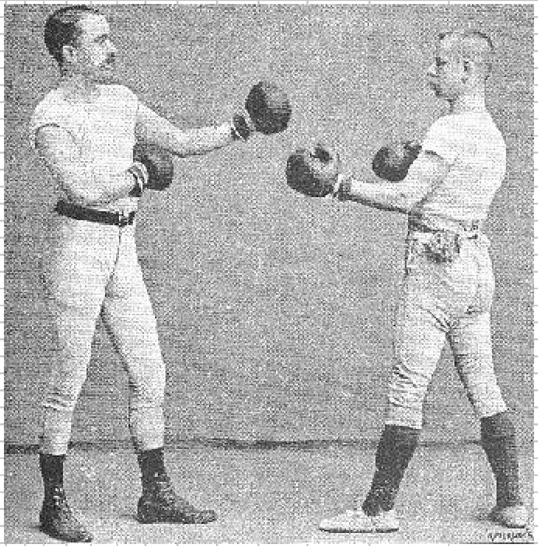

Analysis of the seasonal hydrological forecasting skill over Europe: Which are the control drivers?

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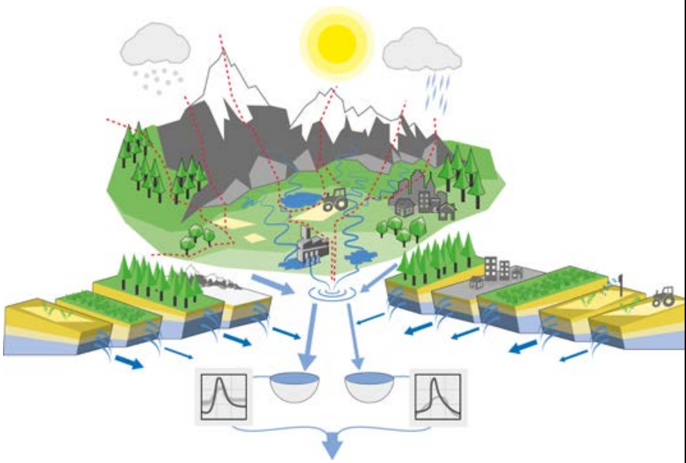
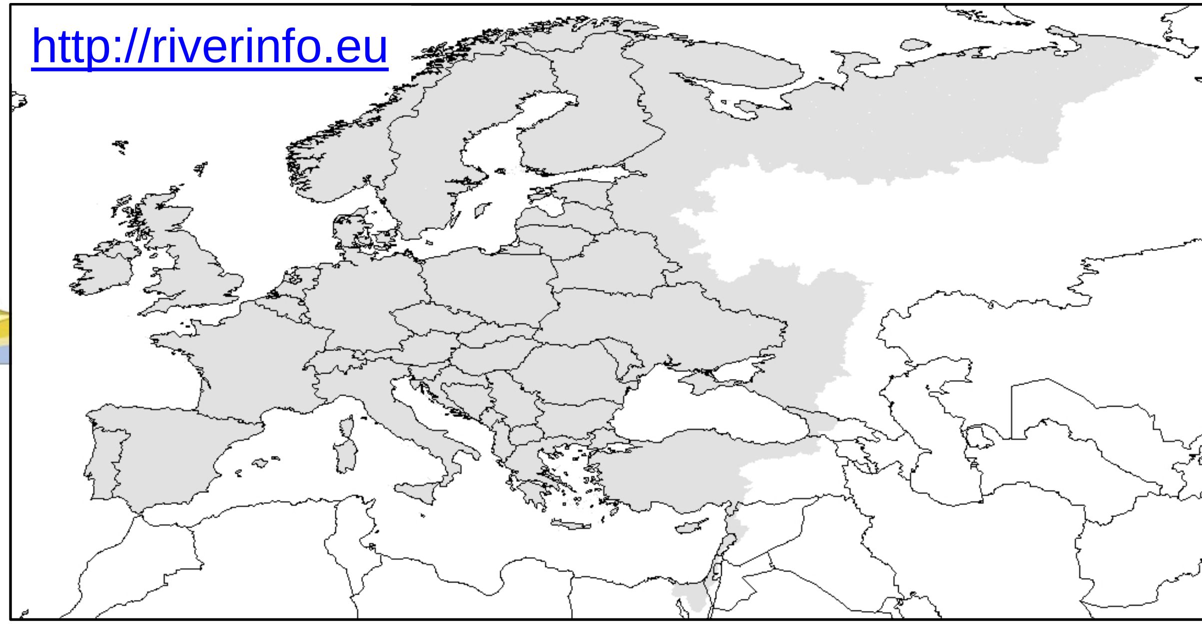
MetOffice, Exeter, 6th Oct. 2016

E-HYPE v3.0



Hundecha et al. (2016) A regional parameter estimation scheme for a pan-European multi-basin model. J. of Hydrol.: Reg. Studies

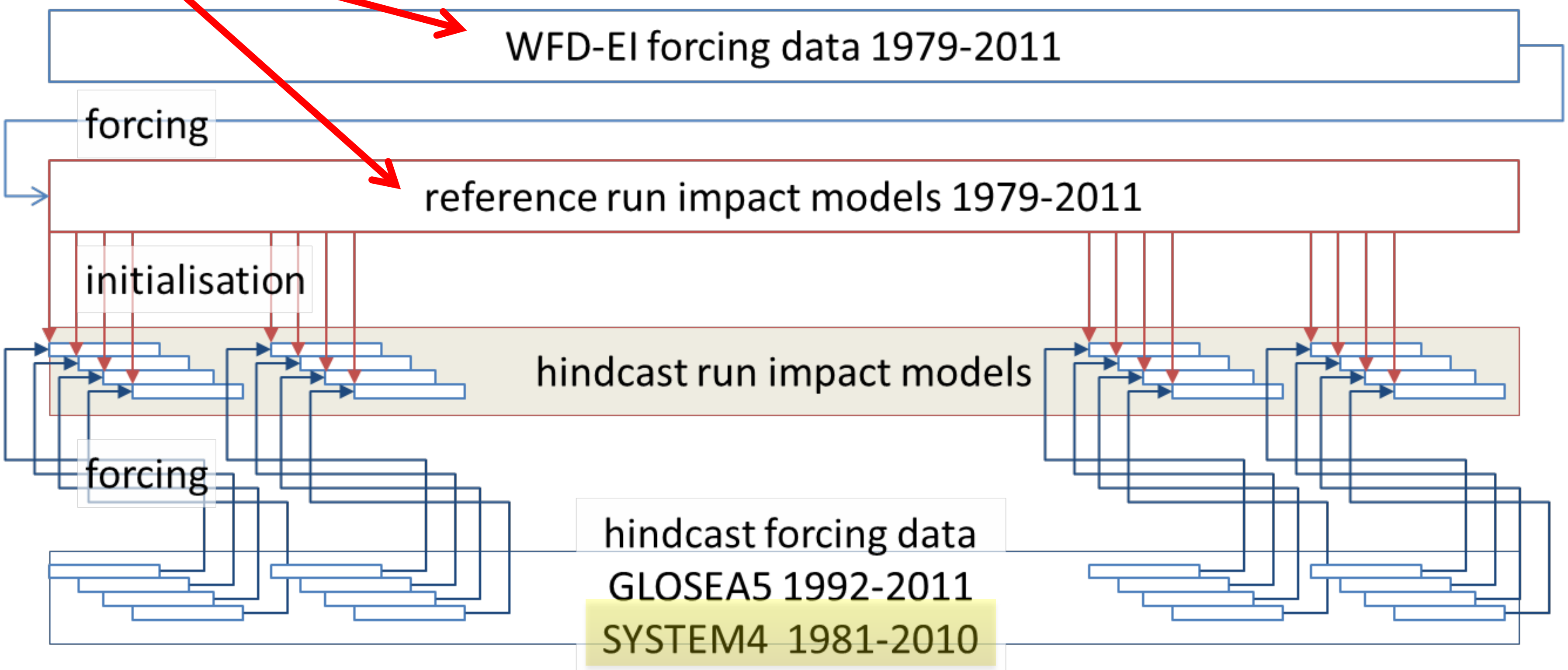


Characteristic/Data type	Info/Name	Provider
Total area (km²)	8.8 million	-
No. of sub-basins	35408 (mean size 215 km²)	-
Topography (routing and delineation)	hydroSHEDS (15 arcsec)	Lehner et al. (2008)
Soil characteristics	Harmonised World Soil Database (HWSD)	Nachtergaele et al. (2012)
Land use characteristics	CORINE	Bartholomé et al. (2002)
Reservoir and dam	Global Reservoir and Dam database (GRanD)	Bernhard et al. (2011)
Lake and wetland	Global Lake and Wetland Database (GLWD)	Lehner & Döll (2004)
Irrigation	Global Map of Irrigation Areas (GMIA)	Siebert et al. (2005)
Discharge	GRDC, EWA and others (around 2600 stations)	http://www.bafg.de/GRDC
Precipitation	WFDEI (0.5° x 0.5°)	Weedon et al. (2014)
Temperature (mean, min, max)	WFDEI (0.5° x 0.5°)	Weedon et al. (2014)
Snow cover area	GlobSnow	Luojus et al. (2013)

Forecasting protocol

EUPORIAS SMHI

WFDEI data were re-formated for E-HYPE
Link E-HYPE to SMHI's operational system for automating the model runs

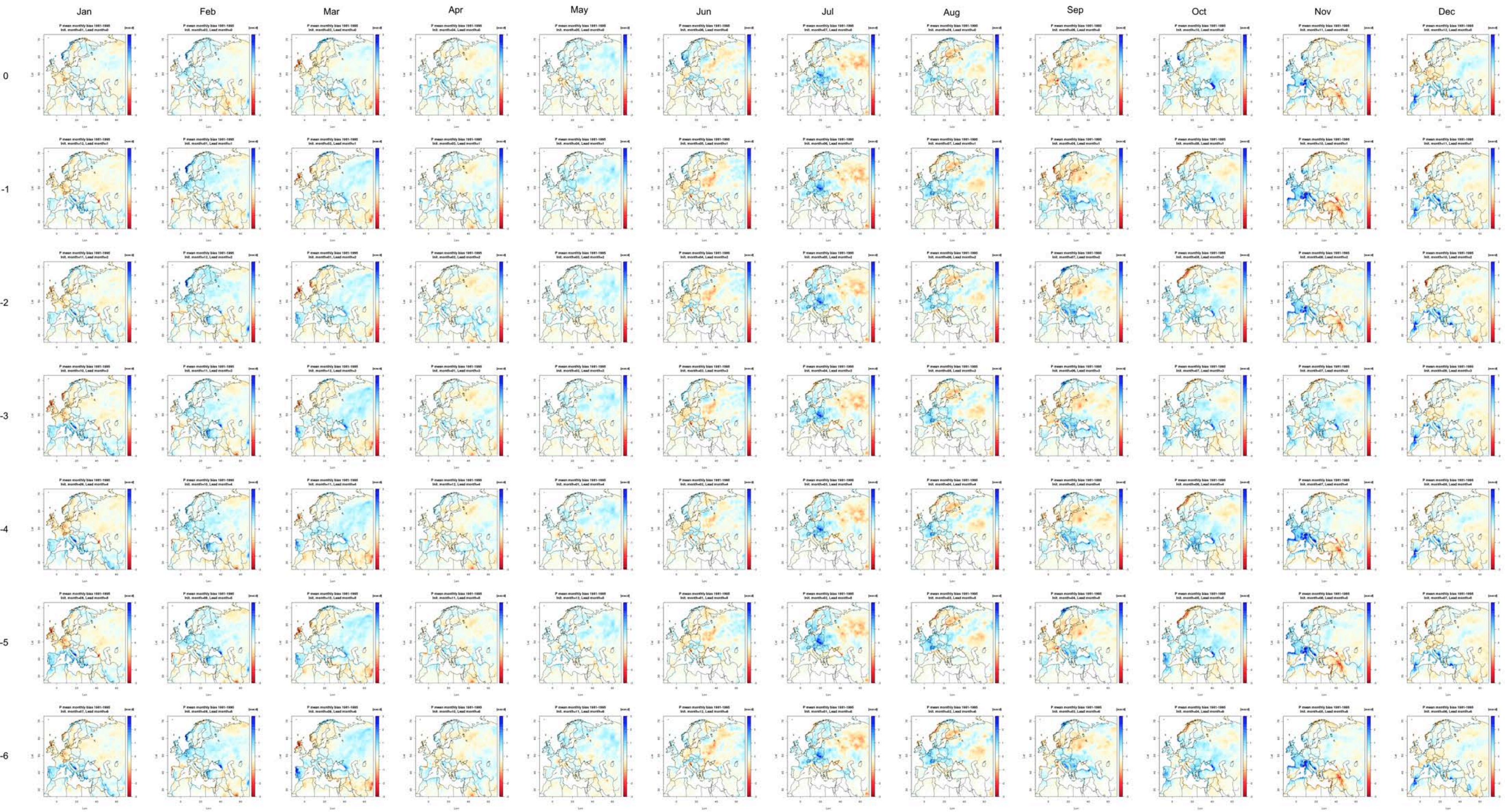


Projections from System4 (15 members initialised every month) were downloaded, bias corrected using the DBM method, and re-formated for E-HYPE

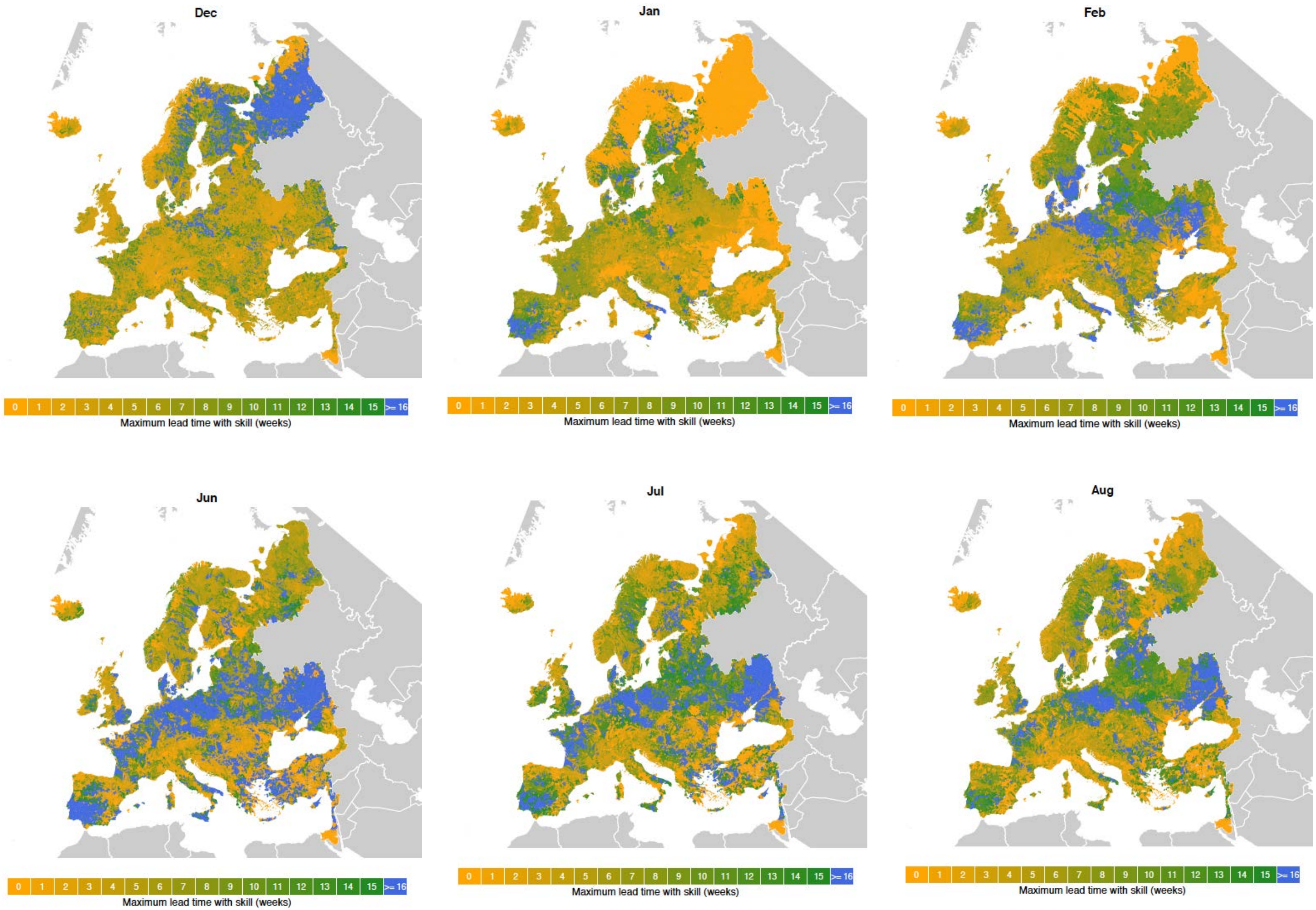
Bias correction

SMHI

Remaining bias in precipitation
validation period (all months and lead months)



CRPS – maximum lead time



Methodology

SMHI

- Evaluation at about 35 400 basins for lead time 0 – 2 – 4 months ahead and all 15 ensemble members:
    - Monthly evaluation (in terms of volume)

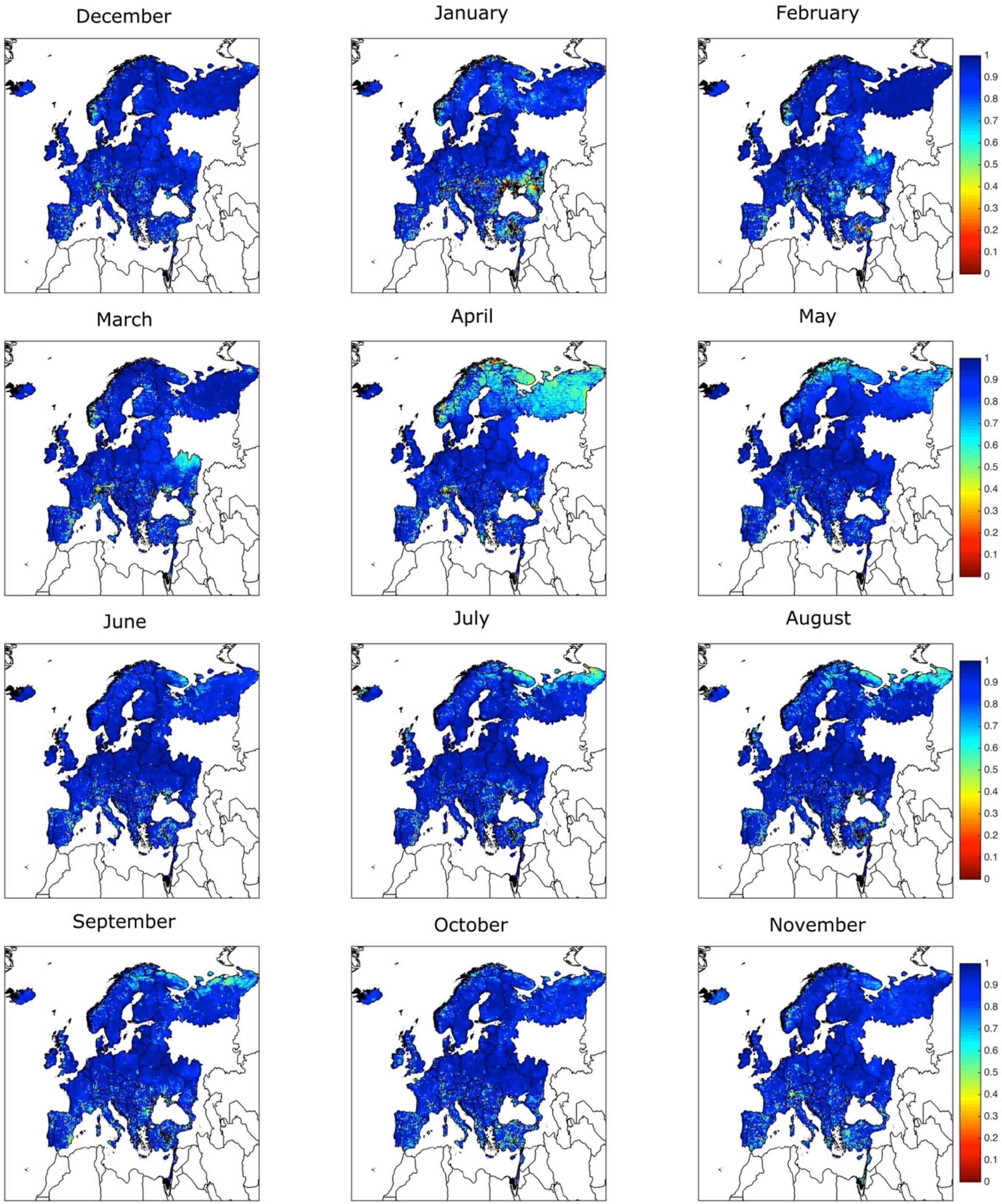
Performance metric of forecasting system

$$beta = 1 - \sqrt{(1 - \frac{\overline{X_F}}{\overline{X_{PO}}})^2}$$

1 indicates perfect representation of monthly volumes

SMHI

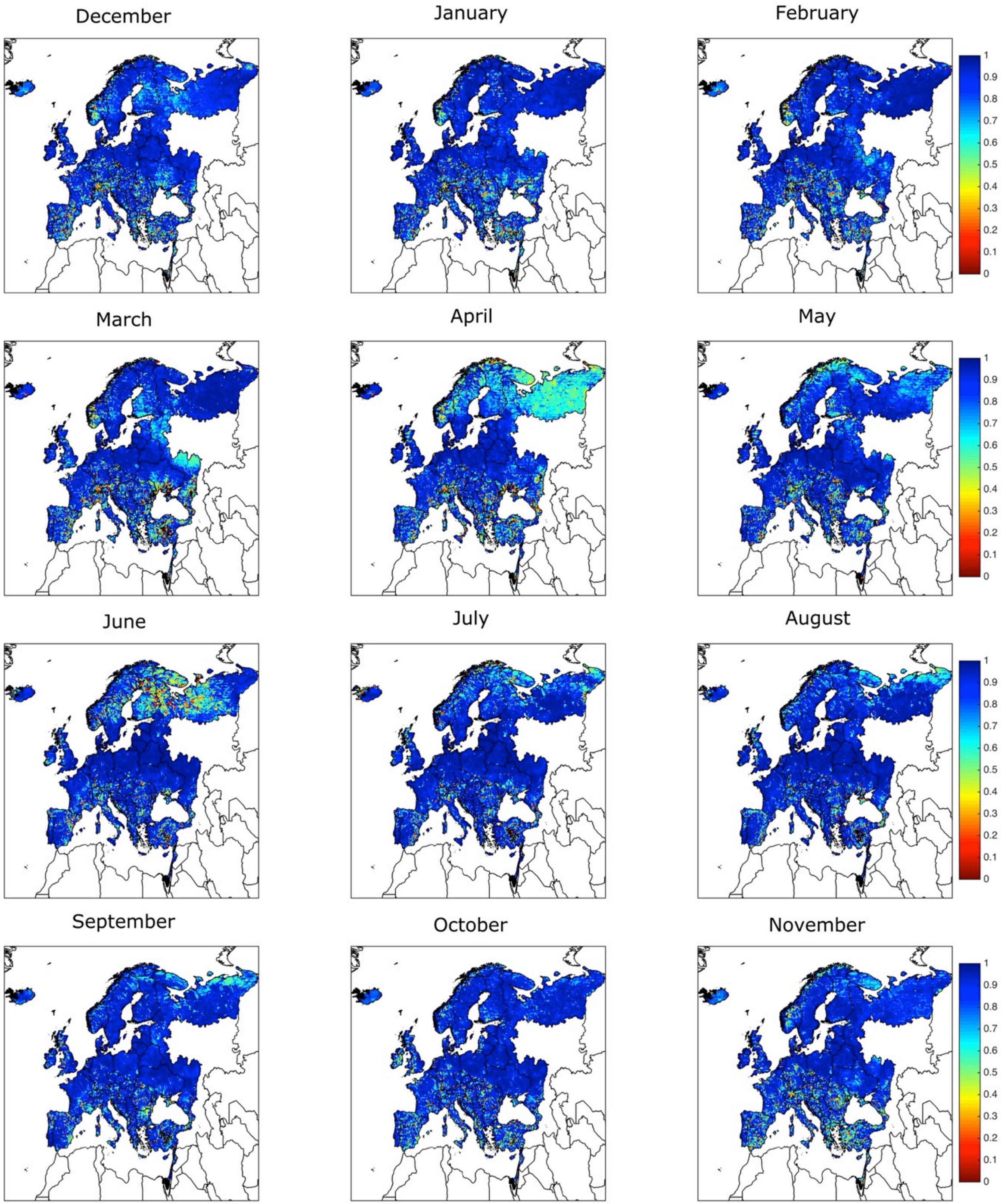
Hydrological forecasting skill



Volumetric Error (beta) metric

1 indicates perfect representation of monthly volumes

Lead month: 0

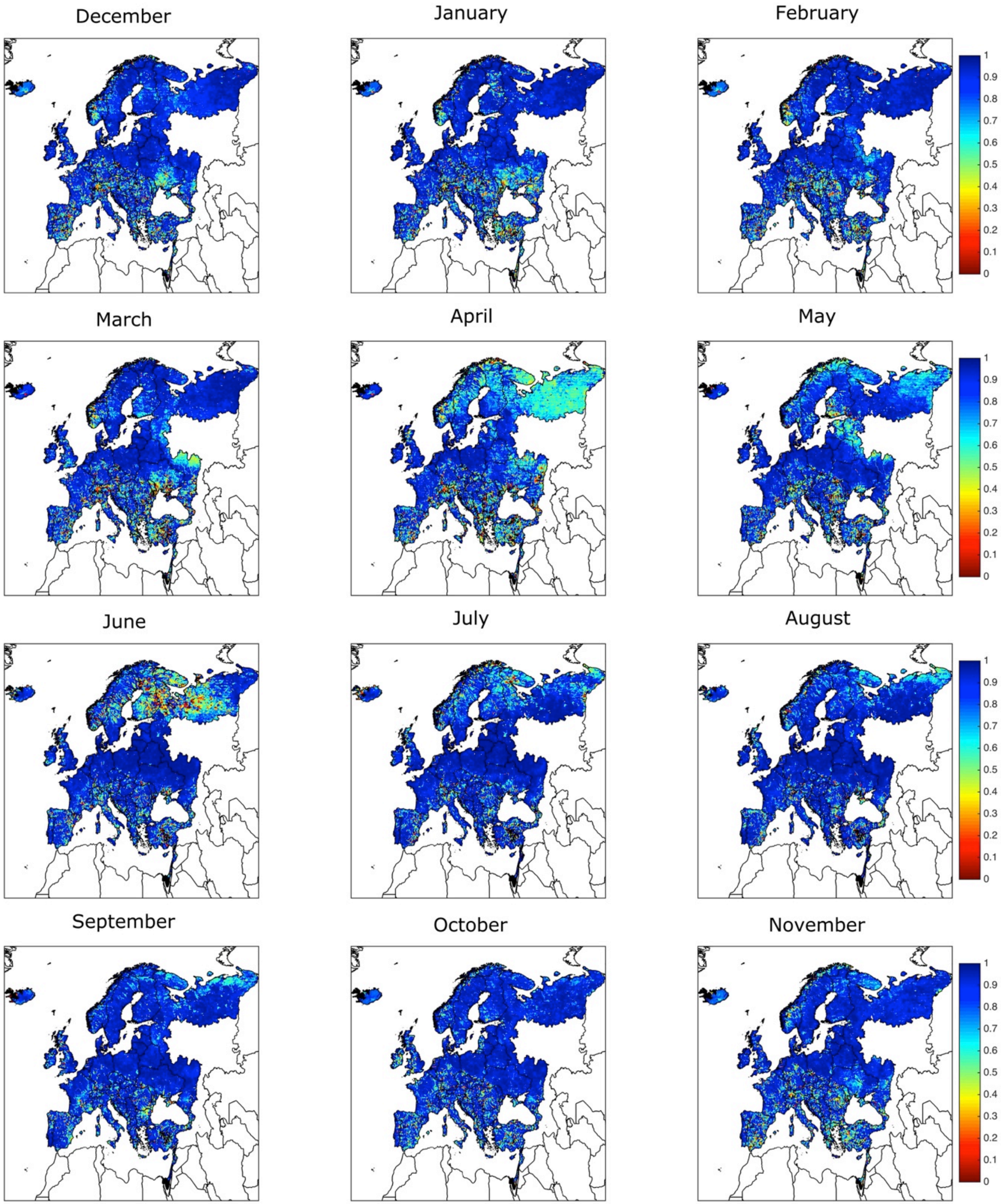


Hydrological forecasting skill

Volumetric Error (beta) metric

1 indicates perfect representation of monthly volumes

Lead month: 2



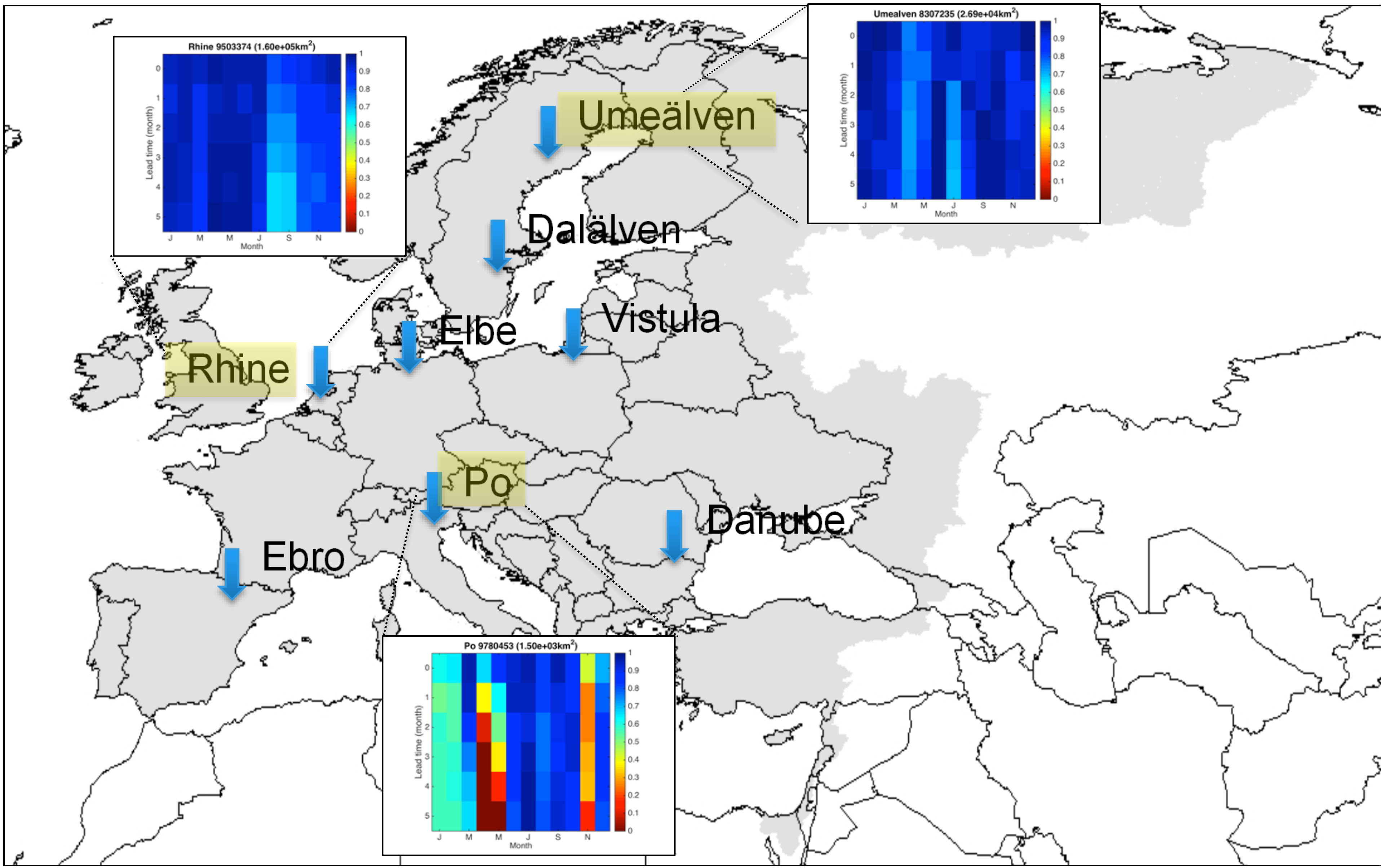
Hydrological forecasting skill

Volumetric Error (beta) metric

1 indicates perfect representation of monthly volumes

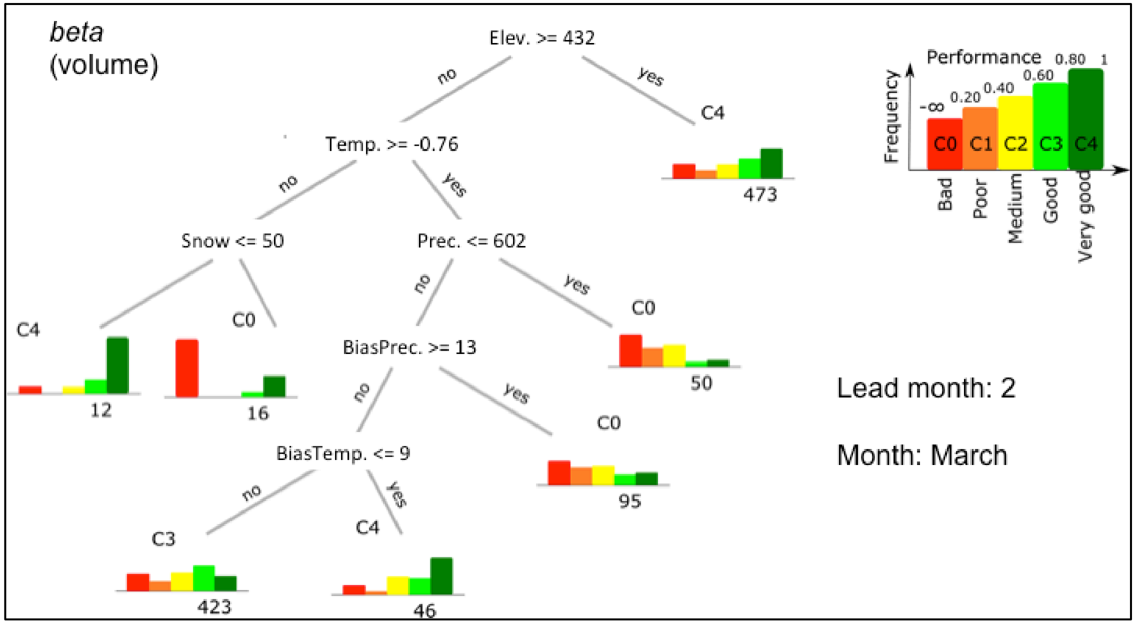
Lead month: 4

Seasonal hydrological forecasting skill



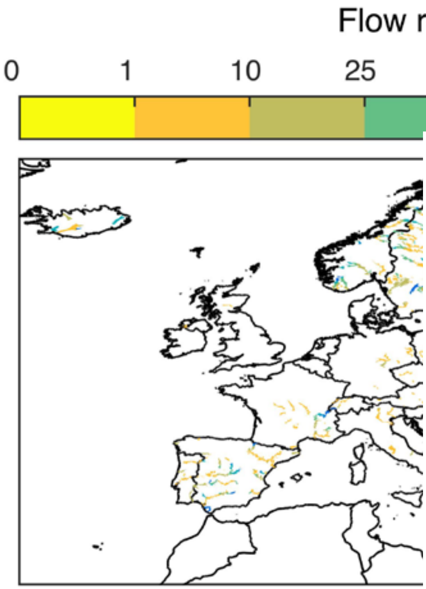
Link skill with physiographic-climatologic characteristics

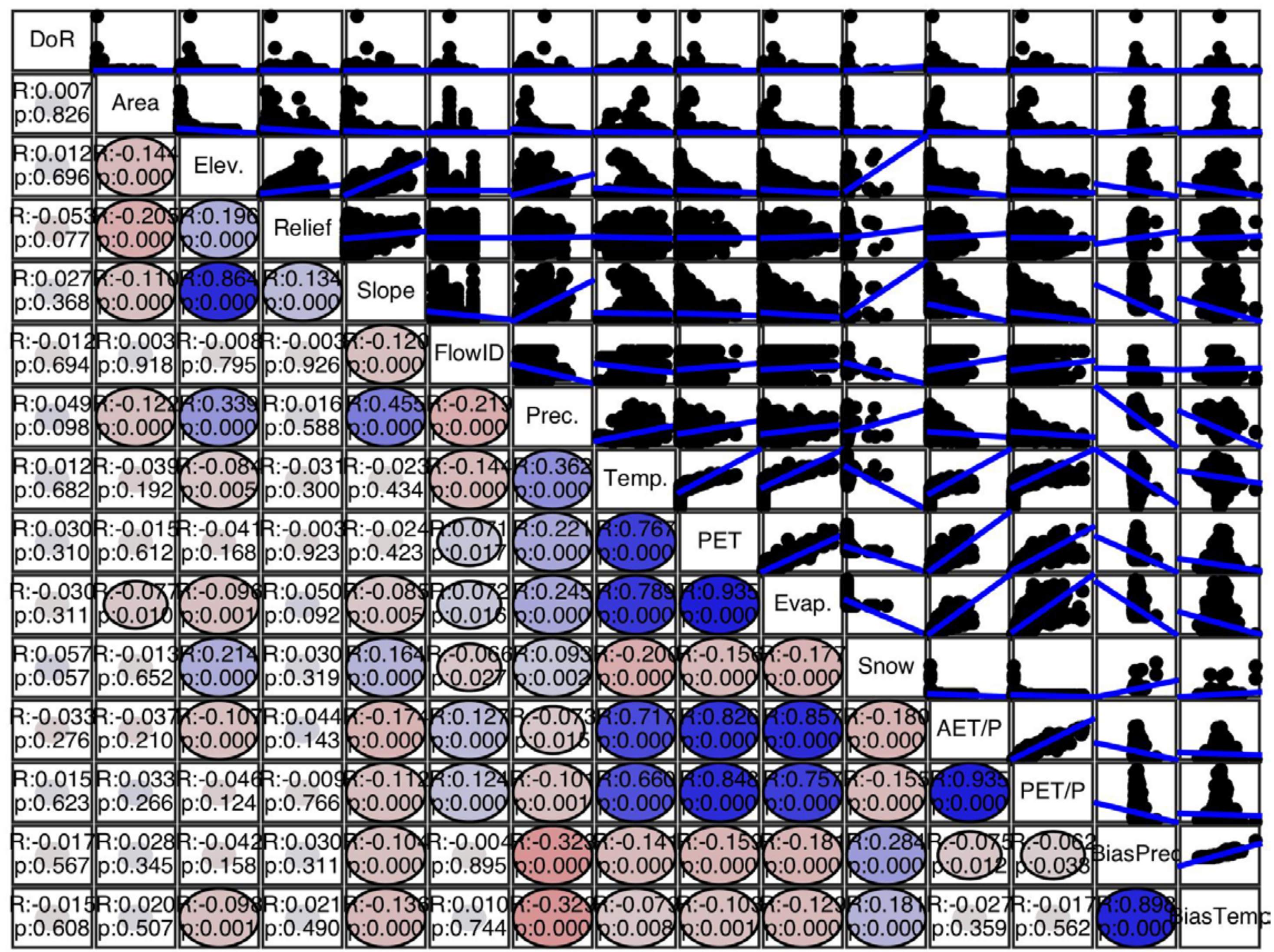
- Classification And Regression Trees (CART)
  - Ranking the physiographic-climatologic characteristics in terms of importance
- Characteristics (14 + *12*)
  - Climate: Prec., Temp., Snow, AET, PET, AET/P, PET/P
  - Topography: Area, Elev., Relief, Slope
  - Human impact: Degree of regulation (DoR)
  - Bias clim. forecasts: Prec., Temp
  - Hydrology: 12 flow signatures

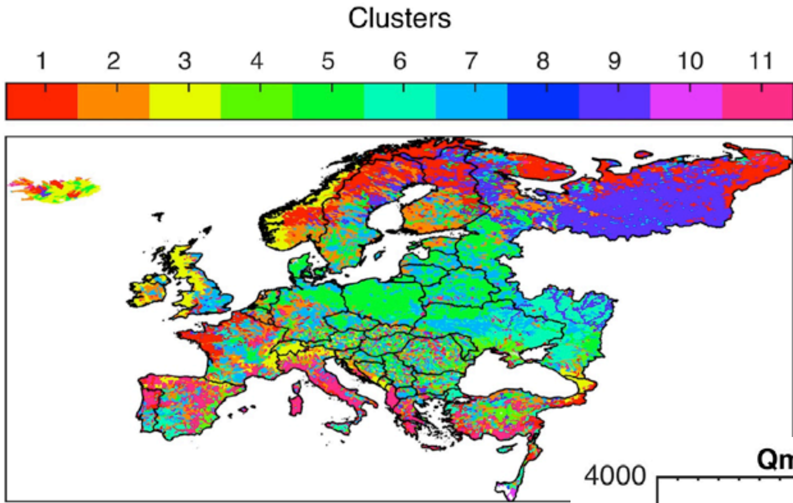


Descriptors

Descriptors correlation matrix



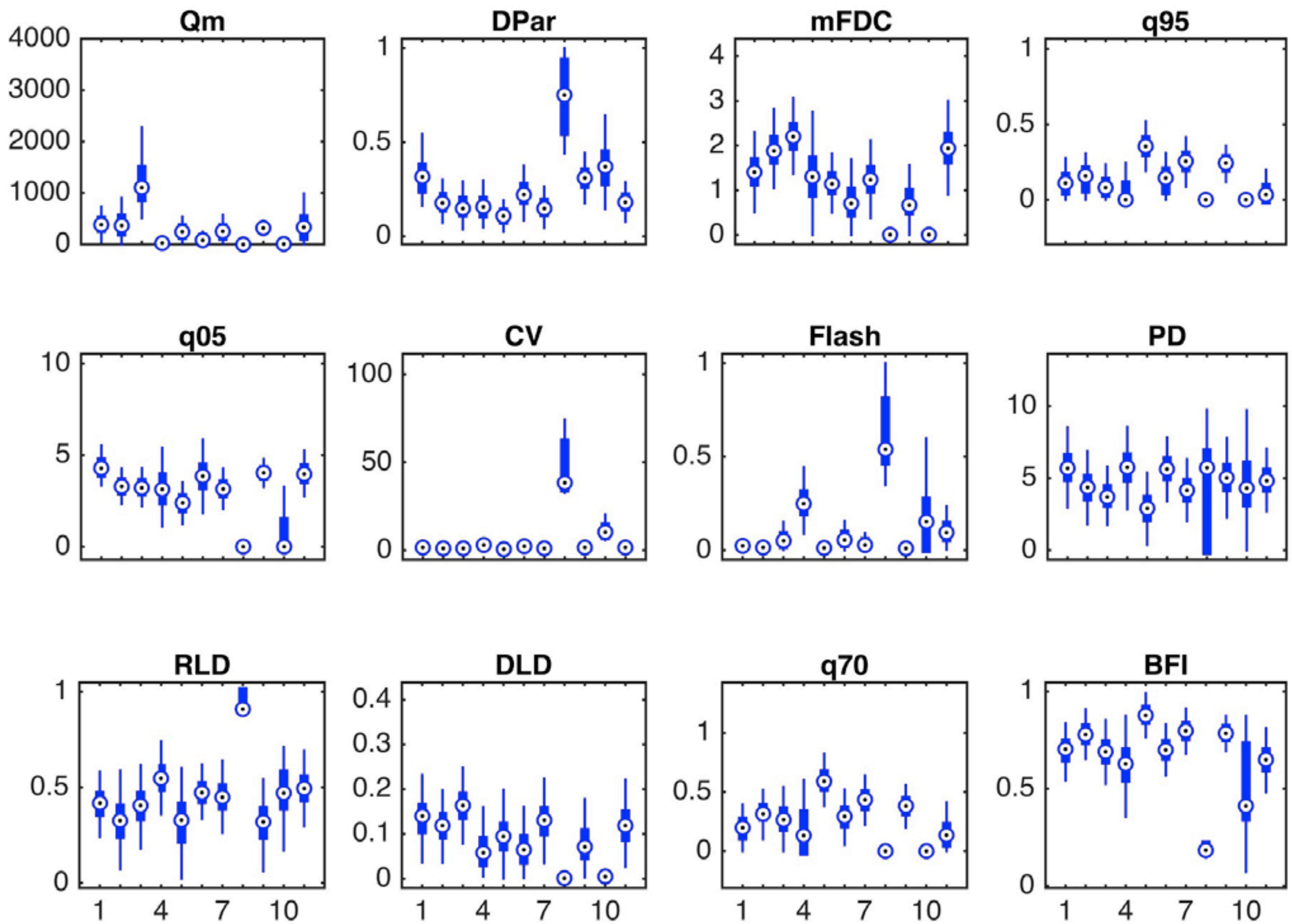




Flow Info

SMHI

Quantify *12 flow signatures bas*ed on modelled daily runoff (mm d^{-1}). We then apply a *k-means clustering* within the 12D space to categorise the subbasins based on their combined similarity in flow signatures.

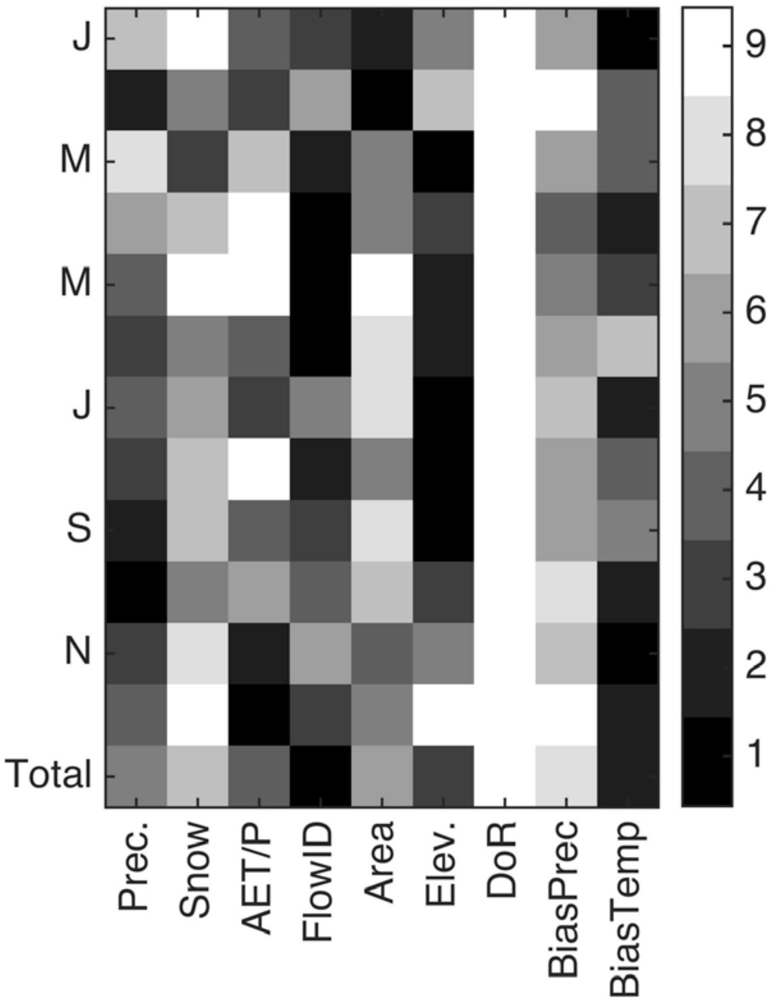


Signature	Abbreviation
Mean annual specific runoff	Qm
Normalised high flow	*q*05
Normalised low flow	*q*95
Normalised relatively low flow	*q*70
Slope of flow duration curve	mFDC
Range of Pardé coefficient	DPar
Coefficient of variation	CV
Flashiness	Flash
Normalised peak distribution	PD
Rising limb density	RLD
Declining limb density	DLD
Long-term mean discharge	Qdm

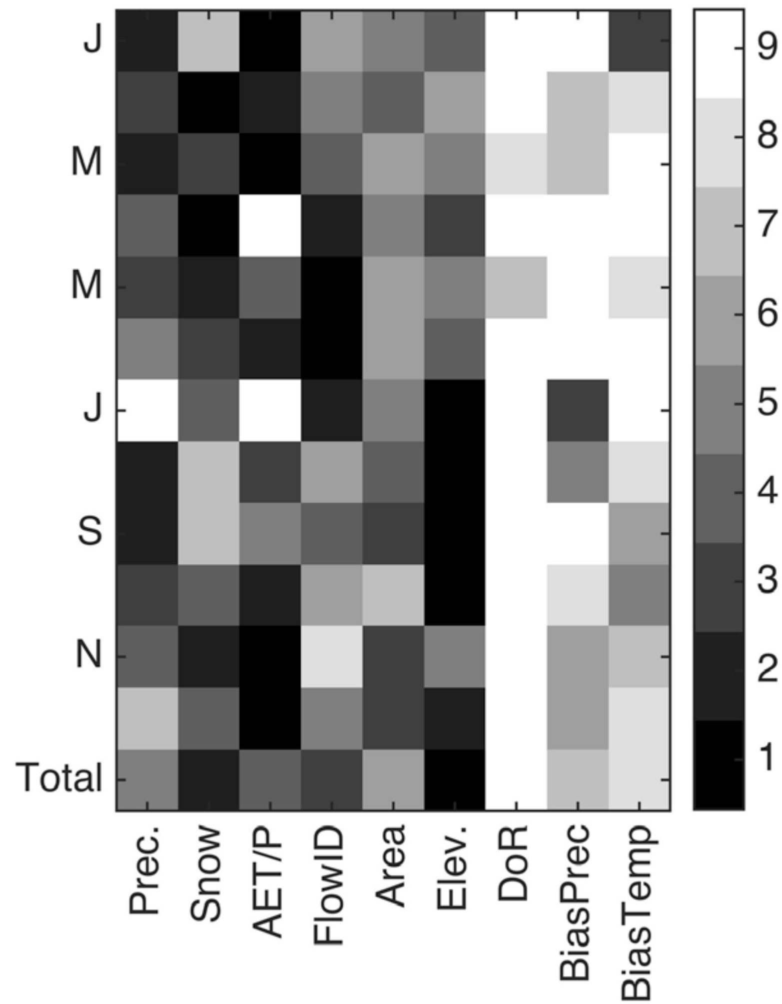
CART analysis

Ranking the descriptors based on their importance (with 1 being the most important)

Lead month: 0



Lead month: 2



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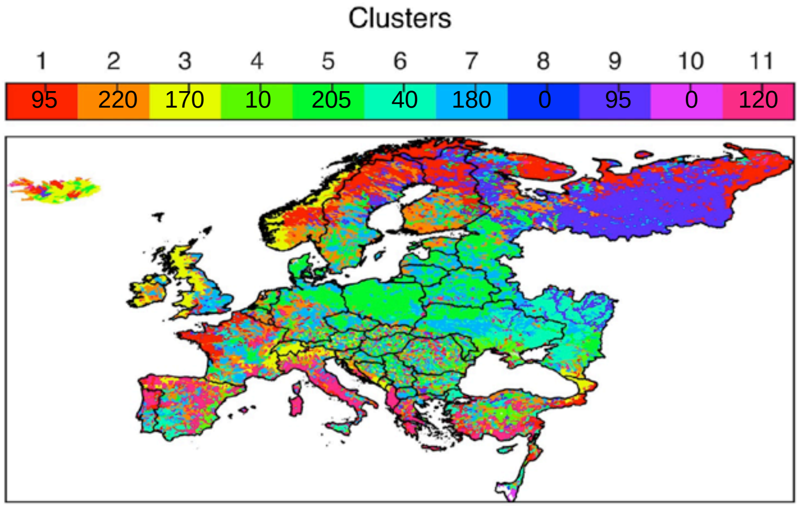
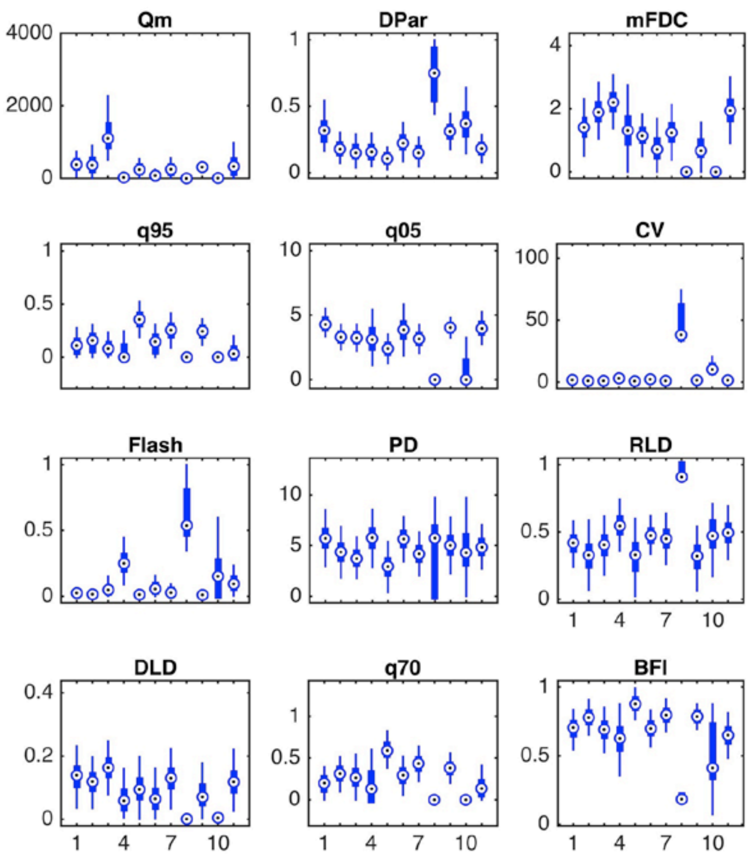
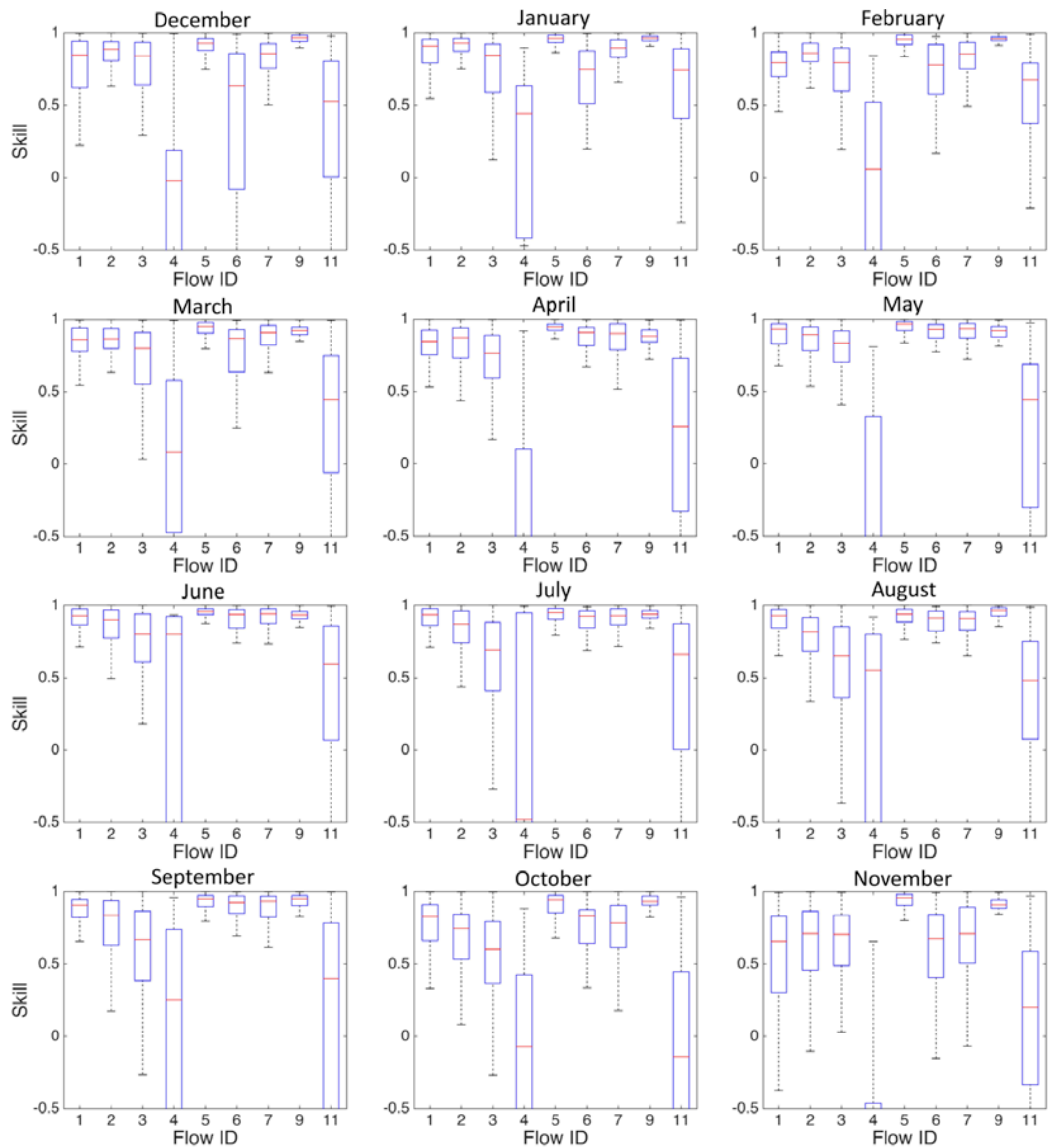
Closer look on the flow regimes







Conclusions

The evaluation spots the strengths and weaknesses of ensemble seasonal forecasts from ECMWF System 4 (15 members), including trends of performance in various months and lead times.

We identified links between forecasting skill and different physiographic and hydro-climatic characteristics.

- Forecasting skill in central/northern Europe (depending on month); however skill deteriorates as a function of lead time (i.e. Mediterranean).

- CART shows that skill is dependent on the basin's hydrologic regime. Elevation and remaining bias in temperature were also identified (dependence of response at mountainous basins to temperature).

- Skill seems to be limited at relatively flashy basins experiencing strong flow dynamics over the year (less memory in the system).

What's next?

- Can we improve the SHF skill by improving model initialisation using EOs?
    - Initial soil moisture
    - Snow
    - Initial level of surface water (e.g. lakes, reservoirs)

- How sensitive the SHF skill is when different SCF systems are considered?
    - System 4
    - GloSea5
    - ??

- Single model *vs* multi-modelling

This study is based on the hard work of all the researchers in hydrology at SMHI

Thank you for your attention!!

Please share your insights with us!!

Acknowledgements

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