ATLAS OF SWITZERLAND 3
A Decade of Exploring Interactive Atlas Cartography

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Abstract

During the last decade digital national atlases have made distinct advancements concerning visualization techniques and atlas functionality. Challenges that atlas authors still are confronted with can be identified mainly in the fields of user-centered design, real-time data management, and map design. The ATLAS OF SWITZERLAND demonstrates in its third edition how to realize a complete atlas framework based on the principles of user-centered design. Basic concepts and cartographic aspects as well as GUI techniques and implementation are treated.

Introduction

During the last two decades several traditional national atlases have witnessed a renaissance in digital form. In the beginning, the concept of a view-only atlas has been widespread used with rasterized map images and limited spatial and thematic navigation interactivity (Ormeling 1995). In the meantime some of them evolved into mature products with tailor-made visualization techniques and extended interactive map and user interface functionality. Concerning the publication platform, atlases shifted from CD-ROM and/or DVD products to Internet sites or portals.
The challenge with such modern interactive atlases are manifold: one of the biggest problems lies in a *data-at-hand strategy,* handling large and heterogeneous quantities of statistical, geographical and image data nearly in real-time. Another point to be considered concerns *user-centered design* (Katz-Haas 1998) combining navigation, visualization and manipulation techniques with aspects of usability, usefulness and visual design by means of a lean and pleasing, easy-to-use graphical user interface. And last but not least challenges in *map design,* where atlas authors striving for high cartographic quality standards are confronted with technical and graphical problems.

The ATLAS OF SWITZERLAND was redesigned and transferred to the digital world in the late nineties, when Multimedia authoring software became applicable. Since then, two editions have been published in 2000 and 2004. Thus, the third version of the ATLAS OF SWITZERLAND, about to be published in early 2010, presents an example of a decade's continuous effort of interactive cartographic evolution.

The paper will give a brief overview of main concepts and strategies of ATLAS OF SWITZERLAND, its content, the handling of data, cartographic techniques, features and tools, dasign of the atlas GUI and cartographic tools, architecture and implementation.

Behind the Scene: Concept and Strategy

The ATLAS OF SWITZERLAND is based on a ten years' research and development program. Within this evolutionary atlas concept three main periods can be differentiated, each of them culminating in a commercial atlas version.

Focus on the Basics

In the first period of atlas work, fundamentals of high interactive maps and 3D representations have been implemented. For atlas authors, this period is the most important one, because basic guidelines for the whole decade are set during this time.

A *GIS in Multimedia approach* was chosen (Bär and Sieber 1999), where the GUI elements are provided by a multimedia-software (Macromedia Director) and all cartographic tools are developed in-house. The atlas system is able to deal with vector and raster data, and even with DTMs for 3D maps. For visualization purposes an *adaptive map concept* (Bär and Sieber 1997) has been elaborated, allowing for nearly every combination of base map and thematic layers and providing more information when zooming in. This basic framework resulted in easy-to-handle visualizations and simple queries of customized maps, 3D panoramas, and blockdiagrams (Hurni et al. 1999). About 250 statistical map topics (Society, Economy, State & Politics) were integrated in this first commercial digital product.

The ATLAS OF SWITZERLAND INTERACTIVE 1 (fig. 1a) has been published in four languages in 2000 on CD-ROM, more than 14,000 copies were sold.

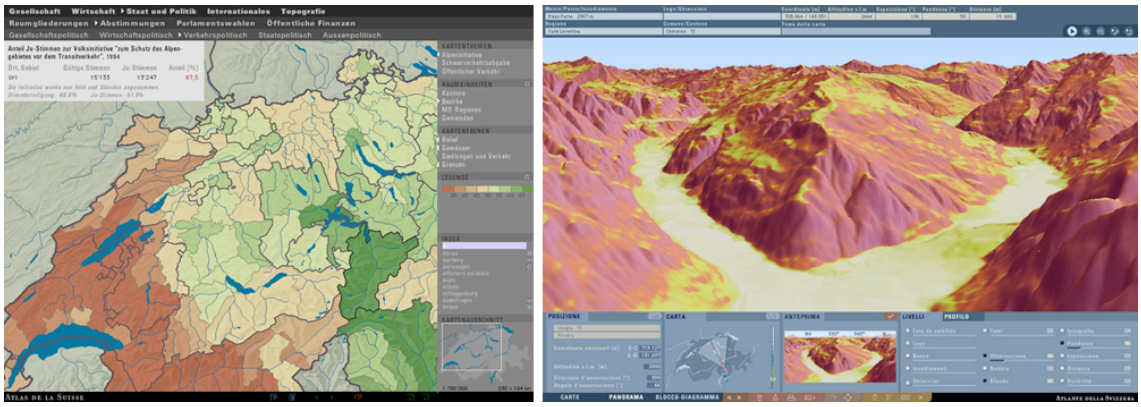

Fig. 1: a) ATLAS OF SWITZERLAND 1 in (2D map modus (left), and b) ATLAS OF SWITZERLAND 2 in 3D panorama modus (right).

Focus on Advanced Visualization, Navigation and Analysis Tools

The second period of research and development concentrated on successive technical advancements and markedly thematic extension of the atlas (Sieber and Huber 2007).

From a technical point of view, a highly *modular atlas tool kit* has been designed (Huber et al. 2005) to achieve future extensibility and reusability. Conceptually, the atlas is split into three sections (GUI, core, data), still operating with Director on the GUI section. XML-based files specify full map description, including map design and query.

New features for *3D navigation* have been implemeted, resulting in tools such as a hill climber that enables the user to jump directly on a mountain peak (Huber and Sieber 2001). *Explorative analysis* tools can be used for comparison of thematic map elements, selection and change of map classes. In the domain of *3D terrain visualization* powerful tools like terrain illumination, fog and haze, hypsography, hill slope gradient, exposition, cast shadow, and terrain profile have been designed (Huber and Schmid 2003). *Multimedia information elements* provide additional text, pictures, tables etc. for every thematic issue. Concerning *map themes*, more than 1000 datasets are available, mainly from the field of Nature & Environment, and updates of the former thematic issues of ATLAS OF SWITZERLAND 1.

The ATLAS OF SWITZERLAND 2 (fig. 1b) launched in 2004, has been sold 7300 times on 2 CD-ROM or 1 DVD with an accompanying booklet.

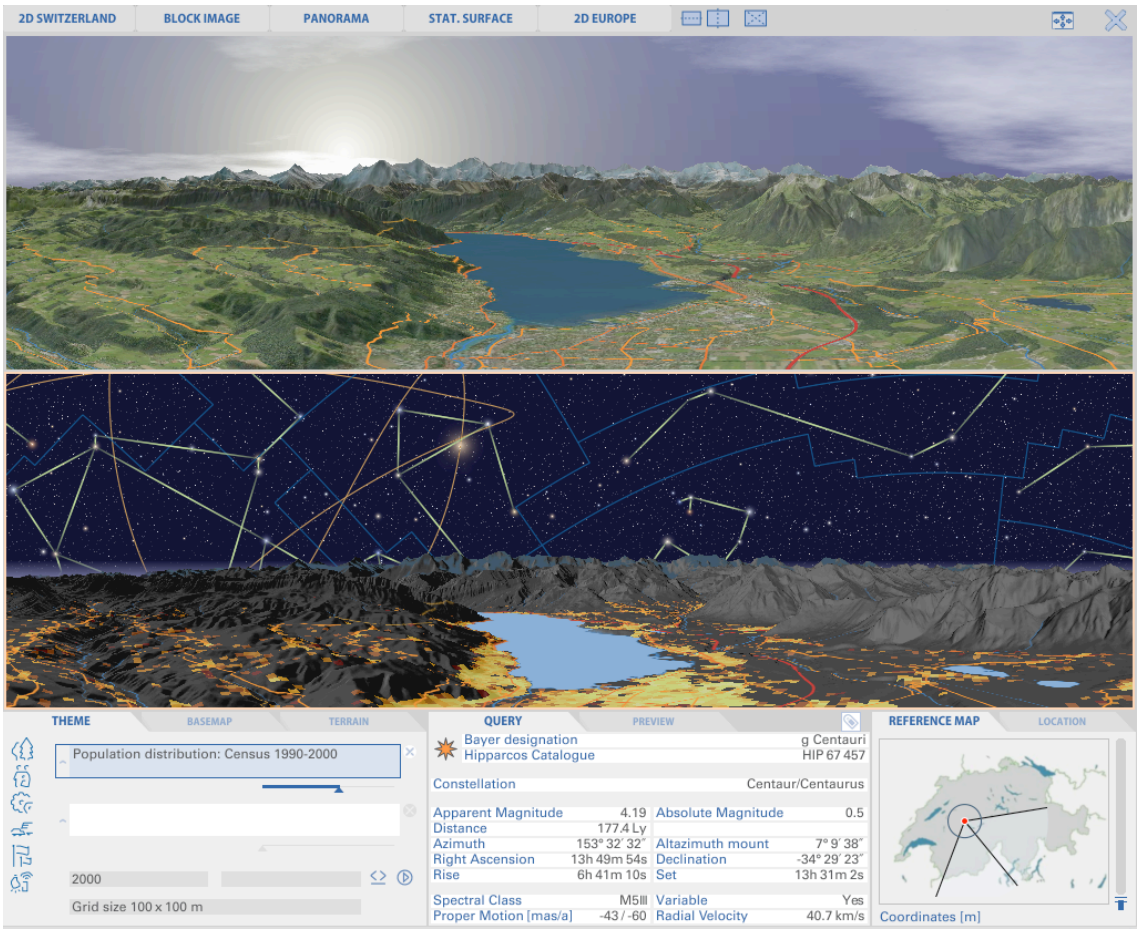

Fig. 2: ATLAS OF SWITZERLAND 3 – GUI prototype with split screen option.

Focus on High-end Visualization and Modularity
The third period can be characterized as high-level enhancement of the atlas. Since the atlas GUI needed total redesign, an *in-house development* of all tools and graphical-technical interface components was realized. At the same time the GUI components of the 2D map part and of the 3D map part were unified. The atlas has been enhanced with *3D object labelling,* a *comprehensive query system,* and a legend module using the *smart legend approach* (Sieber et al. 2005). Concerning 2D visualization, the data-driven *multivariate map approach* (Huber et al. 2007) allows for versatile map symbolization. A new 3D modus dealing with *statistical surfaces* (Sieber et al. 2009) and *augmented panoramic views* complete the rich palette of high-end cartographic representations.
The third edition ATLAS OF SWITZERLAND 3 (fig. 2) will appear in 2010 on 2 DVD and accomplishes the decade of complete, full-version atlases.

In the following sections, some specific challenges, solutions and highlights of the current third edition ATLAS OF SWITZERLAND 3 are discussed in more detail.

About the Atlas Topics: Data and Content Management

Since the ATLAS OF SWITZERLAND is a thematic national atlas covering the entire country most of the data were supplied by Swiss federal offices. For the current ATLAS OF SWITZERLAND 3 the former thematic domains *Nature & Environment, Society, Economy, State & Politics* were updated. In addition, data for the three new domains *Energy, Traffic and Communication* have been collected, resulting in another 250 maps. For example, the *Traffic* section contains maps on issues like road traffic, rail traffic, air traffic, non-motorized traffic, and commuters. Alltogether, the ATLAS OF SWITZERLAND 3 comprises more than 1250 thematic issues!

Not surprisingly with such a huge amount of maps, the atlas deals with rather different data types: Statistical data, geometric data (point, line, area) either from a GIS source or of cartographic nature, DTMs, and satellite images. Concerning data workflow, raster data have to undergo a tiling process, providing several inter-coordinated resolutions. While vector data often need cartographic refinement and encoding, statistical data undergo harmonization, plausibility and aggregation processes. Although the processing can be rather time-consuming, high data quality is thereby ensured.
These newly acquired data partly have a different internal structure than the old ones and evoke additional cartographic visualizations.

Cartography at the Cutting-Edge: Techniques and Symbolization

The very essence of the ATLAS OF SWITZERLAND 3 can be denominated as thematic cartography with high-level interactivity. Starting from the ATLAS OF SWITZERLAND 2 as a reference where graphic standards for base map and thematic symbolization in 2D and 3D have been set, some highlights of the third version can be pointed out.

High standard symbolization is enabled be means of an extensible graphics library that allows for manipulation of areal map features, lines, points and symbols. Using a map

description file atlas authors are able to change colors and blends in general or of single map feature classes. In addition, changes of areal or line pattern, contour color, line and point size, point shape, and point or symbol rotation are at the author's disposal.

Fig. 3: a) Base map layer with line symbolization, areal pattern and point rotation (left), and b) Figurative thematic symbols combined with landcover raster (right).

As in the example of the 2D *base map* (fig. 3a), areal patterns are used for settlements, forest, and glaciers to let the relief shine through and thus enhance plasticity of the map. Together with different colored and patternd lines and rotated symbols (railway stations) the symbolization arrangement results in a graphically pleasing base map, heighly suitable for thematic overlay.
Thematic symbols are now available as *figurative vector or raster objects* (fig.3b), not only as simple geometric objects like circles and squares. Figurative symbols, e.g., airports, alpine huts, etc. are well discernible as thematic layer and decisively contribute to a vivid and appealing map impression.

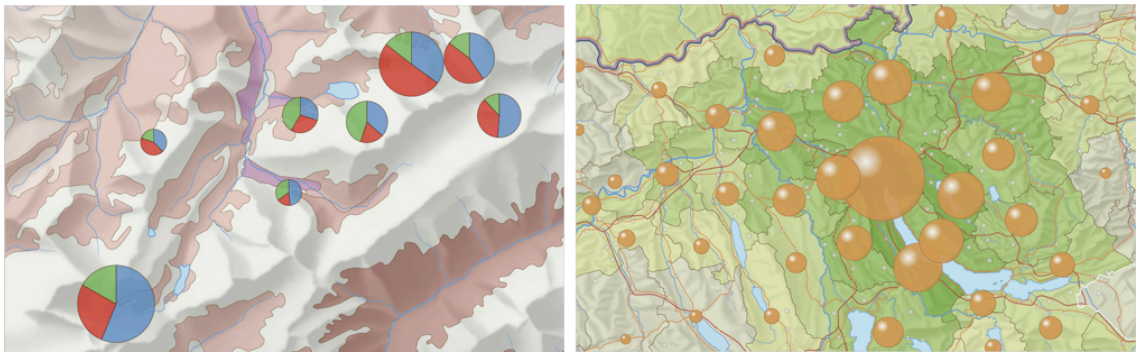

Fig. 4: a) Multivariate pie chart diagrams of overnight stays in alpine huts (left), and b) Pseudo-3D thematic symbols of commuters (right).

The generic approach of *multivariate mapping* (Huber et al. 2007) applied in the ATLAS OF SWITZERLAND 3 supports the consistent handling of different map layer types (point, line, area, raster, chart, etc. for 2D and 2.5D maps) and multiple visual variables. Using

this appoach, it is possible to create chart diagrams of any type (fig. 4a) and even cartographic representations with some special effects like *pseudo-3D symbols* (fig. 4b).

Fig. 5: a) Network symbolization of commuters (left), and b) Radial line symbols of commuters traveling from different counties to Zurich (right).

Another map type integrated – basing as well on multivariate mapping – deals with point-to-point connections. These connections can be visualized either by means of straight lines as it is the case with *network maps* (fig. 5a) and *radial line maps* (fig. 5b), or follow irregularly "cartographic" lines, e.g., railway lines. While network maps show the whole complexity of connections, radial line maps just focus on a specific location of interest. This can be considered as a kind of data browser or graphic selection tool.

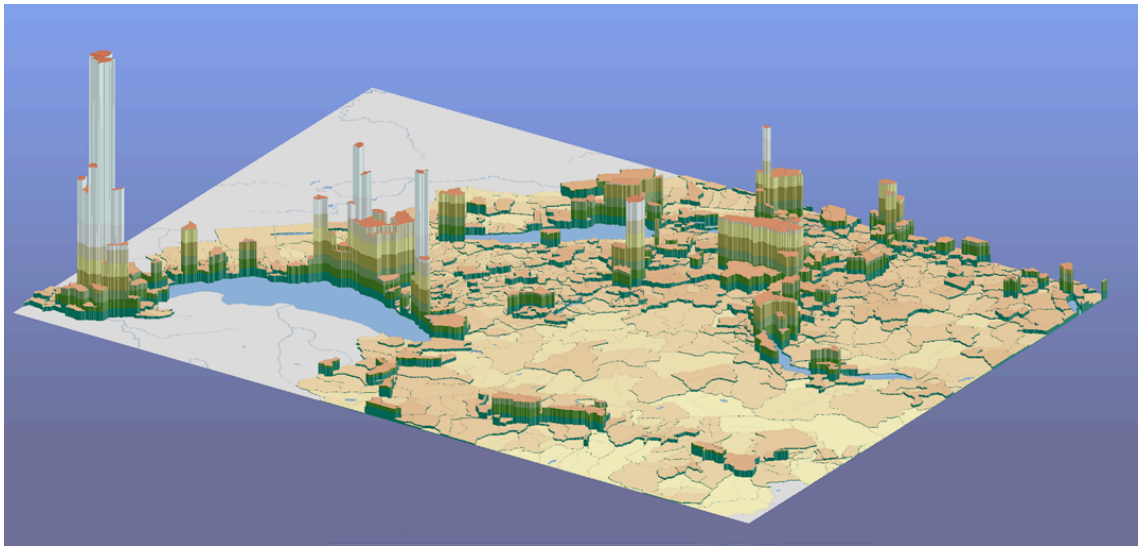

Fig. 6: Statistical Surfaces, a new visualization modus in ATLAS OF SWITZERLAND 3.

The 3D map section of the ATLAS OF SWITZERLAND 3 has been enriched with a new visualization modus of *statistical surfaces* (Sieber et al. 2009) (fig. 6). Thus, the idea of multivariate mapping is persued by using the third dimension for a second thematic

variable. Within the atlas, the statistical surfaces can be interactively exaggerated and many of the 3D tools like illumination, hypsography and cast shadow can be applied.

As an additional 3D feature, geographic *object labelling* (fig. 7) can be activated for panoramic views, block diagrams and statistical surfaces. By clicking on the object or its name, the object name can be easily indicated or omitted. Labelling facilitates spatial orientation and will also meet the demands of publication purposes.

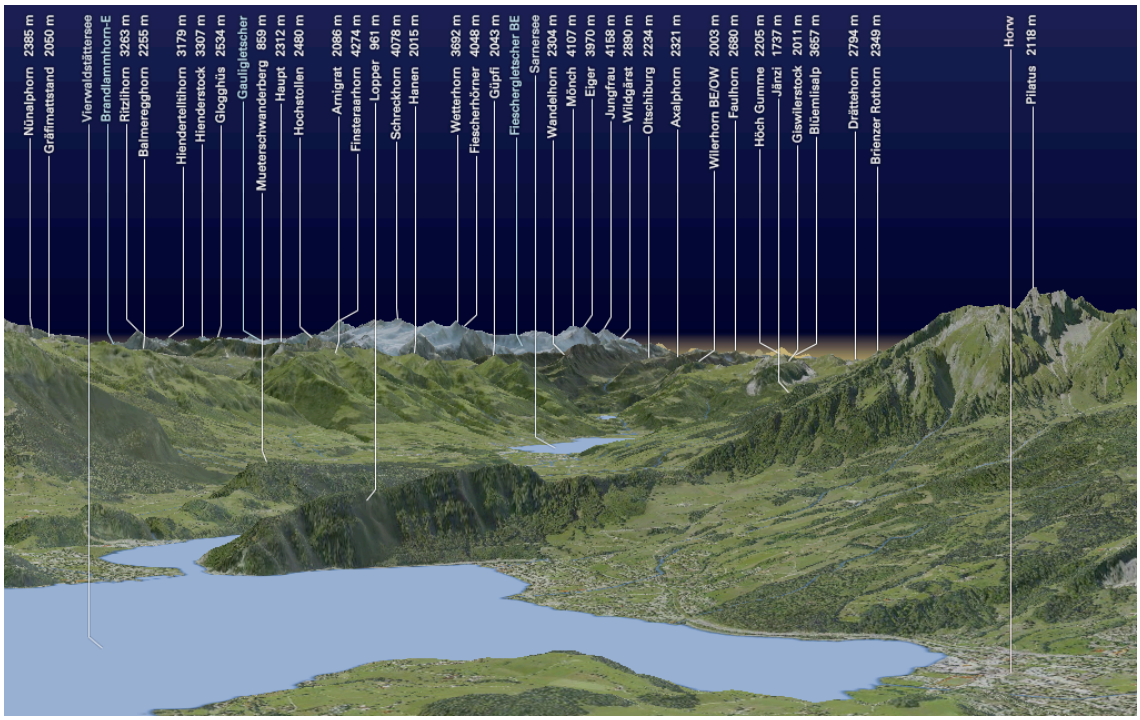

Fig. 7: Object labelling in ATLAS OF SWITZERLAND 3.

Last but not least, the area covered by the ATLAS OF SWITZERLAND 3 has been massively enlarged: The panorama modus contains not only Switzerland and its surroundings, but also the sky. 3D panoramic maps (fig. 2) can be supplemented with weather features (cloud generator) and some astronomical features (sun, stars, planets and their orbits).

As partly depicted above, the visualization options of the ATLAS OF SWITZERLAND 3 are enormous. Therefore, it is very important to rely on a well-designed and structured graphical user interface (GUI).

User-Centered Design: The ATLAS OF SWITZERLAND 3 GUI

The following paragraphs illustrate in how GUI concepts can help in conquering the vast amount of information available in a digital atlas application and presenting cartographic content in pleasing and efficient ways.
Five principles underlying the ATLAS OF SWITZERLAND GUI design have been identified as most influential in satisfying above requirements.

Layered layout. GUI elements (panels) of major importance should be placed at the top level and be easily accessible at every instant of program execution, with importance being mainly based upon frequency and ease of use. This principle is exemplified in the ATLAS OF SWITZERLAND 3 (fig. 2) by the use of permanently visible and amply sized buttons for map mode (2D, block image, panorama, statistical surface) selection, a prominently designed theme selection tool and of course the pivotal placement of the maps area. Advanced or rarely used options should be made accessible indirectly through menus, popups, or tabs.

Staged display of map information. Due to the perpetual challenge of handling space constraints imposed by a dynamically resizable application, data should be presented in a way that allows for selection based upon priority or aggregation in the face of reduced display area. The utilization of this principle in the ATLAS OF SWITZERLAND is manifold: when querying the map, data of lower priority is discarded if place is scarce. Priority assignment to data is left as an editorial choice.
The legend is organized as a tree structure with three main branches “Theme 1”, “Theme 2”, and “Basemap”, each having visual variables as subnodes. Branches can be individually collapsed during automatic or manual layout, only represented by a title; in the automatic layout process, thematic legend nodes bear higher priority than basemap nodes, i.e. basemap nodes are collapsed first.
GUI elements located at the lower end of the application window, the toolbar, are laid out according to two rules: with limited space, elements having redundant representations of the same map information or providing related functionality (like toggling map layers), are combined into tabbed blocks. For example, the reference map panel and the location panel both act as navigational tools and positional indicators, with one featuring a pictorial, the other a textual interface. When space is abundant, tabbed tools are promoted to readily accessible top layer panels.
When map information is only of temporary interest, it should be displayed as such, ephemerally. For example, the 3D preview panel hides behind the query panel after the changes to the 3D map have been committed to the main view.

Ends not means. A sharp line has to be drawn between the needs of the user and the constraints of the implementation. Where this line gets blurred, where interaction is dictated by technology, usability suffers. To put it another way: avoid interactional styles prescribed by the implementation.
Examine the case of choosing colors for a linear progression of values like the temperature legend in figure 8a. The colors at the upper end of the scale are hardly

distinguishable and unable to reflect the differences in temperature above 16 C°. The progression stems from a linear interpolation of RGB values between pastel and pure red. Even though the RGB values do form a linear sequence, the user's color sensation does not. The point is that the RGB color system belongs to the implementational domain of the application, since the display hardware's input is RGB colors. But the peculiarities of the RGB color system should not propagate to the part of the application where user interaction is concerned, since they don't map well to human color sensation. Enter visual perception motivated color systems. The ATLAS OF SWITZERLAND 3 features a color selection dialog (fig. 8b) based upon the Munsell color order system (Shevell 2003) enabling the user to compose linear and nonlinear color progressions by estimating color distances in the hue, saturation and brightness dimensions. Thus, a tool like the Munsell color chooser helps in moving from technology-driven towards user-centered interaction.

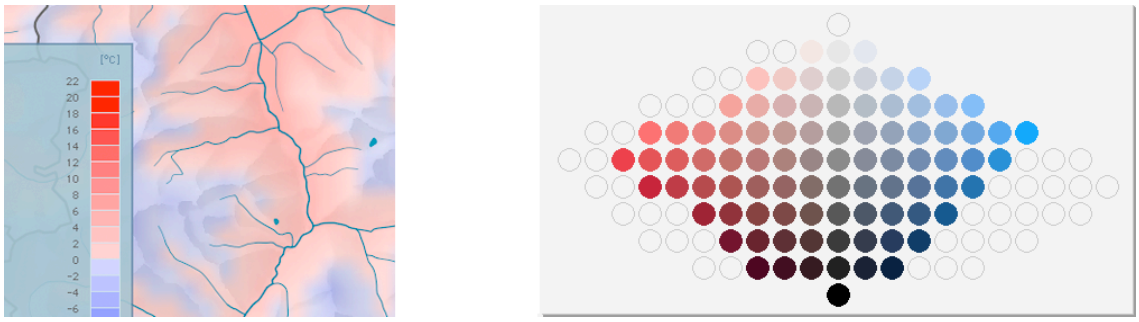

Fig. 8: a) Color legend taken from ATLAS OF SWITZERLAND 2 (left), and b) Prototype for color selection tool in ATLAS OF SWITZERLAND 3 (right).

Map centered view. Attention to the map area should not be diminished by other parts of the GUI, i.e. the user's focus should easily come to rest in this most central region. Distraction is reduced in the ATLAS OF SWITZERLAND by dedicating as much space as possible to the maps, placing permanently visible interaction tools at application window margins. Furthermore, dialogs not integrated into the bordering toolbars are made movable, so they can be shifted away from the point of interest in the map. A mostly achromatic palette for GUI elements contributes to accentuate the colored maps.

Consistent interface for all map modes. Since switching between map modes is a common task, one does not want a complete reconstruction of the GUI every time the map mode changes, but a stable environment without the need for extensive realignment. Thus, a consistent interface for 2D, panorama, block image and statistical surface modes is desirable, with consistency in the sense that GUI elements for common tasks remain in place with only minor variations in content upon mode alteration. Of course there are tools that are only meaningful for specific map modes, examples being the profile or preview tools available only in 3D modes. Floating panels are simply hidden and inaccessible if a mode has no need for them, while tabbed panels are moved back in tab order and deactivated.

A consistent interface also greatly simplifies the simultaneous visualization of multiple maps exhibiting different map modes. The ATLAS OF SWITZERLAND 3 GUI allows for up to four maps being displayed in parallel with exactly one of them being the active map, i.e. the one subject to interaction. The tools represent and modify the state of the active map only.

Implementational issues

From a technical viewpoint, the ATLAS OF SWITZERLAND GUI has undergone a major change between versions two and three from a Macromedia Director based Multimedia application to a special-purpose hand-tailored GUI tool kit (fig. 9), comprising generic elements like sliders, buttons and text entries as well as custom cartography tools. A thin platform abstraction layer implemented for Mac OS X, Windows and Linux provides an application window, user interaction events (mouse, keyboard, resize) and animation timers. The GUI proper is then realized in a single, platform-independent C++ implementation.

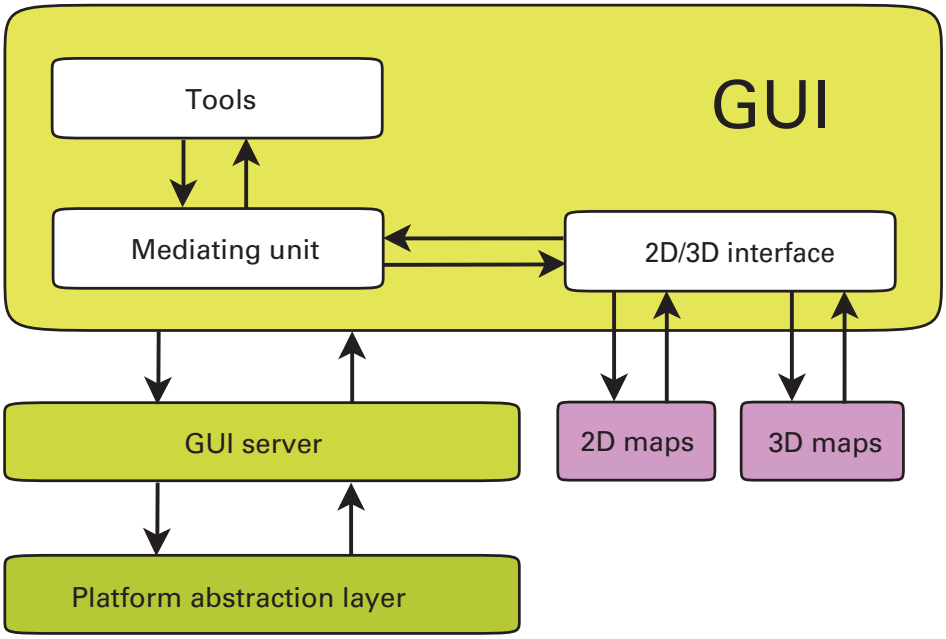

Fig. 9: GUI architecture of ATLAS OF SWITZERLAND 3.

All GUI elements are organized in a tree-structure inside a component called GUI server. The server dispatches incoming user interaction events from the application window to respective panels, maintains their visual stacking order, and provides access for images, fonts, font-metrics and internationalized text used throughout the GUI. Additionally, rendering requests for the panels are forwarded by the server to the application window, to make them appear on screen.

Inside the GUI, functionality is distributed among panels divided into four categories. The map interface panels constitute the connection from the GUI to the 2D/3D map modules where the actual rendering of maps takes place. Tools are panels used for displaying and modifying the state of the active map. Examples include the theme selection, reference map and preview tools. A mediating panel sits between the map interface and tool panels for dispatching messages in either direction. Generic panels like sliders and checkboxes are used as building blocks for more complex GUI elements.

Planning the Future: New Concepts and Developments

Upon release of the third version of the ATLAS OF SWITZERLAND, plans for the future development of the product are already taking shape.
The next atlas generation will be based upon a collaborative concept, broadening application domains and user base. The concept revolves around the idea of an atlas toolbox, i.e. a core unit with pluggable modules for visualization and manipulation depending upon user preferences. The architecture will be open for third party extensions of both data and operation. Furthermore, as part of an atlas construction suite, separate tools will be provided to rationalise the process of data editing and map creation.

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