Nuclear physics and climate science: carbon and oxygen isotopes allow to understand global warming*

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In the seminal paper [1] a quotation, well known among climate scientists, can be find:

"Thus human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future. Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years. This experiment, if adequately documented, may yield a far-reaching insight into the processes determining weather and climate."

How, in 1957, the authors: oceanologist Roger Revelle and nuclear physicist Hans Suess, could write such a statement? The paper dealt with isotopic concentrations of carbon present in the atmosphere and seawater, allowing to determine exchange rate of CO_2 between the atmosphere and the ocean. This, in turn, allowed to understand which fraction of CO_2 emitted from fossil fuel burning dissolves in ocean waters and to explain important details of global carbon cycle in the context of its influence on the planetary greenhouse effect.

Carbon and oxygen are between the most abundant elements in the climate system, i.e. in the atmosphere, hydrosphere, biosphere and land surface. Effects of isotope fractionation by such processes as photosynthesis (carbon) and phase changes of water (oxygen), possible to measure in fossils, sediments, rocks, ice, water, air, plants and other biological systems, are used to retrieve information on states of climate and carbon cycle. In particular, signatures of $\delta^{13}C$ and $\delta^{18}O$ can be used as proxies of past CO_2 concentration in the atmosphere and global temperatures. A wide use of these (and other) isotopic markers allows to understand past climates, which, in turn, helps us to provide more reliable climate projections for the future.

In this presentation I will shortly introduce the basics of climate physics, then discuss climate changes in recent 50 million years. Finally I will talk, in the spirit of Revelle and Suess, on the human imprint on the carbon cycle and on its serious consequences for the future.

[1] R. Revelle and H. Suess, Tellus **IX** (1957) 18-27.

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