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# Evolution in the Semantics of the Term 'Climate'

**Nikolay Takuchev**

*Campus, Stara Zagora, Bulgaria*

*Agrarian Faculty, Dept. of Physics, Trakia University,*

E-mail: nnnpppttt@gmail.com

*Introduction.* When attempting to determine what should be understood by 'climate', an inquisitive reader will be surprised by the lack of sufficient clarity about the content of this concept even today, although the term has been used since antiquity and when translated from Greek means "slope" (of the Sun's rays relative to the Earth's surface). The purpose of the study is to trace the formation of the content included in the concept of climate from antiquity to the present day. *Results.* The concepts underlying the understanding of the concept of climate, such a phenomenon, its properties, weather, regime, and their characteristics such as elements, climatic norms, courses of the element, states, and statistical ensembles are clarified. Examples of the contents included in the concept of climate are provided from antiquity (starting with Hippocrates) to the present day (WMO, NASA, IPCC). The suitability of the examples is critically discussed in light of the previously clarified concepts. *Conclusions.* According to the author, the problem with the shortcomings of the notions of climate cited in the work is the lack of an explicit clarification of the role of the observer. When 'climate' is considered as a four-dimensional space-time phenomenon, an appropriate climate description is: "multiannual weather regime". Since the weather is a local phenomenon, it is understood that this description applies to local climates. The description does not imply the presence of an observer, i.e., it is suitable both for the Earth's climate – from the distant past, through the present to the distant future – and for that of other planets. If the presence of an observer examining the environment through measurements is implied, the climate is considered as a characteristic of the weather conditions, and in this case, an appropriate notion of climate as a characteristic may be proposed as "a set of climatic norms calculated over a multiannual interval, for example, over 30 years, on the measured values of the elements characterising the weather".

Keywords: Climate, Weather, Regime, Element, Definition, Description.

Abbreviation: AN – Author's Note

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## 1 Introduction

We are witnessing changes in the environment at an alarmingly fast pace in terms of the adaptability of organisms – a problem that has gained popularity as "climate change".

When attempting to determine what is meant by 'climate', the curious reader is surprised by the lack of clarity regarding the contents of this concept today, although the term has been used since antiquity and was literally translated from the Greek word for 'slope' (of the Sun's rays relative to the Earth's surface), but also 'propensity' in the social sense, for example in the expression "climate of trust".

The philosopher Martin Schoenfeld [1] perceived climate as a philosophical category: "I cannot 'see' climate because it is a quantitative set of data and a qualitatively holistic structure. I can't point it out, because it envelops me not only in space but also in time, in the past, present, and future".

In his lectures on "Climatology, questions and answers" [2], climatologist G. Rachev described the situation as follows: "Attempts to define the climate were made before the new era, and they are still being made. If we have to summarize the whole scientific history of this issue humorously, we can safely say that the definitions of climate are as many as climatologists. A paradoxical contradiction ensues. If you ask someone if they understand the concept of climate, the answer will be 'Yes'. But if you ask him what the climate is, you will inevitably be left without a clear and specific answer."

The present work aims to trace, in light of modern notions, the evolution of the contents used in the concept of climate from antiquity to the present day.

## 2 Basic notions related to the concept of 'climate'

Several other concepts are intertwined in our perceptions of the climate, which should be clarified to discuss the issue below.

A *phenomenon* (atmospheric, hydrospheric, lithospheric) is understood as happening in the atmosphere, hydrosphere, and/or lithosphere and leading to changes within them. If there is an observer of the phenomena, he/she can perceive the latter with their senses by observing, feeling, and/or judging their existence using devices, but the phenomena exist independently of the observer.

Phenomena have numerous *properties*. For example, the cloud (phenomenon) has a shape (property), color (property), liquid drops and/or water crystals with a given composition (property), and others.

Some of the properties are of interest to the *observer*, which is why the observer introduces and uses their measurable characteristics, called in physics *physical values*, and in meteorology and hydrology – *elements*. Elements are the intensity of solar radiation, the temperature, atmospheric pressure, the intensity of evaporation of water from the Earth's surface, relative humidity, amount of precipitation, etc.

A distinction must be made between the *objectively existing* (whether there is an observer or not) phenomenon with its properties on the one hand and the elements characterizing the properties on the other (introduced by the observer and in this sense *subjective*). Examples of phenomena and their corresponding elements include hot and cold (phenomena) – temperature

(element), air humidity (phenomenon) – relative humidity (element), rain (phenomenon) – precipitation amount (element).

Phenomena can be *described* in more or less detail while the elements are being *defined*. While many of the descriptions may be acceptable, the definition is either correct (single option) or incorrect (all other options). For example, more or less extensive descriptions can be provided for the phenomenon of "air humidity". However, one of the elements that characterize it, e.g., "absolute humidity", requires a definition – it is defined as „the mass of water vapor in a unit volume of air".

Several phenomena can be described together as a *composite phenomenon*, which can be characterized by a mathematical expression (*index*) including elements characterizing the components of the composite phenomenon.

Phenomena depend on time. A *regime* of a given phenomenon is understood as the change of the phenomenon over a given time interval. We talk about the regime in connection with permanently existing phenomena – for example, the regimes of wind, sunshine, thermal conditions, the outflow of rivers, etc.

While diurnal and annual regimes of phenomena are the most frequently recorded, regimes over significant time intervals, e.g., tens of years can also be followed. Indeed, the phenomenon in combination with its regime, is a *four-dimensional space-time object* (with a space-time extent).

Similarly, an element that changes over time outlines a *course* (a series of numerical values), which is a characteristic of the regime of a specific phenomenon.

Weather as referred to below means the integrity of atmospheric phenomena occurring within a limited spatial area (place) and over a short interval (moment) of time. Namely, weather in a given place at a given time can be considered as a composite phenomenon comprising numerous simultaneously occurring phenomena (observed or not).

The set of regimes of individual phenomena is the *composite regime of weather* for a given limited spatial area. The most commonly used description of the climate for a place is: "weather regime for several decades". According to this description, the climate is a locally specific four-dimensional (space-time) phenomenon that exists whether or not it is observed.

Some climatologists prefer to consider the climate not as a phenomenon, but as a characteristic of the phenomena that make up the weather, i.e., as a set of elements that characterize the properties of weather. The course of these elements is a series of numbers that can be subjected to statistical processing, and in particular, be averaged over years.

The World Meteorological Organization (WMO) recommends 30-year intervals to monitor climate change, and the averages obtained are the climatic norms for the relevant elements. The climate of a limited spatial area is often understood as the set of climatic norms for the place. This formulation ignores climate change for the averaging period by comparing climate change as differences in climate norms between the averaging periods. This concept of climate implies, whether expressed explicitly or not, the presence of an observer that would measure the elements of the environment and obtain from them a set of climatic norms.

Other definitions of climate as a characteristic are based on the concepts of *condition* and *statistical ensemble*. The condition of the atmosphere at a given moment and within a certain place is the set of values of the elements characterizing the weather at that moment and place. All conditions, considered together, form a statistical ensemble.

The problem with the semantics of the term 'climate' does not seem to be of much concern to the WMO. However, in the WMO Publication 16 (for the 1974 International Conference on the Physical Fundamentals of Climate in Stockholm [3]), several eminent meteorologists presented definitions of climate, all based on the notion of climate as a characteristic and not as a phenomenon.

According to Edward Lorenz, (Appendix 2.1): "Climate can be identified as a set of statistics of the ensemble from many different states of the atmosphere". Indeed, scientists at the abovementioned conference gathered around the notion of climate as a characteristic with a corresponding definition.

The various points of view described show that there is currently no consensus among the climatologists' professional guild on the meaning of the term 'climate'. The history of the formation of the contents of the term 'climate' is thus described below in light of the above concepts.

## 3 The concept of climate in the past

### 3.1 In ancient literature

In the ancient literature that is preserved today, the term 'climate' was first mentioned in the thesis "On air, water and places" by Hippocrates, written around 400 BC [4]. The term 'climate' was used in the sense of conditions, especially heat, affecting life in a region. The climate was thus considered by the author as a phenomenon. In this work, Hippocrates made an interesting comparison between the characters of the inhabitants of Europe and Asia regarding the differences in climates between the two regions.

In "Meteorology" [5], written around 340 BC, Aristotle introduced the idea that the Earth's surface is divided into five climatic zones parallel to the Equator: two uninhabited cold zones – the Arctic and Antarctic, one uninhabited hot zone around the Equator, and two inhabited temperate zones – between the equatorial and the two cold zones. Again, the term 'climate' was used in terms of atmospheric and thermal living conditions but was perceived as a zonal rather than a local phenomenon [6].

In late ancient geography, the term 'climate' was assigned a meaning corresponding to the modern understanding of latitude. Claudius Ptolemy (100-170 AD) used the climate system [7] in his work "Almagest". In "Almagest", the term 'climate' was expressed by the length of the day during the summer solstice (the longest day for a place on the Earth's surface). Ancient scientists used tables with several 'standard' climates, calculated to the nearest half hour. The "Almagest" included a system of seven climates: Meroe (13 hours, Kush Kingdom, present-day Sudan), Siena (13.5 hours, present-day Aswan, Egypt), Lower Egypt (14 hours), Rhodes Island (14.5 hours), Hellespont (15 hours, today's Dardanelles), Pontus (15.5 hours, the southeastern coast of the Black Sea, in today's Turkey), and the mouth of the Boristenes (16 hours, today's Dnieper, Ukraine) [8].

### 3.2 In the Middle Ages

The criterion for the truth of knowledge in the scientific works during the Middle Ages was the extent to which a certain statement was mentioned by the classics of antiquity. This led to stagnation in all scientific fields, and indeed, no new ideas involving climate were expressed until 1650, when Varenius published his work "Geographia generalis", in which he used the term 'climate' and distinguished geography, especially physical geography, as a separate science [9].

### 3.3 In the 20th century

The beginning of the 20th century was a time of rapid development in the field of climatology. Climatology papers by scientists such as Julius Hahn and Vladimir Koeppen appeared, providing contributions to the general notion of 'climate'.

Khan (early 20th century) described the climate "as a set of meteorological phenomena that characterizes the average atmospheric conditions in each place on the Earth's surface" [9]. For the first time, Khan included the term 'averages' in the description of the climate, the study of which was considered at that time to be rather descriptive, as part of the wider field of geography, and 'averages' meant the measurement and processing of data. Averaging also meant dismissing the time-dependence.

The French theorist in the field of climatology Max Sorre wrote about Hahn's ideas regarding the climate: "This simple and convenient definition uses the average value as a completely unrealistic abstraction, leading to the misuse of arithmetic in characterizing the climate. He presents the climate as static and artificial, without mentioning the development of the phenomenon over time." For Sorre, the climate "is a series of atmospheric conditions in a certain place in their usual sequence" [10].

### 3.4 In modern times

According to climatologist Boris Alisov, "Climate in a broad sense can be defined (AN, "described") as a set of all external influences on the Earth's surface – radiation, hydrothermal, mechanical. In a narrower sense, the climate is accepted as one of the physical-geographical characteristics (AN, the term "features" would be more appropriate) of the area – as a multi-year regime of solar radiation, terrestrial radiation, temperature (AN, perhaps thermal specificity, the temperature is an element) of air and soil, moisture and wind" [11]. Alisov was a supporter of the notion of climate as a regime of a set of phenomena.

The following climate description can be found on the NASA (US National Aeronautics and Space Administration) website [12]:

"The difference between weather and climate is the time for which they are considered. The weather is atmospheric conditions for a short period of time, and climate is the behavior of the atmosphere for relatively long periods of time. In short, the climate is the description of the long-term weather pattern in a given area" (AN, description of climate as a phenomenon), in addition to "When scientists talk about climate, they consider the average rainfall, temperature, humidity, sunshine, wind speed, phenomena such as fog, frost, hail, and other weather measures that occur over a long period of time in a certain place." (AN, i.e., climate, considered as a characteristic of the conditions), and "Some scientists define the climate as the 'average' weather for a given region and a period of time usually taken as 30 years" (AN, an impermissible mix between the characteristic 'average' and the phenomenon of weather, which is neither a good climate description as a phenomenon nor a good climate definition as a characteristic).

In connection with tangible climate change over the last few decades, the professional community of climatologists formed the Intergovernmental Panel on Climate Change (IPCC), which brings together climatologists studying climate change worldwide. Their view of the climate, set out in Annex III to the Fifth Report of the IPCC (2013) [13], is very similar to what was said on the NASA website, which was commented on above. Indeed, according to the author,

it is an unacceptable mix of concepts – phenomena and characteristics, tied in something between description and definition.

## 4 Conclusions

A problem with the above-cited notions of climate is the lack of explicit clarification regarding the role of the observer.

When 'climate' is considered as a four-dimensional space-time phenomenon, an appropriate *climate description* is: "**Multiannual weather regime**". Since the weather is a local phenomenon, it is understood that this description applies to local climates. The description does not imply the presence of an observer, i.e., it is suitable both for the Earth's climate – from the distant past, through the present to the distant future, and for those on other planets.

In the presence of an observer examining the environment through measurements, an appropriate *climate characteristic* may be proposed as "**A set of climatic norms calculated over a multiannual interval, for example, 30 years, on the measured values of the elements characterizing the weather**".

The term climate has been used in scientific papers and in everyday language for 2,500 years. In all these years, it has evolved, without a consensus being reached within the scientific community what this concept should mean. Nonetheless, this is not a major obstacle in the field of climate change research, one of the most important scientific problems in modern times.

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