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MED-GOLD

Turning climate-related information into added value for traditional **MED**iterranean **G**rape, **OL**ive and **D**urum wheat food systems

Deliverable 2.5

A handy easy-to-use manual for stakeholders and practitioners of the climate service tool.

PART I: the olive/olive oil sector

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Disclaimer

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EXECUTIVE SUMMARY

This user guide is designed to provide documentation for end-users who will use the climate service tools developed in the frame of the MED-GOLD project for the olive oil sector. The purpose of this manual is to provide all users of the provided services with a reference manual containing step-by-step instructions on how to log-on, use the tool, download and interpret the results.

The material in this manual includes instructions for the three climate services provided for the olive sector: i) the Olivia platform, a web platform which includes a predictive pest management support system based on artificial intelligence (AI), ii) the MED-GOLD Dashboard, a web-based application that allows the users to easily visualise, interact and even download climate data and indices and iii) the physiologically based demographic model (PBDM) approach, an AI-based application, which captures the weather-driven biology of the interaction between olive and the olive fruit fly.

The aim of the climate service tools is to enable the end-users to adapt their decision making strategies to the climate conditions and climate change. Although the climate services of this manual are for a wide range of end-users (e.g. farmers, agronomists), the PBDM approach mainly addresses researchers and policy makers.

1. OBJECTIVES

With this deliverable, the project has contributed to the achievement of the following objectives (DOA):

No.	Objective	Yes
1	To co-design, co-develop, test, and assess the added value of proof-of-concept climate services for olive, grape, and durum wheat	X
2	To refine, validate, and upscale the three pilot services with the wider European and global user communities for olive, grape, and durum wheat	
3	To ensure replicability of MED-GOLD climate services in other crops/climates (e.g., coffee) and to establish links to policy making globally	
4	To implement a comprehensive communication and commercialization plan for MED-GOLD climate services to enhance market uptake	
5	To build better informed and connected end-user communities for the global olive oil, wine, and pasta food systems and related policy making	

2. IMPACT

No.	Expected impact	Yes
1	Providing added-value for the decision-making process addressed by the project, in terms of effectiveness, value creation, optimised opportunities and minimised risk	The user manual is essential for promoting and exploiting the developed climate services of the project, since it provides all the necessary information to the end-users (farmers, agronomists, policy makers, scientists) to guide and encourage them to use the tool and take full advantage of the product.
2	Enhancing the potential for market uptake of climate services demonstrated by addressing the added value	
3	Ensuring the replicability of the methodological frameworks for value added climate services in potential end-user markets	
4	To implement a comprehensive communication and commercialization plan for MED-GOLD climate services to enhance market uptake	
5	To build better informed and connected en d-user communities for the global olive oil, wine, and pasta food systems and related policy making	

3. DEFINITIONS

Concepts and terms used in this document and needing a definition are included in the following table:

Concept / Term	Definition
Dashboard	Web-based application that was developed to apply climatic services to the agricultural sectors of MED-GOLD project
Tercile	Division of the population distribution into three categories

4. ACRONYMS

Acronyms used in this document and needing a definition are included in the following table:

Acronym	Definition
CSV	comma-separated values
PBDM	Physiologically-Based Demographic Models
AI	Artificial Intelligence
PNG	Portable Network Graphics
Spr32	Spring days with Tmax>32ºC
Sprtx	Mean spring maximum temperature
SU36	Number of summer days with Tmax>36ºC
SU40	Number of summer days with Tmax>40ºC
WINRR	Cumulated winter precipitation from October to May
PDF	Probability Density Function
RCP	Representative Concentration Pathways
CDS-C3S	Climate Data Store of the Copernicus Climate Change Service

5. REFERENCES

The following documents, although not part of this document, amplify or clarify its contents. Reference documents are those not applicable and referenced within this document. They are referenced in this document in the form [RD.x]:

Ref.	Title	Code	Version	Date
[RD.1]	MED-GOLD Deliverable 3.2: Report on the methodology followed to implement the wine pilot services			2020
[RD.2]	MED-GOLD Deliverable 3.6: First feedback report from users on wine pilot service development			2019
[RD.3]	MED-GOLD Deliverable 3.7:Second Feedback report from users on wine pilot service development			2020
[RD.4]	MED-GOLD Deliverable 2.7:Second Feedback report from users on olive oil pilot service development			2020
[RD.5]	MED-GOLD Deliverable 3.5: A handy easy-to-use manual for stakeholders and practitioners of the climate service tool. PART II: the grape/ wine sector			2021
[RD.6]	SEAS5: the new ECMWF seasonal forecast system. (2019) Johnson, Stephanie & Stockdale, Tim & Ferranti, L. & Balmaseda, Magdalena & Molteni, Franco &	Johnson et al., 2019		2019

	Magnusson, Linus & Tietsche, Steffen & Decremer, Damien & Weisheimer, Antje & Balsamo, Gianpaolo & Keeley, Sarah & Mogensen, Kristian & Zuo, Hao & Monge-Sanz, Beatriz.. Geoscientific Model Development. 12. 1087-1117. 10.5194/gmd-12-1087-2019.			
[RD.7]	Palladino, P., 1991. Defining ecology: Ecological theories, mathematical models, and applied biology in the 1960s and 1970s. J. Hist. Biol. 24, 223–243. https://doi.org/10.1007/BF00209430	Palladino, 1991		1991
[RD.8]	Dormann, C.F., Fründ, J., Schaefer, H.M., 2017. Identifying causes of patterns in ecological networks: opportunities and limitations. Annu. Rev. Ecol. Evol. Syst. 48, 559–584. https://doi.org/10.1146/annurev-ecolsys-110316-022928	Dorman et al., 2017		2017
[RD.9]	Evans, M.R., 2012. Modelling ecological systems in a changing world. Philos. Trans. R. Soc. B Biol. Sci. 367, 181–190. https://doi.org/10.1098/rstb.2011.0172	Evans et al., 2012		2012
[RD.10]	Montague, C.L., 2014. Systems Ecology. Oxf. Bibliogr. Ecol. https://doi.org/10.1093/obo/9780199830060-0078	Montague, 2014		2014
[RD.11]	Ponti L, Gutierrez AP, Altieri MA (2015) Holistic approach in invasive species research: the case of the tomato leaf miner in the Mediterranean Basin. Agroecology and Sustainable Food Systems 39:436–468. https://doi.org/10.1080/21683565.2014.990074	Ponti et al., 2015		2015
[RD.12]	Gutierrez, A.P., Curry, G.L., 1989. Conceptual framework for studying crop-pest systems, in: R.E. Frisbie, K.M. El-Zik, L.T. Wilson (Eds.), Integrated Pest Management Systems and Cotton Production. John Wiley and Sons, New York, USA, pp. 37–64	Gutierrez et al., 1989		1989
[RD.13]	Georgescu-Roegen, N., 1976. Energy and economic myths: institutional and analytical economic essays. Pergamon, New York, USA	Georgescu-Roegen, 1976		1976
[RD.14]	Gutierrez, A.P., 1992. The physiological basis of ratio-dependent predator-prey theory: the metabolic pool model as a paradigm. Ecology 73, 1552–1563. https://doi.org/10.2307/1940008	Gutierrez, 1992		1992
[RD.15]	Regev, U., Gutierrez, A.P., Schreiber, S.J., Zilberman, D., 1998. Biological and economic foundations of renewable resource exploitation. Ecol. Econ. 26, 227–242. https://doi.org/10.1016/S0921-8009(97)00103-1	Regev et al., 1998		1998
[RD.16]	Gutierrez, A.P., Ponti, L., Kranthi, K.R., Baumgärtner, J., Kenmore, Peter.E., Gilioli, G., Boggia, A., Cure, J.R., Rodríguez, D., 2020. Bio-economics of Indian hybrid Bt cotton and farmer suicides. Environ. Sci. Eur. 32, 139. https://doi.org/10.1186/s12302-020-00406-6	Gutierrez et al., 2020		2020
[RD.17]	Cure, J.R., Rodríguez, D., Gutierrez, A.P., Ponti, L., 2020. The coffee agroecosystem: bio-economic analysis of coffee berry borer control (Hypothenemus hampei). Sci. Rep. 10, 12262. https://doi.org/10.1038/s41598-020-68989-x	Cure et al., 2020		2020
[RD.18]	Gutierrez, A.P., 1996. Applied population ecology: a supply-demand approach. John Wiley and Sons, New York, USA	Gutierrez, 1996		1996
[RD.19]	Gutierrez A.P., Ponti L., Cossu Q.A. (2009) Effects of climate warming on olive and olive fly (Bactrocera oleae (Gmelin)) in California and Italy. Climatic Change 95:195–217. https://doi.org/10.1007/s10584-008-9528-4	Gutierrez et al., 2009		2009
[RD.20]	Ponti L., Cossu QA, Gutierrez AP (2009) Climate warming effects on the olive-Bactrocera oleae system in Mediterranean Islands: Sardinia as an example. Global Change Biology 15:2874-2884. http://doi.org/10.1111/j.1365-2486.2009.01938.x	Ponti et al., 2009		2009

[RD.21]	Ponti L., Gutierrez AP., Ruti PM., Dell'Aquila A. (2014) Fine-scale ecological and economic assessment of climate change on olive in the Mediterranean Basin reveals winners and losers. Proceedings of the National Academy of Sciences, USA 111:5598–5603. https://doi.org/10.1073/pnas.1314437111	Ponti et al., 2014		2014
[RD.22]	Gutierrez, A.P., Ponti, L., 2014. Assessing and managing the impact of climate change on invasive species: the PBDM approach, in: Ziska, L.H., Dukes, J.S. (Eds.), Invasive Species and Global Climate Change. CABI Publishing, Wallingford, UK, pp. 271–288. https://doi.org/10.1079/9781780641645.0271	Gutierrez and Ponti, 2014		2014
[RD.23]	Ponti, L., Gutierrez, A.P., Cure, J.R., Rodríguez, D., Caboni, F., Boggia, A., Neteler, M., 2019. Bioeconomic analogies as a unifying paradigm for modeling agricultural systems under global change in the context of geographic information systems. Geophysical Research Abstracts 21, EGU2019-13677. https://meetingorganizer.copernicus.org/EGU2019/EGU2019-13677.pdf	Ponti et al., 2019		2019
[RD.24]	Gutierrez AP (1996) Applied population ecology: a supply-demand approach. John Wiley and Sons, New York, USA. 320 pp	Gutierrez, 1996		1996
[RD.25]	GRASS Development Team (2015) Geographic Resources Analysis Support System (GRASS) Software, Version 6.4.4. Open Source Geospatial Foundation. URL http://grass.osgeo.org, Beaverton, Oregon, USA			2015
[RD.26]	Gutierrez AP, Ponti L, Gilioli G (2010) Climate change effects on plant-pest-natural enemy interactions. In: Hillel D, Rosenzweig C (eds) Handbook of climate change and agroecosystems: impacts, adaptation, and mitigation. Imperial College Press, London, UK, pp 209–237. https://doi.org/10.1142/9781848166561_0012	Gutierrez et al., 2010		2010
[RD.27]	MED-GOLD Deliverable 2.2: Report on the tool performance			2020
[RD.28]	MED-GOLD Deliverable 2.6: First feedback report from users on olive oil pilot service development			2019
[RD.29]	Toko, M., Neuenschwander, P., Yaninek, J.S., Ortega-Beltran, A., Fanou, A., Zinsou, V., Wydra, K.D., Hanna, R., Fotso, A., Douro-Kpindou, O., 2019. Identifying and managing plant health risks for key African crops: cassava, in: Neuenschwander, P., Tamò, M. (Eds.), Critical Issues in Plant Health: 50 Years of Research in African Agriculture, Burleigh Dodds Series in Agricultural Science. Burleigh Dodds Science Publishing, Cambridge, UK, p. doi:10.19103/AS.2018.0043.07. https://doi.org/10.19103/AS.2018.0043.07	Toko et al., 2019		2019

6. OLIVIA PLATFORM

The Olivia platform is a decision-making tool designed for the olive sector that provides guidance to farmers and technicians for optimal irrigation, fertilisation and pesticide application. Integrating advanced artificial intelligence, satellite data and climate information for the past, present and future, the tool helps farmers to manage their production in an easy and efficient way.

6.1. General information

Olivia is a web platform that provides services to olive growers including:

- Predictive pest control: the use of predictive models to have insight on the olive fly pest evolution (in terms of % of affected fruit) for the following four weeks gives to the farmers the opportunity to select when, where and how to apply pesticides, minimize the pest damage and the amount of pesticide applied and support an overall sustainable pest control.
- Optimized irrigation and fertilization: through Olivia the farmers are managing their farms with a predictive control system to optimize the use of water and fertilizers, based on productivity models that take into account all the farm characteristics, like geography, location, insolation, slope, soil, variety and also past and future weather and climate.

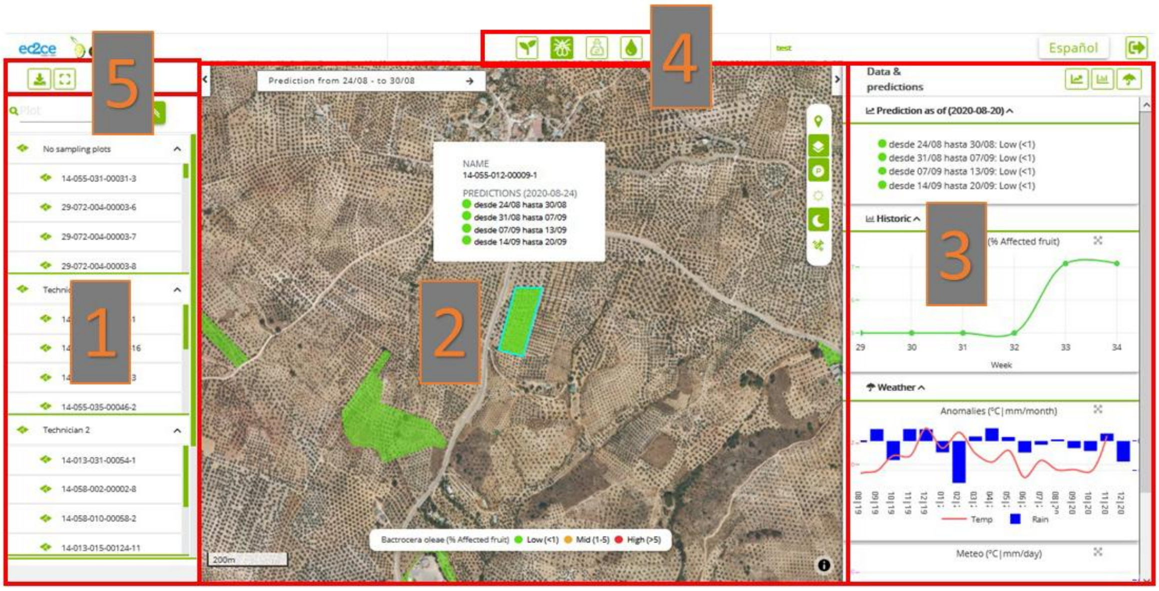
Olivia is showing, within the MED-GOLD project, how climate information can be used as input to provide a direct decision making support, facilitating the use of complex information and relations: it simplifies information on how the climate and weather affects pests evolution and/or productivity, and how the farmer could act in function of predicted climate evolution.

Olivia provides all the information and recommendations through a geolocated interface and all the inputs provided by the farmer can be incorporated through the platform, manually or automatically, depending on the farmer's infrastructure.

The Olivia Platform is divided in 5 main sections (Fig.6-1):

1. Parcel Information and Identification
2. Mapping Area
3. Data results
4. Service Selection (Pest Control, Irrigation)
5. Exporting Data

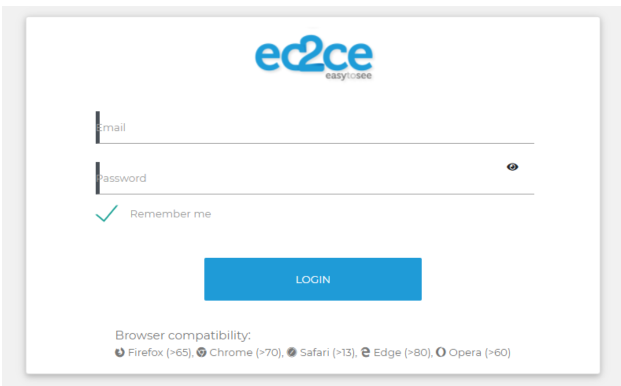
Figure 6-1: Olivia general overview and main sections



6.2 Step-by-step instructions

- Olivia is a climate service provided by ec2ce and is accessed through the company's webpage; www.ec2ce.com (Fig.6-2).

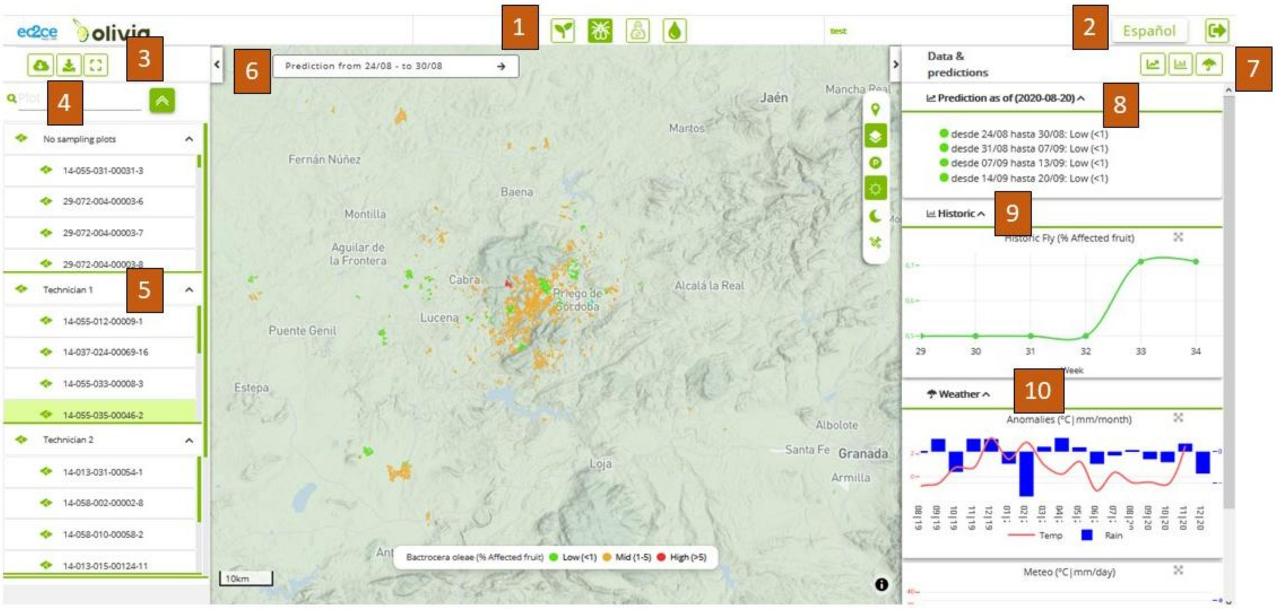
Figure 6-2: Olivia login page



- The user-name and password that provide access to the farms and areas included by the farmer in the service
- Different roles are available; for example a cooperative could have a service for the manager and a different one for the technician, with access to a limited number of farms.
- The user can include the farms through different procedures and geographical information.
- The platform provides, on top of the decision-making support, weather and climatic information, and can be customized to include any operational or economic information of interest to the user.

The steps that the users can use to navigate through the platform are (each step is illustrated under the same number in Fig. 6-3)**:**

Figure 6-3: Olivia homepage



1. Selecting the Service

A. *Productivity*: past information and predictions
B. *Bactrocera oleae pest*: predictions of risk
C. *Greasy yield*: past information and predictions
D. *Fertigation*: past information and predictions

2. Selecting language

A. *English*
B. *Spanish*

3. Downloading reports and data

4. Location (search by parcel)

5. List of parcels in the region of interest

6. Forecasted week

7. Data & Predictions icons

- *A. Predictions*
- *B. Monitoring data*
- C. *Weather data*

8. Predictions (e.g. level of risk, irrigation amount)

9. Monitoring data (e.g. historical data, irrigation, fertilisation)

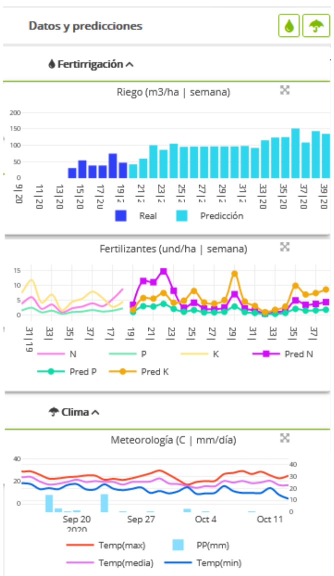
10. Weather data (e.g. anomalies, weather station, observations)

<u>**Fertilisation and irrigation use case** (each step is illustrated under the same number in Fig. 6-5)**:**</u>

Login using your credentials.

1. Select the fertigation icon at the top 
2. From the left panel select the parcel of interest or
3. Click on the map
4. … a new panel on the right side will display information related to the selected parcel (past and future information on irrigation and fertilisation) (Fig. 6-4)

Figure 6-4: Fertilisation and irrigation displayed panel



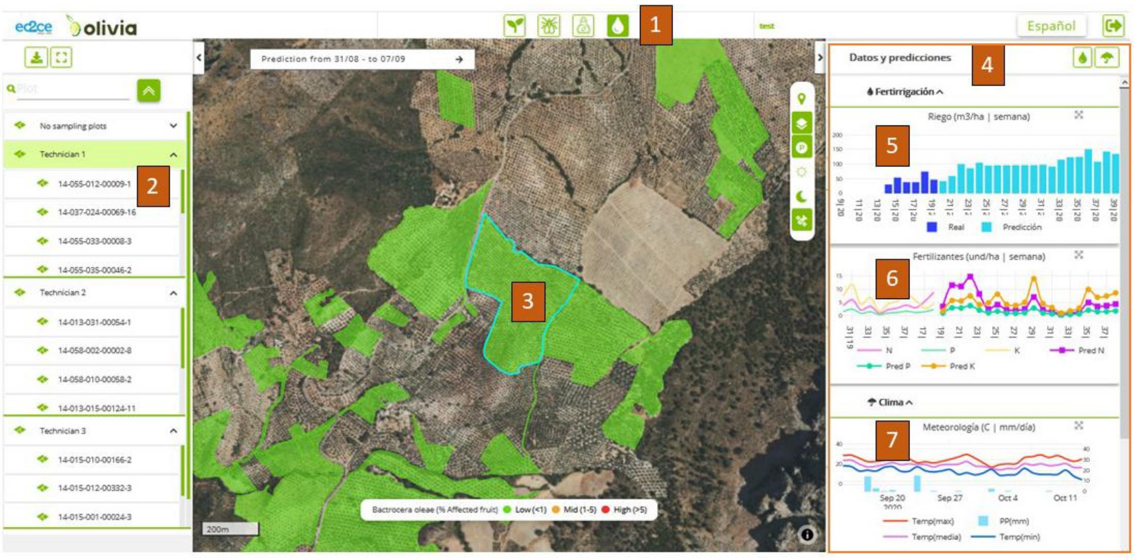
5. **Irrigation** chart (results): You can see that the farmer has applied irrigation for the last 6 weeks (shown by the dark blue bars). In the following weeks, it is recommended to increase the irrigation

amount, since longer than normal summer conditions are foreseen, which are likely to cause water stress.

6. **Fertilisation** chart (results): In this case, future predictions show that the trees will need less potassium but more nitrogen in the following weeks (shown by the pink line 'Pred N'), coinciding with the flowering stage. Thus, the farmer should apply more nitrogen fertiliser.
7. **Weather:** weather information (temperature and precipitation) is also available

Export and download results by clicking on the download icon  on the left panel.

Figure 6-5: Main display for fertilisation and irrigation use case

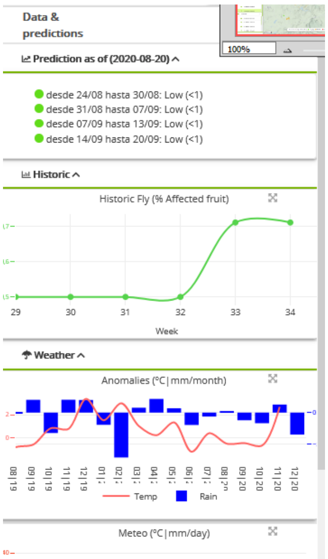


<u>Pest Control use case</u> <u>(each step is illustrated under the same number in Fig. 6-7)</u>**:**

Login using your credentials.

1. Select the Pest Icon at the top 
2. From the left panel select the parcel of interest or
3. Click on the map
4. … a new panel on the right side will display information related to the selected parcel (pest control) (Fig. 6-6)

Figure 6-6: Pest Control displayed panel



5. **Pest Prediction**: Shows the prediction for pests infection at the parcel of interest.
6. **Historic Information**: Shows the percentage of fruits affected by the pests (in this case olive fly)
7. **Anomalies:** The anomalies chart can also be displayed (temperature and rain)

Export and download results by clicking on the download icon  on the left panel.

Figure 6-7: Main display Pest Control use case

6.3 Trouble-shooting

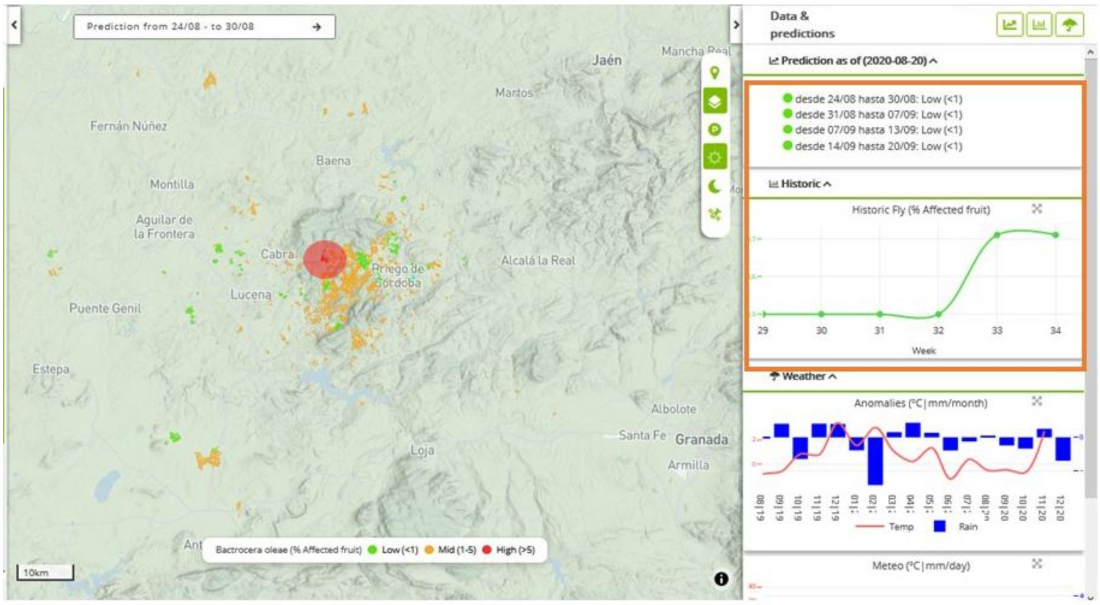
- Olivia is right now in its third version and most of the initial issues have been solved
- More than 400,000 ha are served each year and the most complex issue (transparent for the end user) is related to the data-base configuration and management

6.4 How to download/interpret the results

- The pest evolution could be seen both on a map, showing different farms for a selected horizon of predictions (No 3, Fig. 6-7), or in a graph that provides info for the following four weeks (Fig. 6-8)

- The *Anomalies* result shows the variations of temperature (red curve) precipitation (blue bars) on a monthly basis. The units are *ºC* and *mm,* respectively.

Figure 6-8: Weekly Pest prediction

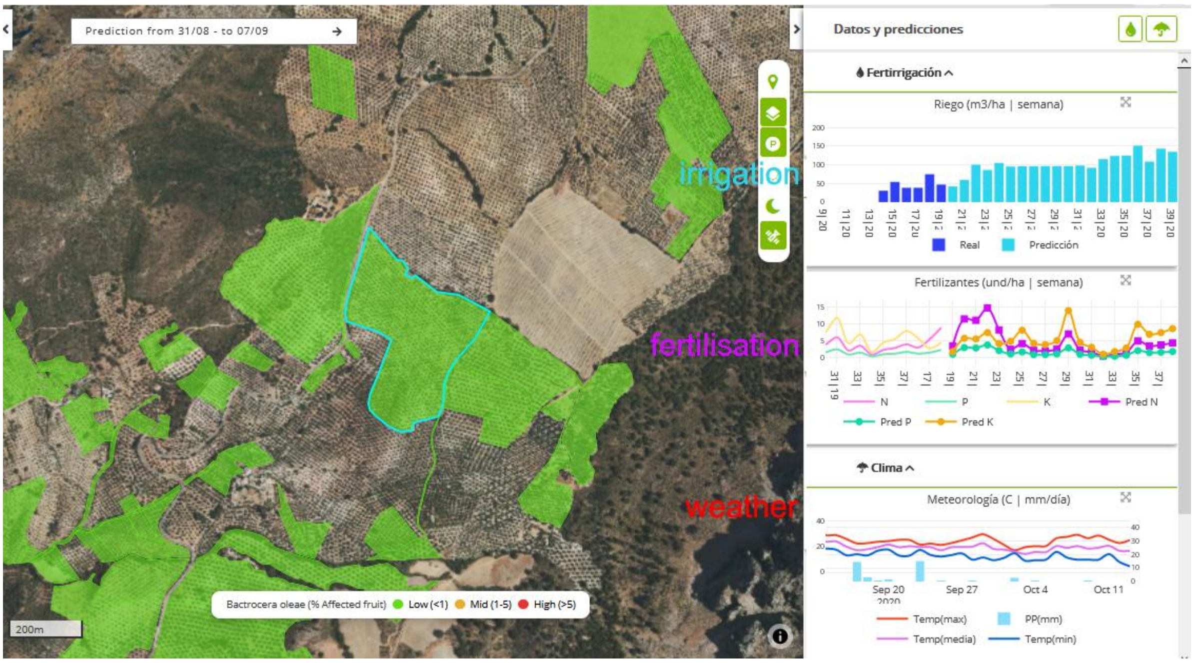


- The irrigation plans (Fig. 6.9) are shown in a graph, and the map shows the total amount of water that each farm has received. In this example, the user can see the results for both real (blue bars) and predicted (cyan bars) irrigation for the selected parcel. The units are (mm/Ha).

- The fertilization graph individualizes weekly plans for each component (N-magenta, P-green, K-orange). The continuous line shows the real fertilizer used on the parcel and the dotted line the prediction for the next few weeks.

- The weather section shows the temperature (mean, max and min), and the precipitation measured from agro-climatic stations.

Figure 6-9: Weekly prediction for irrigation and fertiliser plan



The information presented in the graphs is dynamic and linked to the map, so when zooming in at the map, the data on the graphs is modified accordingly to show just the information related to the farms included in the map.

All the information within the platform, both inputs and outputs, can be downloaded using the download icon 

6.5 Contact and pending issues

For access requests or for any inquiries on the use of the software, and comments on the design and functionalities of the application, please contact ec2ce at www.ec2ce.com or email at info@ec2ce.com.

7. DASHBOARD

7.1 General information

As already reported in the part II of this manual [RD.5], the MED-GOLD dashboard is an easy-to use visualisation tool, which provides access to information on past climate and predictions of future climate at different time scales.

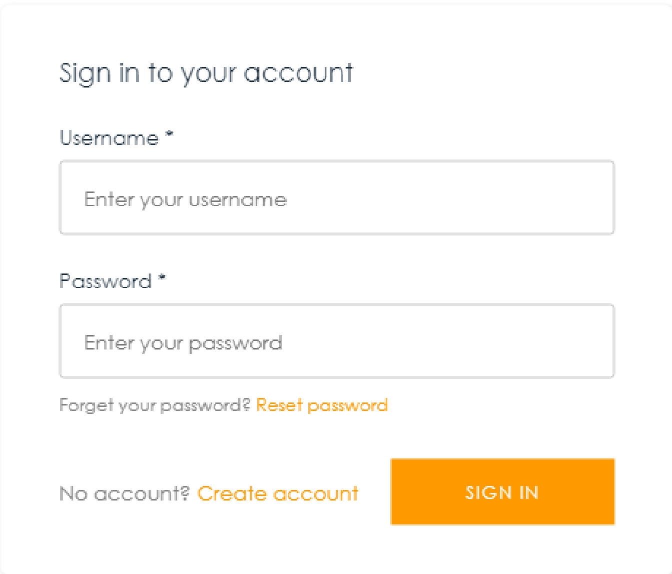
The methodology of the co-design and co-development adopted, including the rounds of interactions with users, has been described in previous deliverables [RD.1, RD.2, RD.3, RD.4]. The climate data shown along with all the technical details are also described in [RD.1]. All these deliverables are available in https://www.med-gold.eu/documents-deliverables/.

All the instructions about the use of the MED-GOLD Dashboard for the olive sector, including the below reported use cases, have been described in the infosheet "*The MED-GOLD Dashboard for the olive oil sector*" available in https://www.med-gold.eu/documents-publications/, translated in the main languages of the project, and here reported in Annex A. The instructions and information for the Dashboard are also explicitly described in Deliverable 3.5 [RD.5] for the wine sector and the reason for being duplicated here is to provide an integrated user manual for the users of the olive sector.

7.2 User access

You can access the dashboard on the MEDGOLD website, and by visiting: https://dashboard.med-gold.eu. For account requests, please contact the MED-GOLD Consortium partners or med-gold.project@enea.it . The Access page is shown in Figure 7-1.

Figure 7-1: Access page of https://dashboard.med-gold.eu



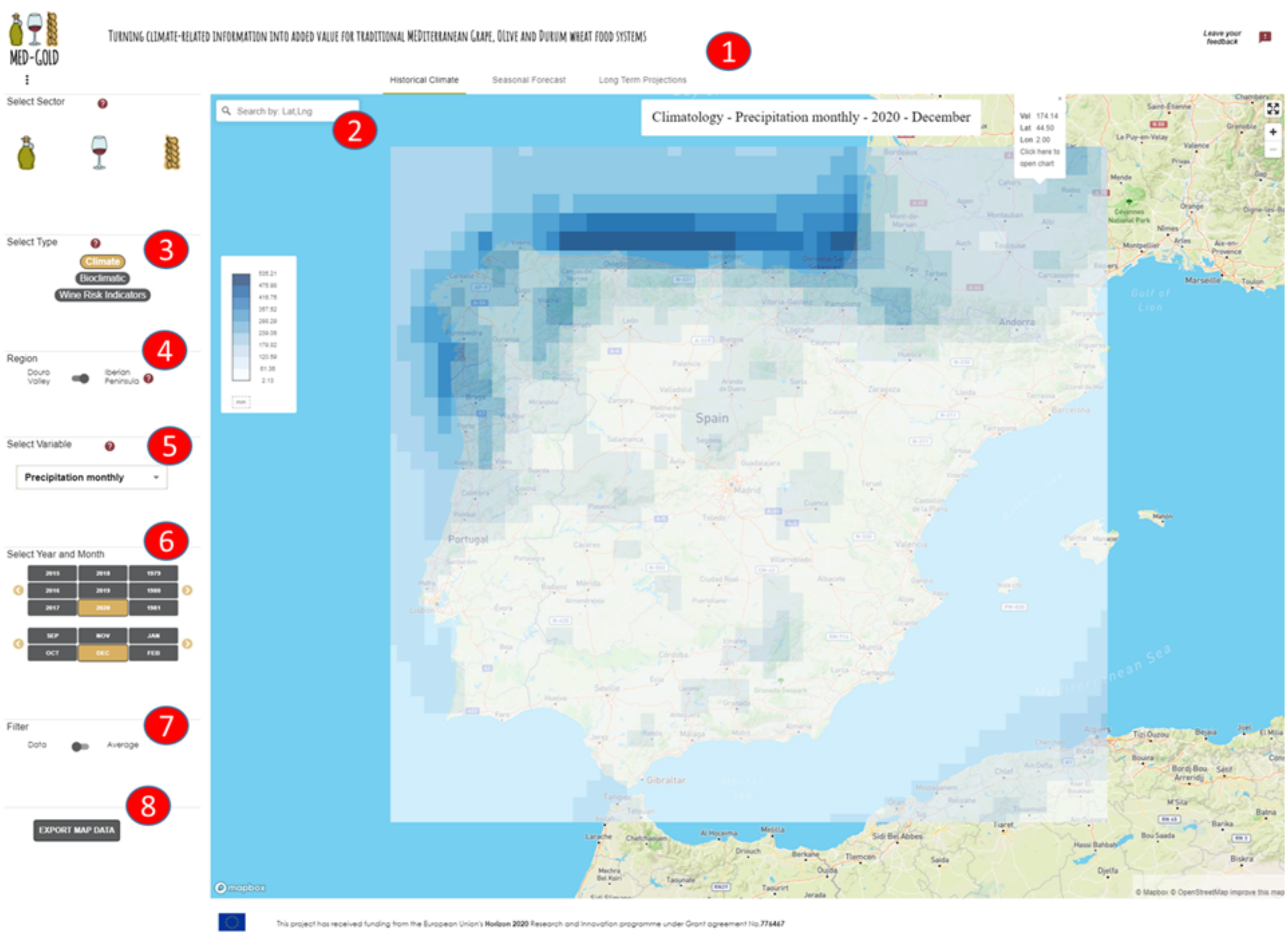
7.3 Landing menu tabs

In the MED-GOLD Dashboard you can access three different times scales: historical climate, seasonal forecast and long-term projections tabs

7.3.1 Historical Climate

The Landing page after the login (and after selecting in step#7 the 'Iberian Peninsula' option) is shown in Figure 7-2 and it corresponds to the default option 'Historical climate' (Step #2)

Figure 7-2: Dashboard homepage after login ("Iberian peninsula" option selected in step#4): Historical Climate tab



The available options are reported below (each option is illustrated under the same number as in Fig. 7-2):

1. **Timescale**
   Historical Climate: past and near-present information [Default and here selected]
   Seasonal Forecast: predictions for the next months
   Long-Term Projections: future scenarios for the 21st century

2. **Location** *(search by geographic coordinates, city or country)*
3. **Type of variables**

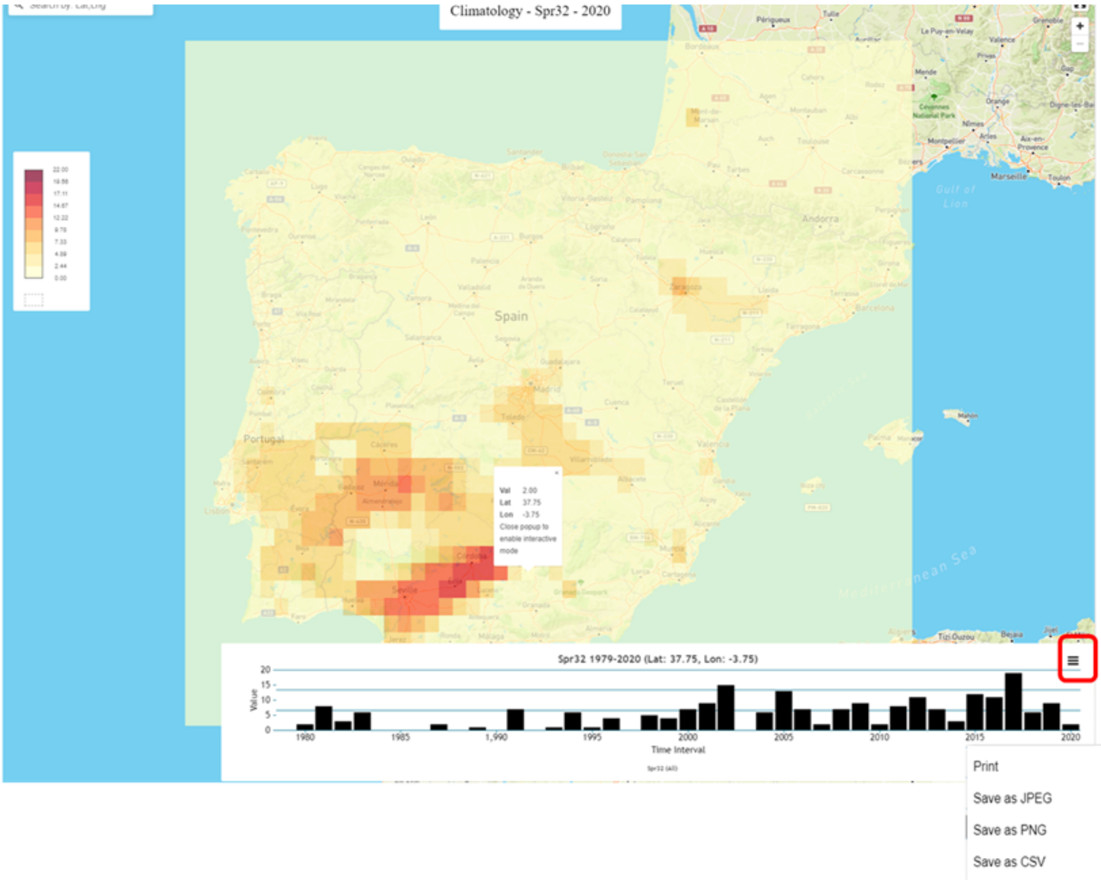
   Climate variables: temperature & precipitation data

   Bioclimatic indicators: indicators taking into account the climate and phenology of the olive tree, e.g. Spr32 (Spring days with Temp Max>32°C), Sprtx (Mean spring maximum temperature), SU36 (summer days with temp max >36) , SU40 (number of summer days with temp max >40) , WINRR (Cumulated winter precipitation from October to May). All these indicators are available on the 'Iberian Peninsula' option (see below, step#4)
   Wine risk indicators: [This Section is mainly for wine sector]
4. **Region of interest**: (Douro region [for wine sector] or Iberian Peninsula).

   The description of high resolution data for Douro Valley, is reported in [RD.2, RD.5]. For the Iberian Peninsula, ERA5 dataset (RD.5) is used, spanning 1979-2020, at 31 km of spatial resolution.
5. **Variable of interest** *(hover over each variable for explanation)*
6. **Time period of interest**
7. **Filter:** Data for each single year or averaged over the period 1981-2010
8. **Export data.** The maps can be exported in .csv (ascii format readable by Microsoft Excel as well as open software like OpenOffice), or .netcdf (standard for scientific computation, readable by basic Java application such as Panoply https://www.giss.nasa.gov/tools/panoply/) or as images in jpg format.

By clicking on the map (or by selecting a location in the above step #2), a chart will appear with the time series of the requested field (Fig. 7-3). The Time series can be printed or exported as csv or as image in jpg or png format.

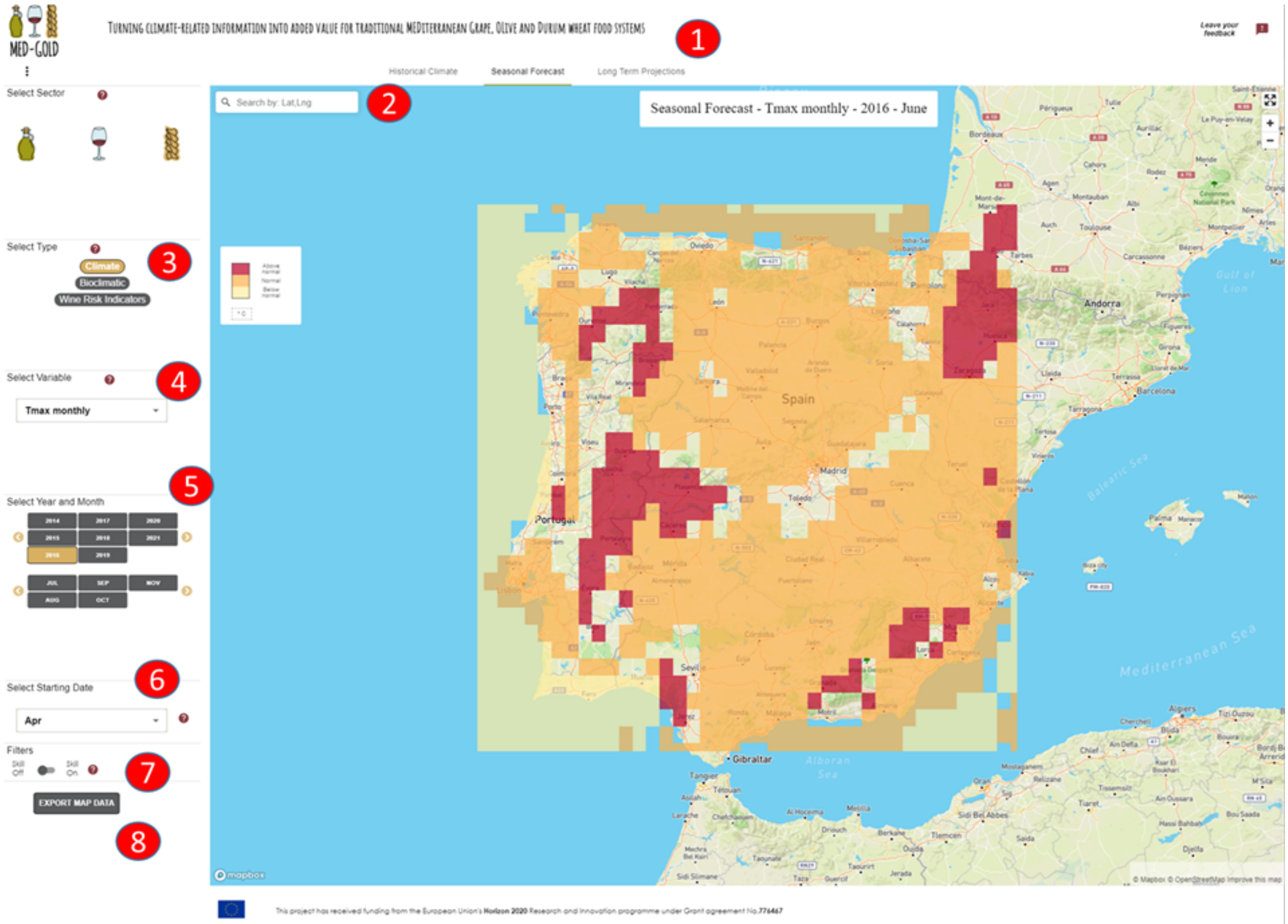
Figure 7-3: Time series for a selected grid point in the Historical Climate tab



7.3.2 Seasonal Forecasts

The Landing page for the 'Seasonal Forecast' Tab is shown in Figure 7-4 . The predictions shown in the MED-GOLD Dashboard are the ECMWF SEAS5 seasonal predictions dataset obtained from the Climate Data Store of the Copernicus Climate Change Service (CDS-C3S) [RD.6].

Figure 7-4: Landing page for the Seasonal Forecast tab



1. **Timescale**
   Historical Climate: past and near-present information
   Seasonal Forecast: predictions for the next months [HERE SELECTED]
   Long-Term Projections: future scenarios for the 21st century
2. **Location** (search by geographic coordinates, city or country)
3. **Type of variables**
   Climate variables: temperature & precipitation data
   Bioclimatic indicators: indicators taking into account the climate and phenology of the olive tree, e.g. v e.g. Spr32 (Spring days with Temp Max>32°C), Sprtx (Mean spring maximum temperature), SU36 (summer days with temp max >36) , SU40 (summer days with temp max >40)
   Wine risk indicators: [This Section is mainly for wine sector]
4. **Variable of interest** *(hover over each variable for explanation)*
5. **Target period of the forecast**
6. **Starting Date**: The "Starting Date" is the initial starting month of that specific forecast, i.e. when the forecast is issued.
7. **Filter:** Turn on the "Skill" filter option to hide areas where the prediction doesn’t provide added value with respect to climatology (See RD.1 for major details)

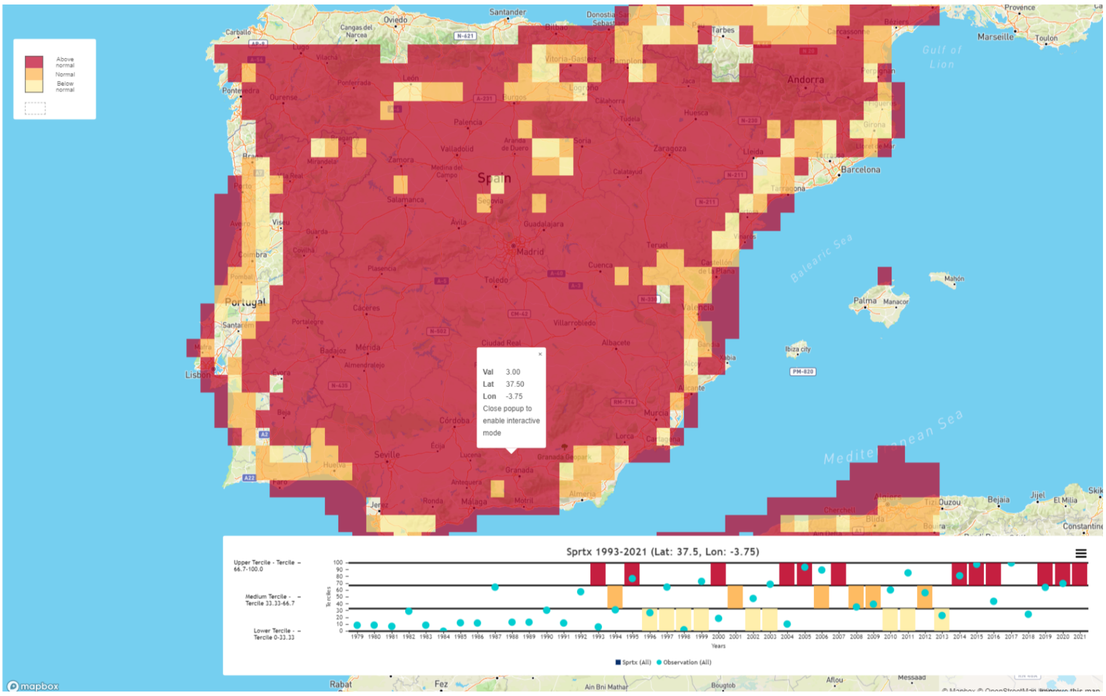
8. **Export data.** The maps can be exported in .csv (ascii format readable by Microsoft Excel), or .netcdf (standard for scientific computation, readable by basic Java application such as Panoply https://www.giss.nasa.gov/tools/panoply/) or as images in .jpg format.

Each prediction is portrayed in three categories: **above normal**, **normal** and **below normal**. Terciles are two values (lower and higher terciles) that divide a set of data (for example, the average temperature for the last 30 years) into three groups: one with the lowest 33% of values (those below the lower tercile or below normal), one with the highest 33% (those above the higher tercile or above normal) and the remaining values, centred around the middle value (normal value), between both terciles. In climate science, values that lie below the lower tercile (lowest 33%) or above the upper tercile (highest 33%) are commonly considered as anomalies.

The categorization is achieved by comparing predicted values with historical registers. The map shown in Figure 7-5 is a Dominant Tercile Summary Map that shows, on a single chart, the areas where a specific tercile probability is prevailing (exceeding 40%) over the others in the selected forecast. Such probabilities are computed by comparing the forecast probability density function (PDF) with the corresponding model climate PDF, estimated over the reference period (1993-2016). If the dominant tercile does not exceed 40% that grid point is not assigned to any tercile and it is not shown. This plot gives a convenient, simple overview of a seasonal forecast.

By clicking on the map (or by selecting a location in the above step #3) , a chart will appear with the time series of the observed/predicted categories for the requested field (see Fig. 7-5 for Sprtx). The colored squares correspond to the most likely predicted tercile (above normal, normal and below normal terciles), while the blue dots are the percentiles for the reference observational dataset (ERA5). The time series can be printed or exported as a csv file or as an image.

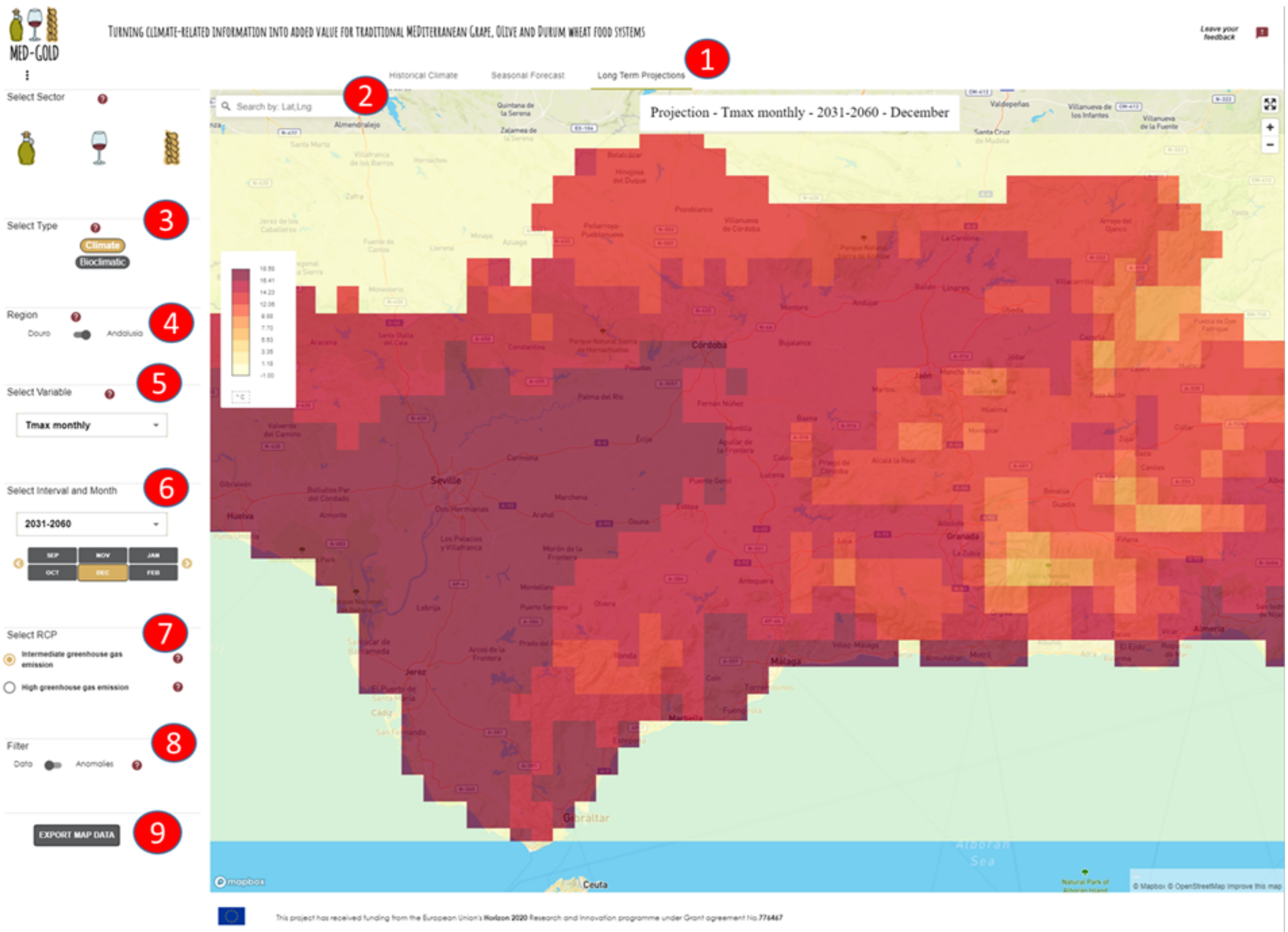
Figure 7-5: Time series for a selected grid point in the Seasonal Forecast tab



7.3.3 Long-term projections

The page for the 'Long-term projections' Tab is shown in Figure 7-6.

Figure 7-6: Landing page for the Long term projections tab ("Andalusia" option selected in step#4)



1. **Timescale**
   Historical Climate: past and near-present information
   Seasonal Forecast: predictions for the next months
   Long-Term Projections: future scenarios for the 21st century [HERE SELECTED]
2. **Location** (search by geographic coordinates, city or country)
3. **Type of variables**
   Climate variables: temperature & precipitation data
   Bioclimatic indicators: indicators taking into account the climate and phenology of the olive tree, e.g. Spr32 (Spring days with Temp Max>32°C), Sprtx (Mean spring maximum temperature), SU36 (summer days with temp max >36) , SU40 (summer days with temp max >40) , WINRR (Cumulated winter precipitation)
4. **Region of interest** (Douro [for Wine Sector] or Andalusia [here, selected]). The climate projection for the Douro valley have been downscaled and bias corrected using PTHRES (1km), while the for

the projections over Andalusia EOBS-19 grd (around 11km) from a five member GCM-RCM sub-ensemble simulations from the EURO-CORDEX modelling experiment have been used (http://www.euro-cordex.net). Major details in [RD.1].

5. **Variable of interest** (hover over each variable for explanation)
6. **Target period of the projections**
   The desired time frame for the future climate projections
7. **Select the RCP (Future emission scenario)**
   Different scenarios describing how carbon emissions might change over the rest of this century - known as the Representative Concentration Pathways (RCPs) - have been developed by climate scientists. The intermediate (**RCP4.5**) and high (**RCP8.5**) emission scenarios are available to select in the MED-GOLD dashboard, corresponding to a global temperature increase of 1.1-2.6°C and 2.6-4.8°C, respectively.
8. **Filter #1: Data or anomalies** It's possible to show the data for the time interval of interest or the deviation of the selected field from the long-term average value over the reference present climate 1971-2000.
9. **Export data.** The maps can be exported in .csv (ascii format readable by Microsoft Excel), or .netcdf (standard for scientific computation, readable by basic Java applications such as Panoply https://www.giss.nasa.gov/tools/panoply/) or as images in .jpg format.

7.4 How to download/interpret the results

Here we report some use cases drafted in order to facilitate the use and the interpretation of the MED-GOLD DASHBOARD for new users. These use cases have been also reported in the Infosheet in Annex A as a basic tutorial.

7.4.1 Use case 1

It's March. You are an agronomist working for an olive cooperative. You need to advise the farmers in your cooperative on the optimal fertigation strategy, taking into account the expected climate conditions in the next months. Are the upcoming months going to be particularly dry? The following steps are also illustrated in Figure 7-7.

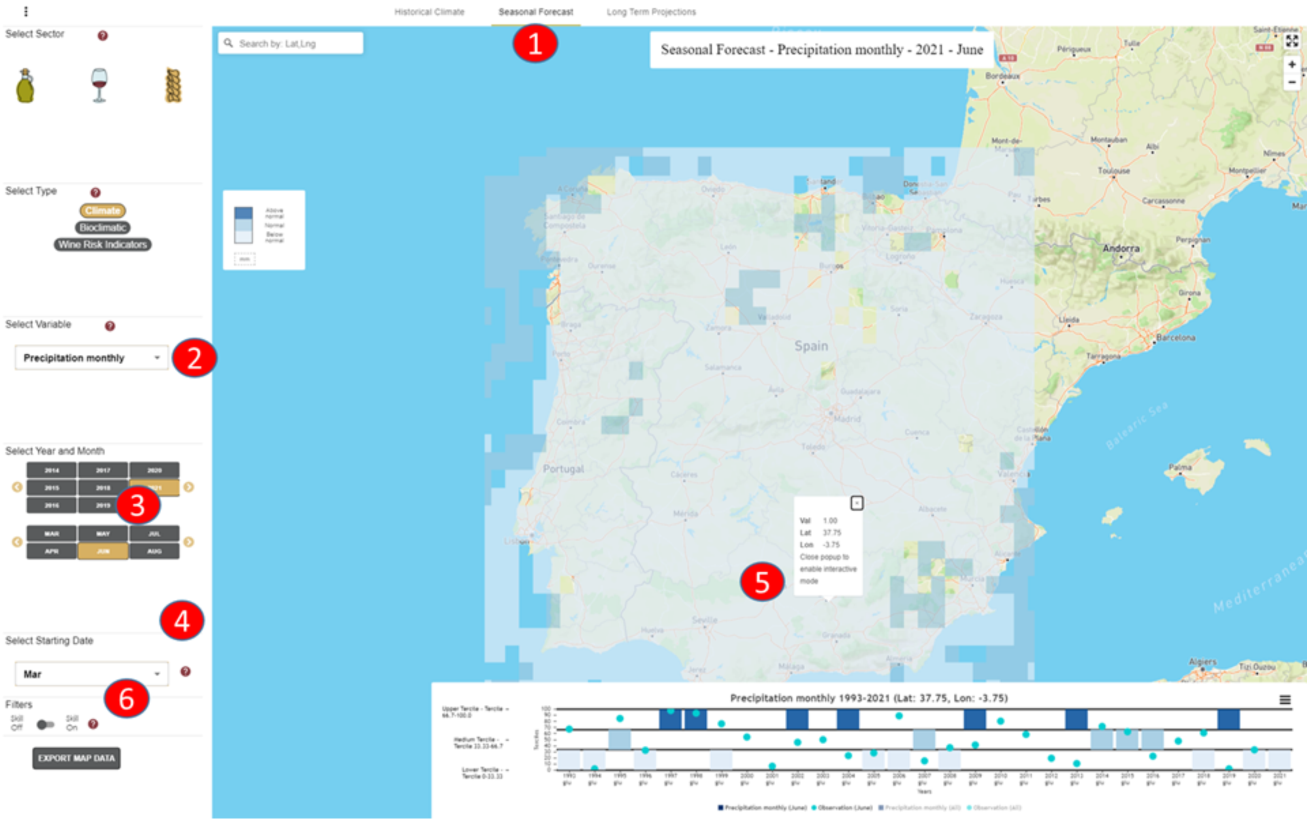
1. Start by selecting the "Seasonal Forecast" timescale, to check if this spring will be wetter than normal, normal, or drier than normal in your area.
2. In climate variables, select the monthly precipitation.
3. Then, select the year and the month you are interested in.
4. Set the current month as the forecast Starting Date, which refers to the month when the forecast is issued.
5. Type in the geographical coordinates or the location of your cultivation site. 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).

   Wetter than normal | upper tercile
   Normal | medium tercile
   Drier than normal | lower tercile

6. To check how accurate the prediction is, turn on the "Skill" filter option. This will hide areas where the prediction is not reliable enough for decision-making.

You can export the map and graph, discuss with the procurement department, and plan the purchase of plant protection products based on the seasonal forecasts and the prediction accuracy in your area in the past

Figure 7-7: Snapshot of Use case 1

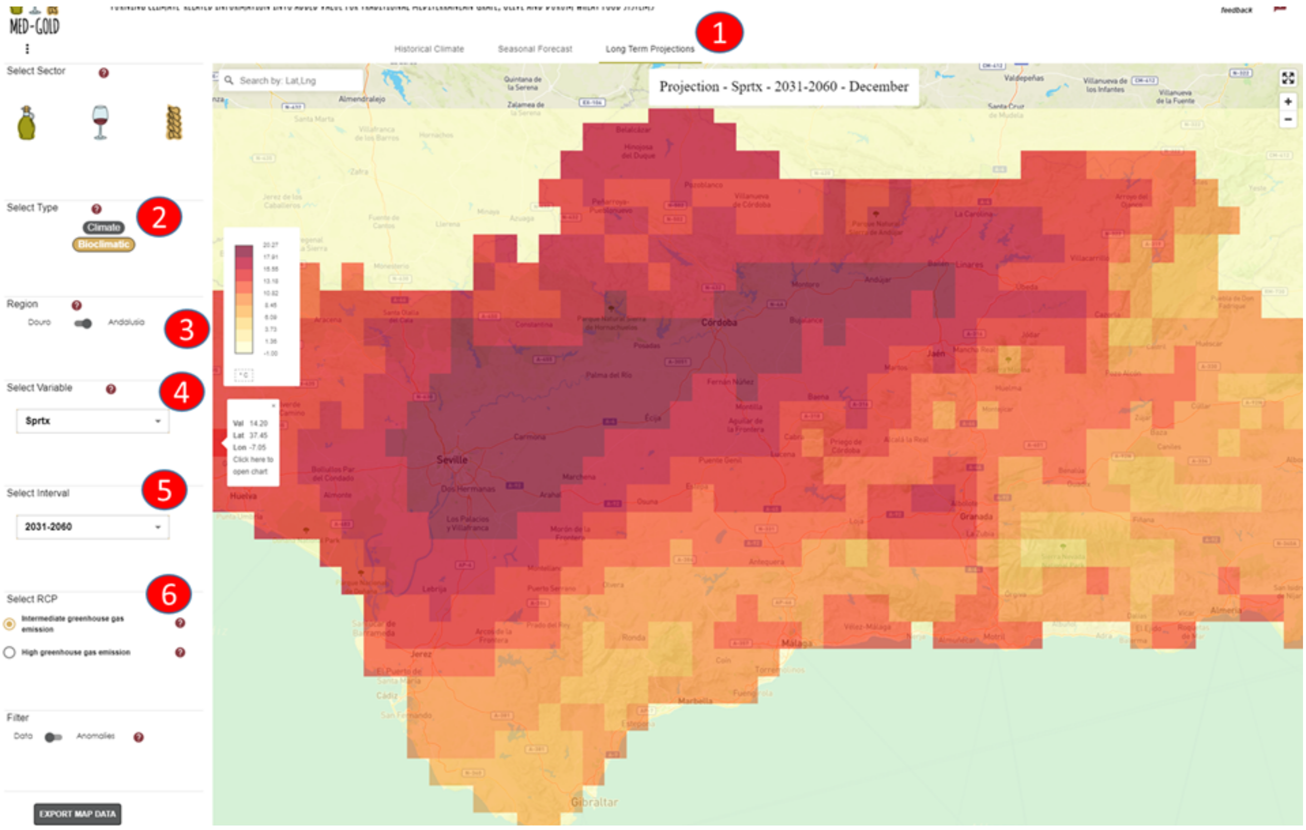


7.4.2 Use case 2

You are a member of the Governing Board from an olive cooperative located in Andalusia, Spain. Your cooperative is concerned about the impact that climate change will have on your olive oil production. High temperatures can have an impact on flowering, which affects the production of olives and eventually of olive oil. Can production be threatened by future climate change? The following steps are also illustrated in Figure 7-8.

1. First, select the "Long-term Projections" timescale.
2. Select the bioclimatic indicator option.
3. Select the Andalusia domain.
4. Select the Spring Maximum Temperature indicator (Sprtx).
5. Then, select the time frame for which you want to see the temperatures in the future (e.g. 2031-2060).
6. Finally, choose an emission scenario (e.g. intermediate greenhouse gas emissions)

Figure 7-8: Snapshot of Use case 2



You can see the maximum springtime temperatures that your region is likely to reach in the future. Higher maximum temperatures in spring might cause either early or less effective flowering.

You can export data from the map as a .csv table and use Excel to further work on potential adaptation measures, such as recommending farmers to introduce adjustments in their fertigation practices in order to adapt to the changes in flowering, and minimize impacts on production levels

7.5 Contact and pending issues

On the top right corner (Fig.7-9) of the landing page there is a feedback form to contact the development team about inquiries on the use of the software, bugs, possible suggestions and comments on the design and functionalities of the application. Every feedback could greatly help in further amelioration of the tool.

Figure 7-9: Entry point for the Feedback form

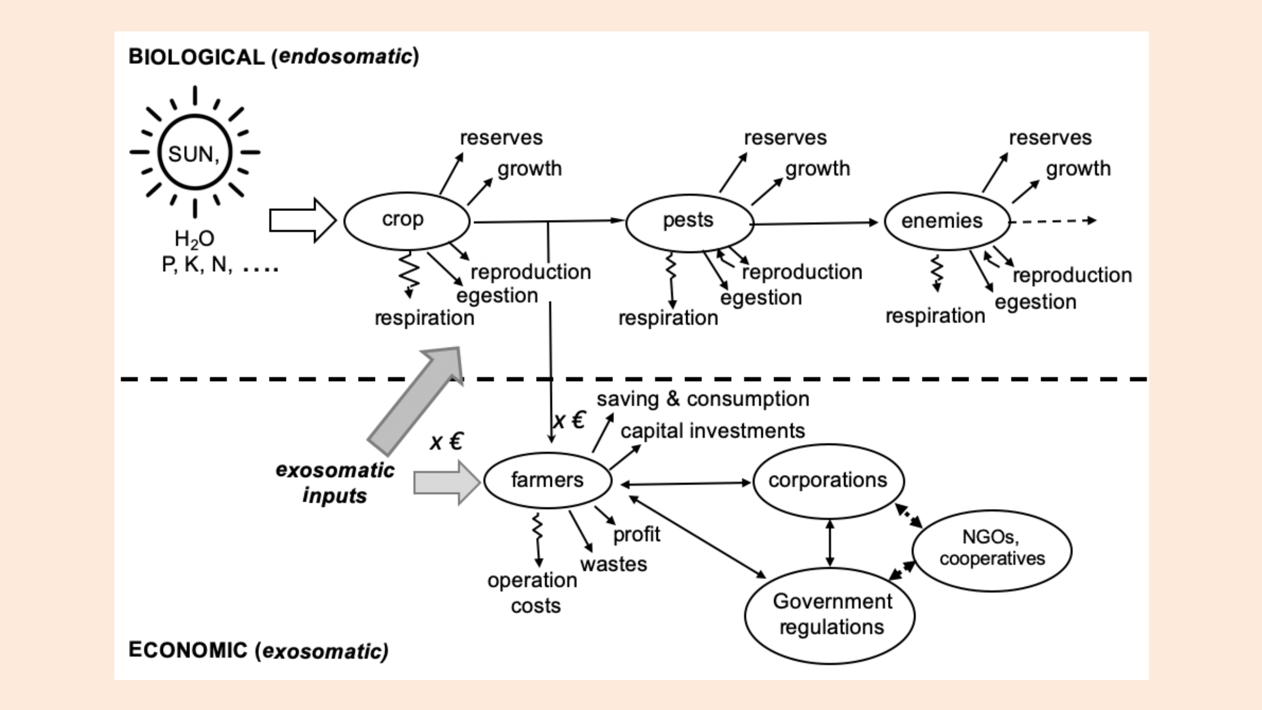
8. Physiologically Based Demographic Models (PBDMs)

CASAS Global, Center for the Analysis of Sustainable Agricultural Systems, (http://www.casasglobal.org/) physiologically based demographic models (CASAS-PBDMs) are one of the key existing technology components of the MED-GOLD project, with CASAS Global's CEO Andrew Paul Gutierrez being part of the project's External Advisory Committee. CASAS-PBDMs are a tool aimed for use in a research context. A climate service can make use of information derived from a PBDM analysis. The output of CASAS-PBDMs may not be considered as constituting a climate service.

It is increasingly recognized that the complexity and bio-economics of populations, species and their interactions as driven by weather in natural and agricultural ecosystems is central for assessing crop yield potential and the effects of pests and diseases that reduce that potential. This difficult problem has been center stage for decades. Palladino (1991) [RD.7] posed a fundamental question: "Is nature idiosyncratic?" (i.e., can it be modelled?) Dormann et al. (2017) [RD.8] opined that "The ecological reality of most species is… frustratingly complex, temporally variable, and full of interactions with other species, direct or indirect, of unknown intensity and importance". In contrast, Evans (2012) [RD.9] proposed that we must use holistic general methods to investigate problems that at every level are ecological and bioeconomic in nature—to develop "… models based on understanding the processes that result in a system behaving the way it does, … remaining valid indefinitely". To do this, we must seek reliable rules ('Laws') of nature common to all species in ecosystems [RD.10].

Upscaling the use of climate services for all stakeholders in the agri-food value-chain, from producers to consumers and policy makers, requires the development of methods that enhance the capacity of scientists globally to assess the effects on yield and sustainability of the various biotic and abiotic components of the agroecosystem. This is a prerequisite for dealing with agricultural systems of unprecedented complexity under global change including technological change, invasive species, and climate change (e.g., see Ponti et al. 2015) [RD.11]. A powerful methodology is weather-driven PBDMs based on mechanistic bioeconomic biology of all species including human economic endeavour (Fig. 8.1). The theoretical biological and economic bases for PBDMs are respectively Gutierrez (1992) [RD.14] and Regev et al. (1998) [RD.15]. In practice, PBDMs have been used to map the regional bioeconomic consequences of crop-pest-natural enemy interactions in several crop systems globally (e.g., cassava, coffee, grape, and olive). Good examples of such analyses are the recent bio-economic assessment of Indian hybrid Bt cotton (genetically modified pest resistant plant variety) and farmer suicides [RD.16] and the holistic local analysis of coffee [RD.17].

Figure 8-1: Conceptual linkages of resource acquisition and allocation across trophic levels in a cotton system including the economics of human harvesting of renewable resources (modified from Gutierrez and Curry, 1989) [RD.12] with endosomatic (natural) and exosomatic (artificial) inputs to the system [RD.13].



The capacity for modeling tri-trophic agroecosystems (i.e., crop/pest/natural enemy systems, [RD.18]) using PBDM agro-ecosystem models including the olive/olive fly system was implemented under MED-GOLD as a scalable modern computing platform in the form of an application as a service accessible via a dedicated Application Programming Interface (API). The CASAS-PBDMs API is part of the MED-GOLD ICT platform (https://platform.med-gold.eu/) as the *pbdm workflow*. A quick overview of CASAS-PBDMs as implemented under MED-GOLD can be accessed in this short video https://youtu.be/dl69l9l8FAM.

The information and related added-value resulting from PBDMs mostly accrues in terms of improved management strategy. PBDMs explicitly capture the weather-driven biology of the interaction between olive and the olive fruit fly *Bactrocera oleae* (Gutierrez et al. 2009) [RD.19]. The PBDM of olive and olive fly predicts the geographical distribution and relative abundance of the two species across time and space independently of the actual species distributions using extant and climate change weather scenarios as drivers for the system.

A PBDM analysis of the olive/olive fly system that included comparison of model output with field data was performed on a geographic scale similar to that of Andalusia for the island of Sardinia, Italy (Ponti et al. 2009) [RD.20]). The linked PBDM for olive and olive fly has also been used in a geographic information system (GIS) context to estimate the fine-scale ecological and economic impact of climate warming on olive yield and fly infestation across the Mediterranean Basin (Ponti et al. 2014 [RD.21]).

The added value of PBDMs generally accrues mostly in terms of regional recommendations for crop management as opposed to precise prediction at field level. This is because PBDMs provide an assessment of the olive/olive fly systems at the regional level that is independent of space and time, and hence provide insight on how best to allocate limited resources for agroecosystem management. This kind of insight would be impossible logistically and economically to obtain otherwise (e.g. Toko, et al. 2019 [RD.29]).

8.1. General Information

The source code for the olive/olive fly PBDM is Borland Pascal code that is embedded in a larger code base of about ten thousand lines of code (without comments) including PBDMs for 40 different species of plants, herbivores, parasitoids, predators, and pathogens (a subset of the species modeled using PBDMs) that were published as PBDM analyses implemented in a GIS context (Gutierrez and Ponti 2014) [RD.22]. Hence, a variety of similar models coded in Pascal exist that draw on the same code base that is currently undergoing rewrite using an object-oriented programming paradigm in a more modern language for release as open source (Ponti et al. 2019) [RD.23]. Like the rest of the PBDM code base developed in the last three decades, the Pascal code for olive/olive fly PBDM is currently not licensed nor it is deposited in a code repository, and is managed by the nonprofit scientific consortium CASAS Global and its CEO Prof. Andrew Paul Gutierrez who is a member of the MED-GOLD EAC. The PBDM algorithms as well as key innovative code such as the Pascal subroutine for distributed maturation times with and without attrition, were published in detail in Gutierrez (1996) [RD.24].

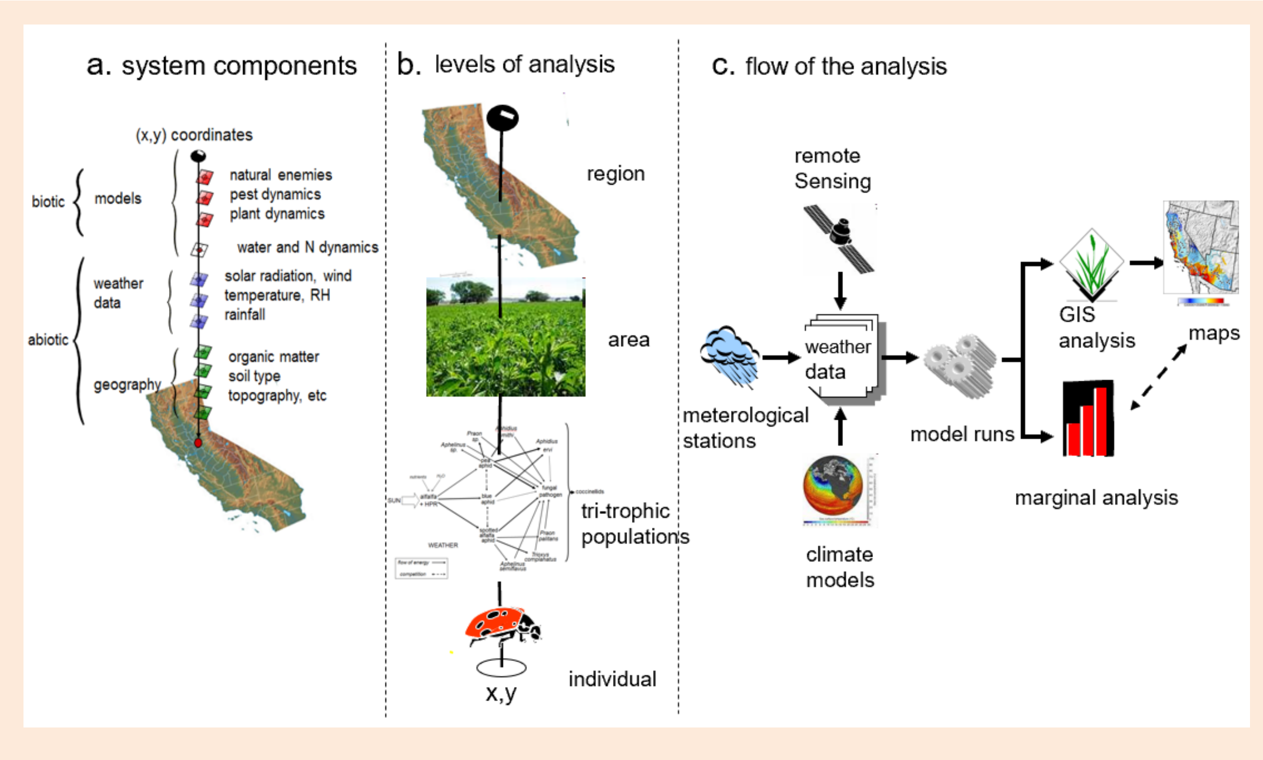
The idea underlying integration of the PBDM analysis into the MED-GOLD ICT platform is to show how the platform can support the operation of heritage software tools, such as the Borland Pascal executables for PBDMs that only run on Windows operating systems, by connecting them to modern sources of climate data. At the same time the PBDM functionality is provided as a Web service using an API, independent of which operating systems the client computer is running. This comes with the added advantage of scalability that is important when working towards the provision of climate services, as the cloud computing MED-GOLD ICT infrastructure is designed to scale efficiently with increasing computational loads and user requests.

Integration of the PBDM for olive and olive fly into the ICT platform required development of several components. First, an adapter is required that reads and converts climate data files from their native NetCDF or GRIB binary format to the CSV text format that is used as input by PBDMs. This also involves taking care of unit conversion if needed, and of computing daily values as appropriate if the climate variables are provided on a different time step in the binary source file. Second, the PBDM is a Windows executable and hence needs to run simulations in a Windows environment using a virtual machine that is provided by the platform. Third, access to all this functionality needs to be made available in a general way using a representational state transfer (REST) API. A fourth step is to develop a software wrapper (i.e., a container) allowing PDBMs to use ICT platform functionality directly, without the need of a Windows virtual machine. Another step is the addition of a scheduler to run the PBDMs periodically unattended. Finally, PBDM output could be managed directly by the ICT platform itself, for example by mapping the CSV output files using the MED-GOLD dashboard, or it can be mapped using a custom external GRASS-based GIS software developed for MED-GOLD.

The open source GIS software GRASS (GRASS Development Team, 2015) (see http://grass.osgeo.org/) [RD.25] is used to map output data from the PBDM. All GIS datasets used in the GRASS-based GIS developed for Andalusia are available open access, and most of them were sourced from the public domain repository Natural Earth (https://www.naturalearthdata.com/). Inverse distance weighting or bicubic spline interpolation is used to map PBDM output as a continuous raster surface, and hence the spatial patterns reflect not only the site specific effects of weather on the biology of the species but also the resolution and arrangement of the weather grid. The digital elevation model used is the NOAA "Global Land One-km Base Elevation" (GLOBE) (www.ngdc.noaa.gov/mgg/topo/globe.html).

The components, levels, and flow of the PBDM analysis in a GIS context are summarized and illustrated in Figure 8-2.

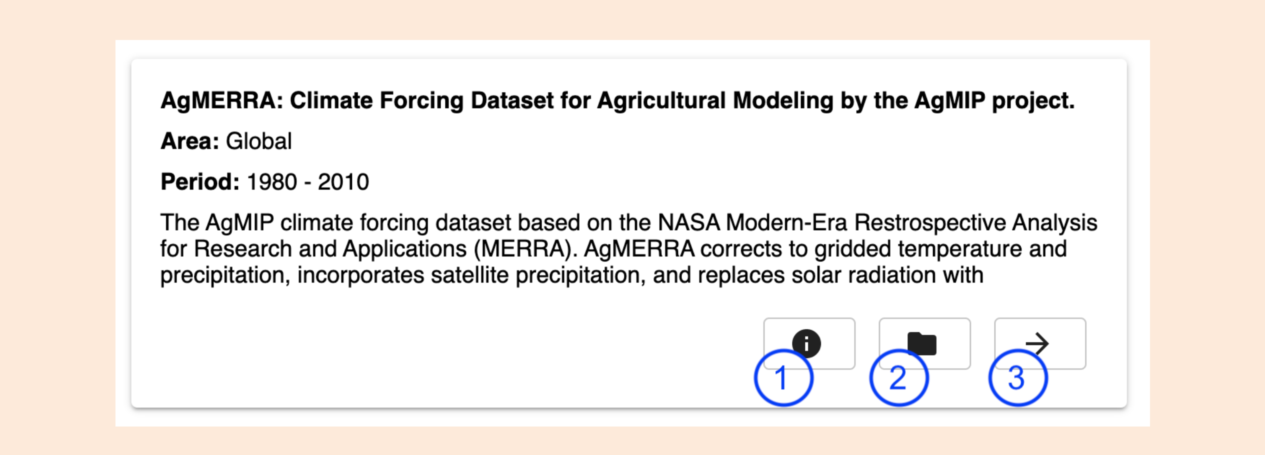
Figure 8-2: Components, levels, and flow of the PBDM analysis in a GIS context as an outcome for the MED-GOLD climate service prototype (Gutierrez et al., 2010) [RD.26].



8.2 Step-by-step instructions

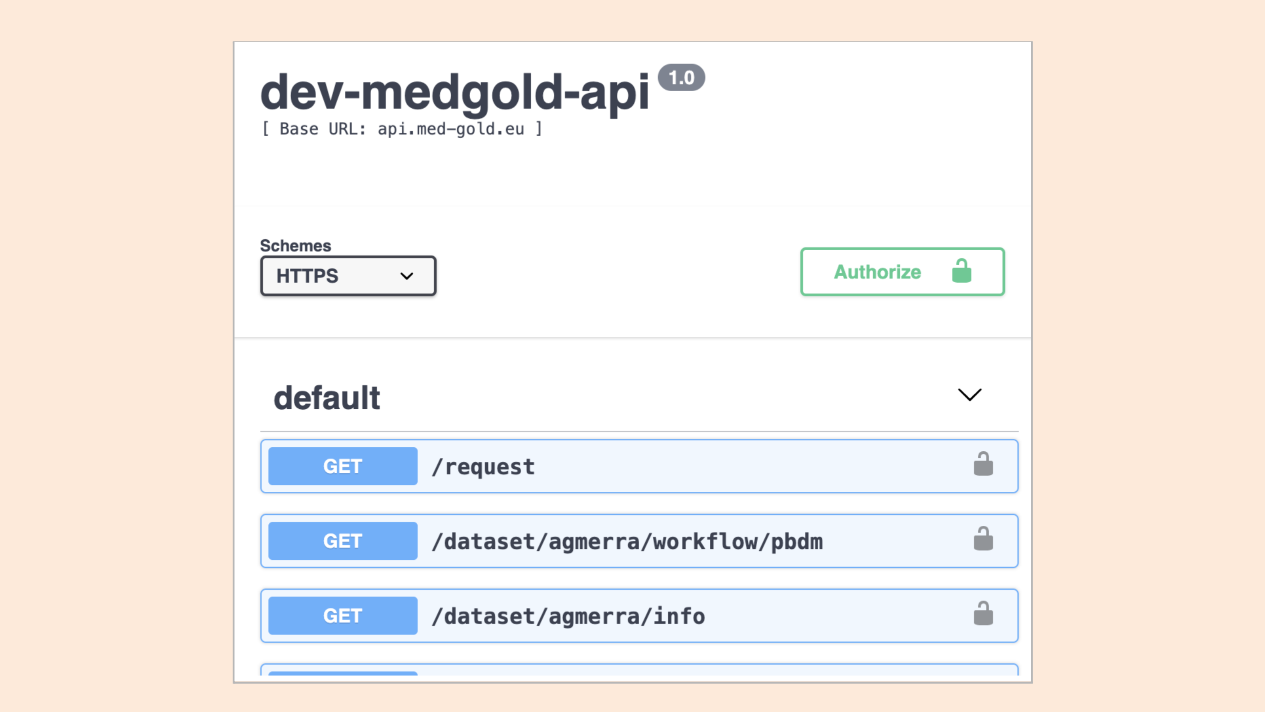
The PBDM API is accessible and was tested successfully on the MED-GOLD platform. Datasets stored on the platform and listed on its Web interface (https://platform.med-gold.eu/) include AgMERRA, AgERA5, and bias adjusted EURO-CORDEX climate projections for Andalusia. For each dataset, (see snapshot in Fig. 8-3 below), the user can get information on the dataset (1), an interface to download the raw data (2), and a programmatic way to run CASAS-PBDMs for olive and olive fly using AgMERRA as input, by assembling an appropriate application programming interface (API) call to the pbdm workflow (3).

Figure 8-3: AgMERRA element of the MED-GOLD platform website (https://platform.med-gold.eu/) providing a short description of the dataset as well as buttons to access: (1) more detailed information about the dataset; (2) an interface to download the raw data; and (3) API documentation in OpenAPI format illustrating a programmatic way to run the PBDM for olive and olive fly using AgMERRA as input, by assembling an appropriate application programming interface (API) call to the pbdm workflow.



Clicking on the arrow button (3) (see Fig. 8-3) exposes the pbdm API functionality (see snapshot in Fig. 8-4) that can be used as done in WP2 for the olive/olive oil case study. After obtaining an authorization token, the API functionality can be accessed via the API server (https://api.med-gold.eu/).

Figure 8-4: Graphical interface of the MED-GOLD API for dataset AgMERRA on the MED-GOLD platform website (https://platform.med-gold.eu/) listing available API calls and related access to API documentation in OpenAPI format, including the *pbdm* workflow that enables running the PBDM for olive and olive fly, for coffee under WP6, and prospectively for any PBDM.



The *pbdm API workflow*, based on the AgMERRA or other available datasets, creates text-based data files by merging source per-variable NetCDF files into columnar daily files, for given geographical locations, that are used to feed the olive model application. The workflow also takes care of uploading the output of the model to the data storage.

The documentation for the pbdm workflow is provided in standard OpenAPI format, is available on the web ICT platform, and includes all available endpoints (including the pbdm one), along with their input/output parameters and the structure of the output in JSON format. It is also possible to invoke APIs directly in the browser by clicking the "Try it out" and then the "Execute" button. An appropriate security token is injected directly by the platform. Figure 6-9 is a snapshot of the OpenAPI documentation for the pbdm workflow.

Figure 8-5: Graphical interface of the MED-GOLD API for dataset AgMERRA on the MED-GOLD platform website (https://platform.med-gold.eu/) showing the API documentation for the *pbdm* workflow in OpenAPI format. Note that when the "olive" string value is assigned to the *model* parameter, the PBDM for olive and olive fly is run, while a "coffee" string would be required for running the PBDM for coffee when implemented.

APIs endpoints including the PBDM one are protected with a typical credentials/token security schema. Each user (and application) of the ICT platform is provided with a username and a password. When an user/application wants to call the pbdm API workflow, they must then first obtain a token (i.e., a unique identifier of an application/user requesting access to your service) via a dedicated API call:

```
https://api.med-gold.eu/security/token?username={username}&password={password}
```

The token, which expires after a set period of time, will be used as an Authorization header to all subsequent API calls:

```
curl -H "Authorization: {token}" https://api.med-gold.eu/...
```

Users/applications are responsible to request a new token when it expires.

Each API call to the pbdm workflow generates a request that is stored in a queue system and executed by the ICT platform in due time. The caller will get as a response a request ID which, in turn, will be passed to a dedicated API to check the status of the request. When the request is completed the response will also include an URL to the data storage containing the workflow's output.

For example, the following API call runs the olive CASAS-PBDM model for Spain and Portugal for the period 2008 to 2010 using AgMERRA climate data (line breaks are for presentation purposes only).

```
curl -H
"Authorization: SOME-VERY-LONG-API-KEY" 'https://api.med-gold.eu/
dataset/agmerra/workflow/pbdm
?country=ESP-POR
&sdate=2008/01/01
&edate=2010/12/31
&model=olive
&dataset=agmerra
&output_time_interval=365'
```

The PBDM model workflow's API implemented in the ICT platform is documented in Figure 8-6.

Figure 8-6:MED-GOLD API Reference for the pbdm workflow.

PBDM workflow

3.1 GET `/dataset/agmerra/workflow/pbdm`

PBDM workflow elaboration

PBDM workflow elaboration
The endpoint returns a link of the file based on information passed

REQUEST

QUERY PARAMETERS

NAME	TYPE	DESCRIPTION
*dataset	enum ALLOWED: agmerra	name of dataset
*model	enum ALLOWED: pbdm	name of model
*country	enum ALLOWED: ESP-POR	required location
*sdate	string	starting date
*edate	string	end date
*output_time_interval	enum ALLOWED: 365	time interval

RESPONSE

STATUS CODE - 200: Link of .zip file which contains OliveSummary.txt, OliveDaily.txt, GisFilesList.txt and a files for each year in interval required

STATUS CODE - 401: Unhautorized

RESPONSE MODEL - application/json

```
{
  message  string  unhautorized error message
}
```

STATUS CODE - 404: Not found

RESPONSE MODEL - application/json

```
{
  message  string  not found error message
}
```

3.2 GET /request

Horta workflow elaboration

Horta workflow elaboration
The endpoint returns a link of the file based on information passed

REQUEST

QUERY PARAMETERS

NAME	TYPE	DESCRIPTION
*id	string	id of request return by api workflow elaboration

RESPONSE

STATUS CODE - 200: returns id of elaboration

STATUS CODE - 401: Unhautorized

RESPONSE MODEL - application/json

```
{
  message string unhautorized error message
}
```

STATUS CODE - 404: Not found

RESPONSE MODEL - application/json

```
{
  message string not found error message
}
```

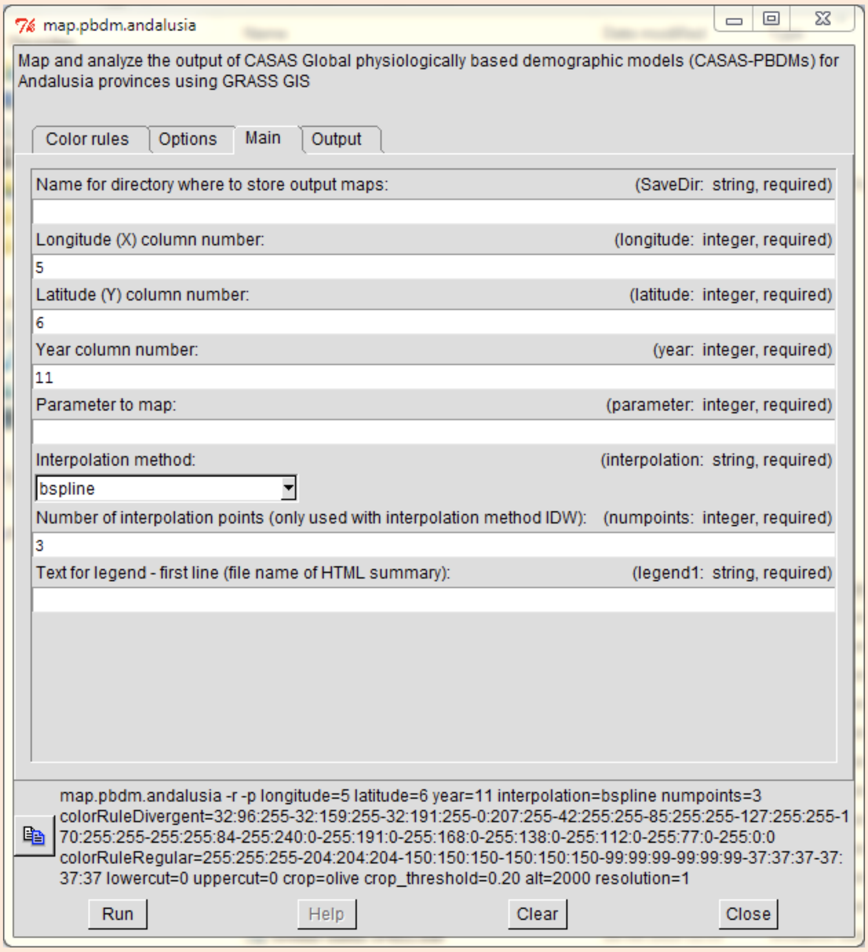
The most recently available version of the PBDM workflow API that is part of the MED-GOLD Platform API (see Fig. 8.6) is currently available at the following link:

http://dev-mgd-platform-docs-hosting-bucket.s3-website-eu-west-1.amazonaws.com/

The output of the PBDM workflow API is a set of CSV tab-separated text files that can be used as input to the Andalusia CASAS GIS (or any other GIS package) or used as input to further statistical analysis (e.g., marginal analysis).

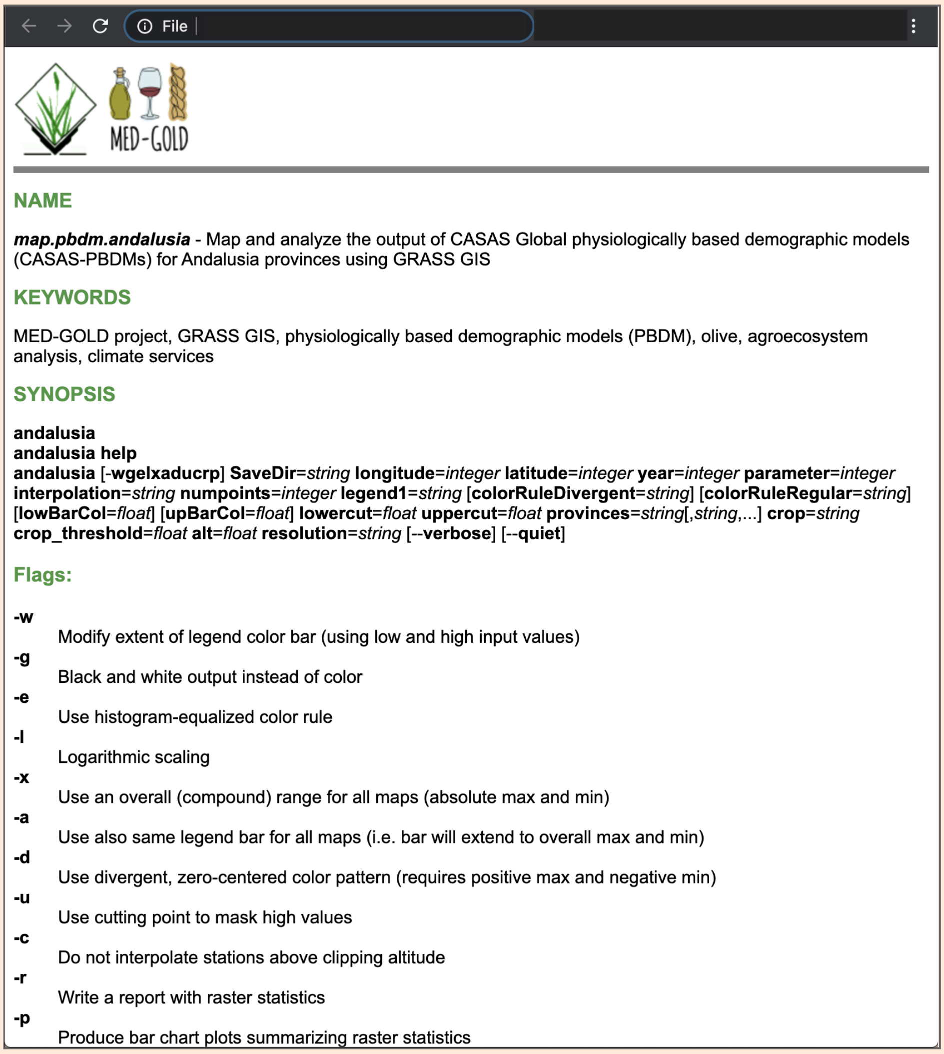
A GRASS-based (GRASS Development Team 2015) [RD.25] GIS for mapping and analysis of PBDM model output in Andalusia was developed under MED-GOLD. It includes custom software called *map.pbdm.andalusia* written in the Bash shell scripting language that uses a wide variety of GRASS modules to map the output of PBDMs and to generate an HTML summary where maps are available, including summary statistics. Both the GRASS geographic database and script will be released as open source under the project. The script includes a graphical user interface (GUI) for easier interaction with its functionality (Fig. 8-7)

Figure 8-7: Graphical user interface of the map.pbdm.andalusia GRASS GIS script.



Documentation is available for the GIS script (see screenshot in Fig. 8-8) and will be released with the source code.

Figure 8-8: HTML documentation for the *map.pbdm.andalusia* GRASS GIS script as displayed in a web browser.



File

MED-GOLD

NAME

map.pbdm.andalusia - Map and analyze the output of CASAS Global physiologically based demographic models (CASAS-PBDMs) for Andalusia provinces using GRASS GIS

KEYWORDS

MED-GOLD project, GRASS GIS, physiologically based demographic models (PBDM), olive, agroecosystem analysis, climate services

SYNOPSIS

andalusia
andalusia help
andalusia [**-wgelxaducrp**] **SaveDir**=*string* **longitude**=*integer* **latitude**=*integer* **year**=*integer* **parameter**=*integer* **interpolation**=*string* **numpoints**=*integer* **legend1**=*string* [**colorRuleDivergent**=*string*] [**colorRuleRegular**=*string*] [**lowBarCol**=*float*] [**upBarCol**=*float*] **lowercut**=*float* **uppercut**=*float* **provinces**=*string*[,*string*,...] **crop**=*string* **crop_threshold**=*float* **alt**=*float* **resolution**=*string* [**--verbose**] [**--quiet**]

Flags:

-w
Modify extent of legend color bar (using low and high input values)
-g
Black and white output instead of color
-e
Use histogram-equalized color rule
-l
Logarithmic scaling
-x
Use an overall (compound) range for all maps (absolute max and min)
-a
Use also same legend bar for all maps (i.e. bar will extend to overall max and min)
-d
Use divergent, zero-centered color pattern (requires positive max and negative min)
-u
Use cutting point to mask high values
-c
Do not interpolate stations above clipping altitude
-r
Write a report with raster statistics
-p
Produce bar chart plots summarizing raster statistics

The *map.pbdm.andalusia* script was derived from a series of GRASS GIS scripts developed by CASAS Global from 2005 to 2021. The map.pbdm.andalusia script can map and analyze the output of CASAS-PBDMs for Andalusia provinces using GRASS GIS. However, CASAS-PBDM output files are CSV files that include latitude and longitude for each location where the PBDM was run, and hence any GIS software could be used for mapping. The map.pbdm.andalusia script is provided as an example of how the GIS analysis of CASAS-PBDM output can be performed.

See this short illustrative video for an overview of a simple use case of the PBDM workflow API and of the Andalusia CASAS GIS:

https://youtu.be/FBpSJ9QUHBg

8.3 Trouble-shooting

For the pbdm API workflow, see API reference above and online OpenAPI documentation.

See https://grasswiki.osgeo.org/wiki/Working_with_GRASS_without_starting_it_explicitly for more info on how the *map.pbdm.andalusia* script works. Further info in the GRASS GIS documentation https://grass.osgeo.org/learn/.

8.4 How to download/interpret the results

Results from CASAS-PBDM simulations are downloaded using the pbdm API workflow that provides a URL where results can be downloaded after the simulation is over (see above). For further information on how to interpret the results, see Deliverables 2.2, 2.6, and 2.7 [RD.4] [RD.27] [RD.28] and the references cited in this section.

8.5 Contact and pending issues

For PBDMs, please contact luigi.ponti@enea.it

ANNEX A. The MED-GOLD Dashboard Infosheet for the Olive Oil Sector

OLIVE SECTOR & CLIMATE CHANGE

Olive and olive oil production is concentrated in a well-defined area around the Mediterranean Sea. This area is heavily affected by climate change, which increases the severity of extreme events, such as droughts and heatwaves. This leads to reduced water availability, affecting both traditional and new production systems (intensive and superintensive).

The changing climate poses challenges in the decision-making processes of olive growers and olive oil producers, who need to adapt their irrigation, fertilisation and pesticide application strategies. It also modifies the occurrence of crop diseases, along with their potential damage, and can favour the development of new pests. Thus, anticipating future climate conditions is key for the adaptation of the olive sector, and climate services can help in this process.

Read more on Climate Services for the Olive and Olive Oil Sector in the MED-GOLD infosheet.

MED-GOLD DASHBOARD FOR THE OLIVE SECTOR

The MED-GOLD dashboard is an easy-to-use visualisation tool for the wine sector, which provides access to information on past climate and predictions of future climate at different time scales. The tool has been co-developed with users to ensure that it addresses their needs and expectations.

You can access the dashboard on the MED-GOLD website, and by visiting: dashboard.med-gold.eu

ABOUT MED-GOLD

MED-GOLD is a 4-year European project on "Turning climate-related information into added value for traditional MEDiterranean Grape, OLive and Durum wheat food systems". MED-GOLD aims to make European agriculture and food systems more resilient, sustainable and efficient in the face of climate change by using climate services to minimize climate-driven risks and costs.

MED-GOLD

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No. 776467.

MED-GOLD Dashboard | User guide **PAGE 2**

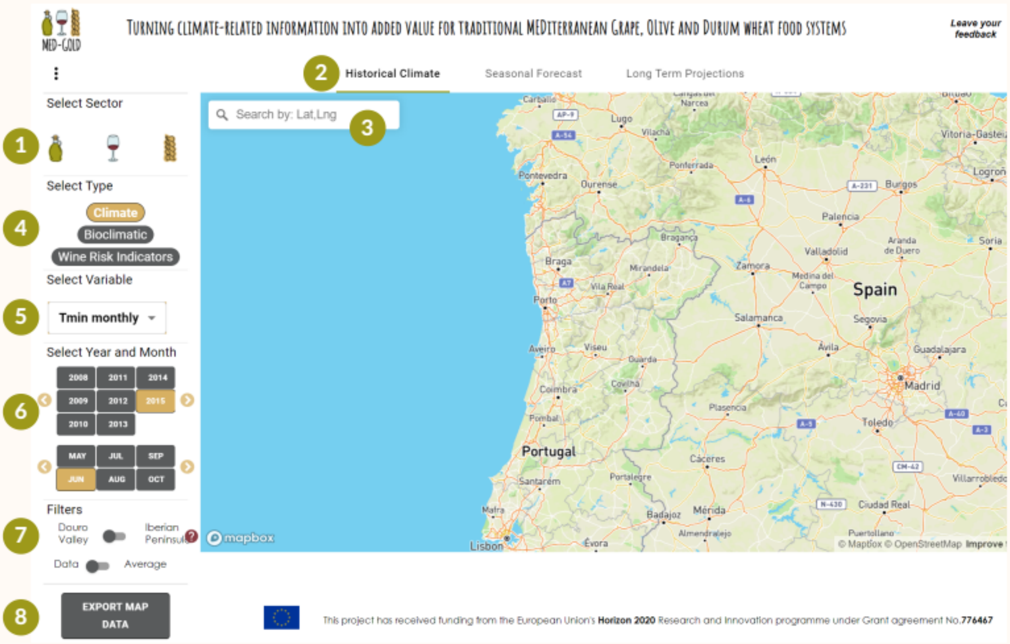
HOW TO USE THE MED-GOLD DASHBOARD

1 Select the sector icon

2 Timescale

- ***Historical Climate***: past and near-present information
- ***Seasonal Forecast***: predictions for the next months
- ***Long-Term Projections***: future scenarios for the 21st century

3 Location (search by geographic coordinates, city or country)



4 Type of variables

- ***Climate variables:*** *temperature & precipitation data*
- ***Bioclimatic indicators:*** *indicators taking into account the climate and the phenology of the olive tree*

5 Variable of interest (hover over each variable for explanation)

6 Time period of interest

7 Other options/filters that change according to selected timescale, *e.g. region of interest, forecast skill, greenhouse gas emission scenario*

8 Export data

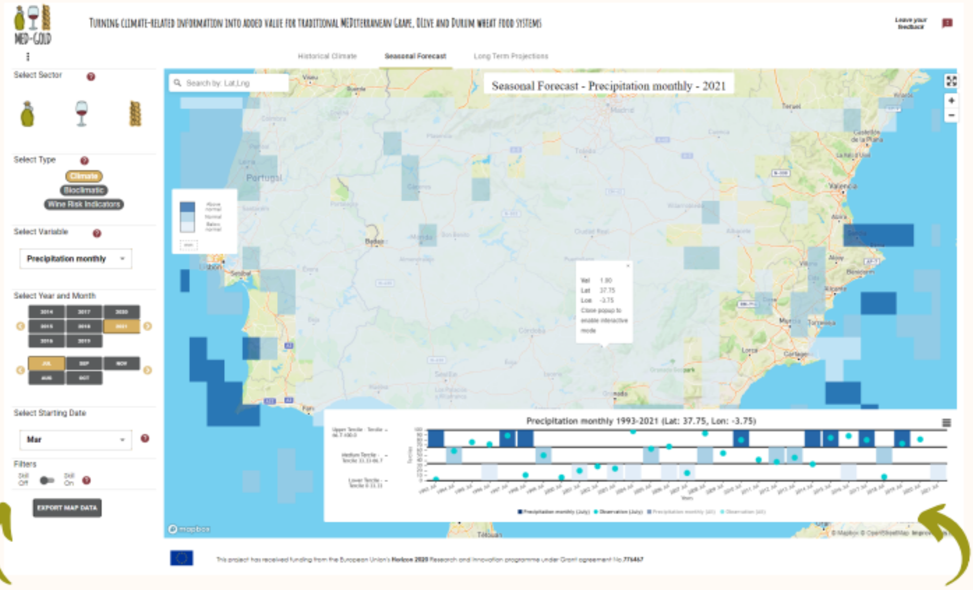
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No. 776467.

USE CASE 1

It's March. You are an agronomist working for an olive cooperative. You need to advise the farmers in your cooperative on the optimal fertigation strategy, taking into account the expected climate conditions in the next months.

Are the upcoming months going to be particularly dry?

1. Start by selecting the "Seasonal Forecast" timescale, to check if this spring will be wetter than normal, normal, or drier than normal in your area.
2. In climate variables, select the monthly precipitation.
3. Then, select the year and the month you are interested in.
4. Set the current month as the forecast Starting Date, which refers to the month when the forecast is issued.
5. Type in the geographical coordinates or the location of your cultivation site.
6. To check how accurate the prediction is, turn on the "Skill" filter option. This will hide areas where the prediction is not reliable enough for decision-making.



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 PRECIPITATION PREDICTED IN THE PAST?

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

You can export the map and graph, discuss with the procurement department, and plan the purchase of plant protection products based on the seasonal forecasts and the prediction accuracy in your area in the past.

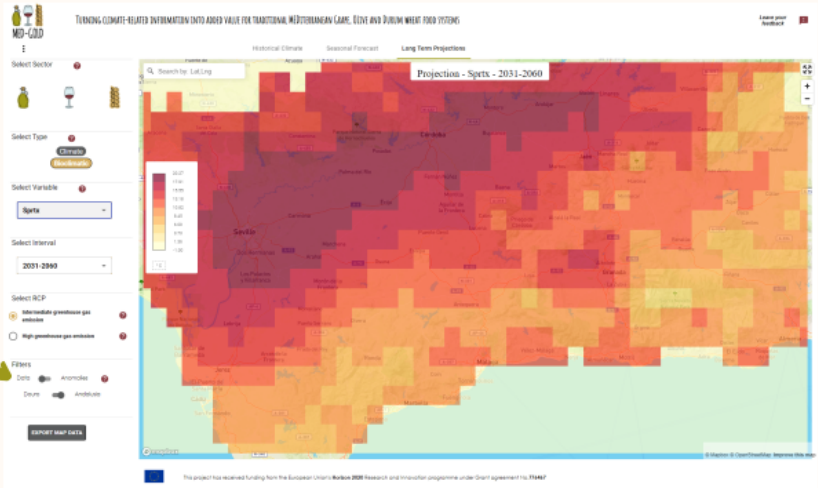
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No. 776467.

USE CASE 2

You are a member of the Governing Board from an olive cooperative located in Andalusia, Spain. Your cooperative is concerned about the impact that climate change will have on your olive oil production. High temperatures can have an impact on flowering, which affects the production of olives and eventually of olive oil.

Can production be threatened by future climate change?

1. First, select the "Long-term Projections" timescale.
2. Select the bioclimatic indicator option.
3. Select the Andalusia domain.
4. Select the Spring Maximum Temperature indicator (Sprtx).
5. Then, select the time frame for which you want to see the temperatures in the future (e.g. 2031-2060).
6. Finally, choose an emission scenario (e.g. intermediate greenhouse gas emissions).



To see the projected difference in temperature compared to present, activate the "Anomalies" filter

You can see the maximum springtime temperatures that your region is likely to reach in the future. Higher maximum temperatures in spring might cause either early or less effective flowering.

You can export data from the map as a .csv table and use Excel to further work on potential adaptation measures, such as recommending farmers to introduce adjustments in their fertigation practices in order to adapt to the changes in flowering, and minimuse impacts on production levels.

DID YOU KNOW?

Greenhouse gas emissions (e.g. CO_2) are expected to rise in the future, increasing the global temperatures. Scientists have defined different *scenarios* of how the emissions will change, known as the Representative Concentration Pathways (RCPs). The intermediate (RCP4.5) and high (RCP8.5) emission scenarios are available to select in the MED-GOLD dashboard, corresponding to a global temperature increase of 1.1-2.6°C and 2.6-4.8°C, respectively.

This document was developed by the Barcelona Supercomputing Center (BSC), 2021.

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No. 776467.

END OF DOCUMENT