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Climate Variability and Change – Past, Presence and Future

Abstract

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Our climate fluctuates and changes at a wide range of time scales and on local, regional and global spatial scales. Natural and anthropogenic (man-made) forcing factors as well as internal variability play together and modulate the processes in the different components or subsystems of the whole climate system (see Fig.1). The climate manifests itself in a characteristic variety of atmospheric circulations, which – through their interaction with the Earth’s surface - are responsible for the genesis of local and regional weather at timescales from minutes to days. The term climate refers to the integral or the summary of many shorter-term weather events over a long time period from months or seasons to millions of years.

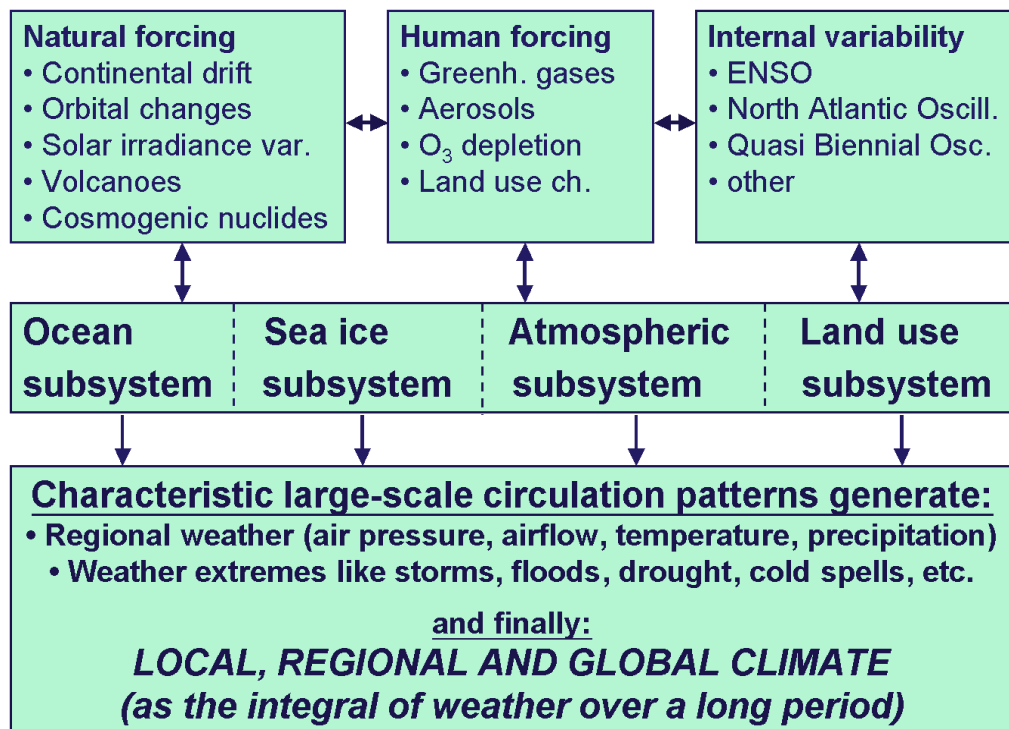


Fig.1: Overview of the climate system.

At the very long time scale of millions of years, the Earth’s climate was strongly determined by changes of the composition of atmospheric gases like O₂ and CO₂, by plate tectonics, and by the activity of the sun. During the last glacial period of about 2.7 million years, changes of the orbit of the earth played a major role. During deglaciation periods the freshwater flow from the melting northern hemisphere ice shields led to remarkable reorganizations in the ocean system and, therefore, to dramatic and rapid climate change (keywords: Younger Dryas or Noah’s Flood). During the Holocene (approximately the last 11,000 years) climate varied respectably in the tropical area. In the northern hemispheric mid-latitudes, the average temperature decreased slightly until 1890 AD.



During the last few thousand years climate fluctuations at the decadal to century time scale were mainly induced by quasi-periodic fluctuations in solar activity and by irregularly occurring volcanic events. With the increasing industrialization of the last two centuries the anthropogenic influence on climate, mainly by greenhouse gases, aerosols and land use changes, has steadily growing. Since 1900, the global mean surface air temperature has increased by about 0.6°C.

To scientifically assess the challenge of man-made climate change, the Intergovernmental Panel on Climate Change (IPCC) has been set up under the auspices of the UN Environmental Programme and the World Meteorological Organization. The purpose of IPCC is to assess climate research, to develop a consensus view, and to foster research on areas of special interest. Thousands of scientists have contributed to IPCC. In its third assessment report in 2001, it has stated that “there is new and stronger evidence that the warming observed during the last 50 years is attributable to human activities”.

In order to develop mitigation and adaptation strategies, climate change scenarios are being developed. To this end, sophisticated climate models are used that represent the key processes of the climate system. These project an accelerating warming of our planet, with an anticipated global mean warming in the range of 1.4 to 5.8°C by the end of the century (see Fig.2).

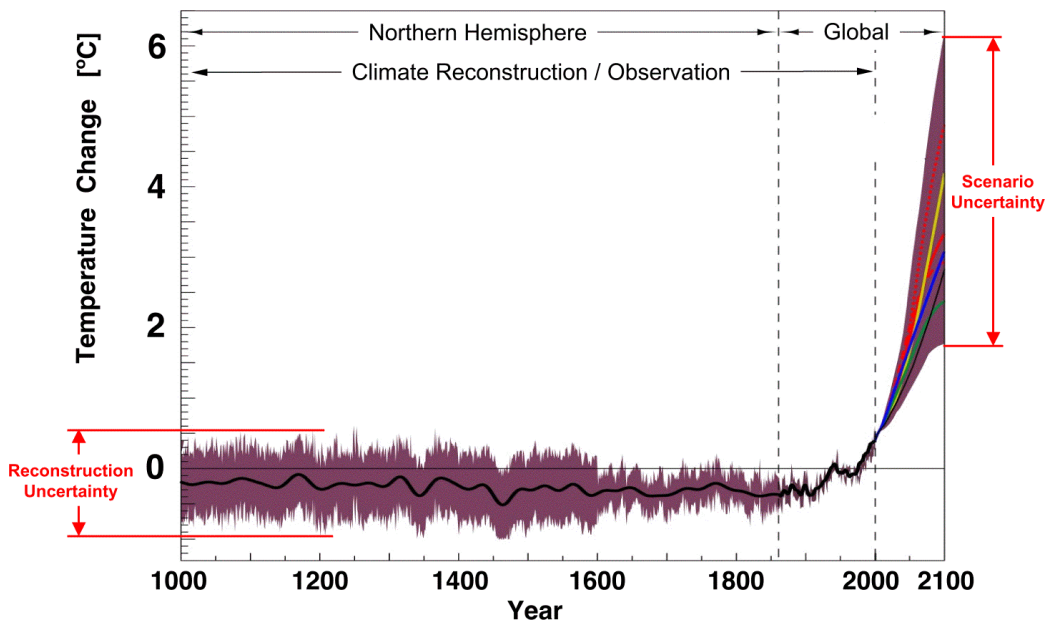


Fig. 2: Reconstructed evolution of the global mean (north-hemispheric) surface air temperature in the last 1000 years, and projections for the next 100 years.



Such a warming would have strong implications on many aspects of the climate system. It would affect the global water cycle and the availability of water resources (e.g., leading to increased droughts in the sub-tropics), the occurrence of extreme weather events (e.g. heat waves and floods), and lead to a pronounced sea level rise (around ~40 cm by the end of this century).

While the climate models are not yet able to provide detailed climate predictions, there is increasing consensus that the anticipated changes are large enough to substantially affect our economy and ecology. Reducing the anthropogenic impact is thus a prime target of the international negotiations under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC).