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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 6.20

Compilation of Publications Abstracts n.3

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REVISION HISTORY LOG

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All partners involved in the production/implementation of the deliverable should comment and report (if needed) in the above table. The above table should support the decisions made for the specific deliverable in order to include the agreement of all involved parties for the final version of the document.

Finally, after the peer review process, the deliverable should be modified accordingly to the comments and the reflections to the comments should be reported in the above table.

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EXECUTIVE SUMMARY

This compilation of publications abstracts provides an overview of the efforts done within the MED-GOLD consortium to inform and connect end-user communities for the global olive/olive oil, Grape/wine, and Durum wheat/ pasta food systems, and their related policy-making. The MED-GOLD project publication abstracts are being collected in three separate deliverables. Twenty-six abstracts were compiled in the first deliverable [RD.1] and fourteen in the second deliverable [RD.2]. This third deliverable presents twenty three abstracts submitted by MED-GOLD partners between September 2020 and September 2021, and these are summarised in Table 6-1.

1. OBJECTIVES

This deliverable compiles abstracts submitted by MED-GOLD partners between September 2020 and September 2021. The abstracts covered topics of interest for the targeted sectors of climate, grapes/wine, olives/olive oil, durum wheat/pasta and agriculture in general. The aim is to build better informed and connected end-user communities for the global olive oil, wine, and pasta food systems, and related policy making (GA, Part B Table1-1).

Table 1-1 project objectives

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	
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	X

2. IMPACT

This deliverable supports Task 6.3 which focuses on the dissemination and capacity building towards policy-makers and general public whose aim is to support the implementation of the EU mitigation and adaptation policies to climate change through better-informed decisions particularly in key vulnerable sectors. This compilation of publication abstracts is intended to raise awareness amongst global end users of olive oil, wine and pasta food systems about MED-GOLD work and services. Table 2-1 shows the expected impact of this deliverable contribution.

Table 2-1

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	
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 end-user communities for the global olive oil, wine, and pasta food systems and related policy making	X

3. DEFINITIONS

Concepts and terms used in this document that require a definition are tabled below:

Table 3-1 Definitions

Concept / Term	Definition
Climate service	Timely production and delivery (translation and transfer) in customized products (projections, forecasts, information, trends, economic analysis, assessments, etc.) of useful climate-related data, information and knowledge that support adaptation, mitigation and disaster risk management to decision makers.
Value	The word 'value' has been defined as the range of benefits (economic and/or non-economic) that can be gained from using climate information in decision-making.
End-user	Organization or person who ultimately uses or is intended to use a product or service.
Communication	Taking strategic and targeted measures for promoting the action itself and its results to a multitude of audiences, including the media and the public, and possibly engaging in a two-way exchange.
Dissemination	Public disclosure of the results by an appropriate communication channel (not only by scientific publications in any medium).
DELPHI	A crop model developed and maintained by the JRC, providing durum wheat yield forecasts and scenarios to BARILLA

4. ACRONYMS

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

Table 4-1 Acronyms

Acronym	Definition
PBDM	Physiologically based demographic modelling
SATP	South American tomato pinworm
RUE	Radiation use efficiency
CDS	Climate Data Store
HD	High density
SHD	Super high density
PAR	Photosynthetically active radiation
EMS	European Meteorological Society
GA	Grant Agreement
EGU	European Geosciences Union

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]:

Table 5-1 Reference Documents

Ref.	Title	Code	Version	Date
[RD.1]	Compilation of Publications Abstracts no. 1	-	-	2019
[RD.2]	Compilation of Publications Abstracts no. 2			2020
[RD.3]	Brasseur GP., Gallardo, L. 2016. Climate services: Lesson learned and future prospects. https://doi.org/10.1002/2015EF000338.			2016

6. DETAILED REPORT

6.1. STATE OF THE ART

Dissemination and communication of results is mandatory in European research and innovation projects, especially Horizon 2020. Good dissemination can increase the impact of research. Compiling abstracts can publicise and help circulate MED-GOLD's results to those who can best make use of them (beyond MED-GOLD), as well as helping the end-users to connect.

6.2 METHODS

Compiling the abstracts submitted by MED-GOLD partners began with an email sent to all Work Packages' mailing lists to request submission abstracts in the targeted sectors of climate, grapes/wine, olives/olive oil and agriculture in general.

6.3 MAIN RESULTS

Twenty three submitted abstracts have been collected by this deliverable and categorised into the five categories of agriculture, climate, wine, grape and durum wheat. These are summarised in Table 6-1.

Table 6-1 Abstracts collected by this deliverable

No	Title	Type of publication/event	Year /Location	Sector
1	Impact of low temperature and host plant on Tuta absoluta. Entomologia Experimentalis et Applicata	Journal article (Published)	2021	Agriculture
2	Invasive potential of tropical fruit flies in temperate regions under climate change	Journal article (Published)	2021	Agriculture
3	Biological invasion risk assessment of Tuta absoluta: mechanistic versus correlative methods	Journal article (Published)	2021	Climate service
4	How the MED-GOLD pilot tools are turning climate data from Copernicus CDS into value for agri-food Mediterranean systems	poster presentation in the General Assembly of C3S	2021	Climate service
5	Engagement, involvement and empowerment: three realms of a coproduction framework for climate services	Journal article (Published)	2021	Climate service
6	Global loss of climatically suitable areas for durum wheat growth in the future. Accepted for publication in Environmental Research Letters.	Journal article (Accepted)	2021	wheat
7	Seasonal climate forecast can inform the European agricultural sector well in advance of harvesting. NPJ Climate and Atmospheric science, 4: 42	Journal article (Published)	2021.	Wheat
8	an R package for agro-climate services. Climate Services	Journal article (Published)	2020	Wheat
9	Estimating resilience of crop production systems: From theory to practice.	Journal article (Published)	2020	Wheat
10	Performance of seasonal forecasts of Douro and Port wine production.	Journal article (Published)	2020	Wheat
11	Time-varying impact of climate on maize and wheat yields in France since 1900	Journal article (Published)	2020	Wheat
12	Early season prediction of durum wheat yield by a hybrid System of Seasonal Weather Prediction and Delphi crop model	Journal article (Submission)	2021	Wheat
13	Multi-annual prediction of drought and heat stress to support decision making in the wheat sector.	Journal article (Published)	2021	Wheat
14	Satellite imagery and climate variables suggest variations in the phenology of olive groves in Southern Spain.	Journal article (Published)	2021	Olive
15	Intercepted photosynthetically active radiation (PAR) and spatial and temporal	Journal article (Published)	2021	Olive

	distribution of transmitted PAR under high-density and super high-density olive orchards			
16	Satellite imagery and climate variables suggest variations in the phenology of olive groves in Southern Spain.	Conference paper	2021	Remote sensing for Agriculture
17	Return period analysis to assess the long-term impact of climate change on olive sector in Andalusia, Spain - results from the MED-GOLD project	poster presentation	2021	Olive
18	Assessing added value of the climate services to the decision-makers in Agriculture and food system: Wine sector	Journal article (Submission)	2021	Wine
19	The Risk of Unprecedented Rainfall in Wine Regions of Northern Portugal	Journal article (Submission)	2021	Wine
20	Assessing the value of climate services for the wine sector	Conference paper		
21	Cold air pooling in the Douro Valley	Journal article (Submission)	2021	Wine
22	Is wine terroir a valid notion under a changing climate?	Conference paper	2021	Wine
23	Performance of seasonal forecasts of Douro and Port wine production.	Journal article (Published)	2020	Wine

6.3.1. Abstracts submitted for Agriculture

1. **Campos M.R., Amiens-Desneux E. Béarez P., Soares M.A., Ponti L., Biondi A., Harwood J.D., Desneux N., 2021. Impact of low temperature and host plant on Tuta absoluta. Entomologia Experimentalis et Applicata.** https://doi.org/10.1111/eea.13094

Abstract: Alternative host plants are among the key factors influencing the spread of invasive pests because they are utilized as a food source and provide shelter in unfavourable conditions. The South American tomato pinworm (SATP), Tuta absoluta Meyrick (Lepidoptera: Gelechiidae), has a high behavioural and physiological plasticity enabling it to rapidly spread in several countries. Among the multiple strategies used by SATP in the invasion process is the use of alternative host plants including black nightshade (BNS), Solanum nigrum L. (Solanaceae), a perennial plant widely distributed across all habitats worldwide. Besides the life table and behavioral parameters of SATP on tomato, its survival and reproduction in low temperatures on alternative host plants should be assessed to evaluate the likely spread in temperate regions with harsh winters. In our study, comparing solanaceous species through generations, the primary difference was in the mean generation time with SATP reared on BNS, whereby it had a longer development time than larvae and pupae reared on tomato plants. Adults preferred tomato plants even if they had been reared as larvae on BNS. Exposure periods of 7, 14, and 21 days to 4 °C indicated that more than 50% of SATP pupae reared on BNS plants survived more than 14 days. The survival of SATP reared on tomato plants exceeded 21 days and after exposure to 4 °C, females reared on both plants remained fertile. The life table and behavioral parameters recorded demonstrated a significant potential of BNS to support the development of SATP, also at low temperature. Therefore, even with effective border surveillance and phytosanitation processes in place, invasion through an alternative host is possible and difficult to detect.

2. **Gutierrez A.P., Ponti L., Neteler M., Suckling D.M., Cure J.R., 2021. Invasive potential of tropical fruit flies in temperate regions under climate change. Communications Biology,** https://doi.org/10.1038/s42003-021-02599-9

Abstract: Tropical fruit flies are considered among the most economically important invasive species detected in temperate areas of the United States and the European Union. Detections often trigger quarantine and eradication programs that are conducted without a holistic understanding of the threat posed. Weather-driven physiologically-based demographic models are used to estimate the geographic range, relative abundance, and

threat posed by four tropical tephritic fruit flies (Mediterranean fruit fly, melon fly, oriental fruit fly, and Mexican fruit fly) in North and Central America, and the European-Mediterranean region under extant and climate change weather (RCP8.5 and A1B scenarios). Most temperate areas under tropical fruit fly propagule pressure have not been suitable for establishment, but suitability is predicted to increase in some areas with climate change. To meet this ongoing challenge, investments are needed to collect sound biological data to develop mechanistic models to predict the geographic range and relative abundance of these and other invasive species, and to put eradication policies on a scientific basis

6.3.2. Abstracts submitted for climate sector

3. **Ponti L., Gutierrez A.P., Campos M.R., Biondi A., Neteler M., Desneux N., 2021. Biological invasion risk assessment of Tuta absoluta: mechanistic versus correlative methods. Biological Invasions.** https://doi.org/10.1007/s10530-021-02613-5

The capacity to assess invasion risk from potential crop pests before invasion of new regions globally would be invaluable, but this requires the ability to predict accurately their potential geographic range and relative abundance in novel areas. This may be unachievable using de facto standard correlative methods as shown for the South American tomato pinworm Tuta absoluta, a serious insect pest of tomato native to South America. Its global invasive potential was not identified until after rapid invasion of Europe, followed by Africa and parts of Asia where it has become a major food security problem on solanaceous crops. Early prospective assessment of its potential range is possible using physiologically based demographic modelling that would have identified knowledge gaps in T. absoluta biology at low temperatures. Physiologically based demographic models (PBDMs) realistically capture the weather-driven biology in a mechanistic way allowing evaluation of invasive risk in novel areas and climes including climate change. PBDMs explain the biological bases for the geographic distribution, are generally applicable to species of any taxa, are not limited to terrestrial ecosystems, and hence can be extended to support ecological risk modeling in aquatic ecosystems. PBDMs address a lack of unified general methods for assessing and managing invasive species that has limited invasion biology from becoming a more predictive science.

4. **Dell'Aquila, A., Calmanti, S., Ponti, L and the MED-GOLD Consortium team. How the MED-GOLD pilot tools are turning climate data from Copernicus CDS into value for agri-food Mediterranean systems: an illustrative brochure.**

MED-GOLD is an EU-funded Horizon 2020 project (https://www.med-gold.eu/), led by ENEA, whose main objective is to demonstrate the proof-of-concept for climate services in agriculture by developing case studies for three staples of the Mediterranean food system: grapes, olives and durum wheat. MED-GOLD has co-developed climate services with sectoral users to provide salient information at the seasonal (next 6 months) and long-term (next 30 years) time scales. At the moment, climate information is provided at the spatial resolution of ERA5 (30 km). To provide the highest value for decision-making, the services have been linked to specific decision making processes as a result of the cooperation with end-users. In this context, a systematic link with C3S has been established since the early stages of the project, and the data have been continuously retrieved from the CDS into the MED-GOLD ICT platform to produce user-oriented predictions of essential climate variables, bioclimatic indicators and input for the crops models used for the MED-GOLD services.
Timely warnings of when climate change might pose disruptive pressures on the production systems offers stakeholders a chance to act proactively both at seasonal (operational campaign planning) and decadal (strategic business planning) time-scales, making the european agro-food sector more resilient to the impacts of climate change.

5. **Bojovic D., Lera St.Clair A., Christel I., Terrado M., Stanzel P., Gonzalez P, Palin E. 2021. Engagement, involvement and empowerment: three realms of a coproduction framework for climate services. Global Environmental Change 68, 102271.**

While knowledge coproduction between climate scientists and climate information users has become a common theme in the climate services discourse, the interface between climate service providers and users is an aspect of climate services projects that still calls for more attention. This is due in part to the dominance of the physical sciences in these projects, as well as the prevalence of an instrumental and narrow interpretation of coproduction. Following up on the World Meteorological Organisation's Guidance on Good Practices for Climate Services User Engagement, and incorporating insights from the social and human sciences, we develop a coproduction framework for climate services to help establish a smooth and effective interface between scientists and stakeholders. This framework is intended for research and innovation projects developing climate knowledge and services. The coproduction framework comprises three realms: (i) engagement using various communication channels; (ii) involvement through interviews, workshops and webinars; and (iii) empowerment of stakeholders and scientists through focused relationships. This incremental participatory process involves

stakeholders in increasingly profound ways: from a broad stakeholder group identified through awareness-raising campaigns, on to potential users with whom we exchange knowledge, and then to a set of "champion users" who co-develop the service and pioneer its use in decision-making processes. This paper illustrates the application of the coproduction framework in PRIMAVERA, an EU H2020-funded project for designing, running and testing new high-resolution global climate models and evaluating their outputs. While PRIMAVERA provided ground breaking scientific findings that could potentially benefit various stakeholders and support climate risk assessment activities, these results are highly specialised and their added value has yet to be assessed. Accordingly, the user engagement component of the project faced the challenging task of both motivating stakeholders' participation in the project and motivating future users of potential services based on PRIMAVERA data. The trial of the framework in PRIMAVERA provided key lessons for enhancing coproduction in research and innovation projects. We demonstrate how the role of scientists gradually shifted in this coproduction cycle from masters of knowledge (Roux et al., 2017) to co-learners, and how the involvement of the project's interdisciplinary team and their interaction with stakeholders served to move the project towards transdisciplinary knowledge production.

6.3.2. Abstract submitted for Durum wheat sector

6. **Ceglar, A., Toreti, A., Zampieri, M., Royo, C. 2021. Global loss of climatically suitable areas for durum wheat growth in the future. Accepted for publication in Environmental Research Letters.**

Durum wheat (Triticum durum Desf.) is a minor cereal crop of key importance for making pasta, couscous, burghul, puddings, bread and many other traditional foods, due to its physical and chemical characteristics. The global demand for high-quality food made of durum wheat has been increasing, which poses a challenge in the face of climate change. Major share of durum wheat production is currently located in semi-arid climates, where the risk of climate extremes such as drought and heat stress will likely substantially increase in the future. To provide a first estimate of future global arable land climatically suitable for growing durum wheat, we develop a suitability model based on Support Vector Machines. The current total share of global arable land climatically suitable to grow rainfed durum wheat is around 13%. Climate change may decrease the suitable area by 19% at mid-century and by 48% at the end of the century. Widespread loss of suitable areas is foreseen in the Mediterranean regions and northern America. On the other hand, climate may become suitable to grow durum wheat in many regions of central and western Europe, while the largest gain in suitability is estimated in some parts of Russia. The overall net loss of suitable areas requires the development and the future adoption of

effective and sustainable strategies to stabilize production and adapt the entire food supply chain. Our study also clearly demonstrates the importance of limiting global warming to levels well below 2 ºC at the end of the century, which would substantially limit the loss of climatically suitable areas.

7. **Ceglar, A., Toreti, A. 2021. Seasonal climate forecast can inform the European agricultural sector well in advance of harvesting. NPJ Climate and Atmospheric science, 4: 42.**

Seasonal climate forecasts are a key component of sectoral climate services. Skill and reliability in predicting agro-climate indicators, co-designed with and for European wheat farmers, are here assessed. The main findings show how seasonal climate forecast provides useful information for decision-making processes in the European winter wheat-producing sector. Flowering time can be reliably predicted already at the beginning of the growing season in central and eastern Europe, thus supporting effective variety selection and timely planning of agro-management practices. The predictability of climate events relevant for winter wheat production is strongly dependent on the forecast initialization time as well as the nature of the event being predicted. Overall, regionally skillful and reliable predictions of drought events during the sensitive periods of wheat flowering and grain filling can be made already at the end of winter. On the contrary, predicting excessive wetness seems to be very challenging as no or very limited skill is estimated during the entire wheat growing season. Other approaches, e.g., linked to the use of large-scale atmospheric patterns, should be identified to enhance the predictability of those harmful events.

8. **Ceglar, A., Toreti, A., Zampieri, M., Manstretta, V., Bettati, T., Bratu, M., 2020. Clisagri – an R package for agro-climate services. Climate Services, 20, 100197**

Crop yields are affected by unfavourable/extreme weather and climate events occurring during sensitive growth stages. Understanding the risks associated with these events is essential to adapt agro-management decisions and reduce losses. For this purpose, we propose a targeted climate service integrating a dynamic crop phenology model with an approach based on dedicated agro-climate risk indicators. The initial set of these indicators has been developed in a co-design approach with agronomists and durum wheat farmers participating as end-users in the H2020-MedGOLD project. Four groups of indicators characterize drought events, excessive wetness, cold stress and heat stress during sensitive growth stages. The proposed approach has been fully implemented as an R-package named Clisagri. The package is complemented with a set of optimization functions, which target optimal variety selection in terms of crop cycle duration.

9. Zampieri, M., Weissteiner, C.J., Grizzeti, B., Toreti, A., van den Berg, M., Dentener, F., 2020. Estimating resilience of crop production systems: From theory to practice. Science of the total environment, 735: 139378

Agricultural production systems are sensitive to weather and climate anomalies and extremes as well as to other environmental and socio-economic adverse events. An adequate evaluation of the resilience of such systems helps to assess food security and the capacity of society to cope with the effects of global warming and the associated increase of climate extremes.

Here, we propose and apply a simple indicator of resilience of annual crop production that can be estimated from crop production time series. First, we address the problem of quantifying resilience in a simplified theoretical framework, focusing on annual crops. This results in the proposal of an indicator, measured by the reciprocal of the squared coefficient of variance, which is proportional to the return period of the largest shocks that the crop production system can absorb, and which is consistent with the original ecological definition of resilience. Subsequently, we show the sensitivity of the crop resilience indicator to the level of management of the crop production system, to the frequency of extreme events as well as to simplified socio-economic impacts of the production losses. Finally, we demonstrate the practical applicability of the indicator using historical production data at national and sub-national levels for France. The results show that the value of the resilience indicator steeply increases with crop diversity until six crops are considered, and then levels off. The effect of diversity on production resilience is highest when crops are more diverse (i.e. as reflected in less well correlated production time series). In the case of France, the indicator reaches about 60% of the value that would be expected if all crop production time-series were uncorrelated.

10. Performance of seasonal forecasts of Douro and Port wine production. Agricultural and Forest Meteorology, 291: 108095.

Wine production is intricately dependant on the evolution of weather conditions in a given year. Therefore, seasonal weather forecasts coupled with empirical wine production models can play a critical role in the short to medium-term management of vineyards and wineries. The implementation of suitable and timely adaptation measures based on predicted wine productions may contribute to risk reduction and improve efficiency. The performance of seasonal forecasts of wine production in the Portuguese Douro & Port wine region (D&P WR)

is here assessed for the first time. This application may serve as a case study to be potentially extended to other wine regions. Here, we develop a predictive logistic model of wine production based on monthly mean air temperatures and monthly total precipitation, averaged over the periods of February–March, May–June, and July–September, complemented with an autoregressive component of wine productions. The wine production in the D&P WR during the period 1950–2017 (68 years) is keyed into three classes: low, normal and high production years. The model reveals a correct estimation ratio of approximately 3/4 for the full period, and 2/3 when applied to independent 10%-random subsamples. We then evaluate the performance of the ECMWF 7-month seasonal weather forecasts, issued from February to August, in predicting the meteorological conditions relevant for the wine production in the D&P WR. Overall, the performance is satisfactory for the meteorological predictors. As for the weather forecasts coupled with the wine production model, results reveal that forecasts from May to August are strikingly the best performing, as 1) more observed data is integrated into the empirical model and 2) the skill of seasonal forecasts for summer months is higher. The operational application of these forecasts in the D&P WR is already foreseen. Given the encouraging results, we believe this case study and the established methodology may be tested and adapted to other wine regions worldwide, with obvious benefits for the winemaking sector.

11. Ceglar, A., Zampieri, M., Gonzalez-Reviriego, N., Ciais, P., Schauberger, B., van der Velde, M., 2020. Time-varying impact of climate on maize and wheat yields in France since 1900. Environmental Research Letters, 15: 094039

Climate services that can anticipate crop yields can potentially increase the resilience of food security in the face of climate change. These services are based on our understanding of how crop yield anomalies are related to climate anomalies, yet the share of global crop yield variability explained directly by climate factors is largely variable between regions. In Europe, France has been a major crop producer since the beginning of the 20th Century. Process based and statistical approaches to model crop yields driven by observed climate have proven highly challenging in France. This is especially due to a high regional diversity in climate but also due to environmental and agro-management factors. An additional level of uncertainty is introduced if these models are driven by seasonal-to-decadal surface climate predictions due to their low performances before the harvesting months of both wheat and maize in western Europe. On the other hand, large scale circulation patterns can possibly be better predicted than the regional surface climate, which offers the opportunity to rely on large scale circulation patterns as an alternative to local climate variables. This method assumes a certain degree of

stationarity in the relationships between large scale patterns, surface climate variables, and crop yield anomalies. However, such an assumption was never tested, because of the lack of suitable long-term data. This study uses a unique dataset of subnational crop yields in France covering more than a century. By calibrating and comparing statistical models linking large scale circulation patterns and observed surface climate variables to crop yield anomalies, we can demonstrate that the relationship between large scale patterns and surface variables relevant for crop yields is not stationary. Therefore, large scale circulation pattern based crop yield forecasting methods can be adopted for seasonal predictions provided that regression parameters are constantly updated. However, the statistical crop yield models based on large-scale circulation patterns are not suitable for decadal predictions or climate change impact assessments at even longer time-scales.

12. **Dainelli., R, Pasqui., M, Calmanti,. S, Monotti, Ch., and Toscano, P. Early season prediction of durum wheat yield by a hybrid System of Seasonal Weather Prediction and Delphi crop model. Climate services - Elsevier (submission estimated by the end of October 2021).**

Early within-season weather conditions forecast and yield prediction can provide useful information to improve farmers' management decisions and to create a unique opportunity for implementing new solutions to specifically address key aspects of agricultural systems. Within the aims of the EU funded Horizon 2020 MED-GOLD project (https://www.med-gold.eu/), a durum wheat case study has been established to assess an innovative climate service tools for the management of climate risks and to increase yield and reduce potential risk. In this study, the added value of seasonal forecast was assessed by looking at the historical yield data and by comparing the data provided by climate service tool with traditional crop forecasting systems. For three hot spot areas (Ravenna, Ancona, and Foggia) and then for the whole Italian area, the skills of three seasonal time-scale forecasting provided through the Copernicus Data Store (CDS) were evaluated as a driver to the crop modeling system DELPHI, to test their added value to durum wheat yield prediction. Initially, the DELPHI model was run with observed daily weather data from sowing to harvest to obtain the reference yield. Then, yield predictions were calculated at a monthly time step, starting from February 1st and April 1st, by feeding the model with synthetic weather scenarios based on historical observations (dry, average, wet scenario - current mode) and with weather seasonal forecast (new tool) until the end of the growing season. Results for yield prediction on the basis of the current DELPHI System (historical scenarios) and on the basis of seasonal forecast (25 ensembles) were compared against reference yield. A ready-to-use tool updating the Delphi system operational version with seasonal forecasts has been delivered and it is available online for end users.

13. **Solaraju-Murali, B., González-Reviriego, N., Caron, L-P., Ceglar, A., Toreti, A., Zampieri, M., Bretonnière, P-A., Samsó-Cabré, M., Doblas-Reyes, F-J. 2021. Multi-annual prediction of drought and heat stress to support decision making in the wheat sector. Nature npj Climate and Atmospheric Science 4, 34.**

Drought and heat stress affect global wheat production and food security. Since these climate hazards are expected to increase in frequency and intensity due to anthropogenic climate change, there is a growing need for effective planning and adaptive actions at all timescales relevant to the stakeholders and users in this sector. This work aims at assessing the forecast quality in predicting the evolution of drought and heat stress by using user-relevant agro-climatic indices such as Standardized Precipitation Evapotranspiration Index (SPEI) and Heat Magnitude Day Index (HMDI) on a multi-annual timescale, as this time horizon coincides with the long-term strategic planning of stakeholders in the wheat sector. We present the probabilistic skill and reliability of initialized decadal forecast to predict these indices for the months preceding the wheat harvest on a global spatial scale. The results reveal the usefulness of the study in a climate services context while showing that decadal climate forecasts are skilful and reliable over several wheat harvesting regions.

6.3.3. Abstract submitted for Olive sector

14. **Fernandez-Carrillo, A., Rivas-Gonzalez, F.W., and Revilla-Romero, B. Satellite imagery and climate variables suggest variations in the phenology of olive groves in Southern Spain. Proc. SPIE 11856, Remote Sensing for Agriculture, Ecosystems, and Hydrology XXIII, 118560M (12 September 2021); https://doi.org/10.1117/12.2599901**

Olive groves have high socioeconomic impacts in Spain. Global warming is leading to changes in agrarian systems, affecting phenology and productivity. Remote Sensing data is useful to study the current trends in olive groves. The MEDGOLD project, funded by the European Union's H2020 programme (No. 776467), aims to develop climate services for the Mediterranean agri-food sector (grape, olives and durum wheat). In this work, images from the MODIS sensor have been used to study the status of olive groves in 2000-2020 in Southern Spain. Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Normalized Multi-band Drought Index (NMDI) were computed and correlated with precipitation and temperature using datasets provided by the Environmental Information Network of Andalusia (REDIAM) and scenarios based on the MED-GOLD outcomes. Additionally, some annual indicators were derived from NDVI to study trends: maximum (MAX), minimum (MIN), mean (MEAN), relative range (RREL), date of the maximum (DMAX) and date of the minimum (DMIN). Reported good and bad production years were reflected

on vegetation indices. Trends were observed in annual indicators. The average photosynthetic activity increased, especially in MIN (Δyear = 0.0025; r2 = 0.68). The trend of RREL (Δyear = -0.012; r2 = 0.52) indicated that vegetation is moving to a more constant seasonal behaviour. The beginning and end of the season tend to occur earlier each year, as showed by DMAX (Δyear = -2.7 days) and DMIN (Δyear = -1.7 years). Management practices may require adaptations to the new seasonal behaviour of herbaceous vegetation, which could affect soil properties.

15. **Rosati A., Marchionni D., Mantovani D., Famiani F., Ponti L., 2021. Intercepted photosynthetically active radiation (PAR) and spatial and temporal distribution of transmitted PAR under high-density and super high-density olive orchards. Agriculture, 11: 351.** https://doi.org/10.3390/agriculture11040351

We quantified the photosynthetically active radiation (PAR) interception in a high-density (HD) and a super high-density (SHD) or hedgerow olive system, by measuring the PAR transmitted under the canopy along transects at increasing distance from the tree rows. Transmitted PAR was measured every minute, then cumulated over the day and the season. The frequencies of the different PAR levels occurring during the day were calculated. SHD intercepted significantly but slightly less overall PAR than HD (0.57 ± 0.002 vs. 0.62 ± 0.03 of the PAR incident above the canopy) but had a much greater spatial variability of transmitted PAR (0.21 under the tree row, up to 0.59 in the alley center), compared to HD (range: 0.34–0.43). This corresponded to greater variability in the frequencies of daily PAR values, with the more shaded positions receiving greater frequencies of low PAR values. The much lower PAR level under the tree row in SHD, compared to any position in HD, implies greater self-shading in lower-canopy layers, despite similar overall interception. Therefore, knowing overall PAR interception does not allow an understanding of differences in PAR distribution on the ground and within the canopy and their possible effects on canopy radiation use efficiency (RUE) and performance, between different architectural systems. View Full-Text

16. **Gratsea, M., K. Varotsos, V. López-Nevado, J. López-Feria, S. Giannakopoulos, C. Return period analysis to assess the long-term impact of climate change on olive sector in Andalusia, Spain - results from the MED-GOLD project (EGU 2021 General Assembly, 13-30 April 2021; poster presentation)**

MED-GOLD project aims to develop climate services for olive, grape and durum wheat crops, which are the hallmarks of the Mediterranean food system. The generated climate related information at different timescales

will be exploited by the end-users for operational decision-making. The objective of this study is to employ the return period method for communicating the effect of climate change on the olive crops in the long-term in Andalusia, which is one of the most important olive growing areas worldwide. Therefore, return periods of bad years in terms of olive yield and olive fly risk are being calculated for the reference period 1971-2000 and for the near (2031-2060) and distant future (2071-2100) under the RCP4.5 and RCP8.5 emission scenarios using an ensemble of five bias-corrected Regional Climate Models. The identification of the bad years - and the corresponding thresholds - is based on observational data from five monitoring stations in Andalusia (Malaga, Granada, Sevilla, Cordoba and Jaen) and the role of certain meteorological parameters (precipitation, temperature, relative humidity) is investigated. The results indicate an overall tendency for increased occurrence probability of bad years in terms of yield due to future higher temperatures and decreased precipitation. The impact is more pronounced towards the end of the century and under the RCP8.5 future emission scenario.

17. **A. Fernandez-Carrillo, F. W. Rivas-Gonzalez, B. Revilla-Romero, Satellite imagery and climate variables suggest variations in the phenology of olive groves in Southern Spain. 2021. Conference paper.**

Olive grove is the main culture in Spain, with high socioeconomic impacts. Global warming is leading to changes in agrarian systems, affecting the typical phenology and productivity. Remote Sensing data is a valuable source of information to study the current trends in olive groves, given the spectral, spatial and temporal resolution of sensors. In this context, the MED-GOLD project, funded by the European Union's H2020 programme (No. 776467), aims to develop climate services integrating Remote Sensing for olive, grape, and durum wheat crops. In this work, satellite images from the MODIS sensor have been used to study the status of olive groves in 2000-2020 in Southern Spain. Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Normalized Multi-band Drought Index (NMDI) were computed. The correlation of these indices with precipitation and temperature was studied using datasets provided by the Environmental Information Network of Andalusia (REDIAM) and scenarios based on the MED-GOLD outcomes. Additionally, the following NDVI annual indicators were derived to study trends: maximum NDVI (MAX), minimum (MIN), mean (MEAN), relative range of NDVI (RREL), date of the maximum (DMAX) and date of the minimum (DMIN).

The correlation between climate and vegetation indices was complex. Good and bad production years were reflected on vegetation indices. Clear trends were observed in annual NDVI indicators. The average photosynthetic activity increased, especially in the minimum, MIN (Δyear = 0.0025; r2 = 0.68). The trend of RREL (Δyear = -0.012; r2 = 0.52) indicated that vegetation is moving to a more constant seasonal behaviour.

The beginning and end of the season tend to occur earlier each year, as showed by DMAX (Δyear = -2.7 days) and DMIN (Δyear = -1,7 years). Management practices may require adaptations to the new intensity and seasonal behaviour of herbaceous vegetation, which should affect soil properties.

6.3.4. Abstract submitted for grape and wine sector

18. Khosravi, F., Bruno Soares, M., Graça, A., Teixeira, M., Assessing added value of the climate services to the decision-makers in Agriculture and food system: Wine sector

Climate change is perceived as an important risk for wine sector. The adoption of timely, cost-effective adaptation strategies may contribute to risk reduction, and enhancing its resilience under a changing climate. Climate services is the production, and use of climate information to support decision-makers towards adapting to climate variabilities. Assessing the value of climate services constitutes a critical area of research in the field of climate services to help us identify any barriers of climate services development. The climate service development in this research benefitted from valuable co-design by a Portuguese Wine company' decision-makers and, with their continued help to assess its usability. In this paper, we provide an assessment of the actual value of climate service co-developed within the wine sector. Data was collected from the decision-makers using an online workshop, and semi-structured interview. The result shows the data provided in the Dashboard are reliable and legitimate, however, the saliency of the Dashboard was questioned and some recommendations were proposed to increase the tool saliency. The recommendations not only further the design of Dashboard, but they may also inform the designs of other decision-support tools used in climate adaptation.

19. Sanderson, M.G. Teixeira, M., Fontes, N., Silva, S., Graça, A., The Risk of Unprecedented Rainfall in Wine Regions of Northern Portugal (to be submitted to OENO One)

Climate is arguably one of the most important factors determining the quality of wine from any given grapevine variety. This study focuses on three wine-growing regions in northern Portugal, Vinho Verde, Trás-os-Montes and Porto and Douro DOC. High rainfall during late spring (April to June) can promote growth of the vines but increases the risk of fungal disease. High rainfall during harvest time (August to October) also bears the potential for severe operational disruption and heavy economic losses. To date, the probability of unprecedented rainfall amounts in spring and the harvest season over northern Portugal wine regions has not been assessed. In a situation of higher climatic variability, establishing the probable limits of rainfall variation during critical

moments of the vine growth cycle will allow for better readiness of farmers as well as higher resilience of the whole value chain. The risk of unprecedented rainfall totals during the important stages of vine growth and grape harvesting is assessed using two different methods. A large ensemble of initialised climate model simulations is analysed, and the probability of unprecedented rainfall in each season is quantified. Extreme value analysis is applied to rainfall totals from observations and the model ensemble, and the return periods of known extreme rainfall events are calculated. Seasonal rainfall totals considerably higher than any observed are possible in the current climate. The probability of an event in either season is less than 0.04; both methods produced similar estimates. The chance of reoccurrence of a year similar to 1993, when both seasons were exceptionally wet, is also small (about 0.014). These results help inform the need for costly adaptation investments for vineyard management, such as better availability of spraying machinery and labour, high-gauge drainage, landslide controls or even abandonment of exposed vineyard areas.

20. Khosravi, F., Bruno Soares, M., Graça, A., Teixeira, M., Assessing the value of climate services for the wine sector. EMS Annual Meeting 2021. 3–10 September 2021.

Climate services involve the production, translation and use of climate information to support users' decisions towards adapting to climate variability and change (ref?). However, the value of climate services to end-users is only truly realised when the information provided by such services is used to support and inform users' decision-making processes (Bruno Soares et al. 2018). Capturing and assessing the value and benefits of climate services constitutes a critical area of research in the field of climate services and can be informed by a range of epistemological and methodological approaches. In this paper, we present the assessment of the socio-economic value and benefits of a climate service developed specifically for the wine sector and implemented under the auspices of the H2020 MED-GOLD project. The assessment was pursued together with the end-users of the climate service using a participatory mixed-methods approach. Our paper describes the process and methods through which the climate service was assessed with the end-users. It then highlights key findings from the study such as typologies of value and benefits yielded by the end-users; usability of information provided by the service across decision-making processes; and key factors influencing use of climate information and the realisation of value.

In doing so, our paper contributes to current knowledge on what constitutes value to end-users in the wine sector and helps unpack some of the complexity between climate information provision, use and the realisation of its value to end-users. It also contributes to wider ongoing discussions on how to effectively assess the value and

benefits of climate services to end-users and how to facilitate the realisation of such value, as well as its assessment, in future climate services initiatives.

21. Sanderson, M.G. Teixeira, M., Graça, A. Cold air pooling in the Douro Valley (to be submitted to the Journal of Applied Meteorology and Climatology).

Cold air pooling in the Alto Douro region of northern Portugal is investigated using data from a pair of weather stations in the Douro valley, and a third located on a hilltop above the valley. Night-time cold air pool events observed between January 2011 and April 2018 were assigned to eight different categories based on their temporal behaviour, and none of them lasted longer than 1 day. There was a clear seasonal cycle in numbers of cold pools, with most seen during winter and the fewest in the summer. The maximum strengths of the cold pools occurred could occur at any time during the night, although the majority peaked around the middle of the night. This study is the first to examine cold pools in the Douro valley.

22. Graça A., Teixeira M., Silva S., Antunes J., Vigo I., Varotsos K. V., Giannakopoulos C., Santos J., Fontes N., Dell'Aquila A. Is wine terroir a valid notion under a changing climate?

The OIVi defines terroir as a concept which refers to an area in which collective knowledge of the interactions between the identifiable physical and biological environment and applied vitivinicultural practices develops providing distinctive characteristics for the products originating from this area, including specific soil, topography, climate, landscape characteristics and biodiversity features.

These distinctive characteristics are in great measure integrated in the taste of wine, one of its characteristics mostly driving consumer preference and, therefore, the value of wine in the marketplace. Geographical indications (GI) are recognized regulatory constructs that formalize and protect the nexus between the taste of wine and the terroir generating it. Despite conceptually having tools for updating their rules, they do not generally consider the nexus to be a dynamic one and have generally no plans for anticipating change, namely of climate. Recently, the OIV has furthered this concept in a resolution updating the definitions of geographical indications and appellations of origin, strengthening the link between the place of origin and the characteristics of wine. Climate is a fundamentally influencing feature of terroir with strong direct and indirect impact on the taste and other characteristics of resulting wines. According to IPCCii, widespread and rapid changes have occurred, the scale of recent changes being unprecedented over many centuries to many thousands of years.

For many wine regions across the world these changes have already been widely reported and projected to increase in frequency and forcing the characteristics of wine away from GI definitions. In this sense, several publications have signalled a probable geographical displacement of current wine producing areas for other better suited for fine wine production, often in different countries. Others have proposed changes in wine production methods such as changing the varietal composition, systems of vineyard management or product innovation. In this paper, we show evidence that climate change is already affecting characteristics of wines produced in the Douro wine region, home of 270-year-old Port GI. We discuss resist or adapt stances in planning for when climate fundamentally changes the nexus between terroir and wine characteristics away from past reality. Using the MED-GOLD dashboard, a tool allowing for easy and visual navigation of past and future climate conditions, we provide a practical demonstration of how grape-growers can identify the closest locations within GI boundaries likely to retain ideal climatic conditions for Port traditional varieties throughout the XXI century.

23. Santos, J.A., Ceglar, A., Toreti, A., Prodhomme, C. 2020. Performance of seasonal forecasts of Douro and Port wine production. Agricultural and Forest Meteorology 291 108095.

Wine production is intricately dependant on the evolution of weather conditions in a given year. Therefore, seasonal weather forecasts coupled with empirical wine production models can play a critical role in the short to medium-term management of vineyards and wineries. The implementation of suitable and timely adaptation measures based on predicted wine productions may contribute to risk reduction and improve efficiency. The performance of seasonal forecasts of wine production in the Portuguese Douro & Port wine region (D&P WR) is here assessed for the first time. This application may serve as a case study to be potentially extended to other wine regions. Here, we develop a predictive logistic model of wine production based on monthly mean air temperatures and monthly total precipitation, averaged over the periods of February–March, May–June, and July–September, complemented with an autoregressive component of wine productions. The wine production in the D&P WR during the period 1950–2017 (68 years) is keyed into three classes: low, normal and high production years. The model reveals a correct estimation ratio of approximately 3/4 for the full period, and 2/3 when applied to independent 10%-random subsamples. We then evaluate the performance of the ECMWF 7-month seasonal weather forecasts, issued from February to August, in predicting the meteorological conditions relevant for the wine production in the D&P WR. Overall, the performance is satisfactory for the meteorological predictors. As for the weather forecasts coupled with the wine production model, results reveal that forecasts

from May to August are strikingly the best performing, as 1) more observed data is integrated into the empirical model and 2) the skill of seasonal forecasts for summer months is higher. The operational application of these forecasts in the D&P WR is already foreseen. Given the encouraging results, we believe this case study and the established methodology may be tested and adapted to other wine regions worldwide, with obvious benefits for the winemaking sector.

7. EXPLOITATION OF RESULTS

The aims of compilation are to inform and connect end-user communities. This is important because there is often insufficient awareness of vulnerability to climate change, and climate services in different sectors have been hindered by a lack of relevant products and services offered by the scientific community[RD.3] Informing stakeholders through publications, networking and other communication channels can increase awareness of their vulnerability and climate service tools that could potentially help them. Communication and dissemination also increases scientific capacity among climate researchers, users and providers; not only in the region of the study but also in the regions where climate services are less developed. It can also broaden climate service applications in the food sector by introducing added value in the pilot services and encouraging the wider community to adapt and exploit the climate services. END OF DOCUMENT

[i] International Organization for Vine and Wine, www.oiv.int
[ii] Intergovernmental Panel on Climate Change, https://www.ipcc.ch/