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aquatic research

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Measuring rainfall with mobile phone antennas

As rain interferes with radio signals, Eawag researchers have been able to measure rainfall using data supplied by the mobile telecommunications company Orange. The new method offers greater spatial resolution than traditional point measurements provided by rain gauges. In the future, this could be combined with intelligent control systems for sewer networks so as to reduce water pollution in urban areas.

Especially in built-up areas, sewer systems are frequently overwhelmed by unexpected rainfall: stormwater is mixed with sewage in pipes, the volume of water exceeds the capacity of retention basins, and the murky mixture overflows into local surface waters. In this way, diluted but untreated wastewater – containing chemicals such as pharmaceuticals, cleaning agents and pesticides – is discharged into streams, rivers and lakes. Across the year as a whole, the inputs are relatively low, with only about 2–5% of the total load (depending on the individual substance) entering surface waters via combined sewer overflows. However, short-term peak pollutant levels can be harmful to algae or fish. In addition, as project leader Jörg Rieckermann of Eawag's Urban Water Management department points out, the problem will be exacerbated as a result of the increase in heavy rainfall events associated with warming of the climate in Central Europe. "More accurate detection of rainfall at the local level would allow sewer systems to be controlled in such a way as to prevent overflows of wastewater as far as possible." Rieckermann, an environmental engineer, is therefore developing a computer model that uses data from a mobile phone network to reconstruct rainfall events at a higher spatiotemporal resolution than is possible with conventional methods.

Winning in the rainfall lottery

How does the method work? Rieckermann and his research team are taking advantage of what is essentially a nuisance for mobile network operators – the fact that raindrops interfere with microwave radio links between base stations, thereby disrupting signal transmission. Data on the attenuation of signal strength is used to calculate the intensity of rainfall along the path between two antennas. Thanks to the density of the mobile phone network, the resolution of the Eawag rainfall data is superior to that provided by rain gauges or weather radar. In contrast to point measurements, the mobile signal data is based on a network of overlapping microwave radio links. However intense a small-scale storm may be, it will not be captured by a rain gauge located even 100 metres away. As Rieckermann says, "It's often a bit of a lottery." While weather radar can cover a wide area, it has the disadvantage that radar signals are heavily attenuated by intense rainfall. In addition, misleading echoes are generated by the terrain – a major problem in a mountainous country like Switzerland.

First-ever data from Switzerland

Although rainfall has previously been measured using radio signals, such measurements have not been applied in practice to date. Using the data made available to Eawag by the mobile telecommunications provider Orange, it is now possible for the first time to employ this system for purposes of water pollution control. In order to apply the method to an area of around 150 km^2 – with an extensive sewer network – in the Zurich region, the researchers analysed data from 23 microwave radio links in this part of Switzerland. For a 2-month period, they compared the data with measurements from 13 rain gauges, 2 disdrometers and the Albis weather radar station operated by

MeteoSwiss. The model was thus calibrated, and precipitation can now be reconstructed from radio signal data. Rieckermann hopes that the accuracy of measurements will be further improved by also including drop size distribution in the calculations: while a few large drops scatter and attenuate the radio signal in a similar way to numerous small drops, they generally mean less rain. Accordingly, a method taking these patterns into account is currently being developed by project partners at the Federal Institute of Technology in Lausanne (EPFL).

Municipal trials planned

In the near future, Rieckermann intends to field-test the model in two municipalities. Here, control systems for retention basins are to be linked to local forecasts of precipitation intensity and movement. In at-risk areas, the retention basins are then to be regulated before and during rainfall events so as to free up capacity to cope with the expected water volumes – keeping wastewater overflows to a minimum. Rieckermann comments: "Against the background of climate change, this may be crucial. It means that existing reserves can be activated without having to rebuild the drainage system." He believes that Switzerland, formerly a pioneer in wastewater treatment, should lead the way once again, "not least because this country has a dense mobile telecommunications network, even in remote areas, and so accurate rainfall data is widely available."

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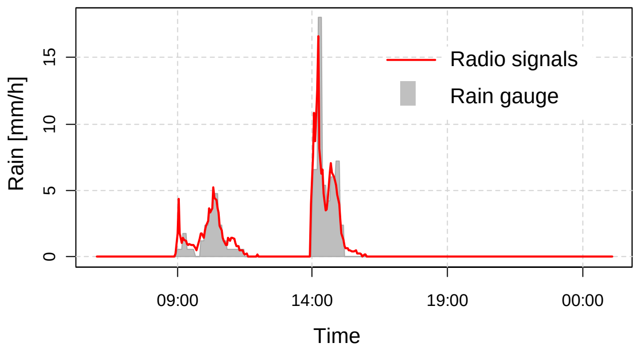

left: Directional antennas transmit mobile phone signals over the rooftops of Zurich.
right: The attenuation of a microwave radio signal is in close agreement with the rainfall intensity measured by a rain gauge (rain rate in mm/10 min); however, this is only the case if a rain gauge happens to be located at the centre of a rain cell.

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