Why weather isn't the same as climate

Ten climate researchers report

A reader from the Cluster of Excellence CliSAP

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Contents

More climate stories ...

Many think of weather when they hear the word climate. Why they are not the same thing and why a cold winter doesn't disprove global warming are explained in the following pages.

As with the previous two, the third reader from the Cluster of Excellence CliSAP is a collection of contributions that scientists published in the "Hamburger Abendblatt". Meteorologists, biologists and physicists as well as peace researchers and media scientists give answers to urgent questions. How much CO_2 does the North Sea swallow? Is polluted air good for the climate? Can nuclear power solve the climate problem?

Have a good read!

Hamburg's soils under climatic stress

Clean water is important for life quality. This is particularly the case in Hamburg, which is strongly shaped by the Elbe River and its tributaries. It is often forgotten that the soil plays a decisive role in this. Soils are namely real all-round talents.

As the link between the atmosphere and the inanimate rock, they serve as a filter, an accumulator and a buffer. They regulate the water and heat balance – and with this, also the climate of the city. On the other hand, climate changes can compromise soil function. This is what my colleagues and I are investigating at the Institute of Soil Science.

A fact that many in Hamburg are not aware of: their region is extraordinarily rich in different types of soil. Due to the particular characteristics of the terrain, almost all of the soils occurring in Germany are present in our area. The lion's share are found in the marshes. These fertile groundwater soils, which lie at sea level, are used intensively for agriculture. That is why the Vierlande and Marschlande areas are known as Hamburg's fruit and vegetable pantry.

However, climate change could bring the system out of balance. Regional model calculations show that average temperatures will increase in the next 90 years by 2.9°C. At the same time, more precipitation is expected, whereby there will be a shift in the seasons. The summers will tend to be drier and the winters wetter and warmer. The consequences: the soils would have to absorb more water in winter, they become water-logged and the groundwater level rises. The affected croplands can then only be cultivated with the help of additional drainage systems.

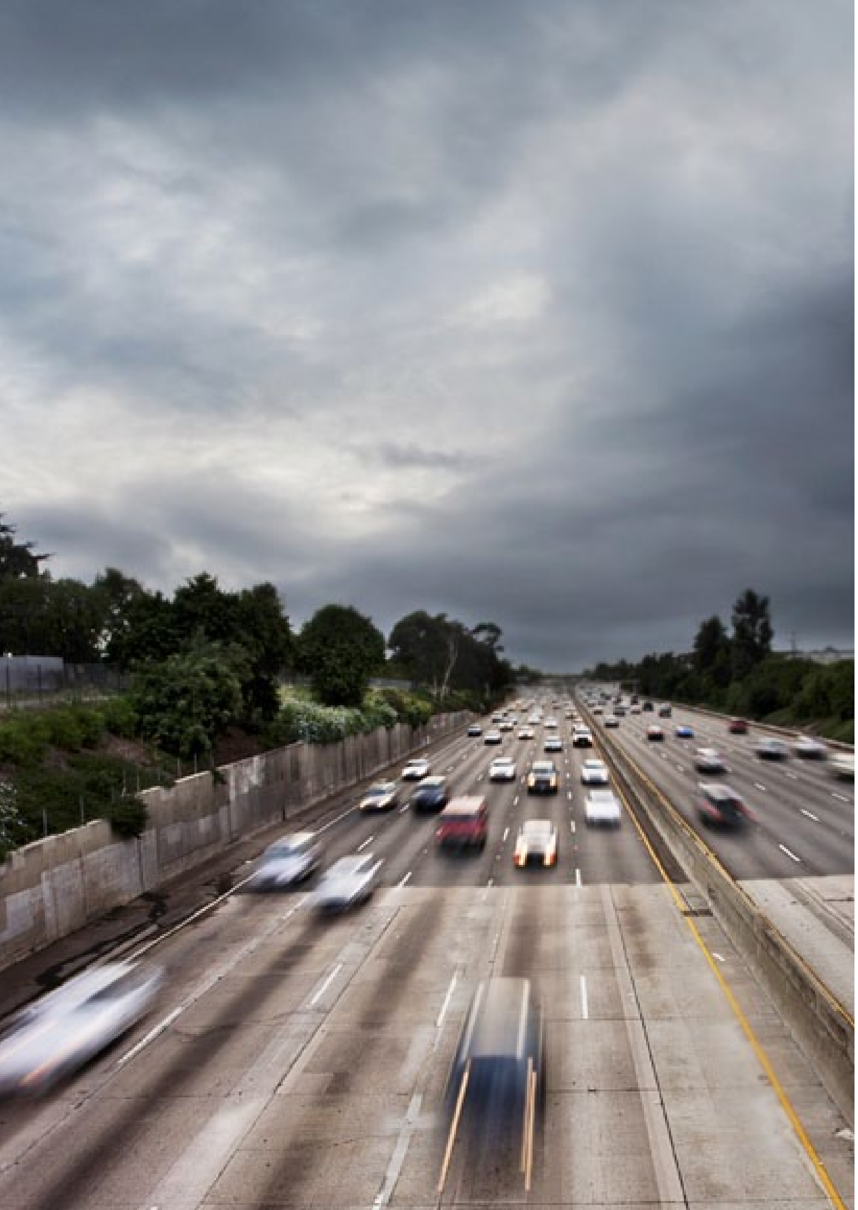
A rise in sea level would further aggravate the situation. The Elbe and its tributaries will then discharge more water and flood more frequently. But since the water-logged soils cannot take up more water, their buffer function is lost. This also disturbs the natural cleaning function: when contaminants seep into the ground, intact soils act as a filter. But when groundwater level is high, they are transported further and contaminate larger areas.

In addition, a regional increase in temperature would heat up the soils. If they are very wet at the same time, organic matter is decomposed more rapidly. Valuable reserves of humus are then lost. Our results show that in marshes and bogs in the lower Elbe region, this would cause more methane to be formed and released – a greenhouse gas 26 times more effective than carbon dioxide.

The water-logging of the marshes is, however, only one side of the coin. On the other side, the higher lying Geest areas, sandy uplands on the North Sea coast, will increasingly dry out. This will hamper the formation of new groundwater. Gardens and parks will then have to be watered at high cost. This is a development that is already seen today.

Our analyses of the soils provide the public authorities and urban planners with a basis for developing adaptation strategies. An important step in this direction would be to anchor the climatic function of the soils in Hamburg's Soil Protection Law in the future.

Prof. Eva-Maria Pfeiffer from the Institute of Soil Science at Universität Hamburg is a geoscientist and an expert on soil ecology.



Is polluted air better for the climate?

Gray and hazy weather? There is no scarcity of that in Hamburg. But when the sky is overcast, this not only influences the number of guests at the ice cream parlors. The long-term climate is also affected by clouds and their characteristics.

A dense layer, for example, reflects a large amount of solar radiation back into space, thus cooling the earth. On the other hand, global warming could change the cloud density. If it increased or decreased only five per cent worldwide, this could have just as strong an effect as a doubling or halving of the CO_2 concentration in the atmosphere.

For more than 30 years scientists have therefore been trying to represent clouds and their changing states realistically in climate models. Because of the complex interactions, however, this has always remained a weak point. My colleagues and I are therefore investigating new aspects of cloud formation at the Cluster of Excellence CliSAP.

At the moment we are looking at the influence of aerosols. These microscopic particles are discharged into

the atmosphere with smoke, exhaust fumes or volcanic eruptions. There they can act as condensation nuclei and accelerate cloud formation. Actually a paradox: a "dirty" cloud cover with a large amount of aerosol appears lighter from space, thus reflecting better and having a stronger cooling effect.

This cooling effect is of interest to science, since global temperatures have risen significantly during the past 100 years. This can be attributed to the increased carbon dioxide (CO_2) emissions during the same period – a logical conclusion. However, the aerosol content of the atmosphere follows the same pattern: due to the increase in industrialization after the 1950s, more and more particles were emitted unfiltered into the air from factory smokestacks. Some scientists therefore fear that the cooling effect of the aerosols is actually masking the true increase due to CO_2, which would be much stronger otherwise. On the other hand, global standards for better air quality might be a boost to global warming.

But do short-lived aerosols really influence cloud formation and the climate in the long run? Namely, after around one week the next rainfall washes the floating particles back down to the ground. Our model is now tackling this question. When we feed it with the known values for "heating" CO_2 and "cooling" aerosols, then we get a surprisingly good representation of the actual temperature curve since 1900: so the model is functioning well.

In the same scenario we can now deliberately "turn off" the influence of air pollution on cloud formation. The particles themselves and their short-term effect through smog, for example, are retained. First results show: this temperature course also corresponds well with reality! The cooling effect of the aerosols on clouds thus seems not to be as strong as assumed. If this is confirmed in further experiments, then no one will have to be "afraid" of better air quality in the future.

Prof. Bjorn Stevens is a director at the Max Planck Institute for Meteorology and investigates the behaviour of the atmosphere in the earth system.

Cold winters do not contradict global warming

"In spite of the cold snap: global warming remains a fact", could be read in many newspapers at the beginning of 2011. Germany was covered with ice and snow for weeks and many asked whether global warming had taken a break.

However, climate change has nothing to do with such a "snapshot", on the contrary, it refers to a change in the average weather. In 1935, the International Meteorological Society had already stated: "Climate is average weather". At that time it also established a reference framework: at least 30 consecutive years must be considered by scientists before they can refer to a trend in the climate. Reliable scientists still hold to this rule today. At the Cluster of Excellence CliSAP we have now proven mathematically that this is more than just an arbitrary convention.

With Australian colleagues we analyzed data, including model data of the US National Oceanic and Atmospheric Administration for the years from 1871 to 2008. It could be shown that a 30 year period is actually

sufficient to capture significant changes from year to year. These, for example, can be extremely cold or warm seasons. On the other hand, this means if values deviate from the 30 year mean it is an indication of climate change.

The mathematical method we used is called "random walk" and describes a random process. It is comparable to a tree that lets its leaves drop in autumn: it cannot be predicted where any one leaf will land. But we can calculate that, in the end, almost all leaves will lie within a certain radius around the tree. The length of the radius (random walk period) corresponds to the 30 year mean of the meteorologists: this is where all leaves land, or all "normal" temperature fluctuations occur, as in our case.

According to the same principle, at the Meteorological Institute we have investigated when and how rapidly the temperature maxima and minima are reached. The random walk is also no more than 30 years in this case. On the contrary: over the ocean, which reacts relatively slowly, shorter analysis periods may suffice under certain circumstances in order to recognize whether it is a matter of a normal deviation from the mean or a consequence of climate change. Our study shows that the 30 year rule of the Meteorological Society – which was based on experience at that time – was correct.

What is decisive, however, is that we test further aspects in the climate system using this mathematical method – for example whether climate change has already shifted the hottest and coldest times of the year. In this, we can reliably differentiate between weather and a climate signal.

Dr. Edilbert Kirk from the Meteorological Institute works in the area of theoretical meteorology and is an expert on climate models.

The power of Toba: a volcanic eruption with climatic effects

On Sumatra, in Yellowstone National Park and near Naples they are sleeping: volcanoes with the potential for so-called super-eruptions.

Such eruptions are, however, seldom. According to statistics, a supervolcano only erupts about every 700,000 years. Then, more than 1,000 billion tonnes of gases and solid particles are discharged – around 150 times as much as during the eruption of Pinatubo in the Philippines on the 15th of June 1991, one of the largest eruptions of the 20th century. A gigantic cloud of gases, ash and sulfur particles is formed that blocks sunlight and can thus affect global climate for years.

But what is the magnitude of the changes after such an enormous eruption? At the Cluster of Excellence CliSAP we tried to answer this question together with colleagues from Cambridge and Kiel.

To do this we simulated the effects of the last super-eruption on the mainframe computer: around 74,000 years ago, the volcano Toba on the Indonesian island of Sumatra erupted. Scientifically, it is a particularly interesting case which is being discussed in connection with a so-called "genetic bottleneck" in human evolution, since the number of Homo sapiens was reduced strongly around 70,000 to 80,000 years ago.

Some researchers attribute this population reduction to the climatic changes which occurred after the Toba eruption. But did the eruption actually have such grave effects? The high survival rate of mammals in Southeast Asia during that period is an argument against this.

In order to investigate the effects of the Toba eruption more precisely, for the first time we considered a factor which had not played a role in earlier simulations. For the climatic effect of a large volcanic eruption, it is not only the amount of sulfur particles released which is of central importance. The size of the particles is also of prime importance. Their extremely high concentration in the volcanic cloud leads them to clump together more easily, becoming heavier and thus sinking more rapidly. Due to this, the sunlight is only weakened over a relatively short period of time. With our computerized earth system model, we were able to show that the reduction in mean temperature after the Toba eruption was significantly smaller than had been calculated in previous model studies: namely a maximum of 3.5°C worldwide.

According to our model, the temperatures in certain regions decreased by up to ten degrees. However, the frostline only shifted slightly. This refutes the thesis that worldwide cooling had dramatic consequences for life on earth – especially since the temperature fluctuations ten years after the eruption were already in the range of natural variability.

Our results show that the eruption of the supervolcano Toba made the conditions for life on earth harder. However the cooling effect was not strong enough to explain the drastic decimation of humans during this time. There must be other reasons for that.

Dr. Claudia Timmreck is a physicist at the Max Planck Institute for Meteorology and works on the supervolcano project.

Nuclear power is climate friendly, but ...

... involves unforeseeable risks. Is the nuclear industry nevertheless indispensible for protecting the climate? Must environmental activists now support nuclear fission, which is low on CO_2 emissions, in order to be consistent?

In the debate surrounding nuclear power, emotions are running high at present and the facts are often blurred as a result. At the Cluster of Excellence CliSAP, my colleagues and I are therefore considering the question of what the actual contribution of nuclear energy is to the reduction of carbon dioxide.

Different methods for producing energy generate different amounts of the greenhouse gas carbon dioxide. The current energy mix in Germany, consisting of coal, petroleum, nuclear, wind and solar power, produces a total of almost 600 grams of CO_2 per kilowatt hour.

These forms of energy can be compared when we break down their values individually. In such a calculation, we consider every CO_2 emission, including the construction of the power station, the exploitation of the necessary resources and waste disposal after shutdown. According to this, nuclear power produces 50 to 100 grams of CO_2 per kilowatt hour. The values for wind, biogas and hydroelectric power are lower, at ten to 30 grams. Brown coal, with around 1,200 grams of CO_2 per kilowatt hour, takes last place. Nuclear energy thus produces a relatively low amount of greenhouse gases. Does this mean that more nuclear power stations make the country more climate friendly?

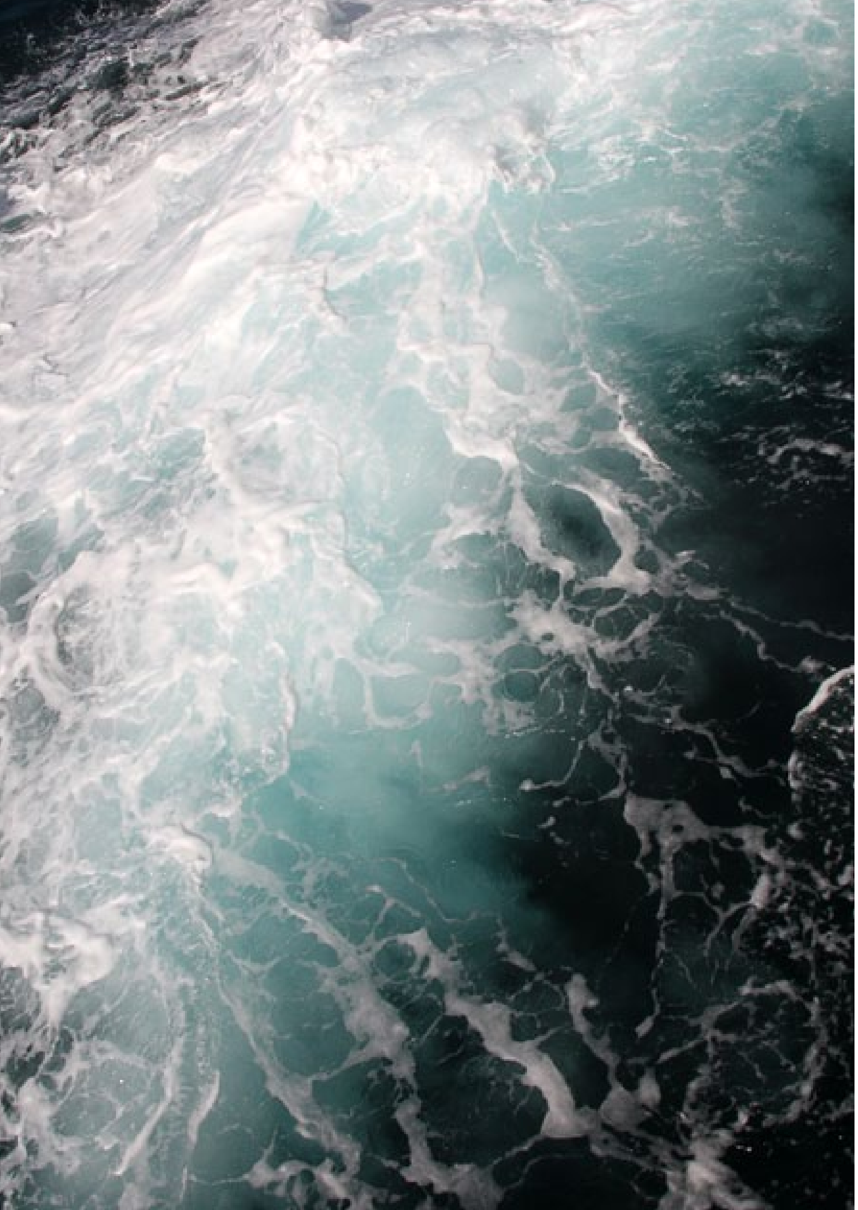
In connection with this we compared the development of energy policy in 30 countries for the period from 1997 to 2005. The result: there is a correlation between the proportion of nuclear power and CO_2 emissions. Countries with a high proportion of nuclear energy of 70 to 80 per cent – such as France and Lithuania – produce only 100 to 150 grams of CO_2 per kilowatt hour.

This is not automatically the case, however, because at the same time, Sweden and Switzerland have even lower CO_2 emissions but use only a third to half as much nuclear energy as France. Switzerland reduced its proportion of nuclear energy during the period considered by a further ten per cent while maintaining its low CO_2 value. Germany, on the other hand, could reduce its emissions per kilowatt hour significantly by increasing its use of wind power – without increasing the proportion of electricity generated by nuclear power beyond 30 per cent.

Exploitation of nuclear power requires uranium, which is mined almost entirely outside of Europe. On the one hand, the environmental standards there are in part evaded dramatically, and nuclear radiation is released. In addition, CO_2 emitted during the mining of uranium doesn't go into the energy budget in the user country. Our calculations show that for every atomic kilowatt hour produced in Europe, 25 grams of CO_2 were emitted overseas. Since uranium producing countries such as Niger or Kazakhstan have no legally binding emission reduction targets, this can be an incentive for industrial nations to outsource their emissions there.

According to this, nuclear power is climate friendly. But there are enough alternatives which have even better results for the climate while being safer and not raising additional questions such as nuclear waste disposal or the production of nuclear-weapons grade material.

Prof. Martin Kalinowski from the Center for Science and Peace Research is physicist and an expert on climate change and peace research.



How much carbon dioxide does the North Sea swallow?

For the most part, the greenhouse gas carbon dioxide (CO_2) in the atmosphere is the cause of climate change. There are many ways for it to get into the air. Usually, humans are responsible. But what happens to the gas then?

Around one third of the greenhouse gas disappears from the atmosphere. It becomes dissolved in sea water and part of it is taken up by algae during photosynthesis. Zooplankton and small marine organisms eat the algae. These later die and then sink to the bottom – and with them the carbon. That makes the sea an ideal repository for the greenhouse gas, considerably slowing down global warming.

In order to examine this process more closely, we at the Cluster of Excellence CliSAP have investigated one small part of the world ocean – the North Sea, a sea at the edge of the North Atlantic. We have fed our supercomputer with all the characteristics and processes of the sea and checked our calculations using long-term measurement data from field research. The result was

quite good: for the first time, a comprehensive computer model of Hamburg's backyard sea was developed under the cooperation of meteorologists, geologists, physical oceanographers, marine biologists and marine chemists.

The North Sea lies on the northwest European shelf – the area where the coast drops off to the ocean. The organisms that live in it are subject to extreme challenges, especially in the southern Wadden Sea: seasonal changes, typical stormy periods as well as the rhythm of the tides are characteristic of this habitat. In addition, climate change and global shipping, which brings in water from all over the world, have displaced entire species.

At the same time, the North Sea is one of the most productive marine areas in the world. That means it can convert a particularly large amount of CO_2. But as far as the buffer function for climate change is concerned, the North Sea is divided into two parts: In the northern part with depths of more than 100 meters, the sunken carbon is transported by deep currents further into the North Atlantic Ocean and thus removed from the atmosphere for a long time. We call this the "continental shelf pump". In the southern part, on the other hand, which is only up to 50 meters deep, the CO_2 is soon returned to the air.

In the same way, further processes influence the path of carbon into the oceans: what role do algae blooms caused by over-fertilization play in the CO_2 budget? What does a permanent elevation in temperature or acidification mean for the shelf sea? How do calcareous algae affect the carbon pump? Our North Sea model helps to clarify these influences.

In a certain sense, the North Sea is only an "appendix" of the North Atlantic, but it is influenced strongly by humans. And although our results are only one piece of the puzzle, they still help to draw important conclusions about the interplay of the global and regional climate systems.

Dr. Johannes Pätsch is a modeler at the Institute of Oceanography.

Climate change as a security risk

Does climate change threaten our security? At the initiative of Germany, this question found its way into a resolution by the Security Council of the United Nations for the first time on the 20th of July, 2011.

After tough negotiations, the 15 members agreed on a very careful statement. This confirms observations made by us at the Institute for Peace Research and Security Policy at Universität Hamburg: the opinions on this problem are very different from country to country.

How can climate change threaten security in the world? There are numerous scenarios for this. The simplest: due to climate change, natural resources will become scarce. Water shortages, for example, can lead to drought periods. One possible consequence is conflict over resources in the affected regions.

At the Cluster of Excellence CliSAP, we have investigated the security concepts of many nations and discovered that most governments regard climate change as only a local problem. Some countries, Germany included, see the necessity for cooperative solutions. Only a few, such as the USA, Great Britain or Russia, are also fearful

for their own security, for example due to massive immigration. In this respect, climate change also becomes a military topic. The USA invests, for example, large sums in scientific investigations into how climate change will affect the armed forces. Among other things, these consider questions of migration or of the global deployment of US troops in disaster areas.

In England, a comprehensive paper with measures concerning climate already exists – from fuel saving tanks to protection against terrorism. In Germany, on the other hand, the significance of climate change for the military is still hardly concrete. Only disaster control has become the focus of interest.

The fact that extreme weather events will increase and that sea level will rise can be regarded as scientifically validated. That conflicts and crises can arise from this, for example in the case of island nations lying only a few centimeters above sea level, is obvious. But here as well, the inhabitants of areas subject to high water levels have to deal with the consequences of the extremes more and more often. What can we do in the way of prevention? Produce less CO_2 and try to stop climate change with all means, that is certainly the first step.

In addition, investigations and discussions must be carried out on how to prevent climate change from becoming a security problem. There are possibilities – technical as well as political – for preventing conflicts before they lead to violence or the deployment of the military. The resolution by the Security Council provides a basis for further international political discussions.

Prof. Michael Brzoska is the director of the Institute for Peace Research and Security Policy.

Thaw in the polar ocean

Is it possible that the North Pole will be completely ice free during summer in a few decades? At the beginning of September 2011 another record low was registered for the ice coverage in the Arctic Ocean.

Perhaps too early, since the mean for the entire month is what has to be compared in order to make reliable statements. Our current data indicate that the record low from 2007 will almost be reached in 2011.

That is a signal we need to take seriously, since the polar region is considered to be an early warning system for worldwide climate change. The sea ice plays an important role in this, because it influences the interactions between the ocean and the atmosphere.

Normally, the Arctic sea ice shrinks in summer, reaches its minimum at the end of September and then grows again. But for several years now we have been observing that the ice is receding unusually far in late summer. The values lie significantly below the long-term average. For our statistical analyses, my team and I from the Cluster of Excellence CliSAP use satellite data extending back to 1972. For this, we concentrate on the month

of September, compare the annual data on the extent of ice coverage over the entire period of time, then use these to make projections. This is similar to the prognoses on election results.

Since the beginning of the measurements we observe a linear trend: each decade the ice decreases by around nine per cent. In addition, it is now melting twice as fast as at the beginning of the time series. That has consequences for global climate. Ice floes are namely able to reflect sunlight. Even a thin layer of snow increases their reflectivity, the so-called albedo, strongly. On the other hand, ice-free expanses of ocean absorb solar energy, thus amplifying the melting process during the polar summer.

In turn, this could influence oceanic currents, since freshwater goes into the ocean. If too much freshwater melts into the salty sea, then the water doesn't become dense and heavy enough during cooling to sink to the deep. In this way, ocean circulation and its corresponding heat transport could be subject to change. In order to predict how fast the ice will melt, not only the extent of the ice coverage but also the thickness counts. Together with colleagues from Finland, Denmark and Germany, my team and I are developing a method for measuring the ice thickness which is coupled to the remote sensing satellite SMOS. We are already using information from the Cryosat satellite today. With its radar, it measures the distance between its orbit, at an altitude of around 700 kilometers, and the surface of the ice as well as simultaneously measuring the distance to the water surface. From this, the height of the ice floes over the water can be calculated. By measuring this so-call freeboard, we can estimate the thickness of the ice.

Our present goal is to combine the results from both satellites in order to gain still more precise information on the volume and loss of sea ice.

Prof. Lars Kaleschke from the Institute of Oceanography is an expert on satellite observations and Arctic sea ice.


DIE ZEIT
WOCHENZEITUNG FÜR POLITIK
Wird die Erde doch nicht wärmer?
Die Wissenschaft warnt vor der Klimakatastrophe. Jetzt finden Skeptiker Gehör, die Entwarnung geben. In einigen Punkten haben sie recht. Aber eine Verharmlosung ist nicht zu verantworten
WISSEN SEITE 35–37
Scharia? Hier nicht
Muslimische Schiedsgerichte können durchaus sinnvoll sein. Doch zu strafen ist allein Sache des deutschen Staates VON HEINRICH WEFING
Lizenz zum Töten
Der schöne Schein
Die Wundersteuer
29. November 2010
FOCUS
Prima Klima!
UMDENKEN: DIE GLOBALE ERWÄRMUNG IST GUT FÜR UNS

Climate change was not created by the media

Climate researchers have on average more contact with journalists than other scientists. It is an interesting fact that German climate scientists are quite satisfied with the work of the media.

This was shown by the comprehensive survey of climate scientists in Germany that I carried out in the year 2011 with my research group at the Cluster of Excellence CliSAP and the independent society for consumer research.

According to the results, neither the preconceived notion that climate change is a product of the media nor that scientists want to manipulate journalists to their own ends is correct. Of course, there are individual examples to the contrary – some highly publicized – but for the main part: the information imparted to the public is the result of a successful exchange between researchers and journalists.

Climate change becomes a central topic in worldwide reporting particularly just before large international events. In such diverse countries as Indonesia, Russia, Germany and the USA, there are reports on the extent of climate change, future prognoses and options for action. This is shown in another study carried out by our research group. The world climate conference in South African Durban at the end of November in 2011 also attracted a lot of media interest.

Further illuminating tendencies: the first contact between researchers and the media is usually initiated by the journalists. Most scientists are willing to discuss their work, because they think reporting on the topic of climate is important. And they are willing to simplify their results for the media as long as they do not need to deviate from scientific quality standards to do so.

In addition, the survey results confirm that climate researchers not only maintain lively contact with the media but also with business, policy makers and environmental organizations. This shows that scientific topics are an important element in the social debate. The stereotype of the lonely scientist in the proverbial ivory tower who – if he reports on his work at all – only speaks incomprehensible technical jargon, belongs mainly to the past, at least with regard to climate research.

In fact the complex topic of climate is presented and debated extensively in the public arena. In the words of Peter Weingart, a sociologist in Bielefeld, one can speak of a "socialization of science". That is why we are carrying out further studies concerning the climate communication of environmental organizations as well as of large German firms.

Prof. Mike S. Schäfer is communications scientist and was head of the CliSAP research group Media Constructions of Climate Change.

Plankton as a climatic factor

Increasing temperatures in the ocean could be detrimental to the phytoplankton in the ocean – or else lead to more growth.

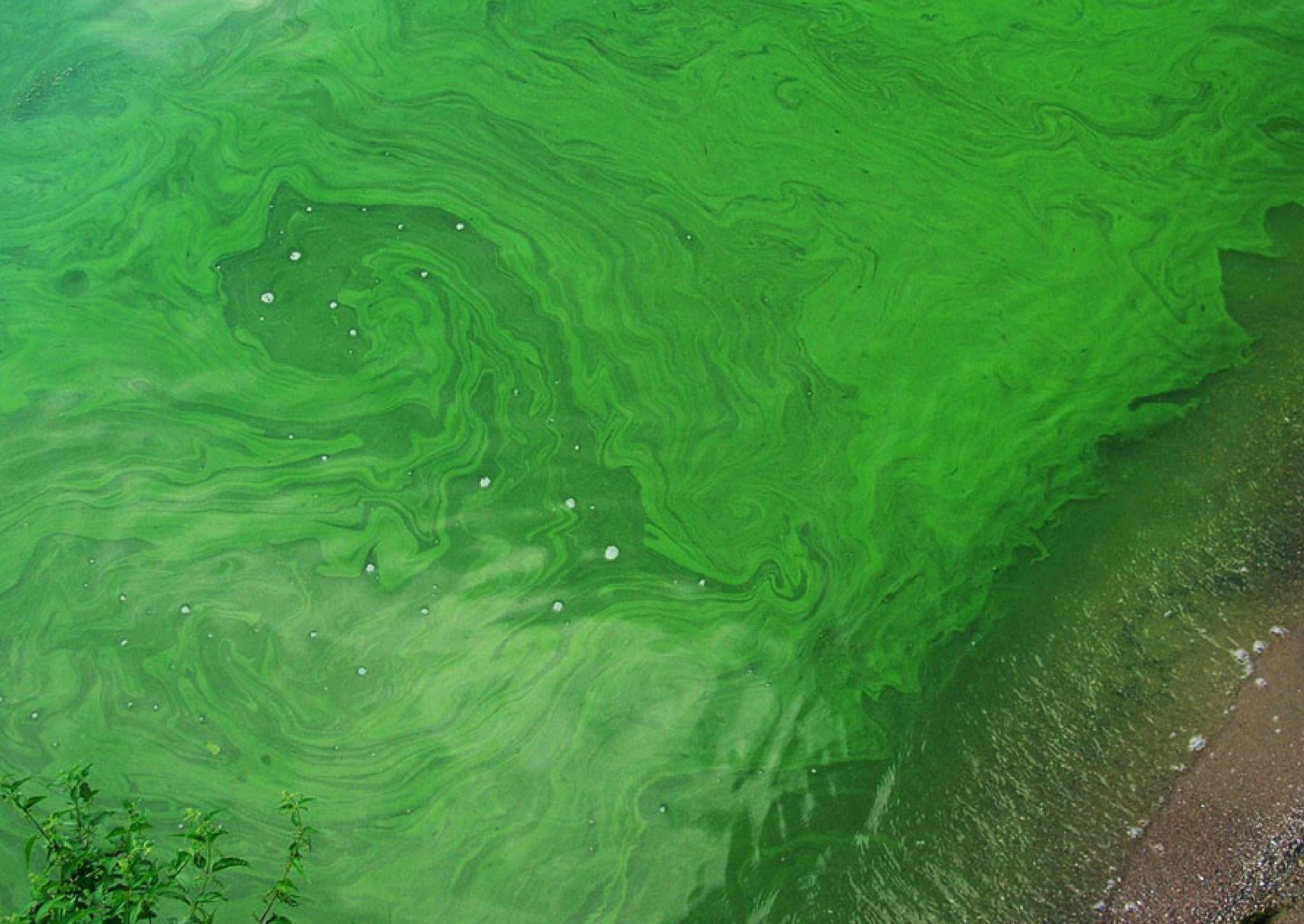
The tiny, single celled algae obtain their nutrients from the upwelling deep water. If it is too warm at the surface, the replenishment stagnates, since cold water is heavier than warm water. The consequence: the algae starve. On the other hand, certain species, the so-called cyanobacteria or blue algae, grow particularly well in warm water. Hence, they profit from climate change. They make up for the missing nutrients by fixating nitrogen from the air. It is already the case today that they dominate in warmer and nutrient poorer regions in the tropics and subtropics. There, they can account for up to 50 per cent of biomass production.

It is an interesting fact that there is a positive feedback in this, the extent of which is still unknown to us. Thus, more algae take up more sunlight and transform it into additional heat. In this way, they optimize their own environment, resulting in their rapid proliferation. This physical influence on their own growth is of interest to us climate researchers. After all, in the course of photosynthesis these little guys incorporate around 45 billion tonnes of carbon into their metabolisms annually, removing the greenhouse gas carbon dioxide from the atmosphere in the process. At the same time, they secure the global supply of oxygen.

However, there is also an important negative effect: the more cyanobacteria just under the surface, the more light is reflected instead of penetrating into the water. Temperature and growth decrease. In addition, we were able to show that water mixing declines when densely packed algae make the surface more inert – the cyanobacteria sometimes form really thick mats.

What interests us scientists is: how strong is the influence of the algae on the optical and mechanical properties of their environment? Do positive or negative feedbacks dominate? Only in this way can we include algal growth as a biological factor in our climate models and examine future scenarios. At the Cluster of Excellence CliSAP we have now been able to quantitatively assess these processes for the first time ever.

For this, we first chose a relatively simple computer model and then added different determining factors one by one. The most important result: although negative



feedbacks also occur, surface temperature and growth of the algae showed a net increase in the model.

This indicates that the biology probably plays a significant role in oceanic processes – and has unjustifiably been neglected in most climate models. This should change: our next project will be to include the consideration of regional distributions of the algae and dispersion due to the large oceanic currents.

Dr. Sebastian Sonntag is a physicist at the Institute for Hydrobiology and Fisheries Science.

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Publisher
Cluster of Excellence CliSAP, Universität Hamburg
www.clisap.de

Editor

Ute Kreis, Franziska Neigenfind, Katja Tholen-Ihnen, Stephanie Janssen, Public Relations, Cluster of Excellence CliSAP

English version
Susan Beddig

Design and layout
HAAGEN design, Hamburg

Hamburg, 2014

Thanks are due to the “Hamburger Abendblatt” for its friendly support.

About the content

Why is polluted air good for the climate? How much CO_2 does the North Sea swallow? Can nuclear power help solve the climate problem?

In a series of articles published in the "Hamburger Abendblatt", scientists from the Cluster of Excellence CliSAP at Universität Hamburg regularly give answers to questions like these. They report on their research comprehensibly and without using technical jargon – the articles are collected here in our third reader.