UNESCO/IUGS International Geoscience Programme Project 609 (2013–2017+2018)

IGCP 609

"Climate-environmental deteriorations during Greenhouse phases: Causes and consequences of short-term Cretaceous sea-level changes"

Contents

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Why to care about climate and sea-level changes?

Why do Cretaceous sea-level changes matter in today's global change discussions?

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Introduction - Timeliness and relevance of the topic

Climate change – global warming and the sea-level rise that results – concerns us all. Sea level constitutes a crucial geographic boundary for humans, and sea-level changes drive major shifts in the landscape. Sea-level changes on the scale of a meter or two will inevitably lead to major impacts on mankind, particularly in vulnerable coastal areas, which host some of the largest cities of the world, and oceanic island regions. The current situation of Bangladesh, for example, has become symbolic for the impact that rising sea level can have on entire nations. Therefore, adaption strategies have become major concerns for maritime nations worldwide.

Global climate and sea-level change are natural phenomena, and these processes have been working throughout Earth history. Today, however, humans add significant anthropogenic global warming that accelerates natural processes such as melting ice volumes and sea-level rise. Indeed, this human-induced acceleration has been observed using continuous worldwide measurements that have been constantly increasing in quality and quantity throughout the last 50 to 100 years. These measurements show a distinct acceleration of sea-level and global temparature rise since the 1990s. We can achieve highly accurate and precise measurements of today's global sea-level but future sea-level rise must be modeled based on expectations of new states for the Earth system.

The main critical issues being controversially discussed among scientists, policy makers, industrial lobbyists, and environmental activists and organizations are 1) what exactly is the man-made portion of contribution to climate change, global warming and resulting sea-level rise in comparison to the ongoing natural processes and changes, and 2) what are the controlling factors for the rates and amplitudes of climate and sea-level change?

An emerging consensus surrounding the Climate Summit Paris in December 2015 (United Nations Climate Change Conference) is: Whatever mankind can and will do against e.g. emission of greenhouse gases to counteract global warming and related climate and sea-level changes, we will not be able to stop climate change or reset the Earth's Climate System within the upcoming many 10s, if not many 100s, of years (another time interval that is strongly discussed). This includes the impossibility of a total stop of all greenhouse gas emissions right now or highly controversial "geo-engineering" ideas to counteract effects of global warming. As a matter of fact, the climate system of the Earth is highly complex, and therefore difficult to comprehend, model and predict scientifically, on the one hand. On the other hand, what we know for sure is that the oceans are a major controlling factor for global and regional climate because they store, transport (i.e. ocean currents) and release heat. Indeed, the oceans work as a ‘climate pump’ that steers the global climate by buffering heat and greenhouse gases within Earth’s climate system, causing a relatively sluggish response to atmospheric temperature and gas content changes.

Why IGCP 609 on climate and sea-level change for times long ago in Earth history?

As the climate system of our planet is so complex and difficult to model and predict, studies from Earth history contribute to our understanding of how and at what rates climate can change over longer time intervals and under different conditions (e.g. different amounts of greenhouse gases in the atmosphere; the distribution and configuration of land and oceans, presence and absence of larger ice sheets on the poles, much higher or lower global sea-levels than today etc.) and provide data to test climate and global change models. There have been different types of global climate modes during Earth history such as icehouse (like today) and greenhouse intervals (through much of Earth history), partially with phases of extreme conditions. Today we are in an icehouse interval, and major landmasses – Antarctica and Greenland – are located near the poles and covered with large ice sheets. The Cretaceous period (145 to 66 million years ago) is the youngest prolonged greenhouse interval in Earth history and was different from our present world in many respects, such as very high global mean temperatures and a very high mean global sea-level up to 250 m above today’s sea-level, but with many fluctuations on scales of ~ 20–50 m. However, “Cretaceous prolonged greenhouse interval” does not mean consistent conditions throughout these 85 million years. As a matter of fact, there were intervals of warm and cool greenhouse conditions and a so-called “Supergreenhouse” interval in the mid-Cretaceous. This was a time when there was no ice at the poles but the cool temperate climate zones reached the polar regions instead, and the global mean temperature is considered to have been up to about 36°C (today it is around 14°C).

This is where IGCP project 609 comes in. **We use the Cretaceous climate and sea-level history as a ‘laboratory’ to investigate the Earth under different climatic conditions with the intention to infer causes (controlling factors and processes) and consequences of climate and sea-level changes, and to model scenarios for the shift between different climate modes (e.g. icehouse to greenhouse) and climate extremes.** This includes the consequences for life on Earth and its climate-related evolution. As well, we deal with fundamental issues such as how sea level is measured today and how it is estimated from the geologic record, how sea level changes and how the respective dominating processes change over time and space, and how regional and global climate change with changing continent and ocean current patterns.

What if sea-level would rise 65 m?

What does this have to do with us today? Today we are close to being at the cusp to a new greenhouse climate interval if global temperature will continue to rise quickly, whatever the man-made contribution may be. By comparison with the Cretaceous climate and sea-level history, we can contribute to the discussion of Earth’s climate system by exploring scenarios with high levels of atmospheric greenhouse gases, high global atmospheric temperatures, warm oceans and without major continental ice sheets.

If we would melt Earth’s major ice sheets on Antarctica and Greenland, global sea-level would rise about 65 m and drive the coastlines of the continents inward (see this great illustrations from National Geographic here based on an estimated sea-level rise of 216 feet or 65 m: http://ngm.nationalgeographic.com/2013/09/rising-seas/if-ice-melted-map). This value, however, does not include the isostatic effect, which accounts for a larger water load depressing the ocean floor, and would reduce the longer-term sea-level rise from 65 to 50 m. If the ice sheets would melt in less than 5000–10000 years, then the 65 m might be closer to reality than 50 m.

Global sea-level changes (rises and falls) at about this amplitude happened more or less regularly (we call this ‘cyclic’) during the Cretaceous and were related to climate changes that are considered to have been ultimately driven by cyclic changes of the Earth’s orbital parameters. The UNESCO/IUGS IGCP project 609 deals with these changes on so-called short-term scales. Short-term here is mentioned in the geological sense and means intervals of about 500 thousand to 5 million years and a few 10s of thousands to some 100 thousand years (cycles of different orders – see literature given below for details). These changes can be reconstructed from shifting fossil shorelines that form repeating sedimentary sequences. We study the factors and processes that drive these changes and their interactions, and we are especially interested in global factors and signals because these allow us to correlate sedimentary sequences over long distances if these can be dated correctly. **Identifying different processes and factors controlling climate and sea-level changes in different scenarios during the Cretaceous is essential to better evaluate global climate models and near future prediction models today.**

References

Many inspirations for, or excerpts of the above text respectively, have been taken from:

Sames, B., Wagreich, M., Wendler, J.E., Haq, B.U., Conrad, C.P., Melinte-Dobrinescu, M.C., Hu, X., Wendler, I., Wolfgring, E., Yilmaz, I.Ö., Zorina, S.O., 2015. Review: Short-term sea-level changes in a greenhouse world — A view from the Cretaceous. Palaeogeography, Palaeoclimatology, Palaeoecology, 441 (3), 391–411.
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The holistic scientific fundamentals and background of today's climate and sea-level change as well as its prediction and impact on our world and societies is freely accessible from the Website of the Intergovernmental Panel on Climate Change (IPCC), namely the 5th Assessment report of 2014: http://www.ipcc.ch/report/ar5/wg2/

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