Climate and Environment: Looking Properly – and for an Extended Period of Time!

In ecosystems and climate research in particular, perspectives extending over several years are important to verify scientific hypotheses. By Professor Hans Peter Schmid.

Measurement tower in the forest: In a number of forests in the Northern hemisphere, scientists studied how vegetation reacts to climate changes. (Photo: Schmid)

Science means gaining knowledge with uncertainty. We researchers generate hypotheses and correct them later on, either on our own or our colleagues do this work. The public rarely perceives this constant questioning and critical assessment of uncertainty of scientific statements. The climate system and in particular the atmosphere, ecosystems, and water are regulated by a multitude of "drivers" and "set screws". Their number appears immeasurable and, hence, cannot be understood by individual scientists at certain places or times. To understand the overall picture, we all together, at many places and over a long period of time, have to constantly monitor numerous variables, systematically analyze them, and integrate them into models. Thanks to modern measurement technology, data processing, and computers, we have meanwhile reached a degree of complexity we did not even dream of twenty years ago.

However, growing complexity inevitably results in the media, citizens, and politicians often receiving a distorted picture of our research results only, often reduced to headlines. The necessity of having to check the results over several years is no longer worth a word and also neglected when funding research. A fatal contradiction results: Research is gaining complexity, while its persistence is decreasing.

In cooperation with colleagues from Harvard University, Ohio State University, and Indiana University as well as from the USDA Forest Service, scientists from the Atmospheric Environmental Research Division of the Institute of Meteorology and Climate Research (IMK-IFU) have succeeded in correcting a long established doctrine in ecosystems research, thanks to long-term research. Increasing carbon dioxide (CO_2) concentration in the atmosphere was assumed to lead to an increase in the efficiency of photosynthesis of plants, binding carbon from the atmosphere, and biomass production. By means of this mechanism, land ecosystems reduce global CO_2 increase. However, we found that the principle "increasing CO_2 concentration leads to higher biomass productivity" is much too simple.

A key parameter in this complex is water use efficiency: During photosynthesis, plants bind CO_2 from the atmosphere. While they take up CO_2 via the open stomata of their leaves, water vapor is released. The ratio between transpired water and bound carbon is water use efficiency. It is the major indicator of the functioning of the ecosystem and plays a key role in the global cycles of matter.

We compared measurements of water use efficiency in a number of forests in the northern hemisphere. The result: In the past two decades, water use efficiency increased more strongly than expected. We succeeded in demonstrating that this is due to the fertilizing effect of CO_2: When the concentration of CO_2 in the atmosphere increases, the leaves partly close their stomata in order to keep the CO_2 concentration inside largely constant. As a result, less water vapor is released from the leaves at the same photosynthesis rate. Water use efficiency of the forest ecosystem increases. Hence, forests can adapt to changes of the environment and save water. On the other hand, forests are among the most important sources of humidity for the atmosphere. Saving water therefore promotes the aridity tendency that accompanies global warming. This may cause considerable problems to sensitive ecosystems. If the aridity tendency continues to persist, high adaptivity of the forests may turn into a global problem.

This finding was possible only, because we were able to use measurement series extending over decades. Verification of our hypotheses will now require data to be collected in the years to come. This is the only way to obtain a realistic picture of the complexity of interactions between the climate and ecosystems.

What do we need for this purpose? Funding programs that are of long-term character. Funding programs that are evaluated regularly, but extend over a period of 30 to 40 years. Persistent research – for us to persist on earth.