# Towards a Distortion Free National Spatial Data Infrastructure in Switzerland: Approach, Developed Tools and Internet Services for the Change of the Reference Frame

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**Key words**: Geoinformation, GSDI, Internet Transformation services, Reference frames, Rectification, Reference systems

## SUMMARY

Switzerland is currently working on the transformation of the spatial data infrastructure into the new, very accurate and distortion free reference frame LV95 (with relation to the European Reference System ETRS89). This concerns among others also the cadastre datasets. According to the law for geo-information all the reference datasets have to be transformed by 2016 and the other base datasets until 2020. In order that the transformation could be done as easily and efficiently as possible by the different stakeholders, the national mapping agency of Switzerland swisstopo developed a multitude of software packages, program libraries and geo services (e.g. for transformations). The following publication gives an overview over the "Swiss approach" for the so-called reference frame change and the provided software tools for this purpose.

## SUMMARY IN GERMAN / ZUSAMMENFASSUNG

Die Schweiz ist zurzeit daran, die Nationale Geodateninfrastruktur NGDI in den neuen, hochgenauen und verzerrungsfreien Bezugsrahmen LV95 - mit Bezug zum europäischen Bezugssystem ETRS89 - zu überführen. Davon betroffen sind unter anderem auch die Kataster-Datensätze. Bis 2016 sollten gemäss dem Geoinformationsgesetz alle Referenz-datensätze in LV95 georeferenziert sein und bis spätestens 2020 auch alle übrigen Geobasis-datensätze. Damit diese Überführung möglichst einfach und effizient durch die verschiedenen Akteure vollzogen werden kann, hat das Bundesamt für Landestopografie swisstopo eine Vielzahl von Software, Programmbibliotheken und Geodiensten (z.B. für Transformationen) entwickelt. Die nachfolgende Publikation gibt einen Überblick über das gewählte Vorgehen für den sogenannten Bezugsrahmenwechsel in der Schweiz sowie über die dafür bereit-gestellten Software-Werkzeuge.

Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)    1/12
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

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## 1. STARTING POSITION AND APPROACH CHOSEN FOR THE REFERENCE FRAME CHANGE IN SWITZERLAND

In the nineties, the national mapping agency of Switzerland, swisstopo, established a new, distortion free reference frame LV95, which is directly related to the European ETRF93. Following this task, various transformation methods according the accuracy and properties of the datasets, e.g. FINELTRA (affine transformation by finite elements), have been developed in collaboration with the Swiss Federal Institute of Technology to be able to transform the data of the National Spatial Data Infrastructure SDI from the historical reference frame LV03 to the new LV95 in high accuracy. The federal law for geo information stipulates now that all the reference datasets have to be transformed until 2016 and for the other base data sets until 2020.

Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)      2/12
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

FIG Working week 2015
From the Wisdom of the Ages to the Challenges of the Modern World
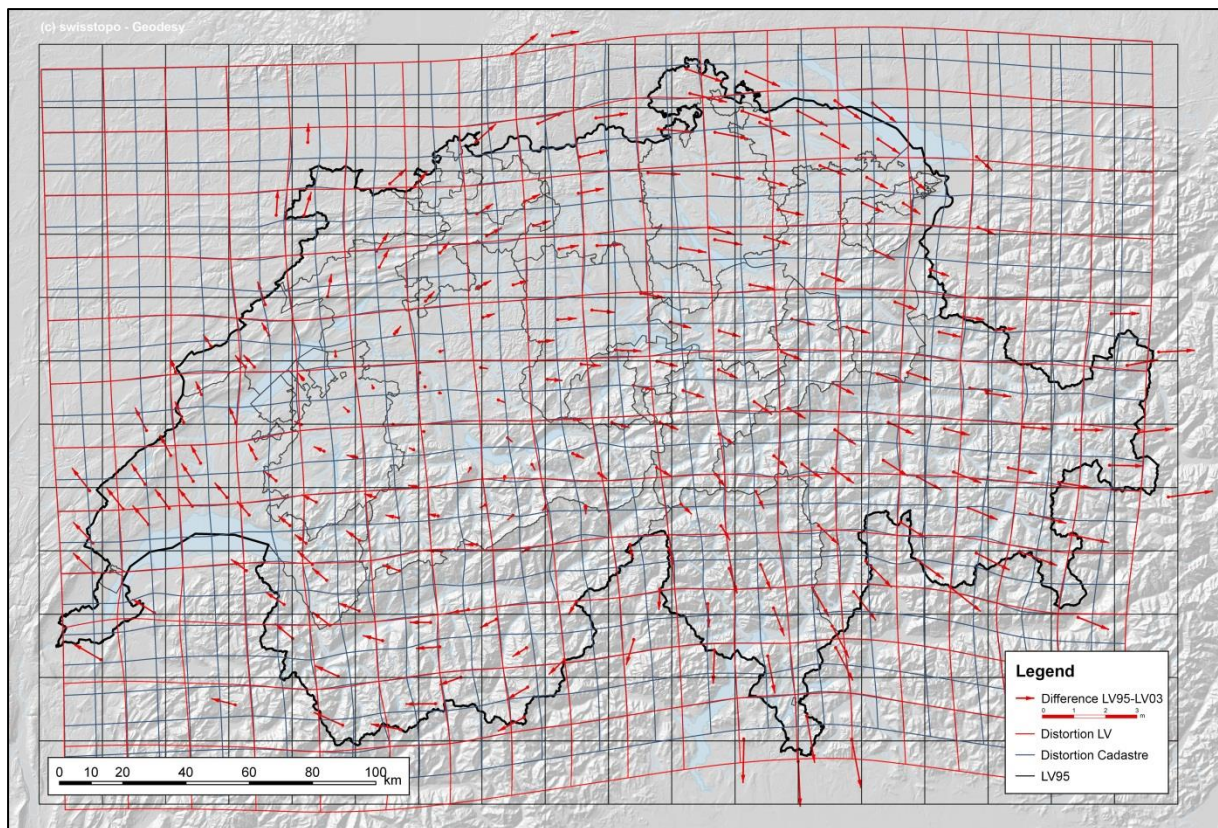Sofia, Bulgaria, 17-21 May 2015

**Figure 1:** Distortion of the old reference frame LV03 in red (national survey LV) and blue (cantonal / state level - cadastral survey) and new reference frame LV95 in black
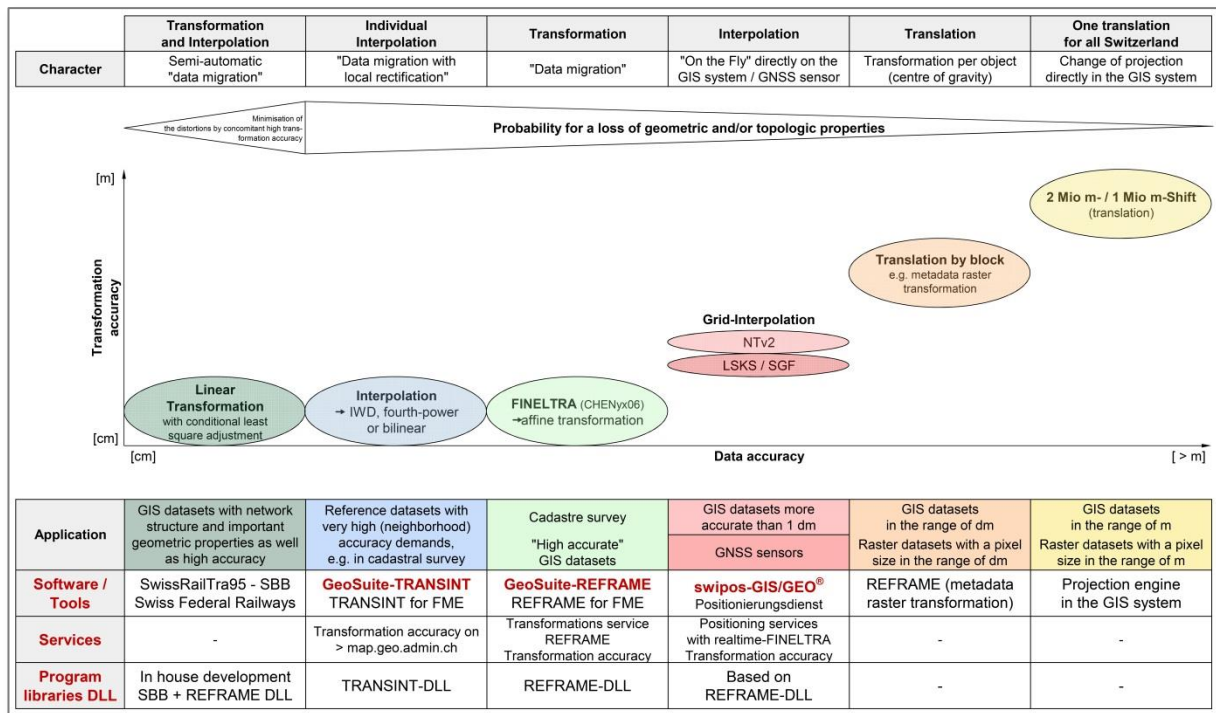
| | Transformation and Interpolation | Individual Interpolation | Transformation | Interpolation | Translation | One translation for all Switzerland |
|---|---|---|---|---|---|---|
| **Character** | Semi-automatic "data migration" | "Data migration with local rectification" | "Data migration" | "On the Fly" directly on the GIS system / GNSS sensor | Transformation per object (centre of gravity) | Change of projection directly in the GIS system |

Minimisation of the distortions by concomitant high transformation accuracy

**Probability for a loss of geometric and/or topologic properties**

[m]

Transformation accuracy

2 Mio m- / 1 Mio m-Shift (translation)

Translation by block e.g. metadata raster transformation

Grid-Interpolation
NTv2
LSKS / SGF

Linear Transformation with conditional least square adjustment

Interpolation → IWD, fourth-power or bilinear

FINELTRA (CHENyx06) →affine transformation

[cm]

[cm]                    **Data accuracy**                    [ > m]

| | | | | | | |
|---|---|---|---|---|---|---|
| **Application** | GIS datasets with network structure and important geometric properties as well as high accuracy | Reference datasets with very high (neighborhood) accuracy demands, e.g. in cadastral survey | Cadastre survey "High accurate" GIS datasets | GIS datasets more accurate than 1 dm / GNSS sensors | GIS datasets in the range of dm / Raster datasets with a pixel size in the range of dm | GIS datasets in the range of m / Raster datasets with a pixel size in the range of m |
| **Software / Tools** | SwissRailTra95 - SBB Swiss Federal Railways | GeoSuite-TRANSINT TRANSINT for FME | GeoSuite-REFRAME REFRAME for FME | swipos-GIS/GEO® Positionierungsdienst | REFRAME (metadata raster transformation) | Projection engine in the GIS system |
| **Services** | - | Transformation accuracy on > map.geo.admin.ch | Transformations service REFRAME Transformation accuracy | Positioning services with realtime-FINELTRA Transformation accuracy | - | - |
| **Program libraries DLL** | In house development SBB + REFRAME DLL | TRANSINT-DLL | REFRAME-DLL | Based on REFRAME-DLL | - | - |

**Figure 2:** Different transformation and interpolation methods according to data accuracy and data properties are available to perform the reference frame change as adequately as possible. Furthermore associated software tools, internet services and program libraries are listed
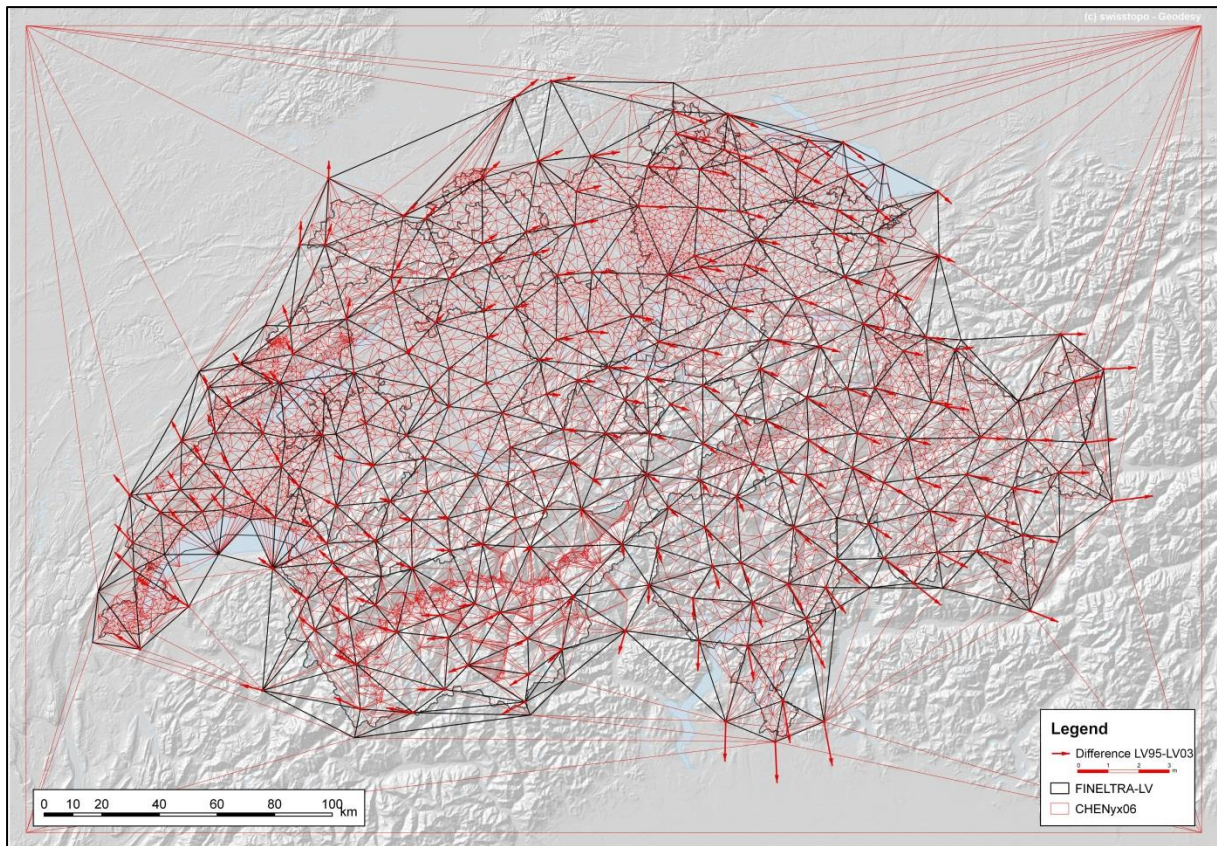
Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)                    4/12
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

FIG Working week 2015
From the Wisdom of the Ages to the Challenges of the Modern World
Sofia, Bulgaria, 17-21 May 2015

**Figure 3:** Swiss national triangular network to perform a affine transformation by finite elements (FINELTRA-Algorithm). In black the triangles from the national survey, in red the ones from cantonal / state level. FINELTRA is the standard method e.g. for cadastral datasets

## 2. DEVELOPED SOFTWARE TOOLS, LIBRARIES AND PLUGINS

So swisstopo was requested to develop a variety of software tools, libraries and services for the reference frame change to support the different stakeholders best possible. In a first step, the client solution GeoSuite with the modules REFRAME and TRANSINT have been developed. This software is not only able to transform or interpolate geo datasets into various formats (e.g. GIS or CAD quasi standard formats), it also provides direct access to all data sets in the SDI of Switzerland over an integrated application programming interface API as well as to any Web Map Service WMS available.
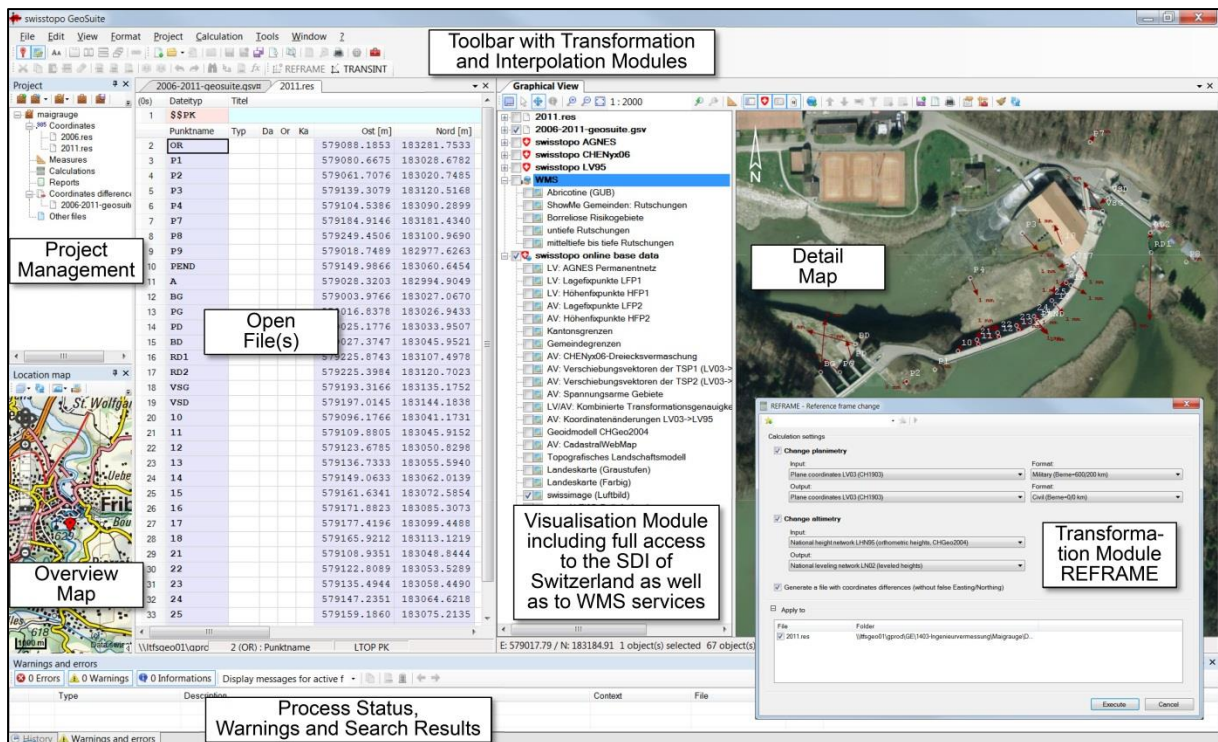
Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)      5/12
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

FIG Working week 2015
From the Wisdom of the Ages to the Challenges of the Modern World
Sofia, Bulgaria, 17-21 May 2015

**Figure 4:** Graphic user interface GUI of the software GeoSuite with the different modules: REFRAME was designed to provide the official transformation algorithms for the reference frame change and TRANSINT for individual transformations or interpolations. The visualisation module includes full access to all datasets of the SDI of Switzerland (e.g. official site descriptions of all survey points of Switzerland) and any other dataset available as WMS services

With this visualization module, the results of a transformation or interpolation can be easily analysed or documented. Furthermore, all the transformation and interpolation algorithms are available as dynamic link library DLL for the integration in third party products, e.g. in GIS extensions for cadastral works, or for the development of Plugins, e.g. realized for FME by swisstopo itself. With the REFRAME- and TRANSINT-Transformer for FME, transformations of any possible file format is supported.

Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

6/12

FIG Working week 2015
From the Wisdom of the Ages to the Challenges of the Modern World
Sofia, Bulgaria, 17-21 May 2015

## 3. INTERNET SERVICES REALISED

In a second step, a set of Internet services has been developed:

### 3.1 Transformation Services

Transformation services as Machine to Human (M2H) service for all the common geo formats and as Machine to Machine (M2M) service for real-time transformation in the federal geoportal map.geo.admin.ch or for the Swiss positioning service swipos. In this way, swipos can offer GNSS corrections for both reference frames
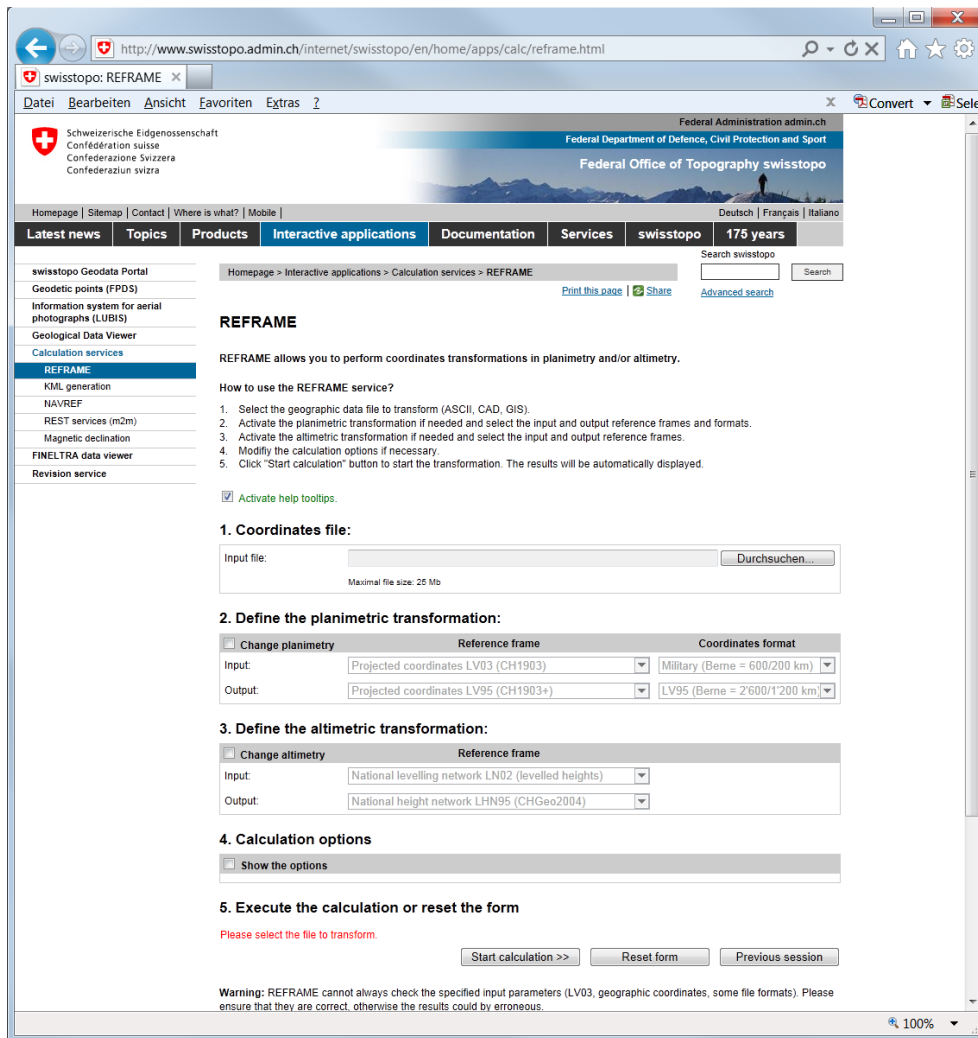


**Figure 5:** REFRAME transformation service

## 3.2 Interpolation Service

Interpolation services for the conversion / rectification of geo datasets on the very local level with big distortions based on deformation grids
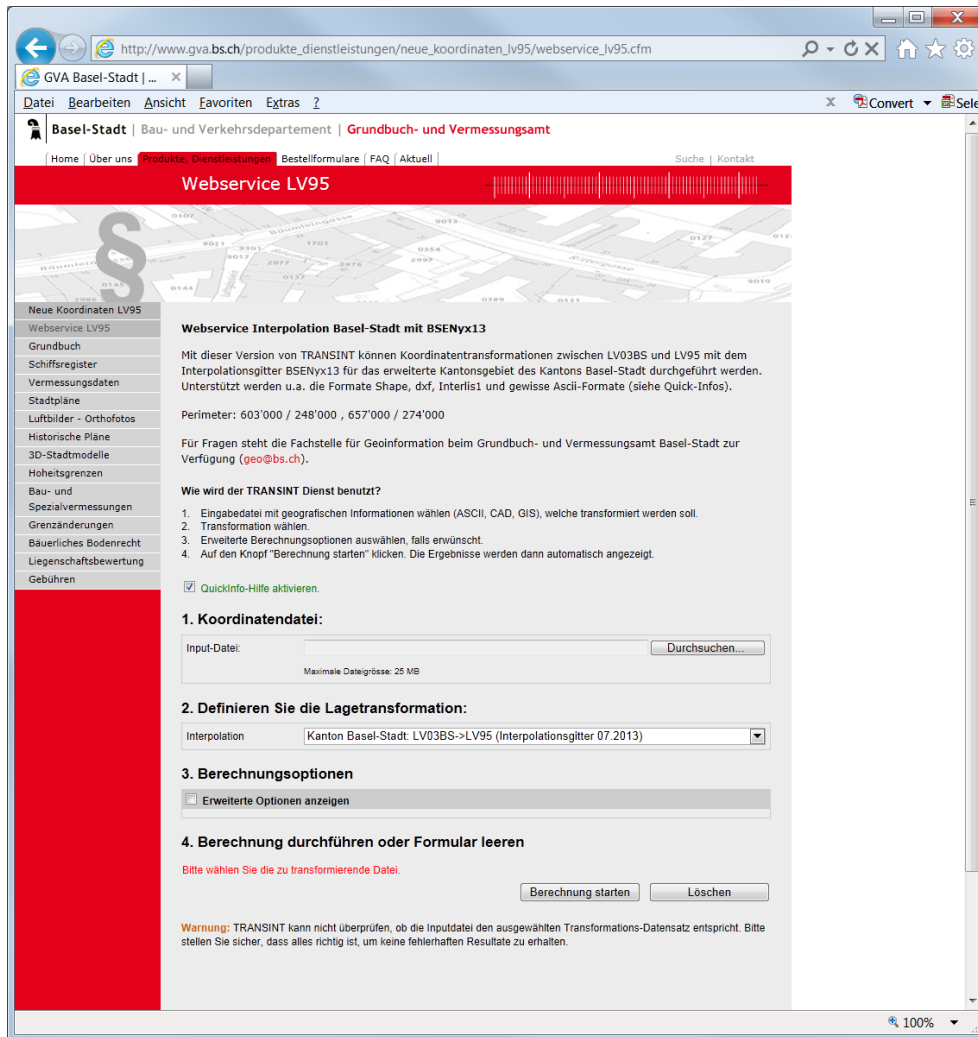


**Figure 6:** TRANSINT interpolation service

## 3.3 Visualisation Services for Survey Points and the Transformation Accuracy

Visualisation services for desktop and mobile devices, e.g. all the survey point site descriptions with old and new coordinates and different metadata are available or a map with the expected transformation accuracy for the whole country.
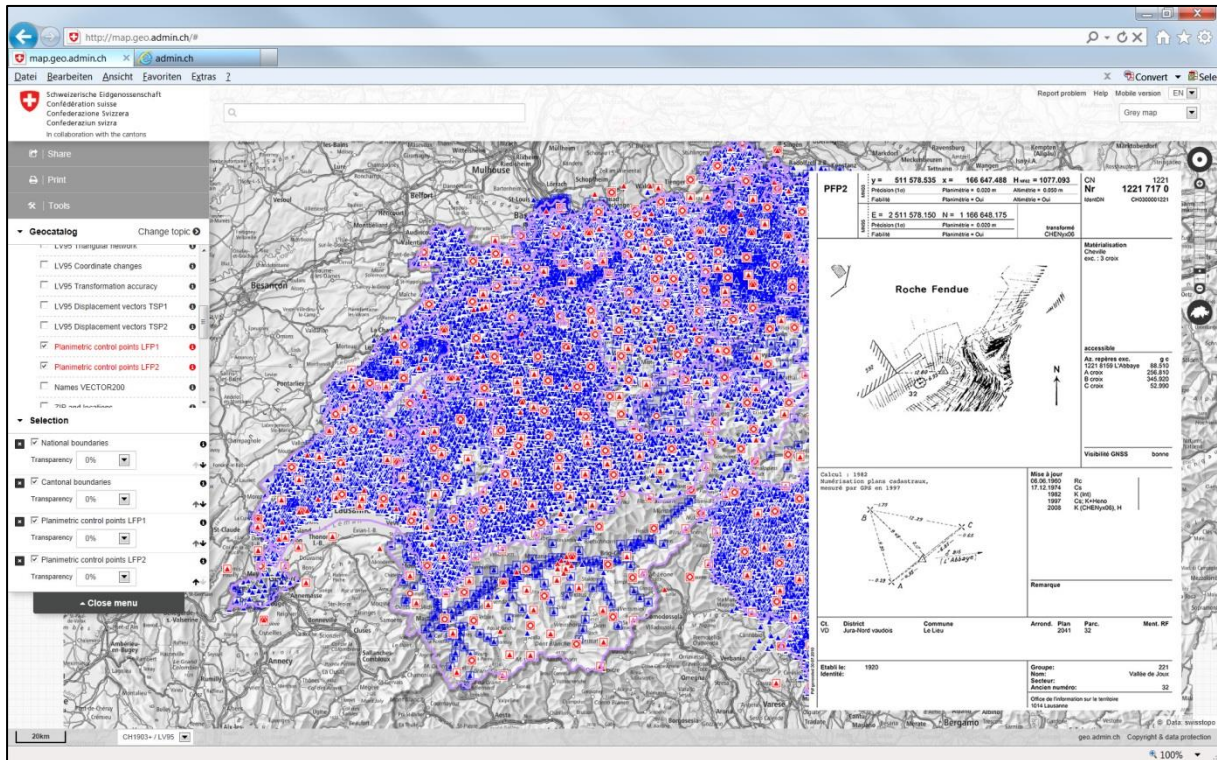


**Figure 7:** Visualisation service for survey points on national (red) and cantonal level (blue). In the site description (see example right), coordinates of these points, which are distributed all over Switzerland, are always available in both reference frames together with many metadata information
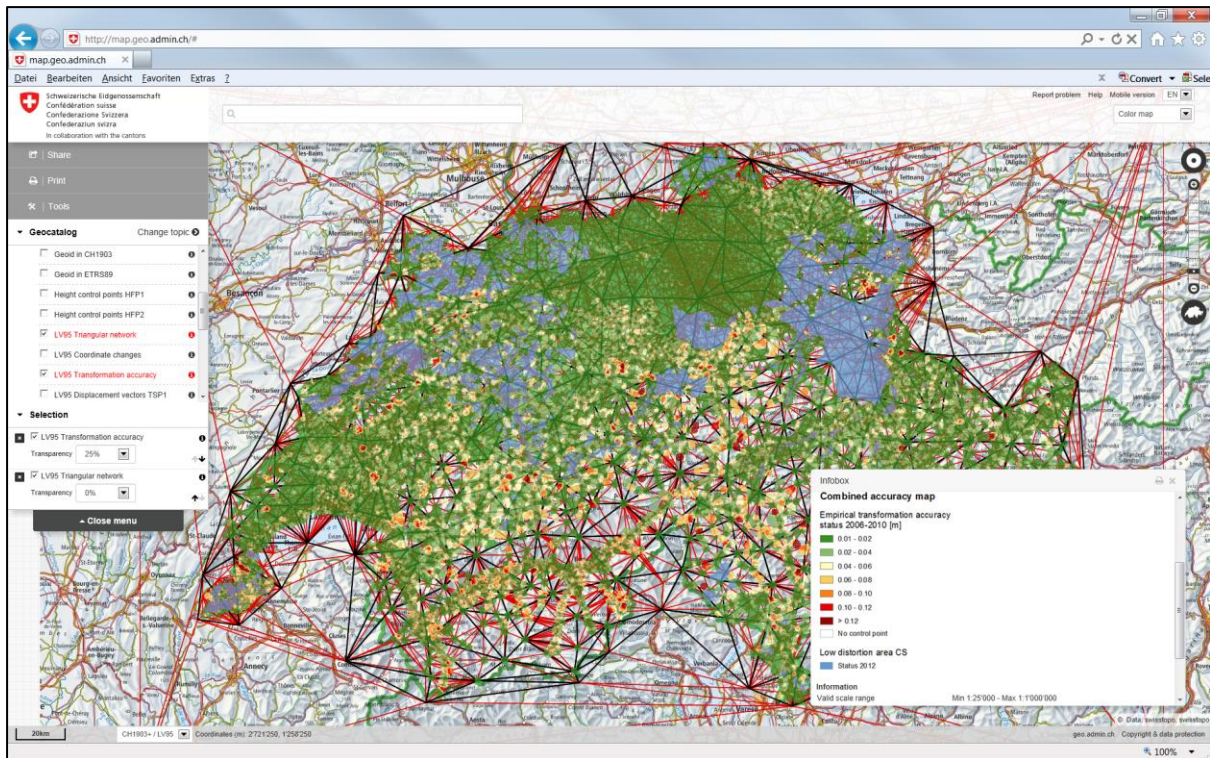
Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)                   9/12
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

FIG Working week 2015
From the Wisdom of the Ages to the Challenges of the Modern World
Sofia, Bulgaria, 17-21 May 2015

**Figure 8:** Visualisation service for the transformation accuracy based on a statistical method over control points distributed all over Switzerland (GNSS measured coordinates in comparison with transformed ones). Furthermore the cadastral authorities nominated so-called low distortion areas (blue surfaces): in these areas, cadastre survey fulfils the higher accuracy requirements related to the new global reference frame, so that measurements with GNSS sensors can be done in an absolute way without having to respect the local situation

Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)    10/12
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

FIG Working week 2015
From the Wisdom of the Ages to the Challenges of the Modern World
Sofia, Bulgaria, 17-21 May 2015

## 3.4 Download Service

Last but not least, different download services for DLLs and transformation datasets have also been realised.

With these different tools, the georeferencing of the SDI of Switzerland can be easily converted to the new reference frame LV95 in the next couple of years. About one third of 23 cantons (state level) have already transformed their SDIs successfully and for another third, the preparation work has already been started.

Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)          11/12
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

FIG Working week 2015
From the Wisdom of the Ages to the Challenges of the Modern World
Sofia, Bulgaria, 17-21 May 2015

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## BIOGRAPHICAL NOTES

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Matthias Kistler, Urs Marti, Jérôme Ray, Christian Baumann and Adrian Wiget (Switzerland)          12/12
Towards a Distortion Free National Spatial Data Infrastructure in Switzerland:
Approach, Developed Tools and Internet Services for the Change of the Reference Frame

FIG Working week 2015
From the Wisdom of the Ages to the Challenges of the Modern World
Sofia, Bulgaria, 17-21 May 2015