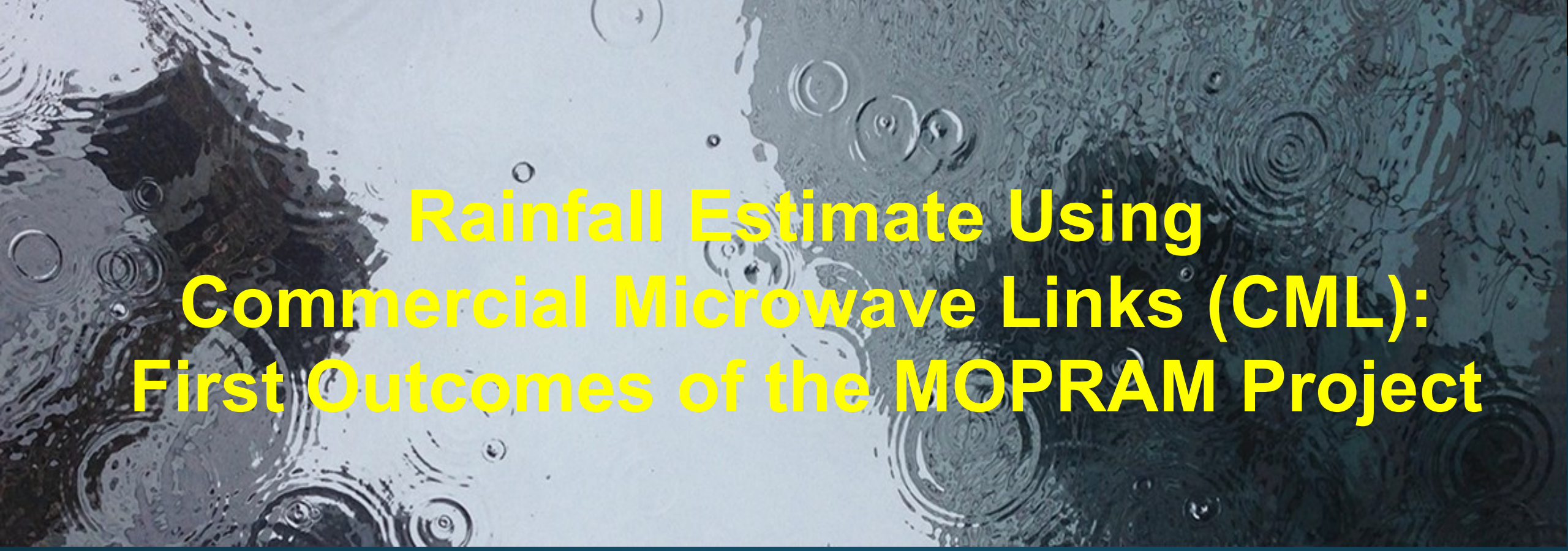

Rainfall Estimate Using Commercial Microwave Links (CML): First Outcomes of the MOPRAM Project

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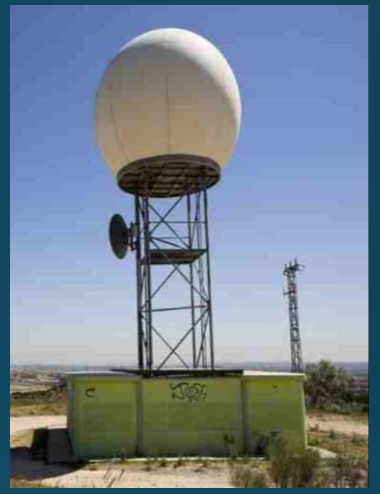
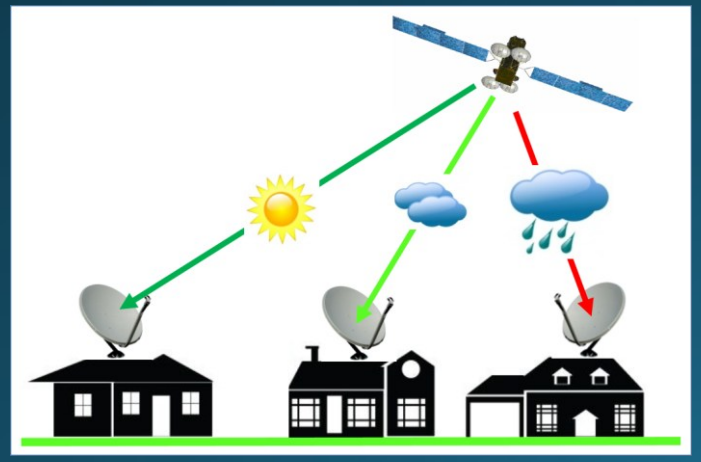
Precipitation Monitoring

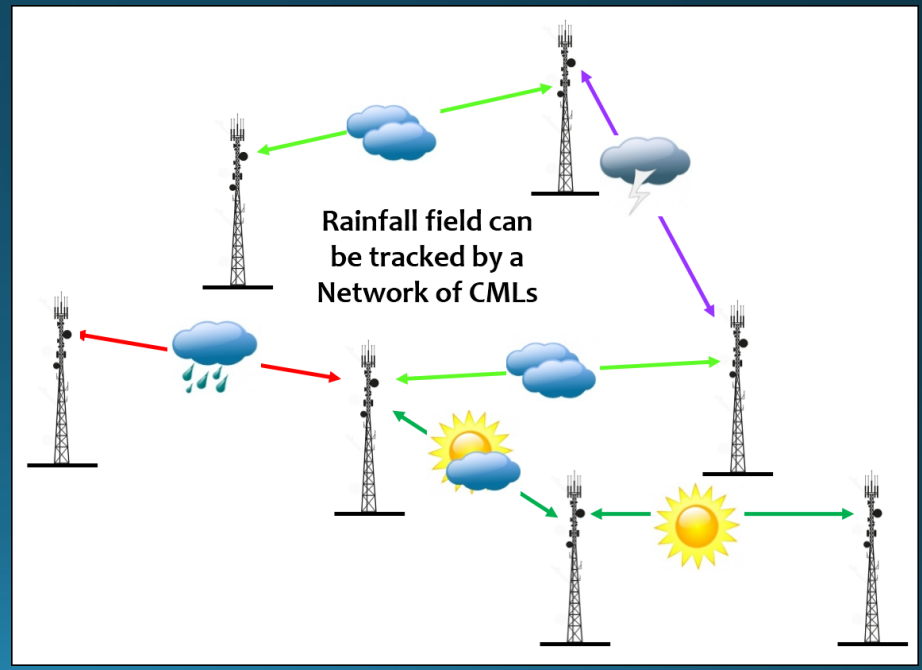
- Conventional sensors
  - Networks of rain gauges
  - Weather radar
  - Disdrometers



- Opportunistic sensors
  - TV-Sat receivers



- Commercial Microwave Links (CML)



The **MOPRAM** Project

- MOPRAM (**MO**nitoring **PR**ecipitation through A network of **RA**dio links at **M**icrowaves) aims at:
  - assessing the usage of CML data for rainfall measurements, especially for extreme weather events
  - evaluating the output of an hydrological model when fed with CML-based rainfall estimates
- Validation in two areas in Northern Italy

- The project activity is divided into 2 main tasks:

1. Meteorological task

2. Hydrological task

THIS PRESENTATION

EGU HS7.1 (Tuesday 5 May)
G. Cazzaniga et al., «Calculating the hydrological response of a mountain catchment using conventional and unconventional (CML) rainfall observations: the case study of Mallero catchment»

1.1
Estimation of rainfall intensity from CML signals and validation vs RG and DIS

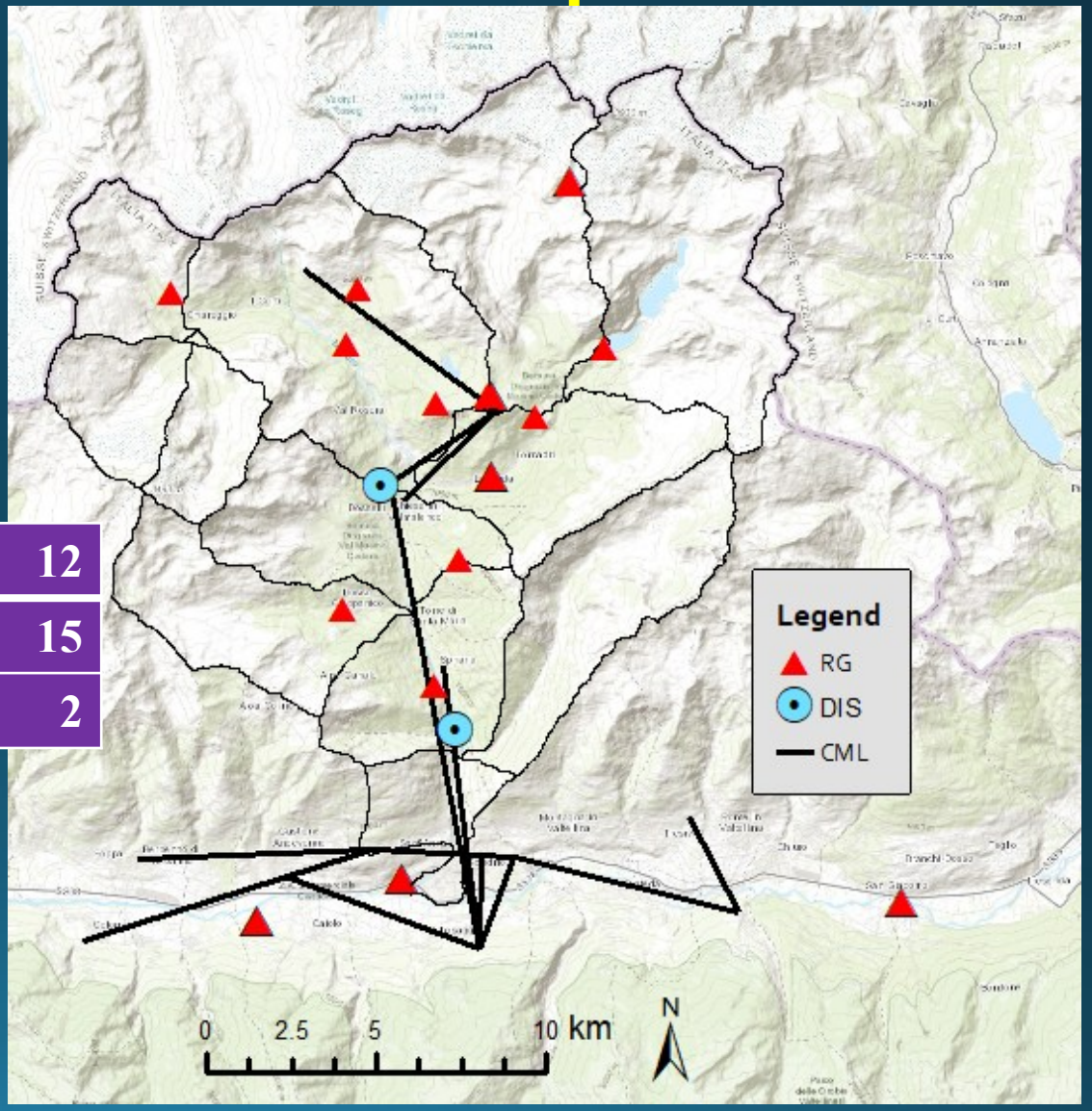
1.2
2D Rainfall field retrieval by a tomographic approach

2.1
Integration of CML data into a hydrological model

2.2
Check of the hydrological response

Study Area & Experimental Set-Up

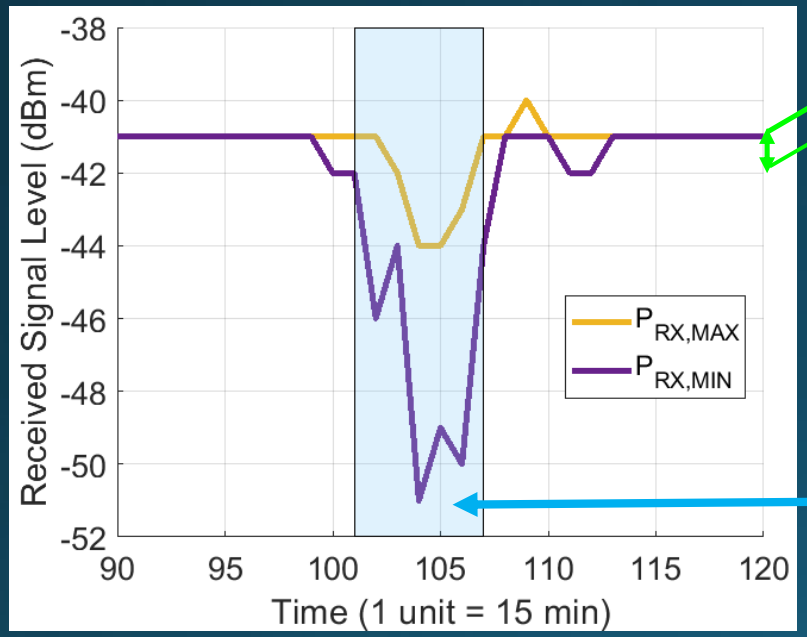
Links (CML)	12
Rain Gauges (RG)	15
Disdrometers (DIS)	2



What a CML actually measures

- Available data: Received Signal Level (RSL) in dBm*

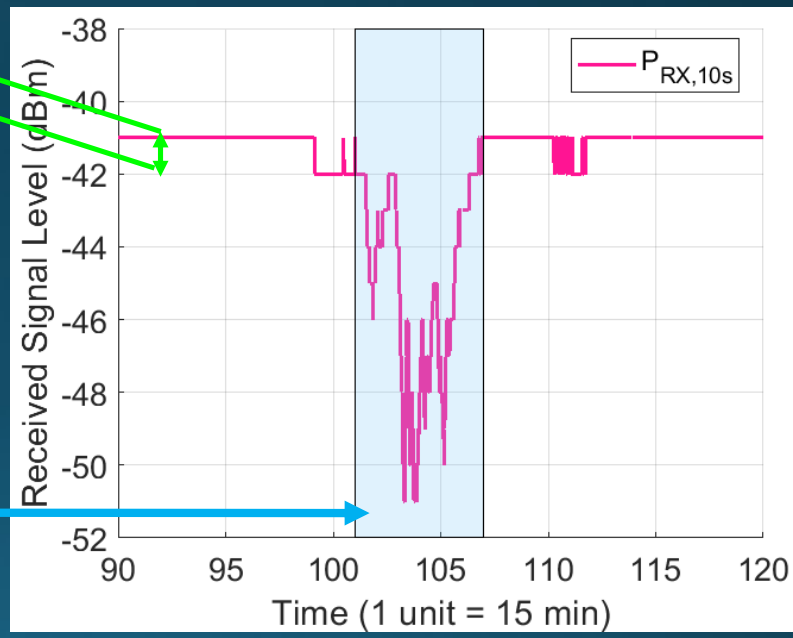
15-min MinMax (standard CML data format)



1 dB* Signal Quantization

Rain event

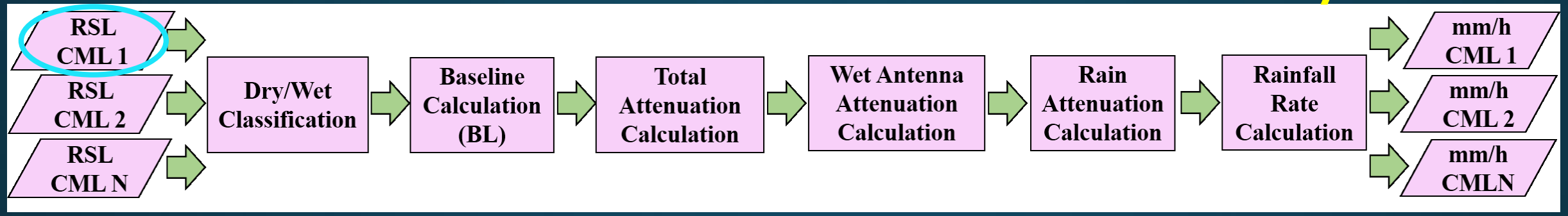
«Instantaneous» data (1 sample every 10-sec)



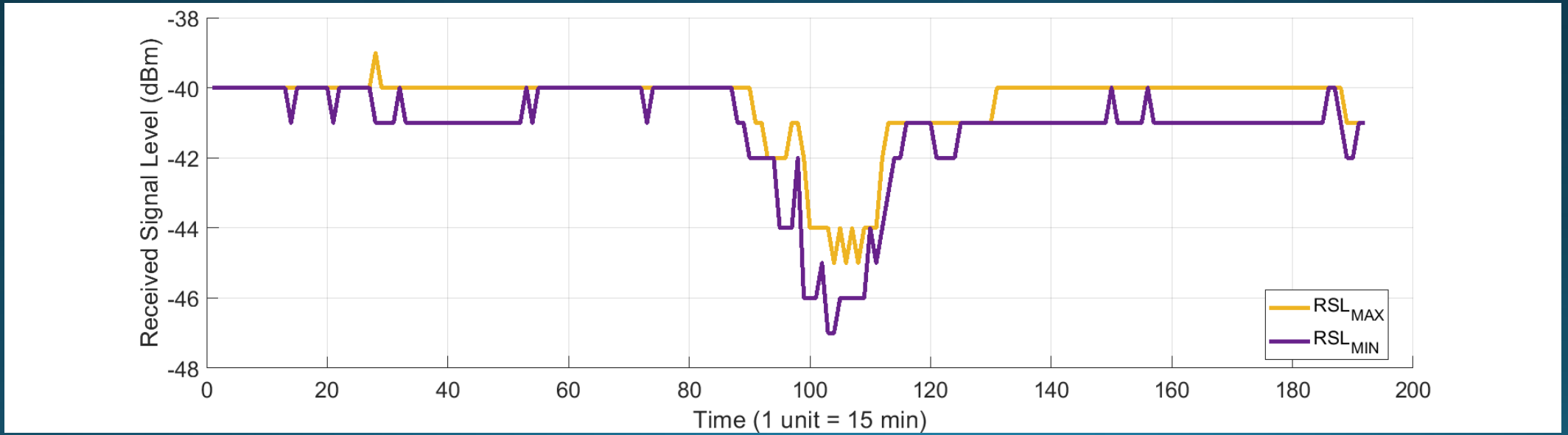
* dBm (used by TELECOM engineers) are units of power on a logarithmic scale, i.e. P (dBm) =10 $\log_{10}$ P(mW)

* 1 dB is a relative unit, corresponding to a 25% increment/decrement of a certain quantity

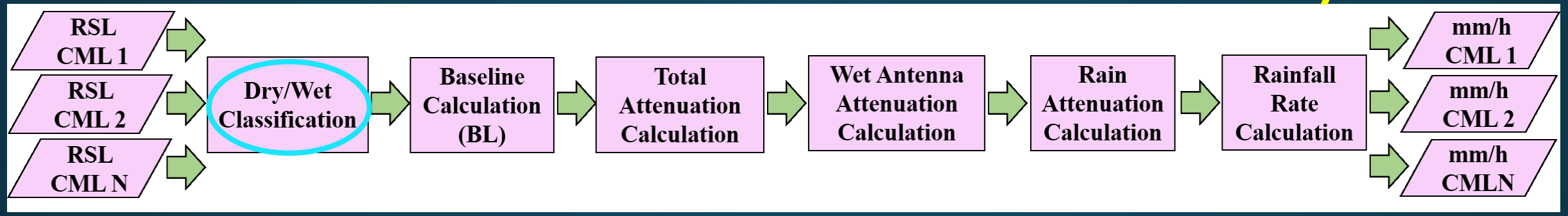
How to turn RSL into rain intensity ? (1)



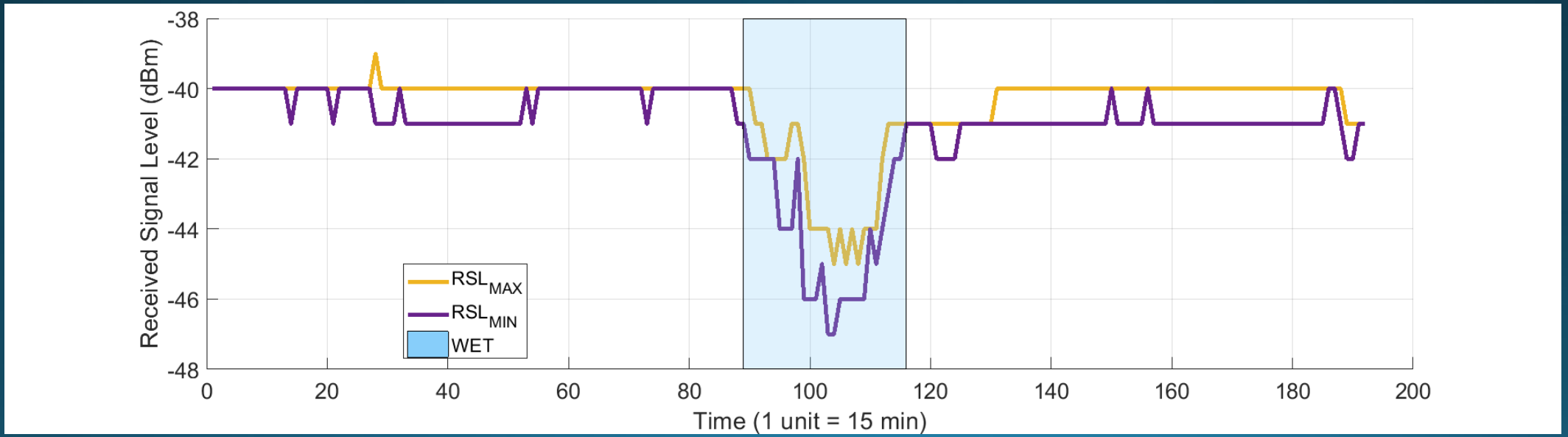
RSL



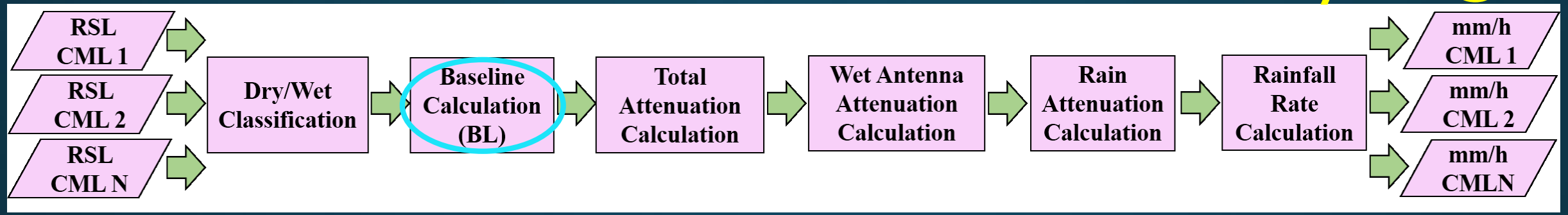
How to turn RSL into rain intensity ? (2)



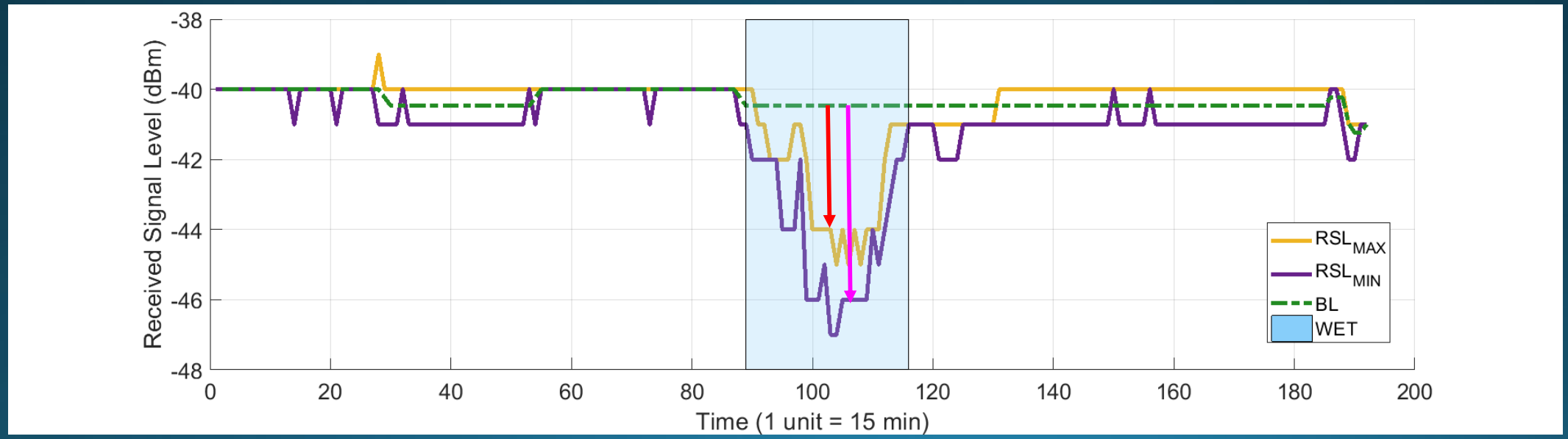
Dry/Wet Classification



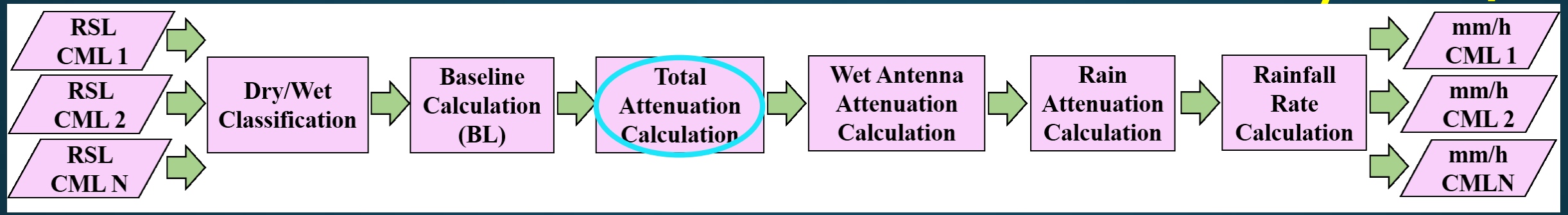
How to turn RSL into rain intensity ? (3)



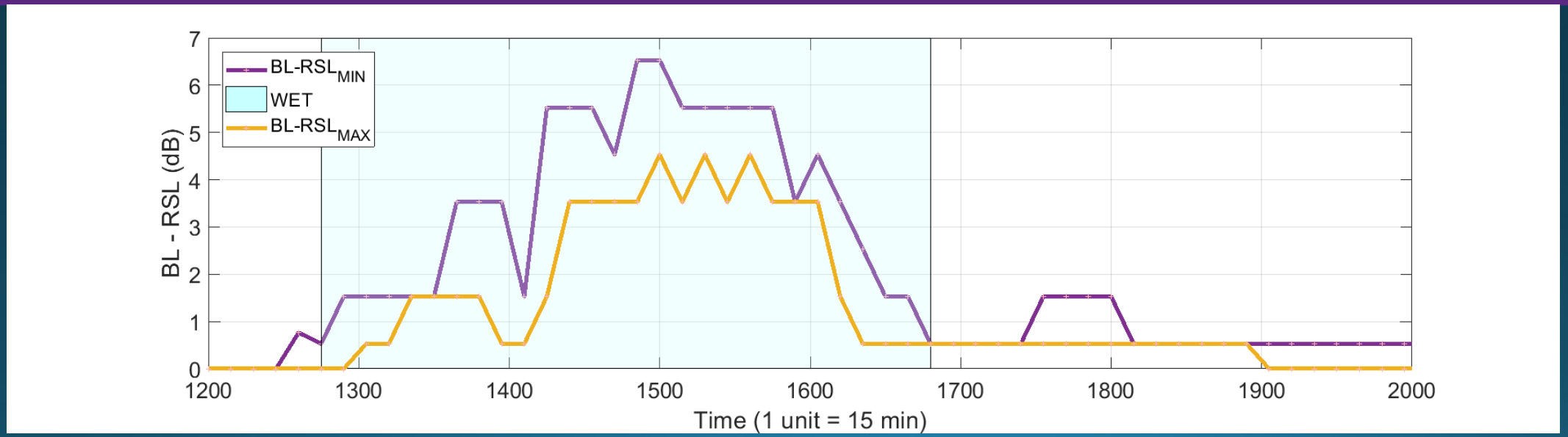
Baseline Calculation



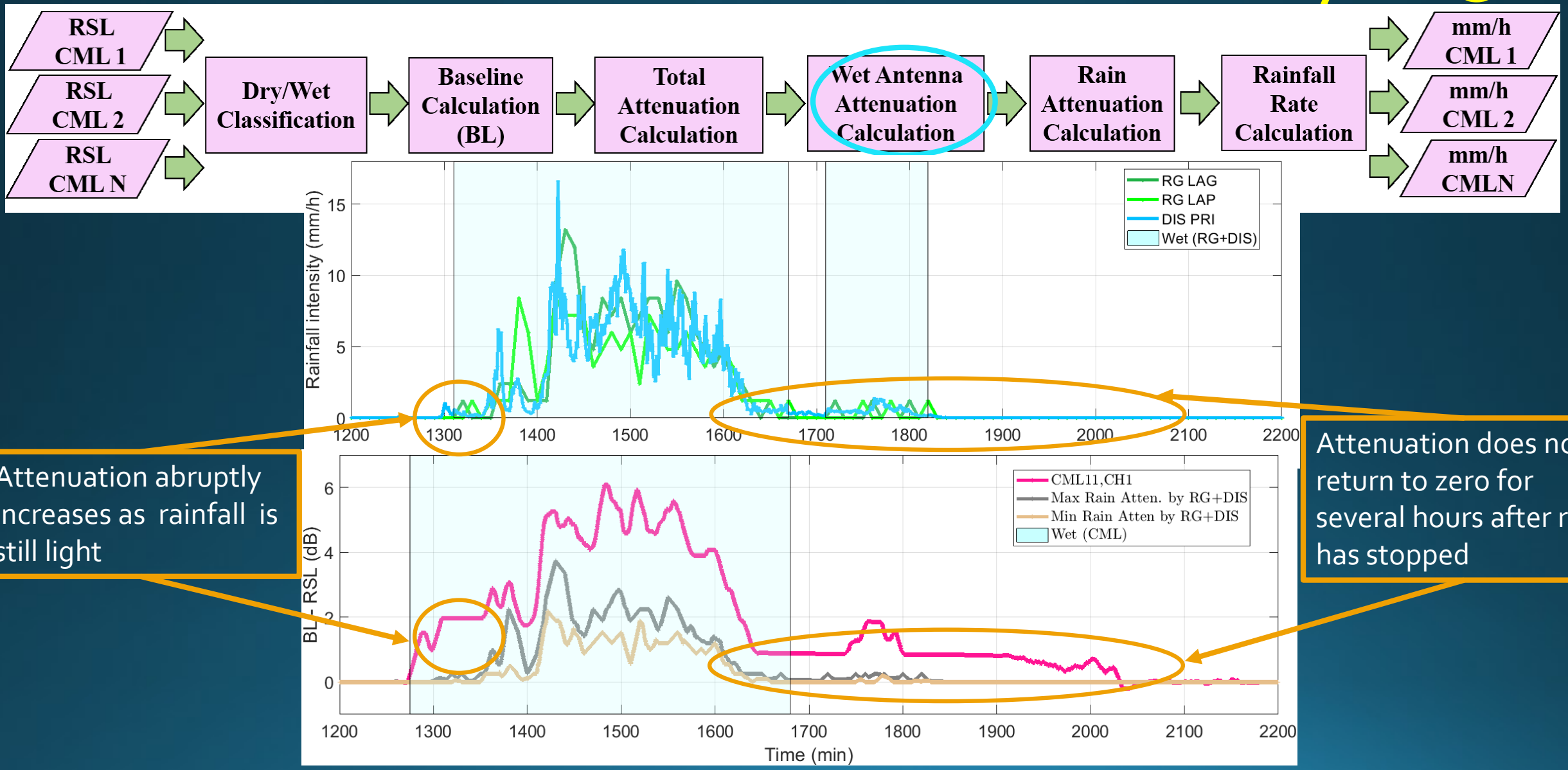
How to turn RSL into rain intensity ? (4)



Total attenuation = A_{tot} = BL - RSL



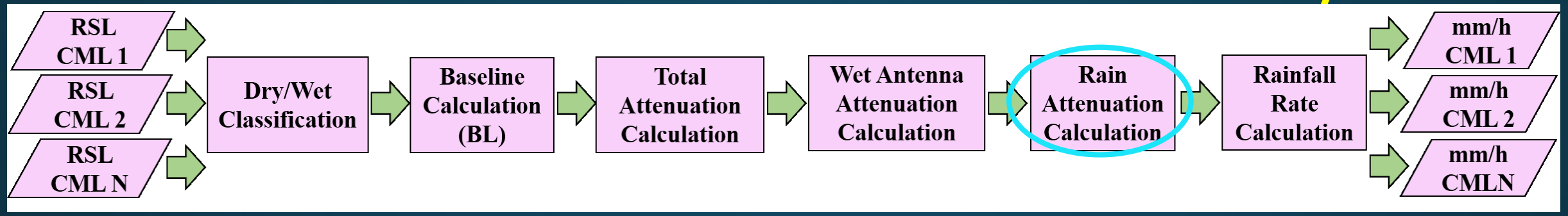
How to turn RSL into rain intensity ? (5)



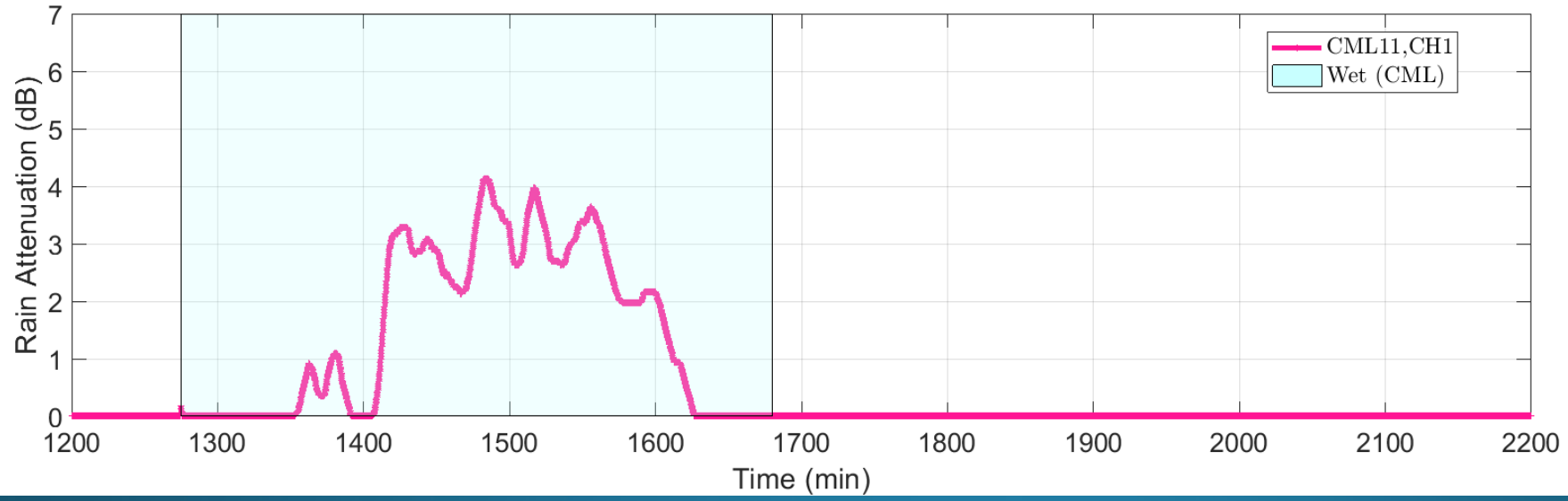
Attenuation abruptly increases as rainfall is still light

Attenuation does not return to zero for several hours after rain has stopped

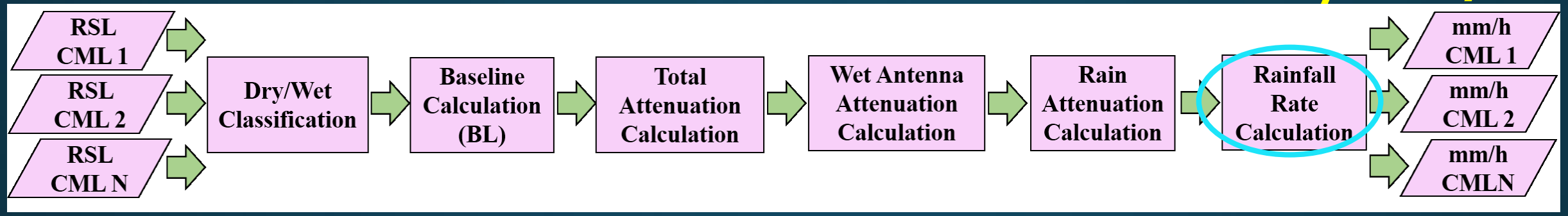
How to turn RSL into rain intensity ? (6)



Rain attenuation: $A = BL - RSL - A_{wet}$

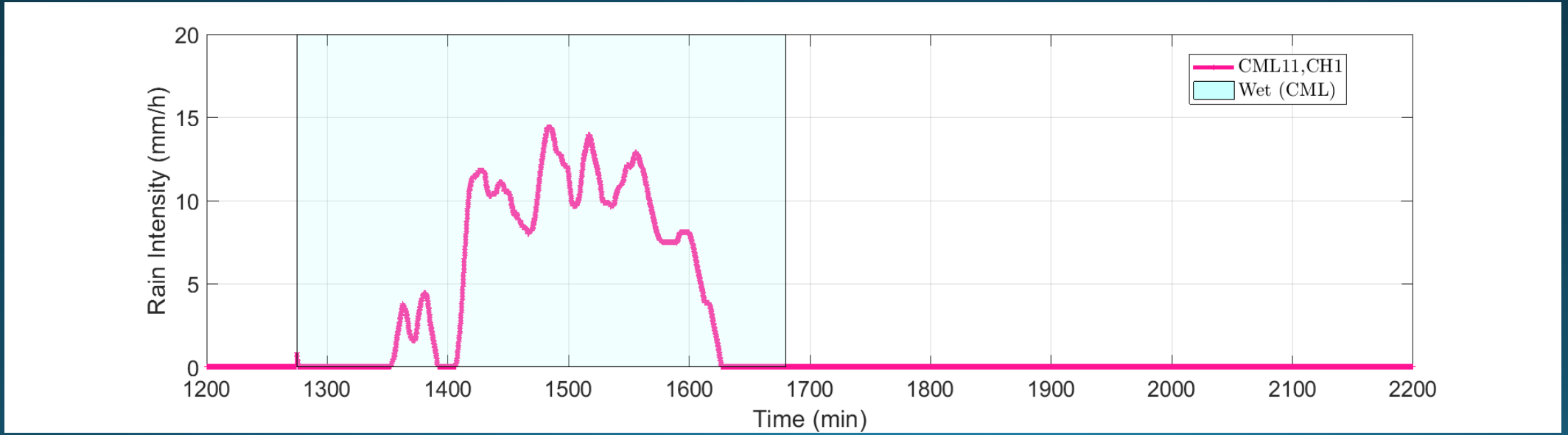


How to turn RSL into rain intensity ? (7)



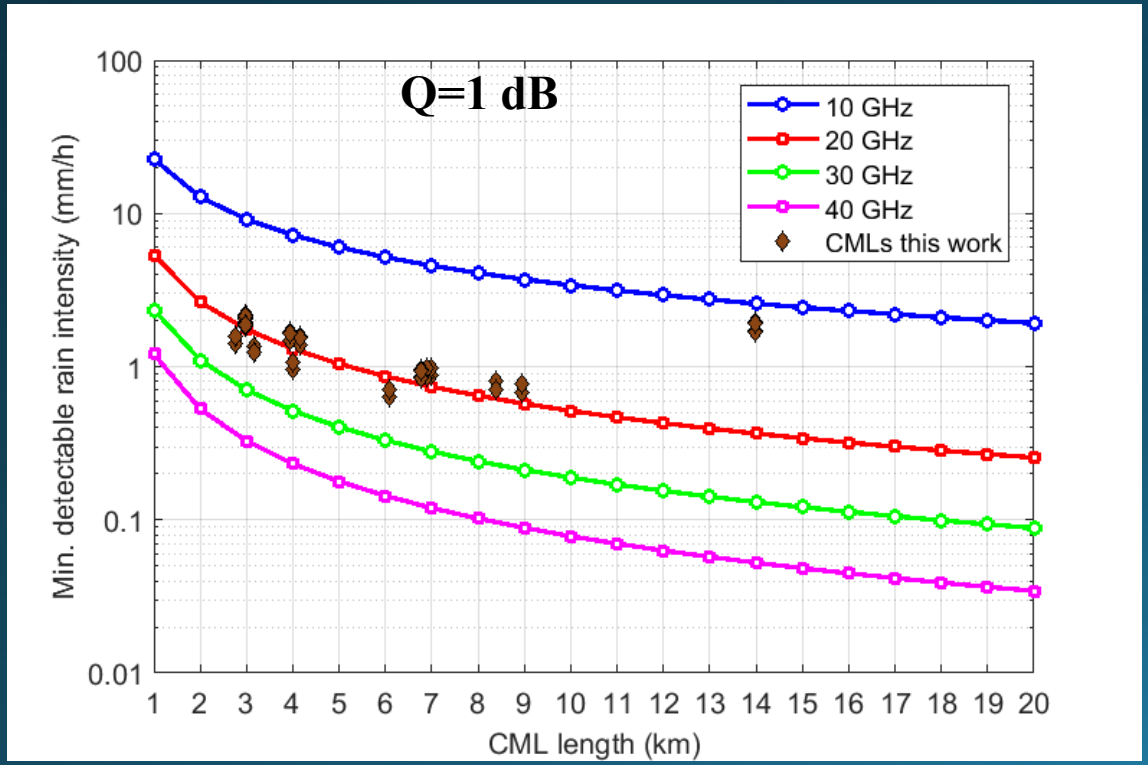
Rain rate from: $A = L\kappa R^{\alpha}$

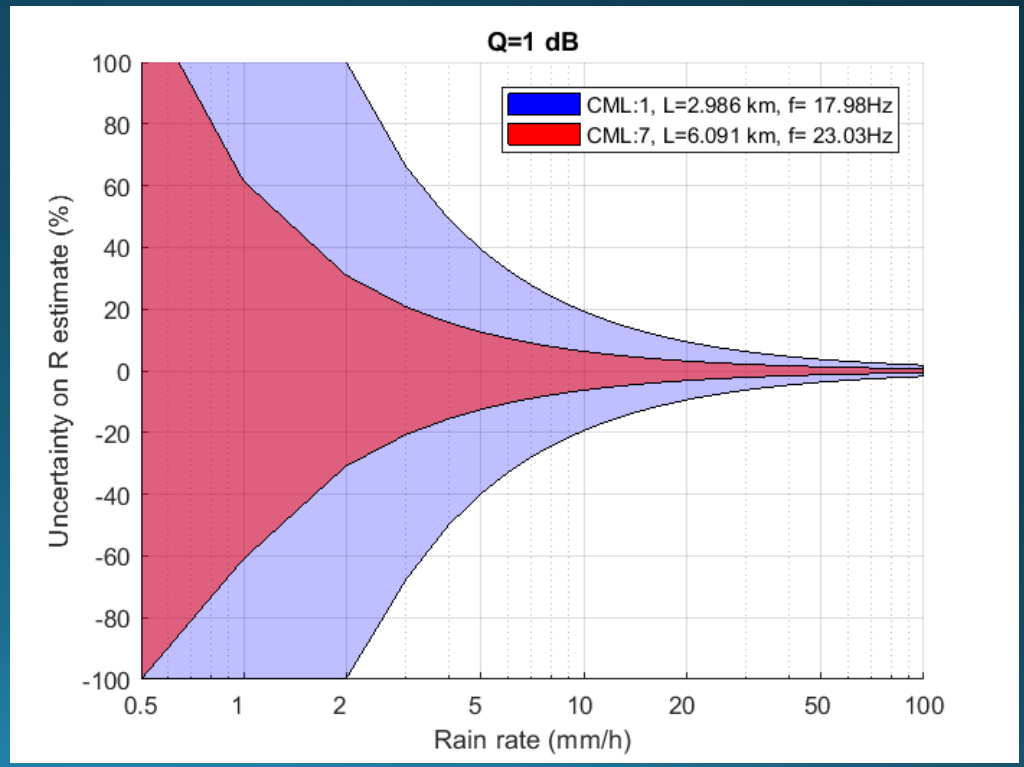
(κ and α from ITU-R P.838-3 used by TELECOM engineers, L is the path length)



Link Sensitivity & Measurement Errors

- Quantizazion error generates
  - False alarms (min. detectable rain intensity)
  - Uncertainty on measured rain intensity
- CMLs in the same network have different sensitivities





A better A-R relationship by disdrometers

DSD
$N(D)$ (m^{-3} mm^{-1})

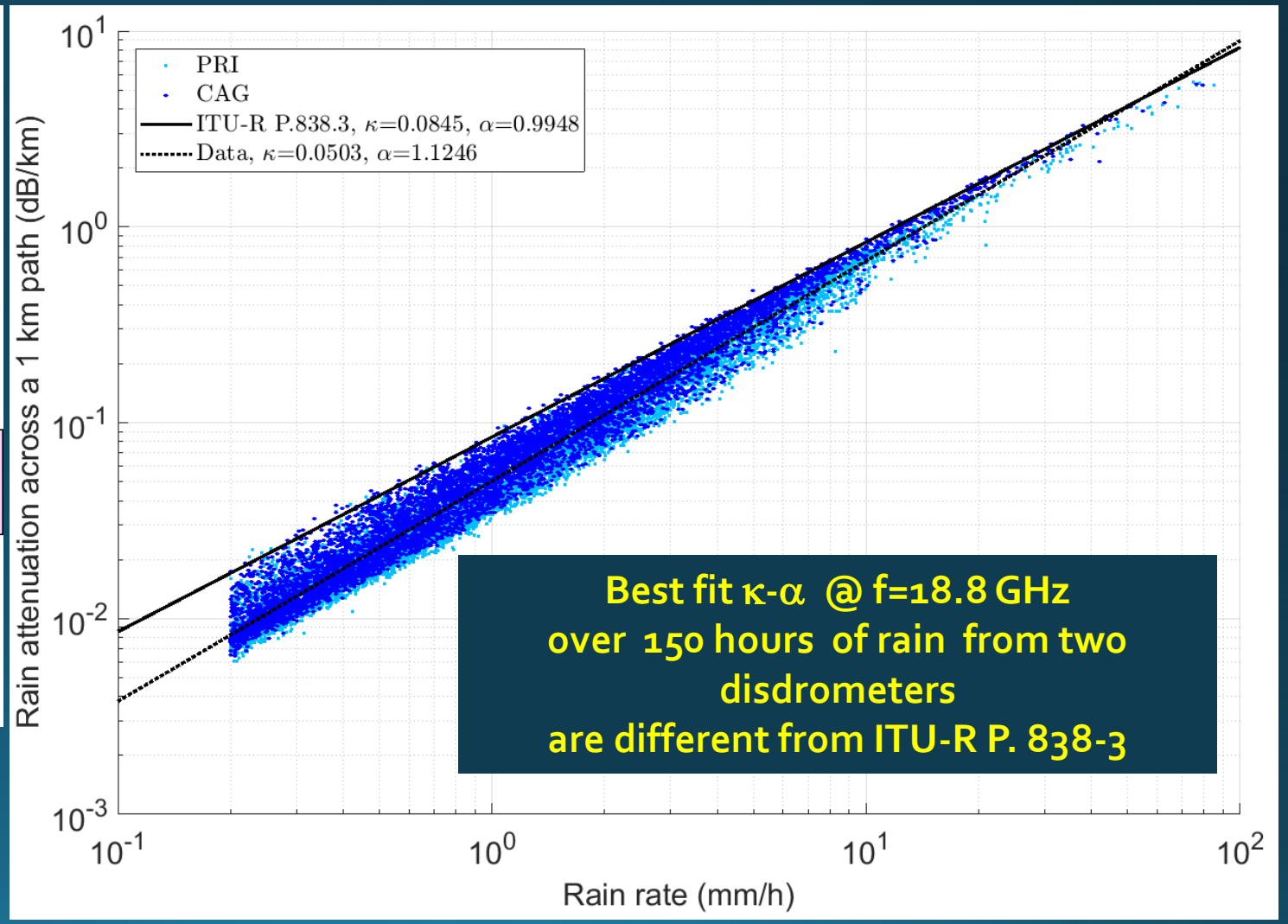
Rain Intensity
R (mm/h)

Raindrops
ELM Scattering
$\sigma(D, f)$

Rain Attenuation
$A = L \int N(D)\sigma(D, f)dD$

Rain Attenuation
(approximated)
$A = L\kappa R^{\alpha}$ (dB)

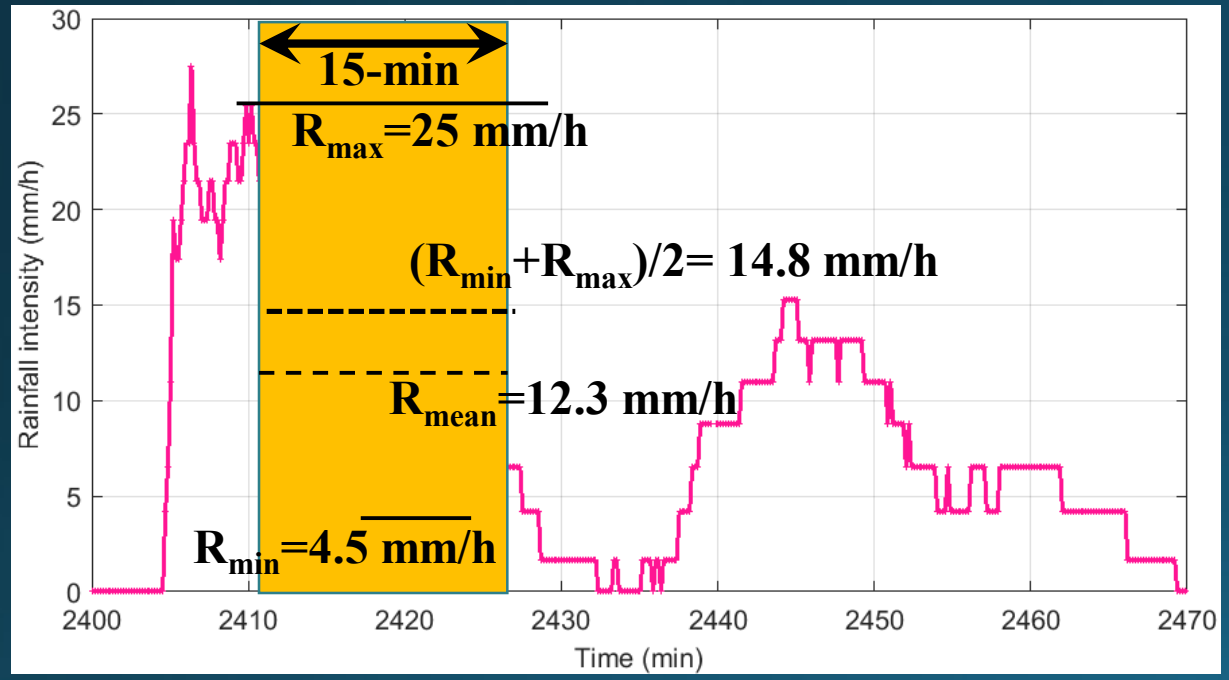
Optimum
κ, α

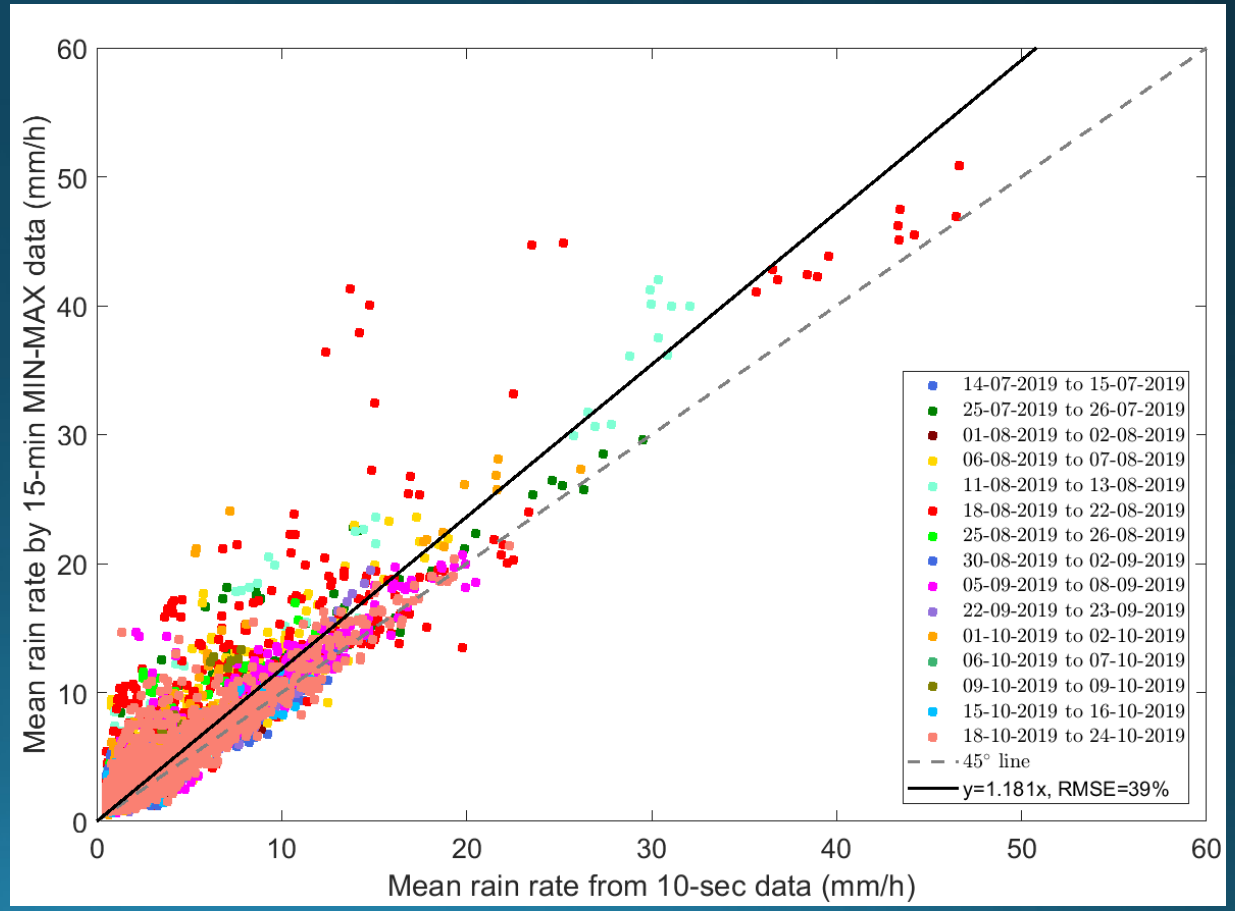


Best fit κ-α @ f=18.8 GHz over 150 hours of rain from two disdrometers are different from ITU-R P. 838-3

Mean rainfall rate by MINMAX data

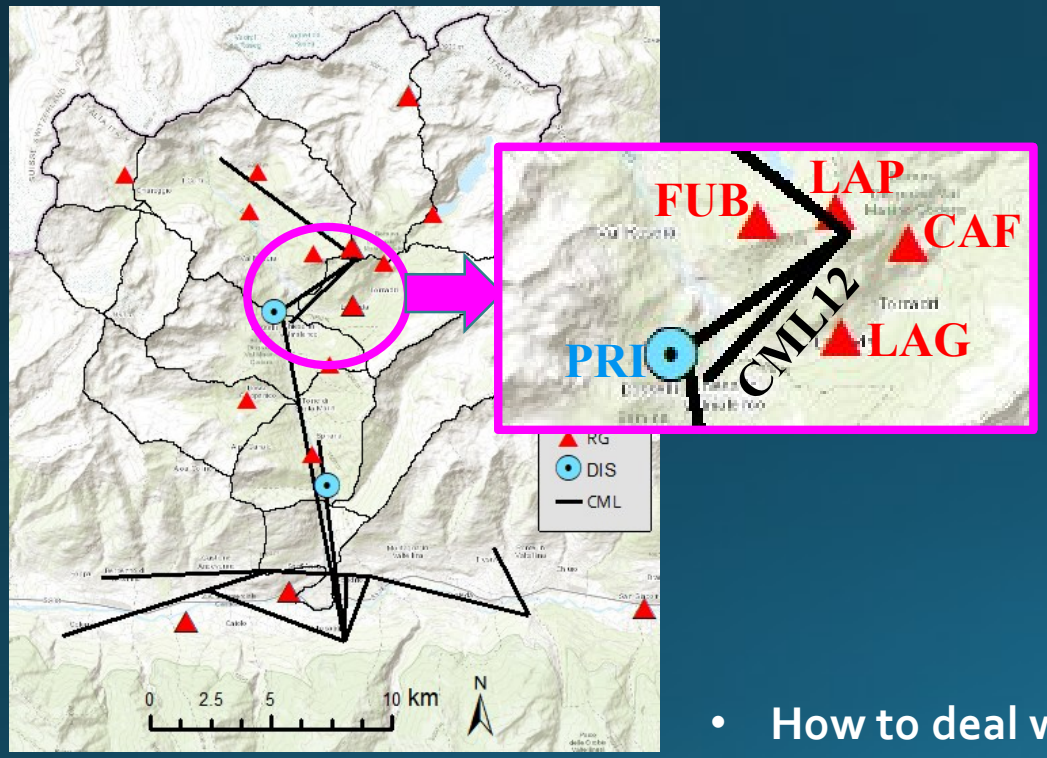
- The average rain rate by MINMAX data (i.e. R_{MIN} and R_{MAX} in a 15-min slot) is biased! By 10-sec data we manage to quantify the bias

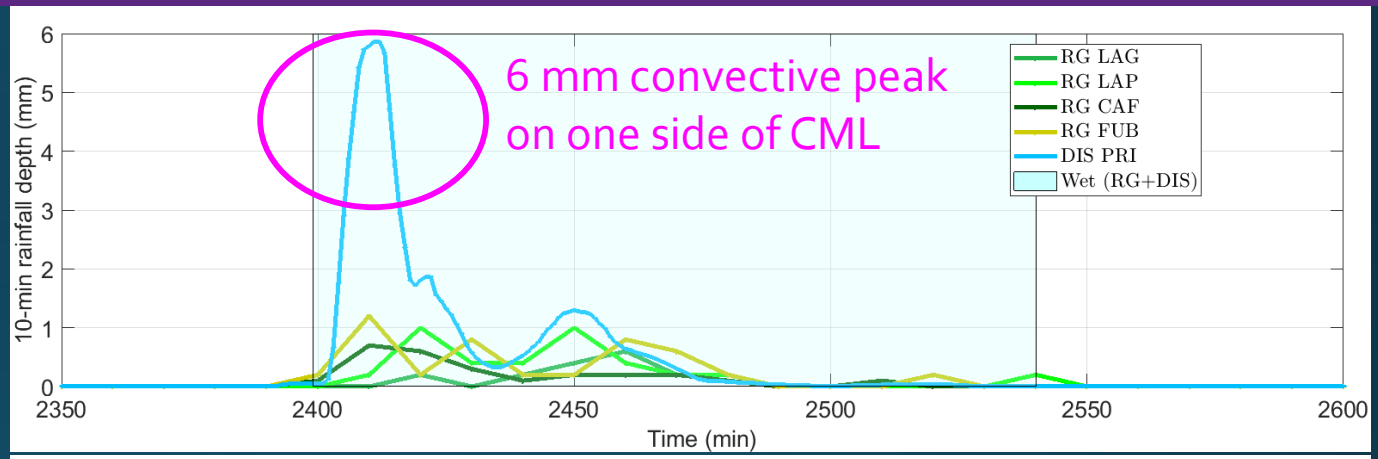


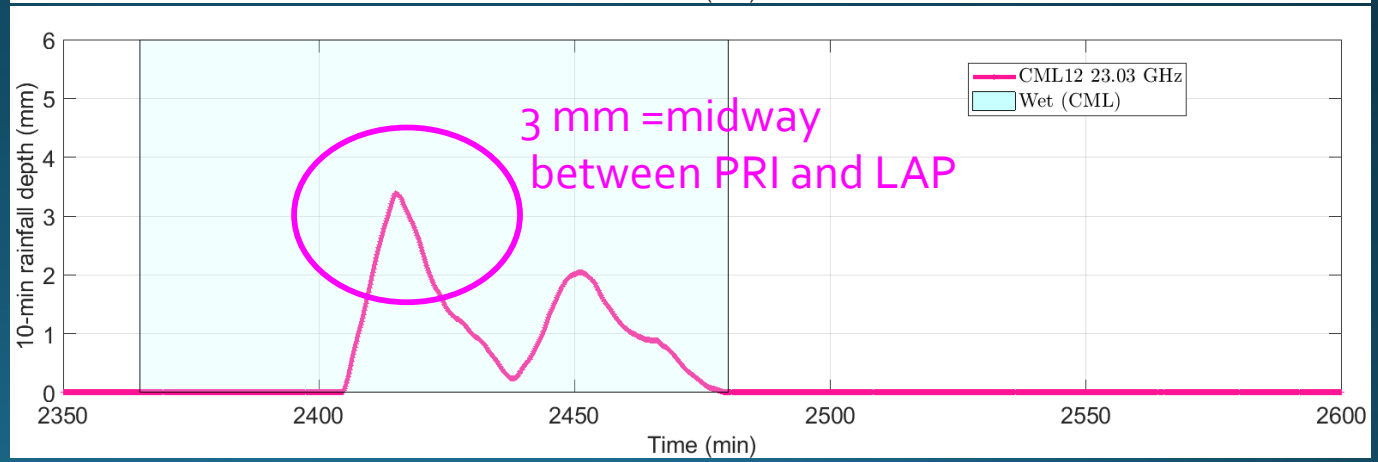


Rain is not uniform along the path

Rain rate from: $A = L\kappa R^{\alpha}$ (this is path averaged rain rate!)

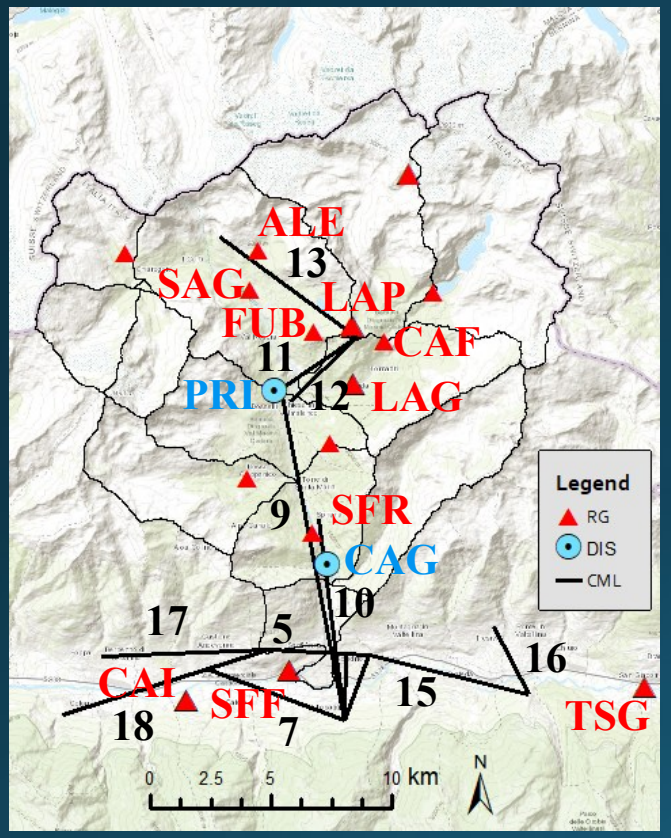


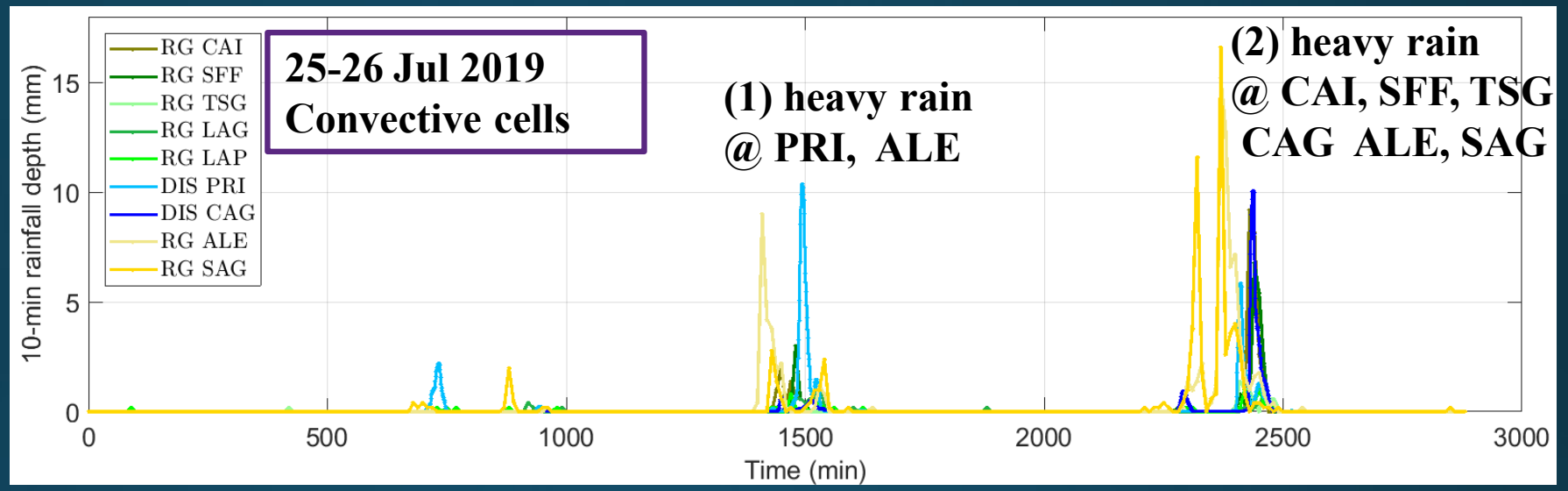


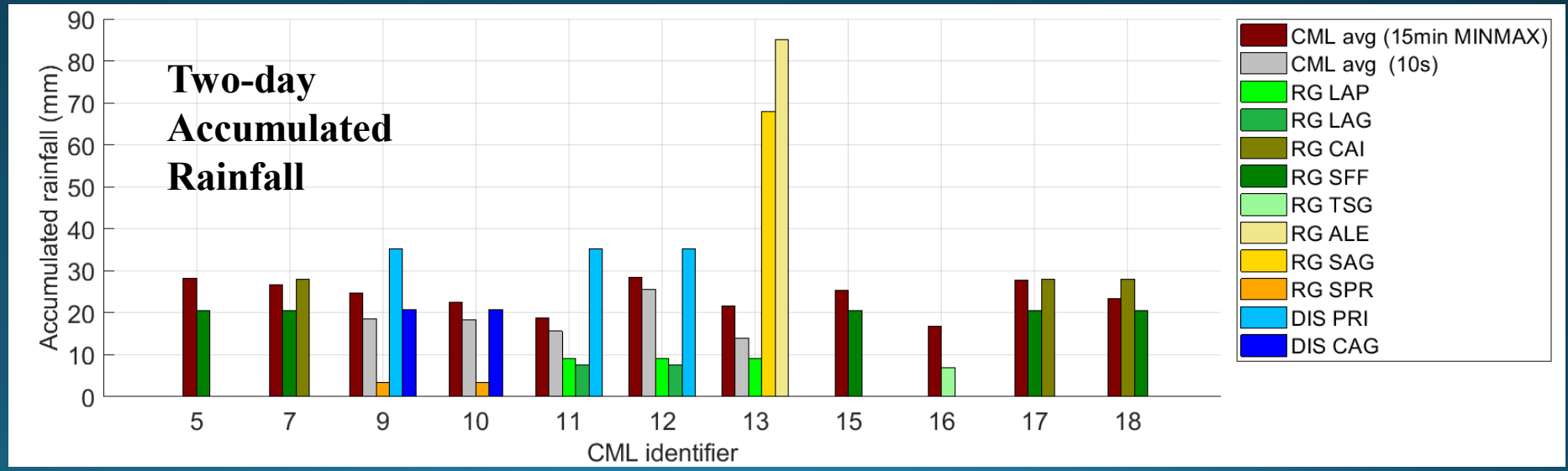


- **How to deal with it? Spatial reconstruction of the rainfall field (if the CML mesh is dense enough) e.g. by tomographic techniques**

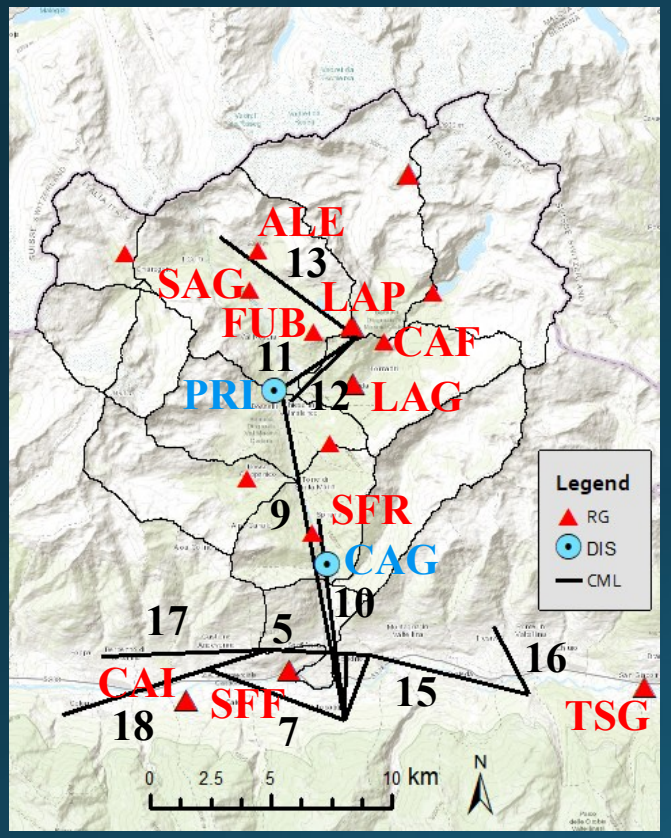
Validation: CML vs RG & DIS, Event #1

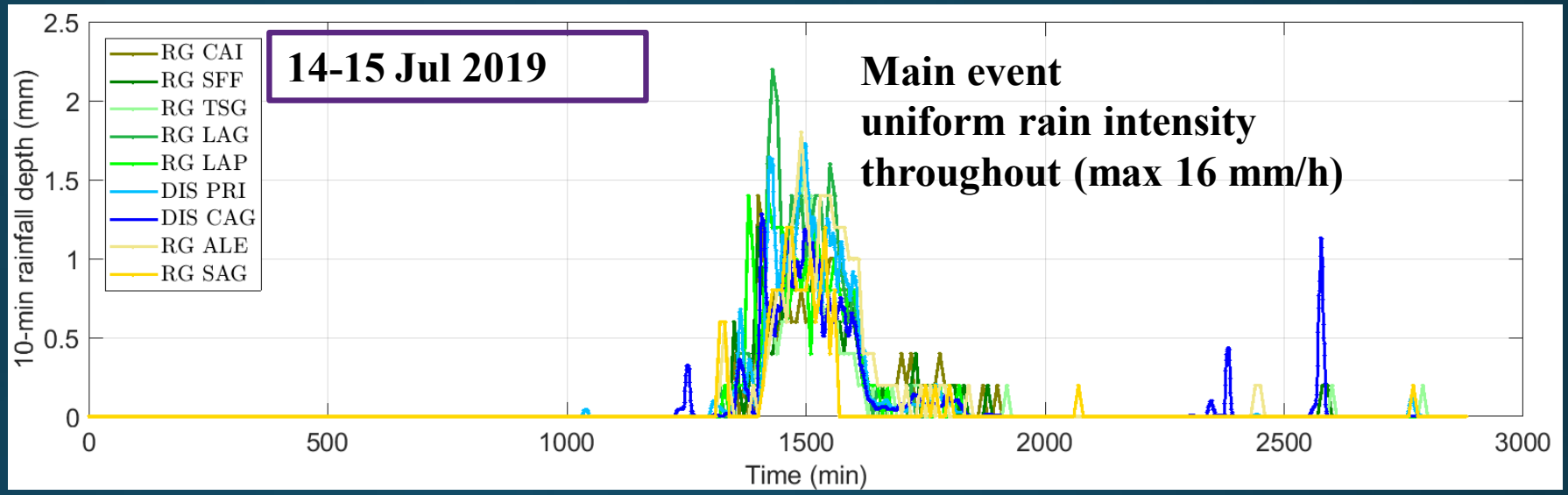


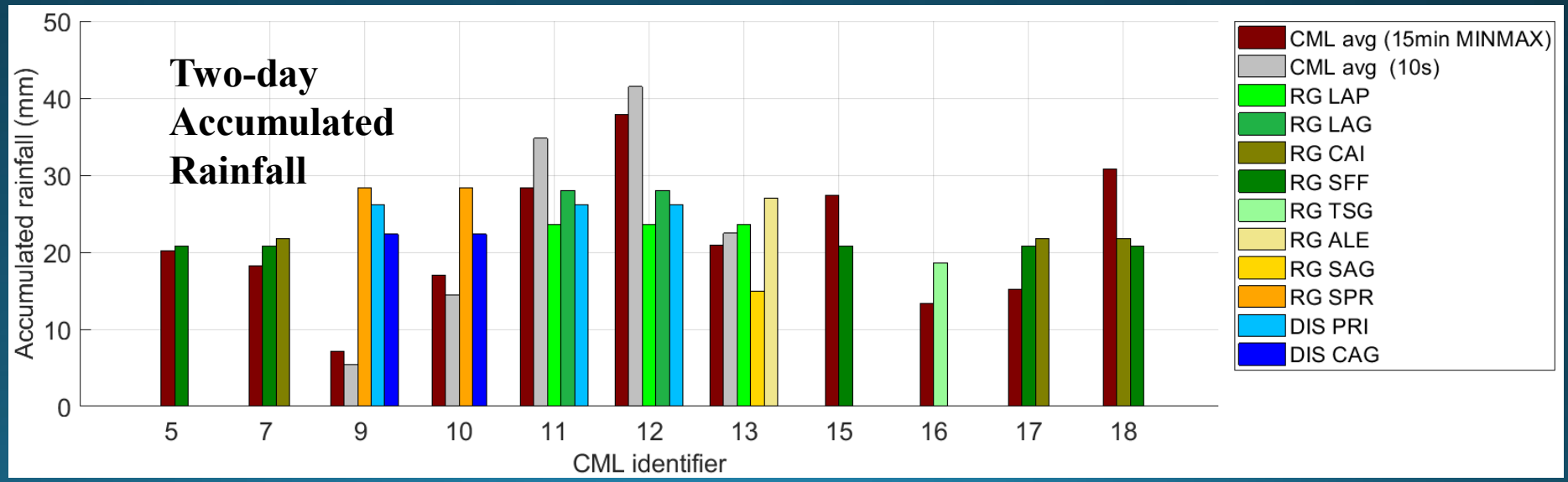




Validation: CML vs RG & DIS, Event #2







Conclusions

Issues of CMLs as rainfall sensors:

- Data format not optimized (quantization, time resolution, only MINMAX values)
- Signal attenuation to rainfall rate conversion
- Rainfall measurement is path averaged

Through basic data processing & CML calibration:

- Fair agreement with rain guages and disdrometers on accumulated rainfall on sample events

How to enhance CML performance:

- 2D rainfall field retrieval
- Calibration by weather radar
- Firmware updates (up to the cellular company)

Thank You By The MOPRAM Team!

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