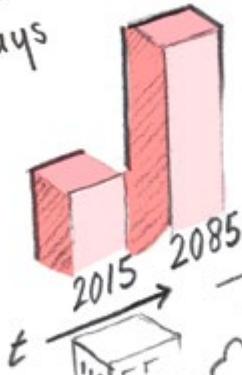
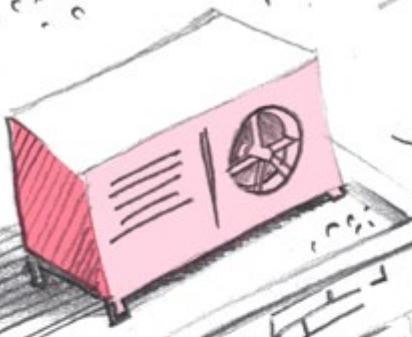


double
the number
of summery
days



air-conditioning
increases
the heat



hardly
any wind



big
differ



Temperature
differences between
urban...

...and rural
areas

So hot!

Cities can quickly become unbearably hot, which reduces productivity and causes health problems. Wageningen researchers are measuring what goes on at the street level, and making weather models for cities in an effort to bring relief.

TEXT MARION DE BOO ILLUSTRATION JORRIS VERBOON

taking measurements
with a delivery bike
full of equipment

Mountains
provide cooling





It is no longer a rare occurrence for us all to be wilting in the heat. According to the Royal Netherlands Meteorological Institute, the number of days with summer temperatures— defined as over 24 degrees Celsius – will double between 2015 and 2085. The number of days defined as tropical – with temperatures over 30 degrees Celsius – will increase too. This will create more heat stress, especially in the cities, where people live close together and generate extra heat with all their activities. The human body then has to work hard to avoid becoming overheated. Healthy adults, including



‘In summer, it is seven degrees hotter in cities than in the countryside’

those in hot countries, feel most comfortable at temperatures of between 18 and 23 degrees. Outside that range, the body has to work harder to stay comfortable.

Last summer, when all the heat records in Europe were broken, Wageningen researchers set off for Dam Square in the middle of Amsterdam on a hot July day. Every two hours over a 24-hour period, they sent up a weather balloon with a beaker containing measuring equipment. At the same time, some colleagues of theirs were doing the same thing in a meadow near Breukelen, a few kilometres outside the city.

The weather balloons measured the temperature, humidity, wind speed and wind direction at an altitude of 2.5 kilometres every two seconds. Their activities got into all the news programmes. Amsterdam city centre turned out to be seven degrees hotter than the meadow outside Breukelen, and this heat was measurable up to a great height, says Wageningen meteorologist Gert-Jan Steeneveld. ‘Even within the city we see big temperature differences. Industrial estates and suburban concrete jungles without much vegetation store extra heat, while the parks usually stay cooler.’

MODELS TOO CRUDE

These measurements are useful to the researchers for refining their urban weather models, says Steeneveld. ‘In those models, the upper layers of the earth’s atmosphere play a bigger role. Urban planners and landscape architects can use such models to improve their designs for limiting heat stress in the city. Up to now, that was done very little or not at all because the existing models are too crude.’

‘The city absorbs more solar heat than the rural areas, because there is more dark material such as asphalt, dark cobblestones and roofing tiles,’ says Steeneveld’s colleague Bert Heusinkveld. And then of course, it is during a heat wave that the use of air-conditioning in the city goes up enormously. ‘Those anthropogenic heat sources make it even hotter in the city, reinforcing the effect,’ says Heusinkveld. ‘There is less wind in the city too, so “heat islands” are created. Above and between the buildings hangs a dome of heat, even in the evening, which doesn’t get absorbed much into the higher, cooler layers of air. As a result, urban heat can hardly escape in the evening. Smog, exhaust fumes and other forms of pollution also linger in the streets under this warm blanket for a long time, and in higher than normal concentrations.’

MORE DEATHS

Heat makes the city less liveable, heat stress sends labour productivity into decline, and city dwellers get health problems. Hot, sticky nights lead to loss of

‘We can make weather forecasts with a resolution of 100 metres’

sleep, and people who don't drink enough become dehydrated. Sunstroke can even be life-threatening. The elderly and people with chronic heart or lung conditions are particularly at risk of dying. According to the Netherlands National Institute for Public Health and the Environment (RIVM), there are an average of 30 additional deaths per week per degree Celsius above the normal summer temperature (the long-term average of the last 30 years).

The police are also called out more often during a heat wave because people are on a shorter fuse; drinking water companies find it harder to keep the drinking water under the safety limit for legionella; and water boards have to deal with blue-green algae and botulism in surface water. Energy companies are allowed to transport less electricity to prevent underground power cables from overheating. Heusinkveld: ‘On hot days, the electricity network is overloaded anyway, because so much solar energy is generated and transported.’

HEAT PROTOCOLS

The government's Spatial Adaptation Plan lays down that water boards, provincial and national government bodies and other stakeholders should prepare for the expected increase in heat waves. Various parties such as municipalities, health services, drinking water companies, water boards, and the police are drawing up their own heat protocols. Steeneveld: ‘For those heat protocols, all sorts of heat maps were in circulation, showing the number of tropical nights, for example, or the highest recorded daytime temperatures. You can make heat maps on a metre scale or on the neighbourhood scale. Until recently, different parties had their different methods for that.’

So, at the behest of the central government, Heusinkveld and Steeneveld designed a standardized method based on the ‘apparent temperature’. ‘This indicates how hot a person feels in given weather conditions, so how easily they can cool down,’ explains Steeneveld. >



HEAT AND AIR POLLUTION GO HAND IN HAND

Research by the Wageningen professor of Air Pollution Maarten Krol shows that air quality and the weather are closely linked. Smog, exhaust fumes and other forms of air pollution accumulate in urban heat islands along with heat. ‘The life expectancy of people living on a busy road in Rotterdam is two years shorter than that of residents of the Wadden islands,’ says Krol. ‘An important source of urban pollution is the traffic. Traffic emits nitrogen oxides, and old diesel vehicles often emit soot as well. Years of inhaling polluted air can take its toll.’

More people die than usual during a heat wave. Krol: ‘During heat waves in the Netherlands we often have land breezes, bringing pollution from Germany and Belgium to the Netherlands. This air is already dirty, and once over the Netherlands it picks up more pollution from traffic, farming and industry. It is often very sunny during heat waves too, which causes photochemical smog. During last year's heat wave, extremely high levels of ozone were measured in the Netherlands. The formation of this poisonous gas is partly influenced by sunlight and emissions from traffic and industry, a process that is very efficient at high temperatures. All these factors came together last year.’



‘The apparent temperature is not just a matter of the air temperature but is also affected by radiation, wind speed and humidity. It can feel five degrees warmer if you are standing in the sun and out of the wind than it does in the shade.’

Engineering consultancy firms are going to roll out this map nationally. Steeneveld: ‘They are going to make heat maps for various cities using the Wageningen method, and we shall then validate them.’

The two researchers made a heat map for Wageningen first. They rode around on a ‘climate delivery bike’ full of measuring equipment for documenting differences in temperature and radiation from street to street around the town. The map represents the average apparent temperature in the town on a hot summer’s day, and shows where the hottest parts of the town are during periods of extreme heat.

They then went on to make heat maps of Amsterdam and Rotterdam. Remarkably, the hottest daytime temperatures during a heat wave in Amsterdam were not in the city centre but in suburban areas such as Holendrecht, Osdorp and Amstelveen. One possible

explanation for this is that the narrow streets of the city centre provide more shade. The Rotterdam map also show how the Kralingse Plas, a lake, forms a cool oasis. And how the suburb of Hillegeersberg, with its shady parks and gardens, and the Noordereiland, an island in the River Maas, stay a lot cooler than the densely populated Oude Noorden neighbourhood.

FORECASTS AT STREET LEVEL

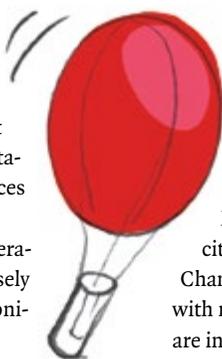
The researchers went on to develop weather forecasting models with which they can forecast the weather down to the street level. Steeneveld: ‘Weather models at the global level work with a resolution of nine kilometres, in which you barely see the Dutch cities at all. Because we use highly detailed information, we can generate weather forecasts with resolutions of up to 100 metres. That was unimaginable five years ago. And the models are becoming more and more refined.’

Very large data sets of geo-information and meteorological data are being collected with a view to getting a good picture of the various microclimates. The Wageningen researchers made use of highly detailed relief maps, on a 50-centimetre scale, and of aerial photos. With such information, you know the exact height of buildings, walls and vegetation. From that you can deduce what time shade falls on a street, and how much heat stress residents are likely to experience, depending partly on local meteorological conditions and the play of sun and shade, radiation and wind. The effect of the vegetation or a feature such as an urban canal becomes visible too. Engineering consultancy Witteveen & Bos is now using the method developed by Wageningen scientists to create a heat map of the whole country which government bodies and health services can use to take timely precautions against heat stress. To decide, for instance whether they should publish warnings of a heat wave, or whether a pop festival should be cancelled.

ON THE BALCONY

A lot of the meteorological research is being done in collaboration with Amsterdam Institute for Advanced Metropolitan Solutions (AMS Institute), an expertise centre on innovation in urban areas. The institute is a collaboration among the Technical University of Delft, WUR and Massachusetts Institute of Technology (MIT), and is co-financed by Amsterdam municipality. AMS Institute co-financed 24 weather stations that measure the temperature continuously in the neighbourhoods. Steeneveld: ‘Using delivery bikes and weather stations is relatively expensive, so we also use data from amateur weather stations. In the Netherlands there are about 15,000 of those mini-weather stations in people’s back gardens or on their balconies. They are not very

‘Urban planners mainly see climate change in terms of flooding, but heat stress in the city deserves more attention’



sophisticated and you shouldn't hesitate to chuck out strange datasets, but in combination those weather stations do provide a pretty good impression of differences between neighbourhoods.'

Smartphones are another source of data, as the temperature of their batteries turns out to correlate very precisely with the outdoor air temperature. A company that monitors the network connections of providers also keeps a record of battery temperatures. This provides the researchers with one and a half million measuring points in the Amsterdam region alone. Steeneveld: 'In the next few years, I would love to do more research on indoor temperatures. The temperature in some bedrooms is 27 or 28 degrees as early as May, which is shocking. I would like to correlate those readings with types of building, building density and, say, energy labels.'

URBAN PLANNING

The two researchers emphasize that smart urban planning can make for a more pleasant climate to live in. Fountains have a cooling effect as the mist they create evaporates, cooling the air around them. Heusinkveld: 'In some German cities, city squares are sprayed from time to time with a shallow layer of water, which then evaporates. That is a very effective way of cooling down squares. The little fountains that suddenly spurt into the air at random intervals, and in which children can play, also help to cool down the city.'

'Hitherto, urban architects mainly saw climate change in terms of flooding,' says Heusinkveld, 'but heat stress in the city deserves more priority. Heat maps and weather models can be of service here. Urban planners know, for instance, how much wind city residents are comfortable with, and our urban weather models show exactly where the windy corners are in the city, how gusts are formed, and how the flow of air around buildings develops under particular meteorological conditions. Planners can use our micrometeorology to optimize their designs.'

Over half the world population is now urban. And the average summer temperature is over 35 degrees in 354 cities, most of them in the Middle East and Asia. By 2050, that will be the case in 970 cities, according to research by the Urban Climate Change Research Network. Cities in tropical regions, with much higher humidity levels than the Netherlands, are in danger of becoming uninhabitable. And whereas practically every square metre of land in the Netherlands has been documented, there is much less information available in poorer countries. Many big cities do not go beyond placing neighbourhoods on a heat scale of 1 to 10. 'People in slums in hot regions can't afford air-conditioning or other cooling methods,' says Heusinkveld. 'We can expect many more additional deaths due to heat stress in those places. Our research results can be used immediately to make these cities more habitable.' Meanwhile, the Wageningen meteorologists are doing their best to quantify the effects of urban planning measures against heat stress. For example, they are involved in a project in Breda in which the filled-in sections of the river Mark will be dug out again to make the city centre more attractive. There are several scenarios for the redesign and landscaping of the river banks, paying careful attention to the potential for providing cooling in the summer. Heusinkveld: 'We made calculations for the current situation and tested the design, after which it went through several more rounds of improvement. You need to be aware of wind direction and shade, for instance. Trees provide shade, but too many trees block the wind. And much use will be made of lighter coloured brick, which absorbs less sunlight, keeping the quayside cooler.' The Wageningen meteorologists will take baseline measurements this summer and will then continue to take measurements to see how the urban climate changes when the New Mark flows through Breda once again. ■

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