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Precipitation and humidity observation with a coherent microwave transmission experiment at 22.235 GHz and 34.8 GHz

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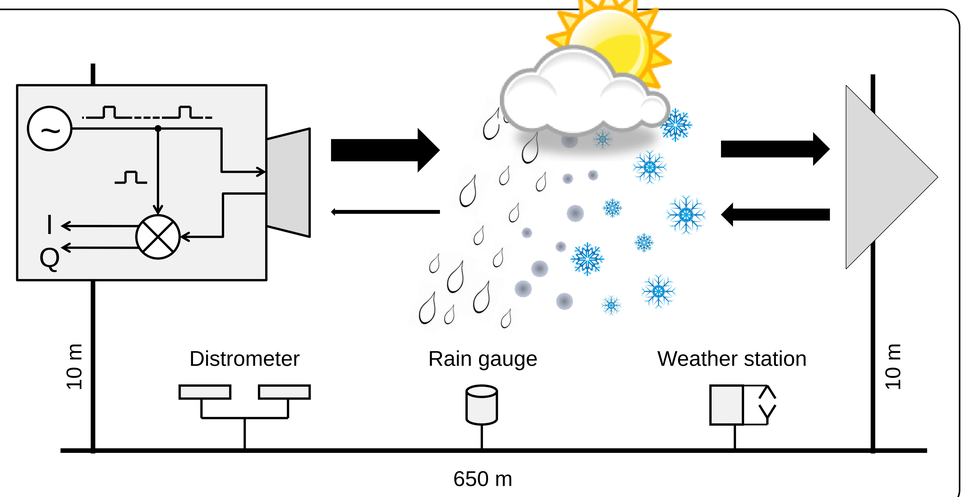
1. Motivation

Near surface humidity and precipitation are important meteorological observables which are hard to detect accurately over a wide area. But both play an important role in modeling and remote sensing the hydrologic cycle. We designed and built a transmission experiment that supports the precipitation remote sensing work currently done with commercial microwave backhaul links, measures line integrated humidity and provides new insight into the interaction of microwave radiation with hydrometeors.

Goals

- Support microwave backhaul link attenuation experiments with accurate small scale data
- Measure near surface absolute humidity
- Study precipitation caused noise in signal spectrum

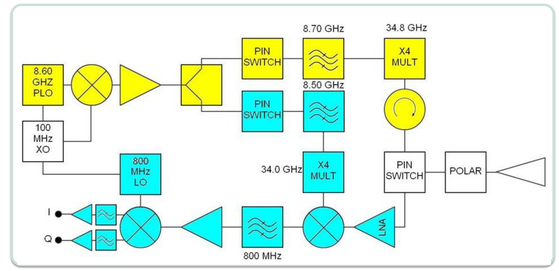


2. System features

- Pulsed transmitter and receiver
- Range gating to exclude rain backscatter
- Coherent receiver with I/Q output
- Quasi simultaneous H/V polarization DAQ
- Simultaneous 35 GHz and 22 GHz DAQ
- Sampling rate of 12,5 kHz

	34.8 GHz	22.235 GHz
Antenna gain	36 dBi	32 dBi
3 dB deam width	2.4°	4.2°
Trihedral RCS	41 dBsm	36 dBsm
Tx power	18 dBm	16 dBm
System noise figure	10 dB	8 dB
PRF	25 or 50 kHz	25 or 50 kHz
Polarizer settling time	35 µs	35 µs
Pulse width	> 50 ns	> 50 ns
Round trip path length	1300 m	1300 m

Simplified block diagram 34.8 GHz system



3. Humidity and phase delay

Method:

The phase φ of the transmitted signal depends on the refractivity of air N, which depends on the temperature T and the vapor pressure P_v:

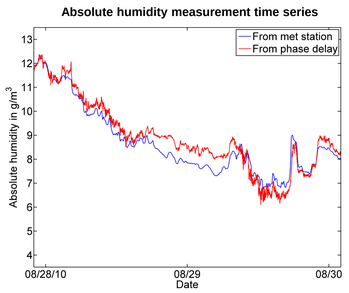
$$N_{vap} = 64.8\frac{P_v}{T} + 3.776 \cdot 10^5 \frac{P_v}{T^2}$$

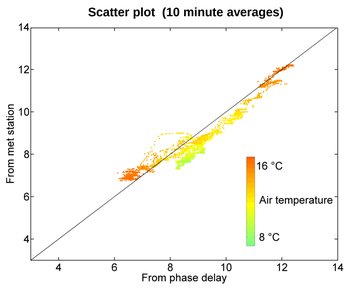
With the vapor pressure depending on the absolute humidity one can derive a relation between phase φ and the absolute humidity:

$$hum_{abs} = \frac{\varphi \cdot c \cdot 10^3}{f \cdot L(2.9 \cdot 10^{-1} + 1.743 \cdot 10^3 \cdot T^{-1})}$$

Results:

The values calculated from the measured phase show good agreement with the ones from the nearby meteorologic station.





→ High temporal resolution line integrated humidity measurement

4. Precipitation caused noise

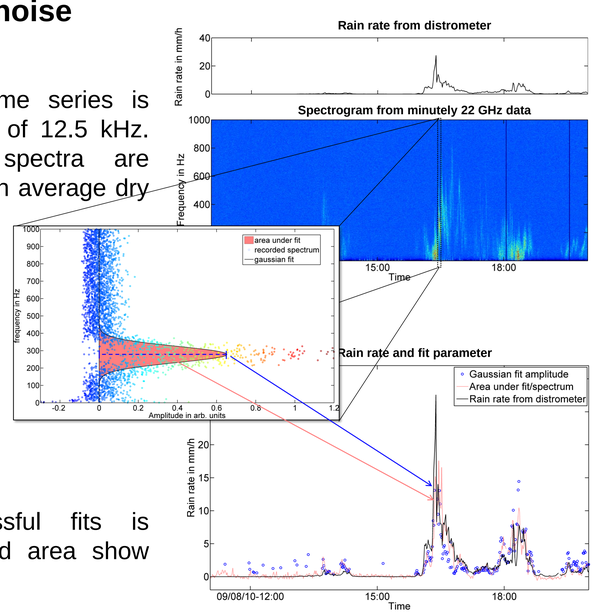
Method:

Every minute a 3 second time series is recorded with a sampling rate of 12.5 kHz. From this data minutely spectra are calculated and normalized by an average dry period spectrum.

Rain causes noise with a gauss-like peak in the spectra. From a gaussian fit the peak's amplitude is estimated. In addition the area under the spectrum is calculated (graph shows only the smoothed area under the gaussian).

Preliminary results:

When data from unsuccessful fits is neglected, both, amplitude and area show correlation with the rain rate.



→ Direct relation between rain rate and changes in signal spectrum

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