S2S4E
Climate Services for Clean Energy

Seasonal hydro-climatic services in the hydropower sector

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with contributions from Louise Crochemore, David Gustafsson (SMHI) and other international colleagues (POLIMI, UPV and IRSTEA)

SMHI

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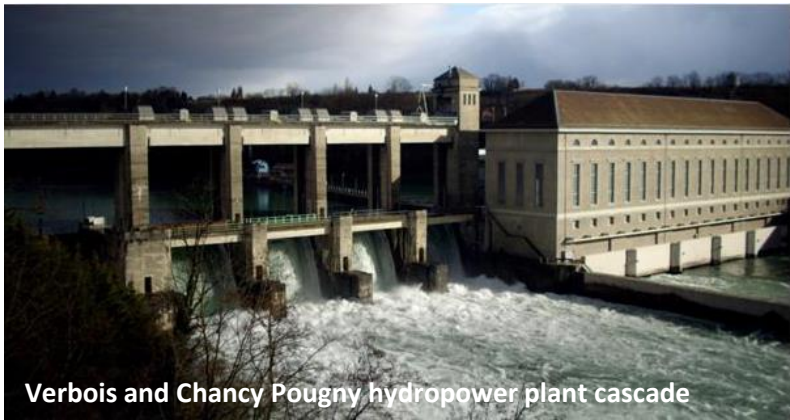
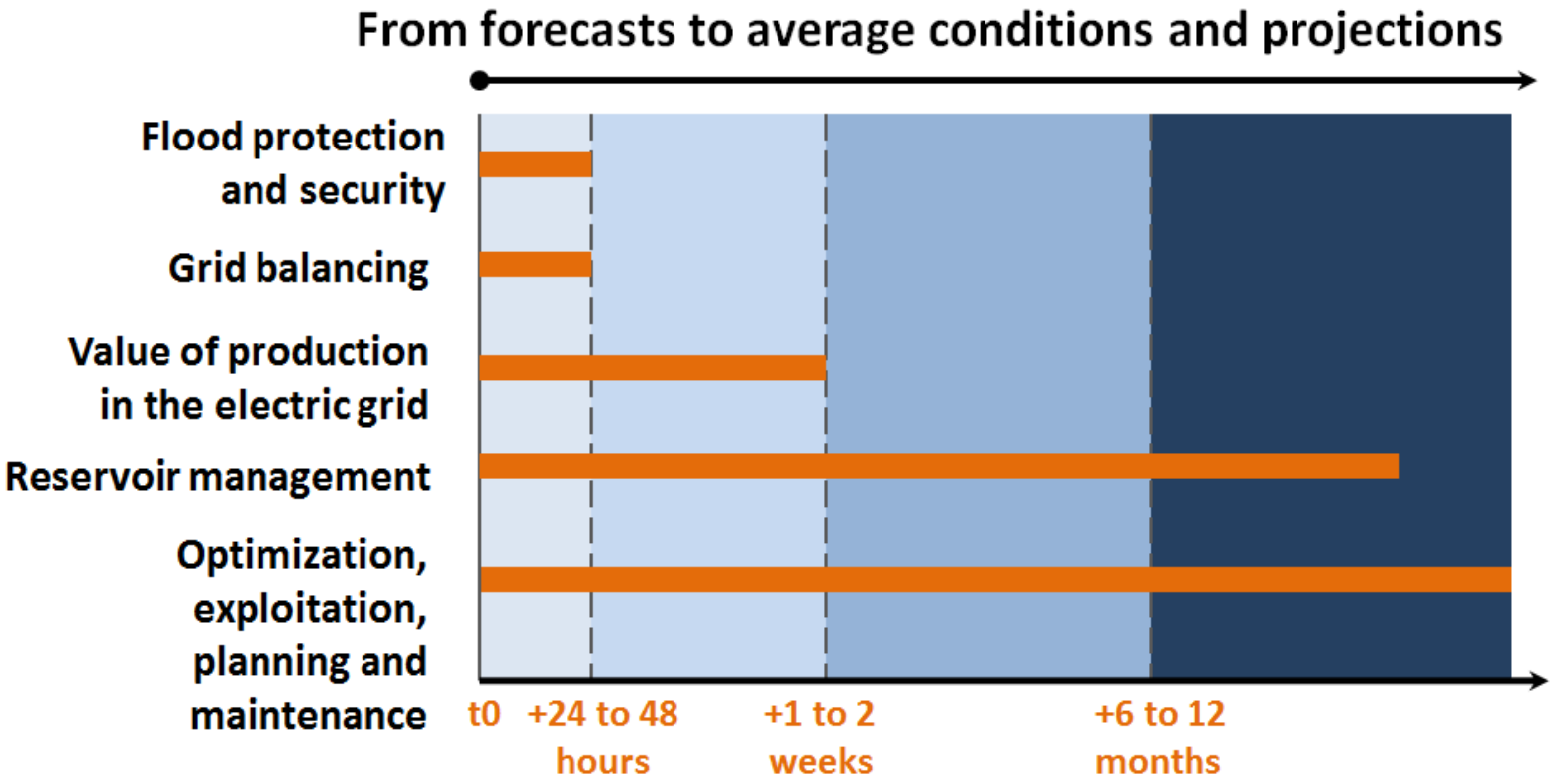
Why focusing on the HP sector?

- The world's largest source of renewable energy (over 16% of global electricity) - High unused potential to be explored in times of a changing global energy policy.
- 48 billion USD have been invested in hydropower projects in 2017 – an enormous market potential for cost saving solutions
  - Operating in a context of multiple uses of water (including environmental uses)
  - Handle peak demands of electricity and contributes to the supply-demand balance
  - Impacted by variability and extremes in weather, climate and hydrology



Verbois and Chancy Pougny hydropower plant cascade

Decision-making in the HP operation



- Directions in HP:
  - Cost and benefit transparency
  - Multi-objective optimisation
  - Resilience to climate change

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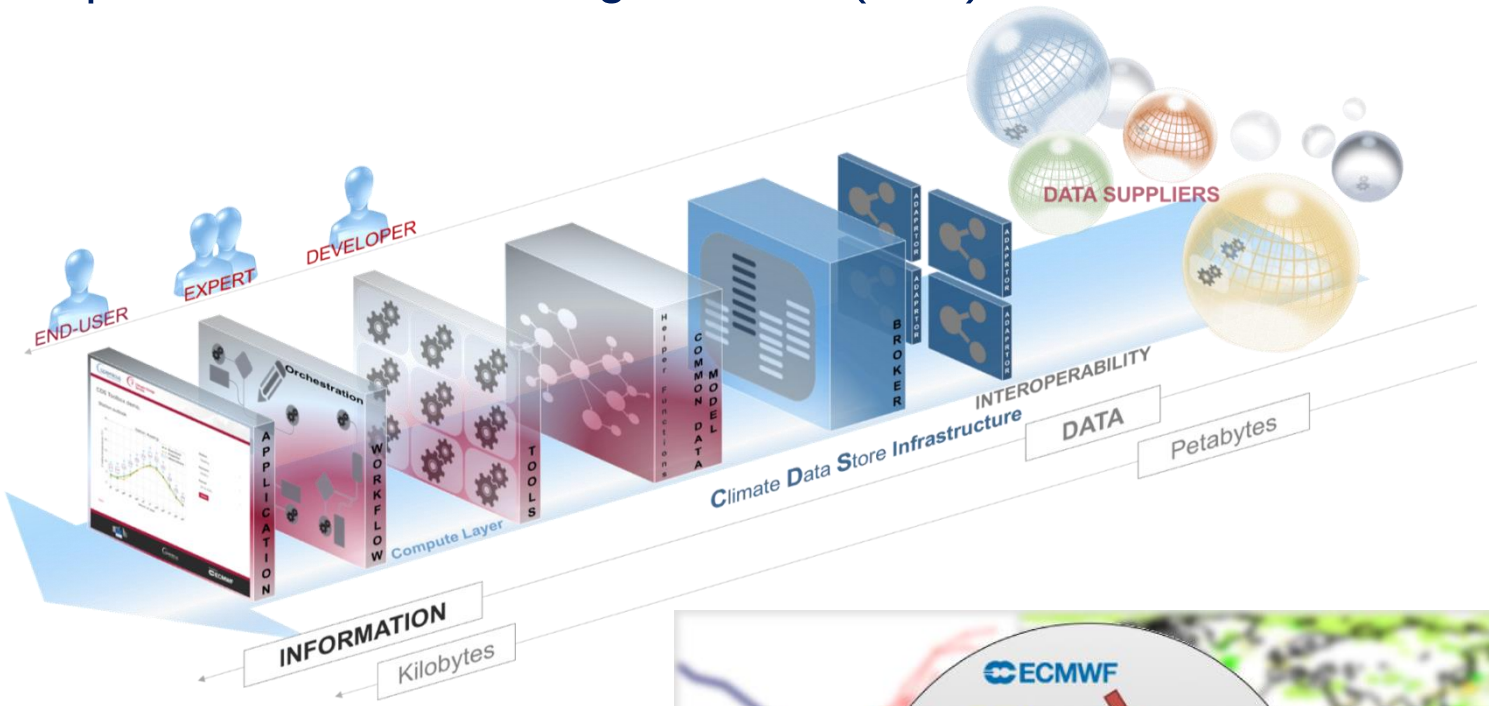
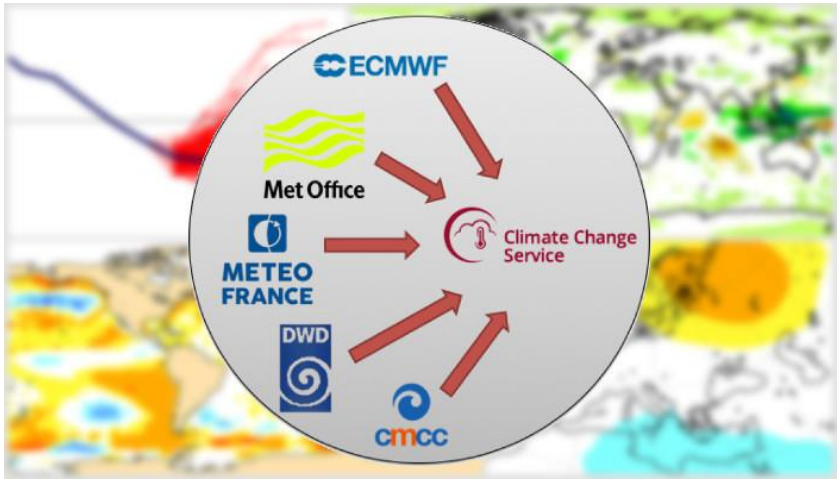
Existing hydro-climatic services

- Unique service providers
- Copernicus Climate Change Service (C3S)



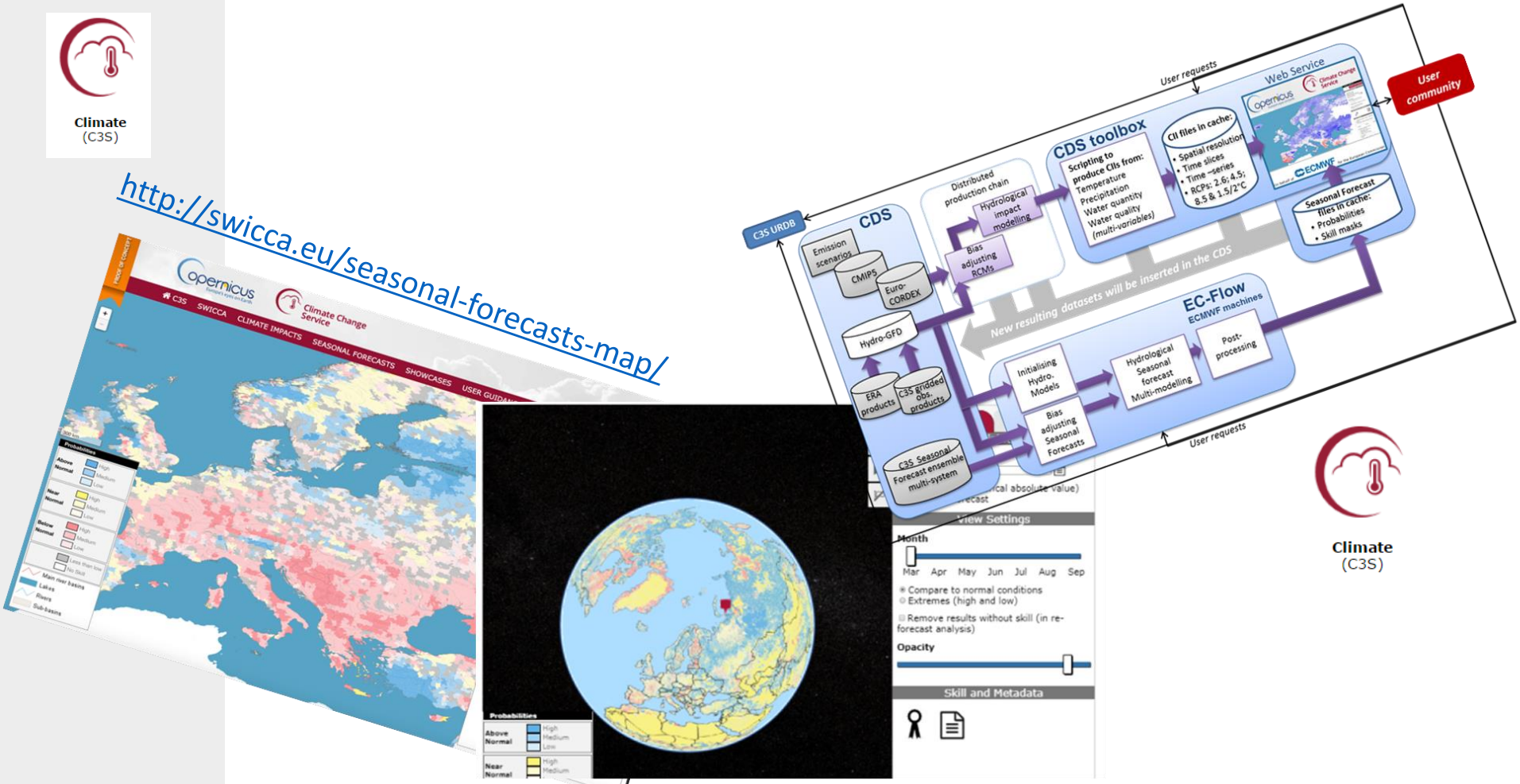


Existing hydro-climatic services

- Large-scale hydrological services

Climate
(C3S)

http://swicca.eu/seasonal-forecasts-map/



https://hypeweb.smhi.se/explore-water/forecasts/seasonal-forecasts-global/

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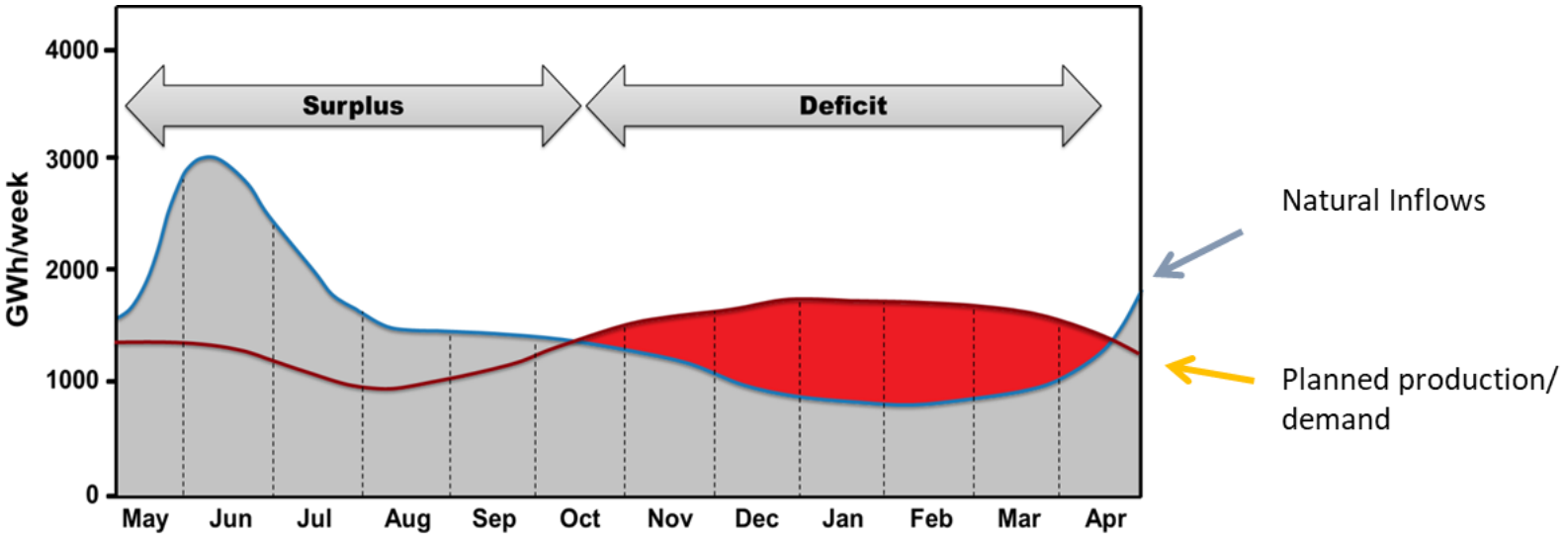
Existing hydro-climatic services

- Large-scale hydrological services
- Availability of seasonal impact indicators (from SMHI)

			Domain			
State	**Variable**	**Statistic**	**Sweden**	**Europe**	**Globe**	**Multi-model**
Operational	**Precipitation**	Monthly mean		X	X	
	Temperature	Monthly mean		X	X	
		Monthly min		X	X	
		Monthly max		X	X	
	Discharge	Monthly mean	X	X	X	
Semi-operational	**Inflows**	Weekly/monthly mean		X		X
	Snow	Weekly/monthly mean		X		
Science	**Soil moisture**	Monthly mean		X	X	
	Snow	Monthly mean		X	X	
	Potential evapotr.	Monthly mean		X	X	
	Actual evapotr.	Monthly mean		X	X	

Understanding the needs in HP

- Asymmetric distribution of inflows and demand over the year



- Current operational systems
  - Climatological P/T ensemble used to run a hydrological model
  - Forecasts of inflow volume for the period May-July
  - Little improvement in forecasts over the last 30 years

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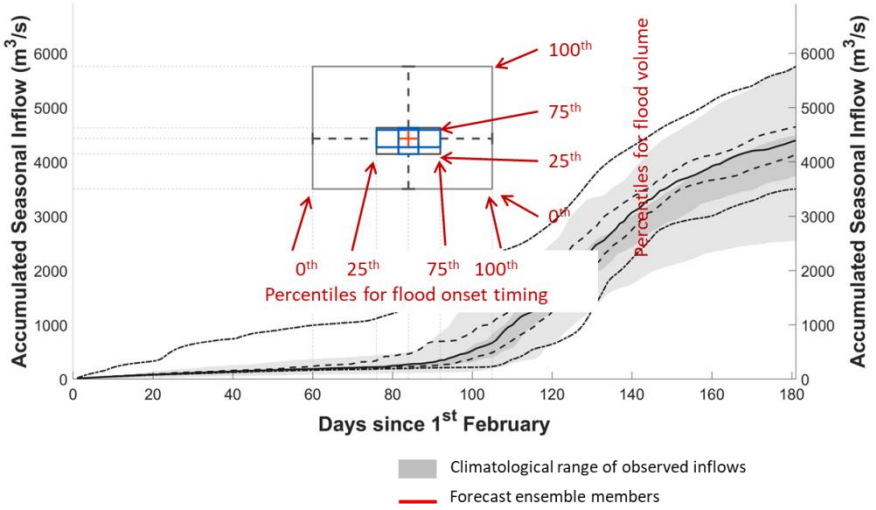
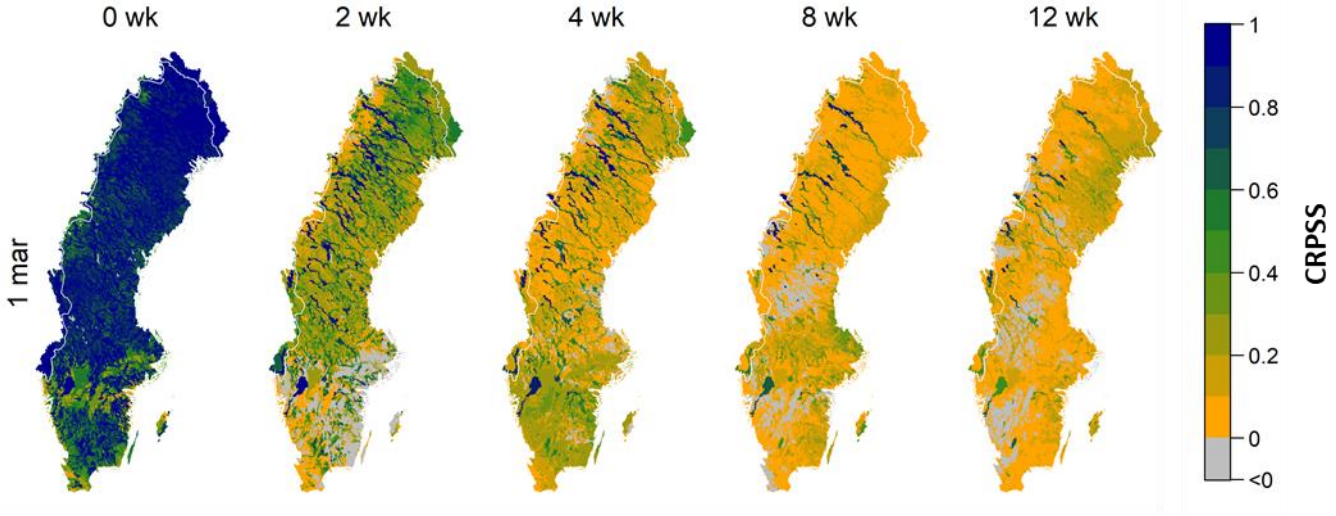
Understanding the needs in HP



Type of information that is useful to gain trust:

- Forecasted inflows to the reservoir?
- Onset of flood?
- Forecasted skill?
- Sources of skill?
- ???



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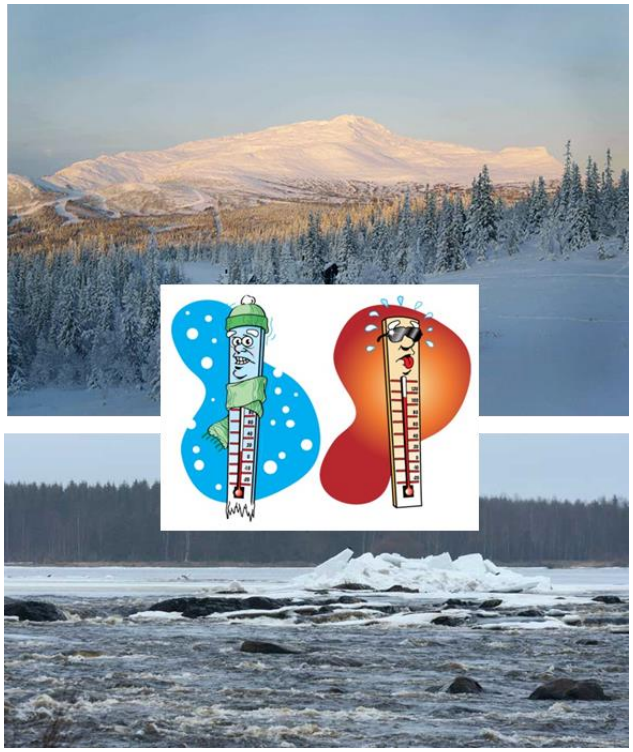
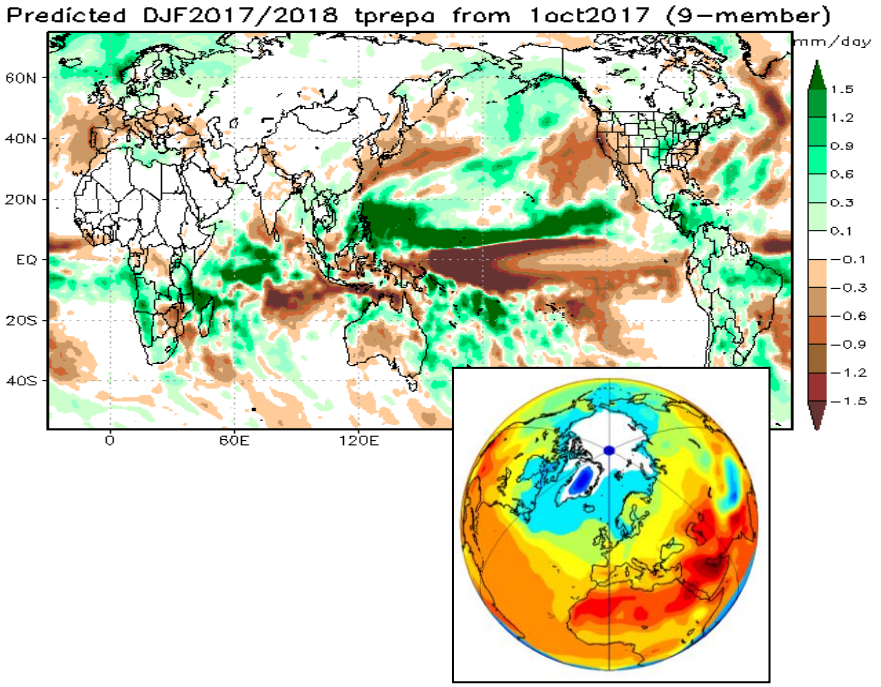
Understanding the needs in HP

Initial conditions



Knowledge of weather during the forecast period



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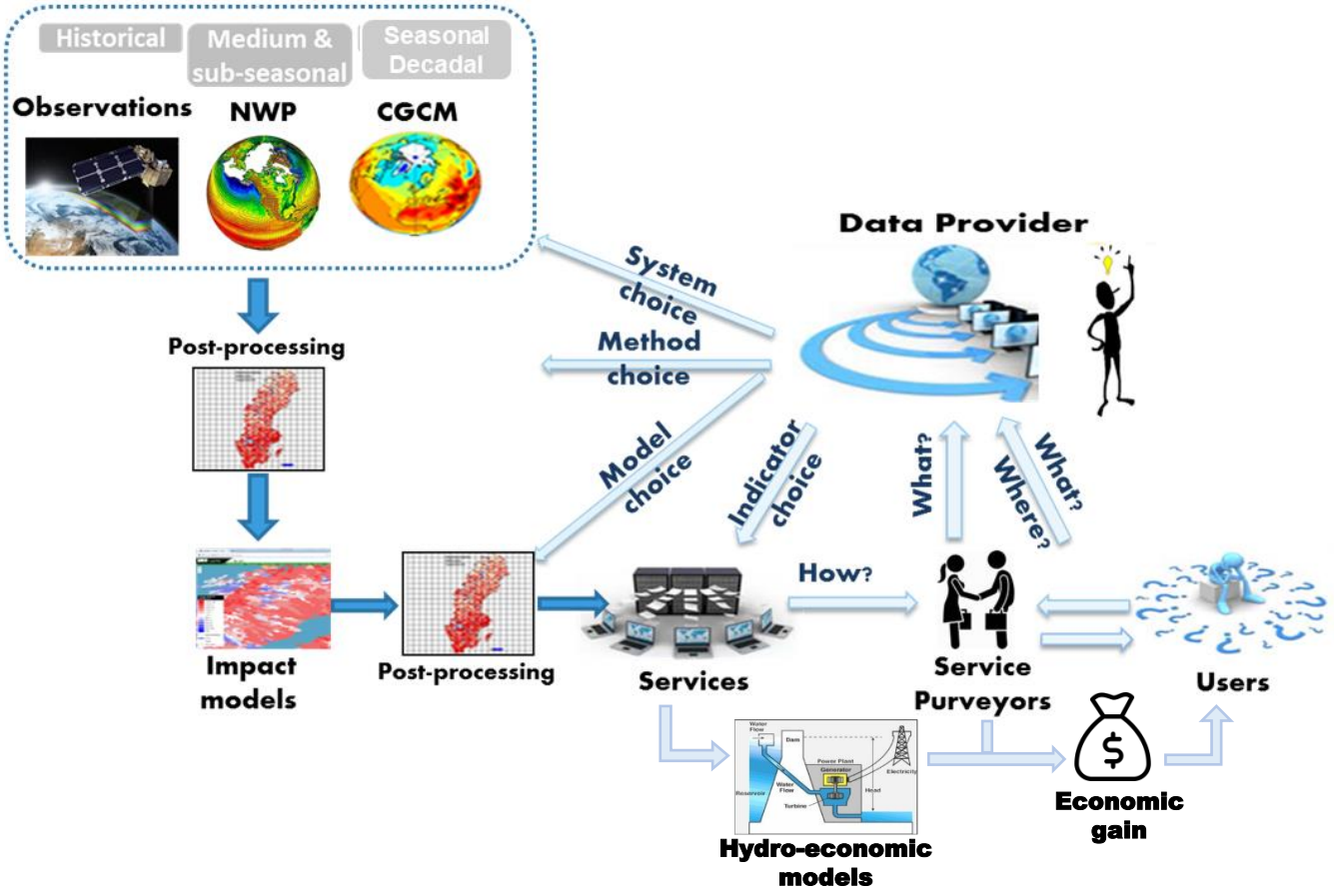
Scientific efforts for HP

- How much can the HP production be improved?
- What is the link between forecast quality and added-value?
- Can improved HP product affect other sectors?
- How to further (co-)evolve the knowledge and services?



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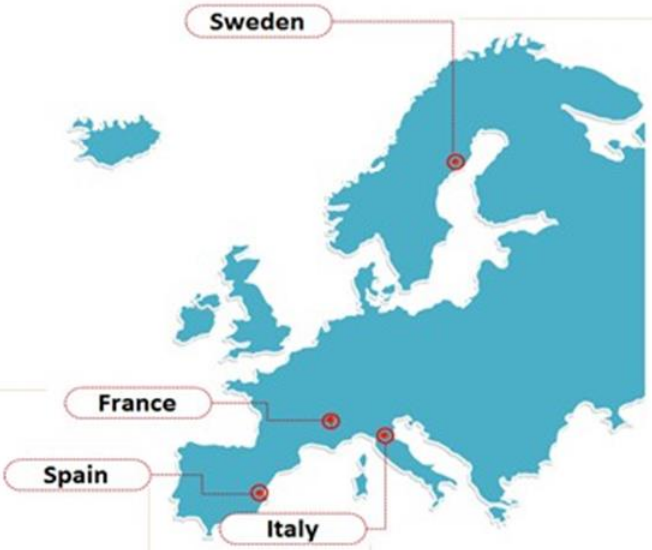
Scientific efforts for HP
A European investigation!

A set of typical mountainous river basins, where 7-day to monthly inflow forecasts are operationally used to inform decision-making:
south-eastern basins in FRANCE



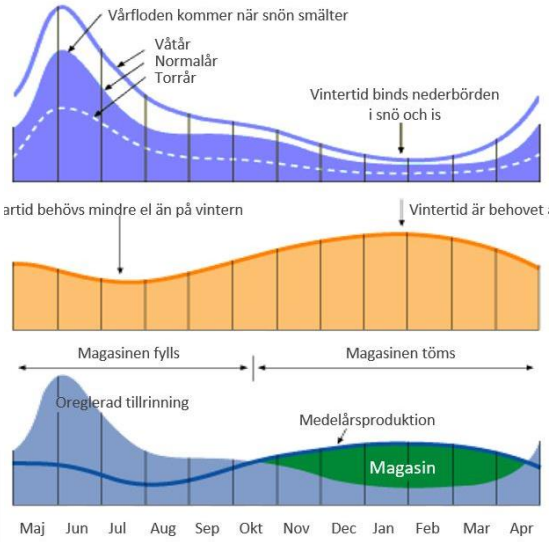
A typical north European basin, highly influenced by snowmelt runoff and volumes for planning the hydropower production for the current and next winter seasons:
the upper part of the River Umeälven in SWEDEN

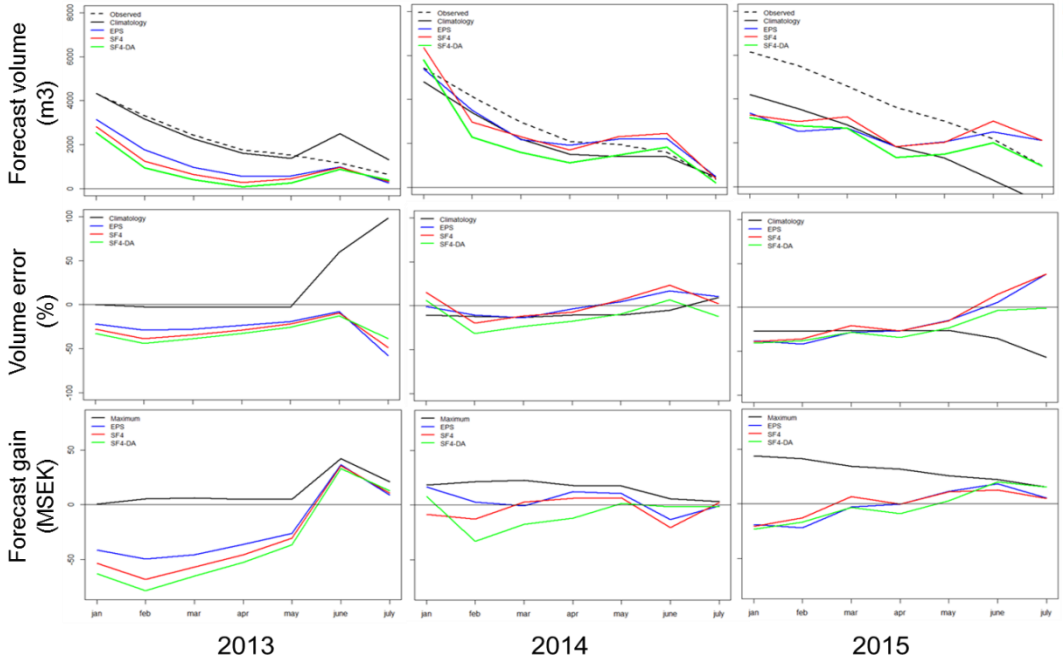
A typical south Mediterranean basin, with a large share of water for irrigated agriculture:
the Jucar River basin in SPAIN

A typical snow-dominated Alpine basin, representing a large socioeconomic system where multiple, conflicting water-dependent activities coexist:
the Lake Como in ITALY

Scientific efforts for HP
A European investigation!

The forecast gain from data assimilation and/or seasonal forecasting systems, compared to a traditional method (historical meteorological observations), may reach 10 MSEK (~1 M€).





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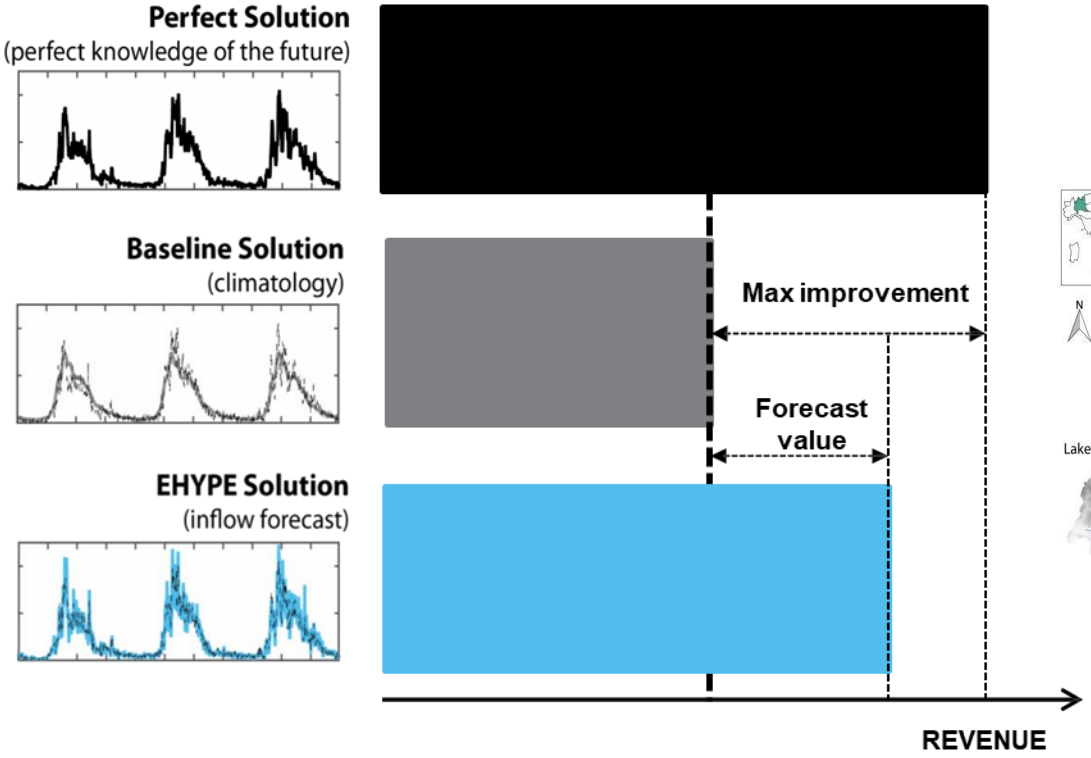
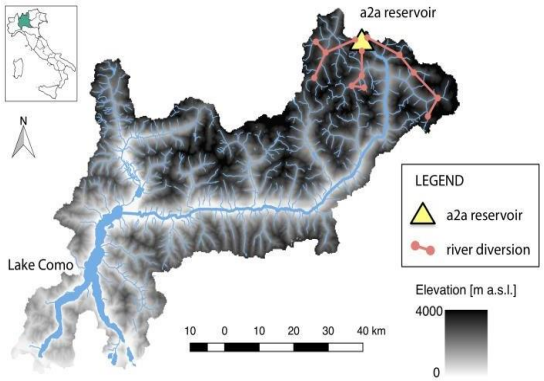
Scientific efforts for HP
A European investigation!





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Policy	Absolute gain	Relative gain
Baseline Solution	-	-
Perfect Solution	+2.82 M€/year	+3.4%
E-HYPE Solution	+1.38 M€/year	+1.6%

Giuliani et al., (in preparation)

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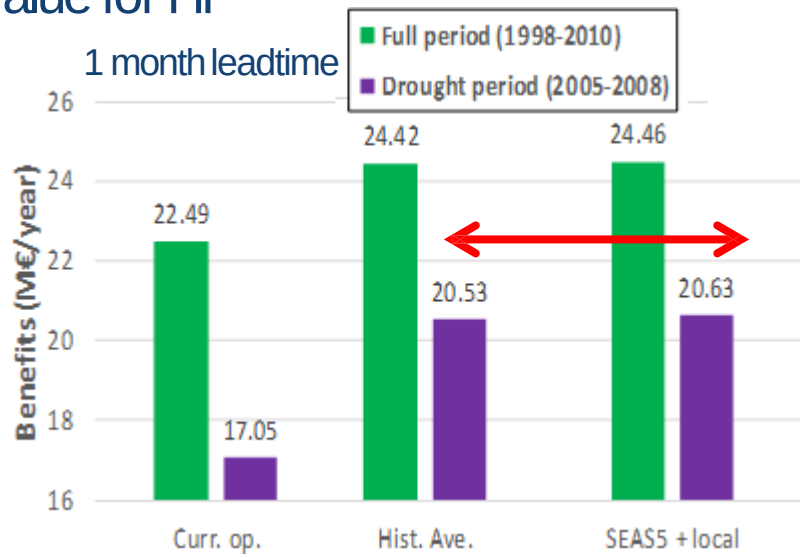
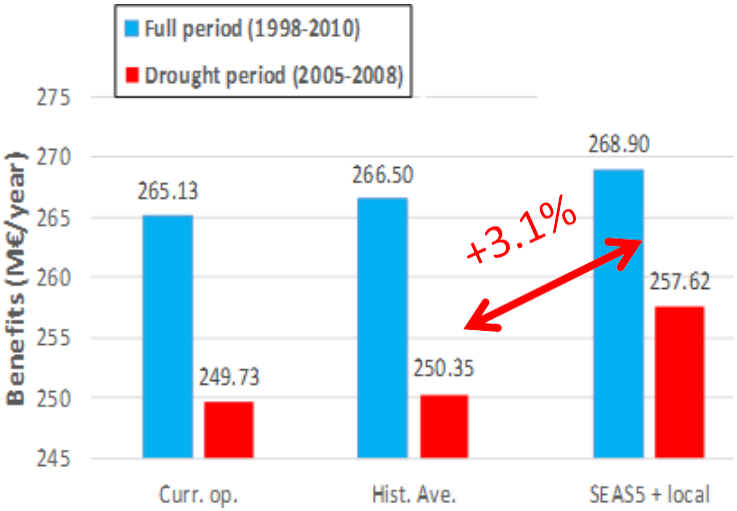
Scientific efforts for HP
A European investigation!

Value for HP



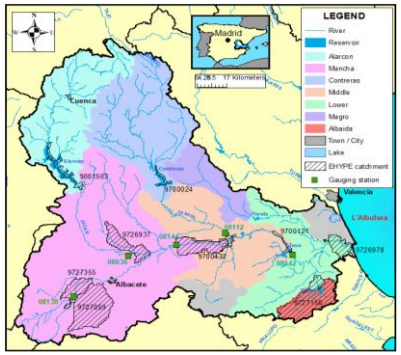
Value for Agriculture



Jucar: A very complex river system

8 reservoirs, 5 aquifers, 7 sub-basins that discharge into different streams of the Jucar river, 17 consumptive demands (5 urban, 12 agricultural and 1 industrial), 9 hydropower plants (all the Jucar river system facilities with more than 3.5 MWh of installed capacity) and 5 streams with prescribed minimum streamflows due to environmental reasons

Jucar river basin



UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Macian-Sorribes et al., (in preparation)

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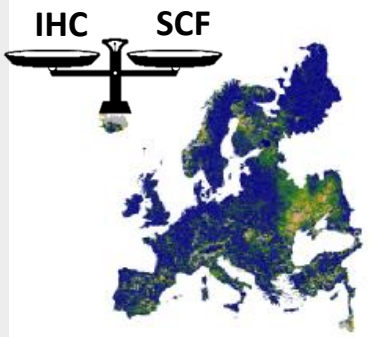
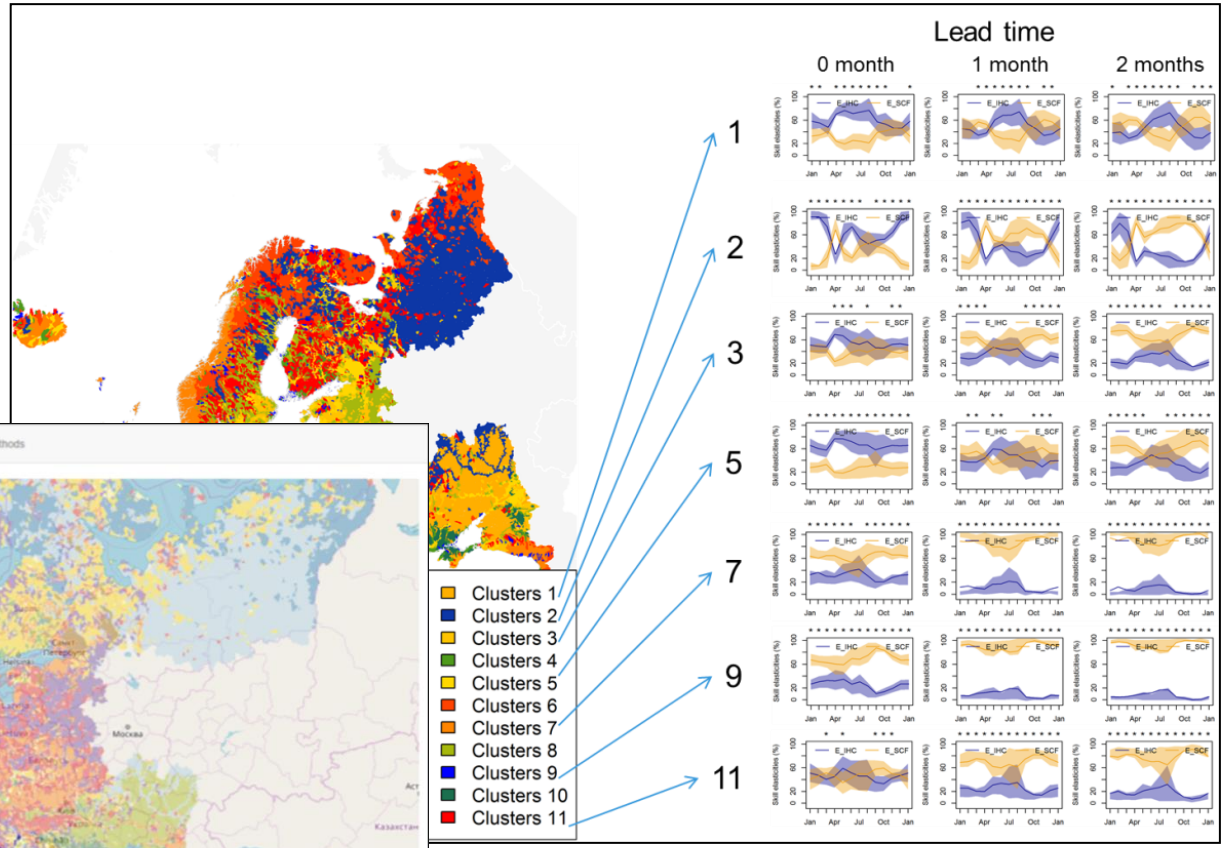
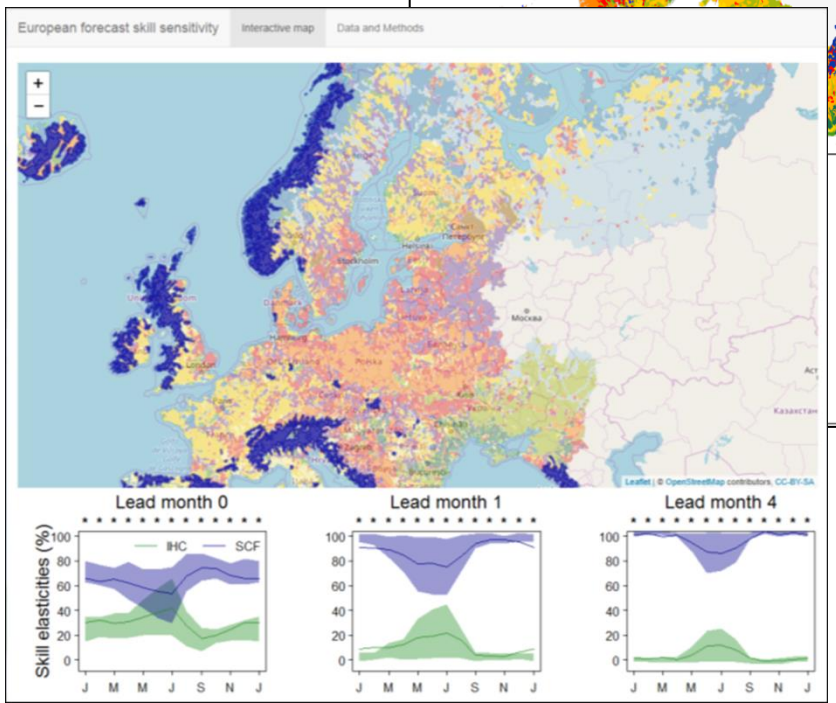
Scientific efforts for HP
Co-evolution of knowledge/services







A diagnostic tool to guide in space and time the relative importance of IHC and SCF

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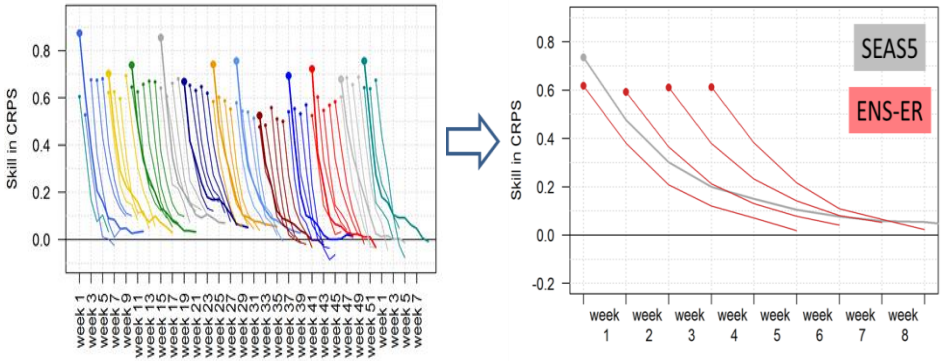
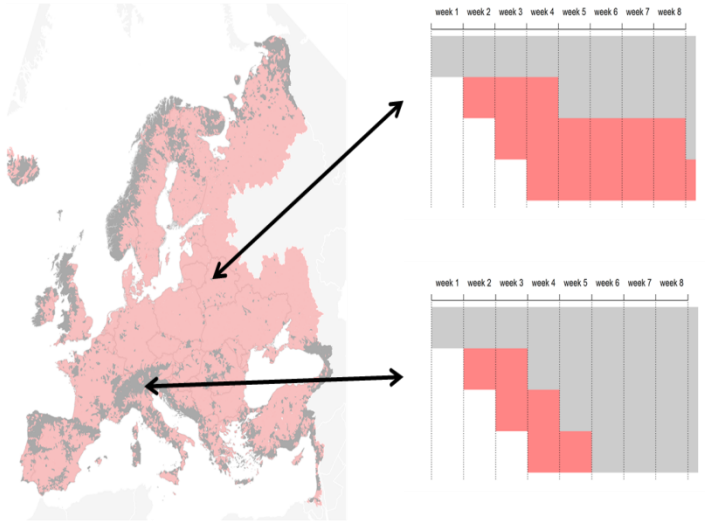
Co-evolution of knowledge/services

S2S seamless approach



Improved skill through frequent initialisation of forecasts



- Two regions identified:
  - In most catchments, ER can be used for the first 3-4 weeks
  - In rain-driven and mountainous regions, the skill of ER is limited to ~2 weeks

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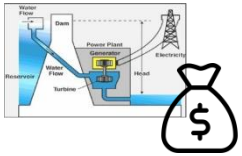
(only a subset of) Take home messages

✓ Large-scale seasonal services provide useful forecast information for a number of sectors (including HP).

It is a matter of extraction for the region, season and lead time of interest.

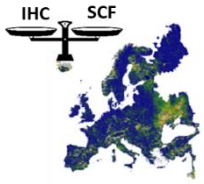


✓ There is a link between quality and value of forecast services for hydropower:

better forecasts => higher value

✓ HP systems are driven by both local climate and hydrology variability, and energy prices variability. Added value in HP means added value in other sectors too.

✓ Need for stronger engagement between service providers and users.



Diagnostic/guiding tools and seamless forecasting can drive the co-evolution of knowledge and services.

Thank you

Get in touch for more information!

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The SMHI Hydrology R&D unit

You are always welcome to share your views!

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