Westfälische Wilhelms-Universität Münster

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External Studies - Project Report

Project:	Atlas of Switzerland
Place of work:	Institute of Cartography and Geoinformation (IKG), ETH Zurich
Address:	Wolfgang-Pauli-Straße 15, 8093 Zurich, Switzerland
Duration:	29.08.2011 - 24.02.2012
Amount of work:	900h (30 ECTS)

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Introduction

Place of work description

My internship took place at the Institute of Cartography and Geoinformation (IKG) at ETH Zurich. The institute is headed by two professors, Prof. Lorenz Hurni and Prof. Martin Raubal. About 25 further postdoctoral researchers, doctoral students and research assistants work there. The institute is specialized in topographic cartography, thematic cartography and atlas cartography. Besides the Atlas of Switzerland, the IKG is known for publishing the Swiss World Atlas and A Literary Atlas of Europe. The main research aim is the development of new cartographic information and interaction methods. Modern cartographic tools and GIS software are part of teaching curriculums. (Hurni, Institute of Cartography and Geoinformation, 2011)

Project description

The Atlas of Switzerland is a digital collection of high-quality 2D and 3D maps of Switzerland and Europe (Figure 2). It comprises 2,000 themes from the fields of transportation, energy, communications, nature and environment, society, economy, State and politics. Several base maps, a terrain model, as well as celestial data put these thematic maps into context.

The atlas offers multiple display options, like night sky in panorama or a mountain climber view (Figure 3). In 3D mode, you can choose between panorama maps, block diagrams and prism maps. All maps are highly customizable and exportable. In addition, simple analyses can be performed. For example, you can compare maps on split screen, animate maps over time, visualise line of sights and compute height profiles. (Hurni, Atlas of Switzerland, 2011)

Project staff

The Atlas of Switzerland team consists currently of the project manager, Dr. René Sieber, two editorial assistants, Benedicte Odden and Livia Hollenstein, and a software architect, Remo Eichenberger.

Project background

The history of the Atlas of Switzerland goes back to 1960. At that time, Prof. E. Imhof initialised the project at ETH Zurich. Five years later, a first printed version of the atlas was published. This edition contained 96 national map sheets from various themes and in three languages. In the following years, the atlas was continually improved by updating data and by adding new maps. With the rise of computer technology and cartographic software, a digital version of the atlas has been developed. Here, the first release was in year 2000. The current version - as described above - is the Atlas of Switzerland 3. (Sieber, 2010)

Objectives

As a recapitulation, here are the objectives summarized from the Learning Agreement:

- Provide scripts to convert automatically existing datasets in compliance with web mapping standards in terms of storing, describing, styling, serving and tiling
- Visualise the transformed data on a virtual globe
- Choose and prepare 8 to 10 exemplary maps for presentation purposes
- Describe and evaluate current web mapping software for integrating new maps in future

Contribution to larger project

From 2012 on, a web-based version of the Atlas of Switzerland is planned. Additionally to computers, it shall be available for tablet PCs and smartphones. Beyond that, the atlas team plans to provide a so-called SwissAtlasPlatform. This platform shall serve as a software development kit (SDK) for other national atlases (e.g. the Historical Atlas of Switzerland). With this, partners shall be able to integrate their own maps and to implement custom modules tailored to their purposes. Being compliant to nowadays web mapping standards will be beneficial for many reasons:

1. Keeping data in a spatial database allows executing special analysis functions, ensures consistency and regulates the authorisation of users.
2. Maps can be discovered in national or international geoportals after having annotated them with standardized metadata.
3. In connection with the Web 2.0, users might soon contribute their own maps to the atlas. Agreeing on common styling rules facilitates this process.
4. Maps can be embedded in applications by partners or in exercises by students.
5. External cartographic and GIS tools can be used for data processing.

As a visualisation engine for the next version of the Atlas of Switzerland, a virtual globe is introduced. A three-dimensional view on the world will be more appealing to users, especially in a mountainous country like Switzerland. Also, navigation on a virtual globe will be more intuitive. (Hurni, Sieber, Eichenberger, Hollenstein, & Odden, 2011)

Workflow

Overview

As an introduction to this chapter, you can see in the Gantt chart below (Figure 1) which stages the project underwent:

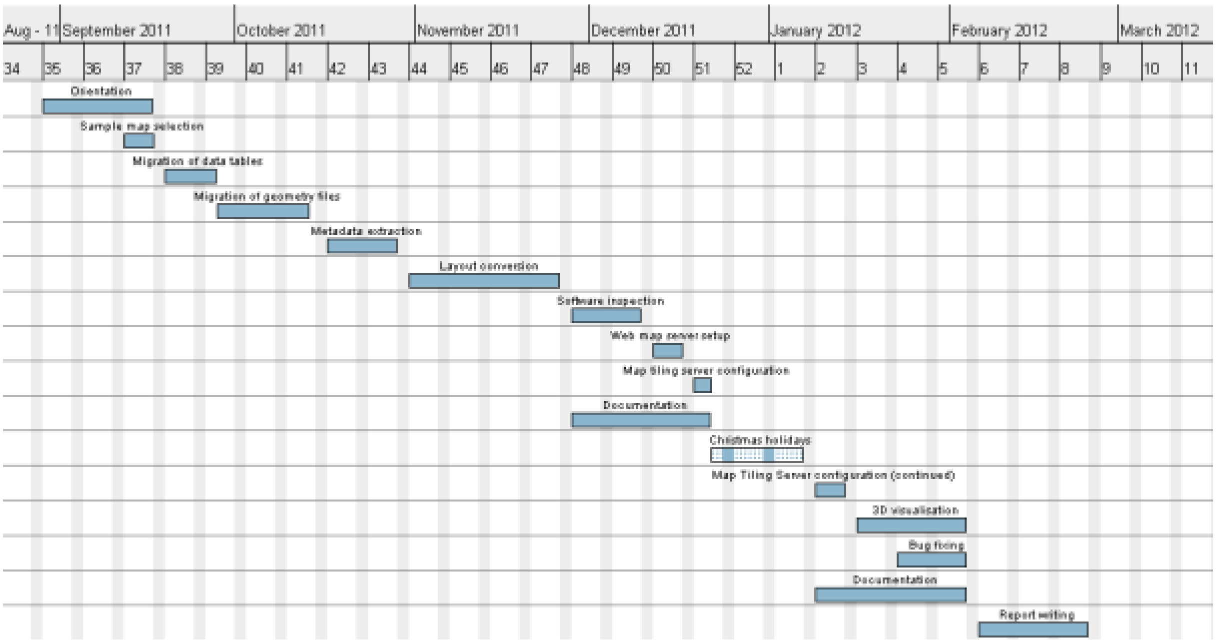

Figure 1: Work packages (overview)

Orientation

In the first weeks of my internship, I got to know the Atlas of Switzerland 3 in detail. I examined maps from various themes and tried out different interaction possibilities. Accompanying, I read the conceptual plan for the years 2012 to 2020 (Hurni, Sieber, Eichenberger, Hollenstein, & Odden, 2011). To gain a better understanding of the history of the project, I also had a look at the former paper-based version. Moreover, I started to familiarize myself with the internal data structure. Since the atlas makes use of many proprietary formats, this was not that easy. A deeper understanding of individual components followed in the subsequent weeks. Next to the preoccupation with the atlas, I assessed current web mapping standards and tested web mapping software such as ArcGIS Server[1] and QGIS Server[2]. I compiled my findings in the Learning Agreement which was reviewed by my internal and external supervisor. The Learning Agreement includes a project description, identifies objectives and contains a working plan.

Sample map selection

Because the current version of the Atlas of Switzerland contains more than 2000 maps, it was clear that I could not convert all of them due to the limited time frame of this internship. That is why I chose a representative sample set for testing purposes. Criteria for this selection were the region - Switzerland or Europe -, the geometric representation - vector (point, line, polygon) or raster -, the

[1] http://www.esri.com/software/arcgis/arcgisserver/index.html
[2] http://qgis.org/about-qgis/features.html

level of measurement - nominal, ordinal, interval or ratio - and visual variables - colour hue or value, size, or shape. The following table illustrates my choice:

Map name	Region	Geometry	Scale type	Visual variables
Wildfires	Switzerland	Point	Nominal	Colour hue
Airports	Switzerland	Point	Nominal	Shape, colour hue, size, rotation
Population: annual data	Switzerland	Point	Ratio	Colour value, size
Natural gas: supply	Europe	Point, line	3 x Nominal	Symbol, colour value, size
Hiking: level of difficulty	Switzerland	Line	2 x Ordinal	Colour hue, size
Natural gas: pipelines	Switzerland	Line	Ratio	Colour value, size
Cantons	Switzerland	Polygon	Nominal	Colour hue
Dominant language	Switzerland	Polygon	Nominal, ratio	Colour hue and value
Activity rate	Switzerland	Polygon	Ratio	Colour value
Main tree species	Switzerland	Raster	Nominal	Colour hue
Diversity of tree species	Switzerland	Raster	Ordinal	Colour value
Precipitation: annual mean	Europe	Raster	Ratio	Colour value

Table 1: Selected sample maps

Maps with charts (e.g. pie and bar charts) were not included because these are not supported by the current version of the SLD specification (Lupp, 2007). Also not considered were special cases such as maps with labels (e.g. European weather conditions) or certain line maps (e.g. Flight movements on a typical day). A distinction between 2D and 3D mode of the atlas has not to be made, since data, styles and geometries can be handled analogously. A later on performed database query showed that approximately 85% of map layers are covered by this selection.

Migration of data tables

In the Atlas of Switzerland 3, feature data are stored in Tab-separated values. This allowed mapping these files nearly 1:1 into database tables. Only slightly different data types had to be chosen and integrity checks had to be performed (e.g. against duplicate IDs, file names and SQL naming rules). Information and warning messages, I stored in separate log files. By the end of the internship, all table files could be integrated successfully into the database (Figure 4).

In favour of the other implementer, I decided to choose Python as programming language so that my scripts could be reused in future. From syntax and programming paradigm, Python is very similar to Java, so it was not a major change for me. Sometimes, it was challenging to embed external libraries and to handle different text file encodings.

A side problem was that the Tab-separated values had to be decrypted from binary files. This was only possible with an internal tool. However, there only one text file could be processed at once which had to be dragged manually into the application. After a good hint by the other programmer in the team, I could bypass this time-consuming task by writing an AutoIt[3] script which simulates the Drag & Drop movement.

[3] http://www.autoitscript.com/site/autoit/

Migration of geometry files

Modified SVG files were used in Atlas of Switzerland 3 for storing point, line and polygon geometries. To integrate them into the database, an internal georeference element had to be parsed and applied on the values. Geometries for Switzerland were projected in the reference system CH1903 / LV03 (EPSG code: 21781); geometries for Europe in a custom Lambert Azimuthal Equal Area projection.

Second, all Bézier curves had to be replaced by straight line segments. Bézier curves are not part of the current OGC Simple Feature Access specification (Herring, 2011) and are also not well-supported by main spatial database systems. It turned out that Python had not any convenient libraries for manipulating SVG files. That is why I chose to program this time in JavaScript since SVG files can be read by all major web browsers (Figure 5). The drawback of this approach was that the database could not be accessed directly anymore. As a workaround, I set up a local server which established this connection. For this, I had to familiarize myself with programming asynchronously. On top, it was not easy finding an algorithm which approximates Bézier curves by straight line segments. I finally implemented an extension to an existing version I found in the web (Kistner, 2011). These obstacles were quite time consuming so that the stage took a week longer as expected. Due to time buffer at the end and since the time frames for other phases fitted well, this had not any further consequences.

Raster data in form of ASCII grids were left out since by this time only experimental versions of PostGIS 2[4] were available.

Metadata extraction

For this phase, I compared at first metadata elements of the GM03 – Metadatenmodell (Schneeberger, 2005), the Swiss metadata standard, with the INSPIRE Metadata Implementing Rules (Craglia, 2010), the European metadata standard. Both standards are based on the international ISO 19115 metadata standard (ISO, 2003), so many similarities could be found between both. My final selection of metadata fields conforms to the ISO and INSPIRE standard and is compatible to the Swiss metadata standard.

The metadata elements had to be assembled from different sources: Map titles in four languages were given an XML document. Map contacts, such as the processor and the owner, were taken from an Excel sheet. Bounding boxes had to be calculated from the geometries. Temporal extents could be inferred from map description files. Thumbnails were kept in separate image files. Except for the thumbnails, I wrote all elements into the database for which I defined a custom schema. From there, ISO and MEF files could be created. These files I validated with GeoNetwork[5] (Figure 6 and Figure 7) and the INSPIRE Metadata editor[6].

For this and the following phases, I programmed in Python again. Progress in this work package was quite straight-forward. Just in the Excel file, some small inconsistencies occurred (e.g. orthographic mistakes in map titles). I reported those to the map editorial staff who corrected them. In contrast to the original plan given in the Learning Agreement, I switched the metadata extraction phase with the layout conversion. It appeared more logical to me first handling the data and then take care of the visualisation part.

[4] http://www.postgis.org/
[5] http://geonetwork-opensource.org/
[6] http://inspire-geoportal.ec.europa.eu/editor/

Layout conversion

In the next phase, I converted map layouts which were defined in a proprietary format, so-called map description files, according to OGC's Styled Layer Descriptor (Lupp, 2007). Four weeks were a good estimation for this task: In the first week, I concentrated on layouts for polygons, in the second on lines, in the third on symbols and in the last on raster data (Figure 10 to Figure 17). Accompanying, I had to program a little interpreter which solves formulas explicitly for SLD.

In my script, it is possible to choose between SLD version 1.0.0 and 1.1.0 since the latest standard is not incorporated in many applications yet. However even with version 1.1.0, it is not possible to include charts and visualise symbol sizes and line widths according to the zoom level. As background information to this topic, I read a master thesis about service-oriented map generation for web-atlases (Ortner, 2011) and a dissertation about cartographic web services (Iosifescu Enescu, 2011).

Software inspection

Next, I examined a series of tools which create files or offer services compliant to nowadays web mapping standards. The motivation behind this was finding a workflow for integrating new maps in future. After a brief characterization, I tested each tool in a basic setup. My findings I recorded in an internal document. At the end, I gave a recommendation which tools are best suited for the next version of the atlas.

Component	# Tested	Best candidate	Main reason
Spatial Database	3	PostGIS	Interoperability with other GIS software
SLD Creator or Export Plugin	6	AtlasStyler and GeoExt Styler	AtlasStyler has the most features, GeoExt Styler convinced by its easy usability
Spatial Metadata Editor	7	GeoNetwork	Most customizable, web-based
Web Map Service	4	GeoServer	Good usability, RESTful API for automation
Map Tiling Service	5	MapProxy	Most features, neat testing environment

Table 2: Recommended web mapping tools

The recommended tools were tested by one of the editorial assistants. With only little help from my side, the assistant managed to style and upload three new maps.

Web map server setup

In the previous work phases, I already visualised intermediary results with GeoServer[7] - a commonly used web map server implementing the Web Map Service (WMS) specification (de Beaujardiere, 2006). Also in comparison to other web map servers, GeoServer remained the best-suited tool for the atlas (Figure 8 and Figure 9). A web map server accesses the database and consumes tables containing feature data and attached geometry columns. After this, styles in form of SLDs are applied to the data and a map image is rendered (Figure 18 and Figure 19).

To automate the configuration, I created database views which join tables and geometries based on shared IDs. Next, I wrote scripts for registering these views and raster files as layers and another one for uploading the styles. A final script assigned the styles to the layers. A HTTP adapter in Python and

[7] http://geoserver.org/

the RESTful API of GeoServer facilitated this task. Accompanying, I read an ArcGIS Server tutorial (ESRI, 2010) which gave me a colleague from the institute.

Map tiling server configuration

After having set up GeoServer as Web Map Service, I configured MapProxy[8] as map tiling server (Figure 20). A map tiling server can be put in front of a WMS to store map tiles in advance or alternatively when the client accesses them. These can then be much faster loaded than rendering the map each time on-the-fly. In the last years, four tiling specifications have evolved: two from OSGeo – the WMS Tiling Client Recommendation (WMS-C) and the Tile Map Service Specification (TMS) - and two from OGC – the Web Map Tile Service Implementation Standard (WMTS) and the KML-Superoverlay (Jurk, 2010). At the moment, MapProxy supports the three latter standards. With my experiences from the previous stages, it did not take much time writing a script which creates automatically a convenient configuration file.

3D visualisation

The last part of my internship consisted of visualising the chosen sample maps in a 3D environment. In advance, the Atlas of Switzerland team has assessed different virtual globes. From all, they valued osgEarth[9] the best. Since osgEarth is written in C++, the software engineer gave me a compiled version of it. With that one, I could test different WMS and TMS connections. In all cases, the globe rendering was still quite slow, however once loaded, it was nice to look at (Figure 21 to Figure 26).

Bug fixing

In this phase, one of the editorial assistants followed my documentation and set up a working environment on her computer to run my scripts. In case anything was unclear, I helped her and improved the documentation at this point. She tested my scripts with further sample data. At some points, some bugs occurred. Fortunately, they were not as severe, so I could fix them promptly.

Documentation

Within my internship, I created the following documents:

- The Learning Agreement
- A comparison of current web mapping standard implementations
- Ideas for potential master theses and study projects in connection with the atlas
- Detailed instructions about how to execute my scripts
- Enhancements for migrating the remaining data from the Atlas of Switzerland 3
- Suggestions for naming conventions for files and database tables in future
- The Project Report

Each time I finished creating a document, I sent it to the whole team and discussed it individually with a member of the team.

[8] http://mapproxy.org/
[9] http://osgearth.org/

Miscellaneous

Besides my scheduled tasks, I did some smaller jobs for the other team members. For the project manager, I brought in some ideas for an article called “Future of Cartography” he wrote for an ESRI journal. I also revised an abstract he submitted on the occasion of the 60th German Cartographer’s Day in Hannover 2012. Another time, I helped one of the editorial assistants to process glacier data in ArcGIS so that she could continue working on them. Moreover, I wrote scripts to detect inconsistencies in the current version of the atlas, for example legacy files. Lastly, I sent in bug reports to some of the web mapping tools I have tested, namely ArcMap2SLD[10] converter, QGIS Server[2] and GeoServer[7].

[10] http://apps.geoinform.fh-mainz.de/arcmap2sld/

Work-related aspects

Communication

Once per week, we had a team internal meeting. There, we spoke about the current work progress, difficulties that occurred, how we plan to solve them and what else we plan to do. With my internal supervisor, I had spontaneous individual chats every, or every second week. At these occasions, I informed him about how my work is proceeding. Sometimes, I showed him intermediary results on my computer. With my external supervisor, I had e-mail contact in the first months and at the end of my internship.

Every three to four weeks, there was an institute meeting. Here, all things on departmental level were discussed. Within the team, small chats about immediate problems arose from time to time. For example, the software architect asked me questions about spatial databases and web mapping components. In return, he gave me valuable hints in programming.

Working atmosphere

The work climate within the team and also within the institute was relaxed and friendly. I had no conflicts with colleagues or superiors. Most of the time, I worked independently, but not isolated. Occasionally, I tested network related parts with the other software architect in the team. It did not take much time that I felt part of the team. I think I have been a good enforcement, especially in the fields of GIS, web map standards and databases.

Professional networking

In the course of my internship, my internal supervisor introduced me to the following people:

Person	Institution	Context
Prof. Sara Fabrikant, Dr. Arzu Çöltekin	Department of Geography, University of Zurich	In a first meeting, we spoke about the state of play in the atlas and research topics. In another meeting, we elaborated potential master theses. At this, the Atlas of Switzerland provides sample data. Prof. Fabrikant and Dr. Çöltekin contribute the facilities for empirical analyses (such as eye tracking).
Dr. Thomas Burri, Donat Fulda, Mark Simoni	Swiss Geotechnical Commission, ETH Zurich	Similar to the Atlas of Switzerland, the team of the Geotechnical Environmental Atlas plans a web-based version of their atlas. In a meeting, we presented temporary results of our work to each other, discussed possible web mapping architectures and exchanged database schemas.
Ernst Hutzler	Institute of Cartography and Geoinformation, ETH Zurich	Ernst has programmed several plugins for Adobe's MAPublisher[11]. One of these replaces Bézier curves by straight line segments. In a meeting, he explained this algorithm to us.

Table 3: Professional meetings I

[11] http://avenza.com/mapublisher/

Furthermore, two research associates have worked for the Atlas of Switzerland during my internship:

Person	Institution	Context
Alžběta Brychtová	Department of Geoinformatics, Palacký University in Olomouc	Alžběta is a doctoral student from the Czech Republic. Her dissertation is about evaluating the density of symbols in maps.
Matthias Thöni	Department of Informatics, University of Zurich	Matthias is a doctoral student specialised in Computer Graphics. He tries to improve the terrain rendering of virtual globes.

Table 4: Professional meetings II

Beyond, I got to know all members of the Institute of Cartography and Geoinformation at daily cafeteria visits. On different occasions, I met former members of the Atlas of Switzerland.

Accompanying events

During my internship, I took part in the following events:

Date	Event	Description
07.09.2011	Workshop in Aarau	Here, the Atlas of Switzerland team discussed with partners (e.g. the Hydrological Atlas of Switzerland) basic guidelines and minimum requirements for the SwissAtlasPlatform.
13.09.2011	Werkschau Kartografie Schweiz	At this conference, latest trends and products in the field of cartography were presented.
07.11.2011	Excursion to ESRI Schweiz	Members of ESRI staff gave insights about current projects and about how the internal bug reporting procedure works.
10.11.2011	Lecture of Tim Sutton	Tim Sutton is one of the main contributors of Quantum GIS. In his lecture, he presented the human aspects of open-source development.

Table 5: Accompanying events

Competences

Used B.Sc. & M.Sc. Geoinformatics courses

All in all, I think I have been well-prepared by the courses of my curriculum for this internship. I believe the most important competence I gained from my studies is to be flexible and to acquaint oneself quickly in a new environment and with new tools. The more course-specific competences, I summarized in the table below:

Course	Helpful content
Spatial Information Infrastructures	Lectures and exercises in web mapping, OGC and ISO standards
Structure and Interpretation of Programming Languages	Ability to quickly adapt new programming languages
Databases & Geospatial Databases	Fundamentals of SQL, spatial functions
GIS Grundkurs & Exercises Advanced GIS	Exercises in ArcMap and ArcGIS Server
Digital Cartography	Cartographic rules
Reference Systems	Geographic and projected reference systems
Project Management	Project planning and organisation
Study Project	Communication, programming and documentation

Table 6: Used B.Sc. & M.Sc. Geoinformatics courses

Wished to have Geoinformatics courses

After my experiences from my internship, I can think of two courses which might be helpful for students in future. The first one, I would call "Programming Practices in Industry and Open Source projects". In this course, students could be trained in everything what is involved around programming. Things like commenting, logging, task tracking and organising, debugging, testing, merging and branching, bug-tracking and fixing, documenting and publishing could be covered in here. The second course could be titled "Exercises in Web Map Standards". Here, students could be given hands-on experience in spatial databases, metadata, styling, web map servers and tiling services. This course shall illustrate that standards are nothing to be afraid of and not as "dry" as the term implies. Bringing the gained knowledge to companies later might increase interoperability between different spatial data sources.

Gained competences

Below, I compiled a list of hard and soft skills I acquired during my external studies:

- Programming experience in Python and JavaScript
- Applying web mapping standards, particularly in terms of styling, metadata and tiling
- An overview about current web mapping tools such as spatial databases, metadata editors, SLD creators and export plugins, web map servers, tiling services, virtual globes
- A deeper cartographic understanding

- Team working and internal communication
- Task organisation
- Problem-oriented learning
- Understanding Swiss German

Future research

Research fields

My internship alludes to several research topics and questions which can be further examined.

In connection with migrating geometries into the database, I learned that Scalable Vector Graphics (SVG) is a popular file format in cartography. Especially the creation and storage of Bézier curves is very efficient. So, possibly the Simple Feature Access specification can be extended by this type of functions. A first approach in this direction has been made in "Freeform curves and surfaces in DBMS - a step forward in spatial data integration" (Zlatanova, Pu, & Bronsvoort, 2006).

Another aspect is the temporal component in web mapping. The Atlas of Switzerland contains several historical maps and maps about unique and cyclic events. At this, temporal navigation and interaction (Stopper, Neumann, Schnabel, & Wiesmann, 2012), for example by timelines, as well as the time parameter in the WMS specification can be analysed.

A key role in the new version of the atlas will play the 3D symbolisation. Up to now, the Styled Layer Descriptor (SLD) specification supports only two-dimensional data. The evolution from SVG symbols to COLLADA models, lines to pipes, polygons to polyhedrons, pixels to voxels and new mapping techniques (e.g. heat maps) have to be considered.

Partly relevant to the atlas and more of general interest is the security part in web mapping. Maps with sensitive data require sometimes hiding certain values and areas, or restricting zoom levels. This reading access as well as writing permissions - for example when uploading new maps or changing existing data - have to be defined for certain user groups. A candidate for this could be GeoXACML - the Geospatial extensible Access Control Markup Language (Matheus, 2011).

Lastly, research focus has to be laid on the mobile version of the atlas targeting tablet PCs and smartphones. A convenient mapping of elements and functions need to be found meeting the constraints on a mobile device (e.g. the smaller screen). Also, it has to be assessed which additional features and interaction methods can enhance the usage of an atlas on a mobile device.

Master thesis

To find a topic for my master thesis, I contacted Simon Jirka and Daniel Nüst from 52°North[12]. While working with virtual globes, I found them very suitable for visualising sensor data. Especially, I liked the idea of integrating real-time sensor data (e.g. current weather conditions) and tracking mobile entities (e.g. means of transportation). Simon proposed to research human user interfaces to sensor discovery. Daniel examined in his diploma thesis visualising interpolations of dynamic phenomena observed mobile sensors. Possibly, my master thesis will cover parts of all three topics.

[12] http://52north.org/

Conclusion

Results

12 sample maps and additional 31 base maps of Switzerland and Europe have been converted according to nowadays web mapping standards. The Atlas of Switzerland team has scripts at hand for migrating remaining datasets into standardized formats. Approximately 85 % of maps of the current version can be processed in this way. As a by-product, my scripts detect inconsistencies among data. Every time, I encountered any erroneous data I informed the map editorial staff so they could fix them. In a next phase of my internship, I characterised, tested and compared 25 web mapping tools. This will help the team in adding new maps to the atlas. Lastly, I gave ideas and enhancements for the henceforth development of the Atlas of Switzerland.

Final self-assessment

All in all, I am satisfied with the results I achieved in the past six months. Especially the final map visualisation on the virtual globe looks quite nice. However, there is still much work to do for the next version of the Atlas of Switzerland. Within the limited time frame of my internship, it was essential to tackle only a part of these tasks. The work plan, I elaborated at the beginning, helped me a lot in orientating what to do and how much time is available for each step. Most problematic has been the conversion of map geometries. The other phases went pretty well. Altogether, I would rate the difficulty of tasks to intermediate. To my point of view, I met all objectives I stated in the Learning Agreement. I see some room for improvement in my programming style and communication skills. I hope to gain experience in those by practice in the next years. In my internship, I learned applying web mapping standards I only knew beforehand from theory. Also, a new experience was to work in a professional team. Finally, I am very graceful to have got the opportunity to get insight in another institute, country and culture.

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Appendix

Figure 2: Atlas of Switzerland 3 - Initial screen

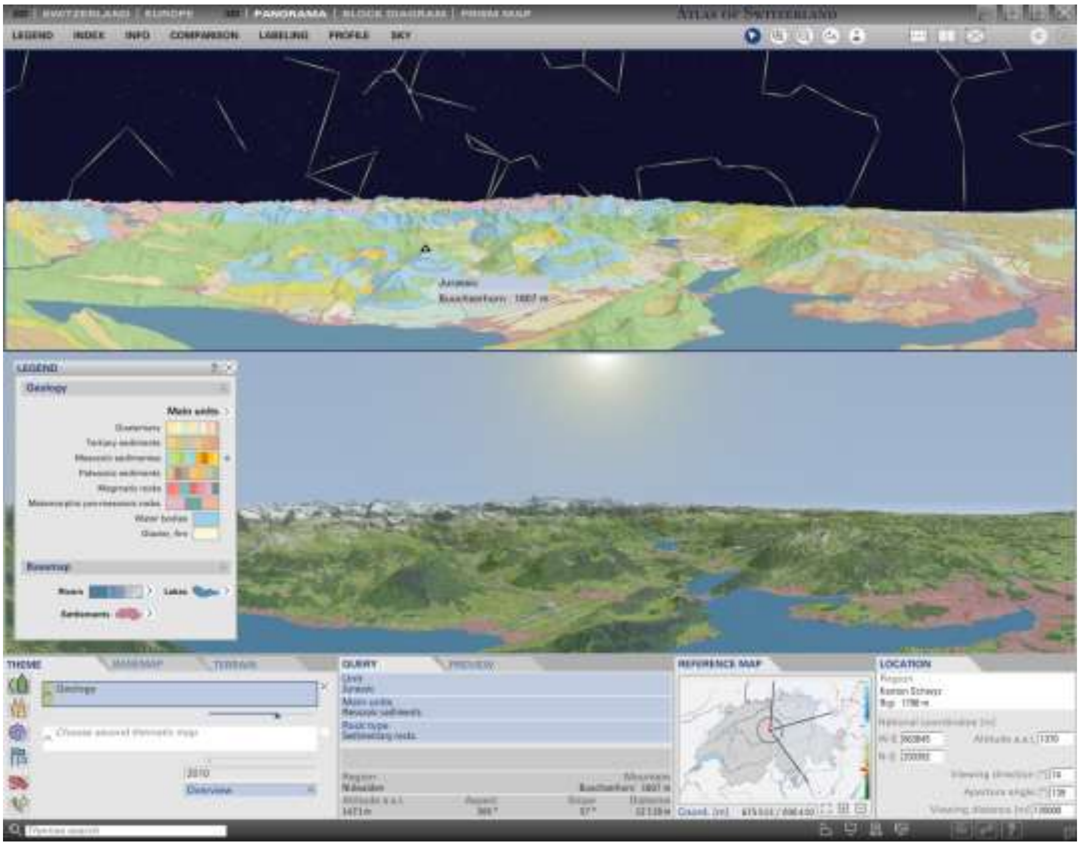

Figure 3: Atlas of Switzerland 3 - Exemplary map

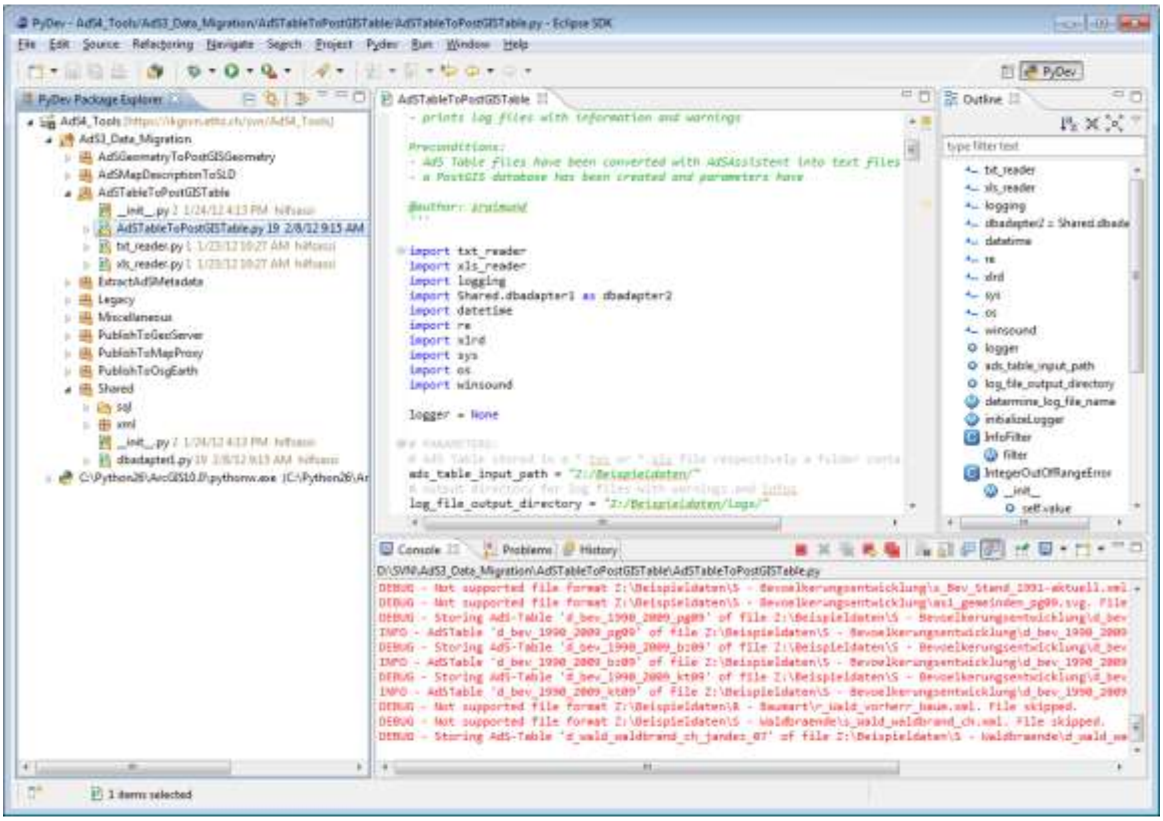

Figure 4: Integrating data tables into the database (with Python in Eclipse)

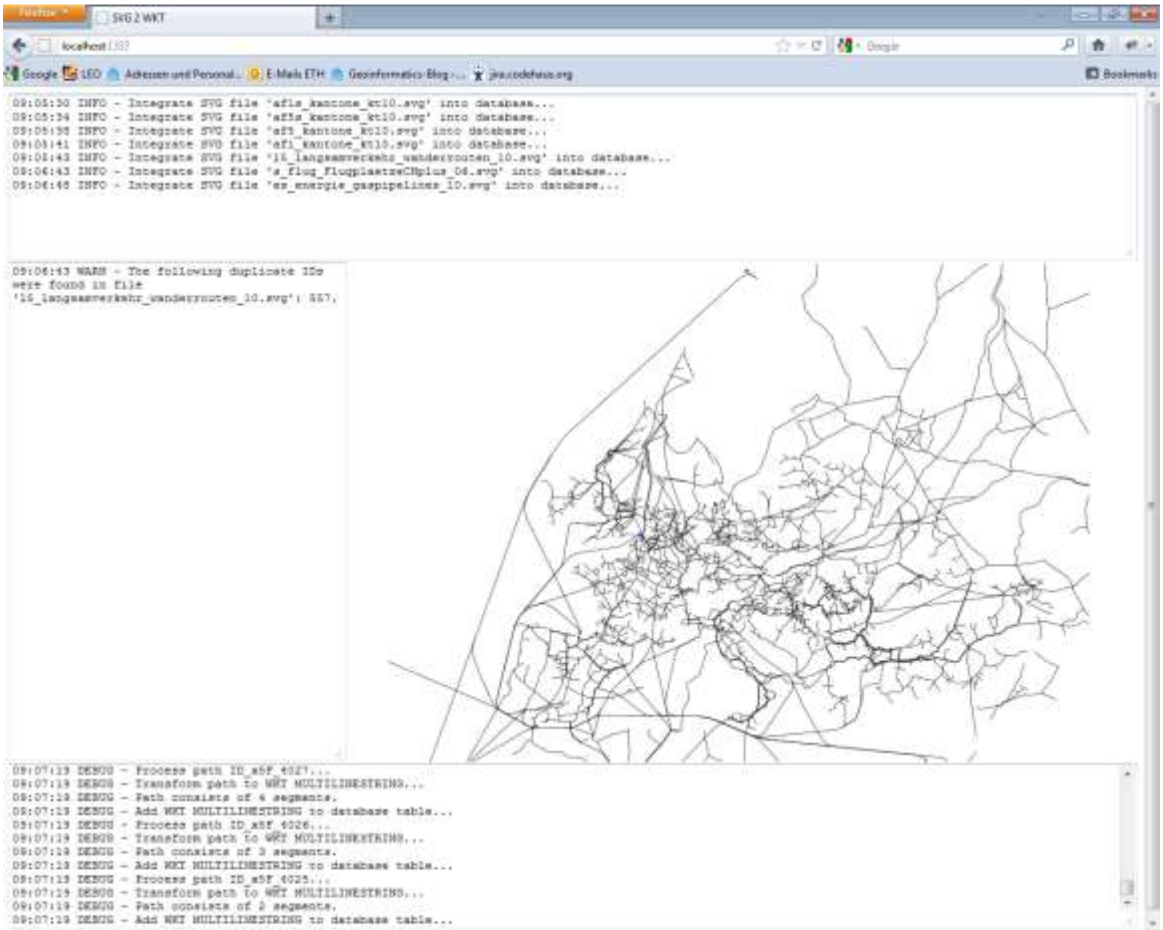

Figure 5: Integrating geometries into the database (with JavaScript in Firefox)

Figure 6: GeoNetwork - Map metadata (overview)

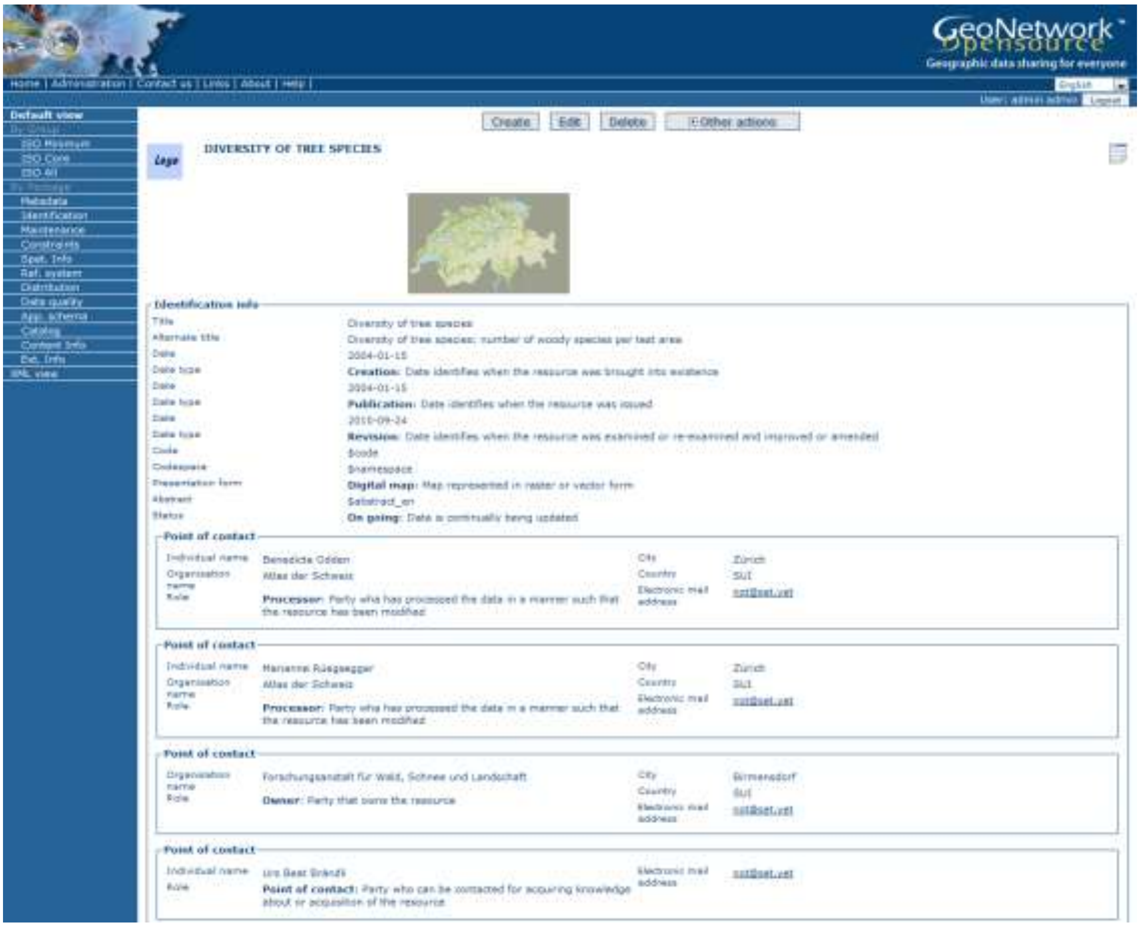

Figure 7: GeoNetwork - Map metadata (detailed view)

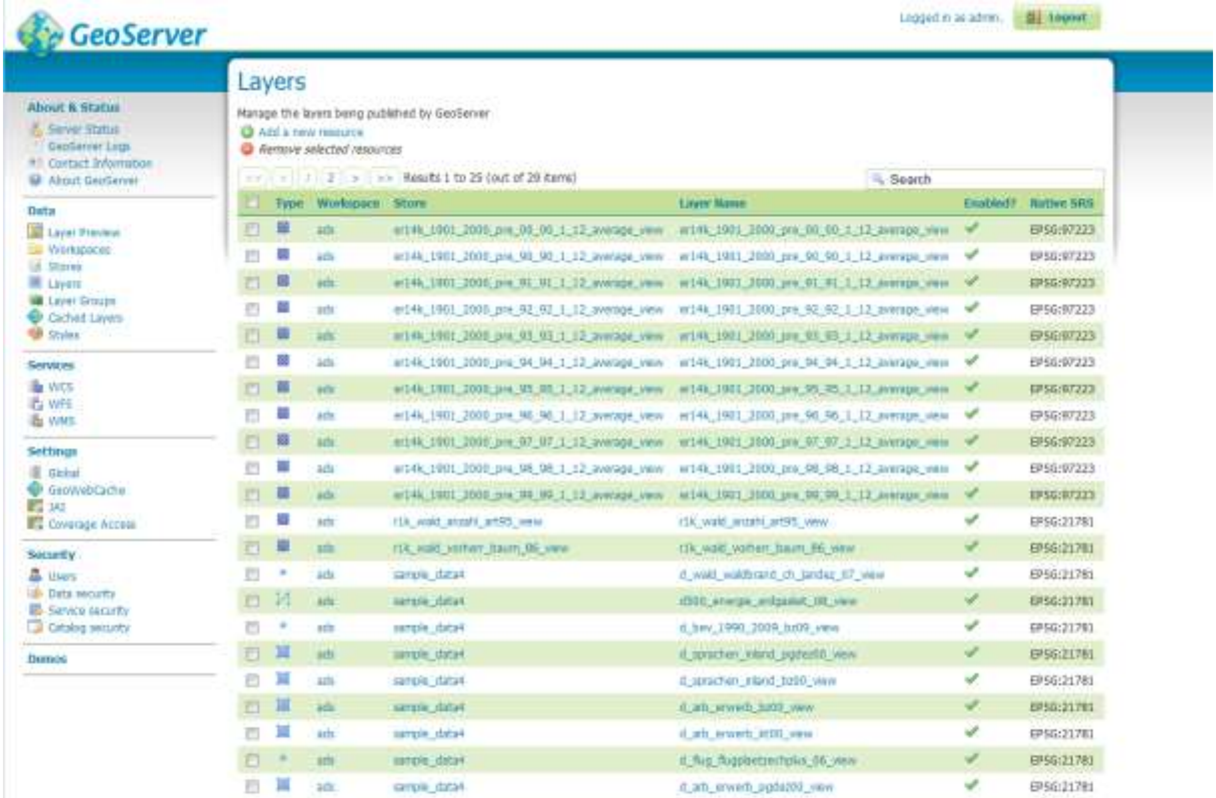

Figure 8: GeoServer - Map layers

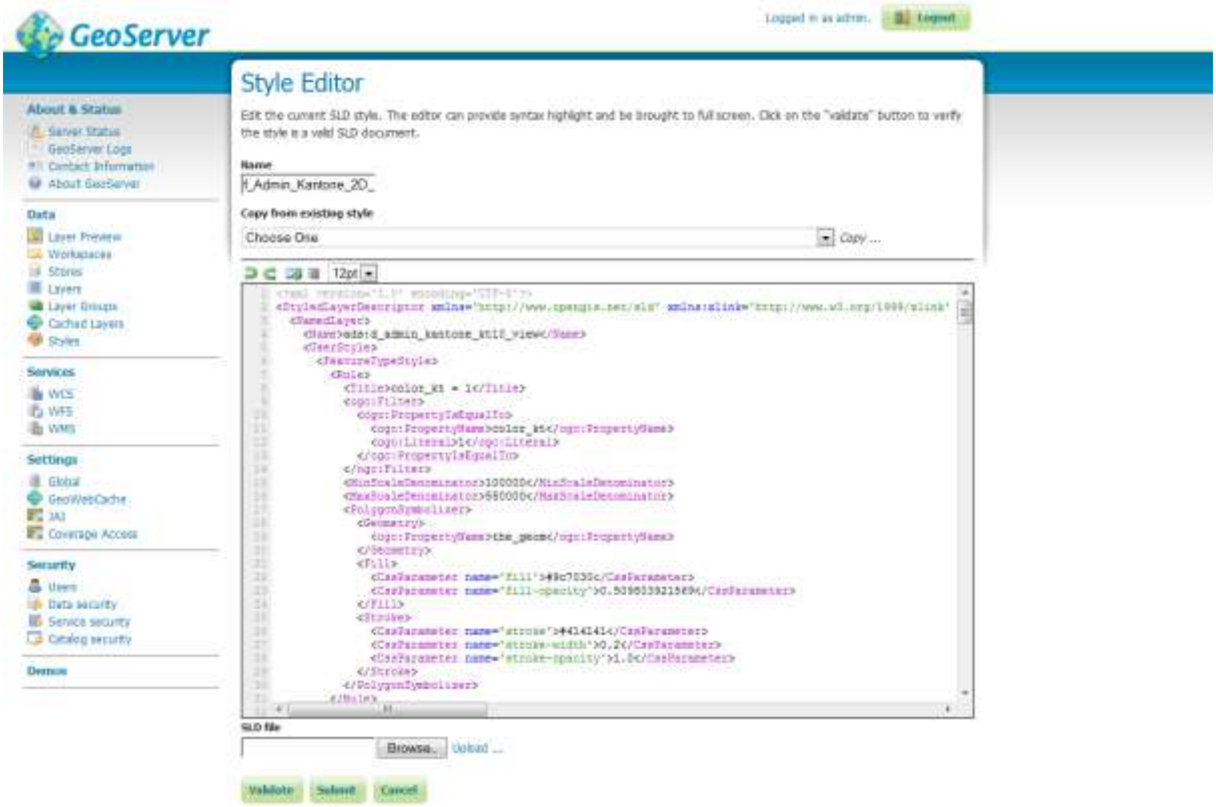

Figure 9: GeoServer - SLD editor

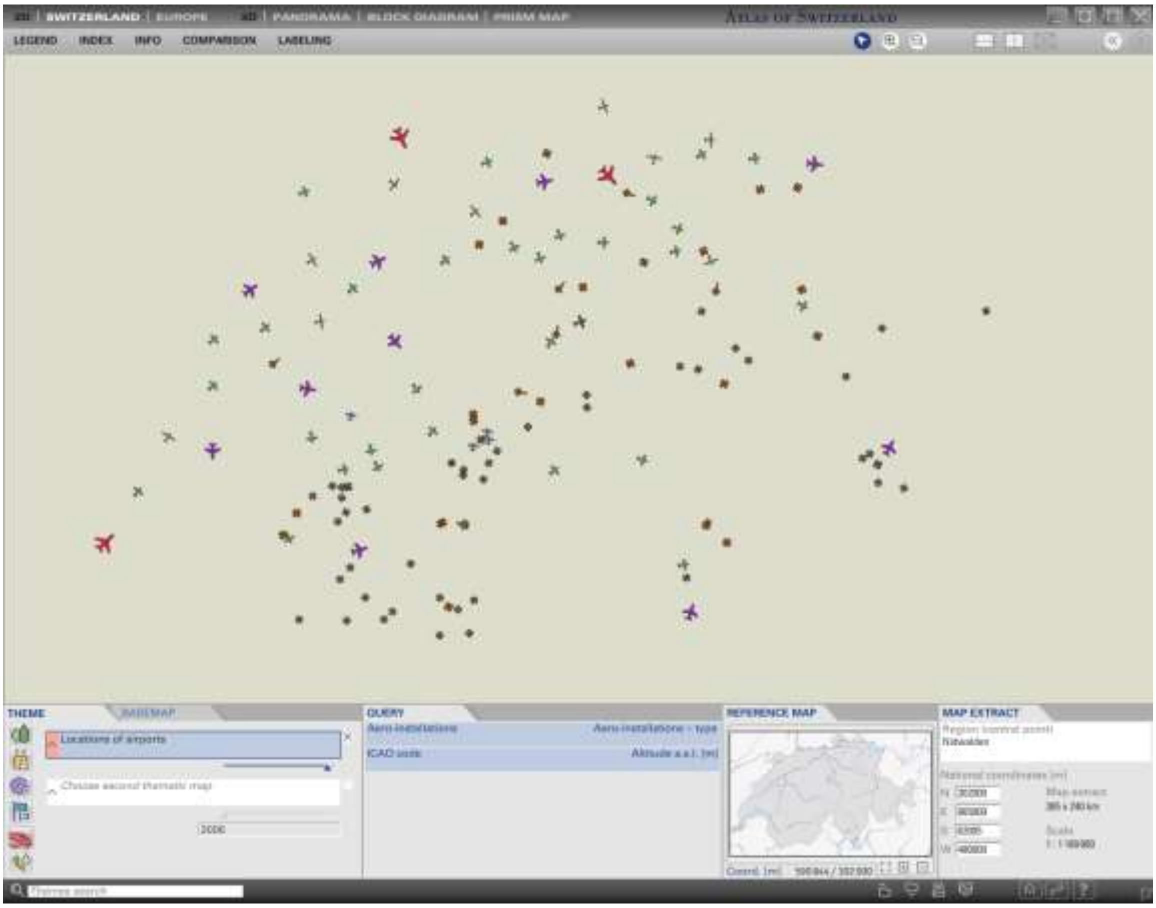

Figure 10: Atlas of Switzerland 3 - Airports

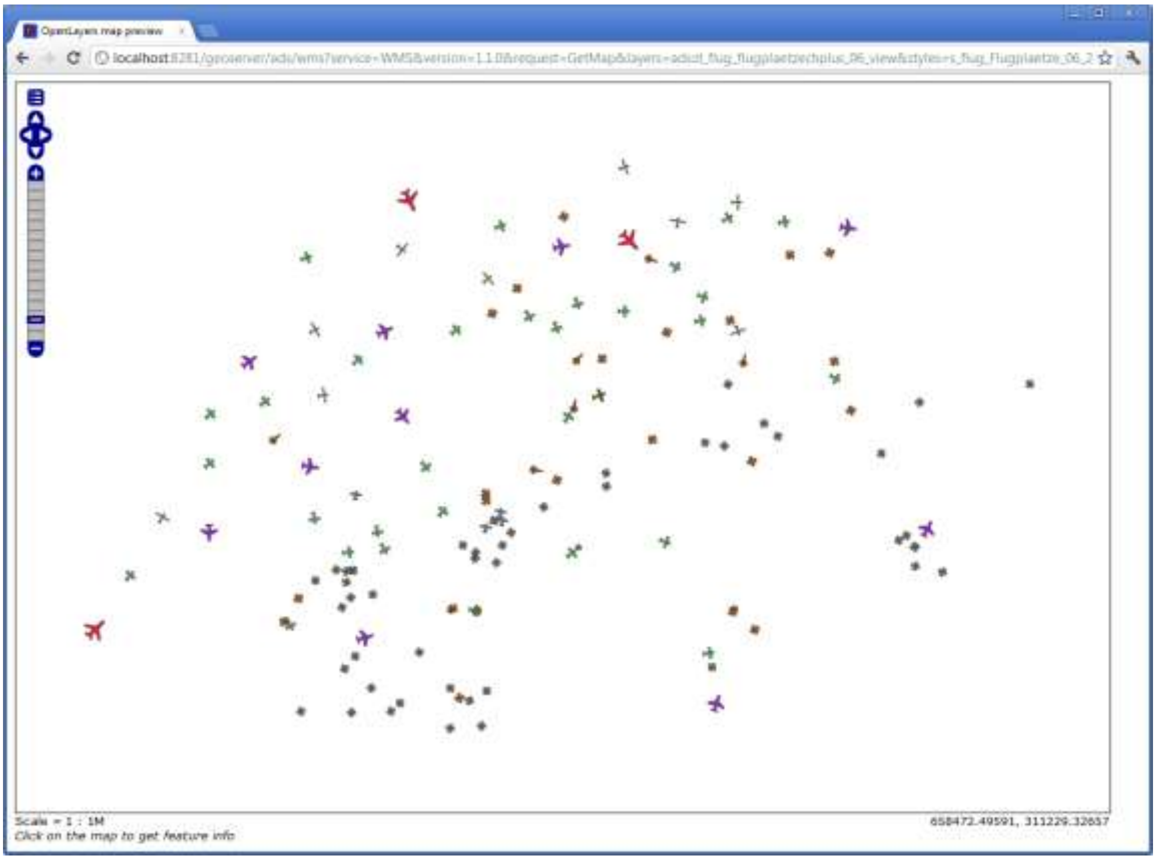

Figure 11: Web Mapping Replication (OpenLayers) - Airports

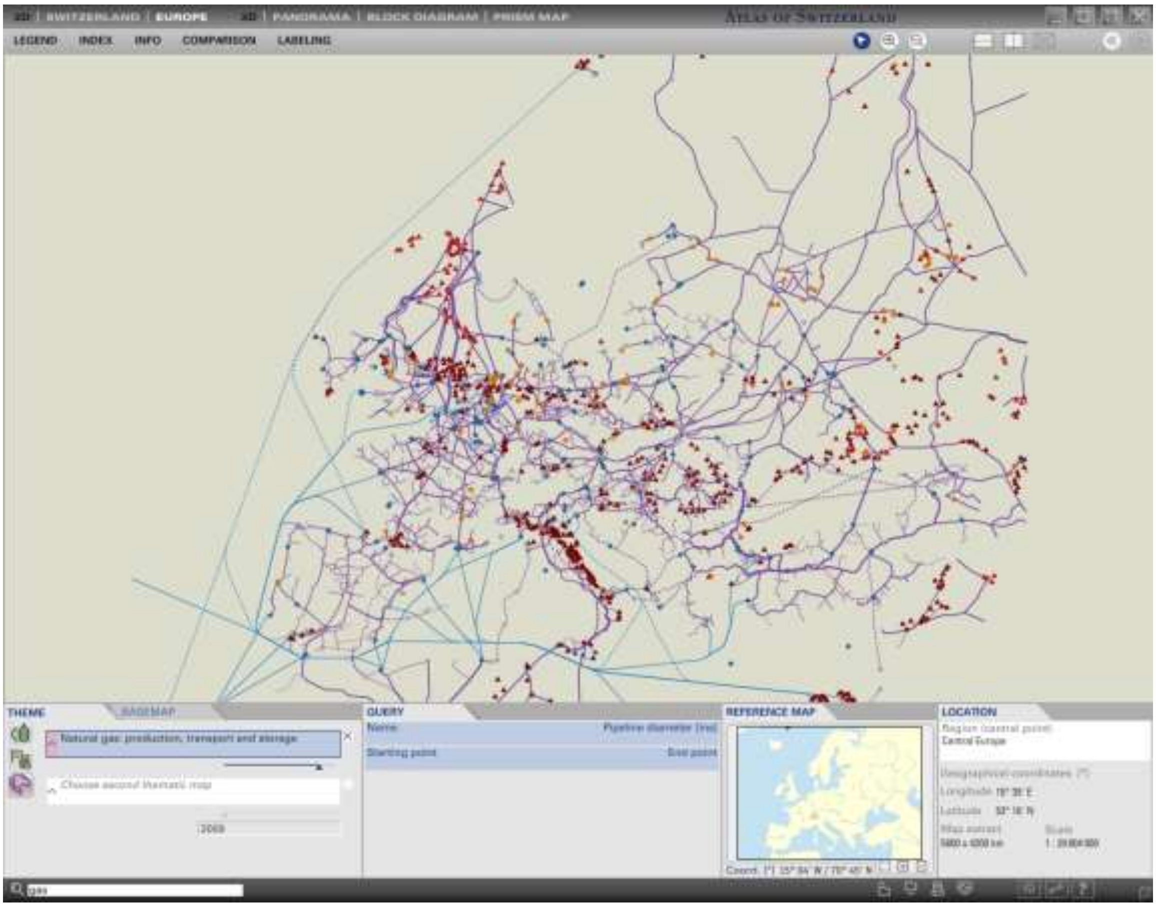

Figure 12: Atlas of Switzerland 3 - Natural gas supply

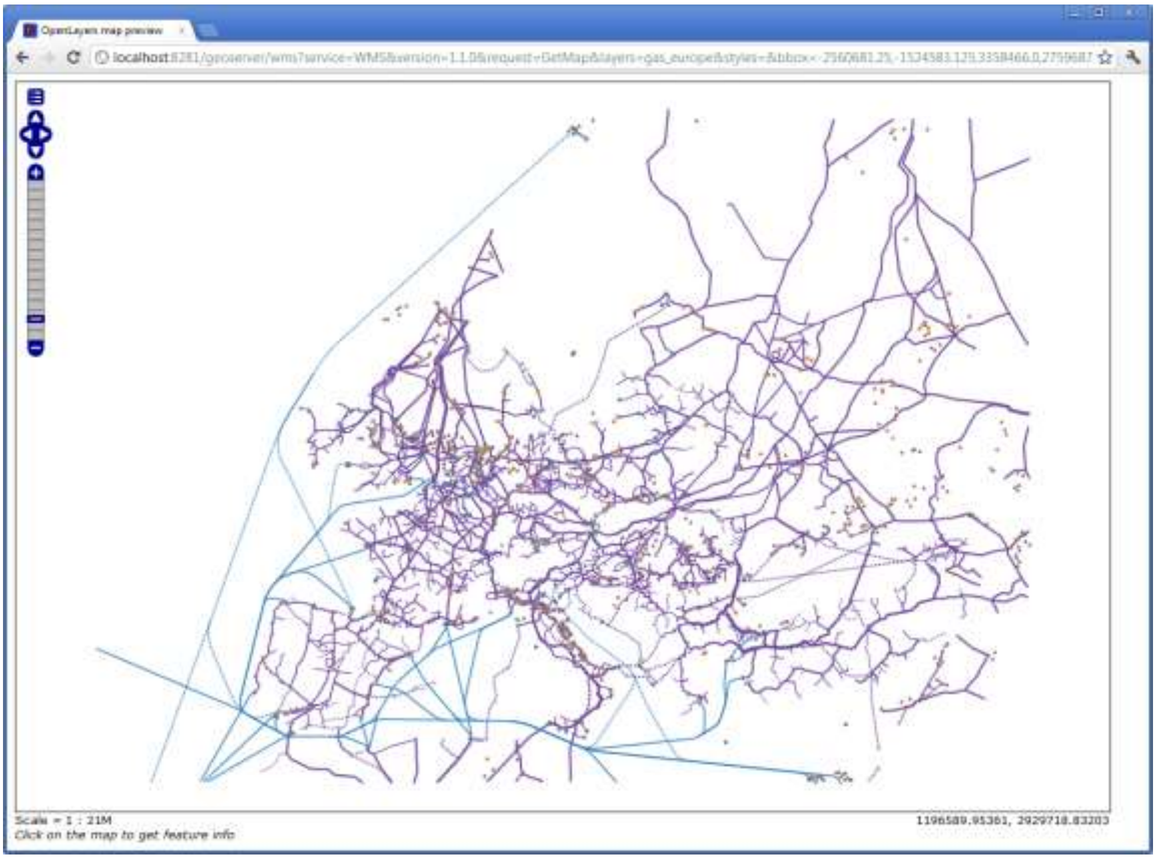

Figure 13: Web Mapping Replication (OpenLayers) - Natural gas supply

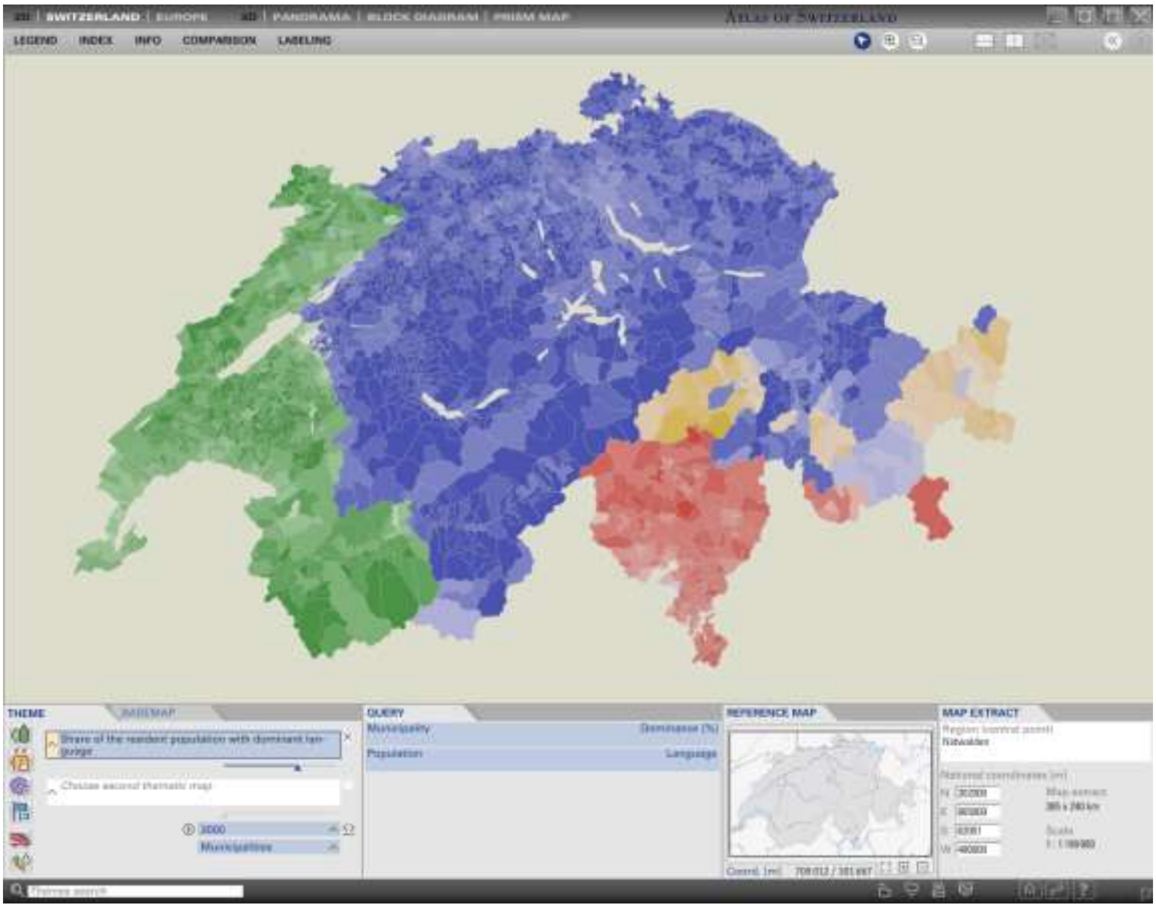

Figure 14: Atlas of Switzerland 3 - Dominant Languages

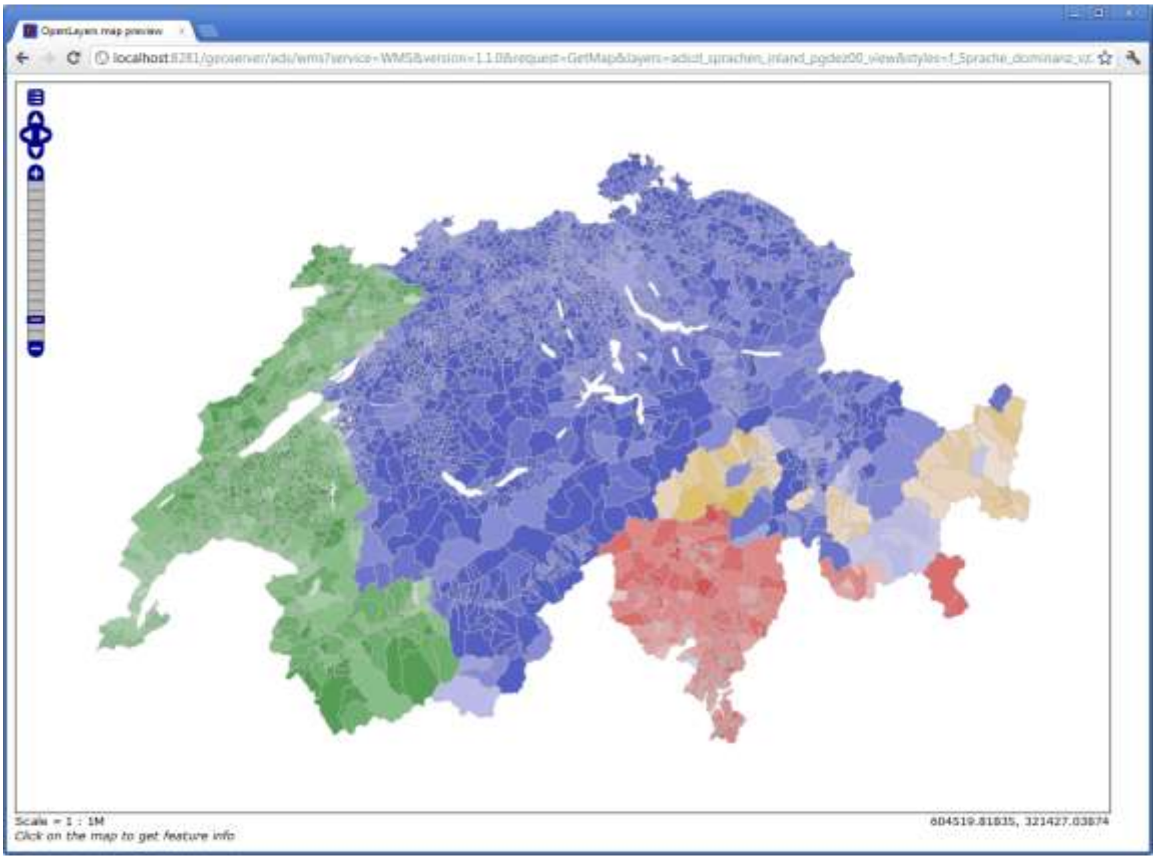

Figure 15: Web Mapping Replication (OpenLayers) - Dominant Languages

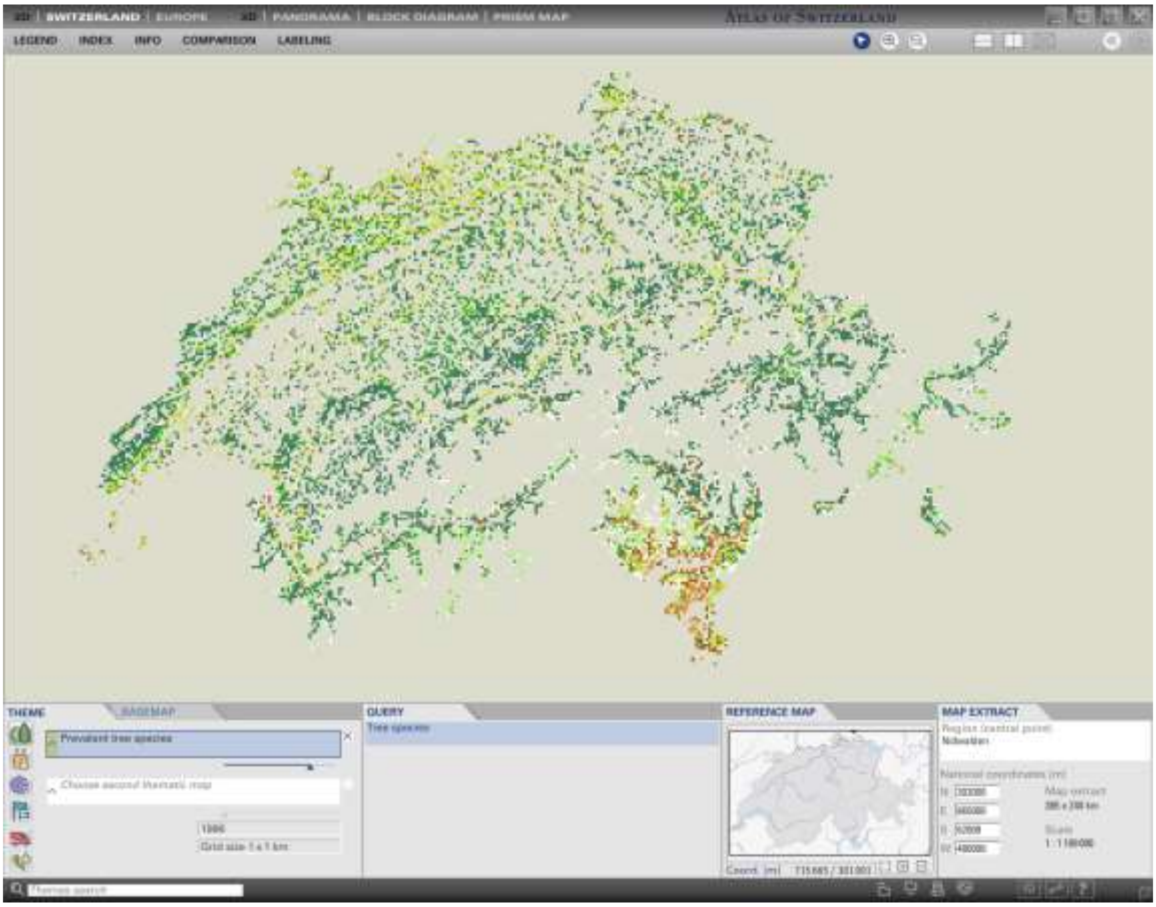

Figure 16: Atlas of Switzerland 3 - Main tree species

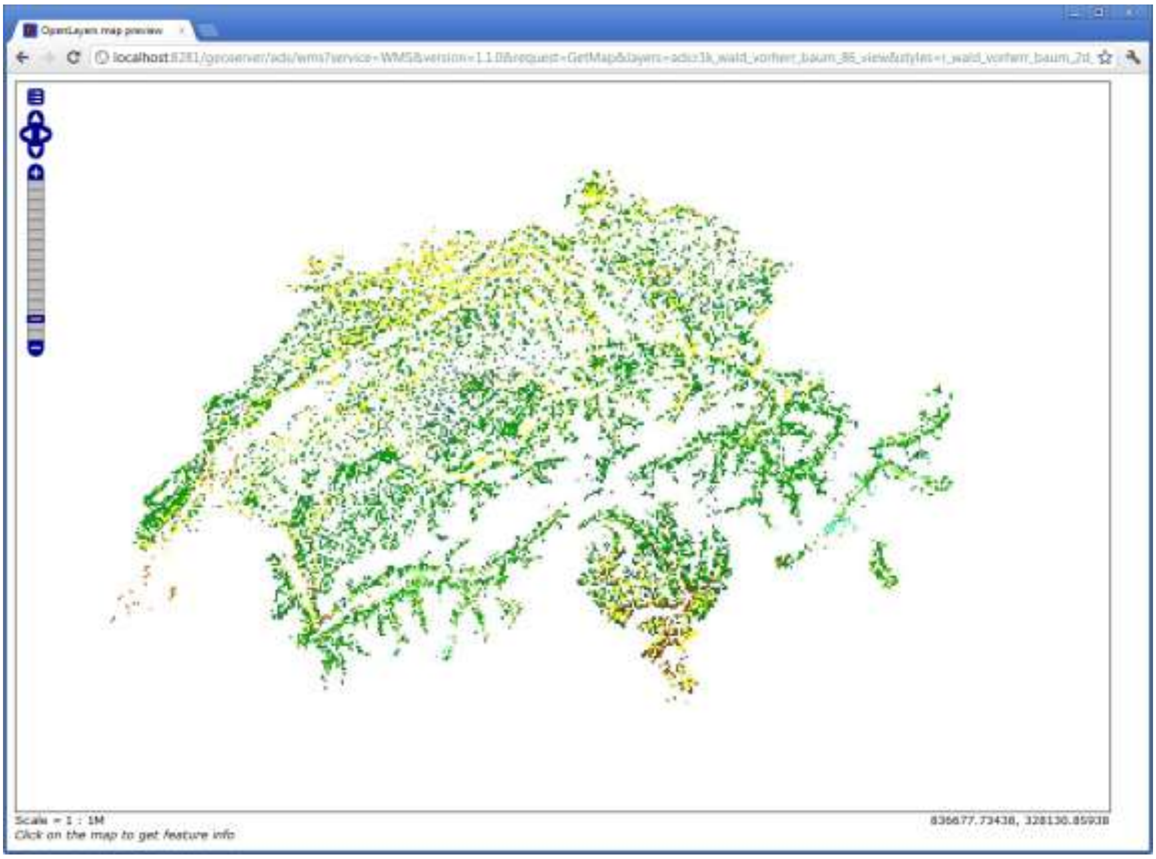

Figure 17: Web Mapping Replication (OpenLayers) - Main tree species

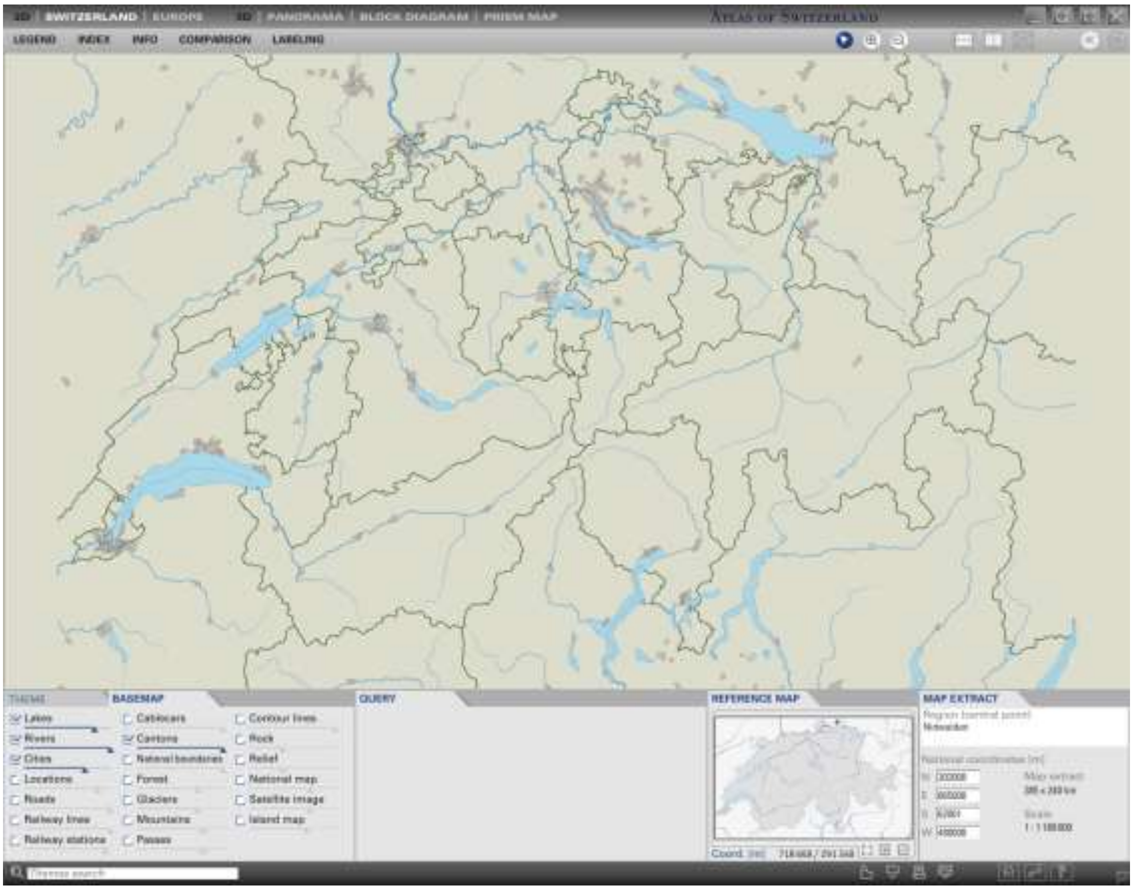

Figure 18: Atlas of Switzerland 3 - Lakes, rivers, cities and cantons

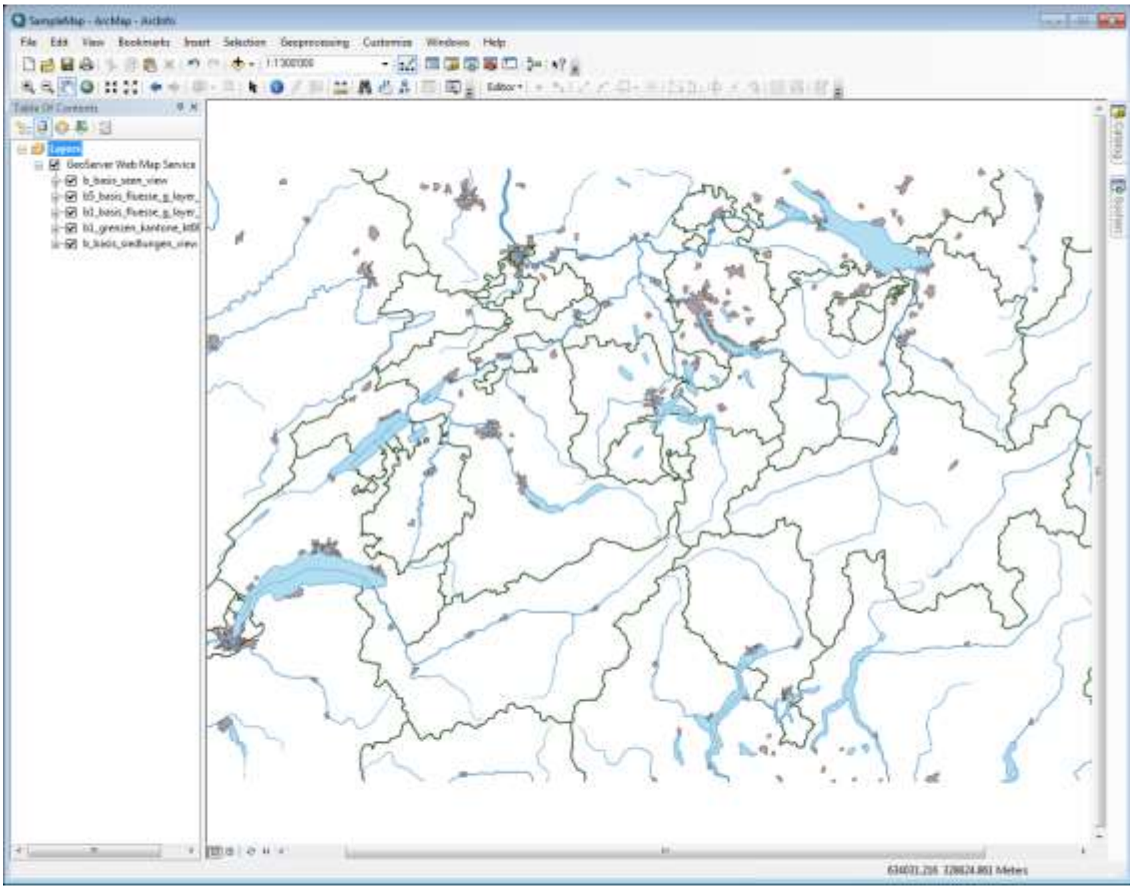

Figure 19: Web Mapping Replication (ArcMap) - Lakes, rivers, cities and cantons

Figure 20: MapProxy - Exemplary TMS layer

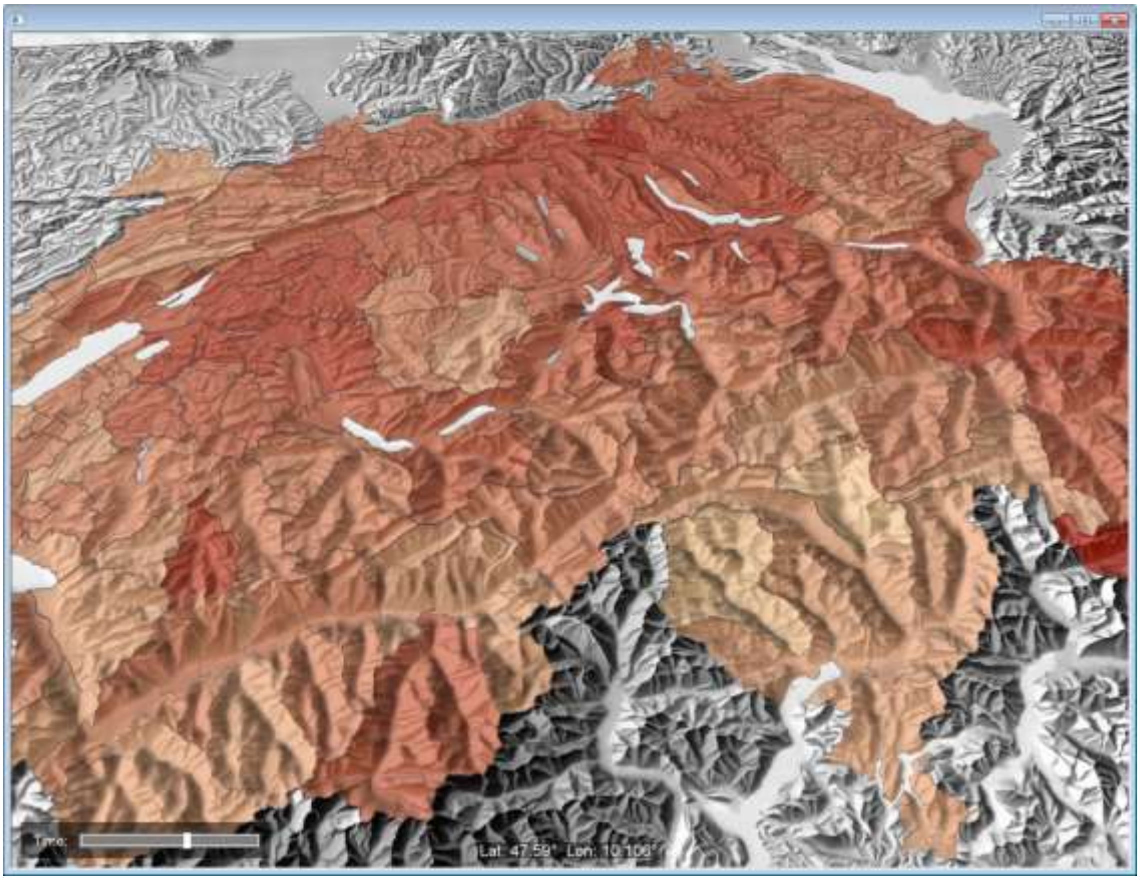

Figure 21: osgEarth - Activity rate and relief of Switzerland

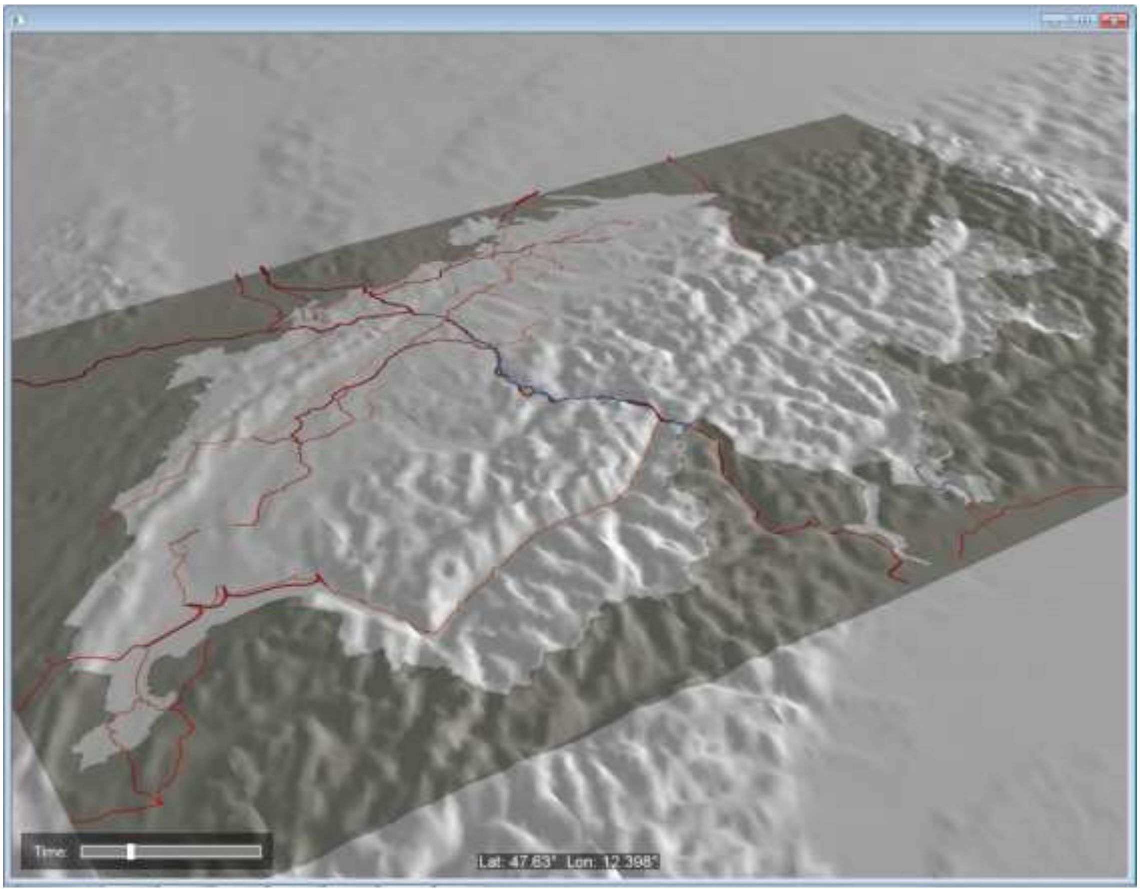

Figure 22: osgEarth - Natural gas pipelines and island map of Switzerland

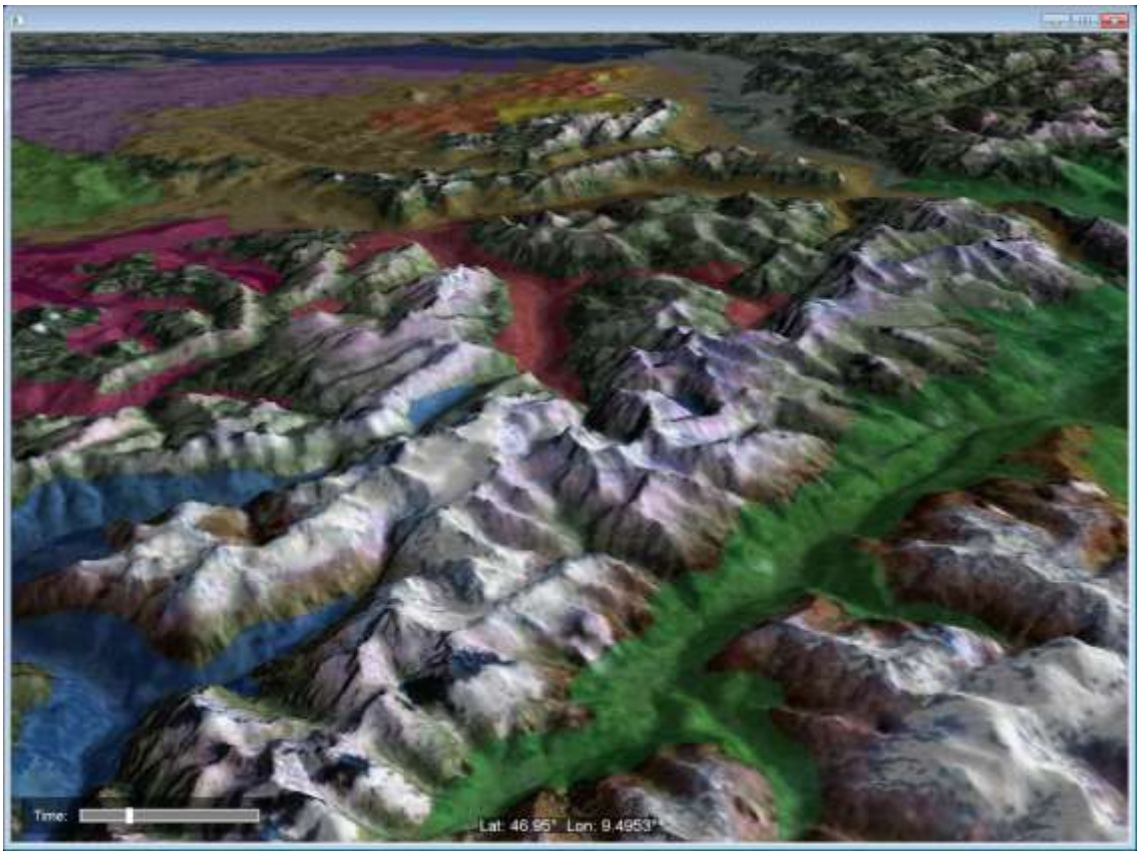

Figure 23: osgEarth - Settlement areas of Swiss cantons

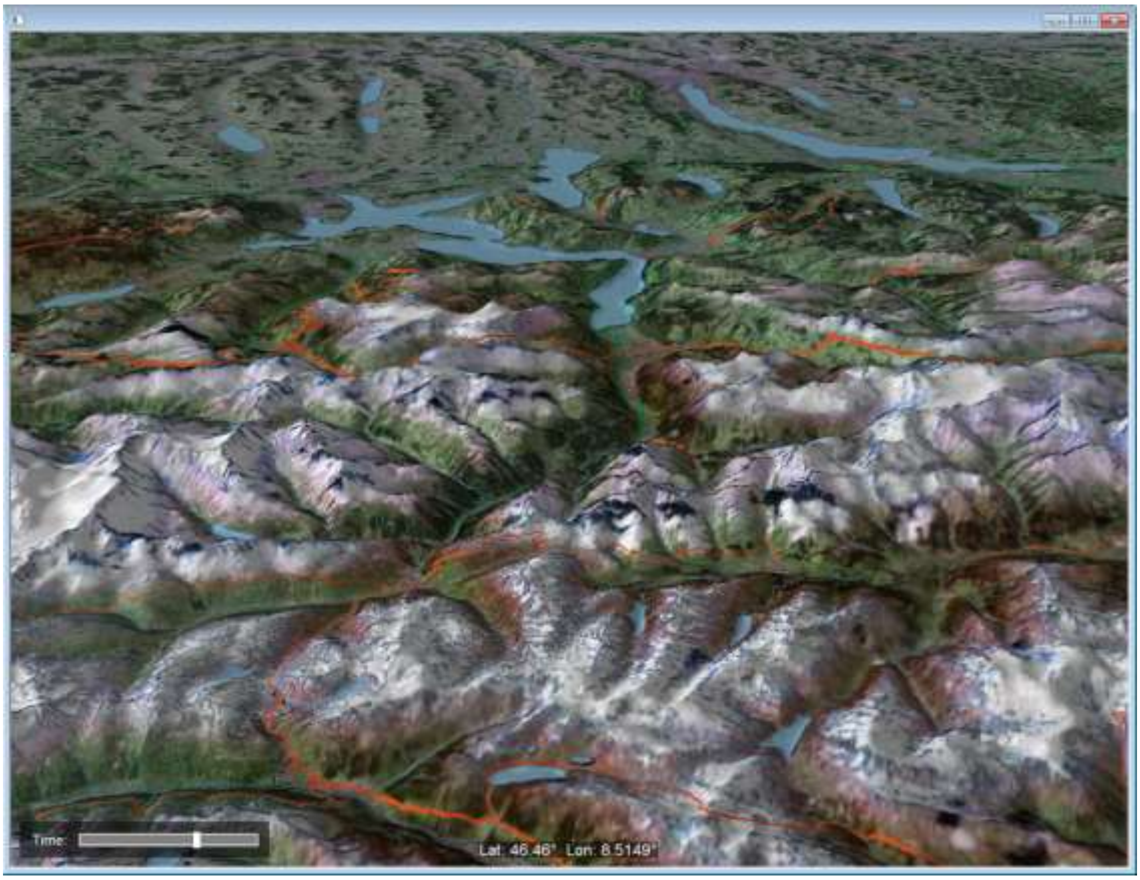

Figure 24: osgEarth - Walking routes, rivers and lakes

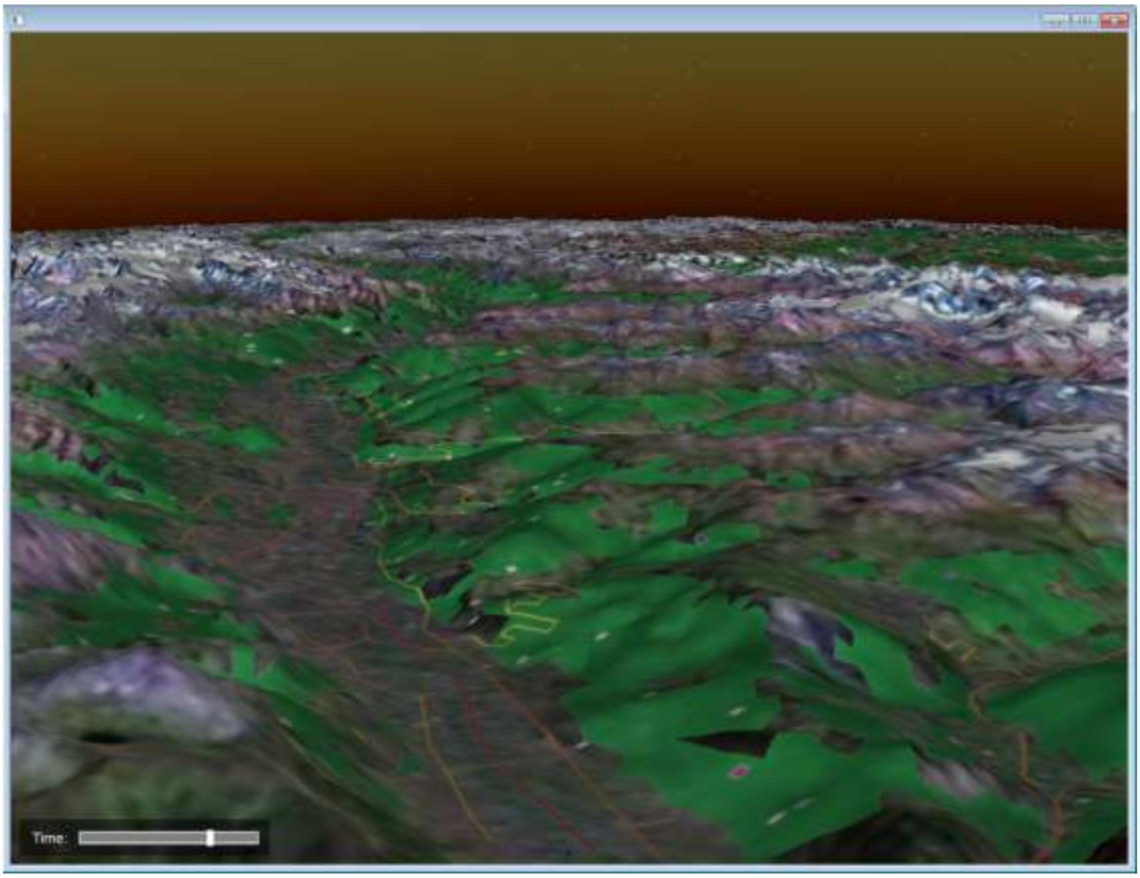

Figure 25: osgEarth - Roads, settlements, forests and wildfires

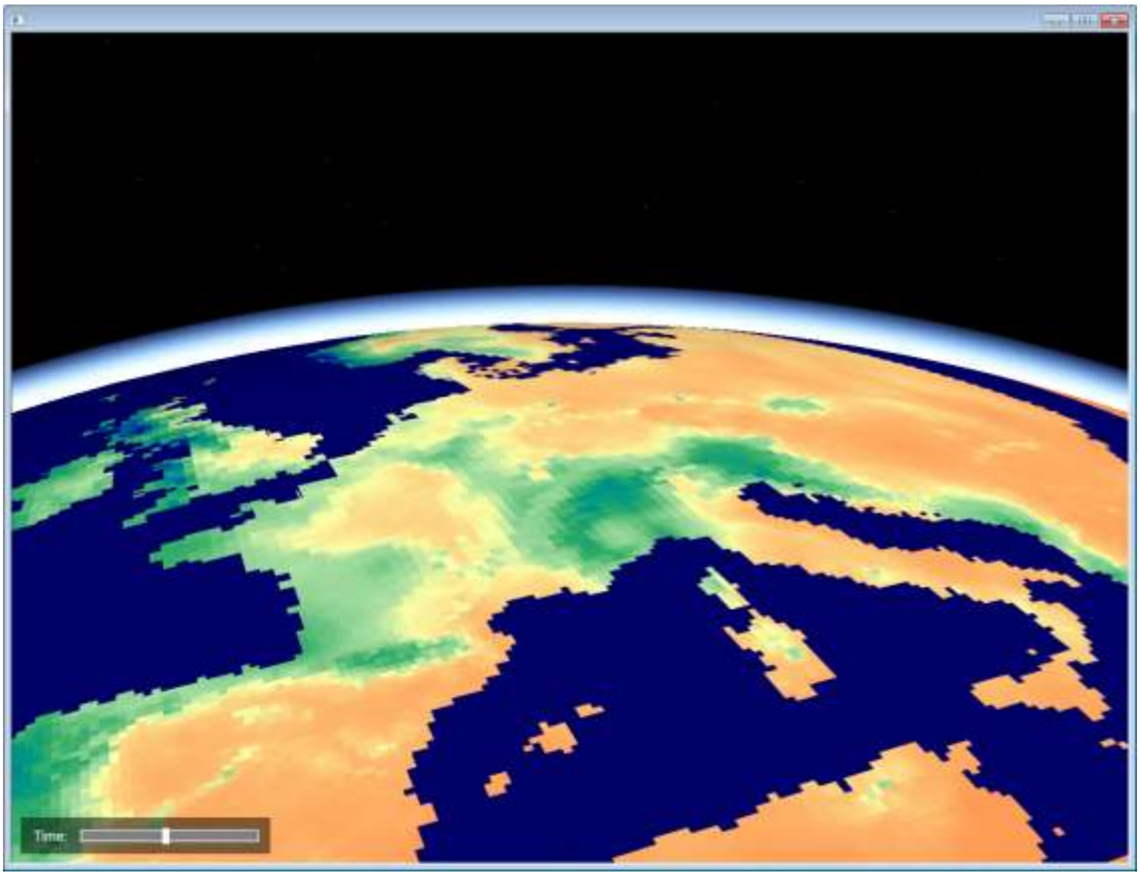

Figure 26: osgEarth - Precipitation (annual mean) in Europe