

# Visually Representing Geo-Temporal Differences

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## ABSTRACT

Data sets that contain geospatial and temporal elements can be challenging to analyze. In particular, it can be difficult to determine how the data have changed over spatial and temporal ranges. In this poster, we present a visual approach for representing the pair-wise differences between geographically and temporally binned data. In addition to providing a novel method for visualizing such geo-temporal differences, GTdiff provides a high degree of interactivity that supports the exploration and analysis of the data.

**Index Terms:** H.5.2 [Information Systems]: Information Interfaces and Presentation—User Interfaces; I.3.6 [Computing Methodologies]: Computer Graphics—Methodology and Techniques;

## 1 INTRODUCTION

While geo-temporal data sets can be very rich, there are often complexities associated with developing visual approaches for analyzing and exploring the data [3, 5]. While the processes for visually representing one or more data sets on a map are well-known [1], constructing interactive approaches that address the specific needs for a particular domain may not be straight-forward. Not only can the data sets become very large [2], but the type of analysis required by the user can be rather complex.

Many approaches to visualizing geo-temporal data sets make it difficult for users to make meaningful comparisons between different spatial and temporal aspects of the data set. Our aim in this research is to provide support for such activities by taking advantage of the human vision capabilities and employing interactive exploration methods to show how data are changing through geo-temporal differences. GTdiff calculates the differences in user-defined spatial and temporal bins, and provides a visual representation that enables the user to identify and examine changes across space and time. The goal is not to just provide a single view of the data that can give users the answers they are seeking, but instead to support their knowledge discovery activities through exploration and analysis of the data.

## 2 GTDIFF

The primary goal in the creation of GTdiff was to support data analysts in exploring and understanding how geospatial data sets change over time. A prototype has been implemented as a Java application, using a virtual globe generated by World Wind [4] for the framework upon which the core geo-visual representations are

layered. The interface of GTdiff supports three key interactive features: temporal filtering and binning, spatial binning and the creation of geo-temporal difference graphs, and further spatial exploration and filtering of the data (see Figure 1).

### 2.1 Temporal Filtering and Binning

GTdiff allows users to easily filter the data temporally, aggregating what remains into a user-specified number of equal length temporal bins. For example, an analyst may wish to filter the data set to only include a five-year timeframe, and then group the data into five one-year bins. Alternately, they may be interested in twelve years of data, grouped into six two-year bins. As will be shown in the description of the difference graphs in the section that follows, this allows GTdiff to clearly illustrate changes that have occurred between the temporal bins.

Each temporal bin is displayed side-by-side under the temporal filter. These representations show a zoomed-out geospatial view of the data. Their purpose is to support users in visual scanning and comparison activities, and to allow users to select one or more temporal bins to investigate in more detail. The value of a specific attribute of the data under investigation is encoded in the volume of a sphere placed at the specific location of the data point, using equally spaced colours from a yellow-blue colour scale of mid-level brightness to distinguish the separate temporal bins.

The spheres that encode the data allow users to readily make volumetric comparisons between the numeric data at different locations and in different temporal bins. A simple shading model enables the proper perception of the three-dimensional shape of the spheres. They are rendered as semi-transparent objects in order to address the occlusion problems that occur when a large sphere covers one or more smaller spheres at nearby locations.

### 2.2 Spatial Binning and Difference Graphs

In order to allow users to perceive how the data are changing between the temporal bins, spatial binning is necessary. Without spatial binning, the only situation in which showing the differences would be meaningful is when data points are at exactly the same spatial location. Spatial binning groups data points that are near one another to avoid this situation. A simple grid is used in the binning process; the resolution is controllable by the users.

For each spatial bin, the difference between the values in each pair of temporal bins are calculated. The maximum of the absolute value of all of the differences is used as the extreme value in a positive/negative scale. A divergent colour scale is used to visually encode these differences within the visual representations of each spatial bin. White represents a value of zero (no change), the degree of saturation of green is used to represent positive values, and the degree of saturation of red is used to represent negative values. In order to assist with decoding, a legend is provided.

A visual representation of the difference between each pair of temporal bins is provided in the form of a difference graph. The difference graphs are organized in an inverted pyramid, where the top layer shows the difference graphs for neighbouring pairs of temporal bins, the second layer shows the difference graphs for pairs of

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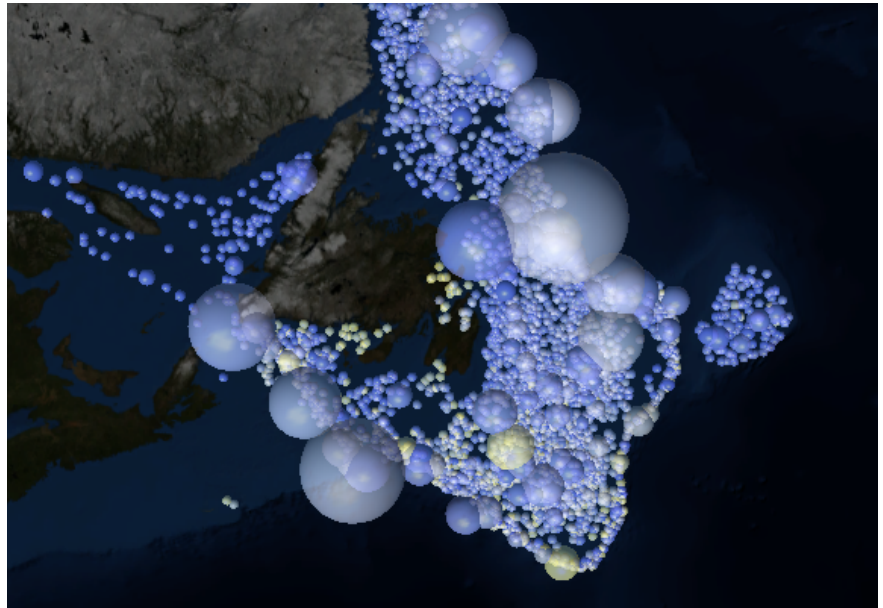
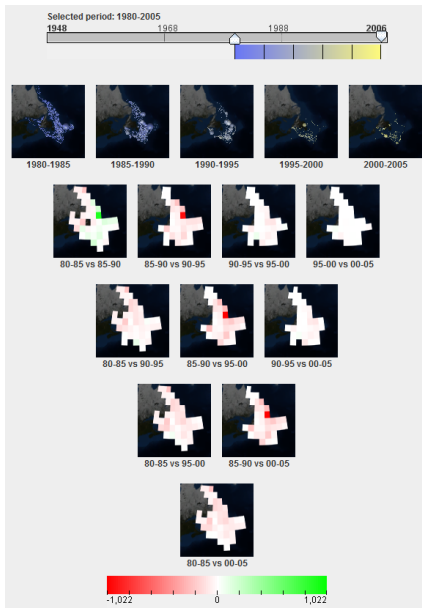


Figure 1: The main visual components of GTdiff provide support for temporal filtering and binning (top portion of the left screenshot; see Section 2.1), spatial binning and the representation of geo-temporal difference graphs (bottom portion of the left screenshot; see Section 2.2), and spatial exploration and filtering of the data (right screenshot; see Section 2.3). The data shown is the catch weight of the cod fisheries off the coast of Newfoundland, Canada. GTdiff has been used in this example to highlight the collapse of the fisheries (i.e., the reduction in catch weight as identified by the red regions in the difference graphs and the small number and size of the yellow spheres that represent the catch data from the end of the temporal range in relation to the blue spheres that represent the catch data from the beginning of the temporal range).

temporal bins with a one-bin gap, and so on until the final layer shows the difference graph between the pair of temporal bins at the extremes of the temporal range. As such, every possible pair-wise comparison of temporal bins (i.e., the data above the inverted pyramid) is shown simultaneously within this visual structure.

### 2.3 Spatial Exploration and Filtering

As users explore the data in the temporal bins and difference graphs, they may wish to investigate specific elements further. One or more temporal bins may be selected in order to conduct a detailed analysis of the data. Or a specific difference graph may be selected for detailed inspection. In either case, the data is layered over satellite imagery in order to provide users with spatial awareness of the data.

In order to enhance the ability of the users to perceive the foreground data from the background contextual information, the system was designed to ensure sufficient luminance contrast between the two. The satellite imagery that makes up the background is darkened by placing a semi-transparent layer over top of it. Bright colours were chosen to represent the foreground information (i.e., the colour encoding for the temporal bins and difference graphs). As such, the foreground information can be readily perceived as being a separate layer placed over the background information.

The geospatial view supports spatial filtering of the data through pan and zoom operations. As the user manipulates the location and scale of the map, all other geospatial representations are updated. In this way, users can manipulate the map in the geospatial view, explore the features of the data within the temporal bins and difference graphs at the desired location and level of detail, and then make further selections of interesting temporal bins and difference graphs in support of their knowledge discovery tasks.

## 3 CONCLUSION

In this poster, we have outlined the features of GTdiff that support the visual representation of geo-temporal differences. The system was designed to allow users to interactively filter and bin the data

both temporally and spatially. The visual representations in the inverted pyramid of difference graphs highlights the temporal differences in the data within corresponding spatial bins, allowing users to discover where and when significant changes have occurred.

Although the features of GTdiff were designed to support knowledge discovery within fisheries-related data, the type of analysis it supports may also be beneficial in the study of population statistics (e.g., examining changing population demographics across regions), business intelligence (e.g., studying national product sales over time), and other domains where there are important spatial elements and changing data values over time.

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