ITU World Radiocommunication Seminar

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

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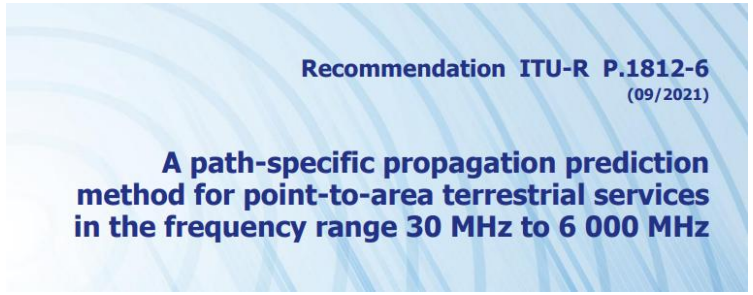
7-11 December 2026, Geneva, Switzerland

Agenda

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

Comparison Rec. ITU-R P.1812 vs P.1546



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



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!

Rec. ITU-R P. 1546

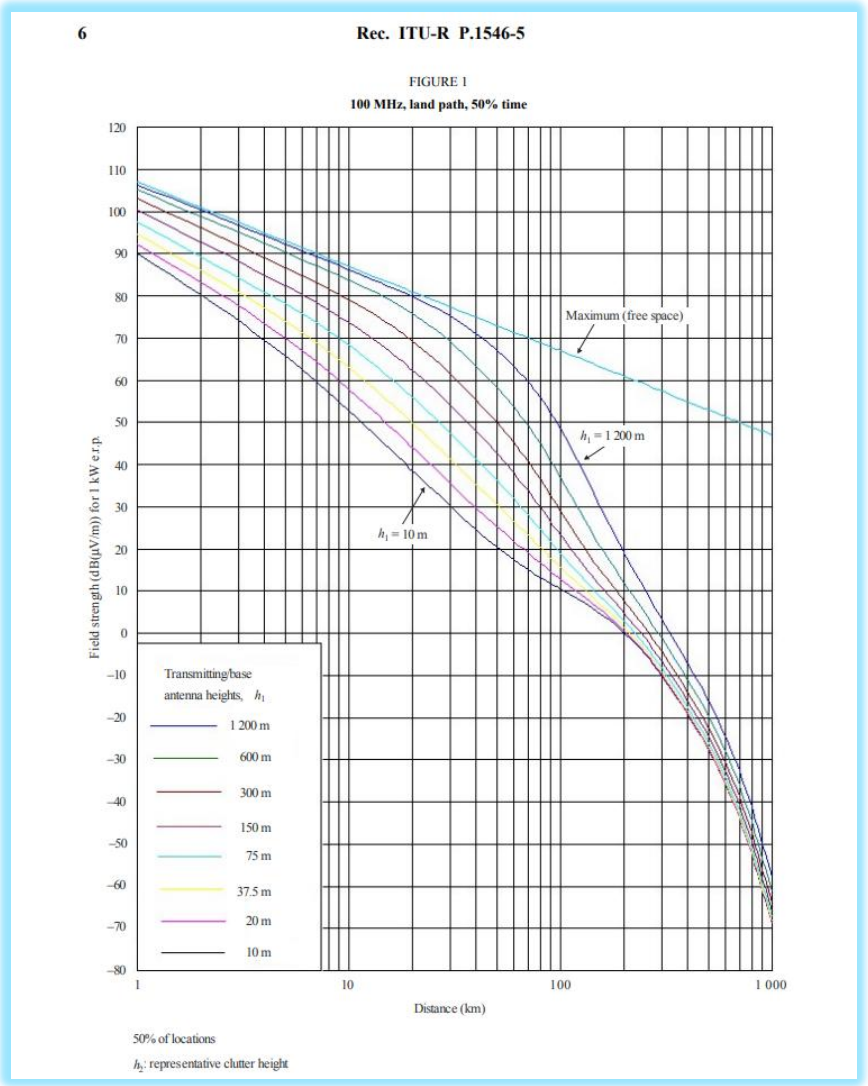
Field-strength curves as functions of *distance, antenna height, frequency and percentage time*

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

Method

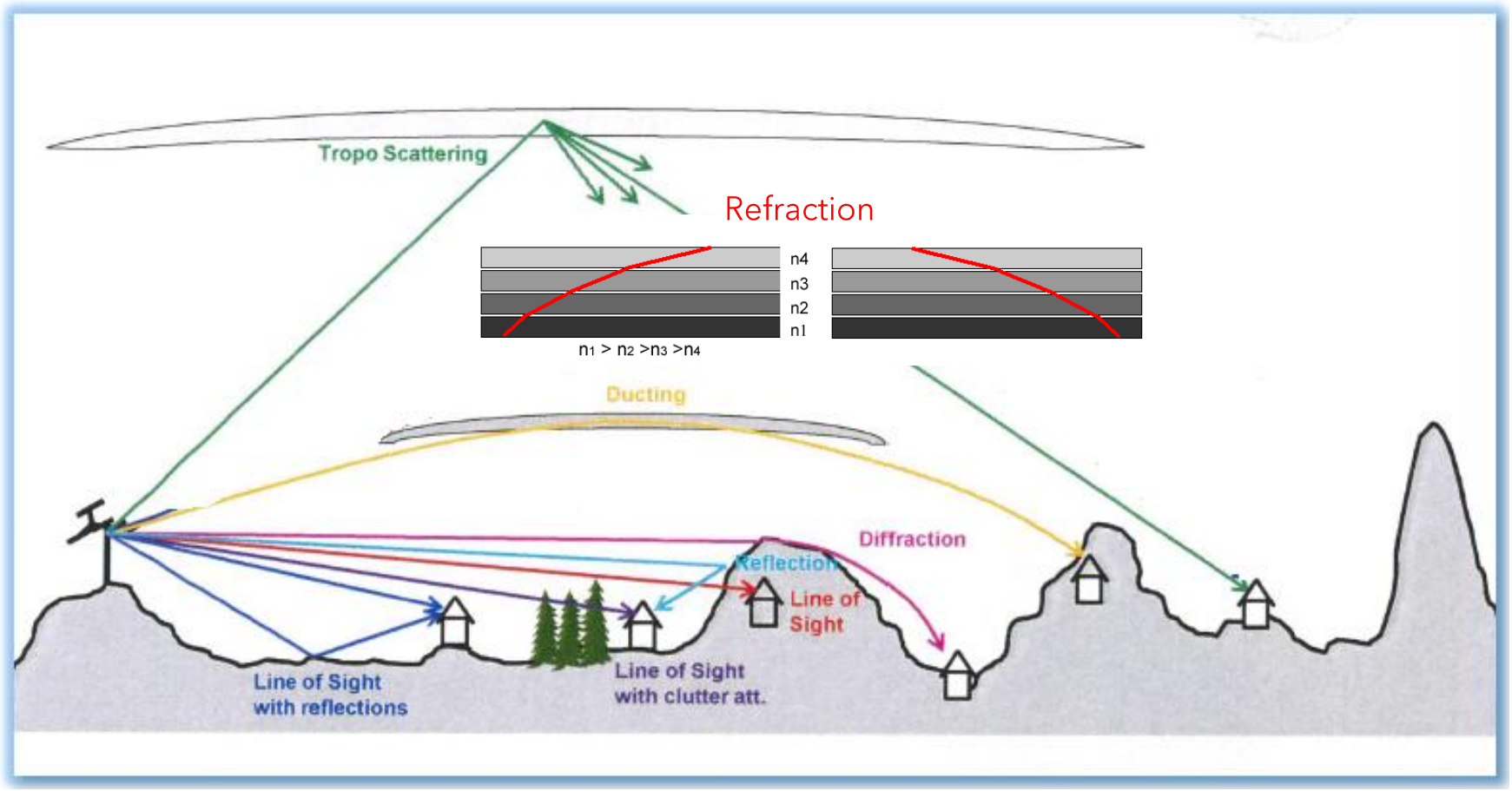
- **interpolation/extrapolation**
- **mixed-path**

Important correction for refractivity index!!



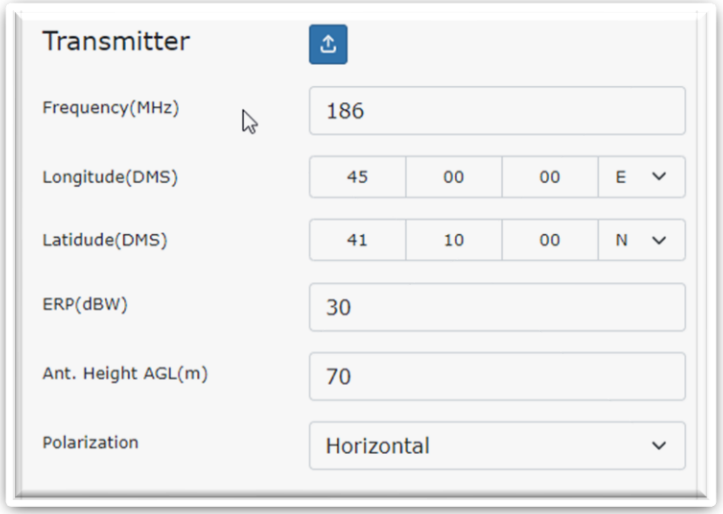
Rec. ITU-R P. 1812

Propagation mechanisms in the VHF/UHF band



Adapted from LS Telcom Propagation training material

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



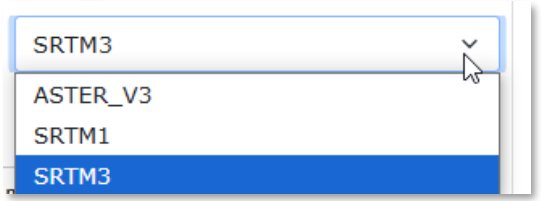
Point to Point

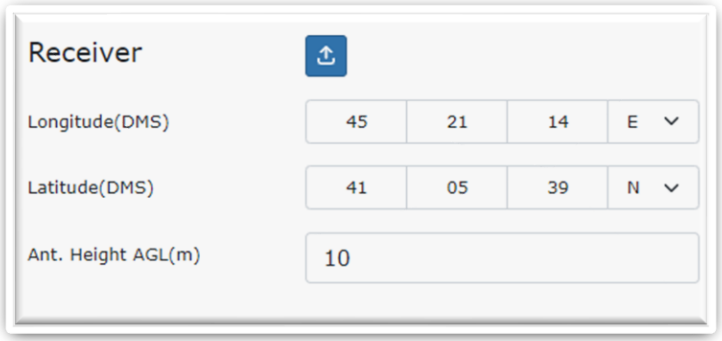


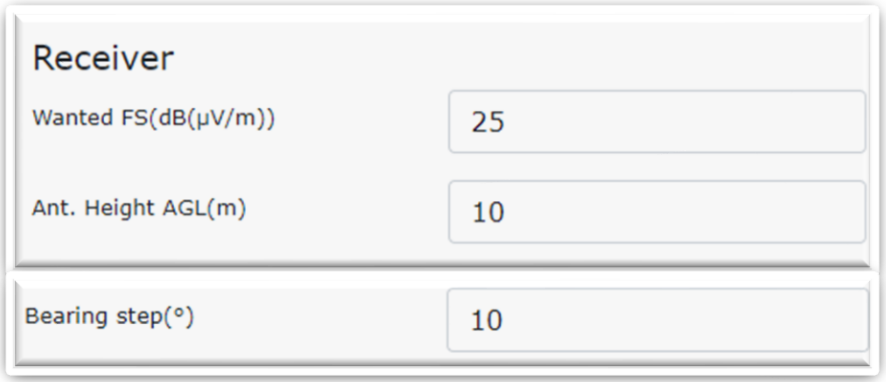
Point to Area



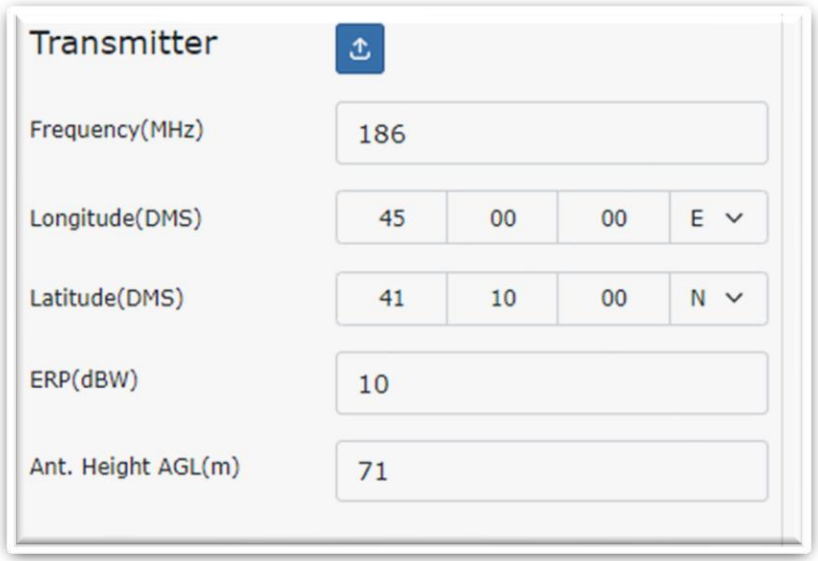
Digital Elevation Model

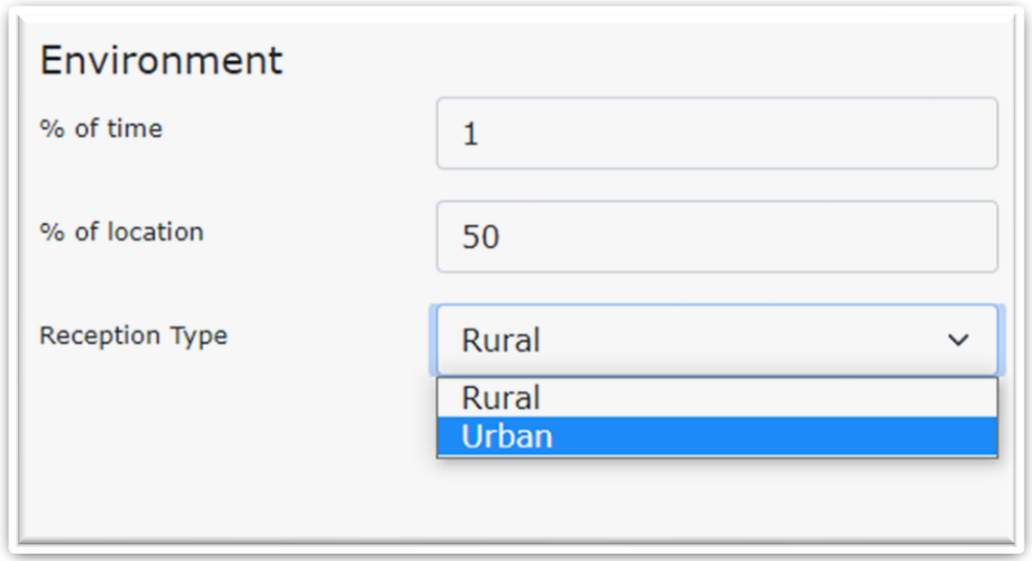






ePropagation: Input parameters (ITU-R P.1546)

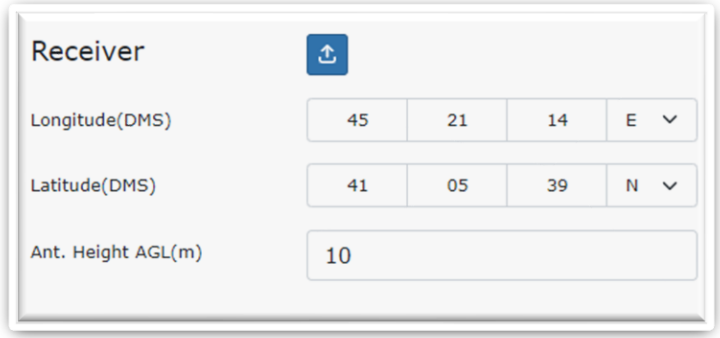




Point to Area



Point to Point



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			

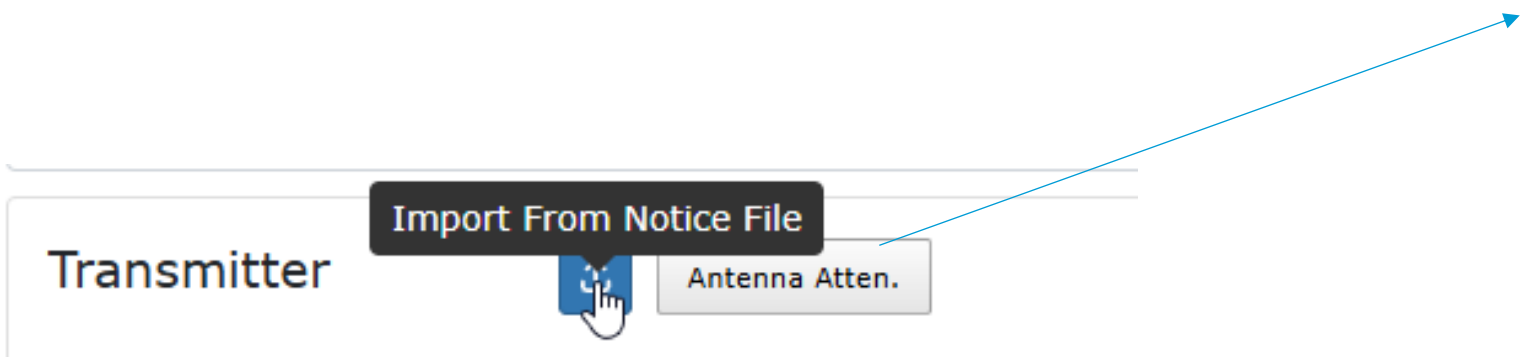
Environment

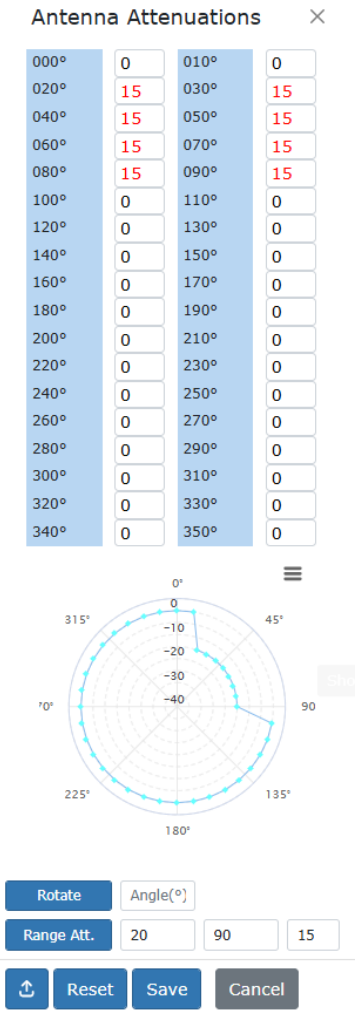
% of time	1
% of location	50
Reception Type	Rural

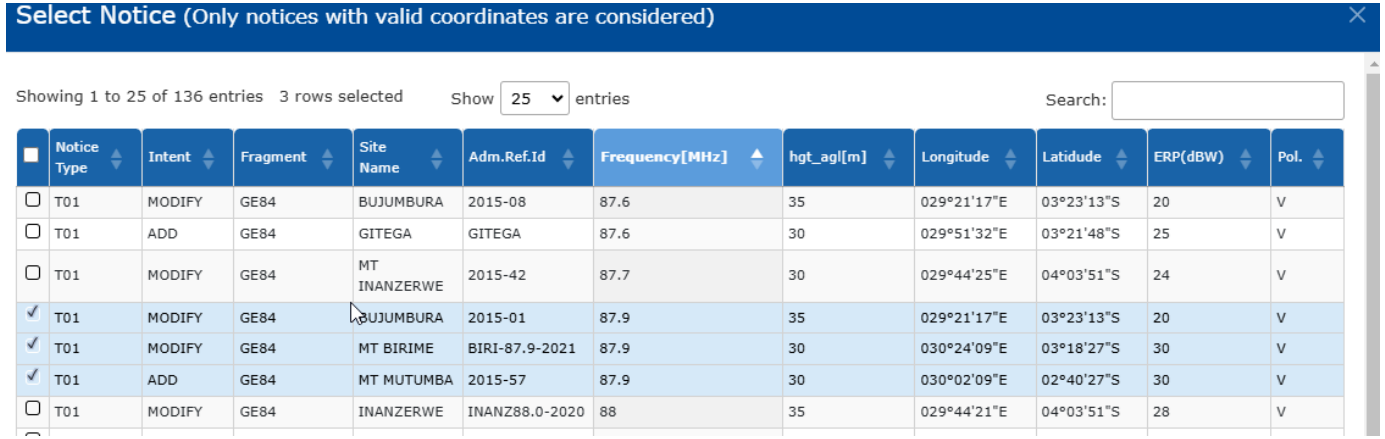
Clear | Add TX | Delete all TXs

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

ePropagation: Input parameters







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

GE84 Agreement

Analogue TV	FM
50% locations 50% time	50% locations 50% time

Interference Analyses (unwanted signal)

Accord GE84

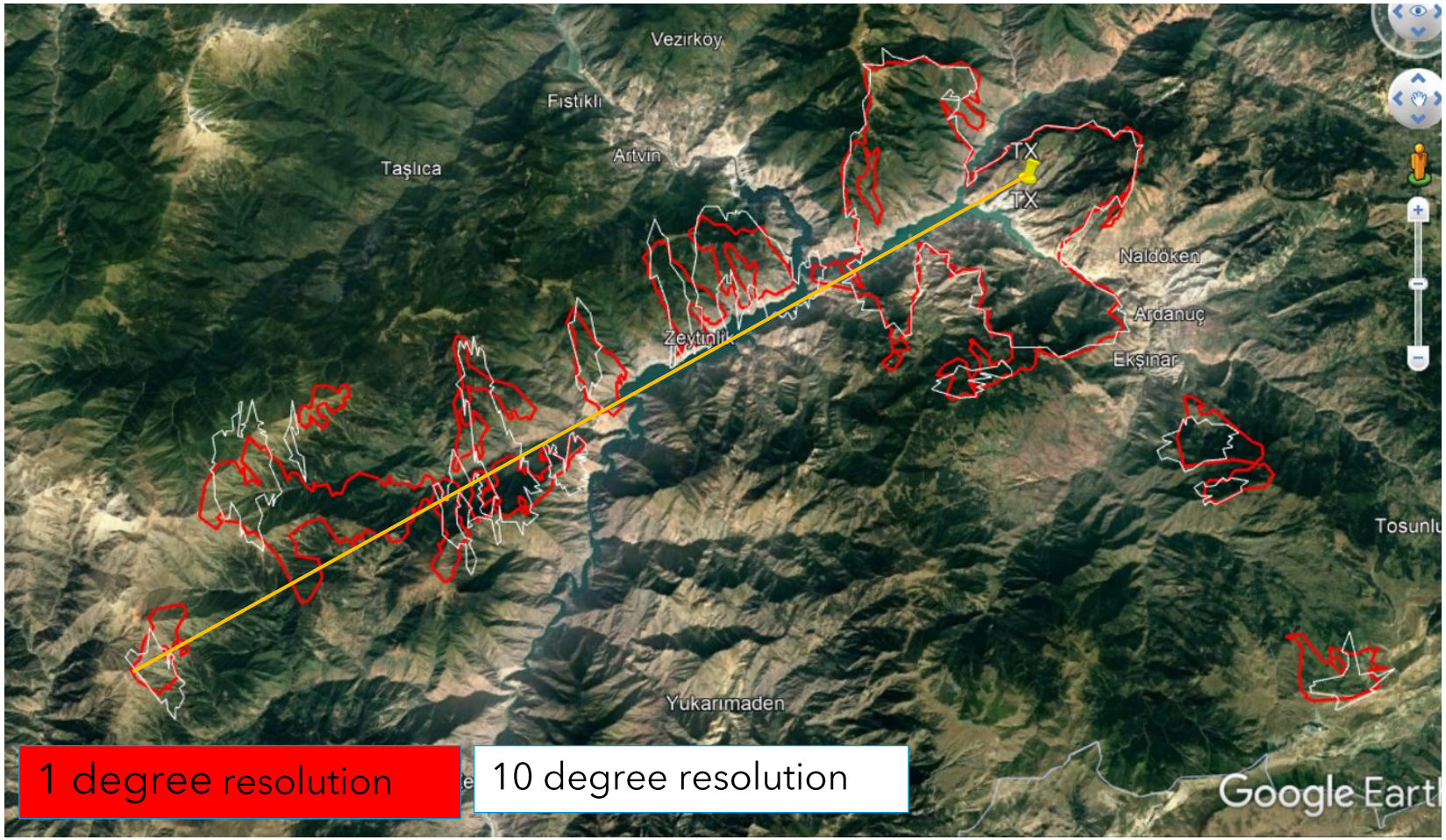
50% locations 1% time	FM (tropo)	FM (steady)
	50% locations 1% time	50% locations 50% time

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

ePropagation: rec. ITU-R P.1812 calculations

Point to Area coverage analyses



1 degree resolution

10 degree resolution

Transmitter	
Frequency[MHz]	186
Longitude	E 042° 00' 00"
Latidude	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

ePropagation: rec. ITU-R P.1812 calculations

Point to Point

Transmitter

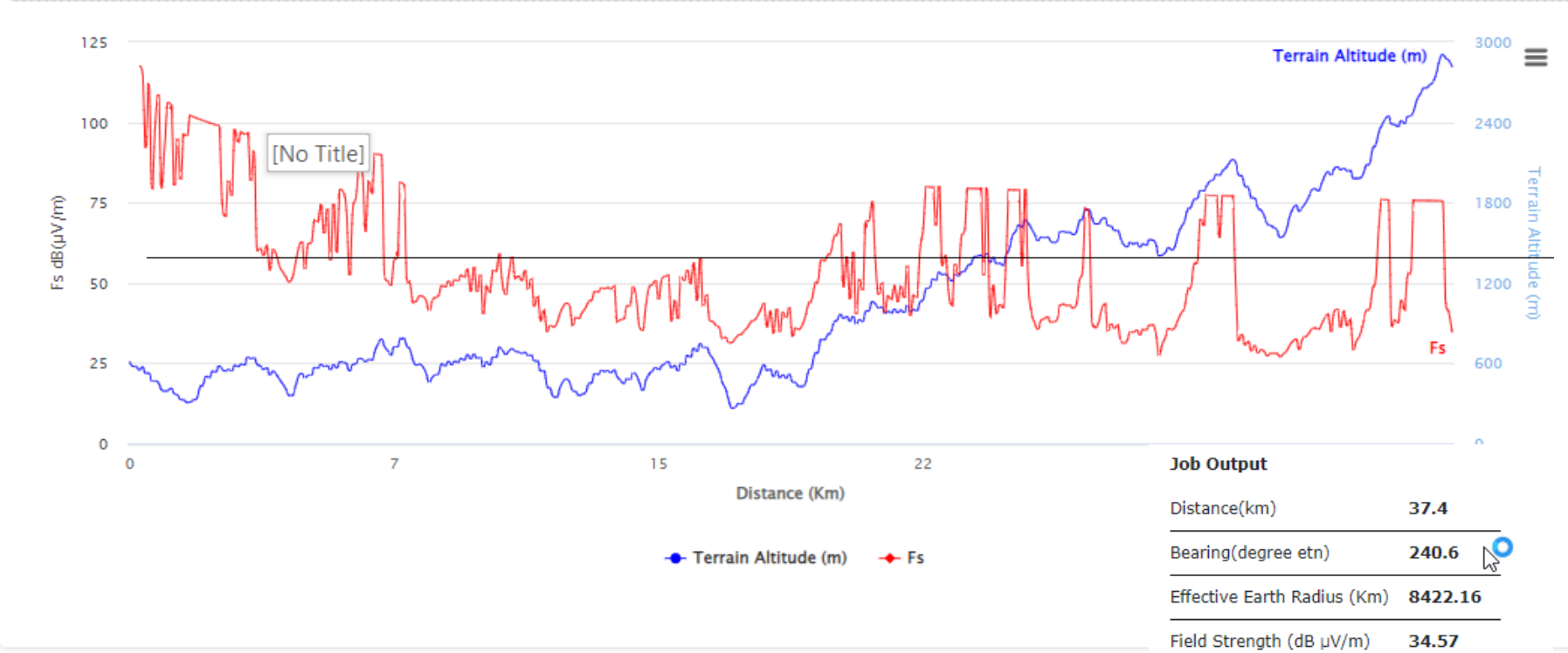
Frequency[MHz]	186
Longitude	E 042° 00' 00"
Latidude	N 41° 10' 00"
Ant. Height AGL(m)	70
ERP(dBW)	30
Polarization	Vertical

Receiver

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

Environment

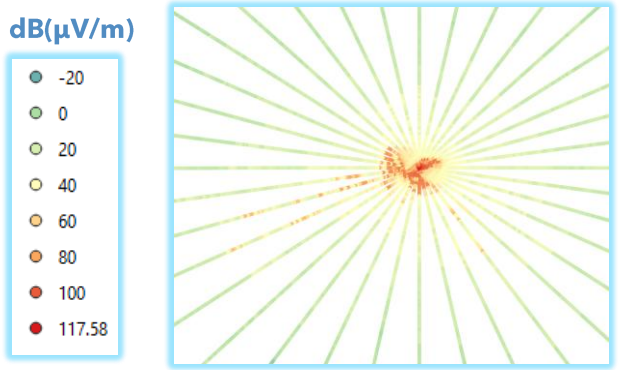
% of time	50
% of location	50
Reception Type	Outdoor
DEM	SRTM3



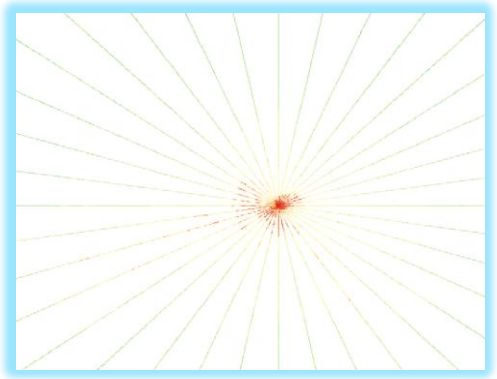
Study FS variation on the path from TX to a RX point in the contours farthest from the TX in the P2A coverage analyses

GIS Analyses field strength contours

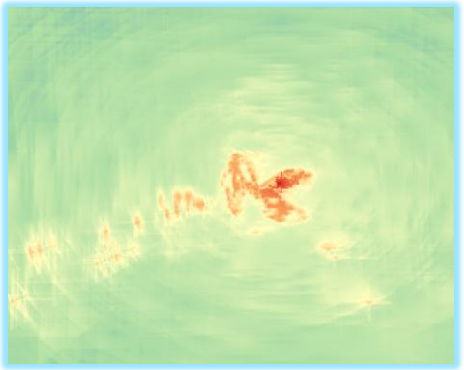
1) P.1812 vector data (location and fs)



2) Convert to raster



3) Interpolate to fill voids



4) Extract fs_wanted contour



5) Simplify geometry



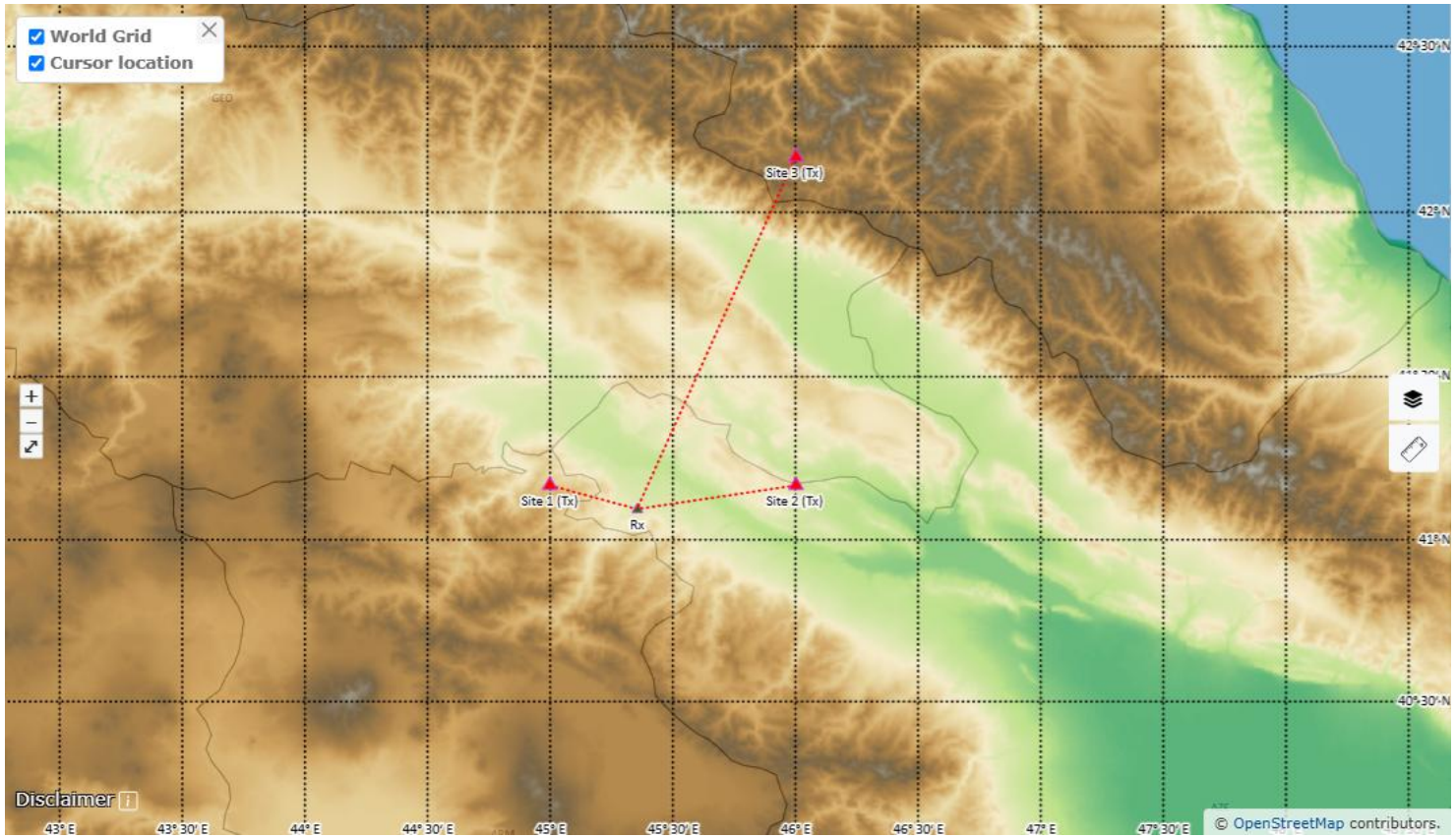
6) Convert to KMZ



OSGeo: GDAL/OGR open source libraries

ePropagation: rec. ITU-R P.1546 calculations

P1546v6 MultiPoint to Point



Power Sum (dB µV/m): **7.3**

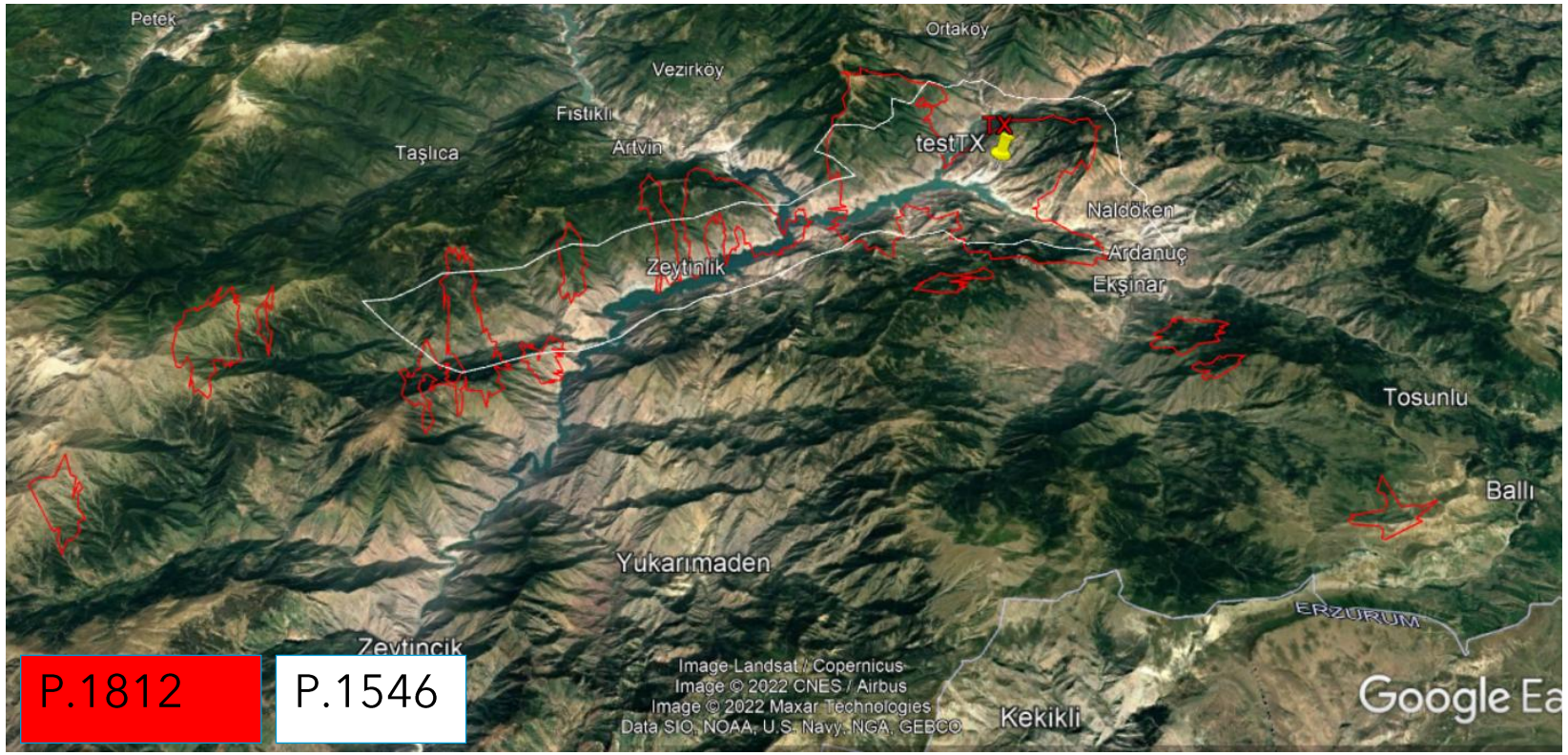
Site Name	Freq. (MHz)	Dist. (km)	Bearing(°)	FS (dB µV/m)
Site 1	186	30.7	105	6.8
Site 2	186	54.7	262	-2.5
Site 3	186	130.8	204	-20.2

ePropagation: rec. ITU-R P.1546 calculations

Point to Area

Coverage analyses

Transmitter	
Frequency[MHz]	186
Longitude	E 042° 00' 00"
Latidude	N 41° 10' 00"
Ant. Height AGL(m)	70
ERP(dBW)	30
Receiver	
Ant. Height AGL(m)	10
Wanted FS(dB(μV/m))	54
Environment	
% of time	50
% of location	50
Reception Type	Rural



Good agreement with ITU-R P.1812 results in this case.

But results can be significantly different!

ePropagation: rec. ITU-R P.1546 calculations

Point to Area

Transmitter

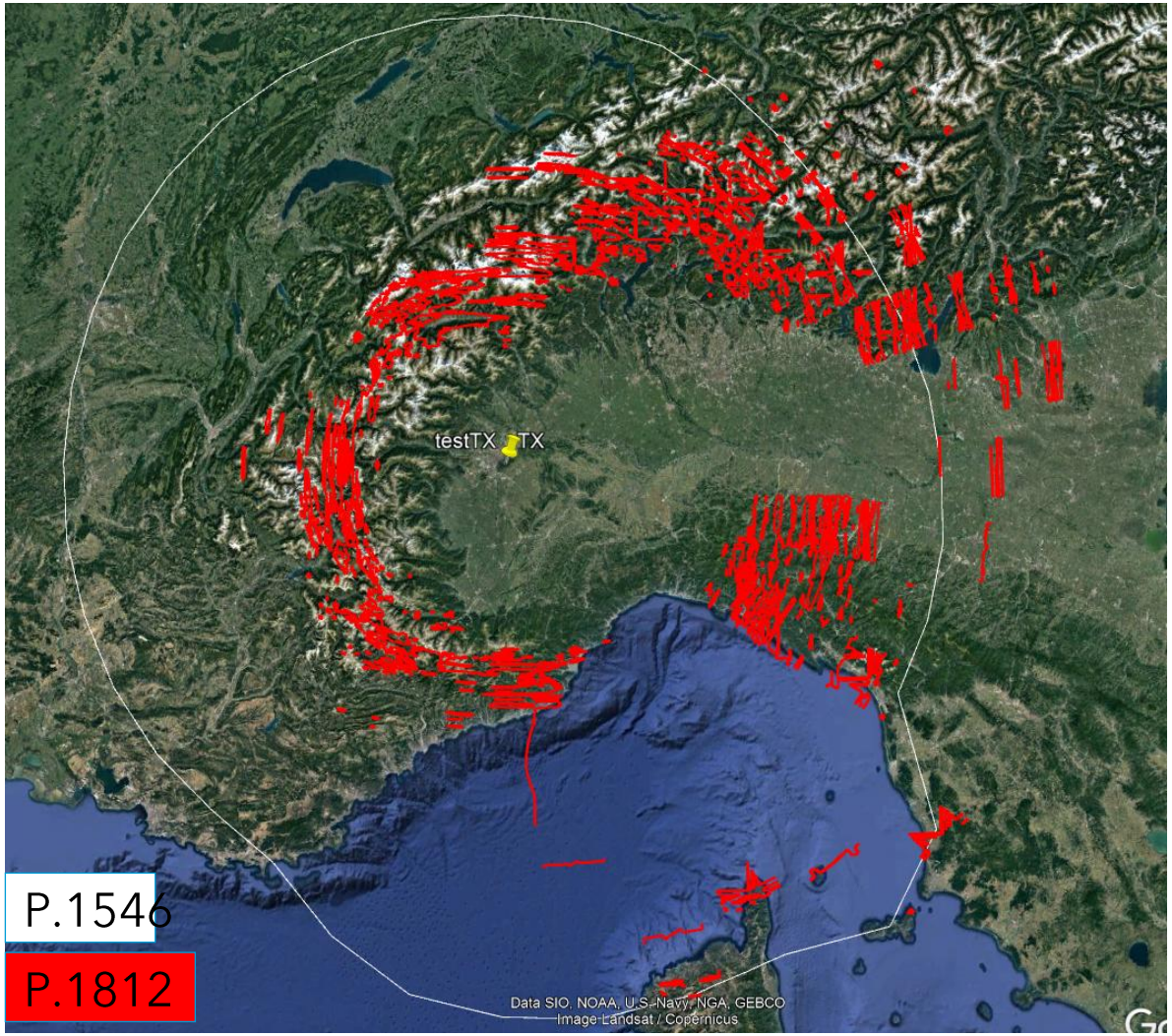
Frequency[MHz]	186
Longitude	E 007° 44' 08"
Latidude	N 45° 02' 27"
Ant. Height AGL(m)	71
ERP(dBW)	30

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

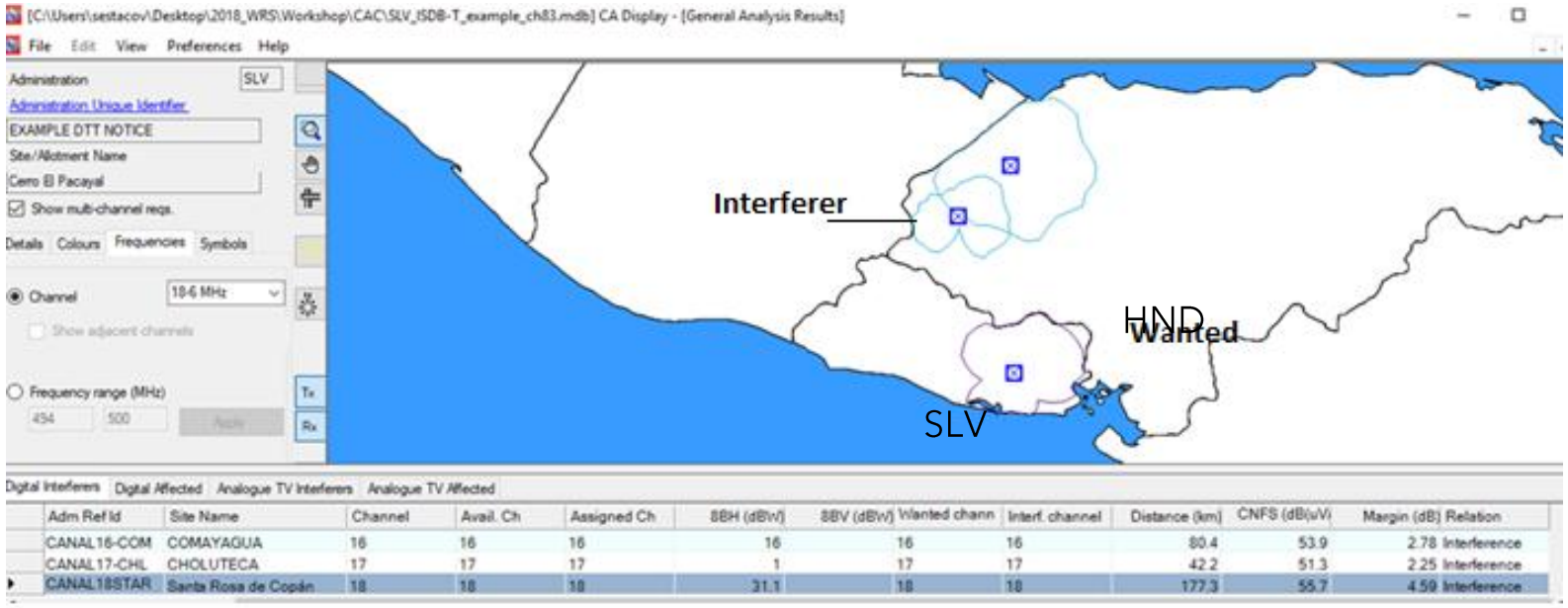
Terrain information considered only via effective antenna height

CA_Display: visualize compatibility analyses results and run detailed calculations

CNFS = 55.7 dB(µV/m)

⬇

FS = 21.9 dB(µV/m)



Adm Ref Id	Site Name	Channel	Avail. Ch	Assigned Ch	8BH (dBW)	8BV (dBW)	Wanted chann	Interf. channel	Distance (km)	CNFS (dB(µV)	Margin (dB)	Relation
CANAL16-COM	COMAYAGUA	16	16	16	16	16	16	16	80.4	53.9	2.78	Interference
CANAL17-CHL	CHOLUTECA	17	17	17	1	17	17	17	42.2	51.3	2.25	Interference
CANAL18STAR	Santa Rosa de Copán	18	18	18	31.1	18	18	18	177.3	55.7	4.59	Interference

```
SLV CERRO EL PACAYAL     EXAMPLE DTT  pol H asignment  RPC 1      FO      chan 14  min med  52.9

 Any potentially interfering requirements are listed


HND CANAL18STAROSACOPAN    SANTA ROSA DE COPCN              chanU 18     chanW 18    prt  33.8 dB
adm identifier          pol                    erph  erpv        erp  effht    bear  dist cnfs  margin  ang wtplng wtplat
HND CANAL18STAROSACOPAN  H                     31.1 -99.9   N   31.1  387.7   146.9 105.9  53.2  1.56  10.0 -88.23  13.95
HND CANAL18STAROSACOPAN  H                     31.1 -99.9   N   31.1  362.6   141.1 109.4  51.5  1.81  20.0 -88.13  13.98
HND CANAL18STAROSACOPAN  H                     31.1 -99.9   N   31.1  388.0   151.1 188.2  50.9  2.10 120.0 -87.92  13.27
HND CANAL18STAROSACOPAN  H                     31.1 -99.9   N   31.1  346.6   154.4 184.1  53.3  3.20 130.0 -88.03  13.25
HND CANAL18STAROSACOPAN  H                     31.1 -99.9   N   31.1  310.6   157.3 177.3  55.7  4.59 140.0 -88.14  13.28
HND CANAL18STAROSACOPAN  H                     31.1 -99.9   N   31.1  294.0   158.7 184.6  54.8  3.86 150.0 -88.18  13.20
HND CANAL18STAROSACOPAN  H                     31.1 -99.9   N   31.1  267.7   160.7 187.2  53.8  1.31 160.0 -88.19  13.16
HND CANAL18STAROSACOPAN  H                     31.1 -99.9   N   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

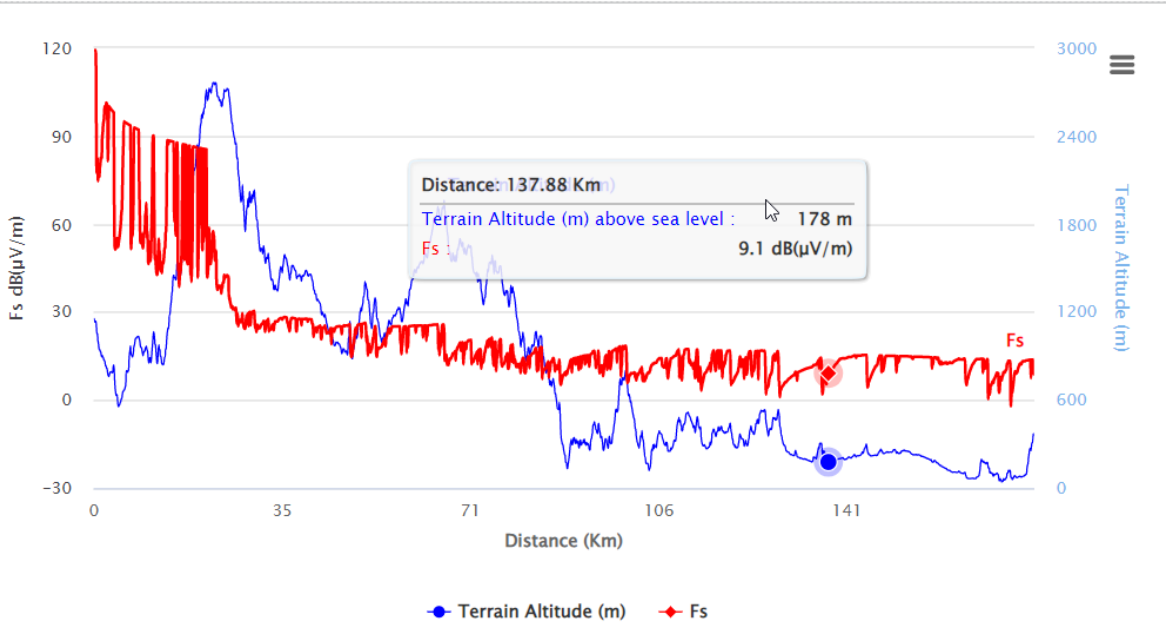
Frequency[MHz]	**497**
Longitude	**W 088° 46' 00"**
Latidude	**N 14° 45' 00"**
Ant. Height AGL(m)	**49**
ERP(dBW)	**31.1**
Polarization	**Horizontal**

Receiver

Longitude	**W 088° 08' 24"**
Latidude	**N 13° 16' 48"**
Ant. Height AGL(m)	**10**
Wanted FS(dB(µV/m))	

Environment

% 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

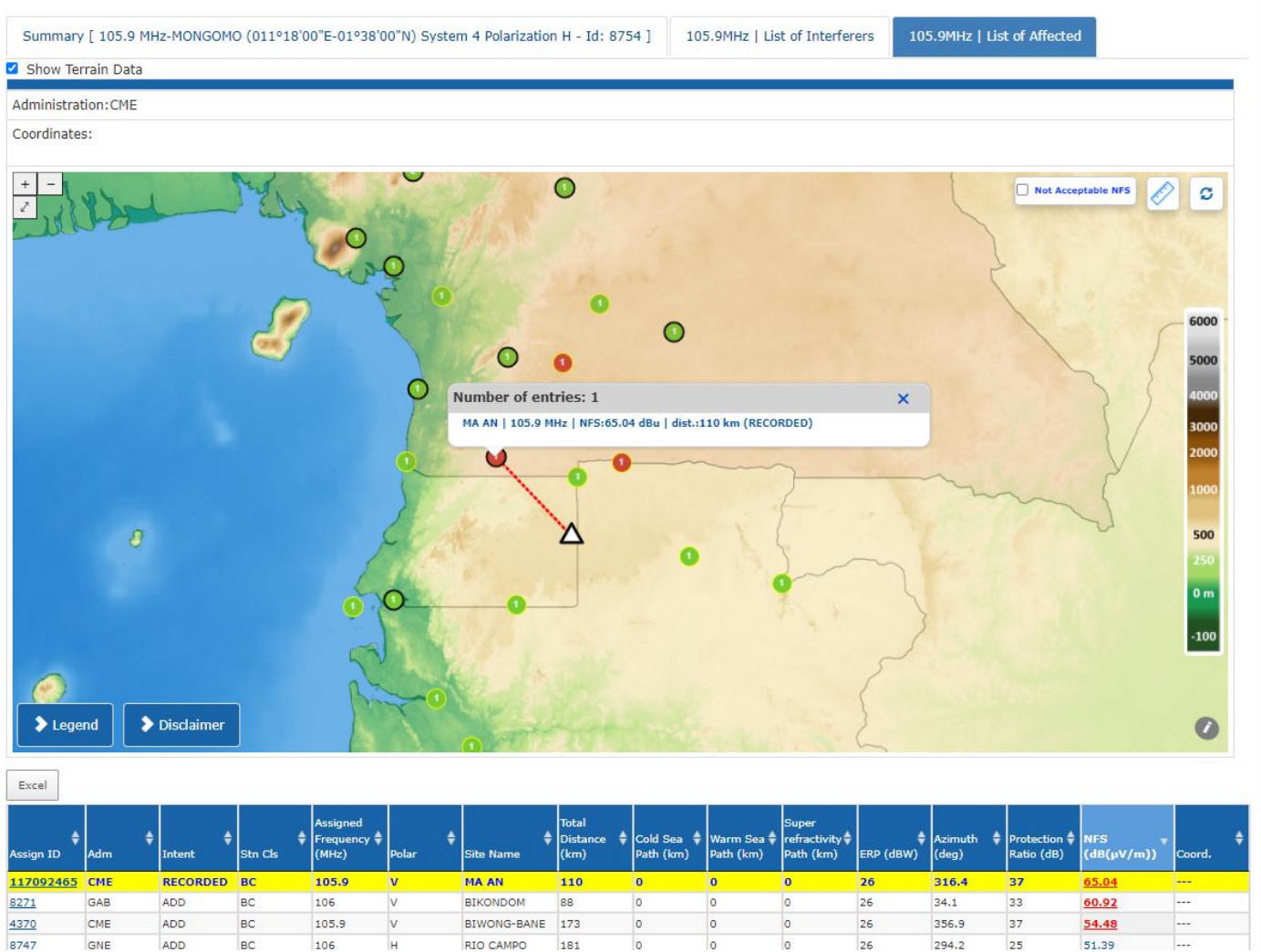
implements GE84 propagation curves (interference analyses).

Terrain information considered only via effective antenna height

Co-channel PR:

Tropo: 37 dB

Steady: 45 dB

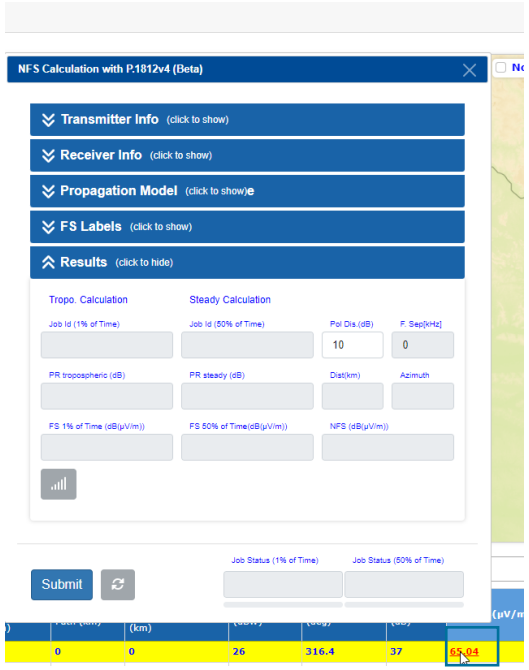


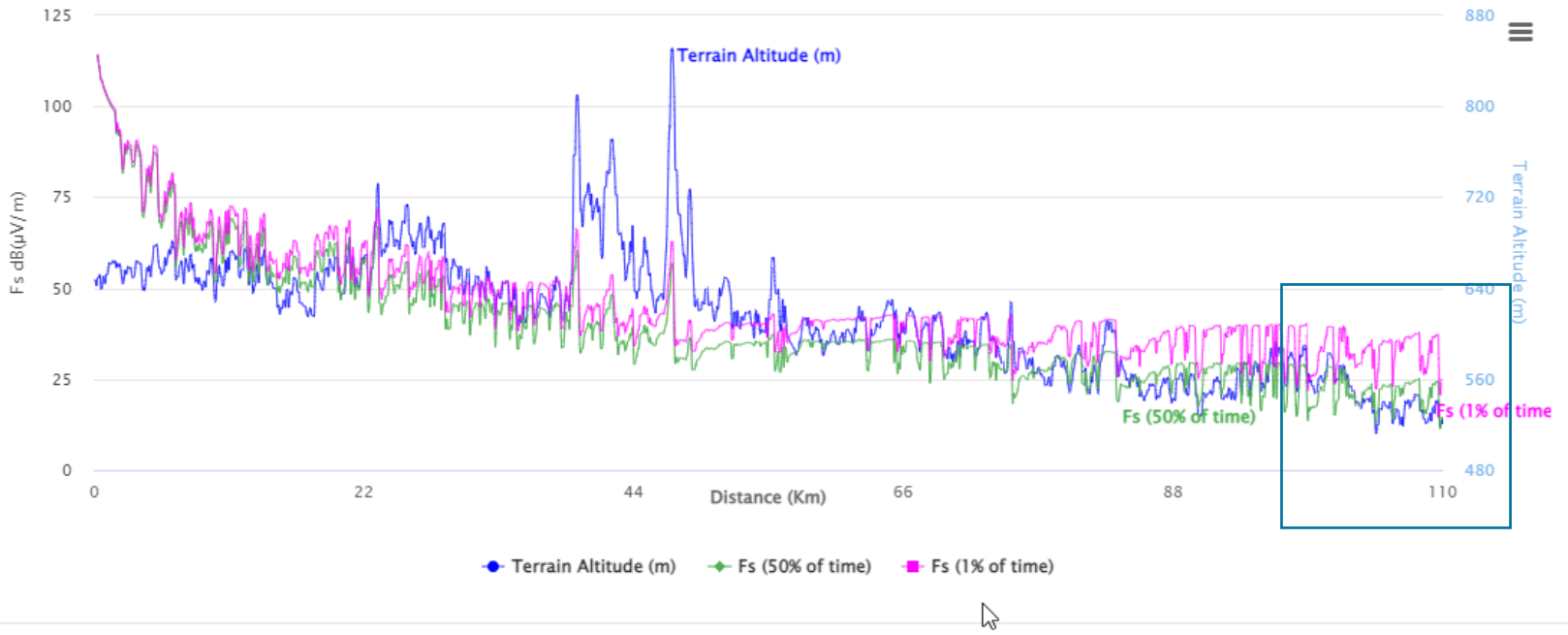
Assign ID	Adm	Intent	Stn Cls	Assigned Frequency (MHz)	Polar	Site Name	Total Distance (km)	Cold Sea Path (km)	Warm Sea Path (km)	Super refractivity Path (km)	ERP (dBW)	Azimuth (deg)	Protection Ratio (dB)	NFS (dB(µV/m))	Coord.
117092465	CME	RECORDED	BC	105.9	V	MA AN	110	0	0	0	26	316.4	37	65.04	---
8271	GAB	ADD	BC	106	V	BIKONDOM	88	0	0	0	26	34.1	33	60.92	---
4370	CME	ADD	BC	105.9	V	BIWONG-BANE	173	0	0	0	26	356.9	37	54.48	---
8747	GNE	ADD	BC	106	H	RIO CAMPO	181	0	0	0	26	294.2	25	51.39	---

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

Use case: GE84 planning activities

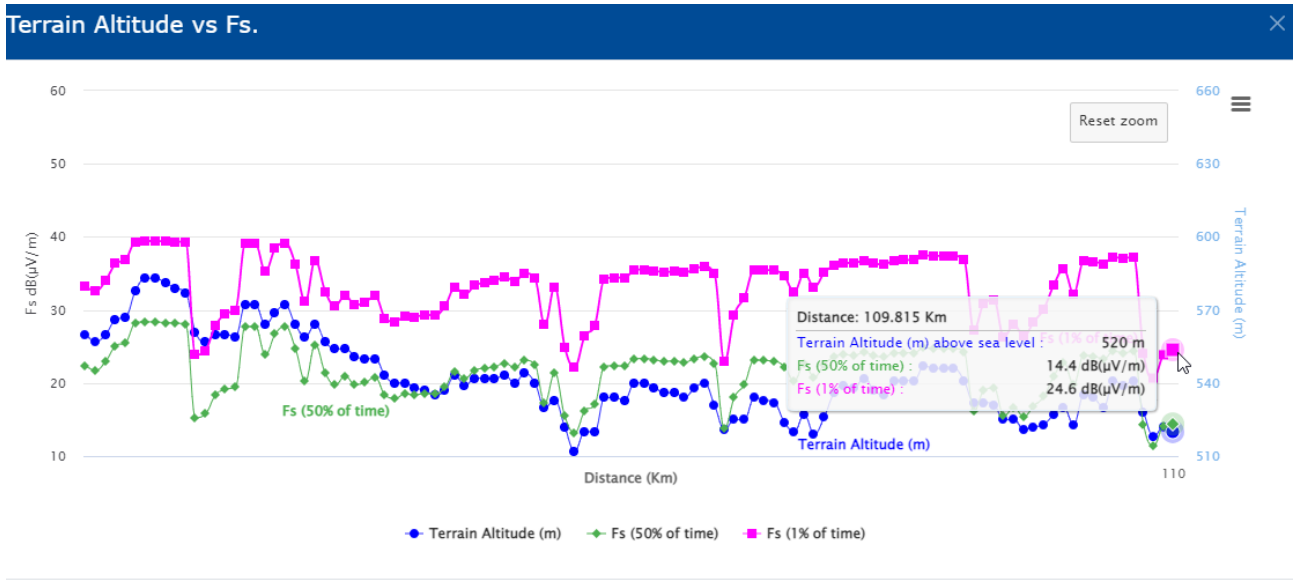
GE84Opt allows to calculate on the fly Point to Point field strength calculations (terrain data) using Rec. ITU-R P.1812





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 dB(µV/m)

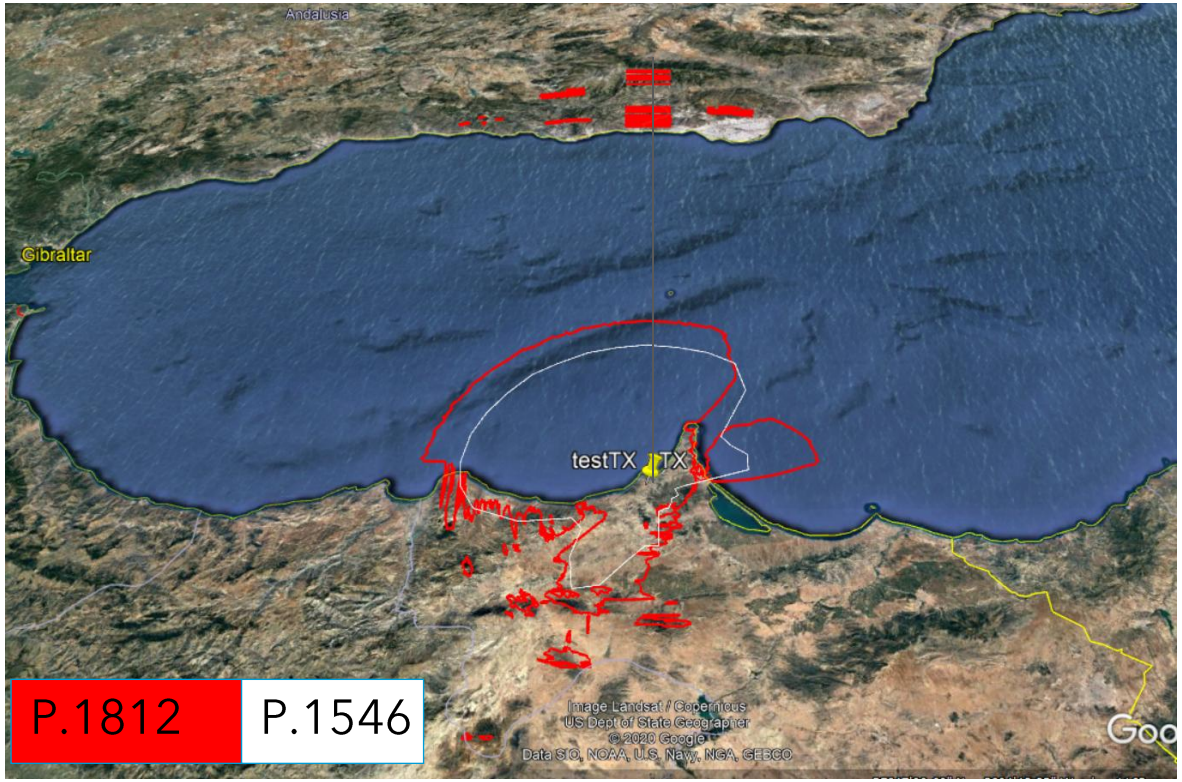
Steady Interference

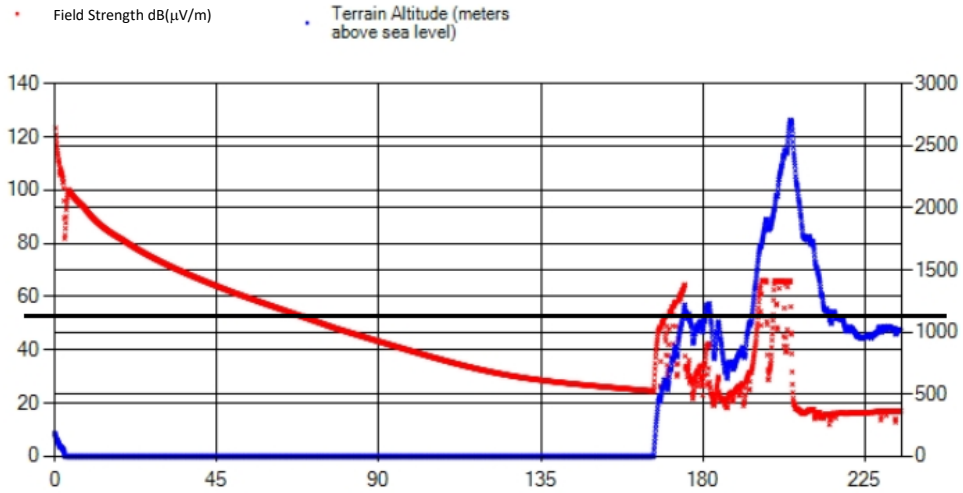
NFS = FS(1%time,50%loc) + PR - Pol Discr =14.4 + 45 - 10= 49.4 dB(µV/m)

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

Use case: FM coverage analyses

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



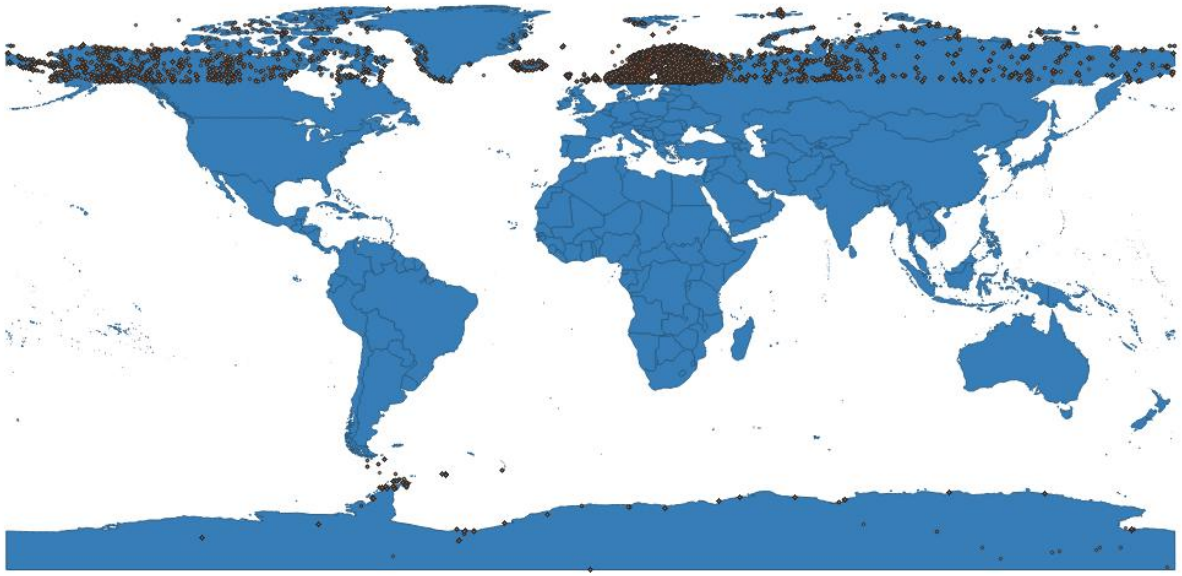


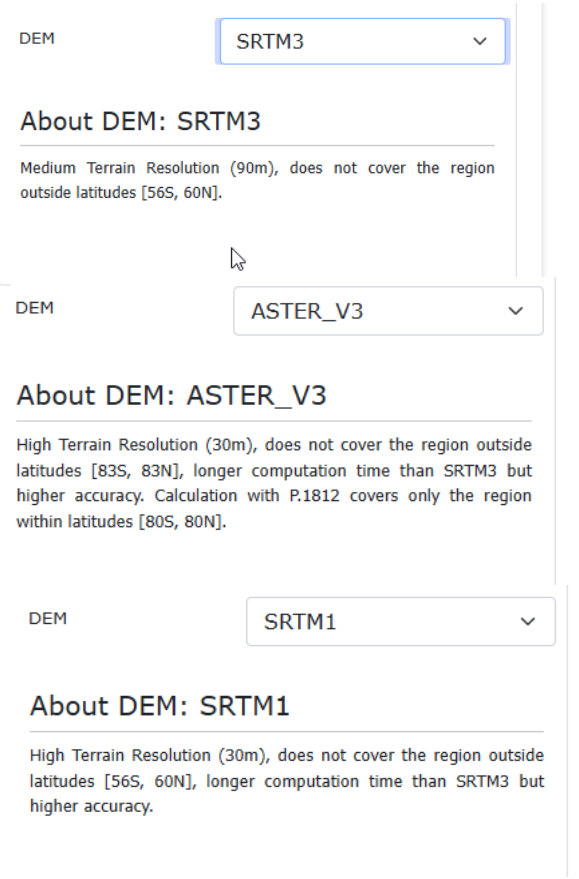
ITU-R P.1812, P.1546 and usages of terrain data

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%)





P1812 and usages of terrain data

Transmitter

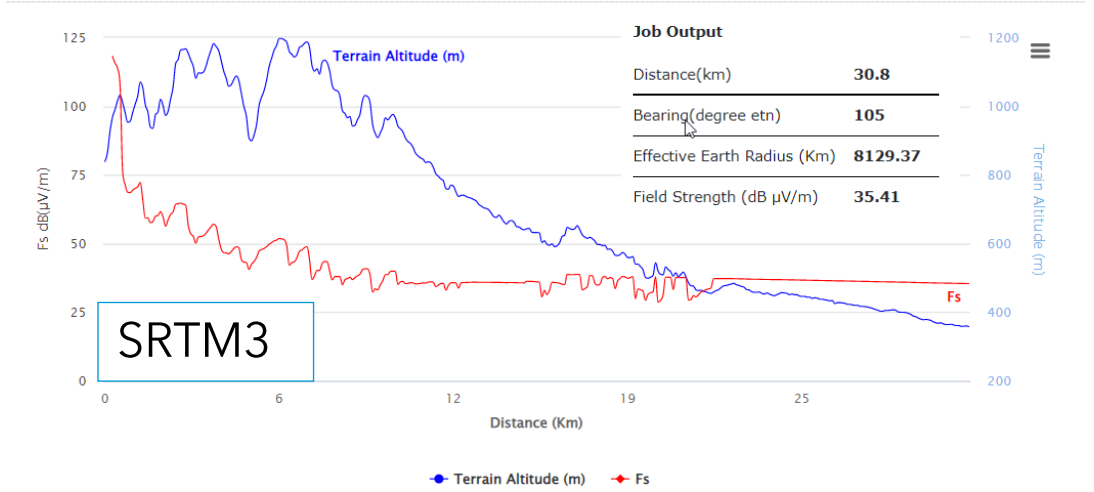
Frequency[MHz]	186
Longitude	E 045° 00' 00"
Latidude	N 41° 10' 00"
Ant. Height AGL(m)	70
ERP(dBW)	30
Polarization	Vertical

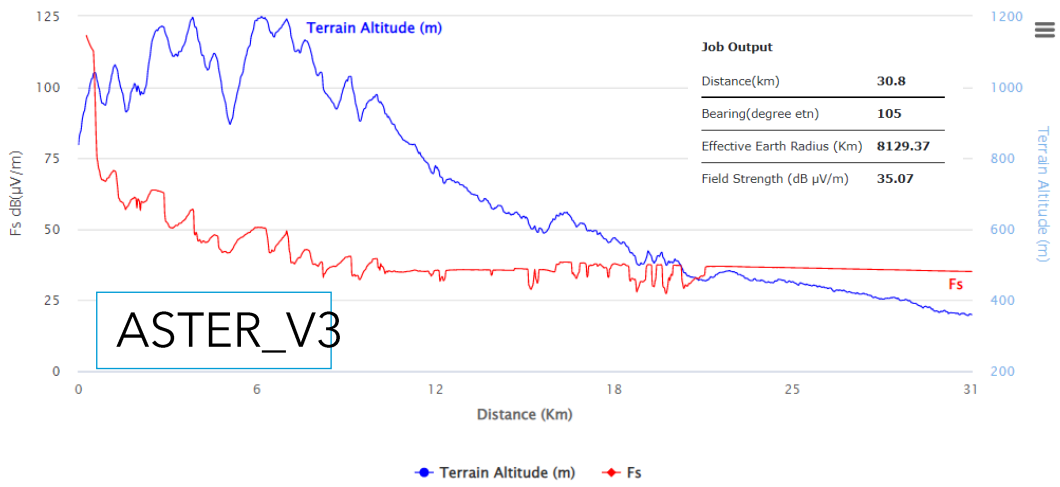
Receiver

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

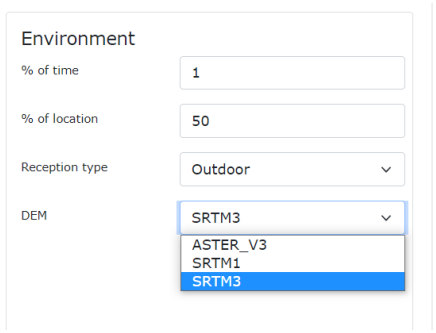
Environment

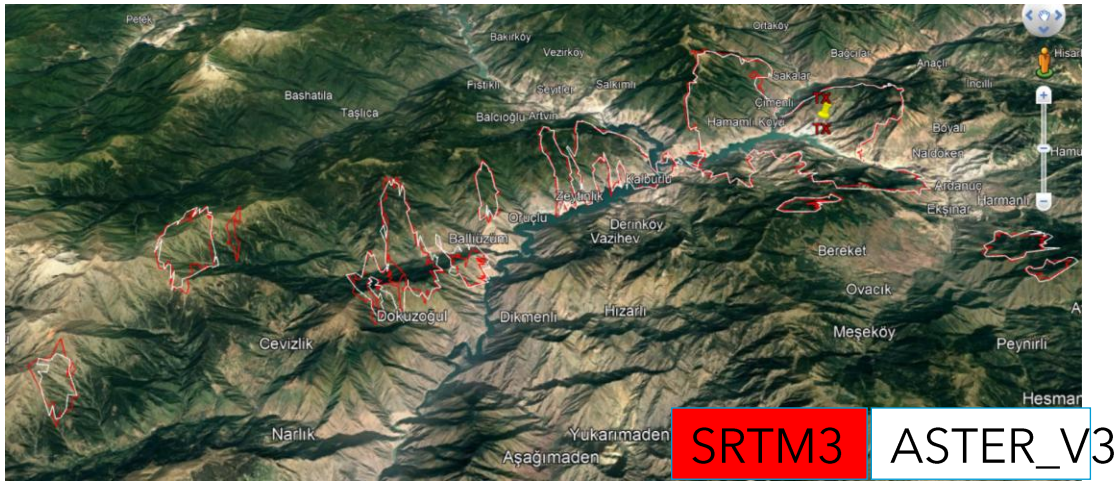
% of time	1
% of location	50
Reception Type	Outdoor

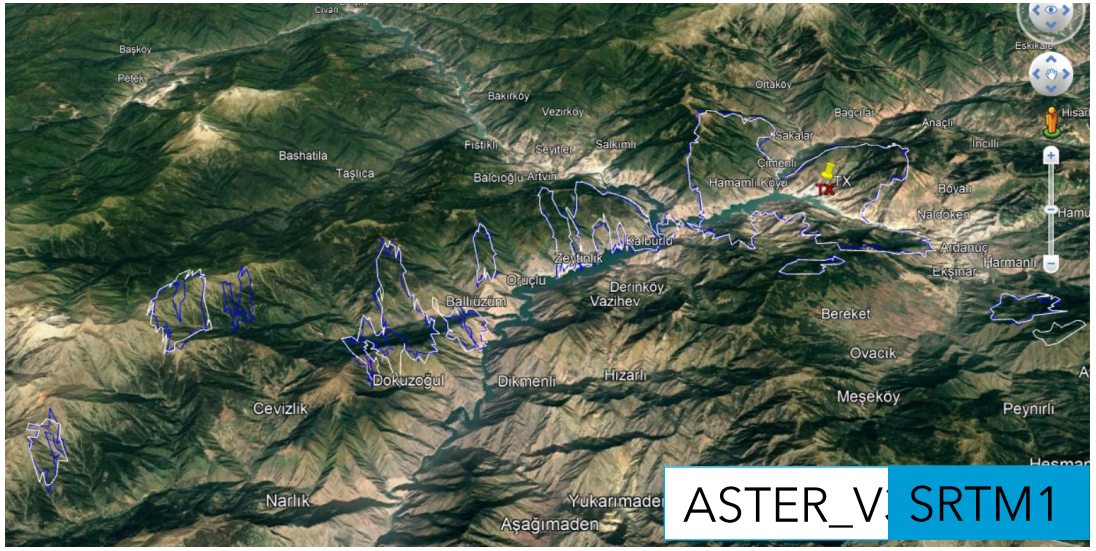




P1812 and usages of terrain data







P1812 and usages of terrain data

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

Transmitter

Frequency[MHz]	186
Longitude	E 021° 06' 47"
Latidude	N 68° 15' 52"
Ant. Height AGL(m)	70
ERP(dBW)	30
Polarization	Horizontal

Receiver

Longitude	E 030° 55' 47"
Latidude	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

Transmitter

Frequency[MHz]	186
Longitude	E 021° 06' 47"
Latidude	N 68° 15' 52"
Ant. Height AGL(m)	70
ERP(dBW)	30
Polarization	Horizontal

Receiver

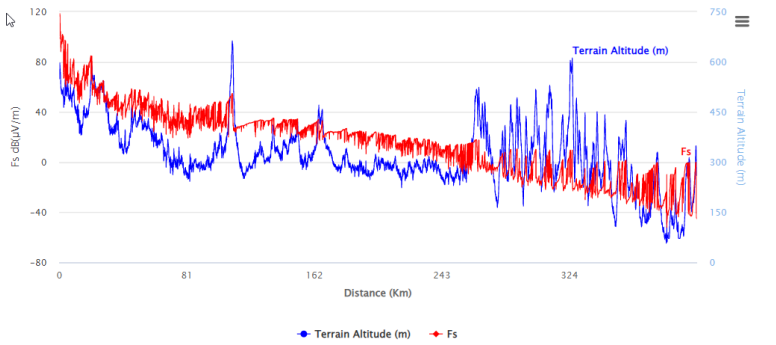
Ant. Height AGL(m)	10
Wanted FS(dB(µV/m))	25

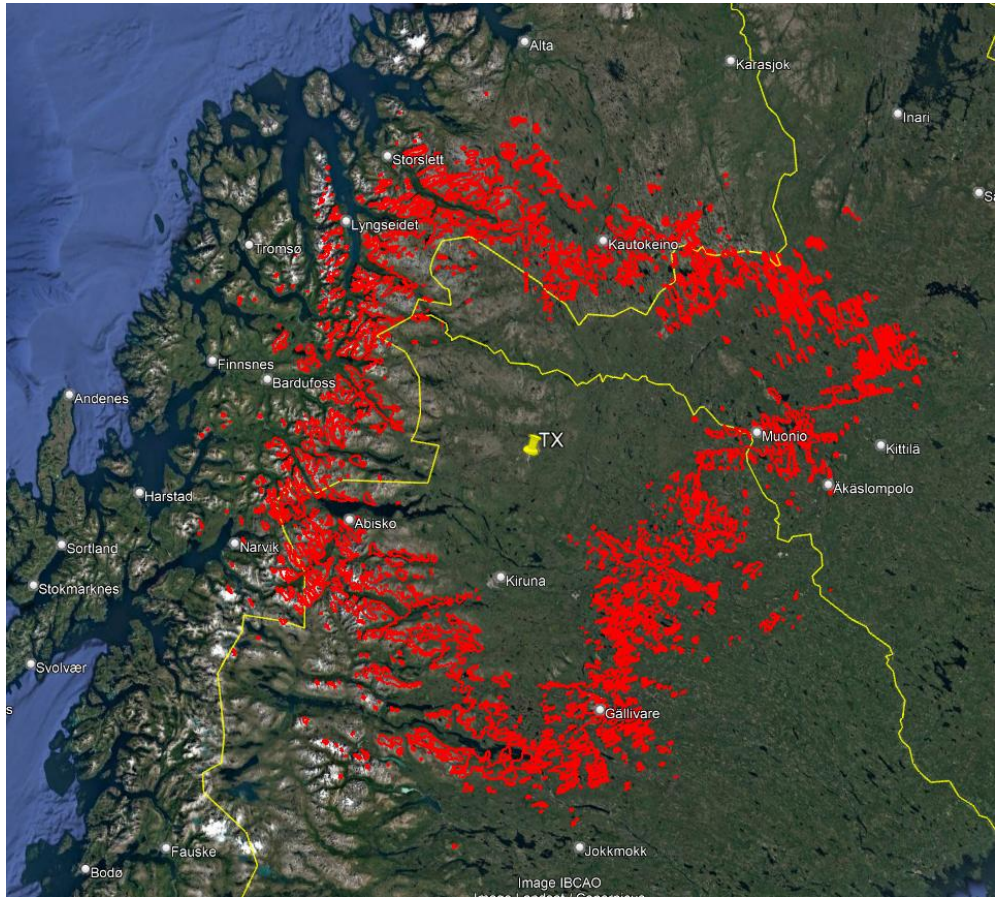
Environment

Bearing step(°)	1
% of time	1
% of location	50
Reception Type	Outdoor
DEM	ASTER_V3

Job Output

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





ITU-R P.1812, P.1546 and usages of terrain data

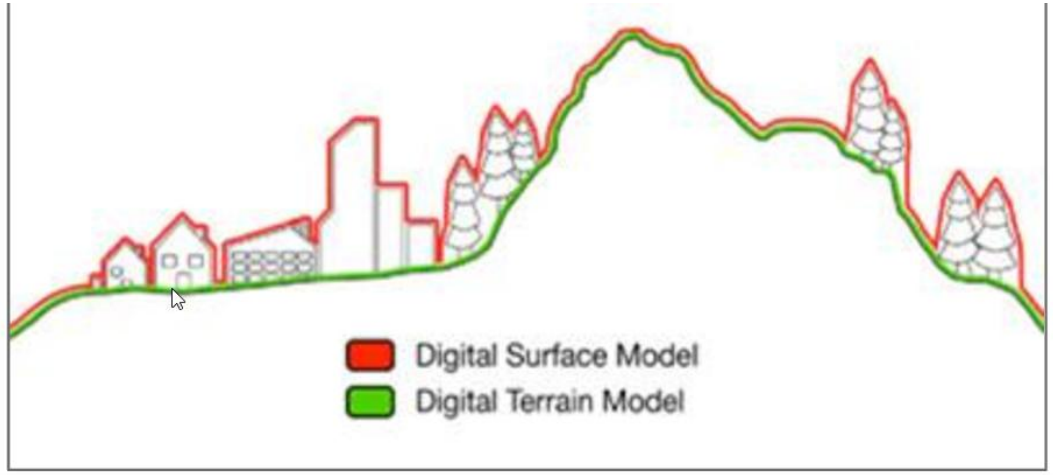


TABLE 2

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

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.

What we have today (open global dataset)

DSM + DTM (e.g. SRTM ~30 m resolution)

What is missing

DTM (terrain height)

Clutter height (DSM – DTM)

Surface classification (buildings / vegetation)

→ Missing inputs → inaccuracies in propagation loss and field-strength prediction

Geospatial Foundation Models: From Imagery to Earth Data Products

Large Language Models (LLMs)
Text → embeddings → tasks
(e.g. summarization, drafting, Q&A)

Geospatial Foundation Models (GFMs)
Imagery → embeddings → outputs

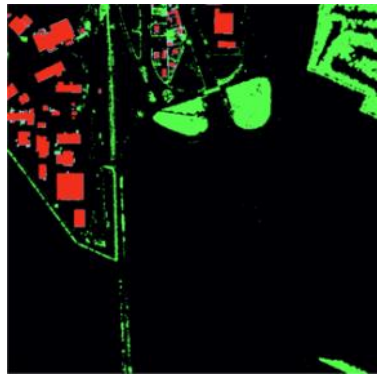


Satellite imagery

Geospatial Foundation Model

Learns general representations

Multiple outputs



Land cover



Surface height (DSM)

Reaching new heights with Geospatial Foundation Models

AI for Good GeoAI Challenge 2026 (video)



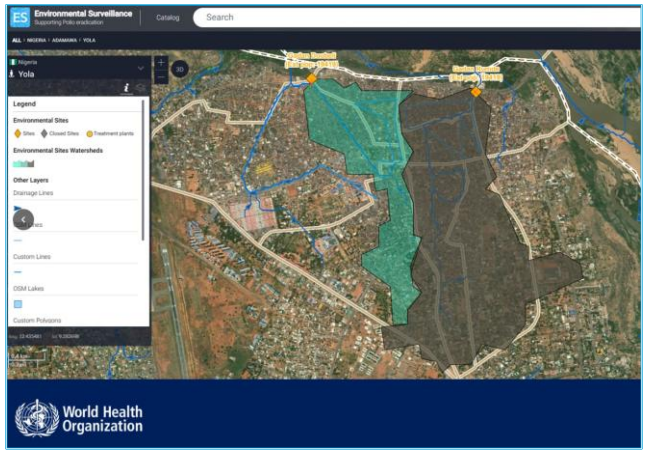
Global participation

- **180 teams worldwide**

Collective innovation to build the next generation of geospatial datasets

WHO–ITU research collaboration

- Developing and validating GFM-based models
- DTM / DSM / land-cover estimation
- Focus on public-health applications



Supporting data-driven decision making in public health

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.

The End!

Thank you!

Andrea Manara
Broadcasting Service Division

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