

ITUWRS
GENEVA2024

2-6 December 2024
Geneva, Switzerland



ITU World Radiocommunication Seminar

Propagation model tools using Rec. ITU-R P.1812 and P.1546

2-6 December 2024, Geneva, Switzerland

- **Short presentation**
 - **Rec. ITU-R P.1812 and P.1546 propagation models**
 - **ePropagation calculations**
 - **Use cases**
 - **Future directions**
- **Demonstration and exercise session**

Recommendation ITU-R P.1812-6 (09/2021)

A path-specific propagation prediction method for point-to-area terrestrial services in the frequency range 30 MHz to 6 000 MHz

Deterministic model

model all the physical phenomena which plays a role in VHF-UHF band

Path specific

Uses terrain profile (elevation above mean sea level).

- 30 MHz - 6 GHz
- 0.25 km - 3000 km
- 1% < time < 50%
- 1% < locations < 99%
- Rx and Tx hgt agl <= 3km

Recommendation ITU-R P.1546-6 (08/2019)

Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 4 000 MHz

Empirical model

based on extensive field measurements and statistical analysis

Path general

The effect of terrain only via:

- Effective antenna height
- Clearance Angle correction
- Tropospheric scattering correction

- 30 MHz - 4 GHz
- <1 km - 1000 km
- 1% < time < 50%
- 1% < locations < 99%
- Rx and Tx hgt agl <= 3km

Interference/coverage analyses!

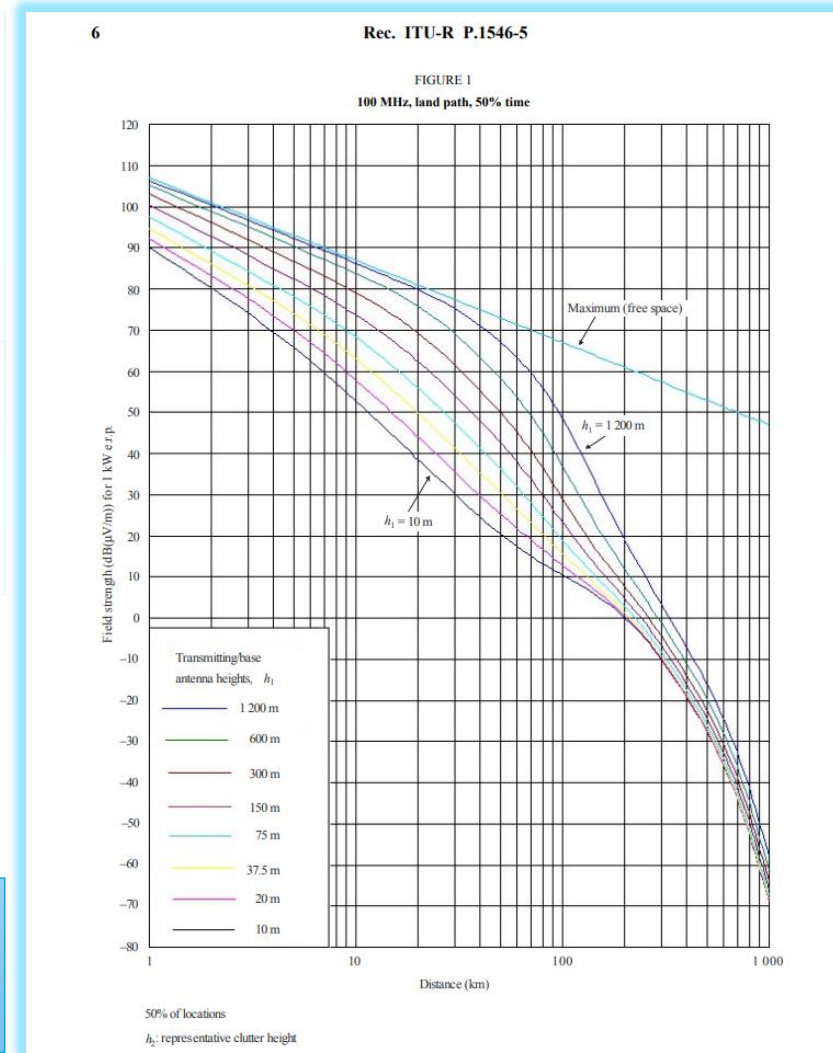
Field-strength curves as functions of *distance, antenna height, frequency and percentage time*

- Land, warm sea, cold sea
- 100, 600, 2000 MHz
- time percentage: 1,10,50

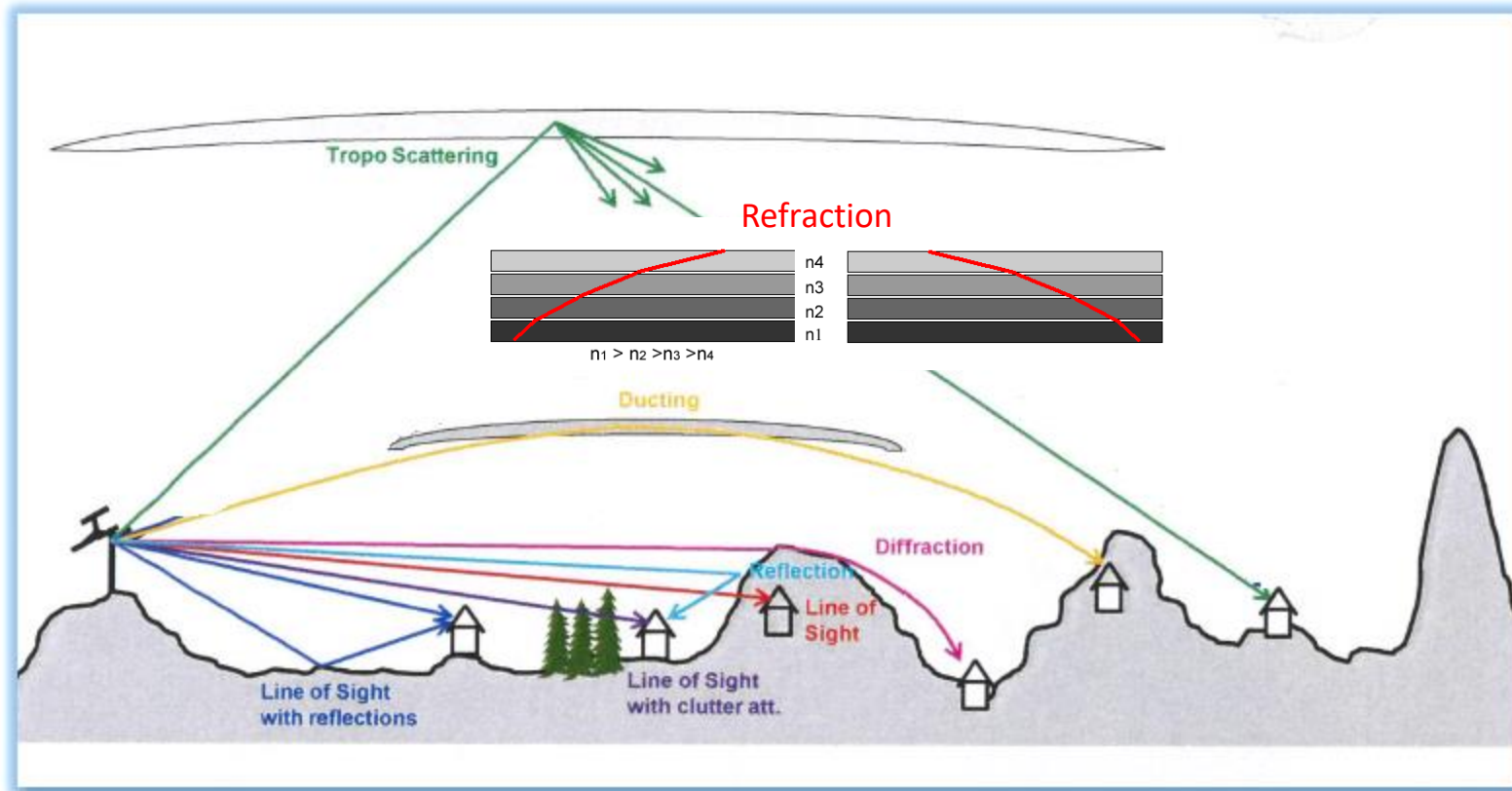
Method

- interpolation/extrapolation
- mixed-path

Important correction for refractivity index!!




Propagation mechanisms in the VHF/UHF band



Adapted from LS Telcom Propagation training material

ePropagation: Input parameters (ITU-R P.1812)

Transmitter 

Frequency(MHz)

Longitude(DMS)

Latitude(DMS)

ERP(dBW)

Ant. Height AGL(m)

Polarization

Environment

% of time

% of location

Reception type


- Outdoor
- Outdoor
- Indoor



Digital Elevation Model

- SRTM3
- ASTER_V3
- SRTM1
- SRTM3

Point to Point

Receiver 

Longitude(DMS)

Latitude(DMS)

Ant. Height AGL(m)

Point to Area

Receiver


Wanted FS(dB(μ V/m))

Ant. Height AGL(m)

Bearing step($^{\circ}$)

ePropagation: Input parameters (ITU-R P.1546)



Transmitter 

Frequency(MHz)

Longitude(DMS)

Latitude(DMS)

ERP(dBW)

Ant. Height AGL(m)

Environment

% of time

% of location

Reception Type

- Rural
- Urban**


Point to Area

Receiver

Wanted FS(dB(μ V/m))

Ant. Height AGL(m)

Point to Point

Receiver 

Longitude(DMS)

Latitude(DMS)

Ant. Height AGL(m)

ePropagation: Input parameters (ITU-R P.1546)



P1546v6 MultiPoint to Point ▼

Transmitter



Antenna Atten.

Frequency(MHz)

186

Longitude(DMS)

46

00

00

E



Latitude(DMS)

42

10

00

N



ERP(dBW)

10

Ant. Height AGL(m)

71

Site Name

Site 3

Receiver



Longitude(DMS)

45

21

14

E



Latitude(DMS)

41

05

39

N



Ant. Height AGL(m)

10

Environment

% of time

1

% of location

50

Reception Type

Rural



Clear

Add TX

Delete all TXs



Id	Site Name	Frequency(MHz)	Longitude(DMS)	Latitude(DMS)	ERP(dBW)	Ant. Height AGL(m)	Distance TX-RX(Km)	Antenna Pattern	Delete
<u>3</u>	Site 3	186	E 046° 00' 00"	N 42° 10' 00"	10	71	130.8	⊙	×
<u>2</u>	Site 2	186	E 046° 00' 00"	N 41° 10' 00"	10	71	54.7	⊙	×
<u>1</u>	Site 1	186	E 045° 00' 00"	N 41° 10' 00"	10	71	30.7	⊙	×

ePropagation: Input parameters



Transmitter **Import From Notice File** Antenna Atten.

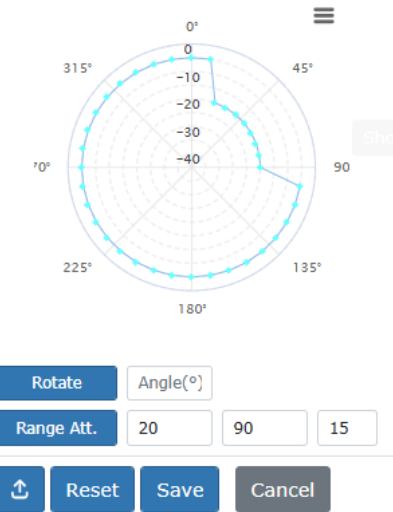
Antenna Attenuations

000°	0	010°	0
020°	15	030°	15
040°	15	050°	15
060°	15	070°	15
080°	15	090°	15
100°	0	110°	0
120°	0	130°	0
140°	0	150°	0
160°	0	170°	0
180°	0	190°	0
200°	0	210°	0
220°	0	230°	0
240°	0	250°	0
260°	0	270°	0
280°	0	290°	0
300°	0	310°	0
320°	0	330°	0
340°	0	350°	0

Select Notice (Only notices with valid coordinates are considered)

Showing 1 to 25 of 136 entries 3 rows selected Show 25 entries Search:

Notice Type	Intent	Fragment	Site Name	Adm.Ref.Id	Frequency[MHz]	hgt_agl[m]	Longitude	Latitude	ERP(dBW)	Pol.
<input type="checkbox"/>	T01	MODIFY	GE84	BUJUMBURA	2015-08	87.6	029°21'17"E	03°23'13"S	20	V
<input type="checkbox"/>	T01	ADD	GE84	GITEGA	GITEGA	87.6	029°51'32"E	03°21'48"S	25	V
<input type="checkbox"/>	T01	MODIFY	GE84	MT INANZERWE	2015-42	87.7	029°44'25"E	04°03'51"S	24	V
<input checked="" type="checkbox"/>	T01	MODIFY	GE84	BUJUMBURA	2015-01	87.9	029°21'17"E	03°23'13"S	20	V
<input checked="" type="checkbox"/>	T01	MODIFY	GE84	MT BIRIME	BIRI-87.9-2021	87.9	030°24'09"E	03°18'27"S	30	V
<input checked="" type="checkbox"/>	T01	ADD	GE84	MT MUTUMBA	2015-57	87.9	030°02'09"E	02°40'27"S	30	V
<input type="checkbox"/>	T01	MODIFY	GE84	INANZERWE	INANZ88.0-2020	88	029°44'21"E	04°03'51"S	28	V



ePropagation: Input parameters (time%, locations%)



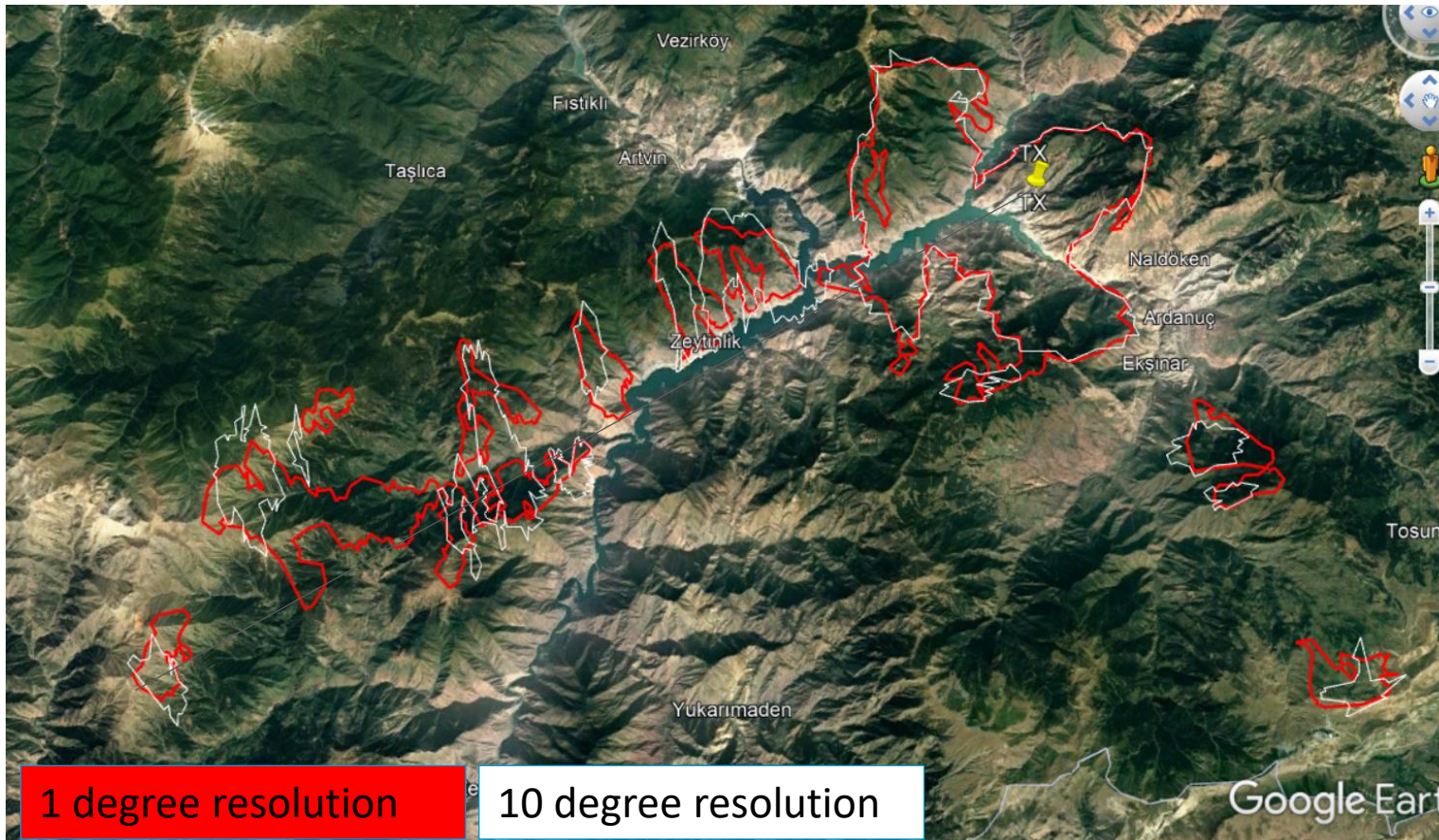
Coverage Analyses (wanted signal) (Report ITU-R BT.2383-1)		
ATSC	ISDB-T	DVB-T , DVB-T2, DTMB
50% locations 90% time	95% locations 90% time	95% locations 50% time
Rec. ITU-R SM.851-1		
Analogue TV		GE84 Agreement
50% locations 50% time		FM
		50% locations 50% time
Interference Analyses (unwanted signal)		
Accord GE84		
50% locations 1% time	FM (tropo)	FM (steady)
	50% locations 1% time	50% locations 50% time

Report ITU-R [BT.2383-1](#) (Note 19 on page 26) Provides formula for applicability of Rec. ITU-R P.1546 for 90% of time.

WP 3K Liaison Statement to the Director BR (March 2017). **The 90% time formula is not generally applicable.** It errs on the conservative/safe side for the desired signal in interference/compatibility analyses which compare desired-to-undesired signal ratios

Point to Area

coverage analyses



1 degree resolution

10 degree resolution

Transmitter

Frequency[MHz]	186
Longitude	E 042° 00' 00"
Latitude	N 41° 10' 00"
Ant. Height AGL(m)	70
ERP(dBW)	30
Polarization	Vertical

Receiver

Ant. Height AGL(m)	10
Wanted FS(dB(µV/m))	54

Environment

Bearing step(°)	10
% of time	50
% of location	50
Reception Type	Outdoor
DEM	SRTM3

Point to Point

Transmitter

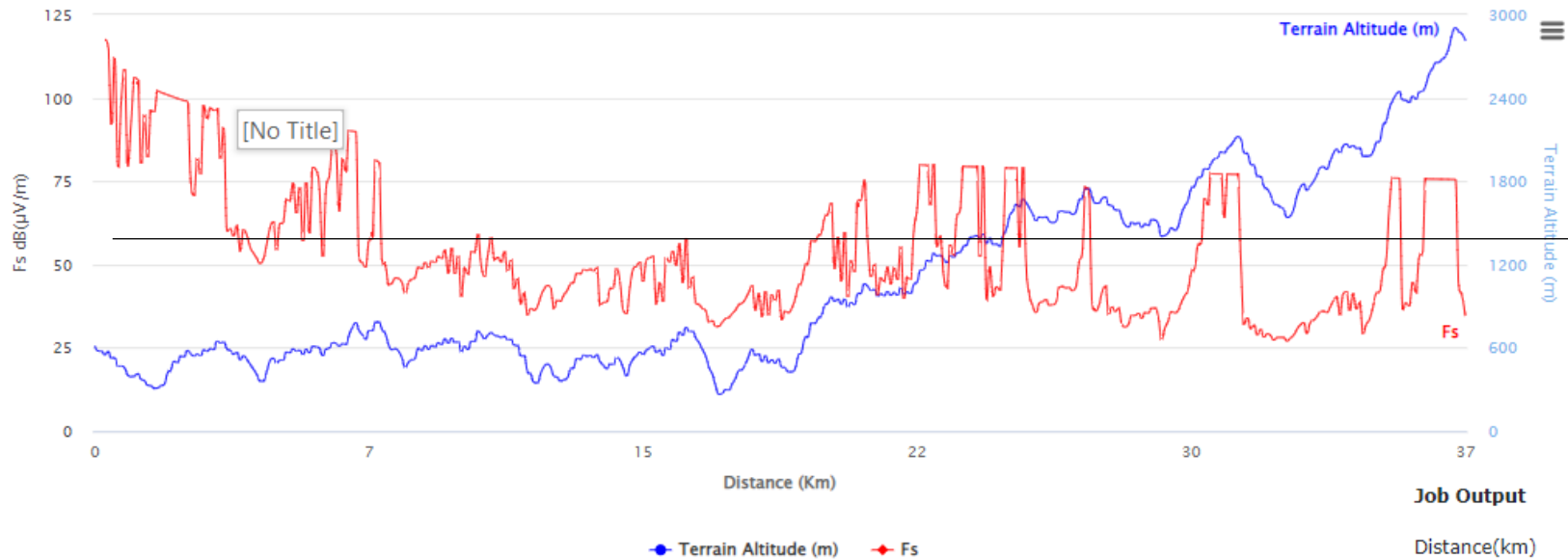
Frequency[MHz] **186**
 Longitude **E 042° 00' 00"**
 Latitude **N 41° 10' 00"**
 Ant. Height AGL(m) **70**
 ERP(dBW)_{M3} **30**
 Polarization **Vertical**

Receiver

Longitude **E 041° 36' 47"**
 Latitude **N 41° 00' 04"**
 Ant. Height AGL(m) **10**
 Wanted FS(dB(μV/m))

Environment

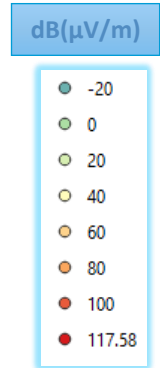
% of time **50**
 % of location **50**
 Reception Type **Outdoor**
 DEM **SRTM3**



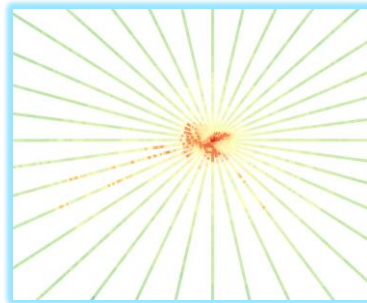
Job Output

Distance(km)	37.4
Bearing(degree etn)	240.6
Effective Earth Radius (Km)	8422.16
Field Strength (dB μV/m)	34.57

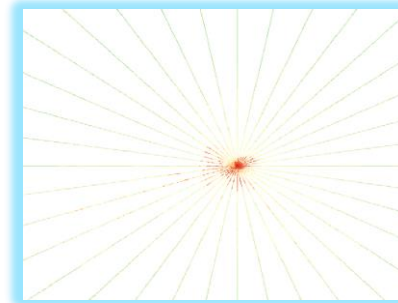
Study FS variation on the path from TX to a RX point in the contours farthest from the TX in the P2A coverage analyses



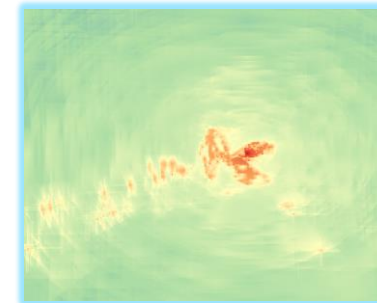
1) P.1812 vector data (location and fs)



2) Convert to raster



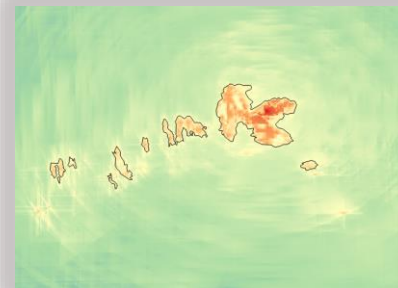
3) Interpolate to fill voids



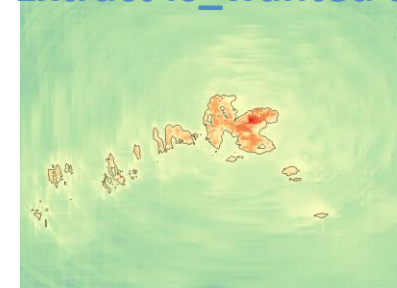
6) Convert to KMZ



5) Simplify geometry



4) Extract fs_wanted contour

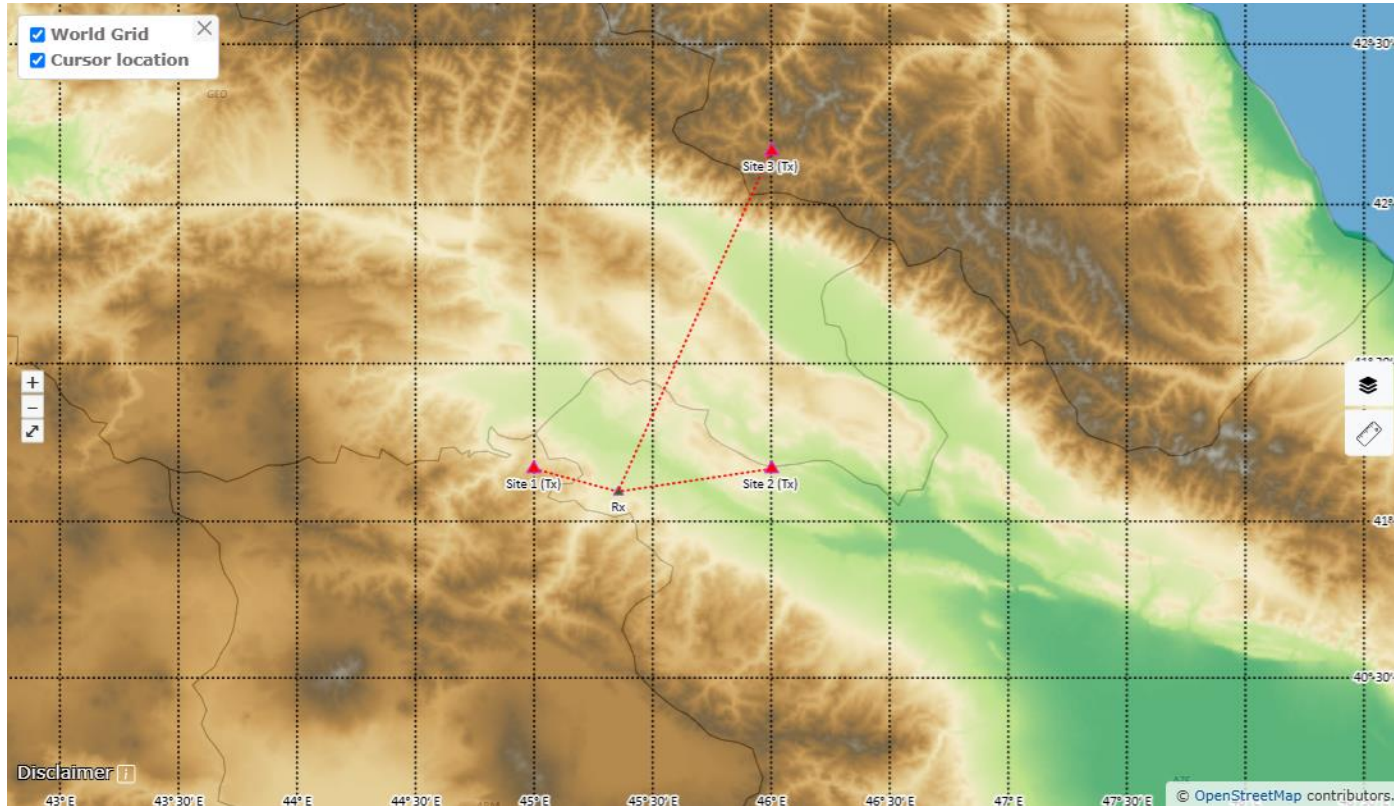


OSGeo: GDAL/OGR open source libraries

ePropagation: rec. ITU-R P.1546 calculations



P1546v6 MultiPoint to Point ▼



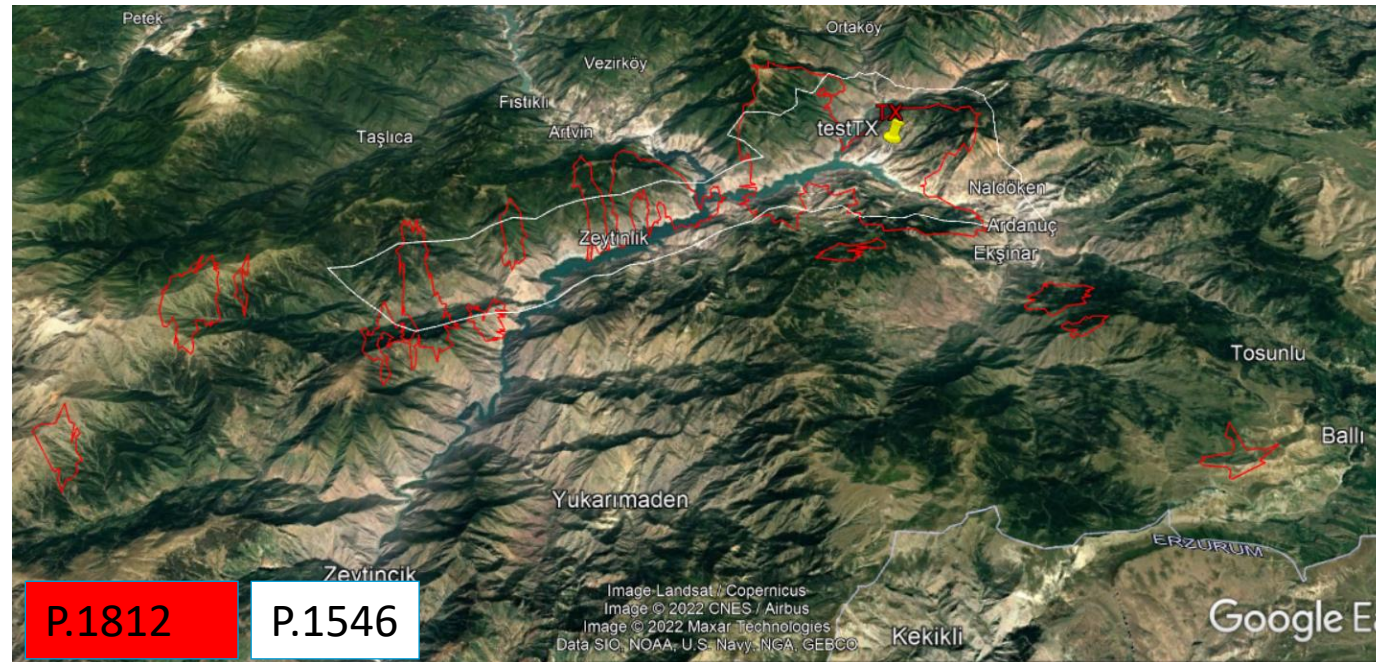
Power Sum (dB μ V/m): 7.3

Site Name	Freq. (MHz)	Dist. (km)	Bearing(°)	FS (dB μ V/m)
Site 1	186	30.7	105	6.8
Site 2	186	54.7	262	-2.5
Site 3	186	130.8	204	-20.2

Transmitter	42.06	41.19	
	42.06	41.18	
Frequency [MHz]			186
Longitude			E 042° 00' 00"
Latitude	42.06	41.17	N 41° 10' 00"
Ant. Height AGL (m)	16		70
ERP (dBW)	42.07	41.15	30
Receiver	42.07	41.14	
	42.08	41.12	
Ant. Height AGL (m)			10
Wanted FS (dB(μV/m))			54
Environment	42.04	41.12	
	42.02	41.12	
% of time			50
% of location	42.01	41.12	50
Reception Type			Rural

Point to Area

Coverage analyses



Good agreement with ITU-R P.1812 results in this case.
But results can be significantly different!

Point to Area

Transmitter

Frequency[MHz] **186**
Longitude **E 007° 44' 08"**
Latitude **N 45° 02' 27"**
Ant. Height AGL(m) **71**
ERP(dBW) **30**

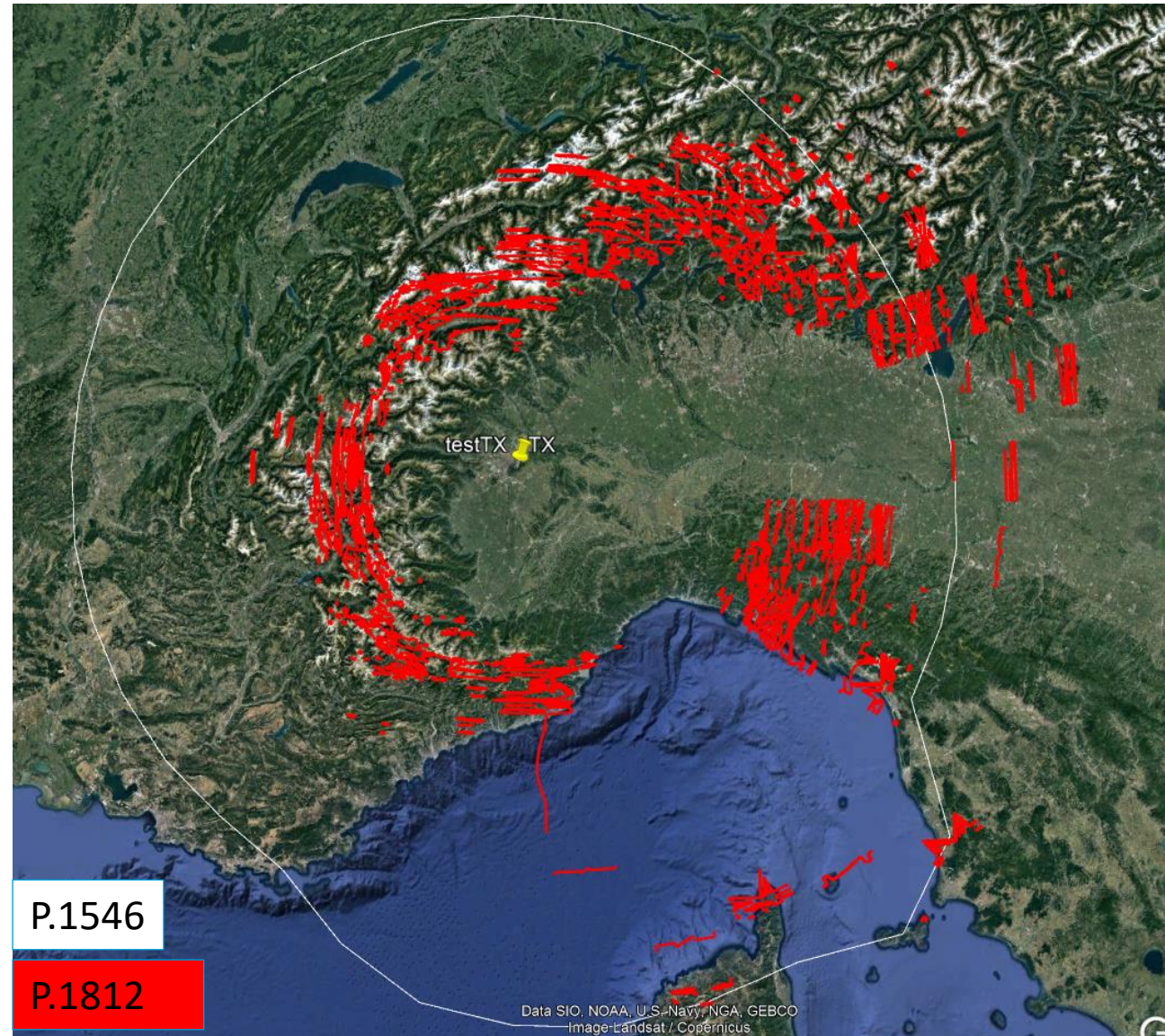
Receiver

Ant. Height AGL(m) **10**
Wanted FS(dB(μV/m)) **20**

Environment

% of time **1**
% of location **50**
Reception Type **Rural**

Interference analyses



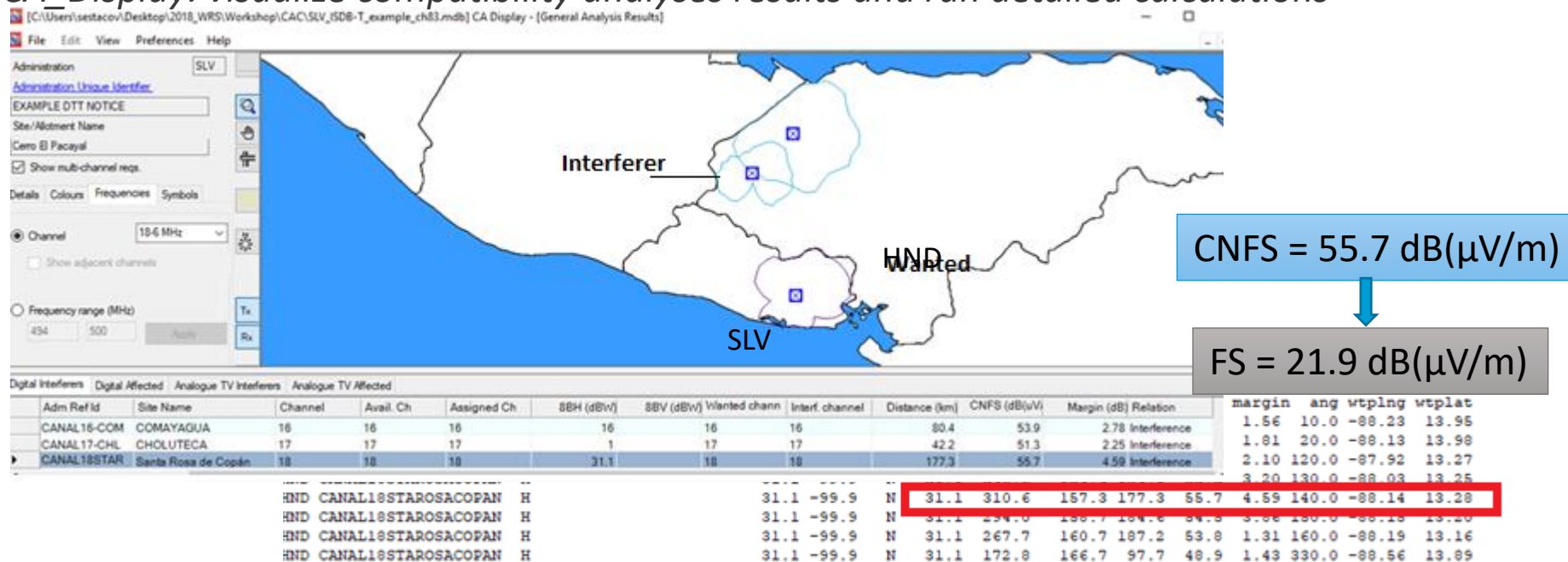
Use case: planning in Central America and Caribbean

eTools: CA_compat implements ITU-R P.1546:

- coverage analyses (wanted service area)
- interference analyses

Terrain information considered only via effective antenna height

CA_Display: visualize compatibility analyses results and run detailed calculations



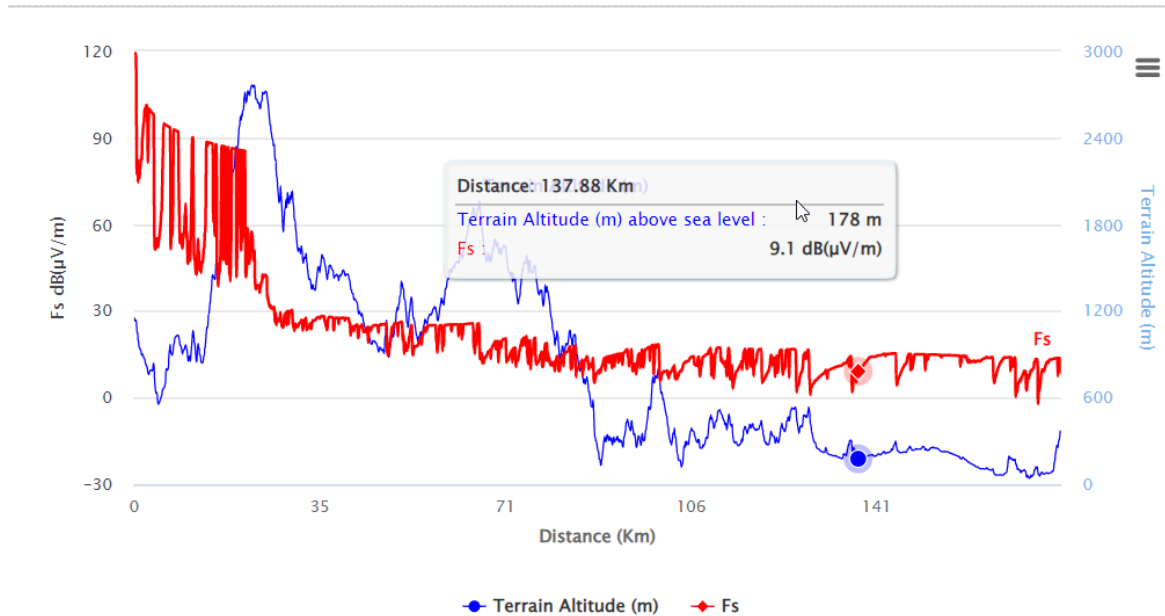
Adm Ref Id	Site Name	Channel	Avail. Ch	Assigned Ch	SBH (dBV)	SBV (dBV)	Wanted chann	Interf channel	Distance (km)	CNFS (dB(µV))	Margin (dB)	Relation	margin	ang	wtplng	wtplat
CANAL16-COM	COMAYAGUA	16	16	16	16	16	16	16	80.4	53.9	2.78	Interference	1.56	10.0	-88.23	13.95
CANAL17-CHL	CHOLUTECA	17	17	17	1	17	17	17	42.2	51.3	2.25	Interference	1.81	20.0	-88.13	13.98
CANAL18STAR	Santa Rosa de Copán	18	18	18	31.1	18	18	18	177.3	55.7	4.59	Interference	2.10	120.0	-87.92	13.27
HND	CANAL18STAROSACOPAN	H			31.1	310.6	157.3	177.3	55.7	4.59	140.0	-88.14	13.28			
HND	CANAL18STAROSACOPAN	H			31.1	294.0	150.7	174.6	54.8	3.66	130.0	-88.13	13.20			
HND	CANAL18STAROSACOPAN	H			31.1	267.7	160.7	187.2	53.8	1.31	160.0	-88.19	13.16			
HND	CANAL18STAROSACOPAN	H			31.1	172.8	166.7	97.7	48.9	1.43	330.0	-88.56	13.89			

Use case: planning in Central America and Caribbean



ePropagation: Rec. ITU-R P.1812 Point to Point field strength calculation (terrain data).

Transmitter	
Alt. (m asl)	140
Frequency [MHz]	497
Longitude	W 088° 46' 00"
Latitude	N 14° 45' 00"
Ant. Height AGL(m)	49
ERP(dBW)	31.1
Polarization	Horizontal
Receiver	
Alt. (m asl)	270
Longitude	W 088° 08' 24"
Latitude	N 13° 16' 48"
Ant. Height AGL(m)	10
Wanted FS(dB(μV/m))	
Environment	
Alt. (m asl)	331
Alt. (m asl)	372
% of time	1
% of location	50
Reception Type	Outdoor
DEM	SRTM3



Job Output

Distance(km)	176.2
Bearing(degree etn)	157.3
Effective Earth Radius (Km)	9905.3
Field Strength (dB μV/m)	8.83

FS = 21.9 dB(μV/m) P.1546 no terrain (CA_Compat)

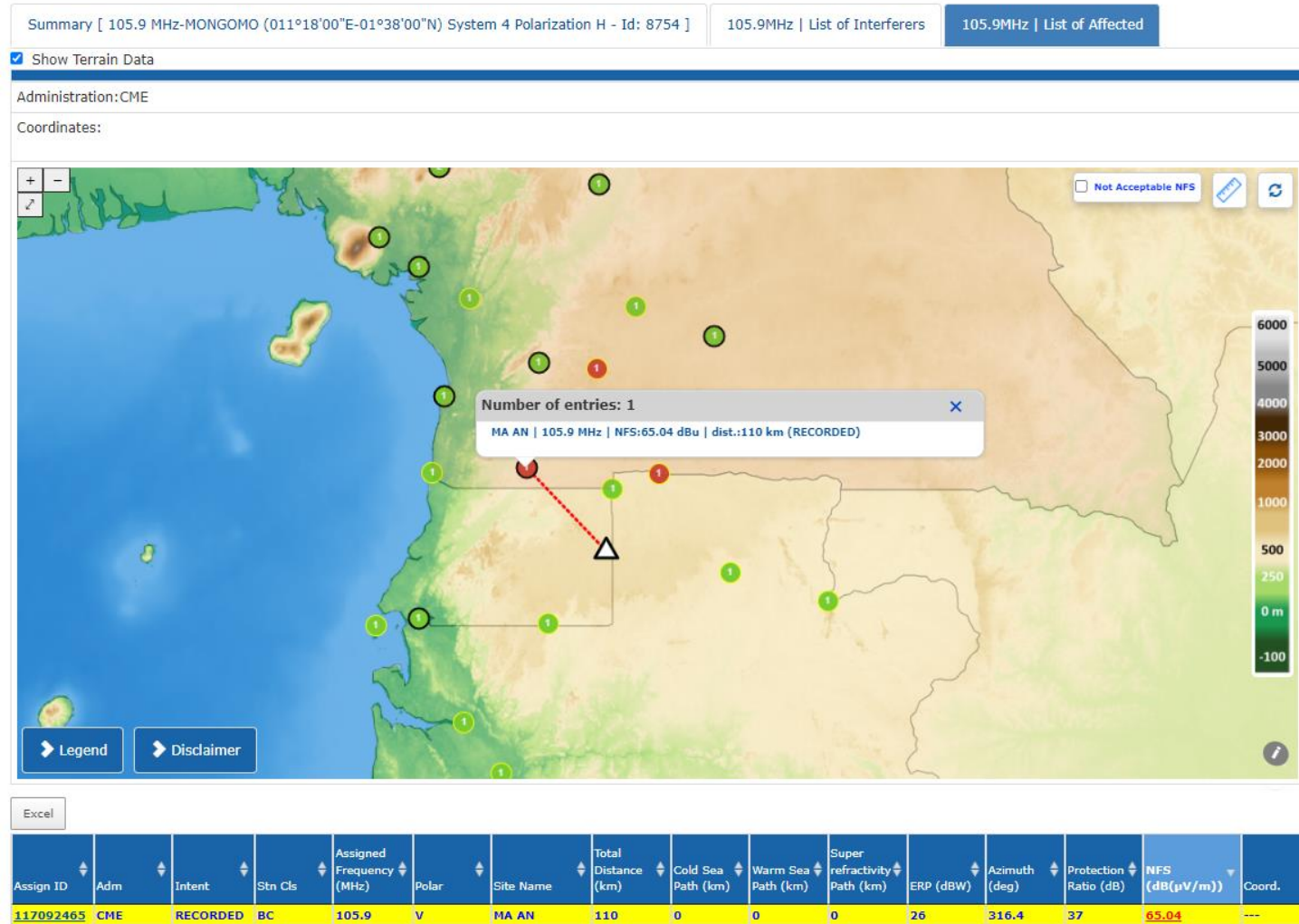
FS = 8.83 (13.1 reduction) dB(μV/m) P.1812 terrain

This value would bring the margin to an acceptable level!!!

Use case: GE84 planning activities

GE84Opt
implements GE84
propagation curves
(interference analyses).

Terrain information
considered only via
effective antenna
height



Co-channel PR:
Tropo: 37 dB
Steady: 45 dB

$$FS(1\%time,50\%loc)_{GE84\ curves} = NFS - PR + Pol\ Discr = 65.04 - 37 + 10 = 38.04\ dB(\mu V/m)$$

GE84Opt allows to calculate on the fly Point to Point field strength calculations (terrain data) using Rec. ITU-R P.1812

NFS Calculation with P.1812v4 (Beta)

- Transmitter Info (click to show)
- Receiver Info (click to show)
- Propagation Model (click to show)
- FS Labels (click to show)
- Results (click to hide)

Tropo. Calculation

Job Id (1% of Time)

PR tropospheric (dB)

FS 1% of Time (dB(μV/m))

Steady Calculation

Job Id (50% of Time)

PR steady (dB)

FS 50% of Time (dB(μV/m))

Poi Dis. (dB)

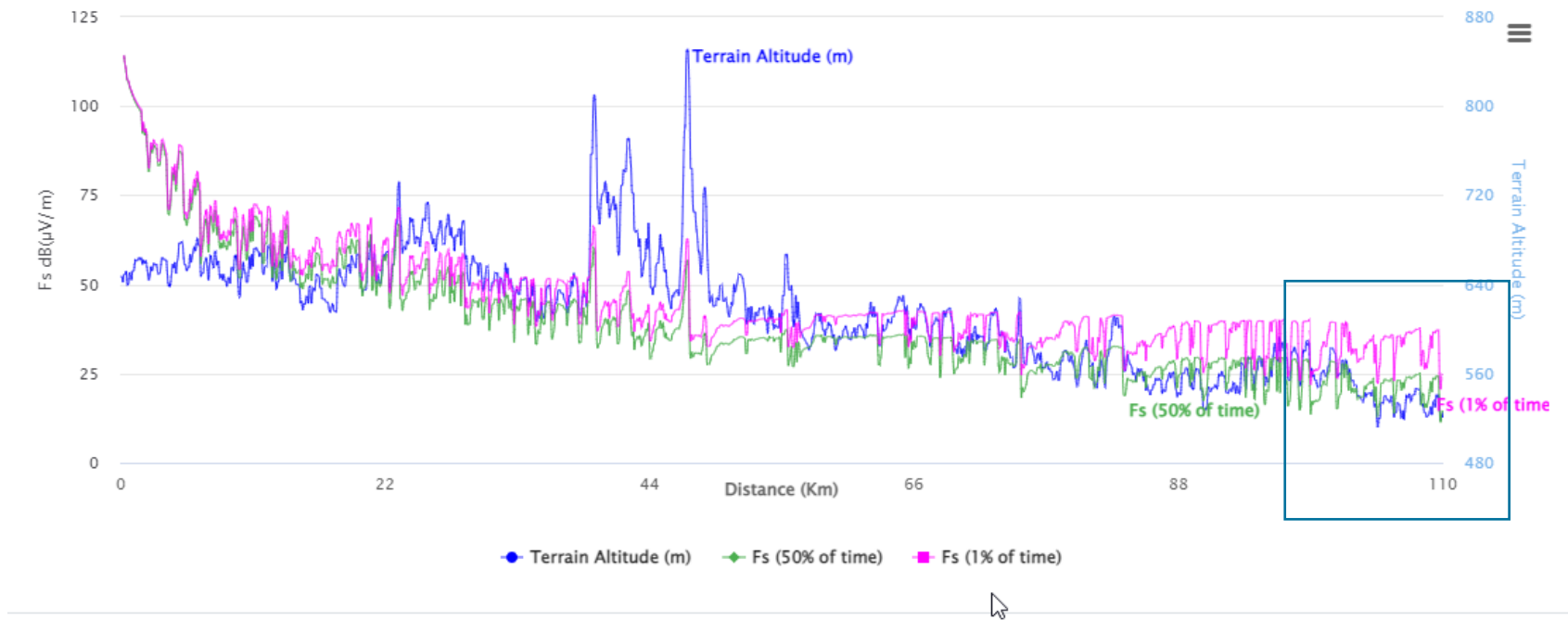
Dist (km)

NFS (dB(μV/m))

F. Sep (kHz)

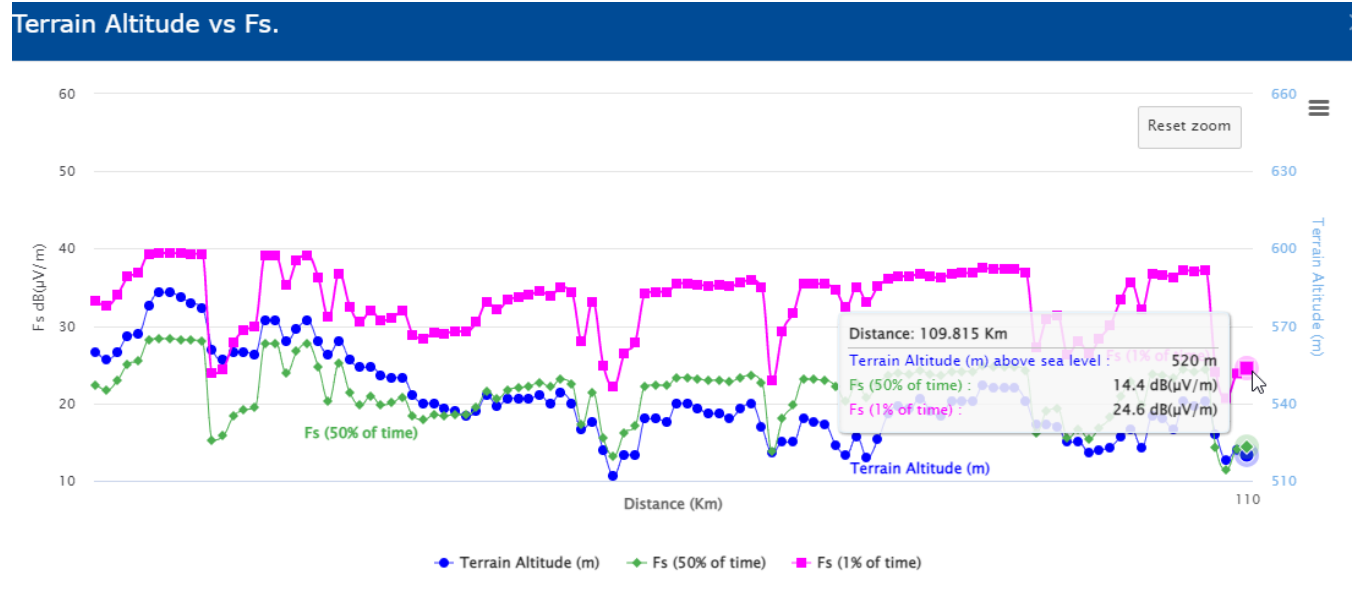
Azimuth

Dist (km)	FS (dB(μV/m))
0	26
37	316.4
110	87.04



Use case: GE84 planning activities

Interpretation of results using field strength calculations using Rec. ITU-R P.1812 and comparison with GE84Opt (no terrain)



Tropo Interference

$$NFS = FS(1\%time,50\%loc) + PR - Pol\ Discr = 24.6 + 37 - 10 = 51.6 \text{ dB}(\mu\text{V/m})$$

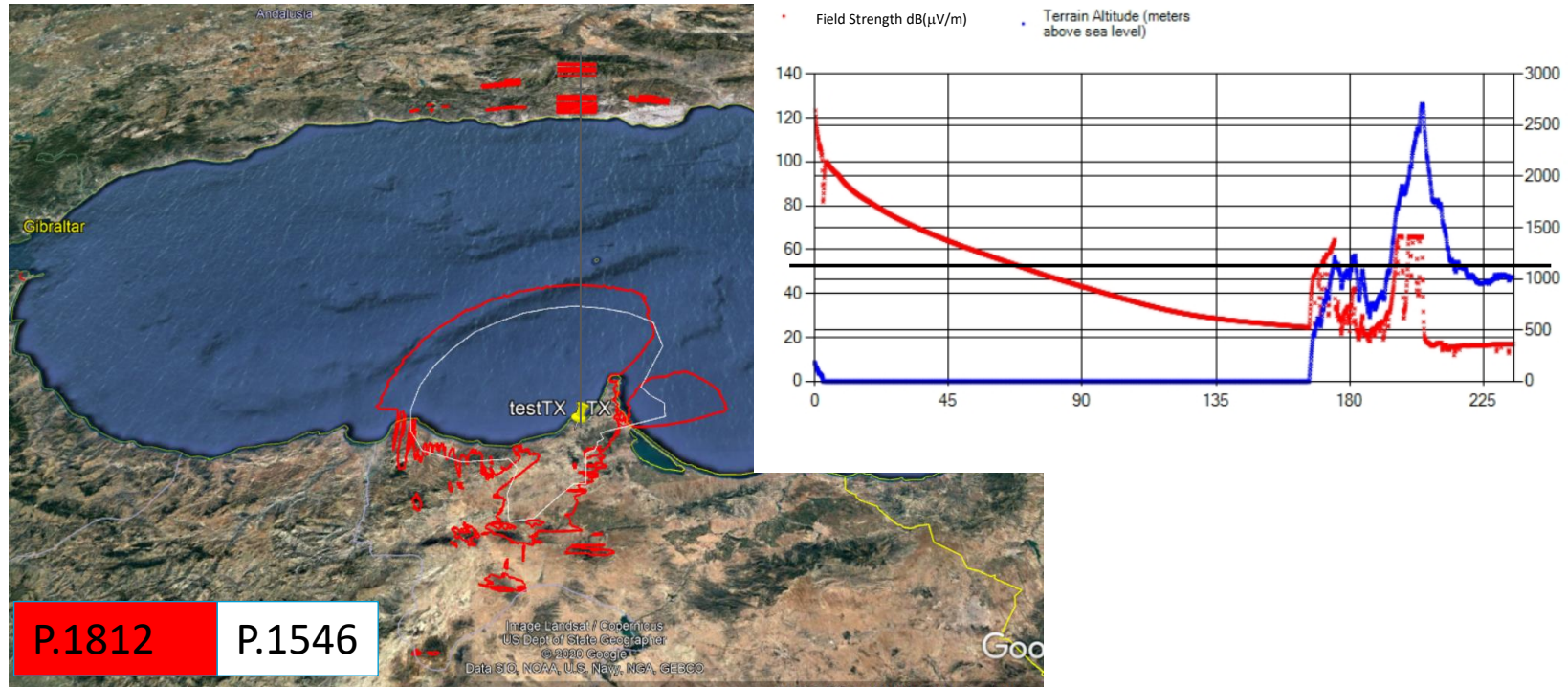
Steady Interference

$$NFS = FS(1\%time,50\%loc) + PR - Pol\ Discr = 14.4 + 45 - 10 = 49.4 \text{ dB}(\mu\text{V/m})$$

The consideration of terrain data brings the interference to an acceptable level!!!

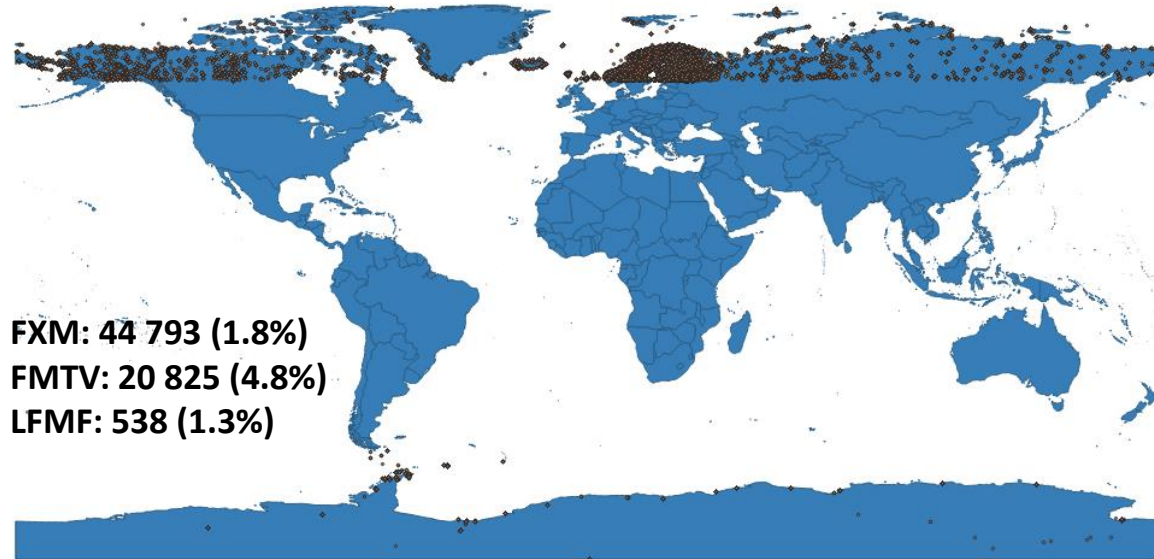
Use case: FM coverage analyses

AZAANEN: P1812P2A Wanted FS = 54 dB(μ V/m)



ITU-R P.1546 uses DEM for the generation of effective antenna heights.

Assignments outside SRTM validity range [56 S : 60 N]



FXM: 44 793 (1.8%)
FMTV: 20 825 (4.8%)
LFMF: 538 (1.3%)

DEM

About DEM: SRTM3

Medium Terrain Resolution (90m), does not cover the region outside latitudes [56S, 60N].

DEM

About DEM: ASTER_V3

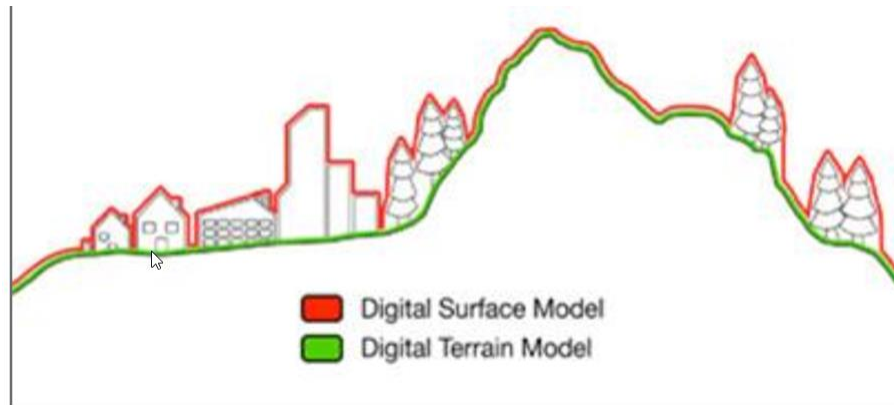
High Terrain Resolution (30m), does not cover the region outside latitudes [83S, 83N], longer computation time than SRTM3 but higher accuracy. Calculation with P.1812 covers only the region within latitudes [80S, 80N].

DEM

About DEM: SRTM1

High Terrain Resolution (30m), does not cover the region outside latitudes [56S, 60N], longer computation time than SRTM3 but higher accuracy.





ITU-R WP3M: [Performance evaluation of Recommendation ITU-R P.1812 using SRTM data](#)

Avoid additional consideration of representative clutter heights (Table 2) if SRTM(1/3)/ASTER are used.

- DSM:** SRTM, ASTER
- DTM:** affordable worldwide DTM not available

ITU trying to procure a worldwide DEM and ground cover features datasets within the UN Geospatial Network

TABLE 2

Default representative clutter height values

Clutter category	Representative clutter height (m)
	Add to profile of equation (1c) for $i = 2$ to $n - 1$
Water/sea	0
Open/rural	0
Suburban	10
Urban/trees/forest	15
Dense urban	20

P1812 and usages of terrain data

Transmitter

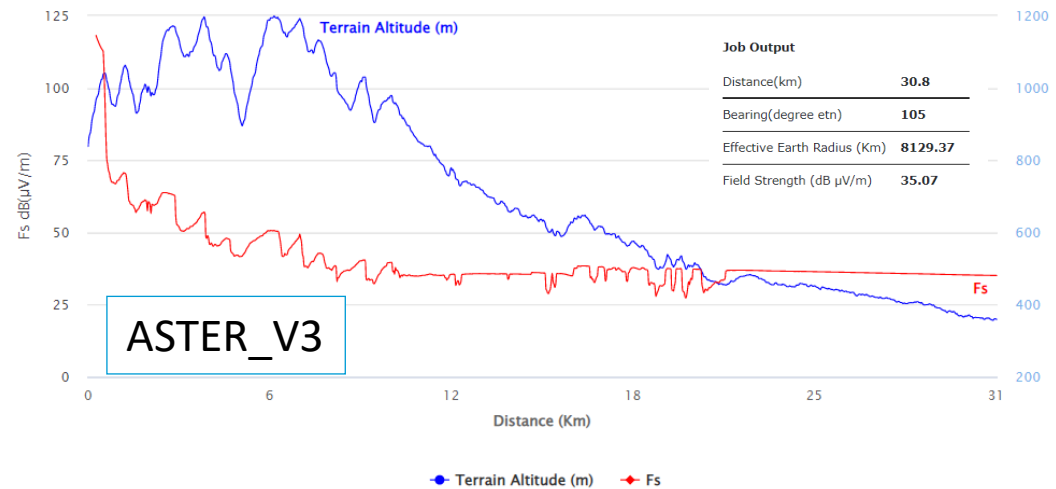
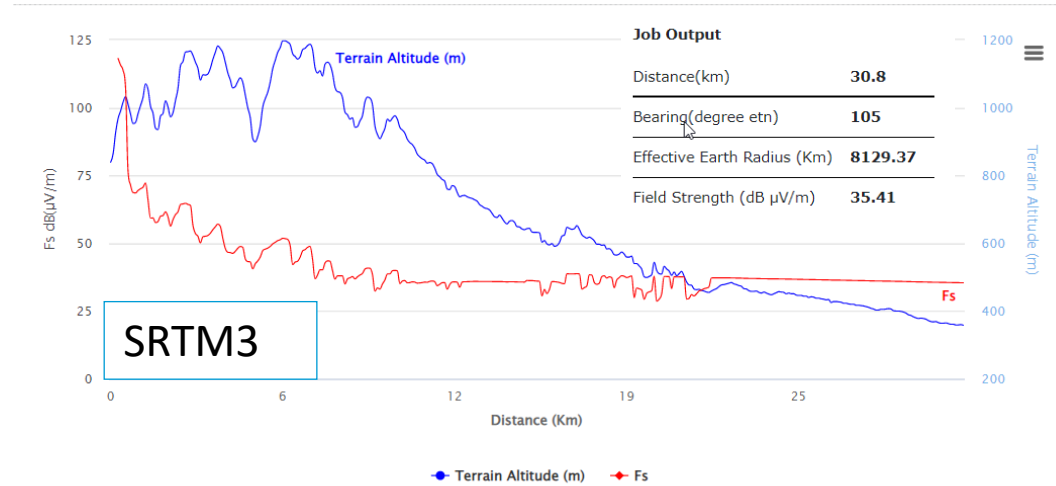
Frequency [MHz] **186**
 Longitude **E 045° 00' 00"**
 Latitude **N 41° 10' 00"**
 Ant. Height AGL(m) **70**
 ERP(dBW) **30**
 Polarization **Vertical**

Receiver

Longitude **E 045° 21' 14"**
 Latitude **N 41° 05' 39"**
 Ant. Height AGL(m) **10**
 Wanted FS(dB(μV/m)) **35.07**

Environment

% of time **1**
 % of location **50**
 Reception Type **Outdoor**



P1812 and usages of terrain data

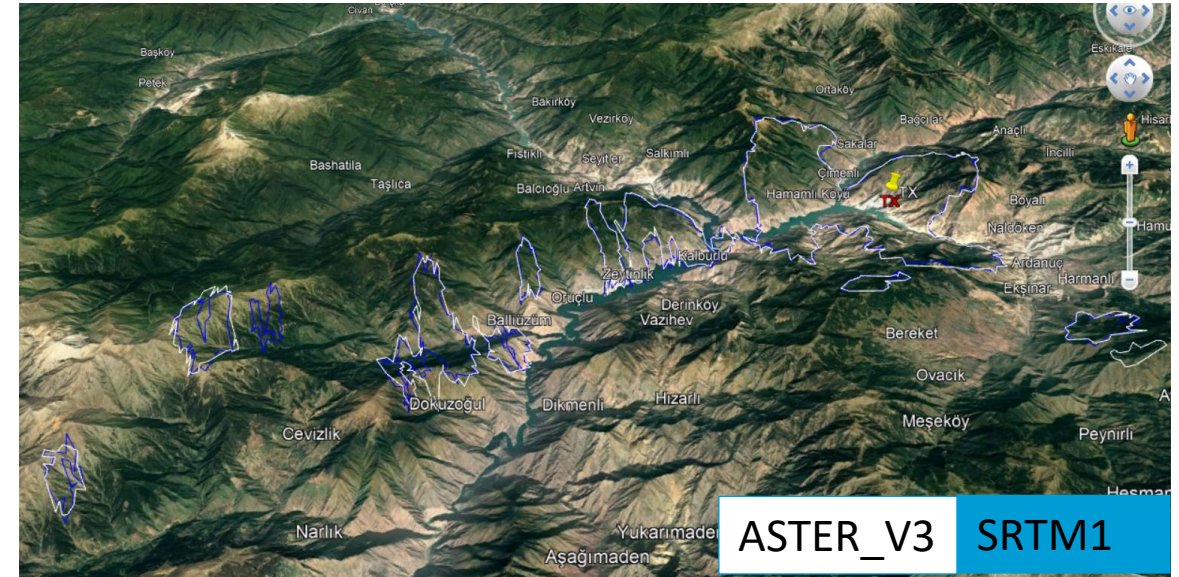
Environment

% of time:

% of location:

Reception type:

DEM:

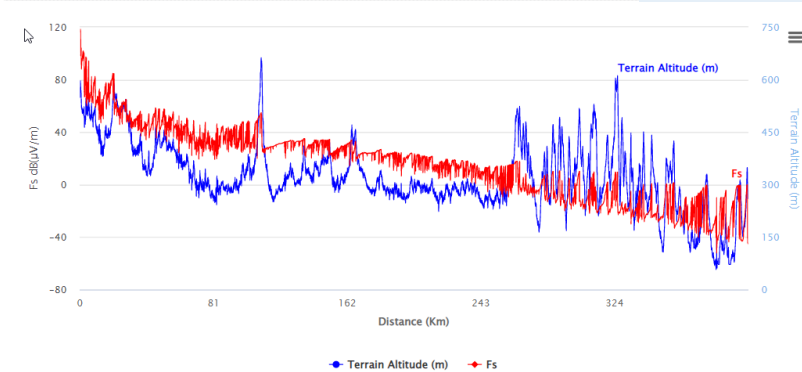


P1812 and usages of terrain data

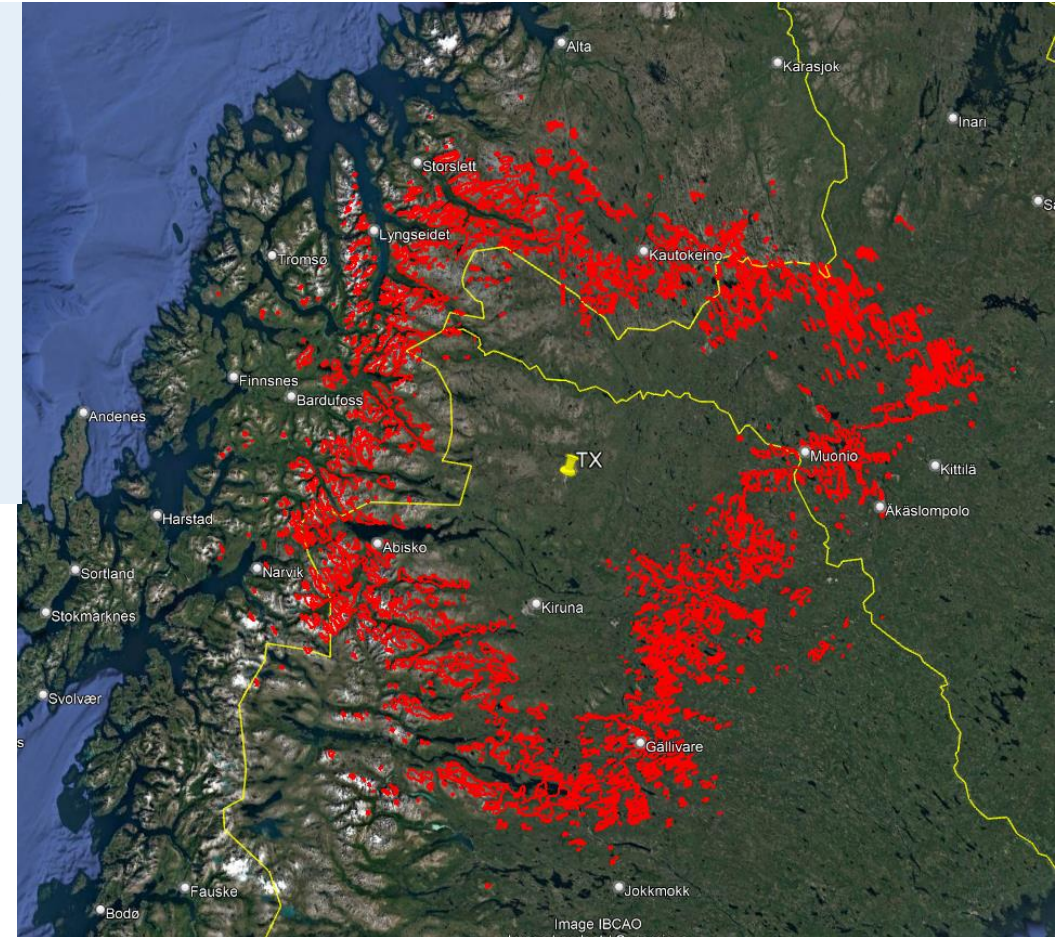
ASTER-V3 (30m) **[83 S : 83 N]**

Transmitter	
Frequency[MHz]	186
Longitude	E 021° 06' 47"
Latitude	N 68° 15' 52"
Ant. Height AGL(m)	70
ERP(dBW)	30
Polarization	Horizontal
Receiver	
Longitude	E 030° 55' 47"
Latitude	N 68° 15' 20"
Ant. Height AGL(m)	10
Wanted FS(dB(μV/m))	
Environment	
% of time	1
% of location	50
Reception Type	Outdoor
DEM	ASTER_V3

Job Output	
Distance(km)	405.5
Bearing(degree etn)	85.6
Effective Earth Radius (Km)	8377.14
Field Strength (dB μV/m)	-45.12



Transmitter	
Frequency[MHz]	186
Longitude	E 021° 06' 47"
Latitude	N 68° 15' 52"
Ant. Height AGL(m)	70
ERP(dBW)	30
Polarization	Horizontal
Receiver	
Ant. Height AGL(m)	10
Wanted FS(dB(μV/m))	25
Environment	
Bearing step(°)	1
% of time	1
% of location	50
Reception Type	Outdoor
DEM	ASTER_V3



ePropagations

1. Read the Disclaimer to make sure you understand scope and limitations of the tool
2. Look at the Documentation link pointing to documents concerning the various calculations provided and browse through few documents of interest to you
3. Submit a Propagation P1812 P2P or P1546 P2P, MP2P or P2A calculation
4. Display the results when the calculation completes (an e-mail will be sent to your ties e-mail account)
5. Share the job with one or more of your neighbors. Verify that your neighbors can access your test data.
6. Delete a job if you are not more interested in it.

Thank you!

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Questions to brbcd@itu.int