Skill improvement of snow-dominated reservoir inflow forecasts using seasonal weather predictions

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HS4.4 – Ensemble and probabilistic hydro-meteorological forecasts: predictive uncertainty, verification and decision making

Outline

1. Case study: Cheboksary reservoir on the Volga River
2. Forecasting system description: Full Ensemble Forecast (FEF)
3. Motivation for improvement
4. FEF post-processing: conditioning on weather and stochastic CDF modelling
5. Seasonal weather predictions: SL-AV model
6. Operational assessment and verification
7. Conclusion & Outlook

ESP: the ECOMAG model

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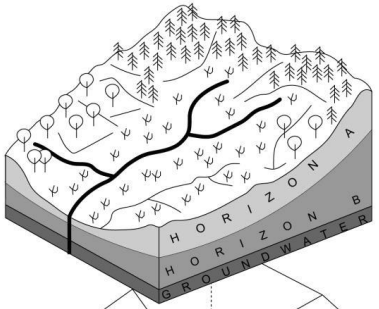
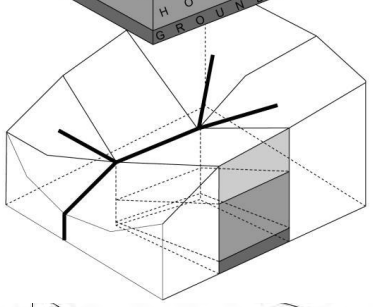
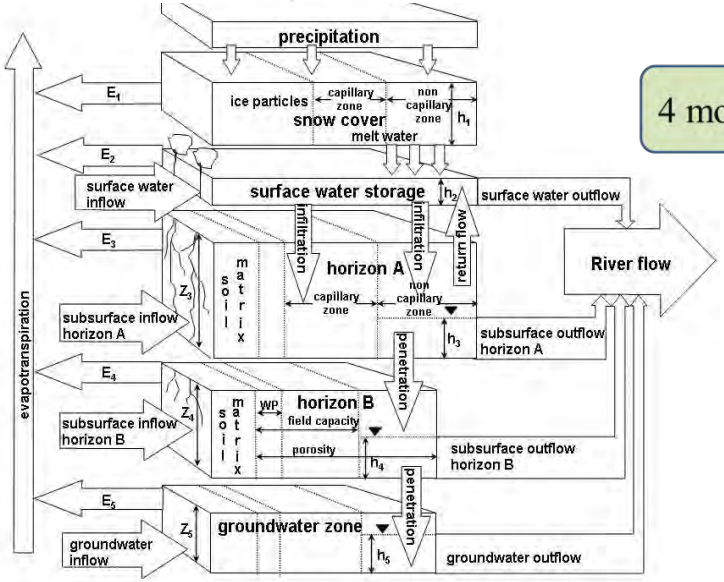
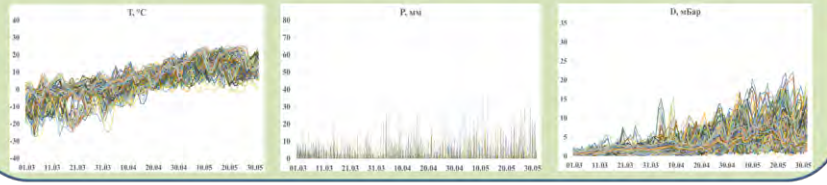






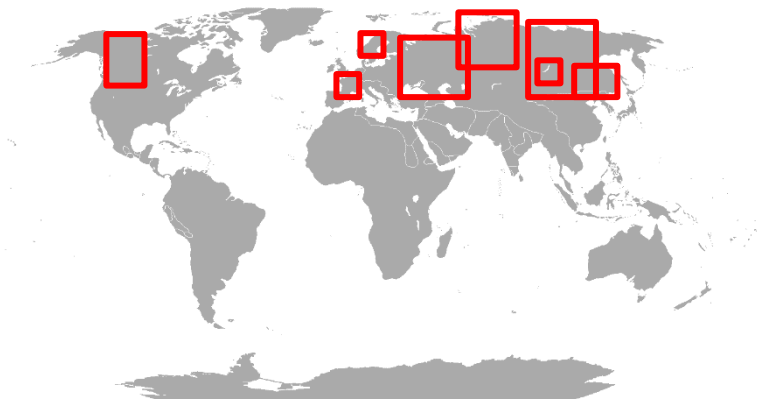
Model initialization for the forecast date (1st of March) based on observed weather

Observer 52-member ensemble for the forecast window (1st of March – 30th of June)



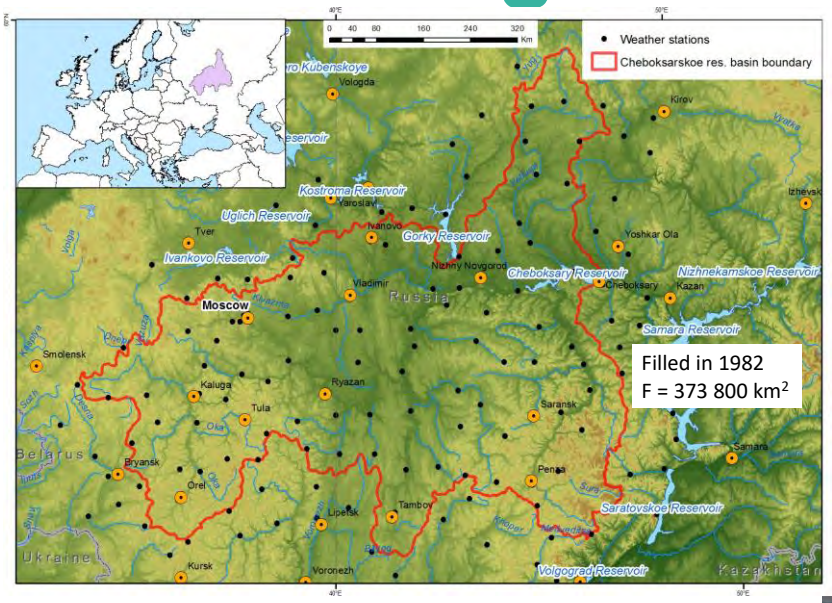
ECOMAG

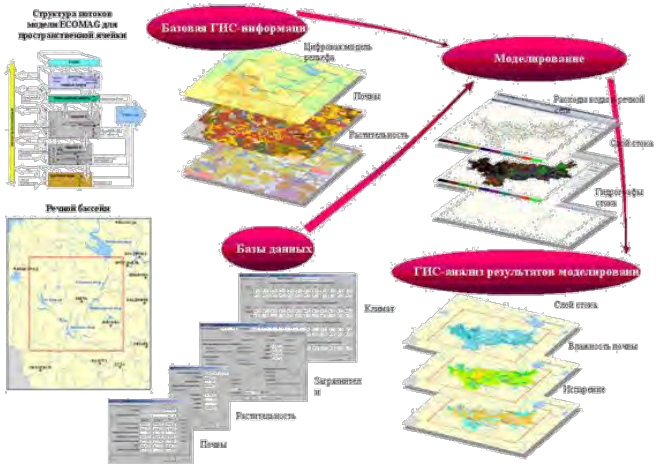
4 months ensemble of daily water inflow into the reservoir



Motovilov, Y. G.: Hydrological simulation of river basins at different spatial scales: 2. Test results, Water Resour., 43(5), 743–753, doi:10.1134/S0097807816050092, 2016.

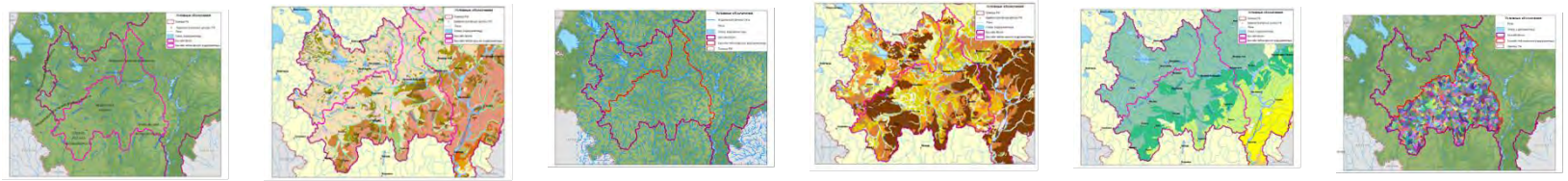
Case study: Cheboksary reservoir on the Volga River





Initial dataset:

- 1x1 km DEM, soil/landuse maps
- Weather from 167 stations
- Calibrated against observed inflow 1982 - 2018



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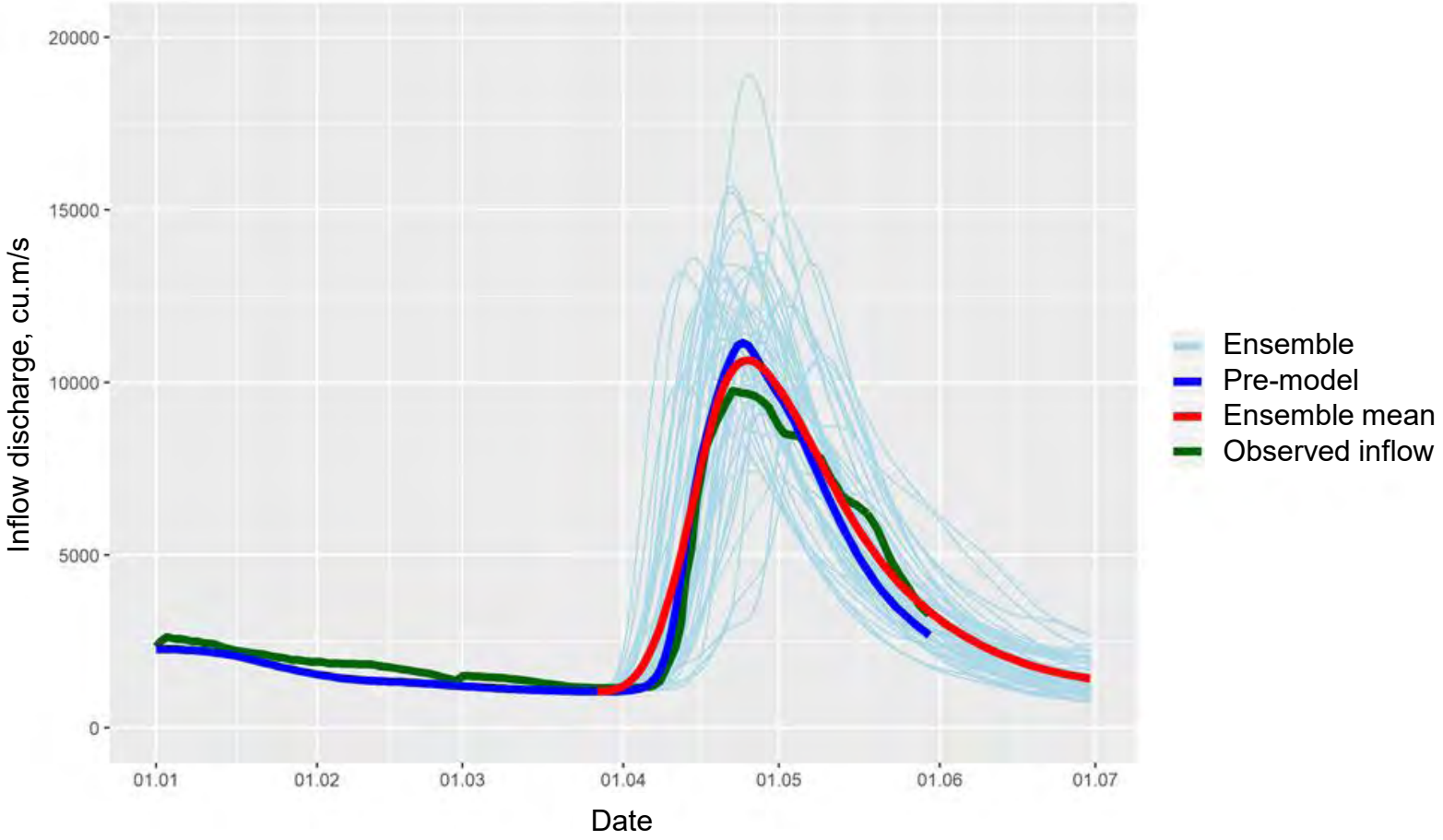
Full Ensemble Forecast (FEF)[1]

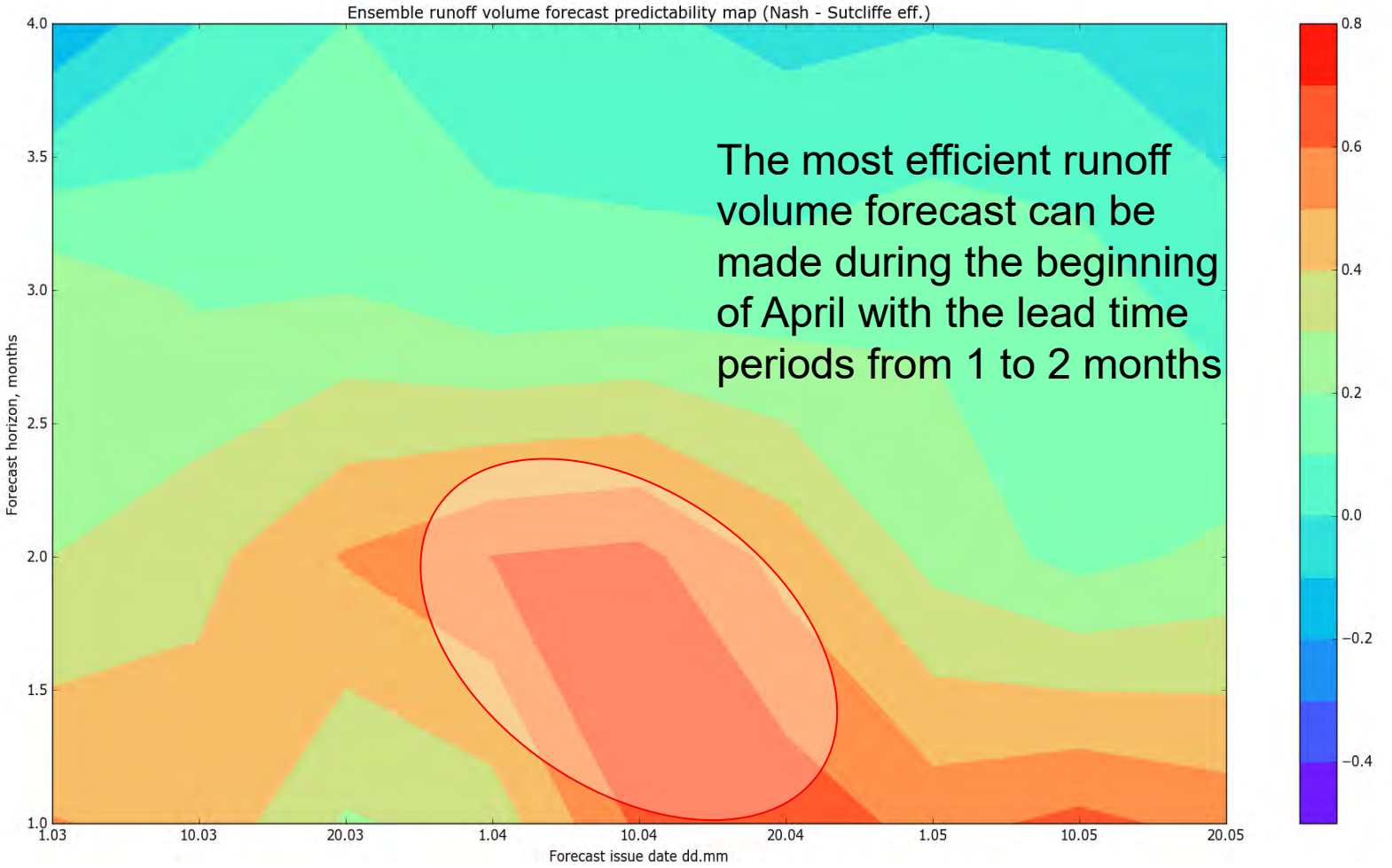
Weather observations data from 1966 – 2018 make up full ensemble of 52 scenarios up to 4 months ahead. 52 streamflow hydrographs are modelled up to 4 months ahead. Full ensemble is averaged to derive mean monthly hindcast of inflow into the Cheboksary reservoir.



1 - Day, J. Water Resour.Plan. Manage,1985; Gelfan et al., HESS, 2018

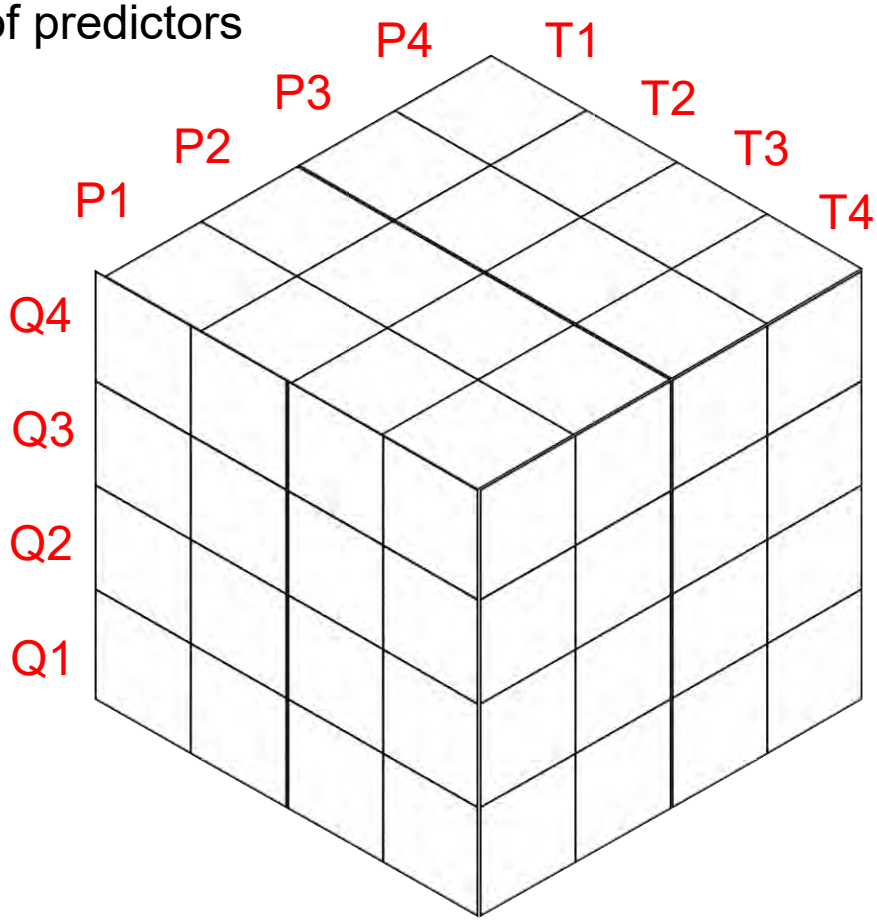
Full Ensemble Forecast (FEF)[1]

Both the initial conditions in the catchment prior to freshet commencement and the weather forecast are critical for the hydrological forecast efficiency, the forecast skill deteriorates with time, and the forecast confidence interval remains impractically wide



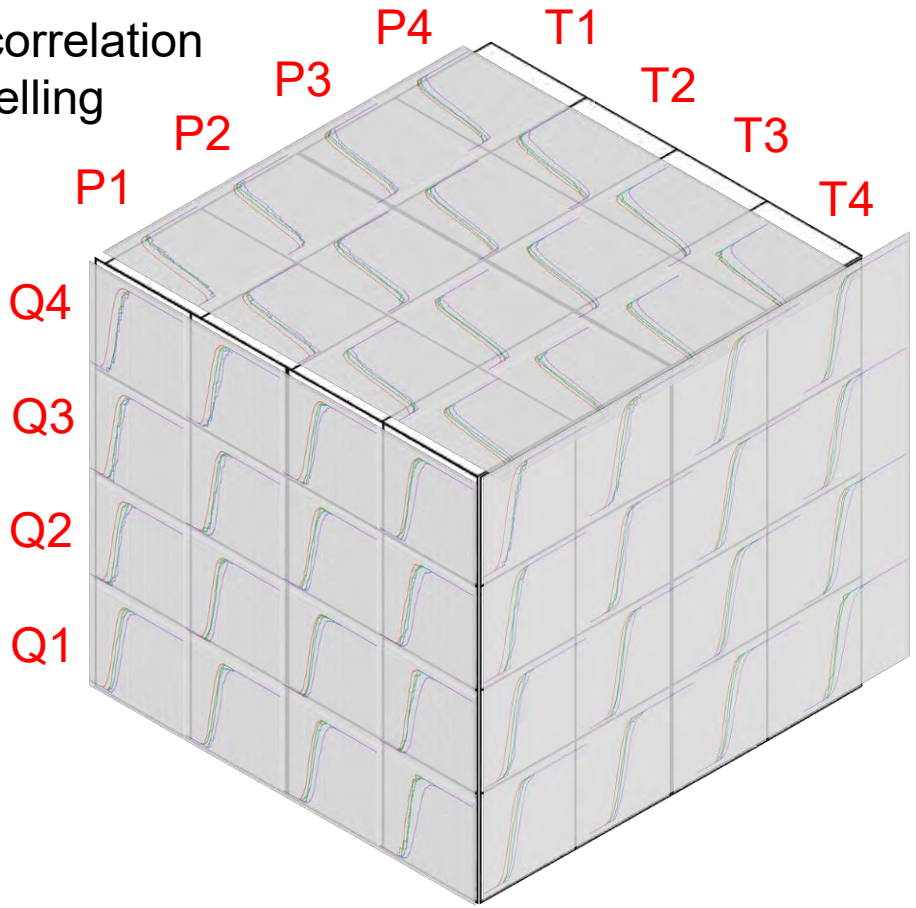
Stochastic post-processing

- Mapping all the hindcasted scenarios into categories based on combinations of the corresponding mean monthly temperature and precipitation conditions
- Conditioning on the quartiles of the observed samples of monthly inflow volume, air temperature and precipitation
- 4 x 5 x 4 = 64 combinations of predictors

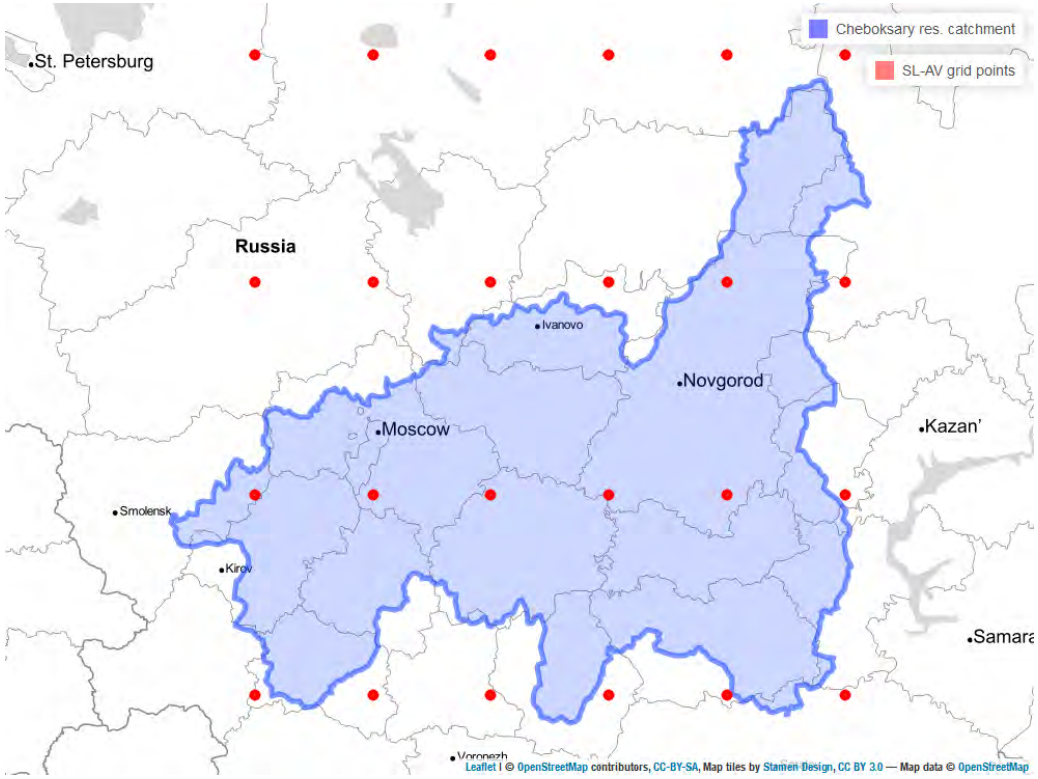


Stochastic post-processing

- The hindcast ensemble means for all months (3 – 6) and years (1966 – 2018) are combined with the observed temperature and precipitation monthly means
- The time-series are checked for normality and transformed if not normally distributed (Tukey transformation)
- The transformed time-series are standardized
- PCA is applied to eliminate correlation
- Monte-Carlo stochastic modelling of the 16000-unit long time-series
- Reverse transformation of the modelled time-series to restore correlation
- Conditioning of the modelled time-series on the quartiles of the initial sample
- CDF construction for each class



SL-AV Seasonal Weather Forecast



Semi-Lagrangian global atmosphere model (SL-AV):

- Developed at the Hydrometeorological Center of Russia and the Institute of Numerical Mathematics of the Russian Academy of Sciences (*Tolstykh 2010, 2011, 2015*)
- Spatial resolution of 1.125 ° x 1.40625 ° (lon x lat).

- Initial conditions: NCEP Reanalysis 2 (hindcast) / HMC data assimilation system (forecast).
- Ocean initial conditions: Reynolds-Smith OI. SSTs are taken 3 days before the forecast period.
- Ensemble size for the hindcasts is 10.
- Ensemble size for the forecast is 20. The forecast ensemble is configured by the original and perturbed (breeding of fast growing modes) analysis fields from the date 2 days prior to current month.

SL-AV Seasonal Weather Forecast

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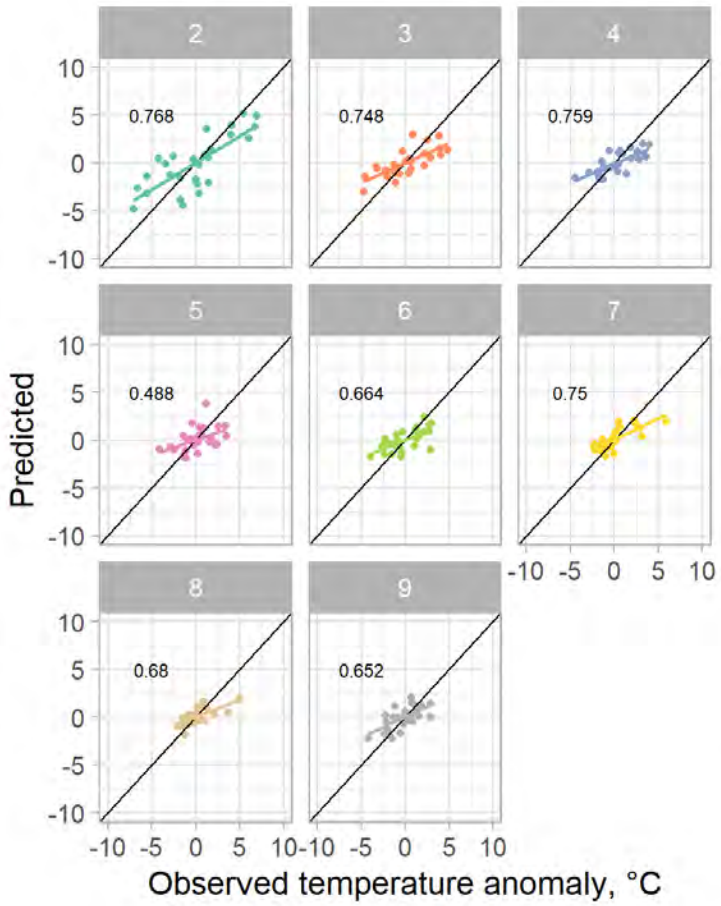

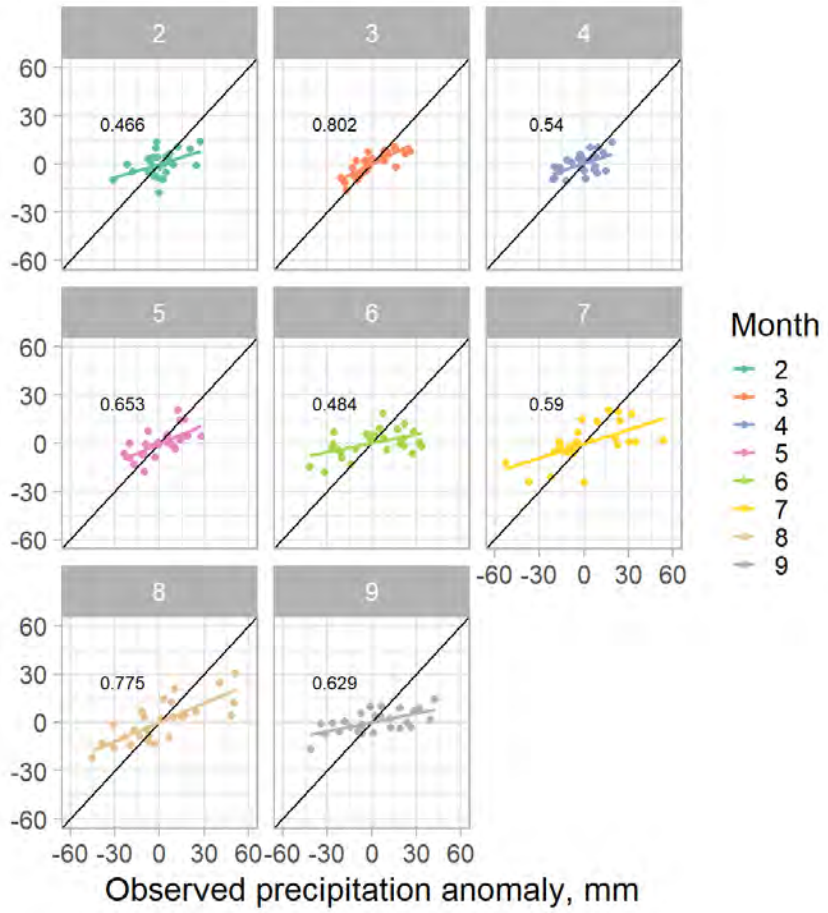

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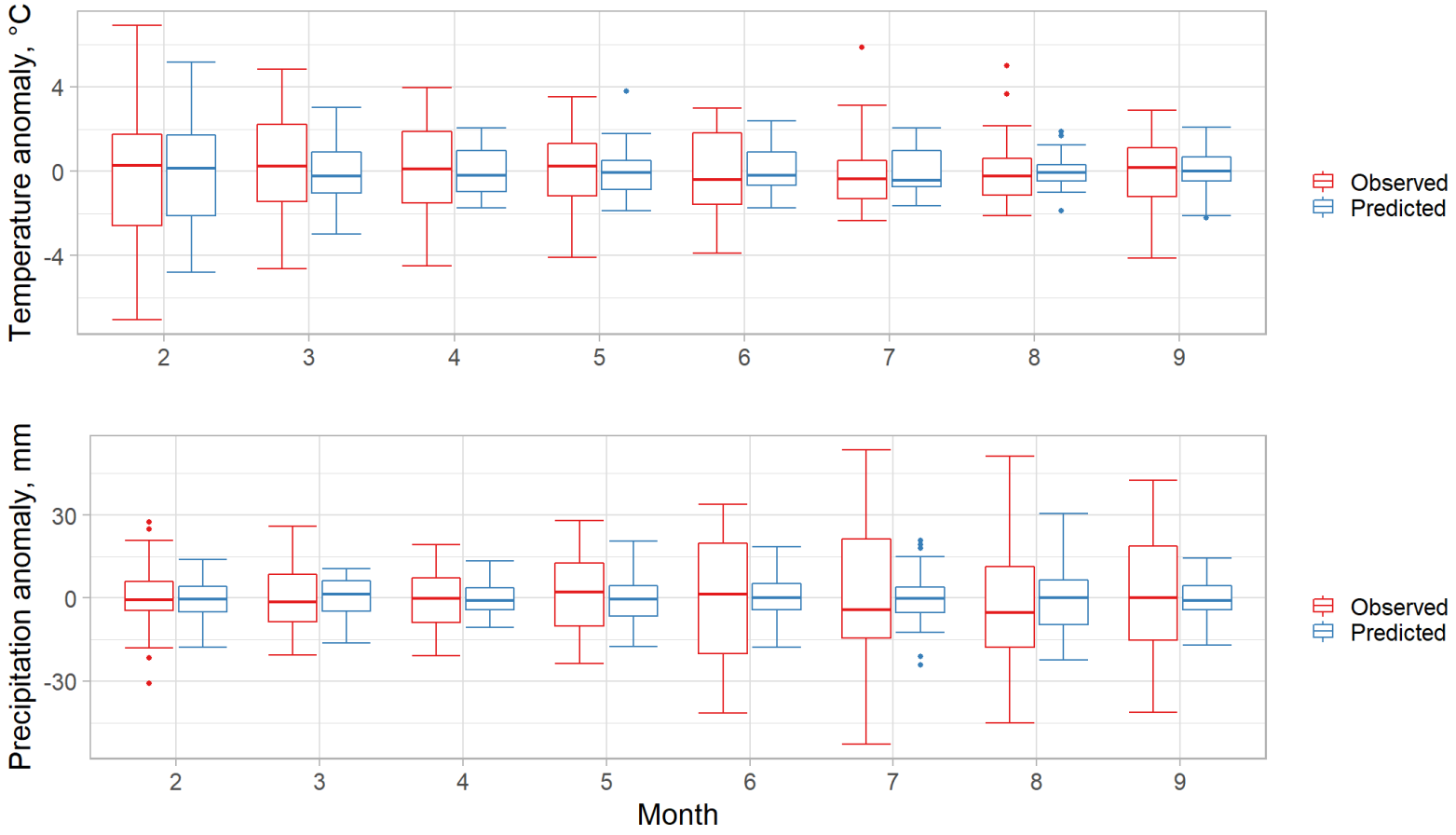
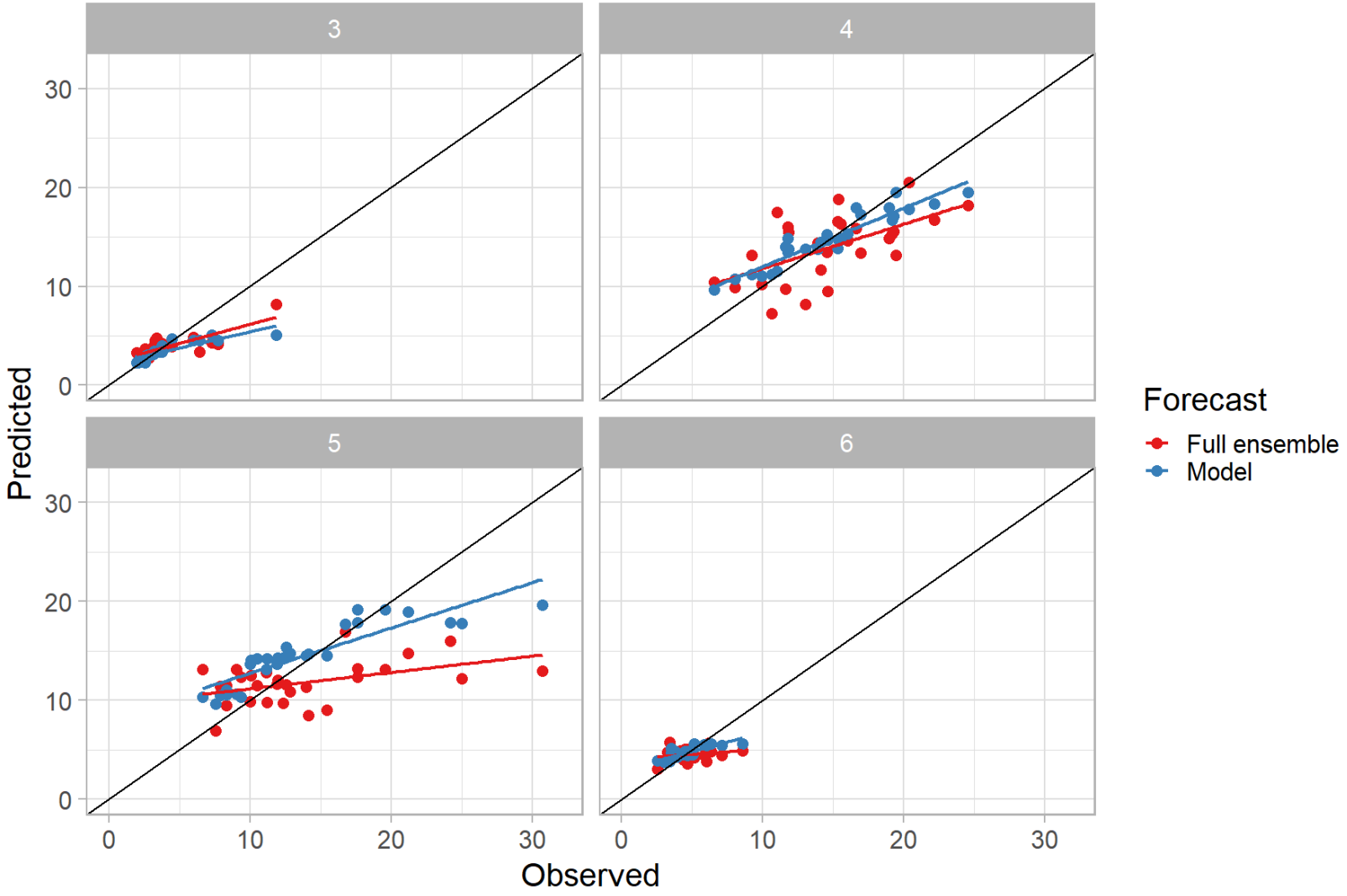


Operational assessment

- Hindcasts for 1983 – 2010, March – June, lead-time 1 to 4 months ahead



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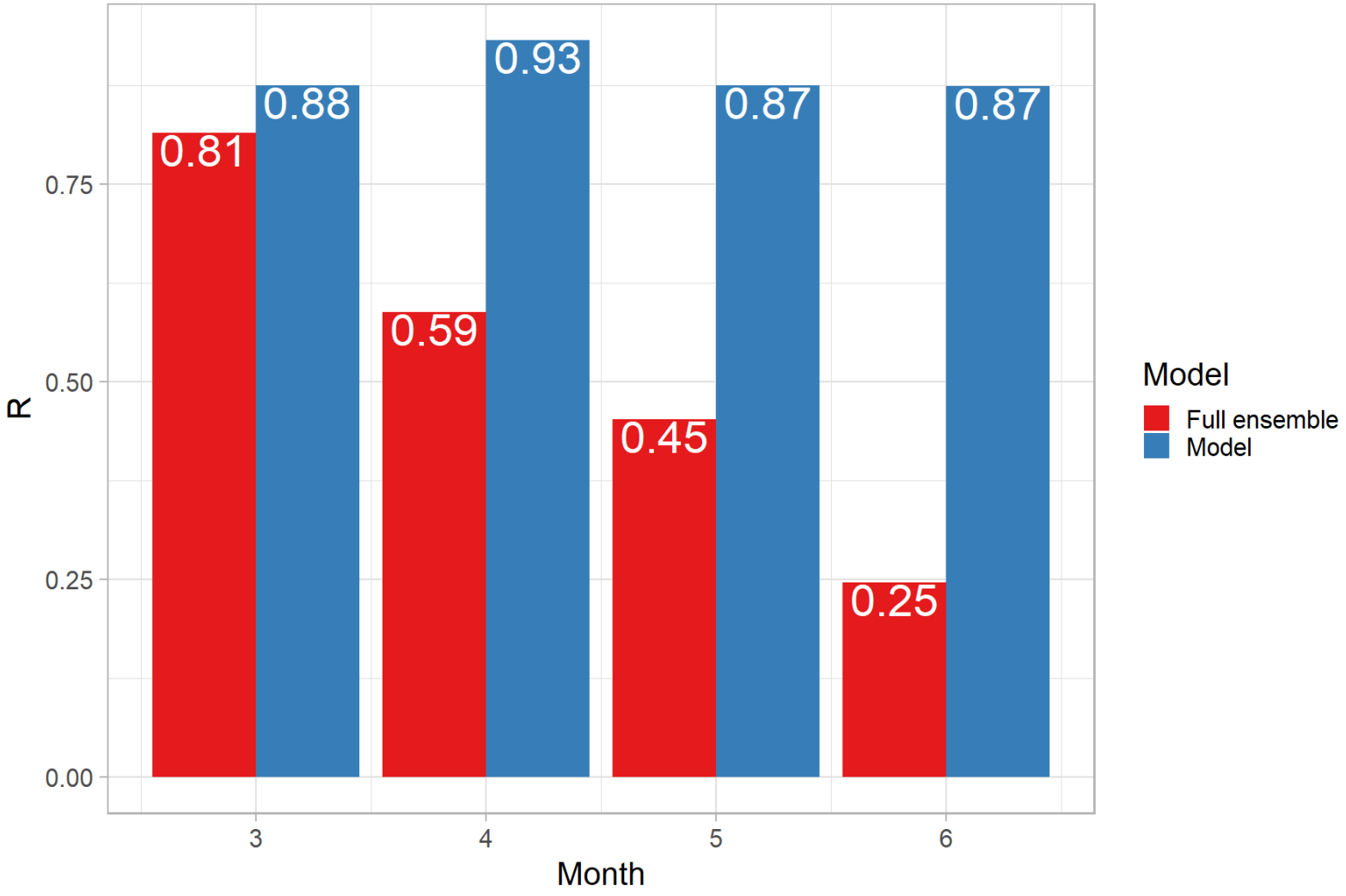

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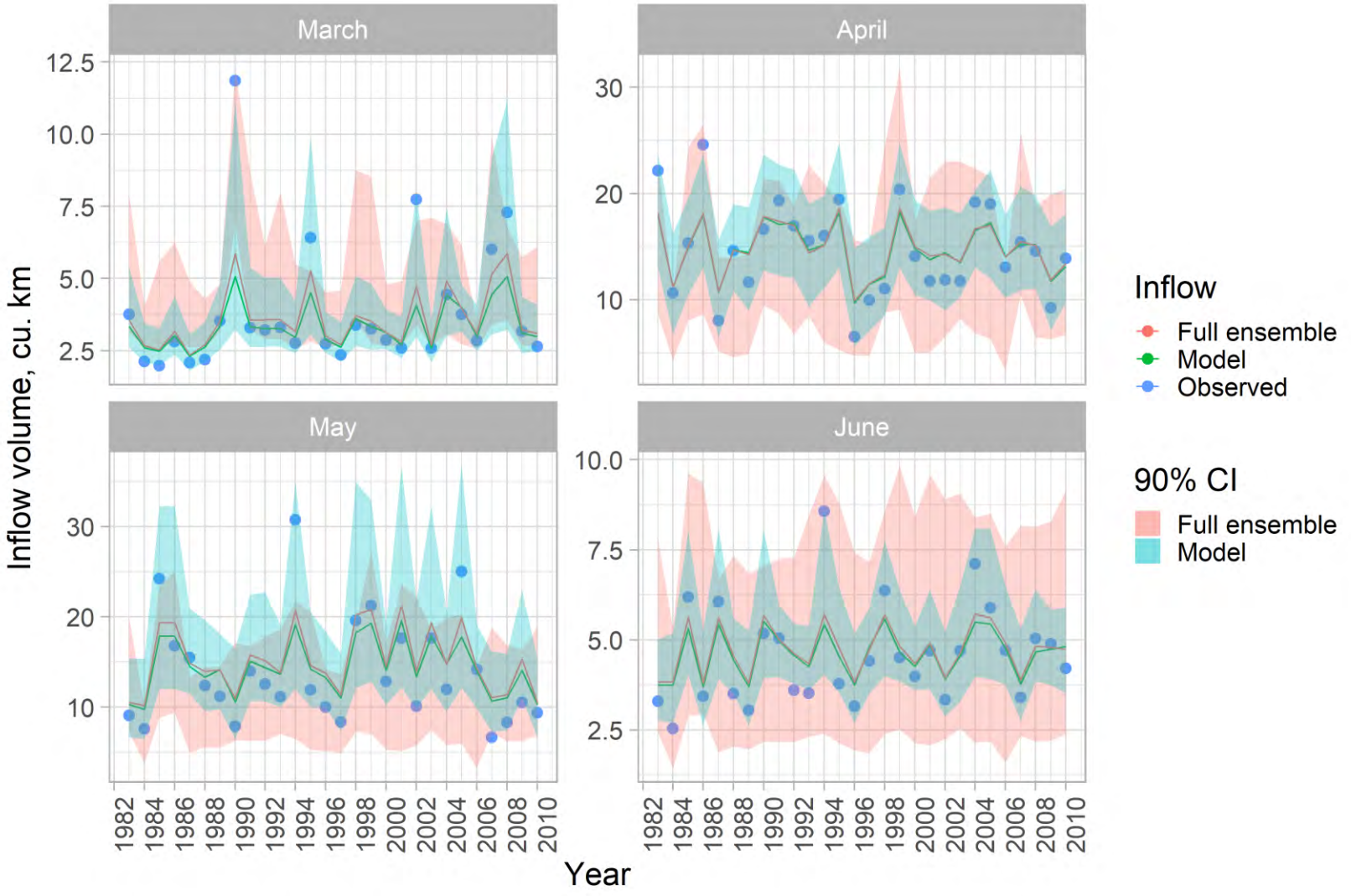

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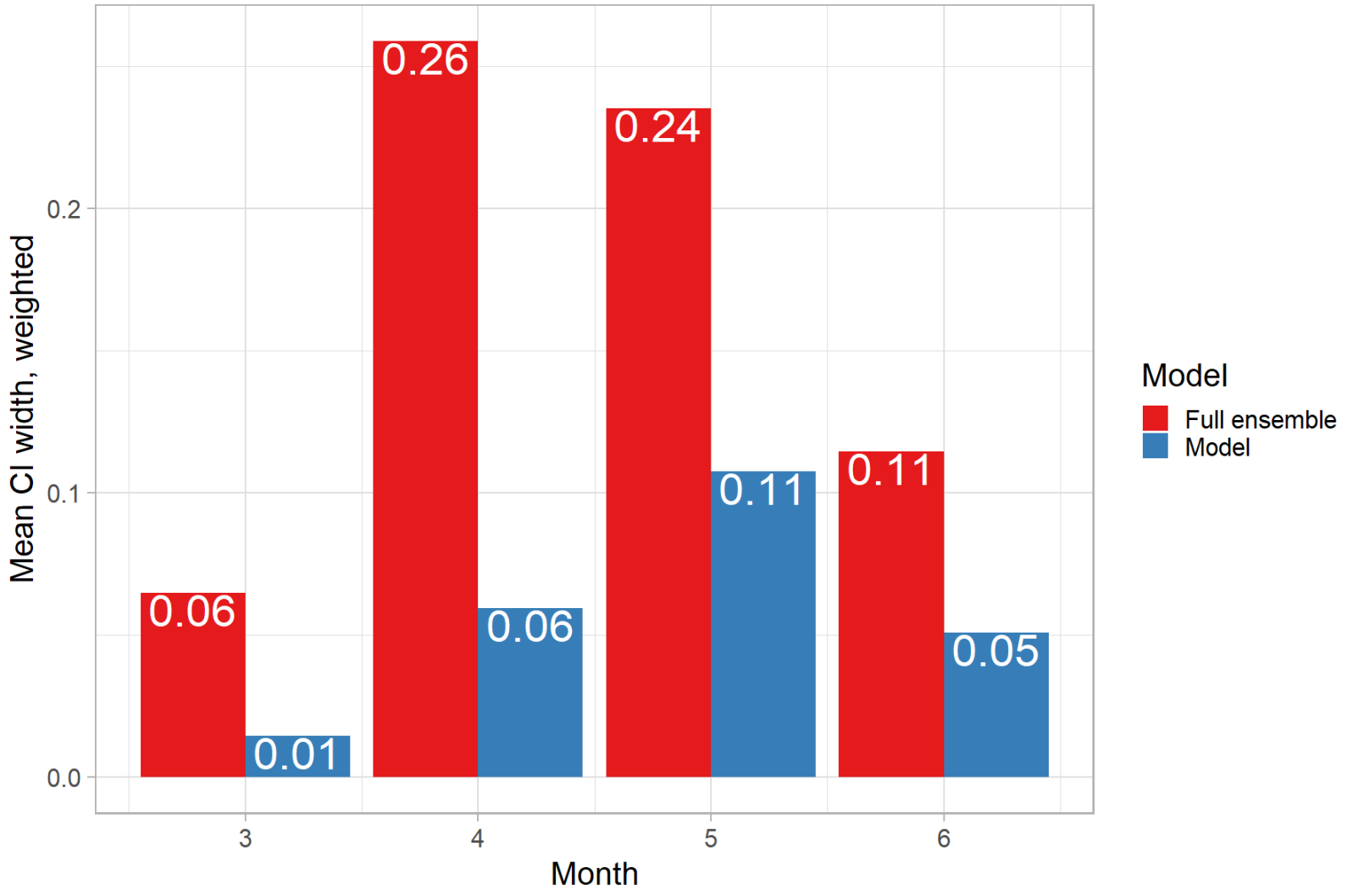

Conclusion & Outlook

- The hindcasts over a long period are conditioned on the observed temperature and precipitation and mapped to different categories according to their combinations
- The limitation of insufficient length of time-series in the categories is overcome by stochastic time-series modelling
- The obtained categories are used as a “lookup table” for forecasts, which is sustainable over time
- Seasonal temperature and precipitation forecasts are used to post-process the streamflow ensemble forecast
- The forecasts are in probabilistic form (inflow volume CDF) – can provide 90% confidence intervals
- Width of 90% confidence intervals is significantly narrower than those of the initial forecasts