Establishment of the International Absolute Gravity Reference System and Frame

Meeting of IAG JWG 2.1.1 at GGHS 2018

Chair: Hartmut Wziontek, BKG (Germany)

Vice-chair: Sylvain Bonvalot, BGI (France)

Agenda

1. Finalizing the definition of system and frame
2. Selection of reference stations
3. Update and define a set of common processing standards
4. Data storage and Processing
5. Documentation: DOI,
6. Deadlines, Report to IAG (IUGG 2019), Publication

1. Definition of System and Frame

Reference System: The principles how the numbers are obtained
→ The definition of gravity must be stable over time!

- Momentary ***acceleration of free fall*** based on the International System of Units (SI)
- Set of conventional corrections for the ***time independent components*** of gravity effects: tidal system (zero tide), standard atmosphere (~ height), IERS reference pole

DC

Reference Frame: The realization of the system: the numbers actually obtained
→ Can be adapted to model improvements / updated requirements

- Observations with absolute gravimeters
- Comparisons of absolute gravimeters: Common level, traceability, compatibility of the observations and its processing, assessment of systematic effects
- Set of conventional models for correction of ***temporal gravity changes***: tides, ocean tide loading, atmospheric variations, polar motion

AC

- Establishment of a compatible infrastructure (markers, points) and documentation (database AGrav)

2. Selection of Reference Stations

Long term stable Reference Level: Absolute gravimeters monitored at reference stations

- Repeated comparisons (monitoring of AG) at international/regional level
- **Reference stations:** continuous gravity reference function (Superconducting/ Quantum Gravimeters, repeated AG) preferred but no exclusive [GNSS]
- **Comparison sites**: reference station with extended facilities for comparisons
- **Core station**: Link to more than one space geodetic techniques (GNSS, SLR; VLBI)
- Accuracy: A few µGal range

2. Selection of Reference Stations: Requirements

“Minimum" criteria for reference stations

- Collocation with one space geodetic technique (e.g. GNSS)

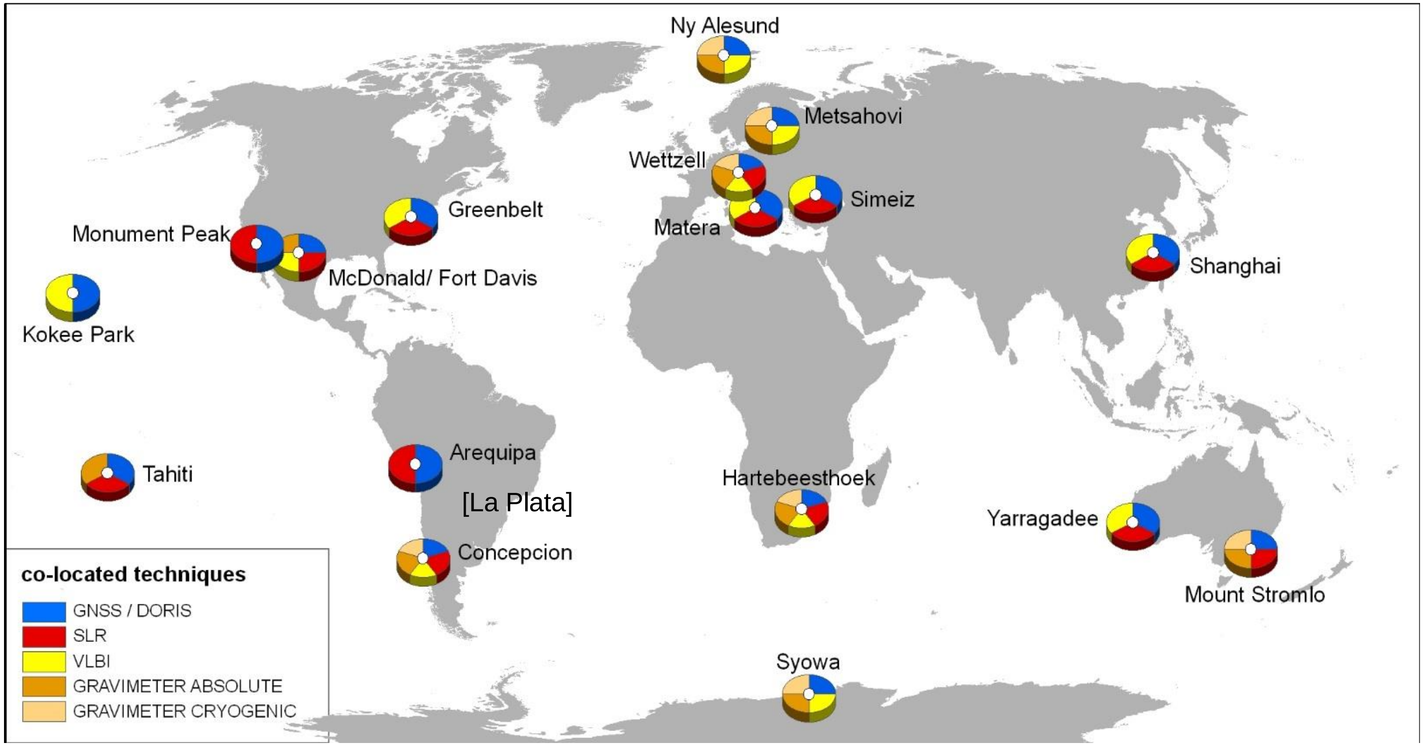
a) In case of AG measurements only: at least 1 measurement/month

b) In case of combined AG+SG measurements:
at least 1 AG measurements during 2(?) years,
with AG taking part at comparison.

- Data transfer:
SG data to IGETS (delay below 6 months),
AG data to AGrav (raw data?) - all corrections (diffraction, self-attraction, etc.
must be clearly specified within the database

2. Selection of Reference Stations: GGOS core stations

- Link to space geodetic techniques (GNSS, SLR, VLBI)
- Stations to be identified



Status 2010

2. Selection of Reference Stations: IGETS

Continuous monitoring of temporal gravity variations with Superconducting Gravimeters

International Geodynamics and Earth Tides Service (IGETS)

Selection from active 21 (+2) stations:

Europe (13+1):
BG, BH, CO, MC, MB, ME, MO, NY, OS, PE, ST, WE, YS, [BF]

North America (3): AP, BO, CA

South America (1): LP

Asia:

- China (3): LH, LI, WU
- Japan (1+2): MA, [MI, IS]

Africa (1+1): SU, [DJ]

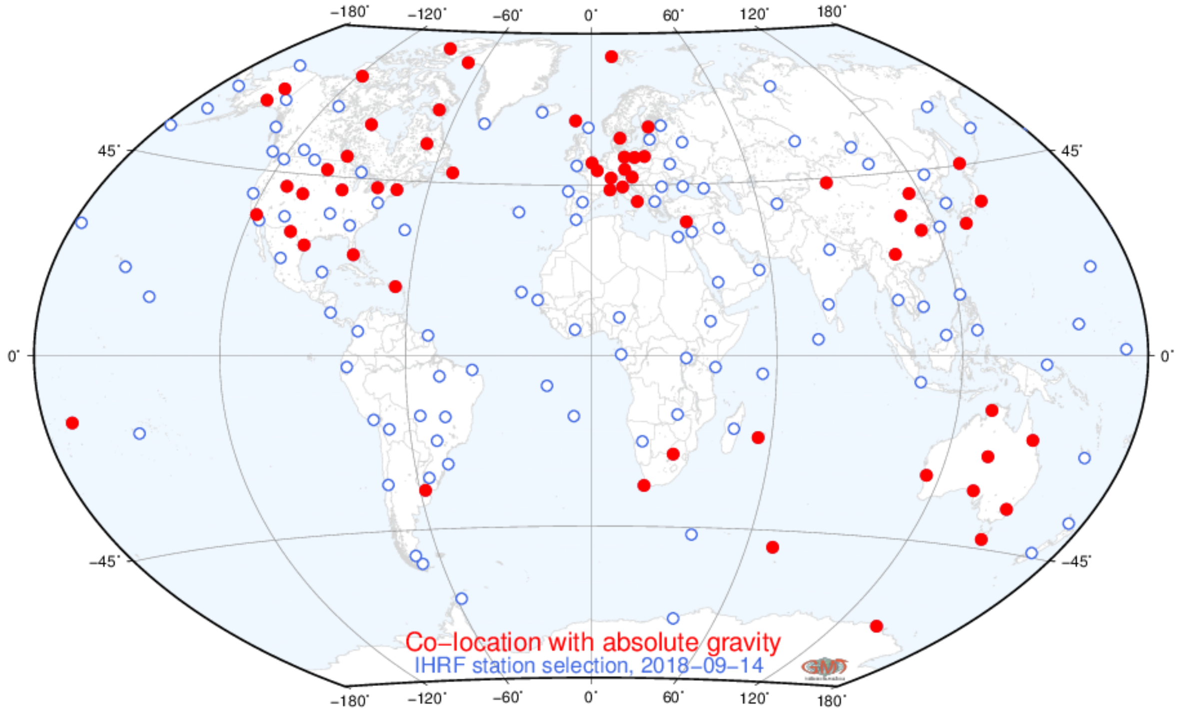
Antarctica (1): SY

http://isdc.gfz-potsdam.de/igets-data-base

IGETS Stations 2018

Link with the International Height References System

- Currently 163 stations proposed by IAG Joint Working Group 0.1.2. “Strategy for the Realization of the International Height Reference”
- Link for 61 AG stations established from AGrav database (red markers)



3: Update of the Processing Standards

International Absolute Gravimeter Base Network (IAGBN) Processing Standards, Boedecker (1988)

- Tides:
  Zero-tide system for the permanent tide *and* *Cartwright-Tayler-Edden with observed tidal parameters or 1.164*
- Atmosphere:
  Use DIN5450 (ISO 2533:1975) Standard Atmosphere *with 0.3 µGal/hPa*
- Polar motion:
  IERS reference pole with *elastic gravimetric factor 1.164*
  in *spherical approximation*

To be added:

Preferred model for *ocean tide loading*

Legend: fixed | improve | change | system | *frame*

IAGBN: Absolute Observations Data Processing Standards

(1992 collection)

As far as possible the basis for the following recommendations were taken from I
resolutions.

- Light travel time correction is based on c = 299 792 458 [ms^{-1}] (IAG 1983 resolution no. 1) Each individual time value should be corrected by

  $$\delta t = - \frac{z}{c}$$

  where z is the distance from the pre-drop resting position.

- Earth tides reduction: It is recommended to apply the Cartwright-Tay
development supplemented by the ICET to yield a total of 505 tidal constituents o
recognized development like Tamura, Büllesfeld or Xi. For the tidal parameters (a
factors and phase lags) values deduced from observations or from a recogniz
model like Wahr-Dehant should be used, which seems better; else, an amplitude
1.164 may be applied. The details must be reported as part of the observation docu

  The tidal reduction generally includes the M_0S_0 tide. Because the direct contribution of this tide, co
time, should be attributed an amplitude factor of 1 instead of about 1.164 for the tides varying wit
difference can be corrected using

  $$\delta g\,(M_0S_0) = -4.83 + 15.73 \cdot \sin^2\psi - 1.59 \cdot \sin^4\psi\ [10^{-8} ms^{-2}]$$

  where

  ψ geocentric latitude

  (c.f. IAG 1983 resolution no. 9 and no. 16; details see Rapp 1983).

- Earth rotation changes: The geometric position of the Earth's body relative to its
has to be referenced to mean position. It is recommended to use (e.g. Wahr 1985)

  $$\delta g = -1.164 \cdot 10^8 \cdot \omega^2 \cdot a \cdot 2 \sin\phi \cdot \cos\phi\,(x \cdot \cos\lambda - y \cdot \sin\lambda)\ [10^{-8} ms^{-2}]$$

  where

4. Data storage and Processing

- Raw data: Times of zero-crossings, generated easily by g-software:
- Alternative software of GOPE/ V. Palinkas:
  - Exact effective measurement height,
  - Plot of average residuals, to identify a lot of potential problems (e.g instrumental)
  - Sensitivity of g-solution on fringe ranges related to the above residuals,
- Minimum requirement for all AG:

a) text-data offered by g-software (including residuals)

b) I. Oshchepkov: GINEX
Comment by J. Liard:
The word "GINEX" exists elsewhere on the web - alternative: "GINEF".

- Standard format without efforts?!

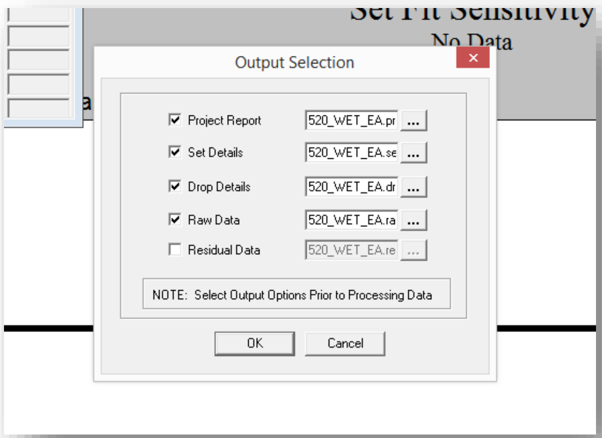
Requirements and suggestions

- Raw data (time and distance intervals or fringe–signals) for every drop.
- Metadata: setup and processing.
- Processing results (solutions): drop, set and final values + NEQ.
- Human–readable, long–time supported and universal format (txt, XML).
- Universal for all types of gravimeters.
- Relative measurements and time–series support.

All we need is GINEX!

GINEX — Gravimeter Independent Exchange Format.

4. Data storage and Processing



Documentation of applied corrections:

Minimum: at reference stations: SAC, DC

Processing software

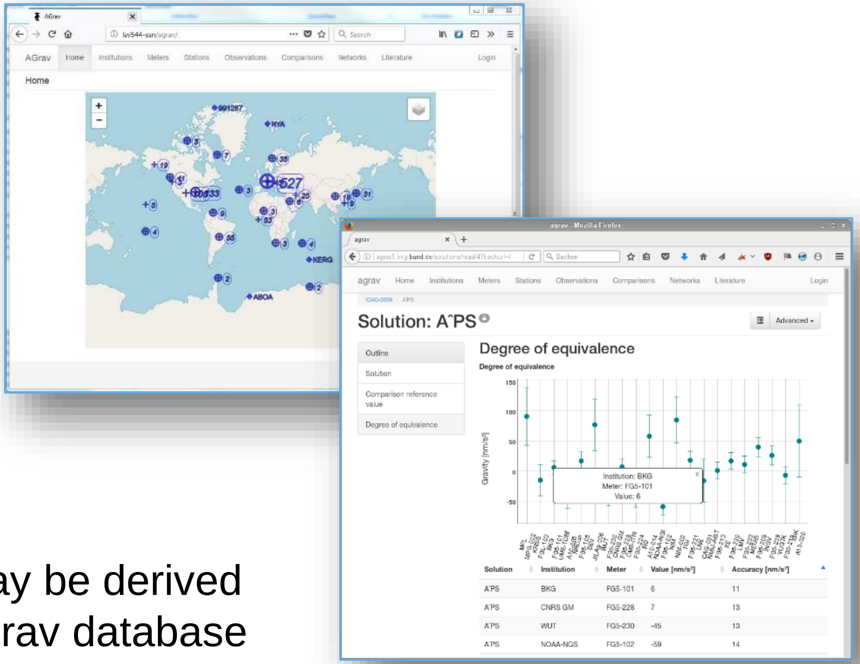
- g-Software, commercial, micro-g, de-facto standard.
  additional output: Times of zero-crossings
- Software by GOPE (V. Panlinkas); Matlab
- Software at NRCan (J. Liard): Fortran
- Proposal of I. Oshchepkov:
  Opensource, free and cross–platform (e.g. Python)

5. Documentation: AGrav database by BGI/BKG

Upgrade coming soon!

- Documentation of AG comparison results, similar to BIPM KCDB
- Time series plots for AG observations Reports for stations, observations and comparison results
- Overview about IGETS observations

Storage of raw data?



Digital Object Identifiers (DOI):

- Referencing absolute gravity observations
- First level DOI prefix retained by BGI: **`10.18168/BGI.DB_AGrav`**

- **Suffixes** may be derived from the AGrav database based on the primary keys:
  - Data provider, identified by institution
  - Network of stations
  - AG comparisons

6. Deadlines, Report to IAG, Publication

1. Deadlines:
   Station selection: Dec 2018, before AGU 2018
   → update of AGrav until then

2. Processing standards: definite Proposal

3. Next meeting: EGU 2019 (Vienna, Austria, 7–12 April 2019)
   Session proposal submitted:
      High accuracy terrestrial gravity observations in the time varying gravity field
      H. Wziontek, V. Pálinkáš, D. van Westrum

4. Preparation report to IAG (IUGG 2019)

5. Publication:
   Special issue in JoG, together with IHRF:
   Station selection, processing standards