

**International Height Reference Frame Coordination Center (IHRF CC)**

Chairman of the IHRF Coordination Center: Georgios S. Vergos

Vice-Chair of the Coordination Center: TBD

Assistant to the IHRF Coordination Center Chair: Elisavet Mamagiannou

## **Terms of References:**

The International Association of Geodesy (IAG) introduced the International Height Reference System (IHRF) in 2015 as the international standard for the accurate determination of physical heights worldwide. The primary vertical coordinates are geopotential numbers referenced to a conventional  $W_0$  value. The realisation of the IHRF is the International Height Reference Frame (IHRF), which corresponds to a global network of reference stations with precise reference coordinates specified in the IHRF. The spatial position of the stations, at which the geopotential numbers are calculated, is defined by their respective coordinates (X, Y, Z) in the International Terrestrial Reference Frame (ITRF). The realisation of the IHRF is thus based on the combination of a geometric component, given by the positions of the stations in the ITRF, and a physical component, given by the determination of the potential values  $W$  at these positions. Through a strong international collaboration, framed by the IAG, it has been possible in recent years to outline the scientific foundations of the IHRF, to compute a first solution of the IHRF, and to identify the key issues for a long-term sustainability of the IHRF. Much progress has been made and it was deemed necessary to ensure the maintenance and availability of the IHRF in the future. Following IAG practice, the development of theory and methods for the continuous improvement of the IHRF/IHRF should be promoted by the IAG Commissions and the Inter-Commission Committee on Theory (ICCT), while the operational performance should be ensured by the IAG Services.

In that respect, the IHRF Coordination Centre (IHRF CC) is established as a central coordinating body under the responsibility of the International Gravity Field Service (IGFS) with direct adherence to the IGFS Central Bureau (IGFS CB), composed of individual modules taking care of the main components of the IHRF. These modules are the IHRF Reference Network Coordination, the IHRF Conventions' Coordination, the IHRF Associate Analysis Centres, and the IHRF Combination Coordination.

## **Objectives**

The IHRF CC coordinates the activities of the IHRF Reference Network Coordination, the IHRF Conventions' Coordination, the IHRF Associate Analysis Centres, and the IHRF Combination Coordination. The IHRF CC has the responsibility to deliver the IHRF coordinates ( $X, Y, Z, C$ ) of the IHRF reference stations and a catalogue of the vertical datum parameters, i.e., the transformation parameters between the existing local height systems and the IHRF. These coordinates are derived based on the conventions set by the IHRF Conventions' Coordination, for stations maintained by the IHRF Reference Network Coordination, computations carried out by the IHRF Associate Analysis Centres and the final combined solution released by the IHRF Combination Coordination, which also takes care of the quality assessment of the regional/national solutions. The IHRF CC release the final (official) IHRF solution.

Moreover, temporal variations of potential values despite the fact that are not considered systematically, will be derived for stations where larger variations take place (GIA or in case of earthquakes), so that the re-estimation of the potential values for these stations will be carried out if there are observed larger variations of geometric heights.

The IHRF CC continues the activities of the Focus Area Unified Height System (FA-UHS) of the IAG's Global Geodetic Observing System (GGOS) and study and working groups within Commission 1 (Reference Frames), Commission 2 (Gravity Field), the Inter-Commission Committee on Theory (ICCT), the International Gravity Field Service (IGFS), and the International Earth's Rotation and Reference Systems Service (IERS).

### *Products and Goals*

The IHRF CC coordinates the efforts for the maintenance, long-term sustainability and realization of the IHRF and its products are made available through the IGFS CB. The IHRF related products are:

- IHRF standards and conventions;
- IHRF network and status;
- IHRF computation cookbook;
- Offsets to national and regional vertical datums;
- IHRF station coordinates for the global core network and contributing regional and national densifications.

The IHRF CC provides the necessary methodological procedures for the estimation of station coordinates, sets the validation procedures for the computed potential values, maintains the list of participating stations, delivers the station coordinates and their status, computes and delivers the offsets to national and regional datums for those IHRF stations that the AAC have determined, and maintains and updates the IHRF standards and conventions.

## **Permanent Components**

The IHRF CC accomplishes its objectives through the following permanent components:

- IHRF Coordination Center;
- IHRF Conventions' Coordination;
- IHRF Reference Network Coordination;
- IHRF Associate Analysis Centres;
- IHRF Combination Coordination.

### *IHRF Coordination Center (CC)*

*CC Coordinator: Georgios Vergos (Greece)*

The CC is the central management body for the maintenance of the IHRF/IHRF. It will be responsible for the general coordination of activities required for the IHRF and for the storage, publication, and servicing of the IHRF. This includes not only related documentation, products, and relevant information, but also the IHRF coordinates (X, Y, Z, C) at the IHRF reference stations and a catalogue of the vertical datum parameters; i.e., the transformation parameters between the existing local height systems and the IHRF. As in the case of the ITRF, it is foreseen that the IHRF solutions will be regularly updated to take into account new technological developments, and new and improved observation data. Moreover, when large and/or systematic potential variations take place (GIA or in case of earthquakes) potential values for these stations will be re-estimated. Our proposal is to synchronise the release of updated IHRF solutions with the release of updated ITRF solutions. This process should be also coordinated

by the IHRF Coordination Centre. The IHRF CC will be hosted by the IGFS CB and report directly to the IGFS and the IAG EC.

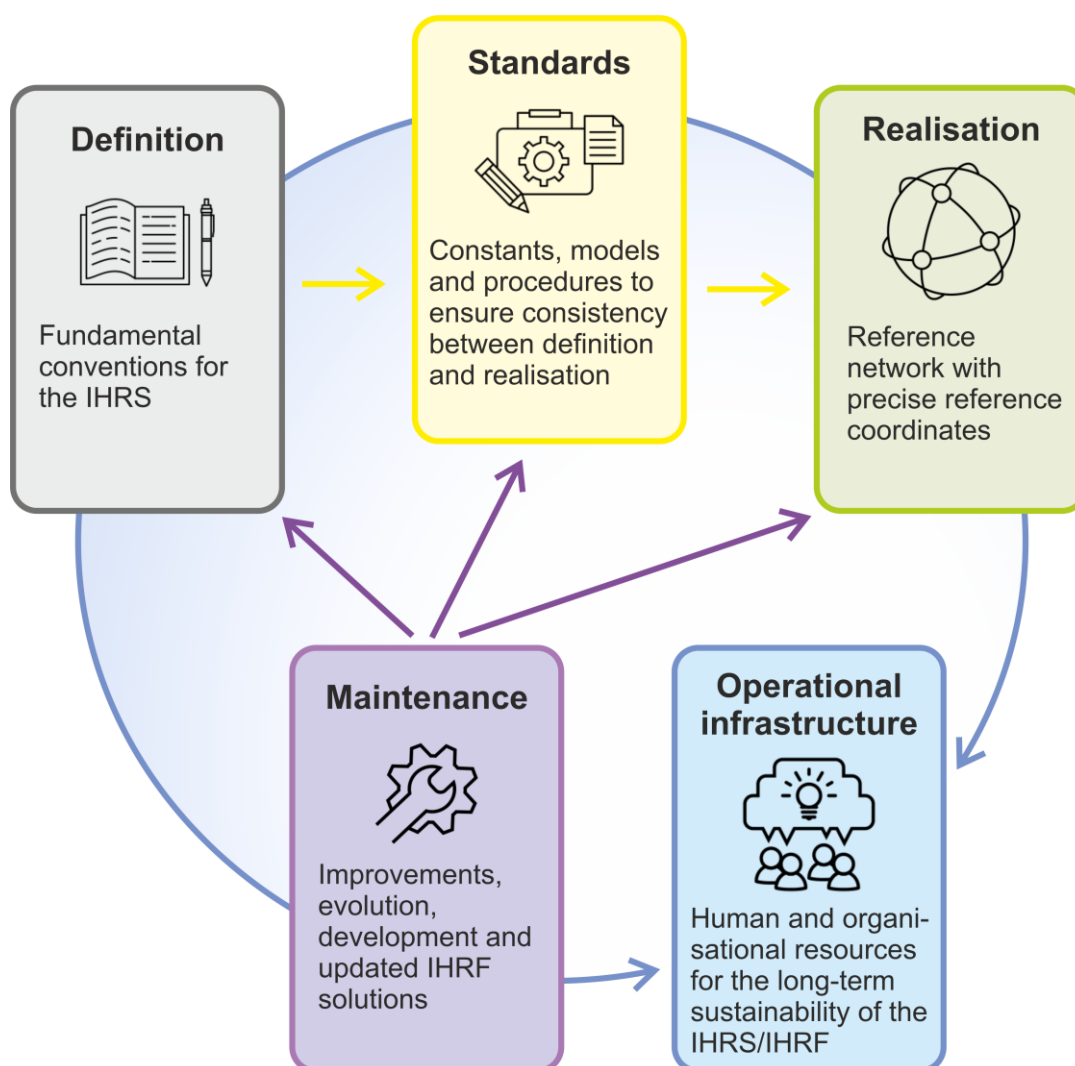


Figure 1: The objectives, products and goals of the IHRF.

### *IHRF Conventions Coordination (CVC)*

*CVC Coordinator: Jialiang Huang (Canada), Jonas Ågren (Sweden)*

The initial IHRF conventions, standards, and constants for the definition and realisation of the IHRF are given in the IAG Resolution 1 (2015), and further commented by Sánchez et al. (2021). These conventions, standards and constants should be updated according to new developments in geodetic theory and technology. The IHRF Conventions' Coordination should maintain a document with the conventions and standards needed for the IHRF. Special consideration should be given to harmonisation with the conventions and standards maintained by the GGOS Bureau of Products and Standards (GGOS-BPO), the IERS Conventions (for the determination of the ITRF), and the standards used by the gravity field related IAG Services in global and regional gravity field modelling. Moreover, the IHRF Conventions' Coordination should assess the impact that revisions in the IHRF conventions will have and provide the necessary theoretical and methodological updates/modifications that need to be introduced to the existing station coordinates.

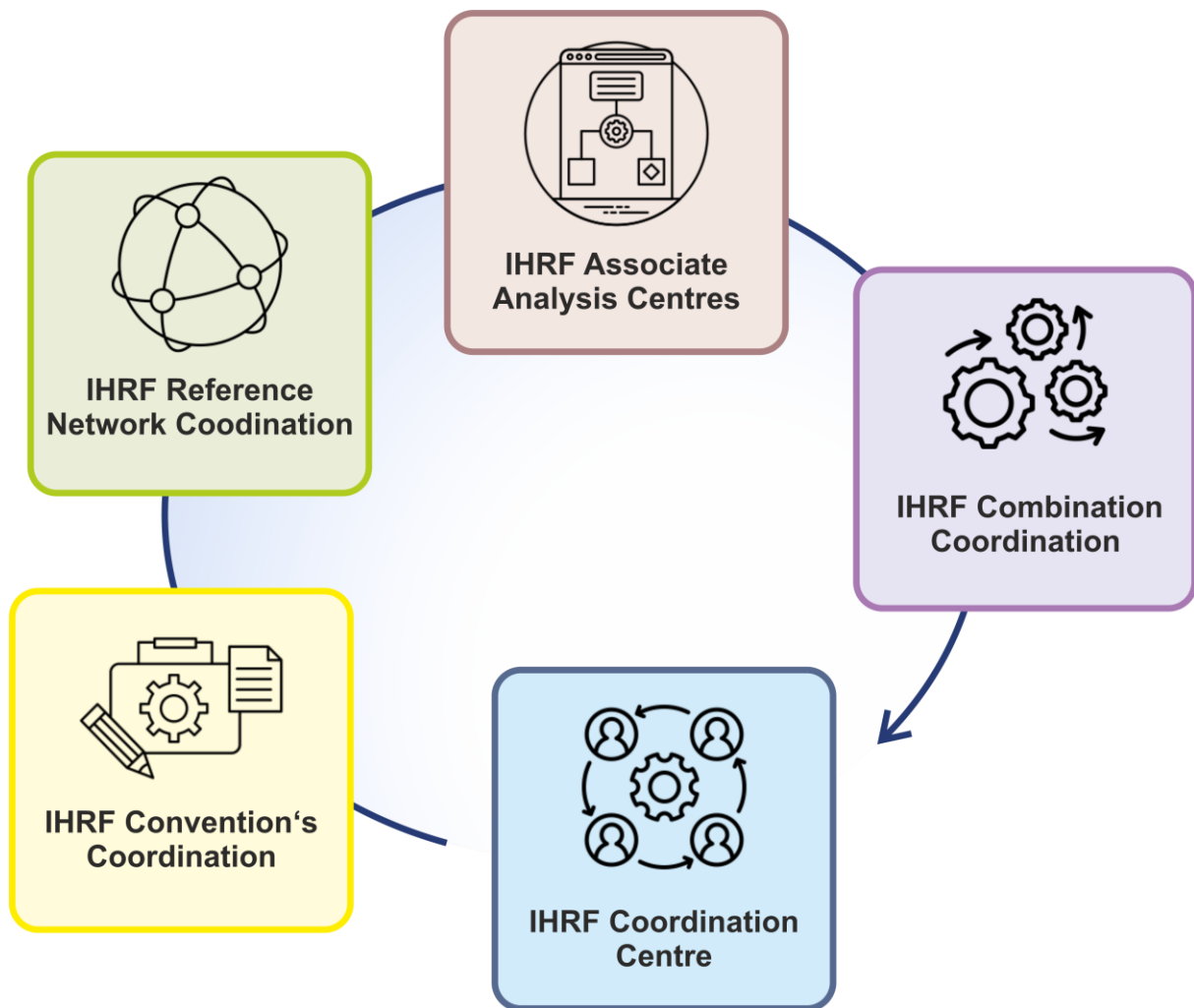


Figure 2: The main modules of the IHRF Coordination Centre.

### *IHRF Reference Network Coordination (RNC)*

*RNC Coordinators: Claudia Tocho (Argentina), Georgios Vergos (Greece)*

The IHRF reference stations should consist of continuously operating GNSS stations co-located with the GGOS core sites, the global ITRF or its regional densifications (such as EUREF, SIRGAS, etc.), the International Terrestrial Gravity Reference Frame (ITGRF) and, if possible, the national levelling networks. The IHRF Reference Network Coordination should implement and keep updated a catalogue of the IHRF global reference stations. This includes the decommissioning of destroyed stations and the addition of new stations to replace removed stations or improve the geographical distribution. Changes in the IHRF station distribution require interaction with the bodies responsible for the other reference frames: the ITRF (IERS), the ITGRF (IGFS), the GGOS core sites (GGOS Bureau of Networks and Observations) and the IAG Sub-Commissions for the regional reference frames and the regional geoid models. The IHRF Reference Network Coordination should also prepare and provide the set of ITRF coordinates to be used for the determination of updated IHRF solutions.

### *IHRF Combination Coordination (CombC)*

*RNC Coordinators: Laura Sánchez (Germany), Riccardo Barzaghi (Italy)*

The IHRF Combination Coordination will be responsible for the combination and quality assessment of the regional/national solutions and for releasing the final (official) IHRF

solution. The quality assessment can be based on redundant calculations or by calibration of computation methods. In the first case, at least two Associate Analysis Centres independently determine the potential values for the same stations. In the second case, IHRF Associate Analysis Centres should determine potential values using a certain set of input data and compare their results with those obtained by other processing approaches. For this purpose, a simulated gravity anomalies data set from a high-resolution gravity field model will be generated (with and without simulated noise) as a baseline for potential determination, along with GNSS/Levelling and digital topography data to act as testbed to investigate new methods, algorithms, approaches and software based on this data set. Especially during the initial period of the IHRF CC establishment, and until methodologies, data and procedures improve, input gravity and topographic data, the GNSS/levelling validation data, and the different geoid/quasi-geoid models produced within the Colorado Experiment are available from the International Service for the Geoid (ISG) and can be used as a basis to evaluate any disturbing potential calculation method or software anywhere.

### *IHRF Associate Analysis Centers (ASC)*

The IHRF Associate Analysis Centres are those national/regional agencies/bodies that contribute to the realisation of the IHRF by providing the potential values at the IHRF stations located in their countries/regions and the vertical datum parameters. These Analysis Centres should strictly follow the conventions outlined by the IHRF Conventions Coordination, use the ITRF input coordinates provided by the IHRF Reference Network Coordination, and provide detailed descriptions about their calculations. In an ideal data flow scheme, the IHRF Associate Analysis Centres would provide the IHRF Coordination Centre with the following products: potential values at the IHRF reference stations; vertical datum parameters; mean gravity anomalies or disturbances; and regional geoid or quasi-geoid models of high resolution. The mean gravity anomalies (or disturbances) and the geoid/quasi-geoid models would then be managed by the Bureau Gravimétrique International (BGI) and ISG, respectively. Coordination of the ASC is done by the coordinators of CombC and RNC.

The initial Associate Analysis Centers, in charge of computing IHRF stations coordinates (potential values), are along with the national/regional responsible (in alphabetical order):

- |                 |  |
|-----------------|--|
| • Africa        | Hussein Abd-Elmotaal   |
| • America North | Yan Ming Wang, Jianliang Huang   |
| • America South | Ana Cristina Oliveira Cancoro de Matos, Claudia Tocho, Gabriel do Nascimento Guimarães |
| • Oceania       | McCubbine Jack   |
| • Europe        | Joachim Schwabe, Heiner Denker   |
| • India         | Ropesh Goyal   |
| • Japan         | Koji Matsuo  |
| • China         | Tao Jiang  |
| • KSA/Arabia    | Rossen Grebenitcharsky, Abdullah Theeb Hassan Al-Qahtani                               |
| • Iran          | tbd  |
| • Turkey        | Bihter Erol  |
| • Greenland     | Rene Forsberg, Hergeir Teitsson  |
| • Antarctica    | tbd  |

Additional Associate Analysis Centers are welcome especially in areas not covered by the already established AAC's. Should a new AAC be proposed, the proposal should be directed to

the coordinators of the RNC, who maintain the list of the available IHRF stations, and CombS, who combine the national/regional solutions.

## Directing Board

The Directing Board sets the objectives, determines policies, adopts standards, and sets the scientific and operational goals for IHRS/IHRF. The Directing Board exercises general oversight of the activities of IHRS/IHRF including modifications to the organization that are deemed appropriate and necessary to maintain efficiency and reliability. The Directing Board may determine appropriate actions to ensure the quality of the IHRS/IHRF products.

### *Membership*

The Directing Board consists of representatives from the IHRF components, appointed members and ex officio members. Its members are:

Elected Members:

- Associate Analysis Center representative

Permanent IHRS/IHRF components

- Chairman of IHRF Coordination Center;
- Chairs of IHRF Conventions' Coordination;
- Chairs IHRF Reference Network Coordination;
- Chairs of IHRF Combination Coordination.

Appointed Members:

- ICGEM representative;
- ISG representative;
- BGI representative;
- IDEMS representative;
- IGETS representative;
- GGOS representative;
- ITRF representative.

### *IHRS/IHRF chair*

The Chairman of the IHRF Coordination Center is also the chair of the IHRS/IHRF service.

### *Meetings*

The IHRF CC is responsible for organizing dedicated meetings and workshops for the analysis of the produced time-variable gravity field solutions and their applications in different branches of the geosciences. The IHRF CC will organize regular business meetings of the CVC, RNC, CombC and ASC to coordinate activities and report to the IGFS and the IAG EC.

### *Membership*

With IHRS/IHRF being a scientific service operating within IGFS, membership is free pending approval by the CC. Interested scientists and users can contact the IHRS/IHRF CC at [ihrf@topo.auth.gr](mailto:ihrf@topo.auth.gr) with their membership request.

*Founding Committee and current Directing Board (2023):*

*Georgios S. Vergos (Greece)*

*Laura Sánchez (Germany)*

*Riccardo Barzaghi (Italy)*

*Jialiang Huang (Canada)*

*Jonas Ågren (Sweden)*

*Claudia Tocho (Argentina)*