



# Visualization tools and Visual Analytics for Big Data analysis on people movement

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UPM

DAY 2: SMART CITIES

TABLE 3: SMART CITY AND URBAN SUSTAINABLE DEVELOPMENT

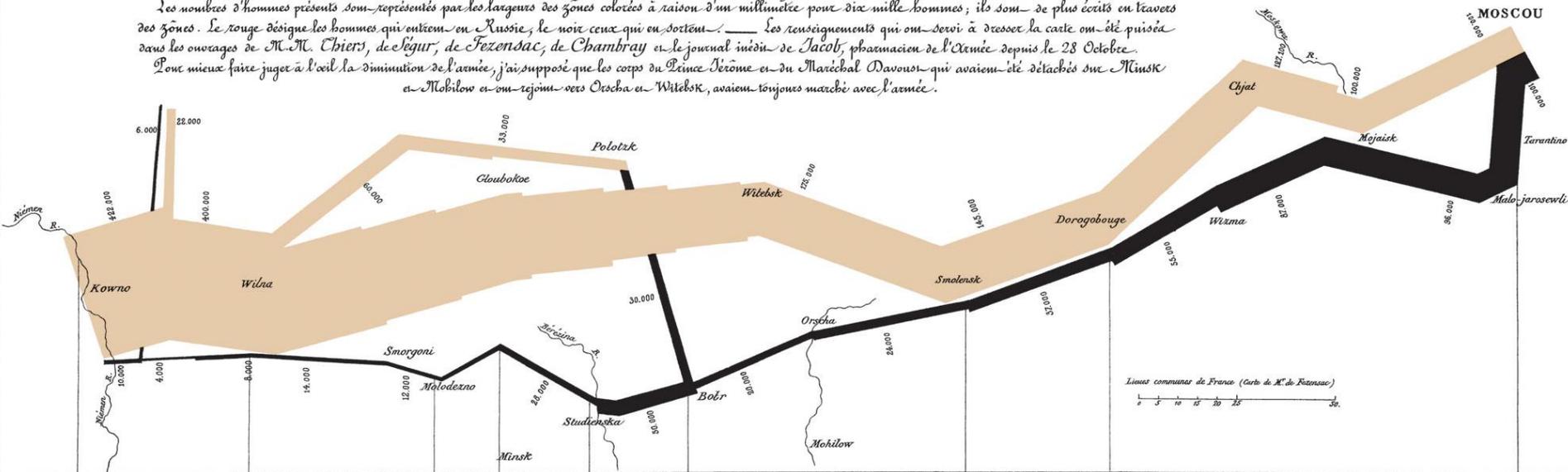
INTERNATIONAL SUMMER SCHOOL  
"SMART GRIDS AND SMART CITIES"

Barcelona, 6-8 June 2017

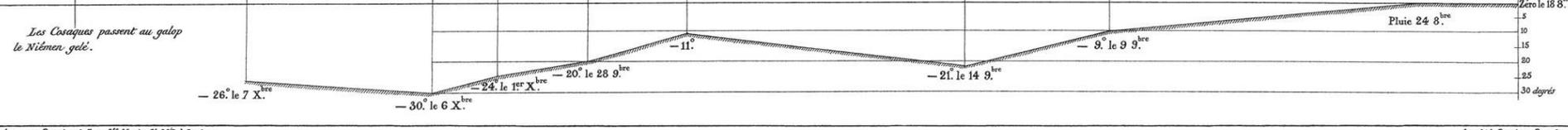
# Introduction – a story

*Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.*  
 Dessinée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zones. Le rouge désigne les hommes qui ont été en Russie, le noir ceux qui en sont sortis. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Thiers, de Ségur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre. Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout qui avaient été détachés sur Minsk et Mobilow et qui rejoignent vers Orscha et Witebsk, avaient toujours marché avec l'armée.



*TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.*



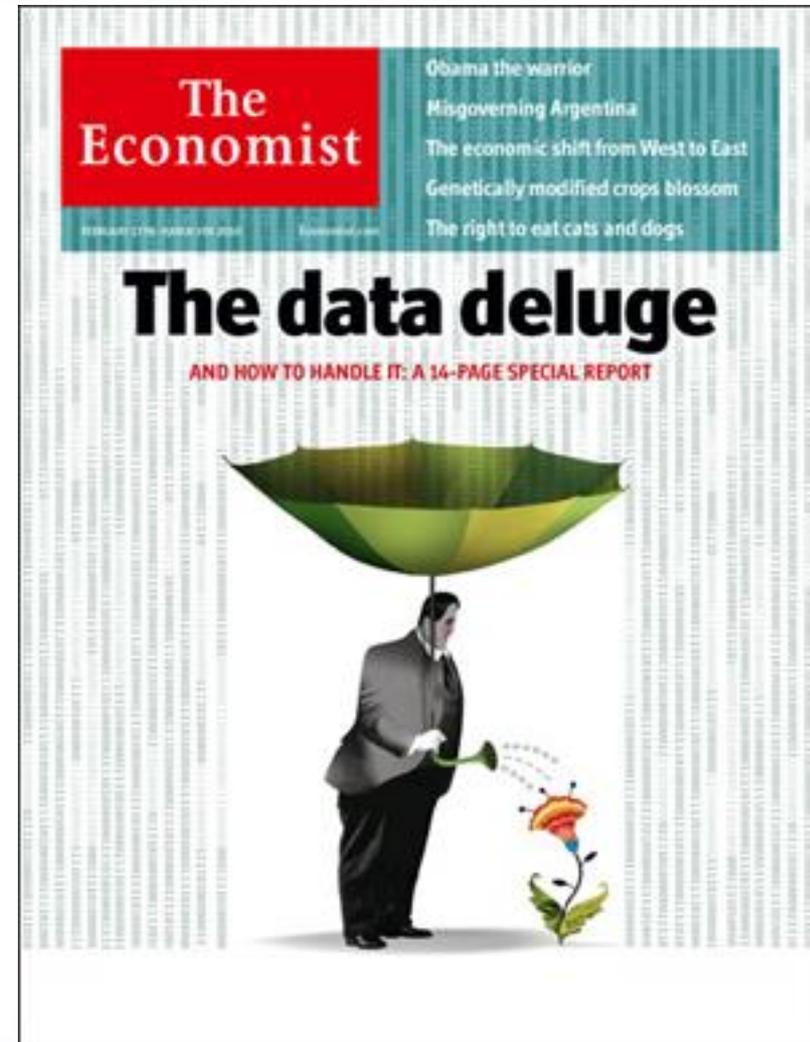
Autog. par Reynier, 8. Pas. S<sup>te</sup> Marie S<sup>te</sup> O<sup>de</sup> à Paris.

Imp. Lit. Reynier et Desrodes.

A bi-dimensional representation of several data types: size of Napoleon's army, geographical context (distances, notable places), direction of the troops march, temporal references, temperatures

## What we ask to our data:

- explain and classify events;
- interpret facts;
- detect patterns;
- solve problems;
- find / propose solutions;
- take decisions;
- look at the past, explain the present, predict the future
- ...



## What we are looking for:

- summarise information / simplify the complex;
- obtain insights from massive, dynamic, ambiguous, and often conflicting data;
- detect the expected and discover the unexpected;
- provide timely, evidence-based, and understandable analysis;
- communicate actionable assessments effectively

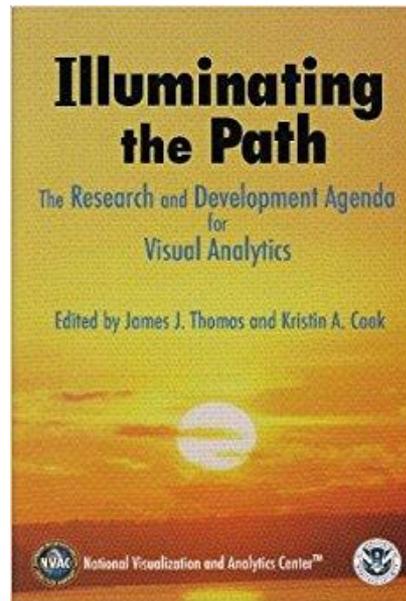


# Visual analytics - I

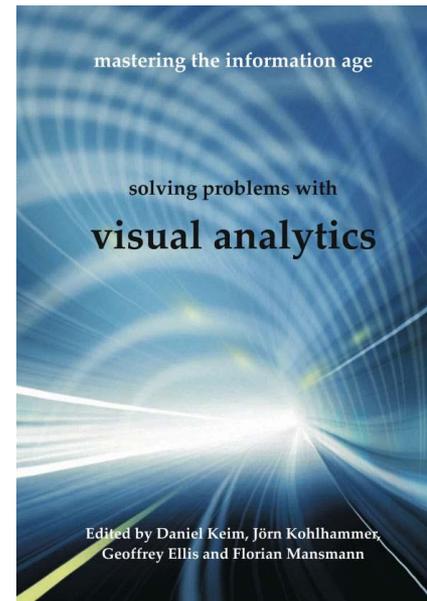
The science of analytical reasoning facilitated by  
**interactive visual interfaces**

Analytical reasoning =

Data → information → knowledge → decisions

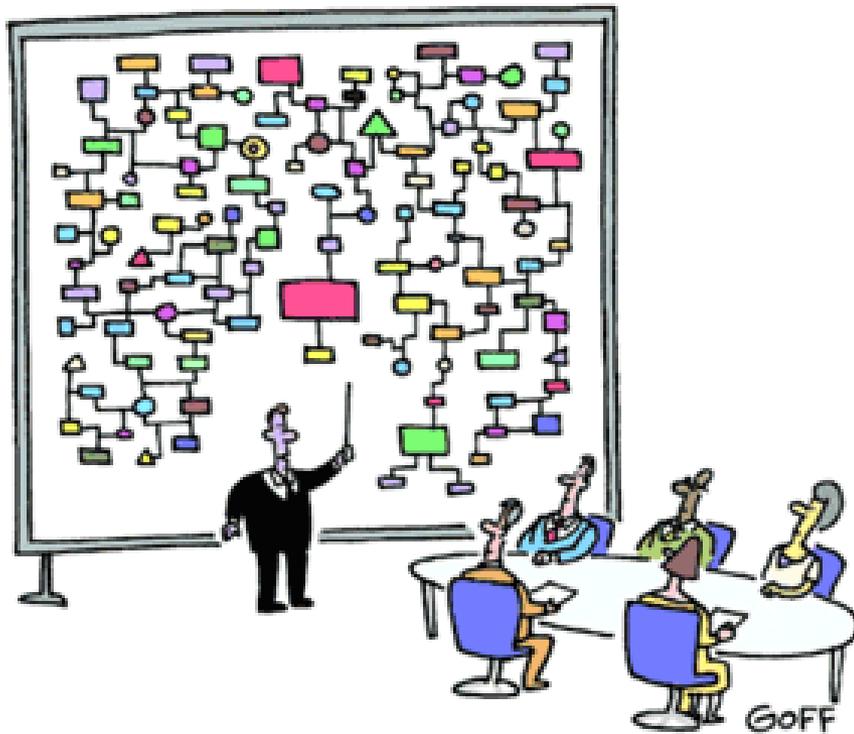


IEEE Computer Society 2005  
<http://nvac.pnl.gov/>

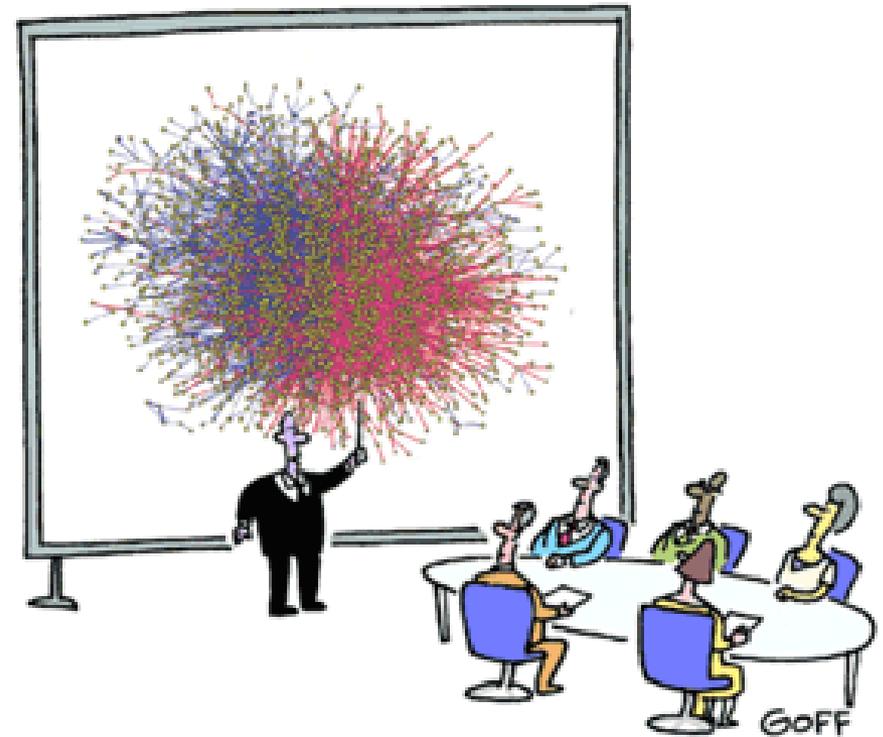


Eurographics 2010  
<http://www.vismaster.eu/book>

# Visual analytics - II

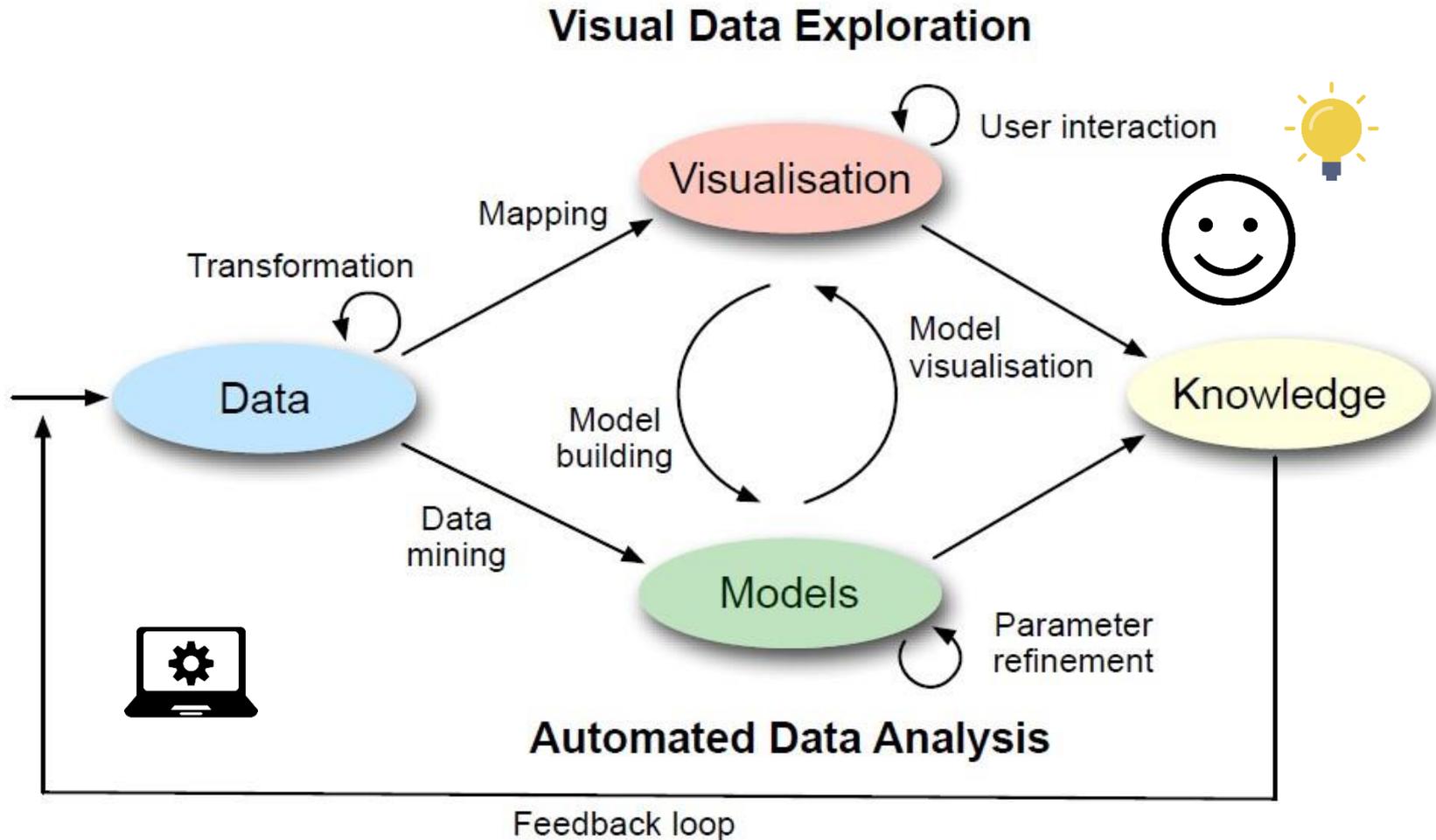


And that's why we need a computer.



And that's why we need a human.

# Visual analytics - III



# Visual analytics - IV

Human thinking – a composite process:

- perception + imagination + abstraction + experience + adaptation + ...

But only human thinking is often insufficient:

- processing and storing limitations, difficulty in grasping high dimensionality, sensibility to external factors, slowness, ...

Visualisation is essential to access the doors of knowledge

VA helps with problems hard to be solved algorithmically:

- ill-defined, involving incomplete and/or uncertain and/or conflicting data

# The urban environment - I

- Cities are complex systems where the global picture of the urban dynamics is given by the sum of several, evolving and intermingled networks;
- The way people create social interactions, give functionalities to the architecture, benefit from services and infrastructures, or connect different areas of the urban fabric introduces a further level of complex dynamics being often difficult to grasp.



# The urban environment - II

- The increasing penetration of modern ICT technologies enriches and improves traditional data sources, in terms of variety, accessibility, topic coverage, reliability, and completeness;
- *“The connections between data and decisions are built one good question at a time until understanding bridges the gap between them” (Few, 2009)*
- Data visualisation approaches should be more and more integrated within decision support tools for urban and regional policy assessment and collaborative planning.



# The urban environment (data)

- Location-based social networks;
- Mobile devices (call, text, app activity, ...);
- Digital commercial transactions;
- Network devices and sensors;
- Transport information;
- Policy simulators;
- Public datasets (including census)
- ...

**Geographical context (e.g. spatial coordinates)**

**Temporal attributes**

**Other dimensions**

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**Spatial event**

**Spatial-time series**

**Flows**

**Trajectories**

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**Dynamic (most of them)**

**Big volume and variety**

**Intra- and inter-inconsistencies**

# The urban environment (mobility)

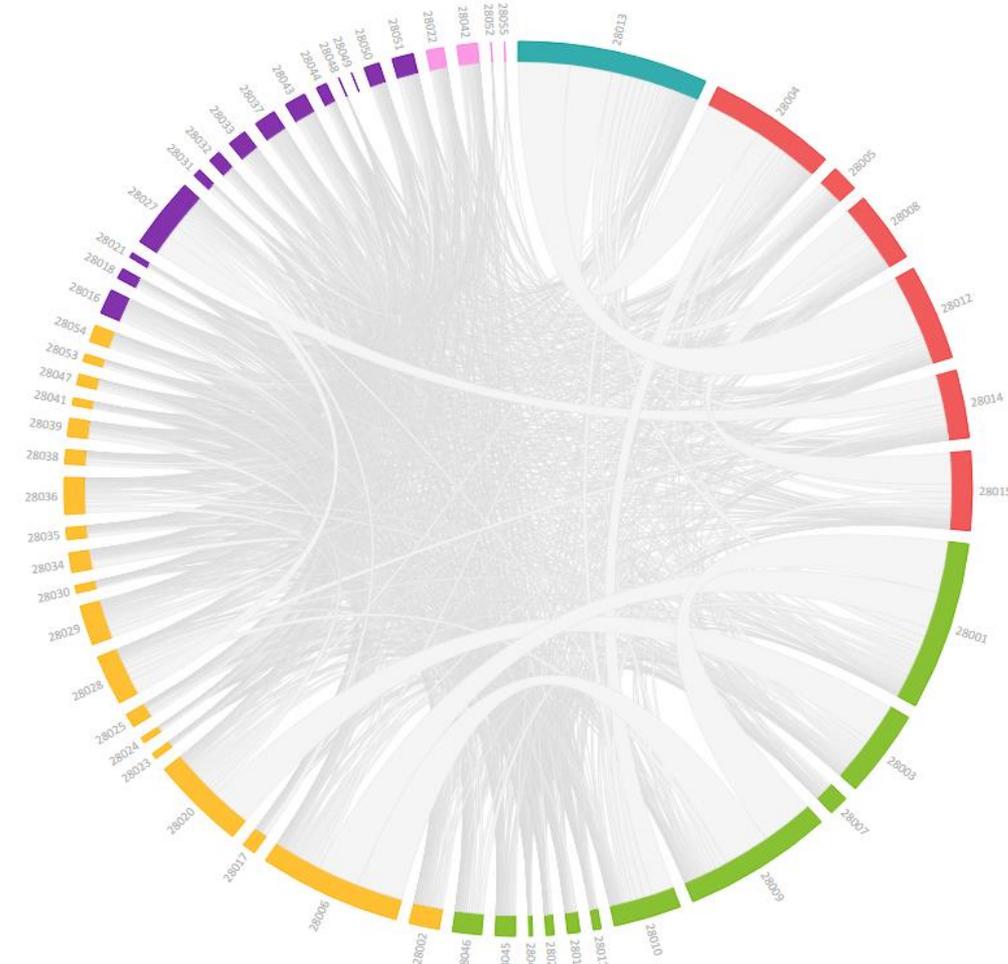
- Regulation of urbanisation and policy making as key drivers to mobility study:
  - Transport infrastructure
  - Administrative services
  - Tourism
- Mobility has an environmental impact:
  - Greenhouse gas emissions
  - Energy efficiency
  - Land usage and distribution; housing
- Mobility has security and healthcare repercussions:
  - Safety (e.g. personal, road traffic)
  - Pandemics

# Visualisations of movements - I

VISUAL ECONOMY FOR MADRID  
Where people go shopping across the city

Number of purchases | Money spent | Mean times

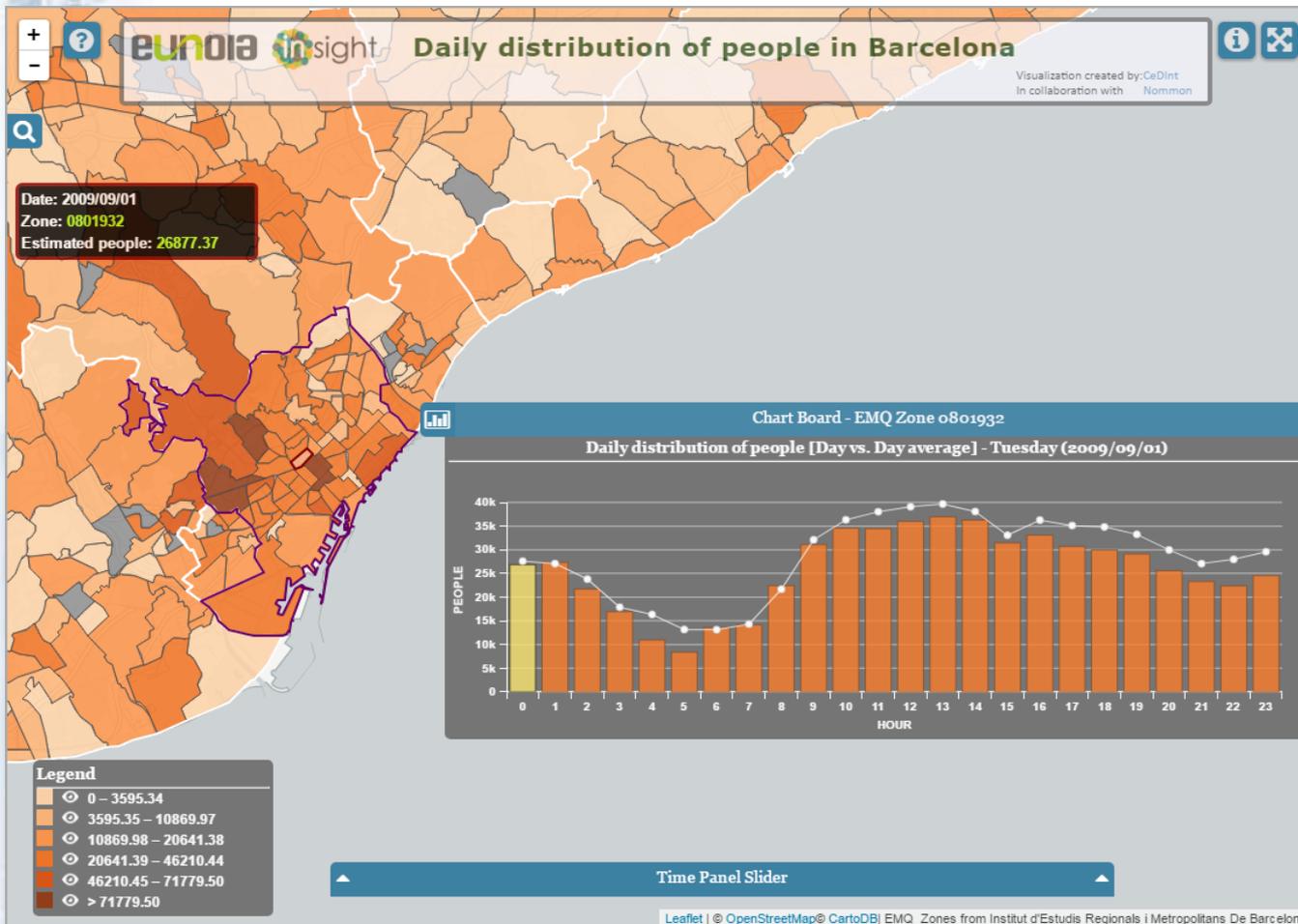
Show inward statistics



## customer movements:

- GOAL: to analyse customer displacements for shopping (consecutive purchases);
- DATA: sample of e-transactions (period of 8 weeks);
- HOW: highlight spatial relationships in a OD matrix

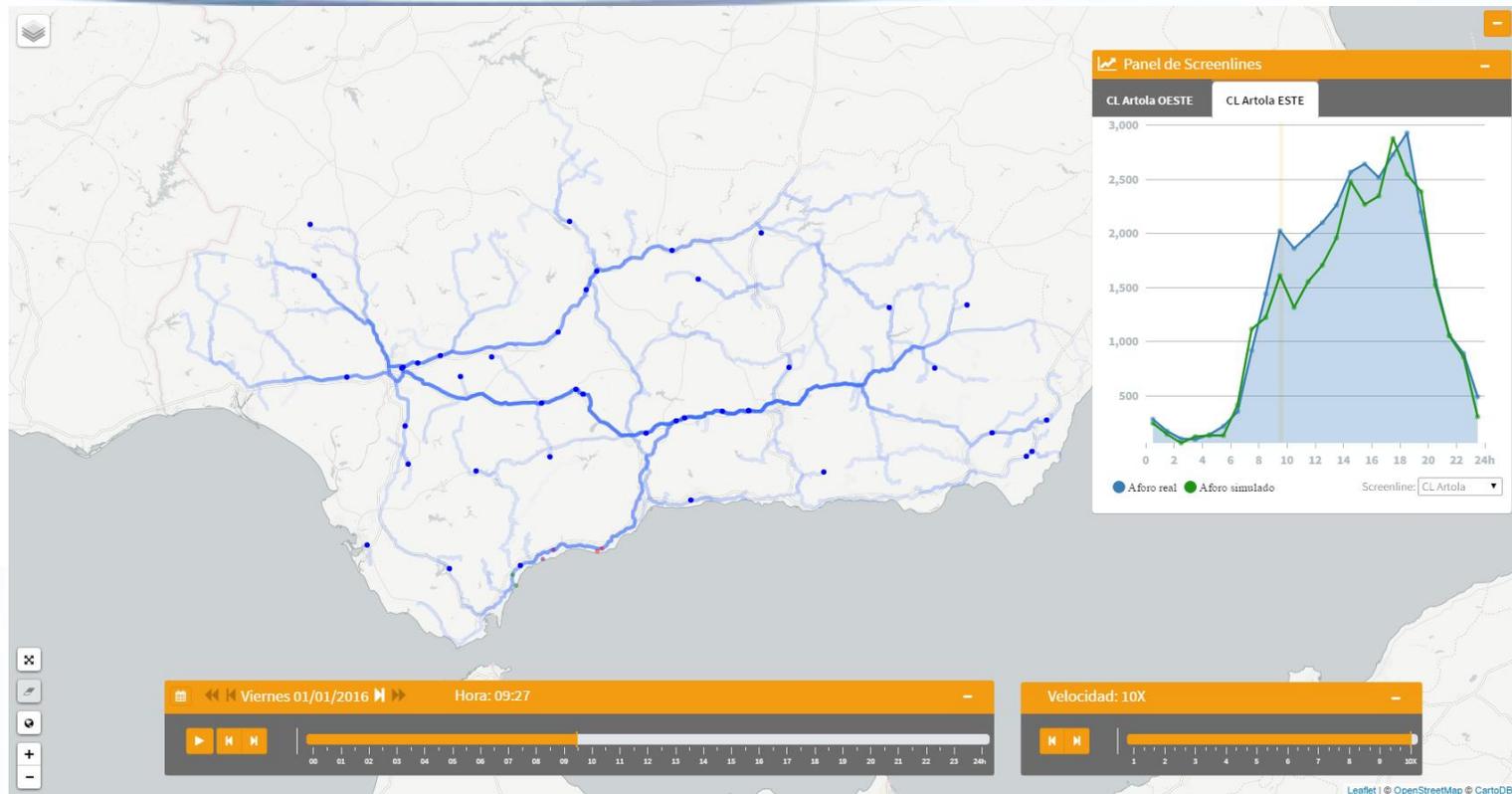
# Visualisations of movements - II



## People density:

- GOAL: to represent people distribution in Barcelona at different time ranges
- DATA: elaboration of CDRs
- HOW: choropleth map to emphasize spatial distribution / bar chart to reveal time patterns

# Visualisations of movements - III



## Trip analysis:

- GOAL: to characterise (and forecast) the possible demand of a highway in the Spanish region of Andalusia;
- DATA: elaboration of CDR records;
- HOW: trip segmentation by OD, hour, and purpose

# Challenges for the future

- ***Data Fusion:***
  - Enrich data coming from different sources;
  - Interfaces / tools for visual exploration;
  - Models improvement;
- ***Data literacy:***
  - Train high-skill level professional to properly use and understand data AND visualisation domains;
  - Make data visualisation as one of the main pillars in every domain
- ***Ubiquitous IV/VA (through Mixed and Augmented Reality?)***
  - Represent data on real environments;
  - Integration with widespread sensors



POLITÉCNICA

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