Practical 05

Interactive visual analysis of trajectory data

given by
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Data

- A single undivided GPS track of a car from the time period 04/12/2006 - 13/10/2007
- Load the project file full_trajectory.app from folder exercises/trajectories/single_car

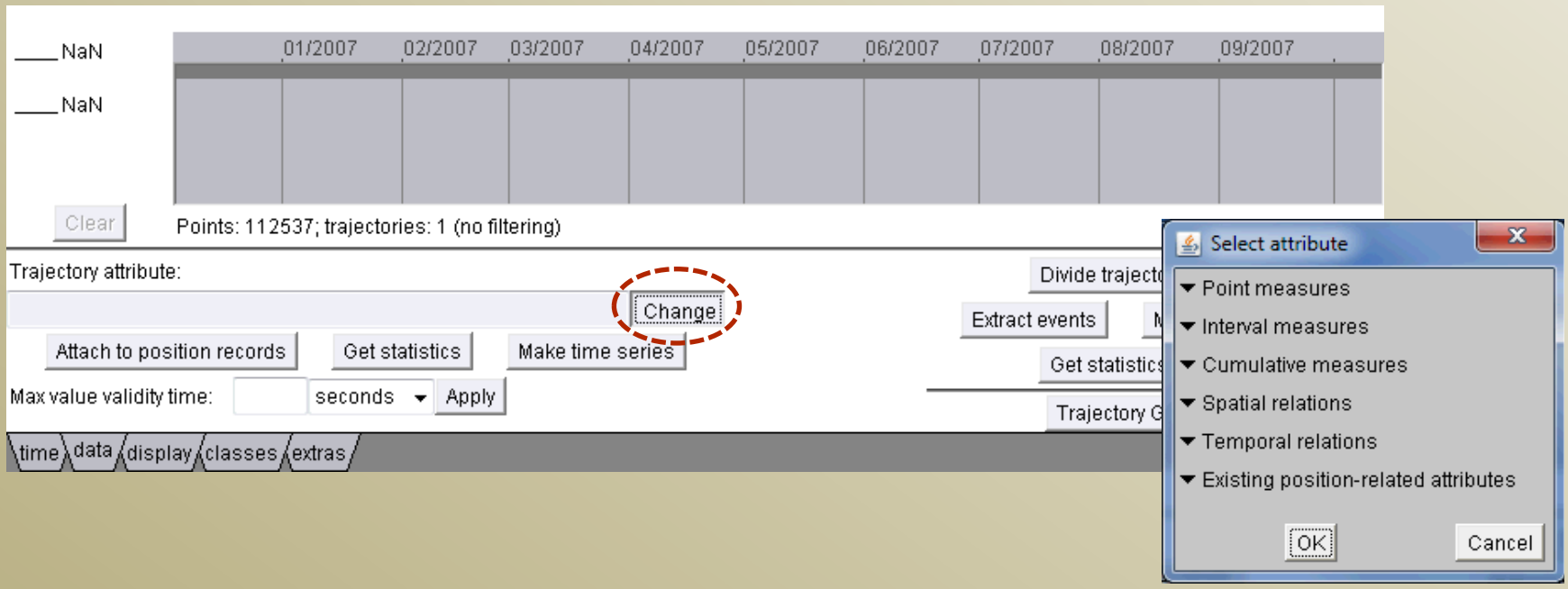
Note the long straight lines: some of them correspond to gaps in data recording (some parts of the track are missing) and others to occurrences of large errors in position measurement.

Exercise 1

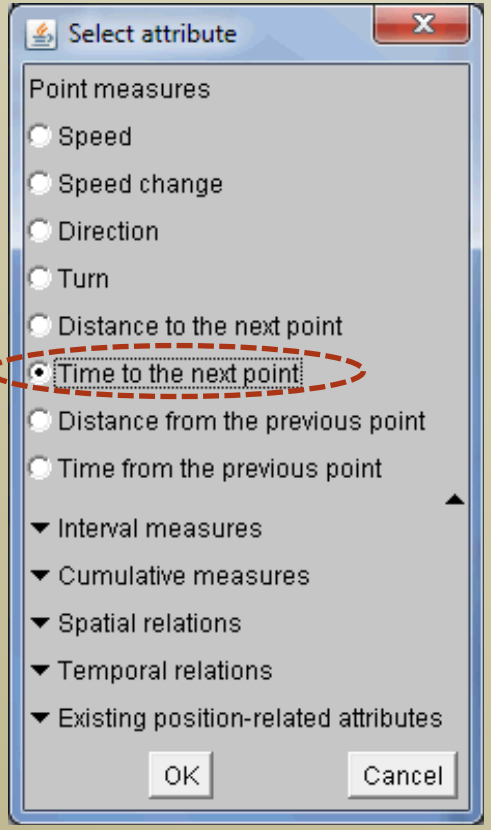
Stop detection, extraction, and exploration

Step 1: detect stop positions by segment filtering

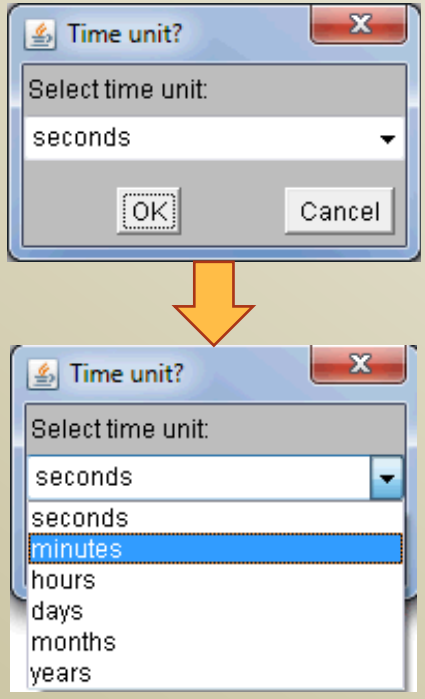
- Open the Timeline view of trajectories (menu “Display”)
  - The display contains a single bar representing the car trajectory.
- Open the tab “data”. Press the button “Change” on the right of a text field labelled “Trajectory attribute:”. A dialog “Select attribute” appears.



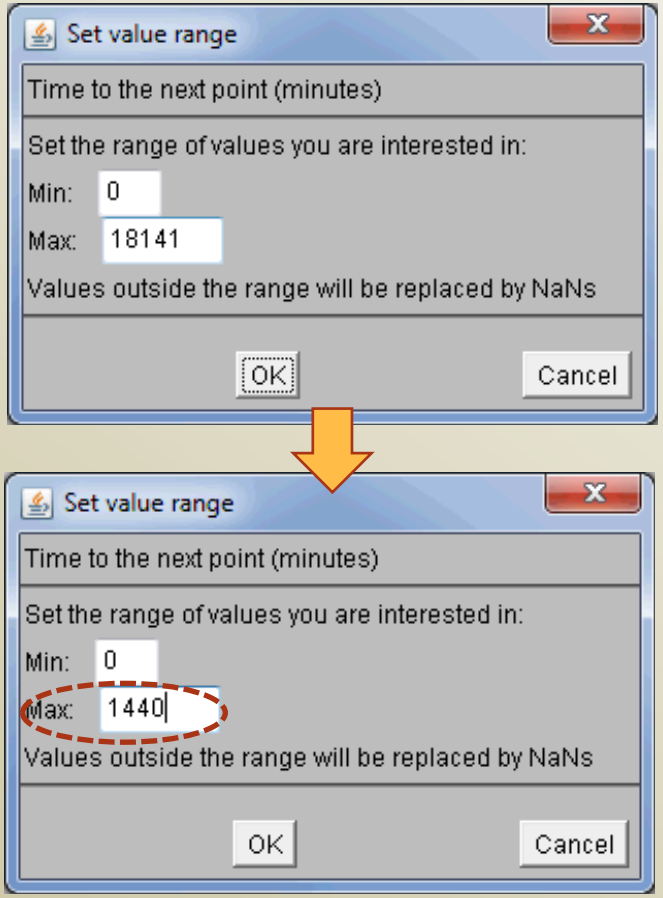
- Open the section “Point measures” and select “Time to the next point”.



- In the next dialog, select time unit “minutes”.

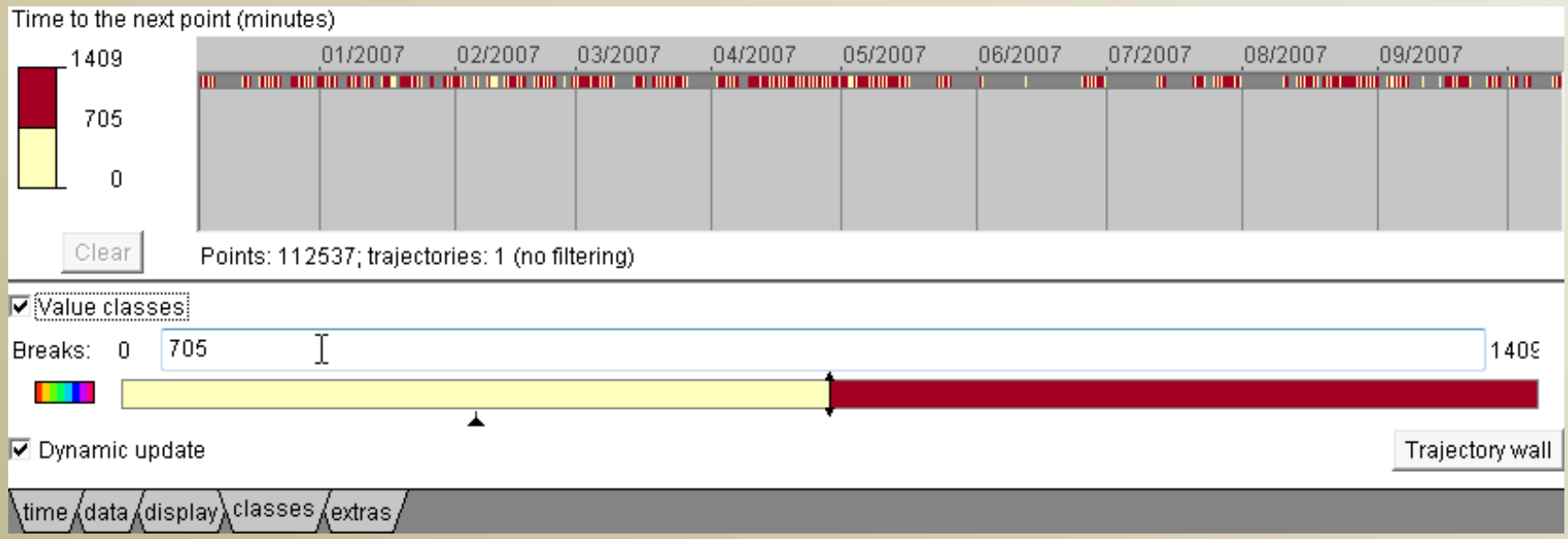


- In the next dialog, set the upper limit of the considered value range to 1440 (i.e., 24 hours).

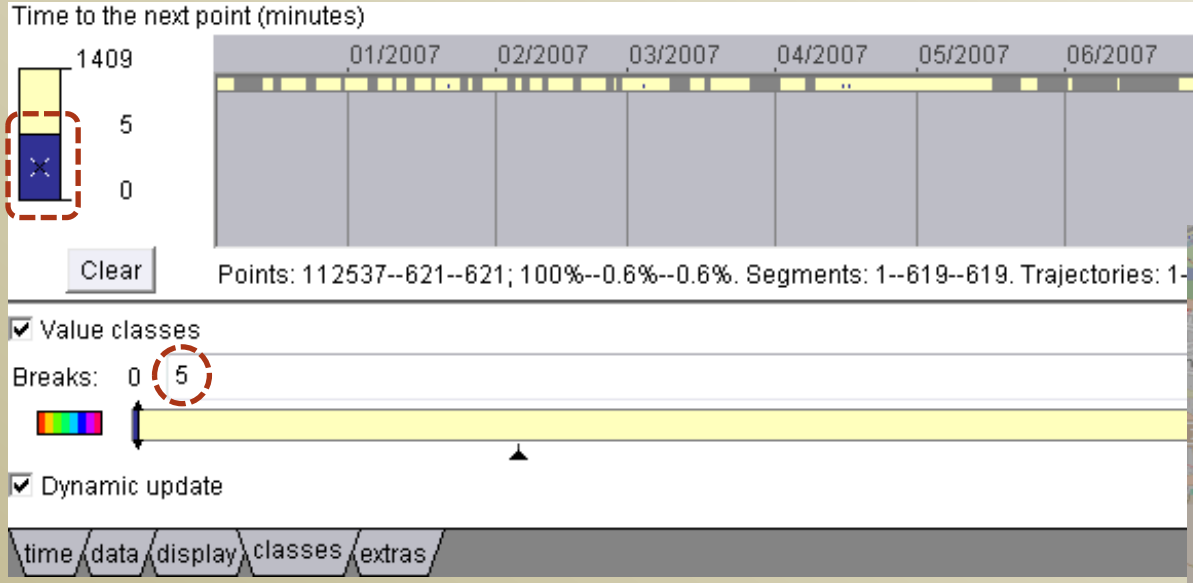


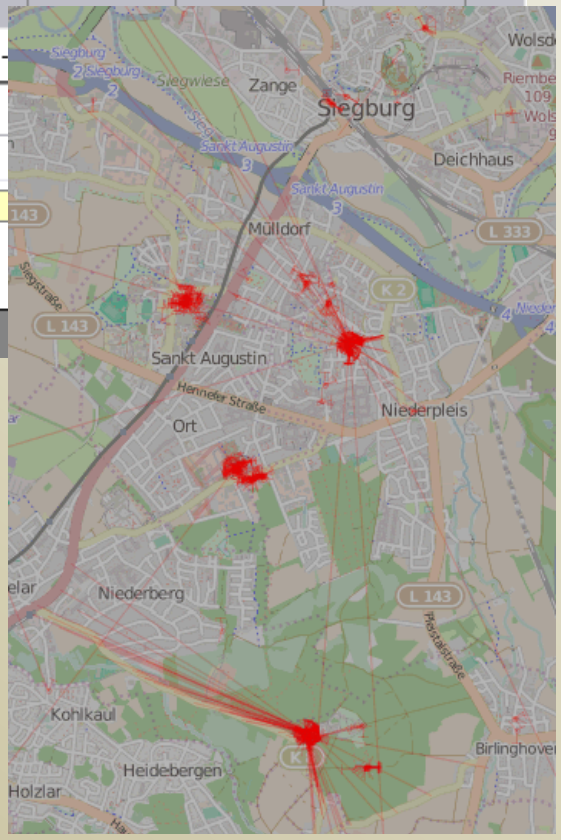
We exploit the data property resulting from the way of collection: the GPS device was switched off during the stops; hence, time gaps between consecutive records correspond to the stops.

- Open the tab “classes” and check the check box “Value classes”. The system automatically divides the value range of the attribute into two equal length class intervals. Bar segments are coloured according to the class intervals of the respective values. Grey segments correspond to time gaps over 1440 minutes.



- Set the class break to 5 minutes and apply segment filtering: filter out the segments where the time between positions is less than 5 minutes. For this purpose, click on the coloured rectangle representing the lower class in the interactive legend on the left of the plot area.

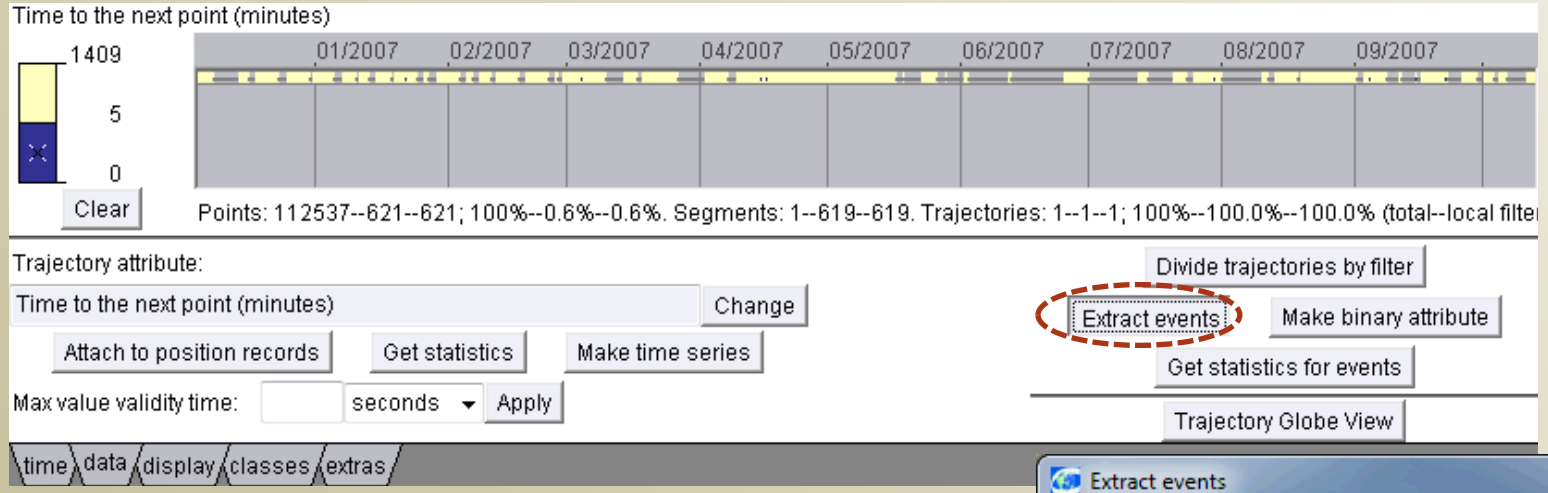




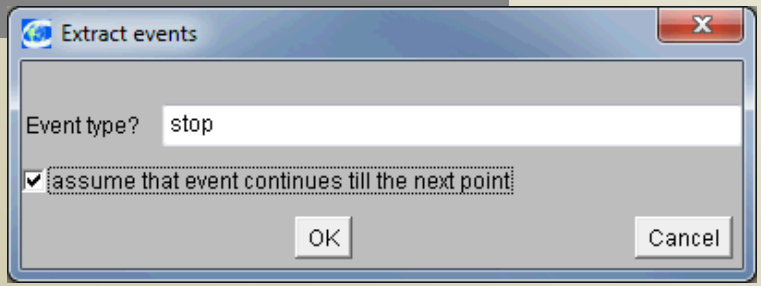
Observe the effect of the segment filtering on the map.

Step 2: Extract stop events

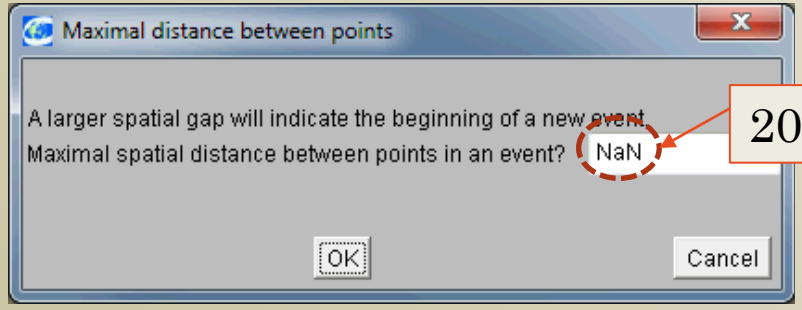
- Open the tab “data” and press the button “Extract events”.

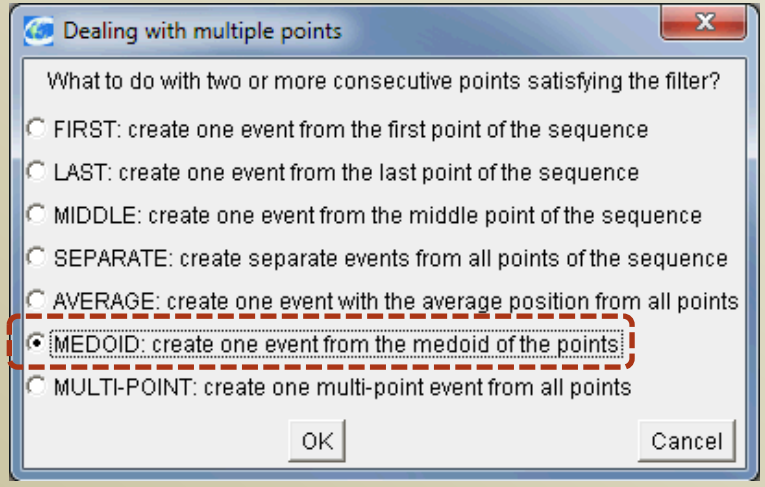


- A dialog “Extract events” appears. Enter the event type (stop) and check the checkbox “assume that event continues till the next point” (important!). Press OK.



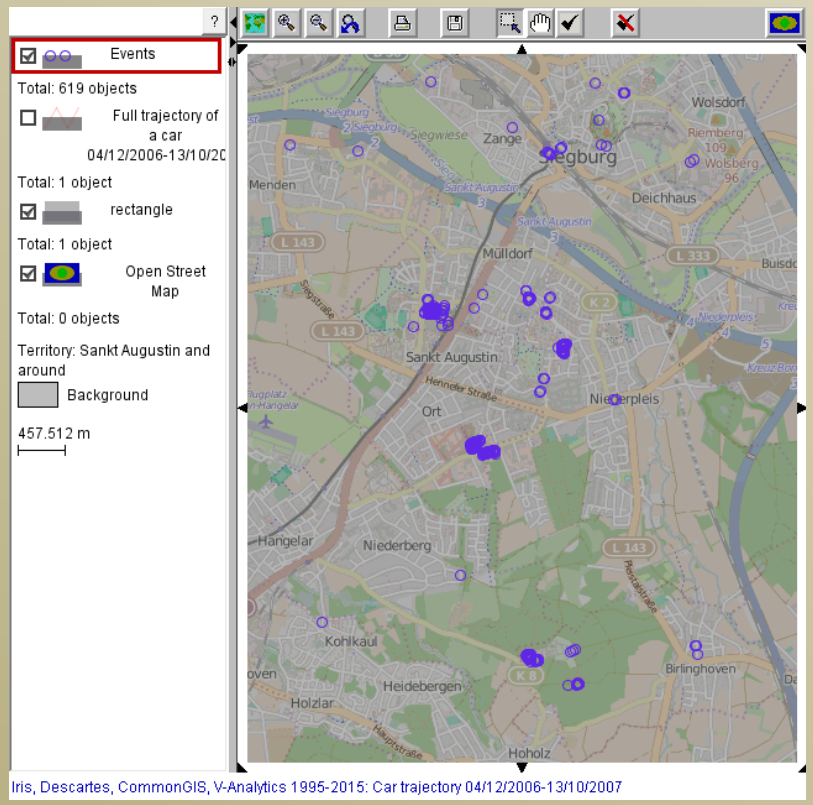
- The next dialog asks for the maximal spatial distance, in metres, between two consecutive stop points that still allows treating them as belonging to the same stop event. Replace NaN by 200. Press OK.





- The next dialog asks about the way of dealing with multiple consecutive points satisfying the segment filter: whether to treat each of them as a separate event or to make a single event from them. In the latter case, there are different options for defining the spatial position of the event. Select the option “MEDOID”*; press OK.

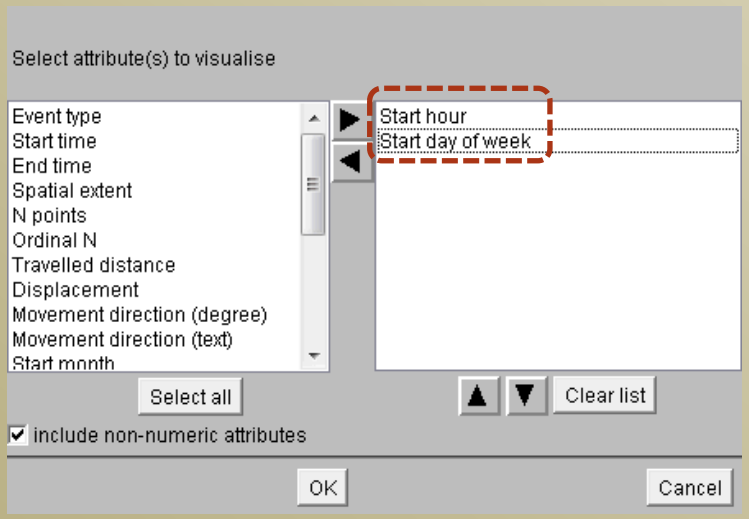
  * The medoid of a group of points is the point with the smallest average distance to all other points in the group.

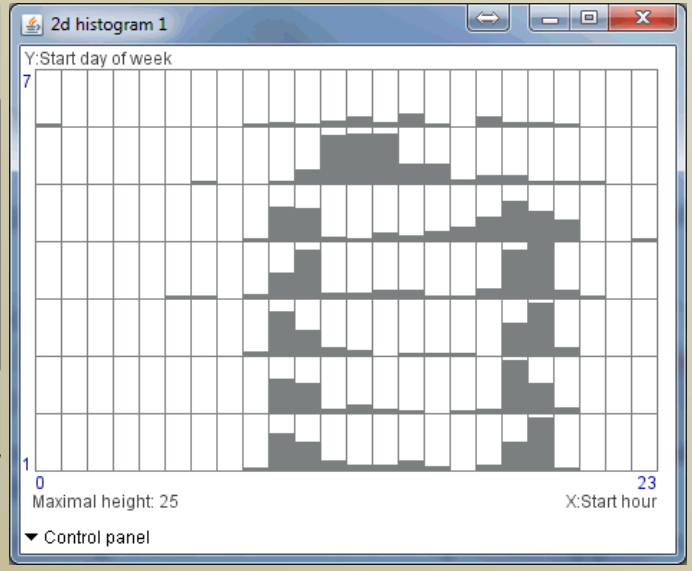


- The system creates a new map layer “Events” consisting of the stop events extracted from the car trajectory.
  You can now switch of the trajectory layer and concentrate on the event layer. You can increase the transparency of the event layer (e.g., to 70%) to better distinguish the places of frequent stops.

Step 3: Explore the stop events

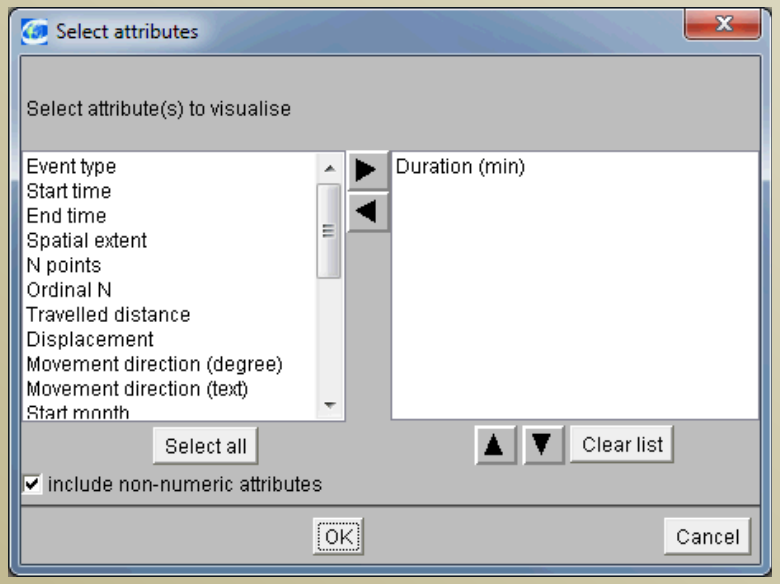
- Open a 2D frequency histogram of the event start hour against the start day of week.
  - Menu “Display” > “Display wizard” > select table “Events” > select two attributes “Start hour” and “Start day of week” in this order (for a better display layout)
    - If necessary, use the up and down buttons below the right list in the dialog to put the selected attributes in the desired order.
  - After pressing OK, a dialog with visualisation options appears. Select “2d histogram” in the right column and press OK. A 2D histogram appears.

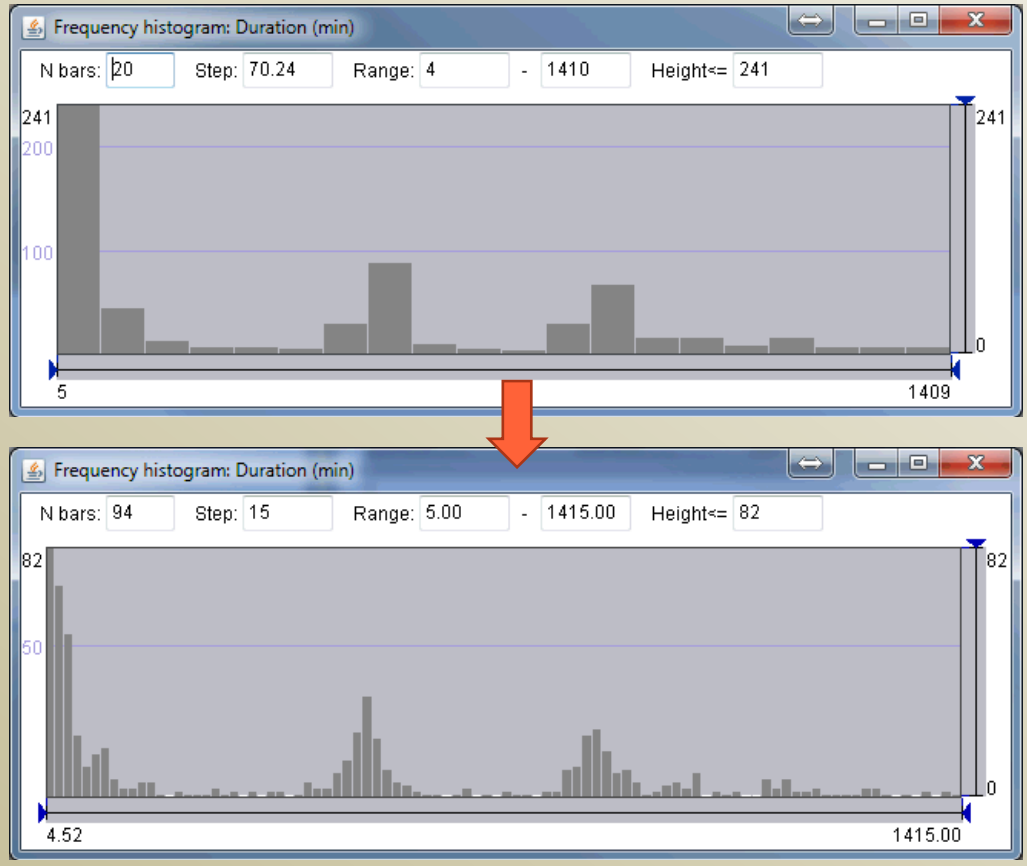




Horizontal dimension (columns) : Start hour; vertical dimension (rows): Start day of week; bar height: event frequency.

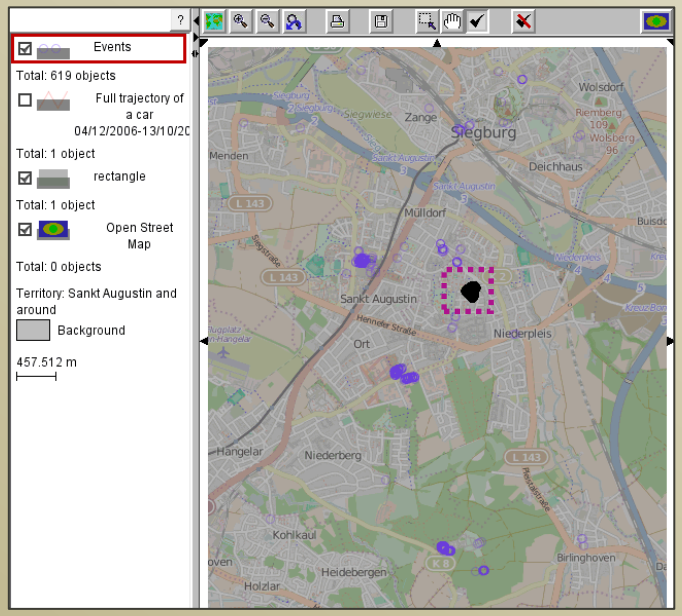
- Open a frequency histogram (one-dimensional) of the event duration (in minutes).
  - Menu “Display” > “Display wizard” > select the table “Events” > select attribute “Duration (min)” > press OK
  - A dialog with visualisation options appears > select “Frequency histogram” in the right column > press OK > a histogram appears.

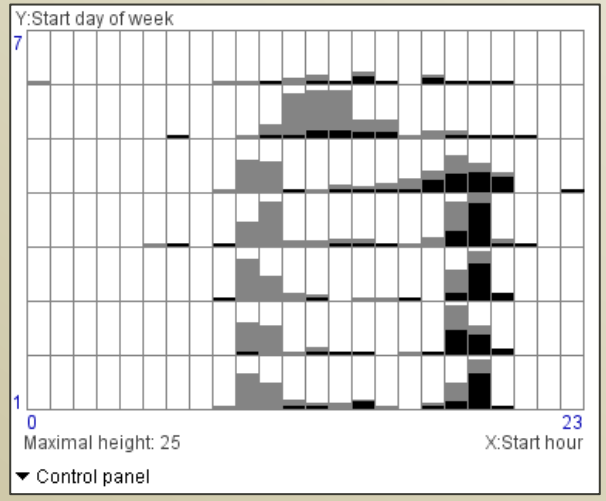


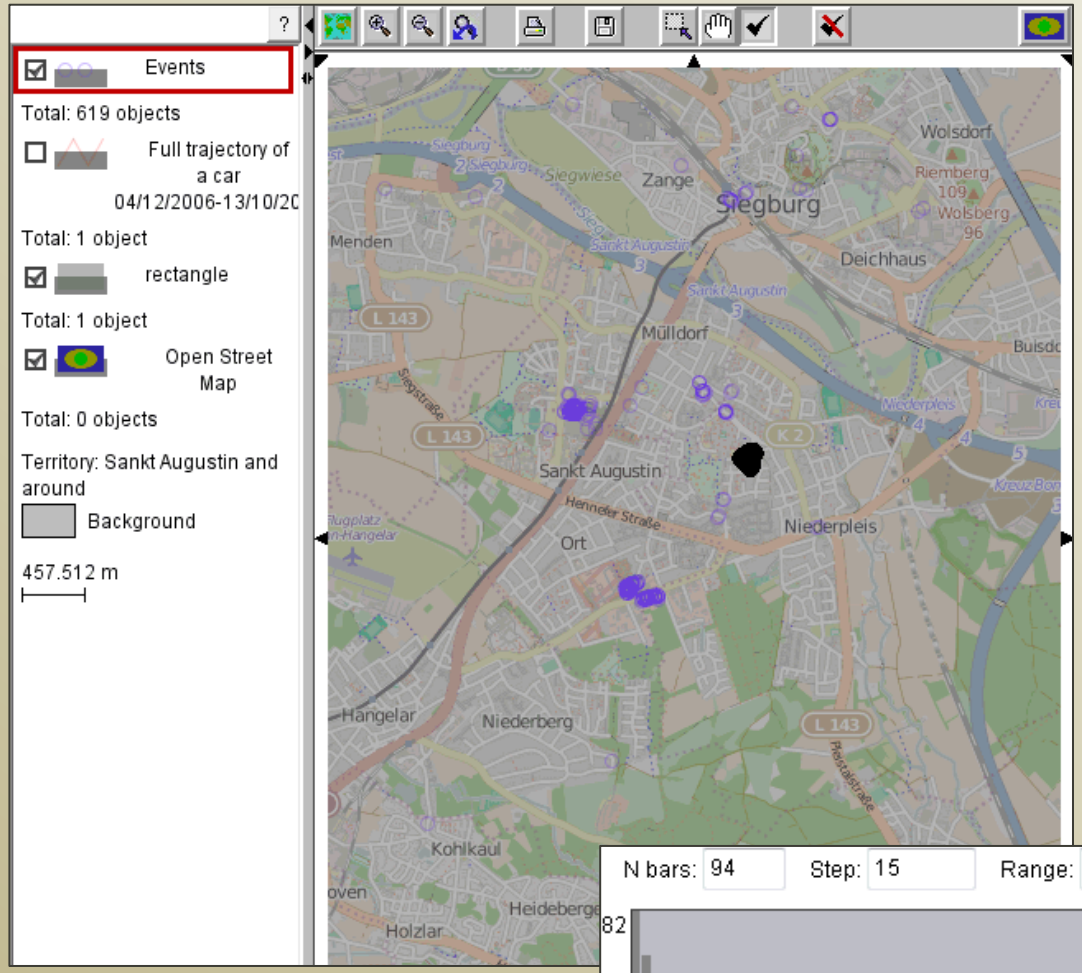


Change the default settings of the histogram display: set the step to 15 and the lower value of the range to 5 (press OK each time after entering a value in a text field).

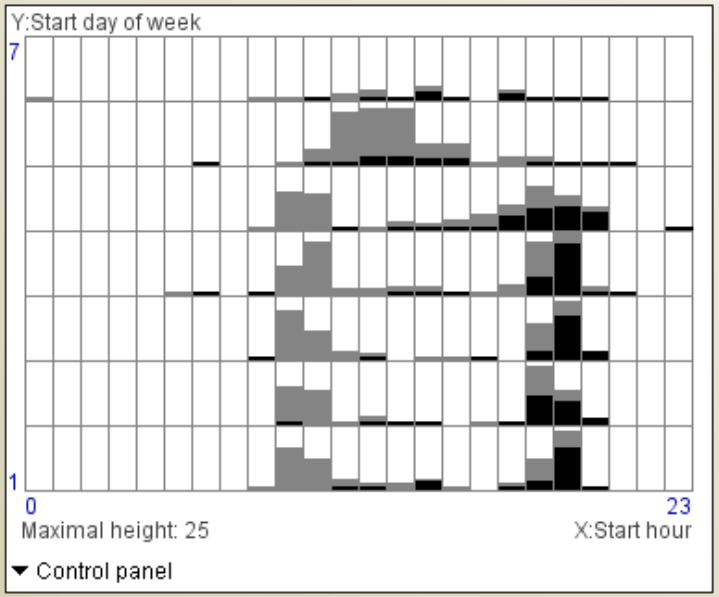
- Explore the times and durations of the stops in the different places of stop event concentrations. Utilise the dynamic linking between the displays.
  - Put the "check" button (✓) above the map in the sunken state and select a group of stop points on a map by mouse dragging (the map layer "Events" must be active; if not, click on its name in the legend). Observe the distributions of black bar segments in the 2d and 1d histograms.
    - To uncheck, double-click on a point-free location in the map or press button 
- Try to guess the meanings of the places based on the stop times and durations.

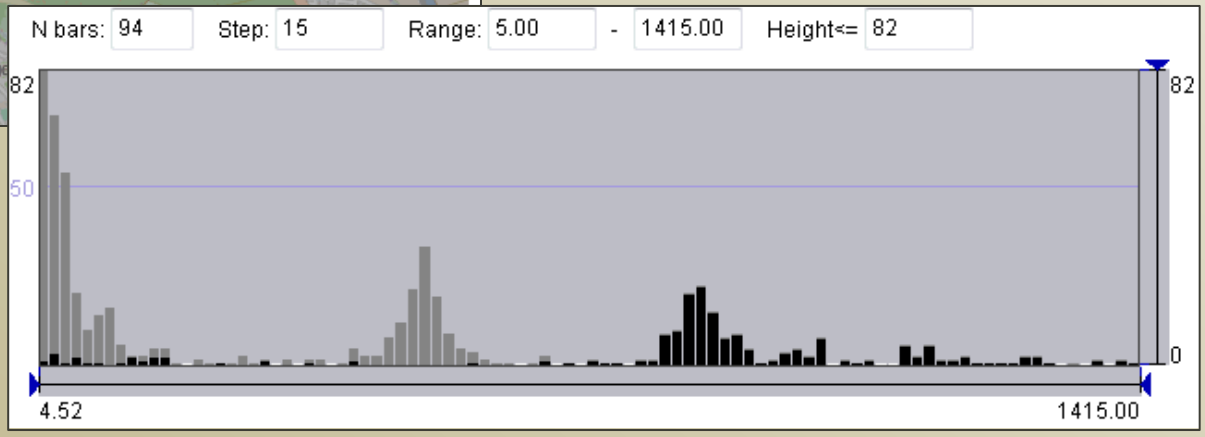






Rows: 1 – Monday, 7 – Sunday.





Questions to exercise 1

- Where are the likely home and work places of the car driver?
- What are the likely meanings of the other places of repeated stops?

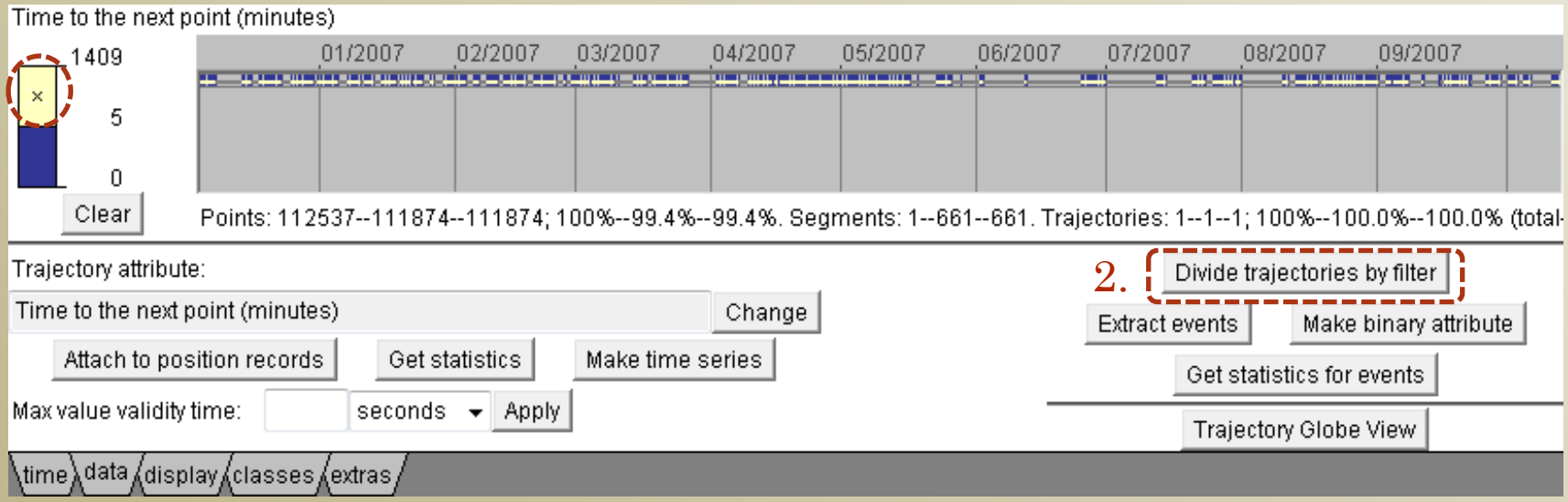
Justify your answers based on the information about the stop times and durations.

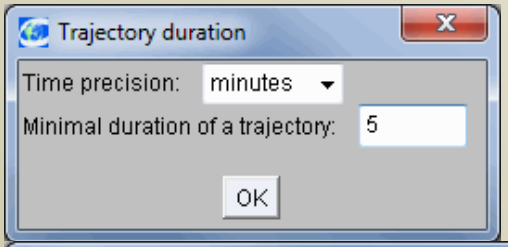
Exercise 2

Division of a track into trips, clustering of trips by route similarity

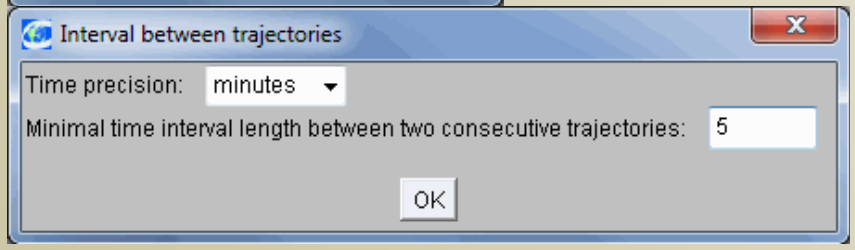
Step 1. Divide the trajectory into trips

1. In the timeline view, invert the segment filter: press the button “Clear” below the legend on the left of the plot area and switch off the upper class interval (> 5) by clicking on the upper rectangle in the legend. This will select the parts of the trajectory where the time intervals between consecutive position records are less than 5 minutes.
2. Press the button “Divide trajectories by filter” in the tab “data”.





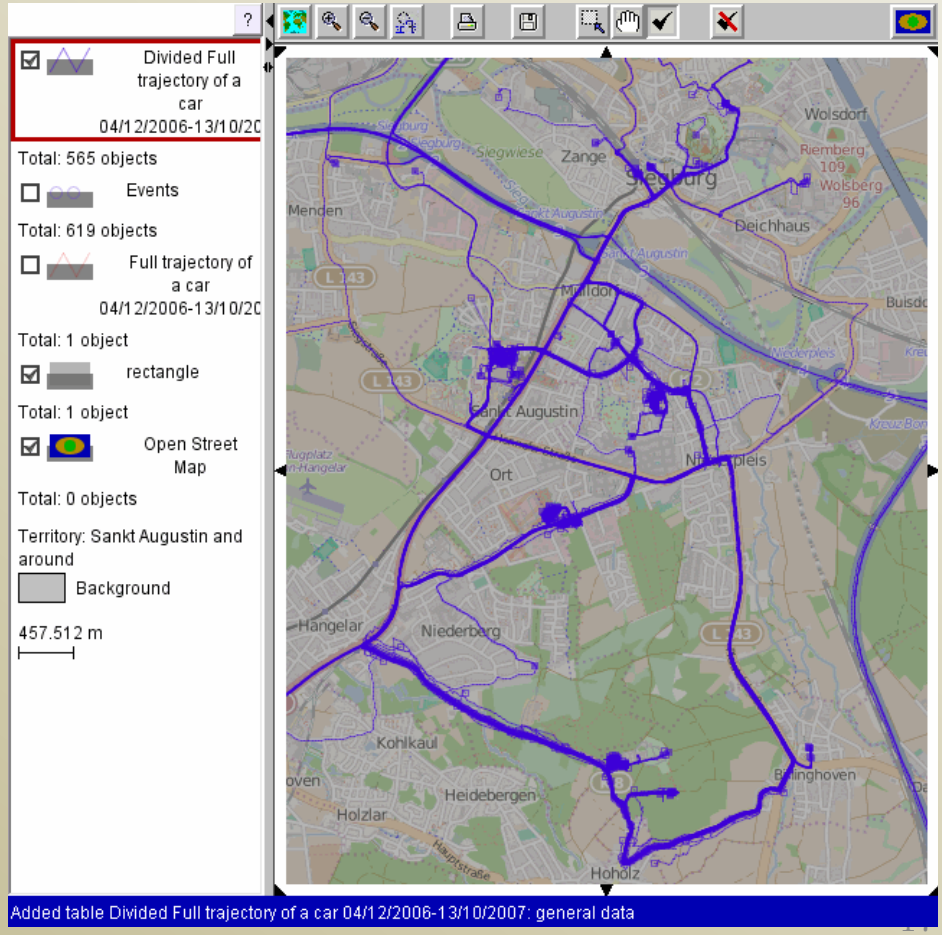
3. In the dialog “Trajectory duration”, which appears next, set the minimal duration of a trajectory to 5 minutes.

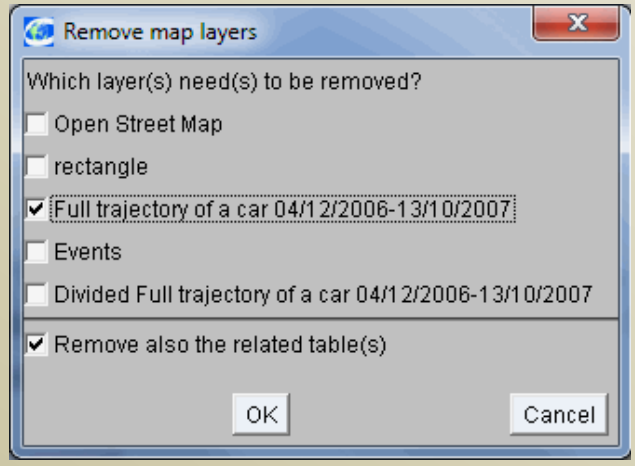


4. Do the same also in the following dialog “Interval between trajectories”.

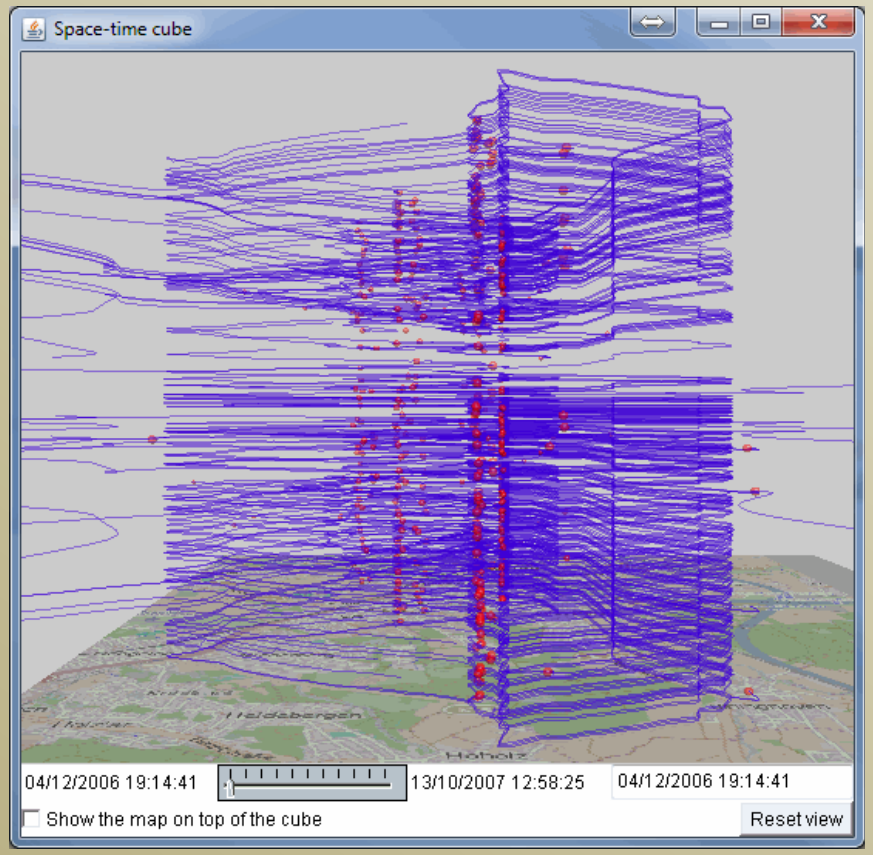
5. The next dialog asks which attributes of the original trajectory need to be attached to the resulting trajectories. Just press OK (no selection is needed).

6. The system creates a new map layer with the trajectories resulting from the division. If you do not like the layer colour, you can change it. You can switch off the visibility of the event layer.





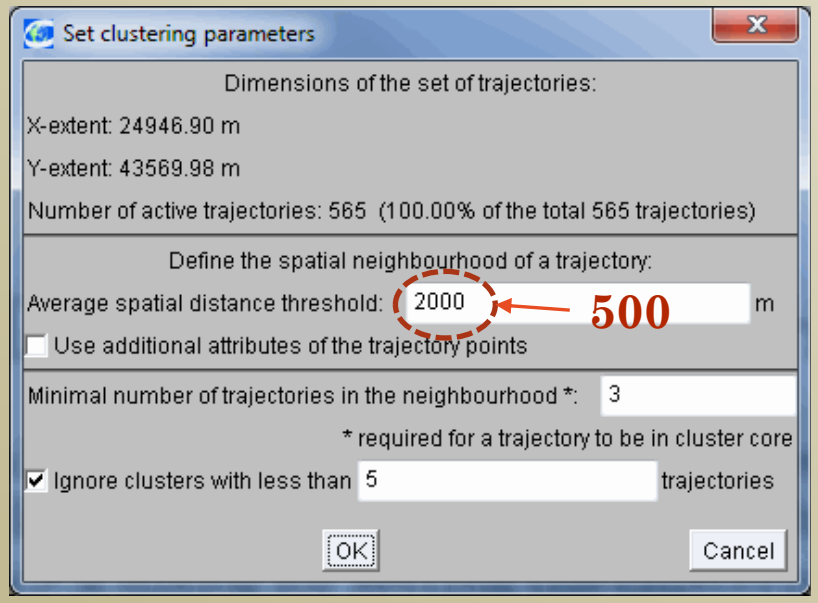
7. Close the timeline view. Remove the map layer with the original trajectory and the corresponding table from the system.
   - Menu "File" > "Remove map layers" > in the dialog, check "Full trajectory of a car 04/12/2006-13/10/2007" and "Remove also the related table(s)" > press OK > in the next dialog, confirm your wish by pressing "Yes".



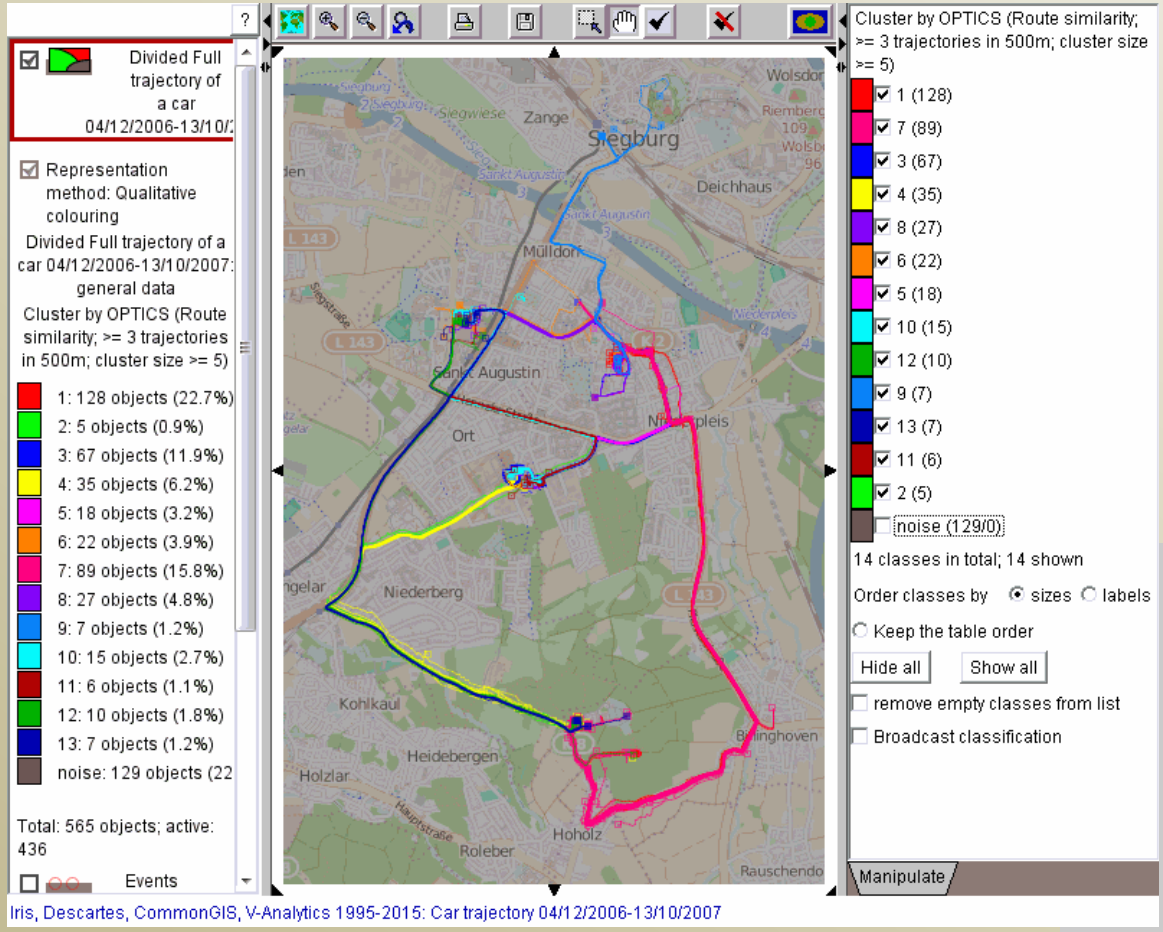
8. Visualise the derived trajectories and the stop events in a space-time cube (menu "Display" > "Space-time cube"). You may need to modify the colour and transparency of the event layer to make the events better visible in the cube.

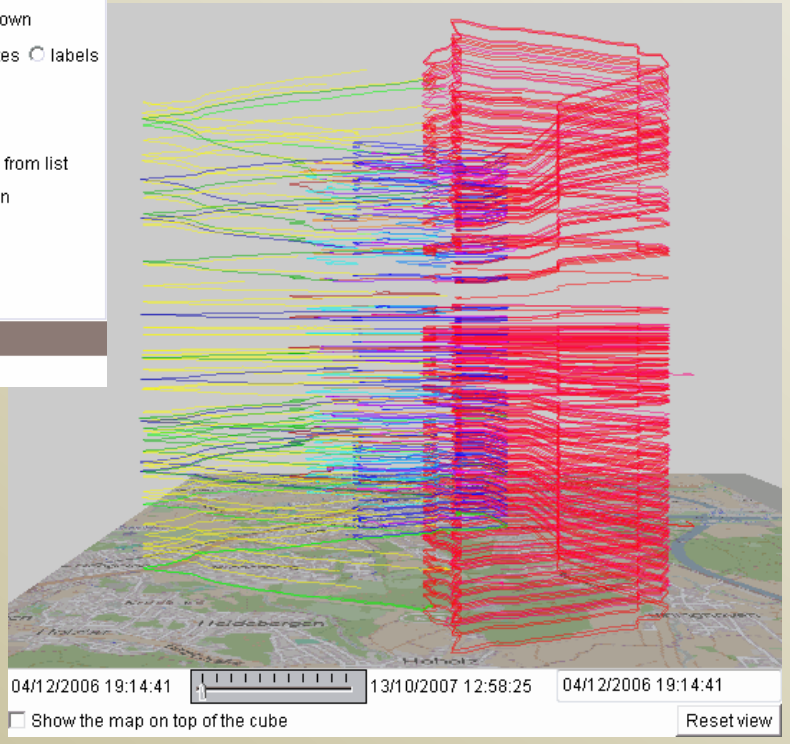
Step 2. Density-based clustering of the trips

- Menu “Analyse” > “Trajectories: density-based clustering by routes” > in the following dialog, select the layer with the divided trajectories > a dialog for setting the clustering parameters appears.



- Set the spatial distance threshold to 500 (metres), press OK and wait for the clustering results.

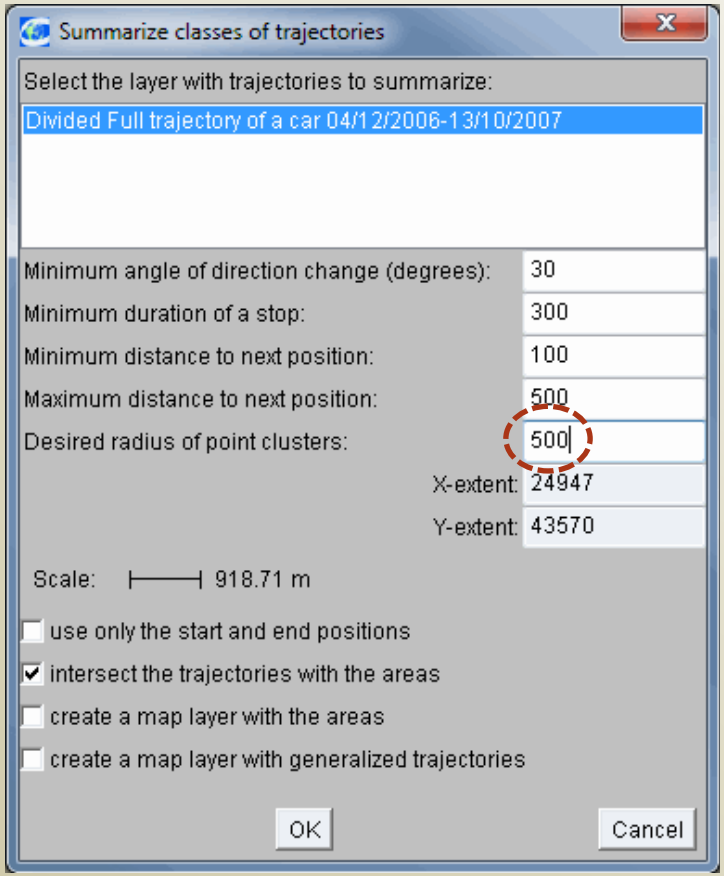


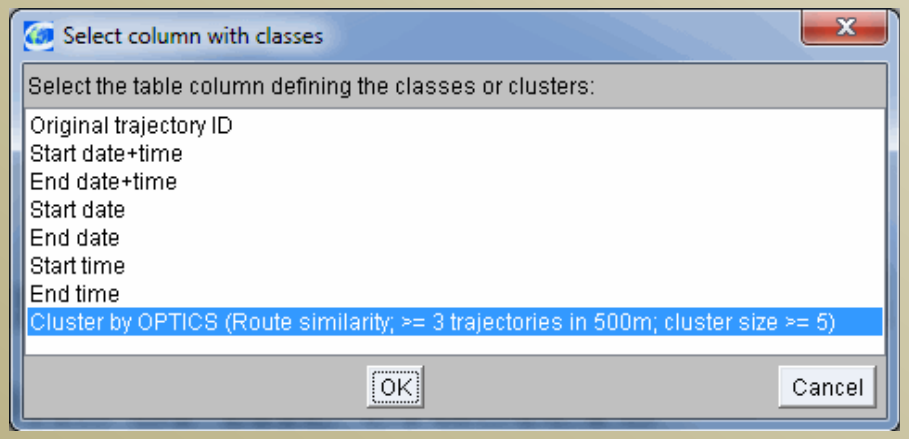


The clustering results are represented on the map by colouring of the trajectory lines; “grey” corresponds to the “noise”. The colouring is automatically propagated to the space-time cube. Switch off the “noise” to see the regular trip routes.

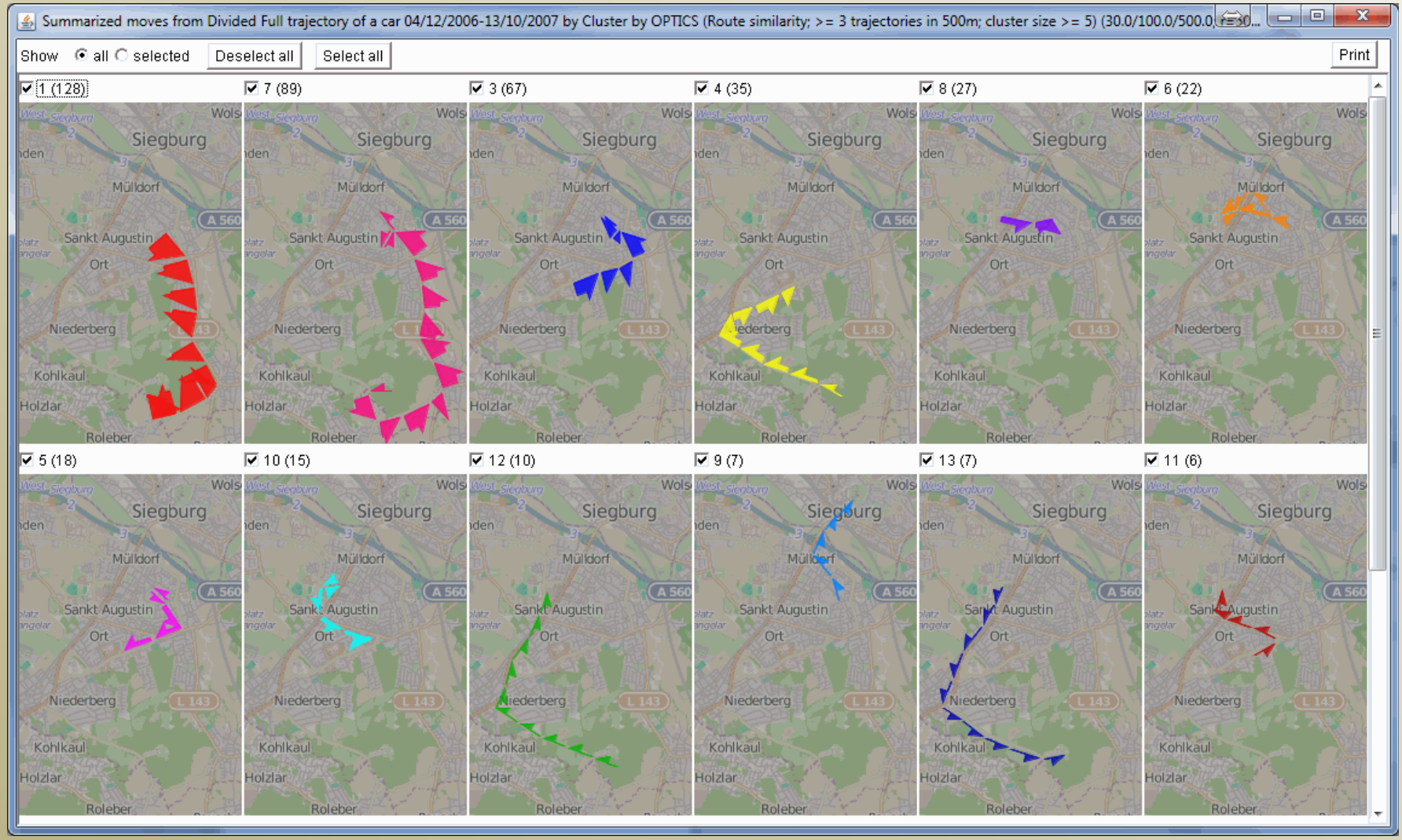
Step 3: Obtain spatially summarised representations of the clusters

- Press the button "Zoom out"  above the map.
- Menu "Analyse" > "Trajectories: summarisation of clusters" > a dialog for setting the summarization parameters appears; set the parameter "Desired radius of point clusters" to 500 (metres).
- In the next dialog for selecting the table column defining the clusters, select the list item starting with "Clusters by OPTICS …" (note: it may be pre-selected)

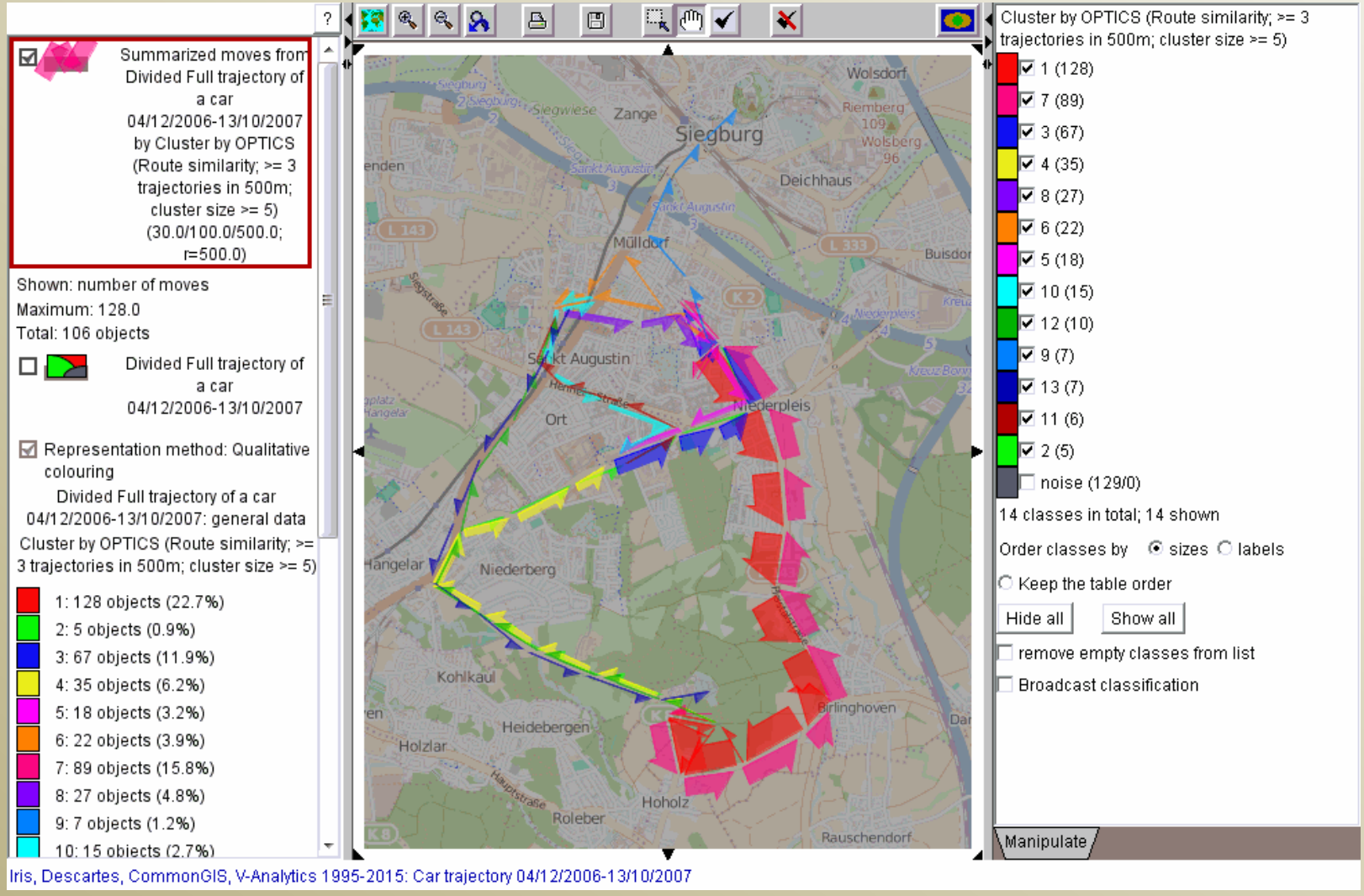




The system creates a window with static images of the summarised clusters of trajectories. The flow symbols show the movement directions and frequencies.

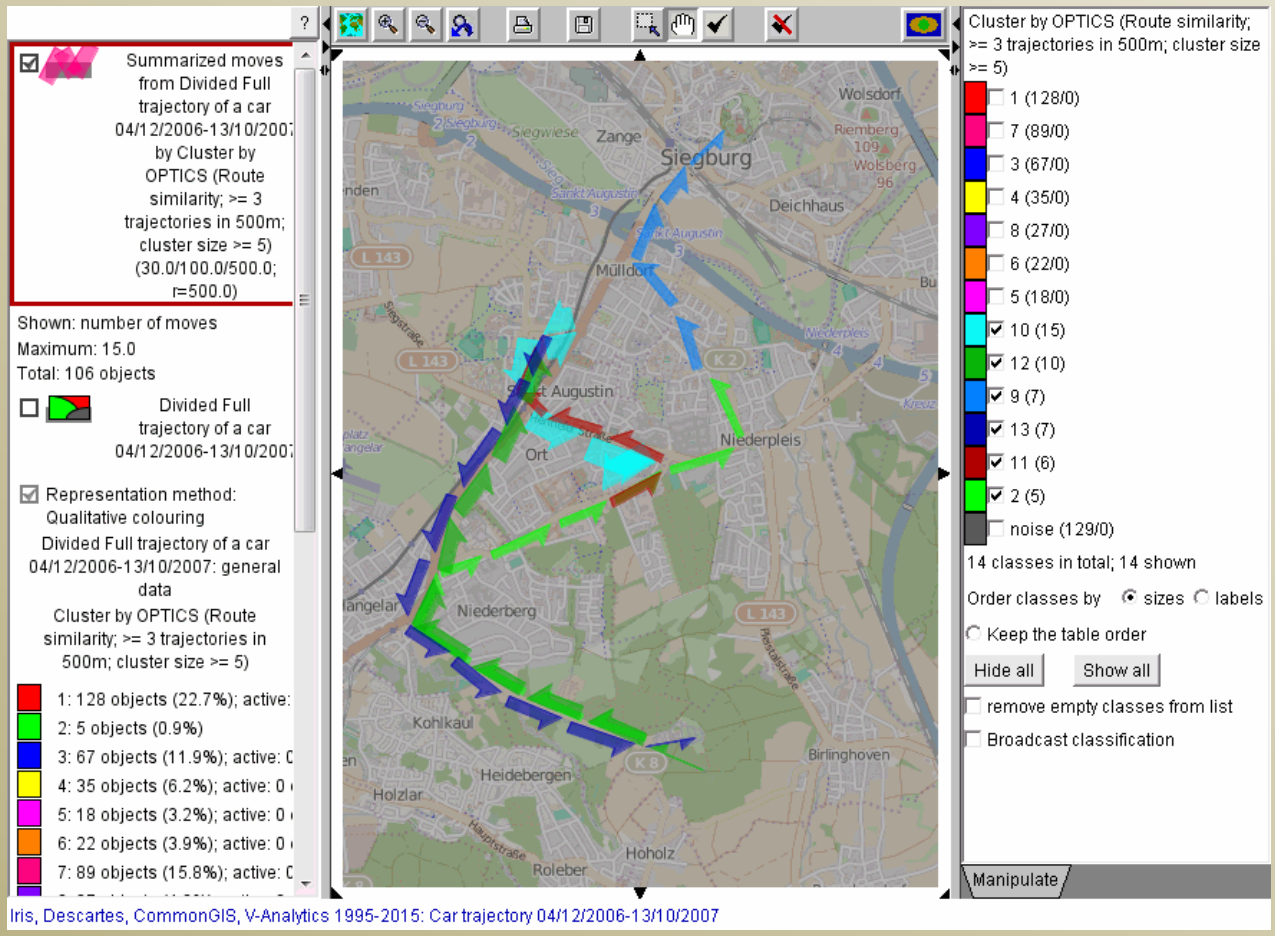


Simultaneously, a new layer with the trajectories summarised into flows appears on the map. The flow symbols are painted in the cluster colours. The previous zoom level of the map can be now restored (buttons  or )



Enable “dynamic aggregation” (which allows the flow layer to react on filtering of the trajectories):

- Menu “Other tools” > “Explore movement data” > in the dialog that appears, check the check box “Enable dynamic aggregation” (it is at the top of the dialog).



Now you can switch off and on the clusters of trajectories and observe the summarised representations of the currently selected clusters on the map. Switching off the larger clusters makes the smaller ones better visible. The visibility of the layer with the trajectories may be turned off, for a clearer view of the summarised clusters.

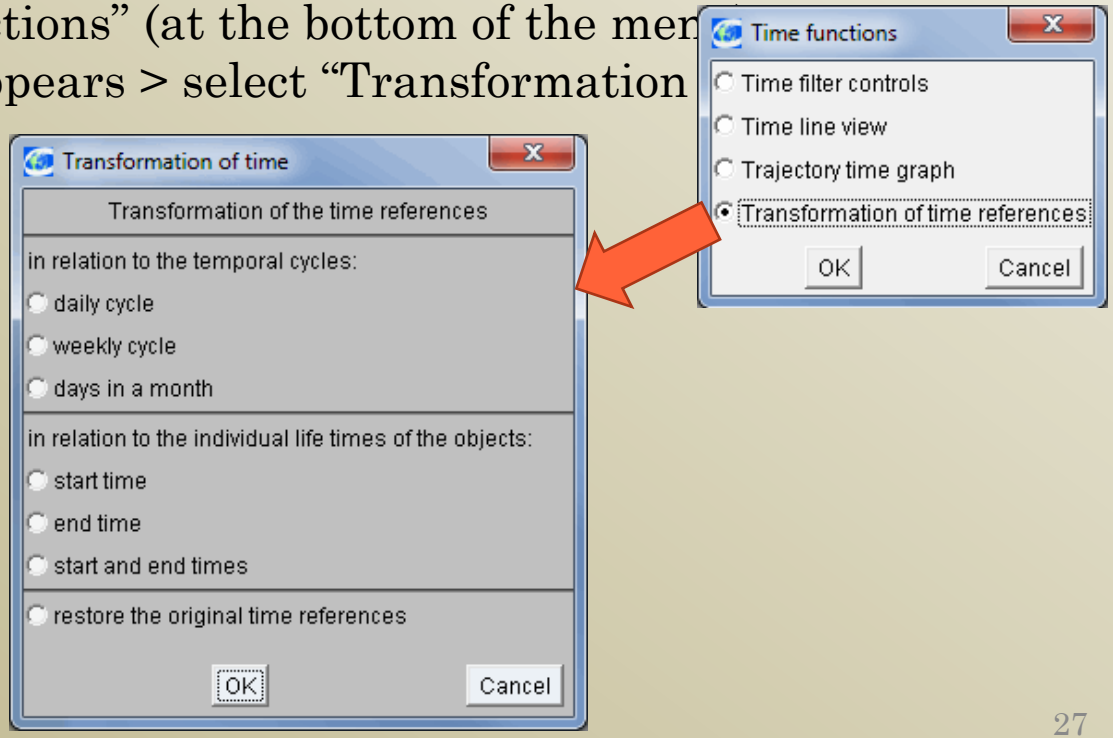
Questions to exercise 2

- By looking at the summarised representations of the clusters of trajectories, describe the most frequent trip routes (clusters with >20 trajectories)).
  - Recall the locations and meanings of the significant (repeatedly visited) places of the car driver and refer to these places in describing the trip routes.
- What was the most usual route of driving from the work place to home?
- Where else did the driver go from the work place?

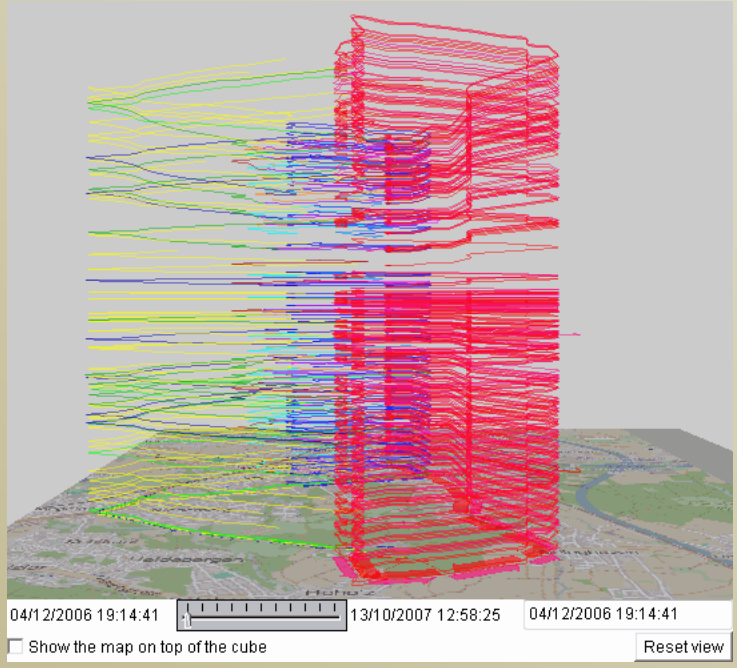
Exercise 3

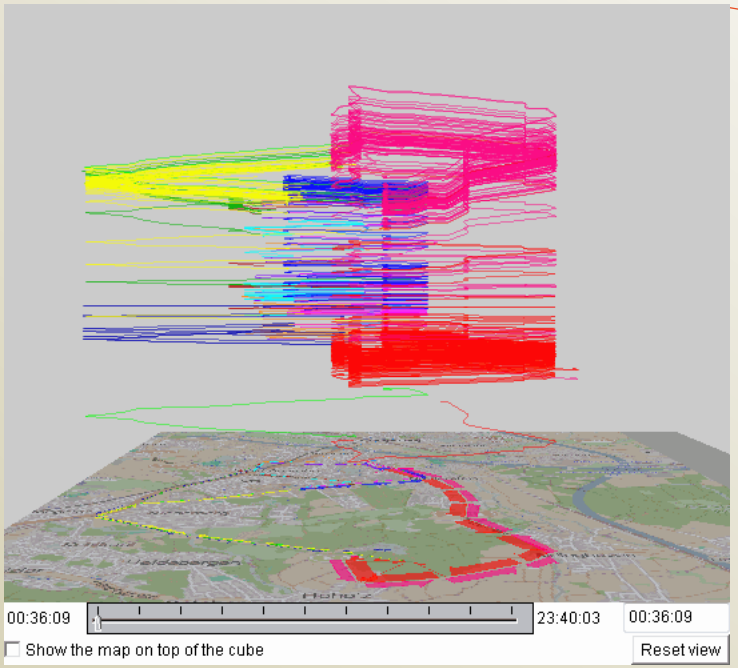
Time transformations

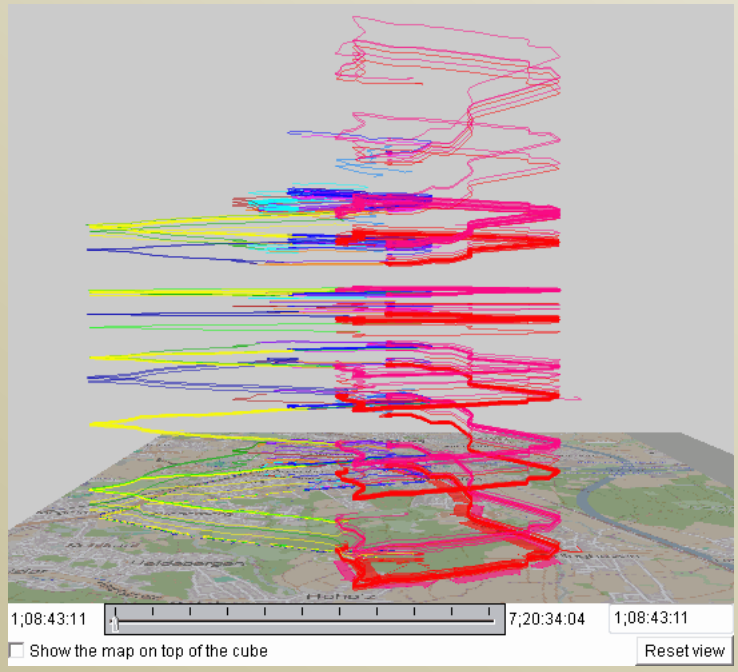
1. Remove the map layer with the stop events and the associated table from the system. Reason: the transformation is applied to all data having time references, and the durations of very long stop events may affect the overall time range resulting from the time transformation.
   - Menu “File” > “Remove map layers” > in the dialog that appears, check “Events” and “Remove also the related table(s)” > press OK > in the next dialog, confirm your wish by pressing “Yes”.
2. Re-create the space-time cube display for the trajectories.
3. To open a dialog with the time transformation functions, go to menu “Other tools” > “Time functions” (at the bottom of the men dialog “Time functions” appears > select “Transformation of time references” > OK



Transform the time references in the trajectories first to the daily cycle, then to the weekly cycle. Observe the changes in the space-time cube (also the texts at the bottom showing the time range of the data).





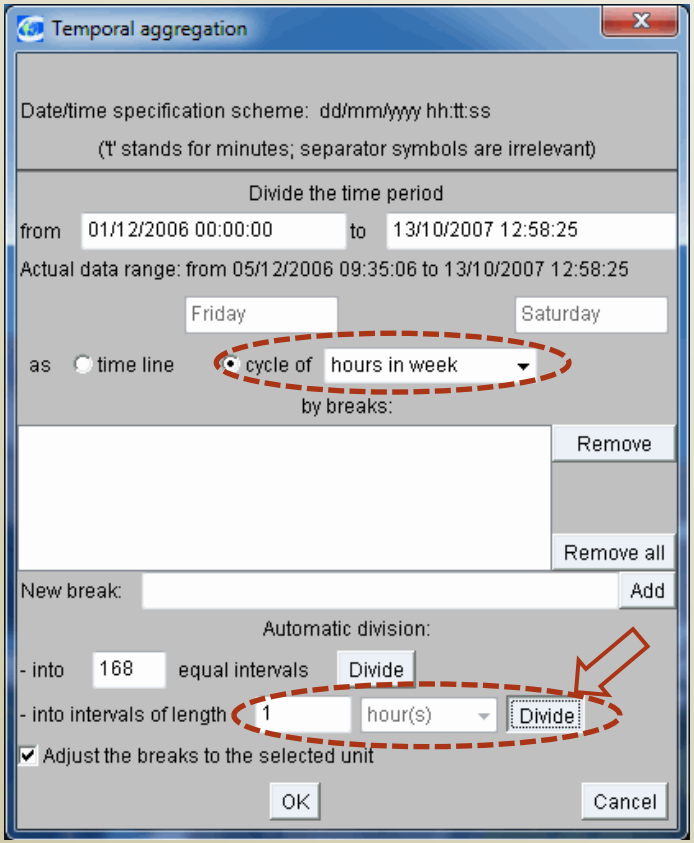


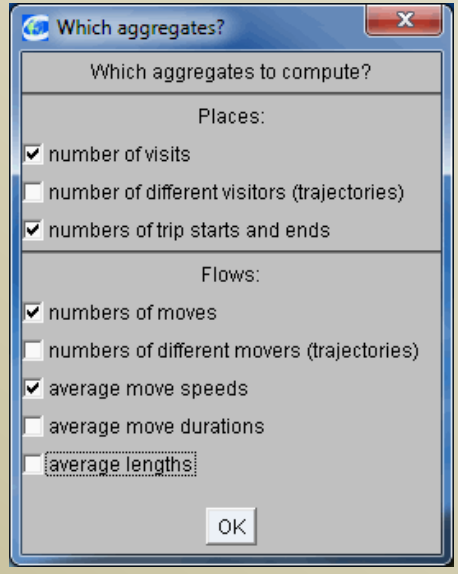
Question: how are the usual trip routes related to the daily and weekly time cycles?

Exercise 4

Spatio-temporal aggregation of trajectories

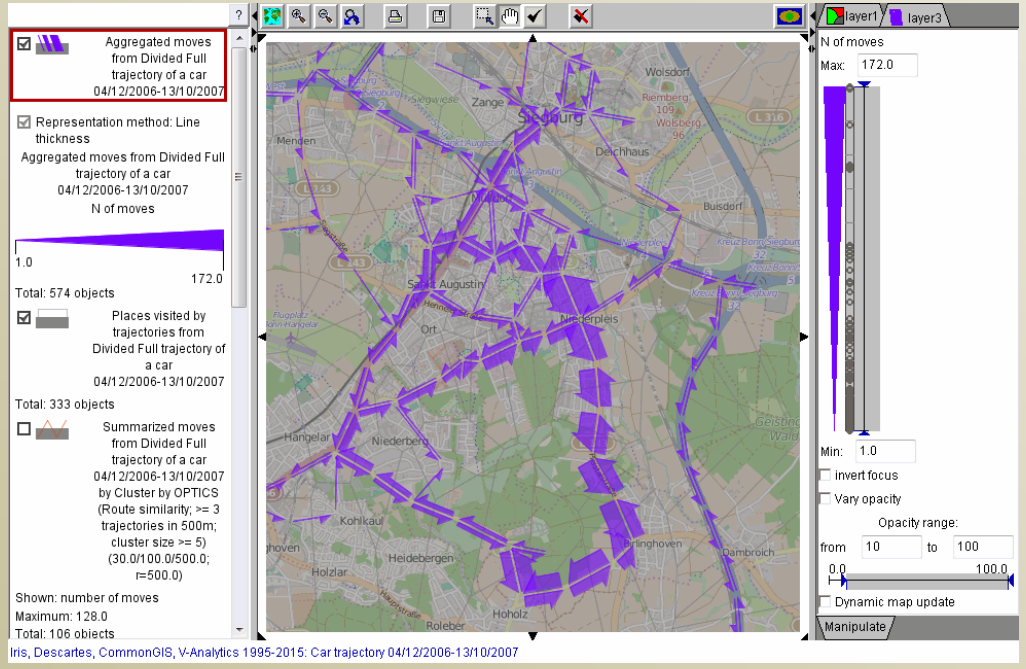
1. Restore the original time references in the trajectories
   - Menu “Other tools” > “Time functions” > “Transformation of the time references” >”Restore the original time references”
2. Cancel the filtering of the trajectories (make all clusters and “noise” visible).
3. Aggregate the trajectories:
   - Menu “Analyse” > “Trajectories: generalisation and summarisation” > a dialog for setting parameters appear; set “Desired radius of point clusters” to **500** (metres) > OK
   - A dialog for specifying the time division appears. Select the radio button “cycle of” and choose the cycle “hours in week”. Then press the second button “Divide”, to divide the weekly time cycle into intervals of 1 hour length.
   - The tool will ask you to confirm producing 168 time breaks; press “Yes” > press OK in the time division dialog.
   - In the next dialog, leave the default settings and press OK.





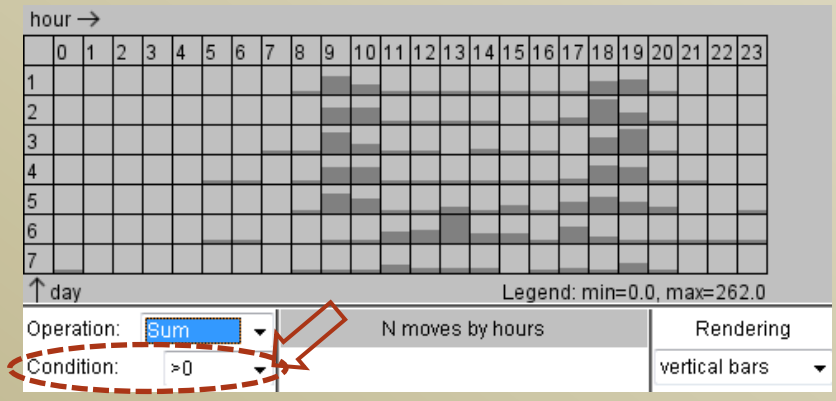
4. In the following dialog “Which aggregates?”, you may un check the aggregates that you do not need.
5. Question “Count also visits in neighbouring areas?” appears; press “No”.
6. A dialog with a suggested temporal parameter name “hour” appears; press OK (you do not need to edit the name).

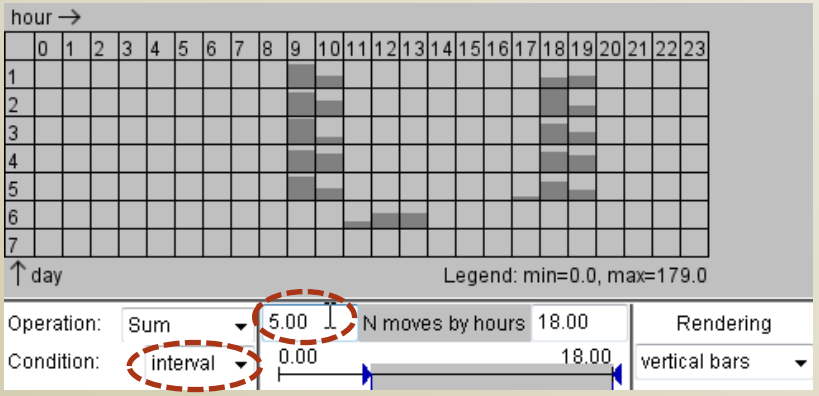
7. The system produces two new map layers with associated tables: “Places visited by trajectories …” consisting of Voronoi polygons and “Aggregated moves from …” consisting of flow links between neighbouring polygons. The system automatically visualises the total move counts by varying the widths of the flow symbols.



Exploration of the aggregation results

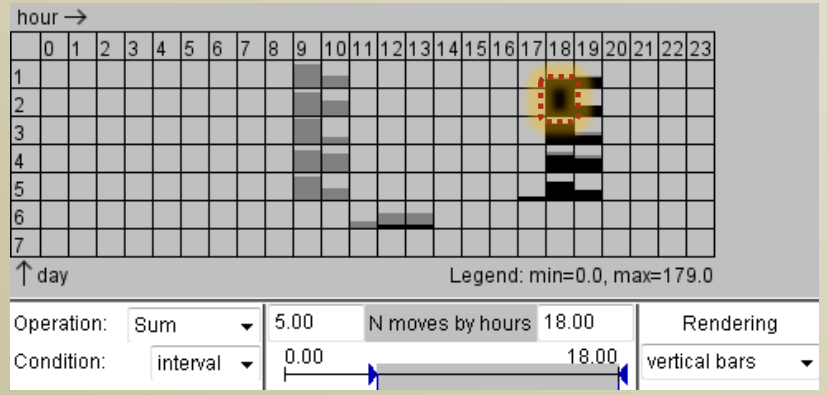
- For the aggregated moves, visualise the time series "(T) N moves by hours" on a 2D time histogram
  - Menu "Display" > "Display wizard" > select the attribute > select "2-dimensional histogram"



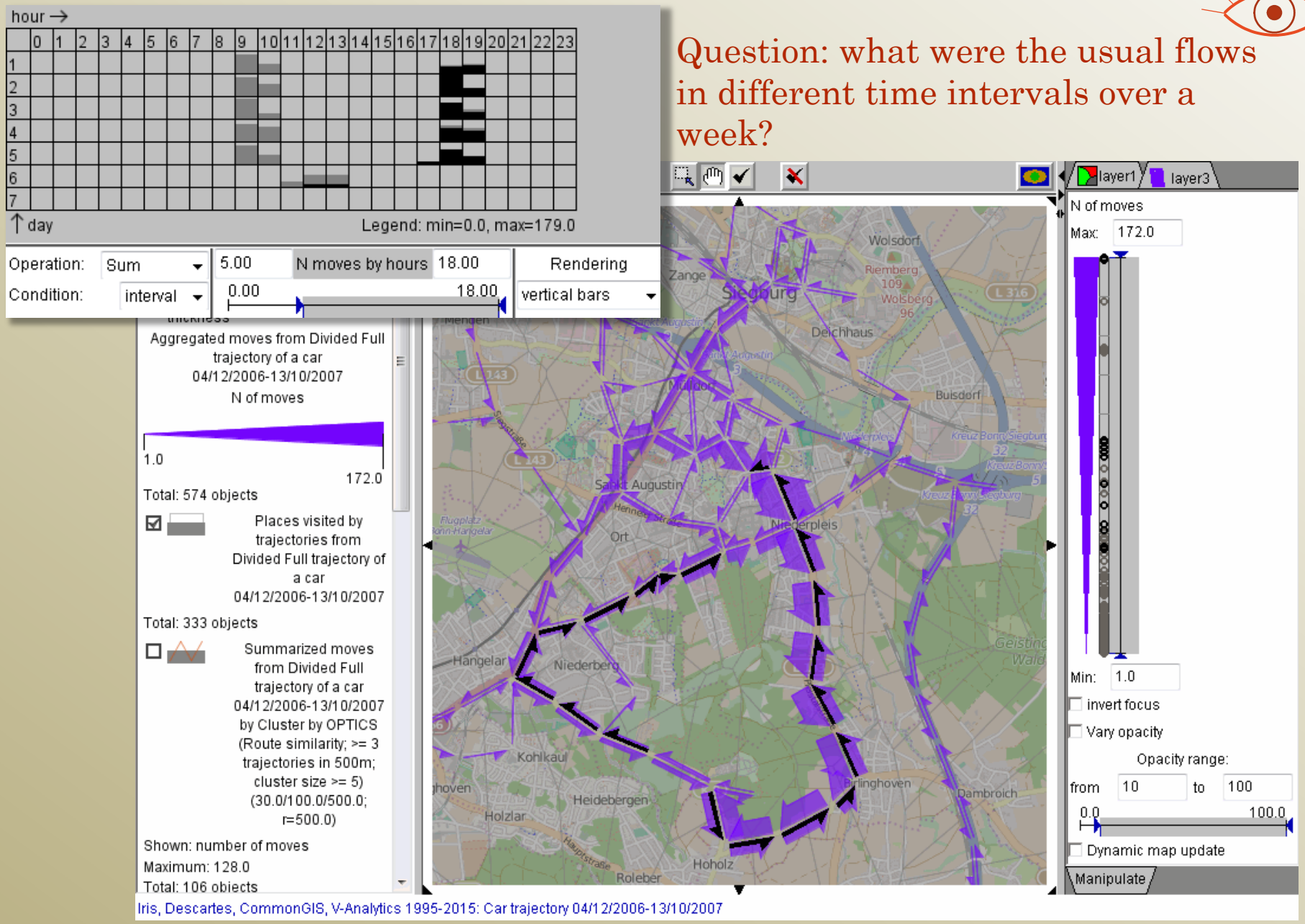


Change the condition (lower left corner) to "interval" and set the lower limit to 5 (to disregard occasional flows).

Clicking on cells will highlight on the map the links contributing to these cells (to cancel the highlighting, click again on the same cell or press button on the map).



Question: what were the usual flows in different time intervals over a week?



Iris, Descartes, CommonGIS, V-Analytics 1995-2015: Car trajectory 04/12/2006-13/10/2007