JWG 2.1.1: Development of the International Terrestrial Gravity Reference Frame

Meeting at IAG SA, 03.09.2025, Rimini, Italy, and online

Chair: Hartmut Wziontek, BKG (Germany)

Vice-chair: Sylvain Bonvalot, BGI (France)

Agenda

1. Coordination of the infrastructure
   a) Regional coordination of ITGRF sites
   b) Reference and comparison sites
2. Site requirements and best practices guides
3. Updates on the AGrav database
4. Future Activities: ITGRF Workshop, Publication

International Terrestrial Gravity Reference System and Frame (ITGRS / ITGRF)

Reference System:

The fundamental principles

Stable definition of gravity

- Measurand: **Instantaneous acceleration of free-fall**, expressed in the International System of Units (SI)
- **Constant components** of conventional models to correct for time dependent gravity effects:
  - Zero-tide system for the tidal correction
  - Standard atmosphere ISO 2533:1975 (DIN 5450) for the correction for atmospheric gravity effects
  - Reference pole of the International Earth Rotation and Reference Systems Service (IERS) for the correction for polar motion.

→ **Conventional quantity „acceleration of gravity”**

Reference Frame:

The realization of the system

Compatibility of gravity measurements

The realization of the ITGRS represented by

- **Absolute gravity measurements** traceable to the International System of Units (SI) (time and frequency)
- **Common reference level**: Absolute Gravimeters have to be checked at comparisons / by calibration
- Models / Recommendations for gravity corrections: **ITGRS 2020 Conventions**
- **Global set of reference stations** with reliable absolute gravity values (relative accuracy of $\leq 10^{-8}$) and monitoring capabilities for temporal changes

→ **Gravity reference function**

1) Reference Stations

Regional coordination:

- for Europe: A. Engfeldt, P. Dykowski
- for North America: D. vanWestrum, J. Crowley
- for Latin America: E. D. Antokoletz
- for Asia:
  Shuqing Wu (NIM China),
  CAS Wuhan
  Koji Matsuo (GSI Japan)
- Middle East ?
- Africa ?

Reference Stations: Link to the International Geodynamics and Earth Tides Service (IGETS)

Continuous monitoring of temporal gravity variations with Superconducting and other stationary gravimeters

Potential stations:

Europe (12+1):
BG, BH, ~~MC, MB~~, ME, MO, NY, OS, PE, ST, WE, YS, [BF]

North America: [BO], CA

Australia: CB

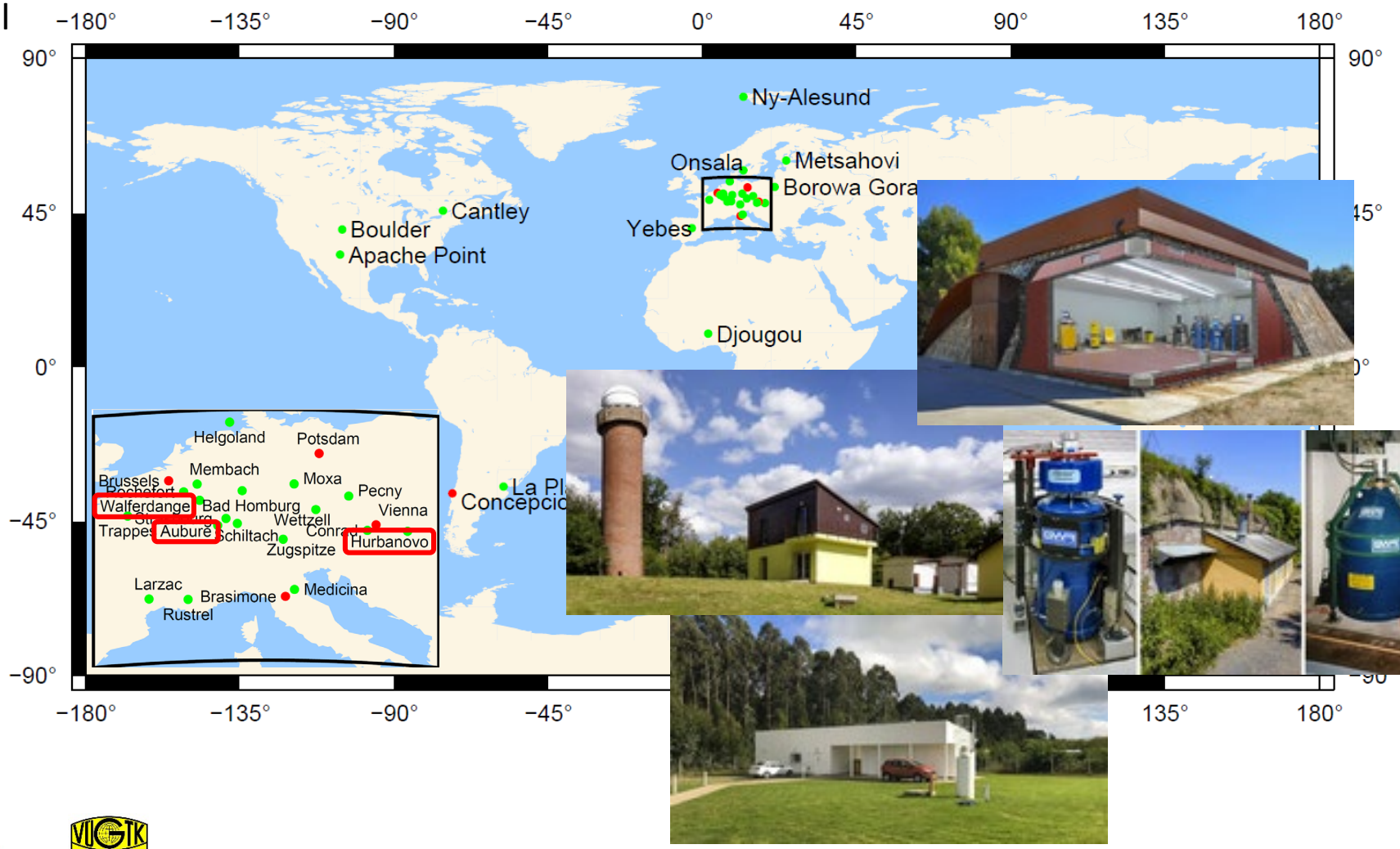
South America: LP

Asia: China (3): LH, LI, WU

Japan (1+2): MA, [MI, IS]

Africa (1): ~~DJ, SU~~

Antarctica (1): SY



ITGRF – CLASSIFICATION OF REFERENCE STATIONS IN EUROPE

ANDREAS ENGFELDT

LANTMÄTERIET

CLASSES (ACCORING TO A PDF FROM HARTMUT & SYLVAIN, MARCH 2021)

- Reference stations

  Any of the three following:

  - Continuously operating SG in combination with AG observtions
  - Continuously operating AQG
  - Repeated AG measurements about every 2nd month
- Comparison stations
  - Extended facilities to check the compability of instruments
- Core stations
  - Link to space geodetic techniques

CLASSIFICATION OF REFERENCE STATIONS IN THE NKG-AREA

- **Core stations:**
  - **Metsähovi (Finland)**
  - **Onsala (Sweden)**
  - **Ny Ålesund? (Norway)**
- **Comparison station:**
  - **Mårtsbo (Sweden)**
- **Reference station:**
  - **Borås (Sweden)**
- **IF Comparison station just meant that there are extended facilities to check the compability of instruments:**
  - **Kivetty (Finland)**
  - **Savukoski (Finland)**
  - **Sodankylä (Finland)**
  - **Vaasa (Finland)**

ITGRF reference stations in Europe

Przemysław Dykowski

1) Institute of Geodesy and Cartography, Centre of Geodesy and Geodynamics, Warsaw, Poland

Recognized locations (based mainly on IGETS)

Czech Republic
- *Pecny (CZ) - AG/SG (FG5-215, FG5X-251, OSG050) – contact: V.Palinkas*

Germany
- *Wettzell (GE) - AG/SG (multiple FG5, multiple SG) – contact: H.Wziontek*
- *Bad Homburg (GE) - AG/SG (FG5, AQG, A10 from BKG, SG044) – contact: H.Wziontek*

France
- *Trappes - AG/SG (FG5X-206, iGrav-005) – contact: S.Merlet*
- *Strasbourg - AG/SG (FG5X-206, iOSG23) – contact: J.P. Boy*

Spain
- *Yebes - AG/SG (FG5-???, A10-???, OSG064) – contact: M. Calvo??*

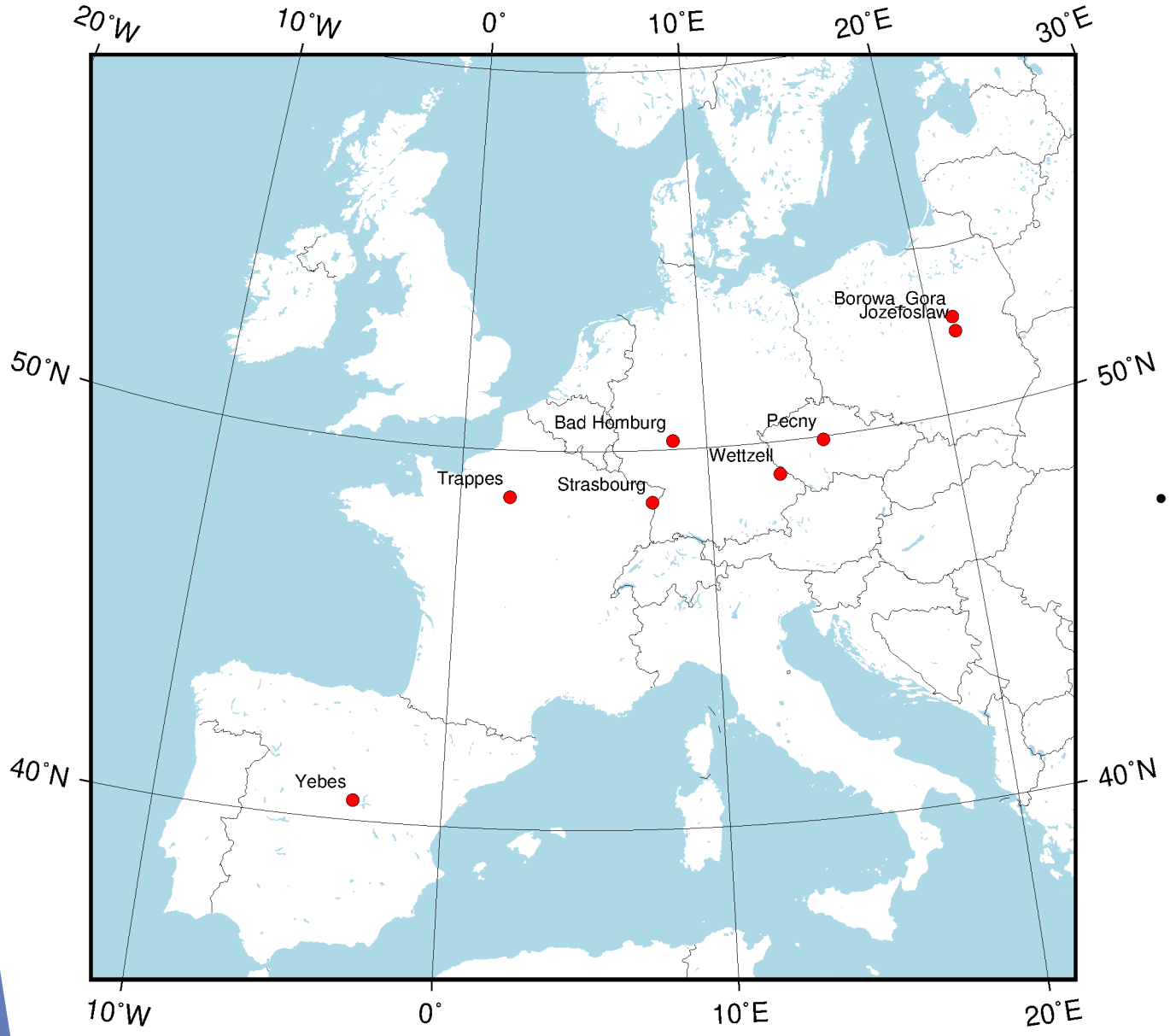
Poland
- *Borowa Góra AG/SG (A10-020, AQG-B07, iGrav-027) – contact: P.Dykowski*
- *Józefosław AG/SF (FG5-230 – 1 month interval) – contact: T.Olszak*

Doubts….

Italy *– currently operational SG locations?*
England *– Vicky Smith? FG5 repeated measurements?*
Austria *– Conrad Observatory, iGrav is operational?*
Slovakia *– Hurbanovo? repeated FG5 measurements?*
Belgium *– Membach?*
Anone else??

UK:
Herstmonceux (SGF) (Vicky Smith)
High frequency AG measurements, very close co-location with SLR and GNSS and gPhoneX installed just over a year ago.

Station distribution



- Questions:
  - How many stations per country we need/want?
  - Define station availability for other users?
  - How to keep track of gravity reference prividing capabilities?
  - Detail station requirements?

Reference Stations: Status North America

Table Mountain Geophysical Observatory (TMGO), Derek van Westrum (NGS)

- FG5X-102: upgraded/modified with an X-Y detector that allows for real time Coriolis and verticality corrections
- Complete gPhoneX (S/N 162) time series going back to its installation in late 2019
- tied to ~weekly FG5X measurements.
- FG5 series goes back to ~1994

Canadian Absolute Gravity Site (CAGS), John Crowley (NRCan)

- Absolute Quantum Gravimeter (B13) since November 2024 (currently under repair)
- FG5-236 at Micro-g Lacoste for upgrade (new SIM-X), back and operational by December
- operate gPhoneX and AQG continuously along with FG5
- planning to rebuild of CAGS with perspective to accommodate future international comparisons.

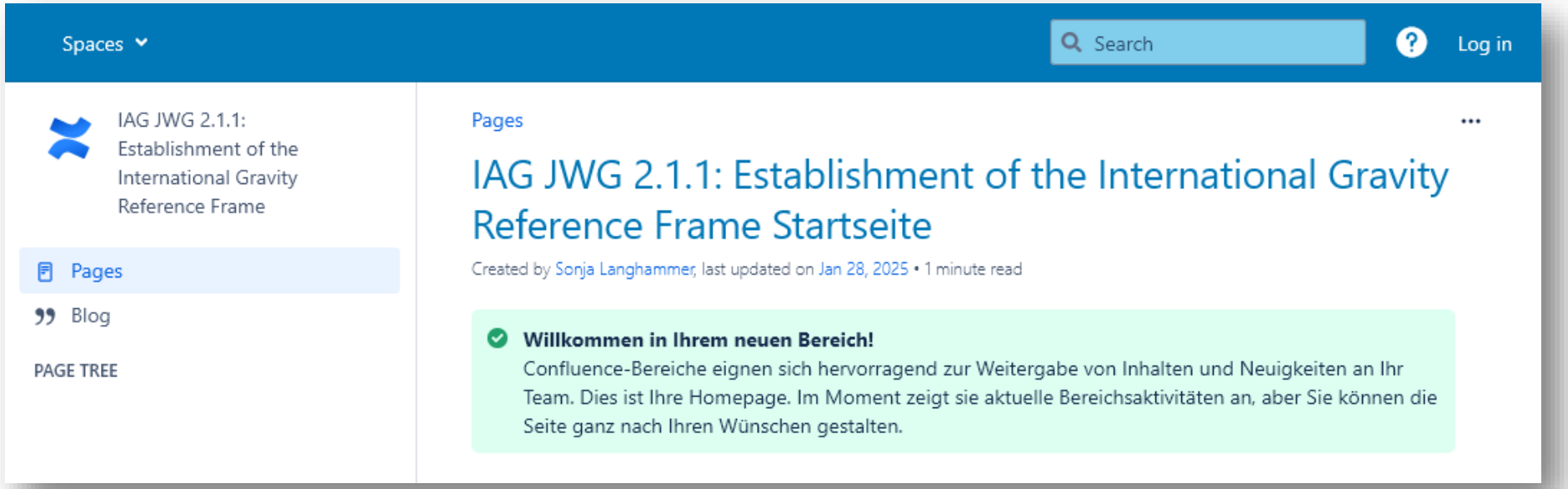
Infrastructure / Wiki

ITGRF Site requirements / recommendations

- Document needs to be developed
- First order stations: More stringent requirements
- Majority of stations: More relaxed specifications to promote the establishment of new stations and avoid to exclude existing ones.
- Connection to GNSS should be considered.

ITGRF Wiki

- operated by BKG: https://share.bkg.bund.de/x/tgDhAg
- Open access, but limited write access to active collaborators!
- Collection of:
  Site requirements, Best Practices Guides …



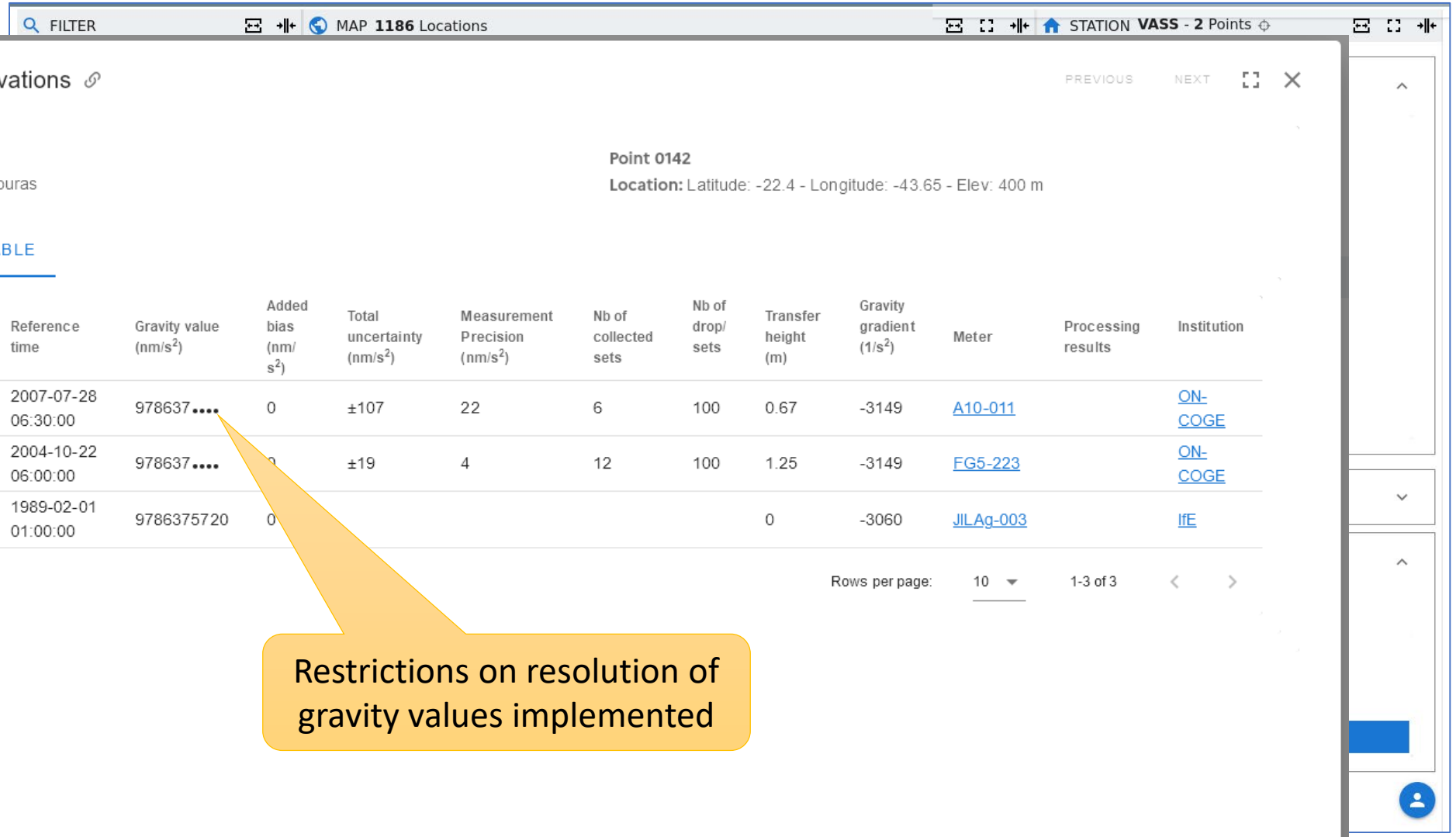
3) International Absolute Gravity Database: AGrav

- Offline at BKG since March 2022 because of IT security concerns
- Re-established in spring 2024 at BGI, with support of BKG
  - https://bgi.obs-mip.fr/data-products/gravity-databases/absolute-gravity-data
  - https://agrav.bkg.bund.de/
- Dataset complete as of March 2022
- New web application based on Java (server) / Javascript (clien)
- New user management,
  authentication based on existing portals
- Features
  - Search criteria: by institutions, networks, stations, meters
  - Data upload from project files (MGL instruments)
  - DOI: meters, networks
  - Web API

Status March 2022:

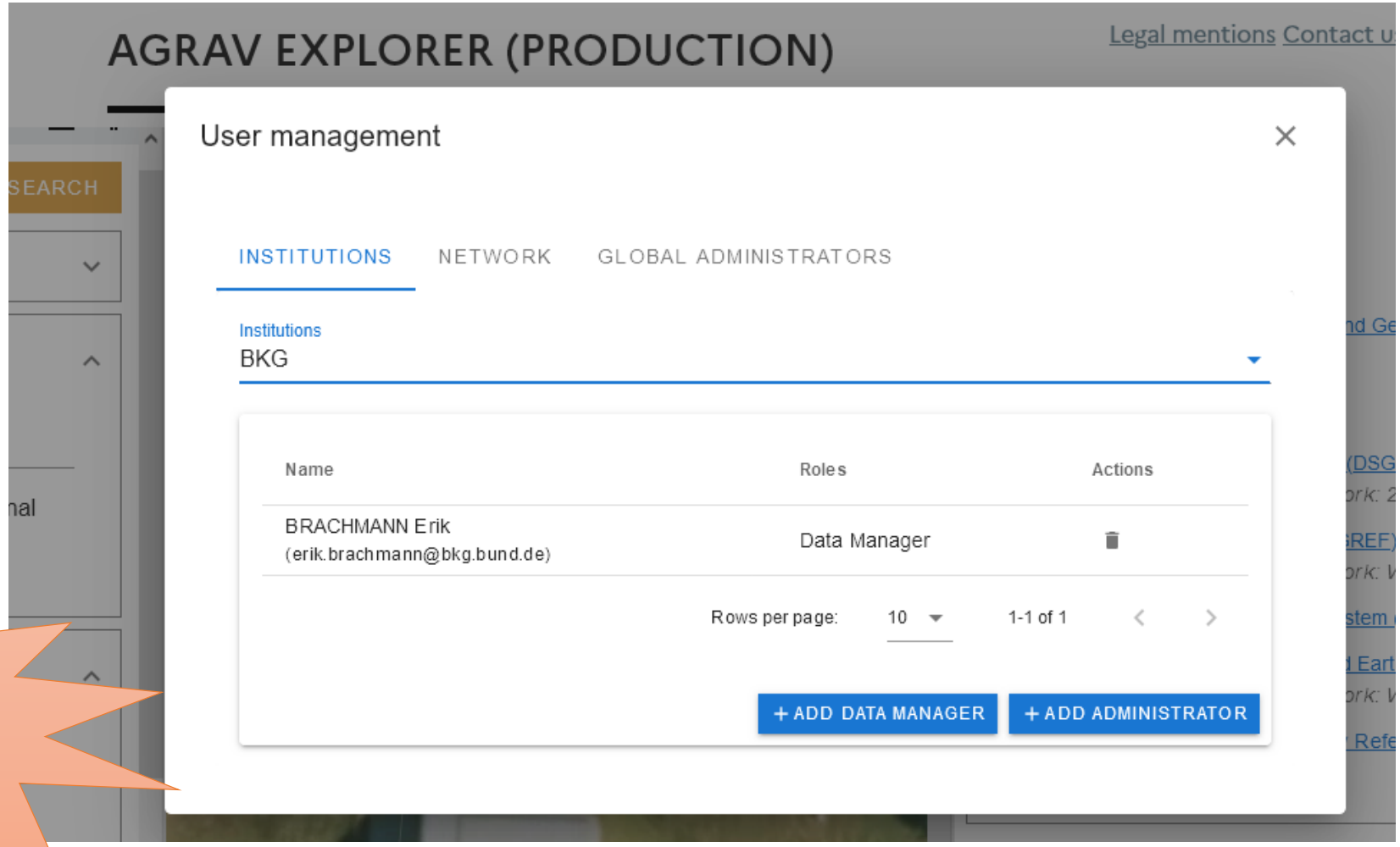
- 65 institutions from 33 countries
- 1390 stations
- 5237 observations, >98% with gravity values
- 78 Absolute gravimeters: 39 FG5, 13 A10, 4 FG5X…

AGrav: New Web Application



AGrav: User Administration

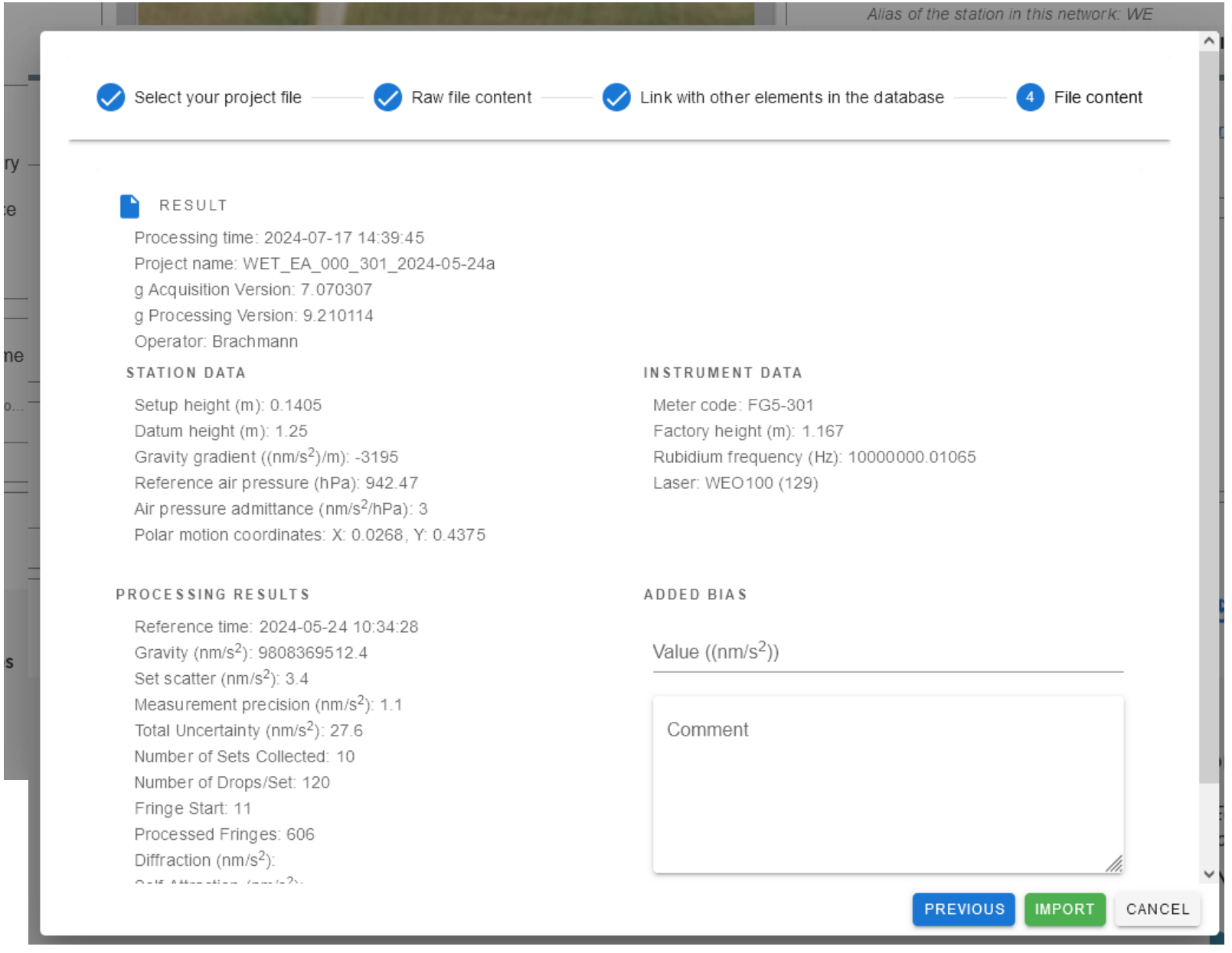
- Existing accounts removed for security reasons
- Registered users: Unrestricted access to own data
- Global Administrators
- Institution Administrators
- Data managers (edit, upload)



Re-register!

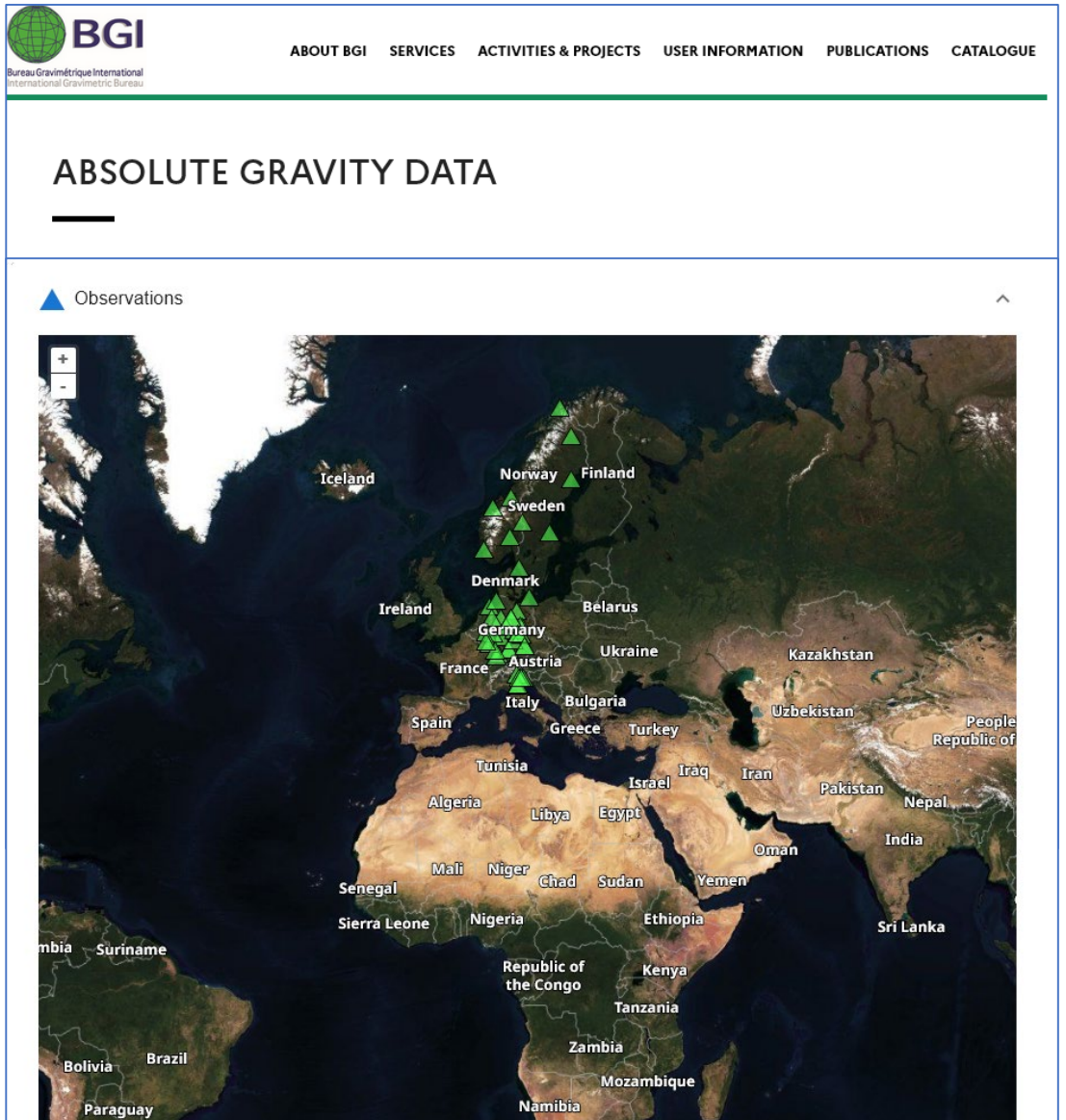
AGrav: Data Upload

- Based on project-files of g-Software by MGL
- Various consistency checks
- Assignment of observing institution and data provider
- Required role: institution administrator or data manger



AGrav: DOI

- DOI for gravimeters and networks
- Implemented for absolute gravimeters, scheme: agrav.m.tt.nnn
- Landing page at BGI
- Display of all linked observations on map
- Example:
  FG5-301 10.18168/agrav.m.FG5.301



Future Activities

ITGRF Workshop 2026

Results from poll: 17 Votes

Is an ITGRF workshop important?	94 %
Shall it be in second half of 2026?	65 %
Would you join in person?	47 %
Is a hybrid option necessary	76 %

Workshop to be planned in 2026 (second half?)
With hybrid option!

Duration / Date in 2026?

Proposals for a location?

Publication on the establishment/status of ITGRF

Selection of Reference- / Comparison- / Core- stations
National infrastructures
Role of AGrav, inclusion of field stations
→ Vision: ITGRF vs. IGSN71?