Swiss Terrestrial Reference Frame CHTRF2022

EUREF2026
Symposium
Paris, France
23 – 25 June 2026

Lars Prange, Daniel Ineichen, Simon Lutz,
Stefan Schaer, Arturo Villiger (PNAC Team)
Federal Office of Topography swisstopo, Wabern, Switzerland

Abstract

Switzerland is located on the stable part of the Eurasian (EURA) tectonic plate. It is, however, affected by alpine uplift and local phenomena such as landslides. The national reference frame is maintained and regularly controlled by the Federal Office of Topography (swisstopo) – Switzerland's national mapping agency. The currently used coordinate reference system of Switzerland was defined to be GNSS-based in the frame of the "Landesvermessung 95" (**LV95**) in the 1990ies. It consists of the following components (Figure 1):

Map coordinate system CH1903+
Official coordinates (incl. land cadastre) in Switzerland refer to this system. It is defined as **static** and there is **only** one **realization** so far: **LV95**. Update of LV95 control point coordinates: on demand only.

Swiss Grid projection
Strict mathematical relation between CHTRS95 and CH1903+, including a shift of the coordinate origin, projection on the Bessel 1841 ellipsoid, and an oblique cylindrical map projection.

Geocentric coordinate system CHTRS95
Kinematic, geocentric, cartesian system. Initial realization **CHTRF95** was defined in ETRF93, epoch 1993.0 and is connected to LV95 realization of CH1903+ by the Swiss Grid projection, thus providing an interface between global, geocentric, kinematic reference frames and the static map coordinate system. Updated CHTRFyy realizations are generated every 6-8 years.

Transformation chain

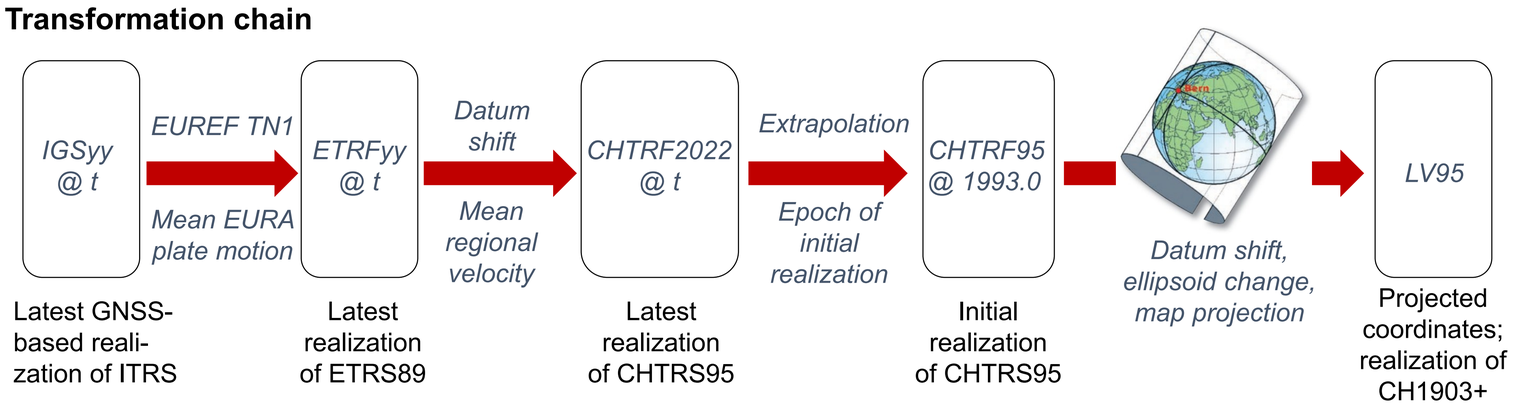


Figure 1: Intermediate steps from coordinates and velocities determined in a global ITRF/IGS reference frame to map projected coordinates in the static national reference frame LV95.

Network and data

Data with different features contribute to each CHTRF realization (Figure 2):

CORS (Continuously Operating Reference Station) **networks**
About 200 stations, including
- **AGNES** (Automated GNSS Network in Switzerland) with 30 (+10 double) stations, since 2000 → **swipos**
- CORS from neighboring states → **swipos** (border regions)
- **IGS, EPN** stations → alignment to **ITRF** by IGS stations
- Other Swiss networks → densification, cooperation

Passive markers
Points with campaign-wise snapshot measurements
- 200 **LV95 control points** → **connection CHTRF95 to LV95**
- Height reference points → connection to height system
- Other → densification



Figure 2: Input data for the CHTRF reference frame: AGNES CORS station (left), LV95 passive marker control point with GNSS rover antenna (center), local tie measurement at SLR telescope at fundamental station Zimmerwald (right).

Local ties
Control measurements between double-antenna stations or in case of unusual CORS velocity are used for validation and constraining.

Data processing strategy

- Stacking of normal equation (NEQ) files generated at swisstopo PNAC (Permanent Network Analysis Center) since the 1990ies:
  - from daily monitoring of the AGNES network and EPN processing (see also Figure 3)
  - from campaign-wise processing of passive marker networks
- Least-squares adjustment with constraints (alignment to ITRF/IGS, avoidance of singularities, relative velocity between nearby stations, loose constraints on uplift velocity of campaign points)
- Determination of station coordinates and velocities aligned to IGb14 and IGc20 frames
- Transformation to ETRF2014 and ETRF2020 (Figures 4 and 5)
- Datum shift to CHTRF95 (Figure 6, Tabs.1 and 2)
- Software: Bernese GNSS Software, version 5.5
- Reference products: CODE IGS (multi-GNSS) products, models according to IAG and IERS standards

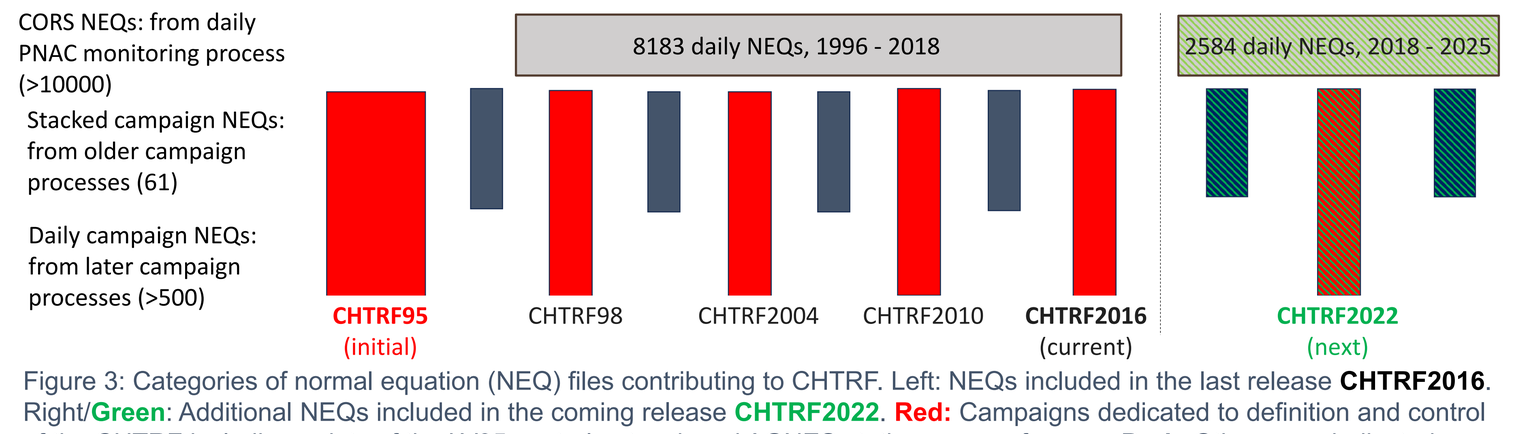


Figure 3: Categories of normal equation (NEQ) files contributing to CHTRF. Left: NEQs included in the last release **CHTRF2016**. Right/**Green**: Additional NEQs included in the coming release **CHTRF2022**. **Red:** Campaigns dedicated to definition and control of the CHTRF including points of the LV95 control network and AGNES stations as a reference. **Dark**: Other, non-dedicated campaigns. **Light grey/green**: NEQs from daily analysis of CORS networks including IGS, EPN, AGNES and others.

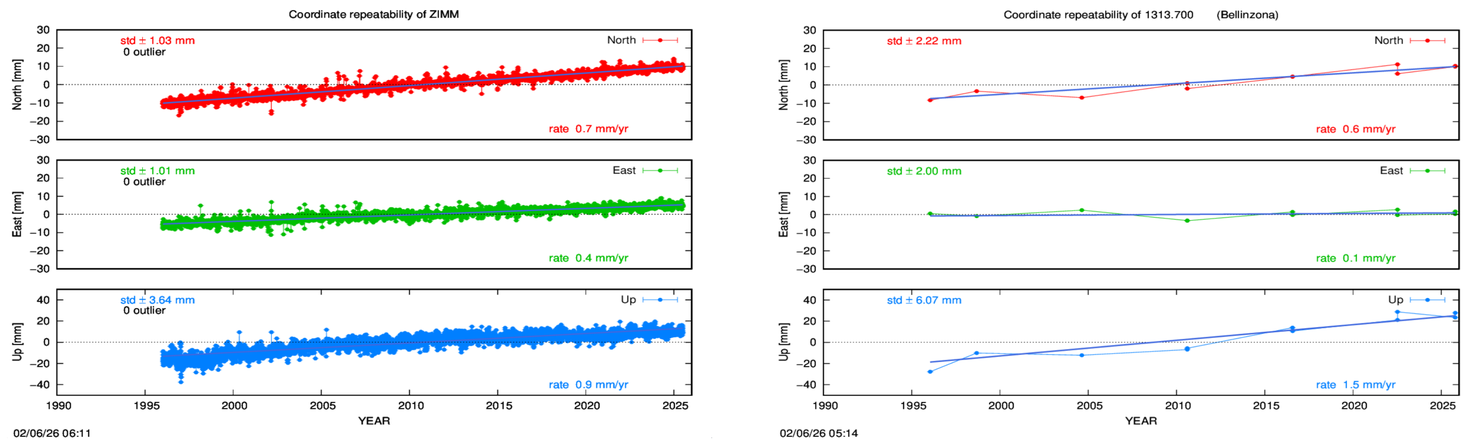


Figure 4: Coordinate repeatability of a CORS station (left) and a LV95 passive marker control point (right) w.r.t. ETRF2020.

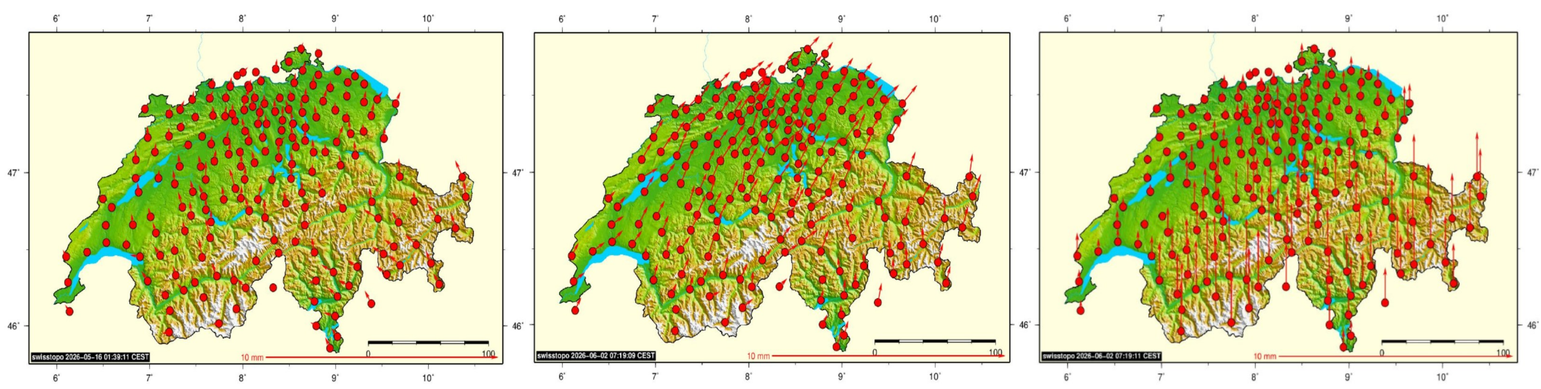


Figure 5: Intra-frame velocity [mm/y] of LV95 points. Left: **ETRF2014** horizontal. Center: **ETRF2020** horizontal. Right: vertical.
⇒ In Switzerland ETRF2014 fits better than ETRF2020 (smaller intra-frame velocities)
⇒ Significant uplift in the Alps (with a tendency to over-estimation - uplift velocity of LV95 points is constrained)

Access to the reference frame

Direct access
- LV95 control points can be accessed in the field
- LV95 coordinates (and velocities) are published

swipos positioning service
- GNSS positioning service provided by swisstopo

Coordinate transformation
- 14-parameter transformation from ITRFyy and ETRFyy to CHTRF2022 (preliminary parameters inTab.1 and 2)

Tab.1: Transformation parameters ETRFyy to CHTRF2022 at epoch 1989.0 and rates/year

ETRFyy	T1	T2	T3	D	R1	R2	R3
	mm	mm	mm	1e-9	mas	mas	mas
ETRF2014	63.4	55.0	-16.2	0.00	0.000	0.000	0.000
rates	-0.2	0.0	-0.7	0.00	0.000	0.000	0.000
ETRF2020	61.1	56.0	-18.0	0.00	0.000	0.000	0.000
rates	-0.1	-0.4	-1.0	0.00	0.000	0.000	0.000

Tab.2: Transformation parameters ITRFyy to CHTRF2022 at epoch 1989.0 and rates/year

ITRFyy	T1	T2	T3	D	R1	R2	R3
	mm	mm	mm	1e-9	mas	mas	mas
ITRF2014	63.4	55.0	-16.2	0.00	0.000	0.000	0.000
rates	-0.2	0.0	-0.7	0.00	0.085	0.531	-0.770
ITRF2020	61.1	56.0	-18.0	0.00	0.000	0.000	0.000
rates	-0.1	-0.4	-1.0	0.00	0.086	0.519	-0.753

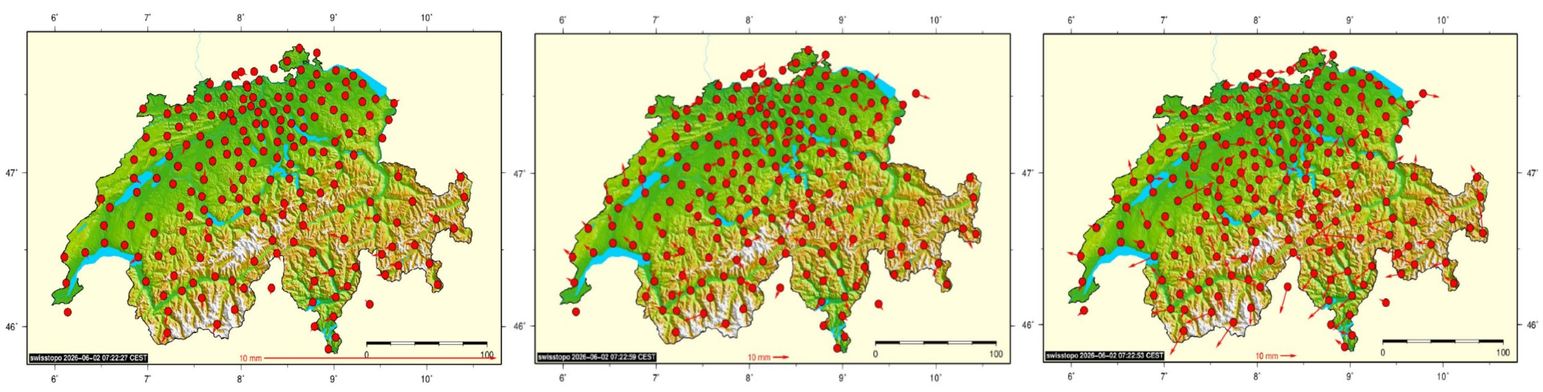


Figure 6: LV95 control points in **CHTRF2022**. Left: Horizontal intra-frame velocity [mm/y]. Horizontal residuals [mm] w.r.t. CHTRF95. Center: Extrapolated to 1993.0 (reference epoch of CHTRF95), RMS=6.4 mm. Right: Residuals at epoch 2025.0, RMS=9.9 mm.
⇒ Residuals are increasing over time – despite small size of intra-frame velocities (deformation model to be considered in the future)

Poster compiled by Lars Prange, June 2026
Federal Office of Topography swisstopo,
Seftigenstrasse 264, 3084 Wabern, Switzerland
lars.prange@swisstopo.ch

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Landestopografie swisstopo
Office fédéral de topographie swisstopo
Ufficio federale di topografia swisstopo
Federal Office of Topography swisstopo