Inter-Commission Committee on Marine Geodesy (ICCM)

https://doi.org/10.82507/iag-gh2024_iccm

President: Valérie Ballu (France)
Vice President: Heidrun Kopp (Germany)

ICCM website - www.iccm.iag-aig.org

1 Terms of Reference

The Inter-Commission Committee on Marine Geodesy (ICCM) was first proposed by the Chinese National Committee to the IAG Executive Committee (EC) in Kobe, Japan, in 2017 and then passed at the 6th and 7th meetings of the IAG EC in 2018. The ICCM was formally approved and established following the IUGG General Assembly in Montreal, Canada, in 2019. With over seventy percent of the planet's surface and the most important zones of crustal formation and destruction covered by the oceans, monitoring and understanding the oceans and the seafloor is of highest relevance to secure the human sustainable development. The oceans provide enormous biological and mineral resources while at the same time modulate the climate and weather patterns and serve as an important sink for atmospheric carbon. The oceans and seafloor are crucial to the evolution not only of life, but of the Earth system, yet 80% of marine realm remain unexplored [NOAA]. The research foci of marine geodesy have enormous economic and scientific potential. However, at present, large gaps in ocean surveys, seafloor mapping and remote sensing exist, which necessitate IAG's immediate attention.

Research contributions to marine geodesy have advanced tremendously during the last two decades:

1. seafloor geodetic networks have been initiated and established by countries or regions including North and Central America, Europe, New Zealand and Japan, and in the near future more coastal countries may start seafloor observatory plans;
2. advanced GNSS/acoustic GPS-A techniques have achieved centimeter accuracy in seafloor geodetic positioning, crucial to marine geohazard monitoring, including undersea earthquakes volcanic eruptions, and submarine landslides as well as monitoring of seafloor infrastructure;
3. multi-ocean environment monitoring data are available to potentially improve seafloor geodetic positioning or monitoring of steric sea level and circulations, including temperature and salinity profiles of the Array for Real-time Geostrophic Oceanography (Argo), expendable bathythermograph (XBT) data, ocean-bottom pressure (OBP) data and surface and subsurface ocean current observations.

ICCM strongly encourages research to:

1. enhance frontier research topics on monitoring changes of the ocean and seafloor, such as sea level change, seafloor tectonic motion and seismological events, steric and mass oceanic variations, changes of the surface and subsurface currents, and changes of waves and wind patterns;
2. refine a series of marine geodetic models, including barotropic and baroclinic ocean tide models, marine geoid models, dynamic topography models, and coastal reference models such as the mean high water (MHW) and the high-water line (HWL);
3. improve the accuracy and resolution of the global seafloor topography particularly in the coastal regions by advancing new seafloor geodetic data acquisitions, innovative data processing, and exploring new topography inversion tools;
4. promote the development of seafloor geodesy networks and regional densification, together with reflexions toward the geodetic tying of seafloor reference points into the International Terrestrial Reference Frame (ITRF) in the coastal and deep ocean.

1.1 Objectives

The overall objectives of the ICCM are:

- to shorten the gaps between theory and applications in marine geodesy, and to encourage transdisciplinary integration of the contemporary geodetic sensors, including marine geophysical sensors, oceanic sonar and physical oceanography instrumentation;
- to improve the global realization of the ITRF by connecting the seafloor geodetic network component with it, and to improve current marine geodetic models by including the space, surface and subsurface geodetic observations;
- to encourage the development of marine geodetic methodology, especially for the fusion methods of multi-marine geodetic observations;
- to promote international collaborations in regional marine geodetic surveys, and to develop and establish international conventions for marine geodetic data processing, the seafloor reference frame, and other standards.

ICCM will interact and collaborate with the IAG Commissions, GGOS, and other IAG entities (Services, Projects) to achieve these aims. Stronger interactions with the International Association for the Physical Sciences of the Oceans (IAPSO), the oceanography component of the IUGG is also encouraged.

1.2 Program of Activities

The anticipated ICCM activities include:

- service as (co-)conveners of geodesy sessions at major conferences such as IAG, EGU, AGU, AOGS, IUGG, etc.
- organization of marine geodesy symposia, and publication of special issues of international journals such as Marine Geodesy, Journal of Geodesy, and Advanced Space Research.
- creation and maintenance of a website for disseminating ICCM-related information and data products.

1.3 Structure

The general structure of Inter-Commission Committees is specified in the IAG Bylaws. The Steering Committee includes the President, the Vice President, the Past President, representatives appointed by each Commission, two representatives of the IAG Services, representatives of GGOS, other ICCs (ICCC, ICCT), one Early Career Scientist (ECS) and members. The ICCM activities will be structured in working groups. Due to the inter-commission character of the ICCM, these are always Joint Working Groups (JWGs), affiliated to one or more of the Commissions, GGOS and/or IAG Services. These groups will be established during the first period of the ICCM.

1.4 Steering Committee

- President: Valérie Ballu (France)
- Vice President: Heidrun Kopp (Germany)
- Past President: Yuanxi Yang (China)

Representatives of IAG entities

- Commission 1: Chris Danezis (Cyprus)
- Commission 2: Xiaoli Deng (Australia)
- Commission 3: Carsten Ludwigsen (Denmark)
- Commission 4: Ana Paula Camargo Larocca (Brazil)
- Services - IERS: Henryk Dobslaw (Germany)
- Services - IERS: Ruediger Haas (Sweden)
- GGOS: Yusuke Yokota (Japan)
- ICCT: Shun-ishi Watanabe (Japan)
- ICCC: to be nominated

Members

- Chair of JWG M.1: Pierre Sakic (France)
- Chair of JWG M.2: James Foster (Germany)
- Chair of JWG M.3: Matt Wei (USA)
- Chair of JWG M.4: Tianhe Xu (China)
- Chair of JWG M.5: Shuqiang Xue (China)
- Chair of JWG M.6: Morelia Urlaub (Germany)
- Lifeng Bao (China)
- Rongxing Li (China)
- Felipe Nievinski (Brazil)
- Ian Church (Canada)
- Kaifei He (China)
- Sajad Tabibi (Luxembourg)
- Keiichi Tadokoro (Japan)
- Laurent Testut (France)
- Fanlin Yang (China)

Representative of Early Career Scientists

- Pierre Sakic (France)

1.5 Overview of Joint Working Groups

Hereafter, the ICCM Joint Working Groups (JWGs) for the 2023-2027 period are listed, together their Chairs (and Vice-Chairs for some of them) and their affiliations with other IAG entities.

JWG M.1 Data and tools exchange
Chair: Pierre Sakic (France)
Affiliations: IERS, GGOS

JWG M.2 GNSS-Acoustic technologies and experiments
Chair: James Foster (Germany)
Affiliations: Commissions 1, 3, 4

JWG M.3 Seafloor pressure - an essential variable for monitoring vertical deformation as well as ocean dynamics
Chair: Matt Wei (USA)
Affiliations: Commission 3, ICCC

JWG M.4 Realtime and post-processed kinematic GNSS positioning: status and perspectives for seafloor and sea-surface positioning
Chair: Tianhe Xu (China)
Vice-Chair: Zhiguo Deng (Germany)
Affiliations: Commission 4

JWG M.5 Acoustic Delay Corrections for Submarine Geodesy
Chair: Shuqiang Xue (China)
Affiliations: Commission 4, IERS

JWG M.6 How marine geodesy can better contribute to coastal hazards assessment and mitigation
Chair: Morelia Urlaub (Germany)
Vice-Chair: Lifeng Bao (China)
Affiliations: Commission 3

2 Joint Working Groups

JWG M.1: Data and tools exchange

Chair: Pierre Sakic (France)
Affiliation: IERS, GGOS

Terms of Reference

This JWG aims to enable the shareability of the seafloor geodesy data collected by the different working groups worldwide and then give better visibility to these data while respecting the FAIR principles. Indeed, clearly defined exchange standards and effective data sharing might be a solid foundation for concrete exchanges between the research groups working on seafloor geodesy questions, thus initiating future international collaborations and, in the long term, establishing a global underwater geodetic observation network.

Objectives

- Enable the shareability of the seafloor geodesy data collected by the different working groups around the world;
- Give better visibility to these data;
- Respect the FAIR data principles (Findable, Accessible, Interoperable, Reusable).
- A special emphasis has to be given to the interoperability of seafloor geodetic data, i.e., the possibility to easily use data of one working group with the software of another, for instance.
- Identify how data can be easily stored in existing repositories or establish expectations for new repositories.
- Establish community-supported data standards that can be adopted by the repositories/data centers.

Program of Activities

The working group initially discussed a range of seafloor geodetic techniques. Given the considerable interest in GNSS-Acoustic by those who participated in this discussion, it was agreed to start with this technique. Nevertheless, the task force is interested in a wide range of techniques, and will likely revisit other techniques in the future. Techniques of future interest may include:

- Acoustic ranging
- Ocean bottom pressure sensors (OBP)
- Tiltmeters
- Optical Fiber Strainmeter
- Seafloor gravimetry
- Mast Seafloor <> Surface combining GNSS+attitude measurement
- Multi-beam Bathymetry

It would be highly valuable if other working groups similar to the current one could emerge within the task force to consider the other techniques mentioned above, like the OBP for instance.

Members

Pierre Sakic (France); Chair
Valérie Ballu (France)
Jesse Hutchinson (Canada)
Martin Heesemann (Canada)
Kaifei He (China)
Motoyuki Kido (Japan)
Yuto Nakamura (Japan)
David Schmidt (USA)
John DeSanto (USA)
Keiichi Tadokoro (Japan)
Surui Xie (USA)
Yusuke Yokota (Japan)
Shun-ichi Watanabe (Japan)

JWG M.2: GNSS-Acoustic technologies and experiments

Chair: James Foster (Germany)
Affiliation: Commissions 1, 3, 4

Terms of Reference

GNSS-Acoustic techniques allow us to measure positions and displacements of the seafloor – an environment that was previously almost entirely unobserved by geodetic techniques. In the last decade, there have been major advances in technologies and processing approaches that have lead to a burgeoning range of research experiments and technological developments. In this rapidly evolving field, many different groups, both academic and commercial, are exploring new technical approaches and strategies, investigating new study areas, and employing new processing algorithms. Although the cost for seafloor geodetic equipment, deployments, and measurement campaigns has been greatly reduced over the last few years, it remains an expensive frontier of research and development. Consequently, it becomes imperative to ensure that there is a venue for the exchange of information about the latest seafloor geodetic technologies and experiments in order to ensure that efforts are not duplicated, that the best available existing solutions appropriate for a particular problem can be found, that potential partners for collaborative efforts can be identified, and that people able to provide crucial guidance and information can be connected with. The Joint Working Group for "GNSS-Acoustic technologies and experiments" is tasked to develop a publicly available web-based document that will provide key information for all significant completed, ongoing, and upcoming seafloor geodetic experiments, and its enabling technologies. This living document will be available as a resource for all individuals interested in seafloor geodesy and the technologies and projects that have, or will, use this geodetic technique.

Objectives

- To provide a publicly accessible catalog of GNSS-Acoustic experiments and technologies;
- To encourage the voluntary listing of relevant technologies and experiments by the PIs and/or companies that are developing/deploying them.

Program of Activities

- Define the form & structure of the web page that will provide key summary information concerning seafloor techniques, applications, experiments and links to relevant PIs, and companies.
- Establish the categories, and minimum necessary information fields and optional sections for inclusion in the web document.
- Solicit document listings from all known active parties in seafloor geodesy.
- Publish document for comments and ongoing contributions.

Members

James Foster (Germany); Chair
Shuqiang Xue (China)
Yusuke Yokota (Japan)
Mark Zumberge (USA)
Laura Wallace (Germany)
Benoit Taisne (Singapore)

JWG M.3: Seafloor pressure - an essential variable for monitoring vertical deformation as well as ocean dynamics

Chair: Matt Wei (USA)
Affiliation: Commission 3, ICCC

Terms of Reference

Seafloor pressure data is quite unique comparing to other commonly used seafloor geodetic methods because it can continuously measure seafloor deformation in the vertical direction. Pressure sensors can be connected to cabled networks or deployed as a temporal array for a couple of years. For the past decade, cabled networks with seafloor pressure sensors have been built in Japan, USA and Canada. Many temporal arrays have been deployed in New Zealand and USA. Most of the data have been used to monitor marine volcano deformation such as Axial Seamount in USA and detect slow slip events in subduction zones such as New Zealand. They provided the needed temporal and spatial resolution at a reasonable cost which are not possible using other methods. The main challenge of using seafloor pressure data is the large oceanic noise. In most places, the ocean noise is at about a few centimeters equivalent of water. It is small comparing to large deformation caused by major earthquakes and volcanic eruption. However, it is quite large comparing to the long-term tectonic loading and

slow slip events in subduction zones. On the other hand, the ocean noise for geophysicists is physical oceanographer's signal. Regional observations of bottom pressure are sensitive to mesoscale circulation effects such as eddies, current meanders, and coastal trapped waves. At basin scales, bottom pressure can provide constraints on circulation mass budgets. Therefore, seafloor pressure is an essential variable for monitoring ocean dynamics too. Reducing water noise to improve our ability to detect small tectonic vertical deformation requires collaborations with physical oceanographers, which is a main objective of this working group.

Another challenge of using seafloor pressure data is the instrumental drift. Most currently used pressure sensors have an uncertain instrumental drift of a few to 10ths of centimeters per year in the first few months or years. This prevented us to monitor long-term, steady tectonic loading. Significant progress has been made to calibrate the instrumental drift and commercial drift-free pressure sensors have been developed and are available now. However, the long-term performance of these drift-free sensors is still a question.

This working group is actively promoting collaborations to solve these challenges so the scientific community can use seafloor pressure data to solve important questions. Seafloor pressure should be combined with GNSS-A and/or direct ranging to provide a 3D view of seafloor deformation.

Objectives

- To reduce ocean noise in seafloor pressure data for better measurements of vertical tectonic deformation;
- To better understand tectonic processes and assess related ocean hazards;
- To encourage collaborations between geophysicists and physical oceanographers;
- To promote international collaborations.

Program of Activities

- Organize workshops between geophysicists and physical oceanographers.
- Create a website for easy access of existing seafloor pressure data.
- Organize sessions in international conferences such as AGU Fall Meeting, Ocean Sciences Meeting, and IUGG meeting.

Members

Matt Wei (USA); Chair
Erik Fredrickson (USA)
Karina Ramos Musalem (Mexico)
Randy Watts (USA)
Heidrun Kopp (Germany)
Valérie Ballu (France)

JWG M.4: Realtime and post-processed kinematic GNSS positioning: status and perspectives for seafloor and sea-surface positioning

Chair: Tianhe Xu (China)
Vice-Chair: Zhiguo Deng (Germany)
Affiliation: Commission 4

Terms of Reference

Global Navigation Satellite System (GNSS) is widely applied in seafloor and sea-surface positioning. For instance, GNSS installed in a buoy can be used to facilitate the measurement of sea surface wave and tidal height, calibration of satellite altimeters, estimation of precipitable water vapor, and even monitoring of tsunamis. Additionally, GNSS/Acoustic (GPS-A) techniques are commonly employed for hydrophone position during seismic exploration, seafloor geodetic positioning, monitoring oceanic plate motion, and studying earthquake cycle deformation, etc.

Precise Point Positioning (PPP) is able to provide decimeter to centimeter-level kinematic positioning accuracy worldwide by using precise GNSS ephemeris. This makes PPP a preferred GNSS positioning technology in ocean environments. International GNSS Service (IGS) has substantially generated precise products with certain delays. These products can be freely accessed for users to carry out post-processed PPP. In response to the real-time application demands, IGS introduced an open-access real-time service (RTS) in 2013, which includes orbit, clock, and other corrections. The advent of RTS allows users to carry out real-time PPP without paying any fees. However, challenges arise in receiving RTS corrections due to the lack of internet-based infrastructures in oceanic regions. Several commercial companies have developed real-time PPP systems, such as OmniStar, StarFire of NavCom, and StarFix of Fugro. In recent years, navigation satellite systems, such as QZSS, Beidou, and Galileo, have also been broadcasting PPP services. In addition, the applications of observable-specific signal bias and atmospheric correction for augmented PPP via Short Message Communication (SMC) or other methods have great potential.

Nevertheless, the lower positioning accuracy and longer convergence time have always been a persistent issue for PPP, as compared to Real-time kinematic (RTK) positioning, particularly in the open ocean where there is no reference station network used to generate regional augmentation corrections. With the increasing deployment of unmanned intelligent systems in marine domains, in addition to high precision, high credibility has also been a key concern. The integrity monitoring server is the tool to ensure the positioning reliability and to obtain the protection level. However, methods, techniques, models, and algorithms for PPP integrity monitoring necessitate further development. This is the reason why it is worth focusing on the seafloor and sea-surface kinematic GNSS positioning within the ICCM.

Objectives

- To investigate the ocean environment influence on the kinematic GNSS PPP positioning and to work out solutions to decrease environment influence;

- To encourage the development of methodology to accelerate PPP convergence in the open ocean;
- To develop PPP integrity monitoring techniques to meet the increasing demands of unmanned intelligent systems;
- To promote international collaborations in seafloor and sea-surface kinematic GNSS positioning.

Program of Activities

- To encourage the seafloor and sea-surface kinematic GNSS data share among scholars and academic societies.
- Organization of real-time and post-processed kinematic GNSS positioning for seafloor and sea-surface positioning symposia, and publication of special issues of international journals such as Marine Geodesy and GPS Solutions.

Members

Tianhe Xu (China); Chair
Zhiguo Deng (Germany); Vice-Chair
Zhixi Nie (China)
Zhetao Zhang (China)

JWG M.5: Acoustic Delay Corrections for Submarine Geodesy

Chair: Shuqiang Xue (China)
Affiliations: Commission 4, IERS

Terms of Reference

The Global Navigation Satellite System-Acoustic (GNSS-A) technique has provided key observations for submarine geodetic positioning and has become the most potential tool for seafloor geodetic network establishment to extend the terrestrial network into the ocean. Nowadays, low-cost GNSS-A systems based on unmanned platforms are revolutionizing the traditional, costly technique based on the survey ship conducting seafloor geodetic observation and in-field sound speed measurement. This offers the possibility of achieving large-scale and even global, nearly real-time seafloor geodetic applications to shorten the gap between terrestrial geodesy and submarine geodesy. However, GNSS-A measurements encounter challenges in achieving precise ranging due to spatio-temporal variations of sound speed. It is feasible to obtain the sound speed profile (SSP) in the field to achieve centimeter-level precision of seafloor geodetic positioning, but the process remains costly and restricts the application of unmanned systems due to their limitations in equipping the SSP profiler.

Drawing on GNSS atmospheric delay estimation, efforts focusing on sound speed variation effects and mitigating these effects have been devoted to improving positioning precision. The acoustic delay relative to the reference SSP has been investigated in the past, and GNSS-A acoustic observation models appended with acoustic delay parameters have been developed. Facilitated by Marine Environment Monitoring

Services (MEMS), the marine environment datasets (MEDs), such as the monthly or daily ocean temperature and salinity profiles, are available for public access, e.g., the World Ocean Atlas (WOA) datasets from the National Centers for Environmental Information (NCEI), the datasets released by the Met Office Hadley Centre, and the datasets released by Mercator Ocean International. With the improvement of spatio-temporal resolution of MEDs, datasets offer a new way to conduct precise seafloor geodetic positioning in the absence of in-filed SSP.

Nevertheless, most of the current studies are to correct the time observations based on the reference SSP, which results in a theoretical gap between well-developed space geodesy and developing submarine geodesy. To reduce the cost of seafloor geodetic measurement and enhance the real-time capability of GNSS-A applications, the acoustic ranging observation corrections, which are implemented by a conventionally defined sound speed and MEDs to produce a priori acoustic delay corrections, need to be further developed, just like GNSS's tropospheric delay corrections. This is of significant importance for conducting submarine geodetic measurements without relying on in-field SSP measurements, especially utilizing unmanned platforms, as well as for future, promising real-time services of submarine geodesy.

Objectives

- To develop a ranging-based seafloor geodetic positioning theory and relevant models and algorithms compatible with the space geodetic positioning technique, e.g., GNSS;
- To contribute to developing future geodetic products and services for remoting ocean environmental changes, refer to a well-selected public global oceanic environmental grid dataset.

Program of Activities

- Working together with ocean physicists to establish a well-defined conventional sound speed serving as a reference for developing acoustic delay products based on one or more well-selected oceanic environmental grid datasets.
- Closely collaborating with the JWG M.1 "Data and tools exchange" to establish the data formats for the acoustic delay correction products and to create models and algorithms that process the oceanic environment re-analysis or forecast product to produce correction product data, which is then used to produce the acoustic delay corrections.
- Interacting with the JWG M.1, actively taking part in GNSS-A experimental trials with correction products, and then making the experimental results available to the public and posting them online.

Members

Shuqiang Xue (China); Chair
James Foster (Germany)
Erik Fredrickson (USA)
Pierre Sakic (France)

Surui Xie (USA)
Cheng Yang (China); contact to Commission 4
Shuang Zhao (China); contact to IERS

JWG M.6: How marine geodesy can better contribute to coastal hazards assessment and mitigation

Chair: Morelia Urlaub (Germany)
Vice-Chair: Lifeng Bao (China)
Affiliation: Commission 3

Terms of Reference

Seafloor deformation over long and short time scales can cause hazards to human life, marine ecosystems, and maritime activities. They can be subdivided into those that act on long time scales (e.g. sea level rise or ocean tidal changes) and those that act on short time scales (e.g. tsunami sources such as earthquakes and landslides or submarine volcanic activity). Monitoring is possible with remote sensing techniques from satellites and ships as well as with instrumentation on the ground (the seafloor).

Objectives

This group aims to explore how seafloor geodesy can help to better understand and detect hazardous seafloor movements. We aim to collate studies that characterise hazardous seafloor movements and to provide a platform for scientific and practical exchange for applications of seafloor geodesy to marine geohazards.

Program of Activities

We collate current publications. Regular meetings and attracting more members are the key activities for the upcoming period.

Members

Morelia Urlaub (Germany); Chair
Lifeng Bao (China); Vice-Chair

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