GRAVITY FIELD MODELLING

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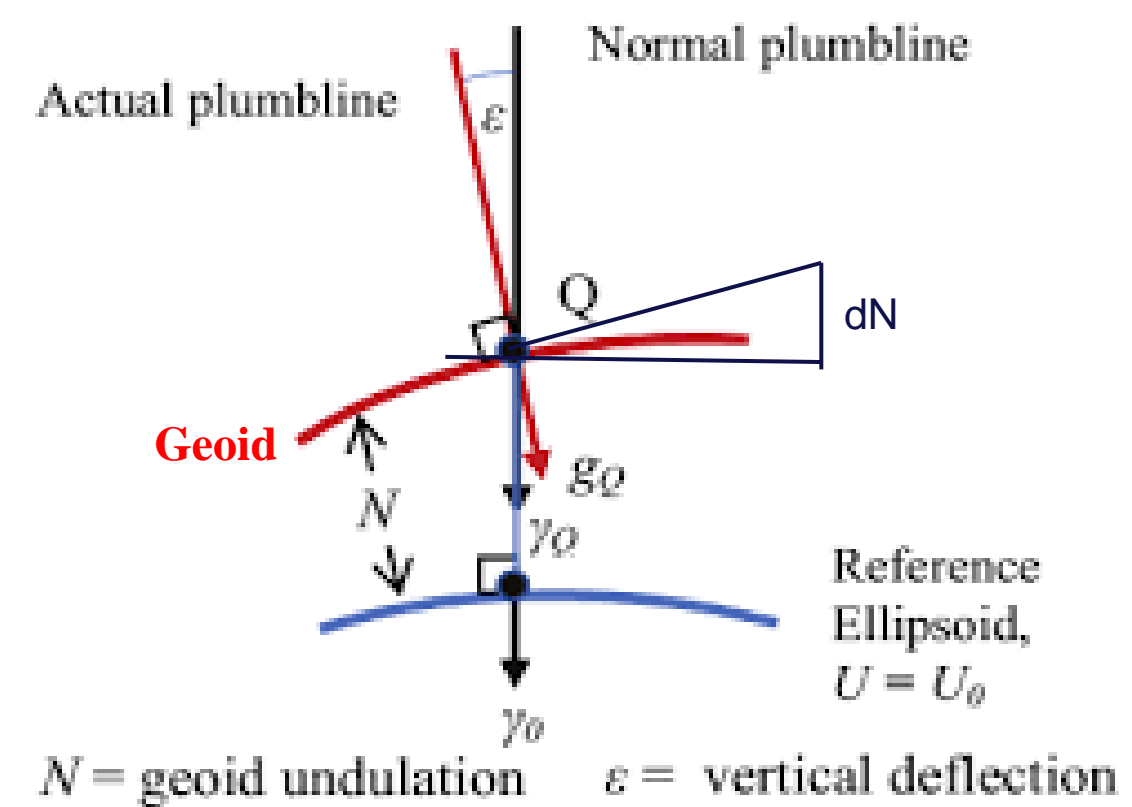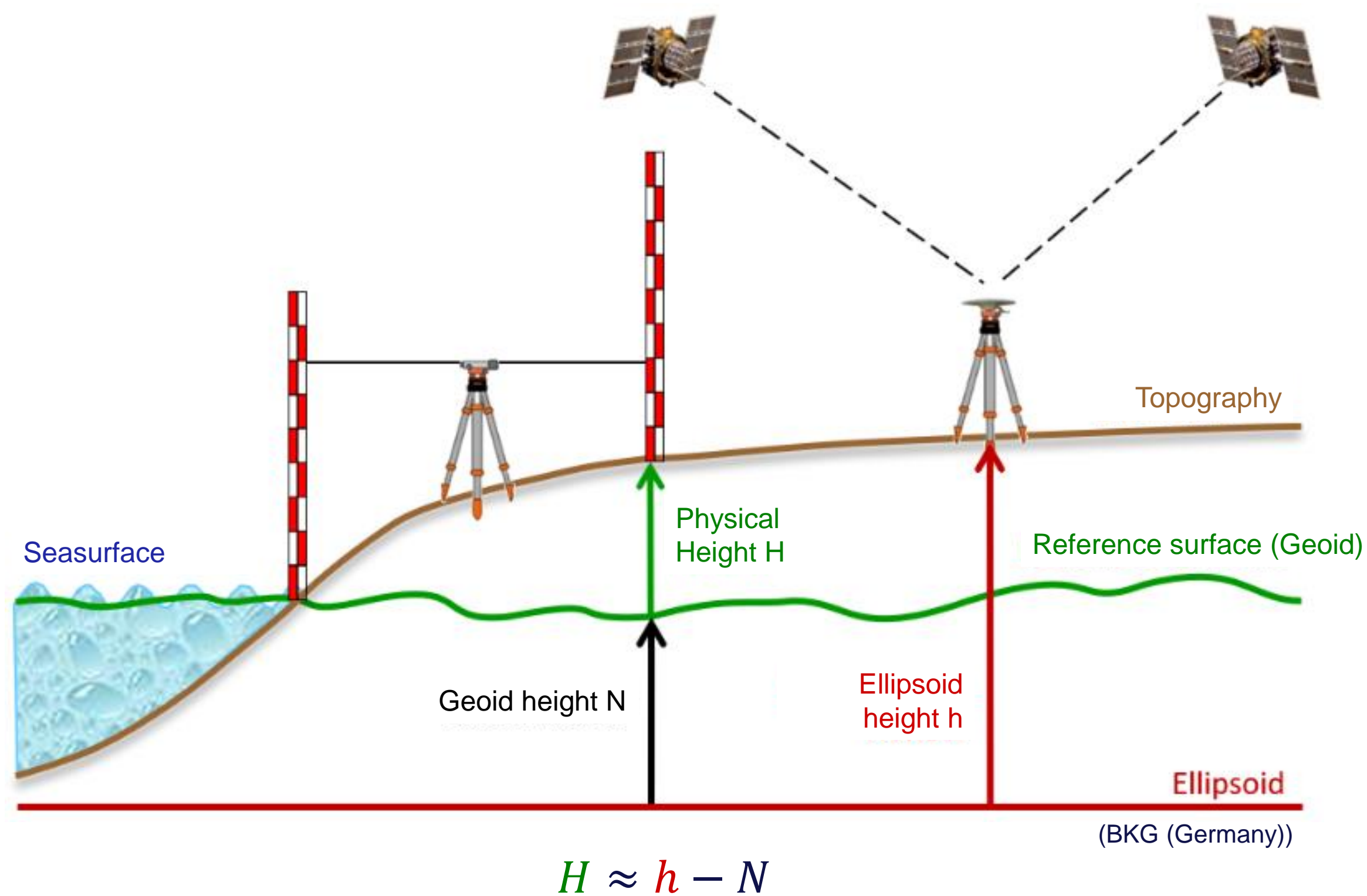[2] Federal Office of Topography swisstopo

Overview

- **Motivation**

- **Available Gravity Fields**

- **Instrumentation and Data Usage**

- **High-accuracy Validation Profile**

- **Conclusion**

Motivation

Definition of the Vertical Datum

(BKG (Germany))

$$H \approx h - N$$

N = geoid undulation ε = vertical deflection
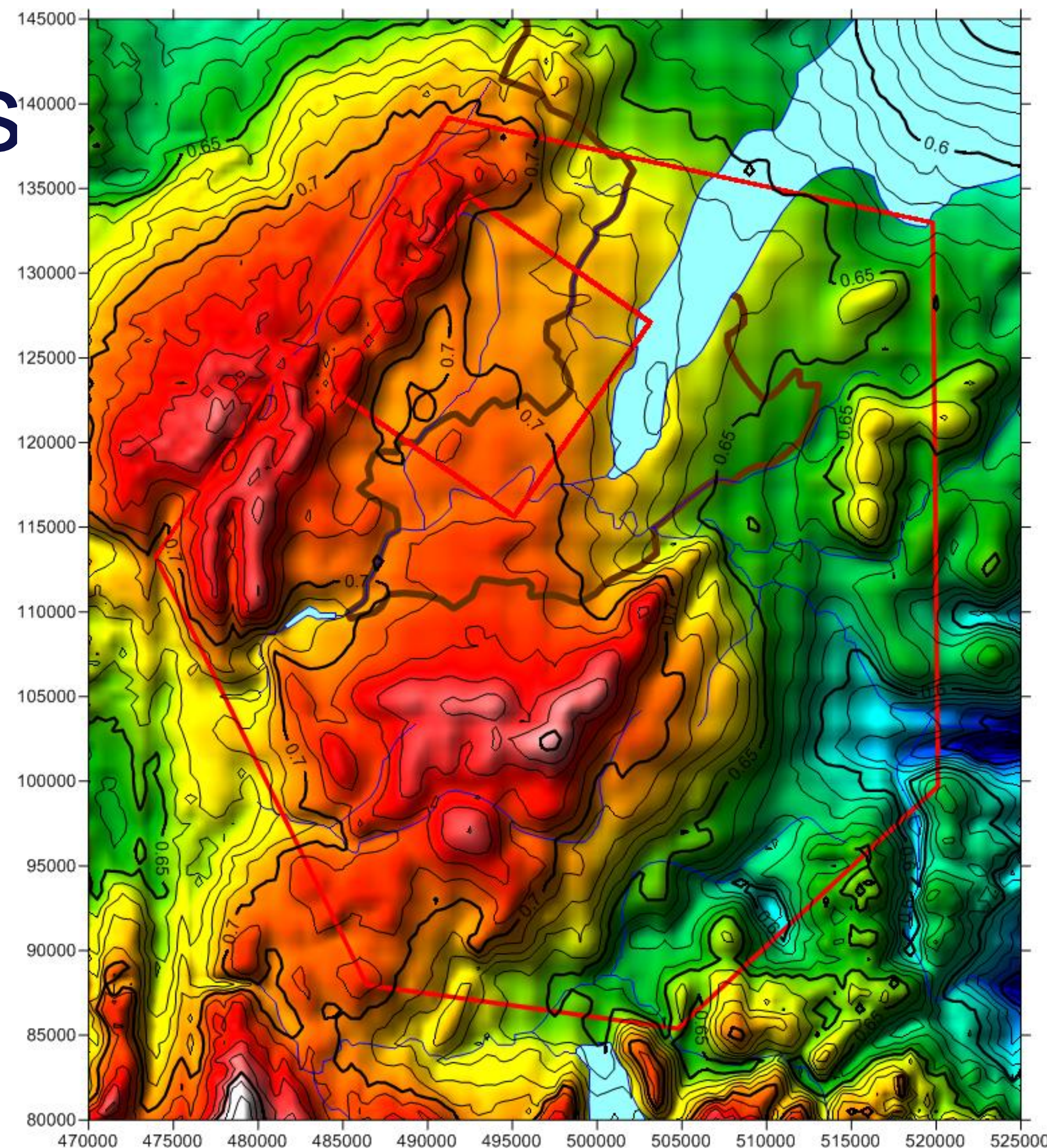
A gravity field model allows the computation of the
- Gravity potential (Geoid)
- Gravity acceleration **g**
- Deflection of the Vertical ϵ

Available Gravity Field Models
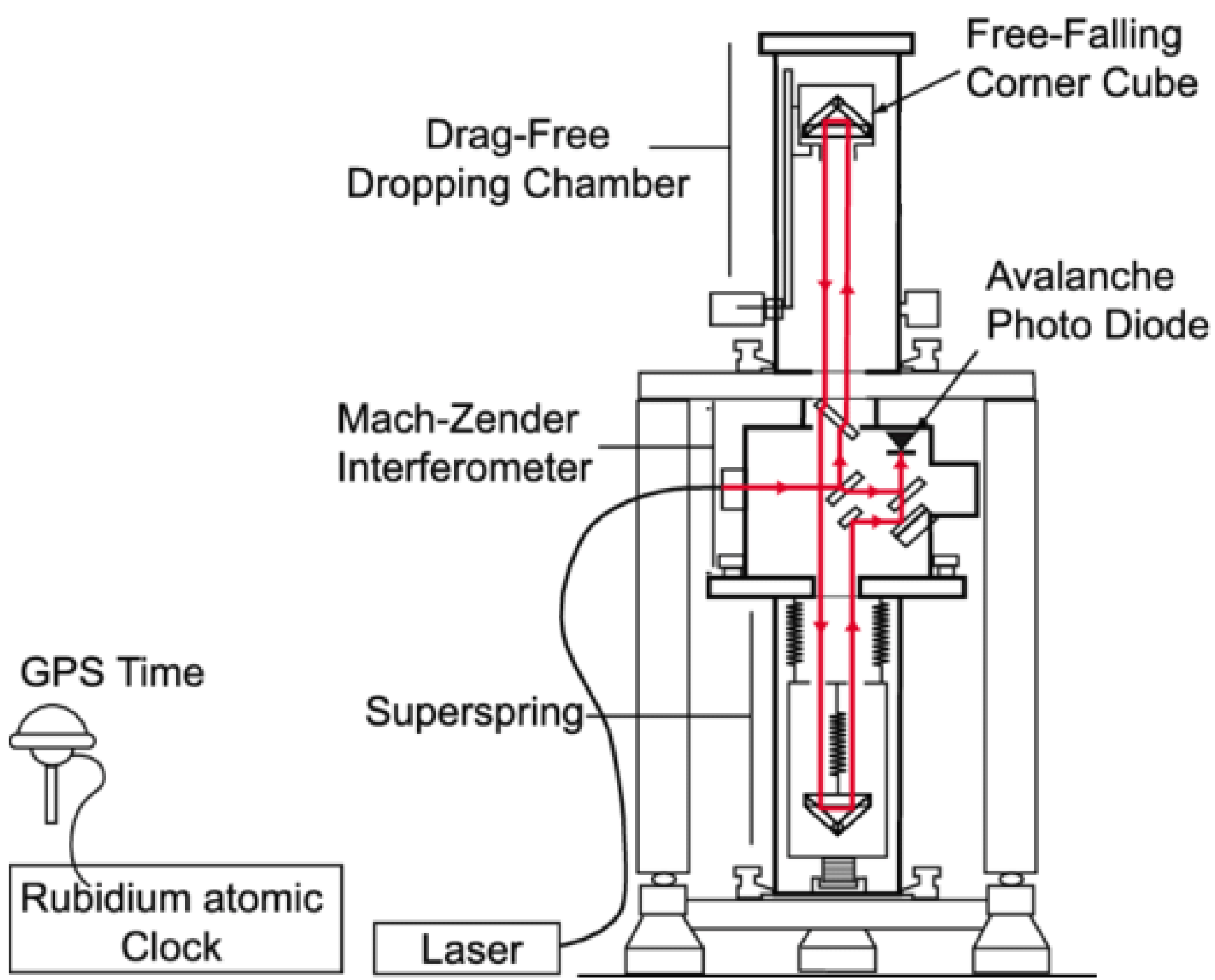
- Switzerland
  - CHGeo98
  - CHGeo2004
- France
  - QGF98
  - RAF98
  - QGF2016
  - RAF20
- Global Models
  - EGM2008 (A,G,S)
  - GOCO05s (S only)

- CERN
  - CG1985
  - CG2000
- D-A-CH
  - D-A-CH-Geoid
  - European Alps Geoid
- Europe
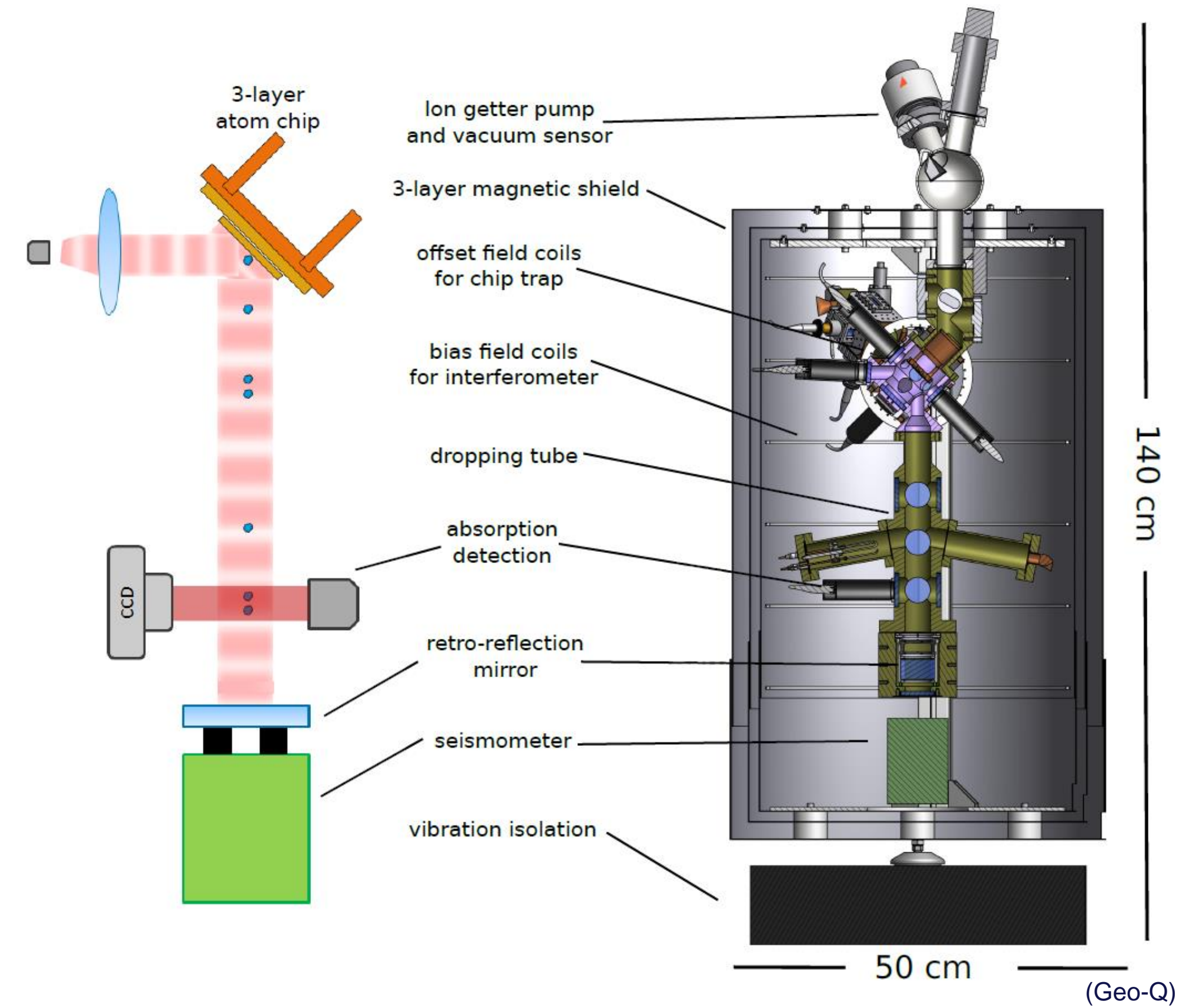 - EGG2015

Difference = CHGeo2004 – QGF98

mean offset: 67 cm, standard deviation: 4.1 cm

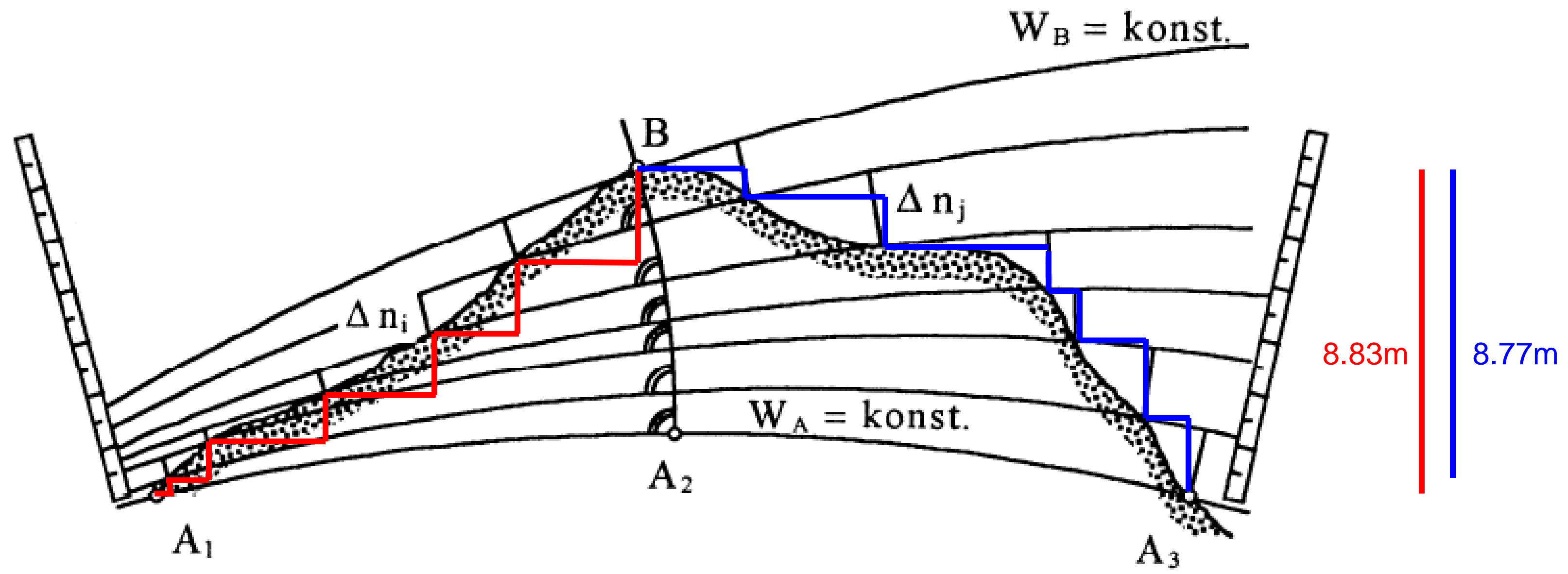# Instrumentation: Absolute Gravimeter

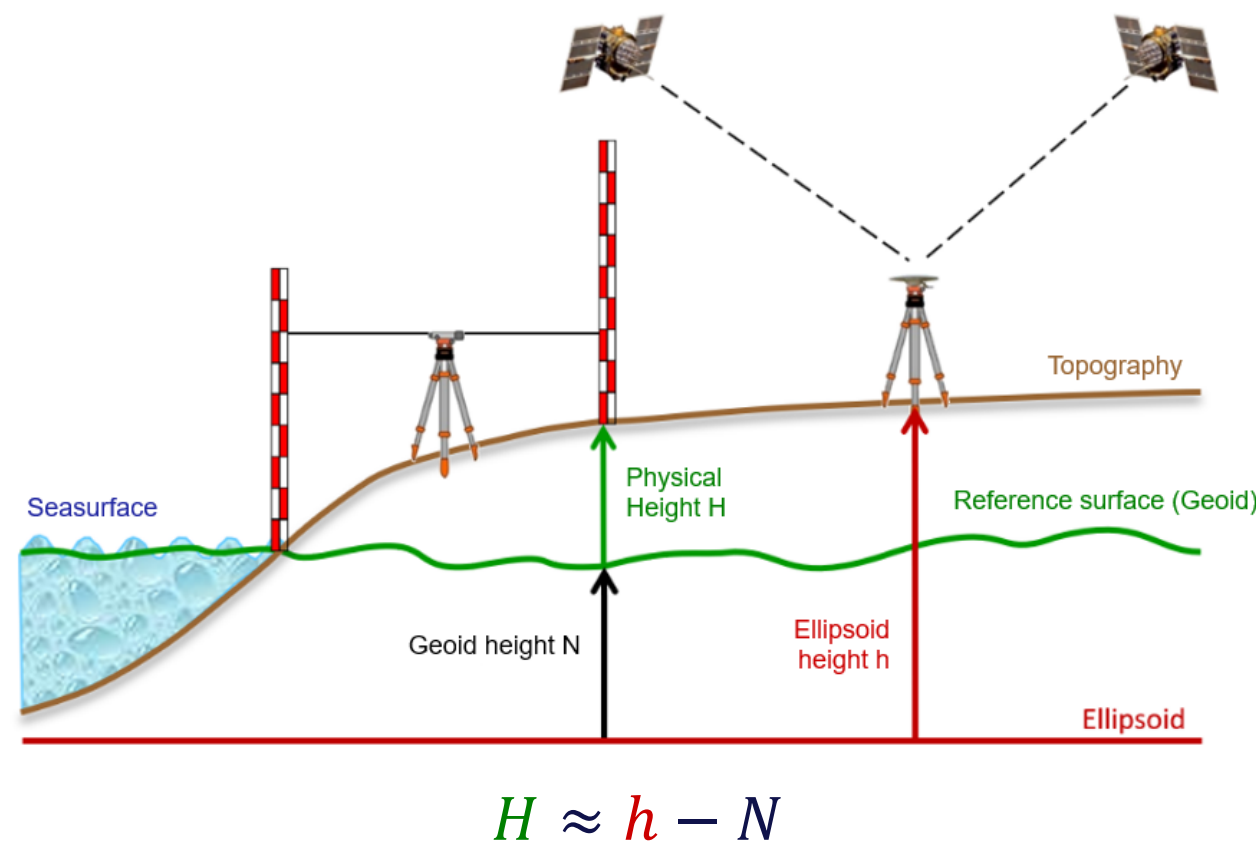(Jacob et al. 2010)

FG5 by Micro-g LaCoste

Geo-Q Collaborative Research Centre 1128

Using Data from Absolute Gravimeters

$$H \approx h - N$$

8.83m   8.77m

Geometrically: $\sum \Delta h$

Physically: $\sum \Delta g \cdot \Delta h$

Digital Zenith Camera System

Instrumentation and Data Usage

COmpact **DI**gital **A**strometric **C**amera

Telescope with protection against condensation

Inclinometer

CCD camera

Inclinometer

Adjusting screw for the inclinometer

Servomotor

Rotating superstructure

Lifting cylinder

Controller for the mounting base

Azimuth motor

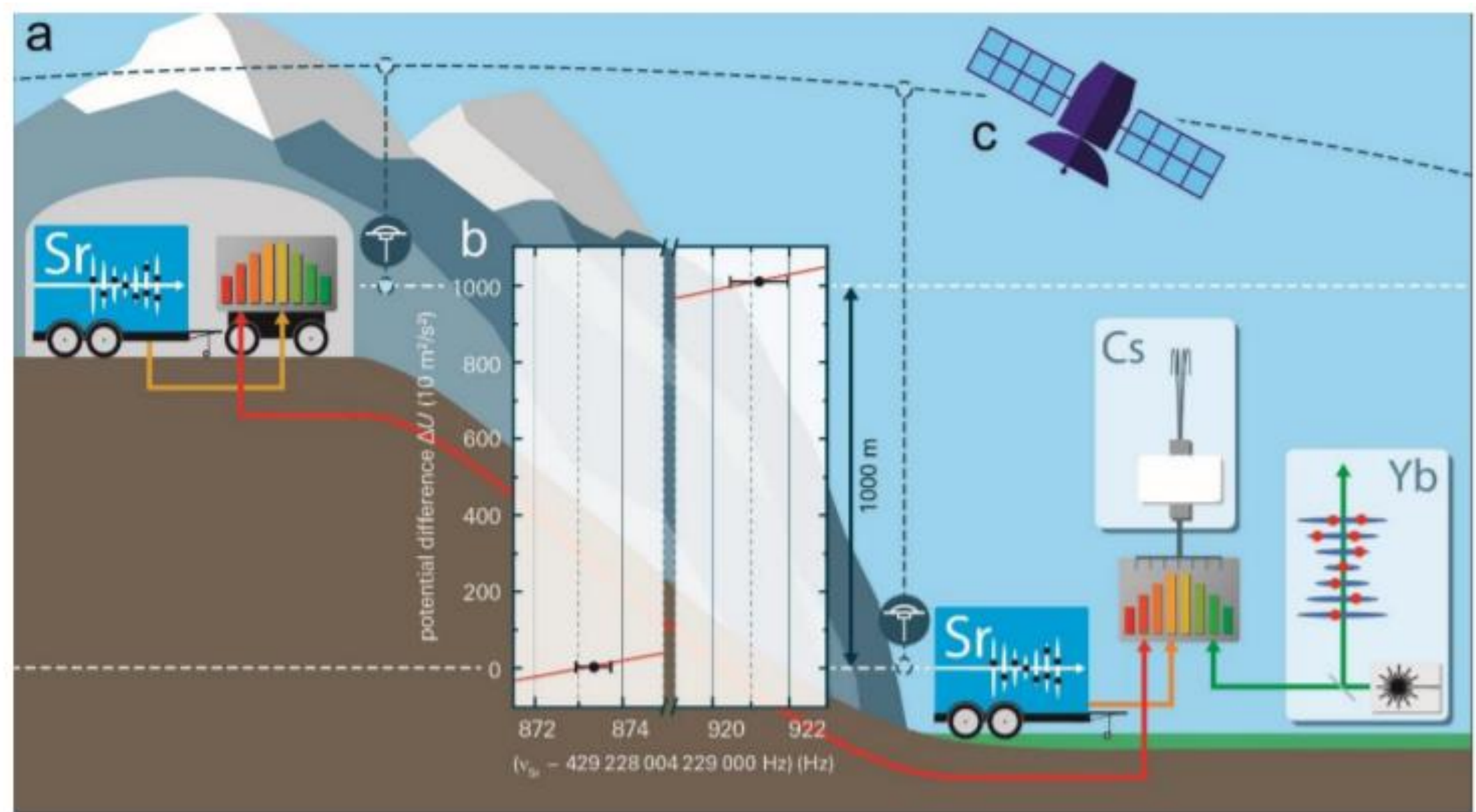Mounting base with turntable

(Swisstopo, 2022)

(Swisstopo, 2022)

$$\Delta N = -\sum(\xi \cdot \Delta x + \eta \cdot \Delta y)$$

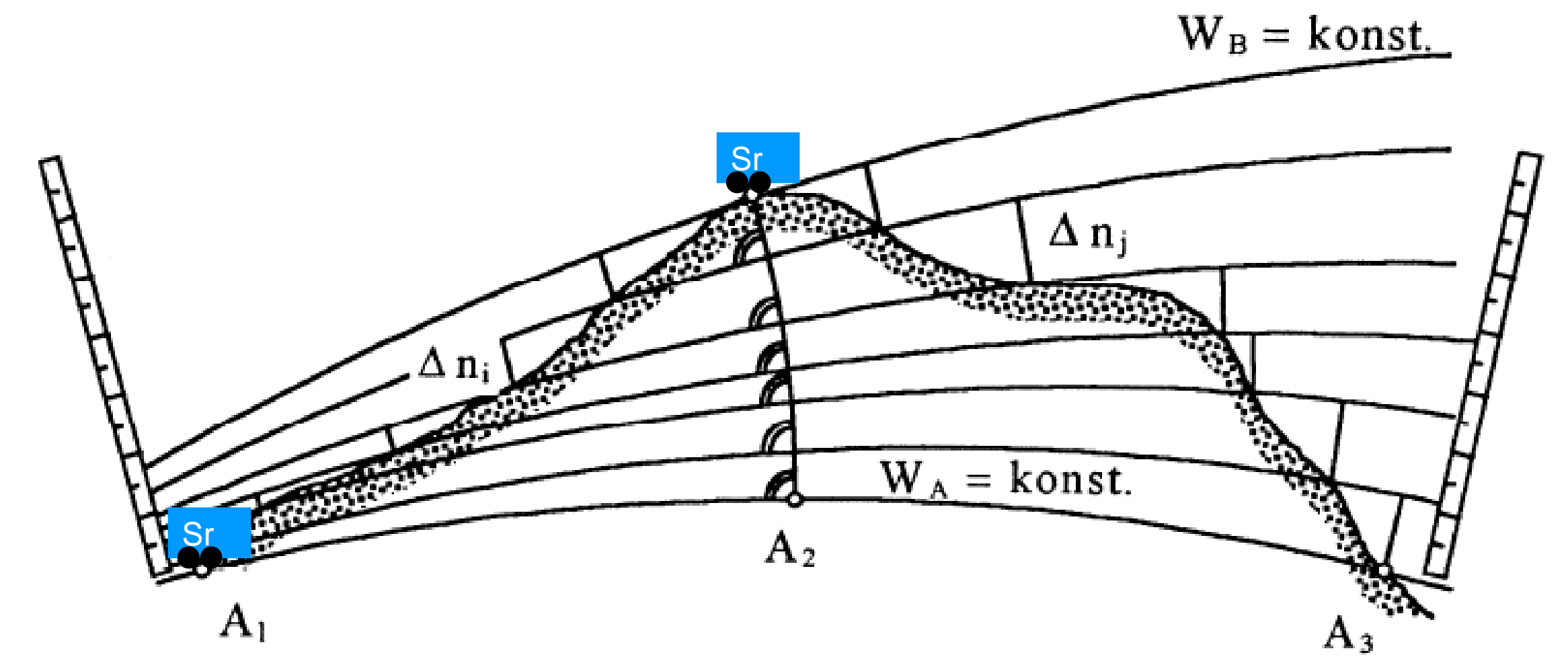N = geoid undulation ε = vertical deflection
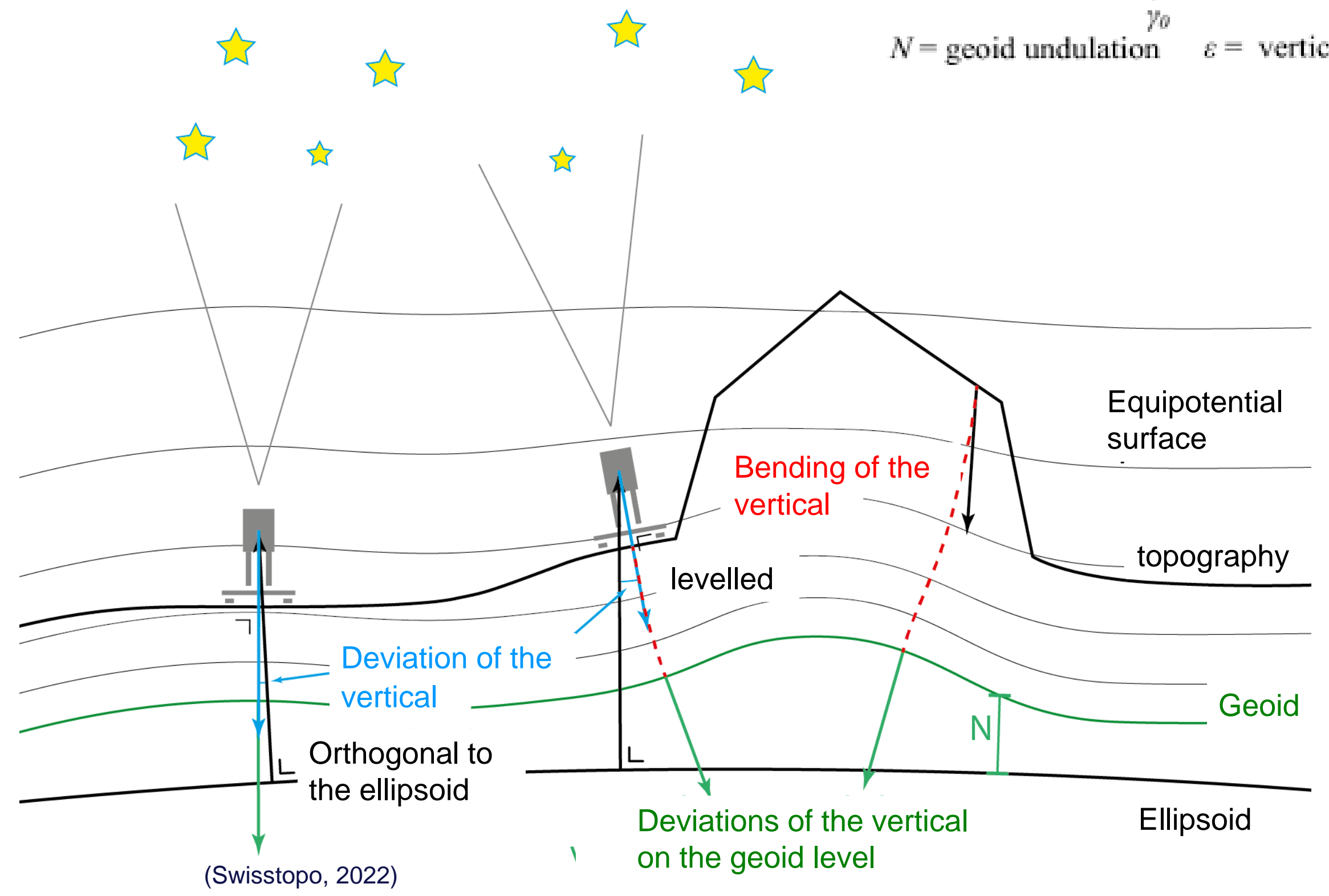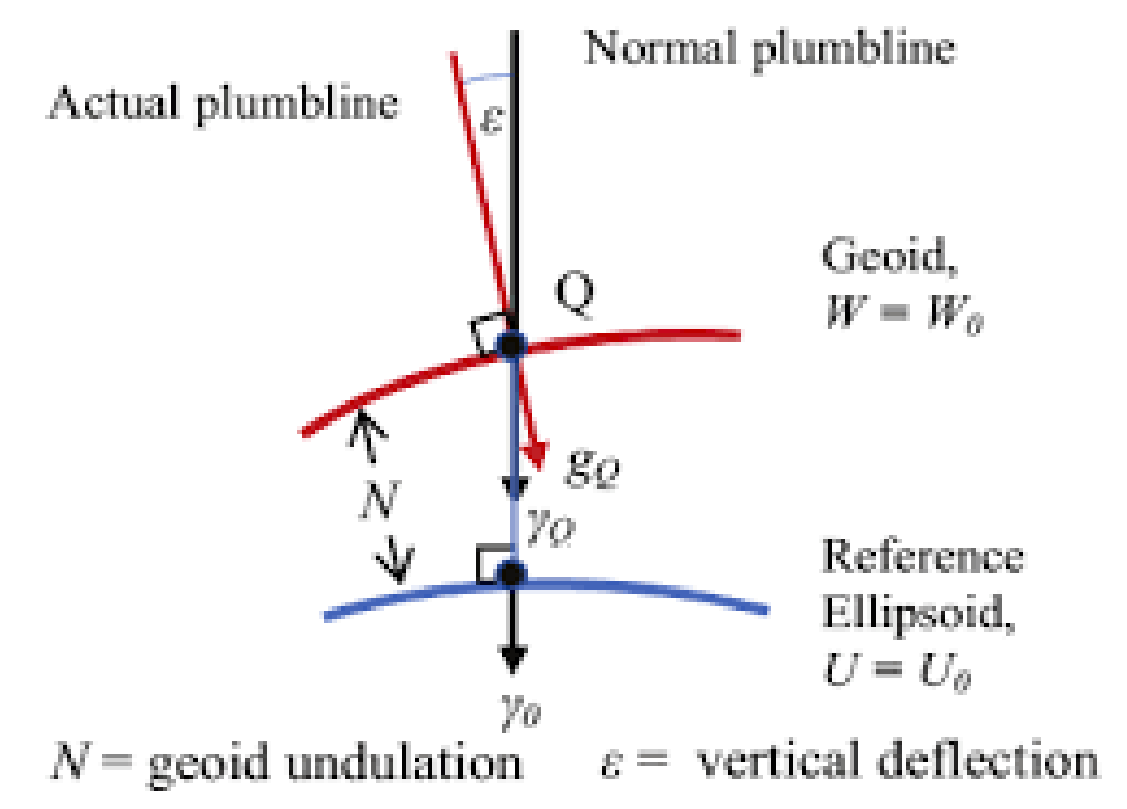
Atomic Clocks for Chronometric Levelling

Instrumentation and Data Usage


(Grotti et al., 2017)

Einstein's theory of General Relativity:
"Gravitational time dilatation" occurs whenever there is a difference in the gravity potential W

$$\Delta W = c^2 \, \Delta v_{rel}/v_0$$

High-Accuracy Profile for Validation

- Establishment of a test profile
 - Length 40km
  - Along Swiss and French levelling lines
  - New connection of Swiss and French levelling lines

- ~40 GNSS/levelling stations (△)
- ~80 Deflections of the Vertical (★)
- ~50 gravity stations (●)
- ~50 gravity stations NW of Annecy (filling data gaps)

- Purpose:
  - Independent measurements
  - Validation of the geoid computations and simulations
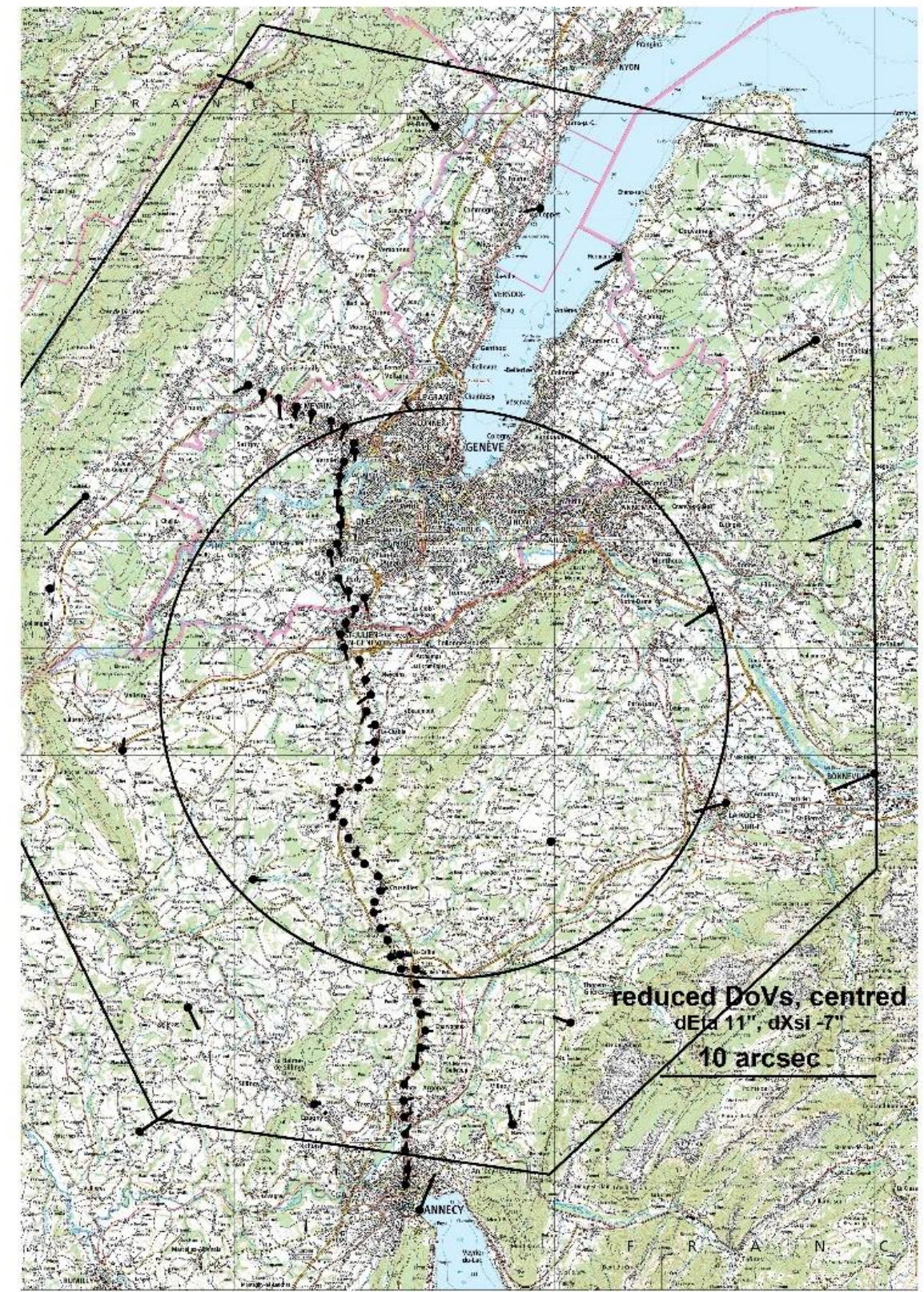 - Validation of new instruments
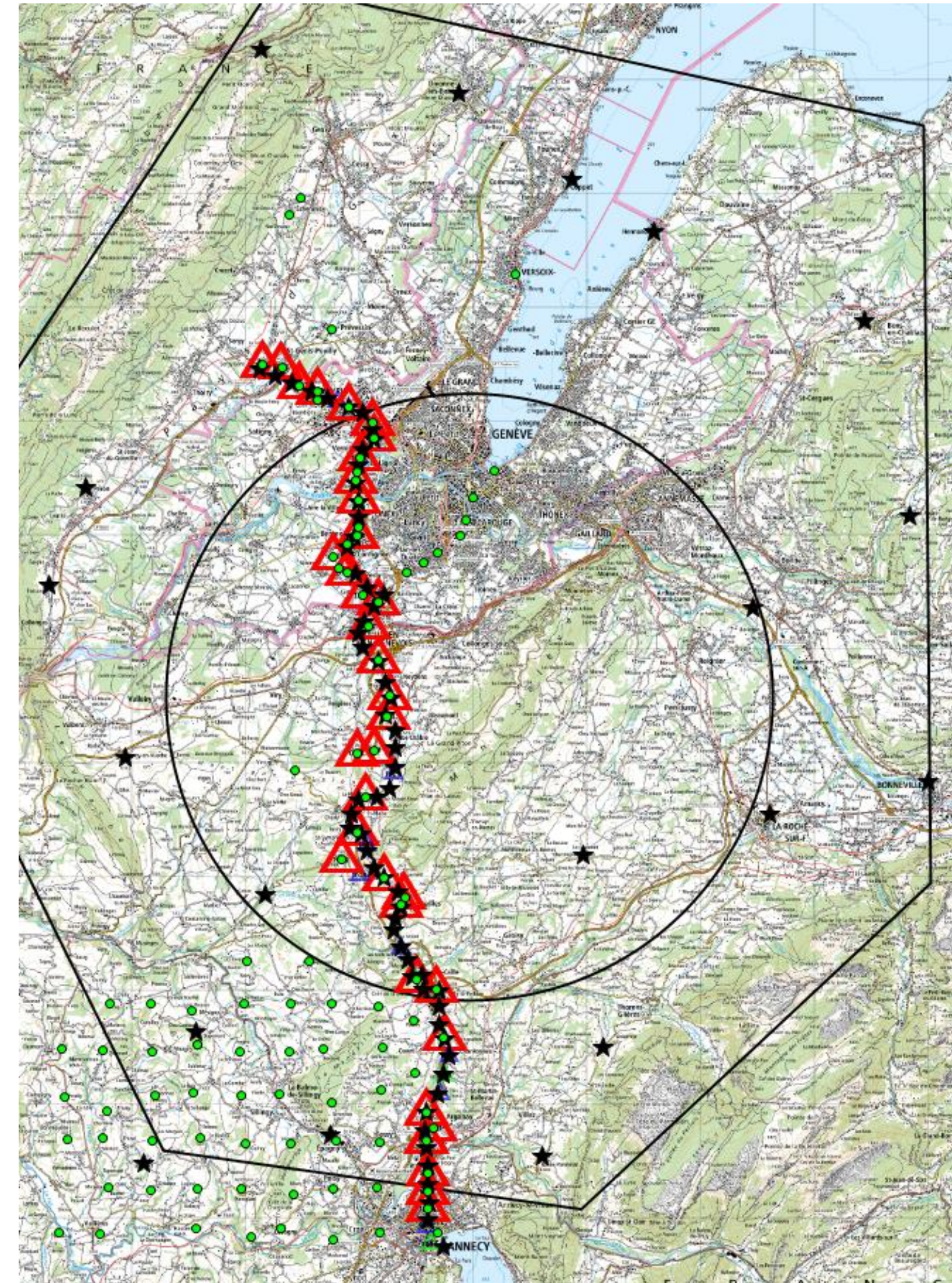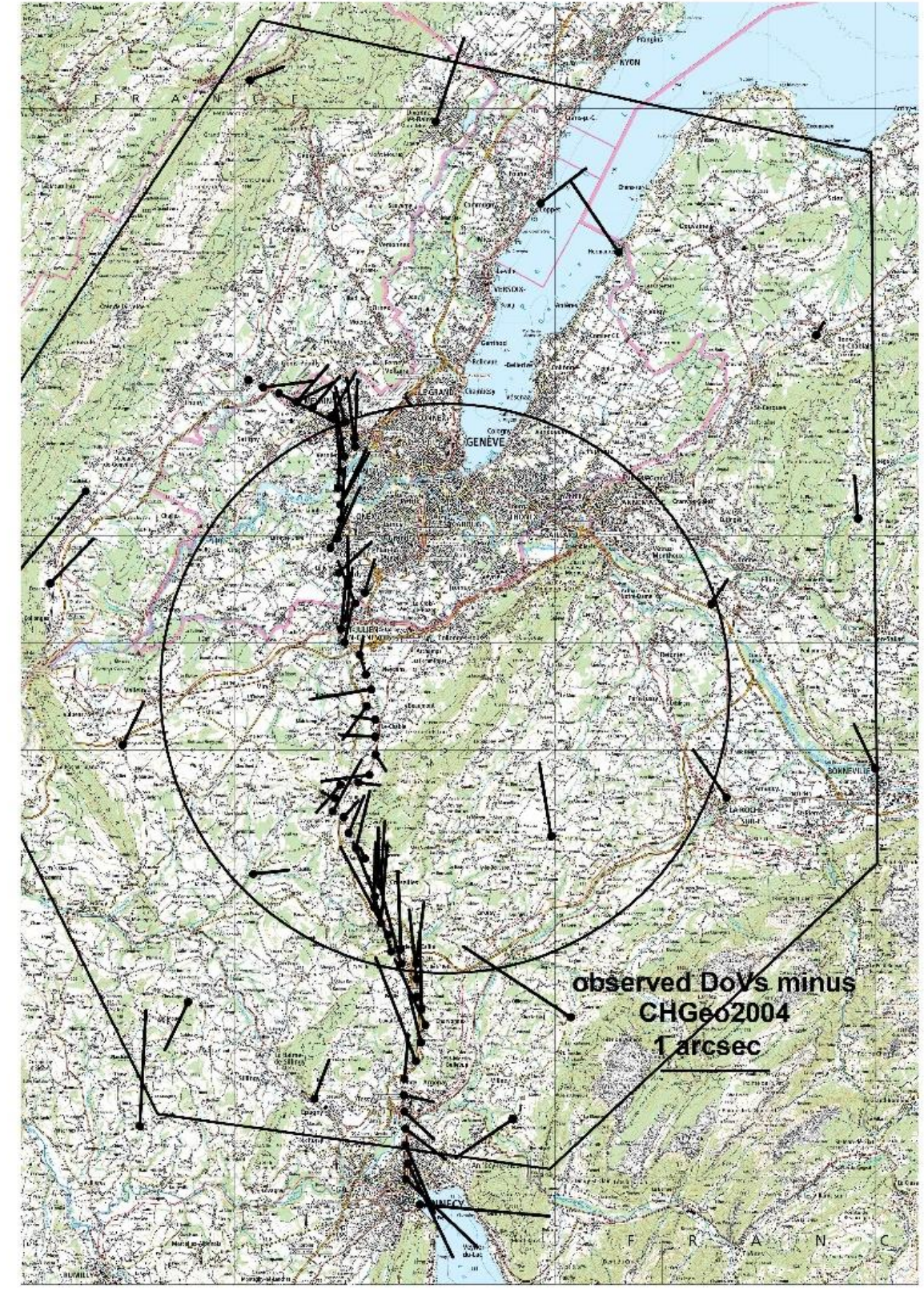
# Deflection of the Vertical along the Profile
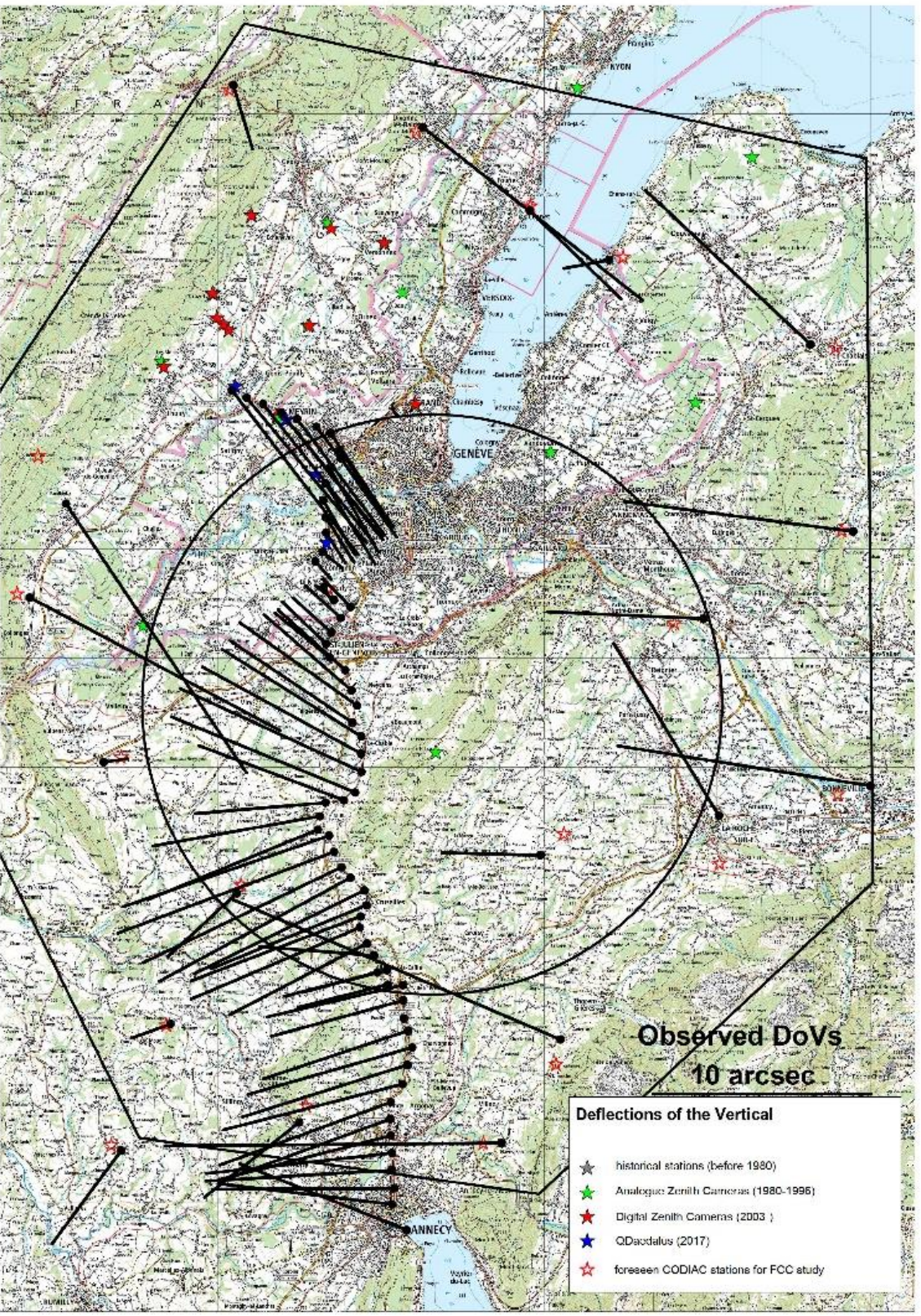
Observed DoV
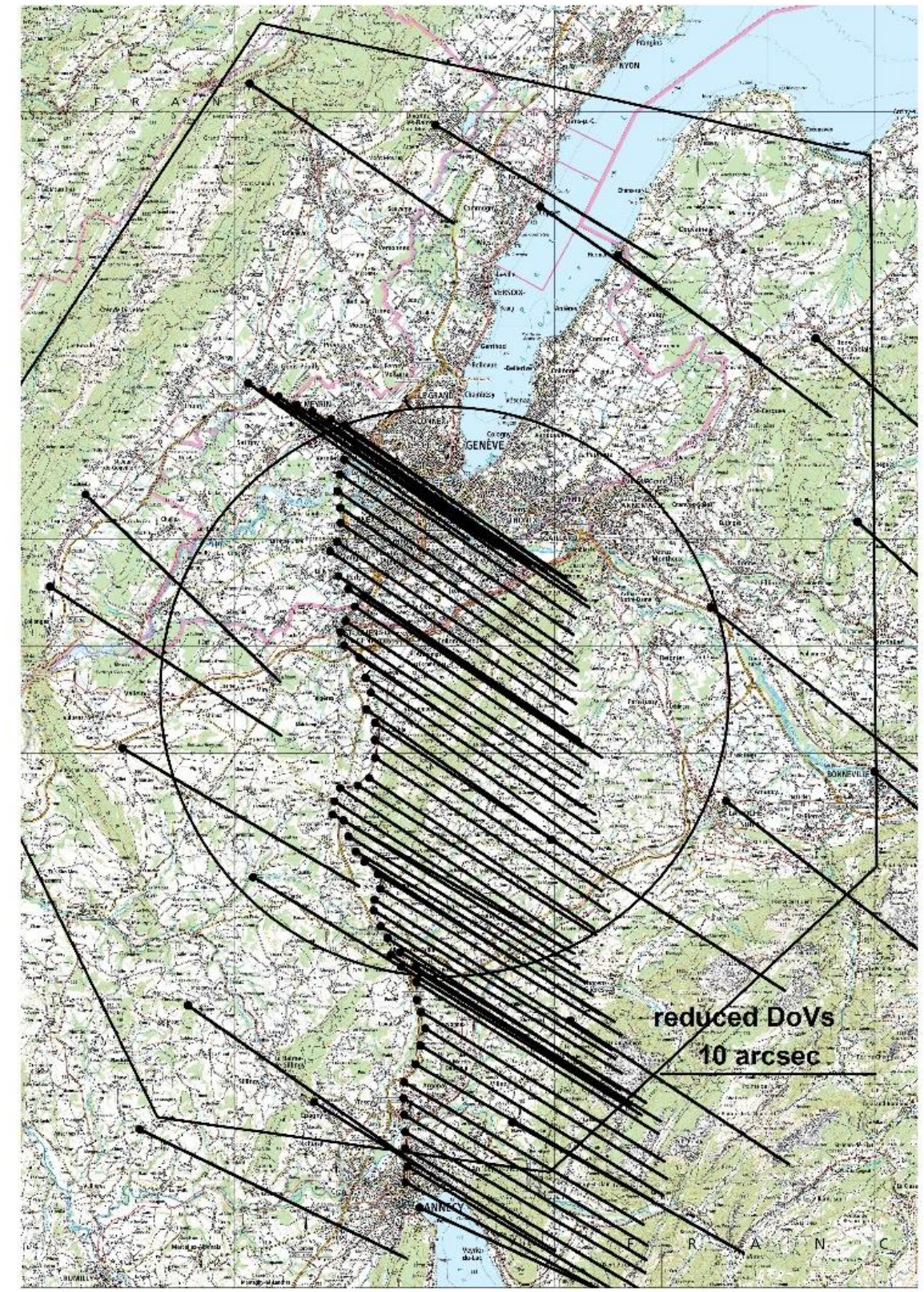
Reduced DoV

+ mean removed ~ 11" and -7"

Compared to CHGeo2004 <1"

Levelling in the Vicinity of the Profile

- Green line by CERN May 2021
- Blue Lines by Canton Geneva 2011/2012
- Red Lines by swisstopo 1998

- Yellow Points Gravity measurements April 2022

- Closed levelling circuit in the vicinity of Geneva
  - Without corrections: 0.9 mm
  - With corrections[1]: 0.6 mm
- Closed levelling circuit in the historical center of Geneva
  - Without corrections: 0.5 mm
  - With corrections[1]: 0.5 mm

- Height differences CH – F official heights
  - St. Genis 32.1 cm
  - St. Julien 31.0 cm
- Height differences CH – F corrected heights[1]
  - St. Genis 36.1 cm
  - St. Julien 34.8 cm
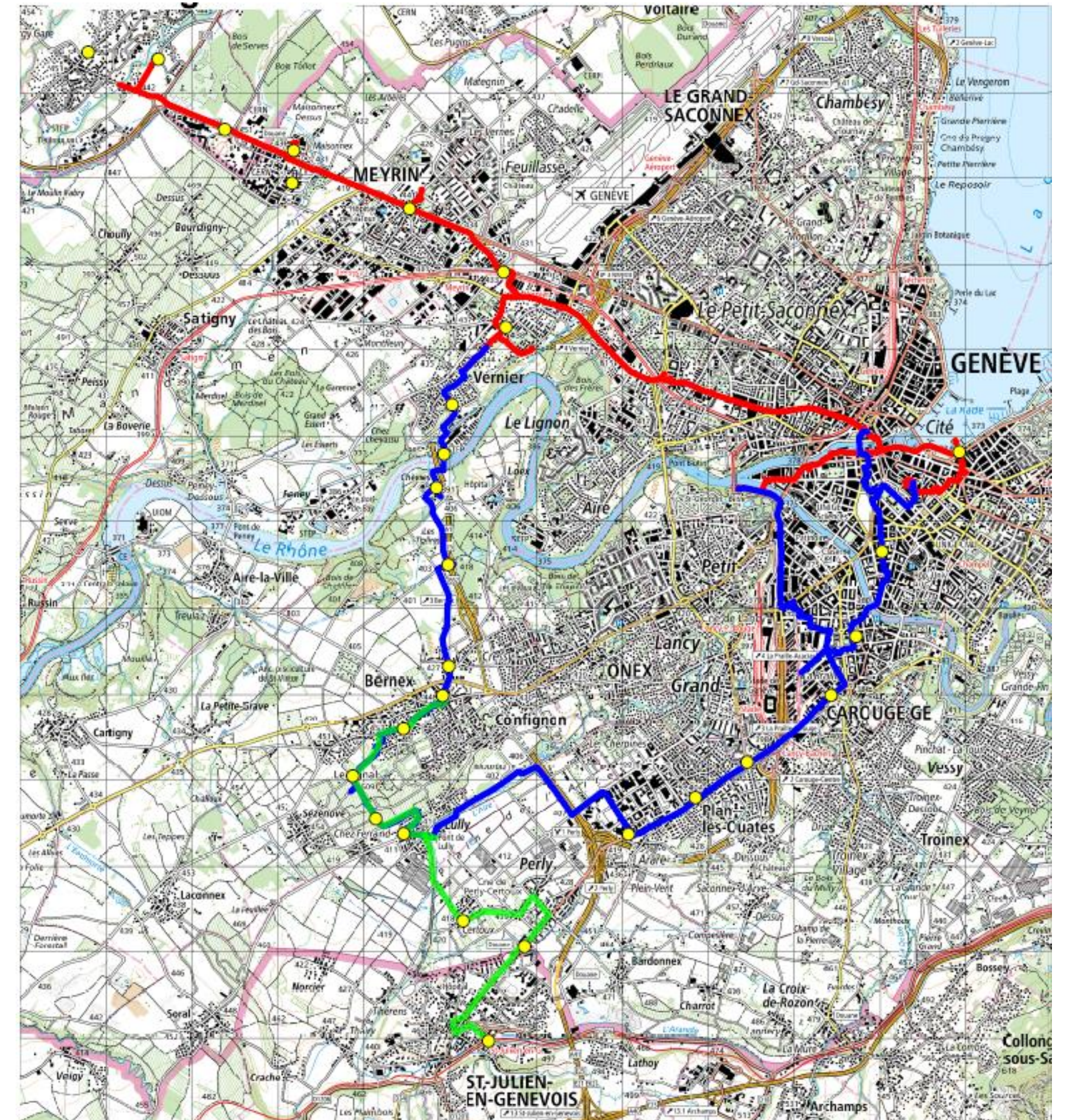
[1] Heights transformed to Normal Heights and gravity corrected

Conclusion

- Gravity potential field model is needed to
  - Establish a consistent height system for FCC
  - Convert geometric heights to physical heights

- Different types of measuring instruments available and still a field of research

- High-Accuracy Profile in FCC area is established for
  - Validation of geoid computations and simulations
  - Validation of new instruments
  - Validation of new geoid computation methods/software

FUTURE
CIRCULAR
COLLIDER

Thank you for your attention.