



Hands-on exercises

Natalia Andrienko^{1,2}

Gennady Andrienko^{1,2}

¹ Fraunhofer Institute IAIS, Sankt Augustin, Germany

² City, University of London, UK



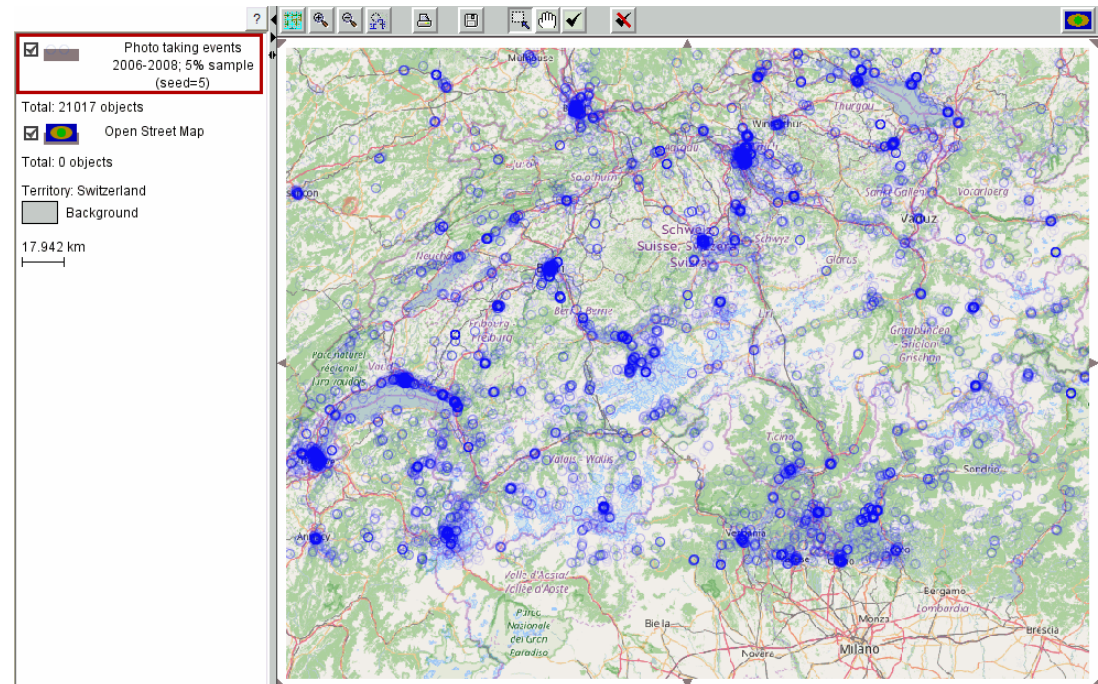
Objectives

- Look at examples of spatio-temporal data
 - Spatial events
 - Spatial time series
 - Trajectories
- Try a few interactive exploratory techniques
 - Visualisation
 - Interactive filtering
 - Combination of interactive visualisation with computational techniques
- Try some data transformations
 - Spatial events -> spatio-temporal aggregation -> spatial time series
 - Spatial events -> integration -> trajectories
 - Trajectories -> spatio-temporal aggregation -> spatial time series



Preparation to the exercises

- Start V-Analytics
 - receive an empty window with a menu at the top
- Menu "File" -> "Load project" -> "Browse" -> select file
photos_2006_2008_sample_5perc.app
in folder flickr_SZ





Data example

- Records describe georeferenced photos from flickr
 - geographical locations (X = longitude, Y = latitude), time of photo taking, image URL, title, user ID
- A 5% sample of the set of photo records from area of Switzerland and years 2006-2008 obtained using flickr API.
- Data type: spatial events; we do not look at the photos as such

	X	Y	Timestamp	User ID	URL	TITLE
3977	6.890100955963135	45.98252868652344	11/10/2008 11:54:00	19479382@N00	http://farm4.static.flickr	Lac Blanc et Aiguille du
3978	7.990322113037109	46.38104248046875	18/10/2008 10:34:00	19479382@N00	http://farm4.static.flickr	Glacier d Aletsch et Be
3979	6.936835765838623	46.48649978637695	02/01/2008 09:00:00	19479382@N00	http://farm3.static.flickr	Folly
3980	8.007488250732422	46.3948974609375	18/10/2008 12:11:00	19479382@N00	http://farm4.static.flickr	Pont suspendu sur la
3981	8.016586303710938	46.37879180908203	19/10/2008 07:17:00	19479382@N00	http://farm4.static.flickr	Riederfurka
3982	8.055038452148438	46.40105438232422	19/10/2008 08:17:00	19479382@N00	http://farm4.static.flickr	Fletschhorn; Lagginho
3983	8.091429710388184	46.427207946777344	19/10/2008 13:36:00	19479382@N00	http://farm4.static.flickr	Glacier d Aletsch
3984	6.246242046356201	46.3916130065918	18/05/2008 10:10:00	19479382@N00	http://farm3.static.flickr	Prangins
3985	6.246242046356201	46.3916130065918	18/05/2008 10:11:00	19479382@N00	http://farm4.static.flickr	Prangins
3986	6.81705904006958	46.35993194580078	21/06/2008 11:23:00	19479382@N00	http://farm4.static.flickr	Lac Léman
3987	6.802768230438232	46.35871505737305	21/06/2008 13:31:00	19479382@N00	http://farm3.static.flickr	Jumelles
3988	6.824225902557373	46.33027648925781	22/06/2008 13:46:00	19479382@N00	http://farm4.static.flickr	Col de Verne
3989	7.306251049041748	46.04678726196289	16/07/2008 10:05:00	19479382@N00	http://farm4.static.flickr	Combin de Corbassière
3990	6.581282138824463	46.29096984863281	19/07/2008 13:17:00	19479382@N00	http://farm4.static.flickr	Mont Billiat
3991	7.643221855163574	46.09287643432617	02/08/2008 12:37:00	19479382@N00	http://farm4.static.flickr	Pointe d Arpitetta
3992	6.026494026184082	47.23564529418945	20/12/2006 19:59:00	19534347@N00	http://farm1.static.flickr	musiques de Rues6

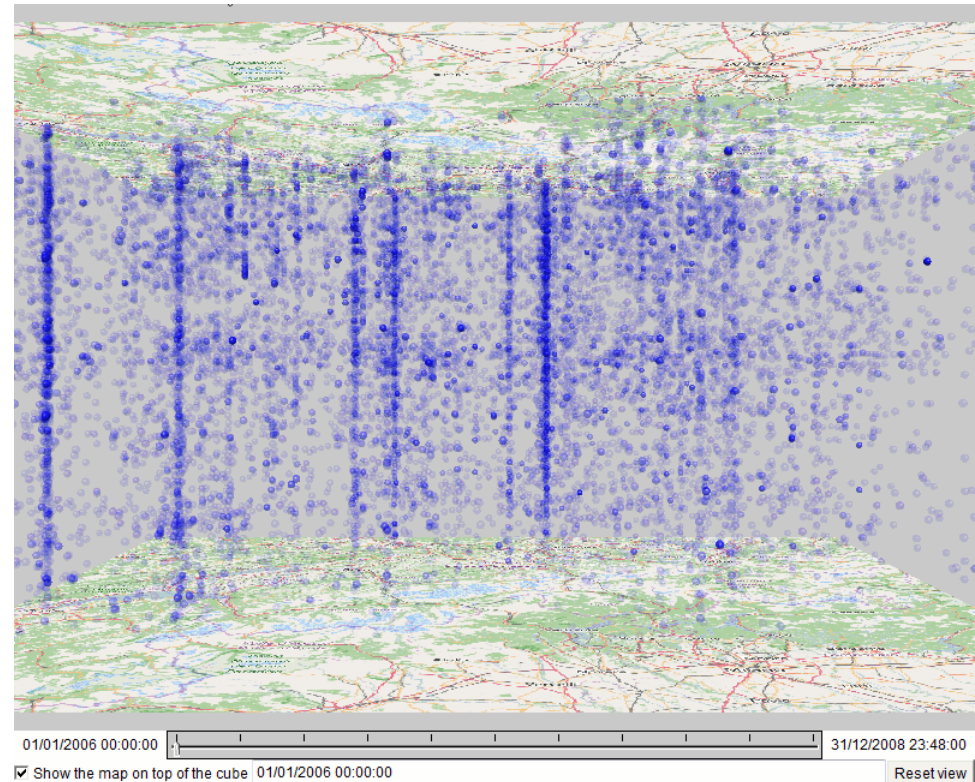
Sort by: No selection Ascending ☐ TableLens Attribute...

Can be got through menu "Display" -> "Table view"



Space-time cube

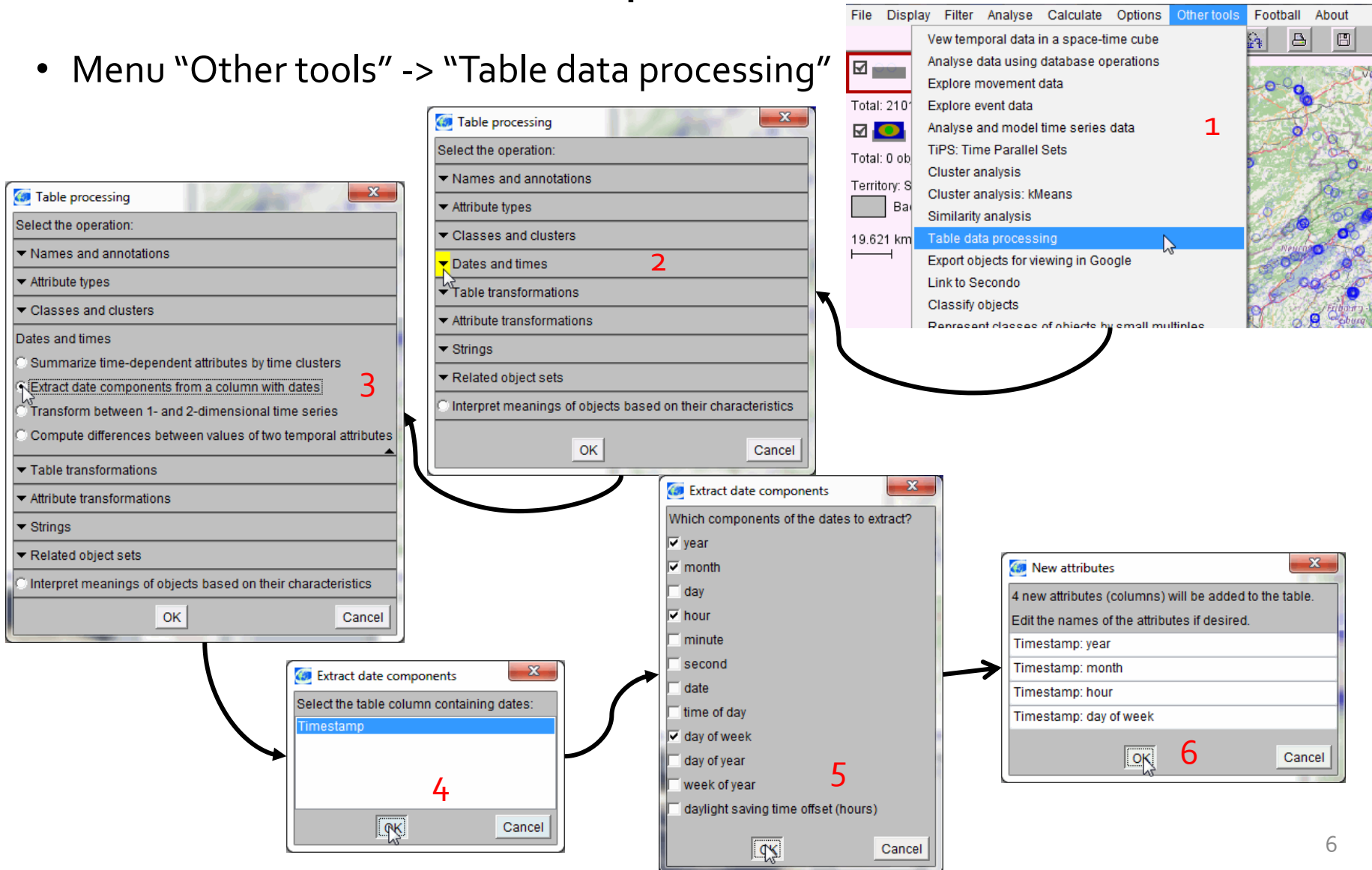
- Menu “Display” -> “Space-time cube” -> dialog appears -> “OK”
- Interactive operations:
 - Switch on and off the upper map: checkbox “Show the map on top of the cube”
 - Rotate the view left or right: press RMB (right mouse button) and move the mouse left or right
 - Move closer to or farther from the viewpoint: press RMB and move the mouse down or up
 - Shift left, right, up, down, etc.: press LMB (left mouse button) and move the mouse
 - Rotate the view forward or backward: press RMB while pressing Control key and move the mouse down or up
 - Reset the view: double-click or button “Reset view”





Extract date/time components

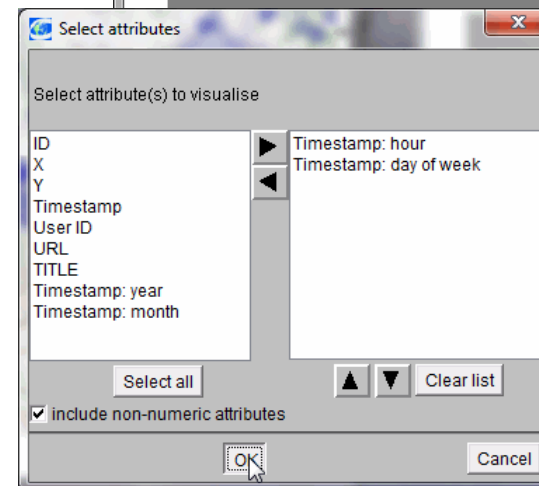
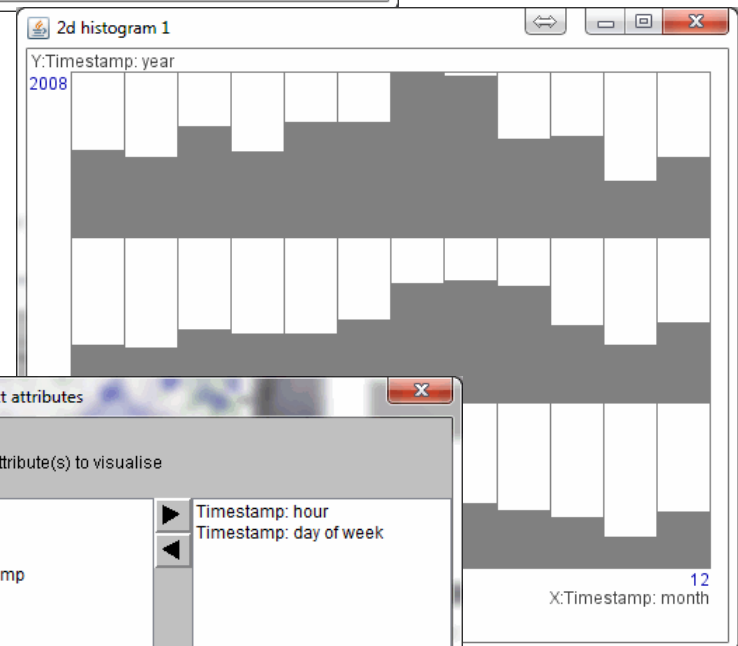
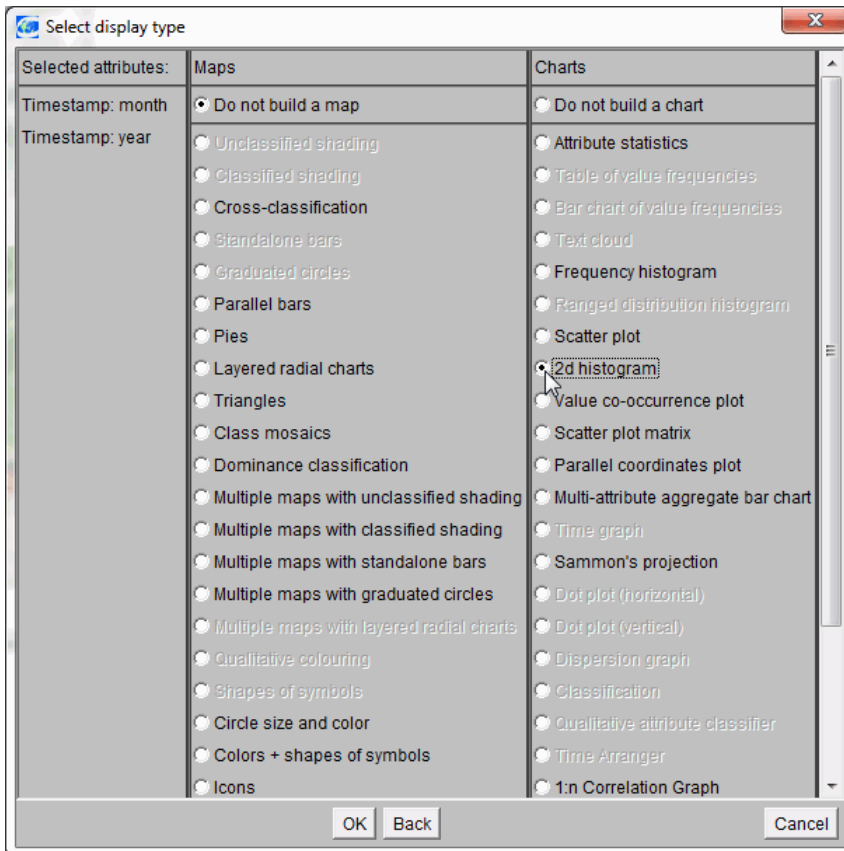
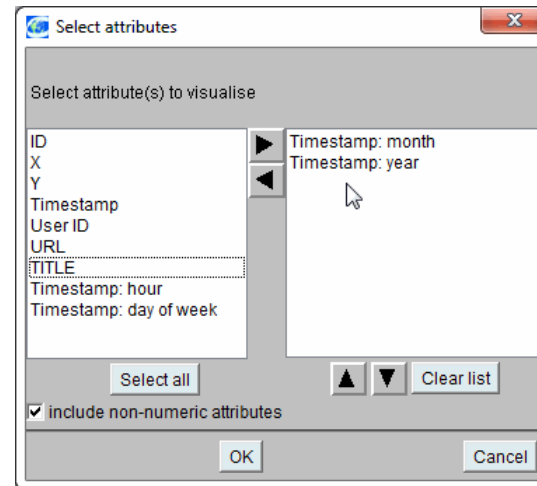
- Menu "Other tools" -> "Table data processing"





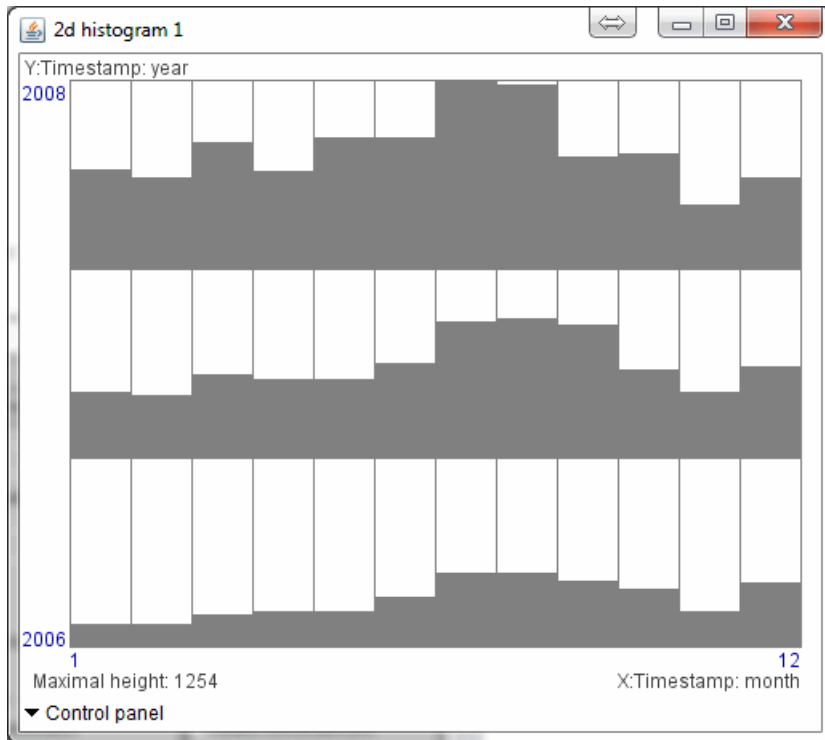
2D histograms

- Menu "Display" -> "Display wizard"
-> select attributes

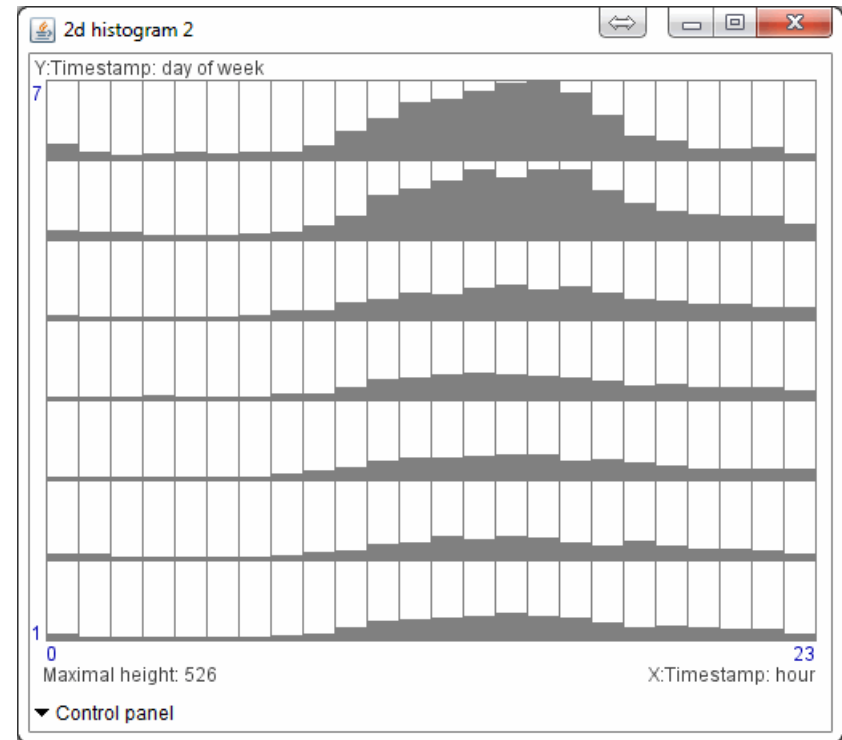




2D histograms of temporal distribution



Months and years

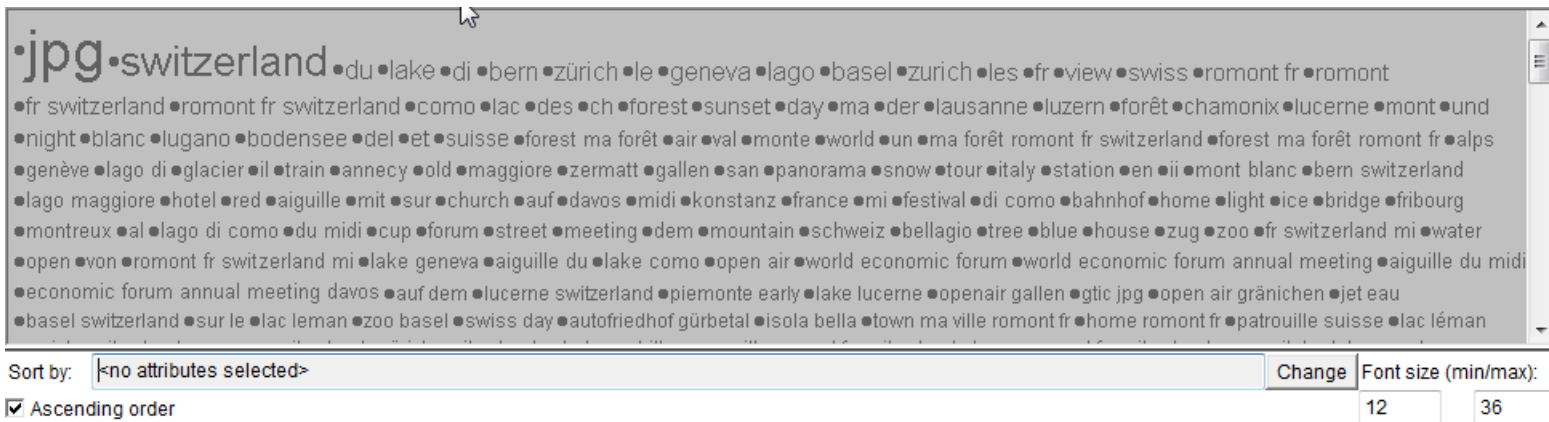


Hours and days of week



Get a summary of text from photo titles

- Start the text summarization tool:
 - Menu “Analyse” > “Texts: extract frequent terms”
 - > a dialog for table column selection appears; select TITLE and press OK > a dialog for setting tool parameters appears.
 - Load a list of stop words from a file: press the button “Take words from text file”, then browse and select the file “stop_words.txt” from the folder with the data.
 - Press “OK” in the dialog.





•lake•bern•zürich•geneva•lago•basel•zurich•view•swiss•romont•como•lac
•forest•sunset•day•ma•lausanne•luzern•forêt•chamonix•lucerne•mont•night•blanc•lugano•bodensee
•suisse•forest ma forêt•air•val•monte•world•un•forest ma forêt romont•alps•genève•glacier•train•annecy•old
•maggiore•zermatt•gallen•san•panorama•snow•tour•italy•station•en•ii•mont blanc•lago maggiore•hotel•red•aiguille
•mit•sur•church•auf•davos•midi•konstanz•france•mi•festival•bahnhof•home•light•ice•bridge•lago como•fribourg•montreux•al
•cup•forum•street•meeting•dem•mountain•schweiz•bellagio•tree•blue•house•zug•zoo•water•open•von•castle•ville•die•valley
•axalp•town•chateau•au•chillon•romont mi•lake geneva•winter•col•parade•matterhorn•isola•lake como•open air
•world economic forum•aiguille midi•world economic forum annual meeting•economic forum annual meeting davos•auf dem•piemonte early
•lake lucerne•openair gallen•open air gränichen•jet eau•lac leman•zoo basel•swiss day•autofriedhof gürbetal•isola bella•town ma ville romont
•home romont•patrouille suisse•lac léman•chateau chillon•como italy•lake parade•axalp ebenfluh•valle aosta•zürcher kantonal schwingfest

Sort by:

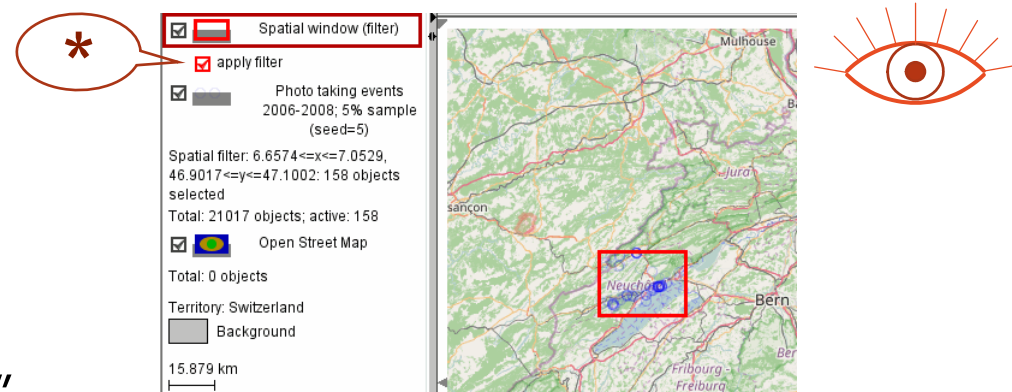
Change Font size (min/max):

☒ Ascending order

12

36

Spatial filtering



- Activate the filter “Spatial window”
 - Menu “Filter” > “Spatial window” > drag the mouse with the left button pressed over the map to create a rectangle, release the button > the data are filtered by the selected rectangle
 - The filter can be changed* by mouse-dragging applied to any of the sides, corners, or the of the rectangle. Dragging in a different part of the map creates a new spatial window and erases the old one.
- Change the position and extent of the spatial window and observe
 - How many spatial events occurred in different areas (shown in the legend on the left of the map)
 - How the events were distributed in time (use the histograms) and in space-time (use the space-time cube)
 - What words frequently appeared in the photo titles

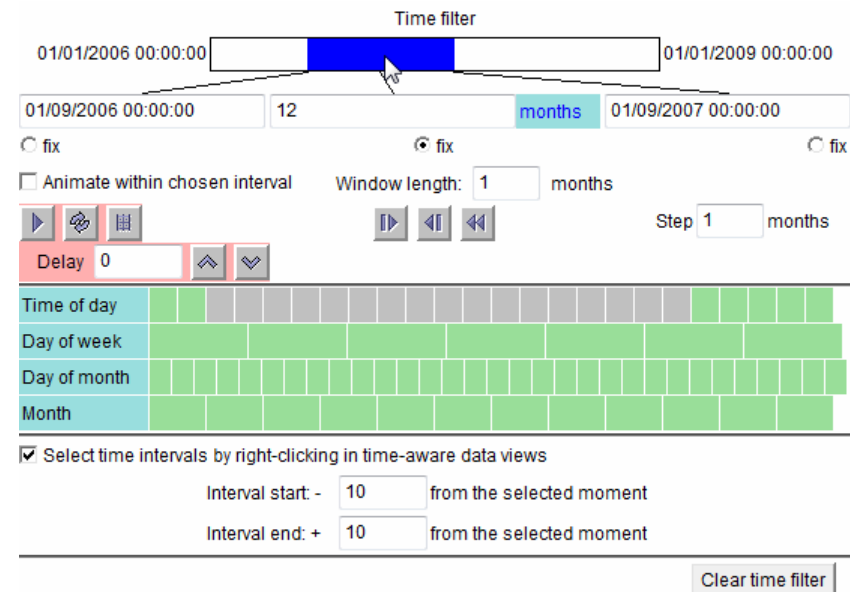
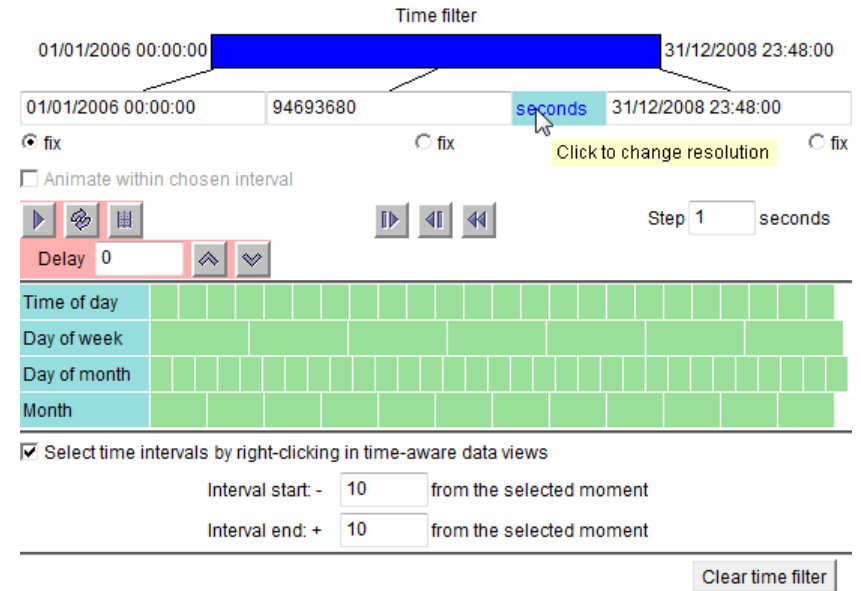
* The interactive operations for changing the filter are enabled when the item “Spatial window (filter)” is active, i.e., marked with a red frame.

To deactivate the spatial filter: menu “Filter” > uncheck the item “Spatial window”



Temporal filtering

- Activate the time filter
 - Menu "Filter" > "Time filter" (at the bottom) > a window with time filtering controls appears
- Interactive operations:
 - Changing time unit: click on "seconds" or another time unit label
 - Changing the extent of the time window: move the right or left side of the blue slider bar by mouse dragging
 - Moving the time window: position the mouse cursor in the centre of the blue slider bar and drag with the mouse to the right (forward in time) or to the left (backward in time)
 - Click on or drag over the green rectangles to (de)select positions in time cycles





Density-based clustering of spatial events by spatio-temporal proximity

- Clear all filters
- Activate the clustering tool:
 - Menu "Analyse" > "Events: density-based clustering" > a dialog appears; the layer with the events is pre-selected > press OK
- Look at the default clustering parameters
 - Set the spatial distance threshold to 5000 m and the temporal distance threshold to 3 hours.
- To run the clustering, press OK
- After the clustering finishes, the system shows the results in two ways:
 - The dots representing the events in the map and space-time cube are coloured according to their cluster membership. Grey colour is used for "noise".
 - For each cluster, excluding the "noise", the system builds its convex hull. A new map layer with the hulls of all clusters is added to the map. The interiors of the hulls are painted in the same colours as the dots from the respective clusters.

Dimensions of the event set:

X-extent: 343675.91 m
Y-extent: 220875.12 m
Time span: 01/01/2006 00:00:00 .. 31/12/2008 23:48:00
Number of active events: 21017 (100.00% of the total 21017 events)

Define the spatio-temporal neighbourhood of an event:

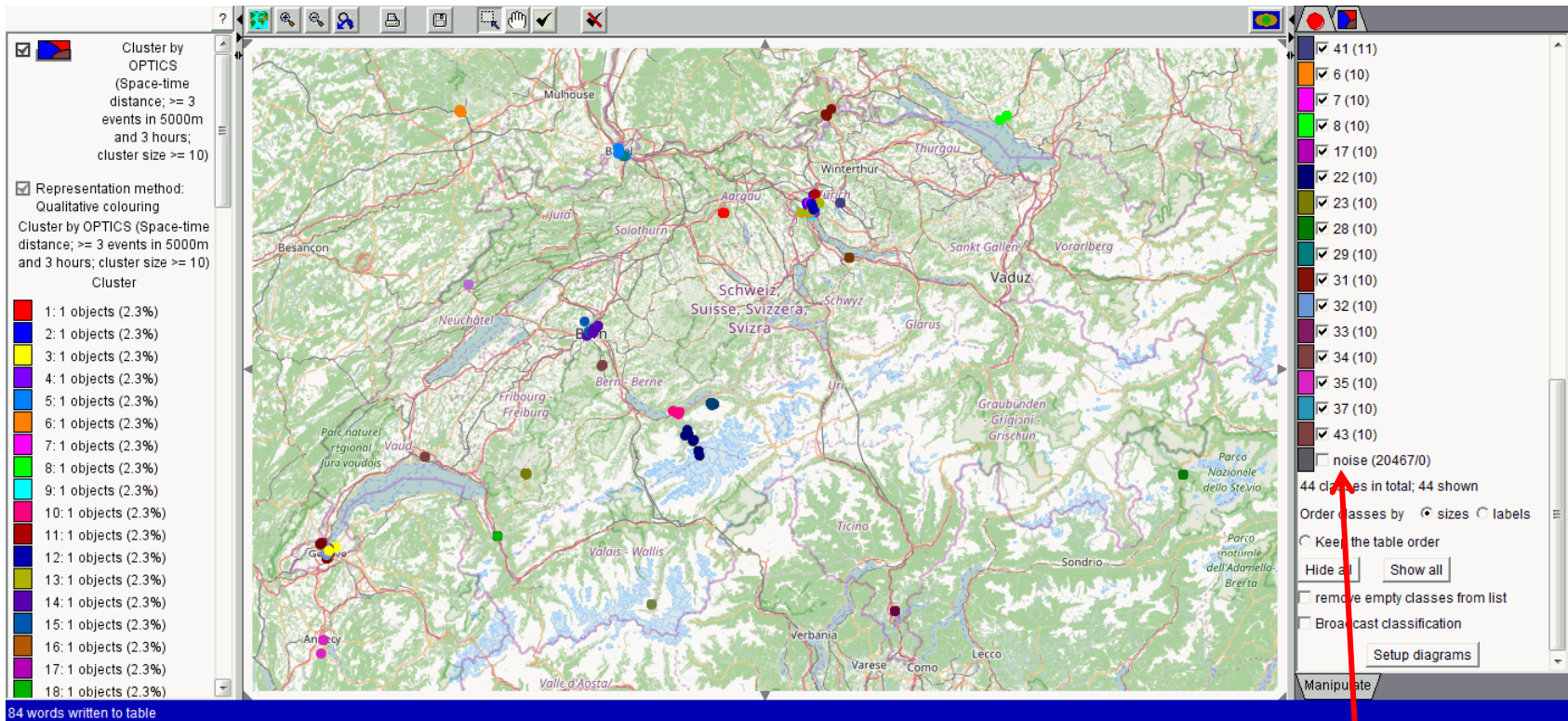
Spatial distance threshold: 5000 m
Temporal distance threshold: 3 hours

☐ Use additional attributes of the events

Minimal number of events in the neighbourhood *: 3
* required for an event to be in cluster core

☒ Ignore clusters with less than 10 events

OK Cancel



Filter the noise out

Reacts to filtering →

•parade•zürich•air•zürcher kantonal schwingfest•schwingfest•kantonal•zürcher
•lake•laternenausstellung•geneva•circle kingz•circle•streetparade•zurich•kingz
•axalp•lake parade geneva•open air gränichen•blues bop•blues•gränichen•bop•open•street
•street parade•freestyle•streetparade zürich•basel•street parade zurich•sechseläuten•patrouille
•patrouille suisse•genève•suisse•blues bop gran finale•eurockeenes•finale•eurocks•luzern•gran•bern•lugano blues bop•air show
•feux artifice•super puma•feux•show•rafale•euro•ted•ligety•au•lokal•artifice•puma•holland•avenger•lugano•weggis•super•heaven
•phoebe killdeer short straws eurockeenes•niederlande italien/the netherland vs italy•streetparade street parade zurich•feux artifice Genève•euro oraniefans bern
•feu fêtes Genève•el lokal•fow bus•basel holland-russland•au semnoz•oranges basel•weathered sculpture•red arrows•oranjegekte basel•sväjc•niederlande
•volkswagen•netherland•bus•von•jungfraujoch•cologny•fans•weathered•fêtes•sculpture•phoebe•matt•oranges•vs•impressionen•short•lr•rinspeed•el•red
•killdeer•Genève•russland•italien/italien/the•oranjegekte•arrows•renault•***•oranjefans•feu•fow•semnoz•moelgg•straws

Sort by: <no attributes selected>

Change Font size (min/max):

✓ Ascending order

12

36

Clusters can be selected one by one



☐ Cluster by OPTICS (Space-time distance; ≥ 3 events in 5000m and 3 hours; cluster size ≥ 10)

☐ Qualitative colouring

Total: 43 objects

☒ Photo taking events
2006-2008; 5% sample (seed=5)

☒ Representation method:
Qualitative colouring
Photo taking events 2006-2008; 5% sample (seed=5)

1: 11 objects (0.1%); active:
2: 12 objects (0.1%); active:
3: 12 objects (0.1%); active:
4: 11 objects (0.1%); active:
5: 11 objects (0.1%); active:

Cluster by OPTICS (Space-time distance; ≥ 3 events in 5000m and 3 hours; cluster size ≥ 10)

- ☐ 12 (29/0)
- ☒ 9 (26)
- ☐ 5 (20/0)
- ☐ 10 (19/0)
- ☐ 11 (17/0)
- ☐ 21 (16/0)
- ☐ 16 (15/0)
- ☐ 18 (15/0)
- ☐ 20 (15/0)
- ☐ 19 (14/0)
- ☐ 25 (14/0)
- ☐ 26 (14/0)
- ☐ 42 (14/0)
- ☐ 15 (13/0)
- ☐ 27 (13/0)
- ☐ 2 (12/0)
- ☐ 3 (12/0)
- ☐ 13 (12/0)
- ☐ 1 (11/0)
- ☐ 4 (11/0)

•streetparade•zürich•street parade•streetparade zürich•parade•street

•street parade zurich•zurich•streetparade street parade zurich

	X	Y	Timestamp	User ID	URL	TITLE	Cluster by OPTICS (Space-time distance; ≥ 3 events in 5000m and 3 hours; cluster size ≥ 10)
3818	8.547104835510254	47.362693786621094	09/08/2008 13:14:00	20188798@N08	http://farm4.static.flickr	CH Streetparade Zurich	9
3819	8.547104835510254	47.362693786621094	09/08/2008 13:31:00	20188798@N08	http://farm4.static.flickr	CH Streetparade Zurich	9
7618	8.542598724365234	47.366981506347656	09/08/2008 13:42:00	29344065@N02	http://farm4.static.flickr	Street Parade de Zurich	9
13806	8.542757034301758	47.37183380126953	09/08/2008 13:43:00	65933351@N00	http://farm4.static.flickr	P1030986.JPG	9
3820	8.547104835510254	47.362693786621094	09/08/2008 13:50:00	20188798@N08	http://farm4.static.flickr	CH Streetparade Zurich	9
14176	8.542814254760742	47.36699676513672	09/08/2008 14:09:00	69203899@N00	http://farm3.static.flickr	StreetParade / Street P	9
14177	8.542814254760742	47.36699676513672	09/08/2008 14:14:00	69203899@N00	http://farm4.static.flickr	StreetParade / Street P	9
7793	8.540152549743652	47.37126922607422	09/08/2008 14:24:00	30771517@N08	http://farm4.static.flickr	Street Parade 08	9
19223	8.544230461120605	47.367069244384766	09/08/2008 14:27:00	90472709@N08	http://farm4.static.flickr	DSC06633	9
14178	8.542814254760742	47.36699676513672	09/08/2008 14:30:00	69203899@N00	http://farm4.static.flickr	Street Parade 2008 Zu	9
18292	8.54769515991211	47.362850189208984	09/08/2008 15:05:00	86675534@N00	http://farm4.static.flickr	Foam	9
13807	8.55154800415039	47.35639572143555	09/08/2008 15:12:00	65933351@N00	http://farm4.static.flickr	Cops	9
13808	8.549031257629395	47.359867095947266	09/08/2008 15:38:00	65933351@N00	http://farm4.static.flickr	Cops	9
3821	8.547104835510254	47.362693786621094	09/08/2008 15:42:00	20188798@N08	http://farm4.static.flickr	CH Streetparade Zurich	9
8384	8.535690307617188	47.36470031738281	09/08/2008 15:57:00	33058881@N00	http://farm4.static.flickr	Switzerland Zürich Aou	9
7651	8.542598724365234	47.366981506347656	09/08/2008 16:00:00	29344065@N02	http://farm4.static.flickr	Street Parade de Zurich	9
1344	8.542256355285645	47.3670539855957	09/08/2008 16:35:00	12389974@N06	http://farm4.static.flickr	Streetparade 2008	9
1404	8.546139711710205	47.364402770996094	09/08/2008 16:39:00	12142259@N00	http://farm3.static.flickr	Fasten your...	9
2811	8.540276527404785	47.36616516113281	09/08/2008 17:56:00	16142991@N00	http://farm4.static.flickr	Streetparade2008	9
3822	8.547104835510254	47.362693786621094	09/08/2008 19:01:00	20188798@N08	http://farm4.static.flickr	CH Streetparade Zurich	9
7022	8.53363037109375	47.374637603759766	09/08/2008 19:19:00	28334498@N06	http://farm4.static.flickr	Switzerland Zürich Aou	9
3402	8.542512893676758	47.36699092709961	09/08/2008 19:24:00	17786864@N00	http://farm4.static.flickr	DSC_0245	9
3823	8.547104835510254	47.362693786621094	09/08/2008 19:24:00	20188798@N08	http://farm4.static.flickr	CH Streetparade Zurich	9
18771	8.543000221252441	47.367000579833984	09/08/2008 20:03:00	88471614@N00	http://farm4.static.flickr		9
5250	8.536291122436523	47.343780517578125	09/08/2008 21:25:00	23169641@N03	http://farm4.static.flickr	Bike @ Rote Fabrik	9
3824	8.547104835510254	47.362693786621094	09/08/2008 23:57:00	20188798@N08	http://farm4.static.flickr	CH Streetparade Zurich	9

Sort by: <no attributes selected>

☒ Ascending order

☒ group by classes Sort by: Timestamp Ascending ☐ TableLens Attribute...

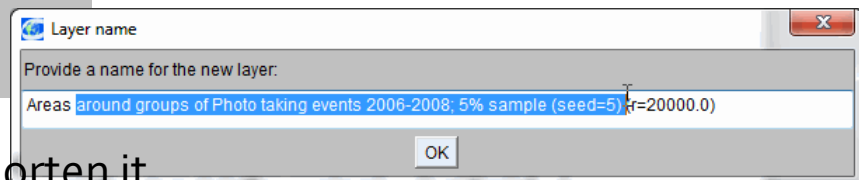
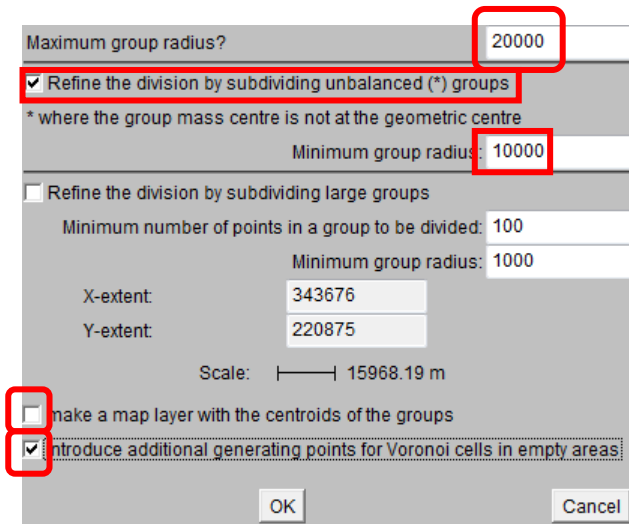
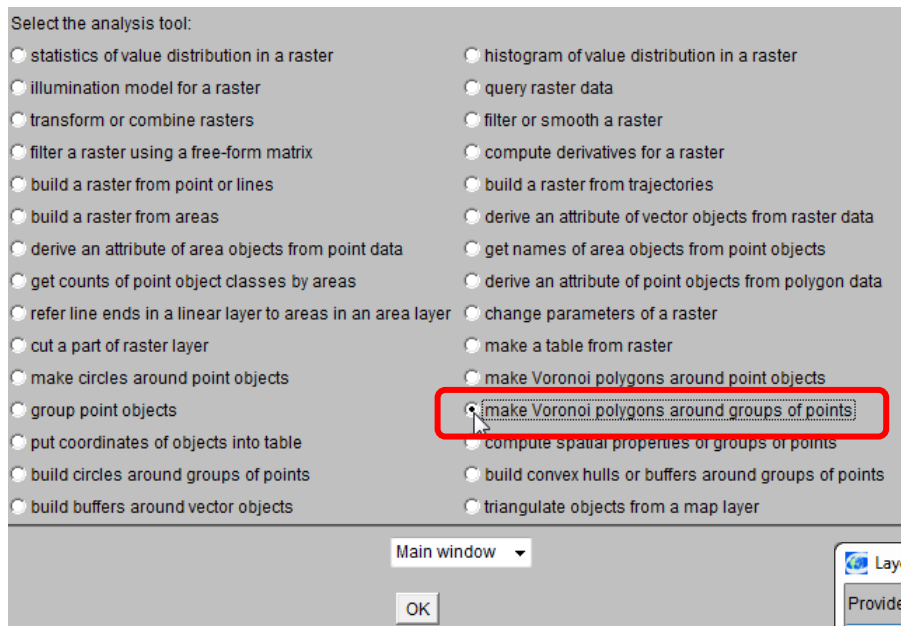
Can be got through menu "Display" -> "Table view"



Spatio-temporal aggregation of events

Step 1: space tessellation

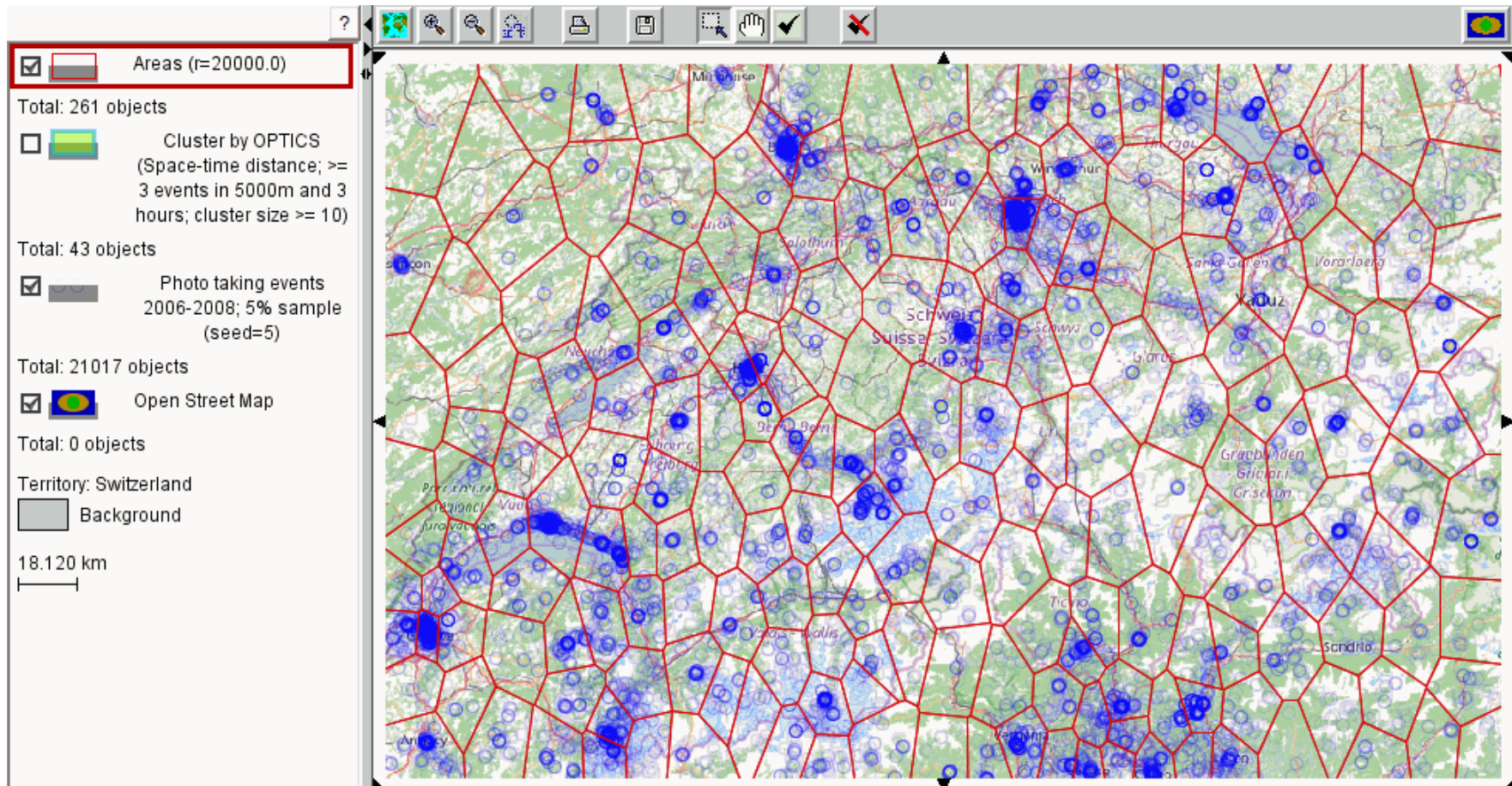
- Clear all filters (you can also “clean the map” through menu “Display”)
- Menu “Calculate” -> “Spatial calculations” -> “Make Voronoi polygons around groups of points” -> OK -> select the layer with points (pre-selected in the dialog) -> OK -> dialog for settings; make settings -> OK



You can edit the name, e.g., shorten it



Voronoi tessellation

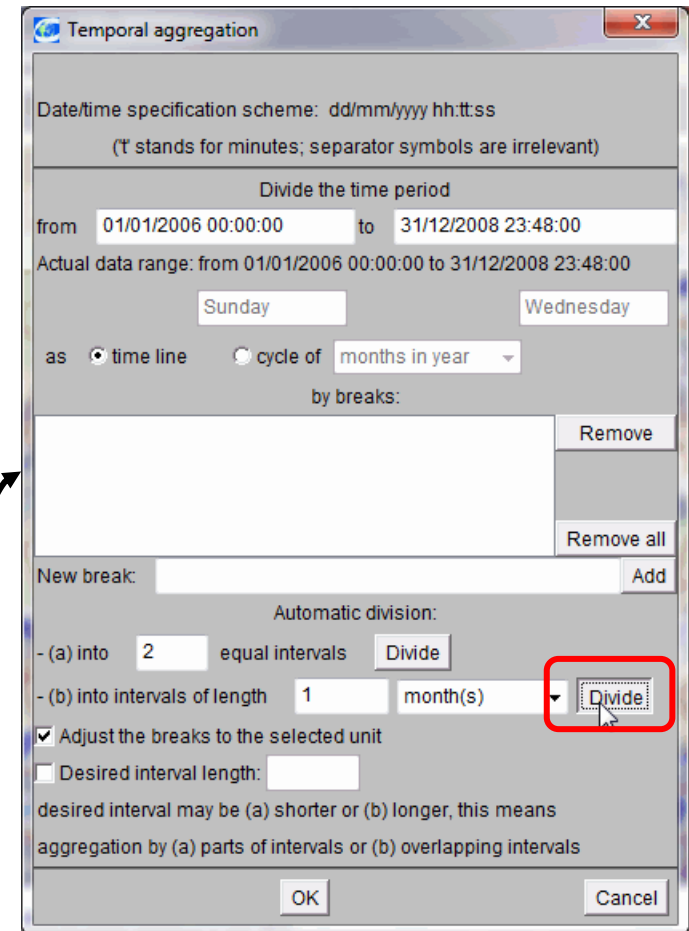
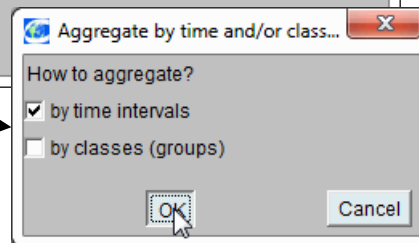
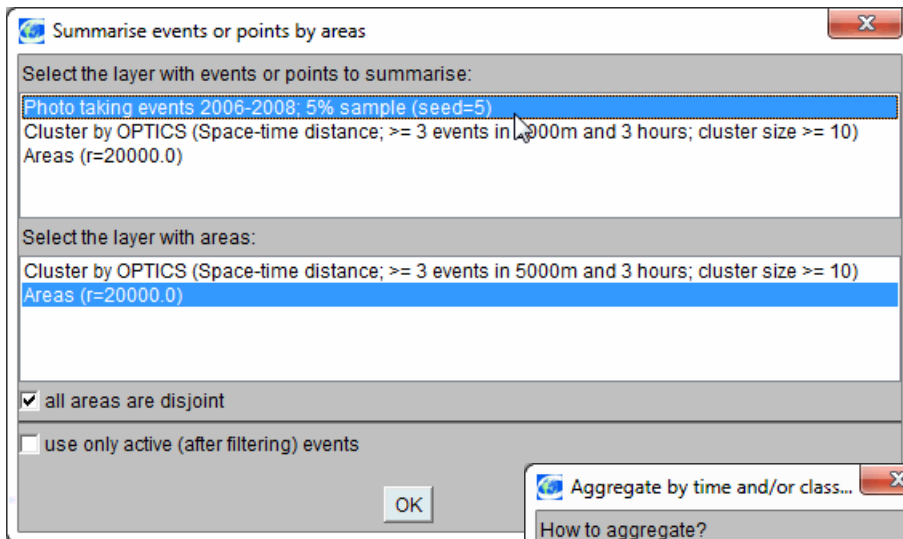


Iris, Descartes, CommonGIS, V-Analytics 1995-2017: Photo taking events 2006-2008; 5% sample



Spatio-temporal aggregation of events

- Menu "Analyse" ->
"Events: spatio-temporal aggregation"

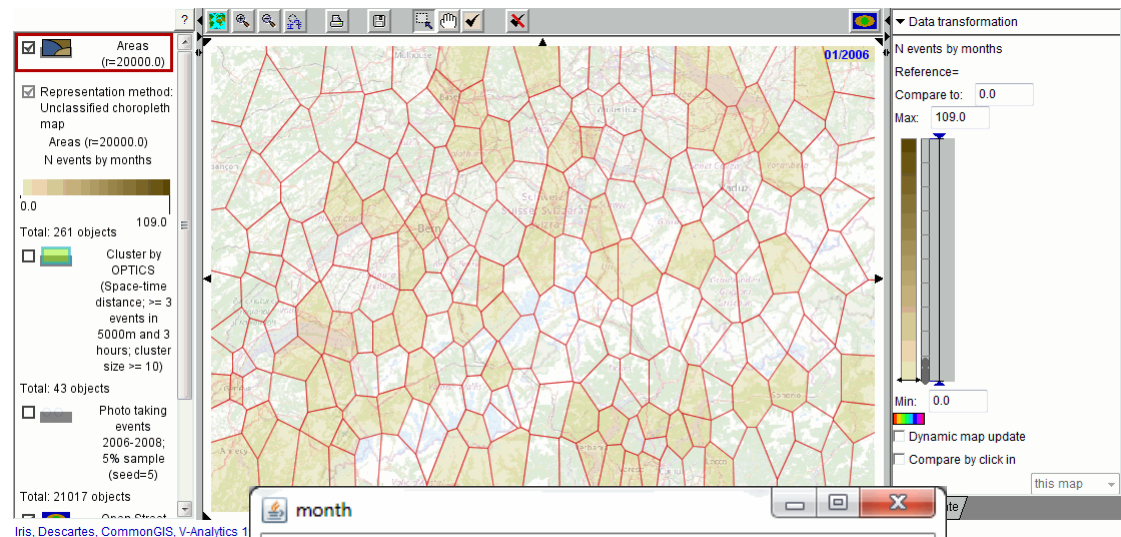
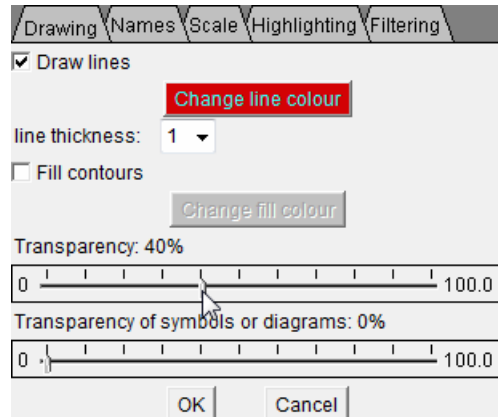
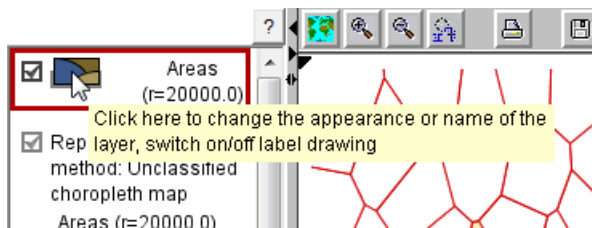


Press OK in the sequence of dialogs that comes next;
answer "No" to question "Account for neighbours"

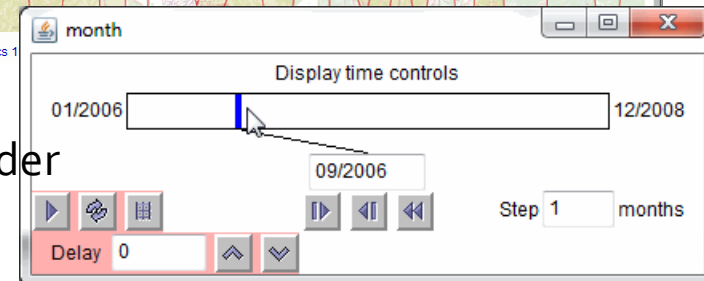


Visualisation of time series: animated map

- Menu “Display” -> “Display wizard” -> select table “Areas ...” (last in the list)
-> select attribute “(T) N events by months” -> select “Animated map” ->
select “Unclassified choropleth map”
- Increase layer transparency



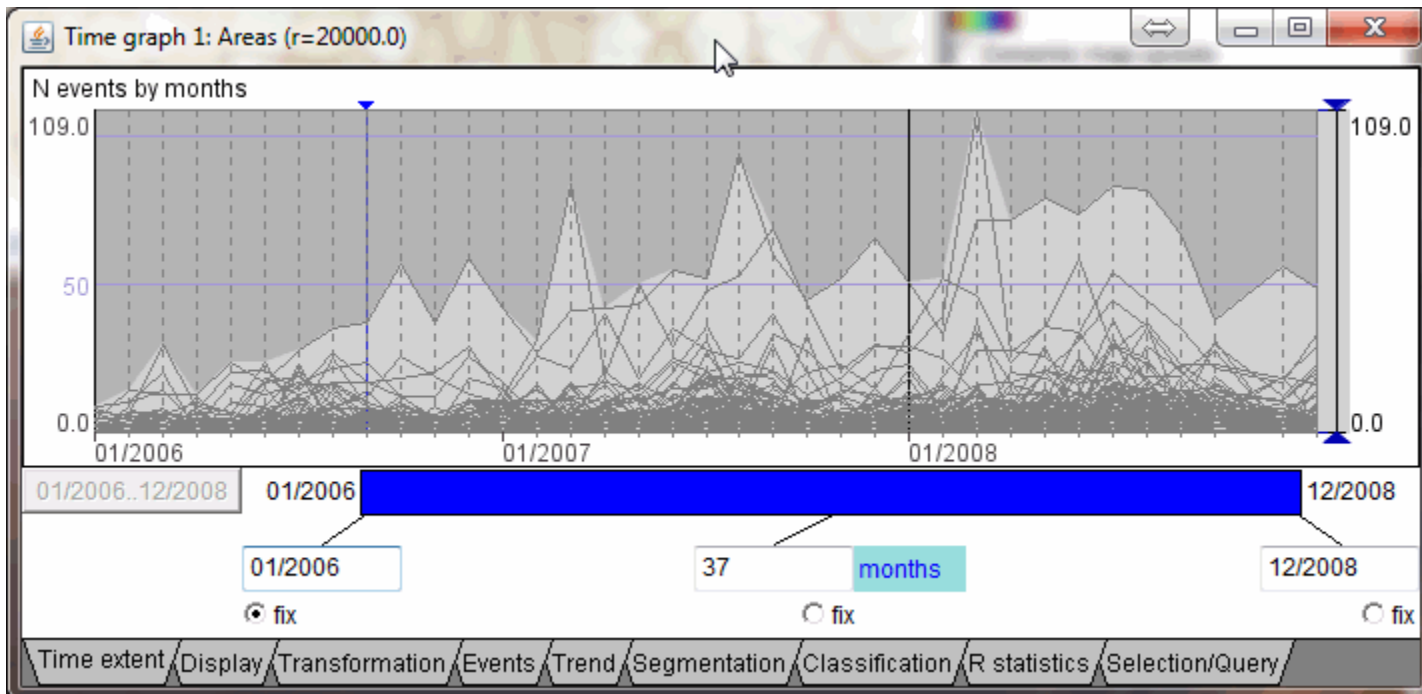
Move the slider





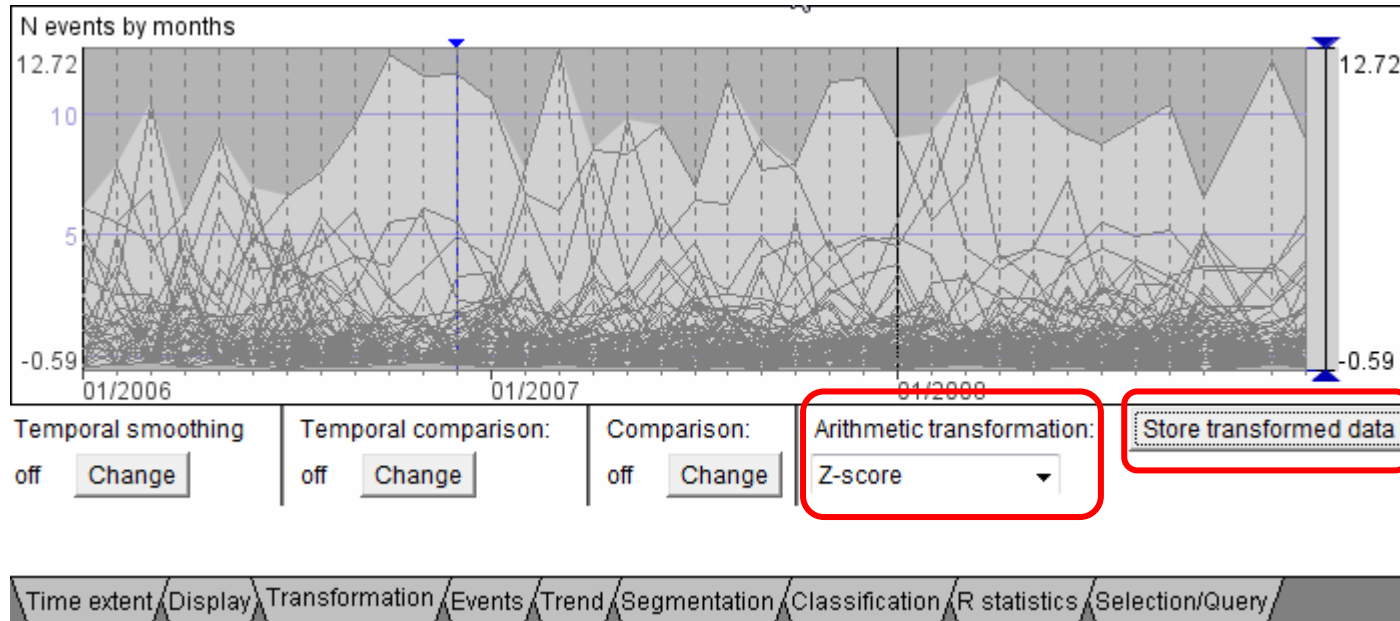
Visualisation of time series: time graph

- Started in the same way as animated map

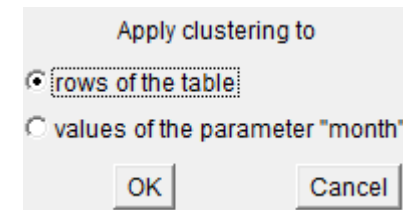




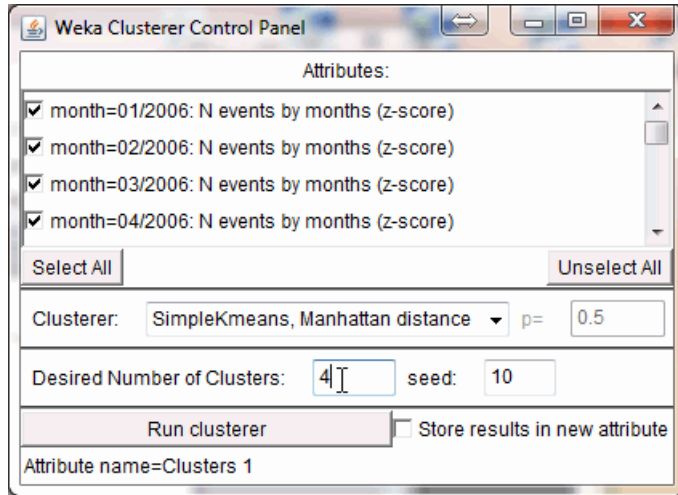
Transform the original values to z-scores and store transformed data



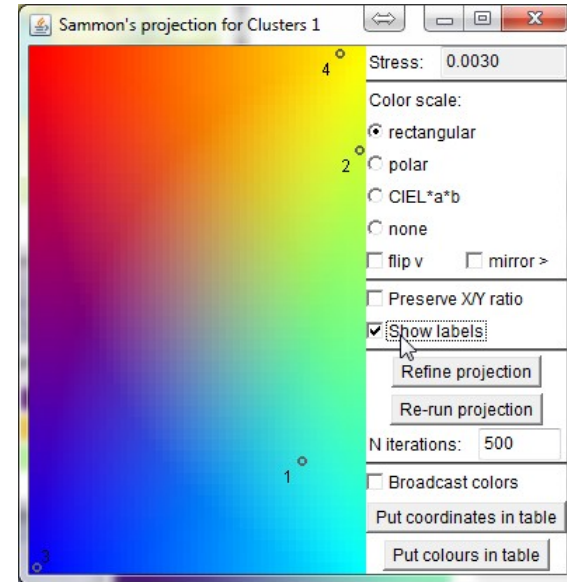
Apply 2-way k-means clustering to the transformed data:
Menu "Analyse" -> "K-means clustering" -> select table
"Areas ..." -> select the transformed time series -> select
all time steps (just press OK in the selection dialog)



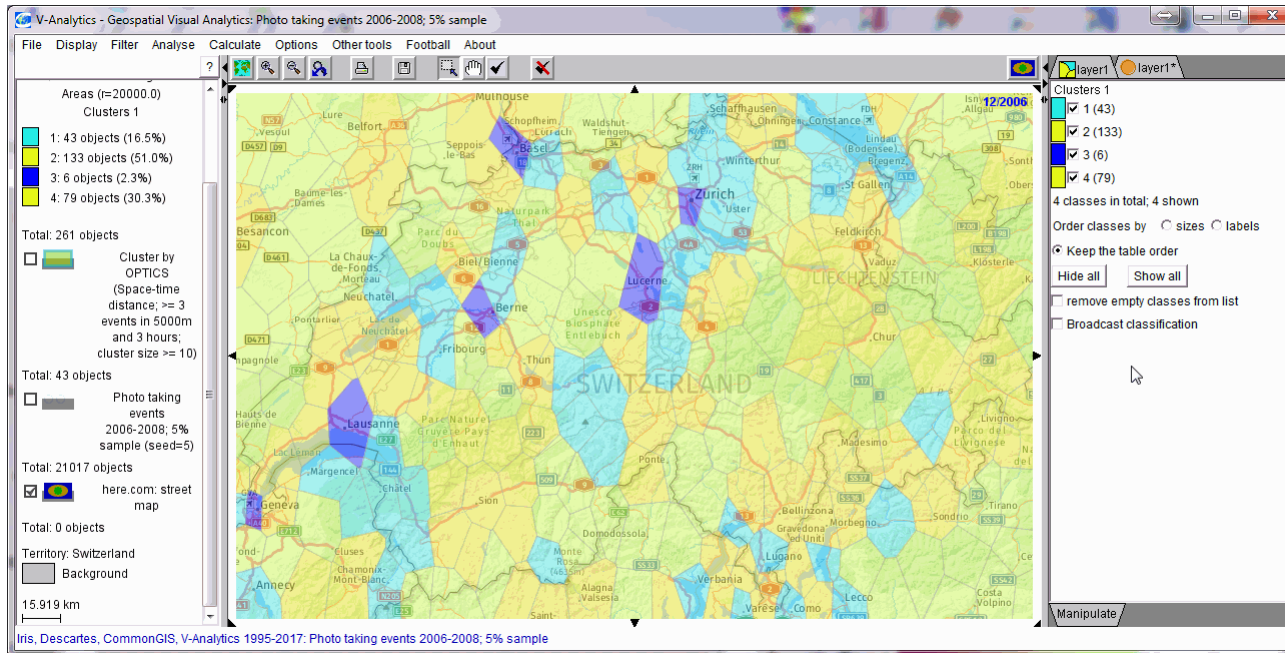
Clustering parameters setting



Assignment of colours to clusters

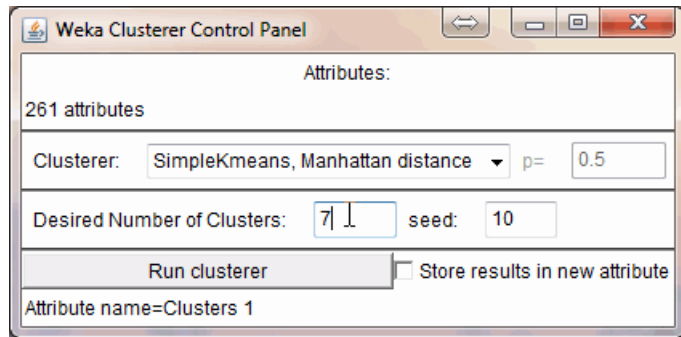


Clustering of rows = places



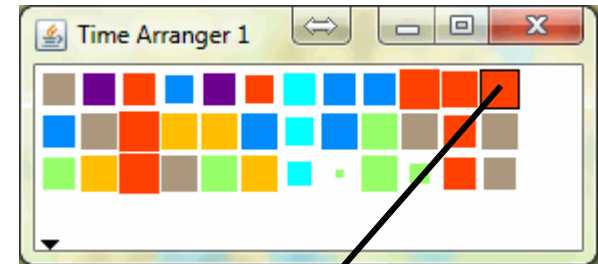


Clustering parameters setting

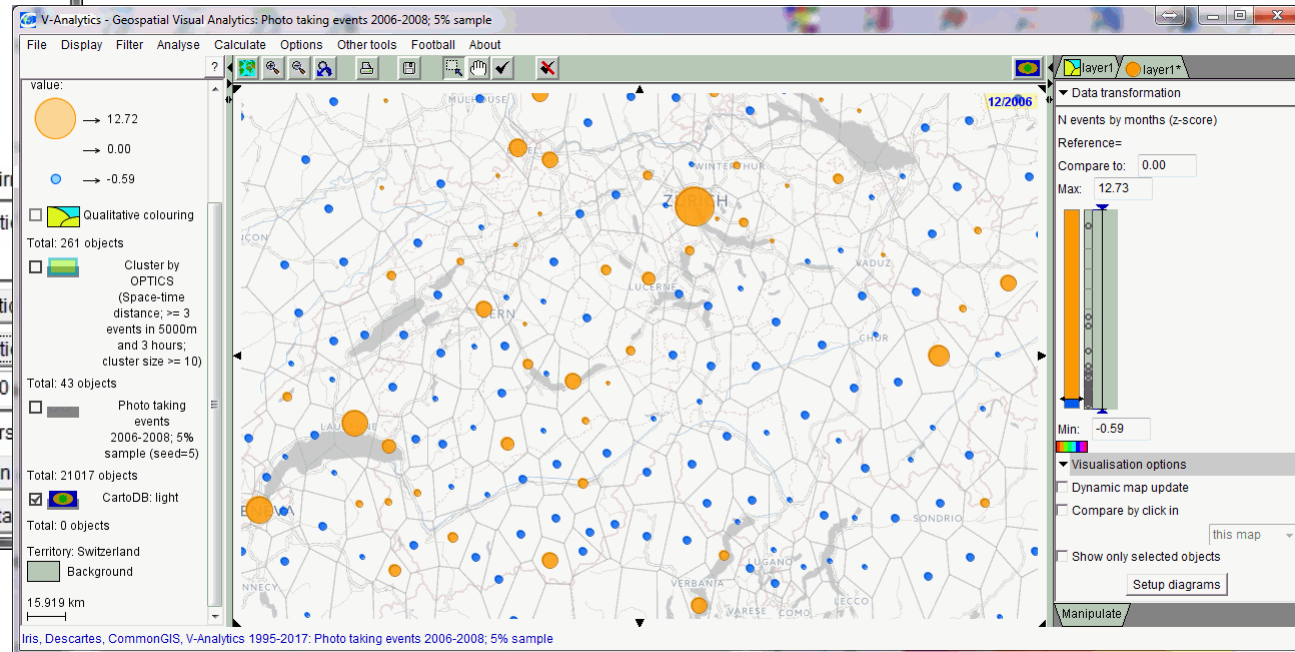
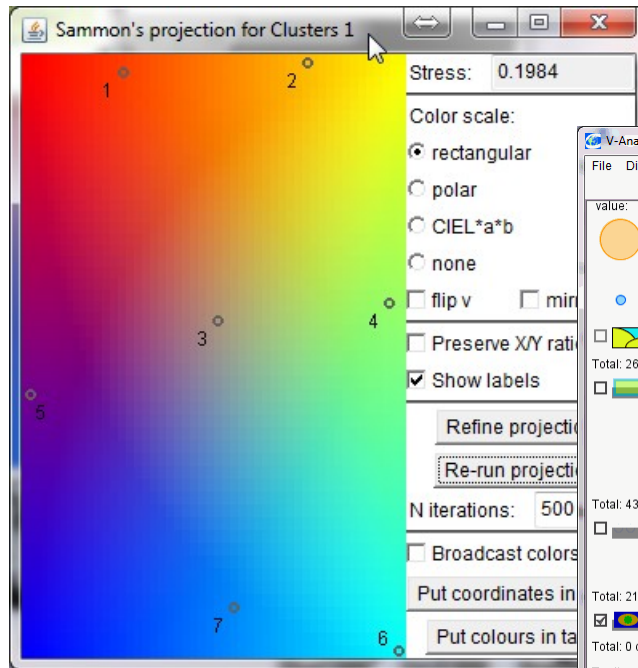


Clustering of columns = time steps

Shows time clusters and can be used to select time steps in an animated map



Assignment of colours to clusters





Construction of trajectories from spatial events

- Menu “Other tools” -> “Explore movement data” -> open section “Build” in the tool dialog -> select “Build a map layer with lines or trajectories of movement” -> OK -> select table with the photo taking events
- Specify the fields with required contents

Specify meanings of table columns

Specify the table columns with the given contents:

ID (character)
X (real)
Y (real)
Timestamp (time)
User ID (character)
URL (character)
TITLE (character)
Timestamp: year (integer)
Timestamp: month (integer)
Timestamp: hour (integer)
Timestamp: day of week (integer)
Cluster by OPTICS (Space-time distance; ≥ 3 events in 5000m and 3 hours; cluster size ≥ 10) (character)
Group N (r=20000.0) (character)
Group size (r=20000.0) (integer)
Area ID (character)

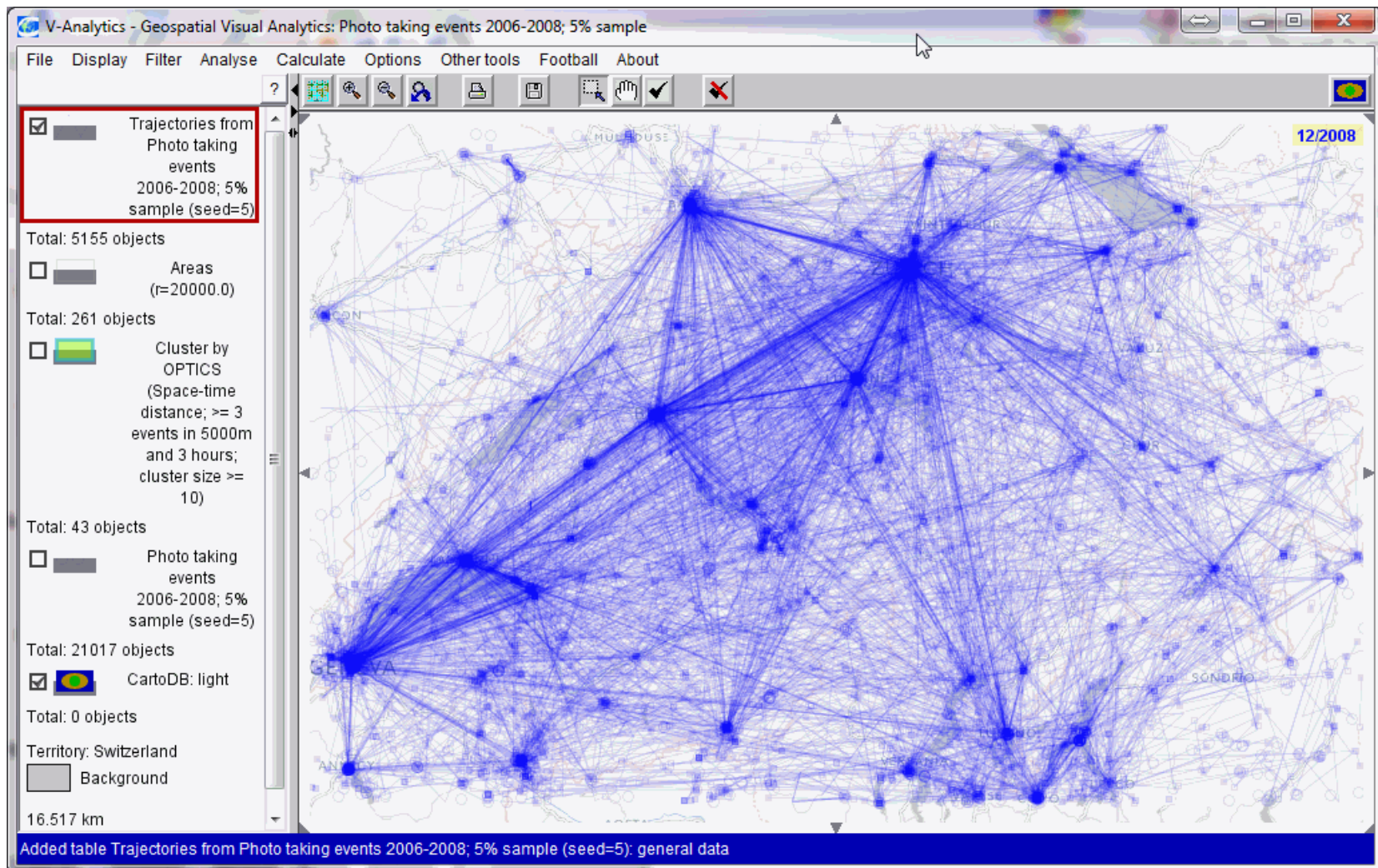
☐ identifiers of lines or trajectories ID
☐ x-coordinates X
☐ y-coordinates Y
☒ **time moments** Timestamp
☐ durations
☐ end time moments
☐ x-coordinates of move ends
☐ y-coordinates of move ends
☐ identifiers of moving objects

Erase

OK Cancel

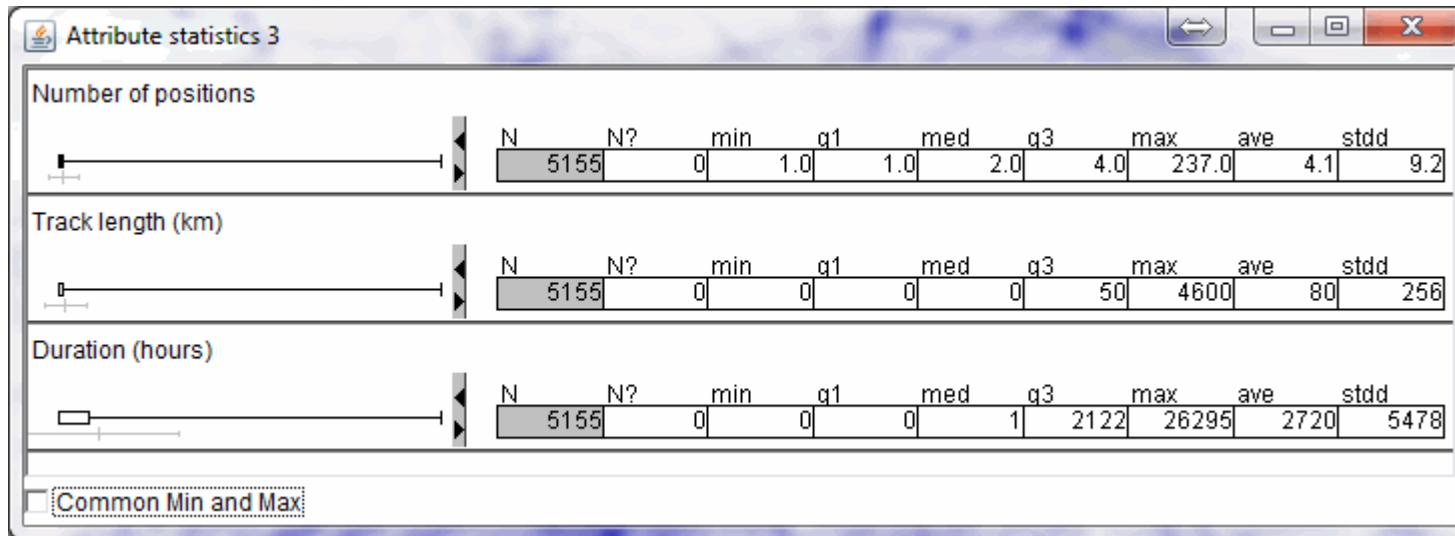


Episodic trajectories





Statistics of lengths and durations

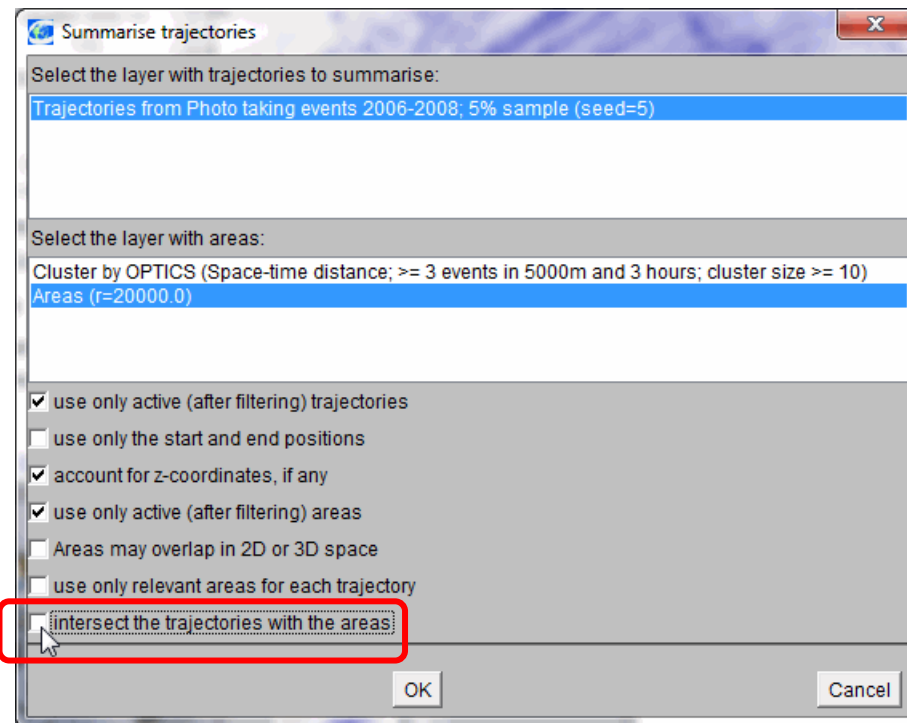


Menu "Display" -> "Display wizard" -> select table describing trajectories (last in the list) -> select attributes -> select "Attribute statistics" in the list of visualisation techniques



Spatio-temporal aggregation of trajectories

- Menu “Analyse” -> select “Trajectories: aggregation by existing areas”; use the same areas as for the events



Must be unchecked
for episodic
trajectories!

Time division: same as for the events



Divide and/or filter?

Trajectories may have wide temporal and/or spatial gaps between consecutive positions. It may be reasonable to divide such trajectories into smaller trajectories, assuming that the latter represent different trips.

Divide the trajectories before the aggregation?

☐ divide by time gaps of more than 15 minutes

☐ divide by space gaps of more than 2.5 km

It may be reasonable to ignore those moves between areas where the speed is unrealistically high or the transition duration is too long. You can set upper bounds for the speed and/or duration.

uncheck

Ignore moves with

☐ speed over 230 km/h

☐ transition duration* over 1 hours

* time interval between leaving the previous area and entering the next area

☒ ignore movements within a single area

How to handle moves that occurred in two or more time intervals?

☐ assign to the first interval

☒ assign to the last interval

☐ assign to all intervals

OK Cancel

uncheck

Which aggregates?

Which aggregates to compute?

Places:

☒ number of visits

☒ number of different visitors (trajectories)

☐ numbers of trip starts and ends

Flows:

☒ numbers of moves

☒ numbers of different movers (trajectories)

☐ average move speeds

☐ average move durations

☐ average lengths

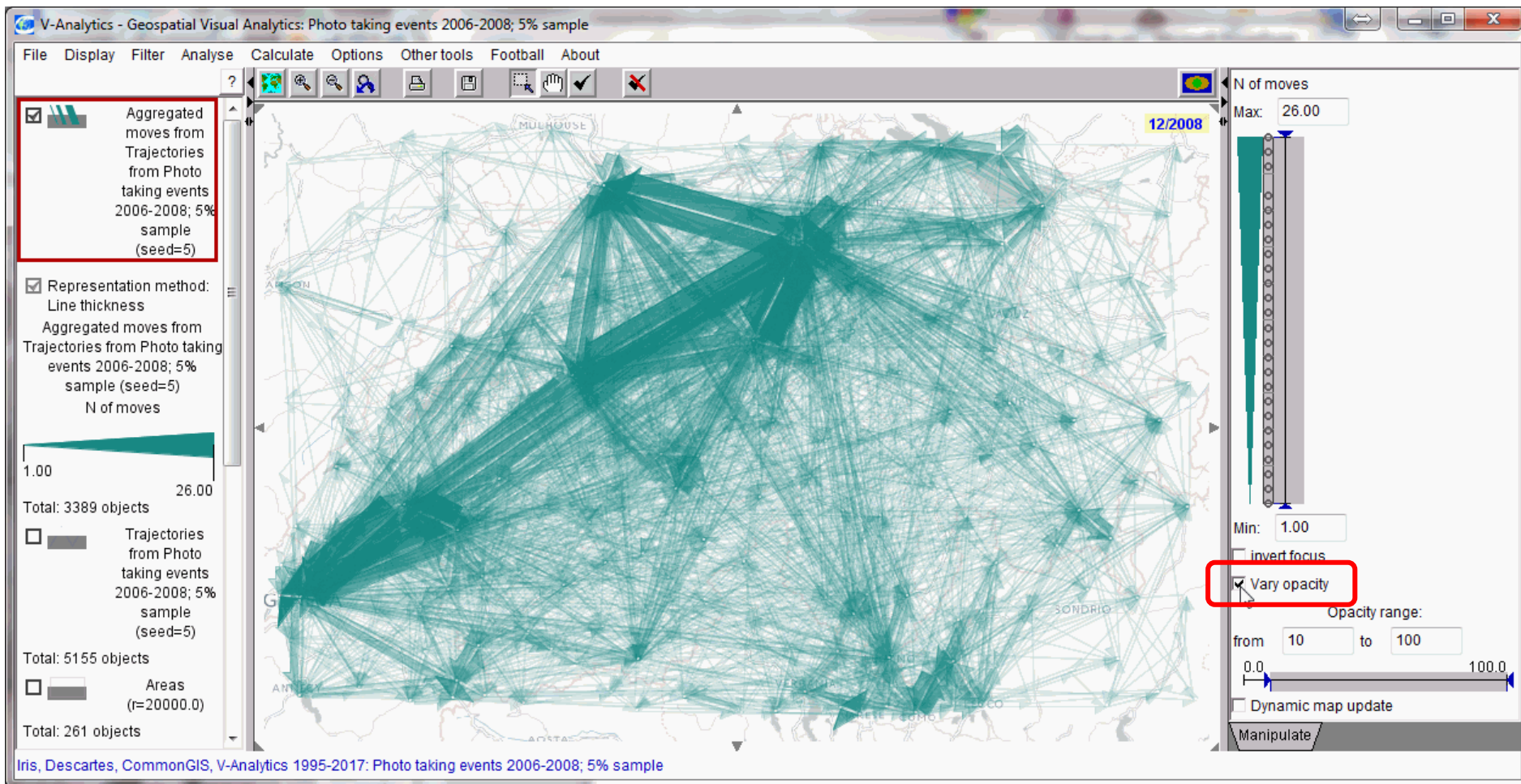
OK

Neighbours?

Count also visits in neighbouring areas?

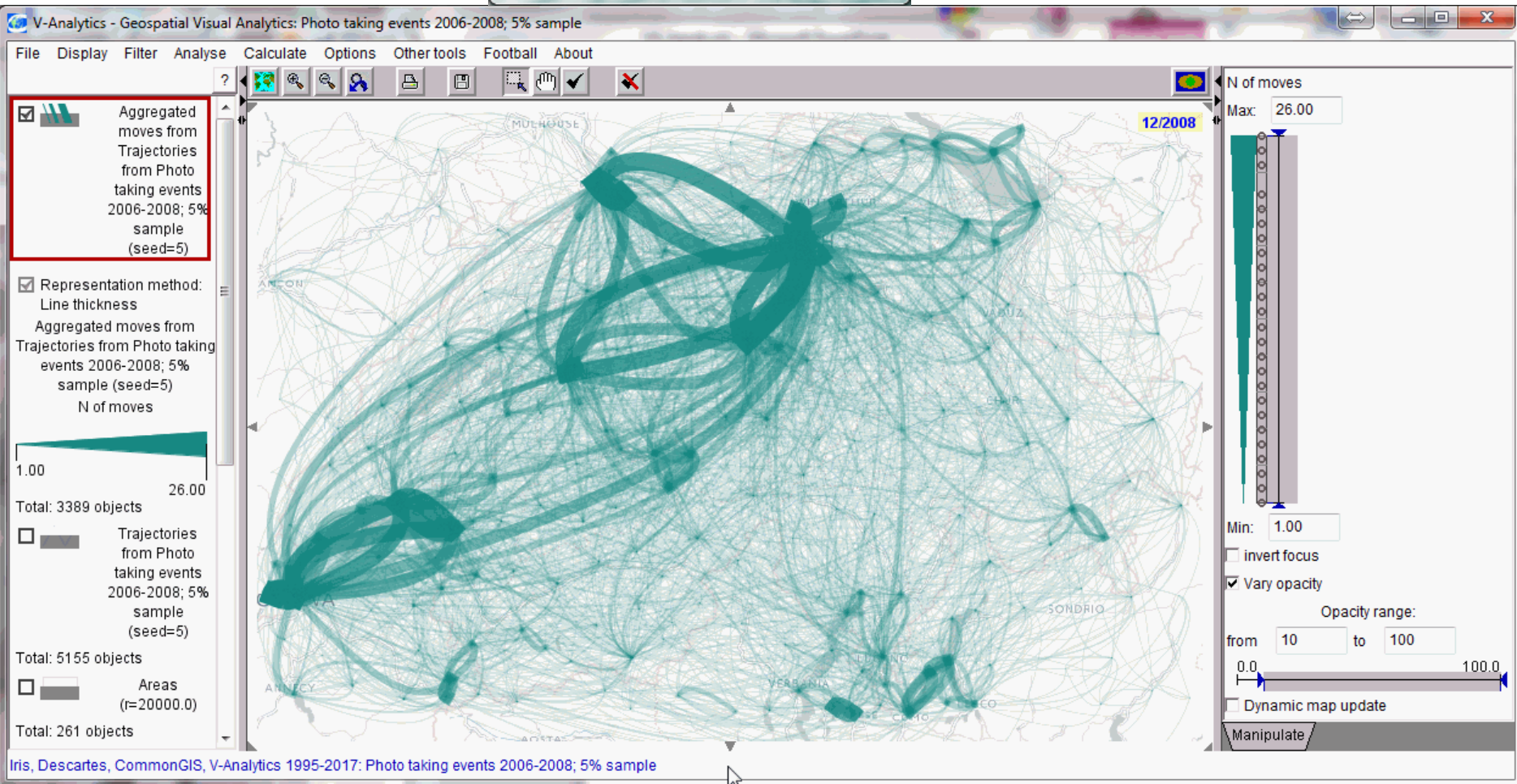
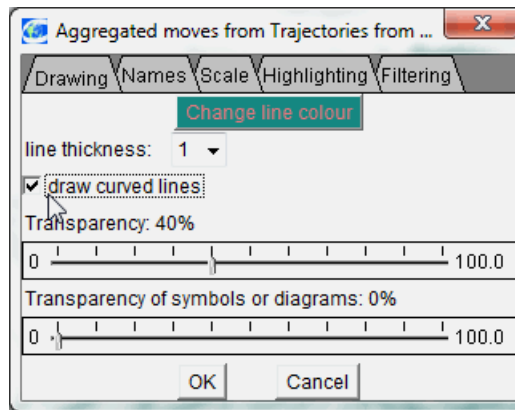
Yes No

Press OK in the dialogs that come next



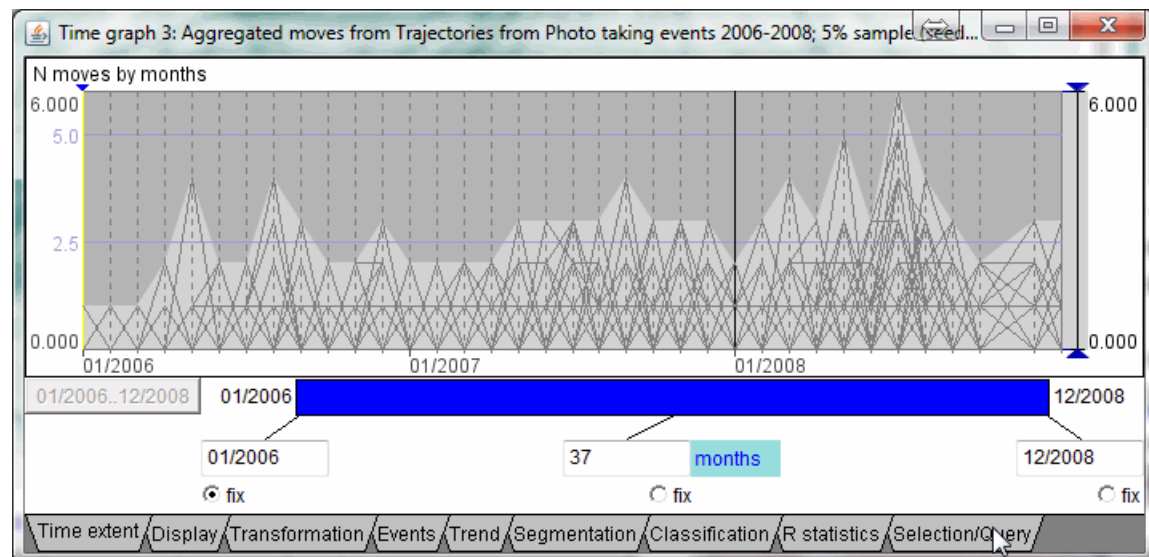
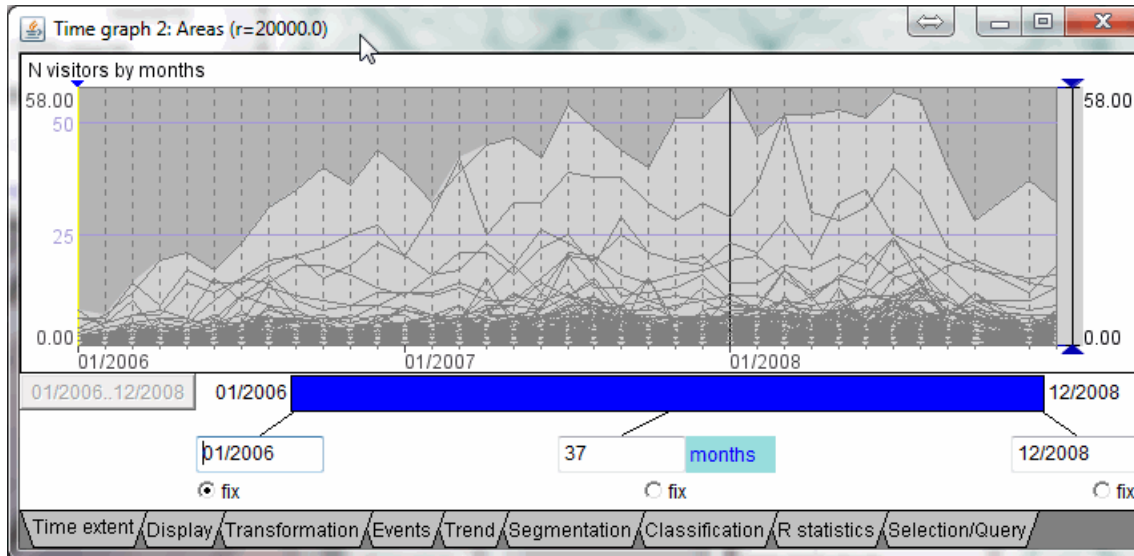


To get this dialog, click
on the layer's icon in the
map legend





Place- and link-related time series

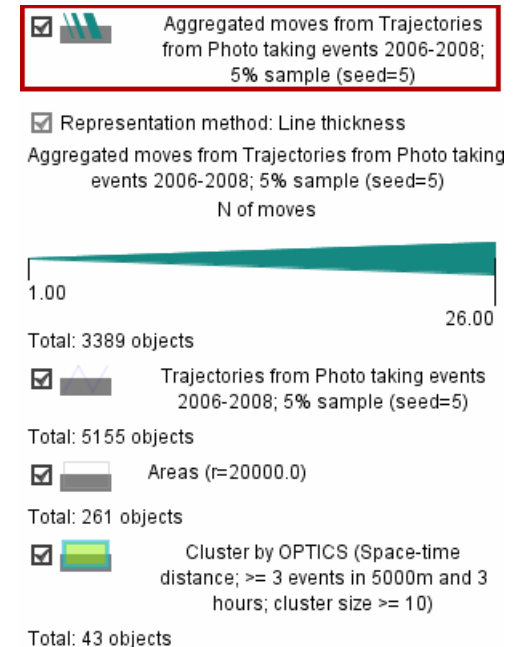




Summary

- Different types of spatio-temporal data: spatial events, spatial time series, trajectories, links and aggregated moves (flows)
- Transformations: creation of complex events (clusters), spatio-temporal aggregation, integration of events into trajectories
- Clustering: density-based, partition-based
- Analytical workflows
- Look how much secondary data we have produced!

Geographic objects



Tables

Cluster by OPTICS (Space-time distance; ≥ 3 events in 5000m and 3 hours; cluster size ≥ 10)
Areas (r=20000.0)
Centroids of Clusters 1 in Areas (r=20000.0)
month
Centroids of Clusters 1 in month
Data about positions of Trajectories from Photo taking events 2006-2008; 5% sample (seed=5)
Trajectories from Photo taking events 2006-2008; 5% sample (seed=5): general data
Aggregated moves from Trajectories from Photo taking events 2006-2008; 5% sample (seed=5)