

## ГЕОИНФОРМАЦИОННЫЕ И КАРТОГРАФИЧЕСКИЕ МЕТОДЫ И ТЕХНОЛОГИИ

## GEOINFORMATIONAL AND CARTOGRAPHICAL METHODS AND TECHNOLOGIES

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Menno-Jan Kraak<sup>1</sup>

### MOVEMENT DATA: ALTERNATIVE OD MATRIX VISUALIZATIONS

The content of an Origin and Destination matrix informs about the nature of movement and connectivity between locations. These could be point locations, like airports, or regions, like countries. The path of the flow can be known in detail (the path of an airplane) or only be abstract (migration between provinces). The type of movement or flow can be qualitative (different airline flying between two airports) or quantitative (the number of migrants between two countries), or both. Traditionally, this type of data is visualized in flow maps. In these maps flows are often represented by arrows of different colors and width to represent the flow between an origin and a destination.

Flow maps have been classified based on different approaches. Here we consider whether and how the OD data are visualized. For flows five different visualization options exist: Not shown (NS), shown (S), shown with qualitative characteristics (QL), shown with quantitative characteristics (QT), and shown with both qualitative and quantitative (QQ). For the origins and destinations, the same options exist. However, with the addition of the option that either the origin or the destination is shown or not shown (NS-S).

Time is inherent in OD data, because movement always “flows” from an origin to a destination. However, time is not always explicitly shown. It is possible to express time in flow maps by directionality and/or by showing the progress of time. Examples of the first are arrows, the use of visual variables such as value, or the animation of moving particles along the path of the flow. The progress of time can be expressed with small multiples, in a Space-Time cube or via animation.

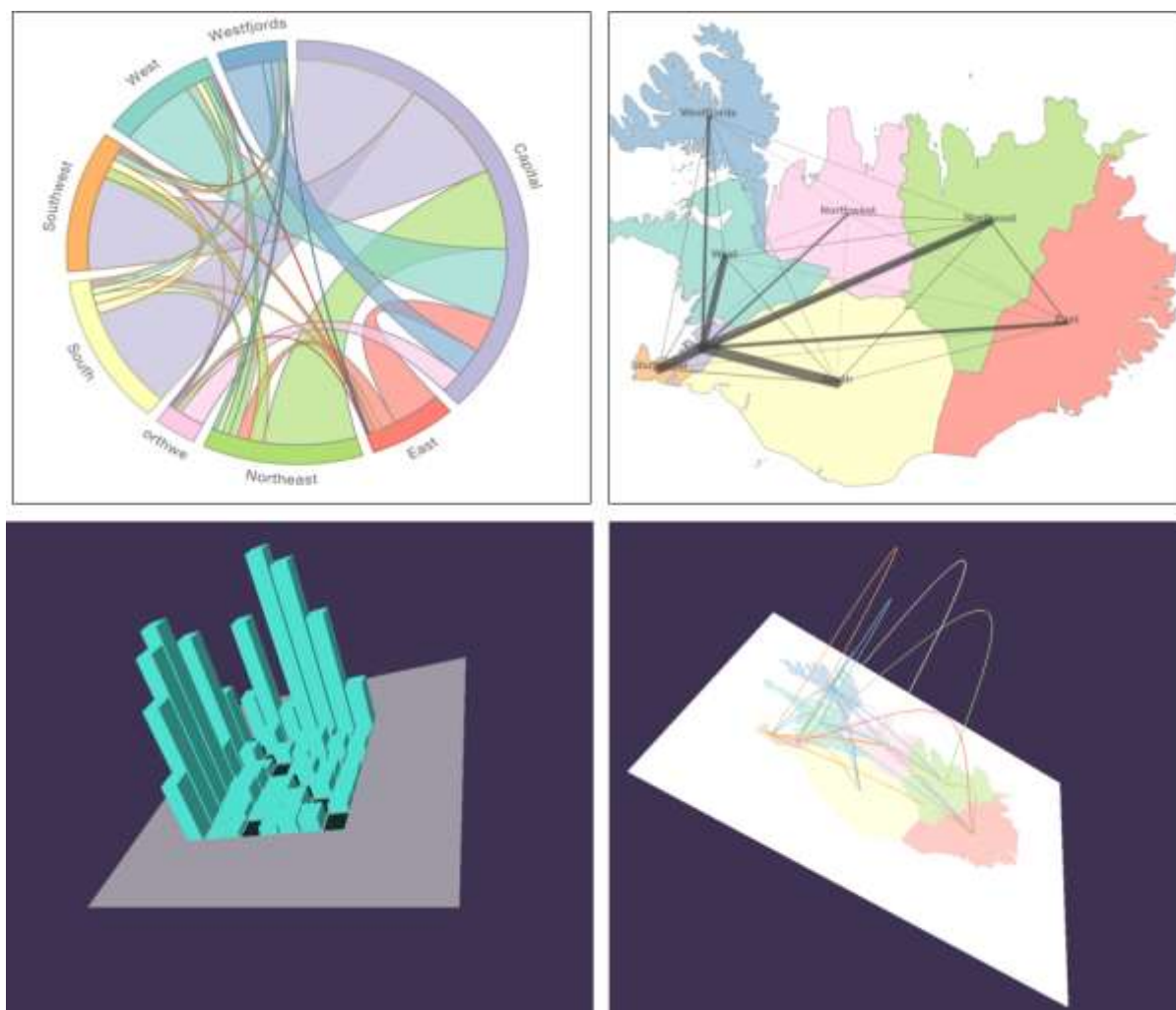
However, flow maps also tend to become visually cluttered quickly. Additional problems arise when time series have to be displayed too. In practice people have tried to work toward solutions applying different algorithms to aggregate or cluster flows or to find a better geographic layout. Others concentrated on interaction techniques that allow filtering or selection via mouse-over. Some looked at other alternative visualizations. These could be cartograms, chord diagrams, tree maps etc. In some of these alternative approaches the geography gets lost. In our suggested solutions, we concentrate on the design of alternative visualizations of the matrix itself. Despite the fact that the origins and destinations refer to locations the matrix represents attribute space, and because of this it is more than likely that the geography gets lost. Therefore, we linked the matrix to the (flow) map. We suggest alternative three-dimensional designs that allow for interaction, and brush time (see Figure 1).

Flow maps are generally displayed in two dimensions, but already at the end of the nineteen eighties [Tobler, 1987] stated: “drawing flows in the third dimension as well creates more space”, and a few years later [Tufte, 1990] argued that escaping flatland is the essential task of envisioning information. Over the years several experiments have been executed with three dimensional visuali-

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<sup>1</sup> President ICA, University of Twente-ITC; *e-mail*: m.j.kraak@utwente.nl

zations of flows. To really appreciate the third dimension, it is not enough to just display this dimension on a flat paper or screen as in Figure 1, because at the end we have the same information density as in a two – dimensional flow map. The first requirement is that one can rotate the three-dimensional flow map to find a suitable view angle to see the parts of the flow one is interested in. Second, to optimally profit from the third dimension and to “create more space” one has to use a viewing environment that indeed offer ‘real’ three-dimensional perception that immerses the viewer into the map. For instance, by presenting the map on real three-dimensional screens or in a virtual reality environment.

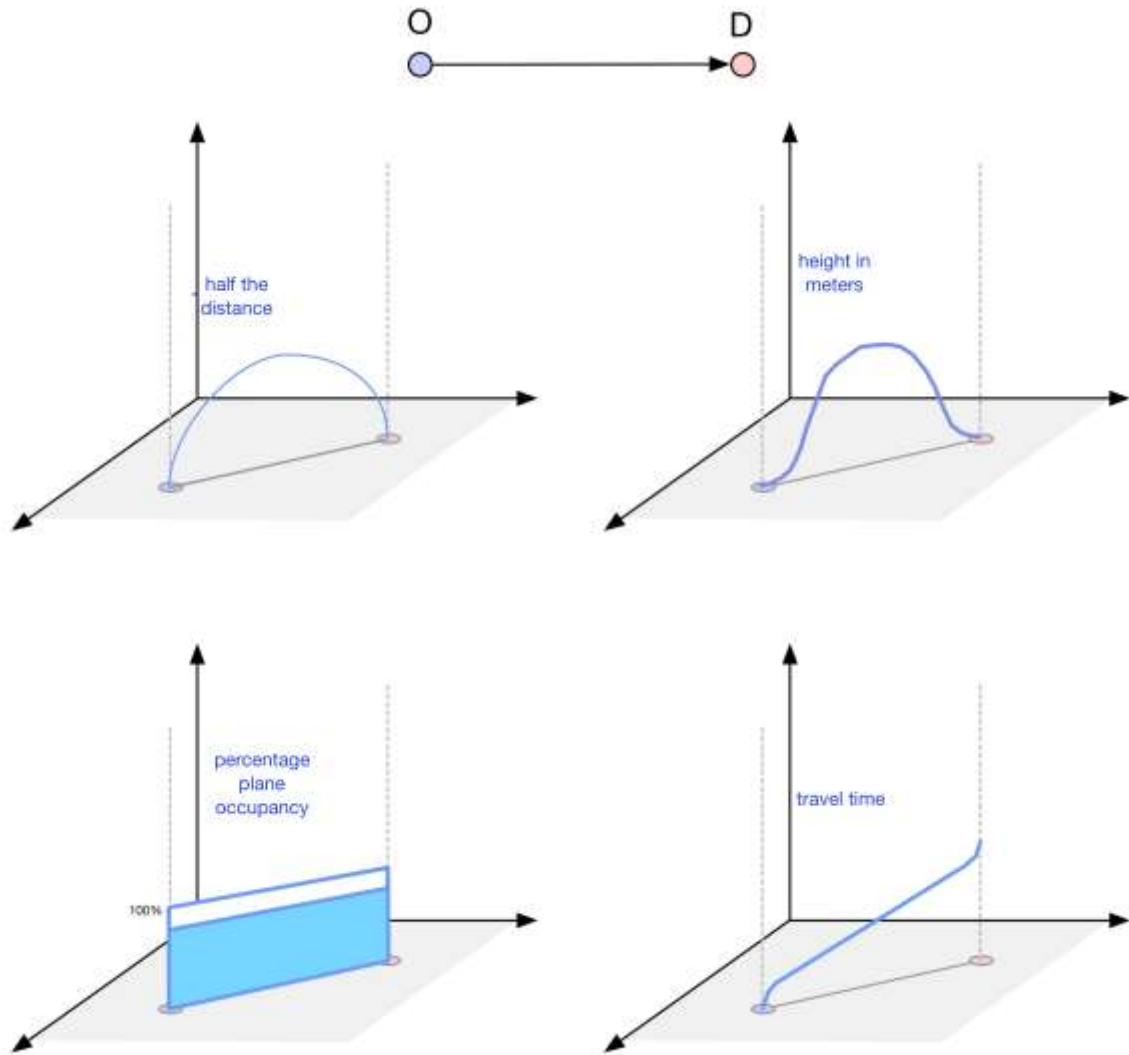


**Figure 1.** Alternatives linked to the flow map

Still, if the above conditions are met there are a few remaining issues. These are related to how one is using the third dimension in a flow map as Figure 2 shows. In other words, what is the third dimension representing. In the upper left of the figure the values along the z-axis are linked to the distance between the origin and destination such that the arcs are half circles. The further apart, the higher the three dimensional flow line. In the upper right the z-axis is linked to the physical height, for instance based on actual heights of an airplane during the flight. Often heights are exaggerated in the maps. The heights could also be related to an attribute. In the lower left the occupancy rate (in %) of an airplane is shown. In the lower right height is linked to time. It shows a traditional space-time path that we are familiar with from time-geography. It is easy to imagine that multiple combination could exist, and the z-axis is used for more than one representation.

Although the suggested alternatives seem promising, they are not without potential problems. Questions like: Do people indeed experience less visual clutter when presented in a real three-

dimensional environment? Can people handle the fact that the third dimension encodes heights, time and attribute in different combinations? It is obvious that the usability of 3D flow map needs further study to determine whether it is an alternative for the 2D flow map.



**Figure 2.** *The use of the third dimension*

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