Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

Current work on attenuation of microwave links

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Outline

- Basics
- Elements in link budget equation
- Baseline (dry attenuation) determination and first result
- Outlook

Basics

- Link: transmitter and receiver antenna, power frequently measured by mobile operator to ensure network consistency
- Basic equation is link budget:

$$\text{Received power[dB]} = \text{Transmitted power[dB]} + \text{Gains[dB]} - \text{Losses[dB]}$$

- Contributions:
  - Gains: antenna directivity
  - Losses: antenna electronics, free space attenuation, wet antenna attenuation, rain attenuation, other (birds, vegetation, humidity, ...)

Free space loss - Lw

- Power loss due to propagation in free space (air), decreasing as R^{-2} due to spreading
- Does not depend on rain rate, but the link frequency

Loss due to rain - Lr

- Loss due to rain is linked to rain rate
- A good approximation for microwave frequencies is the power law:

$$A = aR^b$$

- A is the attenuation by rain along the link
- a,b are mainly functions of link frequency, to a lesser extent also air temperature
- Can be calculated from measured drop size distributions (many studies available)

Wet antenna loss

- Due to thin layer of water accumulated on antenna surface during/after rain
- Can cause significant error in rain rate estimation
- Loss models:
  - Constant loss of 2.3 dBZ
  - Time dependent model with exponential rise/decay
  - Markov chain model

Link budget

- Measurement is difference between transmitted and received power (Pt-Pr)

$$P_T - P_R = \Delta P = La\langle R\rangle^b + f_W(R) + B$$

- Baseline (B) is a sum of all losses that do not depend on rain rate
- All variables (a,b,f_w,B) can also depend on temperature, link frequency, polarization, DSD, ...

Baseline determination

- Crucial to retrieve rain rate from attenuation
- Many different algorithms in literature;
  - Using ITU estimations (calculation of baseline for a given atmosphere),
  - From correlations between two frequencies in a dual-polarization link,
  - Using data from nearby links,
  - Pattern recognition methods,
  - Markov chains.
- Our approach: histogram analysis (using dry or dry/rain cases)

Baseline determination – first result

- Histogram analysis:
  - Fit a joint gaussian (dry) and log-normal distribution (rain)
  - Use histogram IQR as outlier indicator

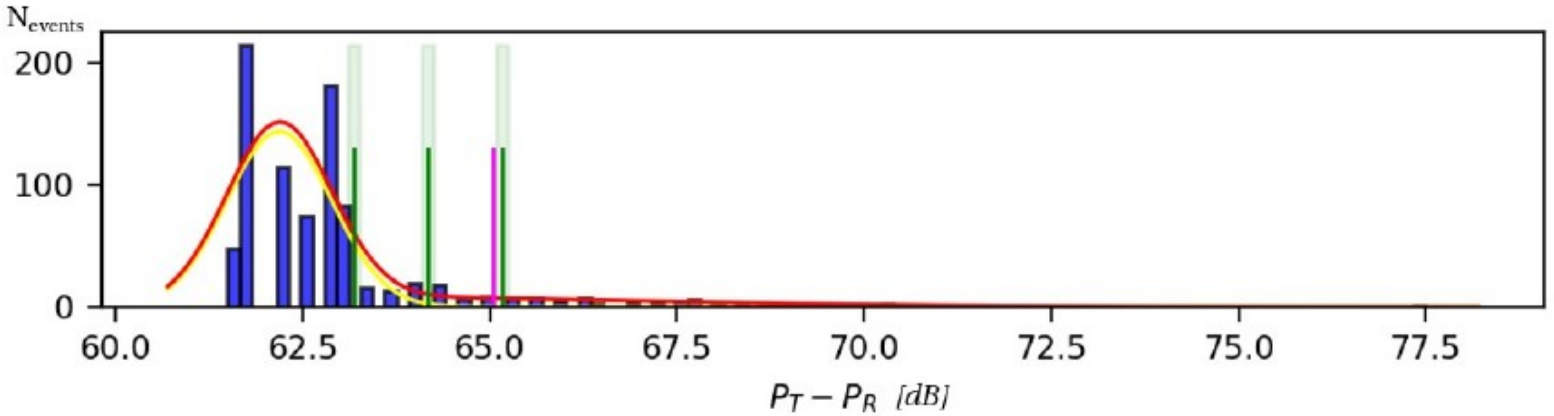

*Figure L1: A fit to the distribution of total link attenuation (transmitted - received power) for 4 days of link data at 5 minute intervals. Fit is made to determine the attenuation baseline: the attenuation of the dry period, either via fit, where the baseline is determined as fit average + 3 * fit sigma (the third green line) or via calculation of IQR (interquartile range) of the histogram (violet line).*

Summary and outlook

- A review of theory/literature
- IQR method for determination of dry/wet attenuation
- Rainy attenuations to be fitted against raingauges (or INCA estimates) to develop a robust relation between attenuation and rain rate.
- In 2020: develop a concept of observation operator suitable for link assimilation