AgroMIND – Agro-meteorological Monitoring INDices

AgroMIND is a part of the cloud storage which hosts the materials of the Observatory for agricultural meteorology and climatology of the Research Center for Agriculture and Environment belonging to the Council for Agricultural Research and Economics (CREA). It stores data and maps related to agro-meteorological monitoring indices, with the aim of supporting agrometeorological services at national level.

The analysis of agro-meteorological and agro-climatic indices allows the understanding of the most important phenomena that affect agricultural production (both in terms of quantity and quality), the planning of farming practices and the management of land resources, such as water availability, heat accumulation for crop development or **weather extremes**. In fact, the increasing frequency of extreme weather events in recent decades makes it more and more difficult the agro-management and can compromise the very survival of the crops.

The indices can be calculated at different spatial and temporal scales, depending on the objectives of the analysis, as for instance the monthly scale for monitoring purposes or the seasonal/yearly one for research aims. Moreover, the analyses can be performed at a sub-annual scale, focusing on the most sensitive phenological phases for different crops.

One of the most important environmental factors affecting crop development and yield is the **air temperature**. Usually, it is described in terms of **heat accumulation** required to reach the different crop development phases. A higher than normal heat accumulation is generally associated with early crop development, while opposite conditions can lead to delays. Changes in the timing of phenological phases can weaken plants, as for example early flowering may increase the risk of damage from late frosts. Summer **heat waves** can also be a dangerous phenomenon during which temperatures remain much higher than average and can potentially damage crops, especially during the most sensitive development stages. Even more important is the analysis of **heat extremes** when temperatures exceed a critical threshold (that is generally set at 35 °C), damaging crops and hindering

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their physiological functions (Bois et al., 2014; He et al., 2018; Luo, 2011). Temperatures above average can besides cause problems during the winter season (the so-called "**mild winters**"), hindering the fulfillment of **chilling requirements** during the plant resting periods. In fact, low winter temperatures are essential both for stimulating frost-hardening and triggering the vegetative growth (Alastair, 2002). **Late frost** during the flowering period (on March and April in Italy) can seriously affect the productions.

Precipitation is the most important weather phenomenon affecting water resources management in agriculture. The prolonged absence or the excess of rain can influence the growing season, to the point of compromising productions, both in terms of quality and quantity, or plant life. In fact, water availability is especially important for crops growth, particularly for water intensive crops, and it is closely related to rainfall and its distribution during the crop year, as well as to crops evapotranspiration. A persistent water shortage can lead to **agricultural drought**, in which the soil moisture deficiency in the root zone can adversely affect crop development (Wilhite, 2000).

In this context, the most relevant phenomena are periodically monitored through the estimation of specific agro-meteorological indices. These indices are based on the MADIA daily gridded dataset over the Italian area (Parisse et al., 2023b), daily updated for internal use, that is built on the agro-meteorological variables derived from ERA5 hourly surface data. Further details on data pre-processing and computational methods are available in Parisse et al., 2023a.

The agrometeorological monitoring indices in Tab. 1 have a spatial resolution of 0.25° (horizontal resolution around 31 km) and consider an area within the coordinates 35.0° - 48.0° N, 6.0° - 20.0 which covers the Italian country. Some indices are estimated considering the **agricultural year**, defined as the period from the 1st November of the current year to the 31st of October of the following year. The monitoring also includes comparisons with the 1991-2020 reference period, in terms of departures from the average values (anomalies) or from several percentile thresholds. The map gallery of the current year is updated monthly.

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Table 1 - List of agrometeorological monitoring indices stored in the AgroMIND repository

Acronym	Definition	Units
TXa	Departure of maximum temperature from the reference period value	°C
TNa	Departure of minimum temperature from the reference period value	°C
TX90p	Warm days, defined as percentage of days when TX>90th percentile (*)	%
TN90p	Warm nights, defined as percentage of days when TN>90th percentile (*)	%
GDD0	Growing degree days, defined as cumulative sum since the 1st of January of daily mean temperature exceedances of 0 °C	°C
GDD0a	Departure of GDD0 from the reference period value	°C
GDD10	Growing degree days, defined as cumulative sum since the 1st of January of daily mean temperature exceedances of 10 °C	°C
GDD10a	Departure of GDD10 from the reference period value	°C
LFD0	Late frost days, defined as count when TN (daily minimum) < 0°C during the early boreal spring	days
LFD0a	Departure of LFD0 from the reference period value	days
HI	Huglin heliothermal index, defined as product of the accumulated daily mean and maximum temperatures with a 10 °C baseline and a latitude dependent coefficient (viticulture specific)	°C
HIa	Departure of HI from the reference period value	°C
RR	Total precipitation amount	mm
RRa	Percentage departure of RR from the reference period value	%
RX1day	Maximum 1-day precipitation amount (*)	mm
RX5day	Maximum consecutive 5-day precipitation amount (*)	mm
ETo	Daily reference crop evapotranspiration according to the FAO56 Penman-Monteith method	mm
EToa	Percentage departure of ETo from the reference period value	%
CWB	Climatic water balance, defined as difference between RR and ETo	mm
CWBa	Departure of CWB from the reference period value	mm
SPEI3	Standardized Precipitation Evapotranspiration Index at 3-month time scale, agricultural drought index based on CWB data (**)	Dimensionless
SPEI6	Standardized Precipitation Evapotranspiration Index at 6-month time scale, agricultural drought index based on CWB data (**)	Dimensionless

(*) https://www.clivar.org/clivar-panels/etccdi/indices-data/indices-data
(**) https://spei.csic.es/index.html

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