Cartography or Geospatial

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23-Nov-2009

The Space-Time Cube Revisited from a Geo-Visualization Perspective

Menno Jan Kraak

International Cartographic Conference, 2003

Previous Work

’60s Hägerstrand’s space-time model:

- Space-Time Path(STP) – limited by capability constraints, coupling and authority constraints
- Terms –stations, activity bundles, path footprint,
- Space-Time Prism – Potential Path Space (PPS), PPA
- Space-Time cube – 3 dimensions, geography along x-y axis, time along z axis

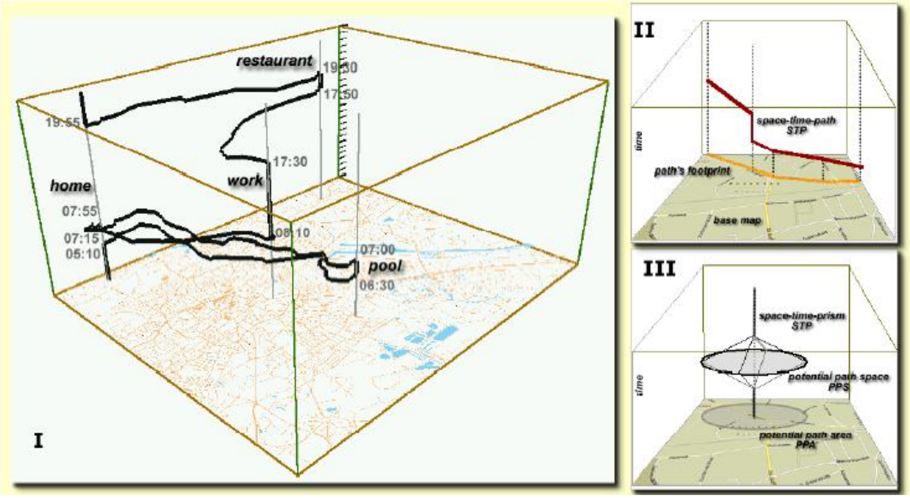


Figure 1 : Authors day at the city of Enschede

Automation and Multiple Views

An interactive visual environment with alternative graphics connected to the cube via multiple linked views

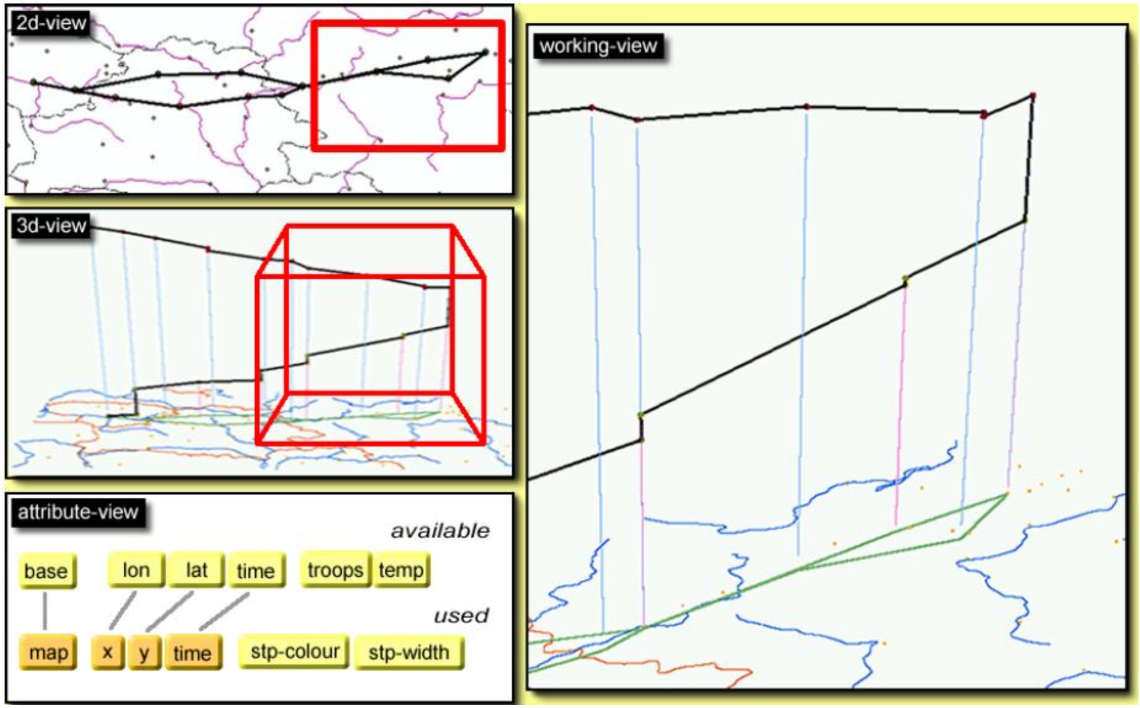
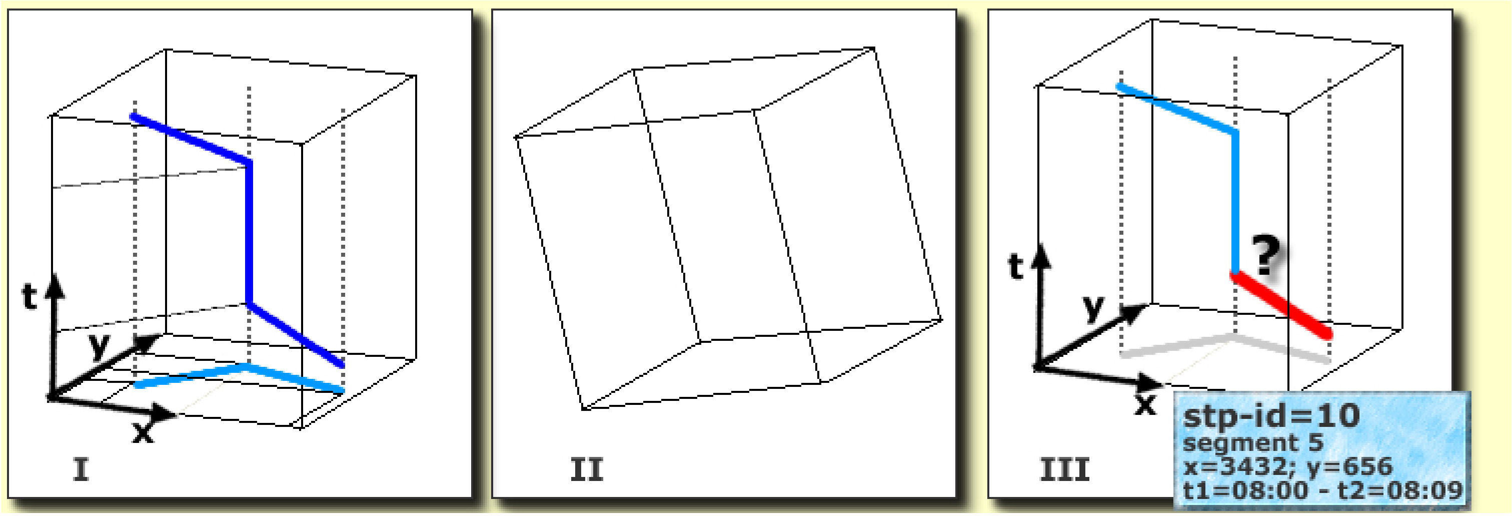


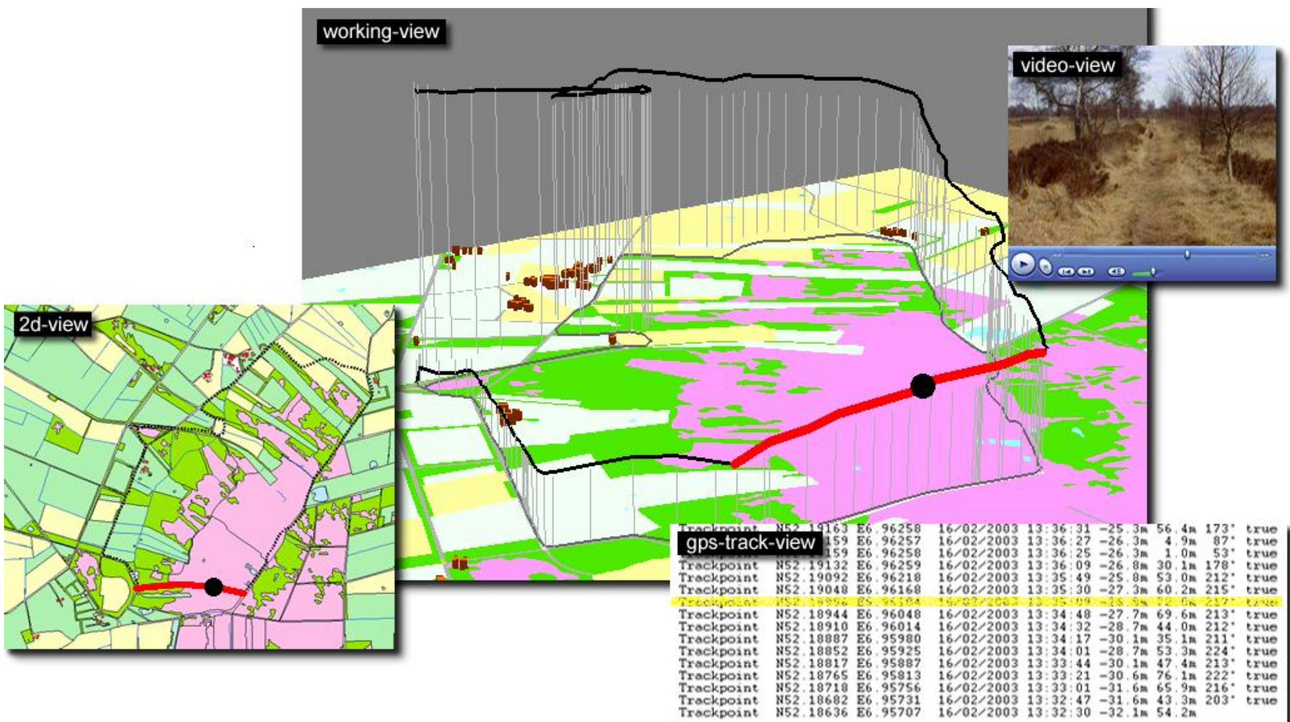
Figure 2 : Napoleon's 1812 march into Russia

Axis Rotation and Measurement



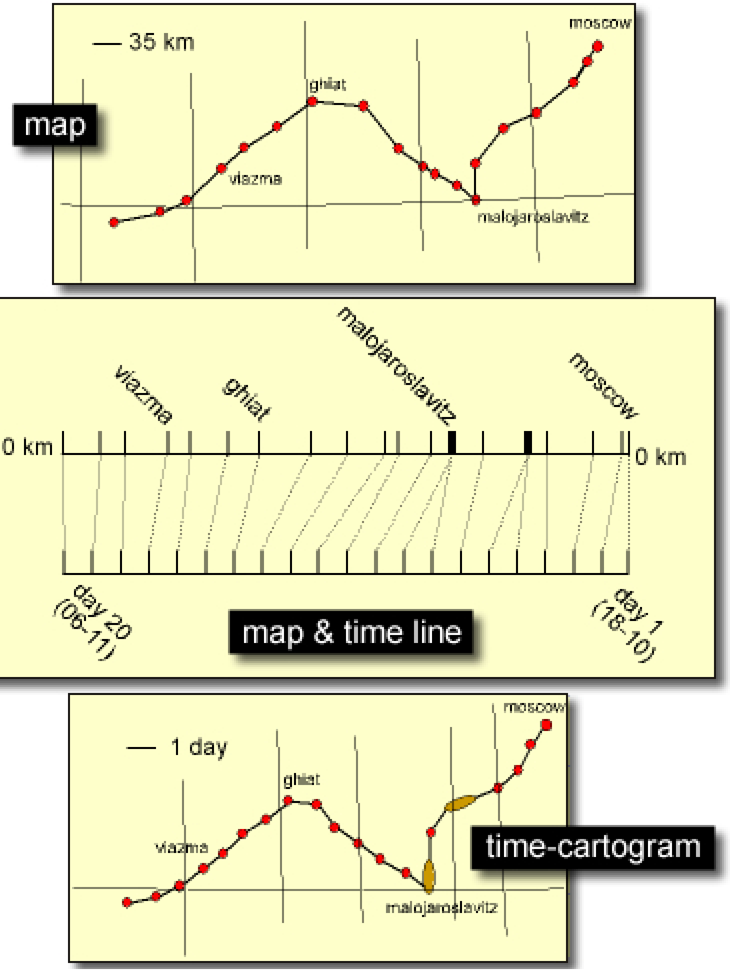
Applications and Extended Functionalities

- Orienteering run, fitness run – terrain and it’s effect, reconstruct participant’s trajectory
- Archaeology – spread of civilization, interesting location



Using Additional Views

Figure : Napoleon's retreat



Critique

Pros:

- Strong tool, can associate axis with other variable
- Scaling along axis possible

Cons:

- Space and time have to be associated to two of the axis
- Need additional views even for basic space concepts like distance

Questions on usability aspects of the cube's viewing environment:

1. How many views can the user handle?
2. Can multiple STPs be shown?
3. How should the interface look like?

Unfolding the Earth : Myriahedral Projections

Jarke J. Van Wijk

The Cartographic Journal, Feb 2008

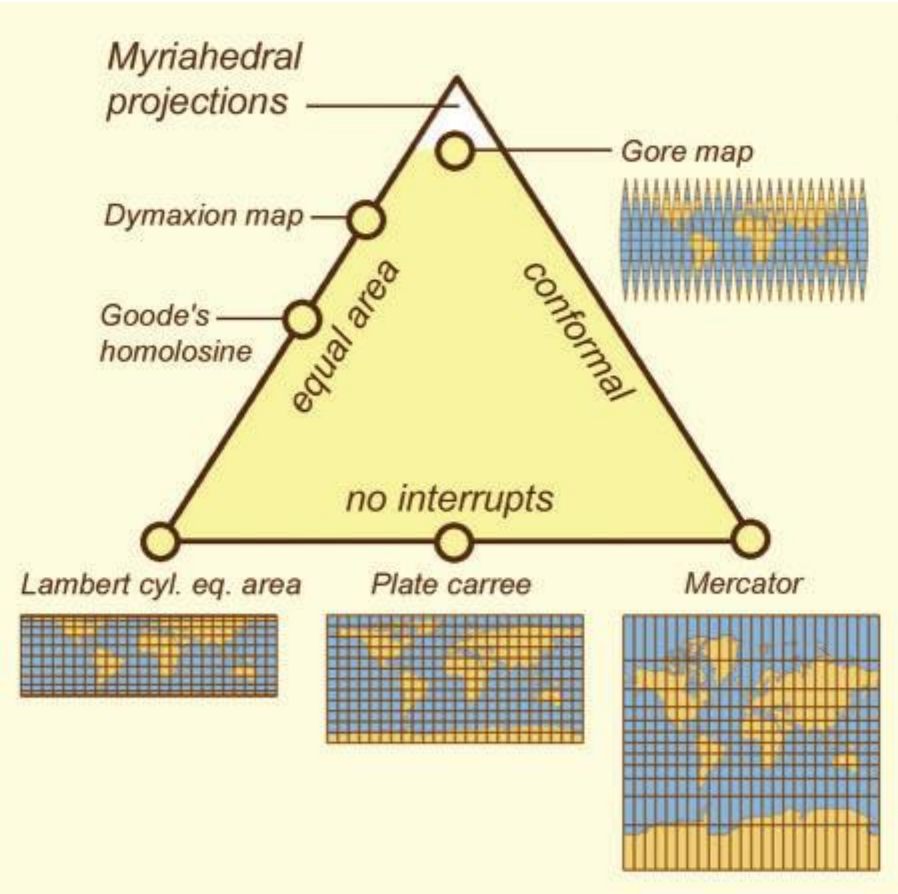
Distortion in Map Projection

Terms :

- Myriahedron
- Parallels and meridians
- Graticulated mesh
- Tissot indicatrix
- Conformal projection
- Equal area projection
- terra incognita projection

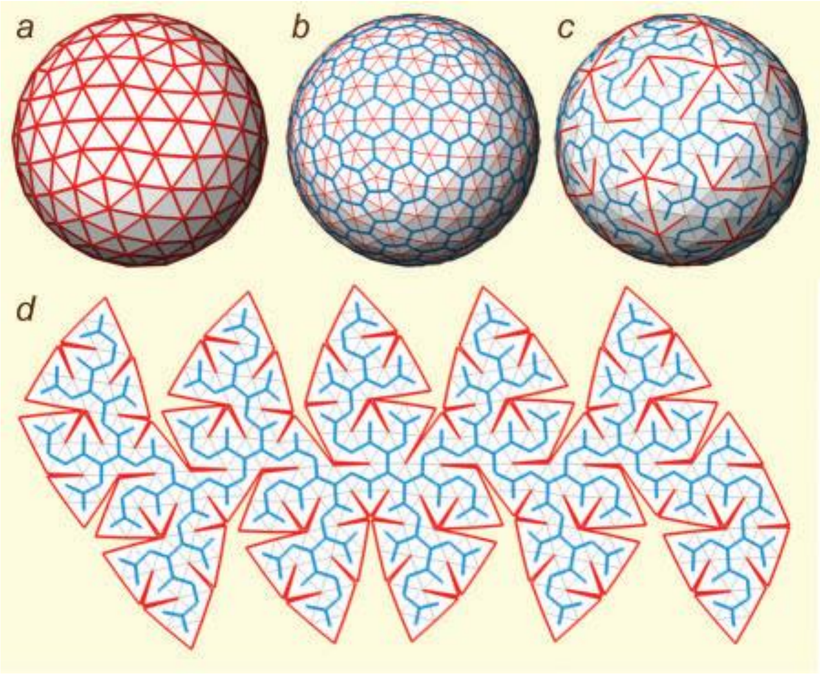
Factors leading to different requirements

1) intended use of the map
2) the available technology
3) the area or aspect



Graticulated Mesh Conditions

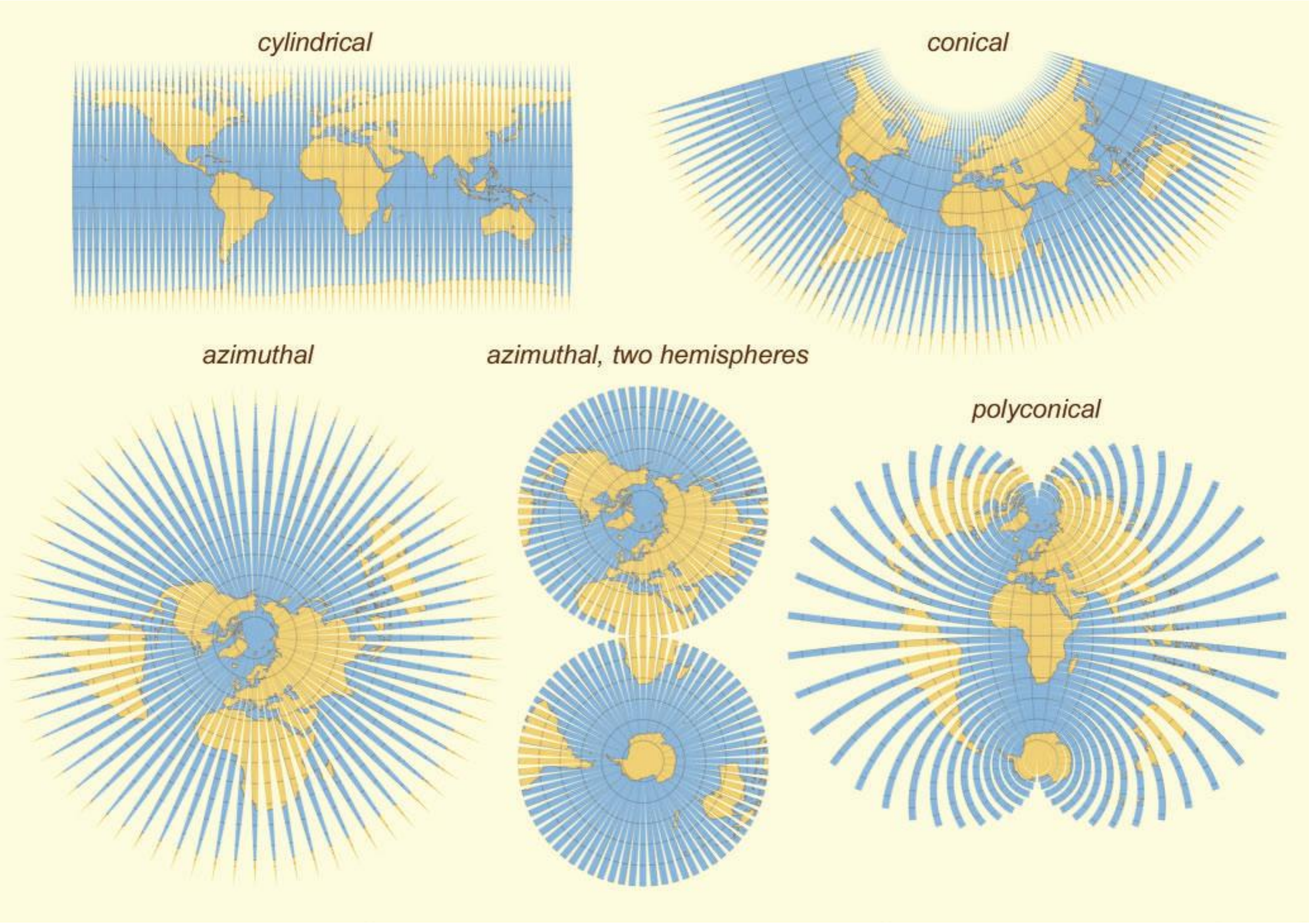
- Triangular faces with small area as node and edges as edge of graph G
- foldout connected and can be flattened implies H_f is a spanning tree
- G_c is a spanning tree
- no fold-overs



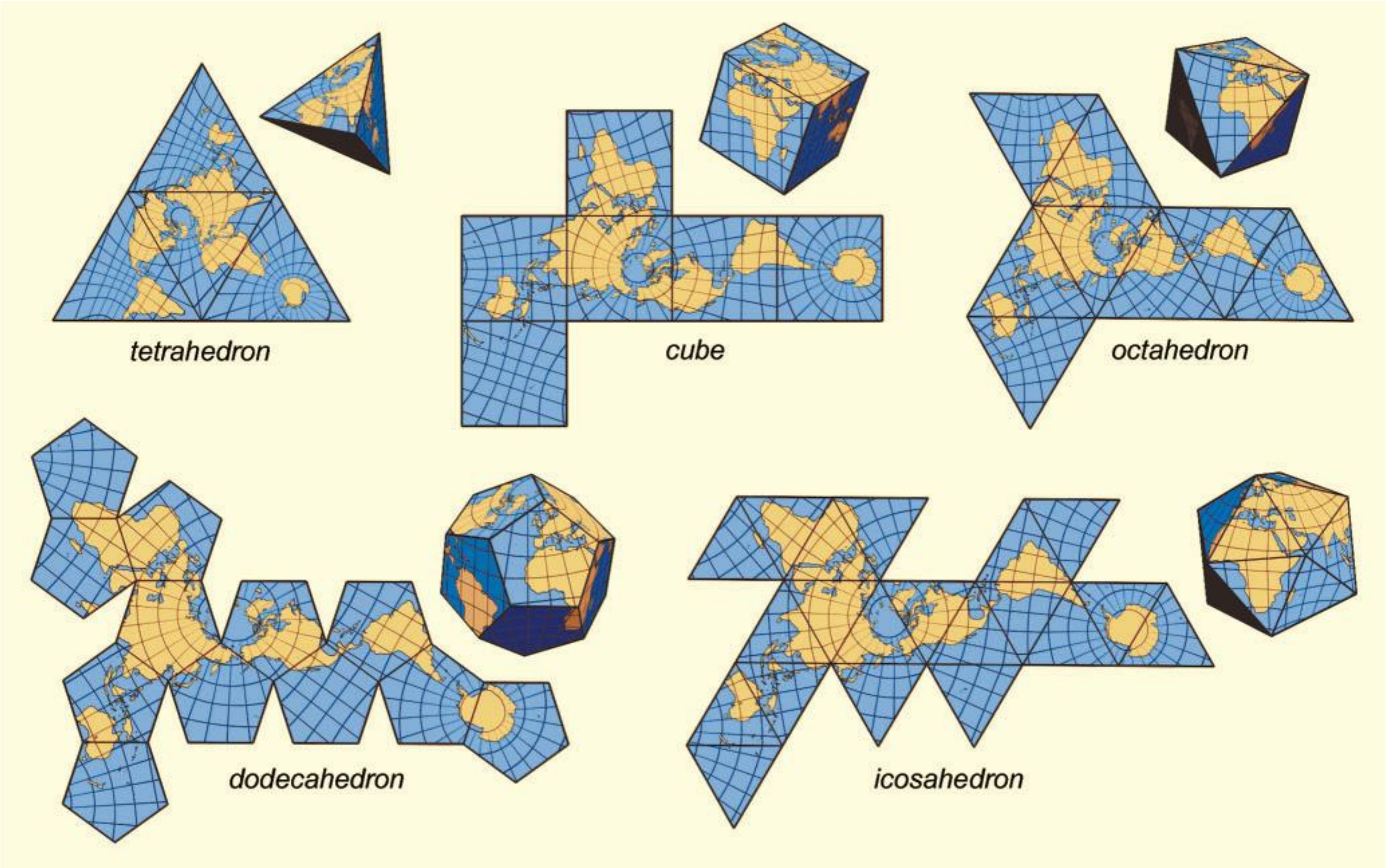
Algorithm to generate myriahedral:

1. Generate a mesh
2. Assign weights to all edges
3. Calculate a maximal spanning tree H_f using Prim's algorithm $O(|E| + |V| \log |V|)$
4. Unfold the mesh
5. Render the unfolded mesh

Unfolding mesh

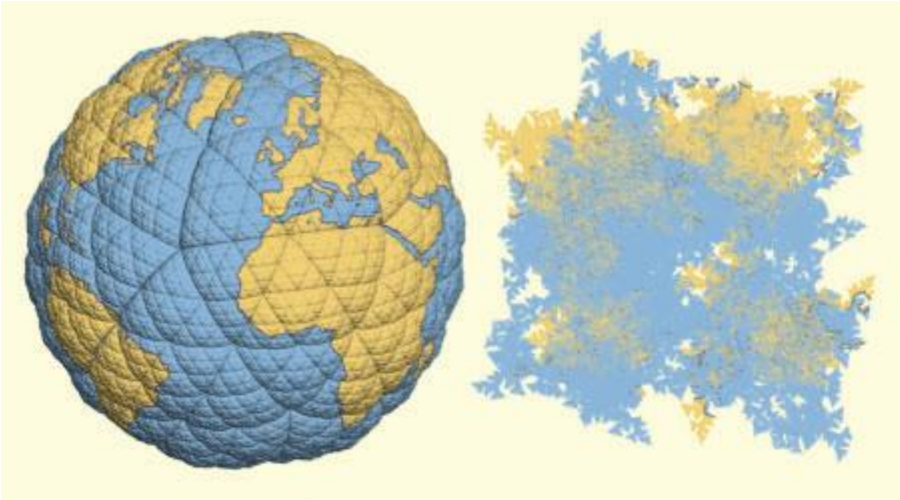


Projections on Platonic Solids



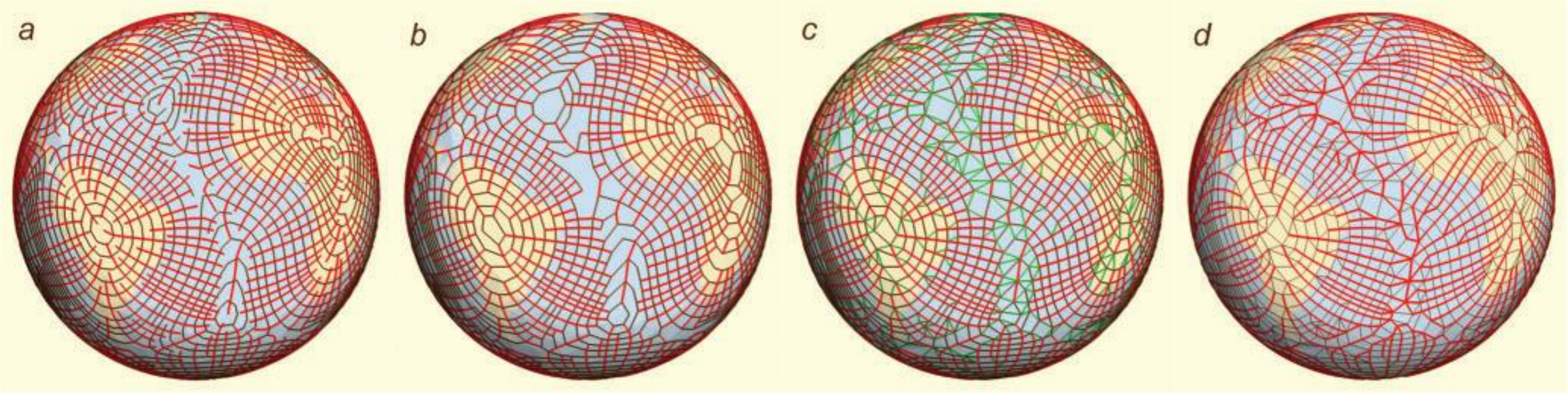
Defining Mesh

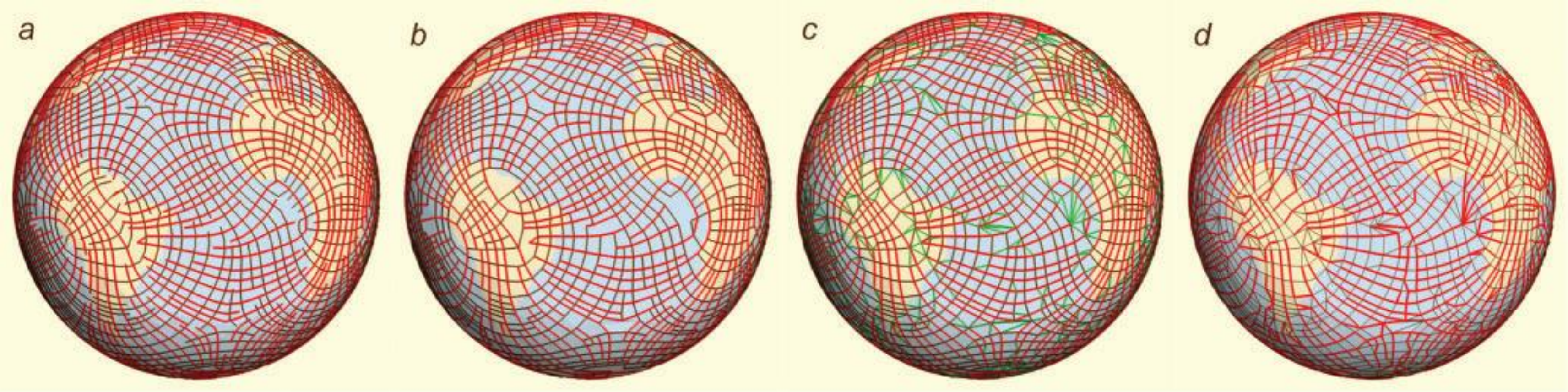
a. Generate mesh lines along and perpendicular to contours of f with the algorithm of Jobard and Lefer;
b. Calculate intersections of these sets of lines, and derive polygons;
c. Tesselate polygons with more than four edges; and finally
d. Use the standard approach to decide on folds and cuts.



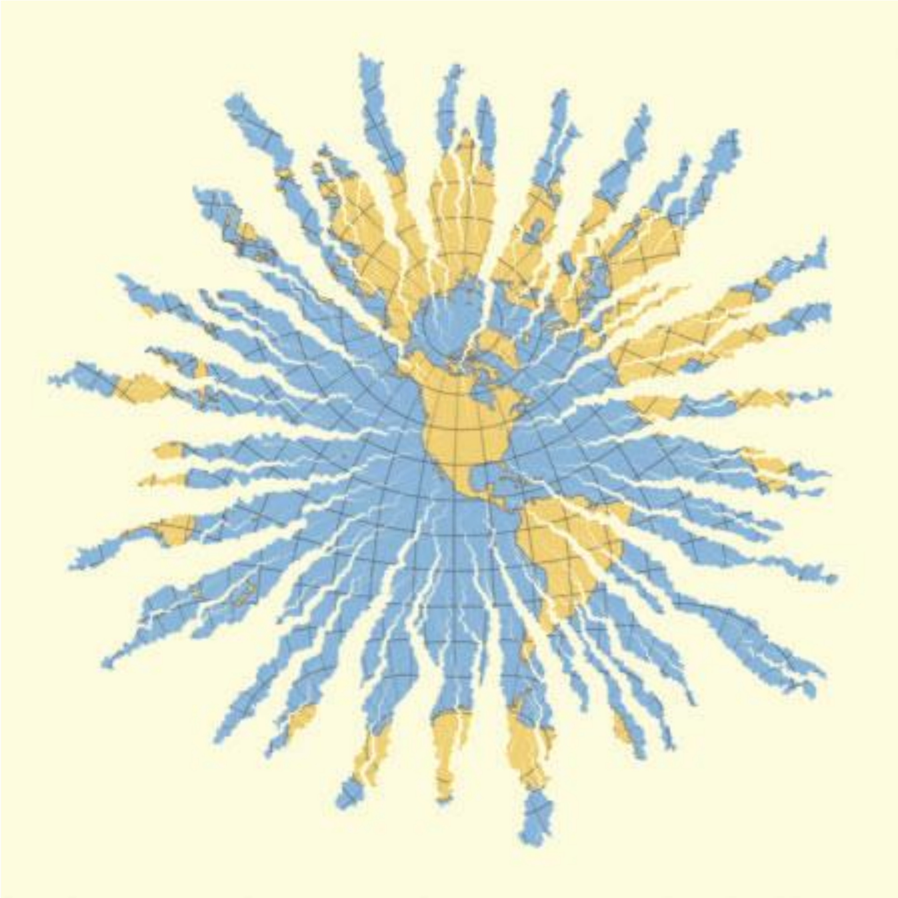
Alternate Mesh Definition

Based on vector fields and tensor fields:





Pretty Maps!



Azimuthal projection, random weights added, 81 920 polygons

Critique

Pros:

- Methodologically interesting in Computer Science perspective
- Can use different weight factors according to presentation target

Cons:

- fold-over rare but not restricted
- Most resultant maps unusual and unusable
- High computational complexity
- Cuts are more disturbing than distortions to most users

Geographically Weighted Visualization: Interactive Graphics for Scale-Varying Exploratory Analysis

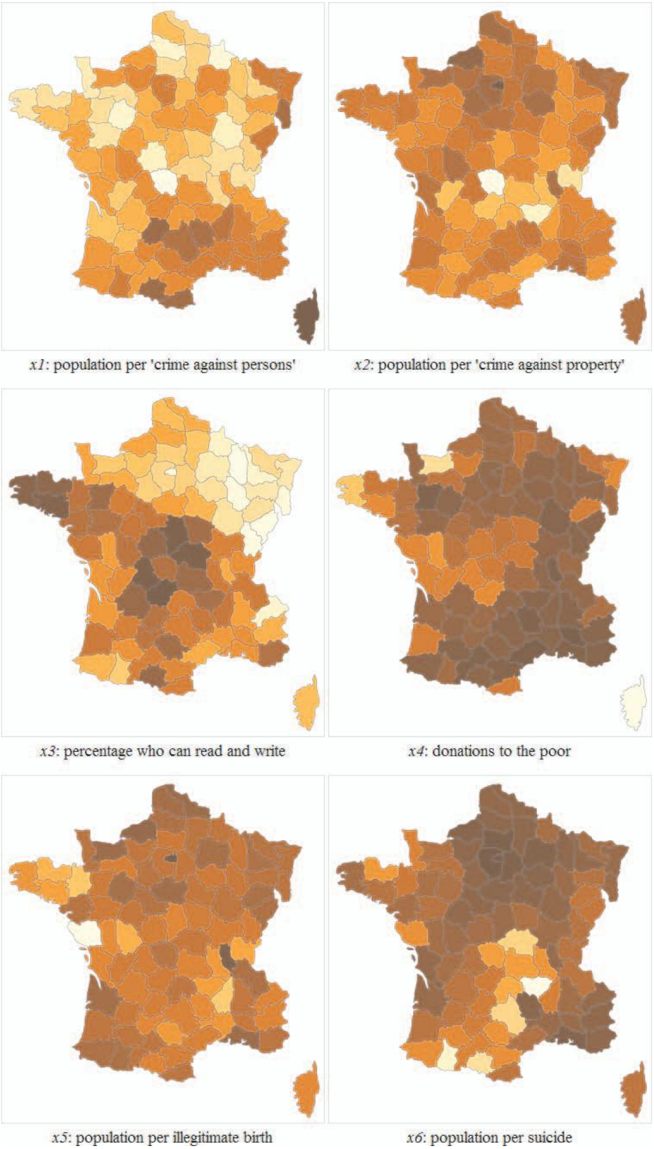
Jason Dykes and Chris Brunsdon
IEEE Transactions on Visualization and Computer Graphics, 2007

Context

André-Michel Guerry on Moral statistics:

- Dataset – related data for the departments of France in the early 19th century
- View – uni-variate choropleth maps to identify trends and outliers

Friendly proved some of Guerry's hypothesis wrong using regression



Summary Statistics

Weighted Mean, M(u, h) = $\dfrac{\sum x_i w_i(u)}{\sum w_i(u)}$

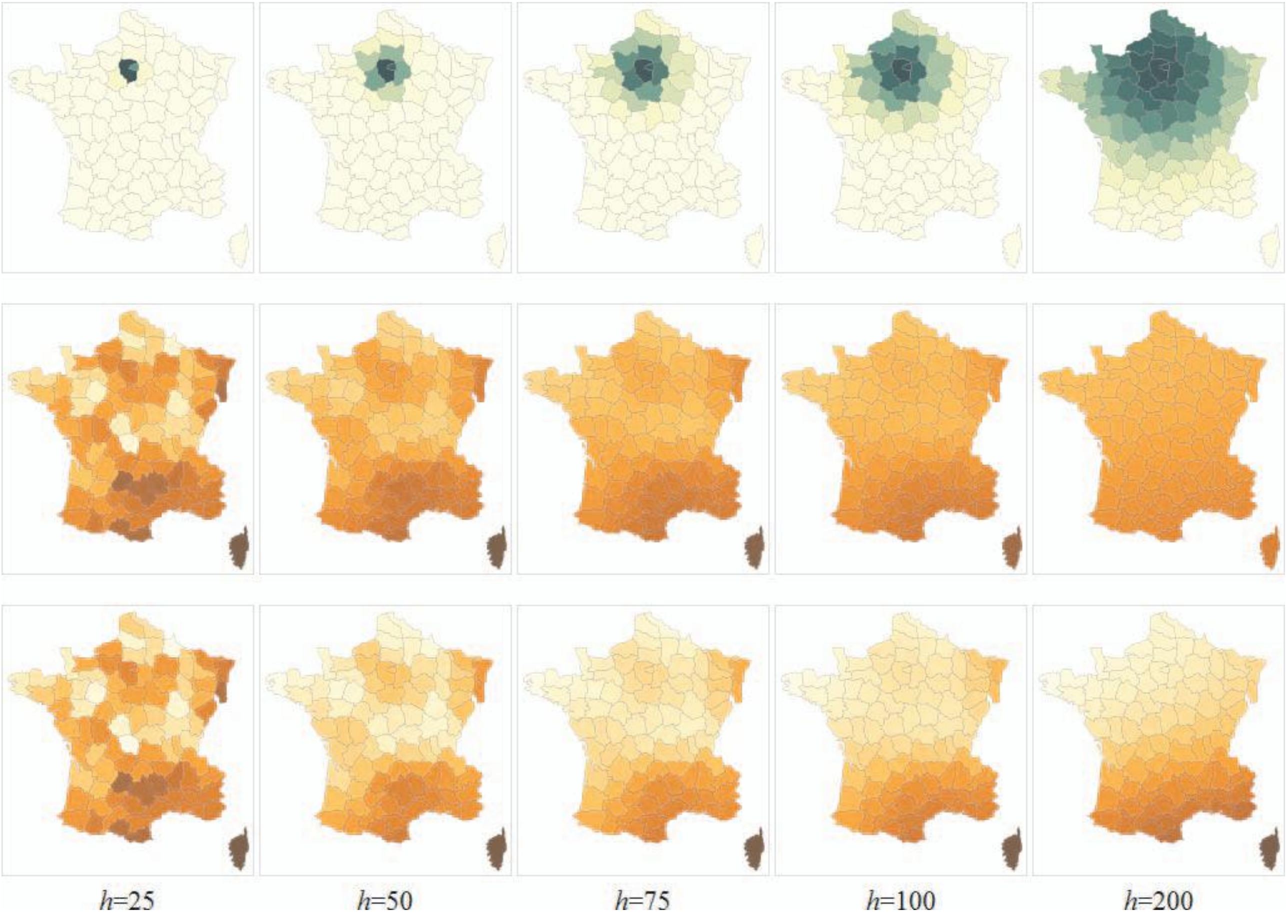
Gaussian decay function, $w_i(u)$ = exp $\left(-\dfrac{\left| u - u_i \right|^2}{2h} \right)$

Redefining weight function as $W_i(u)$ = $\dfrac{w_i(u)}{\sum w_i(u)}$

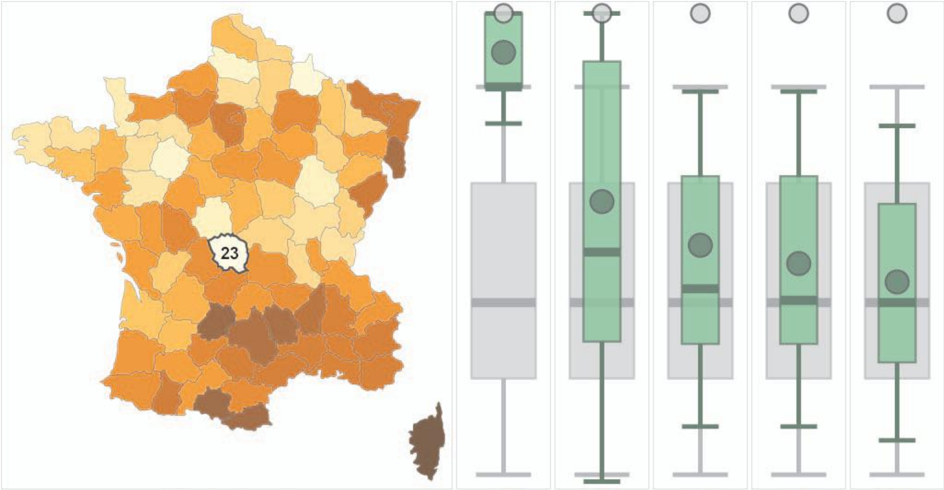
Then M(u, h) = $\sum x_i W_i(u)$

Discrete set of value, probability pairs L = { x_i, W_i}

Weight Maps and Their Effects

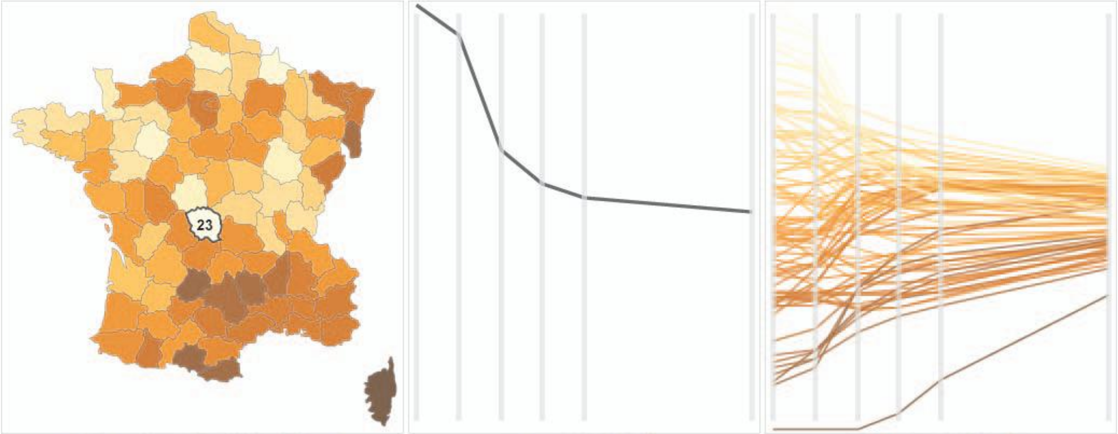


Boxplots, Choropleths and Scalograms



original values $x1$
i=23 highlighted - Creuse

i=23 h=25 | i=23 h=50 | i=23 h=75 | i=23 h=100 | i=23 h=200

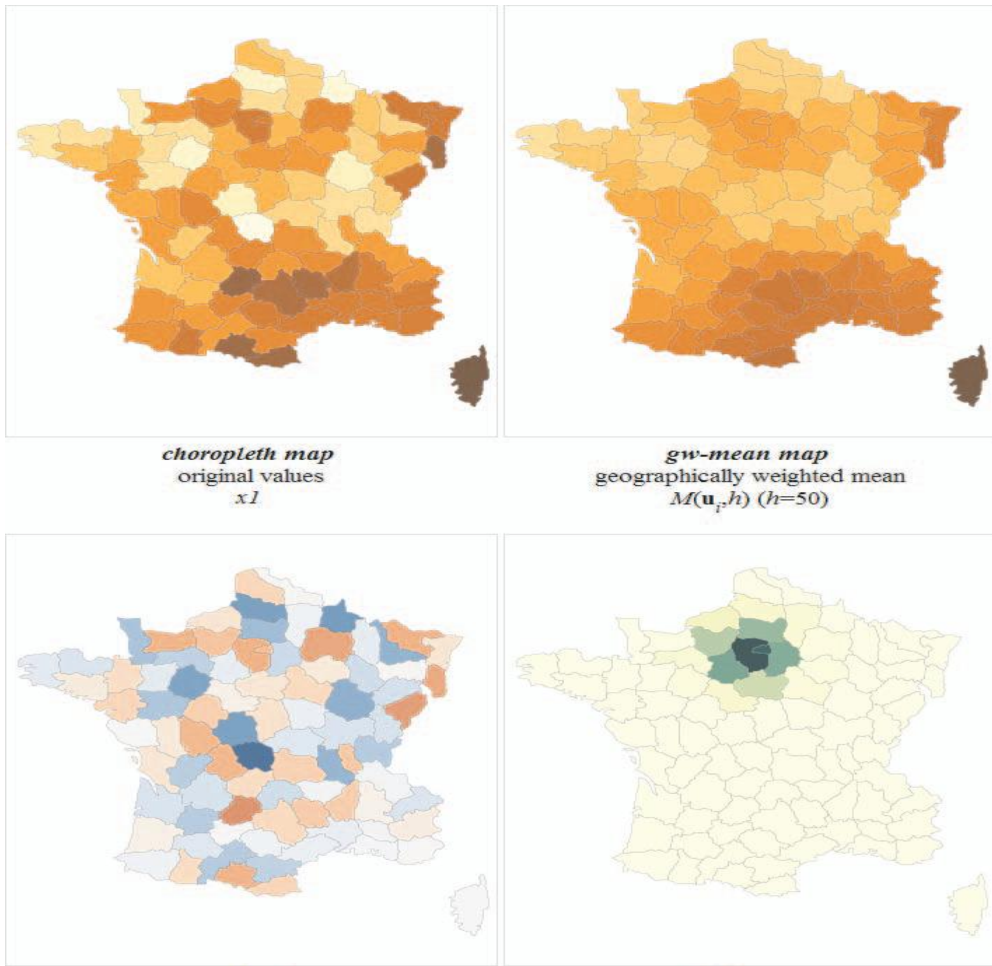


original values $x1$, i=23 highlighted

scalogram $x1$, i=23.
$x_i h$, where h=0, 25, 50, 75, 100, 200

scalogram $x1$, for all i.
$x_i h$, where h=0, 25, 50, 75, 100, 200

Spatial Views



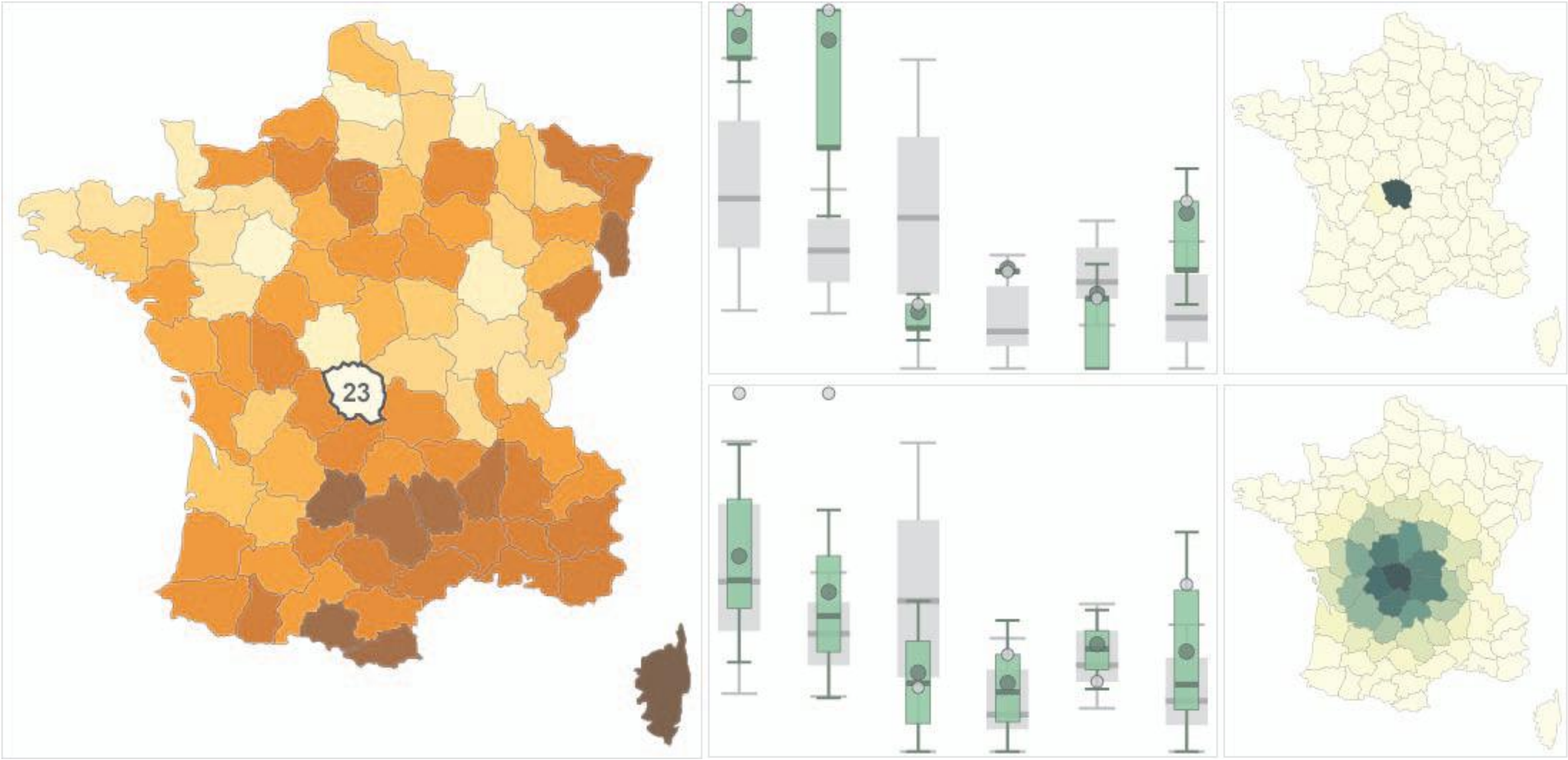
choropleth map
original values
$x1$

gw-mean map
geographically weighted mean
$M(\mathbf{u}_i,h)$ (h=50)

gw-residual map
map of absolute differences
$|x1_i - M(\mathbf{u}_i,h)|$ (h=50)

weighting map
weights for a single department
w_{ij} (i=76, h=50)

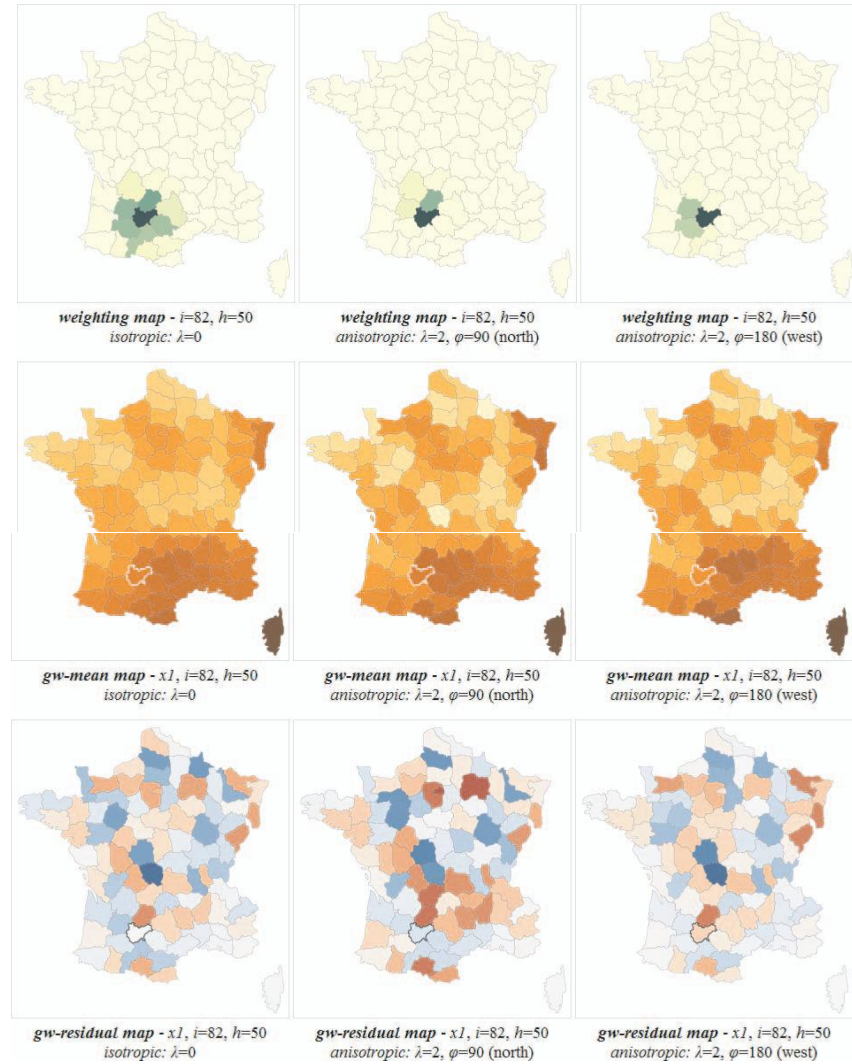
Linked Views



Directed Geographic Weighting

Take $w_i = w_i \exp\left(-\lambda \cos(\theta_i - \varphi)\right)$

Directed GW statistics at clock points to reduce computation time.



weighting map - i=82, h=50 *isotropic:* λ=0

weighting map - i=82, h=50 *anisotropic:* λ=2, φ=90 (north)

weighting map - i=82, h=50 *anisotropic:* λ=2, φ=180 (west)

gw-mean map - $x1$, i=82, h=50 *isotropic:* λ=0

gw-mean map - $x1$, i=82, h=50 *anisotropic:* λ=2, φ=90 (north)

gw-mean map - $x1$, i=82, h=50 *anisotropic:* λ=2, φ=180 (west)

gw-residual map - $x1$, i=82, h=50 *isotropic:* λ=0

gw-residual map - $x1$, i=82, h=50 *anisotropic:* λ=2, φ=90 (north)

gw-residual map - $x1$, i=82, h=50 *anisotropic:* λ=2, φ=180 (west)

Critique

Pros:

- Can compare at different scales (different values of h and θ)
- Moving window approach overcomes the abruptness of aggregation based on regional administrative hierarchy
- Ability to strum the set of scalograms

Cons:

- Computationally expensive and hard to search for trends at large number of scales
- Large number of views

Questions?

Thank You