Radiocommunication Study Groups

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Poland (Republic of)

COMPARISON OF MEASUREMENTS CAMPAIGN DATA WITH THE RECOMMENDATION ITU-R P.1546-5 PROPAGATION MODEL ANALYSIS FOR DIFFERENT DIGITAL ELEVATION MAPS (DEM)

1 Introduction

The important factor in the calculation of electric field strength distribution by the Recommendation ITU-R P.1546-5 propagation method is the digital elevation map (DEM) applied during the computing process. Based on the DEM implementation both transmitting/base antenna height (*h1*) and terrain clearance angle (TCA) for a receiver are calculated. A different implementation of the map reading/sampling algorithm and various DEMs used have a significant impact to final outcomes. Recommendation ITU-R P.1546-5 however, does not provide any detail information concerning accurate and appropriate DEM implementation.

This document presents the comparison of the calculated field strength values by Recommendation ITU-R P.1546-5 with measurement data for the VHF band for two different DEMs with various levels of accuracy. These analyses were conducted for two regions in Poland. First (designated as "Augustów") was a typical flat, open, rural and forest area. The second one ("Warsaw") was an urban/and suburban region with a transmitter antenna located in the city centre.

TABLE 1

The receiver clutter types comparison

Receiver clutter type	Augustów	Warsaw
Open	**82,27%** (7 134 samples)	**65,32%** (18 378 samples)
Suburban/urban	**17,73%** (1 537 samples)	**34,68%** (9 758 samples)

The analyses were conducted for the purpose of the verification of the map and its parameterization impact to the final calculated electric field strength by Recommendation ITU-R P.1546-5. As is presented, there is a correlation between DEM parametrization and calculated field strength values. Results and their interpretation are shown in paragraph 3.

Based on our outcomes it is suggested to add information to Recommendation ITU-R P.1546-5, which informs that "a very dense sampling step of the path profile and very high resolution of DEM could excessively decrease the calculated value of electric field strength, especially in

urban/suburan environments". For obtaining comparable outcomes it is worth to consider also to provide in Recommendation ITU-R P.1546-5 specific recommended values for a) terrain profile sampling step b) horizontal resolution of DEM.

2 Digital elevation maps

The scenario based on two different DEMs: SRTM 4.1 and so called GUGIK NMPT. The first one is well known, the latter was developed by the Polish Head Office of Geodesy and Cartography. According to the SRTM documentation, its horizontal resolution equals 3" (ca. 60x90 m in Poland) with +/- 16 m vertical error for 90% of points. GUGIK NMPT has got a bare horizontal resolution 0.5 and 1 m with average 0.2 m height error. Figures 1 and 2 present the described DEM height rendering for the same city areas.

FIGURE 1

GUGIK NMPT. The elevation height render (city of Wroclaw)

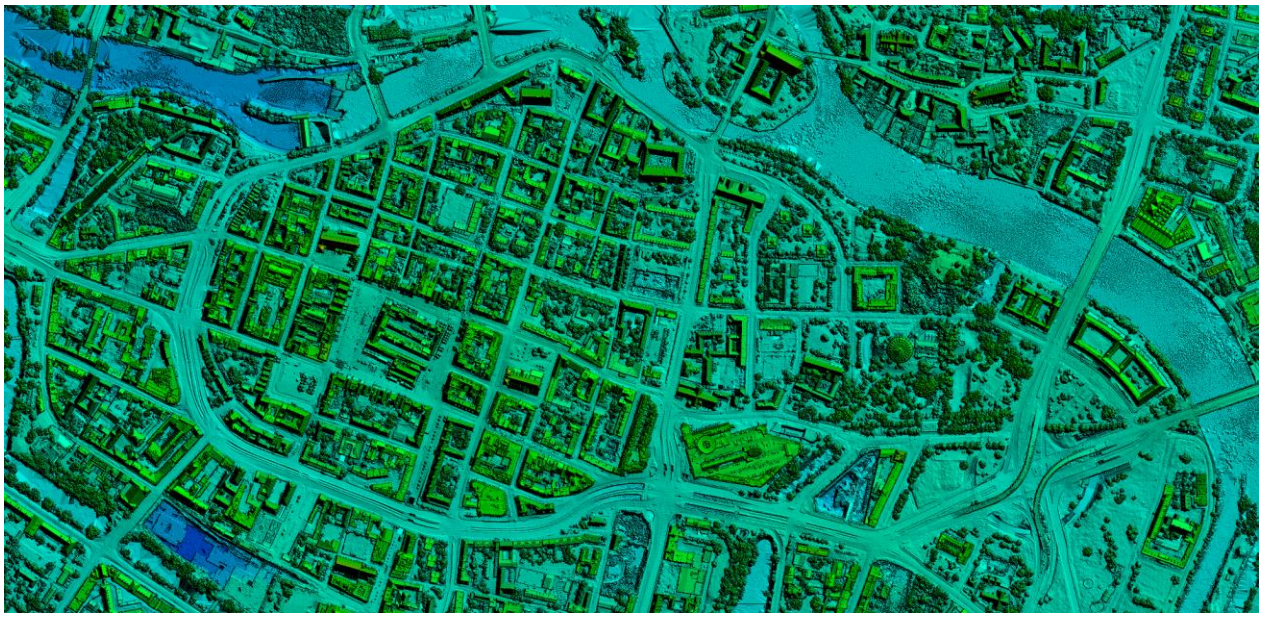
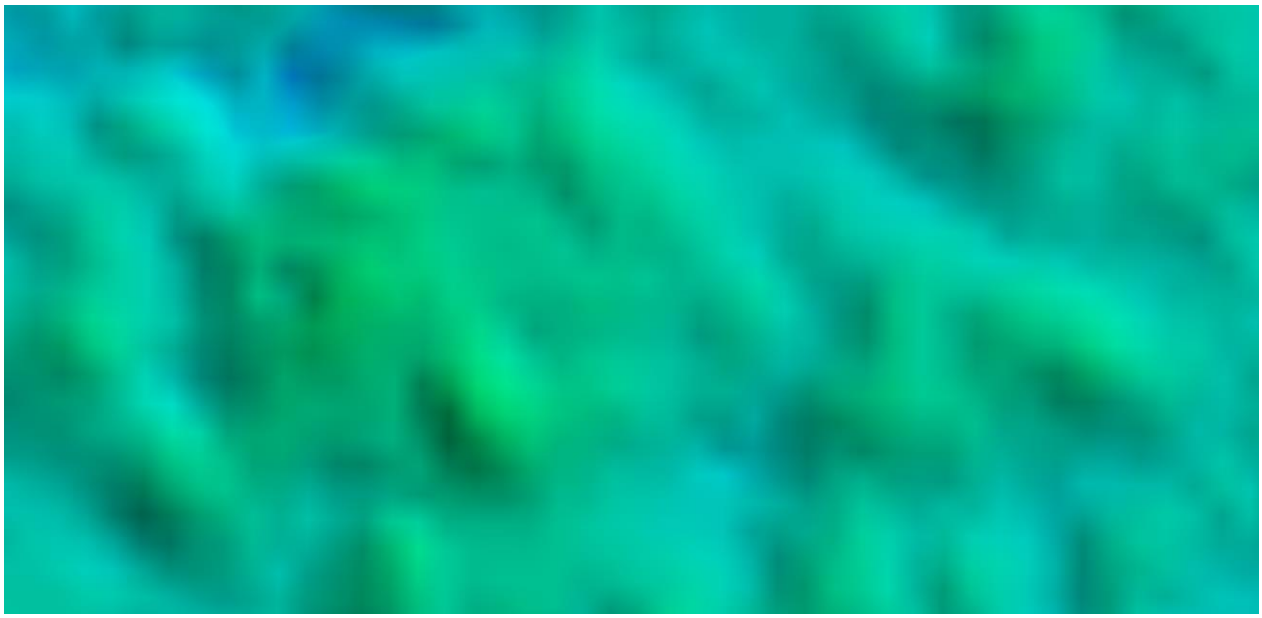


FIGURE 2

SRTM. The elevation height render (city of Wrocław)



3 Measurement campaign scenario

The measurement campaign encompasses two regions and the two narrowband stations working in the VHF band. Those two groups were scrutinized separately in further study. All data were collected as mobile measurements – with reception at 2.1 m above the ground.

TABLE 2

The base stations basic parameters

Region	system	f [MHz]	Location	e.i.r.p. [dBW]	Antenna height [m]
Augustów	Analog PMR	149.075	53.839317N 22.990313E	15.7	30
Warszawa	NXDN	166.040625	52.212007N 21.020995E	15.42	62

During the measurement campaign the areas were free from interfering signal. Before measurements the radio interfering noise was checked in some random places within the coverage of station. The distance between measurement samples was chosen at a length of at least 0.8λ. The samples for each 40λ were averaged. In this way 1 dB confidence interval around the real mean value was obtained. This procedure was conducted in a dedicated vehicle during the measurements trial.

Equipment:

– Spectrum analyser R&S FSP 13 GHz
– Scanner R&S TSMW
– GPS receiver Garmin 18 LVC

– LabView Software

– Antenna Radmor 30834 λ/4

4 Results

All the Recommendation ITU-R P.1546-5 simulations were based on two digital elevation maps. For these two map parameters were set a) terrain profile sampling step b) horizontal resolution. Further analysis based on those values is presented in Table 3.

TABLE 3

DEMs and their parameters

DEM	Horizontal resolution [“]	Terrain profile sampling step [m]
SRTM	3	100
GUGIK	3	100
GUGIK	0.2	10

The results for SRTM 3”/100m and GUGIK 3”/100m let us verify how the more accurate DEM impact on the electric field strength calculation. Then further analysis for GUGIK 0.2”/10m was conducted to verify the more accurate DEM parametrization impact on the final outcomes. In Figure 3 the comparison of measurement data and simulation results is presented. For both GUGIK analysis there is quite a high disparity against the SRTM DEM. A disparity is caused by a greater terrain clearance angle correction. In Figure 4 the empirical CDF of TCA for both maps are presented. This clearly convey that a high quality resolution of DEM has got a big influence for obtaining the high value of TCA angle.

FIGURE 3

Comparison of measurement and model outcomes

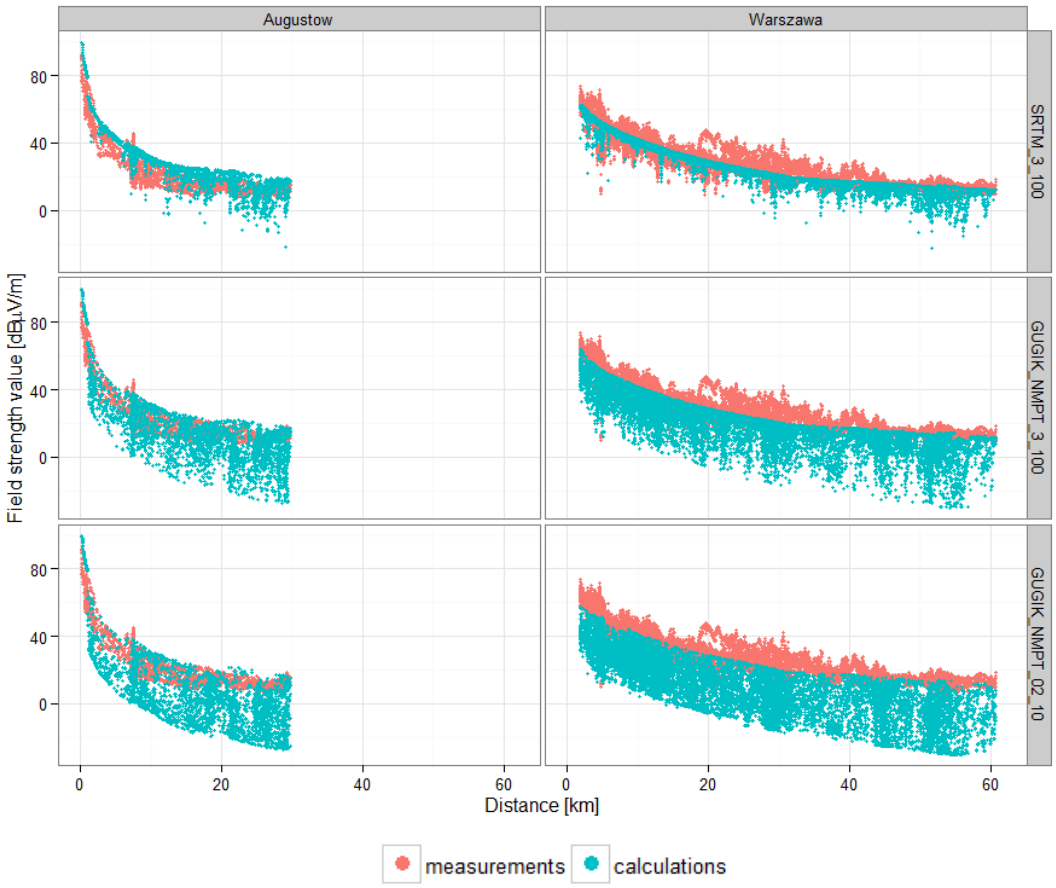
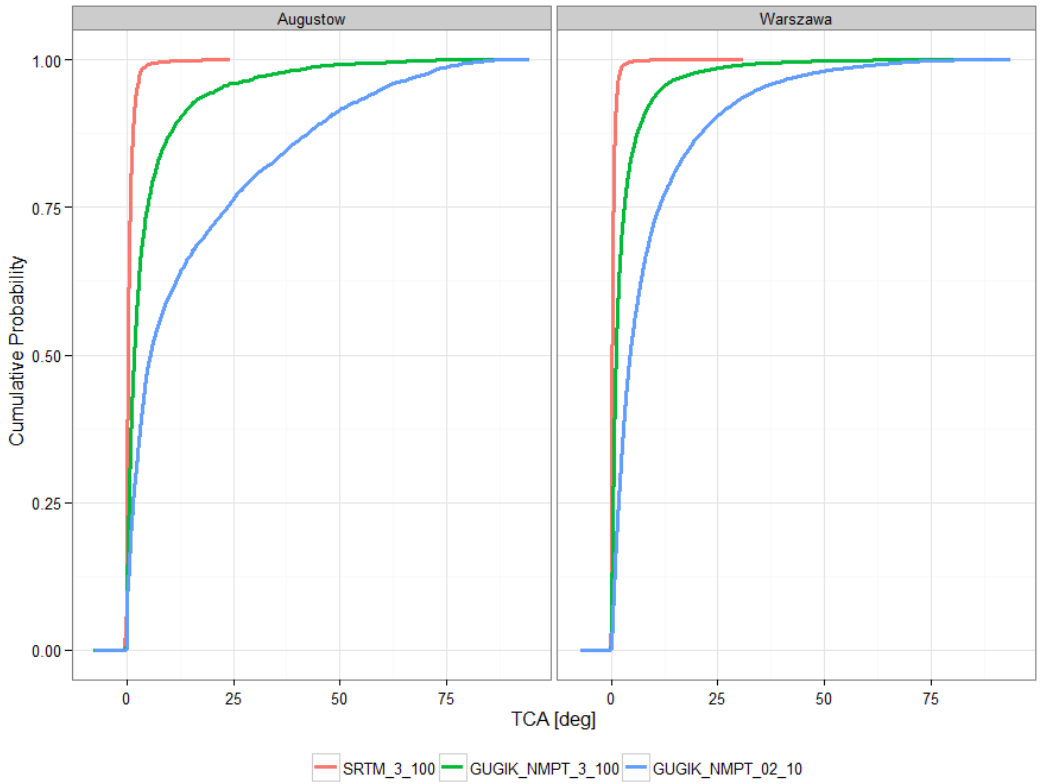


FIGURE 4

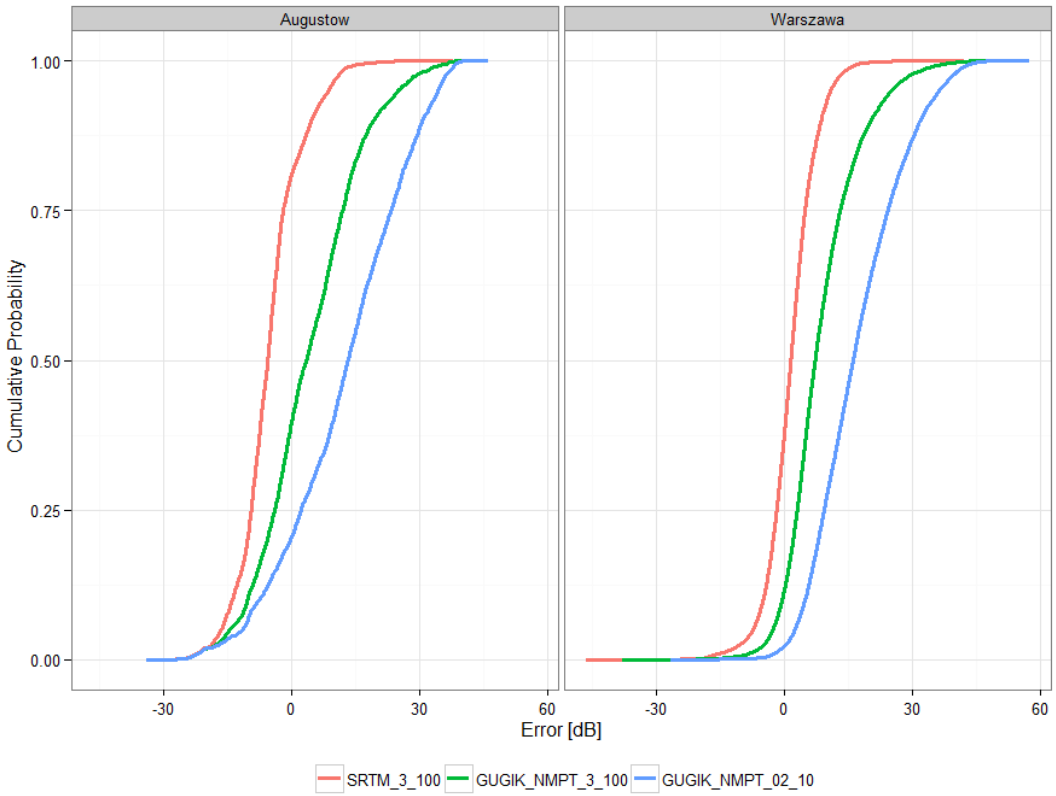
Empirical cumulative distribution function for TCA angles



In the Figure 5 the error of simulation is presented. The error is understood as the difference between measured and computed samples.

FIGURE 5

Empirical cumulative distribution function for model errors



More statistical details for two regions are presented in Tables 4 and 5. The most accurate outcomes derive from the SRTM scenario. It is important to notice, that simulation without TCA makes results more accurate. Our scenarios do not provide specific information if more accurate DEMs improve calculation of h_1.

TABLE 4

Augustów

Region	SRTM	SRTM (no TCA)	GUGIK 3”/100 m	GUGIK 2”/10 m	GUGIK 2”/10 m (no TCA)
Errors mean	8,89	8,76	12,44	18,81	7,81
Errors RMSE	-5,17	-6,79	4,14	12,36	-4,26
Errors standard deviation	7,24	5,54	11,74	14,17	6,55

TABLE 5

Warszawa

Region	SRTM	SRTM (no TCA)	GUGIK 3”/100 m	GUGIK 2”/10 m	GUGIK 2”/10 m (no TCA)
Errors mean	6,01	5,59	12,22	20,14	6,60
Errors RMSE	1,58	0,82	8,69	17,27	2,55
Errors standard deviation	5,80	5,53	8,60	10,37	6,09