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Wet/dry-estimation algorithm for commercial backhaul link attenuation data to derive precipitation intensity in alpine terrain

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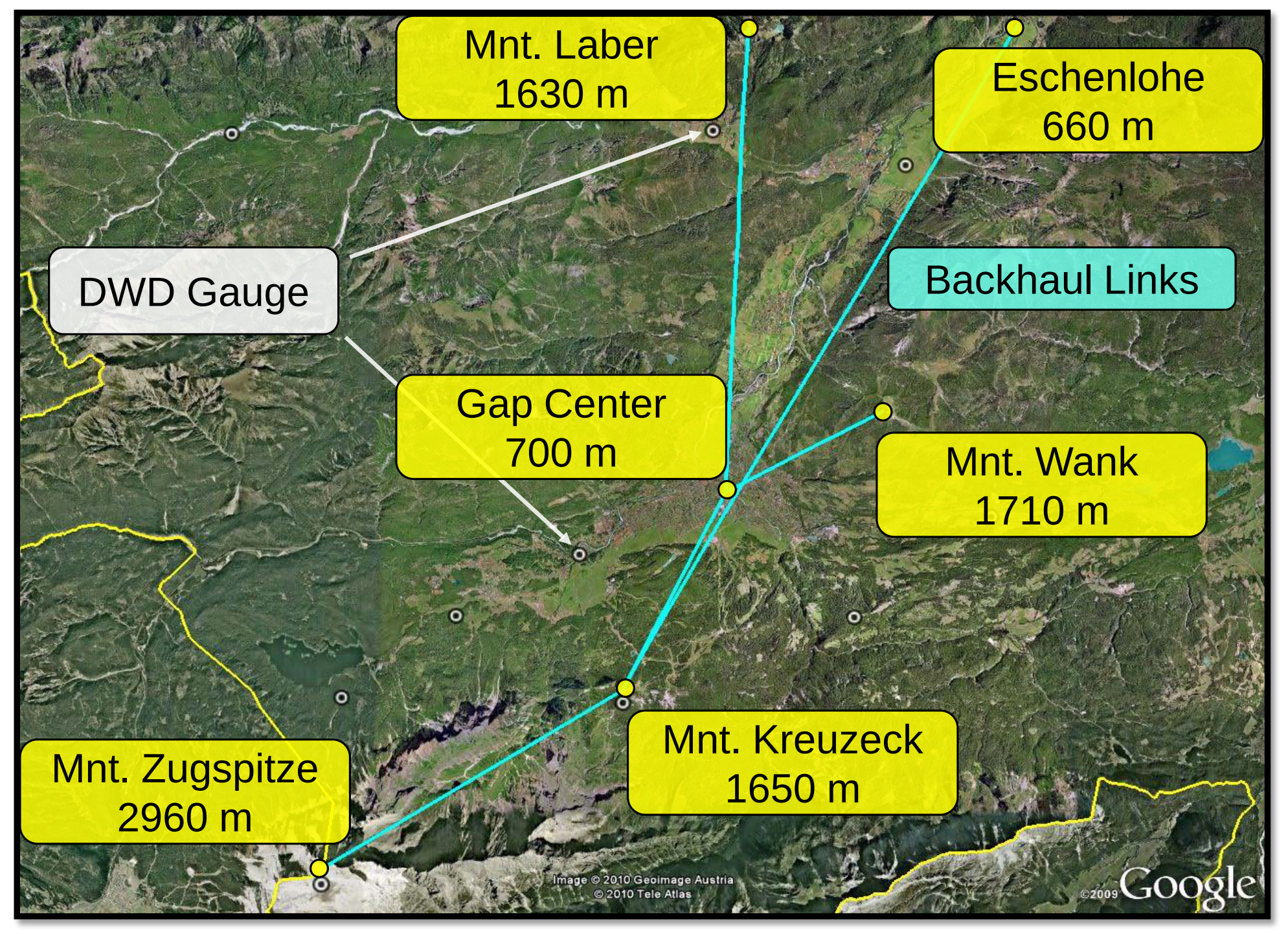
1. Overview

Estimating the spatial and temporal distribution of precipitation is of crucial importance for hydrological analyses. This is particularly true in regions with a high spatial precipitation variability. A new means to accomplish this task is **exploiting attenuation data from commercial backhaul links**, which is a useful complement to traditional rain gauge and radar derived estimations, since it is based on a different spatial and temporal scale.

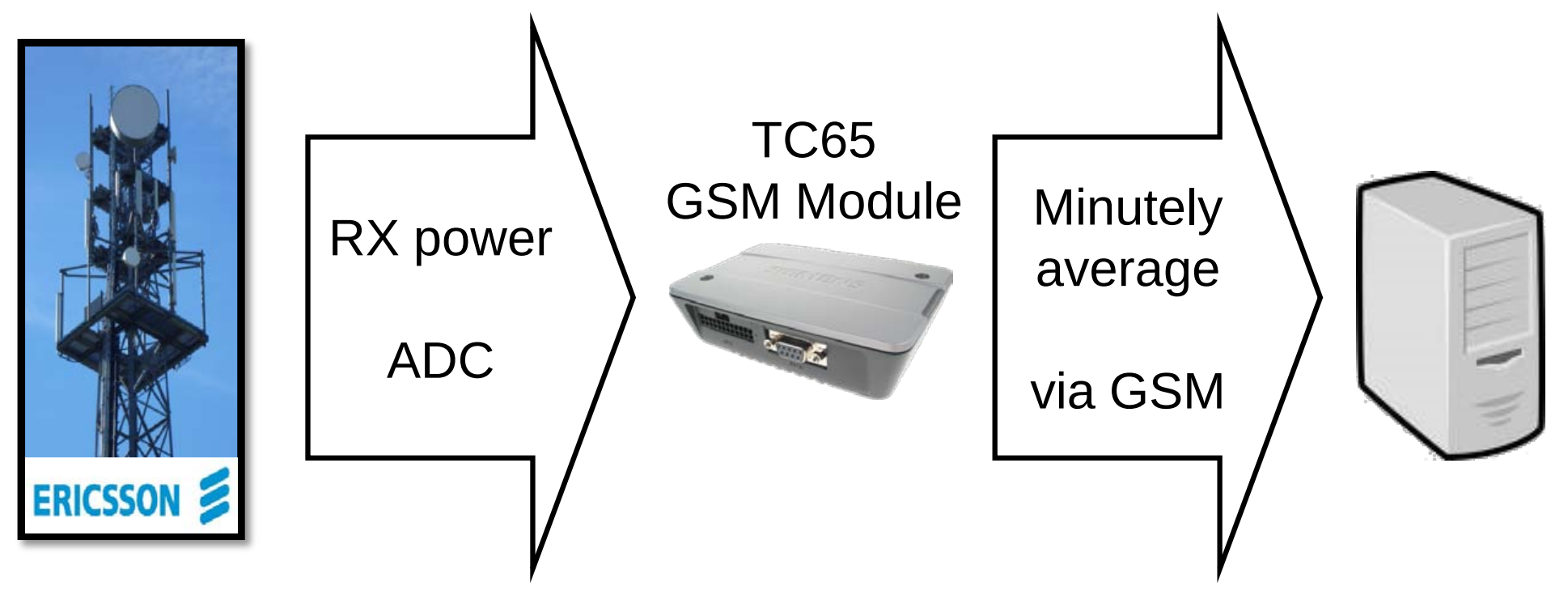
We present a new technique to **detect the onset of a rainy period** by performing a spectral analysis of the RX power time series. This way we **dynamically set the baseline** which is needed to determine the attenuation from which the rain rates then are calculated.

2. Test site and DAQ



Our test site is the **alpine region** around Garmisch-Partenkirchen in southern Germany. The terrain is characterized by complex orography which makes accurate radar and gauge measurements difficult.

We installed GSM data logger modules at **five backhaul link towers** in the test area. They record minutely averages from an analog voltage output of the link receiver unit. Data is then transferred via GSM to a data base for further processing.



Acknowledgment

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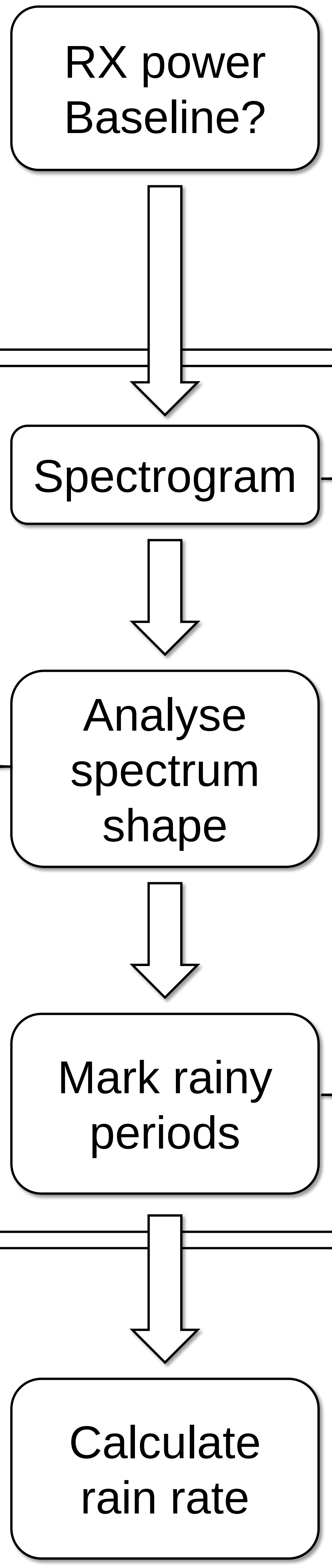
3. Problem

The **attenuation** A (in dB/km) of a microwave signal passing through the atmosphere is linked to the **rain rate** R (in mm/h) along the path by the power law

$$A = aR^b$$

where a and b are constants depending on frequency, rain temperature and drop size distribution. But there are also other atmospheric influences causing attenuation, so that the signal is always fluctuating with magnitudes up to 3 dB. **Thus the baseline for attenuation has to be set dynamically for each rain event**.



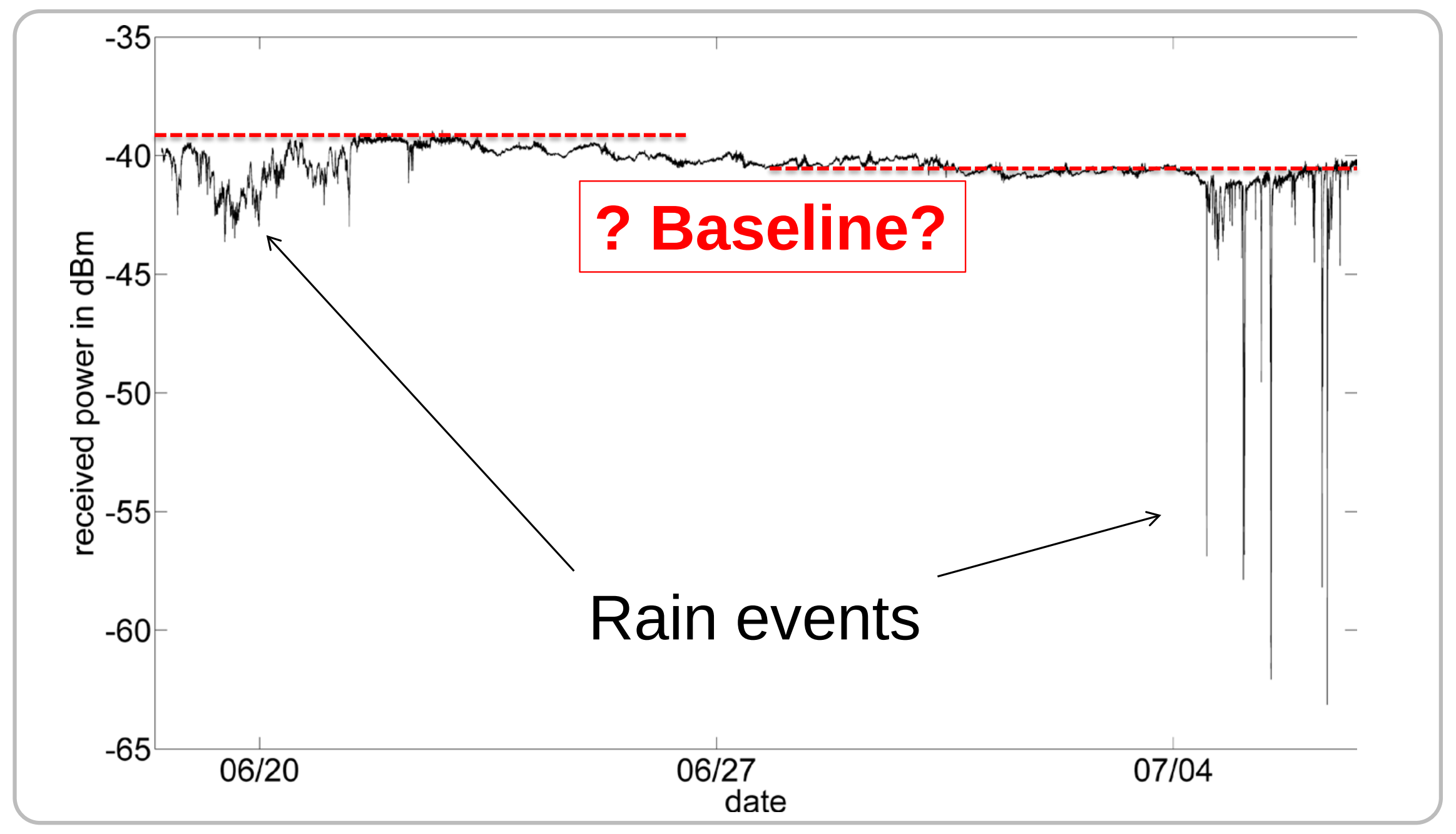
RX power Baseline?

Spectrogram

Analyse spectrum shape

Mark rainy periods

Calculate rain rate

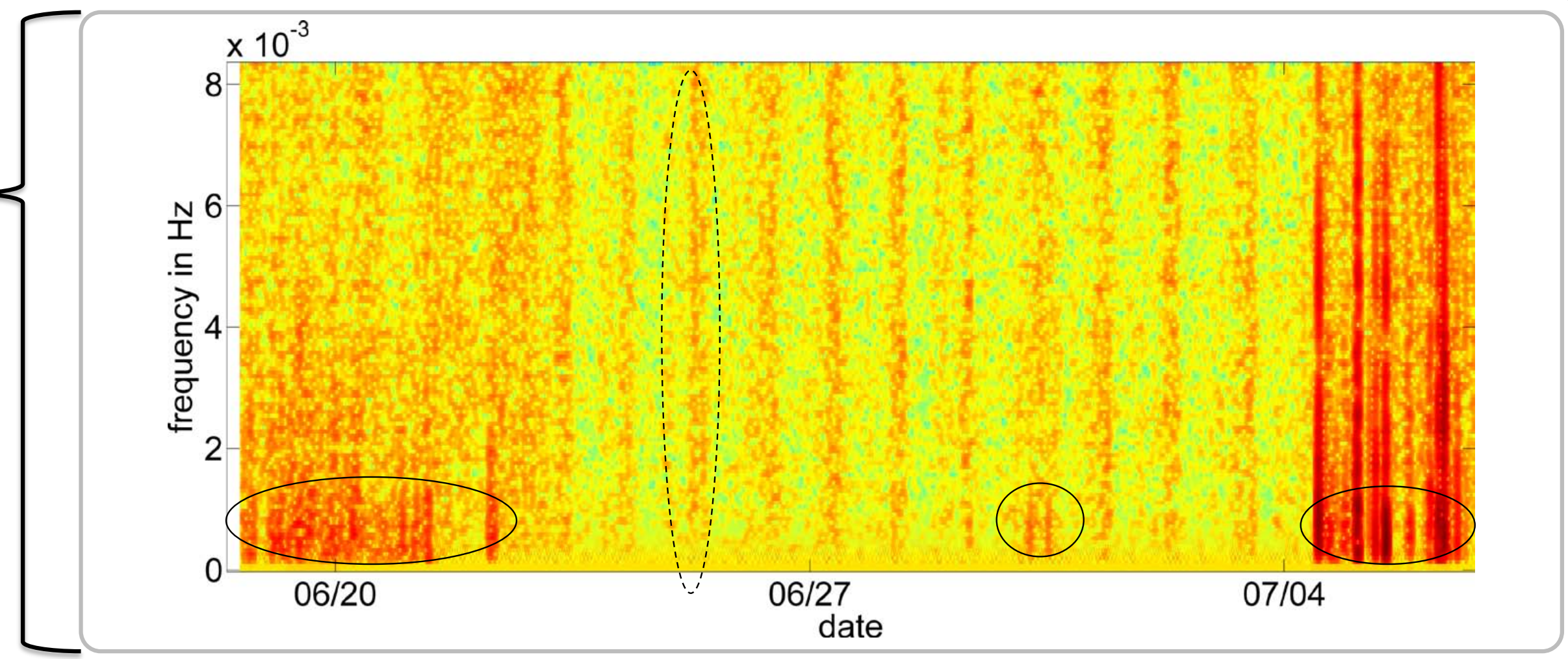


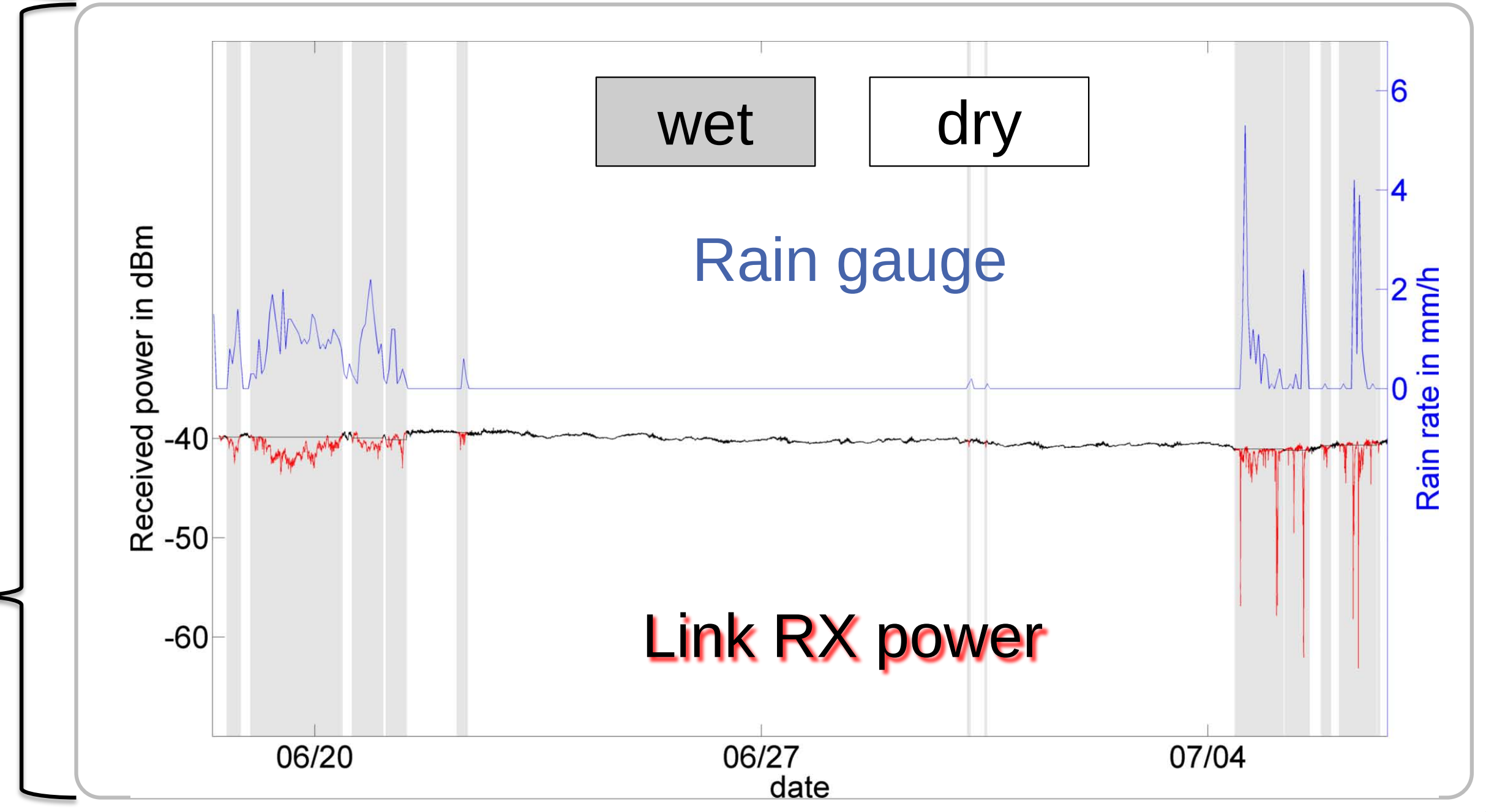
4. Solution

Our first step is to find the rain events in the RX power time series. We therefore **calculate a spectrogram using short-time Fourier transform** with 256 samples, 255 overlapping samples and a Hamming window. The resulting spectra are normalized by a average one from a dry period.

The spectrogram then shows a typical behavior for rainy (wet) periods. There we notice a **strong amplitude increase in the low frequency regime** (⬭). Other “no rain” influences cause an increase over the whole frequency range (⬯). Thus the shape of the spectra at each time step indicates if it’s raining or not. A simple measure for the spectra shape is the **difference of the sum of the amplitudes at low and high frequencies**.

If this difference **exceeds a certain threshold** we mark the according time step as **rainy** (wet). A comparison with a nearby DWD rain gauge aproves this rain event detection.



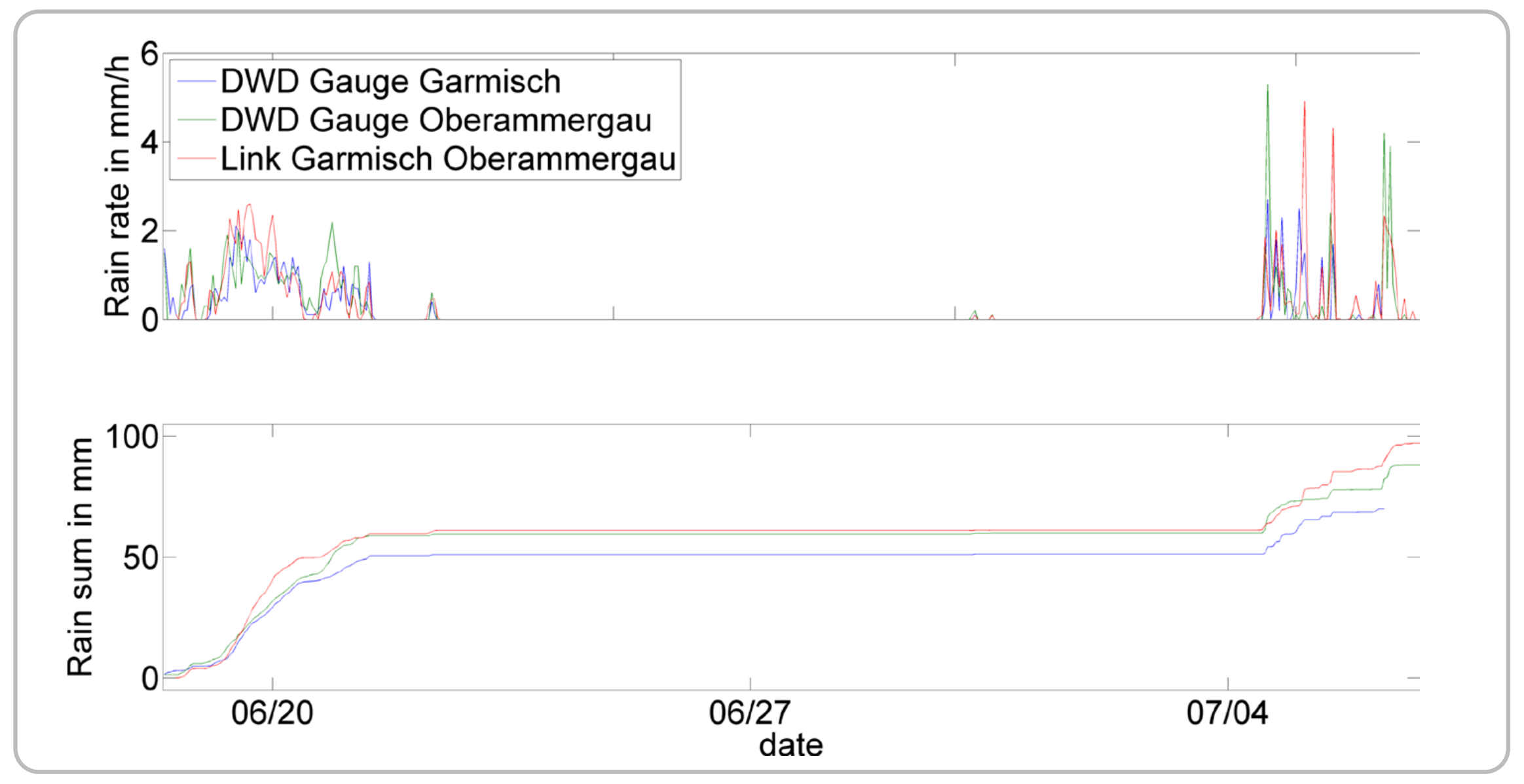


5. Results

To calculate the rain rate with the above formula we set the attenuation baseline to the last value before the rain event.

The derived rain rates and rain sums show very good agreement with the two DWD gauges near the backhaul link.

Small differences have to be expected due to the different locations of both gauges and the link.



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