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Service-driven 3D Atlas Cartography

Master Thesis, D-BAUG, Spring Term 2012
Institute of Cartography and Geoinformation, ETH Zürich
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Outline

I. Goals

II. Motivation

III. Core concepts: *Atlas, Service-driven, 3D Geovisualization*

IV. Requirements for a service-driven 3D atlas

V. Implementation

- Demo
- Architecture
- Strengths & Weaknesses

VI. Conclusions & Outlook

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Goals

- To explore the literature and existing 3D (web) atlases to define the requirements for service-driven 3D atlases
- To explore available solutions and technologies for service-driven 3D atlases
- To implement a prototype to assess strengths and weaknesses of these solutions for 3D atlases and thus make recommendations

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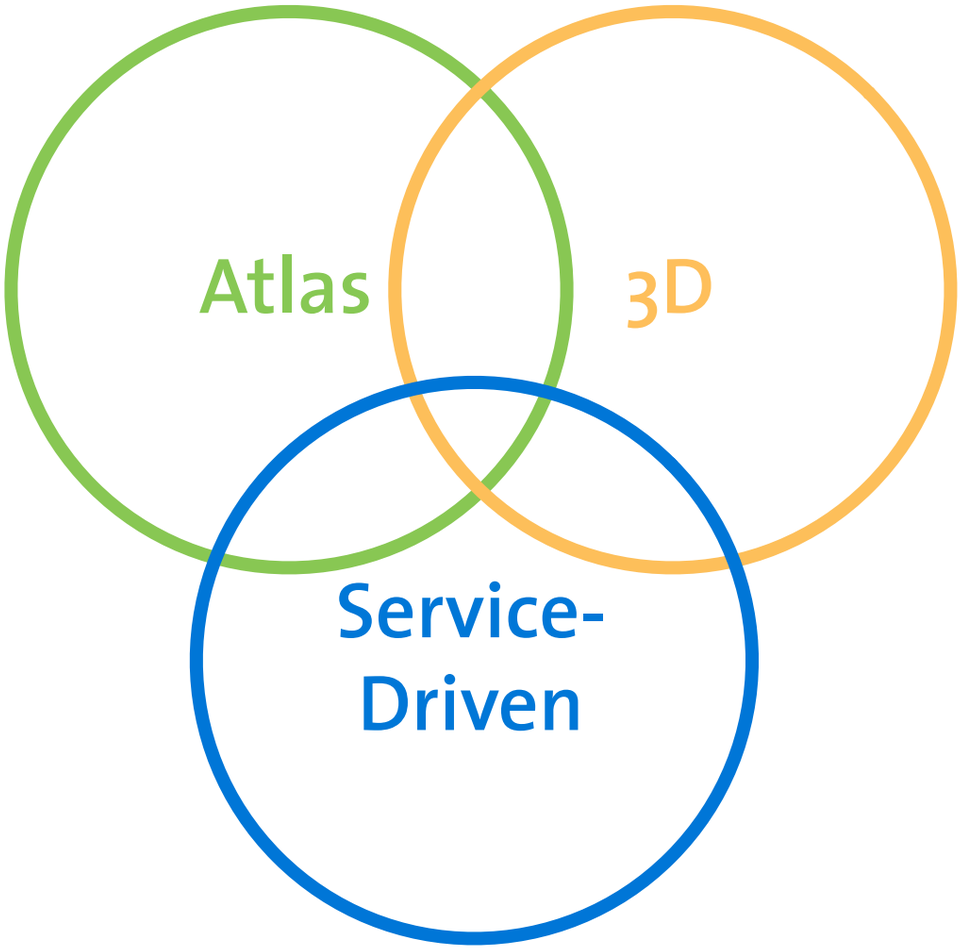
Motivation

- 3D is everywhere
- Advantages of service-oriented architecture
  - Access from thin-client
  - Gain in editing and updating processes of spatial data
- Benefits for modern atlases
- To test available solutions for service-driven 3D atlas



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Atlas

- Definition
  - Mercator's cosmography (end 17th)
  - a collection of single maps systematically organized and picturing the whole earth (18th)
  - collection of maps with a specific purpose and organized in the form of a book, which usually includes tables, graphs and text* (20th)
- Emergence of digital atlases
  - remaining core concepts: narrative faculty and intentional combination, not necessarily of maps, but of processed spatial data *

*(Ramos and Cartwright, 2006)

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Modern Atlas

- Digital vs. analog
- Interactive vs. one-way flow
- Online vs. desktop
- Multimedia vs. only maps
- Dynamic vs. static

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3D Geovisualization

- Changing spatial view point (3D navigation)
- Topographic or perspective view in 3D
  - panorama view
  - block diagram
  - virtual globe
- Thematic variables represented as z-values

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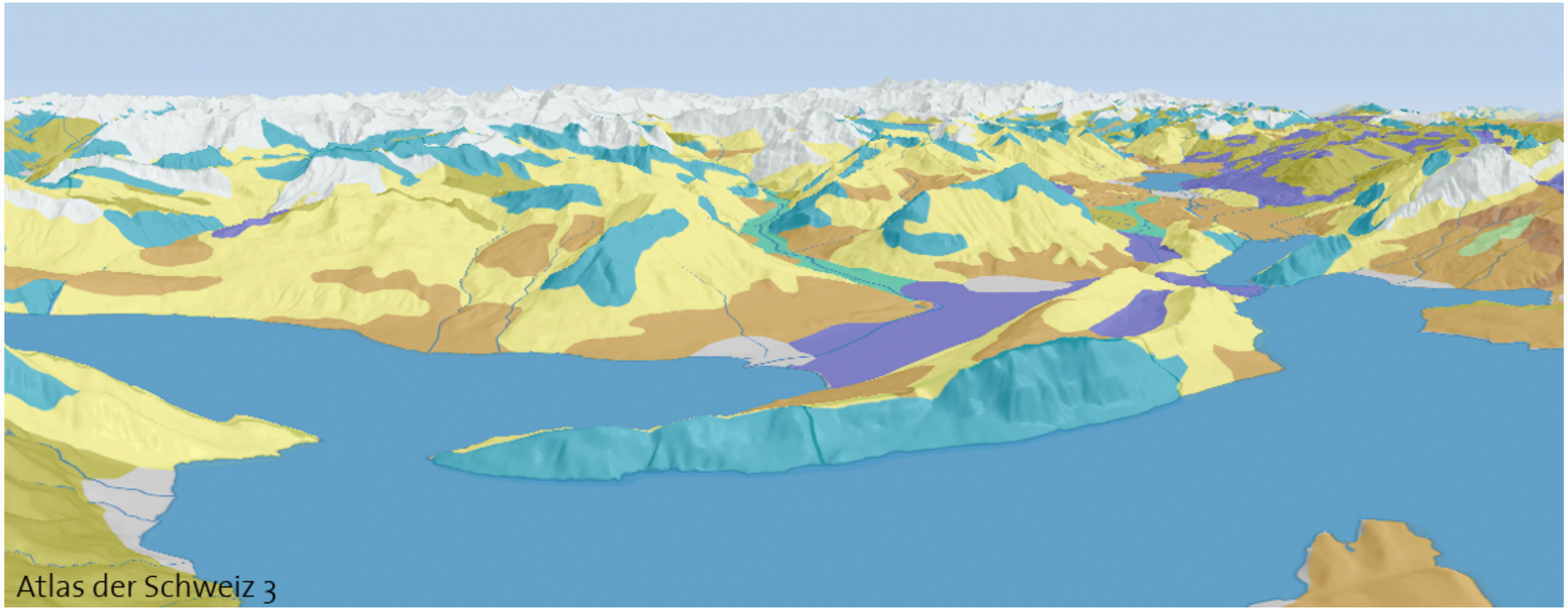
3D Geovisualization



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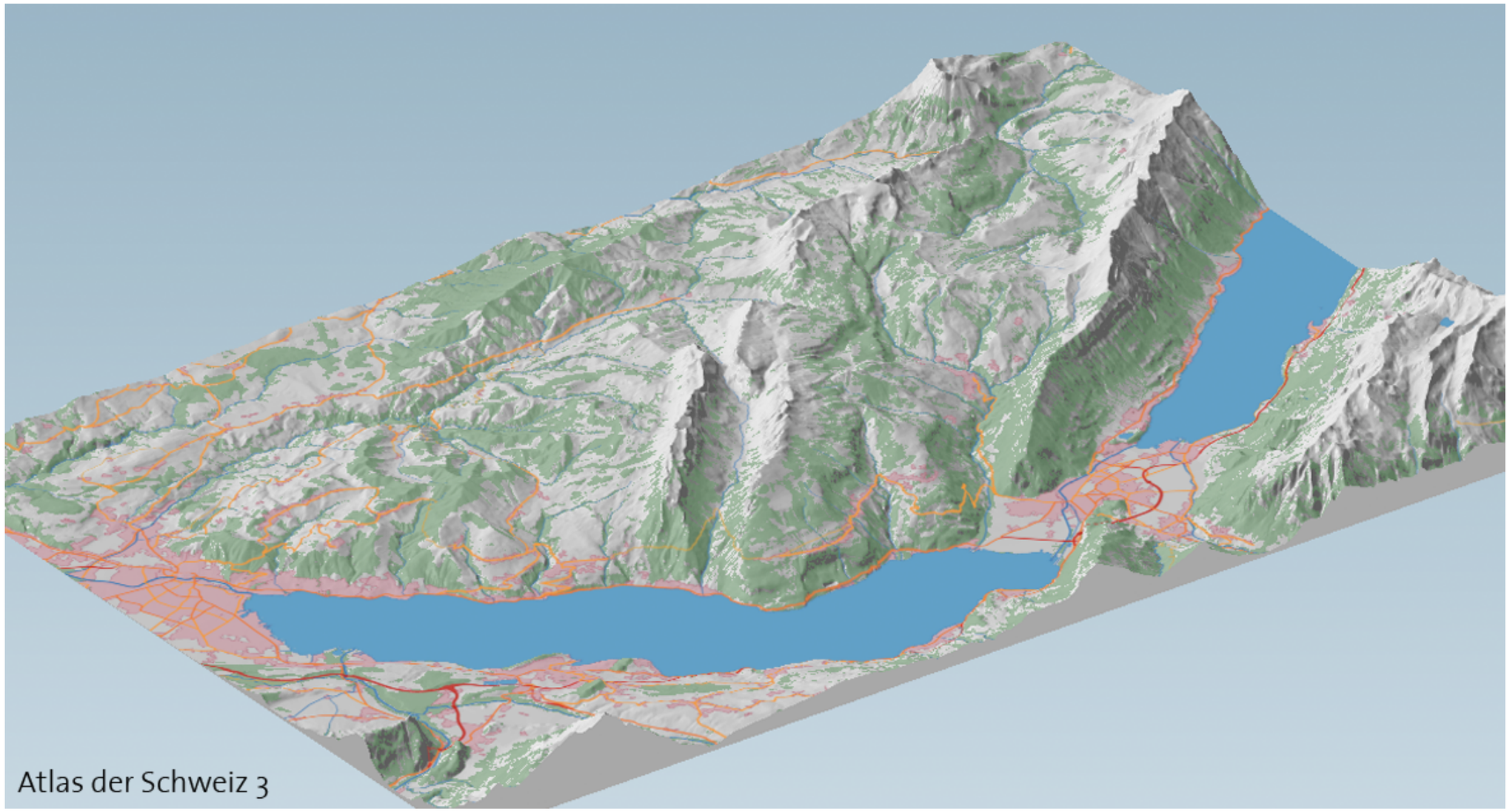
3D Geovisualization



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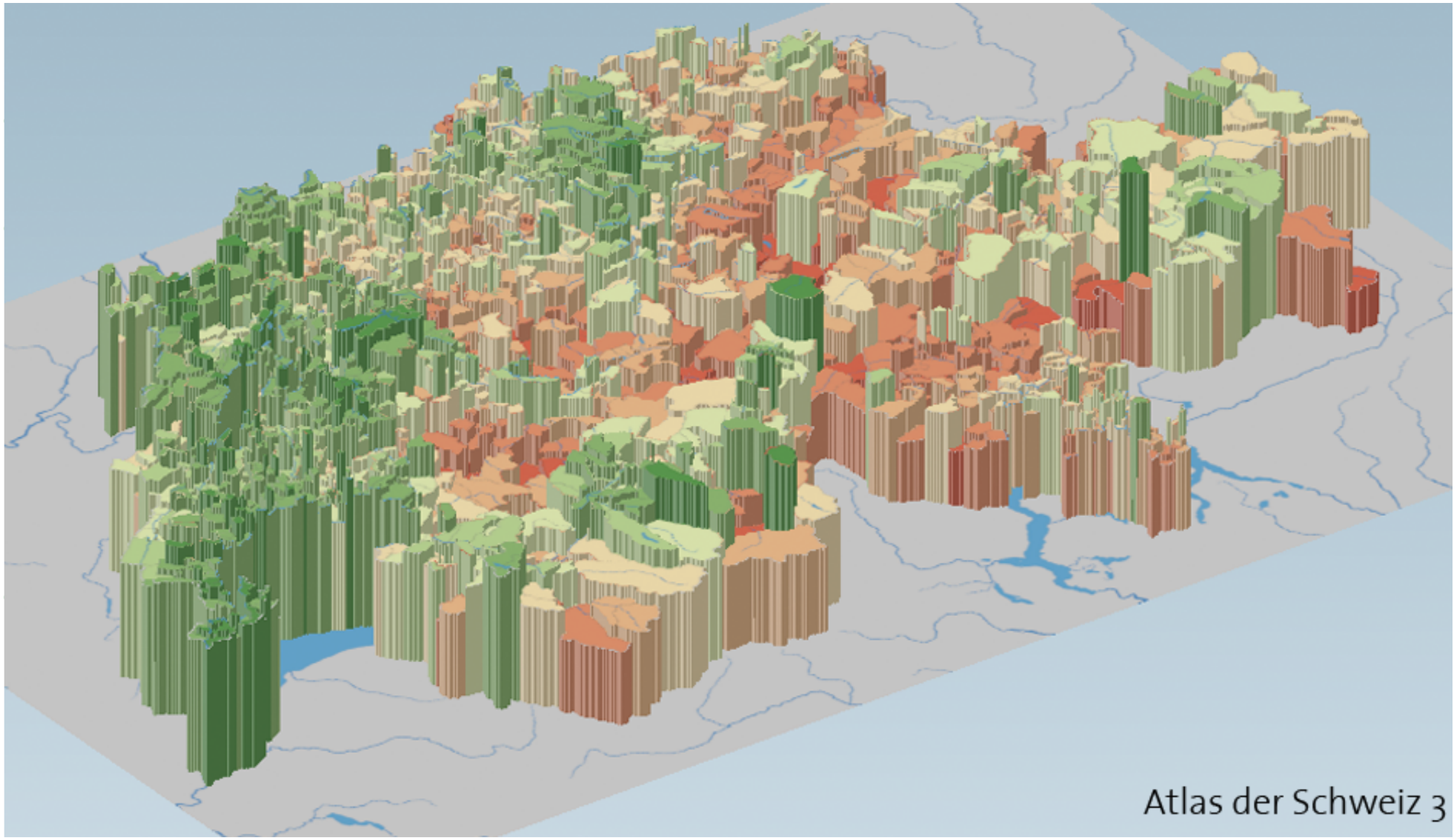
3D Geovisualization



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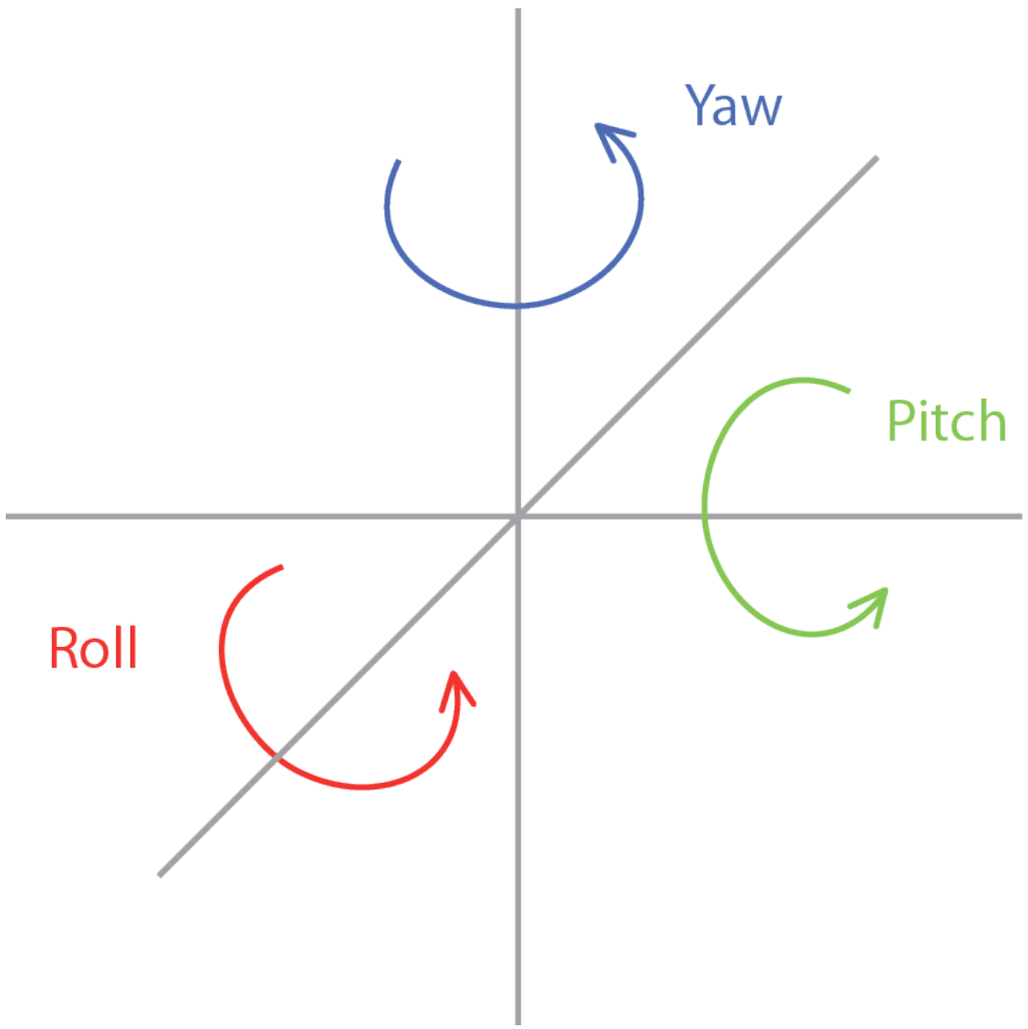
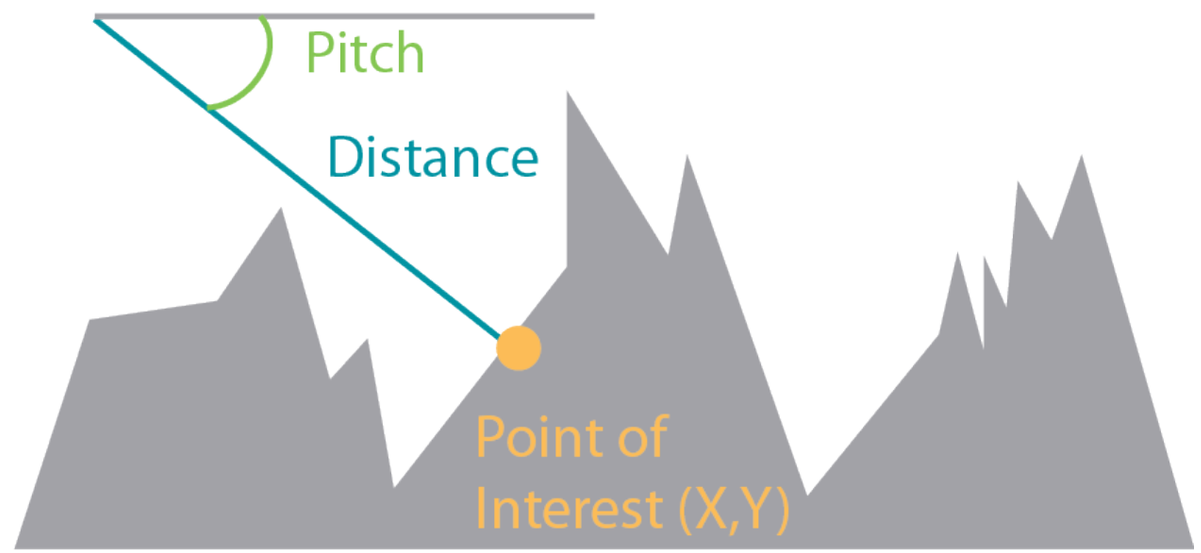
3D Geovisualization





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3D Geovisualization

- Advantages
  - naturalistic display -> more similar to the real world
  - shape understanding, orientation tasks
  - qualitative understanding and surveying of space
- Disadvantages
  - relative positioning
  - non linearly distorted

Service-oriented Architecture

- Web service concept
  - request-response between a client and a server
- Interoperability
- Platform independency
- Modularity and chaining

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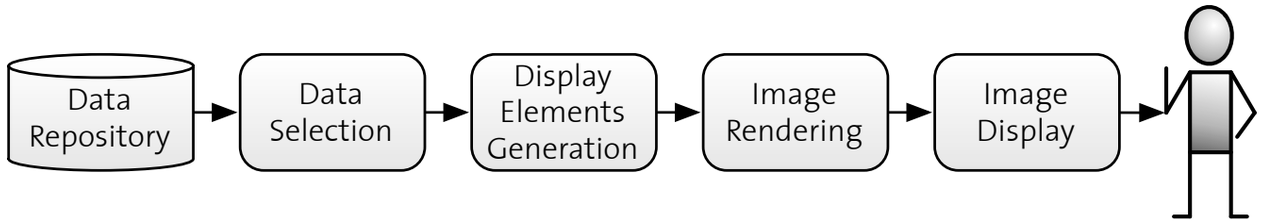
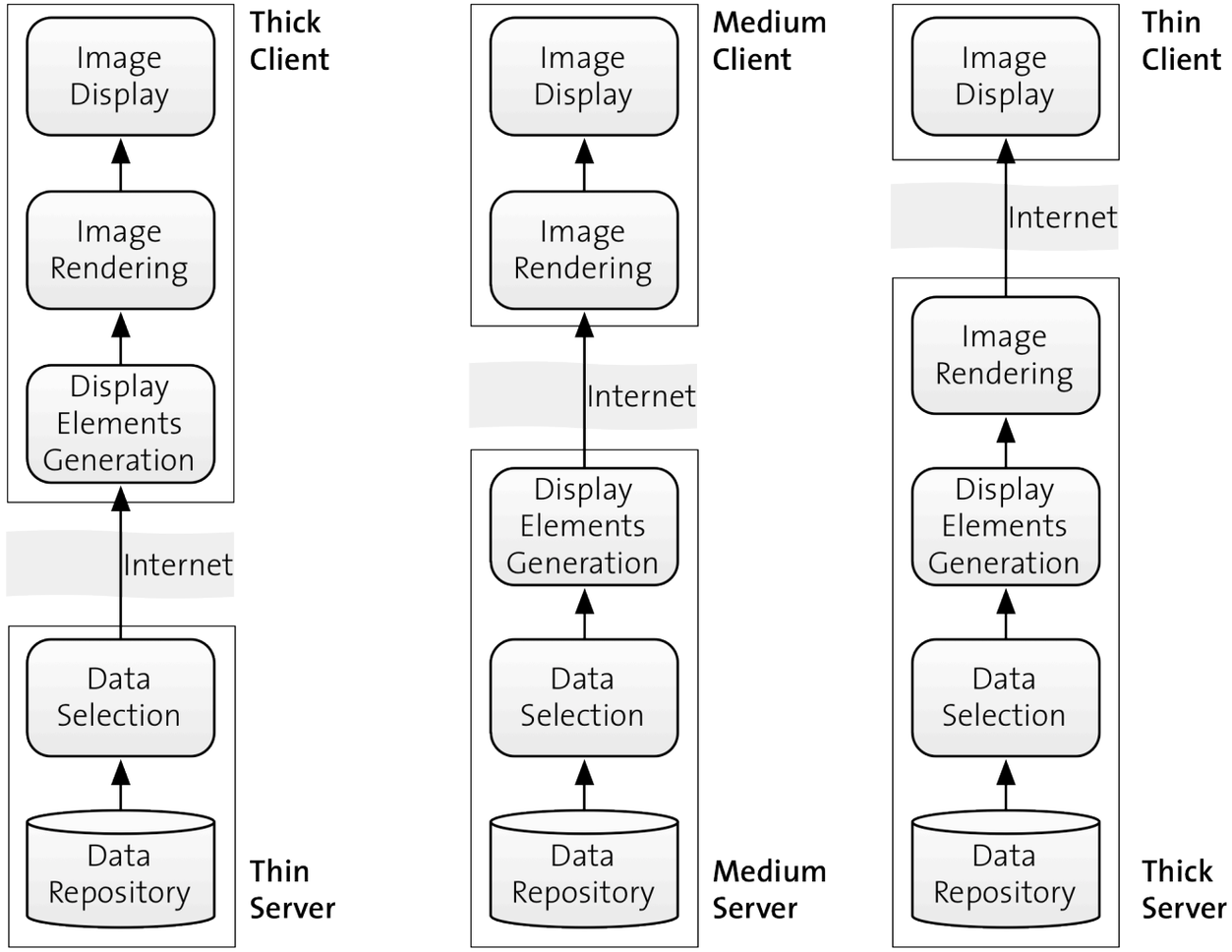
Web Service: Thin Client?

- Visualization pipeline



- Balancing schemes



Open Geospatial Consortium in (Hagedorn, 2010a; Schilling and Kolbe, 2010)

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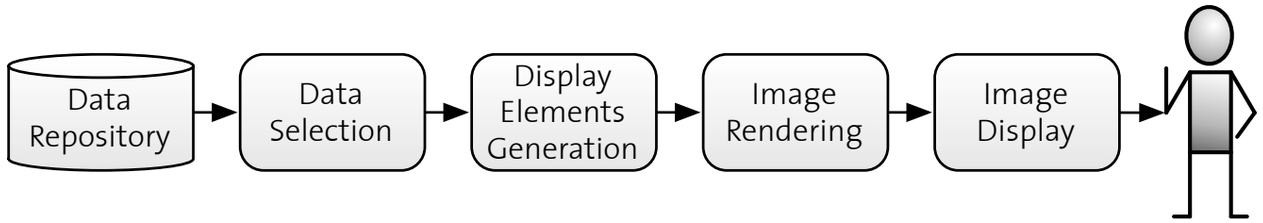
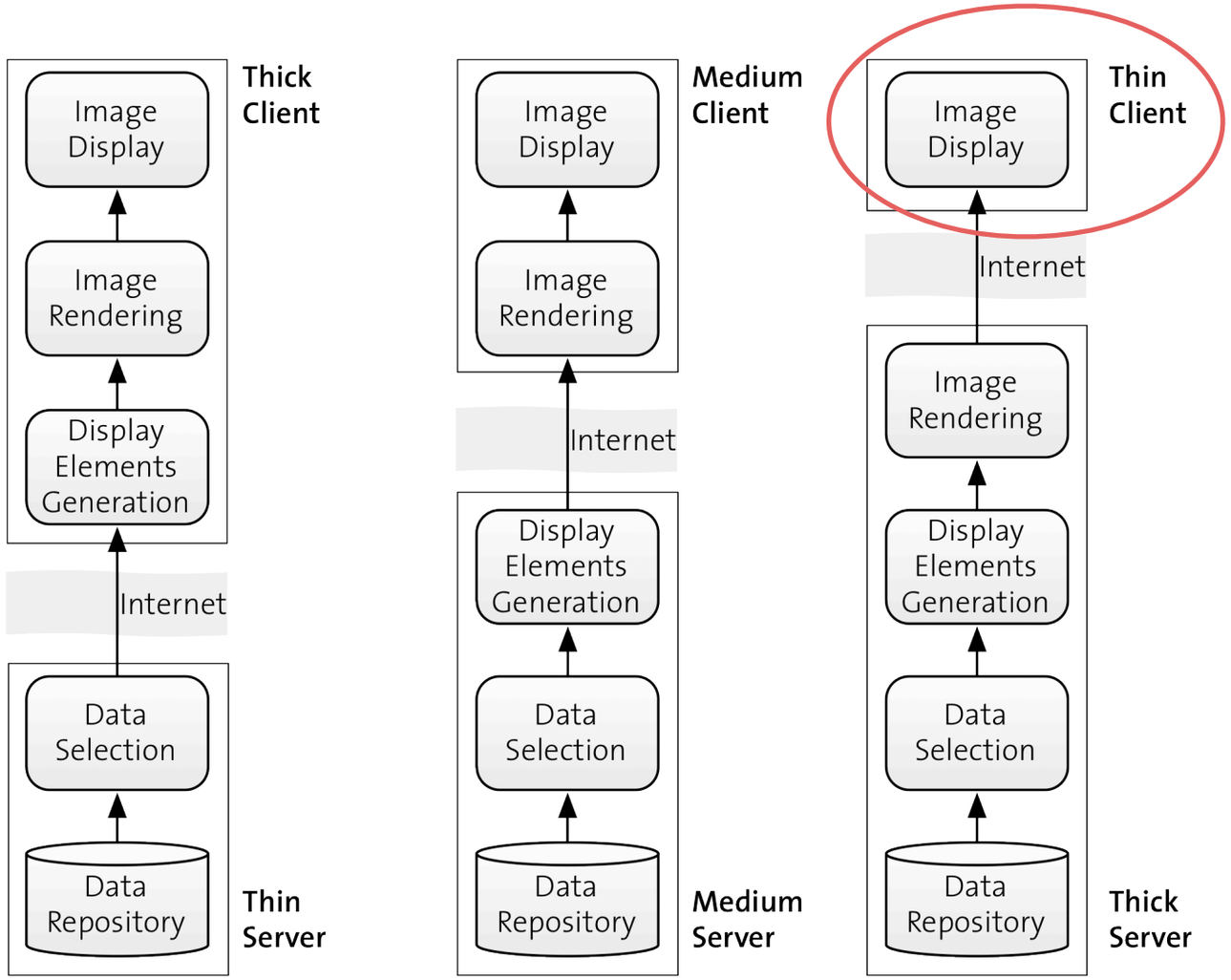
Web Service: Thin Client?

- Visualization pipeline



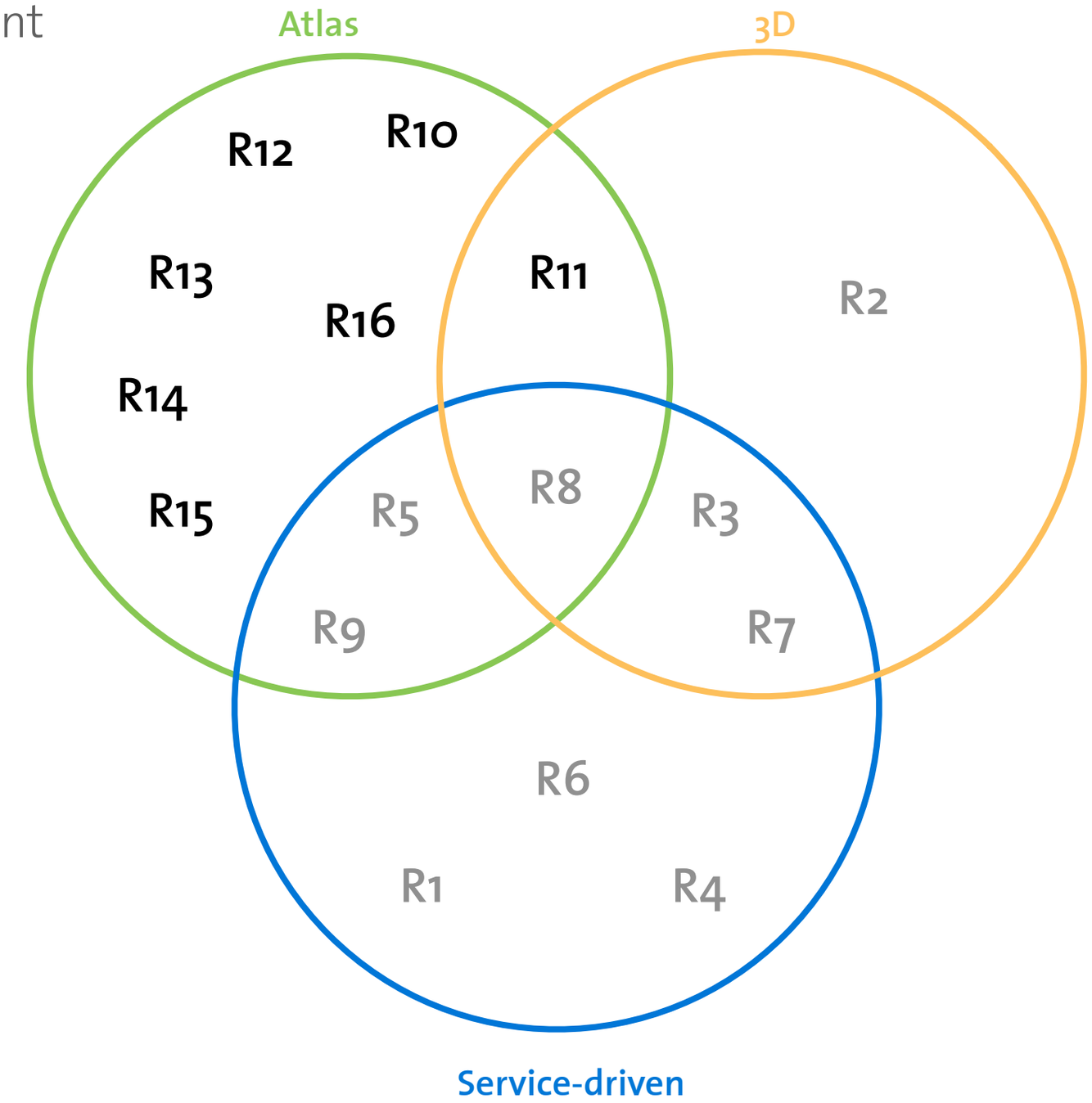
- Balancing schemes



Open Geospatial Consortium in (Hagedorn, 2010a; Schilling and Kolbe, 2010)

Requirements

1. Service-oriented architecture and thin-client
2. No plugin needed
3. Cross-platform
4. Interoperability and integration
5. Extensibility and update
6. Reusable and robust
7. Open-source
8. Support for massive amounts of geodata
9. Dynamic geodata
10. Level of abstraction
11. Effective and high quality visualization
12. User styling support
13. Coordinated and multiple views
14. High degree of interactivity
15. Intuitive navigation
16. Data query and processing



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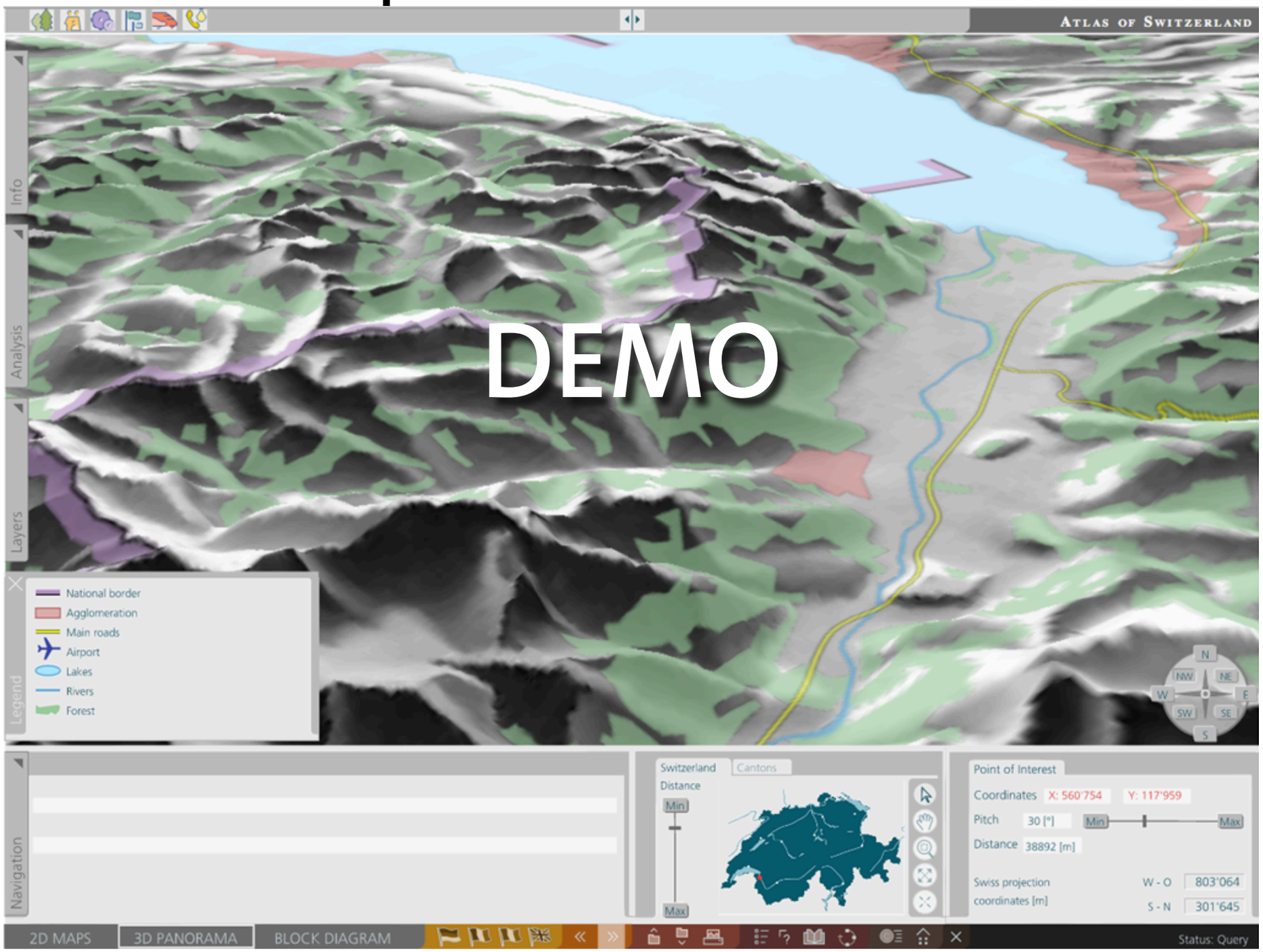
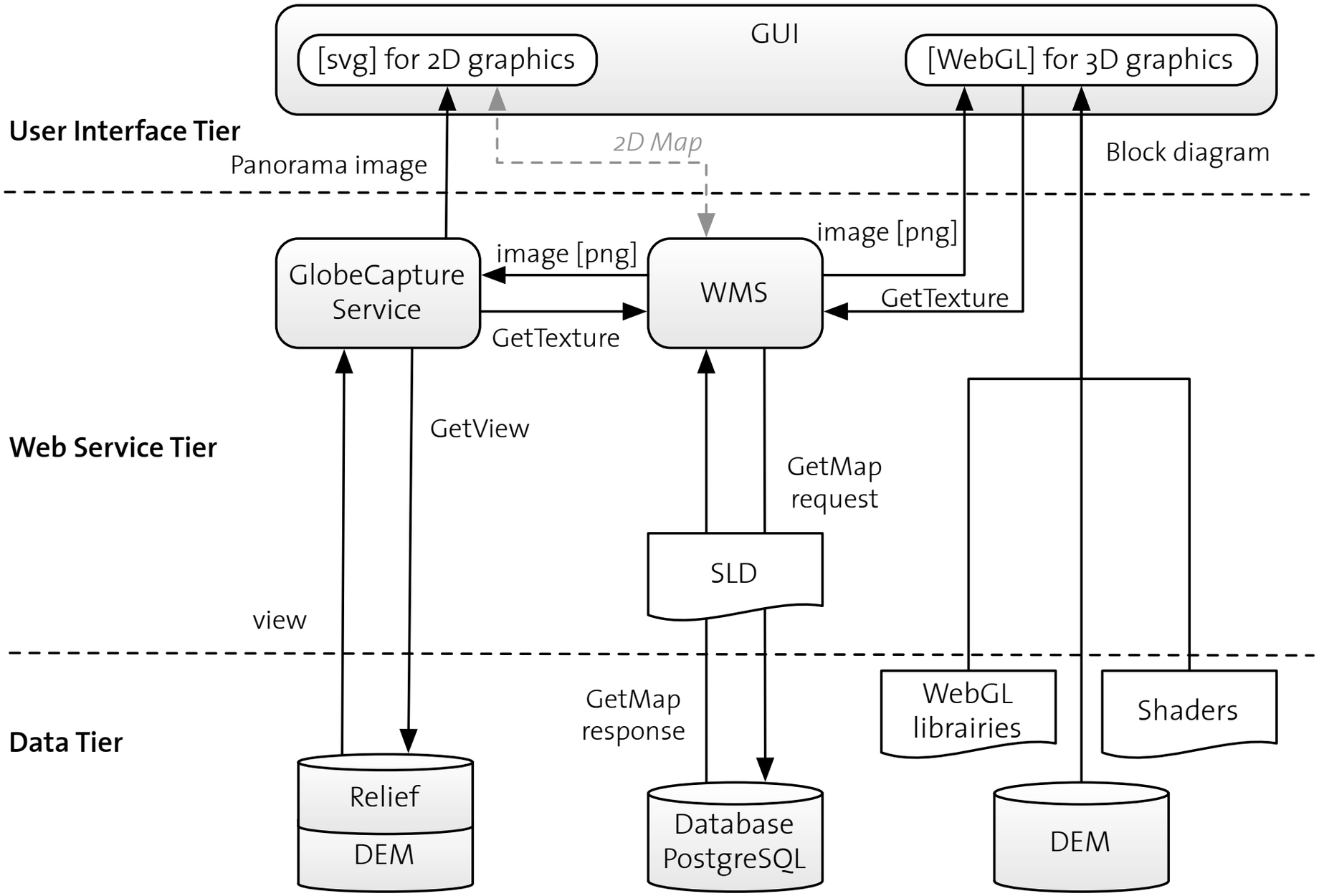
Implementation



Architecture



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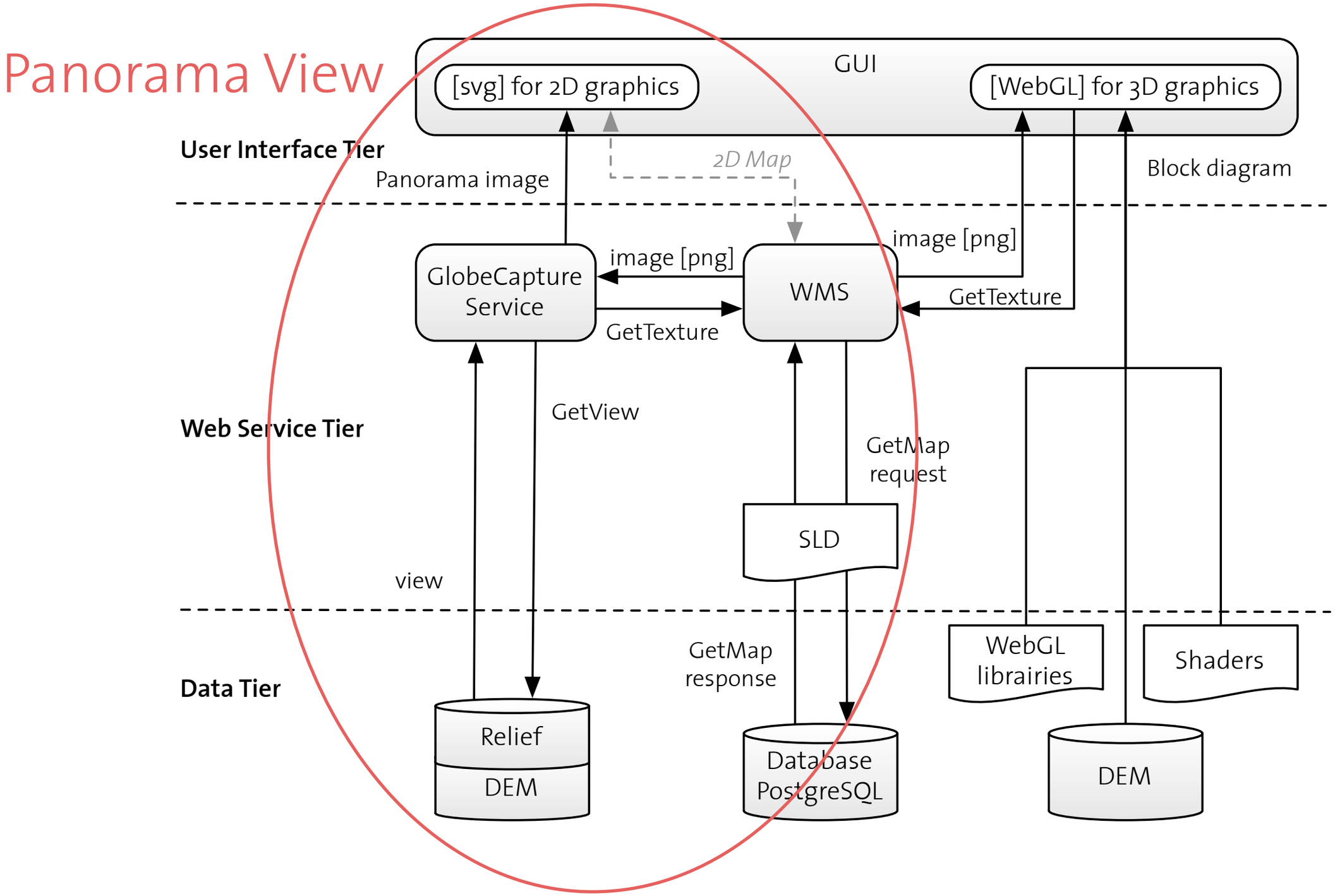
Architecture



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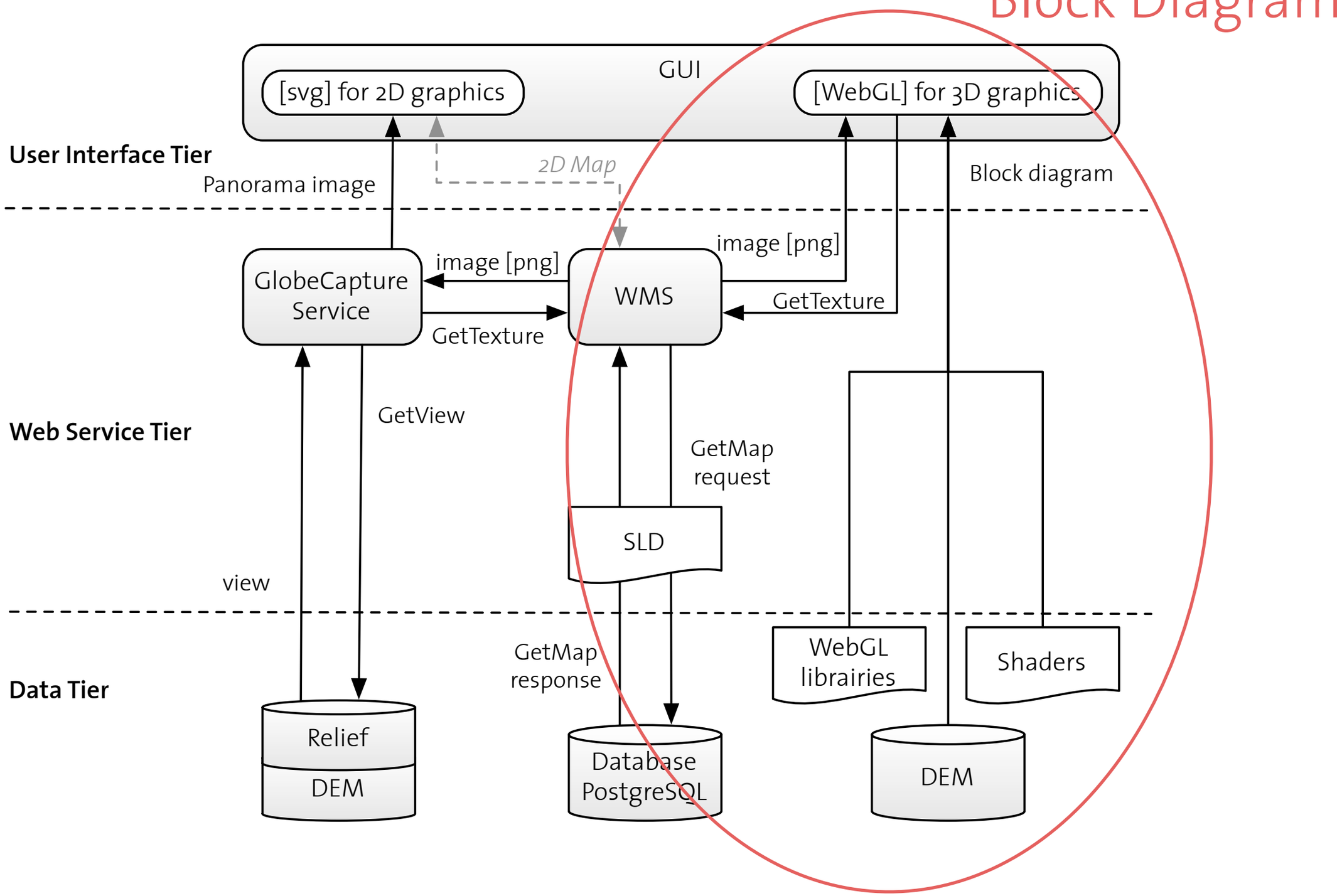
Architecture



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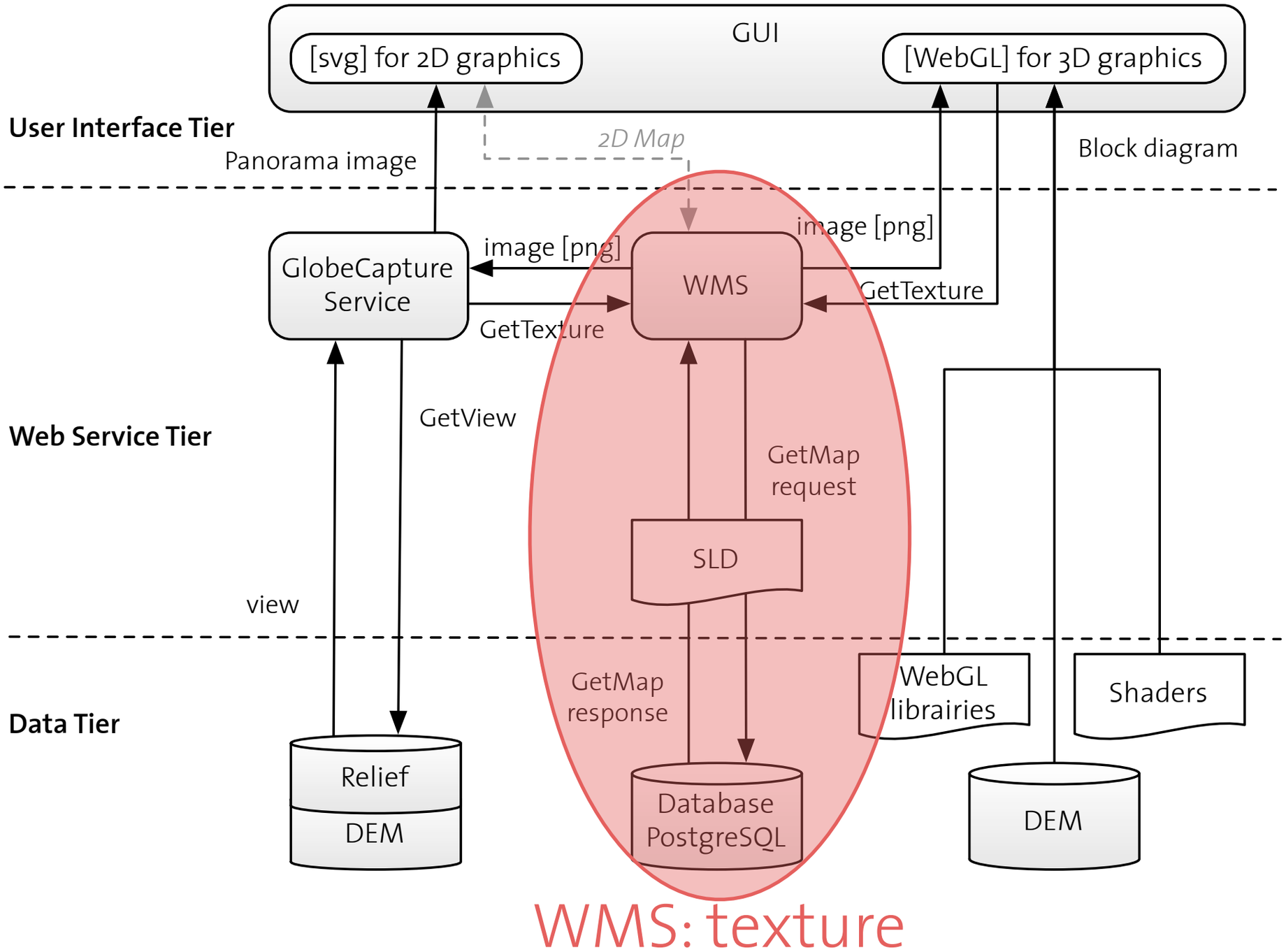
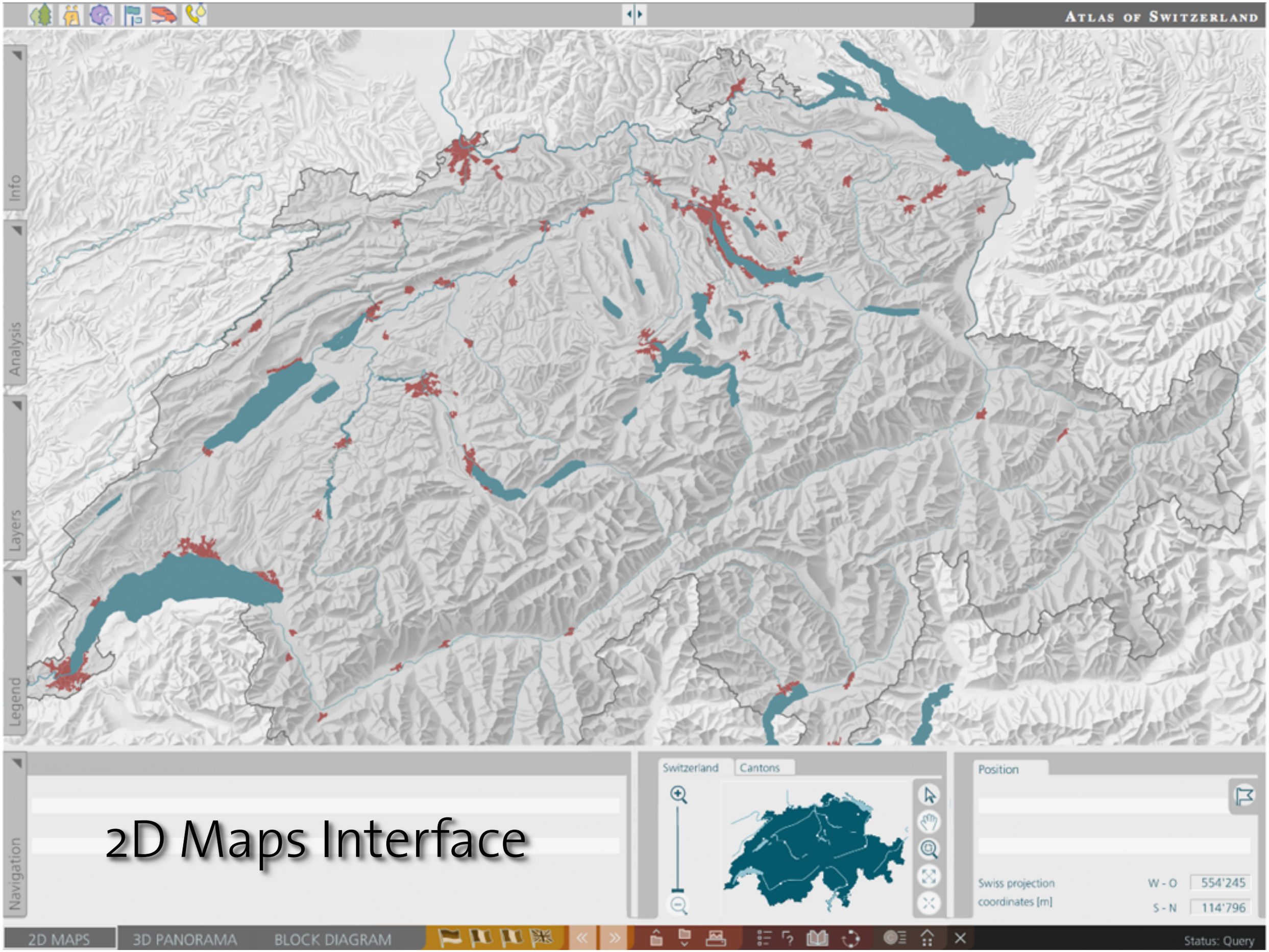
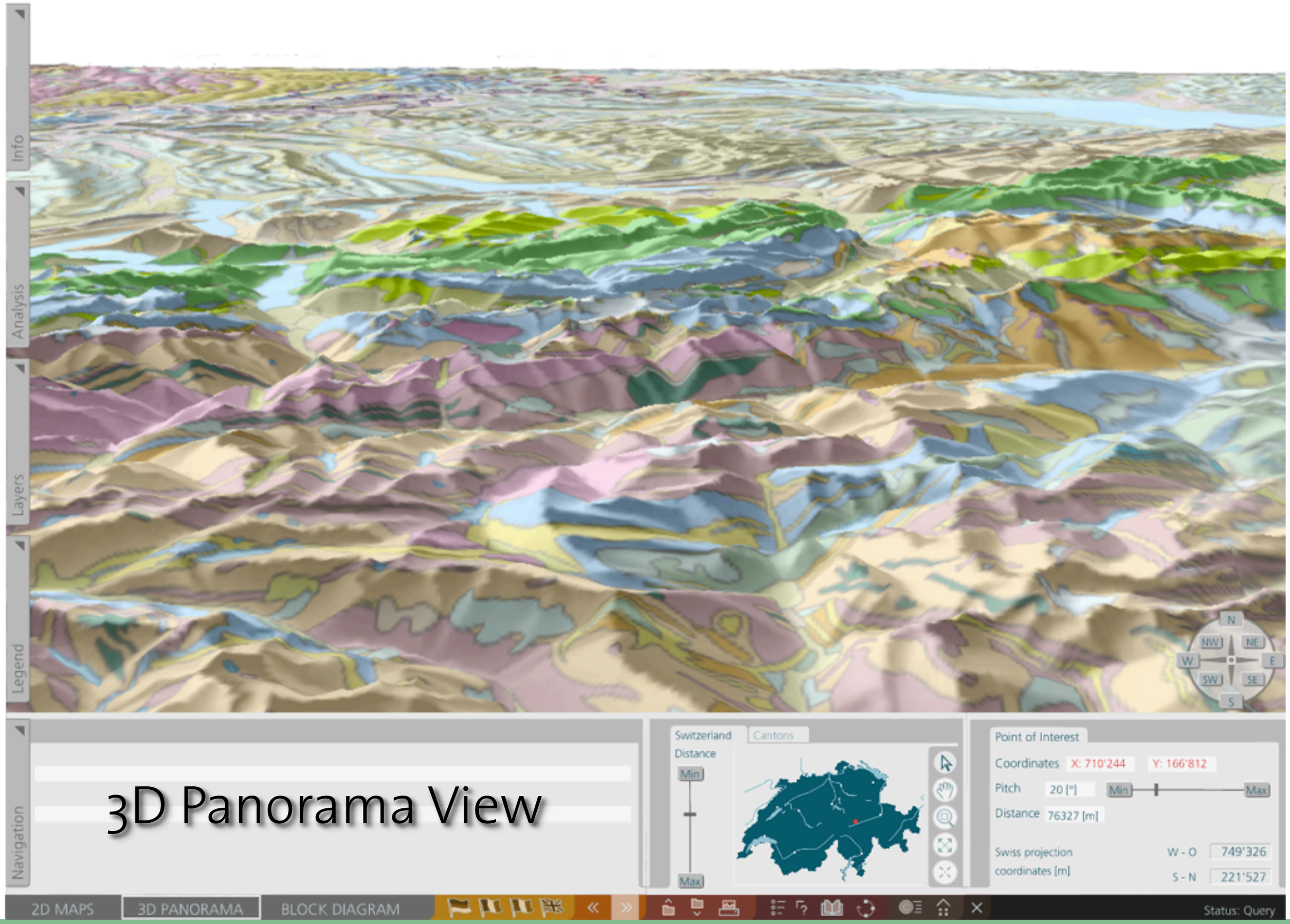
Architecture

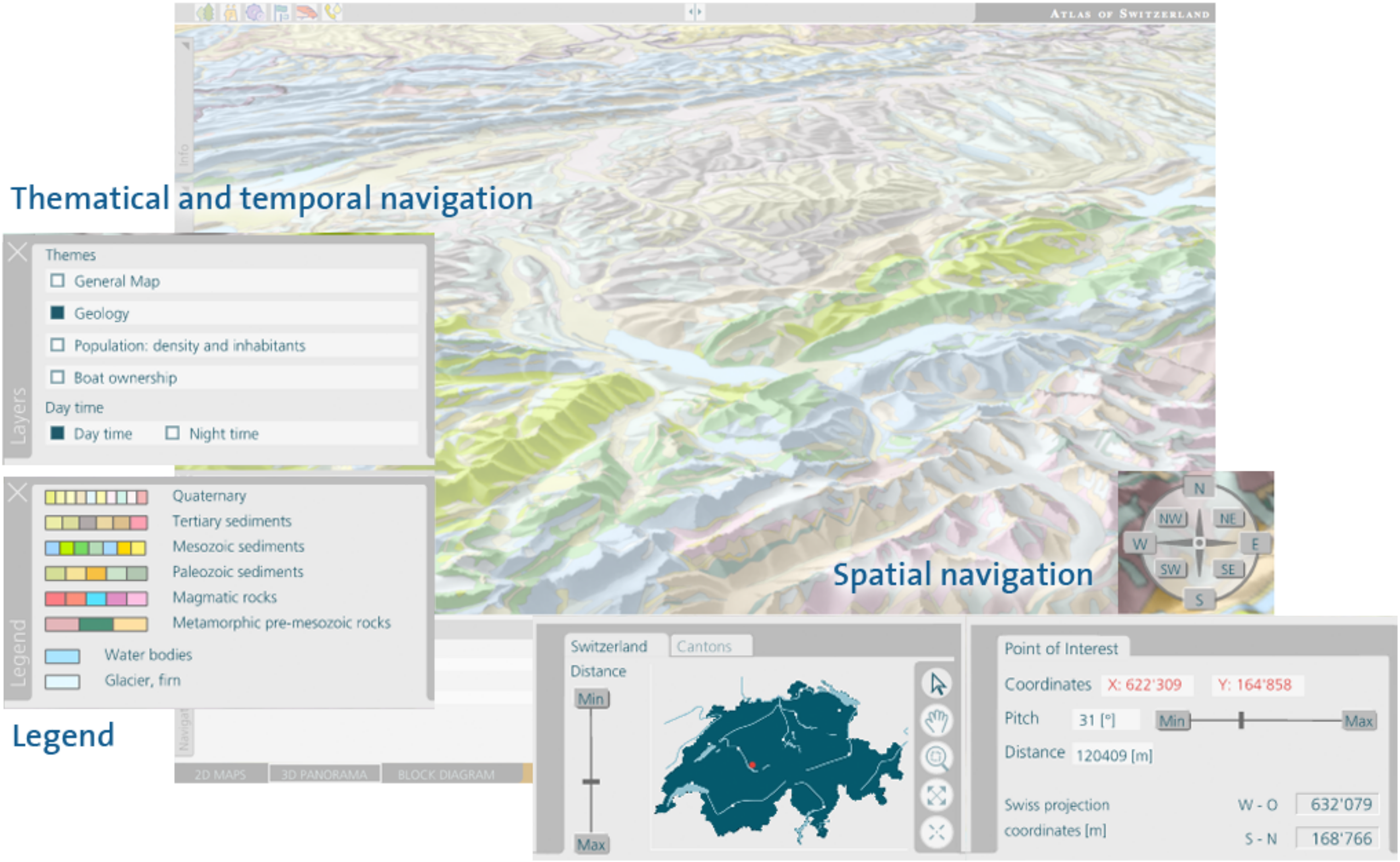


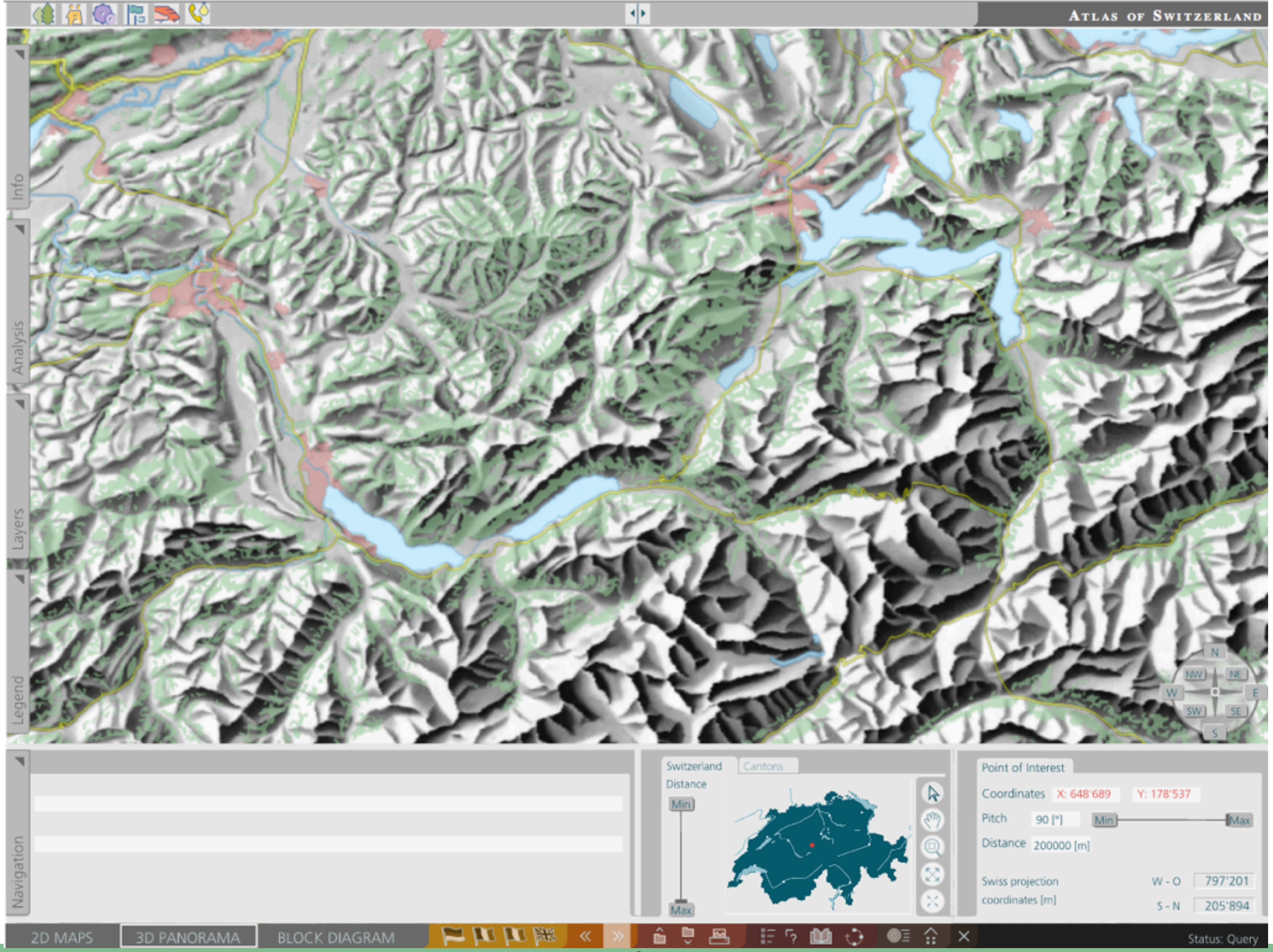


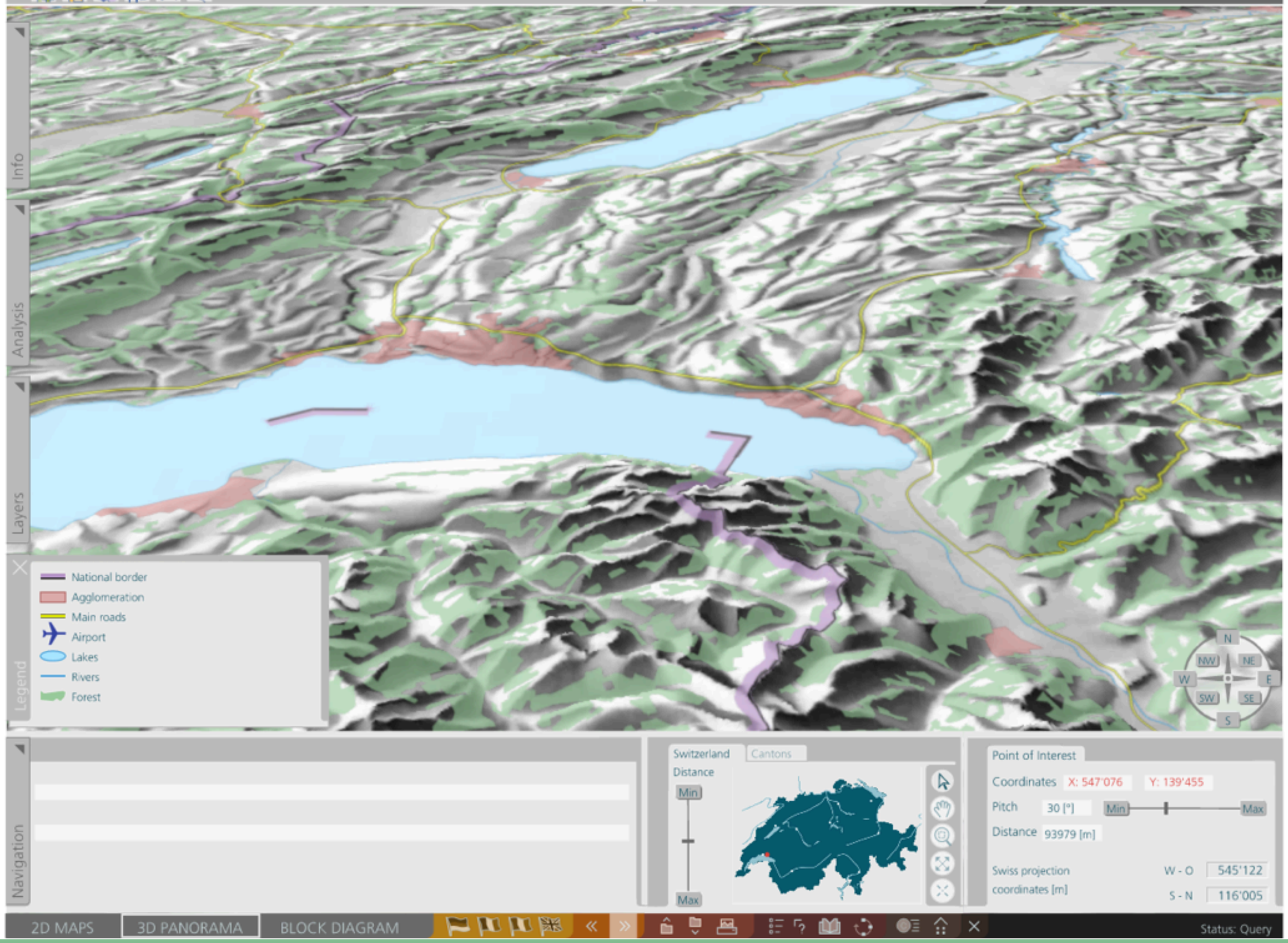
2D Maps Interface



3D Panorama View


Atlas of Switzerland
Thematical and temporal navigation
Themes
General Map
Geology
Population: density and inhabitants
Boat ownership
Day time
Day time
Night time
Layers
Quaternary
Tertiary sediments
Mesozoic sediments
Paleozoic sediments
Magmatic rocks
Metamorphic pre-mesozoic rocks
Water bodies
Glacier, firn
Legend
Legend
Spatial navigation
N
NW
NE
W
E
SW
SE
S
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 622'309
Y: 164'858
Pitch
31 [°]
Min
Max
Distance
120409 [m]
Swiss projection coordinates [m]
W - O
632'079
S - N
168'766


Info
Analysis
Layers
Legend
Navigation
N
NW
NE
W
E
SW
SE
S
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 648'689
Y: 178'537
Pitch
90 [°]
Min
Max
Distance
200000 [m]
Swiss projection
coordinates [m]
W - O
797'201
S - N
205'894
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query


Info
Analysis
Layers
Legend
National border
Agglomeration
Main roads
Airport
Lakes
Rivers
Forest
N
NW
NE
W
E
SW
SE
S
Navigation
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 547'076
Y: 139'455
Pitch
30 [°]
Min
Max
Distance
93979 [m]
Swiss projection coordinates [m]
W - O
545'122
S - N
116'005
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query

Legend

Boat ownership density
[boat/inhabitants]

- fewer than 0.32
- 0.33 - 0.99
- 1.00 - 1.51
- 1.52 - 2.38
- 2.39 - 4.67

N NW NE W E SW SE S

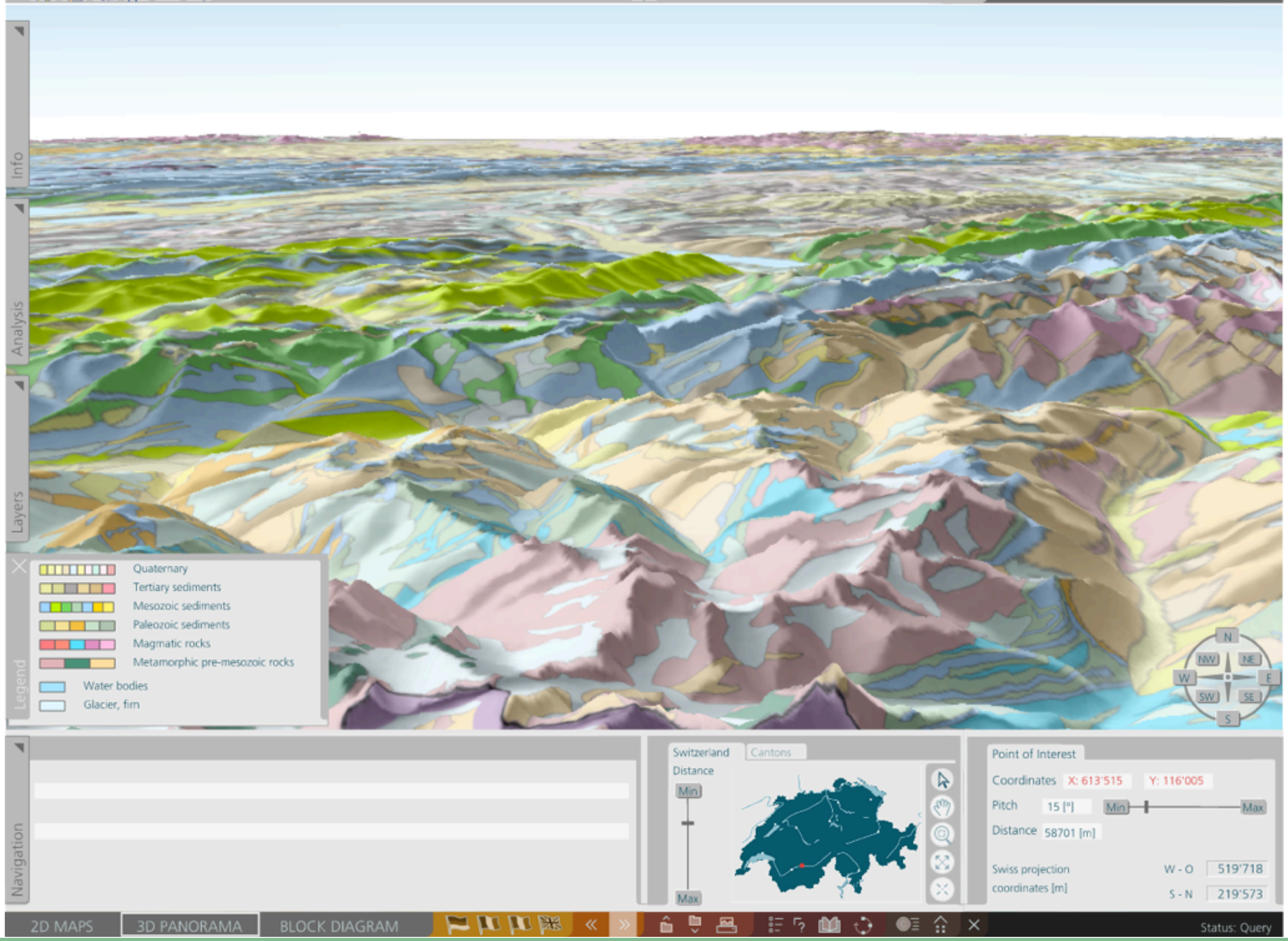
Navigation

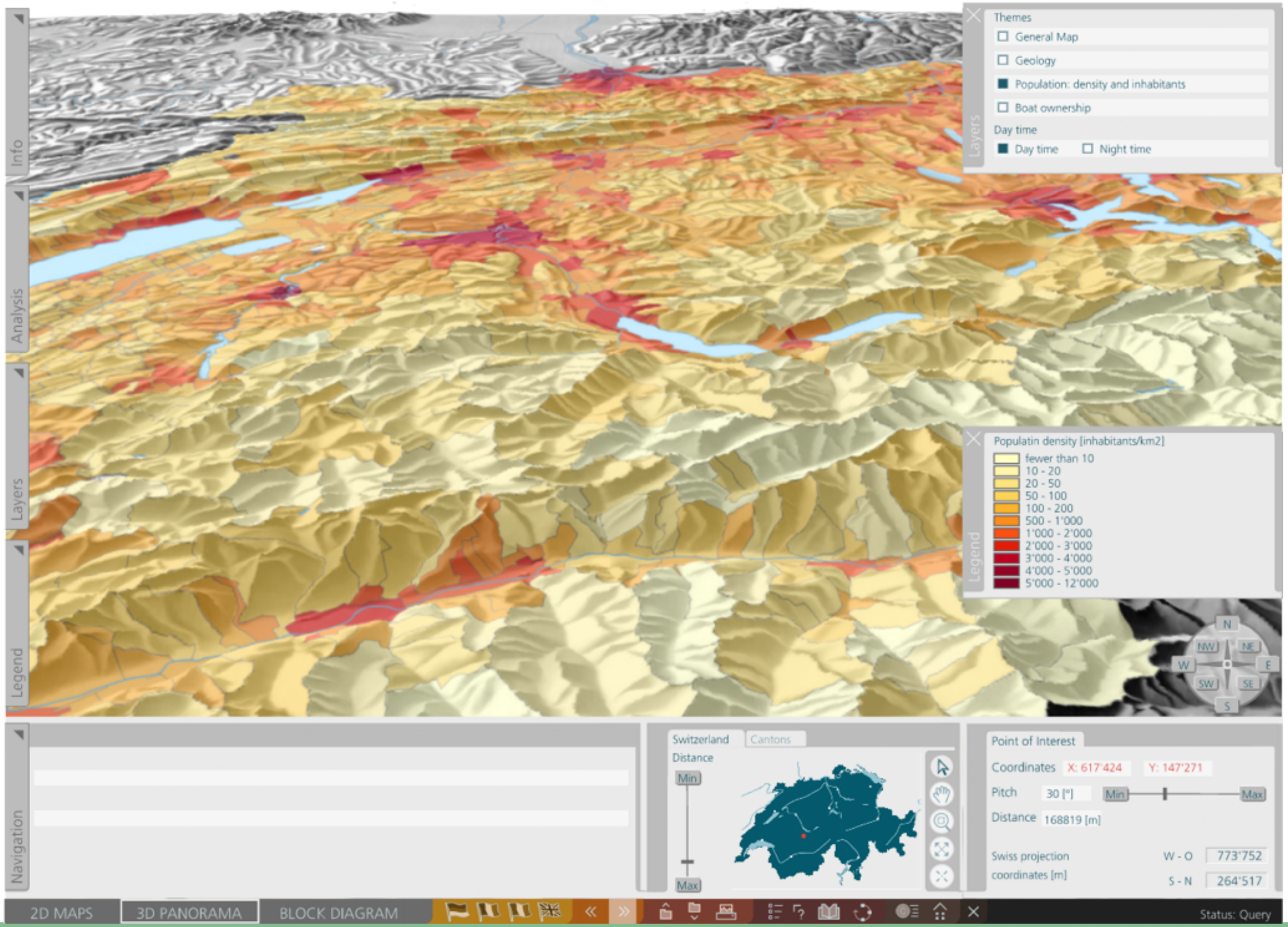
Switzerland Cantons
Distance
Min
Max

Point of Interest
Coordinates X: 658'460 Y: 184'399
Pitch 53 [°] Min Max
Distance 200000 [m]
Swiss projection coordinates [m] W - O 599'837 S - N 237'160

2D MAPS 3D PANORAMA BLOCK DIAGRAM

Status: Query


Info
Analysis
Layers
Legend
Quaternary
Tertiary sediments
Mesozoic sediments
Paleozoic sediments
Magmatic rocks
Metamorphic pre-mesozoic rocks
Water bodies
Glacier, firn
N
NW
NE
W
E
SW
SE
S
Navigation
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 613'515
Y: 116'005
Pitch
15 [°]
Min
Max
Distance
58701 [m]
Swiss projection coordinates [m]
W - O
519'718
S - N
219'573
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query


Info
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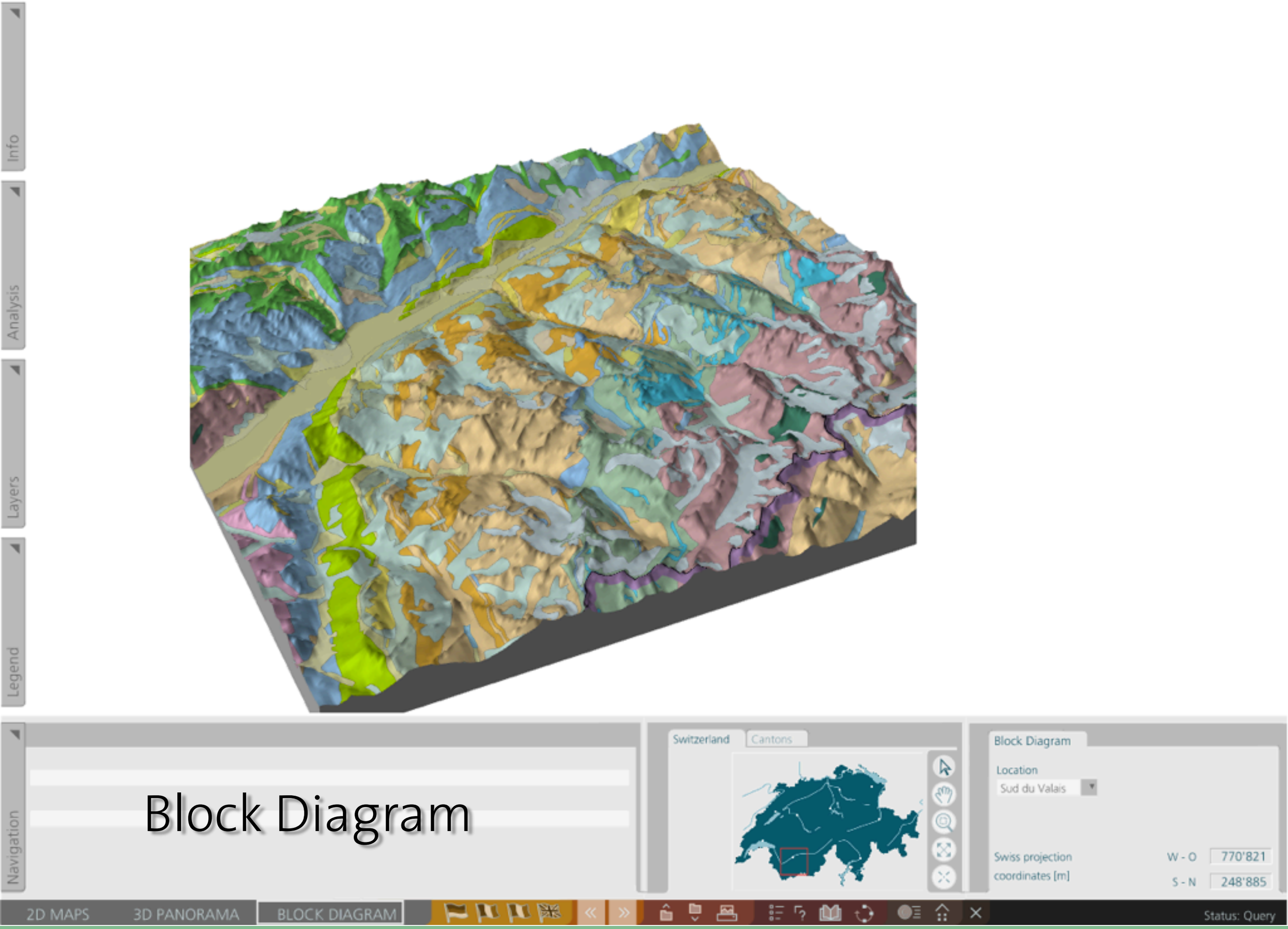
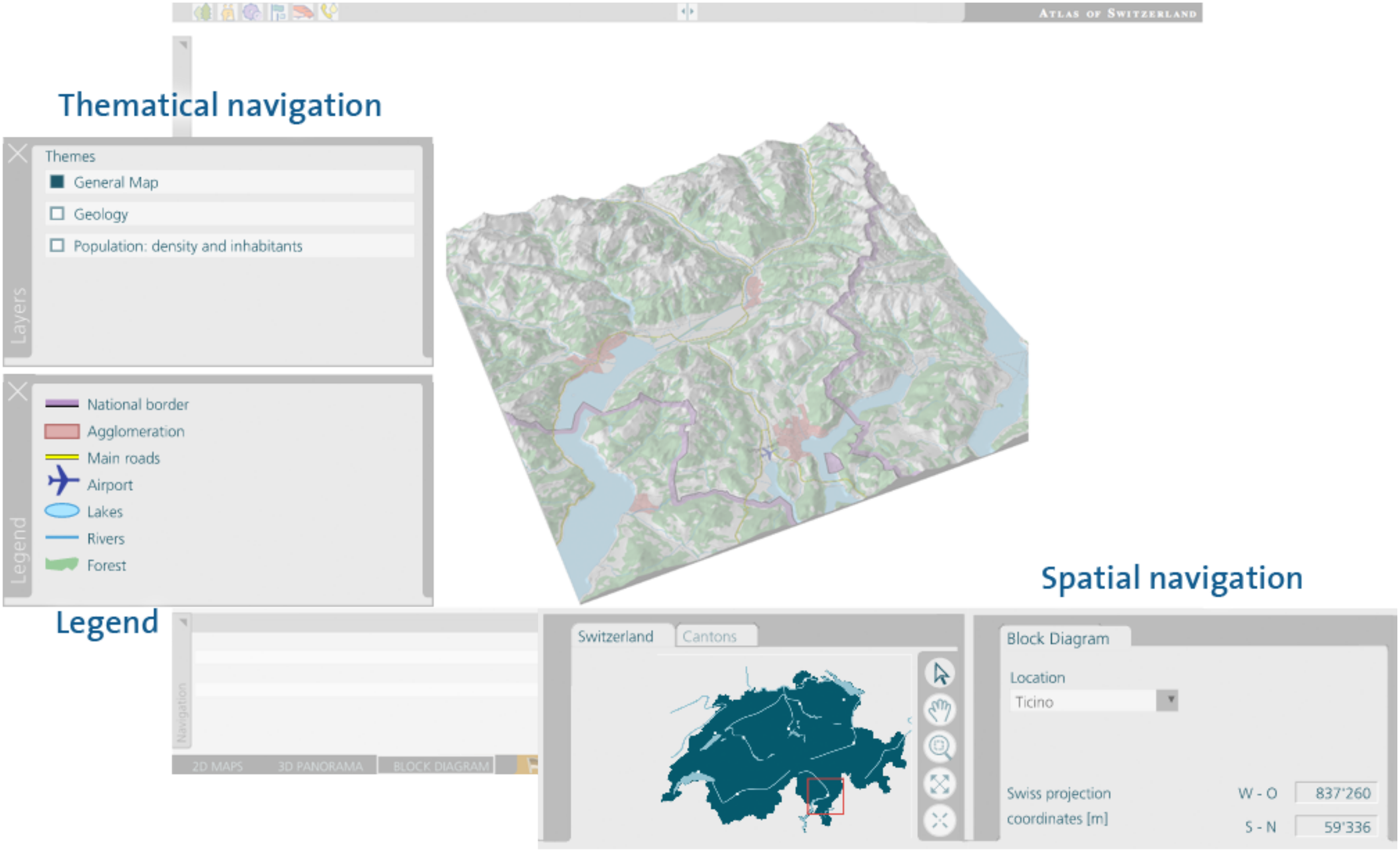
Layers
Legend
Navigation
Themes
General Map
Geology
Population: density and inhabitants
Boat ownership
Day time
Day time
Night time
Populatin density [inhabitants/km2]
fewer than 10
10 - 20
20 - 50
50 - 100
100 - 200
500 - 1'000
1'000 - 2'000
2'000 - 3'000
3'000 - 4'000
4'000 - 5'000
5'000 - 12'000
N
NW
NE
W
E
SW
SE
S
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 617'424
Y: 147'271
Pitch
30 [°]
Min
Max
Distance
168819 [m]
Swiss projection
coordinates [m]
W - O
773'752
S - N
264'517
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query



Block Diagram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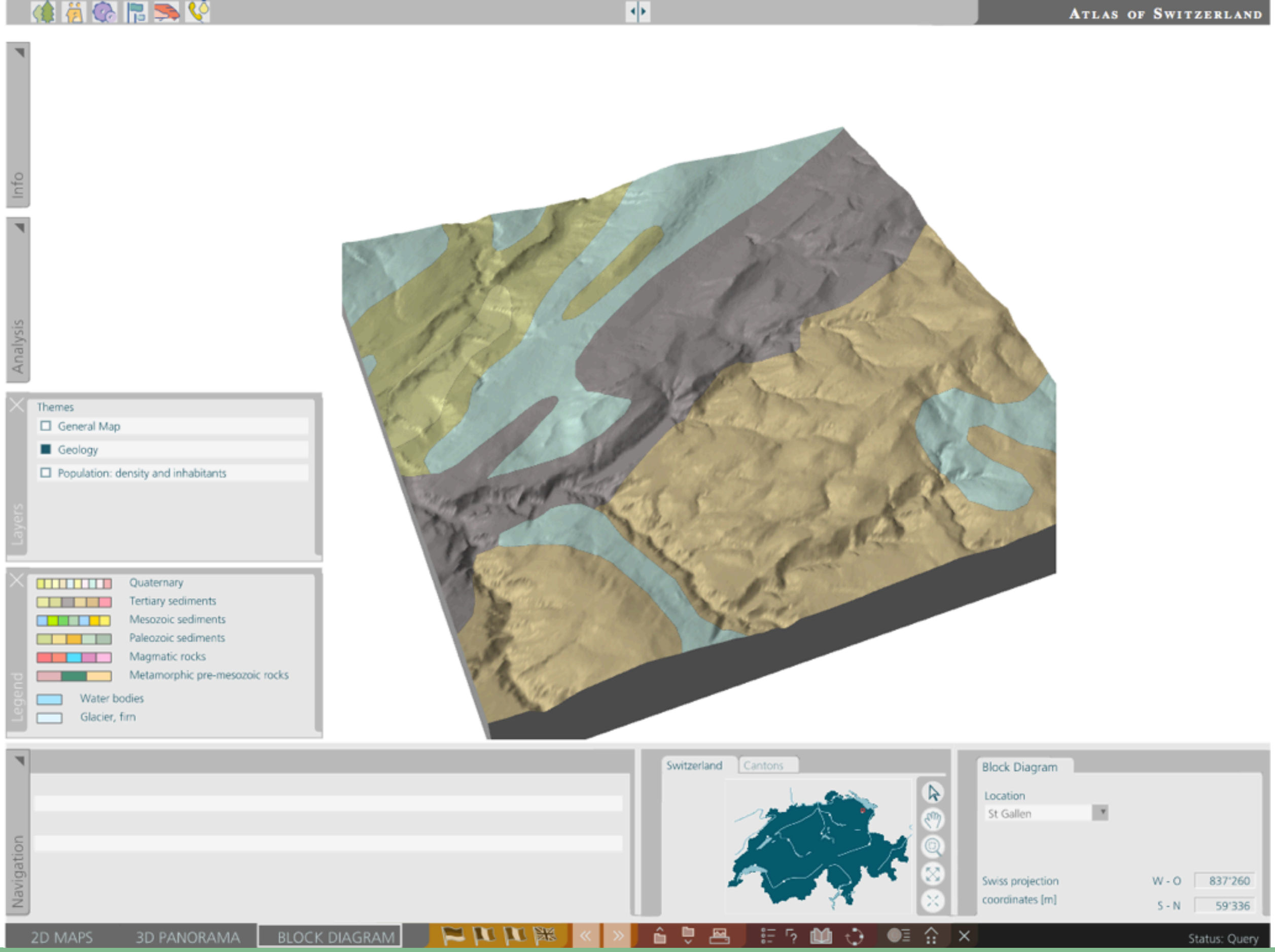
Rivers
Forest
Legend
Spatial navigation
Legend
Navigation
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Switzerland
Cantons
Block Diagram
Location
Ticino
Swiss projection
coordinates [m]
W - O
837'260
S - N
59'336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Metamorphic pre-mesozoic rocks
Water bodies
Glacier, firn
Legend
Navigation
Switzerland
Cantons
Block Diagram
Location
St Gallen
Swiss projection
coordinates [m]
W - O
837'260
S - N
59'336
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query

Info

Analysis

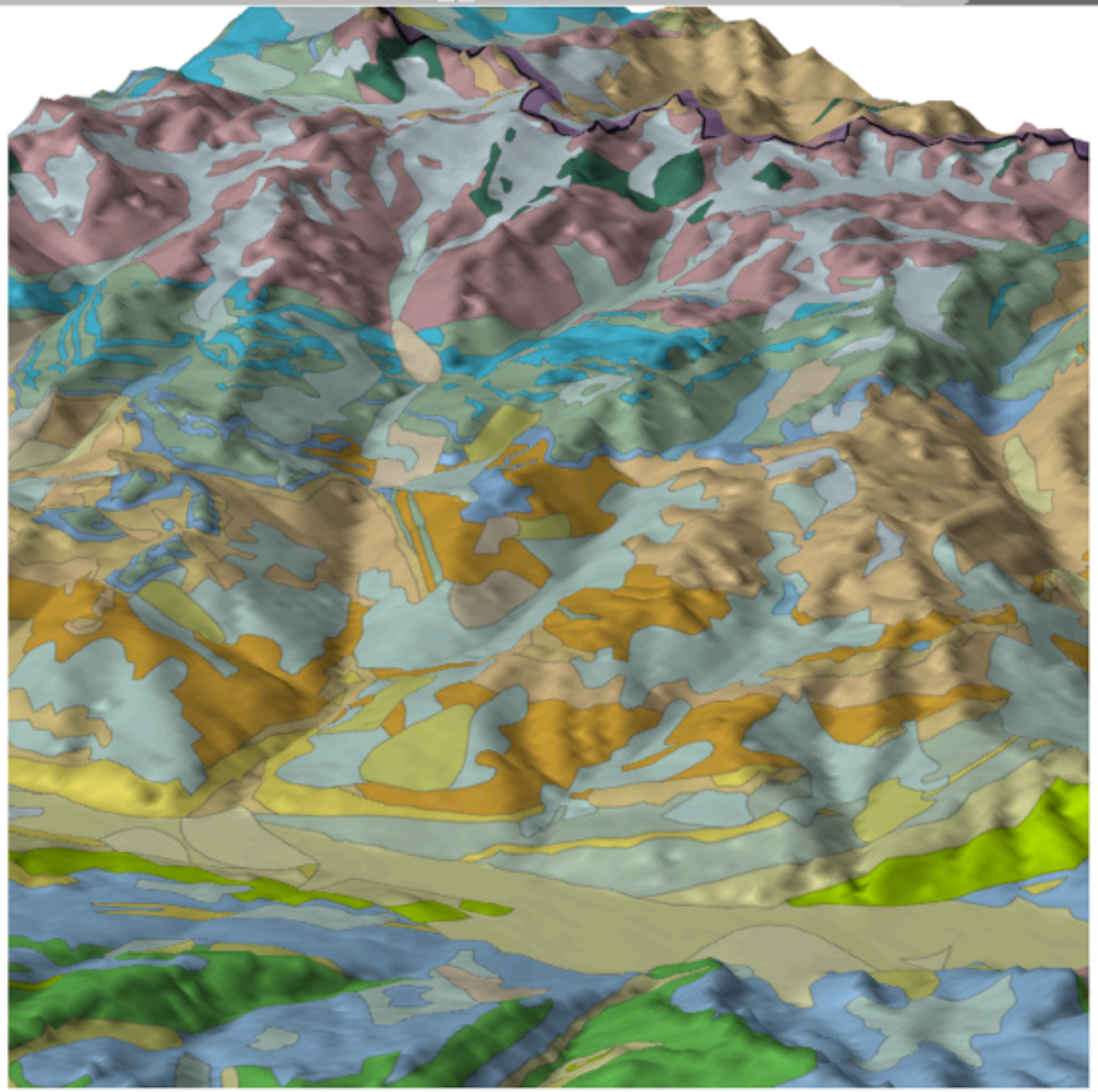
Layers

Themes

- General Map
- Geology
- Population: density and inhabitants

Legend

- Quaternary
- Tertiary sediments
- Mesozoic sediments
- Paleozoic sediments
- Magmatic rocks
- Metamorphic pre-mesozoic rocks
- Water bodies
- Glacier, firn



Navigation

Switzerland | Cantons

Block Diagram

Location

Sud du Valais
Sud du Valais
Ticino
Matterhorn

Swiss projection coordinates [m]

W - O 837'260

S - N 59'336

2D MAPS | 3D PANORAMA | BLOCK DIAGRAM

Status: Query

Info

Analysis

Layers

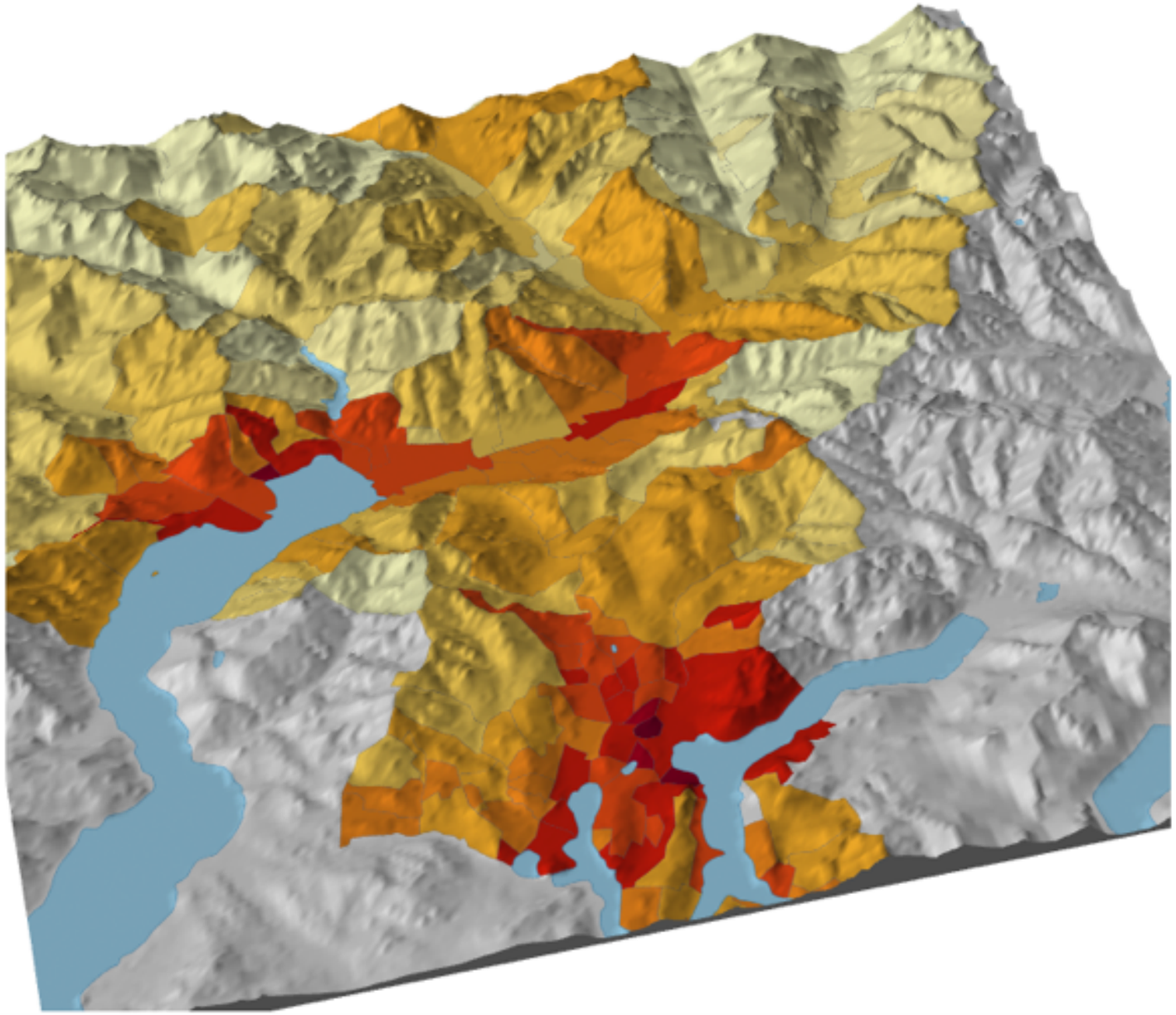
Themes

- General Map
- Geology
- Population: density and inhabitants

Legend

Populatin density [inhabitants/km2]

- fewer than 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 500 - 1'000
- 1'000 - 2'000
- 2'000 - 3'000
- 3'000 - 4'000
- 4'000 - 5'000
- 5'000 - 12'000



Navigation

Switzerland | Cantons

Block Diagram

Location

Ticino

Swiss projection coordinates [m]

W - O

S - N

2D MAPS | 3D PANORAMA | BLOCK DIAGRAM

Status: Query

WMS for Texture

- Topographic maps: polygon and line features
- Thematic maps: choropleth maps (most frequent maps in atlas)

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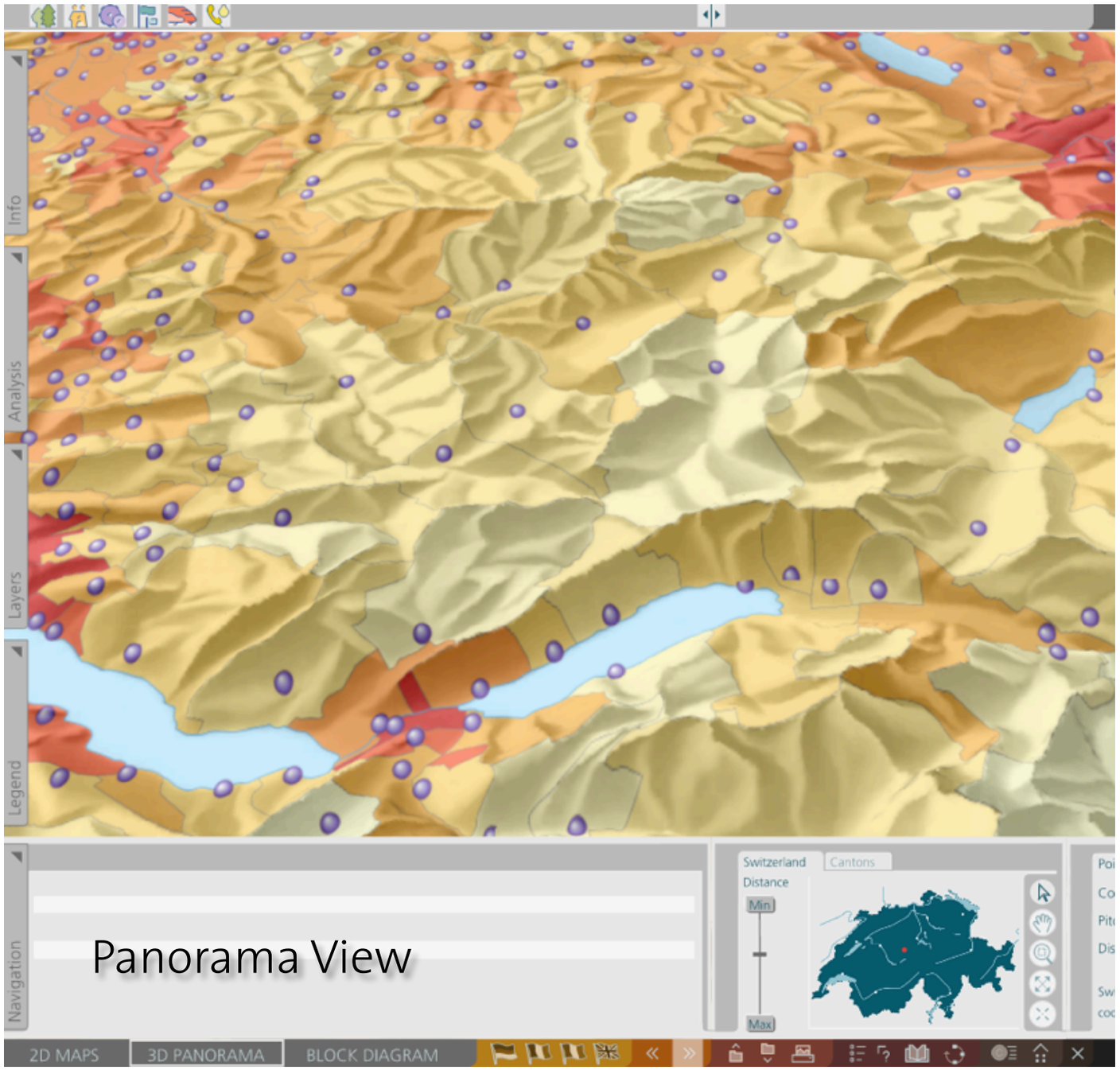
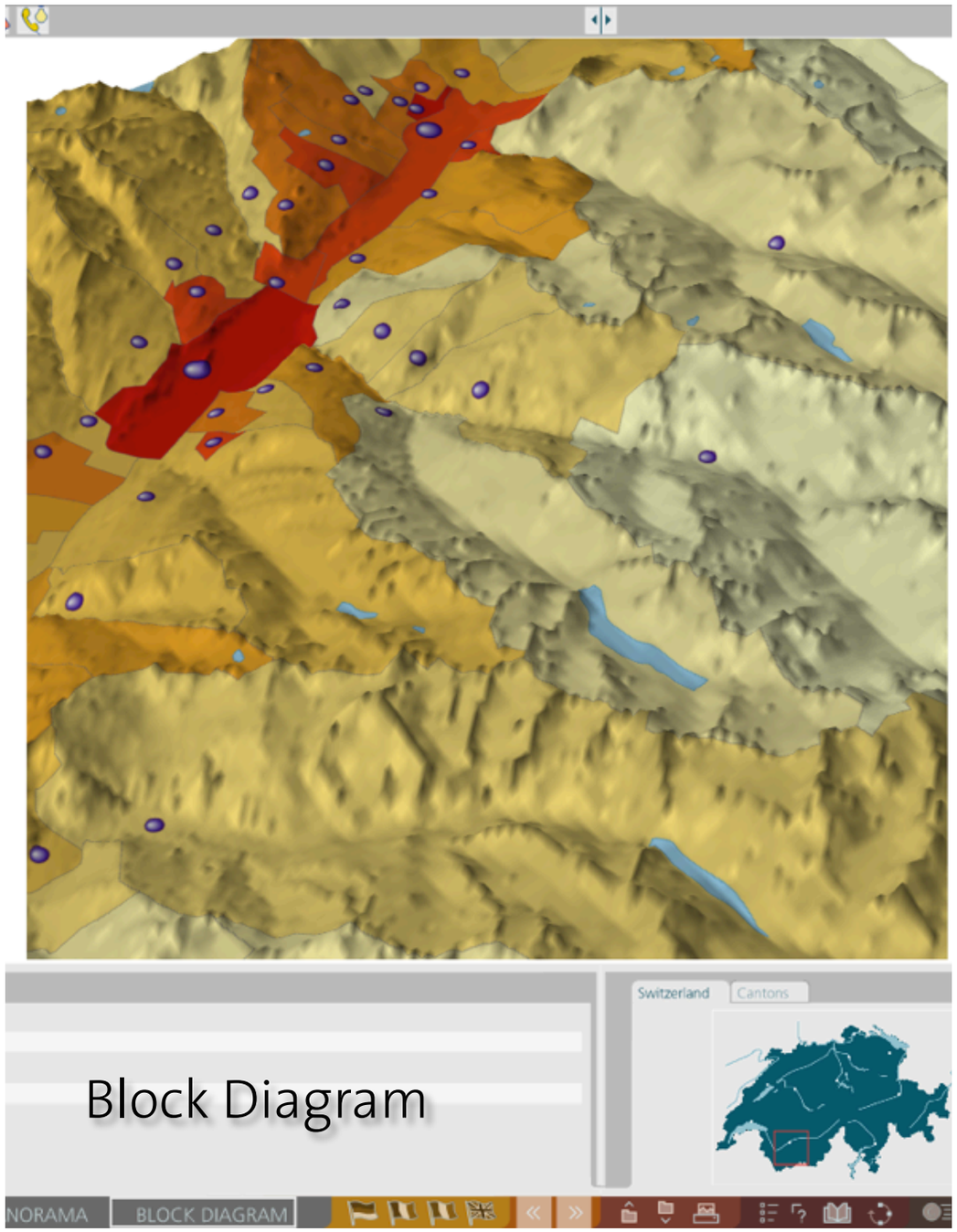
Point symbols

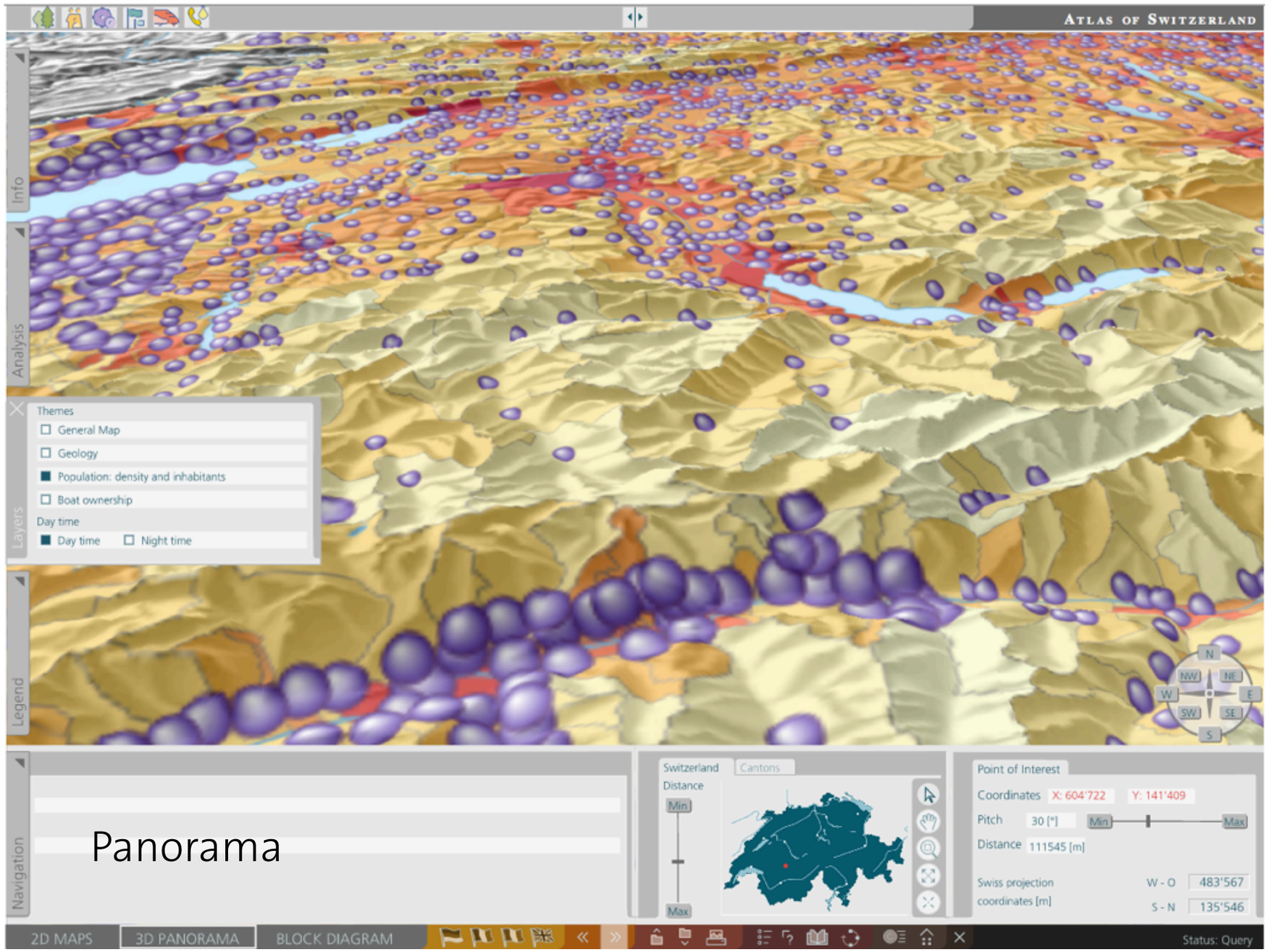


Panorama View



Block Diagram

Tiling Issue



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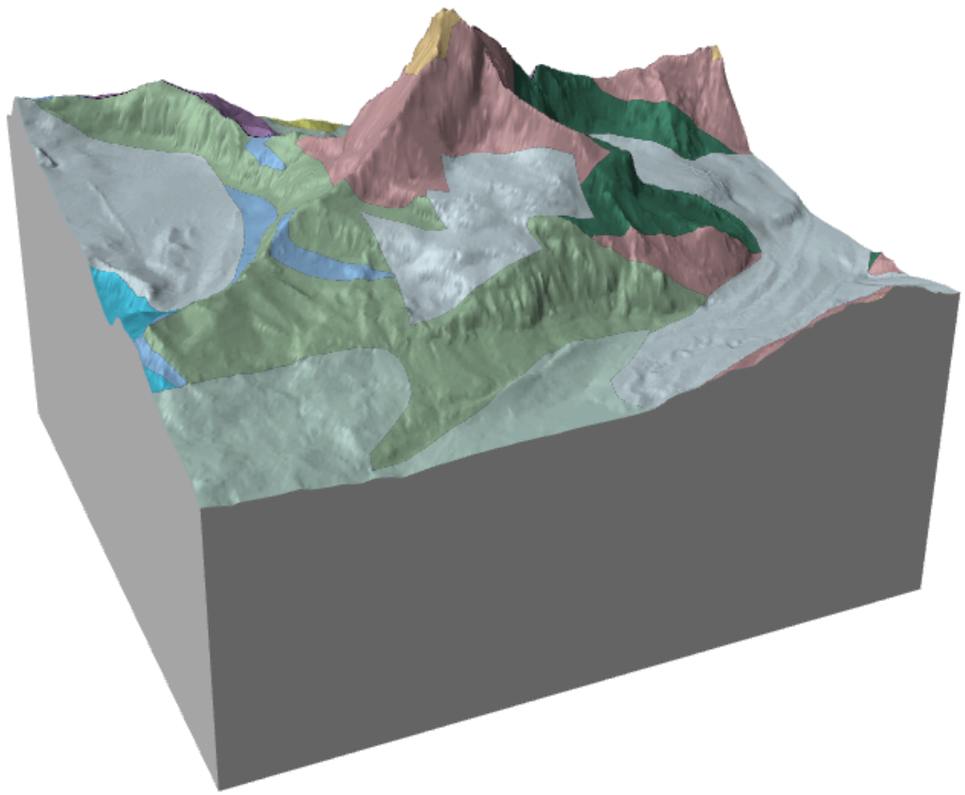
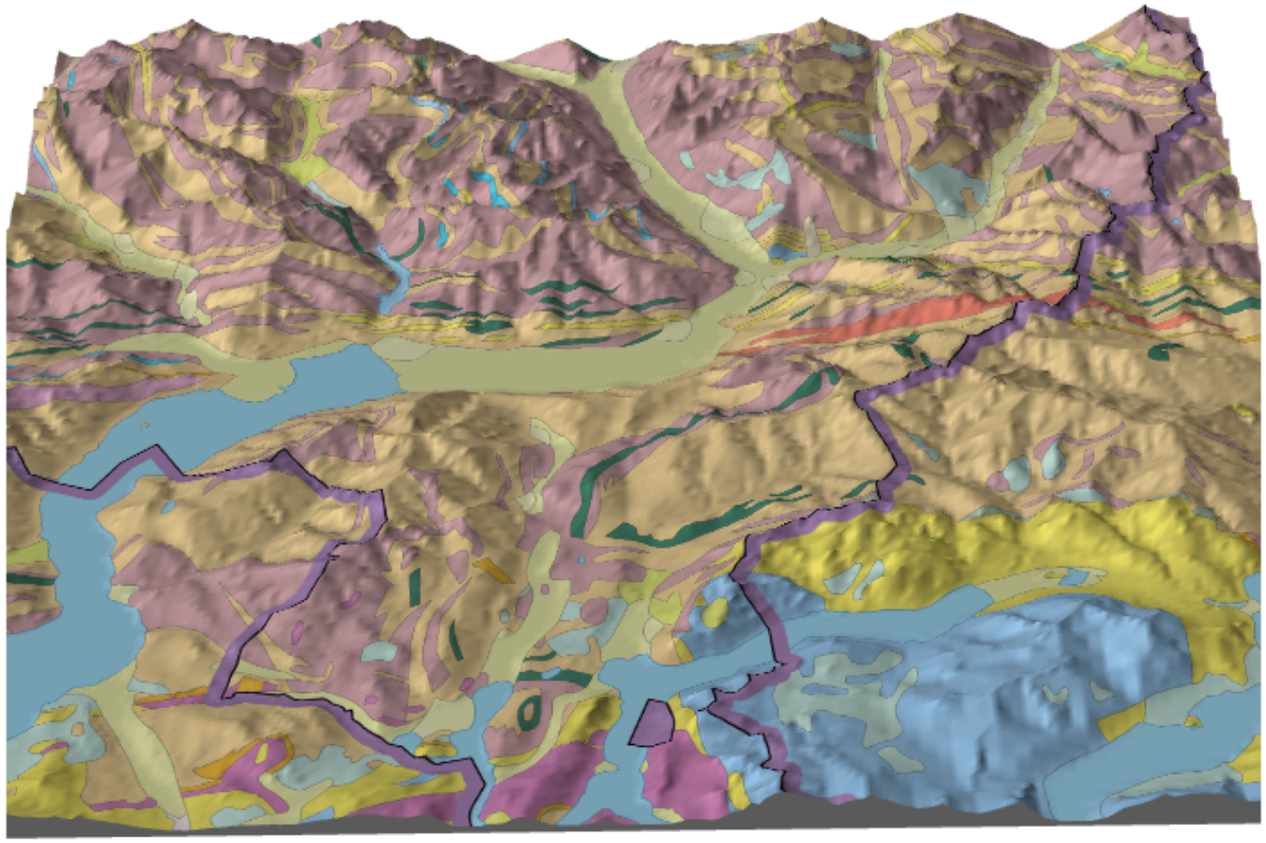
WebGL: size limitation



Matterhorn - DHM25
6 x 6 km²



Ticino - RIMINI
50 x 50 km²

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Are the requirements met?

	GCS + WMS	WebGL + WMS	*WVS + WMS*
R1: system oriented architecture and thin client			
R2: no plugin			
R3: cross-platform			
R4: interoperability, integration			
R5: extensibility and update			
R6: reusable and robust			
R7: open source			
R8: support for massive geodata			?
R9: dynamic geodata			
R10: higher level of abstraction			
R11: high quality and effective visualization			?
R12: user styling options			
R13: coordinated and multiple views			
R14: interactivity			?
R15: intuitive navigation			?
R16: data query and processing			

Tested, works

Theoretically possible

Needs improvement

Weakness

Conclusions

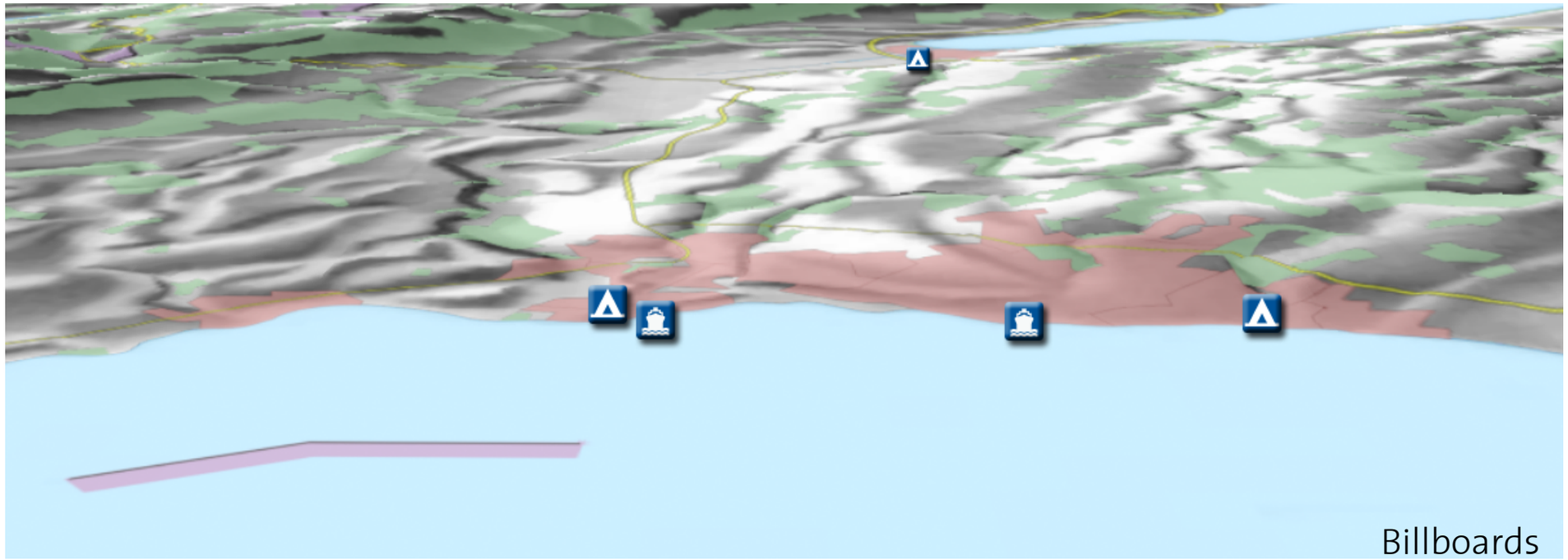
- Service-driven 3D atlases are doable
- WMS is a good solution for texture: topographic maps and choropleth thematic maps
- 3D web atlases could highly benefit from service-oriented architecture
- The definition of standards in the area of 3D web services is highly needed

Recommendations

- WMS for surface and line features
- Point and label symbolization -> billboards (2D)
- WVS/3D Web Map Service -> push for standards
- WebGL -> large scale, small extent maps, 3D objects

Recommendations

- WMS for surface and line features
- Point and label symbolization -> billboards (2D)
- WVS/3D Web Map Service -> push for standards
- WebGL -> large scale, small extent maps, 3D objects



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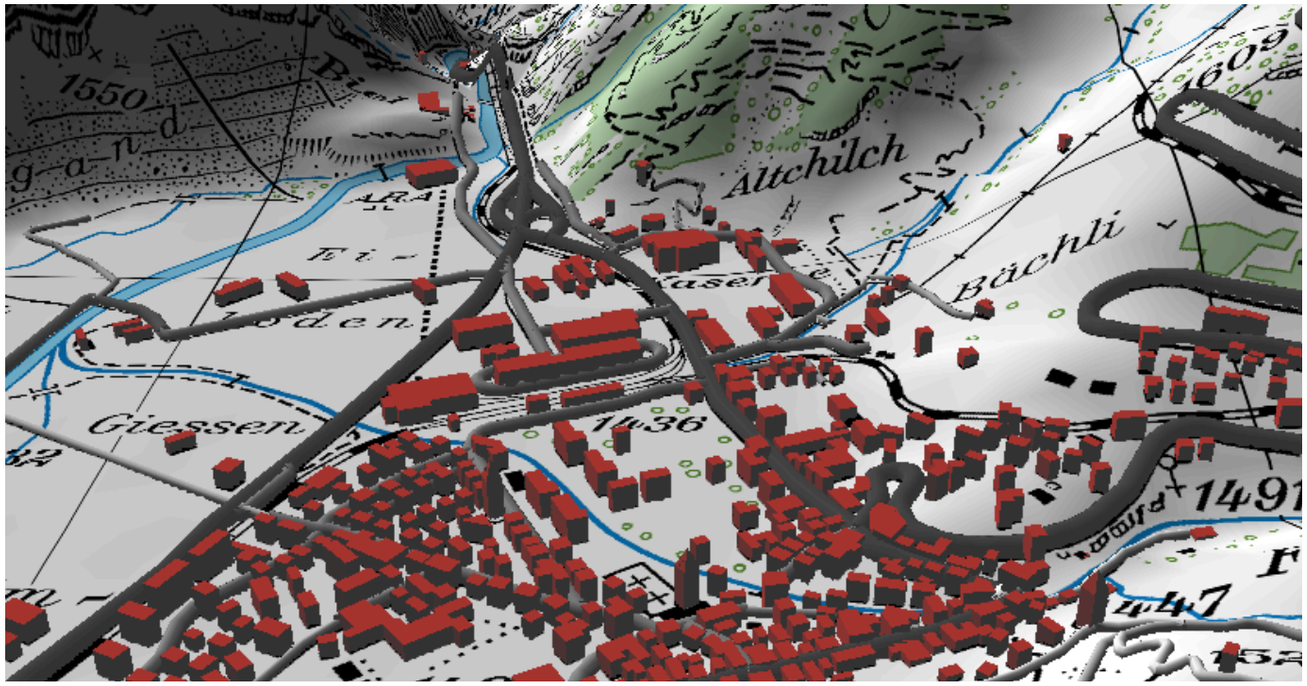


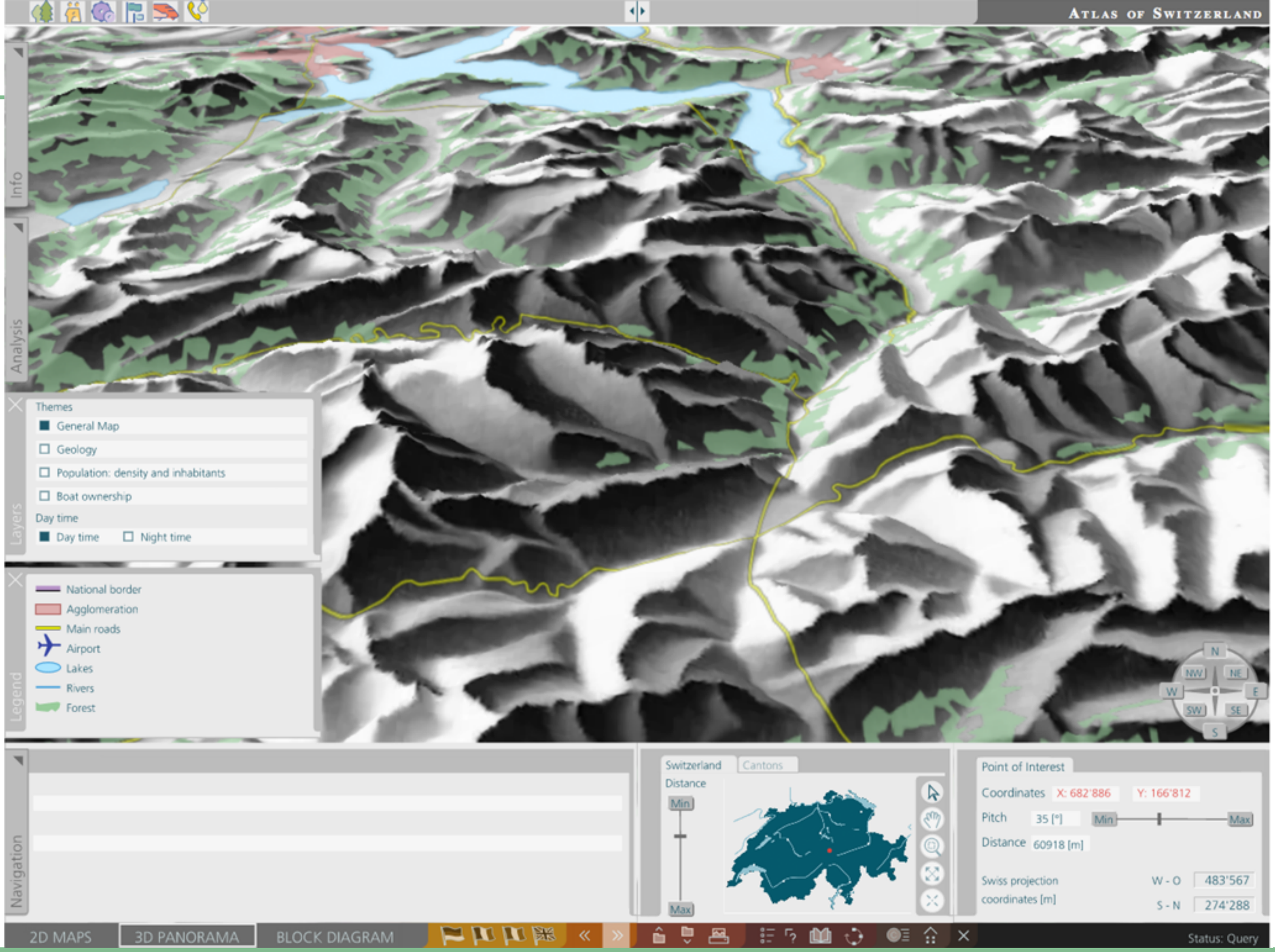
3D objects with WebGL (Friedli 2012)

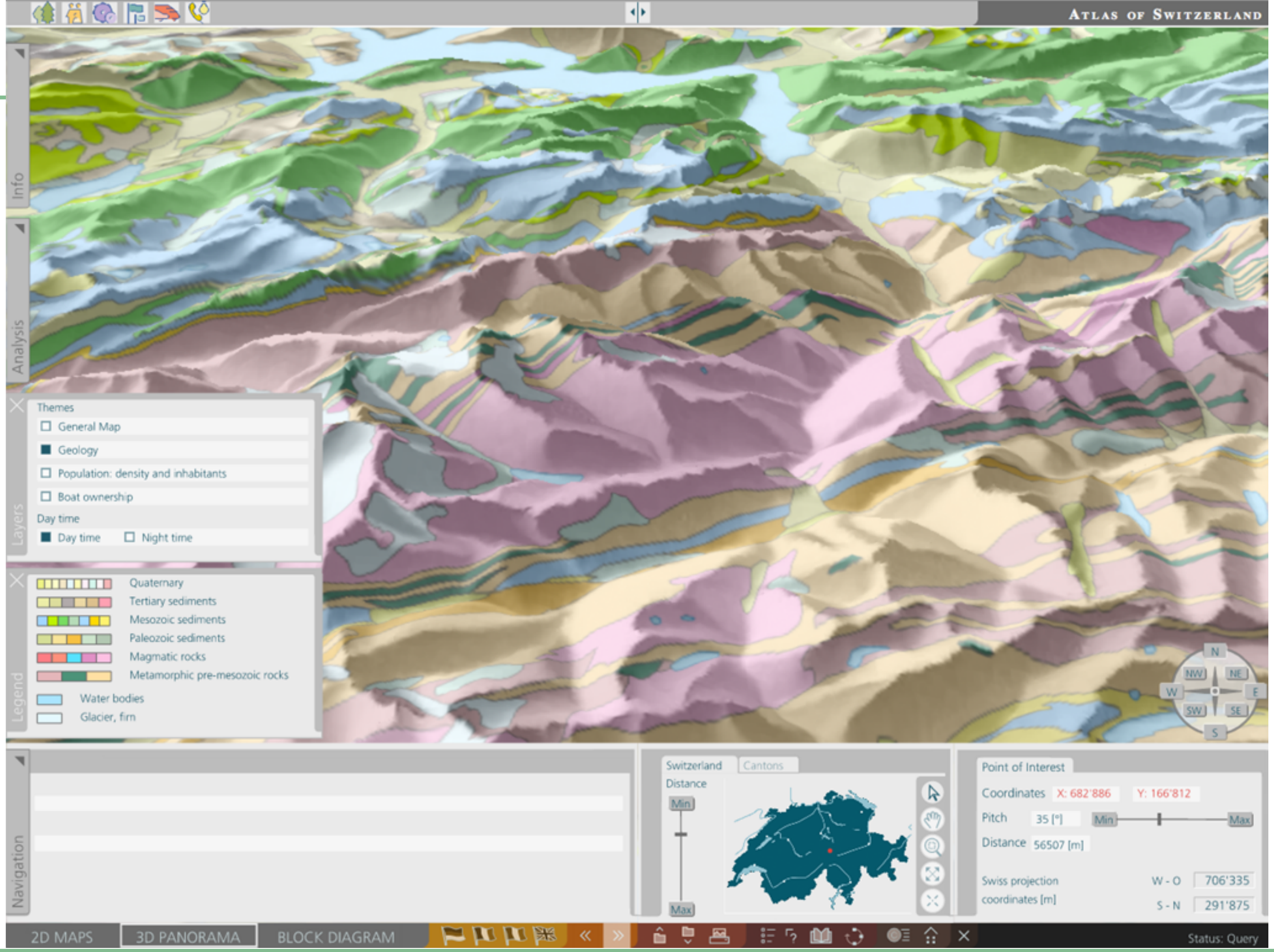
IKG
Institute of Cartography and Geoinformation

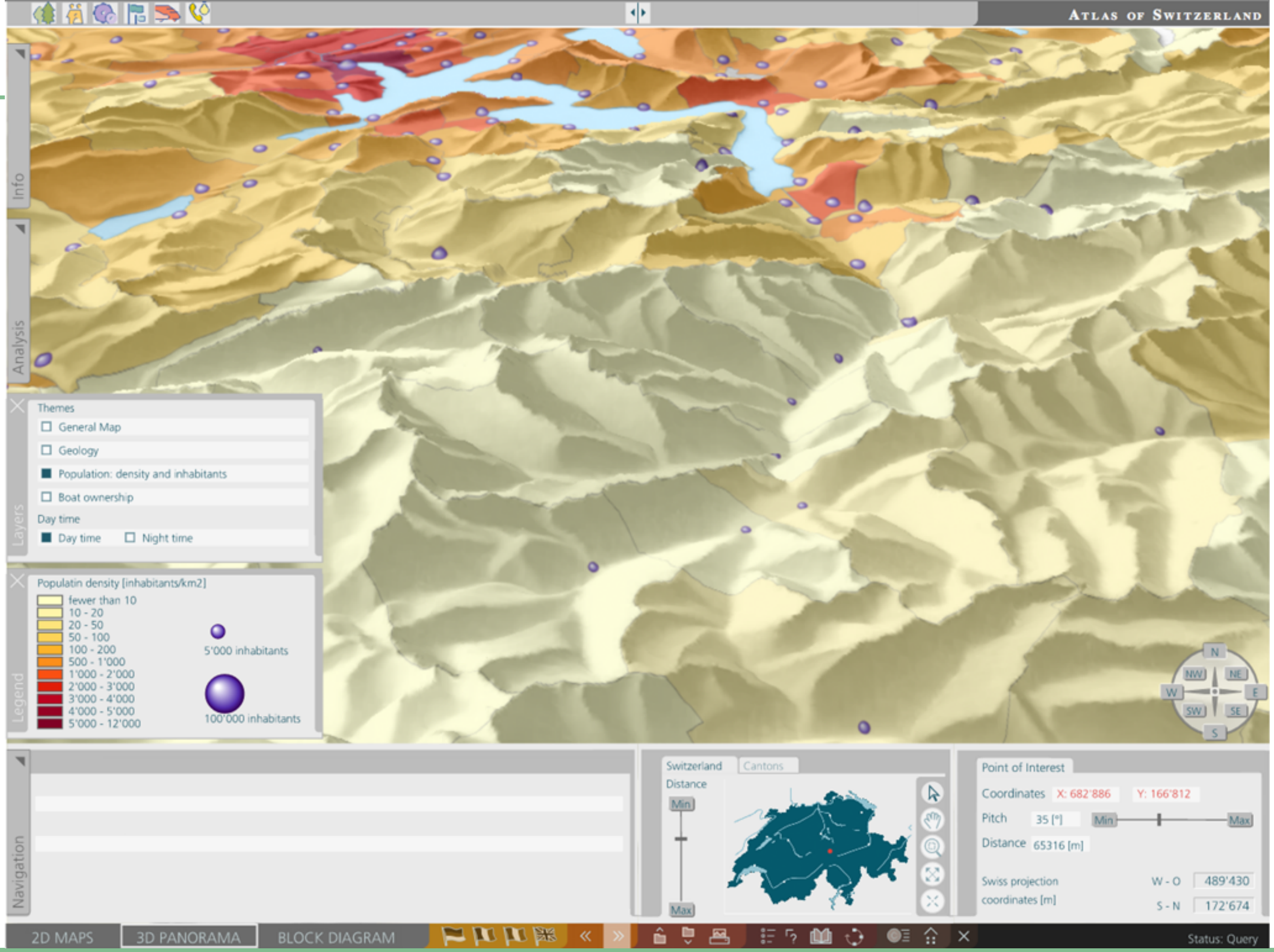
Outlook

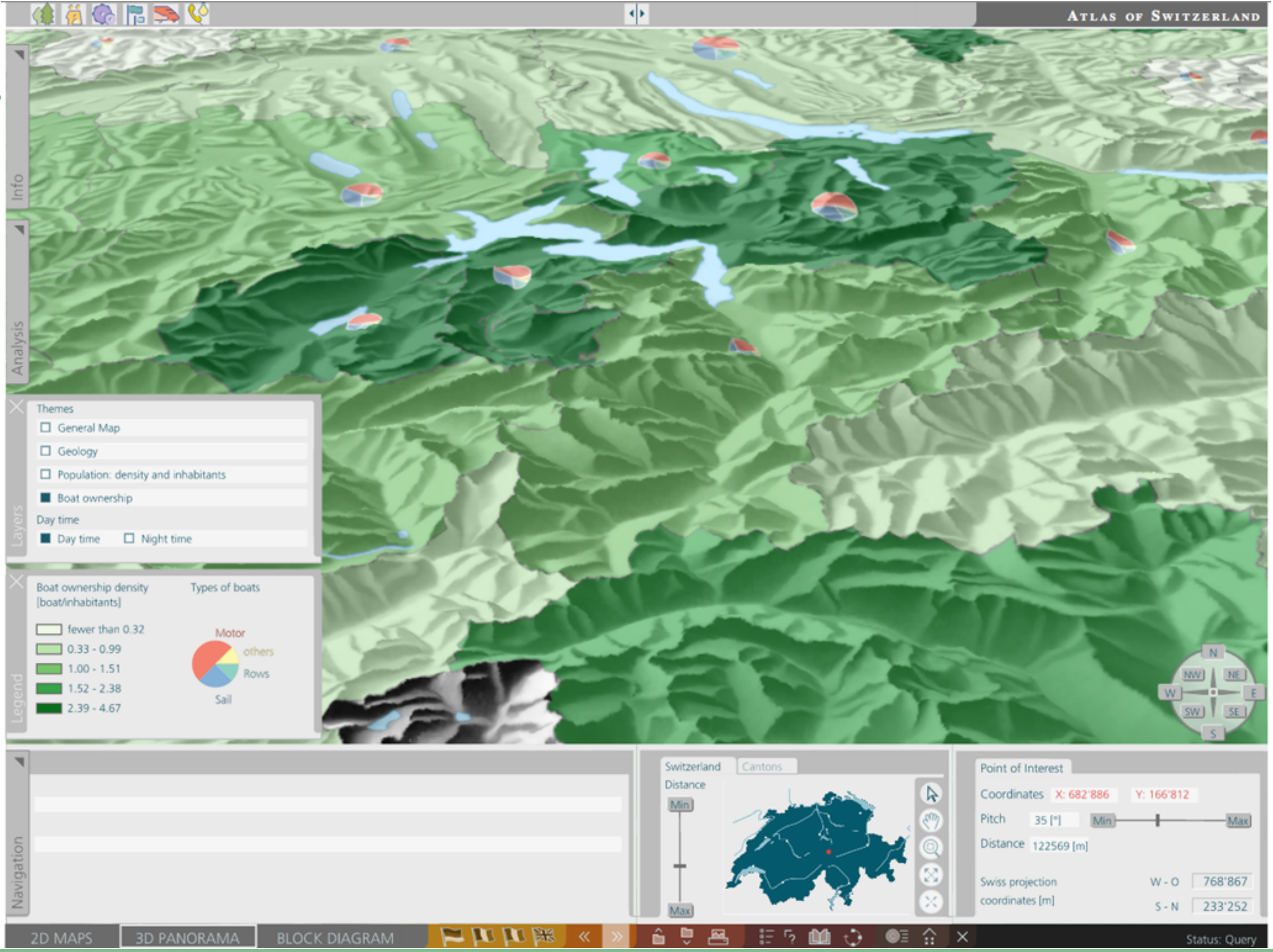
- Additional web services
  - DEM web service (exists, not integrated)
  - 3D symbols web service (does not exist)
- Emergence of virtual globe for cartographic purposes for world atlas
- 3D objects with WebGL

Thank you for you attention, any questions?


Info
Analysis
Layers
Themes
General Map
Geology
Population: density and inhabitants
Boat ownership
Day time
Day time
Night time
Legend
National border
Agglomeration
Main roads
Airport
Lakes
Rivers
Forest
N
NW
NE
W
E
SW
SE
S
Navigation
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 682'886
Y: 166'812
Pitch
35 [°]
Min
Max
Distance
60918 [m]
Swiss projection coordinates [m]
W - O
483'567
S - N
274'288
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query


Atlas of Switzerland
Info
Analysis
Layers
Themes
General Map
Geology
Population: density and inhabitants
Boat ownership
Day time
Day time
Night time
Legend
Quaternary
Tertiary sediments
Mesozoic sediments
Paleozoic sediments
Magmatic rocks
Metamorphic pre-mesozoic rocks
Water bodies
Glacier, firn
N
NW
NE
W
E
SW
SE
S
Navigation
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 682'886
Y: 166'812
Pitch
35 [°]
Min
Max
Distance
56507 [m]
Swiss projection coordinates [m]
W - O
706'335
S - N
291'875
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query


Atlas of Switzerland
Info
Analysis
Layers
Themes
General Map
Geology
Population: density and inhabitants
Boat ownership
Day time
Day time
Night time
Legend
Populatin density [inhabitants/km2]
fewer than 10
10 - 20
20 - 50
50 - 100
100 - 200
500 - 1'000
1'000 - 2'000
2'000 - 3'000
3'000 - 4'000
4'000 - 5'000
5'000 - 12'000
5'000 inhabitants
100'000 inhabitants
N
NW
NE
W
E
SW
SE
S
Navigation
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 682'886
Y: 166'812
Pitch
35 [°]
Min
Max
Distance
65316 [m]
Swiss projection
coordinates [m]
W - O
489'430
S - N
172'674
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query


Info
Analysis
Layers
Themes
General Map
Geology
Population: density and inhabitants
Boat ownership
Day time
Day time
Night time
Legend
Boat ownership density [boat/inhabitants]
fewer than 0.32
0.33 - 0.99
1.00 - 1.51
1.52 - 2.38
2.39 - 4.67
Types of boats
Motor
others
Rows
Sail
N
NW
NE
W
E
SW
SE
S
Navigation
Switzerland
Cantons
Distance
Min
Max
Point of Interest
Coordinates
X: 682'886
Y: 166'812
Pitch
35 [°]
Min
Max
Distance
122569 [m]
Swiss projection coordinates [m]
W - O
768'867
S - N
233'252
2D MAPS
3D PANORAMA
BLOCK DIAGRAM
Status: Query

Strengths & Weaknesses

	Globe Capture & WMS	WebGL & WMS
Strengths	‣ very thin client ‣ cross-platform	‣ intuitive navigation ‣ 3D symbolization
Weaknesses	‣ point and labels symbology (WMS) ‣ 3D symbolization ‣ absence of standard ‣ performance	‣ point and labels symbology (WMS) ‣ size limitation ‣ not cross-platform ‣ more strain on the GUI