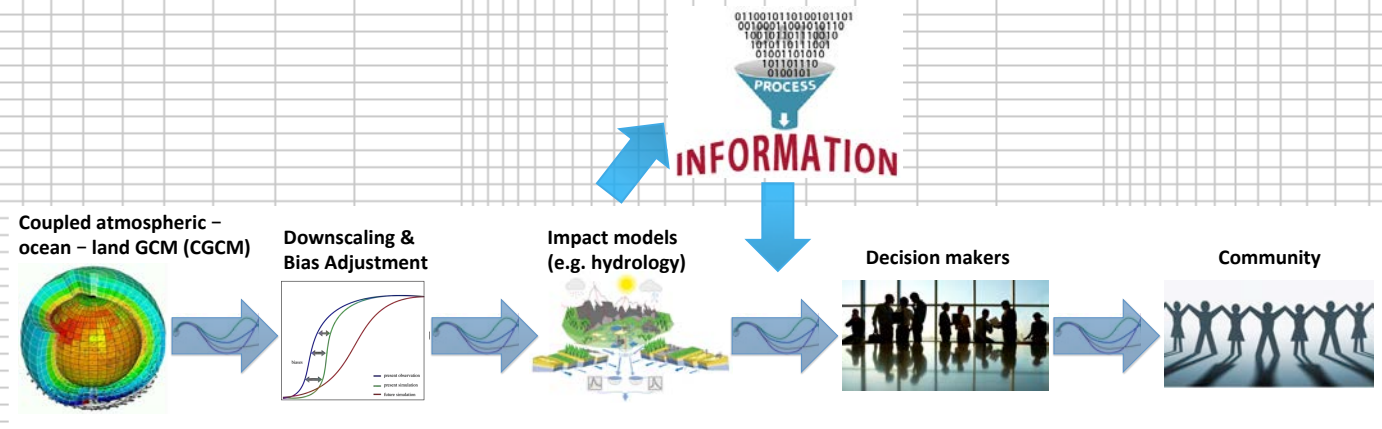


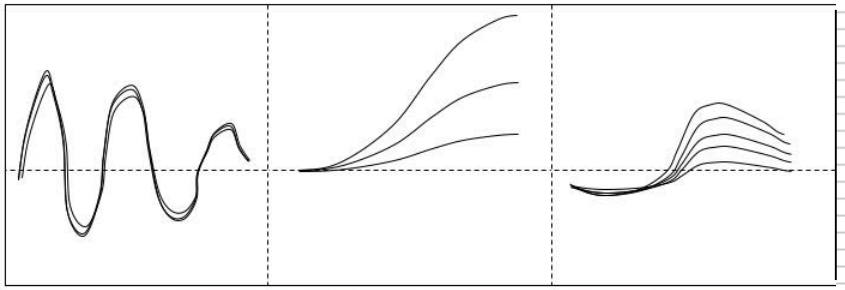
Ilias Pechlivanidis (Hydrology Research)
David Gustafsson (Hydrology Research)

Relevant EU-projects for the hydropower sector: IMPREX and S2S4E

IMPREX (2015-2019) Improving predictions and management of hydrological extremes

S2S4E (2017-2020) Subseasonal to seasonal forecasts for the Energy sector

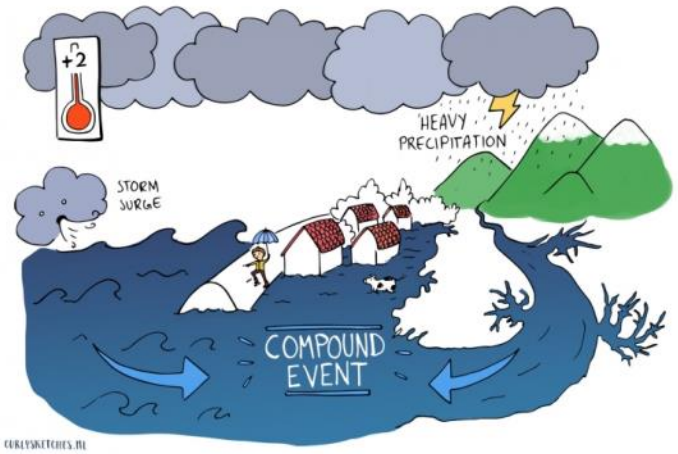
Historic simulation (1981-Today)	Short-medium range forecasts (1-15 days)	(Sub-) seasonal forecasts (1-7months)



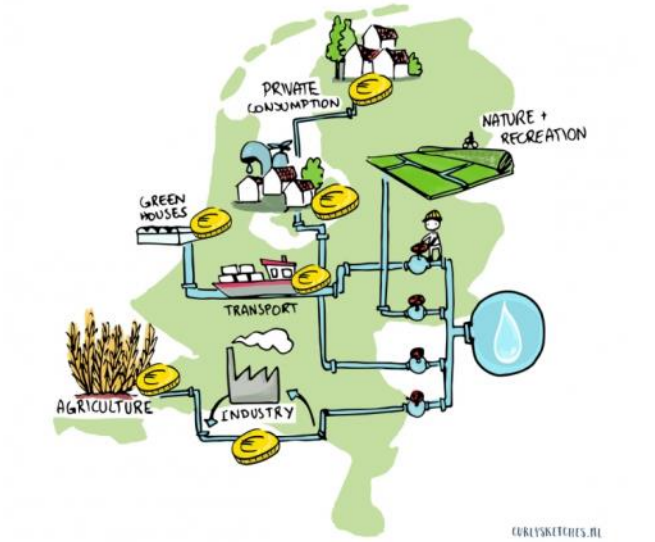
• Hydrological models • Parameters • Observations	• NWP models • Initial conditions • *Hydrol. Models* • *Parameters* • *Initial conditions*	• Climate models • Initial conditions • *Hydrol. Models* • *Parameters* • *Initial conditions*

IMPREX

- Enhance forecast quality of extreme hydro-meteorological conditions and their impacts. Methodological developments and concepts will be tested in case study areas (7) with stakeholders in order to gain experience on their practical applicability and to illustrate their usefulness for decision-making.



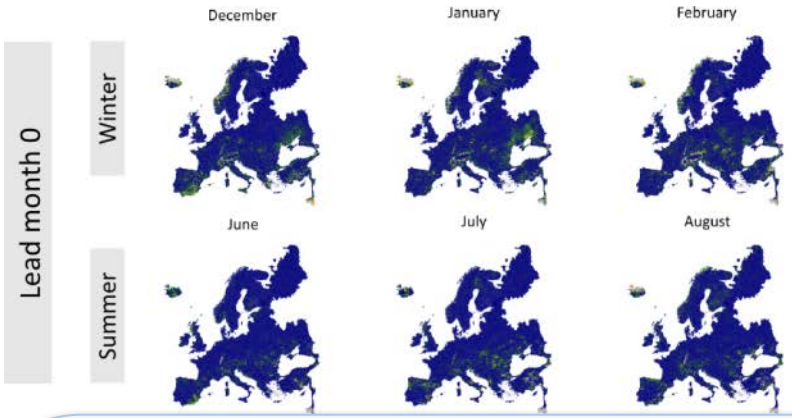
- Tasks:
  - ***Short-range and seasonal forecasting***
  - ***Assimilation of snow info***



Hydrological model: E-HYPE model

Climatic models: ECMWF's System 4 and System 5 (end 2017), MetOffice's GloSea5

NWP: High resolution



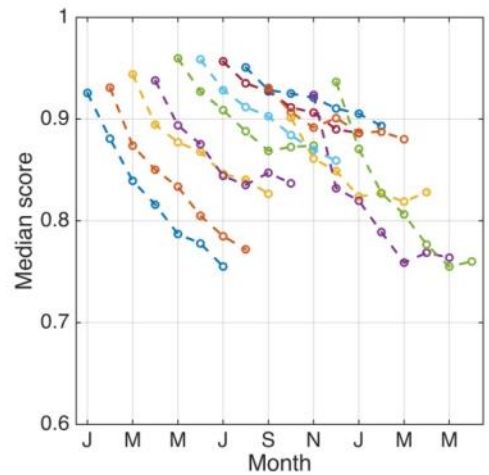
Seasonal hydrological forecasting skill

What are the limits of predictability for forecasting systems?

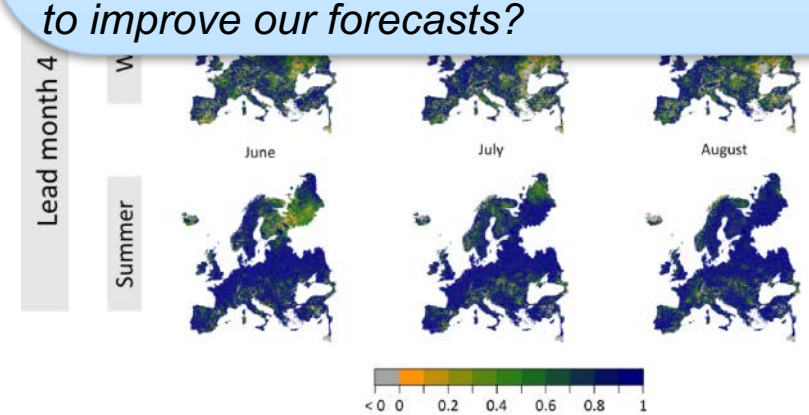
Which are the drivers affecting the seasonal forecasting skill?

What is the relative role of initial hydrological conditions (IHCs) and climatic forcing (CFs) to the forecasting skill?

How can we use new data products for initialisation to improve our forecasts?

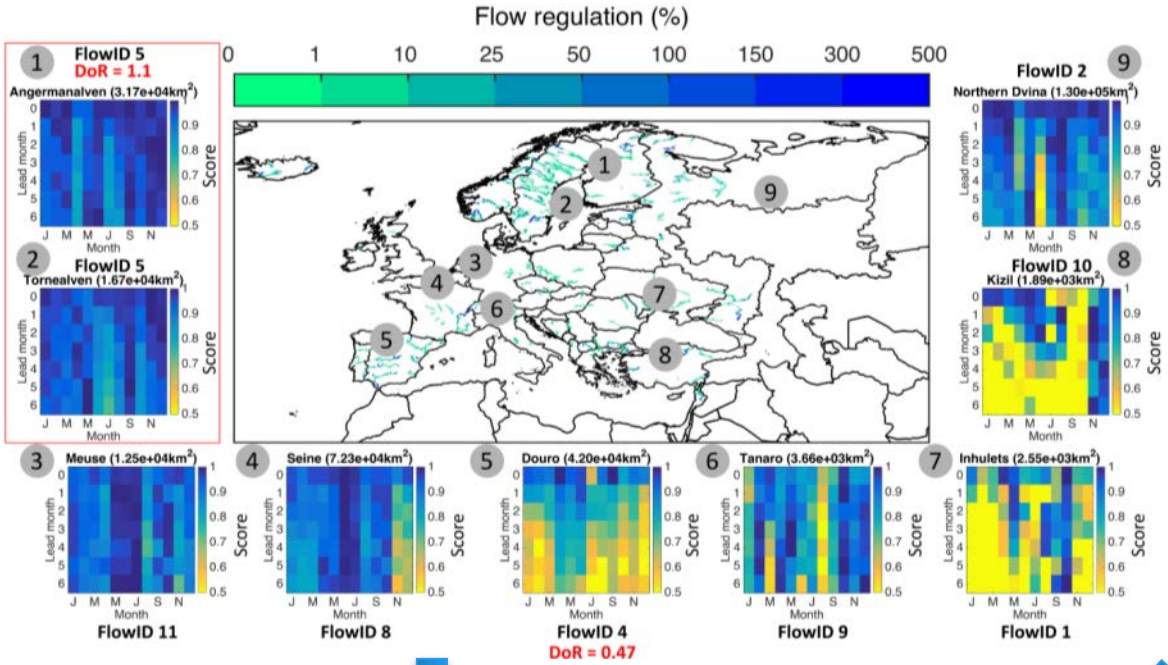


n score in *beta* as a function of lead time and initialisation month over the entire European domain. Each coloured curve corresponds to the hindcasts initialised in a single month.

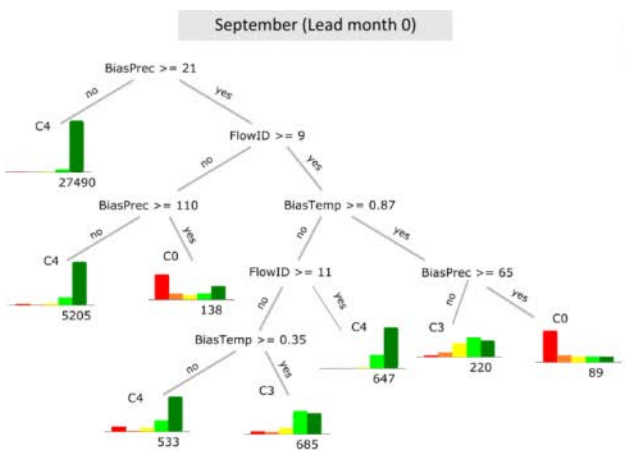


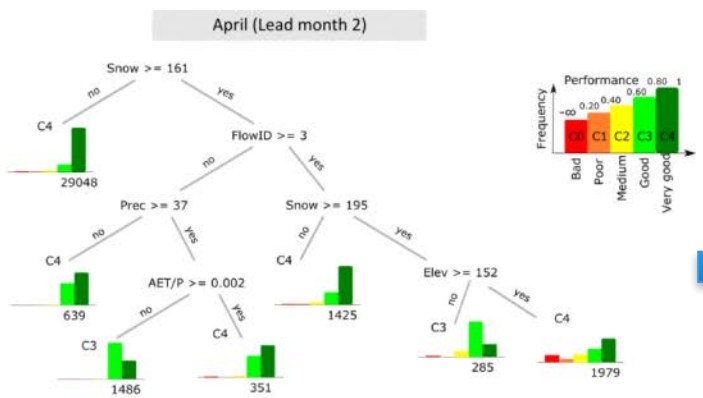
imprex
Learn from today to anticipate tomorrow

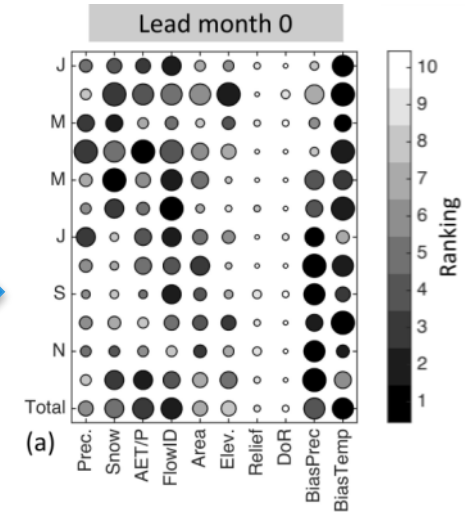
Process understanding



Climatology / Forcing biases (9 characteristics)	Topography (4)	Human impact (1)	Hydrologic signatures (15)
Precipitation (mm/month)	Area (km²)	Degree of regulation (%)	Mean annual specific runoff (Qm)
Temperature (°C)	Elevation (m)		Normalised high flow (q05)
Snow depth (cm/month)	Relief ratio (-)		Normalised low flow (q95)
Actual evaporation (mm/month)	Slope (%)		Normalised relatively low flow (q70)
Potential evaporation (mm/month)			Slope of flow duration curve (mFDC)
Dryness index (-)			Range of Parde coefficient (DPar)
Evaporative index (-)			Coefficient of variation (CV)
Bias in precipitation (%)			Flashiness (Flash)
Bias in temperature (%)			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)

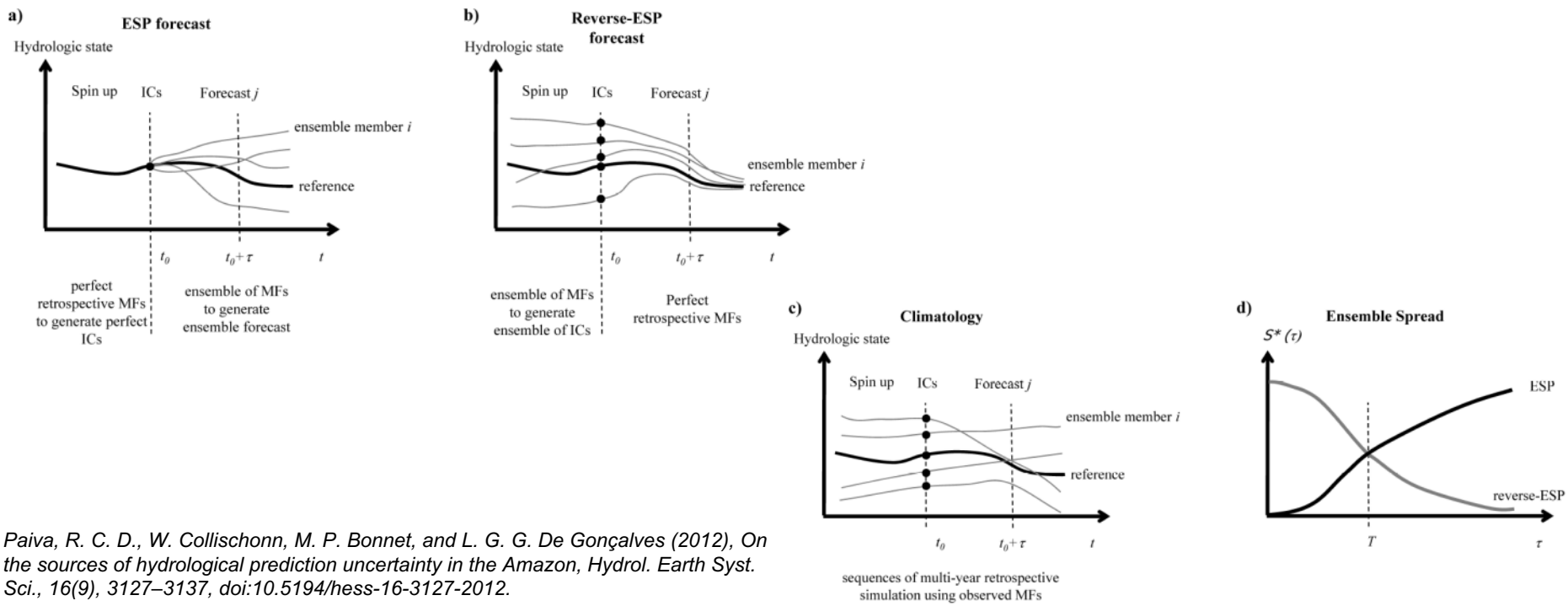




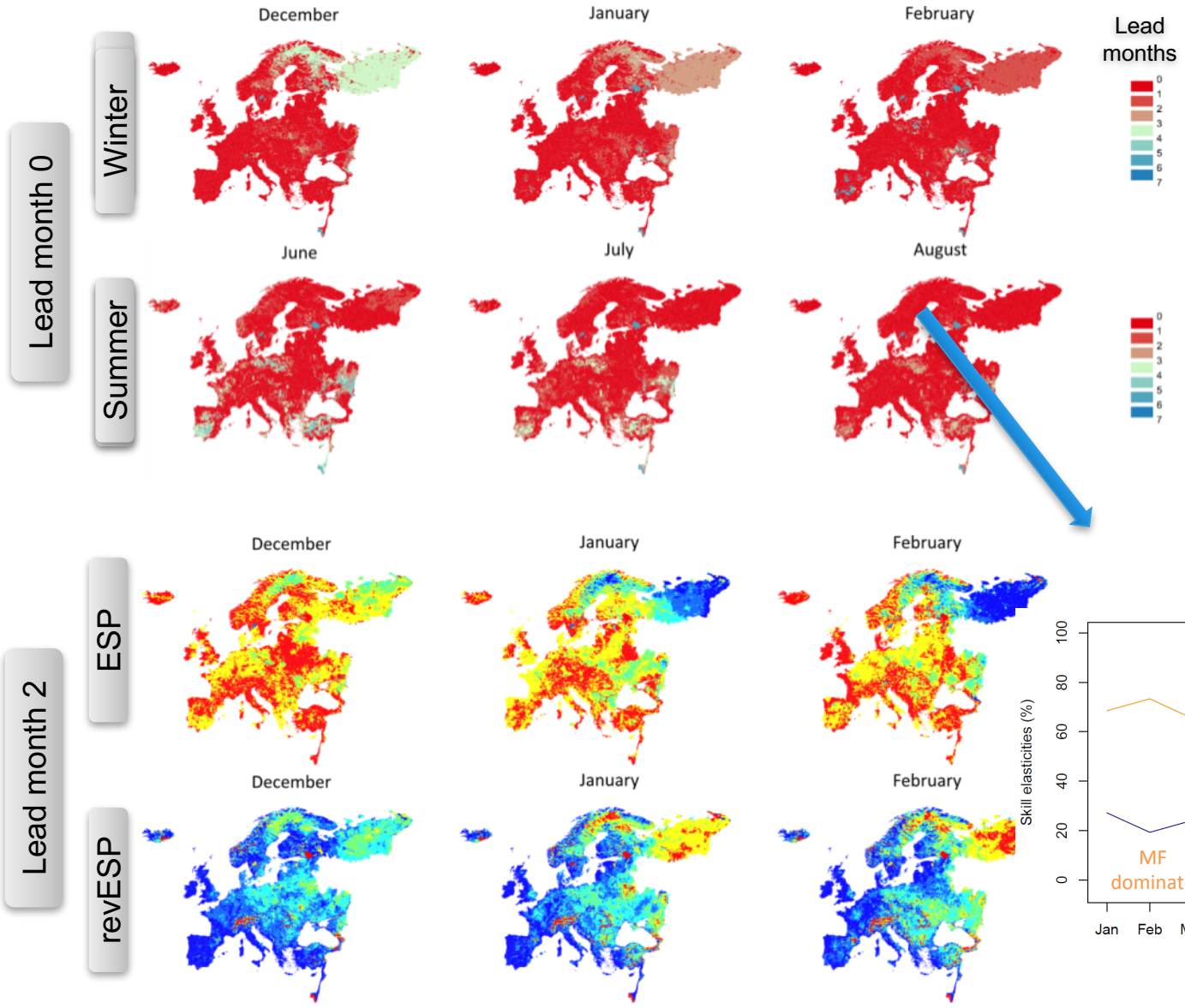


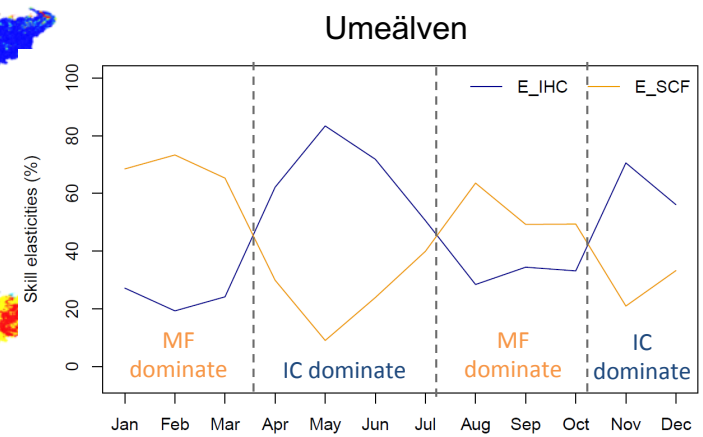
Sensitivity analysis

- 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).
- Use of the EPB (End Point Blending) method (Arnal et al., 2017) to quantify the change in the skill of model output to a known variation in the model input (here CF and IHC).



Paiva, R. C. D., W. Collischonn, M. P. Bonnet, and L. G. G. De Gonçalves (2012), On the sources of hydrological prediction uncertainty in the Amazon, Hydrol. Earth Syst. Sci., 16(9), 3127–3137, doi:10.5194/hess-16-3127-2012.


Lead month 0
Winter
December
January
February
Lead months
0
1
2
3
4
5
6
7
Summer
June
July
August
Lead month 2
ESP
December
January
February
revESP
December
January
February


Umeälven
E_IHC
E_SCF
Skill elasticities (%)
0
20
40
60
80
100
MF dominate
IC dominate
MF dominate
IC dominate
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Umeälven Case study

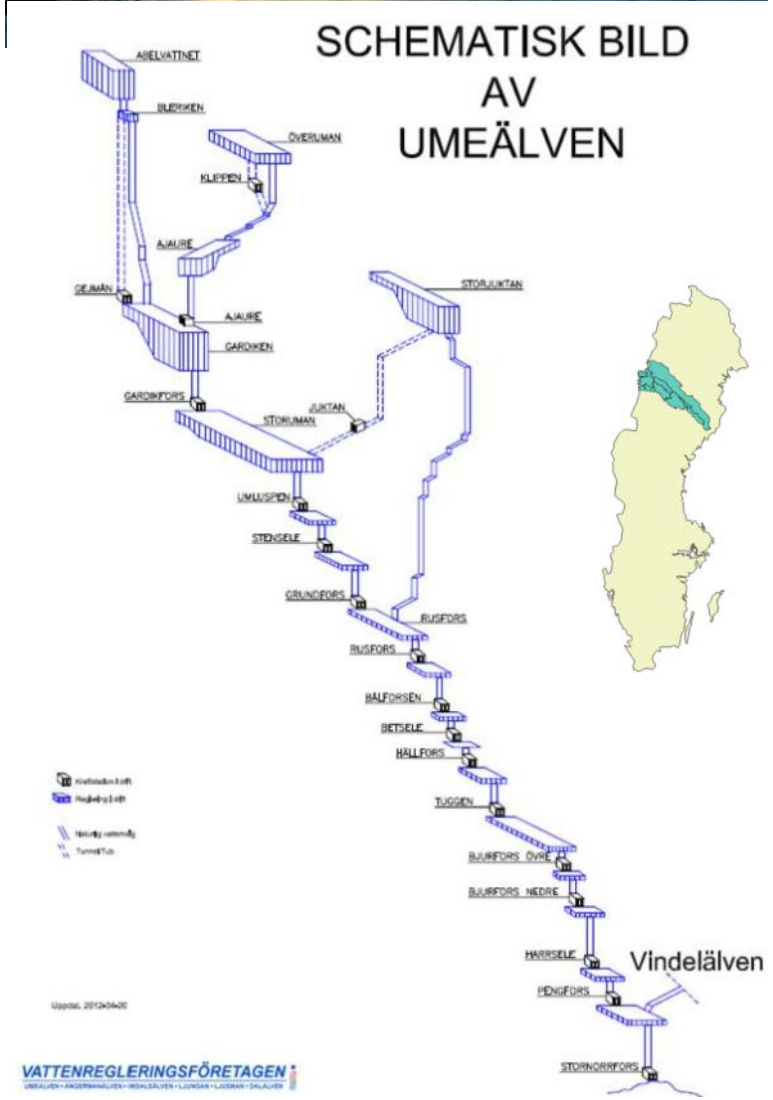
Reservoir inflow forecasts (daily and seasonal) are used for production planning

Seasonal forecasts most important for the *large reservoirs* in the upper part of the river:

- stores water from one winter to the next
- water that can produce in all downstream HP plants
- issued every week (month?) from 1 Jan to forecast the remaining inflow until ~31 July (or August).

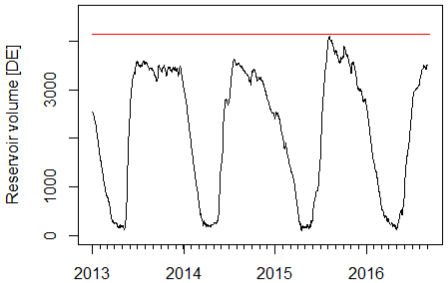
Management goal:

- use as much water as possible for production in the current year
- Reach a target reservoir level of ~90% at the end of snow melt season (31 July or 31 August)

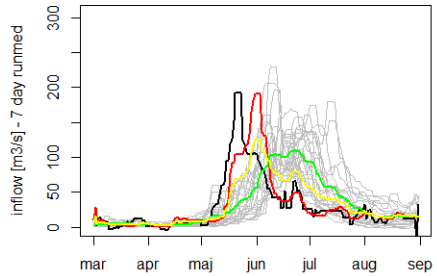


Economical model for seasonal forecast evaluation

Reservoir volume



Inflow forecast



Production capacity

MWh/vol downstream HP

Electricity price (*SEK/MWh*)

Historical prices (Nord Pool)

For each seasonal inflow forecasts (one/month, Jan-July):

1) Available volume for production:

$$prod_{vol} = inflow_{vol} - (0.9 * max_{vol} - curr_{vol})$$

2) Production value:

$$prod_{Val} = prod_{vol} * MWh/vol * SEK/MWh$$

3) Forecast cost:

$$Cost_{forecast} = |prod_{val}(\text{for. inflow}) - prod_{val}(\text{obs. inflow})|$$

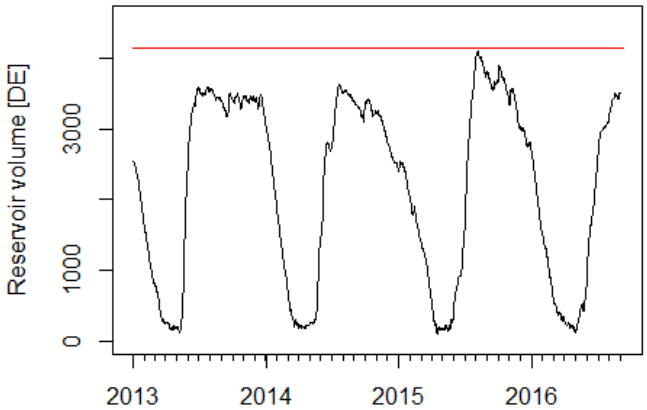
4) Forecast evaluation:

- Value of a new forecast system can be assessed versus the cost of a climatological forecast
- Potential of improvement can be assessed versus the cost of a “perfect forecast” (reference simulation)

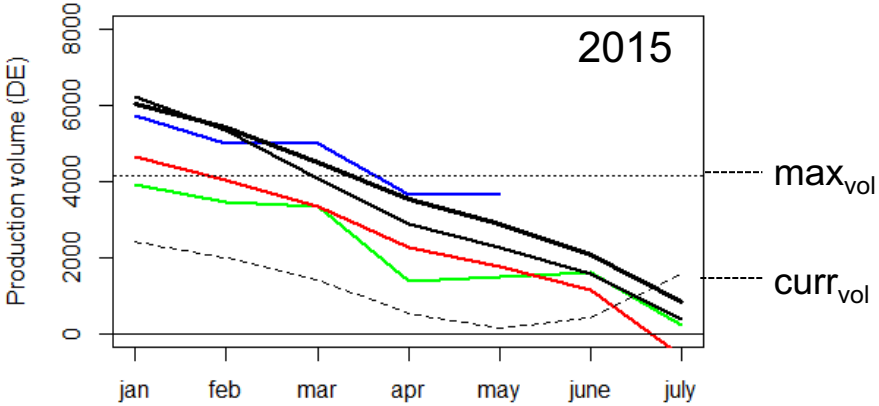
Impact based modelling (economic)

Seasonal forecast evaluation – Överuman 2015 (January-July)

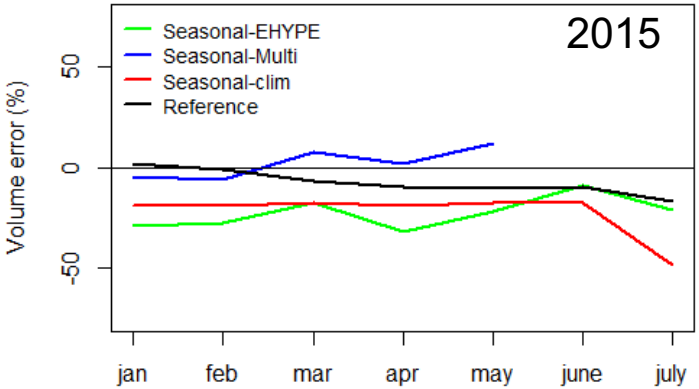
Reservoir volume (DE)



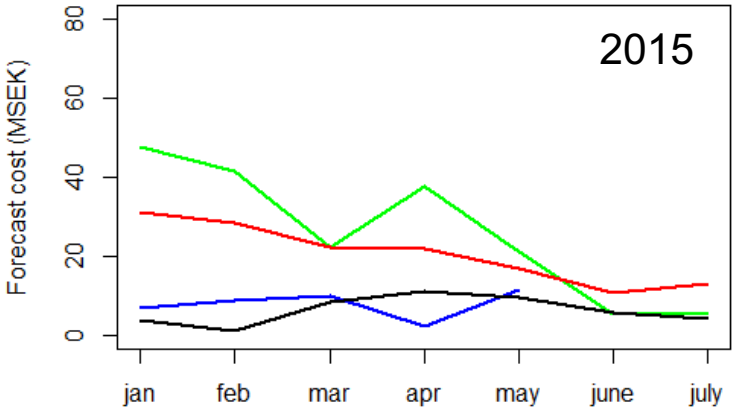
Forecasted production volume (DE)



Forecast Volume Error (%)

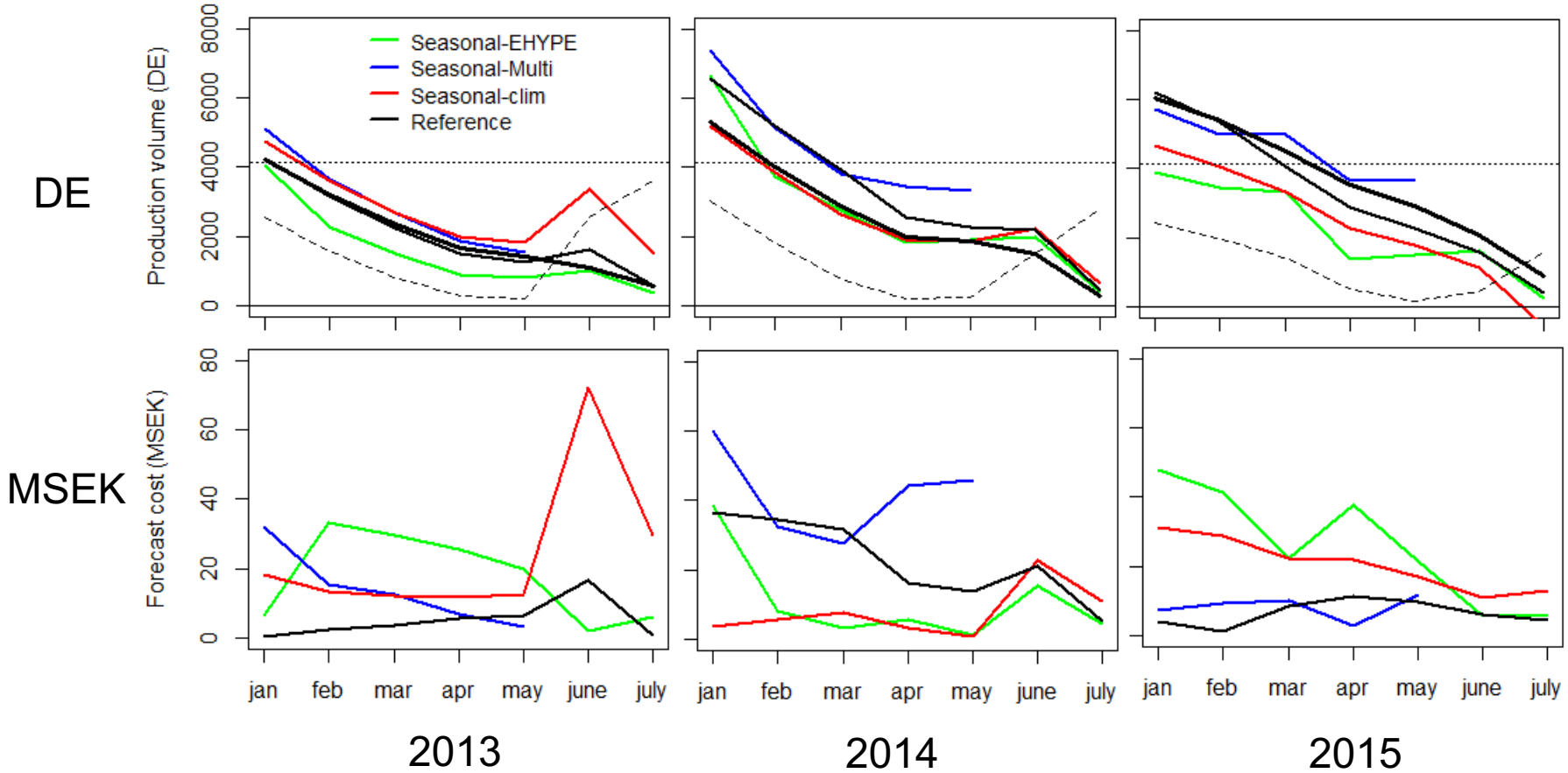


Forecast cost (MSEK)



Impact based modelling (economic)

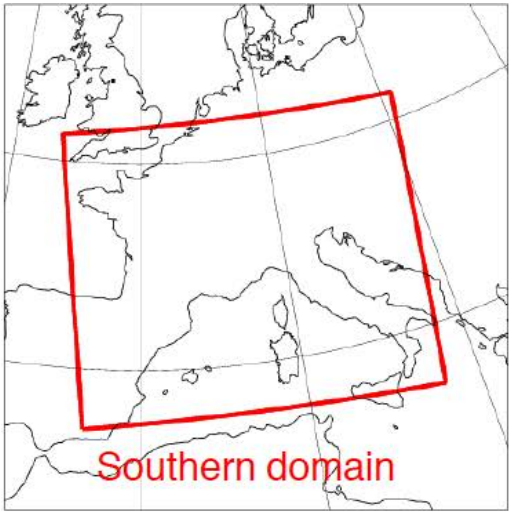
First example results – Överuman 2013-2015 (January-July)

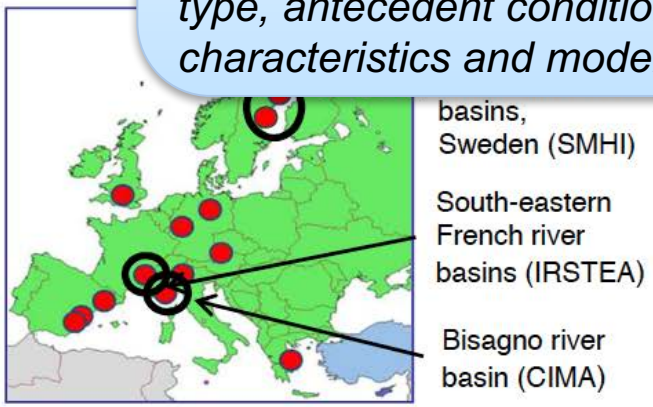


High resolution NWP

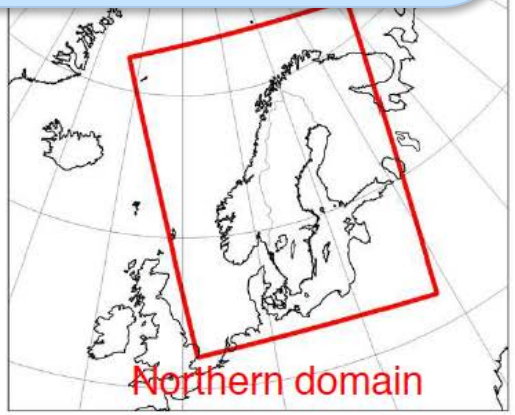
What is the added value for continental services from using high-resolution NWPs in comparison to the benchmark ECMWF deterministic/probabilistic forecasts?

How does this vary as a function of catchment scale, type, antecedent conditions, precipitation characteristics and model resolution?





Location of places for all WP 6 case studies. Black circles those for which has expressed interest in HARMONIE NWP data and for which data has been delivered.



Periods run for South-Eastern French river basin case studies

- 12-19 June 2013
- 21-28 July 2013
- 22-25 June 2014
- 28 June-5 July 2014
- 24 July-1 Aug 2014

Periods run for Bisagno river basin case studies

- 2-5 June 2011
- 8-11 July 2014
- 13-15 June 2015

Periods run for Umeälven, Ångermanälven river basin case studies

- 9 -27 June 2013
- 7 July-6 August 2015

S2S4E

SMHI

Weather forecast	Climate predictions			Climate projections or multidecadal
	Sub-seasonal	Seasonal	Decadal	
1-15 days	10 d-1 month	1 month–2 years	2-30 years	20-100 years

Applications for wind/solar/hydro generation

Post-construction decisions

Energy producers: commit energy sales for next day
Grid operators: Market prices and grid balance
Energy traders: Anticipate energy prices
Plant operators: planning for cleaning and maintenance

Post-construction decisions

Energy producers: Resource management strategies
Energy traders: Resource effects on markets
Plant operators: Planning for maintenance works, especially offshore wind O&M
Plant investors: anticipate cash flow, optimize return on investments

Pre-construction decisions

Power plant developers: Site selection. Future risks assessment.
Investors: Evaluate return on investments
Policy-makers: Asses changes to energy mix
River-basin managers: understand changes to better

Applications for demand

Daily operation decisions

Grid operators:
Anticipate cold days (heating demand).
Anticipate hot days (AC demand).
Schedule power plants to reinforce supply.
Energy traders: Anticipate energy prices.

Mid-term planning

Grid operators:
Anticipate colder seasons (heating demand)
Anticipate hotter seasons (AC demand).
Schedule power plants to reinforce supply.
Energy traders:
Anticipate energy prices.

Lo

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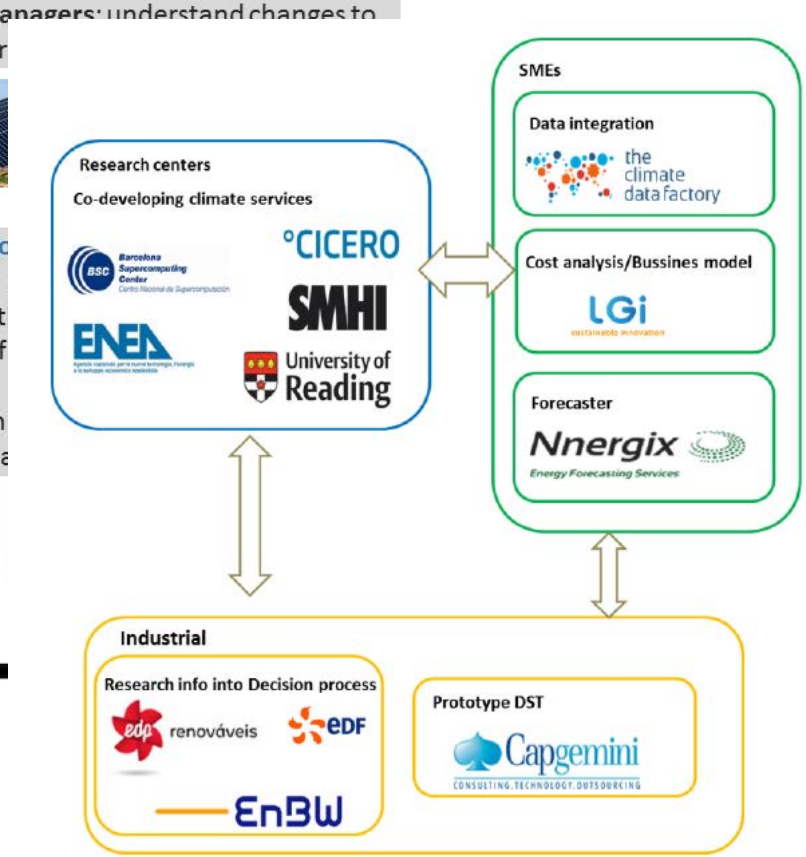
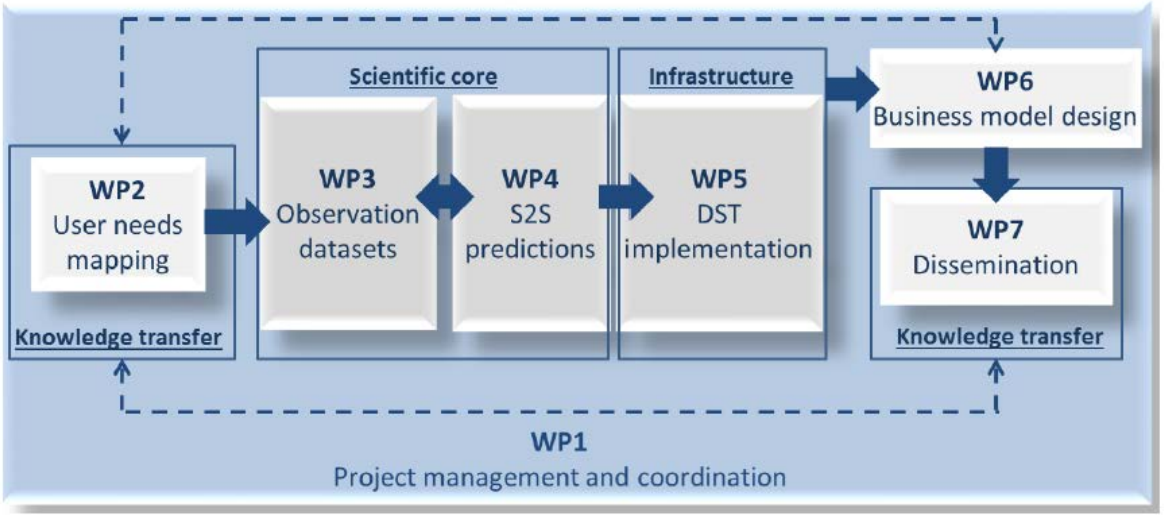
S2S4E project

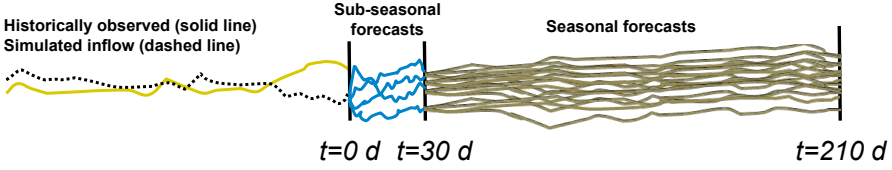


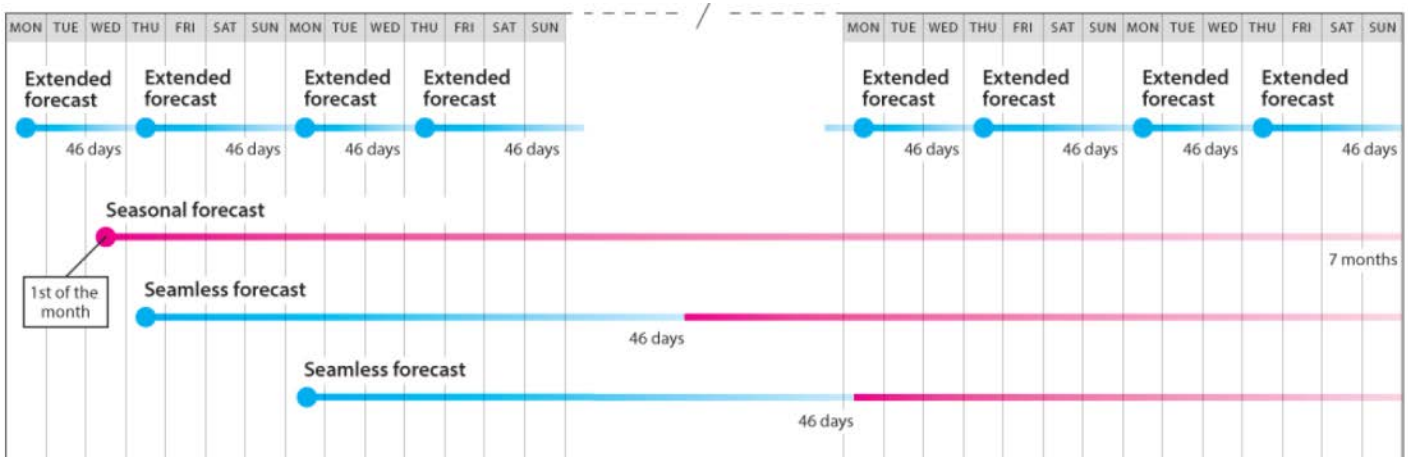
Project WP interactions



Seamless forecasts

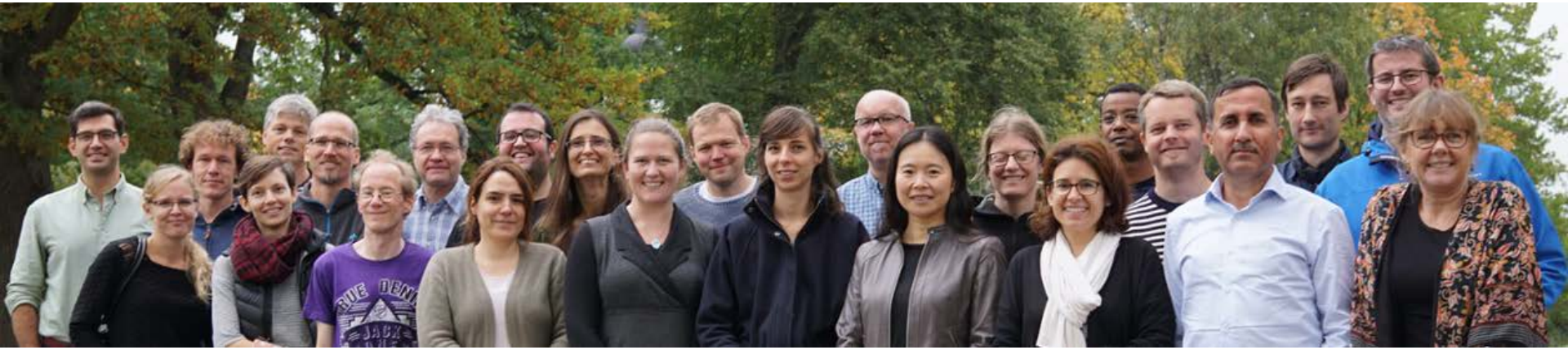
The seamless idea could be translated into the simple concatenation of “the best” forecast at each lead time. Hence it utilizes products that are already in place, thereby avoiding the complications of new developments while generating forecast products to meet different types of users.





Systems:
ECMWF ENS-ER
ECMWF System 5

SMHI



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