Campus climate

Rain gauges that count drops, mobile radars that scan clouds, and hundreds of wind vanes mounted on the windows of the EEMCS building. TU Delft researchers are busily transforming the campus into a laboratory for climate research in the urban environment.

Tomas van Dijk

All it takes is a light wind and starts again: cyclists are literally blown off their bikes as they pass the high-rise Electrical Engineering, Mathematics and Computer Science (EEMCS) faculty building on the Mekelweg. And strangely enough, this happens whatever direction the wind is blowing from. Winds blowing from the west collide with the building sixty meters up, then shoot straight down and blast around the corner at ground level. When the wind is blowing from the opposite direction, it also shoots straight down but then curves up again just above the ground. Regardless of whether the wind is blowing from the west or east, cyclists are usually blown towards the Applied Sciences faculty building. Weather forecasts always give average values over a large geographical area, but in urban environments such figures are not especially meaningful, because cities are dominated by microclimates.

Everyone has had first-hand experience of such microclimates, yet very little is known about this phenomenon. Nick van de Giesen, a professor of Water Management at the Faculty of Civil Engineering and Geosciences, and the head of the Delft Research Initiative Environment (DRI Environment), aims to change that. Together with colleagues from DRI Environment, a partnership involving all TU Delft faculties, he plans to transform the campus into one huge laboratory for studying climate in the urban environment, with the goal being to launch numerous studies within the Climate City Campus project before the end of the year. Most of these multidisciplinary studies will be student projects. The Climate City Campus project was officially launched on 24 February. One of its first sub-projects involves an experiment to measure rainfall.

‘Cyclists are usually blown towards the Applied Sciences faculty building’
Weeds
Stijn de Jong, an MSc student being supervised by Prof. Van de Giesen, is developing rain sensors that will enable him to very accurately measure rainfall in the vicinity of the EEMCS building. “We don’t fully understand how buildings affect rainfall,” he says, while standing on the roof of the low-rise section of the EEMCS building, which adjoins the high-rise block. Pointing at clumps of weeds, he notes: “Here, in the lee of the tall building, there are many plants growing on the roof. Windborne sand and seeds are deposited here, because it’s usually less windy. Perhaps the same goes for raindrops?” Just a hundred metres from this spot, the wind is often much stronger. How does that affect rainfall? Are the raindrops slammed against the building or are they instead blown back up into the air? Moreover, is this behaviour related to the size of the individual raindrops? In attempting to answer these questions, Stijn will install a hundred rain sensors on the building’s roof this summer. Unlike traditional rain gauges, which are just glorified buckets that collect water, these devices are sensitive microphones that count raindrops (see box). This technique not only enables Stijn to monitor rainfall very accurately over time, but he can also use it to measure the size of the drops.

The researchers participating in the Climate City Campus project want to incorporate this raindrop data into various wind models. “It’s very important to understand how buildings affect rainfall and wind,” explains Prof. Van de Giesen. “We expect climate change to cause increased rainfall in the years ahead. Improved drainage facilities will be needed to handle that extra water. Many drainage systems need to be replaced. If we know exactly where we can expect this additional water, we can then modify the drainage systems accordingly. For instance, we could install wider pipes in some parts of the system.”

Chewing gum
The collection of wind data is the specialist field of flow expert, Professor Jerry Westerweel, of the Faculty of Mechanical, Maritime and Materials Engineering (3mE). The way in which wind flows past the building has already been modelled in detail, but Prof. Westerweel still wants to see for himself: “I want to see if the calculations are correct, and that’s why I’m asking the window cleaners to stick wind vanes onto every window of the EEMCS building. Nothing high-tech, they could just stick them on with a piece of chewing gum.” People working at their desks inside the building will then be asked to compile daily reports, simply stating the direction in which their vane is pointing.

The tall EEMCS building does however also have its good points, such as accounting for much of the

Rain sensor
Professor Nick van de Giesen’s room is filled with the mellifluous (if slightly tinny) tones of Diana Ross singing ‘A Brand New Day’. “Hey, this one still works,” shouts PhD student, Rolf Hut, in an attempt to make himself heard above the noise of the music blaring from the open greeting card he’s holding. Most of the other musical cards scattered around Van de Giesen and Hut here in this room are broken.

The researchers cannot resist the lure of cheap consumer electronics. In fact, they are looking for sensors they can use to make measuring instruments for weather stations. Van de Giesen wants to install 20,000 weather stations across Africa, and then link them together using a wireless network. There is however one considerable restriction: these weather stations must cost no more than 100 euro each.

Together with Hut, TU Delft alumnus and engineer Coen Degen, and MSc student Stijn de Jong, Van de Giesen found a way to use the speakers from electronic greeting cards in the African weather stations. Indeed, these hydraulic engineers have a good track record in this area, having previously made an evaporation meter from a Wii controller. “The speaker consists of a thin piezoelectric disc that deforms - thereby producing sound - when an electric current is passed through it,” Hut explains. “But it also works just as well in reverse. If a raindrop strikes the disc, the material vibrates and creates an electrical signal.”

The researchers have already made a prototype rain sensor that operates on this principle. All they need to do now is to calibrate the device, in order to work out the relationship between vibrations and droplet size. They must also ‘strap on’ various other electronic components, so that the data accumulated by the sensor (which is linked to a logger that keeps track of all the drops) can be easily read. When this work has been completed, De Jong will place around a hundred sensors on the roof of the low-rise section of the EEMCS building.
clean air on campus. “The building acts as a natural air freshener,” Westerweel explains. “Depending on the wind direction, masses of polluted air from the nearby A13 motorway tend to drift in our direction. The high-rise building funnels clean air down from a higher altitude, ensuring that the Mekelweg receives blasts of clean air. Vertical mixing occurs.”

Prof. Westerweel hopes to gain fundamental insights into how the ‘roughness’ of a cityscape (the extent to which high-rise and low-rise buildings alternate) affects the through-flow of air: “What is the best way to design a city so that it will blow pollution away? That’s what this is about. There are all kinds of models capable of indicating the average concentrations of pollution, but they provide no details about peaks.”

In addition to wind vanes stuck on with chewing gum, Westerweel wants to set up a large number of monitoring stations all across campus. Their instruments would be used to measure atmospheric concentrations of various oxides of nitrogen. The aim is to install these monitoring stations at sites that are situated ten to a hundred metres apart. The professor is now trying to recruit students who get a kick out of collecting and analyzing data. The flow expert has a fun experiment in mind for those students. “We’ll release a gas at a secret location on campus and then see how long it takes the students to figure out where the gas is coming from. The speed with which they can do this will depend on the number of sensors they use and whether they’ve placed these sensors intelligently.”

**Parsax**

The Parsax cloud radar, situated on the roof of the EEMCS building, is also being used for the Climate City Campus project. This radar installation, which became operational last year, can measure the composition of clouds at altitudes of up to fifteen kilometres, and at resolutions as fine as three meters. For comparative purposes, the KNMI (Royal Netherlands Meteorological Institute) weather radar’s resolution is one kilometre.

“Parsax cannot monitor what happens to raindrops during the final hundred meters, because it only looks straight up,” says remote-sensing researcher, Professor Herman Russchenberg (EEMCS), who will consequently use two small, mobile radars to study how the drops change during that last part of their descent.

“Raindrops also contain currents,” the professor adds “and if they become too strong, through the action of the wind for instance, then the raindrops will shatter. This changes the intensity of the rainfall, as smaller drops fall more slowly.”

According to Russchenberg, all major cities should have a radar network consisting of a few large cloud radars, like Parsax, situated on tall buildings, and a larger number of small radars on the ground. He is eager to use the campus as a testing ground, where his research will determine how far apart, and in which locations, the small radars should be placed in order to compile a reliable picture of raindrops on the neighbourhood level. The professor intends to use the data obtained from the rain sensors for this purpose: “This data also indicates what happens to raindrops during the last one hundred meters of their fall.”

**Green facades**

Cities and rural areas not only differ in terms of wind patterns and rainfall, but also in temperature. Concrete surfaces absorb more heat than grasslands, forests or bodies of water. In addition, plants cool themselves and their surroundings by allowing water to evaporate from their leaves. This cooling effect is less pronounced in cities than in the countryside.

Furnishing buildings with grass roofs and green walls can, to some extent, reduce outdoor and indoor heat. Researcher Marc Ottelé, of the Faculty of Civil Engineering and Geosciences (Microlab), is currently investigating the magnitude of this effect. In addition to building a section of cavity wall (in brick), he had a large wooden box made, the inside of which is lined with thick layers of polystyrene. He will soon start making measurements, which will involve sliding the wall section into the box, putting a plate that is overgrown with ferns in front of it, and using strong PAR (Parabolic Aluminised Reflector) floodlights to simulate the sun. The box, the fern-covered plate, and the wall section are all studded with temperature sensors that will measure the cooling effect of vegetation.

As part of the City Campus Climate project, Ottelé plans to install panels of lush, green vegetation on an outside wall somewhere on campus.