SUPERVISOR'S REVIEW OF MASTER THESIS

Erasmus Mundus Joint Master Degree Programme

Copernicus Master in Digital Earth

Specialization Track Geovisualization & Geocommunication

Title of the thesis: **3D VISUALIZATION AND ANALYSIS OF**

PATAGONIAN GLACIERS CHANGES USING EARTH OBSERVATION DATA

Student: **Felipe Camacho Hurtado**

A1 Methods, techniques, and procedures of processing (data handling)

The thesis aim was to process remote sensing data to analyze Patagonian glaciers and utilize advanced geospatial techniques and cloud computing platforms. The primary data sources included optical satellite imagery from Sentinel-2 and Landsat 8-9 and climate data from the ERA5-Land Monthly Aggregated dataset. These datasets were accessed and processed using Google Earth Engine (GEE). The methodology encompassed several key steps: initially, data acquisition and pre-processing were conducted, involving cloud and shadow masking to ensure data quality. Following this, remote sensing indices like the Normalized Difference Snow Index (NDSI) and Normalized Difference Water Index (NDWI) were calculated to delineate glacier areas and mask water bodies. A time-series analysis was then performed to estimate changes in glacier area, land surface temperature (LST), and air temperature over the summer from 2018 to 2023. The outputs from GEE were further processed using ArcGIS Pro for enhanced visualization and subsequently integrated into a 3D web application developed with CesiumJS. This application enabled interactive, three-dimensional visualization of the glacier changes, providing users with an intuitive and comprehensive understanding of glacier dynamics in the Patagonian Andes.

A2 Literature review

The literature review in this thesis provides a comprehensive and insightful examination of the current state of research on Patagonian glaciers, mainly focusing on using Earth Observation (EO) data. It highlights the significance of glaciers and the impact of climate change, referencing various studies on glacier retreat and volume loss. The review also delves into using Google Earth Engine (GEE) for glacier monitoring, showcasing its advantages in processing large geospatial datasets and its application in glaciological research. Additionally, the review discusses the development and effectiveness of GEE applications for environmental monitoring alongside the benefits of 3D visualization techniques, especially CesiumJS, for enhancing the understanding of glacier dynamics. Overall, the literature review is thorough and well-articulated, providing a solid foundation for the research presented in the thesis.

A3 Theoretical and application difficulty

The theoretical complexity of the work was quite demanding, especially from the combination of GEE and the CesiumJS. The geoinformatics methods used, on the other hand, are standard with special emhaiss to implementation of Google Earth Engine app which required lot of technical skills.

B1 Thesis structure

The structure of the thesis is well designed and no part is missing. The thesis is nicely readable.

B2 Formal and graphic level (editing, stylistics, grammar, tables, graphs, maps)

The work is very carefully prepared and styllisticaly correct. All graphic elements of the work are of high quality.

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B3 Poster

The poster includes all needed parts and describes the whole workflow of the thesis.

B4 Website

Ther are well designed and include all necessary information.

C1 Quality of outputs and results

The quality of the outputs and results in this thesis is excellent. The author has produced highly accurate and reliable data analyses, showcasing a thorough understanding of the methodologies and techniques employed. The results are presented in a clear and comprehensive manner, with well-designed visualizations. These outputs significantly contribute to the field of popularisaton in glaciology and likely climate change offering valuable insights into the dynamics of Patagonian glaciers.

C2 Interpretation of results, discussion

The student comments on the results appropriately. He knows the individual pitfalls and potential problems encountered during the work. Additionally, the author thoughtfully discusses possible further extensions of the research, highlighting areas for future investigation and improvement..

C3 Applicability of achievements

The achievements of this thesis have significant applicability in the field of glaciology and beyond. The developed methodologies and tools for analyzing and visualizing glacier changes can be readily adapted for monitoring other glacierized regions worldwide. The use of Google Earth Engine and 3D visualization through CesiumJS offers a scalable and accessible approach for environmental monitoring, making it valuable for researchers, policymakers, and conservationists. Additionally, the insights gained from this study contribute to a deeper understanding of climate change impacts, supporting informed decision-making for environmental protection.

C4 Thesis aims and their fulfillment

All goals of the work were fulfilled.

D Final comments, questions for the defense

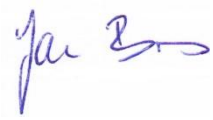
Questions: What are the main limation of Google Earth Engine app development? What could be a future improvement to the app itself to improve the user experience?

E Overall summary and evaluation

The Felipe Camacho Hurtado diploma thesis is a high-quality applied geoinformatics thesis. During the solution of the thesis, the student wor independently. I appreciate the final application. Overall, the thesis is well-written and highly relevant. With solid confidence, I **recommend** the thesis for defense.

In Olomouc 3rd June 2024

Jan BRUS
Supervisor



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