Cartography M.Sc.

Visualizing Decision-Relevant Map Layers to Support Travel Planning

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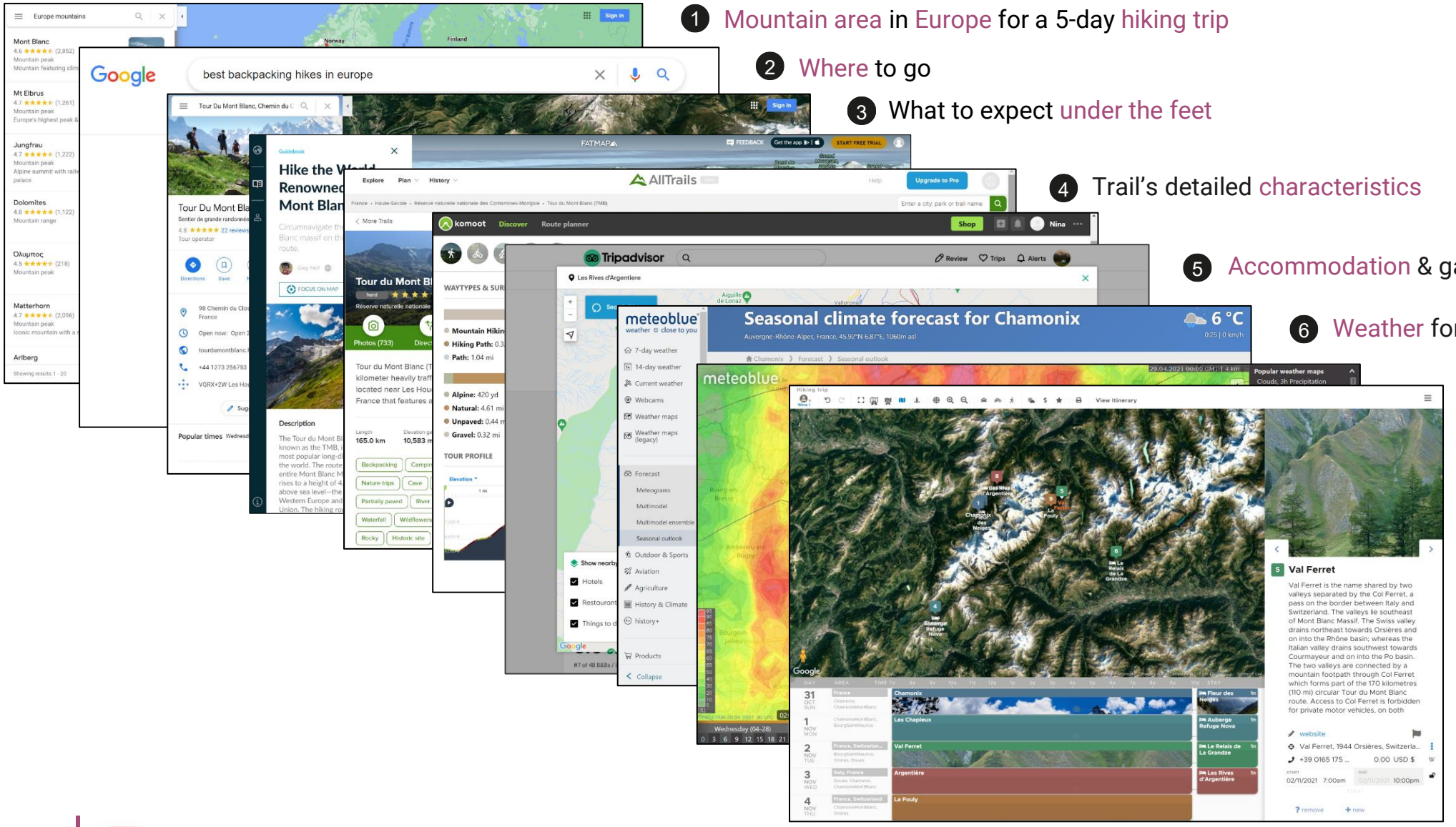
Outline

- Motivation & Background
- Research Objective & Research Questions
- Methodology
- Prototype Implementation
- Prototype Evaluation
- Discussion of Results
- Conclusion & Outlook
- Future Work

Motivation & Background

Travel planning is a complex decision-making process



1. Mountain area in Europe for a 5-day hiking trip
2. Where to go
3. What to expect under the feet
4. Trail's detailed characteristics
5. Accommodation & gastronomy
6. Weather forecasts
7. Preparing an itinerary

The master thesis:

- contributes to a startup's company project that builds a novel decision support system in the context of sports travel (e.g., surfing, skiing, hiking, mountaineering).
- contributes insights on what information can be relevant for making hiking travel-related decisions.
- proposes how map layers and map elements can be visualized in different zoom levels using the implemented prototype.

The startup's system:

- wants to help travelers to decide with ease on a smartphone or a desktop application, 1) where to travel for a specific sport, 2) when to travel, 3) what to do during a trip, and 4) to plan an itinerary.
- considers the mapping tool as the core component of the system but it was not attentively researched before.

Research Objective

- To define, visualize and evaluate decision-relevant map layers of a web-based application.

I. Data phase: Sub-objective I
Defining and designing the data acquisition process.

Research questions:

I-a) What is the decision-relevant information for a decision support system for travellers focusing on hiking activity?

I-b) What APIs are available and relevant for a decision support system focusing on hiking activity, and what criteria do the APIs have to fulfil?

II. Visualization and evaluation phase: Sub-objective II
Visualizing and evaluating decision-relevant web map layers.

Research questions:

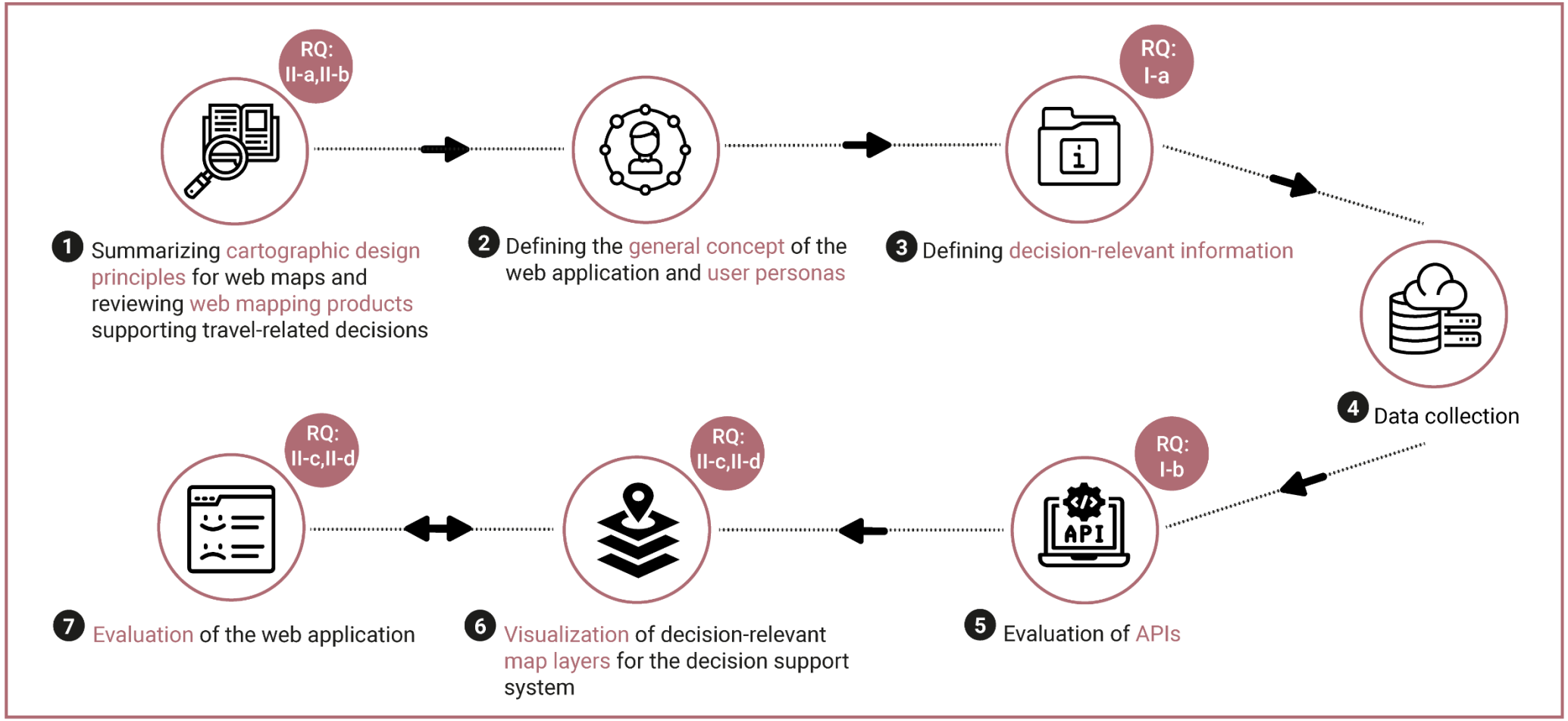
II-a) What web mapping applications exist, and how do they support travellers' decisions?

II-b) How are the decision-relevant map layers visualized in the existing web mapping applications?

II-c) What decision-relevant information should be visualized in different zoom levels?

II-d) How should the map elements be designed to support the traveller best?

Methodology



Defining the General Concept of the Web Application

Global level

- Countries which are:
  recommended,
  less recommended,
  not recommended.
- Top 10 hiking trails within the recommended countries.

Local level

- Regions & subregions which are:
  recommended,
  less recommended,
  not recommended.
- Top 10 hiking trails within the recommended regions & subregions.

Spot level

- Aggregated groups of hiking trails
- Individual markers of hiking trails & points of interest.

Itinerary

- Selected and saved individual items (e.g., hiking trails, hotels, restaurants) visualized by days.

Defining User Personas

	What	When	Where	Details
 Anna 33 years old Experienced hiker	Three day hiking trails	Five days at the end of October	Europe	- Moderate and hard trails - Overnight stays and places to eat along the trails - Use of public transport
 Roman 22 years old Beginner hiker	One day hiking trip	A day to hike depends on the weather 'next' week	Bavaria	- Easy or moderate trails, 4-6 hours long - Lunch at a restaurant near lake and swimming afterwards - Use of public transport

Defining the Decision-Relevant Information

✓ **RQ I-a)** What is the decision-relevant information for a decision support system for travellers focusing on hiking activity?

Decision-relevant map layers

Basemaps

- Customized basemap
- Terrain basemap
- Satellite basemap

Map overlays

- Countries' boundaries
- Country subdivision
- Weather overlays

Decision-relevant places information

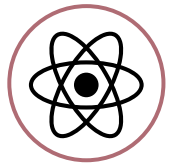
- Accommodation
- Food and drink
- Local facilities
- Health
- Transport
- Tourism
- Hiking trails

Decision-relevant weather information

Weather widgets

- Current weather
- Daily forecast
- Historical temperature
- Precipitation data

Data Collection Tools



React, a free and open-source front-end JavaScript library for building user interfaces or UI components based on the TypeScript programming language and the standard stack.

Python, a script programming language, is used to collect data from public APIs.

Evaluation of APIs

- ✓ **RQ I-b)** What APIs are available and relevant for a decision support system focusing on hiking activity, and what criteria do the APIs have to fulfil?

Choosing Map API

Criteria	Google Maps API	OpenStreetMap API	Mapbox API
Global coverage	More accurate than OpenStreetMap and Mapbox APIs	Inferior coverage depending on a region because it relies on collective mapping	Inferior coverage depending on a region because it relies on collective mapping
Customization options	Limited support for creating a unique look and feel of a map	Flexible but using third-party services	More customizable with unique customization options
Overlays	Images and basic shapes such as polyline, polygon, circle, etc.	Additional use of Overlay API for vectors and pointers on slippy maps	Images and basic shapes such as polyline, polygon, circle, etc.
Map layers	Terrain, satellite, traffic, transit, and bicycle layers	Additional custom layers can be fetched from Leaflet or Mapbox	Streets, terrain, traffic, satellite, boundaries layers
Offline maps	No offline mode available via API	Can be downloaded and used entirely offline	Offline functionality
Complexity of code	Less complex code, well-organized examples	Longest code, but in combination with Leaflet API, it becomes less complex	More complex architecture, standardization, and data flow
Usage limitations	No strict limitations	Limitations for heavy usage	No strict limitations
Cost and pricing	Costs per requests	Open-source, free	Costs per usage

Comparison of Map Libraries

Criteria	Maps JavaScript API (google-map-react)	Leaflet (react-leaflet)	OpenLayers (react-geo)	Mapbox GL (react-mapbox-gl)
The size of the library	12,6 Kbytes	7,1 Kbytes	69,1 Kbytes	15,3 Kbytes
Functionality	A small set of the functionality	Rich functionality by means of plugins	Rich functionality	Rich functionality
Compatibility	Only Google Maps API	OpenStreetMap-project and commercial products	Any source	OpenStreetMap-project and commercial products
Documentation	Well-structured documentation with various examples	Very basic examples	Well-structured documentation but very large	Thorough documentation and demos
Vector tiles support	Supports vector tiles	By third-party plugins	Supports vector tiles	Supports vector tiles
Costs	Pay per use	Free/Pay per use	Free	Pay per use

Choosing Places API

Criteria	Google Places API	Overpass API	Foursquare Places API
Accommodation	+	+	+
Food and drink	+	+	+
Local facilities	+	+	+
Health	+	+	+
Transport	+	+	+
Tourism	+	+	+
Photos	+	-	+
Hiking trails	As a point	As segments	As a point
Characteristics of hiking trails	Limited characteristics	Detailed characteristics	Limited characteristics
Limitations	No limitations	• 10 000 queries per day • Download less than 5GB per day	Need of obtaining an enterprise license
Cost	25$ per 1000 requests	Free	599$ monthly subscription
Compatibility	Google Maps only	Any platform	Any platform

Choosing Weather API

Criteria	OpenWeatherMap API	Accuweather API	Meteoblue API
Weather widgets data	+	+	+
Weather overlays data	+	+	+
Compatibility	All platforms	All platforms	All platforms
Limitations	• 60 API calls minute • 3000 calls a minute (free access to premium data)	• 50 calls per day	• No trial period or free data
Cost	• Free with premium access •180$ per month	• Three pricing tiers of $25 to $500/month	• Depends on the number of desired data points

Visualization Concept of Decision-Relevant Map Layers

Global level

- Countries which are:
recommended,
less recommended,
not recommended.
- Top 10 hiking trails within
the recommended countries.

Local level

- Regions & subregions which are:
recommended,
less recommended,
not recommended.
- Top 10 hiking trails within
the recommended regions & subregions.

Spot level

- Aggregated groups of hiking trails
based on difficulty level.
- Individual markers of hiking trails &
points of interest (e.g., hotels, restaurants).
- Path of a hiking trail.

Basemaps

- Basemap with a customized style.
- Terrain basemap.
- Satellite basemap.

Itinerary

- Selected and saved individual items
(e.g., hiking trails, hotels, restaurants)
visualized by days.

Weather

- Weather overlays for temperature &
precipitation (forecast, current, historical).
- Weather widgets for temperature &
precipitation (forecast, current, historical).

Prototype Implementation

APIs Used

Map API: ~~OpenStreetMap API~~ Google Maps API

Places API: Overpass API (hotels, restaurants)
Outdooractive API (hiking trails)

Weather API: ~~OpenWeatherMap API~~

Datasets

Countries boundaries

Germany's boundaries

- States (e.g., Saxony, Bavaria)
- Administrative districts (e.g., Regierungsbezirk Münster)

- Google Maps' customized default basemap
- Google Maps' terrain layer
- Google Maps' satellite layer

Restaurants & Hotels

- Coordinates
- Name
- Address
- Website link

Hiking trails

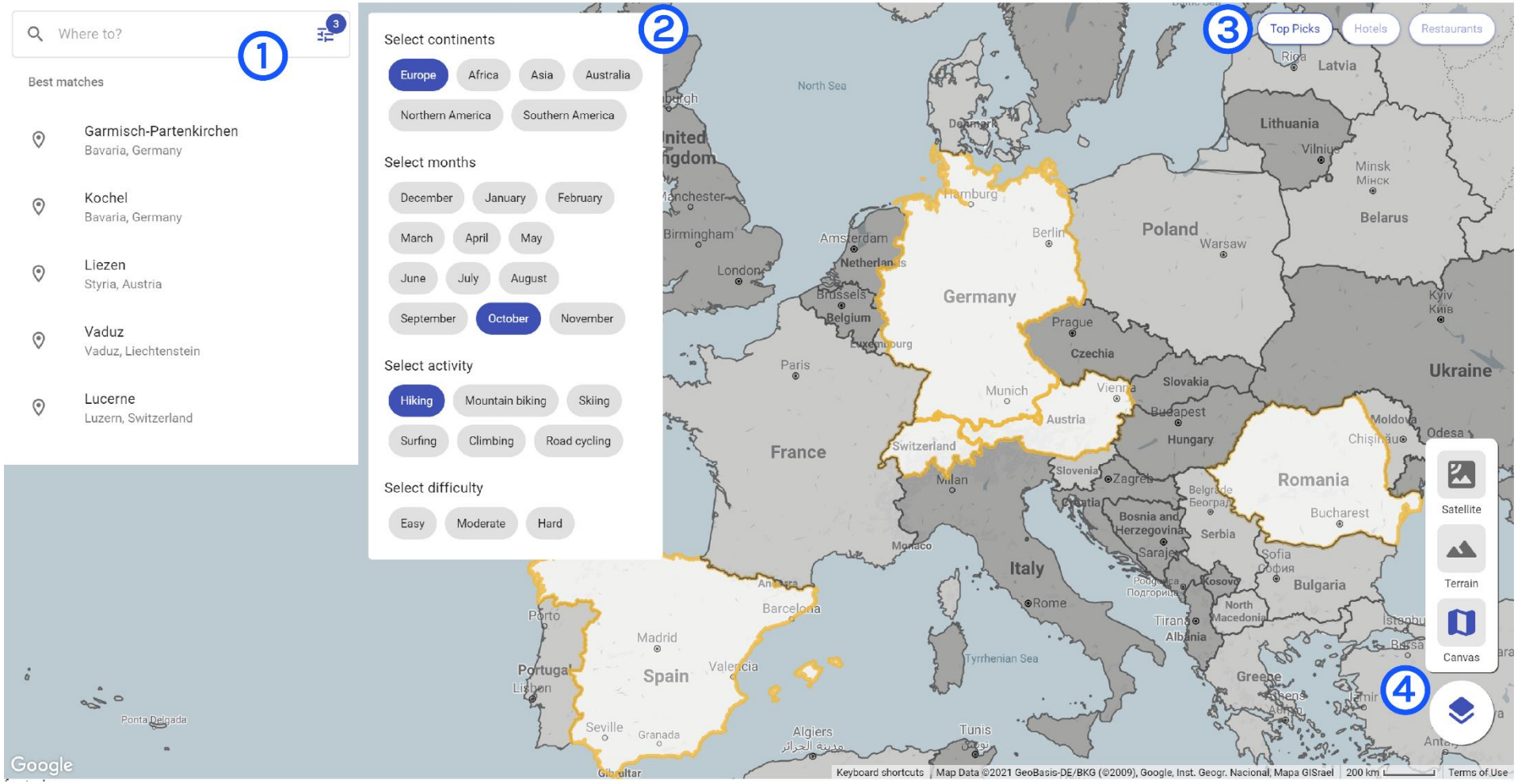
- Title
- Difficulty
- Length
- Elevation
- Geometry

Client-Side User Interface

TypeScript libraries

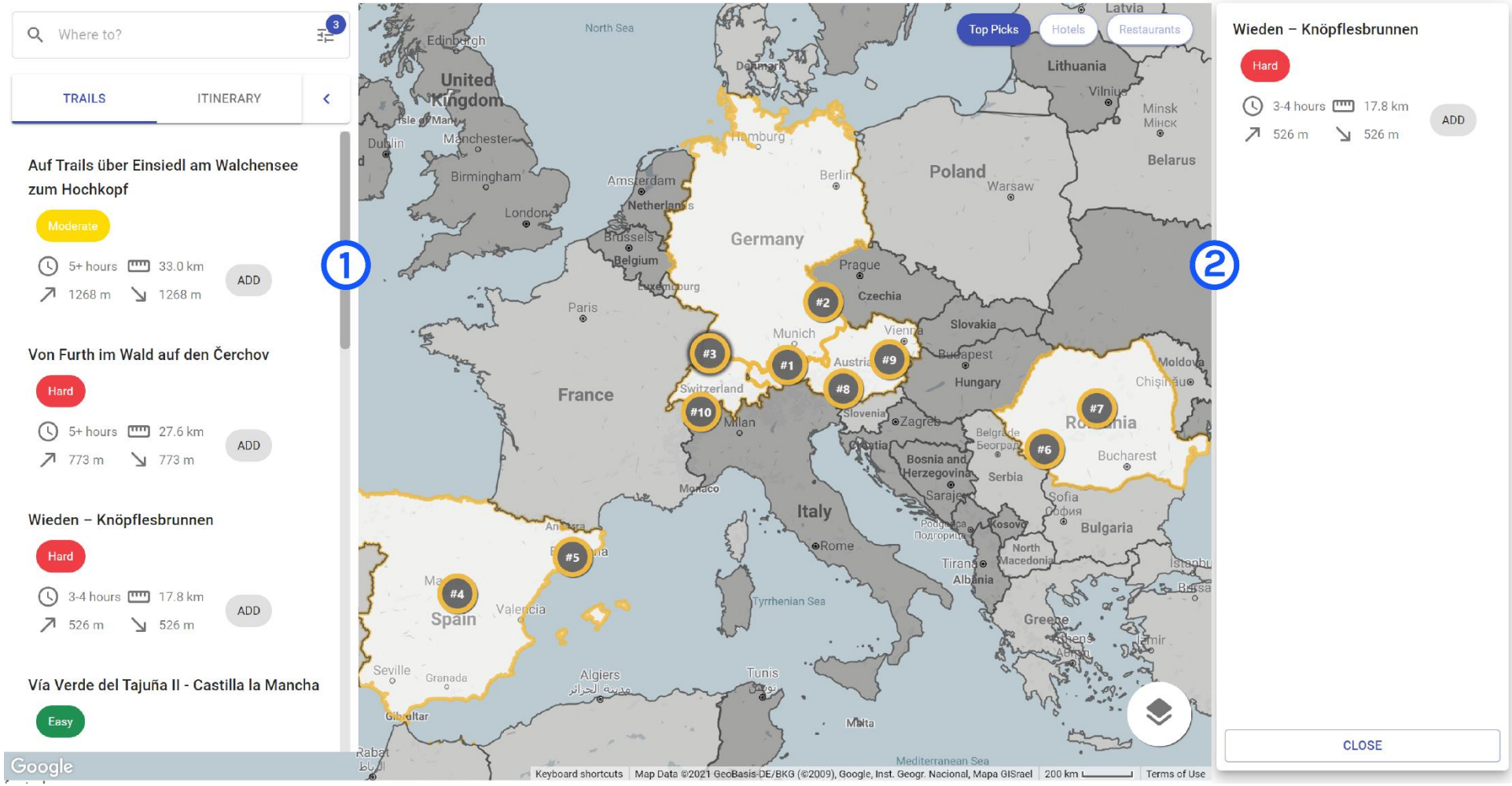
- “Material UI” library
- “Google-map-react” library
- “Supercluster” JavaScript library

UI Elements of the Prototype



(1) search bar
(2) filter menu
(3) buttons *"Top Picks", "Restaurants", "Hotels"*
(4) layer menu

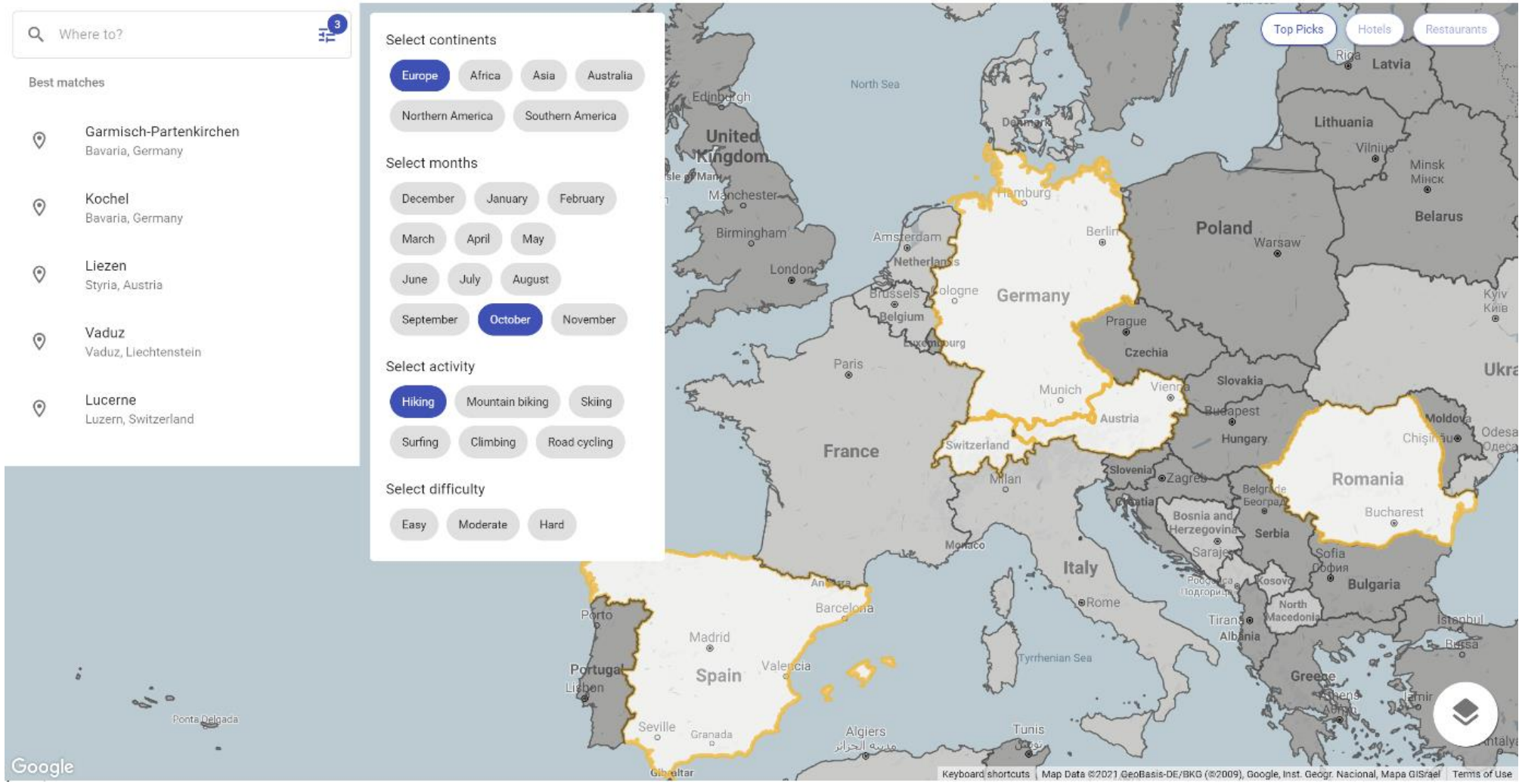
UI Elements of the Prototype



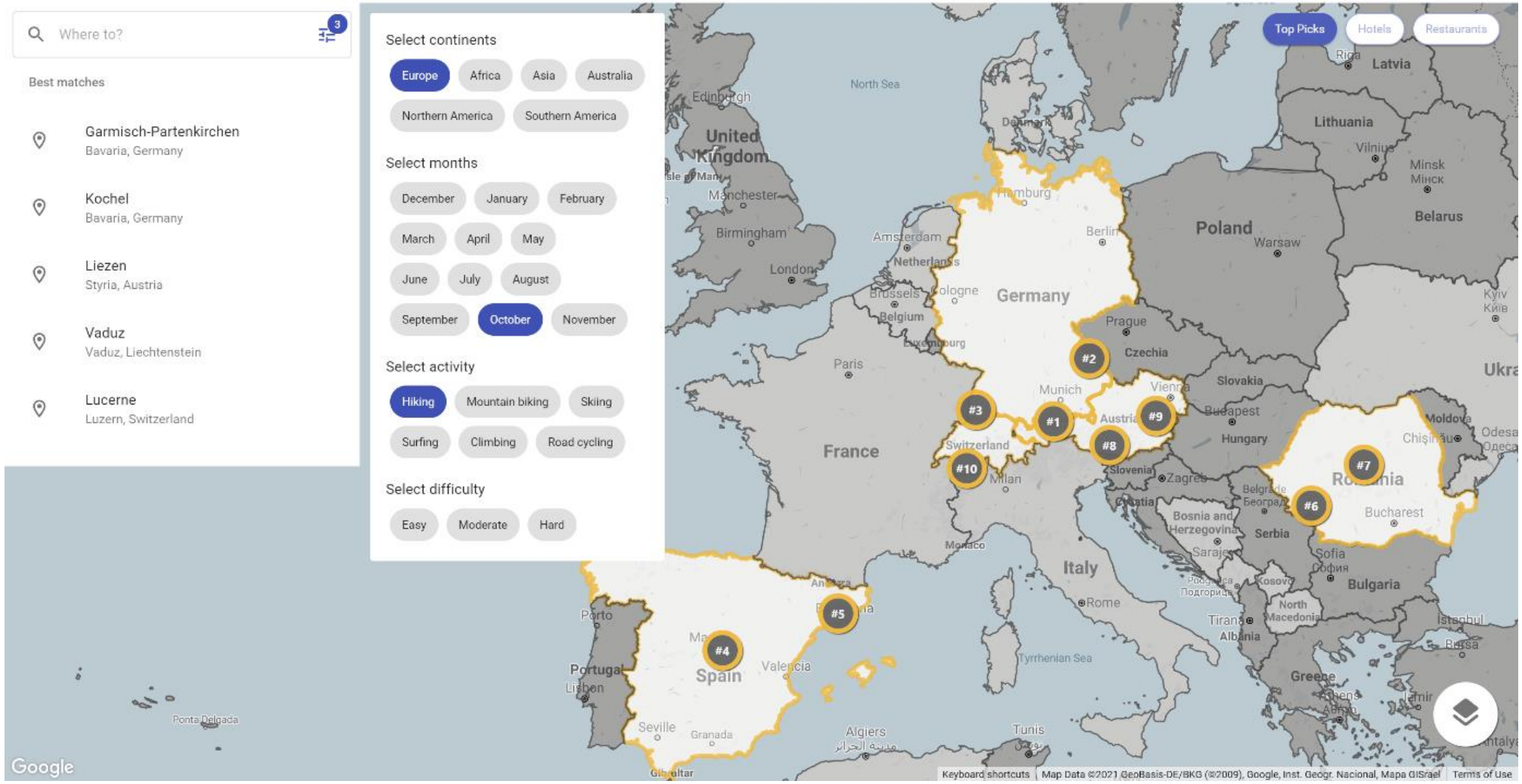
(1) right sidebar
(2) left sidebar

Global level (zoom levels 1-6)

The system's recommendations on the global level:

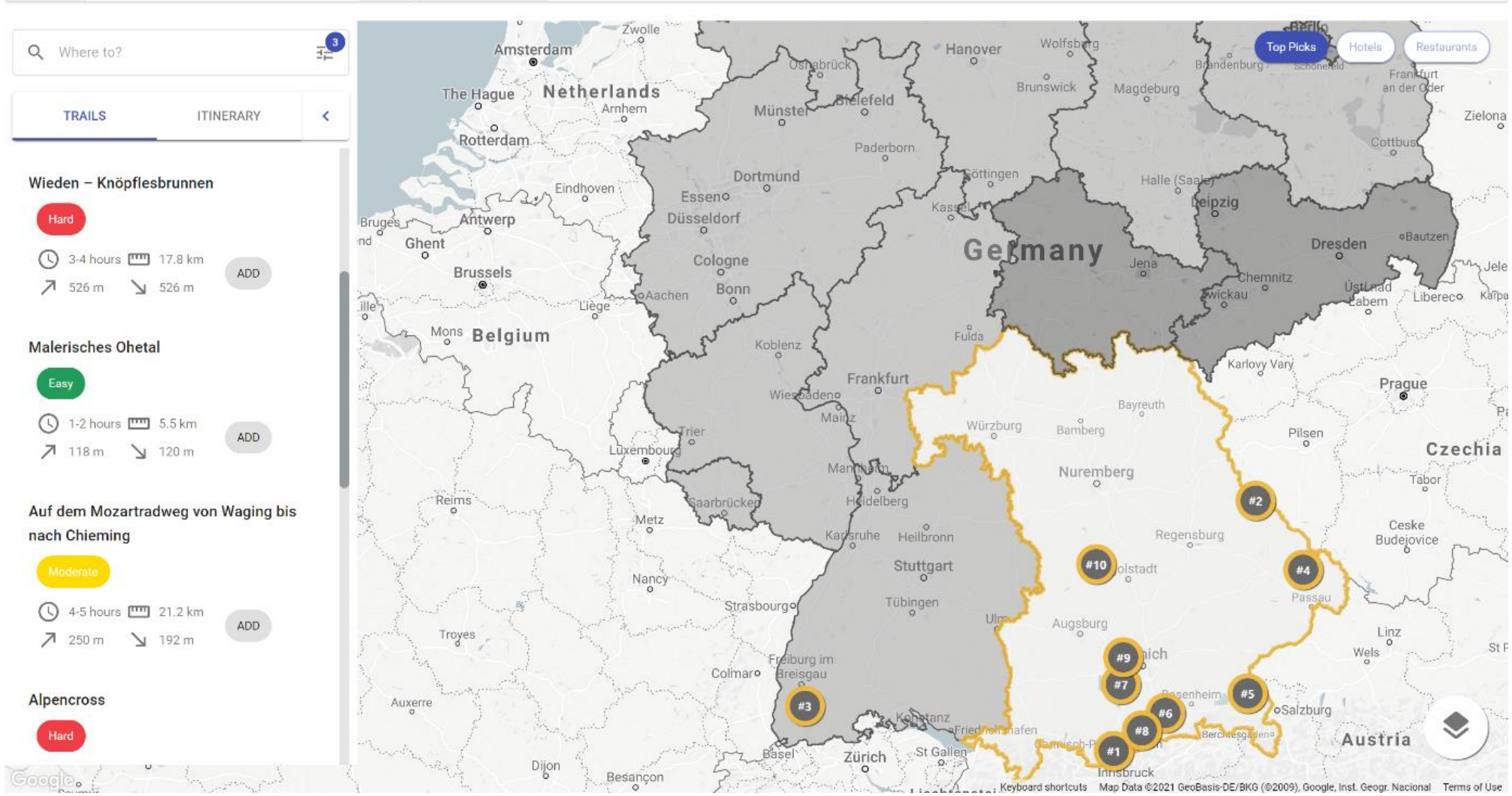


The top 10 recommended hiking trails on the global level:

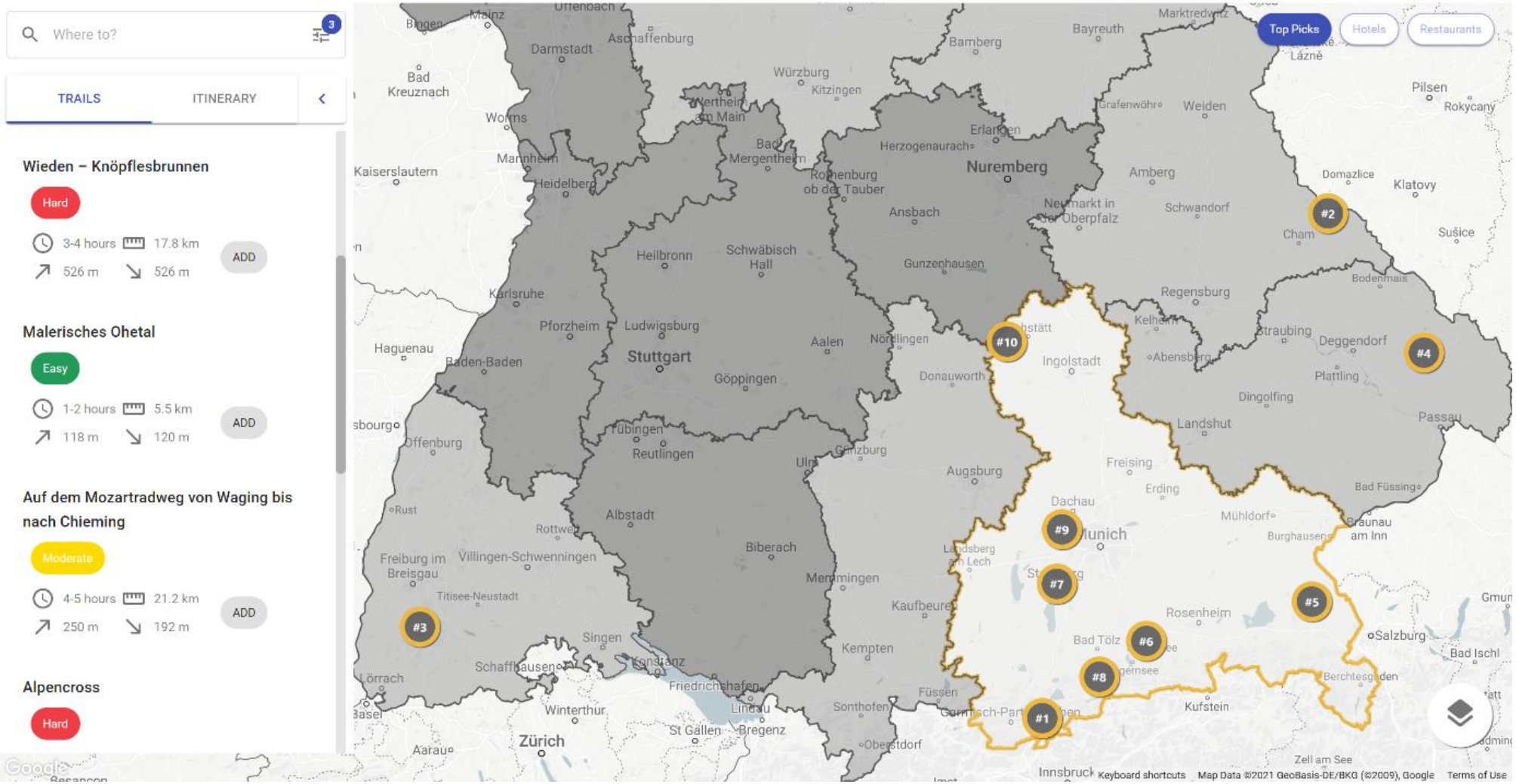


Local level (zoom levels 7-9)

The system's recommendations by regions on the local level:

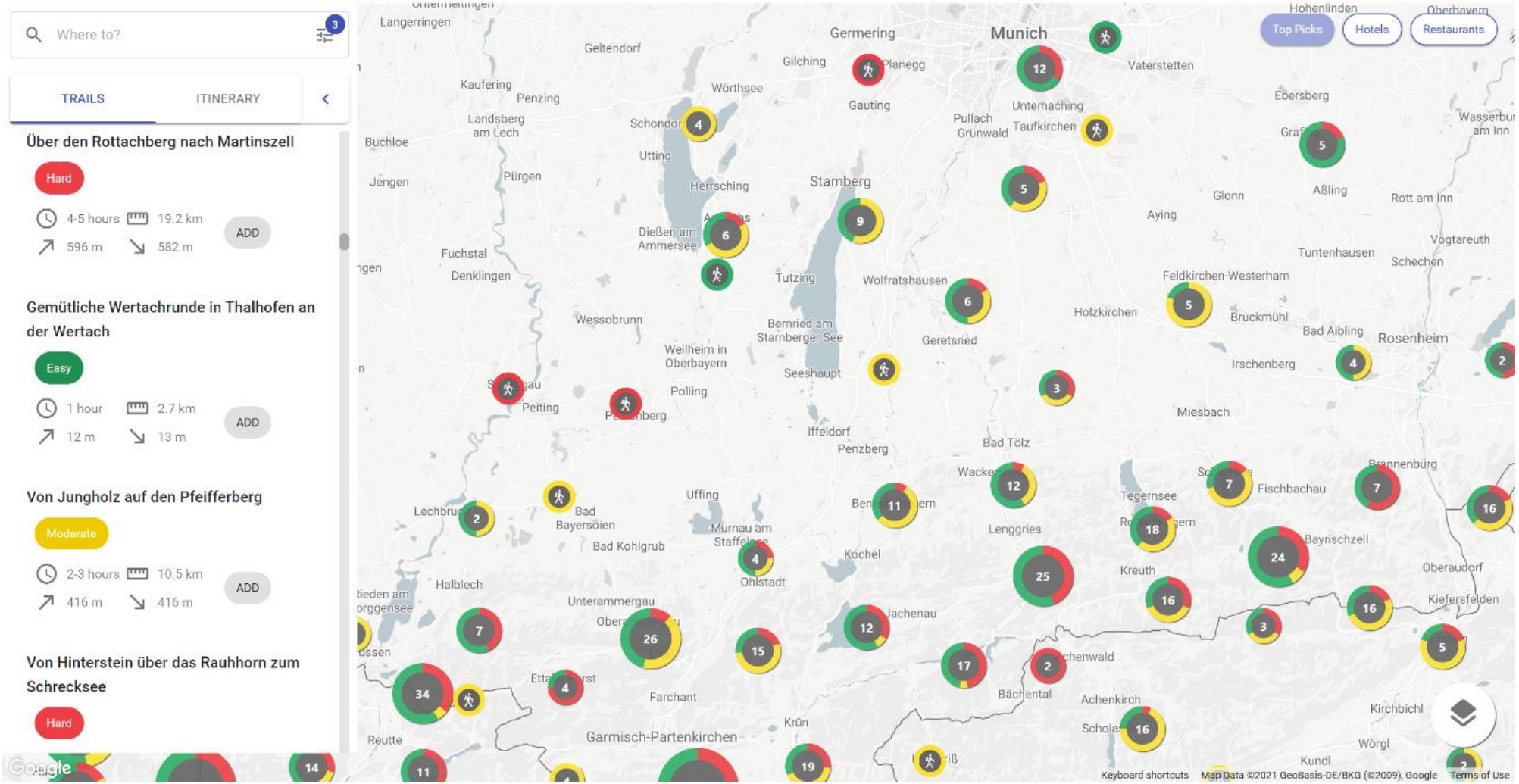


The system’s recommendations by subregions on the local level:

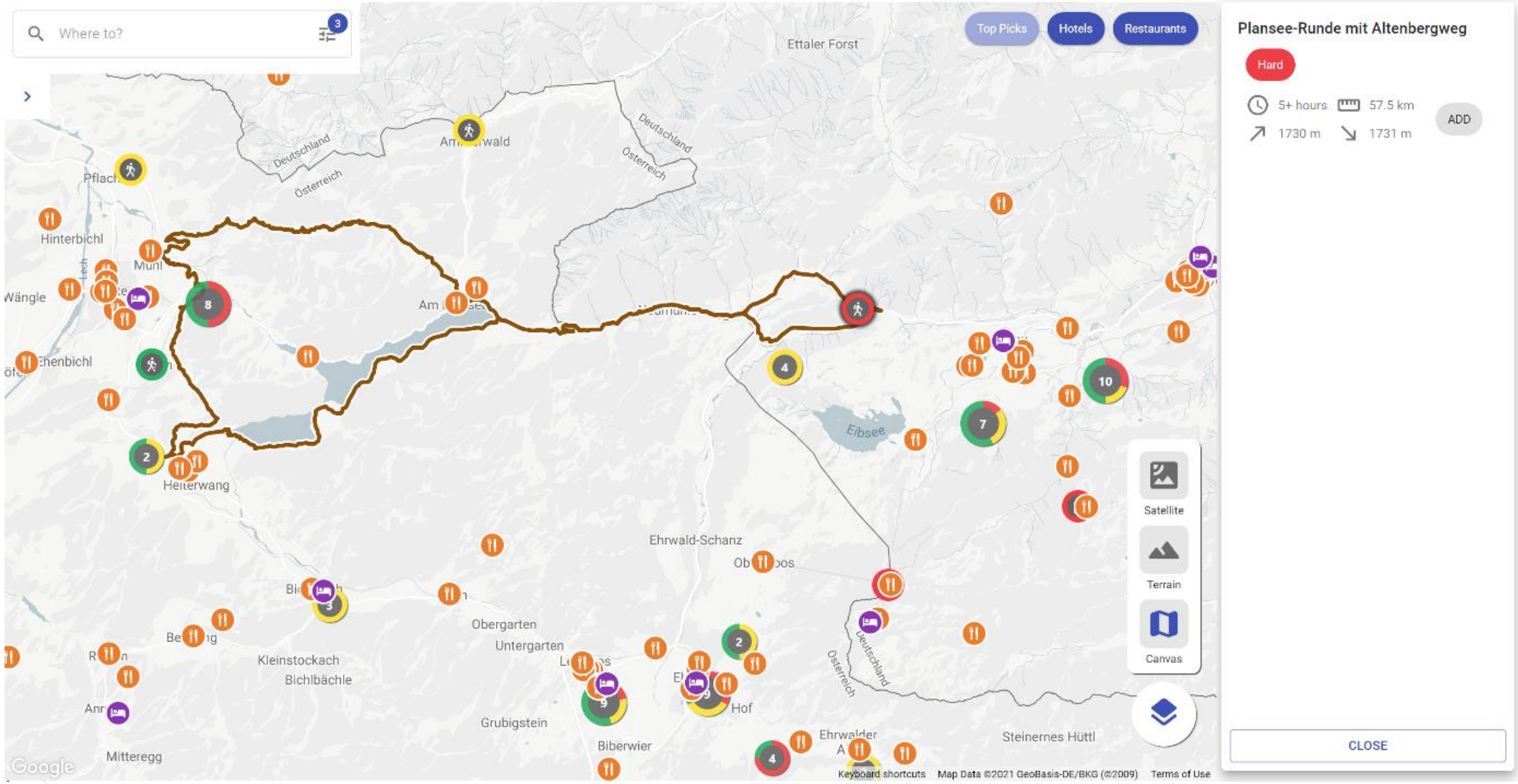


Spot level (zoom levels 10+)

The system's recommendations on the spot level:

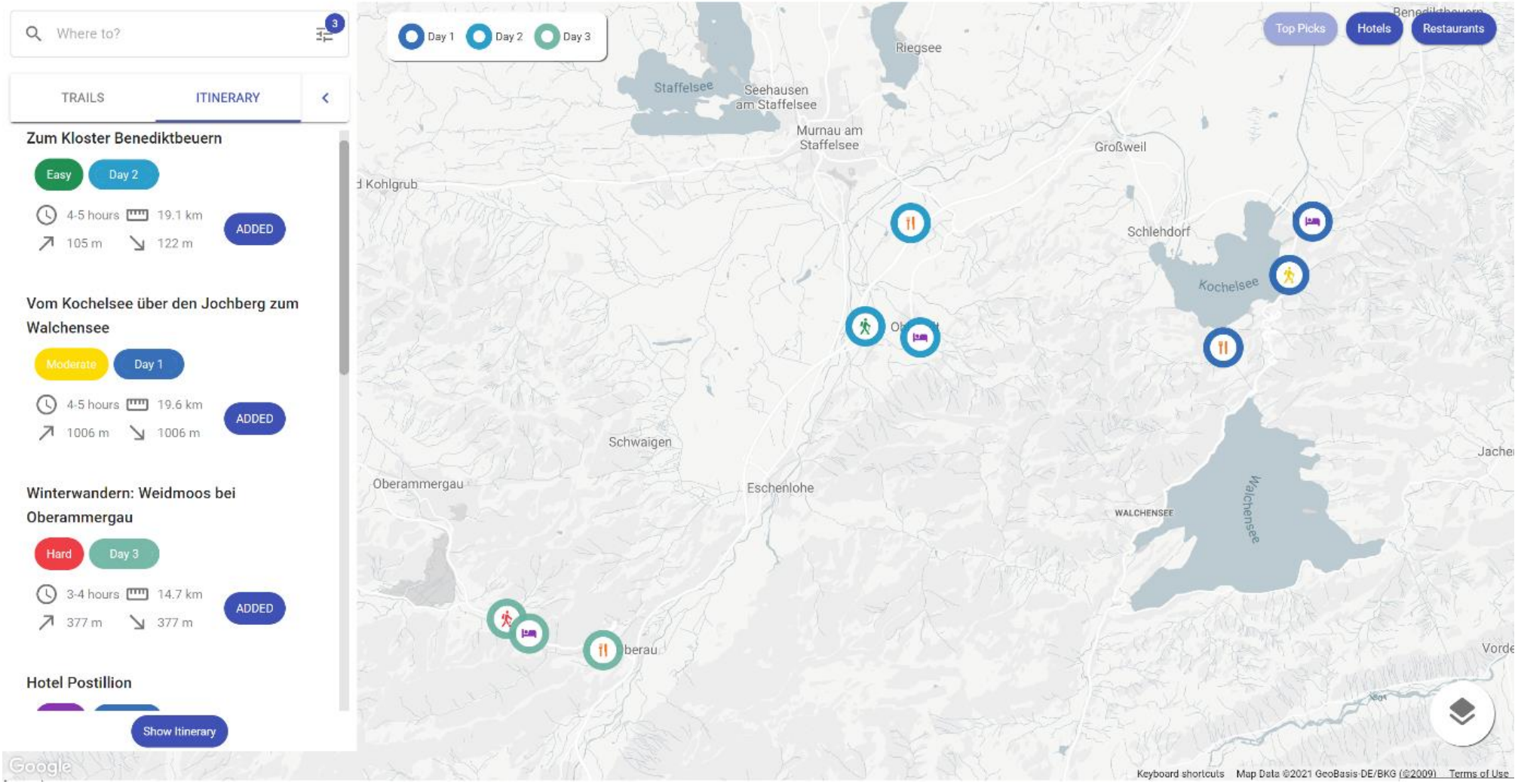


The user's selection of a hiking trail on a spot level:



Itinerary

Visualization of itinerary:



Prototype Evaluation

- Online questionnaire based on static screenshots of the prototype.
- Quantitative questions in the form of multiple-choice, single select matrix, rank order, and Likert scale questions.
- Qualitative questions in the form of comment box open-ended questions: *"Please briefly explain your associations"*.
- Participants were asked to imagine themselves in the role of one of the two user personas.

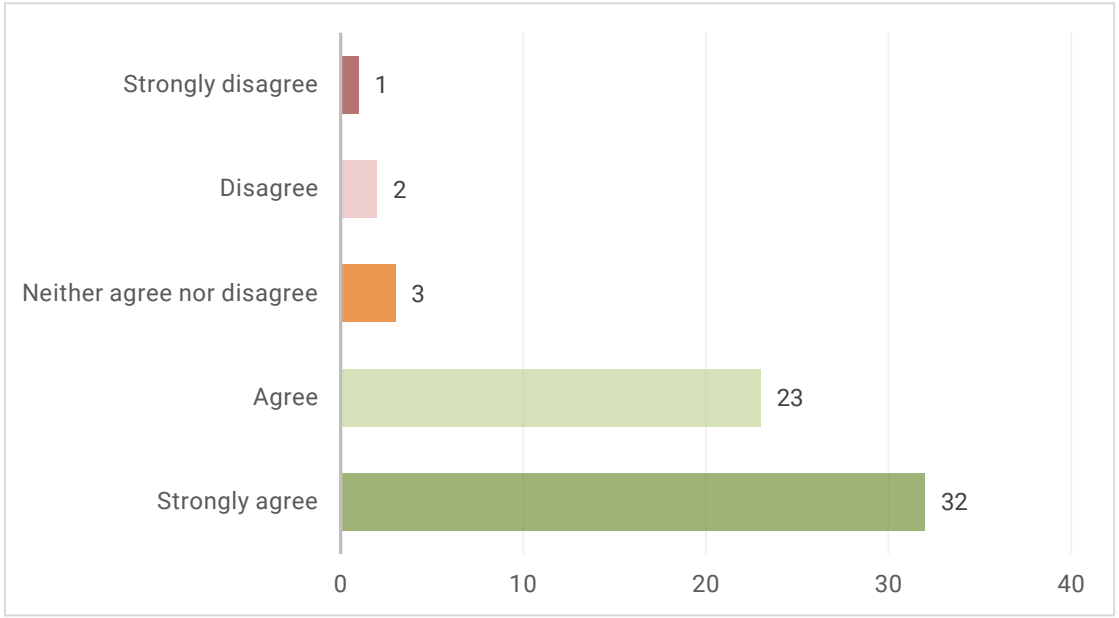
Structure of the Survey

Introduction and Consent
Explaining the purpose of the survey and providing information related to data protection and consent.
1. Participants Overview
Knowing the gender, the age of participants, the experience of trips related to outdoor activities, and the experience of web mapping applications.
2. System's Recommendations
Gaining an understanding of the proposed design of the system's recommendations on the global, local, and spot levels.
3. Responses to Itinerary
Gaining an understanding of the proposed design of the trip itinerary.
4. Responses to Basemaps
Participants were asked to rank the proposed basemaps against each other.
5. Summary
Gaining an understanding of the overall impression of the web app prototype.

Discussion of Results

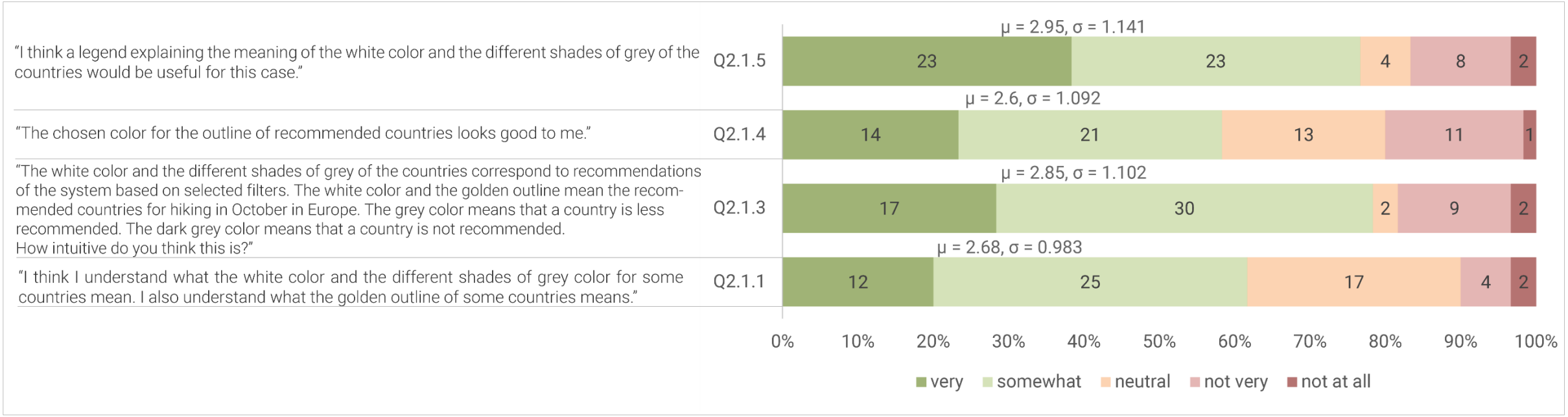
Overview of Participants

- 60 participants, of whom 53 completed the entire questionnaire.
- 32 identified as female, 28 as male.
- 18-29 was the dominant age group of participants.
- 56 participants had ever conducted hiking trips.
- Participants use most often Google Maps among other applications for planning the trips.
- Most of the participants considered themselves as confident or very confident users of web mapping applications.

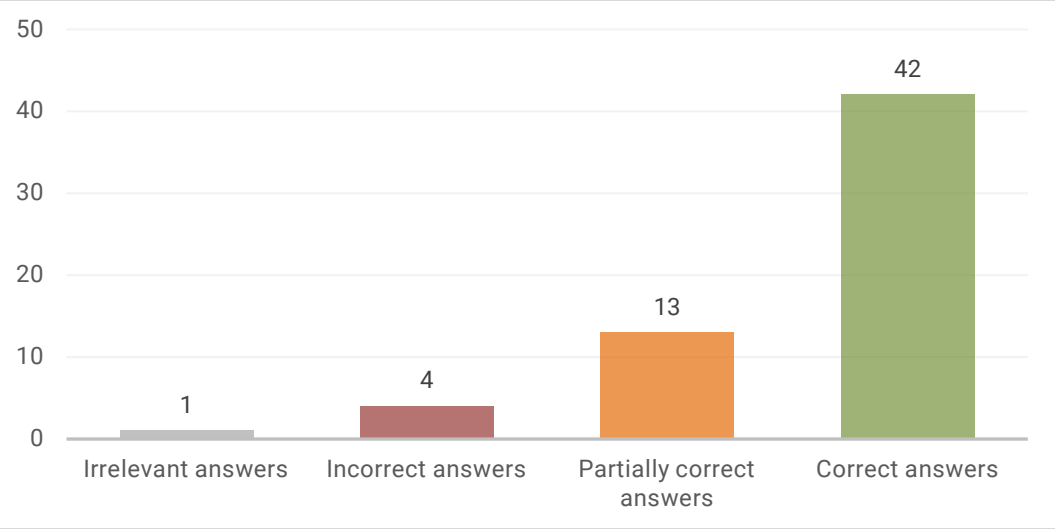


Distribution of answers for the question:
"I think I am a confident user of web mapping applications".

System's Recommendations on Global Level



Distribution of answers for Q2.1.1, Q2.1.3 – Q2.1.5.



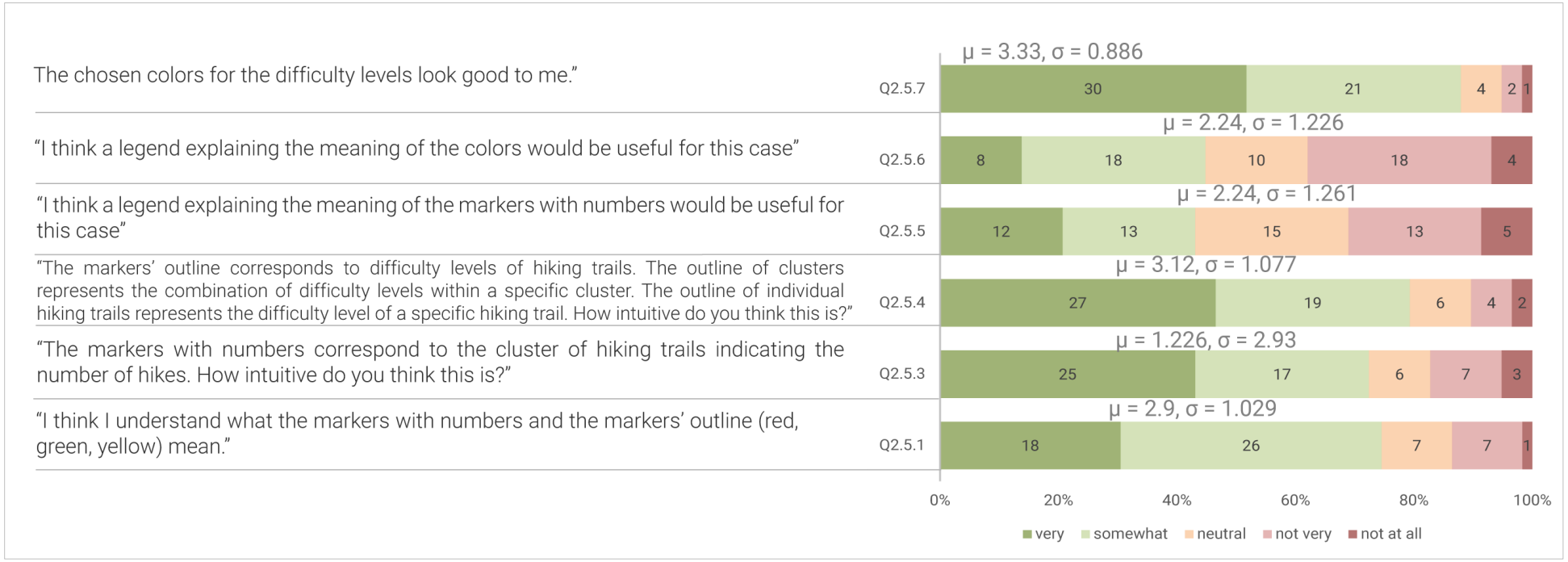
Q2.1.2: Please briefly explain your associations

"It's obvious the white and outlined are the main suggestions that meet all the criteria. Not entirely sure what the grey means, perhaps light grey is ideal for some of the criteria but not all or not the best, and dark grey is not recommended at all for such a trip."

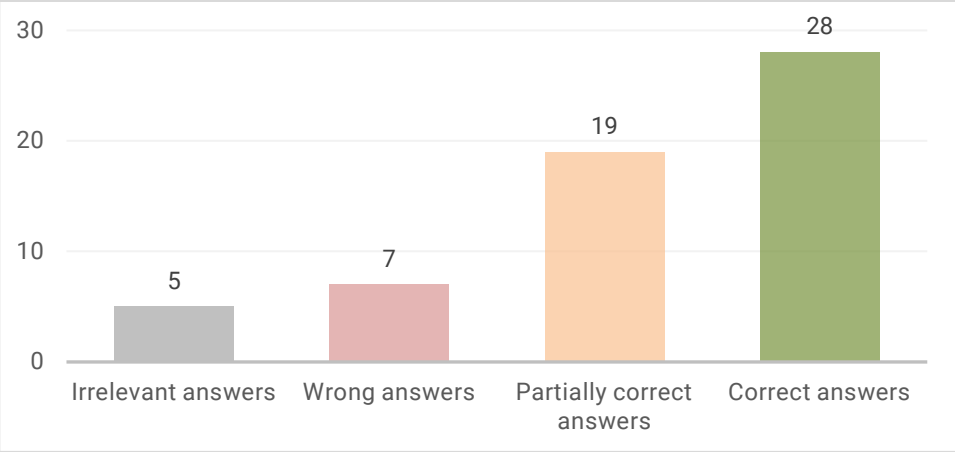
"White areas show the countries that match the filter. Golden outline limit of those countries. Don't know what the grey shades are for."

"The white color representation for the country may be is associated with how safe and unsafe the countries are for hiking during that season. I do not understand the usage of golden outline."

System’s Recommendations on Spot Level



Distribution of answers for Q2.5.1, Q2.5.3 – Q2.5.7.



Q2.5.2: Please briefly explain your associations

"The three colours represent the difficulty of the hikes. The number within the pie charts represents the number of possible hikes in the region and the color represents the percentage of hikes within a certain difficulty."

"I understand that the colors means the level of difficulty, however I do not know what the numbers are representing."

"I think numbers might be kilometers and colors representing the difficulty of different stages of trails."

In the comment field of the question Q3.5:

- *“I can distinguish the colours, but this might not be the case for people with impaired colour reception! Overall the colours are too close to each other”.*

- *“The hue is not differentiated enough, day 2 and 3 are not easily differentiated on the map. Also I wonder how this hue would work with more than 5 days”.*

- *“I think the itinerary map is missing the visualization of the hiking trail itself”.*

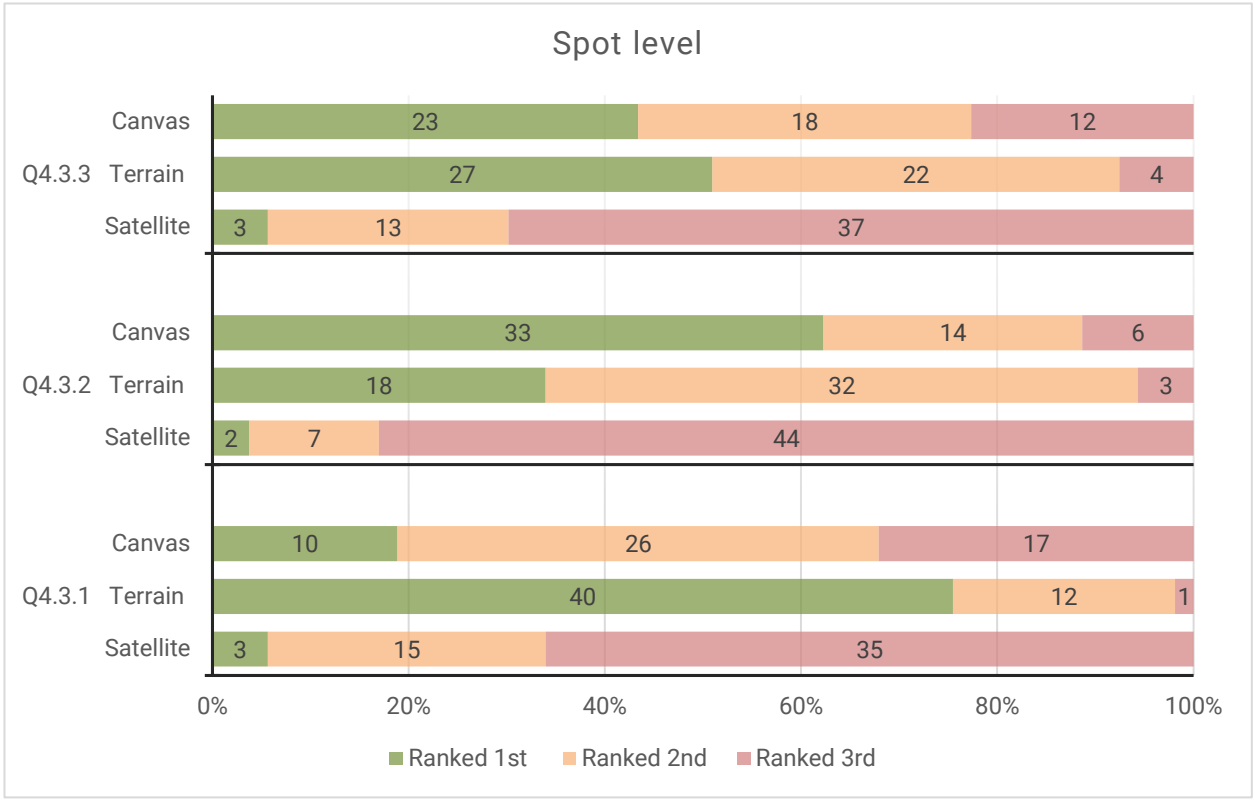
- *“Maybe it could be an option to let people select their own colour per day”.*

Responses to Basemaps on Spot Level

Q4.3.1 Please rank the basemaps based on the look and feel, with 1 being the best.

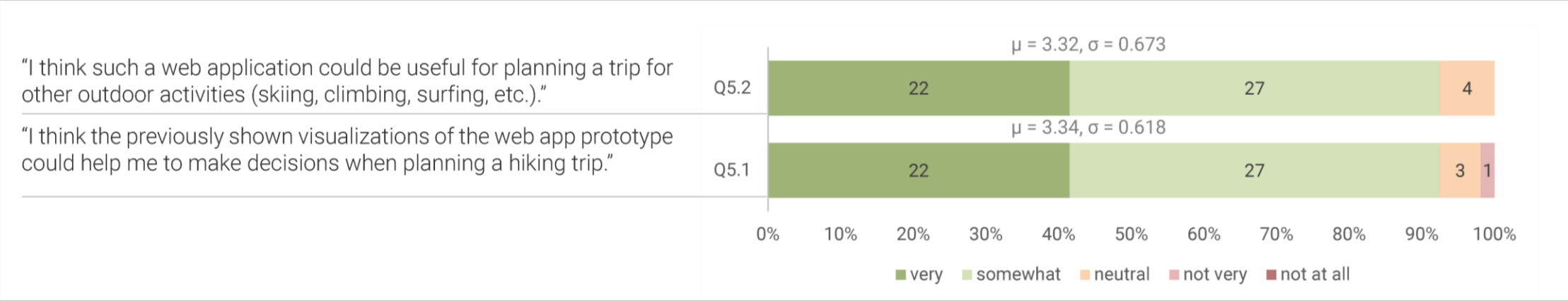
Q4.3.2 Please rank the basemaps based on how the markers look on top of the basemaps, with 1 being the best.

Q4.3.3 Please, rank the basemaps based on how the hiking trail looks on the basemaps, with 1 being the best.



Distribution of answers for Q4.3.1 – Q4.3.3.

Summary Section



Distribution of answers for Q5.1 and Q5.2.

Conclusion

Global Level

RQ II-c) *What decision-relevant information should be visualized in different zoom levels?*
RQ II-d) *How should the map elements be designed to support the traveller best?*

What was visualized and how:

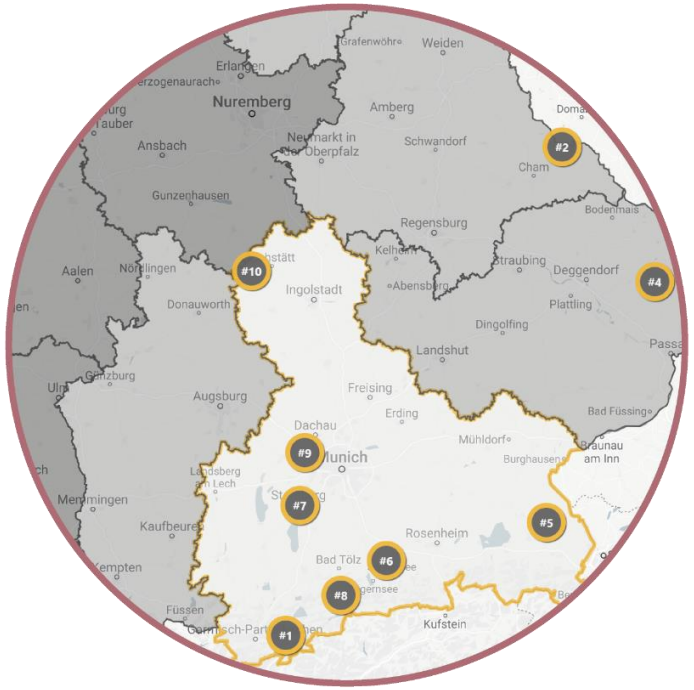
What participants preferred to be visualized:

- Legend explaining the system's recommendations would be useful.
- No consensus opinion if a legend explaining top 10 was needed.
- Terrain basemap is the best choice in terms of overall feel and look.
- Canvas is best in terms of how markers and clusters look.

Local Level

RQ II-c) *What decision-relevant information should be visualized in different zoom levels?*
RQ II-d) *How should the map elements be designed to support the traveller best?*

What was visualized and how:



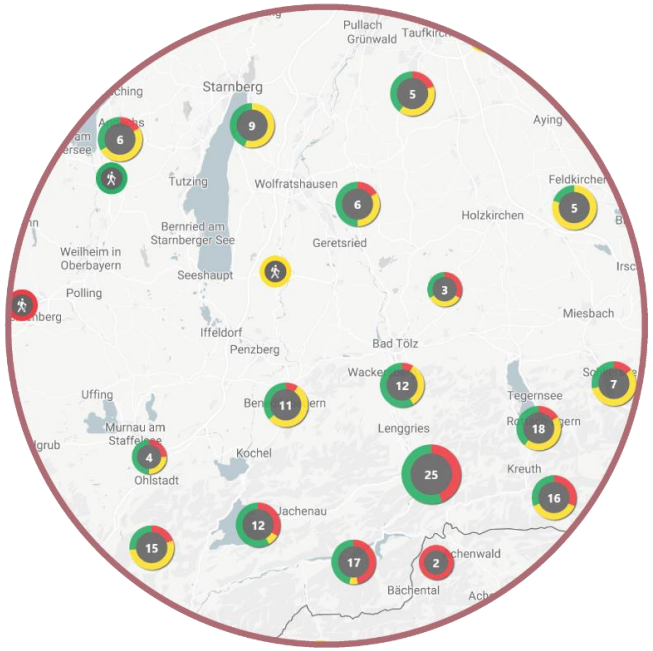
What participants preferred to be visualized:

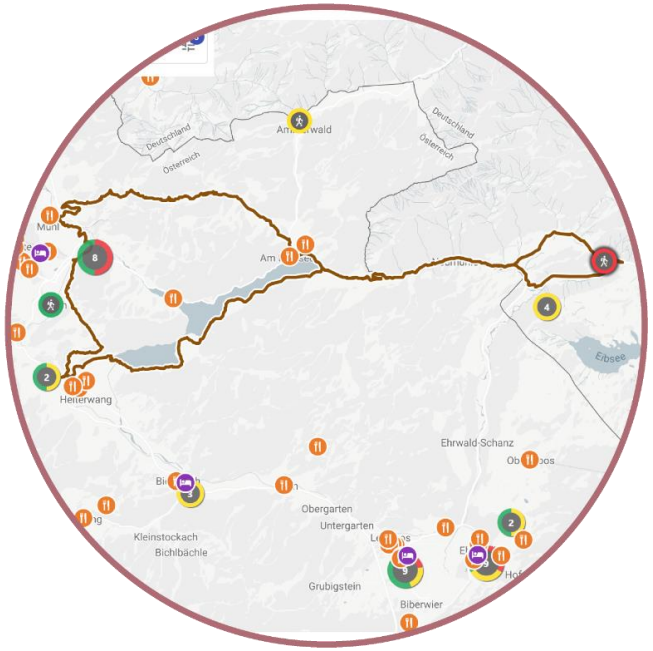
- Legend explaining the system's recommendations would be useful.
- Geographical areas instead of administrative units.
- No consensus opinion if a legend explaining top 10 was needed.
- Terrain basemap is the best choice in terms of overall feel and look.
- Canvas is best in terms of how markers and clusters look.

Spot Level

RQ II-c) *What decision-relevant information should be visualized in different zoom levels?*
RQ II-d) *How should the map elements be designed to support the traveller best?*

What was visualized and how:





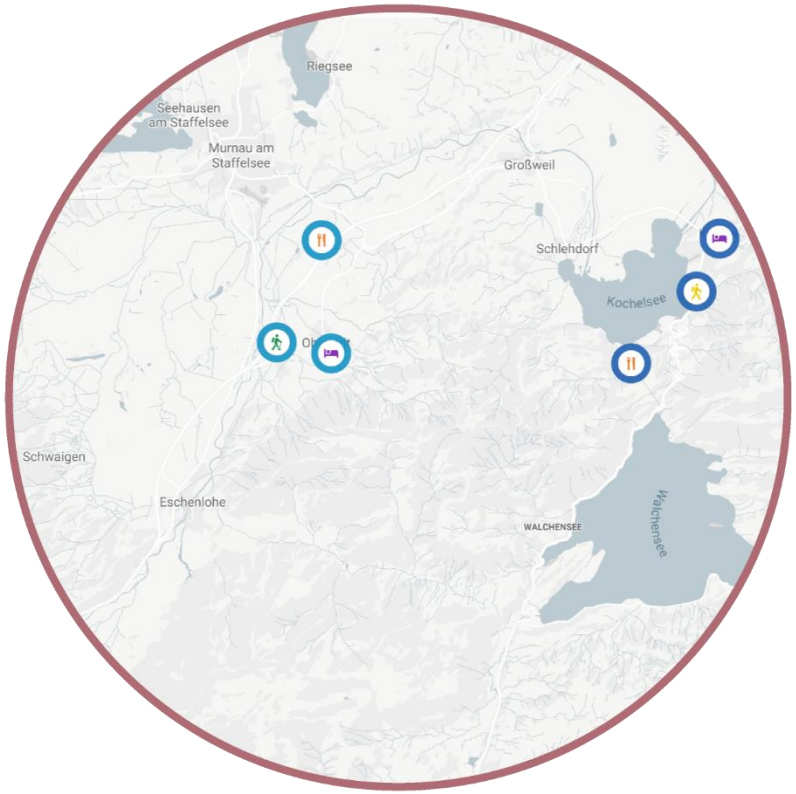
What participants preferred to be visualized:

- Another color scheme: red, blue, green or red, blue, black.
- Markers of individual hikes in the foreground.
- Coloring the path of a hiking trail according to its difficulty level.
- Terrain is the best choice in terms of overall feel and look.
- Canvas is best in terms of how markers and clusters look.

Itinerary

RQ II-c) *What decision-relevant information should be visualized in different zoom levels?*
RQ II-d) *How should the map elements be designed to support the traveller best?*

What was visualized and how:



What participants preferred to be visualized:

- Another color scheme with more distinguishable colors.
- Visualization of a hiking trail's path.
- Legend was considered useful.

Future Work

Global level

- Adding a legend or choosing another more intuitive color scheme to visualize less and not recommended countries or regions on global and local levels.
- Considering redesigning the button “Top Picks” and/or the icons of markers or adding the legend to the interface explaining the top 10 options.

Local level

- Representing the systems’ recommendations based on geographical areas.

Spot level

- Showing the markers of individual hikes in the foreground.
- Coloring the path of a hiking trail according to its difficulty level.
- Proposing an additional color scheme for color blinded users.
- When a user hovers over a cluster, the icons of hiking trails appear on the screen.

Basemaps

- Adding the relief to the canvas basemap.

Itinerary

- Visualizing a hiking trail.
- Using a qualitative color scheme to visualize different days.
- Adding a feature allowing users to select a particular color for a specific day.

Thank you for your attention!