**Comparative Analysis of Levee Elevation Data: Project Overview**

**Objective**

The National Levee Database (NLD) comprises a comprehensive dataset of hand-measured levee topographic profiles and operation information. These topographic profiles, many of which were measured in the wake of Hurricane Katrina, serve as a historical baseline dataset of levee geometries. We aim to compare these historical elevation profiles against the modern, more recently collected datasets from the USGS 3D Elevation Program (3DEP, 2016-present) which postdates historical levee topography collection. By doing so, we aim to uncover anomalies or signs of damage, providing insights into the effectiveness of remote levee characterization and assessment. In Q4 we continued implementing and scaling the protoype (0.1.0) software and database infrastructure for assessing the condition of levees overseen by the Army Corps. Our goal is to deliver a modular, open-source, easy-to-use Python software stack that can be deployed to assist in routine monitoring of levee infrastructure. The prototype architecture is a geospatial data processing stack designed to interact with various APIs and geospatial libraries to retrieve, process, and analyze elevation data associated with levee systems. It leverages a combination of remote sensing data, digital elevation models (DEMs), and geospatial analysis techniques to provide insights into the elevation profiles of levee systems. We interface with two APIs to fetch data about levee systems: the National Levee Database API (NLD2 API v4.12.0) and Google Earth Engine. Best practices are employed to not overwhelm the NLD2 API. The NLD provides a raft of data on each levee system, including their topographic profiles. We employ retry mechanisms and a circuit breaker pattern to handle failures which are not uncommon. Google Earth Engine provides 1-m resolution USGS 3DEP elevation data. Custom formatters were employed to transform the NLD2 API topographic data into standard geospatial data formats. This transformation allowed us to harmonize the NLD2 API profile data with Google Earth Engine data formatting requirements. Sampling involves querying the DEMs at the same hand-sampled locations along the levee profiles. These locations are determined based on the Earth Engine geometries derived from the converted NLD2 API JSON responses. The architecture is scalable and robust and can be deployed on all available NLD API2 levees.

**Progress up to Q4**

**1. Robust Data Retrieval and Processing:**

* Implemented a sophisticated NLDClient with rate limiting and error handling.
* Developed a flexible data retrieval system supporting various NLD endpoints.
* Created efficient data processing pipelines to clean and handle complex NLD data structures.

**2. Advanced Geospatial Analysis:**

* Implemented geospatial calculations for accurate distance and elevation analysis.
* Integrated Earth Engine for 3DEP data retrieval and processing.

**3. Comprehensive Error Handling:**

* Implemented retry mechanisms and a circuit breaker pattern to handle API failures.
* Developed custom exceptions for granular error management.

**4. Scalability and Performance:**

* Utilized caching and parallel processing capabilities for handling multiple levee systems efficiently.
* Implemented adaptive rate limiting for optimal NLD API interaction.

**5. Data Comparison and Analysis:**

* Developed functions to compare NLD and 3DEP elevation profiles.
* Implemented statistical analysis of elevation differences.
* A graph of elevation differences

  Description automatically generated

**6. Visualization and Reporting:**

* Created functions for comparative elevation profile plotting.
* Developed map-based visualizations of mean elevation differences across systems.
* Implemented histogram and bar plot generation for elevation difference analysis.

**A map of the united states

Description automatically generated**

**Key Findings**

**1. Elevation Discrepancies:**

* Successfully compared NLD and 3DEP elevation data across multiple levee systems.
* Identified and visualized mean elevation differences between datasets.
* Filtered out extreme outliers (>20m difference) for more accurate analysis.

**A map of a river and a map of a river

Description automatically generated**

**2. Spatial Distribution:**

* Created a map-based visualization showing the geographical distribution of elevation differences.
* Identified potential regional patterns in elevation discrepancies.

**3. Statistical Analysis:**

* Generated histograms and summary statistics of mean elevation differences.
* Provided insights into the central tendency and spread of elevation discrepancies.

**Interpretation and Decision Making**

The results of our discrepancy analysis provide valuable insights into the current condition of levee systems:

* Systems with significant elevation differences may require further investigation or field surveys.
* The spatial distribution of discrepancies can help prioritize areas for maintenance or more detailed assessment.
* Statistical summaries offer a broad view of overall levee system conditions, aiding in resource allocation decisions.

**Conclusion and Next Steps**

Our Q4 developments have significantly advanced our ability to assess levee conditions using remote sensing data. The implemented system now provides a comprehensive pipeline from data retrieval to analysis and visualization.

Future work will focus on:

1. Refining our statistical models for anomaly detection.
2. Developing more advanced visualization tools for easier interpretation by stakeholders.
3. Integrating additional data sources for more comprehensive assessments.
4. Automating the reporting process for routine monitoring.