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The Classification of Climates from Pythagoras to Koeppen



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ABSTRACT

In this paper attempts are made to trace the ways in which climates were shown on maps of the world beginning with the Greek philosopher Pythagoras and ending with Koeppen. Much of the information was obtained by examining original maps in the Clements Library of the University of Michigan. It is concluded that the most-used climate classification of climates today, that of Koeppen, derives from the five climate zones of the ancient Greeks and that the world is ready for a new classification.

Many modern atlases (National Geographic Society 1995) show maps of the world in which the continents are divided into various climatic types according to the classification of the German scientist Wladimir Koeppen (1846–1940). The purpose of the present paper is to trace the evolution of climate classification from the sixth century B.C. to the time of Koeppen. The word “climate” is derived from the Greek word “clima-ata,” defined as “the slope of the earth from equator to pole” (Barnhardt 1957). The concept of a spherical world is attributed to the Greek philosopher Pythagoras in the sixth century B.C. His disciple Parmenides stipulated five zones on the surface of this spherical world (one torrid, two temperate, and two frigid) and stated that the central torrid zone was uninhabitable because of the heat from the direct rays of the sun (Harley and Woodward 1987). Not all Greek intellectuals held this belief. Herodotus in the fifth century B.C. maintained that the earth was flat, and because of this it was hotter in India in the morning, when the sun was closer to the earth, than it was at noon (Bagrow 1964).

In the fourth century B.C., the Greek philosopher Aristotle (384–322 B.C.) reviewed the opinions of earlier philosophers about the earth and agreed with Parmenides that the earth was a sphere in the center of the universe, that there were five zones, and that the habitable world was confined to the temperate zone between the Tropics and the northern frigid zone (Lee 1962). He suggested that the western half of the temperate zone on the other side of the world from Greece might be habitable and that, because of symmetry, there must be in the Southern Hemisphere a temperate zone corresponding to that in the northern. He believed, however, that the excessive heat in the torrid zone would prevent the exploration of this southern zone (Harley and Woodward 1987).

Although Anaximander in the fifth century B.C. had invented the gnomon or sundial, permitting the measurement of the sun’s altitude and therefore the latitude of a place, there were few such scientific measurements available to the early theorists. There had been voyages to the west coast of Africa by Hanno (470 B.C.), to England by Himilco (mid-fifth century B.C.), to the North Sea by Pytheas (330 B.C.), and to the east by Alexander the Great (350 B.C.). Pytheas was the first to suggest that “length of longest day” could be the criterion determining the limits of the various climates, but the Greek geographers lamented the failure of the explorers to take scientific measurements such as the altitude of the sun or the length of the longest day.

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Erastosthenes (275–194 B.C.) was a scientific geographer whose great contribution was the accurate estimation of the circumference of the world (25 000 mi) based on the distance between Syene and Alexandria in Egypt, and the geometry of the sphere. He also wished to delimit the habitable world, which he believed to be surrounded by a world ocean, and set down specific dimensions for the habitable world: 7800 mi from west to east and 3800 mi south to north. He divided his habitable world by lines drawn parallel to the equator through familiar places such as Alexandria or Rhodes, rather than making them equidistant from each other (Brown 1949).

The astronomer Hipparchus in 140 B.C. attempted to correct Eratosthenes's map in an article entitled "Against Eratosthenes," stating that it was impossible to locate exactly any place on the earth without astronomical observations. He took the principal parallel of Eratosthenes (through Alexandria) as the basis for his division of the known world and was the first to apply the term "climata" to the regions between these equidistant lines. He stated that countries lying beyond the clima with a longest day of 17 h were uninhabitable on account of the cold and, thus, were of no interest (Bagrow 1964).

It is from the philosopher-traveler Strabo (63 B.C.–23 A.D.) that we obtain most of our information about ancient cartography (Brown 1949). He quoted Poseidonius (135–51 B.C.) as saying that there were seven zones on the earth's surface, including two "super torrid" zones on either side of the equator where the land was thoroughly parched and uninhabitable. According to Strabo, Poseidonius was the first geographer to relate climate to man, saying that the people in the torrid zone, as a consequence of the heat and lack of rain, were born with woolly hair and protruding lips, their extremities being, as it were, gnarled (Brown 1949).

Strabo accepted the five zones of Pythagoras rather than Poseidonius's seven since he believed that symmetry was a tool of geographic research. Strabo used the term "torrid" to mean a region so burnt up with heat as to be uninhabitable and argued that the term could not be applied to the whole region between the Tropics since the region from Syene in Egypt to the land of Cinnamon (Somaliland) was known to be inhabited. He said that India, being inhabited, could not lie in the torrid zone and, therefore, must lie in an east–west rather than a north–south direction. For this reason, for centuries India was oriented to the east on all maps. Strabo also accepted Eratosthenes's idea of the exist-

ence of a habitable zone south of the equator but stated that there was no proof of it being habitable, and since the geographers' duty was to delimit the "known" world, it was not worth discussion. Strabo quoted many examples of the way in which men and crops were correlated with the climata, and his monumental treatise fixed for centuries in European thought the idea that the climata controlled the crops, temperature, even the physical characteristics of the people, rather than the astronomical lines they were intended to be (Harley and Woodward 1987).

The Roman geographers added little to the scientific ideas of the climata. Pomponius Mela in the first century A.D. wrote a brief description of the earth with five zones. His treatise is interesting chiefly because of his mention of "antichthones," people whom he believed inhabited the southern temperate zone, although like the earlier Greeks he believed that this zone was inaccessible because of the intervening torrid zone.

The celebrated Greek astronomer and mapmaker Ptolemy (87–150 A.D.) of Alexandria played a most important role in the renaissance of learning in fifteenth-century Europe. He stated that his aim was to reform the map of the world and base it on sound astronomical principles. He drew much of his material from Marinus of Tyre, although he did not hesitate to point out Marinus's errors, for example, that Marinus had not made the climata equidistant from one another. Ptolemy laid down 21 equidistant parallels between the equator and the parallel of Thule (Greenland), and an additional parallel was added south of the equator. Ptolemy gave three legends to his maps "horae diei longissimi (length of the longest day)," "gradus latitudinis (latitude in degrees)," and "numeri climatum (climate number)," the latter being merely the numbering from one to seven of the zones having the following lengths of solstitial day in hours: 1) 13–13.5; 2) 13.5–14; 3) 14–14.5; 4) 14.5–15; 5) 15–15.5; 6) 15.5–16; 7) 16.5–17. No climata were shown north of the seventh clima (the latitude of northern England) or south of clima 1 (southern Arabia), presumably because these areas were regarded as uninhabitable. Ptolemy firmly believed that climate and latitude were synonymous, since he stated:

Reason herself asserts that all animals and all plants have a similarity under the same kind of climate and under similar weather conditions, that is, when under the same parallel and situated at the same distance from either pole (Stevenson 1932).

Thus Ptolemy perpetuated the climata of earlier geographers, since his maps became the outstanding authority in renaissance Europe.

The Arab geographers, borrowing from the earlier Greeks and later from Ptolemy, also showed climata on their maps. The most famous of the Arab map makers, Idrisi, showed seven climata on his 1154 A.D. map (Bagrow 1964). This division into seven was much beloved by the Arabs, since seven was thought to be a magic number. In western Europe during the Middle Ages, the man most responsible for perpetuating the idea of the five climatic zones was the Italian geographer Macrobius, who lived about 400 A.D. He believed in a spherical world and based his concept of the universe on the writings of Pythagoras. Like Pythagoras, he believed that the two polar zones were uninhabitable, and the southern temperate zone was habitable, but this could not be proven because of the intervening torrid zone (Harley and Woodward 1987).

During the Middle Ages, most of the maps of the world were of the T-O type (the letter T within the letter O) showing a circular world divided into three continents (Asia, Europe, and Africa) and oriented to the east (Fig. 1). The all-powerful church denied the existence of the antipodes since, according to the Bible, during the Great Flood all people were destroyed except those with Noah on Mount Ararat, which of course is in the Northern Hemisphere. There were a few exceptions to the usual T-O maps. The maps of Capella about 410 A.D. were circular but showed the zones; those of Isadore of Seville (early seventh century) and Beatus (776 A.D.) were of the T-O type but included zones. Honoré de Autun (twelfth century) combined a T-O map with zones, and in 1448 A.D. Johannes Leardes of Venice drew a map of the habitable world with east at the top, and two areas north and south labeled “uninhabitable because of the cold or heat” (Bagrow 1964).

When Ptolemy’s work became known to the western world, beginning with the Angelus translation into Latin in 1408 A.D., it was usually presented in its original form, with new works added as an appendix. Since the “habitable” world was now known to extend below the equator, the “new” lands south of the equator and the corresponding new climata were added to Ptolemy’s maps. Sylvanus (1511) in Venice drew a heart-shaped map of the world, showing Ptolemy’s seven zones north of the equator, and adding four new climata south of the equator. Apianus’s (1520) map of the world showed a “clima 8” above the “clima 7” of Ptolemy. Figure 2 is a photograph (courtesy of the

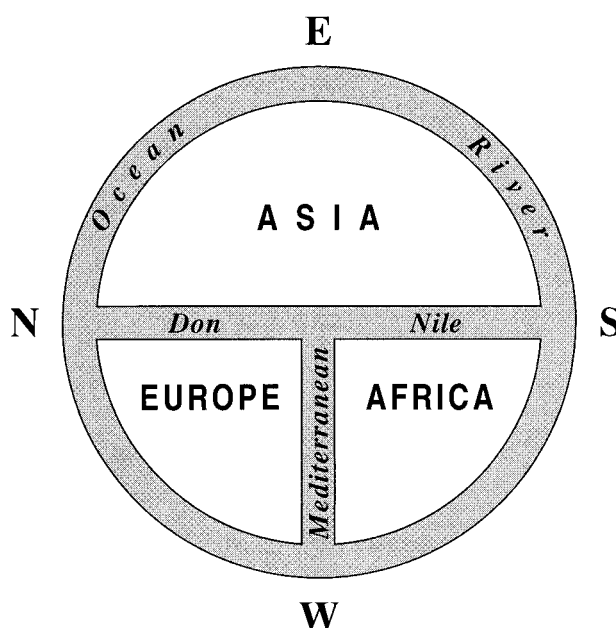


FIG. 1. Generalized T-O map, oriented to the east.

Clements Library) of the 1584 Ptolomaeus world map showing the climata on the right side and length of the solstitial day on the left (note the distortion of India to the east). The habitable world was stretching north as well as south in the sixteenth century! In 1492 Behaim constructed a globe showing the climata. He stated

the planet moon rules the seventh clima. Her house is the Crab. The people of this climate are inconsistent, somnambulist. The longest day is 16 hours long (Ravenstein 1908).

How similar this sounds to the statements of the early Greeks and yet how like the later environmental determinists! Some mapmakers of the period, perhaps more adventuresome than others, dared to ignore Ptolemy’s climata and printed their maps without them [the Strassburg (Ptolemaeus 1520) and the Münster (Ptolemaeus 1540) editions of Ptolemy].

By the middle of the sixteenth century there were scientific methods of determining latitude by the height of the sun and by the polestar and, gradually, as such information became available, maps began to show degrees of latitude instead of lengths of the longest day. As the climata were replaced by latitude shown in degrees, many mapmakers, wishing to show some indication of climate on their maps, and having no climate classification, reverted to the original Greek theory of five zones: one torrid, two temperate, and two frigid. When maps of the new world appeared,

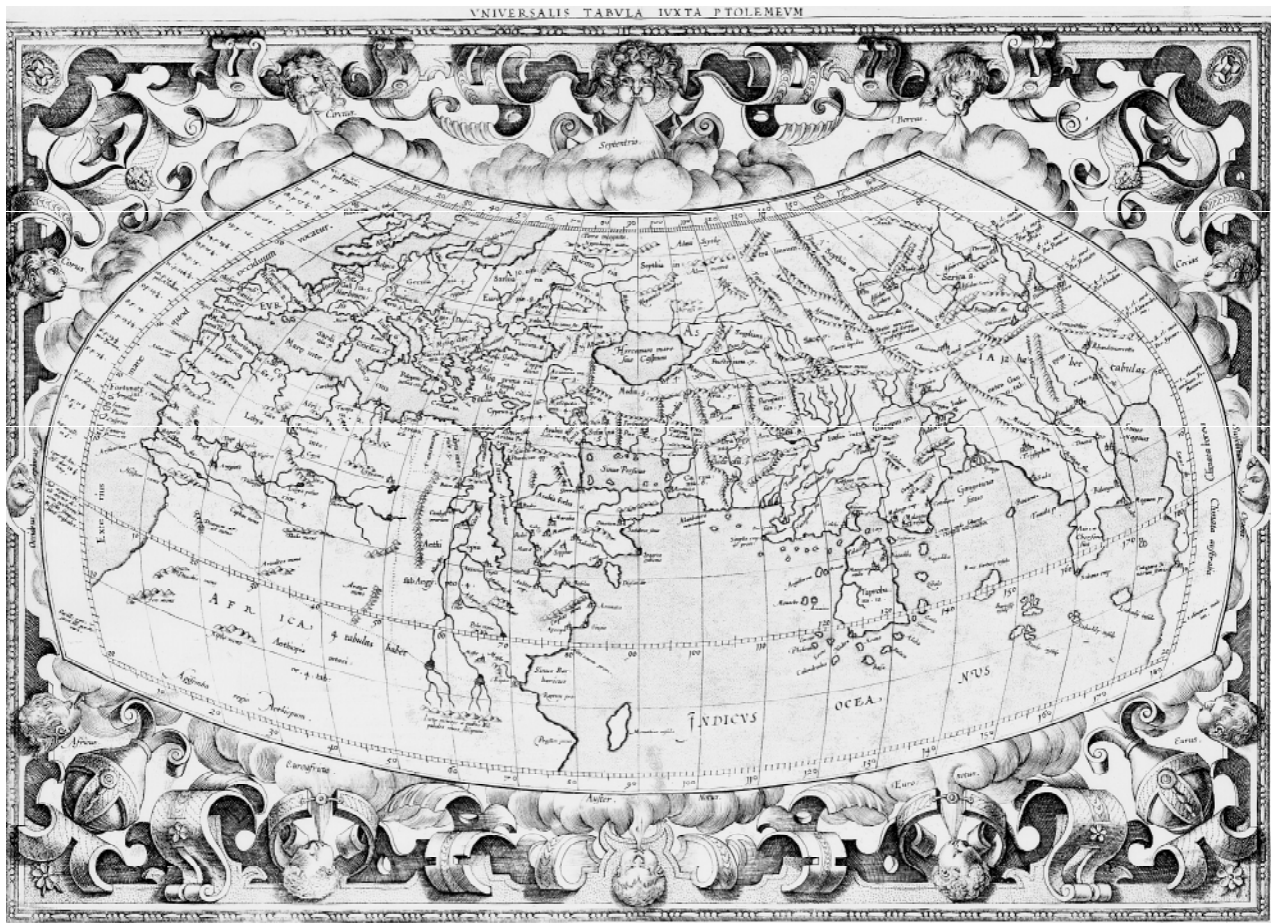


FIG. 2. Photograph of 1584 Ptolomaeus world map (courtesy of Clements Library, University of Michigan).

mapmakers extrapolated these zones to the new territories. Homem's (1554) map and the Blaeu (1648) atlas show the latitudinally extrapolated "zona frigida," "zona temperata," and "zona torrida" on their maps of North and South America. The idea of limits to the habitable world also persisted for centuries. In his geography text, Malte-Brun (1834) stated "the 78th parallel of latitude seems to be the limit of the habitable world in the Northern Hemisphere."

The persistence of the Greek idea of latitudinal climatic zones seems amazing when the geographical explorations that began in the fifteenth century showed that the lands in the new world had climates that were not simple extrapolations of European climates, but highly irregular areas exhibiting contrasts in moisture supply as well as temperature. The zonal system continued to be shown on maps because of a lack of quantitative climatic information. With the development of meteorological instruments such as the thermometer in the late eighteenth century in Europe, regular climatic observations began to be taken. The German

botanist Dove (1853) published the first world maps of temperature and precipitation in 1848.

The first quantitative classification of world climates was made by the German scientist Wladimir Koeppen in 1900. Koeppen was trained as a plant physiologist and realized that plants could serve as synthesizers of the many climatic elements. He chose as symbols for his classification the five vegetation groups of the late nineteenth century French botanist De Candolle, which was based on the climate zones of the Greeks: A, the plants of the torrid zone; C, the plants of the temperate zone; D and E, the plants of the frigid zone, while the B group represented plants of the dry zone. A second letter in the classification expressed the moisture factor (an Af climate is tropical and rainy). Throughout his long life Koeppen attempted to fit various isolines of temperature to the vegetation boundaries of de Candolle. His famous "Handbuch de Klimatologie," published in 1936, brought his classification to the attention of world geographers. When English translations of his work

were made, the English-speaking world eagerly adopted his numerical classification of climates, and maps of the climates of every continent using the Koeppen classification began to appear (Mather and Sanderson 1996).

Although the American climatologist Thornthwaite (1899–1963) published a more rational classification of climate based on the relationship between potential evapotranspiration and precipitation (Thornthwaite 1948), it never became widely used. The reason probably lies in the less understood concept of “potential evapotranspiration” and the cumbersome four symbols used by Thornthwaite. Modern atlases and geography textbooks continue to use the 100-year old Koeppen classification of climates, which was based on de Candolle’s vegetation groups, themselves based on the five climatic zones of the ancient Greeks! Is it not time for modern atmospheric scientists to develop a “new” classification of world climates?

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