Hydro Tasmania's Short- to Long-range Ensemble Inflows Prediction (SLEIP) SYSTEM

James C Bennett[1], Kim Robinson[2], Jason Hunter[2], Anna Matala[2], Jean-Michel Perraud[1], Simone De Kleermaeker[3], Andrew Schepen[1], David E Robertson[1], Durga Lal Shrestha[1]
[1]CSIRO Environment, Australia. Contact: james.bennett@csiro.au
[2]Hydro Tasmania, Hobart, Australia. Contact: kim.robinson@hydro.com.au
[3]Deltares, Brisbane, Australia. Contact: Simone.deKleermaeker@deltares.nl

Hydro Tasmania identified the need to upgrade their deterministic 7-day inflow forecasting system to an ensemble system with longer lead times. In response, we developed the SLEIP ensemble forecasting system to predict inflow i) 0-10 days at the hourly time step and ii) 3+ months at the daily timestep.

Streamflow forecasting method

We use **a hybrid statistical-dynamical** forecasting method. Hydrological modelling is carried out with **semi-distributed** models. Initialised hydrological models are forced with **calibrated ensemble rainfall forecasts**. Uncertainty in the hydrological modelling is handled with **error models**. Uncertainty is propagated through lead time and through space, from upstream to downstream.

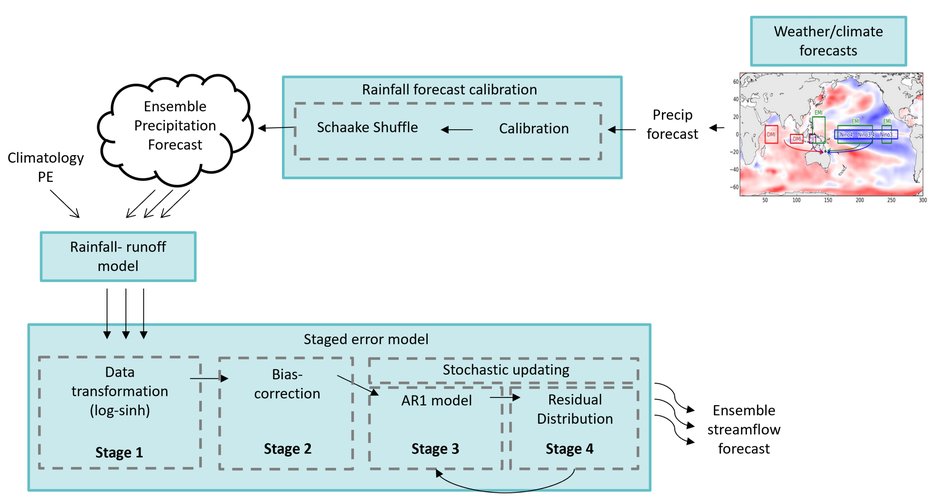

Figure 1: Schematic of the hybrid forecasting system.

Forecast evaluation: 0-10 day forecasts

ECMWF-ens NWP rainfall forecasts proved more skillful than **ACCESS-GE**, but still required calibration. We calibrate the **ensemble mean**.

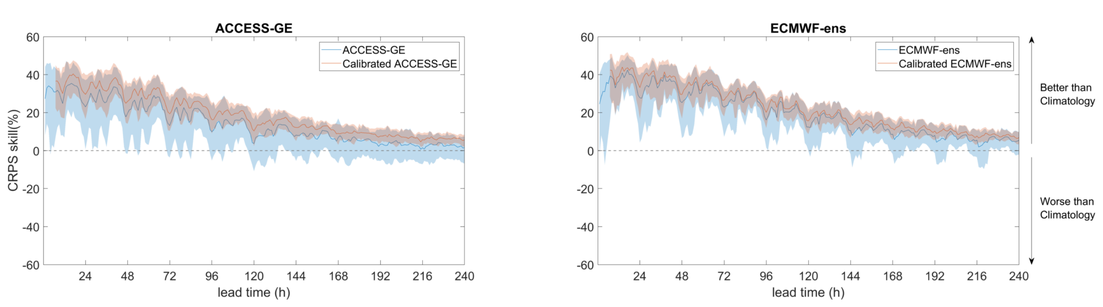

Figure 2: Skill of calibrated and raw forecasts. Confidence intervals show [0.1, 0.9] intervals from 563 subareas.

Ensemble streamflow forecasts outperformed the existing **deterministic forecasts,** largely due to the representation of uncertainty.

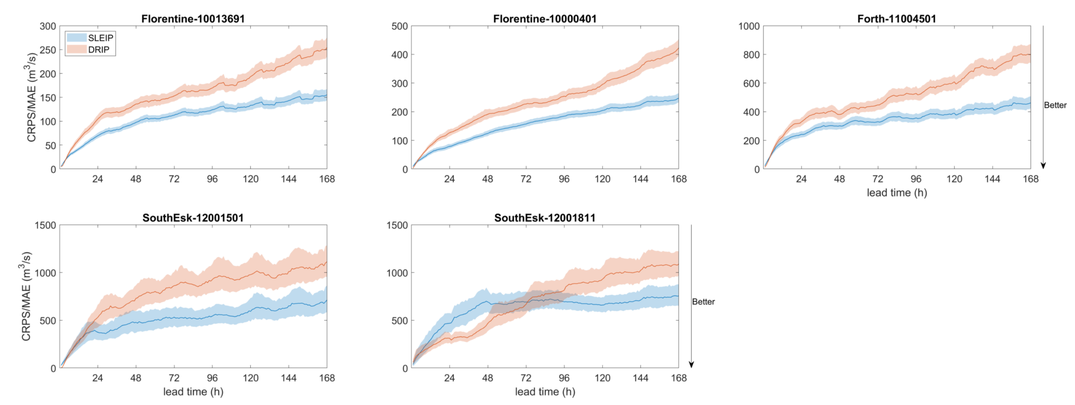

Figure 3: Forecast errors for ensemble (blue) and deterministic (red) streamflow forecasts at example gauges. [0.1, 0.9] confidence intervals generated by bootstrapping with 500 repeats.

Forecast evaluation: Outlooks

ACCESS-S2 and **ECMWF-SYS5** rainfall forecasts are both skillful after calibration. **Ensemble spread** adds little value to the calibration.

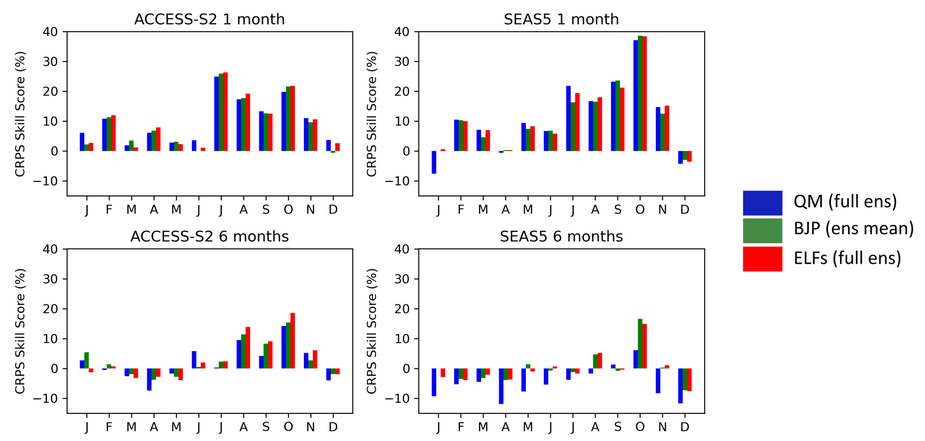

Figure 4: Skill of seasonal rainfall forecasts at 1 (top) and 6 (bottom) months for S2 (left) and SYS5 (right). Forecasts are corrected with quantile mapping (QM), calibrating the ensemble mean (BJP) and calibrating the full ensemble (ELFs).

Streamflow outlooks are skillful only for the first month at certain times of year, due to low catchment memory. **Accumulated outlooks** can be skillful to accumulations of >2 months, but errors can also accumulate.

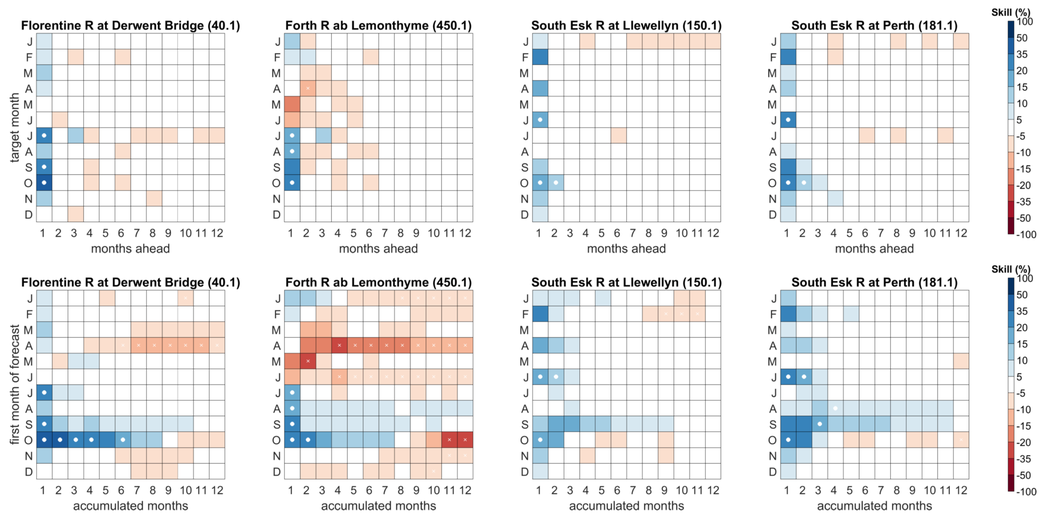

Figure 5: Skill of streamflow outlooks at selected gauges at individual forecast months (top row), and accumulated volume forecasts (bottom row).

Operationalisation

The forecasts are generated on ms-windows with CSIRO's C++ **SWIFT, CHyPP, CCliR** and **FoGSS** software wrapped in Matlab and Python. Rainfall forecasts are from ECMWF. The workflows are called and visualised with Deltares' **Delft-FEWS**. Infrastructure is modelled with Deltares' **RTC-tools.**

The system comprises:

- 22 catchments
- 563 subareas
- 79 inflow forecast points
- Full automation

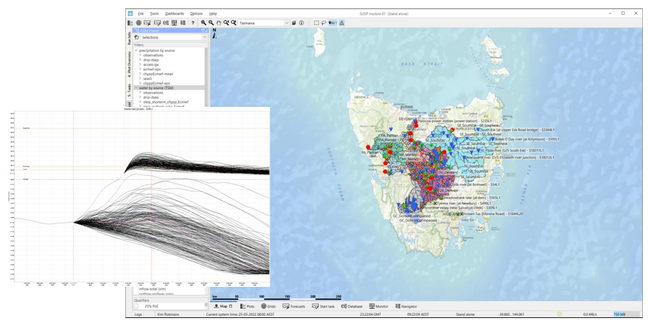

Figure 6: Example of forecast visualisation with Delft-FEWS.

As Australia's national science agency and innovation catalyst, CSIRO is solving the greatest challenges through innovative science and technology.

CSIRO. Unlocking a better future for everyone.

FOR FURTHER INFORMATION
Dr James Bennett
james.bennett@csiro.au
https://people.csiro.au/B/J/James-Bennett

REFERENCES
Bennett et al. 2021. ***J Hydrol*** doi: 10.1016/j.jhydrol.2020.125739
Bennett et al. 2021. ***AWR***, doi: 10.1016/j.advwatres.2021.103891
Schepen et al. 2020. ***IJCL***, doi: 10.1002/joc.6346
Shrestha et al. 2015. ***MWR*** doi: 10.1175/mwr-d-14-00329.1.

ACKNOWLEDGEMENTS
This research was conducted on the traditional lands of the Wurundjeri, Boonwurrung, Djaara and Muwinina peoples. We acknowledge their custodianship of these lands and pay our respects to their elders. We also acknowledge the traditional owners of the catchments used in this study.

Hydro Tasmania
The power of natural thinking