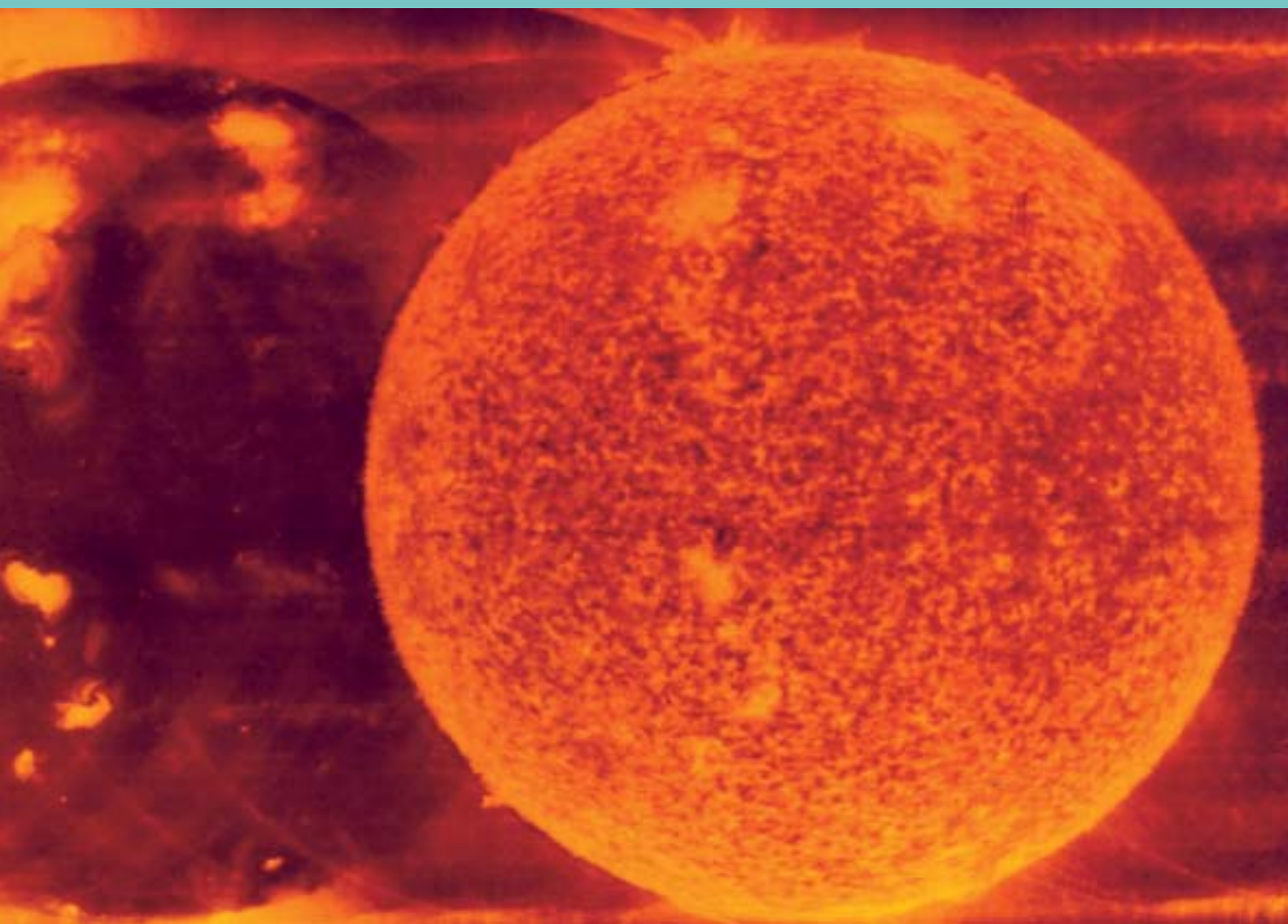


The climate sceptics

Media reports repeatedly focus on sceptics. Some of them do not believe in climate change, others attribute it to natural causes, and others consider it harmless or even favourable. How seriously should we take these theories?

Stefan Rahmstorf

The sun with sunspots and prominences, captured in September 1973 during the second Skylab mission. Can fluctuations in solar activity explain global warming?



Many aspects of the climate system are still insufficiently understood and are the subject of ongoing research and scientific discussion. One example is the mechanism of abrupt climate changes that have occurred repeatedly in earth's history, and the causes of which are still being debated > Rahmstorf "Abrupt climate change", p. 70.

On the other hand, some important core findings of climate research have been so well confirmed in recent decades that they are generally accepted as facts by climate researchers. These core findings include the following:

- 1 The atmospheric CO₂ concentration has risen strongly since about 1850, from 280 ppm (a value typical for warm periods during at least the past 400,000 years) to 380 ppm.
- 2 This rise is caused by humans and is primarily due to the burning of fossil fuels, with a smaller contribution due to deforestation.
- 3 CO₂ is a gas that affects climate by changing the earth's radiative budget: an increase in its concentration leads to a rise in near-surface temperature. If the concentration doubles, the resulting global mean warming will very likely be between 1.5 and 4.5°C.
- 4 In the 20th century, global climate warmed by ~0.6°C (in Germany by ~1°C). Temperatures in the past ten years have been the highest since instrumental records started in the 19th century and for at least several centuries before that.
- 5 Most of this warming is due to the rising concentration of CO₂ and other anthropogenic gases; a smaller part is due to natural causes, like fluctuations in solar activity.

These findings are based on decades of research and thousands of studies – it is almost inconceivable that they could be overturned by a few new results. The extraordinary consensus is seen in the statements of many international and national professional bodies which have extensively and critically assessed the scientific evidence. In addition to the well-known reports of the IPCC, there are public statements of the American National Academy of Sciences, the American Geophysical Union (AGU – the world's largest organisation of Earth scientists), the World Meteorological Organisation (WMO), the meteorological organisations of many countries (e.g. a joint declaration

by the German, Austrian, and Swiss meteorological societies), the scientific Advisory Council on Global Change (WBGU) set up by the German government, and others. All of these bodies have again and again arrived at the same key conclusions.

Anyone relying on the media for information, however, could get a completely different impression: namely that the above core conclusions of the scientific community are still disputed or regularly called into question by new studies. This is mainly due to the untiring PR activities of a small, but vocal mixed bag of climate sceptics (or "contrarians") who vehemently deny the need for climate-protection measures.

The various climate sceptics hold very different positions. We can distinguish trend sceptics (who deny there is global warming), the attribution sceptics (who accept the global warming trend but see natural causes for this), and the impact sceptics (who think global warming is harmless or even beneficial). Representatives of the various sceptics' camps quarrel, sometimes ferociously, in internet forums.

Trend sceptics

Given that the warming is now evident even to laypeople, the trend sceptics are a gradually vanishing breed. They argue that no significant climate warming is taking place at all, claiming that the warming trend measured by weather stations is an artefact due to urbanisation around those stations ("urban heat island effect"). In fact, the measured trends have already been adjusted to allow for this effect by comparing adjacent urban and rural stations. The warming above the oceans as measured by ships, the global retreat of glaciers, and the declining Arctic sea ice provide further evidence against this claim.

A classic argument used by trend sceptics is the satellite measurements of microwave radiation from the atmosphere (so-called MSU data, for microwave sounding unit), from which temperatures can be calculated which they claim show no, or only a weak, warming trend since these measurements started in 1979. However, the calculation of reliable long-term trends from such data is difficult and depends on several model assumptions. The life cycle of each satellite is only a few years; they use different instruments with different calibration errors. Satellite orbits decay, and measurements are made at different times of the day. Therefore, the calculated trends had to be strongly revised several times. Recently, it was shown that these satellite measurements included radiation from the stratosphere, which has cooled strongly (mainly due to ozone depletion); this has distorted the trend. The various published analyses of the MSU data show trends between 0.08°C and 0.26°C per decade, compared to 0.17°C per decade found in surface measurements.

Attribution sceptics

The attribution sceptics doubt that human activities are responsible for the observed trends. A few of them even deny that the rise in the atmospheric CO₂ content is anthropogenic; they claim that the atmospheric CO₂ is released from the ocean by natural processes. However, we simply know how much fossil fuel has been extracted and burnt and how much CO₂ was released to the atmosphere as a result. Only half of this amount is still there, the rest has been absorbed by the oceans and to a smaller extent by the biosphere. What is more, fossil carbon has a characteristic isotopic composition. This enabled Hans Suess to demonstrate already in the 1950s that the increase in atmospheric CO₂ is fossil in origin and cannot stem from the oceans. In the meantime, the rise in CO₂ in the oceans has also been documented by some 10,000 measurements around the world. The oceans have certainly not released CO₂ into the atmosphere; on the contrary, they have absorbed some of the extra fossil CO₂ load. (Incidentally, this is leading to an acidification of sea water, causing considerable damage to coral reefs and other marine organisms, even without any climate change.)

Although most attribution sceptics do not doubt that the CO₂ trend is human-induced, they do doubt that we are responsible for the warming trend. This argumentation

requires two premises: (1) that additional CO₂ does not lead to discernible warming, and (2) that there must be other – natural – causes for warming.

One argument in favour of premise (1) runs that the absorption bands of CO₂ are already saturated, so that more CO₂ will hardly lead to changes in the radiation balance. This argument is 100 years old by now: it was used early in the 20th century against the Swedish Nobel prize winner Svante Arrhenius, who, in 1896, was the first to calculate the warming effect of CO₂ on climate. This argument was conclusively refuted in the 1950s. The radiative transfer in the atmosphere (including the saturation effects) is physically very well understood by now; otherwise, satellite-based measurements would hardly be possible.

Another argument put forward for premise (1) is that, although the calculations of radiation are correct, the response of the climate system is weaker than previously thought, because negative feedbacks lessen any warming (the formation of additional cloud cover, say). This argument must be taken more seriously. Indeed, any uncertainty still existing today on the strength of the CO₂ effect is largely due to the fact that the strength of the feedbacks (water vapour, clouds, ice, and snow) is only known imprecisely. Still, many studies using different approaches have provided increasingly hard evidence that the most likely value of the “climate sensitivity” (i.e. the equilibrium response of the climate to a doubling of the CO₂ concentration) is close to 3°C. This results independently both from our physical understanding of the various feedbacks (which can be observed in today’s climate, e.g. in the seasonal cycle) and from an analysis of the role played by CO₂ during past climate changes. It would not be possible to understand the extent of the ice ages if the lower CO₂ concentration at the time had not amplified climatic cooling. (Note that CO₂ is not the primary cause of the ice ages; that can be found in changes in the earth’s orbit.) Another problem with this argument of the sceptics is that the negative feedbacks would dampen any climate change irrespective of its cause – anyone believing in strongly negative feedbacks will have great difficulty explaining the observed warming trend with other causes, such as solar activity.

The most popular argument by far in favour of premise (2) is the claim that changes in solar activity and/or cosmic rays (due to their effect on cloud formation) are responsible for climatic warming. To underpin this, a series of statistical correlations has been proposed, none of which so far has stood up to closer analysis with

further data. It is widely accepted that variations in solar activity have contributed to climate variability in the past – e.g. to the cool climate during the Maunder Minimum, a period of virtual absence of sun spots around the year 1700. If variations in solar activity (which can be reconstructed from isotopic data) are taken into account in model calculations, the climate variations of the last 1,000 years can be reproduced quite well. Nevertheless these solar variations cannot explain the warming in the 20th century. For one thing, they are not large enough; the radiative effect of anthropogenic greenhouse gases is by now several times stronger. And while reconstructions of solar activity do indicate a rise until 1940, they show no significant trend since then. The same is true of measurements of cosmic rays.

Impact sceptics

So, what is left are the arguments of the impact sceptics. They underscore the possible positive consequences of climatic warming, like a potential extension of agriculture into higher latitudes. No doubt, a warm climate is not necessarily worse than a colder one. However, we must bear in mind that rapid changes will have predominantly adverse effects because society and ecosystems are highly adapted to the recent climate. Higher runoff amounts after heavy precipitation, for example, are not a problem per se. But if river beds and human infrastructure are not adapted for this, the result is water standing in Prague and Dresden (as in 2002). Nor is a higher sea level bad in itself – it is just unfortunate that our cities tend to be located along the present coastlines. Not least, global warming will make our living conditions more unpredictable – we are travelling into uncharted waters without being able to foresee all the consequences.

In the absence of climate protection measures, we will probably see a warming by several degrees in this century. The most recent comparable period of major global warming occurred when the last ice age ended ~15,000 years ago: at that time, the climate warmed by approx. 5°C in global mean. This warming had serious implications for man and ecosystems. But the process unfolded over a period of 5,000 years – humankind is now threatening to bring about a similarly large climate change within the space of a century. This extraordinarily rapid change would most likely exceed the adaptive capacity of man and nature.

Along with the scientific arguments, which should always be to the fore, of course, it may also help us understand the climate sceptics phenomenon if we take a brief glance at their backgrounds and the various organisations involved. The three archetypes of climate sceptics are the Paid Lobbyist (the coal industry, among others, is fighting

emission reductions), the Don Quixote (emotionally committed laypeople, frequently pensioners, but also including a few journalists – many of them literally fighting windmills), and the Eccentric Scientist (they are few and far between and are hardly ever climatologists, often coming from related fields like geology). All three groups act like lobbyists: from a thousand research results, they cherry-pick and present the three that happen to support their own position – albeit only with a liberal interpretation. Any neutral and reputable scientist, by contrast, will try to explain, as balanced as is possible, what conclusions can be drawn from all of the thousand results – with all the uncertainties and question marks they come with.

Especially in the US, the PR work of the climate sceptics took on a highly professional form in the 1990s and gained substantial influence on politics. A study by American political scientists came to the conclusion that the intensive lobbying of well over a dozen industry-funded organisations was instrumental for the turnaround in American climate policy and helped engineer the exit from the Kyoto Protocol. Among these organisations we find Frontiers of Freedom (FF), the Science and Environmental Policy Project (SEPP), and the Global Climate Coalition (which discontinued its work in early 2002 after the withdrawal of leading companies like BP, Shell, Ford, and DaimlerChrysler).

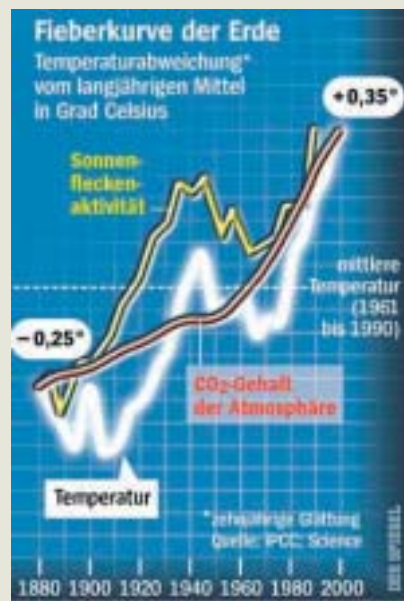
In 1996, well-known US climate sceptics set up the European Science and Environment Forum (ESEF), in an attempt to influence Europe’s climate policy as well. A leading role in several of these organisations is played by the “godfather” of the climate lobbyists, Fred Singer. In the 1980s, Singer fought the Montreal Protocol and denied the connection between CFCs and the ozone hole (for the explanation of this connection, Paul Crutzen was awarded a Nobel prize in 1995). German climate sceptics and Denmark’s Björn Lomborg maintain good contacts with Singer and obtain argumentation aids from him.

Scientific criticism, constant scrutiny, and a healthy scepticism are welcome, of course – they are at the heart of science and an important part of its appeal. Unfortunately, the PR work of the climate sceptics is frequently dishonest – including specious arguments that skilfully exploit the lack of background knowledge in their lay audience. The media must share responsibility here: all too often, news is uncritically printed without proper in-depth research and with no questions asked (see box).

The PR work of climate sceptics – some examples

Der Spiegel, a German weekly news magazine, in June 2001 published a hot story in which the sun was held responsible for the warming of the climate. The centrepiece was the graph depicted below, supposedly showing a correlation between temperature and solar activity.

Comment: The solar curve was taken from a 10-year-old scientific publication and had long been publicly withdrawn by its author as being faulty. His conclusion from the corrected solar reconstruction: the warming of recent decades cannot be explained by solar activity. A brief check-back with a climate researcher would have spared the *Spiegel* this error.



Graph taken from *Der Spiegel*, 2 June 2001.

In costly PR work, the *Federal Institute for Geosciences and Natural Resources (BGR)*, subordinated to Germany's Economics Ministry, has for years been playing down the impact humankind has on the climate.

Comment: Regrettably, the BGR shirks from engaging in the usual scientific discourse by failing to publish its propositions in the scientific literature. What is more, the BGR's position is very changeable. In the year 2000 (in the book "Klimafakten"), the warming trend was not denied but claimed to be caused by the sun – the faulty solar graph published by the *Spiegel* (see above) can be found here in a very similar form. In 2002 (brochure "Klimaentwicklung"), by contrast, a correct solar curve is depicted which shows no rise since 1940. But the BGR now morphed into a trend sceptic: with an illustration showing the MSU satellite data, warming was now denied altogether. Following criticism, the BGR in its new brochure ("Klima", 2004) has now come a long way towards the consensus view of independent climate experts: the warming of recent decades is now a fact of life again and the sun no longer the culprit. But some questionable statements can still be found here, e.g. when it is claimed that "the temperatures reconstructed and measured for the end of the 20th century [are] roughly at the level of the annual temperatures of the year 1000 AD". This is contradicted by all quantitative reconstructions published in the scientific literature – including the two shown in the BGR's brochure, in which the maximum medieval values are already reached in the middle of the 20th century, i.e. before the start of the strong warming trend of recent decades.

The journalist Dirk Maxeiner reported in 2002 in *Die Welt*, a German daily, that the "Schroeter Institute for Research on Cycles of Solar Activity" had found that man-made carbon dioxide plays "a very much smaller role than previously thought" for the climate.

Comment: The alleged "institute" could not be found on the internet. Investigations showed that the imaginative institute name was a front for a retired lawyer and long-time activist in the climate sceptics scene. A layperson can hardly distinguish such a newspaper report from serious scientific news.

Often cited in recent sceptics' publications as a scientific publication is an article which appeared in *21st Century Science* in late 2003, written by the self-appointed climate researcher Zbigniew Jaworowski under the headline *The Ice Age Is Coming! Solar Cycles, Not CO₂ Determine Climate*.

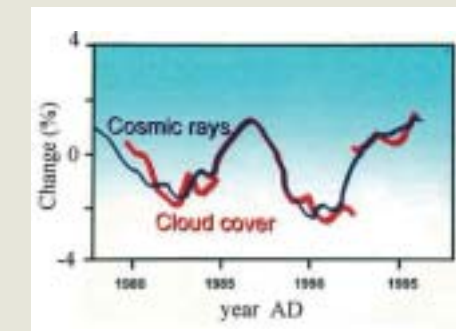
Comment: This article by the Polish nuclear researcher is written for laypersons. Along with sceptics' standard arguments, he asserts, among other things, that the warmest temperatures in the 20th century were reached around 1940, that a cooling of the climate has already commenced, and that a new cold phase will reach its climax in 20 years' time. The periodical *21st Century Science* belongs to the organisation of American multi-millionaire and conspiracy theorist Lyndon LaRouche. According to its own advertising, this organisation also flatly rejects the theory of relativity, quantum theory, and other achievements of modern science.

In October 2003, journalist Edgar Gärtner, writing in *Wirtschaftsbild*, a German fortnightly economic information service, blamed the present warming on cosmic rays: "The drifting apart of solar activity and terrestrial temperature development observed since 1980 is due, according to Veizer and Shaviv, to the fact that our solar system is currently leaving the Sagittarius-Carina arm of the Milky Way." This sentence is repeated in a speech manuscript of a Member of the Bundestag, Ms. Lengsfeld.

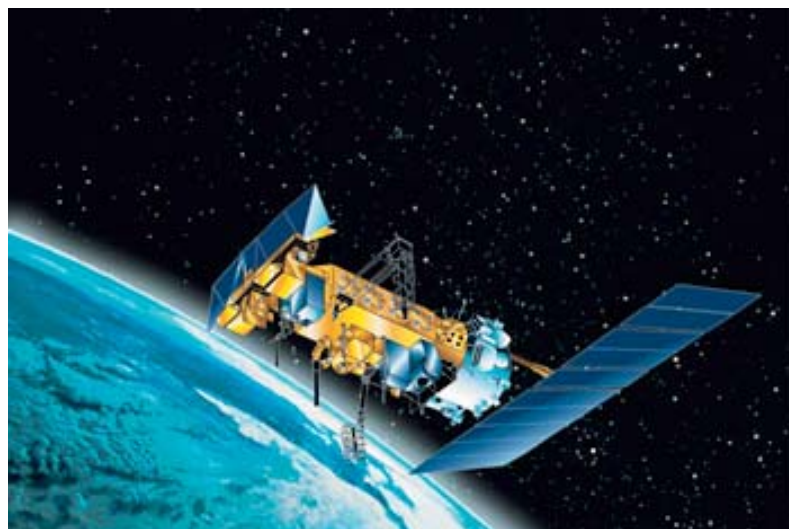
Comment: This theory is not supported by any scientists (including those actually named, who explicitly describe it as wrong). If the position in the galaxy were to have any influence at all on the climate (and the evidence for this is weak), the process would unfold in the course of several million years and, over a period of 20 years, account for at most one millionth of a degree.

In 2003, the *Ruhr University Bochum* in a press release disseminated the graph shown below (initially without stating its source), which seemingly proves a high correlation between cosmic rays and cloud cover.

Comment: This graph, which has been circulating in the sceptics' scene for years, is deliberately misleading. Different sections of the red curve depict completely different data sets that cannot be compared with one another. Whereas this was clearly indicated in the original publication by Svensmark (1998) by using different symbols, the present graph, by leaving out this crucial caveat, suggests that the red curve shows a homogenous data record for clouds. Parts of the same cloud data records that do not fit the suggested correlation were omitted from the graph, even though the missing data had long been published. The alleged correlation has not held up in the further course of satellite measurements: the red branch, which shows a downward kink in 1992, continues to fall after that year. Although several climatologists pointed out the problem to the Ruhr University, it has refused to make a correction to the internet page concerned. It merely added a confusing commentary referring to a number of publications relating to other correlations, but the dubious graph is still offered for download. (Incidentally, the undisputed blue curve of cosmic ray intensity shows that cosmic rays cannot explain the warming of recent decades, as they show only oscillations but no trend.)



Graph taken from a press release issued by Ruhr University, 1 July 2003.



One of the main arguments long put forward by sceptics was that satellite recordings proved the atmosphere had not heated up in recent decades. It is now certain that there is no scientific evidence to support this claim.

The activities of the climate sceptics pose a dilemma for us climate researchers: should the sceptics' dubious assertions be left uncommented when they appear in the media? What then follows is a reproach that no climate researcher is willing to comment or even that researchers have no counter-arguments. Or are we to go in for a public debate? Such a discussion quickly becomes very technical, with diagrams, data, and quotes from the literature flying about, so that the lay public can hardly judge who is right and who is wrong. In the end, what is often likely to remain is precisely the impression that the climate sceptics are trying to invoke: that everything is still highly controversial.

Many colleagues have responded to e-mail campaigns launched by the sceptics and got involved in extensive technical discussions with them. Most of us have found that factual arguments, even in unequivocal cases, were unable to convince one single climate sceptic. Nevertheless, the sceptics' arguments should be taken seriously

and answered. A list of responses to many current sceptics' arguments is maintained, e.g. on the internet site of Germany's Federal Environmental Agency.

The general public can only be advised to take with a generous pinch of salt any media reports and statements made by individuals – no matter whether they dramatise or play down climate change. A balanced and well-founded assessment of the state of knowledge can best be obtained wherever a larger group of experts (not self-appointed ones, but those who have earned a reputation through their research) produce a joint statement, like those of the IPCC or the other organisations mentioned earlier. Extreme opinions of individuals or dubious arguments cannot prevail where there is broad and open discussion among specialist scientists.

Recommended reading

Further articles with a more detailed discussion of the arguments put forward by sceptics may be found on the author's website: www.pik-potsdam.de.

The Federal Environmental Agency's website: "Skeptiker fragen, Fachwissenschaftler antworten": www.umweltbundesamt.de/klimaschutz/faq.htm.

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The author

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He continued his research at the New Zealand Oceanographic Institute, at the Institute of Marine Science in Kiel, and since 1996 at the Potsdam Institute for Climate Impact Research. His work focuses on the role of ocean currents in climate change.

In 1999, he received a US\$-1m fellowship award from the US-based James S. McDonnell Foundation. He has been teaching physics of the oceans as a professor at Potsdam University since 2000. Rahmstorf is a member of the NOAA Panel on Abrupt Climate Change and of the advisory board on sustainable development of the state of Baden-Württemberg.