

Is the term ,climate' too unspecific for a fruitful discussion?

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Abstract: While the debate on the climatic change issue has reached unprecedented global prominence over the recent years, the content is often a fierce clash of opinions rather than a fruitful discussion. One reason could be the use of insufficiently defined terms in climatology. The key term 'climate' is used by lay persons, politics, and science alike, while the UN Framework Convention on Climate Change (1992) does not define the term at all. Instead the Convention defines 'climate change' and 'climate system', which does not necessarily mean that it makes the terminology more definite. This requires looking at the ordinary meaning as used since Ancient Greek, and how science explains the terms nowadays, and whether it is done in a manner that avoids confusion, or misleading interpretation. As science is supposed to define and use terms and definitions with care, the current situation may require that the major terms used in climatology are revised.

Does the term ,climate' hinders a fruitful discussion?

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1. Introduction

“Climate” has become a prominent issue and the scientific terminology used in this respect should be clear, useful, and meet academic standards. Scientific work and research depend on the willingness to understand, and the ability for being understood. Science can be characterized as the possibility of making precise statements which are susceptible of some sort of check or proof. A trained scientist should be able to reason by logic, by order, and by critical thinking skills what others have said, and to communicate his own findings in a way that it can be recognized, discussed, and either be confirmed or rejected. At any stage of scientific process the clarity of words, expression, terms, or definition matter. Atmospheric science should be no exception, but it seems that the scientific community, and politics, are paying too little attention to the meaning of “climate”, which is widely regarded as ‘average weather’.

But can it be wrong when the words “weather” and “climate” are used in a very unspecific and broad meaning? Yes if presented as a scientific term; definitely not as in everyday use. Even without any concrete meaning as term, or as definition the two terms weather and climate are part of everyone’s life, which is understood, shaped, and expressed individually and according to the situation, while a corresponding application in science would be

unacceptable. Civil societies have used the terms since the Greek epoch, or much longer, and the general public knows how to deal with them, and has no problem to discuss aspects at length. But if scientists talk the same way as laymen, that will inevitably cause great uncertainty and confusion. That is the issue this paper is concerned about. Should science be required to say explicitly what they mean when they talk about “weather” and “climate”?

As addressee for clear terms and definitions also politics and those international institutions need to be named, which are active in regard to the implementation of the United Nations Framework Convention on Climate Change from 1992 (UNFCCC). Although the word climate is prominently included in the title, the Convention is silent on the term “climate”.

For a basic orientation, the terms in question are usually explained as follows:

WEATHER:

- The state of the atmosphere, mainly with respect to its effects upon life and human activities [1]. (American Meteorological Society Glossary, AMS)

CLIMATE:

- Climate refers to conditions of the atmosphere at a particular location over a long period of time; it is the long-term summation of the atmospheric elements (and their variations) [2]. (Encyclopædia Britannica)

CLIMATE CHANGE

- Climate change is a long-term shift in the statistics of the weather (including its averages) [3]. (National Oceanic and Atmospheric Administration, NOAA)

CLIMATE SYSTEM

- Climate system comprises the atmosphere, the hydrosphere, the cryosphere, the surface lithosphere and the biosphere [4]. (World Meteorology Organisation, WMO)

None of these common explanations reflect the fact that the atmosphere is ruled by physico-chemical processes, which make and control local and global weather and climate phenomena.

None of the mentioned explanations provides any indication of what all the talking about the weather means, for example by naming those matters that make weather, or those that depress weather feature:

1. Pro-Weather: humid air, low air pressure, ocean space; and
2. Anti-Weather: dry air, high air pressure, continental space.

While these aspects should be kept in mind, the focus of the paper is the question whether the terminology used by science and politics is sufficient, or very unreasonable, weak, and unscientific, and whether a substantial redrafting should be undertaken.

2. The historical context

Although the word “weather” is presumably one of the most used terms in every persons life for many thousands of years, for the general public it is an undefined expression and used by every individual according imagination, usually by arbitrary selection of one or more aspects, e.g. sun-shine, cloudiness, season, location. It covers atmospheric aspects the person can see, or feel, or has heard of. However, “weather” is so much part of every persons daily life, that single weather elements are usually recognized not in an abstract manner, but by an imaginative picture, e.g. the today’s temperatures, rainfall, cloudiness on the way to work, or at the holiday resort in the Caribbean next week. This type of “weather” understanding is very distinct from how science has to look at the issue.

The study of weather parameters requires systematical observations, measurement, recording, and assessment, which is the main task of meteorology. Meteorology is the science that deals with the phenomena of the atmosphere, especially weather and weather conditions [5]. As for the derivation of the term, "meteorologist" originated from the ancient Greeks who named the study of heavenly phenomena "meteorologica" and called rain-drops, hail-stones and snow-flakes "meteoron," meaning "thing in the air" [6]. Although modern meteorology is concerned with understanding of atmospheric physics and weather forecasting since the beginning of the 20th Century, the word "weather" is only defined in very general terms, if any at all.

Concerning 'climate' the late F. Kenneth Hare said just 30 years ago that the word "climate" could be hardly heard professionally before the 1940s, as it was a layman's word [7]. To the Ancient Greek "klima" meant: *inclination*. It had to do with the height of the sun above the horizon but was used as synonym for the effect of the seasons at different locations regarding wind, water, and terrain, and the particularities of the weather. In this broad context the word "climate" was used for more than two thousand years. As soon as meteorology, as a scientific discipline, had been established in the 18th Century, "climate" was e.g. explained as the total sum of the meteorological phenomena that characterizes the average condition of the atmosphere in a certain place on the Earth's surface [8]. This was still in line how the general public would have described climate, and the National Aeronautics and Space Administration (NASA) explains it nowadays:

- Climate is the description of the long-term pattern of weather in a particular area [9].

At a general meeting, in Warsaw, 1935, the International Meteorology Organization (IMO, 1873-1950) confirmed that: "Climate is the average weather", and adopted the years 1901-1930 as the "climatic normal period" [10]. The difference to a laypersons approach is the focus on a 'snap-shot' image of expected weather conditions, in the sense of the expectation of walking, travel or holiday weather. Meanwhile science has extended the "classical period" to a "period of time ranging from months to thousands or millions of years" [11]. This makes the terminology in question not clearer.

3. Weather and Climate today

3.1 WMO - The authoritative voice?

The World Meteorology Organization (WMO) is a specialized agency of the United Nations (UN) [12]. Within the UN system, the WMO understand itself as:

- "the authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources" (WMO-Homepage, 1st paragraph),

and as the specialized agency:

- "For meteorology (weather and climate) operational hydrology and related geophysical sciences" (WMO-Homepage, 2nd paragraph).

The WMO website does not spend much space on the term climate and weather. However the WMO site has a theme-section (WMO-Themes), which includes the two terms in question. Concerning weather, the section "Weather" offers no explanation, but has the opening sentence: "Everyone is interested in the weather", while subsection: Understanding Climate/What is Climate (WMO-Themes) begins with the sentence: "At the simplest level the weather is what is happening to the atmosphere at any given time." In the same section the Organization offers for climate three options, namely:

- in a narrow sense Climate is usually defined as the "average weather",

- in a more rigorously way, Climate is the statistical description in terms of the mean and variability of relevant quantities over a period of time¹, and
- in a broader sense, Climate is the status of the climate system which comprises the atmosphere, the hydrosphere, the cryosphere, the surface lithosphere, and the biosphere.

None of these items are clear. For example:

- “average weather” explains nothing, and if renamed in “climate” it makes nothing clearer;
- A “statistical description” is possible only where statistics are available, actually only when data have been collected and recorded, and can only be applied for the past. The future has no “statistical description”.
- How can an authoritative UN agency seriously say that “climate is the status of the climate system...”, which is a senseless tautology. To recognize immediately the emptiness of explanation, one needs only use WMO’s own explanation by replacing ‘climate’ in the last (broader sense) sentence, e.g.:
 - “average weather” is the status of the climate system....; or
 - “statistical description in terms of the mean” is the status of the climate system...

None of the WMO explanations reflect in any way what they claim the organization is the authoritative UN institution (see above), e.g.: interaction with the oceans, operational hydrology and related geophysical sciences.

3.2 Explanations by IPCC, NASA and AMS

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the WMO and the United Nations Environment Programme – UNEP- [13]. Since 1990, it has produced four reports, which are based on peer reviewed papers. The last was released as the Fourth Assessment Report (AR4) in 2007. Since the First Report, ‘climate’ was defined as the average weather [14], while weather received no special attention. Over the years some slightly varying explanations were used, either in the reports or in glossaries, of which we consult only the last material of the Working Group I in 2007. The IPCC Glossary, as Ref. [11], has not listed weather, and on climate it is said this:

- Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

This text is widely identical with the WMO text given above. But there are often variations even within the latest report of WGI. The section “Frequently Asked Question”, FAQ, which covers two topics [15], express the matter, inter alia, as follows:

- The atmospheric component of the climate system most obviously characterises climate;

¹ NOTE: *Statistics* are the science of collecting, analyzing, presenting, and interpreting data. (...) Data are the facts and figures that are collected, analyzed, and summarized for presentation and interpretation. (Encyclopædia Britannica, www.britannica.com)

- Climate is generally defined as average weather, and as such, climate change and weather are intertwined.
- While weather and climate are closely related, there are important differences;
 - Projecting changes in climate (i.e., long-term average weather) due to changes in atmospheric composition or other factors is a very different and much more manageable issue.
 - As an analogy, while it is impossible to predict the age at which any particular man will die, we can say with high confidence that the average age of death for men in industrialized countries is about 75.
- The chaotic nature of weather makes it unpredictable beyond a few days.

Not one of the explanations meets basic academic reasoning, and if not straight false or illogical, the statements are of little help to use them for scientific work, or for communication with politics and the general public.

The Ref. [9], NASA, explains that:

- Weather is basically the way the atmosphere is behaving, mainly with respect to its effects upon life and human activities, and that there are “really a lot of components” to weather, which include sunshine, rain, cloud cover, wind, hail, snow, sleet, freezing rain, flooding, blizzards, ice storms, thunderstorms, steady rain from a cold front or warm front, excessive heat, heat waves and more.

The enumeration of weather aspects is certainly a reasonable way to explain weather. But at the same time it should make it clear that this is done on a limited scope and is an insufficient way to be used in scientific research. The topics mentioned by NASA are arbitrarily chosen from several dozen weather parameters.

This is well illustrated in the way the Ref. [1], AMS, makes the following distinction:

- The “present weather” table consists of 100 possible conditions,
- with 10 possibilities for “past weather”, while
- popularly, weather is thought of in terms of temperature, humidity, precipitation, cloudiness, visibility, and wind.

If the weather consists of 100 possible conditions, how can “past weather” consist only of 10 conditions? Who is making the selection? Who decides over the period of time, whether data are used over a period of time ranging from months to thousands or millions of years? What are the “10 possibilities for past weather”? Which mix of data represents the past weather or the future weather? The extreme shortcoming of the explanation is revealed by the reference to “popularly weather”, which may reflect the layman’s version reasonably, but not necessarily. If the AMS Glossary actually says that popular weather exist –presumably- of five conditions, past weather consists of 10 conditions and present weather consists of 100 conditions it seems that this is nonsense talking. There is no such thing as small, medium, and big weather, with few, several, or many dynamo-physical atmospheric elements. Weather is either weather, or it is statistics of one or several weather components.

This is underlined by a further Ref. [9] explanation, whereby:

- “The difference between weather and climate is a measure of time scales. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere “behaves” over relatively long periods of time”.

As just demonstrated the NASA is inconsistent by reducing the difference to a question of time. Not less superficial is the AMS Glossary by describing 'climate' as:

- “The slowly varying aspects of the atmosphere–hydrosphere–land surface system; typically characterized in terms of suitable averages of the climate system over periods of a month or more, taking into consideration the variability in time of these averaged quantities” [16].

It requires a lot of guessing and own imagination to make something up from this explanation. That the Ref. [9] does not dare to understand the terms weather and climate just in the same way as any layperson may be demonstrated with the following reference:

- Climate, however, is the average of weather over time and space. An easy way to remember the difference is that climate is what you expect, like a very hot summer, and weather is what you get, like a hot day with pop-up thunderstorms.

The NASA-Glossary says correspondingly [17]:

- Weather: “Atmospheric condition at any given time or place. Compared with climate”; while
- A term “climate” was not listed in the glossary, (when visiting the site in May 2010 and August 2011), whereas
- Climatology is described as: “Science dealing with climate and climate phenomena” (without explaining “climate phenomena”).

As NASA draws the distinction between weather and climate as a measure of time (see previous paragraph), it seems they understand under climatology the science about “short time weather” and “long time weather”, making it difficult to regard the description as clear, correct and useful.

3.3 The UNFCCC terminology

A preliminary look at the most relevant legal instrument on climatic matters, the United Nations Framework Convention on Climate Change, 1992², - FCCC – shows that it is in no way any clearer in the terminology as those of the institutions already mentioned. Article 1 on definitions covers nine topics, of which sub-paragraph 2 and 3 are relevant for this analysis:

- For the purposes of this Convention: “Climate change” means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
- For the purposes of this Convention: “Climate system” means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions.

It is astonishing, to say the least, that an international UN Convention is coming up with two compounded words, which include 'climate' without defining the term in the first place.

One can even ask the question, whether the FCCC needed to define these terms at all, as Article 2 confines the task of the convention to the “ultimate objective ...the ...stabilization of greenhouse gas concentrations in the atmosphere”, which indicates a lot about the competence of the drafters, but can be left aside as long as only the quality of specific terms and definitions is in question.

² NOTE CONCERNING UNFCCC:

In December 1990, the UN General Assembly approved the start of treaty negotiations (Resolution 45/212). The Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/FCCC) met for five sessions between February 1991 and May 1992, and due to a strict deadline - the June 1992 Rio "Earth Summit"- negotiators from 150 countries finalized the Convention in just 15 months. It was adopted in New York on 9 May 1992.

3.4 Meteorology and Atmospheric Science

In contrast and for comparison it seems necessary to list a few explanations how the concerned scientific disciplines are recognized, to show that it is about physics and chemistry, e.g.:

- Meteorology - The study of the physics, chemistry, and dynamics of the earth's atmosphere, including the related effects at the air–earth boundary over both land and the oceans, as Ref. [1]. (AMS-Glossary).
- Atmospheric sciences encompass the study of all physical and chemical phenomenon occurring within the Earth's atmosphere or the atmosphere of any other planet [18]. (University of British Columbia).
- Atmospheric science is the study of the atmosphere—the blanket of air covering the Earth. Atmospheric scientists study the atmosphere's physical characteristics, motions, and processes, and the way in which these factors affect the rest of our environment. The best-known application of this knowledge is forecasting the weather [19]. (U.S. Bureau of Labour Statistics)
- Atmospheric Physics. The atmospheric phenomena observed on Earth and other planets range over various scales and involve various physical processes, such as dynamical, radiative and cloud physical ones [20]. (The University of Tokyo).
- Atmospheric sciences. The comprehensive study of the physics, chemistry, and dynamics of the earth's atmosphere, from the earth's surface to several hundred kilometers; this usually includes atmospheric chemistry, aeronomy, magnetospheric physics, and solar influence on the entire region [21]. (AMS-Glossary)

4. What is the Problem?

4.1 Basics

The presented examples hardly show that science uses the words weather and climate in a different way as the general public has used them for some millenniums. There are variations but in substance the meaning is the same and differs not very much. That could be taken for granted if any confusing, and misunderstanding is excluded. Presumably it did not matter as long as science showed little interest in climate matters, which was the case well until the middle of the last century, until which climatology was regarded as the mere dry-as-dust bookkeeping end of meteorology [22]. But since science has raised the climate issue to a top policy issue on mankind's survival and a multi billion dollar investment matter, a need for clarity in language and whether the matter is understood and sufficiently handled is obvious. But science has not come up with more than that 'climate' is average or statistical weather. As a scientific definition it would require in the first place to say what "weather" is, and in the second place why it makes sense to call average weather or statistical weather 'climate', although the subjects remains the same: average weather, or statistical weather.

On the other hand, the two terms "climate change" and "climate system" do not originate in the layman's sphere. They became prominent with the start of the global warming debate in the 1980s. Either due to this debate or a general belief of everybody to know what climate is all about, many may say that they have an idea about climate change and climate system at least in broad terms. That would be sufficient in the layman's sphere, but unacceptable in science.

4.2 Climate

It is difficult to understand and to discuss, why 'average weather' shall be named 'climate'. Worse, if it is not said what is covered by the term "weather", with five, twenty, hundred, or

all physical elements. If necessary it is sufficient to talk about temperatures, cloudiness, or increased carbon dioxide, but none of these items represent THE WEATHER at a certain place and time, or makes it to ‘average weather’. But while temperatures, humidity, or CO₂ are physical parameters, the term CLIMATE is standing for nothing.

Another problem would be the time span. Does Climate cover two months, one year, 30 years, thousand, or one Million years? The IPCC-2007 Glossary, as Ref. [11], says that the possible time span is without any time limit, “ranging from months to thousands or millions of years”. It seems absurd to quantify a longer time period, e.g. 100’000 years, as “average weather”, and even less reasonable say it is “climate”. This is also in a stark contrast what the predecessor of the WMO agreed in 1935, namely that the period from 1901 to 1930 should be used to express departures from mean data [23]. Not only has this fixed indicator been abandoned, but also the time span of 30 years. What is now a ‘change’?

4.3 Climate Change & Climate System

Meanwhile the two terms are international law and are frequently used by governments, politicians, science and organizations to pursue a high stake global agenda, specifically on global warming and greenhouse gas emissions. In the Nobel Peace Prize Lecture, 2007, the Chairman of IPCC, R.K. Pachauri, said:

- “.....climate change will have several implications, as numerous adverse impacts are expected for some populations in terms of: access to clean water, access to sufficient food, stable health conditions, ecosystem resources, security of settlements” [24].

Terminology used should therefore be clear, unambiguous, and relevant for the subject matter.

The term “climate change” lacks a qualifying substantive. A scientifically reasonable definition for climate is not available. Neither the FCCC offers one, nor any other organization as has been shown in the previous section. It is not possible to quantify a “change” if the subject of change has not been defined. It is defiantly neither a solution to use the common explanation on “average weather”, because “average weather” in scientific terms (see WMO above) is statistics, and remains statistics regardless of any name given to the set of statistics. But even if one is willing to say: OK, it is not necessarily the best solution, but better than nothing, it raises several other uncertainties. There would be e.g. the problem of the selection, which weather components are chosen: two, five, twenty or one hundred, or the time period to apply, if this period is not covered by weather statistics?

4.4 Climate System

The absolute uselessness of a term ‘climate system’ is quite obvious, as it is synonym with the term “nature” [25]. “What is the point of a legal term if it explains nothing? All that this boils down to is: “the interactions of the natural system”. Why any circumvention if could be said directly: “weather system” means the totality of the atmosphere, hydrosphere, biosphere and geo-sphere and their interactions. The attempt to construe from “average weather” or “statistical weather” a system is a failure. It ignores completely the basis of all atmospheric processes: physics. The definition “climate system” explains nothing.

5. Conclusions

Concerning climate terminology science is still in the Middle Ages. All relevant terms are presented in a way as in use by laypersons since time immemorial. For scientific work the terminology is a mess and neither reasonable definite nor intelligible. For communication with the general public they are insufficient, useless, and of no help. Not one of the numerous terms in question, explains anything about the composition of the atmosphere and its

performance. The reason seems simple. Science is either unable or unwilling to present and explain to themselves, politics and the general public that any status or change in the atmosphere is a physical process. They define ‘meteorology’ and ‘atmospheric science’ as a matter of physics, chemistry, and dynamics, but present and communicate the issue, as if it is a complete separate sphere, namely that of laypersons. It ignores that for the people, their every day weather and climate is a very immediate and often emotional aspect, and any unspecific use of the terms is irresponsible.

In any case the adopted terminology should ensure that the physical relevance is not ignored, as it is the case with regard to the word “climate”. It is possible, and has been widely done, to raise specific items, e.g. CO₂, temperature, or sea level rise, and to put it context to other physical parameters, as well to local, regional, global application, based on average, time period, and changes. The lack of specification is the most effective way to sap a fruitful discussion. As science avoided until now to define “weather” in physical terms in the first place, it is out of reach to consider the next step of giving the word ‘climate’ a reasonable meaning in an academic manner.

As the terms weather and climate belong to the laymen’s sphere, it is doubtful whether science should use them for their terminology. They should not, as it is a source of confusion. However, if science and politics want to use the word “climate” in service for themselves and the general public they should lay the focus on the essence of the weather system, or the driver of the weather system, by saying: “Climate is the continuation of the oceans by other means”, see Ref. [25], or to say it with Leonardo da Vinci (1452-1519): “Water is the driver of nature”.

Further material discussed at: <http://www.whatisclimate.com/>

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