Fine fuel moisture code

Description

The Fine fuel moisture code ($FFMC$) is one of the three fuel moisture code components of the Canadian forest fire weather index (
FWI) system. The $FFMC$ represents the moisture content of litter and other cured fine fuels in a forest stand, in a layer of dry weight about 0.25 kg/m2, and assesses the relative ease of ignition and the flammability of fine fuels at mid-afternoon. It requires temperature, relative air humidity, wind speed and precipitation (at noon) as input data (Van Wagner 1987).

Like the two other fuel moisture codes of the
FWI (cf.
DMC and
DC), the $FFMC$ comprises two phases: one for wetting by rain and one for drying.

As the $FFMC$ measures the moisture content in fine surface fuels, it is well appropriated for predicting fire occurrence (Van Wagner 1987).

Formula

The $FFMC$ is calculated as follows (Van Wagner and Pickett 1985):

First, the previous day's $FFMC$ becomes $FFMC_{t-1}$.

Then, the fine fuel moisture content from the previous day m_{t-1} has to be calculated:

$$m_{t-1} = 147.2 \cdot \frac{101 - FFMC_{t-1}}{59.5 + FFMC_{t-1}}$$

In case of rain (i.e. when $P > 0.5, cf. below$), $the fine fuel moisture content of the current day \ (m_{r_t}$ for wetting phases (which will become the new m_{t-1}) is calculated as follows:

$$m_{r_t} = \begin{cases} m_{t-1} + 42.5 \cdot P_f \cdot \left(e^{\frac{-100}{251 - m_{t-1}}}\right) \cdot \left(1 - e^{\frac{-6.93}{P_f}}\right), & \text{for } m_{t-1} \leqslant 150 \\ m_{t-1} + 42.5 \cdot P_f \cdot \left(e^{\frac{-100}{251 - m_{t-1}}}\right) \cdot \left(1 - e^{\frac{-6.93}{P_f}}\right) + 0.0015 \cdot (m_{t-1} - 150)^2 \cdot P_f{}^{0.5}, & \text{for } m_{t-1} > 150 \end{cases}$$

where P_f is effective rainfall [mm] and calculated as follows:

$$P_f = P - 0.5, \text{ for P} > 0.5$$

where P [mm] is rainfall in open measured once daily at noon.

NB: if m_{r_t} > 250, then m_{r_t}=250

Then, the fine fuel moisture content for drying phases where E_d has to be calculated as follows:

$$E_d = 0.942 \cdot H_{12}^{0.679} + 11 \cdot e^{\frac{H_{12}-100}{10}} + 0.18 \cdot (21.1 - T_{12}) \cdot (1 - e^{-0.115 \cdot H_{12}})$$

where H_{12} is relative air humidity [%] and T_{12} air temperature [°C] at noon.

- If E_d is smaller than m_{t-1}, then the log drying rate k_d has to be calculated with the following equations:

$$k_o = 0.424 \cdot \left(1 - \left(\frac{H_{12}}{100}\right)^{1.7}\right) + 0.0694 \cdot U_{12}^{0.5} \cdot \left(1 - \left(\frac{H_{12}}{100}\right)^{8}\right)$$

$$k_d = k_o \cdot 0.581 \cdot e^{0.0365 \cdot T_{12}}$$

  where U_{12} is wind speed [km/h] at noon.

  Then, the fine fuel moisture content m can be calculated as follows:

$$m = E_d + (m_{t-1} - E_d) \cdot 10^{-k_d}$$

- If $E_d is greater than \(m_{t-1}$, then the fine fuel equilibrium moisture content for wetting phases E_w has to be calculated instead:

$$E_w = 0.618 \cdot H_{12}^{0.753} + 10 \cdot e^{\frac{H_{12}-100}{10}} + 0.18 \cdot (21.1 - T_{12}) \cdot (1 - e^{-0.115 \cdot H_{12}})$$

  - If E_w is greater than m_{t-1}, then the log wetting rate k_w has to be calculated with the following equations:

$$k_1 = 0.424 \cdot \left(1 - \left(\frac{100 - H_{12}}{100}\right)^{1.7}\right) + 0.0694 \cdot U_{12}^{0.5} \cdot \left(1 - \left(\frac{100 - H_{12}}{100}\right)^{8}\right)$$

$$k_w = k_1 \cdot 0.581 \cdot e^{0.0365 \cdot T_{12}}$$

    Then, the fine fuel moisture content m can be calculated as follows:

$$m_t = E_w - (E_w - m_{t-1}) \cdot 10^{-k_w}$$

  - If $E_w \leqslant m_{t-1} \leqslant E_d$, then $m_t = m_{t-1}$

Finally, the $FFMC$ is calculated as follows:

$$FFMC_t = 59.5 \cdot \frac{250 - m_t}{147.2 + m_t}$$

The $FFMC$ is supposed to be calculated on a daily basis. The meteorological data used for its calculation have to be recorded at noon (for fire danger prediction at about 4 pm).

The $FFMC$ calculation starts, in regions normally covered by snow in winter, on the third day after snow has essentially left the area. In regions where snow cover is not a significant feature, the calculation starts on the third successive day with noon temperature greater than 12 °C (Lawson and Armitage 2008). The starting value of the index has to be set to 85.

References

Original publications:
Van Wagner and Pickett (1985)
Van Wagner (1987)

Other publication:
Lawson and Armitage (2008)
