Causes of climate change

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Introduction

The problem of climate change, and especially global warming, is a serious topic in the modern world. There are a lot of evidence that climate is getting warmer such as melting of arctic ice or late beginning of winters. At the same time weather is changing, and it is possible to observe weather phenomenon which are unusual for particular places. It is used to think that human activities such as pollution from factories and cars or disafforestation can harm the nature and cause the global warming. However, the climate has been changing throughout the whole history of the planet. For example, during the Middle Ages (900–1350 AD), the climate of areas of the Northern Hemisphere was warmer with a mean temperature 1–2 °C higher than the average temperature during the 20thcentury. This relatively warm weather allowed northern dwellers to organize prosperous settlements in Greenland. Also, during the Last Ice Age the area where Norway is located nowadays was covered by ice of approximately 1 km thick.

The climate is a quite complex thing, and there are a lot of mechanisms that influence on it. Changes in solar radiation and volcanic activity, internal feedbacks and the ocean heat uptake are clue things for understanding physical processes of climate. It is important to realize the main external forcing mechanisms underlying in climate changes to make a prediction about future of the planet. This knowledge will also allow avoiding wrong interpretation of current climate processes.

In current work there will be an overview about the basis for understanding the physical processes governing climate variations in the past, present and future. Also, the ways how scientists discovered that the climate had been changing in the global meaning will be described briefly. The main goal of this work is to explain briefly main mechanisms which can facilitate to changing the global energy budget and cause climate variations.

Natural radiative forcing

Over the last several centuries human activity such as emission of greenhouse gases and aerosols have influenced on climate changing. However, before this climate changes were caused by natural phenomenon such as sun radiation or volcanoes eruptions.

The sun is the source of life on the planet and one of the main forces influencing on climate. The amount of radiation which Earth gets from the sun depends on its location in relation to the sun and sun activity. There are three main parameters which reflect the Earth position.

- The Earth moves on elliptical orbit which eccentricity changes approximately every 100,000 – 400,000 years. Currently, eccentricity is equal to 0.0167 while by 24000 the Earth orbit will take the shape of a circle.
- The obliquity, or tilt, of the Earth's axis gives us seasons. However, the tilt is not constant in relation to the orbit. It has been changing from 22.0 to 24.5 degrees with periodicity of 41,000 years. If the tilt was 90 degrees, we would have only one season, which is spring, throughout the year. Now the obliquity is 23.4 degrees.
- It is used to think that the north end of the Earth's axis points to Pole star. However, it is not complete true. Instead it slowly rotates (or precesses) making a cone. Gravitation of the sun and the moon cause this phenomenon, which is called precession. The whole circle the axis does in 21,000 years.

The current interglacial era is the result of a number of changes in orbital parameters. However, the total solar irradiance changes over time and can be subjected to sunspot activity. Higher activity relates to growth of the solar irradiance towards Earth, and vice versa.

Volcanoes are the next source of the natural radiative forcing. Volcanic eruptions cause emission of sulphuric gases which immediately turn to aerosol in the atmosphere. The aerosol reflects sun energy that leads to Earth cooling. At 1550-1800 there were a period, known as little ice age, which followed by volcano's eruption. Aerosols are not collected in atmosphere unlike steam and carbon dioxide, which volcanoes also emit during their eruptions. This has a long term influence: after thousands or even millions years due to big volcano's eruptions, increasing concentration of CO2 in the atmosphere can contribute global warming.

Man-made radiative forcing

First of all let us define the concept of radiative forcing. Radiative forcing is the net change in the energy balance of the Earth system due to some imposed perturbation. It is usually expressed in watts per square meter averaged over a particular period of time and quantifies the energy imbalance that occurs when the imposed change takes place. If radiative forcing equals to zero, the Earth is in radiative balance. If it is greater than zero, the influence is positive, and it is possible to tell about global warming. If radiative forcing is less than zero, the influence is negative, and the Earth is cooling. While natural radiative forcing can be positive or negative, man-made one is rather positive.

Life in the modern world requires a lot of energy. To compare, nowadays people consume more than 30 times the amount of energy they used 150 years ago. Burning fossil fuels is a resource of almost 80% of energy. The byproduct of this process is CO2 emissions which, as in case of volcanoes, can be collected in the atmosphere and lead to the global warming. However, these emissions do not only contain carbon dioxide: they are also a source of aerosols. These aerosols consist of different small particles containing soot and sulfate. Unlike CO2, these aerosols stay in the atmosphere only for a few weeks. However, in spite of this short lifecycle, they play important role in human inducing the climate. Aerosols are the second biggest effect

that people have on the climate. Some of these particles reflect sun radiation, and increasing of these particles leads to cooling the planet. At the same time the growth of others which absorb the radiation will have warming effect. These properties are denoted as “direct effect”.

Heat transport and ocean heat uptake

As it was mentioned before, the sun is the main force driving the climate. However, the amount of energy, received by the planet at the same time, varies from latitude. Thus, the equator, where the Sun’s rays are directed straight, gets the biggest amount of solar radiation while the places close to poles, where rays are directed by the angle, receive the least amount of sun energy. This difference in received energy causes the pressure drop which leads to driving currents in the atmosphere and the ocean. The ocean and atmosphere streams transport heat which reduces temperature contrast on the Earth. The illustration for this can be the Gulf Stream, the biggest current in the world, which starts in the Gulf of Mexico picking up the heat to transport it through the North Atlantic Ocean to the Norwegian Sea, where the highest amount of heat is emitted to the atmosphere. The Gulf Stream makes the climate in Europe softer. If it stops only for one week, the temperature in Norway, for example, will decrease on several degrees.

The ocean covers more than 70% of the Earth surface. The ocean receives more than half of the energy entering the climate system, and has an enormous capacity to store heat. The ocean is the largest thermal reservoir on the Earth and the effective heat capacity of the ocean will determine how fast the Earth responds to a radiative forcing. Effective heat capacity is the measure which reflects how much energy is required to change the temperature of the thermal reservoir by one degree. In other words, how fast the Earth responds to radiative forcing. Effective heat capacity of the ocean varies every time, however, the reasons for these changes are unknown. Meanwhile, it is important to notice that effective heat capacity does not influence on the Earth temperature. It only changes time which is required to reach the equilibrium to the radiative force. For example, in the figure 1 it can be seen how the size of the effective heat capacity influences the speed of the warming.

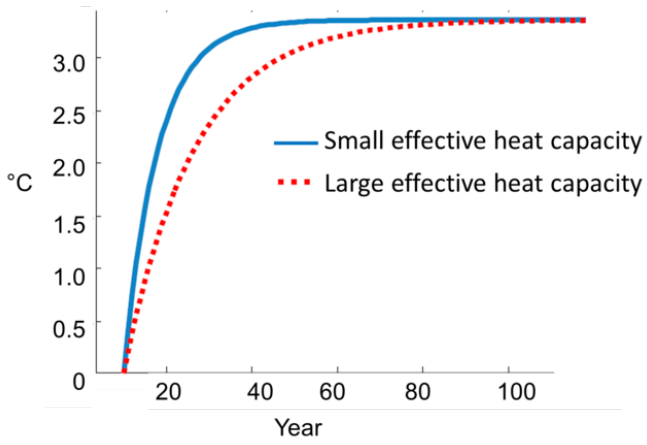

Fig. 1

Archives of past climate changes

Studying climate changes in the past allows scientists make conclusion about how climate works and predict how it will vary in the future. It is important to understand techniques which are used by scientists to know these processes. Palaeoclimatologists, researches in the field of past climate, focus on reconstruction the climate (e.g. temperature/precipitation/ocean currents) with as little margin of uncertainty and as fine a time resolution as possible back in time. To do it, they must apply data from different archives. The sources can be: Geological data (marine organisms, sediment composition); Land data (sediment from lakes, moraines, calcium deposits in caves); Glaciological data (ice cores and glacial moraines); Biological data (pollen, plant remains, insects, tree rings); Bones and skeleton remains; Historical data (recorded information in church annals, letters etc.); Marine fossils in (these include fossils of organisms preserved in sediments on the ocean floor and reflect temperature, nutrient content and salinity in the water at the time these lived; Sediment composition and the size distribution of subsea particles and debris (these give information on the strength of ocean currents, sea ice distribution and drop-stones from drifting icebergs).

Using all these data palaeoclimatologists can conclude what climate was in the past and how it has changed.

Summary

The climate is a very complex concept; a lot of factors influence on it and form it. Although over the last several centuries the man activity affect on it, the climate has been changing throughout the whole history of the Earth. In my personal view, the human activity can speed up or slow down these changes but not to cancel them. It is important to understand all aspects of climate changing to make a prediction about future of the planet and avoid wrong interpretation about current processes.

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