

Rainfall retrieval from commercial microwave links : from a validated potential towards worldwide operational applications (?)

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Summary

Microwave backhaul links from cellular communication networks provide an *opportunistic*
20 source of high-resolution space– time rainfall information, complementing traditional in situ measurements (rain gauges, disdrometers) and remote sensing (weather radars, satellites). Over the past decade, a growing community of researchers
25 has demonstrated the potential of this technique through experimental pilot sites in several European countries, Israel and more recently in Africa, in close collaboration with cellular communication companies. Open source retrieval algorithms have
30 been developped, that convert the raw data stored by telecom operators operational management systems, into rainfall estimates. Operational meteorological and hydrological services are

showing an increased interest in using this
35 complementary source of rainfall information to improve the products and services they provide to the population. The greatest potential of these opportunistic environmental sensors lies in those geographical areas over the land surface of the Earth
40 where the densities of traditional rainfall measurement devices are low: mountainous and urban areas, and above all the developing world. Different sectors of activities and downstream services could benefit from the operationalization of
45 this innovative technique if the delivery of the raw data from the mobile operators were guaranteed: water planning ; flood or weather prediction and risk management ; agriculture ; insurances ; traffic control or post-disaster organization.
50 International agencies, hydro-meteorological experts and telecommunication regulators/operators

should start a common reflection to make communication network based rainfall measurement an operational reality.

5 Rainfall retrieval from commercial microwave links (CML) : Principle

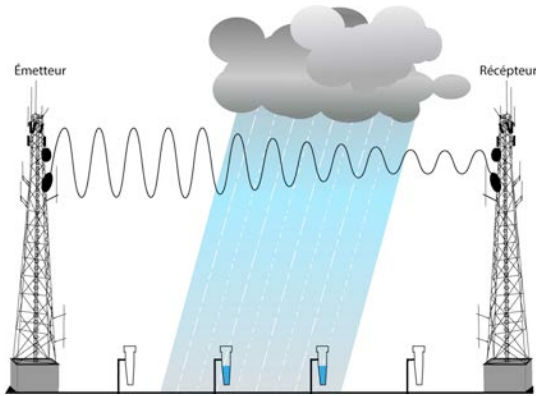


Figure 1 (copyright AM Cousin, GET) – Principle of CML based measurement. The micro-wave signal between the telecom backhaul antenna is attenuated by rain. If this attenuation is measured it can, be used to estimate the mean rainfall over the link.

Rainfall measurement by CML is based on the robust relationship between micro-wave signal attenuation and rainfall intensity over the link (between two telecommunication antennas). This principle is summarized in Eq 1::

$$PIA = aR^b \times L, \quad (1)$$

the Path Integrated Attenuation (PIA in dB) measured by the link of length L, can be related to the Rainfall intensity over the link (R), through a simple power law relation – the coefficients a and b

depend on the operation frequency and can be estimated easily. a increases with frequency. b is close to 1 (0.5 to 2) for common telecom frequencies and the relation is quasi-linear near 30 GHz. If the PIA is provided by the mobile operator, Eq 1 can be inverted to estimate rainfall all over the network.

The accuracy in rainfall measurement using the CML network and equation 1 depends on many factors such as the variability of the coefficients a and b in Eq. 1; the density and length of the links ; the accuracy of the PIA itself. The latter depends on the method used by the operator to collect and record the raw power levels (typically accuracy of 1 dB or 0.1 dB are common).

40 CML rainfall measurement pilot sites in Africa : a step further towards operationalization of this technique in developing countries.

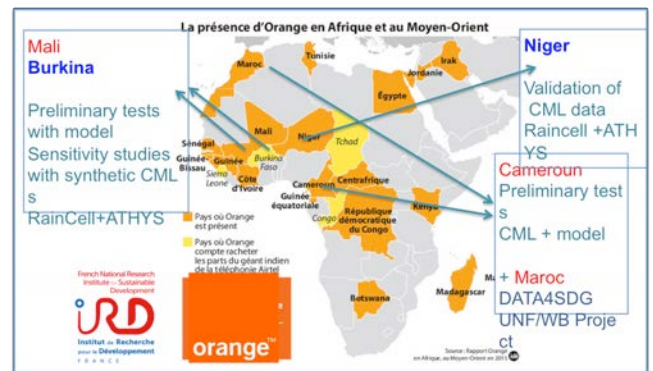


Figure 2 (copyright IRD and Orange) – A summary of the 5 pilot sites that IRD has set up in Africa in order to test and promote operational use of CML based measurement of rainfall.

As part of three WB/GFDRR/KGGF/UN-data4SDGs supported programs (Rain Cell in Burkina Faso, Mali –with KGGF- and Niger, SMART in Cameroun/Morocco) IRD was able to test operationalization of the mobile-data driven system for monitoring rainfall.

The technological approach proposed in Rain Cell/SMART is a three-stage processing/visualization of the data: i) collection and provision through dedicated server of the radio signals transmitted/received levels over the mobile phone networks (with 15-minute time steps); ii) open source software for transformation of signal level into rainfall intensities and 2D maps; and iii) integration of rain maps in flood model and visualization of flood risk maps – including possible diffusion of flood alerts through mobile networks.

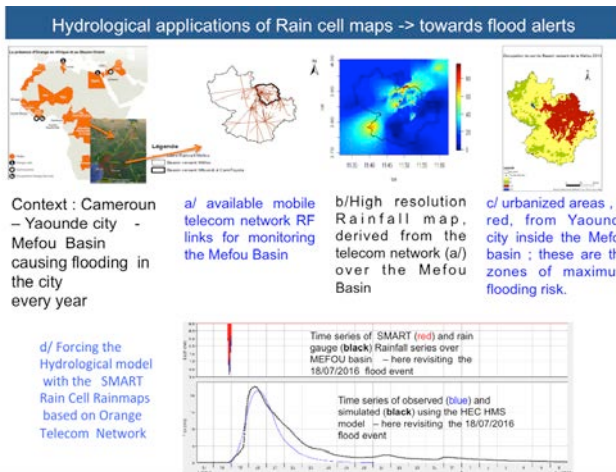


Figure 3 : summary of the SMART project objective in Cameroun

A new step in operationalization of the technique was achieved in 2018 with the first ever set up of a **real time flux of data** (15 minutes time step) from a mobile operator continuously over the season. Since May 2018, through an IRD-Orange collaboration RT monitoring of rainfall is demonstrated on the pilot sites of Yaounde and Douala in Cameroun ; and a similar system for Niger should follow closely.

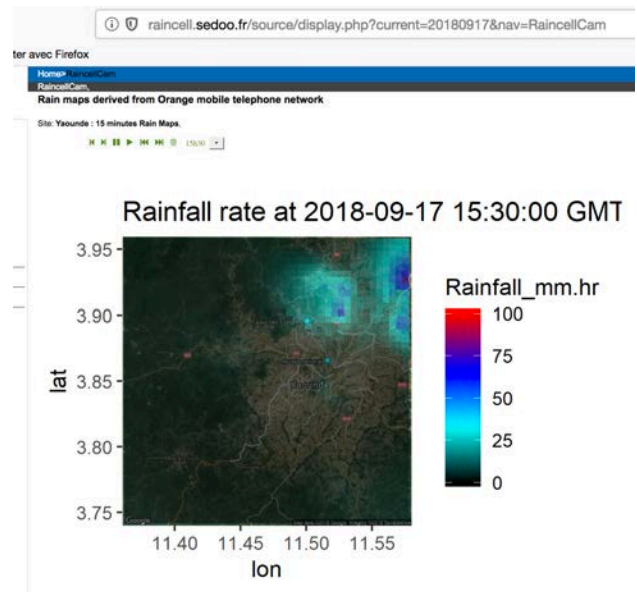


Figure 4 : first RT monitoring of Rainfall based on CMLs in Africa. Here Cameroun (city of Yaounde for this example) with provision by Orange of a 15 minutes time step data flux over more than a thousand links, country wide. An open source code (based on R Shiny package) developed by IRD provides high-resolution rain maps from this CML data every 15 minutes over the web site.