



**Barcelona  
Supercomputing  
Center**  
*Centro Nacional de Supercomputación*

# Decision-making II

## Success story from the agriculture sector

**Marta Terrado** & colleagues in the Earth System Services group  
at BSC

6-10 June 2022

MPE CDT Virtual Summer School on Attribution, Causality, and Decision-Making

# Earth System Services

## Air Quality Services

Developing air quality products and services tailored to user's needs, from global/regional to local urban scale.

## Climate Services

Applying state-of-the-art climate knowledge for the co-development of climate information and solutions for key societal sectors to adapt to climate change.

# Earth System Services

## Global Health Resilience

Applying a transdisciplinary approach to co-designing policy-relevant solutions to enhance response to climate-sensitive disease outbreaks and emergence.

## Knowledge Integration

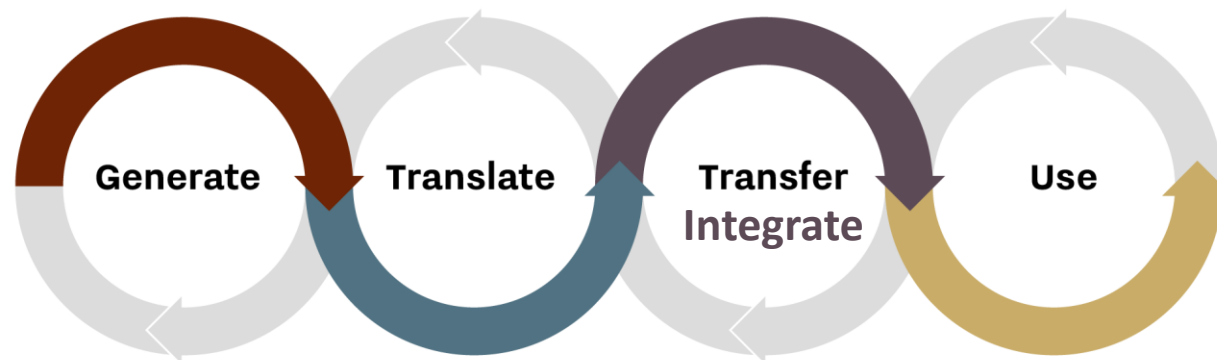
Coproducing knowledge regarding environmental topics, as well as technology transfer, communication and dissemination, visualisation, education, and outreach.

# Closing the gap between science & society



■ Generate climate information and knowledge - learn from the past, monitor the present, forecast the future.

■ Transfer the translated information to the appropriate beneficiaries, in formats and media most useful to their operations

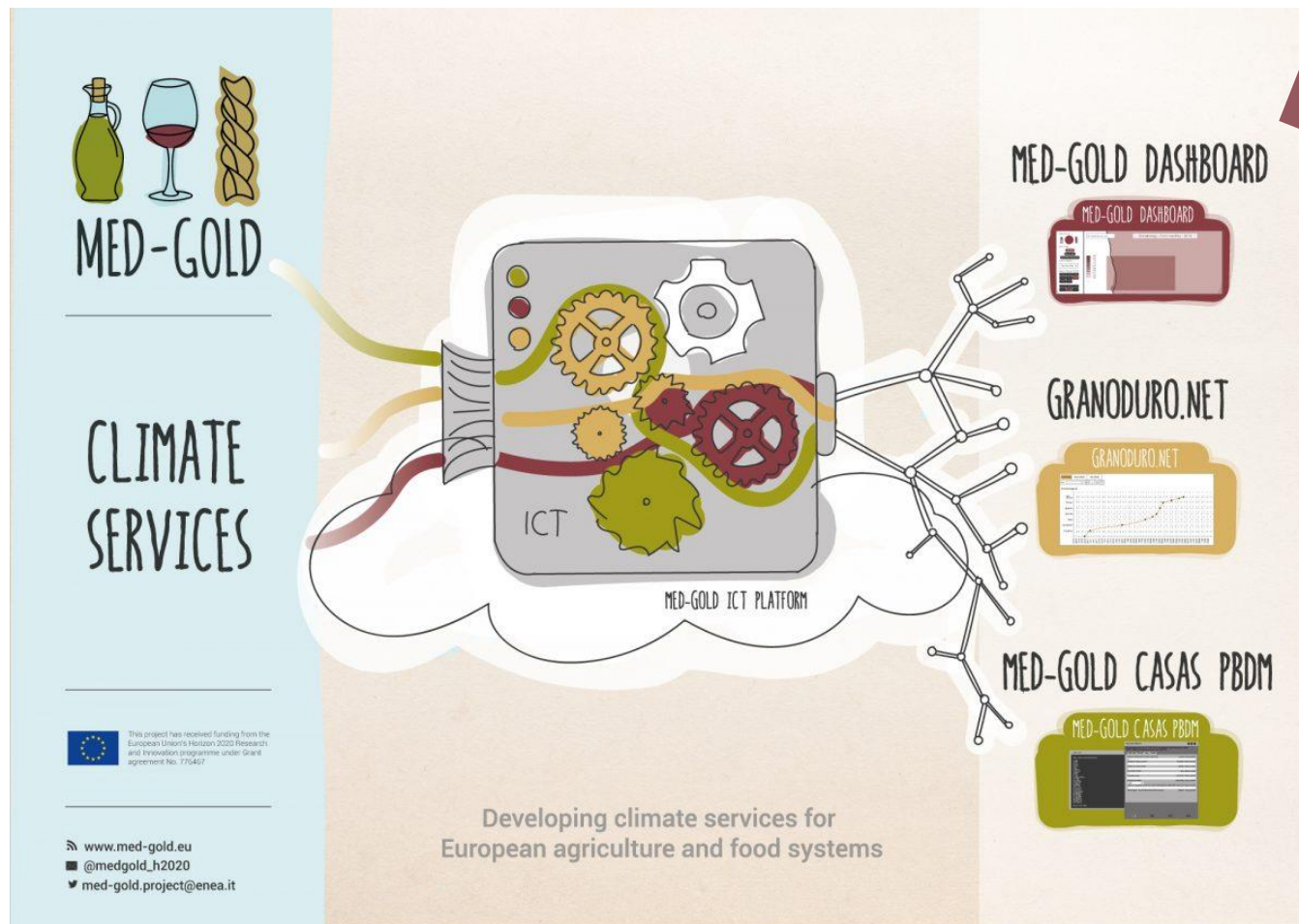


■ Translate the climate knowledge into Information that is relevant to agriculture, public health and other target sectors.

■ Put the translated and transferred climate knowledge to use in operational decision processes, policies and plans. Learn what works and what doesn't.



# Success story: climate services for agriculture

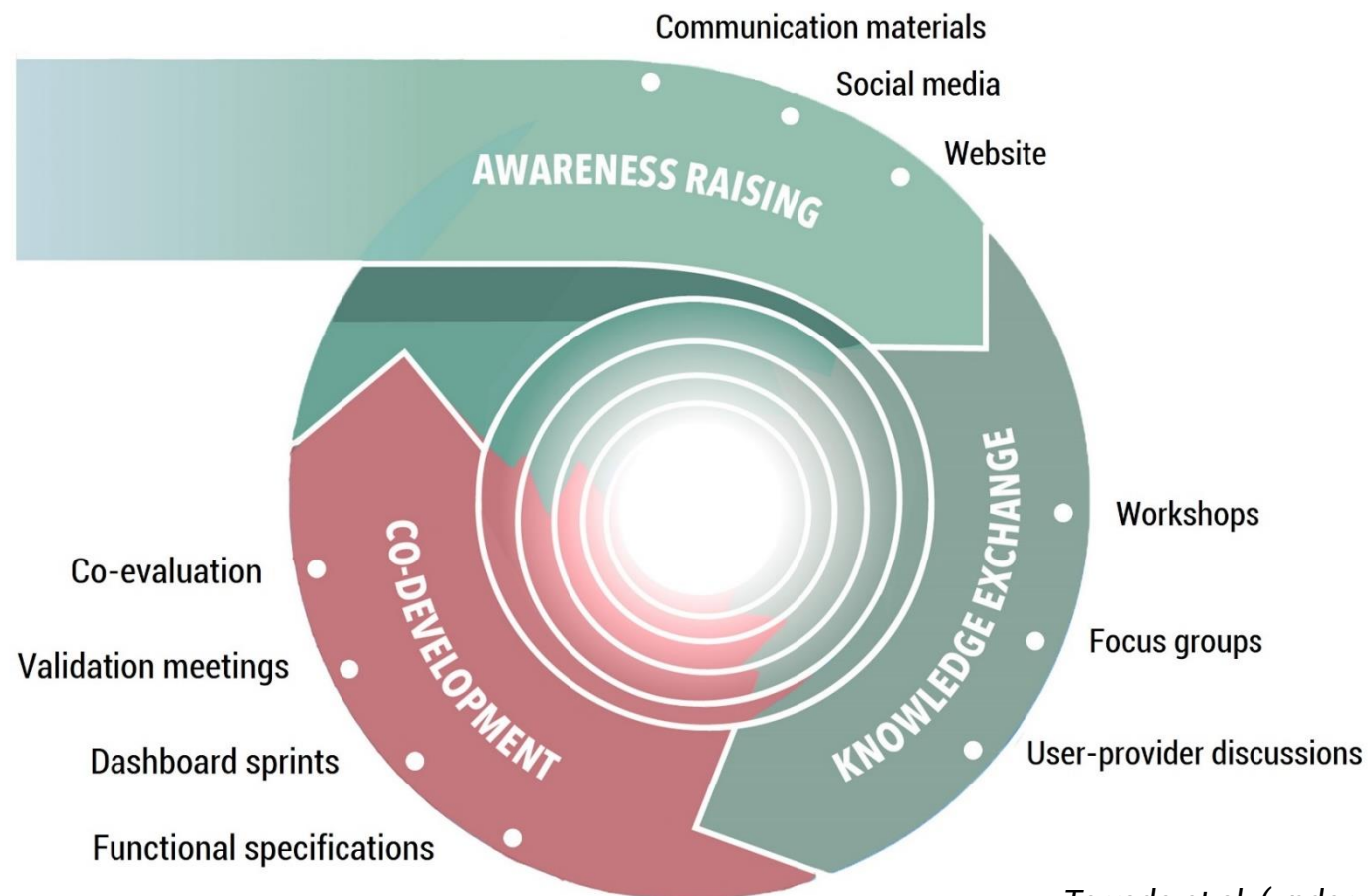


**Make European agriculture and food systems more resilient, sustainable and efficient in the face of climate change**

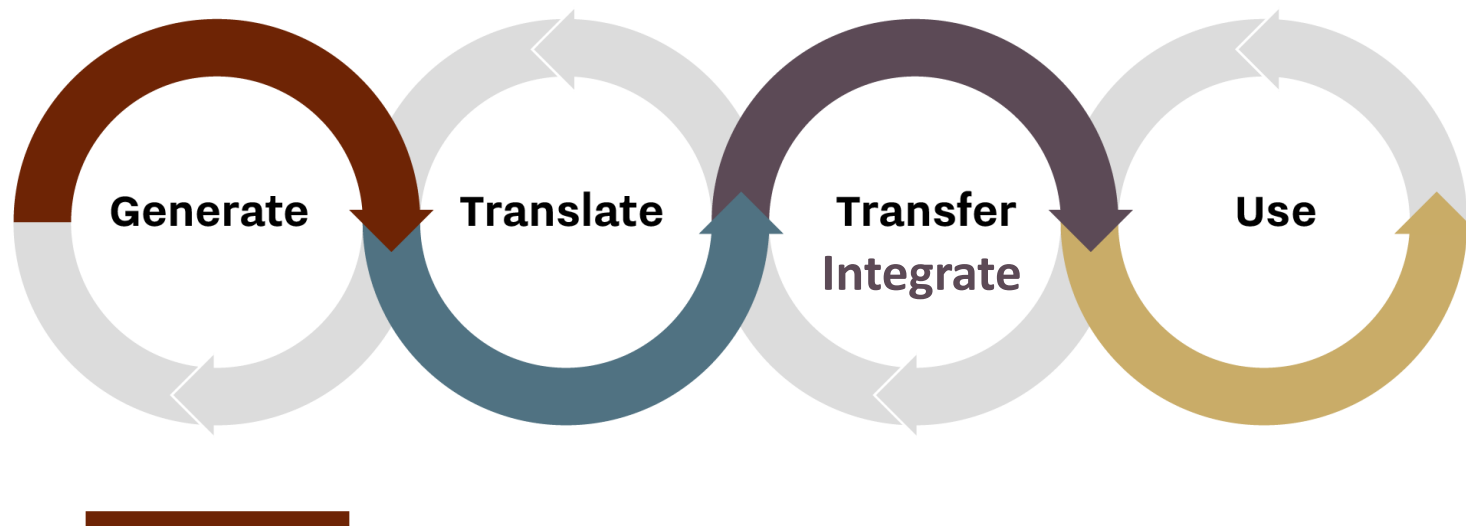
- **Proof-of-concept** for climate services in the agriculture sector
- **Co-design** pilot services involving suppliers and users from 3 Mediterranean food systems: grape/wine, olives/olive oil, durum wheat/pasta
- **Identify key decisions** that can benefit from climate-related information at different timescales

# Success story: climate services for agriculture

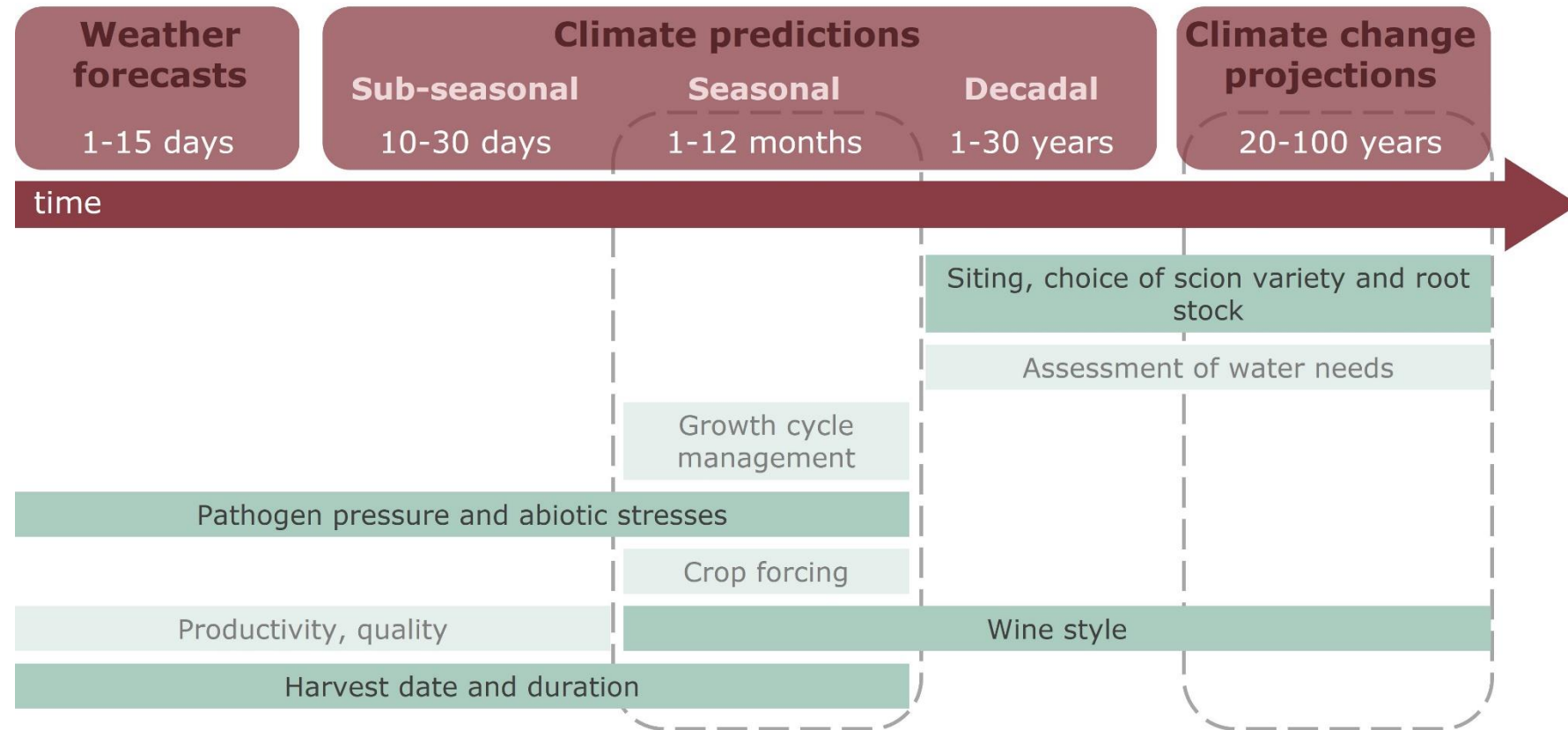
## Co-production of a climate service for the wine sector



Terrado et al. (under review). Adapted from Bojovic et al. (2021) *Global Environ. Change*




# Generate: needs from the wine sector



*Adapted from Gishen et al. (2016)*

# Generate: needs from the wine sector

## Infosheets



### CLIMATE SERVICES FOR THE GRAPE AND WINE SECTOR

*"Timely knowledge of climate can save an entire production"*  
Antonio Prieto-Solà, IRTA

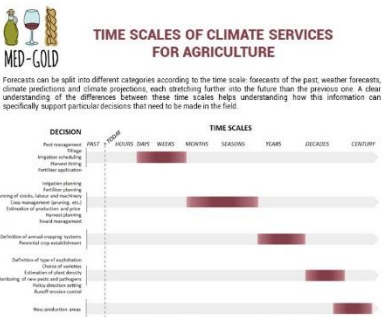
Grape and wine production is heavily affected by weather and climate, thereby is highly vulnerable to climate change. MED-GOLD will propose climate services displaying forecast information at the medium (next 6 months) and long-term (next 30 years). This information will be provided at higher spatial resolution than what is currently available. To provide the highest value for decision-making, the services will be co-developed with professional users from the sector.

Wine producers face diverse challenges affecting several decision processes in their business, such as strategic definitions, viticulture, oenological and stock management. Some examples are presented below to show how climate services - in this case, predictions of climate variables and bioclimatic indices - can improve decision-making and win over challenges posed by climate variability and climate change.

Time scale	Decision area	Challenge	MED-GOLD climate service	Benefit
Long-term (30 years)	Long-term strategy	<ul style="list-style-type: none"> <li>Purchase of new vineyards and/or selection of future new locations.</li> <li>Choice of grape varieties, rootstocks and vineyard design.</li> <li>Anticipation of needs to change wine style.</li> </ul>	<ul style="list-style-type: none"> <li>Temperature</li> <li>Precipitation</li> <li>Growing season average temperature</li> <li>Warm spell duration index</li> <li>Growing degree days</li> </ul>	<ul style="list-style-type: none"> <li>Indication of areas with suitable climate to meet production and quality goals for the next decades.</li> <li>Matching adequate grape varieties and rootstocks to</li> </ul>
Medium-term (6 months)	Viticulture management	<ul style="list-style-type: none"> <li>Better pruning and canopy management.</li> <li>Improves planning of treatments and/or harvest setting with higher economy.</li> <li>Better labour management, operational subcontracting and environmental protection.</li> </ul>	<ul style="list-style-type: none"> <li>Temperature</li> <li>Precipitation</li> <li>Relative humidity</li> <li>Soil moisture</li> <li>Soil temperature</li> <li>Soil water deficit</li> <li>Soil water deficit index</li> <li>Soil water deficit index</li> <li>Soil water deficit index</li> </ul>	
	Oenological management	<ul style="list-style-type: none"> <li>Better maturation control planning.</li> <li>Improve harvest efficiency.</li> </ul>	<ul style="list-style-type: none"> <li>Temperature</li> <li>Precipitation</li> <li>Relative humidity</li> <li>Soil moisture</li> <li>Soil temperature</li> <li>Soil water deficit</li> <li>Soil water deficit index</li> <li>Soil water deficit index</li> <li>Soil water deficit index</li> </ul>	
Stock management	Stock management	<ul style="list-style-type: none"> <li>Better prices and supply chain.</li> <li>Marketing and promotions.</li> </ul>	<ul style="list-style-type: none"> <li>Temperature</li> <li>Precipitation</li> <li>Relative humidity</li> <li>Soil moisture</li> <li>Soil temperature</li> <li>Soil water deficit</li> <li>Soil water deficit index</li> <li>Soil water deficit index</li> <li>Soil water deficit index</li> </ul>	

### TIME SCALES OF CLIMATE SERVICES FOR AGRICULTURE

Forecasts can be split into different categories according to the time scale of the past, weather forecasts, climate predictions and climate projections, each stretching further into the future than the previous one. A clear understanding of the differences between these time scales helps understanding how this information can specifically support particular decisions that need to be made in the field.



Relevant time scales of decision-making in the agriculture sector (collected from Hoggan et al. 2016)

## Type of questions answered by each temporal scale?

### Weather forecasts

Temperature in Porto in the next few days in absolute values (°C)

### Climate predictions

Most likely category for next spring temperature in Porto in relative values or anomalies (either below normal, normal or above normal)

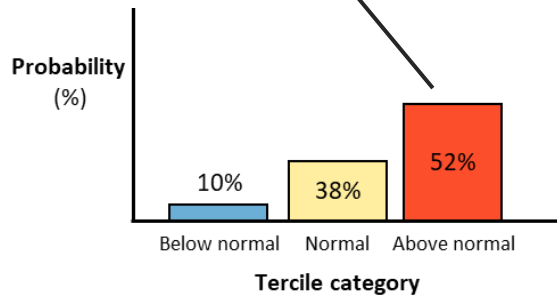
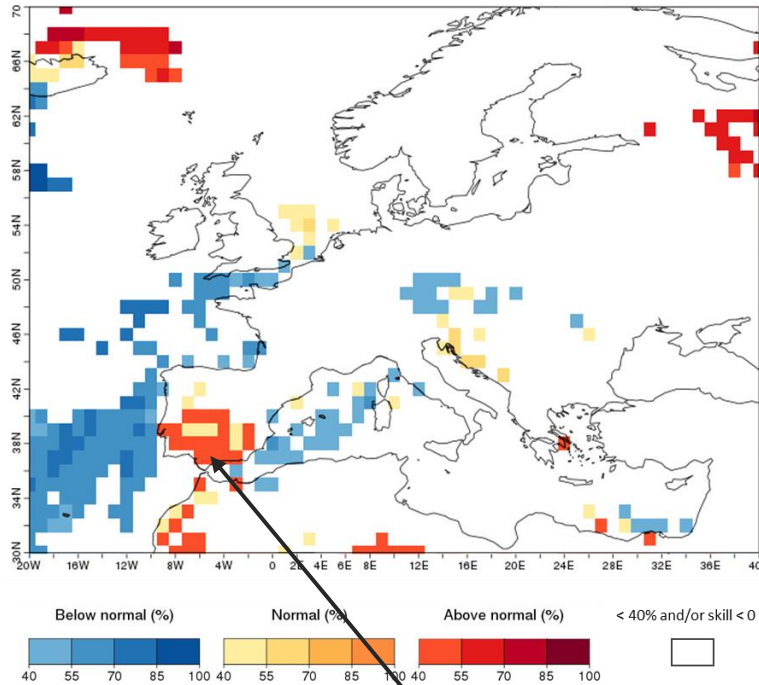
### Climate projections

Variation of temperature expected in Porto during this century (°C change)



# Generate: needs from the wine sector

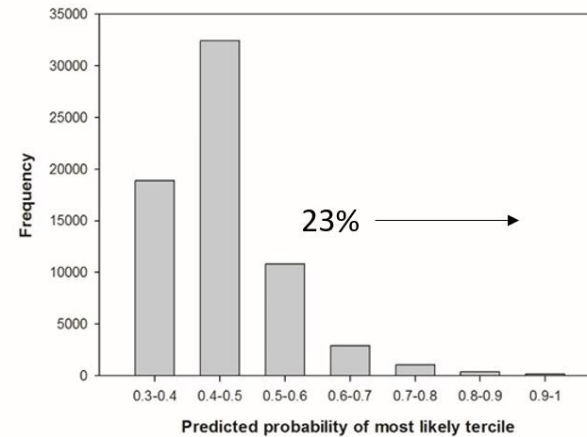
Seasonal prediction of temperature May 2016



## Barriers for the uptake of climate predictions by decision-makers

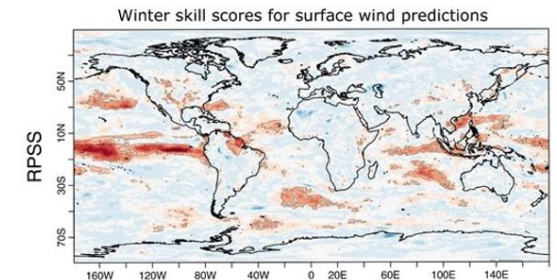
### Decision uncertainty

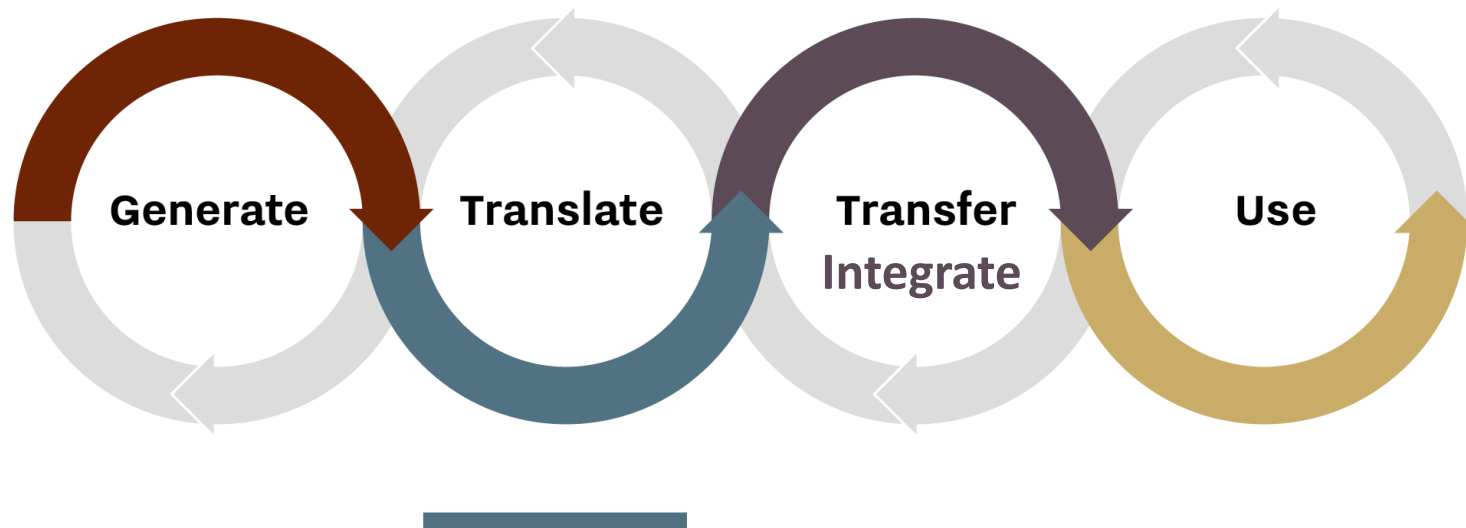
Users request high predicted probabilities



### Forecast uncertainty

Scientific community calculates different metrics, such as skill scores (forecast quality)





# Translate



*Terrado et al. (2022) BAMS*

# Translate: from data to economic value



## The Weather Roulette

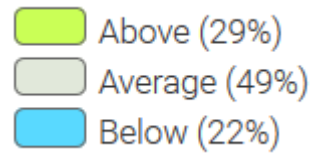
- ▶ **Communication and engagement tool** that shows the potential benefits of climate predictions over climatology in the long term
- ▶ Based on the approach of Hagedorn & Smith (2009)
- ▶ Addressed to the wind energy sector
- ▶ <https://weatherroulette.earth.bsc.es>



# Translate: from data to value

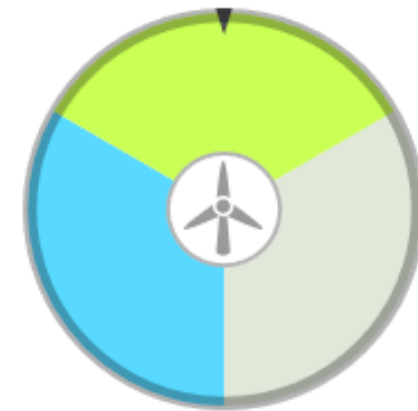
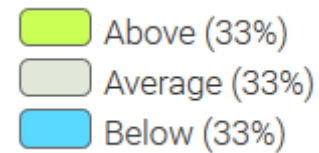
2 playing options

## OPTION 1 CLIMATE PREDICTIONS



Calibrated ECMWF System 4 prediction system  
Seasonal predictions of wind speed

## OPTION 2 CLIMATOLOGY

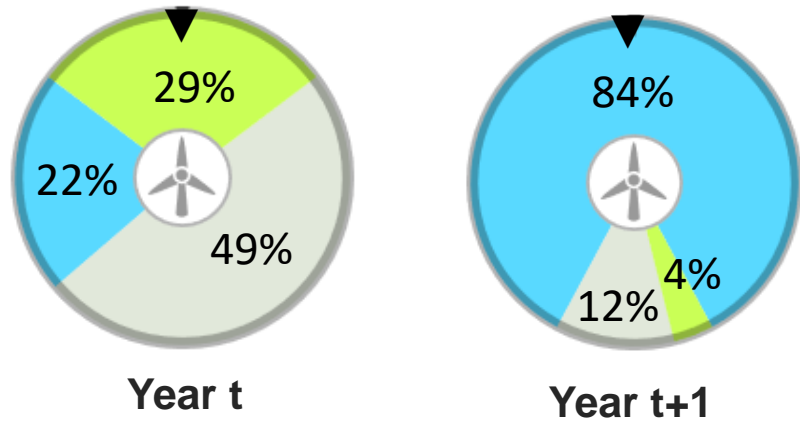


Historical wind speed observations

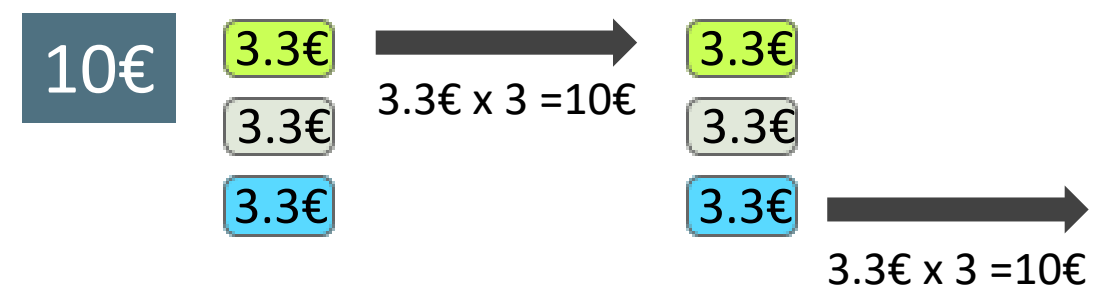
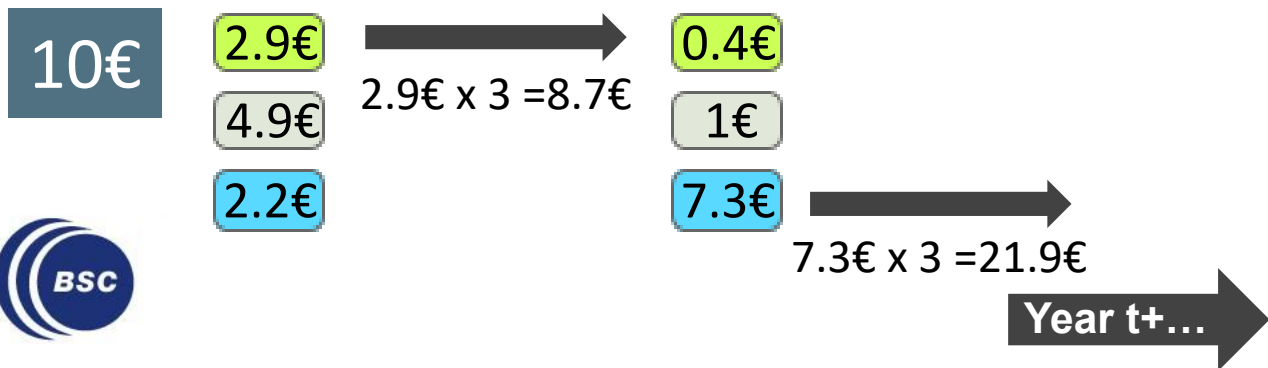
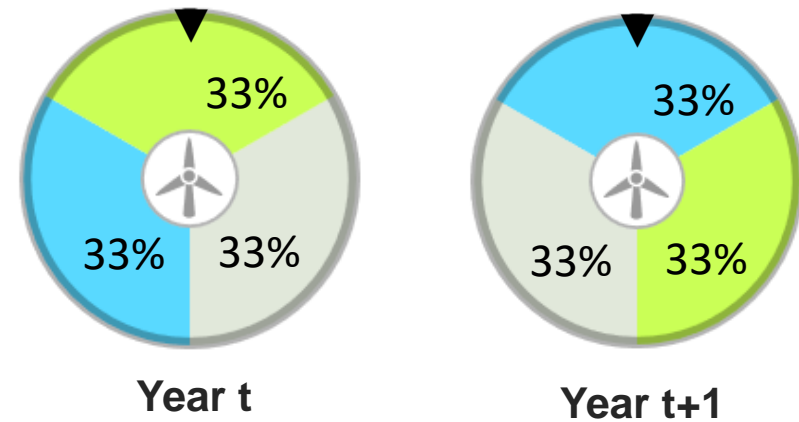
# Translate: from data to value

## betting scheme

### OPTION 1 CLIMATE PREDICTIONS

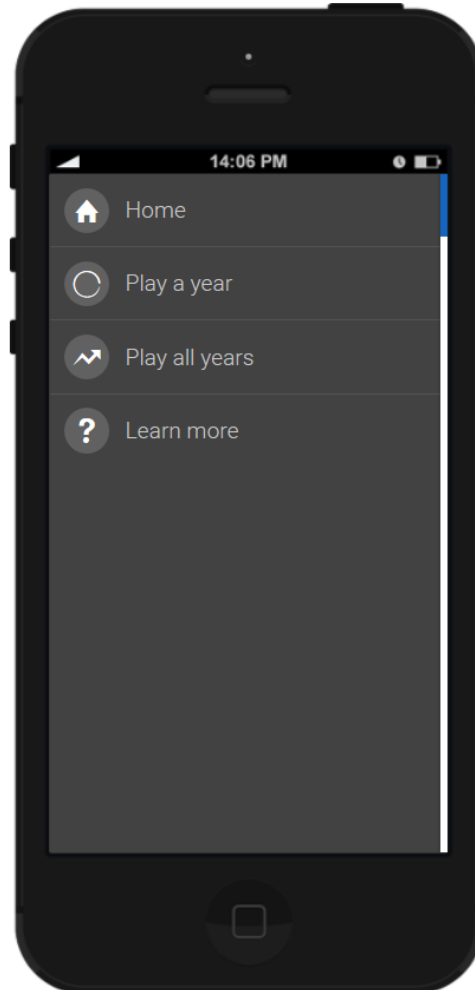


### OPTION 2 CLIMATOLOGY



# Translate: from data to value

How to play?



Possibility to play the roulette **1 year**

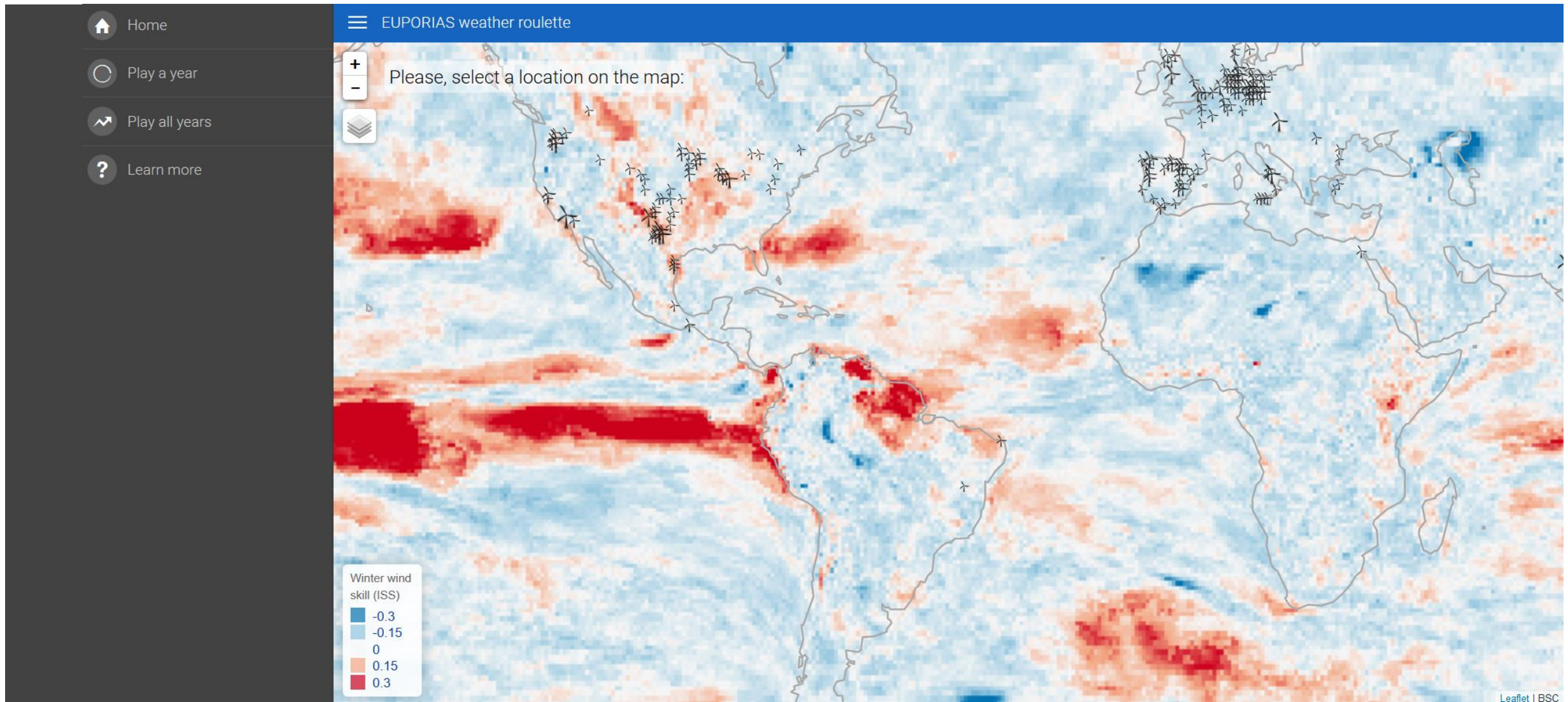


Possibility to play the roulette for **the whole period of 33 years (1981-2013)**

# Translate: from data to value

Play 1 year

Map of skill. The player can select a location according to the level of skill ▼





# Translate: from data to value

## Play 1 year

☰ EUPORIAS weather roulette

< 1981 >

Skill (ISS): 0.17054

Prediction by RESILIENCE:  
Above: 29% / Normal: 49% / Below: 21%

Play this year using RESILIENCE

Play this year using climatology

# Translate: from data to value

## Play 1 year

EUPORIAS weather roulette

< 1981 >

Skill (ISS): 0.17054

Prediction by RESILIENCE:  
Above: 29% / Normal: 49% / Below: 21%

Play this year using RESILIENCE

Play this year using climatology

Above (29%)  
Average (49%)  
Below (22%)



### YOU LOSE

Best prediction by: CLIMATOLOGY.  
Return ratio (r): 0.88235

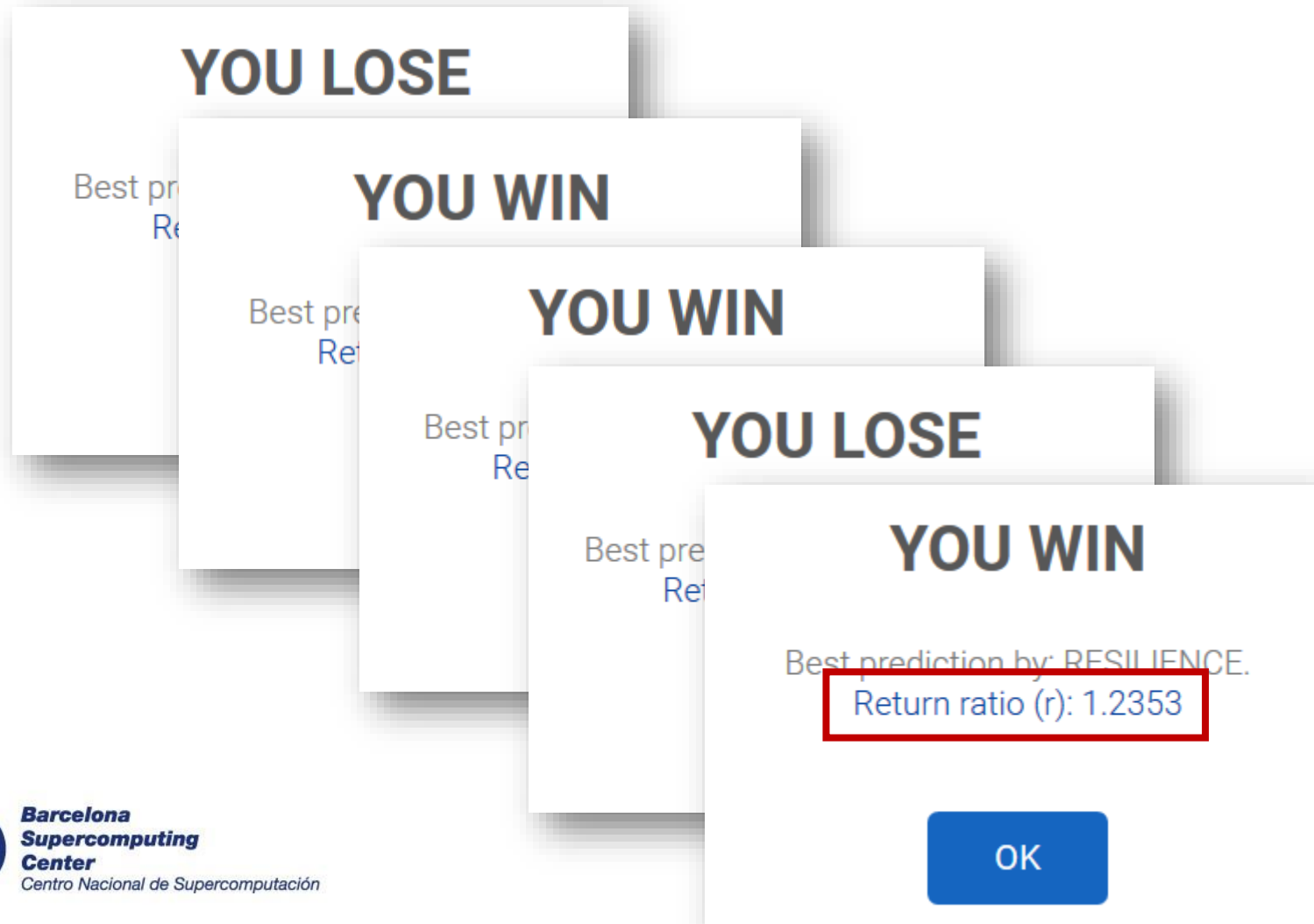
OK

Above (33%)  
Average (33%)  
Below (33%)



# Translate: from data to value

Play 1 year



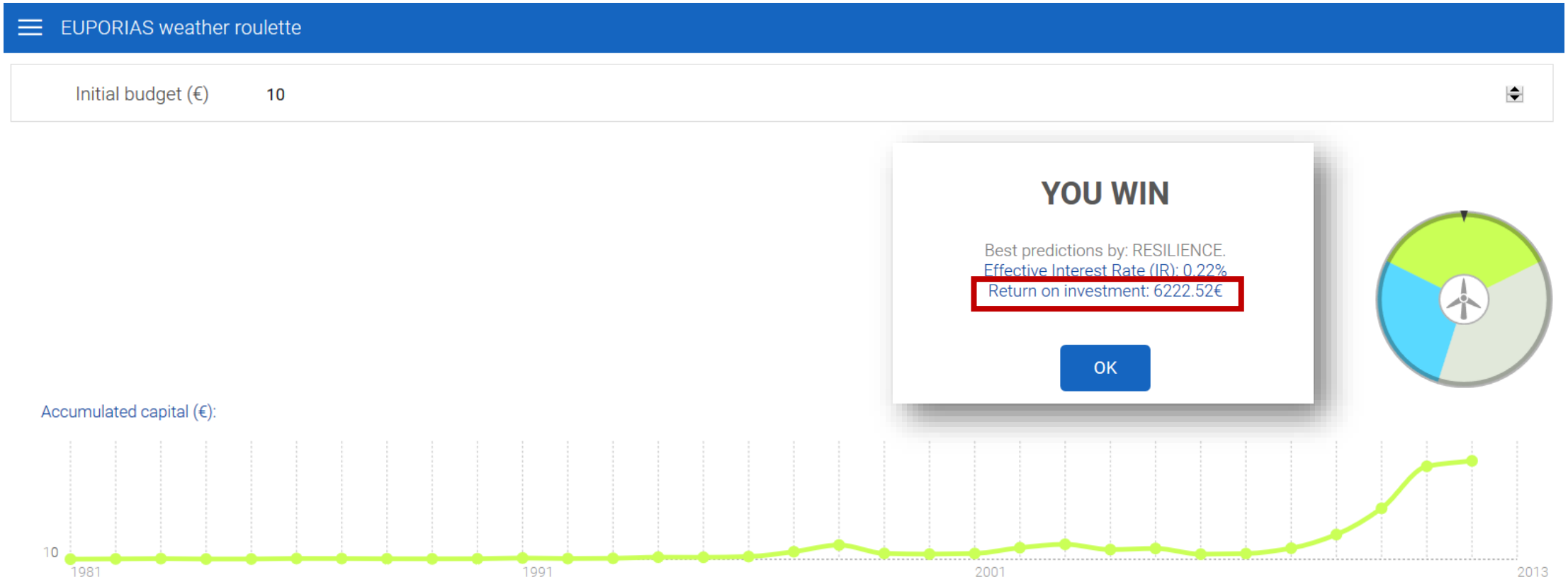
► Helps users understand the uncertainty of probabilistic outcomes

► When playing for individual years, resulting return ratios can indistinctly be found above or below 1 (win or loose)

# Translate: from data to value

What happens when we play all years?

Skill (ISS) : 0.18



► Playing all years helps users understand that in areas with skill benefits are seen in the long term

► Translation of technical concepts into economic value (ROI):  $(C_n - C_0) / C_0$



# Translate: from data to value

What happens when we play all years?

Skill (ISS) : -0,02

☰ EUPORIAS weather roulette

Initial budget (€) 10

**YOU LOSE**

Best predictions by: CLIMATOLOGY.

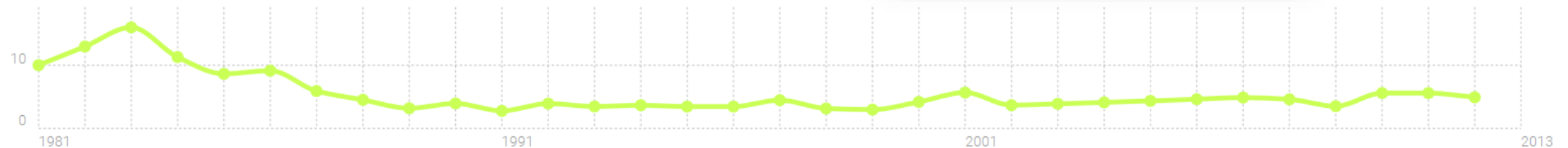
Effective Interest Rate (IR): -0.02%

Return on investment: -4.78€

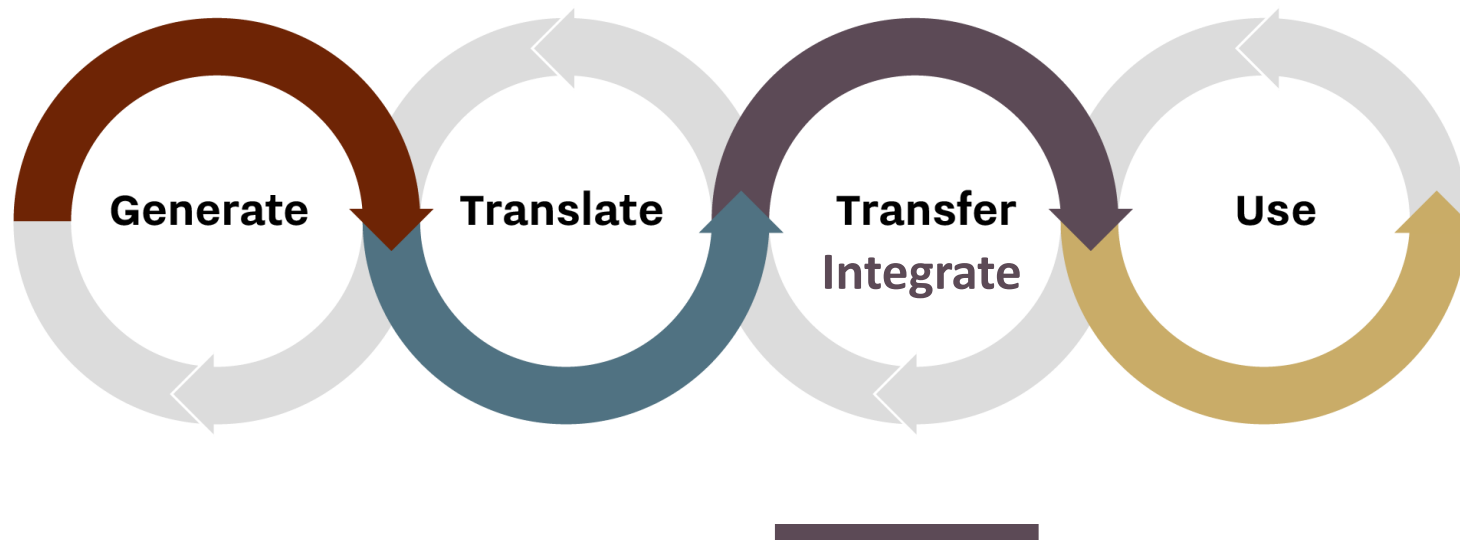
OK



Accumulated capital (€):

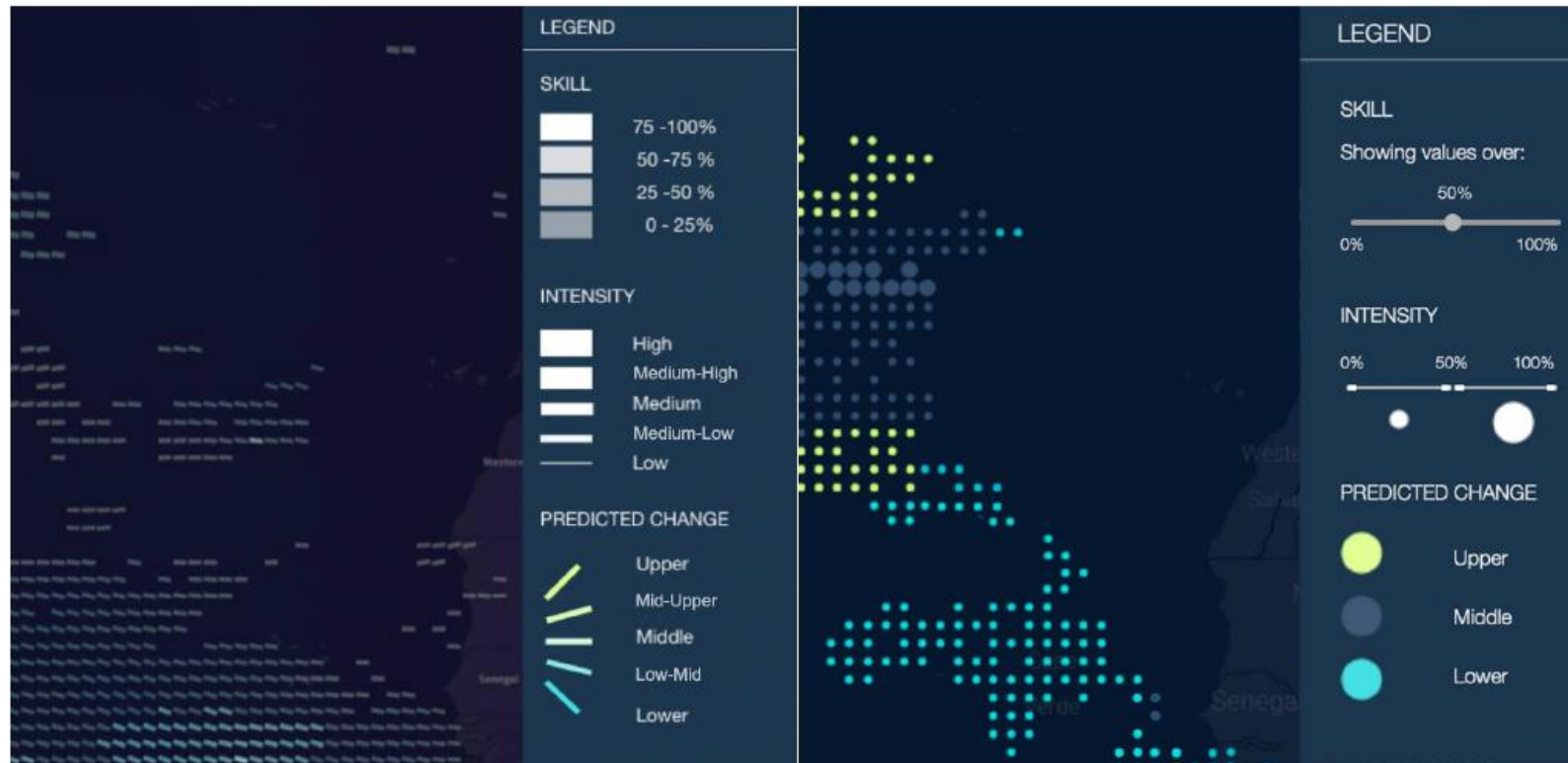


► Helps users understand that no benefits are obtained in the long term in areas without skill



# Integrate

Importance of visualisations to reduce users' cognitive load and highlight salient information for decision-making



# Integrate: MED-GOLD Dashboard



TURNING CLIMATE-RELATED INFORMATION INTO ADDED VALUE FOR TRADITIONAL MEDITERRANEAN GRAPE, OLIVE AND DURUM WHEAT FOOD SYSTEMS



Type of information ▶

Select Type

**Climate**

Bioclimatic

Wine Risk Indicators

Select Region

Iberian Peninsula

Select Variable

Precipitation monthly

Select Year and Month

2015	2018	1979
2016	2019	1980
2017	<b>2020</b>	1981

SEP	NOV	JAN
OCT	<b>DEC</b>	FEB

Filter

Data  Average

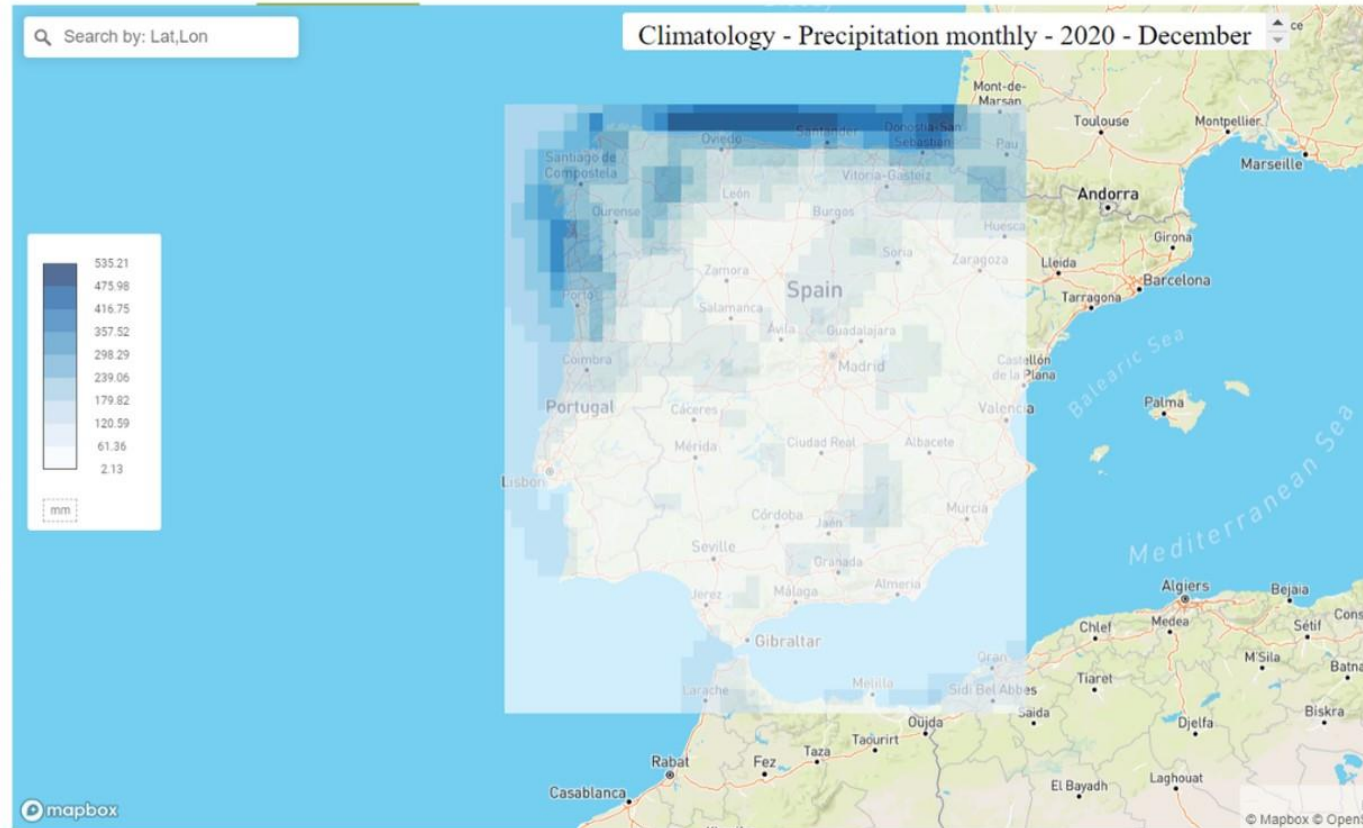
**EXPORT MAP DATA**

Historical Climate

Seasonal Forecast

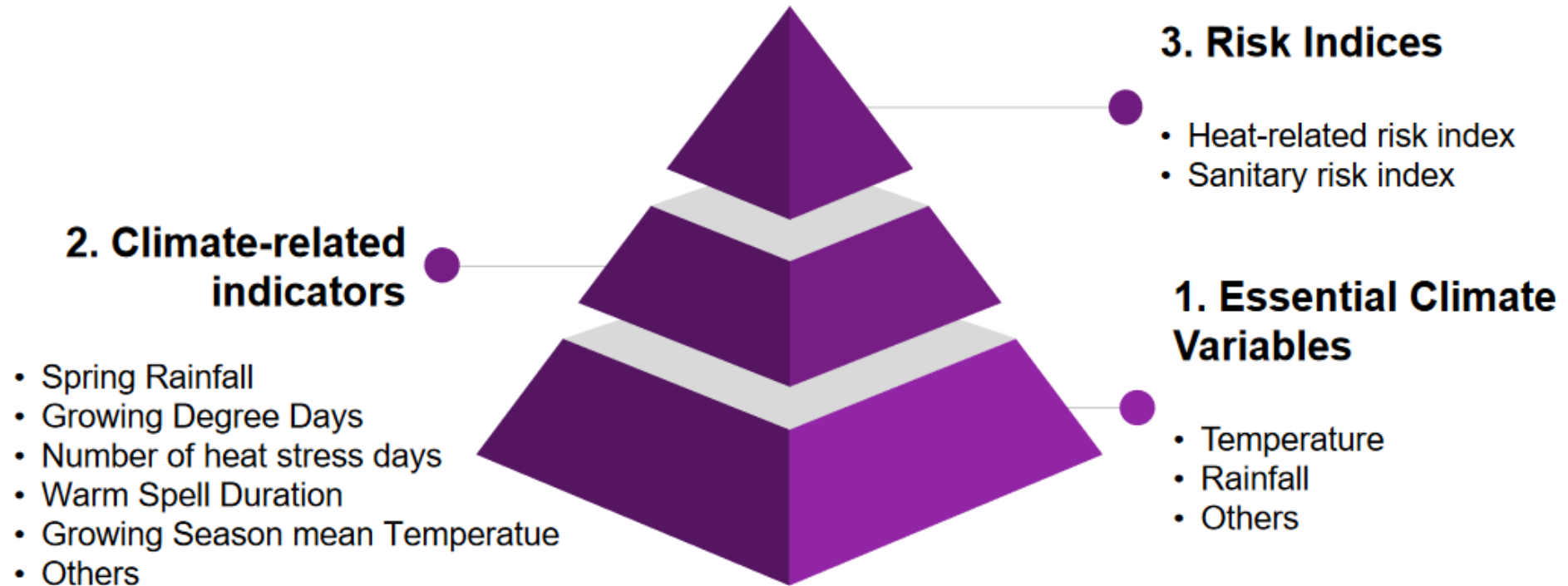
Long Term Projections

Time scales ▶



# Integrate: MED-GOLD Dashboard

Type of information  
Different levels of complexity





# Integrate: MED-GOLD Dashboard

## Test the service with users

#	Comment (# mentions)
1	When choosing options to visualise from the dropdown menus, a short caption explaining their meaning should pop-up as the cursor hovers over each option (especially abbreviations and acronyms). The same should happen when hovering above tab names (historical, seasonal and long-term) or type of data (7)
2	Navigation is overall easy and intuitive; map updating is quick enough (3)
3	The parameter panel needs to be better organised; it wastes too much space which would be better used to have more space for map viewing (2)
4	Having the dashboard in English slows down [the process] and makes interpretation sometimes difficult. It would be much better if it was in Portuguese (2)
5	Maps often take extremely long to load or do not load at all. There is a lot to be done in terms of susceptibility to user handling of the tool. It seems overly sensitive to movements or clicks on the map while loading. When zooming in, sometimes data colours disappear altogether and will not reappear when zooming out, especially in seasonal forecasts (3)
6	Export GeoJSON and, particularly NetCDF, do not know what they are and how to use them. They should be available for those requiring them, but in a less prominent way than JPEG, PNG and other user-familiar formats (3)
7	Many features and possibilities of the tool remain undiscoverable because of insufficient on-screen guidance (e.g. the chart that opens if a spot is clicked in the map). On-screen guidance must be everywhere (2)
8	The map data-box that pops when a map grid cell is clicked is sometimes hard to close, requiring many clicks. It won't disappear when visualisation parameters are changed, creating wrong readings from the part of users (2)
9	If in long term projections anomaly is reported in %, the legend caption needs to be changed [to reflect that] (2)
10	The base map should not be displayed before all needed choices are made. After visualising a map, if choices are changed, the base map should redisplay again only after loading the visual data. Maintaining the map when parameters are changed is misleading (2)

# Integrate: MED-GOLD Dashboard

Co-explore potential applications: long-term projections

## USE CASE 1

Your wine company is concerned about the impact that climate change will have on your top-selling iconic wine. The grape variety used has an optimal growth of 16-19°C. If your vineyard sees higher temperatures in the future, you will need to look for alternative sites to maintain your production.

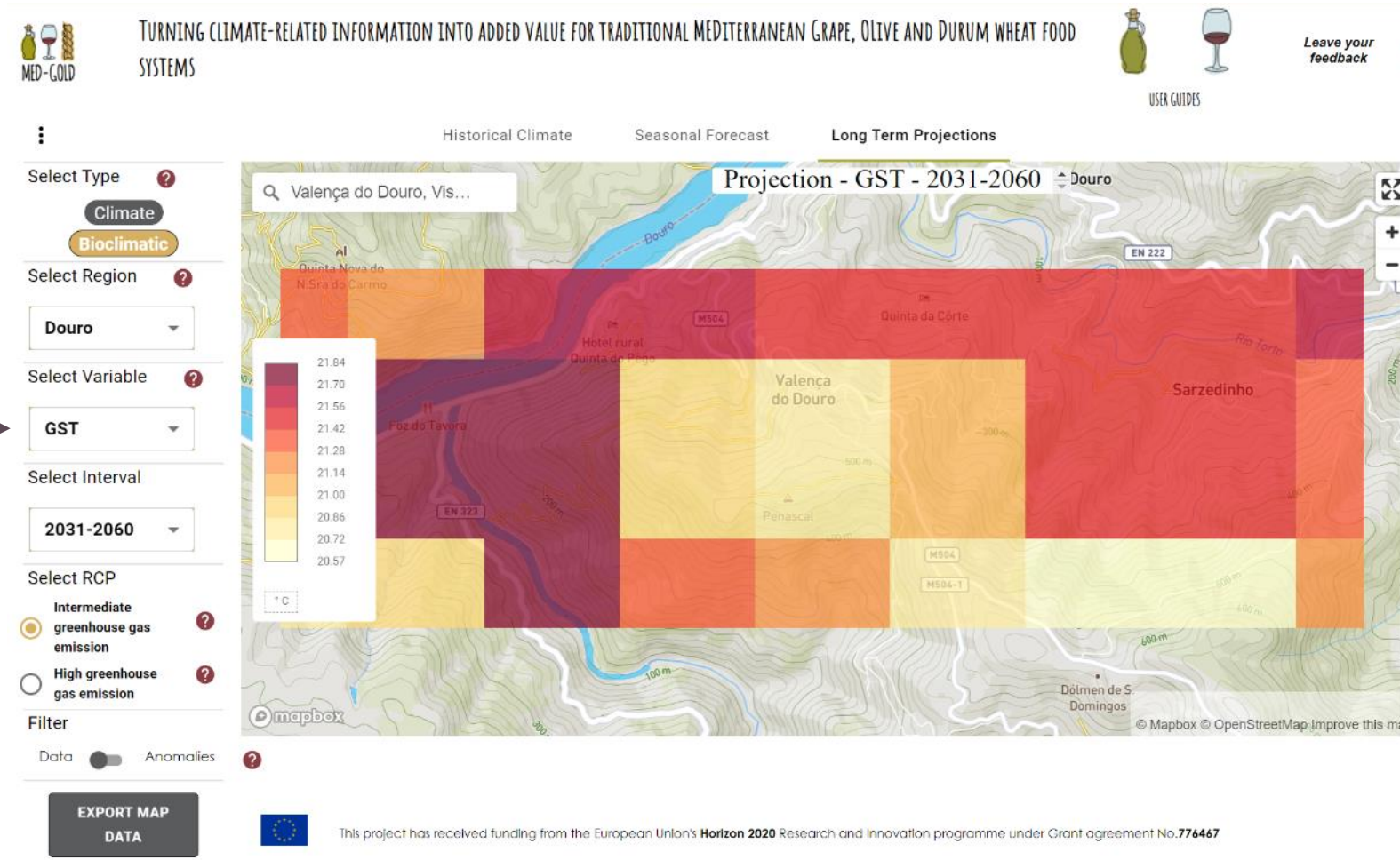
*Is the quality of your iconic wine threatened by future climate change?*



# Integrate: MED-GOLD Dashboard

Co-explore potential applications: long-term projections

Growing season temperature



Average growing season temperature in the area is expected to be above 20 degrees Celsius, outside the range of your grape variety

# Integrate: MED-GOLD Dashboard

Co-explore potential applications: seasonal forecasts

## USE CASE 2

---

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?*



# Integrate: MED-GOLD Dashboard

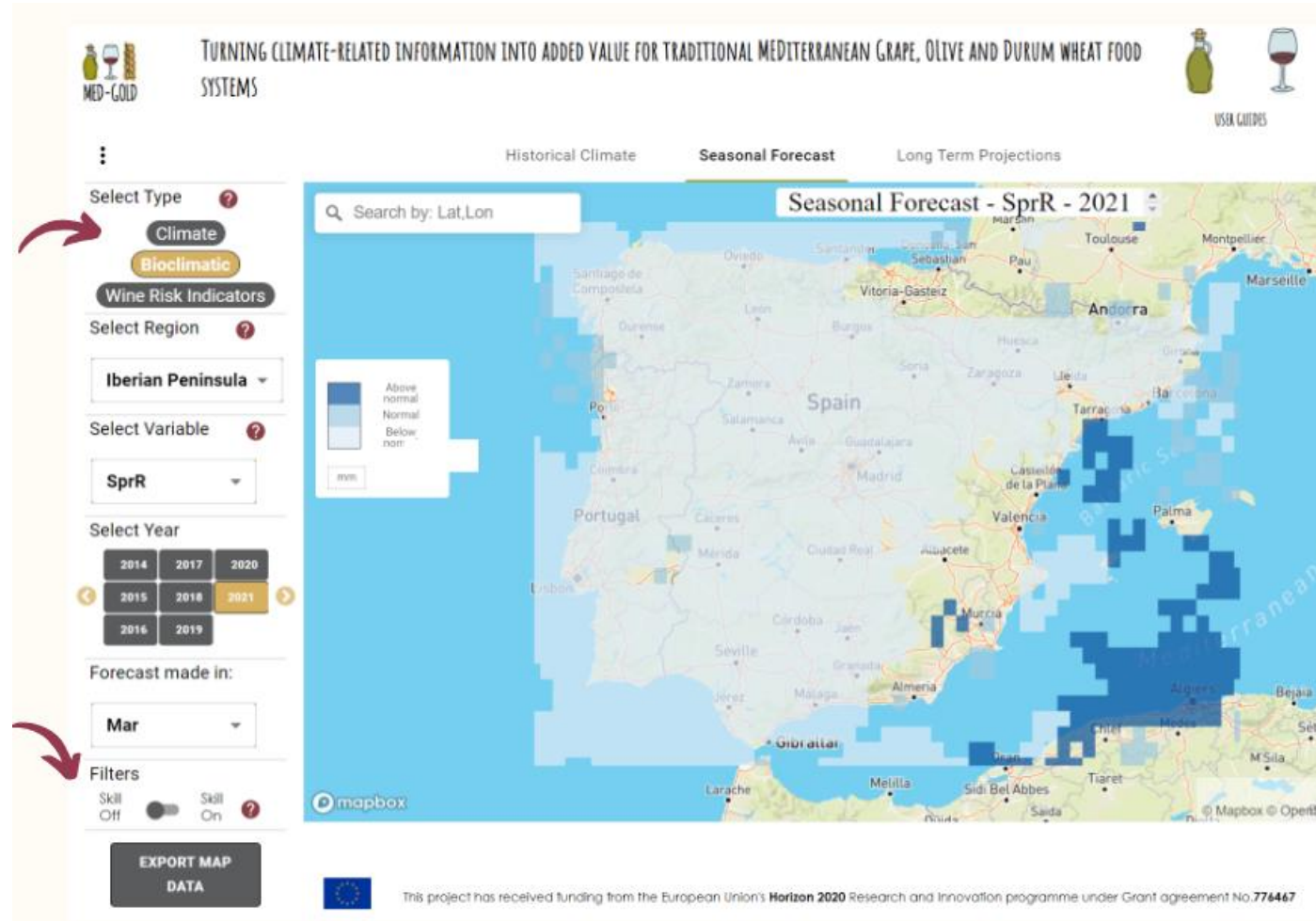
Co-explore potential applications: seasonal forecasts

## Risk of pests and diseases?

Check the bioclimatic indicator Spring Rain (SprR)

## How accurate is the prediction?

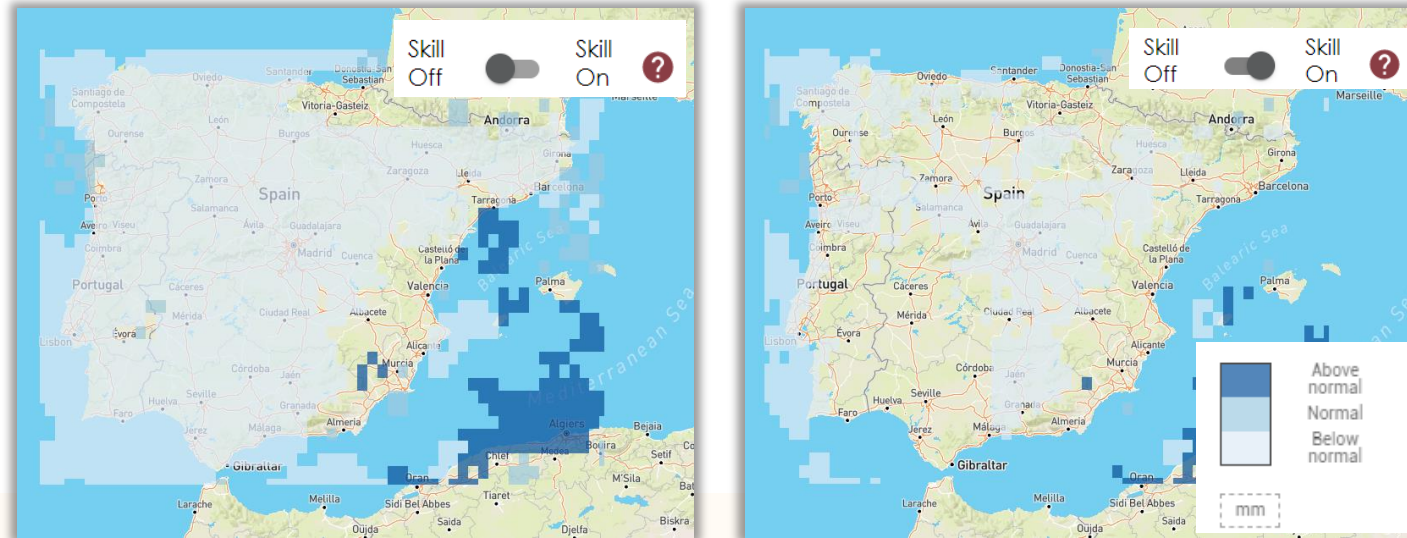
Turn on the 'skill' filter option to hide areas where the prediction is not reliable enough for decision making





# Integrate: MED-GOLD Dashboard

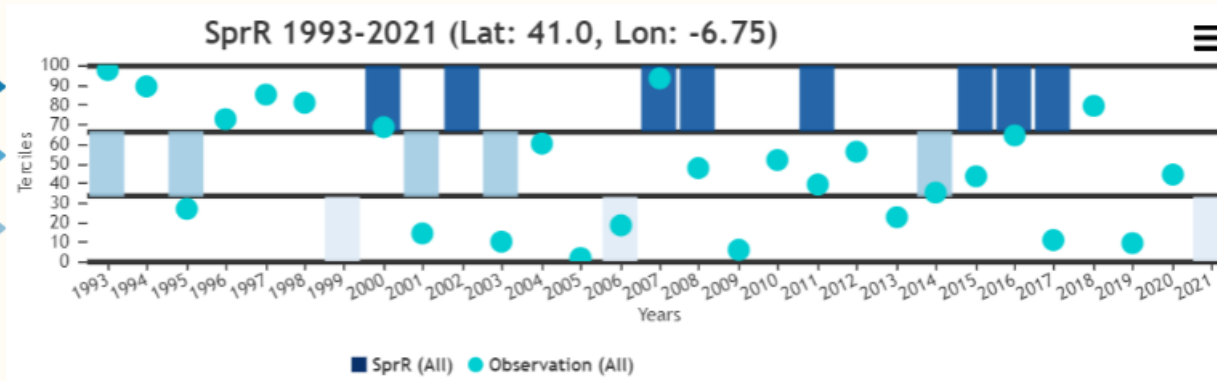
## Seasonal forecasts



**Wetter than normal**  
(upper tercile, 66.7-100)

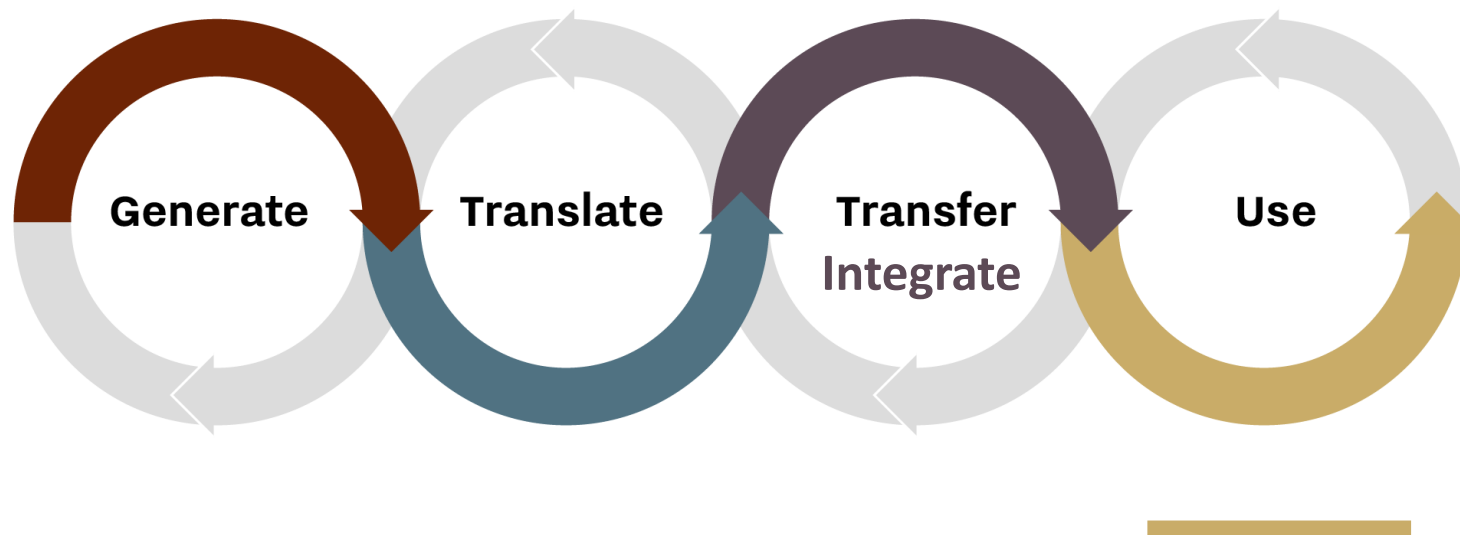
**Normal**  
(medium tercile, 33.3-66.7)

**Drier than normal**  
(lower tercile, 0-33.3)



### 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*).





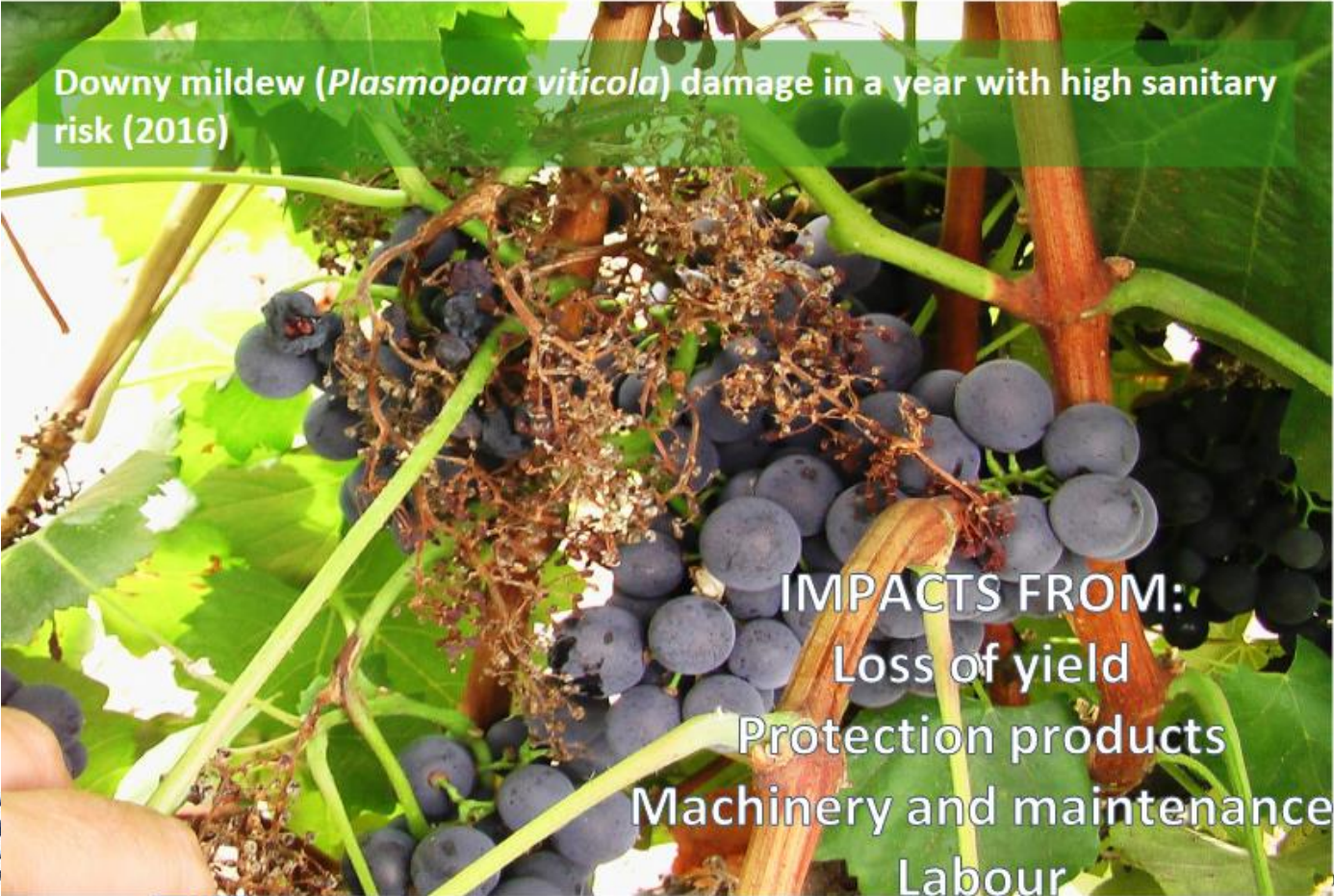
# Use: Decision-making

Spring rain and temperature: risk of fungal disease



**SOGRAPE**  
ORIGINAL LEGACY WINES

## Challenge



## Related user decisions



# Use: Decision-making

## Business as usual strategy (BaU)

- Vineyard manager applies same strategy independently of climatic conditions
- January: purchasing department orders plant protection products and plans contracting labour

Scenario (Action;Observation)	Cost plant protection products (€/ha)	Cost canopy management (€/ha)	Revenue Yield (€/ha)	Payoff (€/ha)
N;AN (=BaU)	315	495	1400	590
N;N (=BaU)	315	495	2000	1190
N;BN (=BaU)	315	495	2000	1190

▶ Underspending translates in yield losses

▶ Waste of plant protection products. Validity of 12 months

*Vigo et al. (under review)*



# Use: Decision-making



## Methodology

Decision Theory (Rubas et al, 2006)

- Climate service (CS) user has to make a **decision**
- With the goal of **maximising an objective** (Payoff =  $\Pi$ )
- **CS' Value** =  $\Pi_{wcs} - \Pi_{woCS}$

$$\begin{aligned}\Pi_{woCS} &= \Pi \text{ decision without CS} \\ \Pi_{wCS} &= \Pi \text{ decision with CS}\end{aligned}$$

Vigo et al. (under review)



# Use: Decision-making

## Climate prediction strategy

Scenario (Action;Observation)	Cost plant protection products (€/ha)	Cost canopy management (€/ha)	Revenue Yield (€/ha)	Payoff (€/ha)
AN;AN	410	520	2000	1070
AN;N	410	520	2000	1070
AN;BN	410	520	2000	1070
N;AN (=BaU)	315	495	1400	590
N;N (=BaU)	315	495	2000	1190
N;BN (=BaU)	315	495	2000	1190
BN;AN	220	495	1000	285
BN;N	535	495	2000	970
BN;BN	220	495	2000	1285

▶ No yield losses  
Losses due to inefficient  
purchase and contracting

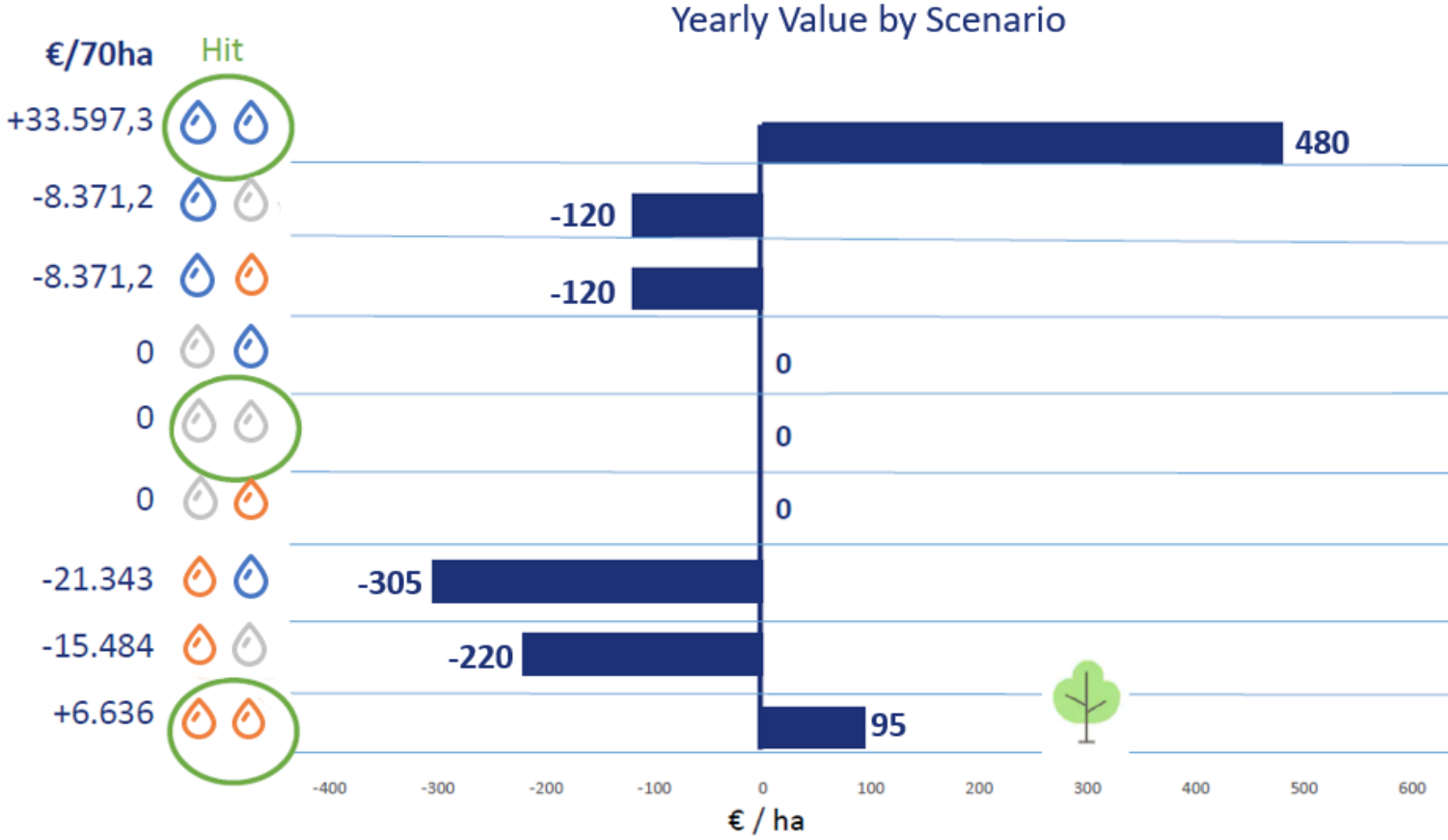
▶ Yield losses  
Protection products  
supply shock

▶ Higher savings and  
sustainability

$$\text{Payoff } (\Pi) = \text{€Y} - \text{C}_{pp} - \text{C}_{cm}$$

# Use: Decision-making

## Seasonal climate service value



Vigo et al. (under review)

# Conclusions

- Climate data is a key part of a climate service but it needs to be **transformed into information** that can support the decision-making of users
- **Generate:** apply a co-production framework to climate services, involving users through awareness raising, knowledge exchange and co-development
- **Translate:** explain research findings in a way that is easily understood by users and that allows them to connect with the meaning of the information provided
- **Integrate:** deliver and exchange information in a suitable and tailored way. Visualisations can be effective to reduce the users' cognitive load and better highlight salient information for them
- **Use:** demonstrate the application of the climate service in the user's decision making context to boost uptake



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# Thanks!

EUPORIAS



MED-GOLD

VITIGE OSS



**S2S4E**  
Climate Services  
for Clean Energy



The work presented has received funding from the EU Seventh and Horizon2020 Framework Programme under grant agreements nº 308291 (EUPORIAS), 776467 (MED-GOLD), 869565 (VitiGE OSS), 776787 (S2S4E) and 689029 (Climateurope)

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