

Ilias Pechlivanidis, L. Crochemore, F. Gyllensvärd, T. Bosshard, P. Berg, B. Arheimer

An operational pan-European seasonal hydro-climatic forecasting service

How to better communicate improved forecasts with users?

What are the limits of predictability for forecasting systems?

How would the users respond to forecasting signals of different quality; narrow the gap between results and interpretation?

Ilias Pechlivanidis, Nicholas J. Mcchemore, F. Gyllensvärd, T. Bosshard, P. Berg, B. Arheimer

Operational pan-European seasonal hydrological forecasting service



Climate
Change

Sectorial Information System: P o C W A T E R

WHAT WILL THE INFORMATION BE USED FOR?

The wealth of climate information will be the basis for generating a wide variety of climate indicators aimed at supporting adaptation and mitigation policies in Europe in a number of sectors. These include, but are not limited to, the following:

WATER MANAGEMENT **AGRICULTURE & FORESTRY** **TOURISM** **INSURANCE** **TRANSPORT**

ENERGY **HEALTH** **INFRASTRUCTURE** **DISASTER RISK REDUCTION** **COASTAL AREAS**

C3S WILL DELIVER SUBSTANTIAL ECONOMIC VALUE TO EUROPE BY:

- 1** **INFORMING**
POLICY DEVELOPMENT TO PROTECT CITIZENS FROM CLIMATE-RELATED HAZARDS SUCH AS HIGH-IMPACT WEATHER EVENTS
- 2** **IMPROVING**
PLANNING OF MITIGATION AND ADAPTATION PRACTICES FOR KEY HUMAN AND SOCIETAL ACTIVITIES
- 3** **PROMOTING**
THE DEVELOPMENT OF NEW SERVICES FOR THE BENEFIT OF SOCIETY

- ‘Proof-of-Concept’ in C3S for Sectorial Information System
- Nov. 2015 – Feb. 2018:
 - Co-design a web service with users (Knowledge Purveyors)
 - Define & Provide Climate Change Indicators and Seasonal Indicators (CII and SI)
 - Evaluate user uptake
- <http://swicca.climate.copernicus.eu/>



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PROOF OF CONCEPT

Opernicus Europe's eyes on Earth | Climate Change Service

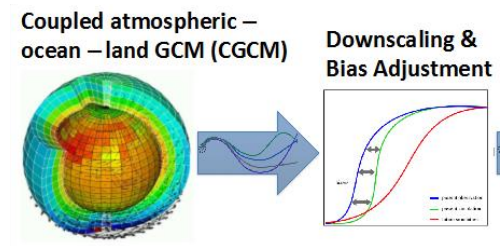
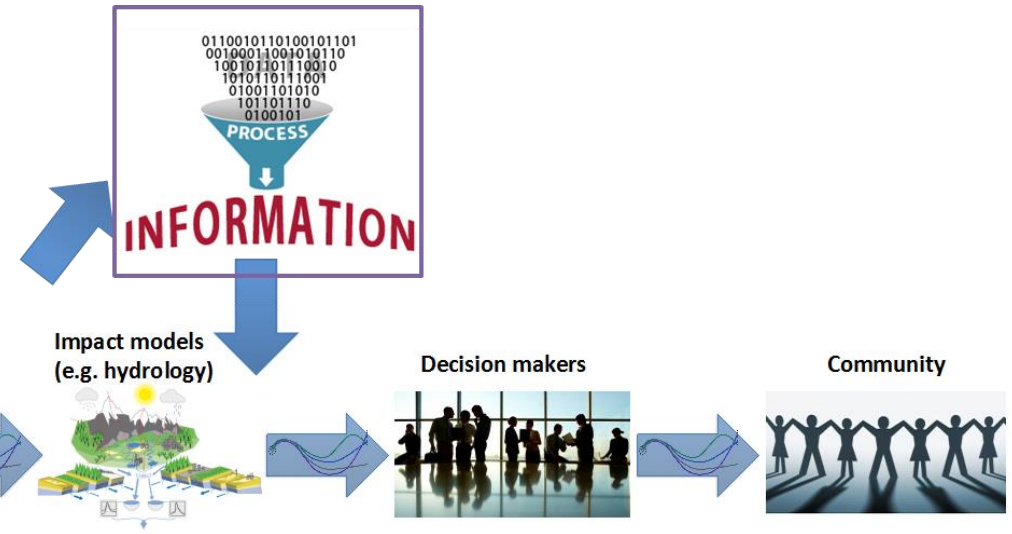
C3S SWICCA CLIMATE IMPACTS SEASONAL FORECASTS SHOWCASES USER GUIDANCE ABOUT

SWICCA
Service for Water Indicators in Climate Change Adaptation

SWICCA offers readily available climate-impact data to speed up the workflow in climate-change adaptation of water management across Europe.

- Getting started
- Maps, graphs and downloads
- About SWICCA data
- Showcases

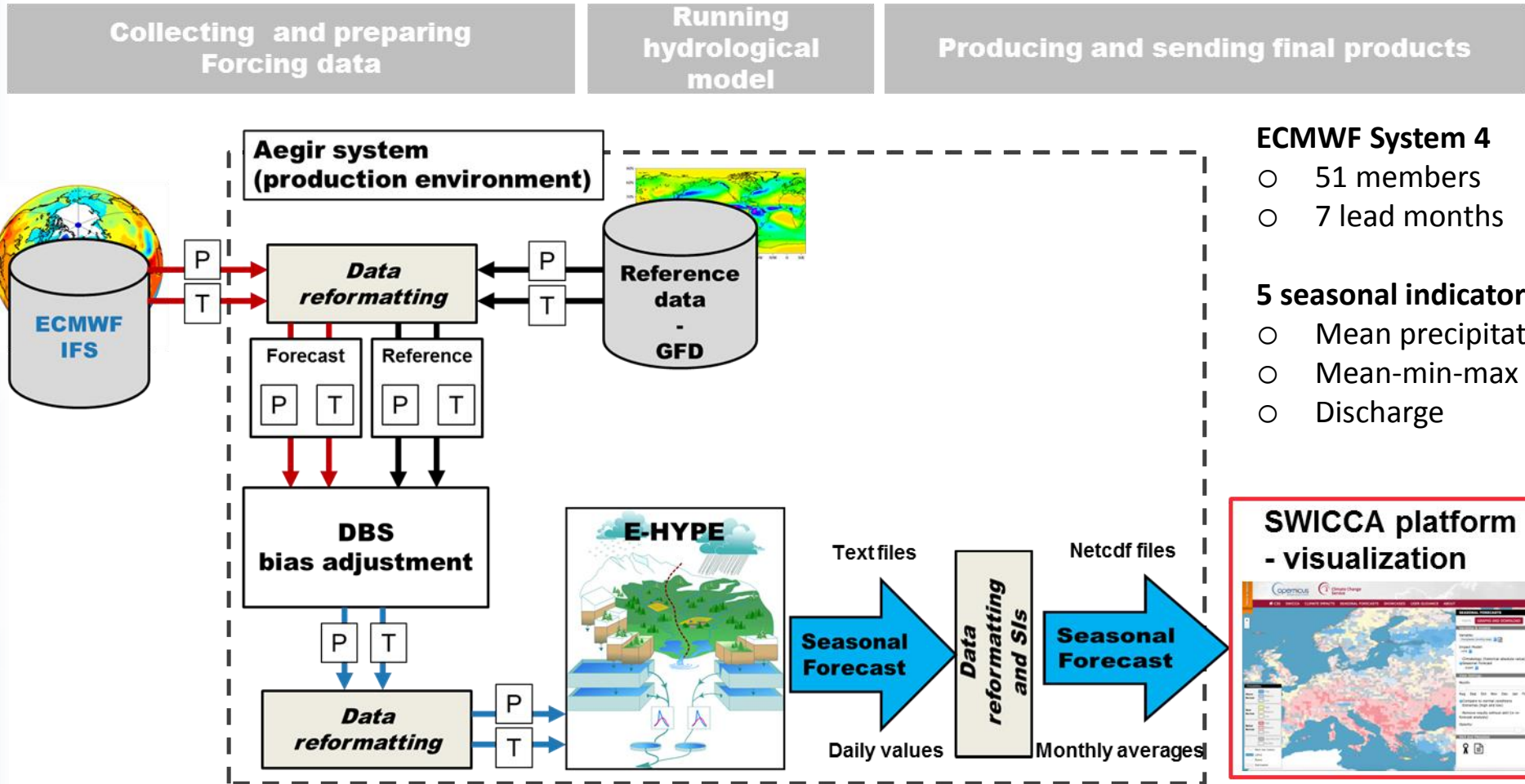
Consulting engineers: Make your own climate impact assessments!





Climate
Change

Seasonal forecasting service



ECMWF System 4

- 51 members
- 7 lead months

5 seasonal indicators (SIs)

- Mean precipitation
- Mean-min-max temperature
- Discharge

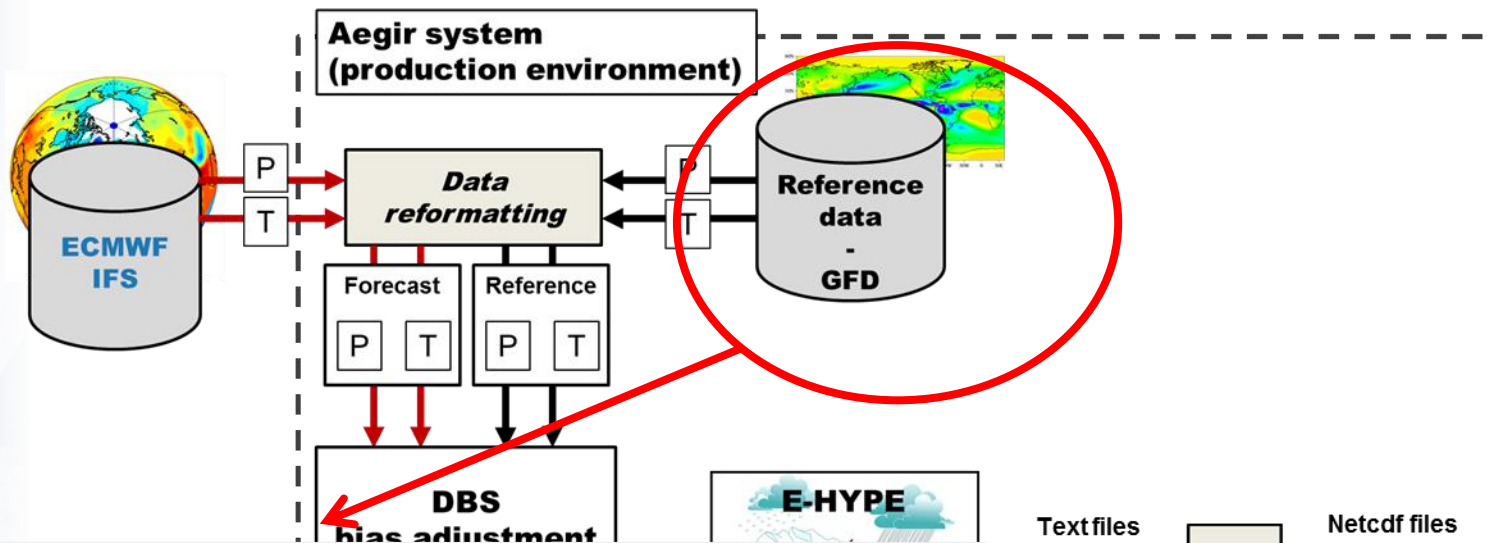
SWICCA platform - visualization





Climate Change

Seasonal forecasting service

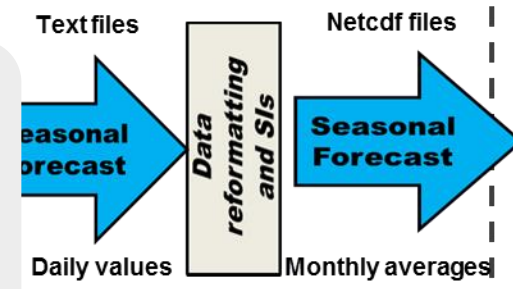
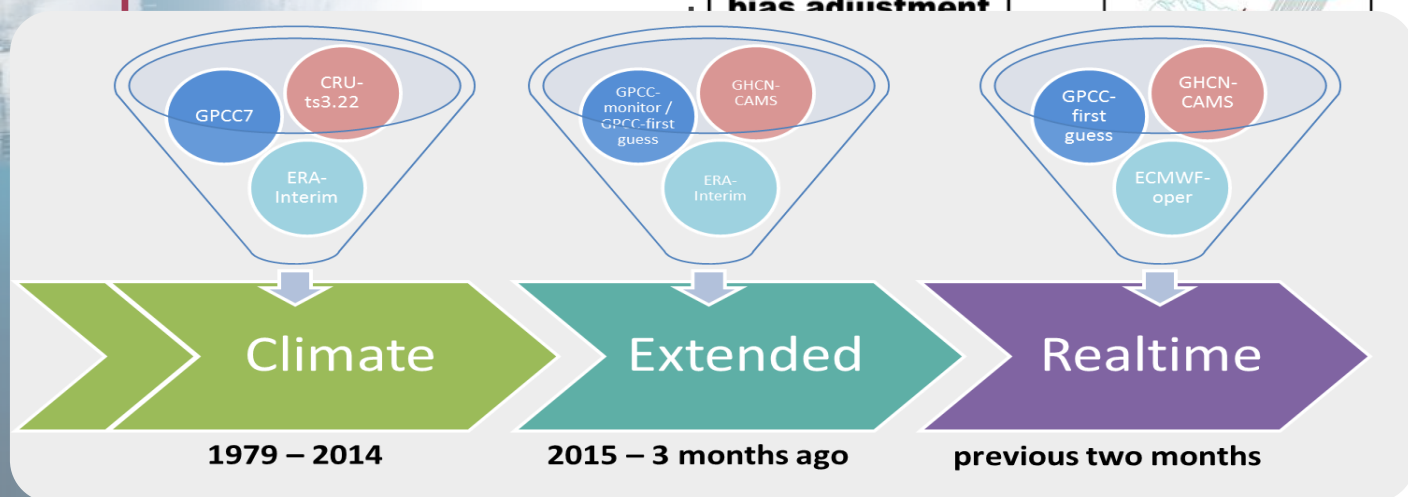
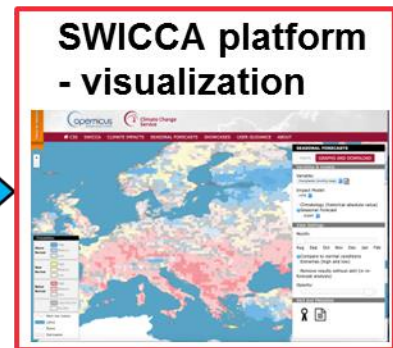


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Climate Change

C3S for Water content: Maps

PROOF OF CONCEPT

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C3S SWICCA CLIMATE IMPACTS SEASONAL FORECASTS SHOWCASES USER GUIDANCE ABOUT

SEASONAL FORECASTS

MAPS | **GRAPHS AND DOWNLOAD**

Variables & models

Variable: Precipitation (monthly mean)

Impact Model: HYPE

Climatology (historical absolute value)

Seasonal Forecast

ECMWF

View Settings

Month: Aug Sep Oct Nov Dec Jan Feb

Compare to normal conditions

Extremes (high and low)

Remove results without skill (in re-forecast analysis)

Opacity: [Slider]

Skill and Metadata

Legend:

Probabilities	
Above Normal	High
	Medium
	Low
Near Normal	High
	Medium
	Low
Below Normal	High
	Medium
	Low
Less than low	
No Skill	
Main river basins	
Lakes	
Rivers	
Sub-basins	

Probability

Low 35-50%

Medium 50-75%

High 75-100%

Otherwise unreliable

Monthly (month compared to normal month)

Above Normal >66%

Near Normal >33% and < 66%

Below Normal < 33%

Extremes (month compared to extreme month)

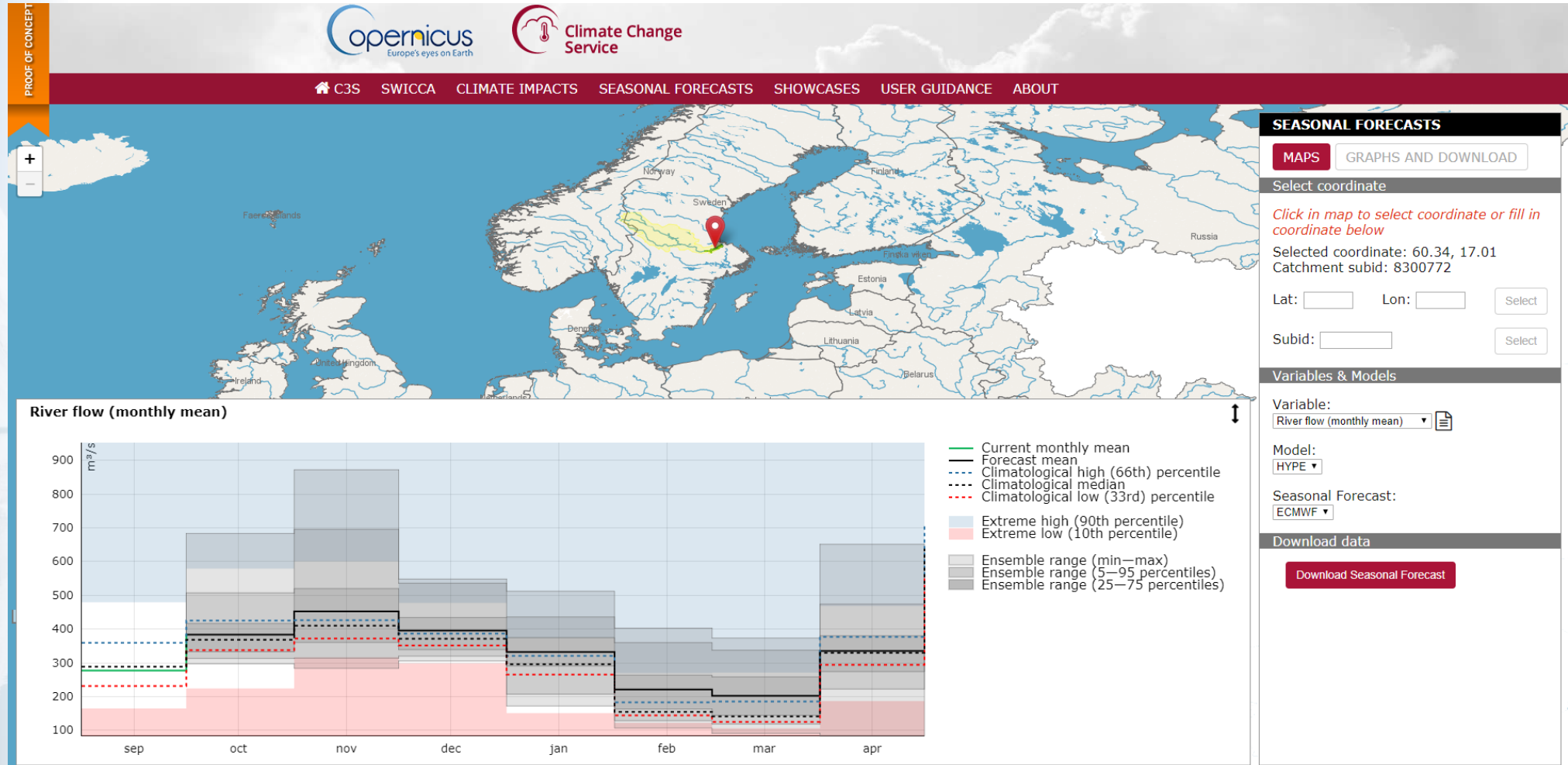
High Extreme > 90%

Low Extreme < 10%



Climate Change

C3S for Water content: Graphs & Downloads

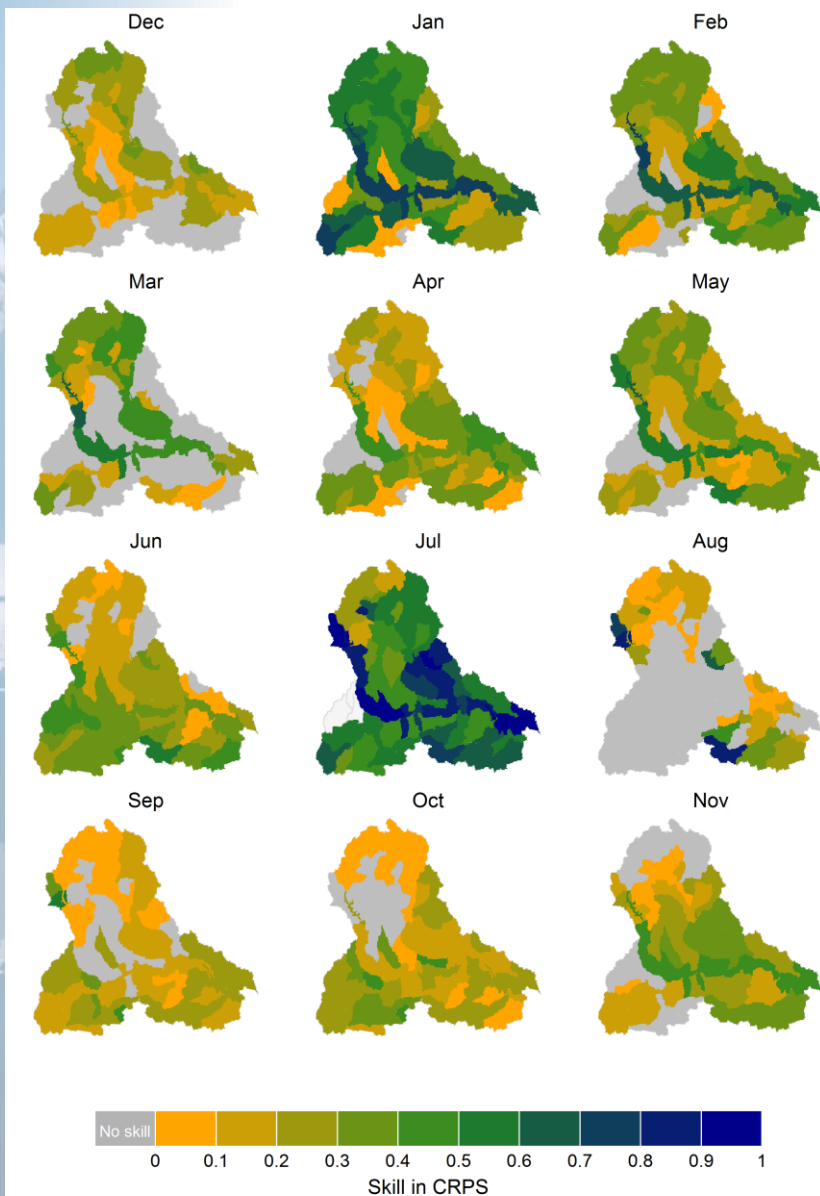




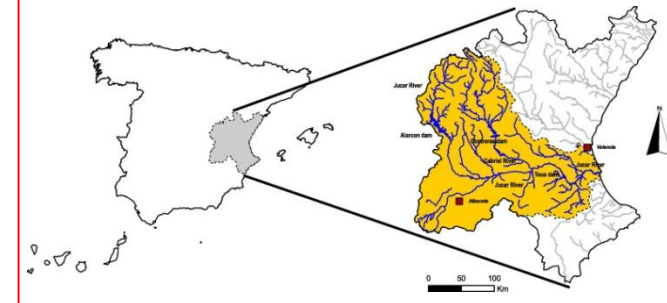
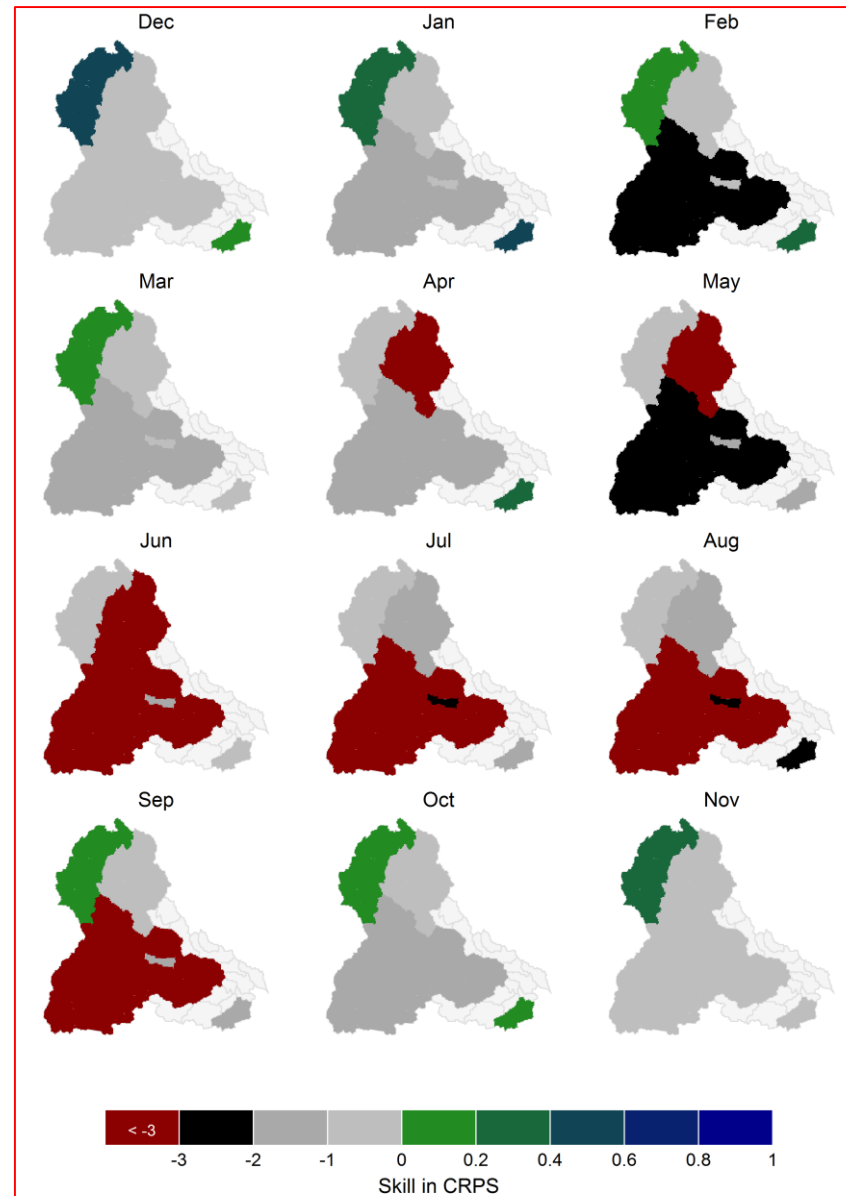
Climate
Change

Limitations of services: the Jucar river

Pseudo-reality



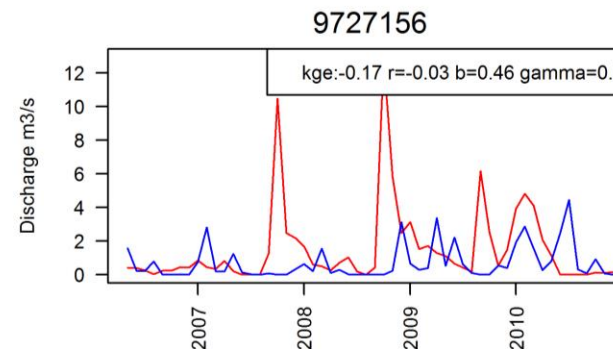
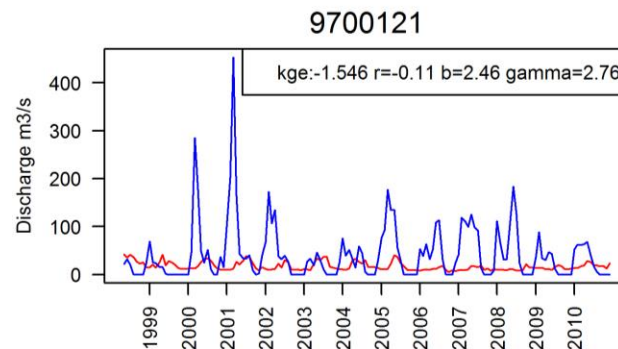
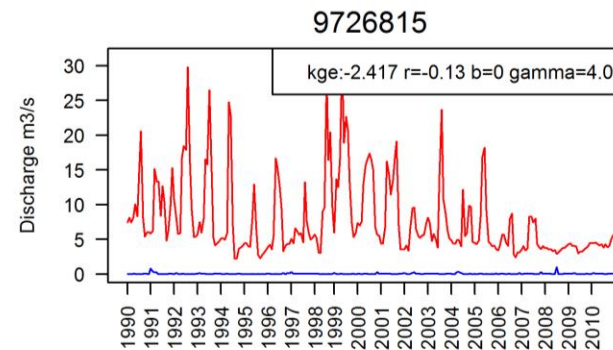
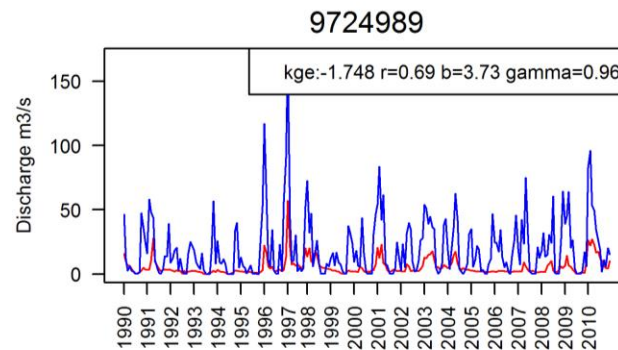
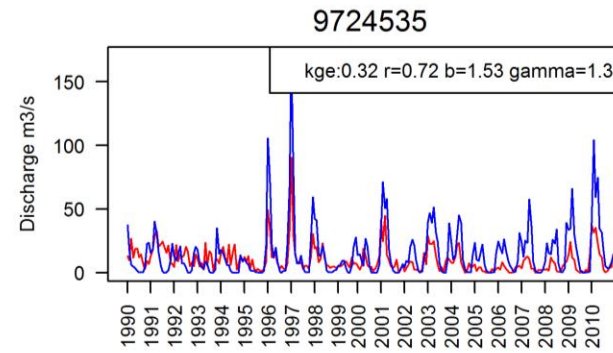
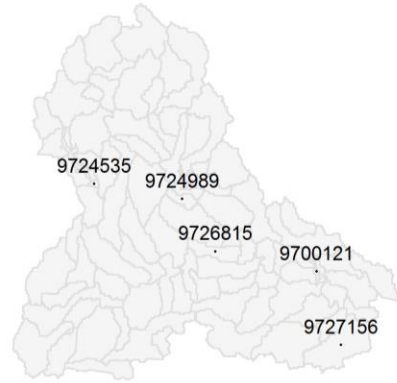
Reality





Climate
Change

Limitations of services: the Jucar river



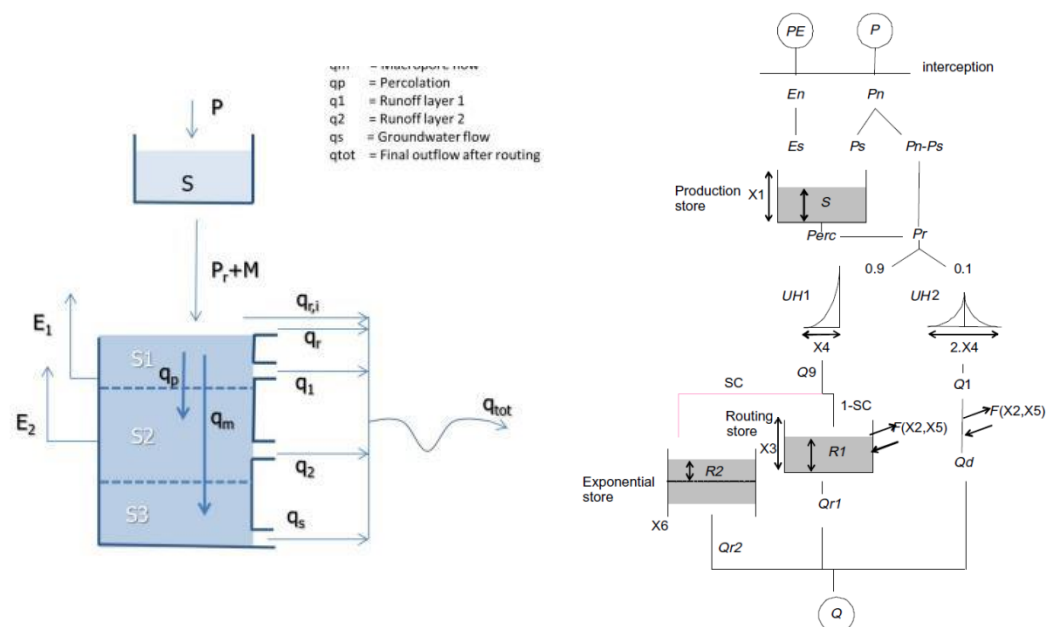
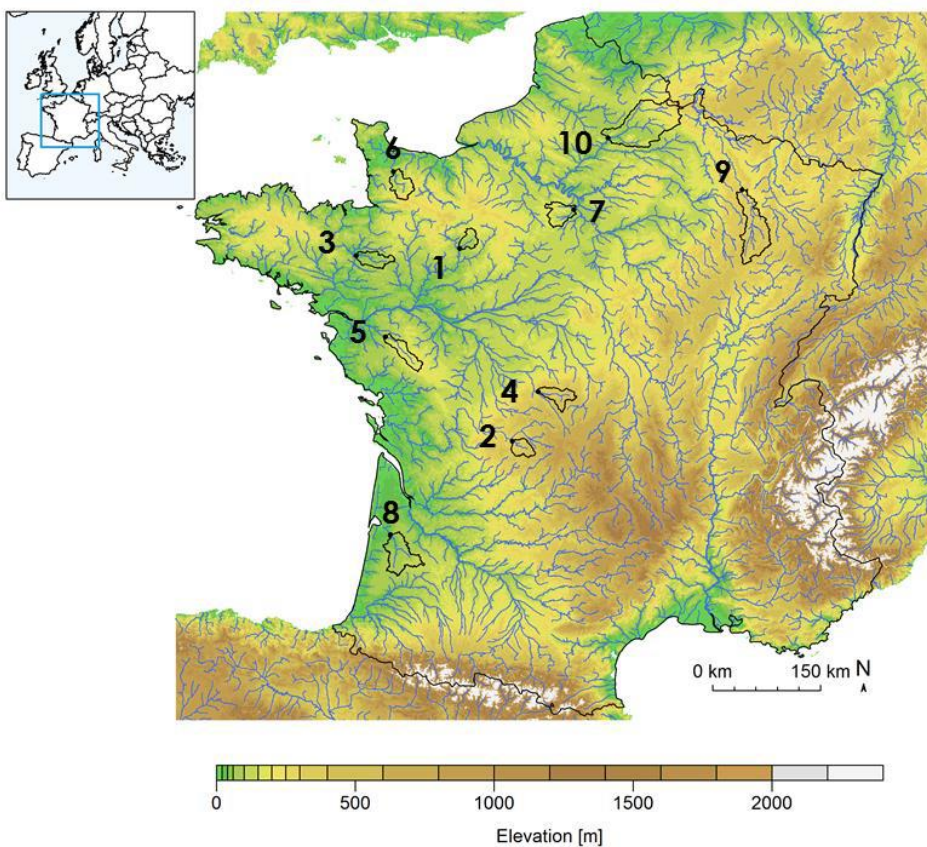
Jucar river is a complex system due to management and groundwater interaction.



Climate Change

Methods for information extraction?

**Continently calibrated vs regionally calibrated hydrological assessments:
Analysis over 10 French basins**



	EHYE	GR6J
Model characteristics		
Type of model	Process-based	Conceptual
Number of parameters	100 +	6
Calibrating framework		
Scale	Calibrated continentally	Calibrated regionally
Strategy	Period split	Leave-one-out
P/T time series	GFD	Météo-France
Q time series	Selected catchments in Europe	Banque Hydro database



Climate Change

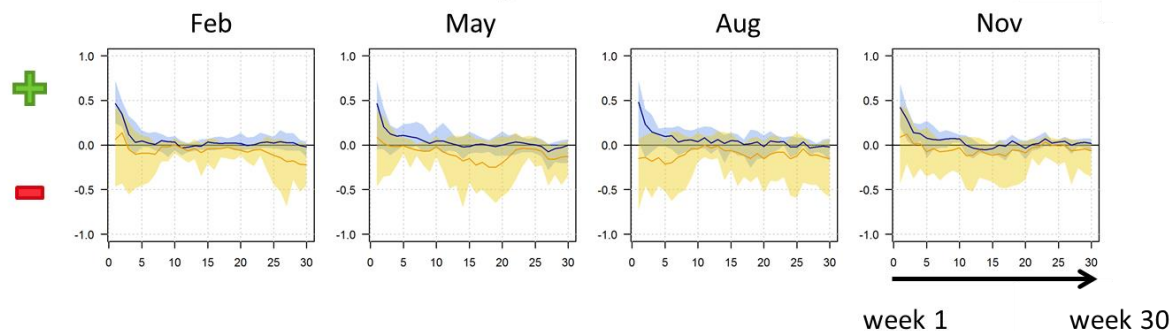
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 GR6J
 EHYPE

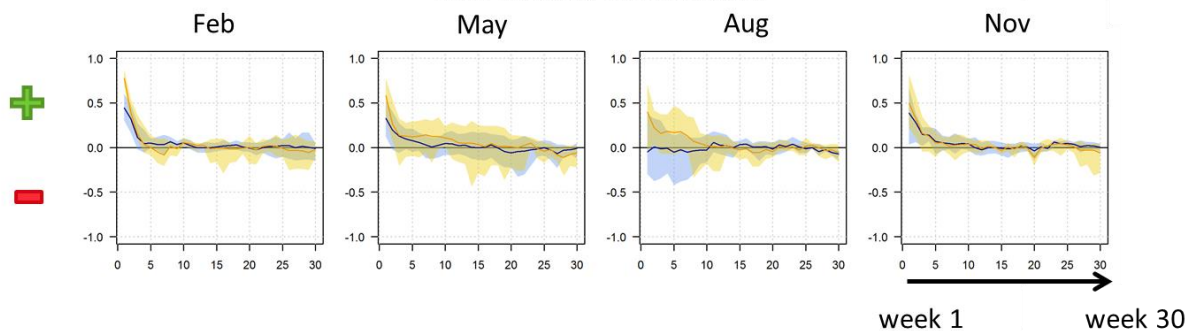
Skill against observations

GCM + IC + Mod

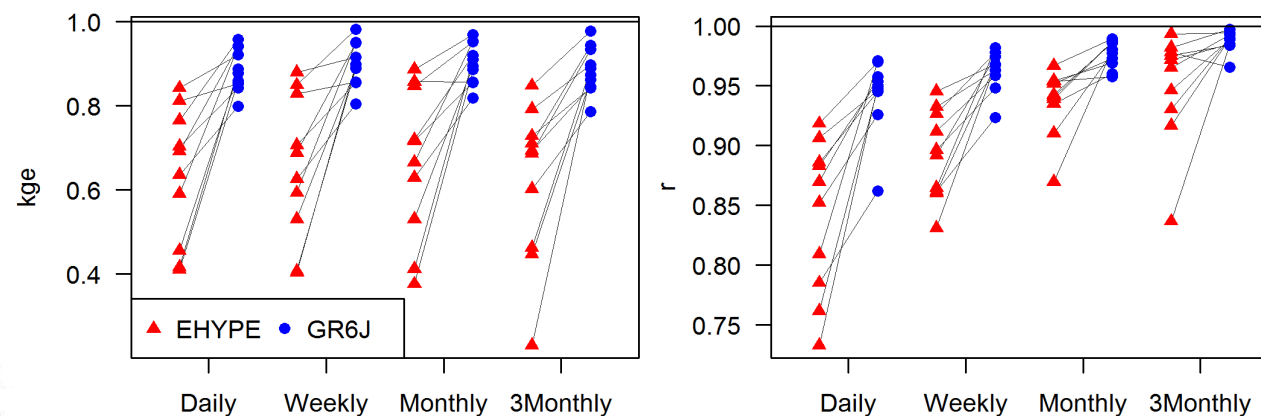


Skill against simulations

GCM + IC



KGE and r model performance



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Climate
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Co-design with Knowledge Purveyors

- Local SMEs/Agencies interacting with Clients in 15 case-studies

Resource allocation (multiple use)

- Climate-proof Irrigation Strategies, IT
- Snow Effects on Water Availability, SP
- Extensive Drought Operations, SP

Risk management

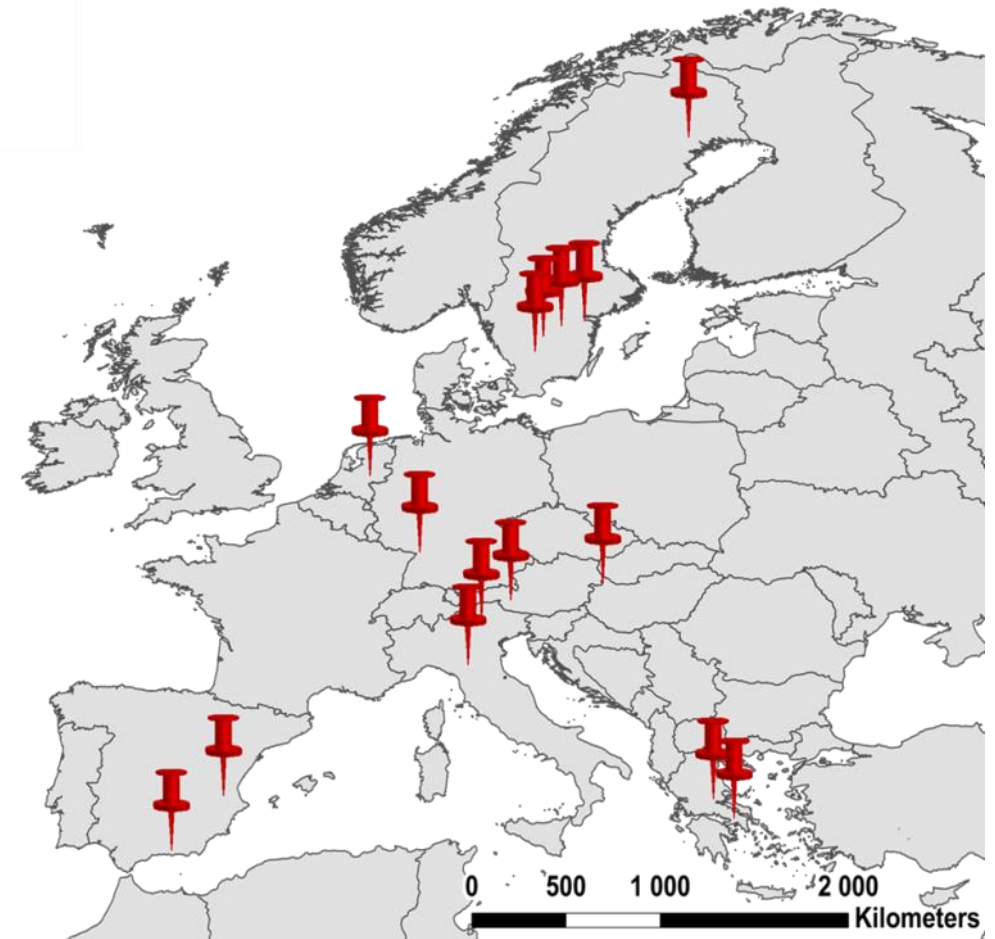
- Climate Change and Flash-Floods, AT
- Warnings for Extreme River Floods, SL
- Risk for River Flooding in Lake-rich Regions, SE

Ecological status

- Environmental flows and point source emissions, GR
- Climate-proof River Water Balance, IT
- Predicting Change in Lake Ecosystems, SE
- Climate Change Effects on Water Quality, SE

Water related industry

- Drinking water in a future climate, SE
- Inland Navigation (Rhine River), DE
- Future proof region and brewery chain, NL
- Water demand and supply of metallurgy sector, GR
- Hydro Power production in a future climate, SE





Climate
Change

You can give your FEEDBACK!!!

What do you prioritise most in a seasonal forecasting service:

- Guidance?
- Data quality?
- User friendliness of web interface?
- Technical tools?
- Key messages?
- Maps and graphs?
- Data downloads?
- Predictability at the local scale?
- Support service?
- Showcases?
- Hands-on training?
- *Anything else? (suggestions are Welcome!)*

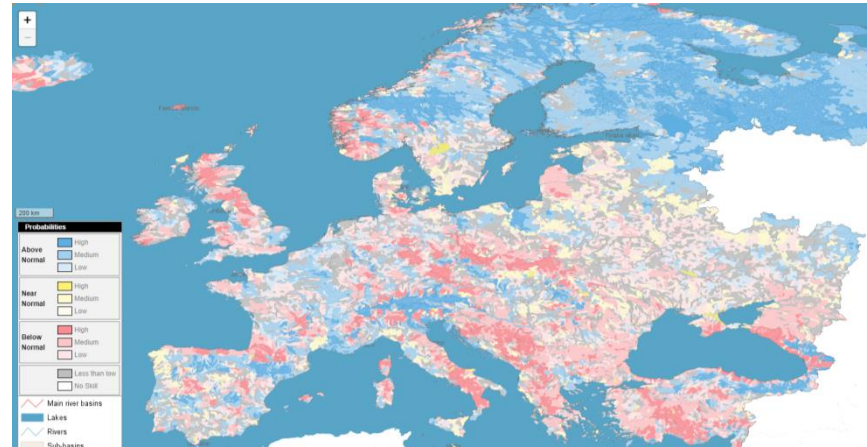


Climate Change

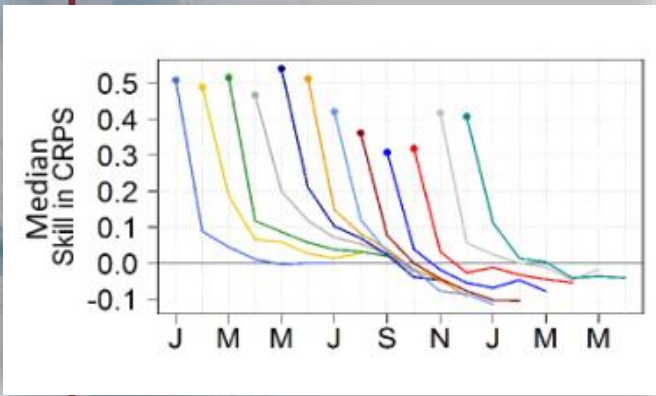
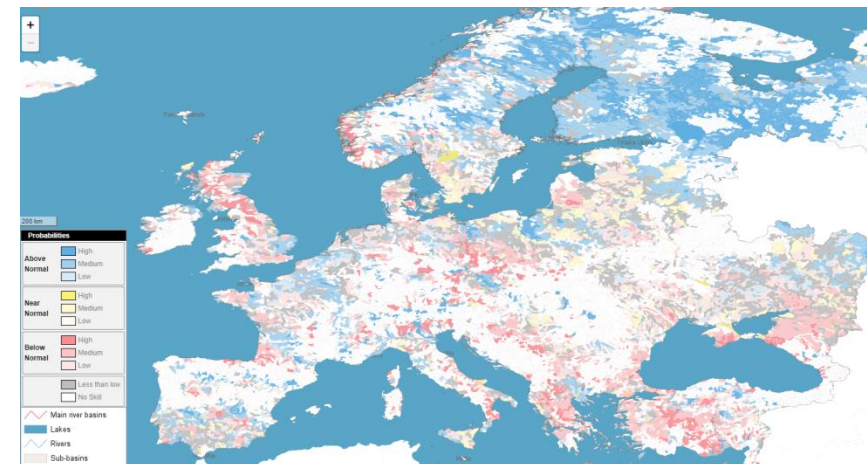
Lessons learnt from user engagement

1. Communication... communication... communication!!!

All catchments



ONLY catchments with skill



Forecasting performance: season, lead time, location, regime...

SEASONAL FORECASTS

MAPS **GRAPHS AND DOWNLOAD**

Variables & models

Variable: Precipitation (monthly mean)

Impact Model: HYPE

Climatology (historical absolute value)

Seasonal Forecast

ECMWF

View Settings

Month: Aug Sep Oct Nov Dec Jan Feb

Compare conditions

Extremes (high and low)

Remove results without skill (in re-forecast analysis)

Opacity:

Skill and Metadata



Climate Change

Lessons learnt from user engagement

- 2. The users want Guidance rather than technical tools for local use.
 - *Climate science is difficult and the climate signal is not clear...*

The screenshot shows the Copernicus Climate Change Service website. The top navigation bar includes links for C3S, SWICCA, CLIMATE IMPACTS, SEASONAL FORECASTS, SHOWCASES, USER GUIDANCE, and ABOUT. A search bar is located in the top right corner.

The main content area is divided into two sections:

- Tutorials:** A section titled "SWICCA Tutorials" featuring several video thumbnails:
 - Seasonal prediction of climate
 - Introduction to the C3S SIS...
 - Discussion after the C3S S...
 - Identifying User Needs
 - Uncertainty in SWICCA
 - Bias Correction and Downsc...
 - SWICCA Climate Impact Ind...
- SWICCA Forum:** A forum page titled "SWICCA Forum" with a sub-header "Start > Forums > SWICCA Forum". It states: "This forum contains 16 topics and 109 replies, and was last updated by [user] 1 week, 4 days ago." Below this is a table listing forum topics:

Topic	Voices	Posts	Freshness
Using seasonal forecasts in water management	5	9	2 months, 3 weeks ago
Communicating Confidence	9	9	2 months ago
Doubts about indicators and bias correction	2	2	1 year, 6 months ago
Demonstrator Updates 1 2	6	29	2 months, 3 weeks ago
Hydrological models	2	3	1 week, 4 days ago
Downscaling data/indicators to higher resolution for test cases.	6	12	1 month, 1 week ago
PET equations	3	3	2 months ago
Versions of GCM-RCM data	2	3	2 months, 2 weeks ago

At the bottom of the page, there are logos for Copernicus (Europe's eyes on Earth), the European Union flag, and the Commission logo.



Climate Change

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PROOF OF CONCEPT

FAQ

- [**How to use this SWICCA Demonstrator?**](#)
- [How to estimate climate change impact?](#)
- [What is a climate impact indicator?](#)
- [What is a seasonal forecast variable?](#)
- [Why and how to use an ensemble?](#)
- [Why the spread of values in the ensembles?](#)
- [How to use different RCPs?](#)
- [How to explore confidence in SWICCA results?](#)
- [How does SWICCA Soil Moisture compare to Earth Observations?](#)
- [How does SWICCA Water Temperature compare to Earth Observations?](#)
- [What are the future trends for water resources across Europe?](#)
- [What are the future trends for population across Europe?](#)
- [What are the future trends for land use across Europe?](#)
- [What is the SWICCA Forum?](#)
- [What is the SWICCA project?](#)

Definitions of terms used can be found at the following links:

SWICCA Forum

Start > Forums > SWICCA Forum

This forum contains 16 topics and 109 replies, and was last updated by ladislavgaal 1 week, 4 days ago.

Viewing 15 topics - 1 through 15 (of 16 total) [Log In](#) [Register](#) [Lost Password](#)

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Using seasonal forecasts in water management Started by: hutie001	5	9	2 months, 3 weeks ago Louise C.
Communicating Confidence Started by: Lorna Little	9	9	2 months ago HasseGoosen
Doubts about indicators and bias correction Started by: mapedmon	2	2	1 year, 6 months ago Ingela Oleskoq
Demonstrator Updates 1 2 Started by: Lorna Little	6	29	2 months, 3 weeks ago Frida_G
Hydrological models Started by: ladislavgaal	2	3	1 week, 4 days ago ladislavgaal
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Europe's eyes on Earth Commission



Climate Change

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PROOF OF CONCEPT



C3S SWICCA CLIMATE IMPACTS SEASONAL FORECASTS

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Definitions of terms used can be found at the [Glossary](#)

About SWICCA data

A Climate Impact Indicator is an aggregate quantitative measure used to show the impact of climate change on complex environmental phenomena in terms of trends and variability. Estimates of essential climate variables (ECVs) and associated climate impact indicators may be derived from reanalysis, seasonal forecasts and climate projections as well as observations. The indicators are of different complexity. They can be based on time-series of water and climate from projections, a combination of variables, or be composed using information from other disciplines such as socio-economics. SWICCA only provides indicators and ECV's that have been requested by Knowledge Purveyors in the [case studies](#) for climate adaptation in the water sector.

European patterns and relevance describes the future trends of climate change across Europe, and lists the showcases of climate impact adaptation that are relevant to each future trend. The metadata of climate impact indicators describes the SWICCA impact indicators and how they have been produced. All listed indicators are available for inspection and download at '[Maps, Graphs and Downloads](#)'.

- [Metadata of Climate Impact Indicators](#)
- [Metadata of Seasonal Forecasts](#)
- [European Patterns and Relevance](#)
- [Which indicator should I use?](#)
- [Impact Models](#)

Metadata of Climate Impact Indicators

Metadata is given for datasets of different resolution (below). The catchments are on average, 215 km² across Europe. Click on the links to read Metadata!

Note: Indicators with a * should be used with caution at this stage, as the spatial representation is uncertain.

Water Quantity	Water Quality	Temperature	Precipitation	Air	Socio-economic
Flood recurrence (0.5 deg grid)	Phosphorous concentrations (catchment)	Freezing degree days (0.5 deg grid)	Dry spell (0.5 deg grid)	Cloud cover (0.1 deg grid)	GDP-SSP Scenarios

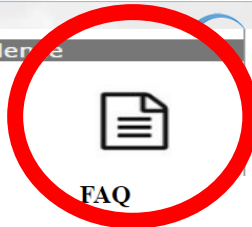
Flood recurrence (catchment)	Phosphorous loads (catchment)	Freezing degree days (catchment)	Dry spell (catchment)	Relative humidity (0.1 deg grid)	Land Use Projections
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Climate Change

Lessons learnt from user engagement

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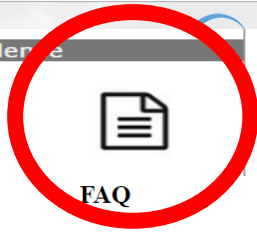
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FAQ

[How to use this](#)

[How to estimate](#)

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[How does SWIC](#)

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Definitions of terr



Search

CLIMATE IMPACTS SEASONAL FORECASTS SHOWCASES USER GUIDANCE ABOUT

River flow (catchment): monthly mean

1. General

Forecast monthly averages are calculated for each catchment. The service is updated on a monthly basis when the new seasonal forecasts become available (usually on the 9th of the month).

The seasonal impact indicators are based on hydrological impact modelling using the hydrological model E-HYPEv3.1.2. The hydrological modelling was done for SWICCA with an ensemble of bias-corrected seasonal climate forecasts (51 members) provided by the ECMWF System 4.

1.1. Description

River flow is the volume of water flow that is transported through a given cross-sectorial area. It is synonym to river discharge or streamflow.

For each monthly period, the available indicator for river flow based on daily data is:

Monthly mean: full monthly period mean of all daily values

1.2. Maps

For the reference period (1982-2010) the absolute values are given (see the option "Climatology (historical absolute value)"), while for the seasonal forecast periods (see the option "Seasonal Forecast") the probabilities of reaching above/near/below normal conditions are provided.

The map shows the anomaly for each catchment and lead month using as reference either the normal values for the month of interest ("Compare to normal conditions") or the extreme values for the catchment conditions ("Extremes (high and low)"). The colours show the indicator's anomalies for each catchment over the forecast period (up to 7 months of lead time).

For "Compare to normal conditions", blue (yellow) [red] colours indicate the probability of forecasts being above (near) [below] normal conditions for the forecast month. The thresholds to define the normal conditions are the 66th and 33rd percentiles for the monthly averages and for each month as these are derived from the water balance simulation for the period 1982-2010. The water balance simulation is a continuous evaluation of the E-HYPE model forced with the Global Forcing Dataset (GFD; an SMHI operational system for generating corrected re-analysis fields of precipitation and temperature. GFD combines re-analysis and forecast products from ECMWF, corrected to observations from GPCC and GHCN-CAMS). The analysis is month specific.

For "Extremes (high and low)", blue [red] colours indicate the probability of forecasts being above [below] the extreme conditions for the forecast month. The thresholds to define the extreme conditions are the 90th and 10th percentiles for the monthly averages and for each month as these are derived from the water balance simulation for the period 1982-2010. The analysis is month specific.

The intensity of the colour represents the forecast probability (percentage of ensemble members) of exceeding (falling in between) [falling below] the selected thresholds (either for the normal conditions or the extremes) within the forecast month (see Figure 1). The probability categories are defined as high = 75 - 100%, medium = 50 - 75%, and low = 35 - 50%. If the probability is less than 35% for crossing either threshold, the region is shown as grey on the map ("Less than low").

SWICCA data

SWICCA data is an aggregate quantitative measure used to show the impact of climate change on complex environmental phenomena in Europe and its variability. Estimates of essential climate variables (ECVs) and associated climate impact indicators may be derived from reanalysis, observations, and climate projections as well as observations. The indicators are of different complexity. They can be based on time-series of observations, projections, a combination of variables, or be composed using information from other disciplines such as socio-economics. SWICCA data includes indicators and ECV's that have been requested by Knowledge Purveyors in the [case studies](#) for climate adaptation in the water sector.

SWICCA data and relevance describes the future trends of climate change across Europe, and lists the showcases of climate impact adaptation that have been produced. The metadata of climate impact indicators describes the SWICCA impact indicators and how they have been produced. The metadata is available for inspection and download at 'Maps, Graphs and Downloads'.

[Metadata of Climate Impact Indicators](#)
[Metadata of Seasonal Forecasts](#)
[Metadata of Patterns and Relevance](#)
[Which Indicator should I use?](#)
[SWICCA Models](#)

Climate Impact Indicators

SWICCA provides datasets of different resolution (below). The catchments are on average, 215 km² across Europe. Click on the links to read more about each indicator.

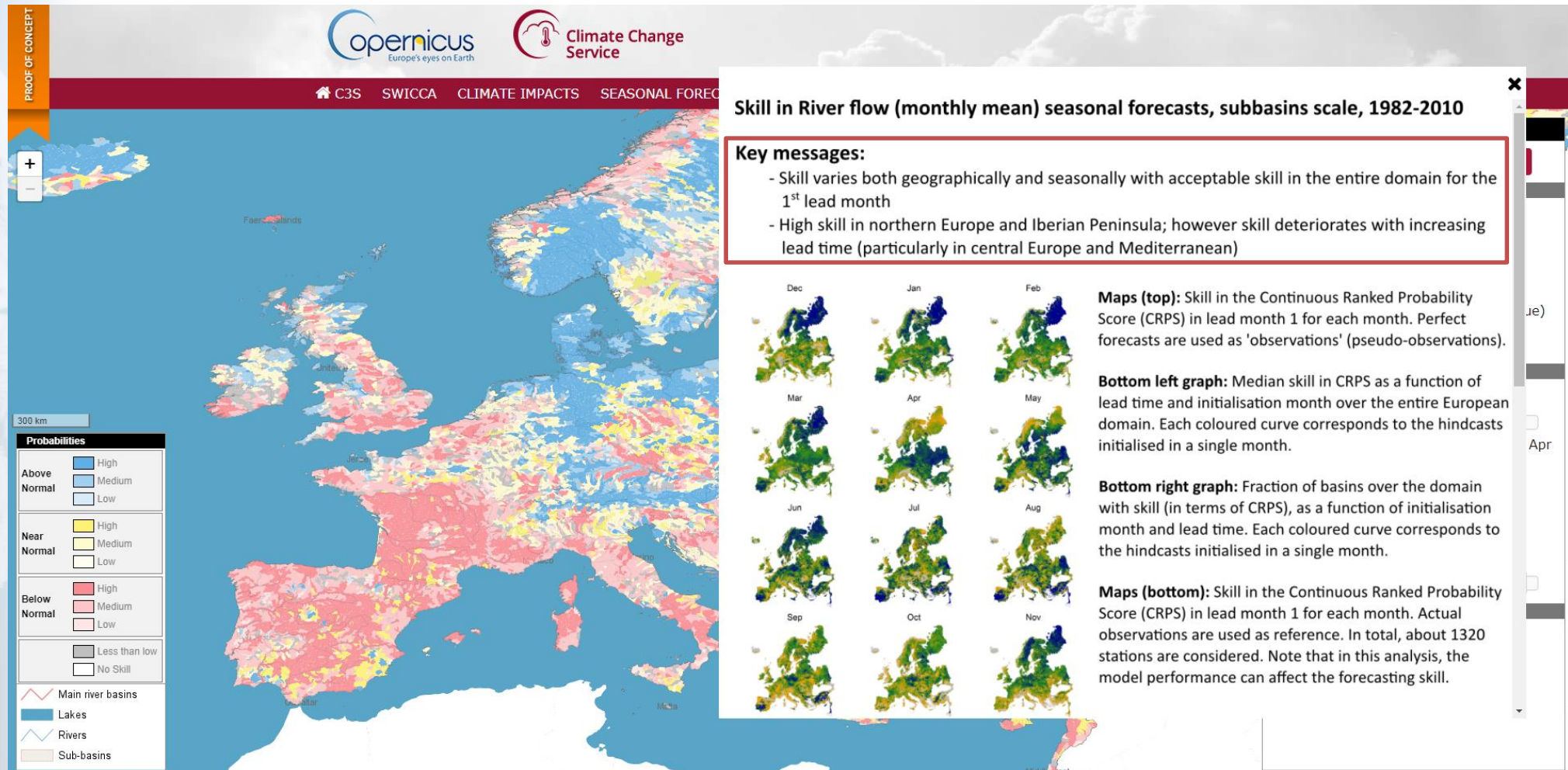
*with a * should be used with caution at this stage, as the spatial representation is uncertain.*

	Water Quality	Temperature	Precipitation	Air	Socio-economic
0.5	Phosphorous concentrations (catchment)	Freezing degree days (0.5 deg grid)	Dry spell (0.5 deg grid)	Cloud cover (0.1 deg grid)	GDP-SSP Scenarios

	Phosphorous loads (catchment)	Freezing degree days (catchment)	Dry spell (catchment)	Relative humidity (0.1 deg grid)	Land Use Projections
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- 3. Key messages must follow with the data for user uptake.
 - *Climate science is difficult and the climate signal is not clear....*

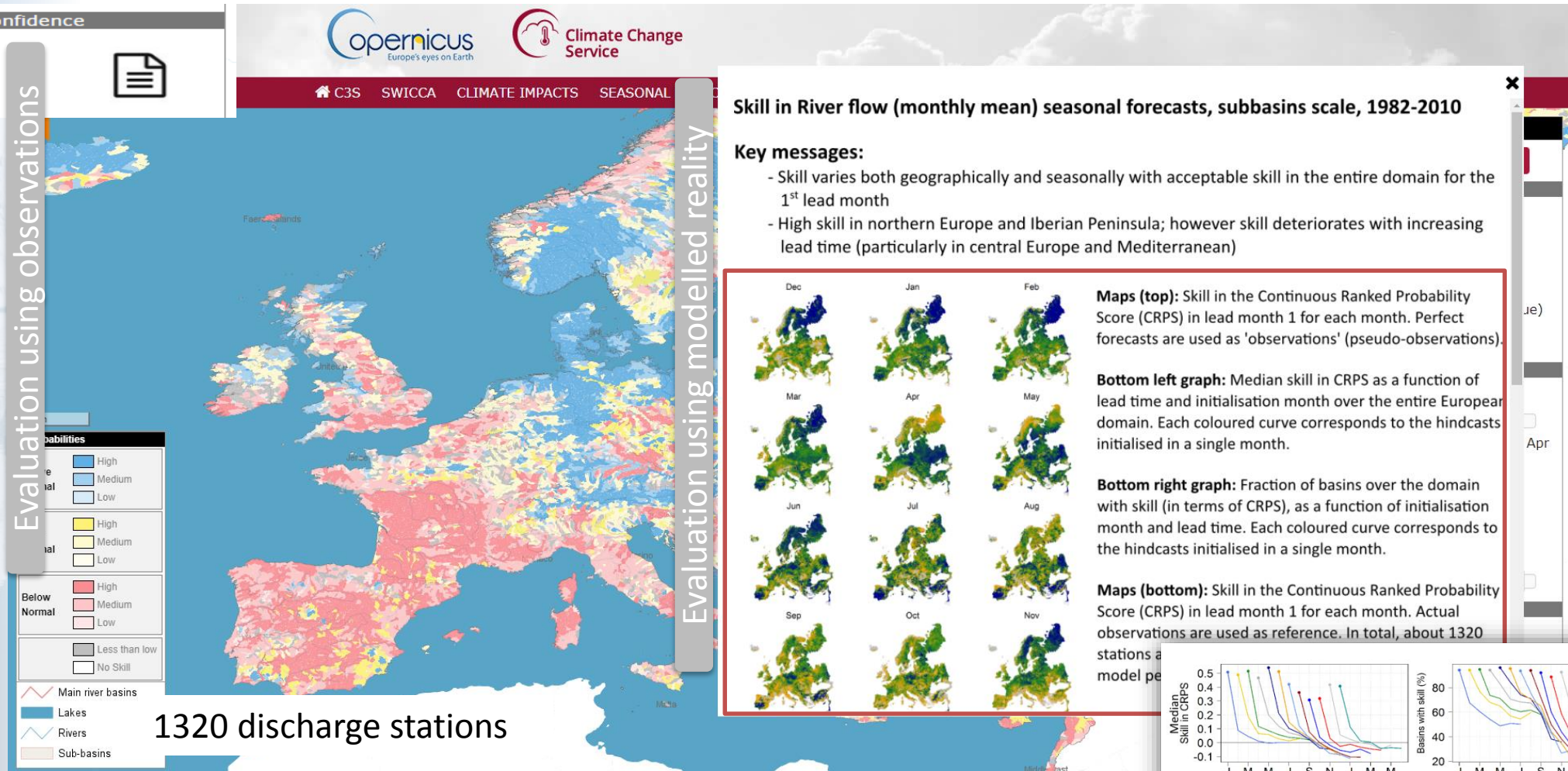




Climate Change

Lessons learnt from user engagement

- 4. Skill and reliability of forecasts are important to communicate.
 - *Climate science is difficult and the climate signal is not clear...*



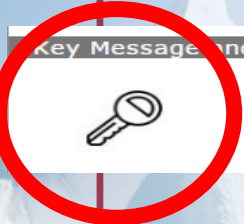
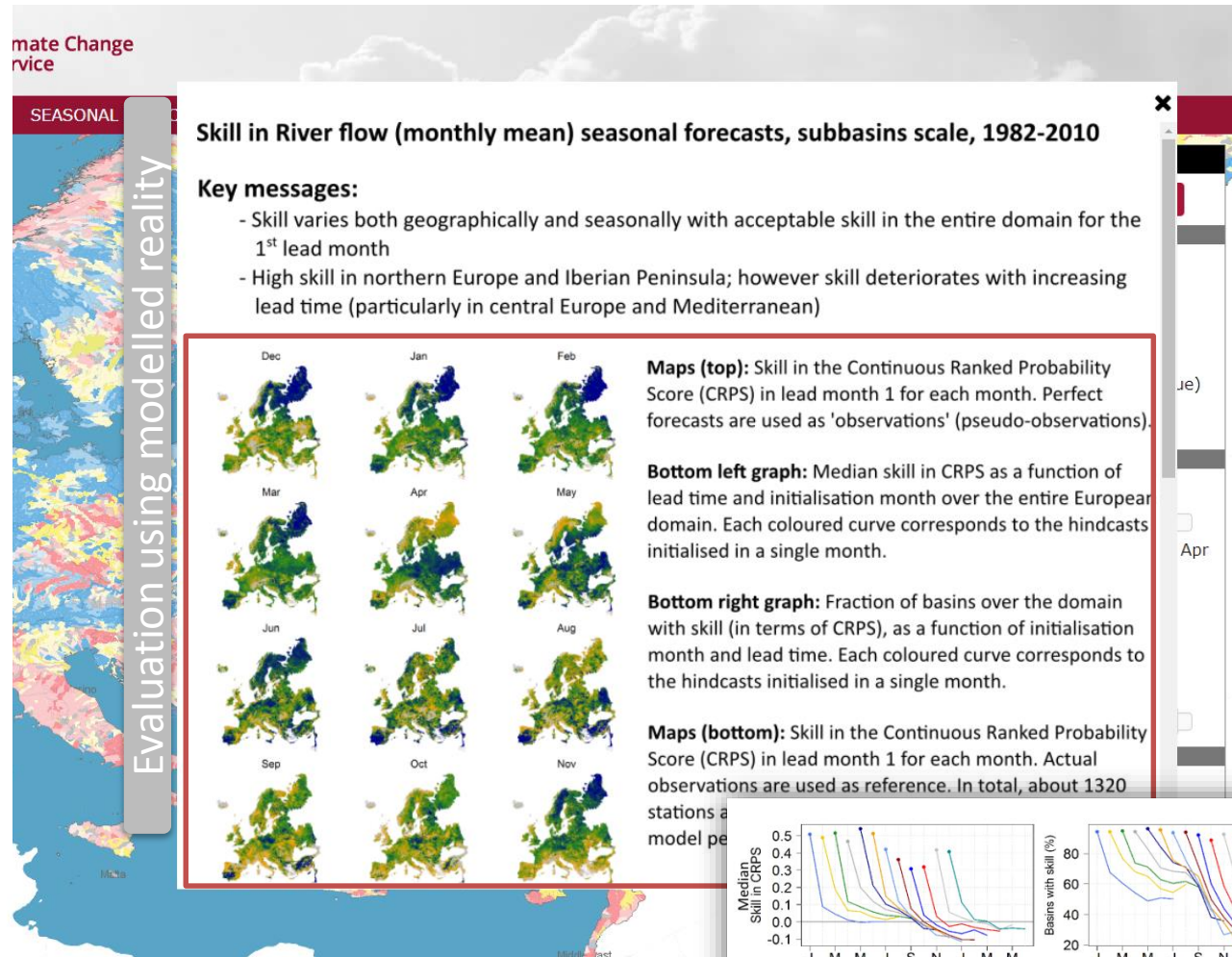
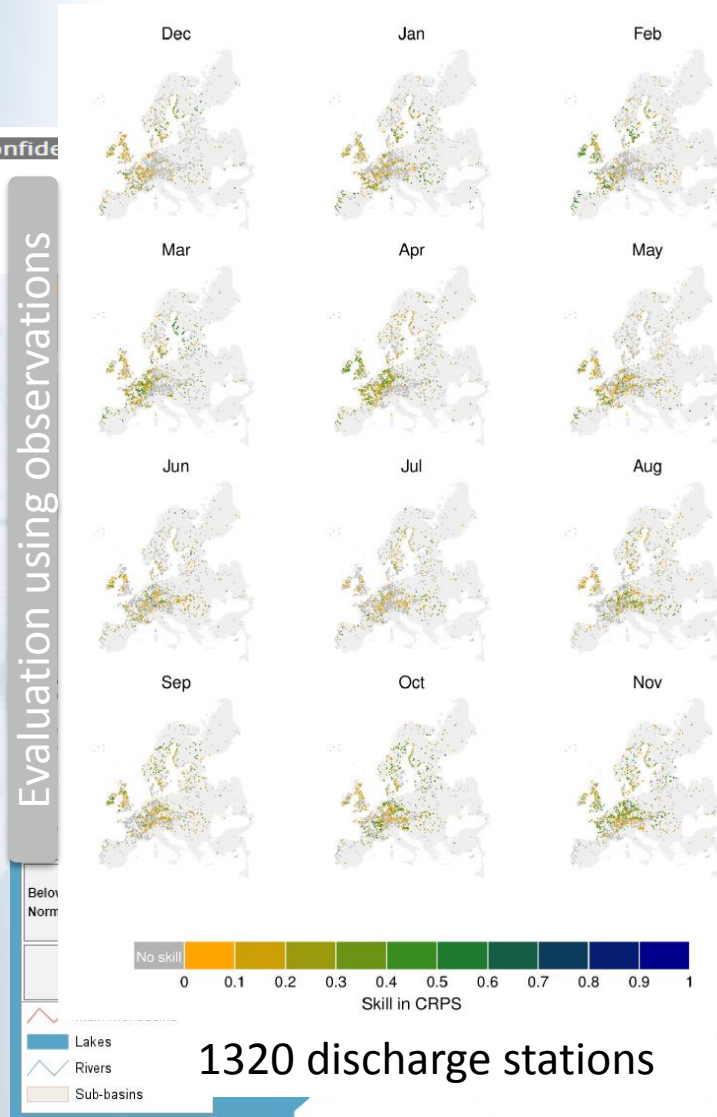


Climate Change

Lessons learnt from user engagement

4. Skill and reliability of forecasts are important to communicate.

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Lessons learnt from user engagement

5. 'Teach the teachers'

- *Purveyors need to understand to be able to communicate results with clients*



The screenshot shows the Copernicus Climate Change Service website. At the top, there is a search bar and navigation links for C3S, SWICCA, CLIMATE IMPACTS, SEASONAL FORECASTS, SHOWCASES, USER GUIDANCE, and ABOUT. Below the navigation bar, the 'Tutorials' section is highlighted, specifically the 'SWICCA Tutorials' sub-section. It features a grid of video thumbnails with the following titles:

- Seasonal prediction of clima...
- Introduction to the C3S SIS...
- Discussion after the C3S S...
- Identifying User Needs
- Uncertainty in SWICCA
- Bias Correction and Downsc...
- SWICCA Climate Impact Ind...



Climate Change

Lessons learnt from user engagement

5. 'Teach the teachers'

– *Purveyors need to understand to be able to communicate results with clients*



Copernicus Europe's eyes on Earth | **Climate Change Service**

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Tutorials

SWICCA Tutorial

2017, 21st August

Webinar #1: Seasonal climate forecasts

Tuesday, August 22nd, 14:00-15:00 CEST

Experiences regarding the skill and opportunities of using seasonal forecasts, EUPORIAS project (European provision of regional impact assessment on a seasonal-to-decadal timescale)

Christiana Photiadou, the Royal Netherlands Meteorological Institute and the Swedish Meteorological and Hydrological Institute

Copernicus seasonal forecast products

Anca Brookshaw, European Centre for Medium-Range Weather Forecasts

To participate at the webinar, please register at: <https://goo.gl/forms/UuQF15UnfLirUUr12>

SWICCA Climate Impact Ind...





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My 3 key messages

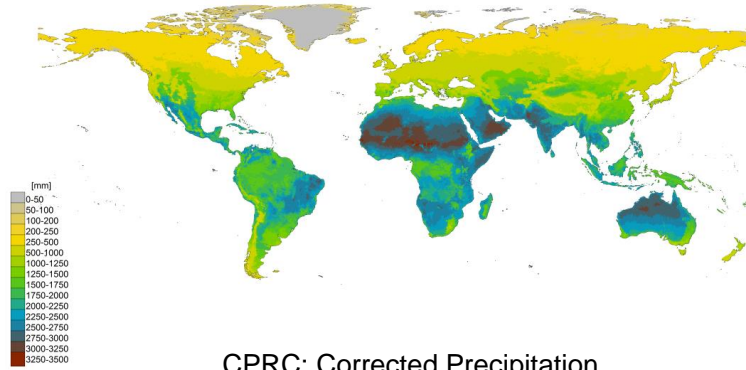
- European climate services can provide useful seasonal information for a number of sectors, (i.e. energy, water, agriculture etc). Skill and reliability is region, season and lead time dependent.
- There is a strong need to engage with users and co-design user-tailored services together with knowledge purveyors.
- Reliable forecasts, communication, guidance, and metadata are the key characteristics of a user-oriented seasonal forecasting service.



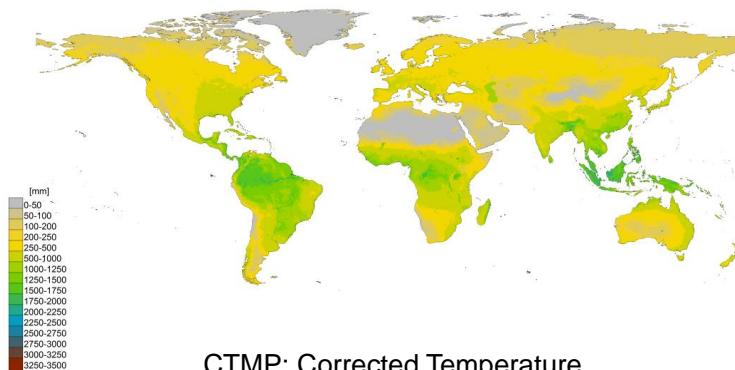
Climate Change

Exciting developments at SMHI !!!

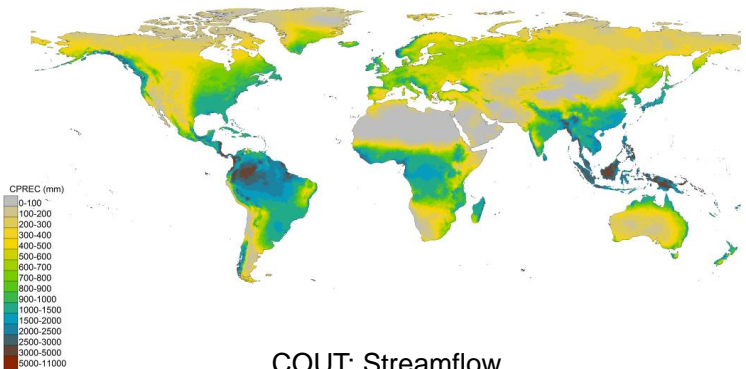
EPOT: Potential Evapotranspiration



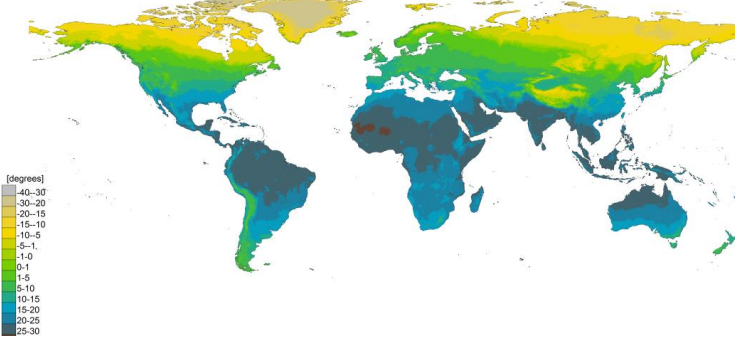
EVAP: Actual Evapotranspiration



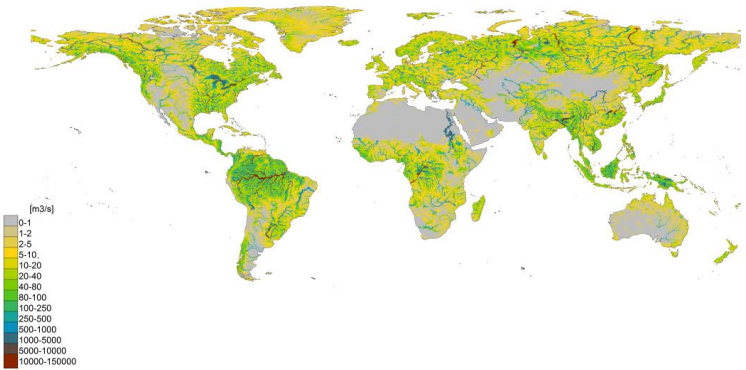
CPRC: Corrected Precipitation



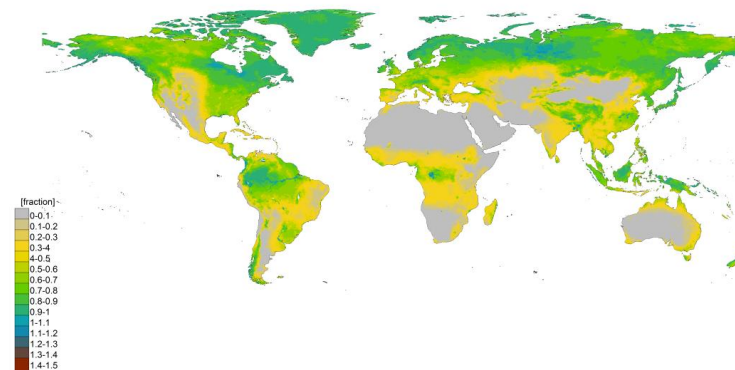
CTMP: Corrected Temperature



COUT: Streamflow



SRFF: Soil moisture fraction of field capacity volume



WW-HYPE

Area: 135 million km²

131,000 subbasins

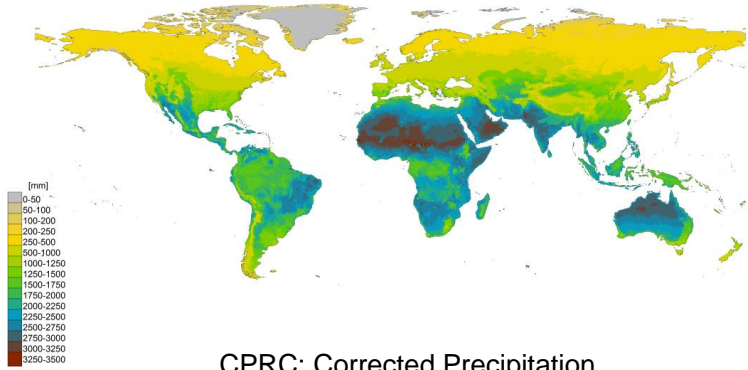
11,400 discharge stations



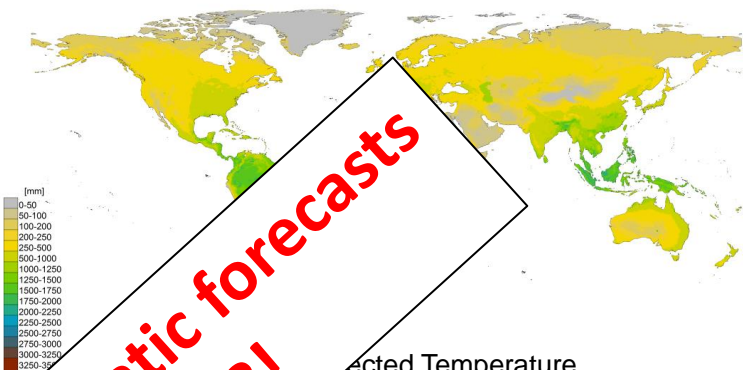
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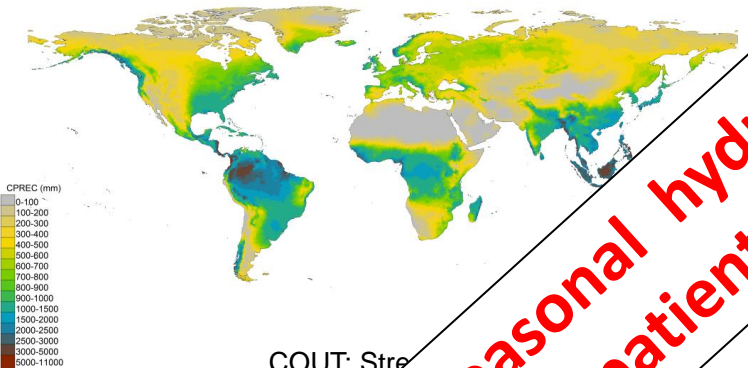
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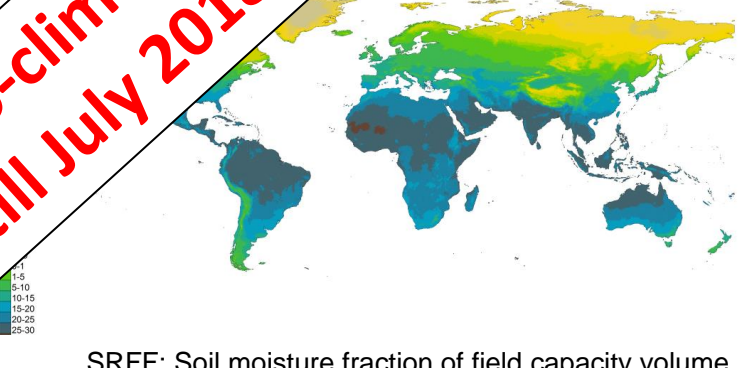
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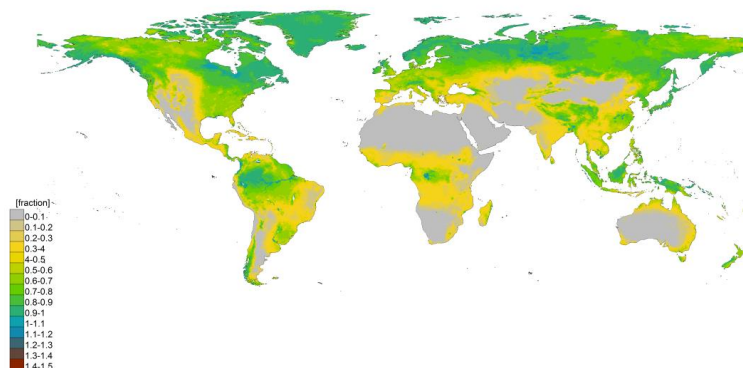
Corrected Temperature



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**Global seasonal hydro-climatic forecasts
Be patient till July 2018!**

WW-HYPE

Area: 135 million km²

131,000 subbasins

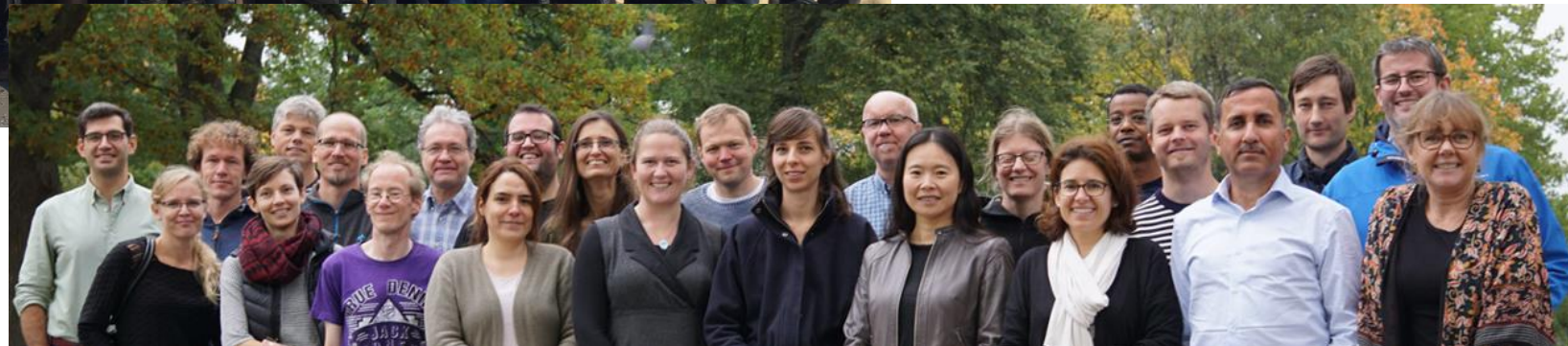
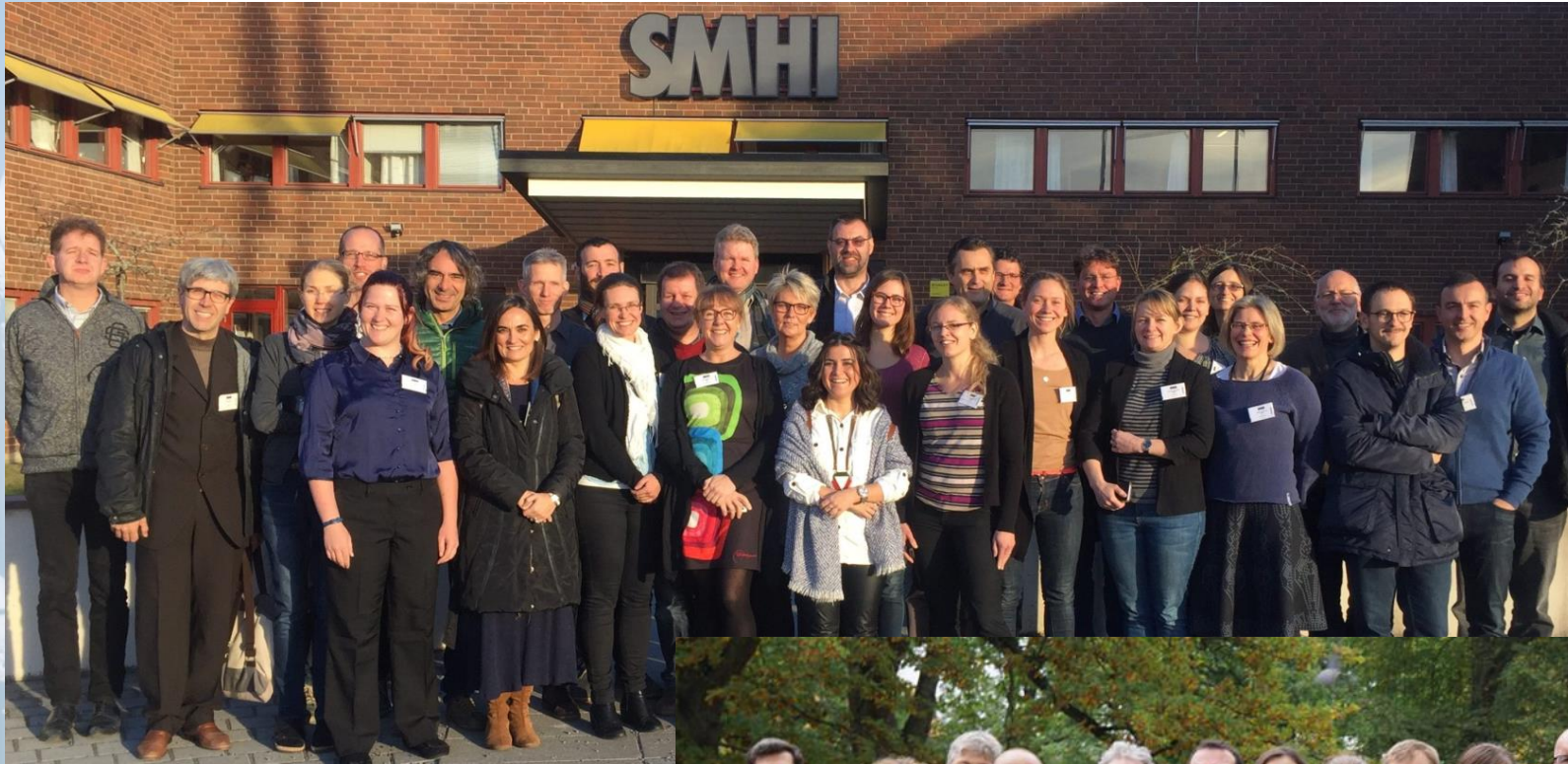
11,400 discharge stations





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Thank you from the team!



Feel free to try a real demo!!

<http://swicca.climate.copernicus.eu/indicator-interface/seasonal-forecasts-maps/>

<http://swicca.eu>