Evaluation of a multi-model seasonal hydrological forecast prototype for the spring flood period in Sweden

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Hydropower was the driving force
Background - Hydropower in Sweden

- Sweden is the biggest hydropower producer in the EU and the 10th biggest worldwide (IEA 2012)

- **Hydroelectric capacity**: 16 781 MW
  - % of total installed capacity: 42.79%
  - % of total renewable capacity: 67.81%

- **Annual production (last 10 years)**: 73 TWh
  - approx. 45% of the country’s total consumed electricity
IHMS – Integrated Hydrological Monitoring System
Climatological ensemble:

Historical time series

The Ångerman River

The hydropower system of the river Ångermanälven
Climatologic ensemble: Limitations

- Climatologic ensemble → Seasonal forecast evolution follows the climatology of the driving data

- No notable improvement in performance over the last 25 years

Arheimer et al. 2010
Schematic of the Multi-model prototype

Climatological ensemble

Analogue ensemble

S2D ensemble

Snow data

Hydrological model

Weighted Multi-model

Statistical model

Hydrologic seasonal forecast
Reduced ensemble:

Historical time series


HBV

Forecast
Reduced ensemble: TCI method

- Teleconnection Climate Indices
  - NAO
  - AO
  - SCAND

- Select all years with comparable TCI combinations

- Run HBV with reduced ensemble

Analogue years → HBV → Spring flood volume forecast Maj-Jun-Jul
Seasonal NWP based forecast:

NWP

~100 km

HBV

Forecast
ECMWF forecasts in HBV: method

- ECMWF seasonal forecasts
  - 51 ensemble members
  - Daily P and T → Bias correction and remapping to HBV grid format
- Run HBV with ECMWF ensemble

ECMWF ensemble P och T  ➔  HBV  ➔  Spring flood volume forecast Maj-Jun-Jul
Statistical downscaling:

NWP

SVD

~100 km

Forecast
Statistical downscaling: method

- Atmospheric variables predictors from NWP (ECMWF)
  - Pressure field variables
  - Temperature/radiation variables
  - Moisture variables
- Observed Seasonal discharge volumes

In December
GCM forecast
Jan-Feb-Mar

\[ \text{SVD} \]

Forecast
spring flood volume
May-Jun-Jul
Multi-model Forecast example:
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Multi-Model Forecast validation stats:
Multi-Model Forecast validation stats:

![Graph showing RMSE as % of Obs and Relative Improvement](image)
Multi-model Forecast example:

[Spaghetti graph showing accumulated volume and inflow over time]
Multi-Model Forecast example:
Forecast example: Initialised 1 Jan
Conclusions

- Climatological spring flood forecasts are difficult to beat.
- For single basins and forecast dates, a reduction of the forecast error by up to 30%.
- The Multi-model shows more skill at forecasting anomalies and is able to reduce the forecasted volume error by 10% points on average.