Rain measurements from opportunistic sensors: insights from radar and disdrometer measurements at SIRTA

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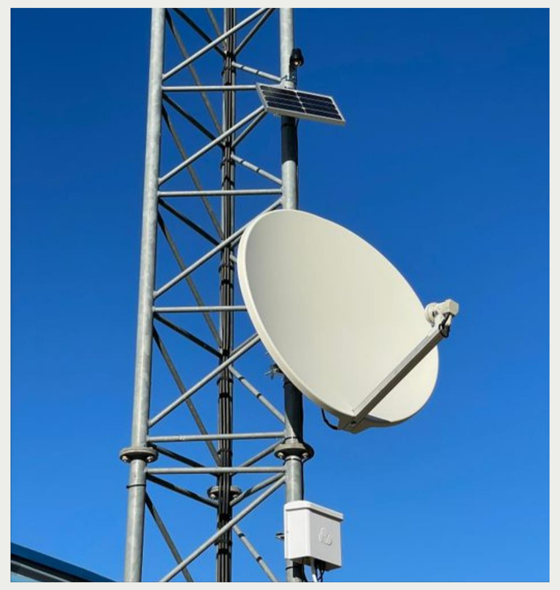
Abstract

Three opportunistic rain sensors have been installed at SIRTA. These sensors allow to measure the power received from commercial TV satellites in the Ku-band. Rainfall is deduced from the attenuation it produces on these signals. Several phenomena cause errors on these rain assessments, notably extra-attenuation due to wet antenna, effects of the melting layer, drop size distribution, or saturation of the signal.
The campaign conducted at SIRTA aims at improve the understanding and parameterization of these phenomena. To do so, rain sensors are installed near two vertically-pointing Doppler radars, ROXI (X-band), and BASTA (W-band), as well as several disdrometers and rain gauges.
Preliminary data from SIRTA will provide initial insights, highlighting the project's potential.

Opportunistic rain measurements

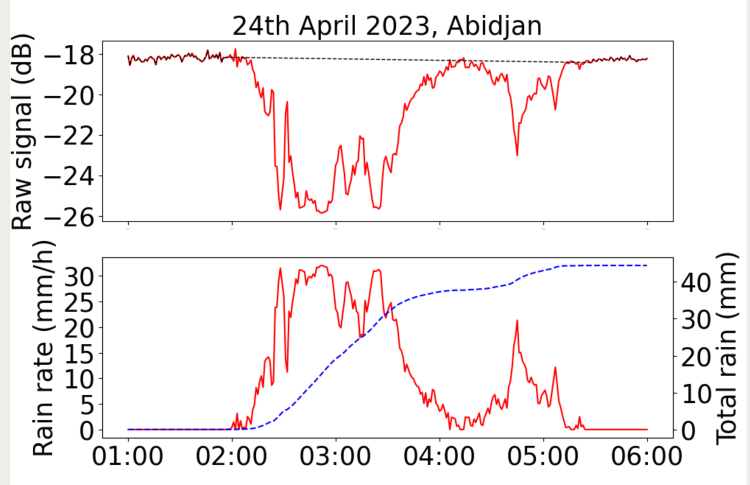
Sensor description



- Measurement: total power received from a TV-satellite.
- Rain assessment from the attenuation produced by rain drops on the signal.
- Ku-band (10.5 – 12.5GHz).
- Sequential measurements at 2 frequencies and 2 polarizations..

Standard rain retrieval (*)

- Standard approach: attenuation over 1 frequency band
- Baseline estimation (machine learning):
- A-R relationship:
  - Freezing level from ARPEGE
  - MP DSD with T-matrix

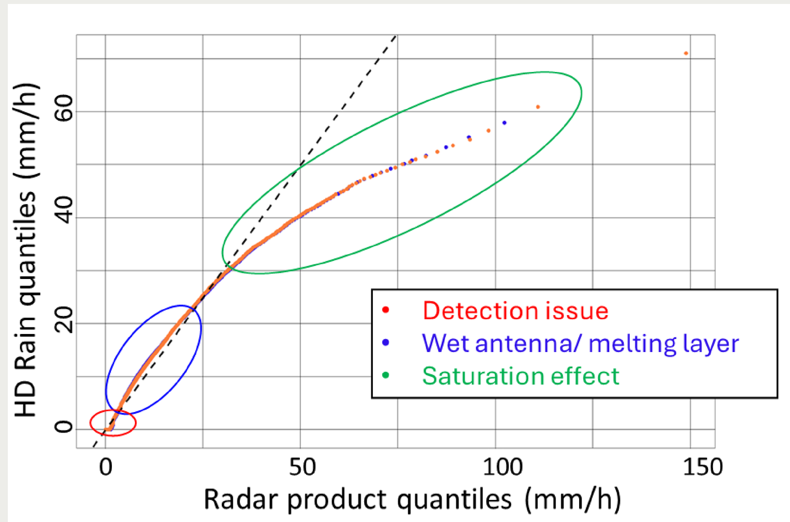


(*) Barthès, L., & Mallet, C. (2013). Rainfall measurement from the opportunistic use of an Earth–space link in the Ku band. *Atmospheric measurement techniques*, *6*(8), 2181-2193.

Limitations

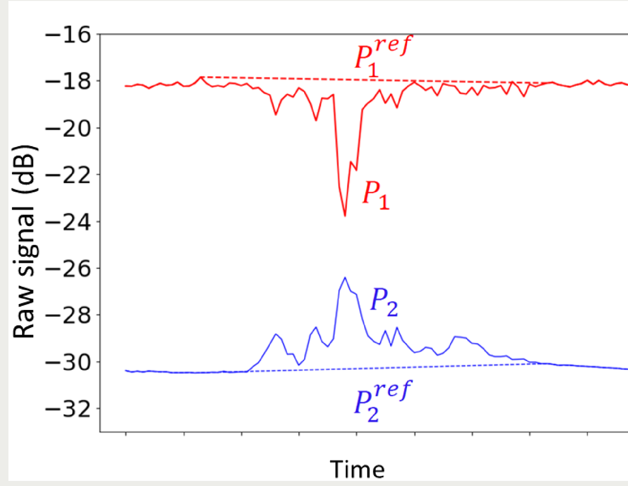
Limitations

- Systematic Errors:
  - Underestimation of heavy rainfall
  - Overestimation of low rainfall
- One-off errors :
  - False detection compare to a product reference
  - Undetected rain event



Saturation effect and dual channel approach

- In case of heavy rainfall, the attenuation of the signal is compensated by the background noise increase due to rain.
- For some satellites, the noise increase in rain is directly measured (blue line), which allows to correct the rain transmittance estimation :



$$(1)\ t_R = \frac{P_1 - P_2}{P_1^{ref} - P_2^{ref}}$$

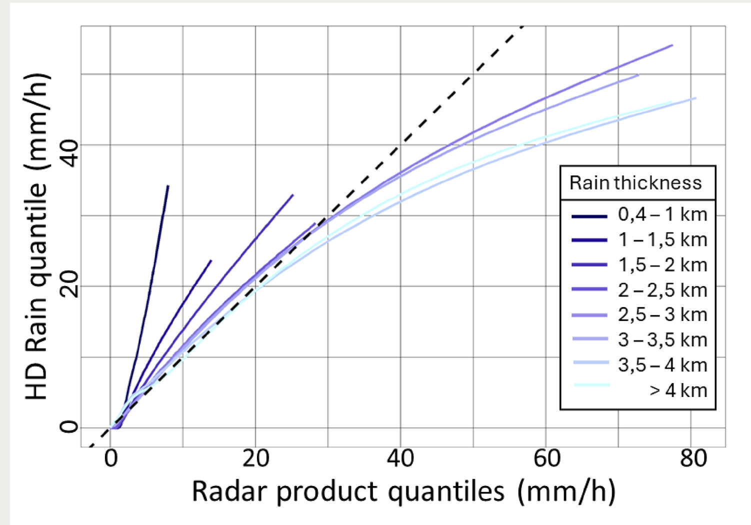
- In Ivory Coast: remaining underestimation

Wet antenna

- Thin film of water on the LNB attributed to rain, leading to overestimation
- Significant effect on light rainfall

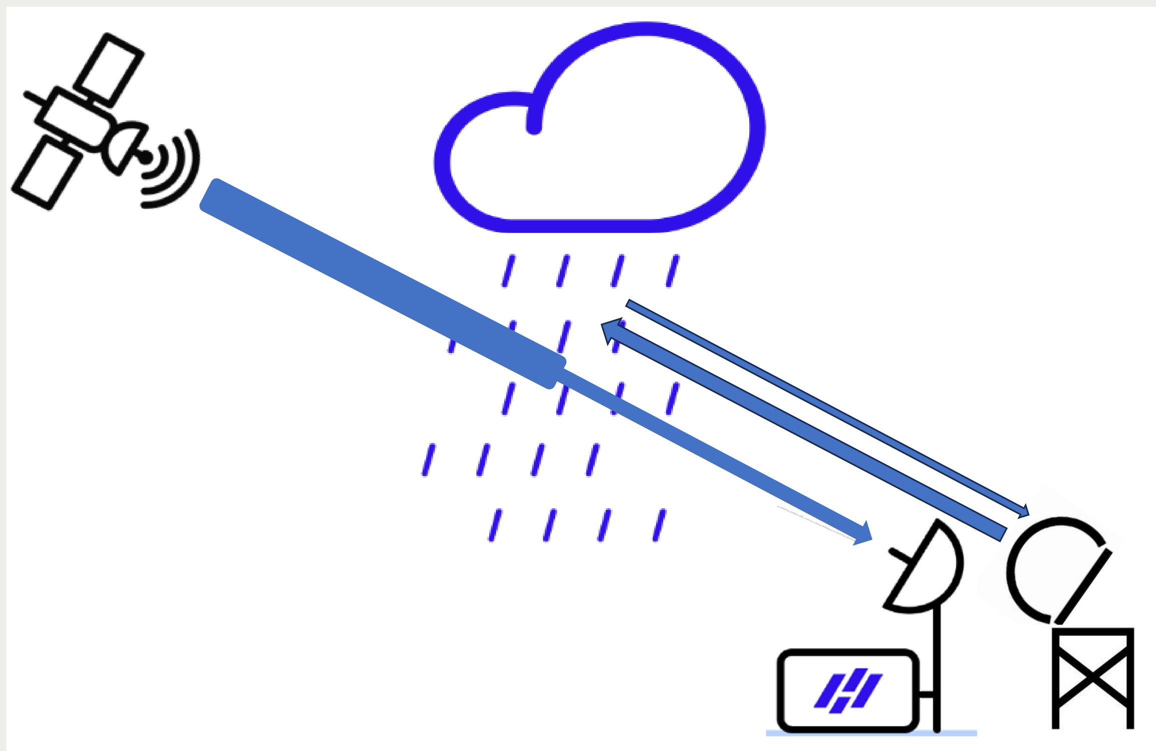
Melting Layer

- Overestimation due to ice cristal surrounded by liquid water in the melting layer.

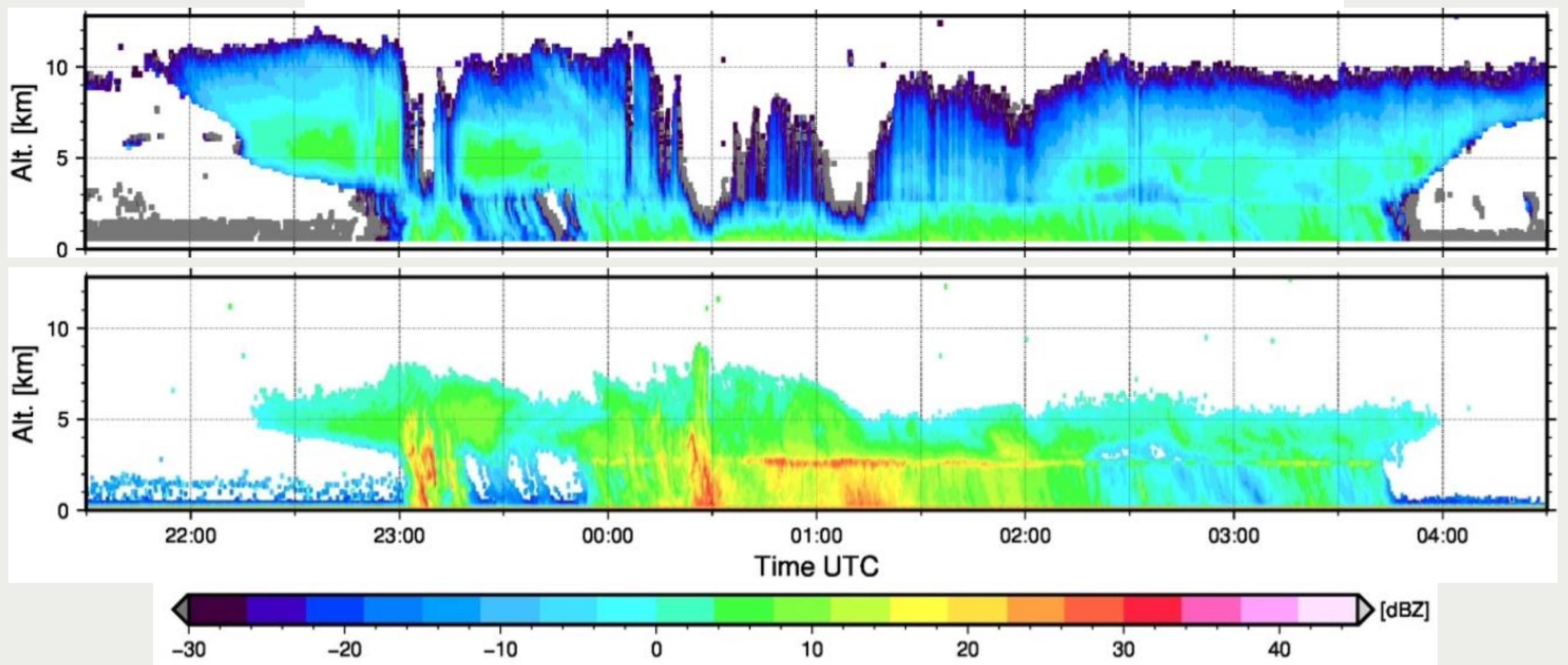


$$(2)\ A = aR^b L_R + aR^b m_x L_{ZdF} + A_0\left(1 - e^{-\frac{R}{R_0}}\right)$$

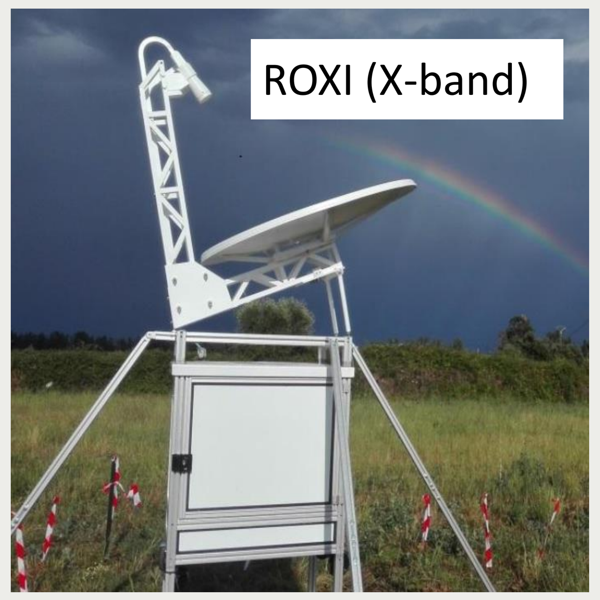
Instruments



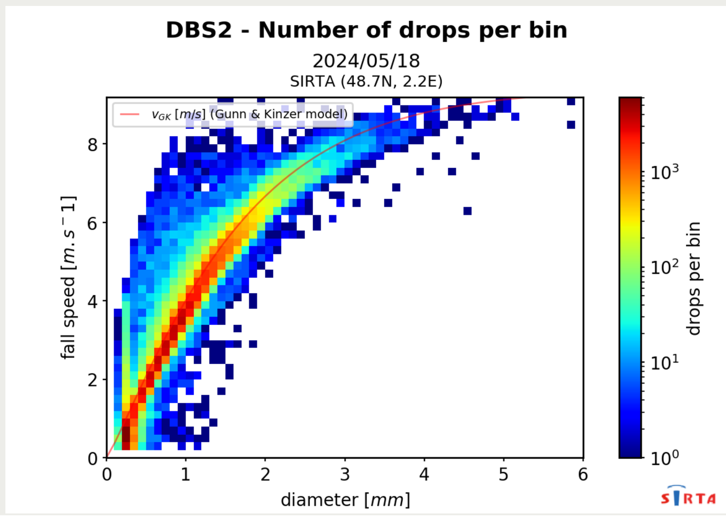
Example of BASTA vs. ROXI daily reflectivities



HD Rain sensor @SIRTA



- 2 vertically-pointing radars
- ROXI, X-band, 9.4GHz
- BASTA, W-band, 95GHz
- Disdrometer
- 3 HD Rain sensors
- Rain gauges



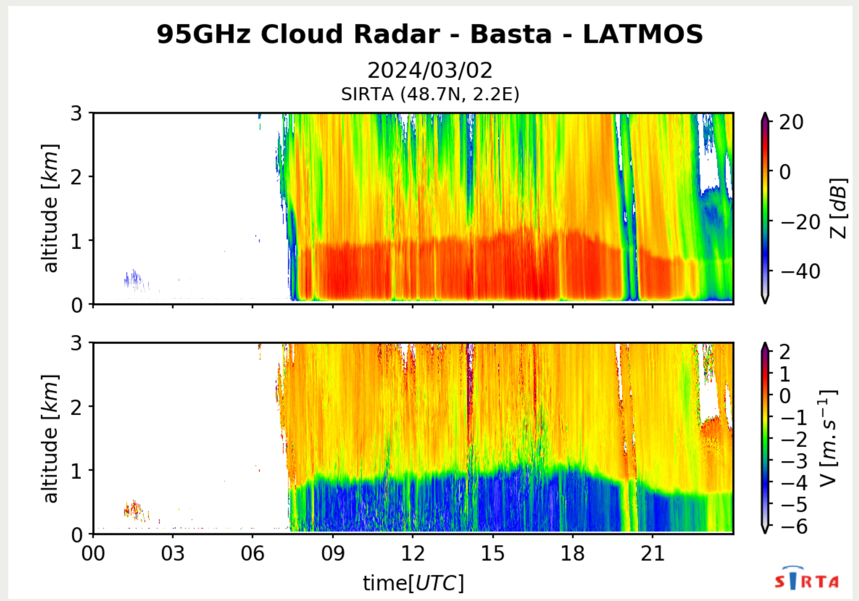
Example of DBS measurements @SIRTA (18/05/2024)

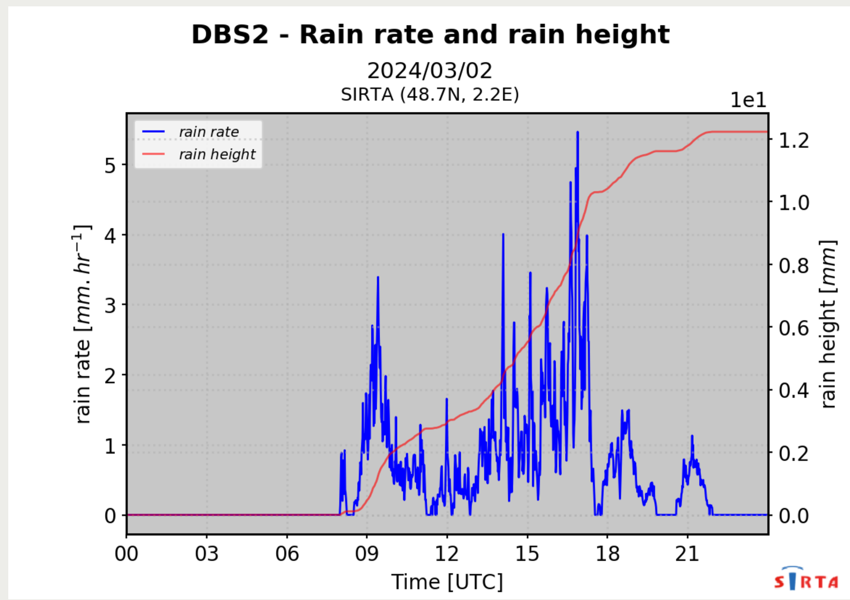
Viltard et al. 2019
Barthès 2010
Leaître et al. 2019

Perspectives

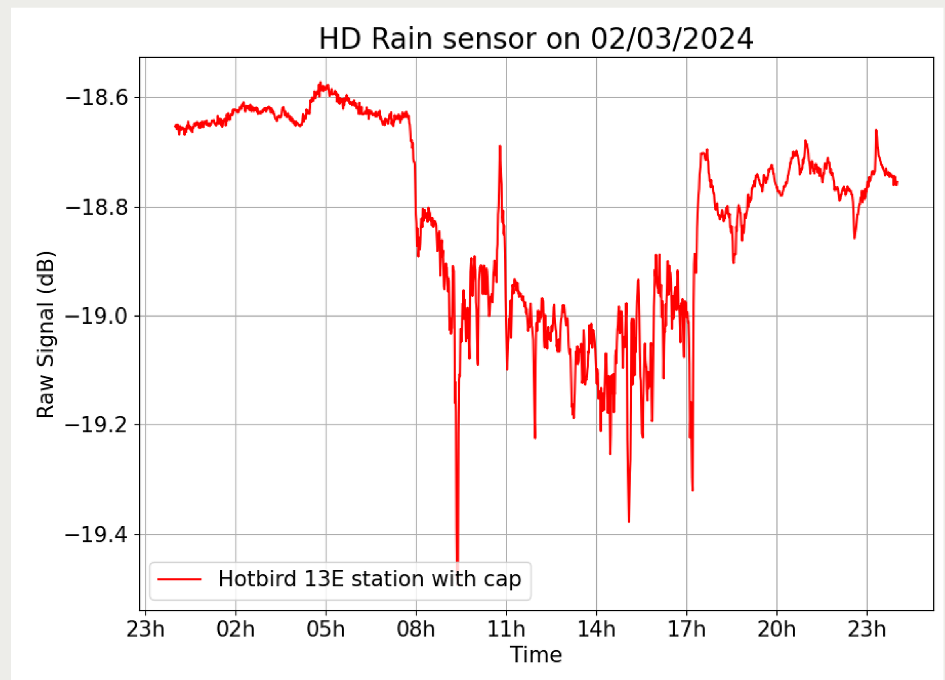
2 March 2024

Data from Basta and the DBS disdrometer





Data from HD Rain sensor



To be continued

- Compare and understand the different effects that affect our measurements, with colocated instruments:
  - Radar data (iso0, melting layer)
  - Disdrometers (DSD)
  - Rain gauges (rainfall)
- Parameterize the terms in the equation (2)