Earth Sciences Department

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Climate services
Science for and with society

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BSC is the national supercomputing center in Spain, hosting Marenostrum 5 supercomputer, one of the most versatile machines at the service of the international scientific community and of industry that requires HPC resources.

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Earth Sciences Department: research groups

The Earth Sciences Department performs fundamental research, develops global and regional environmental modelling, forecasts, data solutions and tailored services using dynamical models and artificial intelligence with HPC.

Atmospheric Composition

The **Atmospheric Composition** group works to better understand and predict the variability of atmospheric pollutants and their effects on the weather, climate, health, and a range of socioeconomic sectors.

By quantifying anthropogenic and natural emissions, the group investigates the impact of physical and chemical processes on the atmosphere's chemical composition from urban to global scales.

Computational Earth Sciences

The **Computational Earth Sciences** group provides all department members with cutting-edge software solutions, technical support, and expert guidance to address any technical challenges they may face in pursuing their scientific objectives.

The group also researches topics like the best use of high-performance computing, artificial intelligence applications, workflows, and data management and curation. They conduct profiling and optimisation of scientific software to scale up the community's computational capabilities.

Earth System Services

The **Earth System Services** group develops climate and air quality services to integrate scientific knowledge with other kinds of knowledge to enhance the resilience of societal sectors and support adaptation to environmental change.

Through a co-production process that involves scientists, intermediaries, and users, the group co-explores future risks and co-develops new knowledge to communicate and enhance the equitable uptake of climate and environmental information.

www.ess.bsc.es

Climate Variability and Change

The **Climate Variability and Change** group aims to understand the global Earth system, using models and observations to investigate how it responds to emissions from human activities, as well as well as to internal processes like El Niño, and their interactions.

Every year, the group also provides climate predictions for the next decade, enabling the development of strategies to mitigate and better adapt to the unavoidable consequences of climate change.

Global Health Resilience

The **Global Health Resilience** group co-designs policy-relevant decision-support tools to enhance surveillance, preparedness, and response to global health challenges. The group applies cutting-edge approaches to understand the links between climate change, socio-economic inequalities, and infectious disease emergence and spread, from local to global scales.

It contributes to international initiatives to ensure these digital tools have a downstream impact to strengthen global health resilience to emerging threats.

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Who we are

Earth System services
www.ess.bsc.es

Interdisciplinary research team of experienced scientists and young talents working together to close the gap between science and society.

Our competences

Post-processing

Forecast quality assessment

Applied research (physics, computer science…)

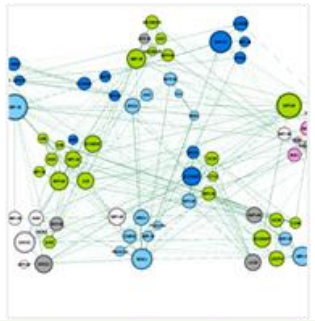
Operationalisation of services

Engagement and knowledge co-production

Value assessment

Science communication & dissemination

User experience and product design



Computational social analysis

Knowledge Integration team

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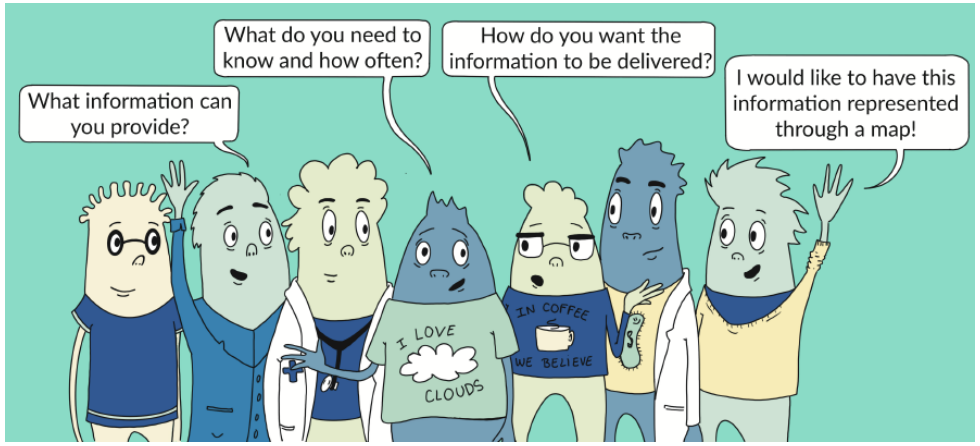
What we do

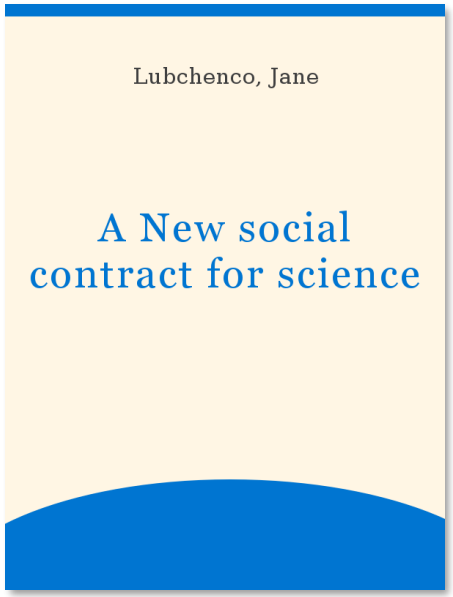
We **coproduce** climate, air quality and health resilience services to build a more resilient and sustainable society.

We exchange knowledge and tools with stakeholders in relevant socio-economic sectors at local, national, and international levels.

Motivation



Drawing by Inés Martín del Real, Barcelona Supercomputing Center.



"

I believe that we have an obligation to be helpful to society

A new contract must now ensure that scientific knowledge is 'socially robust', that its production is both transparent and participative and that certainties and uncertainties are effectively communicated to society.

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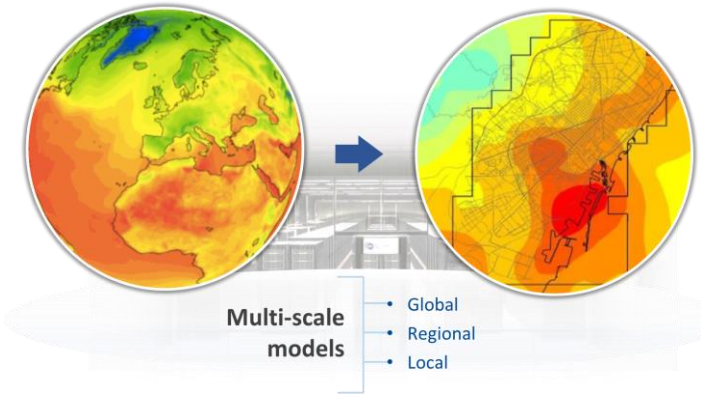
Models

We use models to simulate, understand, predict and test different scenarios.



Spatial scales

Temporal scales

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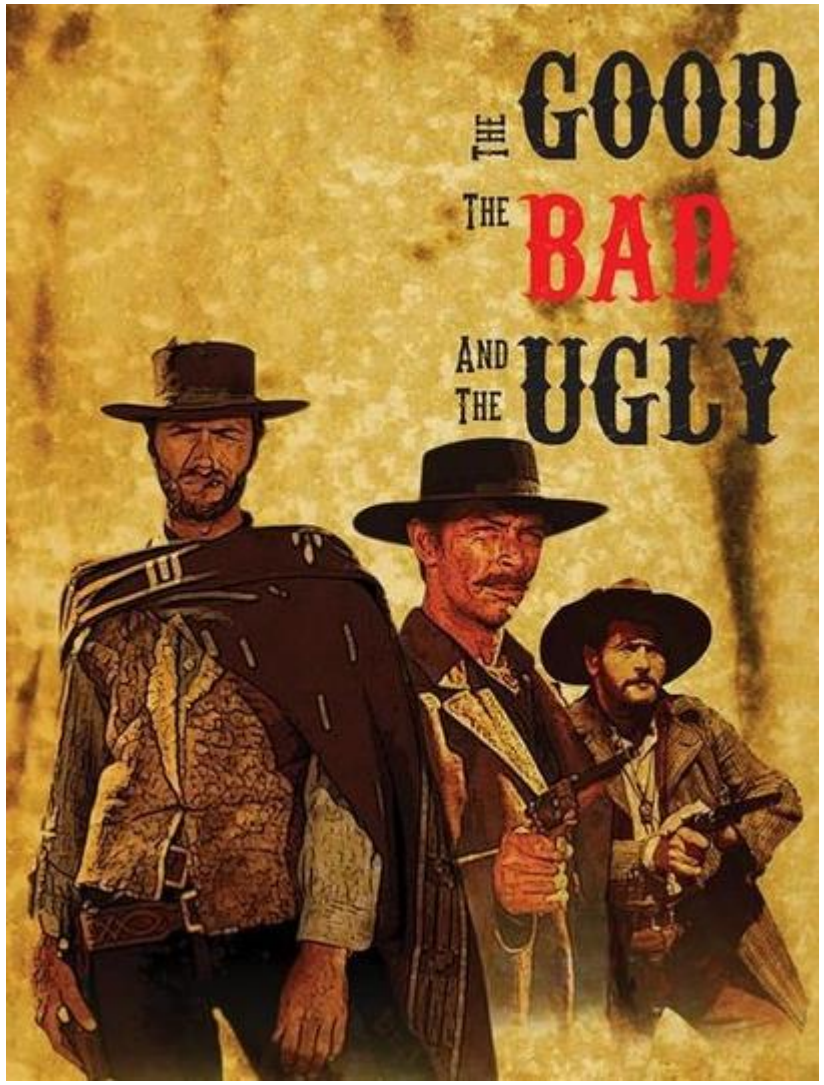
Models

The landscape of models is like the wild West.



- **No clear rules -** Not easy for an outsider to figure out which is which.
- **Lack of universal definition -** The word ‘model’ itself can mean very different things in diverse fields such as economics, epidemiology, physics, and policy.
- **Lack of understanding -** This may result in outsider misconceptions about how models work and how results should be understood and applied.

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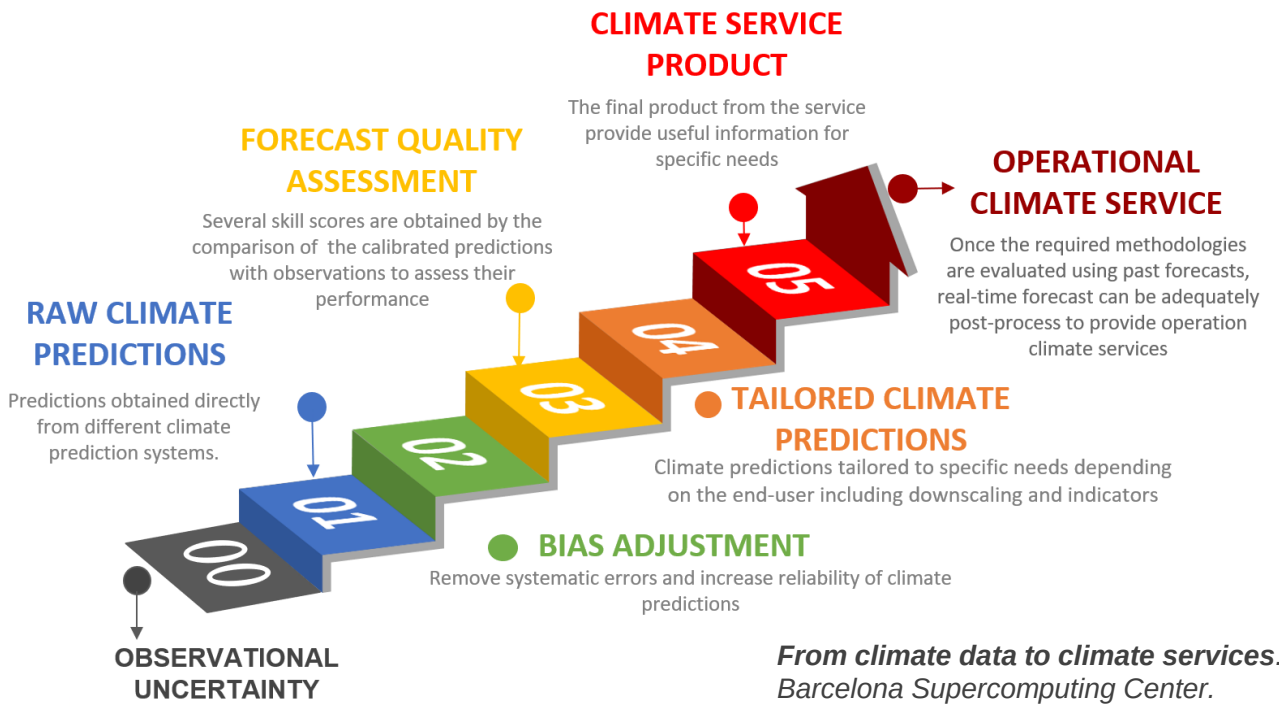
How can we help?

1. Tailoring model outputs

Post-process and transform raw data to information and knowledge to be used by society.

2. Interdisciplinary & transdisciplinary approaches

Natural sciences are essential for this endeavor, but there is a need to involve social sciences, other complementary disciplines and potential users.



From climate data to climate services.
Barcelona Supercomputing Center.

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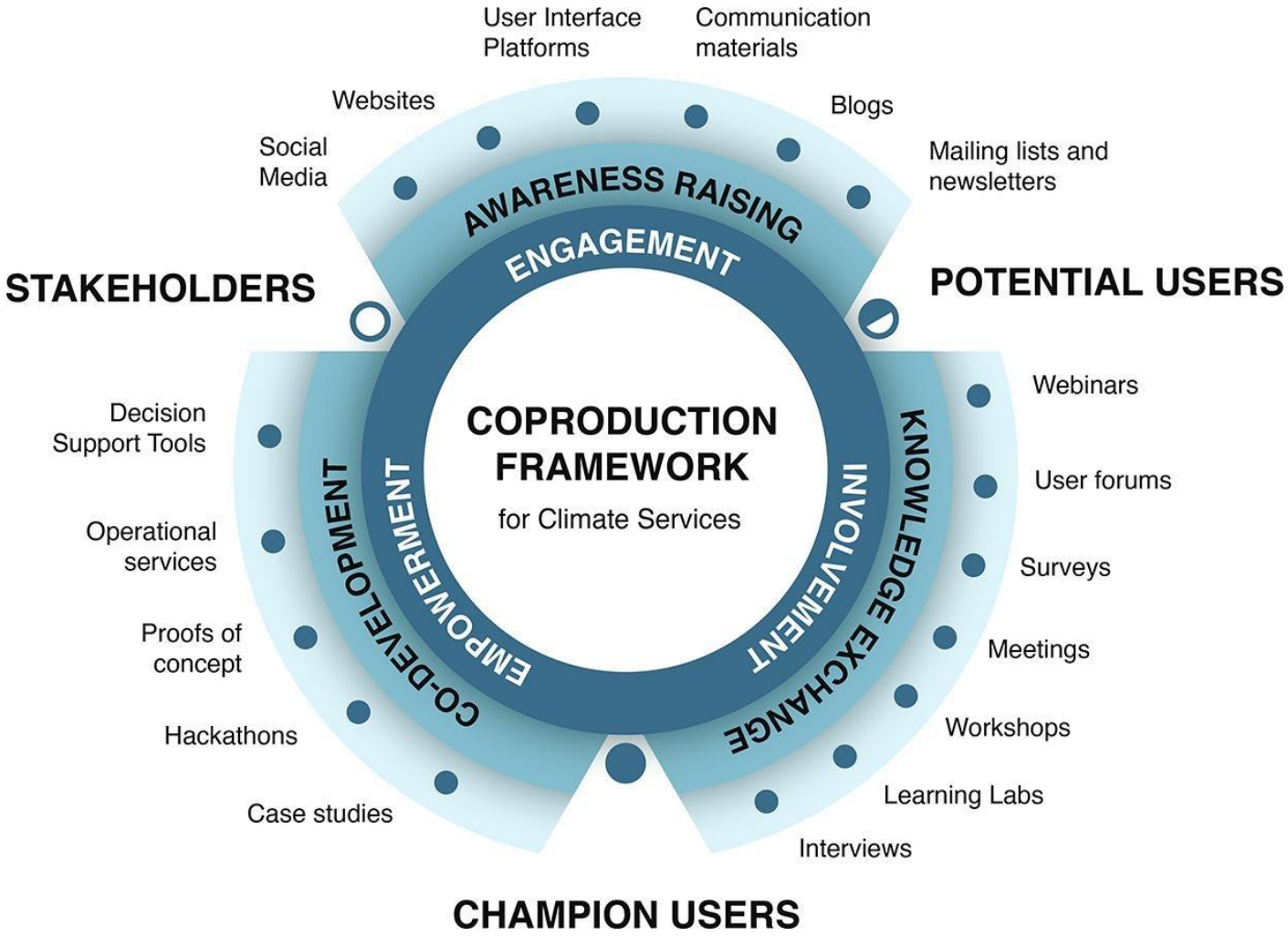
Engagement and knwoledge co-production

We apply a transdisciplinary co-production framework

…that allows feedback loops between users and providers.

Bojovic et al. (2021) Engagement, involvement and empowerment: Three realms of a coproduction framework for climate services. Global Environ. Change.



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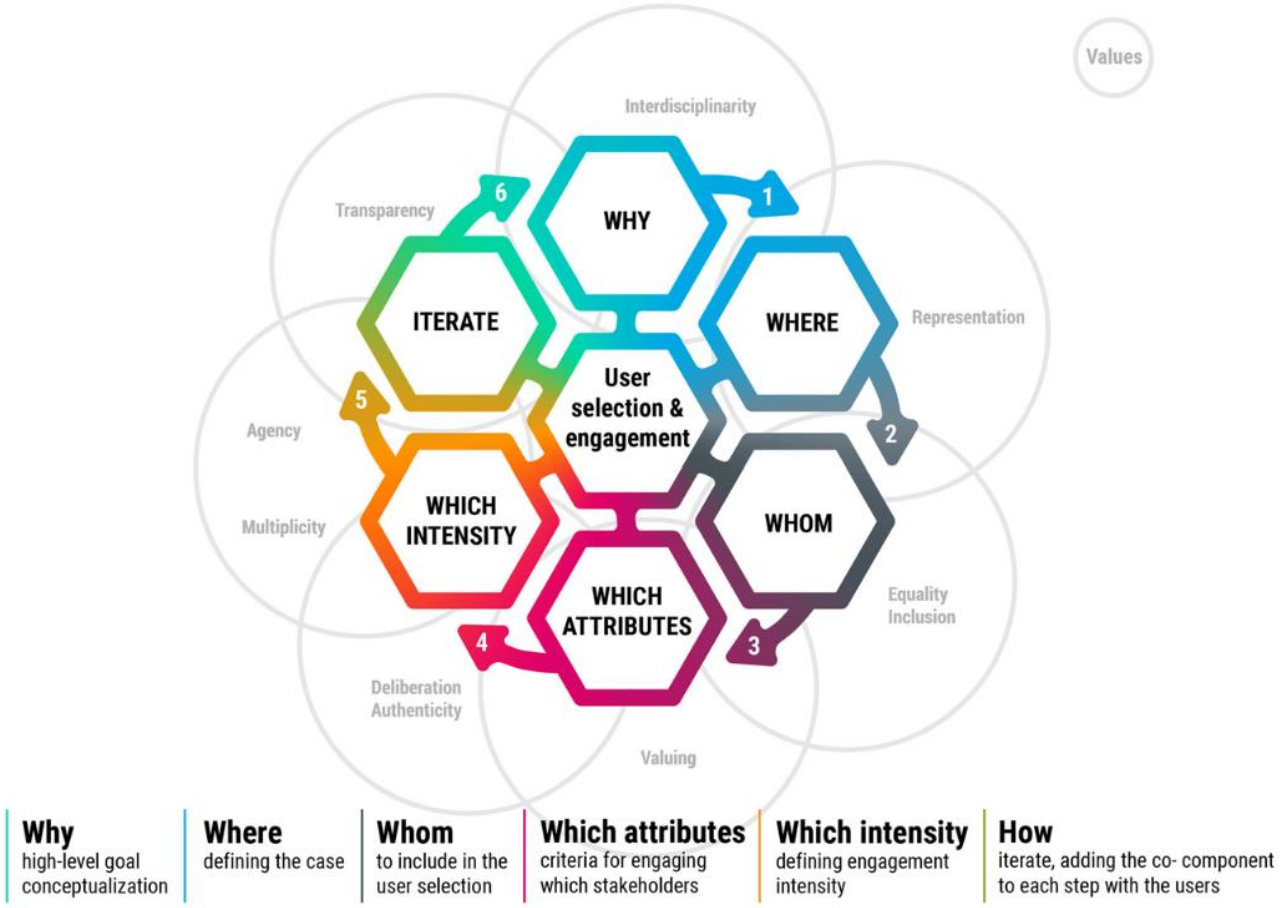
Guidance on user selection and engagement for co-production

…integrating values of participatory science such as legitimacy, representativity and agency.

Baulenas et al. (2023) User Selection and Engagement for Climate Services Coproduction. Weather Clim.Soc,.

Engagement and knwoledge co-production



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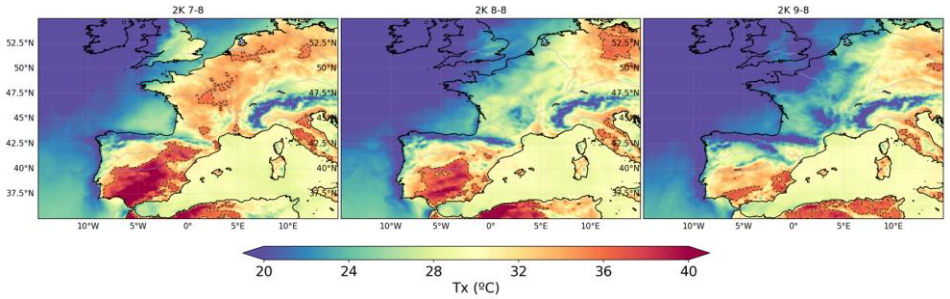
Computational social analysis

Systematic identification, collection, storage, and analysis of qualitative and quantitative data.

Computational social analysis



Quantitative data

- Climate model outputs (e.g. max temp)
- Impact model outputs (e.g. capacity factor, risk of frosts, etc.)

Qualitative data

- Surveys and interviews
- Focus group discusion
- Co-creation sessions

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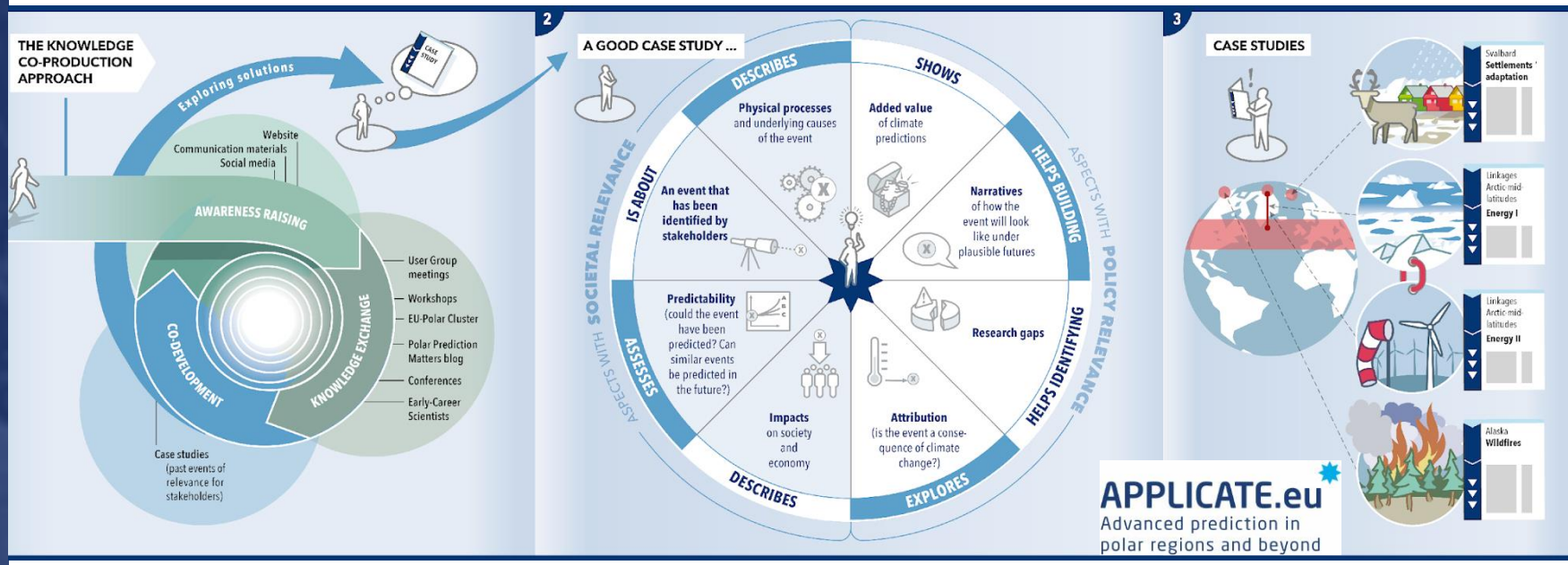
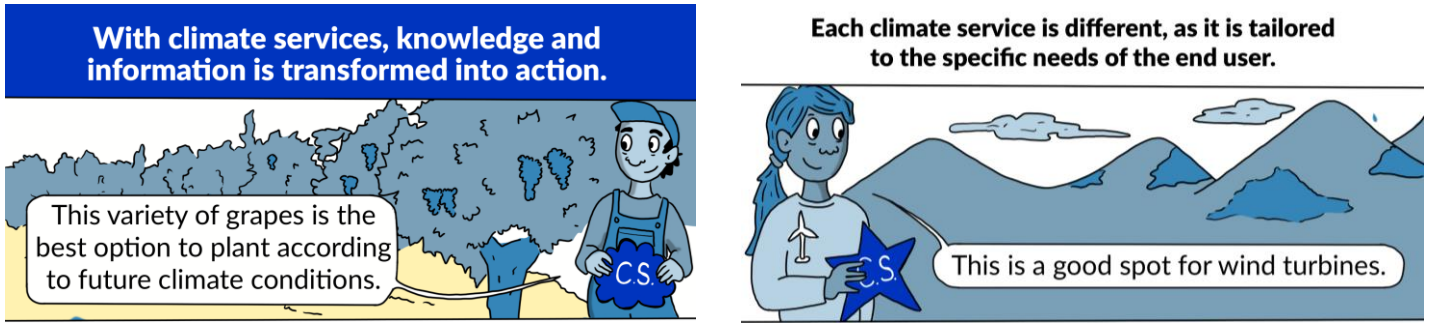
Engagement and knwoledge co-production

Co-define case studies with users

…including specifications for time scales of interest, variables, locations, resolution, etc. to support user's decision-making.

Terrado et al. (2023) Good practice for knowledge co-development through climate related case studies. Clim. Risk Manage.





User decisions that can be supported by climate services. *Drawing by Inés Martín del Real, Barcelona Supercomputing Center.*

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Climate services for agriculture: a case study for the wine sector

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MED-GOLD

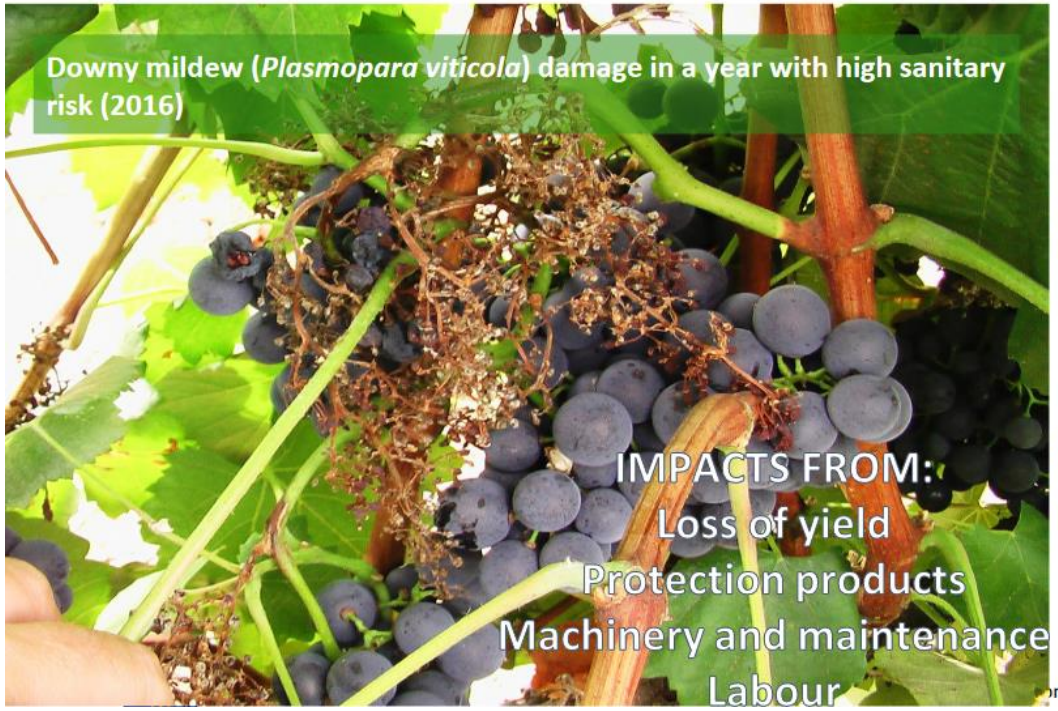
A viticulture case study

USE CASE

You are a viticulturist. It's March, and you need to decide how much stock of plant protection products to buy this season. Rainy and warm springs can favour pest outbreaks in vines.

Is this spring going to be particularly dry or wet?

Challenge → Rain in warm Springs



Related user decisions

Pictures: Sogrape Vinhos.

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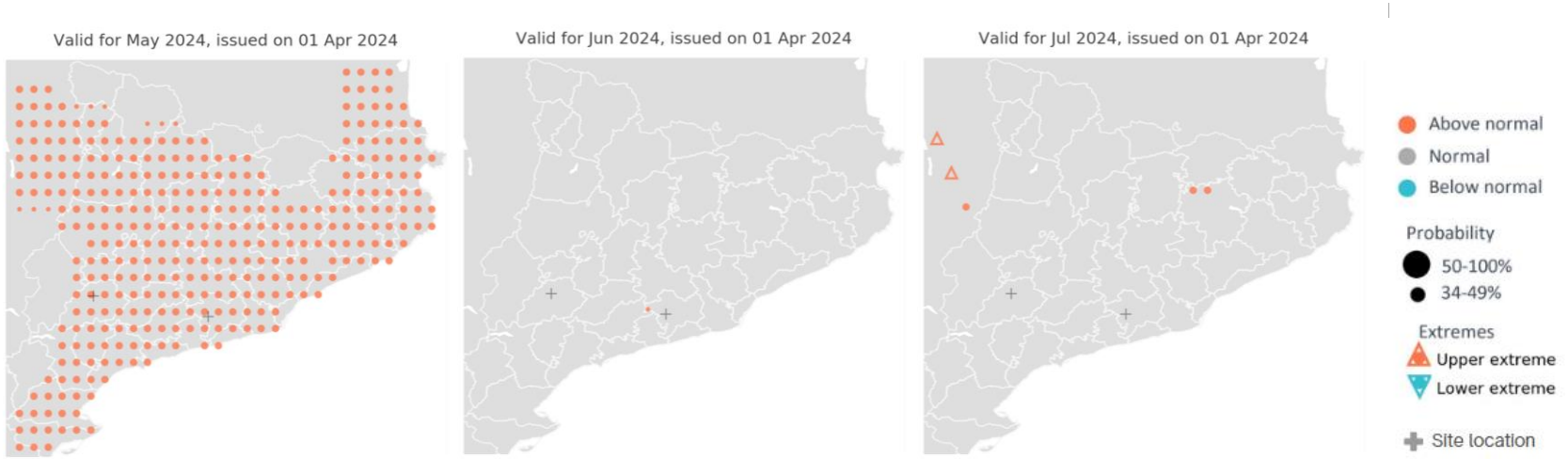
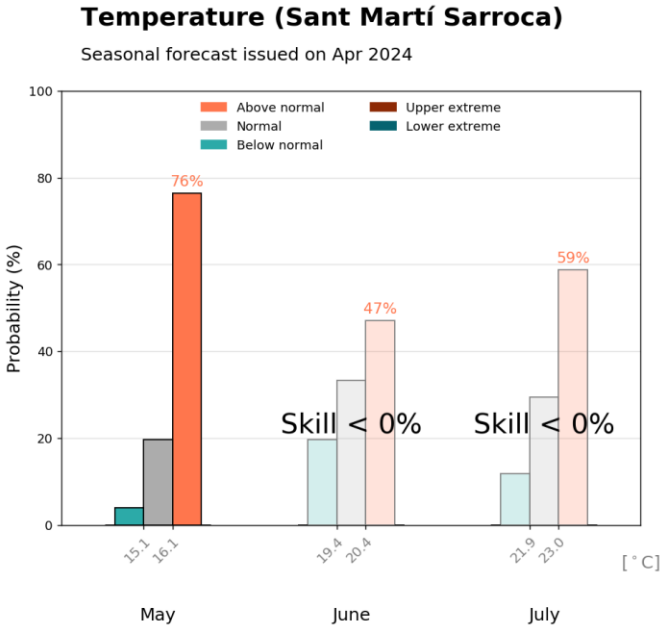
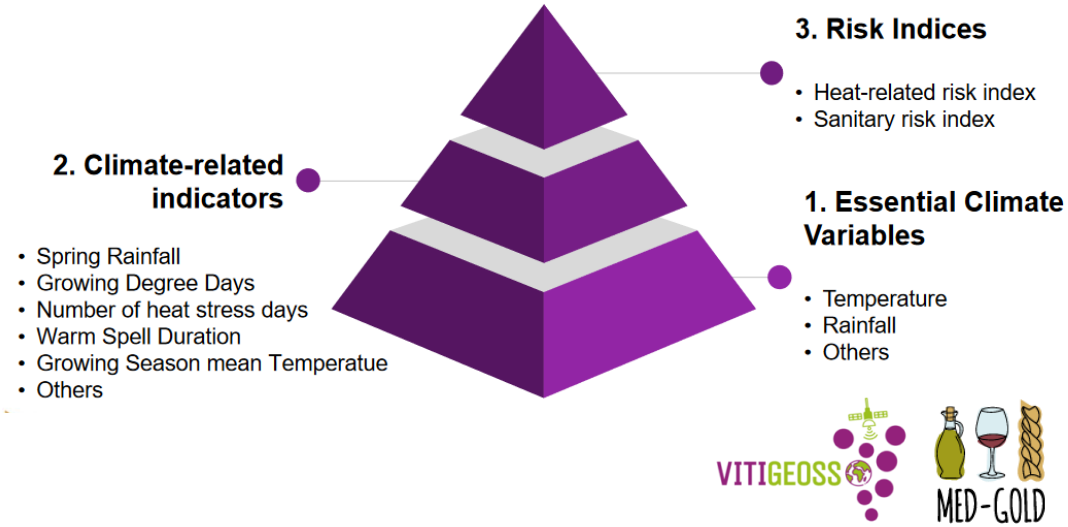
A viticulture case study

How to interpret seasonal predictions of mean temperature







VITIGEOSS
MED-GOLD

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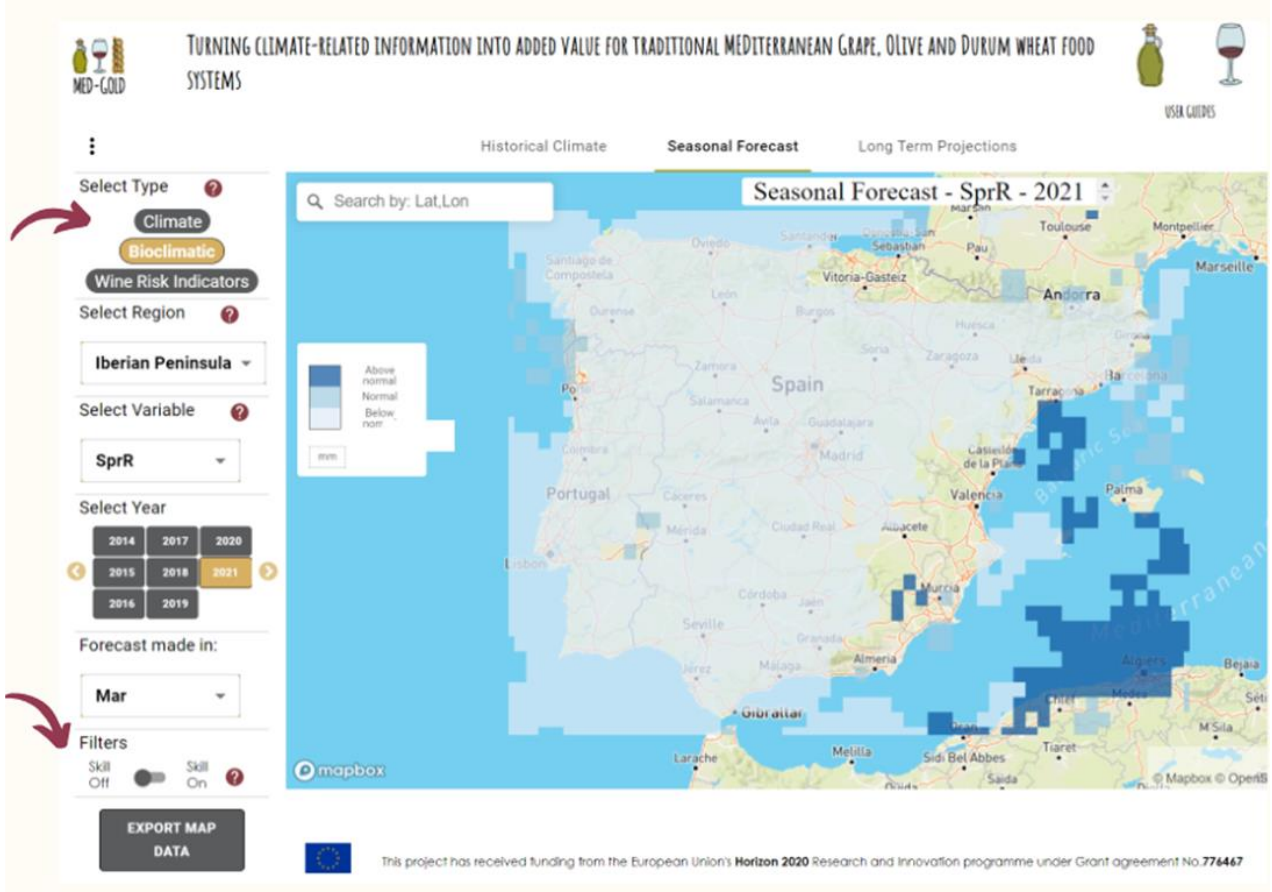
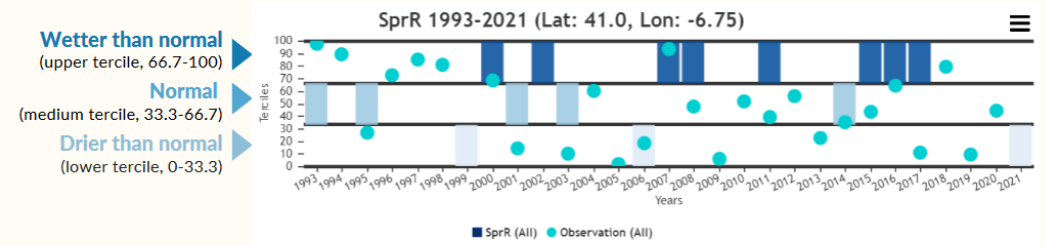
A viticulture case study

A dashboard with climate variables and indicators

Risk of pests and diseases?
Check the bioclimatic indicator Spring Rain (SprR)

How accurate is the prediction?
Turn on the 'skill' filter option to hide areas where the prediction is not reliable enough for decision making





HOW WELL WAS SPRING RAIN PREDICTED IN THE PAST?

By clicking on the map, a chart will appear where circles correspond to values of spring rain observed in past years, and squares show model predictions (*above normal, normal and below normal terciles*).

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How do we overcome the challenges for the uptake of services?

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Communication to raise awareness

Science communication, including outreach activities, refers to a variety of practices that transmit scientific information, knowledge and research findings to non-specialised audiences in an accessible, understandable and useful way.

Science communication

Material

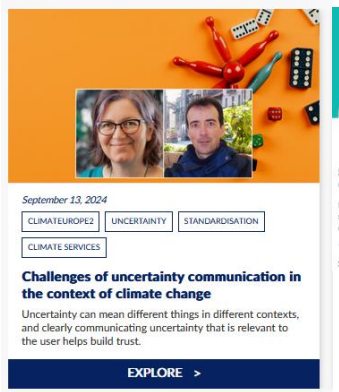
Factsheets, flyers, infographics, user guides

Events

Webinars, festivals, targeted events

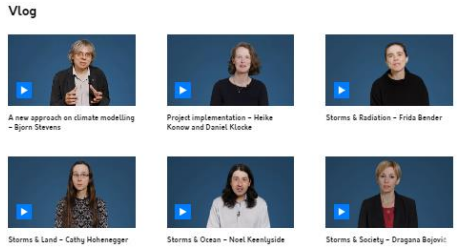
Web/social media

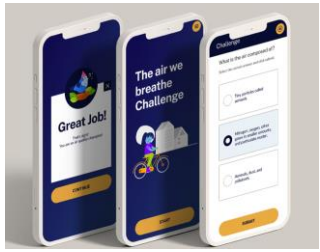
Content creation, campaigns, blogs



Multimedia

Videos, pocasts, explorable explanations, apps





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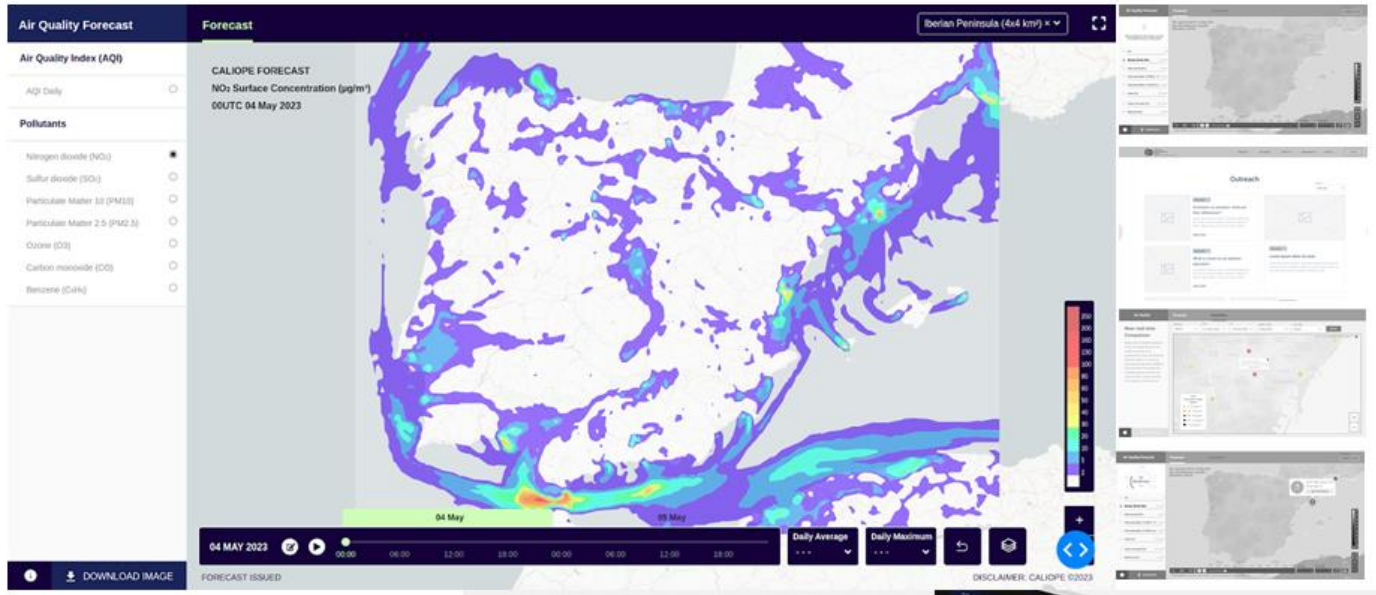
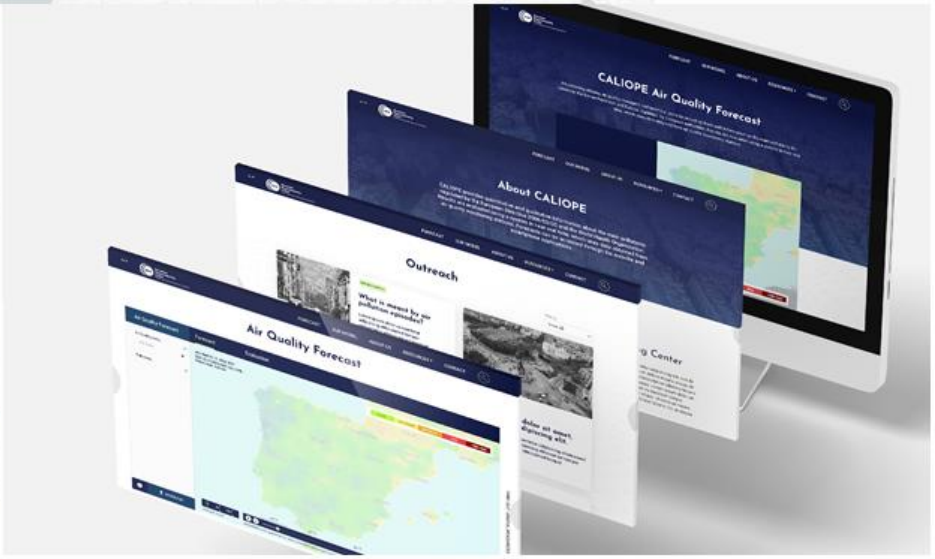
Improving user experience

Considers user's feelings when using a product, application, system or service, the quality of the user's perception and how easy or pleasing to use the product or service is.

User experience and product design





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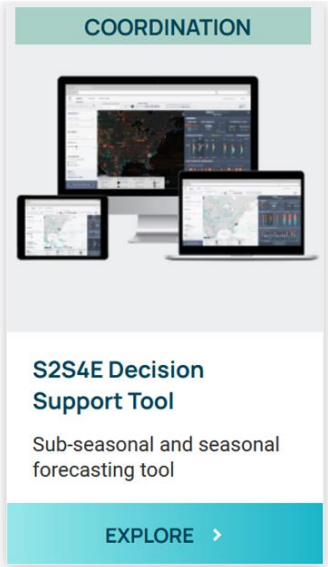
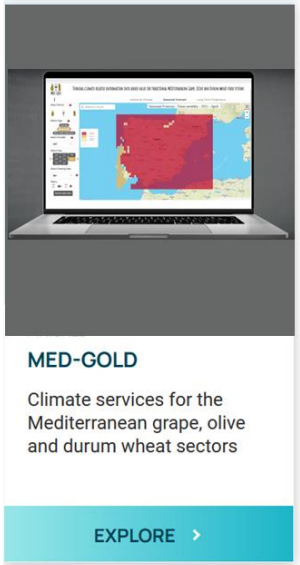
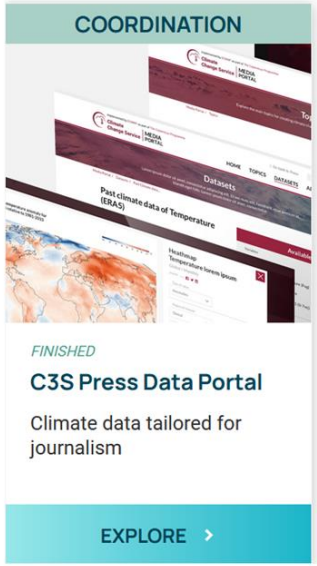
Co-developed platforms for climate and air quality services



DST
Energy (wind, solar, hydropower, energy demand)

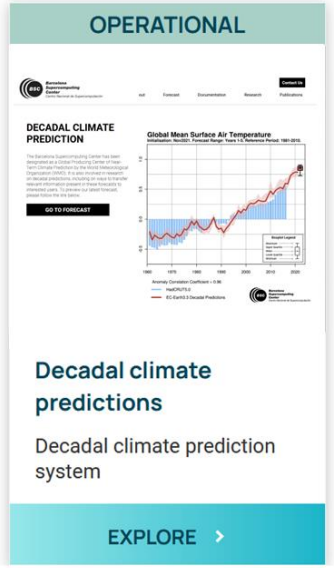


DST
Agriculture (grapes/wine, olives/olive oil, durum wheat/pasta)



Data portal
Journalists, communicators

Information platform
Re-insurance, general public



Information platform
Academia

Information platforms
Academia, health practitioners, general public, aviation

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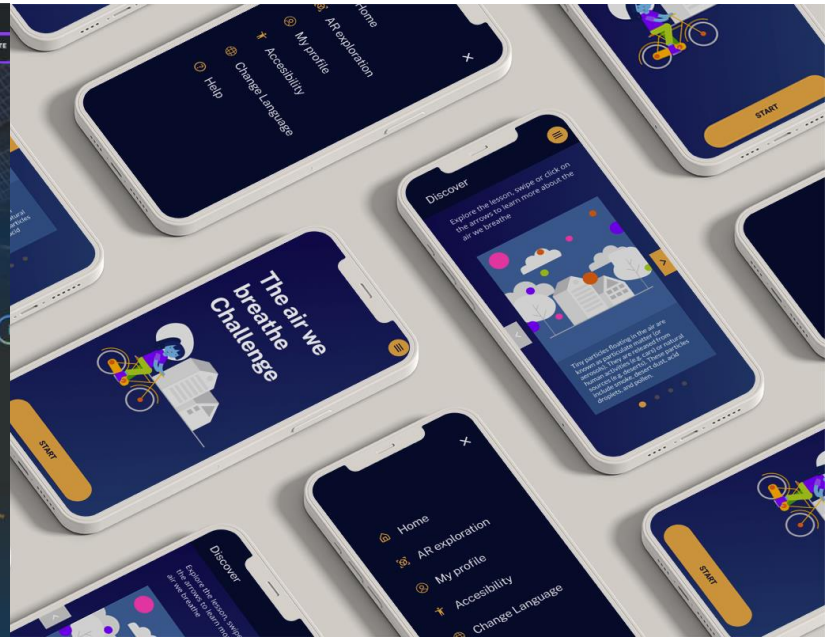
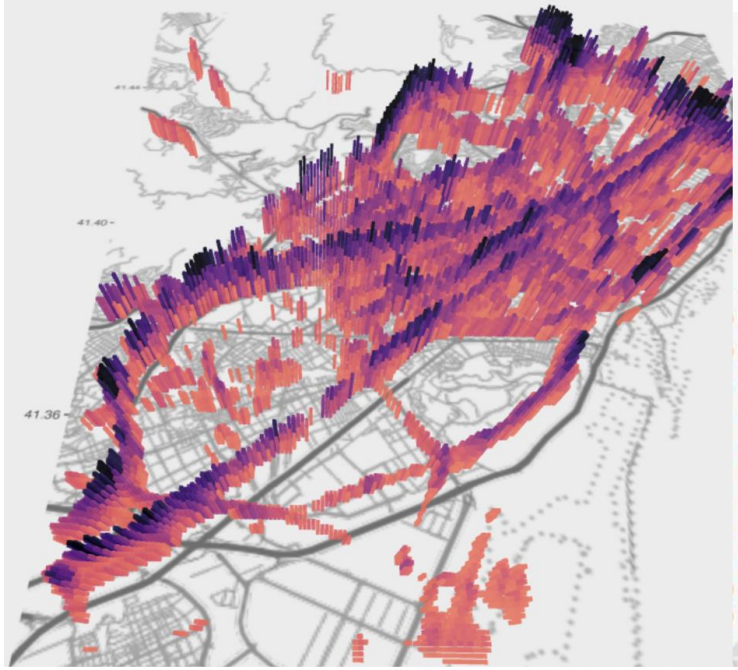
Develop effective ways of visualising complex data

Wow effect, but not only…





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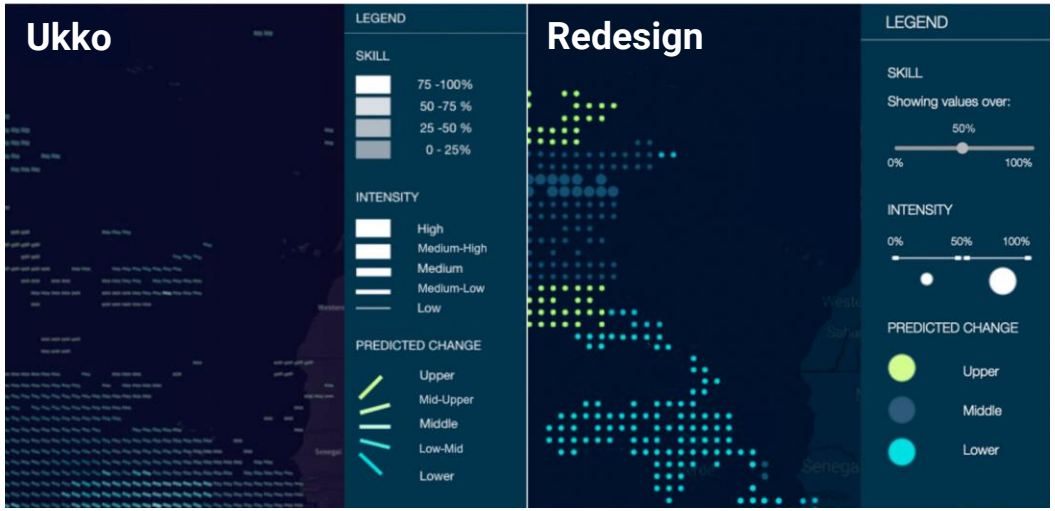
Develop effective ways of visualising complex data

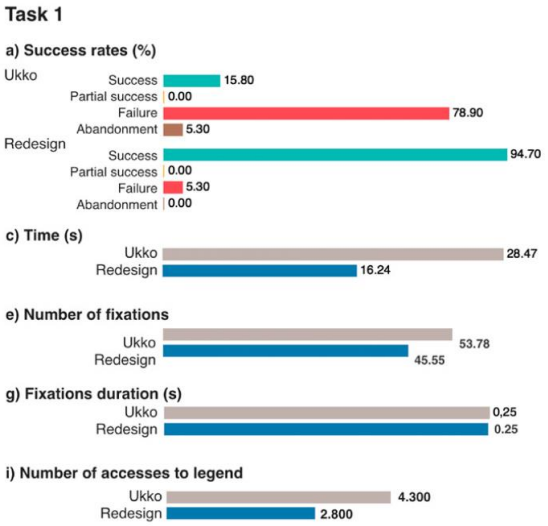
Importance of testing visualisations with users

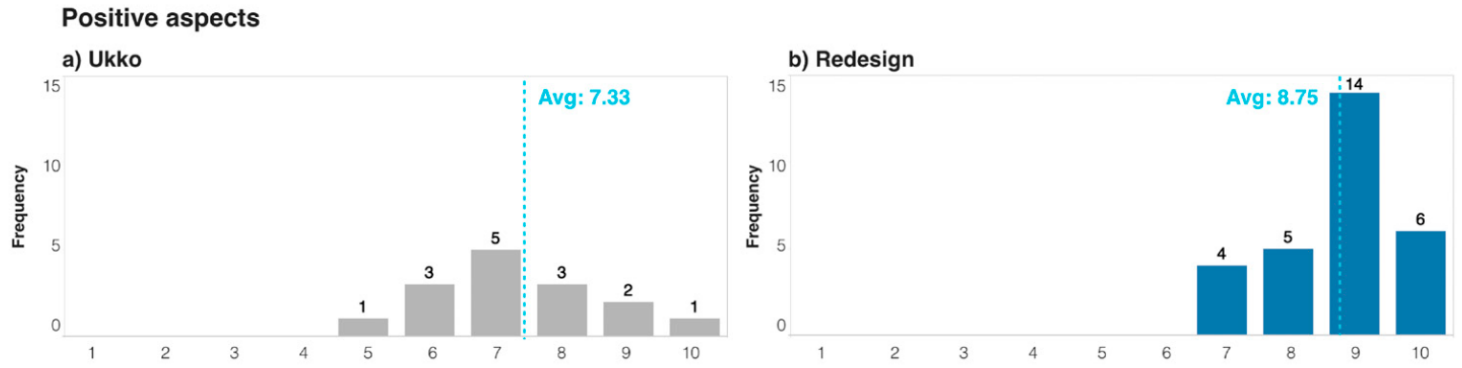
Calvo et al. (2021) Users cognitive load: A key aspect to successfully communicate visual climate information. BAMS.

User experience and product design

Quantitative and qualitative indicators to assess the effect of the redesign on the users' experience







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Develop effective ways of visualising complex data

Consider lessons from other fields

Terrado et al. (2022) Towards more effective visualisations in climate services: good practices and recommendations. Clim. Change.

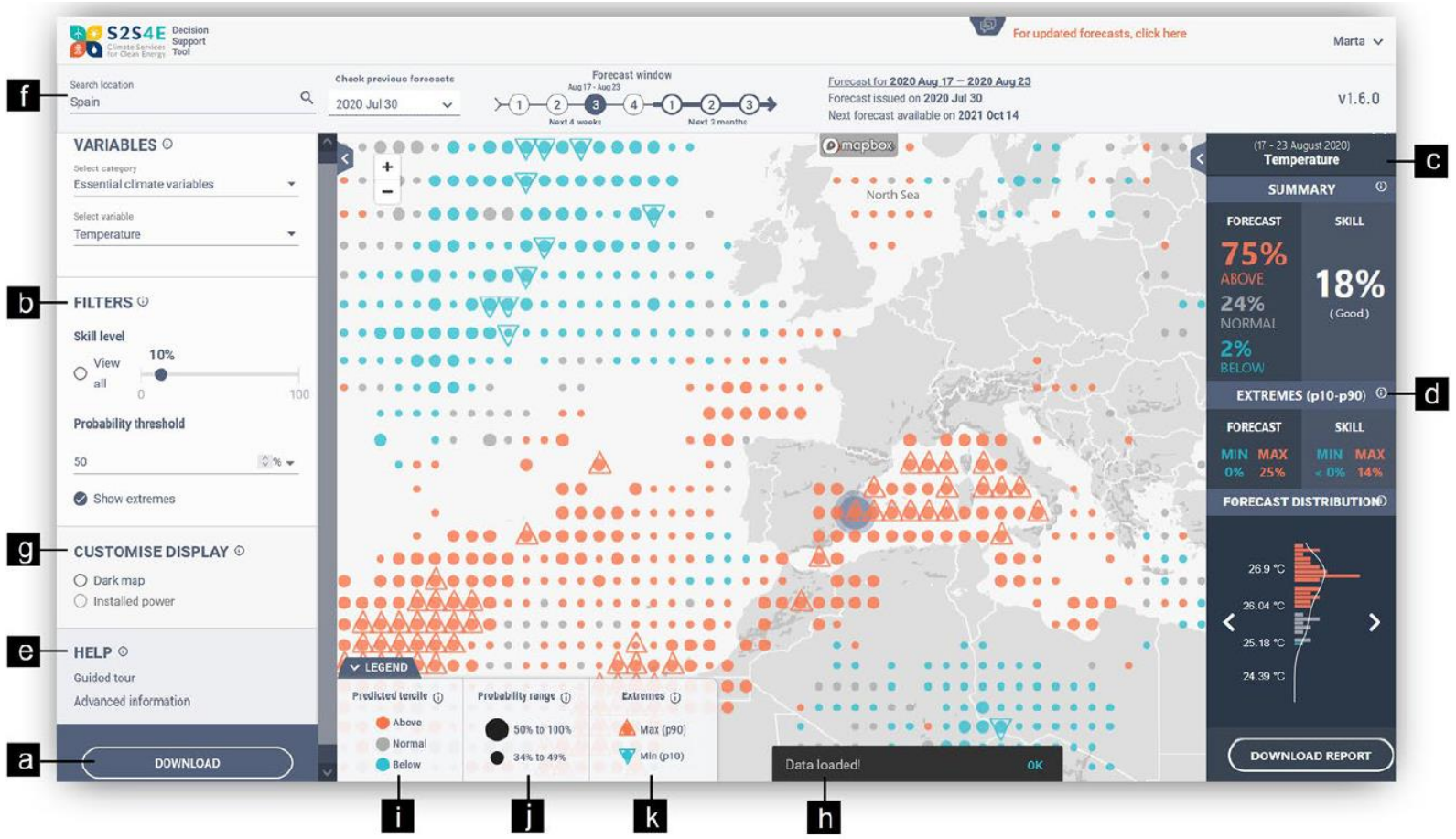

Fig. 1 Interactive decision support tool for the energy sector that considers aspects from different disciplines (source: S2S4E 2020). In the upper panel, highlighted features that are further expanded in the lower panel, exemplify particular aspects explained in the paper. *User experience aspects*: **a** button reflecting available actions; **b** possibility to filter information for skill, probabilities and extremes; **c** basic panel that can be expanded into advanced panel; **d** tooltips and hyperlinks; **e** help documentation section; **f** search location; **g** customisation options; **h** feedback of system status. *Visualisation design aspects*: **g** use of intuitive patterns and conventions, **i** and **j** glyph map variables' representation (e.g. temperature, precipitation) with circles of changing size and colour and use of contrasting colour hues in a dynamic legend. *Graphic design aspects*: **i** typography with good readability and use of colour blind-friendly palettes. *Psychology aspects*: **k** use of triangle symbols for extremes to enhance attention, **i** simple visual encoding

S2S4E Climate Services for Clean Energy

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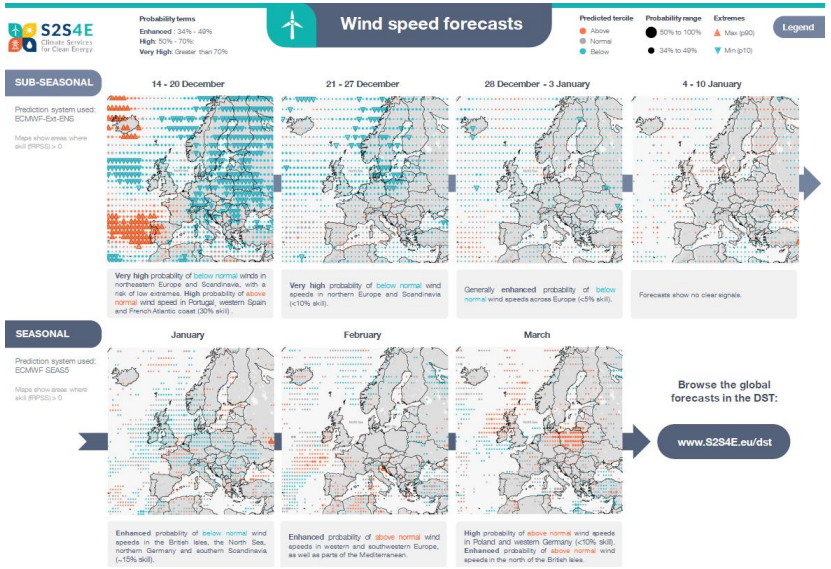
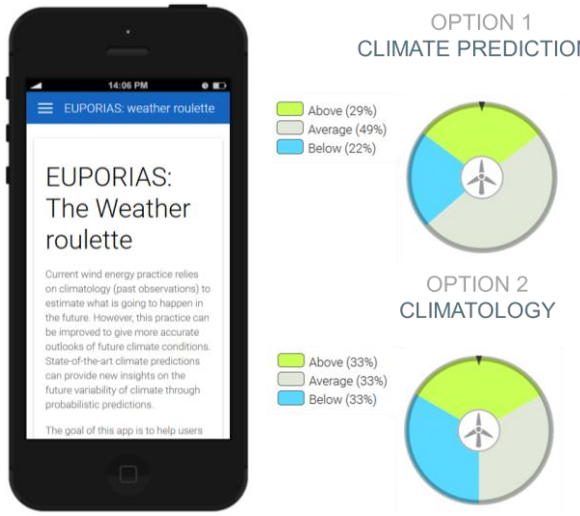
Dissemination

Dissemination

Planned process that involves the consideration of target audiences, the settings or contexts in which research findings are to be received and integrated, and interacting with wider audiences in innovative ways to facilitate research uptake and understanding.





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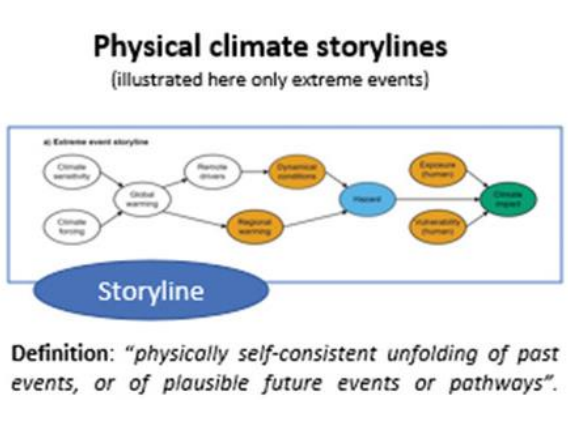
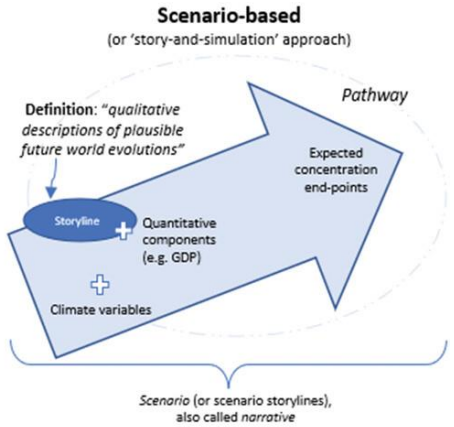
Storylines

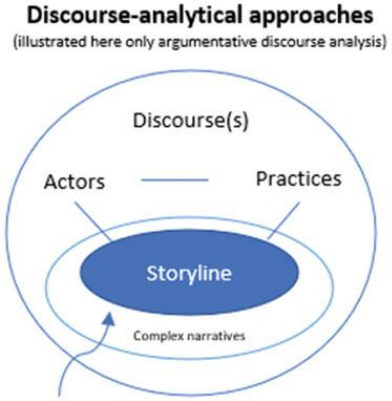
Storylines are introduced in climate science to provide unity of discourse, integrate the physical and socioeconomic components of phenomena, and make climate evolution more tangible.

Baulenas et al. (2023) Assembling the climate story: use of storyline approaches in climate-related science. Global Challenges.

Approaches





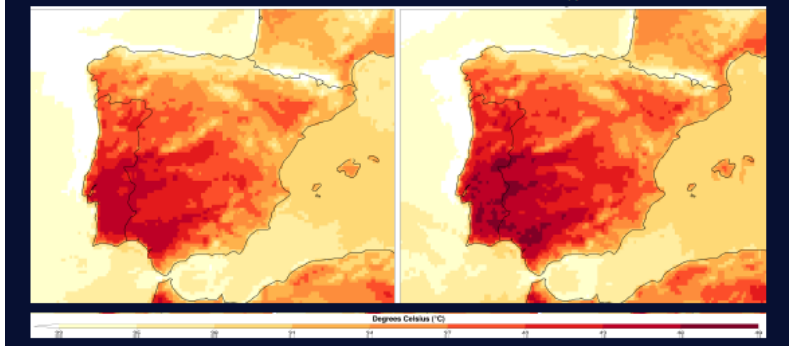


Challenge:
Combine physical and social component of storylines

Interactions with users to define extreme events of interest and exploration of options for reducing risk

What if the heatwave that affected Europe in 2018 occurred in a +2°C warmer world ?

The digital twin allows not only to understand the conditions under which the 2018 heatwave had occurred, but also to simulate how much worse could this heatwave be if it occurs in a future warmer world.



Storyline plots generated with IFS-FESOM, courtesy of AWI

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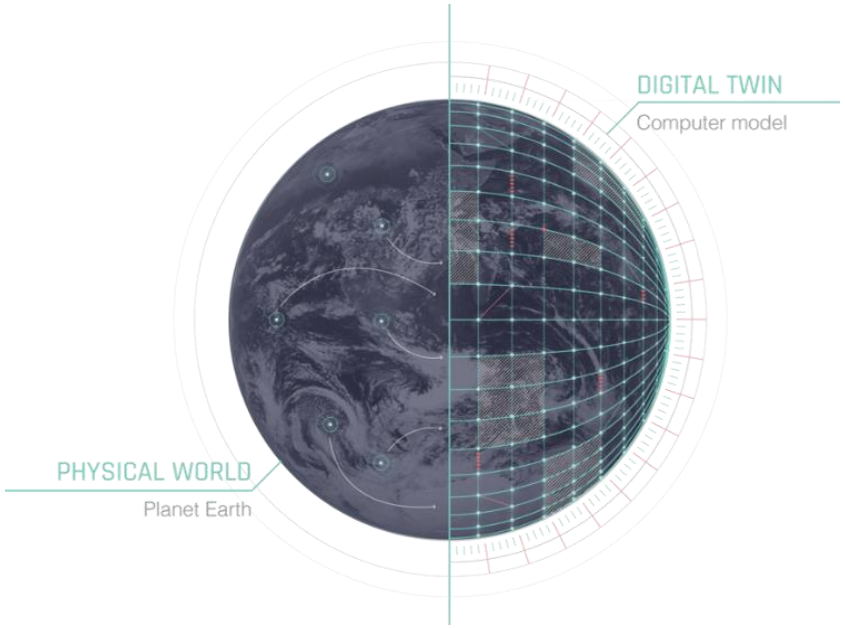
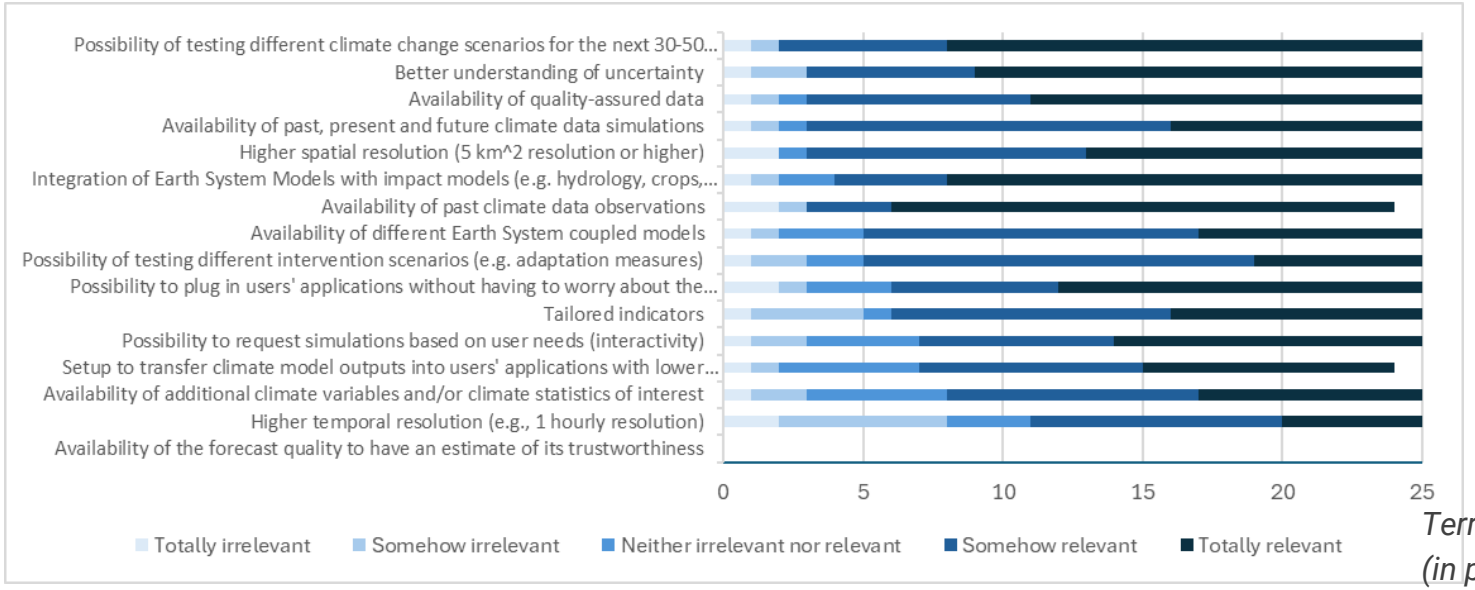
Awareness and expectations from the climate adaptation digital twin

Does people know about it?



Main perceived opportunities by the climate adaptation community



Terrado et al. (in prep)

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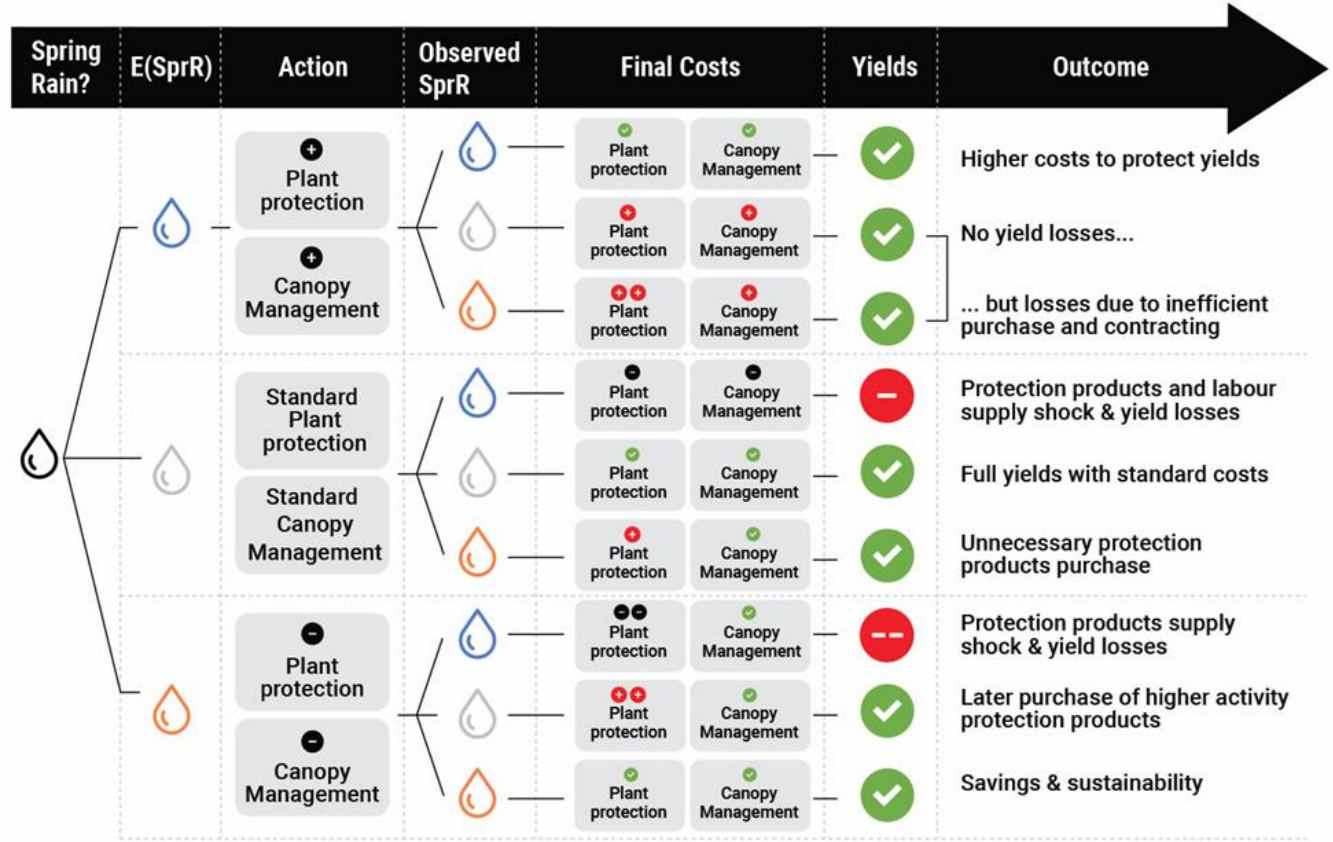
Exploring the value of climate services

Evaluating the impacts while learning to navigate climate risks and opportunities.

Vigo et al. (2023) Managing Spring rain risks in vineyards: A user-centred approach to identify climate decision triggers in seasonal forecasts. Clim. Serv.

Value assessment



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Thank you!

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