

**A Cold Case
Turns Hot** The Potsdam Institute
for Climate Impact
Research Investigates



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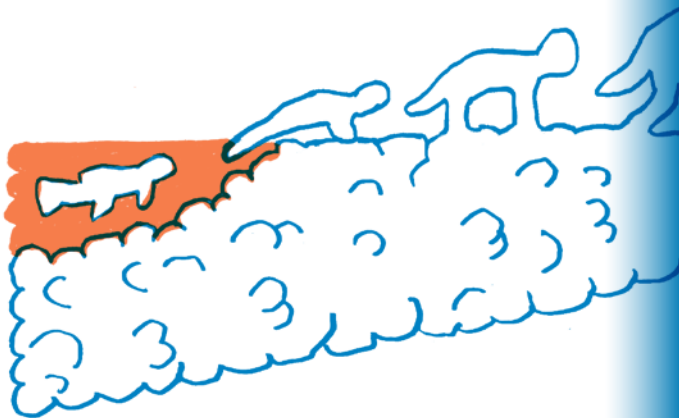
**A Cold Case
Turns Hot**

**The Potsdam Institute
for Climate Impact
Research Investigates**

About 12,000 years ago After the end of the last ice age, an epoch of great climatic stability with moderate, warm temperatures allows for the development of a civilisation based on agriculture.



1787 By burning fossil fuels, man becomes a geological force. This brings with it a novel scientific and individual responsibility to “preserve creation”. Instead of being tied to his immediate ecological environment as he was until



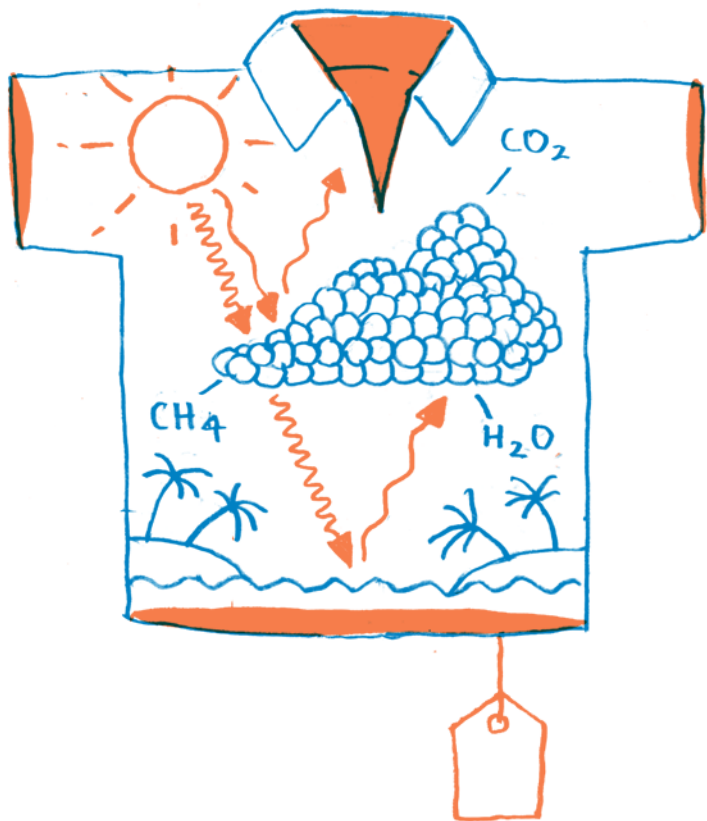
the industrial revolution, man everywhere is now part of a global development. With his actions, he changes the entire Earth System, increasing temperatures as well as sea levels, thus determining the life and survival of every individual.



Since its foundation in 1992, the Potsdam Institute for Climate Impact Research (PIK) has promoted both scientific work and political discourse on climate change. But how did man even come to realise that he is changing the climate? The history and success of the PIK can only be understood in the tradition of the Enlightenment and in the context of previous research. Three scientists contributed particularly to the discovery and explanation of the greenhouse effect: Joseph Fourier, John Tyndall and Svante Arrhenius.

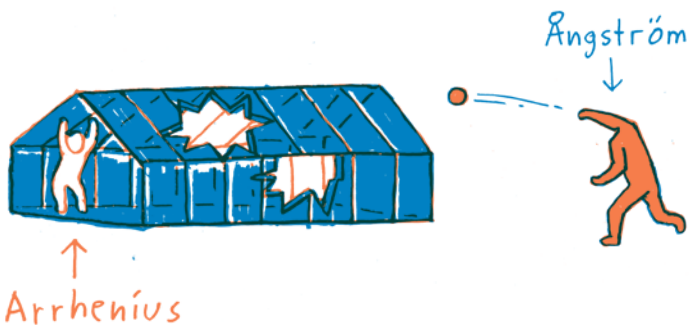


1827 In 1827, Fourier first links infrared radiation to the temperature of the atmosphere. About 30 years later, in 1859, Tyndall investigates the effect of important trace gases on the spread of infrared rays. Carbon dioxide and water vapour in particular interfere with long-wave radiation traversing the atmosphere on its way into space by absorbing these electromagnetic waves and re-emitting them, often with changed wavelengths and in all directions. As a result the atmosphere warms up like the air in a greenhouse.

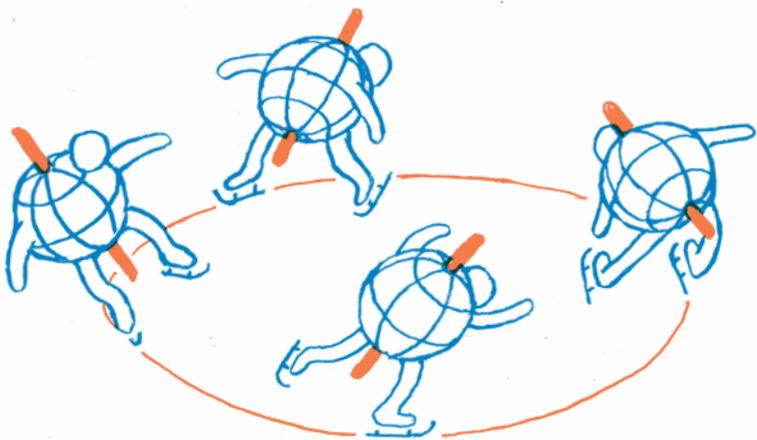


The Greenhouse Effect

1896 The Swedish scholar Svante Arrhenius calculates the warming influence of atmospheric carbon dioxide on the Earth's climate in 1896. He is, however, mistaken in thinking the greenhouse effect caused by burning fossil fuels is relatively harmless because the ocean would absorb the additional heat. Soon afterwards, the scientist Knut Ångström, on the strength of a badly designed experiment, convinces professional circles that Arrhenius' work is worthless. This is how a problem affecting the whole of humanity disappeared from view for more than fifty years.

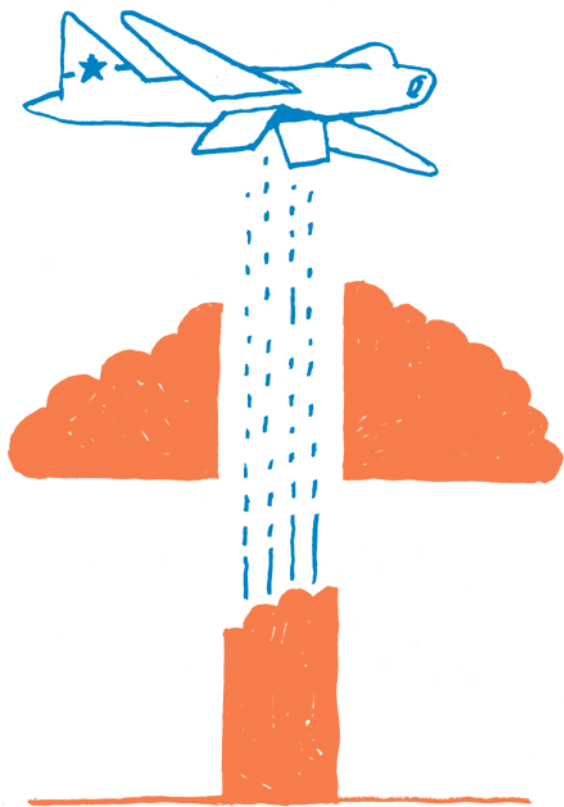


1920 Independently, in the first half of the
to 20th century, Milutin Milancović begins
1941 to investigate how ice ages come about.
He is able to explain how quasi-periodic
changes in the Earth's orbit and axis lead to
fluctuations in the amount of sunshine falling
on the northern hemisphere, thereby changing
the global mean temperature by several degrees
Celsius - enough to cause an interglacial period
or an ice age.



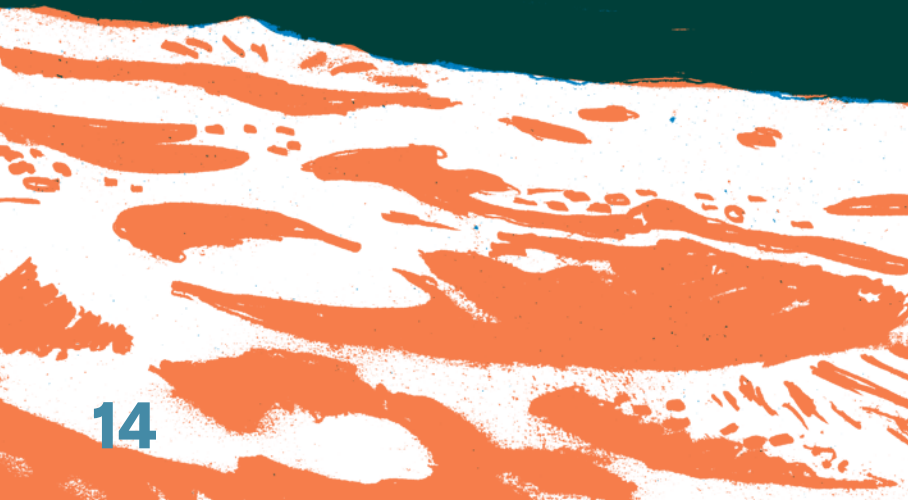
Ice Dancing with Milancović

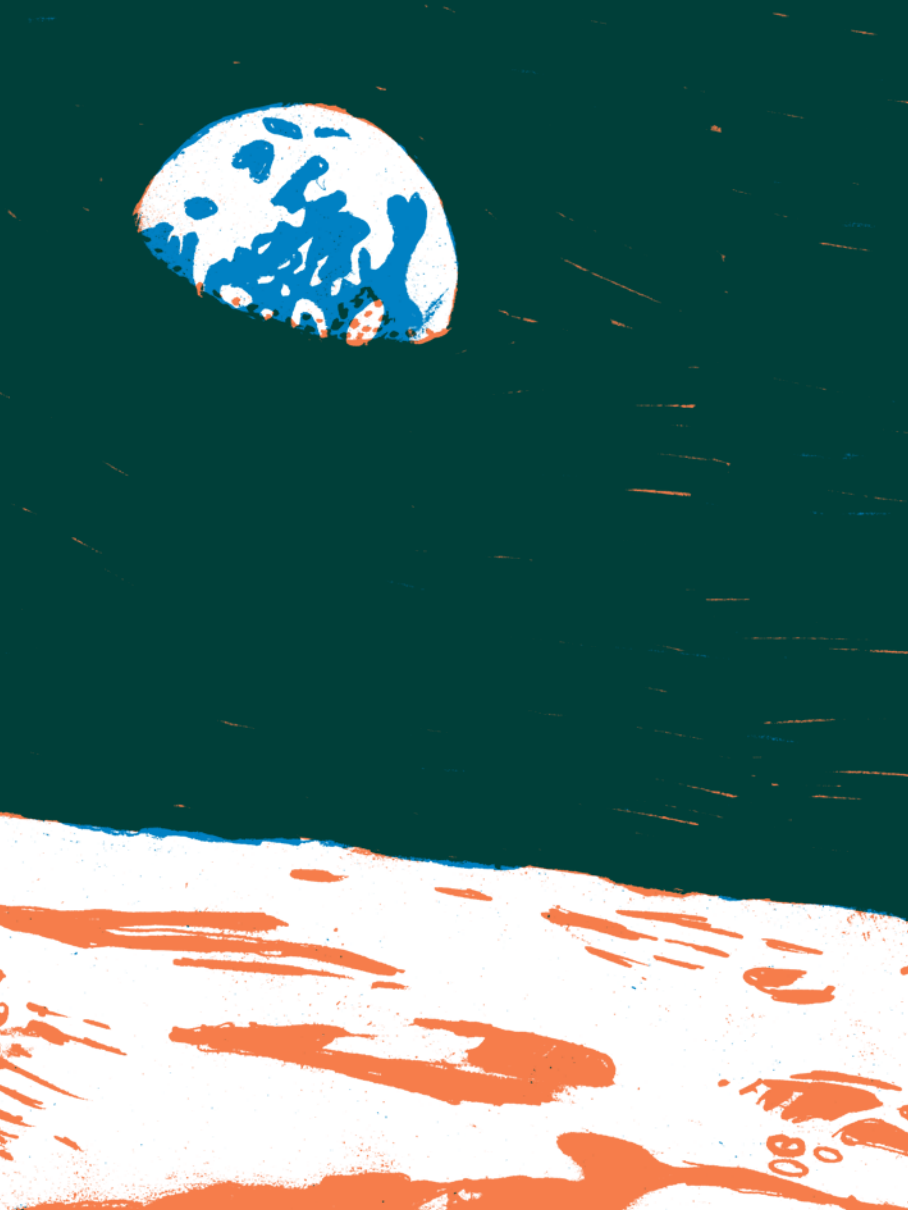
1950s During the Cold War, both the Americans and Russians consider manipulating the weather for military and economic purposes. In doing this, they unintentionally promote methodological developments that allow further exploration of the climate: John von Neumann, a dark genius already well known for his role in the construction of the atomic bomb, does pioneer work on modern numerical weather prediction – and thus computer simulations – of non-linear atmospheric dynamics. At the same time, climate researchers Charles Keeling (with his carbon dioxide measurements in Hawaii) and Hans Suess (using isotope chemistry) are able to show that man directly changes the atmosphere's carbon dioxide content. Although a warming is expected, observational data from 1945 to 1970 shows the Earth's surface cooling! Whether this is an error in measurements or a veiling of the greenhouse effect due to air pollution has not been fully clarified to this day.



Weather Engineering

1968 The legendary photograph “Earthrise”, taken on December 24, 1968 by the astronaut Bill Anders during the Apollo 8 mission, marks the beginning of a new perception of Earth as our fragile, beautiful home planet.

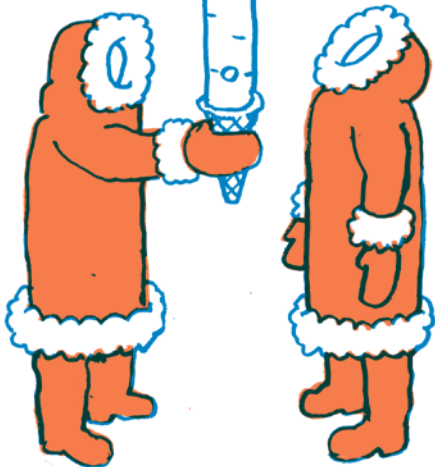




1960s From around 1960 on, climate researcher
to the Suki Manabe and others employ computer
1970s models for weather forecasting. They
begin to include carbon dioxide measure-
ments and thus create the first scientific simu-
lation models. In the 1970s, ice drilling begins in
Antarctica. By analysing air bubbles enclosed in
ice cores, scientists are able to reconstruct the
carbon dioxide content of the atmosphere over
the past millennia. By 2005, it is already possible
to look back 650,000 years! It becomes clear that
the carbon dioxide concentration of the air in-
creased faster during the last 120 years than at
any time over the last hundred thousands of
years. While the cooling period after World War II
is still under discussion, the temperature of the
Earth's atmosphere is rising significantly.

-2005

-650,000 Years



1989 When the Berlin Wall falls, the global mean temperature is already half a degree Celsius above that of the pre-industrial period (1880–1920).



The collapse
of Heavy Industry
in the Soviet Block

1992 Leading environmental scientists call for an institute for climate change research to be established. Initially it should serve to investigate the reaction of ecosystems and agrarian systems to rising temperatures.

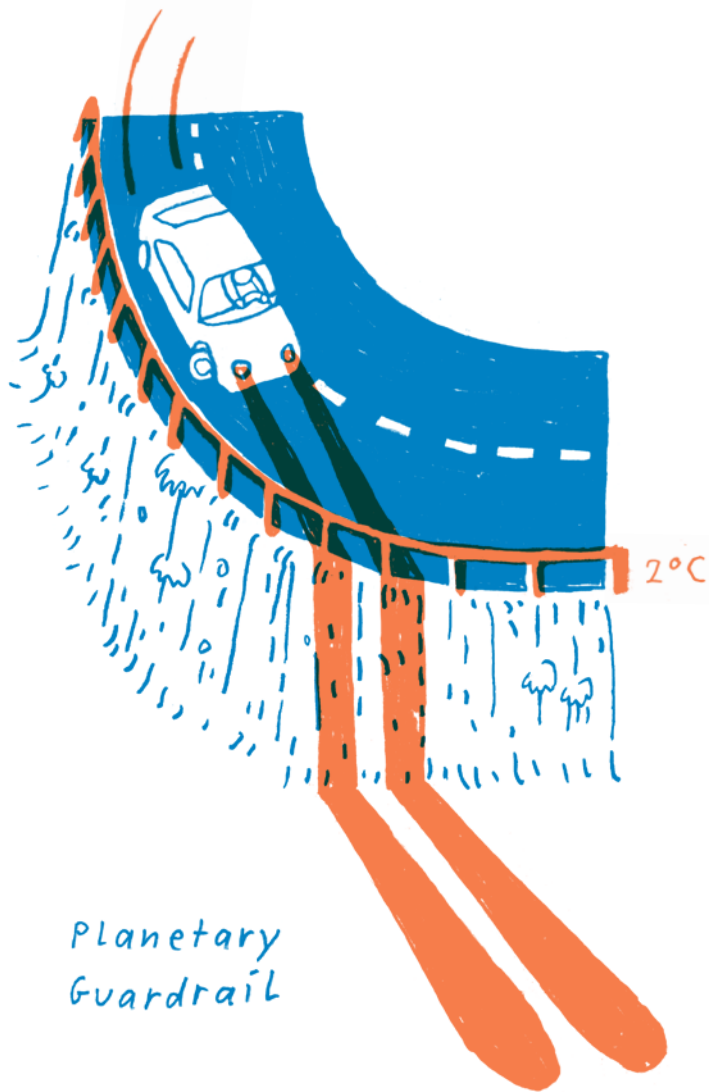


1994 Under the guidance of its founding director, Hans Joachim Schellnhuber, the research approach soon shifts from sectoral single studies to a system analysis. The central question is now: which transregionally significant processes in the planetary machinery can a temperature increase disturb? This approach attempts to capture not only gradual but also disruptive changes: where are possible catastrophe domains? At a conference on Earth System analysis organised by PIK the idea emerges that global mean temperature rise should be limited to two degrees Celsius. Paleoclimatic changes are also included in this field of research. The causal factors determining a warm-cold periodicity are well known, but it is still not clear how the most important processes mesh: what feedback cascades are conceivable in the Earth System? Not only data integration and computer modelling are used, but above all the insights of non-linear dynamics play a role.



Outside, Looking in

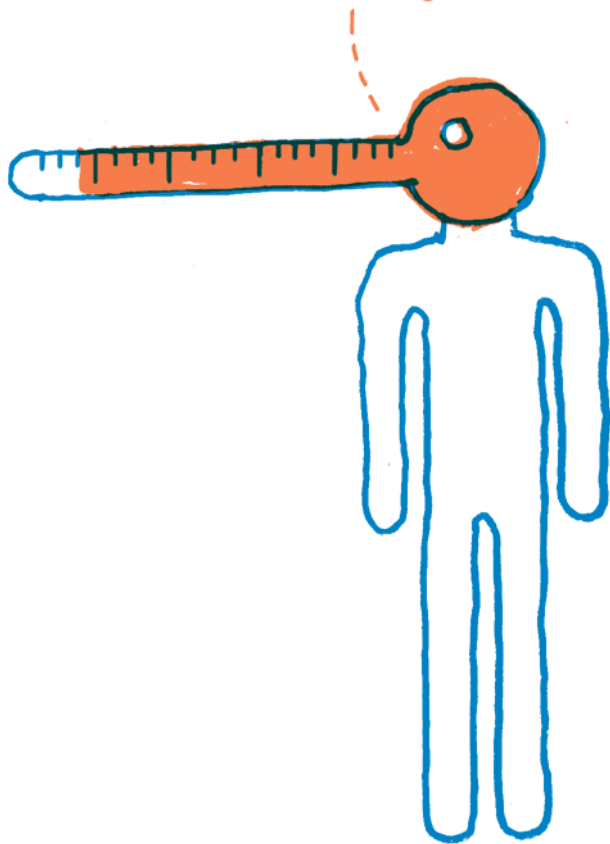
1995 While climate scientists from all over the world are gathering evidence against the perpetrators of global warming, Hans Joachim Schellnhuber develops the concept of a planetary guardrail, supported by PIK and the German Advisory Council on Global Change. For concrete scientific reasons, the global mean temperature must not rise more than two degrees compared to pre-industrial times. This limit receives a certain amount of attention prior to the Berlin Climate Conference in 1995, the very first Conference of the Parties (COP). It will take another twenty years for this concept to come into its own.



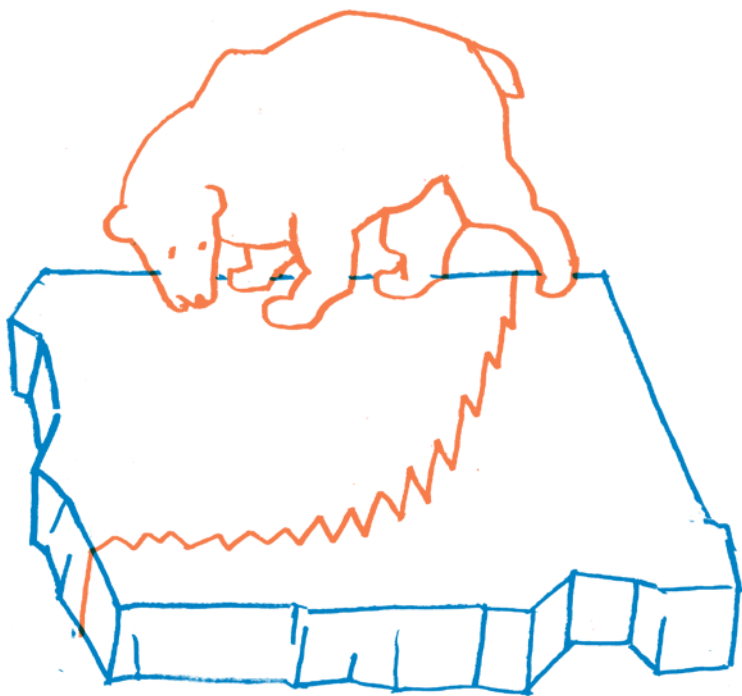
Planetary
Guardrail

Despite a further rise in the global mean temperature, the connection between global warming and human activity is still called in question for a long time. Economic interests play a role in this, but also the fact that many natural fluctuations in the climate system are not yet fully understood. The discussion is entangled for years in the question of whether the increase in extreme weather events is directly related to global warming. Unanswered questions, such as the function of clouds or exact climate sensitivity, are also used as arguments to block allegedly expensive climate protection measures.

There's No Such Thing
as Climate Change!



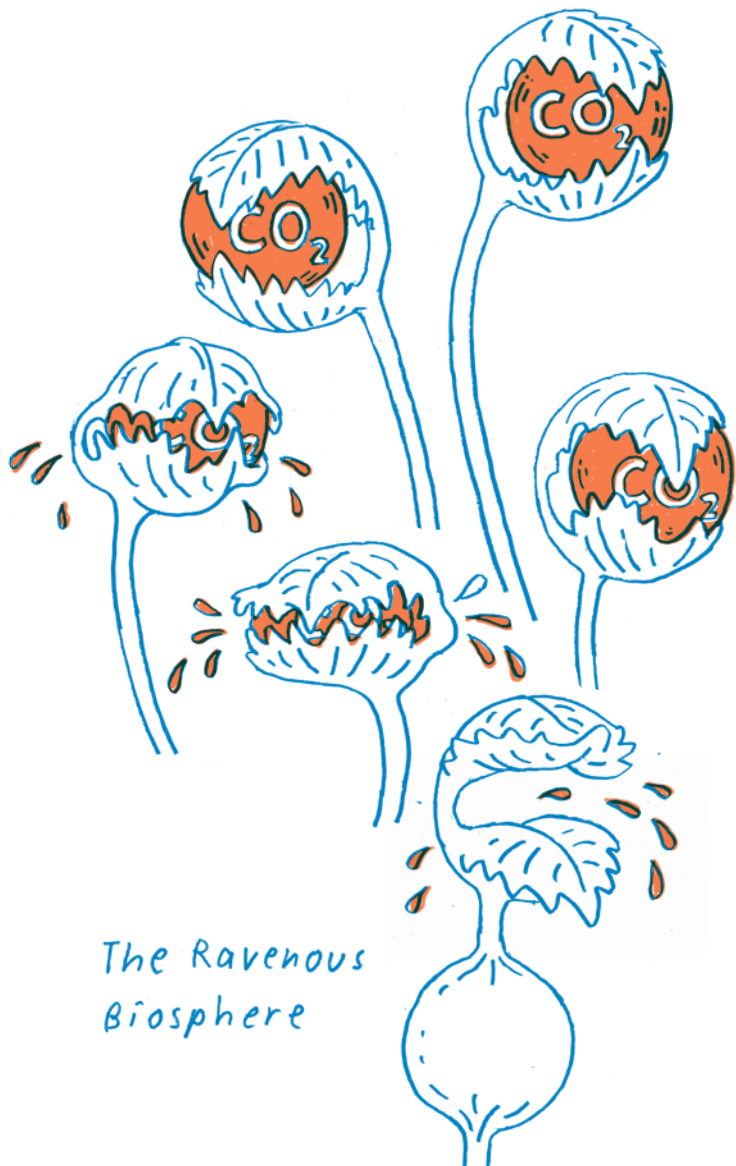
1996 One hundred years after Arrhenius's first calculation of the greenhouse effect, a research group led by Klaus Hasselmann in Hamburg is able to filter the signal of man-made global warming from the noise of natural climatic fluctuations. In the following years, more and more studies point to the conclusion that human-kind is the cause of the rather abrupt contemporary global warming.



The Holocene Crack Up

1999 With participation of PIK, researchers succeed in 1999 in quantifying how much man-made carbon dioxide is absorbed by vegetation. Of course the oceans too absorb carbon and thereby slow down global warming. But on the one hand, it doesn't stop dangerous climate change, and on the other hand fatal ocean acidification is the consequence.

The PIK scientist Stefan Rahmstorf receives the James S. McDonnell Foundation's one-million-dollar "Century Prize" in recognition of his pioneering work on the stability of thermohaline circulation in the oceans. The main concern in this research is the North Atlantic Gulf Stream, which actually shows signs of weakening, as Rahmstorf explains in a later analysis (2015).



The Ravenous
Biosphere

2000 Climate change is already deeply affecting the Earth's structures, with serious consequences for both nature and civilization. The identification and study of so-called tipping elements – an approach developed by Hans Joachim Schellnhuber in 2000 – is intended to determine at which temperature global warming must be stopped. Tipping elements are parts of the Earth System which have a climate-sensitive tipping point, in other words, global warming could change their qualitative state for a long time or even forever – with dangerous effects on life as we know it on Earth. This includes the melting of the Greenland ice sheet, the coral die-back, the change of sea currents and wind systems and more.



2001 PIK, initially housed in a former Stasi complex in East Berlin, then temporarily working in containers, moves into the former Royal Astrophysical Observatory in 2001. The building, erected in 1878 and abandoned in the 1970s, once housed the world's first astrophysical institute.



2003 Around the world, and at PIK under the leadership of Vladimir Petoukhov, more and more insights are gained into how extreme weather events and climate change interrelate. Since 2003, the institute has worked on the behaviour of jet streams – meandering bands of high velocity winds at very high altitudes. They are caused by temperature differences and equilibria between the poles and the equator as well as by the Earth’s rotation. Jet streams create high and low pressure areas and change their stability and dynamics with climate change. This is due in particular to the disproportionate warming of the Arctic and the continents, which results in more frequent “standing” bulges – the so-called quasi-resonant Rossby waves – in the northern hemisphere jet stream, bringing with it persistent weather conditions. Extreme droughts and flooding are the result.



When the Jet Stream Makes Waves

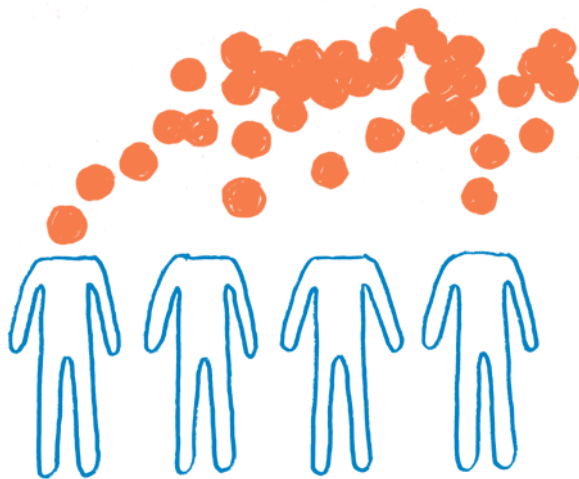
With the help of attention-seeking outsiders, numerous lobbyists and certain members of the media attempt to hijack climate scientists' professional interpretations of environmental issues to spread doubt about climate change. Meanwhile members of the PIK have long been thinking about solutions: how can we systematically introduce innovations to reduce carbon dioxide emissions?



2007 How can the use of energy be fundamentally reshaped worldwide in order to decelerate climate change? The Potsdam Memorandum, the result of a sensational Nobel Prize laureate symposium, introduces the concept of a “Great Transformation” into the public debate.



2009 At PIK and in Oxford, the idea of a carbon budget is born. It should at least ensure that the ambitions on climate protection are being discussed anew at climate conferences. Every human being in the world has the right to the same individual quota of our limited carbon credit in the natural world. This raises the fundamental question of climate justice. At the Copenhagen conference, however, there is no rapprochement between industrialised and developing countries on this issue.



A Headcount of CO₂ Emissions

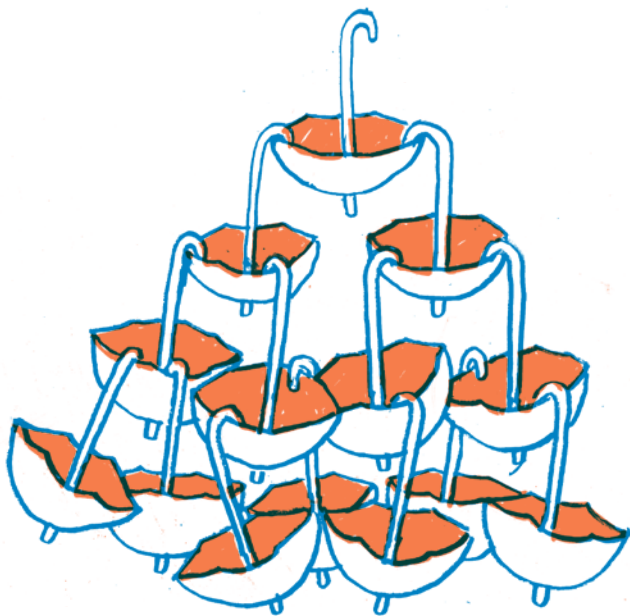
2011 In Germany, the aversion to nuclear power is deeply engrained. The Fukushima disaster finally triggers a complete German nuclear power phase-out. The renewable energy industry will from now on play the key role. Unfortunately, the both dirty and heavily subsidised coal industry is still up and running. But the process of energy transformation is now irreversible in Germany.



2012 PIK's reputation is so well established that the World Bank commissions a flagship report. The publication "Turn Down The Heat" goes online and reaches more than a billion people through social media.



2013 A group of young PIK scientists under the leadership of Katja Frieler begins a mammoth project. In order to produce a solid climate impact assessment in the most important sectors, a joint data and scenario base (ISI-MIP) is compiled, comparing results of all available models on climate change worldwide.



Climate Impact Cascade

2013 In addition, PIK is pushing forward
2014 method development: which mathematical algorithms will allow faster and more precise conclusions about the dynamics and operational robustness of networked systems? One example is the so-called “Basin Stability Concept”, which assesses the risk of blackouts in large power-supply structures and helps to avoid such disturbances. Further examples are the prediction of the monster El Niño of 2015/16 by PIK and the University of Giessen or the prediction of Indian monsoons developed at PIK – both prediction methods have proven to be successful in recent years.



Basin Stability Concept

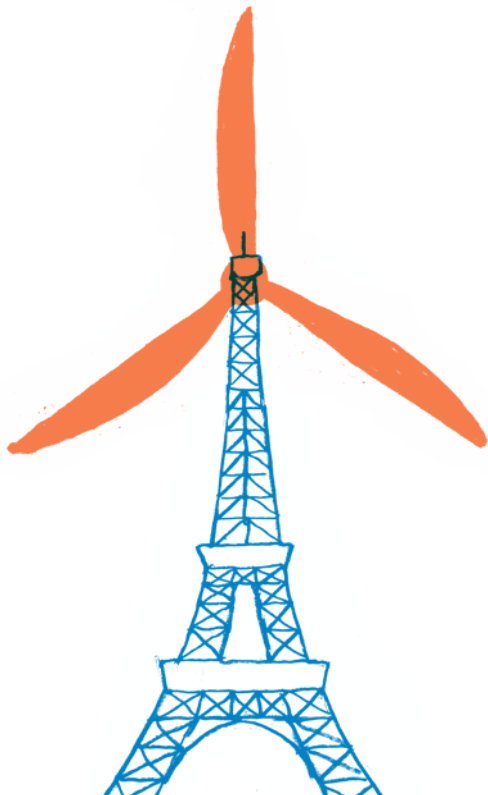
2014 The eagerly awaited report of the Inter-governmental Panel on Climate Change (IPCC) is published. The report of Working Group III, which deals with strategies for limiting global warming and is headed by PIK Chief Economist Ottmar Edenhofer, is particularly important. The IPCC shows that the two-degree limit can be achieved at a reasonable cost. This finding will come to influence the Paris Climate Conference.



2015 Shortly before the climate conference in Paris, Pope Francis calls for a rethinking of our relationship to creation in his encyclical “Laudato Si’”. The Pope was intensely advised by PIK on climate issues: for Pope Francis, Science and the Church do not contradict one another per se. On June 17, 2015, Professor Schellnhuber is invited to present, along with the highest church dignitaries, the “Green Encyclical” in Rome.



The Paris Convention, which is agreed upon by the international community of states at the 21st Conference of the Parties (COP 21) in 2015, is the first to make demands on non-industrialised countries as well. All states are called upon to implement suitable measures to contribute nationally to climate protection. The aim is to limit global warming to well below two degrees Celsius, preferably even to one and a half degrees.

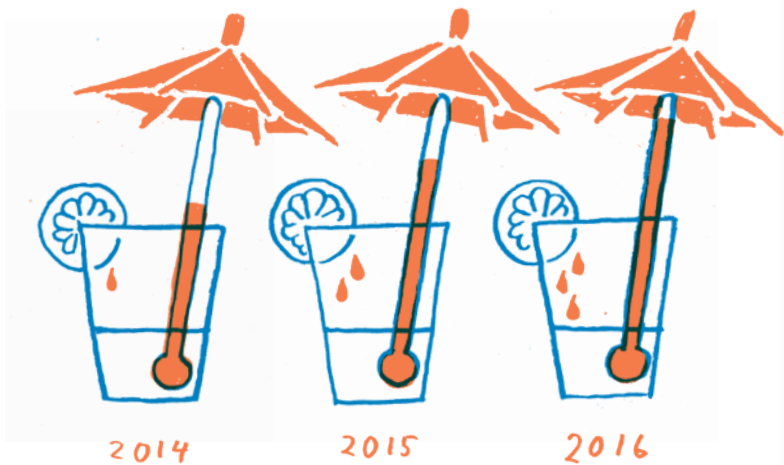


2016 PIK publishes a groundbreaking study on the Earth's icing dynamics. After more than 20 years of fundamental research, Andrey Ganopolski and his team of scientists are able to reproduce the glacial and warm periods of the last 800,000 years in a computer model. They are the first to do this successfully without supporting assumptions and supplementary data, using calculations driven solely by the fluctuations of terrestrial orbital parameters and the resulting changes in the atmosphere's carbon dioxide content. It was now possible to calculate the beginnings of the last ten glacial periods exactly. The scientists are also able to derive the worrying insight that the next natural ice age (due in about 50,000 years) has already been suppressed by man-made emissions!



The Ice Age on the Computer

The fruitless debate about a supposed pause in global warming becomes redundant. Ocean acidification due to carbon dioxide uptake also increases unchecked.



Three Record Warm Years in a Row

2017 The global mean temperature has already risen by about 1.1 °C compared to the period from 1880 to 1920. Accelerated action is now required to bring about a clean industrial transformation.



The state of the world and the climate politics of the near future in particular depend on how this and related information affects personal and collective action. Therefore, please do not throw this document into the waste-paper bin after reading it, but hand it on.



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The Potsdam Institute for Climate Impact Research has been advancing both the science and the political discourse on climate change for more than 25 years. But how did one even come to realize that mankind is changing the Earth's climate?

A trip for traces.

