

Modernisation of the Swiss Vertical Reference System



Borlat E.¹, Deillon Y.¹, Willi D.²

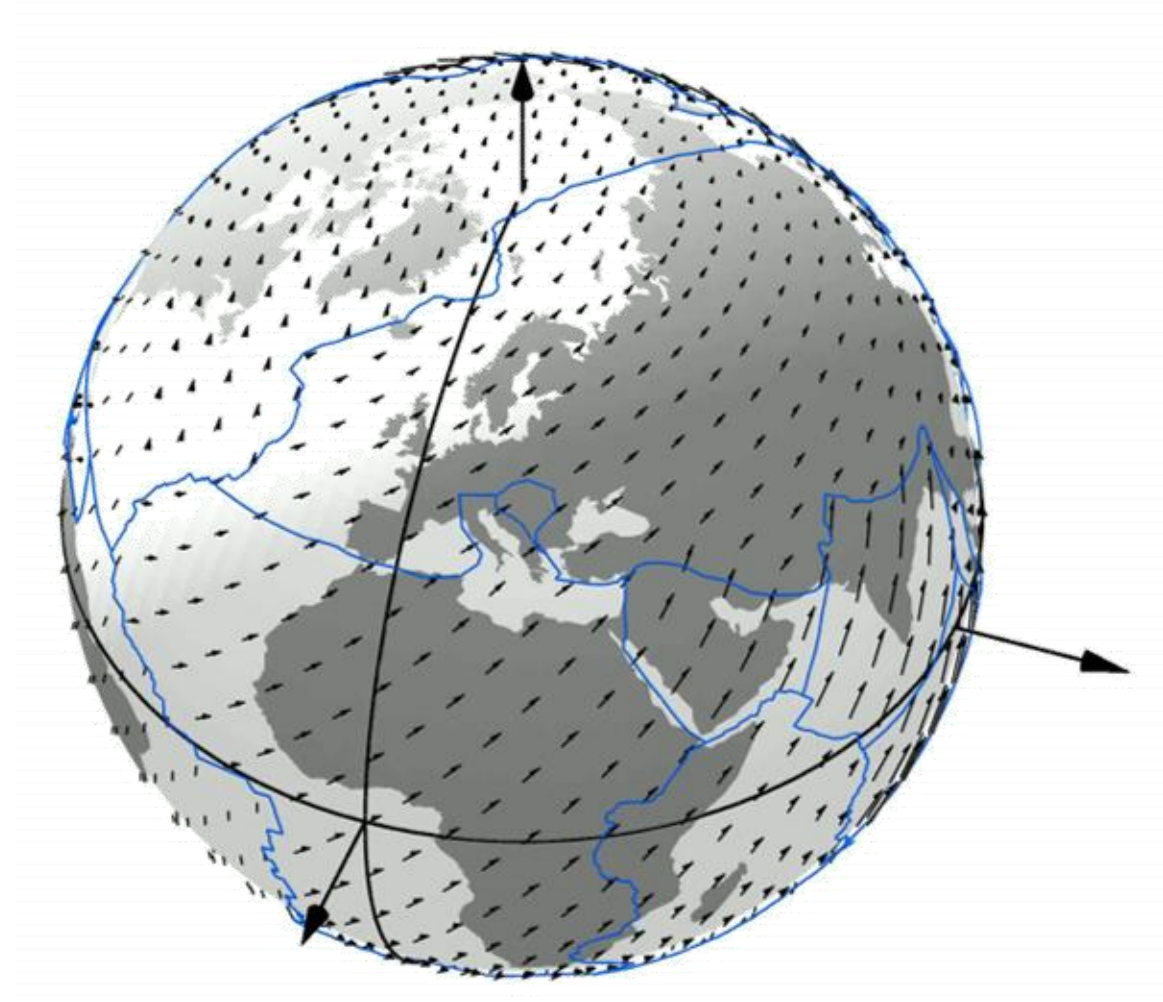
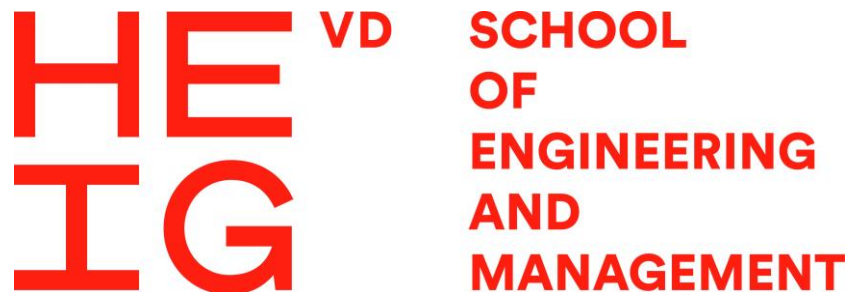
Session : 22. Geodesy

18th November 2023

21st Swiss Geoscience Meeting, Mendrisio 2023

¹ School of Engineering and Management HEIG-VD

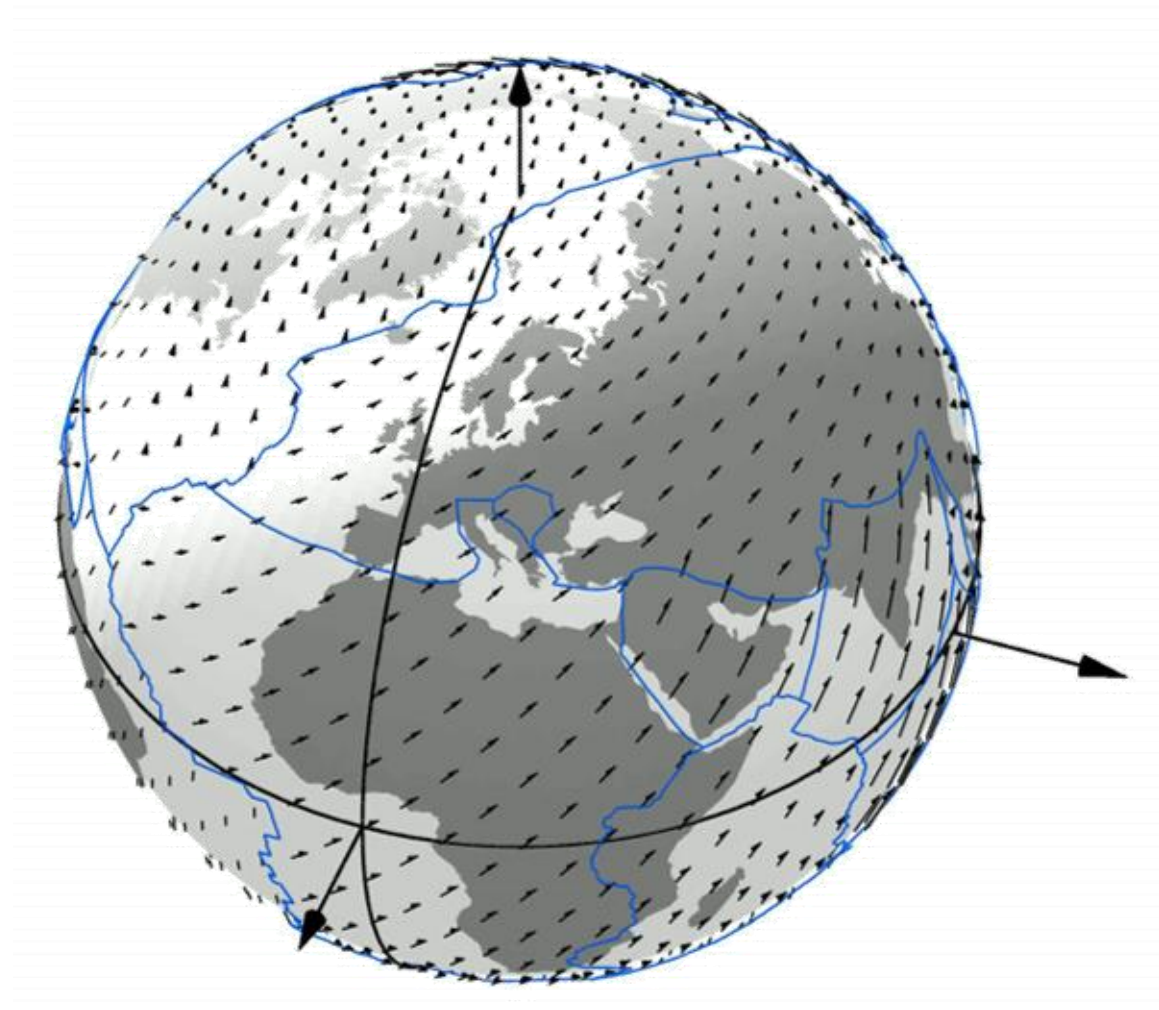
² Federal Office of Topography swisstopo

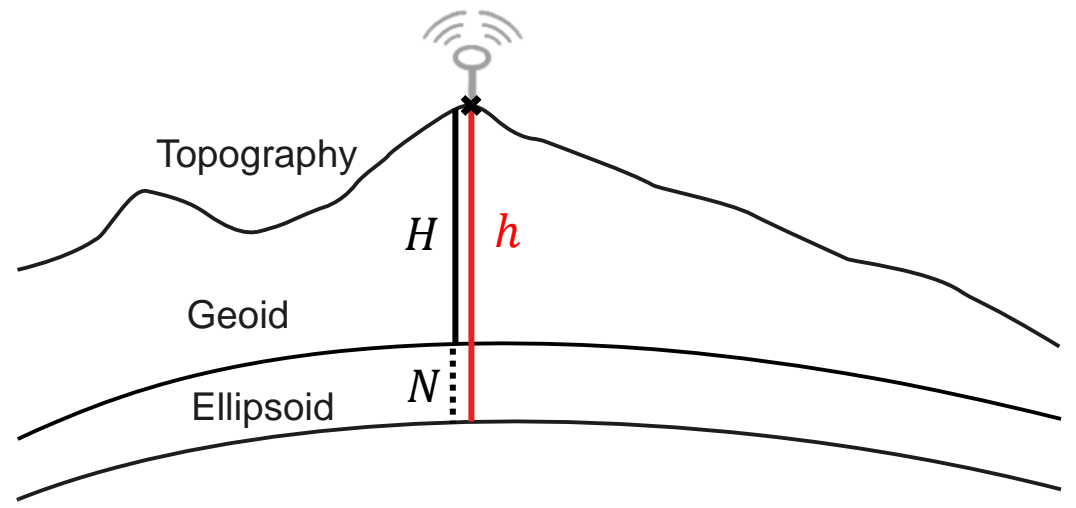
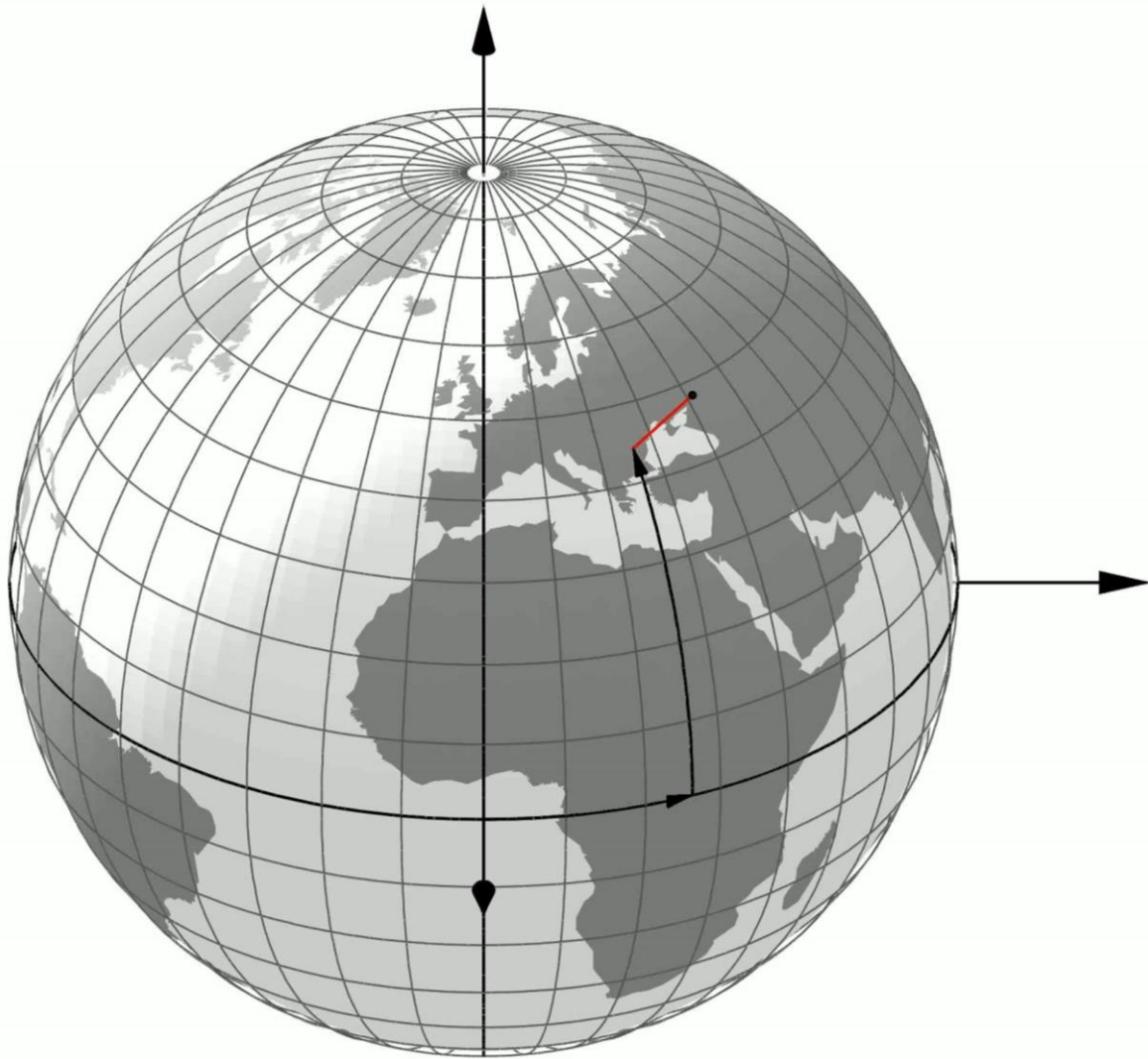




Stable and precise
reference systems over time

Local physical height system





h : ellipsoidal height

→ purely geometric height

N : geoid undulation

Taking into account the
Earth's gravitational field

H : orthometric height

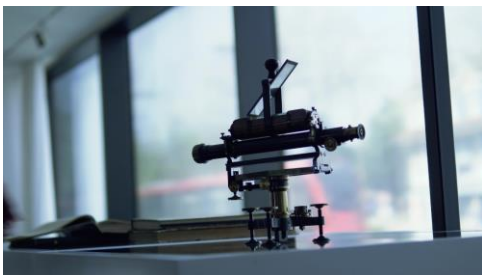
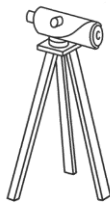
→ physical height

$$h = H + N$$

What is the situation in Switzerland today?

LN02

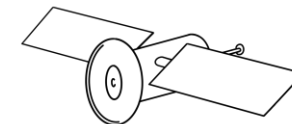
National precise levelling 1902



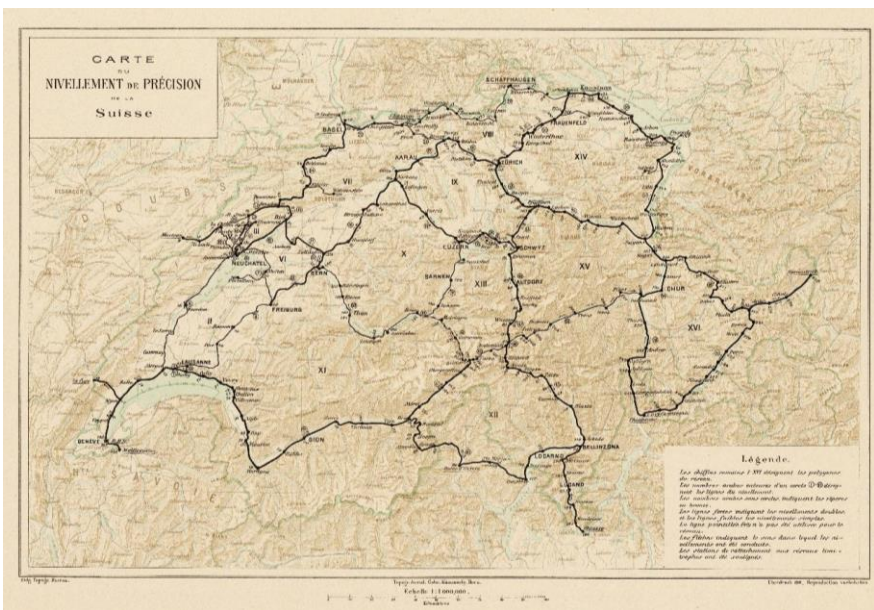
- Uncorrected leveled heights

LHN95

National height network LHN95
Scientific system



- Orthometric heights
- Used for scientific purposes and large infrastructure projects
- Used indirectly for GNSS height determinations through the geoid (CHGeo2004) and the HTRANS transformation.

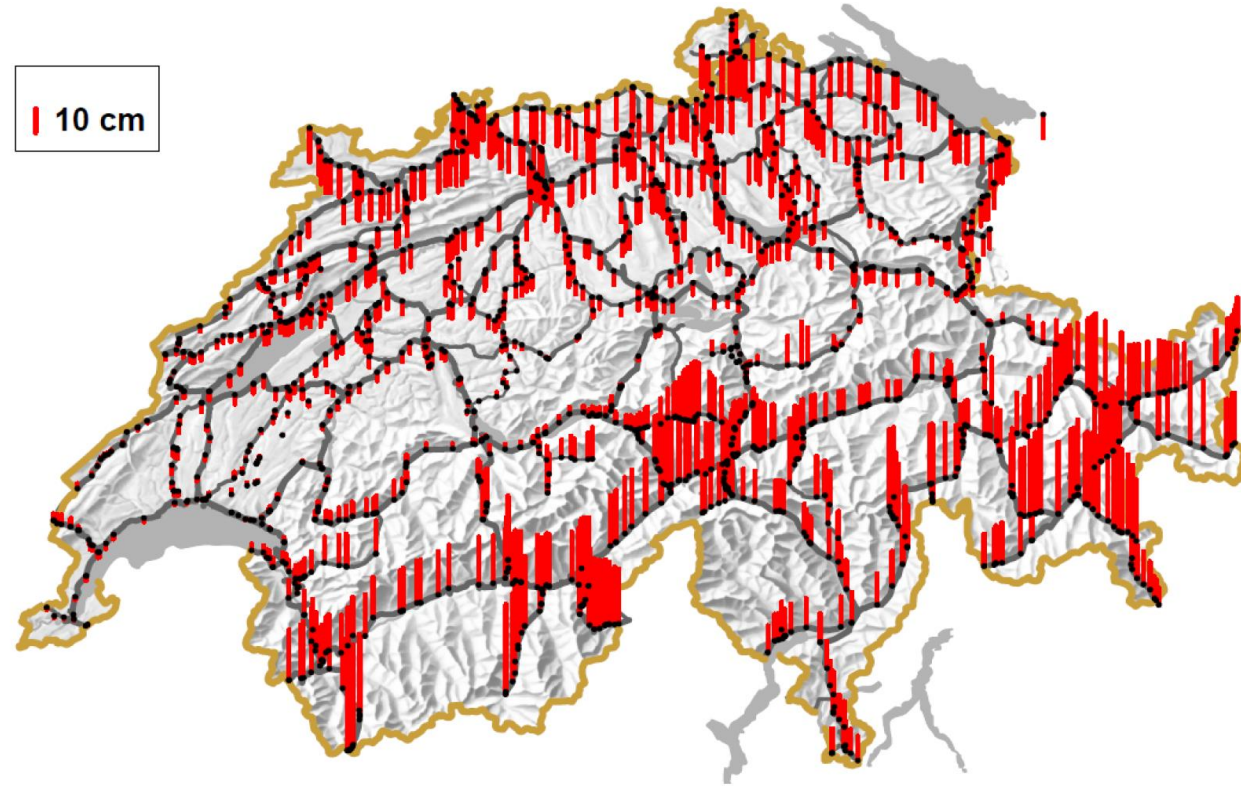


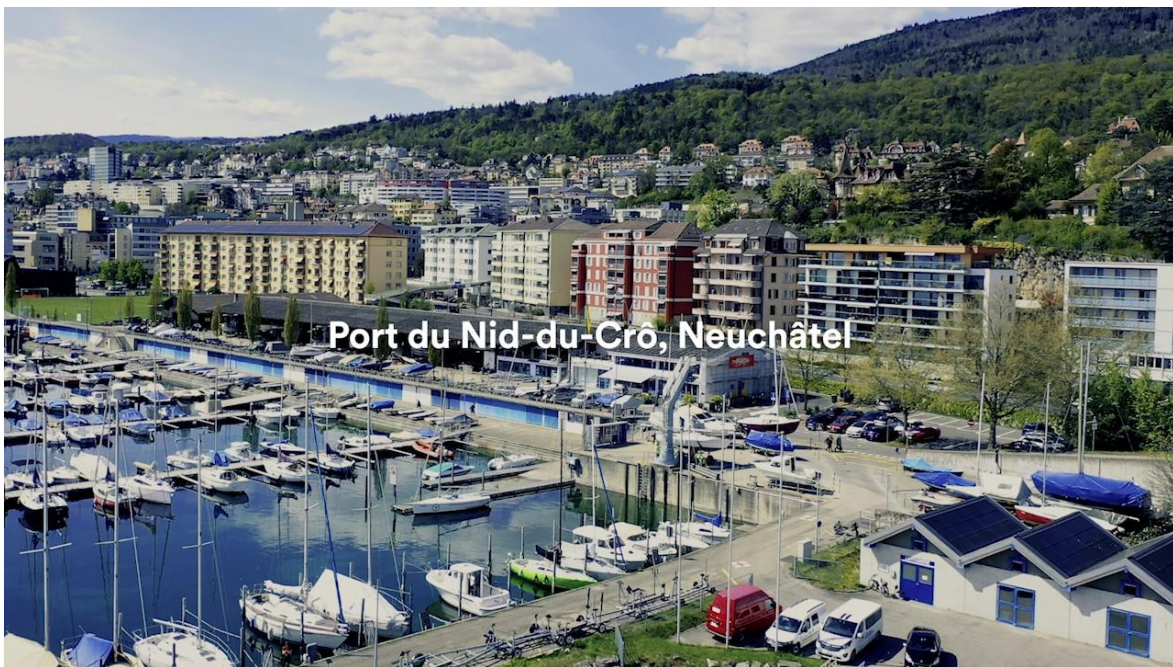
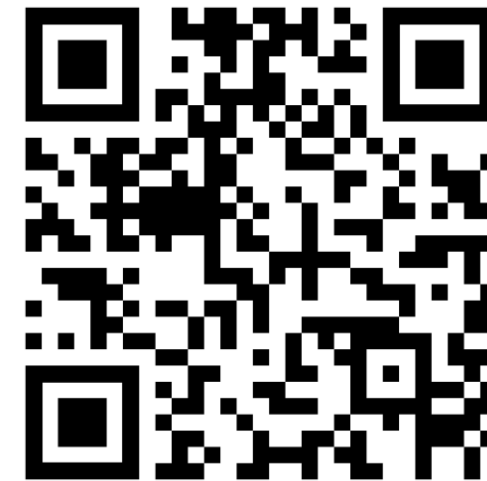
Up to 40 cm differences...

Total difference between rigorous heights (LHN95) and uncorrected leveled heights (LN02)

- 1 LN02 is based on leveled height with an error of around 1 cm per 100 m of height difference (scale factor)
- 2 the measurements on which LN02 is based are over 100 years old, leading to errors of 10 to 20 cm
- 3 vertical movements of the crust have not been taken into account, leading to errors of 10 to 20 cm

10 cm

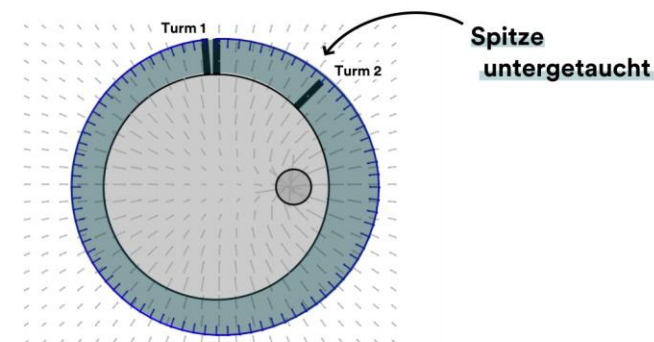




- 1 Motivations of the project
- 2 Definitions and scientific basis

Welche Punkte haben **das gleiche Schwerepotential** wie die Spitze des Turmes 1?

Kugelförmige
und **inhomogene** Erde




Status of height geodata through a questionnaire

Target audience :

1. Federal offices
2. Cantons
3. Cities
4. Professional organisations
5. Large companies with extensive geodata sets

HE^{VD}
IG
INSIT
Institut
d'Ingénierie
du territoire

 Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Landestopografie swisstopo
Office fédéral de topographie swisstopo
Ufficio federale di topografia swisstopo
Uffizi federal da topografia swisstopo

Willkommen zu unserer Umfrage über die in der Schweiz verwendeten Höhenangaben im Hinblick auf einen möglichen Wechsel des Höhenbezugs für die Geobasisdaten des Bundes



Das Ausfüllen dieses Fragebogens dauert etwa 20 bis 30 Minuten.

Zurück zur Sprachauswahl

Weiter →

HE^{VD}
IG



Project swiss height system

Elisa B., Deillon Y., Willi D.

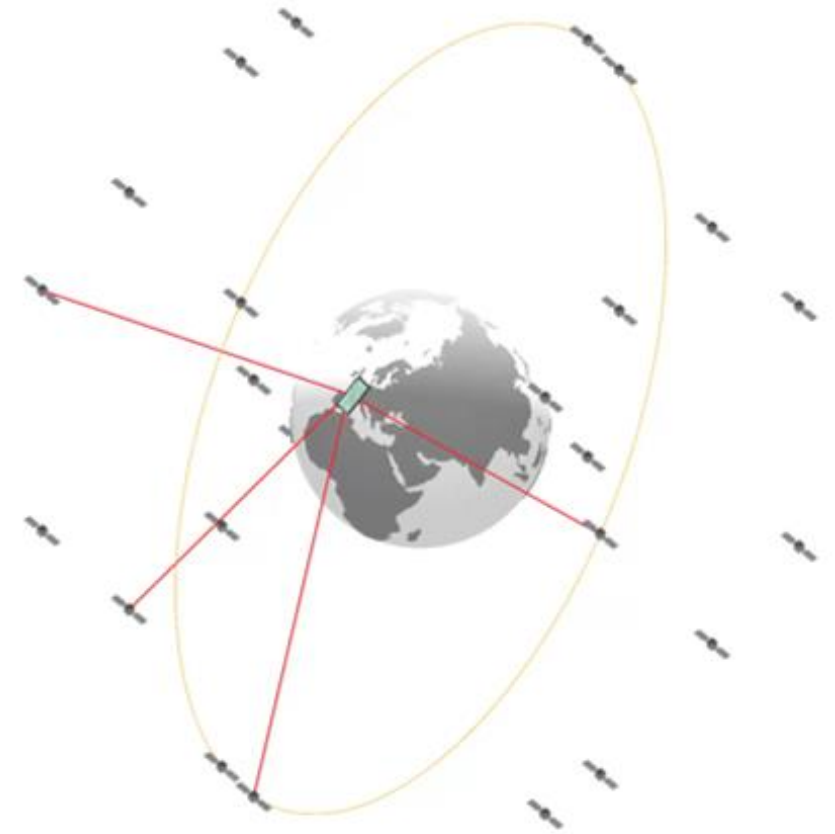
Main results of the questionnaire

- 90% of height geodata are in digital form
- 90% of height geodata are in the official height system (LN02)
- 40% of height geodata are currently obtained from global geopositioning services
- 80% of heights geodata needs are compatible with the accuracy of global GNSS positioning



Risks of the status quo

- the introduction of a height reference system imposed de facto by GNSS geopositioning services
- a lack of preparation for changing system
- a high risk of confusion and errors in the long term between official heights and heights from GNSS geopositioning services



Requirements for the modernisation of the Swiss Vertical Reference System (CHVRS)

- International compatibility
- Compatibility with space geodesy
- Countrywide introduction
- Durability



Main technical orientations for CHVRS

Normal heights

Normal gravity fields : GRS80 ellipsoid

User friendly : defined in order to have minimal changes of height values on the swiss Plateau → kinematic system

In terms of nomenclature, the following abbreviations are used:

CHVRS : Swiss Vertical Reference System

CHVRF202x : Swiss Vertical Reference Frame 202x, with 202x the year of the frame

CHVKM202x : Swiss Vertical Kinematic Model 202x

Why choose normal heights?

$$h = H + N$$

h : ellipsoidal height
 H : orthometric height
 N : geoid undulation

Molodensky's approach

$$h = H^* + \zeta$$

h : ellipsoidal height
 H^* : normal height
 ζ : height anomaly (quasi-geoid)



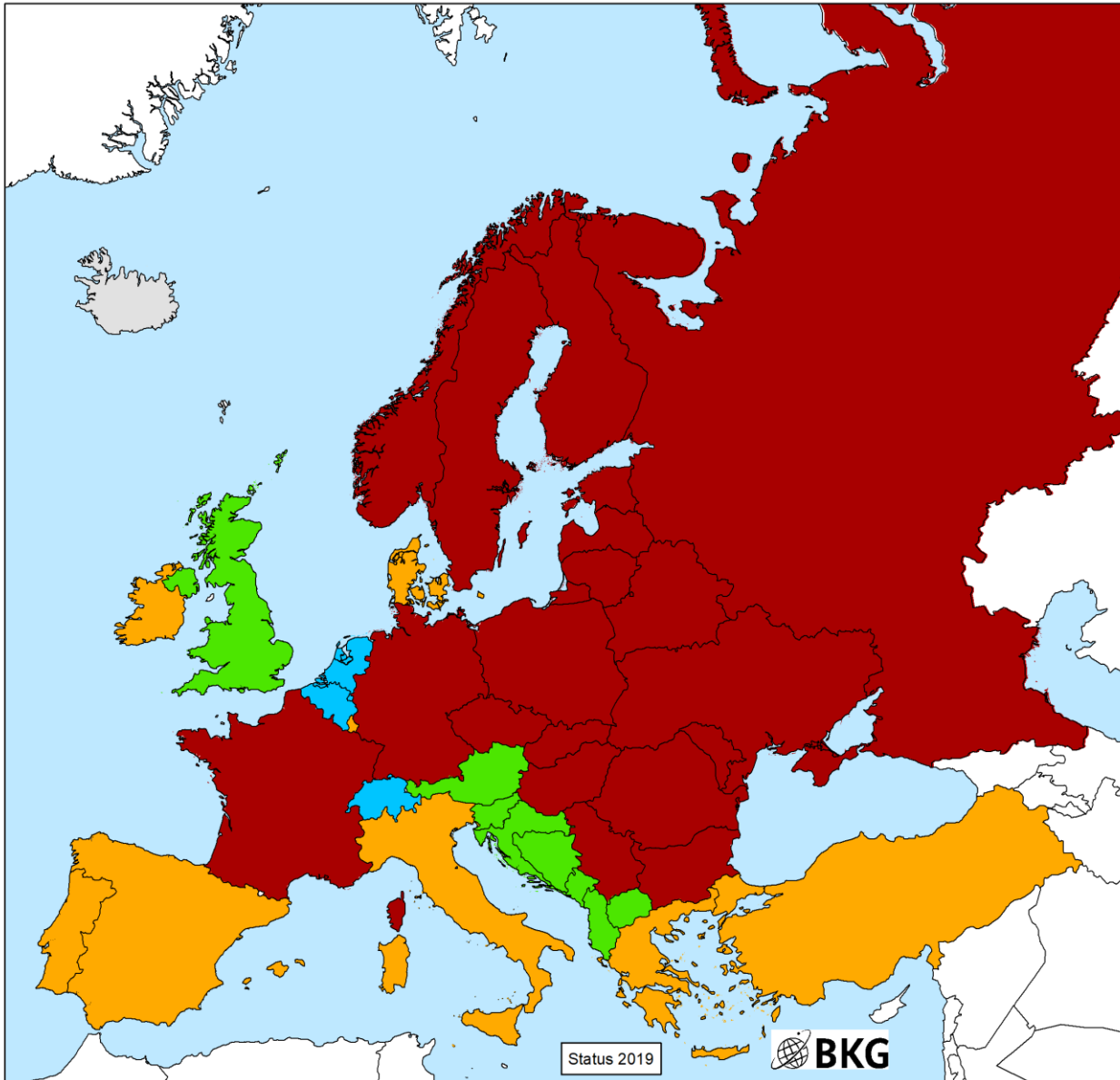
International compatibility



No assumption required on mass distribution



Why choose normal heights?



Kind of heights of national height systems in Europe



European compatibility

Kind of heights

- no leveling network
- uncorrected leveled heights
- normal heights
- orthometric heights
- normal-orthometric heights
- no information

Agenda's proposal for introduction CHVRS



2024 - Development of the technical basis and tools at swisstopo

2025 - Proof of concept with 1 to 2 cantons

2026 - Consultation with the cantons and users

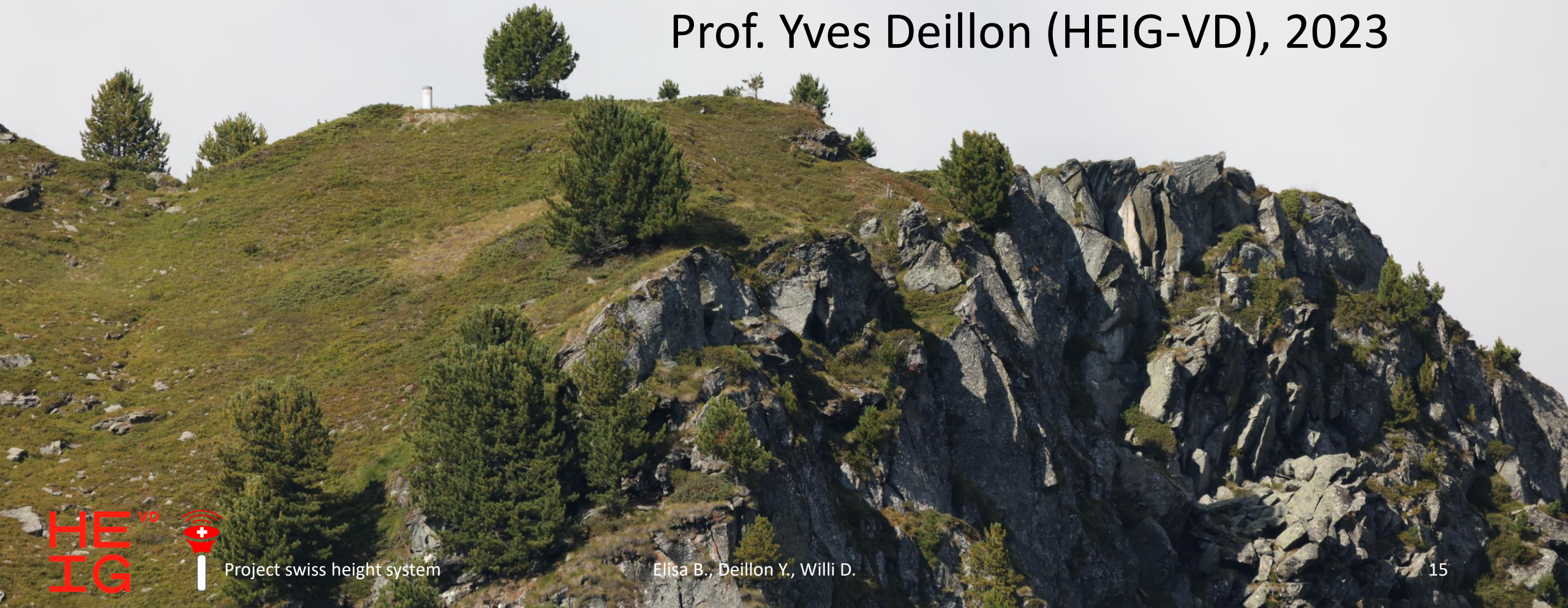
2027 - Official acceptance of CHVRS

2028 - Start of implementation



It is necessary to modernise the uncorrected leveled heights (LN02) with a rigorous height reference system to avoid a high risk of confusion and errors with future global GNSS geopositioning services.

Prof. Yves Deillon (HEIG-VD), 2023



Publications :

- 🎯 Study on the modernisation of the height reference system and reference frame in Switzerland, Part I - Fundamentals, state of the art and international comparison
- 🎯 Results of the questionnaire of height informations used in Switzerland with a view to a possible change system and reference frame

<https://swiss-height-system.heig-vd.ch/>



Videos :

- 🎯 Video 1 : Motivations of the project swiss height system
- 🎯 Video 2 : Scientific basis for the definition of altitude