Carrega I87

Description

The I_{87} was developed by Carrega (1988, 1991) in order to predict fire danger in Southern France. It is based on the principle that fire occurrence and fire spread are conditioned by the combined effects of wind, air humidity, temperature and soil water reserves (i.e. surface and deep reserves). The I_{87} requires thus air temperature and relative humidity, wind speed, and potential evapotranspiration (according to Thornthwaite 1948) as input variables. It also includes a phenological coefficient in order to take seasonal differences in vegation condition into account (Carrega 1988).

Formula

The I_{87} is calculated as follows Carrega 1988):

$$I_{87} = \frac{1}{\sqrt{\bar{r} \cdot r_s}} \cdot max[10, T] \cdot \frac{U}{H} \cdot PC$$

where r is the deep water reserve [mm] corresponding to the Orieux water reserve r (cf. Orieux 1974), r_s the surface water reserve [mm], T air temperature [°C], U mean wind speed [m/s], H relative air humidity [%], and PC a phenological coefficient.

PC equals 200 in winter and in summer when r is smaller than 50 [mm] or when grass is yellowed, 100 in spring and in autumn when grass is green.

Carrega (1988) set the maximum surface water reserve r_s to 10 [mm], and assumed that r_s decreases exponentially as a function of the cumulated daily values of potential evapotranspiration (according to Thornthwaite 1948). It is assumed that r_s cannot be lower than 1 [mm]. r_s is calculated as follows:

$$r_s = 10^{\frac{15 - \sum PET}{15}}$$

Similarly to the Orieux water reserve r, r_s increases when rainfall occurs until reaching the saturation water capacity (i.e. 10 [mm]). r_s also increase when dew occurs. One millimeter of water is arbitrarily added to r_s for a night with dew, and two millimeters in the case of a night with a strong dew.

Similarly to the Orieux water reserve, the exact computation procedure is not indicated in the original publication. Probably due to empirical reasons the term 15 was used and not the $r_{s_{max}}$ (in this case 10 mm) and the base of 10 instead of e. We therefore propose to use one of the following formulations:

The daily water balance r_{s_t} could be calculated as follow:

$$r_{s_t} = max\left[1, min\left[r_{s_{max}}, r_{s_{t-1}} + P_t + Pdew_t - \frac{r_{s_{t-1}}}{r_{s_{max}}} \cdot PET_t\right]\right]$$

where P_t is daily rainfall [mm], and

$$Pdew_t = \begin{cases} 1\,\text{mm}, & \text{for a night with dew} \\ 2\,\text{mm}, & \text{for a night with strong dew} \end{cases}$$

is the amount of water to be added in case of dew during the night.

Otherwise we could use following procedure:

$$r_{s_t} = 10^{\frac{15-PETcum_t}{15}}$$

with

$$PETcum_t = \begin{cases} min[15, PETcum_{t-1} + PET_t], & \text{if } P_t = 0 \\ max\left[0, 15 - 15 \cdot log_{10}\left(r_{st-1} + P_t - \dfrac{r_{s_{t-1}}}{r_{s_{max}}} \cdot PET_t\right)\right], & \text{if } P_t > 0 \end{cases}$$

NB1: The exponential function to describe r_s is questionable, since in the example brought by the author, in case of no rain, the reserve decrease from 10 to 3.98 mm with a PET of 6 mm, thus of an amount of 6.02 which is bigger than 6 (theoretically should be of an amount smaller than PET, corresponding to the real ET). We therefore suggest to use the first formulation (water balance).

NB2: in the last formulation of r_s dew has been omitted.

The I_{87} can be calculated on a hourly basis, according to the availability of meterological data. However the values of r and r_s are calculated only daily, notably at 6:00 in the morning.

No particular values or conditions are required when starting the index calculation. But the deep and surface water reserves have to be saturated, as e.g. after strong rainfall. Thus the starting values of r and r_s have to be set to 150 [mm], 10 [mm] respectively.

Index interpretation

High index values correspond to high fire danger. Values above 100 indicate a very high fire danger.

References

Original publications:
Carrega (1988)
Carrega (1991)

Other publications:
Thornthwaite (1948)
Orieux (1974)