Cartography M.Sc.

Testing approaches to visualize land cover/land use changes in time series with cloud-based tools

Jesse Friend

29 October 2021

Outline

- Introduction and Motivation

- Context and Background

- Research Objectives & Hypothesis

- Methods

- Discussion

- Conclusion and Outlook

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# Problem Statement

Introduction and Motivation

The aim of this thesis is to develop a framework to visualize changes to LC/LU classes in time-series through the researching and prototyping of cloud-based visualization tools.

1. Communicate complex information clearly

2. Assist decision making of end-users

3. Display time-series effectively

4. Provide intuitive graphical interfaces

5. Focus on user-centered design

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Motivation

- Improve understanding of how to harmonize research within multiple cartographic fields to create time-series visualizations in microservices

- Work together with GAF AG to investigate methods in context of Corine Land Cover+ (CLC+) project based on historic CLC data
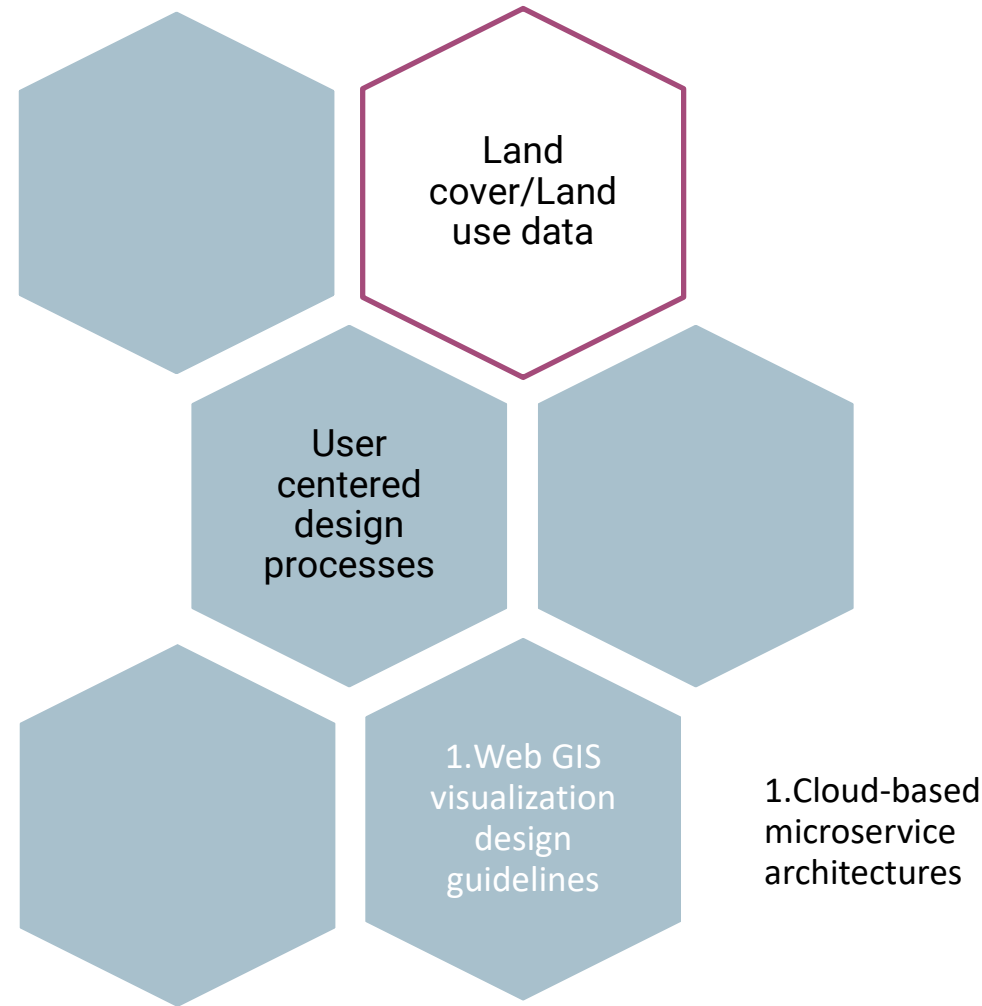
Testing approaches to visualize land cover/land use changes in time series with cloud-based tools

Context & Background

Land cover/Land use data

User centered design processes

1.Web GIS visualization design guidelines

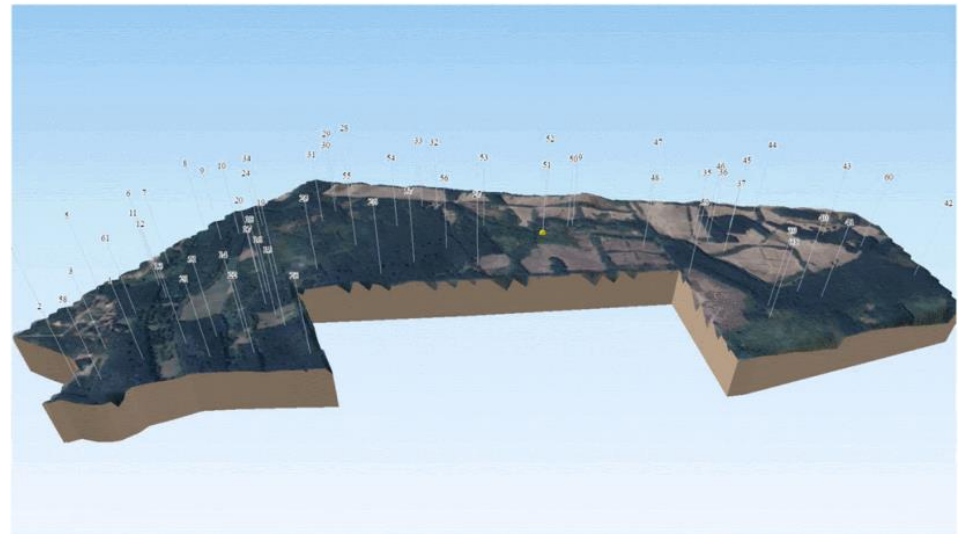1.Cloud-based microservice architectures

Testing approaches to visualize land cover/land use changes in time series with cloud-based tools
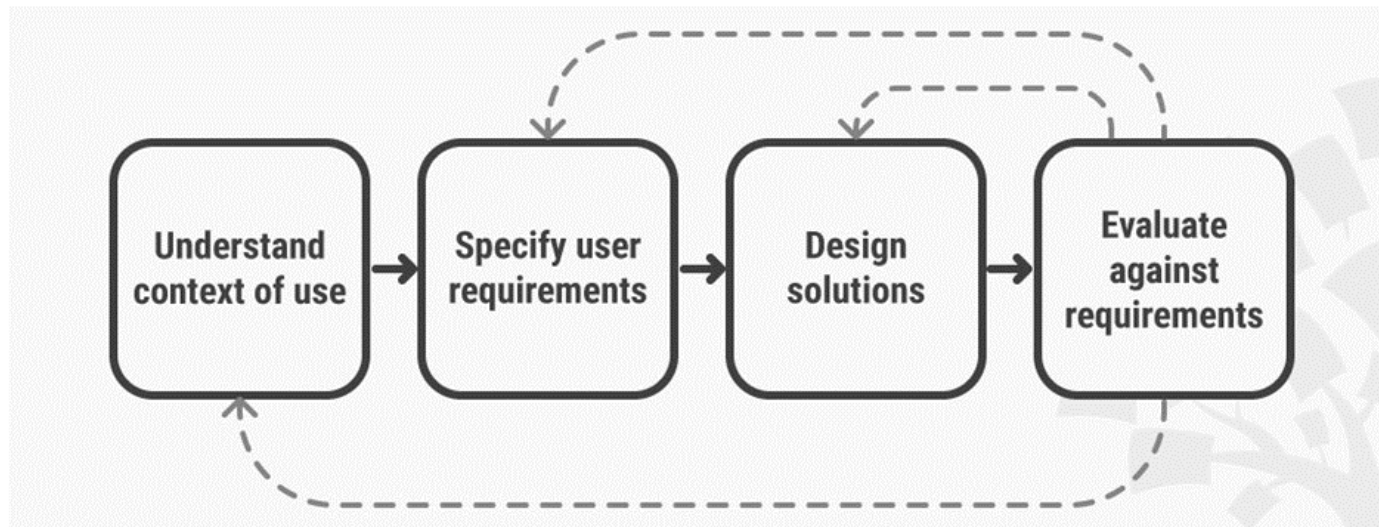
Land Cover/Land Use Data

Context & Background

- **Land Cover:** Description of the natural or man-made cover of the surface of the earth

- **Land Use:** The purpose for which the land is used

(Balla et al., 2017)

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User-Centered Design Processes

Context & Background

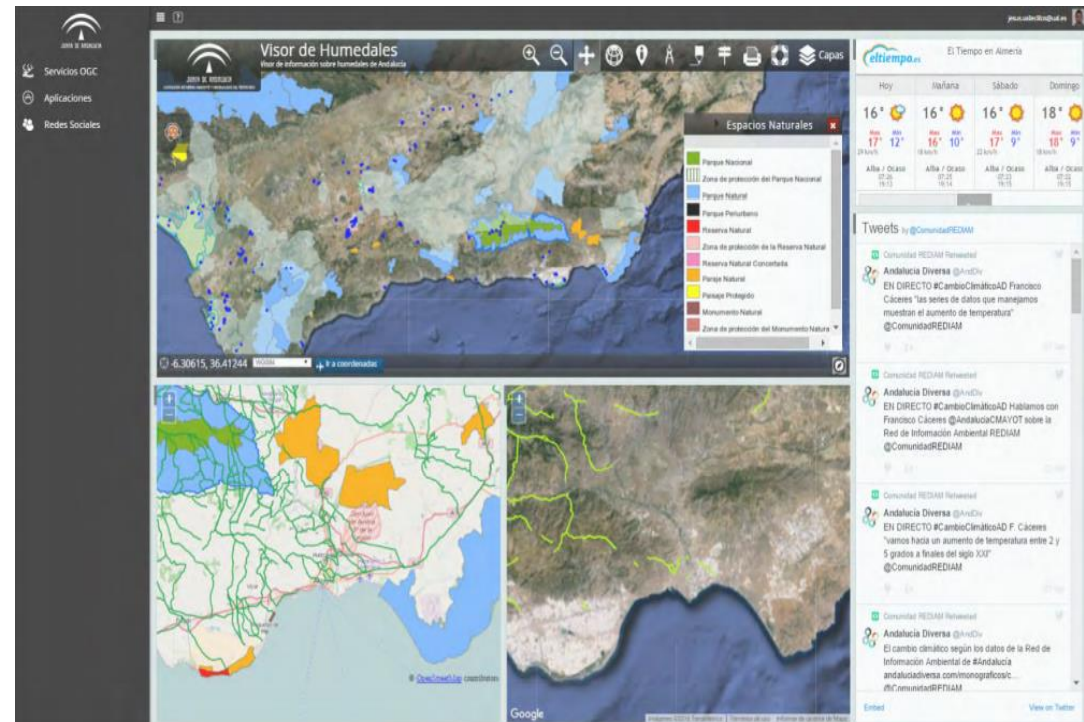**Testing approaches to visualize land cover/land use changes in time series with cloud-based tools**

Web GIS visualization design guidelines
Context & Background

- Web front-ends
- Web GIS graphical user interfaces

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(Mena et al., 2019)

Cloud-based microservice architectures
Context & Background

- Individually executable services

- Reduce server load

- Increase reusability of services/code

- High flexibility with the use of APIs

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(Mena et al., 2019)

Hypothesis

Research Objectives & Hypothesis
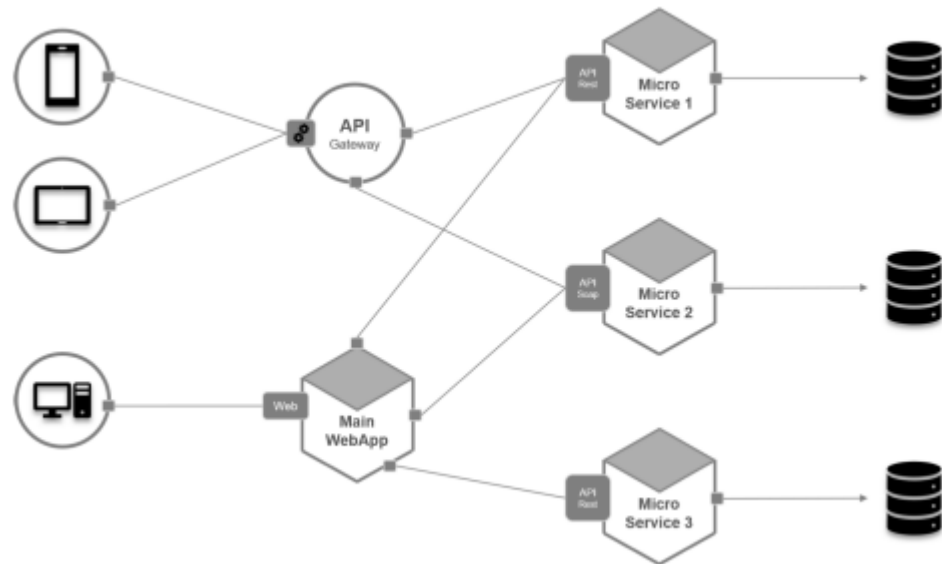
- **Hypothesis**

1. Cloud-based cartographic time-series visualizations of remote sensing derived products can be an advantage to include within organizational microservice architectures.

2. Cartographic projects with integrated user-feedback cycles can help improve the understanding of earth observation derived products.

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Research Question 1
Research Objectives & Hypothesis

How can the concept of digital cartographic visualizations be constructed so that it conveys information in an effective form with regard to information developed within the context of the CLC+ project?

1. What are the needs of end-users and clients, who will be using the service?

2. How can a product be designed with intuitive use as a core function?

3. What visual aspects are necessary within the final product?

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Research Question 2
Research Objectives & Hypothesis

How can visualizations of remote sensing derived time-series be integrated into a cloud-based digital microservice infrastructures?

1. Do new web-based cartographic visualizations offer value to ongoing work flows in the cartographic domain?

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Research Question 3

Research Objectives & Hypothesis

What are the advantages of creating new visualization applications over implementing existing technologies, or traditional methods such as static maps, reports, and other graphics?

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Methods

To answer all the research objectives, the thesis has been separated into three distinct methods:

1. **Expert Interviews**

2. **Microservice Prototype Application**

3. **User Study**

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Expert Interviews

- Semi-structured one-on-one interviews

- 4 interviews conducted with GIS experts

  - Backend developer, frontend developer, geohazard visualization manager, CLC+ raster product manager

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Results
Expert Interviews

RQ1

How can the concept of digital cartographic visualizations be constructed so that it conveys information in an effective form with regard to information developed within the context of the CLC+ project?

- **Deliver raster geotiff product for experts and public**
- **Capabilities are priority**

  - **Appearance is important**

- **Understanding the data is key**

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Results

Expert Interviews

RQ2

How can visualizations of remote sensing derived time-series be integrated into a cloud-based digital microservice infrastructure?

- **Pulling data directly from distributed servers to keep web app as "light" as possible**

- **Utilizing existing JavaScript libraries to perform on-the-fly operations directly in the app**

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Results

Expert Interviews

RQ3

What are the advantages of creating time-series visualization applications over implementing methods such as static maps, reports, and other graphics?

- **Democratization of data**

- **Users have a sense of ownership over the results if they see an application complete their request**
- **Unified presentation of large amounts of data offers relative ease in understanding the data**

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Microservice Prototype

Technology Stack

- JavaScript/HTML/SCSS

- jQuery

- Parcel

APIs

- OpenLayers

- Chart.js

- Grid.js

publicdomainvectors.org

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Data
Microservice Prototype
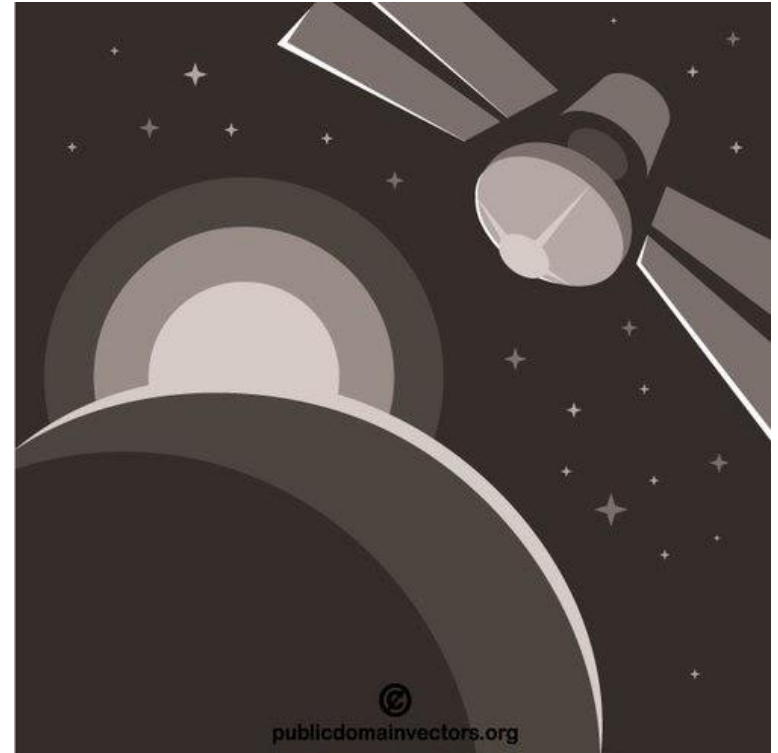
Copernicus Land Cover (CLC)

- Land cover dataset for the EEA38+UK

- Post processed raster and vector products

- 44 land cover classes

- 25 ha MMU

- 2000-2018

ArcGIS Rest Services Directory

- Feature label layer

- Transportation layer

- Basemap layers

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Results
Microservice Prototype

http://129.187.45.33/TimeServer/

Testing approaches to visualize land cover/land use changes in time series with cloud-based tools
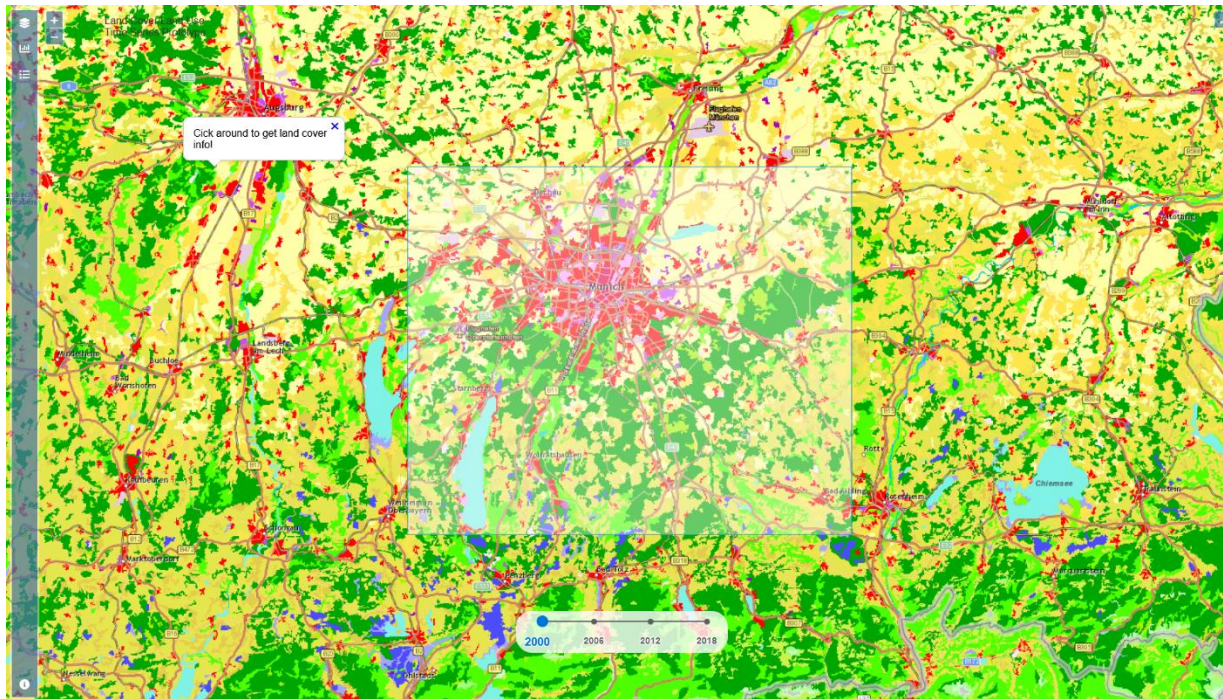
User Study

- Three U's of Cartographic Interface Success

    - **Usability**: How easy is it to use an interface to complete the objectives at hand?

    - **Utility**: How useful is the interface to complete the objectives at hand?

    - **User base**: Who is the target group that will be using the interface?

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(R. Roth et al., 2015)

User Study

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(R. Roth et al., 2015)

User Study

- Investigative study

- 20 questions

  - 1 consent question

  - 3 background questions

  - 4 task related questions

  - 12 quantitative questions

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Task

User Study

- Find the coniferous forest % in AOI around Munich

  - Two groups

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Reduced Functionality Results
User Study

Participant	2000	2006	2012	2018	Average Δ
Truth	12.79%	11.10%	5.96%	5.94%	~
1	20%	19%	12%	10%	6.30%
2	30%	29%	24%	23%	17.55%
3	N/A	N/A	N/A	N/A	N/A
4	18%	17%	9%	8%	4.05%
5	40%	38%	28%	25%	23.80%
6	20%	19%	15%	14.5%	8.18%
7	N/A	N/A	N/A	N/A	N/A
8	100%	70%	50%	20%	51.05%
9	12%	11%	7%	6%	.05%
10	30%	28%	25%	24%	17.80%
Average Δ					**16.10%**

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Full Functionality Results

User Study

| Participant	2000	2006	2012	2018	Average Δ
Truth	12.79%	11.10%	5.96%	5.94%	~
1	12.78%	11.10%	5.96%	5.95%	0%
2	12.81%	11.06%	5.96%	5.95%	-.003%
3	12.73%	11.05%	5.88%	5.87%	-.065%
4	12.82%	11.08%	5.98%	5.97%	.015%
5	12.81%	11.07%	5.97%	5.95%	.003%
6	35.6%	32.55%	30.05%	29.35%	22.94%
7	12.76%	11.06%	5.97%	5.95%	-.013%
8	12.68%	11.08%	5.92%	5.07%	-.26%
9	N/A	N/A	N/A	N/A	N/A
10	12.81%	11.06%	5.97%	5.96%	.003%
Average Δ					**2.51%**

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Full Functionality Results

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9	N/A	N/A	N/A	N/A	N/A
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Average Δ					2.?%

-.04%

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Functionality Results

User Study

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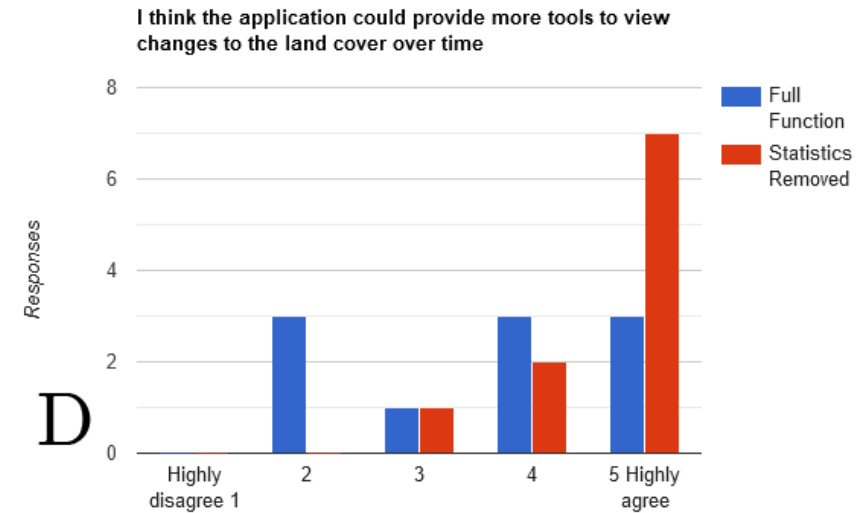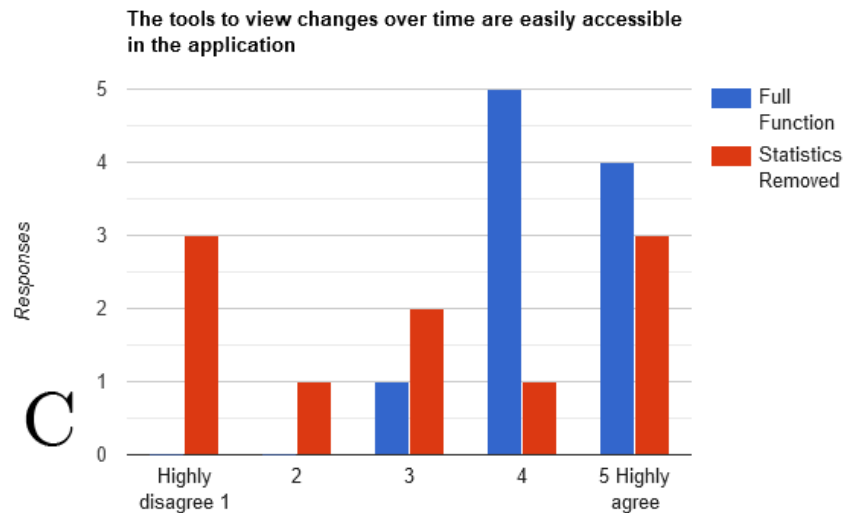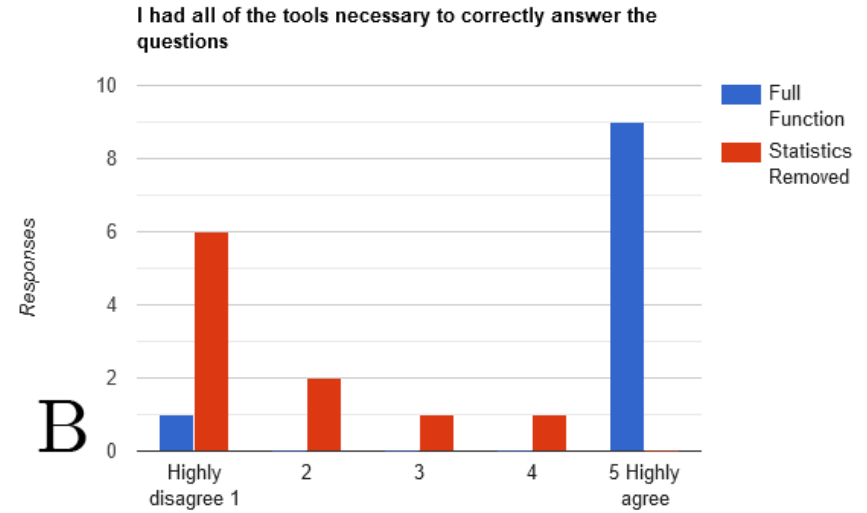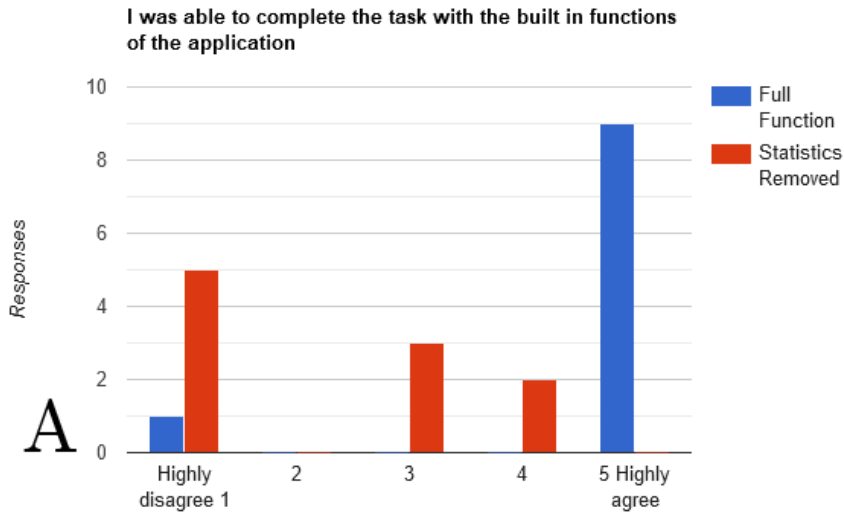
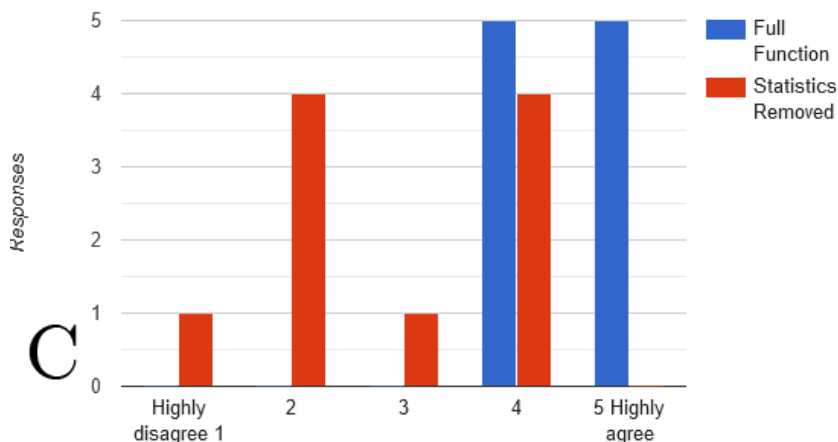# Change Analysis Results

User Study

I was able to easily distinguish the changes to coniferous forest cover over time with the application
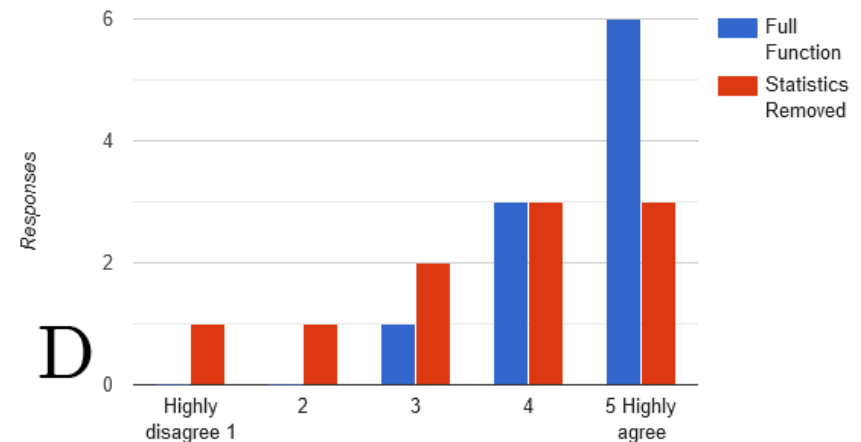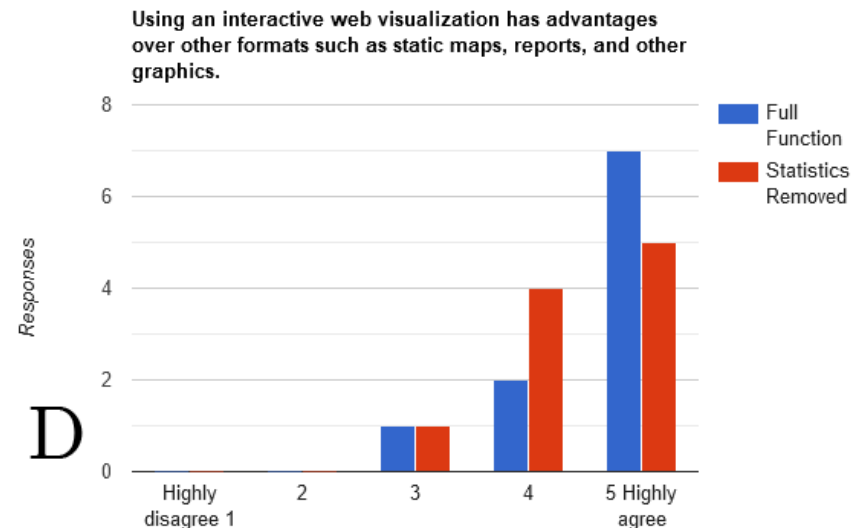
A
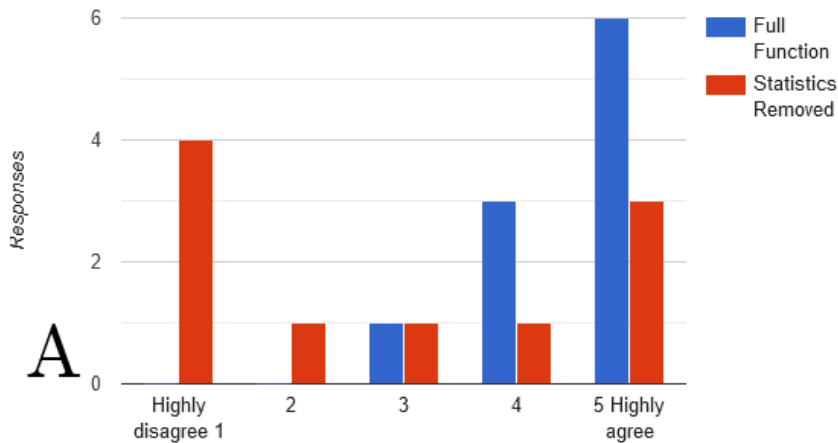
I could understand how the forest cover has evolved over time in the study area

B
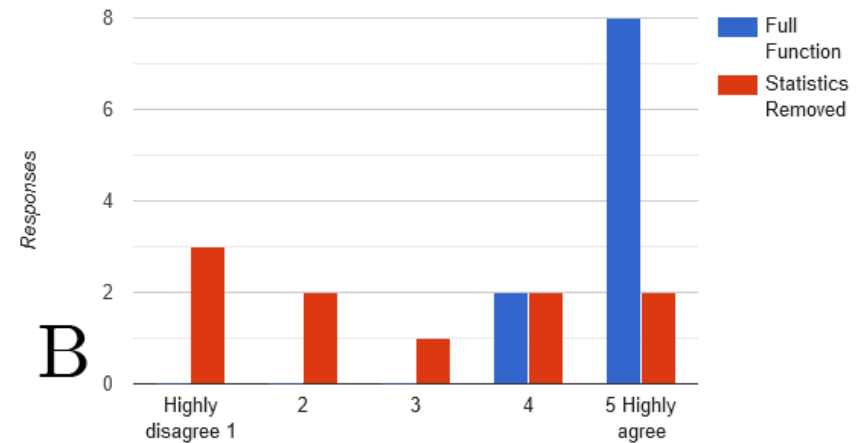
I would use information from visualizations such this application to help shape my understanding of the changes to our earth

C

I can grasp the changes occurring over time to earth when viewing interactive land cover maps such as this prototype
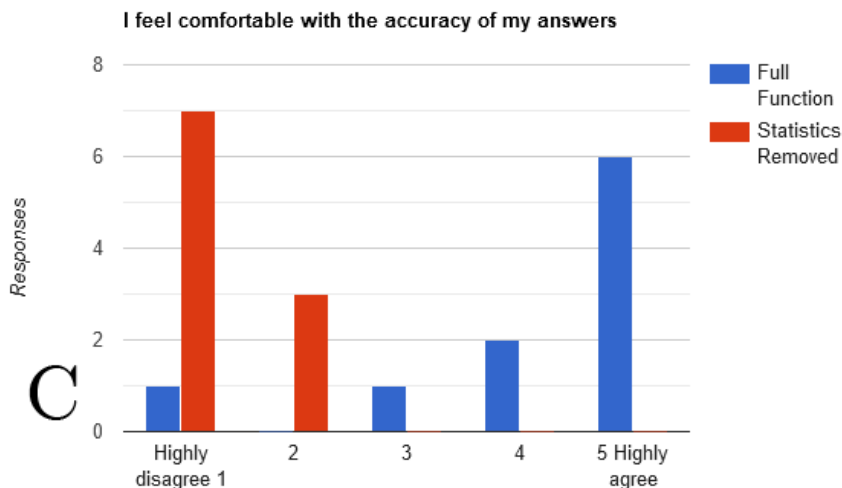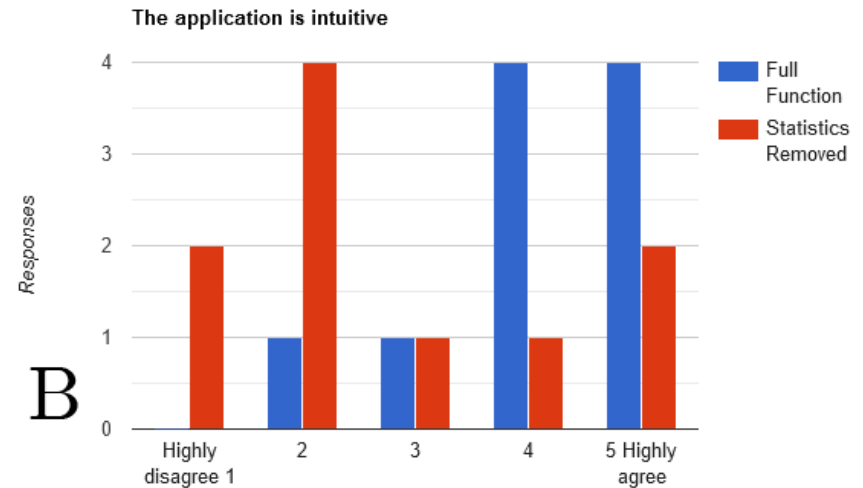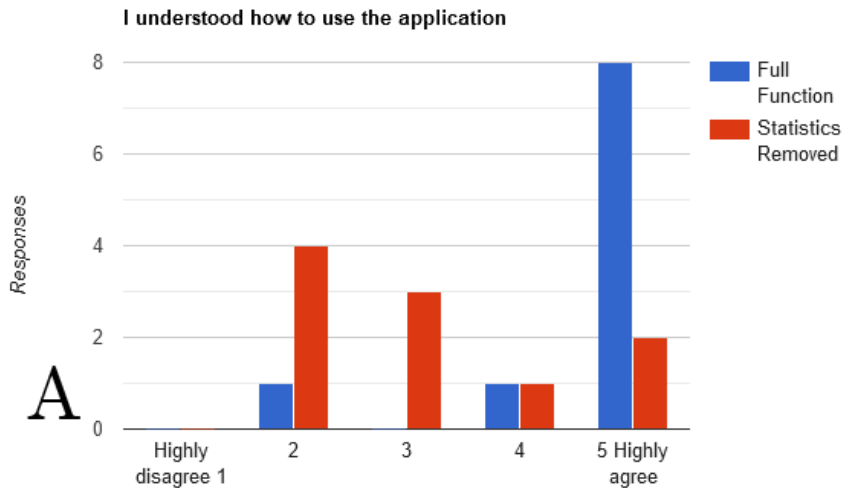
D

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Intuitiveness Results

User Study

I understood how to use the application

The application is intuitive

I feel comfortable with the accuracy of my answers

Using an interactive web visualization has advantages over other formats such as static maps, reports, and other graphics.

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Discussion

Web GIS Application

- Land cover data

- User centered design

- Time Series visualizations

- Microservice architectures

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Discussion

- Three U's of Cartographic Interface Success

  - **Usability**: How easy is it to use an interface to complete the objectives at hand?

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Hypothesis
Discussion

1. Cloud-based cartographic visualizations of remote sensing derived products can be an advantage to include within organizational microservice architecture.

2. Cartographic projects with integrated user-feedback cycles can help improve the continual development of earth observation derived products.

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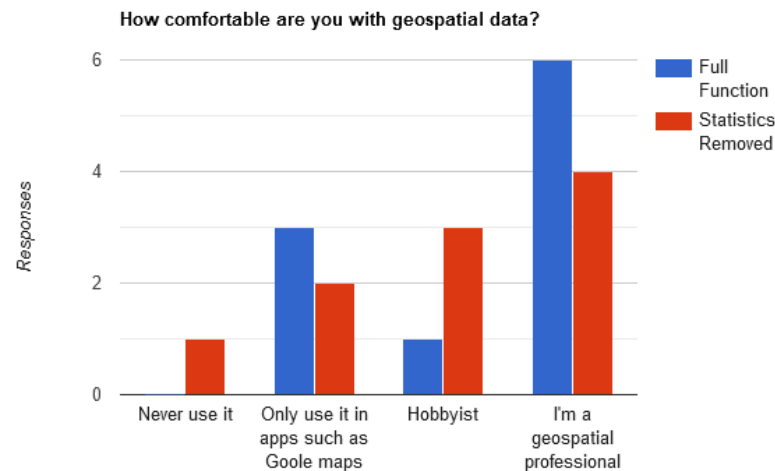
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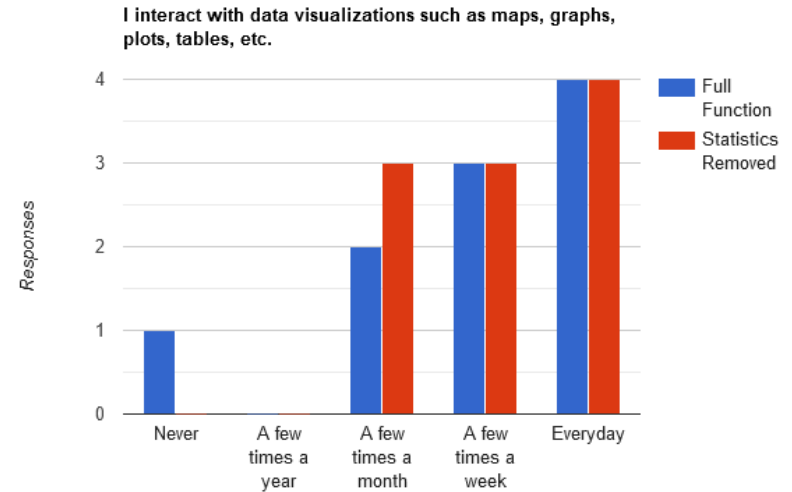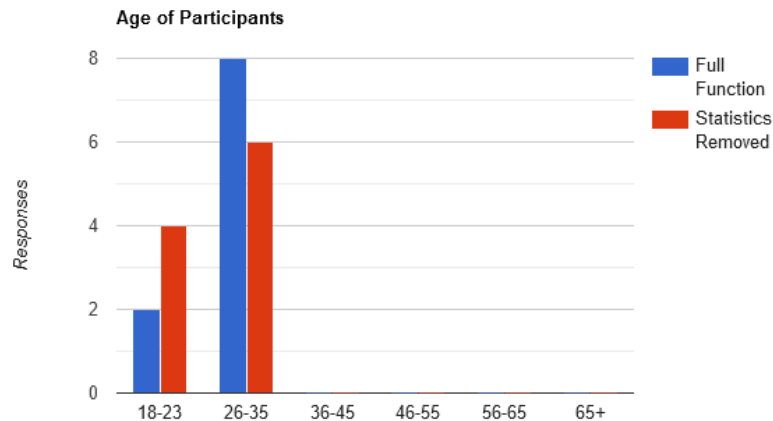
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Reliability & Relevance

Discussion

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Conclusion

Web GIS time-series microservice prototype

- Better understanding

- Increased accessibility

- Higher overall satisfaction

Microservice positives and negatives

Real world applicability

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cloud-based tools**

Outlook

Web GIS Microservice Potential

- Mena et al. (2019)

Topics

- Value of modularized maps as a component of web and micro-frontends

- Statistic visualizations in slippy maps

- Speed performance of Web GIS microservices

Copernicus Land Monitoring Service

- https://land.copernicus.eu/dashboards/clc-clcc-2000-2018

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Thank you for your attention

https://github.com/jessefriend

This is a koala
(Source, 2018)

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References

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Mena, M., Corral, A., Iribarne, L., & Criado, J. (2019). A Progressive Web Application Based on Microservices Combining Geospatial Data and the Internet of Things. IEEE Access, 7, 104577–104590. Retrieved 2021-04-21, from https://ieeexplore.ieee.org/document/8782470/.

https://www.interaction-design.org/literature/topics/ux-design?page=8. User Experience (UX) Design. Accessed 20 July 2021.

Roth, R., Ross, K., & MacEachren, A. (2015, March). User-Centered Design for Interactive Maps: A Case Study in Crime Analysis. *International Journal of Geo-Information*, *4*, 262–301.

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