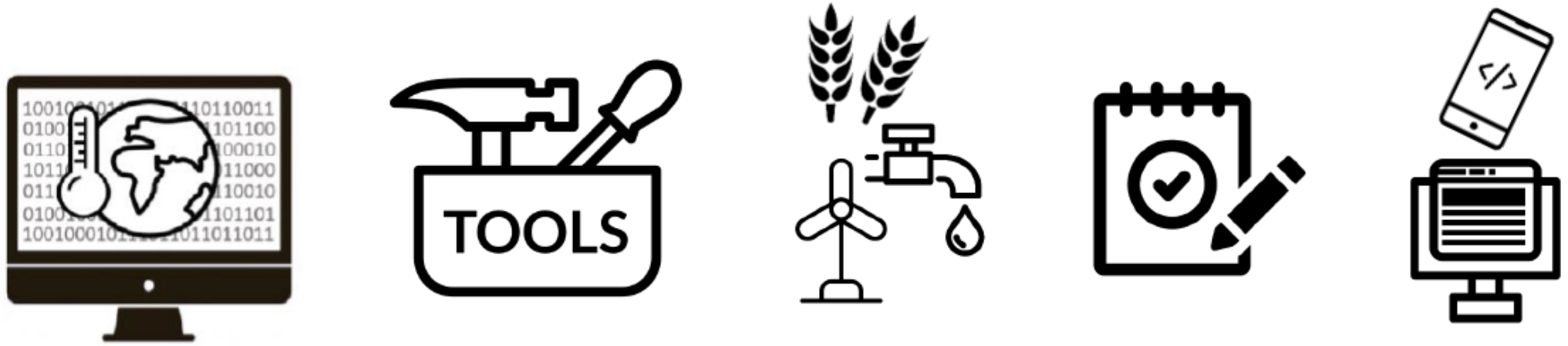
Co-design of sectoral climate services based on seasonal prediction information in the Mediterranean



Esteban Rodríguez-Guisado, Ernesto Rodríguez-Camino, Eroteida Sánchez-García, Valentina Bacciu, Marta Chiarle, Jose Costa-Saura, Maria Nieves Garrido, Llorenç Lledo, Beatriz Navascués, Roberta Paranunzio, Silvia Terzago, Valentina Mereu, Guido Nigrelli, Monia Santini, Albert Soret, and Jost von Hardenberg

MEDSCOPE

ERA4CS European Research Area for Climate Services

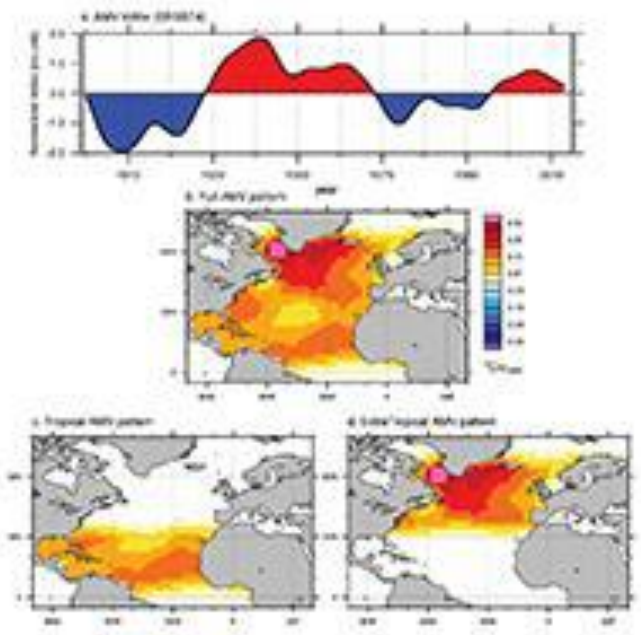
GOBIERNO DE ESPAÑA VICEPRESIDENCIA TERCERA DEL GOBIERNO MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

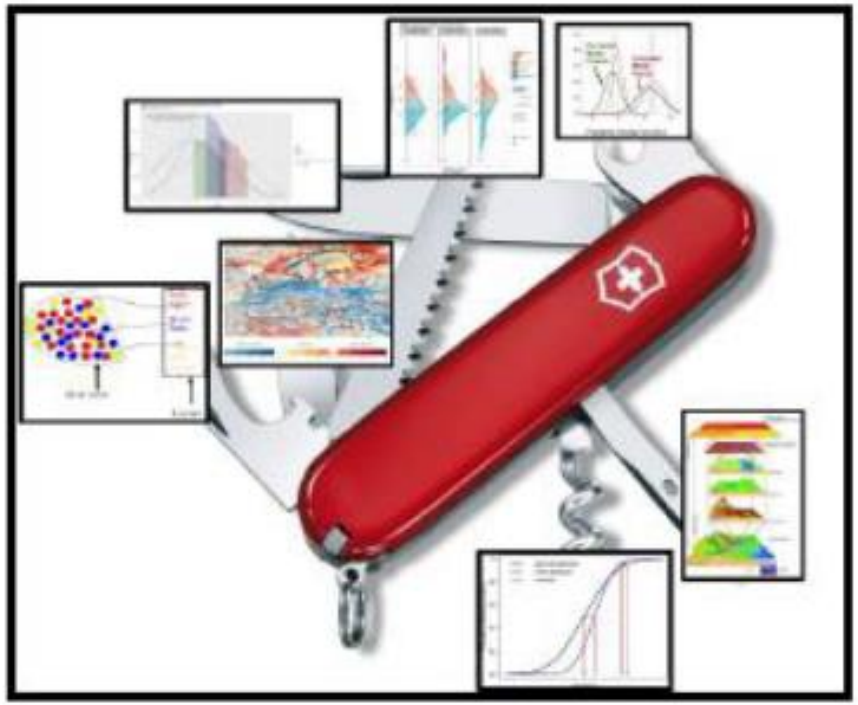
AEMet Agencia Estatal de Meteorología

EMS

ERA4CS MEDSCOPE Project:

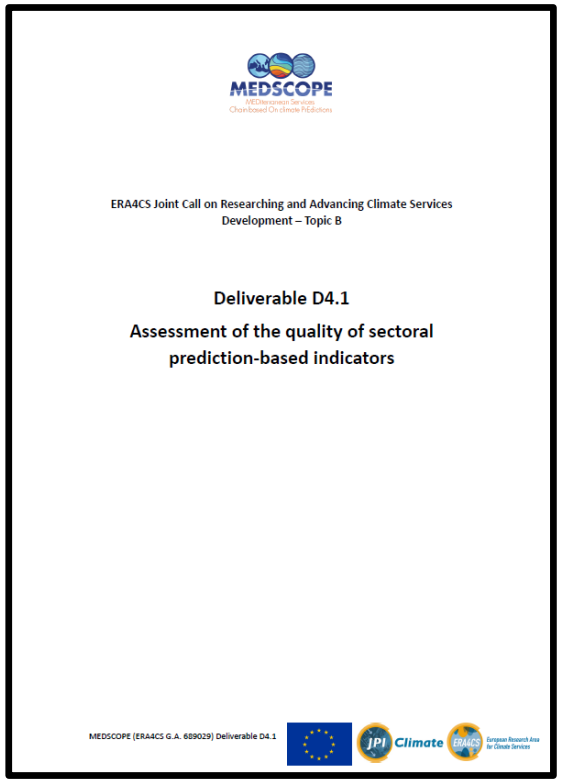
main objectives





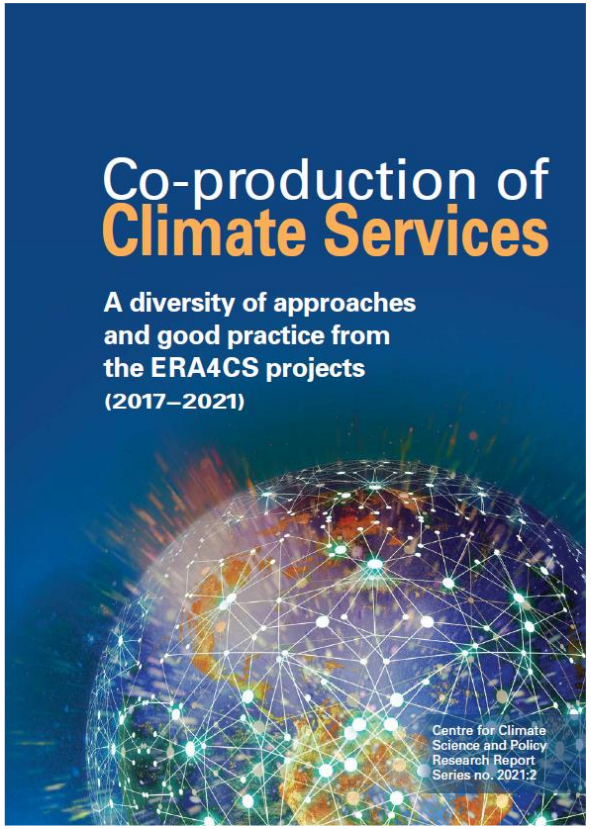


Climate services based on seasonal predictions for the Mediterranean



- 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

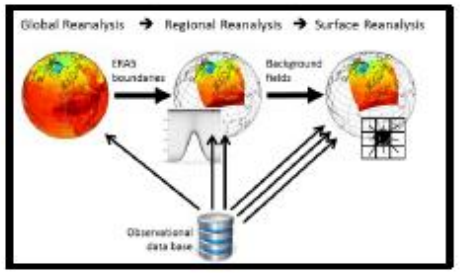


Steps in MEDSCOPE CSs

Copernicus CDS

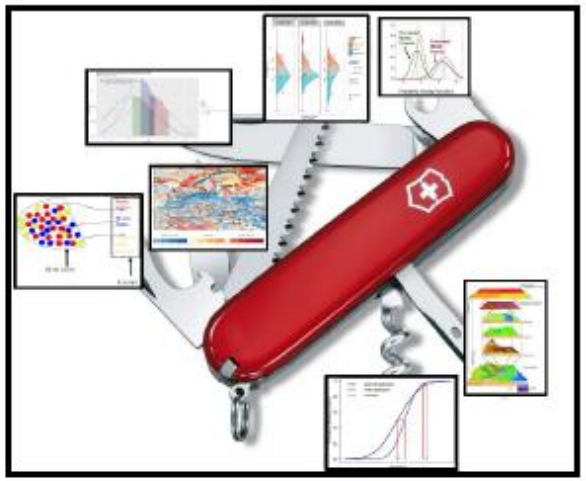


Optimal forcing: reanalysis
(or station data)



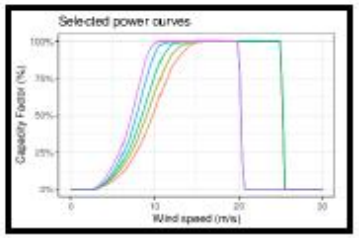
CS-tools

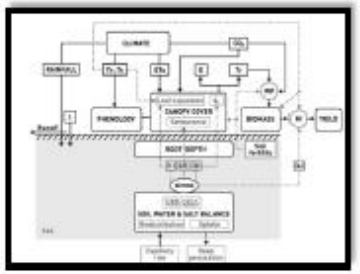
Bias correction, downscaling, members weighting, etc.

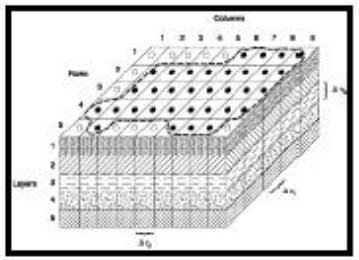


Application model

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

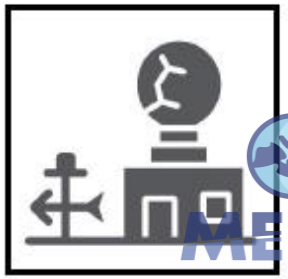
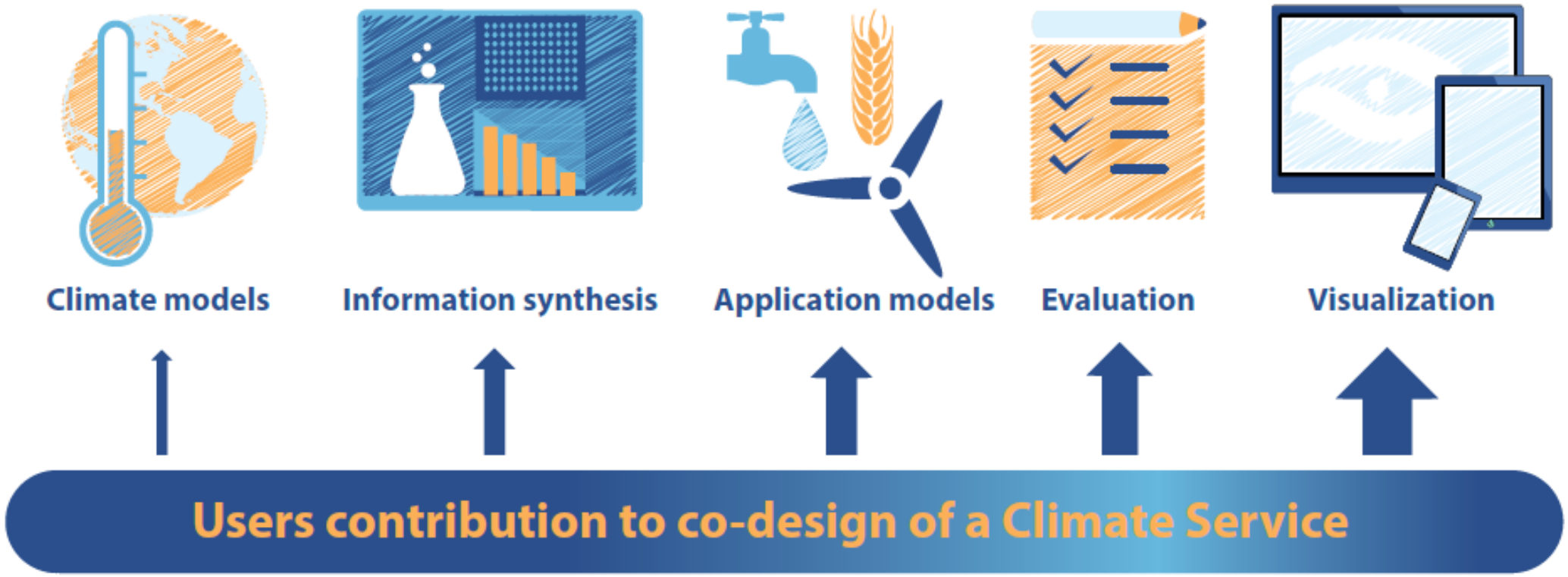


Diagram with a simplified climate services chain based on climate predictions. Users' contribution to co-design is represented by the gradual increase in thickness of the arrows



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

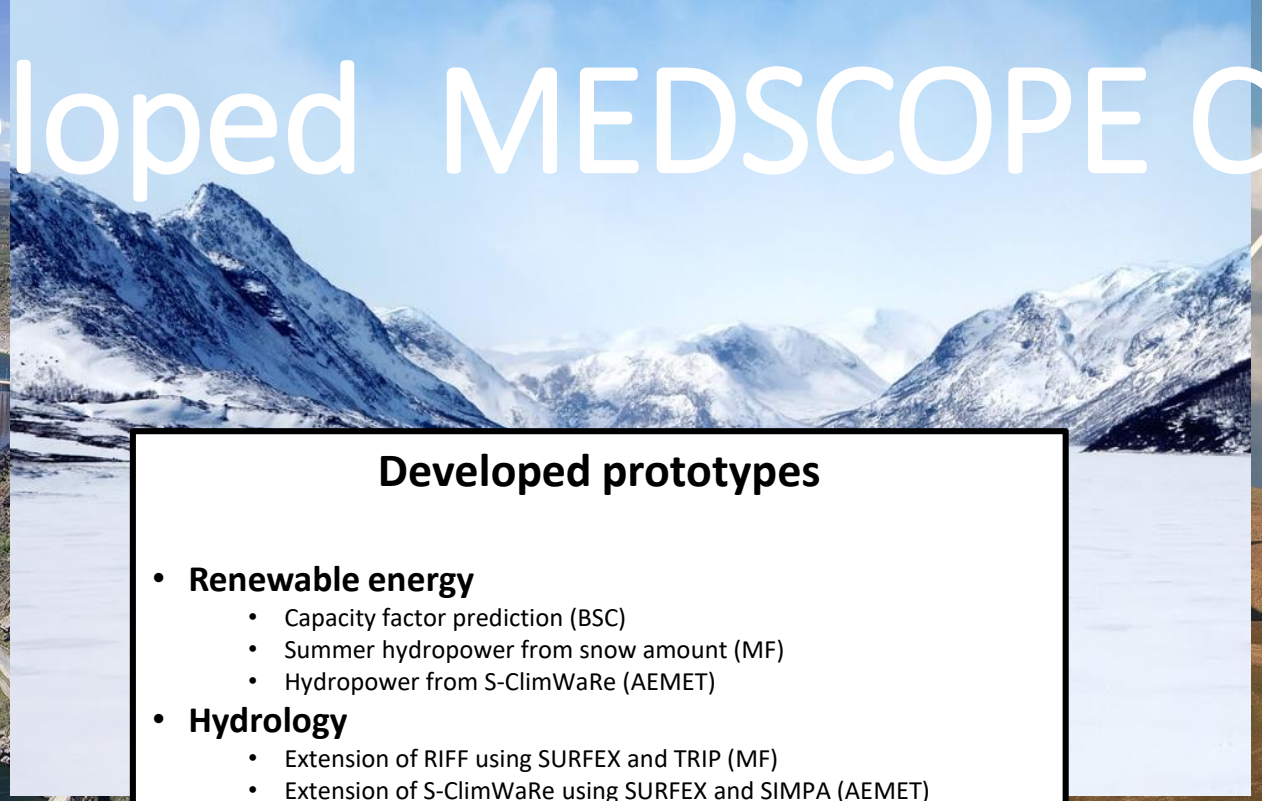
Summary of the metrics of evaluation for climate service co-production and user engagement in a sample (n=16) of the ERA4CS projects



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

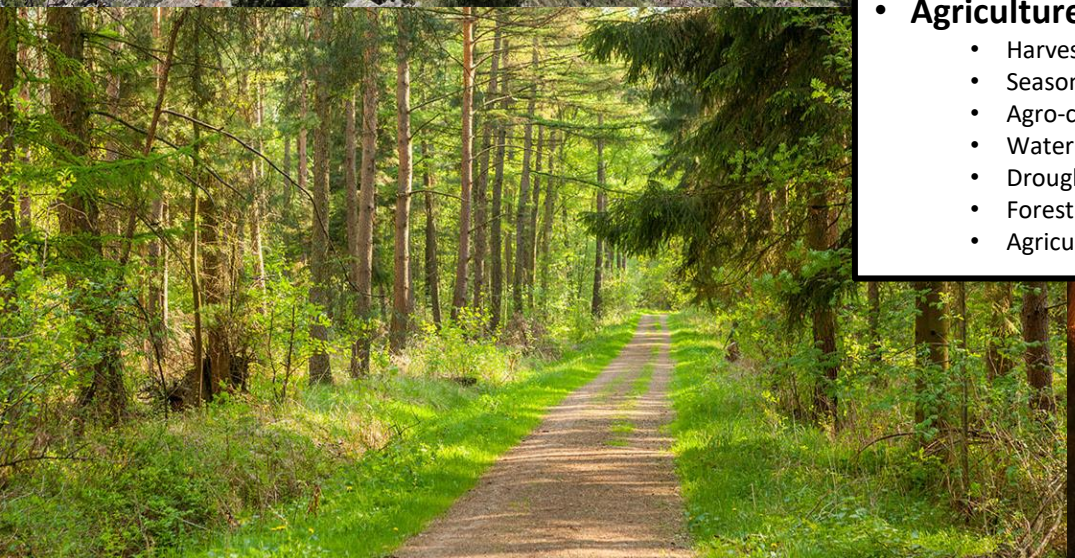






Developed prototypes

- **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)

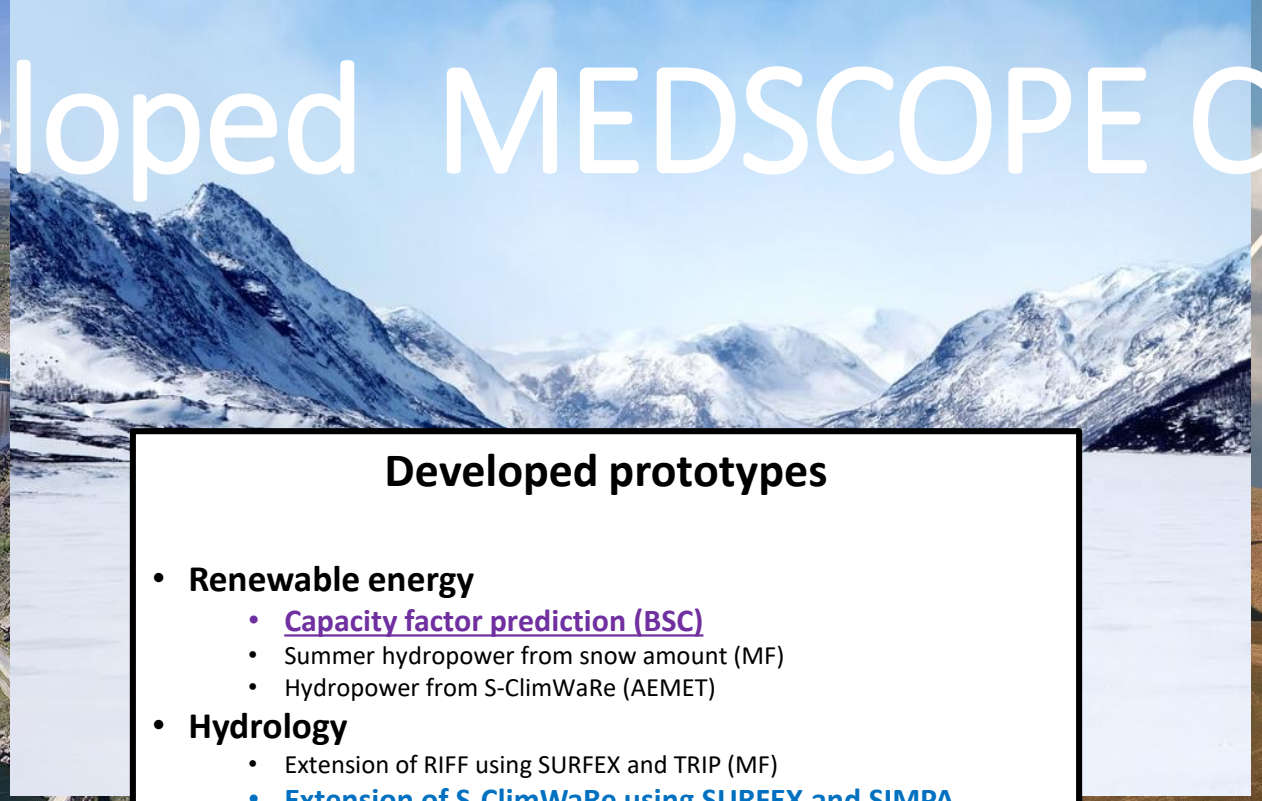






Developed MEDSCOPE CSs







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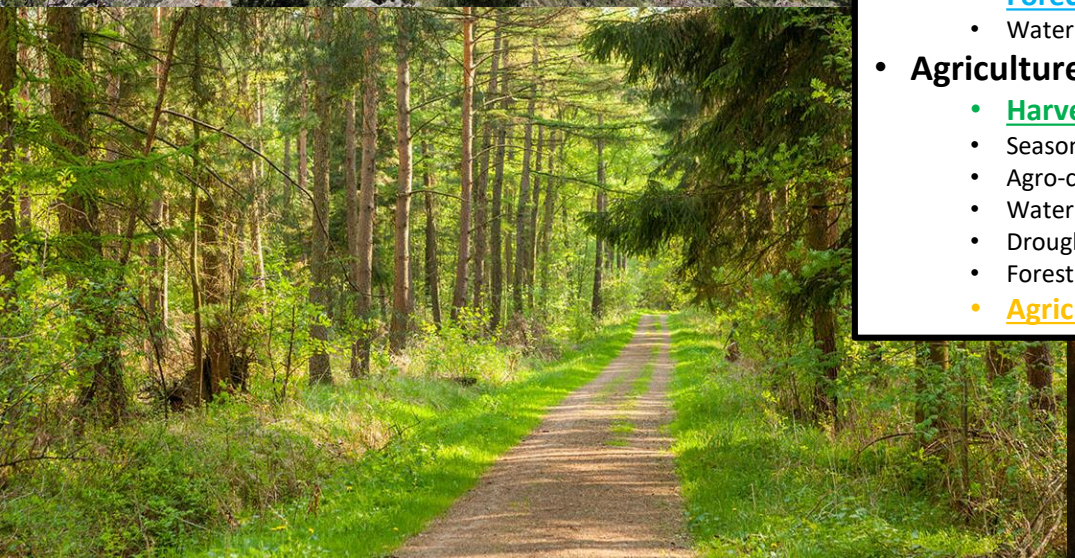






Box 1: Seasonal predictions of wind capacity factor in Spain

***Objective and motivation**:* Wind power generation is affected by atmospheric variability at several timecales. Having forecasts in seasonal timescales helps electricity network operators and wind farm owners to planify in advance

***User needs**: Different needs from users, from monthly to seasonal information, mean values or extremes.*

***Prototype discussion**:* Every ECMWF member Surface winds are bias corrected and extrapolated to 100m height. Then an application model for capacity factor is applied, producing probabilistic forecasts

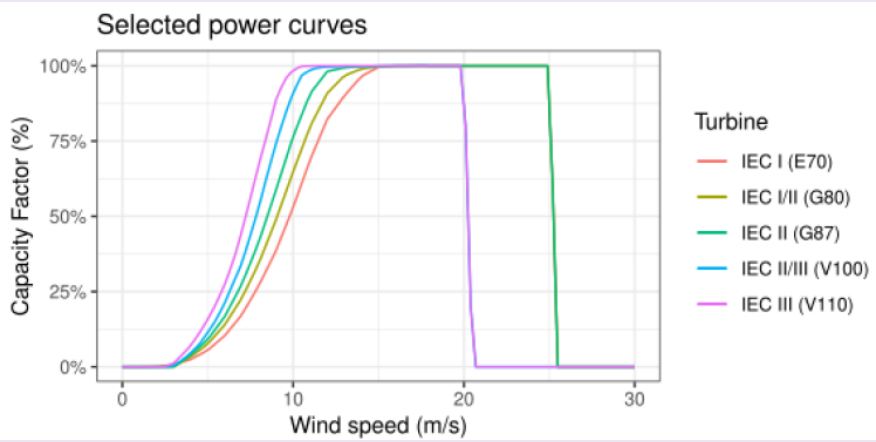
Role of users:

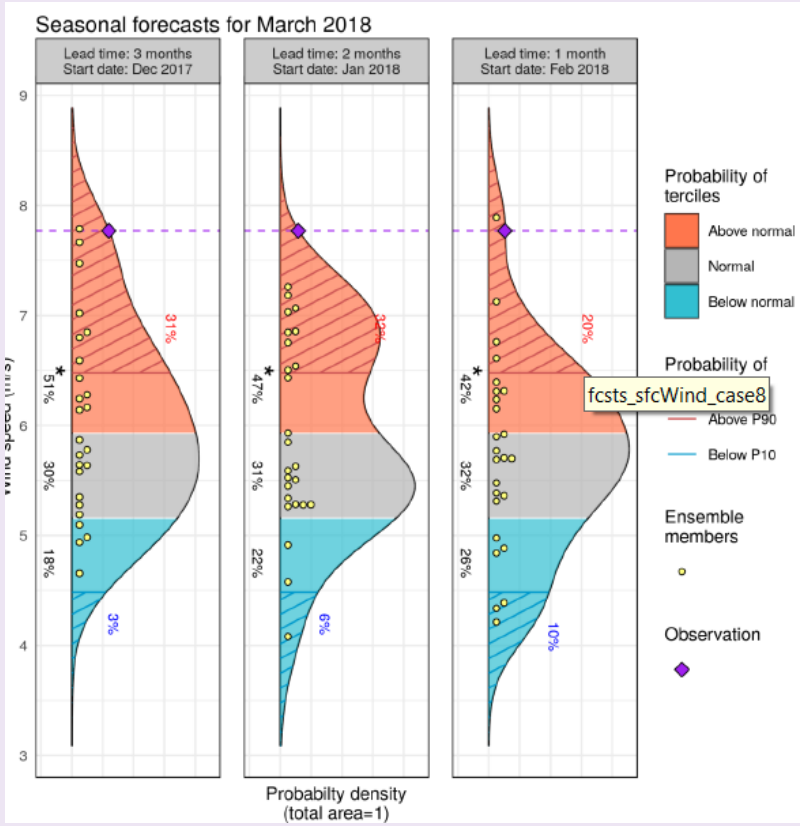
-Participation and discussion over the whole process.

Co-developement of the capacity factor application model, and identifying 100m as a typical turbine height.

Participation in visualization design.

Participation in discussions for evaluation and economic value.





Box 2: Seasonal forecast of snow and ice resources over Italian Alps

***Objective and motivation**:* Snowpack and glaciers are fundamental in providing water resources during the summer season. Providing information in advance is critical for all sectors involved.

User needs:

-Planify water usage and anticípate shortages

-Regulation of summer farming activities depending on irrigation

-Hydropower producers can adjust dam managing depending on irrigation needs, minimun ecological river flow and planning reservoirs management

-Artificial snow makers from ski stations can use forecasts to adjust their provisions.

***Prototype discussion**:* SNOWPACK model coupled to C3S models, run in November, providing snow depth and snow water equivalent for the following 7 months. Glacier model is run at beginning of May to simulate variation of glacier lenght and mass over the summer. Skill of the prototypes have been assessed in glacierized basins over Western Italian Alps.

Role of users:

Prototypes were designed and demostrated to a series of selected users, identifying their needs adapting the protoype according to their suggestions, i.e. Initialization time, length of the forecast and lead time, temporal resolution or visualization

Concluding remarks

Users expressed strong interestç, although they need time to adapt the prototypes into their current operations. Communication of uncertainty has been challenging.

http://wilma.to.isac.cnr.it/diss/snowpack/snowseas-eng.html

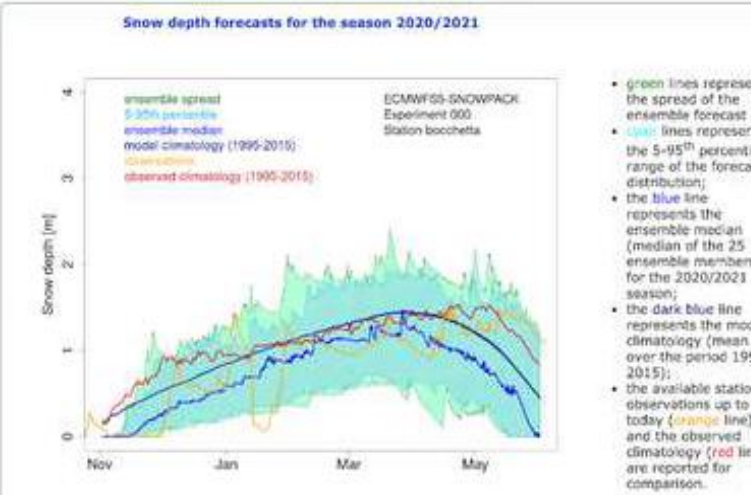


Figure 1: ECMWF SEAS5-SNOWPACK snow depth ensemble forecast (25 ensemble members) initialized on November 1st, 2020 and issued for the 7 months ahead, up to May 31st, 2021.

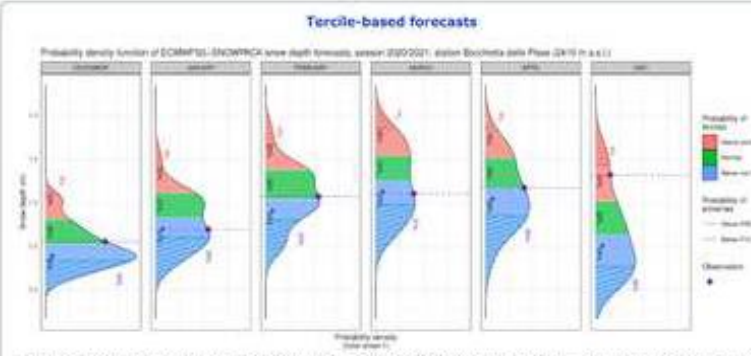


Figure 2: Probability density function (PDF) of the ECMWFS5-SNOWPACK monthly mean snow depth forecast f each month of the season.
Areas in coral, green and light blue color represent the probabilities to have monthly average snow depth below near and above the normal conditions, respectively, and the 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 abov the 90th percentile, respectively.

Box 3: Viewer of seasonal climate predictions supporting water reservoir management in Spain

Objective and motivation: River basing authorities, coordinated by Spanish D.G. Water, are in charge of management of over 1500 reservoirs over Spain. Information of water inflow in advance helps water planning.

User needs: Water planning, in order to satisfy wáter demands, grant supply over drought periods, and coping with flood risk.

Prototype discussion: S-ClimWaRe web tool provides information at 388 water reservoirs (covering 95% of total storage capacity) by means of two panels: diagnostic shows current situation and historical information for atmospheric and hydrologic variables and risks over the extended Winter (NDJFM), including linkage between inflow and its main driver (NAO). Forecast panel provides seasonal pedictions for NAO, water reservoir inflow, accumulated precipitation and snowfall and mean temperatura.

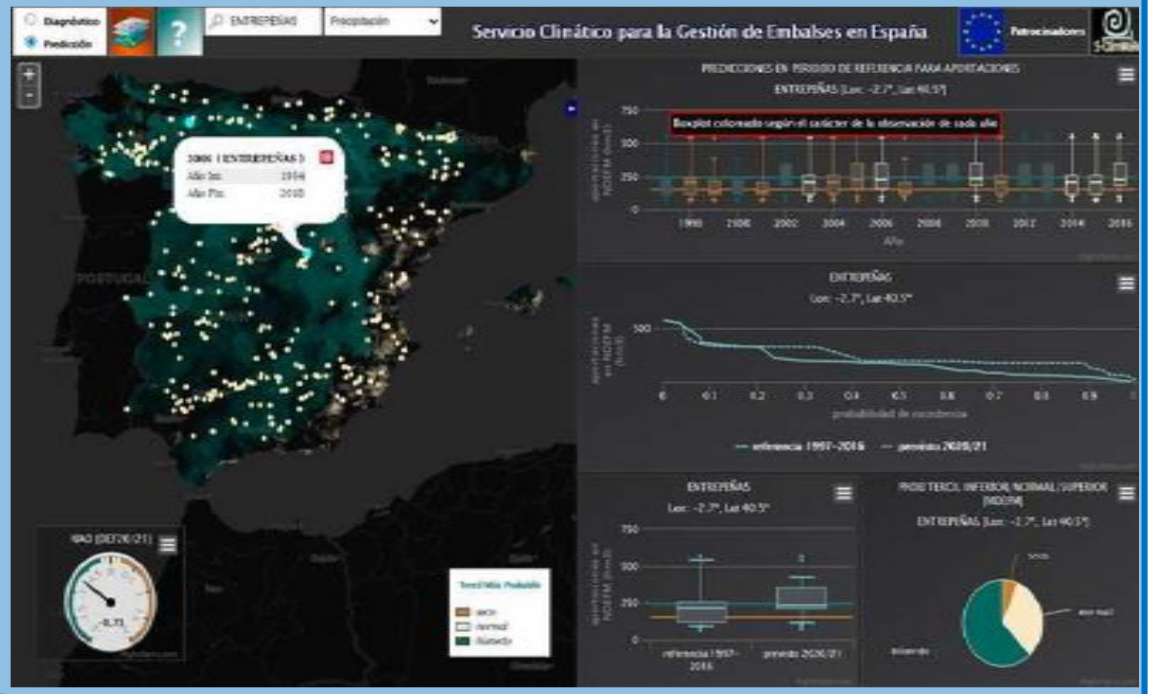
Role of users:

SClimWare has been fully user driven since its beggining, and it is characterised by a fluid dialogue and interaction between developers and users/stakeholders, trough the joint leadership by AEMet and D.G. Water. User requeriments were collected trough surveys and workshops. Selection of indicators and impact model was decided jointly with users, and workshops are regularly maintained, discussing possible improvements, and exchanging expertise.

Concluding remarks:

Communication of probabilistics forectasts and uncertainty has been one the the barriers. The involevement of users in the developing of the viewer has been critical fir its usability.

http://www.aemet.es/es/serviciosclimaticos/apoyo_gestion_embalses



Box 4: Estimation of cereal crop yield for Castile and Leon region (Spain)

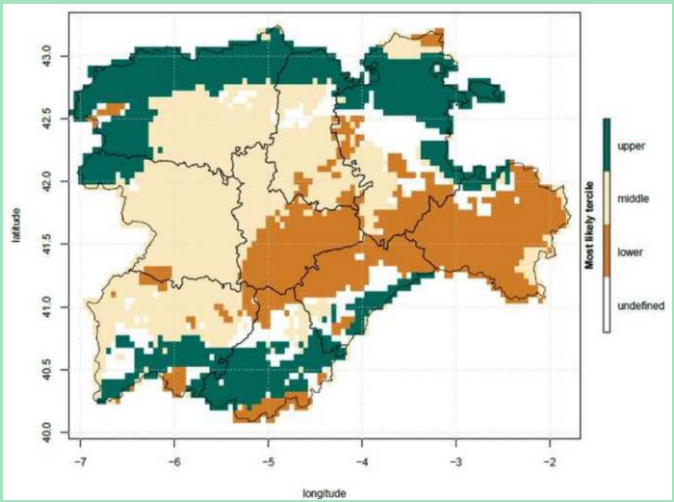
Objective and motivation: CyL is the main national producing region of winter cereals in Spain. The objective of this climate service is to provide some estimation of winter cereals yield at the harvest time (end of June) with 3 months of anticipation.

User needs: Farmers must make some decisions in spring about the usage of more fertilizers (top-dressing), plant protection products and possibly irrigation. Those decisions are based on an updated farmer yield expectancy that at that time is in the range of 3-4 months to harvest. The service here described is specifically focused on those decisions that could comprise about 30% of the costs depending on the crop. With a low yield forecast farmers could decide to reduce top-dressing fertilization and not to apply some plant protection products obtaining some savings. From the environmental perspective, especially on the nitrogen crop nutrition aspects, it is important to accommodate the fertilizers applications with yield extractions.

Prototype discussion: This operational climate service produces expected cereal yield for the CyL region based on the crop growth model Aquacrop developed by FAO, which simulates every agricultural year from September to June. From 25th September until 1st April, Aquacrop is driven by meteorological forcing coming from observational grids. After 1st April simulations are fed by short and medium range weather forecasts and after - until the end of June- by seasonal forecasts (SF) based either on climatological data or on outputs from the ECMWF SF System (SFS) version 5.

Role of users: The prototype has been developed jointly by AEMet and ITACyL (Agriculture Technical Institute from Castille and Leon. The contribution from the latter have been Mainly providing the needed setup for Aquacrop, and interpretation and evaluation of results.

Concluding remarks: The prototype has shown promising results, although it is felt that more training is needed to help interpretation of results and uncertainty.



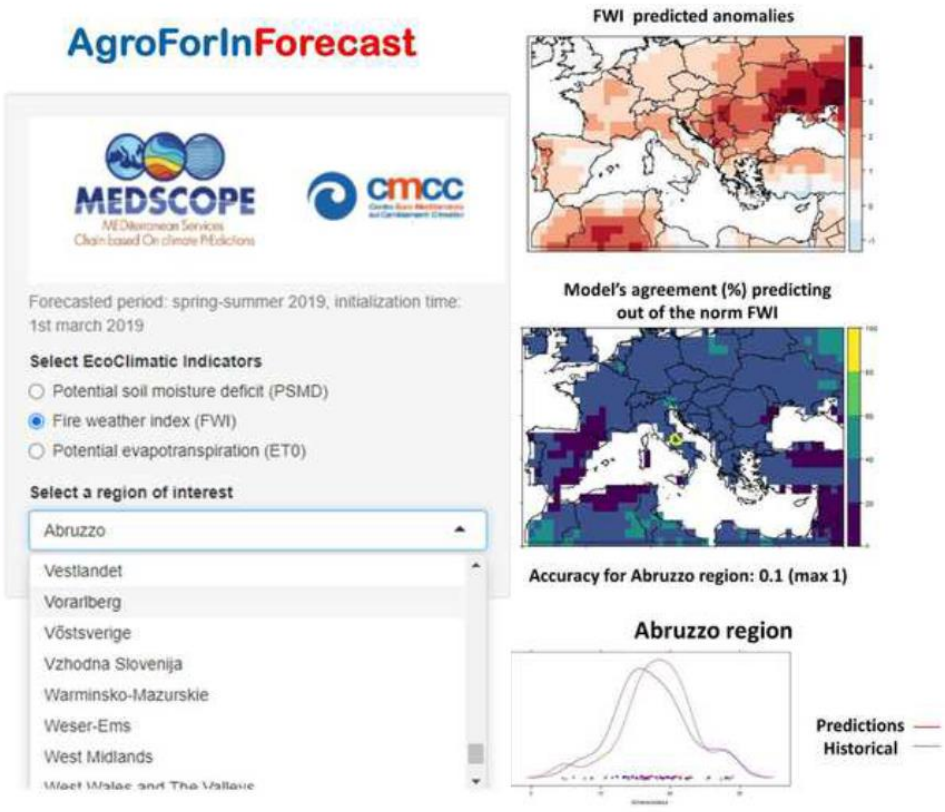
Box 5: Seasonal forecasts of climatic indicators for ecosystem management

Objective and motivation: Several types of decisions in the agro-forestry sector, from operational to strategic, need to be taken several months in advance
of any water scarcity period. Accurate climate predictions clearly communicated to the end-users and stakeholders, without mismatching concepts, greatly benefit land managers and practitioners for adaptation and planning.

User needs: Users from agricultural and forestry require information on water availability, vegetation water stress or fire risks for guiding decision making. Variables like potential evapotransoiration and soil moisture are key for irrigation planning and fire and drought prevention.

Prototype Description: The prototype focuses in three agroclimatic indicators: Ptential Evaportranspiration (PET), Potential Soil Moisture Deficit (PSMD) and Canadian Fire Weather Index (FWI). Indicators were calculated from CMCC s3 and ECMWF s5, and corrected and prostprocessed using CSTools. Skill is assessed using anoaly correlation coefficient and brier skill score.

Role of users: The prototype was developed after interaction with users in revious projects and discussions, where users needs were collected.



Conclusions:

- Different models of collaboration:
  - -Research community develops the pilot and demonstrate to users ((2,5)
  - -Extension ofcollaboration in other applications/scales into climate predictions (1,3,4)
  - -In the less frequent case, initiative can come from the user, as they identify the potential benefits or potential of climate predictions
- Users have intervened in:
  - -Identification of variables or indicators to be forecasted
  - -Identification of start dates and lenght of the forecast period, time resolution and lead time.
  - -Suggestion and/or supply and cofiguration of impacts model used
  - - Introduction to additional stakeholders
  - -Analysis, interpretation and evaluation of results
  - -Provision of data
  - -Selection of demonstration cases
  - -Suggestion of format of displaying results
  - -Outreach of the climate service
- Fluid communication with users have been established along the project. Many users have manifested their interest in expanding the prototypes to broader areas.
- There is a barrier regarding communication of probabilistic forecasts, uncertainty and skill, that sometimes limits the incorporation of the services into users operational scheme.

Concclusions

element in the whole lifetime of the
service. Although continuous feedback is an option (as in Box 1 or Box 4) other ways based
on cycles of interaction (as in Box 2 and 3) -comprising the phases of: collection of
requirements, co-design and planning, co-supply of the needed data, co-monitoring of work
progress, co-assessment of the prototype, operationalisation and training- have demonstrated
to be very efficient and provide a good characterization of the initial and evolving needs of
climate information.
Training and knowledge transfer in both directions -providers to users and users to providersis
critical to generate a common body of knowledge including concepts, terminology, etc. for
all agents intervening in the design, development and application of the service. Some of the
described prototypes (as Box 3) have conducted a very comprehensive plan of workshops
mainly aiming to convey to users the benefits and limitations of the science behind seasonal
forecasts. In the opposite direction, a clear picture of relevant decisions and schedules of
water managers has permitted the service to focus on the right