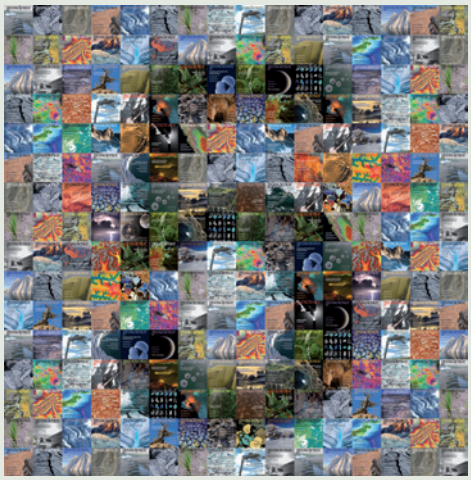
Five years of Earth science



Nature Geoscience launched five years ago. This timescale, just enough to complete a research project or two, may not seem a long time. But a lot has happened in the collective of disciplines that are covered in our journal. Some of the most violent plate-boundary earthquakes have shaken the planet; public perception of climate change has been on a rollercoaster ride (from the 2007 Nobel Peace Prize to Climategate); and planetary missions have ventured to new horizons. We have asked nine Earth and planetary scientists to look back at fields where scientific understanding, or the public's perception of the science, is now substantially different than it was in 2007. Some of the pieces mark step changes, and others more gradual progress — but they all provide a glimpse at the rapid evolution of an exciting science, both in the past half-decade and into the future.

Adapting the assessments

The current assessment of climate change is nearing completion. It is now time to consider how best to provide increasingly complex climate information to policymakers, suggests **Thomas F. Stocker.**

The five years since the launch of *Nature Geoscience* in January 2008 have been a rough ride for climate scientists. When the journal's first issue appeared, the public was well informed about current and projected future climate change. Since then, many people's trust has been shaken in the concerted attack on the climate sciences (that was termed Climategate), and this trust has had to be painstakingly rebuilt.

Back in 2008, decades of climate research had produced results based on reliable observations, quantitative palaeoclimate reconstructions, theoretical studies, and numerical modelling using the most powerful computers. This body of work was recognized by the public and the media as a solid scientific foundation for the understanding of the climate system and its changes. The Intergovernmental Panel on Climate Change (IPCC), a unique process of assessing and presenting complex scientific findings to policymakers and the wider public, was an important element in the dissemination of information on the state of the climate system and possible future change as a result of human activities. Public regard for climate science culminated when the diagnosis of unequivocal warming, mostly caused by human activities, was made in the fourth assessment report of the IPCC in February 2007. The award of the Nobel Peace Prize in the same year, jointly to Al Gore and the process and institution of the IPCC, lent further recognition to climate scientists and their work. In this atmosphere of public support, hopes were high for the Copenhagen Summit in December 2009, which hosted the fifteenth Conference of the Parties to the United Nations Framework Convention on Climate Change, intended to transfer knowledge about climate change into firm commitments by the world's governments.

© OLIVER OETTLI, BIEL

Three weeks before the summit, however, a perfectly orchestrated break-in at the University of East Anglia's e-mail server and the unauthorized release of thousands of e-mails between climate researchers initiated a skyfall in the public regard of the climate sciences, particularly in the United States and the United Kingdom. Claims about a grand scientific conspiracy were made, based on text from a select few e-mails among the thousands on that server. Some blogs were used for

anonymous defamations and systematic slandering attacks. Even political assaults were launched on individual climate scientists, leading to very difficult personal situations and tragedies for those targeted. The tactic of doubt-mongering is not particularly innovative. But when it hit climate scientists, they were unprepared.

In the mean time, the integrity of climate science has proved robust to such blunt attacks and manoeuvres. No fewer than six independent investigations were carried out, all concluding that there is no substance to the allegations of foul play. When the IPCC called for expert volunteers to participate in its fifth assessment report, the response was overwhelming. And the latest surveys around the world show that public opinion on natural and human-induced climate change is again more in line with the hard scientific evidence.

The next five years of climate science will continue to produce new and deeper insight into this extremely complex system of our planet. By the end of the year 2014, policymakers and the public will receive from the IPCC the most up-to-date account of a changing world, a comprehensive scientific assessment of the climate system, its past, present and projected future changes. The assessments will also reflect on the impacts of further fossil fuel emissions on the physical climate system, on ecosystems and on human systems, and on the options that remain for mitigating climate change.

But the next five years will also be challenging. Once more, the IPCC will deliberate on how to carry out its scientific assessment most effectively. Comprehensive periodic reports were a great success in the past: the IPCC process with its sequence of carefully formulated, thoroughly reviewed, robust consensus documents is now being considered as a template by bodies assessing other global-scale problems, such as biodiversity. But since the IPCC started in 1988, climate science has grown into a wide, multidisciplinary field. The number of studies and their level of complexity have all increased by orders of magnitude, as a natural consequence of scientific progress. For example, the volume of the model data obtained from coordinated climate model simulations for the assessment reports has increased from 35,000 gigabytes in 2007 to over 1.7 million gigabytes (1.7 petabytes) by the end of 2012, an amount that would fill the hard discs of some 3,400 personal computers. The data are now stored in a dedicated open archive maintained by the Program for Climate Model Diagnosis and Intercomparison (PCMDI), accessible to all who would like to contribute to their analysis. Nevertheless, even the transfer of some of this volume of data to the research centres has become a serious technical challenge that calls for innovative solutions.

Apart from occasional serendipitous step-changes in understanding, the knowledge gain per time tends to decline in a mature scientific field. Hence the questions must be raised whether the IPCC's 5- to 7-year assessment cycles can still be maintained with a reasonable effort, whether the volunteer scientists who act as lead authors are equipped with an adequate infrastructure for this Herculean task, and whether enough researchers will continue to donate their time.

We may want to explore alternative approaches to achieve the same goal of disseminating the best and most robust understanding of "the scientific basis of risk of human-induced climate change". One possibility is a carefully selected series of assessments that are narrower in scope and each deal with a specific, policy-relevant issue. Alternatively, each of the previous reports' chapters — for example on sea-level change, or on near-term climate change — could be run as a series of assessments that are updated individually, rather than all at the same time, in line with specific scientific progress in the respective fields. Chapters on observations might then follow a different pace from, for example, chapters on climate model evaluation, or computer-intensive analysis of projection simulations.

The IPCC's unique and extremely successful all-round climate assessments must also be considered in the context of the climate services that are now being established around the world. Climate services have the task of preparing information on climate-related issues for local communities, regional policymakers, practitioners and the public, but that information will need to reflect the context of continuing global climate change. To make the climate services sustainable and successful, a common understanding of the long-term change, from global to regional scales, is therefore indispensable. Such an evolving consensus can only grow from comprehensive assessments of the peer-reviewed scientific literature, independent from the daily business of climate services.

Nature Geoscience has made an important contribution to the climate sciences in the past five years, by providing a platform for scientific high-impact publications. In view of the changes ahead, the next five years of *Nature Geoscience* will be no less interesting and enlightening than the first five. ❐

Thomas F. Stocker is at the Oeschger Centre for Climate Change Research and the Physics Institute of the University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland, and serves as Co-chair of Working Group I of the Intergovernmental Panel on Climate Change.
e-mail: stocker@climate.unibe.ch

The epoch of humans

People have changed the world irrevocably. **Jan Zalasiewicz** discusses whether formalization of the Anthropocene as an epoch in geological time will help us understand our place in Earth history.

Humans are just another animal species, albeit with peculiar habits: buildings, factories, oil rigs, cars and travel. Magnified a few billion times across the Earth, human activity adds up to some remarkable geology. There's been nothing remotely like it since the world began.

The idea that humans have propelled a new chapter in Earth history is not new. In 1778, George-Louis Leclerc de Buffon, a French naturalist, wrote *Epochs of Nature*, demarcating episodes in history of an Earth he suggested was an outlandish seventy-five thousand years old (privately, Buffon guessed three million years, but dared not publish that yet more heretical age). The last epoch was one in which humans dominated — and a good thing too, he thought: to slow the cooling of a planet he thought destined for frozen oblivion. Buffon's ideas did not catch on. And