Assessing the Variation of Visual Complexity in Topographic Multi-Scale Maps with Visual Clutter Measures

Marion Dumont, Guillaume Touya, Cécile Duchêne
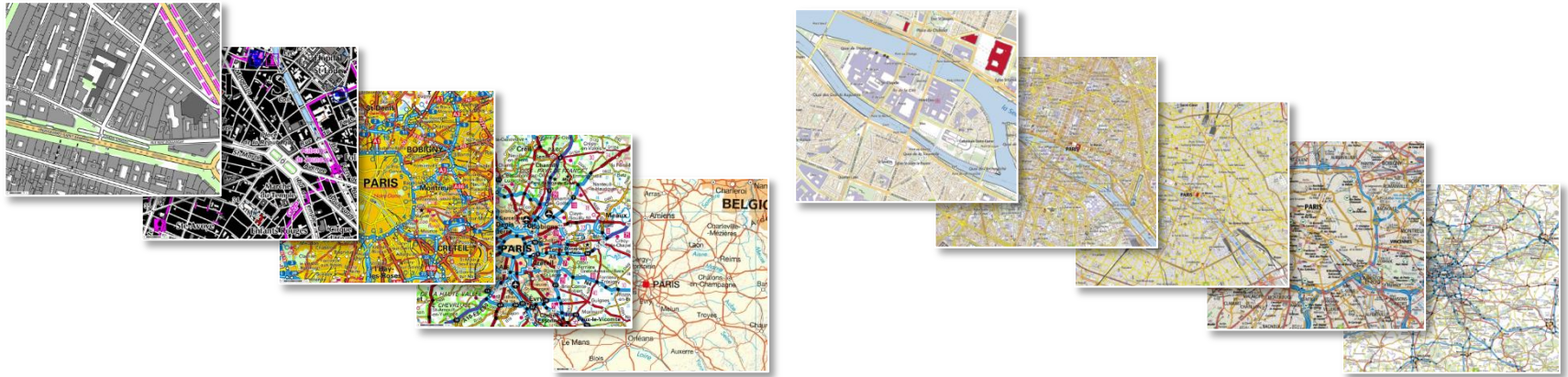COGIT – IGN France

In multi-scale maps

Smooth navigation across scales = « smooth zooming »

Scale

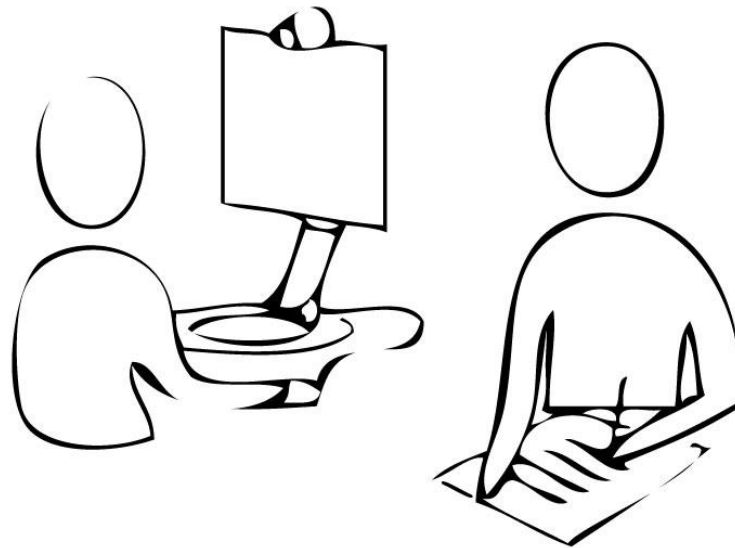# Context: multi-scale maps

- Symbolization/content differences

- Levels of abstraction

Cognitive Load and Visual Complexity Measures

Assessing the visual complexity of a display may serve to estimate the cognitive load required for its understanding, and inversely, estimate its effectiveness. [Harper et al., 2009]

[Bravo & Farid, 2008]
[Harrie et al., 2015]
[Rosenholtz et al., 2007]

In multi-scale maps
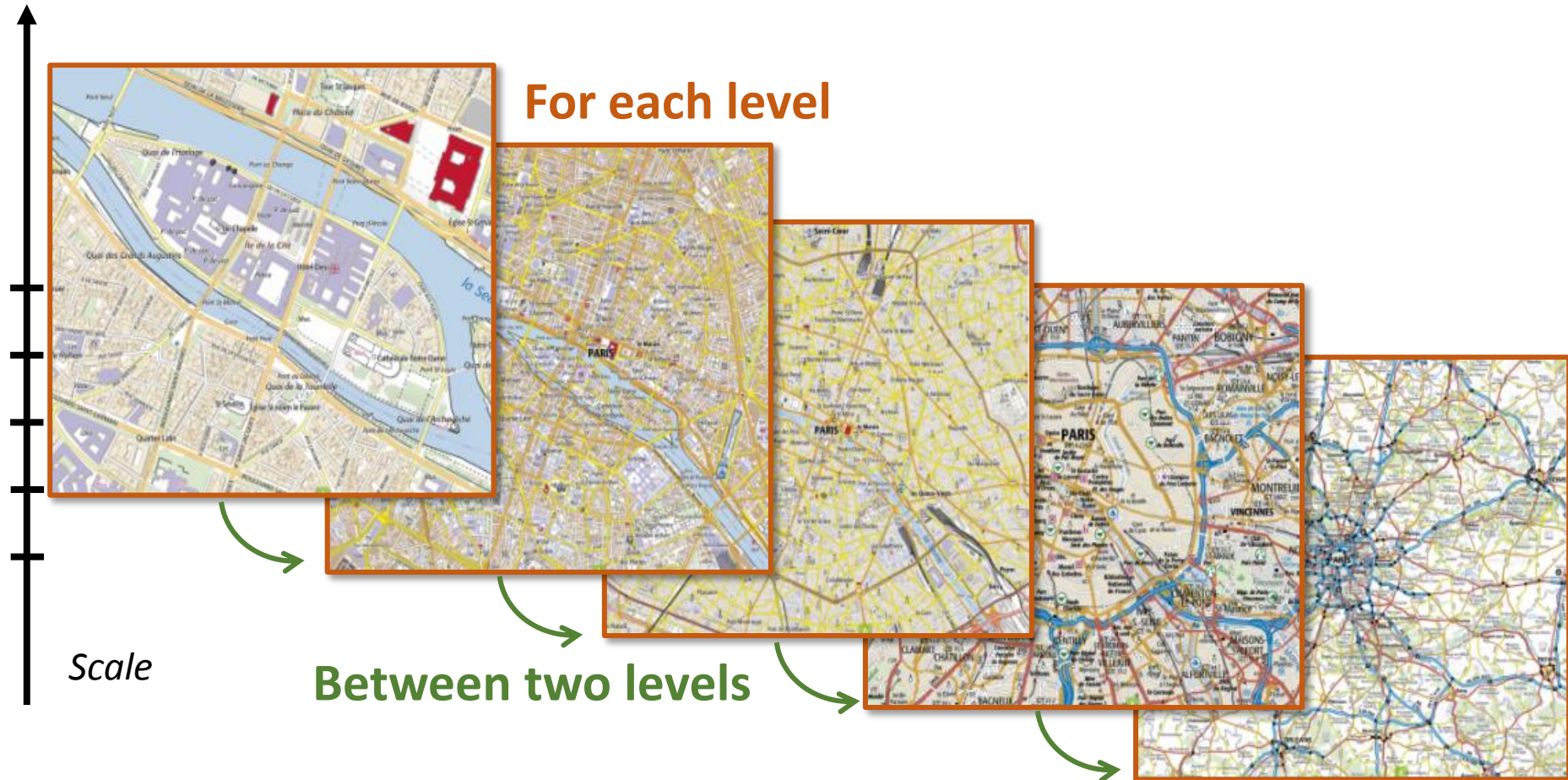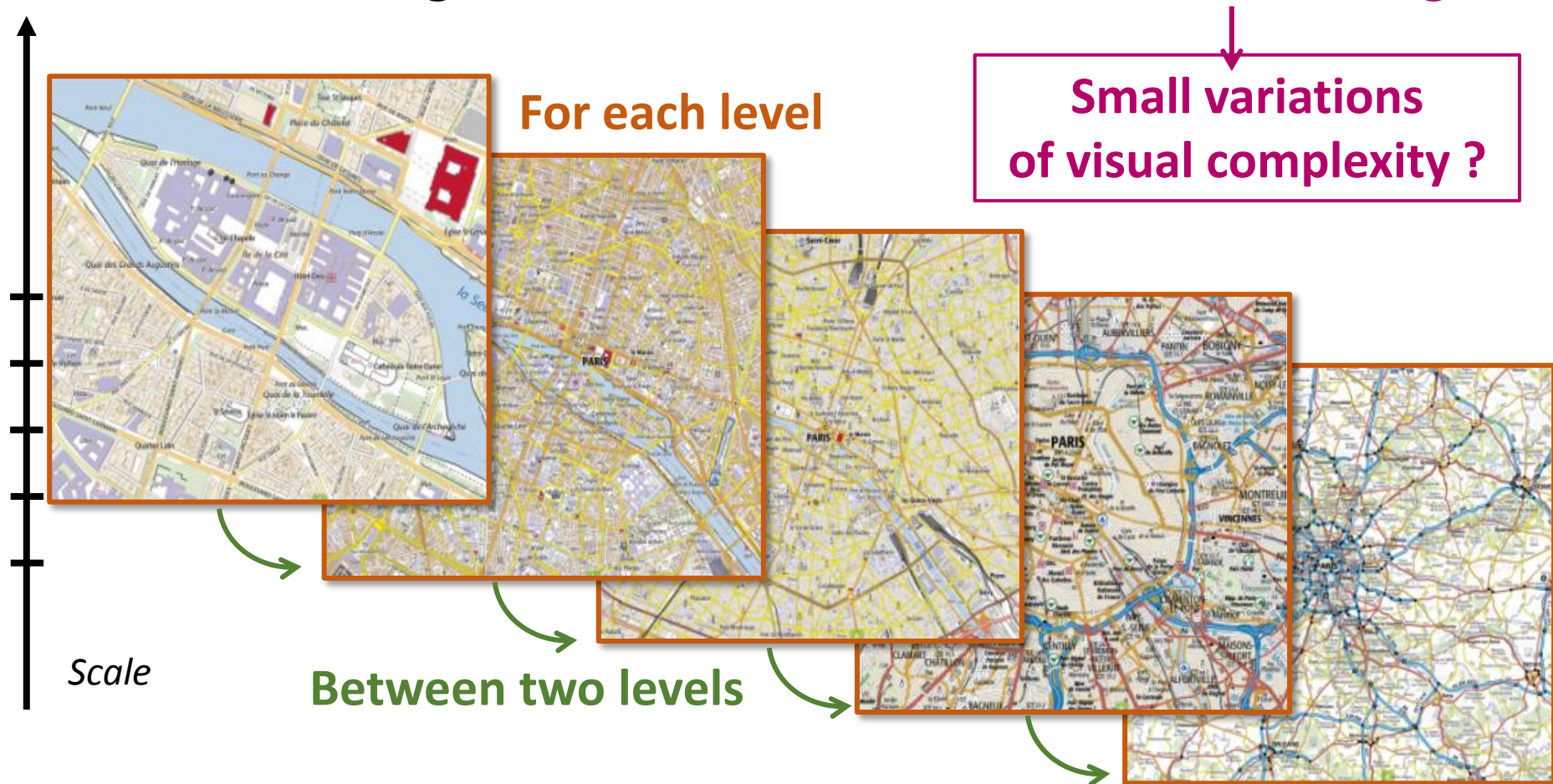
Smooth navigation across scales = « smooth zooming »

Scale

In multi-scale maps

Smooth navigation across scales = « smooth zooming »

For each level

Scale

In multi-scale maps

Smooth navigation across scales = « smooth zooming »

For each level

Between two levels

Scale

In multi-scale maps

Smooth navigation across scales = « smooth zooming »

Small variations of visual complexity ?
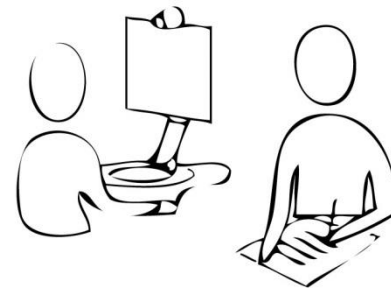
For each level

Between two levels

Scale

Visual Clutter Measures

Visual clutter corresponds to a threshold above which the increase of visual complexity leads to a degradation of user performance at some task.

[Rosenholtz et al., 2007]

"Clutter measures" = methods for assessing visual complexity in cluttered images

Visual Clutter Measures

- Images-based methods *and* applicable on maps

[Harper et al., 2009]

[Miniukovich & De Angeli, 2014]

[Purchase et al., 2012]

[Bravo & Farid, 2008]

[Fairbairn, 2006]

[Jégou & Deblonde, 2012]

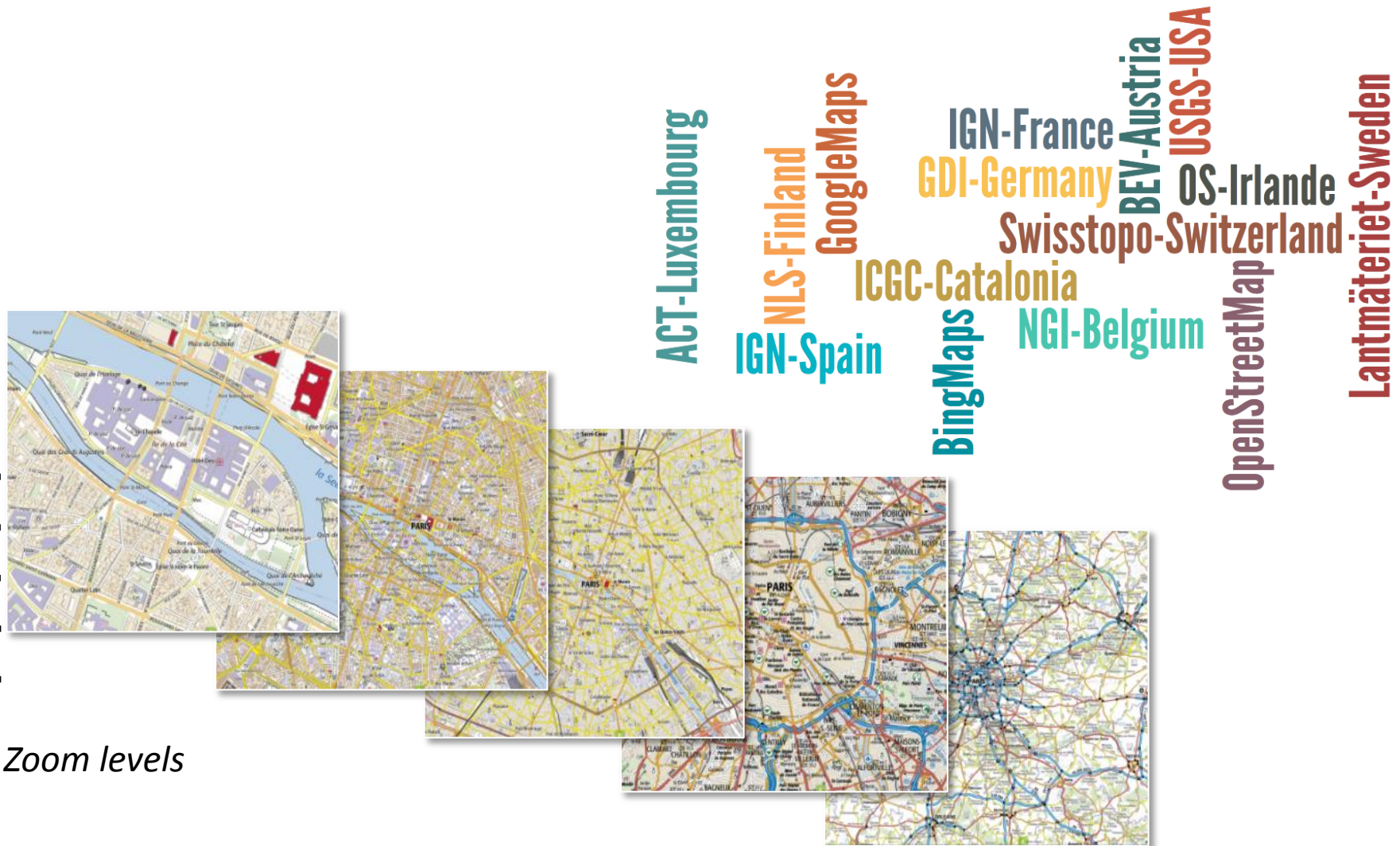[Rosenholtz et al., 2007]

[Touya et al., 2015]

- Vector-based methods developed for maps

[Fairbairn, 2006]

[Harrie et al., 2015]

[MacEachren, 1982]

Visual Clutter Measures

- Images-based methods *and* applicable on maps

[Harper et al., 2009]

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[Purchase et al., 2012]

[Bravo & Farid, 2008] Segmentation

[Fairbairn, 2006]

[Jégou & Deblonde, 2012] Quad Tree

[Rosenholtz et al., 2007] Subband Entropy

[Touya et al., 2015]

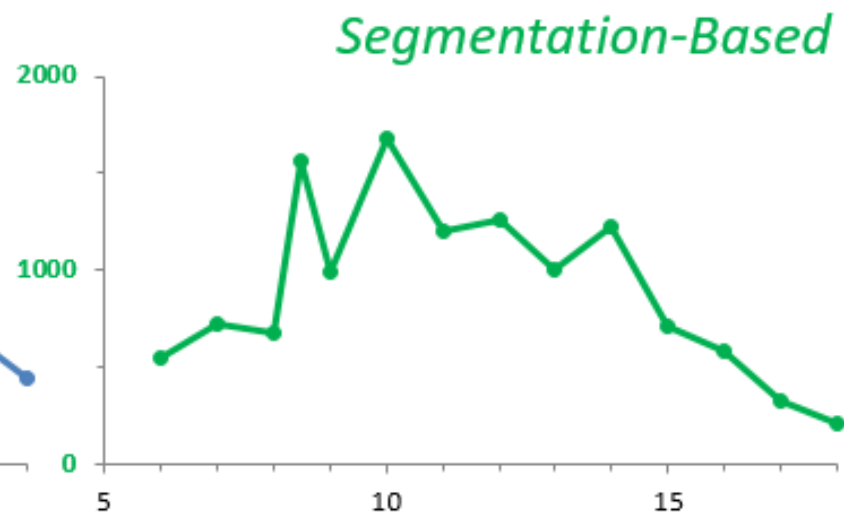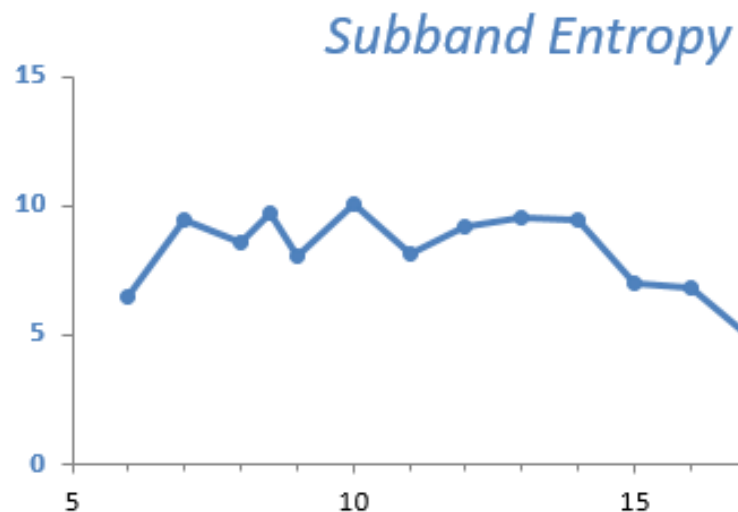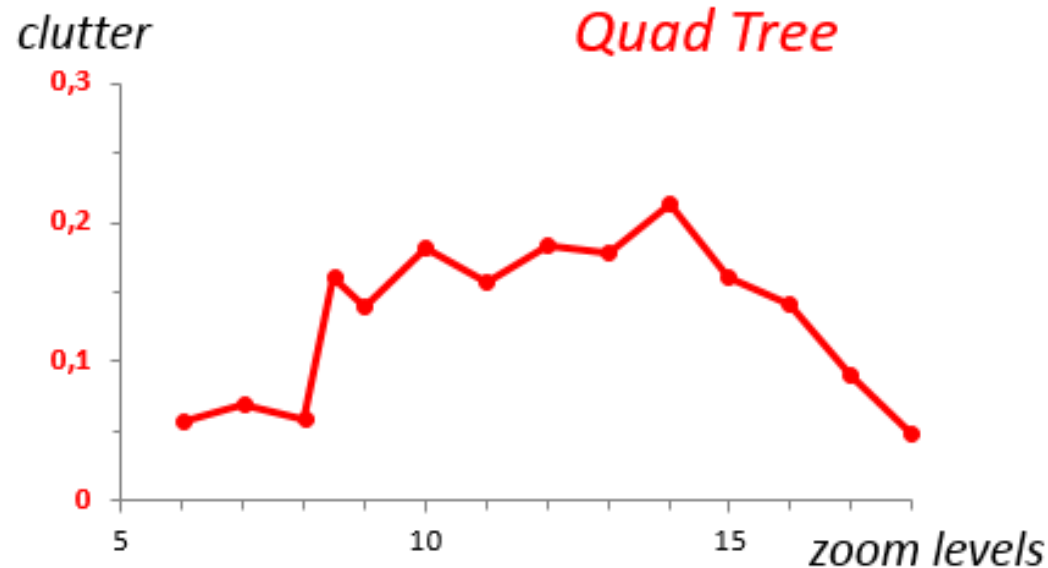- Vector-based methods developed for maps

[Fairbairn, 2006]

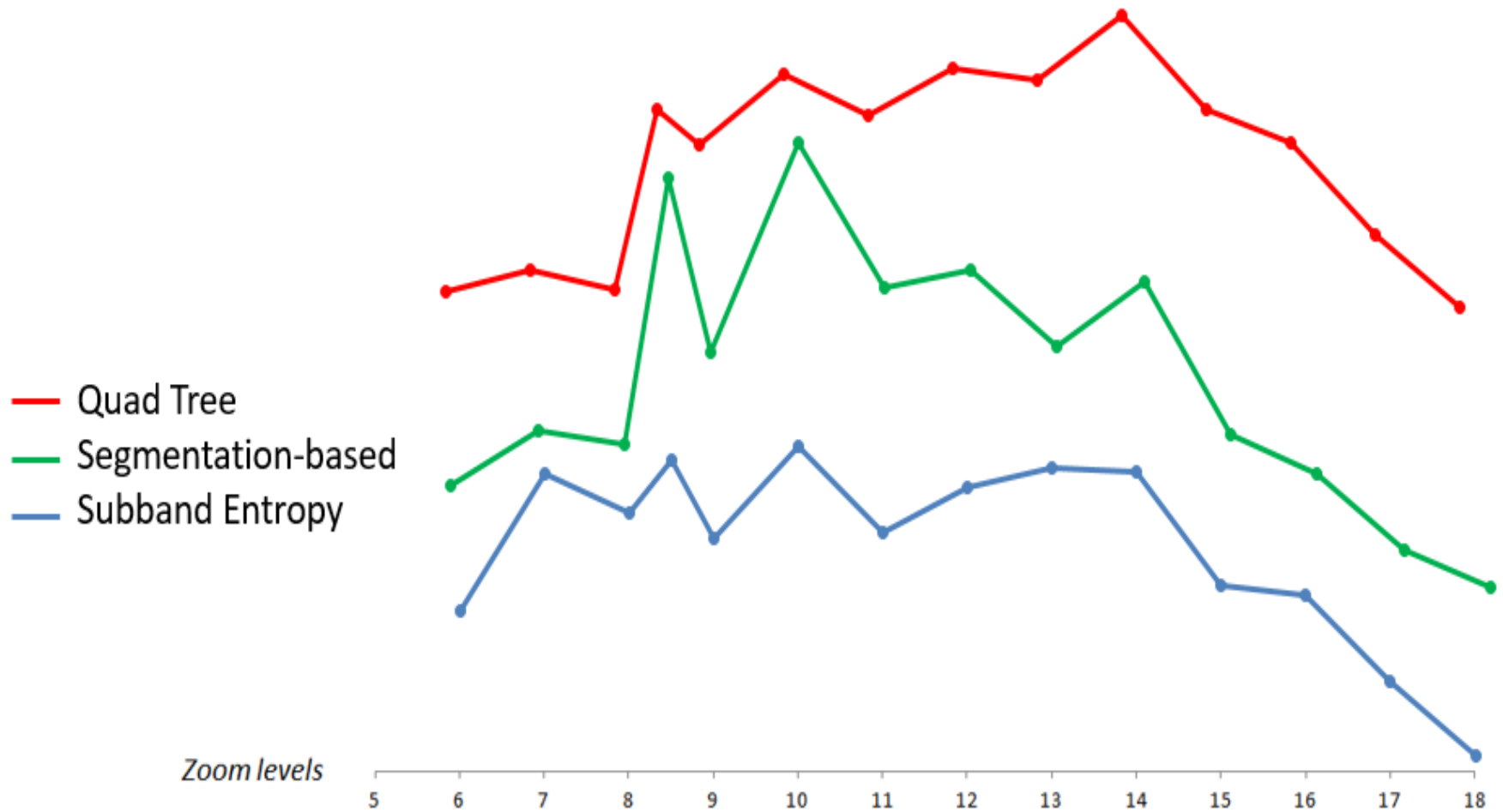[Harrie et al., 2015]

[MacEachren, 1982]

Assessing the variation of visual clutter in 16 existing multi-scale maps

Zoom levels

ACT-Luxembourg
NLS-Finland
GoogleMaps
IGN-France
GDI-Germany
BEV-Austria
USGS-USA
OS-Irlande
Swisstopo-Switzerland
ICGC-Catalonia
IGN-Spain
BingMaps
NGI-Belgium
OpenStreetMap
Lantmäteriet-Sweden

Variation of visual clutter across scales

Comparison between clutter mesures

Legend:
- **Quad Tree** (red)
- **Segmentation-based** (green)
- **Subband Entropy** (blue)

Zoom levels

5 6 7 8 9 10 11 12 13 14 15 16 17 18

Research issues

- Does the variation of measured clutter relate to the perceived variation of visual complexity?

- How does clutter vary across scales in existing maps?

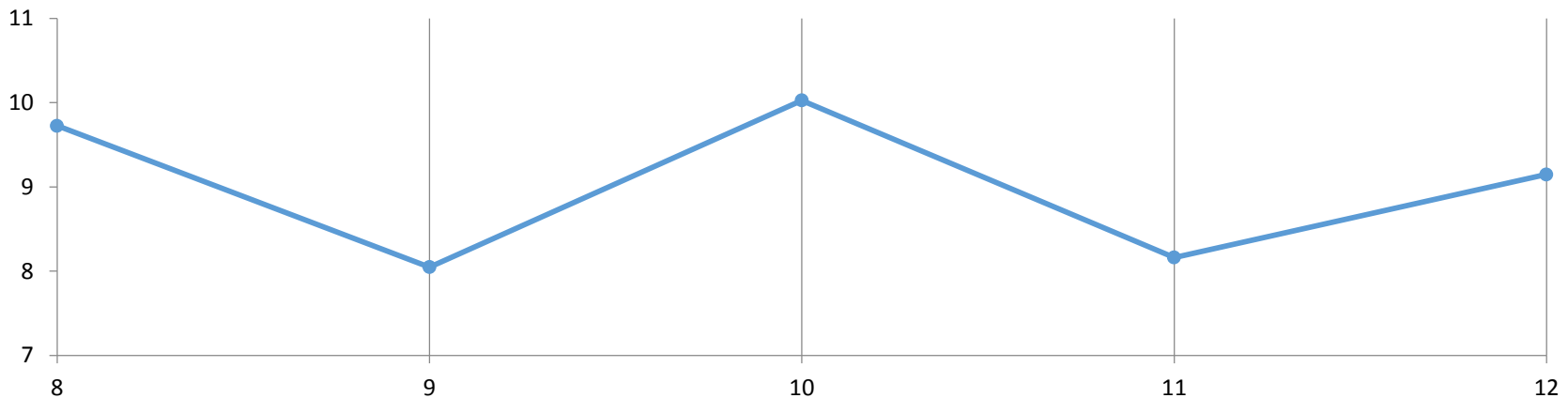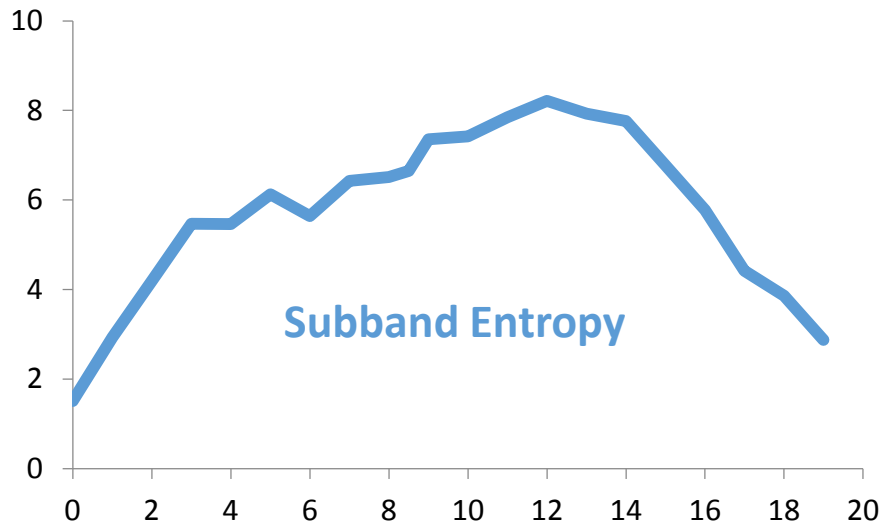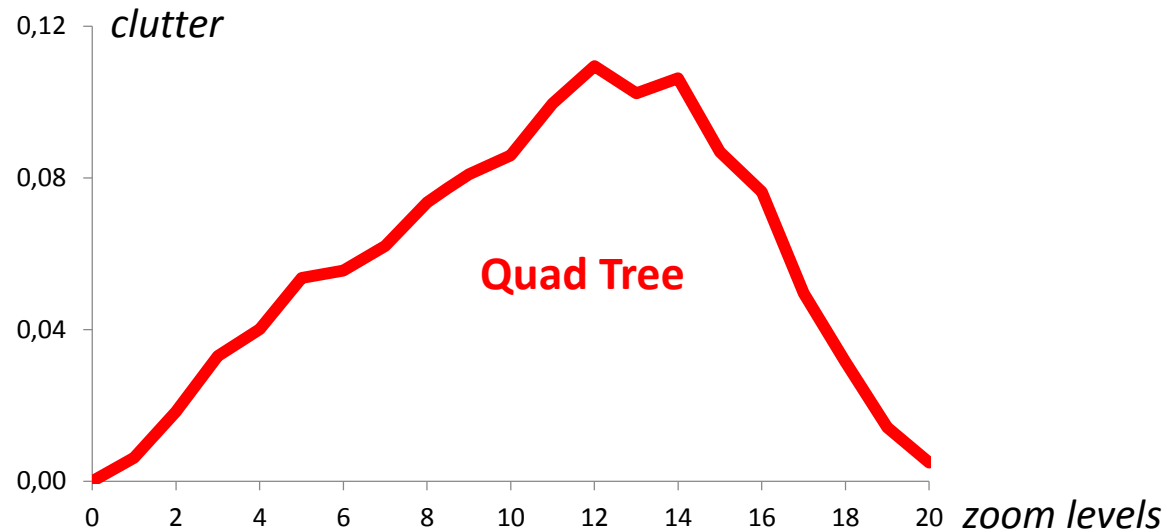- Which map elements are potential factors of visual clutter?

Research issues

- **Does the variation of measured clutter relate to the perceived variation of visual complexity?**

- How does clutter vary across scales in existing maps?

- Which map elements are potential factors of visual clutter?

Clutter variation & perceived variation of visual complexity
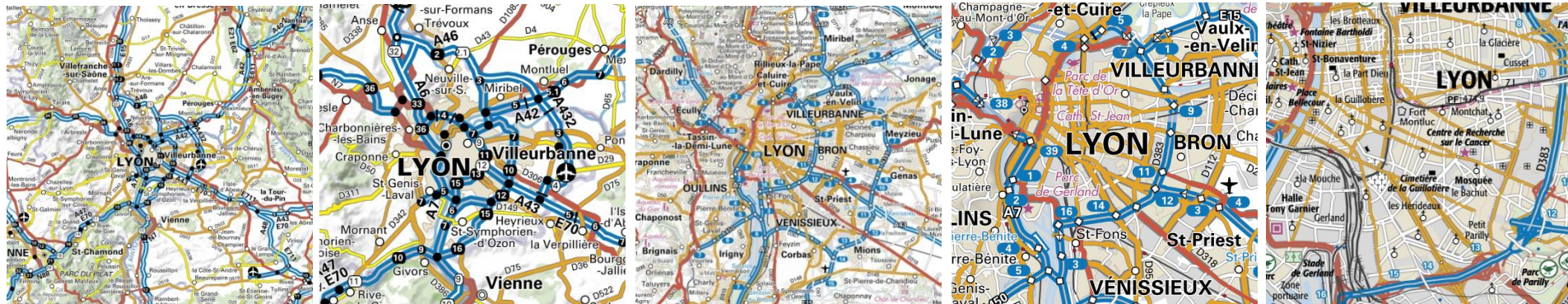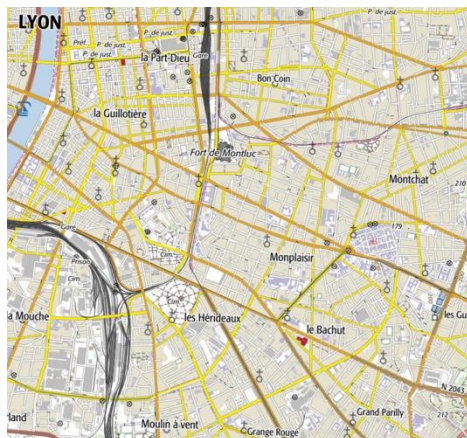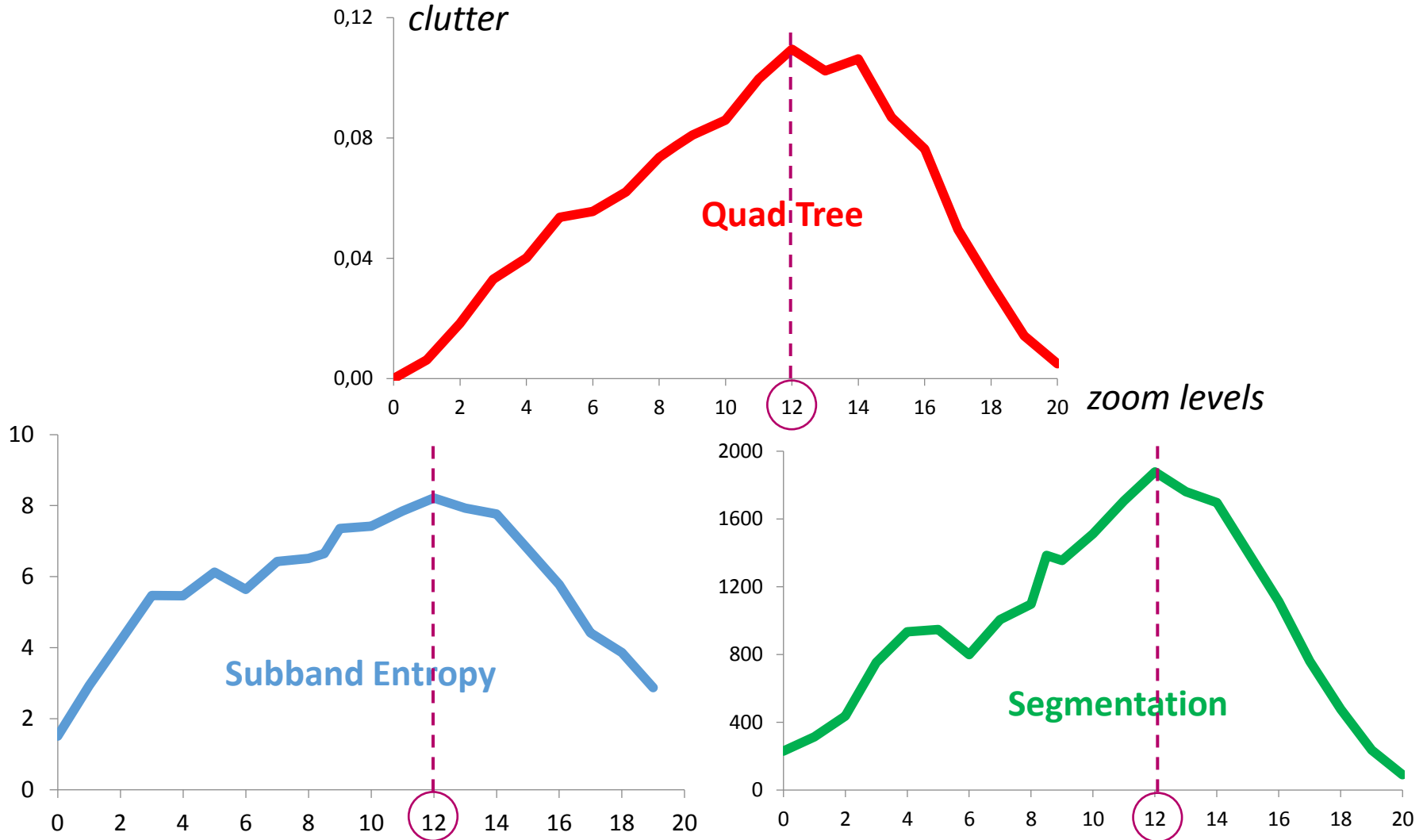
Intermediate representation
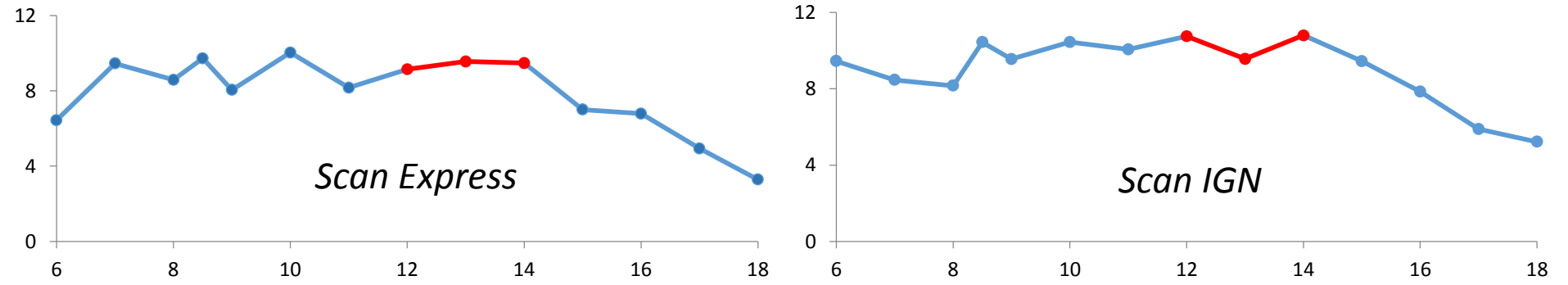
Research issues

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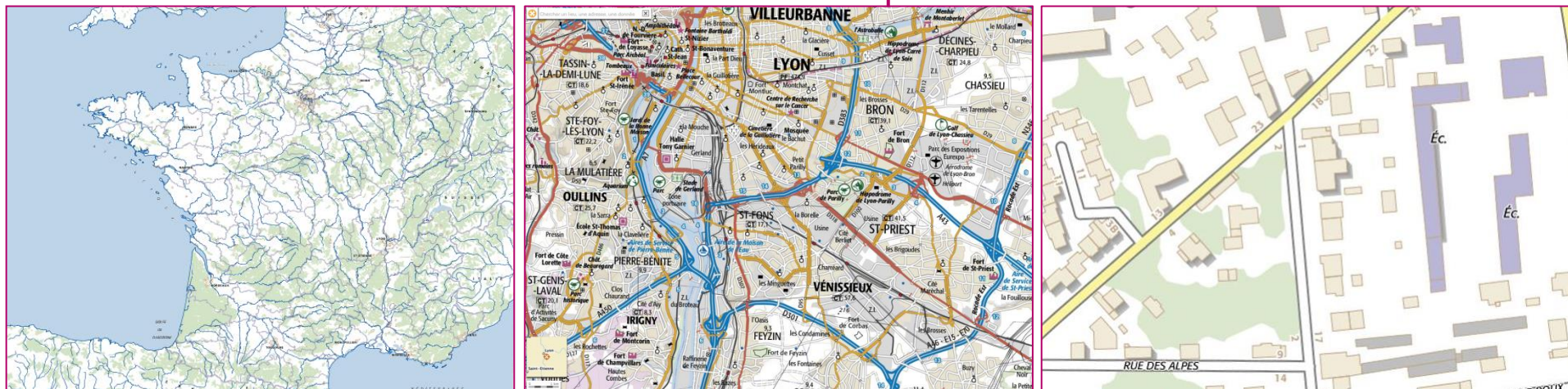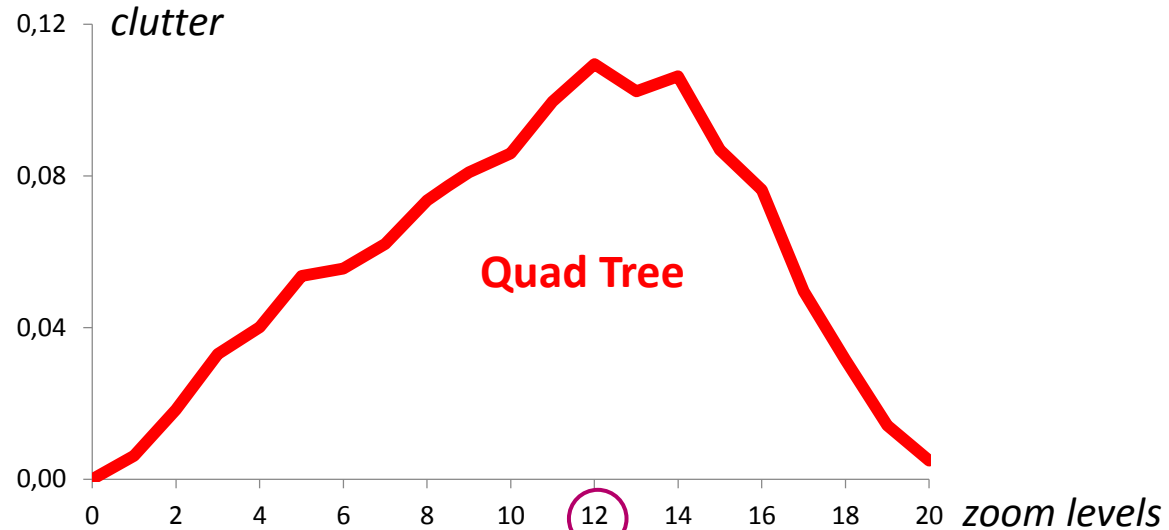- Which map elements are potential factors of visual clutter?
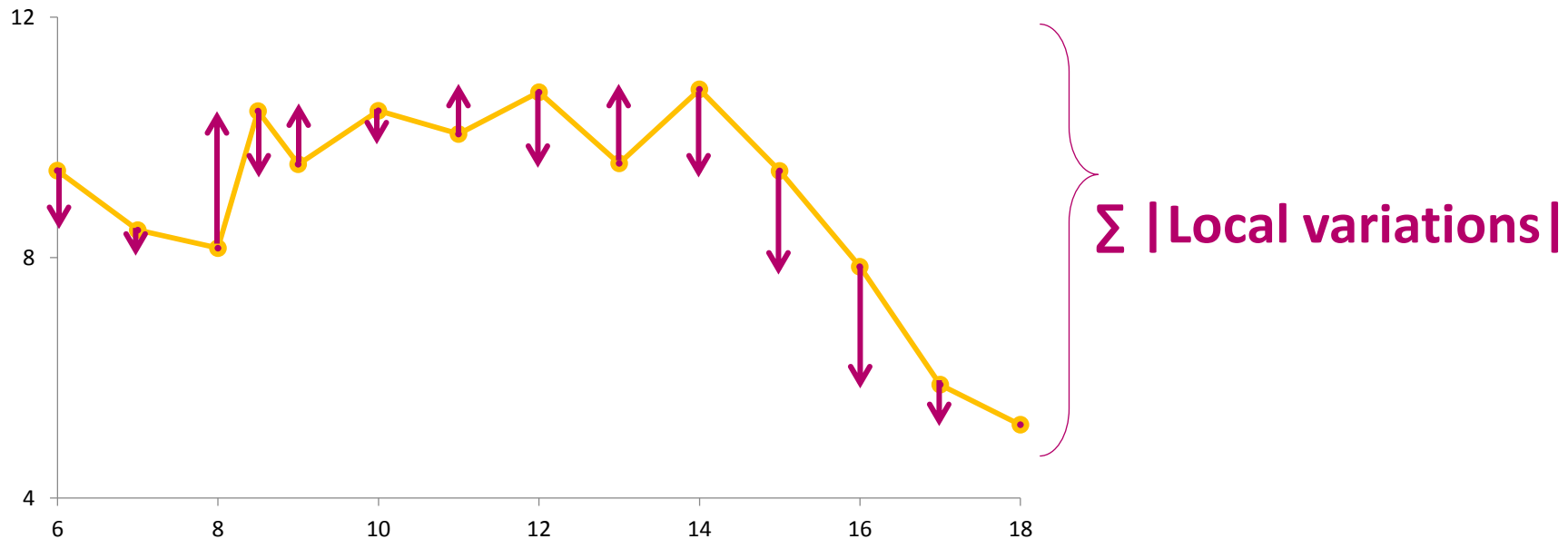
General trends: average clutter variation

General trends: average clutter variation

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Local clutter variations

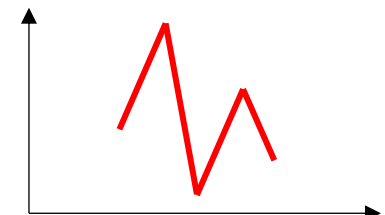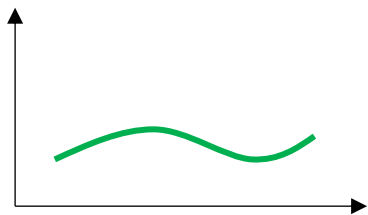$\sum |$ **Local variations** $|$

Smallest Variations
Bing Maps
Google Maps
GDI Germany
USGS United-States

Largest Variations
Scan IGN
IGN Spain
Swisstopo
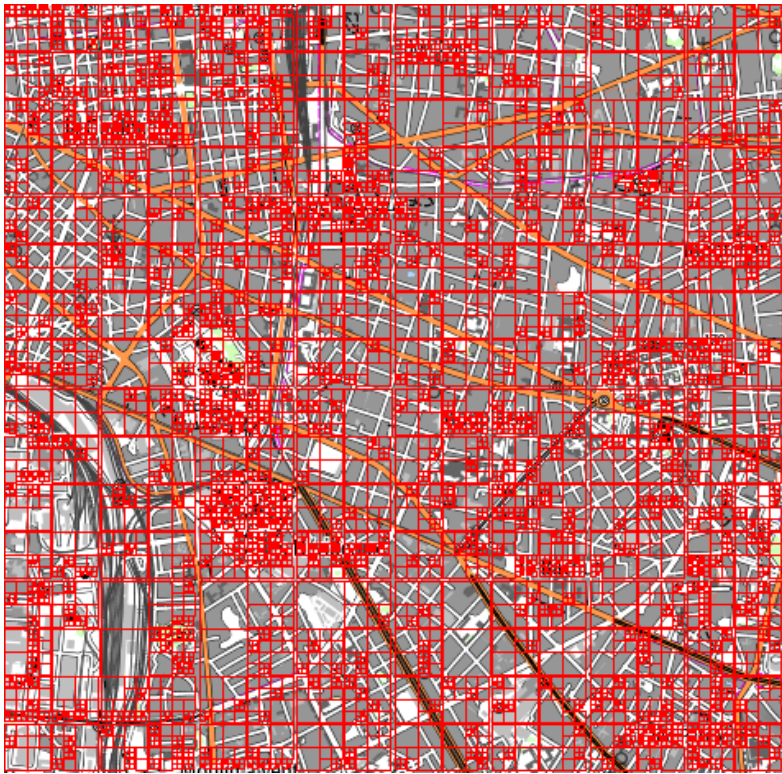Lantmäteriet Sweden
Scan Express

Research issues

- Does the variation of measured clutter relate to the perceived variation of visual complexity?

- How does clutter vary across scales in existing maps?

- **Which map elements are potential factors of visual clutter?**

Potential factors of visual clutter
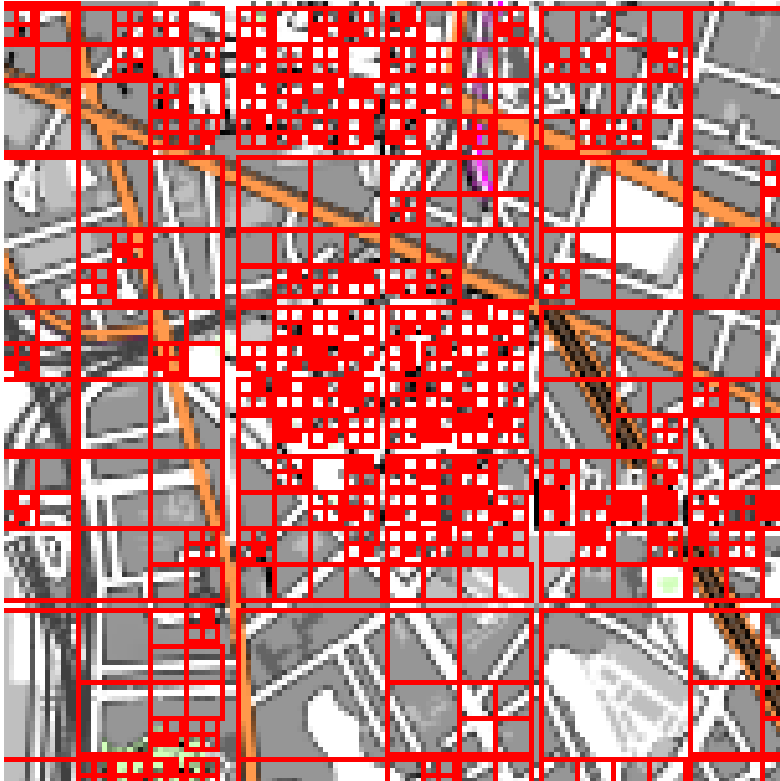
Visual results of clutter measures

Quad tree method

Segmentation-based method
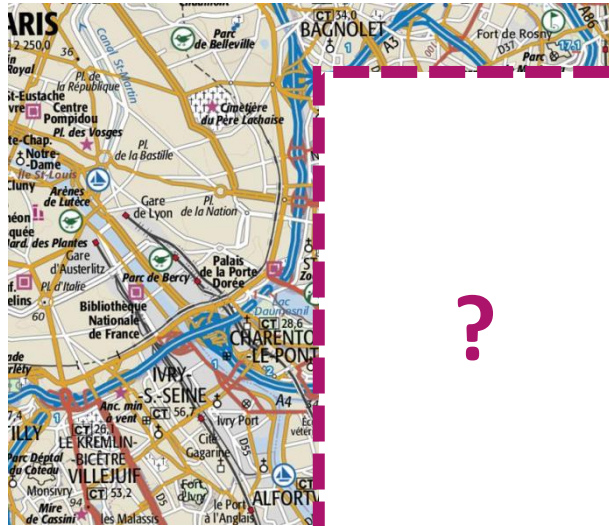
Potential factors of visual clutter

Going further
Compute clutter measures on each layer -> maps in vector format

Going further

**Intermediate Representation
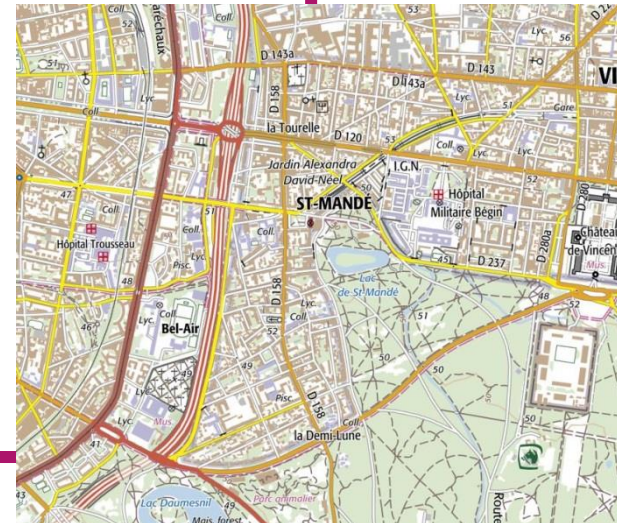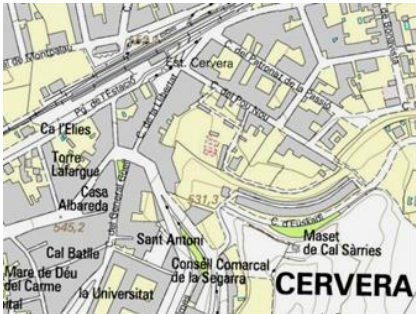=> transition to evaluate**
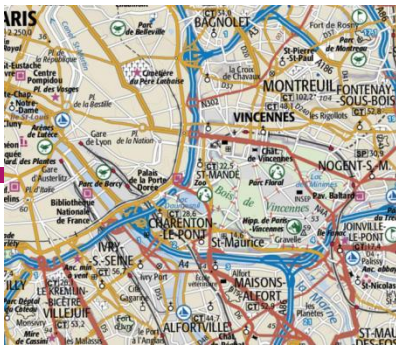

1: 100K

?

?

?

1: 25K

Going further

- Transition between abstraction levels ?

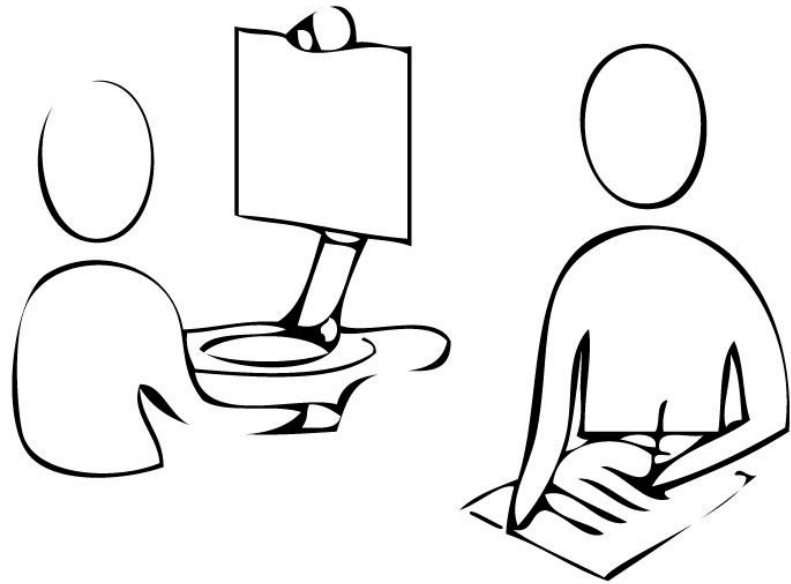- Degree of generalisation ?

?

Going further

- Test our hypothesis with a performance evaluation of user task

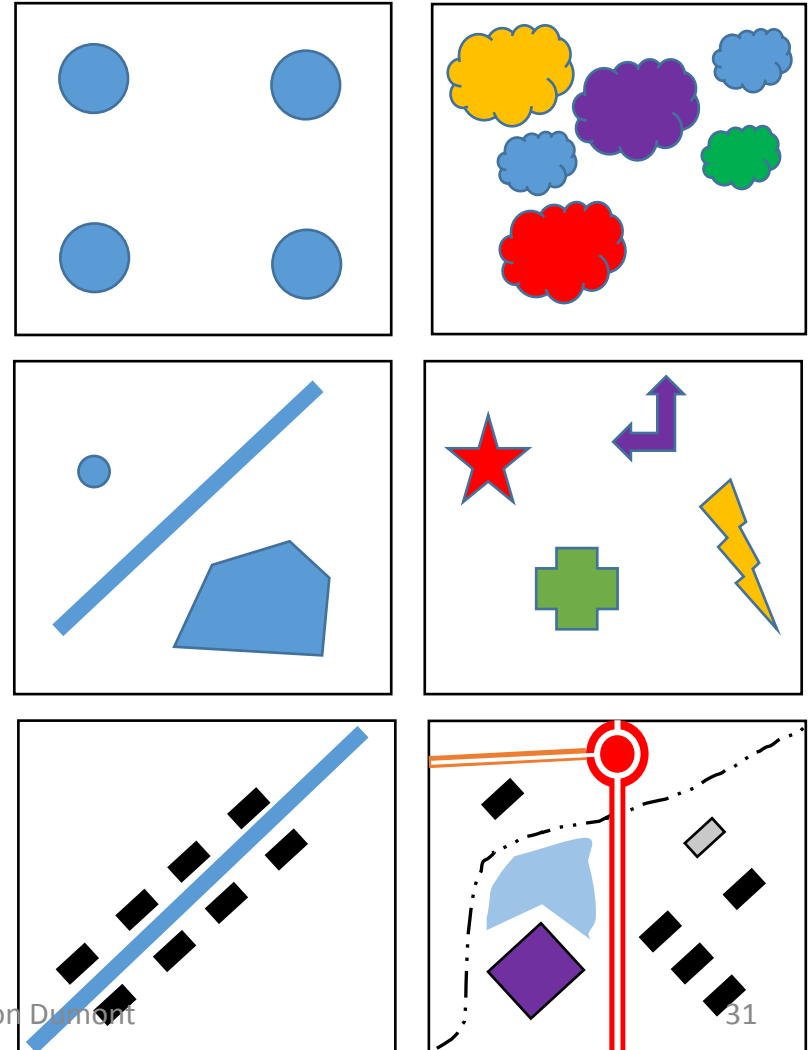- Assess the cognitive load of scale transitions

Thank you!

Any questions?

Responsible factors for map complexity

- Visual complexity

- Semiological complexity
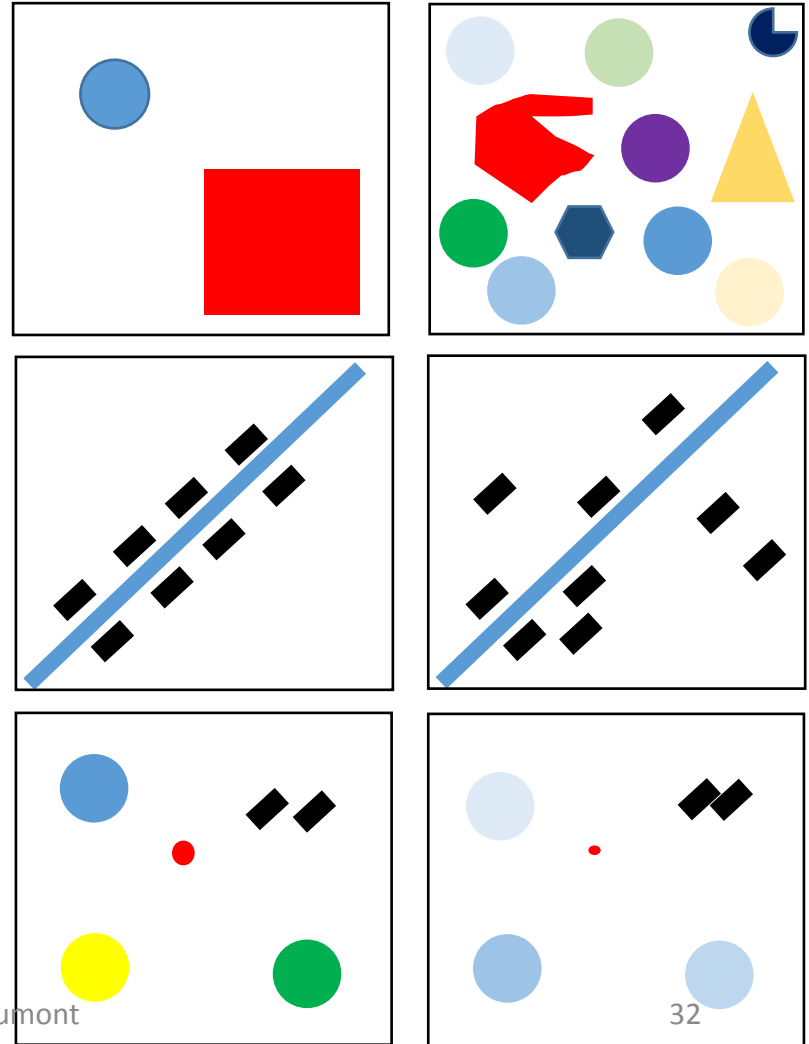
- Intellectual complexity

[Fairbairn 2006]

[Jégou & Deblonde, 2012]

[MacEachren 1982]
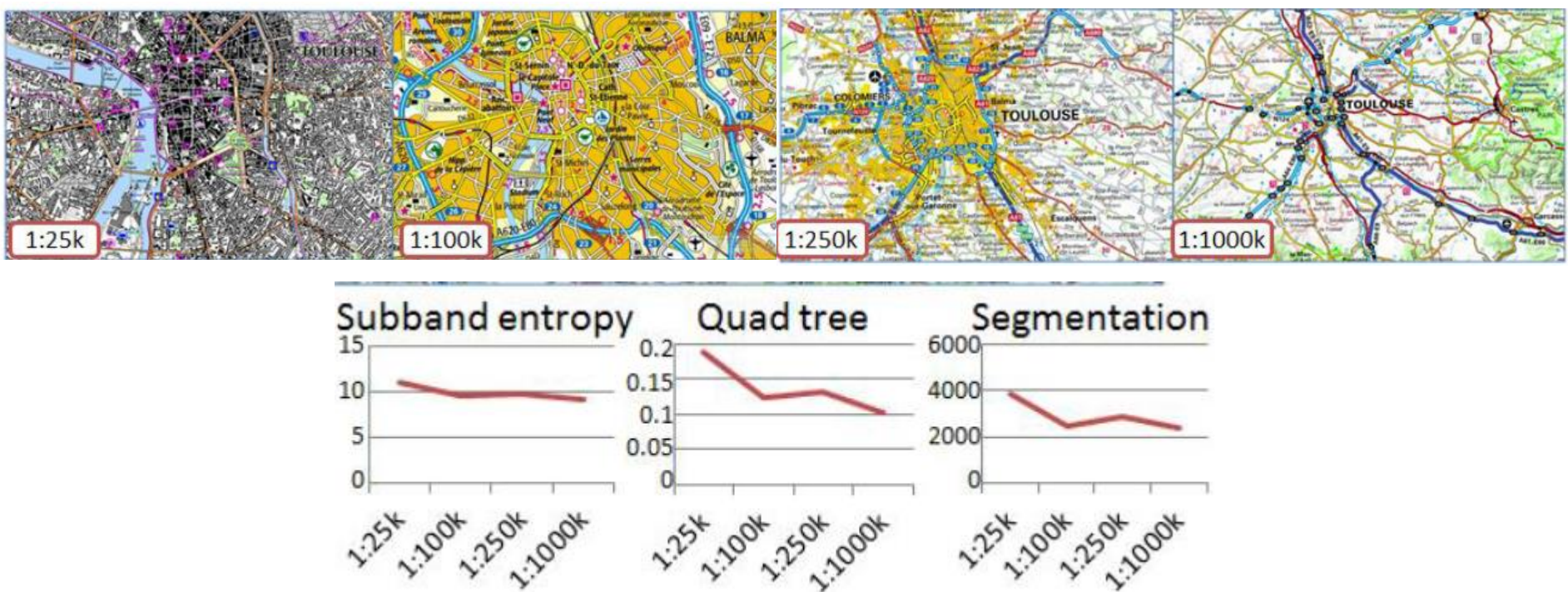
[Touya et al., 2016]

Responsible factors for visual clutter

- Amount of information

- Information organization

- Information discriminability

Previous study

[Touya et al, 2015]

=> Highlights the potential for generalization purpose

Clutter Measures: quad tree method

[Jégou & Deblonde, 2012]

- converts the assessed image in grayscale

- computes a quad tree on it, based on the homogeneity of pixel values

- clutter is the resulting number of

cells, when all of them are considered

homogeneous

- developed for maps and considered consistent by cartographic experts
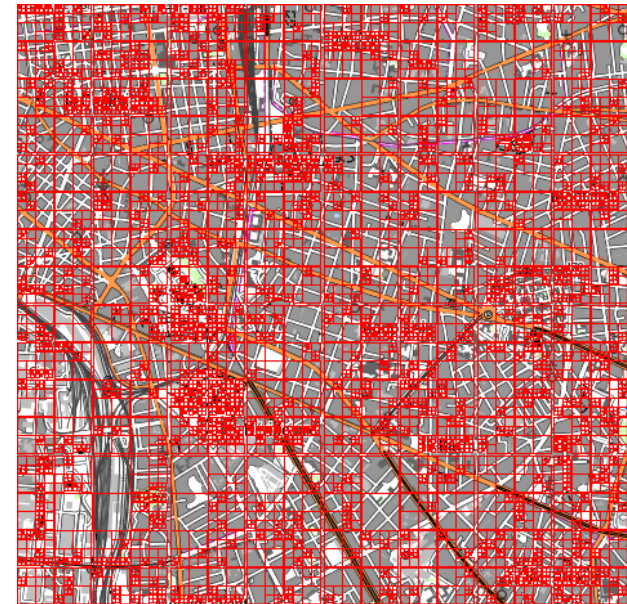
Clutter Measures: subband entropy method
### [Jégou & Deblonde, 2012; Rosenholtz et al, 2007]

- similar to JPEG compression

- decomposes the image into wavelets for each CIELab channel

- Computes the clutter value as a weighted sum of subbands entropies

- validated on maps with a performance evaluation of user tasks [Rosenholtz et al, 2007]

Clutter Measures: segmentation-based method

[Bravo & Farid, 2008]

- computes an efficient segmentation algorithm [Felzenszwalb & Huttenlocher, 2004] on the image

- the number of identified objects

gives the clutter value

- validated on images with a

performance evaluation of user tasks

- relevant on maps: [Rosenholtz et al, 2007] shows
its consistency with subband entropy method
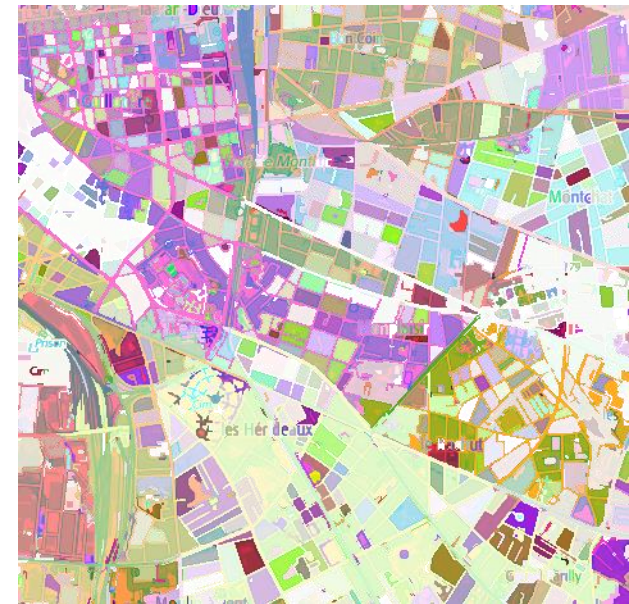
Colour variability

Classic Legend   Standard Legend   Grayscale Legend