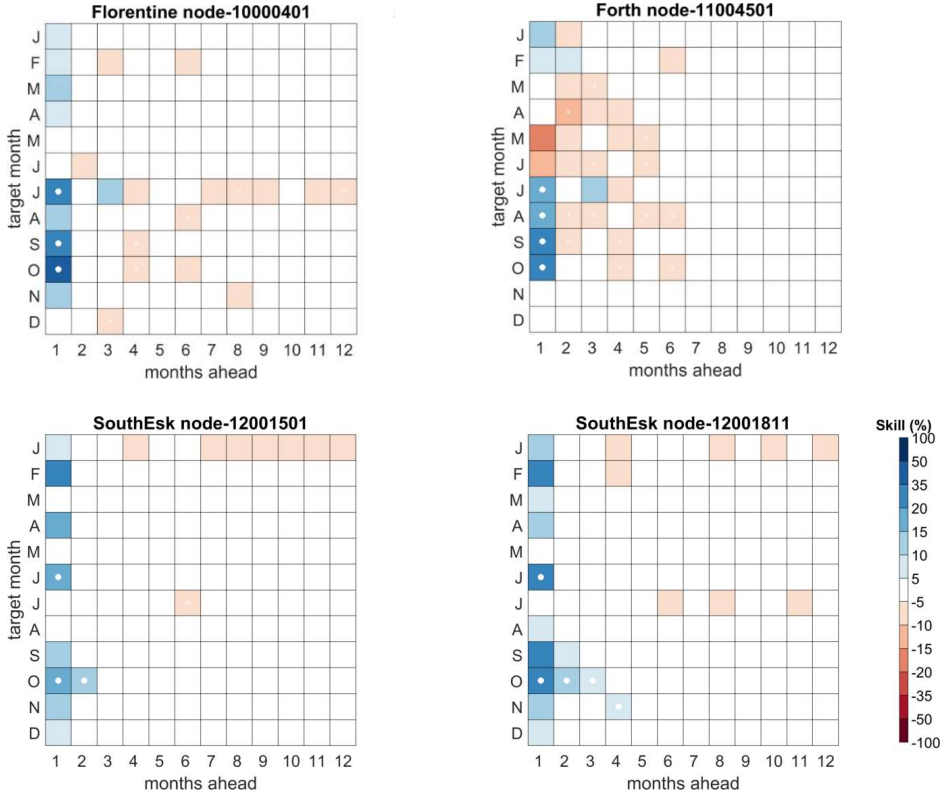
- Rainfall forecast analysis
- Rainfall forecast calibration methods
- Retrospective forecasts
  - Outlooks: 1981-2018 (456 forecasts)
  - Strict cross-validation
  - 200 ensemble members
- 4 gauges in 3 catchments



Outlook Forecasting

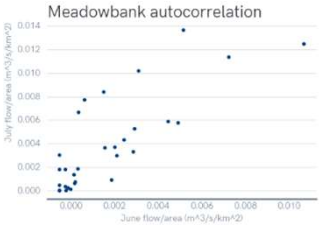
Modelling Method - Research Design - **Findings**

- Skilful (climatology) to 1-month in some seasons
- Accumulations can be skillful to 2 months or more
- Reliable
- Sharpness only ok
- Biases mostly ok, with some underestimation in dry months in South Esk

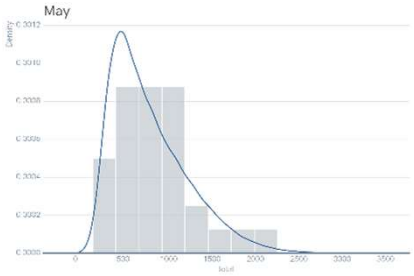


Long-term modelling

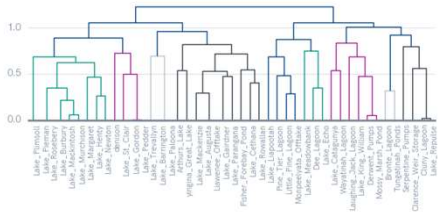
Methodology



Time correlation



Bayesian Inference

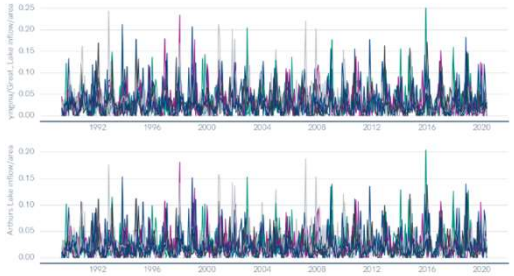


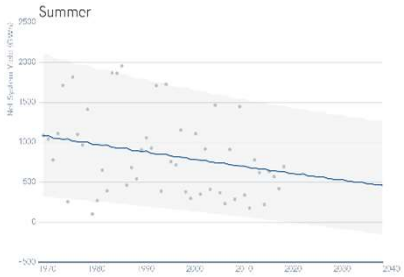
Spatial correlations

$$\mu = \sum_{k=0}^{2} \mu_{k,0} \sin(t) + \mu_{k,0} \cos(t)$$

Fourier Series

Synthetic Inflows



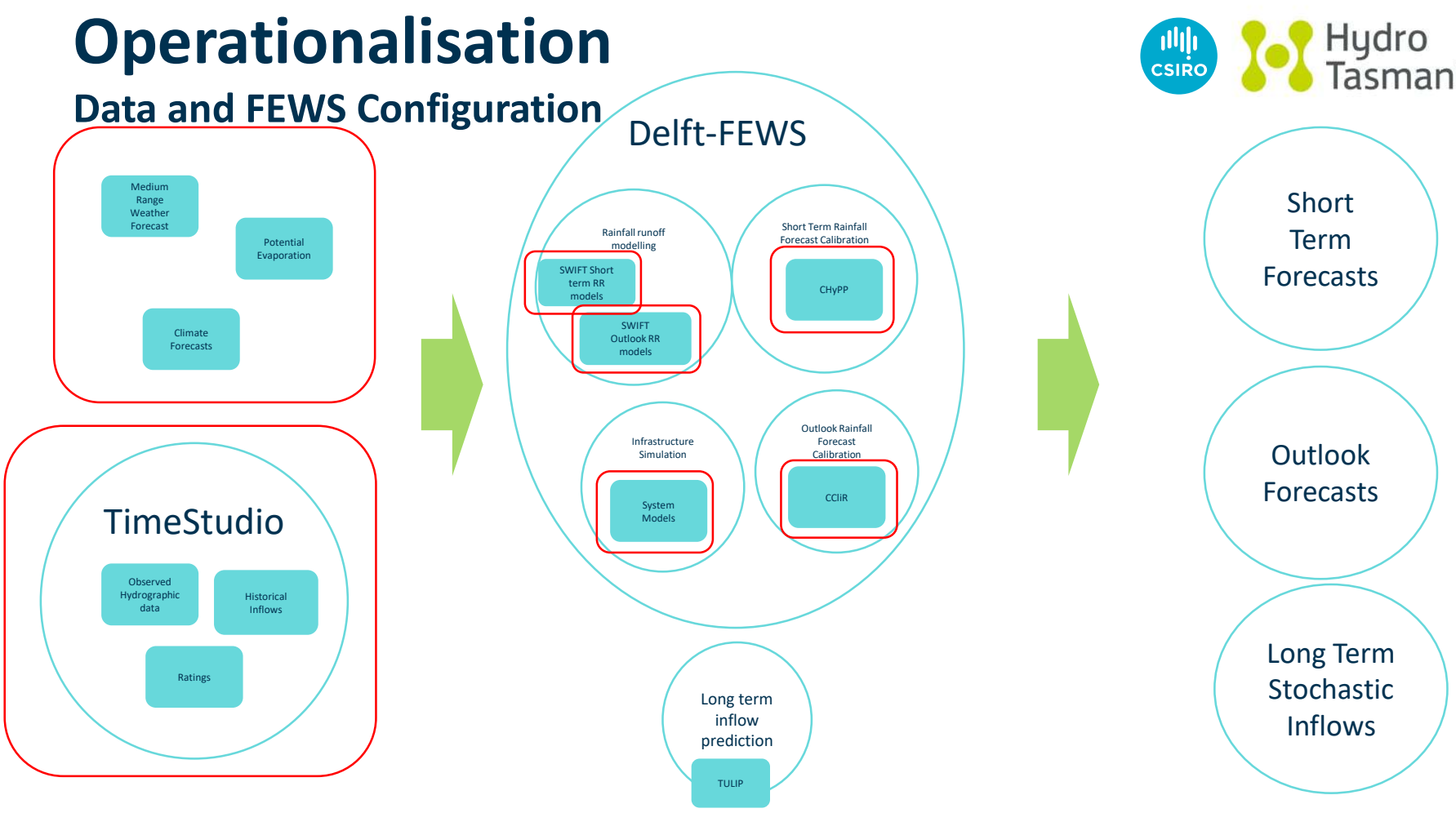


Climate trends

Research still Underway.

Operationalisation

Data and FEWS Configuration

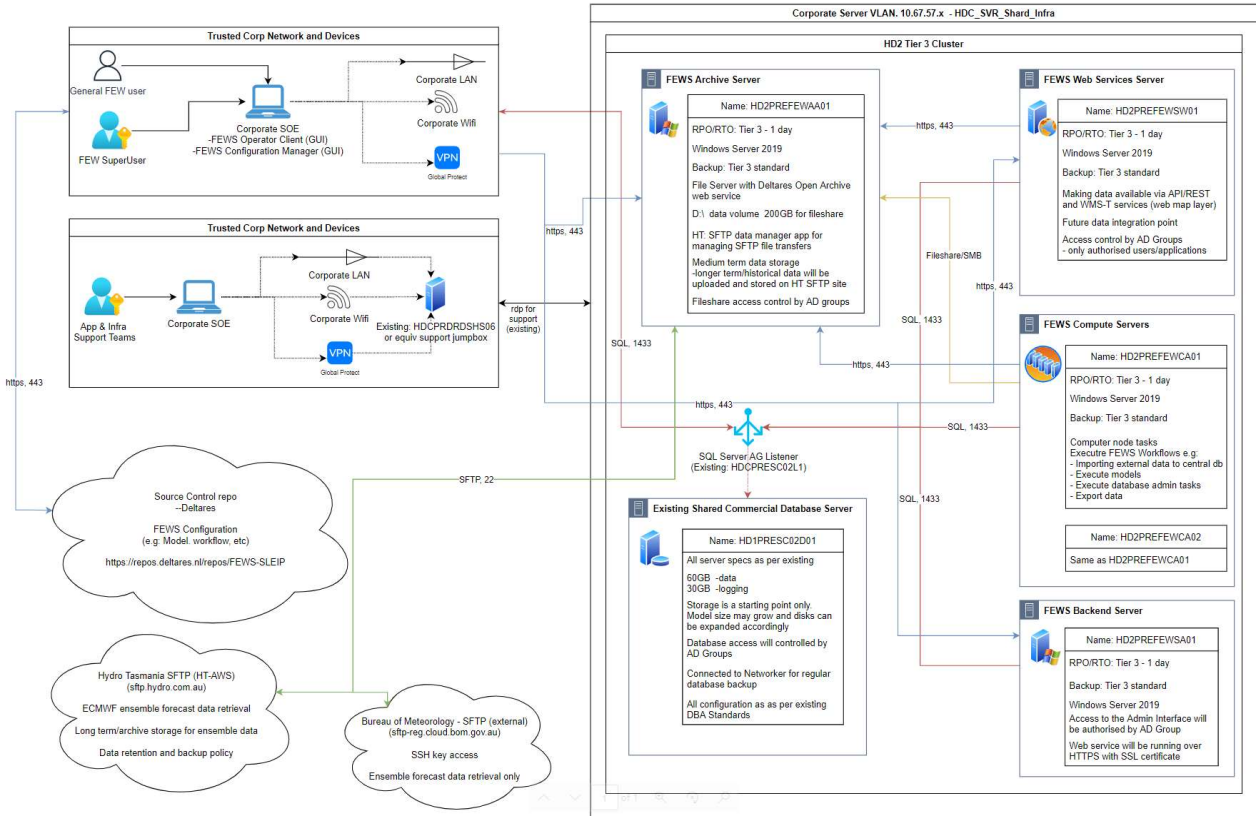


Operationalisation

Infrastructure

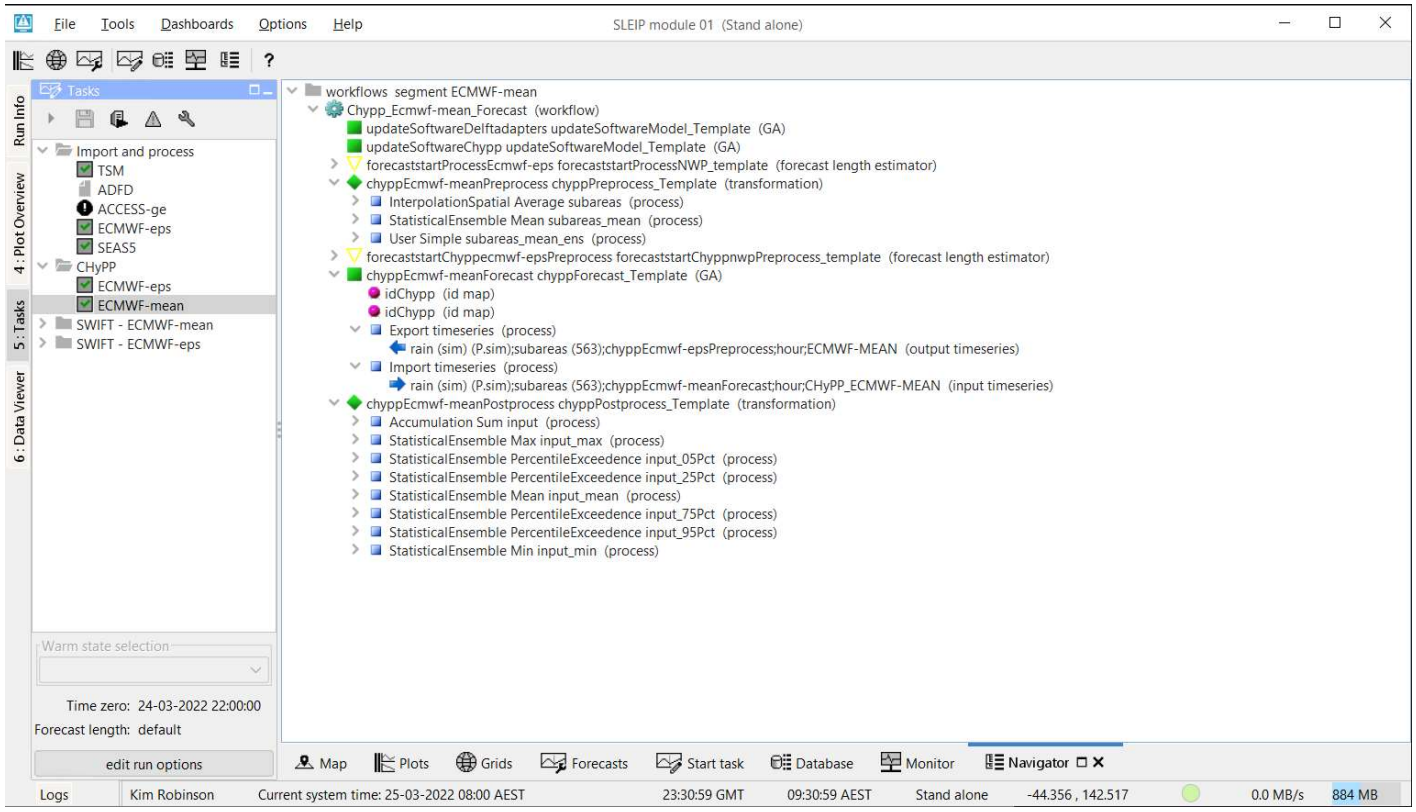
Hydro Tasmania

Delft-FEWS Pre-Production Client-Server Architecture Diagram



FEWS Configuration – Work to date

Hydro Tasmania



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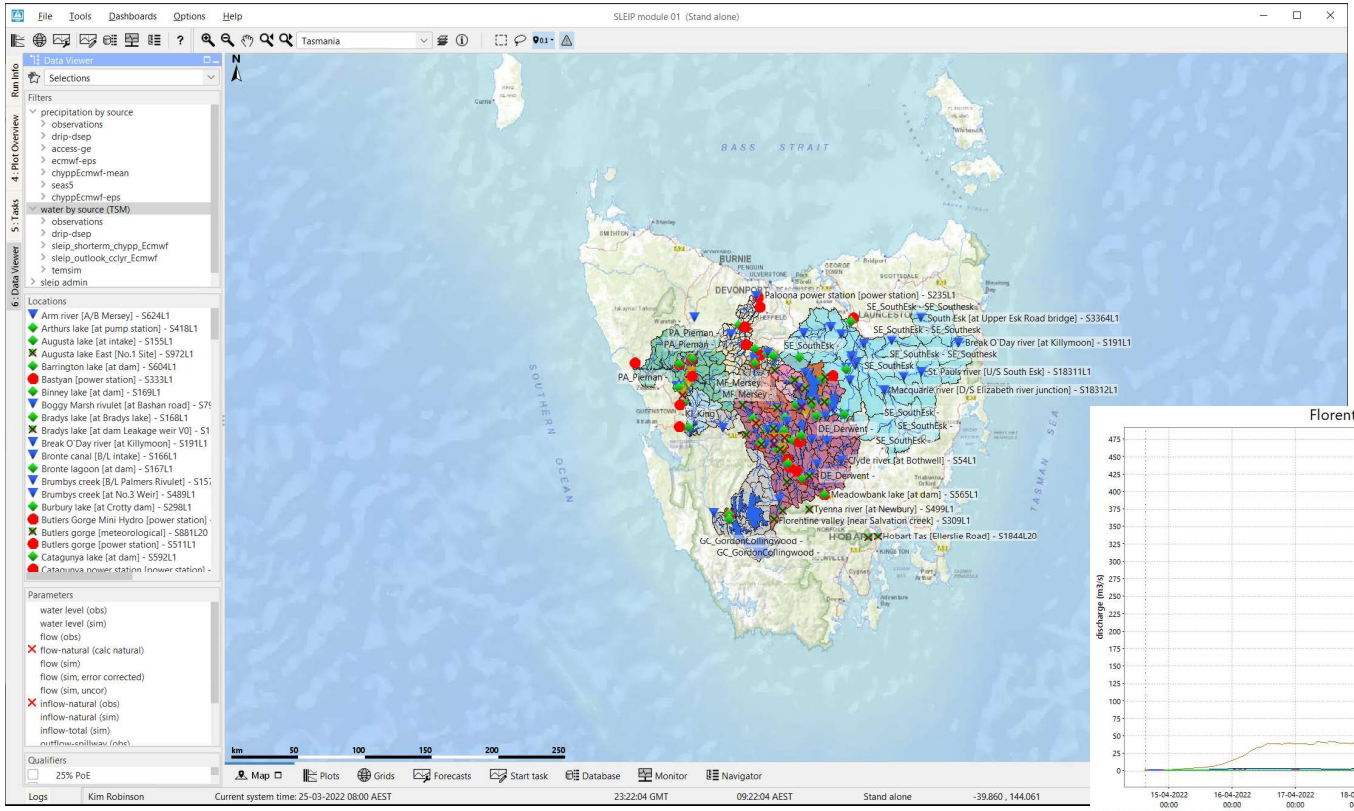
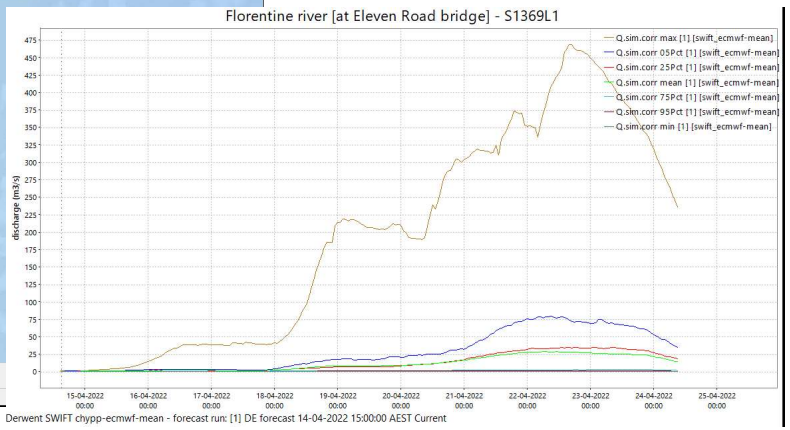
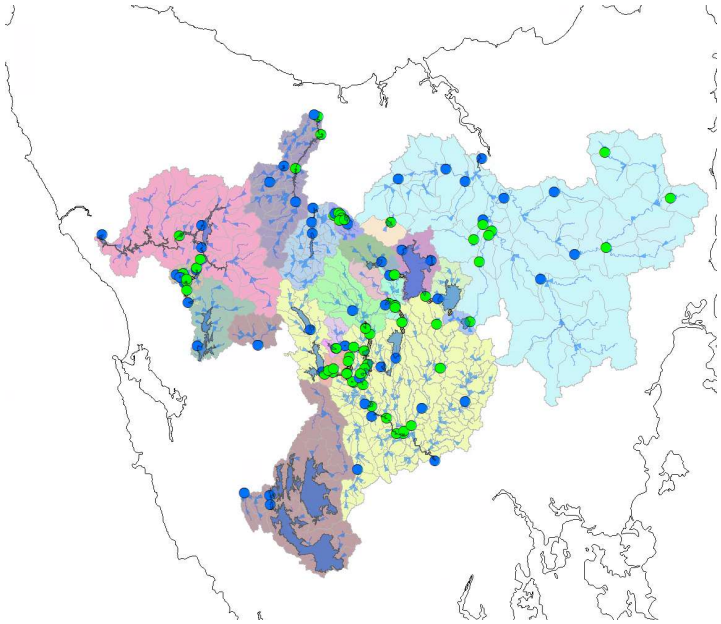


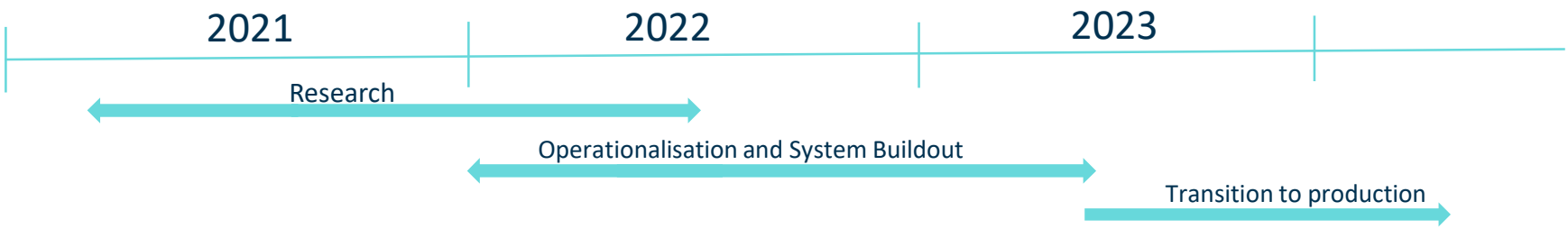


SLEIP modelling system scale



- Catchment area: 23,000 km^2
- > 100 forecast points
- >1000 time series feeds from Hydrographic DB
- 3 * Rainfall forecast ensemble feeds
- 5 * modelling software packages
- Many models
- Short term and outlook forecasts generated autonomously.
- 500,000 time series generated for each complete update.

Project timeline and status



Thank you

Kim Robinson
Senior Hydrologist
Kim.Robinson@hydro.com.au

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