ResFlow: Visualizing Global Resource Flows

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Abstract

Global resource flows and indicators for emerging challenges relevant to the realization of sustainable development goals are of high interest for research on sustainable development and geopolitics. Such complex sets of information require advanced methodological approaches that enable effective communication of data and participatory data exploration. To address this need, we present ResFlow, an interactive web-based application for the visualization and exploration of flow data, in particular for analysing resource flows between countries. ResFlow visualizes resource flows to and from countries using 3D arcs and provides tailored interaction and filtering techniques to facilitate flexible exploration of the data at hand.

CCS Concepts

• ***Human-centered computing*** → ***Geographic visualization;***

1. Introduction

In the research areas of sustainable development and geopolitics, global resource flows and indicators for emerging challenges, relevant for the achievement of the sustainable development goals, represent distinct and complex sets of information that require advanced methodological approaches to science communication and participatory data exploration. We propose a tool specifically designed for science-policy-practice dialogues and to support exploration and deliberation on sustainable development and geopolitical challenges. We present the design and development of ResFlow, a tool that aims to visualize resource flows and indicators related to environmental and geopolitical challenges, as well as indicators for the achievement of the Sustainable Development Goals [UN].

2. Related work

Flows representing movement of people or goods between origins and destinations are typically drawn in 2D using lines, arrows or curves to connect the origin-destination pairs. Tobler was one of the first to create computer based flow maps [Tob87] and many approaches have been proposed since (e.g., [PXY*05], [Guo09]).

Efficient representation of flows suffers from clutter due to the large number of links and increased crossings. Many approaches have been proposed to overcome these drawbacks [GKE18]. Interaction is used to select single or a few origins/destinations and to only look at flows connecting out of/into these. This eliminates crossings of flows but a large number of links can still make the view cluttered. In addition, visualization approaches that merge neighbouring parts of flows have been proposed to make the view less cluttered. Phan et al. [PXY*05] used hierarchical clustering and edge routing in order to improve their flow map layout. Holten et al. [HVW09] proposed a self-organizing edge bundling method that does not require a hierarchy of edges to be defined.

Another approach that has been used for reducing clutter in flow representation is to draw them as 3D arcs on a flat map or globe. The use of 3D can dramatically reduce the number of crossings at the expense of an increased need for interaction. Using 3D for representing links between locations is not new; Cox et al. [CEH96] and Munzner et al. [MHCF96] used it for representing networks. Recently, 3D representations have been gaining popularity again ([GKE18], [DRST15]). Yang et al. [YDJ*19] explored different spatial encodings for flow maps on flat maps and globes. Zhang et al. [ZZLL18] propose an approach for exploring geospatial networks inside a spherical virtual reality environment. The use of lenses has also been proposed to filter flows based on their shape [DSD15] and direction [VFAA17].

Our work draws inspiration of the presented related work. We build further on a representation similar to Cox et al. [CEH96] and Munzner et al. [MHCF96] and propose a tool for representing resources as flows and relate these to relevant indices using choropleth maps. Our focus has not been on the presentation of a new technique for representing the data but rather for the in context exploration such a tool can make possible.

3. ResFlow

ResFlow is a web-based tool for visualizing resource flows and relevant overlays of geospatial datasets. The design is aimed for the visualization of countries' incoming and outgoing resources as origin-destination (OD) flows on a 3D globe [ABS*ng]. The visualized resources are crops such as wheat, rice, maize and soy. The flows are represented as 3D arcs connecting the OD pairs (figure 1). In order to visualize the magnitude of these flows, the thickness of the flowlines is drawn proportional to the magnitude of the resource flow they represent. The height of the lines is proportional to the distance between the origin and destination so that longer flows are

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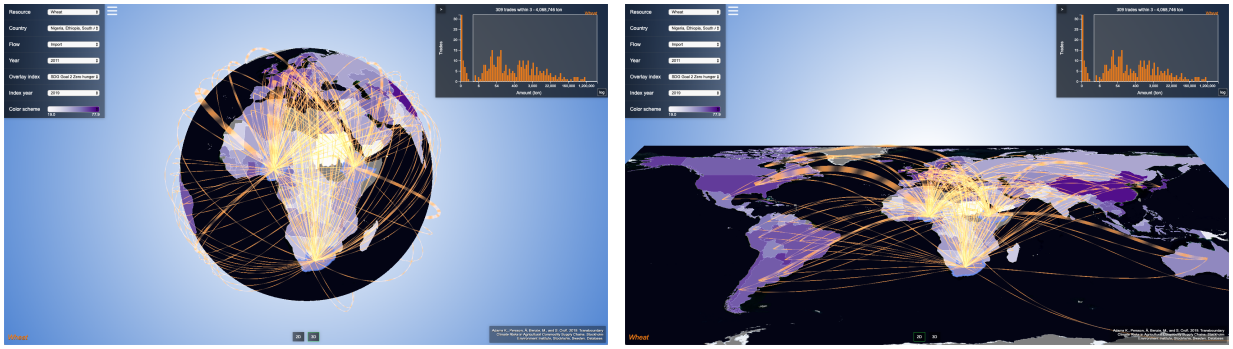

(a) 3D globe view (b) Tilted 2D map view

Figure 1: *The main views of ResFlow.*

lifted further away from the sphere than shorter ones. The type of resource is mapped on the colour of the arcs.

The flowlines are animated to provide an indication of which direction the flow is heading to clearly distinguish between incoming and outgoing flows. The animation uses the opacity value colour vector to produce a visible change in the appearance of the flows. The result of this is the appearance of particles travelling along the flowline. The underlying map representation in ResFlow can be toggled between the 3D globe and a 2D map (figure 1). In both cases however the representation is three dimensional. The 2D map can be tilted in order to better distinguish the flows, which are still drawn in 3D (figure 1(b)). In addition to resource flows, ResFlow allows for the visualization of different indices as choropleth maps. In the given example, indices for the current level of achievement for the Sustainable Development Goals (SDG) [SSTK*19], as well as trans-national climate indices [HFCB18] were selected. When an index is selected, countries are coloured accordingly.

4. User interface and interaction

The ResFlow user interface has three main components: (1) the main visualization of the flows on the globe or map, (2) a side control panel for making selections and changing settings, and (3) a histogram displaying the number of flows and their magnitude.

The main view of ResFlow is the visualization of the flows as arcs on the 3D globe or flat map (figure 1), as described in section 3. Two buttons are included on the bottom of the view for switching between the default 3D globe (figure 1(a)) view and the 2D map view . The user can interactively tilt the 2D map view in order to expose the 3D arcs (figure 1(b)). The countries to be included in the flow representation can be selected by clicking on the map.

ResFlow supports standard interaction such as rotation, zooming, panning and picking. Filtering is supported through selections in the side control panel, by direct interaction with the flow visualization and direct interaction with the histogram.

5. User engagement

The user scenario for ResFlow was outlined by the concrete demands for stakeholder engagement in dialogues with focus on geopolitics and global food security. ResFlow has been employed in seven sessions with 2-6 participants in each, representing the type of setting that was outlined in the design specification. The sessions were not specifically designed to assess the tool, but used the tool in the intended setting of focus group discussions on sustainable food systems and geopolitics, in which participants were allowed to explore the tool individually, but as part of a moderated dialogue. As such, users explored specific flows and data overlays during a limited time, while also discussing the content of the visual representations with the rest of the group. The participants expressed positive attitudes towards the usability of the tool within their field of expertise and provided several examples of possible applications within food supply chains.

6. Conclusions

We have presented ResFlow, a tool for visualizing resource flows and indicators related to environmental and geopolitical challenges. The central feature of ResFlow is a three dimensional representation of resource flows as arcs on a globe.

In this work we have attempted to reduce clutter by using a 3D representation of flows and by allowing one to many interactions; the domain experts, while interacting with the tool, have been exploring resource flows relating to one country at a time so that the visual clutter has been, most of the time, avoided. Filtering the data in this manner implies of course both an advantage and a drawback. As with the choice of 3D, filtering significantly reduces clutter but at the same time the overview of the flows is lost and the demands on interaction are increased.

The functionality of ResFlow has been tested with the targeted stakeholders that explored the tools as part of a moderated discussion. The user engagement provided important insights about the usability and challenges related to ResFlow and the tool has been refined based on them. Future work will consider other types of usage than the setting that was outlined for the tool design.

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