

**Palacký University Olomouc  
Faculty of Science  
Department of Geoinformatics**

# **ET2GIS MANUAL**

**Diploma thesis appendix  
(Number 2)**

**Bc. Jan ŠENKEŘÍK**

**Thesis supervisor RNDr. Stanislav POPELKÁ, Ph.D.**

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## 1. INTRODUCTION TO ET2GIS TOOL

The ET2GIS tool was created as an output of the Master's thesis at the Department of Geoinformatics in 2023. The creation of the tool follows the previous work of a foreign student Minha SULTAN (2021), who created a tool within her Master's thesis that allows converting eye-tracking data from a static interactive map into shapefile or geojson formats. These formats can then be uploaded into GIS programs for further visualization or analysis.

The ET2GIS tool enables easy import of this output data from ET2Spatial into ArcGIS Pro, while offering several simple analyses or visualizations. This English manual has also been created for the ET2GIS tool to facilitate both the use of the ET2GIS tool and the collection of Eye-tracking data or conversion.

The ET2GIS tool is available for download as a single ZIP file that contains a separate Toolbox (.tbx), Project Template (.aptx) and a folder with Symbology Layers (ET2GIS Layer).

The Toolbox can be uploaded to ArcGIS Pro as a standalone Toolbox (.tbx) or can be run directly in Project Template (.aptx), which contains not only the ET2GIS tool itself, but also, for example, preset Maps, scales, etc. For the ET2GIS tool to work properly, it is necessary to have an ET2GIS Layers folder, which contains the needed Symbology Layers that create the appearance of the outputs. This folder must be placed in the native ArcGIS Pro directory (C:\Users\"USER"\Documents\ArcGIS\ET2GIS\_Layers). Only then can ET2GIS work as it should.

### [ET2GIS Download](#)

(Toolbox, Project Template, Symbology Layers, Sample Data)



## CREATION OF A NEW EYE-TRACKING PROJECT

This chapter covers how to create test maps (static interactive), where to upload these maps, how to run them, how to create an eye-tracking project, how to do it properly, and what to be aware of.

### 1.1 Creation of test map

The easiest way to create new test map is to download the ET2GIS test maps and start from these files. The original files are taken, and modified as needed, from Minha SULTAN's (2021) ET2Spatial tool testing.

A whole ZIP file (Maps.zip) is available for download which contains three types of maps: a blank map, a map with a raster layer and a map with a vector layer.

Only one file needs to be edited: **mapa.js**, which contains the map start position and zoom level settings, map base layers, map additional layers, etc.

### 1.2 Creation of a blank map

This is what the mapa.js file looks like for a blank map. The only things that need to be set are the coordinates (latlng), the starting zoom level (zoom) and the base map (mapTypeId), where you can use the Google Maps base maps: Roadmap, Satellite, Terrain and Hybrid.

```
1 // Google Maps Demo
2 /////////////////
3 var map;
4
5 function initialize() {
6     var latlng = new google.maps.LatLng(49.283587675163496, 17.812931875540084);
7     var myOptions = {
8         zoom: 10,
9         center: latlng,
10        mapTypeId: google.maps.MapTypeId.ROADMAP
11    };
12    map = new google.maps.Map(document.getElementById("map"),
13                            myOptions);
14
15 }
16
17 // Map creation
18 /////////////////
19
20 $(document).ready(function() {
21     initialize();
22 });
23
```

**Image 1** Preview of mapa.js file with a blank map (*download in Chapter 1*)..

### 1.2.1 Creation of a map with a raster layer

This is what the mapa.js file looks like for a map with a raster layer. As with the blank map, it is possible to set, for example, coordinates, zoom level, etc. In addition, for this map it is necessary to have a pre-made raster layer in the form of tiles. Other important raster layer settings in mapa.js file is: mapBounds, mapMinZoom and mapMaxZoom.

Also, don't forget to change the URL on line 32, where the URL must be loaded with raster tiles. Pay attention to whether the website has HTTPS or just HTTP. It can cause problems with displaying the layer.

```

1 // Google Maps Demo
2 ///////////////////////////////////////////////////////////////////
3 var map;
4
5 function initialize() {
6   map = new google.maps.Map(
7     document.getElementById('map'),
8     {
9       center: new google.maps.LatLng(50.376209186374695, 26.909323251552323),
10      zoom: 8,
11      mapTypeId: google.maps.MapTypeId.ROADMAP
12    });
13
14 // Tady potřeba přepsat mapBounds + mapMinZoom + mapMaxZoom (vykopirovat z maptileru)
15 var mapBounds = new google.maps.LatLngBounds(
16   new google.maps.LatLng(57.7672392, 25.48808516),
17   new google.maps.LatLng(59.3139297, 27.6333526));
18 var mapMinZoom = 6;
19 var mapMaxZoom = 12;
20
21 var imageMapType = new google.maps.ImageMapType({
22   getTileUrl: function(coord, zoom) {
23     var proj = map.getProjection();
24     var z2 = Math.pow(2, zoom);
25     var tileXSize = 256 / z2;
26     var tileYSize = 256 / z2;
27     var tileBounds = new google.maps.LatLngBounds(
28       proj.fromPointToLatLng(new google.maps.Point(coord.x * tileXSize, (coord.y + 1) * tileYSize)),
29       proj.fromPointToLatLng(new google.maps.Point((coord.x + 1) * tileXSize, coord.y * tileYSize)));
30
31     if (!mapBounds.intersects(tileBounds) || zoom < mapMinZoom || zoom > mapMaxZoom) return null;
32     // Tady potřeba přepsat URL dlaždic + upravit na radku 20 !!!!!
33     return "http://ewetracking.upol.cz/senkerik/estoneskola/(z)/(x)/(y).png".replace("(z)",zoom).replace("(x)",coord.x).replace("(y)",coord.y);
34   },
35   tileSize: new google.maps.Size(256, 256),
36   minZoom: mapMinZoom,
37   maxZoom: mapMaxZoom,
38   name: 'Tiles'
39 });
40
41 map.overlayMapTypes.push(imageMapType);
42
43 google.maps.event.addDomListener(window, 'load', initialize);
44
45
46 // Map creation
47 ///////////////////////////////////////////////////////////////////
48
49 $(document).ready(function() {
50   initialize();
51 });
52 
```

**Image 2** Preview of mapa.js file with a raster layer (*download in Chapter 1*).

### 1.2.2 Creation of a map with a vector layer

This is what the mapa.js file looks like for a map with a vector layer. As with the previous maps, it is possible to set, for example, coordinates, zoom level, etc. Then the previously created vector layer in Keyhole Markup Language (.kml) format is inserted into the map folder.

Next, the URL address in the mapa.js file on line 14 must be changed to refer to the KML layer in the folder. Again, pay attention to whether the web page has HTTPS or just HTTP. This can cause problems with the layer displaying.



```
1 // Google Maps Demo
2 ///////////////////////////////////////////////////////////////////
3
4 var map;
5 function initialize() {
6   map = new google.maps.Map(
7     document.getElementById('map'), {
8       center: new google.maps.LatLng(49.33717911427964, 17.992797561355264),
9       zoom: 12,
10      mapTypeId: google.maps.MapTypeId.ROADMAP
11    });
12
13   var ctalayer = new google.maps.KmlLayer({
14     url: "http://eyetracking.upol.cz/senkerik/vsetin/Vektor_Vsetin.kml",
15     map: map,
16   });
17
18 }
19 google.maps.event.addDomListener(window, 'load', initialize);
20
21
22 // Map creation
23 ///////////////////////////////////////////////////////////////////
24
25 $(document).ready(function() {
26   initialize();
27 });


```

**Image 3** Preview of mapa.js file with a vector layer (*download in Chapter 1*).

## 1.3 Eye-tracking project creation

The first requirement is to have the test maps prepared. After that, task folders (e.g. Task\_1) containing the test maps must be created and then uploaded to the server (one map per task).

Then create a project in the **Experiment Center**, where in addition to addressing, mentioning a few rules (e.g. the respondent is allowed to move the map, but not to change the base map layers) a pair of slides need to be created (question and map). The map is displayed via a slide with the URL to the Task (e.g. eyetracking.upol.cz/senkerik/TASK1). This is repeated for other questions and an acknowledgement is written at the end.

## 1.4 Eye-tracking testing

It is necessary to launch the browser in fullscreen before running the experiment, so that the map is not displaced on the monitor. At the beginning of testing, the respondent needs to be calibrated. If the calibration is made without problems the respondent can proceed further. The respondent should read the opening slide carefully with instructions on what to expect. If everything is clear, the respondent may proceed. The next slide should contain the map task and a browser with the map will pop up.



The respondent types their assigned ID (e.g. P01) into the map and presses the F2 key. It is crucial that the respondent presses the key, otherwise the information will not be written to the results file and the start of the task cannot be determined. After completing the task, the respondent must press the F2 key again to exit the map. Then, the respondent needs to press the F9 key to move on to the next task. This continues until the end of testing.

## 2. EYE-TRACKING OUTPUT DATA PROCESSING

This chapter covers how to download all necessary files, how to convert these files correctly and what to watch out for. Lastly, how to import these converted files into ArcGIS Pro.

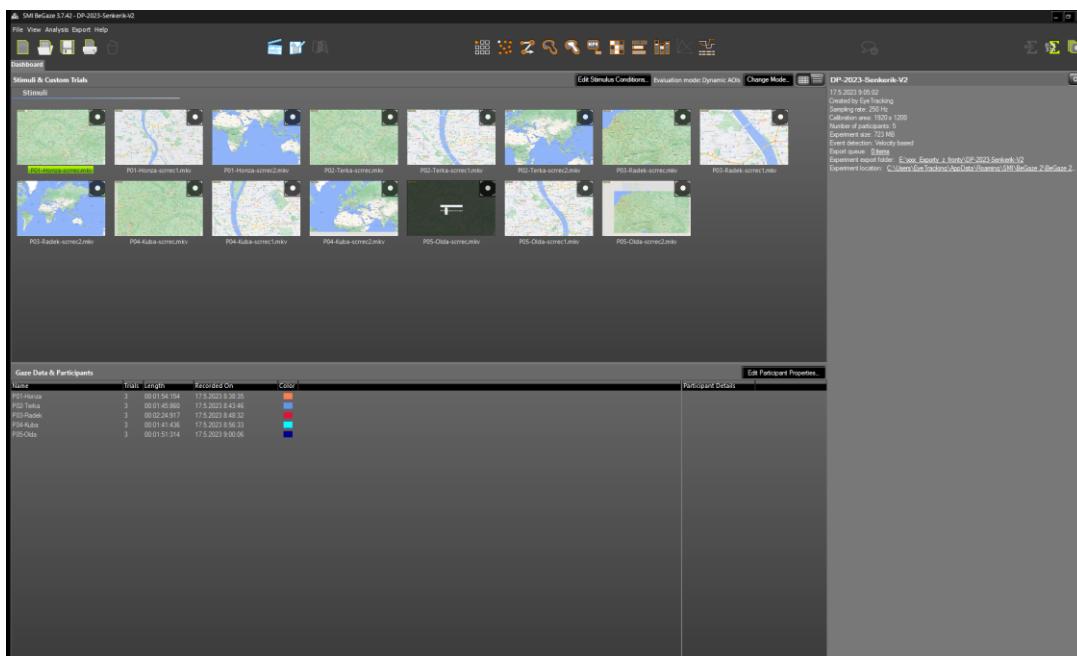
### 2.1 Output data acquisition and processing

When the experiment is complete, MapTrack files are created in the Results folders for each Task. Therefore, you must connect back to the server and download these files (Image 4).

/srv/www/vhosts/eyetracking/public_html/senkerik/TASK3/results		
Název	Velikost	Změněno
..		17.5.2023
session-1684305622816-P01.xml	4 KB	17.5.2023
session-1684305918812-P02.xml	4 KB	17.5.2023
session-1684306254466-p03.xml	3 KB	17.5.2023
session-1684306694606-P04.xml	3 KB	17.5.2023
session-1684306915043-p05.xml	3 KB	17.5.2023

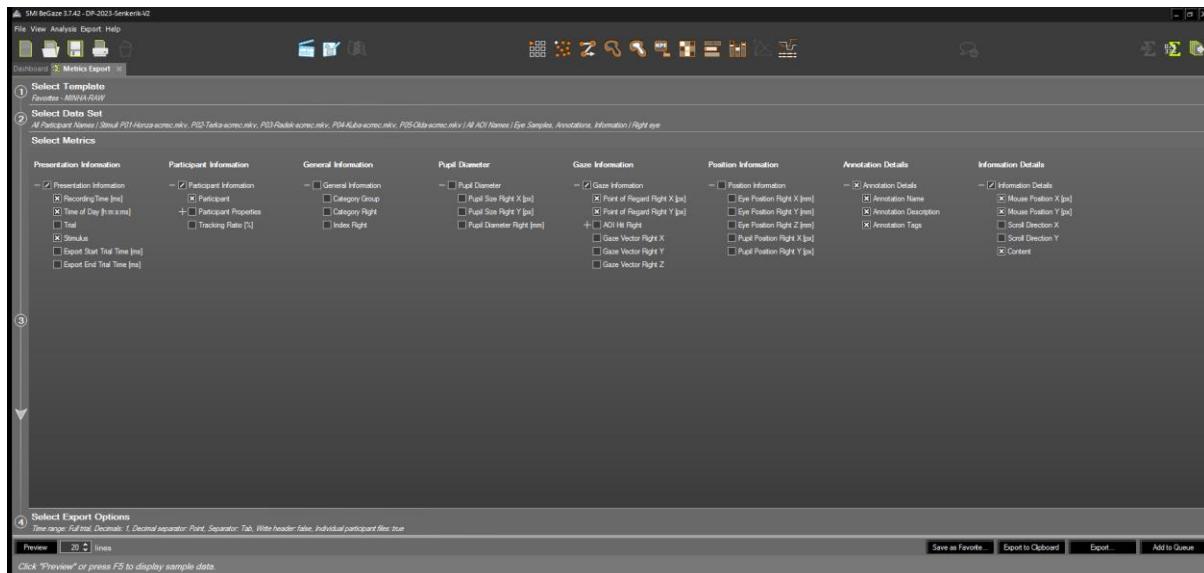
**Image 4** Preview of the Results folder with output files (.xml).

Then the BeGaze program must be opened. Select the New from folder option and choose the desired experiment. Then just load the data. It should look like Image 5.



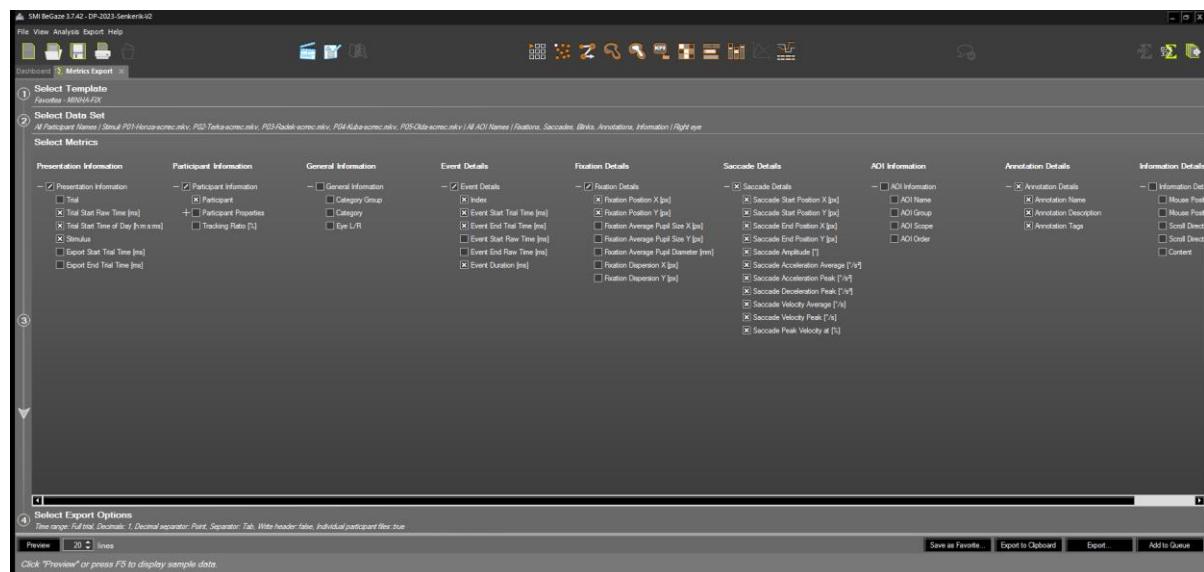
**Image 5** Preview of BeGaze with loaded experiment.

Then select the Metrics Export tab. If there is already a preset **Favorites - MINHA RAW**, select it. If not, this can be set manually (Image 6). All respondents must be selected during the export and one Task at a time (Scrrec/Scrrec1/Scrrec2, etc.) needs to be exported to the Task1, Task2, etc. folders. In the last tab, it is necessary to manually check Individual participant files.



**Image 6** Preview of MINHA RAW export settings.

For the second export, it is possible to select an existing **Favorites - MINHA FIX**. In case it does not yet exist, it must be set up manually again (Image 7). The data export is done in the same way as MINHA RAW.



**Image 7** Preview of MINHA FIX export settings.

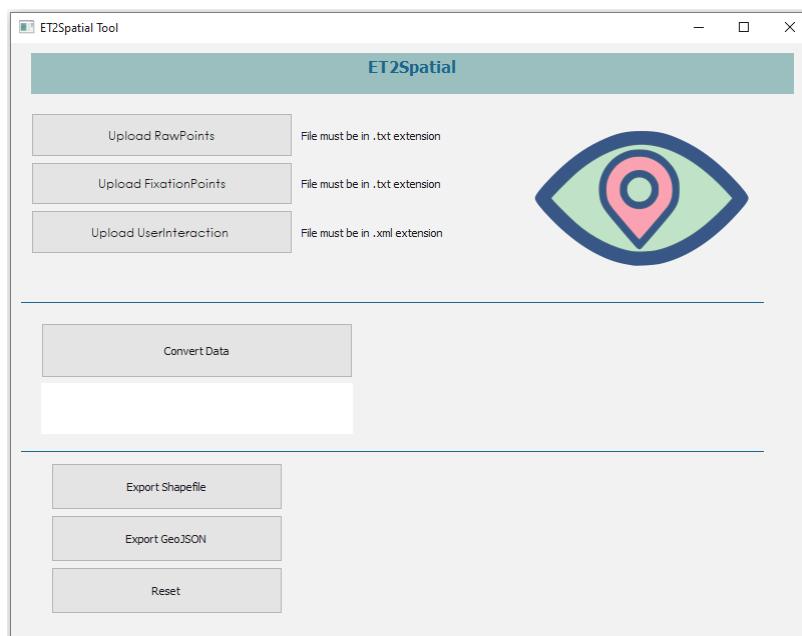
In the end, folders called Task1, Task2, etc. will be created, containing three types of files: MINHA FIX, MINHA RAW and MapTrack files, for each participant (Image 8).

Název	Přípona		Velikost	Datum	Čas	Atributy
		ADR	17.5.2023	9:02:54		
Favorites - MINHA-FIX - P01-Honza.txt	.txt	17 733	17.5.2023	9:18:12		A
Favorites - MINHA-FIX - P02-Terka.txt	.txt	12 929	17.5.2023	9:18:12		A
Favorites - MINHA-FIX - P03-Radek.txt	.txt	54 183	17.5.2023	9:18:12		A
Favorites - MINHA-FIX - P04-Kuba.txt	.txt	26 474	17.5.2023	9:18:14		A
Favorites - MINHA-FIX - P05-Olda.txt	.txt	24 070	17.5.2023	9:18:14		A
Favorites - MINHA-RAW - P01-Honza.txt	.txt	912 929	17.5.2023	9:15:04		A
Favorites - MINHA-RAW - P02-Terka.txt	.txt	408 322	17.5.2023	9:15:44		A
Favorites - MINHA-RAW - P03-Radek.txt	.txt	868 739	17.5.2023	9:15:06		A
Favorites - MINHA-RAW - P04-Kuba.txt	.txt	416 174	17.5.2023	9:15:06		A
Favorites - MINHA-RAW - P05-Olda.txt	.txt	533 919	17.5.2023	9:15:08		A
session-1684305524217-P01.xml	.xml	1 184	17.5.2023	8:34:40		A
session-1684305833781-P02.xml	.xml	458	17.5.2023	8:39:40		A
session-1684306120523-p03.xml	.xml	2 477	17.5.2023	8:44:50		A
session-1684306601088-P04.xml	.xml	1 189	17.5.2023	8:52:38		A
session-1684306825629-p05.xml	.xml	458	17.5.2023	8:56:12		A

**Image 8** Preview of the Task folder with all output files (FIX, RAW and MapTrack files).

## 2.2 Data conversion with ET2Spatial tool

Once the export from BeGaze is complete, these exported files must be uploaded to ET2Spatial. ET2Spatial is available for [free download](#). Simply launch the tool and wait a moment for it to load. Three files must be uploaded to the tool: Rawpoints, Fixationpoints and UserInteraction (MapTrack file) (Image 9).

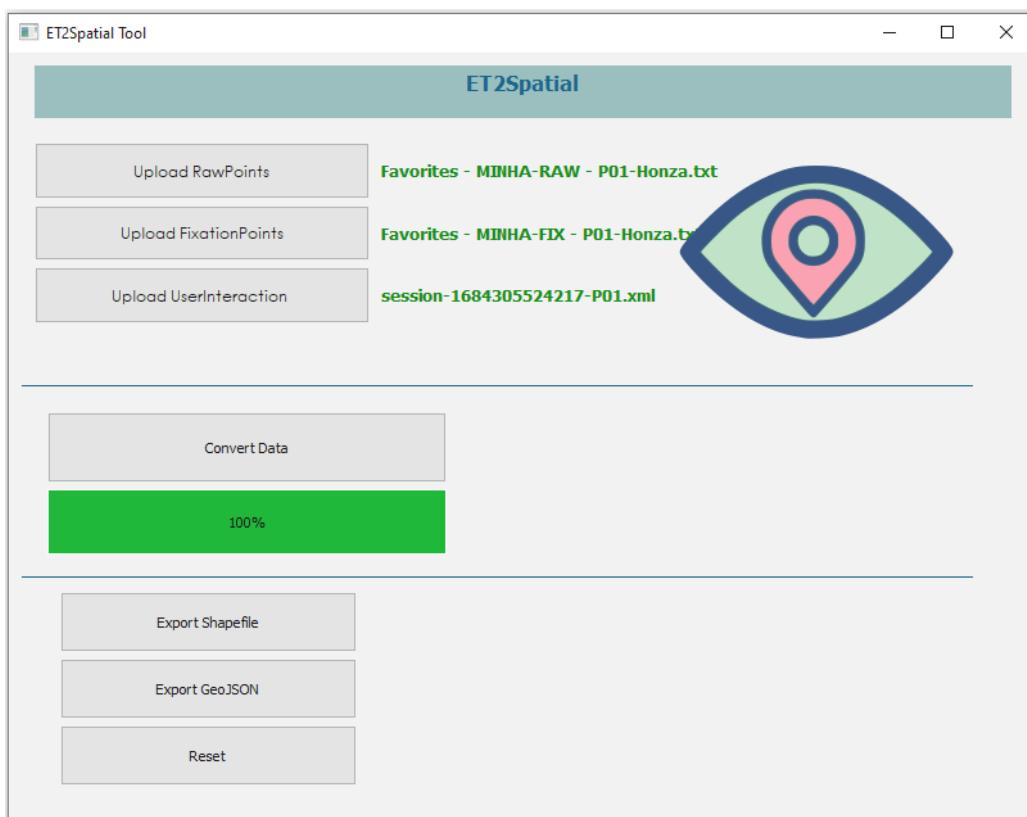


**Image 9** Preview of empty ET2Spatial program.

Then just press the Convert Data button. If everything goes well, a green text and bar is displayed, and the output can be downloaded as a Shapefile or GeoJSON (Image 10). **Recommendation:** use Shapefile.

This is done for each Task and each respondent. It is recommended to create Task folders and export the Shapefile or GeoJSON files into them. This will make it easier to import the data into ArcGIS Pro. When importing files into ArcGIS Pro, just select all Fixationpoints or Rawpoints from one folder.

Another tip is that the converted files have the same names across tasks (e.g. P01\_fixationpoints will be written for Task1, Task2, etc.). Hence, it is recommended to rename these files afterwards and add a number according to the task (e.g. P01\_1\_fixationpoints and P01\_2\_fixationpoints). ArcGIS Pro might have a problem importing files with the same name.



**Image 10** Preview of successfully converted data in ET2Spatial program.

It is possible that there may be problems with files and the conversion will fail. One case where conversion has failed a couple of times was when respondents made no movement in the map. This caused no record of the movement in the MapTrack file, and the conversion failed. It is necessary to keep this in mind and fix this file. The fix can be done by adding artificial motion in the text editor, but it must be minimal.

How to detect that a file does not contain a movement in the map? The MapTrack file will have only one `<event>` in the `<events>` section. Therefore, it is necessary to add a second `<event>`, which will have `<time> 1`, `<name> move` and `<center>` shifted by a small value. The rest should remain the same (i.e. `<zoom>` and `<value>`). A sample of the corrected file is on Image 11. The highlighted part is added and thanks to it this file is functional again and can be used in the conversion through ET2Spatial.



```
1  <?xml version="1.0"?>
2  <session>
3    <id>1684305833781</id>
4    <ip>158.194.94.96</ip>
5    <var>p02</var>
6    <start>2023-05-17 08:43:53</start>
7    <mapsize>1920x1200</mapsize>
8    <screen>1920x1200</screen>
9    <browser>Chrome 113</browser>
10   <os>Windows</os>
11   <events>
12     <event>
13       <time>0</time>
14       <name>init</name>
15       <value>0</value>
16       <center>(49.75480440021709, 15.288548465797426)</center>
17       <zoom>8</zoom>
18     </event>
19     <event>
20       <time>1</time>
21       <name>move</name>
22       <value>0</value>
23       <center>(49.75480440021709, 15.288548465797427)</center>
24       <zoom>8</zoom>
25     </event>
26   </events>
27 </session>
28
```

Image 11 Preview of the edited MapTrack file (*download in Chapter 1*).



### 3. INSTRUCTIONS FOR USING ET2GIS TOOL

This chapter covers importing ET2Spatial converted data into ArcGIS Pro, running ET2GIS using Project Template or without using the Project Template, and a description of how to run each ET2GIS subtool, including a demonstration of their output.

#### 3.1 Eye-tracking data import into ArcGIS Pro

Once the data conversion has been completed and the Shapefile or GeoJSON files have been created, these files can be uploaded into the GIS environment, in this case into ArcGIS Pro. It is worth mentioning that the ET2GIS tool was created in **ArcGIS Pro version 3.1.0**. So to make everything work as it should, it is necessary to make sure that the version of ArcGIS Pro is up to date.

To import the data, you can use the existing Project Template, which includes the ET2GIS tool, pre-made Maps (Locked Scale, Unlocked Scale, 3D Maps), Google basemaps, etc. Alternatively, you can upload only the Toolbox itself to an already created project and finish the rest of the settings manually - see **Chapter 5**.

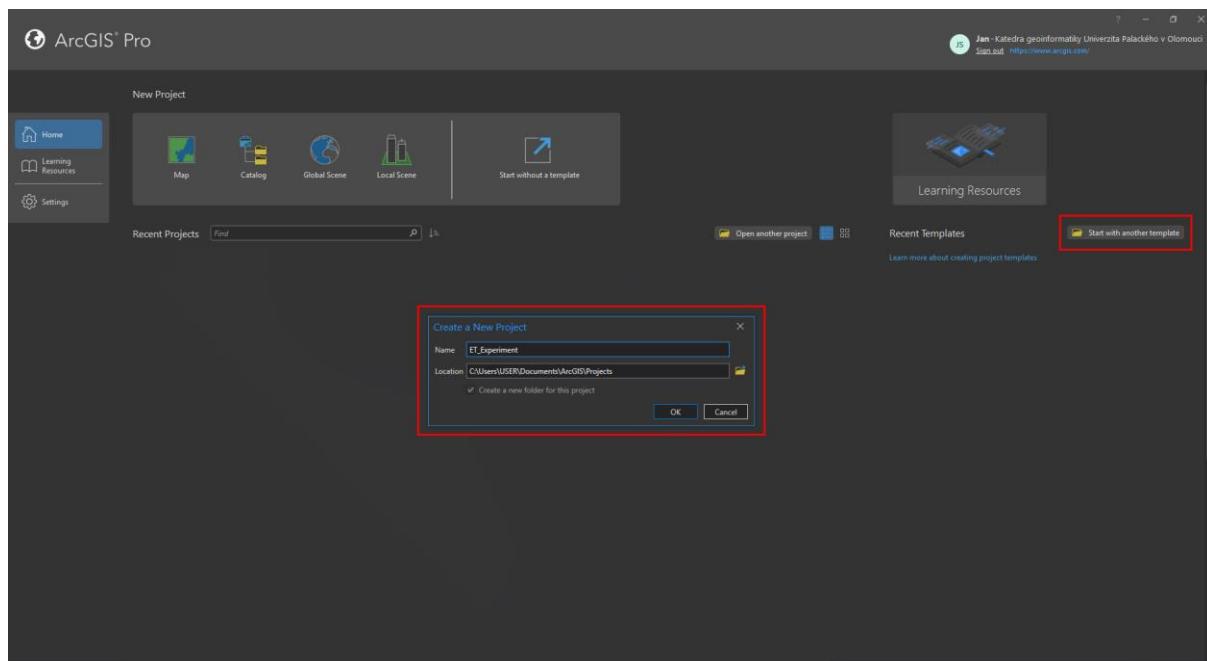
**CAUTION:** The files in each subtool need to be selected directly from the file browser and not from the map. If the ET data layer is selected from the map, an error will occur.

##### 3.1.1 Launching ET2GIS with Project Template

Before starting a new project using the Project Template, it is necessary to first download all the necessary files: [ET2GIS zip file](#) (ET2GIS Layers folder, ET2GIS Toolbox and ET2GIS Project Template). To make everything work as it should, upload the ET2GIS Layers folder to the native ArcGIS Pro directory (C:\Users\USER\Documents\ArcGIS\ET2GIS\_Layers). This will ensure that the tool outputs are in the correct form.

Starting a new project from ET2GIS Project Template is very easy. Just open the main ArcGIS Pro page. On the right side, there is an option to "Start with another template". When clicked, the downloaded Project Template (ET2GIS\_PT.aptx) can be selected. The name of the Project and its Location should be filled in (Image 12).

**CAUTION:** It is important that the Location must remain natively in the Projects folder in the ArcGIS Pro subdirectory where the ET2GIS Layers folder is also located. Otherwise, the tool outputs will not function properly.



**Image 12** Preview of launching ET2GIS Project Template ArcGIS Pro in the main page.

After launching, a new project will be created which will contain four Maps (Locked Scale, Unlocked Scale, Local 3D and Global 3D Map). Each of these maps contains four Google Maps basemaps (Roadmap, Satellite, Terrain and Hybrid). It also includes, of course, the ET2GIS Toolbox. How the ET2GIS Toolbox is launched, what it contains and what the outputs look like is shown in **Subchapter 4.2**.

### 3.1.2 Launching ET2GIS without Project Template

If the user would like to use the ET2GIS Toolbox in an existing project, there is no problem. With one big **BUT**. If the existing project is not in the native ArcGIS Pro folder: Projects, the layer symbologies cannot be automatically applied and must be manually searched for in the directory. The project will not include the basemaps of Google Maps. Locked Scale Map relevant to one subtool (Zoom Level Clustering) will need to be set manually etc. All manual settings are explained in **Chapter 5**. It is obvious that it is recommended to use ET2GIS Project Template, which has everything preconfigured.

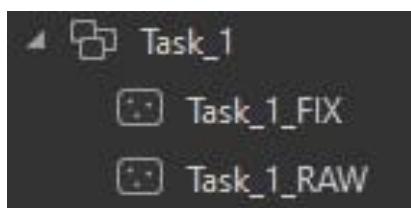
## 3.2 ET2GIS Subtools

This subchapter lists all the subtools that the ET2GIS Toolbox contains. It also details how to run them, along with a sample of their outputs.

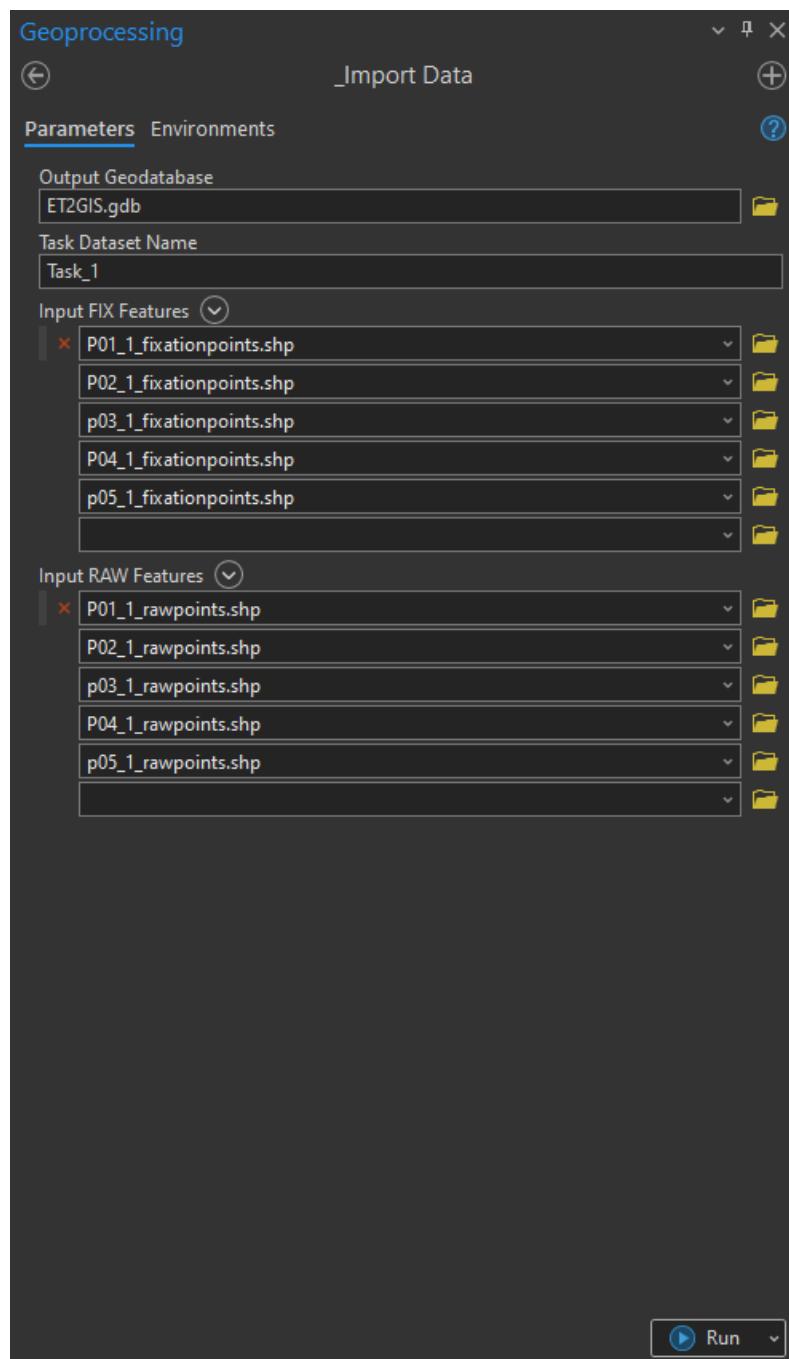
### 3.2.1 Import Data

The Import Data subtool, as the name says, is used to load Shapefile files into ArcGIS Pro in a unified manner. The subtool creates a New Dataset, into which it creates two new Feature Classes: Fixationpoints with the acronym FIX and Rawpoints with the acronym RAW. At the same time, new columns are created in these files: File name, Participant number and Time (Date format).

To run the Import Data subtool, it is needed to fill in the Output Geodatabase, rename the Task Dataset Name according to the Task name, and upload all FIX and RAW shapefiles (Image 13). Then just press the Run button and the new Dataset will be created containing two Feature Classes with merged shapefiles (Image 14).



**Image 13** Preview of the new Dataset along with its Feature Classes,



**Image 14** Preview of filled parameters of the **Import Data** subtool.

### 3.2.2 AOI Intersect (Area of Interest)

The AOI Intersect subtool writes information about the intersection of data with areas of interest to an attribute table. New fields are created in the table with names AOI\_1, AOI\_2, etc., into which a value of zero (not included) or one (included) is written based on their location. Areas of interest can overlap, allowing for internal subdivision of areas of interest (e.g., a map marking as a whole and a map field, legend, title in it, etc.).

Two parameters need to be filled in when the subtool is started (Image 15). The first parameter is the ET data layer (Fixationpoints or Rawpoints). The files need to be selected directly from the file browser and not from the map. If the ET data layer is selected from the map, an error will occur. The second parameter is the actual AOI polygon layer. The AOI polygons should have the same coordinate system as the ET data.

**Before starting, make sure that the layer (Fixationpoints or Rawpoints) is present in the map.** Otherwise new columns will not be created, and values will not be written. A second run will already show errors, because even if there are no new columns, the program will think so and the subtool will not work (it will need to re-import the shapefiles using Import Data).

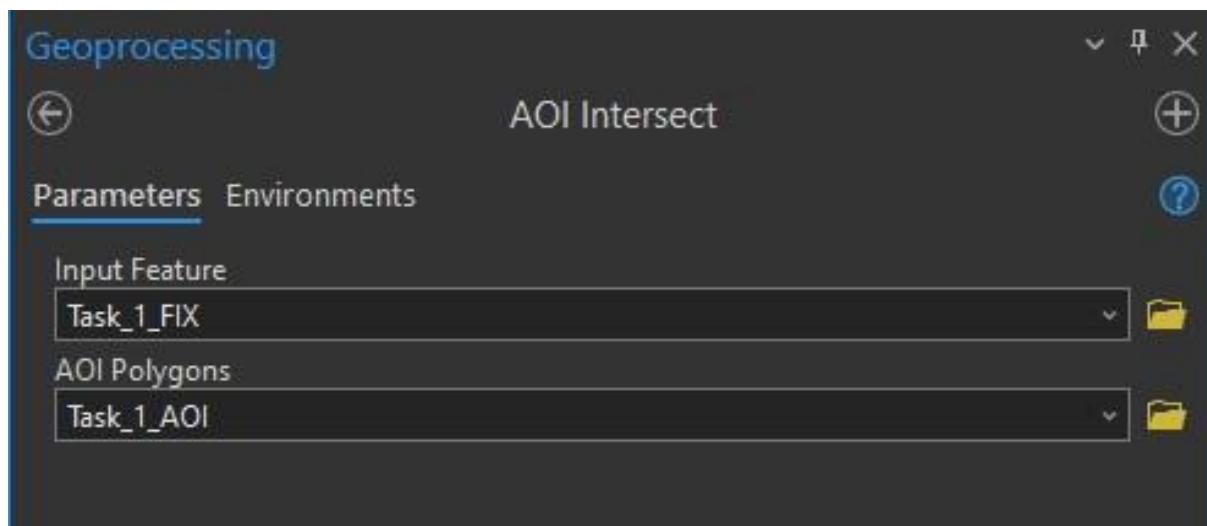
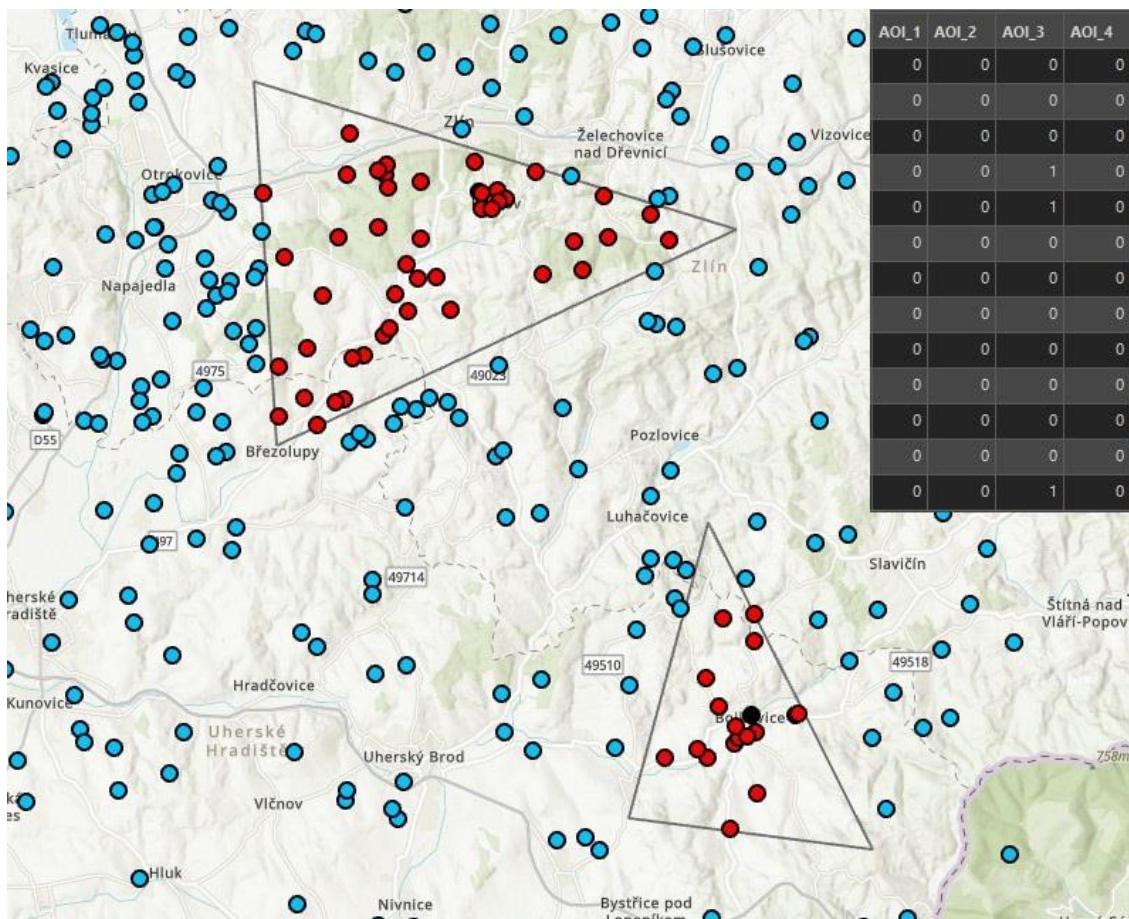


Image 15 Preview of filled parameters of the **AOI Intersect** subtool.

The output of the subtool is new fields in the attribute table of the original ET data Feature Class. These columns contain zeros or ones that indicate which region of interest intersects with the ET data. The final attribute table and an example of custom AOI polygons is shown in Image 16.

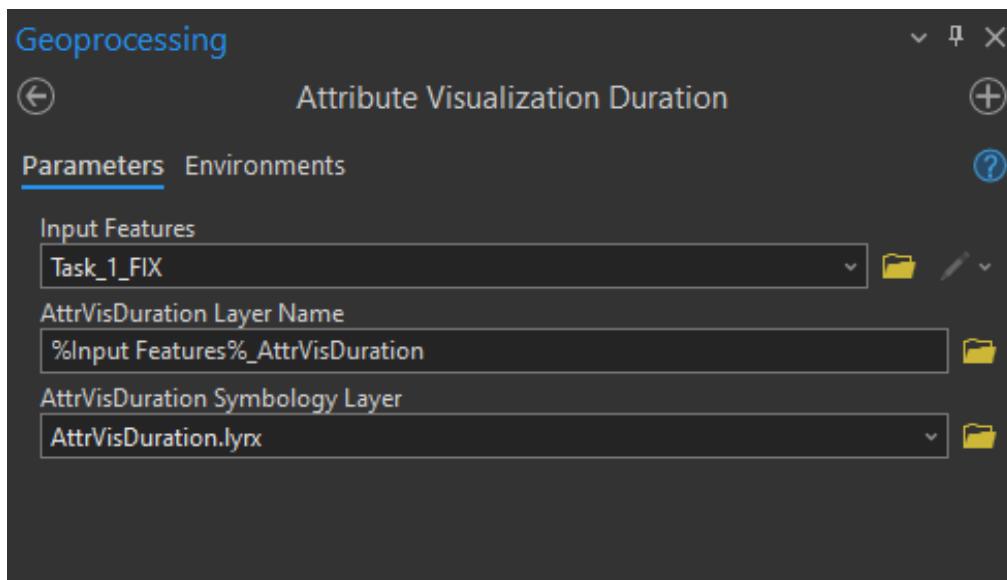


**Image 16** Preview of the attribute table and output layer of the **AOI Intersect** subtool.

### 3.2.3 Attribute Visualization Duration

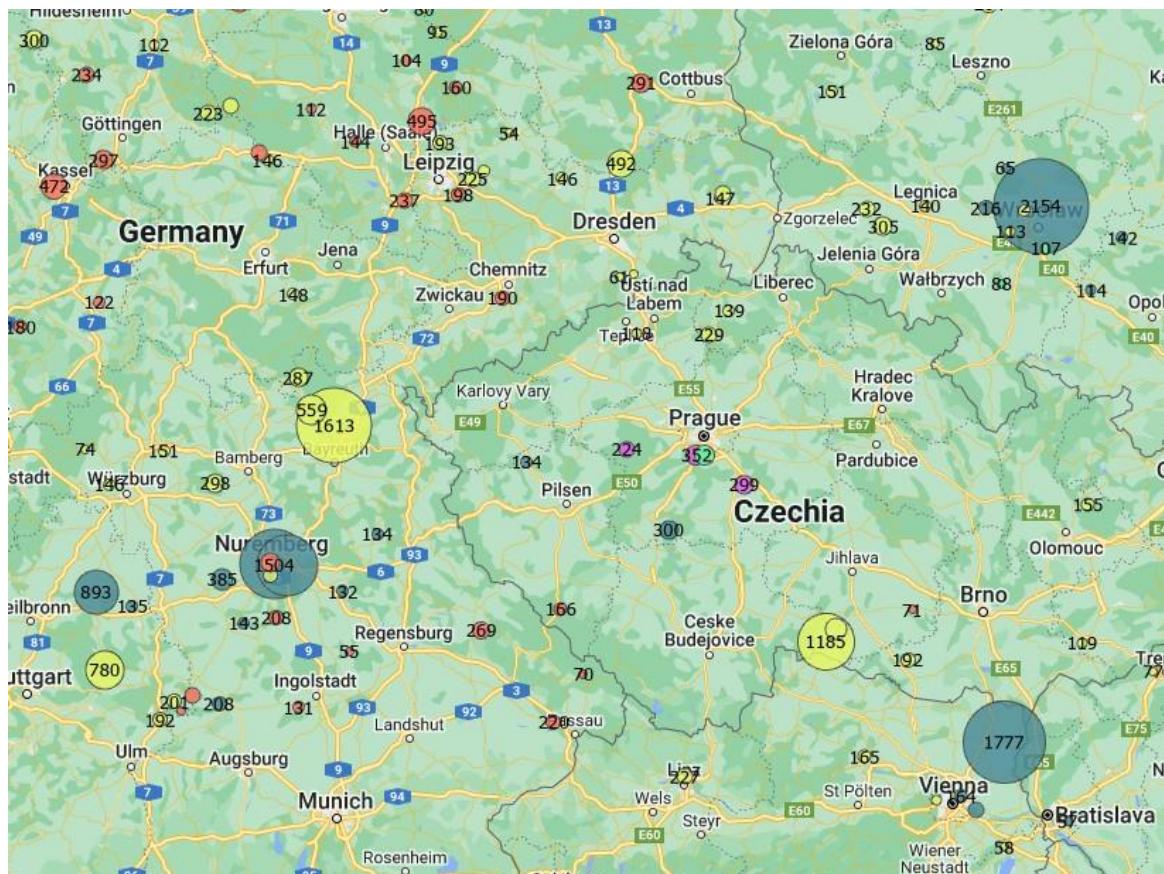
As the name of the subtool suggests, it is a simple visualization of ET points using the Duration attribute. This graphical visualization shows, using proportional symbols, how long the respondent has been looking at a given location.

When the subtool is opened, the required Fixationpoints layer must be selected (e.g. Task\_1\_FIX). Assuming the user has followed the instructions in the manual and uploaded the ET2GIS\_Layers folder to the native ArcGIS Pro folder, the rest of the subtool is already preconfigured, and the subtool can be started with the Run button (Image 17).



**Image 17** Preview of filled parameters of the **Attribute Visualization Duration** subtool.

The output of the subtool is a new layer with the ending \_AttrVisDuration, which is automatically displayed in the opened Map. Each participant has its own color. The resulting layer is shown in Image 18.



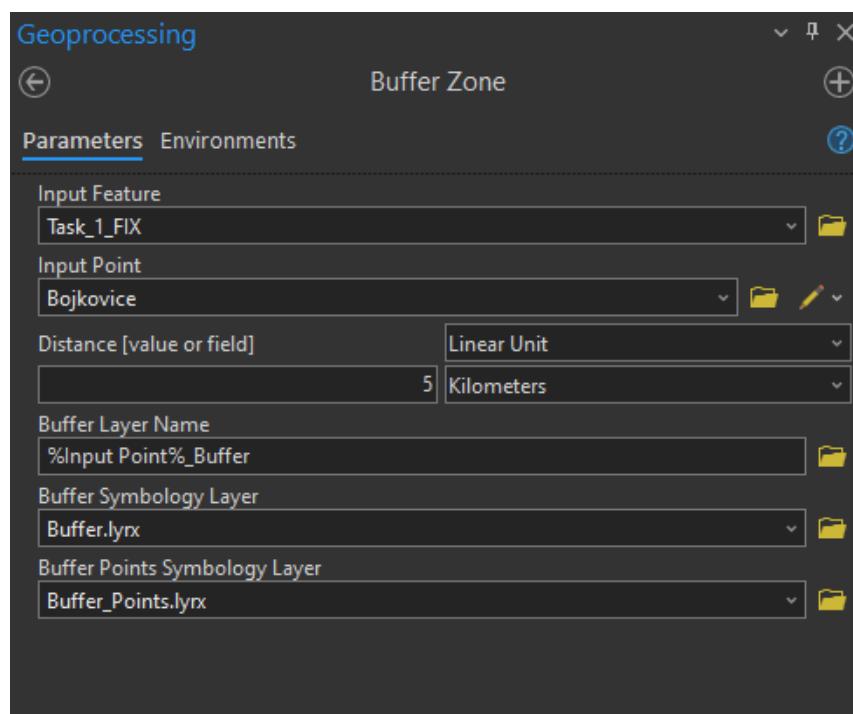
**Image 18** Preview of the output layer of the **Attribute Visualization Duration** subtool.

### 3.2.4 Buffer Zone

The Buffer Zone subtool is ideal for detecting nearby points within a predefined distance. Simply create or use an existing layer with point or points of interest, define a distance around it and the subtool will highlight the points within that distance with a color. The red color represents their occurrence within the user-defined distance and the blue color the opposite. Additionally, a new field Buffer is created in the original Fixationpoints layer, containing zeros (it's outside) or ones (it's inside).

Before running the sub-tool itself, it is necessary to use an existing or create a custom point layer with a point or points of interest around which the sub-tool will automatically create Buffer Zones. Create a New Feature Class as a Point layer and use the data Spatial Reference (WGS 1984 Web Mercator (auxiliary sphere)). Then just select the Modify tool in the top Edit panel and create a new point or points.

When the subtool is started, only two parameters need to be filled in and one needs to be modified according to the needs (Image 19). The first mandatory parameter is the Fixationpoints or Rawpoints layer (e.g. Task\_1\_FIX). The second mandatory parameter is the actual point layer. The optional parameter Distance is preset to 5 km, but this distance, including units, can be changed. The reason why the remaining parameters are visible, even though they are set automatically, is because they are overwritten when the subtool is used again on the same data. Therefore, it is necessary to rename the output files manually. Or change the name of the Buffer field before running the subtool so that the values are not overwritten.



**Image 19** Preview of filled parameters of the **Buffer Zone** subtool.

The output of the tool is a new Buffer zone layer showing the area around the point or points and a new column (Buffer) in the table. This column differentiates the ET data with colors. Zeros (points outside the Buffer zone) are shown in blue, and ones (points inside the Buffer zone) are shown in red. The subtool automatically displays these outputs in the map (Image 20).



**Image 20** Preview of the attribute table and output layers of the **Buffer Zone** subtool.

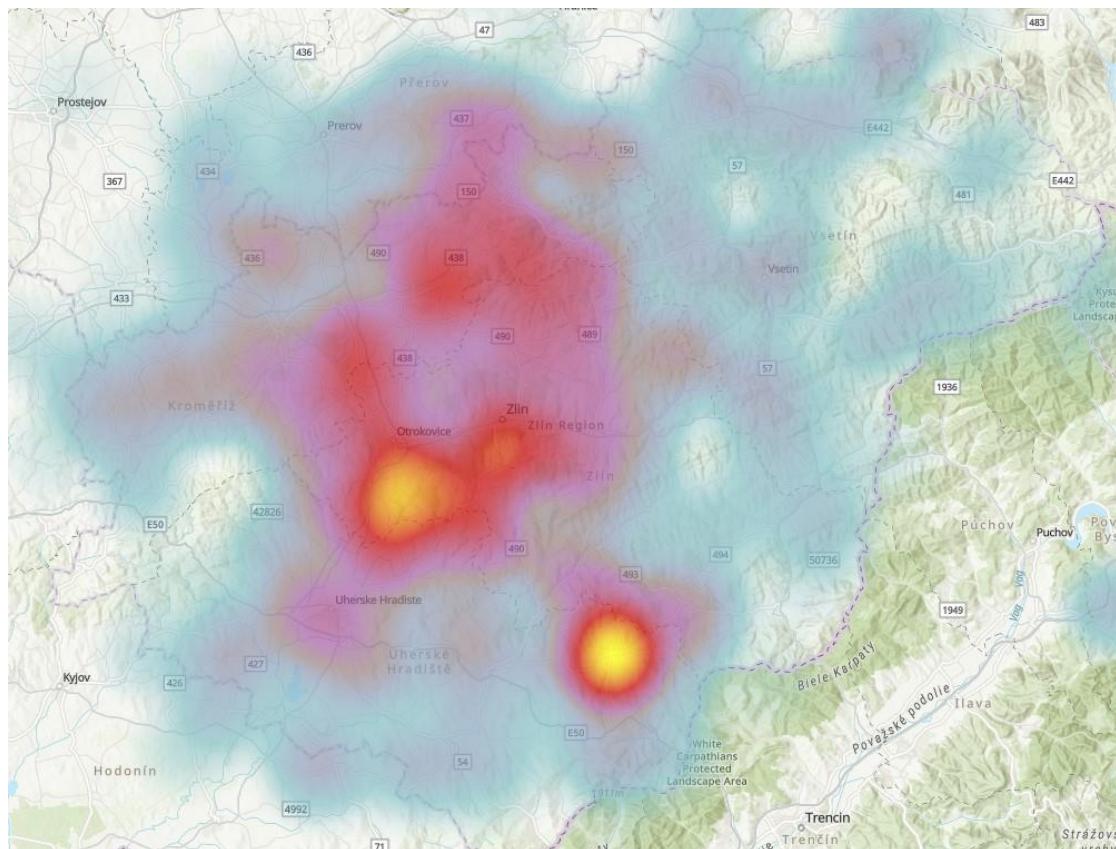
### 3.2.5 Heatmap

Heatmap method is one of the most common visualizations of ET data. It can be found for example in the ET program OGAMA. When running the subtool, it only needs to fill in the required Fixationpoints layer (e.g. Task\_1\_FIX). The rest of the tool is already preconfigured and only needs to be run (Image 21).



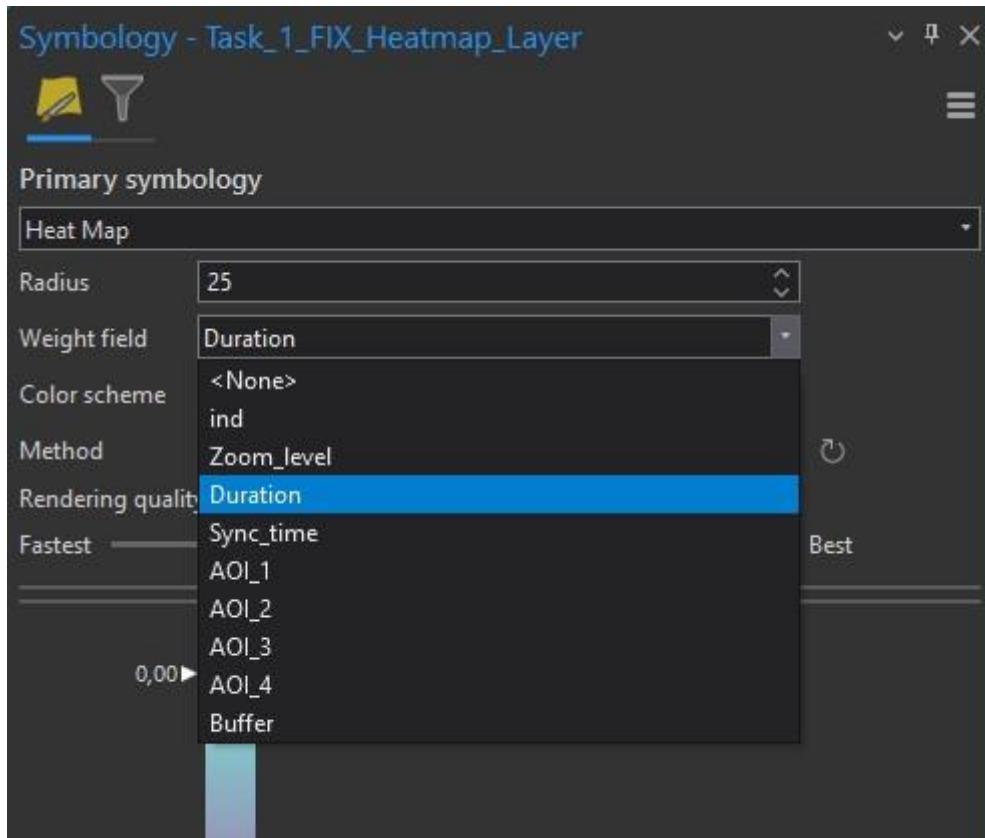
**Image 21** Preview of filled parameters of the **Heatmap** subtool.

The output of the subtool is a new layer with the ending `_Heatmap`. This layer does not contain any new information in the attribute table. It only provides a spatial visualization of the ET data. The resulting layer is shown in Image 22.



**Image 22** Preview of the output layer of the **Heatmap** subtool.

The output layer can be modified in the Symbology tab. Here it is possible to edit its Radius and Weight field (Image 23). By default, the Radius is set to 25 and the Weight field to Duration, but this can be changed as needed.

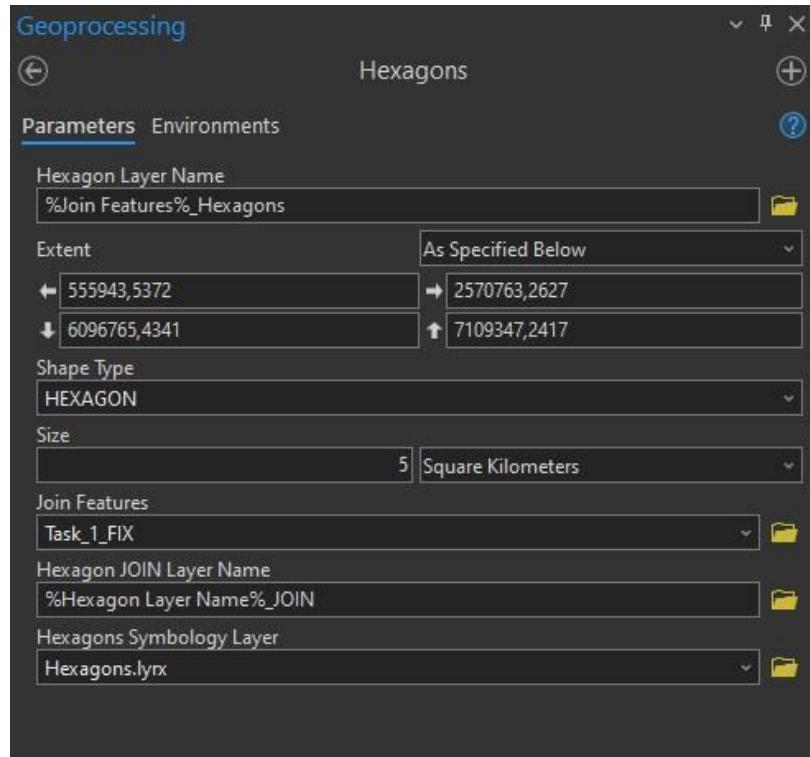


**Image 23** Preview of the Symbology tab of the **Heatmap** output layer.

### 3.2.6 Hexagons

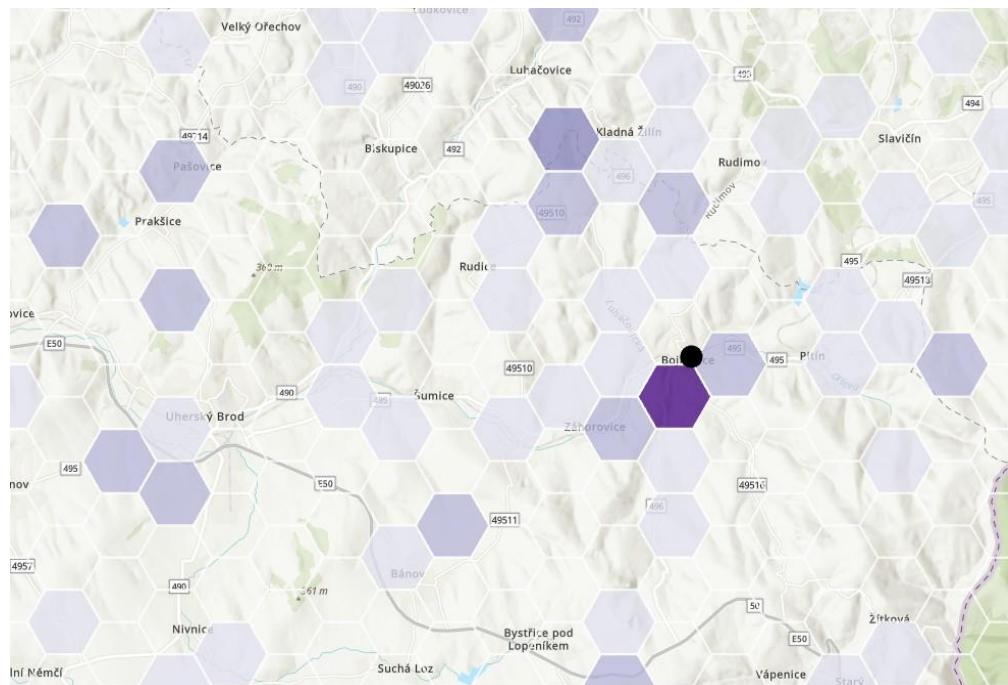
This subtool allows to visualize the density of ET data points (Fixationpoints and Rawpoints) in hexagons. The subtool allows visualizing data that might be hidden (especially for Rawpoints).

It is important to set the Extent (hexagon layer extent) when running the subtool. Here it is recommended to use Current Display Extent or Browse. For Current Display Extent, the current extent of the map being displayed is used. The Browse setting allows selection of any layer from a folder to set the hex grid extent. Although this subtool is called Hexagons, it is possible to change the Shape Type (e.g. Triangle, Square, etc.). Another important element required for setting is the Size (cell size). The default value is 5 km<sup>2</sup>, but this can be changed along with the units. The last necessary part before running the tool is to select the desired set of Fixationpoints or Rawpoints. All parameters of the tool can be found in Image 24.



**Image 24** Preview of filled parameters of the **Hexagons** subtool.

The output of the subtool is a new layer with a hexagonal grid. The layer has the ending \_Hexagons\_JOIN and displays the number of ET points inside the hexagons. If there are no detected ET points in a particular hexagon, this field is colorless. Other hexagon colors have 25% transparency. The resulting layer is shown in Image 25.



**Image 25** Preview of the output layer of the **Hexagons** subtool.

### 3.2.7 Kernel Density

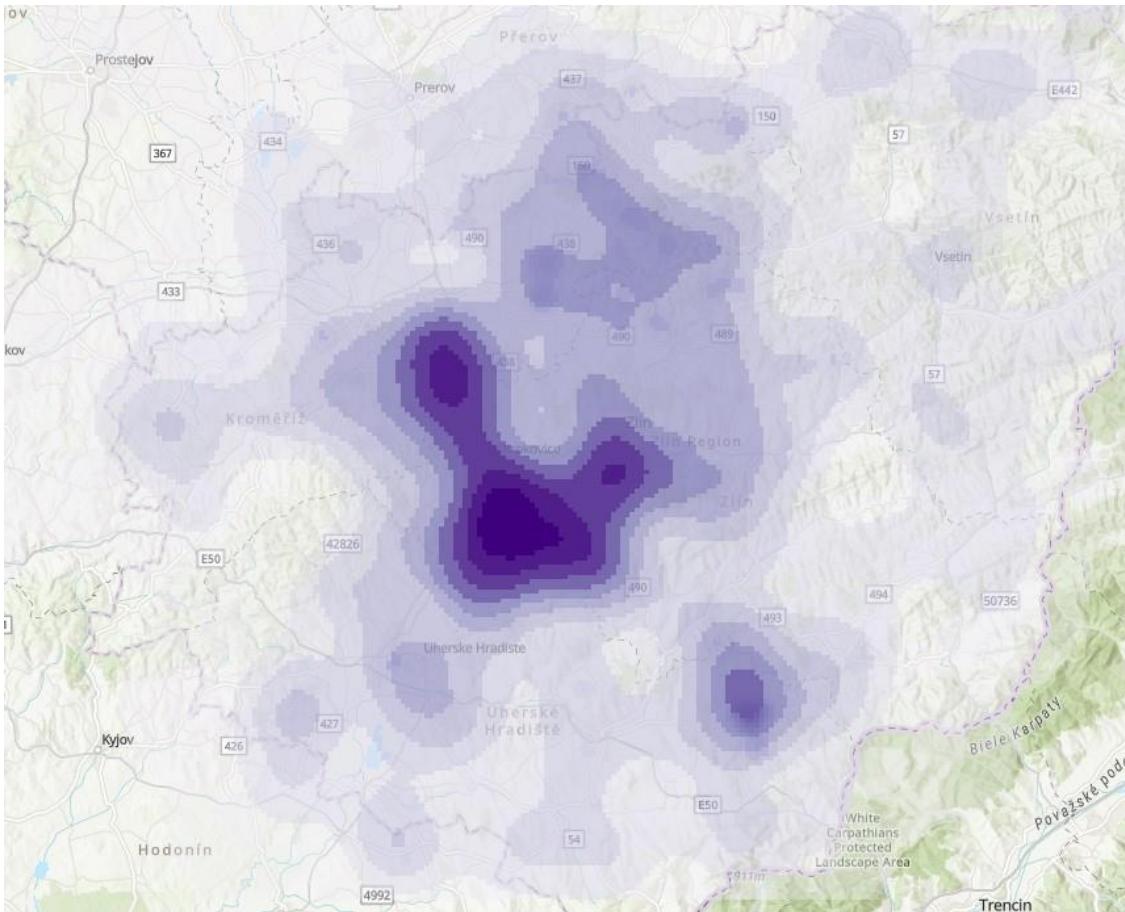
The Kernel Density subtool is very similar to the Heatmap method and the outputs look almost identical. However, their use in a GIS environment is different. The Heatmap subtool only creates a visualization of existing vector data. On the other hand, the Kernel Density subtool operates on a newly created raster layer. This raster layer can be further used, for example, for summing raster layers.

Before running the subtool, just insert the Input Feature (Fixationpoints or Rawpoints) and the remaining parameters will be set automatically. The parameters are visible due to the possibility of user modification. Cell Size, Population Field and Output Name can be edited. Population Field can be used with the default setting of **NONE**. If the input layer is Fixationpoints this parameter can be changed to **Duration**. The launch of the subtool can be seen in Image 26.



**Image 26** Preview of filled parameters of the **Kernel Density** subtool.

The output of the subtool is a new raster layer. Due to problems with automatic naming of the file with the ending (e.g. \_KernelD), it was necessary to switch to a non-conflicting solution, that is, naming by the program. Of course, the user has the possibility to change this name. The name created by ArcGIS Pro has the prefix KernelD\_. This layer can be also set to be more transparent. The final raster raster layer is shown in Image 27.



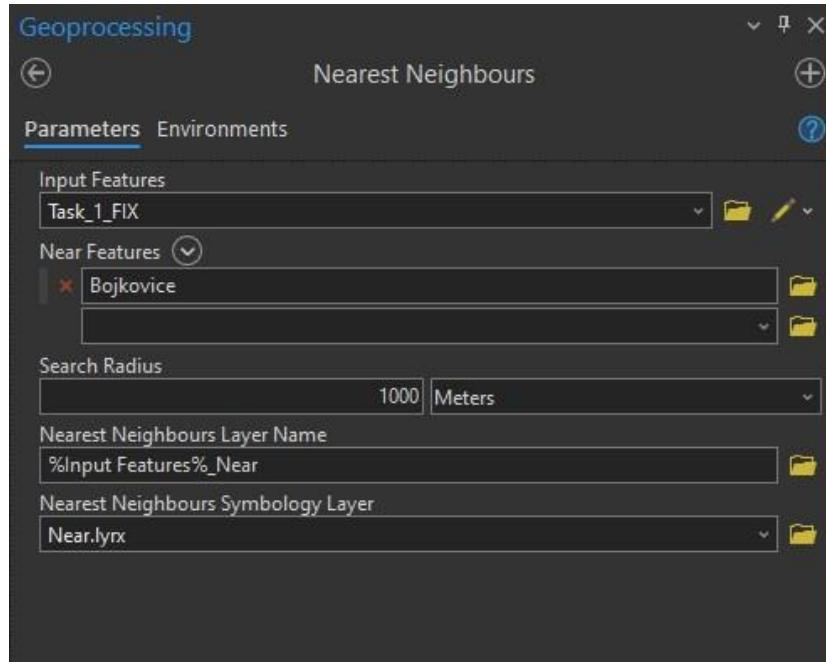
**Image 27** Preview of the output raster layer of the **Kernel Density** subtool.

### 3.2.8 Nearest Neighbours

The Nearest Neighbours subtool is like the Buffer Zone subtool. The Buffer Zone uses a Buffer Polygon and assigns values of zero or one based on the location of the ET points. The Nearest Neighbours does not create any Buffer polygons.

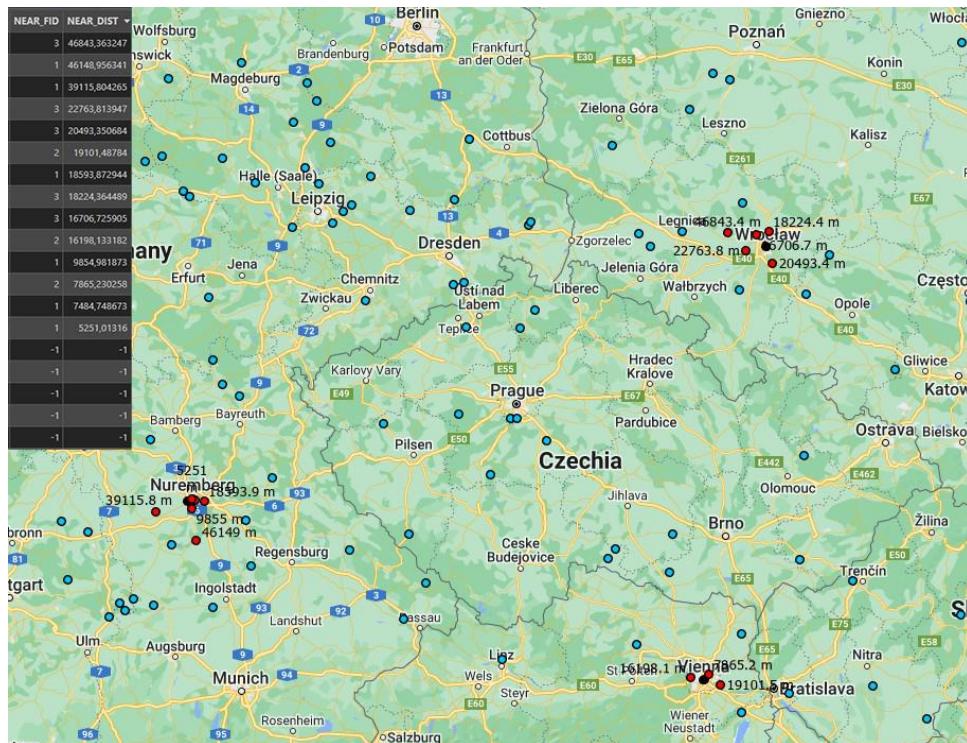
The Nearest Neighbors subtool uses the Near tool (from ArcGIS Pro), which works directly with the distance from the input points of interest and records these values in an attribute table (NEAR\_DIST column). At the same time, a second NEAR\_FID column is created in the table to indicate whether the ET point is inside or outside the search radius. A negative value in the column indicates that the point is not within the specified distance and a positive value indicates that it is and how far.

Launching the Nearest Neighbours subtool is shown in Image 28. There are three important parameters. The Input Layer (Fixationpoints or Rawpoints), the Layer with interest points from which the distance is calculated and the last parameter, the Search Radius Distance. The remaining parameters are editable but otherwise set automatically.



**Image 28** Preview of filled parameters of the **Nearest Neighbours** subtool.

The output of the subtool is a new layer with the ending \_Near, which contains two new columns (NEAR\_FID and NEAR\_DIST). In the map, the layer is represented by blue and red points. The red points are labelled with their distance in meters to one decimal place. The map with the output layer is shown in Image 29.

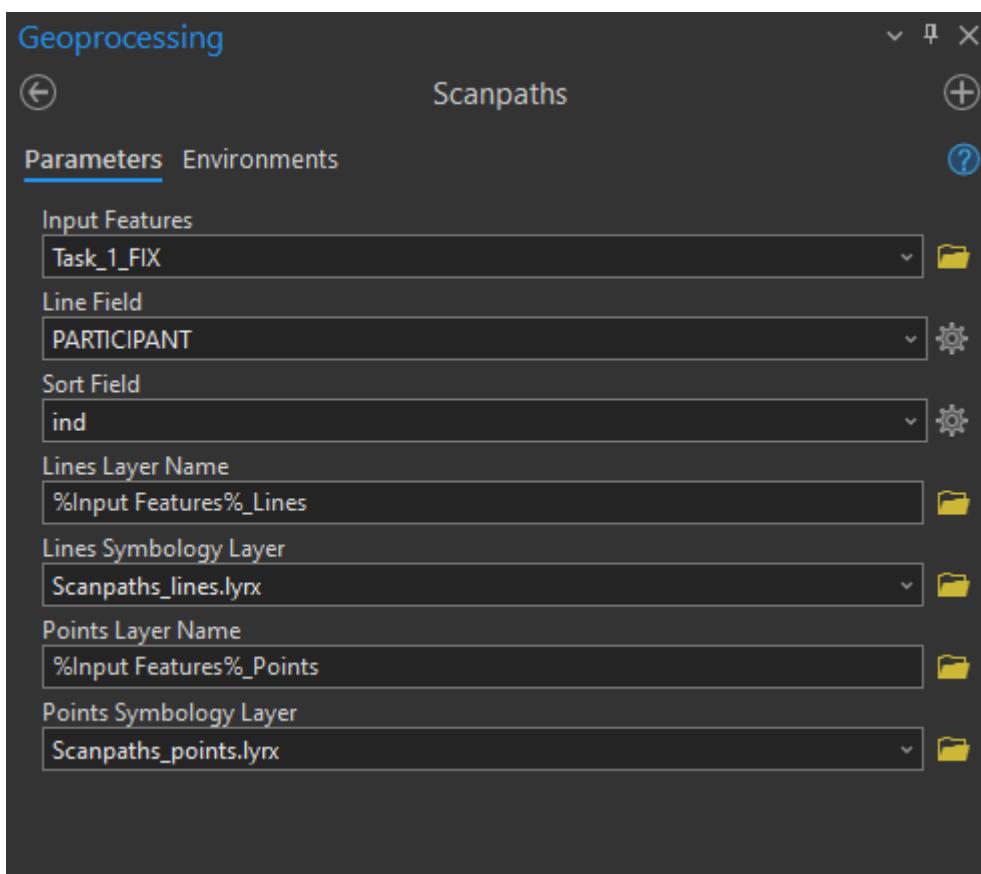


**Image 29** Preview of the attribute table and output Layer of the **Nearest Neighbours** subtool.

### 3.2.9 Scanpaths

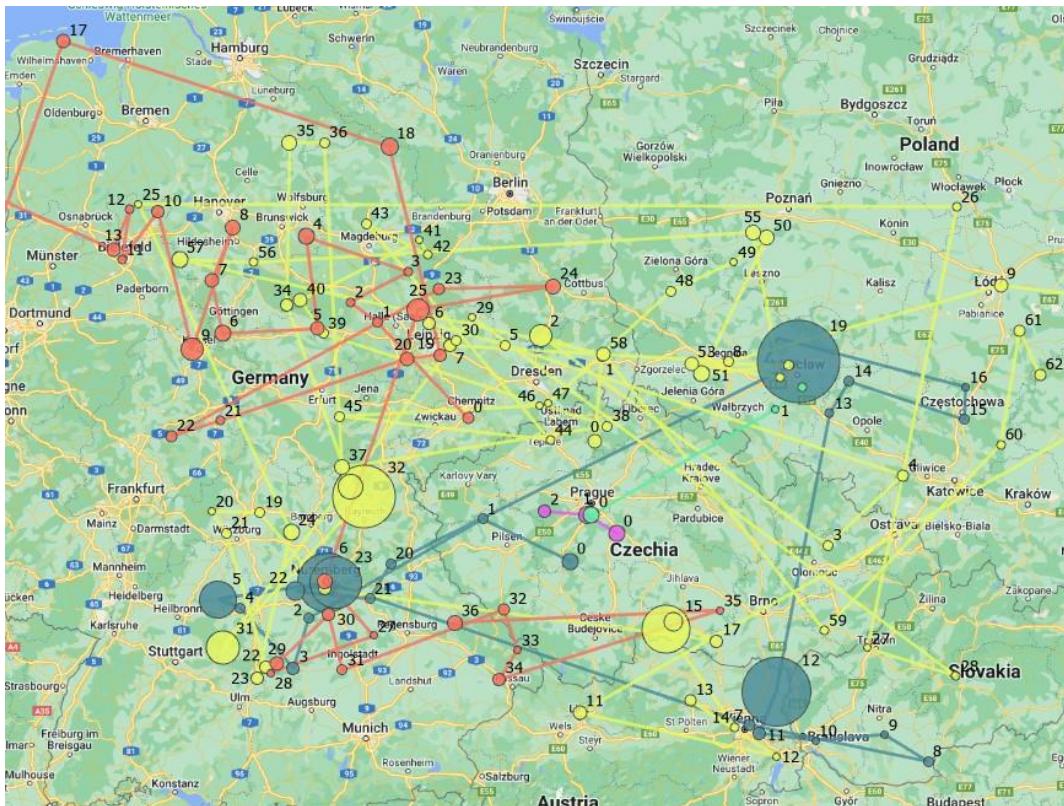
The Scanpaths subtool was inspired by the visualization in OGAMA, which uses lines to connect ET points in the order of their origin. With this visualization, the order of ET points for each respondent and the Fixation Time can be represented.

When launching the subtool, the user is required to fill in only one parameter Input Feature. In this case, only ET Fixationpoints can be imported as the input layer, since only this layer contains the Duration column. This column is required for the fixation time visualization. The remaining parameters are editable but changing them may cause problems in the exported layer. The tool run is shown in Image 30.



**Image 30** Preview of filled parameters of the **Scanpaths** subtool.

The output of the subtool are two new layers. Their combination is shown in Image 31. The first layer represents the colour-coded ET points of the respondents, whose size represents the length of fixation. For each ET point there is a label with a number showing the order of occurrence. The second layer represents the lines that connect these ET points to each other, in their order of occurrence. This makes it possible to visualize the mapping procedure of each respondent and to compare these procedures with each other. For both layers, the transparency was set to 20%.



**Image 31** Preview of the output layers of the **Scanpaths** subtool.

### 3.2.10 Space Time Cube

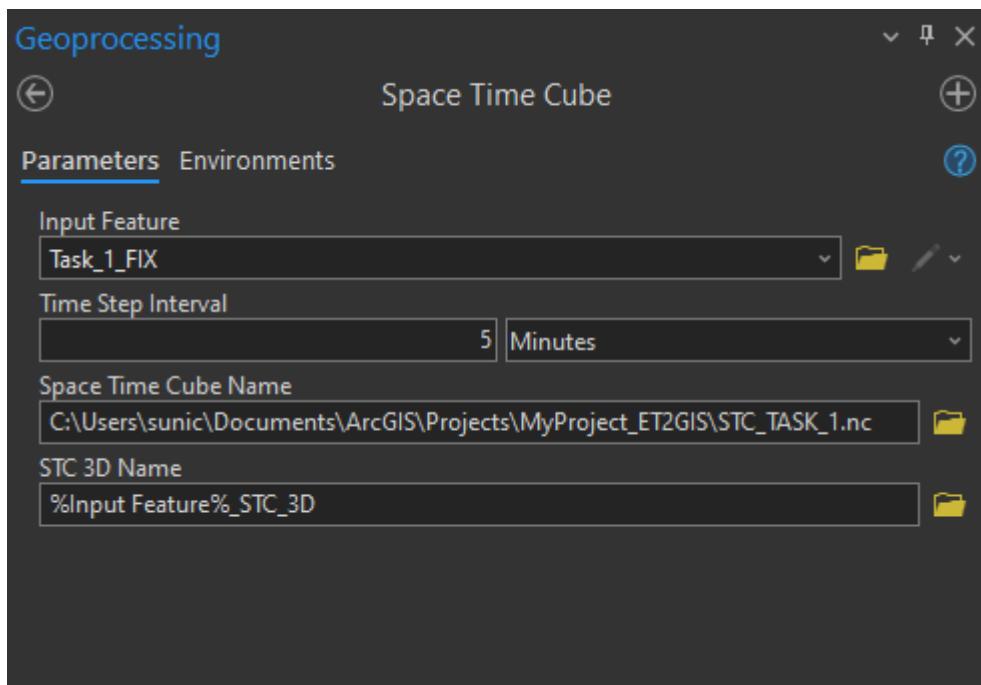
This is the first of two ET2GIS visualizations that use 3D space. The Space Time Cube (STC) subtool is also the first tool to actively use the newly created Date column. The Date column is required for the Create Space Time Cube from Defined Locations tool (from ArcGIS Pro).

When starting the STC subtool, the user is required to fill in the Input Layer (Fixationpoints) and set the name of the new STC (Image 32). Unfortunately, this parameter cannot be automatized because the automatic naming caused errors. Therefore, when the user sets this parameter manually, the ending automatically fills itself (.nc) and everything goes through without any problems.

The remaining parameters can be adjusted. It is recommended that only the Time Step Interval parameter should be left unchanged. An inappropriately chosen time interval may cause problems when visualizing points in 3D space (e.g. points will be too close together or too far apart on the Z-axis).

The STC and STC Lines subtool has a WARNING Message 110067<sup>1</sup> that is not green, but this does not change the functionality of the outputs.

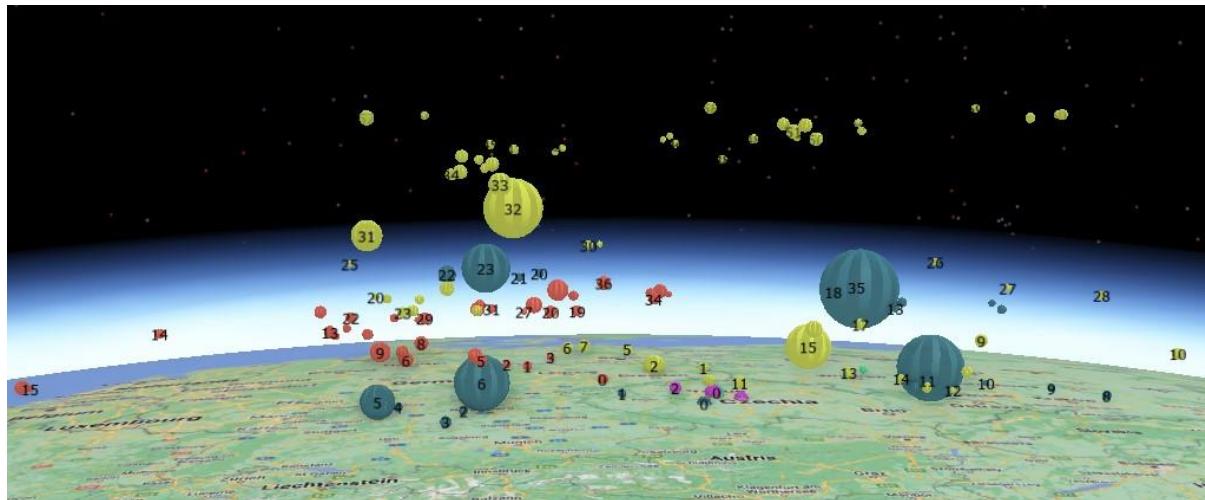
<sup>1</sup> WARNING 110067: Your spatial reference is not compatible with CF Conventions. You may experience difficulties using the resulting space-time cube with other NetCDF tools and software.



**Image 32** Preview of filled parameters of the **Space Time Cube** subtool.

The output of the STC subtool is primarily a layer with the ending **\_STC\_3D\_Points** (Image 33). An error occurred when attempting to automatically apply the symbology directly in the model. Therefore, it is necessary to apply the symbology manually using the Symbology Layer (STC.lyrx).

The STC and STC Lines subtools are the only ones that do not show a green success message. The message comes with a warning, but it does not change the functionality. The label with the point order numbers can be manually turned off.



**Image 33** Preview of the output layer of the **Space Time Cube** subtool.

To achieve the appearance of the STC\_Points layer, it is necessary to manually import the symbology (the reason is ERROR 000968<sup>2</sup>). The first option is to insert this layer into the 3D Map and click on the top tab Feature Layer. This is where the Import button is located. The second option is to click directly on the Symbology settings of the layer. Then click the top right burger menu and select Import symbology. Then just import the symbology file from ET2GIS\_Layers (STC.lyrx) and make sure the import window looks like Image 34. Do not forget to **Update ranges**.

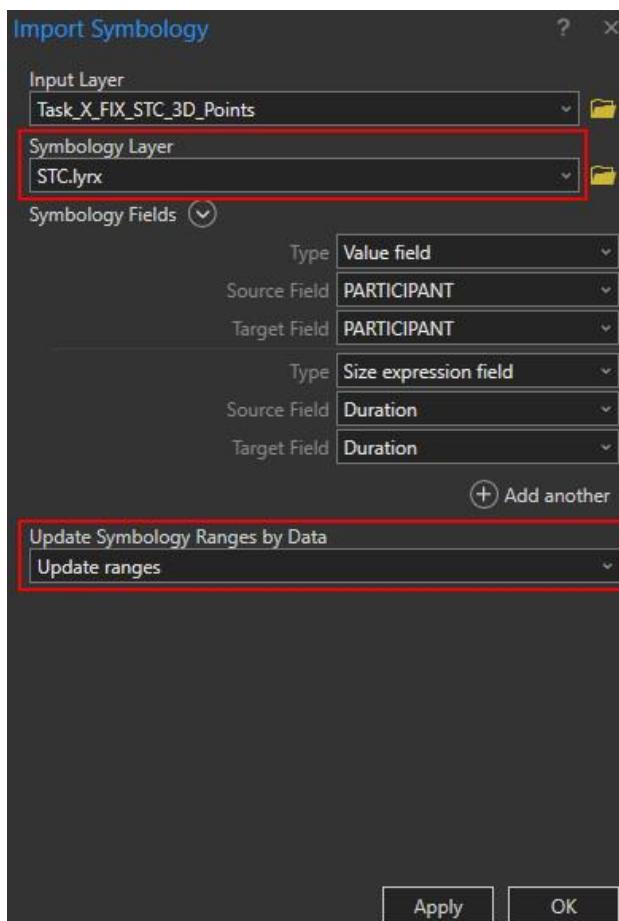


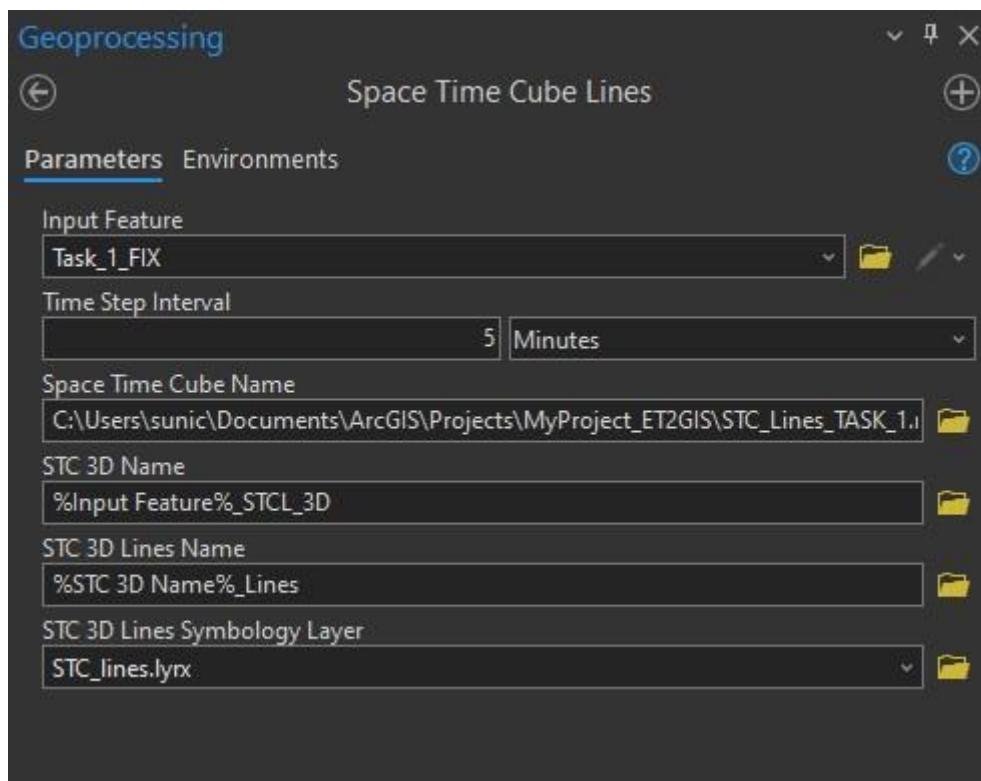
Image 34 Preview of the **Space Time Cube** subtool symbology settings.

### 3.2.11 Space Time Cube Lines

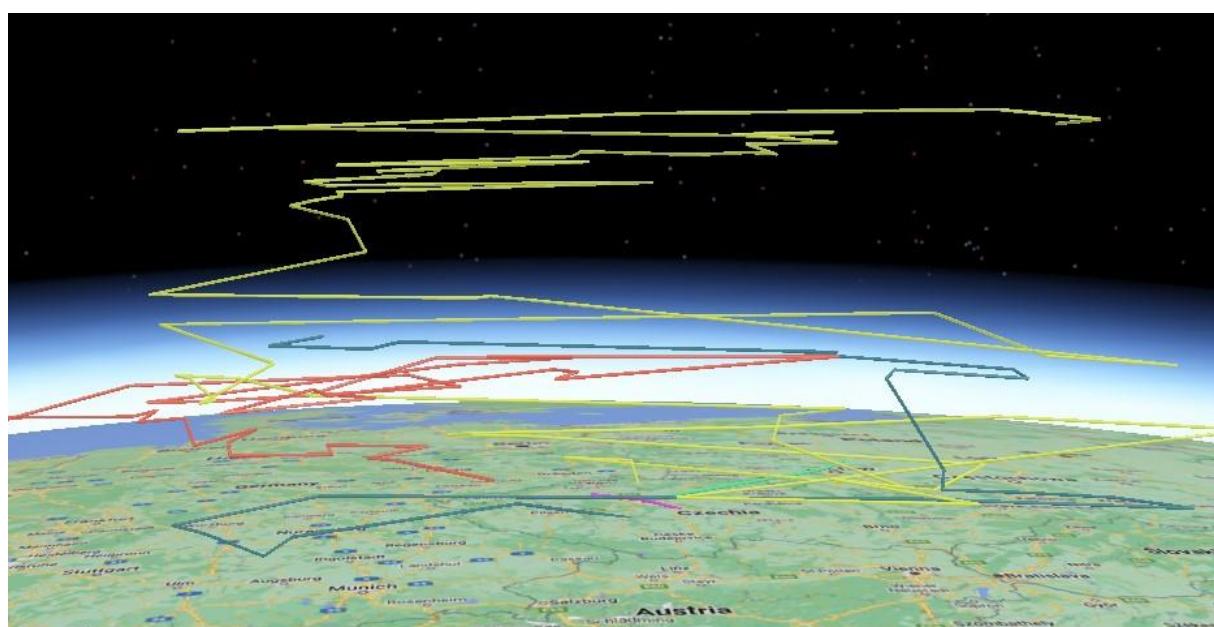
The second subtool using 3D spatial visualization Space Time Cube Lines (hereafter STC Lines) is based on the previous STC subtool. Like the Scanpaths subtool, it creates lines using the Points to Line tool, but in 3D space. Lines are color coded by the PARTICIPANT column and ordered on the Z-axis by the IND column. The symbology is then applied with the STC\_lines.lyrx file.

<sup>2</sup> ERROR 000968: The symbol layer does not match the input layer.

Running the subtool looks identical to the STC subtool with the only difference being that the name of the resulting layer is changed, and the symbology is applied automatically (Image 35). The rest of the parameters remain the same. The output of the STC Lines tool is primarily a layer with the ending \_STC\_3D\_Lines (Image 36).

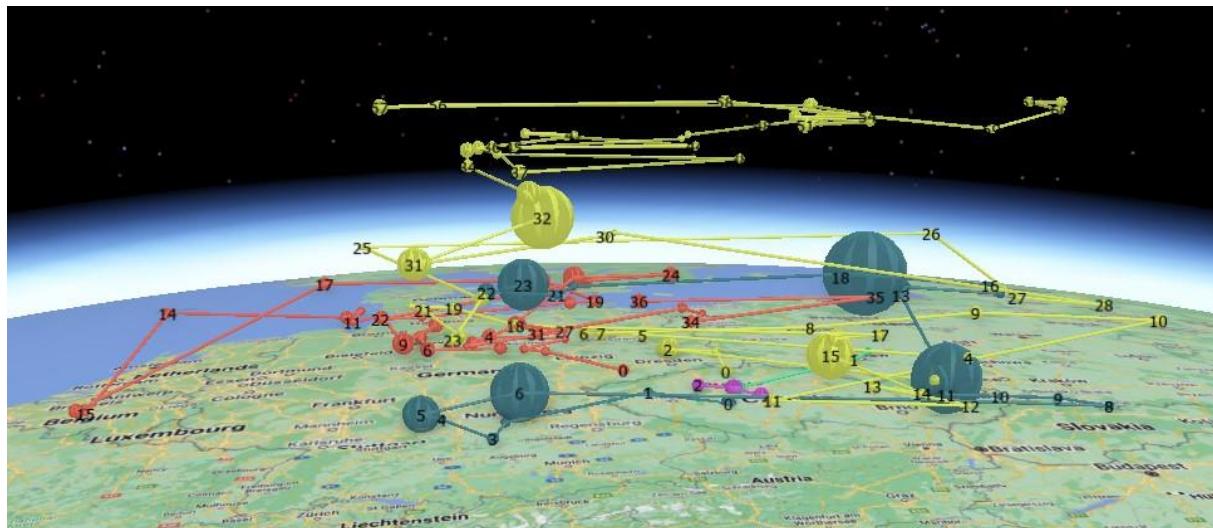


**Image 35** Preview of filled parameters of the **Space Time Cube Lines** subtool.



**Image 36** Preview of the output layer of the **Space Time Cube Lines** subtool.

By combining the outputs of the STC and STC Lines subtools, a 3D visualization of the Scanpaths subtool can be achieved. This 3D visualization allows for a clearer view of the data structure than a simple view in 2D space (Image 37).

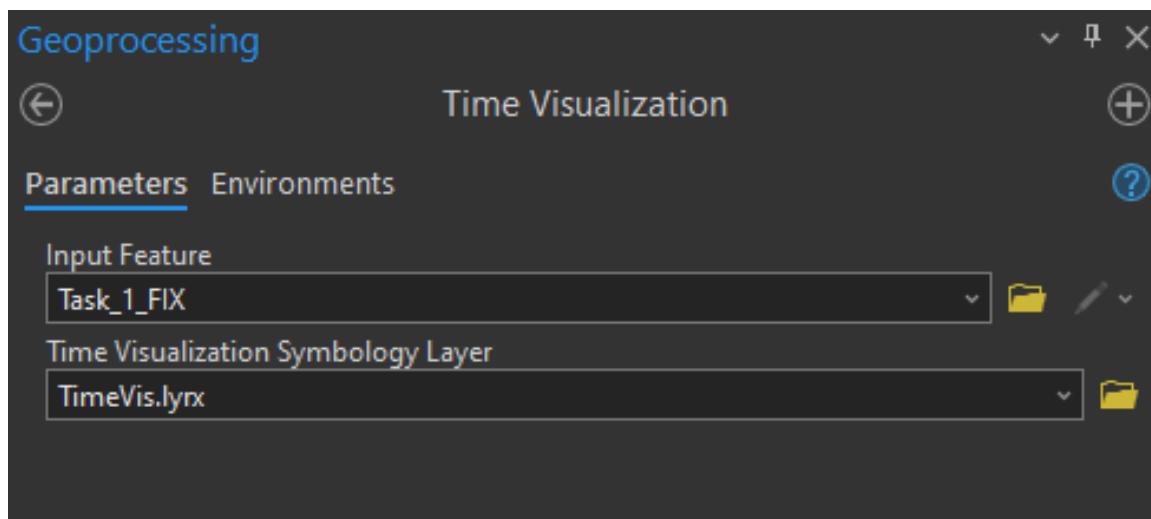


**Image 37** Preview of the combination of **STC** and **STC Lines** subtool outputs.

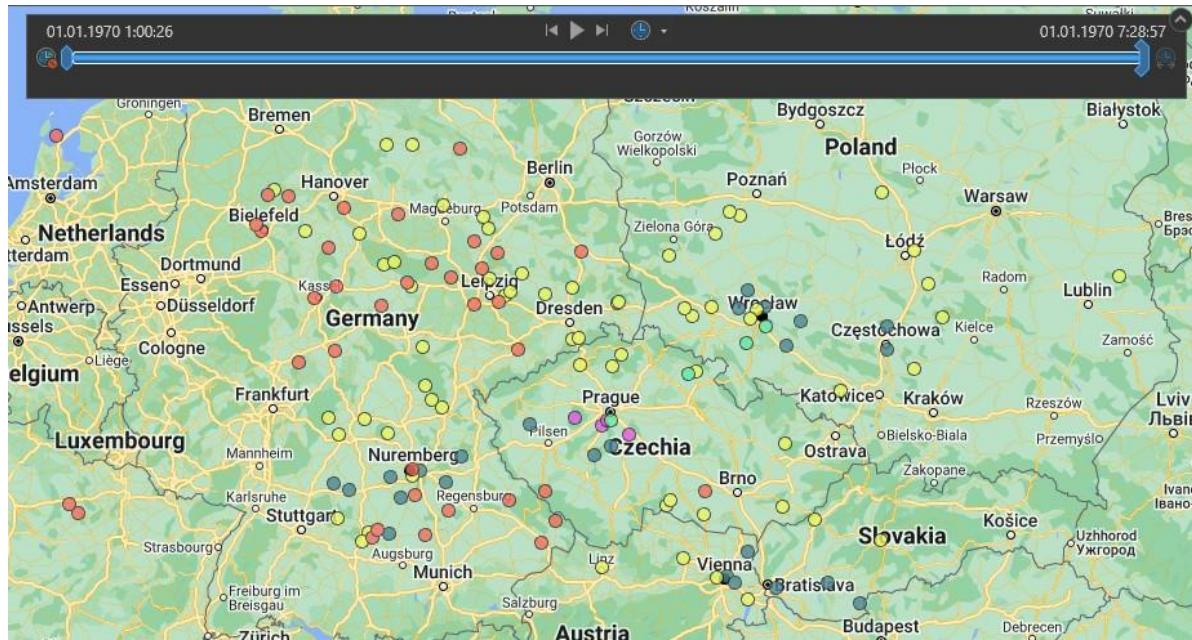
### 3.2.12 Time Visualization

The Time Visualization subtool allows the user to view ET data in time. The time is represented in the layer in relative terms by the Date column. The layer can be controlled and configured in the top Time tab (playback speed, loop playback, rewind, etc.).

Starting the tool is very simple. Just load the Fixationpoints or Rawpoints layer and press the Run button (Image 38). The output of the tool is a new layer with the ending \_TimeVis. The layer displays ET points classified by participant with active time visualization (Image 39).

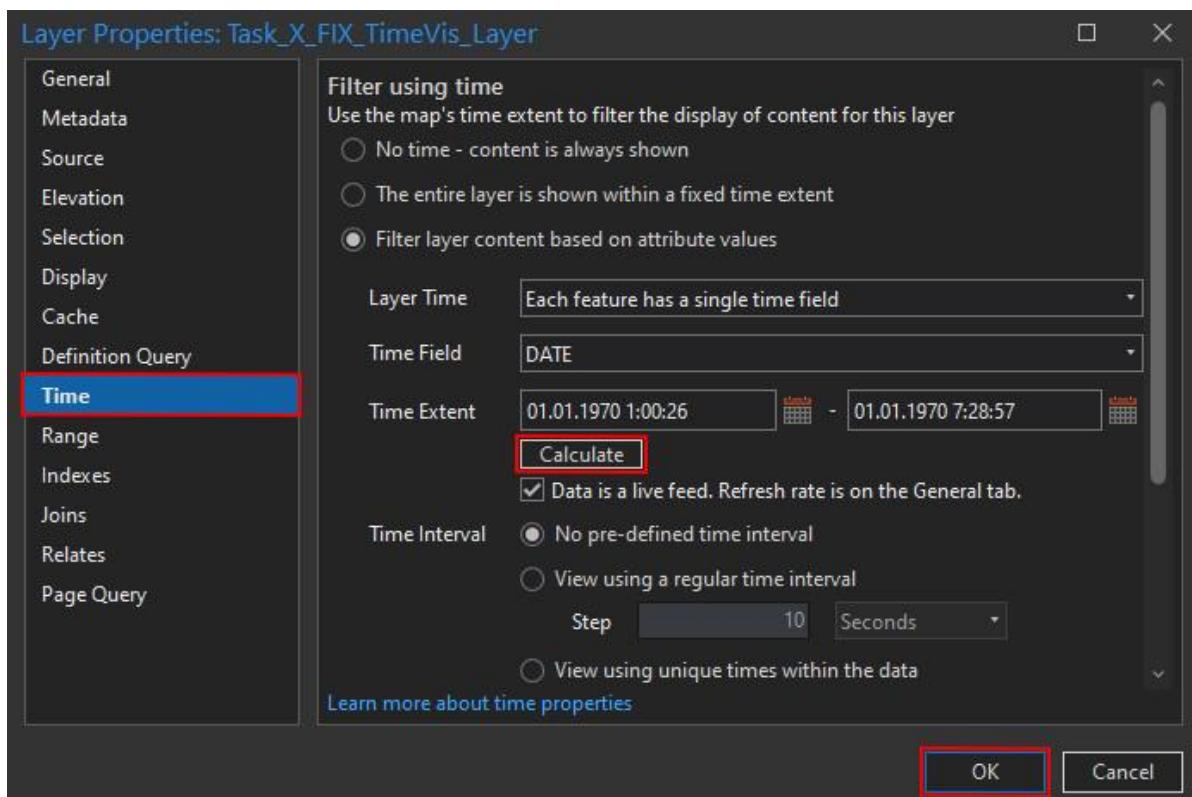


**Image 38** Preview of filled parameters of the **Time Visualization** subtool.



**Image 39** Preview of the output layer of the **Time Visualization** subtool.

Unfortunately, applying the Symbology Layer (TimeVis.lyrx) does not allow to calculate the current time range. For this reason, the calculation must be done manually in the layer settings (Properties) in the Time tab (Image 40). Simply click on the Calculate button and the Time Extent will be updated.

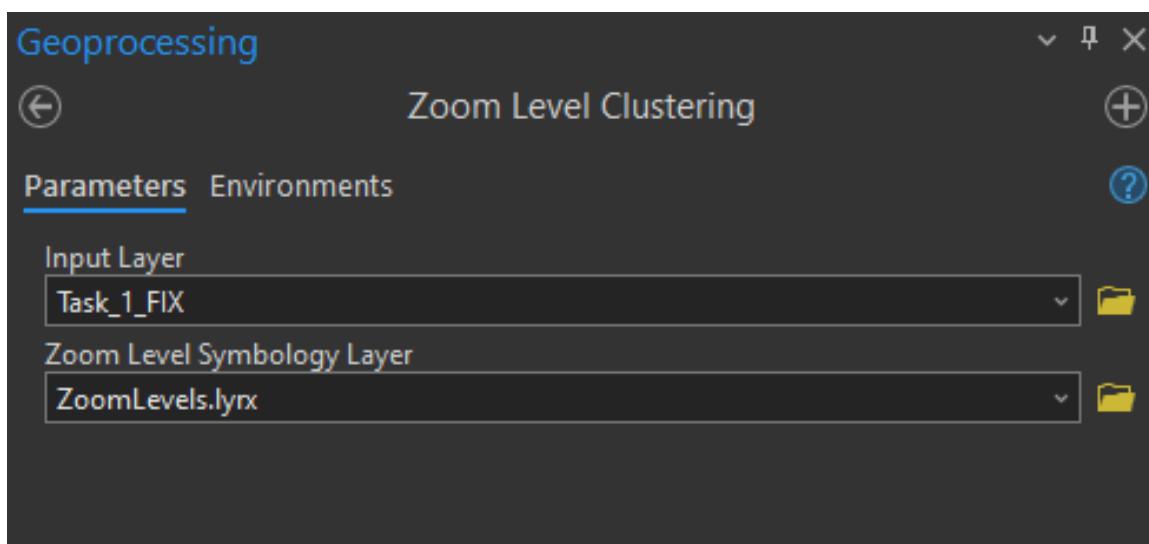


**Image 40** Preview of **Time Extent** update in settings.

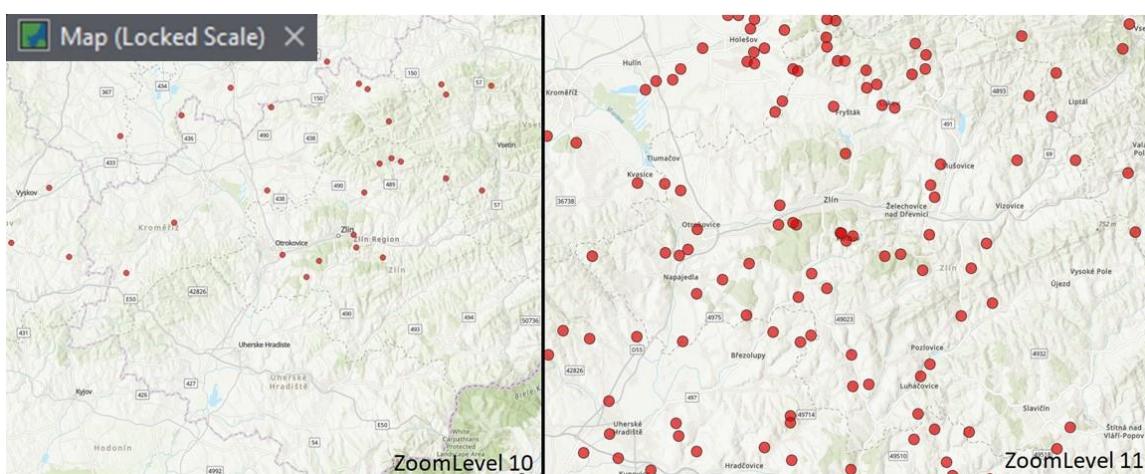
### 3.2.13 Zoom Level Clustering

The last subtool is dedicated to visualizing ET data by zoom level. Since it is possible to change the zoom level of statically interactive web maps, it is also possible to visualize them according to that. The Zoom Level Clustering tool works on the principle of preset map scales and a range of scales by which the data is displayed.

Running the subtool is like the Time Visualization subtool. Just load Fixationpoints or Rawpoints and press Run (Image 41). A new layer is created in the map, which uses the Symbology Layer (ZoomLevels.lyrx) to display ET points in the map according to the current zoom level (Image 42). The displayed ET points dynamically change according to the current map scale - as they were collected by the respondents.



**Image 41** Preview of filled parameters of the **Zoom Level Clustering** subtool.



**Image 42** Preview of the output layer of the **Zoom Level Clustering** subtool in the Locked Scale Map.

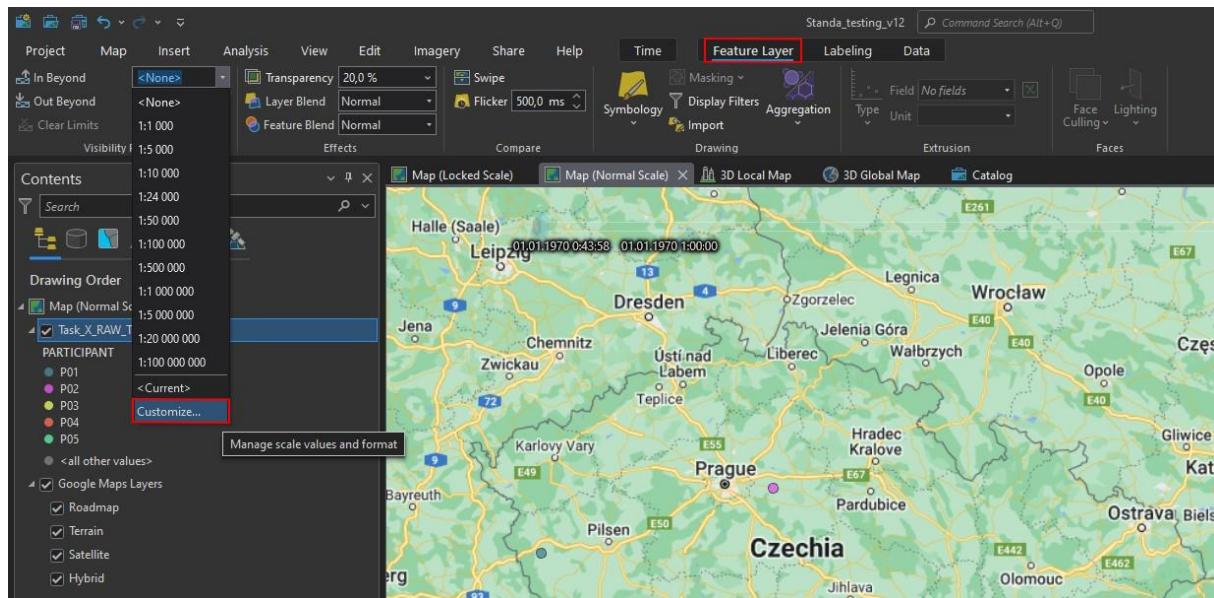


For the ET points to be displayed correctly in the map, it is necessary to load a text file (ZoomLevels.txt) in the Scale Properties or use the Map (Locked Scale) included in the Project Template. The Locked Scale Map contains the preset scales. How the Locked Scale Map can be set manually is explained in **Subchapter 5.1.**

## 4. INSTRUCTIONS FOR MANUAL PROCESSING

### 4.1 How to set up Locked Scale Map

- Click on any layer in the map
- Select the top tab of the **Feature Layer**
- Click on **Customize** in the **Visibility Range** tab (Image 43)



**Image 43** Preview of how to adjust and set scales in the map.

- Then select the **Load** button at the lower right
- Select **From File...**
- From the ET2GIS\_Layers folder select the **ZoomLevels.txt** file
- Then at the bottom select **Alias (Scale)** and check the box **Only display these scales when zooming** (Image 44)
- Click **OK** and it's done

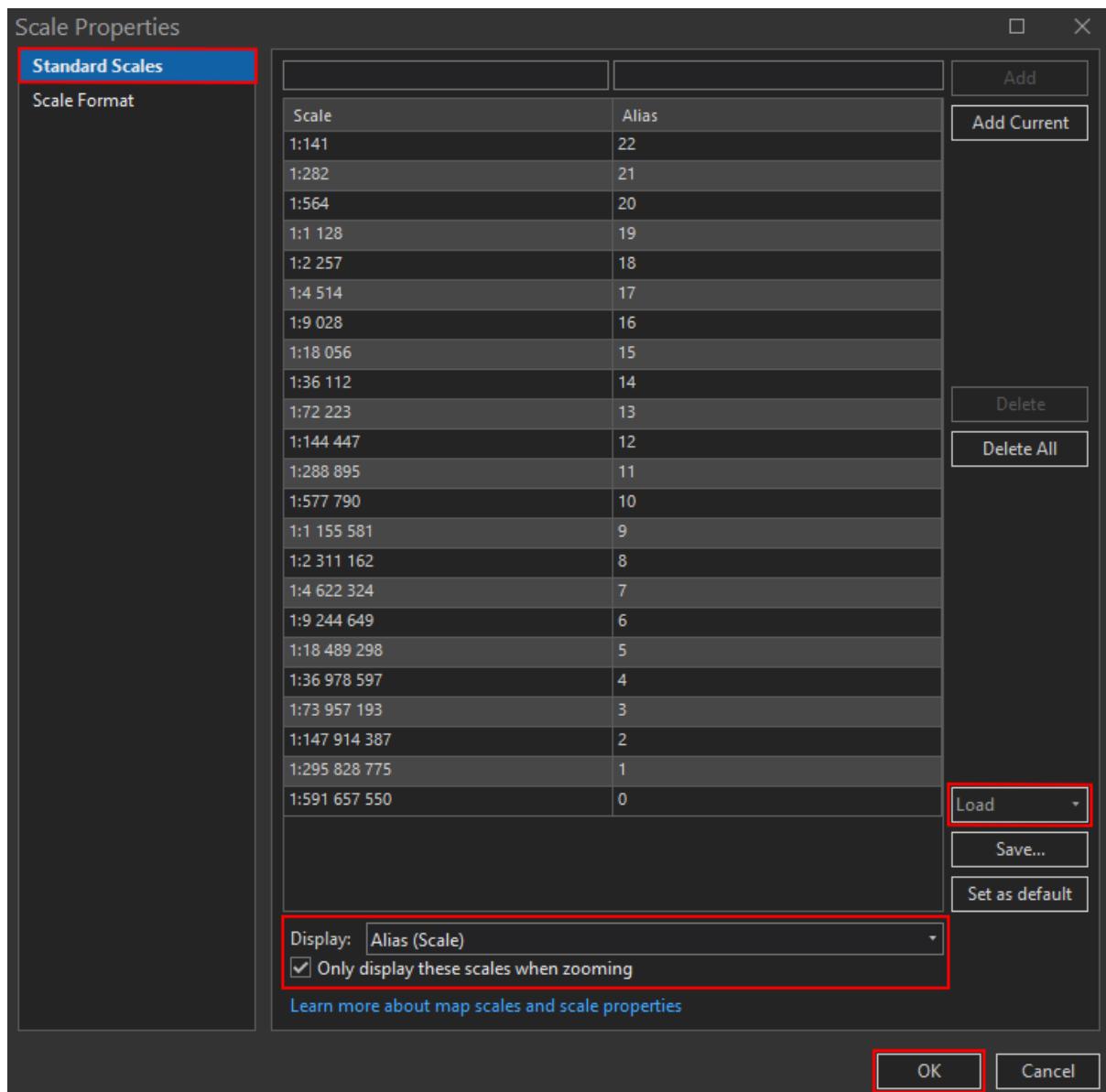
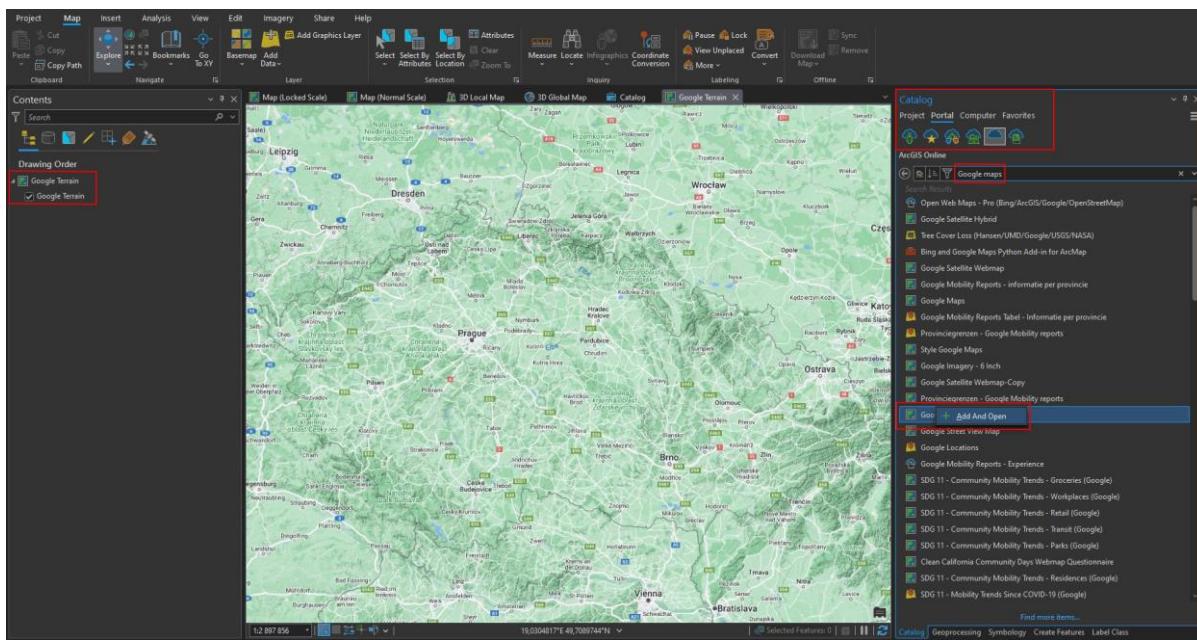


Image 44 Preview of correctly set **Scale Properties** tab.

## 4.2 How to upload Google basemaps into GIS

- Open **Catalog** and select the **Portal** tab
- This will select the second to last "cloud icon" that represents **ArcGIS Online**
- Type "Google Maps" into the search bar and select the desired map
- Right click on it and select **Add And Open** (Image 45)
- This will open a new Map, in which this basemap layer will be
- This can easily be copied into another Map
- This is how it continues with other Google Maps layers

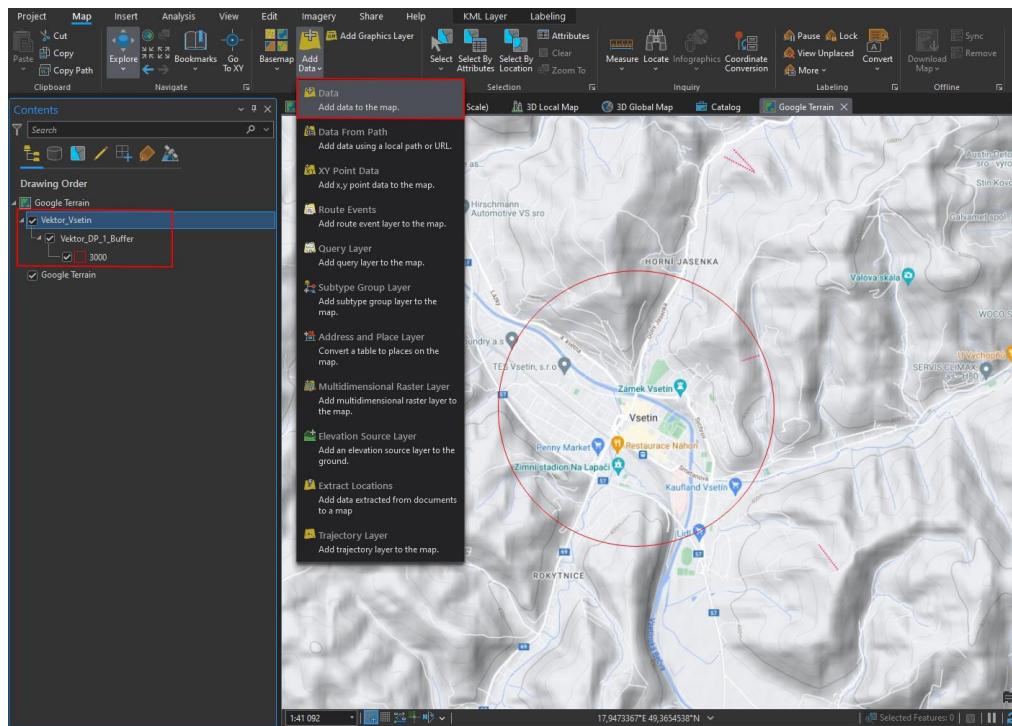


**Image 45** Preview of how to import **Google Maps basemap layers** from Portal into the map.

### 4.3 How to load a KML vector layer or Raster Tile into GIS

#### KML:

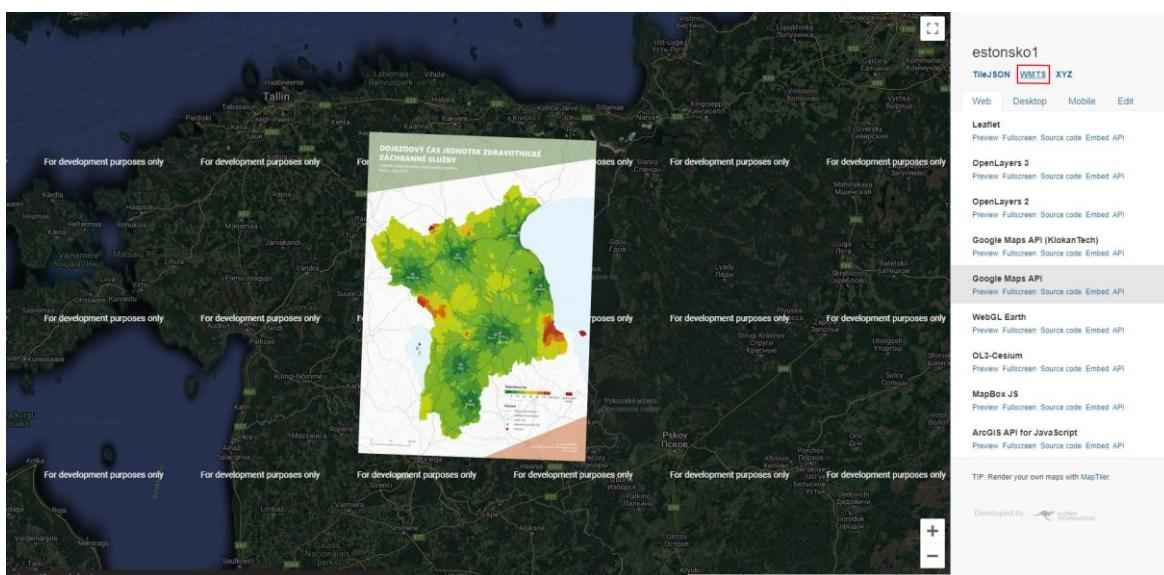
- In the top **Map** tab, select **Add Data**
- Select the first **Data** option (Add data to the map) (Image 46)
- Then select the appropriate **KML file**
- The layer will be displayed in the currently opened map



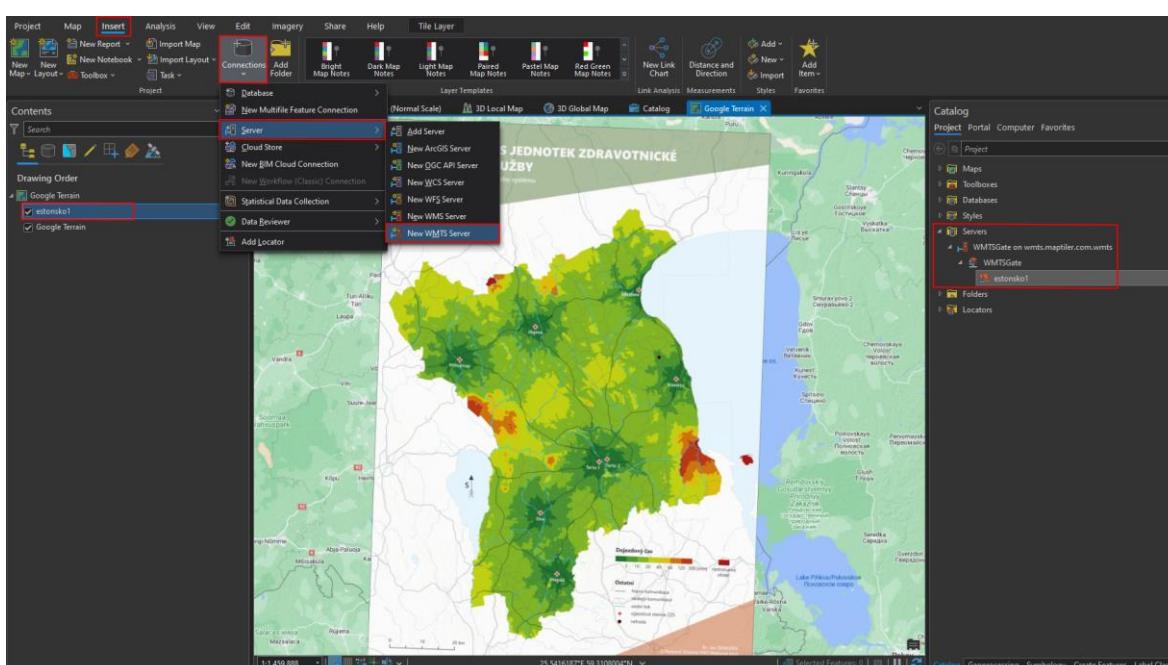
**Image 46** Preview of how to import **KML vector layer** into the map.

## Raster Tiles:

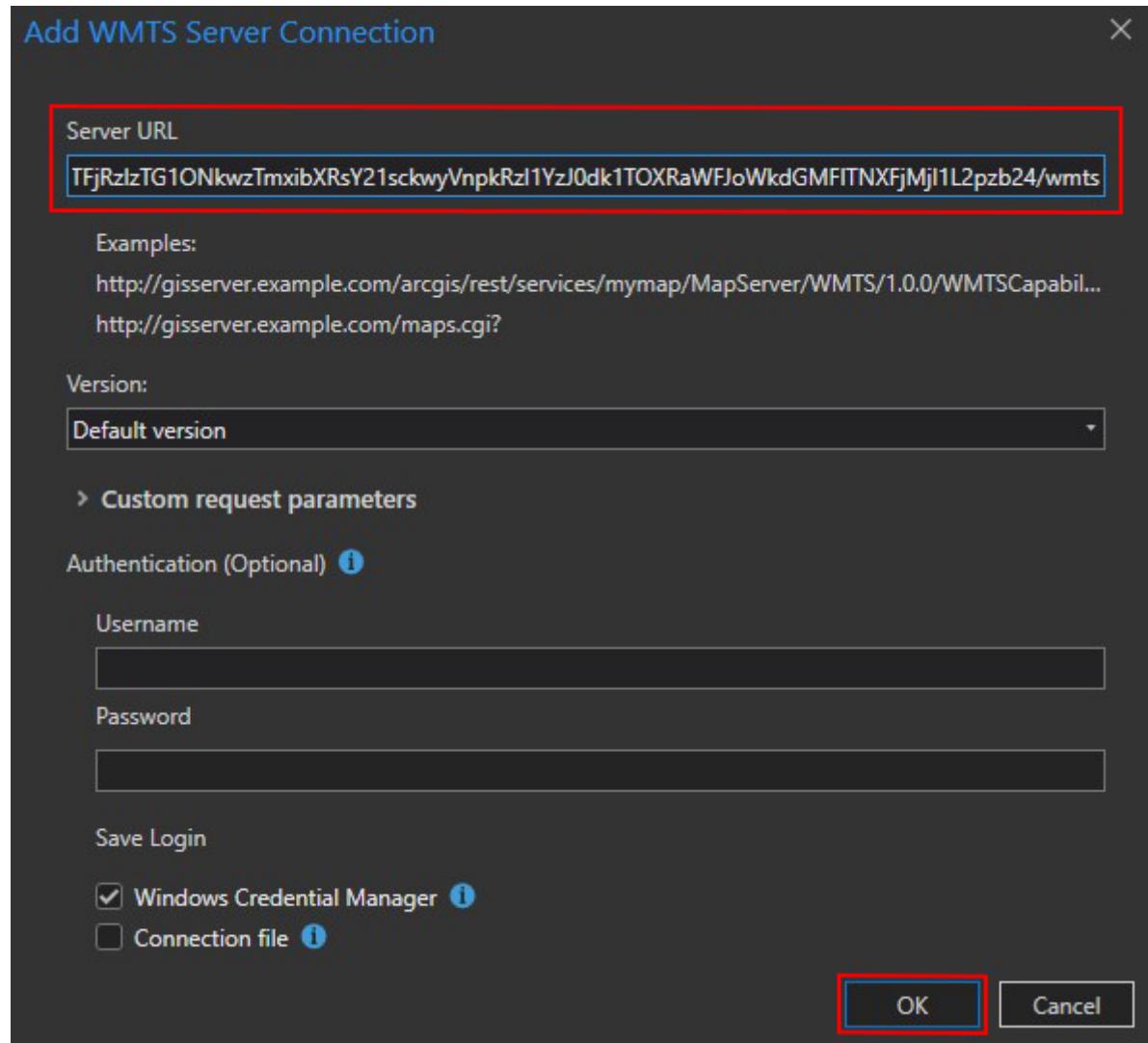
- First of all, **WMTS URL link** of the layer must be obtained
- If the layer was created with **MapTiler** and is uploaded to the server, then just click on the WMTS hyperlink, and copy the URL (Image 47)
- Next, in ArcGIS Pro select **Insert** in the top tab and then **Connections**
- Here the **Server** is selected and in it the **New WMTS Server** (Image 48)
- Paste the copied link into the **Server URL** and click **OK** (Image 49)
- A new **Servers folder** will appear in the **Catalog** and the WMTS layer will be located there
- Then just put it in the map and it's done



**Image 47** Preview of how to obtain **WMTS URL link** from **MapTiler**.



**Image 48** Preview of how to import **WMTS layer** into **ArcGIS Pro**.



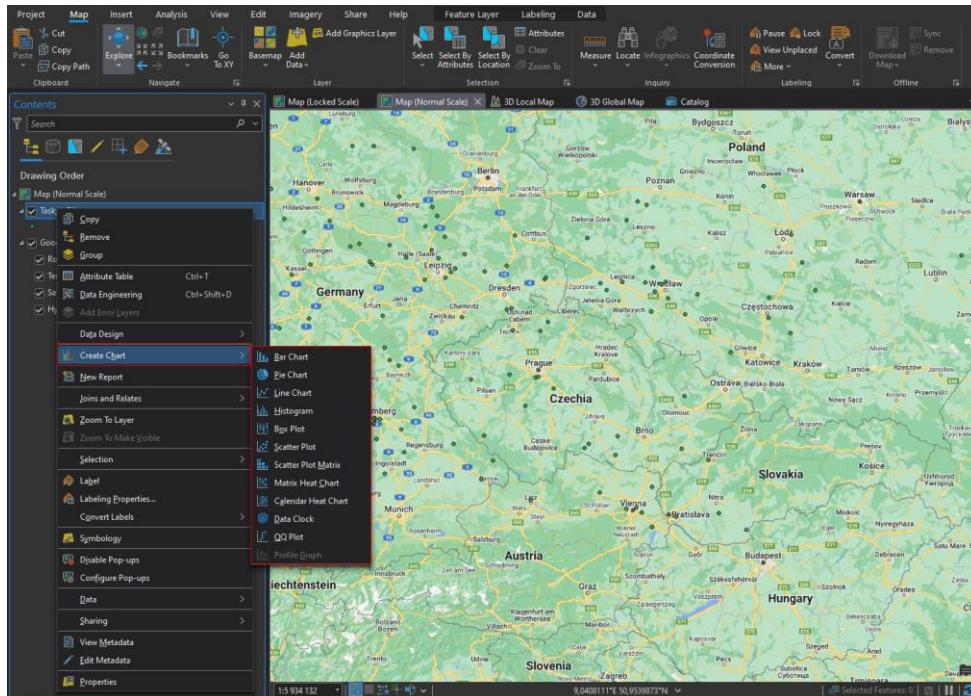
**Image 49** Preview of how to correctly fill **WMTS Server Connection** tab.

## 4.4 Charts

### 4.4.1 How to...

#### Create a Chart:

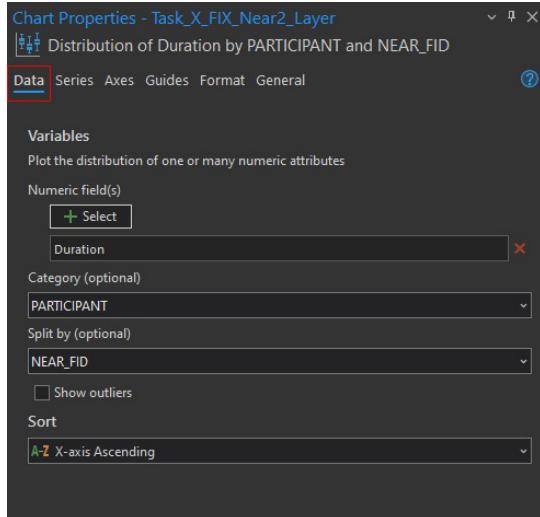
- Right click on the desired layer
- Select **Create Chart**
- Select the desired chart format (Image 50)



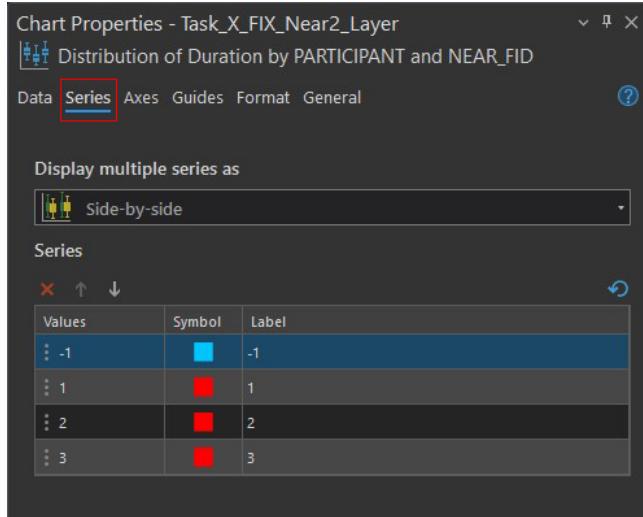
**Image 50** Preview of how to create a chart.

#### Edit Chart:

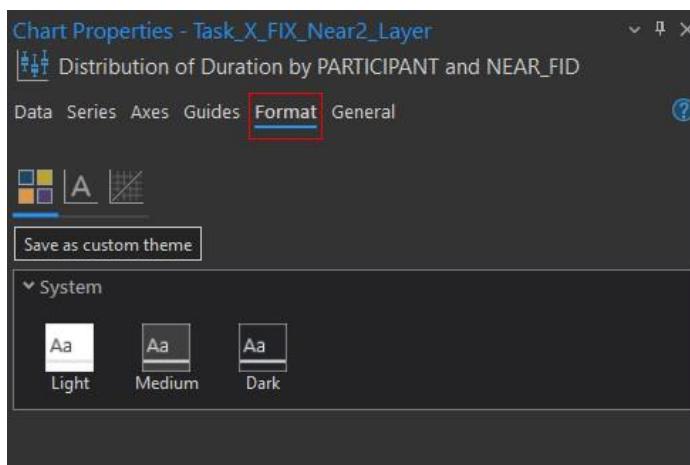
- On the right side it can be adjusted
- Useful tabs:
  - **Data** is the setting of the main axes of the chart (Image 51)
  - **Series** is the setting of symbology and colors of objects in the chart (Image 52)
  - **Format** is the color settings for the appearance of the chart (background, font, etc.) (Image 53)
  - **General** is used to possibly rename the axes or the entire chart (Image 54)



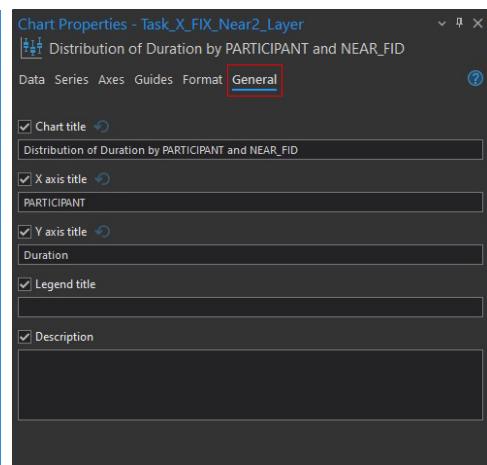
**Image 51** Data tab.



**Image 52** Series tab.



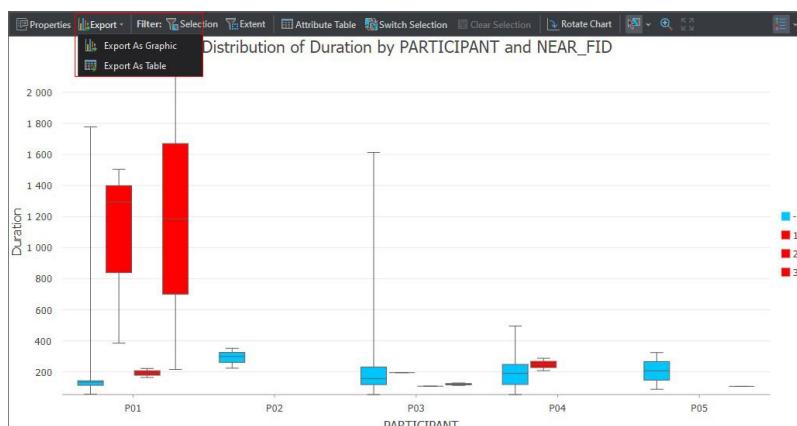
**Image 53** Format tab.



**Image 54** General tab.

### Export Chart:

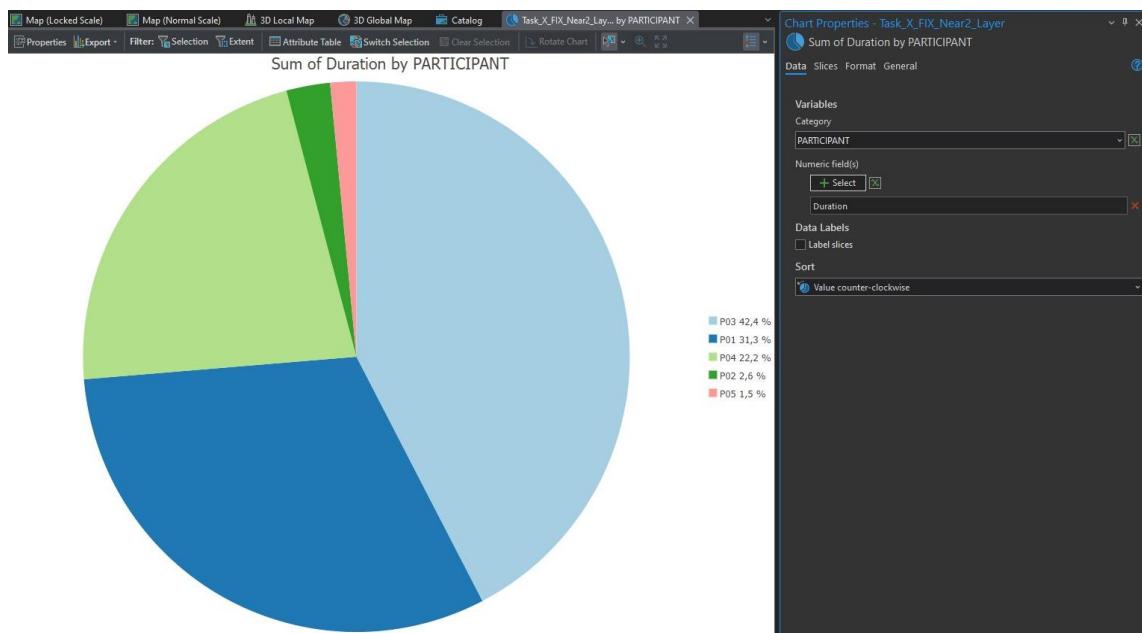
- Click on **Export** and choose between **As Graphic** and **As Table** (Image 55)



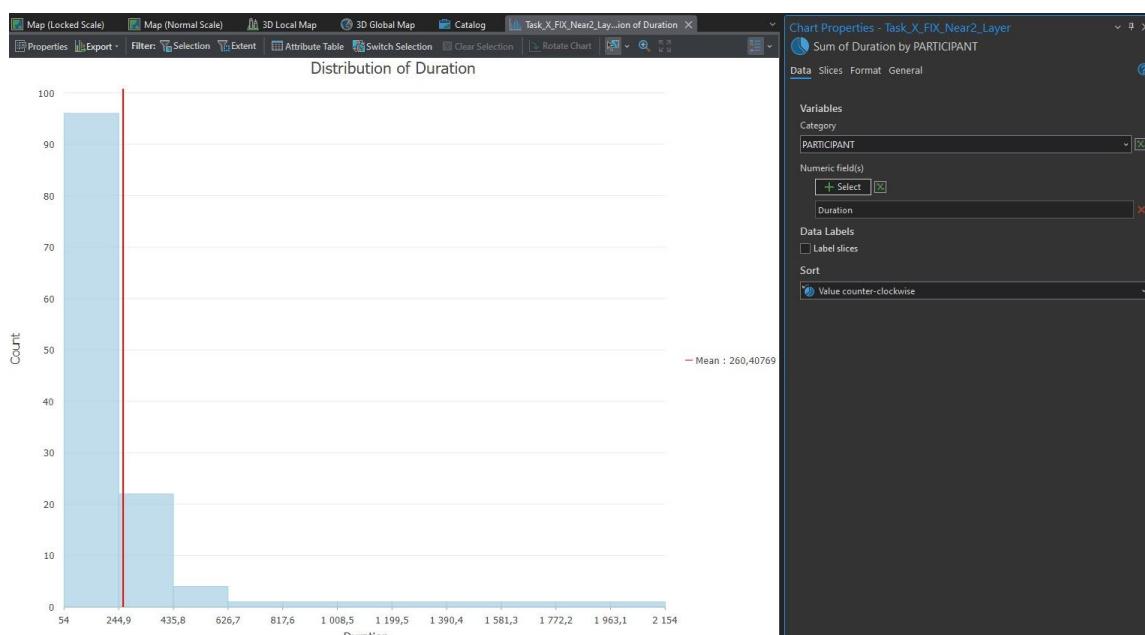
**Image 55** Chart exporting.

#### 4.4.2 Universal Charts

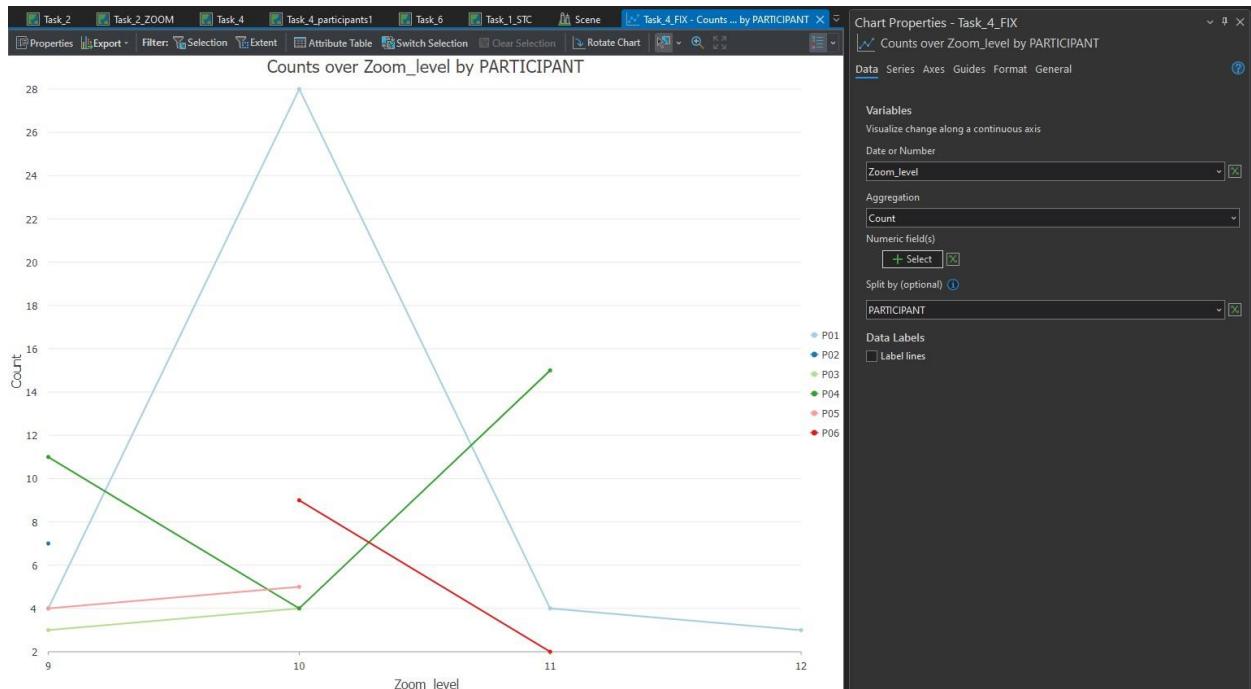
- These charts can be made from any **Fixationpoints** output of **any tool**
- Axis settings are on the right side
- Most of the Charts are **interactive** - i.e. it is possible to mark data in the chart and it will be displayed in the map (this also works the other way around)
- Other variations are possible based on creativity and needs (important parameters: *PARTICIPANT, ZoomLevel, Duration*)



**Image 56** Sum of Duration by PARTICIPANT.



**Image 57** Distribution of Duration.

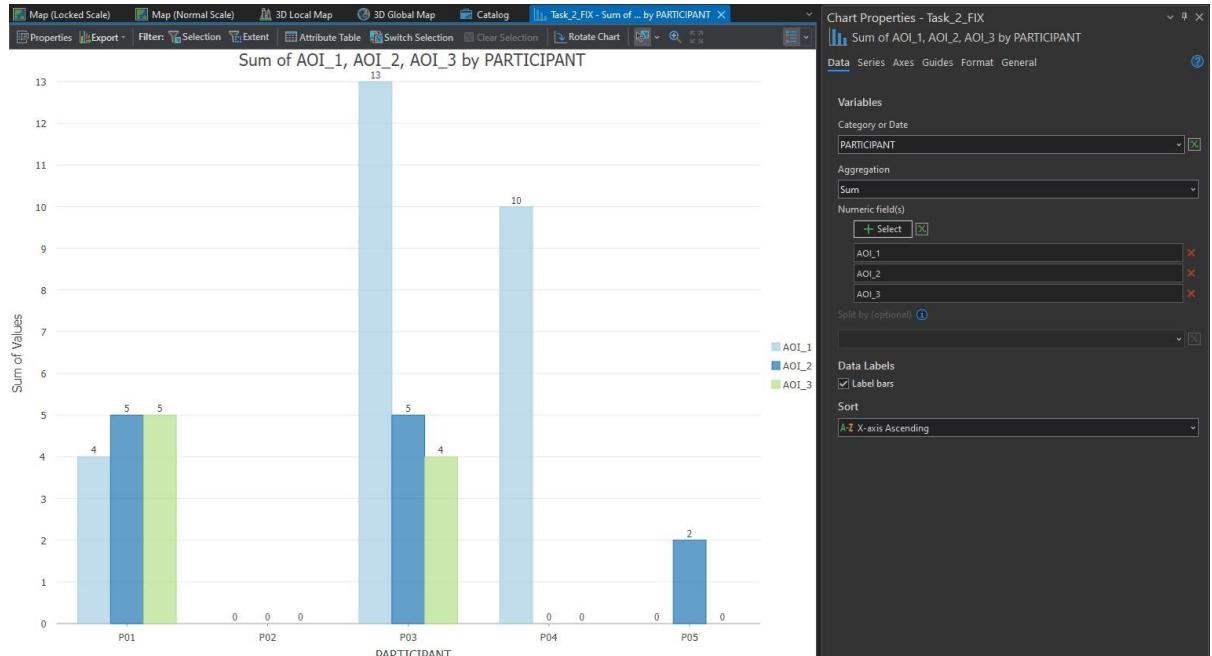


**Image 58** ZoomLevel by PARTICIPANT.

#### 4.4.3 Charts for specific tools

- **AOI Intersect**

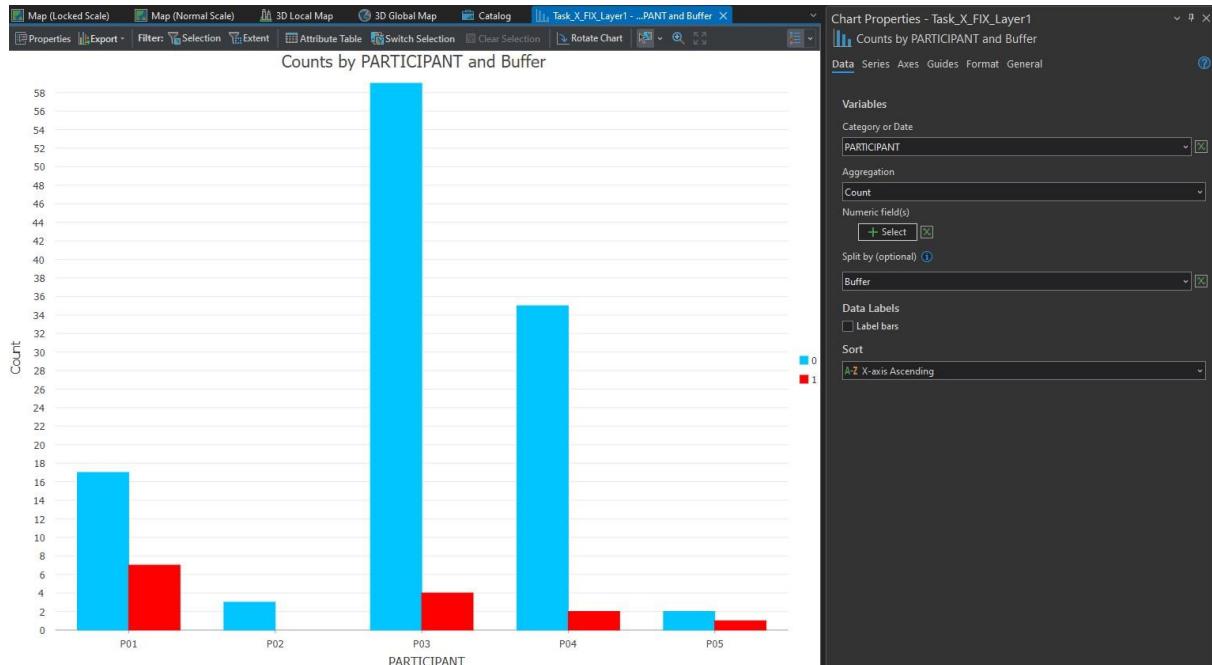
- Graphical overview of the AOIs that participants looked at



**Image 59** Sum of AOIs by PARTICIPANT.

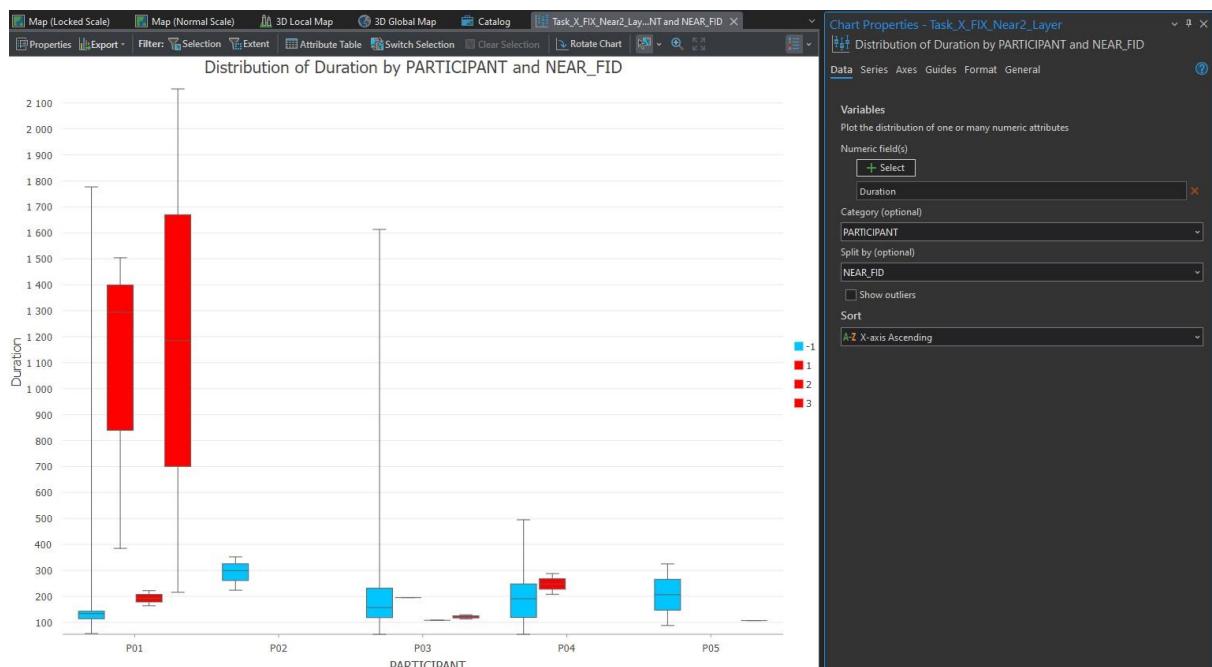
- **Buffer Zone**

- Graphical overview of the Buffer that participants looked at

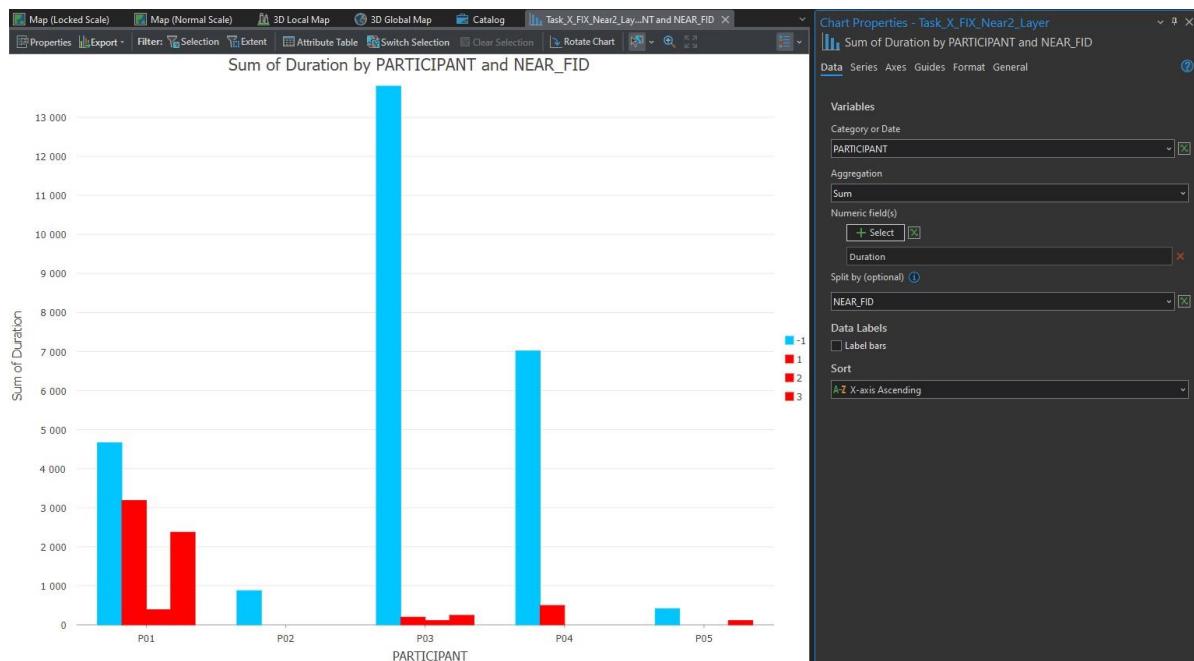


**Image 60** Counts by PARTICIPANT and Buffer Zone.

- **Nearest Neighbours**

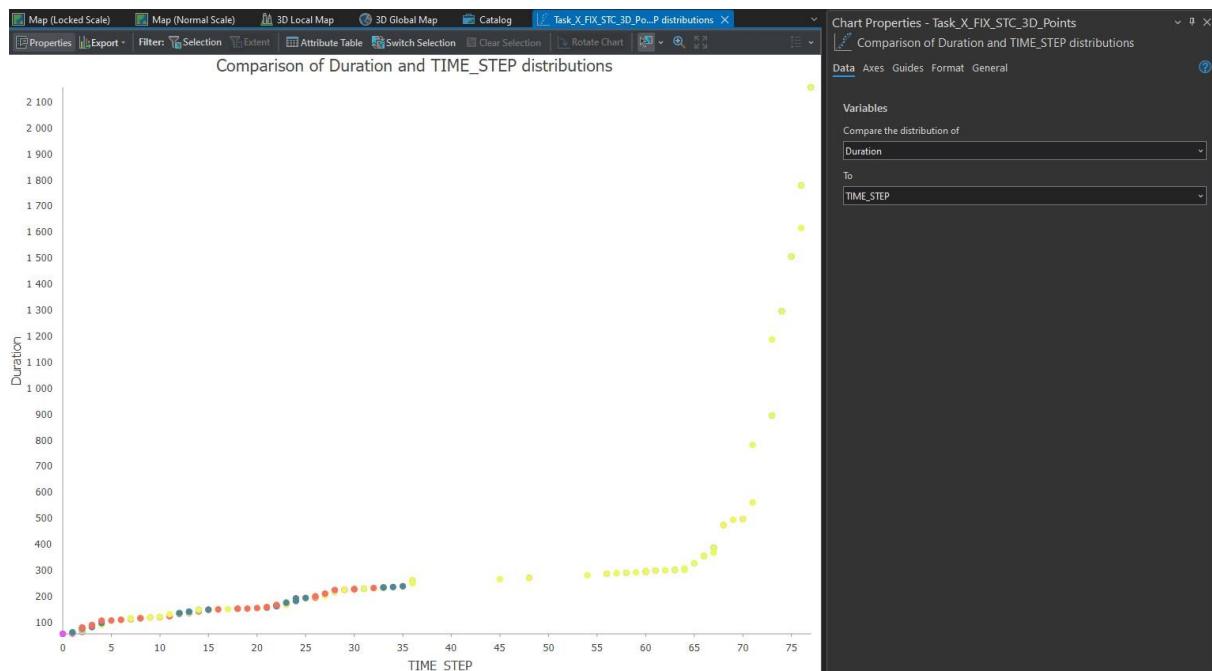


**Image 61** Distribution of Duration by PARTICIPANT and Near polygons.



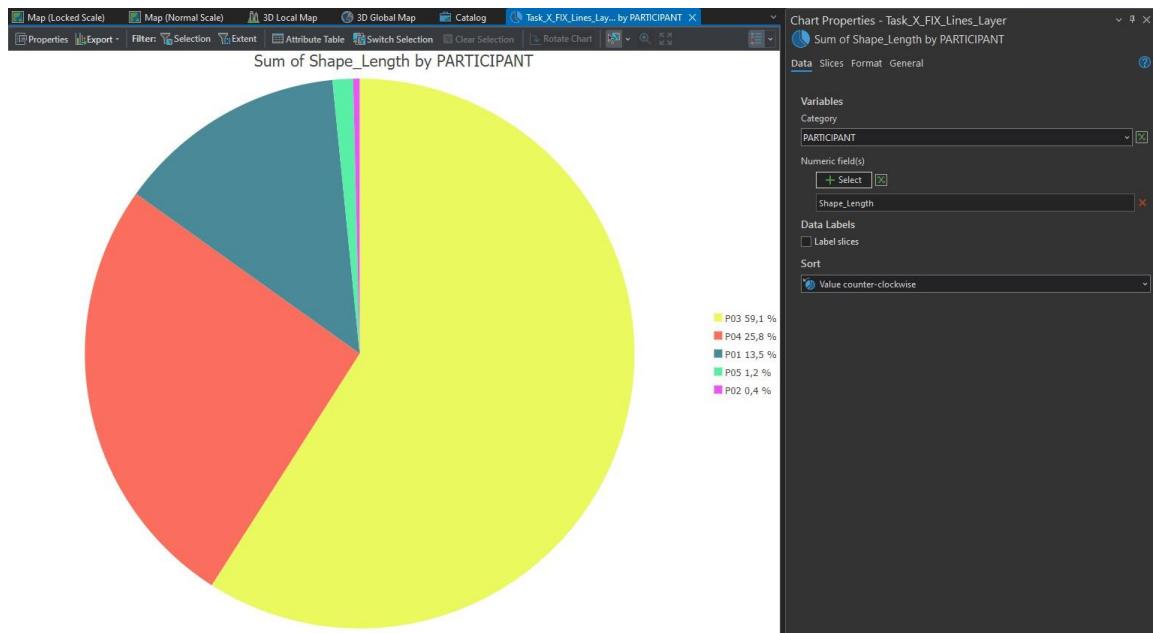
**Image 62** Sum of Duration by PARTICIAPANT and Near polygons.

- **Space Time Cube**



**Image 63** Comparison of Duration and Time Step distributions.

- **STC Lines and Scanpath Lines**



**Image 64** Sum of Shape Length by PARTICIPANT.

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More information can be found on the [website](#), which also has a Download Button for ET2GIS ZIP file (Toolbox, Project Template, Symbology Layers, Sample Data). For any further questions, please use email: **jan.suna.senkerik@gmail.com**.

*This document was created in 2023 as an appendix to a thesis entitled Eye-tracking analysis of static interactive maps using ET2Spatial. Thesis supervisor: RNDr. Stanislav POPELKA, Ph.D.*