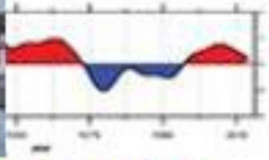
Production of OSF for Mediterranean region
On-line Training Workshop
1st June 2022

Climate services prototypes for water sector

Esteban Rodríguez and Ernesto Rodríguez

AEMET

ERA4CS MEDSCOPE: designed as the scientific arm of MedCOF



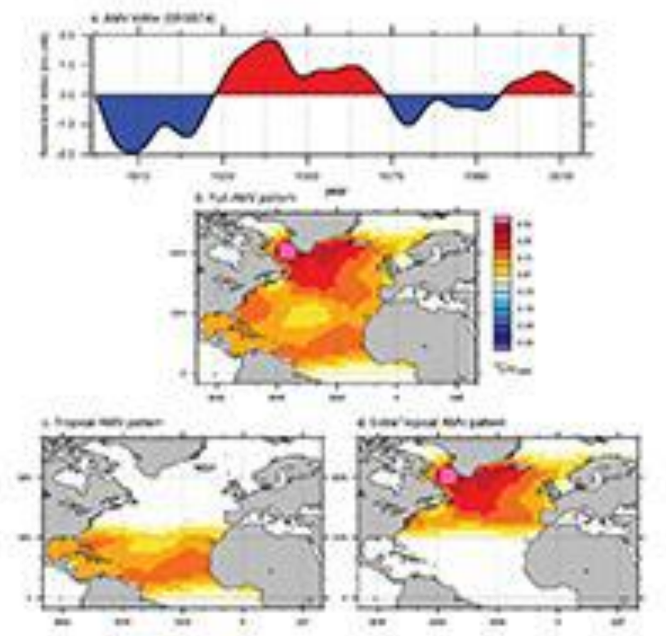
MedCOF community and national users

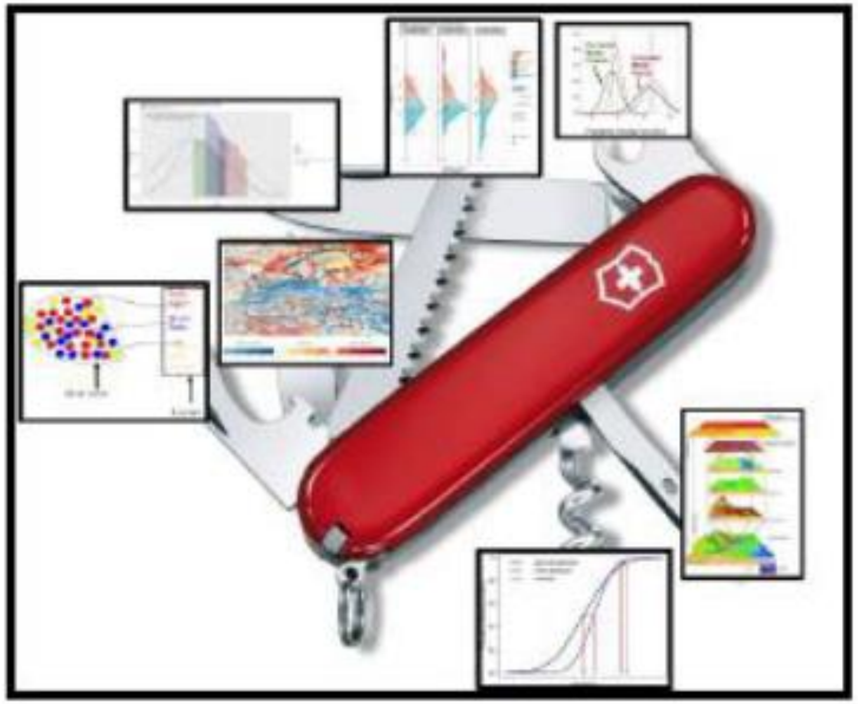
Research community and seasonal forecast producers (e.g. Copernicus)

(Thanks to S. Gualdi, CMCC)

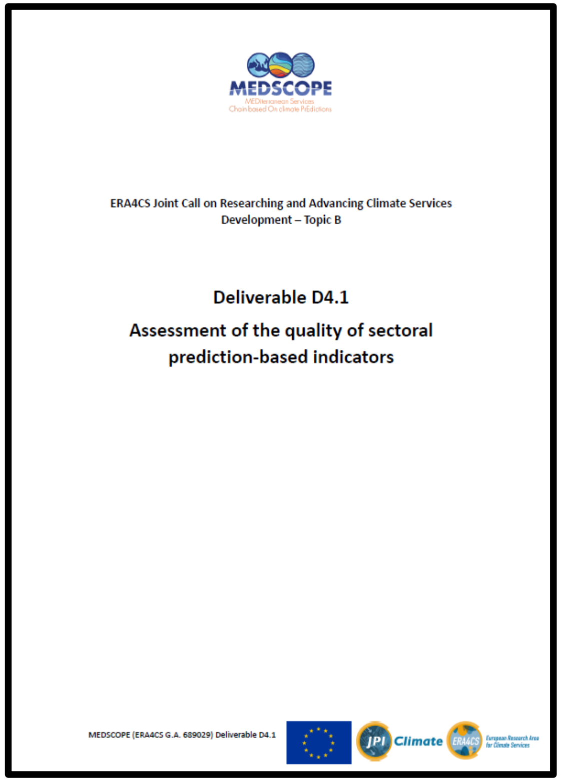
ERA4CS MEDSCOPE Project:

main objectives





Climate services based on seasonal predictions for the Mediterranean



MEDSCOPE

ERA4CS Joint Call on Researching and Advancing Climate Services Development – Topic B

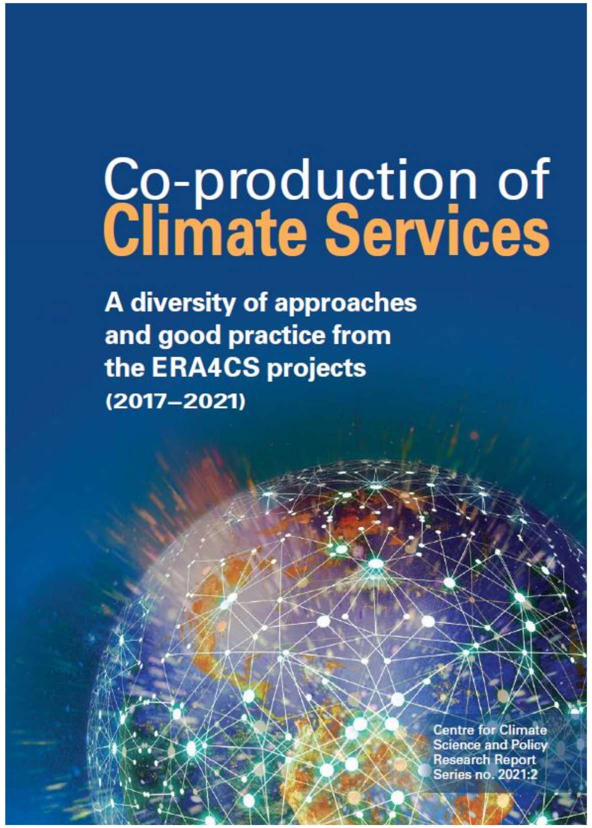
Deliverable D4.1

Assessment of the quality of sectoral prediction-based indicators

MEDSCOPE (ERA4CS G.A. 689029) Deliverable D4.1

- A detailed description of all services developed during the project -including their evaluation is provided in deliverable D4.1 (available from https://www.medscope-project.eu)

- Co-production of Climate Services: A diversity of approaches and good practice from the ERA4CS projects (2017–2021). https://doi.org/10.3384/9789179291990

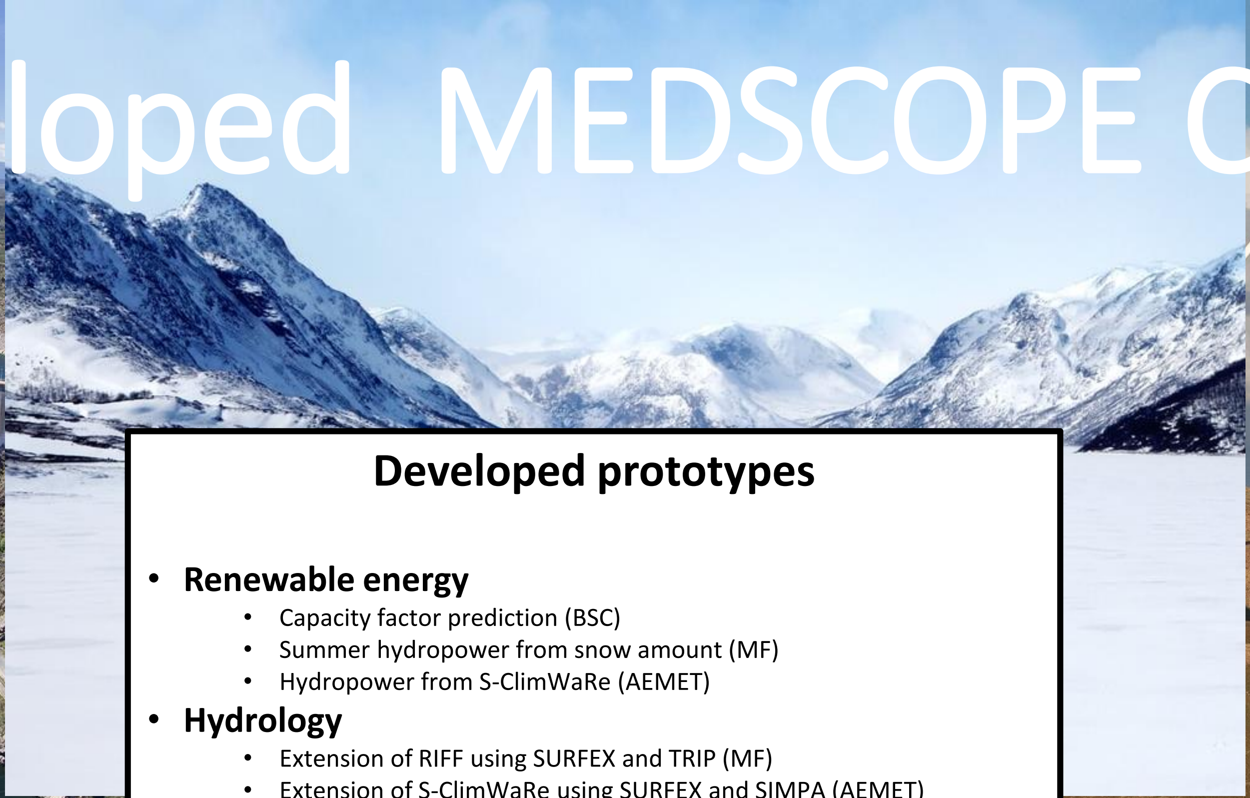


Temporal scale of climate services developed in 15 of the analysed projects of the ERA4CS Programme

Summary of the metrics of evaluation for climate service co-production and user engagement in a sample (n=16) of the ERA4CS projects

User engagement	• Development of innovative engagement instruments • High level of discussion with users • Sharing ideas with bigger groups from those initially proposed • Evaluation questionnaires during the project' lifetime • Feedback forms • Number of key aspects proposed by users and stakeholders and implemented in the Climate Service	• Number of engagements • Statistical test about significance in mean values of number of engagements • Number of stakeholders contacted and informed about the expected results of the project • Number of stakeholders who provided feedback • Number of ideas co-generated with stakeholders and implemented in the project
Climate Service quality		• Metrics of performance of targeted users' variables • Purpose specific metric defined by the users • Objective verification skill scores applied to targeted users' variables
Degree of Climate Service implementation	• Degree of operational performance • Achievement of the initial issue/scope • Evaluation questionnaires about final user' perception • Targeted information • Vulnerability of the current sectorial situation covered • Degree of learning about new ideas or impact reports • Assessment of technology-readiness levels	• Assessment of changes introduced by the Climate Service
Climate Service life	• Willingness of stakeholders to continue working with the consortium • Level of inclusion of broad community • Climate Service fits users' purposes • Climate Service is used by the initial users or by external users through a new implementation process	• Lifetime of the project network • Number of installations of the app

Developed MEDSCOPE CSs



Developed prototypes

- **Renewable energy**
    - Capacity factor prediction (BSC)
    - Summer hydropower from snow amount (MF)
    - Hydropower from S-ClimWaRe (AEMET)
- **Hydrology**
    - Extension of RIFF using SURFEX and TRIP (MF)
    - Extension of S-ClimWaRe using SURFEX and SIMPA (AEMET)
    - Forecast of snowpack and glaciers (CNR)
    - Water availability for hydro-power and irrigation using SCHEME (RMI)
- **Agriculture and Forestry**
    - Harvest prediction tool using AquaCrop (AEMET)
    - Seasonal soil wetness forecasts (MF, INRA)
    - Agro-climatic indicators (INRA)
    - Water requirements for irrigation (INRA)
    - Drought and fire indicators (INRA)
    - Forest indicators (INRA)
    - Agriculture, forestry and forest fire risk indicators (CMCC)

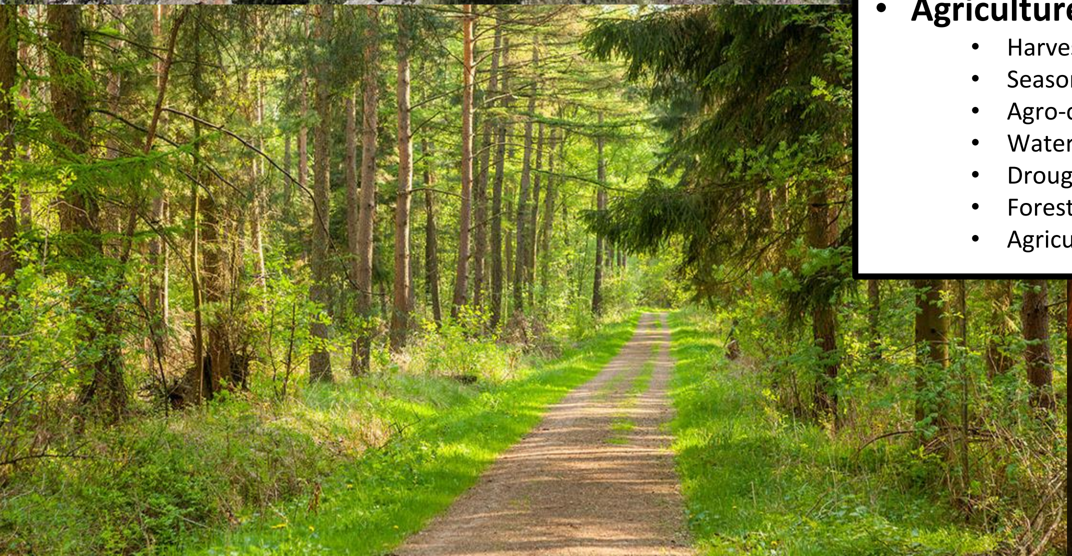
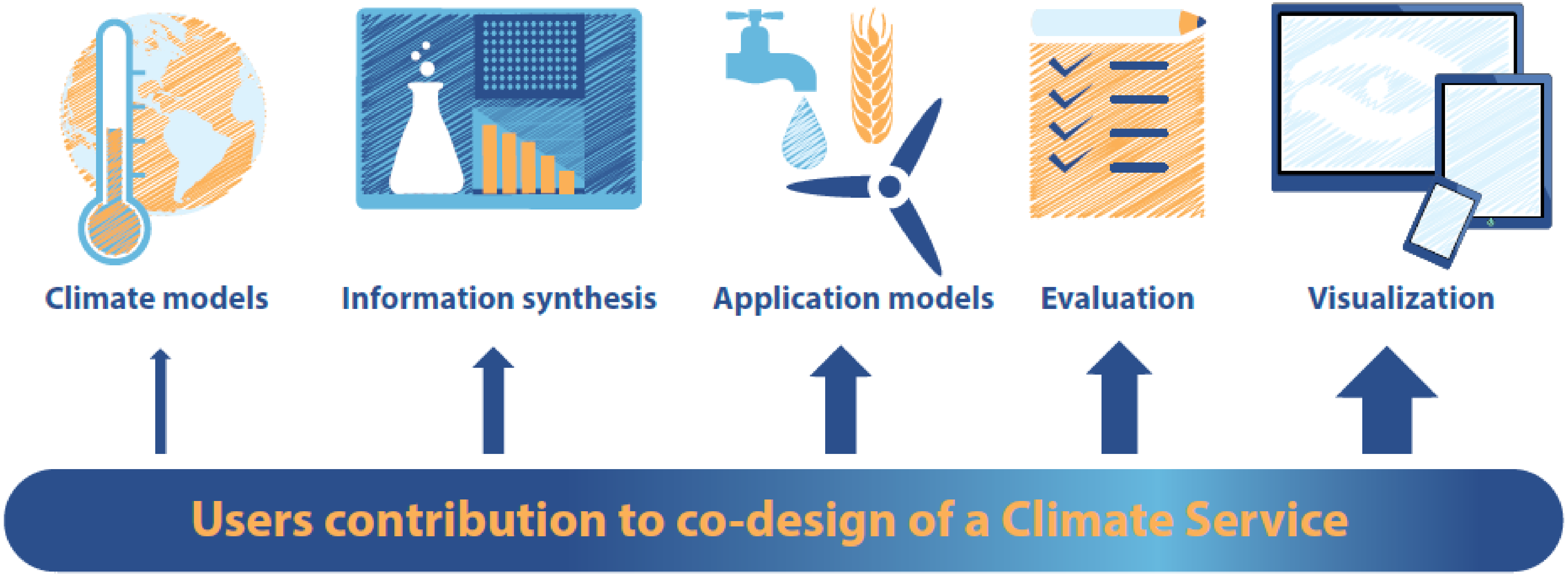


Diagram with a simplified climate services chain based on climate predictions. Users' contribution to co-design is represented by the gradual increase in thickness of the arrows



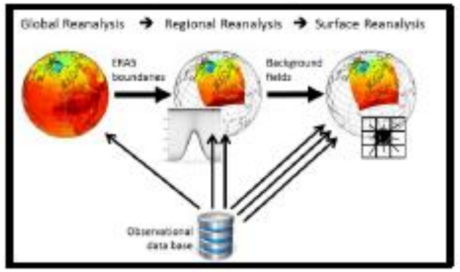
Máñez Costa et al. (2021). Co-production of Climate Services. CSPR Report No 2021:2, Centre for Climate Science and Policy Research, Norrköping, Sweden. https://doi.org/10.3384/9789179291990

Steps in MEDSCOPE CSs

Copernicus CDS

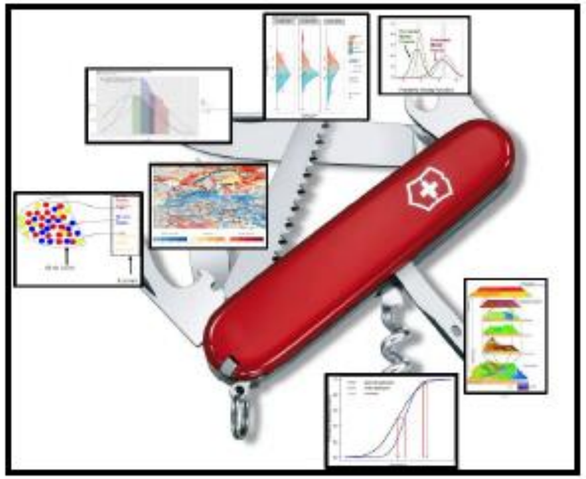
Optimal forcing: reanalysis

(or station data)



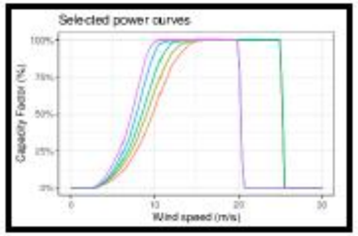
CS-tools

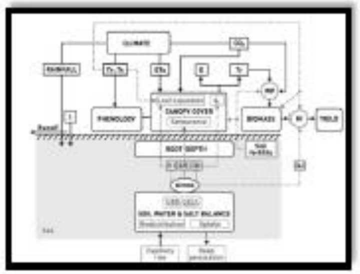
Bias correction, downscaling, members weighting, etc.

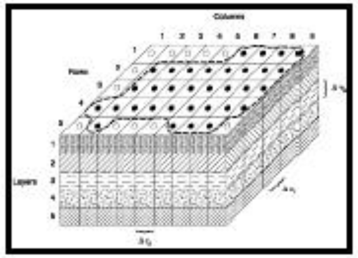


Application model

Translating climate variables (e.g., temperature, precipitation, wind, etc into users indicators (e.g., crop yield, capacity factor)







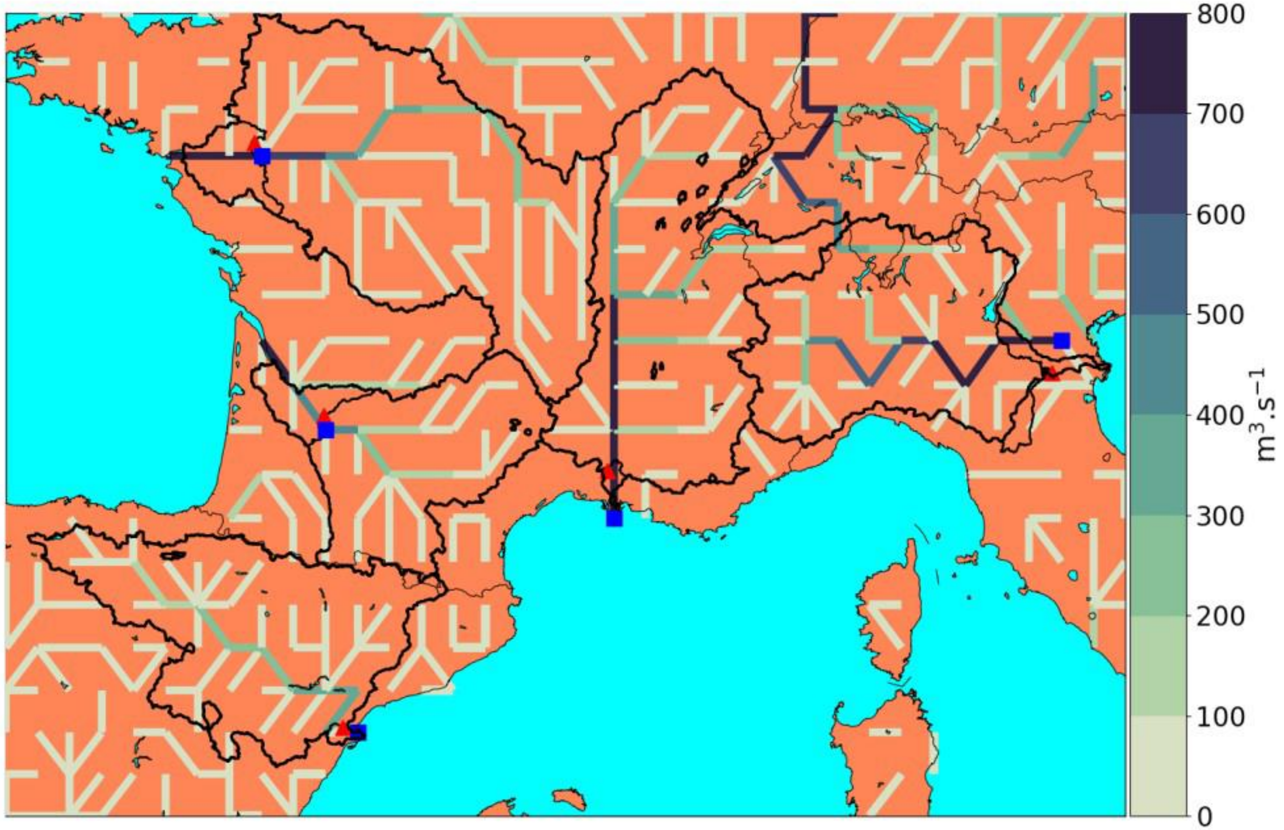
Evaluation

Typically computing verification:skill scores for forecasted indicators over a hindcast period

- Objective scores
- Cost/benefit

Actual or synthetic obs

Seasonal forecasts of Durance, Ebro and Po river discharge



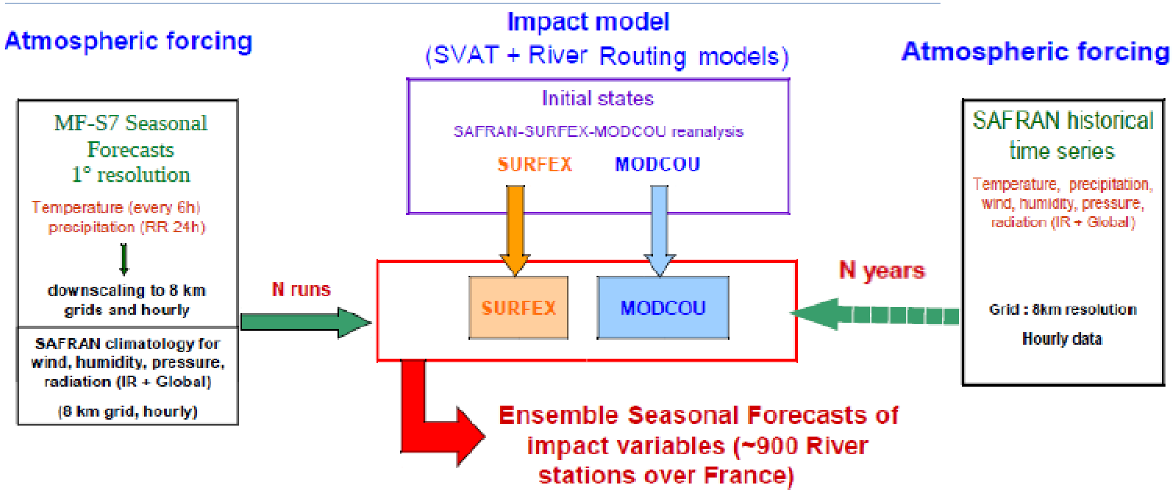
MEDSCOPE domain and mean discharge (1993-2016 period)
over each section of SURFEX-CTRIP routing network

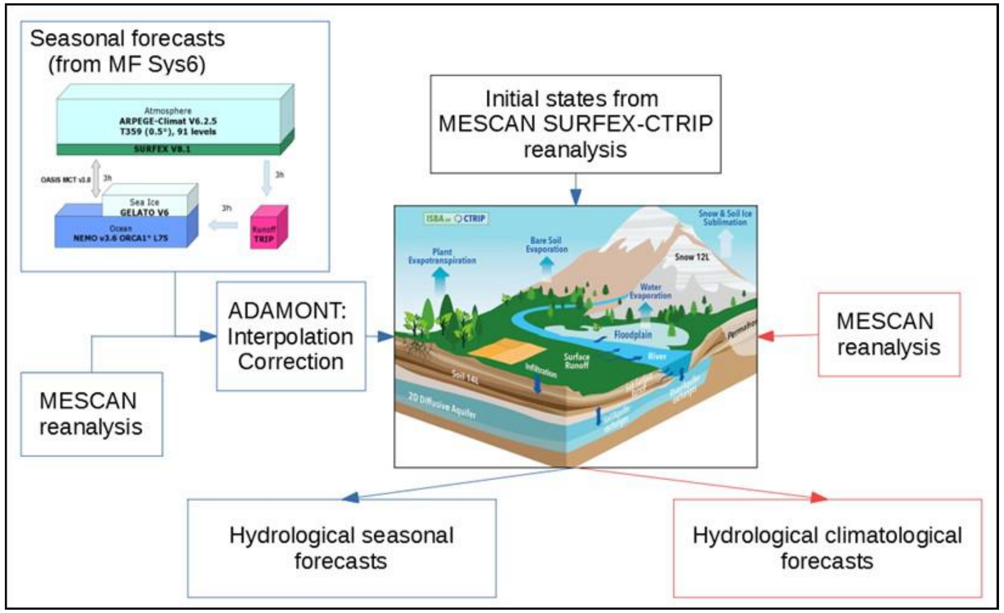
Seasonal forecasts of Durance river discharge

- **Prototype**: Seasonal forecasting of Serre Ponçon dam outflows in irrigation support over the Durance valley.
- **Objective**: Testing the production of probabilistic forecasts for summer water reservoir draining from Serre Ponçon water reservoir to meet irrigation needs based on hydrological models (SURFEX MODCOU vs SURFEX CTRIP) forced by seasonal forecast models (MF Syst 7 or MF Syst 6) and historical scenarios (MEDSCOPE WP4.2 and WP4.3)
- **Developers**: F. Besson G. Dayon, ,K. Iraoui, J.-M. Soubeyroux, C. Viel, P. Etchevers (Meteo-France), A. Chanzy (INRAE)
- **Stakeholders**:
  - J Granjier (Commission Executive Durance)
  - C Le-Normant et P Bernard (EDF-DTG)
  - M Kroppin (Direction Régionale de l'Agriculture, Alimentation et Forêt : DRAAF)

Seasonal forecasts of Durance river discharge

- Meteo-France has also developed **two hydrological suites (called SIM2 and MSC)** driven by SAFRAN and MESCAN analysis data, respectively, serving as synthetic observational data to compare the seasonal forecasts of hydrological variables (see Annexes 4, 5 and 7).
- The first suite, SIM2, is based on the hydrological seasonal application developed in the frame of the EUPORIAS project (Viel et al, 2016).
- The second suite, MSC, -developed during the MEDSCOPE project is based on the coupled **hydrological model SURFEX-CTRIP** (Decharme et al., 2019). SURFEX runs at a resolution of 0.05° and the routing model CTRIP at 0.5°. It covers the western part of the Mediterranean basin and uses the **MESCAN analysis** (Bazile et al., 2017) as an atmospheric reference.
- Results from both suites have been extensively compared and both against observations (Dayon 2019).





Seasonal forecast of snow/ice resources in the Italian Alps

- CNR developed **two prototypes based on snow and glacier models**, respectively, forced by the meteorological variables provided by the Copernicus seasonal forecast systems.
- The first prototype is based on the **SNOWPACK model** (Bartelt and Lehning 2002), which is run at the beginning of November to simulate the evolution of snow depth and snow water equivalent over the 7 months ahead.
- The second prototype is based on a **simple glacier model** (Peano et al., 2016) and it is run at the beginning of May to simulate the variation of glacier length and mass over the summer season ahead.
- The prototypes have been evaluated in glacierized basins in the Western Italian Alps, providing observational data to calibrate models and evaluate their forecasts. The skills of the prototypes have been assessed in comparison to simpler forecasting methods based on climatology. Their performances strongly depend on the forcing and thus on the global seasonal forecast system employed (MEDSCOPE 2021).

Terzago et al. 2021 in MEDSCOPE deliverable D4.1 Annex 9

Seasonal forecast of snow/ice resources in the Italian Alps

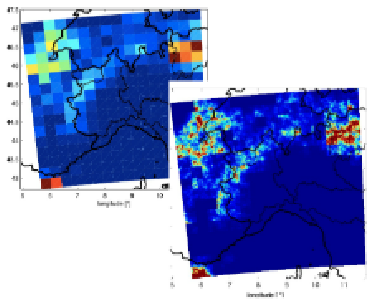
Figure 1: *a) Scheme of the workflow for the two prototypes; b) Location of the sites in North-Western Italian Alps selected for demonstrating the prototypes. Detailed information on these sites is provided in Table 1.*

Study area	Upper Stura di Ala Valley	Upper Sesia Valley	Upper Orco Valley
Main glaciers	Bessanese, Ciamarella	Piode, Bors, Sesia, Vigne	---
Municipality	Balme (TO)	Alagna Valsesia (VC)	Ceresole Reale (TO)
AWS	Rifugio Gastaldi	Bocchetta delle Pisse	Lago Agnel
AWS managing body	ARPA Piemonte	ARPA Piemonte	ARPA Piemonte
AWS Elevation (m a.s.l.)	2659	2410	2304
Coordinates (WGS 84)	45.298056, 7.143333	45.875556, 7.901111	45.467778, 7.139167
Distance between AWS and glaciers (km)	2.9	3.5	---
AWS type	Thermometer, Non-heated rain gauge, Anemometer, Radiometer and Snow depth sensor	Thermometer, Non-heated rain gauge, Anemometer, Radiometer and Snow depth sensor	Thermometer, Non-heated rain gauge, γ-rays sensor and Snow depth sensor

Table 1: *Description of the three mountain areas selected for the study in terms of geographical position and instruments available for measuring meteorological, snow and glacier variables.*

Seasonal forecast of snow/ice resources in the Italian Alps

Pre-processing
CSTools v3.0.0
R package



Seasonal Forecasts of meteorological variables (1°, daily or 6-hourly)

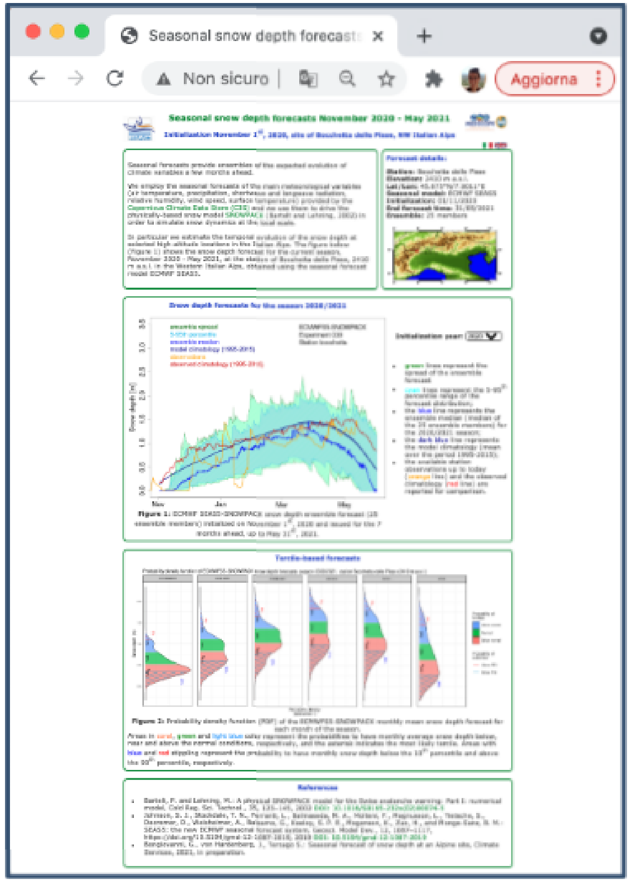
Bias Correction, Spatial and temporal downscaling

SNOWPACK/GLACIER models
1D simulations

Hindcast evaluation with station data

Forecasts of snow depth & glacier length change

Visualization and dissemination of the forecasts on the website



Seasonal forecast of snow/ice resources in the Italian Alps

Seasonal snow depth forecasts November 2020 - May 2021

Initialization November 1st, 2020, site of Bocchetta delle Pisse, NW Italian Alps

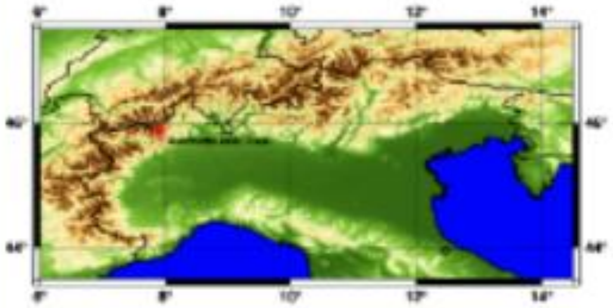
Seasonal forecasts provide ensembles of the expected evolution of climate variables a few months ahead.

We employ the seasonal forecasts of the main meteorological variables (air temperature, precipitation, shortwave and longwave radiation, relative humidity, wind speed, surface temperature) provided by the Copernicus Climate Data Store (C3S) and we use them to drive the physically-based snow model SNOWPACK (Bartelt and Lehning, 2002) in order to simulate snow dynamics at the local scale.

In particular we estimate the temporal evolution of the snow depth at selected high-altitude locations in the Italian Alps. The figure below (Figure 1) shows the snow depth forecast for the current season, November 2020 - May 2021, at the station of Bocchetta delle Pisse, 2410 m a.s.l. in the Western Italian Alps, obtained using the seasonal forecast model ECMWF SEAS5.

Forecast details:

Station: Bocchetta delle Pisse
Elevation: 2410 m a.s.l.
Lat/Lon: 45.875°N/7.9011°E
Seasonal model: ECMWF SEAS5
Initialization: 01/11/2020
End forecast time: 31/05/2021
Ensemble: 25 members



Seasonal forecast of snow/ice resources in the Italian Alps

Snow depth forecasts for the season 2020/2021

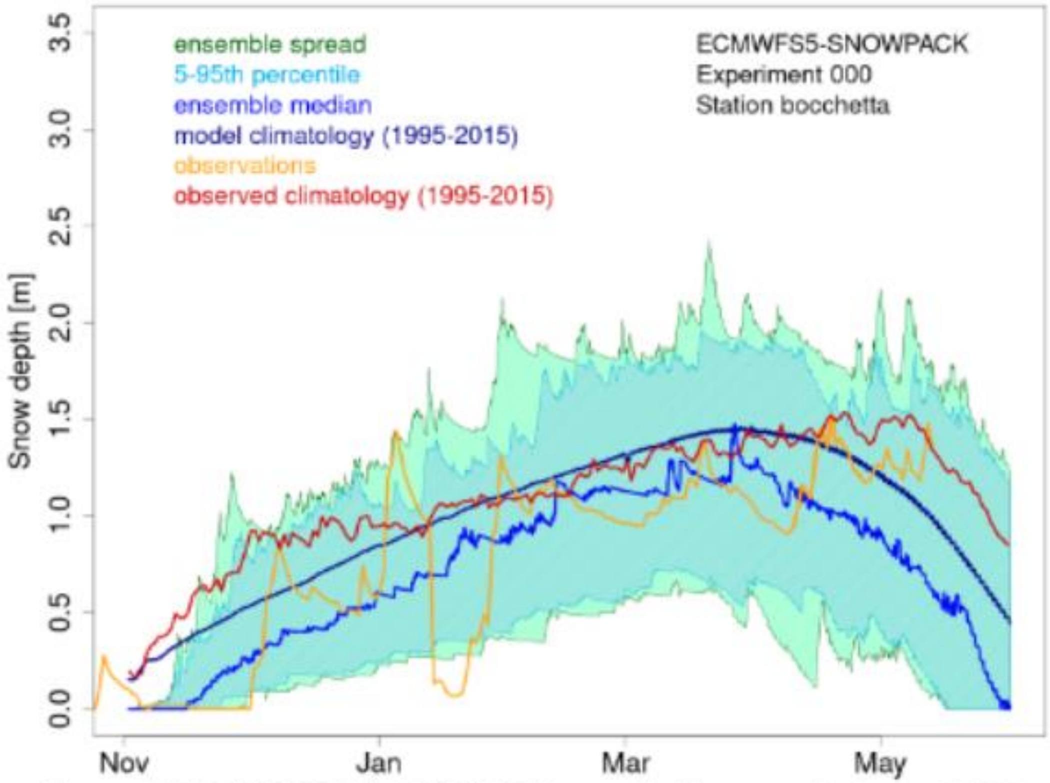
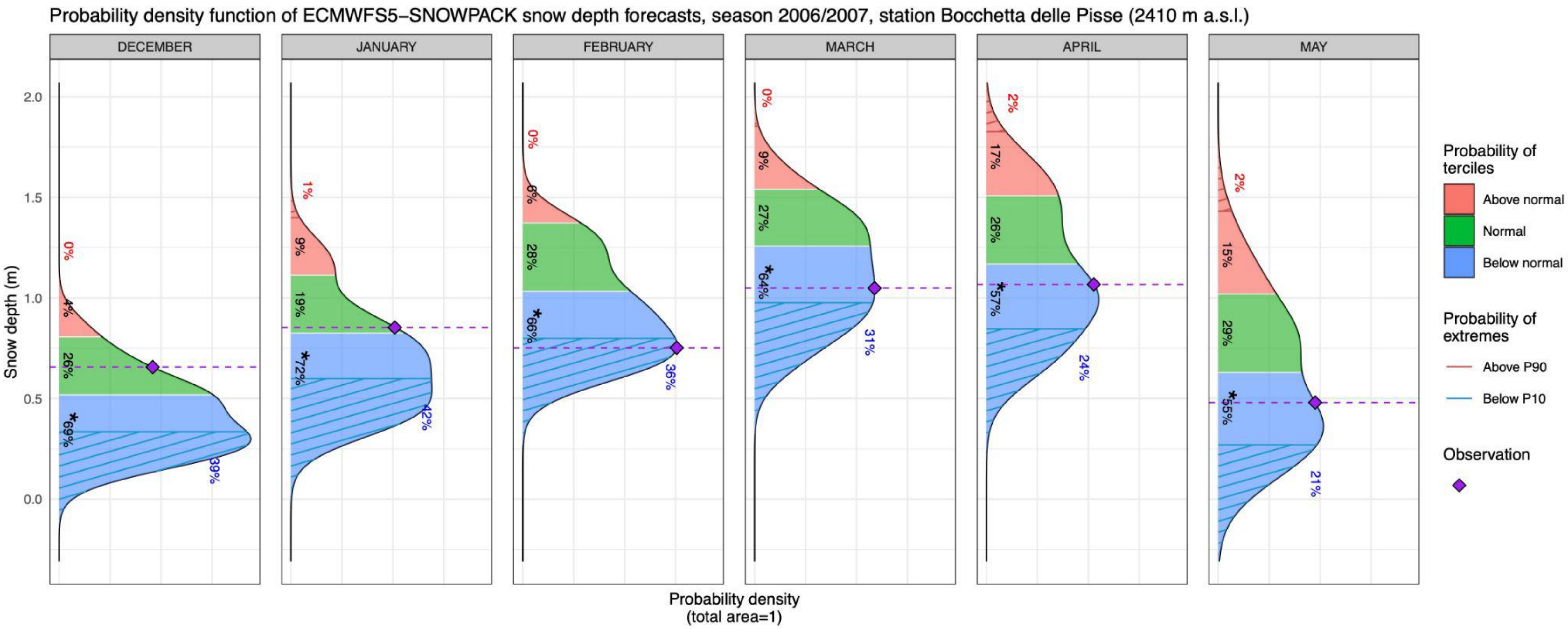


Figure 1: ECMWF SEAS5-SNOWPACK snow depth ensemble forecast (25 ensemble members) initialized on November 1st, 2020 and issued for the 7 months ahead, up to May 31st, 2021.

Initialization year: 2020

- green lines represent the spread of the ensemble forecast
- cyan lines represent the 5-95th percentile range of the forecast distribution;
- the blue line represents the ensemble median (median of the 25 ensemble members) for the 2020/2021 season;
- the dark blue line represents the model climatology (mean over the period 1995-2015);
- the available station observations up to today (orange line) and the observed climatology (red line) are reported for comparison.

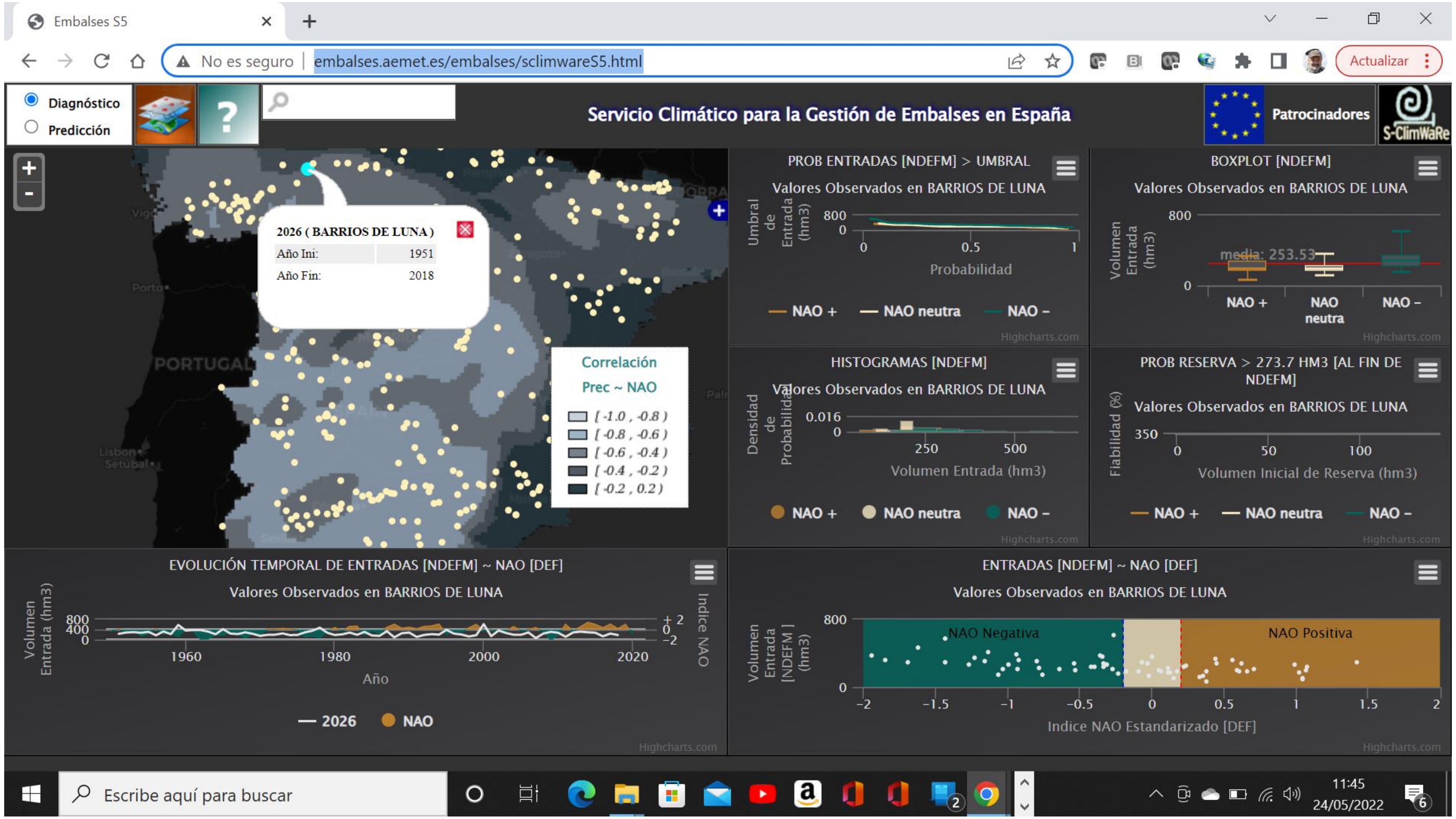
Seasonal forecast of snow/ice resources in the Italian Alps



Probability density function (PDF) of the ECMWFS5-SNOWPACK monthly mean snow depth forecast at Bocchetta delle Pisse for each month of the 2006/2007 season. Areas in coral, green and light blue color represent the probabilities to have monthly average snow depth below, near and above the normal conditions, respectively, and the asterisk indicates the most likely tercile. Areas with blue and red stippling represent the probability to have monthly snow depth below the 10th percentile and above the 90th percentile, respectively.

Climate service tailored to water reservoirs management

http://embalses.aemet.es/embalses/sclimwareS5.html



- Sanchez-García et al. Upgrade of a climate service tailored to water reservoirs management. Climate Services 25 (2022) 100281 (2022). https://doi.org/10.1016/j.cliser.2021.100281
- Sanchez-García et al. Regionally improved seasonal forecast of precipitation through Best estimation of winter NAO. Adv. Sci. Res. 16, 165–174 (2019). https://doi.org/10.5194/asr-16-165-2019
- Voces et al. Web based decision support toolbox for Spanish reservoirs. Adv. Sci. Res. 16, 157–163 (2019). https://doi.org/10.5194/asr-16-157-2019
- Hernanz et al. Evaluation of statistical downscaling methods for climate change projections over Spain: present conditions with perfect predictors. International Journal of Climatology. 1–15 (2021). https://doi.org/10.1002/joc.7271
- Resource video from preCOF session (MedCOF-15): http://medcof.aemet.es/images/doc_events/medcof15/pre-cof/Seasonal_forecasts_of_winter_inflow_to_reservoirs_AEMET.mp4

Combination of different NAO index information sources to enhance the skill of precipitation

- The **Best NAO algorithm** combines different skillful DJF NAO index forecasts to obtain an optimal NAO pdf that is used to weight ensemble members forecasts (Sánchez-García et al., 2019).
- At least **two different seasonal forecast systems that have shown to be skillful** in predicting the winter NAO index are selected.
    - Statistical system that relies on the snow cover advance in the boreal autumn (calculated using the IMS snow product) and DJF NAO teleconnection (Voces et al., 2016).
    - Forecasts predicted by the ECMWF SEAS5
- The method **characterizes the errors of the two selected** estimates and a Gaussian Best NAO pdf is obtained using a **statistical linear estimation algorithm** that takes into account the errors characteristics of the two previous estimates and provides the optimal NAO index and its accuracy. This Best NAO index correlates the most with ERA-Interim derived observations.
- This **NAO pdf is finally used to weight** the ensemble members' forecasts depending on their respective predicted NAO index.

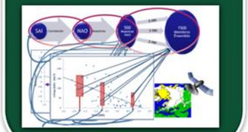
Table 1
Correlation coefficient between DJF NAO index obtained with ERA-Interim reanalysis and the ensemble mean of NAO index for different lead time seasonal forecasts. The correlation coefficients reached by a superensemble based on SEAS5 forecasts with two different lead times (before and after bias correction), and that obtained by S-ClimWaRe statistical method, are also included. Verification period: 1997–2015.

Source of NAO index forecast	Forecast starting date	R (Correlation coefficient)
SEAS5	1st September	0.53
SEAS5	1st October	0.43
SEAS5	1st September + 1st October	0.59
Bias corrected SEAS5	1st September + 1st October	0.64
S-ClimWaRe	–	0.32
Bias corrected SEAS5 + S-ClimWaRe	–	0.65

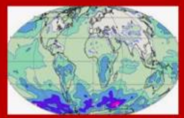
BEST NAO WEIGHTING

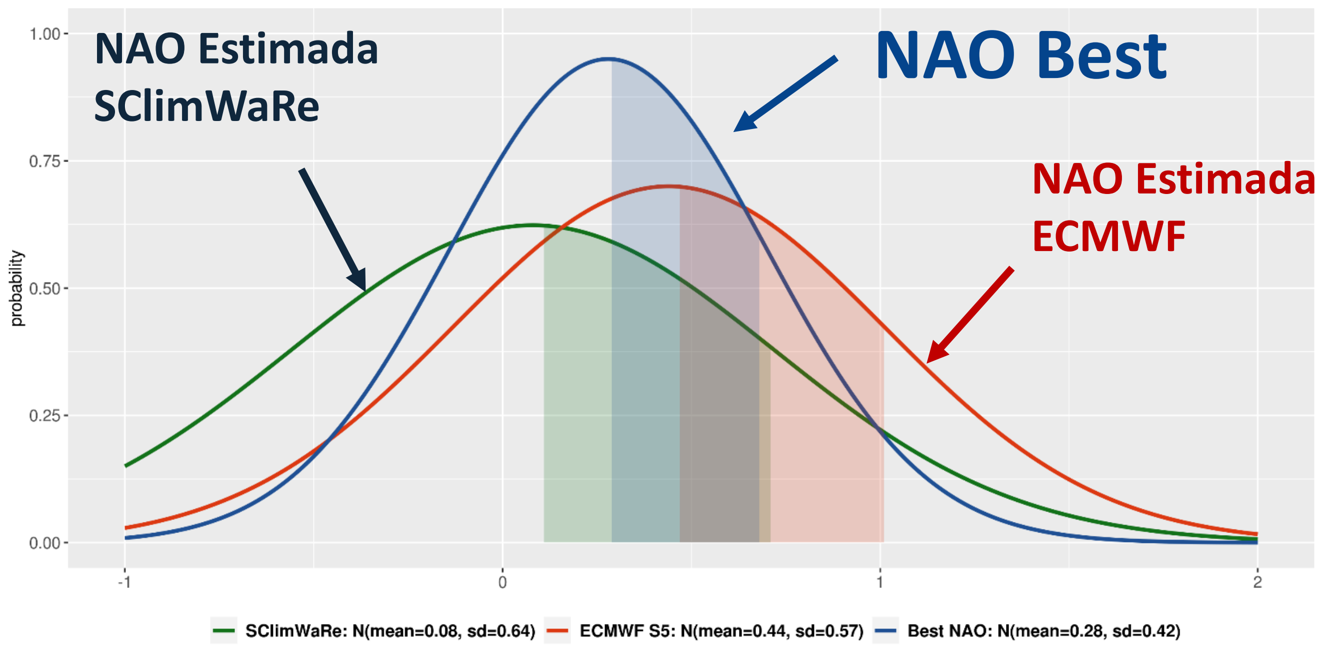
NAO Best DJF
0.28

S-ClimWaRe
Modelo empírico de AEMET



ECMWF-S5
Modelo dinámico



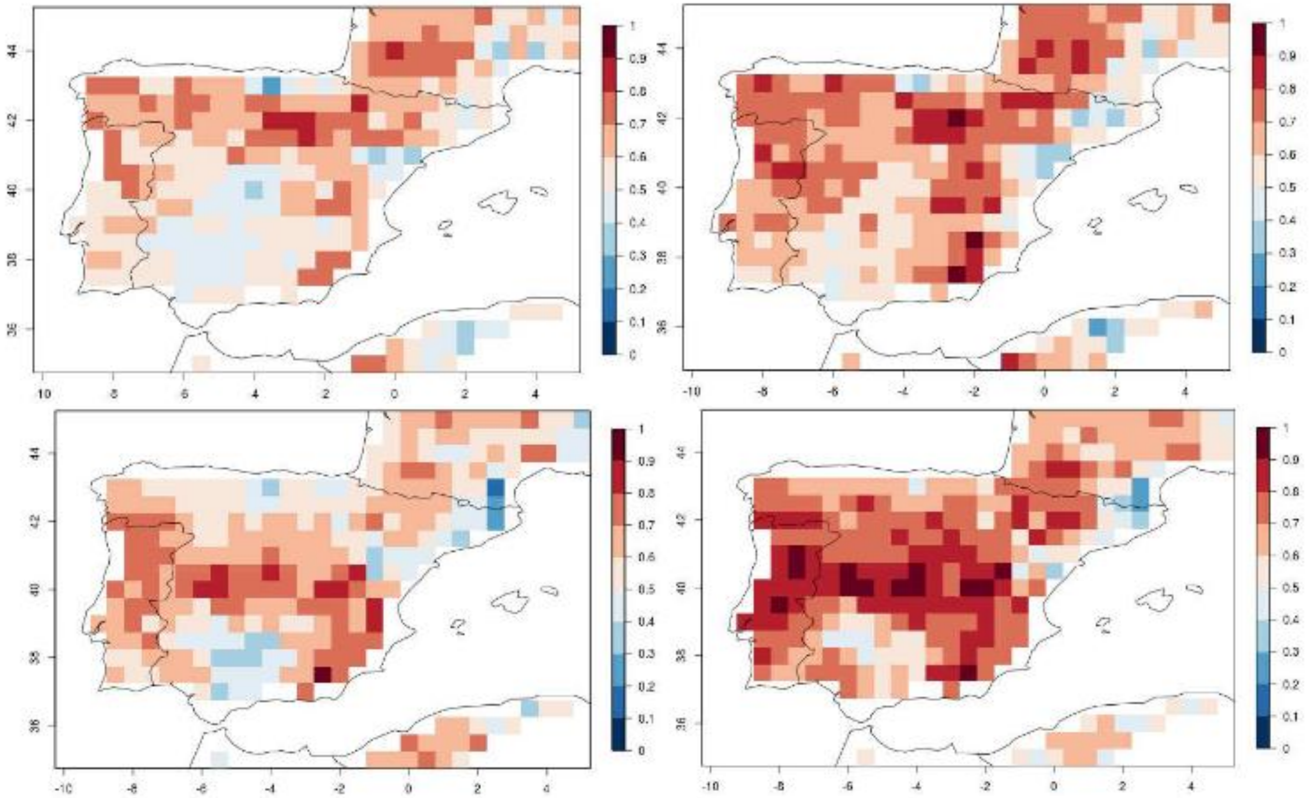


Combinando modelos empíricos + dinámicos

Equiprobable members | Best NAO weighted members

Upper tercile

Lower tercile



Extension of Best NAO to other drivers, regions and seasons

- Weighting of ensemble members based on an **enhanced prediction of a climate driver strongly affecting meteorological parameters** over a certain region can improve seasonal forecast.
- This particular service made use of an **optimally combination method (similar to the OI analysis)** to better exploit the window of opportunity coming from two skillful seasonal forecasts for a certain region and season.

https://cran.r-project.org/web/packages/CSTools/vignettes/BestEstimateIndex_vignette.html

Statistical downscaling

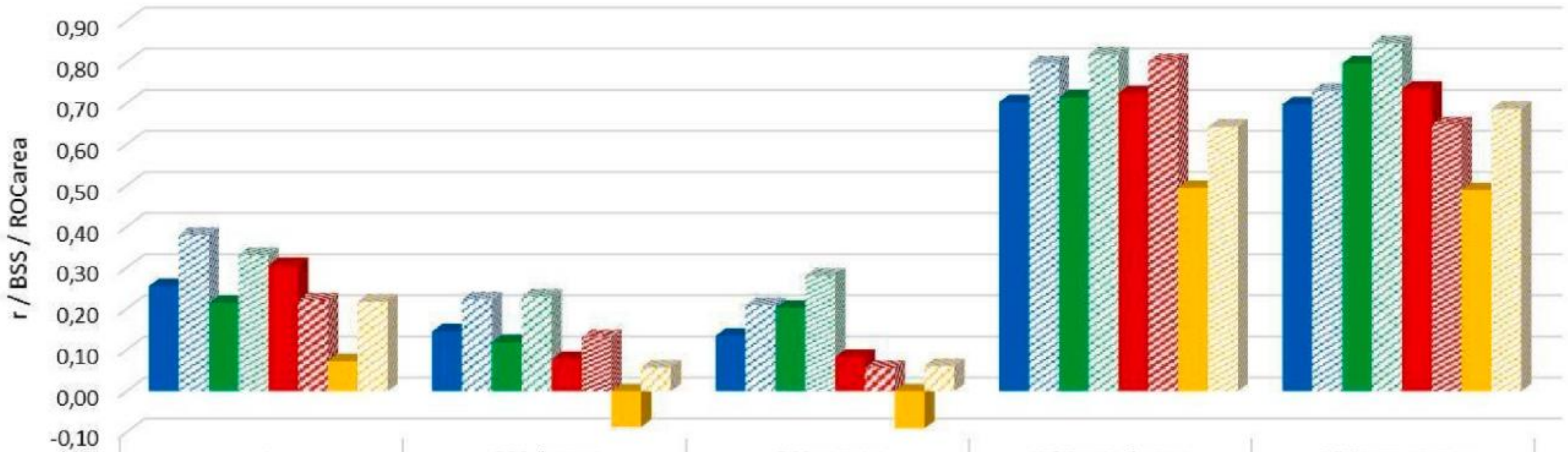
- This CSTools function is an **analogs based method** that had been used as a regionalization technique for climate change projections in this area (Hernanz et al., 2021). The method has been applied to SEAS5, to obtain an ensemble of seasonal forecasts for precipitation and daily extreme temperatures on the **5 km resolution grid** used by the web tool.

Verification scores obtained by the seasonal forecasts of November to March water inflow to Belesar reservoir

Experiment	Model (resolution)	Meteorological forcings	Ensemble forecasts postprocessing strategy
SIMPA-EQ	SIMPA (500 m)	SEAS5-D	EQENSM
SIMPA-W	SIMPA (500 m)	SEAS5-D	WENSM
SURFEX-EQ	Offline SURFEX (5 km)	SEAS5-D	EQENSM
SURFEX-W	Offline SURFEX (5 km)	SEAS5-D	WENSM
SClimWaRe	S-ClimWaRe (local)	Not needed	EQENSM
SClimWaRe-H	Hybrid S-ClimWaRe (local)	Not needed	WENSM
SEAS5-EQ	ECMWF System-5 TESSEL (35 km)	SEAS5	EQENSM
SEAS5-W	ECMWF System- 5 TESSEL (35 km)	SEAS5	WENSM

Characteristics of the experiments carried out in the prototype to produce seasonal forecasts of water inflow to Belesar reservoir concerning the method used, resolution, meteorological forcings (SEAS5: ECMWF System-5, or SEAS5-D: downscaled SEAS5) and strategy to postprocess the forecasts by the different ensemble members (EQENSM: equiprobable members, or WENSM: members weighted with Best NAO pdf)

Verification scores obtained by the seasonal forecasts of November to March water inflow to Belesar reservoir



	r	BSS_lower	BSS_upper	ROCarea_lower	ROCarea_upper
SIMPA-EQ	0,26	0,15	0,13	0,70	0,70
SIMPA-W	0,38	0,22	0,21	0,80	0,73
SURFEX-EQ	0,21	0,12	0,20	0,71	0,80
SURFEX-W	0,33	0,23	0,28	0,82	0,85
SClimWaRe	0,31	0,08	0,08	0,73	0,74
SClimWaRe-H	0,22	0,13	0,06	0,80	0,65
SEAS5-EQ	0,07	-0,09	-0,09	0,49	0,49
SEAS5-W	0,22	0,06	0,06	0,64	0,69

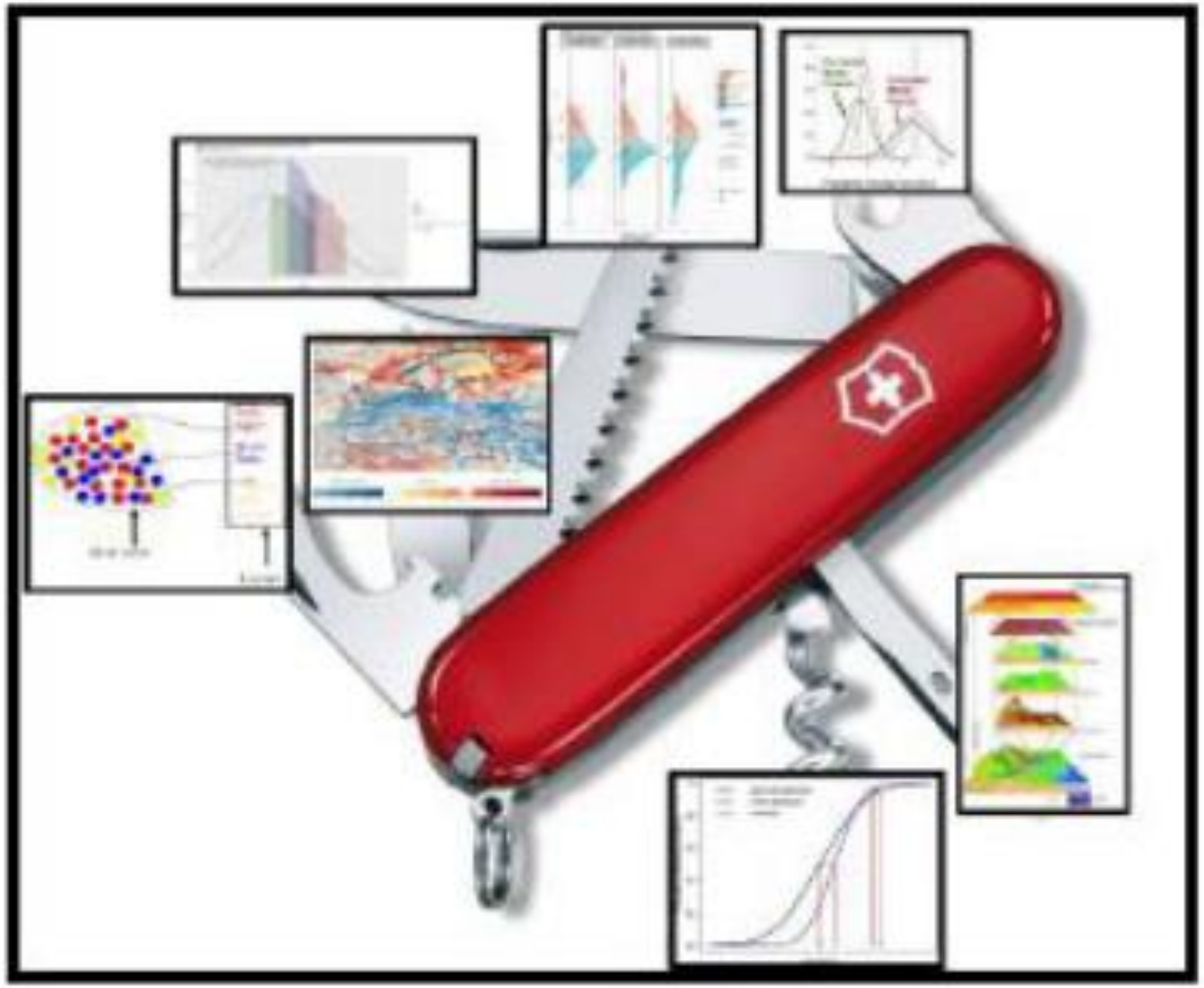
Verification scores of the different experiments: correlation coefficient (r) of the ensemble mean, and BSS and ROC area for probabilistic forecasts to be below/above the lower/upper tercile.

Overview of the forecasting displaying panels showing seasonal forecasts for November to March of accumulated water inflow (a), accumulated precipitation (b), accumulated snowfall (c) and mean temperature (d).

Co-design, co-develop, co-evaluacion

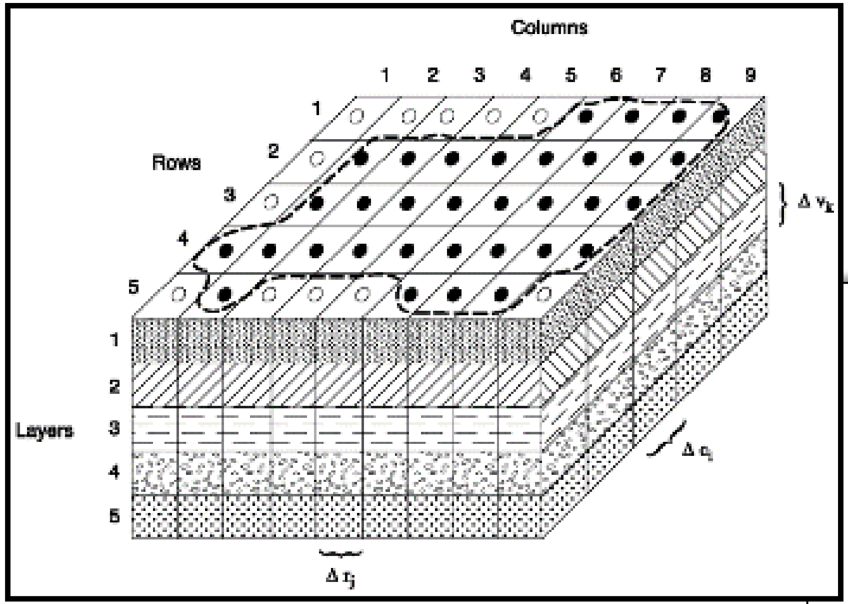
Tools for syntethizing model outputs

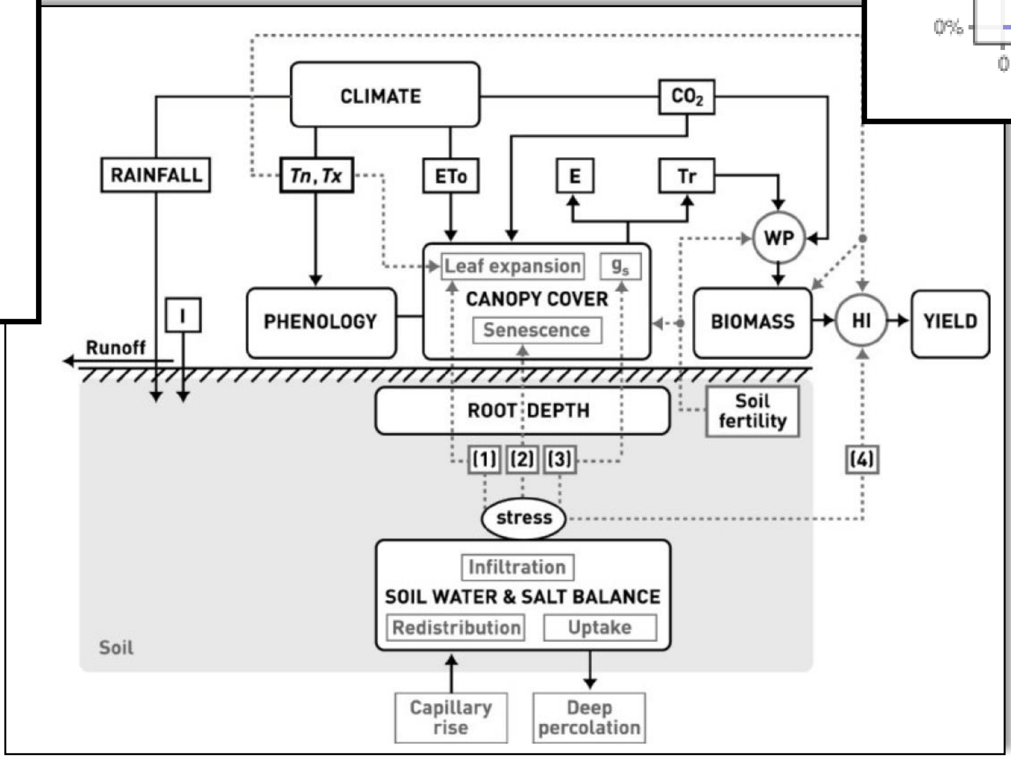
The package has functions for forecast verification and comprehensive skill assessments – including those for user-oriented applications – for downscaling, calibration and bias adjustment of the forecasts, and develop methodologies of optimal forecast combination to provide a single source of information.

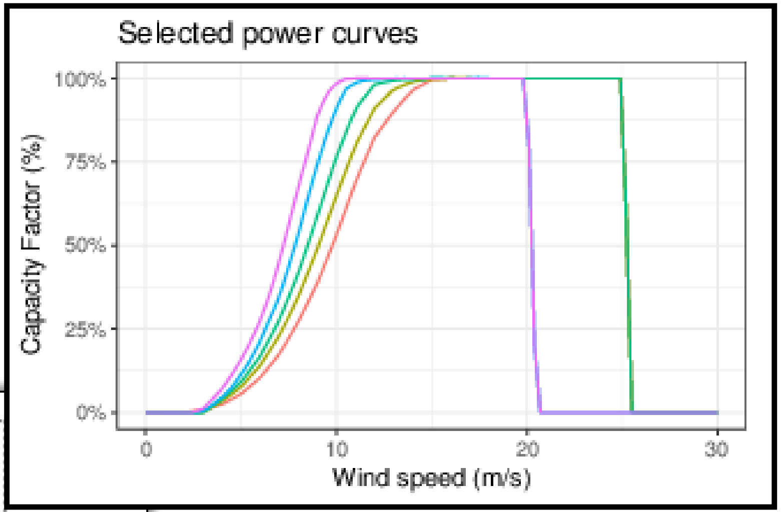


European Research Area for Climate Services

Importance of application models







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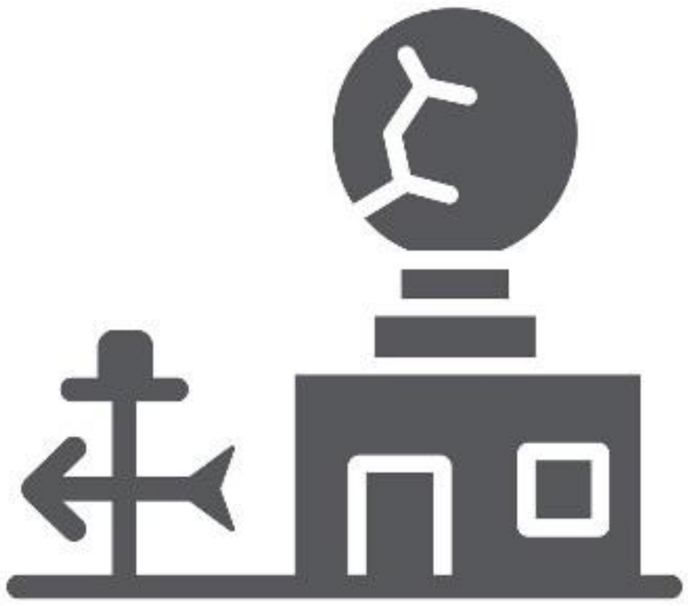
Importance of co-evaluation

Evaluation

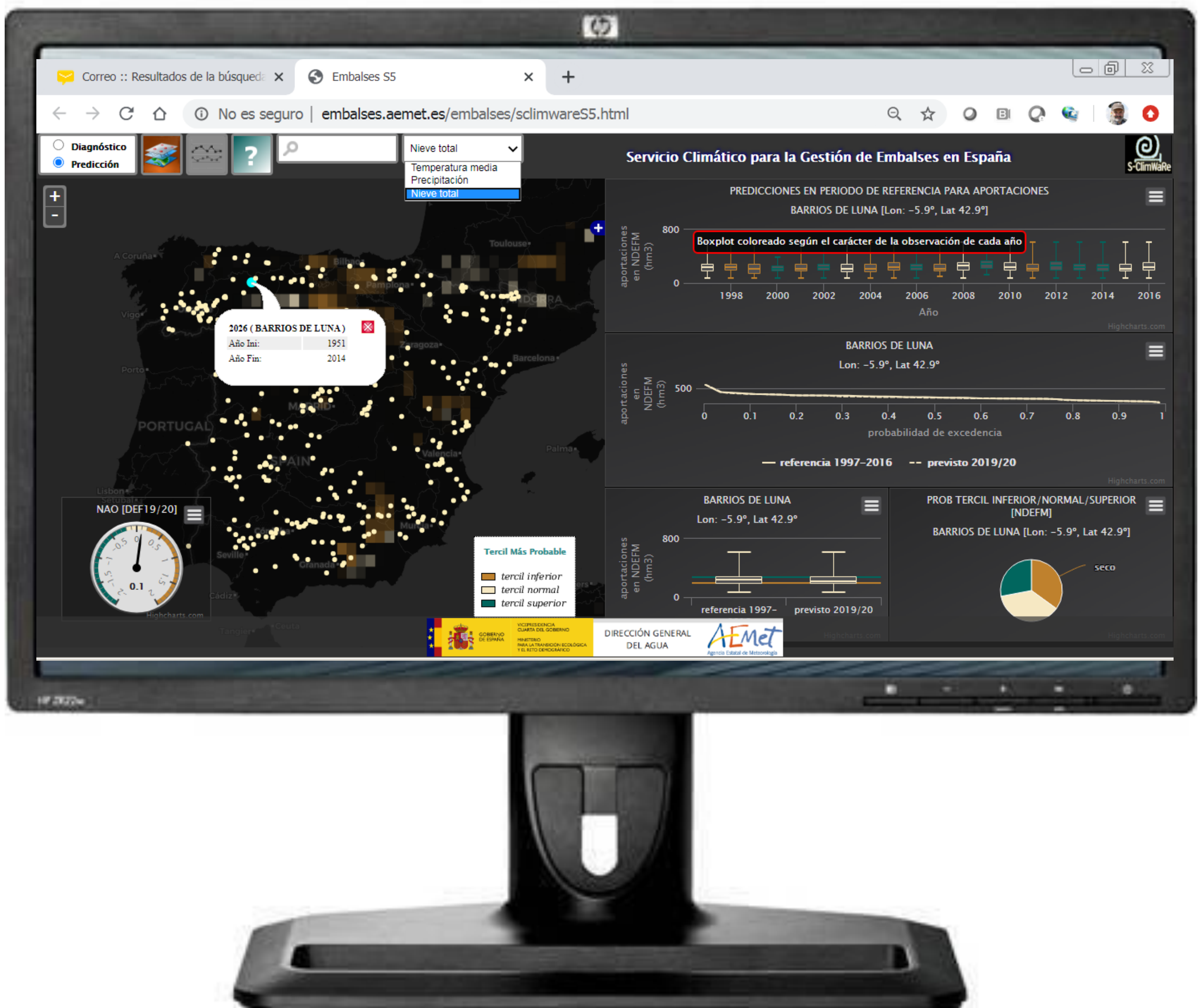
Typical verification: skill scores for forecasted indicators over a hindcast period



- Objective scores
- Cost/benefit

Actual or synthetic observations

Importance of a friendly visualization



ERA4CS European Research Area for Climate Services

MEDSCOPE

Summary

- MedCOF community took the initiative to propose MEDSCOPE Project → **User led CS**
- Final users contribution to co-design **depends greatly on different steps** leading to the generation of a CS. **Visualization, evaluation and application models** are the most frequent playground for co-design
- Most CSs make use of **specific data usually provided by users**. These data are needed for calibration and evaluation of the application models. When users data are not available, **synthetic data can be generated**, although some evaluation/comparison of such data against actual observations is desireable.
- **More than one application model** would help to estimate their contribution to the final uncertainty.
- Services with different **degree of users participation, operationalization and standarization**.
- More details of all services developed during the project -including their evaluation is provided in **deliverable D4.1** and annexes.

Thanks for your attention!