A CRITIQUE OF REPRESENTATIVE CLIMATIC CLASSIFICATIONS

Professor Mahdi Amin EL Tom,
Geography Department, Faculty of Arts
University of Khartoum.

The workers in the field of regional climatology have always been concerned with the question of classifying the climates of the world. The complexity of the problems involved has necessitated the adoption of various approaches and techniques and has therefore resulted in the presence of several systems of climatic classifications . The criteria used in some of the major systems have varied between vegetation, precipitation effectiveness, temperature and air masses which were used either as independent variables or in different combinations.

The present paper is an attempt to throw some light on the systems suggested by Koppen (1900 – 1918), Thornthwaite (1931 – 1948) Strahler (1951) and Miller (1931) , which seem to represent the major approaches in the field of climatic classifications.

The utilization of the vegetation factor was started by Koppen in 1900. Here he depended on the identification of the major plant groups on the assumption that plants are very demanding in their climatic requirements and so each distinct plant group tends to flourish within restricted climatic conditions that can hardly be suitable for another plant group. So Koppen started with recognizing the major plant groups and then he worked out the climatic conditions within which each group grows. He utilized this information to define the climatic boundaries

between the major plant groups which were regarded as being equivalent to the major climatic types. The utilization of the vegetation factor in this sense differs to a large extent from that of Thornthwaite (1931) who used the plant groups as a guide to the location of the climatic boundaries . He worked out the characteristics of the various climatic types according to his thermal efficiency and precipitation effectiveness indices and then he defined the boundaries on the basis of vegetation distribution.

The precipitation effectiveness has also served as a basis for classifying the world's climates. This factor is intended to express the relation between water-gain and water-loss with the view of assessing the availability of water for plants . It started with the rain factor of Koppen (1900) which was then followed by various formulae in which a temperature factor has been used instead of evaporation due to the difficulty of obtaining sufficient and reliable data on evaporation. When evaporation figures became available, they were used extensively. Thornthwaite extended this eventually in 1948 to become potential evapotranspiration that can occur under unlimited water supplies.

Many workers in this field have also used the temperature as a basis of classification. However, there are wide differences in the ways or the techniques of utilizing the temperature factor. Koppen (1918) for example used the temperature of the coldest and warmest months to identify his major climatic belts. This differs from the case of Miller (1931) who was interested in the presence or absence of a cold season .Miller also believed that the duration of the cold or the warm season is important and so it could also serve as a basis for identifying some of the climatic types. This forced Miller to suggest a new definition of the cold and warm months.

A more sophisticated use of the temperature factor was made by Thornthwaite (1931 and 1948) who suggested new thermal factors which

he called the thermal efficiency indices. These are used as tools for recognizing the major thermal belts or thermal zones of the world. Although these thermal provinces or zones occupy the second place in his literal order , yet they are by no means less significant than the moisture zones that occupy the first position in his system of classification. Beside this ,three of his major climatic belts are identified on the basis of this thermal factor.

In 1931 Thornthwaite used the formula (T-32) to obtain Thermal Efficiency Ratio.However, in 1948 he regarded the thermal efficiency ratio as being equivalent to the potential Evapotranspiration and so he used one formula to serve the two purposes. The formula is in the form of :-

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$$e = 1.6\,(10\,t / I)^{a}$$

Where e = Monthly potential evapotranspiration in cms.

t = Monthly temperature in °c

$I = 12\,(t/5)^{1.514}$

a = A constant

The air masses form the basis of Strahler's classification. This classification is one of the so-called genetic classifications that attempt to identify the climatic variations on the basis of the causes of these variations. Although this seems to be a valid approach yet it requires a detailed understanding of the types and the characteristics of the air masses in the different parts of the world .It is true that an ideal air mass of a certain type should have certain basic characteristics. However, there is no guarantee that the actual effects of such an air mass will be identical

throughout the track followed by that particular air mass. In addition to this , the local variations, that may be very significant in some areas, can hardly be recognized in Strahler's system.

Almost all the systems under consideration have failed to rely entirely on a single element or a single criterion on the basis of which one may identify the various climatic types of the world .It is true that most of these systems depend largely on a single element or criterion for identifying most but not all of their major climatic types. For example , in the case of the systems that use a Thermal factor for recognizing the major climatic belts, it has always been necessary to deviate from such an approach when the arid climates are to be identified. This has always been so due to the fact that over the Arid areas, hygrometrical considerations are more important and critical than the thermal ones.

Somewhat similar deviations are also found in the systems that use a hygrometrical or a moisture factor for identifying the major climatic types. The deviation here involves the polar regions where the temperature is far more critical than the moisture.

These observations are applicable to the simple as well as to the complicated systems of climatic classification. Examples of the latter systems are the ones suggested by Thornthwaite in which most of the major climatic types are identified on hygrometrical basis either in the form of a precipitation effectiveness index (1931) or a moisture index (1948).In both cases cold climates are identified on thermal basis . In the 1931 system the identification is on basis of the thermal efficiency index while in the 1948 system the identification is on the basis of the potential

evapotranspiration which is regarded as being equivalent to the thermal efficiency index.

Beside this, there has always been a need to subdivide the major climatic regions in order to recognize the innumerable climatic variations within the major regions. This task led to the use of an extremely large number of variables such as :-Precipitation regimes, (Koppen) location relative to the sea (Miller&Strahler),duration of the cold or the warm season (Miller),presence of a moisture deficit or surplus (Thornthwaite),summer concentration of thermal efficiency or potential evaportranspiration (Thornthwaite),local plants, animals, unique weather phenomenon (Koppen), seasonal domination of air masses (Strahler), possible interaction between air masses (Strahler),....etc. This led to the creation of a large number of climatic subtypes, which in turn added to the complexity of the problem.

The validity of these various approaches should be measured in terms of the success of the individual systems to meet the aims of climatic classifications. Of the various aims of a climatic classification one may mention :-

1. The simplification or generalization of climatic data.
2. The provision of a concise description of climate in terms of the Truly Active Factors.
3. The provision of a means by which climatic regions can be identified accurately.
4. The applicability on a world scale as well as on a local or even a micro-scale.

5. It should throw light on the causes of the observed climatic variations.

As far as the systems under consideration are concerned one may assume that they all agree on the first point concerning the simplification and the generalization of the climatological data. This should have been the main aim of all the contributors to this field of knowledge. They are also similar in their attempts to provide a concise description of the climates in term of truly active factors . However, they differ considerably in their evaluation of the so-called truly active factor or factors . Thornthwaite for example believed that the moisture is the truly active factor and so used it as a basis for identifying most of his major climatic types except for his three cold zones for which he thought that the temperature is the really active or critical factor. Koppen , on the other hand, thought that the temperatures of the coldest and the warmest months are the truly active factors and so he used certain critical values for these two months in order to identify his major climatic belts. For the Arid climates , however, Koppen thought that the precipitation effectiveness is the truly active factor and so he employed it for recognizing this particular type of climate.

Miller followed Koppen's steps in regarding the temperature as the truly active factor but his evaluation of the role of the temperature factor differs from that of Koppen .For him the temperature of the coldest month is the really active factor in the hot region while in other regions the presence , absence and duration of the cold and warm seasons could be the all important.

Strahler's approach is distinctly different . For him the type or nature of the dominating air mass is the most important and so the air mass over a certain area should be regarded as the truly active factor as far as the weather and climate are concerned.

When we consider the point of the accuracy with which climatic regions can be identified and their boundaries located, we find noticeable differences between the systems under consideration. The required accuracy could be achieved whenever a numerical or a critical value is given .This is provided throughout the Koppen's and Thornthwaite's systems of classification. In the case of the Miller's system this condition applies only to the major climatic belts whose boundaries could be located according to the critical or the numerical values provided. The difficulty with Miller's system arises when one attempts to subdivide the main climatic types .Here the division should be very arbitrary since no one can determine precisely the boundary between the suggested continental and marine climates. Miller also failed to provide a means by which the boundaries of the Western margin and the Eastern margin climates could be located accurately.

Strahler's system fails completely to provide an accurate means for locating the climatic boundaries. This limitation applies to the major climatic types as well as to the subtypes. This is due to the fact that the entire system is based on air masses whose areal extents can hardly be shown with sharp lines.

However, despite the fact that Koppen, Thornthwaite and to some extent Miller had provided us with numerical or critical values for the various boundaries that allow us to determine the climatic type of any

station according to the respective system, yet one has all the right to doubt the accuracy or the general applicability of these critical values themselves. In fact selection of such numerical values is governed, by many factors such as the selection of variables, and the availability of data.

An example of this is the case of Thornthwaite's potential evapotranspiration. Several workers in this field (e.g.Chang 1959) believe that the potential evapotranspiration is determined by many factors such as solar radiation, air temperature, humidity and wind speed. Thornthwaite, however, expresses the potential evapotranspiration as a function of the mean monthly air temperature. If some or all of the remaining factors were taken into consideration a very different formula might have been obtained.

The same criticism applies to the Koppen's system. For example in his precipitation effectiveness formula, he combines the precipitation and the temperature in the form of: -

$$8r/(5t + 120)$$

in which he is ignoring all the other climatic factors and providing 3 constants which could be replaced by any other figures if more variables were used in the preliminary calculations.

A direct consequence of such differences in the use of variables is that the areal extent of any climatic type tends to vary with the various systems. The arid climates provide a good example in this connection. Arid climates of Koppen, Thornthwaite and the others are hardly identical.

As far as the causity of climate is concerned, Strahler's system stands ahead of all the others since it is the only one that can be regarded as genetic classification. In addition to this , Strahler's system is also much simpler and easier to absorb than the others. It is followed in this latter property by Miller, Koppen and then Thornthwaite respectively. Also all of the systems under consideration can be used to provide a generalized map of the world's climates but in the regional and micro scales they have different limitations.

In conclusion it may be stated that it is really difficult to find a climatic classification that may be regarded as a satisfactory or as an-all purposes classification. Each classification has its own merits, limitations and weaknesses, and so when they are to be applied one must take into full consideration their various limitations .This latter point led some of the recent and contemporary climatologists to suggest some changes or modifications to the existing systems in order to suite certain purposes or certain areas (Gentilli 1958). Some other climatologists are now working towards a more satisfactory classification that must take into consideration all the weak points and the limitations of the classical systems of classification. Until such systems come to existence, climatologists have no choice except to use the available systems but they should be quite aware of their various limitations.

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