Report of the CCM Working Group on Gravimetry

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18th CCM meeting, 20-21 May 2021

Bureau International des Poids et Mesures

WG Meetings held since last CCM

- 29 April 2021,CCM-WGG meeting, held online on ZOOM

  28 attendees from 24 institutes (18 NMIs, DIs and BIPM)

  Main items：

1、 Review of CMC entries on gravity acceleration

2、 Seven reports of activites in NIMs and DIs

3、 Next Key Comparison (NIST host next KC ,CCM.G-K2.2023)

4、 Discussion on the new Terms of reference of CCM-WGG

5、 Next Meeting (joint meeting between CCM-WGG and IAG WGs in 2022)

WG Meetings planned

The **joint meeting** of CCM-WGG and WGs of International Association of Geodesy is planned to be held at **University of Montpellier (France) in 2022**.

University of Montpellier will offer to host a meeting (consisting oral presentations, poster session and instruments demonstration) concerning **research and developments of instrumentations** (land, marine, borehole) **for measurements of gravity field**.

The next meeting of CCM-WGG is planned to be organized during the event to discuss issues concerning CMCs, comparisons, etc in 2022.

Main actions taken and main achievements

- 3 New CMCs on gravity acceleration

NO.	Country	Measurement method	Uncertainty (k=2)	Approved date
1	Mexico	Free-fall experiment	4.8 µGal	2020-04-01
2	Czech Rep.	Free-fall experiment	4.4 µGal	2020-09-15
3	Czech Rep.	Comparison against a gravity value of a reference station	6.0 µGal	2020-09-15

Main actions taken and main achievements

- The contribution of **absolute "g"** measurement (covered by CMC) to Kibble balance experiments was significantly reduced: relative **expanded uncertainty** decreased **from 8.0E-9 to 4.4E-9** in 2020.
- **Key comparisons** CCM.G-K2.2017 and the linked EURAMET.M.G-K3 have been **reviewed** and the results **published in KCDB.**
- CIPM **key comparison in 2023** has been announced. One venue (Observatory in Boulder) was **proposed by NIST** as the Pilot Laboratory.
- „CCM – IAG Strategy for Metrology in Absolute Gravimetry" has been discussed with geodesy community to ensure **traceability to the SI** for gravity measurements in the **International Gravity Reference System.**

Progressing the state of the art

- Absolute gravimeters with **cold-atom sensors** did huge progress. Best instruments have uncertainty **of about 2 µGal** (2E-8 m/s^2). **AQG** commercial gravimeter shows **repeatability of 1-2 µGal**, however the uncertainty has not been validated, yet.
- Very Long Baseline (**10 m**) **Atom Interferometer** is build in Leibniz University Hannover, which potentially might serve as a new gravity standard in the future.
- A set of newly determined or updated **corrections** were evaluated for **FG5/FGX** gravimeters based on laser interferometry. The associated instrumental **uncertainty** could be reduces **slightly below 2 µGal**.
- Strategy of **evaluation of comparisons** of absolute gravimeters ,which among others take into account correlations between measurements, has been published.

Liaison & stakeholders

- Cooperation with International Association of Geodesy (IAG):
  - IAG SC 2.1: Land, Marine and Airborne Gravimetry
  - IAG JWG 2.1.1: Establishment of International Gravity Reference System and Frame
  - IAG WG Q.1: Quantum gravimetry in space and on ground International Gravimetric Bureau
- National geodetic agencies
- NMIs who are not operating absolute gravimeters
- Universities, Geohysical institutes

KCs completed and underway

- Results of the CCM.G-K2.2017 and EURAMET.M.G-K3 key comparisons have been published in KCDB in 2020.

- According to the document of “CCM-IAG Strategy for Metrology in Absolute Gravimetry”, traceability to the SI for non-NMI/DIs was ensured by an “Additional comparison” – published in “Journal of Geodesy”.

KCs planed

- CCM.G-K2.2023

CIPM key comparison of absolute gravimeters will be piloted by **NIST in 2023** at **Table Mountain Geophysical Observatory** located near Boulder, Colorado USA, operated by the National Oceanic and Atmospheric Administration's National Geodetic Survey.

Program of work for the next 5 years

- **Planning** RMO KCs to the CIPM KC in 2023
- **Review** of CIPM and RMO KCs - **Task group** concerning evaluation of results has to be established
- **Discussion** on systematic errors of asolute gravimeters (both, cold-atom and with macroscopic masses) – **Task group** concerning evaluation of uncertanties has to be established, together with sharing templates
- **Organization** of scientific and technical Workshops (in 2022 joined with IAG-WGs)
- **Guidance** of Good practice guide for FG5/FG5X gravimeters
- **Support** the International Gravity Reference System by ensuring traceability for Comparison stations, where absolute gravimeters can be calibrated
- **Improvement** of CMCs

Proposed changes (membership, chairmanship, ToRs)

- Modifications of ToR for CCM-WGG

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New proposal of ToR for CCM-WGG

- To review the technical protocols and results of ~~completed~~ key and supplementary comparisons and plan and support new comparisons
- To facilitate the submission and review of CMCs by establishing technical review criteria and service categories and providing guidance on and coordinating the review process

Proposed changes (membership, chairmanship, ToRs)

- To maintain contacts with international organizations and stakeholders active in gravimetry
- To support stakeholders to ensure and promote the traceability of gravimetric~~y~~ measurements to the SI
- To follow and discuss the main research activities in gravimetry
- To produce working documents for analyses of comparisons and the evaluation of uncertainty

Thanks for your attention!

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