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From Abrupt Change to the Future (Hans Oeschger Medal Lecture)

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The award of the Oeschger Medal 2009 is a particular honor and pleasure for me as I was given the chance to take over from Hans Oeschger the lead of a wonderful Institute at the University of Bern in 1993. Very apprehensive first, in front of the huge expectations and challenges, I quickly found dear colleagues, close collaborators and extremely supportive staff who all dedicated their time and creativity to work for the common goal of better understanding the Earth System, its variations in the past and its sensitivity to perturbations that man is inflicting on it today. Although met with innate skepticism first by the experimental physicists, our efforts in modelling, particularly the approach of using climate models of reduced complexity, quickly paid off and provided added value to the hard won data and measurements from polar ice cores. It is clear that modelling in such a diverse environment is so much more stimulating and enriching than working on a sophisticated parameterisation in a big modelling centre.

Simple models have suggested that the Earth System may have limited stability and that rather fundamental changes could be triggered by the increase of greenhouse gases. However, it is the unique results from polar ice cores, particularly from Greenland that showed that, indeed, the Earth System has limited stability and can react in extremely abrupt ways to changes in forcing. Likewise, the Antarctic ice cores have provided one of the corner stones of our knowledge about climate change: Concentrations of CO_2 are today 29% higher than ever during the last 800,000 years.

These two fundamental insights from the paleoclimatic archive call for accelerated research into the sensitivity of the climate system and its components to perturbations, as well as the investigation of feedback mechanisms in the biogeochemical cycles that are disturbed by the input of CO_2 into the atmosphere by burning fossil fuels and land use change.

Our research has only scratched the surface and many questions are still unresolved. A consistent simulation of ice age cycles including the remarkable transition from the 40 kyr to 100 kyr world is still missing. Evidence for interhemispheric connection, a persistent feature of the last ice age, remains circumstantial during earlier ice ages. Recent ice core analyses suggest extremely rapid climate change in the high latitude which is faster than any model has suggested. Sea ice changes must play an important role in that they may operate as an efficient accelerator. Modelling results are reviewed which suggest that instabilities in sea ice coverage can occur in response to relatively slow changes of the background climate. Such behaviour has been demonstrated in simulations of future climate, but it may well apply to past abrupt climate change.

The paleoclimate record may therefore hold much more and more detailed information about instabilities and surprises if marine and atmospheric proxies are combined. However, only through the combination of highest-resolution paleoclimatic data and a clever hierarchy of models are we able to address and resolve these questions.