European meteorological data: contribution to research, development and policy support

Irene Biavetti[a*], Sotiris Karetsos[a], Andrej Ceglar[a], Andrea Toreti[a], Panos Panagos[a]
European Commission, Joint Research Centre, Institute for Environment and Sustainability
Via E. Fermi 2749, I-21027 Ispra (VA), Italy

*irene.biavetti@jrc.ec.europa.eu ; phone +39 0332 789476; http://mars.jrc.ec.europa.eu/mars/About-us/AGRI4CAST

ABSTRACT

The Joint Research Centre of the European Commission has developed Interpolated Meteorological Datasets available on a regular 25x25km grid both to the scientific community and the general public. Among others, the Interpolated Meteorological Datasets include daily maximum/minimum temperature, cumulated daily precipitation, evapotranspiration and wind speed. These datasets can be accessed through a web interface after a simple registration procedure. The Interpolated Meteorological Datasets also serve the Crop Growth Monitoring System (CGMS) at European level. The temporal coverage of the datasets is more than 30 years and the spatial coverage includes EU Member States, neighboring European countries, and the Mediterranean countries. The meteorological data are highly relevant for the development, implementation and assessment of a number of European Union (EU) policy areas: agriculture, soil protection, environment, agriculture, food security, energy, climate change.

An online user survey has been carried out in order to assess the impact of the Interpolated Meteorological Datasets on research developments. More than 70% of the users have used the meteorological datasets for research purposes and more than 50% of the users have used those sources as main input for their models. The usefulness of the data scored more than 70% and it is interesting to note that around 25% of the users have published their scientific outputs based on the Interpolated Meteorological Datasets. Finally, the user feedback focuses mostly on improving the data distribution process as well as the visibility of the web platform.

Keywords: crop growth, precipitation, temperature, user survey, vapour pressure, food security, crop modelling

1. INTRODUCTION

Meteorological data are extensively used in research purposes in different sectors including agriculture and economy. For instance, they can be used for crop yield and hydrological monitoring and forecasting, for the assessment of economic impacts of climate change and to assess the impacts of extreme weather events.

After the 2008 crisis[1,2], food security has become one of the highest priorities in the European Commission. European Union policies aim at ensuring the European Union independence from price volatility. In the Joint Research Centre (JRC), the Monitoring Agricultural Resources Unit (MARS) serves the agriculture and food policies of the European Union, their impact on rural economies and on the environment, encompassing the global issues of food security and climate change. A large set of expertise includes crop modeling, agro-meteorology, sampling methods, environmental geo-spatial analysis, econometrics through European and global data infrastructures. Based on this skill-set, JRC generates evidence-based information and forecasts for the management of agricultural practices and early warnings on Food Security.

In this framework, the Crop Growth Monitoring System (CGMS) has been developed. It encompasses remote sensing, meteorological observations, agro-meteorological modelling, and statistical analysis. The results of the crop growth monitoring activities are synthesized in the 'MARS Bulletin – Crop Monitoring in Europe'[3], a monthly report published since 1975.

The Crop Growth Monitoring System (CGMS) provides reliable and timely spatial information about crop status in Europe. The CGMS includes three components:

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- Agro-meteorological analysis - it processes meteorological data and develops meteorological indicators for early alert warning and crop modelling.
- Crop growth modelling - it produces crop status indicators after processing weather data and auxiliary datasets such as crop parameters, soil information.
- Statistical methods - it assesses the results and infers relationships between crop indicators and crop yield with further objective of yield forecasting.

The objective of this paper is to present the meteorological datasets developed and maintained by the MARS Unit to evaluate its use through a survey, to enhance its distribution, visibility and usability.

2. DATA

At European level, the Crop Growth Monitoring System (CGMS) manages the meteorological, crop yield and crop area data since 1975. The spatial coverage includes EU Member States, neighboring European countries, candidate countries and the Mediterranean countries (North Africa). More specifically, the meteorological data have been collected from a network of around 5.000 meteorological weather stations throughout Europe.

The original station (point) data are interpolated to produce raster maps with a resolution of 25km x 25km grid cell. The raster datasets are also aggregated to different administrative levels (Countries, regions, provinces), such as NUTS[4], Nomenclature of territorial units for statistics. The CGMS includes the following meteorological attributes at 25km x 25km grid cells:

- Maximum air temperature measured in °C. The maximum air temperature is the highest air temperature (at a height of 200 cm) reached in a time period of 1 day. Figure 1 represents an example of maximum daily air temperature, reached during summer 2013 in Europe and surroundings.
- Minimum air (2m) temperature measured in °C. The minimum air temperature is the lowest air temperature (at a height of 200 cm) reached in a time period 1 day.
- Relative Air Humidity (at different times) measured in %. Relative humidity (RH) is calculated from the vapour pressure (e) and the saturation vapour pressure (eS) at the prevailing temperature (T). The vapour pressure is the pressure exerted by the water vapour molecules present in the atmosphere. This pressure is a component of the total air pressure. The saturation vapour pressure is the vapour pressure at which the air is in equilibrium with a water or ice surface. A higher vapour pressure is not possible under the given conditions because the water vapour will condense, i.e. there will be a transition from the gaseous phase (or vapour phase) to a liquid phase. The saturation vapour pressure depends among other things on the temperature: $RH = e / eS(T) * 100\%$.
- Daily mean wind speed at 10 measured in m/s. The mean wind speed refers to the average of the horizontal speed of the packets of air passing a given geographic point 10 metres above the surface during 1 day. In operational terms, this comes down to the arithmetic mean of all the averages recorded during the period of 1 day.
- Mean daily vapour pressure, measured in hPa. The vapour pressure is the pressure exerted by the water vapour molecules present in the atmosphere. Detailed description is given under Relative Air Humidity.
- Total daily precipitation, measured in mm: The total daily rain refers to the volume of water per unit area (1 m^2) that reaches the earth's surface during the observation period of 1 day in solid and/or liquid form. Figure 2 represents an example of rainfall sum during summer 2013.
- Total daily radiation, measured in Joule/m^2. Global radiation is the solar radiation which strikes the earth's surface on a horizontal area. The global radiation consists of the directly incident radiation (direct radiation) and the radiation which reaches the earth's surface, diffused by clouds, water- and dust-particles (diffuse radiation).
- Snow depth, measured in cm. Snow depth is the total amount of snow on the ground and includes both old and fresh snow, that has fallen during the period of last day.

Other derived meteorological variables can be extracted from CGMS, such as daily evaporation and evapotranspiration. The daily evapotranspiration is calculated on the Penman-Monteith method[5] and represents daily sum of evaporation and plant transpiration.

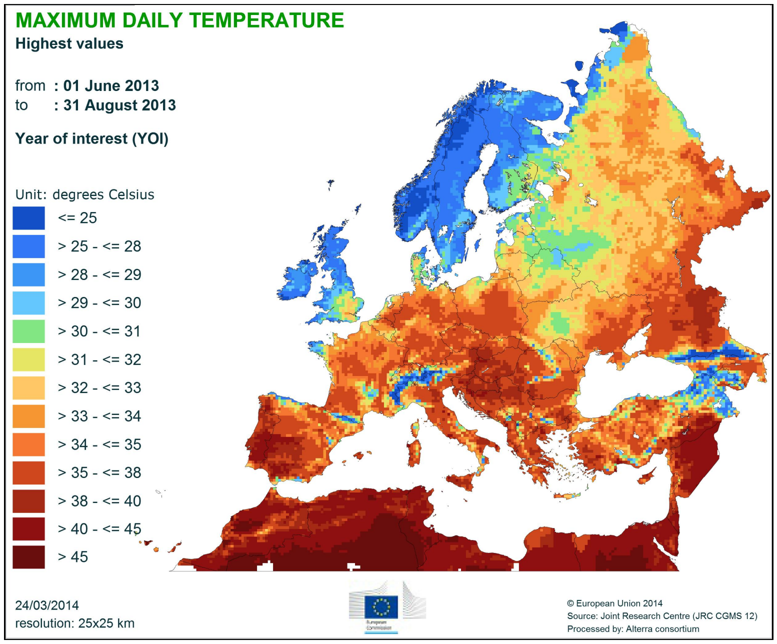

Figure 1: Maximum daily air temperature reached during summer 2013.

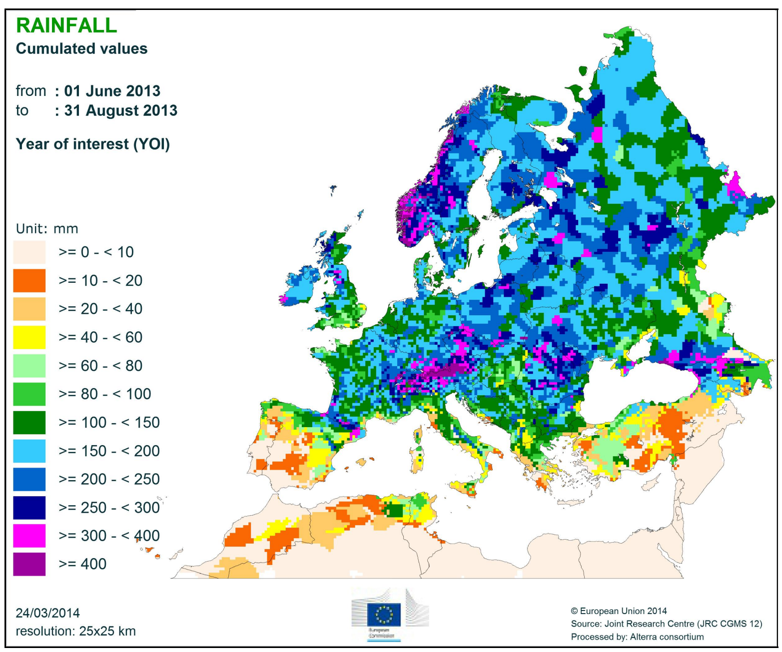

Figure 2: Summer rainfall sums in 2013.

3. DISSEMINATION OF INTERPOLATED METEOROLOGICAL DATA

3.1 Data distribution policy

In December 2011 the European Commission adopted a revised Decision[6] on the re-use of Commission documents. The decision on the re-use of European Commission documents has 'the aim of facilitating a wider reuse of information, enhancing the image of openness of the European Commission, and avoiding unnecessary administrative burdens for re-users and the Commission services alike'. Nevertheless, it is not allowed the re-use of information protected by third party intellectual property rights, and/or received by other institutions (e.g., national weather services).

3.2 Agri4cast Resources DATAPORTAL

The dissemination of the interpolated meteorological datasets is performed through the Agri4cast Resources Portal, at the webpage http://agri4cast.jrc.ec.europa.eu/dataportal/. Through a direct online registration procedure, interpolated meteorological datasets are freely available to the public. They can be used, for instance, for scientific analyses, provided that meteorological data are duly acknowledged and cited. However, the interpolated meteorological datasets cannot be redistributed to third parties and cannot be used for commercial activities.

3.3 Restricted data dissemination

The Agri4cast Resources Data-portal adopts an open access policy to all public resources. A further authorization request, though online, will be limited to restricted resources such as the heating and cooling degree days.

3.4 Data downloads

Since 2011, 542 users asked to register to data portal; among them, around 27% felt discouraged in continuing with a data request. The 73% of the users who downloaded meteorological datasets have done around 3,000 requests. Each data request includes a combination of a meteorological attribute, period (1975-2013) and geographical coverage (around 50 countries). The combination of those three options results in more than 14,000 datasets available for distribution. The users have downloaded more than 550,000 datasets.

The most requested parameters are maximum/minimum temperature and precipitation representing together the 43% of the total requests. Whereas, snow depth is the least requested parameter, having the 5% of the total requests. The datasets have a temporal coverage of 39 years (1975-2013), and the year with the maximum number of requests is 2003 (extreme hot summer). Comparing the decades, it have been noticed that users have almost equal preference to each of the covered decade, with slight preference for data in the period 1991-2000.

Regarding geographical coverage, users downloaded data for the five bigger European countries: France, Germany, Italy, Spain and United Kingdom. The temperature dataset covering France in 2003 was the most requested.

4. USER EVALUATION SURVEY

4.1 Survey purpose and structure

A questionnaire on Interpolated Meteorological Data was distributed to the user community, so as to assess the actual use and usefulness of the meteorological data, the audience reached, the visibility and the concrete worth of the service. The survey was made of six focused closed-ended questions and one open-ended question to let the user community express freely their contribution and to allow a meaningful outcome from the survey.

Here below the questionnaire (please note that AGRI4CAST Interpolated Meteorological Data is synonym of Interpolated Meteorological Data, after the name of the group taking care of the data distribution platform) :

- **Main Purpose**: What was the main purpose/objective that you requested the AGRI4CAST Interpolated Meteorological Data for?
- **Use of data**: Which was the main use of the AGRI4CAST Interpolated Meteorological Data?
- **Usefulness of data:** Have the AGRI4CAST Interpolated Meteorological Data been useful for the envisaged purpose?

- **Other Purposes:** Have the AGRI4CAST Interpolated Meteorological Data been useful for other purposes?
- **Publications:** Have you published articles, posters, reports, or other type of publications based on the AGRI4CAST Interpolated Meteorological Data?
- **Access to Data** - How did you learn about the AGRI4CAST Interpolated Meteorological Data?
- **Your Contribution**: Is there anything you would like to suggest and propose regarding the AGRI4CAST Interpolated Meteorological Data, before submitting your contribution?

The questionnaire offered the possibility to choose more than one answer for the questions 1, 2 and 6 implying that the sum of the responses can be more than 100%.

4.2 Survey outcome

The survey was sent to the 395 users that actually downloaded data since 2011. Here, we report the analysis of the survey questions:

Interpolated meteorological data served mainly the research community (77%). On a good basis, interpolated meteorological data served Consulting (19%), Education (13%), Policy Support (12%), and Business (10%) (Fig.3).

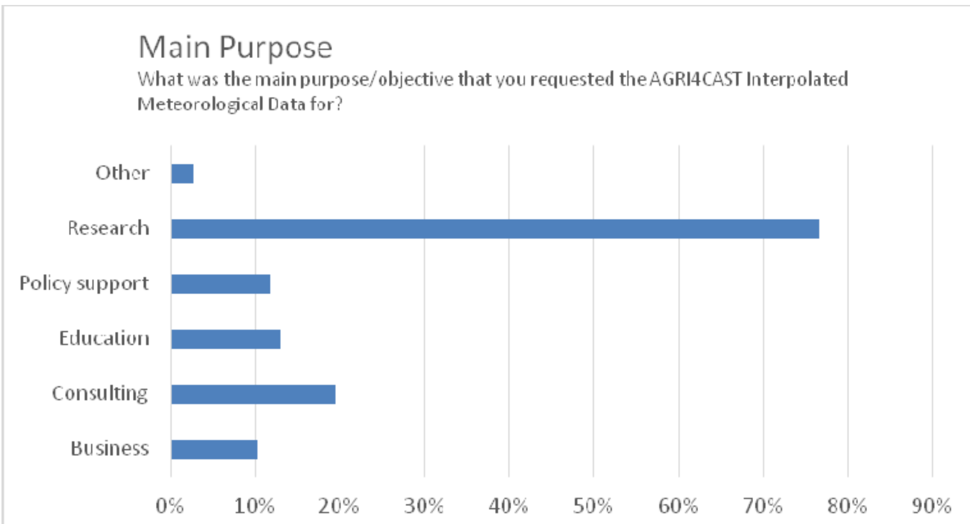

Figure 3. Main Purpose of Interpolated Meteorological Data

Interpolated meteorological data have strongly been used both as a main and as an additional source of information, 52% and 56% respectively. Interpolated meteorological data have been also used in validation (16%) and comparison (13%) studies (Fig.4).

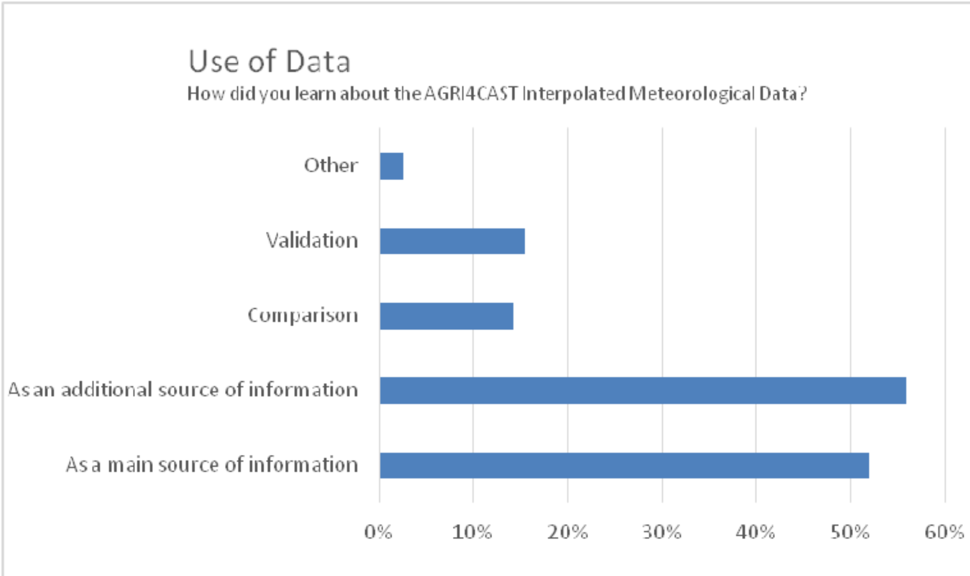

Figure 4. Use of Interpolated Meteorological Data

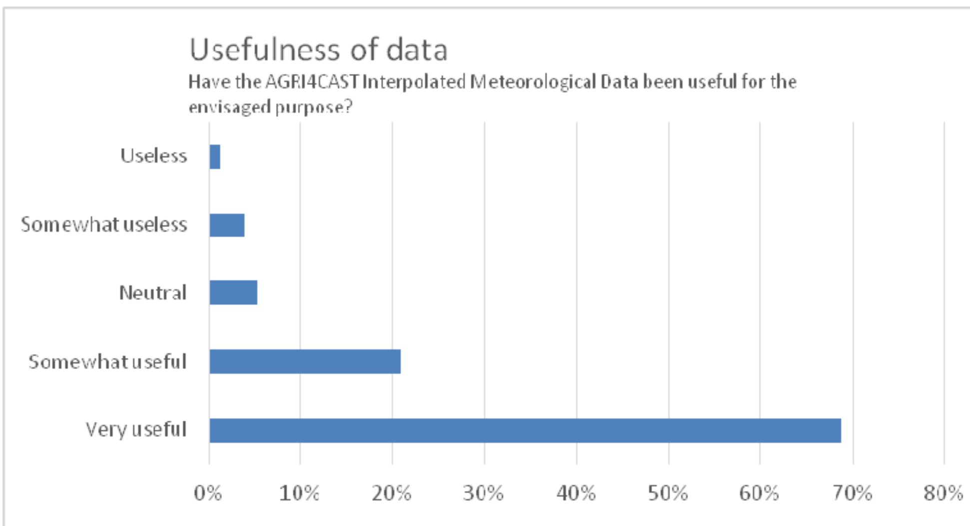

Figure 5. Usefulness of Interpolated Meteorological Data

Interpolated meteorological data proved to meet the expectations of the users, as 92% of the users have been able to use them for the intended purpose. Still, 8% of the user community re-used the information for other purposes. Indeed, 69% of the users rated the data very useful, adding 21% of useful rating. "Somewhat Useless" and "Useless" rating hardly reach 5% together. Same rating for 'Neutral' (Fig.5).

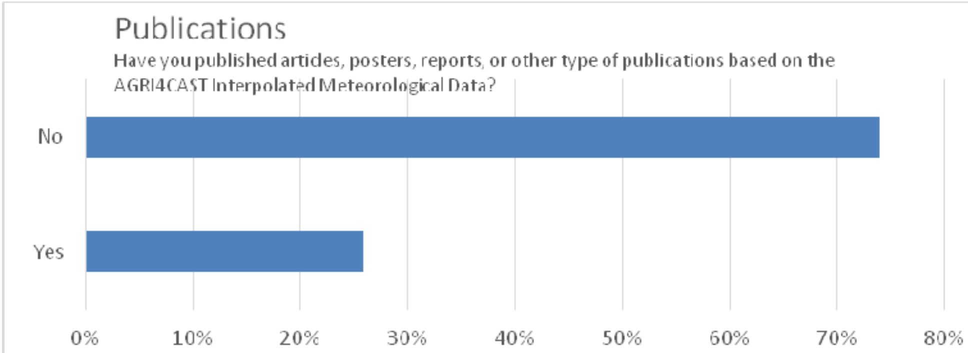

Figure 6. Publications based on Interpolated Meteorological Data

An interesting output of the survey was that 26% of the users (Fig.6) have used the data for producing publications (papers, posters, conference proceedings). As the visibility of the service, most of the users (51%) were recommended by colleagues, 18% discovered the data through the JRC web pages, 16% contacted JRC staff directly, and 6% learnt of the data through JRC events (Fig.7). Only 9% were able to discover the service through sources other than JRC.

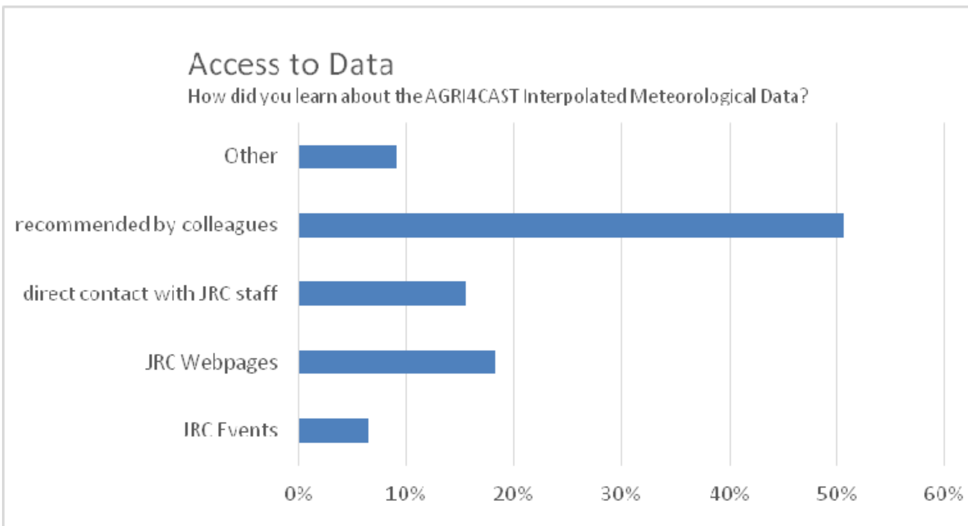

Figure 7. Access to the data

The user community encourages the continuation of the service and highlights the importance of the meteorological data especially for scientific studies. A very important feedback is the user appreciation for free data distribution.

On the other hand, users badly judged the procedure to get data through long and inefficient paper-based authorization process. Thus, the new data portal adopts an open access policy that will avoid unnecessary administrative burden for the users. A direct online registration procedure is expected to increase the number of users actually downloading data and to decrease the number of discouraged users. Authorization requests, though online, will be limited to restricted resources such as the heating and cooling degree days. Another useful feedback from users is the lack of detailed documentation for the methods of interpolation and description of the weather parameter. Finally, users suggested to implement a better dissemination strategy and increase the visibility of the current web platform.

5. METEOROLOGICAL DATA AND POLICY SUPPORT

The analysis of the projects supported by the Interpolated Meteorological Data shows that meteorological data are highly relevant for the development, implementation and assessment of a number of EU policy areas: agriculture, soil protection, environment, agriculture, food security, energy, climate change, health and sustainable development. Specific examples include:

Soil Protection: Temperature and precipitation data are included in models for soil organic carbon estimation at 0-30 cm[7]. The rainfall data are considered as an important input factor for the estimation of erosion by water both in the past application such as PESERA[8] and in recent developments such as RUSLE and G2[9] model. Wind speed is considered as main input factor for the qualitative wind erosion models[10].

Food security: The relative humidity data are used by the European Food Security Authority (EFSA) for assessment of pest risk. In research activities, precipitation and temperature data are used for the groundwater risk assessment for pesticides and pesticides exposure. Modelling activities have also used precipitation and temperature data for estimating plant health and growth at regional and European applications[11]. The most important use of meteorological data is the development of yield forecast at European scale implemented at the JRC and published through the MARS Bulletin[3]. Based on the current precipitation and temperature data and using past trends and statistical models, scientists can predict the crop growth and production of 18 crops.

Environment: Modelling activities use the rainfall, humidity and temperature data for the development of biomass production indicators, fire risk indexes, flood alerts[12], drought monitor data[13], soil moisture datasets and air quality indicators.

Agriculture: The rainfall data allow modellers to run scenarios about specific plant growth[11,14] (e.g. Citrus, cotton, maize, vegetable oil) and production in various regions of Europe. Moreover, the meteorological data have been used in genomic selection framework[15] of certain crops.

Energy: The datasets on heating degree days are used in the energy sector for estimating the heat recovery ventilation against natural ventilation[16]. The same dataset and the temperature data have been used by gas market.

Climate change: The meteorological datasets are time-series of more than 30 years. Those data have been also used in climate change modelling in detecting trends and identifying projections of rainfall decrease and temperature increase[17]. The impact of climate change to certain crops has also been investigated[18].

Research & Development: numerous of EU research projects in 6th and 7th framework programme (e.g. DESIRE, SEAMLESS, PRATIQUE, CARBOEUROPE, CIRCE, HAIR, GEOLAND-2, FUME) have requested the available datasets as input for their modelling activities.

Health: The data are useful input for exposure assessments[19] and forecasting seasonal diseases such as malaria, blue tongue.

Water management and water protection: The meteorological data have been used in the implementation of scenarios for future water usage in Europe.

6. CONCLUSIONS

The European Meteorological datasets developed by Joint Research Centre (JRC) have been proved to be a useful source of information for research and modelling purposes, as revealed by a dedicated user survey. Free availability, daily updates, the temporal coverage (more than 30 years) as well as the spatial coverage (European Union, neighboring countries and North Africa) are significant advantages of this product that has been already used in several different research fields, e.g.: climate change, food security, sustainable growth and agriculture.

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