



# Animal Movement Analysis:

## *A tutorial on visualizing bird tracking data with CARTO*

Original tutorial by Peter Desmet, September 01, 2015

Adapted by: Judy Shamoun-Baranes, June 29, 2017

*This document is a revision of the original tutorial developed for CartoDB by Peter Desmet and available here: <https://lifewatch.inbo.be/blog/posts/cartodb-tracking-data-tutorial.html> Peter Desmet and colleagues had been using [CartoDB for bird tracking data](#) for some time and Peter developed this tutorial which he gave as a hands-on workshop at the Animal Movement Analysis summer course in 2015. Since then, CartoDB has changed into CARTO and the user interface and functionality has changed a bit, but the general principles are quite similar.*

### **Introduction**

[CARTO](#) is a tool to explore, analyse and visualize geospatial data online. CARTO is used in a [wide area of domains](#) and has [great documentation](#). This tutorial will focus on how it can be used for exploring and visualizing animal tracking data. In this tutorial we will use the lesser black backed gull data used in the AMA 2017, however you could just as easily use your own data. This tutorial is by no means meant to be exhaustive: it's a step by step guide to get you started and hopefully inspire you to do cool things with your own data.

### **Create an account**

Go to <https://carto.com/signup/> to create an account, if you haven't got one already. Free accounts allow you to upload 50MB of data, but keep in mind that all your data and maps will be public.

### **Login**

1. Once logged in, you see your private dashboard. This is where you (and only you) can upload data, create maps and manage your account.
2. CARTO will display contextual help messages to get you to know the tool. For an overview, see the online [documentation](#) and [guides](#).
3. At the top, you can toggle between your **Maps** and **Datasets**.
4. You also have a public profile (<https://user.carto.com/maps>). All datasets you upload and maps you create, will be visible there.

### **Upload data**

For this tutorial, we will use the AMA 2017 migration data or your own data. To facilitate the workshop the *migration\_data* table was exported to a csv file for easy import into CARTO. The table was exported as follows: (1) Open the **AMA2017** database in sqlite (2) right click on the table *migration\_data* and select "export the table", (3) follow instructions and export the table to a csv file.

1. In CARTO go to your datasets dashboard.

2. Upload the file by dragging it to your browser window. CARTO recognizes [multiple file formats](#).

## Data view

1. CARTO is powered by PostgreSQL & PostGIS and has created a database table from your file and done some automatic interpretation of the data types. Some additional columns have been created as well, such as *cartodb\_id*.
2. Geospatial data are interpreted automatically in *the\_geom*. This interpretation assumes the geodetic datum to be WGS84. *the\_geom* supports points, lines and polygons, but only one type per dataset.
3. Click the menu next to field name to manipulate columns, such as sorting, renaming, deleting or changing data types.
4. Additional functionality is available via the toolbar on the right, such as adding rows or columns, or exporting data.

cartodb_id	geometry	device_info_serial	migration_start	migration_end	pending_rows	length	date_time
1	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
2	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
3	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
4	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
5	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
6	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
7	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
8	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
9	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z
10	POINT	313	1473412570000000	1473412570000000	0	4.0070363	2010-07-25T00:33:00Z

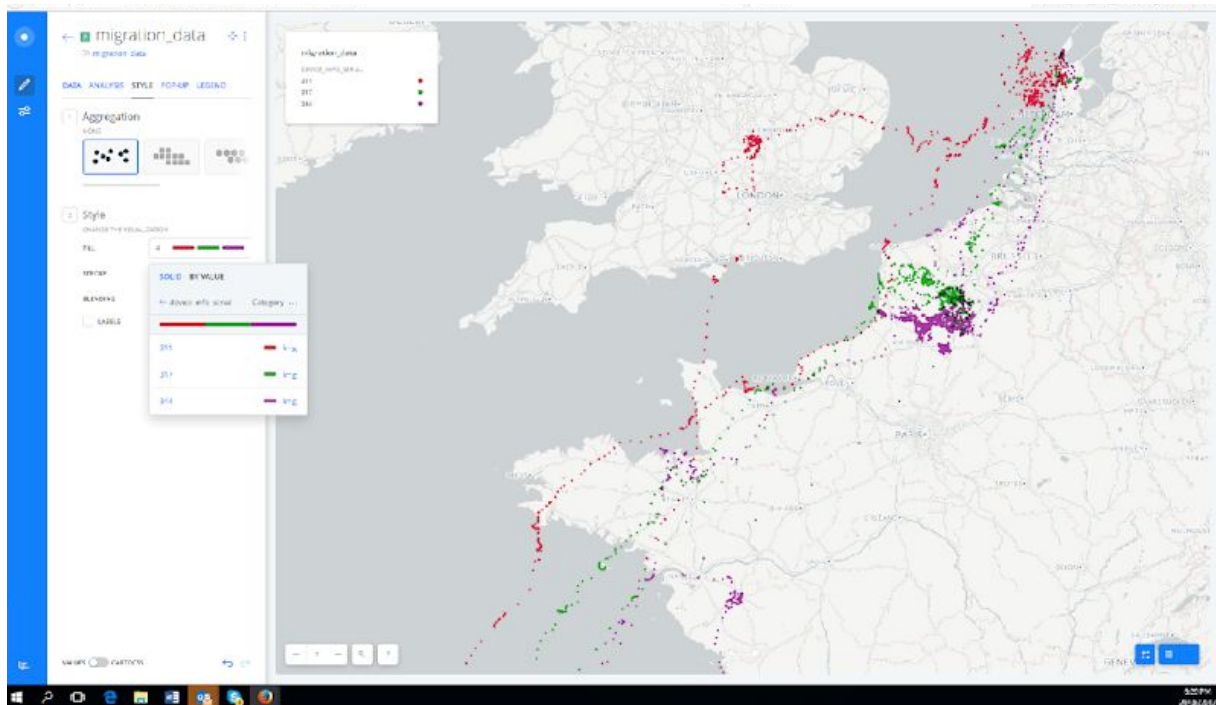
5. Click SQL in the bottom left panel and try this SQL to get some statistics about the scope of the dataset, click APPLY once you have typed the query:

```
SELECT
  count(*) AS occurrences,
  min(date_time) AS min_date_time,
  max(date_time) AS max_date_time,
  count(distinct device_info_serial) AS individuals
FROM migration_data
```

6. From the Export menu in the top right you can export any query you make, in multiple file formats.
7. **Click Clear** to remove any applied SQL.

## Create your first map

1. **Click create map** in the bottom right to create your first map.
2. Once created, click the title `migration_data` map and rename it if you'd like.
3. You can change the background map by clicking `basemap`. `Positron` is a good default basemap, but there are many other options available. Note that for the `Positron` and `Dark matter` basemaps, city labels will be [positioned on top of your data](#), making them more readable. Choose `Positron` (labels below) to turn this off or `Positron (lite)` to have no labels at all.
4. Click `Options` on the left to select the map interaction options you want to provide to the visitors of your map, such as `Zoom controls` or a `legends` button.
5. The map view also provides options to create subsets of data or calculate new fields. Click on the dataset on the left and select `Analysis` in the toolbar and create a new analysis, or `Data` to write an SQL query to subset your data or calculate new fields (in order to write an SQL query make sure `SQL` is toggled on at the bottom left, then click `apply`).
6. **Click Style** in the toolbar to see a plethora of visualization options.
7. To visualize GPS points with different colours attributed to each bird **try Style** with the following options: Aggregation “None”; Style fill “by value” (click on the fill menu to get a list of fields that can be selected and select `device_info_serial`). This gives an impression of how migration routes differ between these individuals. See the [Style by Value guide](#) for more ideas and instructions.



8. **Try other Style or Aggregation** options.
9. Just like the filters are powered by SQL, the wizards are powered by `CARTOCSS`, which you can use to fine-tune your map. **Click CARTOCSS** in the toolbar (bottom left) to discover how the markers are defined per bird. To create the map shown above the follow CSS was used (you do not need to type this into your CSS window unless you want to replicate the exact same visualization):

```
#layer {
  marker-width: 4;
  marker-fill: ramp([device_info_serial], (#dc1644, #19a923,
    #a638a2), (311, 317, 344), "=", category);
  marker-fill-opacity: 1;
  marker-allow-overlap: true;
  marker-line-width: 0;
  marker-line-color: #FFF;
  marker-line-opacity: 1;
  marker-comp-op: darken;
} }
```

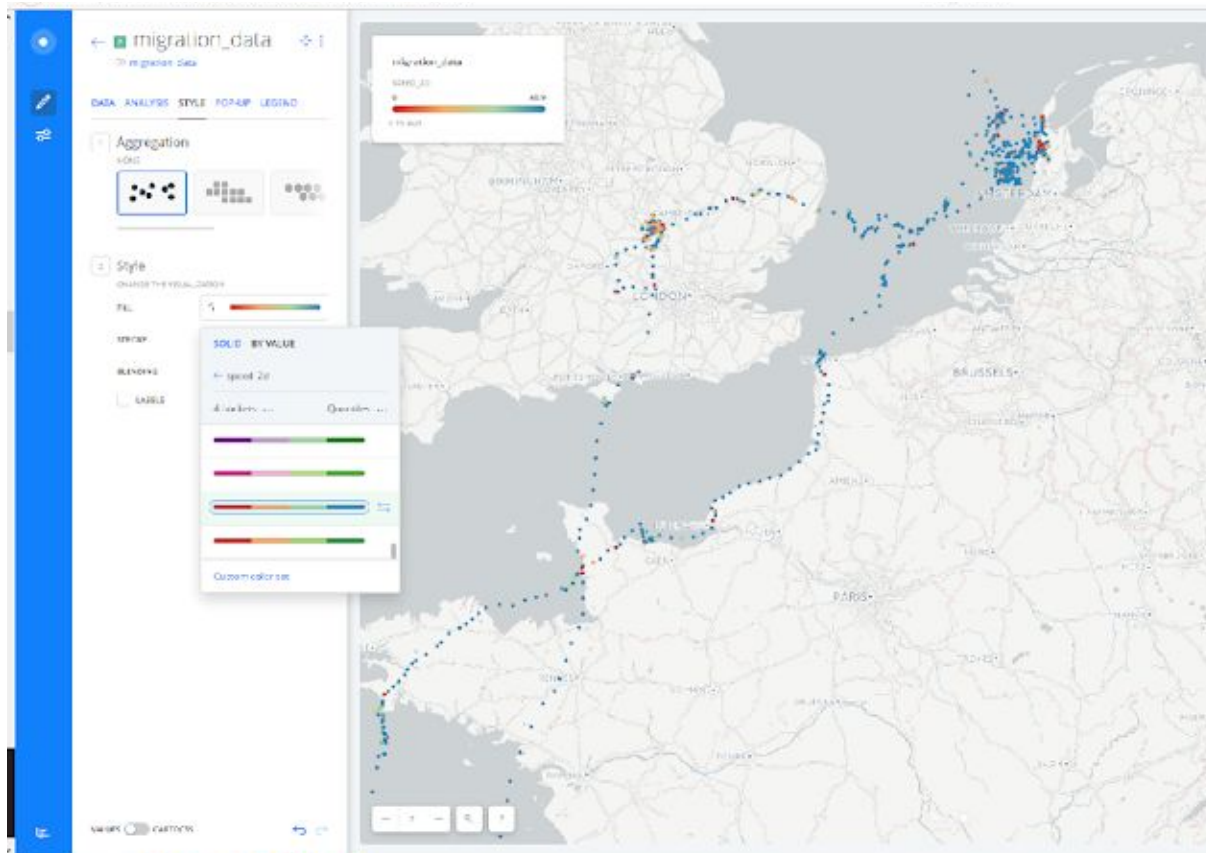
NOTE: CSS stands for Cascading Sytle Sheets and is used to describe how HTML elements are displayed. CartoCSS can be a powerful way of defining exactly which colours, symbols or symbol sizes you use in your visualizations. However once you have altered the CartoCSS you cannot simultaneously use the visualization wizards, you must choose your preferred way of working. For a tutorial a general online CSS tutorial see: <https://www.w3schools.com/css/>

### **Create a map of migration speed**

1. We want to save our previous work and create another map. Click on the **Options** near the map name > **Duplicate** and > **Rename** and name it "travel speed 311"
2. **Add a WHERE clause to the SQL** to only select gull 311:

```
SELECT *
FROM migration_data
WHERE
  device_info_serial = 311
```

3. We want to visualize the travel speed of gull 311. The best way to start is to **create a Choropleth map**, you can use the **STYLE** functions to colour each fix according to the **speed\_2d** field. with the following options:



4. OPTIONAL: If we only want to see where the bird stops to rest, we can fine-tune the map using the CARTOCSS. We basically set all dots to green, except where the speed is below 2 m/s, which we show larger and in red. If you would like to try to replicate the same exact visualization, **click** on the *migration\_data* layer, **click** STYLE, **toggle** CARTOCSS (bottom left button) on and copy and paste the code below into the CARTOCSS box:

```
/** choropleth visualization */

#layer{
  marker-fill-opacity: 0.8;
  marker-line-color: #FFF;
  marker-line-width: 0.5;
  marker-line-opacity: 1;
  marker-width: 6;
  marker-fill: #1a9850;
  marker-allow-overlap: true;
}
#layer [ speed_2d < 2 ] {
  marker-fill: #d73027;
  marker-width: 8;
  marker-line-width: 0.8;
}
```

5. **Click** `Legends` in the toolbar to manually set what to be shown in the legend (using template `Custom`):



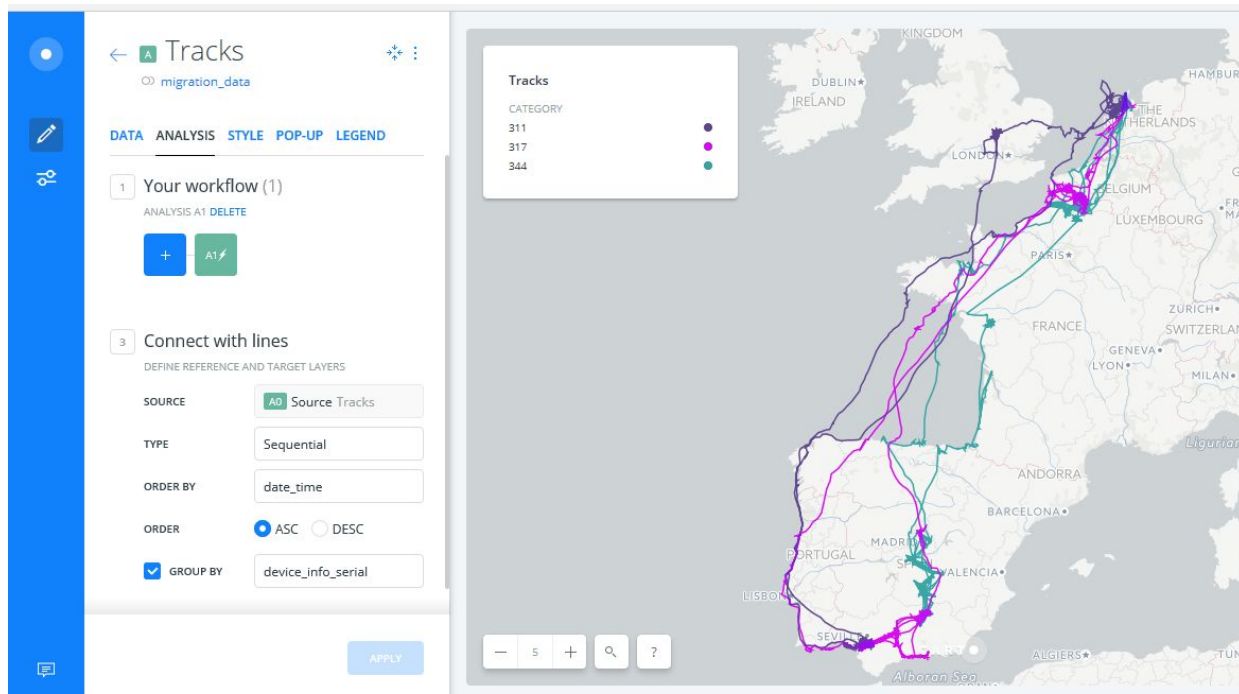
6. **Describe your map** by clicking `Edit metadata...` in the top left.
7. **Share your map** by clicking `Publish` in the top left. The dialog box provides you with a link to the map or the code to embed it in a web page. Note: `CartoDB.js` is for advanced use in apps.
8. **Copy the link and paste it in a new browser tab** to verify the info windows are working and the bounding box makes sense, i.e. are the interesting part of the data visible? Anything you update in your map (including zoom level and bounding box) will affect the public map (reload the page to see the changes).
9. Researchers often ask if they can export the map. There are now multiple options for exporting the map as an image, or exporting the properties of the map as a carto file.

NOTE: you can use unique colours or symbols for up to 7 categories at a time in a single layer. If, for example, you would like to show more than 7 individuals, each with a unique colour code or symbol, you can do so by creating separate layers for different subsets of your data, each subset including a maximum of 7 individuals. This is one workaround the current software design. Note however, when working with animations (see below) you can only animate one layer at a time.

### Create a map of tracks

1. **Create a new map and name it Tracks.**
2. This time we want to string the occurrences together as lines: one line per individual (with the occurrences sorted by date). **This can be done in with the Analysis tools.** Select `Analysis > add new analysis > connect with lines`. Type = `sequential`, order by `date_time`, group by `device_info_serial`, to create one sequential line per individual. This creates an extra geospatial field in the dataset.
3. To understand the SQL code used to generate the line, toggle SQL on.

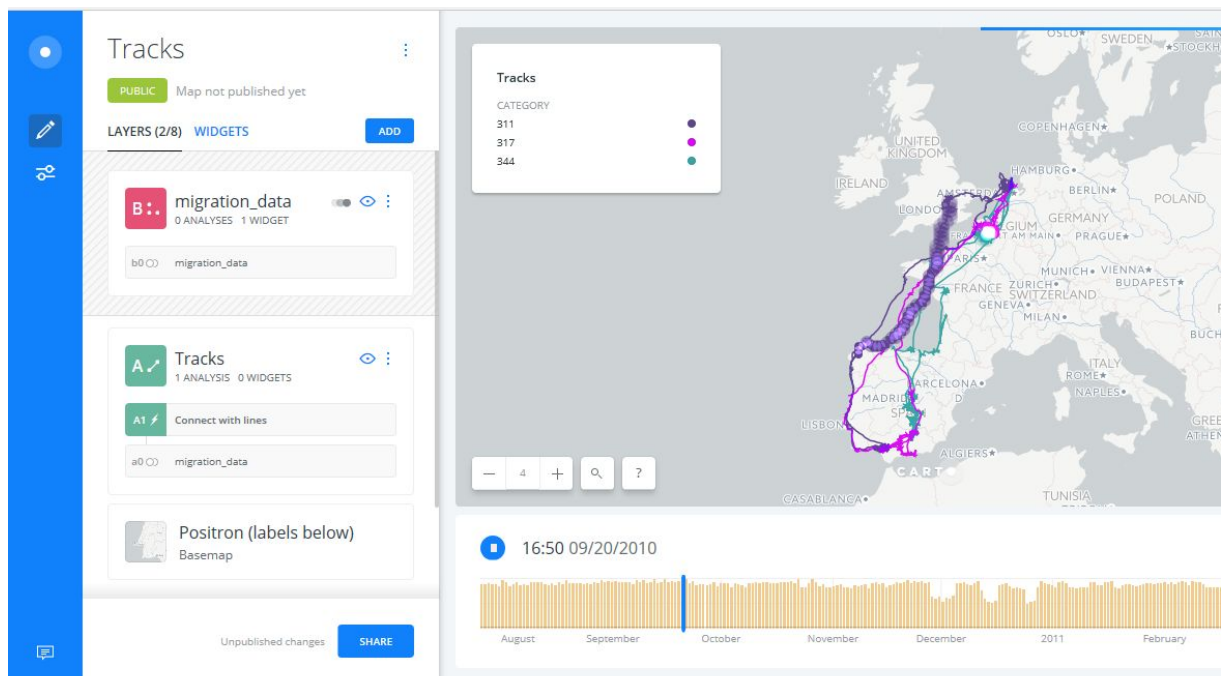




4. You can use `Style` to stylize your lines.
5. Using different SQL code you can create different line segments and data aggregations, for example, you can extract the month from the `date_time` stamp and create separate lines per month.

### Create an animated map

1. **Duplicate** your map and **name it** Migration in time.
2. This time, we'll add a map on top of the previous one. **Click** ADD on the left by layers to add a new layer and **choose the same table** `migration_data`.
3. From the `Style > Aggregation`, **choose Animated**. In `Style`, The Time Column should always be your date.
4. You can then fine tune things like the duration, trails, number of steps in the animation. It's best to explore this on your own to see what works best for you. Using the colours and hexadecimal codes you can fine tune the colours so that the animation and tracks have exactly the same colours.
5. You can add `widgets` such as the time slider to your animation.



6. Once you are satisfied with the results, **publish your map**.

You can see an example map here:

<https://ama2017.carto.com/builder/479caefc-01eb-43c6-9b82-840e7b8efd89/embed>

## Go forth and start mapping

For inspiration and tutorials, see:

- [INBO blog posts on CartoDB](#), including more specific tutorials and things we've built.
- [INBO CartoDB maps](#), mostly using bird tracking data.
- [Carto map gallery](#): a diverse gallery of CARTO maps.
- [Carto academy](#): step by step tutorials on how to create maps in CARTO.
- [Carto documentation](#): if you want to know more about all the features.