

The Köppen System

Wladimir Köppen made one of the most lasting and important contributions in the field of climatic classification. He was trained as a botanist. In the early stages of his work, he was strongly influenced by the writings of botanists. The systems he formulated range from a highly descriptive vegetation zonal scheme to a classification in which boundaries are defined in relatively precise mathematical terms.

Beginning with his doctoral dissertation (Leipzig) in 1870 and continuing up to his death in 1940, Köppen proposed, modified, and remodified his system. By 1951, it had become so established that F. Kenneth Hare reported to the Royal Meteorological Society of Canada that some regarded the system "as an international standard, to depart from which is scientific heresy." Such rigorous interpretation was not probably intended by Köppen, to whom the scheme was never completely satisfactory. The evolution of the system shows that Köppen was not so concerned with the precise boundaries as he was with attempting to use simple observations of selected climatic elements to provide a first-order world pattern of climates.

Köppen's early work was completed at a time when plant geographers were first compiling vegetation maps of the world. His early publications (1870, 1884) were concerned with temperature distribution in relation to plant growth, and it was not until 1900 that any of his publications were really concerned with world climatic classification. The 1900 system, which did not get much notice, is a highly descriptive scheme making use of plant and animal names to characterize climate. In 1918, Köppen produced a system that is substantially the one in use at the present time. Boundary values have changed and new symbols have been introduced, but the framework of the present system was clearly evident. The scheme demonstrates Köppen's major contribution to the systematic treatment of the climates of the world. He recognized a pattern underlying world climatic regions and introduced a quantitative method that allows any set of data to be categorized within the system. The classification is considerably enhanced by the introduction of a unique set of letter symbols that obviates the necessity of long descriptive terms.

The classification is based on the distribution of vegetation. Köppen's assumption was that the type of vegetation found in an area is very closely related to the temperature and moisture characteristics of the region. These general relationships were already known at the time Köppen's classification was produced, but he attempted to translate the boundaries of selected plant types into climatic equivalents. The Köppen system is based on monthly mean temperatures, monthly mean precipitation, and mean annual temperature.

Table 10.2 Köppen's Major Climates

- A Tropical rainy climates
- B Dry climates
- C Mid-latitude rainy climates, mild winter
- D Mid-latitude rainy climates, cold winter
- E Polar climates

Principal Climatic Types According to Köppen's Classification

Af	Tropical rainy	Cw	Mid-latitude wet-and-dry, mild winter
Aw	Tropical wet-and-dry	Cf	Mid-latitude rainy, mild winter
Am	Tropical monsoon	Dw	Mid-latitude wet-and-dry, cold winter
Bs	Steppe	Df	Mid-latitude rainy, cold winter
BW	Desert	ET	Tundra
Cs	Mediterranean	EF	Ice cap

Köppen recognized four major temperature regimes: one tropical, two mid-latitude, and one polar (Table 10.2). After identifying the four regimes, he assigned numerical values to the boundaries (Table 10.3). The tropical climate is delimited by a cool month temperature average of at least 18°C (64.4°F). This temperature was selected because it approximates the poleward limit of certain tropical plants. The two mid-latitude climates are distinguished on the basis of the mean temperature of the coolest month. If the mean temperature of the coolest month is below -3°C (26.6°F), it is **microthermal**. If the temperature is above -3°C (26.6°F), the climate is **mesothermal**. The fourth major temperature category is the polar climate. The boundary between the microthermal and polar climates is set at 10°C (50°F) for the average of the warmest month, which roughly corresponds to the northern limit of tree growth. A fifth major regime, the dry climates, was based not on temperature criteria, but lack of moisture. Dry climate boundaries are obtained using derived formulas. Figure 10.7 shows the distribution of the identified climatic types.

The system has been subjected to criticism from two aspects: (1) There is no complete agreement between the distribution of natural vegetation and climate. This is to be expected since factors other than average climatic conditions (e.g., soils) affect the distribution of vegetation. (2) The system is also criticized on the basis of the rigidity with which the boundaries are fixed. Temperatures at any site differ from year to year as does rainfall, and the boundary based on a given value of temperature changes location from year to year. Despite the criticisms and empiric basis of the classification, it has proved quite usable as a general system.)

Table 10.3 The Köppen Classification

A	<i>Temperature of the coolest month above 18°C (64.4°F)</i>
	Subcategories:
	<p>f: rainfall in driest month at least 6 cm (2.4 in)</p> <p>m: rainfall in driest month greater than $10 - r/25$, but less than 6 cm when r = annual rainfall in cm OR rainfall in driest month greater than $3.94 - r/25$, but less than 2.4 in., when r = annual rainfall in inches</p> <p>w: rainfall in driest month less than 6 cm (2.4 in), but insufficient for m and dry season in low sun period</p> <p>s: rainfall in driest month less than 6 cm (2.4 in), but insufficient for m and dry season in high sun period</p> <p>w': maximum rainfall in autumn</p> <p>w'': two rainfall maxima, with intervening dry periods</p> <p>i: annual temperature range less than 5°C (9°F)</p> <p>g: warmest month precedes summer solstice</p>
B	<i>Evaporation exceeds precipitation for the year</i>
	Subcategories:
	<p>BS (Steppe): Derived by the following, when</p> <p>70% of rainfall in summer six months:</p> <p>70% of rainfall in winter six months:</p> <p>Even rainfall distribution or neither of above:</p> <p>OR, when</p> <p>and</p> <p>70% of rainfall in summer six months:</p> <p>70% of rainfall in winter six months:</p> <p>Even rainfall distribution or neither of above:</p> <p>The value r is the BS/humid boundary. When the derived r is greater than the value on the right of the equation, the climate is humid; when less it is B. If B, then determine if BS by dividing the answer by 2. If, after dividing, r is greater than value on right, climate is BS; if less, climate is BW (desert).</p>
	<p>r = annual rainfall in cm and t = annual average temperature in °C</p> <p>$r = 2(t + 14)$</p> <p>$r = 2t$</p> <p>$r = 2(t + 7)$</p> <p>r = annual rainfall in inches t = annual average temp. in °F</p> <p>$r = .44t - 3.5$</p> <p>$r = .44t - 14$</p> <p>$r = .44t - 8.5$</p>

Table 10.3 (continued)

BW (Desert): Derived as indicated above	
Subcategories of BW:	
h:	average annual temperature above 18°C (64.4°F)
k:	average annual temperature below 18°C (64.4°F)
k':	average of warmest month below 18°C (64.4°F)
n:	high frequency of fog
s:	70% of rainfall in winter six months (summer dry season)
w:	70% of rainfall in summer six months (winter dry season)
C	<i>Coollest month temperature averages below 18°C (64.4°F) and above -3°C (26.6°F); warmest month is above 10°C (50°F)</i>
Subcategories:	
f:	at least 3 cm (1.2 in) of precipitation in each month; or, neither <i>w</i> nor <i>s</i>
w:	minimum of 10 times as much precipitation in a summer month as in driest winter month
s:	minimum of 3 times as much precipitation in a winter month as in driest summer month, and one month with less than 3 cm (1.2 in) of precipitation
x:	rainfall maximum in late spring or early summer; dry in late summer
n:	high frequency of fog
a:	warmest month over 22°C (71.6°F)
b:	warmest month under 22°C, but at least four months over 10°C (50°F)
c:	only one to three months above 10°C
i:	mean annual temperature range less than 5°C (9°F)
g:	warmest month precedes summer solstice
t':	hottest month delayed until autumn
s':	maximum rainfall in autumn
D	<i>Coollest month temperature averages below -3°C (26.6°F) and warmest month over 10°C</i>
Subcategories:	
d:	coldest month below -38°C (-36.4°F)
Other subcategories same as for C	
E	<i>Warmest month temperature averages less than 10°C (50°F)</i>
Subcategories:	
ET:	average temperature of warmest month between 0°C (32°F) and 10°C (50°F)
EF:	average temperature of warmest month below 0°C (32°F)

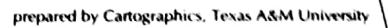


Figure 10.7
The Köppen classification of climate (from Griffiths, J. F. and Driscoll D. M., *Survey of Climatology*, © 1982, Prentice Hall, Upper Saddle River, N.J.).