Introduction

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Advance in our understanding of recent changes in the climate system results from the combination of observations, studies of feedback processes, and model simulations [1]. Instrumental observations and climate modelling provide a comprehensive overview of the variability and long-term changes in the atmosphere, the oceans, the cryosphere, and the land surface.

Observations of the various systems of the climate come from surface-based measurements and satellite-based remote sensing observations. However, instrumental records for the key meteorological variables, such as surface air temperature and precipitation amount are available for a period extending back only to the 17th century. The earliest instrumental data date back to 1654 for temperature [2] and to 1697 for precipitation [3]. Global-scale observations from the instrumental era began around the mid-19th century for temperature and other variables with more comprehensive and diverse set of observations available mainly for the second half of the 20th century. Palaeoclimatological reconstructions, however, can in some cases extend our knowledge back over hundreds to millions of years.

A global climate model (GCM) is a complex mathematical representation of the major climate system components (atmosphere, land surface, ocean, and sea ice), and their interactions. The Earth's energy balance between the four components is the key to long-term climate prediction [4]. Each of the components (atmosphere, land surface, ocean, and sea ice) has its own equations calculated on a global grid for a set of climate variables. Model components have not only computed how they change over time, and how the different parts exchange fluxes of heat, water, and momentum, but model components also interact with one another as a coupled system [4].

A recent study investigated the long-term response of the Earth's global climate system in the future using periods in climate history that were warmer than our recent past [5]. The study showed that marine and terrestrial ecosystems will spatially shift

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and sea level will rise by several meters over the next few thousand years even under strict mitigation scenarios as foreseen in the Paris Agreement [6]. This evidence stresses the need for climate models to include such long-term effects to forecast the full spectrum of future Earth System changes.

This chapter collects seven papers dealing with different aspects of climate research. Georg Feulner briefly reviews the current state of the climate system and discusses certain related questions in light of the Paris Agreement. József Pálfy and his co-authors summarize state-of-art knowledge about a possible analogue for current conditions at ~200 million years ago, when the Earth's atmosphere was characterised by very high atmospheric CO_2 concentrations, climate change and ocean acidification. They conclude that the reconstruction and understanding of such past environmental and biotic crises may allow us to take a crucial step towards an understanding of processes operating in the Earth's climatic system at times of extreme change. Beside greenhouse gases of the Earth's atmosphere incoming solar energy is also a crucial external factor driving the global climate. Zoltán Mitre discusses the effects of changes in solar radiation on scales ranging from the multimillennial to sub-decadal. Judit Bartholy and Rita Pongrácz report the projected climate change for the Carpathian Region. The authors keep the focus of the contribution on the regional temperature and precipitation extremes. Árpád Barsi presents a short introduction to geographic information systems and attempts to highlight their potential in application to climate protection efforts. In the next paper, János Mika gives an overview of contributions from space-borne observations to climate science. A successful and a less successful example for validation of climate models against satellite-based observations are presented in this contribution. Finally, as a case study of satellite derived records Stamatia Doniki presents the calculation of the ozone longwave radiative effect from satellite observation. This is an important issue because ozone is a radiatively active component and its radiative forcing was not well understood until recently.

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