Climatic Classification after Thornthwaite : 1931 and 1948

Part II (1+1+1 System) Geography Hons.
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Two classifications of climate developed by the American climatologist C.W. Thornthwaite need to be distinguished apart, one dated 1931 (when he applied it to North America) and 1933 (he extended the system to the world) and the other dated 1948.

Superficially the two systems appear relatively similar, although their author quite rightly insists that they are fundamentally different.

Thornthwaite's 1931 classification

It departs from the Koppen system primarily in its use of expressions for precipitation effectiveness and temperature efficiency.

The effectiveness of precipitation is regarded as a function of precipitation and evaporation and is calculated by dividing the monthly precipitation by the monthly evaporation, to find the P/E ratio.

The sum of the 12 monthly P/E ratios becomes the P/E index.

Faced with a widespread lack of data on evaporation, Thornthwaite developed a formula to express the P/E index in terms of precipitation and temperature. For each month the ratio

$$\text{P/E ratio} = 115(r/t - 10)^{10/9}$$

where, r = Mean monthly precipitation in inches
t = Mean monthly temperature in °F

Based upon the P/E index, Thornthwaite distinguished five humidity provinces each of which appears to be associated with a characteristic vegetation type.

Humidity province	Characteristic vegetation	P/E Index
A, wet	Rainforest	128 & above
B, humid	Forest	64 - 127
C, subhumid	Grassland	32 - 63
D, semiarid	Steppe	16 -31
E, arid	Desert	Under 16

The five principal humidity provinces are subdivided into four subtypes based upon seasonal concentration of precipitation:

r =	Rainfall abundant at all seasons
s =	Rainfall deficient in summer
w=	Rainfall deficient in winter
d =	Rainfall deficient in all seasons

In a similar manner, temperature efficiency ratio (T/E) can be computed. Temperature efficiency is a function of monthly temperature yields.

$$\textbf{T/E index = sum of twelve monthly value } \left(\frac{t-32}{4}\right)$$

where, t = Mean monthly temperature in °F

Based upon the thermal efficiency six temperature provinces are recognized:

Temperature province	T/E Index
A', tropical	128 & above
B',mesothermal	64 - 127
C', microthermal	32 - 63
D', taiga	16 -31
E', tundra	1 - 15
F', frost	0

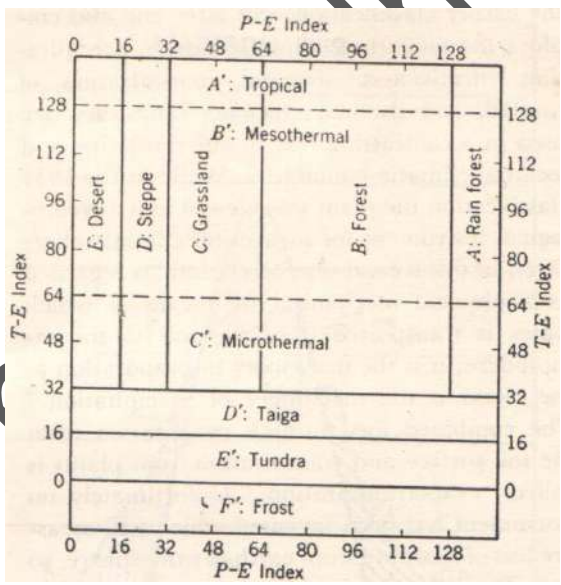

Fig.: Temperature and humidity provinces according to Thornthwaite system of climatic classification

Theoretically 120 combinations of the three elements, precipitation effectiveness, seasonal concentration of rainfall and temperature efficiency are possible. Nowhere near had all these combinations actually occur and he recognized 32 climatic types.

Salient features of 1931 classification

The classification is very much similar to Koppen in that

- It attempts to define boundaries quantitatively
- It is based on vegetation

- Employs combination of symbols to designate climatic types

It differs from Koppen classification in that

I. Koppen employed simple temperature and and precipitation values as limiting boundaries, whereas Thornthwaite introduced new concepts, temperature efficiency and precipitation effectiveness. This new concept cannot be expressed in ordinary climatic values. Consequently the boundaries are not easily comprehended.
II. The number of different climatic types appearing on the world map of Thornthwaite reaches a total of 32, approximately three times the number of Koppen types.
III. In Thornthwaite classification, the number of symbolic letters is few and their combinations are simple and easy to remember.
IV. The climatic types have no descriptive names, so that they can be designated only by their letter formulas.

Weakness:

I. Like Koppen's classification, this classification seems to be inefficient in comparing climate of two different locations. Precicipation effectiveness cannot be precisely ascertained due to lack of proper data of monthly temperature and precipitation.
II. Climatic classifications as devised by both Koppen and Thornthwaite are more powerful to zoologists, botanists and geographers but fail to serve the purpose of meteorologists and climatologists because the interplay between the weather elements and other climatic factors is not clearly depicted.

Thornthwaite's 1948 classification

In 1948, Thornthwaite proposed a rational classification of climates based on the concept of potential evaporation, the moisture budget and a moisture index.

The potential evapotranspiration (PE) is calculated from the mean monthly temperature (°C), with corrections for day length. For a 30 day month (12 hour days),

$$\mathbf{PE\ (cm) = 1.6 \times \left(\frac{10t}{I}\right)^{a}}$$

where, I = The sum for 12 months of $\left(\frac{t}{5}\right)^{1.514}$
a = A further complex function of I
t = Mean monthly temperature in °C

The monthly surplus (S) or Deficit (D) is determined from a moisture budget assessment, taking into account stored soil moisture. A moisture index (I_m) is given by

$$\mathbf{I_m = \frac{100S - 60\,D}{PE}}$$

The weighting of a deficit by 0.6 is supposed to allow for the beneficial action of a surplus in one season, when moisture is stored in the subsoil to be drawn on during subsequent droughts by deep-rooted perennials.

Moisture Index	Humidity Province	PE		Climatic type
		cm	inch	
>100	Perhumid (A)	>114	> 44.9	Megathermal (A')
20 to 100	Humid (B_1 to B_4)	57 – 114	22.4 – 44.9	Mesothermal (B_1' to B_4')
0 to 20	Moist subhumid (C_2)	28.5 – 57	11.2 – 22.4	Microthermal (C_1' to C_2')
-33 to 0	Dry subhumid (C_1)	14.2 – 28.5	5.6 – 11.2	Tundra (D')
-67 to -33	Semi arid (D)	< 14.2	< 5.6	Frost (E')
-100 to - 67	Arid (E)	-	-	-

Seasonal Moisture Adequacy

Moist climates (A, B, C_2)	Aridity Index
r, little or no water deficit	0 - 10
s, moderate summer deficit	10 - 20
w, moderate winter deficit	10 - 20
s_2, large summer deficit	above 20
w_2, large winter deficit	above 20

Dry climates (C_1, D, E)	Humidity Index
d, little or no water surplus	0 - 16.7
s, moderate winter surplus	16.7 - 33.3
w, moderate summer surplus	16.7 -33.3
s_2, large winter surplus	above 33.3
w_2, large summer surplus	above 33.3

Criticism of 1948 classification:

I. Owing, in part, to inadequacy of data for computing potential evapotranspiration for large areas of the earth no map of world climates based upon this newer classification has been produced.
II. This classification has proved successful only in case of North America whose vegetation boundaries nearly coincide with particular PE values, but not for tropical and semi-arid areas.
III. This classification is quantitative as well as empirical but it does not consider various causative factors of climate.
IV. Since its employs lot of calculation, therefore it is more difficult to determine the climatic type of a particular place or locality.

Evaluation: The significant aspect of Thornthwaite's study is that his concept can be applied to studies of water balance and water use.