CLIMWAT 2.0 for CROPWAT

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CLIMWAT 2.0 for CROPWAT is a joint publication of the **Water Resources, Development and Management Service** and the **Environment and Natural Resources Service** of the Food and Agriculture Organization of the UN.

CLIMWAT 2.0 offers observed agroclimatic data of over 5000 stations worldwide distributed as shown below. CLIMWAT 2.0 has been produced in two versions; one containing the worldwide database and the second in which the databases are divided by continent. Both versions can be freely downloaded from: http://www.fao.org/landandwater/aglw/climwat.stm

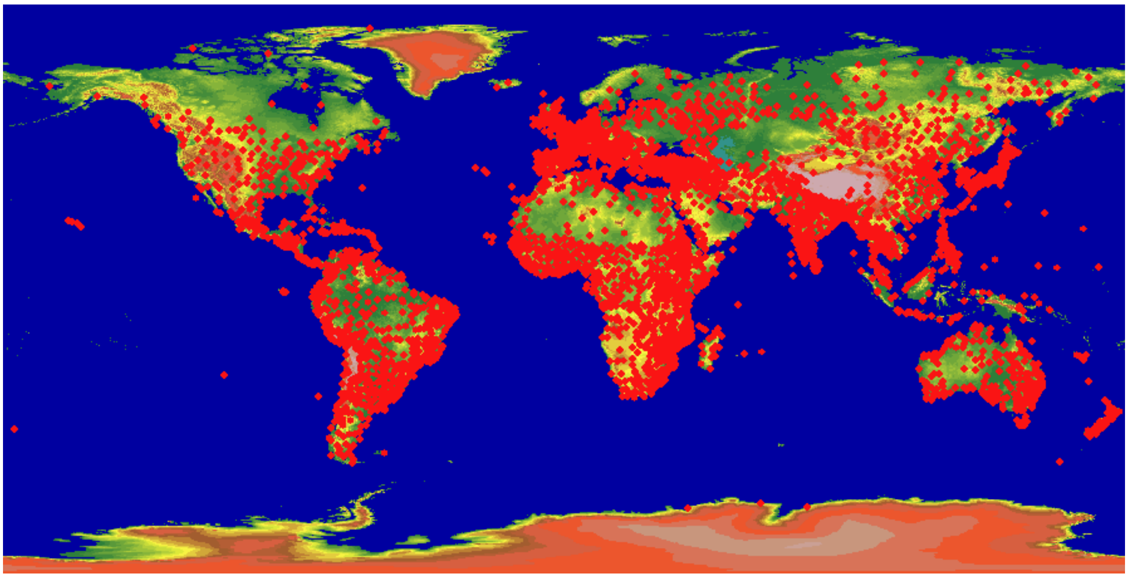

Fig. 1: Location of stations included in CLIMWAT 2.0.

CLIMWAT provides long-term monthly mean values of seven climatic parameters, namely:

- Mean daily maximum temperature in °C
- Mean daily minimum temperature in °C
- Mean relative humidity in %
- Mean wind speed in km/day
- Mean sunshine hours per day

- Mean solar radiation in $MJ/m^2/day$
- Monthly rainfall in mm/month
- Monthly effective rainfall in mm/month
- Reference evapotranspiration calculated with the Penman-Monteith method in mm/day.

The data can be extracted for a single or multiple stations in the format suitable for their use in CROPWAT (for further information on CROPWAT, visit (http://www.fao.org/landandwater/aglw/cropwat.stm). Two files are created for each selected station. As an example, these files are presented below in the case of Rome in Italy as displayed by CROPWAT. The first file (Rome.cli) contains long-term monthly rainfall data [mm/month]. Additionally, effective rainfall is also included calculated through the USDA Soil Conservation Service formula. Please refer to the Help information provided by CROPWAT for information on alternative methods for calculating effective rainfall.

Table 1: CLIMWAT rainfall data as displayed by CROPWAT 8.0.

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MONTHLY RAIN DATA
(File: C:\Program Files\CROPWAT\data\climate\Italy\ROME.cli)

Station: ROME

Eff. rain method: USDA Soil Conservation Service formula:
                  Peff = (Pdec * (125 - 0.6 * Pdec)) / 125  for Pmon <= 250 mm
                  Peff = 125 / 3 + 0.1 * Pdec  for Pmon > 250 mm


               Rain   Eff. rain
                mm        mm

January        81.0      70.5
February       68.0      60.6
March          71.0      62.9
April          64.0      57.4
May            56.0      51.0
June           38.0      35.7
July           16.0      15.6
August         25.0      24.0
September      65.0      58.2
October       124.0      99.4
November      112.0      91.9
December       98.0      82.6

Total         818.0     709.9
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As seen in Table 2 below, the second file consists of long-term monthly averages for seven climatic parameters, namely maximum temperature, minimum temperature, relative humidity, wind speed, sunshine hours, radiation balance and reference evapotranspiration calculated according to the Penman-Monteith method. This file also contains the coordinates and altitude of the location.

Table 2. CLIMWAT climatic data as displayed by CROPWAT 8.0.

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MONTHLY ETO PENMAN-MONTEITH DATA
(File: C:\Program Files\CROPWAT\data\climate\Italy\ROME.pen)

Country: Location 9864             Station: ROME
Altitude: 17 m.                    Latitude: 41.90 °N     Longitude: 12.48 °E


Month      Min Temp  Max Temp  Humidity    Wind    Sunshine Radiation    ETo
              °C        °C         %      km/day    hours   MJ/m²/day   mm/day

January      4.5       11.1       77       181       3.4       6.0       0.88
February     5.4       12.6       75       164       3.4       7.9       1.17
March        7.2       15.2       70       181       4.7       11.9      1.90
April        9.8       18.8       69       156       5.9       16.2      2.66
May          13.3      23.4       66       147       7.2       19.8      3.63
June         17.2      27.6       61       130       7.8       21.4      4.41
July         19.6      30.4       56       130       9.7       23.6      5.16
August       19.4      29.8       58       130       8.9       20.9      4.63
September    16.9      26.3       67       121       7.2       15.9      3.25
October      12.8      21.5       73       147       5.3       10.6      2.03
November     9.3       16.1       77       156       3.2       6.3       1.18
December     6.4       12.6       78       164       2.6       4.9       0.86

Average      11.8      20.4       69       150       5.8       13.8      2.65
```

All station information is drawn from the database of The Agromet Group of FAO (agromet@fao.org).

Humidity and radiation can be expressed through different variables. With respect to humidity, data can be provided as relative humidity, dew point temperature or water vapour pressure. These three variables can be uniquely converted into each other if the mean temperature is known. However, if humidity is measured and provided in more than one of these variables, the actual numbers would not necessarily be in line. In this case one has the freedom to decide which variable to use. We decided to use water vapour pressure as a core variable and only where it is not available, use dew point temperature and relative humidity. However, there is a risk that the provided value of vapour pressure is higher than the one that is possible to obtain, given the mean temperature. The original databases were crosschecked for this possible inconsistency and one of the other variables was used in the few cases where it occurred.

The same problem arises with radiation. Instead of the solar energy flux at the surface often only sunshine hours or sunshine fraction are provided, which can be converted to radiation. In order to calculate evapotranspiration using the Penman-Monteith method, one needs both radiation and sunshine fraction. To keep both these values in agreement we used the observed radiation as base variable and estimated sunshine fraction from it. When only the sunshine fraction (or hours) has been observed we used this to estimate radiation. If both (fraction and radiation) are observed radiation is preferred.

As a result, the provided relative humidity and sunshine hours are often deduced from observations of vapour pressure and radiation, even if the former are observed. The procedure, however, ensures that the different expressions are in line.

All variables, except potential evapotranspiration, are direct observations or conversions of observations. Penman-Monteith evapotranspiration is calculated mainly in accordance with the FAO Irrigation and Drainage Paper 56, entitled *Crop Evapotranspiration – Guidelines for Computing Crop Water Requirements* (hereinafter FAO56). However, there are some minor deviations from the FAO56 where more recent knowledge is available. This is the case with respect to the estimates of mean monthly water vapour pressure from mean relative humidity and temperatures. Whilst the original FAO56 suggests using minimum and maximum temperatures to estimate the saturation vapour pressure, when only average relative humidity is available, conceptual investigations and newer analysis of observations suggest using the mean daily temperature instead yields more accurate results (forthcoming new editions will be changed accordingly). Therefore, instead of using equation (19) of FAO56 we used:

$$e_a = \frac{RH_{mean}}{100} e_0\left(T_{mean}\right)$$

Where $e_o(T_{mean})$ is calculated using equation (11). Furthermore, instead of equation (23) of FAO56 we used the better approximations of the inverse relative Earth-Sun distance

$$d_r = \frac{1}{\left[1 - .01673 \cdot \cos\left(0.017214 \cdot \left(j - 1\right)\right)\right]^2}$$

where j is the number of the Julian day of the year.

For the solar declination we used

$$\delta = \delta_0 + \sum_{i=1}^{4} \left(A_i \cdot \cos\left(p_i\right) + B_i \cdot \cos\left(p_i\right)\right)$$

with

$p_i = i \cdot p_0,\ p_0 = .017214 \cdot j - 3.1588$

and the coefficients δ_0=0.39508 and the coefficients

A(1) = 22.85684,	B(1) = -4.29692,
A(2) = -0.38637,	B(2) = 0.05702,
A(3) = 0.15097,	B(3) = -0.09029,
A(4) = -0.00961,	B(4) = 0.00593.

Though these approximations are more precise than the corresponding equations in FAO56 the differences are below 1%.

We prepared the dataset and the extraction software with great care and made every effort to provide reliable data. However, we cannot ensure that all the observations that went into the procedure are free of errors.

Disclaimer: