Carto user manual

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Introduction

Welcome to the Carto user manual, our powerful AI tool for monitoring nature, agriculture, water, and biodiversity. Whether you work in nature management, urban planning, agriculture, or any other field that benefits from spatial insights, Carto allows you to train Satellite-AI models with just one click, and easily scale them to large geographic areas. Not only that, Carto also lets you review historical maps, enabling you to analyze trends and changes over time.

This manual will guide you step by step through Carto's functionalities and provides all the information you need to fully utilize the application. We'll cover how to set up Carto, use its various features, and train high-quality Satellite-AI models.

Disclaimer

The information and features offered by Carto assist users in analyzing and interpreting geospatial data. While Carto is a powerful tool, it is important to critically assess the results.

Users are strongly encouraged to:

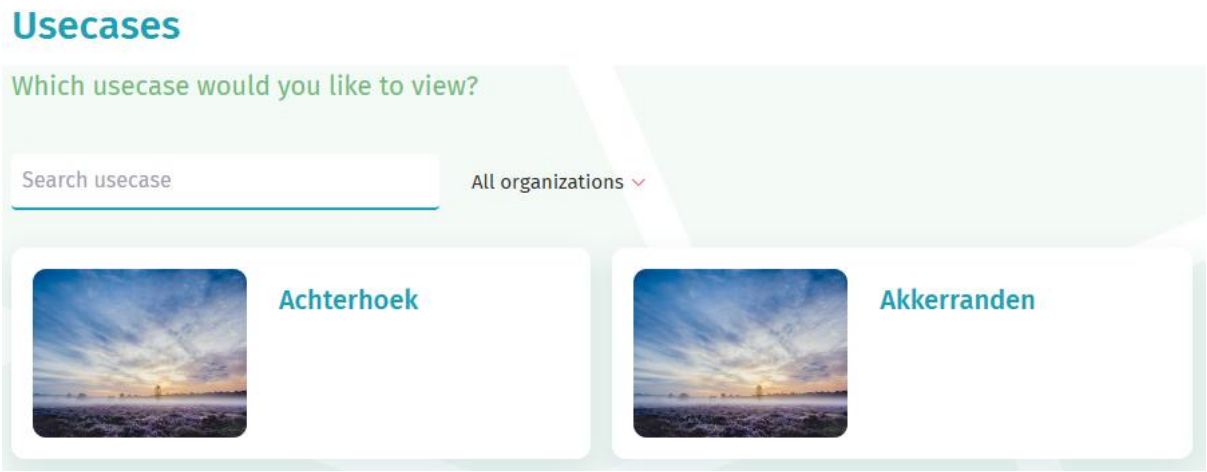
1. Provide high-quality examples and counterexamples to Carto for optimal results.
2. Carefully review Carto's results and compare them with existing knowledge and expectations about the area or the data the models are based on.
3. Keep in mind that each indicator in a Carto project is accessible to all users with access to that project. We recommend carefully considering any changes to indicators, as modifications by one user can impact the models and results for other users.

Terminology

- **Usecase**: One or more areas that are monitored as a single unit. A usecase can contain multiple models.
- **Model**: A model what can be trained to monitor a specific phenomenon.
- **Observations**: The user-drawn examples and counterexamples that are used to train a model.

Logging in to Carto

- If you are using Carto for the first time, you will receive a login link via email. Be sure to check your spam folder as well. During your first login, you will be prompted to set a password.
- Once your password is set, you can log in directly at carto.spheer.ai using your email address and password



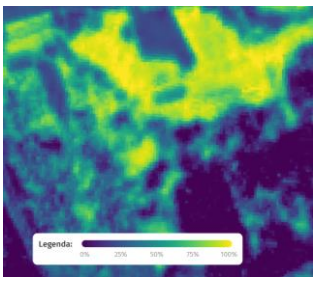
How to use Carto

Watch the instruction videos on our Youtube channel for a visual introduction!

How do I create a new model?

- Select the usecase of your choice
- Click on the model panel (E in the image on the next page)
- Choose 'new model.
- Choose between regression and classification (see directly below) and give the model a unique name.

How do I choose between regression and classification?

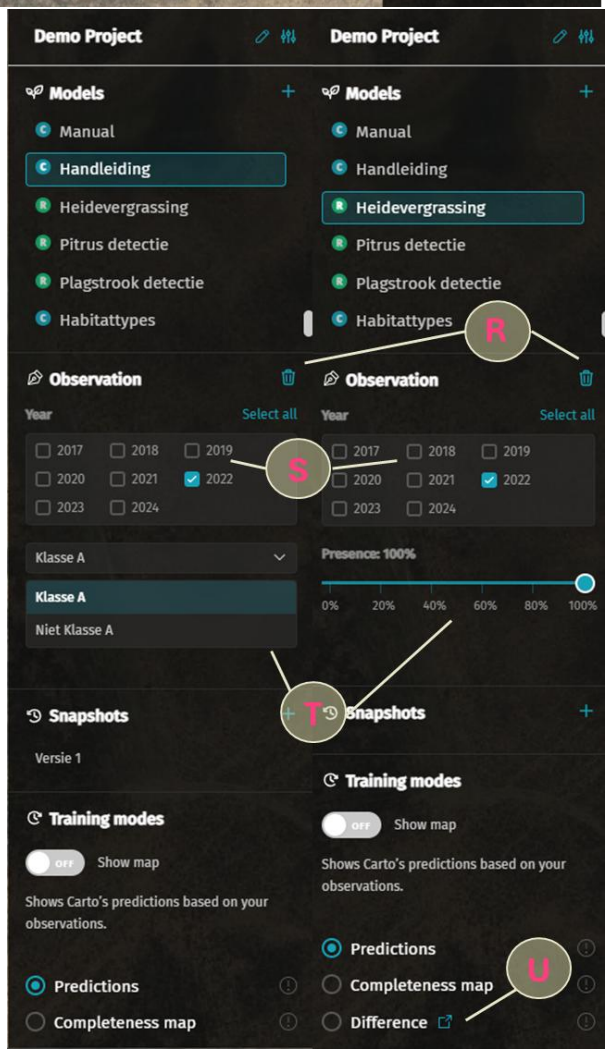


- **Choose regression** when you want to predict a continuous value, such as the degree of vegetation cover or the concentration of a substance. The model will provide a percentage (0% to 100%) for each pixel within your area of interest.

- **Choose classification** when you want to categorize areas into distinct classes, such as different vegetation types, soil types, or land use categories. The model will assign each pixel to one of the defined classes.

Meaning letters in figures:

In the figure above no observation is selected. The figures on the right show the sidebar with an observation being selected for the regression and classification model.



A. The Profile Icon
B. Select
C. Draw Polygon
D. Year in which the map is presented
E. Train Model
F. Settings
G. Edit Usecase
H. Create New Model
I. Edit Model
J. Export Predictions
K. Import Observations
L. Delete Model
M. List of classes in a classification model
N. The layer-button to change Carto's background
O. Create new snapshot
P. Show map
Q. Select Trainings mode
R. Delete Observation
S. Select years for the observation
T. Class or Value of Observation
U. Select Difference Maps (regression)

How do I train an AI model?

- Select the model for which you want to train a model or create a new one (H).
- Draw or import an observation
- Draw observations
    - Select the 'Draw Polygon' icon (C) from the toolbox.
    - Draw an observation by clicking to create vertices and use a double-click to finalize the shape.
    - Assigning a value to an observation differs between regression and classification:
        i. Regression: Click on the observation and specify the degree of presence (0% means 'not present', 100% means 'fully present') (T).
        ii. Classification:
            1. Make sure *no* observation is selected and define one or more classes first (M). If needed, change the colour by clicking on the dot and selecting a new colour.
            2. Click on the observation to assign it to a class (T).
    - Observations must be completely within the usecase area of interest, which is marked on the map with a yellow dashed line.
    - Ensure that you are drawing for the correct year (D) in which the observation applies.
    - Tip: Select additional years (S) for which this observation is also valid. This prevents the need to redraw the same observation multiple times and improves trend analysis over time.
- Import observations
    - Click the 'Import' icon (K) from the toolbox.
    - Select the GeoPackage containing the observations you want to import.
    - Choose the years in which these observations apply. This prevents redundant imports and improves trend analysis over time.
        i. If you do not specify the years, Carto takes the "years" column from the file. The years in this column must be a string and multiple years separated by a comma. If this is not the case, or the column does not exist, the import will fail.
    - Optional: Specify a column name that contains values for the observations. If you do not specify a column, all observations will be imported without assigned values, and you can manually assign them in Carto, just like when drawing observations.
        i. For regression: The values in the column must be whole numbers between 0 and 100 (percentages).
        ii. For classification: Ensure all required classes are created in Carto before importing. Any classes not already present in Carto will not be imported.
- Move observations
    - Select the 'Select' icon (B) from the toolbox.

- Click on the observation you want to modify so that points appear at the corners.
- Drag the entire observation to a new location if necessary.

- Edit observations
  - Select the 'Select' icon (B) from the toolbox.
  - Click on the observation you want to modify so that control points appear at the corners.
  - Adjust the observation by dragging the corner points or add a new corner by dragging the control points on the edges of the observation.

- Delete observations
  - Select the 'Select' icon (B) from the toolbox.
  - Select the observation you want to delete and remove it by clicking the trash icon (R).

- Train the model
  - Make sure that Carto is in prediction mode (Q). Click on 'Train Model' (E). The training process will start in the background. Once it's finished, you will receive a notification.
  - N.B. Carto requires both observations and counter-observations to train a model. Ensure that you have drawn examples with varying percentages (for regression) or for all the classes you want to monitor (for classification).

- View the prediction
  - Make sure that Carto is in prediction mode (Q). Turn on the button near 'Show map' (P) to show the prediction.
  - It may take some time for the map to fully load.

- Iteratively improve the model
  - Add new observations, retrain the model, and check if the predictions improve.

How do I see the prediction for a different year?

1. Train a model and click on 'Show map'.
2. Use the slider (D) to navigate to different years.

How do I export Carto's results?

Once you've generated a prediction, you can export the map directly (J). When you click 'Export all maps and observations', the download of your predictions for each year in GeoTIFF format will start automatically. You can easily share this file, integrate it into other reporting systems, or further analyse and edit it in your own GIS software. The downloaded observations can be loaded into different usecases.

Getting more out of Carto

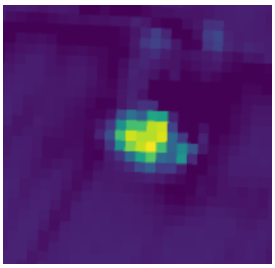
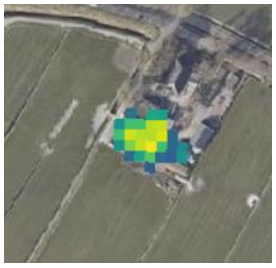
How do I improve and clarify my predictions?

Good predictions start with good observations. Here are some tips for creating observations that help Carto build the best version of your models:

- **Quality over quantity**: It's better to have a few precise observations than many less accurate ones. The more specific and precise your observations are, the easier it is for Carto to recognize interesting patterns.
- **Make your examples specific**: Split up observations if needed. Instead of drawing a single large 50% block, divide it into separate 100% and 0% observations if that better reflects reality. This helps Carto distinguish subtle differences in your data, leading to a more refined model.
- **Vary your observations**: Ensure that you not only add observations for the specific indicator you are interested in but also for other examples. This helps Carto distinguish features more effectively and prevents unclassified areas from being misinterpreted. This applies to both regression (where you indicate varying degrees of presence) and classification (where you define multiple categories and potentially an "other" class).
- **Draw observations for multiple years**: This helps Carto better understand growth patterns and changes over time, as growth patterns do not look exactly the same every year. Experiments have shown that including observations from at least two different years already significantly improves predictions. Adding three or more years can provide even more stability, though the added benefit decreases as more years are included.
- **Improve iteratively**: Start with a small number of observations and train the model. Gradually add new observations and assess if the predictions improve. Begin with observations you are absolutely certain about and only add the "edge cases" in a later iteration. By refining the model step by step, you can see quick results and easily make adjustments, allowing Carto to get closer to the ideal prediction.
- **Observation size**: Make sure your observations are at least 10m x 10m and no larger than 1km x 1km. Smaller observations do not contain enough satellite pixels for training, while larger observations unnecessarily increase processing time.
- **Out of Distribution Map**: When training a good model, it's important that Carto has seen a sufficiently wide variety of pixels in the observations. If the drawn examples lack variation, the model may struggle to make reliable predictions. The Out of Distribution map shows which pixels Carto still lacks observations for. This allows you to add new examples specifically in places where the model still has limited knowledge. See 'How do I use the Out of Distribution map?' for more information on how to interpret and apply this map.

In the settings menu (F), there are two options that make it easier to analyse Carto's predictions:

- **Make predictions transparent**
    - **Threshold** value for regression models: The threshold setting allows you to specify the percentage at which a prediction becomes visible. For example, if you set the threshold to 20%, all predictions with a lower probability will be displayed as more transparent, giving you a clearer overview. See the image below for an example: left without a threshold, right with a 50% threshold.

    - **Select classes** for classification models: This option allows you to make certain classes transparent in the prediction map, helping you visualize how different classes are being predicted.
- **Observations**: Choose whether to display only the observations drawn for the selected year or all observations from all years. This is useful for checking whether observations are consistent and for understanding the data on which Carto bases its predictions.

How do I change Carto's background imagery?

Click the layers button (N). You'll see an overview of available background layers for this use case. Click the background you want to use. Do you have your own background layer that you would like to use? Let us know by mailing it to support@spheer.ai and we can add it for you.

How do I use the Out of Distribution map?

The Out of Distribution (OOD) map shows which areas within your use case are still 'unknown' to the model. In these areas, Carto has seen few or no similar pixel time series in the observations you've drawn so far. By adding extra observations in these areas, you help Carto train a more complete and robust model.

The OOD map only shows where the model has seen few similar pixel time series during training. That does not automatically mean predictions in those places are wrong. Sometimes Carto still makes a perfectly fine prediction in an 'unknown' area, for example because those pixels best match other classes the model does know. Still, it's wise to give these areas some extra attention, especially if you suspect they're important for your analysis.

Use the OOD map as follows:

1. Put Carto in Out of Distribution mode (Q).
2. Then click Train Model (E).
3. Focus on areas that light up red. These are places where Carto hasn't seen comparable pixels in observations.
4. Add new observations there where possible.
5. Recalculate completeness and watch red areas disappear.

How do I use difference maps?

The difference map compares two years within the same use case and shows the difference in predicted values between those years. This lets you immediately see where values have increased or decreased, helping you quickly spot trends and changes. The difference map only works for regression models.

Note: The difference map shows differences in model predictions, not directly measured field values. Differences can also arise from data quality, coverage, or noise between years. Use the map as a starting point for analysis and verify notable patterns with your observations or by viewing the individual years separately.

Use the difference map as follows:

1. Train your regression model as usual.
2. Switch the view to 'Difference Map' (U).
3. Select the two years you want to compare.
4. Make sure 'Show Map' is enabled (P).
5. Interpret the map: areas with higher values indicate an increase between the selected years; lower values indicate a decrease.
6. Zoom in on areas of interest and verify your findings by inspecting the individual years or adding more observations.

How do I use snapshots?

Snapshots let you revisit previously saved moments within your use case. You can see which observations existed at that time and what the model's predictions were. You can also export those observations and predictions for further analysis in other tools. This way, you can easily experiment with changing the model and observing the impact of these changes.

Note: snapshots are not automatic. To view a point in the past, you must save it first. We recommend creating a snapshot before any important changes.

Use snapshots as follows:

1. Click the plus icon next to 'Snapshots' (O).
2. Enter a name for the snapshot and click Save.
    a. If you leave the name empty and click Save right away, the snapshot will be named automatically after the model name and the time of creation.
3. Repeat this whenever you want to capture a new moment (e.g., after adding observations or retraining your model).

4. Open ‘Snapshots’ by clicking on it and select the desired snapshot to view its observations and predictions.
    a. To go back to the most recent version, click once more on the same snapshot
5. Use ‘Export’ (O) to download observations and/or predictions from the selected snapshot for further analysis.

Admin functions

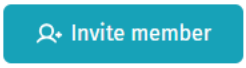
As an administrator you have additional permissions in Carto.

How do I open my organization page?

- Click ‘My organizations’ under your profile icon (A). Then click the organization you want to add users to and select ‘Manage organization’.

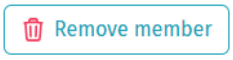
How do I add a new user?

- Go to your organization page and click ‘Members’. Click ‘Invite member’. Enter the first name, last name, and email address of the user you want to invite. You can also choose to make this user an administrator right away.



How do I remove a user?

- Go to your organization page and click ‘Members’. You’ll see your active users here. Click the member you want to remove and then ‘Remove member’.



How do I promote an existing user to administrator?

- Go to your organization page. On the right you’ll see which users are administrators, which users have an outstanding admin invite, and at the bottom you can invite existing users to become administrators. Choose an email address from the list and click ‘Invite selected user’.

How do I change my organization details?

- Go to your organization page. In the middle you can edit your organization’s name and image.

How do I start a new use case?

- Send an email to support@spheer.ai with the use case name, the GeoPackage of the area of interest, and the users who should have access. We aim to add new use cases within 5 business days.

How do I change use case details?

- Click the pencil icon next to the use case name (G). There you can add or edit the name, description, and an image.
  If you want to adjust the area of interest, email a GeoPackage of the desired new area of interest to support@spheer.ai and mention which use case it concerns. We aim to apply the change within 5 business days.

How does the tech behind Carto work?

Carto uses a foundation model developed by Spheer to recognize pattern in satellite imagery. This foundation model is highly advanced and has processed vast amounts of satellite data. It filters, analyzes, and summarizes the data into a set of numbers that serve as a base for user models tailored to specific indicators. Thanks to this foundation, you can quickly train advanced models and generate maps within minutes.

Each time you create an observation, you draw it for a specific year. These observations are not just visual; they are automatically linked to the satellite data available for that year. Carto uses satellite images with a resolution of 10 meters per pixel, providing insights at a detailed level of 10 meters per pixel. The aerial photos in the background are for visual reference only and are not currently used by Carto.

When you train a model, you build on the fixed foundation model and refine it using your observations for the selected years. This creates a model tailored to your specific situation. Carto then generates predictions for all years in your area, enabling you to quickly and easily analyze how your indicator develops over time based on your observations.

Troubleshooting

- **My predictions do not match the expected results.** First, check if the observations have been drawn correctly and assigned the correct value. Make sure you have included both examples and counterexamples of an indicator. Also, refer to the section 'How do I make my predictions clearer?' for tips on drawing observations.
- **My prediction map is completely one colour.** This can happen if Carto has only received observations with one value. Ensure you add observations with various values so that both examples and counterexamples of the indicator are present.
- **I don't see a prediction.** It may take some time for the predictions from all years and areas to load, depending on the size of the area of interest and the amount of data.
- **My observations are missing or have changed.** All users with access to a project can modify all indicator observations within that project.
- **I cannot export my prediction.** You can only click 'Export all maps and observations' once the model is finished training and has created the prediction maps. If the download does not start after clicking, check if your model has fully completed training, and contact support if you continue to encounter issues.

Support

Do you have questions or are you facing issues that you cannot resolve on your own? Contact our support team at support@spheer.ai. We're ready to help you with any technical issues or to collect feedback to further improve Carto.