ARCHIVO *Online* ARCHIVE

http://www.acoge.net/Repositorio.html

1968

Director
Dr. Héctor F. Rucinque
Presidente de ACOGE

[*Al final de la separata: páginas de Contenido y Directivos de la Asociación*]

Separata — *Reprint*
Del volumen **1,** N°1, enero de 1968:

Butzer, Karl W. 1968. Remarks on a dynamic classification of climates. ***El Correo Geográfico*** [Tunja, Colombia, **ACOGE**], vol. 1 (1), 17-26.

Asociación Colombiana de Geógrafos (ACOGE)

REMARKS ON A DYNAMIC CLASSIFICATION OF CLIMATES

by Karl W. Butzer.

El doctor KARL W. BUTZER, de Mülheim, Alemania, es profesor de Antropología y Geografía de la Universidad de Chicago. Previamente ha sido investigador asociado con el Dr. Carl Troll, y profesor de Geografía de la Universidad de Wisconsin, Madison. En 1954 recibió, con honor en Matemáticas, su B. Sc. en la Universidad McGill, institución que luego le confirió un M. Sc. en Meteorología. En 1957 obtuvo el grado Dr. rer. nat. en Geografía Física, de la Universidad de Bonn.

The Problem

Climatic classification, as a synthetic summarization of selected climatic data, has long been and will presumably remain a problem for geographers. With some 60 published climatic classifications in the geographical literature, the theme itself is not an edifying one. Climatic classifications have generally been delineated with the distribution of non-climatic phenomena in mind. Theoretically, climatic classifications could be devised according to the planetary distribution of one or more of the following elements:

a. great soil groups
b. gradational processes
c. water resources
d. plant life i. native vegetation
ii. agricultural crops
e. animal life
f. human comfort or energy levels
g. climate *sensu stricto*.

However a strict classification of climate according to the principle of "climate for its own sake" is seldom attempted. Indeed what significance does a 64°F isotherm or a 12 inch isohyet have unless it is related to plant factors, human comfort, etc. Of all the statistical values employed in existing classifications only the value of 32°F, as the freezing temperature of water under certain ideal conditions, has a really objective existence. This means that, if one disregards the distribution of the non-climatic phenomena listed above, it is impossible to provide meaningful statistical units of climate, so for example on the basis of temperature or precipitation. It may be permissible to speak of climates qualitatively as being hot, cold, seasonal, etc. but such distributions could not then be shown on the map. The only logical independent classification of climate according to strictly climatic criteria would be *genetic*. Any other classification of climates is necessarily *applied* in purpose.

The Purpose of Genetic Classification

All climatic classifications in widespread classroom use today, with exception of those used in certain Russian texts, are "applied" in character, most frequently constructed on the basis of plant life. In a broad way most climatologists will agree that such classifications are a useful teaching device on a high school or unspecialized college level. This is a delicate point, and it is not my intention to touch upon this controversy. In a recent review F. Kenneth Hare (1960) has expressed feeling for a necessary subdivision in climatological instruction. Hare believes that one level should be designed for the general geography student who needs a descriptive climatology as part of the description of the earth as the home of human society. But, according to Hare, another level of climatology must serve the needs for climatological specialists, who may act as skilled and authoritative interpreters between geography and meteorology

The problem then arises whether an "applied" or a genetic classification can best serve the requirements of instruction in regional macro-climatology at the intermediate or advanced level. I am personally convinced this question cannot be answered as an "either--or" proposition, rather, it is simply a question of *purpose.*

Graduate or research level regional climatology cannot be divorced from the synoptic-dynamic approach, as Hettner had already stressed in 1930 (p. 7-8). But what regions are to be most effectively used? Continents or political units are unwieldy, as several distinct genetic climates may occur within the region so chosen. Similarly empirical-descriptive climatic types defined on the basis of convergence of various physical phenomena are unsatisfactory as a framework for genetic-dynamic discussion. This statement, I believe, requires a brief elaboration. The greater number of climatology texts in the English language give their genetic treatment of regional climates within the framework of Koppen's climatic types. At a general level this may be quite adequate, as there is a broad convergence between the planetary wind belts and Koppen's natural eco-zones. At an advanced level however, such a unit becomes unsatisfactory and lacks scientific accuracy. One glaring example is the climatic identity of the Ganges and lower Mississippi valleys in the Koppen system. Koppen himself implicitly admitted the divergence between his general climatic units and his wind and circulation provinces (Plates I and IX, 1923 and 1931).

If one could admit that continental, political or "appulied" climatic type—regions do not best suit the purposes of dynamic regional climatology, what does? Hettner first raised this issue in 1911 when he criticized Koppen for de-emphasizing climatic causation. At the same time he proceeded to outline climatic regions on a genetic basis.

Hettner's Genetic Outline of Climatic Regions (1911)

Hettner (1911; 1931, p. 83-85) argued that a scientific classification must be based on climatic genesis, and should primarily emphasize general characteristics: air circulations, precipitation, radiation and temperature. Apart from his general climatic types he also outlined specific genetic regions (Gebiete der atmospharischen Zirkulation auf den Kontinenten: 1911; 1931, p. 30-36). The regional types he outlines are given in Table I.

It may be noted that this admittedly incomplete and not uniform characterization of the world's genetic climatic provinces by Hettner is the first of its kind. Its intellectual antecedents are to be sought in A. I. Voeikof via Hettner's teacher A. Kirchhoff (Hettner 1930, p. 10). The available synoptic-dynamic data of the time was however deficient, so that Hettner's classification is chiefly of historical and methodological interest today.

In the first edition of his volume *Klimate der Erde* Koppen (1923; p. 301-2, plate IX) outlines seasonal wind or circulation zones, which could well have been carried a step further into a synthetic characterization of climates. These first steps were followed up by Flohn only in 1950.

A similar attempt at climatic classification on the basis of mean annual pressure distributions by P. I. Brounow in 1925 (cited by Alisov *et al.* 1956, p. 151-153) has not been effective or successful.

In 1929 a revolution in the methods and approach of climatology was ushered in by Thor Bergeron's plea for a "dynamic" climatology employing airmass concepts and frontal theory (Bergeron, 1930). (1) Only now was the empirical and theoretical framework available, whereby an effective and consistant regional breakdown of genetic climates became possible.

The Airmass and Frontal Classification of B. P. Alisov (1936)

The Bergeron idea was systematically followed up by the noted Russian climatologist B. P. Alisov in 1936 (see also Alisov *et al.* 1956, p. 119-141). Alisov delineated the boundaries of his regions according to the seasonal positions of the statiscal or climatological fronts. The zones between these broadly latitudinal belts were subdivided according to seasonal or permanent dominance of airmass types, and again subdivided according to geographical considerations, namely: 1) continental and maritime sections as reflecting the distribution of land and water, and 2) eastern and western coasts as reflecting circulation features. In practice these last subdivisions are neglected and only 7 major divisions are identified and located on the map by Alisov.

Although acceptable as a natural and logical system, as it stands Alisov's classification requires revision. So, for example, it is weakened by emphasis of "arctic" and "equatorial" airmass types. Neither airmass type is admitted as a really distinctive class by most authors today. Although a case could be made that *mTm* is a characteristic airmass of the equatorial trough, airmasses of the polar regions are anything but areally

(1) Hettner (1930, p. 7-8) also regards the synoptic approach as the most promising avenue for modern climatology to follow. He considered it capable of providig more than a climatographical study of statistical facts. Rather he contended that only the synoptic weather map can express the aperiodic day-to-day variation of weather and hence also climate.

uniform and are seasonally rather variable. Similarly the arctic front is a poor boundary criterion, at least for the northern hemisphere continents. Also, few of the boundaries given on Alisov's map coincide with the usually accepted average seasonal locations of these fronts (including the Russian literature, e.g. S. P. Chromov, 1950). On closer inspection, then, Alisov's system is not fully satisfactiory in its details. A criticism could also be made of the general approach, in particular the primary use of arbitrarily selected statistical features (climatological fronts) and only secondary use of really dynamic units or entities (airmasses). This is born out by Alisov's subsequent detailed description of the climatic types which is not dynamic but genetic, and in general does not provide a major improvement of Hettner's older genetic treatment.

The Circulation Classification of H. Flohn (1950)

Unaware of Alisov's important contribution, H. Flohn published a rather different classification in 1950. Its specific aim was to materialize Hettner's plea for a modern genetic classification. At the same time Flohn followed up Koppen's (1923) seasonal wind belt analysis and suggested a means of integration between the widely used Koppen system and a true dynamic approach. G. T. Trewartha has effectively integrated the two in the third edition of *An Introduction to Climate (1954).*

Flohn proposes two criteria: 1) mean seasonal wind components at 500 - 2000m, and 2) effective vertical motions as expressed by precipitation periodicity, intensity, and frequency. On these bases he distinguishes 6 major zones (Table III). These are shown on Koppen's hypothetical continent as well as on a meridian cross-section, although unfrotunately no better cartographic representation is given.

This consistent system has been carefully constructed and is theoretically sound. It has the decided advantage that a certain measure of integration with the physiological units of climate and eco-regions, expressed in the empirical descriptive classification systems of Koppen and others, is feasible. Yet such a wind belt and precipitation type classification is not necessarily better than one based on airmasses. Flohn emphasizes that airmasses are too inhomogeneous, both horizontally and vertically, and subject to extremely rapid modification. True as this certainly is, it does not invalidate the airmass concept. No one familiar with synoptic work can dispute that airmasses are sufficiently real and practicable, although they cannot always be statistically defined by certain thermodynamic properties and lapse rate conditions as certain authors have claimed.

A Dynamic System of Climates based on Airmass Characteristics

Possibly, however, a dynamic analysis based primarily on the seasonal dominance or interplay of the four major airmass types (*mP, mT, cP, cT*) will in the long run prove most acceptable for both a genetic and dynamic synthesis of weather and climate. The details can be improved by giving auxiliary consideration to the number of months with maritime or continental airmasses dominant, to seasonal or semi-permanent airmass source regions, climatological fronts, wind and pressure belts. Such a synthesis would be based upon Alisov's original airmass province concept.

An attempt to achieve this has been made in Table IV and on the map presented. Although the dynamic system of climates suggested here as a working hypothesis cannot be integrated with an empirical classification such as Koppen's, it may be preferable for a discussion of regional dynamic climatology. Units so obtained are particulary suitable for airmass or synoptic climatologies. Only by considering source regions and areas of typical airmass exchange can the fundamental principle of meridional energy transfer be integrated into a realistic concept of the general circulation. Such regions of dominant vertical airmass transformation or dominant horizontal heat transfer are by definition more "dynamic" than average seasonal wind or pressure fields.

Any classification must necessarily remain suggestive if it should serve a wider purpose. A rigid emphasis of boundaries — which are here explicitly designed to be general — would impair the possibilities of any dynamic classification as a working tool. Each region suggested must obviously be subjected to a searching dynamic analysis and characterization, and modification introduced accordingly. There may, for example, prove to be no satisfactory dynamic reason for separating classes 1ª and 2ª. The distinctions of maritime and continental provinces are made on the basis of seasonal or annual dominance of maritime or continental airmasses. Obviously there are, at present, no satisfactory statistics on airmass frequency for any part of the world outside of certain northern hemisphere, middle latitude areas. Consequently crude approximations based on seasonal precipitation and duration of rainy seanson were used. In general, numerous oversimplifications have been necessary.

The question may then be raised, is it at all possible to devise a dynamic classification of climates on the basis of contemporary knowledge of world synoptic climatology? In fact, it may be argued that our present knowledge is so imperfect, that a dynamic or genetic classification might contain serious factual errors, so obscuring rather than improving our understanding of world climates. Unless synthesis and evaluations of contemporary information are attempted, however, no visible progress is made. Things must be thought about and attempted, and it is in this sense that the suggested dynamic classification is presented here. It will fully serve its purpose if it shows that dynamic classification is possible and may serve a teaching function.

TABLE I.

Circulation Provinces according to Hettner

TYPE	CIRCULATION CHARACTERISTICS
1. *Equatorial Climates.*	Doldrum and convergence belt of the equatorial trough.
2. *Extra-equatorial continental tropical Climates.*	Summer: light winds in the continental interiors, with monsoonal winds nearer the coasts, particularly on eastern coasts. Winter: trade winds and allied circulations.

3. *Tropical Monsoon Climates.* Seasonal reversals of pressure and wind systems.

4. *Trade-wind Climates.* Trade winds or allied circulations throughout the year.

5. *Etesian Climates.* Transitional between the tropical and extra-tropical circulations, with trade wind or allied circulations in summer, westerlies and middle-latitude cyclone in winter. A continental subtype is distinguished.

6. *Extra-tropical maritime Climates.* Westerlies and middle-latitude disturbances dominant throughout the year, limited to the oceans and west coasts of the continents.

7. *Extra-tropical continental Climates.* Disturbed westerlies are weakened and frequently interrupted by periods of light circulation; notable seasonal fluctuations of pressure.

8. *Extreme Continental Climates.* Extreme interior locations affected by topographic barriers are characterized by subdued non-periodic but large seasonal variations of pressure. Anticyclonic circulation permanent in winter, local circulations with lower pressures dominant in summer.

9. *Extra-tropical "monssoonal" Climates.* Middle-latitude east coasts located in the lee of the westerly circulation, modified by a localized monsoonal-type circulation.

10. *Polar Climates.* Anticyclonic circulations fringed by easterly wind belts.

TABLE II.

Dynamic Provinces according to Alisov

PROVINCES CHARACTERISTICS

1. *Zone of Equtorial Airmasses* (humid tropics). Located between the equator and the low-sun seasonal positions of the ITC, considered as the source region of equatorial airmasses.

2. *Zone of Equatorial Monsoons* (winter-dry tropics). Located between the high-sun season extreme positions of the ITC, including those subequatorial areas with alternating continental and maritime circulations of "monsoonal" type.

3. *Zone of Tropical Airmasses* (low-latitude arid zone and trade- wind belt). Located between the summer position of the ITC and

winter position of the polar front, permanently occupied by tropical airmases.

4. *Subtropical Transitional Zone* (humid lower middle latitudes). Located between the seasonal positions of the polar front, with tropical airmasses dominant in summer, modified polar airmasses in winter.

5. *Temperate Zone* (higher middle latitudes). Located between the summer position of the polar front and winter position of the arctic front, winth polar airmasses dominant all year.

6. *Subarctic Transitional Zone.* Located between the seasonal positions of the arctic front, dominated by polar airmasses in summer, arctic airmasses in winter.

7. *Arctic Zone.* Dominated by arctic airmasses all year.

Table III. – Dymanic Provinces according to Flohn

ZONE	PRECIPITATION	PRESSURE & WIND BELTS	WINDS[2] Summer	Winter	"TYPICAL Koppen Climate
1. Inner tropics	Moist all year, mostly heavy rains	Equatorial westerlier or doldrums > 8 months	T	T	Af, Am
2. Outer tropics	Sume rains	Equatorial westerlies (< 8 months) alternating with trades	T	P	Aw. in part also Cw
3. Subtropical arid zona	Prevailingly dry (rare downpours)	Trades or subtropical high	P	P	BS, BW
4. Subtropical winter rain zone	Winter or transitional season rainfall	Subtropical high in sumer, westerlies in winter	P	W	Cs
5. Moist temperate zone	Rain at all seasons	Middle latitude westerlies	W	W	Cf, in part also Cw
6a. Boreal zone	Dominantly summer presipitation, winter snow cover	Westerlies, in part also polar easterlies	E	W	Df, Dw
6. Subpolar zone	Limited reinfall throughout the year	Polar easterlies and westerlies	E	W	ET
7. Hingh polar zone	Limited snowfall throughout the year	Polar easterlies	E	E	EF

2 The wind abbreviations employed by Flohn are as follows:

T equatorial westerlies or doldrums
P tropical easterlies (trades)
W middle latitude westerlies
E polar easterlies

Table IV. A Dymanic Clasification based en Airmass Characteristics

ZONE [3]		DOMINANT AIRMASS WINTER	SUMMER	NUMBER OF MONTHS WITH MARITIME AIR MASSES DOMINANT	AIRMASS SOURCE [4] REGION (if any)	PRESSURE OR WIND SYSTEM
Equatorial	(1)	mT	= mT	10 - 12	....	Doldrums and equatorial westerlies
Subequatorial	(2a)	cT	mT	5 - 12	....	"Monsoonal" circulations, ITC zone in summer
	(2b)	cT	mT — cT	0 - 4	....	
Tropical	(3a)	cT, mT	mT	5 - 12	mT	Trades and Subtropical highs
	(3b)	cT	cT	0 - 4	cT	
Transitional	(4ai)	mP— mT	mT	7 - 10	(mP)	Winter westerly regimes of the west coasts
	(4bi)	mP— mT	cT	5 - 7	(cT)	
	(4aii)	cP	mT	5 - 12	....	Middle latitude east coasts (Westerlies)
	(4bii)	cP	cT	0 - 4	(cT)	Middle latitude interiors (Westerlies)
Subpolar	(5ai)	mP	mP— mT	10 - 12	mP	Higher latitude west coasts (Westerlies)
	(5aii)	cP	mP	5 - 7	(mP)	Higher latitude east coasts (Westerlies)
	(5b)	cP	cP — cT	0 - 4	cP	Higher latitude interiors (Westerlies)
Polar	(6a)	cP	mP	0 - 4	(cP)	Polar easterlies
	(6b)	cP	mP	0 - 4	cP	

3 "a" subdivisions refer to "maritime" as opposed te continental regions ("b"), while (i) subdivisions refer to the western coasts of the continents as opposed to the eastern coasts (ii), (Maritime and continental here imply seasonal or annual dominance of maritime or continental airmasses, rather than "continentality" in the conventional sense).

4 Seasonal airmass source regions indicated in parentheses.

BIBLIOGRAPHY

ALISOV, B. P. Geographical climatic types (Russian). *Meteorologiia i Gidrologiia* (Moscow), 6, 1936, 16-25.

ALISOV, B. P., DROZDOV, O. A. and RUBINSTEIN, E. S. *Lehrbuch der Klimatologie.* Berlin. 1956. 536 pp. Russian original: Leningrad, 1952.

BERGERON, T. Richtlinien einer dynamischen Klimatologie. *Meteorologische Zeitschrift* 47, 1930, 246-262.

BRUNNSCHWEILER, D. H. Die Luftmassen der Nordhemisphere. *Geographica Helvetica,* 12, 1957, 164-195.

CHROMOV, S. P. The geographical arrangement of the climatological fronts (Russian). *Izvestia Vsesoiuznogo Geograficheskogo Obshestva* 82, 1950, 126-137.

FLOHN, H. Neue Anschauungen über die allgemeine Zirkulation der Atmosphare und ihre klimatische Bedeutung. *Erdkunde* 4, 1950, 141-162.

FLOHN, H. Zur Frage der Einteilung der Klimazonen. *Erdkunde* 11, 1957, 161-172.

HARE, F. K. The dynamic aspects of climatology. *Geografiska Annaler* 39, 1957, 87-104.

HARE, F. K. Climatology and the geography student. *Canadian Geographer* 4, 1960, 36-38.

HENDL, M. *Einführung in die physikalische Klimatologie. II: Systematische Klimatologie.* Berlin, 1963. 40 pp.

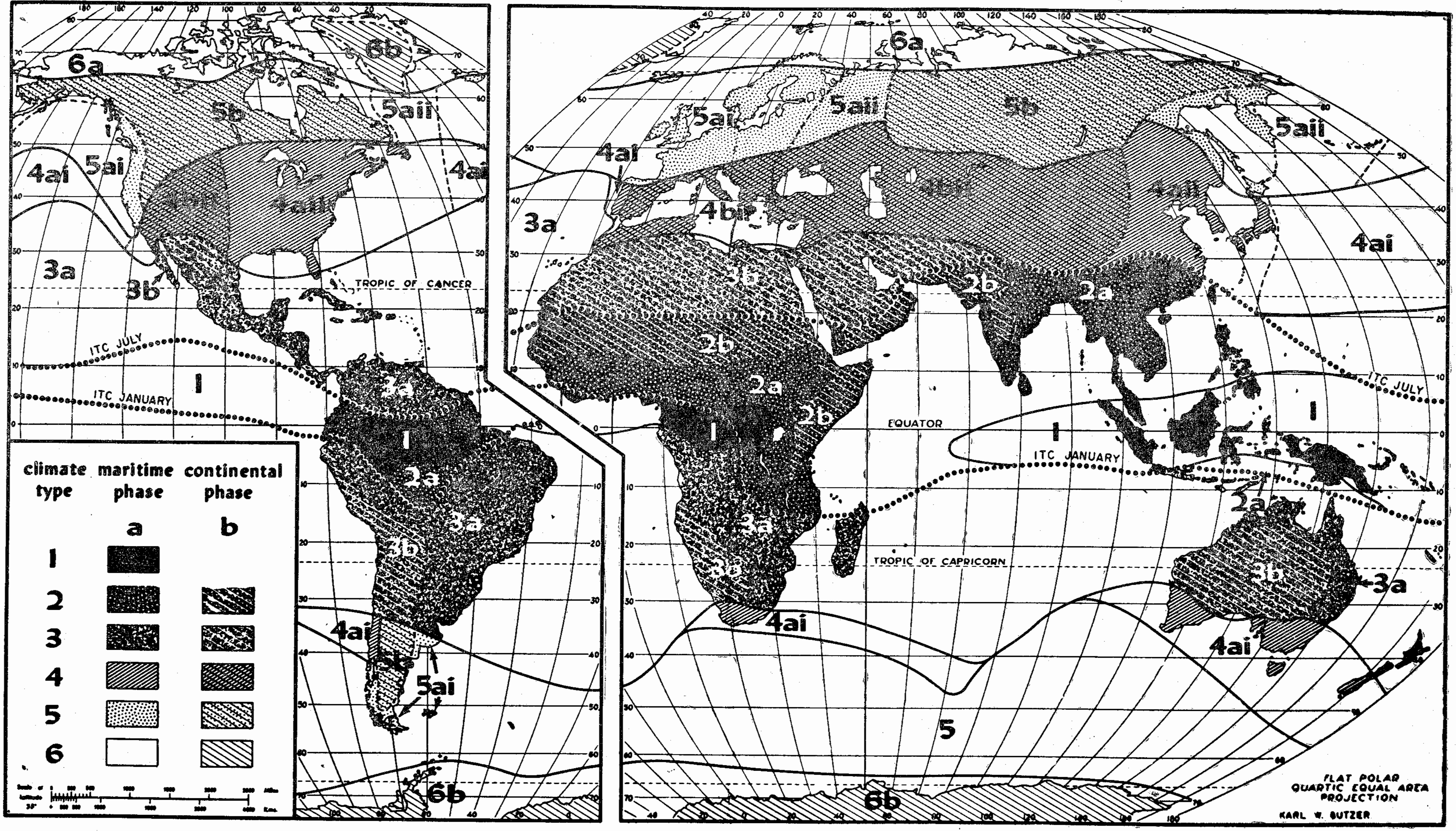
HETTNER, A. Die Klimate der Erde. (II) Die atmospharische Zirkulation. (VII) Die Klimate. *Geographische Zeitschrift* 17, 1911, 482-502, and 675-685.

HETTNER, A. *Die Klimate der Erde. Geographische Schriften* (Leipzig and Berlin) Nº 5, 1930. 115 pp.

KOPPEN, W. *Die Klimate der Erde. Grundriss der Klimakunde.* Berlin and Leipzig, 1923. 2nd edn. 1931, 388 pp.

TREWARTHA, G. T. *An Introduction to Climate.* New York, 1954 (3rd edn.). 402 pp.

A DYNAMIC CLASSIFICATION OF CLIMATES



CONTENIDO:

Prensas de la Universidad Pedagógica y Tecnológica de Colombia - Tunja.

ASOCIACION COLOMBIANA DE GEOGRAFOS —ACOGE—

CONSEJO DIRECTIVO PROVISIONAL

Presidente:

Dr. HECTOR F. RUCINQUE

Profesor visitante Asociado, Louisiana Polytechnic Institute, Ruston, Louisiana, U. S. A.

Vicepresidente:

Dr. JOSE AGUSTIN BLANCO

Instituto Geográfico "Agustín Codazzi", Universidad Nacional de Colombia, Bogotá.

Secretaria:

Sra. CARMENZA M. DE HANKE

TUNJA, BOYACA, COLOMBIA.

Tesorero:

Lic. FRANCISCO ORTEGA

Universidad Pedagógica y Tecnológica de Colombia, Tunja.

CONSEJEROS

Gral. JULIO LONDOÑO

Sociedad Geográfica de Colombia y Academia Colombiana de Historia.

Dr. ERNESTO GUHL

Departamento de Geografía Universidad Nacional de Colombia, Bogotá.

Dr. EDUARDO ACEVEDO LATORRE

Departamento de Investigaciones Económicas, Banco de la República, Bogotá.

Dr. FELIPE CANCELADO

Instituto Colombiano de la Reforma Agraria, Asociación de Ingenieros Geógrafos.

EDITORES

Director "El Correo Geogáfico":

Dr. HECTOR F. RUCINQUE

Presidente de —ACOGE—.

Asistente Editorial:

Lic. CARLOS CUERVO E.

Departamento de Ciencias Sociales, Universidad Pedagógica y Tecnológica de Colombia, Tunja.