Climatic and continentality indices

In 4C a variety of climatic and continentality indices are implemented. Short descriptions are given in the following tables (Table 1, Table 9) together with classification tables.

Table 1 Climatic indices

	Indices	4C variable
1.	$I_{Cm} = \frac{12n}{t+10}$ with $t < 0$ $I_C = 12n$ $I_C = \frac{1}{12}\sum_{m=1}^{12} I_{Cm}$ I_{Cm}– monthly value, I_C - annual value Limit of aridity I=20 (Coutagne, 1935) monthly, annual	I_cout
2.	$I_W = \frac{12n}{t+7}$ with $t < 0$ $I_W = 12n$ Limit of aridity I=20 (Wissmann, 1939), monthly, annual	I_wiss
3.	$I = \frac{P}{T+10}$ with $T < -9.9$ = 100 (De Martonne, 1941) annual, see Table 2	I_mart
4.	$AI = \frac{P}{PET}$ (UNEP, 1992) monthly, annual, see Table 3	I_arid
5	CWB=P – PET	Cwb_an

	Indices	4C variable
	(DWD)	
6	$$Q = \frac{P \cdot 100}{2 \cdot \left[\left(\frac{M+m}{2} \right) \cdot (M-m) \right]} = \frac{P \cdot 100}{(M^2 - m^2)}$$ Emberger – ‚quotient pluviothermique' (Wangerin, 1933) annual, for region with winter precipitation, see Table 4	I_emb
7	$$I = \frac{P}{T}$$ **(Lang, 1915), see** Table 5	I_lang
8.	$$I = \frac{P}{1.025^{(1.8T+32)}}$$ Bailey I threshold subhumid/semiarid = 12 $$I = P - (T + 0.05 \cdot T^2)$$ (Schreiber, 1973) approximated with: Bailey II threshold subhumid/semiarid = 26 (Bailey, 1958)	
9.	$$I = \frac{P}{3 \cdot (1.5 \cdot T + 0.04 \cdot T^2 + 20)}$$ Schreiber I >1 perhumid; <1 subhumid	

	Indices	4C variable
	$I = \frac{P}{1.5 \cdot (1.5 \cdot T + 0.04 \cdot T^2 + 20)}$ Schreiber II >1 humid; <1 subhumid $I = \frac{P}{1.5 \cdot T + 0.04 \cdot T^2 + 20}$ Schreiber III >1 subhumid; <1 semiarid $I = \frac{P}{0.5 * (1.5 \cdot T + 0.04 \cdot T^2 + 20)}$ Schreiber IV <1 arid (Schreiber, 1973)	
10.	$I = \frac{P + p}{(T + 10) \cdot 180}$ annual (Reichel, 1928), ((Mitscherlich, 1949; Mitscherlich, 1950a; Mitscherlich, 1950b), see Table 6	I_reich
11	$I = \frac{P \cdot pn \cdot (Z - 60)}{(T_{mj} + 10) \cdot 92 \cdot 100}$ (Weck, 1954), annual	I_weck
12	$D = \frac{R_n}{\lambda P \cdot 1000}$ annual, Dryness, Budyko radiation index, λ= 2.51 MJ kg^{-1} enthalpy of evaporation (Nikol'skii et al., 2006), classification see	I_Budyko

	Indices	4C variable
	Table **7**	
13	$I_A = \frac{N_h}{\sum_{d=91}^{274} P_d}$ Index according to (Bruschek, 1994), Climatic fire risk	Fire_indb
14	$IN = \sum_{i=60}^{275} (T_{max}(i) - T_{tau}(i)) * T_{max}(i)$ Index according to Nesterov Summation for days i with daily P(i) < 3 mm and $T_{max}(i) > 0$. (Fosberg et al., 1996), see Table 8	I_Nesterov
15	$SHC = \frac{\left(\sum_{i=1}^{dn} Pd_i(T_i \geq 10°C)\right) \cdot 10}{\left(\sum_{i=1}^{dn} T_i(T_i \geq 10°C)\right)}$ Index according to Seljaninov (hydrothermal coefficient) (Ray et al., 2016), calculated from daily precipitation and temperature, see Table 9	Ind_SHC

Variables:

n – monthly precipitation sum [mm]

t – monthly mean temperature [°C]

P – annual precipitation sum [mm]

P_d – daily precipitation

pn – number of days with precipitation >=0.1mm May - July

PET – potential evapotranspiration

M- mean temperature of the warmest month

m – mean temperature of the coldest month

T – mean annual temperature [°C]

T_{mj} - mean temperature May – July

T_{tau} – dew point temperature, calculated (DVWK, 1996)

R_n – annual net radiation sum [kJ m^{-2}]

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

Table 2

I (Martonne)	classification
> 60	perhumid
60 - 30	humid
30 -20	subhumid
20 - 15	Semiarid
15 - 5	Arid(Steppe)
5 - 0	Extrem arid (desert)

Table 3

AI (UNEP)	classification
< 0.05	hyperarid
0.05 < AI < 0.2	arid
0.2 < AI < 0.5	semi-arid
0.5 < AI < 0.65	dry subhumid

Table 4

Emberger	classification
>90	humid
90-50	subhumid
50-30	semiarid
<30	arid

Table 5

Linsser/Lang	classification
>160	humid
160-100	wet temperate
100-60	warm temperate
60-40	semiarid
<40	arid

Table 6

Reichel (Mitscherlich)	classification
pine	26 - 44
oak	30 (northeast Germany) – 55 (Nordspessart)
Beech (growing area)	30 (northeast Germany) - >60 (Südschwarzwald)

Table 7 According to (Giese, 1969)

	Budyko-Index	Geobot. characteristics

	Budyko-Index	Geobot. characteristics
Excessive wet	< 0.45	Arctic desert, Tundra, forest tundra, Alpine grassland
Wet	0.45 -1.0	forest
Insuffcient wet	1.0 – 3.0	Forest steppe, steppe, Xerophyt. Subtropic vegetation
Dry	> 3.0	desert

Table 8 Nesterov-Index

Forest fire danger	Nesterov-value	Nesterov-Index
minimal	IN < 300	1
moderate	300 < IN< 1000	2
high	1000 < IN < 4000	3
Extremly high	4000 < IN	4

Table 9 Index SHC

SHC	**Characteristics**
<0.5	Extremely dry
0.5 – 0.7	Very dry
0.7 – 0.9	dry
1.0 – 1.3	Insufficiently wet
1.3 – 1.5	Moderately wet

1.5 – 2.0	wet
2.0 – 3.0	Very wet
➢ 3.0	Extremely wet
1. – 1.5	Optimum climatic conditions for outbreaks of Dendrolimus pini
1.2	Area with most serious outbreaks
>1.5	Too humid for outbreaks
<1.0	Too dry for outbreaks

Table 10 Continentality indices

	Continentality indices	4C
1.	$K = 1.7 \frac{A_j}{\sin(f(\varphi))} - 20.4$ (Gorczynski, 1920)	CI_gor
2.	$IC = \frac{M - m}{\left(1 + \frac{1}{3}\varphi\right)}$ (Currey, 1974) annual, see Table 11	CI_cur
3.	$IC = 1.7 \cdot \frac{M - m}{\sin(f(\varphi + 10))} - 14$ (Conrad, 1946), annual, see Table 11	CI_con

A_J – amplitude of the annual temperature [K] (=M-m)

AT – amplitude of the mean daily temperature [K]

φ…latitude

f - recalculation of degree in Radian: $f(\phi) = \frac{\phi \cdot 0.5 \cdot \pi}{90}$

Table 11

IC (Currey)	Classification
0-0.6	hyperoceanic
0.6 – 1.1	oceanic
1.1 – 1.7	subcontinental
1.7 -2.3	continental
2.3 – 5.0	hypercontinental
IC (Conrad)	**Classifikation**
-20 - 20	hyperoceanic
20 - 40	oceanic
40 - 60	subcontinental
60 - 80	continental
80 - 120	hypercontinental

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