Technical sheet

Policy
Italy: *Azioni del programma Rete Rurale Nazionale. Azione 4.2.1 Servizi per la diffusione della innovazione. C:/Users/Admin/Downloads/Allegato_azioni_RRN_Rev_Dic_2016..pdf; Law n. 4/2011 National Integrated Production Quality System; National guidelines for integrated crop production / phytosanitary defense and weed control (DM n.4890 of 08.05.2014). Strategia Nazionale di Adattamento ai Cambiamenti Climatici (SNAC), approvata dal MATTM - DG Clima ed Energia, con decreto direttoriale 16 giugno 2015, n. 86.*
Campania Region: *Integrated Production Regulations of the Campania Region (Decree n. 29 of 29.02.2019); Technical Rules for Defense Plant Health And Integrated Weeding ff Crops (Decree n. 27 of 19/03/2019)*

First draft

TOOL CLIMATE CHANGE RESILIENCE – *Territorial Scale: National, Regional*

WHY

Climate change, including changing in rainfall and temperature patterns, has both direct and indirect effects on agricultural productivity with drought, flooding and the geographical redistribution of pests and diseases. Plant phenology is strongly controlled by climate and the long term climate change will determine a shift in crop cycles and a change in the land suitability for specific crops. Future climatic scenarios need to be investigated in order to better plan on-farm management and territorial policy interventions so as to increase climate resilience of territories. Thus the aim of these climate change scenarios tools, is to support long-term land and farm planning that considers both: the future impacts on the vegetative crops cycles and the spatial variation in land suitability (in the current constrain of 8km pixel size). These land management strategies are also important for the reduction of the environmental impact of agriculture and the increasing of farm revenues.

FOR WHOM

The “Climate Change Resilience” tool can be used: (i) at national level to build the National Adaptation Strategy and National Adaptation Plan, (ii) by regional authorities having the task to build the adaptation strategy/plan and iii) both single farms and farm associations/consortia that plan agricultural activities affected by climatic impacts. The tool is also of interest for stakeholders (e.g. environmental protection authorities, water district authorities, regional parks, service management company, trade associations, non-profit associations, business groups) who are involved in national or regional planning of adaptation strategy/plan.

HOW – if you want to *select your Region Of Interest (ROI)*[i]

The tool can provide data for any site within the Italian territory and, potentially, for other regions in Europe. The user can select the Region of Interest (ROI) and retrieve the data of interest through a very simple procedure:

Operational procedure

- Simply select the Administrative limits or;
- Click on the "Draw (Polygon)" button on the top bar and draw the ROI boundary;
- Assign a name to the selected ROI[ii];
- Click on the "Save" button to keep the ROI available in the system for further queries.

TOOL LAND – GENERAL CLIMATIC ANOMALIES

HOW – if you are interested in retrieving “LAND – GENERAL CLIMATIC ANOMALIES”

Operational procedure

By selecting the "Climate change indicator" icon and then clicking on the "Land – General climatic anomalies" button from the Toolbox, the user can choose the region of interest previously saved (or Administrative limits), the IPCC scenario[iii] and the scenario period.

By accessing the “elaborations” sub-folder, in the “elaboration detail” folder, users can view - and download - the processing result, as a .pdf report that will contain the following climate anomaly set of indicators:

- Maximum Temperature anomaly Indicators
- Minimum Temperature Indicators
- Mean Temperature Indicators
- Precipitation anomaly indicators

Anomalies of the General Climatic Indicators are calculated (and thus reported) as the difference between the selected Scenario period (2011-2041 or 2041-2070 or 2071-2100) and the reference period (1981-2010), by taking into account the selected IPCC scenario (RCP4.5 or RCP 8.5)[iv].

What for

The tool can be used for having a general evaluation about the expected climatic changes with respect to the main general climatic indicators. For example, an analysis of scenarios can be used by a policy maker to design policies that promote, in the long term, land uses and crop systems that have less impact on territories.

TOOL CROP – THERMAL SUMS ANOMALIES

HOW – if you are interested in retrieving “CROP – THERMAL SUMS ANOMALIES”

Operational procedure

By selecting the "Climate change indicator" icon and then clicking on the "Crop – thermal sums anomalies" button from the Toolbox, the user can choose the region of interest[v] previously saved (or Administrative limits) and the crop type between 18 different species.

By accessing the “elaborations” sub-folder, in the “elaboration detail” folder, users can view - and download - the processing result, as a .pdf report; for each analyzed crop, specific temperature thresholds for sowing, emergence, flowering and harvesting were applied[vi]. Crop thermal indicators anomalies (mean value) have been calculated (and thus reported) as the difference between the future period (2021-2050) and the reference period (1981-2010)[vii]. The climate anomalies have been carried out by taking into account the IPCC (Intergovernmental Panel on Climate Change) scenarios RCP4.5 and RCP8.5.

What for

The tool can be exploited for the sustainable land planning and planning at farm level. For example, an analysis of scenarios can be used by a policy maker to design policies that promote, in the long term, land uses and crop systems that have less impact on territories. The same can be said of farmers who intend to plan their future farm activities by minimizing environmental impacts and wasting resources.

LIMITATIONS

Main limitations are due to the (i) the coarse spatial resolution (8 km); for this specific tool, CMCC suggests that reliable queries must refer to a minimum ROI of 5x5 pixel size (pixel width 8 km), (ii) For the current stage of development of the “crop- thermal sum” sub-tool, we have masked coastal and mountain areas to avoid erroneous results. Therefore, regions of interest close to coastal and mountainous areas can produce N/A values (see below for future development) (iii) inherent uncertainty of RCP climate scenarios.

FUTURE DEVELOPMENT

The active mask in coastal and mountainous areas, active for “CROP - THERMAL SUMS ANOMALIES” tool (see note v), will be better defined using higher resolution data and this will mitigate the occurrence of erroneous results in areas close to coasts and mountains.

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[i] Special care is required when user draws/select the Region of Interest. In fact LANDSUPPORT is a multi-scale decision support system. Each of the 15 available tools is designed for a specific application and for a specific scale. Furthermore, the databases using specific standards required for that specific scale. The users of LANDSUPPORT web platform must therefore be well aware

of the limitation embedded in the different maps that they require for their specific application. The users must be expert on their specific problem and must understand if the input data offered by the platform are suitable for their problem. In light of the above, the system provides very reliable results only if used appropriately.

[ii] It is also possible to draw a ROI with numerous polygons. In this case, it is possible to assign different values (eg numbers) to each of the drawn polygons.

[iii] The RCP (Representative Concentration Pathway) scenarios developed by the IPCC foresee an increase in greenhouse gas emissions in the future.

- The RCP 4.5 scenario is consistent with a reduction in emissions in the future: it assumes that by 2070 carbon dioxide (CO2) emissions will fall below current levels and the atmospheric concentration will stabilize by the end of the century at around double the pre-industrial levels.
- The RCP 8.5 scenario is consistent with a future in which no emission reduction policies will be implemented; it assumes that by 2100 the atmospheric CO2 concentration has tripled or quadrupled compared to pre-industrial levels.

For additional information on the RCP scenarios: https://ar5-syr.ipcc.ch/topic_futurechanges.php

[iv] Here is given a brief explanation on methods employed to calculate future climate anomalies.

The expected climate anomalies were obtained by using the high resolution regional climate model (RCM) COSMO-CLM (Rockel et al., 2008), with a configuration employing a spatial resolution of 0.0715° (about 8 km), optimized by CMCC over the Italian area. Data validations over different Italian regions, using high resolution observational datasets, showed a good model capability to represent, in terms of both average temperature and precipitation in Bucchignani et al. (2015) and in terms of extreme events in Zollo et al. (2015). Initial and boundary conditions for running RCM simulations with COSMO-CLM were provided by the general circulation model CMCC-CM (Scoccimarro et al., 2011), whose atmospheric component (ECHAM5) has a horizontal resolution of about 85 km. The simulations covered the period from 1971 to 2100; more specifically, the CMIP5 historical experiment (based on historical greenhouse gas concentrations) was used for the period 1976–2005 (Reference Climate scenario - RC), while for the period 2006–2100, a simulation was performed using the IPCC scenario mentioned.

[v] At the current stage of development, we have masked coastal and mountain areas to avoid erroneous results. Therefore, regions of interest close to coastal and mountainous areas can produce N/A values (see future development).

[vi] Here is given a brief explanation of on employed methods to obtained crop thermal indicators:

Crop thermal indicators anomalies (mean value) have been calculated (and thus reported) as comparison between the reference period (1981-2010) and the future period (2021-2050).

For each analyzed crop specific thresholds of temperature for sowing, emergence, flowering and harvesting were applied. As example here we provide a scheme for maize.

The starting data for identifying sowing dates and then following phase of thermal counting is different between the different species in agreement with the specific crop growing season. For instance:

Winter crops: 01 September - Sugar beet, Alfalfa, Fennel, Artichoke; 1 October – Oilseed rape; 01 November – Barley, Durum Wheat; 01 December – Rye.

Spring- Summer crops: 01 January – Soybean, Foxtail millet, Maize, Tomato, Potato, Zucchini, Eggplant.

Tables of specific crop: e.g. maize (summer crop)

Crop	Phenological phase	Thermal sum	Temperature		
			Base	Cutoff	Sowing
		GDD	(C°)		
Maize FAO class 700	Sowing	0	0	0	15
	Emergence	30	9	40	
	Flowering	1300	6	40	
	Harvest	3100	6	40	

Thermal indicators are evaluated as follows.

The procedure consists in four steps:

A. Identification of sowing date: steady mean temperature (e.g. equal or upper to specific threshold, e.g. for maize 15°C) for 7 consecutive days;

B. Thermal sum calculation using different zero vegetative temperature (Tbase) thresholds in agree with crop phenological stage (e.g. emergence, flowering, harvest: See the table above).
The applied formula is:

$$\text{GDDcrop} = \sum_{S}^{H} \text{Tmean} - \text{Tbase}$$

S= Sowing, H= Harvest, T mean= mean daily temperature.

C. Check whether the thermal crop requirement is achieved and determine in how many days. When the mean daily temperature is lower than the Tbase for more than 7 days the calculation is stopped (the crop does not close the cycle, then there is no adaptation in that specific year). Basically the model verifies when the following condition applies “7 consecutive days having Tmean<Tbase”. Once this condition applies, then the GDD calculus stops.

D. Once the crop phenological phases are identified and the crop cycle is achieved (point A, B and C), the probability of extreme thermal events during the flowering (hot wave) or in emergence stage (frosts) are calculated:
Extreme events (Emergence) Tmin<-2°
Extreme events (Flowering) Tmax>32°

The following indicators are calculated as variation from 1Jannuary (spring-summer crops) or 1 September (winter crops):

- Variation of Emergence crop stage Length (number of days)
- Variation of Harvesting crop stage Length (number of days)

Crop Indicators.

- Sowing period Length variation (number of days): refers to the change estimated as number of days of sowing period between the reference climate and future climate scenario analyzed. Negative numbers have to be interpreted as an anticipation of sowing date, while a positive value a postpone of it.
- Variation of Emergence crop stage Length (number of days): refers to the change estimated of the length (in days) of emergence plant phenological stage between the reference climate and future climate scenario analyzed. Negative numbers have to be interpreted as a contraction of sowing date, while a positive value as an expansion of it.
- Variation of Harvesting crop stage Length (number of days): refers to the change estimated of the length (in days) of harvesting crop phenological stage between the reference climate and future climate scenario analyzed. Negative numbers have to be interpreted as a contraction of sowing date, while a positive value as an expansion of it.
- Extreme events of minimum temperature (during the emergence period): refers to the change estimated of numbers of thermal extreme events (Tmin<-2 °C) during the emergence crop phenological stage between the reference climate and future climate scenario analyzed. Negative numbers have to be interpreted as a reduction of extreme events, while a positive value as an increase of that. The presence of low temperatures during the crop emergence can lead to a sensible reduction of crop production.
- Extreme events of minimum temperature (during the first 15 days of the emergence period): refers to the change estimated of numbers of thermal extreme events (Tmin<-2 °C) during the first 15 days after crop emergence between the reference climate and future climate scenario analyzed. Negative numbers have to be interpreted as a reduction of extreme events, while a positive value as an increase of that. The presence of low temperatures after the crop emergence can lead to a sensible reduction of crop production
- Extreme events of maximum temperature (during the flowering period): refers to the change estimated of numbers of thermal extreme events (Tmax>32 °C) during the flowering crop phenological stage between the reference climate and future climate scenario analyzed. Negative numbers have to be interpreted as a reduction of extreme events, while a positive value as an increase of that. The presence of high temperatures during the crop flowering can lead to a reduction of pollination with a negative effect on crop production
- Difference in crop adaptation (harvesting reached): refers to the estimated change in terms of number of years in which the crop is adapted (thus when specific crop thermal requirements have been reached) between the reference climate and future climate scenario analyzed. Negative numbers have to be interpreted as an improvement of crop adaptation, while a positive value a worsening.

[vii] The analysis of crops thermal sums anomalies was conducted by Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici -CMCC (Capua –CE, Italy) in collaboration with Institute for Mediterranean Agricultural and Forest Systems - CNR-ISAFOM (Ercolano -NA, Italy). Part of the work has been performed within of regional project “Reducing the distance between Research and agricultural companies –RURAL” (PSR Regione Campania 2014-2020 - Sottomisura 16.5 – Tipologia d'intervento 16.5.1).
These data are used and further geospatially processed in the framework of an agreed collaboration between CRISP University of Napoli Federico II and CMCC.

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