Climatic forest fire indices

1 Forest Fire Index (Käse), I_C

The index I_C according to (Käse, 1969) is calculated for days d with $46 \le d \le 274$.

The daily index

1. $$I_{C,d} = k_p \cdot I_{C,d-1} + k_{phen} \cdot (T_{\max} + 10) \cdot \Delta vp \qquad (0.0.1)$$

with:

Δvp - air vapour pressure deficit at 13 h, calculated by

$$\begin{aligned} P_{sat}^{13} &= 6.1078 \cdot e^{\left(\frac{17.62 \cdot T_{\max}}{243.12 + T_{\max}}\right)} \\ P_{vap}^{13} &= P_{sat}^{13} \cdot h_r / 100 \\ \Delta P_{vap} &= P_{sat}^{13} - P_{vap}^{13} \end{aligned} \qquad (0.0.2)$$

T_{max} – maximum daily temperature [°C]

h_r – relative humidity

Precipitation modifier, k_p

$$k_P = \begin{cases} 0 & if\ P_d \ge 10\ \ or\ \ n_{snow} > 2 \\ 0.25 & if\ 5 \le P_d < 10\ \ or\ \ n_{snow} = 2 \\ 0.5 & if\ 1 \le P_d < 5\ \ or\ \ n_{snow} = 1 \\ 1.0 & else \end{cases} \qquad (0.0.3)$$

with n_{snow} - number of snow days

P_d – daily precipitation [mm]

Phenology modifier, k_{phen}

$$k_{phen} = \begin{cases} 0.5 & if\ d_{endVP} < d\ and\ P_d \ge 5 \\ 1.0 & if\ d_{BB,robinia} < d < d_{endVP}\ and\ P_d \ge 5 \\ 2.0 & if\ \ d_{BB,birch} < d < d_{BB,robinia}\ and\ P_d < 5 \\ 3.0 & if\ d < d_{BB,birch} \end{cases} \qquad (0.0.4)$$

The day of bud burst for birch is calculated according to the 4C approach (Schaber, 2002). The day of bud-burst for black locust is determined with a simple temperature sum model: The d_{BB} is reached, when the temperature sum, T_{sum}, is above a critical value T_{crit} = 537 degree days.

T_{sum} is calculated by:

$$T_{sum} = \sum_{d=1}^{d_{BB}} T(d) \qquad (0.0.5)$$

The daily fire hazard level is calculated according to Table 1.

Table 1 Fire hazard level definition

fire hazard level (international)	Fire alert level (German)	Condition
1	0	$I_{C,d} \leq 500$
2	1	$500 < I_{C,d} \leq 2000$
3	2	$2000 < I_{C,d} \leq 4000$
4	3	$4000 < I_{C,d} \leq 7000$
5	4	$7000 < I_{C,d}$

Annual fire risk index $I_{C,a}$ calculated as average of the daily fire hazard levels (Mid February through October).

2 Bruschek-Index, I_A

The annual index I_A for forest fire risk according to (Bruschek, 1994) is defined:

$$I_A = n_h \Big/ \sum_{d=91}^{274} P_d \qquad (0.0.6)$$

n_h - number of hot days between day 91 and day 274, a hot day is defined as a day with a maximum temperature greater or equal than 25°C.

P_d – daily precipitation

3 Nesterov-Index, I_N

The simple fire danger rating index I_N developed by (Nesterov, 1949) describes the daily ignition risk of the forest floor in dependence of the maximum day temperature T_{max} and dew point temperature T_{dew}. The index is calculated for days d with $60 < d < 275$, $T_{max} > 0$ °C, and without snow cover. I_N^{val} ist the cumulative sum for periods of consecutive days with precipitation less than 3 mm. If the precipitation is greater than 3 mm, the index is set to zero and the process starts again. The Nesterov-Index is defined by

$$I_N^{val}(t_i) = \sum_{i=1}^{n} \left(T_{max}(t_i) - T_{dew}(t_i)\right) \cdot T_{max}(t_i) \qquad (0.0.7)$$

with

n - number of consecutive days with precipitation less than 3 mm

t_i - day of the year with precipitation less than 3 mm.

The dew point temperature is defined as that temperature at which the actual water vapour corresponds to 100 % relative humidity and the actual vapour pressure P_{vap} is equal to the saturated vapour pressure. It is less or equal than the actual air temperature and does not depend on it. The calculation follows (DVWK, 1996)

$$T_{dew} = a \cdot \frac{\ln P_{vap} - c}{b - \ln P_{vap}} \qquad (0.0.8)$$

with

a, b, c - parameters (see Table 2).

Table 2 Parameters of calculation of dew point temperature (DVWK, 1996) in dependence on air temperature T

Scope of application	a	b	c
T ≥ 0°C	243.12	19.43	1.81
T < 0°C	272.20	24.27	1.81

Because of the cumulative addition over the days since last precipitation the value of the index I_N^{val} increases each day of the considered period. For each day the Nesterov-index as a fire danger level will be determined (Table 3).

Table 3 Fire danger levels of Nesterov-Index

Value of I_N^{val}	Fire danger	Level of I_N
$I_N^{val} \leq 300$	minimal	1
$300 < I_N^{val} \leq 1000$	moderate	2
$1000 < I_N^{val} \leq 4000$	high	3

$I_N^{val} > 4000$	extreme	4

4 References

Bruschek, G.J., 1994. Waldgebiete und Waldbrandgeschehen in Brandenburg im Trockensommer 1992. In: H.-J. Schellnhuber, Enke, W., Flechsig, M (Editor), Extremer Nordsommer 1992. PIK-Report. PIK, Potsdam, pp. 265-298.

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