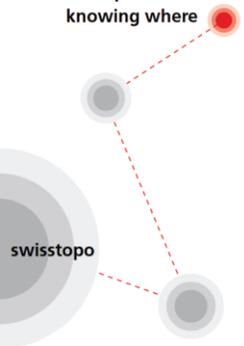




wissen wohin
savoir où
sapere dove
knowing where



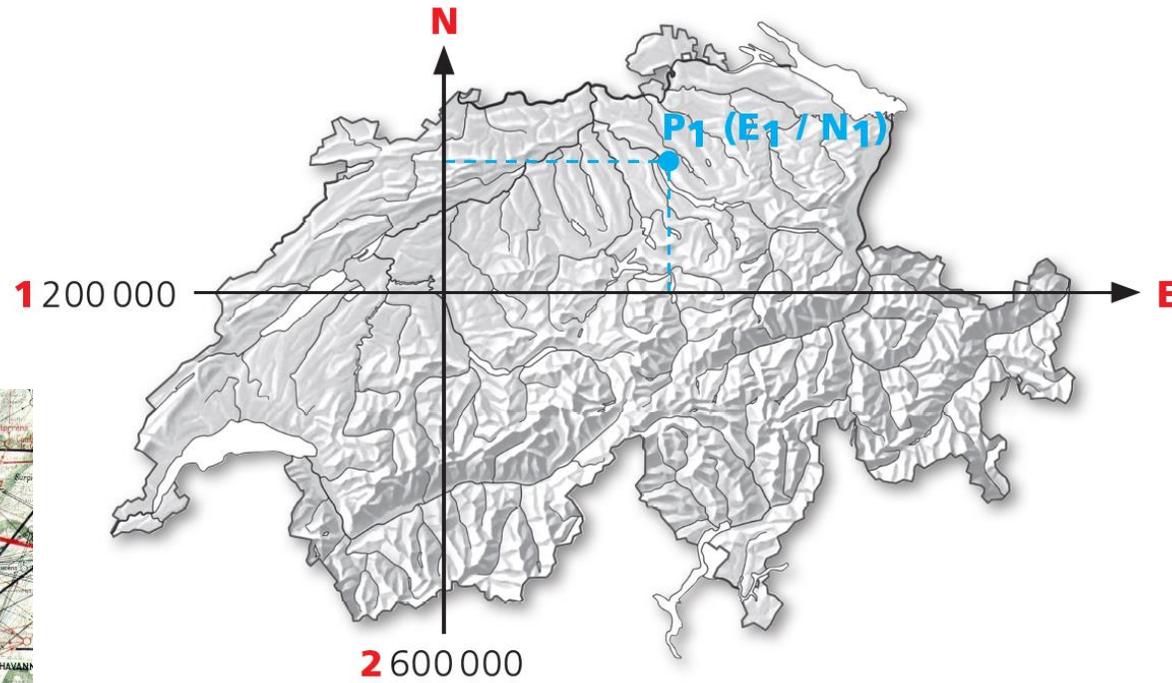
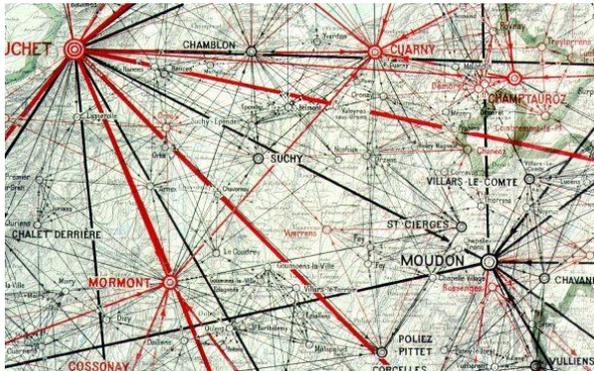
PROJ – usage of transformations in Switzerland (swisstopo)

E. Brockmann (Geodesy), M. Clausen (Web/GIS)



Swiss Reference Frames

- Old System LV03 (**Triangulation** based)
- y, x
- origin $y_0=600'000$, $x_0=200'000$
- New System LV95 (**GNSS** based)
- E, N
- origin $E_0=2'600'000$, $N_0=1'200'000$





LV95-LV03 Differences (FINELTRA; horizontally)

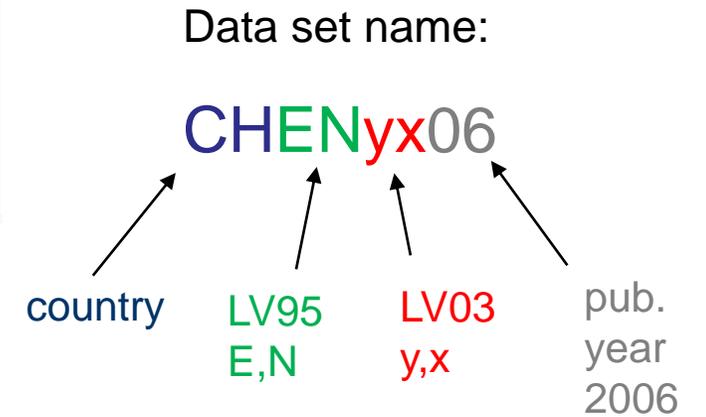
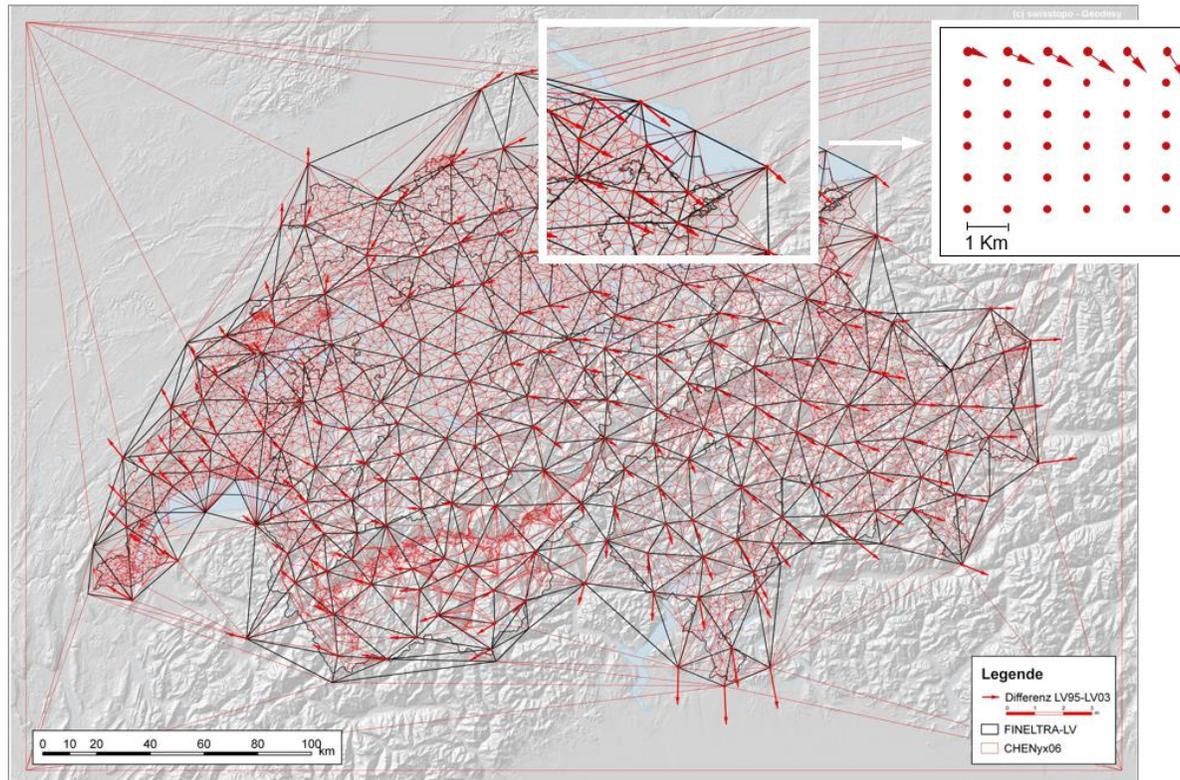
1995

1903

- A) FINELTRA: Finite Element Transformation (identical forward and backward)
- B) 1x1 km grid available (forward and backward < 1cm)

New is official system from 2017 onwards for federal law geobasisdata

New is official system from 2020 onwards for ALL geobasisdata



±1.5 m differences

- 10 - 30 cm accuracy transformation available since 1995
- 2 - 3 cm accuracy transformation available beginning 2007



Web Tools for coordinate transformations

REFREAME: CH – UTM – ETRS

- horizontal
- vertical (levelled / ellipsoidal)

REFREAME

REFREAME allows you to perform coordinates transformations in planimetry and/or altimetry.

1. Coordinates file:

Input file:

2. Define transformation:

Change

Input:

Reference frame i

- Projected coordinates LV03 (CH1903)
- Projected coordinates LV95 (CH1903+)
- Projected coordinates UTM (ETRS89/CHTRS95/~WGS84)
- Global coordinates ETRF93/CHTRF95 (ETRS89/CHTRS95/~WGS84)

Output:

Coordinates format:

3. Define the altimetric transformation:

Change altimetry

Reference frame i

Input:

Output:

4. Calculation options

No option is available for current selection.

5. Execute the calculation or reset the form

Please select the file to transform. i

<https://www.swisstopo.admin.ch/en/maps-data-online/calculation-services/reframe.html>

NAVREF: CH – WGS84

NAVREF

NAVREF allows you to transform Swiss projection coordinates into global WGS84 coordinates (GPS) and vice versa.

1. Define the transformation:

Input	Output
Coordinates system: i <input type="text" value="Swiss coordinates LV03"/> <input type="text" value="New Swiss coordinates LV95"/> <input type="text" value="Global coordinates WGS84"/>	Coordinates system: <input type="text" value="Global coordinates WGS84"/>
Format / unit: i <input type="text" value="LV95 (Berne – 2'600/1'200 km)"/>	Format / unit: <input type="text" value="Geographic Lon/Lat/Alt [°]"/>

2. Enter the coordinates to transform:

LV95	WGS84 (–ETRS89)
East: <input type="text"/> [m]	Longitude: <input type="text"/> [°]
North: <input type="text"/> [m]	Latitude: <input type="text"/> [°]
Altitude: <input type="text"/> [m]	Altitude: <input type="text"/> [m]

3. Execute the calculation or reset the form

Please enter the input East coordinate. i

<https://www.swisstopo.admin.ch/en/maps-data-online/calculation-services/navref.html>



Other methods

- Web API (REST service)

call: `geodesy.geo.admin.ch/reframe/wgs84tolv95?easting=7.43863&northing=46.95108&altitude=550.0`

return: `{"easting": "2599999.81004", "northing": "1199999.68019", "altitude": "500.37779"}`

JSON ||
GeoJSON

- also available 2D:

- WGS84 to LV95
- LV95 to WGS84
- WGS84 to LV03
- LV03 to WGS84
- LV95 to LV03
- LV03 to LV95

heights-only

- LN02 to LHN95
- LHN95 to LN02
- LHN95 to Bessel
- Bessel to LHN95
- LN02 to Bessel
- Bessel to LN02

- REFRAME library for own .NET or C++ applications (e.g. REFRAME.DLL)
- NTV grids (1x1 km; not the FINELTRA approach)

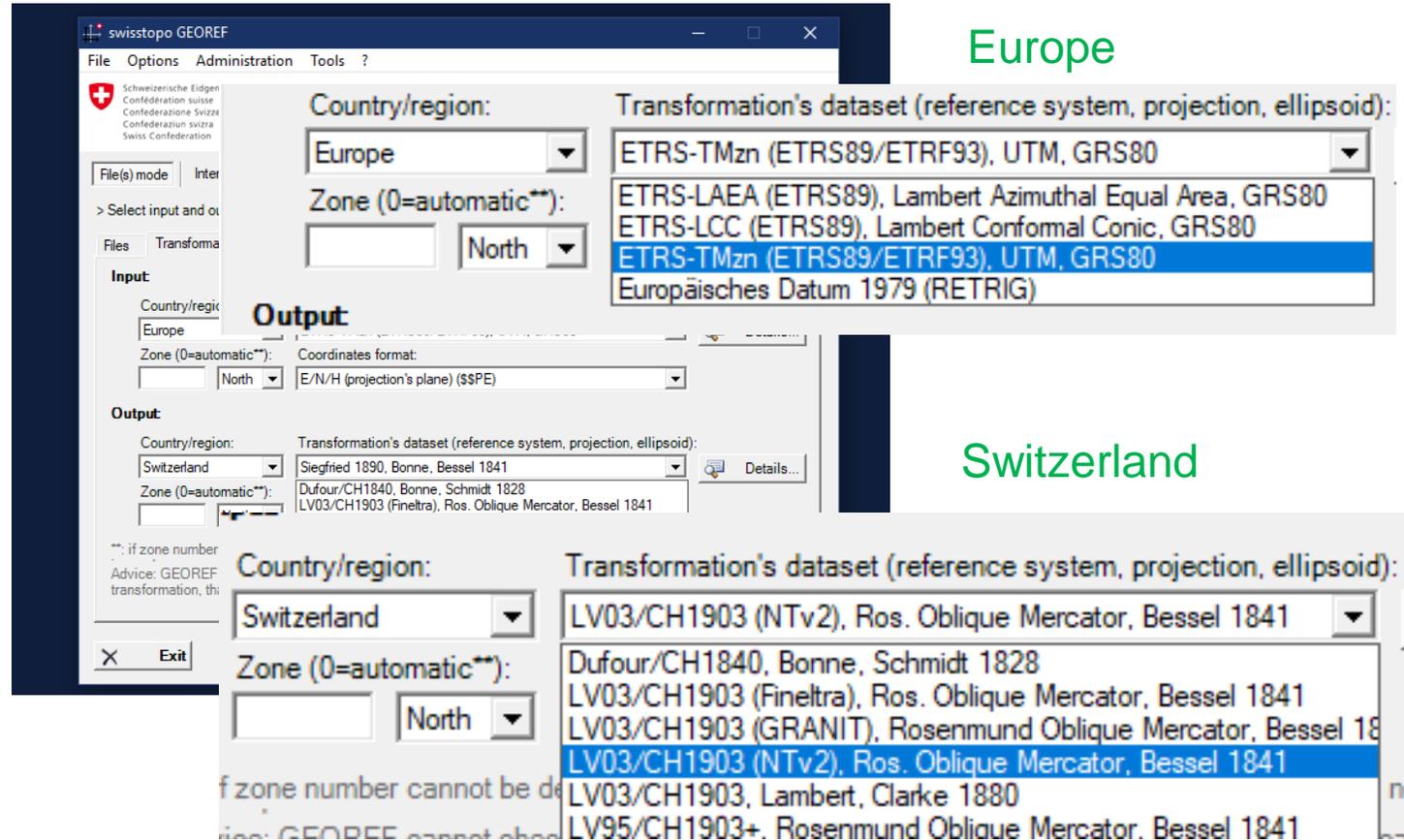


Software

- **GEOREF (PC program)**

Some countries

(Albania, Armenia, Austria, Europe, France, Germany, Guatemala, Italy, Kosovo, Luxemburg, Switzerland)



Europe

Switzerland

- GIS-Systems, GNSS manufacturers: via **NTV grid** or via **DLL**
- swipos positioning system (via **DLL implemented in Trimble VRS**; access to different mountpoints; corrections constant within 1 km)



PROJ for Geodesy

- Install:
 - Version 5.1 from source on linux redhat6 (5.2 requires higher compiler)

- Usage: (|| epsg:21781 – without grid) LV95

call: `echo 637549 126844 | cs2cs +init=CH:1903_LV03 +to +init=epsg:2056 -f "%.4f"`

Config CH:1903_LV03: /usr/share/proj/chenyx06etrs.gsb (NTV grid)

return: `2637548.7189 1126843.7212 -50.8212`

- Compare with reframe web API (1-2 mm difference: grid versus algorithm)

call: `geodesy.geo.admin.ch/reframe/lv03tolv95?easting=637549&northing=126844`

return: `{ "type": "Point", "coordinates": [2637548.7165, 1126843.7207] }`



PROJ config

Special CH using the grid:

LV03

```
<21781> +proj=somerc +lat_0=46.95240555555556 +lon_0=7.439583333333333 +k_0=1  
+x_0=600000 +y_0=200000 +ellps=bessel +units=m +nadgrids=chenyx06etrs.gsb +no_defs
```

(replace default `|| <CH:1903_LV03>`)

Standard debian proj packages:

LV95

```
<2056> +proj=somerc +lat_0=46.95240555555556 +lon_0=7.439583333333333 +k_0=1  
+x_0=2600000 +y_0=1200000 +ellps=bessel +towgs84=674.374,15.056,405.346,0,0,0,0 +units=m  
+no_defs
```

EPSG Code `<21781>` - LV03
`<2056 >` - LV95



PROJ in Web applications

- GDAL (Geospatial Data Abstraction Library)
 - raster / vector handling and utility programs
 - open source (May 2019: GDAL 3 release)
 - command-line oriented
 - comes with **debian packages** and used within other OpenSource Map projects: **PostGIS**, GRASS, QGIS, **MapServer** (**Swiss Army knife in geomatics**)



- Courses (e.g. «Proj4 and OGR/GDAL: GIS data processing»)





PROJ in Web applications

<https://map.geo.admin.ch>

+

<https://test.map.geo.admin.ch>

(used for global data view and vector data -> EU dense velocity viewer)

The screenshot shows the swisstopo map application interface. At the top left, there is a logo and text in German, French, Italian, and Romansh. Below this is a search bar with the text "Ort Zimmerwald (BE) - Wald (BE)". The main map area shows a topographic map with labels for "Zimmerwald station", "Fundamentalpunkt LV95", "chboumacher", "Bei der Kirche", and "Pfruendschür". A popup window titled "Position" is open over the map, displaying the following information:

CH1903+ / LV95	2'602'030.7, 1'191'778.3
CH1903 / LV03	602'030.64, 191'778.30
WGS 84 (lat/lon)	46.87712, 7.46527
	46°52'37.646"N 7°27'54.982"E
UTM	383'055, 5'192'653 (zone 32T)
MGRS	32TLS 83055 92653
what3words	protect.string.picture
Elevation	897.9 m
	Link with bowl crosshair

Below the text in the popup is a QR code. On the left side of the map, there is a sidebar menu with options like "Share", "Print", "Draw & Measure on map", "Advanced tools", "Geocatalog", and "Maps displayed".

PROJ in JavaScript:
<http://proj4js.org/>

Different coordinate systems:

- LV03 (reframe api)
- LV95 (source, right click)
- UTM (proj4js)
- MGRS (proj4js)
- What3words (w3w api)



PROJ in swisstopo FSDI services

- WMTS GetTile restful proxy -> mapserver 7.0.7 / gdal 2.3.0 / proj 5.1.0
- WMS (GetMap/GetFeatureInfo) mapserver 7.0.4 / gdal 2.1.2 / proj 4.9.3
- API backend postgres 9.4 / postgis 2.1 / proj 4.9.1
- API frontend proj4js

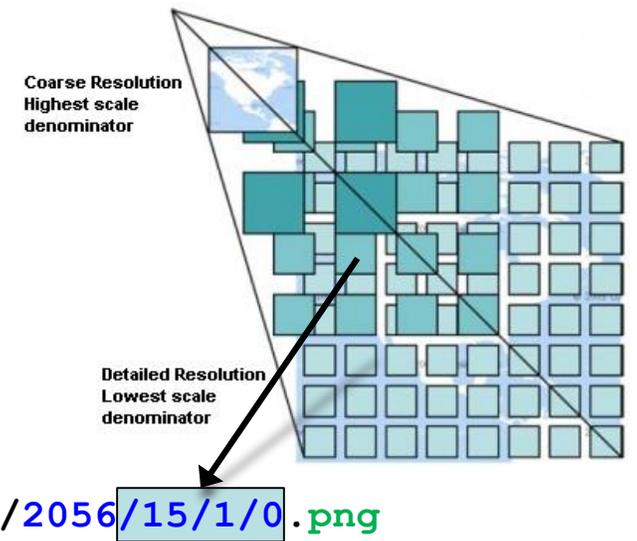
	EPSG	Utilization	Data source
WMTS	2056, 21781, 4326, 3857	200 req/s	Filesystem (6TB, LV95, LV03) Database (500GB, LV95)
WMS	2056, 21781, 4326, 3857, 3034, 3035, 4258, 31287, 25832, 25833, 31467, 32632, 900913,...	5 req/s	Filesystem (6TB, LV95, LV03) Database (500GB, LV95)
api (p.e. identify)	2056, 21781	50 req/s	Database (500GB, LV95)

PROJ delivers on-the-fly tiles (from LV95 source system to various coordinate systems)



WMTS – Tiles on Demand in FSDI

- WMTS = [OGC restful georeferenced map tiles service](#)
- WMTS Request:
 - `1.0.0/ch.bav.laermbelastung-eisenbahn_tatsaechliche_emissionen_tag/default/current/2056/15/1/0.png`
- will be translated into WMS GetMap
 - `?CRS=EPSG:2056&SERVICE=WMS&FORMAT=image/png&REQUEST=GetMap&HEIGHT=256&WIDTH=256&VERSION=1.3.0&BBOX=2548000.0,1222000.0,2676000.0,1350000.0&LAYERS=ch.bav.laermbelastung-eisenbahn_tatsaechliche_emissionen_tag&TIME=current&TRANSPARENT=true`
- tiles are generated and cached on-demand on aws s3 with mapserver v7
- wmts cache size: 20 TB, 850 Mio objects generated by mapserver/gdal/proj
- wmts cache pyramids are available in EPSG:2056,21781,4326,3857
- <http://api3.geo.admin.ch/services/sdiservices.html#wmts>





Summary

- Quite a lot specialties in the various national mapping projections
- quite “complicated” to support users and manufacturers with different tools (and keep them always updated)
- An open tool like PROJ is very much appreciated and is already heavily used especially in web-GIS applications. The default `cheryx06etrs.gsb` grid needs proper license to be included in the standard configuration.
- Implementations of “time-dependent” transformations using velocity models will be realized based on PROJ (no individual development foreseen)