Why the past is a key to the future

In the coming years climates and environments on Earth will change. This is due to changes in the Earth System, which are partly caused by human impact. The main question is how the System will change. One way of helping to find the answer to this question, is to look back into the past.

Large-scale infrastructural works cause irreversible damage to the geological record.

**Geological Records and Natural Archives**

Our history is preserved in archives. For the last decades, most climate and environmental parameters (e.g. temperature, water quality, etc) are recorded instrumentally. For climate data, we can even rely on written records from the past 200 years. However, when going back further in time, we need to rely on the natural archives. From mountain lakes, lowland lakes, ponds, coastal areas to the deep sea, sediments are laid down more or less continuously. The succession of preserved sediments is the Earth’s geological record. These sediments contain (a mix of) minerals, organic chemical components, the remains of living organisms (fossils), etc. The specific composition is a result of the climate and environment present at that time. In turn, by studying the geological record with geobiological, geophysical and geochemical methods, the conditions of past climates and environments can be reconstructed. An example is the study of fossil pollen, produced by trees and plants. One of the driving conditions for vegetation is temperature. By transferring the fossil pollen record into a vegetation and, consequently, by transferring the vegetation into a temperature parameter (e.g. coldest winter month, average year temperature), the temperature at a certain point in time can be reconstructed. In this way, a fossil pollen assemblage acts as a proxy for temperature. By studying the natural archives, a whole range of climatic and environmental variables can be recalled (temperature, rainfall, nutrient-level, etc.). This can be done per year, per decade or per century, depending on sediment-accumulation rate per time-unit. By studying successive samples from the geological record, a time series of climatic and environmental variables can be established. Paleo-studies are used in several topics. A short overview is given below.

**Time series and Model Validation**

One method to predict the climate of the future is to use physical/mathematical
**Climate and crops**
Historical records from agricultural production in the Netherlands show significant relations with the instrumental climate records during the last centuries. Periods characterised by large amounts of winter rain (i.e. periods with positive NAO indices) show strong reductions of crop yields. For instance wet winters during the sixties of the 18th century and in the years around 1825 show crop reductions up to 30%. The reductions were mainly caused by the complete failure of winter cereal production as a consequence of high ground water tables during these periods. Based on this information, it is possible to estimate the loss of crop yield due to the predicted increase in rainfall in the Netherlands in the coming years.

**Records of atmospheric pollutants in lake sediments**
Analyses of well-dated lake sediments deposited in the last centuries show detailed records of the temporal and spatial trends in atmospheric deposition of pollutants. Heavy metal concentrations like lead and zinc, in these sediments, show good correlations with the instrumental record of industrial activities in the area. The concentration in the lake sediments of spheroidal carbonaceous particles (SCP), microscopic products of high temperature combustion of fossil fuels, provide an unambiguous record of the atmospheric deposition of industrial anthropogenic pollutants during the last century. Linkage of this information with population statistics and weather shows...??

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Thalassiosira nordenskiöldi, a diatom associated with melting sea-ice.

Aporrhais scaldensis.

Lake Vechten, The Netherlands, a natural archive.
models in computer simulations. Best known are the daily weather forecasts. But computer models are also developed to predict large-scale weather patterns with elevated CO₂-levels and rising temperature. To validate these models, they can be run over a period in the past. For instance, this can be period in which there is very little or no human influence on our world, but other conditions were more or less comparable to today. Reconstruction of the paleo-climate and establishing a time series of paleo-temperatures allows comparison of the model results with the natural archive information. This model-nature comparison allows developers to adjust and precise their models.

**Detailed climate scenarios**

Almost all prediction tools on Global Change operate on a very large scale (continental to global). However, one of the main aspects in future prediction of Global Change is the effect it will have on the local climate and environments. Increase in temperature has obvious effects e.g. an earlier start of the flowering and nesting season. But this also effects the biodiversity, the variety of plants and animals in a region. However, there are also lesser-known effects such as toxic algal blooms due to increased river discharge. By looking in detail at environments in the past, such (unknown) effects can be traced. This may help policy makers to protect sensitive environments such as coastal regions.

### Base level determination

In the last decade, the combination of climate and water have caused significant social and economical damage in Europe, in particular, due to excessive rainfall and river floods. The main question, obviously, is the future development of the climate and its effect on the socio-economic life of people and on natural environments. A first issue to be addressed is the natural variability of the climate and environment. The main approach to improve our understanding of natural variability to study a period in the past, during which the human impact on climate was negligible, while other factors were more or less comparable to today.

### Socio-economic Effects and Raising Awareness

Changing climates and environments affect peoples lives, sometimes positively, with a long nice summer. But often the effects are negative, with floods and droughts, damage due to extreme weather events, loss of harvest. These events also happened in the past. In combination with historic records on disasters (e.g. famines, floodings), paleo-studies can produce estimates on socio-economic effects. This may range from insurance damage due to extreme hailstorms, to loss of food production to increasing winter wetness. The awareness of these effects may support the development of policies for regional, national and EU policy makers to counteract these effects. The (geological) history appeals to our imagination (e.g. dinosaurs and ice-ages). This combined with the fact that a changing world affects people, makes paleo-studies a good tool to raise awareness about the climate and environment.

**Cannosphaeropsis utinensis.**

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**TNO’s Geobiology Team**

From 400-million-year-old, microscopic worm jaws (Devonian conodonts) to murder cases (forensic palynology), the Geobiology Team, part of TNO Built Environment and Geosciences Geological Survey of the Netherlands, studies it all.

The Geobiology Team develops and applies biogeological knowledge for climate and environmental research. The activities consist of age-dating and characterisation of the subsurface layers, reconstructing and interpreting (paleo)climate changes, and archives biogeological data and standards. Main sponsors are governmental organisations, oil industry, archaeologists and forensic organisations.