CALIBRATION OF THE ATTENUATION-RAIN RATE POWER-LAW PARAMETERS USING MEASUREMENTS FROM COMMERCIAL MICROWAVE NETWORKS

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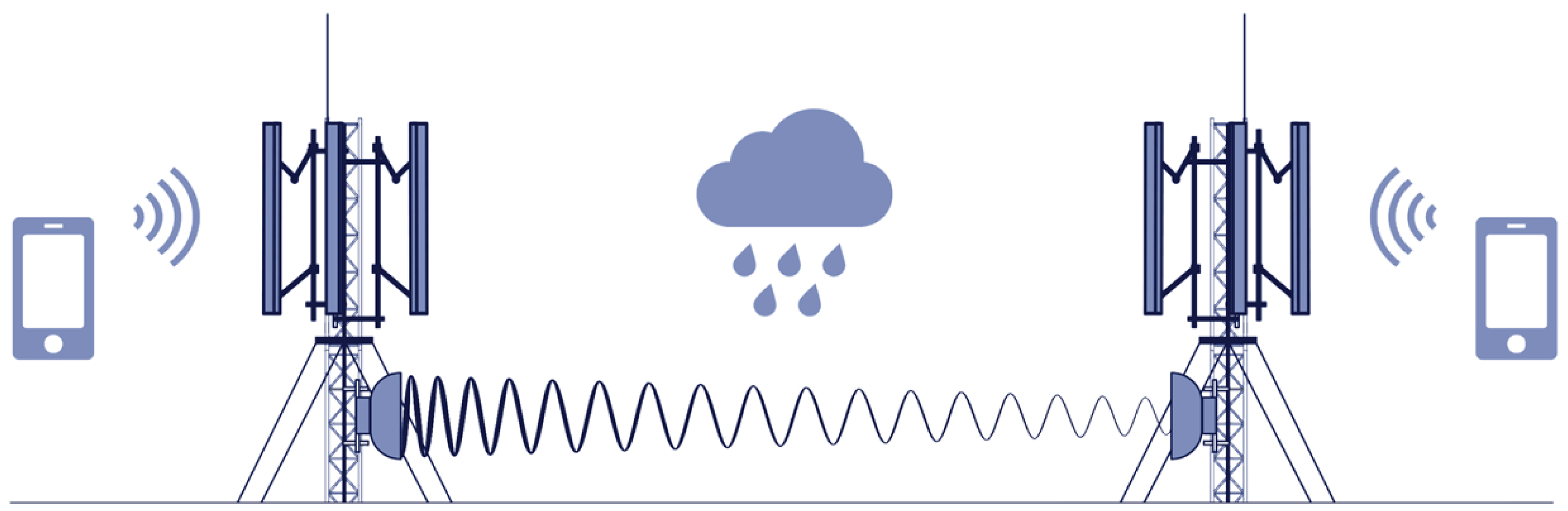
MOTIVATION

THE POWER - LAW

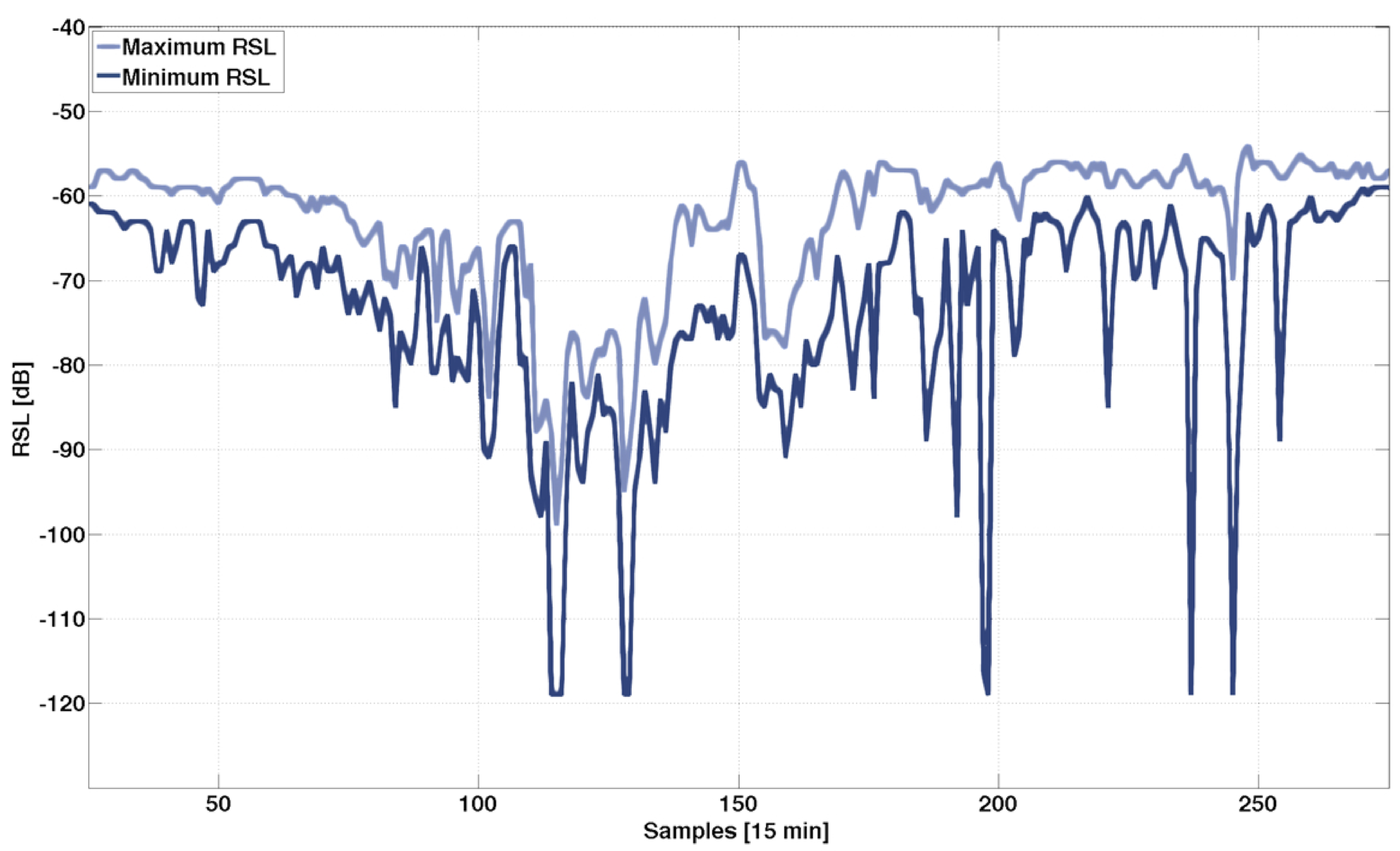


The relationship between Microwave Link (ML) induced attenuation A (dB) and the rain-rate R (mm/h) is given by the "Power-Law" [1]:

$$A = a \cdot R^b L$$

Where L is the link's length, and a & b are the Power-Law parameters. Their values are regularly updated [2].

ACTUAL ATTENUATION MEASUREMENTS



The cellular operators log only the minimum and the maximum measured Received and Transmitted Signal Levels, for every 15-minute interval.

The Motivation: To calibrate the values of the a & b parameters, in order to enhance the accuracy of the Power-Law locally.

The Challenge: To estimate the a & b parameters when only extreme attenuation measurements are available.

METHODOLOGY

THE RAIN-RATE STATISTICS

The rain-rate intensity has been shown to follow the exponential distribution [3]:

$$f_{R_i}(r, t_i; \theta) = \frac{1}{\theta} e^{-r(t_i)/\theta}$$

And so, the average rain-rate can be substituted with the rain-rate expected value:

$$R_{avg} = \hat{E}[R_i] \underset{N\to\infty}{\to} E[R_i] = \theta$$

Which can be further developed for the rain-rate extremes:

$$E\left[R_i^{min}\right] = \frac{\theta}{K}$$

$$E\left[R_i^{max}\right] \approx \theta \cdot \left(\ln(K) + \gamma\right)$$

EXTREME ATTENUATION POWER-LAW

From the expected values of the rain-rate extremes, the "extreme" version of the Power-Law can be formalised:

$$\hat{E}[R_{avg}^{min}] = \frac{\sum_{i=1}^{M} (A_i^{min})^{\frac{1}{b}}}{M(a \cdot L)^{\frac{1}{b}}} \approx \frac{\theta}{K}$$

$$\hat{E}[R_{avg}^{max}] = \frac{\sum_{i=1}^{M} (A_i^{max})^{\frac{1}{b}}}{M(a \cdot L)^{\frac{1}{b}}} \approx \theta(\ln(K) + \gamma)$$

THE a & b CALIBRATION

By substituting the expected values of the rain-rate extremes with the measured averaged rain-rate value, the following relationships hold:

$$R_{avg} \approx \frac{\sum_{i=1}^{M} (A_i^{min})^{\frac{1}{b_{cal}}}}{M(a_{cal} \cdot L)^{\frac{1}{b_{cal}}}}$$

$$R_{avg} \approx \frac{\sum_{i=1}^{M} (A_i^{max})^{\frac{1}{b_{cal}}}}{M(a_{cal} \cdot L)^{\frac{1}{b_{cal}}}}$$

Which, connects the "original" Power-Law a & b parameters with the parameters of the "extreme" Power-Law.

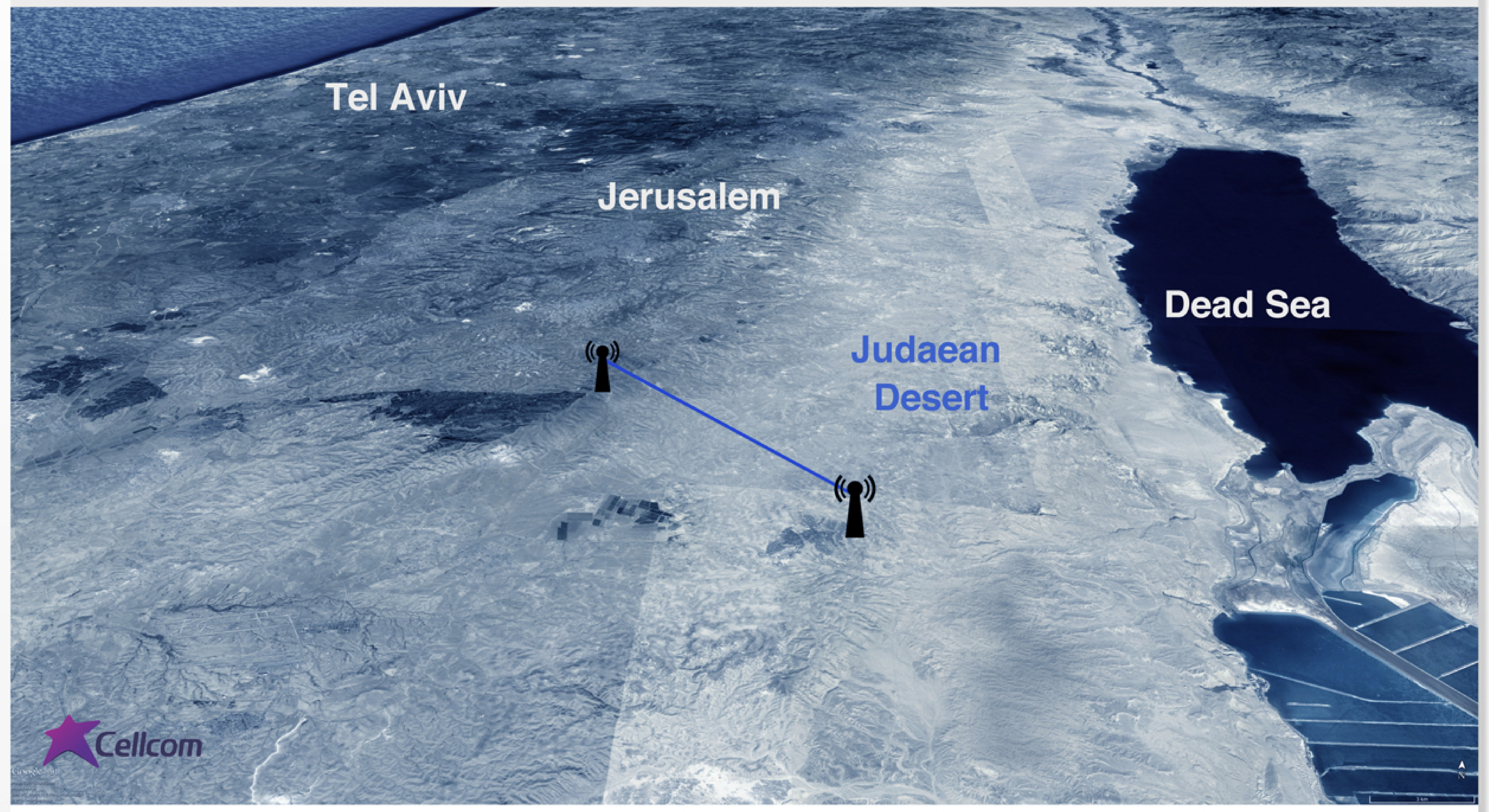
And, the a & b parameters of the original Power-Law can be estimated!

$$a_{cal} = \begin{cases} \frac{a}{K^b} & ; \text{for} \quad A_i^{min} \\ a \cdot \left(\ln(K) + \gamma\right)^b & ; \text{for} \quad A_i^{max} \end{cases}$$

$$b_{cal} = b$$

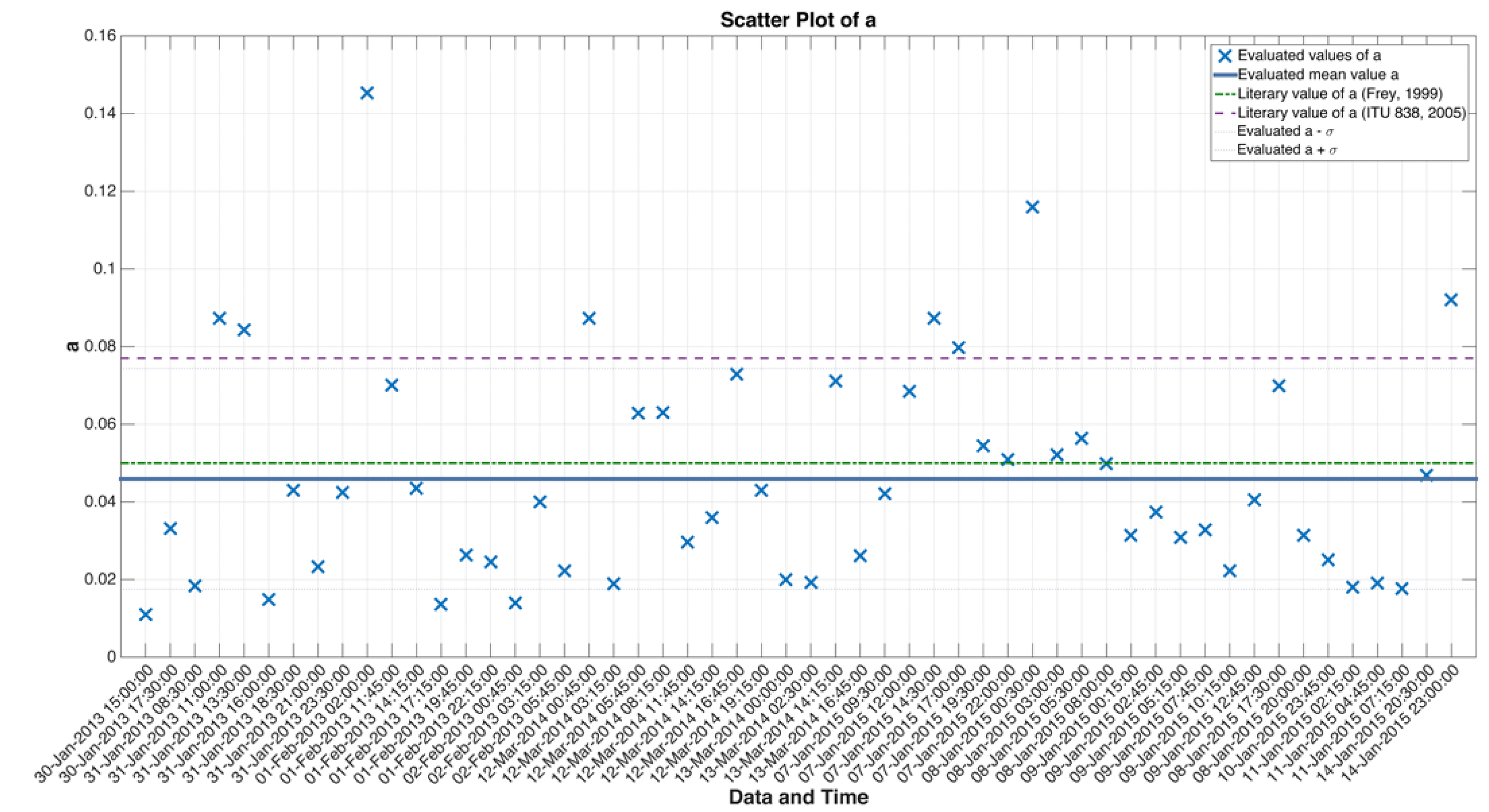
EXPERIMENTAL RESULTS

EXPERIMENTAL SETUP



The maximum attenuation levels from a 16km microwave link, located in the semi-arid Judaean Desert were observed, as well as measurements from standard rain-gauges (near each tower).

CALIBRATION RESULTS



From January 2013 until February 2015, 54 rainy periods were analyzed. For each event, the value of the parameter a was calculated.

And, the calibrated values were found:	Compared to the literary values [2] of:
$a = 0.046 \pm 0.028$	$a = 0.077$
$b = 1.074$	$b = 1.074$

CONCLUSION

In this research we presented a new approach for calibration of the Power-Law parameters, using the available commercial microwave links min/max attenuation measurements, and measurements from standard rain-gauges. This calibration process was tested in a real world scenario, and showed promising results.

1. Olsen R., Rogers D., and Hodge D. The ar^b relation in the calculation of rain attenuation. *IEEE Transactions on Antennas and Propagation*, 26:318-329, 1978.
2. ITU-R. Specific attenuation model for rain for use in prediction methods. ITU-R, P. 838-3, 2005.
3. Dan'azumi, Salisu, Supiah Shamsudin, and Azmi Aris. "Modeling the distribution of rainfall intensity using hourly data." American Journal of Environmental Sciences 6.3 (2010): 238-243.

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