CLASSIFICATION OF THE CLIMATE OF THE EARTH

E.I. Khlebnikova
Main Geophysical Observatory, St. Petersburg, Russia

Keywords: climate, climate classification, climate zoning, descriptive climate classifications, genetic climate classifications, hydrological classifications, landscape, landscape-geographical classifications, macroclimate, mesoclimate, microclimate, objective empiric climate classifications, specialized climate classifications, underlying surface, vegetation-based climate classifications

Contents

Summary

The problem of climatic classification, its methodology and significance is discussed. Major approaches to climatic classifications used in climatology from the beginning of its development to the present are considered. The most important classifications of principal significance for progress in climatology, including rather unknown systems, are examined.

1. Introduction

Climatology is a comparatively new science which has been progressing rapidly in recent decades. Essentially, conceptualization of its subject—“climate”—is not yet complete. The concept of climate has been transforming along with the development of climatology. At the beginning of the new century climatology is in front of necessity to extend the sense of the concept of climate as compared to the definitions of the 1970s, taking into account modern global and regional changes in the atmosphere. In this chapter, when speaking about the climate of a locality, or the climate of the Earth as a whole, we shall mean the naturally conditioned regime that creates the continuing sequence of weather.

Processes creating climates take place in definite geographical conditions, so climate is caused by geographical factors: latitude, height above sea level, relief (mountain chains, plateau, lowlands, uplands), peculiarities of the subsurface, etc. In turn, climate affects the geographical features of localities (vegetation, soil, relief, water bodies, etc.). This is why climate should be considered as an element of geographical environment. Among the physical processes in the atmosphere, the most important in influencing large-scale regional climatic are levels of incoming and outgoing solar radiation, atmospheric circulation (i.e. the system of air currents bringing different amounts of heat and moisture), and vertical heat and moisture exchange in the atmosphere and surface layer.

The first attempt to explain climatic differences was made in ancient Greece. The Greeks attributed the differences to varying Sun height over the horizon in different latitudinal belts, compounded by the effects of air movement.

Since the beginning of meteorological observations it has been possible to analyze and generalize observational data on air temperature and humidity, precipitation, atmospheric pressure, cloudiness, wind, various atmospheric phenomena, etc., and so compare regional climates quantitatively. Because of the large number of factors that affect climate, in general, no two places on Earth have identical climates. Nevertheless, it is obvious that many well separated localities have similar climates.

Climatic classification is usually meant to present the climate of the Earth (or a part of it) as a system of regions which are characterized by comparatively homogeneous climatic conditions. Of course, this requires some generalizing, because meteorological variables in lowlands change gradually, and any grouping is to some extent a simplification.

Classification of the climate of the Earth is aimed at systematizing vast volumes of available meteorological data of weather phenomena in various regions of the globe. Scientific analysis of climate classification, with the objective of differentiating types of climate and recognizing similarities and differences in climatic conditions, involves interpretation of the different processes that create climates and estimation of climatic potentialities and their perspectives for individual regions of the globe.

To compare climates of localities, such concepts as macroclimate, microclimate and local climate (mesoclimate) are introduced. The features of climate that are common for large areas of the globe are usually known as macroclimate. Differences in macroclimate are manifested over distances of hundreds of kilometers and are caused by zonal distribution of solar radiation, atmospheric circulation regime and large-scale non-homogeneities in the surface (land, sea, mountains, plains, etc.). The particularities of climate that occur at scales of less than hundreds of meters and which are affected by qualities of small areas (such as a forest, glade or valley) are called microclimate. To characterize climatic features of intermediate scale, the concept “mesoclimate”, or local climate, is used (see *Local Climate*). In this chapter we will consider classification systems of macroclimate, i.e. we shall discuss typification of climates of the Globe as a whole, or climates of continents, conditioned by large-scale processes.

2. Methods of climate classification

A scientific approach to the problem under consideration came be realized in the nineteenth century when data from instrumental observations had accumulated sufficiently to permit generalization. By the middle of the nineteenth century, maps of average temperature and rainfall had appeared, and it came to be possible to group climates, by taking a multi-dimensional view of climate.

There are two aspects to classification of climates. On the one hand, it is possible to distinguish areas with differing climatic conditions, on the other, there is the possibility of finding similar climates in different parts of the globe.

By the end of the nineteenth century, in the initial stage of climatology development, the most widely used approaches were those which stressed the aspect of discriminating areas (climatic provinces) with distinctive climatic conditions.

The first attempts at scientific climatic classification date from the 1870s. At that time the works of the French scientist de Candolle appeared, using the idea of a vegetation-based classification. De Candolle proposed to divide the Earth surface into five zones based on vegetation types which are determined by climatic conditions:

1. plants that need permanently high temperature,
2. plants that are tolerant of moisture deficiency,
3. plants that need a moderate temperature throughout the year,
4. plants that are tolerant of deficiency of heat,
5. plants that are tolerant of temperatures below zero for most of the year.

This division was of great importance because it was the first which outlined the principal features of geographical zonality.

Naturally, the first classifications were schemes based on a comparatively low level of knowledge of climate. At that time authors of classifications did not intend to find regions with precise climatic conditions or to set the laws of distribution of similar climates on the globe; they simply fixed the boundaries of areas (provinces) with unlike climates. The idea of climatic provinces was much used in later works (e.g. Zupan (1884), Hult (1892)) and remained in climatology until the end of the nineteenth century.

As meteorological data accumulated, it became possible to establish a clear view of the factors determining climate laws, and allocation of climates over the globe.

A noticeable forward step was the work of the German climatologist Vladimir Koeppen. In 1900 he proposed the first version of his system of climatic zoning of the globe, and he continued to improve it until his death in 1940. This was based on objective criteria—definite combinations of various characteristics of temperature and precipitation regime. The principle of analogy and the concept of climatic types introduced by Koeppen were of great importance in subsequent investigations on classifying climates. The main point of the principle of analogy was not just to divide the Earth's surface into regions with distinctive features, but—above all—to find in well separated areas climates of similar types and to ascertain the reasons for their distribution.

Like the classifications of many of his predecessors, Koeppen's system was vegetation-based in its origin, i.e. in developing the system the main goal was to establish correspondence between botanical zones and definite criteria with respect to special climatic indicators. In addition to botanical classifications, scientists and geographers of the nineteenth and early twentieth centuries were engaged in intensive studies aimed at clarifying the role of climate as an element of the zonality of various natural processes—soil, hydrological and landscape processes in general.

Modern science divides classifications of climate into two categories (see *Methods of Climate Classification*). The first one involves the so-called genetic classifications based on real mechanisms of climate formation which not only give the characteristic of various types of climate, but also explain the reasons for observed climatic patterns in different parts of the globe. The other grouping systems (the second category) can be referred to as descriptive classifications, which differentiate climatic types on the basis of criteria constructed without regard to the factors of climate formation. Descriptive classifications often combine climates of quite different genetic origin, and, by using formal criteria, ascribe them to the same type.

In addition to universal classifications we shall also consider those classifications which have particular applied orientations. There are many specialized classifications developed for use in agriculture, the building industry, public health, etc. (see *Applied Classifications of Earth's Climate*).

Descriptive classifications of climate arose from the requirements of various sciences and areas of economic activity. Generally, the development and realization of a classification system, methodologically has to involve several stages: establishing significant (with respect to the area of application) distinctions between regions, finding parameters to characterize climate (indicators) that could explain these differences, and, finally, elaborating the classification scheme on the basis of exposed indicators. In reality, as regards methodology, not all classifications can be considered complete.

In this respect descriptive classifications can be subdivided further into two groups. Classifications developed on the basis of quantitative criteria using data from meteorological observations are attributed to objective empiric classifications (see *Objective Empiric Classifications of Earth's Climate*). The other group developed from Koeppen's classification, in which initially botanical zones caused by climate were distinguished, but subsequently the boundaries of corresponding climates were determined on the basis of definite values of meteorological indices, despite discrepancies in climatic and vegetation boundaries. The advantage of this classification approach is its objectivity, but its serious shortcoming is its formality, that in some cases results in serious consequences and prevents correct interpretation of similarity of climates.

The second group of descriptive classifications joins geographical (landscape-botanical, soil, hydrological, etc.) classifications (see *Methods of Climate Classification*), which differentiate climate on the basis of characteristics dependent on climate, but not directly meteorological. The starting-point of these classifications is to establish the correspondence between landscapes (soil types, river types) and definite characteristics of temperature-precipitation regime. However, this relationship doesn't result in formalized criteria, and phenomena which are effected by climate, in essence, remain the basis of classification. Despite certain descriptivism in this type of classification, they are of great value for scientific progress, since they give the possibility of setting the interrelation between climate and the most important large-scale geographical concepts.

There are various basic approaches to genetic classification, and the most widely used are those that categorize climates on the basis of characteristics of atmospheric circulation. Classifications that employ the concept of air mass are among them. An air mass is interpreted as a large body of air with comparatively homogeneous physical characteristics in the horizontal. It is believed that the weather regime in a locality is determined by features of the prevailing air mass for the time period in consideration. The system of Russian scientist B.P. Alisov that was proposed in 1936 seems to be the first of such classifications. Similar principles were developed in well-known works by the American geographer A. Strahler and his followers from the 1950s to the 1970s.

The second important type of genetic classifications involves those that employ characteristics of the Earth's energy budget. Very notable in this scientific stream is the investigations carried out in Russia by M.I. Budyko, the founder of so-called heat-balance climatology, being most influential in statement and solution of the problem of climate change. In the 1940s and 1950s, Budyko proposed and realized the principles of climate classification based on characteristics of surface heat balance and their interrelation with characteristics of water balance (see *Genetic classifications of Earth's Climate*). The principles of Budyko's classification take into account radiation characteristics, which are closely and directly correlated with temperature in the warm season, and circulation factors, which are indirectly correlated with quantitative characteristics of precipitation and moistening regime. The work of the American geographer Terjung (1970) who devised the system for distinguishing climatic zones based on combination of different characteristics of incoming radiation, is also important.

There are many zoning schemes that use spatial variation of one of the meteorological elements (temperature, precipitation, etc.) to differentiate climatic zones. Of course, such works were useful in development of the science, but it is doubtful that such grouping can be called a genetic classification. Real observed climate is essentially a multidimensional concept, and climatic classification has to take into account all the most important controlling factors.

Some authors believe that it is useful to distinguish between the concepts of "classification" and "zoning". When considering one influencing factor, such as temperature or precipitation, it is perhaps appropriate to use the term "zoning". There is another opinion that the term "zoning" should be used for applied grouping systems of climates.

-
-
-

Bibliography

Berg L.S. (1938). Fundamentals of Climatology, 455 pp., Leningrad: Uchpedgiz [in Russian]. [This contains a description of Berg's landscape-geographical classification]

Critchfield H.J. (1983). General Climatology. [This is a general guide on air-mass analysis and climate classification]

Drozdov O.A., V.A.Vasiliev, N.V.Kobysheva, A.N.Raevsky, L.K.Smekalova, E.P.Shkolny (1989). Climatology, 568 pp., Leningrad: Gidrometeoizdat [in Russian]. [This contains a critical review of various climatic classification systems]

Oliver J.E., Wilson L. (1987). Climatic Classification. In J.E. Oliver and R.W. Fairbridge (eds.). The Encyclopedia of Climatology, pp. 221-237.

Strahler A.N. and Strahler A.H. (1987). Modern Physical Geography. [This contains a consideration of various approaches to classifying climates and a detailed description of Strahler's system using the concept of potential evapotranspiration]

Trewarta G.T. (1981). The Earth's Climate Problems. [This contains a description of the main climatic types, soils and also vegetation]

Biographical Sketch

Elena I. Khlebnikova was born in 1945 in Leningrad, USSR. In 1963 she entered Leningrad State University, Mathematics and Mechanics Faculty, and in 1968 graduated from the Dept. of Theory of Probabilities and Mathematical Statistics of this University. In 1968 she began to work at the Main Geophysical Observatory in the Dept. of Climatology and in 1975, after postgraduate studies in meteorology and climatology, received a scientific degree of Candidate in Math & Physics. Since 1998 she has held a position as leading scientist in the Dept. of Applied Climatology. Dr. Khlebnikova has thirty years of experience in climatology including research on statistical modeling of meteorological processes, methodology of climate monitoring and different aspects of statistical interpretation of meteorological and other observations. She has more than 50 publications in these fields.