

Online visualization of multi-dimensional spatio-temporal data

Visualization of weather data of Germany in a large time scale

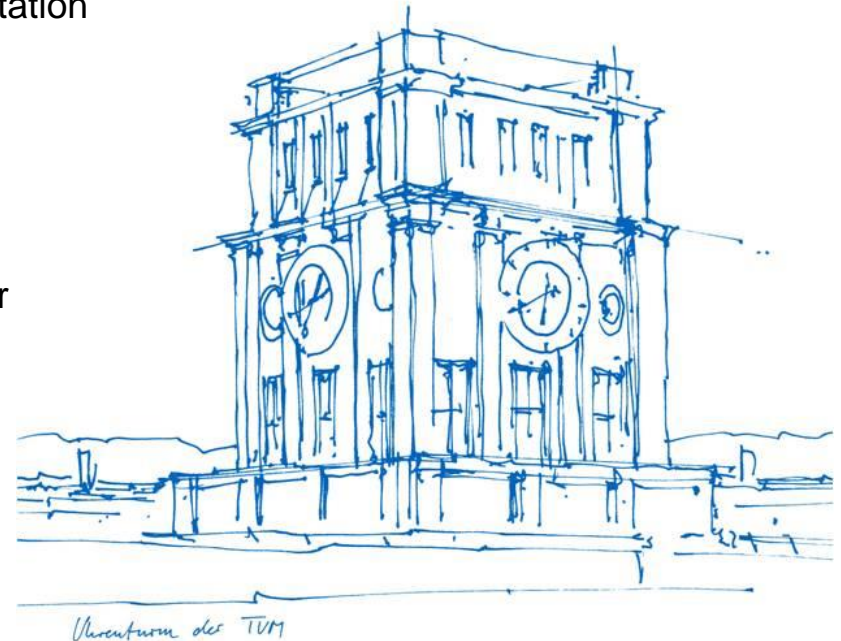
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Final presentation

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Munich, 26. April 2018



Outline

1. Introduction
2. Methodology
3. Case study
4. Map evaluation
5. Evaluation results
6. Discussion
7. Outlook

1. Introduction

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Introduction

Background

- Time parameter in cartography
- Web-based technology
- The vastly increasing volume of spatial data
- Map evaluation as a tool to test map utility and usability

Introduction

Research goal

Develop methodology to visualize multi-dimensional spatio-temporal visualization data, and to fill in the gap of the performance of applied techniques.

- Find methodologies for visualization
- Develop a method to evaluate the map utility and usability
- Draw conclusions from the evaluation results



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Methodology

Medium for the map

- Web mapping: why and how?

Desktop GIS, online GIS, and web mapping

Trend

Accessibility

Flexibility

Interactivity

- Options of web maps

Depiction of movement & change; Multimedia maps; Virtual worlds; Scientifically explore spatial data

Methodology

Visualization methods

- Animated map: why and how?

General interest

Vivid presentation

Technology capability

Animation parameters

Speed

Direction

Smoothness

JavaScript

`window.requestAnimationFrame(`

`setTimeout()`

`setRenderer()`

Methodology

Visualization methods

- Chart

Why?

Climate
change
visualization

Detailed
statistically
presentation

How?

Chart.js

Methodology

Visualization methods

- Multi-dimension in a web map

Multi-variate and multi-dimension

Dimensional
reduction

Interaction

Multi-method
visualization

Methodology

Map evaluation

- Map usability and utility
- Eye-tracking technology

mind-eye hypothesis , free-examination task, goal-directed task



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Case study

Data description

- Weather data from DWD Climate Data Center :

Weather and climate?

Characteristics
of the data

Weather/climate
visualization

Public
perception

Case study

Data description

- Weather parameters:

Temperature, Precipitation, Ice days, Snow cover days, Hot days, Temperature in July,
Precipitation in winter

- Structure of the data:

Format

Resolution

Interpolation

Temporal range

Case study

Applied software and APIs

- Esri products

Capabilities

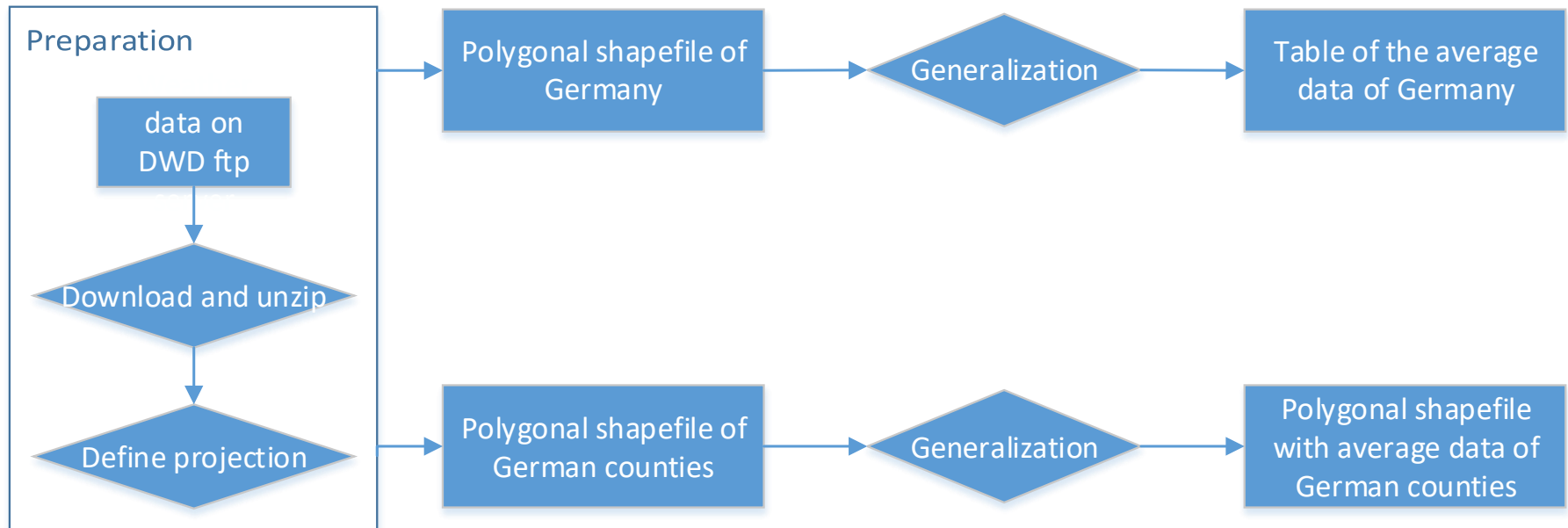
Compact process

Consistency

- Python
- HTML and JavaScript, CSS, Framework

Case study

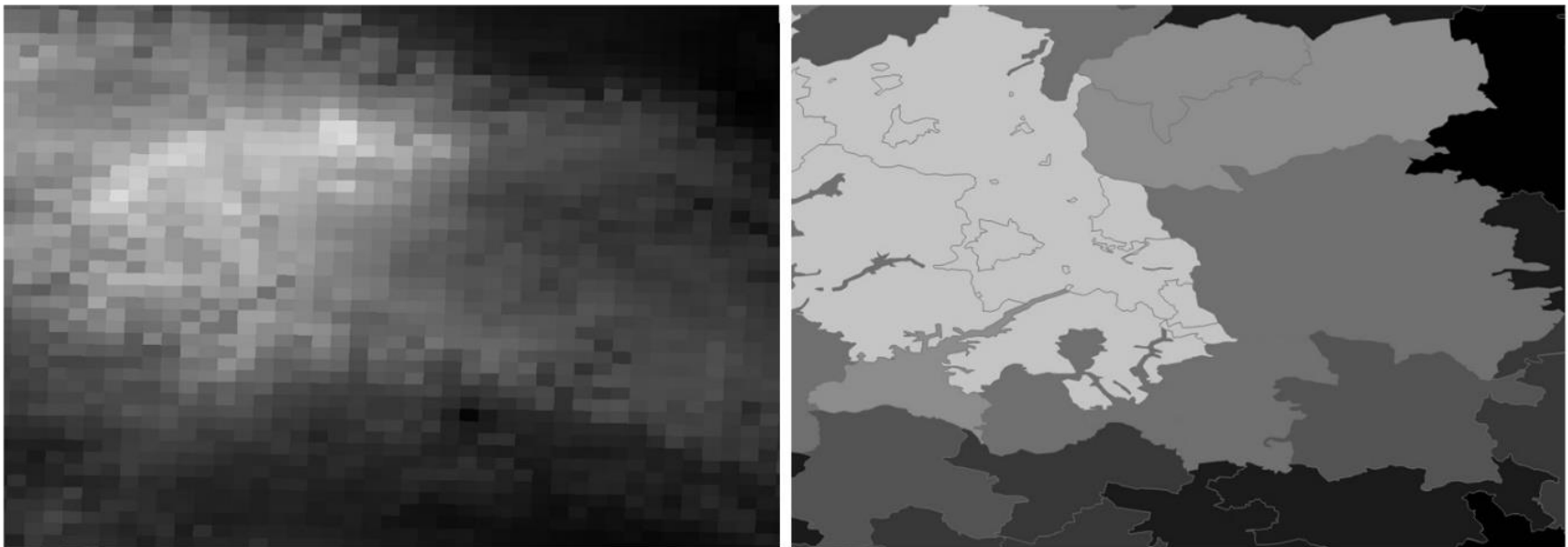
Data retrieving and processing



Python: ArcPy, Pandas...

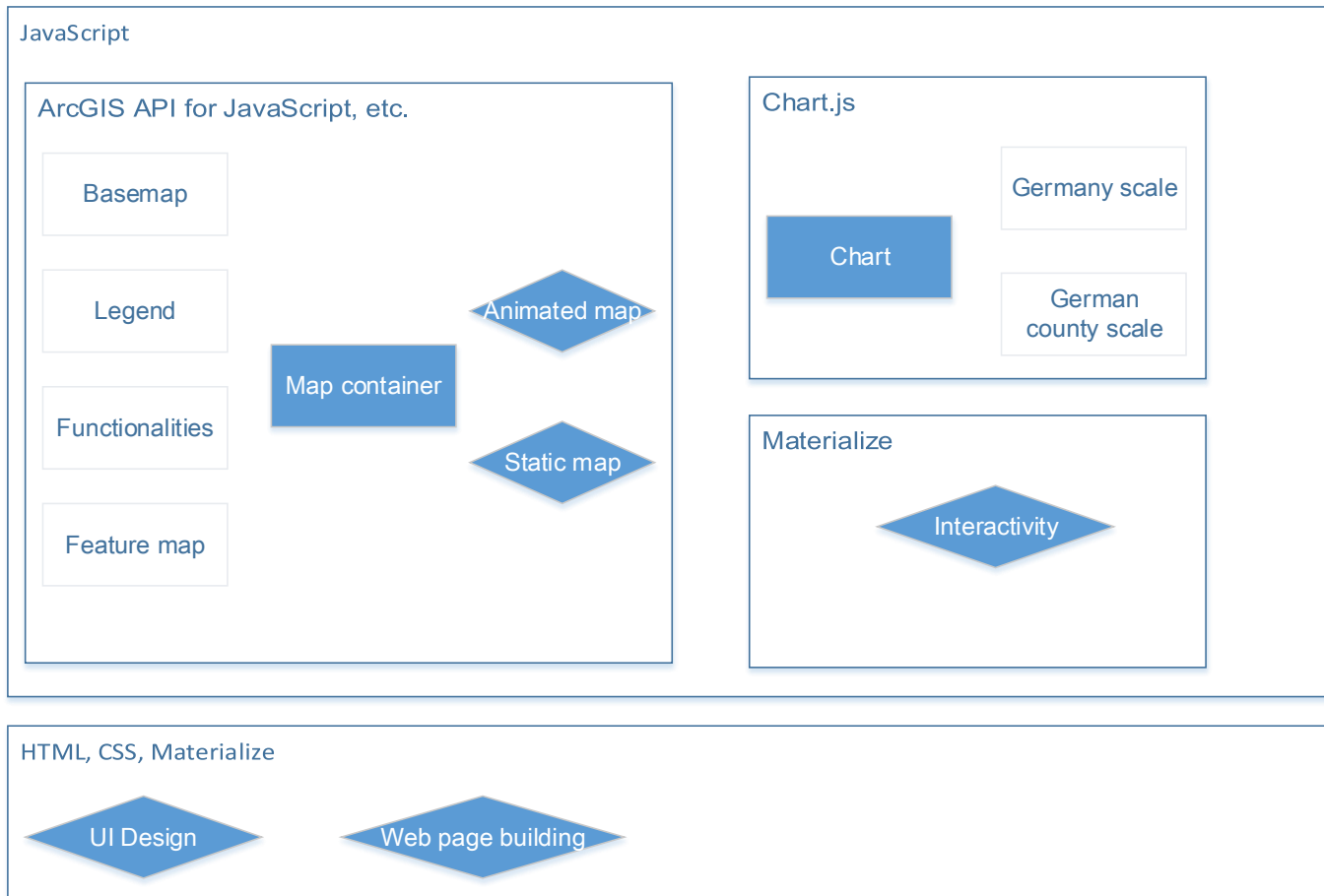
Case study

Data retrieving and processing



Case study

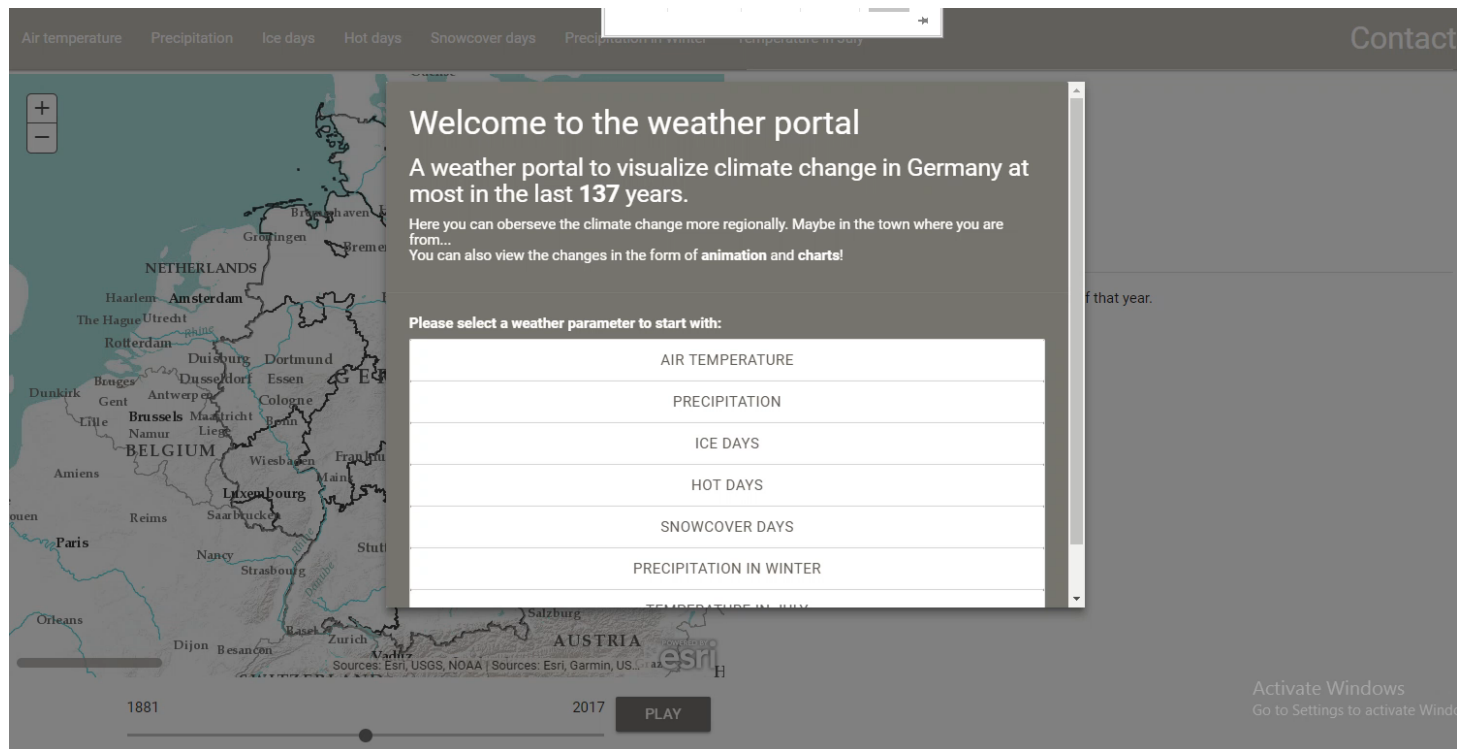
Web mapping



Case study

Data visualization

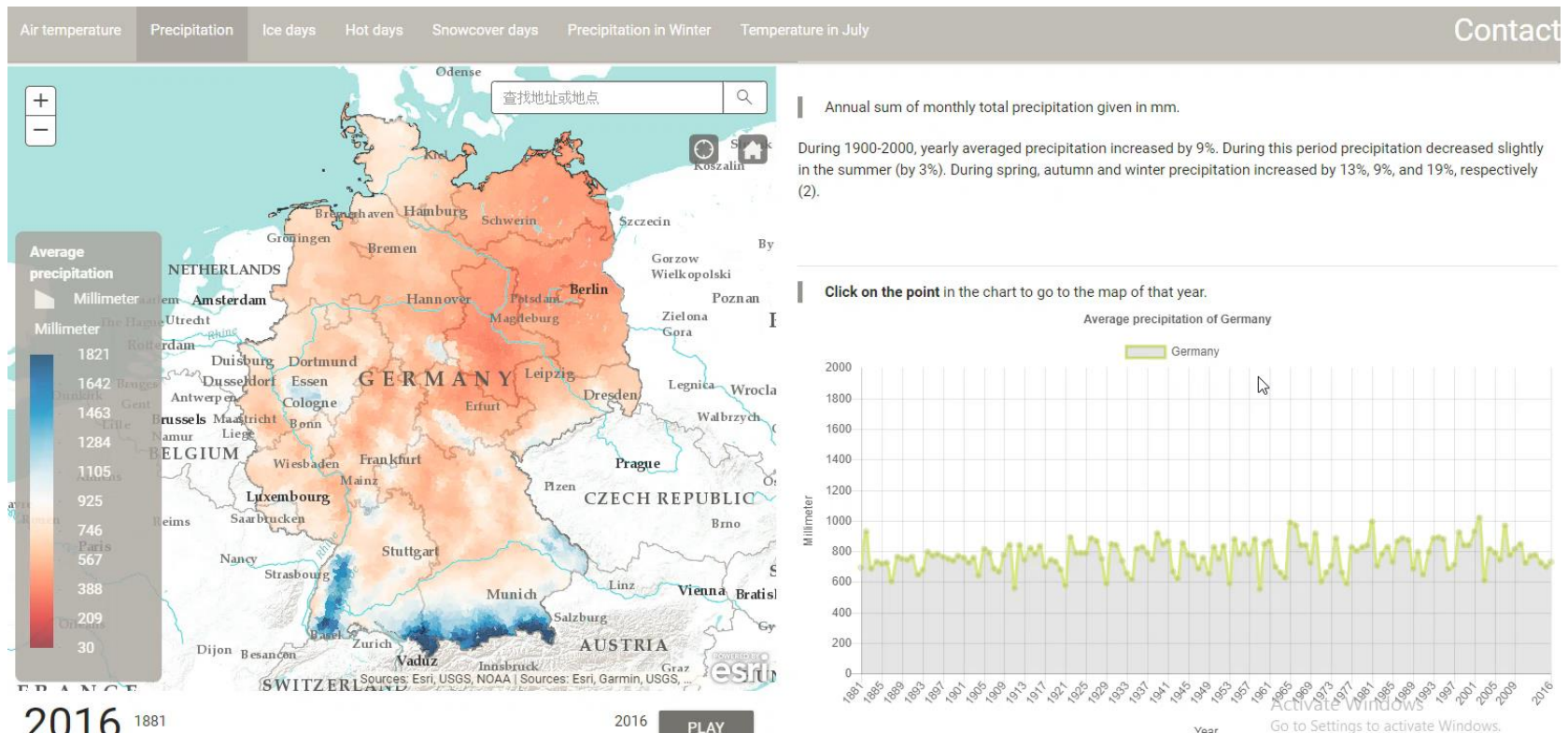
- Multi-dimensional <G:\thesis\presentation\Multi-dimensional.mp4>



Case study

Data visualization

- Chart <G:\thesis\presentation\chart.mp4>

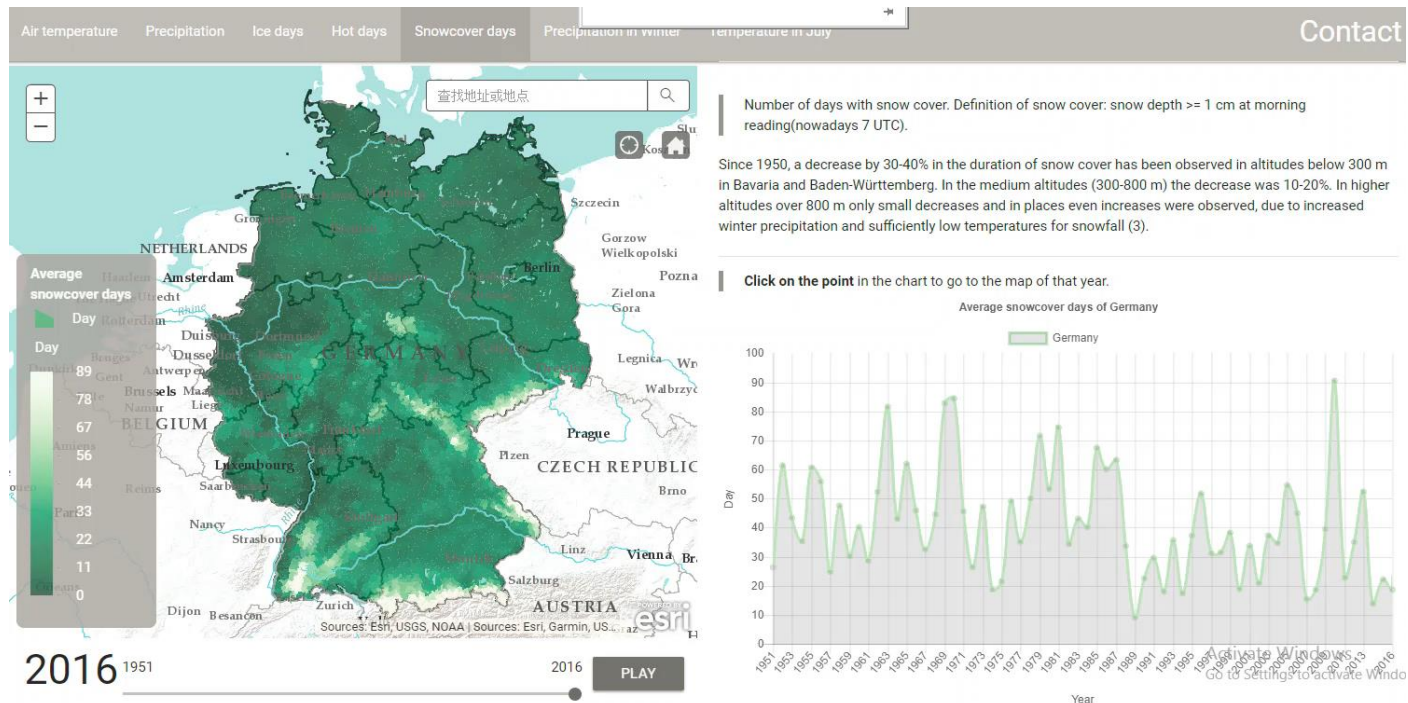


Case study

Data visualization

- Web mapping: Functionalities, User-interface design

<G:\thesis\presentation\webmapping.mp4>



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Map evaluation

Why evaluate?

- How do people allocate their eyes when they are viewing this multi-component map? Is there any difference when viewing without any tasks and viewing with tasks?
- Which kind of information is generated by different parts of the map?
- When users have tasks, how do the different viewing strategies influence their effectiveness and efficiency?

Map evaluation

How to evaluate?

- Free-examination task

Universal introduction,

Users' same knowledge level of the functionalities of the application

- Goal-directed task

15 questions

3 categories

3 orders

Clarity of the statement

Confidence level

Map evaluation

How to evaluate?

Number	Type	Question	Answer
Aa	Regional trend	Between 1881 and 2000, there were more years where <u>southern Bavaria in the Alps</u> has less average precipitation than <u>south-western Germany</u> .	False
Ba	Overall trend	Between 2000 and 2016, 2007 was the year with the lowest number of snow cover days.	False
Cb	Quantitative trend	Between 1881 and 2017, the annual average temperature in July in <u>Berlin</u> was not always over 17 Celsius degree.	True
Db	Regional+ overall trend	Between 1881 and 2016, the <u>southern Rhine basin</u> has stayed the region that has the highest air temperature in Germany comparing to the other regions in the map below.	True

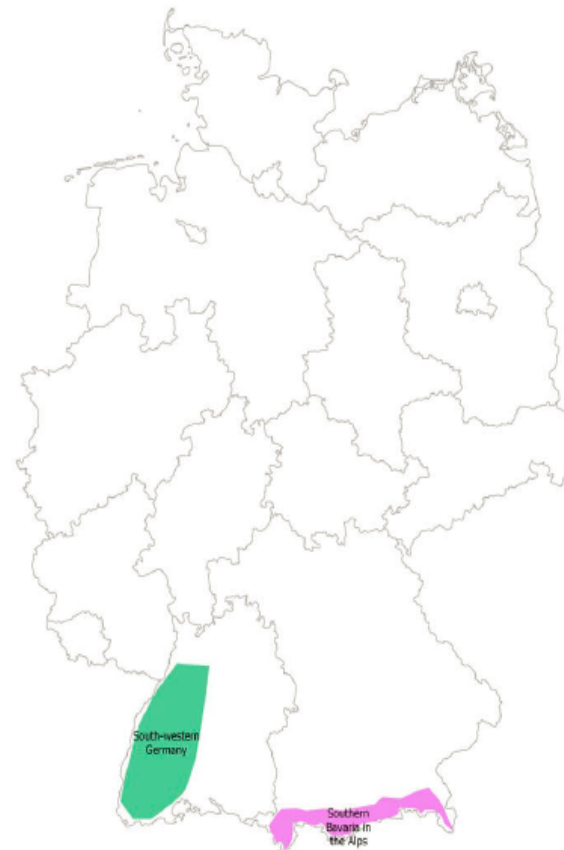
Map evaluation

How to evaluation?

- Goal-directed task

Please select **Precipitation 1881-2000**

1. Between 1881 and 2000, there were more years where southern Bavaria in the Alps has less average precipitation than south-western Germany.(Aa)



Map evaluation

Material and participants

- Location

Eye-tracking lab

- Map components coordination

Part	Left	Right	Top	Bottom
Map	0	0.4927	0.1519	0.8574
Chart	0.5034	1	0.3504	0.8313
Legend	0.0077	0.0968	0.3566	0.8573
Text	0.5034	1	0.1519	0.3442

- Hardware and software

Gazepoint Analysis, GP3 eye-tracker,
Windows 10 operating system

- Participants

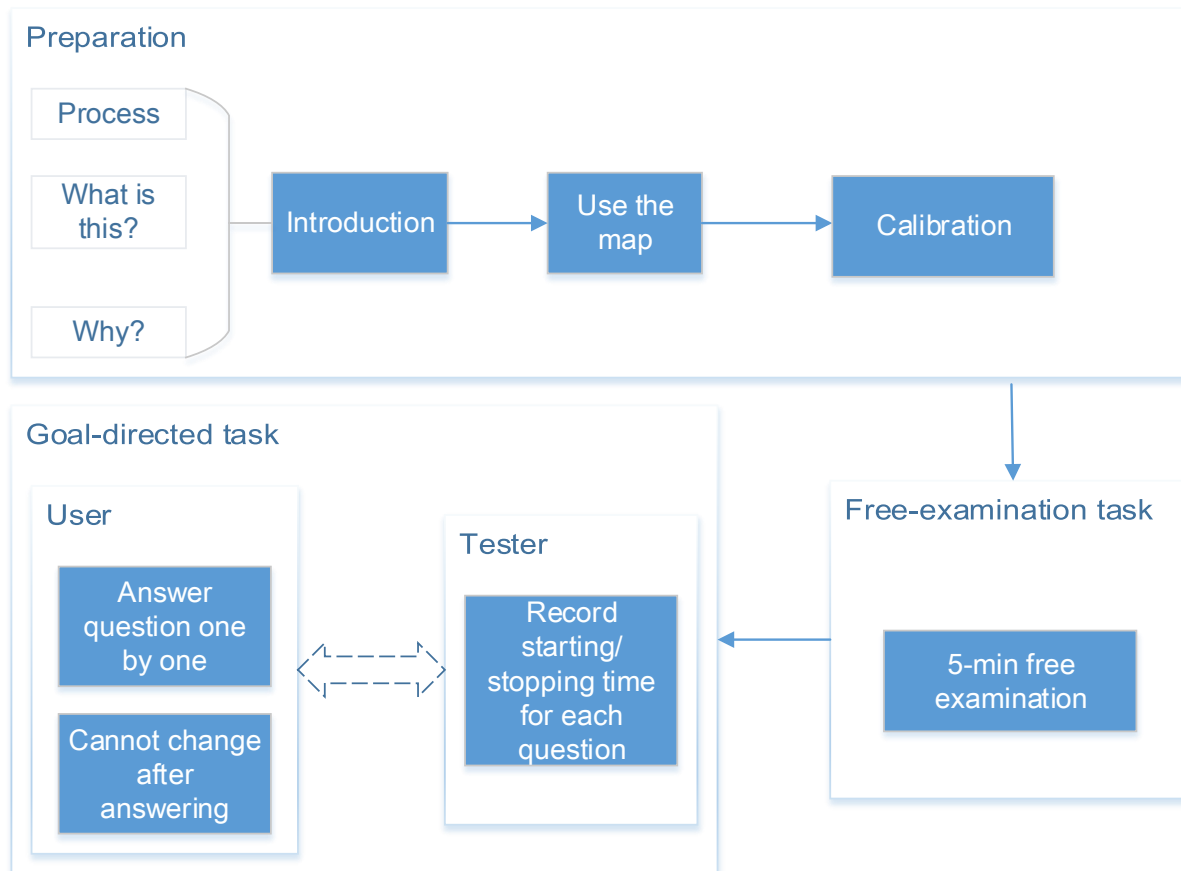
24 participants

13 female

11 male

Map evaluation

Evaluation procedure



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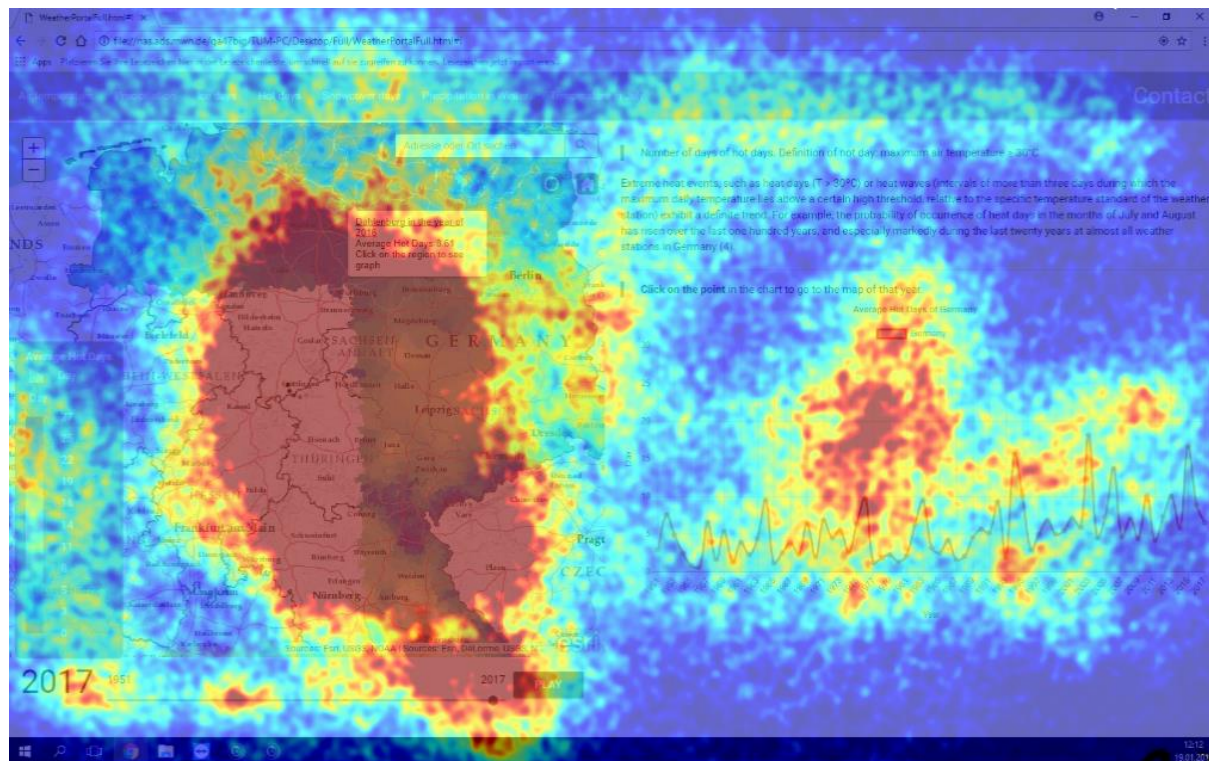
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Map evaluation results

Free-examination task

- Overall area of interest analysis



Map evaluation results

Free-examination task

- Overall area of interest analysis

Map container							
	Duration	Map	Animated map	Static map	Chart	Legend	Description
Mean	310.82	134.07	40.46	93.61	45.33	6.63	11.03
Minimum	293.57	46.47	0.00	2.39	4.90	1.31	0.34
Maximum	347.54	190.26	100.00	170.99	103.44	18.53	51.18

Map evaluation results

Free-examination task

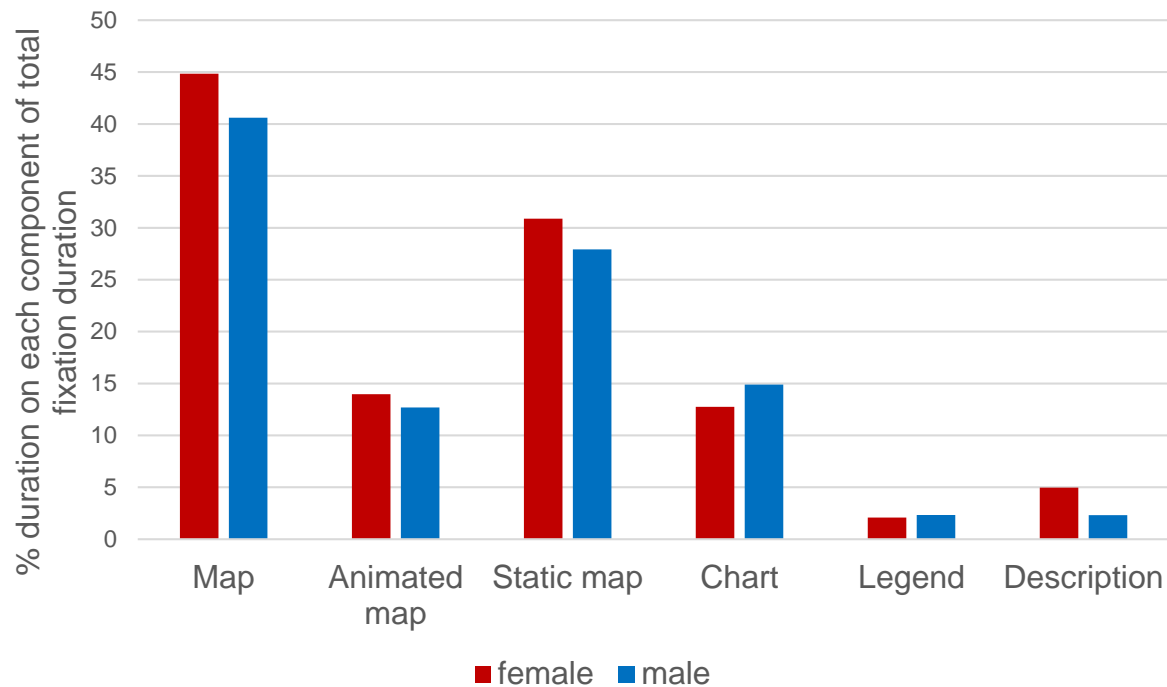
- Overall area of interest analysis

	Map container					Description
	Map	Animated map	Static map	Chart	Legend	
% of the whole duration	43.13	13.02	30.12	14.58	2.13	3.55
% of the monitor	34.76	34.76	34.76	23.87	4.46	9.55
Relation between these two(ratio)	1.24	0.37	0.87	0.62	0.48	0.37

Map evaluation results

Free-examination task

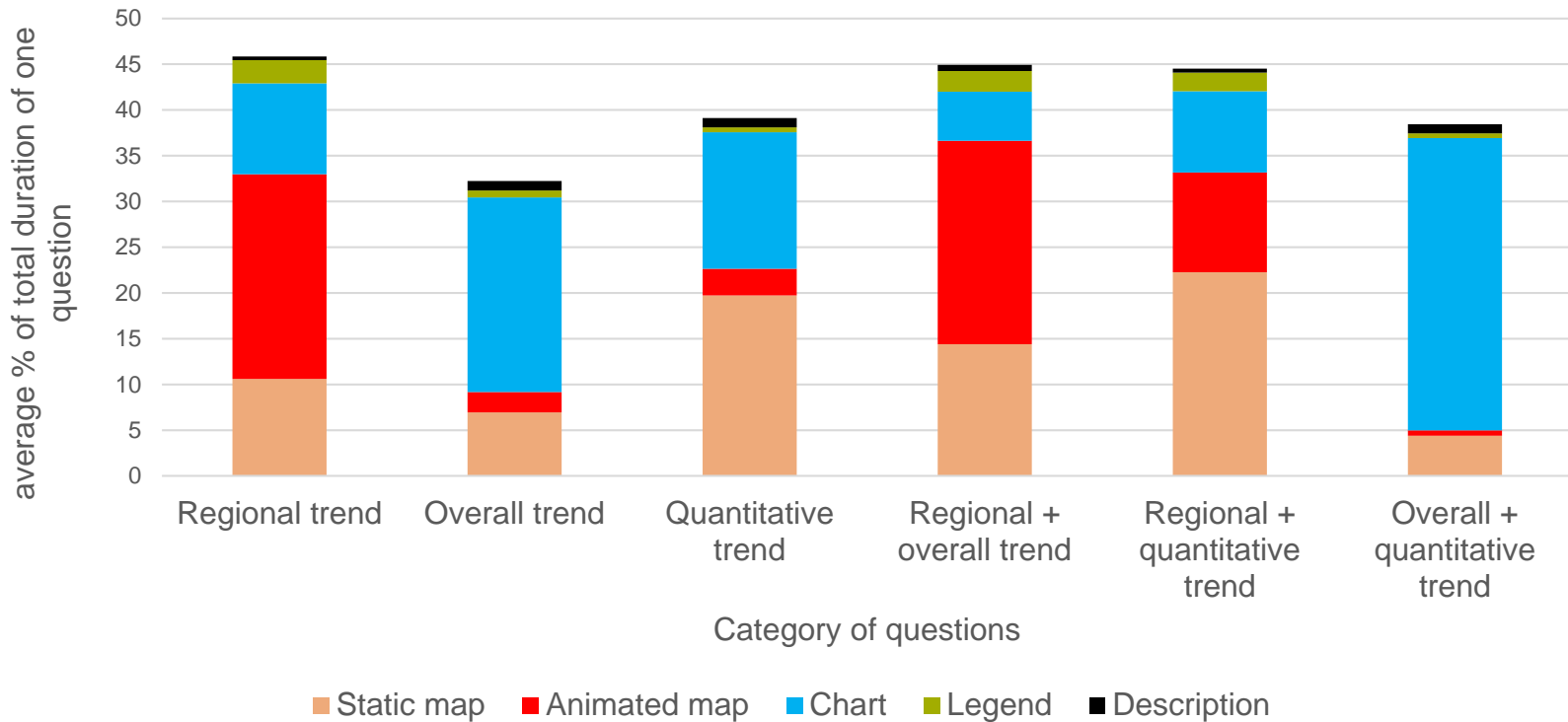
- Area of interest analysis based on gender



Map evaluation results

Goal-directed task

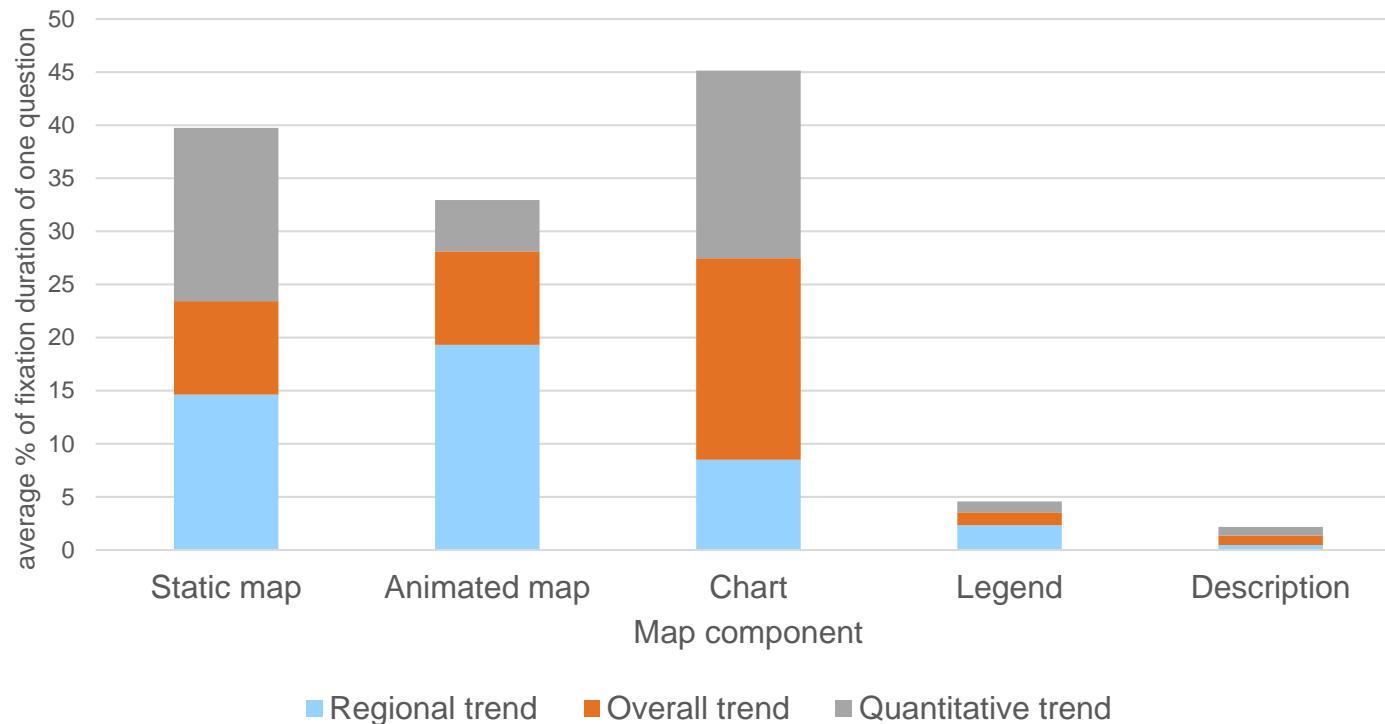
- Area of interest analysis based on questions



Map evaluation results

Goal-directed task

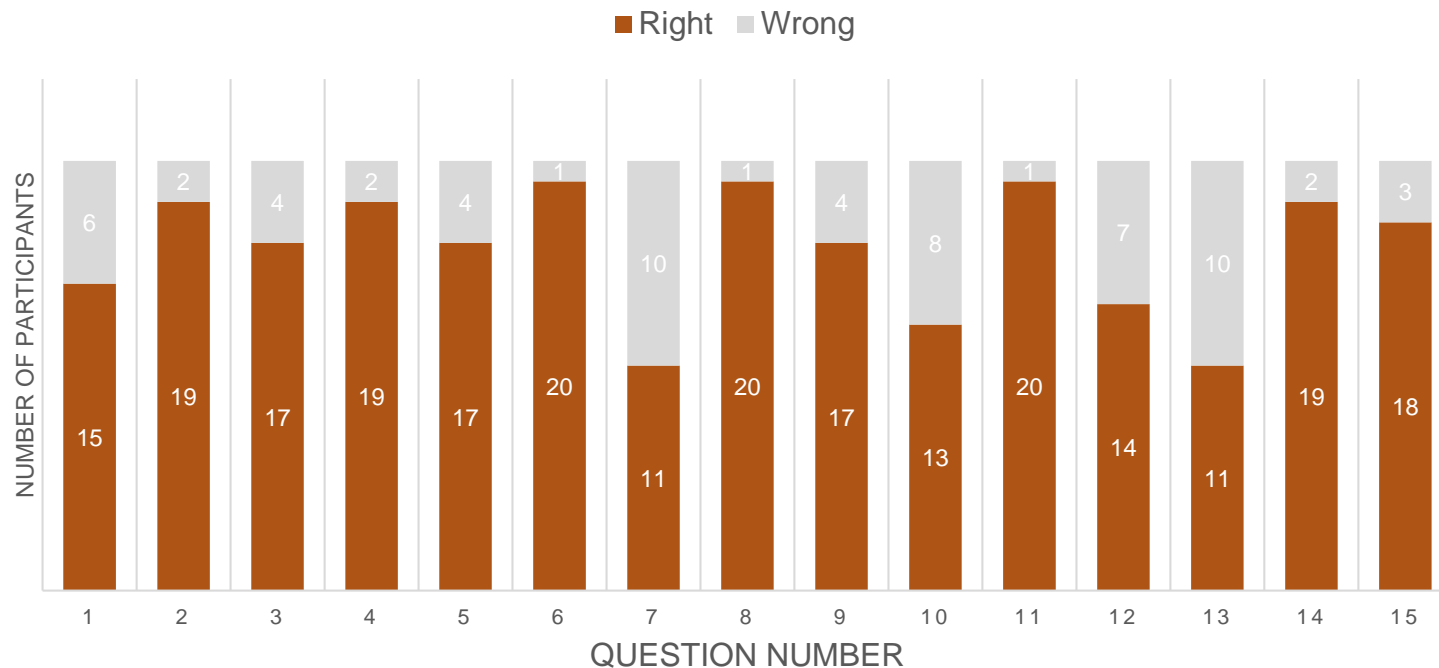
- Area of interest analysis based on questions



Map evaluation results

Goal-directed task

- Area of interest analysis based on accuracy

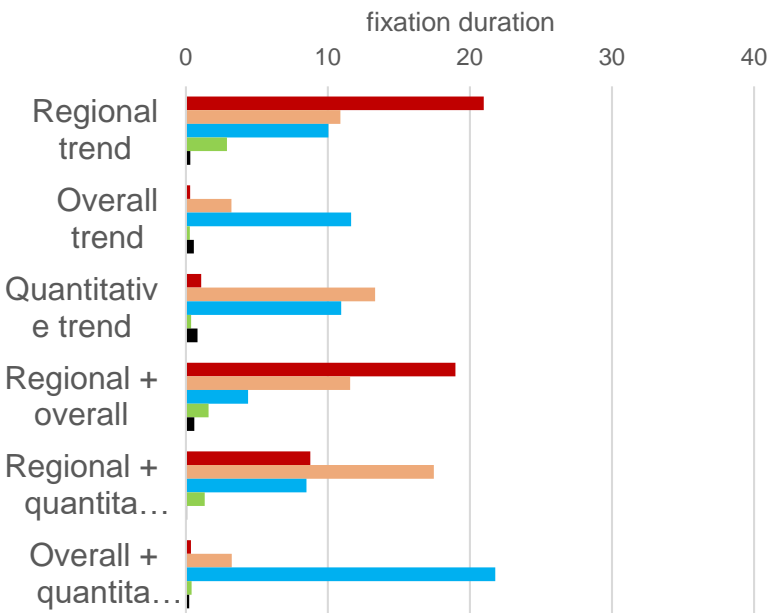


Map evaluation results

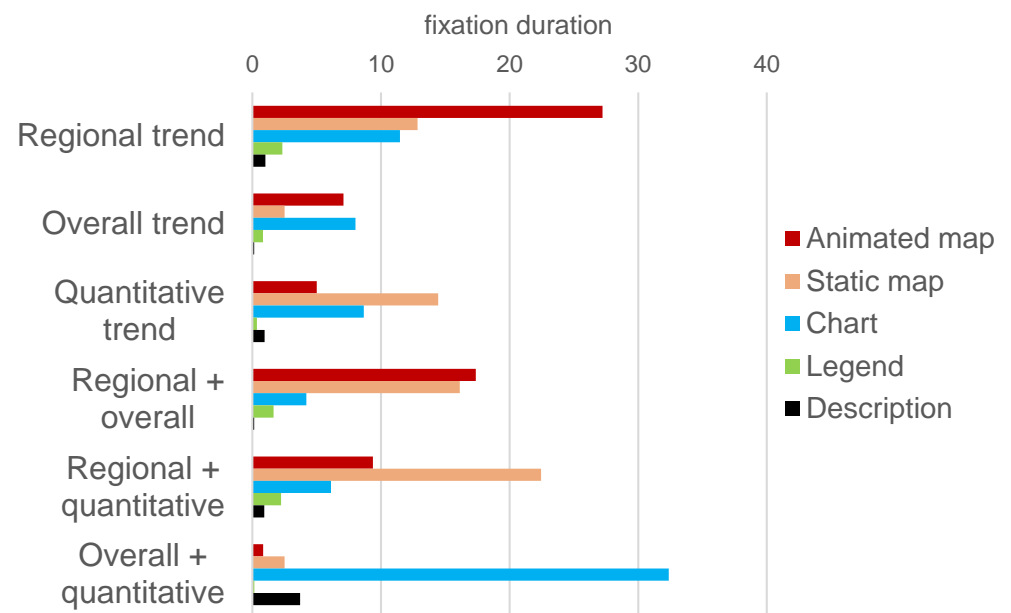
Goal-directed task

- Area of interest analysis based on accuracy

correct



incorrect



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Discussion

Free-examination task

- Map container attracts the majority of participants' attention.
- The applications of animated map and chart are appealing enough.
- There is also distinction of viewing time on static map and animated map.
- Female participants find map more interesting than men do, while male participants separate more of their attention on chart than women do.

Discussion

Goal-directed task

- Utility of the major components

Both with and without accuracy check, both preference and proof

Component	Better generated information?
Animated map	Regional trend,
Chart	Overall trend, quantitative trend

- Legend helps with obtaining specific information from a map.

Discussion

Goal-directed task

- However, participants who view the animated map for a longer time tend to have poorer performances. **A threshold of viewing time on animated map** could possibly be observed, as to achieve the best performance .

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Outlook

- The feedback and the evaluation results to be taken into consideration in future work and design.
- The speed of the animated map should be better handled and controlled.
- Automatic visualization update with the update of data.
- There still exists a need for a better explanation of the map evaluation results, in terms of the participants viewing behavior.

Thanks for your attention!

Keni Han

Munich, 26. April 2018

