Techniques for Dynamic Visualization of Time-Varying Flood Data

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April 2025

Abstract

This project aims to develop visualizations for the general public of satellite-based flood data from the Copernicus Emergency Management Services, focusing on the Storm Babet event in northern Germany in October 2023. The goal is to effectively communicate flood extent, likelihood, and uncertainty to the general public. Methods include literature review, visualization design, and user evaluation with an emphasis on interpretability and accessibility.

Keywords: Flood Visualization, Geospatial Data, Uncertainty Visualization, Public Communication, Human-Centered Design, Storm Babet, Time-Varying Data

1 Introduction

The Copernicus Emergency Management Services (CEMS) data set provided for this project consists of satellite-observed, time-dependent flood data in the Baltic Sea near the city of Strahlsund (see Fig 1). The flooded area near the city of Zingst, at the Baltic coast of Northern Germany, was affected by Storm Babet on October 20, 2023 (see Wikipedia (2024)). Therefore, we will focus on the data from the period from October 11 to 25th, 2023, as this storm was a major event that affected entire northern Europe. As the extent of flooding varies over time, visualizing these changes in a way that is understandable to a wider audience is a particular challenge.

2 Problem Statement

The aim of this project is to develop and propose new visualization techniques that can effectively communicate these time-varying flood events, ensuring that they are accessible to the general public. The research question is:

How can flood risk be effectively combined and visualized for the general public?

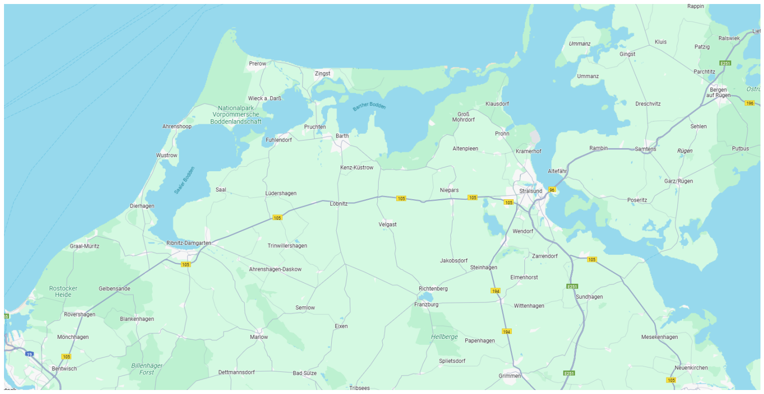

Figure 1: Region of Interest near Strahlsund in Google Maps

We define flood risk as a combination of current and future flood likelihood and flood extent. Our definition of the general public refers to civilians without experience in analyzing flood visualizations, who must be able to correctly interpret flood risk information, even in unfamiliar regions. For our assessment, we will select users with no formal training in geography, flood monitoring, or data science. Participants will range in age from 18 to 64 years, and the group will include individuals without a university degree. Our target users are not expected to have detailed knowledge of the regions being assessed.

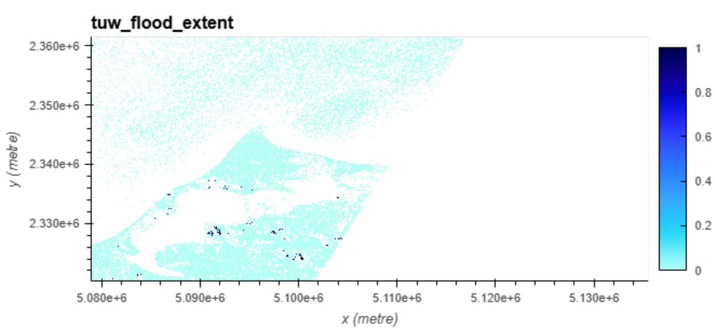

Figure 2: Basic flood extent visualization of TU Wien

3 Methodology

3.1 Literature Research

To get a better understanding of effective flood visualizations, existing literature on geospatial data representation and interactive mapping tools will be reviewed. Several relevant approaches have emerged in recent years, for example Rahman et al. Rahman and Thakur (2018) propose overlaying flood maps from different timestamps to highlight temporal changes in flood extent. A broader survey by Yussof et al. (2015) presents various visualization techniques, including technical, interactive, 3D, and virtual reality approaches, which can improve user engagement with complex geospatial data. The challenge of communicating uncertainty in flood predictions is discussed in both **?** and **?**, who emphasize the importance of visual encodings that convey confidence levels effectively. The literature review will focus on papers published within the last 10 years that address the visualization of flood risk (including flood likelihood and flood extent) for non-expert audiences.

3.2 Data

The project uses the Global Flood Monitoring dataset, which provides data for detecting floods from satellite observations. The data is already largely preprocessed and includes data from the region of northern Germany. For each coordinate and time of the data, the probability and extent of flooding from several models are given. In addition, a mask for the water surface of the permanent water body is included. Despite the dataset's preprocessing, additional steps are necessary to make it suitable for proper visualization. These steps may include temporal aggregation of variables, binning to reduce complexity, and alignment of the permanent water body masks.

3.3 Visualization

A new visualization technique will be implemented and compared to the basic (see Fig: 2) visualization for time-varying flood data. This could include interactive dashboards with time sliders, layered visualizations combining flood probability, magnitude, and uncertainty, or other methods found in the literature search. The focus is on developing visualizations that are intuitive and informative for a broader audience, especially nontechnical users.

At least two compelling visualization techniques should be proposed and evaluated against the baseline

3.4 Evaluation

To evaluate how effective the developed visualizations are, we will use a mix of performance-based and qualitative criteria, focusing on two main aspects, interpretability and accessibility.

Interpretability will be evaluated through user feedback using A/B testing with task-specific questions. This will help us see whether the new visualizations offer improvements over the baseline ones provided by TU Wien. If there are multiple visualization approaches, each will be tested in the same way. Example questions might include: "Should the user leave this area within the next 24 hours?" or "Is it safe to visit this area in the next 24 hours?". We'll measure effectiveness based on how successfully users complete these tasks, how long it takes them, how accurately they interpret the information. Users will also rank the different visualizations based on their personal preferences. The testing process will follow standard experiment design principles to make sure results are consistent and reproducible.

Accessibility will be evaluated by assessing how well the visualizations support users with color blindness, using a color blindness simulator, and by making sure they meet contrast ratio standards in the WCAG guidelines.

Together, these criteria will help ensure that the visualizations are effective and inclusive for a wide range of users.

4 Domain Specific Lecture

I successfully completed the course *Introduction to Earth Observation* for 1,5 ECTS in the previous semester. The remaining 1.5 ECTS credits will be completed in the upcoming semester.

5 Supervisor

Supervisor: Dipl.-Ing. Thais Sarinho Beham
Supervisor: Dr. Martin Schobben
Co-Supervisor: Assistant Professor Astrid Weiss

References

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