CloudRF Documentation

Farrant Consulting Ltd

Apr 07, 2025

CONTENTS

This documentation is up-to-date for the following components:

Component	Version
API	3.23
UI	3.16
SLEIPNIR	1.16
GPU Engine	1.12
3D Engine	0.2
Phase Tracing UI	1.1

If you find parts of this documentation are missing or incorrect contact support@cloudrf.com.

CHAPTER

ONE

ABOUT CLOUDRF

CloudRF is an accessible service for modelling radio propagation.

The scalable service was built and shaped from user feedback since its inception as a popular Android app "RFSignal" in 2011.

CloudRF was built for radio operators and engineers who either could not justify the extortionate price tags for legacy desktop packages and/or do not have weeks of time required to use complex tools, designed for planning cellular networks, effectively.

At CloudRF, we pride ourselves on **innovation** and have transformed the way people conduct radio coverage modelling, disrupting what was a very expensive, and exclusive, desktop market.

1.1 Benefits

1.1.1 Accuracy

Our API supports LiDAR at 1m resolution, soft clutter / land cover and custom obstacles. You can define regional clutter profiles for different trees, seasons and building architectures.

1.1.2 Speed

Our CPU and GPU engines are the fastest, and most economical, on the web and support 1m LiDAR.

We include global soft buildings and clutter in all our plans, but with a clear price which we are proud to publish.

1.1.3 Availability

Our global terrain data, 10m land cover and 2m buildings are ready to go now. Save yourself hours of mission preparation.

This is why we're used globally for fire-fighting, search and rescue, events, security operations and disaster management.

1.1.4 Economy

User-friendly interfaces designed for busy humans with options to support most radio technologies from HF to SATCOM.

Cross-platform interfaces with tips and videos to help you plan your network today, not next week.

1.2 Our Mission

Our mission is to make radio planning **simple** and **accessible**.

Radio modelling is complicated that usually needs an enormous number of resources and preparation to do it accurately. We want it to be accessible, accurate, and user-friendly.

1.3 Innovation Roadmap

Year	Milestones
2011	RFSignal for Android launched. Top 50 in communications category on Play Store.
2012	CloudRF.com website launched with web interface
2013	Keyhole Radio™ interactive layer for Google Earth.
2014	Virtual machines offered.
2015	ITU propagation models added to engine. Channel intersection. Mesh functionality.
2016	LiDAR high resolution data in engine and interfaces. UK 2 meter and US city DSM uploaded.
2017	Drone photogrammetry support via Pix4D. Global 30m DSM
2018	New LiDAR propagation engine SLEIPNIR developed. LiDAR uploaded for New Zealand, Estonia, Sweden, DC and Baltimore GPU prototype engine
2019	30 meter landcover with 584 types for CONUS and EU. KML "do-it-yourself" clutter upload utilty. 3D clutter with material densities.
2020	3D building support with configurable attenuation. 3D cross-platform interface. 26k antenna patterns added ATAK integration
2021	ATAK chatbot SOOTHSAYER™ virtual machine with BYO LiDAR 10 meter global clutter More API client examples inc Windows Points API for many-many analysis CSV coverage metrics
2022	GPU area API Satellite planning tool MANET planning tool Hardware API integration GPU Best site analysis API
2023	GPU Multisite / MANET GPU clutter attenuation ATAK plugin
2024	3D API with multipath and phase effects. General purpose model and multi-obstacle diffraction modelsOutput bounded GPU calculations for SATCOM viewsheds
2025	Phase Tracing interface for BYO glTF based simulations. ATAK plugin with output bounds polygon toolHF Skywave with frequency prediction

1.4 Supported Technologies

- Anything that uses radio from **2-90,000 MHz**.
- The protocol agnostic API can be used to model specific technologies like **LoRa / LTE / 4G / 5G**.

1.5 Platforms

The following platforms are supported:

- **Android**, **Linux**, **Mac/OSX** and **Windows** are supported.
- Our **ATAK** plugin lets you pick radios from a list and it's server based architecture won't deplete your battery..
- Our **3D interface** will adjust to any device from phones to desktop computers.

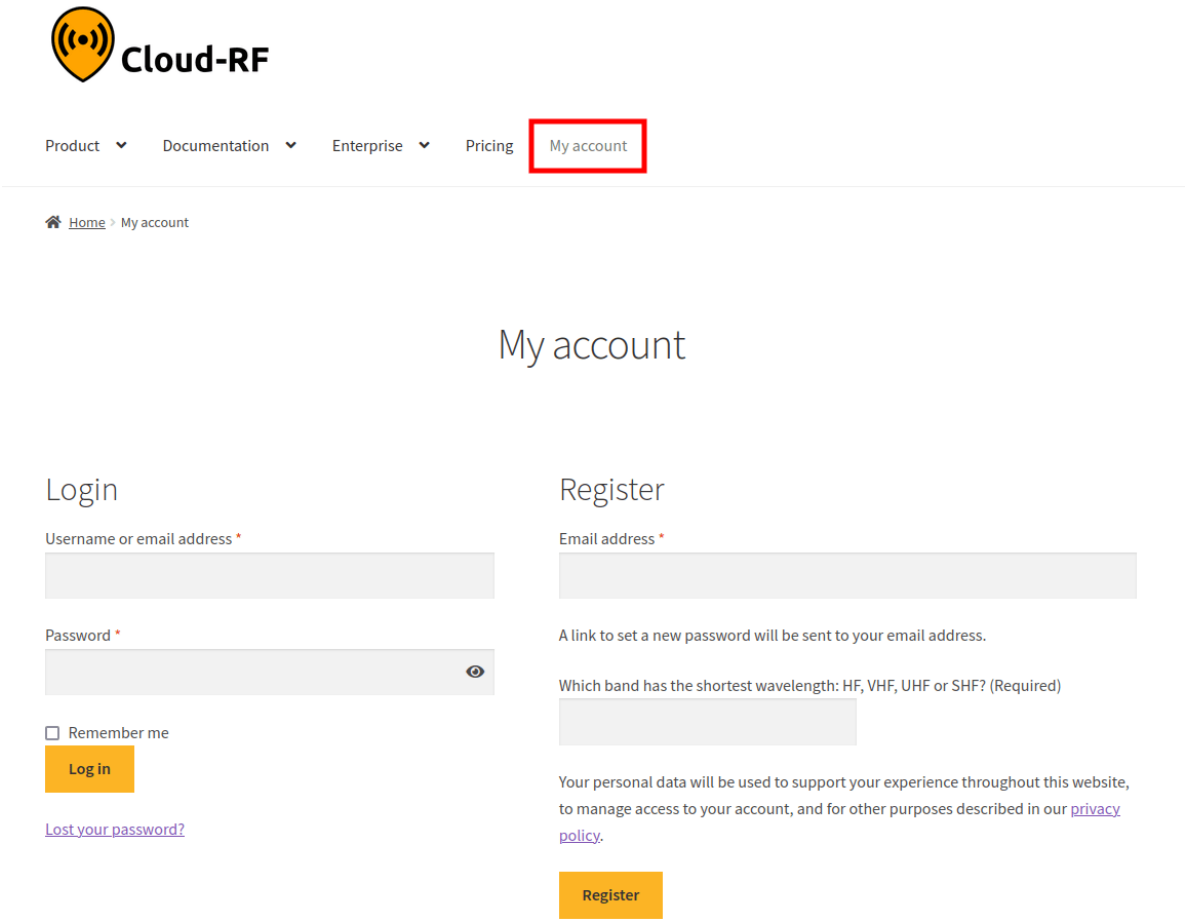
Google Chrome is recommended for best performance.

1.6 CloudRF.com (public API)

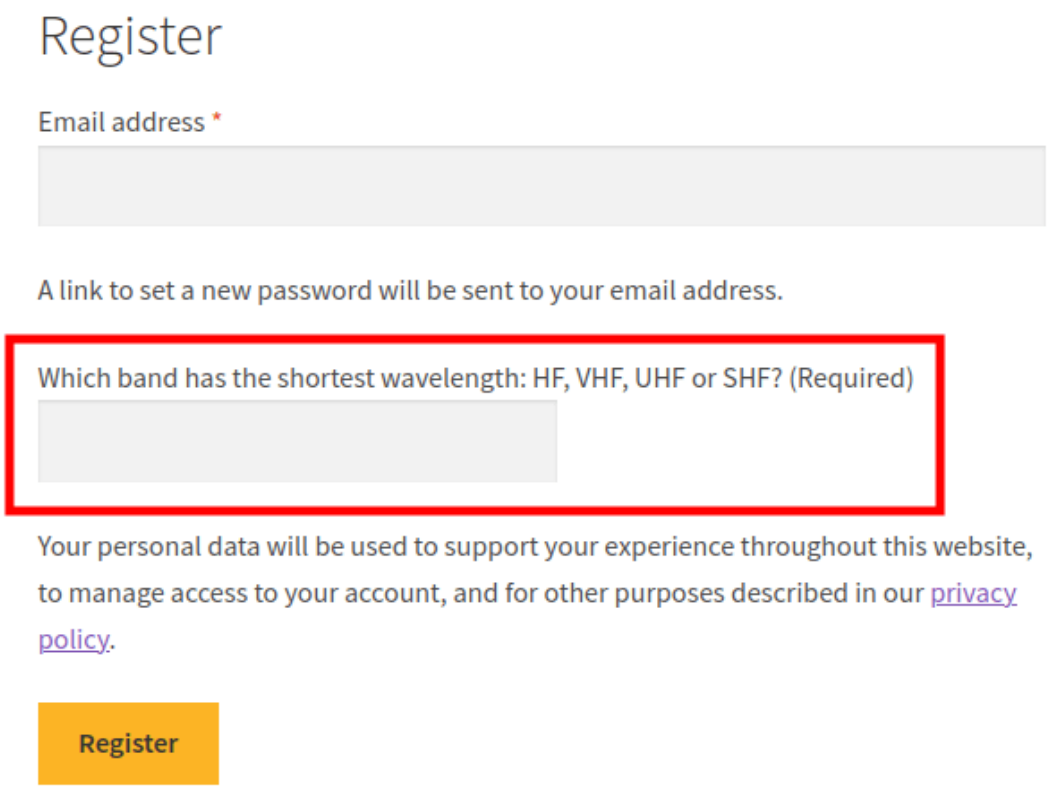
1.6.1 Account Registration

To **Register your Account** on the CloudRF:

- On the **CloudRF website** (https://cloudrf.com/):
  - Click on **My Account** tab.
  - The **My Accounts** screen will appear.



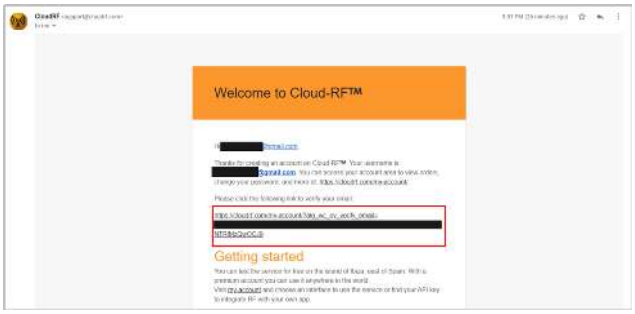
- Under the **Register** section,
  - In the **Username** field, enter the username as desired.
  - In the **Email Address** field, enter your email address.
  - In the **Quiz** field, enter your answer to the respective question.



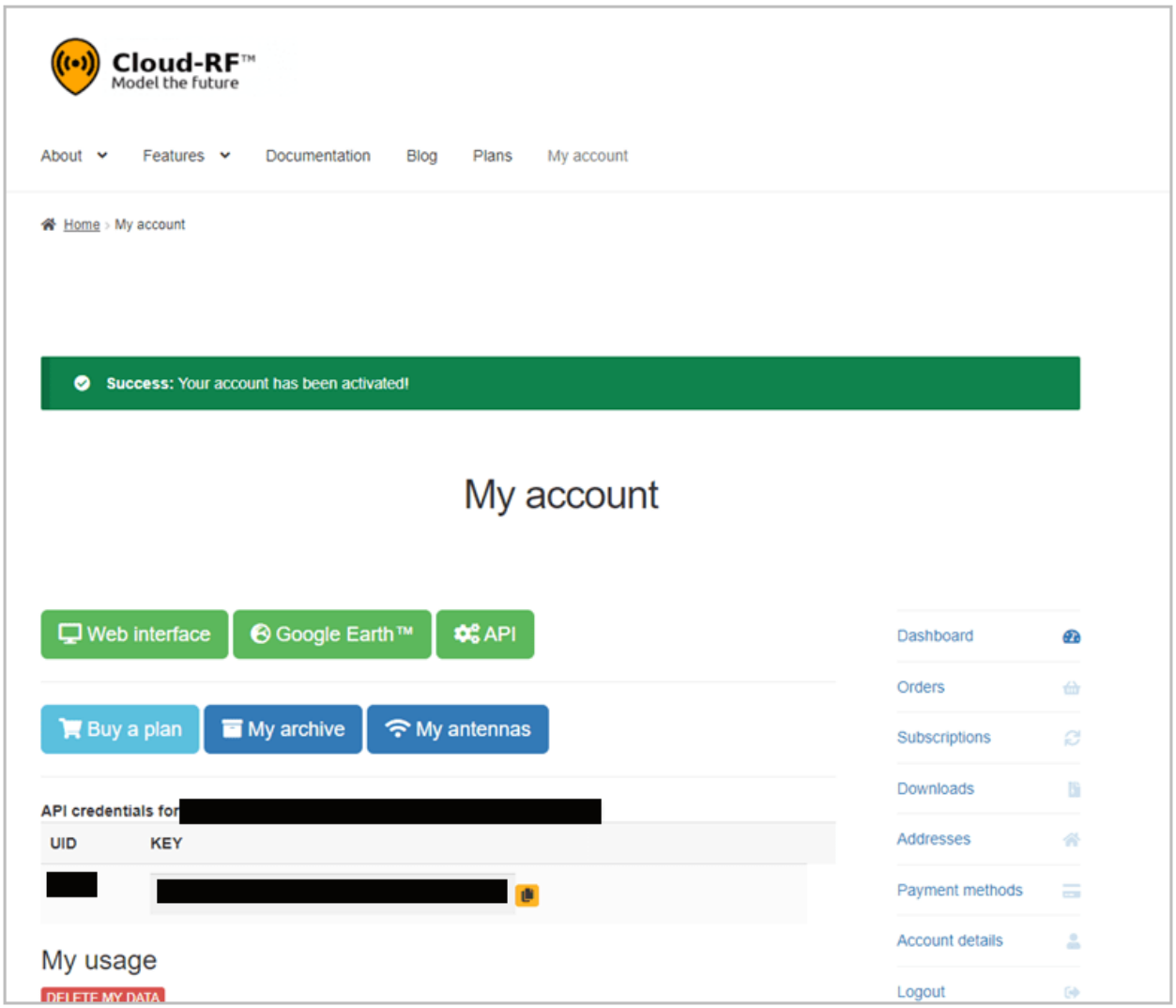
  - *This is to make sure that the user is a **human**. If you do not know the answer, you can always **Google** it!*
  - Click on **Register** button.
- A **Verification link** will be sent to your registered email id.
- Open your registered **email id**.

*If you have not received the email, please check you registered email **SPAM** folder. You may set CloudRF email as **Not Spam** in your email to receive the emails directly in your inbox.*

- Click on the **Verification link**.



- The **Success Message** pop-up will appear, and you will be **logged in** into your account.

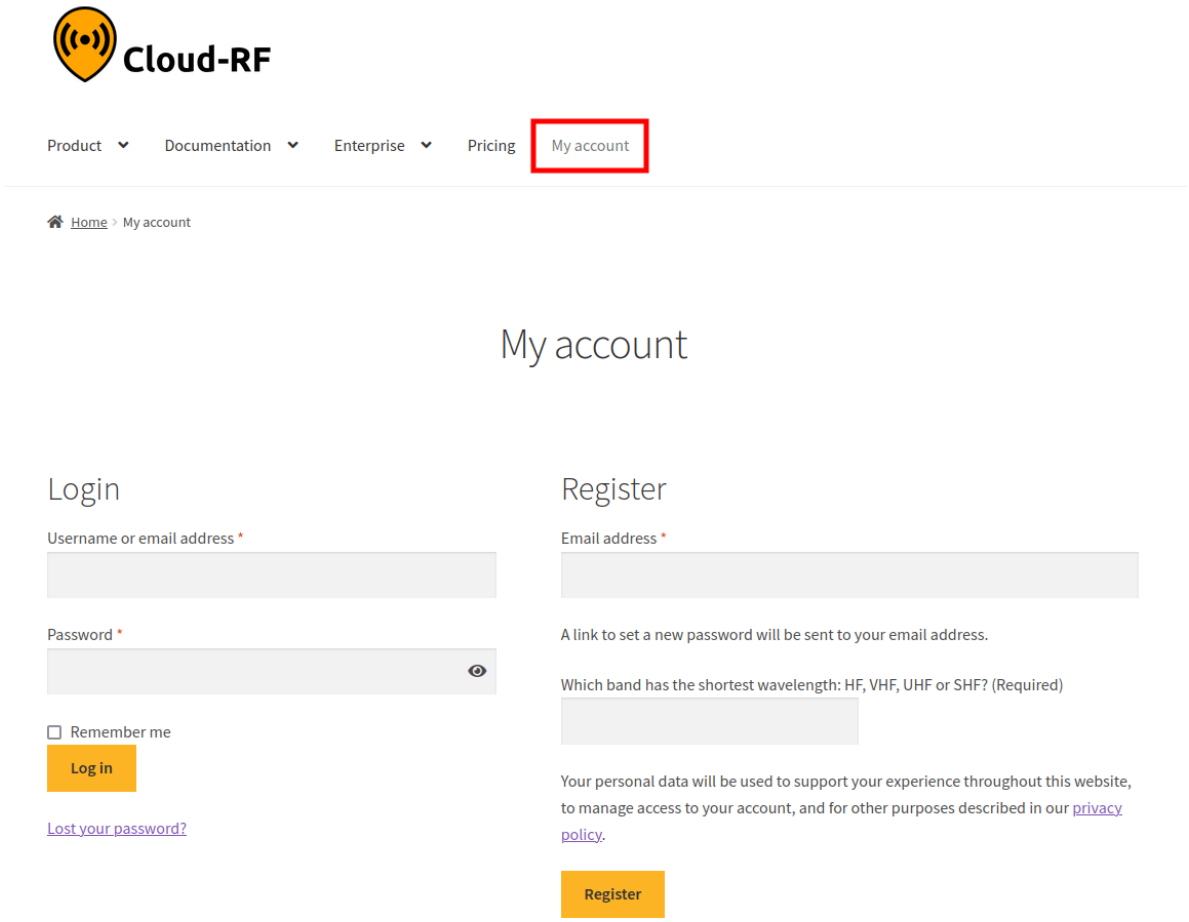


- The **CloudRF Tool Home Page** will be displayed.

1.6.2 Login

To **Log in into your Account** on the CloudRF:

- On the **CloudRF website** (https://cloudrf.com/):
  - Click on **My Account** tab.
  - The **My Accounts** screen will appear.



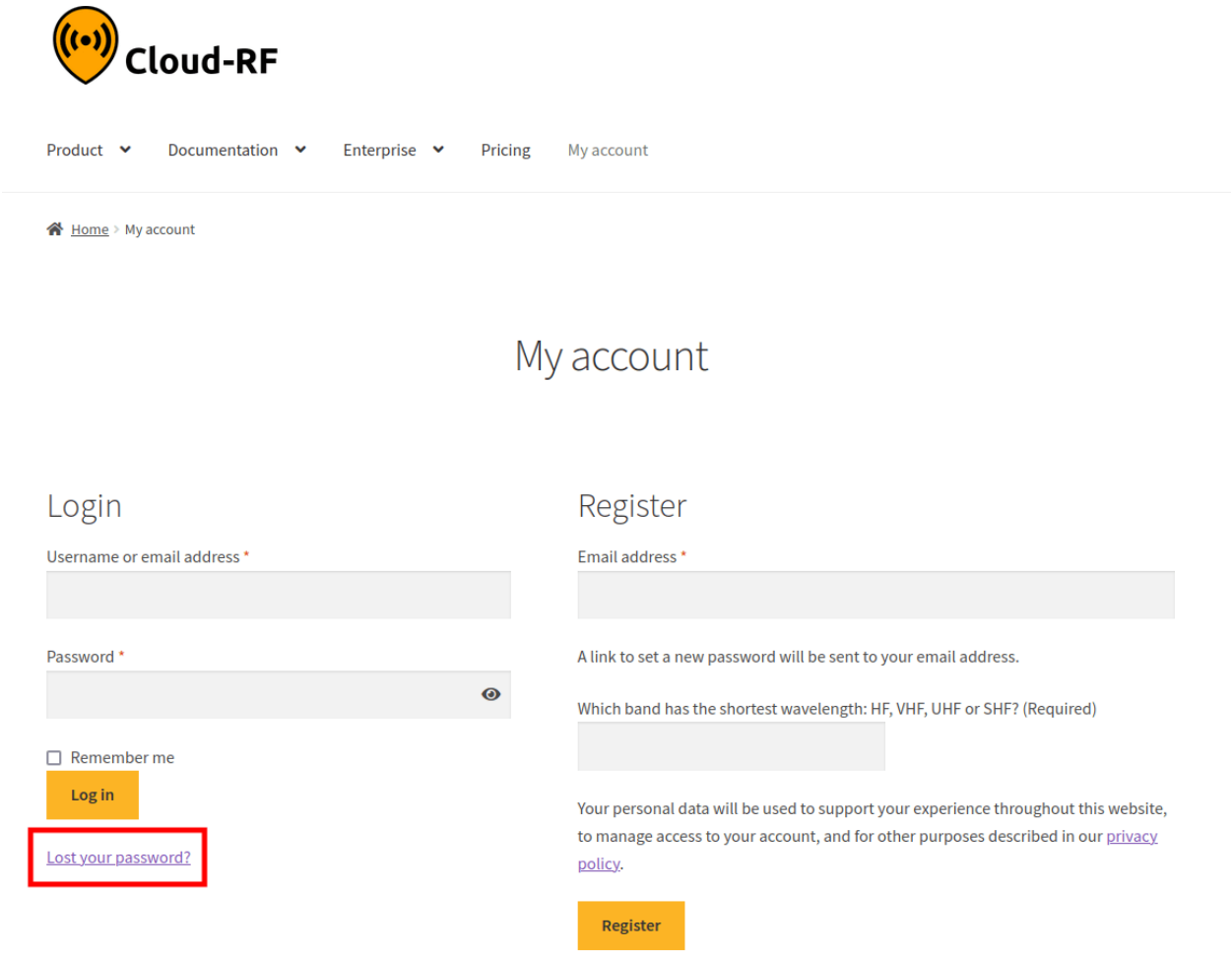
- Under the **Login** section:
  - In the **Username or email address** field, enter your username or email address.
  - In the **Password** field, enter your password.
  - You may select the **Remember me** checkbox to save the credentials on your device.
  - Click on **Log in** button.

1.6.3 Lost Your Password?

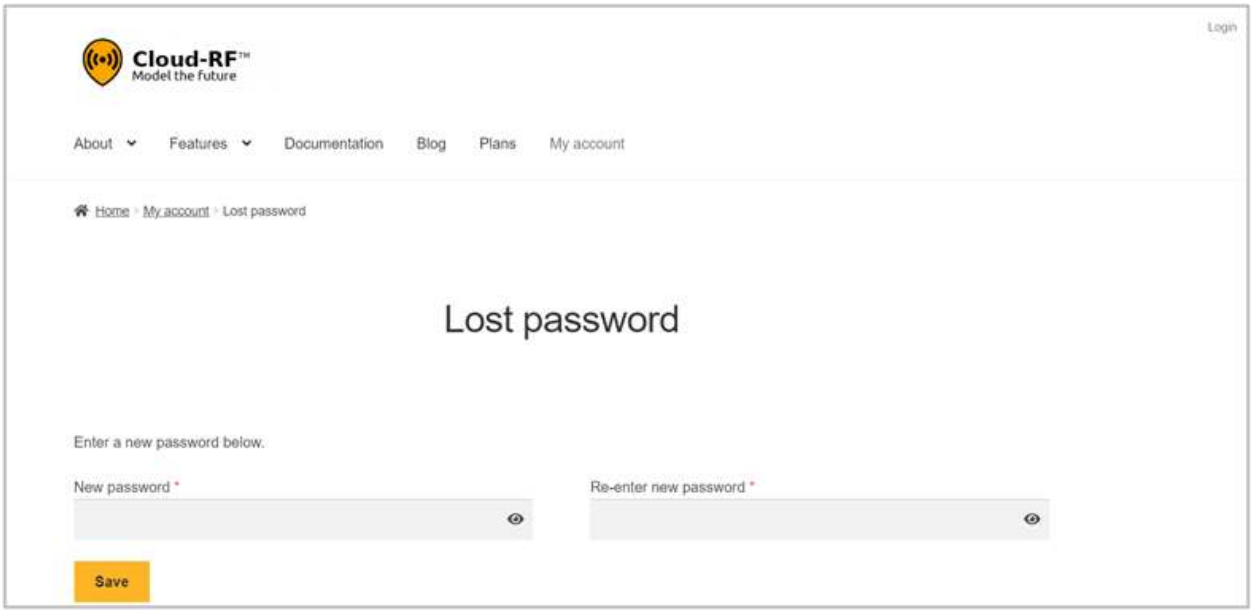
If you have lost your password, you can reset it through your **registered email address**.

To do so:

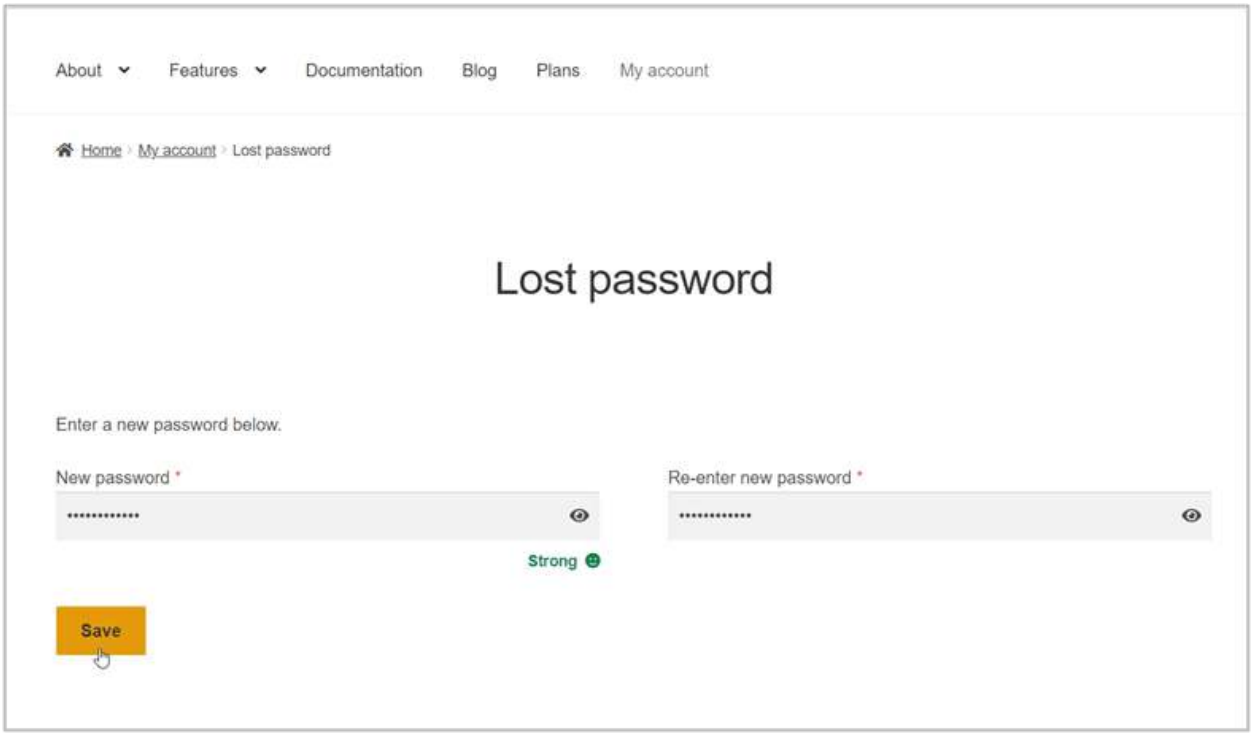
- Click on **Lost your Password?** link.



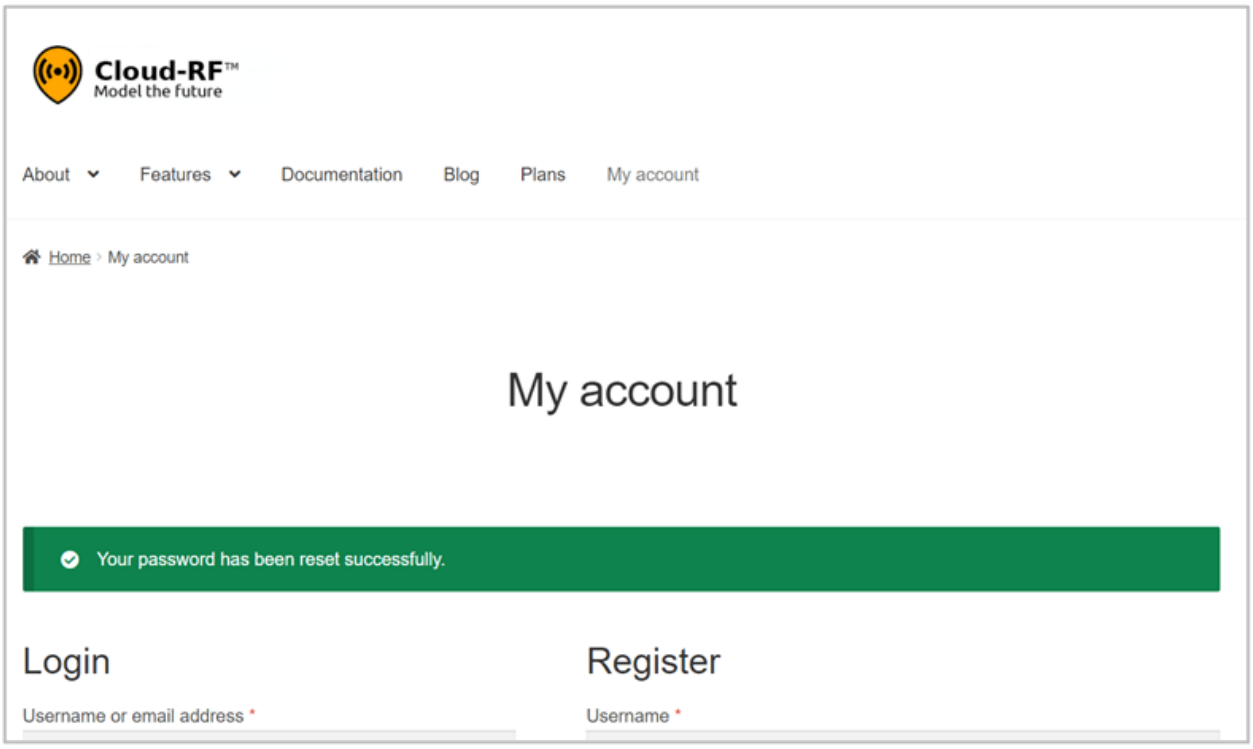
- The **Lost Password** screen will appear.



- Enter the **New Password** as desired.
- **Re-enter new password** to confirm.
- Click on **Save** button.

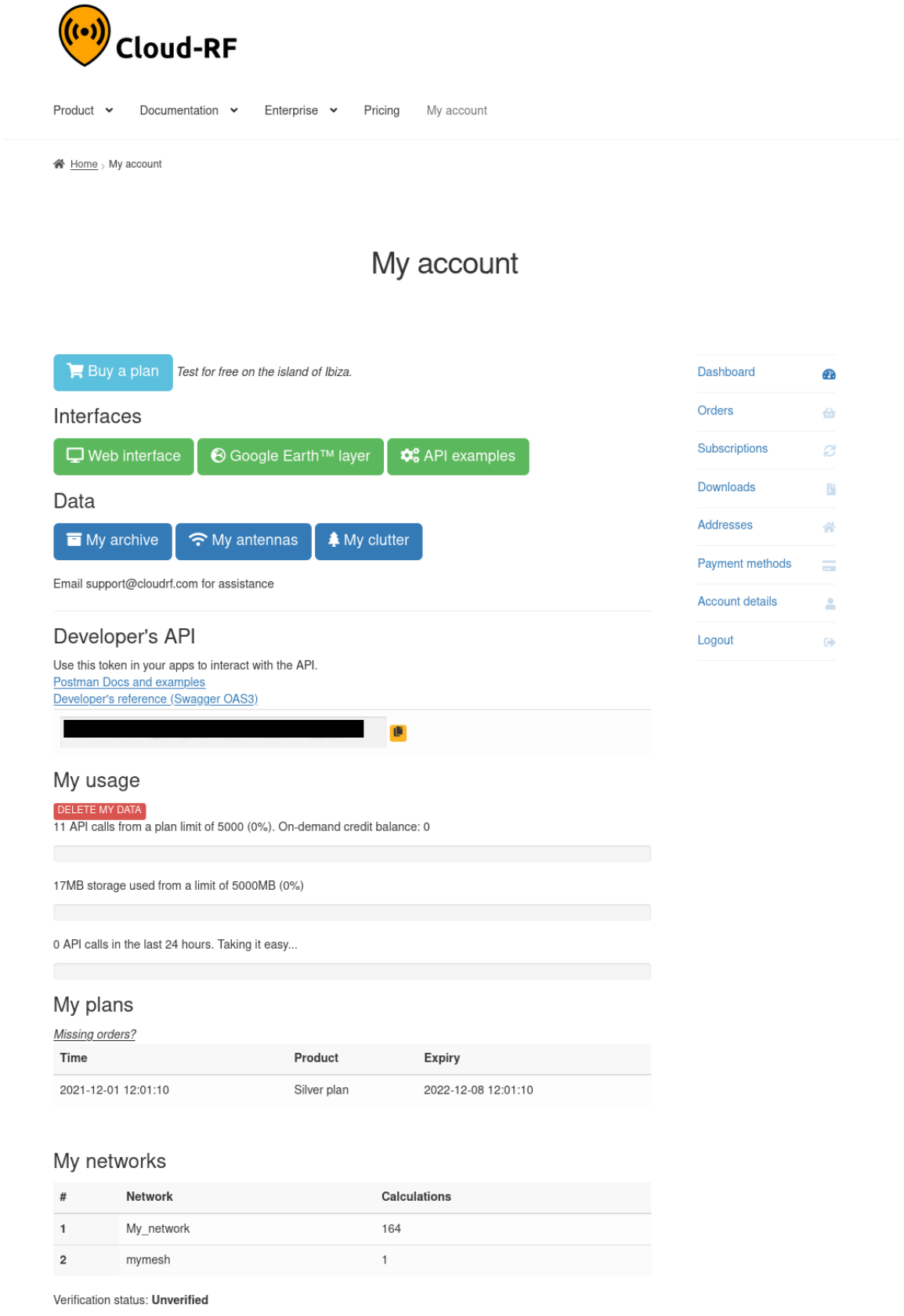


- The **Success message** pop-up will appear.

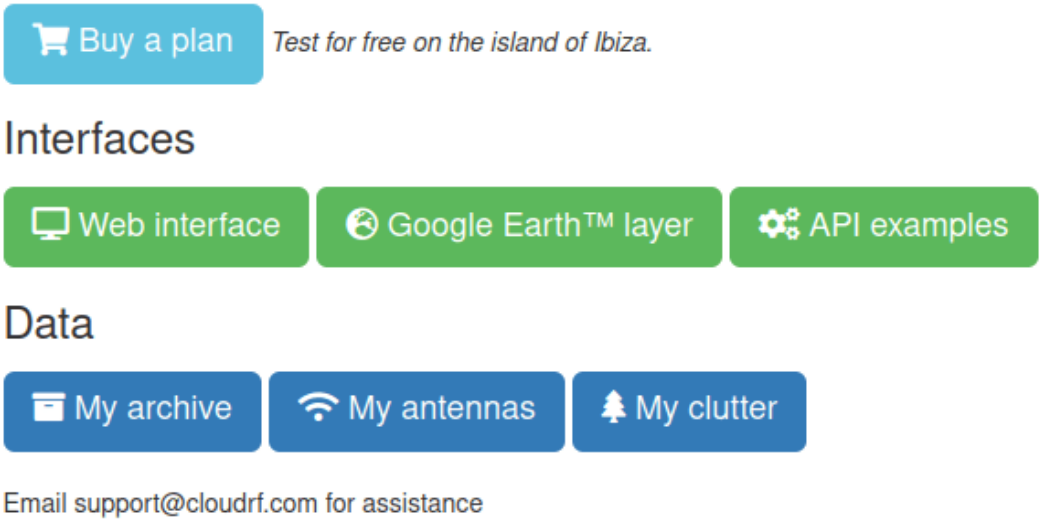


1.6.4 The Home Page

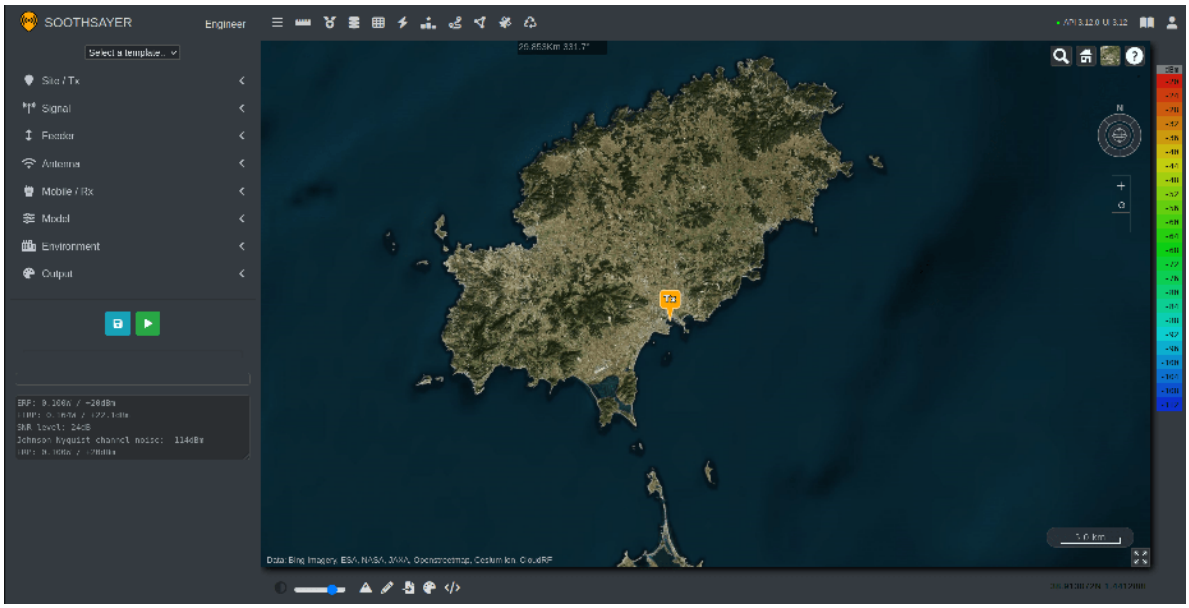
After you login into your CloudRF account, the **Home Page** will be displayed.


Cloud-RF
Product
Documentation
Enterprise
Pricing
My account
Home › My account
My account
Buy a plan
Test for free on the island of Ibiza.
Interfaces
Web interface
Google Earth™ layer
API examples
Data
My archive
My antennas
My clutter
Email support@cloudrf.com for assistance
Developer's API
Use this token in your apps to interact with the API.
Postman Docs and examples
Developer's reference (Swagger OAS3)
My usage
DELETE MY DATA
11 API calls from a plan limit of 5000 (0%). On-demand credit balance: 0
17MB storage used from a limit of 5000MB (0%)
0 API calls in the last 24 hours. Taking it easy...
My plans
Missing orders?
Time
Product
Expiry
2021-12-01 12:01:10
Silver plan
2022-12-08 12:01:10
My networks
#
Network
Calculations
1
My_network
164
2
mymesh
1
Verification status: Unverified
Dashboard
Orders
Subscriptions
Downloads
Addresses
Payment methods
Account details
Logout

- You can access the **Web Interface**, **API**, **My archive**, **My antennas** and **My clutter** by clicking on the respective button on the Home Page.



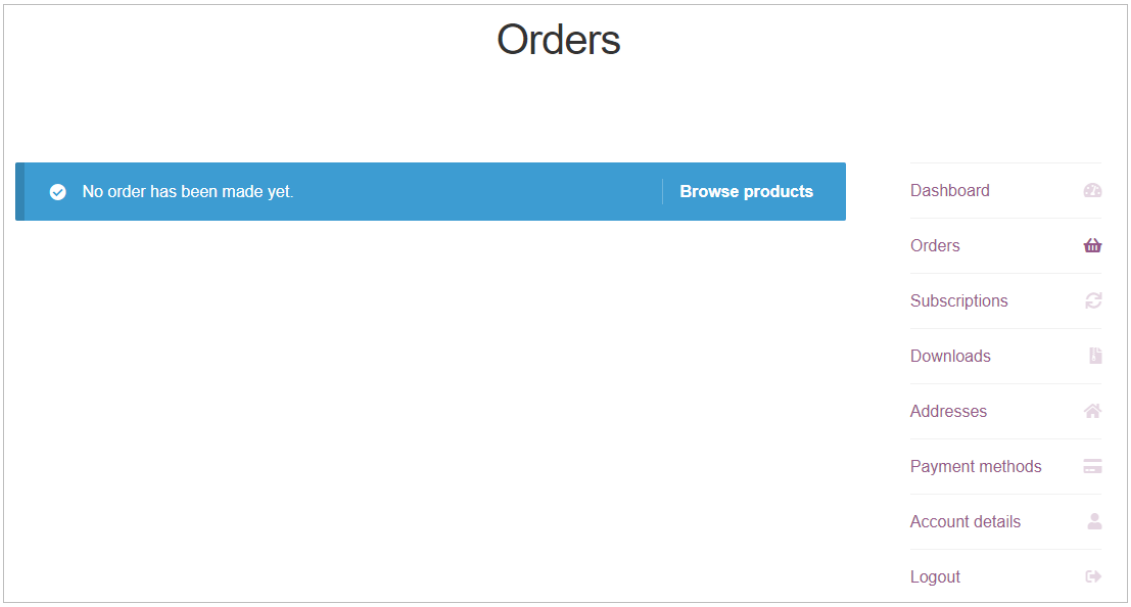
- Click on **Web Interface** button to know how you will access the CloudRF Modeling tool itself right in your web browser.



- Click on **API** button to access the API.
  - You can see your API key and your current subscription plan as well.
  - The **CloudRF API** for radio planning lets you model radio coverage for any RF system between *20 and 90,000MHz*.
  - A **CloudRF account** and **active plan** are required to use the API.
- Click on **Buy a Plan** button to purchase a plan.
  - Moreover, it lets you upgrade your account as well to access all the available features.

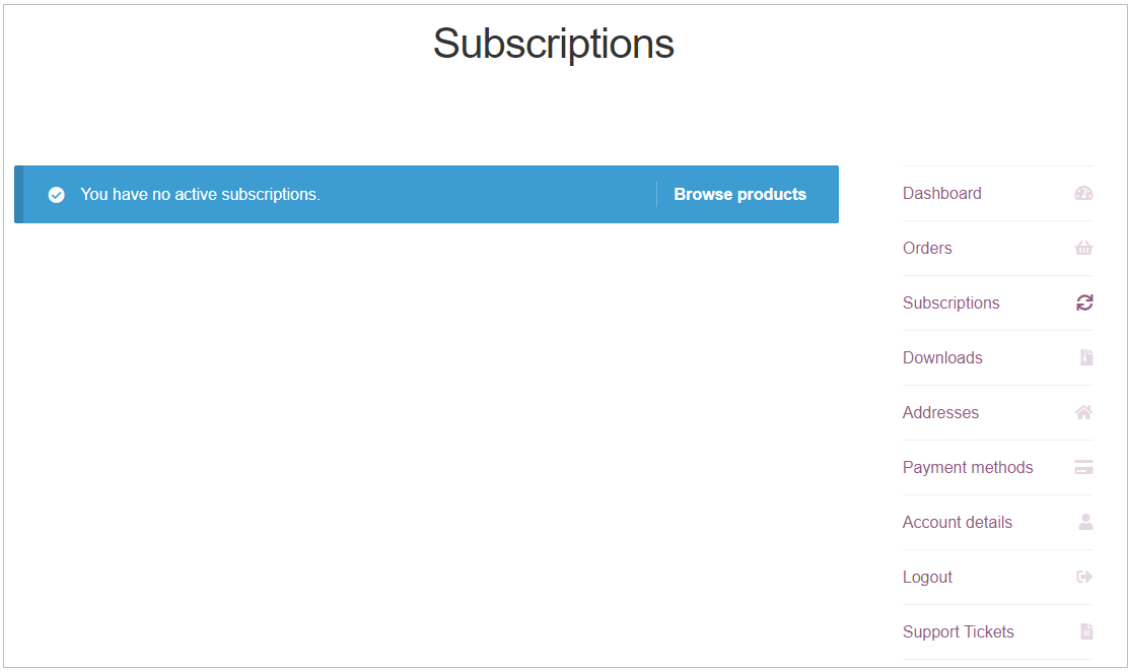
  - You can add the desired plan(s)/subscription(s) to your cart by clicking on the **Add to Cart / Sign up now** button.
  - You may also scroll down to view the **FAQs** section.

- The **Right Navigation Menu** with the following menu options will be displayed. You can click on the:
  -  **Dashboard** - for accessing the Home Page.
  -  **Orders** - to view all your orders.



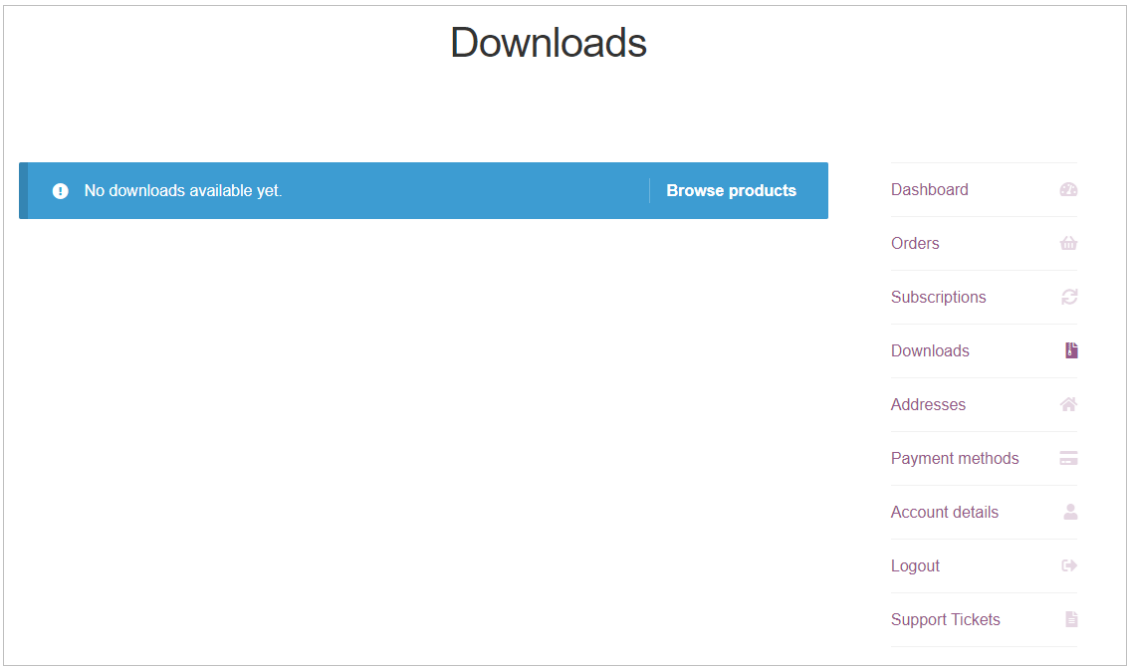
    * If no orders have been made, you may click on *Browse products* button to browse the available products.

  -  **Subscriptions** - to view all your subscriptions.



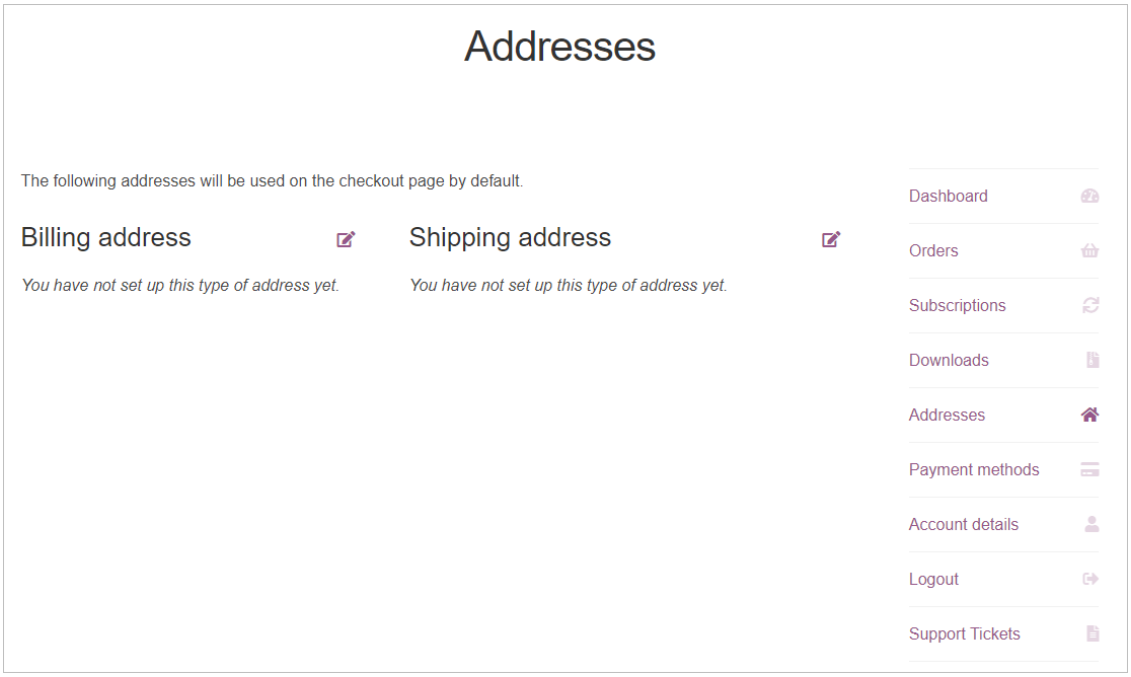
* If you have no active subscriptions , you may click on *Browse products* button to browse the available subscriptions.

–  **Downloads** - to view all the downloaded files.

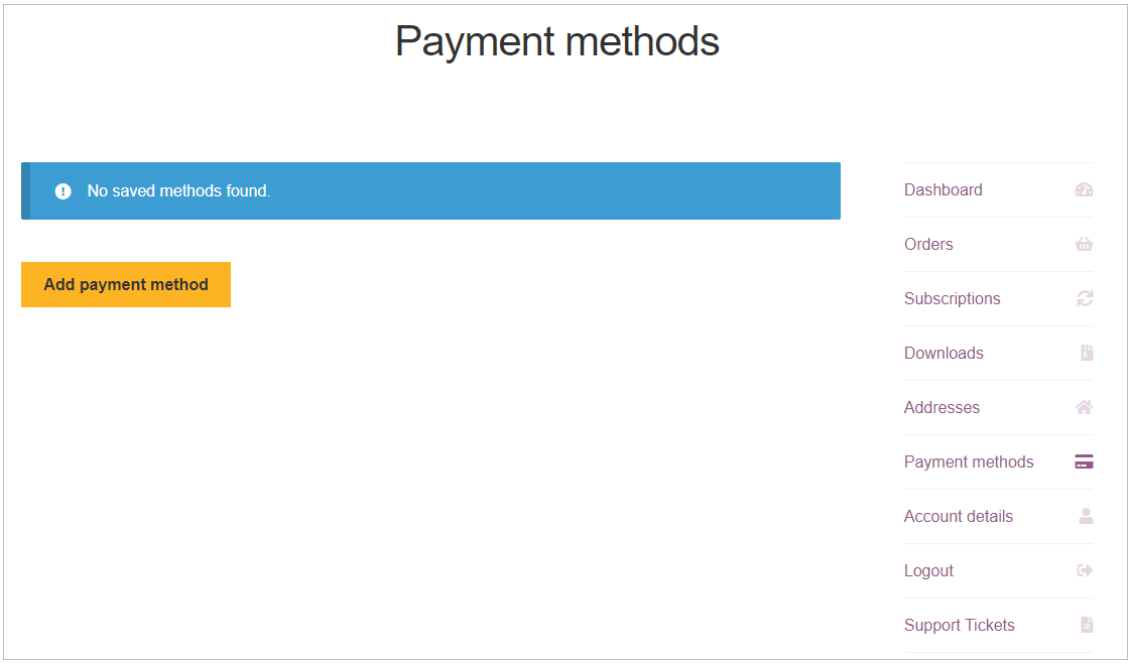


* You may click on *Browse products* button to browse the available products.

–  **Addresses** - to view the shipping and billing addresses added to your account.



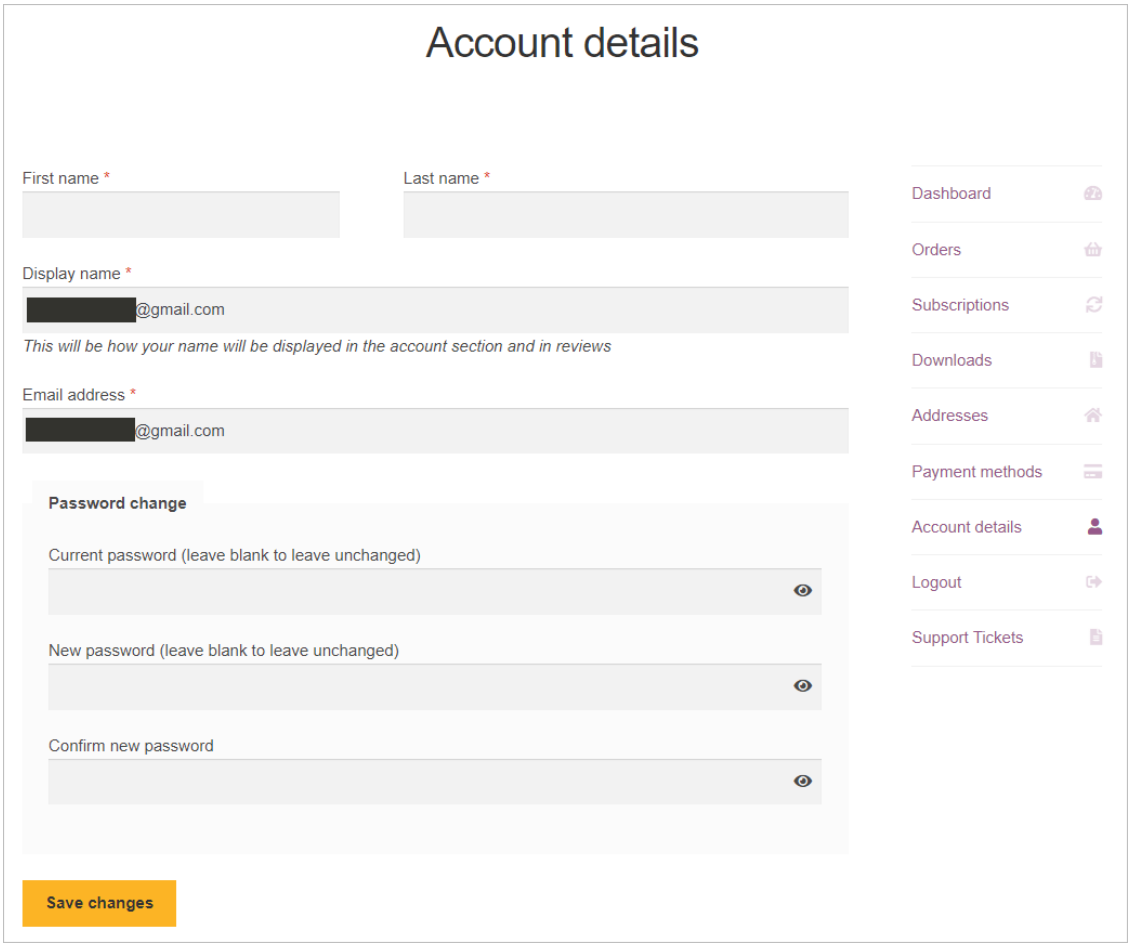
– **Payment methods** - to view the payment methods added to buy your orders or subscriptions.



  * You may also add a payment method by clicking on the *Add Payment Method* button.

– **Account details** - for accessing your account details and edit them if required.

  * You can change your **password**, **contact preference**, and **time zone settings** from here.

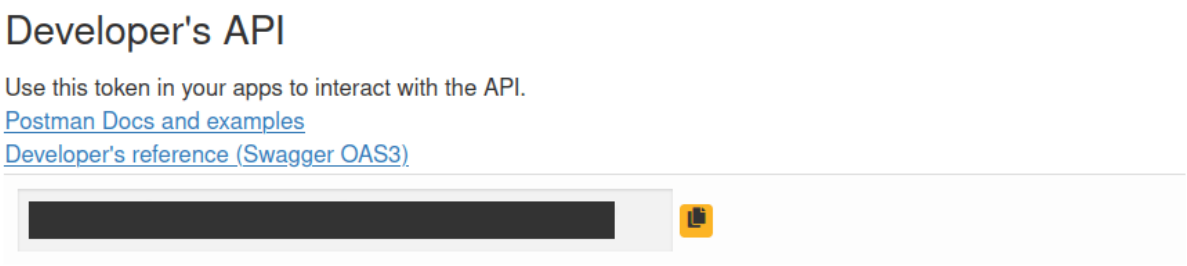


  * Click on **Save Changes** button after making the required changes.

-  **Logout** - if you wish to logout from your account.
  * The *Login/Register* screen will be displayed.

1.6.5 Dashboard

- The **API credentials** of your account - *UID* and *KEY* will be displayed.
- To copy the **API Key**, you can click on the *copy*  icon.



- Under **My usage** section:
  - The **API Calls details** and the **Storage used** will be displayed.
  - You may click on the **Delete My Data** button to delete the data of your usage.
- Under **My Plans** section:
  - Your **Plan details** (*Time, Product and Expiry*) will be displayed.
  - You can click on **Missing your orders** link as per your requirement.
- Under **My Networks** section:
  - Your **Network details** (*Network and Calculations*) will be displayed.

1.6.6 Ordering a Plan

You can order a plan or a subscription by adding the desired product in your cart and then paying for the same.

To order a plan or a subscription:

- Under **My Accounts** tab, you can click on the **Buy a plan** button.

OR

- Click on **Plans** tab.

OR

- Under **My Accounts** tab:
  - Click on **Orders**, **Subscriptions** or **Downloads**.
  - Click on **Browse Products** button.
- The **Plans** screen will be displayed.
- You can add the desired plans or subscriptions by clicking on the **Add to cart** or **Sign up now** button respectively.
  - You can also upgrade your account from here to access all the available features.

1.7 Choosing an Interface

In CloudRF tool, there are **four major Interfaces** available:

- **3D Interface**
- **ATAK plugin**
- **CloudRF API**

The following is the description and the steps of loading of each interface:

1. **3D Interface**

- The **3D interface** is the primary user interface for CloudRF that works on desktops, tablets and mobiles.
- To load the **3D Interface**:
  - Under *My Accounts* tab, click on **Web Interface** button.
  - The 3D Interface will be displayed.

2. **ATAK plugin**
   - The SOOTHSAYER **ATAK plugin** works with ATAK for Android. You must already have this installed to use this. To use the plugin:
   - Install the .apk file from the Github repository
   - Enter the plugin settings and update your API key
3. **CloudRF API**
   - The **CloudRF API** is a *public programming interface* which allows developers to pull upon the power and data of CloudRF with just a few lines of code (in a language of your choice).
     - Moreover, with this, you can integrate radio planning into your application or website without worrying about the heavy CPU, memory or disk resources required to do RF planning.
     - It's up all year round, 24 hours a day!
   - To load the **CloudRF API**:
     - Under *My Accounts* tab, click on **API** button.
     - You can access your API and view your API key & your current subscription plan.
   - The **CloudRF API** for radio planning lets you model radio coverage for any RF system between *20 and 90,000MHz*.
   - A **CloudRF account** and **active plan** are required to use the API.

1.7.1 Performance Tips

Following are the tips and tricks that can help you maximise 3D interface performance.

- Ensure you have a GPU video card and a web browser that supports WebGL. If it does not you will be warned.
- Reduce your screen resolution to no more than 1920 x 1080px.
- Switch off 3D terrain and 3D buildings layers in the interface as these layers use a lot of memory.
- Close any other applications like Google Earth which will compete for video memory.
- Close unused browsers and tabs. Every open page will cost memory and resources.

CHAPTER

TWO

WEB INTERFACE OVERVIEW

The 3D web interface is the primary user interface for CloudRF. This interface is compatible with desktops, laptops, tablets and even mobile phones.

The interface supports Android, Linux, Mac/OSX and Windows and works best with Google Chrome.

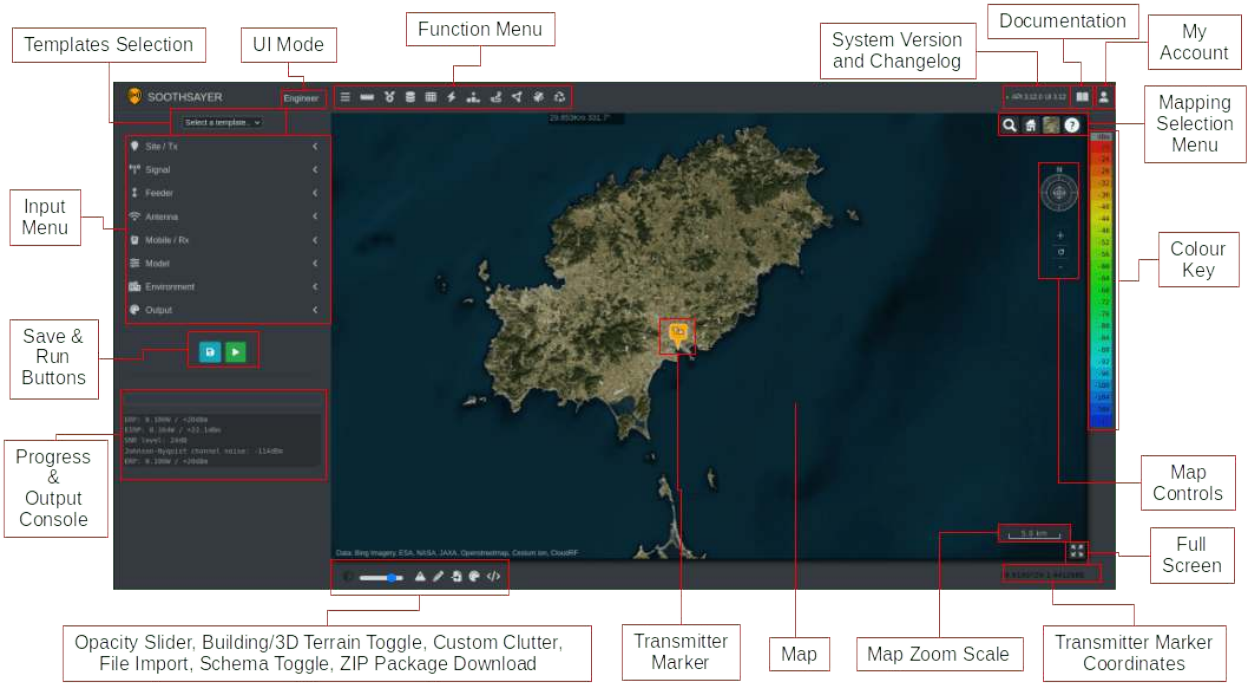
MINIMUM HARDWARE: 4GB of memory, dual core CPU

RECOMMENDED HARDWARE: 8GB of memory, quad core CPU, 1GB GPU

To access the CloudRF 3D Interface:

- Click on the **Web Interface** button on the Home Page.

2.1 Interface elements



2.2 Hot Keys / Keyboard Shortcuts

There are a number of hot keys / keyboard shortcuts which are enabled in the interface which can allow you to manipulate your view/settings without moving your mouse.

You can use the following keyboard shortcuts:

- `Home` - Reset your view to your current Tx marker.
- `Page Up` - Zoom out.
- `Page Down` - Zoom in.
- `Left Arrow` - Pan view left.
- `Up Arrow` - Pan view up.
- `Right Arrow` - Pan view right.
- `Down Arrow` - Pan view down.
- `Control + Left Arrow` - Move Tx marker left.
- `Control + Up Arrow` - Move Tx marker up.
- `Control + Right Arrow` - Move Tx marker right.
- `Control + Down Arrow` - Move Tx marker down.
- `Control + Space` - Run a calculation.

2.3 UI Mode

The CloudRF UI supports users of different radio knowledge.

You can quick toggle between the two modes by clicking on the mode name which you are currently using.

2.3.1 Engineer Mode

Engineer mode will be indicated by "Engineer" in the UI Mode portion in the top left of the window.

In engineer mode you will have full access to all tools and input fields to fully customise your requests.

This mode is typically used by advanced users, or those who wish to fine-tune calculations.

2.3.2 Operator Mode

Operator mode will be indicated by "Operator" in the UI Mode portion in the top left of the window.

Operator mode is designed to provide the minimum required fields to allow a user to execute calculations, whilst avoiding overwhelming with fields which might not be fully understood. Therefore, in operator mode you will notice that many of the tools and input fields are removed. If you wish to use these then you should use a different mode.

This mode is typically used by beginner or novice users, or those who don't need to be able to fine-tune settings.

The following settings are used when making use of operator mode.

- The general purpose model is used as the propagation model (See *model section* for more details).
- Deygout 94 is used as the diffraction model (See *model section* for more details).
- A DTM elevation is used with landcover and 3D buildings (See *environment section* for more details).
- Various values are calculated which would otherwise be manually input:
  - Noise floor and receiver sensitivity are inferred from the bandwidth value which is used.
  - The maximum radius is calculated based upon the maximum theoretical radius that could be achieved based upon your settings.
  - The resolution of the output is calculated based upon the maximum megapixel output which can be produced by your subscription plan and combining it with your specified radius. A larger radius will result in a reduced resolution output.

2.4 Transmitter Marker

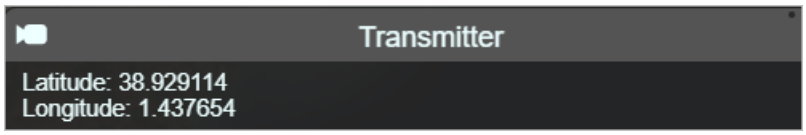
The **Transmitter Marker (Tx)** indicates your *Antenna Location*.

To update your **antenna location settings**:

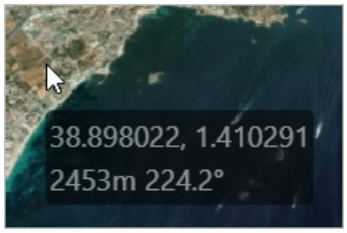
- On the map, click on the **desired location**.
  - The transmitter marker will move to your clicked location.

  - The location settings under the input menu will be updated respectively.

- Click on the transmitter marker to view the **location parameters** of the Transmitter - *Latitude* and *Longitude*.

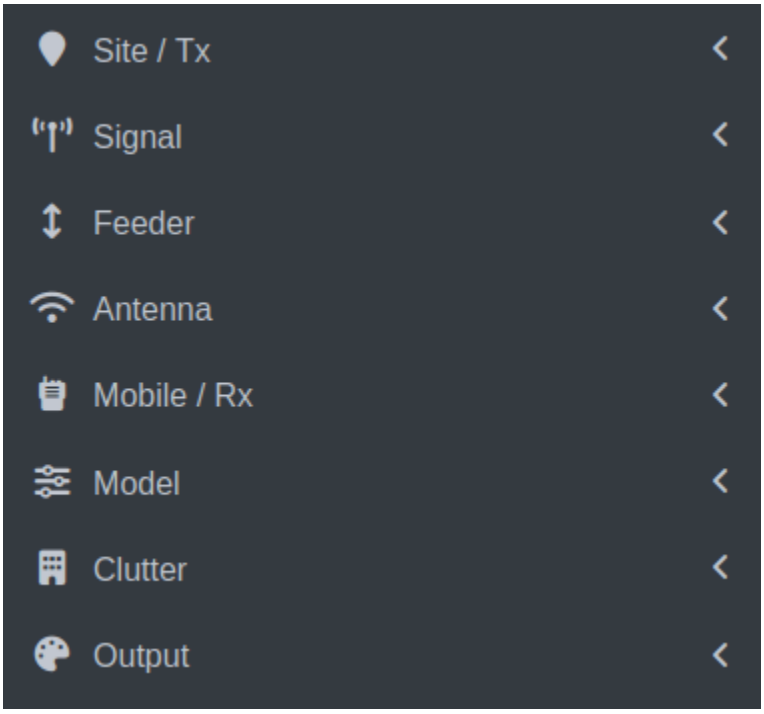


- When you have a layer, the **information box** next to the cursor will display the current co-ordinates, signal strength, distance and angle from the site.



2.5 Input Menu

The **Input Menu** is an accordion style menu consisting of various collapsible sections with input fields. It allows you to focus on several settings which are further grouped into the various categories making it user-friendly.

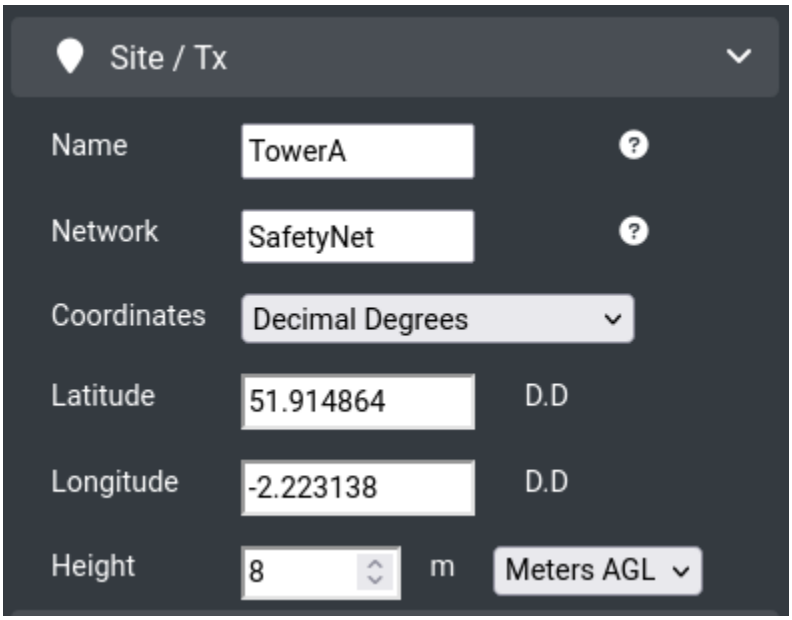


The fields in the various input menu categories have a **Help**  icon beside them. To know the details regarding a field, you can click on the Help icon of the respective field.

2.5.1 Site / Tx

The Site / Tx (Transmitter) input menu consists of the settings related to the **physical location of the antenna**. These settings are relative to the ground and the Name & Parent of the site.

> The Site/Tx settings will be of greater importance as your network grows and you need to perform analysis such as the best server analysis.



You can set location in the following two ways:

- **Manually** - You can enter the Location fields (Latitude and Longitude) manually in the respective fields.

OR

- **Clicking on the Map** - You can click on the map and the location fields will be set accordingly.

  All the inputs in the form of Decimal Degrees, Degrees/Minutes/Seconds and NATO MGRS are acceptable. The system will make necessary conversions automatically.

Configure the following **Site/Tx fields**:

Name

Enter the desired unique name for your site.

Network

Enter the network name for logical grouping (as per the cities/area) of your site(s). Minimum length 2 characters eg. "N1"

```
NOTE: Setting the network is really important as it will help you group and analyse data␣
↪in the future.  Do not use the same value eg. TEST for all your work as you will never␣
↪find it or be able to run analysis functions on it like the 'network' analysis or
↪'interference' tools.
```

Coordinates

Select the desired coordinate format from the drop-down.

- **Latitude** and **Longitude** - These location fields can be entered manually or set automatically by clicking on the map.

Height

Enter the height (in meters or feet) as either above mean sea level (AMSL) or above ground level (AGL). If using LiDAR and height AGL this is the height above the roof, otherwise it's relative to the ground. The system's resolution is 1m minimum so a shoulder mounted radio should be set as 2m and a smart meter on (or below) the ground should be 1m.

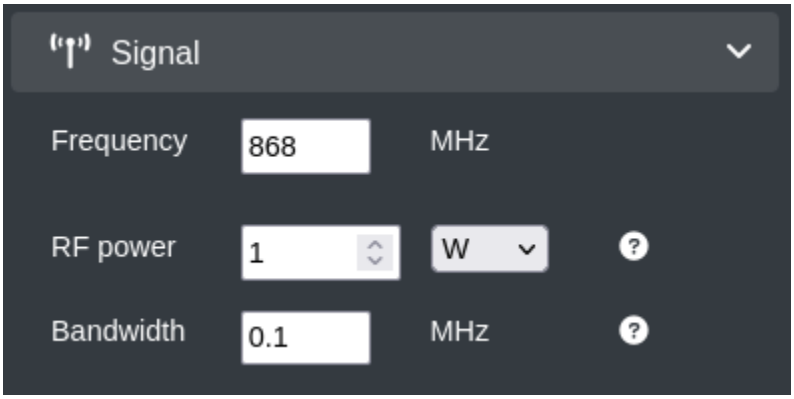
The height above mean sea level is relative to the DTM used vs the WGS84 ellipsoid. All sea levels in CloudRF are 0 without tidal adjustments.

The Distance units applying to all heights and radiuses are set here. The default units of the system are metric (m/km)

Choosing Feet will set the distance calculations to Imperial (ft/Mi)

2.5.2 Signal

The Signal input menu consists of the settings related to the **actual radiation**.



Configure the following **Signal fields**:

Frequency

Enter the system frequency (MHz) in the range: **2 to 90,0000 MHz**. For a wideband system use the center frequency. For a dynamic system which can go low and high, use the higher value since this will produce the more conservative coverage for planning purposes.

RF Power

Enter the transmitter power (watts or dBm) before feeder loss and antenna gain.

ERP will be auto-calculated and displayed in the output console.

Bandwidth

Enter the channel bandwidth (MHz). Range is 1KHz (0.001MHz) to 200MHz.

- Bandwidth will affect Channel Noise and Signal-to-Noise ratio.
- Wideband channels will incur increased channel noise and reduced Signal/Noise Ratio.

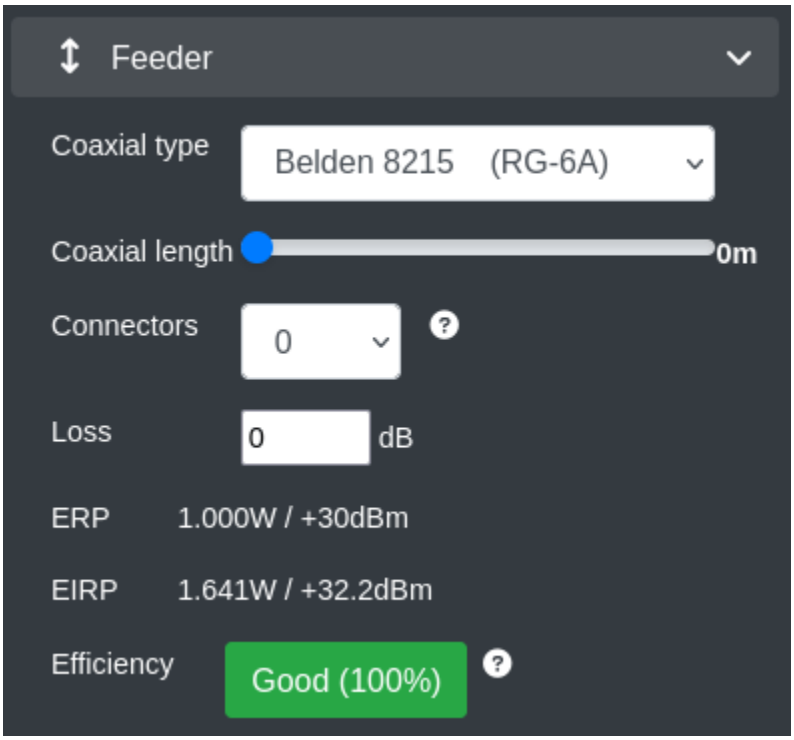
  The system will compensate for wide-band noise by making adjustments to the receiver sensitivity inline with Shannon's theorem.

  WARNING: Bandwidth is ignored for Received power mode (dBm) which is independent of channel noise as it is just the carrier (eg. cw). It becomes very relevant in SNR and RSRP modes, where it will make a significant difference in coverage.

2.5.3 Feeder

The Feeder input menu consists of the settings related to the cabling & connectors between a transmitter and a radio.

If you have a long feeder, it will absorb power and reduce the efficiency of your system. The most efficient systems have no feeder as the antenna screws onto the radio.



For UHF signals above 300MHz, feeder loss is a significant issue which must be budgeted carefully. A long cable will introduce a lot of loss into a antenna system. They're also more expensive so get the shorter cable and communicate further!

Coaxial Type

Select the Coaxial standard from the drop-down as per your requirement. The Coaxial Cable used will affect the feeder loss.

This can be safely ignored if the antenna screws directly onto the radio.

Coaxial length

Set the slider to the desired Coaxial length of the cable. The cable length will significantly affect the feeder loss. Even a few meters of coaxial could reduce your system efficiency by 50%.

This can be safely ignored if the antenna screws directly onto the radio.

Connectors

Select the number of connectors from the drop-down as per your requirement.

This will affect the feeder loss.

Loss

Enter the computed feeder loss in decibels. This will typically be in the range: 0 to 15dB.

If the feeder loss is more than 15dB, it indicates that your system is *very* inefficient and a redesign is recommended.

- **ERP** and **EIRP**- The dynamically calculated Effective Radiated Power (ERP) and Effective Isotropic Radiated Power (EIRP) will be displayed in the respective fields.

The ERP and EIRP values will change as you manipulate the powers and gains on the interface and will be visible in the corner console.

- **Efficiency** - This label will display the computed efficiency for your system based upon the RF input power and the computed ERP.

2.5.4  Antenna

The Antenna input menu consists of the settings that lets you choose or build an antenna.

Configure the following **Antenna fields**:

- **Origin** - You can select *My Patterns* (system template) or *Custom Pattern* option from the drop-down. A custom pattern lets you build an antenna using beamwidth values in degrees.
  - If you select the **Custom Pattern** option:
    - You can configure the fields:
      - *Beamwidth* (horizontal and vertical)
      - *Gain*, *Front-to-back ratio* (use gain if unsure)
      - *Down-tilt* relative to the horizon
      - *Azimuth* relative to true north. You can use more than one azimuth at a time to simulate the same antenna pointing in different directions. To do this please use a comma-separated list, for example `0,120,240` would simulate 3 antennas spaced 120 degrees apart from true North. You can enter up to a maximum of 20 azimuth values. Works with the 'Area' API only.

    For further information, refer **Custom Antenna Pattern Generation** topic.

- **Antenna Pattern database** - Explore thousands of patterns in the database and select favourites to appear on your pattern select list.

  For further information, refer **Antenna archive - searching and favouriting a pattern** topic.

- **Polarisation** - You can select *Vertical* or *Horizontal* option from the drop-down. Circular polarisation is not yet supported but can be adjusted for using the gains/losses if known.

- **Gain** - Enter the antenna gain relative to an isotropic radiator. A dipole is 2.15 dBi

  The peak gain is measured in decibel-isotropic (dBi) and will affect the ERP. For further information, see **Feeder** input menu.

- **Azimuth** - Enter the horizontal direction of the main lobe relative to grid north (in degree).

  – You can use more than one azimuth at a time to simulate the same antenna pointing in different directions. To do this please use a comma-separated list, for example `0,120,240` would simulate 3 antennas spaced 120 degrees apart from true North. You can enter up to a maximum of 20 azimuth values.

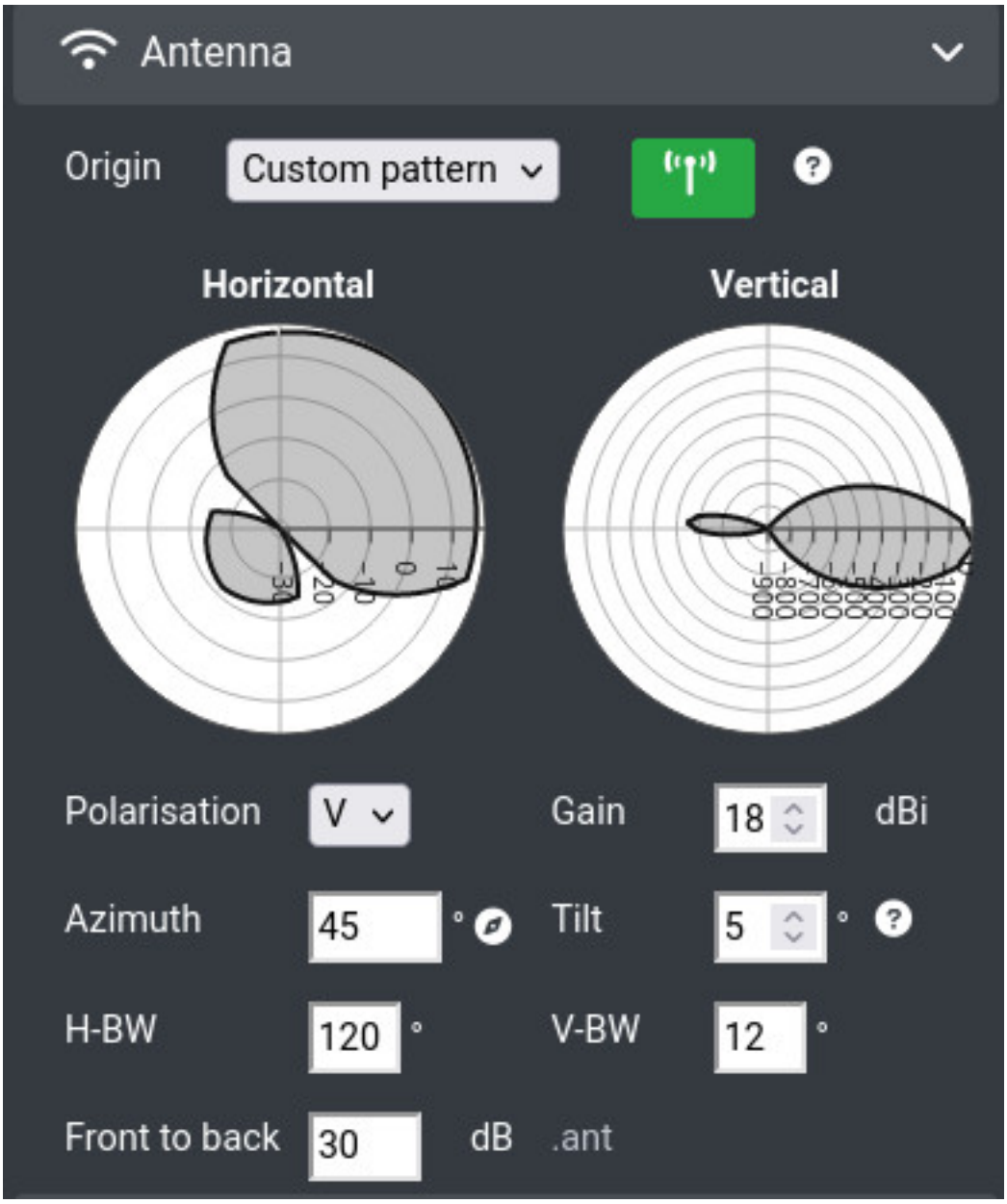
  – You can disable this in path profile mode so it always points along the path by clicking on the **Compass** icon. 

  – To enable it, click on the Compass icon again.

- **Down-Tilt** - Enter the vertical direction of the main lobe relative to the horizon.

  A positive value is towards the earth and a negative value is towards the sky.

Custom Antenna Pattern Creation



You can create custom antenna patterns using the extended options, available when you choose “custom pattern” from the selection.

- **Custom: Horizontal Beamwidth** - Enter the beamwidth in degrees between the half power (-3dB) points on the pattern in the horizontal plane. A cell tower panel might be 120.
- **Custom: Vertical Beamwidth** - Enter the beamwidth in degrees between the half power (-3dB) points on the pattern in the vertical plane. A high gain cell tower panel might be 30.
- **Polar Plots** - The polar plots of the antenna pattern will update as you change the settings so you can see if it looks right.
- **Custom: Front to back ratio** - Enter the Ratio in decibels between the forward and rear gain values of a pattern. Use gain value if unsure.

Ensure you set a positive gain and front-to-back ratio when building a custom pattern.

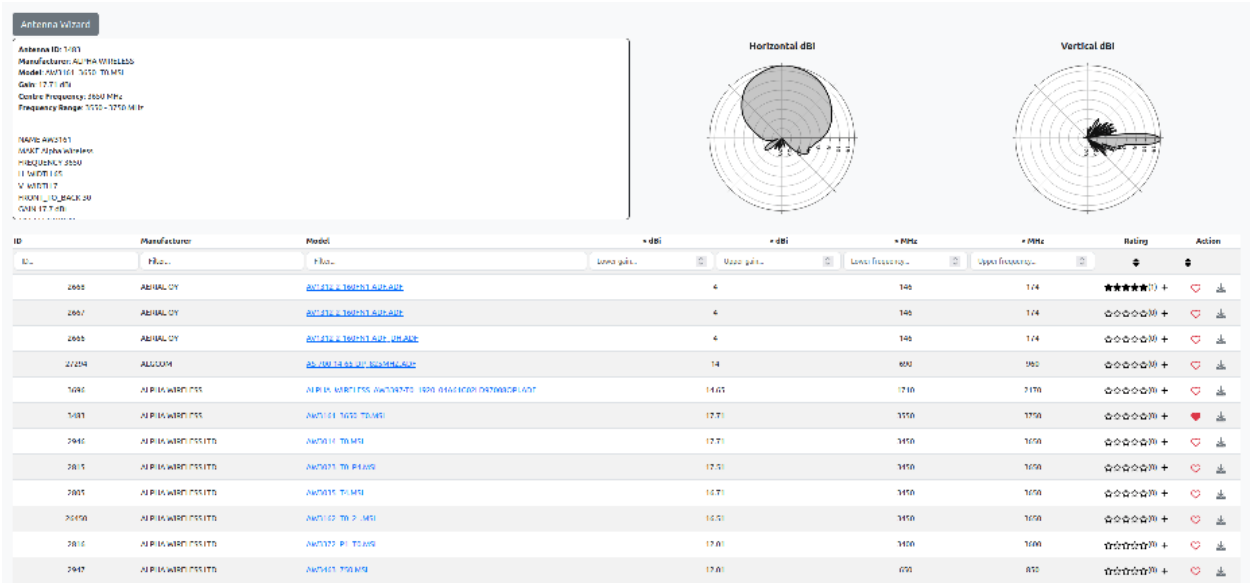
Antenna database

You can explore antenna patterns in the central database. This is the source for patterns visible when you use the "pop-up" search form in the web interface. The table has columns on the right which may be hidden from view. To reveal them, use the slider at the bottom of the pop up window.

To find and use pattern files:

- Click on **the green Antenna** icon to launch a pop-up form and then click the "Manage My Antennas" hyperlink to redirect.

- The *Antenna Database* screen will appear in a modal window. You can click a link to open it in a new tab.



- to antenna patterns to your list, you can either **Search and favourite a pattern** or use the wizard to **upload** them. For more information on pattern formats and validation, see the antennas section within the reference data section.

Selecting patterns for use

- To **Search** an Antenna Pattern:
  - Select the **Manufacturer** from the drop-down.
  - Select the Model by typing characters from the name eg. DIP..
- For **Favouriting** an Antenna Pattern:
  - In the 'Action' column on the right of the table, click on the heart  icon of the pattern.
  - The icon will turn red  indicating that the pattern has been short-listed. It will appear in your antennas list after re-loading the user interface.

Antenna ratings system

Antenna patterns vary in quality. You can provide feedback on good patterns which helps your team find them quicker since they are ranked by score. Click the rating stars and provide a score and a reason.

Removing patterns

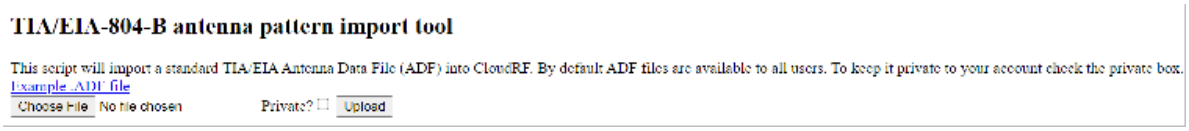
At the time of writing, patterns can only be removed by emailing support@cloudrf.com with the name and ID number(s). A delete function is scheduled.

Antenna pattern validators

An ADF validator is here.

A multi-format conversion wizard is here.

- To upload a new antenna pattern,
  - Click 'Add ADF file' to open the form and upload your file:



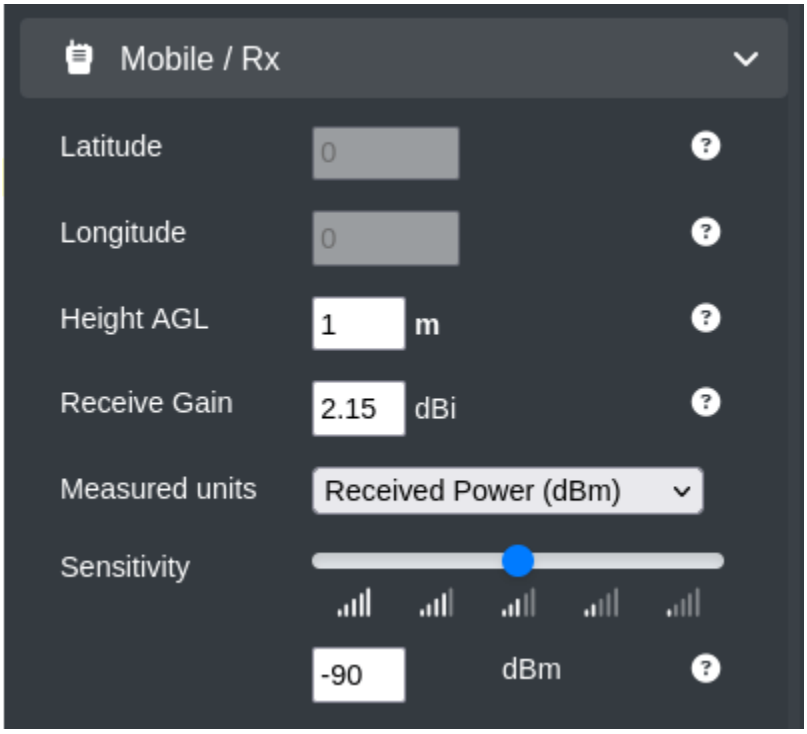
- Click on **Choose File** button to browse and select the desired file to upload.

  If you wish to keep the uploaded pattern file private to your account, select the **Private?** checkbox. Be aware that the OEM will still be public.

- Click on the **Upload** button.

2.5.5  Mobile / Rx

The Mobile / Rx (Receiver) input menu contains settings for the **remote** end of the link. This could be a mobile outstation, a customer or a vehicle.



Configure the following **Mobile/Rx** fields:

Latitude and Longitude

These location fields will be disabled by default. To enable the fields, you can click on the **Path Profile tool**  icon on the *Function Menu*.

You can set the receiver location by one of the following ways:

- Click on the **map**. The location values will be set automatically.
- Enter the values **manually** if you know the GPS or map locations.

Height

The height (surface model) in meters or feet. The Height units (*metres/feet*) and mode (AMSL or AGL) can be set under **Site/Tx** Input Menu in the Height field. For example: If the surface model is LIDAR that includes a 30m building and your mobile station is 4m on the roof then the Height AGL will be 4m.

If LIDAR is not present the height should be 34m AGL, and if height units above sea level (AMSL) are used, with a ground height of 100m, then the height should be 134m.

For a handheld or shoulder mounted radio, you should use a height value of 2m as the system's minimum resolution is 1m. Using 1.5m would be rounded to 2m at the API. Using 1.4m would give a more conservative prediction as it would be rounded down to 1m.

Receive Gain

Enter the receiver gain in dBi. This is the combined receiver and antenna gain. The receiver gain considers the antenna, receiver noise and (receive) feeder loss. For example: If the receiver has a 3dBi antenna and a 3dBi receiver noise figure, the Receive gain would be 0 dBi.

For a Mobile Phone, you should use a gain value of 0dBi. The actual performance varies by band, so a phone may have 1dBi gain for GSM900 but 0dBi for UMTS2100. Choose the lower value if you are unsure.

Measured units

Select the output units option from the drop-down as per your requirement. CloudRF has support for a wide range of different measured units. The units must correspond with the selected colour key if performing area coverage plots.

Path Loss (dB)

Discounts transmitter power. Useful for selecting equipment for a link as this will give you an idea of what transmit power you will need to overcome the path loss.

Received Power (dBm)

Default units for consumers and operators. This is for modelling the carrier/signal only so **it discounts noise floor and bandwidth** and is used widely in IoT / LPWAN, WiFi and consumer applications. For full-bandwidth modelling see RSRP below.

Field Strength (dBµV)

Decibel-micro-volt-per-meter. Used for broadcasting and specialist power measurement. Has a relationship with received power so you can convert one to the other.

```
dBuV = dBm + 90 + 20log(ohms)
```

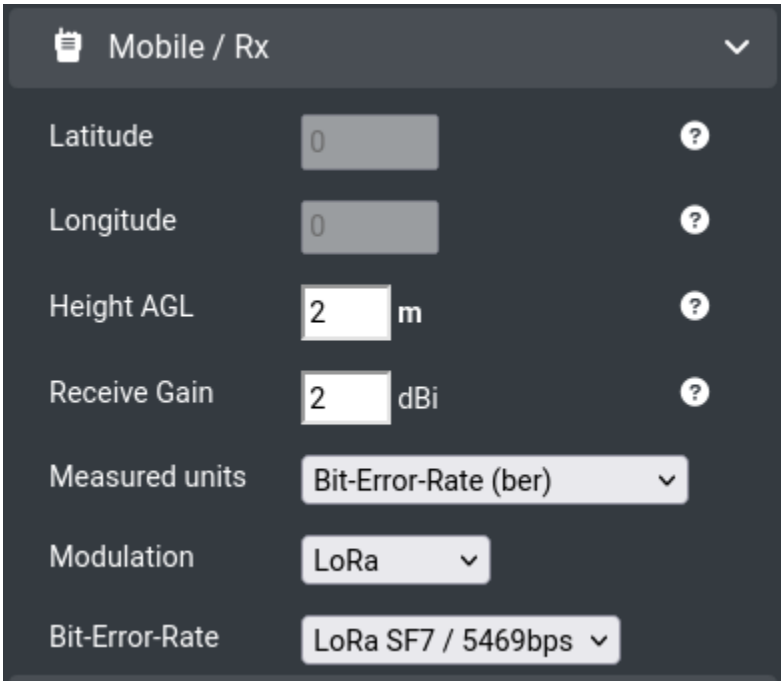
Signal to Noise Ratio (dB)

SNR considers noise floor and bandwidth. Used for MANET, Radar, cellular, 4G and 5G technologies. If you have noise data for the noise API, you need to be using SNR.

Bit-Error-Rate (BER)

Uses modulation curves and the noise floor to dynamically compute an SNR value as a threshold. Used for SATCOM and microwave links.

Pick your modulation schema from the list, then select the Bit-Error-Rate. The system will use these inputs, in conjunction with the noise floor to apply the appropriate SNR as dB.



LoRa spreading factor (SF) can be applied by choosing "LoRa" as the modulation. SF7 gives the best throughput but has a higher SNR requirement. Conversely, SF12 has the best range at the cost of throughput.

Reference Signal Received Power (dBm)

RSRP considers bandwidth. This is widely used in cellular systems with variable bandwidth like 4G (LTE) and 5G-NR and is **always a lower figure** than the received power (dBm) for the same signal.

Best Site Analysis (%)

The output for BSA is a percent (%) denoting relative site efficiency. Please note that BSA is only supported with *Best Site Analysis calculations*.

Sensitivity

Set the sensitivity slider to define the sensitivity of the mobile station in units corresponding to the measured units.

WARNING! SET WITH CARE

Use -90dBm if unsure.

A mobile phone's sensitivity is between -100dBm and -115dBm. Setting the sensitivity too low (eg. -120dBm) will result in an unrealistic BIG prediction. Be aware also that phones can report signal strength as RSRP **or** received power yet the difference between the two is significant depending on bandwidth. RSRP is the lower value.

IoT protocols like LoRa / LPWAN can theoretically operate down to -140dBm but this is under ideal conditions. To simulate man-made noise, add a margin of at least 10dB so your threshold is at least -130dBm.

Noise floor (SNR and BER units only)

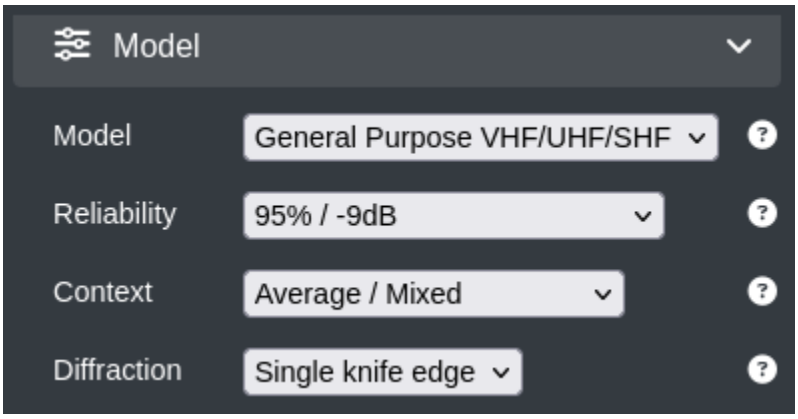
Since v3.9, noise floor has been moved to the environment menu. Enter the local noise floor value in dBm. It is used in conjunction with the required SNR to establish the sensitivity.

The system will help you with a thermal noise value (Johnson-Nyquist) based upon your chosen bandwidth but for best results, you need to measure the noise in your area and enter a measured value.

Since v3.9, you can enter noise in real time through the noise API. If you have live measurement data, you can then ensure that your planning matches the reality, whatever the reality may be. Click the network icon next to noise to enable "database" mode instead of system default, or guessed, values.

2.5.6  Model

The Model input menu consists of the settings related to the Propagation Model.



Configure the following **Model fields**:

- **Model** - Select the Propagation model from the drop-down as per your requirement. Some empirical models like Hata and SUI have minimum frequencies and heights. This is enforced as these models will only be accurate if used within their parameters.

Use the ITM model if you are unsure. This is used by the FCC for general purpose applications and is the most advanced model here where VHF/UHF diffraction is present.

Code	Model	Purpose	Frequency Range	Minimum Tx Height
1	Irregular Terrain Model	General Purpose VHF/UHF	2 - 20,000 MHz	0.1m
2	Line of Sight (LOS)	Visibility testing	~	~
3	Okumura-Hata	Cellular	150 - 1500 MHz	3m
4	ITU-R P.1546	VHF/UHF/Terrestrial	30 - 4,000 MHz	0.1m
5	SUI Microwave	UHF/SHF	1900 - 11,000 MHz	3m
6	COST231-Hata	Cellular	150 - 2000 MHz	3m
7	ITU-R P.525 (Free Space)	*Reference model*	2 - 90,000 MHz	0.1m
8	RADAR with RCS	RADAR for surveillance	2 - 90,000 MHz	0.1m
9	Ericsson 9999	Cellular	150 - 1900 MHz	3m
10	General Purpose	General Purpose VHF/UHF/SHF	~	~
11	Egli VHF/UHF	General Purpose	2 - 1500 MHz	0.1m
12	HF NVIS	Ionospheric communication to 500km	2 - 20 MHz	~
13	HF Skywave	Ionospheric communication to 10000km	2 - 20 MHz	~

These models are grouped as the following, which are reflected in the dropdown selection:

- Deterministic Models
  - General Purpose
  - Irregular Terrain Model
- Cellular Models
  - Okumura-Hata
  - COST231-Hata
  - Ericsson 9999
- Empirical Models
  - SUI Microwave
  - ITU-R P.525 (Free Space)
  - Egli VHF/UHF
- Special Purpose
  - HF NVIS
  - HF Skywave
  - RADAR with RCS
  - Line of Sight (LOS)
  - ITU-R P.525 (Free Space)

  WARNING: The ITU-R P.525 model is a simple reference model. It will provide a *very* optimistic prediction (eg. +20dB gain) unless you temper it with losses elsewhere.

  WARNING: When selecting the "Line of Sight" model knife edge diffraction should be disabled.

RADAR

When you select the RADAR propagation model you will also be prompted to specify a RADAR Cross Section (RCS) value. This value is used to descrive an object's reflective surface and is measured in square meters (m2). In general, the larger the object the higher its RCS value. Some examples are listed below:

- **RCS**
  - Bird: `0.01` m2
  - Small drone: < `0.04` m2
  - Human: `1.0` m2
  - Jet aircraft: `2` - `6` m2
  - Cargo aircraft: `100` m2
  - Automobile: `100` m2
  - Coastal vessel: `300` - `4000` m2
  - Container ship: `10,000` - `80,000` m2

HF NVIS

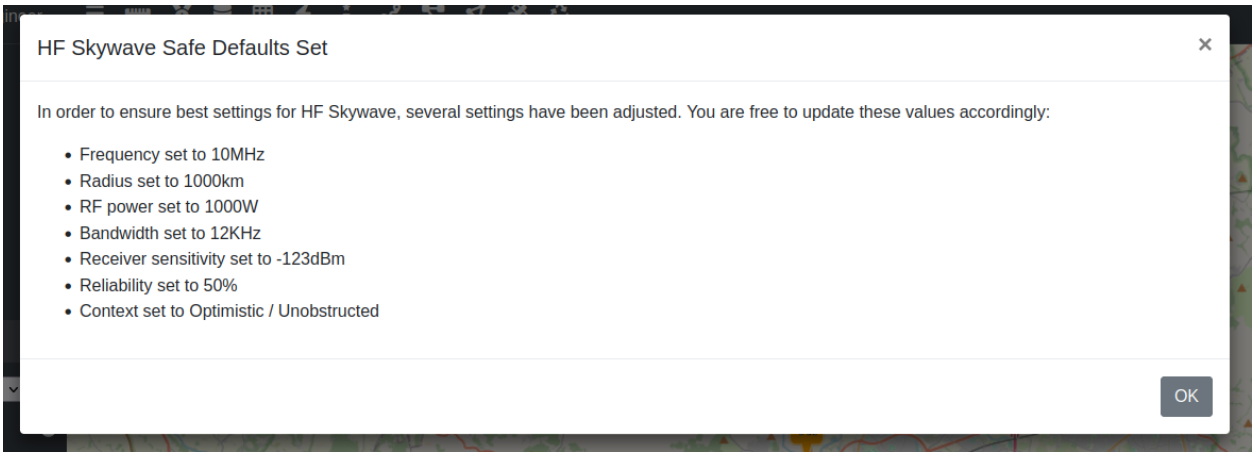
When you select HF NVIS, the context will change to allow you to select the reflective height. For more on this see the context section. The antenna will also be set as a horizontal dipole with a special pattern to consider the local nulls found around a horizontal dipole. You may change the gain and azimuth but not the pattern.

```
HF NVIS will not work with frequencies greater than 30MHz. Optimal frequencies are 4 to␣
↪8MHz, subject to season, location and time of day.
```

HF Skywave

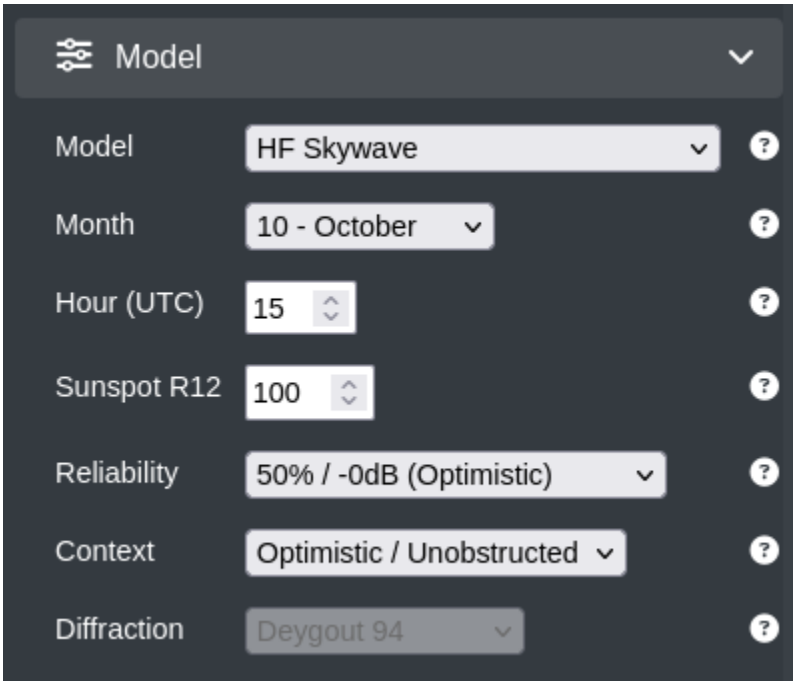
The HF Skywave model is a special case which opens up several form elements which are specific to HF Skywave. HF Skywave is based upon VOACAP (https://github.com/jawatson/voacapl).

When you enable HF Skywave several settings will be checked and appropriate values will be set if your settings are not currently suitable. These values will be indicated in a modal window when you switch to HF Skywave.



HF Skywave also requires several other settings to correctly work. These values are added into the "Model" menu.

- **Month** is the month under which you wish to run HF calculations. By default this will be set to the current month.
- **Hour** is the hour of the day, relative to UTC, under which you wish to run HF calculations. By default this will be set to the current hour. Please note that you will need to adjust your hour value for your location timezone relative to UTC. For example, if you wanted to see HF coverage for a transmitter in Thailand at 08:00, you would need to set the hour value to 01:00 because Thailand is at UTC+7.
- **Sunspot R12** is the average International Sunspot Number (SSN).



Reliability

This field enhances a model with a configurable (10dB) fade margin. You can select the reliability percentage as per your requirement.

```
99% indicates a conservative 'high confidence' prediction (+9.9dB path loss)

90% is the default set value.

50% is an optimistic "sunny day" prediction (+0dB margin on path loss)
```

Context

Select the context of the model from the drop-down as per your requirement. Many models have environmental variables which provide different outputs. Typically code 1 is urban/conservative, 2 is average and 3 is rural/optimistic. For the HF NVIS model, context refers to the reflective layer where 1 is D, 2 is E and 3 is F.

```
For a conservative output, select Conservative/Urban as the option. Else, keep the␣
↪default Average/Mixed option and use the reliability for tuning.
```

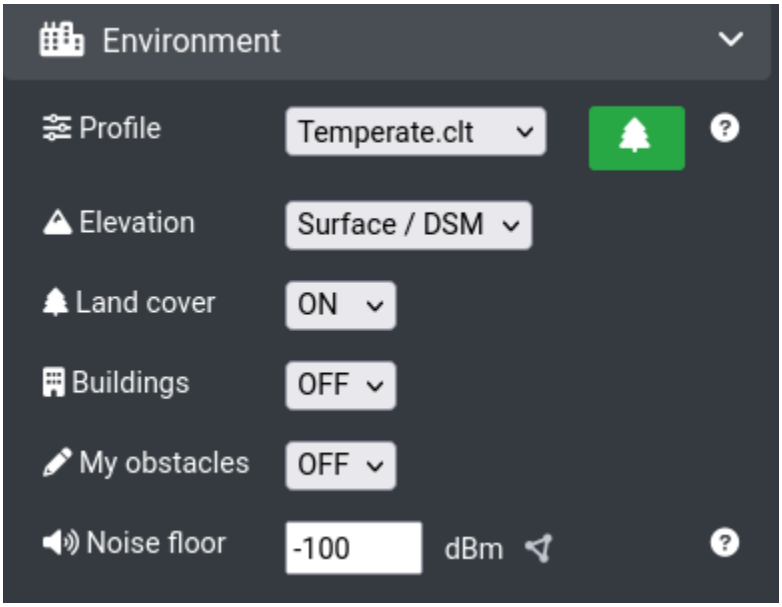
Diffraction

Diffraction will show coverage beyond an obstacle. The radio shadow size will vary by frequency and the obstacle distance/height with a low frequency having a low angle of diffraction. If Line of sight is critcal eg. Microwave links, then switch this off. If you are using a sub-GHz system eg. VHF or UHF-L then this should be on. The recommended model is Bullington.

Model	Description
Single Knife Edge	Basic `Huygens` formula which considers each obstacle in isolation. Can be optimistic
Bullington	Advanced multi-obstacle model with approximation. Good trade off between accuracy and speed
Deygout	Advanced multi-obstacle model. Can be conservative

2.5.7 Environment

The Environment input menu consists of the settings related to the system and custom clutter. For more information see the *clutter reference*.



Profile

Select the regional profile from the drop-down as per your requirement. If no profile has been created you will be shown `Minimal.clt`. See the clutter manager section below for how to manage clutter profiles.

Elevation

Select the digital elevation model.

- `Surface / DSM` will use a rough surface model or LiDAR if it is available. Heights are relative to rooftops.
- `Terrain / DTM` will use a bare earth model so heights are relative to the ground.

Land cover

Select the Land cover mode from the drop-down as per your requirement.

- `OFF` will just use terrain data.
- `ON` will add system 10m landcover.

Buildings

Select the Buildings mode from the drop-down as per your requirement.

- `OFF` will just use terrain data.
- `ON` will add a buildings layer to the surface model (Coverage varies by region)

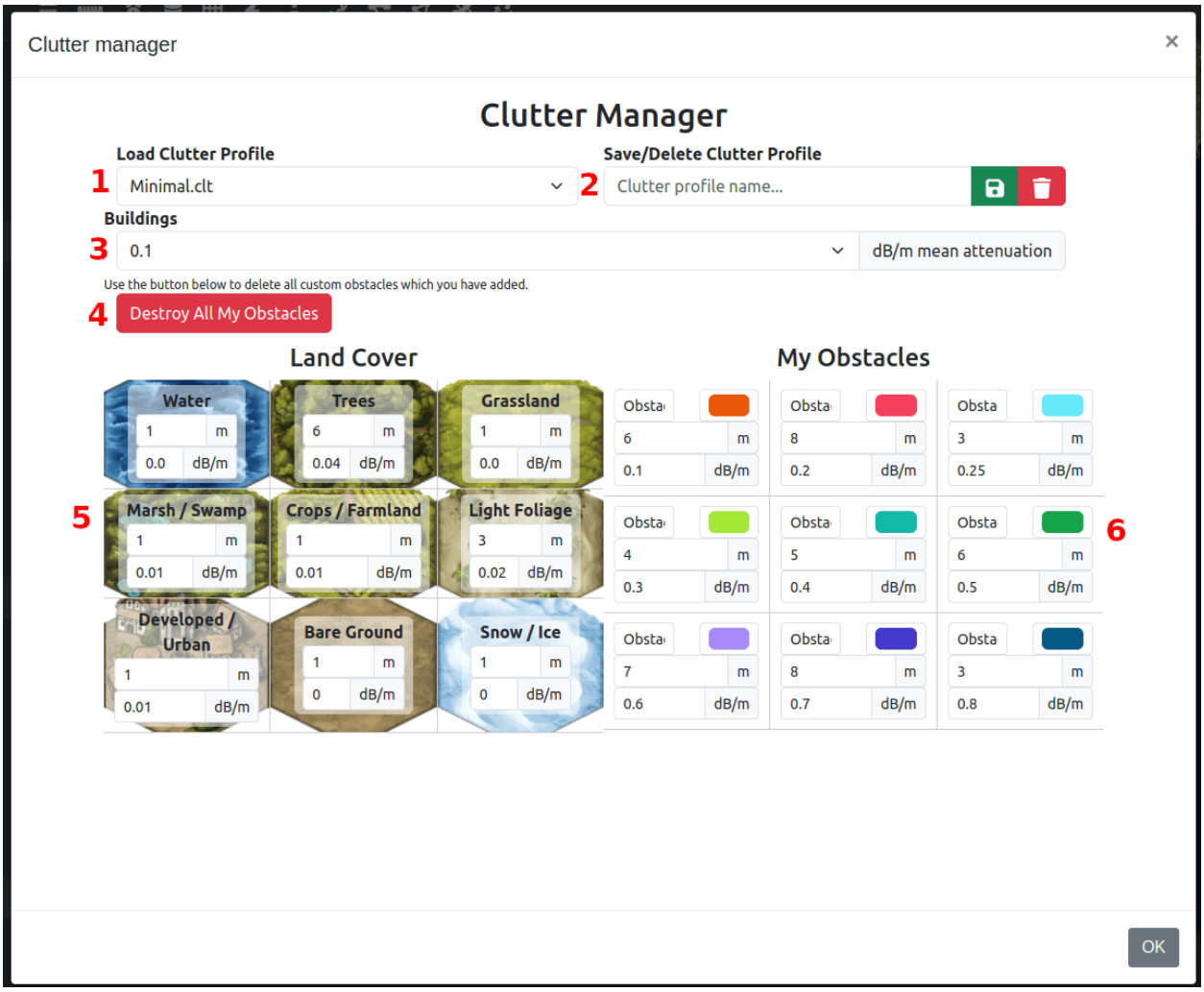
My obstacles

Choose to enable your custom clutter. Your items, such as a building, will be placed upon the terrain by default and can be used alongside land cover. To use this function, you must have clutter items saved to your account. See the *clutter reference* for more.

- `OFF` will not add any custom clutter.
- `ON` will add custom clutter on the chosen elevation model. Use with care.

Clutter Manager 

The clutter profile manager can be opened with the green-tree clutter manager button.



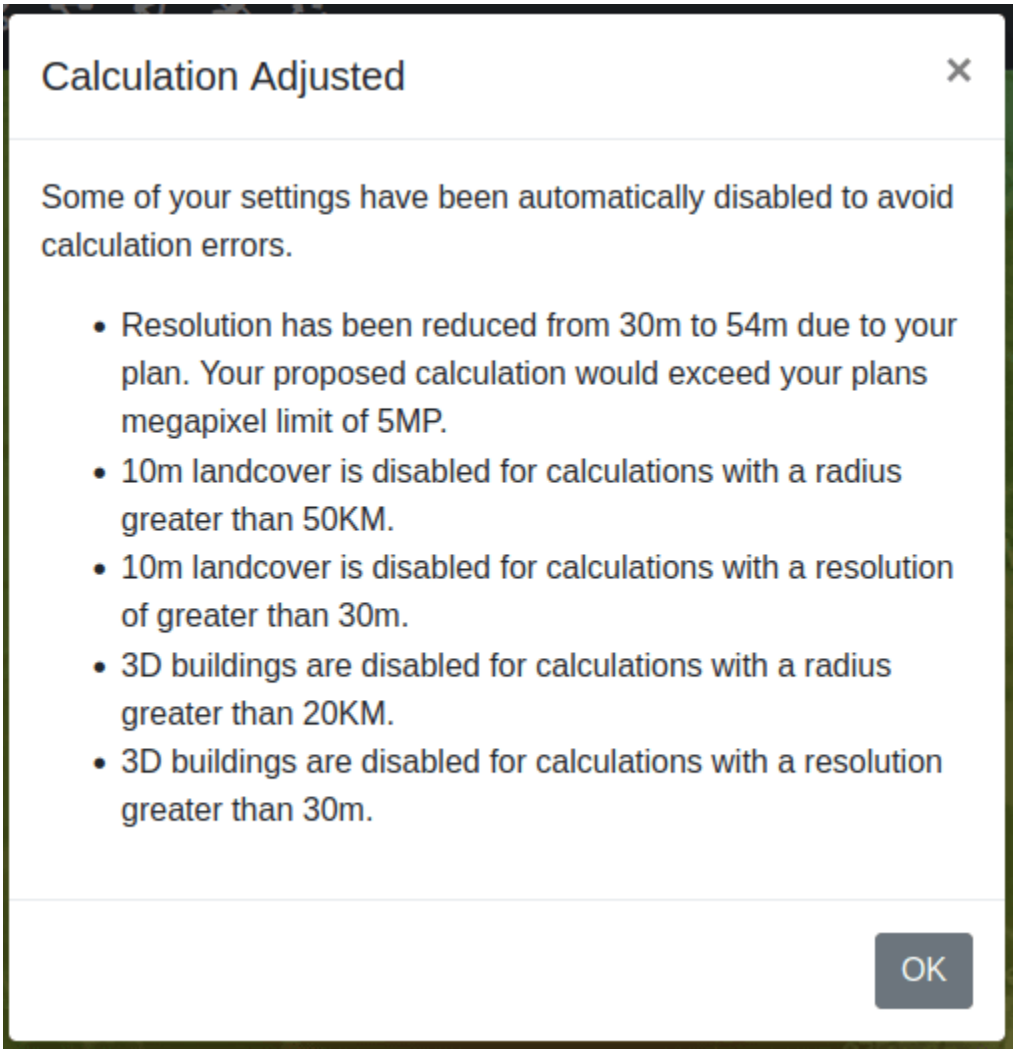
1. Selected clutter profile
2. Save/delete profile as name
3. Building attenuation
4. Delete all obstacles on your account
5. Land cover types with customisable height and attenuation values
6. My obstacle (clutter) types with customisable name, colour, height and attenuation values

Clutter Restrictions

Please note that there are restrictions in place on the public API which will protect it from being run with unnecessary or bogus values. The rules which are enforced on the API are:

- Enabling 10m landcover on calculations with a radius greater than 50km.
- Enabling 10m landcover on calculations with a resolution greater than 30m.
- Enabling 3D buildings on calculations with a radius greater than 20km.
- Enabling 3D buildings on calculations with a resolution of greated than 30m.

In such circumstances you will receive a "Calculation Adjusted" message with your response indicating what has been adjusted or disabled from your request.



Clutter attenuation

The Clutter Attenuation is a nominal value measued in decibels per metre (dB/m) for an obstacle, not the material itself, based on the principle of a hollow composite house or a forest with uniform gaps between trees.

For example: A 10m house with 2x 7dB brick walls and 2x 3dB partition walls would have an average of 2.0dB/m. This would be very conservative due to the Windows which permit signals, at the right angle ;), so by using a quarter of this we get 0.5dB/m which is a better nominal value for "a house".

No two houses or forests are the same so **results will vary by town and country**. For best results, calibrate a profile based upon **street level measurements**. Taking measurements from up high will miss clutter and likely provide an optimistic profile.

The following values are used in the minimal template. For codes, see the *clutter reference*.

```
1       1       0.0
2       5       0.05
3       1       0.0
4       1       0.02
5       1       0.05
6       2       0.05
```

(continues on next page)

(continued from previous page)

```
7        1        0.03
8        1        0
9        1        0
10        0        0
11        6        0.1
12        8        0.2
13        3        0.25
14        4        0.3
15        5        0.4
16        6        0.5
17        7        0.6
18        8        0.7
19        3        1.0
```

Building attenuation

Building attenuation is a separate value to the 9 land cover attenuation values as it is a distinct layer. Like other types, it is a nominal attenuation value measured in dB/m and is applies to the whole of a building, not just the walls.

For example, a house with 2x 10dB thick walls, measuring 8m deep, will have a value of (2 x 10) / 8 = 2.5dB/m. In reality, a house has windows which allow signals to pass. Depending on the glass, this could be as low as 2dB so a glass house becomes (2 x 2) / 8 = 0.5dB/m. Taking an average of the two gives 1.5dB/m.

```
For celular networks, building attenuation is significant. Most of the signal behind a␣
↪house is diffracted from the roof, so going away from the house to the end of the␣
↪garden will boost your signal.
```

Value	Building type
0.1	Timber
0.2	Light brick
0.3 - 0.5	Brick / Concrete
0.5 - 0.8	Concrete
0.8 - 4.0	Concrete / Metal

Saving and deleting profiles

Enter the name for your profile eg. POLAND and click the save button. To delete, enter the full name of the profile plus the file extension eg. POLAND.clt then click the delete button.

Noise floor

Since v3.9, noise floor has been moved to the environment menu.

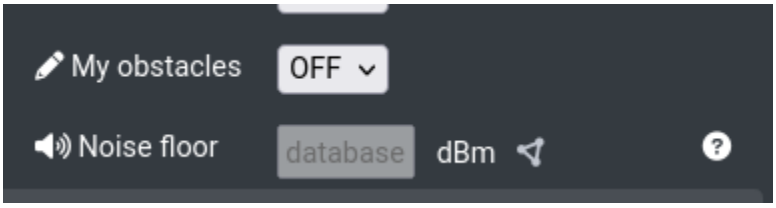
Enter the local noise floor value in dBm. It is used in conjunction with the required SNR to establish the sensitivity when using **SNR, RSRP or BER units only**.

```
NOTE: Noise floor is ignored in received power mode (dBm)
```

The system will help you with a thermal noise value (Johnson-Nyquist) based upon your chosen bandwidth but for best results, you need to measure the noise in your area and enter a measured value.

Since v3.9, you can enter noise in real time through the noise API. If you have live measurement data, you can then ensure that your planning matches the reality, whatever the reality may be. Click the network icon next to noise to

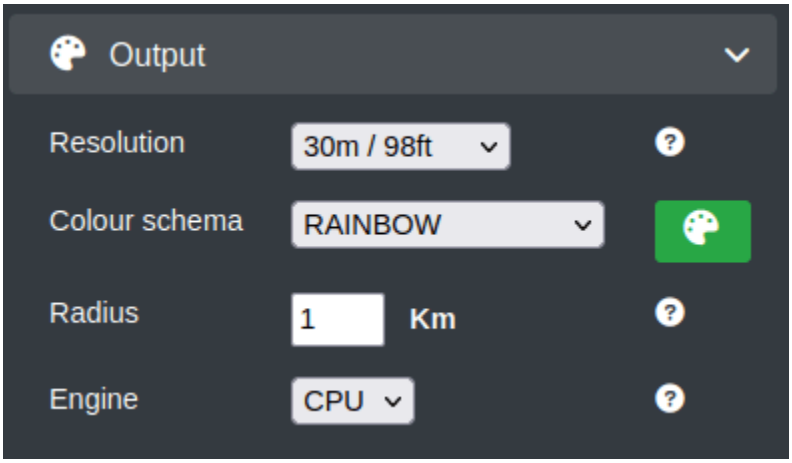
enable “database” mode instead of system default, or guessed, values.



To push in noise data, send a POST request to the https://api.cloudrf.com/noise/create endpoint or paste CSV data into the hosted form at https://cloud-rf.github.io/CloudRF-API-clients/integrations/noise/noise_client.html

2.5.8  Output

The Output input menu consists of the settings related to the system output.



Configure the following **Output fields**:

Resolution

Select the desired resolution from the drop-down as per your requirement. Make sure that the resolution when combined with the radius to compute a mega-pixel value, is within your plan limit.

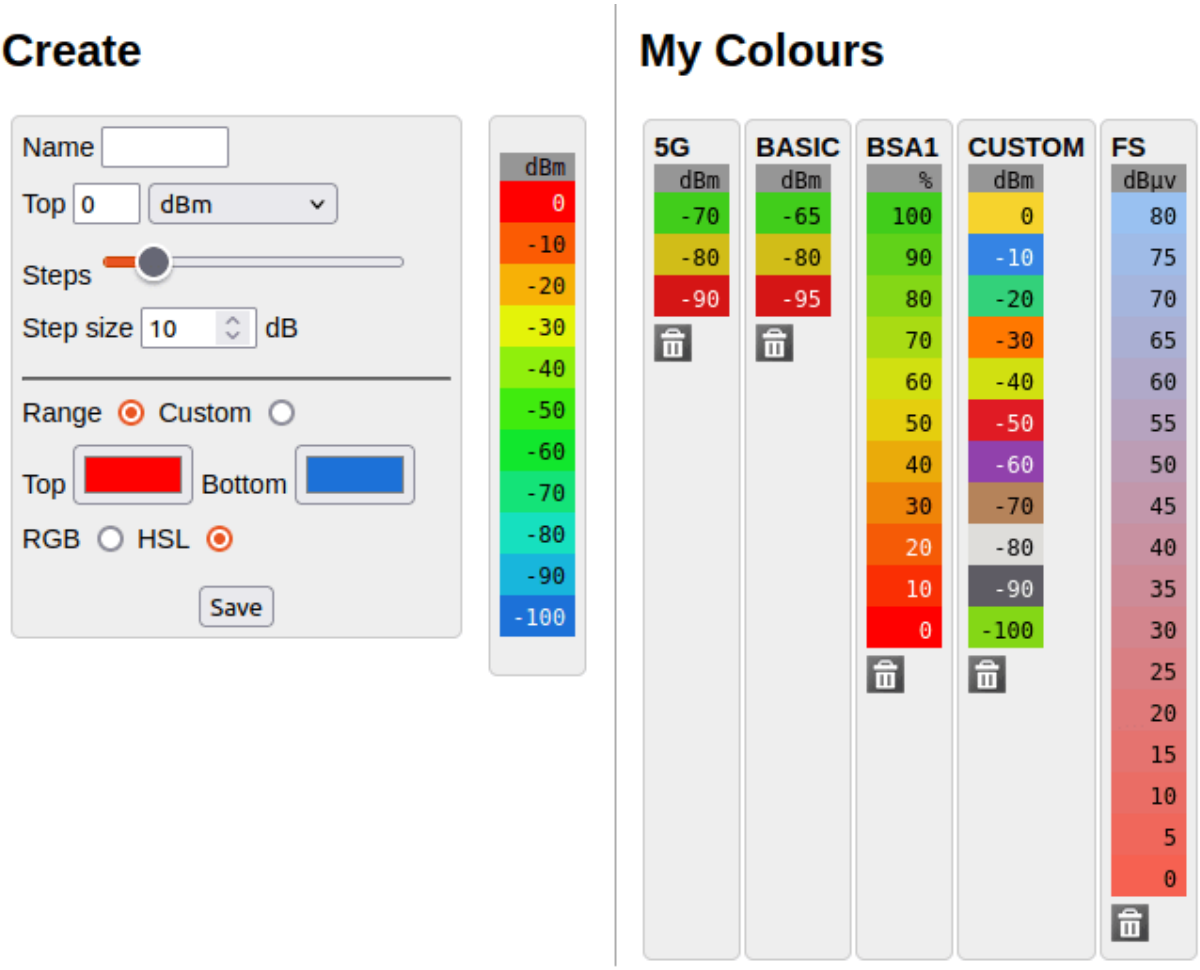
- 2m is not recommended unless you know that the city or area supports this data via LiDAR.
- TIP: **20m** presents a much better compromise for accuracy in most countries due to proximity to the underlying surface model and the use of 10m landcover.

Colour Schema

Specify how the produced calculation will be coloured based on a selected colour schema.

- **Please Note** that schemas here listed are based on your selected “Measured Units” value in the *“Mobile / Rx” menu*. If you are looking for a schema which isn’t listed here then it is likely caused by the schema belonging to a different measured unit eg. dB vs dBm
- You have a list of system-default colour schemas to choose from, however if these do not fit your use-case then you can also create your own colour schema by clicking on the **colour palette** icon. 

When you do this you will be presented with the **My Colours** screen.



Here you can build a colour schema. As you update the settings on the left, the preview will be automatically updated.

1. Give your schema a name, e.g. `GREEN2RED`
2. Choose your measured units, e.g. `dBm`
3. Choose a sensible top value. When you change you units in the dropdown a good default will be chosen.
4. Choose a step size and steps with the slider.
5. Choose your colours. Here you can choose between a colour range or custom buckets. Below shows screengrabs of the interface to highlight the differences.
    1. A colour range will take a top and bottom colour and then interpolate between them, based upon the previously set values. You can set your range as either "red, green, blue" (RGB) or "hue, saturation, lightness" (HSL). HSL is recommended for a dynamic rainbow range.
    2. When selecting custom colour buckets you can set the individual colours for the particular buckets. This provides more control over the colour schema, and can be used to help isolate certain values.
6. When you are satisfied with your colour schema you can save it and it will become available for use.

Colour Range

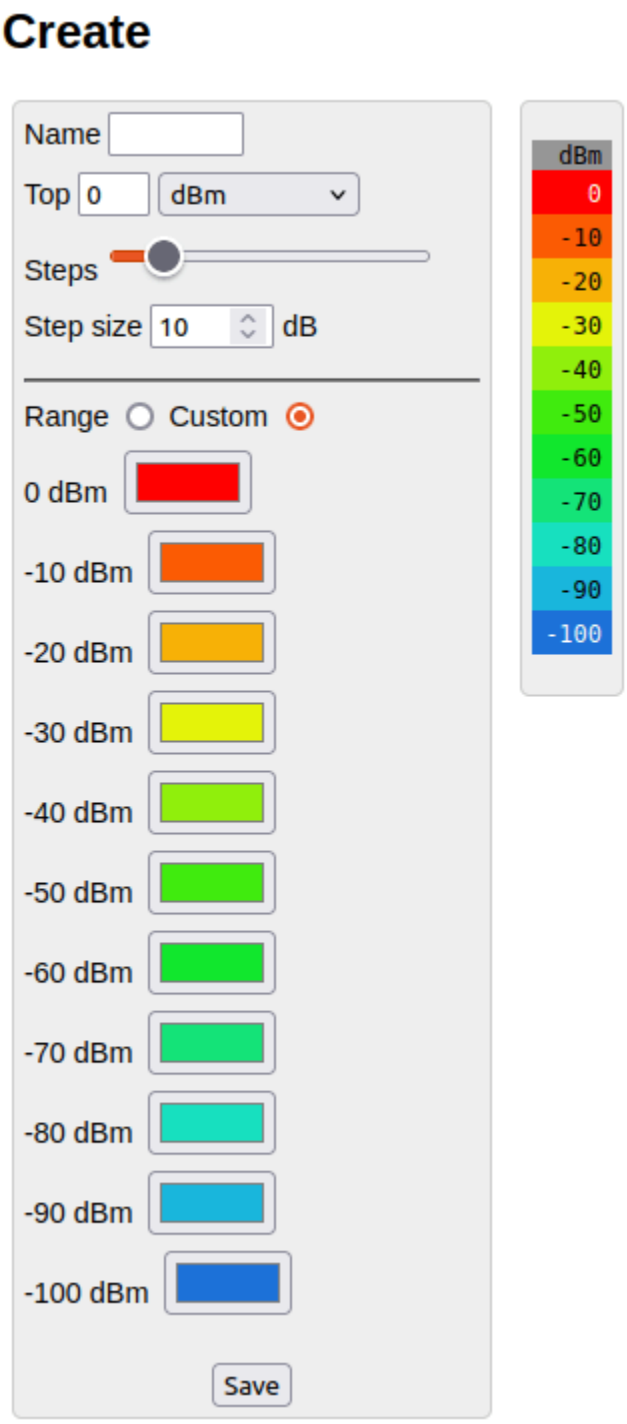
Below shows an example output for colour range.

RGB:

HSL:

Colour Custom Buckets

Below shows an example output for custom colour buckets, where you can adjust the colour of individual values:



Radius

Enter the desired radius in the units as chosen in the *transmitter menu*. This value is used with resolution to compute mega-pixels which are displayed in the corner console. For example: 5km radius calculation at 2m resolution would result in 25MP image. Similarly, 5km at 10m = 1 MP.

> **NOTE**: Do not request an excessive radius/resolution eg. > 32MP. For example, a 20km radius calculation at 2m resolution would create a 400(!) megapixel image which would crash any image processing software

and web browser - if you generated it. There are restrictions in place on the API to enforce limits.

Target radius	Recommend resolution	Megapixels
1km	1m	4MP
2km	2m	4MP
5km	10m	1MP
10km	10m	4MP
20km	20m	4MP
30km	30m	4MP
500km	180m	32MP

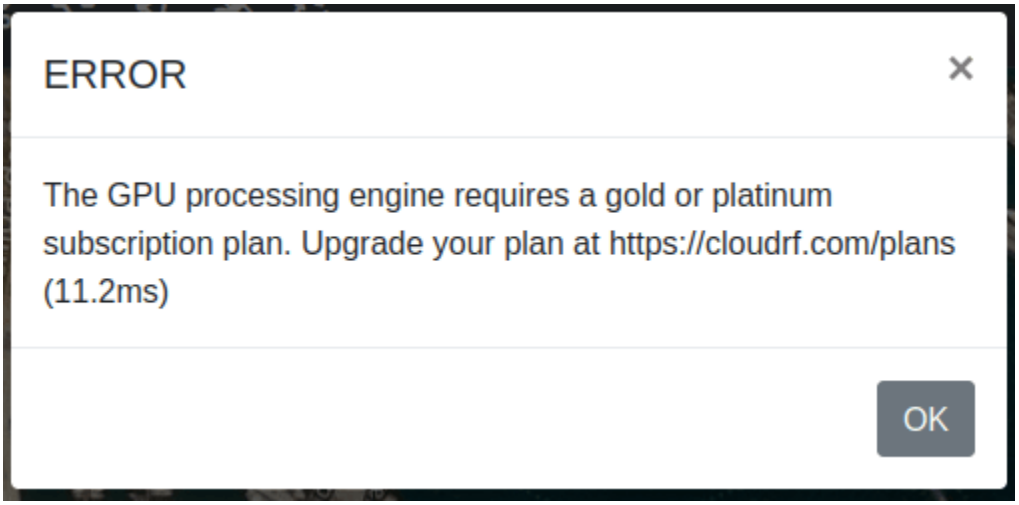
Engine

Choose your desired processing engine to produce the calculation. You have a choice between **CPU** or **GPU**.

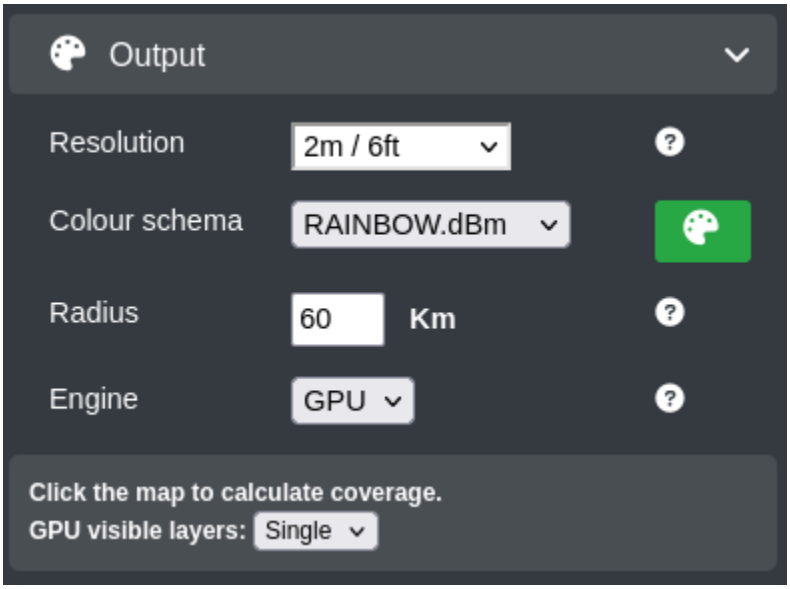
- **CPU** is our most robust and tested processing engine "SLEIPNIR". It uses a traditional computer CPU in the background to run through your calculation. This has the benefit of being well matured and tested and so your results will be as accurate as the inputs you specified.
- **GPU** is our newest processing engine. It uses a graphics card so is 20 times faster than CPU processing. It can do diffraction, attenuation and the same propagation models as the CPU engine.

GPU Engine

In order to make use of the GPU processing engine you will need to have either a gold or platinum subscription plan, or an enterprise server. If you do not have either then you will receive a forbidden message for the reponse.



When you select "GPU" from the "Engine" dropdown a section will show at the bottom:



This indicates that you are in GPU mode and you should note a few things:

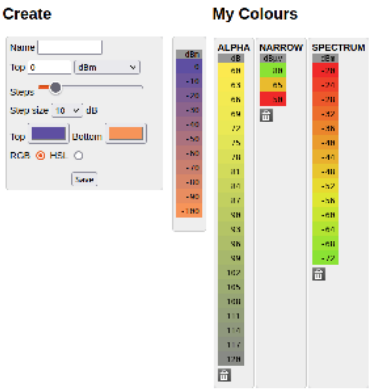
- You can now click on the map to run a calculation. The GPU engine is so fast that a progress bar is not required and so the classic green "Calculate" button is hidden.
- You can change the GPU visible layers:
  - **Single** means that only one GPU calculation will be kept on the map at a given time.
  - **Many** means that you can have as many GPU calculation layers on the map as you wish. However, please note that the GPU engine is fast and so it can very quickly use up your browser resources if you are adding many layers. You can manage layers in the same way as you do for CPU calculations in the top right.

Colour Palettes

You may find that the system-defined colour schemas do not meet all of your requirements and so to resolve this CloudRF has functionality to build your own colour schema with your own colours, units and limits.

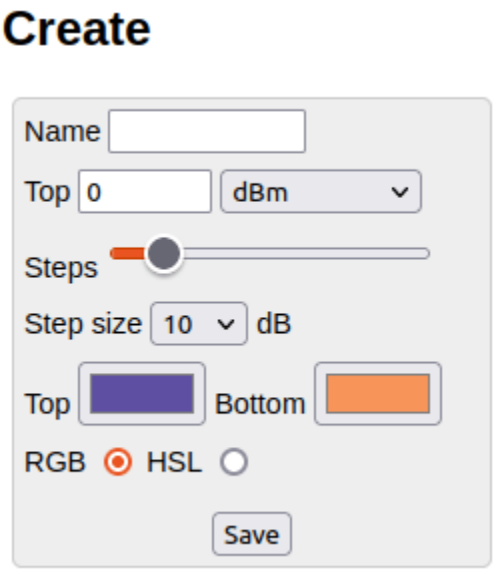
To create custom colour pattern:

- Select the colour schema by clicking on the **Manage My Colours**  icon. This button can be found in both the "Output" menu and also in the *"Account Information" modal*.
- The **My Colours** screen will appear in a separate tab on your browser.



Note When you load this manager you may have no colours to the right under the "My Colours" heading. This is normal, as you have not yet created any colours.

You may create a customised colour pattern by using the form on the left.



- **Name** is the name of your custom colour schema.
  - To edit an existing pattern, enter the colour pattern name here. You may edit the fields as per your requirement.
- **Top** is the top-most value of the colour pattern. Use -30 for a received power schema.
  - As part of **Top** you should select the unit under which your colour pattern will be used. Your pattern can only be used with that measured unit. If you require patterns for other units then you should create those separately.
    - **dB** - Decibels
    - **dBm** - Decibel milliwatts
    - **dBuV/m** - Decibel microvolts per meter
    - **%** - Percentage coverage for *best site analysis* calculations

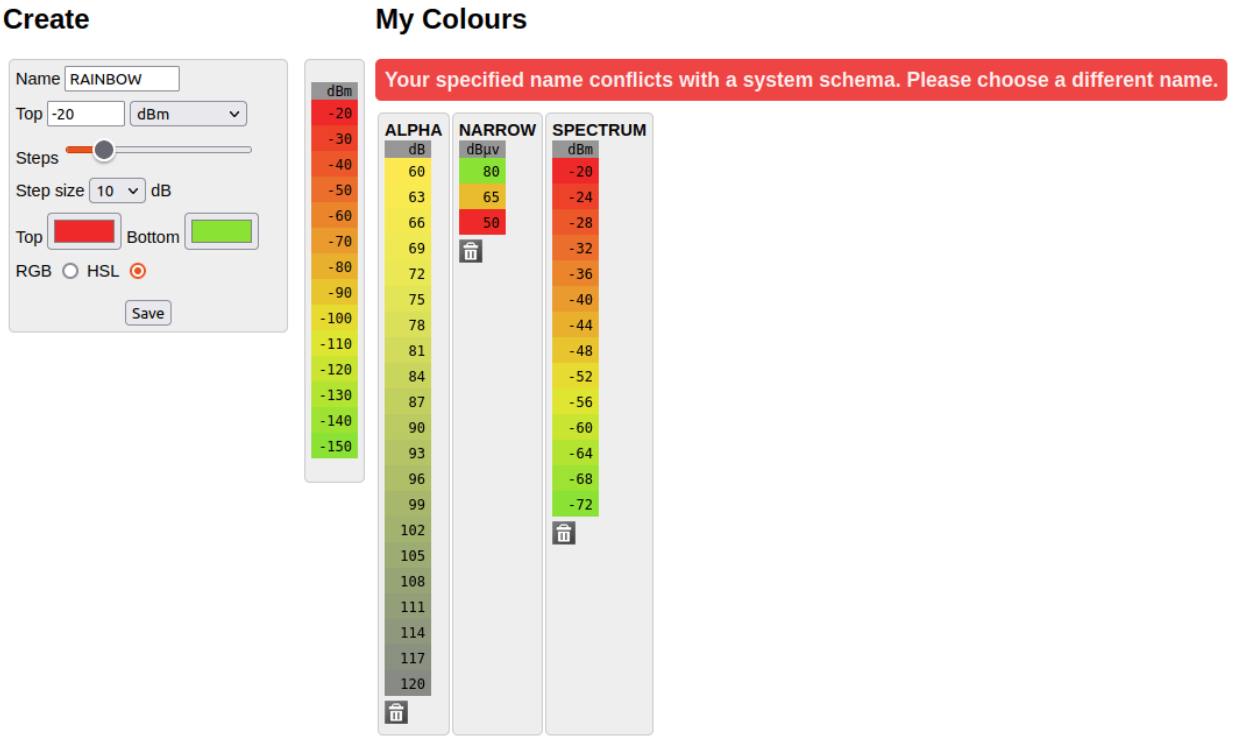
    - **BER** - Bit-error-rate
        - When selecting BER you will see a second dropdown get created which asks you for your modulation.
    - **RSRP (dBm)** - Reference signal received power in decibel milliwatts

- **Steps** is the number of steps/buckets you wish to be displayed in the colour pattern.
- **Step size** is how spaced apart each step/bucket is, for the total number of **Steps**.
- **Top** and **Bottom** are the colours you wish to use for the top and bottom of the colour pattern.
- **RGB** and **HSL** correspond to the colour format to be used between the steps. **RGB** (red, green, blue) are more computer-readable. **HSL** (hue, saturation, lightness) are more human-readable and will provide a better dynamic range.

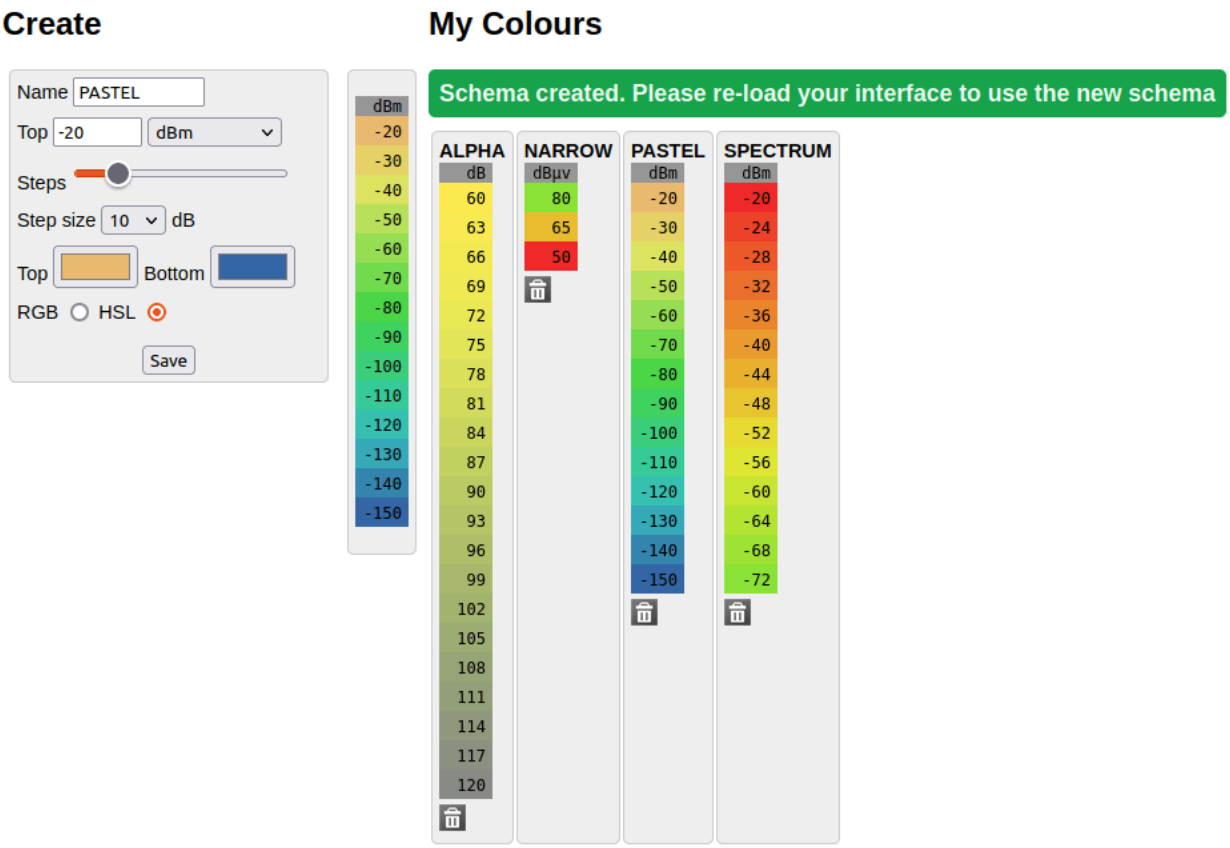
As you adjust the settings from the form the colour schema will be built on-the-fly to the right of the form.RAINBOW

Once you get the colour schema to a stage which you are happy with then you can click on the **Save** button where your colour schema will be attempted to saved to your profile.

If there are any problems then you will received a validation message towards the top of the screen.



If your colour schema could be created successfully then you will be notified with a success message and your new colour schema will be displayed on the right under the “My Colours” heading.



You can now return to the web interface and your colour schema will be present in the "Colour Schema" dropdown on the "Output" menu, as long as you have the correct "Measured Units" selected from the "Mobile / Rx" menu which matches your new colour schema.

2.6 Save and Run Buttons

After configuring the Input Menu, you can **Save** and **Run** the configuration by clicking on the respective button.

These buttons are displayed below the Input Menu.

2.6.1  Save

Save button lets you create a template with all your configured settings that you can reuse later whenever required.

For further information, refer *Templates* topic.

2.6.2  Run

Run button will execute a coverage calculation using your configured settings.

- The execution may take several seconds depending on the resolution and the radius. The **Progress Bar** will be displayed in this case.
- In case there are **errors** in the configuration, the respective error dialog box will appear.

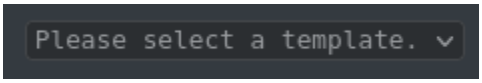
  - Make the necessary corrections and re-run the updated configuration.

- After successful execution, the ***Site name (Network name)*** field will be displayed in the *Output Console*.

  For further information, refer the **Output Console** topic.

2.7 Templates

Templates allows you to quickly apply settings from a saved/custom or system-defined configuration.

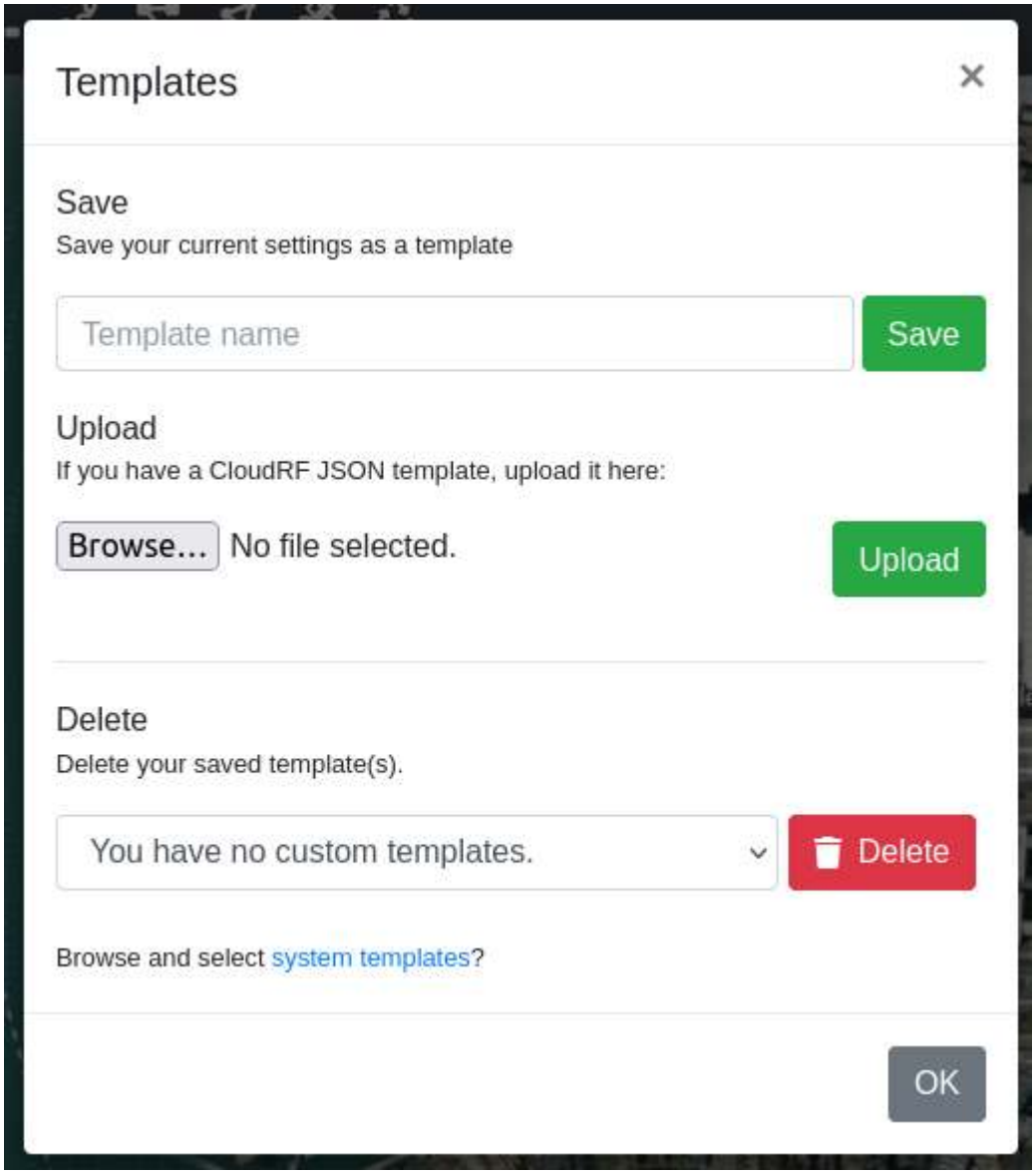


Templates are useful in a shared account where an Engineer might prepare the template(s) and a sales person might use them to qualify customers.

2.7.1 Custom Templates

To manage your custom templates:

- Configure the Input Menu as per your requirement.
- Click on the **Save**  button.
- The **Manage Your Templates** dialog box will appear.



Saving a Custom Template

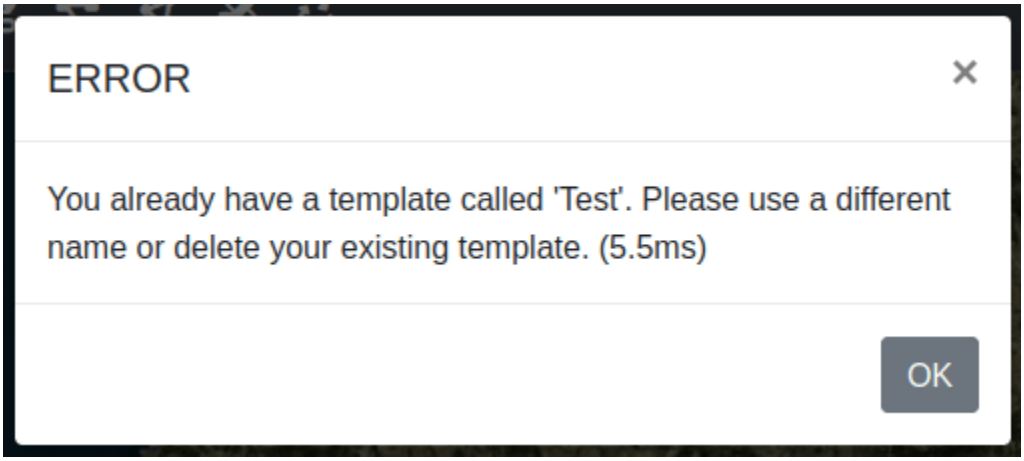
To save a custom template:

- After configuration in the Input Menu, click on the **Save** button.
- In the **Manage Your Templates** dialog box.
  - In the **Template Name** field, enter the desired name of your custom template.

    You can give a user-friendly name, for example: "Radio X".
  - Click on **Save** button.
- The created Template will be displayed under **My Templates** drop-down. All custom templates will be prefixed with the words "Custom".

If your settings have any issues when you attempt to create a tempalte then you will be notified via a modal window.

An example of a bad template upload is below.



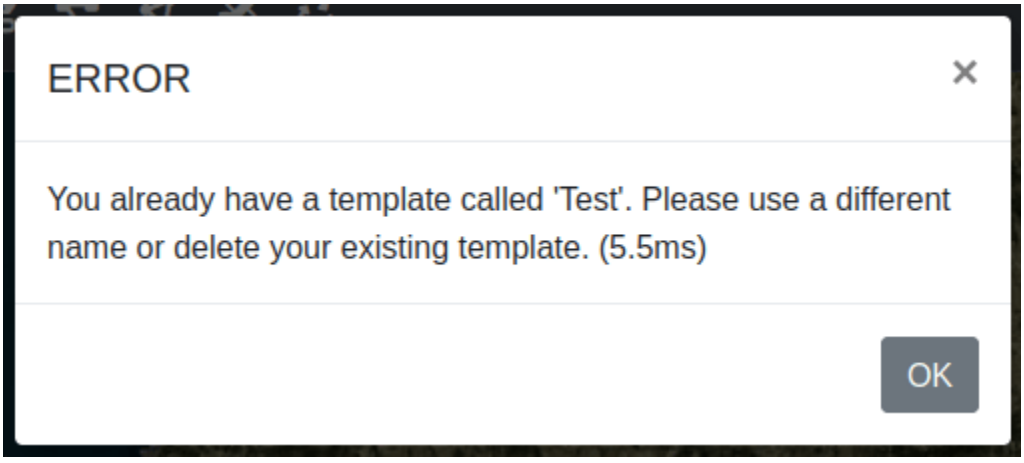
Uploading a Custom Template

You can upload templates directly into the system. This is useful if you would like to create and share your own templates.

To upload a custom template:

- Click on the "Browse…" button to search through your local filesystem to find the JSON template which you wish to upload.
- Click on the "Upload" button.
- The template will be uploaded and validated. If your template has all of the required fields in the correct formats then your template will be made available to use in your user account. If your uploaded template has any problems then you will be notified via a modal window.

An example of a bad template upload is below.



Deleting a Custom Template

To delete a custom template:

- Click on the **Template save**  button.

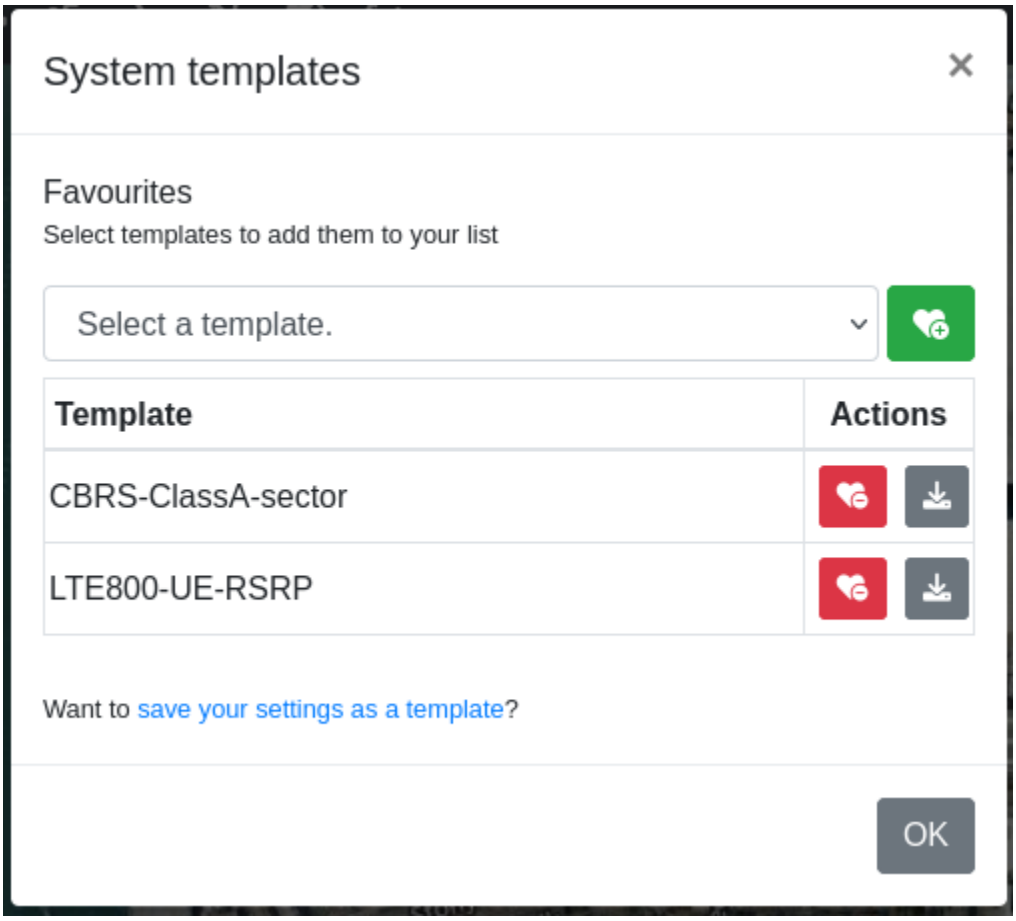
- In the **Templates** dialog box.
  - In the **Delete** field, select the Template Name that you wish to delete.
  - Click on **Delete** button.
- The deleted Template will be removed from the **My Templates** drop-down.

2.7.2 System Templates

System Templates provide a list of pre-built templates, built from product data sheets.

To manage your system templates there are 2 methods:

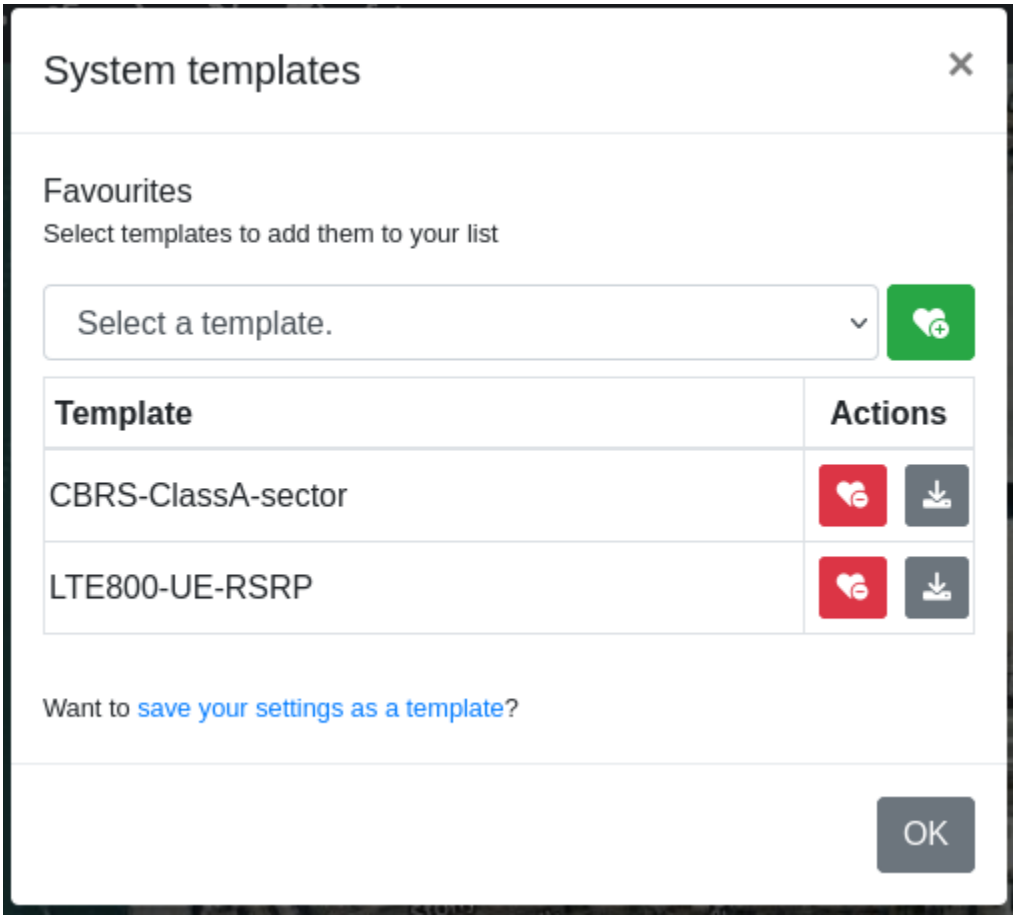
1. Click on the "Templates" button  in the manager in the "Account Information" modal.
2. Click on "system templates" in the *"Templates"* modal.



Favouriting System Templates

To add a system template to the templates dropdown you can find the template you wish to favourite from the select list, then click the favourite button  .

The chosen template will then be shown in the list below where you will have the option to either remove it or download the system template as a JSON file.



When you have favourited a system template it will be populated into the **My Templates** dropdown and will be prefixed with the words "System".

Unfavouriting System Templates

To unfavourite a system template click on the "Unfavourite" button  .

This will remove it from the list of templates at the bottom of the system-template manager, but also from the **My Templates** dropdown.

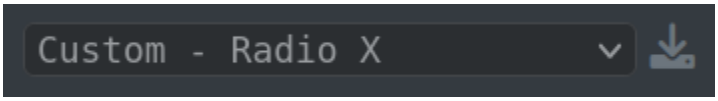
Downloading System Templates

To download the content of a system template click on the "Download" button  .

This will download directly to your browser the raw content of the template in a JSON file. You may edit this in any text editor. A reference for the values is linked in the header of each file.

2.7.3 Download Templates

You can download the raw content of a template directly to your browser by clicking on the download button to the right of the dropdown.



This will download the template as a JSON text file. This will contain all of the settings related to applying that template.

You can download both custom and system templates in this way. You may edit this in any text editor. A reference for the values is linked in the header of each file.

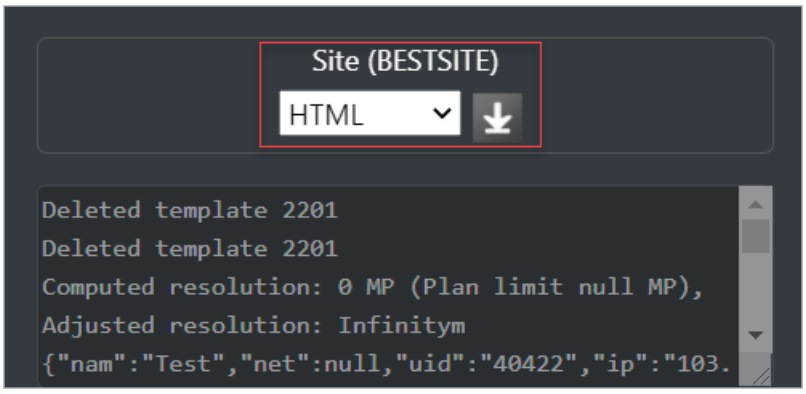
2.7.4 Template privacy and copyright

A template file is potentially sensitive as it can describe equipment configurations and performance. User templates are stored in a user's private folder with a random cryptographic hash to prevent file guessing attacks. The copyright for a created template belongs to the customer and (JSON file) sharing is actively encouraged.

2.8 Output Console

The output console provides the useful feedback related to the settings, errors, API inputs and API outputs as you use the CloudRF tool.

- The **Effective Radiated Power (ERP)** and the computed **resolution (in mega-pixels)** will be printed in this console as you adjust the settings so that you can keep an eye on the same.
- As an area calculation processes, you will see periodic updates in the console from the SLEIPNIR propagation engine.
- When you submit a calculation for processing, all the API parameters will be displayed here. If you are a developer, you can directly copy paste this to use it in your code.
- To do so:
  - Click on the **Run** button for execution, the ***Site name (Network name)*** field will be displayed in the *Output Console*.

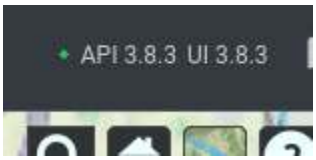


– Select the **file format** in which you wish to download the configuration settings file.

  * Click on **Download**  icon.

2.9 System Version

In the top right corner of the interface indicates the current version of the API and UI which you are using. The discrete green / amber / red light to the left denotes connectivity to the backend processing service / API. Green is good, amber is connected but the API has been under a sustained load for more than a minute and red is API unavailable.



You can click on either of the API or the UI which will open up a modal window in the interface which will give you a full changelog of what has changed in the version you are using.

2.10  Documentation

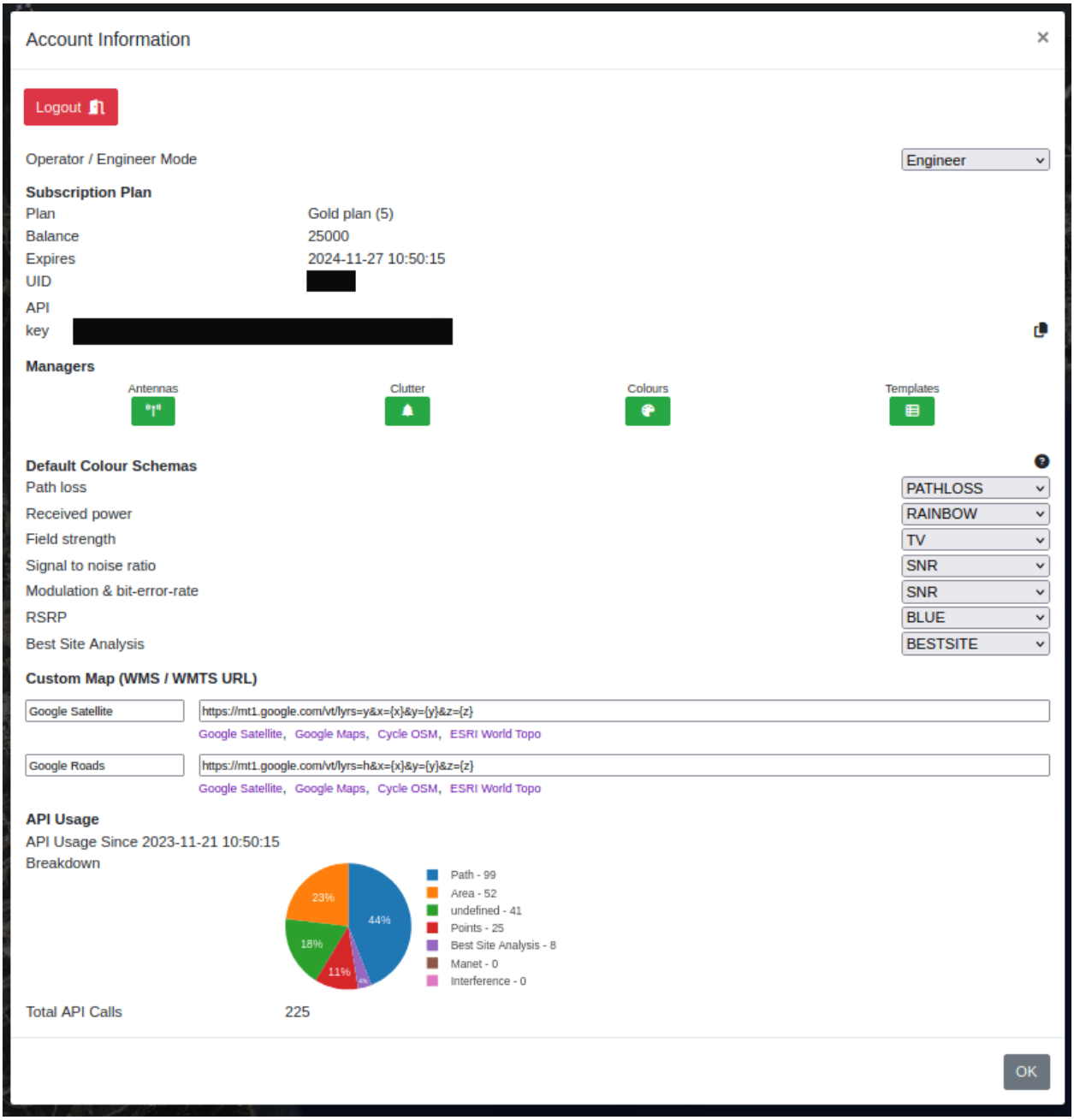
To refer to the 3D Interface Documentation:

- Click on the **Documentation**  button located on the top right of the interface.

2.11  Account Information

You can view information about your account by clicking on the **Account Information**  icon located on the top right of the interface.

When you click on this a modal window will be opened which will contain various information.



- **Logout** is used to log you out from the system.
- **Operator / Engineer Mode** is used to toggle between operator and engineer mode. See *UI Mode* for more details.
- **Subscription Plan** contains information about your current subscription details.
- **Managers** are buttons to other tools to allow you to customise your system settings.
- **Default Colour Schemas** allows you to specify which colour schemas are selected by default for each of the available measured units.
- **Custom Map** lets you define either WMS or WMTS URLs which can be used in the UI to set your own custom

map service.

- **API Usage** gives a breakdown of your API usage over the period of your subscription.

2.11.1 Logout

You can logout from the interface by clicking on the logout button at the top of the "Account Information" modal.

2.11.2 Subscription Plan

Details about your current subscription plan are listed in the "Account Information" modal. Such information includes:

- Your plan name.
- Your account balance.
- The expiry date of your current subscription.
- Your UID.
- Your API key, with a quick copy button.

2.11.3 Managers

CloudRF by default may not have the required settings or customisations which you require, and so we include a number of different managers to allow you to build elements yourself.

-  **Manage My Antennas** allows you to import your own antenna patterns. Please consult the *antenna management reference* for further details.
-  **Manage Clutter Profiles** allows you to define the height and attenuation of environments. Please consult the *clutter profile management reference* for further details.
-  **Manage My Colours** allows you to build your own colour schemas. Please consult the *colour management reference* for further details.
-  **Manage System Templates** allows you to manage your favourite system templates which can be quickly selected from the **My Templates** dropdown. Please consult the *templates reference* for further details.

2.11.4 Default Colour Schemas

With CloudRF we support a number of different *measured units*. As such there are limitations to using some measured units with some colour schemas. The utility in this section allows you to easily select a default colour schema for a number of different measured units:

- Path loss
- Received power
- Field strength
- Signal-to-noise ratio
- Modulation and bit-error-rate
- Reference Signal Received Power (RSRP)
- Best site analysis

The schema which you choose here will be the default when you switch your measure unit in the *"Mobile / Receiver" menu*.

2.11.5 Custom Map

The **Custom Map** URLs let you define your own map tile servers which can then be used in the interface and selected on the imagery icon. This is useful if the default map layers provided do not meet your own particular needs or requirements.

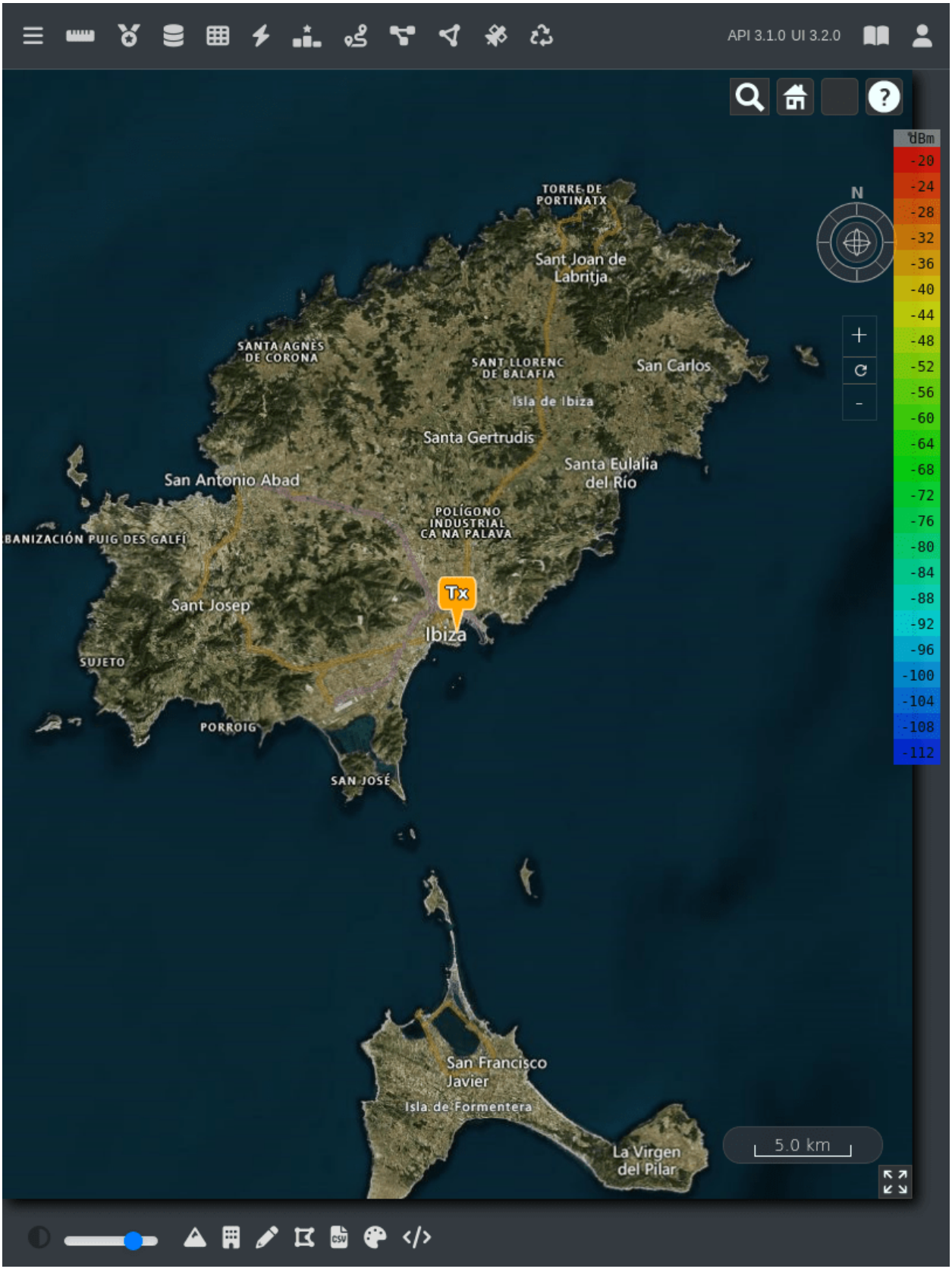
2.11.6 API Usage

API usage will give you a breakdown of your usage since your subscription was created. This includes a chart and full breakdown of the number of each individual API requests.

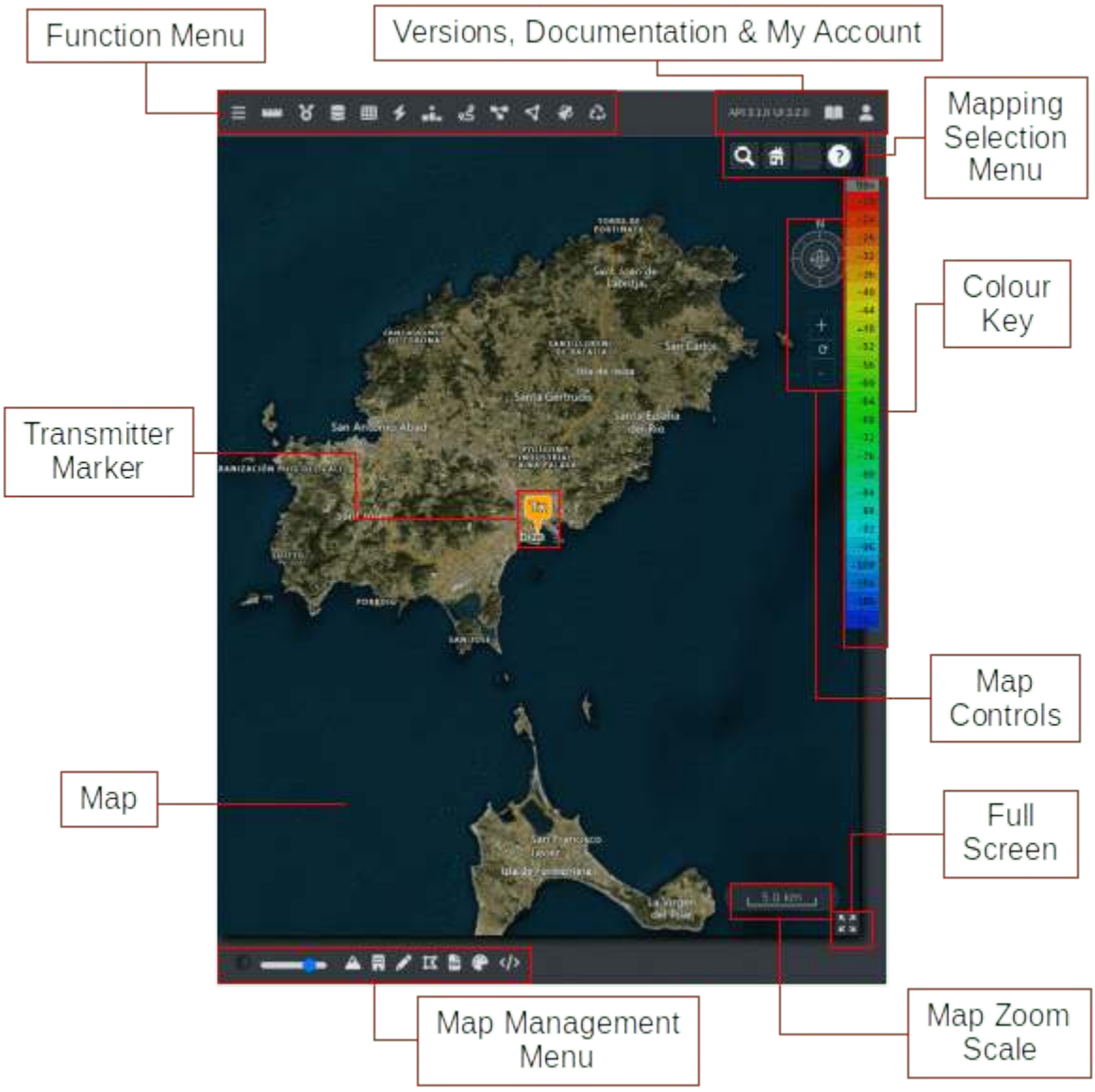
2.12 Mobile Operation

The CloudRF 3D Interface can be easily accessed on your mobile phone.

The following UI will be displayed on your mobile phone, with a collapsed menu:


API 3.1.0 UI 3.2.0
dBm
-20
-24
-28
-32
-36
-40
-44
-48
-52
-56
-60
-64
-68
-72
-76
-80
-84
-88
-92
-96
-100
-104
-108
-112
N
TORRE DE PORTINATX
Sant Joan de Labritja
SANTA AGNÈS DE CORONA
SANT LLORENC DE BALAFIA
San Carlos
Isla de Ibiza
Santa Gertrudis
Santa Eulalia del Río
San Antonio Abad
POLÍGONO INDUSTRIAL CA NA PALAVA
BANIZACIÓN PUIG DES GALFÍ
Tx
Sant Josep
Ibiza
SUJETO
PORROIG
SAN JOSÉ
San Francisco Javier
Isla de Formentera
La Virgen del Pilar
5.0 km

2.13 3D Interface Elements - Mobile View



2.13.1 Expand/Collapse

The **Expand/Collapse**  button of the Function Menu lets you expand or collapse the Side Menu consisting of Templates, Input Menu and Output Console.

CHAPTER

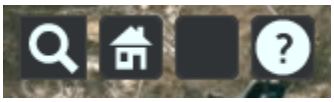
THREE

WEB INTERFACE MAP

3.1 Mapping Selection Menu

The **Mapping Selection Menu** is a set of key mapping functions located on the top-right of the interface.

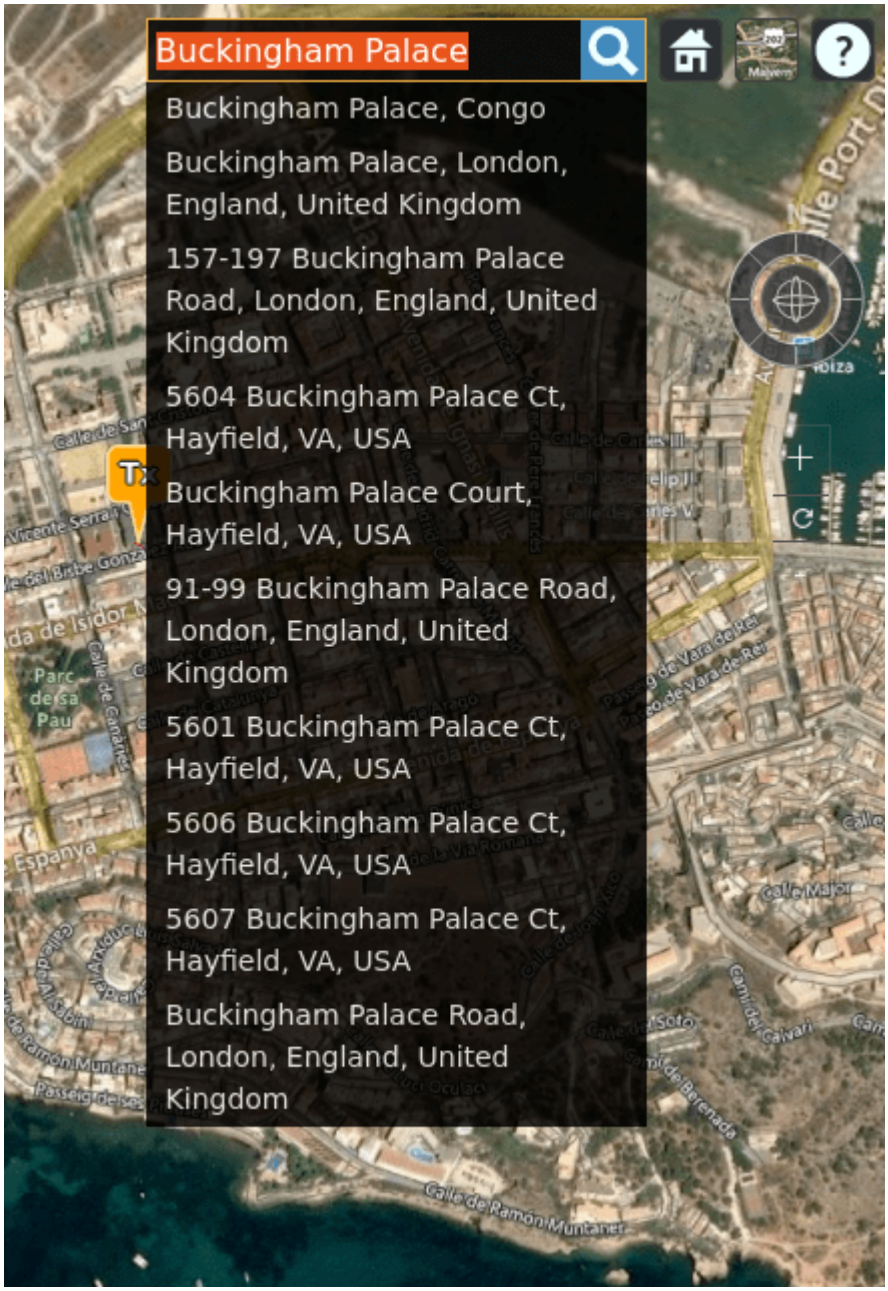
3.1.1 Mapping Selection Menu Elements



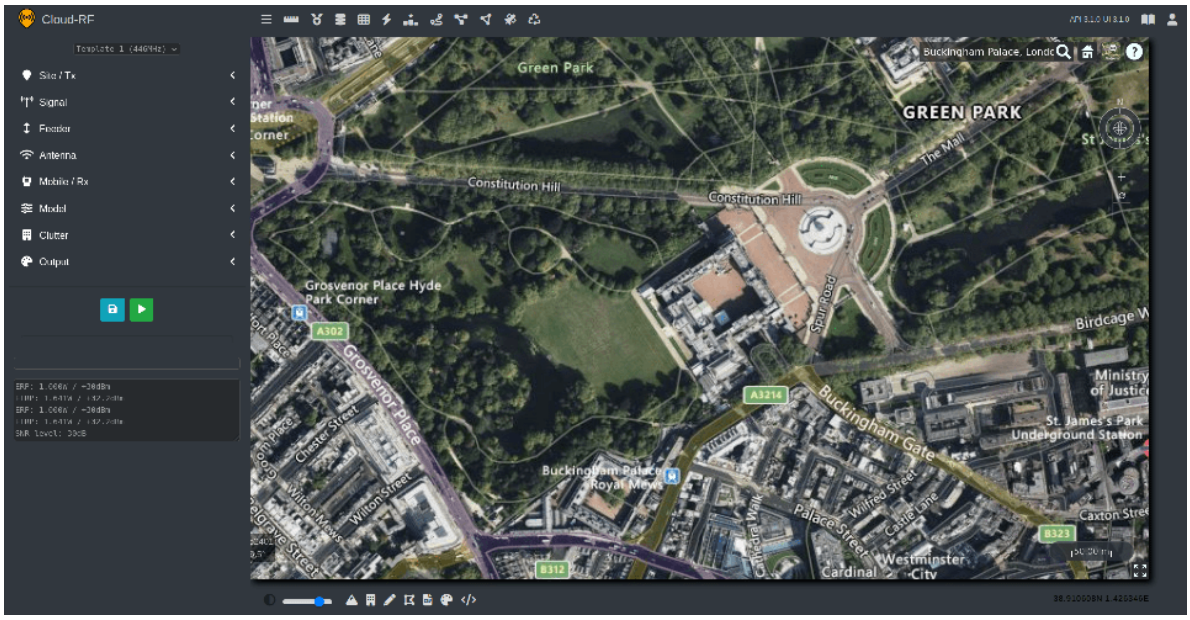
 **Address search**

The search tool lets you search an address, landmark, geocode or postcode / ZIP code.

- Click on the **Search**  icon to open the search box.
- Type the desired address or landmark you wish to search on the map. You will be prompted with different suggestions.



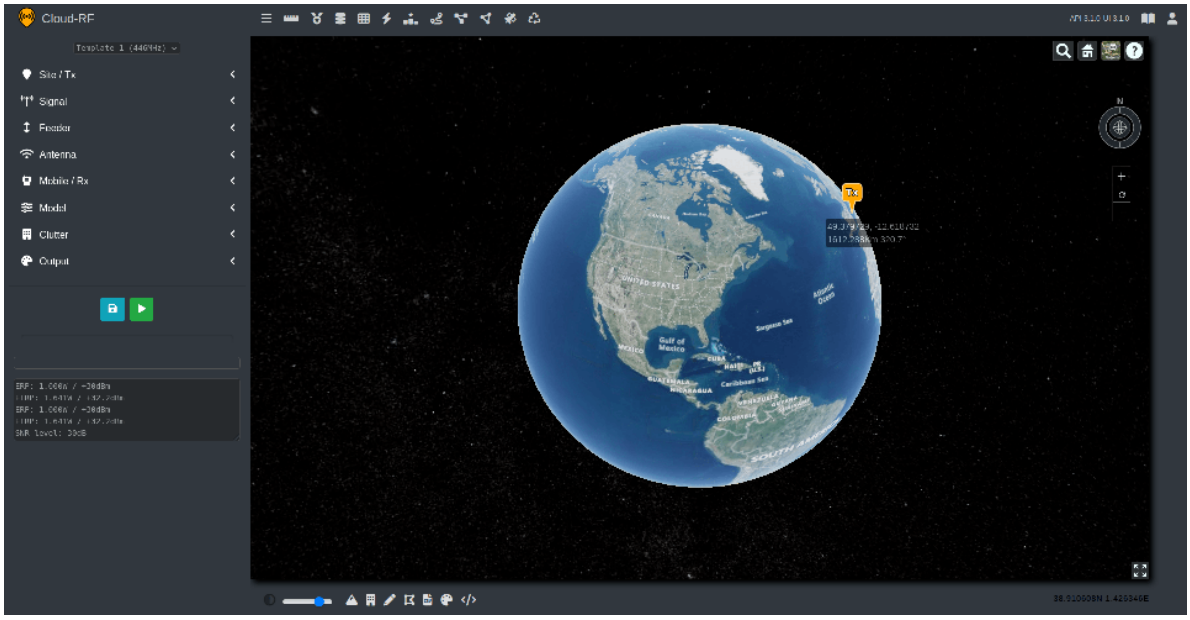
- Select your chosen address/landmark/geocode/postcode and the map will be moved to the location.



View Home

The **View Home** button is used to reset the interface back to an overview of the whole of the Earth.

- Click on the **View Home**  icon.
- The following screen will be displayed.



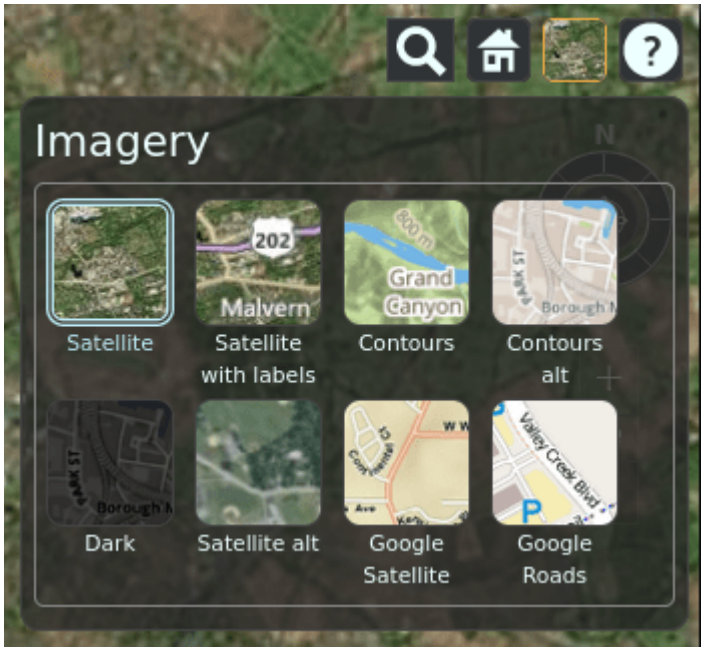
Choosing Imagery

The **Imagery** tool lets you change the mapping/imagery style.

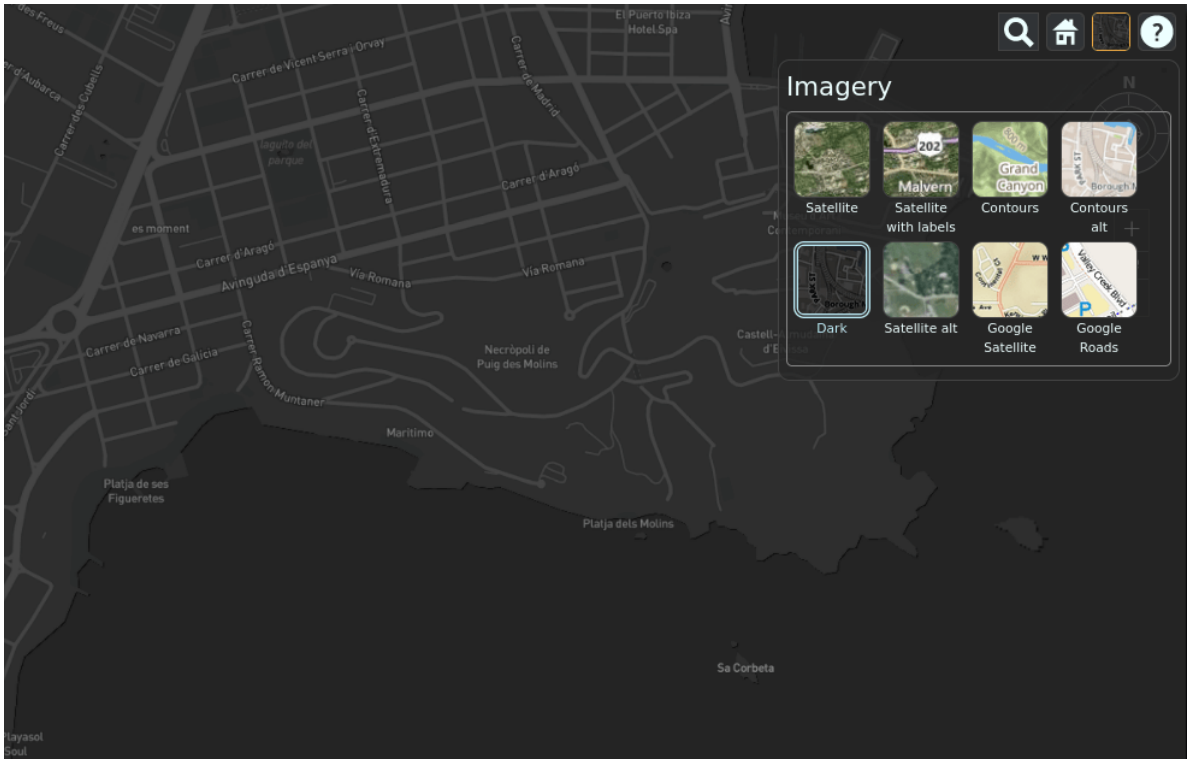
The **Imagery choices** offered include satellite imagery, street mapping and high contrast 'dark' layers for use with colourful overlays.

To choose the desired imagery:

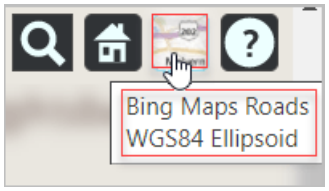
- Click on the **Imagery** icon.
- The **Imagery** dialog box will appear and the various imagery options will be displayed.



- Choose the desired Imagery.
- The same will be reflected on the map.



- The **Imagery** icon and the **mouse-over text** will be changed depending upon the selected imagery.
  - For Example: On selecting the *Bing Maps Road* imagery, the following icon and mouse-over text will be displayed.

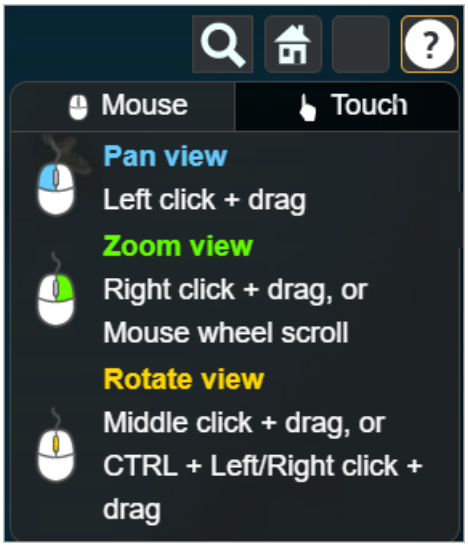


- You can also **enable/disable** the underlying **3D terrain** here.
  - By default, the 3D terrain is disabled to improve performance.
  - You can enable it by clicking the **Toggle 3D Terrain**  icon located at the bottom-left of the interface.
  - The same will be reflected on the map.

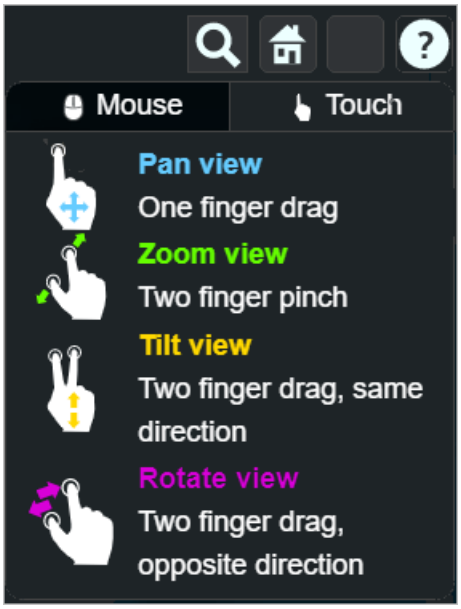
Navigation Instructions

The Navigation Instructions tool will display the navigation instructions for using the 3D interface on your computer and mobile.

- Click on **Navigation Instructions**  icon.
- The ***Navigation Instructions*** dialog box will appear.



- For navigating the 3D Interface on your *computer*, click on the **Mouse**  tab.
- For navigating the 3D Interface on your *mobile*, click on the **Touch**  tab.



3.1.2  Full Screen View

To **enable** the Fullscreen view:

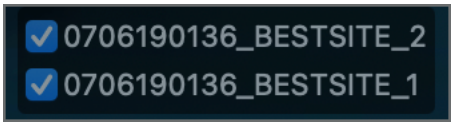
- Click on  icon located at the bottom right of the 3D Interface.

To **exit** the Fullscreen view:

- Click on  icon located at the bottom right of the 3D Interface.

3.2 Managing Layers

Any created heatmap **Layer(s)** will be displayed on the map and listed as a filename with a checkbox in the top right corner.



- You may **enable** or **disable** the layers as per your requirement by simply checking and unchecking the checkboxes.

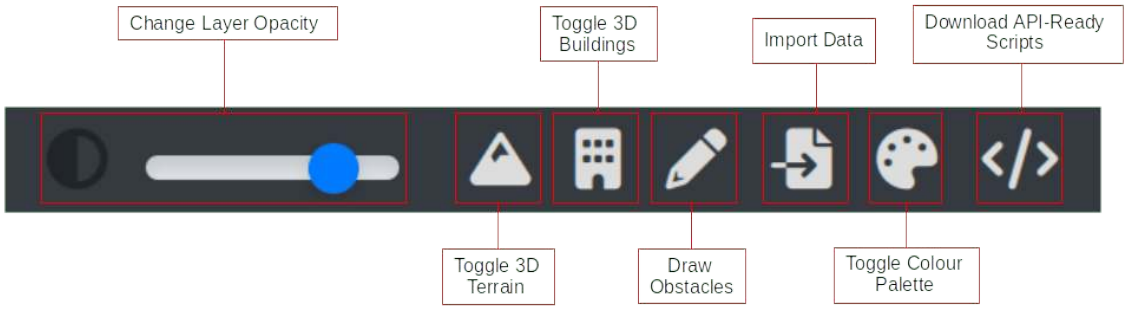
To clear the layers from the map (but not delete them from your archive) use the recycle button on the top menu.

To hide the list of layers if it becomes very long, use the layer list toggle button located next to the search and home icon. Click it once to hide the list and again to show the list.

3.3 Map Management Menu Elements

The map tools located at the bottom of the interface lets you manage several elements which is detailed in the following section.

The left side of the bottom of the interface contains a number of tools which can be used to improve the interactivity of the interface.



The right side of the bottom of the interface contains the decimal degrees location of the current transmitter location. This is a duplication of the information which is already available in the menu on the left of the interface, and is provided as a quick reference.

3.3.1 Changing Layer Opacity

You can change the opacity of the layer(s) on the map with the help of the opacity slider.

- To increase the opacity, move the slider to the right.
- To reduce the opacity, move the slider to the left.

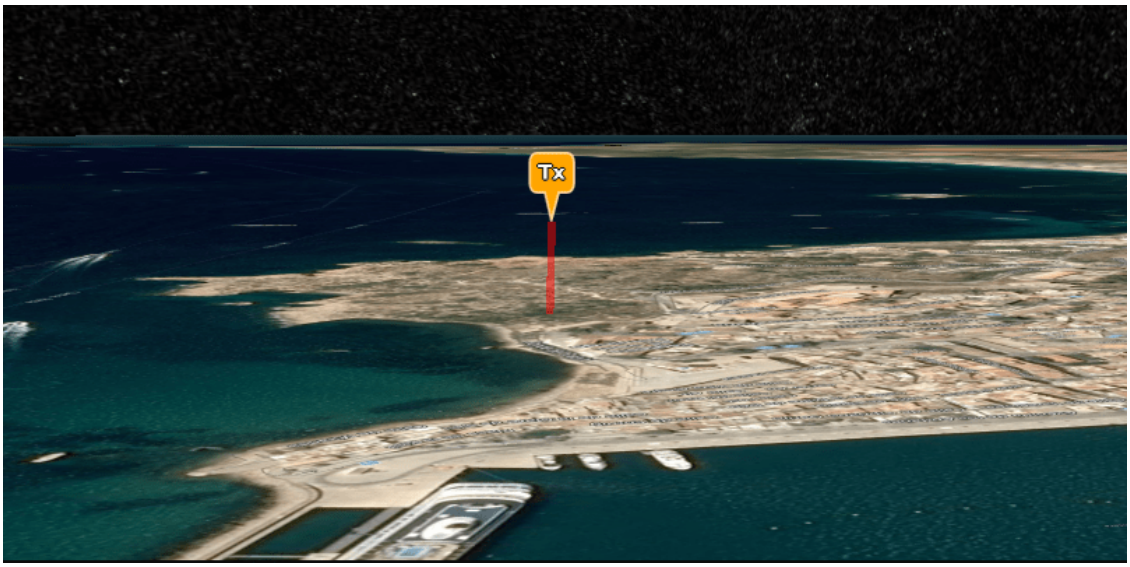
3.3.2  Toggle 3D Terrain

You can toggle (enable/disable) the **3D Terrain** as per your requirements by clicking on the **Toggle 3D Terrain** icon. For performance, 3D terrain is disabled by default.

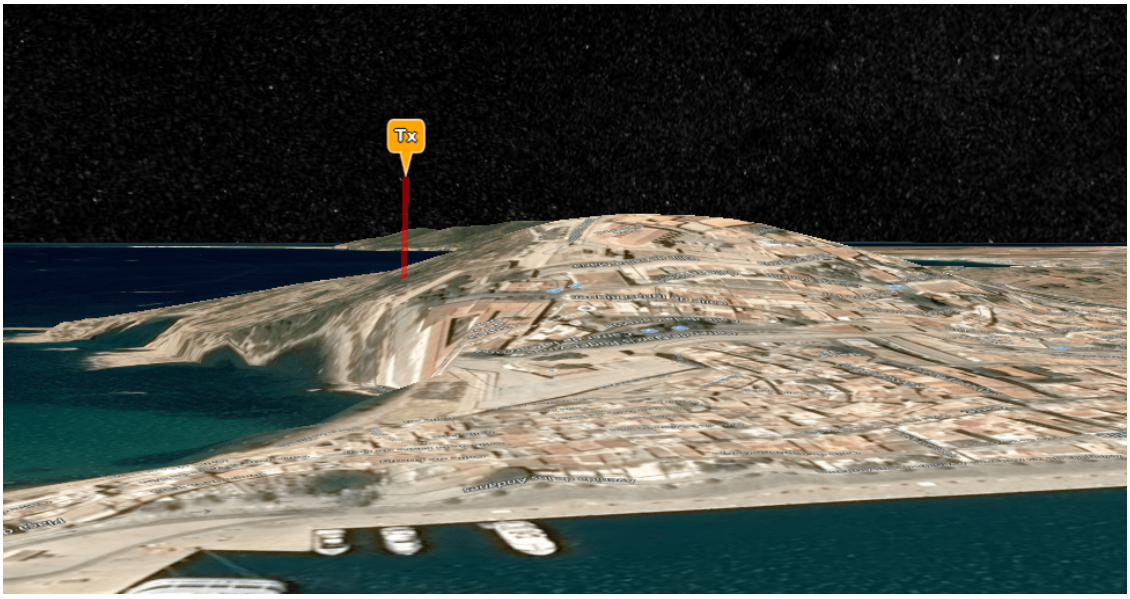
-  icon indicates that the 3D Terrain has been disabled.
-  icon indicates that the 3D Terrain has been enabled.

Please note that when you enabled 3D buildings, 3D terrain will automatically be enabled.

- Following are the screenshots for reference showing the changes in the Map when the 3D Terrain is disabled and enabled:
  - **Map when the 3D Terrain is Disabled** 



  - **Map when the 3D Terrain is Enabled** 



3.3.3  Toggle 3D Buildings

You can toggle (enable/disable) the **3D Buildings** as per your requirement by clicking on the **Toggle 3D Buildings** icon. For performance, 3D buildings area disabled by default.

-  icon indicates that the 3D Buildings have been disabled.
-  icon indicates that the 3D Buildings have been enabled.

Please note that when you enabled 3D buildings, 3D terrain will automatically be enabled.

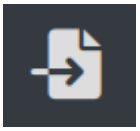
Following are the screenshots for reference showing the changes in the map when the 3D Buildings are disabled and enabled:

- **Map when the 3D Buildings are Disabled** 

- **Map when the 3D Buildings are Enabled** 

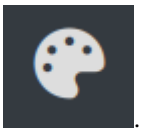
3.3.4  Draw Custom Clutter

The "Draw Obstacles" tool is used for drawing your own custom clutter, with support for polygons. Please consult the *clutter reference* for more information.

3.3.5  Import Data

For more details on this please consult the *dedicated documentation resource*.

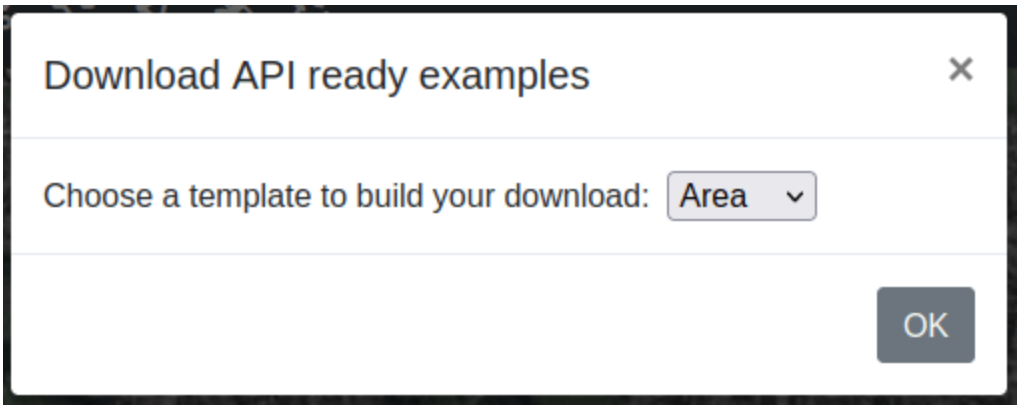
3.3.6  Toggle Colour Palette

At the bottom of the interface there is a palette icon  . When you click on this button this will hide your colour palette on the right side of the screen. This can be useful when you are working on devices with smaller screen sizes as the colour palette may obscure certain interface elements.

3.3.7  Download API Ready Scripts

If you wish to build up a number of settings which you can then take away and use in your own scripts which make use of the Cloud-RF public API, then you can click on the "Download API ready scripts"  icon.

When you click on this icon you will be presented with a modal window:



From the dropdown you can select one of the following endpoints:

- **Area** will download scripts with your current settings suitable for an `area` calculation.
- **Path** will download scripts with your current settings suitable for a `path` calculation.
- **Points** will download scripts with your current settings suitable for a `points` calculation.

Regardless of which you choose, each will download a respective ZIP file with a number of files which have been built with your specific settings. The files included should contain the following:

- `readme.txt` with some basic instructions on hbow to use the downloaded scripts.
- `sites.csv` with your transmitter and, if present, receiver locations along with their network names.
- `template.json` with a raw request as it would be made to your chosen endpoint.
- A Python script named after the chosen endpoint, such as `area.py` if you selected **Area**.
- `cloudrf.ini` with some configuration values based on your particular values, such as your API key, and the URL for the Cloud-RF public API.
- `cloudrf.py` is the Python base class if you wanted to extend your own requests and is based on the Python script available on GitHub.

3.4 My Obstacles

Custom obstacles or **Clutter** can be defined as anything which could impede a signal's path.

For RF planning purposes, the clutter can predominantly be trees and buildings. As the trees and the buildings vary greatly in density, you may wish to, we have included their different types.

The global clutter data for telecommunications planning is very expensive, and often outdated, despite their price. We have developed a much more flexible way of self-generating accurate clutter models.

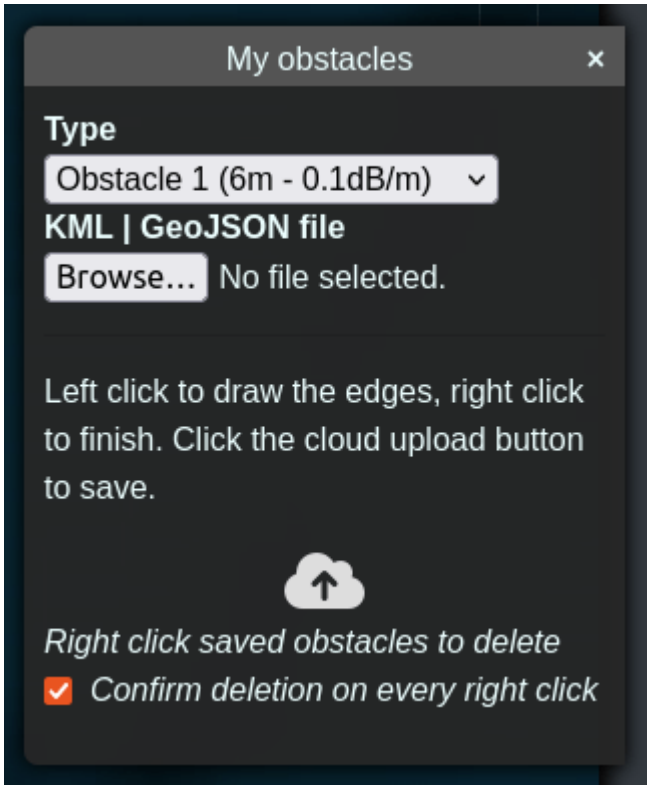
Whether you need to define one big building which is being planned for construction or you need to upload a plan for an entire city - we support both **DIY (Do It Yourself)** and **BYO (Bring Your Own)** clutter.

- **DIY Clutter** - You can draw your own clutter directly in the Cloud-RF interface to meet your requirements, defining the **Type** of the clutter.
- **BYO Clutter** - You can upload your own **KML / GeoJSON file** directly.

3.4.1 DIY Clutter

DIY clutter allows you to draw and build your clutter directly in the Cloud-RF interface to meet your requirements.

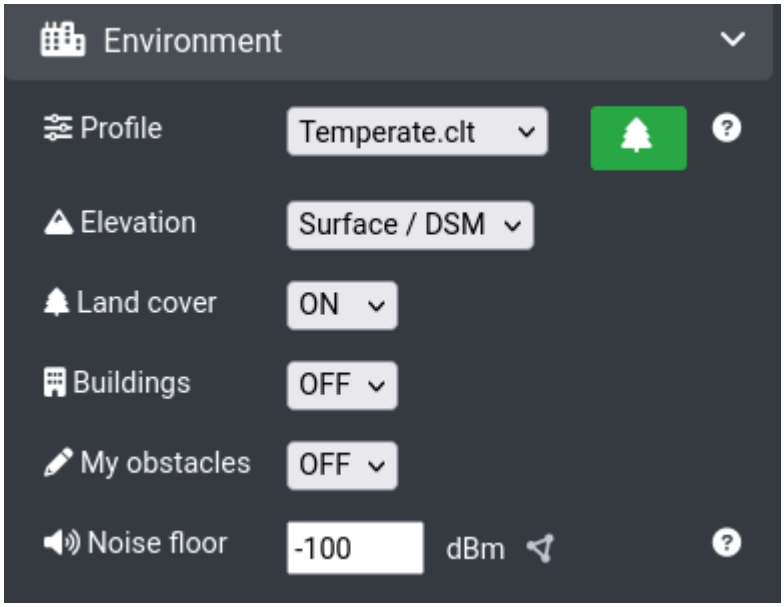
- Click on the **Draw obstacles button**  icon to draw custom clutter located at the bottom-left of the interface.
- The **My obstacles** Dialog box will appear.



For information regarding Drawing Clutter, refer to the *Drawing a Polygon* section.

The dialog box is split into several parts.

- **Type** determines the type of the material under which you clutter will be allocated. This is for DIY clutter. The value set here will be taken based upon your clutter profile which you select in the "Environment" menu from the "Profile" dropdown on the input menu on the left of the interface. This is used to determine the height, attenuation, name and colour of the clutter.



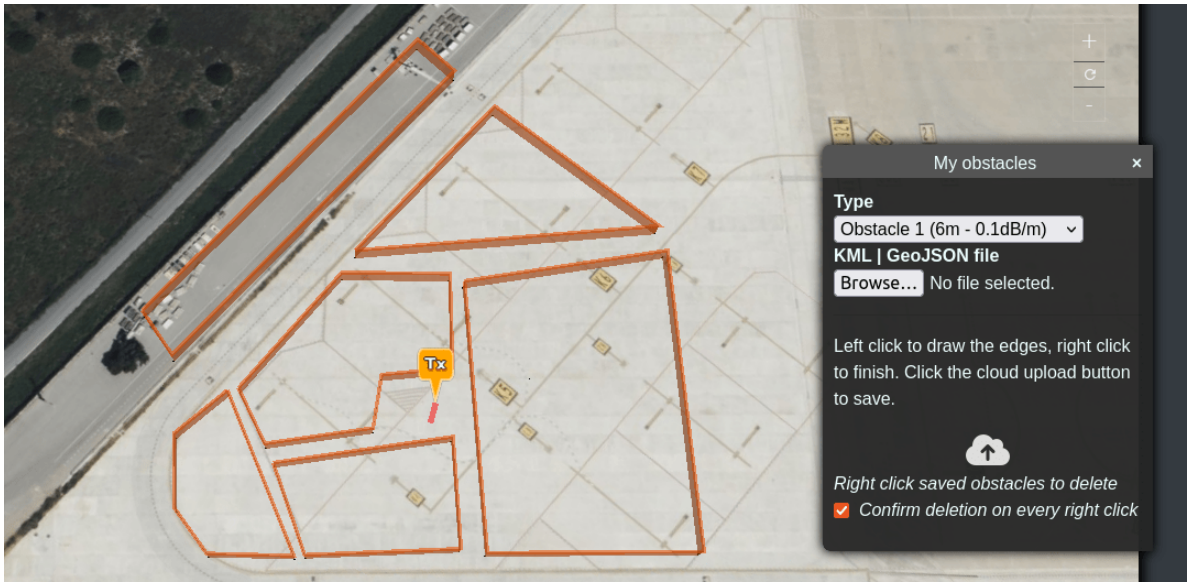
- The "Browse"/"File" button is used to submit **KML** or **GeoJSON** files for BYO clutter.
- The upload button is used to send your clutter to the Cloud-RF service to handle your clutter. 
- The checkbox at the bottom for "Confirm deletion on every right click" is a safety catch as you may have multiple clutter on your profile - rather than having to confirm deletion of every one you might decide to disable this checkbox at which point right-clicking on a clutter will instantly delete it without any confirmation.

Drawing Custom Clutter

To define a clutter polygon:

- Click on the **Draw Obstacles**  icon located at the bottom-left of the interface.
- ***Left-Click*** on the map to draw the edges of the polygon as per your requirement.

- ***Right-Click*** to finish. You can repeat as many times as necessary to draw multiple polygons with the same properties.

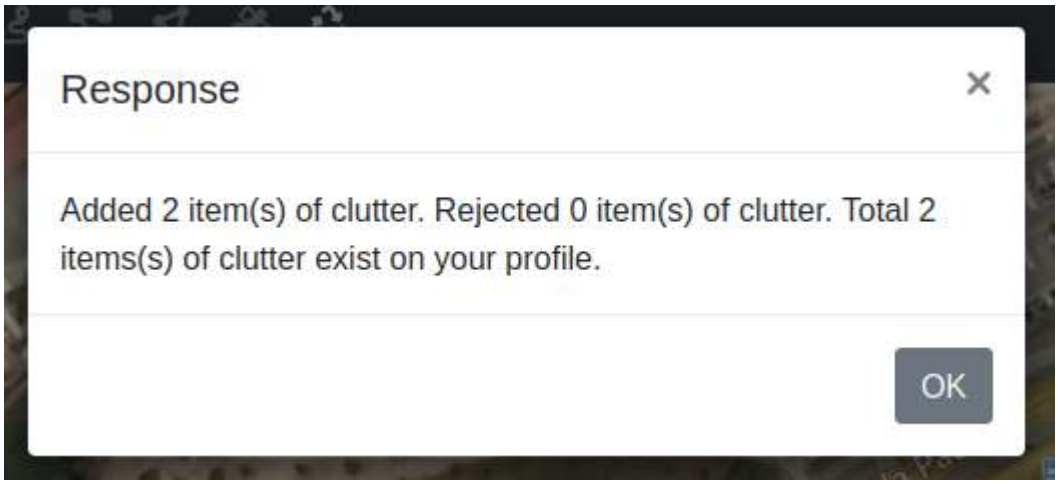


- You can change the "Type" to draw as many different types of clutter as you wish with the available types you have to work with. The properties of each type is taken from your clutter profile.

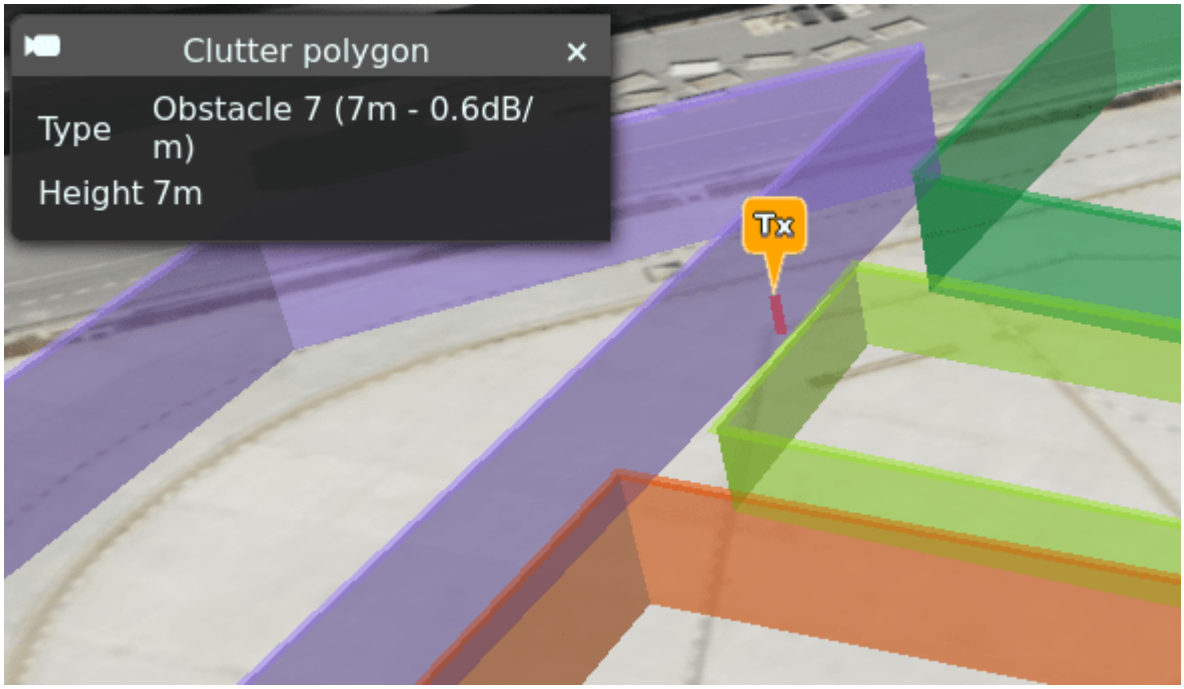
- The **Custom Clutter** Dialog box will also be displayed.

  For more information, refer to the **Custom Clutter** section.

- After you have finished drawing your clutter you should then click on the upload button. 
- You will be presented with an overview of the clutter which was uploaded to your profile.



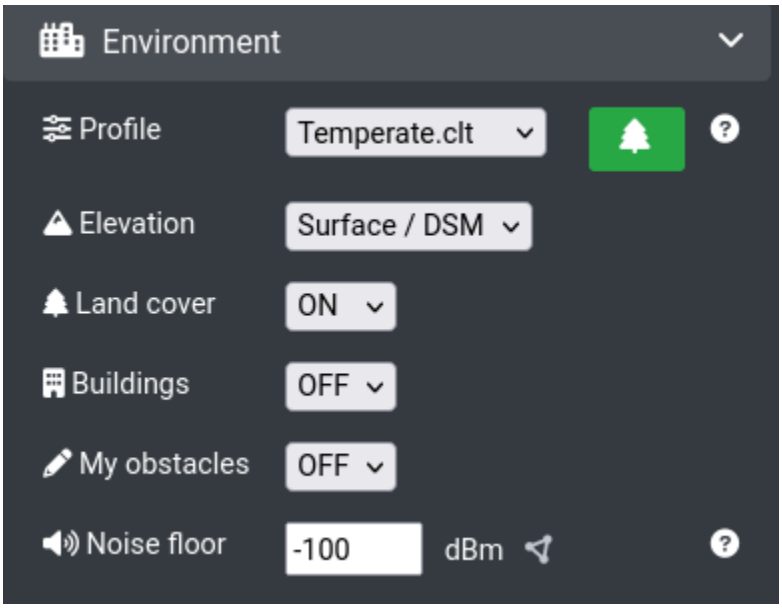
- When you close the clutter menu your drawn clutter will be displayed on the map. You can left-click on it to show its properties.



Selecting/Changing Clutter Type and Height

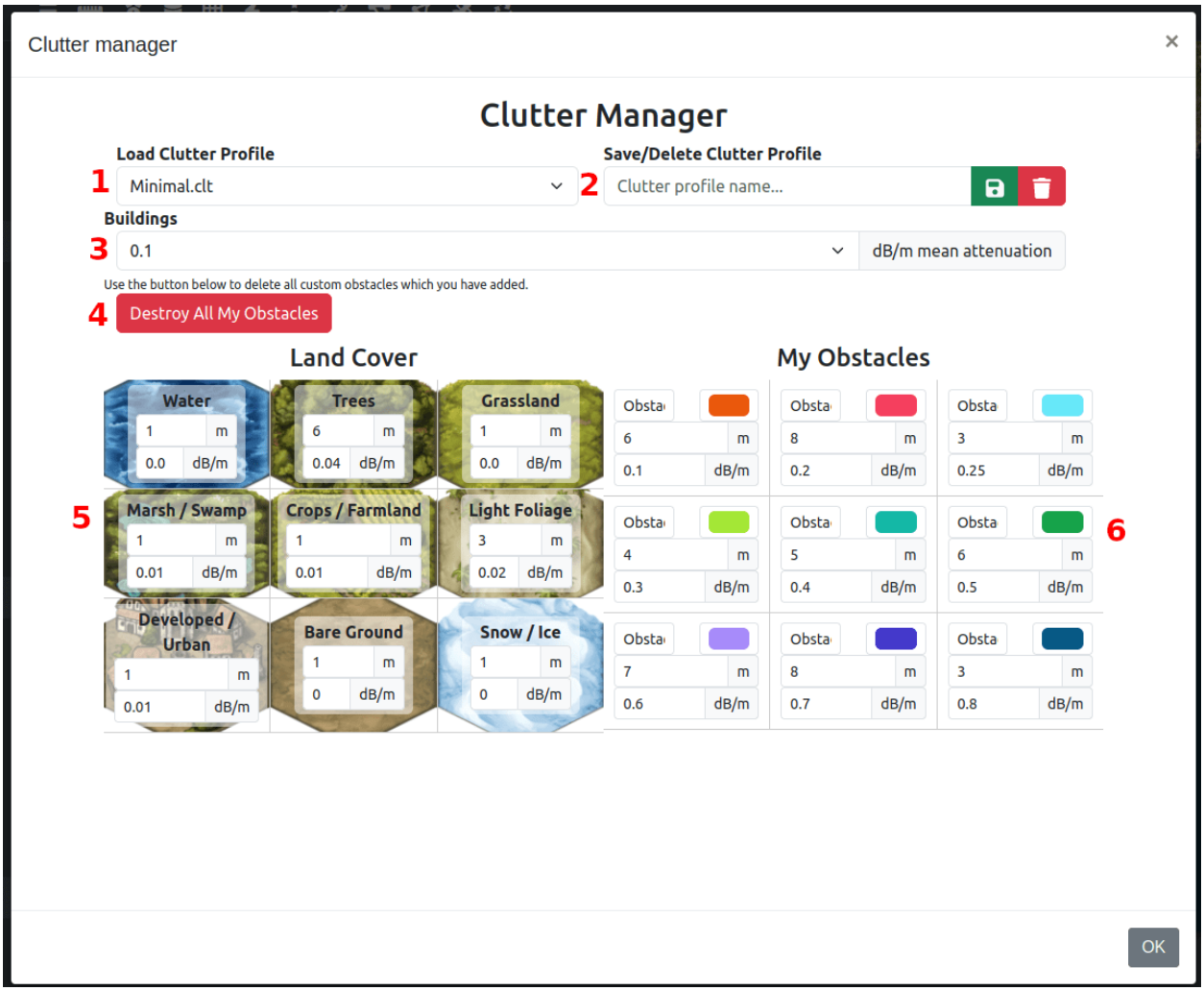
Clutter properties are applied based on the **Type** you choose from the clutter dialog box.

The attenuation and height for these types are defined in your clutter profile which is selected from the "Environment" menu.



You can choose different clutter profiles to match your environment, or you can create your own clutter profile to define your height and attenuation by clicking on the "Clutter Manager" button. 

From the clutter profile manager you can create and define your own attenuation and heights for listed materials.



1. Selected clutter profile
2. Save/delete profile as name
3. Building attenuation
4. Delete all obstacles on your account
5. Land cover types with customisable height and attenuation values
6. My obstacle (clutter) types with customisable name, colour, height and attenuation values

Deleting Clutter Profile

If you wish to delete a custom clutter profile then please enter its name into the input box then press on the delete button. Please note that the name must exactly match, including the casing and the extension name. You are also unable to remove system clutter profiles.

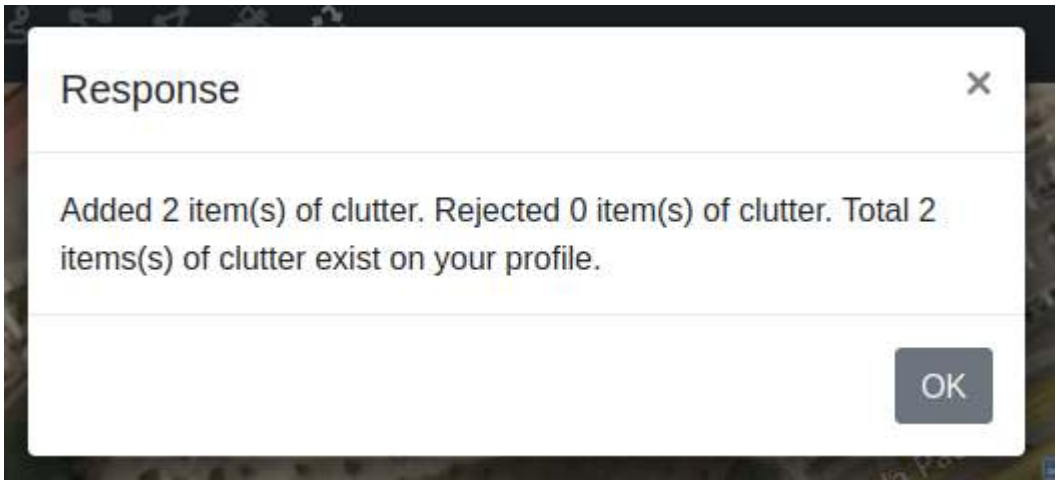
3.4.2 BYO Clutter

Uploading a KML / GeoJSON file

This is a **BYO** type of clutter.

You can import multiple clutter items as a KML or GeoJSON file.

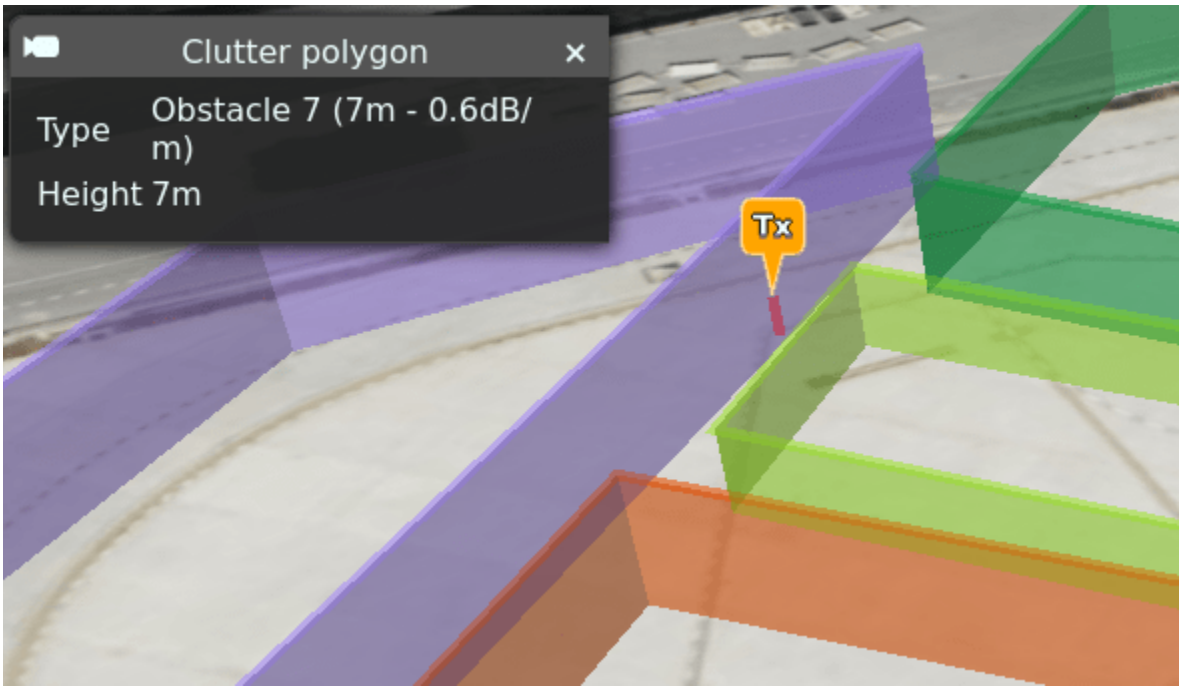
- Open the custom clutter menu by selecting the **Draw obstacles button**  icon located at the bottom-left of the interface.
- Click on **Choose File** button.
  - Select the desired *KML/GeoJSON* file.
- Click on the **Upload**  icon to save the clutter.
- A **Response** box will be displayed stating that the Clutter has been added.



3.4.3 Viewing the Defined Clutter

After drawing, defining and uploading the clutter, you can view the defined clutter on the map.

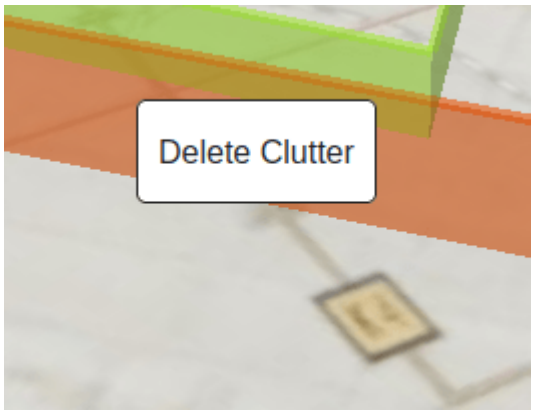
Polygon Clutter



3.4.4 Deleting Clutter

To delete a clutter:

- *Right-Click* on the respective clutter on the map.
- If you had the "Confirm deletion on every right click" checked in the custom clutter dialog box then you will be prompted to confirm deletion of each peice of clutter. Otherwise the clutter will be deleted without any confirmation.



You can also delete all clutter in your profile by opening the clutter manager and pressing the "Delete my obstacles" button.

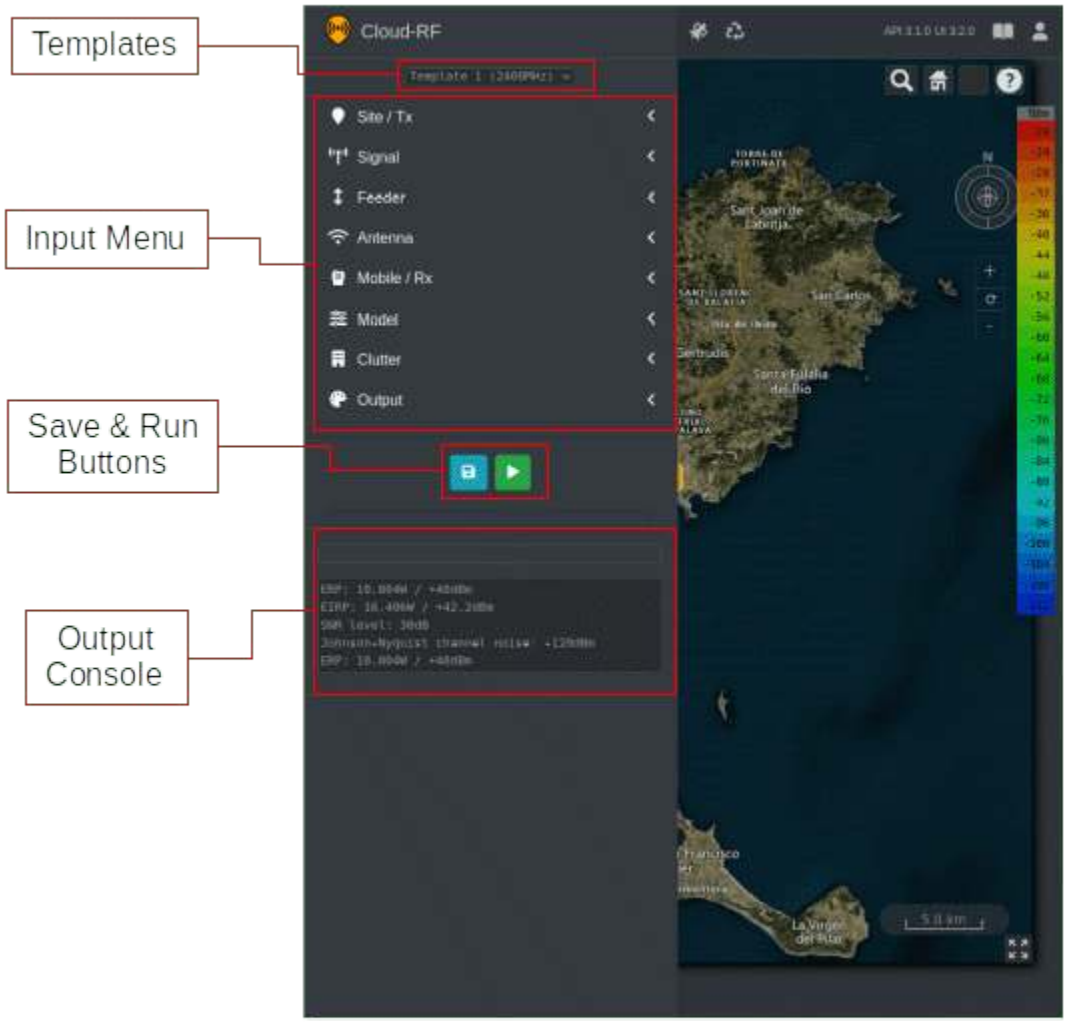
3.5 LiDAR

LiDAR data is the highest accuracy data available and is available for many cities at 2m resolution.

> Check the coverage map to see if you are covered.

It's a surface raster, hence, it is not permeable like the custom clutter but is very useful for line of sight analysis as even trees and bushes are represented.

3.6 Mobile View



3.6.1 Hiding the Side Menu

To hide/collapse the Side Menu, you can tap on map area on the right side.

3.6.2 Touch Screen Gestures

You can pan view, zoom, tilt and rotate on your touch screen phone using the following finger gestures:

Pan Map

You can pan the map by selecting with a single finger and dragging your finger across the screen.

Zoom Map

You can zoon the map by placing two fingers on the map and pinching the fingers together or away from one another to either zoom in or zoom out, respectively.

Tilt Map

You can tilt the map by placing two fingers on the map and dragging them both in the same direction up or down the screen.

Rotate Map

You can rotate the map by placing two fingers on the map and rotating your hand clockwise or counter-clockwise.

3.7 Outputs

3.7.1 Embed Code

The new **Embed Code** functionality lets you **Copy** the HTML code and upload it to your website with the desired filename and the html extension.

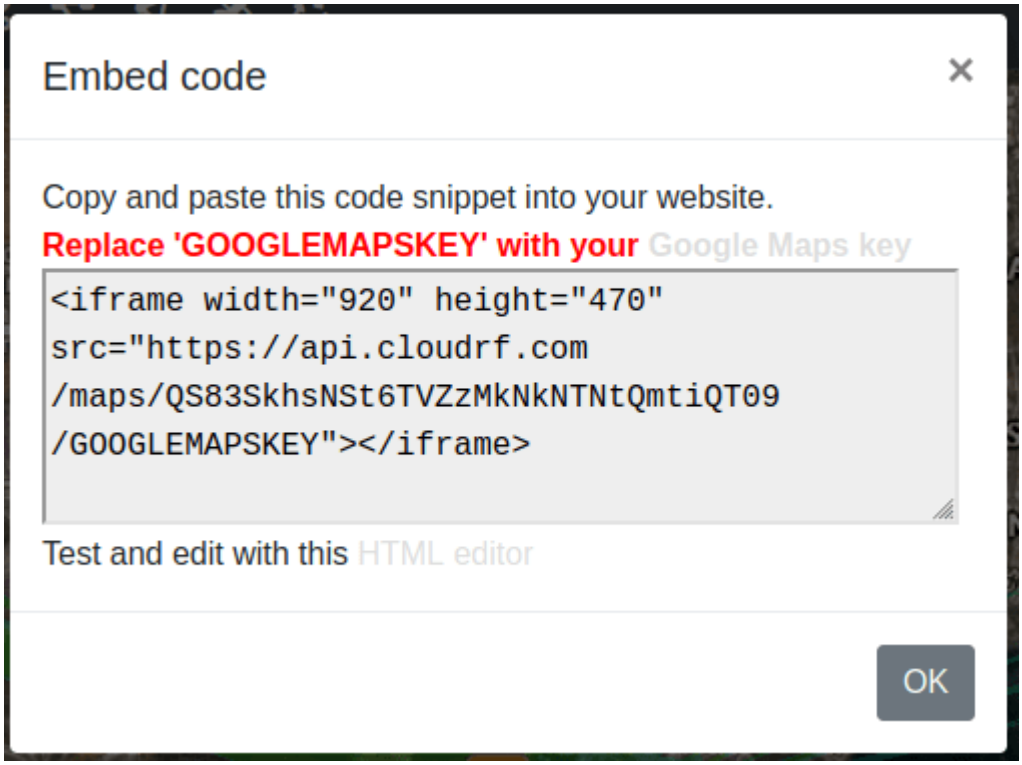
You can reap the following benefits and more using the HTML Embed Code functionality:

- Build your own Coverage Map.
- Create radio heatmap for your website.
- Add Google Maps to your website.
- Add RF Coverage on the Google Maps.

  For more information regarding this, refer to the Embed Code Benefits topic.

To access the *Embed Code* functionality:

- Click on **My Archive**  button on the Function Menu.
- The **My Archive** dialog box will appear.
- Click on the **HTML Embed Code**  icon.
- The **Embed Code** dialog box will appear.



- You can copy the HTML code snippet from here and paste it to your website.
  - Replace the `GOOGLEMAPSKEY` in the code with your Google Maps Key.
  - You may **Test** and **Edit** the code snippet with the help of HTML editor

3.7.2 Build Your Own Coverage Map

Are you a wireless internet service provider or an organisation that requires an online coverage map to be displayed on their website?

Building your own Coverage Map is just a few clicks away…

The most basic option is to accomplish this is using an arbitrary polygon on a free map like Google Maps. However, if you require **a beautiful and accurate physics-based coverage map, at no extra cost**, *CloudRF's Embed Code* functionality is all you need.

Using the CloudRF's **Embed Code** functionality is the easiest way to add a map to your website or blog that supports the HTML content. You just need to copy-paste an HTML code snippet to your website and replace the `GOOGLEMAPSKEY` in the code with your own Google Maps API key.

> For further information regarding *Hosting your own Network Map*, click on this link.

3.7.3 Create Radio Heatmap for Website

The **Embed Code** functionality lets you create the radio heatmap for your website.

With the help of GIS mapping and the LIDAR Imaging from the satellites, the CloudRF tool will output a heatmap of the signal strength on the 3D map. Hence, you can create the radio heatmap for your website and also determine how well your signal propagate based on some variables that you configure in the tool.

For further information, refer to this link.

3.7.4 Add Google Maps to the Website

All you need is a web browser and you are just three steps away from adding the Google Map plus RF layer to your website:

- **Create a basic HTML web page**
- **Add a Map**
- **Get your own API Key**

CHAPTER

FOUR

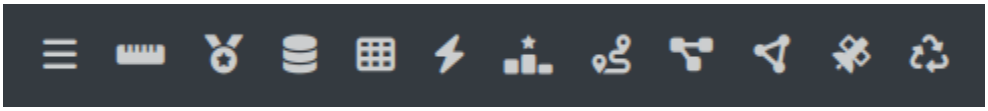
WEB INTERFACE RF TOOLS

4.1 Function Menu

The **Function Menu** is a set of various key functions located on the top of the interface.

Each function has a designated clickable button that allows you to locate them easily on the interface, thus making the tool easy-to-use and user-friendly.

4.2 Function Menu Overview



4.3  Expand/Collapse Side Menu

The **Expand/Collapse** button lets you expand or collapse the Side Menu consisting of Templates, Input Menu and Output Console.

To **Collapse** the side menu:

- Click on the **Expand/Collapse**  button.
- The *Side Menu* will collapse.

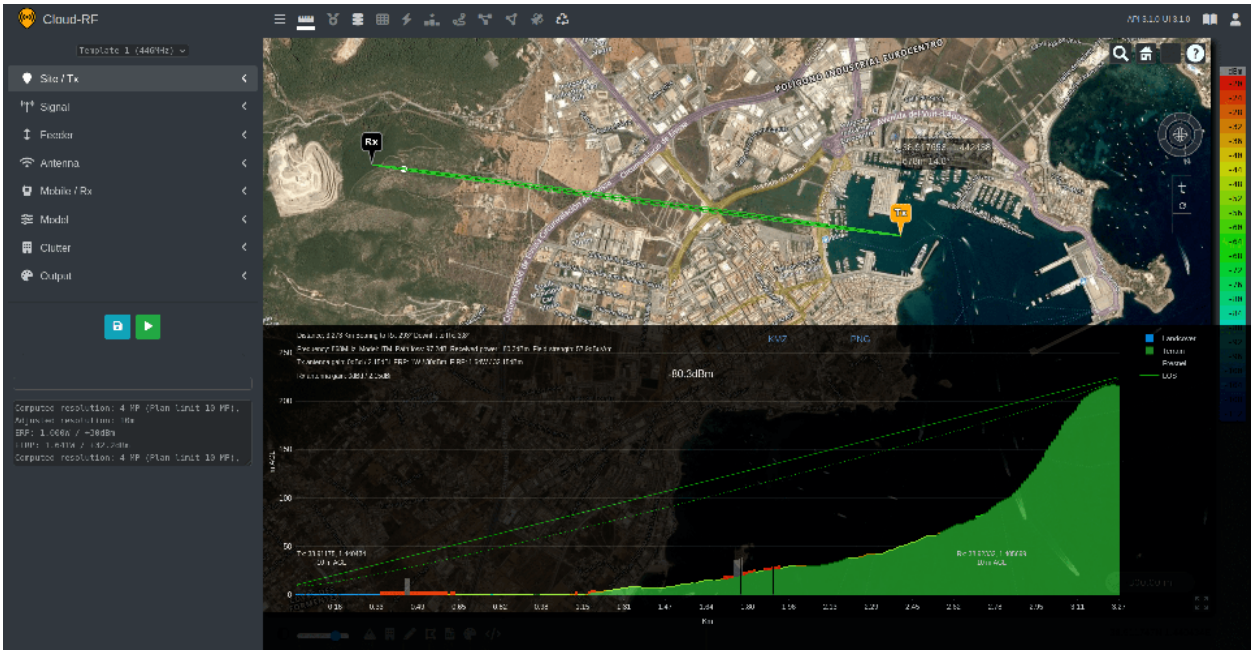
    When you mouse-over upon the Side Menu, the expanded view of the menu will appear.

To **Expand** the side menu:

- Click on the **Expand/Collapse**  button.
- The *Side Menu* will expand.

4.4  Path Profile Tool

The Path Profile Analysis tool lets you inspect the terrain profile between two positions - **Transmitter** and **Receiver**.



4.4.1 Point-to-Point Path Profile Analysis (Tx to Rx)

For Point-to-point path profile analysis (Tx to Rx), you can set the Transmitter and Receiver location either by *Visual Map Placement* or *Precise Location Entry* method.

1. **Visual Map Placement**

   You can click on the Map to site your **Transmitter** and **Receiver** location visually:

   - Site your **Transmitter** location on the map.
   - Click on the **Path Profile Tool**  button on the Function Menu.
   - Click on the map to site your **Receiver** location.

2. **Precise Location Entry**

   To use GPS co-ordinates, you can configure the **Transmitter** and **Receiver** location manually:

   - Configure your **Transmitter** location (Latitude and Longitude) in the *Site/Tx* Input Menu.
   - Click on the **Path Profile Tool**  button on the Function Menu.
   - Configure your **Receiver** location in the *Mobile/Rx* Input Menu.
   - Click on **Run**  button.

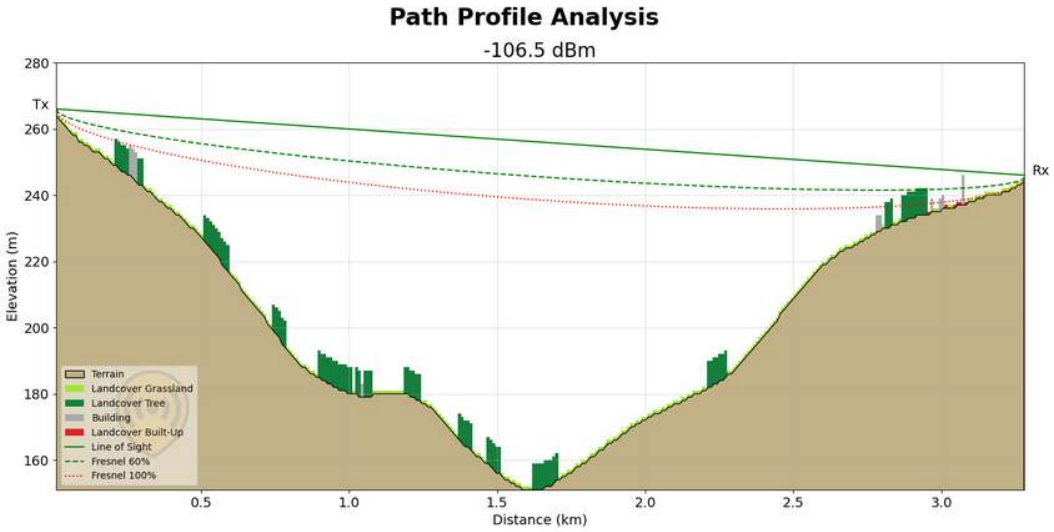
Dynamic chart

After setting your Transmitter and Receiver locations, the **Dynamic chart** will appear.

- The **Path Profile** in the form of a dynamic chart consisting of the path profile components - ***Terrain***, ***Fresnel*** and ***LOS*** will be displayed.

- The Transmitter and Receiver related information (*Distance, Frequency, Model, Path Loss, Received Power, Field Strength, Tx Antenna Gain, ERP, EIRP, Rx Antenna Gain*) will also be displayed along with the interactive chart.
- You can click on the **PNG** link to download the Path Profile as a static PNG image suitable for insertion into a report. Attribution is included as a watermark behind the key.

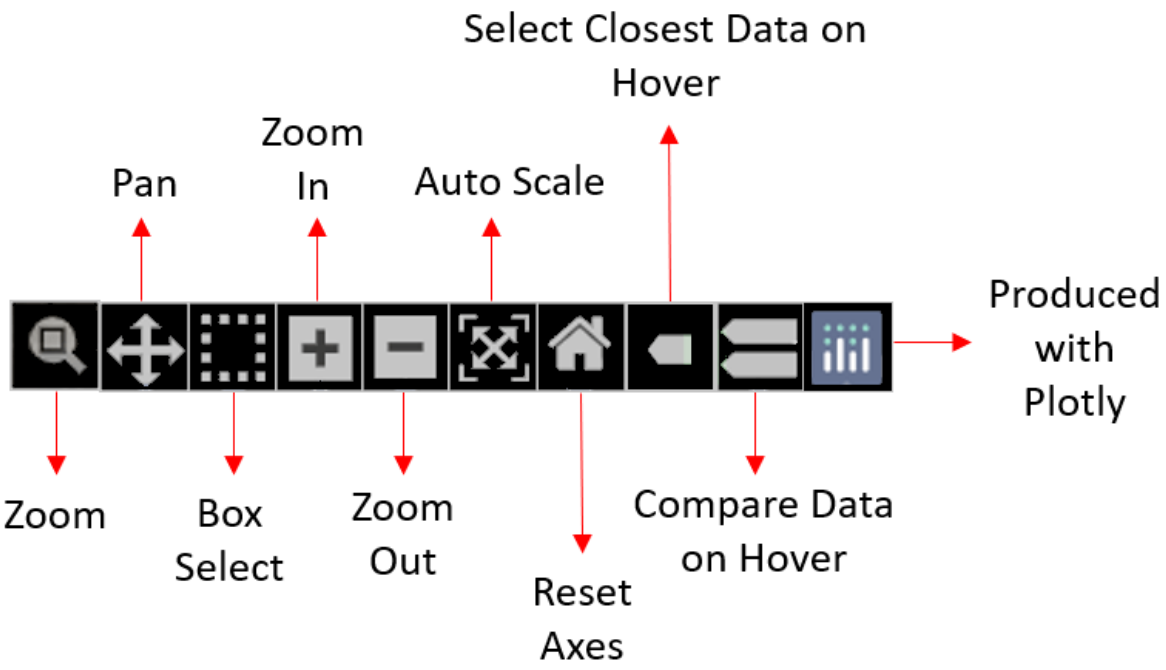
Note the static image will appear with different dimensions but the same result as it comes from the same API but uses a different plotting library.



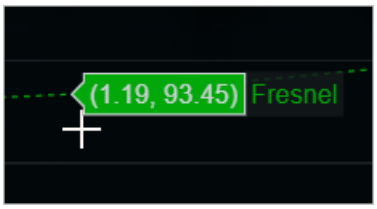
Transmitter
Location: 51.80818, -2.188895
Height: 2 m
Frequency: 800 MHz
Power: 1 W
Gain: 1 dBi
ERP: 0.768 W / 28.85 dBm
EIRP: 1.259 W / 31 dBm
Model: Egli VHF/UHF
Azimuth to Receiver: 79.0°
Downtilt: 0.3°
Distance: 3.28 km

Receiver
Location: 51.81377, -2.142099
Height: 2 m
Gain: 2 dBi
Path Loss: 136.5 dB
Received Power: -106.5 dBm
Field Strength: 29.8 dBµV/m
Freespace Loss: 97.8 dB
Azimuth to Transmitter: 259.0°
Downtilt: -0.3°

- Various **Function Icons** will be available as you mouse-over on the dynamic chart.



- **Zoom** - lets you zoom the desired section of the Path Profile Graph.
  - Click on the desired section's starting point and without releasing the mouse, select the section.
- **Pan** - lets you pan view the graph interactively.
  - On selecting the *Pan function* icon, the pan mode for axes gets turned on in both `x` and `y` directions.
  - Click on the graph and without releasing your mouse, move in the direction you wish to pan view the Path Profile.
- **Box Select** - lets you select a particular section of the graph that you wish to view.
  - The selected box section will be highlighted from the rest of the path profile graph for clear view.
- **Zoom In** - lets you zoom in the Path Profile Graph.
- **Zoom Out** - lets you zoom out the Path Profile Graph.
- **Auto Scale** - lets you auto scale the axes of the graph.
- **Reset Axes** - resets the axes as per the original graph.
- **Show Closest Data on Hover** - shows you the closest data from the point on the graph where you hover.
  - The closest path coordinate will be displayed as below:



- **Compare Data on Hover** - shows you the comparison of the data from the point on the graph where you hover.
  - The graph comparison will be displayed as below:

- **Produced with Plotly** - redirects you to the Plotly website.

To Change the Resolution

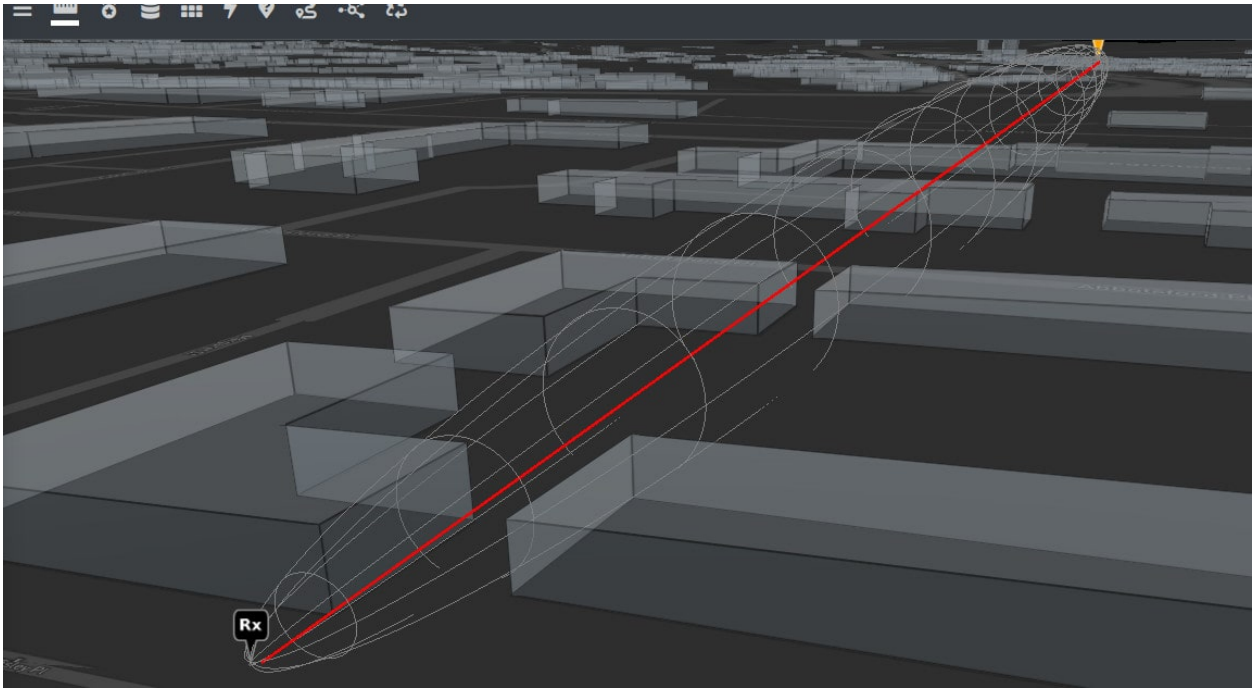
- Click on **Output** Input Menu.
- In the **Resolution** field, select the resolution that you wish to set from the drop-down.

To Change the Building / Clutter Attenuation

- Click on **Clutter** Input Menu.
- In the **Clutter Mode** field, select *Soft/NLOS* as the option from the drop-down.
- In the **Min attenuation** field, select the Clutter attenuation that you wish to set from the drop-down.

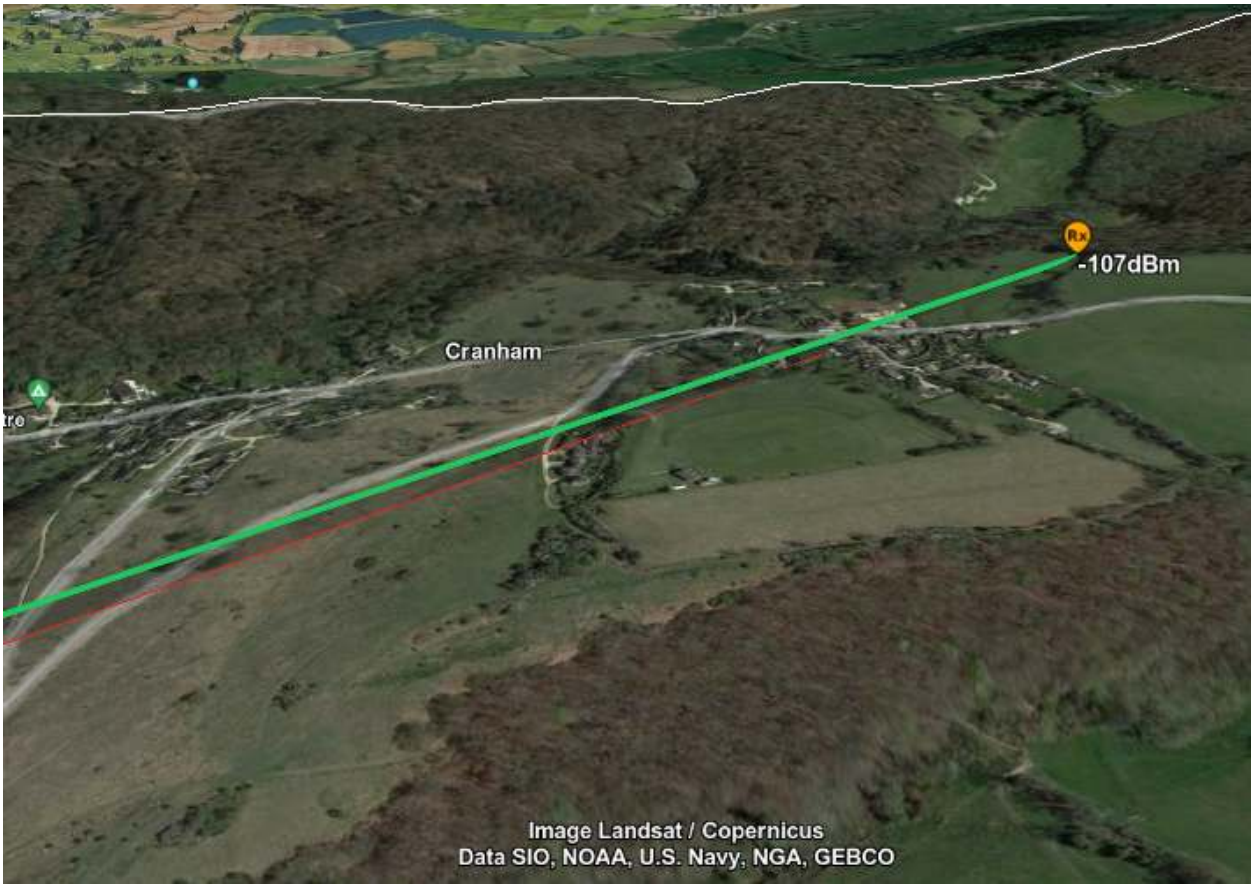
4.4.2 Fresnel zone

Around each link will be a 3D ellipsoid showing the estimated fresnel zone. This cone of power has a direct relationship with frequency/wavelength so a VHF signal has a huge fresnel zone and a SHF signal has a small focused one, like a laser. An ideal link would have an unobstructed fresnel zone otherwise you will be losing power. A viable microwave link needs at least 60% of its fresnel zone to be clear of obstructions. If you are modelling over the sea and a link is near the water you should budget for tides also as these can be more than 10m and will disrupt a marginal link.



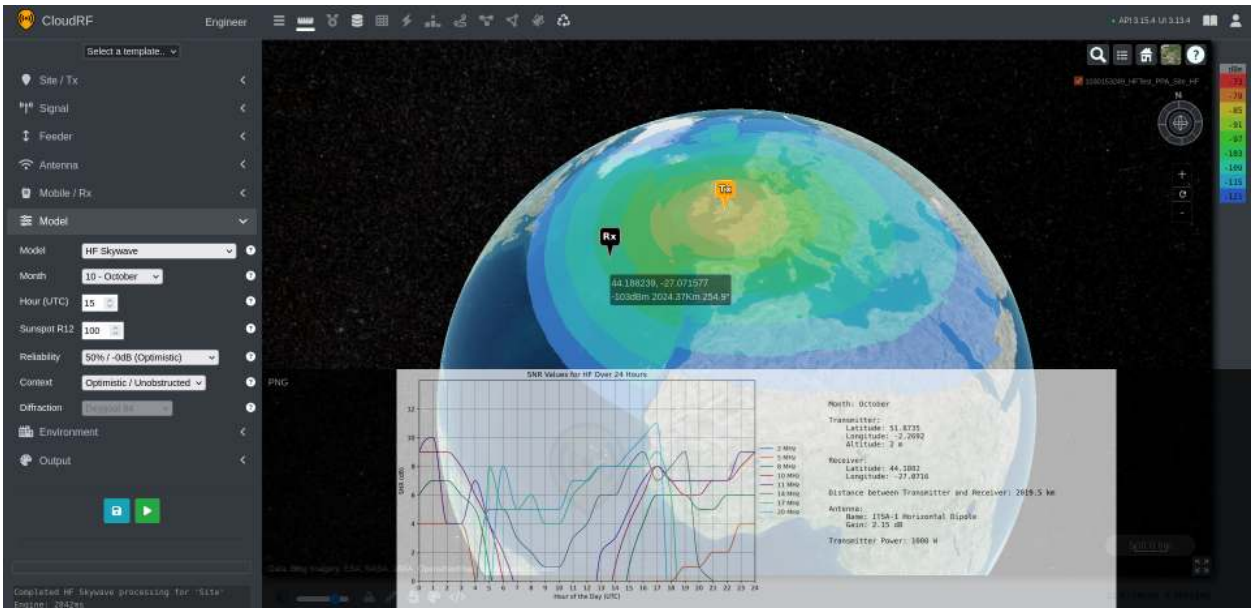
4.4.3 Path Profile KMZ

The **KMZ** link on the dynamic chart will download a KMZ path for use in a suitable viewer, such as Google Earth. It contains Tx and Rx placemarks, a 3D fresnel zone and an interactive balloon with a path chart and full metadata from the API if you click anywhere upon the path.

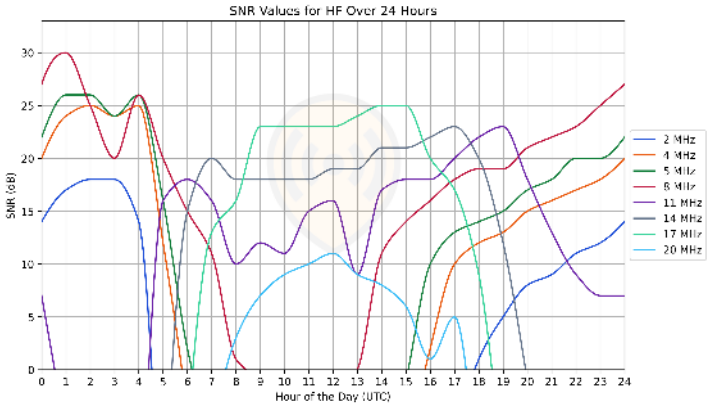


4.4.4 HF Skywave PPA (HF Prediction)

When using the HF Skywave propagation model, the PPA chart output is different. Rather than showing you the signal values across the link, instead a static chart is displayed which shows you predicted signal values at varying frequencies spread across a 24 hour period. This can allow for you to choose the best frequency for your application.



The below chart shows an example of what can be downloaded by clicking on the “PNG” link in the top left of the chart viewer.




```
Month: March

Transmitter:
    Latitude: 51.8656
    Longitude: -2.207
    Altitude: 6 m

Receiver:
    Latitude: 41.86
    Longitude: 12.78

Distance between Transmitter and Receiver: 1508.7 km

Antenna:
    Name: ITSA-1 Horizontal Dipole
    Gain: 2.15 dB

Transmitter Power: 10 W
```

4.5 Best Server Tool

The **Best Server Tool** is useful for checking coverage against an established network. A typical use case for this would be a Wireless Internet Service Provider (WISP) who want to check ZIP codes or properties for coverage.

To use the **Best Server Tool**:

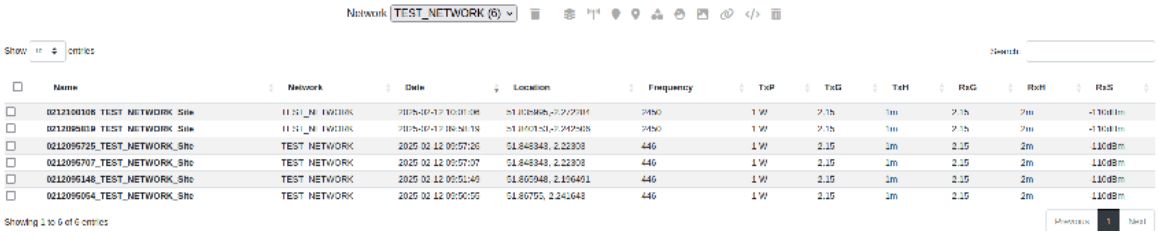
- Click on the **Best Server Tool**  button on the Function Menu.
- The *Best Server Tool* dialog box will appear.
- Site your **Transmitter** location on the map.
- **Select a network to test coverage** at the set transmitter location from the drop-down.
- Click on **Check Coverage** button.
- The **Network Coverage** as per your transmitter location will be reflected on the map.

- You can change your transmitter location on the map to check the **best server location and the network coverage**.

4.6 My Archive

My Archive lets you view the list of your saved networks and their details. It's also where you can download data in open GIS formats like KML, KMZ, SHP, GeoTIFF and HTML.

- Click on **My Archive** button on the Function Menu.
- The *My Archive* dialog box will appear, where you can see saved calculations which have been previously made.



4.6.1 Searching and filtering by network

You can select and filter the Network(s) to reduce the entries in your table. This allows you to quickly recover a project or find MESH or MANET networks which are tagged with these network names.

- Select the desired **Network** from the drop-down.
- The list of networks will be displayed.
- Select a network to filter results to those tagged sites only
- You can then find a specific site(s) with the **Search box** on the right side
- The **filtered entries** will be displayed.

4.6.2 Sorting

You can sort the Network entries in ascending or descending order as per your requirement.

To do so:

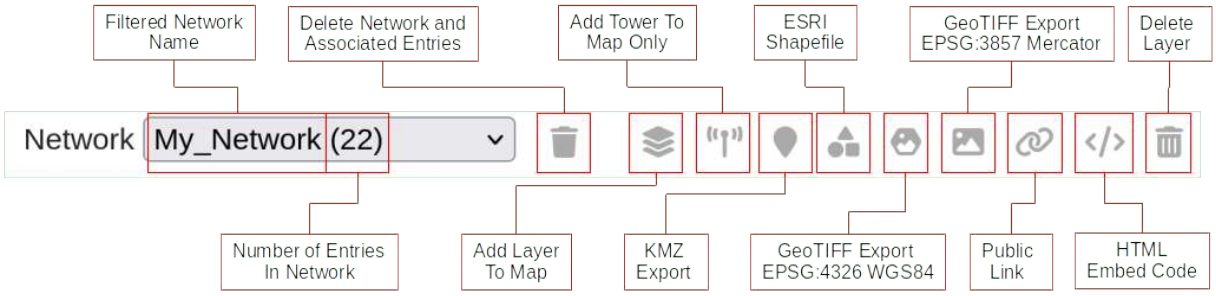
- Click on the **Sort** icon of the respective column.
- The sorted entries will be displayed in the table.

indicates Sorting in the **Ascending** Order.

 indicates Sorting in the **Descending** Order.

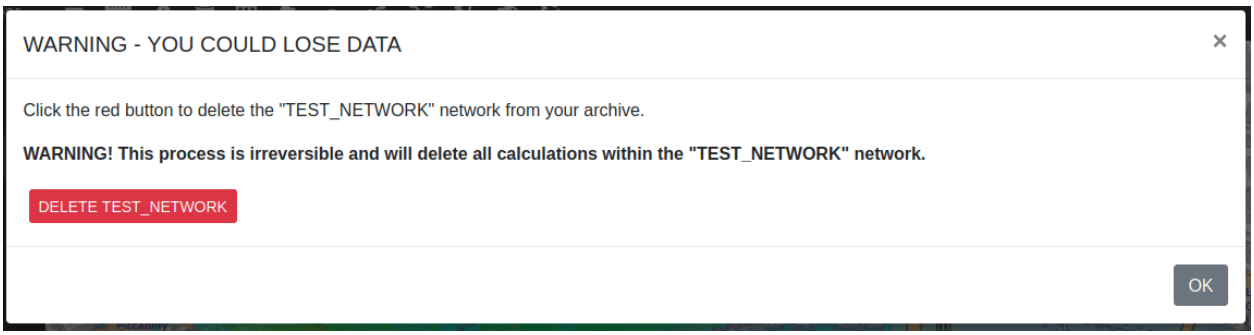
4.6.3 Functions

Various **Function Icons** are also available to aid with managing previous calculations. The tools provided here allow you to interact with individual calculations which have been made previously by your account.

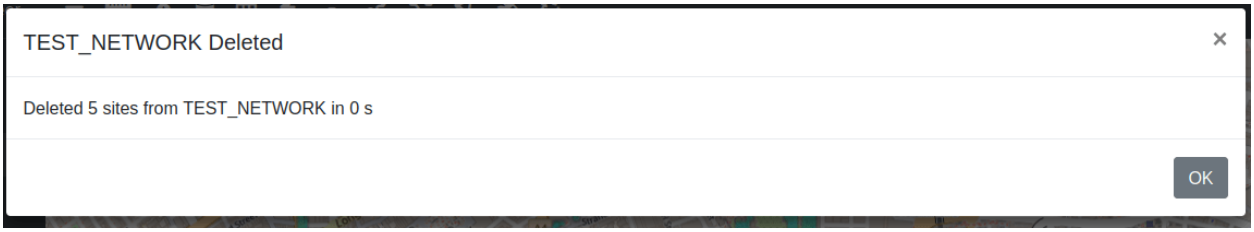


You can filter through specific networks by choosing a specific network from the dropdown list.

To delete an entire network, select it from the "Network" dropdown and then click on the delete button. Upon clicking on this you will be prompted with confirmation modal window.



After confirming deletion, the network will be deleted from your account.

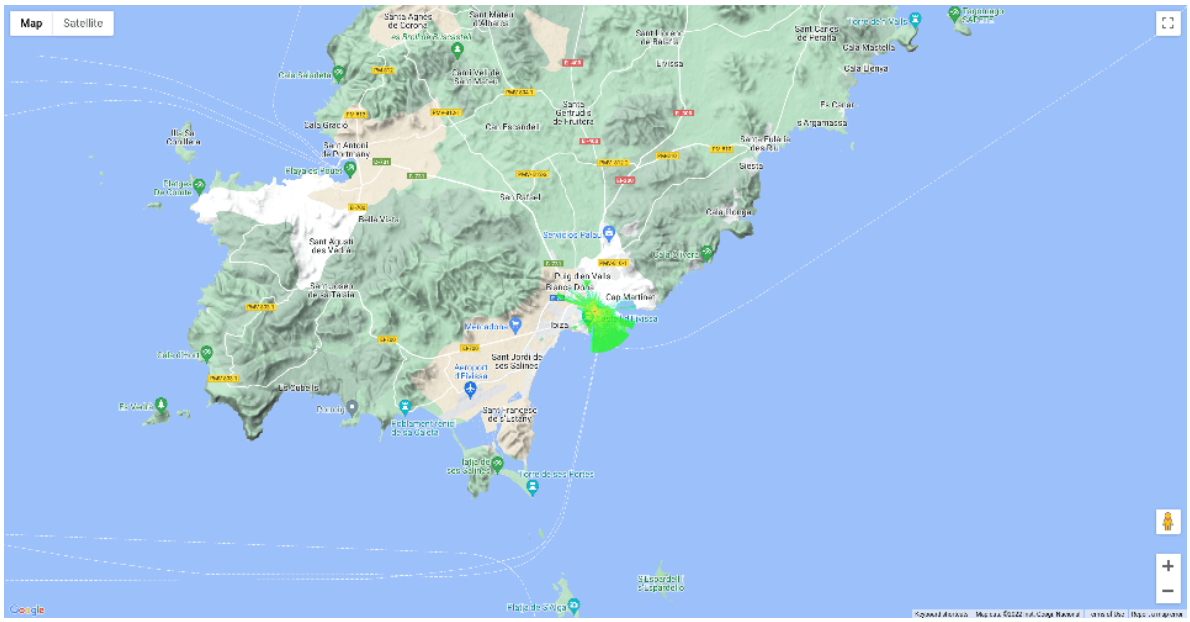


Individual Calculation Actions

There remaining buttons within the archive are related to interacting with a single calculation, and so you should select the checkbox for the calculation you are trying to act upon. For convenience, there is a "Select All" checkbox at the top of the column which all you to easily select all of the checkboxes on the current page.

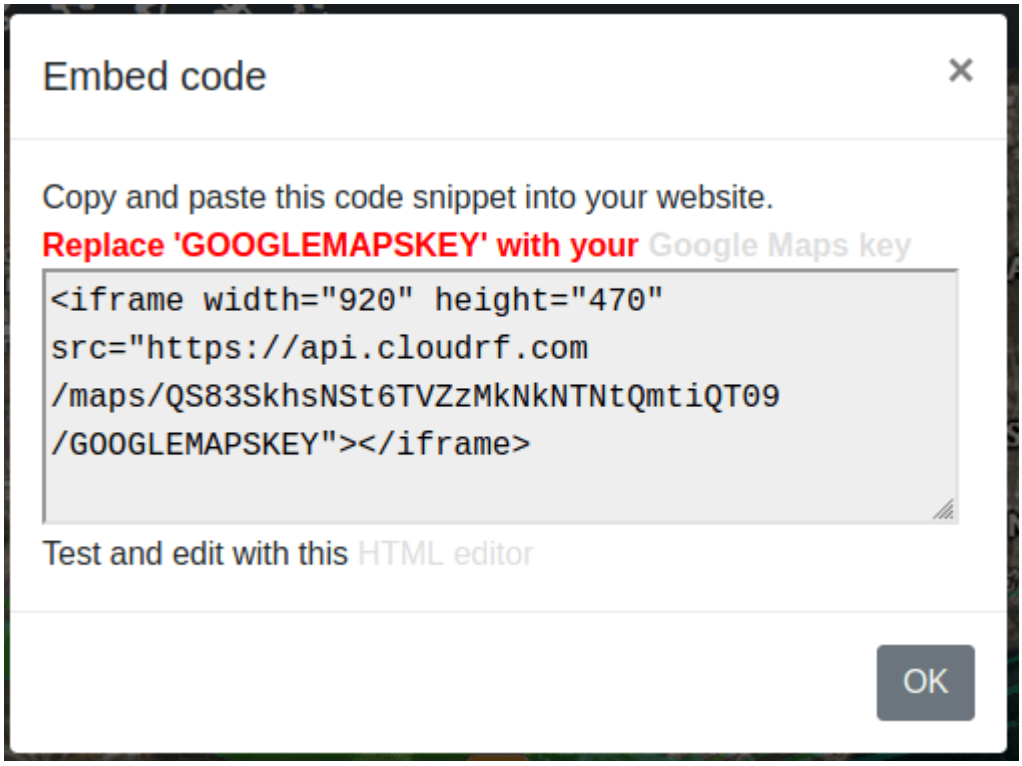
- **Add Coverage Layer(s) to Map** - lets you add the selected network(s) coverage layer(s) to the map.
  - You can manage (select/deselect) the network site locations by clicking on the respective *layer checkbox*.
- **Add Tower(s) only to Map** - lets you add the tower(s) to the map in the selected network(s).

- **KMZ with Local Content** - lets you download the KMZ file with the local content.
- **ESRI Shapefile** - lets you download the Coverage zip file consisting of the *DBH*, *PRJ*, *SHP*, *SHX* files of the selected network(s).
- **GeoTIFF Export** - lets you download the *GeoTIFF* image of the selected network(s). You can choose either 4326 or 3857 projection.
- **Public Link** - lets you view the selected Network(s) in the **Google Map**.

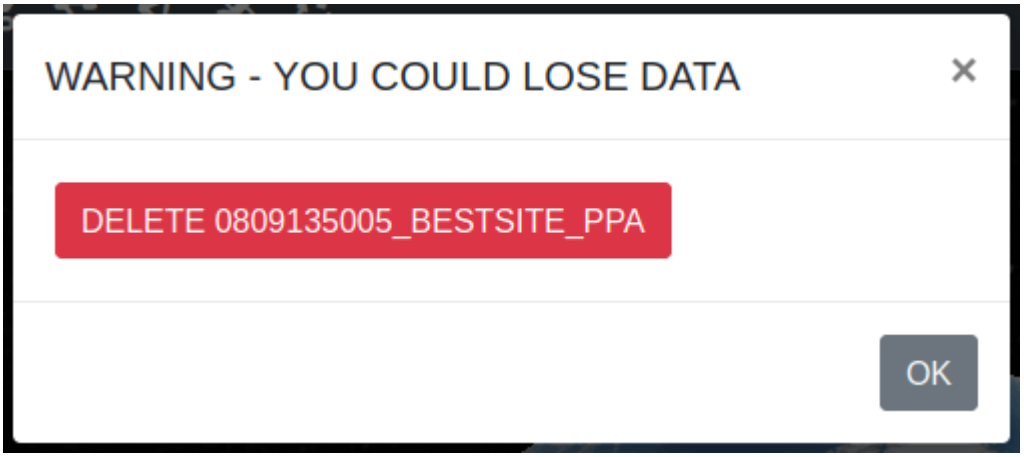


- **HTML Embed Code** - opens a modal window with a code snippet which you can use to embed the layer on your own web page. Please note that here we make use of Google Maps. You should have your own Google Maps API key to properly embed the code.

    All the API parameters of the selected network(s) will be displayed here. If you are a developer, you can directly copy paste this to use it in your code.

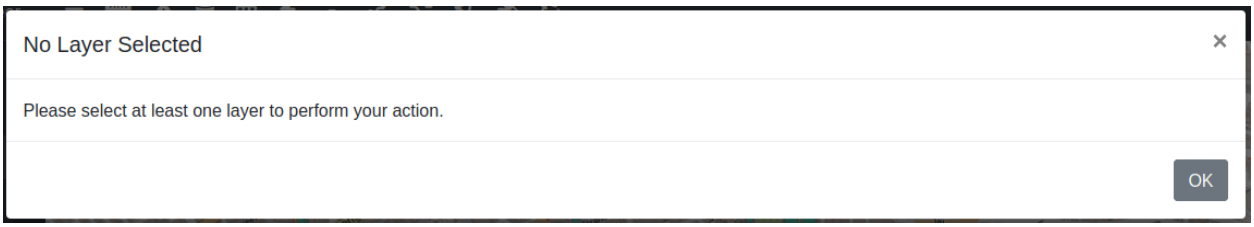


- **Delete Selected** - lets you delete the selected Network(s).
  - When you click on the *Delete Selected* button, the following warning dialog box will appear.



    * Click on **OK** button to confirm.

Please note, that in order to use tools designed for interactions with a single calculation, you must first select the checkbox of the calculations which you wish to interact with. Otherwise, you will be presented with a modal window, indicating that no calculation was selected.

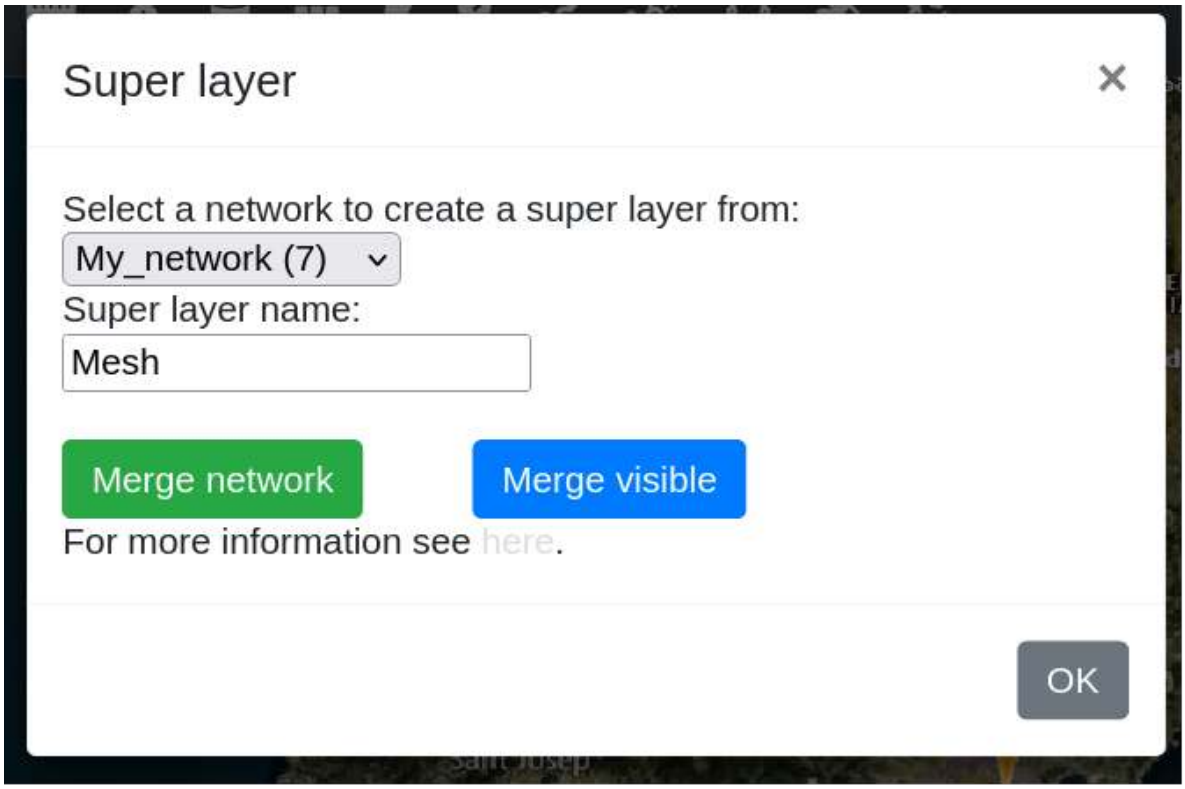


4.7  Super Layer

The super layer tool lets you generate a super layer composed of different layers. The layers can be from the same network or different networks by using whatever visible layers are on the map.

Layers must use the same colour schema.

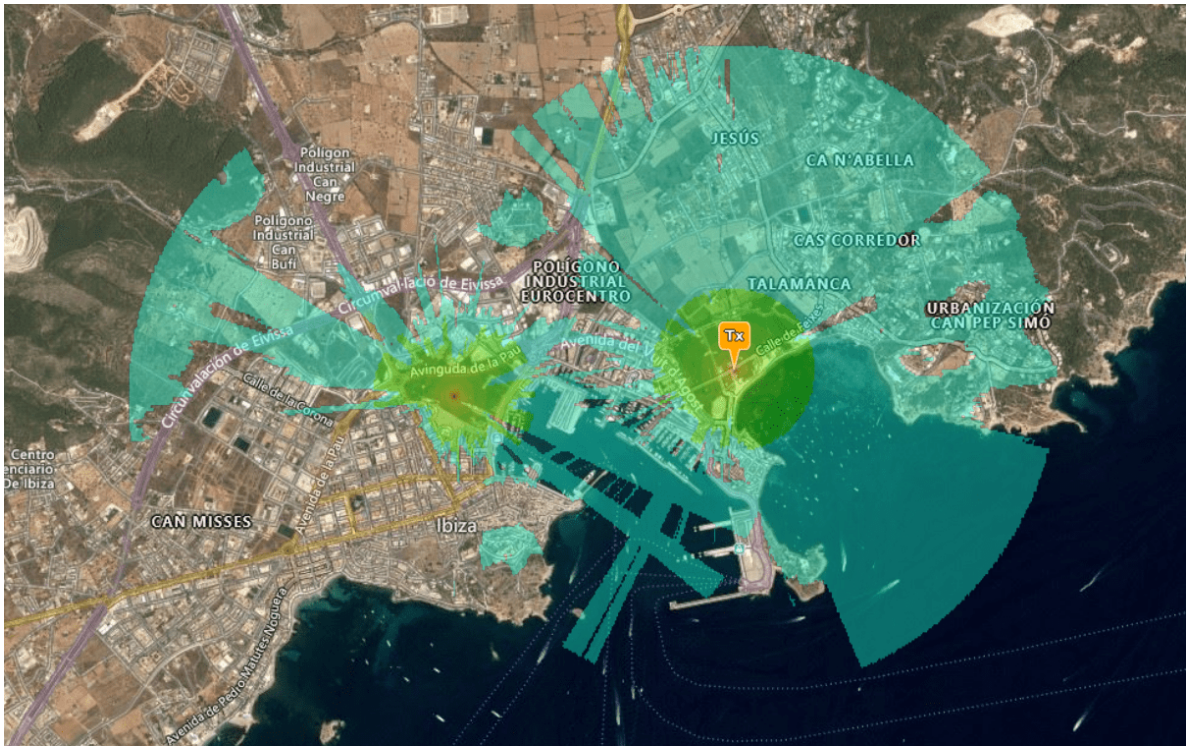
- Click on **Super Layer**  button on the Function Menu.
- The **Super layer** dialog box will appear.



4.7.1 Merge network

- In the **Select a network to create a super layer from:** field, you can select a network to create a super layer from the drop-down.
- In the **Super layer name:** field, enter the desired super layer name.
- Click on the **Merge network** button

  For further information, click **here**.
- The created **Super Layer** will be highlighted on the map and the corresponding checkbox (enabled) will be displayed.



- You may **enable** or **disable** the *super layer checkbox* as per your requirement.

  The super layer will be displayed on the map when the checkbox is enabled and will not be displayed when the checkbox is disabled.

4.7.2 Merge visible

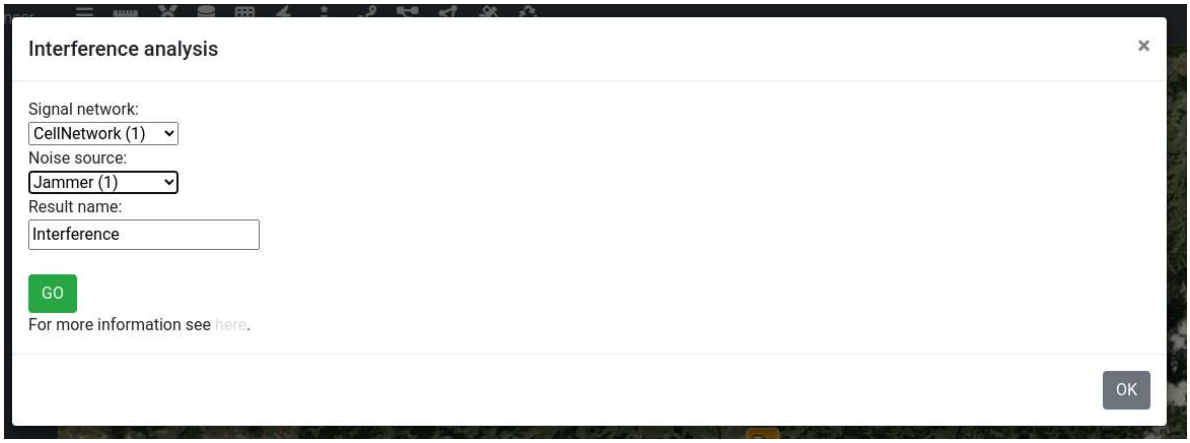
The tool will use the layers which are on the map. These must use the same colour schema. Click on the **Merge visible** button

4.8 Interference Analysis

The Interference Analysis tool generates a special interference layer, showing the interference between two networks.

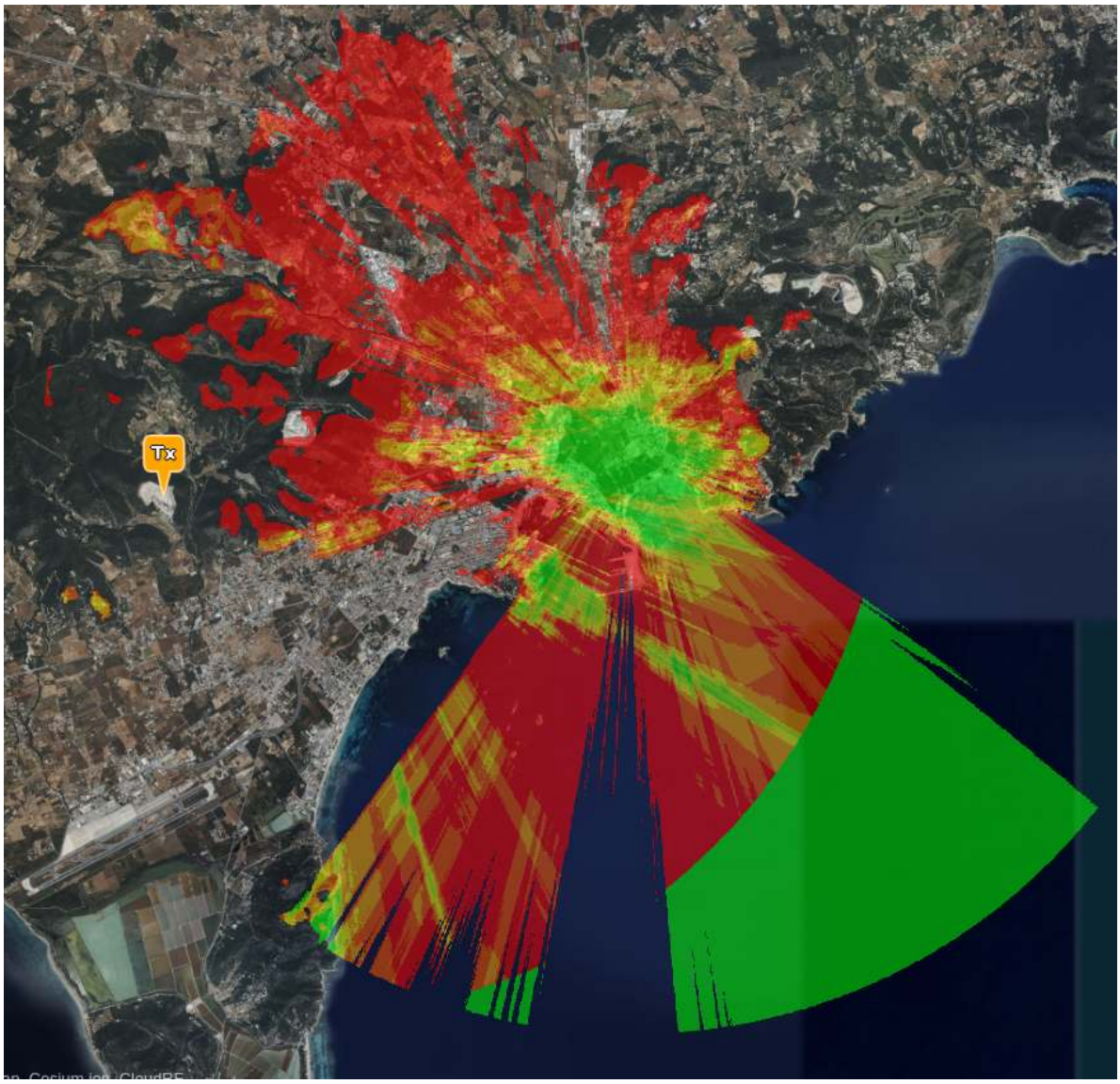
It supports frequency, power and bandwidth so can perform co-site interference studies where systems are separated in frequency but physically nearby.

- Click on **Interference Analysis** button on the Function Menu.
- The **Super layer** dialog box will appear.

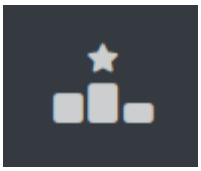


- In the **Signal network:** field, you can select the network you want to analyse.
- In the **Noise source:** field, you can select the interference source.
- In the **Result name:** field, enter a name to label it in the archive.
- Click on the **Go**  button.

  For further information, click ***here***.
- The created **Interference Layer** will be highlighted on the map as a new layer. It will enable Signal-to-Noise mode and use the JS.dB colour key. This colour key uses red for bad interference and green for a good signal.



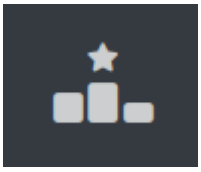
NOTE - Interference analysis requires you to use calculations which have been generated with measured units that include power, such as received power, field strength, SNR, BER and RSRP. If you attempt to analyse calculations which do not include power then they will be removed from the analysis.

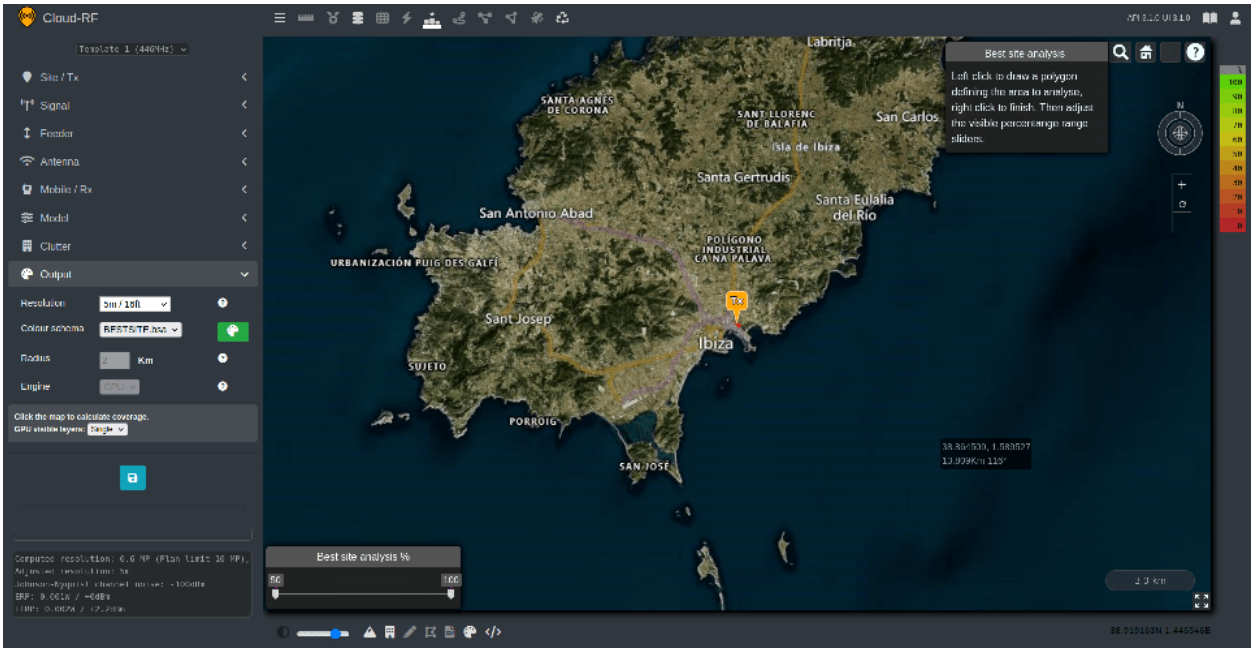
4.9  Best Site Analysis

The best site analysis tool is GPU-powered analysis tool to allow you to find the best locations in a large area for a transmitter.

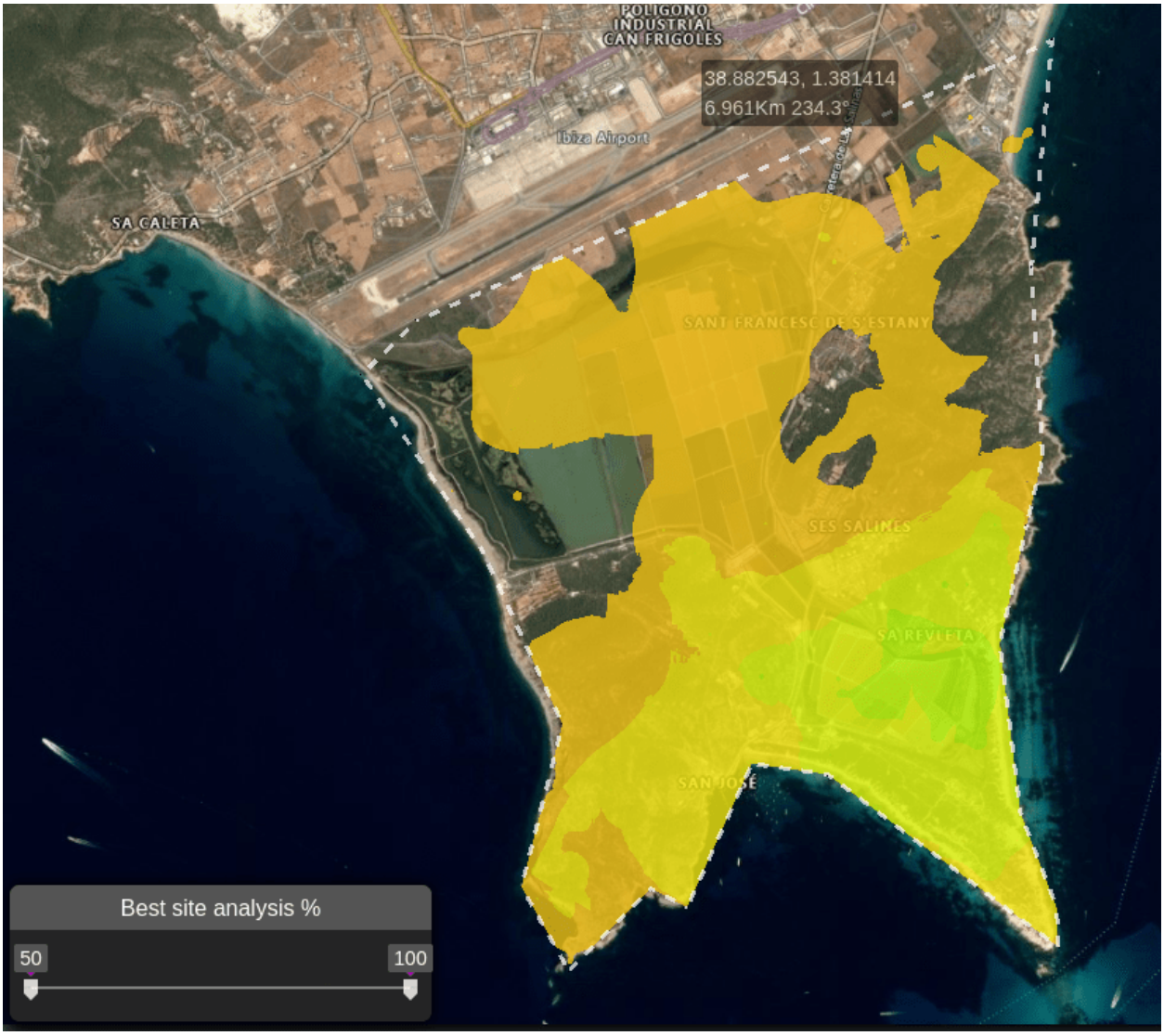
Please note that the response from a best site analysis calculation is **NOT** a response of signal strength. Instead it is normalised result which takes an input `bsa` colour schema to show the absolute best locations in an area.

Best Site Analysis is used in the following way:

- Click on **Best Site Analysis**  button on the Function Menu.
- The interface will be converted to Best Site Analysis mode. With this you may notice a number of things:
  - The small dialog in the top right of the interface indicating you are in Best Site Analysis mode.
  - The percentage slider in the bottom left of the interface.
  - "Radius" in the "Output" menu has been disabled.
  - "Engine" in the "Output" menu has been disabled and set to "GPU".
  - "Colour schema" int the "Output" menu has been changed to a `bsa` colour schema.



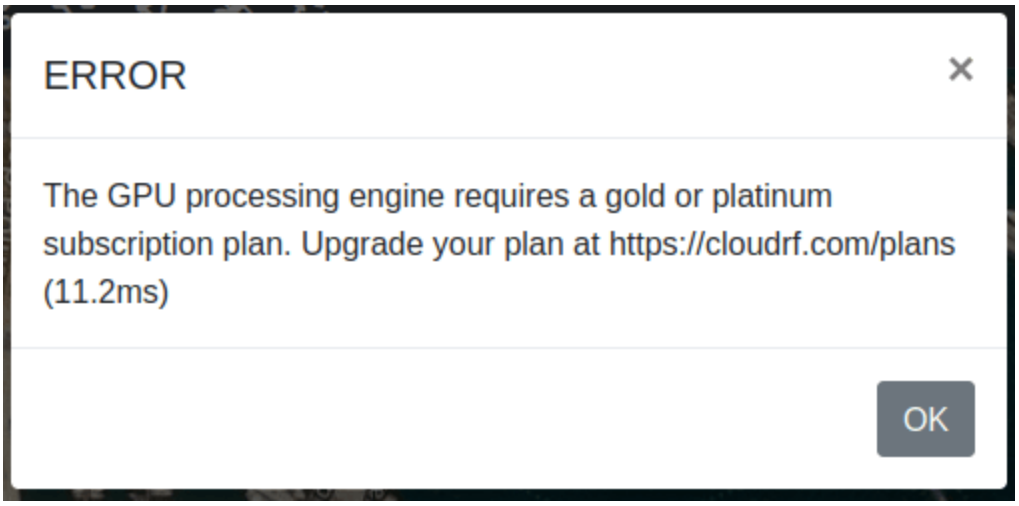
To use the best site analysis tool you can draw a polygon around an area by making use of left-click on the map to set the points of your polygon. Once you have finished drawing your polygon you can right-click to join up to the first point and set an area. Once you right-click your area will be sent to the Cloud-RF API where it will be handled and return your response.



You can then use the slider in the bottom left corner to fine-tune your result and show results between certain percentage thresholds.

This is useful for showing coordinates which meet your threshold, as it allows you to pinpoint the best locations to place your transmitter.

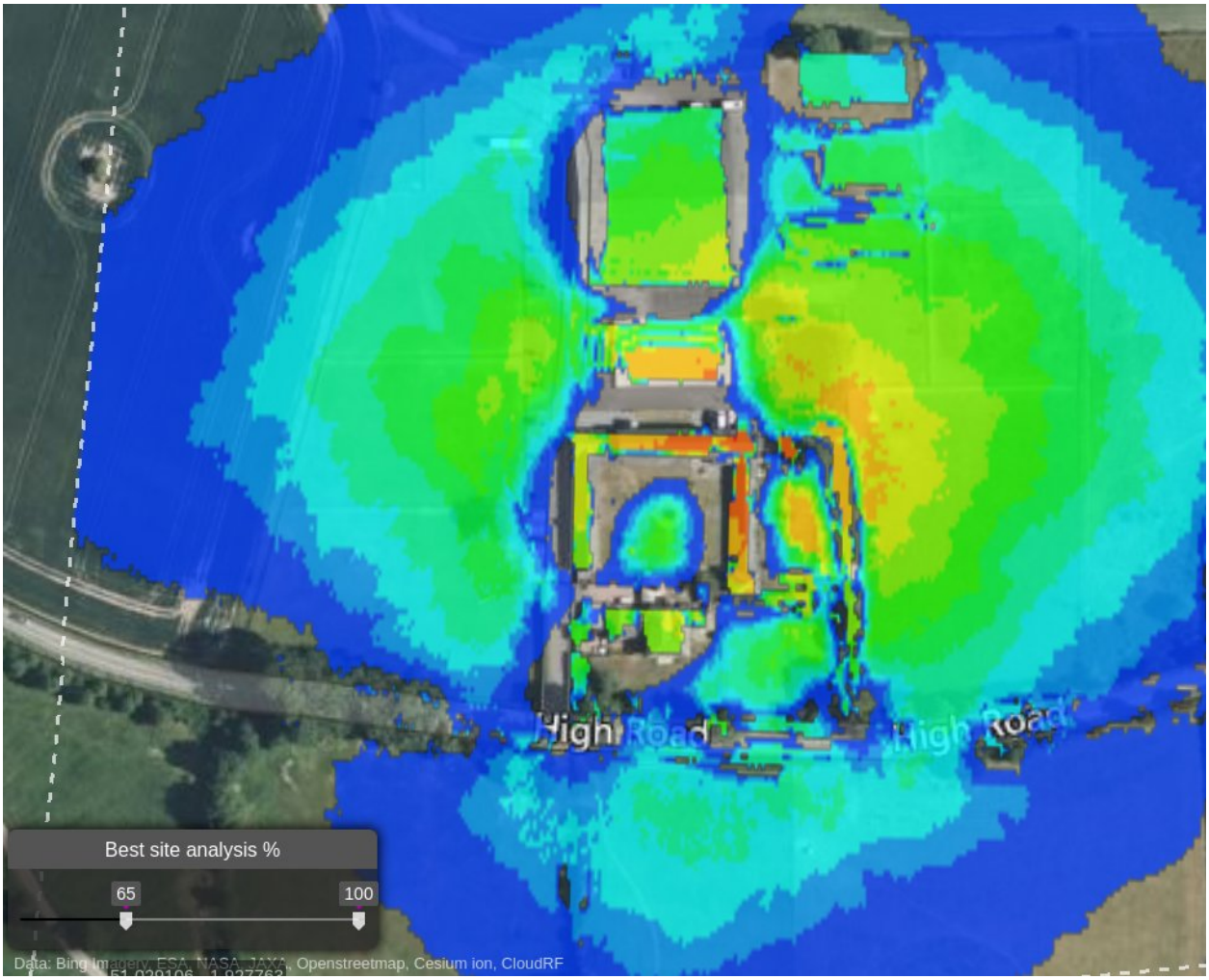
Please note that to make use of the Best Site Analysis tool you will require a Gold or Platinum subscription plan. If you do not have either then you will receive a forbidden message for the reponse.



4.9.1 Satellite NTN LOS analysis (Starlink, Oneweb, Lync)

The BSA tool is ideal for LOS analysis for LEO ground terminals as it can recommend the best site for maximum visibility of the sky. As Low Earth Orbit (LEO) satellites are almost omni-directional in the sky, and fast, isolating one or two is impractical.

To use BSA for LEO, expand the search perimeter beyond the area of interest and then set the receiver altitude to be higher than local obstructions eg. 30m to achieve a steep angle of incidence. As a rule of thumb, set the receiver height to the search radius to achieve a 1:1 (45 degree) angle.



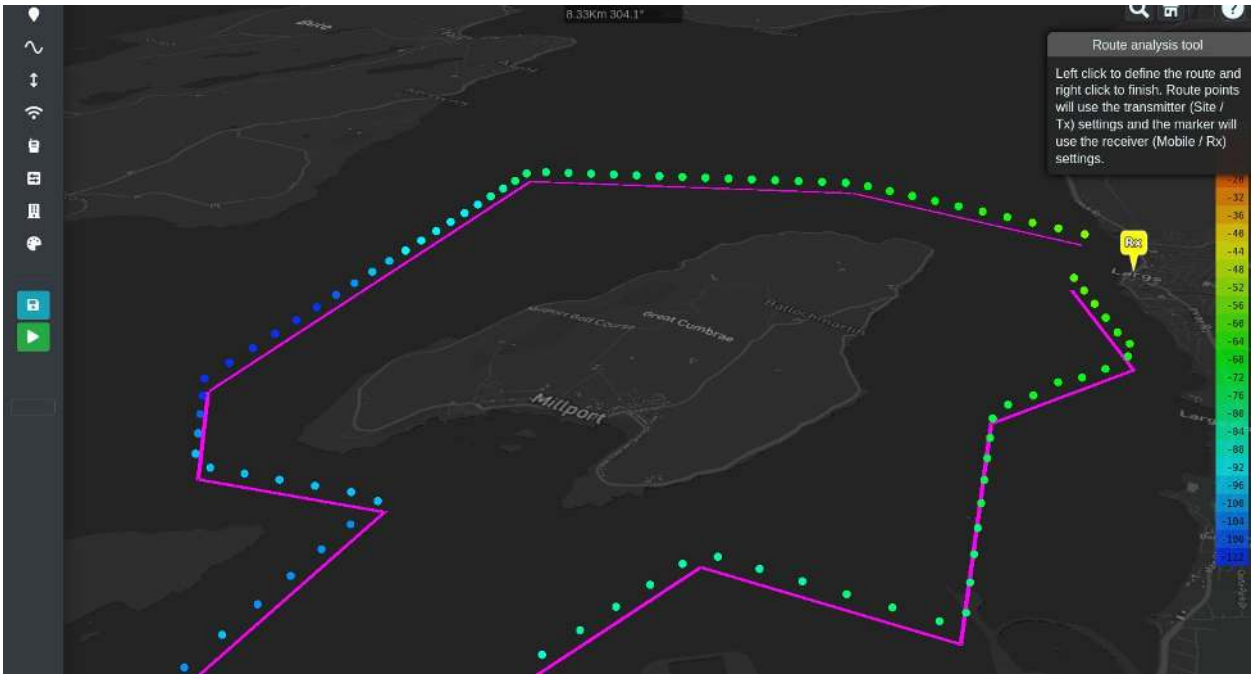
4.10 Route Analysis

The route analysis function will let you define a route by clicking upon the map. Points along the route will be tested as transmitters back to your map marker's location which assumes the role of receiver. The transmitter and receiver settings will come from the form.

To add a route:

- Left click route analysis button.
- Left click points on the map to draw a route. A polyline will appear.
- Right click to finish the route. Result will appear after a brief delay.
- The points are colour coded based upon the selected colour key.
- Click the recycle button to remove the layers.

  WARNING - Routes are not saved to your database



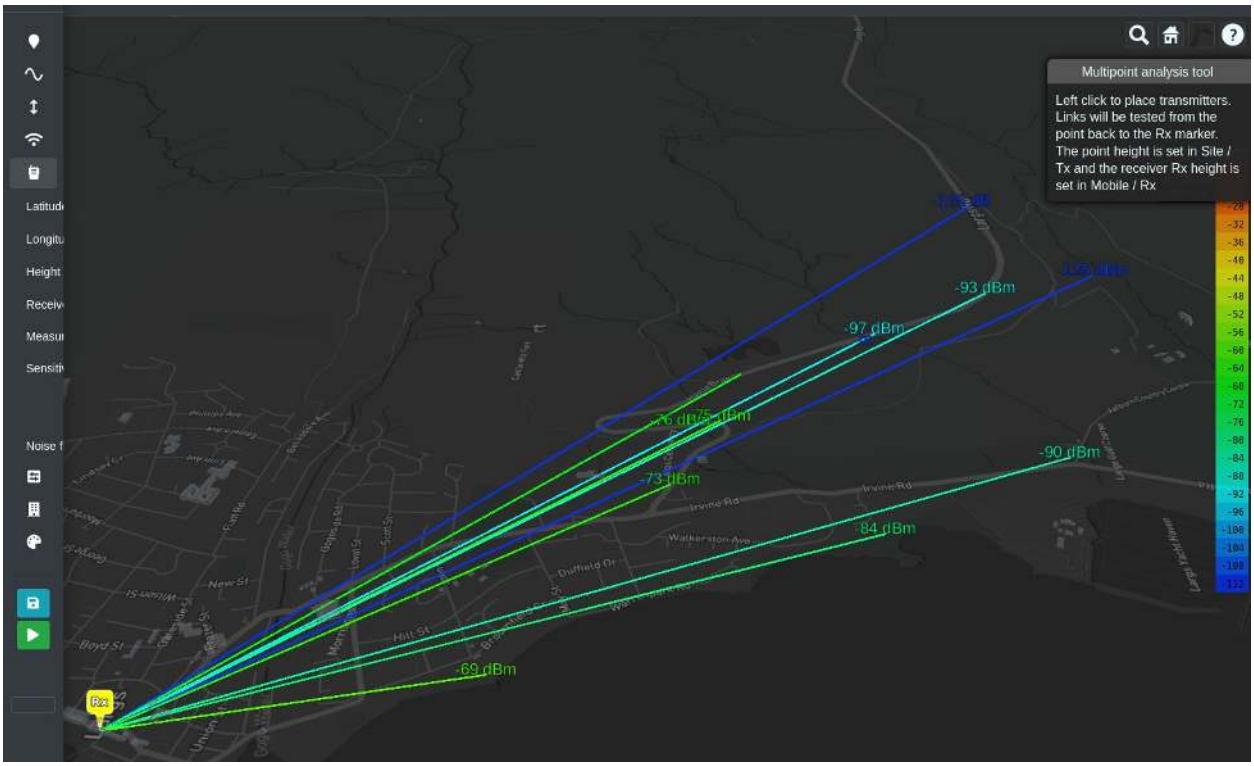
4.11 Multipoint Analysis

The multipoint analysis function will let you define many links quickly by clicking upon the map. Points will be tested as transmitters back to your map marker's location which assumes the role of receiver. The transmitter and receiver settings will come from the form.

To add points:

- Left click multipoint analysis button.
- Left click points on the map to draw links.
- The points are colour coded based upon the selected colour key.
- Click the recycle button to remove the layers.

  WARNING - Multipoint links are not saved to your database

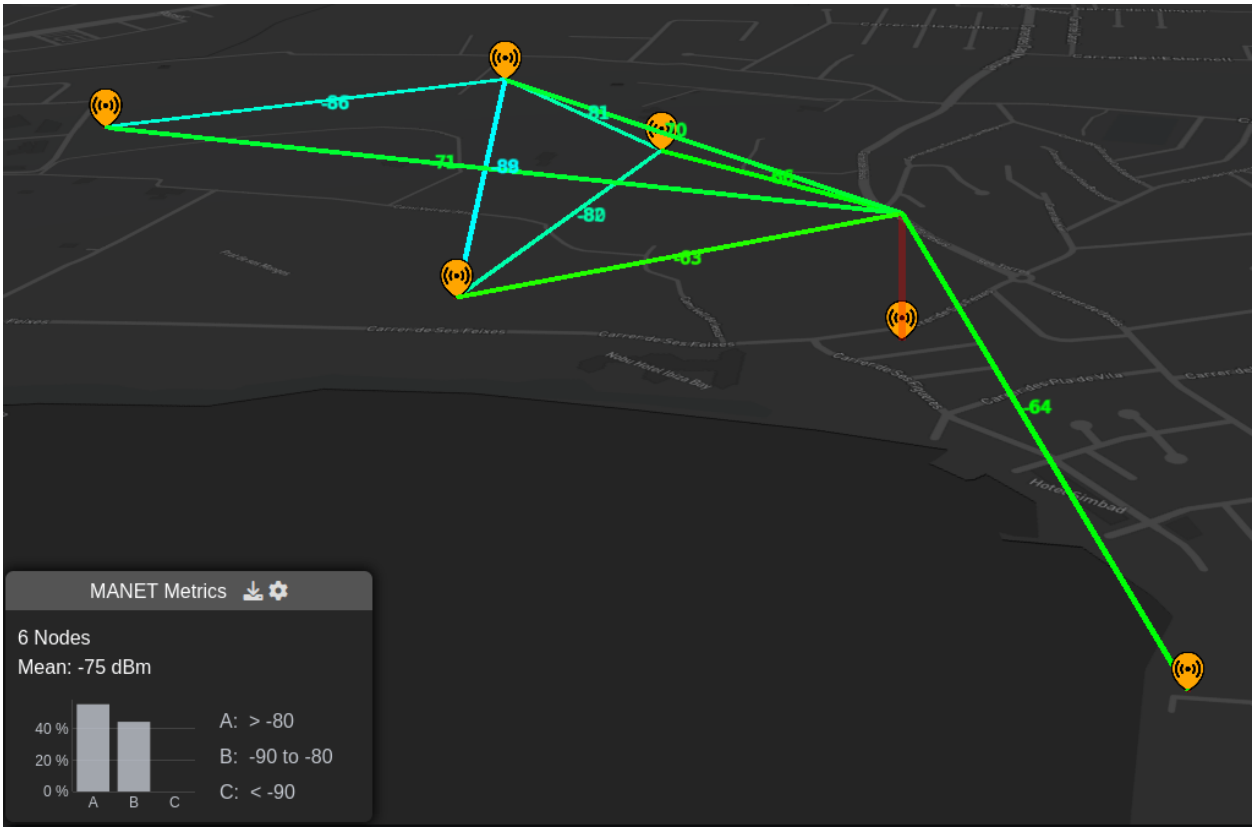


4.12 MANET planning tool

The Mobile Autonomous Network (MANET) planning tool lets you rapidly define a MANET network composed of indepdendent nodes. Nodes can have distinct configurations so you can simulate different radios and/or antennas together.

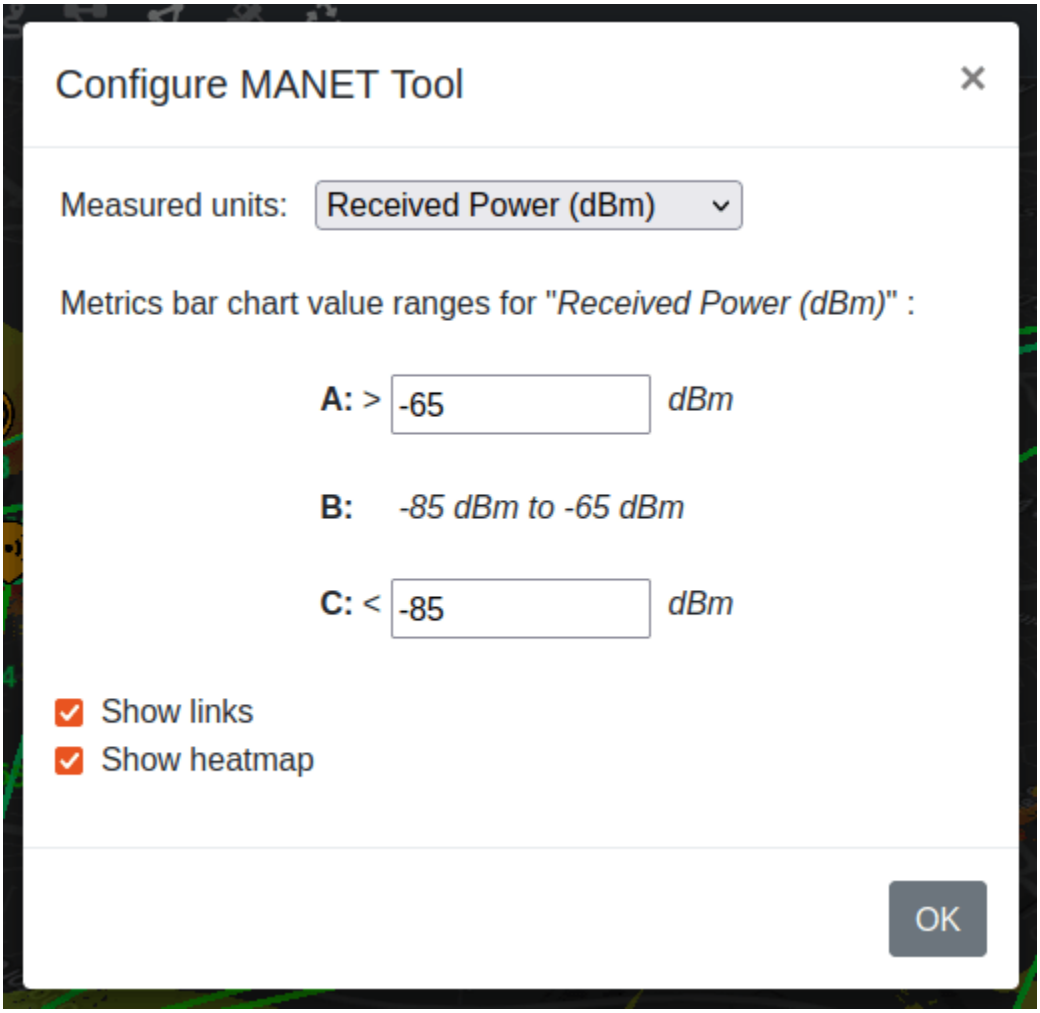
To create a MANET network:

- Define or select a template for your radio
- Left click the MANET button.
- Left click on the map to add a node / radio.
- The nodes will use the settings defined in the input menu. If you need different settings, make the change then add the node.
- Drag a node to move it to a better location
- Right click a node to delete it



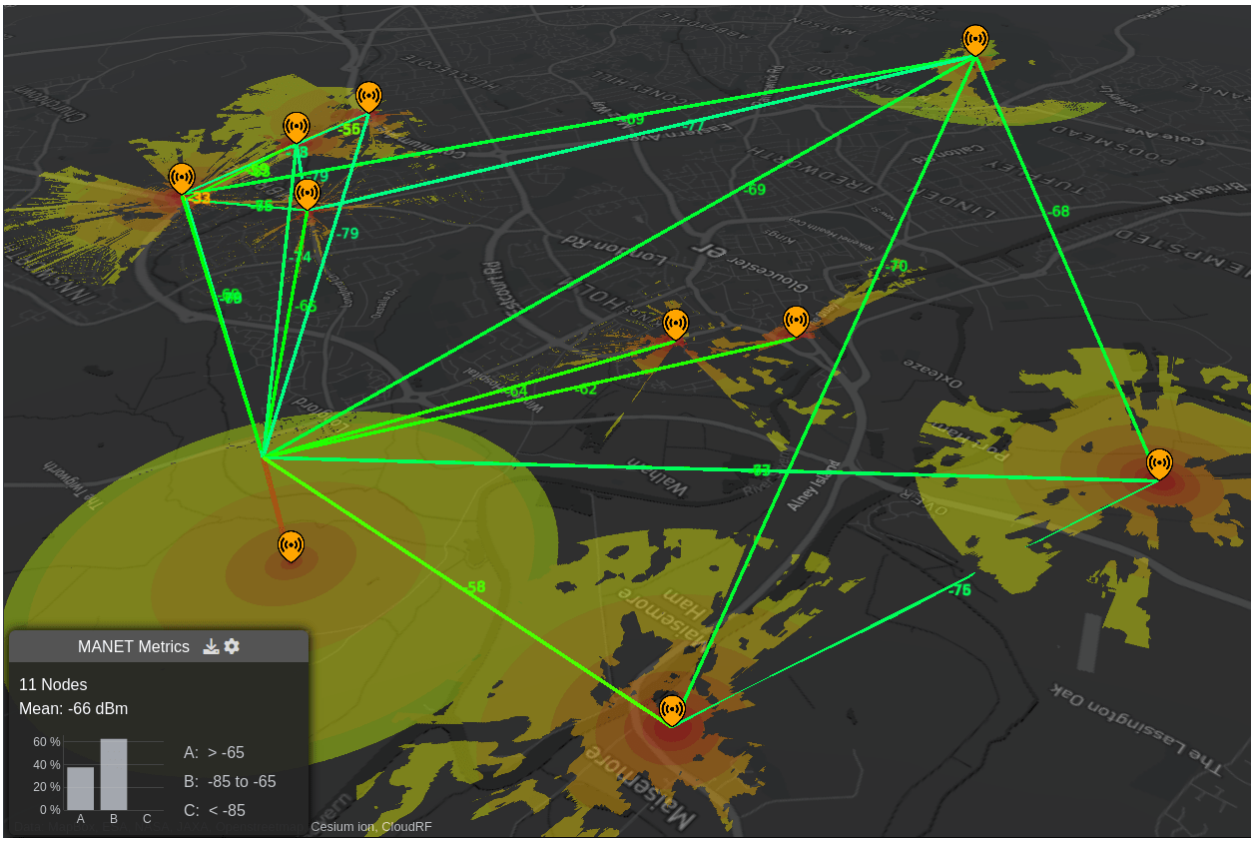
You can configure options for the “MANET Metrics” modal in the bottom left of the screen by clicking on the settings cog icon which is located to the right of this “MANET Metrics” heading. 

When you select the settings then this will open up a modal where you can configure a number of settings:



- **Measured units** drop down allows you to select the measured unit which is being used to calculate your MANET network links. Default is Received Power but you can set SNR here also.
- The bar chart thresholds allow you to dynamically configure the QoS thresholds for your MANET network so you can model efficiency for different waveforms or requirements eg. video.
- **Show links** allows you to enable coloured links between network nodes. A link will be shown if it exceeds your receive threshold - otherwise it will not be drawn.
- **Show heatmap** shows you a coverage heatmap for all the MANET network ndoes, out to the defined threshold. This uses the GPU engine so a premium plan is required.

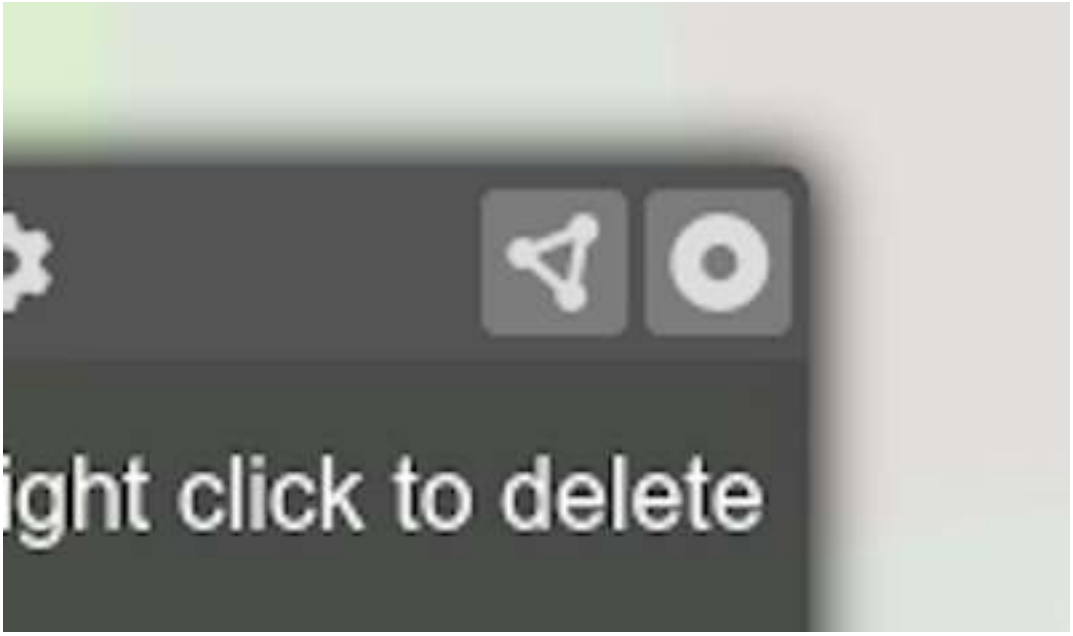
Below shows an example of a MANET network with both links and heatmap enabled.



NOTE - Heatmaps are GPU accelerated and require a Gold subscription.

4.12.1 MANET layer controls

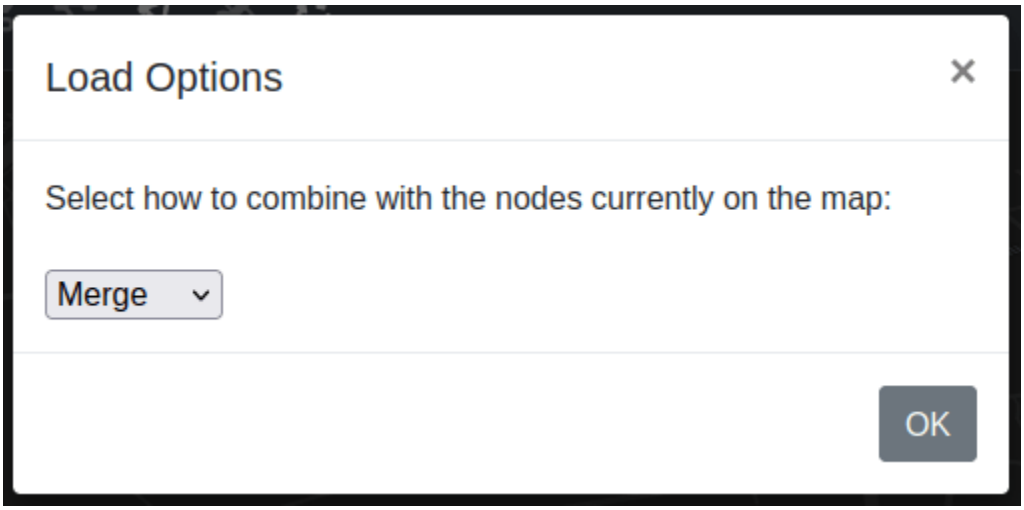
The links and heatmap layers can also be toggled on and off by clicking the relative icons in the top right corner of the MANET dialog.



4.12.2 Saving and loading MANET networks

The MANET network is auto-saved after every re-calculation. A re-calculation is performed when a node is added, removed or added. Unlike other API calls, MANET networks are saved to a file instead of the database due to their complexity. This will appear in your archive under the **MANET** network and can be reloaded by selecting it and choosing to add it to the map.

You can choose to reset or merge with existing MANET networks. This allows you to merge two puddles of radios. Please note that you will only be prompted with this window if you have existing MANET nodes already on the map.



4.12.3 Downloading a MANET network

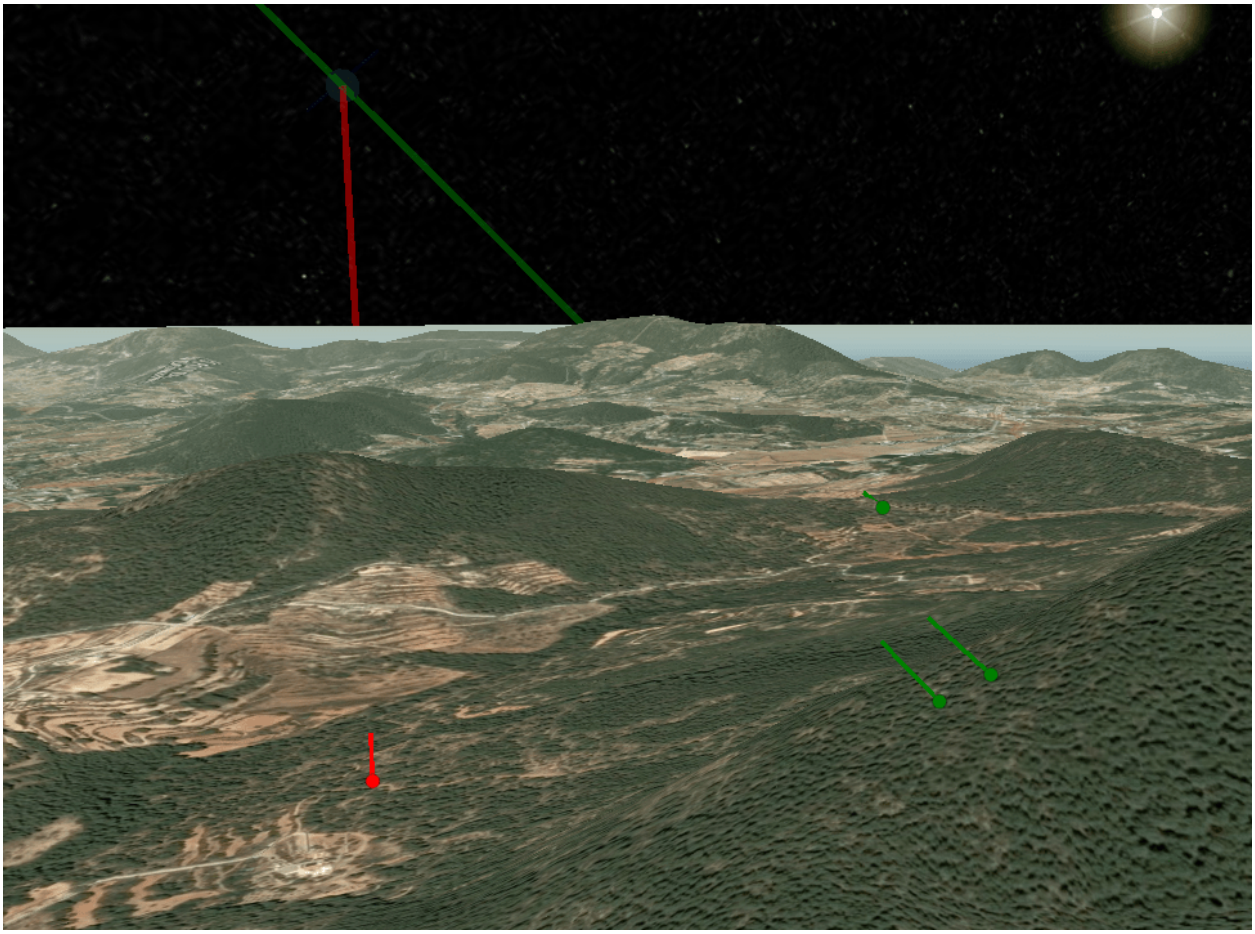
A network can be downloaded as either KMZ, SHP, GeoTIFF, URL or HTML from either the bottom left menu directly after completion, or via the archive using the standard workflow for fetching files.

4.13  Satellite planning tool

The Satellite planning tool lets you test for visibility to over 5400 active satellites from a database. Unlike sat-finder apps this considers topography and clutter to determine visibility.

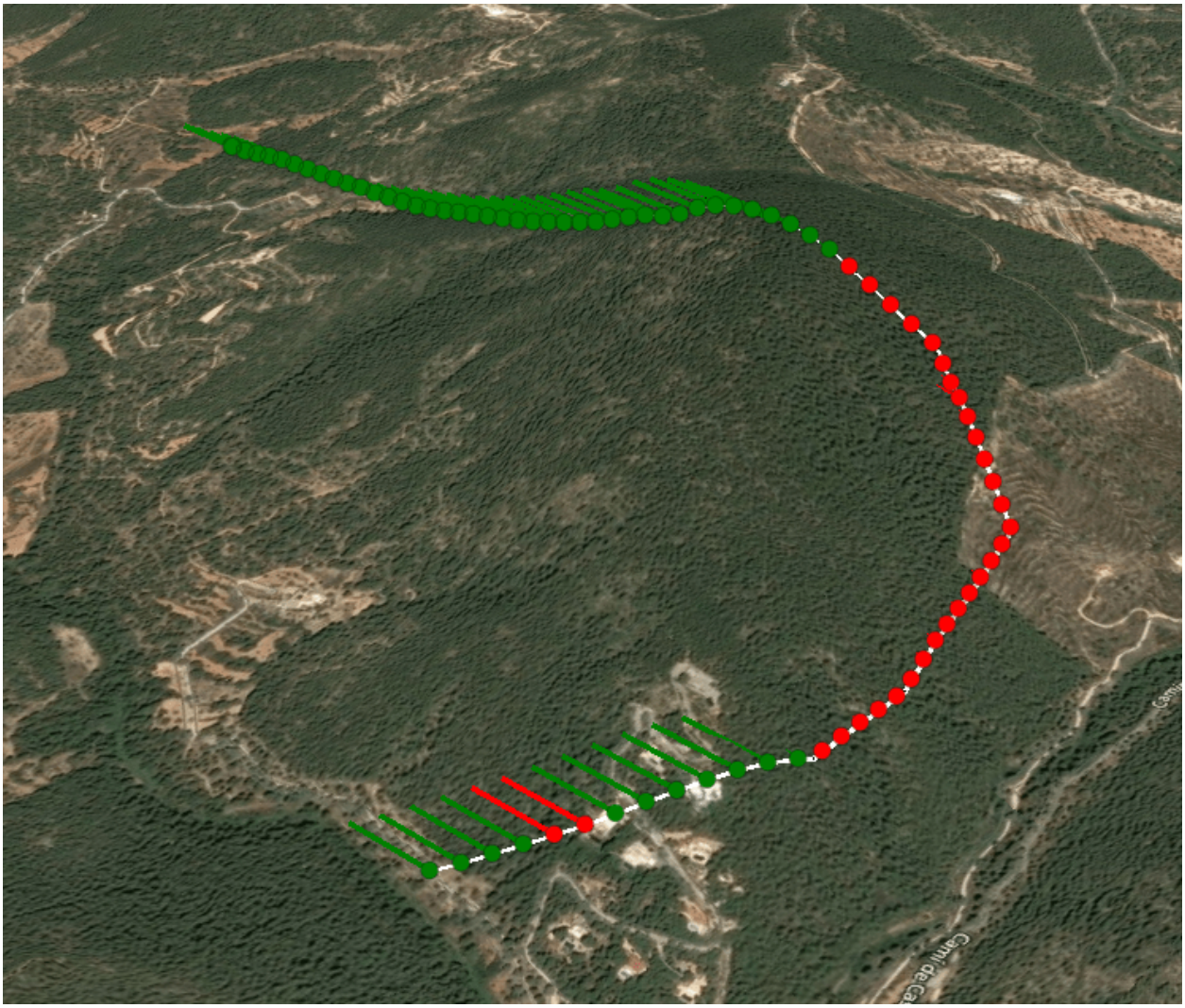
To test a point for satellite visibility:

- Left click SATELLITE button.
- Enter search parameters eg. STARLINK in the search popup
- The results will be listed. Click the satellite of interest
- The satellite will now be added above the earth on an orbit which you control the time of using the time slider at the bottom of the screen.
- Use the multipoint tool to test points by clicking on the earth.



To test a route for satellite visibility:

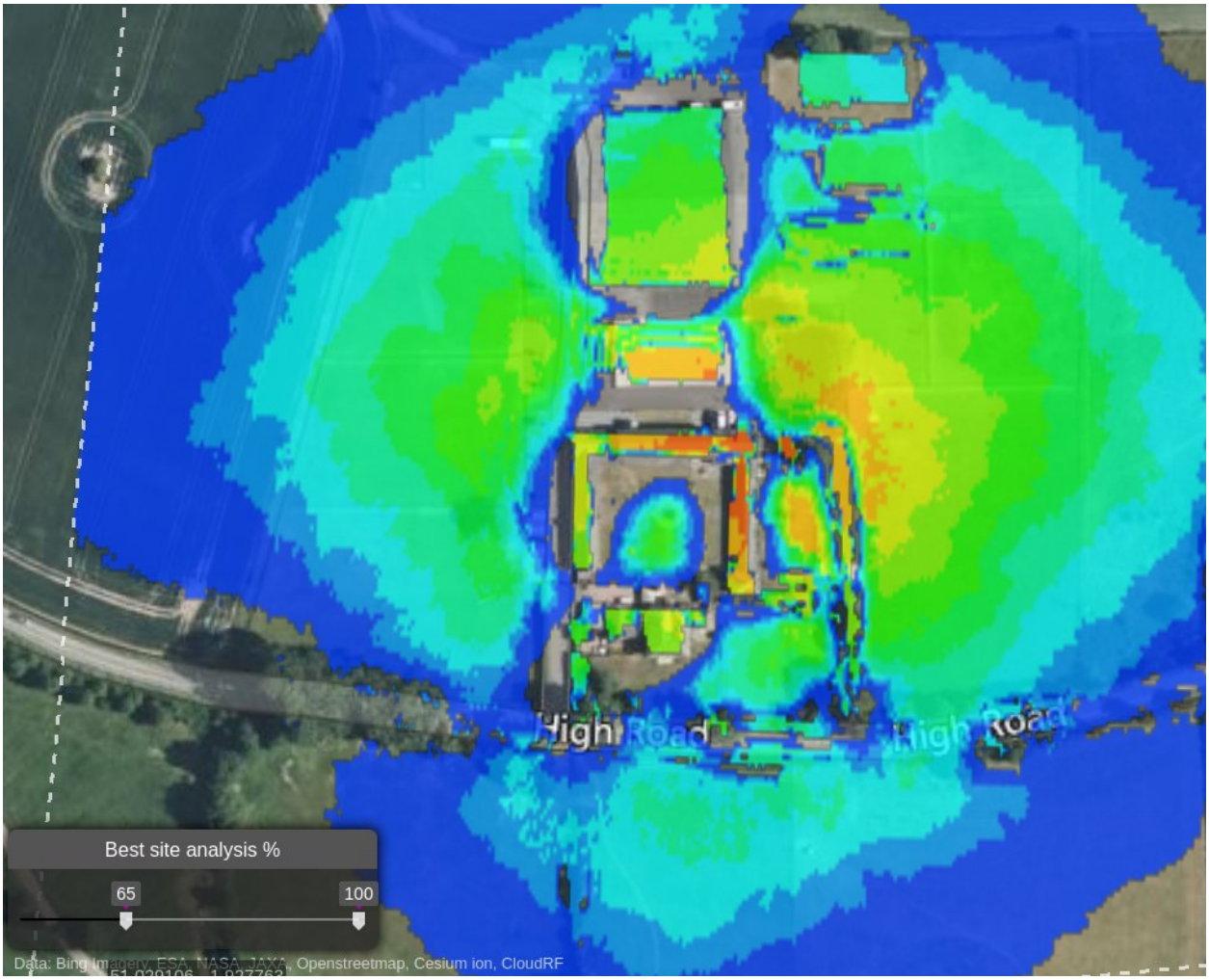
- Left click SATELLITE button.
- Enter search parameters eg. STARLINK in the search popup
- The results will be listed. Click the satellite of interest
- The satellite will now be added above the earth on an orbit which you control the time of using the time slider at the bottom of the screen.
- Use the route tool to test a route by left-clicking a path upon the earth then right clicking to finish.



4.13.1 Satellite NTN LOS analysis (Starlink, Oneweb, Lync)

The Best Site Analysis (BSA) tool is ideal for LOS analysis for LEO ground terminals as it can recommend the best site for maximum visibility of the sky. As Low Earth Orbit (LEO) satellites are almost omni-directional in the sky, and fast, isolating one or two is impractical.

To use BSA for LEO, expand the search perimeter beyond the area of interest and then set the receiver altitude to be higher than local obstructions eg. 30m to achieve a steep angle of incidence. As a rule of thumb, set the receiver height to the search radius to achieve a 1:1 (45 degree) angle.



4.14 Clear Layers

The recycle icon will clear and reset the map of all layers. The layers can be reloaded from within your archive.

To clear the layers on the map:

- Click on **Clear Layers** button on the Function Menu.
- All the layers on the map will be **cleared** and **reset**.
- The required layers can be reloaded from the *Archive*.

CHAPTER

FIVE

WEB INTERFACE IMPORT DATA

You can import structured data in different open formats by clicking on the  which is located at the bottom of the web interface. This will open a dialog modal window from where you can select a function to work with.

This modal window is separated into the following sections:

5.1 Reference display

Add markers / boundary lines to the map from a KML

5.2 Coverage analysis

Import zip codes / locations to study coverage statistics

5.3 Route analysis

Import a route or flight path to analyse coverage

5.4 MANET network

Import locations from a file to model a network

5.5 Survey data

Import field measurements (Lat, Lon, RSSI)

5.6 Calibration

Import field measurements (Lat, Lon, RSSI)

5.7 Best Site Analysis

Import an area to study it using a Monte Carlo simulation

5.8 Automatic processing

Import a spreadsheet of data for processing via the API

To make use of this tool simply select your chosen "Purpose" and upload your data in one of the specified formats.

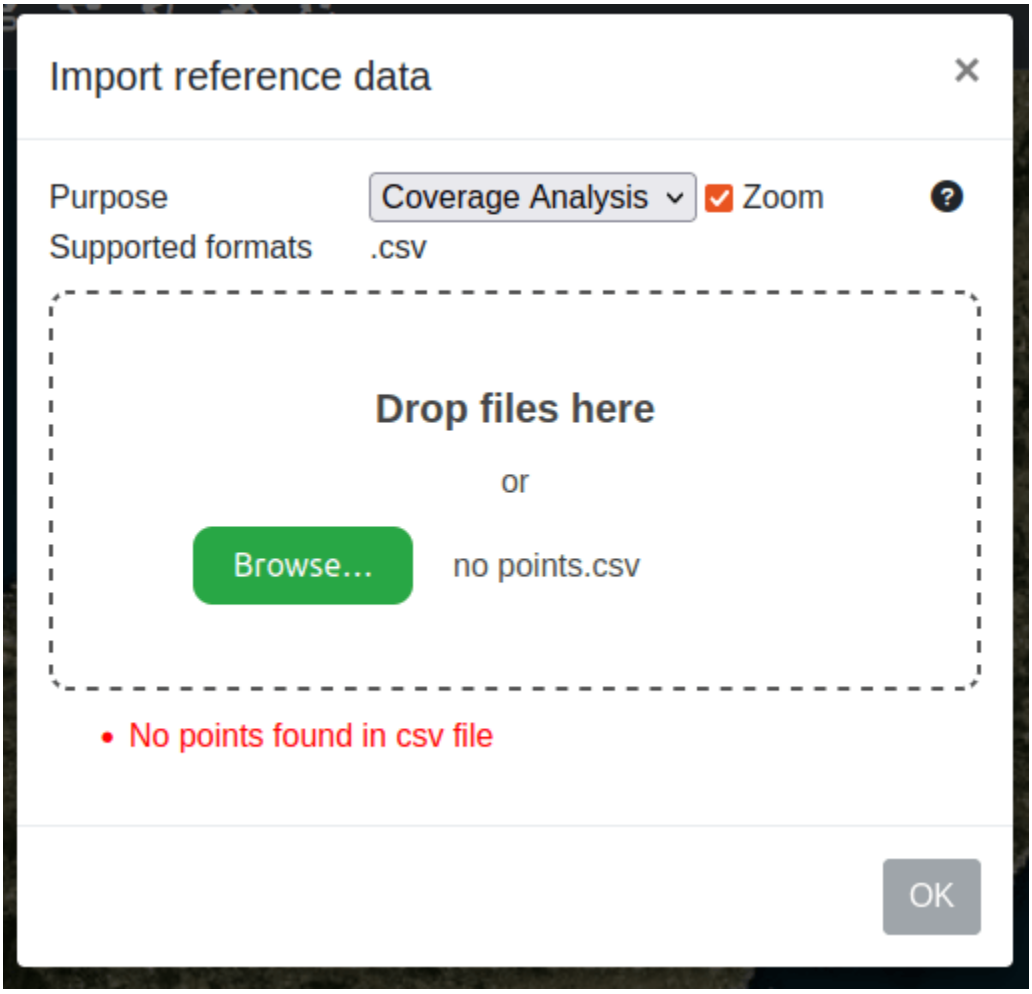
At any point if you wish to remove your reference data from the map then you can simply click on the "Clear Layers"  button along the top of the interface.

For more guidance on automatic processing, please *consult the dedicated section*.

5.9 File Validation

Regardless of the "Purpose" selected, your files will be validated when you upload them. This ensures that your files will work with the interface and be interpreted correctly.

If you have an error in your reference data then this will be displayed in the modal window.



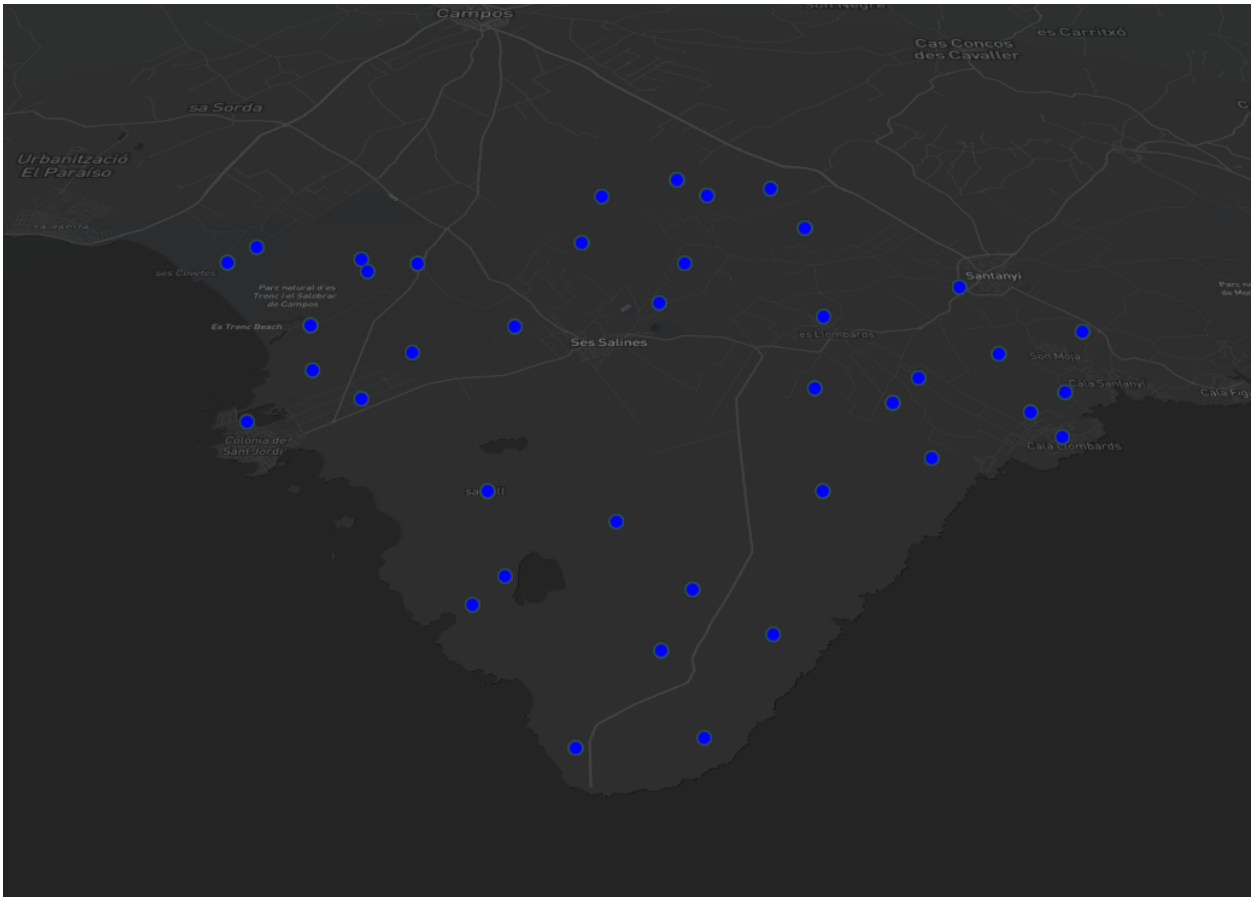
5.10 Reference Display (Shapes on the map)

If you select “Reference Display” from the “Purpose” dropdown then this can be used to display imported data on the map such as polygons or pins.

When you select this option from the “Purpose” dropdown this will also show a new colour picker input which can be used to set the colour of your import data when it is drawn on the map.

This functionality can be used to create guides on the map where you can visualise where certain points or boundaries may be. For example, you may upload a CSV of points to indicate important landmarks, or you may upload a GeoJSON file which includes a boundary.

Below shows uploaded points using the “Reference Display” from a CSV:



Below shows a sample CSV which was partially used to produce the above screenshot:

```
longitude,latitude,rssi
3.0505242,39.2707224,-70
3.0807366,39.2866678,-50
3.0560174,39.304735,-92
3.068377,39.2935764,-90
3.0340447,39.3100479,-67
3.0910363,39.3100479,-75
3.0381646,39.295702,-81
3.0632271,39.2842762,-91
```

Below shows a boundary uploaded using the “Reference Display” from a GeoJSON file:

Below shows the GeoJSON which was used to produce the above screenshot:

```
{
  "type": "FeatureCollection",
  "features": [
    {
      "type": "Feature",
      "properties": {},
      "geometry": {
        "coordinates": [
          [
            [
              1.4256018139448656,
              38.92015233473046
            ],
            [
              1.4280509904125438,
              38.91581165124461
            ],
            [
              1.4449950785628118,
              38.91780215762395
            ],
            [
              1.441954782658172,
```

(continues on next page)

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```
              38.92844609186906
            ],
            [
              1.4256018139448656,
              38.92015233473046
            ]
          ]
        ],
        "type": "Polygon"
      }
    }
  ]
}
```

5.11 Coverage Analysis (Measurements, Locations, Routes)

If you select "Coverage Analysis" from the "Purpose" dropdown then this powerful utility can be used for several purposes:

- Upload field measurements / RF survey data which can be used to calibrate and optimise simulation settings by reporting the error
- Upload location data eg. zip / postal codes which can be used to gather metrics about coverage for areas and points.
- Upload a KML route for coverage analysis. This will report the percentage (%) of the route covered

5.11.1 Coverage analysis of locations

You can upload a CSV with data about multiple points, for example customer properties by ZIP or UPRN.

For basic 'points' your CSV should follow the following rules:

- The following fields are accepted:
  - `id` is a unique identifier of the point.
  - `latitude` is the latitude coordinate of the point. Should be a decimal value between -180 and 180.
  - `longitude` is the longitude coordinate of the point. Should be a decimal value between -90 and 90.
  - `group` is an optional field which allows you to group certain points together.
- Your CSV must contain a header indicating the ordering of your fields.

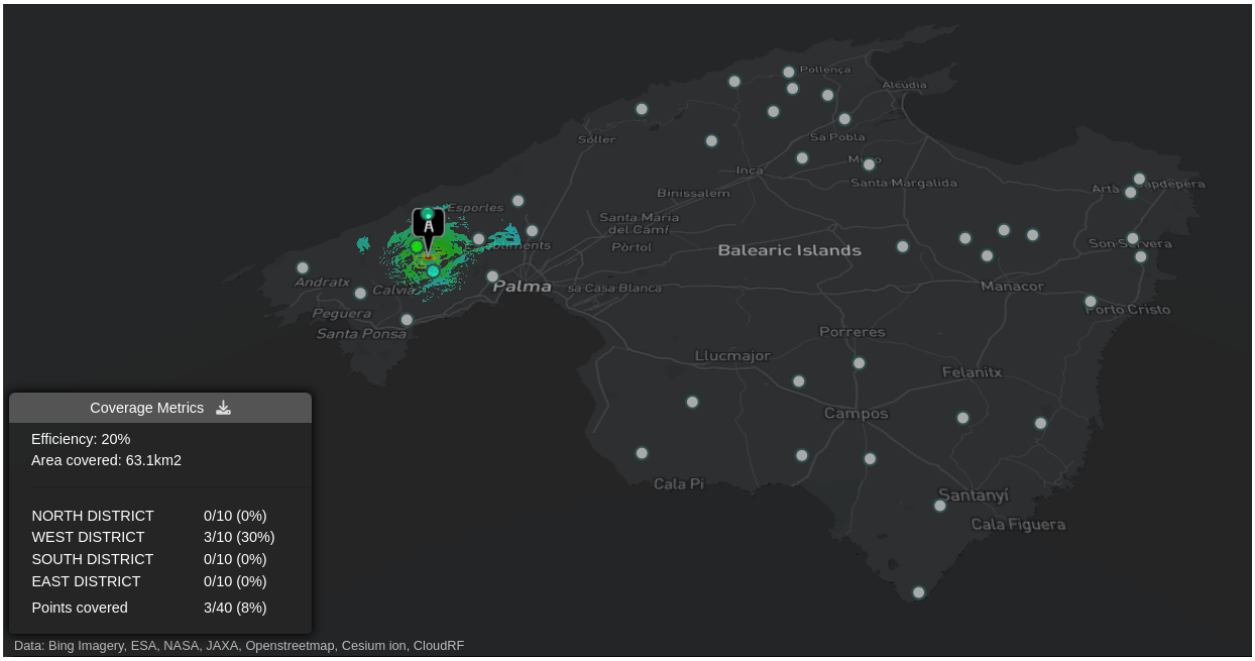
An example CSV might look something like the below:

```
id,longitude,latitude,group
Point 1,3.0505242,39.2707224,SOUTH DISTRICT
Point 2,3.0807366,39.2866678,SOUTH DISTRICT
Point 3,3.0520286,39.3742523,NORTH DISTRICT
Point 4,3.0678215,39.3787639,NORTH DISTRICT
```

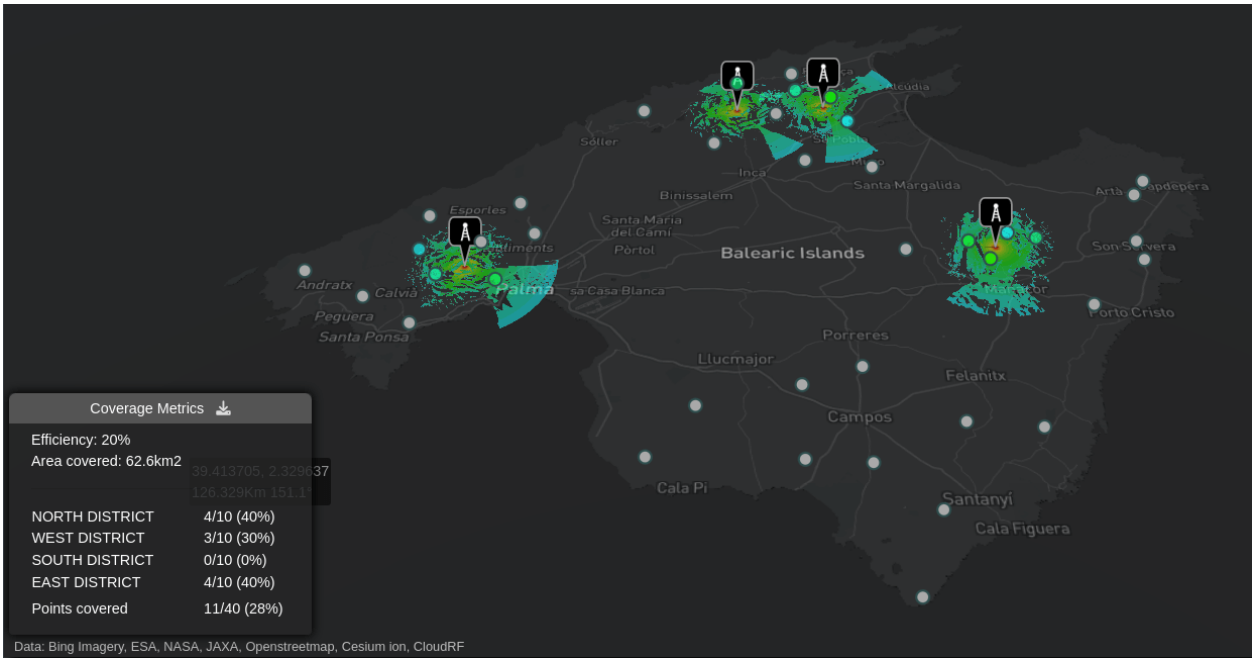
After successfully uploading your CSV it will be parsed and the interface will automatically draw your points onto the map.

You may notice that a new window will be added to the bottom left of the screen. This is a live-updating metrics report which gives you details about your calculations, giving indications as to whether your points are covered or not.

If you next click on the map and run through a calculation you should see the points being coloured based on the signal strength but also the metrics report should update automatically when new calculations cover points.



As you add new calculations this will update the metrics report showing you how much coverage you have in total. Each group as defined in your CSV will also be calculated based on its coverage.



As you do multiple calculations this will build up your available layers on the map. As you check/uncheck them it will automatically update your metrics report in the bottom left of the interface. This is useful for seeing the effect removing a single layer has on an overall network.

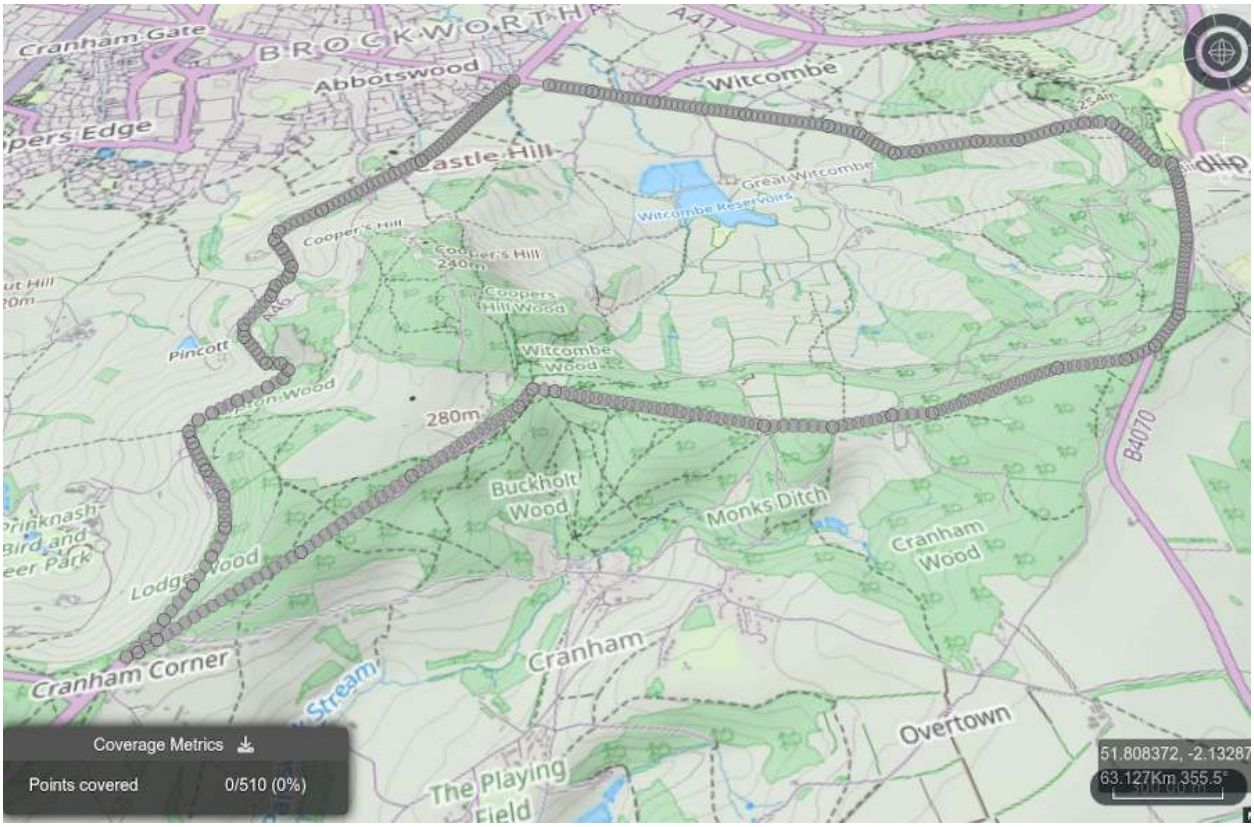
In the "Coverage Metrics" window you can click on the "Download Coverage Metrics Report" icon  to obtain a report from your calculations. This is a `txt` file with information:

```
Location Coverage Metrics Report
Thu Apr 06 2023 12:56:54 GMT+0100 (British Summer Time)
Cloud-RF

NORTH DISTRICT: 4/10 (40%)
WEST DISTRICT: 3/10 (30%)
SOUTH DISTRICT: 2/10 (20%)
EAST DISTRICT: 4/10 (40%)

TOTAL COVERAGE: 13/40 (33%)

Layers:
0406125414_My_Site
0406125639_My_Site
0406125642_My_Site
0406125645_My_Site
0406125651_My_Site
```

5.12 Route analysis

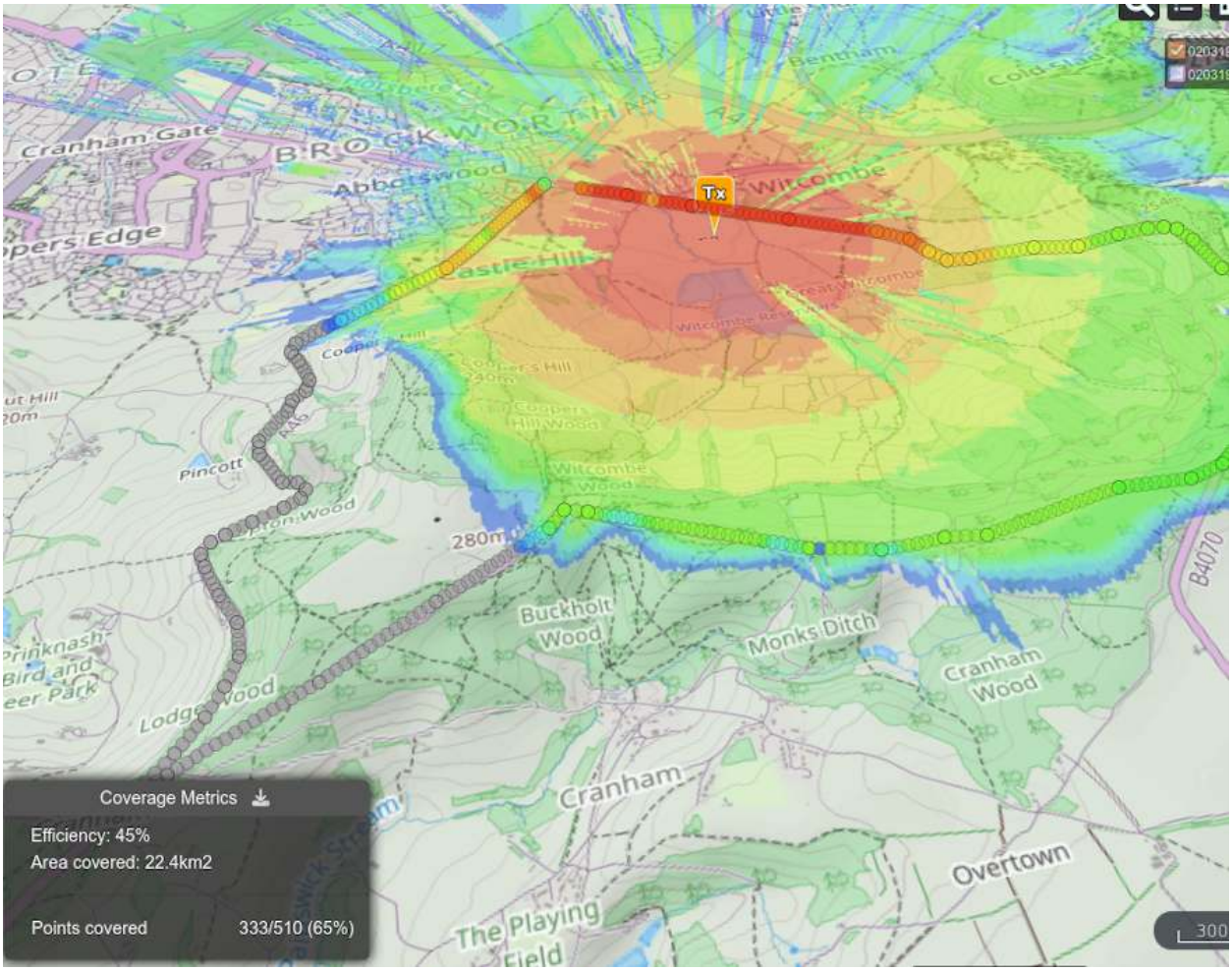
The route import feature lets you load a CSV, KML or KMZ polyline describing a route for analysis. This is a more advanced and powerful alternative to the "route analysis" tool which is only a freehand "quick look" against the start position.

Load in the KML to render it on the map and then create or reload a heatmap layer. This layer can be either an "area" calculation or a multisite heatmap using the MANET tool.

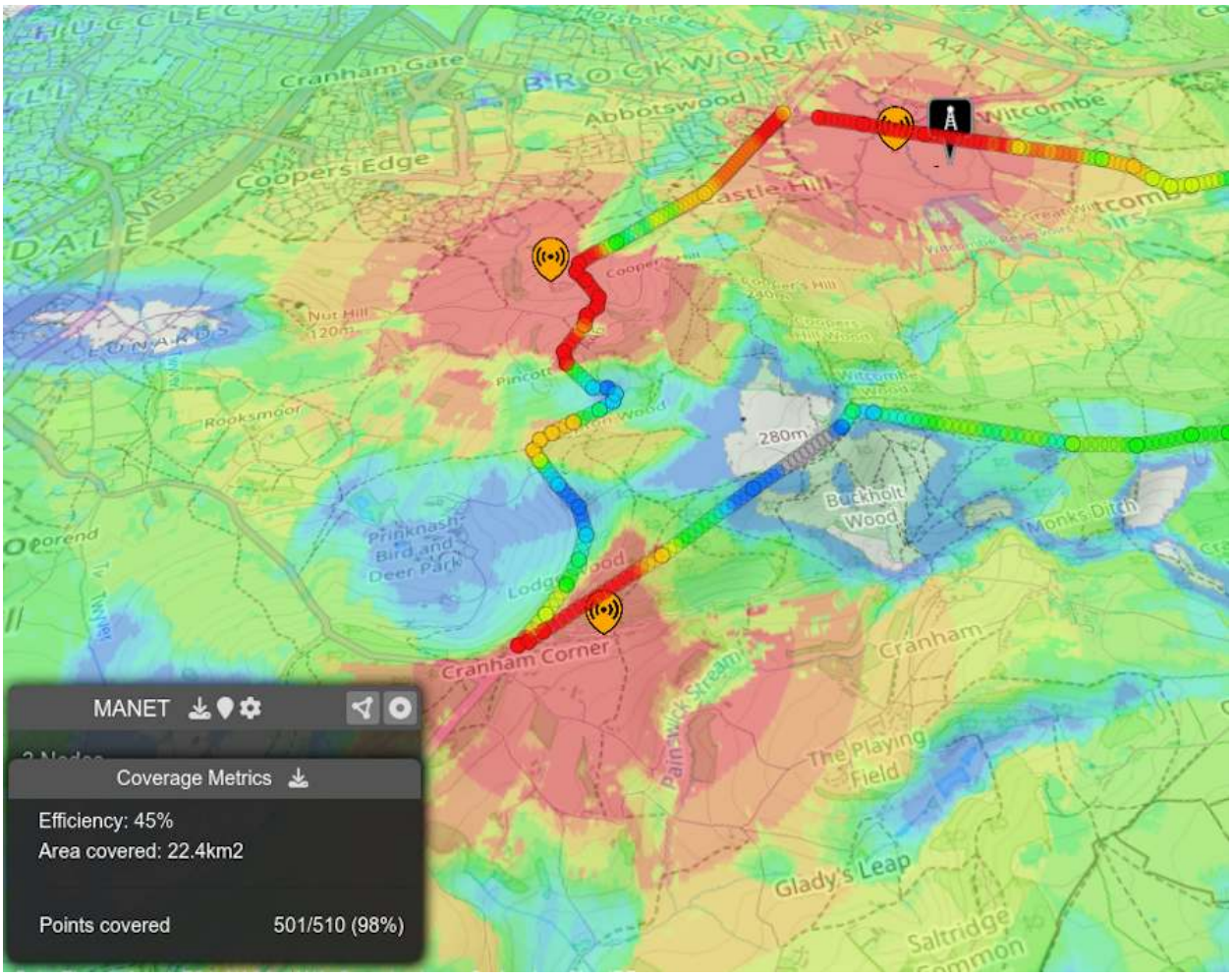


Multiple layers can be added to the map for analysis. When a layer is removed, it is updated.

Note that clearing the map at this point will also clear the route so use the layer manager instead to hide layers.



The MANET tool, when used in conjunction with route analysis will update the coverage statistics after every change.



5.12.1 Import a flightpath

The data only needs points for each vertex as it uses interpolation to complete the route. Route coverage is presented in the corner as a percentage against use defined radio parameters eg. 75%.

The route import feature supports flightpaths above the ground as CSV or KML. Both OGC line strings and gx extensions are supported. You can fetch a flightpath from ADSB exchange and load it in directly.

Only one flightpath is supported within a KML file and sometimes ADSB files contain several; for example one for taxiing and another post take off.

Altitudes will be placed using the selected altitude units. If you need height AMSL then ensure you select this.

To test coverage to a ground site, click on the map to site the receiver and click the play button to test the path using the points API.

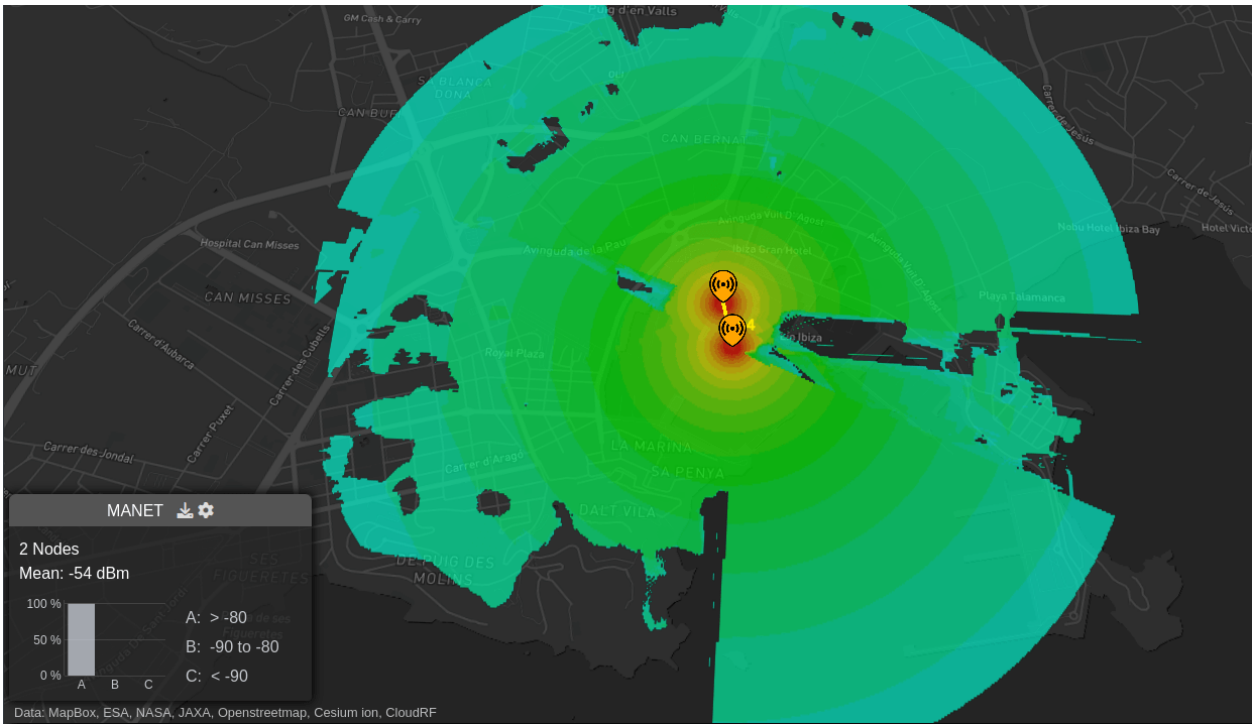
5.13 MANET network

If you select "MANET Tool" from the "Purpose" dropdown then this can be used to import points for use with the MANET tool (GPU required). This is useful when you wish to use the MANET tool but don't want to have to keep redrawing markers at the same locations if you want to test different profiles for example.

Please note that when you upload your file using "MANET Tool", each point in your uploaded file will be applied with the same values that you currently have set for your settings.

After you submit your uploaded file a MANET calculation will be fired off immediately using your settings and preferences.

Below shows the result of a MANET calculation after being uploaded from a KML file:

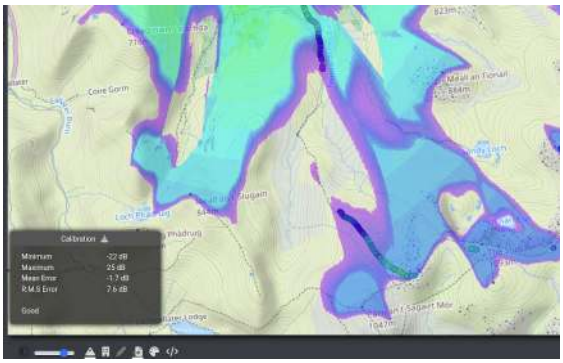


The above screenshot is taken from the following KML:

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml/2.2">
  <Document>
    <Placemark>
      <name>Point 1</name>
      <Point>
        <coordinates>
          1.4397022,38.9146682,0
        </coordinates>
      </Point>
    </Placemark>
    <Placemark>
      <name>Point 2</name>
      <Point>
        <coordinates>
          1.440185,38.9130821,0
        </coordinates>
      </Point>
    </Placemark>
  </Document>
</kml>
```

For more information please consult the section relating to the *MANET planning tool*.

5.13.1 Survey data and Calibration



You can upload a CSV with field measurements for easy modelling calibration. This was developed with CSV output from Cellmapper which is recommended for cellular surveys like the LTE800 survey in the image above.

Survey hardware like Nemo Handy and SDRs are also supported providing power measurements can be represented as dB or dBm.

For basic power measurements, your CSV should follow the following rules:

- The following fields are accepted:
  - `latitude` is the latitude coordinate of the point. Should be a decimal value between -180 and 180.
  - `longitude` is the longitude coordinate of the point. Should be a decimal value between -90 and 90.
  - `rssi` is the measured signal strength in dBm. For cellular this can be either received power or RSRP providing it matches what you are using in your modelling.
- Your CSV must contain a header indicating the ordering of your fields.

An example CSV might look something like the below:

```
longitude,latitude,rssi
3.0505242,39.2707224,-77
3.0807366,39.2866678,-82
3.0520286,39.3742523,-83
3.0678215,39.3787639,-88
```

Your CSV will be automatically validated when you upload it, if there are any errors then this will be displayed in the dialog window.

After successfully uploading your CSV it will be parsed and the interface will automatically draw your points onto the map and compute the delta between any visible layer upon it.

You may notice that a new window will be added to the bottom left of the screen. This is a live-updating metrics report which gives you details about the ***computed error***. A good error value is less than 8dB and an excellent value is less than 5dB. Anything greater than 8dB normally requires adjustments to your modelling parameters.

Be aware that field measurements contain receiver error. This can vary from 1dB for a high quality receiver to 3dB for a cell phone. This inherent error is separate to modelling error so if you achieve 9dB alignment with cell phone measurements then this is represents a modelling error of about 6dB - pretty good.

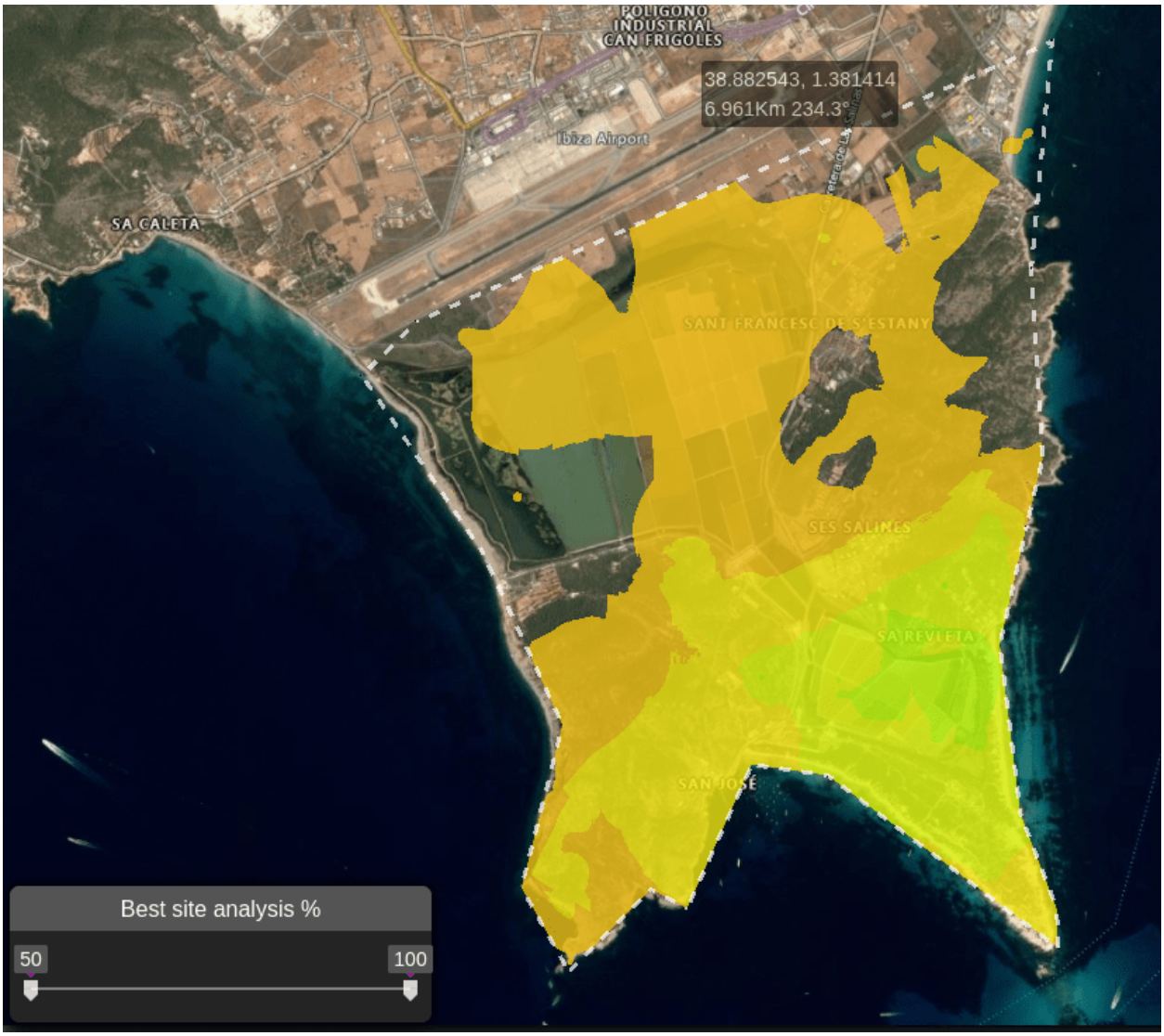
If you next click on the map and run through a calculation you should see the points being coloured based on the signal strength but also the metrics report should update automatically where new calculations cover points.

As you do multiple calculations this will build up your available layers on the map. As you check/uncheck them it will automatically update your metrics report. This is useful for comparing settings.

5.14 Best Site Analysis

If you select "Best Site Analysis" from the "Purpose" dropdown then this is used to upload a polygon of a boundary which is used with the best site analysis functionality. This is useful if you are working with very specific boundaries and don't wish to keep redrawing the area. Instead you can upload your file and have the calculation repeated with the same values every time.

Upon successful upload of your boundary the best site analysis tool will be immediately fired off using your current settings.



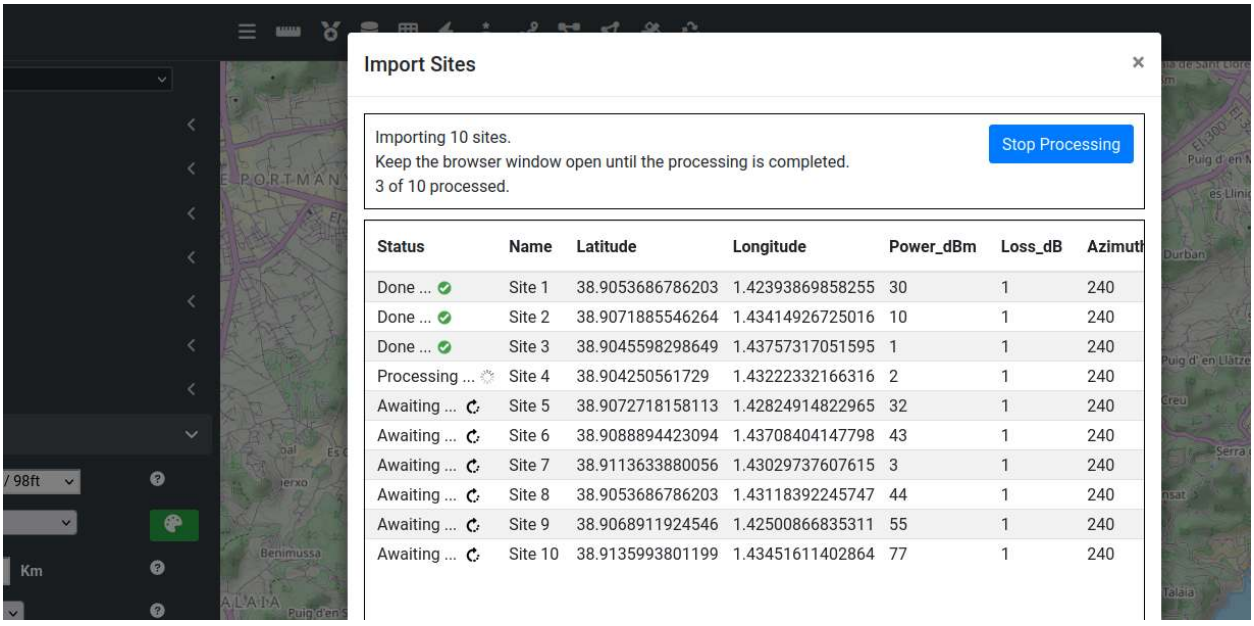
For more information please consult the section relating to the *best site analysis planning tool*.

5.15 Automatic Processing Guidance

If you select "Automatic processing" from the "Purpose" dropdown then this will enable you to upload a simple CSV spreadsheet describing the sites in your network. This uses a subset of what is available in the API and all other settings will be set in your form at the point of upload eg. Radius and Resolution.

This is a simplified way to use the API via the user interface which has limited options compared to the full

examples documented on GitHub



The CSV format must conform to one of two standards; a short format or a long format.

5.15.1 Short format CSV

Your CSV files must have these column headers:

- `Name`
- `Latitude`: between -90 and 90 (required)
- `Longitude`: between -180 and 180 (required)
- `Power_W`: (required)
- `Loss_dB`
- `Azimuth_deg`: between 0 and 359
- `Downtilt_deg`: between 0 and 359
- `Height_m`: between 0.1 and 60000 (required)
- `Gain_dB`

Example CSV

```
Name,Latitude,Longitude,Power_dBm,Misc Loss (dB),Azimuth_deg,Downtilt_deg,Height_m,Gain_
↪dB,Loss_dB
Site 1,38.9053686786203,1.42393869858255,30,0,240,10,6,8,1
Site 2,38.9071885546264,1.43414926725016,10,0,240,10,1,8,1
Site 3,38.9045598298649,1.43757317051595,1,0,240,10,10,8,1
Site 4,38.904250561729,1.43222332166316,2,0,240,10,11,8,1
Site 5,38.9072718158113,1.42824914822965,32,0,240,10,10,8,1
Site 6,38.9088894423094,1.43708404147798,43,0,240,10,9,8,1
Site 7,38.9113633880056,1.43029737607615,3,0,240,10,7,8,1
Site 8,38.9053686786203,1.43118392245747,44,0,240,10,8,8,1
```

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```
Site 9,38.9068911924546,1.42500866835311,55,0,240,10,9,8,1
Site 10,38.9135993801199,1.43451611402864,77,0,240,10,7,8,1
```

5.15.2 Long format CSV

Your CSV files must have these column headers:

- `Site`
- `Latitude`: between -90 and 90 (required)
- `Longitude`: between -180 and 180 (required)
- `Height_m` (required)
- `Frequency_MHz`: between 2 and 100000(required)
- `Bandwidth_MHz`: between 0.1 and 200
- `Power_W` (required)
- `Receiver_Height_m`: between 0 and 60000
- `Receiver_Gain_dBi`: between -30 and 60
- `Receiver_Sensitivity_dBm`
- `Antenna_Pattern`: Pattern name or "Custom"
- `Antenna_Polarisation`: "V" for vertical or "H" for horizontal
- `Antenna_Gain_dBi`
- `Antenna_Loss_dB`
- `Antenna_Azimuth_deg`: between 0 and 359
- `Antenna_Tilt_deg`: between 0 and 359
- `Antenna_Horizontal_Beamwidth_deg`: between 0 and 360 (required for custom patterns)
- `Antenna_Vertical_Beamwidth_deg`: between 0 and 360 (required for custom patterns)
- `Front_to_back`: between 0 and 360 (required for custom patterns)
- `Noise_floor_dBm`
- `Measured_units`
- `Colour_schema`
- `Model`
- `Context`
- `Diffraction`
- `Reliability`
- `Profile`

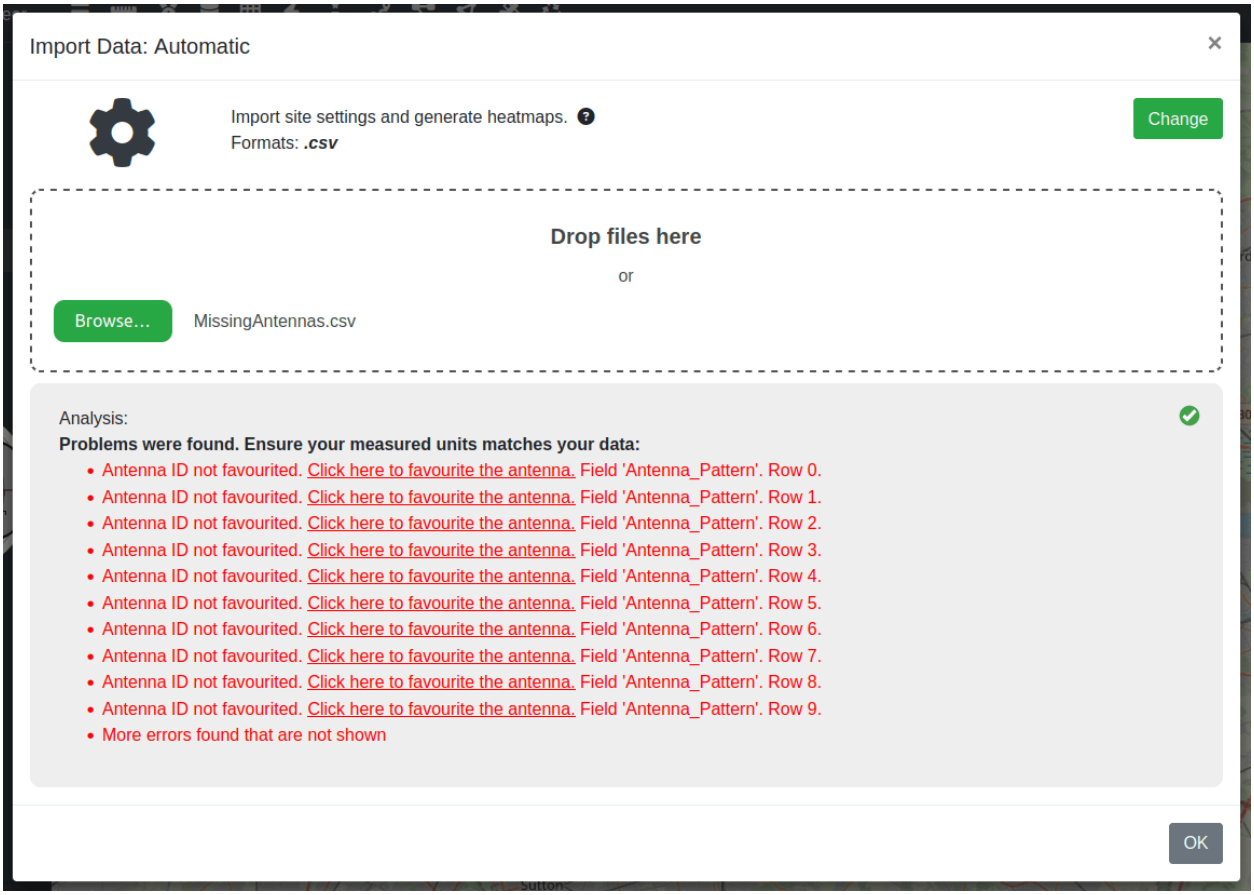
Example CSV

```
Site,Latitude,Longitude,Height_m,Frequency_MHz,Bandwidth_MHz,Power_W,Antenna_Pattern,
↪Antenna_Polarisation,Antenna_Loss_dB,Antenna_Azimuth_deg,Antenna_Tilt_deg,Antenna_Gain_
↪dBi,Noise_floor_dBm,Model
Site 1,38.9053686786203,1.42393869858255,10,446,1.4,30,OEM Half-Wave Dipole,V,0,240,10,8,
↪-120,Egli VHF/UHF (< 1.5GHz)
Site 2,38.9071885546264,1.43414926725016,11,800,10,10,OEM Half-Wave Dipole,V,10,240,10,8,
↪-90,Egli VHF/UHF (< 1.5GHz)
Site 3,38.9045598298649,1.43757317051595,20,2400,20,1,OEM Half-Wave Dipole,H,11,240,10,8,
↪-70,Egli VHF/UHF (< 1.5GHz)
Site 4,38.904250561729,1.43222332166316,15,2100,22,2,OEM Half-Wave Dipole,V,4,240,10,8,-
↪180,Egli VHF/UHF (< 1.5GHz)
Site 5,38.9072718158113,1.42824914822965,7,900,1.9,32,OEM Half-Wave Dipole,H,5,240,10,8,-
↪90,Egli VHF/UHF (< 1.5GHz)
Site 6,38.9088894423094,1.43708404147798,30,1700,1.8,43,OEM Half-Wave Dipole,V,6,240,10,
↪8,-120,Egli VHF/UHF (< 1.5GHz)
Site 7,38.9113633880056,1.43029737607615,31,1800,18,3,OEM Half-Wave Dipole,H,1,240,10,8,-
↪140,Egli VHF/UHF (< 1.5GHz)
```

Troubleshooting - Missing Antenna

When specifying an antenna ID within your CSV for automatic processing, you should have the the antenna pattern favourited, otherwise you will be prompted with a validation error.

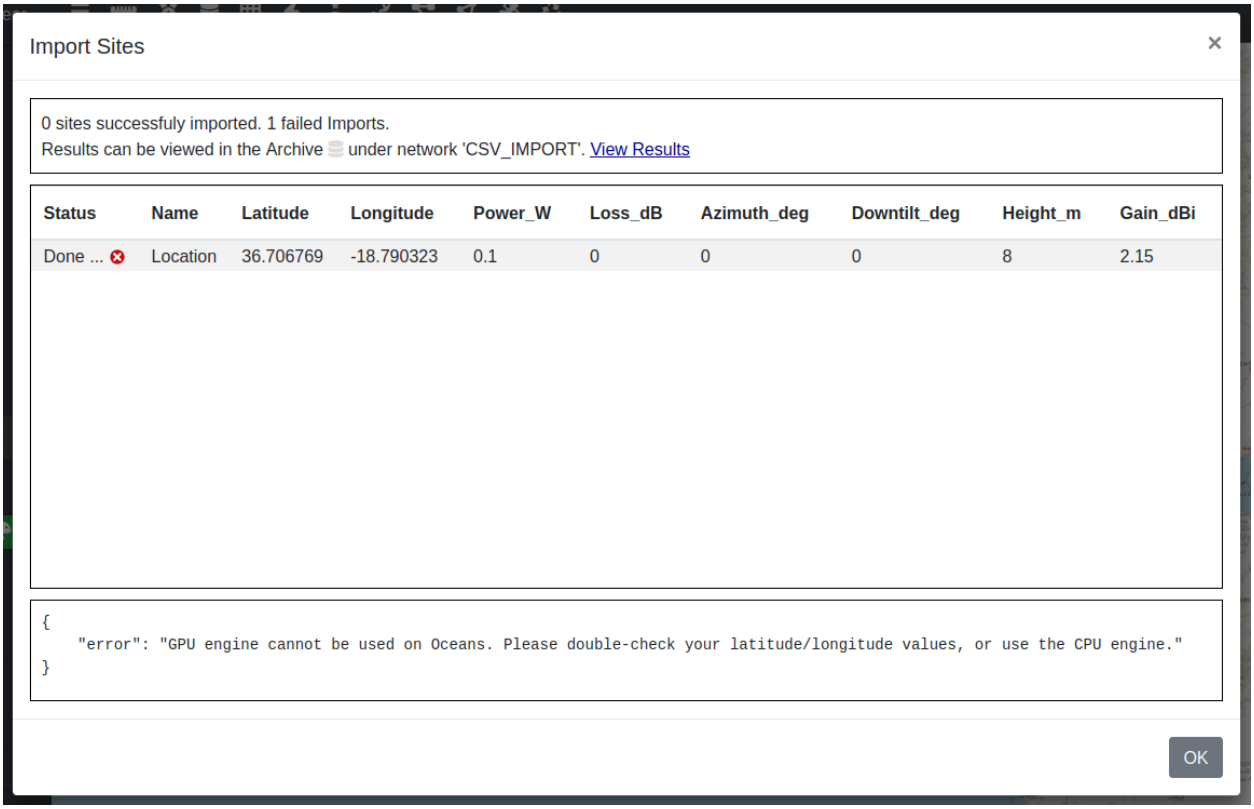
You can either *follow the guide on favouriting antenna patterns*, or during validation you can click on the prompt and the missing antenna patterns will be favourited, providing that they exist within the antennas database.



Troubleshooting - Calculation Response

If you wish to see the response for a calculation, you can click on the status icon for that calculation (or).

After clicking on this a guidance box will be displayed at the bottom of the modal window. This can be useful for identifying why individual calculations have failed. Below shows an example.


Import Sites
0 sites successfuly imported. 1 failed Imports.
Results can be viewed in the Archive under network 'CSV_IMPORT'. View Results
Status Name Latitude Longitude Power_W Loss_dB Azimuth_deg Downtilt_deg Height_m Gain_dBi
Done ... Location 36.706769 -18.790323 0.1 0 0 0 8 2.15
{
"error": "GPU engine cannot be used on Oceans. Please double-check your latitude/longitude values, or use the CPU engine."
}
OK

CHAPTER

SIX

ATAK PLUGIN

Android Team Awareness Kit (TAK) is a US Government situational awareness application, available for free on Android (ATAK). The civilian version is available for free on the Google Play store.

ATAK-CIV https://play.google.com/store/apps/details?id=com.atakmap.app.civ

6.1 Requirements

- ATAK (CIV or MIL)
- A CloudRF account *or* a SOOTHSAYER server
- A network connection

Our plugin is signed by the TAK Product Center (TPC) which at the time of writing means it should work on Civilian and Government flavours.

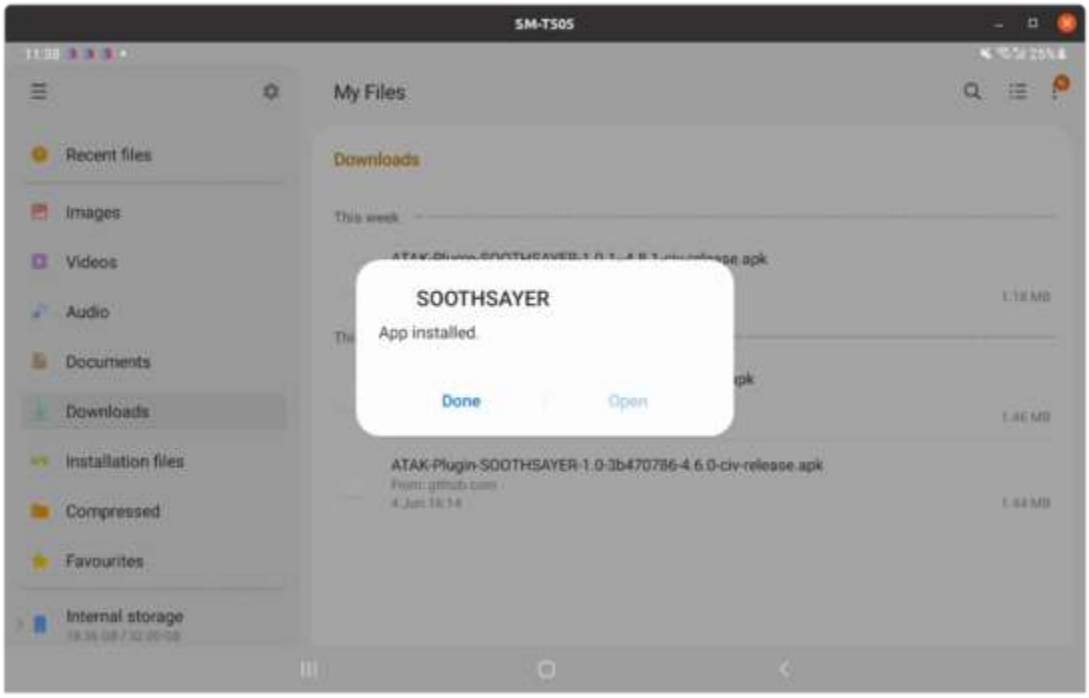
6.2 Plugin installation

Install ATAK on your phone/tablet and then download the latest APK file from https://cloudrf.com/atak-plugin

At the time of writing, v1.5 (March 2025) is the latest.

You can download it directly from the device with a browser, send the file to the device via email/IM or copy it over via USB.

Before you attempt installation of the APK, ensure ATAK is running. If it is not running, installation will fail which is expected behaviour.



Within ATAK, open the plugin manager (jigsaw icon) and you should see the SOOTHSAYER plugin listed as available but not loaded. At this point you need to check the central status box to load the plugin. This is also where ATAK will check compatibility.

6.2.1 Validating the plugin version

To see details about the plugin version, click the report icon to the right. It should specify the required Android OS (10 in our case) and ATAK version (4.8.1.CIV) as well as the signature validity which for a TPC signed plugin should be valid:

6.2.2 Adding a shortcut in ATAK

Once installed the plugin will be available within ATAK. To add it to the quick menu, click the pencil marker adjacent to the "Tools" label above the icons. This opens up the navigation bar to editing so you can drag your new plugin up there.

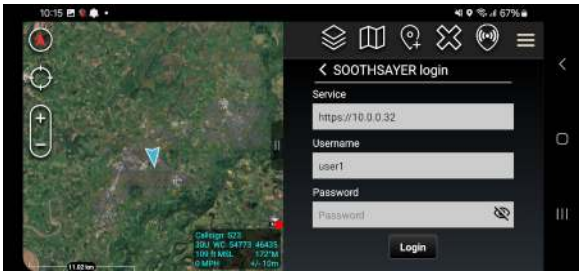
6.3 Logging in to your account

Press the new SOOTHSAYER button to open the plugin. You should have a list select and a top row of buttons.

The plugin needs a CloudRF or SOOTHSAYER account to function. To login to your account, press the corner settings button and then navigate to the account login page via the account button at the bottom.

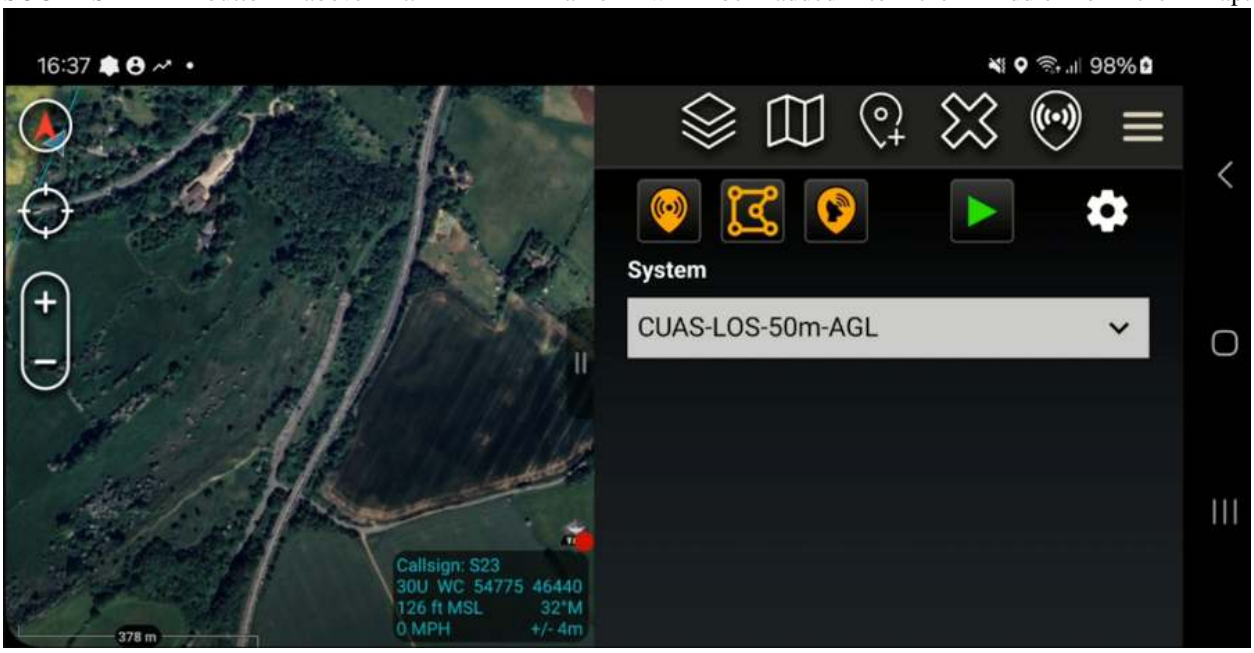
- Enter your server's address starting with **https://**
- Enter your username and password then click 'Login'.

A successful login will redirect you back to the plugin start page and synchronise RF templates from your account to your device.



6.4 Using the plugin

To add a radio to the map, choose the system from the drop down list, then click the SOOTHSAYER button above it. A marker will be added to the middle of the map.



To trigger a calculation, you can press the green Play button or press and then drag the marker to the desired location using a “long press”.

6.5 Settings

6.5.1 Coverage layer

Single site mode places each radio coverage as a separate image layer. This can get cluttered with many radios but can be managed via the native layer manager.

Multisite (GPU) mode is a more powerful capability which models **all radios** together to show network coverage. This updates one “MULTISITE” layer only.

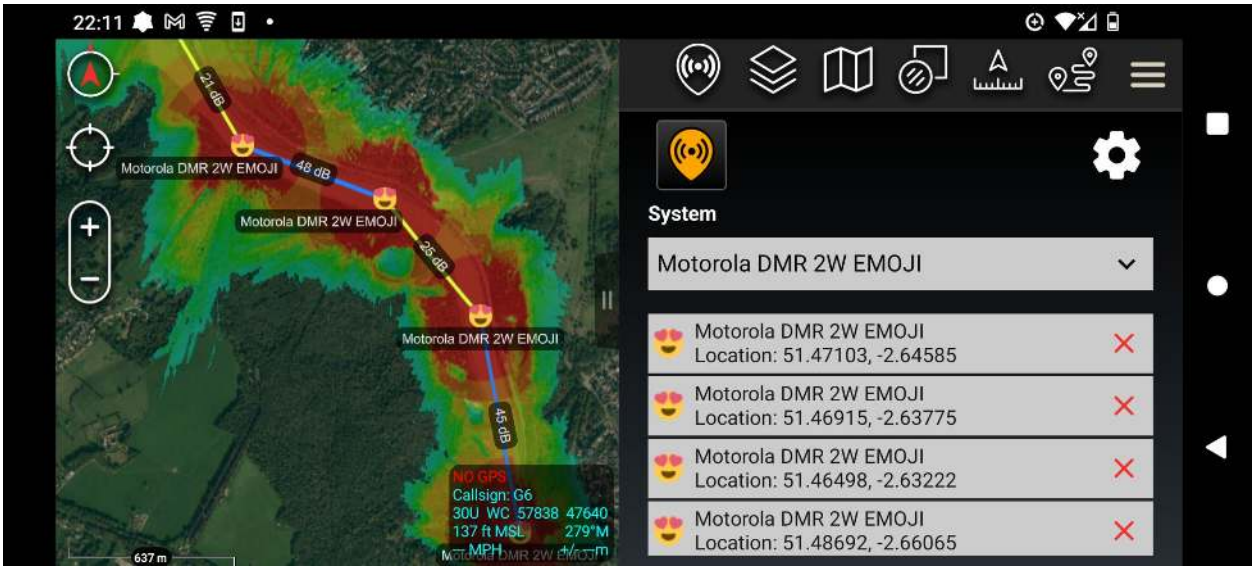
`Multisite requires a server with a GPU or a premium CloudRF subscription.`

6.5.2 Show coverage

This checkbox will show or hide RF coverage. This can be useful to save bandwidth if the interest is links.

6.5.3 Show links

This checkbox will show or hide RF links between radios. This uses less bandwidth than coverage layers, and is faster.



A multisite layer is a single layer which is available in the ATAK layers menu under the “SOOTHSAYER” category. It can be hidden or deleted to suit.

6.6 Polygon tool

The polygon tool allows focused studies of distant areas using the "bounds" parameter in the API. This allows faster, smaller, higher resolution calculations which reduce bandwidth and memory consumption in the viewer whilst keeping the wider map clear.

To use it, click the polygon button and draw a shape upon the map. This shape will be referenced for all future calculations.

6.7 Editing a transmitter

Transmitter settings can be edited once they're on the map.

Select the transmitter to open the menu then click the pencil to edit the settings. An edit form will open which supports **Height, Power, Frequency, Azimuth, Bandwidth and Noise.** Click recalculate to apply any change(s). Template files are unaffected and multiple azimuths are supported separated by commas.

Other template settings can be edited in the .json template file on the SD card.

6.8 Satellite tool

The Satellite coverage feature lets you test an area for line-of-sight to a GS satellite. It offers a high resolution study beyond basic sat-finder apps which will recommend a shot through a mountain.

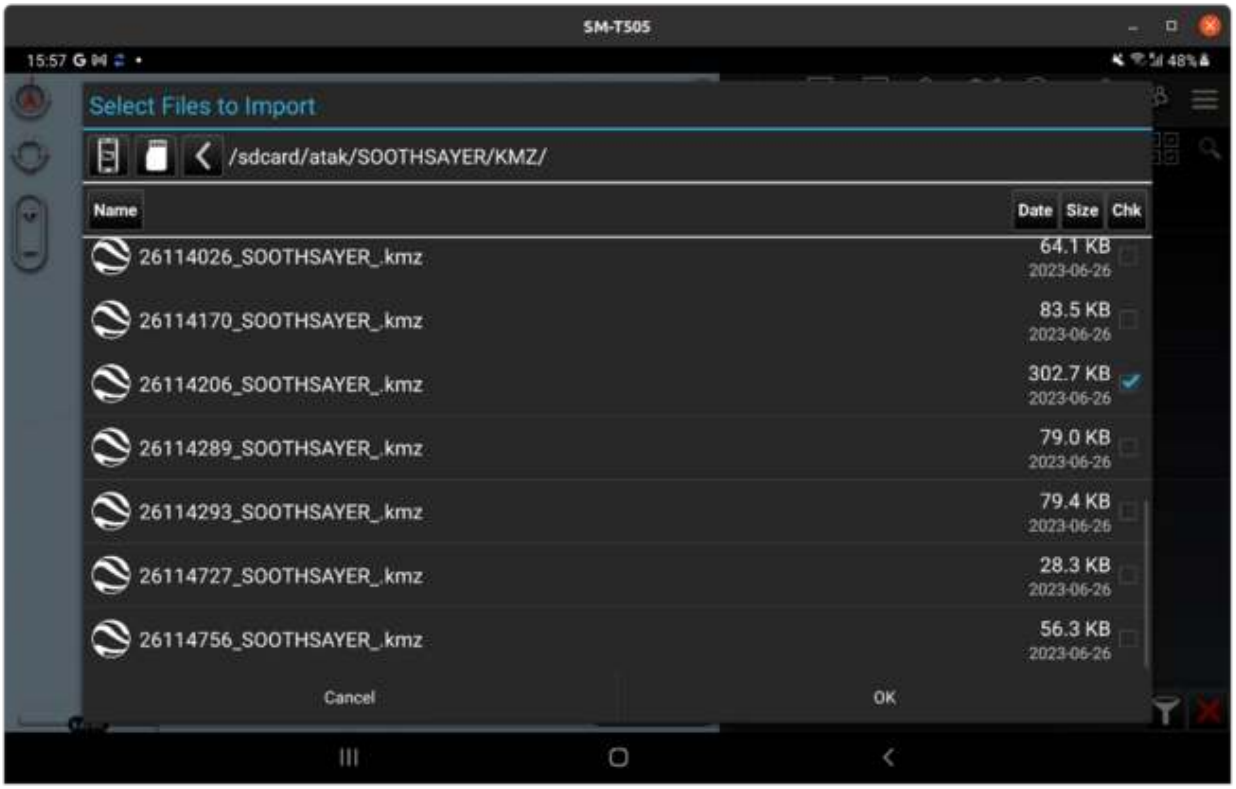
Select your satellite and time of day, resolution and finally drag the marker to test that area. A high resolution will reduce the study area to produce the layer quicker.

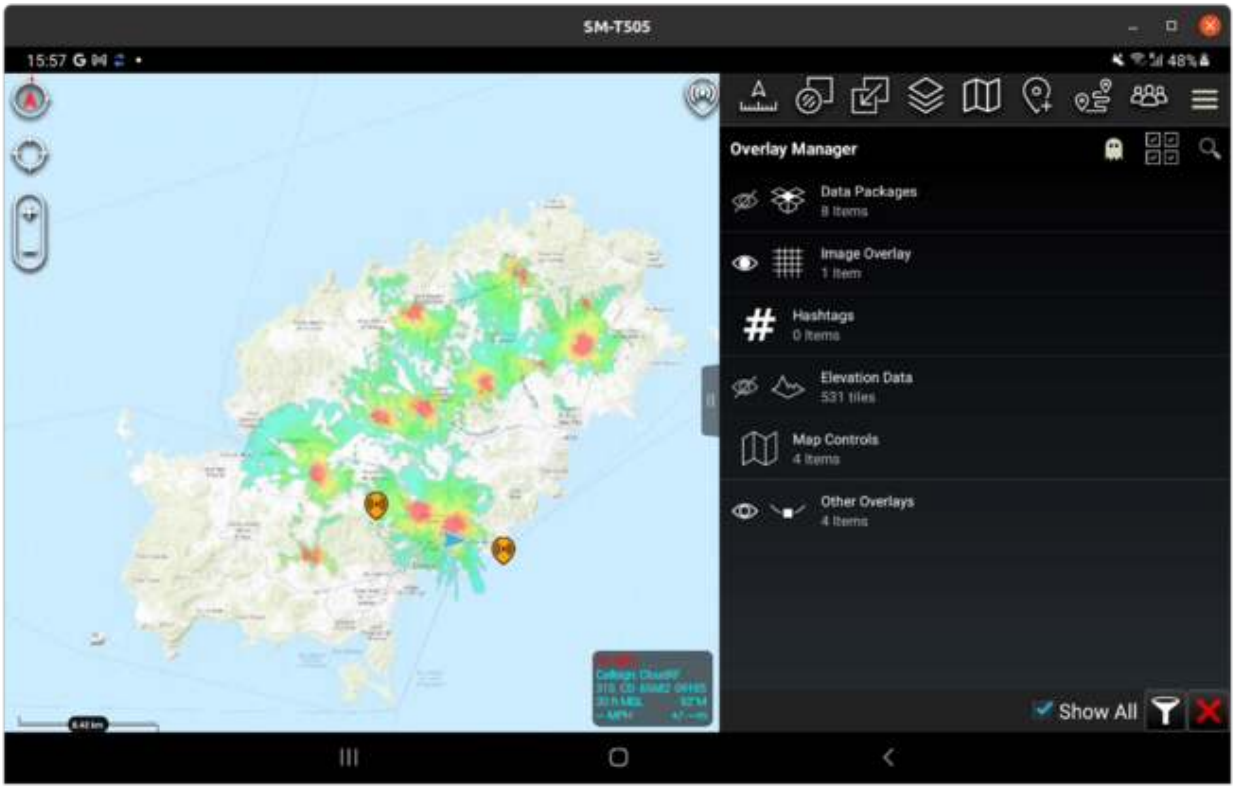
Satellite TLE data is updated periodically on CloudRF from public sources and SOOTHSAYER server customers can manage their TLE data and source via their admin dashboard.

6.9 KMZ export

Layers generated with the plugin are saved as KMZ on the SD card in the atak/SOOTHSAYER/KMZ/ folder. You can load them into ATAK as standard KMZ overlays using the "Local import" dialog or export them to another viewer such as WinTAK or TAK-X. When prompted for a choice of the import method, choose "Image Overlay File".


SM-T505
15:56
Overlay Manager
Data Packages
Hashtags
Select Import Type
Local SD
Gallery
KML Link
HTTP URL
Choose App...
Cancel
Show All


SM-T505
15:57
Select Files to Import
/sdcard/atak/SOOTHSAYER/KMZ/
Name
Date
Size
Chk
26114026_SOOTHSAYER_.kmz
64.1 KB
2023-06-26
26114170_SOOTHSAYER_.kmz
83.5 KB
2023-06-26
26114206_SOOTHSAYER_.kmz
302.7 KB
2023-06-26
26114289_SOOTHSAYER_.kmz
79.0 KB
2023-06-26
26114293_SOOTHSAYER_.kmz
79.4 KB
2023-06-26
26114727_SOOTHSAYER_.kmz
28.3 KB
2023-06-26
26114756_SOOTHSAYER_.kmz
56.3 KB
2023-06-26
Cancel
OK



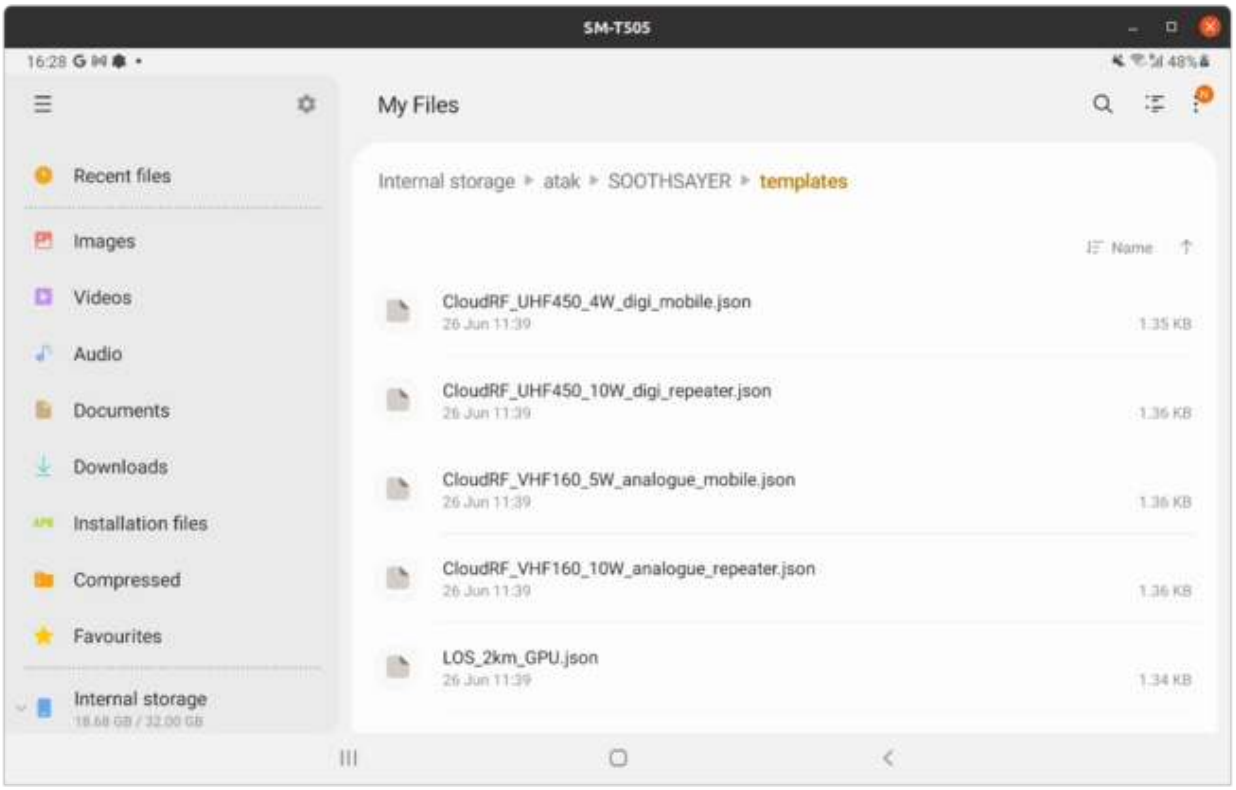
To send a KMZ to another TAK user, load it onto your map to validate it's the right one, then using ATAK's native send functionality, click the 3 bars to the right of the selected layer to open the send dialog. From here you can choose to send it to a contact, server or third party app eg. Bluetooth or Google Drive.

6.10 Radio Templates

Templates are synchronised after you login with your account.

To add local radio systems, place your CloudRF/SOOTHSAYER JSON templates in the atak/SOOTHSAYER/templates folder. You can also download templates as .json files from the top left corner in the CloudRF/SOOTHSAYER web interface.

A template can be edited within any text editor and must conform to the CloudRF API specification detailed at https://cloudrf.com/documentation/developer/



6.10.1 Example DMR template

This template is for a 700MHz handheld radio with 2W of RF power, a GPU engine (engine: 1) with the General Purpose model (#10), Deygout diffraction (#4), a 3km radius and 4m resolution and buildings data.


```
{
    "version": "CloudRF-API-v3.8.2",
    "reference": "https://cloudrf.com/documentation/developer/",
    "template": {
        "name": "Motorola DMR 2W",
        "service": "CloudRF https://api.cloudrf.com",
        "created_at": "2023-04-12T06:35:40+00:00",
        "owner": 1,
        "bom_value": 0
    },
    "site": "Site",
    "network": "MOTO",
    "engine": 1,
    "coordinates": 1,
    "transmitter": {
        "lat": 51.96403,
        "lon": -2.113952,
        "alt": 2,
        "frq": 700,
        "txw": 2,
        "bwi": 0.1,
        "powerUnit": "W"
```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```
    },
    "receiver": {
        "lat": 0,
        "lon": 0,
        "alt": 1,
        "rxg": 2,
        "rxs": -100
    },
    "feeder": {
        "flt": 1,
        "fll": 0,
        "fcc": 0
    },
    "antenna": {
        "mode": "template",
        "txg": 2.15,
        "txl": 0,
        "ant": 39,
        "azi": 0,
        "tlt": 0,
        "hbw": 1,
        "vbw": 1,
        "fbr": 2.15,
        "pol": "v"
    },
    "model": {
        "pm": 10,
        "pe": 2,
        "ked": 4,
        "rel": 70
    },
    "environment": {
        "clt": "Minimal.clt",
        "elevation": 1,
        "landcover": 1,
        "buildings": 1,
        "obstacles": 0
    },
    "output": {
        "units": "m",
        "col": "LTE.dBm",
        "out": 2,
        "ber": 1,
        "mod": 0,
        "nf": -124,
        "res": 4,
        "rad": 3
    }
}
```

6.10.2 Example GPU 'line of sight' template

This template uses the more powerful GPU engine (engine: 1) to model line of sight out to 3km at 2m resolution (if your area of interest has 2m LiDAR).


```
{
    "version": "CloudRF-API-v3.8.2",
    "reference": "https://cloudrf.com/documentation/developer/",
    "template": {
        "name": "LOS_3km_2m_GPU",
        "service": "SOOTHSAYER https://185.11.204.106",
        "created_at": "2023-05-05T15:43:42+00:00",
        "owner": 8,
        "bom_value": 0
    },
    "site": "Site",
    "network": "TALON",
    "engine": 1,
    "coordinates": 1,
    "transmitter": {
        "lat": 50.806335,
        "lon": -1.112032,
        "alt": 2,
        "frq": 1250,
        "txw": 2,
        "bwi": 0.1,
        "powerUnit": "W"
    },
    "receiver": {
        "lat": 38.913,
        "lon": 1.45,
        "alt": 1,
        "rxg": 2,
        "rxs": -90
    },
    "feeder": {
        "flt": 1,
        "fll": 0,
        "fcc": 0
    },
    "antenna": {
        "mode": "template",
        "txg": 2,
        "txl": 0,
        "ant": 39,
        "azi": 0,
        "tlt": 0,
        "hbw": 1,
        "vbw": 1,
        "fbr": 2,
        "pol": "v"
    },
    "model": {
        "pm": 7,
```


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```
        "pe": 2,
        "ked": 0,
        "rel": 50
    },
    "environment": {
        "clm": 0,
        "cll": 0,
        "clt": "Temperate.clt"
    },
    "output": {
        "units": "m",
        "col": "GREEN.dBm",
        "out": 2,
        "ber": 1,
        "mod": 0,
        "nf": -124,
        "res": 2,
        "rad": 3
    }
}
```

6.10.3 Template limits

As a server based system, limits for APIs and accounts are set at the server. For premium users this means a 500km / 310Mi radius and a resolution between 1m / 3ft. The combination of these two will determine the resulting file size. *The API will automatically reduce unreasonable parameters to fit within memory.*

As well as memory, a large layer needs more bandwidth to communicate and is generally not recommended. You should be aiming for smaller layers which can be generated and communicated quickly. You can still do a large radius eg. > 100km, but will need to offset your resolution to keep the total size less than 1 mega pixels (1000 x 1000px).

`As a rule of thumb, multiply the radius in km by 2 to get the resolution in metres`

The following guide is recommend for practical 1MP ATAK templates:

Desired radius km	Recommended max resolution m
1	2
2	4
5	10
10	20
20	40
50	100
100	200
150	300

6.10.4 Giant airborne calculations

The API can model out to 500km radius for aircraft. If you set 500km as the radius with 100m resolution you are generating a 10k x 10k image measuring 100 mega pixels! This will take a long time to make, a long time to download and then will crash ATAK, and any other Android map for that matter. To do this scale of calculation, use a resolution of 300m which makes a more digestible 11MP image. Better still reduce the radius to the radio horizon which is 357km for an aircraft at 10,000m (33,000ft).

6.10.5 Custom icons

You can insert a *small* custom icon into a JSON template as a base64 encoded PNG with the "custom_icon" value. The example JSON template below has a name of CUSTOM_ICON with a PNG radio icon and a GPU engine defined at the top level of the template. Keep the PNG images small (~ 48x48px) to keep memory use down.

```
{
    "custom_icon": "
↪iVBORw0KGgoAAAANSUhEUgAAACAAAAAgCAYAAABzenr0AAAH4HpUWHRSYXcgcHJvZmlsZSB0eXBlIGV4aWYAAHjarZdpciM7DoT/
↪8xRzBG7gchxwi5gbvOPPB0py2912jx3xVKFiicViAUhkAnL7n/
↪8e9x8+MbfsstRWeimeT+65R+Wi+cen33Pw+Z7vJz5v8fvDvHu7EZlKjOnxs+pzvTIvvx54vSOMj/OuPe/
↪E9tzoeeO1YbI329vWeyOZj4/5kJ8b9f24KL3V96aOp6nzufCa8vzO/
↪fAwPF9mv937iVyJ0hJWpRh3Yvqe28OCZN+UlLFxjqnZOu5rkiSOIaeXrwTkg3uv0fv3AfoQ5NeV+z36b1e/BT/
↪qcz79FsvyjBEXn94I8nnwb4jfvTi9WRQ/3qjrDeE/
↪gnzOaufsh3eaCxEtz4zy7hUde4aFg5Cn+1jhqHyF63qPztG8+gnky08/
↪OGboIYLKcSGHFTScsO84w8TEHHesjDFOYLG5lmrscYJYAByOcGJNPS0QjGnG7QA0p/
↪hmS7jv7fd9MzTevAJLY2CzwCNfHu5vN39yuHOmhSj49hYr7IqWuZhhyNmZVQASzhM3uQF+HU/4/
↪bv8IVVBUG6YGw6qH48thoRfuZUuzol1wvigUHDA/
↪diAEPFuwZiQQMCXkCSU4GuMNQTi2ABIsTymHAcIBJG4MDLmlEp0NUIZ3s0zNdy1UWKJNo02GX1SSRVselLAylnIn4qS9axQLItIkSi
↪cfsEtWV1bl7EHiy0mPoE+1ijsTm+3nP6zhi71LmTnLxWnb1myuSQvmSm5cpaofi0p3xzty9G942FIKyn4nHfRBifdNQ9qG2L2M5SF
↪Cib6kaVm3kTUm56gWd2imLoNvMEGded9k4uvF99nikDjaf68hIGZzqGCtkCXnmO4gV/
↪D9G99WNINun3IdP6+iYYQ9q5JQ4GuEuulYkT4n/XvyKWh1NBvVBdElRDVqhxEKyyAroYGI2cIDc7LpKxw/
↪6nSD2RBLJSrXiRiBhHXGzAK6xG9FcykhKmlSadf7bo8XokHrQtbaw8oBlXqe93865WUlVbOstiPaRD8nf7D0IbecxAJEFEC4dG5Ol
↪9yM9CSwoRCKEwU9YBZzsh6QslWru0x9Q4qElNrkvQv3pSPz5HmhBtqxrfvJbx0LZnRDQoJ2XjZbNoYpxVbGpkf0J2xe6sZAIvKJexG
↪s4I++PYdejRYBddu5EwXbRxBQthcsGsoLuoUZlm8ggSWbFgDmNGPpdrnazbgHYduUPxUQrFYa7i78Ih86yyVwmLcgMcom2zJ2jwwIZ
↪8+ThyMQRMsEuXJ7eTCY9hLOxdA6agvQwXkw75M68/ABVgwPm+EphQ9VqJNkJNu1OsOA/
↪IKD+kvr4ULY8PdkGuBYWhnV5RQRRQ6NH7K+sd9+mx0nTnl6mpVcWSeICG5dlc/
↪Qu0ZRsjYMqaJWomSdTKlnB8LsnEDWvGrEry8MRNp3mCE0Epcyog6NcXkeK1VFaShzABQKgwQhCTf6LJrnPCfJLo6x/
↪82ZE6zI6Z/a8wZcHBgm0MMVKNiaMrpch+uTI3924eJhUURM58/
↪dlSnYdQAyBRJ1XiHQZkusy9bAwpx8USKSa7GrQhHbBBBwyG0Gh8jKx3VzRX2zCBVHUxwRboHS2gbAivoU/
↪ftt6EX9zI+HKsQFX4k2taQ69XFnGmfR0xTwxSFi4dxnNlVuNIUlOPy769CnmSuJiuluMolq4b9SNRnNDD52QxBsvt3VIaNWgLbqQQ
↪9rc+sIx8T8NEwG+FQu9Jp4pJ1j7iB7Pp4nLAjtX/jBpm7efB0SIig/
↪ER2qSJv+hvRXwhHtbLMoqRfAMRTpyMyj6LqsK6NAr6xIxvyeEM6WNs+nDUmlVvkEGEkF6kncG1kSgWViH3pwQYPwqoQr+hW61AouQ
↪EbAqOJMOTZgcyftYk0cP+XxkwJ2w9XptKSx/la0UyEX3RhUgloJyda+kFqijrFM5Niy/Rr2v8k6wtZ0WKe7/
↪qpLib8Xndbvf+u2y/C+p/
↪+xAAABhGlDQ1BJQ0MgcHJvZmlsZQAAeJx9kT1Iw0AcxV9TpUUqDmYQ6ZChOrUgKqKbVqEIFUKt0KqD+egXNGlIUlwcBdeCgx+LVQc
↪F9SaBHjwXE/3t173L0DuGZV0ayeMUDTbTOTSgq5/KoQekUYUfCIY0ZSLGNOFNPwHV/3CLD1LsGy/M/
↪9OfrVgqUAAYF4VjFMm3iDeGrTNhjvE/
↪NKWVKJz4njJl2Q+JHpssdvjEsucyyTN7OZeWKeWCh1sdzFStnUiCeJY6qmUz6X81hlvMVYq9aV9j3ZCyMFfWWZ6TSjSGERSxAhQEYd
↪uD391axYlxLymSBHpfHOdjBAjtAq2G43wfO07rBAg+A1d6x19rAtOfpDc6WuwIGNgGLq47mrwHXO4AQ0+GZEquFKTJFYvA+xl9Ux4Y
↪/nmn39wP57XLd+8ZLEQAAAAZiS0dEAP8A/wD/
↪oL2nkwAAAAlwSFlzAAAOwwAADsMBx2+oZAAAAAd0SU1FB+cIHBQ3LSPd1ZEAAAWWSURBVFjDrVfdixxVFv+de2999XTPJNNtME4yE9
↪vqsyzs/
↪gO7BFYQJB+u7Bp9UBSR4Iu+BR8EEQQfZBcE0UUTYYNmkujmY5PMjPPRPfU1XVX3nH2oqp6el9FUvHTX7a7uW+d3zvn9zrmXRAT3Mq
↪nYGP3g2nr/w/PnP/
↪gH7mOYe13Q7nRw5+7dJy9dutybmdl7Dfc5fhGAl186+dYPP9747YG5mTOnzvz9ozhKMhCQ5zkBwL8++3Ri19SuYZEP+ehTT/
↪Pzfz0x3W538pOnzoQ/92z1SwCkafrMrVs3H/vu+4XfXLr0HwoCPxMWTE1NJgDw1b+/Pv/m2+9EFy588+jnn//
↪TFear/fX1ldfOvvz7XyUCU1NTXxZFfjiMoqNnTp961w+8A67rIEnS5/
↪70xz98O9npHI7j2F1dHzzxzdcXzGAwmNbG4fV+f/
↪hzz6adSPi3l148snh38YTnt55duHx5l2WG67rQWiOOY2RZDgEAAYqiQK+7CzP7Zy+mcfLYdLcrcwf2n/
↪zf7aV3Xz376lIzAKdf+MJafmpxeQUiAhFGkiSwLGAWEIDvF67hkYcPwHMdbA6HyPMCPy3/
↪hMOHj2BldQlpmhWPHz126Owrr/
↪x4zykwxuXCpgCkAiAAKTDniOMERhtoraG1hjEGbWMgIoiiBFeuXoXneyDArK2udgHcO4DC5v2bt25jc3MIrTV83wcABL4PAsF1HRi
↪s2QPPc7C8vIyH9u6F0gqO1lXocyRpCt/3MRhsIAgCEAEiwOLikm0kw8D3EwUCM4OFQQRYtugPNrA5HGJzc4j/
```

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```
↪Xr+OOE6wsrqGywvXEEYxwjAEqFyXZzm6vS41AjDMhqHS5V+01iBFMNqArQWBSl6UXAYqb4WrO0SwlgEC5ucPNqsDwgKlNECENEmhK
↪NGAPxWIIoUQASpWF33DpGt6lcCGvs+lggBoTM52Ww/4DjuEFR6Uz6vYj4INKq/
↪VNmUbaV4tASCXm9PMxIO+v0+VblXSm03oNSWozUn6gQQjWYRwHHdZgCybEhECoW1cIwBM29jm0iddxmTYakSIhrJ9vjx3zXjQGdyK
↪UhpdTyKoyd8P2g5xlHGccJutxevra2BupS3gmAlL4rJMAzdKAr3hVFS7iIEsNZ+1/
↪hgsiUz4NTpF2dv3rgxr7U+OMyygxCZL4r8EEHNGcesDNPN3V7gr25sDGbCOAVA8D3vh9n9+58+d+7cnfsCsNO4ePGief/
↪99x6JouhgFEeHtFLz/Y3wQdfxZG5u9s9vvP769Z3W/x+NojQvpvBOhQAAAABJRU5ErkJggg==",
   "template": {
       "name": "CUSTOM_ICON",
       "service": "CloudRF https://api.cloudrf.com",
       "created_at": "2023-09-05T20:40:56+00:00"
   },
   "site": "Site",
   "network": "DTC",
   "engine": 1,
   ...
```

CHAPTER

SEVEN

PHASE TRACING INTERFACE

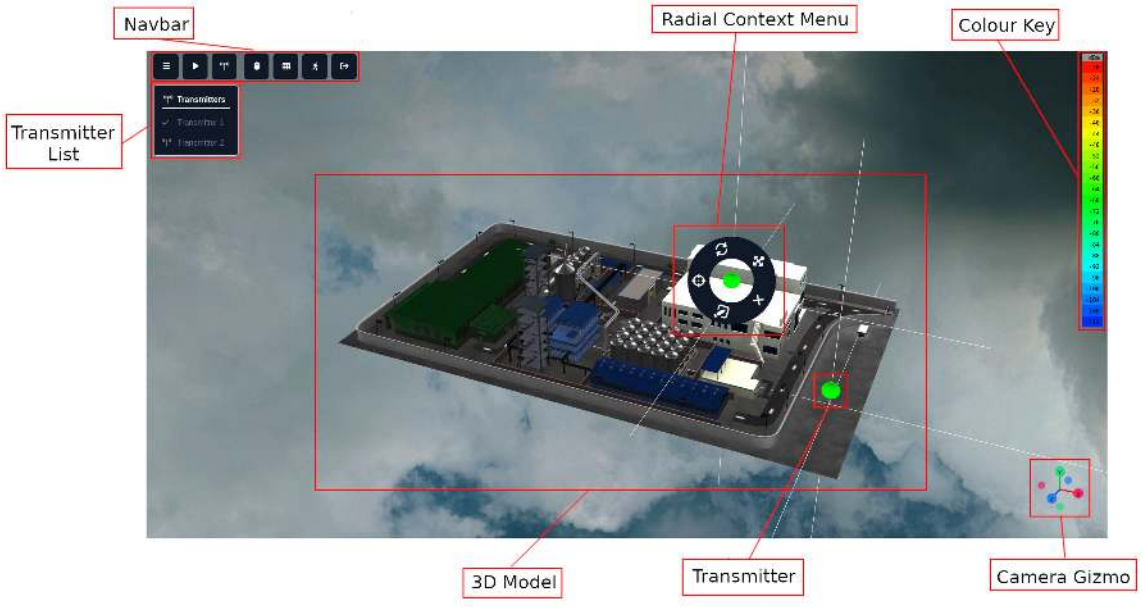
The Phase Tracing interface is for simulating multipath RF propagation in complex, three-dimensional environments, and is particularly powerful at modelling environments which include complicated structures such as stairways, tunnels, bridges and towers.

The Phase Tracing interface can be accessed from the `/phase-tracing` endpoint, for example available on CloudRF at https://cloudrf.com/phase-tracing.

The Phase Tracing interface has been tested to work best in the latest version of Google Chrome. It's recommended that you use it in this browser, however any browser which supports WebGL technology should be functional.

7.1 Interface Elements

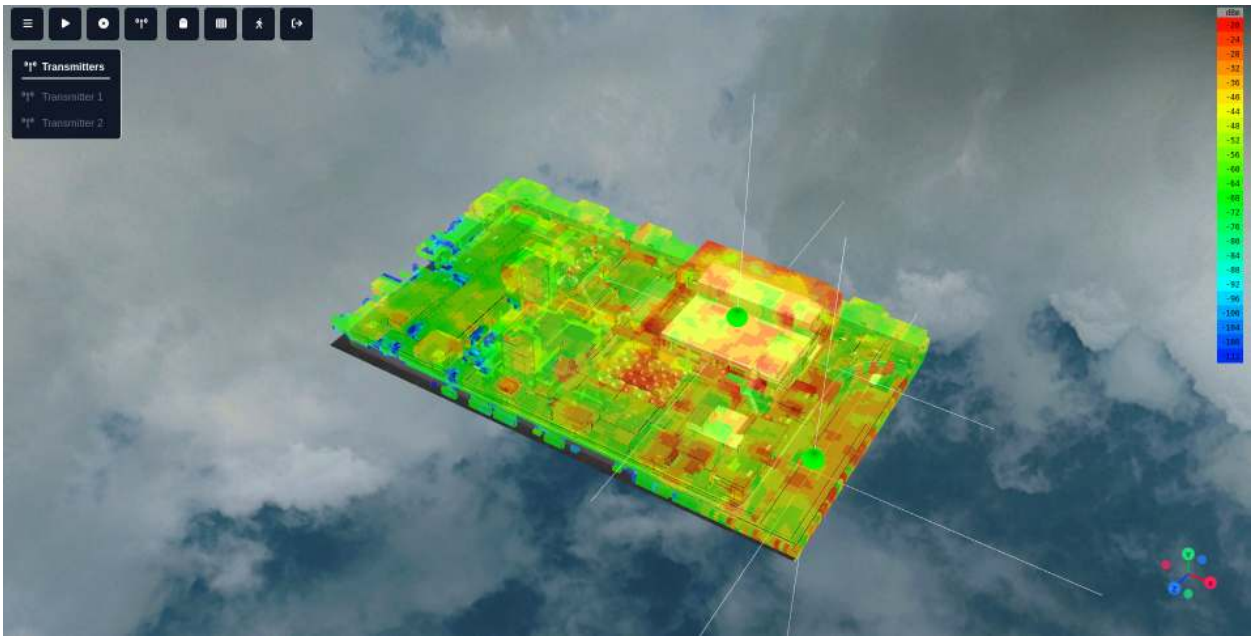
Below shows an overview of the Phase Tracing interface.



7.2 3D Scene

The Phase Tracing interface centers around the 3D scene, where the currently loaded scene model is displayed as seen above.

After a calculation, a viewshed model will be shown over the scene model. The viewshed model consists of coloured voxels, where the colour corresponds to the received power (dBm) inside that voxel.



The 3D scene also includes the transmitters, displayed as a 3D antenna pattern. The pattern will change shape when the antenna pattern is changed using the *transmitter settings modal*.

A transmitter can be selected by clicking on the pattern, which brings up the *radial context menu*.

To deselect a transmitter, click the scene model when no tool is active, which is indicated by no active buttons in the navbar.

7.3 Camera Controls

To rotate the camera:

- If using a desktop with a mouse you can click and drag with the left mouse button.
- If you are using a touch-screen device you can move the camera with a single finger and dragging your finger across the screen.

To pan the camera:

- If using a desktop with a mouse you can click and drag with the right mouse button.
- If you are using a touch-screen device you can move the camera with two fingers and dragging your fingers across the screen.

Panning the camer will also move the pivot point for where the camera rotation is made from.

To zoom the camer:

- If using a desktop with a mouse you can either scroll with the mouse wheel, or hold the mouse wheel and move the mouse forwards and backwards to zoom.
- If you are using a touch-screen device you can zoom the camera by using two fingers and pinching them together, or moving them apart apart to zoom.

In the bottom right of the screen there is a camera gizmo which can also help with quickly moving the camera to pre-set positions. You can click opn one of the colour balls to quickly manipulate the scene to move to that position.

If you wish to reset you view of the scene, this can be done by clicking on the *"Reset Camera"* item within the menu.

If you have transmitters within your scene, you can select a particular transmitter from the *transmitter list* to quickly jump to that transmitter.

There is also a *walking mode* which can be used to interact with the scene in a first-person view where you can walk around the model. This can be toggled on and off.

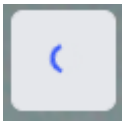
7.4 Navbar

The navbar runs along the top of the screen and contains the majority of the tools which are used to interact with the Phase Tracing interface.

7.4.1  Toggle Menu

The Toggle Menu button collapses and expands the *dropdown menu*.

7.4.2  Start Calculation

Press this button to start a calculation. While processing, the button shows a spinlock  and another calculation cannot be started.

Once the calculation is finished, the resulting viewshed will be shown over the input model.

7.4.3  Clear Viewshed

This button can be clicked to clear any previously calculated viewsheds from the scene.

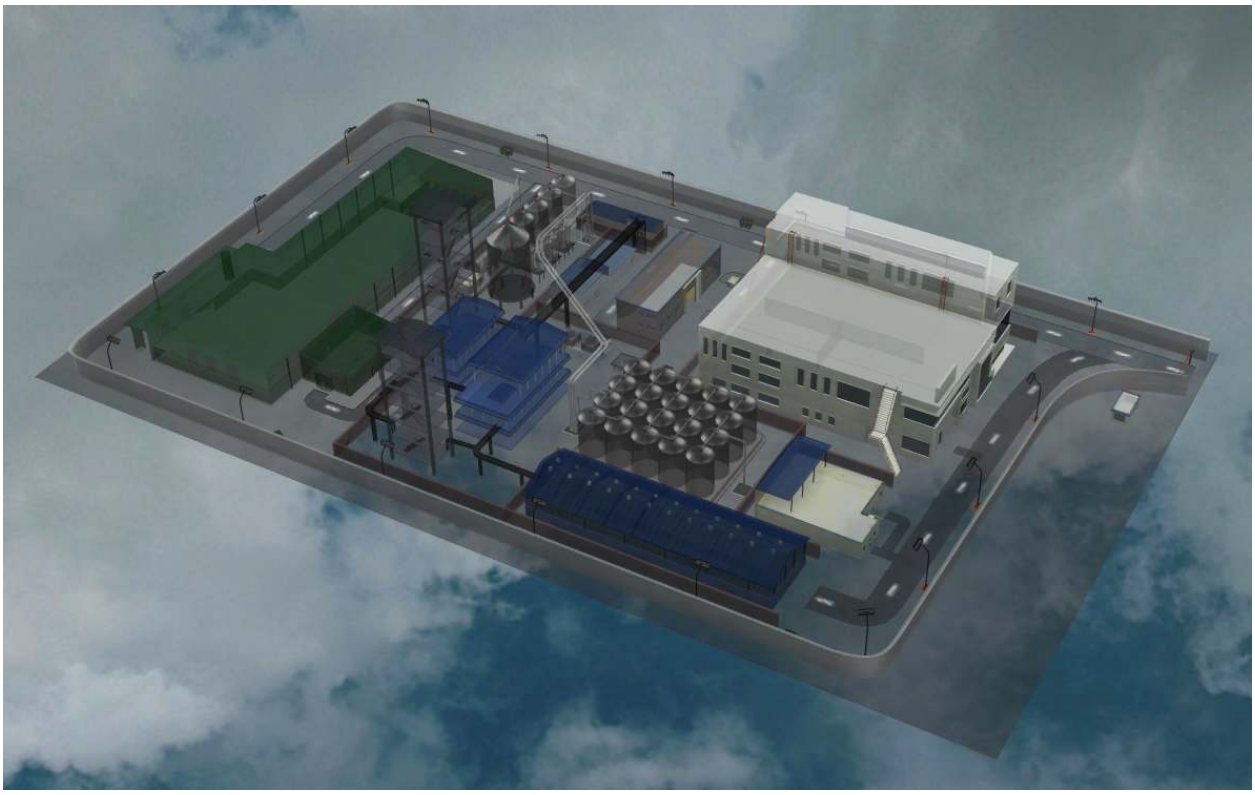
7.4.4  Add Transmitter

While this button is active, clicking on the model will add a transmitter.

When clicking the transmitter will be placed on the first available surface from your current view.

7.4.5  Transparency/See-Through Mode

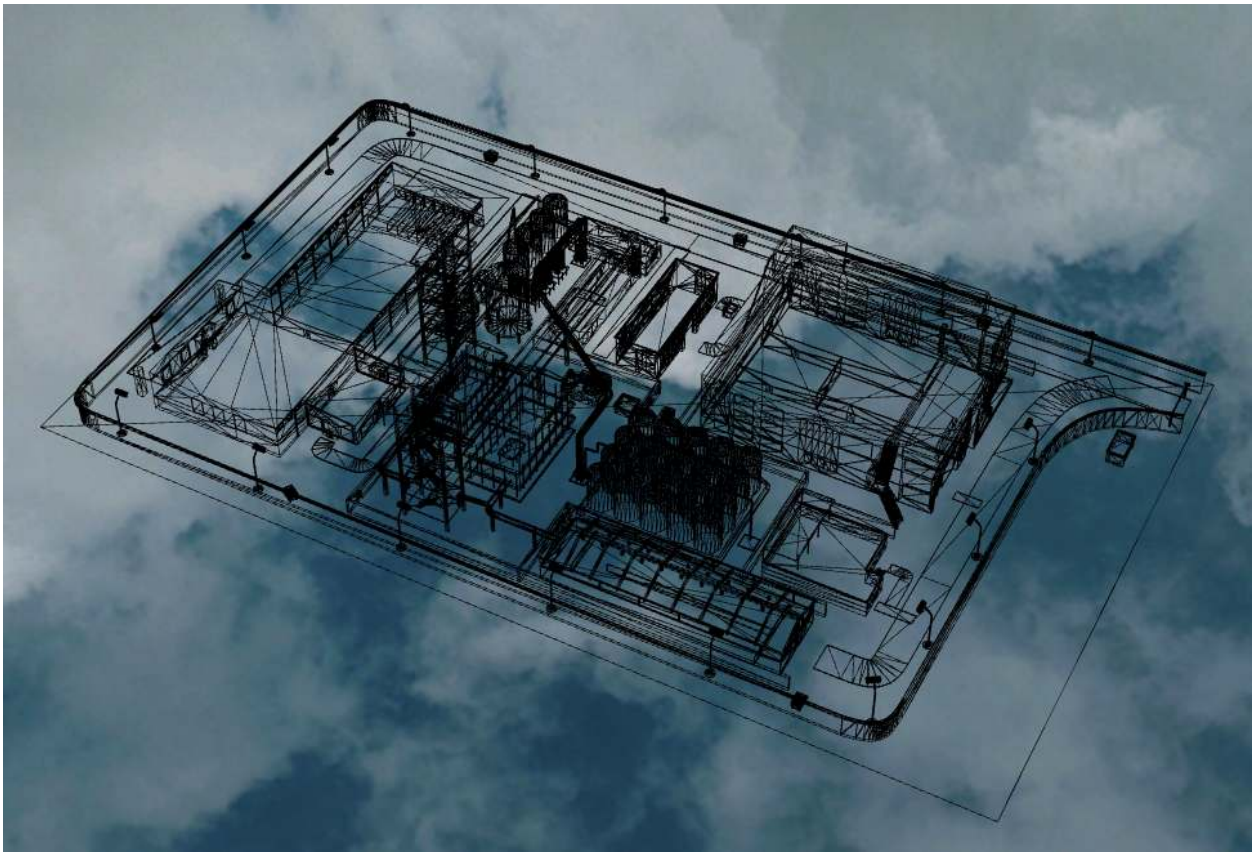
While this button is active, it will be possible to see through walls/floors.



This is useful for dense buildings with many floors, such as a tower-block.

7.4.6  Wireframe Mode

While this button is active, the mesh will be rendered as wireframe.



7.4.7  Walk Mode

Walk mode provides alternative camera controls to the default ones described in the *camera controls section*.

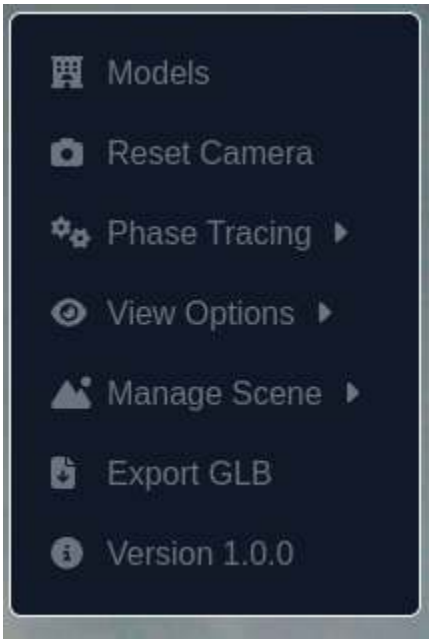
In walk mode, you can click on the scene to teleport the camera there.

The camera can still be rotated using the left mouse button and you can still zoom with the scroll wheel/middle button, but it cannot be panned. Instead, you can move around the scene with the arrow keys.

7.4.8  Log Out

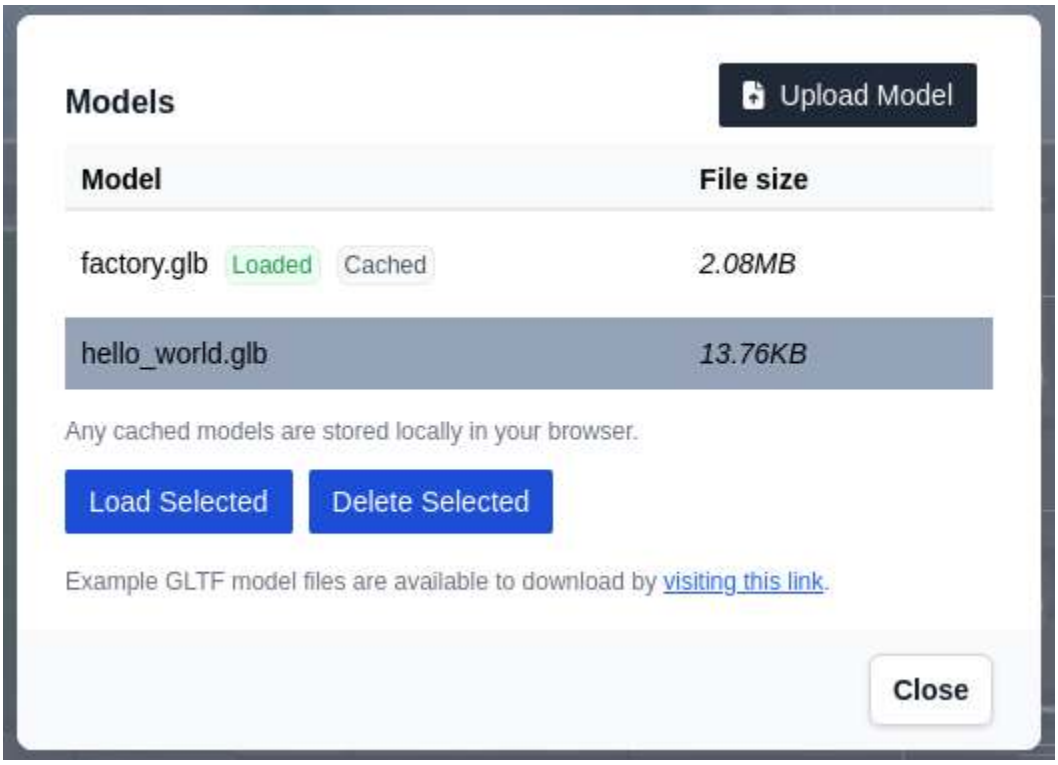
Press this button to log out of the interface.

7.5 Dropdown Menu



7.5.1 Models

Press “Models” to open the model manager:



The model manager shows a list of models you have uploaded to your account.

You can load or delete each model.

The model currently in the interface is marked with a green "Loaded" tag, and the currently cached model is marked with a grey "Cached" tag. This model will load quickly when the interface is next opened. Cached models are stored within your local browser.

The "Upload Model" button can be pressed to open the model upload modal:

When the button is pressed, the model will be uploaded to your account and loaded in the interface. This can take some time depending on the size of the model you are uploading and your connection speed to the Phase Tracing API.

7.5.2 Reset Camera

Pressing the "Reset Camera" item in the menu will move the camera such that it frames the whole model.

If your model is dimensionally large (thousands of meters), the camera will be too far away so you will need to zoom in to see the model.

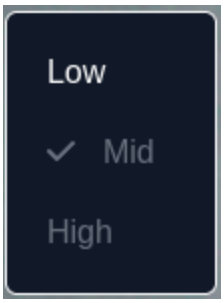
7.5.3 Phase Tracing

The "Phase Tracing" menu allows you to configure calculation settings for the scene:

- Resolution
- Maximum number of reflections
- Material density

Each can be set to one of three, preset values which are calculated dynamically based upon your input model:

- Low
- Medium
- High



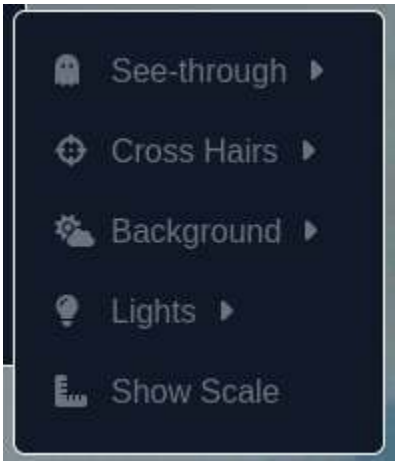
Resolution configures the size of the output voxels. A higher resolution will include more detail but calculations take more time to compute.

Reflections configures the maximum number of collisions that are simulated during a calculation.

Density configures the amount of power lost when a photon moves through a material within the input model.

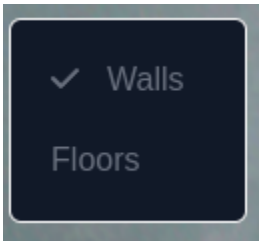
7.5.4 View Options

The "View Options" item contains settings that are related to how the scene is rendered, and have no effect on calculations.



See-Through

The "See-Through" menu configures which of the walls and/or floors are transparent when the *"Transparency/See-Through"* mode is on.



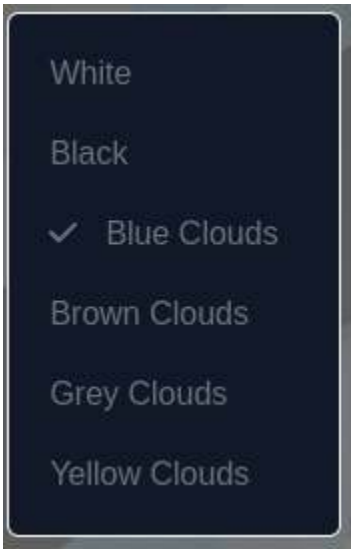
Whether or not a part of the model is considered "wall" or "floor" is detected by looking at the direction it faces.

Cross Hairs

The "Cross Hairs" menu can be used to enable/toggle the white cross-hairs that indicate the position of each transmitter.

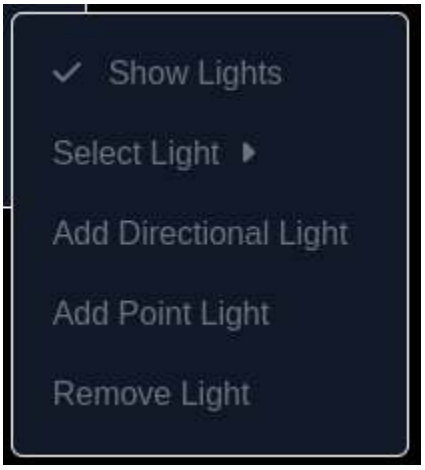
Background

The "Background" menu allows you to select a background for the scene. Options include solid colour 'White' and 'Black' as well as skybox images.

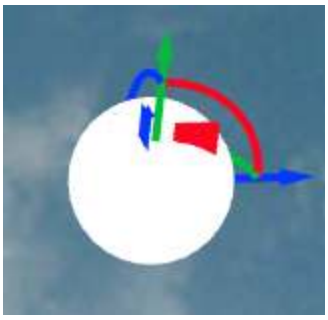


Lights

The "Lights" menu allows you to configure the scene lighting. This can be useful where the default lighting may not be suitable for your particular model.



With "Show Lights" enabled, lights are shown as orbs in the 3D scene. They can be selected by clicking on them, or in the Select Light menu.



When a light is selected:

- It can be moved by clicking and dragging the arrows that appear on it.
- It can be deleted by clicking Remove Light in the Lights menu.
- Its intensity can be changed using a slider that appears at the bottom of the screen.

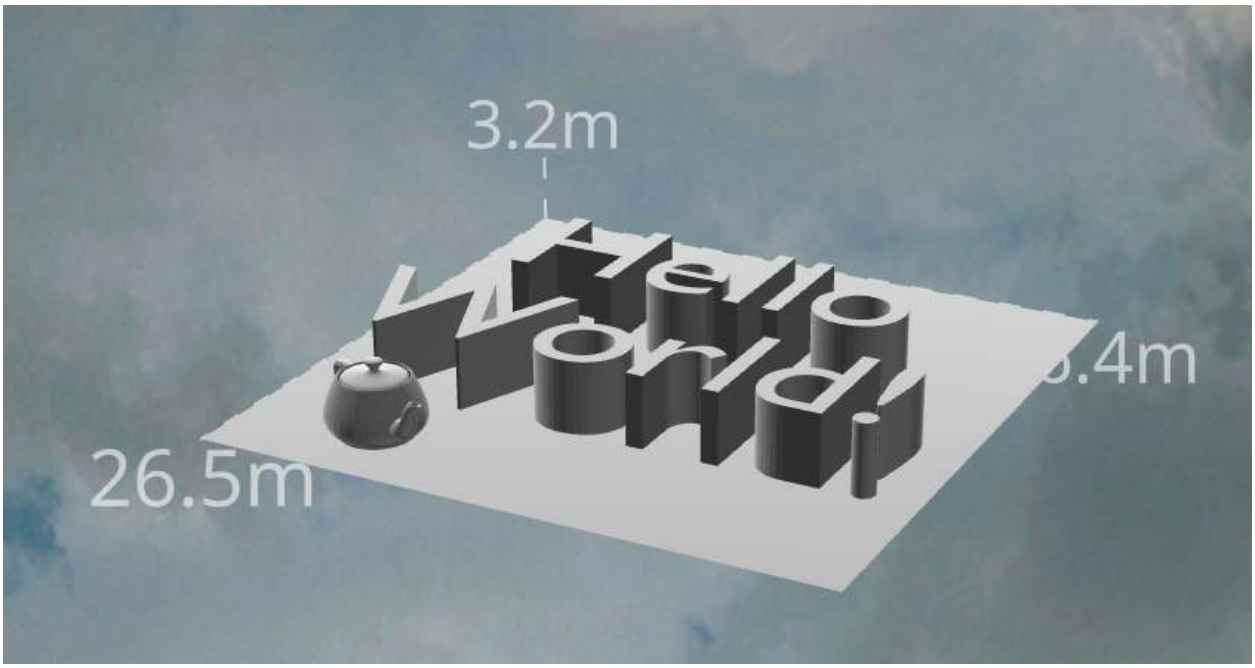
Lights can also be added to the scene from the Lights menu. There are two supported types of light:

- Point lights emit light from a point in space and are controlled by moving that point.
- Directional lights emit light all over the scene, but in a direction defined by the vector from one point to another, both of which can be moved in the scene.

Show/Hide Scale

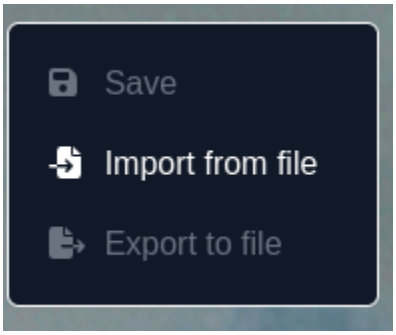
The "Show/Hide Scale" button can be used to toggle rulers that display the size of the scene model in each dimension.

The rulers are enabled by default to ensure that you check that the dimensions of your model are correct.



7.5.5 Manage Scene

The "Manage Scene" menu allows you to save and load your work, or to export as a file and move your work to another machine.



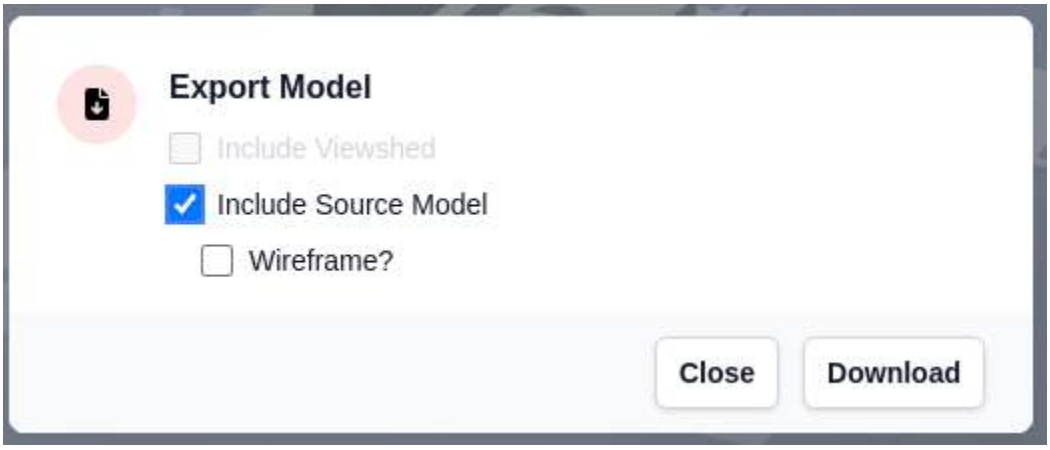
The save button will save the scene to your browser's local storage, and next time you open the interface the saved scene will be loaded automatically. Please note that because this is saved to local storage this will not be accessible if you log in from another browser. If you wish to move your work between browsers or devices then you should export and import your work, as detailed below.

To move scenes between browsers/computers, you can export the scene to a JSON file and similarly import a scene JSON file.

For details on what is saved, see the *scene format section*.

7.5.6 Export GLB Button

The "Export GLB" option brings up the export GLB modal.



This modal can be used to export a model including the viewshed (if present) and/or the source model. The source model can be exported as a wireframe if desired, to make the viewshed easier to see.

7.5.7 Version Number

Clicking the version number brings up the changelog for the Phase Tracing interface.

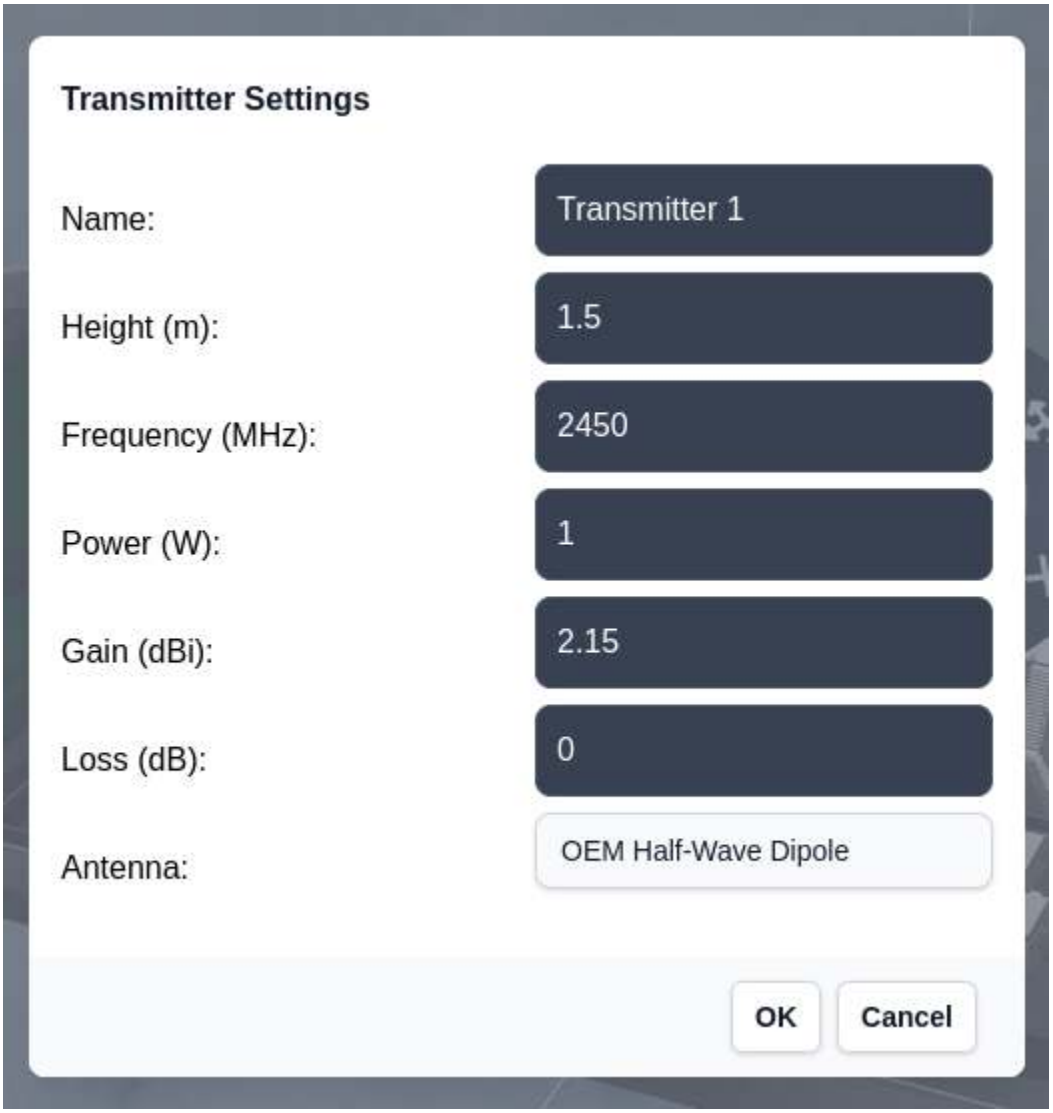
7.6 Radial Context Menu

When a transmitter is selected, the radial context menu is displayed around it.

7.6.1 Edit Button

Pressing the edit button brings up the transmitter settings modal.

Transmitter Settings Modal



The transmitter settings modal can be used to edit the following settings:

- Name
- Height (m)

- Frequency (MHz)
- Power (W)
- Gain (dBi)
- Loss (dB)
- Antenna pattern

Note that the height is defined as above the ground point, which is where the transmitter's crosshair is centered.

7.6.2 Move

When the move tool is active, left clicking on another location within the model will move the selected transmitter's ground point to that location.

7.6.3 Aim

When the aim tool is active, left click on the model will rotate the transmitter such that it points in that direction of where you click.

7.6.4 Rotate

When the rotate tool is active, the transmitter can be rotated by dragging the line that appears. This allows aiming the transmitter into free-space where there is no model to click.

7.6.5 Delete

Clicking the delete button will delete the transmitter.

7.7 Transmitter List

When the dropdown menu is not open, the transmitter list will be displayed.

The currently selected transmitter is marked with a tick, and transmitters can be selected by clicking their name on the menu.

Clicking a selected transmitter moves the camera to focus on that transmitter.

7.8 Input Model Format

Phase Tracing is performed on glTF 2.0 models, an extendable open standard file format for describing 3D scenes and models.

The model files must be binary `.glb` files, where all the data is containing inside the file, whereas the JSON `.gltf` files reference external `.bin` files.

The glTF file format is extensible, with extensions divided into two groups: **required** and **used**. If a **required** extension is not in the following list the API is unlikely to work with the model:

- `KHR_draco_mesh_compression`

The third party glTF Report can be used to preview and validate a glTF model, and to see the required extensions.

7.9 Calculation Speed

The level of detail in a model does not effect the calculation speed, except that larger files take longer to load.

To get a faster calculation, use a lower resolution. Doubling the resolution increases the calculation difficulty by a factor of eight.

The API has a 30 second timeout so if a calculation takes longer than 30 seconds you will not receive the result. The first calculation after changing the model or resolution will be slower than subsequent as the model needs to be re-processed. The Phase Tracing API will cache your previous model to allow for subsequent calculations to be more performant.

7.10 Scene Format

Scenes are stored as JSON. They contain:

- The name of the model
- Transmitter settings
- Calculation settings

- Background + lighting configuration

An example scene JSON follows:


```
{
    "modelName": "hello_world.glb",
    "backgroundType": "sky-box",
    "backgroundColor": "blue",
    "transmitters": [
        {
            "id": "Transmitter 1",
            "x": 10.0897452365192,
            "y": 0,
            "z": -7.5563530828073855,
            "rotationX": 0,
            "rotationY": 0,
            "rotationZ": 0,
            "height": 1.5,
            "antennaPatternId": 1,
            "r": 0,
            "g": 255,
            "b": 0,
            "frequency": 2450,
            "power": 1,
            "gain": 2.15,
            "loss": 0
        },
        {
            "id": "Transmitter 2",
            "x": 2.883337910636127,
            "y": 0,
            "z": 11.044576366827863,
            "rotationX": 0,
            "rotationY": 0,
            "rotationZ": 0,
            "height": 1.5,
            "antennaPatternId": 1,
            "r": 0,
            "g": 255,
            "b": 0,
            "frequency": 2450,
            "power": 1,
            "gain": 2.15,
            "loss": 0
        }
    ],
    "lights": [
        {
            "id": "Northern spotlight",
            "type": "directional",
            "enabled": true,
            "intensity": 2.2,
            "position": {
                "x": 0,
```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```
                "y": 50,
                "z": -100
            },
            "target": {
                "x": 0,
                "y": 0,
                "z": 0
            }
        },
        {
            "id": "Eastern spotlight",
            "type": "directional",
            "enabled": true,
            "intensity": 3,
            "position": {
                "x": -100,
                "y": 49.749654418312204,
                "z": -0.7387491921762099
            },
            "target": {
                "x": 0,
                "y": 0,
                "z": 0
            }
        },
        {
            "id": "Southern spotlight",
            "type": "directional",
            "enabled": true,
            "intensity": 2.2,
            "position": {
                "x": 0,
                "y": 50,
                "z": 100
            },
            "target": {
                "x": 0,
                "y": 0,
                "z": 0
            }
        },
        {
            "id": "Western spotlight",
            "type": "directional",
            "enabled": true,
            "intensity": 2.2,
            "position": {
                "x": 100,
                "y": 50,
                "z": 0
            },
            "target": {
```

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```
                "x": -0.011472404568427241,
                "y": 0,
                "z": 0.002287903721230944
            }
        },
        {
            "id": "Subsurface light",
            "type": "directional",
            "enabled": true,
            "intensity": 1,
            "position": {
                "x": 0,
                "y": -100,
                "z": 0
            },
            "target": {
                "x": 0,
                "y": 0,
                "z": 0
            }
        }
    ],
    "settings": {
        "resolutionMode": "MidResolution",
        "reflectionsMode": "MidReflections",
        "densityMode": "MidDensity"
    }
}
```

CHAPTER

EIGHT

API

The CloudRF API offers a powerful and scalable service to model almost any radio hardware, anywhere. When integrated into another system you can automate modelling to save significant time and money and realise capabilities not possible with a modest budget. The next generation performance also unlocks new analysis possibilities allowing "real time" decision making for autonomous vehicles and drones, for example.

Use cases

- Automate customer qualification based upon a zip code
- Robot / drone route selection
- Best site analysis for optimal & economic deployments
- Receiver modelling for signal multi-lateration
- Generation of network coverage maps for marketing or briefing rooms
- Automated regression testing for network changes
- Integration with cognitive radios for smarter site/frequency/power selection based on topography

8.1 OpenAPI 3 Schema

For a complete OpenAPI 3 schema of the CloudRF API please consult the Swagger UI documentation.

8.2 API Endpoint

For CloudRF users, the API endpoint is `https://api.cloudrf.com`.

Users with a SOOTHSAYER server will have an IP address instead.

8.2.1 Security

All requests are encrypted at the transport layer with TLS.

8.3 Authentication

Each user has a unique private API key which resembles a long random string of characters. You should protect this key to prevent unauthorised use of your account.

An example of such API key is as below:

```
101-ec94622a4cb939a77101a118c6871d03cea88af3
```

8.3.1 API Key Security

It is important to keep your API key secure. Publicly exposing your key can compromise your account, which could result in a loss of data or unexpected charges. A key does not give access to your interface or shop login which is separate.

To keep your API keys secure, follow some best practices:

Keys as Environment Variables

Store API keys as environment variables. This has an added benefit of accessing your key via a friendly environment variable name rather than having to remember your full key each time.

Do not embed API keys directly in code. API keys that are embedded in code can be accidentally exposed outside your circle of trust.

Keys as Files

You can store your API key in a file and make reference to that file each time you need to use your API key.

If you store API keys in files, store those files outside your application's source tree.

Doing so helps to ensure that your keys do not end up in your source code version control system. This is particularly important if you use a public source code management system such as GitHub.

8.3.2 Using the API Key

The CloudRF API requires API key authentication in the request header. This provides a key-value pair with `key` as the first value and your personal key as the second, paired value.

For example, Postman allows you to enter your key from their interface.

8.4 API "Hello World!" Getting Started Example

Send this curl request to model coverage for a VHF radio, 2m above the water with 1W of power:

```
curl --location 'https://api.cloudrf.com/area' \
    --header 'key: YOUR-API-KEY-GOES-HERE' \
    --data '{
        "site": "HelloWorld",
        "network": "Testing",
        "transmitter": {
            "lat": 38.916,
            "lon": 1.448,
            "alt": 2,
            "frq": 160,
            "txw": 1,
            "bwi": 1
        },
        "receiver": {
            "lat": 0,
            "lon": 0,
            "alt": 2,
            "rxg": 0,
            "rxs": -90
        },
```

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```
        "antenna": {
            "txg": 0,
            "txl": 0,
            "ant": 1,
            "azi": 0
        },
        "output": {
            "units": "metric",
            "col": "LTE.dBm",
            "out": 2,
            "res": 30,
            "rad": 5
        }
    }'
```

8.5 Example API Requests

Below lists some basic examples of some of the most common types of requests made to the CloudRF API.

For a complete list of available schemas please consult the Swagger UI documentation.

With all requests some values are required and so the response will return any validation errors or any failures should your request not be able to be processed.

8.5.1 Area

The `area` endpoint accepts a JSON object in the request **body** describing your network and will run a point-to-multipoint "heatmap" calculation.

Request

The below example is for an omni-directional antenna on an 8m mast at 446MHz. The request is sent as a `POST` request to `https://api.cloudrf.com/area` and it will return a JSON response containing metadata and URLs to image layers for your map.

```
{
    "site": "Harbour",
    "network": "PMR",
    "engine": "2",
    "transmitter": {
        "lat": "38.913767",
        "lon": "1.440017",
        "alt": "8",
        "frq": "446",
        "txw": "1",
        "bwi": "0.1"
    },
    "receiver": {
        "lat": 0,
        "lon": 0,
        "alt": "2",
        "rxg": "2",
```

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```
        "rxs": "-90"
    },
    "antenna": {
        "txg": "2.15",
        "txl": "0",
        "ant": "1",
        "azi": "0",
        "tlt": "0",
        "hbw": "0",
        "vbw": "0",
        "fbr": "0",
        "pol": "v"
    },
    "model": {
        "pm": "1",
        "pe": "2",
        "ked": "1",
        "rel": "50"
    },
    "environment": {
        "clt": "Minimal.clt",
        "elevation": "2",
        "landcover": "1",
        "buildings": "0",
        "obstacles": "0"
    },
    "output": {
        "units": "m",
        "col": "RAINBOW45.dBm",
        "out": "2",
        "nf": "-124",
        "res": "20",
        "rad": "8"
    }
}
```


Response

The `PNG_Mercator` image is warped for slippy maps like Mapbox, Leaflet and Google Maps. The `PNG_WGS84` is for globes like Google Earth, Cesium and WinTAK.


```
{
    "kmz": "https://api.cloudrf.com/archive/eFYyWFpUYW0zR1pxcTIyRlRKREQxUT09/kmz",
    "PNG_Mercator": "https://api.cloudrf.com/users/1/0812210016_PMR_harbour.3857.png",
    "PNG_WGS84": "https://api.cloudrf.com/users/1/0812210016_PMR_harbour.4326.png",
    "bounds": [
        39.00613,
        1.532378,
        38.82141,
        1.347656
    ],
    "id": 8191195,
```


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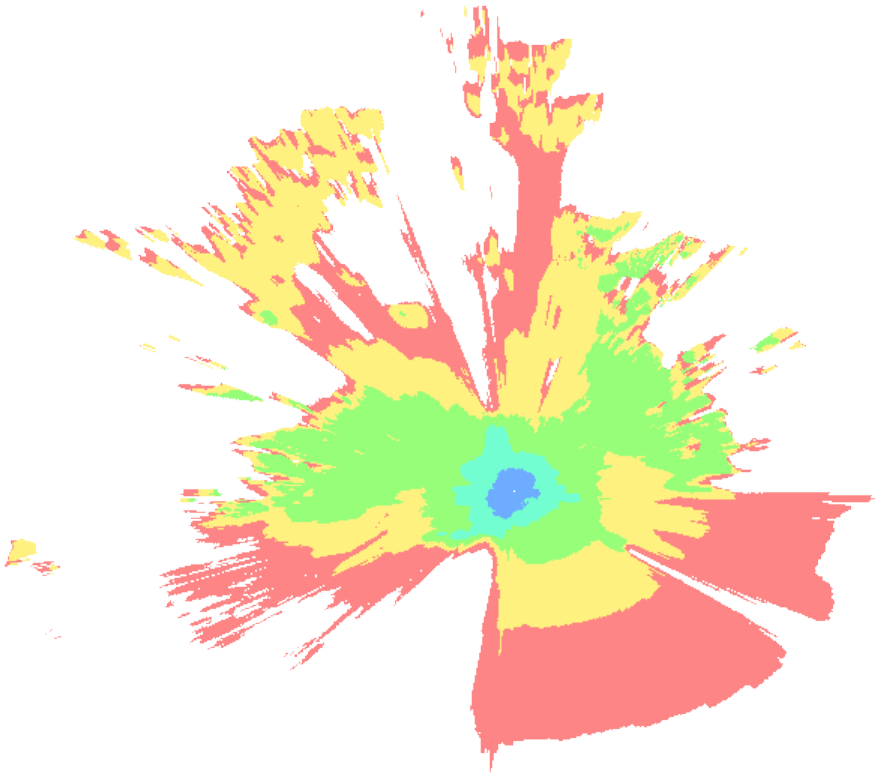
```
    "sid": "eFYyWFpUYW0zR1pxcTIyRlRKREQxUT09",
    "area": 55.9,
    "coverage": 28.0,
    "key": [
        {
            "l": "-45dBm",
            "r": 37,
            "g": 131,
            "b": 255
        },
        {
            "l": "-55dBm",
            "r": 46,
            "g": 254,
            "b": 187
        },
        {
            "l": "-65dBm",
            "r": 98,
            "g": 254,
            "b": 55
        },
        {
            "l": "-75dBm",
            "r": 254,
            "g": 234,
            "b": 63
        },
        {
            "l": "-85dBm",
            "r": 254,
            "g": 72,
            "b": 72
        }
    ],
    "elapsed": 2297.0,
    "balance": 23476
}
```


PNG image with RGB colours which map to the signal levels in the JSON output:



Go Faster With The GPU Engine

Switch the engine parameter to 1 to use the GPU engine. All other settings are the same.

```
{
    "site": "Harbour",
    "network": "PMR",
    "engine": "1",
    ... snipped for brevity ...
}
```

Please note that to be able to make use of the GPU engine you require an active GPU subscription or SOOTHSAYER with GPU functionality enabled.

Multi-Azimuth Requests

You can specify an array of azimuths to model panels on a cell tower for custom patterns and templates. Pass azimuths in as a comma separated list in quotes like `"0,90,180,270"`. The maximum number of azimuths you can pass in one API request is 90. This works for CPU and GPU engines.

```
{
    "site": "FourPanels",
    "network": "800MHZ",
    "engine": "2",
    "transmitter": {
        "lat": "38.881037",
        "lon": "1.468",
        "alt": "12",
        "frq": "800",
        "txw": "1",
        "bwi": "0.1"
    },
    "receiver": {
        "lat": 0,
        "lon": 0,
        "alt": "2",
        "rxg": "2",
        "rxs": "-90"
    },
    "antenna": {
        "txg": "21",
        "txl": "0",
        "ant": 0,
        "azi": "0,90,180,270",
        "tlt": "1",
        "hbw": "80",
        "vbw": "80",
        "fbr": "21",
        "pol": "v"
    },
    "model": {
        "pm": "11",
        "pe": "2",
        "ked": "1",
        "rel": "50"
    },
    "environment": {
        "clt": "Minimal.clt",
        "elevation": "2",
        "landcover": "0",
        "buildings": "0",
        "obstacles": "0"
    },
    "output": {
        "units": "m",
        "col": "RAINBOW45.dBm",
        "out": "2",
        "nf": "-120",
```

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```
        "res": "20",
        "rad": "5"
    }
}
```

8.5.2 Path

The `path` endpoint accepts a JSON object describing your network and will run a point-to-point calculation.

Request

The following example includes some optional parameters and provides the required data to model a link with land cover and 3D buildings enabled at 30m resolution. ***The request is similar to the `area` call except the receiver latitude (`lat`) and longitude (`lon`) values are populated.***

The below example is sent as a `POST` request to `https://api.cloudrf.com/path`.

```
{
    "site": "HarbourLink",
    "network": "LPWAN",
    "transmitter": {
        "lat": "38.9090",
        "lon": "1.44094",
        "alt": 12,
        "frq": "868",
```

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```
        "txw": "0.1",
        "bwi": "0.1"
    },
    "receiver": {
        "lat": "38.9173881",
        "lon": "1.46864923",
        "alt": 12,
        "rxg": "2",
        "rxs": "-90"
    },
    "antenna": {
        "txg": "2.15",
        "txl": "0",
        "ant": "1",
        "azi": "0",
        "tlt": "0",
        "hbw": "1",
        "vbw": "1",
        "pol": "v"
    },
    "model": {
        "pm": "1",
        "pe": "2",
        "ked": "1",
        "rel": "95"
    },
    "environment": {
        "clt": "Minimal.clt",
        "elevation": "2",
        "landcover": "1",
        "buildings": "1",
        "obstacles": "0"
    },
    "output": {
        "units": "m",
        "col": "RAINBOW45.dBm",
        "out": "2",
        "res": "30",
        "rad": "2"
    }
}
```

Response

The response contains metadata about the link along with raw values necessary to build a chart using a graphing library such as Matplotlib or Plotly. It also contains a link to a KMZ so you can see the profile in 3D.

```
{
    "Engine": "Sleipnir 1.7.8",
    "Frequency MHz": 868,
    "Propagation model": "ITM",
    "Earth dielectric constant": 13,
```

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```
    "Earth conductivity": 0.002,
    "Radio climate": "Maritime Temperate (Land)",
    "Atmospheric bending constant": 301,
    "Fraction of situations": 95,
    "Fraction of time": 95,
    "Receiver": [
        {
            "Latitude": 38.91739,
            "Longitude": 1.468649,
            "Ground elevation m": 28,
            "Antenna height m": 12,
            "Receiver gain dBd": -0.15,
            "Receiver gain dBi": 2
        }
    ],
    "Transmitters": [
        {
            "Latitude": 38.90908,
            "Longitude": 1.440943,
            "Ground elevation m": 1,
            "Antenna height m": 12,
            "Distance to receiver km": 2.572,
            "Azimuth to receiver deg": 68.92,
            "Downtilt angle deg": 0.6,
            "Antenna gain dBd": 0,
            "Antenna gain dBi": 2.15,
            "Polarisation": "Vertical",
            "Power W": 0.1,
            "Power dBm": 22.15,
            "ERP W": 0.1,
            "EIRP W": 0.164,
            "ERP dBm": 20,
            "EIRP dBm": 22.15,
            "Free space path loss dB": 95.3,
            "Bandwidth MHz": 0.1,
            "Johnson Nyquist noise dB": 0.2,
            "Noise floor dBm": -120,
            "Channel noise dBm": -119.8,
            "Signal power at receiver dBm": -88.6,
            "Signal to Noise Ratio dB": 31.2,
            "Computed path loss dB": 108.6,
            "Model attenuation dB": 13.3,
            "Field strength at receiver dBuV/m": 49.6,
            "RX voltage 50 ohm dipole uV": 14,
            "RX voltage 50 ohm dipole dBuV": 23,
            "RX voltage 75 ohm dipole uV": 17,
            "RX voltage 75 ohm dipole dBuV": 24,
            "Raise RX antenna for LOS": 0,
            "Raise RX antenna for fresnel 60%": 0,
            "Raise RX antenna for full fresnel": 19,
            "Obstructions": [],
            "Distance": [
```


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```
            0.03,
            0.059,
            0.089,
            0.119,
            0.148,
            ... snipped for brevity ...
        ],
        "Terrain": [
            1,
            1,
            1,
            1,
            1,
            ... snipped for brevity ...
        ],
        "Terrain_AMSL": [
            1,
            0,
            0,
            0,
            0,
            ... snipped for brevity ...
        ],
        "Landcover distance": [
            0.03,
            0.059,
            0.089,
            0.119,
            0.148,
            ... snipped for brevity ...
        ],
        "Landcover codes": [
            80,
            80,
            80,
            80,
            80,
            ... snipped for brevity ...
        ],
        "Landcover heights": [
            1,
            1,
            1,
            1,
            1,
            ... snipped for brevity ...
        ],
        "Fresnel": [
            0,
            -3.18,
            -4.47,
            -5.45,
```


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```
                -6.25,
                ... snipped for brevity ...
            ],
            "dBm": [
                -50,
                -56,
                -60,
                -62,
                -64,
                ... snipped for brevity ...
            ],
            "dB": [
                70,
                76,
                80,
                82,
                84,
                ... snipped for brevity ...
            ]
        }
    ],
    "calculation_adjusted": [],
    "elapsed": 130.0,
    "Chart image": "https://api.cloudrf.com/API/archive/data?
↪sid=c2ZrYXdUa0tPeGFrbG5wS1dLd3RIdz09&type=ppa",
    "kmz": "https://api.cloudrf.com/API/archive/data?
↪sid=c2ZrYXdUa0tPeGFrbG5wS1dLd3RIdz09&type=path"
}
```


8.5.3 Points

The `points` endpoint accepts a JSON object describing an array of points (transmitters) which will be tested back to a single point (receiver).

Request

The following example is for route a boat will take. The location varies with each point but all the other values are constant.

The request is sent as a `POST` body to `https://api.cloudrf.com/points`.


```
{
    "site": "RIB",
```


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```
    "network": "VHF",
    "transmitter": {
        "lat": 38.914381,
        "lon": 1.436988,
        "alt": "2",
        "frq": "160",
        "txw": "1",
        "bwi": "0.1"
    },
    "points": [
        {
            "lat": 38.91086406303705,
            "lon": 1.444486542453175,
            "alt": 2
        },
        {
            "lat": 38.91041372754393,
            "lon": 1.444495874752767,
            "alt": 2
        },
        {
            "lat": 38.90996339201471,
            "lon": 1.4445052069344337,
            "alt": 2
        },
        {
            "lat": 38.909513056449505,
            "lon": 1.444514538998178,
            "alt": 2
        }
    ],
    "receiver": {
        "lat": 38.914381,
        "lon": 1.436988,
        "alt": 2,
        "rxg": "2",
        "rxs": "-90"
    },
    "antenna": {
        "txg": "2.15",
        "txl": "0",
        "ant": "1",
        "azi": "0",
        "tlt": "0",
        "hbw": "1",
        "vbw": "1",
        "fbr": "2.15",
        "pol": "v"
    },
    "model": {
        "pm": "11",
        "pe": "2",
```


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```
        "ked": "1",
        "rel": "50"
    },
    "environment": {
        "elevation": "2",
        "landcover": "1",
        "buildings": "0",
        "obstacles": "0"
    },
    "output": {
        "units": "m",
        "col": "RAINBOW45.dBm",
        "out": "2",
        "nf": "-124",
        "res": "30",
        "rad": "8"
    }
}
```

Response

The response contains JSON metadata for the points, in this case received power levels for each point.

```
{
    "Engine": "Sleipnir 1.7.8",
    "Frequency MHz": 160,
    "Propagation model": "Egli VHF/UHF",
    "Model subtype": "Suburban",
    "Receiver": [
        {
            "Latitude": 38.91438,
            "Longitude": 1.436988,
            "Ground elevation m": 1,
            "Antenna height m": 2,
            "Receiver gain dBd": -0.15,
            "Receiver gain dBi": 2
        }
    ],
    "Transmitters": [
        {
            "Latitude": 38.91086,
            "Longitude": 1.444487,
            "Ground elevation m": 0,
            "Antenna height m": 2,
            "Distance to receiver km": 0.758,
            "Azimuth to receiver deg": 301.08,
            "Downtilt angle deg": 0.1,
            "Antenna gain dBd": 0,
            "Antenna gain dBi": 2.15,
            "Polarisation": "Vertical",
            "Power W": 1,
            "Power dBm": 2.15,
```

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```
            "ERP W": 0.001,
            "EIRP W": 1.641,
            "ERP dBm": 0,
            "EIRP dBm": 2.15,
            "Free space path loss dB": 70,
            "Bandwidth MHz": 0.1,
            "Johnson Nyquist noise dB": 0.2,
            "Noise floor dBm": -124,
            "Channel noise dBm": -123.8,
            "Signal power at receiver dBm": -66.2,
            "Signal to Noise Ratio dB": 57.6,
            "Computed path loss dB": 96.2,
            "Model attenuation dB": 26.2,
            "Field strength at receiver dBuV/m": 27.3,
            "Raise RX antenna for LOS": 5,
            "Raise RX antenna for fresnel 60%": 77,
            "Raise RX antenna for full fresnel": 128,
            "server": 1
        },
        {
            "Latitude": 38.91041,
            "Longitude": 1.444496,
            "Ground elevation m": 0,
            "Antenna height m": 2,
            "Distance to receiver km": 0.786,
            "Azimuth to receiver deg": 304.18,
            "Downtilt angle deg": 0.1,
            "Antenna gain dBd": 0,
            "Antenna gain dBi": 2.15,
            "Polarisation": "Vertical",
            "Power W": 1,
            "Power dBm": 2.15,
            "ERP W": 0.001,
            "EIRP W": 1.641,
            "ERP dBm": 0,
            "EIRP dBm": 2.15,
            "Free space path loss dB": 70.3,
            "Bandwidth MHz": 0.1,
            "Johnson Nyquist noise dB": 0.2,
            "Noise floor dBm": -124,
            "Channel noise dBm": -123.8,
            "Signal power at receiver dBm": -66.8,
            "Signal to Noise Ratio dB": 57,
            "Computed path loss dB": 96.8,
            "Model attenuation dB": 26.5,
            "Field strength at receiver dBuV/m": 26.7,
            "Raise RX antenna for LOS": 5,
            "Raise RX antenna for fresnel 60%": 80,
            "Raise RX antenna for full fresnel": 132,
            "server": 2
        },
        {
```


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```
            "Latitude": 38.90996,
            "Longitude": 1.444505,
            "Ground elevation m": 0,
            "Antenna height m": 2,
            "Distance to receiver km": 0.816,
            "Azimuth to receiver deg": 307.06,
            "Downtilt angle deg": 0.1,
            "Antenna gain dBd": 0,
            "Antenna gain dBi": 2.15,
            "Polarisation": "Vertical",
            "Power W": 1,
            "Power dBm": 2.15,
            "ERP W": 0.001,
            "EIRP W": 1.641,
            "ERP dBm": 0,
            "EIRP dBm": 2.15,
            "Free space path loss dB": 70.6,
            "Bandwidth MHz": 0.1,
            "Johnson Nyquist noise dB": 0.2,
            "Noise floor dBm": -124,
            "Channel noise dBm": -123.8,
            "Signal power at receiver dBm": -67.5,
            "Signal to Noise Ratio dB": 56.3,
            "Computed path loss dB": 97.5,
            "Model attenuation dB": 26.9,
            "Field strength at receiver dBuV/m": 26,
            "Raise RX antenna for LOS": 4,
            "Raise RX antenna for fresnel 60%": 82,
            "Raise RX antenna for full fresnel": 136,
            "server": 3
        },
        {
            "Latitude": 38.90951,
            "Longitude": 1.444515,
            "Ground elevation m": 0,
            "Antenna height m": 2,
            "Distance to receiver km": 0.848,
            "Azimuth to receiver deg": 309.74,
            "Downtilt angle deg": 0.1,
            "Antenna gain dBd": 0,
            "Antenna gain dBi": 2.15,
            "Polarisation": "Vertical",
            "Power W": 1,
            "Power dBm": 2.15,
            "ERP W": 0.001,
            "EIRP W": 1.641,
            "ERP dBm": 0,
            "EIRP dBm": 2.15,
            "Free space path loss dB": 70.9,
            "Bandwidth MHz": 0.1,
            "Johnson Nyquist noise dB": 0.2,
            "Noise floor dBm": -124,
```


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```
            "Channel noise dBm": -123.8,
            "Signal power at receiver dBm": -68.1,
            "Signal to Noise Ratio dB": 55.7,
            "Computed path loss dB": 98.1,
            "Model attenuation dB": 27.2,
            "Field strength at receiver dBuV/m": 25.3,
            "Raise RX antenna for LOS": 4,
            "Raise RX antenna for fresnel 60%": 85,
            "Raise RX antenna for full fresnel": 141,
            "server": 4
        }
    ],
    "calculation_adjusted": [],
    "elapsed": 111.0,
    "kmz": "https://api.cloudrf.com/API/archive/data?points=0812220045_mymesh_PPA_POINTS&
↪uid=1",
    "json": "https://api.cloudrf.com/users/1/0812220045_mymesh_PPA_POINTS.json"
}
```


8.5.4 Best Site Analysis

The `bsa` endpoint accepts a JSON object in the request **body** describing a location with a radius, similar to an 'area' call except it uses a random Monte-Carlo technique to rank locations within the area to identify the best. The colour key is irrelevant for the API since the response is always a greyscale image which you must style.

Request

The below example is for a planned Sub GHz LPWAN gateway in the hills. The request is sent as a `POST` request to `https://api.cloudrf.com/bsa` and it will return a JSON response containing metadata and URLs to image layers for your map.

```
{
    "site": "BestSite",
    "network": "Ibiza",
    "engine": "1",
    "transmitter": {
        "lat": 38.938092,
        "lon": 1.389430,
        "alt": "2",
        "frq": "446",
        "txw": "1",
        "bwi": "0.1"
    },
    "receiver": {
        "lat": 0,
        "lon": 0,
        "alt": "2",
        "rxg": "2",
        "rxs": "-90"
    },
    "antenna": {
        "txg": "2.15",
        "txl": "0",
        "ant": "1",
        "azi": "0",
        "tlt": "0",
        "hbw": "0",
        "vbw": "0",
        "fbr": "2.15",
        "pol": "v"
    },
    "model": {
        "pm": "7",
        "pe": "2",
        "ked": "0",
        "rel": "95"
    },
    "environment": {
        "clt": "Minimal.clt",
        "elevation": "2",
        "landcover": "0",
        "buildings": "0",
        "obstacles": "0"
```

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```
    },
    "output": {
        "units": "m",
        "col": "BSA8.bsa",
        "out": "7",
        "nf": "-120",
        "res": "10",
        "rad": 3
    }
}
```

Response

The `PNG_Mercator` image is warped for slippy maps like Mapbox, Leaflet and Google Maps. The `PNG_WGS84` is for globes like Google Earth, Cesium and WinTAK.

A BSA response is almost identical to an area response. The real difference is in the image which is always greyscale where white is 100% efficiency and black is 0% efficiency. The colour key returned can be used for styling by isolating only the red channel since the green and blue channels will be the same eg. RGB(254,254,254) = 95% coverage. The area and coverage fields are zero since this is not a site.

```
{
    "kmz": "https://api.cloudrf.com/archive/a2s1bWJkTDJYdGMrNUNHZVhpTUtUQT09/kmz",
    "PNG_Mercator": "https://api.cloudrf.com/output/projection/3857/1/0816125807_IBIZA_
↪BestSite",
    "PNG_WGS84": "https://api.cloudrf.com/users/1/0816125807_IBIZA_BestSite.4326.png",
    "bounds": [
        38.96563941396777,
        1.4248893862148355,
        38.91054585887422,
        1.3539723152977645
    ],
    "id": 8201477,
    "sid": "a2s1bWJkTDJYdGMrNUNHZVhpTUtUQT09",
    "area": 0,
    "coverage": 0,
    "key": [
        {
            "l": "95%",
            "r": 254,
            "g": 0,
            "b": 0
        },
        {
            "l": "90%",
            "r": 254,
            "g": 91,
            "b": 0
        },
        {
            "l": "85%",
            "r": 254,
```

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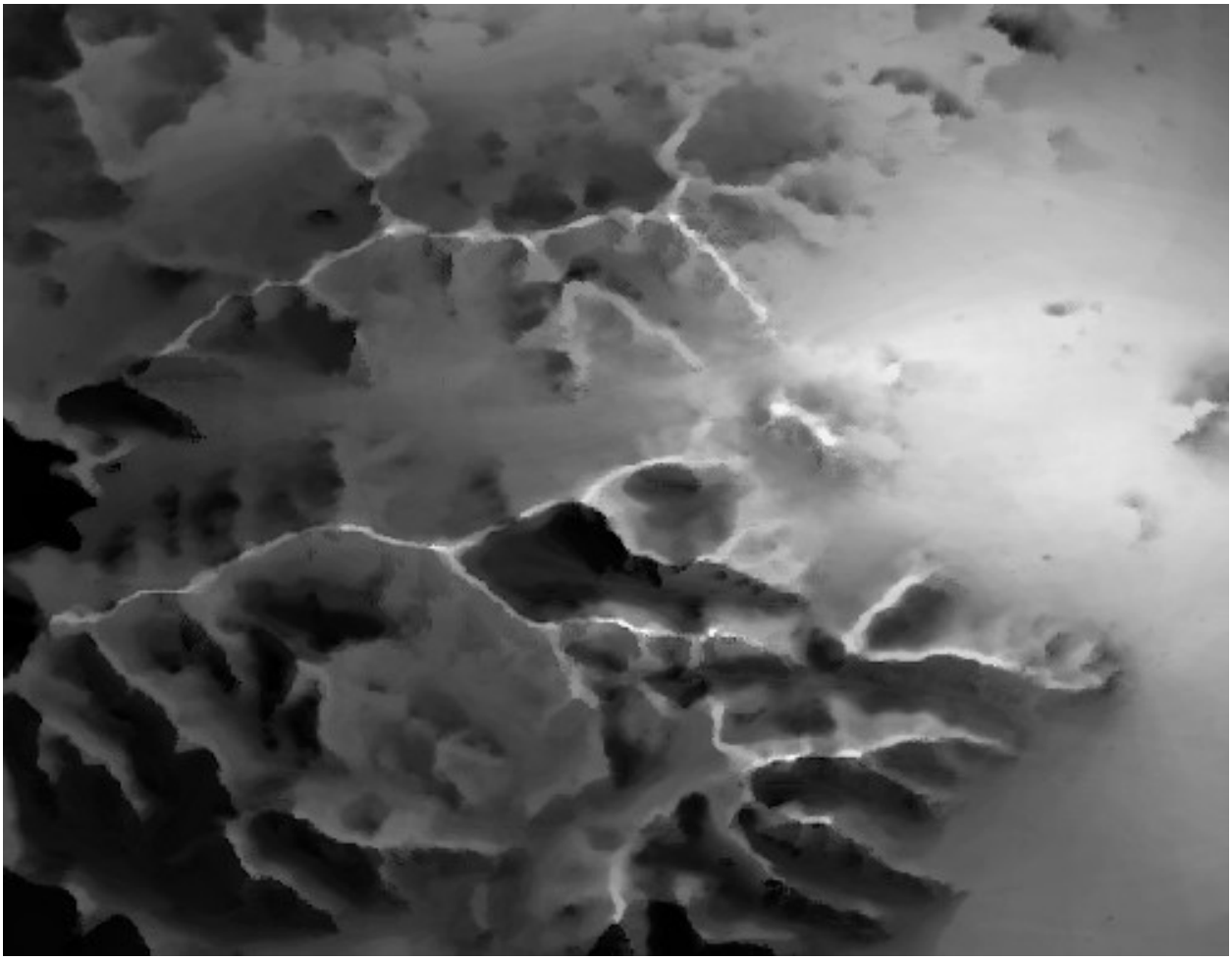
```
            "g": 183,
            "b": 0
        },
        {
            "l": "80%",
            "r": 236,
            "g": 254,
            "b": 0
        },
        {
            "l": "75%",
            "r": 145,
            "g": 254,
            "b": 0
        },
        {
            "l": "70%",
            "r": 53,
            "g": 254,
            "b": 0
        },
        {
            "l": "65%",
            "r": 0,
            "g": 254,
            "b": 38
        },
        {
            "l": "60%",
            "r": 0,
            "g": 254,
            "b": 129
        },
        {
            "l": "55%",
            "r": 0,
            "g": 254,
            "b": 221
        },
        {
            "l": "50%",
            "r": 0,
            "g": 198,
            "b": 255
        }
    ],
    "elapsed": 1147.0,
    "balance": 23305
}
```


A BSA response is shown below. Notice that ridgelines rank high, but not as high as the low ground to the east which has the best visibility of the entire area:



Request With A Polygon

If you want to use a polygon shape to define boundaries, you can use the `edges` array to define each point. A minimum of 3 points are needed as `lat/lon` pairs within the `edges` array. With this you can draw political or property boundaries. A radius is automatically computed using this method so it doesn't matter what radius you request.

```
{
    "edges": [
        {
            "lat": 38.94,
            "lon": 1.39
        },
        {
            "lat": 38.94,
            "lon": 1.399
        },
        {
            "lat": 38.945,
            "lon": 1.395
        }
    ],
    "site": "Triangle",
```

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```
    "network": "Ibiza",
    "engine": "1",
    "transmitter": {
        "lat": 38.945,
        "lon": 1.392,
        "alt": "2",
        "frq": "446",
        "txw": "1",
        "bwi": "0.1"
    },
    ... snipped for brevity ...
}
```

By defining 3 points, we have reduced the study area to a triangle:

8.5.5 Multisite

The `multisite` endpoint is a GPU only function for simulating many transmitters at once. It accepts a JSON object in the request **body** describing an array of `transmitters`, using familiar fields from an `area` call. An antenna is defined for every transmitter so you can have different patterns in a network. You can even model a group of distant radios with omni antennas and a long range parabolic in the same request.

It renders the legacy `mesh` API call obsolete (unless you only have a CPU) as it merges sites by design.

Transmitters must be within 2000km of each other. eg. You cannot request a multisite across the Ocean.

Antenna azimuths must be between 0 and 359 degrees.

Request

The below example is for three local UHF radios, with omni dipoles (ant: 1) in the hills. The request is sent as a `POST` request to `https://api.cloudrf.com/multisite` and it will return a JSON response containing metadata and URLs to image layers for your map.

```
{
    "site": "3amigos",
    "network": "UHF",
    "transmitters": [
        {
            "lat": 38.941501808741165,
            "lon": 1.3709467181497763,
            "alt": 2,
            "frq": 868,
            "txw": 1,
```

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```
            "bwi": 0.1,
            "ant": 0,
            "antenna": {
                "txg": 2.15,
                "txl": 0,
                "ant": 1,
                "azi": 0,
                "tlt": 0,
                "hbw": 1,
                "vbw": 1,
                "fbr": 2.15,
                "pol": "v"
            }
        },
        {
            "lat": 38.94210625018613,
            "lon": 1.3847431304250852,
            "alt": 2,
            "frq": 868,
            "txw": 1,
            "bwi": 0.1,
            "ant": 0,
            "antenna": {
                "txg": 2.15,
                "txl": 0,
                "ant": 1,
                "azi": 0,
                "tlt": 0,
                "hbw": 1,
                "vbw": 1,
                "fbr": 2.15,
                "pol": "v"
            }
        },
        {
            "lat": 38.94370157813472,
            "lon": 1.4006969012717958,
            "alt": 2,
            "frq": 868,
            "txw": 1,
            "bwi": 0.1,
            "ant": 0,
            "antenna": {
                "txg": 2.15,
                "txl": 0,
                "ant": 1,
                "azi": 0,
                "tlt": 0,
                "hbw": 1,
                "vbw": 1,
                "fbr": 2.15,
                "pol": "v"
```


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```
            }
        }
    ],
    "receiver": {
        "alt": 2,
        "rxg": 2,
        "rxs": -105
    },
    "model": {
        "pm": 11,
        "pe": 2,
        "ked": 1,
        "rel": 95
    },
    "environment": {
        "clm": 0,
        "cll": 1,
        "clt": "Minimal.clt"
    },
    "output": {
        "units": "m",
        "col": "LTE.dBm",
        "out": 2,
        "nf": -120,
        "res": 10,
        "rad": 2
    }
}
```

Response

The `PNG_Mercator` image is warped for slippy maps like Mapbox, Leaflet and Google Maps. The `PNG_WGS84` is for globes like Google Earth, Cesium and WinTAK.

```
{
    "kmz": "https://api.cloudrf.com/archive/WUMya3l4a3ZmcVFDajZ4THZVckVuQT09/kmz",
    "PNG_Mercator": "https://api.cloudrf.com/output/projection/3857/1/0816124833_UAS_PPA_
↪MULTISITE",
    "PNG_WGS84": "https://api.cloudrf.com/users/1/0816124833_UAS_PPA_MULTISITE.4326.png",
    "bounds": [
        38.96165650015791,
        1.4238207375342375,
        38.92354146204287,
        1.3478216615351617
    ],
    "id": 8201557,
    "sid": "WUMya3l4a3ZmcVFDajZ4THZVckVuQT09",
    "area": 43,
    "coverage": 0,
    "key": [
        {
            "l": "-60dBm",
```

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```
            "r": 248,
            "g": 14,
            "b": 14
        },
        {
            "l": "-65dBm",
            "r": 248,
            "g": 107,
            "b": 14
        },
        {
            "l": "-70dBm",
            "r": 247,
            "g": 199,
            "b": 14
        },
        {
            "l": "-75dBm",
            "r": 203,
            "g": 247,
            "b": 14
        },
        {
            "l": "-80dBm",
            "r": 110,
            "g": 247,
            "b": 14
        },
        {
            "l": "-85dBm",
            "r": 17,
            "g": 246,
            "b": 13
        },
        {
            "l": "-90dBm",
            "r": 13,
            "g": 246,
            "b": 102
        },
        {
            "l": "-95dBm",
            "r": 13,
            "g": 246,
            "b": 194
        },
        {
            "l": "-100dBm",
            "r": 13,
            "g": 205,
            "b": 245
        },
```

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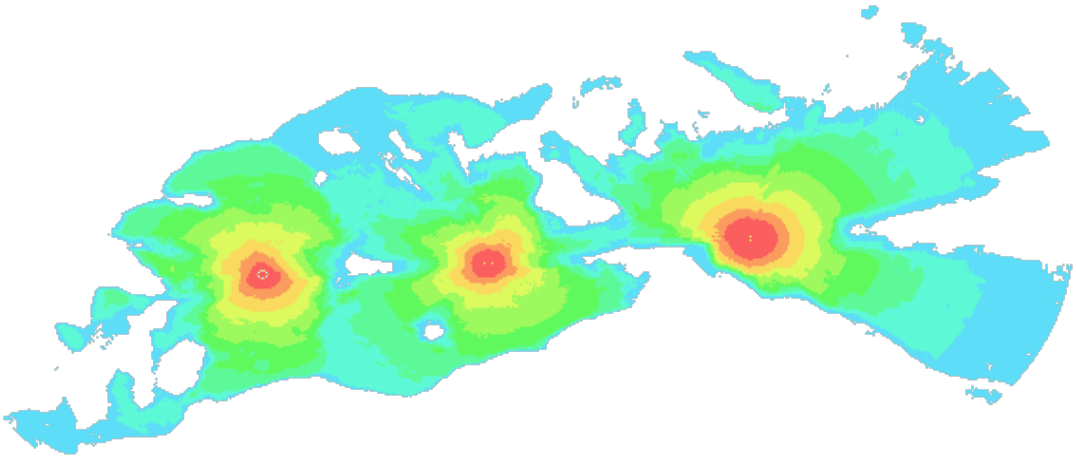
```
        {
            "l": "-105dBm",
            "r": 13,
            "g": 113,
            "b": 245
        }
    ],
    "elapsed": 430.0,
    "balance": 23248
}
```

RADAR With Mixed Heights Example

The below example shows how to use the `multisite` API with RADAR transmitters (`model.pm` value of `8`) where the transmitters are positioned with an elevation relative to the ground (AGL), and the receiver has an elevation above sea level (AMSL). This is indicated with an `output.tx_units` value of `m` and `output.rx_units` value of `m_amsl`, respectively.


```
{
    "site": "Multisite",
    "network": "RADAR_TEST",
    "transmitters": [
        {
            "lat": 30.510523,
            "lon": -86.830194,
            "alt": 5,
            "frq": 8000,
            "txw": 100,
            "bwi": 1.2,
            "antenna": {
                "txg": 15,
                "txl": 0,
```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```
                "ant": 1,
                "azi": 0,
                "tlt": 0,
                "hbw": 30,
                "vbw": 30,
                "fbr": 0,
                "pol": "v"
            }
        },
        {
            "lat": 30.500163,
            "lon": -86.814786,
            "alt": 5,
            "frq": 8000,
            "txw": 100,
            "bwi": 1.2,
            "antenna": {
                "txg": 15,
                "txl": 0,
                "ant": 1,
                "azi": 0,
                "tlt": 0,
                "hbw": 30,
                "vbw": 30,
                "fbr": 0,
                "pol": "v"
            }
        }
    ],
    "receiver": {
        "alt": 500,
        "rxg": 0,
        "rxs": -100
    },
    "model": {
        "pm": 8,
        "pe": 2,
        "ked": 1,
        "rel": 50,
        "rcs": 100
    },
    "environment": {
        "elevation": 2,
        "cll": 0,
        "clm": 0,
        "clt": "Minimal.clt"
    },
    "output": {
        "tx_units": "m",
        "rx_units": "m_amsl",
        "col": "RAINBOW.dBm",
        "out": 2,
```

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```
        "nf": -120,
        "res": 50,
        "rad": 100
    }
}
```

8.5.6 Merge

The `merge` function, previously `mesh`, is a legacy function which merges pre-calcuated layers into a composite layer. This function is now done automatically with the `multisite` function but this is still useful for post-processing such as creating network coverage maps.

Request

The below example is a HTTP `GET` request for meshing the layers (max 1000) belonging to the `BLUENET` network and using the name `mymap` for the output. You must send your API key in the request header as normal.

```
https://api.cloudrf.com/mesh?network=BLUENET&name=mymap
```

You can also specify up to 100 sites in the URL as a list:

```
https://api.cloudrf.com/mesh?network=mymap&calcs=0816143545_BLUENET_Site,0816143541_
↪BLUENET_Site
```

Response

The response is a JSON object containing images and metadata about the calculations which were used to create the mesh image:

```
{
    "kmz": "https://api.cloudrf.com/archive/WkYveUVDdmZTNG1IbDdPbjVKUVVLUT09/kmz",
    "PNG_Mercator": "https://api.cloudrf.com/output/projection/3857/1/0816133557_Mesh",
    "PNG_WGS84": "https://api.cloudrf.com/users/1/0816133557_Mesh.4326.png",
    "bounds": [
        51.99334,
        -2.159573,
        51.76476,
        -2.378462
    ],
    "id": 3541,
    "sid": "WkYveUVDdmZTNG1IbDdPbjVKUVVLUT09",
    "key": [
        {
            "l": "50dB",
            "r": 115,
            "g": 242,
            "b": 15
        },
        {
            "l": "45dB",
            "r": 150,
            "g": 243,
```

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```
            "b": 14
        },
        {
            "l": "40dB",
            "r": 186,
            "g": 243,
            "b": 12
        },
        {
            "l": "35dB",
            "r": 222,
            "g": 243,
            "b": 11
        },
        {
            "l": "30dB",
            "r": 243,
            "g": 228,
            "b": 11
        },
        {
            "l": "25dB",
            "r": 243,
            "g": 192,
            "b": 10
        },
        {
            "l": "20dB",
            "r": 243,
            "g": 155,
            "b": 9
        },
        {
            "l": "15dB",
            "r": 243,
            "g": 118,
            "b": 9
        },
        {
            "l": "10dB",
            "r": 242,
            "g": 81,
            "b": 8
        },
        {
            "l": "5dB",
            "r": 242,
            "g": 44,
            "b": 8
        },
        {
            "l": "0dB",
```

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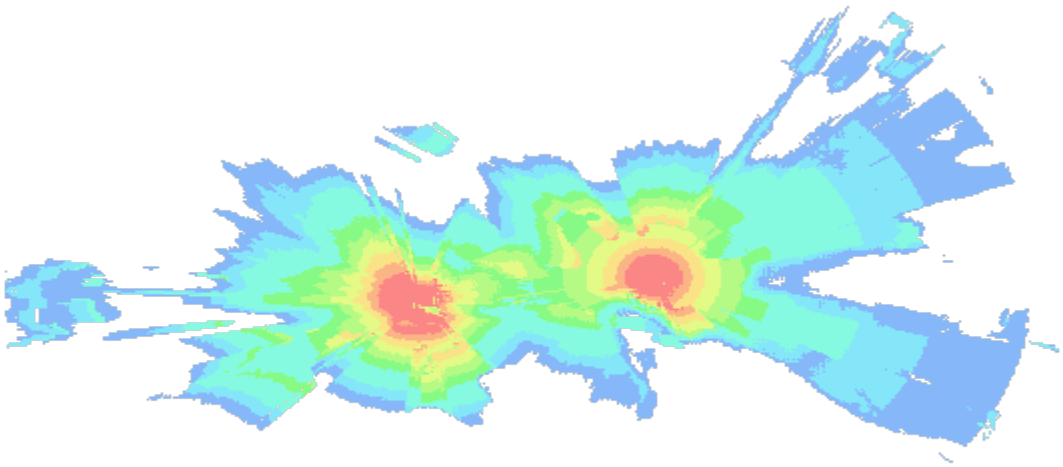
```
            "r": 242,
            "g": 7,
            "b": 7
        }
    ],
    "elapsed": 697.0,
    "balance": 10000000000,
    "resolution": 5
}
```

8.5.7 Interference

The `interference` function compares a set pre-calculated 'signal' sites with a set of pre-calculated 'noise' sites, and calculates a Jamming-to-Signal ratio per pixel.

Signal sites can be specified with either a network name `s_network` or an array of site names `s_sites`, interferers are specified similarly with `j_network` and `j_sites`.

Request

The below example is a HTTP `POST` request for comparing the layers (max 1000) belonging to the InterferenceSignal network against three specified layers from the InterferenceJamming network. The name `QRM2` is used for the output, and the `JS.dB` colour scheme is specified. You must send your API key in the request header as normal.

```
{
    "s_network": "InterferenceSignal",
    "j_sites": [
        "1125164804_InterferenceJamming_A",
        "1125164820_InterferenceJamming_B",
        "1125164852_InterferenceJamming_D"
    ],
    "name": "InterferenceExample",
    "colour_key": "JS.dB"
}
```

Response

The response is a JSON object containing images and metadata about the calculations which were used to create the interference image:

```
{
    "kmz": "https://localhost/archive/M3paazRnWE84Nk0xWWc2d2RzT05zZz09/kmz",
    "PNG_Mercator": "https://localhost/output/projection/3857/1/1126160715_
↪InterferenceExample_QRM",
    "PNG_WGS84": "https://localhost/users/1/1126160715_InterferencExample_QRM.4326.png",
    "bounds": [
        51.99334,
        -2.159573,
        51.76476,
        -2.378462
    ],
    "id": 3541,
    "sid": "M3paazRnWE84TG4xWWc2d2RzT05zZz09",
    "key": [
        {
            "l": "12dB",
            "r": 254,
            "g": 0,
            "b": 0
        },
        {
            "l": "11dB",
            "r": 254,
            "g": 21,
            "b": 0
        },
        {
            "l": "10dB",
            "r": 254,
            "g": 43,
            "b": 0
        },
        {
            "l": "9dB",
            "r": 254,
            "g": 64,
            "b": 0
```

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```
        },
        {
            "l": "8dB",
            "r": 254,
            "g": 85,
            "b": 0
        },
        {
            "l": "7dB",
            "r": 254,
            "g": 106,
            "b": 0
        },
        {
            "l": "6dB",
            "r": 254,
            "g": 128,
            "b": 0
        },
        {
            "l": "5dB",
            "r": 254,
            "g": 149,
            "b": 0
        },
        {
            "l": "4dB",
            "r": 254,
            "g": 170,
            "b": 0
        },
        {
            "l": "3dB",
            "r": 254,
            "g": 191,
            "b": 0
        },
        {
            "l": "2dB",
            "r": 254,
            "g": 212,
            "b": 0
        },
        {
            "l": "1dB",
            "r": 254,
            "g": 234,
            "b": 0
        },
        {
            "l": "0dB",
            "r": 254,
```


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```
            "g": 254,
            "b": 0
        },
        {
            "l": "-1dB",
            "r": 234,
            "g": 254,
            "b": 0
        },
        {
            "l": "-2dB",
            "r": 213,
            "g": 254,
            "b": 0
        },
        {
            "l": "-3dB",
            "r": 191,
            "g": 254,
            "b": 0
        },
        {
            "l": "-4dB",
            "r": 170,
            "g": 254,
            "b": 0
        },
        {
            "l": "-5dB",
            "r": 149,
            "g": 254,
            "b": 0
        },
        {
            "l": "-6dB",
            "r": 128,
            "g": 254,
            "b": 0
        },
        {
            "l": "-7dB",
            "r": 106,
            "g": 254,
            "b": 0
        },
        {
            "l": "-8dB",
            "r": 85,
            "g": 254,
            "b": 0
        },
        {
```

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```
            "l": "-9dB",
            "r": 64,
            "g": 254,
            "b": 0
        },
        {
            "l": "-10dB",
            "r": 43,
            "g": 254,
            "b": 0
        },
        {
            "l": "-11dB",
            "r": 21,
            "g": 254,
            "b": 0
        },
        {
            "l": "-12dB",
            "r": 0,
            "g": 254,
            "b": 0
        }
    ],
    "elapsed": 810.0,
    "balance": 10000000000,
    "resolution": 10,
    "percentages_above_js": [
        {
            "js": 12.0,
            "percentage": 11.737680295098624
        },
        {
            "js": 9.0,
            "percentage": 21.294148830428732
        },
        {
            "js": 6.0,
            "percentage": 32.65301614648908
        },
        {
            "js": 3.0,
            "percentage": 45.59119121772359
        },
        {
            "js": 0.0,
            "percentage": 59.5531553022773
        },
        {
            "js": -3.0,
            "percentage": 71.56362511872419
        },
```


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```
        {
            "js": -6.0,
            "percentage": 81.5077419212334
        },
        {
            "js": -9.0,
            "percentage": 88.70850175601352
        },
        {
            "js": -12.0,
            "percentage": 93.6209219623175
        }
    ]
}
```

8.5.8 Network

The `network` function is a legacy function which tests links to pre-calcuated sites to reveal the strongest server(s) at the tested receiver site (eg. a customer's house).

Request

The below example is a HTTP `GET` request for testing a location with receiver gain 2dBi and receiver height 2m to the BLUENET network. You must send your API key in the request header as normal.

```
https://api.cloudrf.com/network?lat=38.938322&lon=1.398755&net=BLUENET&rxg=2&rxh=2
```

Response

The response is a verbose JSON object containing metadata about each link tested. This can be parsed to reveal the required information eg. RSSI so you can plot coloured links for example:


```
[
    {
        "Engine": "Sleipnir 1.7.8",
        "Frequency MHz": 868,
        "Propagation model": "Egli VHF/UHF",
        "Model subtype": "Suburban",
        "Receiver": [
            {
                "Latitude": 38.93832,
                "Longitude": 1.398755,
                "Ground elevation m": 91,
                "Antenna height m": 2,
                "Receiver gain dBd": -0.15,
                "Receiver gain dBi": 2
            }
        ],
        "Transmitters": [
            {
                "Latitude": 38.94411,
                "Longitude": 1.399756,
                "Ground elevation m": 92,
                "Antenna height m": 2,
                "Distance to receiver km": 0.651,
                "Azimuth to receiver deg": 187.65,
                "Downtilt angle deg": 0.1,
                "Antenna gain dBd": 0,
                "Antenna gain dBi": 2.15,
                "Polarisation": "Vertical",
                "Power W": 1,
                "Power dBm": 32.15,
                "ERP W": 1,
                "EIRP W": 1.641,
                "ERP dBm": 30,
                "EIRP dBm": 32.15,
                "Free space path loss dB": 83.3,
                "Bandwidth MHz": 0.1,
                "Johnson Nyquist noise dB": 0.2,
```


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```
    "Noise floor dBm": -115,
    "Channel noise dBm": -114.8,
    "Signal power at receiver dBm": -87.2,
    "Signal to Noise Ratio dB": 27.6,
    "Computed path loss dB": 117.2,
    "Model attenuation dB": 33.9,
    "Field strength at receiver dBuV/m": 50.9,
    "RX voltage 50 ohm dipole uV": 16,
    "RX voltage 50 ohm dipole dBuV": 24,
    "RX voltage 75 ohm dipole uV": 20,
    "RX voltage 75 ohm dipole dBuV": 26,
    "Raise RX antenna for LOS": 102,
    "Raise RX antenna for fresnel 60%": 313,
    "Raise RX antenna for full fresnel": 344,
    "Obstructions": [
        [
            38.93995,
            1.399037
        ],
        [
            38.94017,
            1.399075
        ],
        [
            38.94039,
            1.399113
        ],
        ... snipped for brevity ...
    ],
    "Distance": [
        0.012,
        0.025,
        0.037,
        0.049,
        0.062,
        ... snipped for brevity ...
    ],
    "Terrain": [
        102,
        103,
        108,
        109,
        112,
        ... snipped for brevity ...
    ],
    "Terrain_AMSL": [
        101,
        102,
        104,
        108,
        109,
        ... snipped for brevity ...
```


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```
                ],
                "Fresnel": [
                    0,
                    -2.04,
                    -2.86,
                    -3.47,
                    -3.96,
                    ... snipped for brevity ...
                ],
                "dBm": [
                    -21,
                    -31,
                    -38,
                    -42,
                    -46,
                    ... snipped for brevity ...
                ],
                "dB": [
                    51,
                    61,
                    68,
                    72,
                    76,
                    ... snipped for brevity ...
                ]
            }
        ],
        "Chart image": "https://api.cloudrf.com/API/archive/data?ppa=5d0ffce3&uid=1",
        "Network KML": "https://api.cloudrf.com/users/1/b7ce7077.kml",
        "Server ID": 8201612,
        "Server name": "0816143545_BLUENET_Site"
    },
    {
        "Engine": "Sleipnir 1.7.8",
        "Frequency MHz": 868,
        "Propagation model": "Egli VHF/UHF",
        "Model subtype": "Suburban",
        "Receiver": [
            {
                "Latitude": 38.93832,
                "Longitude": 1.398755,
                "Ground elevation m": 91,
                "Antenna height m": 2,
                "Receiver gain dBd": -0.15,
                "Receiver gain dBi": 2
            }
        ],
        "Transmitters": [
            {
                "Latitude": 38.94279,
                "Longitude": 1.386807,
                "Ground elevation m": 117,
```


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```
                "Antenna height m": 2,
                "Distance to receiver km": 1.148,
                "Azimuth to receiver deg": 115.66,
                "Downtilt angle deg": 1.3,
                "Antenna gain dBd": 0,
                "Antenna gain dBi": 2.15,
                "Polarisation": "Vertical",
                "Power W": 1,
                "Power dBm": 32.15,
                "ERP W": 1,
                "EIRP W": 1.641,
                "ERP dBm": 30,
                "EIRP dBm": 32.15,
                "Free space path loss dB": 88.3,
                "Bandwidth MHz": 0.1,
                "Johnson Nyquist noise dB": 0.2,
                "Noise floor dBm": -115,
                "Channel noise dBm": -114.8,
                "Signal power at receiver dBm": -96.9,
                "Signal to Noise Ratio dB": 17.9,
                "Computed path loss dB": 126.9,
                "Model attenuation dB": 38.6,
                "Field strength at receiver dBuV/m": 41.3,
                "RX voltage 50 ohm dipole uV": 5,
                "RX voltage 50 ohm dipole dBuV": 14,
                "RX voltage 75 ohm dipole uV": 6,
                "RX voltage 75 ohm dipole dBuV": 16,
                "Raise RX antenna for LOS": 80,
                "Raise RX antenna for fresnel 60%": 92,
                "Raise RX antenna for full fresnel": 100,
                "Obstructions": [
                    [
                        38.93835,
                        1.398676
                    ],
                    [
                        38.93843,
                        1.398467
                    ],
                    [
                        38.93847,
                        1.398363
                    ]
                    ... snipped for brevity ...
                ],
                "Distance": [
                    0.01,
                    0.02,
                    0.03,
                    0.04,
                    0.05,
                    ... snipped for brevity ...
```


(continues on next page)

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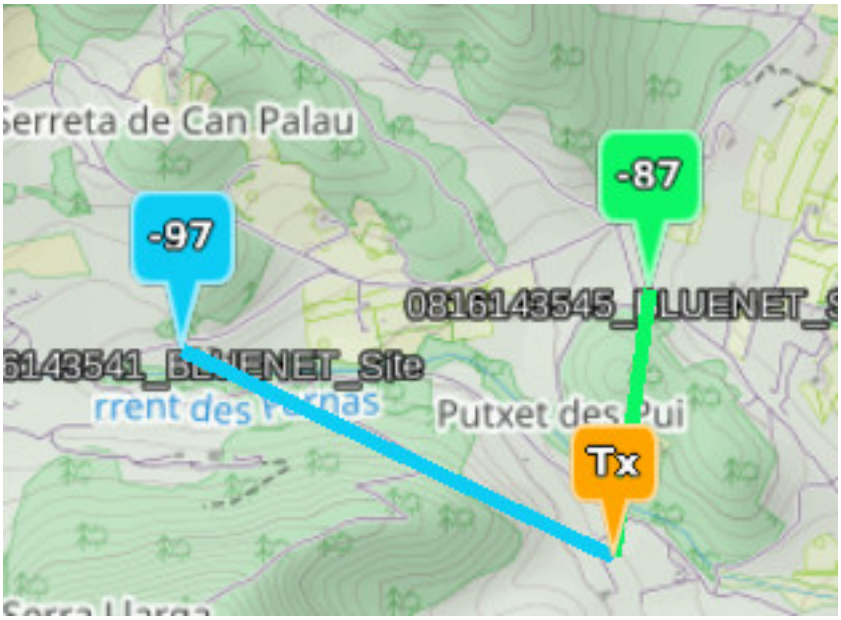
```
                ],
                "Terrain": [
                    111,
                    111,
                    110,
                    110,
                    110,
                    ... snipped for brevity ...
                ],
                "Terrain_AMSL": [
                    114,
                    112,
                    112,
                    111,
                    111,
                    ... snipped for brevity ...
                ],
                "Fresnel": [
                    0,
                    -1.85,
                    -2.61,
                    -3.18,
                    -3.65,
                    ... snipped for brevity ...
                ],
                "dBm": [
                    -16,
                    -27,
                    -34,
                    -39,
                    -43,
                    ... snipped for brevity ...
                ],
                "dB": [
                    46,
                    57,
                    64,
                    69,
                    73,
                    ... snipped for brevity ...
                ]
            }
        ],
        "Chart image": "https://api.cloudrf.com/API/archive/data?ppa=3a949f40&uid=1",
        "Network KML": "https://api.cloudrf.com/users/1/b7ce7077.kml",
        "Server ID": 8201611,
        "Server name": "0816143541_BLUENET_Site"
    }
]
```



8.5.9 HF Area

The `/hf/area` endpoint accepts a JSON object in the request **body** describing your network and will run a point-to-multipoint "heatmap" calculation using VOACAP.

Request

The below example is for a 4MHz signal at 00:00 UTC in July. The request is sent as a `POST` request to `https://api.cloudrf.com/hf/area` and it will return a JSON response containing metadata and URLs to image layers for your map.

```
{
    "site": "Test",
    "network": "HFTest",
    "transmitter": {
        "lat": 51.833992,
        "lon": -2.231319,
        "frq": 4.0
    },
    "antenna": {
        "txg": 2.0,
        "txl": 0.0,
        "ant": 1,
        "pol": "h",
        "azi": 90
    },
    "model": {
        "month": 7,
        "hour": 0,
        "rel": 50
    },
    "output": {
        "col": "SNR1.dB",
        "bounds": {
```

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```
            "north": "72.499717",
            "east": "40.944650",
            "south": "6.353099",
            "west": "-60.400436"
        },
        "nf": -140,
        "out": 4
    }
}
```

Response

The `PNG_Mercator` image is warped for slippy maps like Mapbox, Leaflet and Google Maps. The `PNG_WGS84` is for globes like Google Earth, Cesium and WinTAK.

```
{
    "kmz": "https://api.cloudrf.com/archive/M2JUbU5yOU5XNFFWZ29JZjNmaFFUdz09/kmz",
    "PNG_Mercator": "https://api.cloudrf.com/output/projection/3857/1/1017080906_HFTest_
↪Test_HF",
    "PNG_WGS84": "https://api.cloudrf.com/users/1/1017080906_HFTest_Test_HF.4326.png",
    "bounds": [
        72.499717,
        40.94465,
        6.353099,
        -60.400436
    ],
    "id": 2025,
    "sid": "M2JUbU5yOU5XNFFWZ29JZjNmaFFUdz09",
    "key": [
        {
            "l": "40dB",
            "r": 37,
            "g": 131,
            "b": 255
        },
        {
            "l": "30dB",
            "r": 49,
            "g": 254,
            "b": 127
        },
        {
            "l": "20dB",
            "r": 218,
            "g": 254,
            "b": 60
        },
        {
            "l": "10dB",
            "r": 254,
            "g": 72,
            "b": 72
```

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```
        }
    ],
    "elapsed": 2364.0,
    "balance": 10000000000
}
```


PNG image with colours which map to the signal levels in the JSON output:

8.5.10 HF Prediction

The `/hf/prediction` endpoint accepts a JSON object in the request **body** describing your network and will run a point-to-point calculation using VOACAP.

It produces an output for multiple frequencies, and so can be used for frequency selection.

Request

The below example is for a 4MHz signal in March. The request is sent as a `POST` request to `https://api.cloudrf.com/hf/prediction` and it will return a JSON response containing a link to a chart png.


```
{
    "site": "Test",
    "network": "HFTest",
    "transmitter": {
        "lat": "51.8656",
        "lon": "-2.207",
        "frq": 4.0,
        "txw": 10,
        "alt": 6.0
    },
    "receiver": {
        "lat": "41.86",
        "lon": "12.78",
        "rxg": "2.15"
    },
    "antenna": {
        "txg": 2.15,
        "ant": 2
    },
    "model": {
```


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```
        "month": 3,
        "sunspots_r12": 50
    },
    "output": {
        "nf": -140
    }
}
```

Response


```
{
    "Transmitters": [
        {
            "Latitude": 51.8656,
            "Longitude": -2.207
        }
    ],
    "Receiver": [
        {
            "Latitude": 41.86,
            "Longitude": 12.78
        }
    ],
    "Chart image": "https://api.cloudrf.com/users/1/1029125124_HFTest_Test_HF_PPA.png",
    "elapsed": 1295.0,
    "balance": 10000000000,
    "metadata": {
        "locations": {
            "transmitter": {
                "latitude": 51.8656,
                "longitude": -2.207,
                "altitude_m": 6.0
            },
            "receiver": {
                "latitude": 41.86,
                "longitude": 12.78
            },
            "distance_km": 1586.7
        },
        "antenna": {
            "name": "ITSA-1 Horizontal Dipole",
            "gain": 2.15
        },
        "month": "March",
        "power_w": 10.0
    },
    "hours": {
        "hour0": [
            {
                "frequency": 2.0,
                "snr": 14.0
```


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```
            },
            {
                "frequency": 5.0,
                "snr": 22.0
            },
            {
                "frequency": 8.0,
                "snr": 27.0
            },
            {
                "frequency": 11.0,
                "snr": 7.0
            },
            {
                "frequency": 14.0,
                "snr": -32.0
            },
            {
                "frequency": 17.0,
                "snr": -77.0
            },
            {
                "frequency": 20.0,
                "snr": -76.0
            },
            {
                "frequency": 4.0,
                "snr": 20.0
            }
        ],
        "hour1": [
            {
                "frequency": 2.0,
                "snr": 17.0
            },
            {
                "frequency": 5.0,
                "snr": 26.0
            },
            {
                "frequency": 8.0,
                "snr": 30.0
            },
            {
                "frequency": 11.0,
                "snr": -6.0
            },
            {
                "frequency": 14.0,
                "snr": -74.0
            },
            {
```


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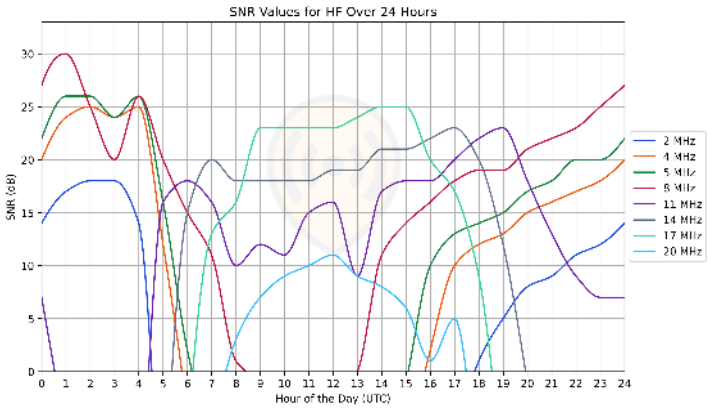
```
                "frequency": 17.0,
                "snr": -74.0
            },
            {
                "frequency": 20.0,
                "snr": -73.0
            },
            {
                "frequency": 4.0,
                "snr": 24.0
            }
        ],
        ...snipped for brevity...
    }
}
```

Chart image showing which frequencies are stronger at different times of day:




```
Month: March

Transmitter:
    Latitude: 51.8656
    Longitude: -2.207
    Altitude: 6 m

Receiver:
    Latitude: 41.86
    Longitude: 12.78

Distance between Transmitter and Receiver: 1506.7 km

Antenna:
    Name: ITSA-1 Horizontal Dipole
    Gain: 2.15 dB

Transmitter Power: 10 W
```

8.6 Area API with bounded output

Often the study area is far away from the transmitter, for example a suburb which is served by a mountain repeater. By bounding the output area in the request, only this focus area is computed and returned.

Aside from being very fast and efficient, it allows for higher resolution calculations than would be possible by testing the entire town / valley in all directions.

For example, to test an airfield with LiDAR accuracy that is 42km away from the transmitter you would populate the "bounds" array within the "output" section of an area request.

```
{
  ... snipped for brevity ...
    "output": {
        "units": "m",
        "col": "3",
        "out": "2",
        "ber": "1",
        "mod": null,
        "nf": "-120",
```

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```
        "res": "2",
        "rad": "42",
        "bounds": {
            "north": 51.677,
            "south": 51.655,
            "east": -2.039,
            "west": -2.076
        }
    }
}
```

8.7 More Information

For a complete OpenAPI 3 schema of the CloudRF API please consult the Swagger UI documentation.

8.7.1 Compression

CloudRF uses gzip compression for output files. The official client handles this but if you are writing your own you should use the MIME type rather than writing raw data as a `.tiff` may actually be `.tiff.gz`.

Below shows an example of this in Python 3:

```
# WARNING: Will write a gzipped file
shutil.copyfileobj(response.raw, outputFile)

# Will handle gzip decompression
outputFile.write(response.content)
```

8.7.2 Verbose Environment Variables

Since `v3.8`, the `environment` block has been redesigned to replace the cryptic `cll` and `clm` values with simpler boolean layers describing `elevation`, `landcover`, `buildings` and `obstacles`. This enables easier layering of custom clutter upon DTM for example (elevation = `2`, obstacles = `1`).

Both methods are supported in `3.8` but the long form is now the standard, as used in the web interface, and the old trigraph method is deprecated. It still features in places such as templates.

The following table translates old to new values:

Legacy Value	New Value (3.8)
cll = 0	landcover = 0
cll = 1	landcover = 1
cll = 2	landcover = 1, buildings = 1
clm = 0	obstacles = 0
clm = 1	obstacles = 1
clm = 2	elevation = 2, obstacles = 1

8.8 API scripts

A list of ready-to-use scripts are available on the CloudRF public GitHub repository.

- Python
- Bash
- Slippy maps

Some radio templates are here to help you pick good settings for hardware:

CHAPTER

NINE

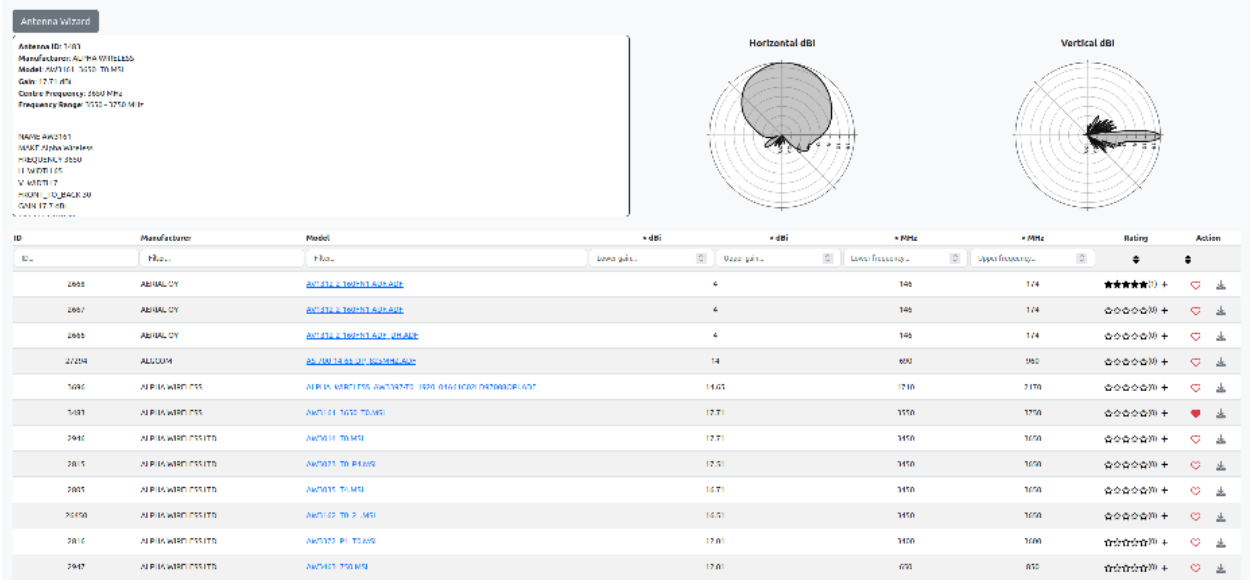
REFERENCE DATA

9.1 Antenna Patterns

The antenna database lets you search for patterns by manufacturer, model and/or physical parameters like gain.

To access the Antenna Database:

- Under the **Antenna** Input menu, click on the **Manage my Antennas**  icon.
- The **Antenna Database** dialog box will appear. You can choose to open this in a separate tab with the hyperlink at the bottom.



- In the table, you can search the Antenna Database by filtering on parameters.

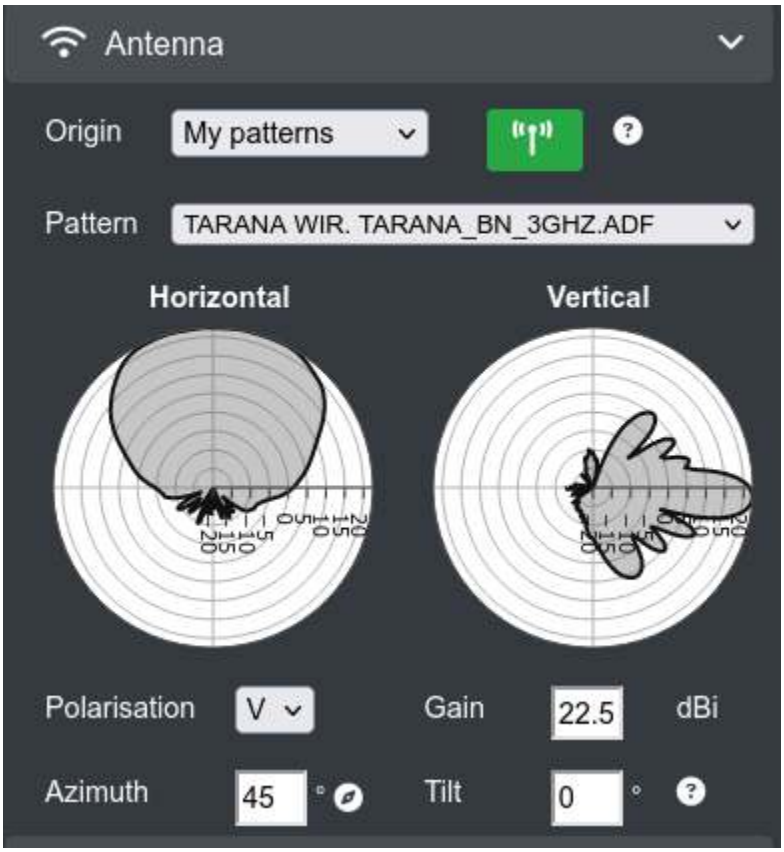
To do so:

- Select the desired **Manufacturer**.
  - The respective manufacturer's list of *Antenna Patterns* will be displayed.
- Select the desired **Model**.
  - The respective **Antenna Pattern's information** - *ID, Name, Description, Frequency, Gain, Polarisation* and *Polar Maps* will be displayed once a row is clicked.

9.1.1 Choosing a favourite pattern

Each row has a heart icon to the right. Click the heart to 'favourite' a pattern and click it again to 'unfavourite' it.

When a pattern is a favourite, the heart will be red and it will appear on your list within 10 seconds.



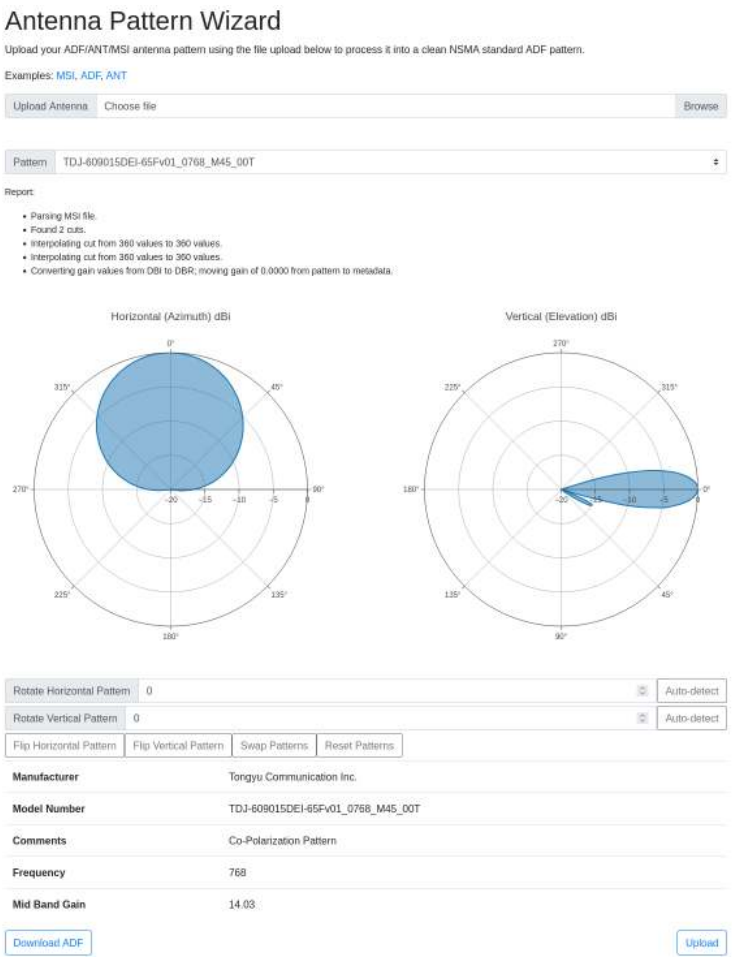
9.1.2 Antenna pattern data

At the top of the atenna database interface there is a link to the Antenna Wizard.

The wizard can be used to:

- Upload antenna patterns for use in calculations,
- Convert antenna patterns to TIA/EIA-804-B (NSMA) ADF format.

The wizard works with ADF, MSI and ANT formats. The patterns can be flipped, swapped, and rotated.



Some ADF files contain multiple patterns for the same antenna, different patterns for different frequencies and polarizations. Currently, the system treats these as seperate patterns so the must be uploaded separately.

For more information see Antenna patterns.

To validate an ADF pattern use our online tool here: https://api.cloudrf.com/API/antennas/validator/index.php

Example TIA/EIA-804-B pattern file

This example data shows the unique colon-comma formatting this TIA standard uses. It might not make sense compared with modern information standards but it is a ratified standard and is widely supported as a result.

```
REVNUM:,TIA/EIA-804-B
COMNT1:,Standard TIA/EIA Antenna Pattern Data
ANTMAN:,RFI Antennas for Bird Technologies Group
MODNUM:,CC806-06 @ 870
DESCR1:,Corporate collinear, 746-870 MHz
DESCR2:,Omnidirectional, 5dBd, 0o Downtilt
DTDATA:,20060213
LOWFRQ:,746
HGHFRQ:,870
GUNITS:,DBD/DBR
MDGAIN:,4.8
AZWIDT:,360
```

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```
ELWIDT:,17
CONTYP:,7/16 DIN Silver Plated
ATVSWR:,1.5
FRTOBA:,0
ELTILT:,0
MAXPOW:,500
ANTLEN:,1.85
ANTWID:,0.077
ANTWGT:,7.1
PATTYP:,Typical
NOFREQ:,1
PATFRE:,870
NUMCUT:,2
PATCUT:,V
POLARI:,V/V
NUPOIN:,360
FSTLST:,-179,180
-179,-0.053
-178,-0.179
-177,-0.374
-176,-0.639
-175,-0.971
-174,-1.376
-173,-1.857
-172,-2.425
-171,-3.089
-170,-3.866
-169,-4.772
-168,-5.831
-167,-7.069
-166,-8.515
-165,-10.202
-164,-12.146
-163,-14.296
-162,-16.376
-161,-17.699
-160,-17.679
-159,-16.748
-158,-15.657
-157,-14.757
-156,-14.132
-155,-13.777
-154,-13.665
-153,-13.770
-152,-14.066
-151,-14.532
-150,-15.146
-149,-15.888
-148,-16.736
-147,-17.668
-146,-18.656
-145,-19.667
```

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```
-144,-20.654
-143,-21.546
-142,-22.234
-141,-22.588
-140,-22.512
-139,-22.014
-138,-21.214
-137,-20.261
-136,-19.278
-135,-18.338
-134,-17.483
-133,-16.730
-132,-16.084
-131,-15.544
-130,-15.107
-129,-14.767
-128,-14.520
-127,-14.358
-126,-14.277
-125,-14.271
-124,-14.337
-123,-14.468
-122,-14.662
-121,-14.914
-120,-15.221
-119,-15.579
-118,-15.986
-117,-16.439
-116,-16.935
-115,-17.472
-114,-18.048
-113,-18.659
-112,-19.305
-111,-19.982
-110,-20.689
-109,-21.424
-108,-22.185
-107,-22.972
-106,-23.782
-105,-24.618
-104,-25.481
-103,-26.374
-102,-27.304
-101,-28.282
-100,-29.320
-99,-30.441
-98,-31.672
-97,-33.053
-96,-34.640
-95,-36.507
-94,-38.739
-93,-41.001
```

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```
-92,-41.317
-91,-43.387
-90,-43.536
-89,-43.387
-88,-41.317
-87,-41.001
-86,-38.739
-85,-36.507
-84,-34.640
-83,-33.053
-82,-31.672
-81,-30.441
-80,-29.320
-79,-28.282
-78,-27.304
-77,-26.374
-76,-25.481
-75,-24.618
-74,-23.782
-73,-22.972
-72,-22.185
-71,-21.424
-70,-20.689
-69,-19.982
-68,-19.305
-67,-18.659
-66,-18.048
-65,-17.472
-64,-16.935
-63,-16.439
-62,-15.986
-61,-15.579
-60,-15.221
-59,-14.914
-58,-14.662
-57,-14.468
-56,-14.337
-55,-14.271
-54,-14.277
-53,-14.358
-52,-14.520
-51,-14.767
-50,-15.107
-49,-15.544
-48,-16.084
-47,-16.730
-46,-17.483
-45,-18.338
-44,-19.278
-43,-20.261
-42,-21.214
-41,-22.014
```

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```
-40,-22.512
-39,-22.588
-38,-22.234
-37,-21.546
-36,-20.654
-35,-19.667
-34,-18.656
-33,-17.668
-32,-16.736
-31,-15.888
-30,-15.146
-29,-14.532
-28,-14.066
-27,-13.770
-26,-13.665
-25,-13.777
-24,-14.132
-23,-14.757
-22,-15.657
-21,-16.748
-20,-17.679
-19,-17.699
-18,-16.376
-17,-14.296
-16,-12.146
-15,-10.202
-14,-8.515
-13,-7.069
-12,-5.831
-11,-4.772
-10,-3.866
-9,-3.089
-8,-2.425
-7,-1.857
-6,-1.376
-5,-0.971
-4,-0.639
-3,-0.374
-2,-0.179
-1,-0.053
0,0.000
1,-0.080
2,-0.200
3,-0.700
4,-1.300
5,-1.987
6,-2.509
7,-3.159
8,-3.946
9,-4.882
10,-5.982
11,-7.264
```

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```
12,-8.756
13,-10.498
14,-12.551
15,-15.021
16,-18.110
17,-22.259
18,-28.598
19,-34.203
20,-27.412
21,-23.162
22,-20.560
23,-18.783
24,-17.499
25,-16.553
26,-15.866
27,-15.396
28,-15.122
29,-15.033
30,-15.127
31,-15.406
32,-15.876
33,-16.547
34,-17.431
35,-18.537
36,-19.862
37,-21.359
38,-22.862
39,-23.992
40,-24.280
41,-23.680
42,-22.631
43,-21.539
44,-20.590
45,-19.839
46,-19.287
47,-18.922
48,-18.725
49,-18.682
50,-18.776
51,-18.997
52,-19.333
53,-19.771
54,-20.300
55,-20.905
56,-21.568
57,-22.264
58,-22.963
59,-23.627
60,-24.216
61,-24.695
62,-25.041
63,-25.251
```

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```
64,-25.343
65,-25.345
66,-25.294
67,-25.220
68,-25.146
69,-25.091
70,-25.066
71,-25.076
72,-25.125
73,-25.214
74,-25.343
75,-25.509
76,-25.711
77,-25.945
78,-26.210
79,-26.502
80,-26.818
81,-27.154
82,-27.506
83,-27.871
84,-28.243
85,-28.617
86,-29.000
87,-30.000
88,-31.000
89,-34.000
90,-36.000
91,-34.000
92,-31.000
93,-30.000
94,-29.000
95,-28.617
96,-28.243
97,-27.871
98,-27.506
99,-27.154
100,-26.818
101,-26.502
102,-26.210
103,-25.945
104,-25.711
105,-25.509
106,-25.343
107,-25.214
108,-25.125
109,-25.076
110,-25.066
111,-25.091
112,-25.146
113,-25.220
114,-25.294
115,-25.345
```

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```
116,-25.343
117,-25.251
118,-25.041
119,-24.695
120,-24.216
121,-23.627
122,-22.963
123,-22.264
124,-21.568
125,-20.905
126,-20.300
127,-19.771
128,-19.333
129,-18.997
130,-18.776
131,-18.682
132,-18.725
133,-18.922
134,-19.287
135,-19.839
136,-20.590
137,-21.539
138,-22.631
139,-23.680
140,-24.280
141,-23.992
142,-22.862
143,-21.359
144,-19.862
145,-18.537
146,-17.431
147,-16.547
148,-15.876
149,-15.406
150,-15.127
151,-15.033
152,-15.122
153,-15.396
154,-15.866
155,-16.553
156,-17.499
157,-18.783
158,-20.560
159,-23.162
160,-27.412
161,-34.203
162,-28.598
163,-22.259
164,-18.110
165,-15.021
166,-12.551
167,-10.498
```

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```
168,-8.756
169,-7.264
170,-5.982
171,-4.882
172,-3.946
173,-3.159
174,-2.509
175,-1.987
176,-1.300
177,-0.700
178,-0.200
179,-0.080
180,0.000
PATCUT:,H
POLARI:,V/V
NUPOIN:,360
FSTLST:,-179,180
-179,-1.097
-178,-1.096
-177,-1.095
-176,-1.094
-175,-1.091
-174,-1.088
-173,-1.085
-172,-1.080
-171,-1.075
-170,-1.070
-169,-1.064
-168,-1.057
-167,-1.050
-166,-1.043
-165,-1.034
-164,-1.026
-163,-1.017
-162,-1.007
-161,-0.998
-160,-0.987
-159,-0.977
-158,-0.966
-157,-0.955
-156,-0.944
-155,-0.933
-154,-0.921
-153,-0.910
-152,-0.898
-151,-0.887
-150,-0.875
-149,-0.863
-148,-0.852
-147,-0.841
-146,-0.829
-145,-0.818
```

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```
-144,-0.807
-143,-0.797
-142,-0.786
-141,-0.776
-140,-0.766
-139,-0.756
-138,-0.747
-137,-0.738
-136,-0.730
-135,-0.721
-134,-0.713
-133,-0.706
-132,-0.699
-131,-0.692
-130,-0.685
-129,-0.679
-128,-0.673
-127,-0.668
-126,-0.662
-125,-0.658
-124,-0.653
-123,-0.649
-122,-0.644
-121,-0.640
-120,-0.637
-119,-0.633
-118,-0.630
-117,-0.627
-116,-0.623
-115,-0.620
-114,-0.617
-113,-0.614
-112,-0.611
-111,-0.608
-110,-0.605
-109,-0.602
-108,-0.599
-107,-0.595
-106,-0.592
-105,-0.588
-104,-0.584
-103,-0.580
-102,-0.576
-101,-0.571
-100,-0.566
-99,-0.561
-98,-0.556
-97,-0.550
-96,-0.544
-95,-0.538
-94,-0.531
-93,-0.524
```

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```
-92,-0.516
-91,-0.509
-90,-0.501
-89,-0.492
-88,-0.484
-87,-0.474
-86,-0.465
-85,-0.455
-84,-0.445
-83,-0.435
-82,-0.424
-81,-0.413
-80,-0.402
-79,-0.391
-78,-0.379
-77,-0.367
-76,-0.355
-75,-0.343
-74,-0.330
-73,-0.318
-72,-0.305
-71,-0.293
-70,-0.280
-69,-0.268
-68,-0.255
-67,-0.242
-66,-0.230
-65,-0.217
-64,-0.205
-63,-0.193
-62,-0.181
-61,-0.170
-60,-0.158
-59,-0.147
-58,-0.136
-57,-0.125
-56,-0.115
-55,-0.105
-54,-0.096
-53,-0.087
-52,-0.078
-51,-0.070
-50,-0.062
-49,-0.055
-48,-0.048
-47,-0.041
-46,-0.035
-45,-0.030
-44,-0.025
-43,-0.020
-42,-0.016
-41,-0.013
```

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```
-40,-0.010
-39,-0.007
-38,-0.005
-37,-0.003
-36,-0.002
-35,-0.001
-34,0.000
-33,0.000
-32,0.000
-31,-0.001
-30,-0.002
-29,-0.003
-28,-0.004
-27,-0.006
-26,-0.008
-25,-0.010
-24,-0.012
-23,-0.014
-22,-0.017
-21,-0.020
-20,-0.022
-19,-0.025
-18,-0.028
-17,-0.031
-16,-0.034
-15,-0.037
-14,-0.039
-13,-0.042
-12,-0.045
-11,-0.047
-10,-0.049
-9,-0.052
-8,-0.054
-7,-0.056
-6,-0.057
-5,-0.059
-4,-0.060
-3,-0.061
-2,-0.062
-1,-0.062
0,-0.063
1,-0.063
2,-0.063
3,-0.062
4,-0.062
5,-0.061
6,-0.060
7,-0.059
8,-0.057
9,-0.056
10,-0.054
11,-0.052
```

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```
12,-0.049
13,-0.047
14,-0.045
15,-0.042
16,-0.039
17,-0.037
18,-0.034
19,-0.031
20,-0.028
21,-0.025
22,-0.022
23,-0.020
24,-0.017
25,-0.014
26,-0.012
27,-0.010
28,-0.008
29,-0.006
30,-0.004
31,-0.003
32,-0.002
33,-0.001
34,0.000
35,0.000
36,0.000
37,-0.001
38,-0.002
39,-0.003
40,-0.005
41,-0.007
42,-0.010
43,-0.013
44,-0.016
45,-0.020
46,-0.025
47,-0.030
48,-0.035
49,-0.041
50,-0.048
51,-0.055
52,-0.062
53,-0.070
54,-0.078
55,-0.087
56,-0.096
57,-0.105
58,-0.115
59,-0.125
60,-0.136
61,-0.147
62,-0.158
63,-0.170
```

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```
64,-0.181
65,-0.193
66,-0.205
67,-0.217
68,-0.230
69,-0.242
70,-0.255
71,-0.268
72,-0.280
73,-0.293
74,-0.305
75,-0.318
76,-0.330
77,-0.343
78,-0.355
79,-0.367
80,-0.379
81,-0.391
82,-0.402
83,-0.413
84,-0.424
85,-0.435
86,-0.445
87,-0.455
88,-0.465
89,-0.474
90,-0.484
91,-0.492
92,-0.501
93,-0.509
94,-0.516
95,-0.524
96,-0.531
97,-0.538
98,-0.544
99,-0.550
100,-0.556
101,-0.561
102,-0.566
103,-0.571
104,-0.576
105,-0.580
106,-0.584
107,-0.588
108,-0.592
109,-0.595
110,-0.599
111,-0.602
112,-0.605
113,-0.608
114,-0.611
115,-0.614
```

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```
116,-0.617
117,-0.620
118,-0.623
119,-0.627
120,-0.630
121,-0.633
122,-0.637
123,-0.640
124,-0.644
125,-0.649
126,-0.653
127,-0.658
128,-0.662
129,-0.668
130,-0.673
131,-0.679
132,-0.685
133,-0.692
134,-0.699
135,-0.706
136,-0.713
137,-0.721
138,-0.730
139,-0.738
140,-0.747
141,-0.756
142,-0.766
143,-0.776
144,-0.786
145,-0.797
146,-0.807
147,-0.818
148,-0.829
149,-0.841
150,-0.852
151,-0.863
152,-0.875
153,-0.887
154,-0.898
155,-0.910
156,-0.921
157,-0.933
158,-0.944
159,-0.955
160,-0.966
161,-0.977
162,-0.987
163,-0.998
164,-1.007
165,-1.017
166,-1.026
167,-1.034
```

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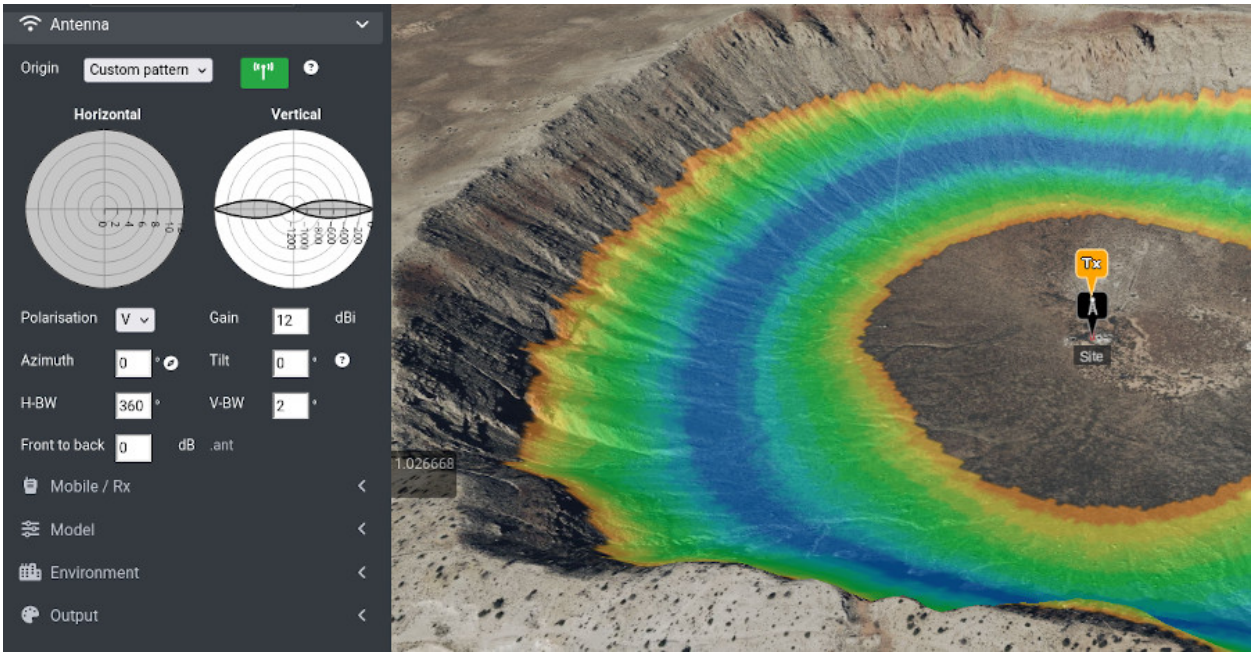
```
168,-1.043
169,-1.050
170,-1.057
171,-1.064
172,-1.070
173,-1.075
174,-1.080
175,-1.085
176,-1.088
177,-1.091
178,-1.094
179,-1.095
180,-1.096
ENDFIL:,EOF
```

9.1.3 Antenna pattern test range

As well as testing over water, the Meteor crater west of Winslow, Arizona is recommended for proving vertical antenna patterns as the elevation plane can be seen clearly on the walls.



9.2 Terrain data

The system works with raster data in the GeoTIFF format with WGS-84 projection.

SOOTHSAYER users with a private server can add their own tiles by placing them in the mapped `/data/DEM/` *folder and importing them within the admin dashboard. See the SOOTHSAYER documentation for more information on adding your own data.*

GeoTIFF tiles need to be of type `Int16` in `WGS-84 (EPSG:4326)` projection with a pixel resolution of between 1 and 30m. LZW compression is recommended.

For a map of current CloudRF system data see Terrain data map. Data is continuously added and refreshed so this is a

live map.

9.3 Buildings and LiDAR

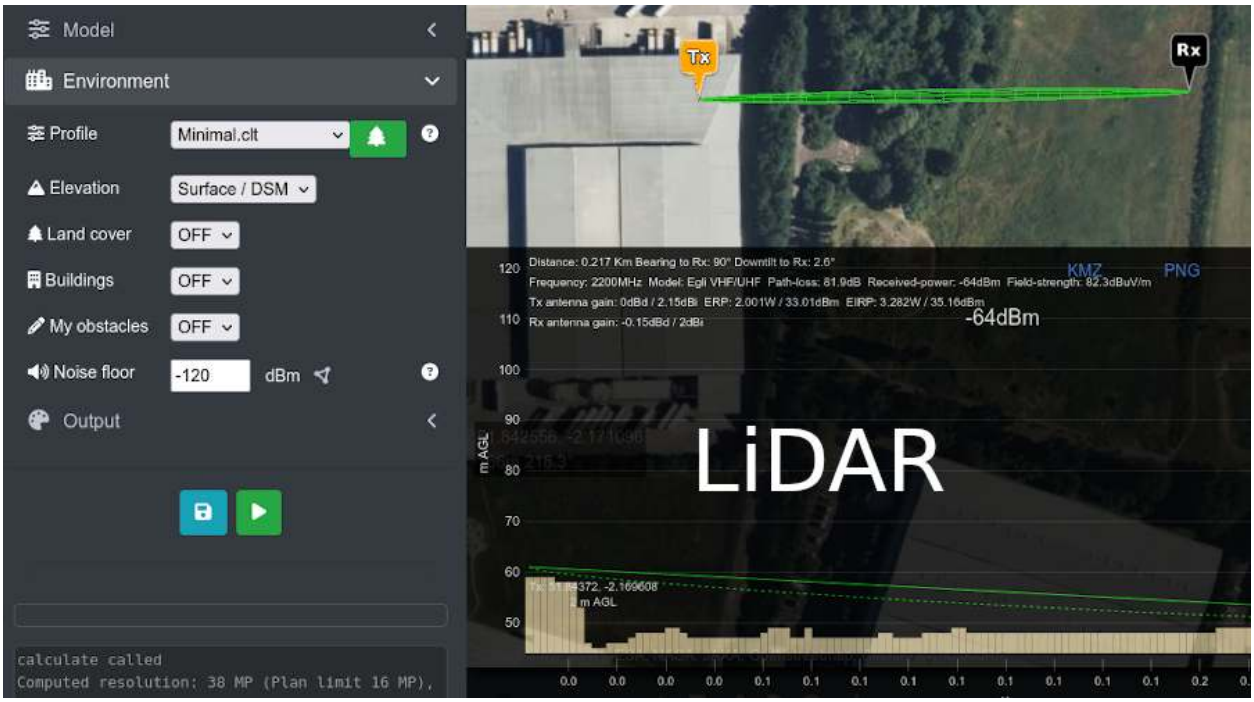
When using LiDAR data, users should be aware that it is a single surface layer (DSM) which *includes* buildings. Therefore if you need a 2m mast on top of a 9m building this is still a **relative height** of 2m for the input form.

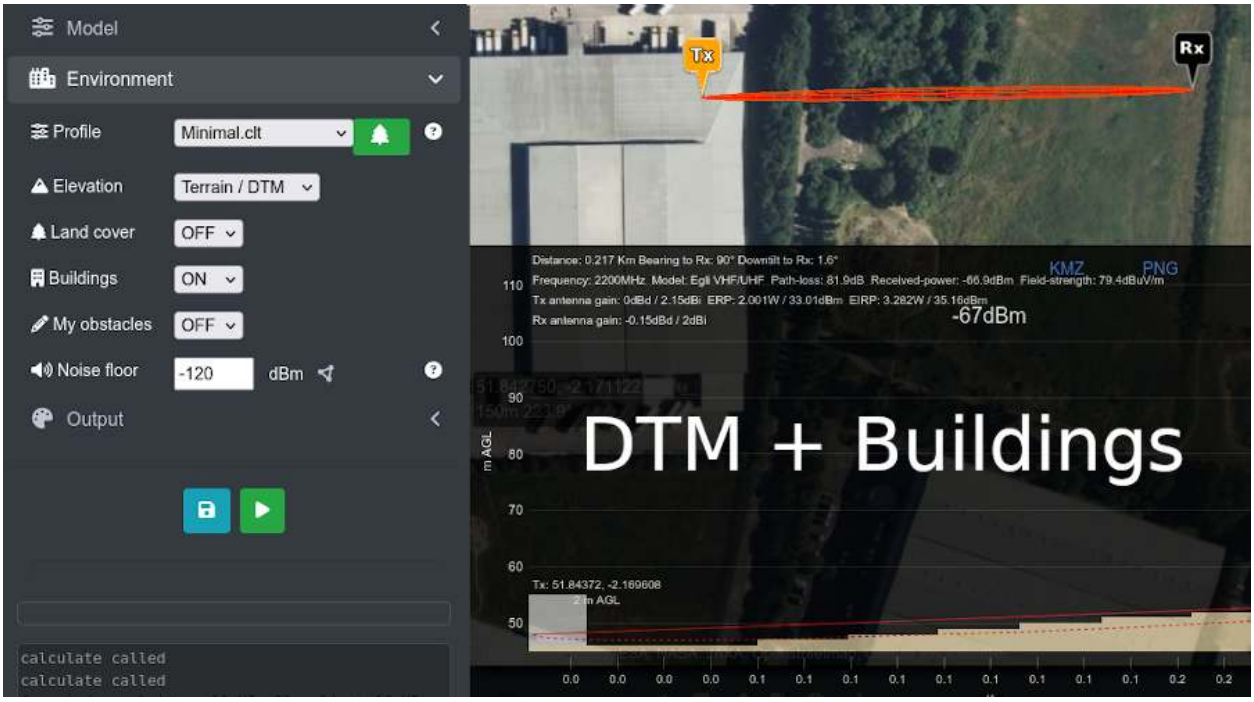
```
To test for LiDAR, use the path tool with DSM and without the buildings layer at high␣
↪resolution eg. 5m. If you see buildings you have LiDAR in your area.
```

If you do not have LiDAR, use the digital terrain model (DTM), which describes most of the earth, and enter an **absolute height** above ground of 11m to simulate a 2m mast atop a 9m building.

In the web interface, LiDAR data is used when the terrain type is DSM and the resolution is <= 30m. If it is not available, a 30m DSM model will be used. This does not contain buildings so must be enhanced with the buildings layer.

In these images, a 2m high antenna is modelled using DSM LiDAR and DTM with buildings. Note the DTM link appears obstructed since it is inside the obstacle so needs elevating to the absolute height of 11m above ground to budget for the 9m building.





9.4 Clutter data

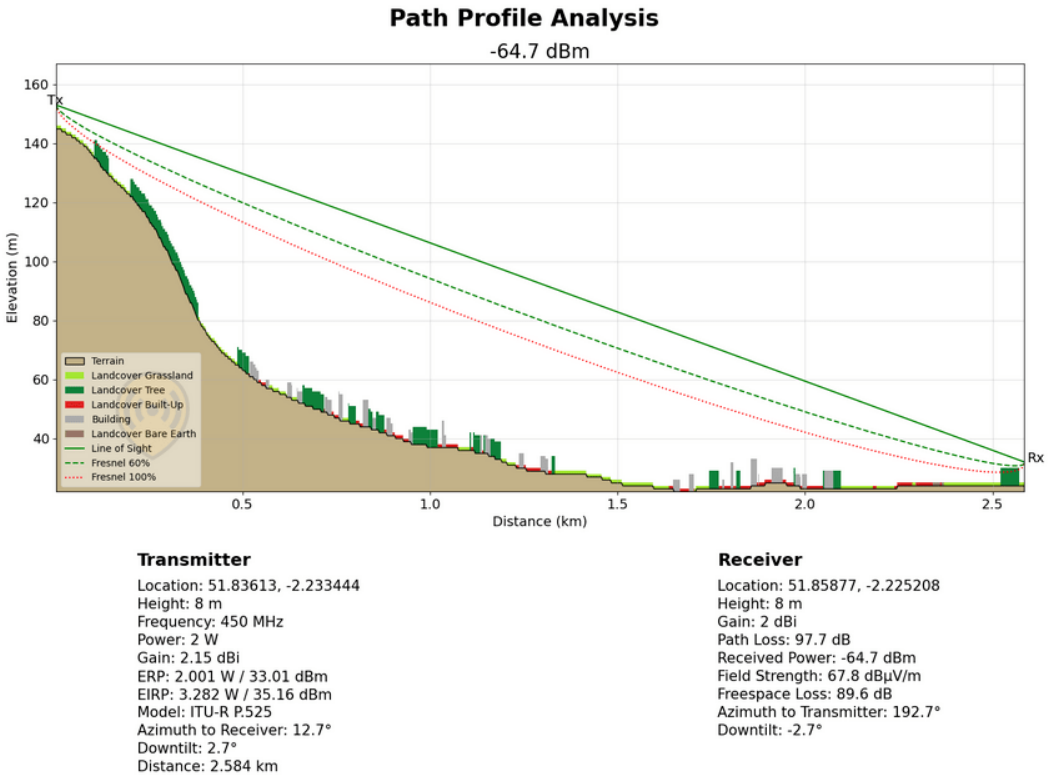
The system has several forms of landcover data to enhance above surface accuracy, especially in urban areas.

All users can draw and self-classify private clutter items in the web interface as polylines or polygons. Using this technique you can represent almost any obstacle from light trees through to concrete and solid metal.

Large numbers of obstacles can be uploaded as KML or GeoJSON in the web interface.

Uploaded clutter belongs to a user and is not visible to others.

For more information on landcover classes see Clutter data.



9.4.1 10m Landcover

The primary clutter source is European Space Agency (ESA) 10m Landcover data, published in October 2021.

WorldCover provides a new baseline global land cover product at 10 m resolution for 2020 based on Sentinel-1 and 2 data that was developed and validated in almost near-real time and at the same time maximizes the impact and uptake for the end users.

A tremendous step forward towards the joint use of Sentinel satellite data for worldwide land cover mapping.

© ESA WorldCover project 2020 / Contains modified Copernicus Sentinel data (2020) processed by ESA WorldCover consortium

This comprehensive dataset covers the planet and has 9 bands for Trees, Shrubland, Grassland, Crops, Built-up, Bare ground, Snow/Ice, Water, Swamps and Mangroves.

WARNING: Be careful when setting the 'urban' landcover height since this elevates roads (and car parks etc) as well as buildings! Keep this height low and use the buildings layer instead for urban planning.

9.4.2 3D Buildings

A supplementary clutter source are 3D Buildings, derived from satellite imagery using machine learning. These are accurate to 2m and have better global coverage than crowd sourced equivalents.

The height of buildings is either estimated or crowd sourced. Where height is unknown an approximate local value is used based upon neighbour heights. The minimum height is 3m.

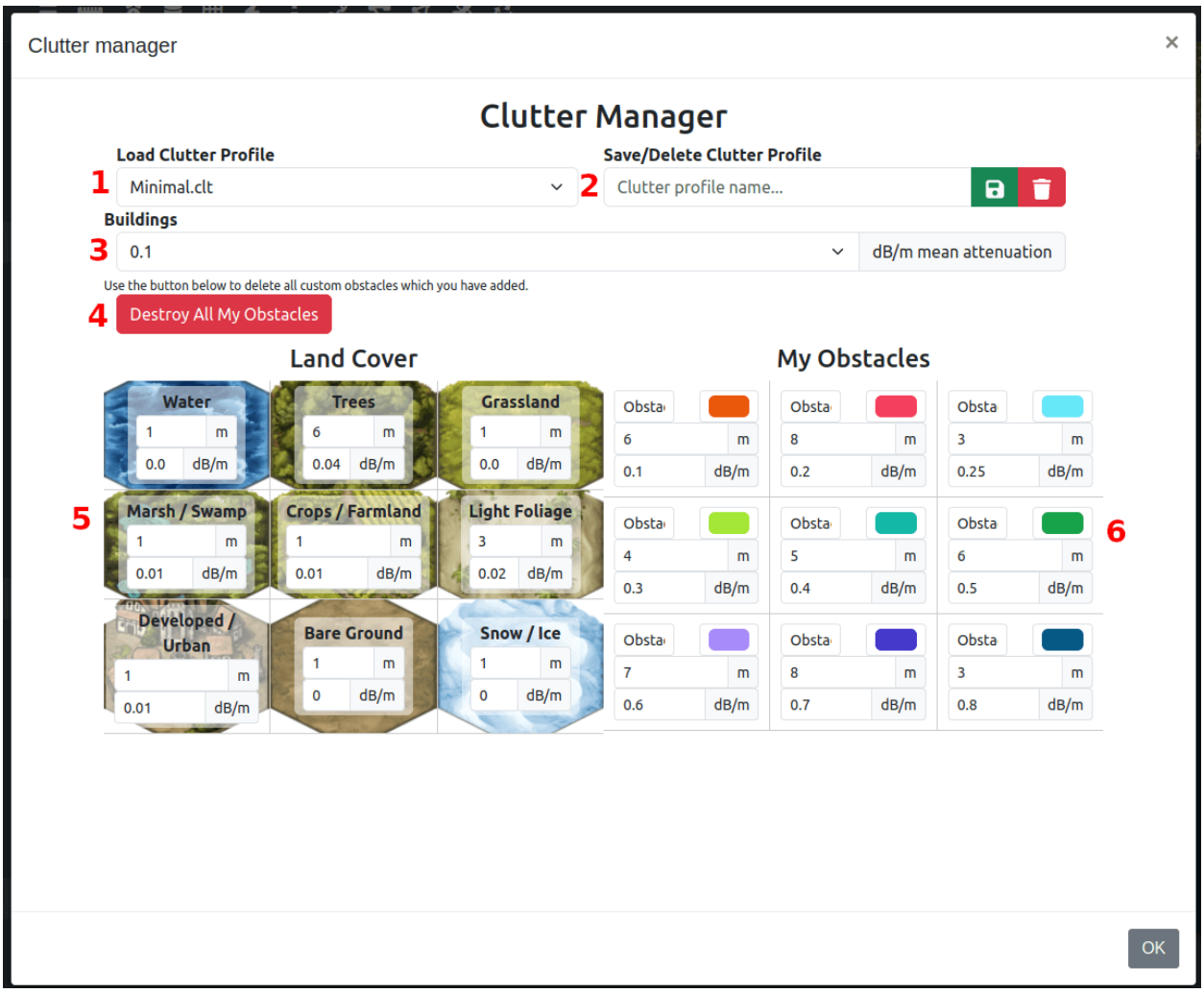
9.4.3 Custom Clutter

All users can draw and self-classify private clutter items in the web interface as polylines or polygons. Using this technique you can represent almost any obstacle from light trees through to concrete.

Large numbers of obstacles can be uploaded as KML or GeoJSON in the web interface.

Uploaded clutter belongs to a user or the system. VM administrators can override clutter ownership manually in the SQL clutter table to make it system clutter for the benefit of all users.

For more information on land cover classes see Clutter data.



1. Selected clutter profile
2. Save/delete profile as name
3. Building attenuation
4. Delete all obstacles on your account
5. Land cover types with customisable height and attenuation values
6. My obstacle (clutter) types with customisable name, colour, height and attenuation values

9.4.4 Clutter codes

In a clutter profile the codes represent different types of landcover.

System Landcover

- 1 Water
- 2 Trees
- 3 Grassland
- 4 Swamp
- 5 Crops
- 6 Shrubland
- 7 Built-up
- 8 Bare ground
- 9 Snow / Ice

Custom Clutter

Codes 11 through 19 represent "Custom Clutter". These codes are free to be customised as per your particular usecase and environment. You have the ability to define a name and a colour for each of these clutter codes which will be represented in calculations.

For more information on how to add clutter with these codes, please consult the *clutter documentation*.

9.4.5 Clutter Profiles

Premium users can define custom clutter profiles for regions eg. `AFRICA.clt`, `POLAND.clt`. These are saved within your folder as `.clt` files. VM users can add these locally by placing `.clt` files in the folder.

A `.clt` is a simple text format with tab delimiters and 3 columns: "Code", "Height (m)" and "Nominal Attenuation (dB/m)".

Codes 11 through 19 represent your "My Obstacles" and also have 2 additional columns of "Name" and "Colour Code". This allows you to customise your custom obstacles further.

The system default, `Minimal.clt`, looks like this. Code `10` is not used.

Please note that the columns are separed by tabs (`\t`).

```
1       1       0.0
2       1       0.01
3       1       0.0
4       1       0.001
5       1       0.002
6       1       0.002
7       1       0.02
8       1       0
9       1       0
10       0       0
11       6       0.1       "Obstacle 1"       "#ea580c"
12       8       0.2       "Obstacle 2"       "#f43f5e"
13       3       0.25       "Obstacle 3"       "#67e8f9"
14       4       0.3       "Obstacle 4"       "#a3e635"
```

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```
15        5        0.4        "Obstacle 5"        "#14b8a6"
16        6        0.5        "Obstacle 6"        "#16a34a"
17        7        0.6        "Obstacle 7"        "#a78bfa"
18        8        0.7        "Obstacle 8"        "#4338ca"
19        3        1.0        "Obstacle 9"        "#075985"
```

CHAPTER

TEN

COMMON TASKS

The following are instructions for completing several common tasks in radio engineering. They are intended as a guide only. For detailed instructions on each component see the relevant documentation section.

10.1 Measure the coverage of a WISP tower

A WISP tower is going to be built and evidence is needed to justify the cost/benefit.

10.1.1 1. Create the tower coverage

Create the tower coverage as a layer using the interface. If the antenna pattern is known then use that for the most accurate model, otherwise you can use custom beamwidth values from the datasheet.

10.1.2 2. Upload zip code data for properties

Prepare a CSV spreadsheet for the area containing zip codes. These can be grouped by streets or neighbourhoods and the zip or address is the unique value in the id column.

Example property data

latitude	longitude	id	group
51.8668	-2.2066	GL43HX	Barnwood
51.8641	-2.2129	GL43HY	Barnwood

10.1.3 3. Download the results

You can download results as CSV by clicking the download button in the bottom left analysis window. This download will show you if a property is covered or not with a YES or NO. If your input data can be sorted and contains the same number of rows as the output, you can paste the YES/NO column into your input CSV for a very granular report into neighbourhood coverage.

10.2 Model multiple sites for multiple frequencies

The problem is how to efficiently model multiple locations but with different frequencies. The locations do not change.

10.2.1 1. Prepare a CSV spreadsheet

Instead of entering locations manually into the user interface, enter them into a CSV spreadsheet to eliminate error with (repeat) siting. The format should as a minimum contain the fields latitude and longitude:

latitude	longitude
51.8668	-2.2066
51.8641	-2.2129

10.2.2 2. Save radio settings as templates

Create your radio settings in the interface form and save them as a template. You will need a template for each frequency you need to test.

10.2.3 3. Import data

Select a template for the first frequency eg. Frequency1, then using the data import "MANET tool" option, load in the CSV. Each site will be modelled with the chosen frequency and associated settings. Repeat by loading the next template, and loading in the same CSV.

10.3 Design a network that meets a coverage requirement

The requirement is for 95% coverage of a city with a LPWAN smart meter network. The network must be economical yet provide good coverage. The consultant must be able to demonstrate planned coverage meets the requirement.

10.3.1 1. Prepare your data

The most important aspect of this task is to prepare your data. You need CSV spreadsheets for the properties or locations you would like covered (maximum 60,000 rows per spreadsheet in the interface) and another for the gateway locations (maximum 1000 rows in the interface).

Pay particular attention to the site name and network name fields as these will be needed later when finding, deleting or analysing the data.

Example property data

latitude	longitude	id	group
51.8668	-2.2066	CloudRF	Barnwood
51.8641	-2.2129	Roundabout	Barnwood

Example gateway data

This verbose format is for the user interface "site import" feature only. If you choose to use the API directly, you can use any format so long as it conforms to the API at the point of request. Examples are here: https://github.com/Cloud-RF/CloudRF-API-clients/tree/master/python

```
Site,Latitude (degrees),Longitude (degrees),Transmitter Height (m),Receiver Height (m),
↪Receiver Gain (dBi),Receiver Sensitivity (dBm),Frequency (MHz),Bandwidth (MHz),RF␣
↪Power (W),Antenna Pattern,Antenna Polarization,Antenna Loss (dB),Antenna Azimuth␣
↪(degrees),Antenna Tilt (degrees),Antenna Gain (dBi),Noise floor (dBm),Model,Measured␣
↪units,Context,Diffraction,Reliability,Profile,Colour schema,Antenna Horizontal␣
```

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```
↪Beamwidth (degrees),Antenna Vertical Beamwidth (degrees),Front to back
Site 1,38.9053686786203,1.42393869858255,10,10,8,-50,446,1.4,30,OEM Half-Wave Dipole,V,0,
↪240,10,8,-120,Egli VHF/UHF (< 1.5GHz),Received Power (dBm),Average / Mixed,Knife edge,
↪50% / -0dB (Optimistic),Minimal.clt,RAINBOW,1,1,8
Site 2,38.9071885546264,1.43414926725016,11,1,10,-60,800,10,10,OEM Half-Wave Dipole,V,10,
↪240,10,8,-90,Egli VHF/UHF (< 1.5GHz),Received Power (dBm),Average / Mixed,Knife edge,50
↪% / -0dB (Optimistic),Minimal.clt,RAINBOW,1,1,8
Site 3,38.9045598298649,1.43757317051595,20,5,5,-70,2400,20,1,OEM Half-Wave Dipole,H,11,
↪240,10,8,-70,Egli VHF/UHF (< 1.5GHz),Received Power (dBm),Average / Mixed,Knife edge,50
↪% / -0dB (Optimistic),Minimal.clt,RAINBOW,1,1,8
```

10.3.2 2. Process the gateway data

Using either an API client or the new "site import" functionality in the user interface, push the CSV data into the API with the "Area" API. This could be CPU or GPU powered and will create heatmaps in your account for analysis. If you have labelled the network properly it will be easy to find the data in your archive.

10.3.3 3. Load the data in the user interface

Load the layers on the map by either clicking their names from your archive or merging them into a super layer using the super layer utility. If you processed the data using the MANET API this is unncessary as the data is already a single layer.

10.3.4 4. Perform coverage analysis using the property data

Import the CSV data containing customer properties using the **Coverage Analysis** import option and expect to see coverage results displayed in the bottom left corner. Results will report coverage as a percentage so 90% would be covering 9/10 properties in an area.

10.3.5 5. Move or remove a gateway

If a gateway needs changing to meet the requirement (95%), remove it from the network by selecting and deleting it in the archive and then do it again at the new location.

10.3.6 6. Download results

You can download results as CSV by clicking the download button in the bottom left analysis window. This download will show you if a property is covered or not with a YES or NO. If your input data can be sorted and contains the same number of rows as the output, you can paste the YES/NO column into your input CSV for a very granular report into neighbourhood coverage.

10.4 Model HF NVIS coverage

1. Enter an appropriate frequency between 2 and 8MHz and a Tx power in watts.
2. Choose the HF NVIS model in the model menu. The antenna will be automatically set although you may choose the azimuth and gain. Use 0dBi if you are not sure of the gain or it is a whip. Set diffraction off to reveal any shadows although it will likely diffract into them given the frequency.
3. Choose the context/height to match the scenario. If it's day time then the D layer will be present but will attenuate low frequencies so bear this in mind. If it's night time, use the F layer. If there's uncertainty then use the E layer for a compromise.
4. For the receiver use 0dBi for a whip antenna.

5. Use the CPU engine with 180m resolution for links out to 200km. Otherwise use the GPU engine.
6. Click the map or press play or change a value like azimuth to trigger a calculation.

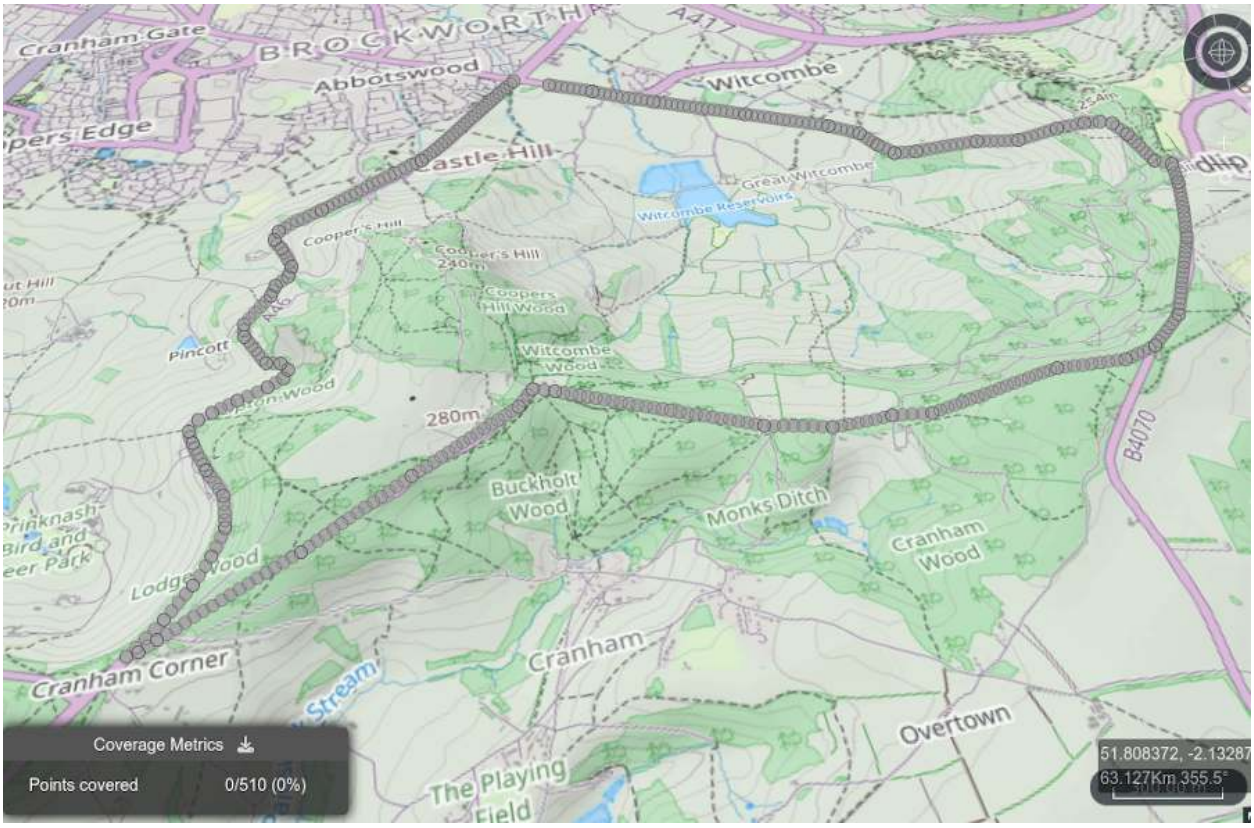
10.5 Find the best HF frequency for a month

1. Choose the HF Skywave model in the model menu
2. Choose the month and hour
3. Set the sunspot number to match latest data (100 if unsure)
4. Use the path tool to click on the distant station on the map. The link chart will display showing the best frequencies to use for the link and time. If the chart is blank, there is nothing to show above 0dB SNR so you should consider your antenna, antenna height and power.

10.6 Model a flight path

1. Prepare your flight path as a KML linestring. These files can be exported from adsb exchange.
2. Open the import dialog and choose “route analysis”. Load in the KMZ/KMZ.
3. The points should display on the map if a valid linestring was found.
4. Place and configure your ground station and click calculate to observe coverage along the flight path. If different altitudes are detected, the option to model a ground overlay will be removed so you only get coloured balls floating above the ground.

10.7 Test a route for coverage against a network



1. Create your route as a KML linestring in a suitable application, such as Google Earth or equivalent. Save it as KML or KMZ.
2. Import the KML/KMZ file using the file import dialog as "Coverage analysis". Lots of grey points will be added to the map.
3. Create or reload a heatmap layer to test for coverage. The coverage will be reported in the coverage analysis dialog in the bottom left corner.
4. For a MANET network, enable the MANET tool and ensure heatmaps are enabled by clicking the donut icon in the MANET dialog. Links are ignored here. Place the MANET nodes by clicking upon the map.

Note that the settings for each node can be different but can only be defined prior to placing the node. Once placed, a node's frequency and power cannot be changed but you can change global network values such as environmental settings.

See the Web Interface Import Data > Coverage Analysis section for more detail on this topic

CHAPTER

ELEVEN

DOCUMENTATION CHANGELOG

11.1 2.9.0

- Deprecation: Chatbot is no longer supported by CloudRF. Removed Chatbot documentation. To integrate with TAK please make use of the CloudRF ATAK plugin.
- Deprecation: Google Earth is no longer supported directly by CloudRF. Removed Google Earth documentation. If you still wish to use Google Earth you can export your calculations as KMZ/KML.
- Feature: Updated for SOOTSHAYER `1.9.0`.
- Feature: Added `/3d/models/` and `/3d/model/delete` to Swagger.
- Feature: Inteference API and UI documentation.
- Feature: `/mesh`,`/merge` API documentation.
- Feature: Added documentation for custom colour buckets in "My Colours".
- Feature: Added documentation for HF Skywave.
- Feature: Swagger document updated for API `3.21.0`.
- Feature: Added sections for troubleshooting automatic processing with missing antenna pattern and identifying calculation responses.
- Feature: Chatbot is no longer supported by CloudRF. Removed Chatbot documentation. To integrate with TAK please make use of the CloudRF ATAK plugin.
- Feature: Added documentation for the phase tracing interface.
- Update: Updated antenna pattern upload and wizard documentation.
- Fix: Tweaks to `/noise/get` and `/noise/create`.
- Fix: Updated screenshot of antenna database.
- Fix: Removed `output.col` for `/bsa` in Swagger document as it is not used.

11.2 2.8.0

- Feature: Updated documentation for SOOTHSAYER 1.8.0.
- Feature: SOOTHSAYER is no longer offered as a VM. Removed VM specific documentation.
- Feature: Added satellite update information to SOOTHSAYER documentation.
- Update: Updated SOOTHSAYER DEM importing documentation.

11.3 2.7.1

- Feature: Added SOOTHSAYER compatibility matrix for different operating systems.
- Feature: Added Operator / Enginer mode description.
- Feature: Added Swagger documentation for `output.bounds` and `transmitter.remote`.
- Feature: Added 'megavoxels' to swagger.
- Update: Revised SOOTHSAYER requirements.

11.4 2.7.0

- Feature: Added Swagger documentation for 3D API.
- Update: Swagger `v5.17.14`.
- Fix: Search functionality not reporting words within pages.

11.5 2.6.1

- Update: Support for SOOTHSAYER `1.7.1`.

11.6 2.6.0

- Feature: Diffraction IDs added into Swagger.
- Feature: "Import Data" moved up to top-layer of hierarchy due to frequency of reference.
- Feature: Sections relating to "My Obstacles" clutter updated with custom names and colours.
- Fix: Swagger documentation brought up in line with `3.9.6`.
- Fix: Screenshots of drawing "My Obstacles" brought up-to-date.
- Fix: Imagery layer brought up-to-date.
- Fix: PPA PNGs for LiDAR and clutter brought up-to-date.

11.7 2.5.6

- Feature: Archive tools includes details about exporting projections.
- Fix: Refreshed screenshots of receiver menu and archive tools section.
- Improvement: HF NVIS
- Improvement: Diffraction models
- Improvement: Models table with codes
- Update: ATAK 4.10 supported

11.8 2.5.5

- Improvement: Wording on "API" section.
- Feature: P.529 replaced with P.1546 model.

- Feature: Added `multisite` example of RADAR with mixed heights.
- Fix: Changelog missing.
- Fix: Swagger `multisite` values not respecting correct units for `receiver.alt`.
- Fix: GPU now supports ITM.

11.9 2.5.4

- Feature: Added details about deleting all clutter.
- Fix: Broken GitHub links on API introduction.

11.10 2.5.3

- Fix: Blank PDF caused by broken "micro-" symbol.
- Fix: RADAR missing for list of propagation models.
- Fix: Swagger document for API `3.9` is incorrectly named as `3.9-dev`.

11.11 2.5.2

- Upgrade: Support for API `3.9.0`, UI `3.9.0` and CPU engine `1.8.0`.
- Feature: Added `/noise/get` and `/noise/create` endpoints to Swagger.
- Improvement: Updates to images.

11.12 2.5.1

- Improvement: Added "Multi-azimuth requests" to API introduction.

11.13 2.5.0

- Upgrade: Support for API `3.8.10`, UI `3.8.8`, CPU engine `1.4.3` and GPU engine `1.4.3`.
- Improvement: API documentation included sections which needed additional detail.

11.14 2.4.0

- Improvement: API status light
- Improvement: LEO planning under Best Site Analysis
- Improvement: Updated TAK Interface for OG TAK Server
- Improvement: Added warning about "Line of Sight" model should have knife edge diffraction disabled.
- Fix: Plane earth loss model is no longer accepted.
- Feature: Added `remaining_calculations_since_last_purchase` to `my-metrics` Swagger UI.
- Feature: Added sections about new "Import refrence data" functionality in the UI.
- Feature: Overview of management tools improved.

- Fix: Removed reference to clutter polylines as this is no longer used in the UI.
- Fix: Improvements to headings.
- Improvement: Added details on the `edges` array which is optional for the `bsa` endpoint and allows the definition of a bounding box to run a BSA inside.
- Fix: Load Swagger UI 3.8 by default.
- Fix: Incorrect version on Swagger UI for 3.7 API.
- Fix: Correct validation limits for bandwidth and noisefloor.

11.15 2.3.0

- Upgrade: Support for API `3.8`, UI `3.8` and GPU Engine `1.3.0`.
- Improvement: Environment menu.

11.16 2.2.0

- Upgrade: Support for API `3.7`, UI `3.7` and GPU Engine `1.2.0`.
- Upgrade: Swagger UI updated to `v4.15.5`.
- Feature: Added heatmaps/multisite sections to MANET.
- Feature: Added new `/multisite` endpoint to Swagger UI.

11.17 2.1.2

- Upgrade: Support for API `3.5`, UI `3.6`, Sleipnir `1.6.1` and GPU Engine `1.1.0`.
- Feature: Added details on multi-azimuth antennas.
- Feature: Updated templates section to include new details about system templates, new templates manager, and downloading templates.
- Fix: Updated the "Account Information" section in line with live and added missing "Custom Map" section.
- Fix: Removed historic `mat` value from API reference.

11.18 2.1.1

- Upgrade: Components updated for API 3.3, UI 3.4.2 and Sleipnir 1.6.1.

11.19 2.1.0

- Upgrade: Swagger UI updated to `v4.13.0`.
- Feature: Updated Swagger with better layout for "Schema" section.
- Feature: Added section on system versions.
- Feature: Updated the overview of the web interface with new screenshot and annotations for both desktop and mobile view.
- Feature: Consolidation on a number of different sections to make the documentation easier to follow and remove duplicate sections.

- Feature: New screenshots and icons added to match current systems.
- Feature: Poor quality or difficult to read screenshots, images and icons have been removed or replaced with higher quality.
- Feature: Details about "Calculation Adjusted" messages in a response.
- Feature: `/bsa`, `/my-metrics` and `/clutter/delete/0` endpoints added to Swagger UI.
- Feature: Added `Terrain_AMSL`, `Landcover distance`, `Landcover codes` and `Landcover heights` on `/path` request in Swagger UI.
- Feature: Added annotated overview of a number of different menus and tools.
- Feature: Added "Account Information" and API ready scripts sections.
- Feature: Minified all images to reduce page size and page load times.
- Feature: Innovation roadmap extended to current day.
- Feature: Improvements to a number of different headings to allow for better nesting.
- Fix: Removed API reference document from Sphinx/ReadTheDocs as was causing confusion. Unique contents from the old reference have been moved to Swagger UI.
- Fix: Removed "Support Ticket" section on "About Cloud-RF" page as is no longer present.
- Fix: Broken markdown styling on some icons.
- Fix: "View Home" details are incorrect.
- Fix: Updated measured units to list all available units.
- Fix: Missing or incorrect values/types on `/path` example response in Swagger UI.
- Fix: Swagger UI gives incomplete endpoint for retrieving clutter.
- Fix: Swagger UI updated with `engine` parameter for `/area` calculations.
- Fix: Naming of "Mesh" to "Super Layer" on "Web Interface RF Tools" page.
- Fix: Clutter section on "Web Interface Map" listing historic management of height data.
- Fix: Issue on `clm` in Swagger UI with default values.
- Fix: Missing `fbr` option in the `output` "Schema" section.
- Fix: Updated noise floor accepted range in Swagger UI.
- Fix: `area` value from `/area` calculation response schema updated in Swagger UI as `km2` value is no longer appended.

11.20 2.0.1

- Support for API 2.8, UI 2.7 and Sleipnir 1.5.9.
- Added component versions to beginning of documentation.
- Fixed PDF where everything was under a "Contents" heading.
- Improvements to internal tooling to allow for better standardisation of documentation.

11.21 2.0.0

- Changed to Sphinx "Read the Docs" template.
- PDF included in documentation.
- Added search functionaltiy.
- Added satellite and MANET tools.
- Consolidated docs.cloudrf.com & https://cloudrf.com/documentation/developer/swagger-ui/.
- Added "Import Multiple Points from CSV" section to `interface_map`.
- Improvements to internal tooling and processes.