Knowing Next Summer's Weather in Winter

Ten climate researchers report

A booklet from Hamburg's Cluster of Excellence CliSAP

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Content

New Climate Stories!

Can we expect to see a white Christmas? Will the summer be rainy, or will we be able to enjoy our vacation on the North Sea? Speculations on the weather and climate are common every time of the year. In this booklet, you'll learn how researchers at the Cluster of Excellence CliSAP are working to answer those questions.

In the following pages we present invited articles by CliSAP researchers that appear once a month in the Hamburger Abendblatt, and take you on a journey through the various disciplines of climate research. You'll find papers on justice and climate protection, water shortages in East Africa, and the spread of volcanic ash – all presented in an accessible, reader-friendly format.

We hope you'll enjoy reading them!

What Plants Can Tell Us About Urban Temperatures

Wild tulips in Vierlande, snake's head in Wittenberge, viper's bugloss at the container terminal – Hamburg is considered the greenest metropolitan region in Europe, and offers a rich diversity of plant species.

Our city is home to more than 1,500 naturally occurring plant species, as recently confirmed in the latest plant atlas released by the Hamburg Botanical Association. But how are climate changes affecting these plants? And what can the plants tell us about our urban climate?

To find answers to these questions, as a biologist I look for patterns in how different species are distributed throughout Hamburg. The plant atlas, which includes extensive data on Hamburg's local flora, offers a real treasure trove. Using data from the atlas, my colleague Benjamin Bechtel from the Institute of Geography and I developed a new approach to investigating the city's climate. To do so, we combined methods and insights from biology with urban geography and meteorology.

Our study is based on the assumption that the composition of species in a given area offers clues to its respec-

tive climate. We tested whether or not plants offer suitable indicators for what are referred to as urban heat islands. Heat islands are a phenomenon found in urban climates: inner cities tend to be warmer than their surroundings. In Hamburg, the mean temperature difference is 1.1 degrees Celsius. There are various causes for this effect. The sun warms covered areas especially intensively, as they store more heat than green areas. Traffic and the warmth produced by heating facilities and industrial plants also contribute to certain parts of the city being warmer than others.

Previous analyses of urban heat islands are still incomplete, since there are no comprehensive measurements over a longer timeframe. With our new method, heat islands' intensity can be measured on the basis of local plant life. In this regard, we assigned an indicator value to each species, one that reflects its preferred locations and geographic distribution. Plants with extremely low values prefer cooler locations like alpine regions; higher values indicate plants that thrive on warmth, like those from the Mediterranean. In this way we were able to assign unique indicators to a total of 625 species.

Our results show a clearly recognizable pattern: the high values are in the city center. The farther away from the center you go, the lower the values become. But the inner city isn't just home to many warmth-loving plants; you'll also see higher numbers of invasive species toward the center. One example is the tree of heaven, originally found in China and Vietnam.

The mean values for all species and the percentage of species thriving on warmth are clearly related to the intensity of the heat islands – which tells us that the air temperature influences the mix of species, and that the plants' indicator values offer valuable clues to how temperatures vary across the city.

Dr. Katharina Schmidt is a biologist and completed her doctoral degree at Universität Hamburg.

A Tricky Prognosis:
the Weather in Three Months

The weather forecast – for many of us, it's a daily ritual after the evening news. After all, the forecast is often right, despite what critics may say. But why can't anyone say whether the next winter will be harsh, or the next summer especially hot?

Though climate models offer longer-term prognoses, they often look decades into the future – and only describe general trends. Think you'll find a forecast for the winter of 2032? Guess again.

At the Cluster of Excellence CliSAP, we're working on ways to use seasonal forecasts to predict the weather for the next two to eight months. Unfortunately, this time range falls precisely in the gap between conventional weather forecasts and climate prognoses.

The two approaches are based on models designed to meet wholly different requirements. Climate models consider entire global cycles and questions like: how do ocean currents influence water temperatures? How do winds transport thermal energy around the globe? These models seek to represent the system as a whole in a mathematically

sound way. If you want to use them to make a prognosis, you simply enter a set of starting values and let the model do the rest. But weather forecast models are very different: they are constantly "fed" with real-world data from the last few days – because tomorrow's weather greatly depends on today's weather conditions. Here, long-term global processes can largely be ignored.

How can the advantages of both methods be combined? To do so, we've worked together with colleagues from the Max Planck Institute and the German Weather Service to modify a complex climate model – one that is also used for the IPCC's Assessment Reports – so that it can constantly be fed new data. Essentially, we confront the model with the reality, and in so doing we refine its prognosis.

The real challenge: climate models were never intended to constantly accommodate new input. For example, every month we enter real weather data into the new model. And at the end of the month it puts out results that differ from the actual weather – sometimes more and sometimes less. The real trick at this point is a task called data assimilation. It involves finding a sensible mix of calculated data and real-world data to enter so that the prediction is as close to the reality as possible.

Now that we've developed a suitable method, we have a global model that can continuously adapt to new data, but can still run for extended periods – a tremendous leap forward! For example, we have now used what are called "retrospective predictions" to accurately forecast the tropical weather phenomena "la Niña" from 1989 and "el Niño" from 1997/1998.

So will we have a white Christmas? That's a much tougher question to answer, because so many different air currents come together in Europe. As such, the chaotic element is much larger, and with it, the room for error. Nevertheless, the German Weather Service will soon start routinely using our model for seasonal forecasts.

Prof. Johanna Baehr is an oceanographer at Universität Hamburg.

How Green Areas Cool Cities

It's a little known fact, but cities have their own climates, influenced not only by their geographical location, but also by the degree of urban development, the size of their population and the traffic. Green areas play a vital role in urban climate.

Lawns, parks and street-side trees act like natural air conditioning – particularly in hot summers.

In the "Hamburg Urban Soil Climate Observatory", soil scientists and meteorologists are working together to investigate whether some types of green area cool their surroundings better than others, and if so, how great the effect is. The soil on which the green area is located is a decisive factor – or to be more precise the soil-water balance: If a park is near groundwater, even in dry periods plants have a supply of water, which they can utilize and which subsequently evaporates. If, however, the water table is deep below the surface, there is a danger that during hot summers, the green area will dry out and heat up.

While rainwater is absorbed by natural soil like a sponge, on sealed areas it runs directly into the sewage system. In addition, concrete and stones heat up more rap-

idly and give off this heat to their immediate surroundings over long periods, particularly at night.

In contrast, the water in naturally moist soil evaporates, which has a cooling effect on the surroundings. Plants intensify this effect because their roots are able to use water from deeper soil layers for evaporation.

In this way, the soil in a city can influence its local climate. In order to discover just how great this influence is, we set up measuring stations at various locations in Hamburg: in a sealed courtyard in the city center; in Langenhorn, which is particularly damp, and at a comparatively dry site in Stellingen. At these stations, soil scientists Professor Annette Eschenbach and Sarah Wiesner from the Cluster of Excellence CliSAP measure the water and heat exchange between the soil and the atmosphere, while I process the data related to wind, rain and humidity.

Our measurements to date have shown that there are substantial temperature differences at the different stations: in the courtyard, the average yearly temperature is up to 1 degree warmer than at the station in “dry” Stellingen. This may not seem like much, but it’s a big difference in terms of a city’s heat balance. In Stellingen, in turn, it’s an average of 0.3 degrees warmer than at the damp-soil station in Langenhorn.

Our assumption that damp soils cool their surroundings much better than dry ones appears to be correct. Next we plan to investigate what percentage of these temperature variations are the result of the different water balances in soils.

When it comes to urban planning, the role of groundwater shouldn't be underestimated, as planners can use sound data on this aspect to devise local climate adaptation measures.

Prof. Felix Ament is a meteorologist at Universität Hamburg and the Max Planck Institute for Meteorology.

Conflict or Cooperation: What's the Best Course of Action When Water Is Scarce?

Those who aren't upstream are sometimes left high and dry. This also holds true for Africa's longest river, the Nile. It flows through eleven countries, all of which depend on it for their livelihood. Situated at the end of the river, Egypt is last in line.

For years, this wasn't a problem. However, now the neighboring countries are becoming more industrialized and are using more water as a result. Added to this is climate change: Could this exacerbate the situation further?

As peace researchers at the Cluster of Excellence CliSAP, we are interested in whether violent conflicts are more common as a result of global warming – and the conditions under which actors peacefully cooperate. Back in 1959, because of its vulnerable position at the end of the river's course, Egypt signed the first agreement regulating water extraction with Sudan. In the decades that followed, Egypt gained a position of economic dominance on the Nil At the same time, Sudan, which was less developed, didn't use its full water quota – because it simply didn't need to.

But the region has since changed: in the future Sudan wants to extract the full amount stipulated in the agreement. And smaller countries in the upper reaches – and nearer the source – are now becoming aware of the power they hold. While for ten years the *Nile Basin Initiative* has been working on a cooperation between the neighboring countries for managing the entire river, several countries in the upper reaches have, without much ado, signed a separate agreement, snubbing Egypt in the process. Though its water requirements may be marginal at the moment, the message is clear.

How should the parties involved best move forward? Using a computer model, we have monitored the four major Nile water users: Uganda, Ethiopia, Sudan and Egypt, all of which want sufficient water supplies. There are four political options to ensure this: saving water through more efficient use; tapping new resources, for example by building reservoirs; cooperations between neighboring countries; and aggression.

However, the price of providing an extra cubic meter of water is different for each of these four options. Information on the country's current water price, water consumption, gross domestic product and population growth is fed into the model. This is then used to calculate which combination of measures it makes sense for each individual country to invest in. Furthermore, we include various climate prognoses in the calculation: in one scenario we assume that in the next 20 years, the amount of available water in the Nile will drop by 20 percent.

Surprisingly: even such a drastic loss of water wouldn't have a major effect on water distribution. The short-term political options have a far greater influence than the long-term climate effect. At the same time we've discovered: armed conflicts are the most expensive solution for all concerned – which means that, even from a purely economic point of view, cooperation remains the best choice.

Dr. Michael Link is a geographer at Universität Hamburg.

For Governments, Taking a "Wait and See" Stance on Climate Protection Can Pay Off

Year after year, disappointment spreads around the globe: another United Nations climate conference has come and gone without the governments committing to any meaningful agreement.

Many people ask themselves why such important decisions keep being put on the back burner. Aren't politicians being shortsighted when they choose to adopt a "wait and see" stance?

At the Cluster of Excellence CliSAP, my colleagues Yu Fu Chen, Nicole Glanemann and I analyzed the actors' behavior under economic aspects and made an astounding discovery: for governments, opting to wait and see can be a thoroughly rational choice. But how can that be? Shouldn't it be their goal to take action today so as to avoid the projected long-term costs of climate change?

Simply put, governments have two options: they can invest in climate protection now – or choose to do nothing. Choosing to invest means they can reduce emissions of harmful greenhouse gases and lessen the potential long-term costs. But in the short term, doing nothing is the more


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attractive choice: the money put out for investments has to be spent today, but will only pay off somewhere down the road – and no one can say to what extent. Since we can't predict the future, the option of waiting takes on an economic value. The key consideration here: the longer I wait, the more valuable information I gain about the situation, as I continue to learn.

This waiting and seeing is only abandoned once a certain threshold has been passed. Just as companies don't immediately hire new employees or build new factories in response to short-term spikes in demand, many countries also prefer to wait and observe how things develop. The greater the uncertainty, the higher the threshold – after all, investment decisions can't generally be reversed without producing losses.

This aspect is also important when it comes to weighing climate-protection-related measures. What will the damages really look like? Will temperatures truly rise so dramatically? The current state of research shows: our emissions of greenhouse gases contribute to climate change. Nevertheless, researchers can only broadly predict the actual consequences. For example, we can only safely say that the global mean temperature will most likely rise by two to six degrees Celsius over the next 100 years – two very different figures. And who knows, maybe 20 years from now we'll have discovered an efficient and affordable way to remove CO_2 from the atmosphere? At the same time, the gradual progression of climate change to date suggests that we still have time to take action.

We use what are referred to as real options models to represent the interplay of all these factors. This approach, which hails from financial mathematics, allows us to identify the optimal time to act. What the models clearly show: continuing to wait is certainly rational. But if our goal is to limit global warming to an average of two degrees Celsius, our window of opportunity is rapidly shrinking. Accordingly, we also included a factor reflecting the limited time to act. Nevertheless: even when the clock is ticking, in the end the high degree of uncertainty tends to dictate our actions.

Prof. Michael Funke is an economist at Universität Hamburg.

Warm-Water Plankton Species are Profiting From Climate Change

Lake Plußsee (in Northern Germany) is 29 meters deep and roughly the size of 20 football fields. It is home to numerous plant and animal plankton species that serve as food sources for larger organisms.

My colleagues from the Cluster of Excellence CliSAP and I are currently working to investigate how climate change has affected the lake's animal plankton. Our analysis of the statistical data shows that both the water temperature and oxygen concentration changed significantly between 1969 and 2006 – with consequences for the small organisms.

In this regard, water circulation is extremely important. In summer and winter the lake water forms different water layers of varying temperatures and densities. Given this stable structure, nutrients and oxygen can barely be exchanged, and by the end of this stratification period the amount of nutrients in the upper layer is greatly reduced, as is the oxygen level at the bottom of the lake. This forces some species of the animal plankton to move to other depths, where they then have to compete with other species. It is only when the water is again mixed that the

vital nutrients and oxygen are again distributed throughout the entire lake.

This complete mixing of the lake water normally happens in the spring and fall. As the temperatures at different depths grow closer together, the differences in density also fade away. During this phase the plant plankton can thrive: nutrients can be found once again, and there is enough light for photosynthesis. And, when the microalgae bloom, there is also ample food available for the animal plankton, allowing a variety of species to flourish.

In the wake of climate change, the air temperatures in spring and winter have risen, as a result of which the stratification period sets in earlier and the uppermost water layer is sooner and more intensively warmed. For the timeframe of our study, the recorded data shows that the average temperature in the upper water layer in April has risen by roughly three degrees; in summer, there is a similar rise.

Since the increasingly warmer surface layer enhanced the stability of stratification, the mixing phase in the fall now tends to start later in the year, and the period characterized by a stable water column, which also means competition for nutrients and a lack of oxygen, is now roughly three weeks longer.

And the plankton species are adapting: Warm-water species profit from these conditions and now enjoy a longer active phase. In contrast, cold-water species are increasingly being forced to withdraw to deeper and cooler water layers. Or they are outcompeted by other species that are better able to adapt to the changed conditions. Further, in the fall those species that can get by with less food are at a distinct advantage.

In short, while some species of plankton benefit from these changes, others are disadvantaged, which in turn is introducing a new dynamic to the structuring of the species composition. As plankton forms the basis of the ecological pyramid, this may very well affect the diets of fish and other larger organisms that depend on them.

Dr. Ralph Rösner is a biologist and completed his doctoral studies at Universität Hamburg.

How Thick the Cloud Cover was in 1632? Tree Rings Hold the Answer

Imagine this: a forester fells an old tree and examines the cross-section in detail. Shortly afterwards he announces that in 1632 the sky must have been particularly cloudy. A fairytale?

Yes, of course. But with a bit of technical help, we can actually use tree rings to determine what the cloud cover was like in a given year. How?

My aim is to understand the climate of the last 2,000 years, as it can provide us with valuable information. A major question mark surrounds cloud behavior: Will global warming mean thicker or thinner average cloud cover? This is hardly unimportant, since a thin layer lets more sunlight through and increases global warming. A thick layer on the other hand could even slow down global warming.

At the Cluster of Excellence CliSAP, my colleagues and I have conducted research into a new technique that yields valuable information on past cloud cover. For example we know that there was the "Little Ice Age," which happened about 300 years ago. What's interesting for us is whether the clouds then were thick, or whether the sky was often clear.

Here trees can help us – they are to some extent gourmets, and not all "food" is the same to them. When they take in carbon or carbon atoms during photosynthesis, there are two stable forms in the surrounding air: 12C and 13C atoms. However, 12C simply "tastes" better, so trees prefer it and convert it into biomass to grow.

In strong sunlight, however, the situation is different: Now plants have the chance to photosynthesize as rapidly as possible, which lets them grow particularly intensively. But during these periods of extreme growth, there's a shortage of the preferred atom, and the tree is forced to fall back on 13C atoms. We take advantage of this effect!

To be specific, we've tested this technique for Scandinavia, where samples were taken from around 50 trees in various locations and used the tree rings to determine the age of the respective tree. We then used a device called a mass spectrometer to measure the level of 13C atoms. When we found more of them, it told us there was plenty of solar penetration, which means the cloud layer was thin – an accurate indicator for the years in question.

To sum it up: During the "Little Ice Age," Scandinavians often enjoyed clear blue skies in summer. Our study shows that, for the entire 300-year cold spell, the average cloud cover was thinner. That allows us to infer that, for this region, rising temperatures produce a thicker cloud layer – which could in turn lessen future global warming on a local scale.

But every new method has to first be validated, which is why we were very glad to see similar results in our next study, conducted in the Pyrenees. That means these vegetable "eyewitnesses" now offer a valuable tool that helps us better determine the connections between sun, cloud cover and local climate.

Dr. Eduardo Zorita is a paleo-climatologist at the Helmholtz-Zentrum Geesthacht.

What's Fair When it Comes to Environmental Protection?

By now nearly everyone agrees: In order to keep climate change in check, we have to cut back on harmful emissions. But who should do more, and who less?

Up-and-coming newly industrialized countries want to increase their gross national product, which will also mean more emissions – and feel that industrialized Western countries are the ones who should pay the bill. The latter in turn don't feel they should have to bear all the weight and responsibility alone, making it hard to find middle ground.

As social debates certainly influence politics and policy-making, I'm currently investigating the different standpoints by means of media analysis. In the late 1980s for example there was a "hot phase" in the history of environmental policy. With environmental issues high on political agendas around the globe, many people used the public debates to exert pressure for change. One result was the 1992 "Earth Summit" in Rio de Janeiro, after which an initial framework agreement was created.

Between 2006 and 2010 public interest rose once again in connection with international efforts to draft a new pro-

tocol to succeed the expiring Kyoto Protocol from 1997. Yet this time, despite considerable public pressure, the result was ultimately a failure. Why were the countries involved unable to agree on common goals?

For my analysis, I have focused on the examples of Germany, India and the USA. I sorted through more than 1,900 press articles from the years 2007 to 2010, identifying the different political standpoints. In addition, I reviewed the press releases, statement papers and newsletters from environmental protection groups, religious organizations, unions and commercial associations.

What they boil down to: The vast majority of parties involved are in favor of political measures to stop or slow climate change. Yet there are very different opinions, not only between countries but also between the interest groups in each country, on what a "fair" approach should look like.

If we oriented ourselves on the so-called "grandfathering principle," then all countries would have to reduce their emissions by the same amount. For example, under the Kyoto Protocol the EU and USA had agreed to cut their CO_2 emissions by roughly eight percent. Yet this ignored the fact that at the time the USA was already producing above-average pro capita emissions – and that the suggested reductions wouldn't make any difference to that in the short term. If we instead followed the "equality principle," then all countries would have the right to develop up to a certain industrial standard. This would mean that some countries would be allowed to generate significantly more greenhouse gases in the future, while the most developed countries would need to implement drastic reductions. Lastly, the "responsibility principle" focuses on the question of who emitted the most in the past and should therefore pay more now.

Within the respective countries, various groups have translated these principles into concrete demands: Whereas many in India feel that the historical responsibility lies with the industrialized nations, small but financially powerful groups in the USA still completely deny that climate change is a reality. The German business sector is in favor of setting a fair price for CO_2 emissions, but wants no other political involvement in the market. In contrast, labor unions in all three countries are thinking along the same lines, favoring the equality principle. As such, though environmentally aware, the public remains divided – surely one of the main reasons why there has still been no binding agreement to date.

Dr. Andreas Schmidt is a communication scientist and received his doctoral degree from Universität Hamburg.

Hamburg Geo Software Drafts Plan for Africa's Land Use

Geographical information systems: We run into them almost unnoticed every day as the basis for weather maps or in car navigation systems. At the same time they are indispensable for us climate researchers when we want to fine-tune simulation models in order to examine something more closely, for example in at-risk regions of Africa where we are looking at future agriculture.

However, with existing climate models we can only "zoom in" to 25 km, which isn't accurate enough for a detailed analysis of individual farms' fields. With the aid of geo software, at the Cluster of Excellence CliSAP we have managed to map the agricultural conditions down to a scale of one kilometer.

In the project "The Future Okavango" we are investigating the land around the freshwater Okavango River, a vital lifeline flowing through Angola, Namibia und Botswana. To do so we are using SAGA, a geographical information system I developed. This software can link geometrical surface data like the location, form and size of mountains and rivers with information on population size or soil charac-

teristics. Like a set of building blocks, this offers the basis for various three-dimensional maps. SAGA is freely available and has a global user community with up to 2,000 downloads per week.

To estimate the harvest along the Okavango, we are looking at the area's natural resources potential, which includes ecosystem conditions such as temperature, precipitation and soil characteristics. This enables us to calculate how many people the area can potentially feed. To evaluate this valuable information locally, we need to convert existing large-scale climate models to smaller units.

For the project, our colleague Daniela Jacob first created a regional low-resolution climate model, which you can think of as a grid with 25-kilometer squares. Each of these squares provides a single value per characteristic, such as temperature.

However, for our analysis we need smaller grid squares that are only one kilometer in size, this is, in each large grid square there are 25 times 25 smaller squares. That makes 625 temperature values where before there was only one. Where do we get these values?

Here we used the well-known correlation between temperature and altitude: the higher the altitude, the colder it is. We know the altitude of the terrain, since there

are already global high-resolution measurements of the earth. SAGA enables us to use these data sets.

We then take several of the large grid squares and their temperature values and link them with the average altitude of that square. From this basic information we can calculate a curve that shows the temperature for any given altitude in that terrain. Using the high-resolution data for the site, the temperature can be found for each of the 625 small grid squares – simple but effective.

Using different methods we can calculate precipitation and wind to deliver an accurate picture of which plants will grow well where, where it would make sense to build reservoirs for rainwater and which areas are better left uninhabited. Working closely with officials and farmers in the area, we are now developing concrete recommendations for action.

Dr. Olaf Conrad is a geographer at Universität Hamburg.

Optimizing Simulations for Suspended Particles

Computer simulations are an essential tool for preparing weather and climate forecasts. However, they also tend to involve a great deal of calculation, as they are tasked with representing our complex reality.

The more precise the desired details are, the more computing power is needed. Together with my colleagues at the Cluster of Excellence CliSAP I'm working to develop new methods to make these calculations more efficient – for example in order to determine the spread of what are referred to as aerosols.

These suspended particles are for instance released by volcanic eruptions, or find their way into our air as pollutants from industrial production and car exhaust. Since they promote cloud formation, influencing both our weather and climate, our goal is to determine where the winds transport these aerosols. To do so, we use a three-dimensional simulation grid that consists of individual cells as a model.

The smaller these cells are, the more precisely we can predict the concentration of aerosols at a specific place.

So, if we want higher resolution for the model, it means looking at more and smaller cells: For example, if we cut the size of cube-shaped cells in half, the computer will need at least eight times as much calculation time, which also means more electricity and higher costs. Therefore it makes better sense to only refine the grid in places where we know there actually are aerosols. For instance, if there is a volcanic eruption, we can very accurately localize the source of the particles.

When it comes to the spread of aerosols, we first calculate the concentrations within the individual cells – and then the exchange of information with neighboring cells. Here my goal is to save time and money. The problem: A computer can only work with data in its cache memory, which is in its processor – in other words, in the same place it does its calculations. And this cache memory is relatively small. So when the computer has to process large amounts of data, it has to access the main memory or hard drive in order to load the data in the cache. This costs time, because it can't do any calculations in the meantime.

That's why we use a trick: Instead of individual pieces of information, the computer loads data blocks in the cache. Here our goal is to collect as many relevant pieces of information as possible in a single block. To do so, we

do our best to sort the data, grouping cells together with their neighbors. As a result, the computer loads the presorted data in the cache – and doesn't have to resort to accessing the main memory or hard drive nearly so often.

Generally speaking, you could think of the aerosol concentration as a mosaic of tiles and the computer as the person laying the tiles. When it lays smaller tiles, we can see the fine details; when it uses bigger tiles the image becomes more basic, but takes less time to finish. My method allows me to sort out the tiles for the computer ahead of time. Then it can finish the mosaic much faster, because it receives batches of tiles that all belong together. So we see that presorting the data can greatly accelerate simulations without changing the actual simulation method used.

Oliver Kunst is a mathematician and worked at Universität Hamburg.

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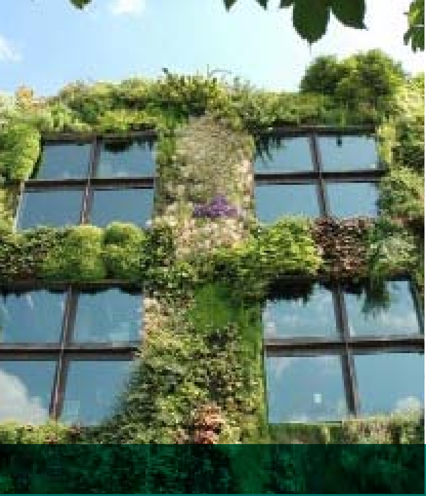

About This Booklet

Why do green areas influence urban climates? How can cropland be used more sustainably in the future? Can tree rings give us clues to climate changes?

In a series of regular articles in the Hamburger Abendblatt, researchers from the Cluster of Excellence CliSAP address key questions in climate research. In our fifth booklet, we've gathered ten articles from the series for you!