SMHI

Skill sensitivity in Europe and site-specific diagnostics based on catchment characteristics

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The questions

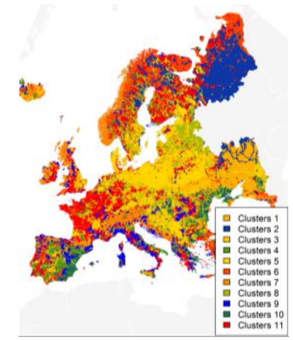
Skill

January – LT2
against simulation

What causes
this skill pattern?

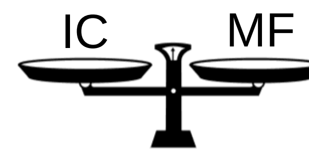
Skill vs Catchment characteristics

Which catchment characteristics can explain
this pattern ?



Skill sensitivity

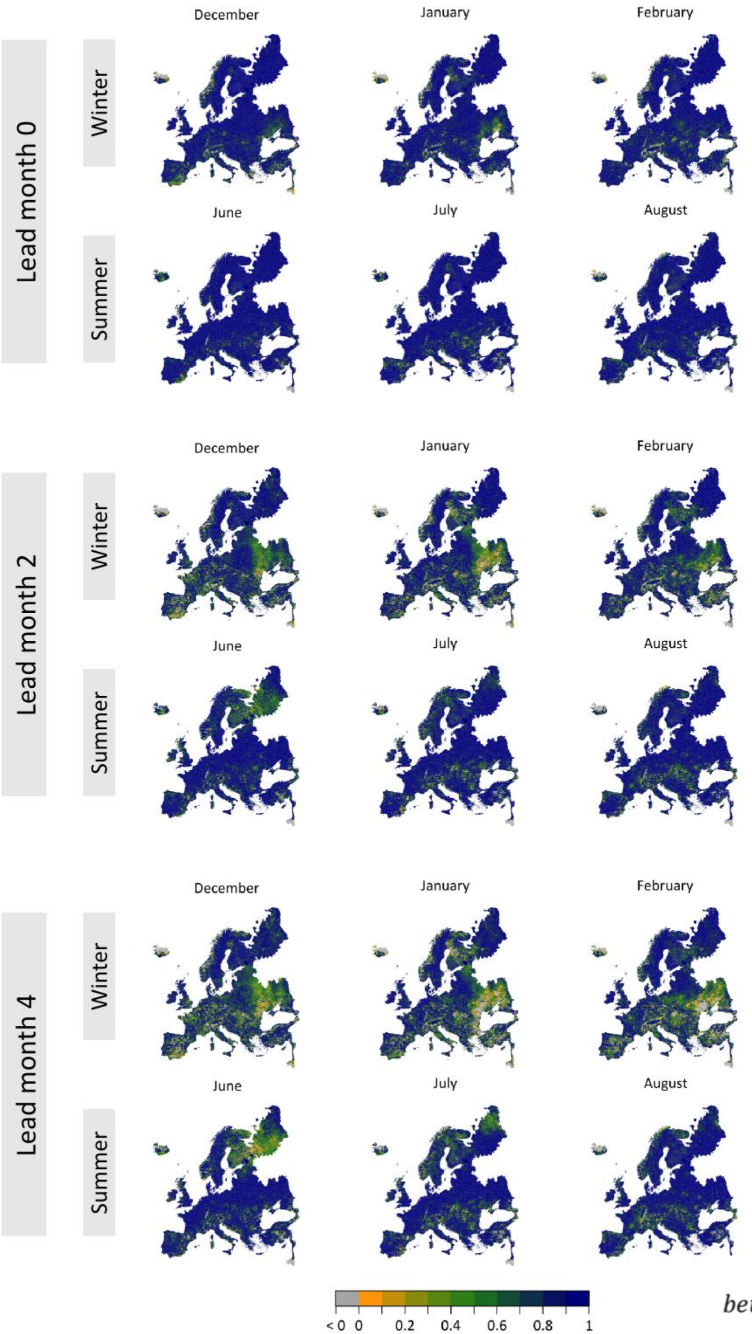
Where does the predictability comes from?
or
How to improve these forecasts?



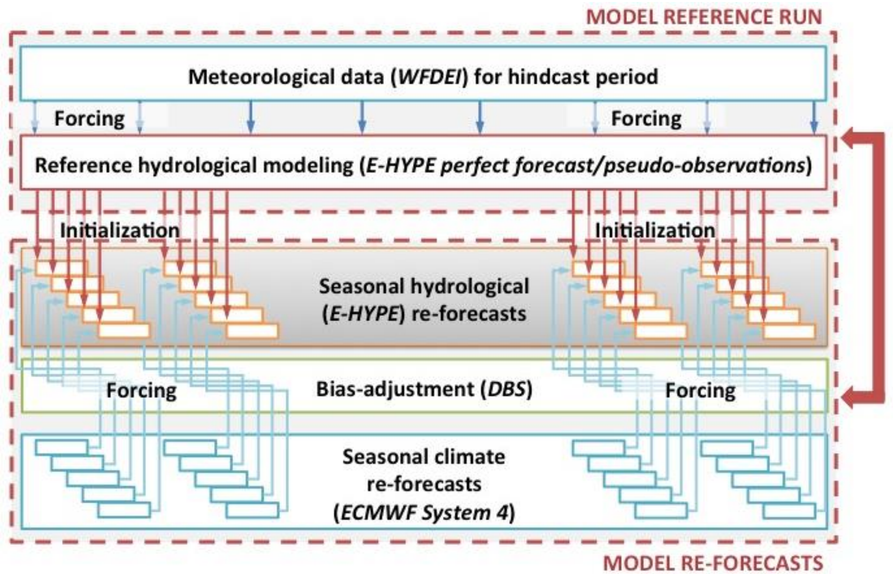
Skill graph from http://swicca.eu

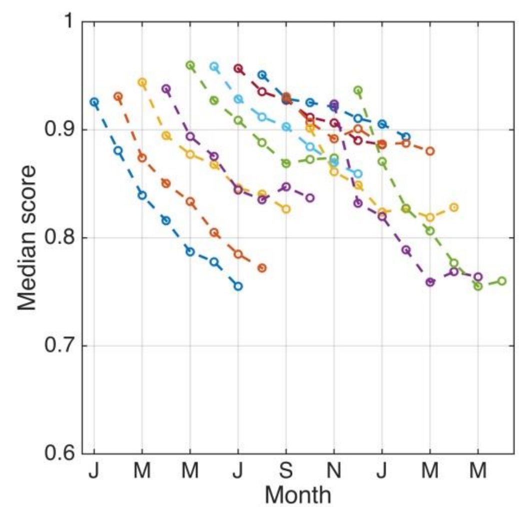
1. Which catchment characteristics can explain this pattern ?

Seasonal hydrological forecasting skill



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

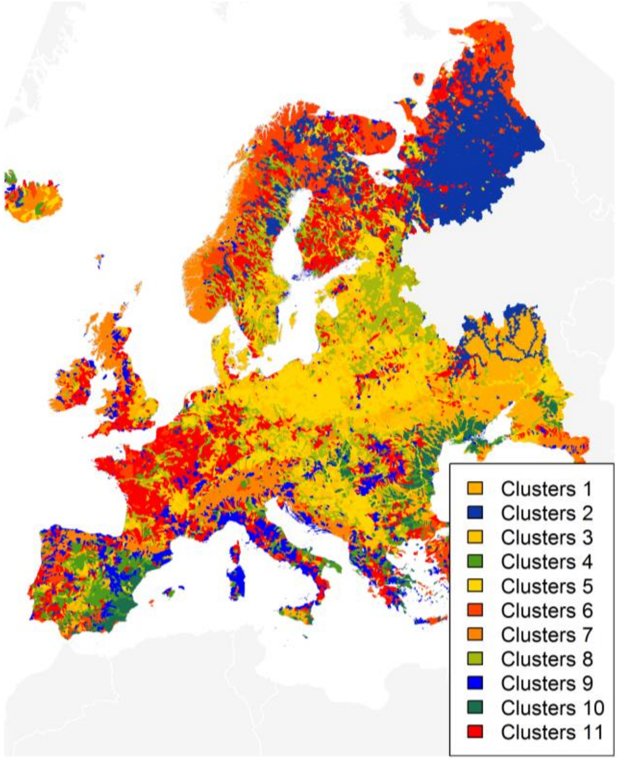


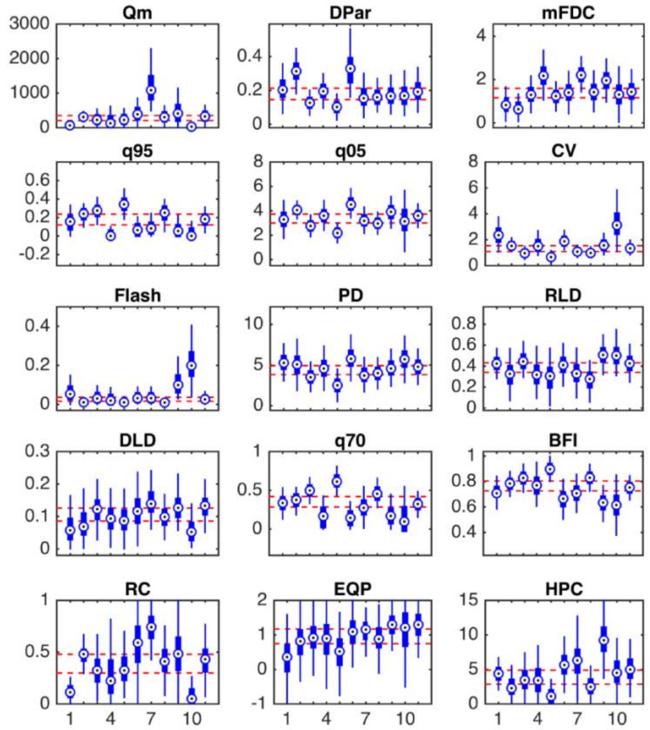


Clustering of European catchments

15 flow signatures → 11 clusters → Cluster characteristics

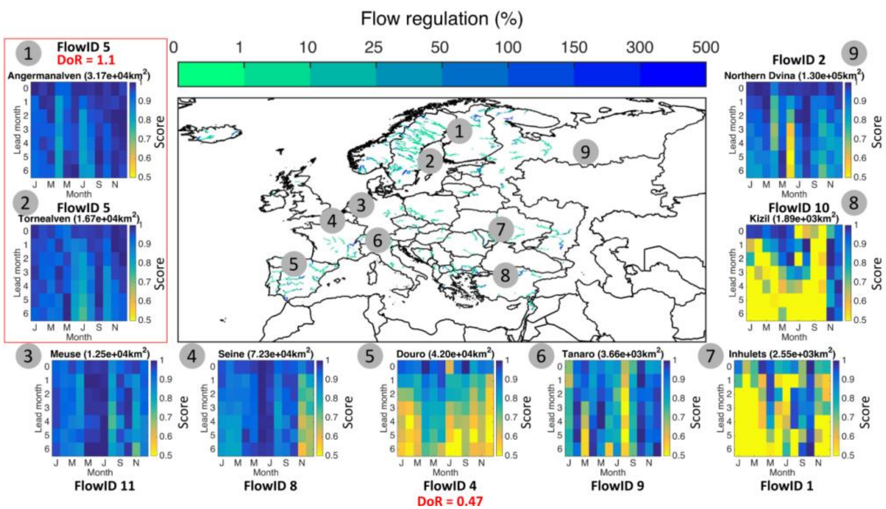
- Mean annual specific runoff (Qm)
- Normalised high flow (q05)
- Normalised low flow (q95)
- Normalised relatively low flow (q70)
- Slope of flow duration curve (mFDC)
- Range of Parde coefficient (DPar)
- Coefficient of variation (CV)
- Flashiness (Flash)
- Normalised peak distribution (PD)
- Rising limb density (RLD)
- Declining limb density (DLD)
- Baseflow index (BFI)
- Runoff coefficient (RC)
- Streamflow elasticity (EQP)
- High pulse count (HPC)





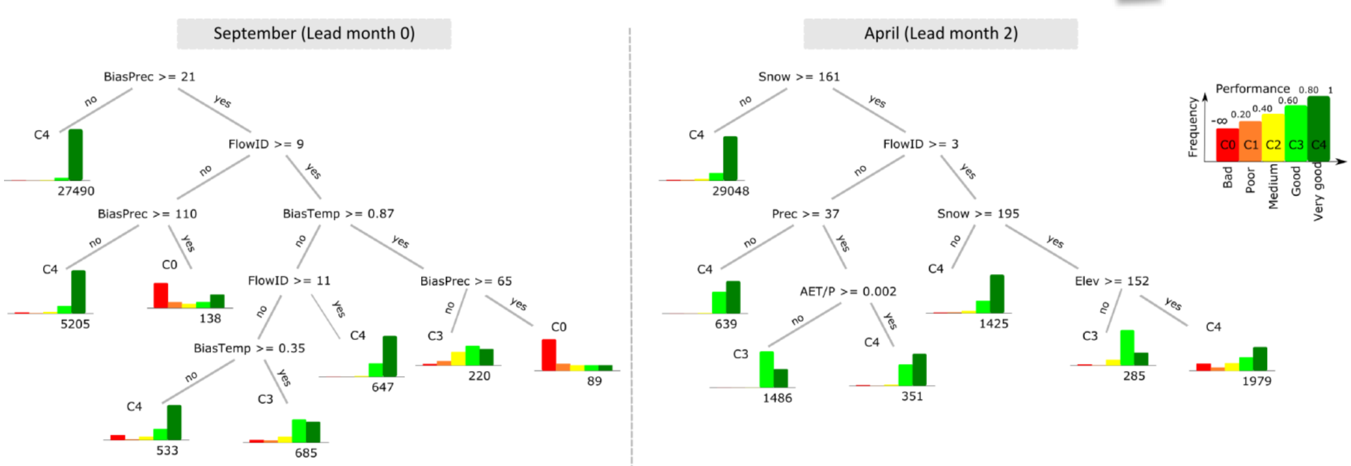
Pechlivanidis et al., 2018 (to be submitted)

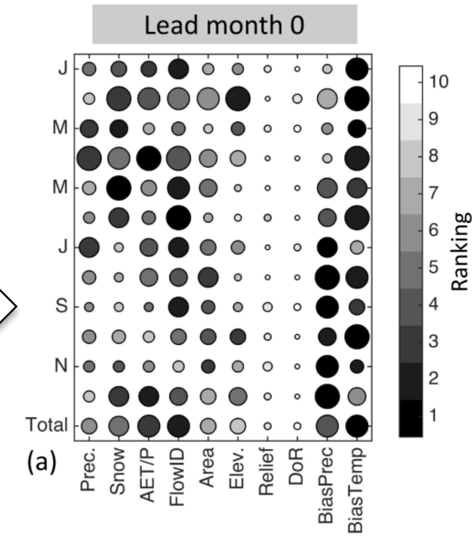
Process understanding



Climatology / Forcing biases (9)	Topography (4)	Human impact (1)
Precipitation (mm/month)	Area (km^2)	Degree of regulation (%)
Temperature (ºC)	Elevation (m)	
Snow depth (cm/month)	Relief ratio (-)	
Actual evaporation (mm/month)	Slope (%)	
Potential evaporation (mm/month)		
Dryness index (-)		
Evaporative index (-)		
Bias in precipitation (%)		
Bias in temperature (%)		

+ Flow characteristic regions





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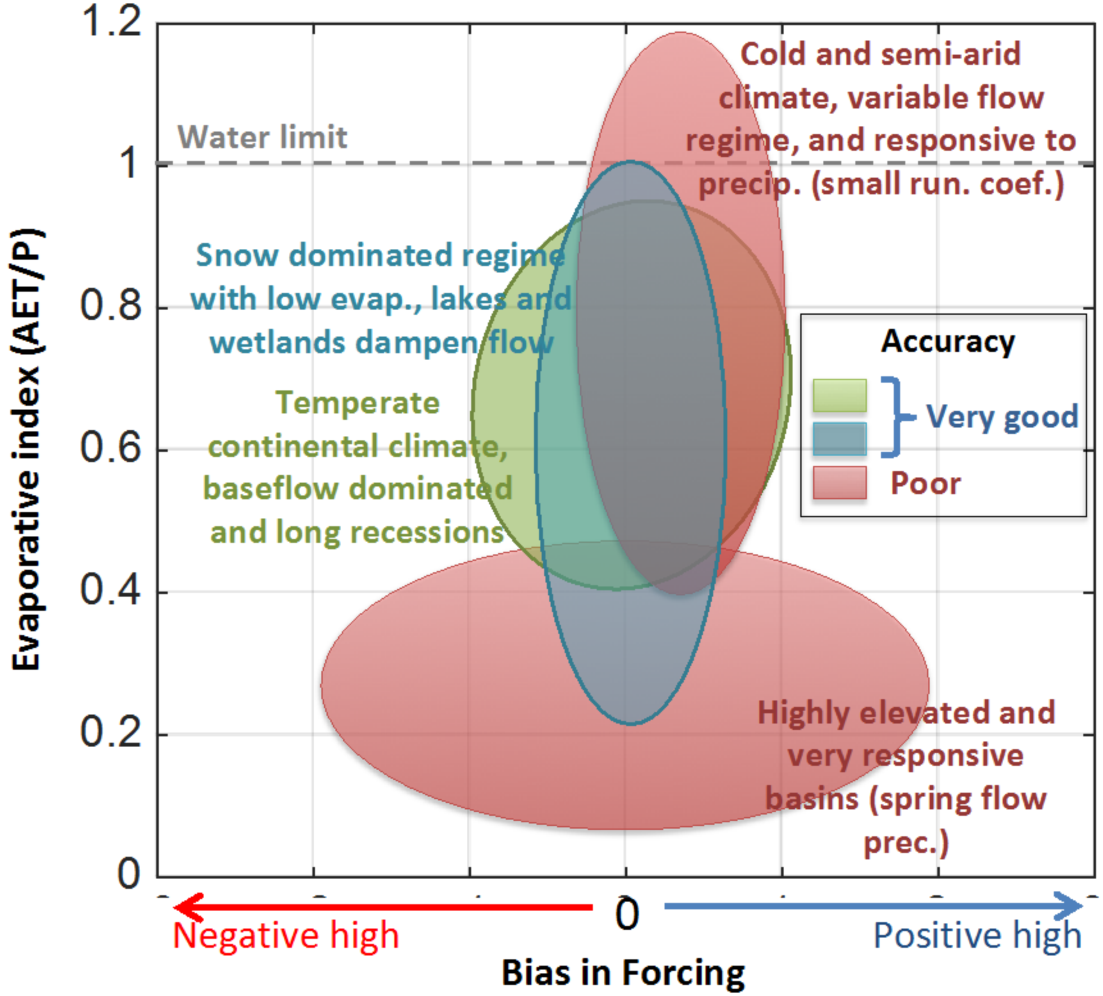

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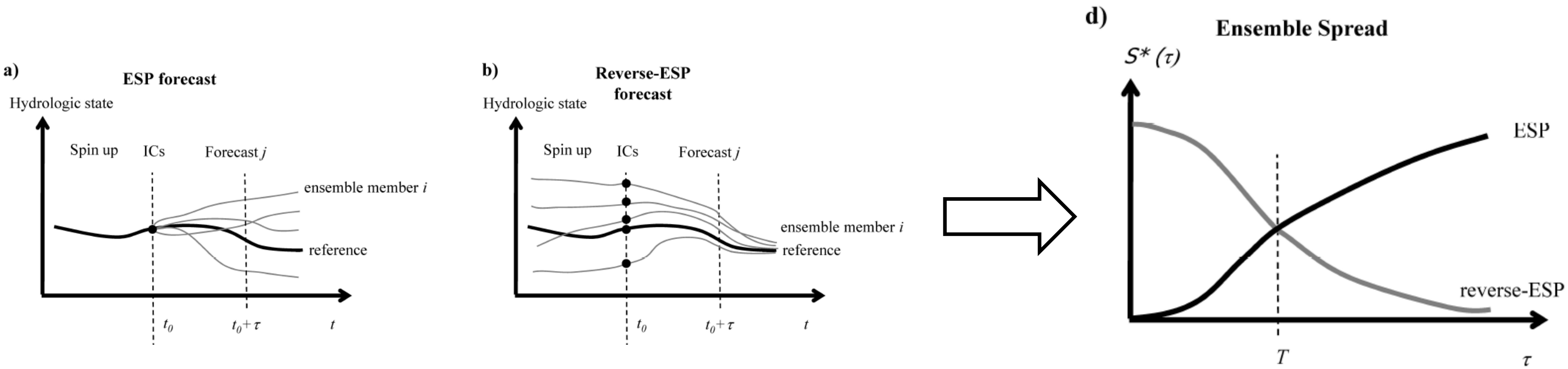
Exploring further the sensitivities

- Use of the Ensemble Streamflow Prediction (**ESP**) and reverse ESP (**revESP**) procedures to explore the impact of the two sources of uncertainty: IHCs and CFs (Wood and Lettenmaier, 2008).

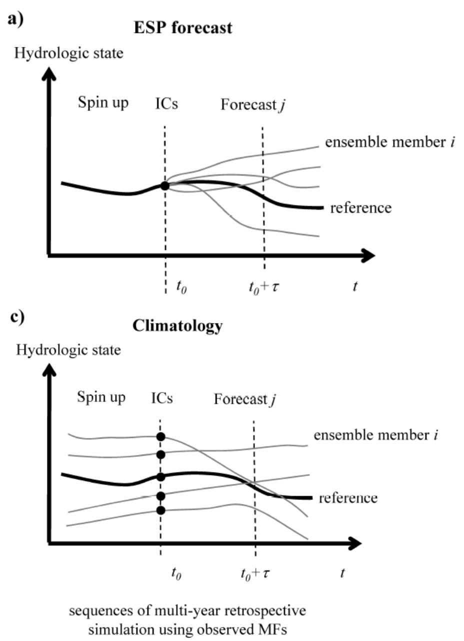


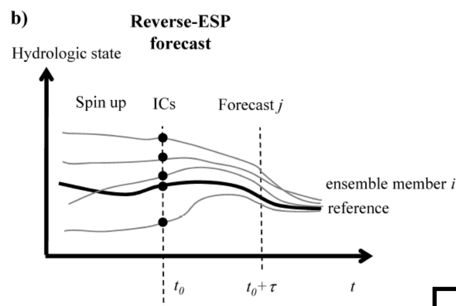
Figures modified from Paiva et al. (2012)

Wood, A.W., Lettenmaier, D.P., 2008. An ensemble approach for attribution of hydrologic prediction uncertainty. Geophysical Research Letters 35, L14401. https://doi.org/10.1029/2008GL034648
Paiva, R.C.D., Collischonn, W., Bonnet, M.P., de Gonçalves, L.G.G., 2012. On the sources of hydrological prediction uncertainty in the Amazon. Hydrology and Earth System Sciences 16, 3127–3137. https://doi.org/10.5194/hess-16-3127-2012

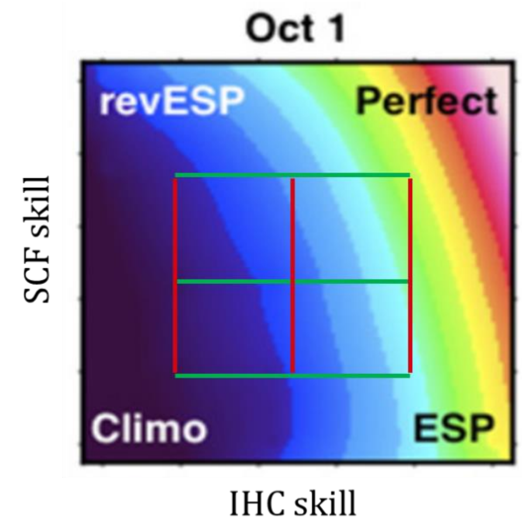
Exploring further the sensitivities

- Use of the End Point Blending method of the VESPA analysis (Arnal et al., 2017; Wood et al., 2016) to quantify the change in the skill of model output to variations in the model input and model initialization.





+ Perfect Forecast



Figures modified from Wood et al. (2016) and Paiva et al. (2012)

Arnal, L., Wood, A.W., Stephens, E., Cloke, H.L., Pappenberger, F., 2017. An Efficient Approach for Estimating Streamflow Forecast Skill Elasticity. J. Hydrometeor. 18, 1715–1729. https://doi.org/10.1175/JHM-D-16-0259.1
Wood, A.W., Hopson, T., Newman, A., Brekke, L., Arnold, J., Clark, M., 2016. Quantifying Streamflow Forecast Skill Elasticity to Initial Condition and Climate Prediction Skill. Journal of Hydrometeorology 17, 651–668. https://doi.org/10.1175/JHM-D-14-0213.1

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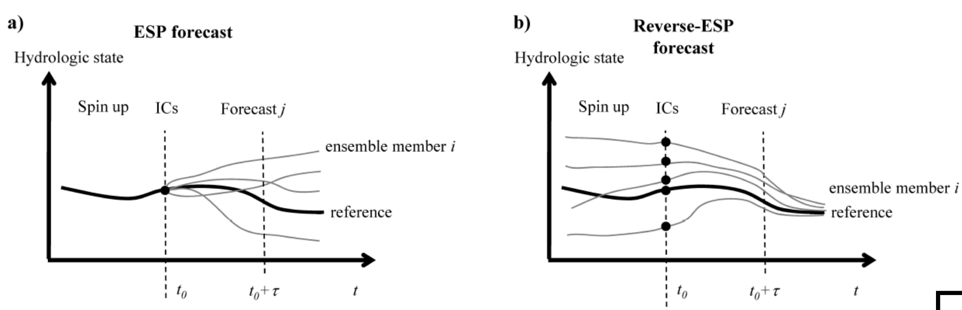

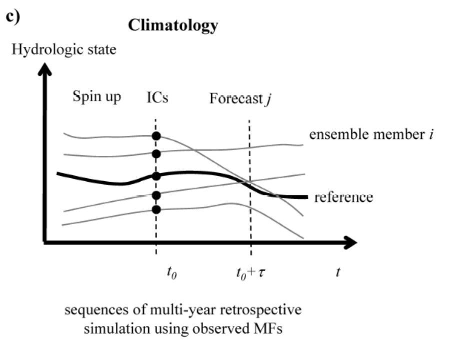

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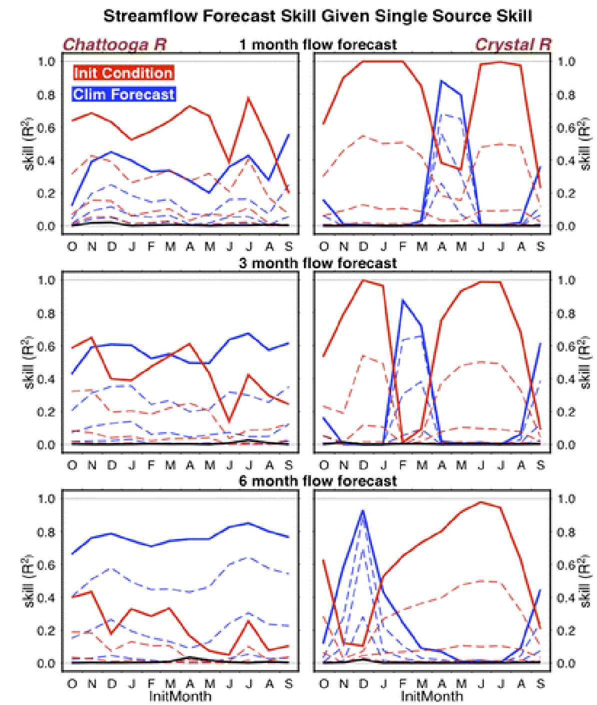

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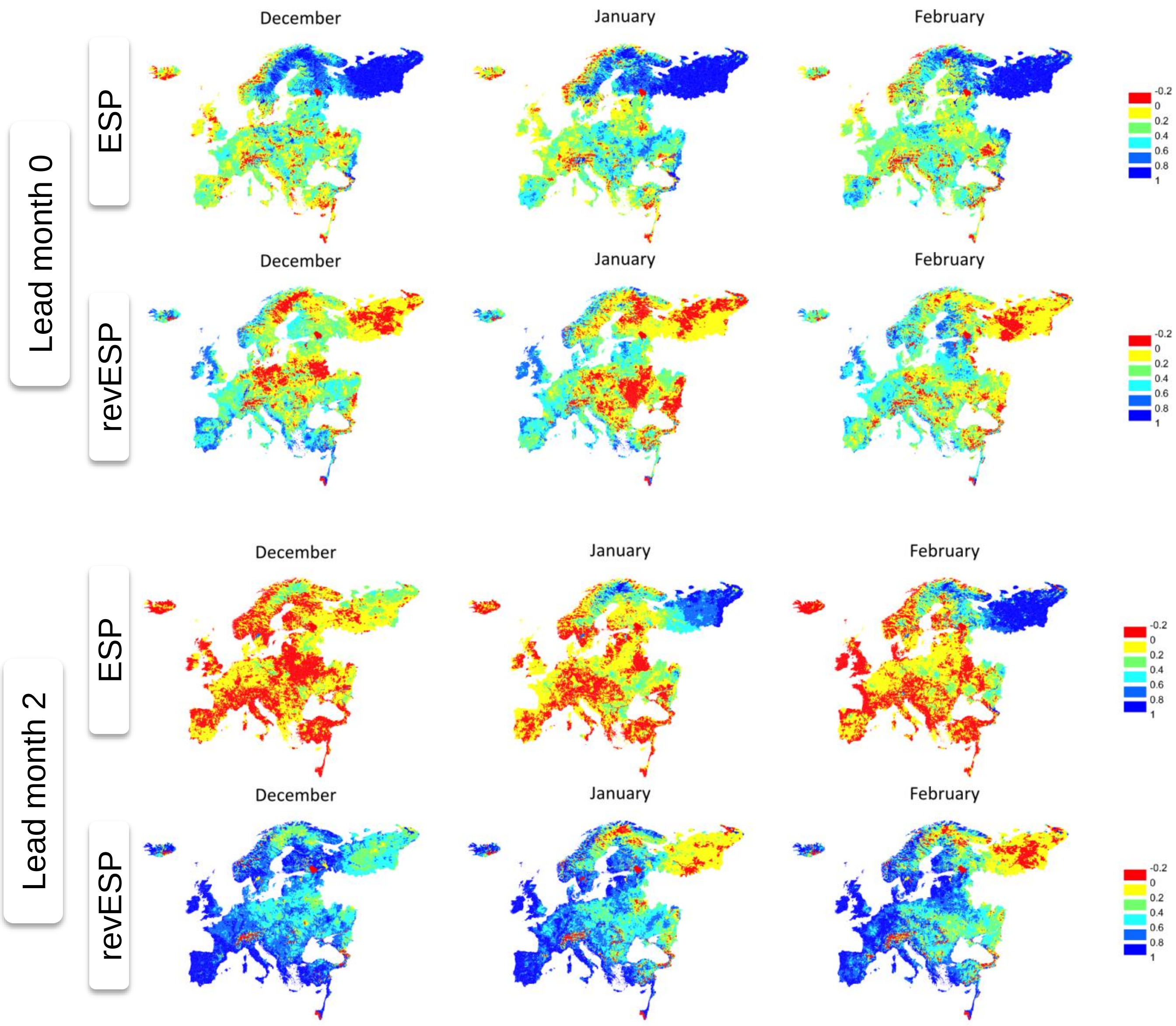
Lead month 0
ESP
revESP
Lead month 2
ESP
revESP
December
January
February
December
January
February
December
January
February
December
January
February
-0.2
0
0.2
0.4
0.6
0.8
1

2. Where does the predictability come from?

imprex
Learn from today to anticipate tomorrow

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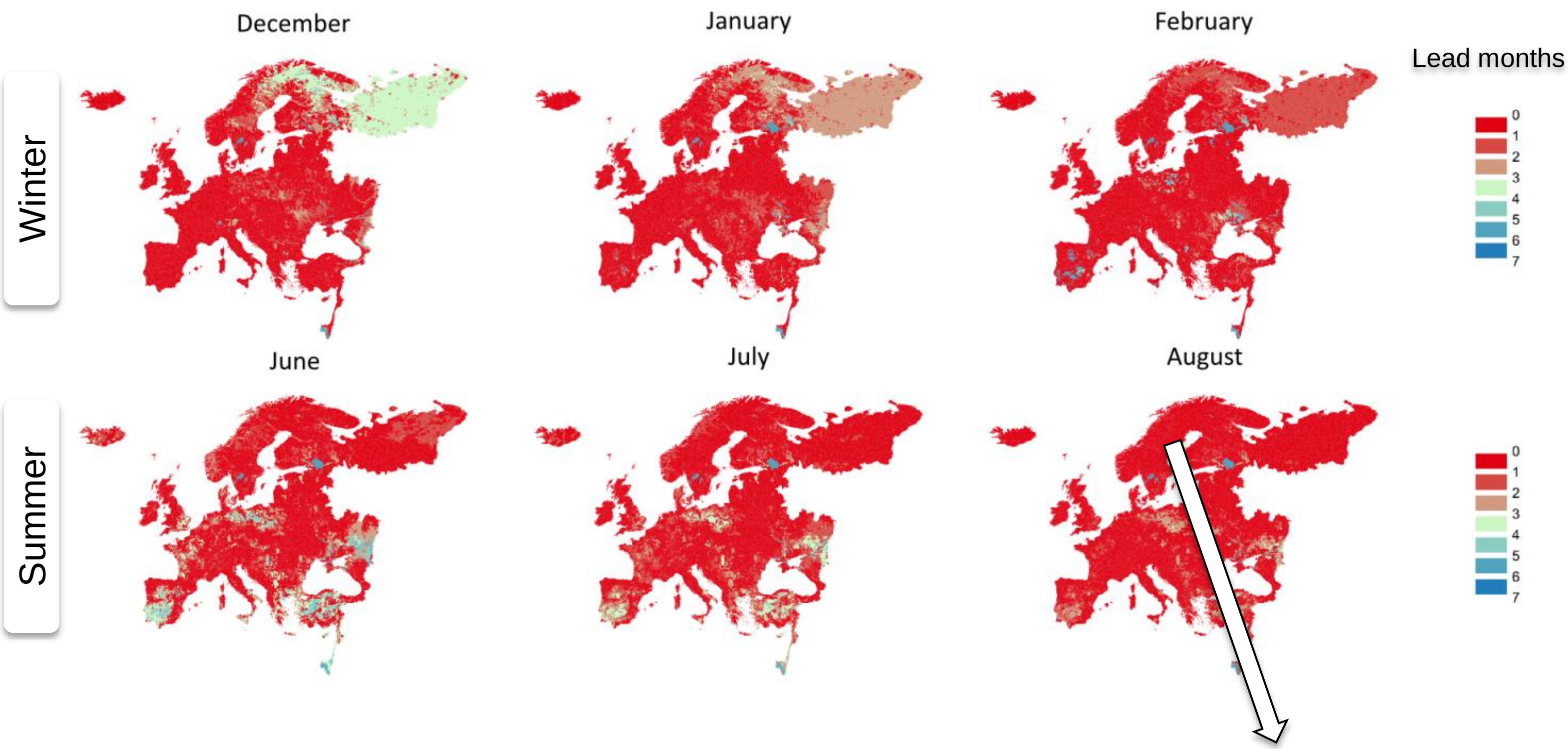
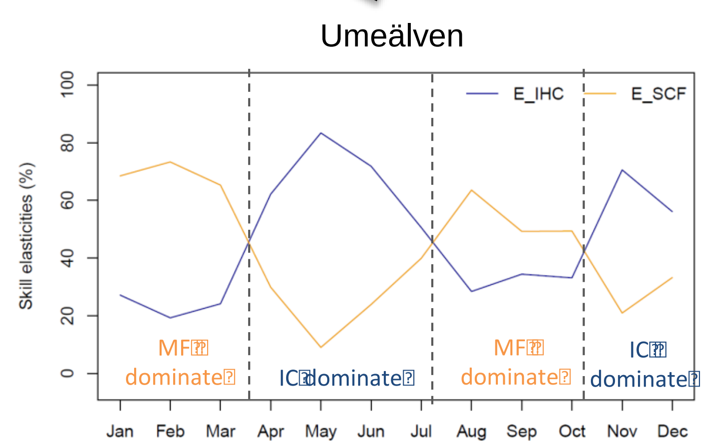
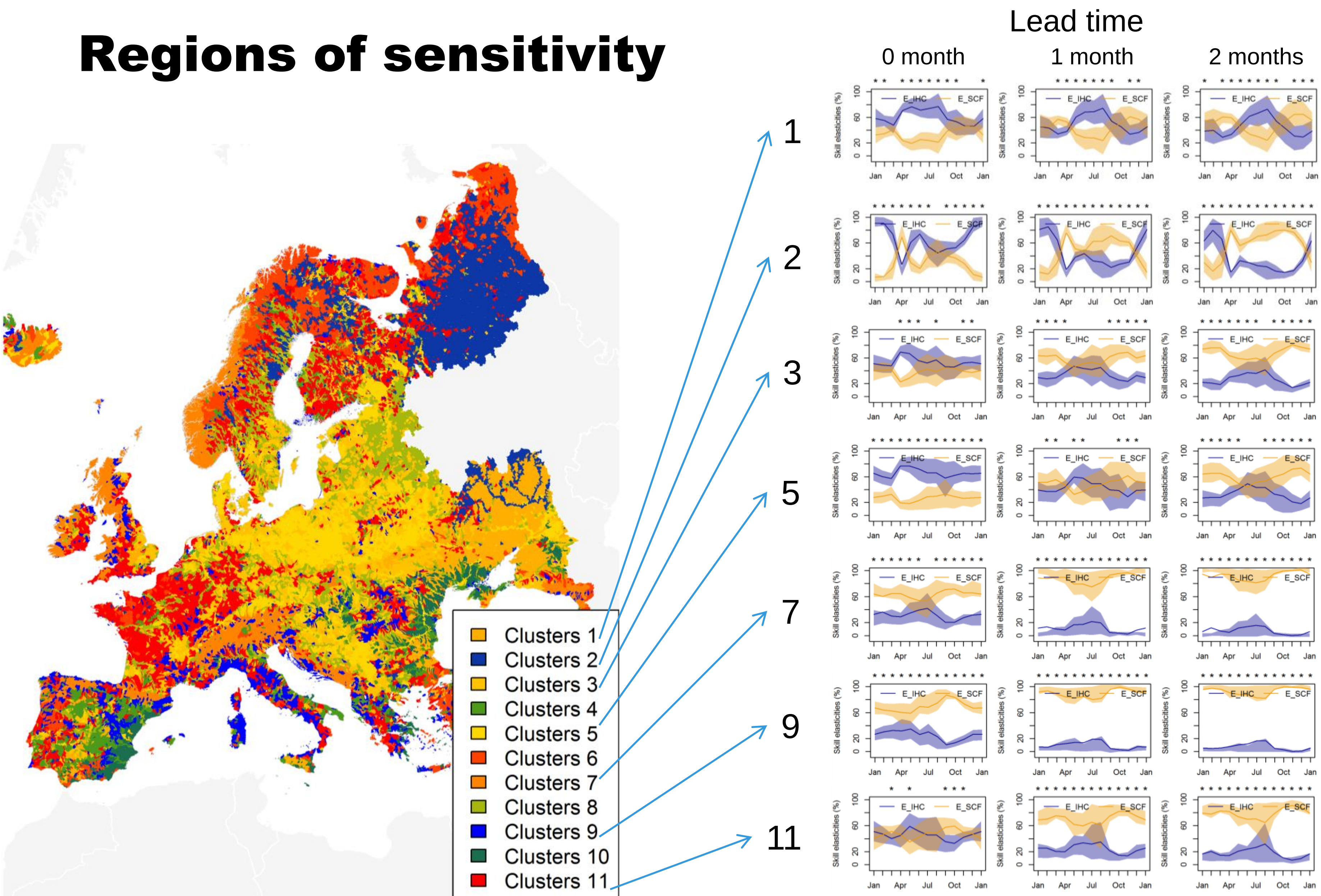




Regions of sensitivity



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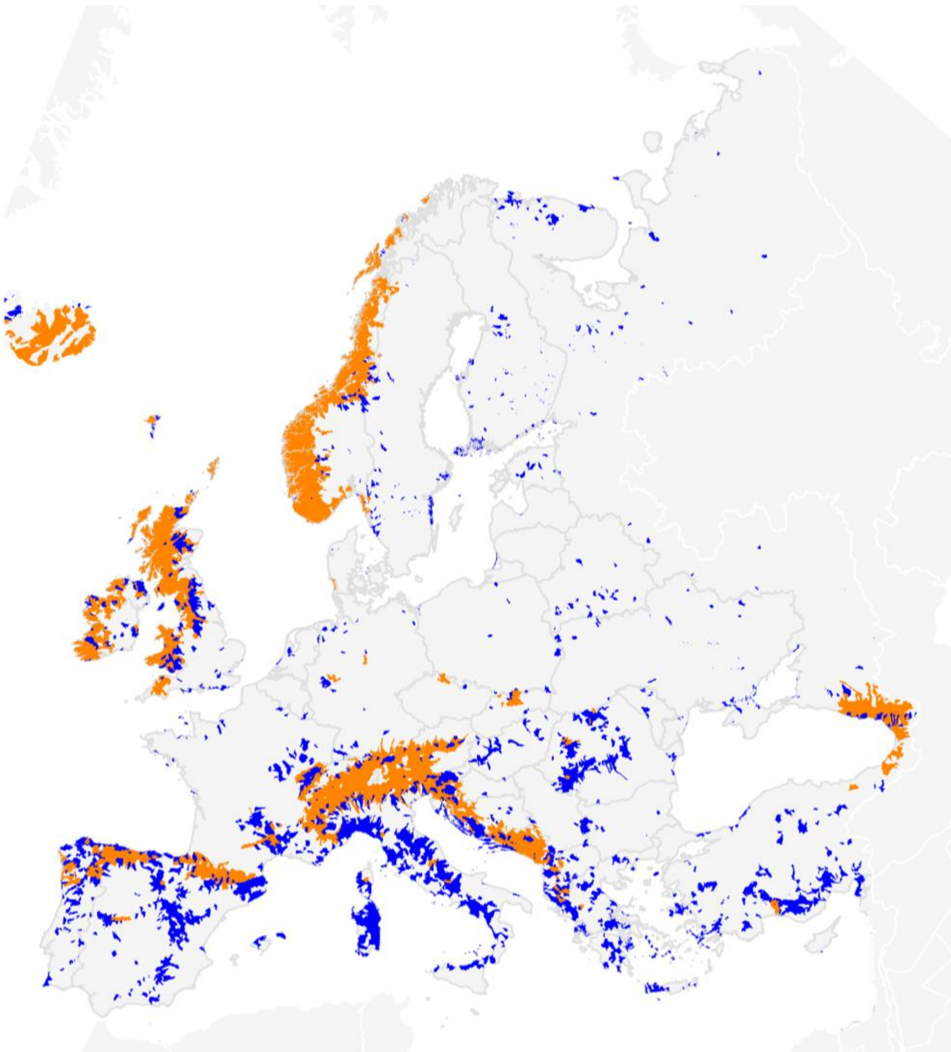
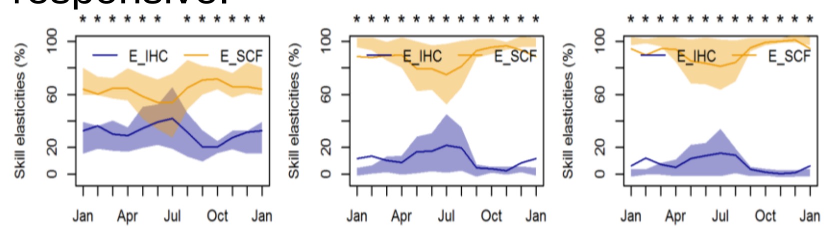


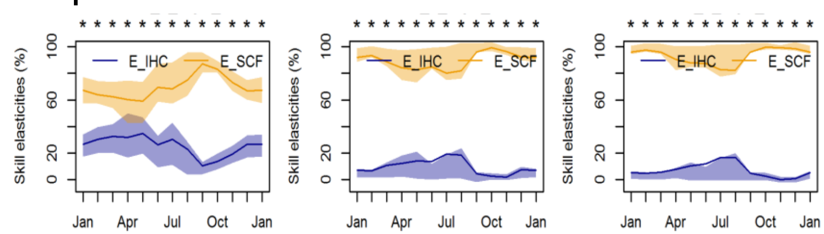
- **Dominated by SCFs even at short LT**

Low : Q95, BFI
High : Qm, slope of FDC, HPC

Orange : High precipitation and very responsive.



Blue : High variability in the flow regime. Precipitation results into flashy flow responses.



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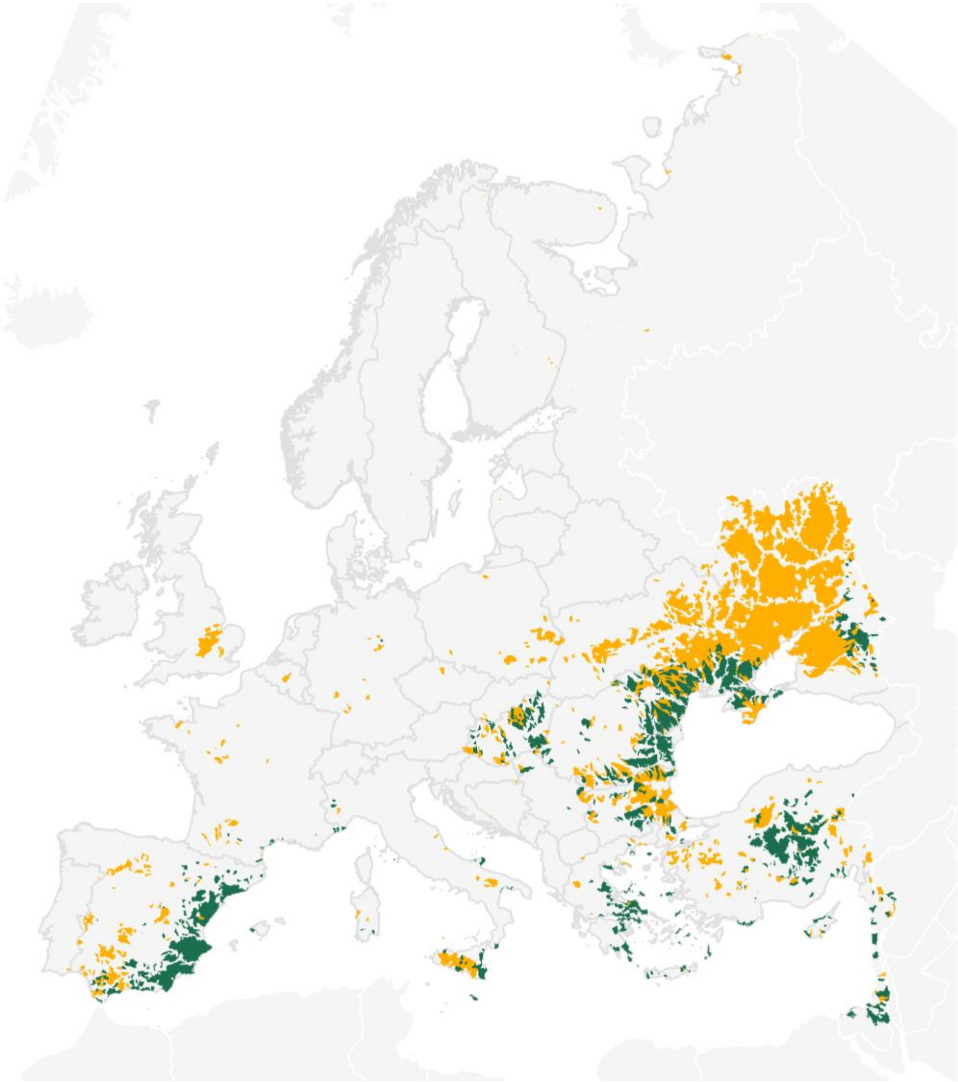
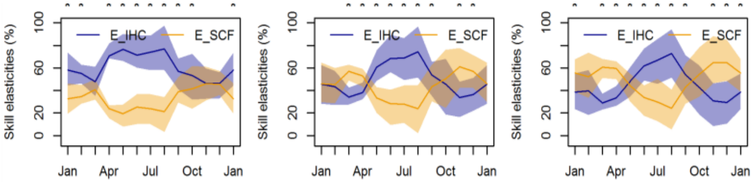


- **Dominated by IHCs even at long LT**

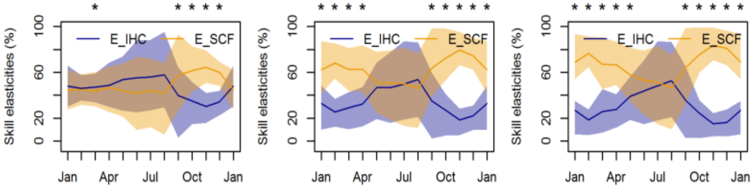
Low : Qm, Runoff Coefficient, BFI

High : Coefficient of Variation, Flashiness

Yellow : Low runoff coefficient, yet fast response to precipitation and recession. Can be influenced by human impacts.



Green : Highly variable regime with relatively small runoff coefficient, yet with quick response to precipitation



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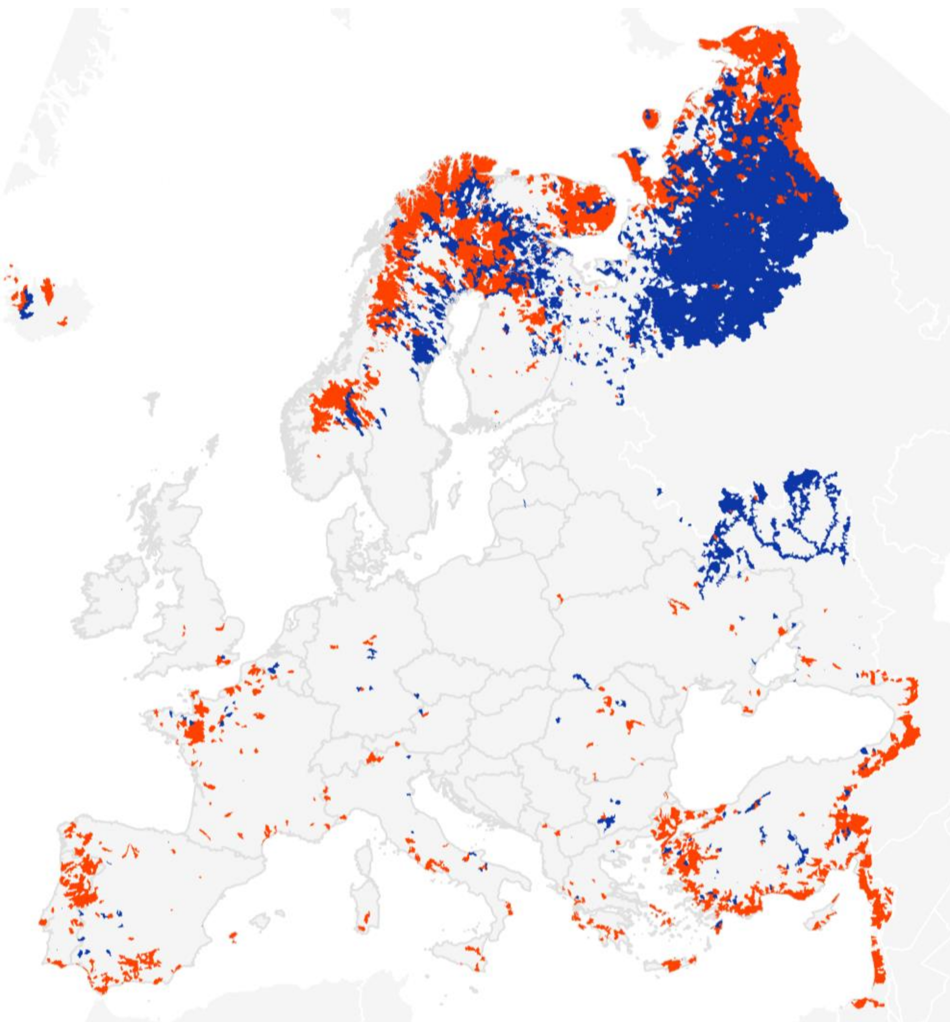
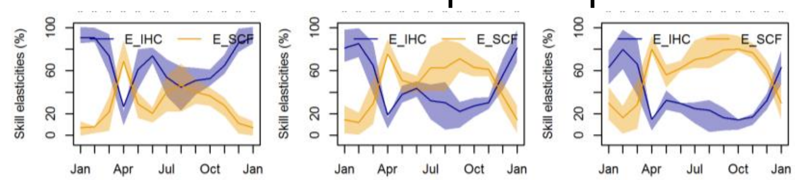
Regions of sensitivity



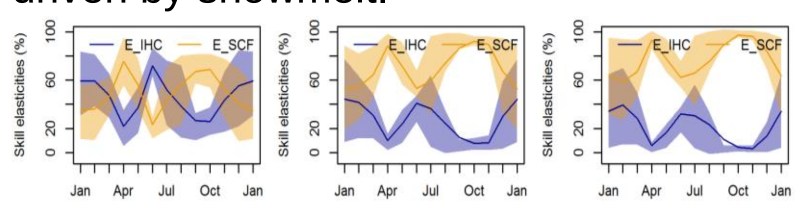
- **High variability in sensitivity**

High : Range of Parde function, q05, Normalized peak distribution

Blue : High inter-annual variability. Snow-dominated flow regime. Presence of lakes and wetlands. Low evapotranspiration.



Red : Basins with high runoff coefficient due to low evapotranspiration, and a highly variable flow regime. Response is driven by snowmelt.



Conclusions

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1. Which catchment characteristics can explain this pattern ?

- ✓ European catchments were split into 11 regions based on streamflow characteristics
- ✓ Skill seems to be limited at relatively flashy basins experiencing strong flow dynamics over the year (less memory in the system).
- ✓ Skill is high in snow-dominated or baseflow-dominated regions, as well as in regions with lakes and wetlands

2. Where does the predictability come from?

- ✓ Catchments dominated by meteorological forcing at one-month lead, dominated by initial conditions at 3-month lead and catchments with a high variability in sensitivity were identified
- ✓ On the west coasts, as well as in mountaineous regions, meteorological forcing dominate as early as in the first month.

Further

- ✓ Apply EPB to more catchments per region
- ✓ Fully close the circle

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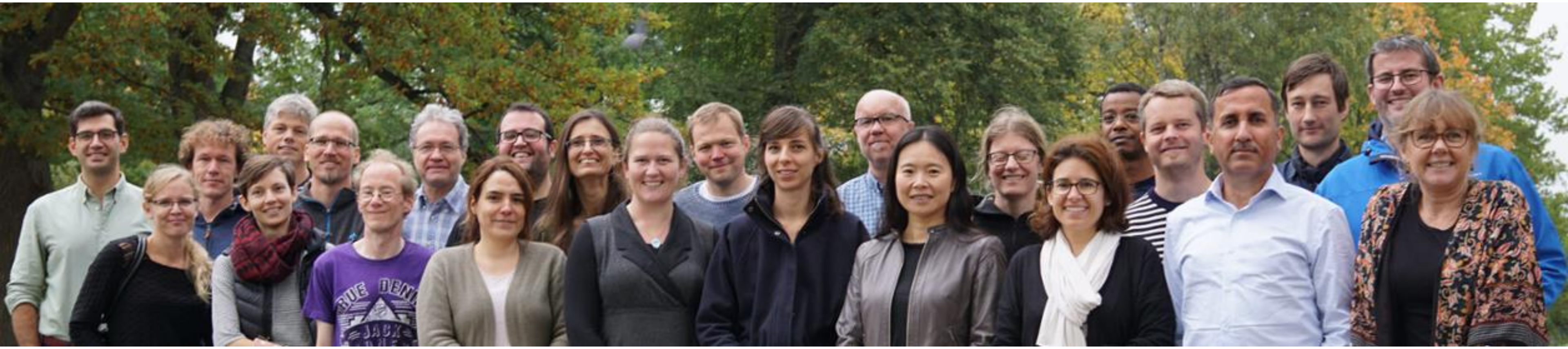

This study is based on the hard work of all the researchers in hydrology at SMHI

Thank you for your attention!

Please share your insights with us!

imprex
Learn from today to anticipate tomorrow

S2S4E