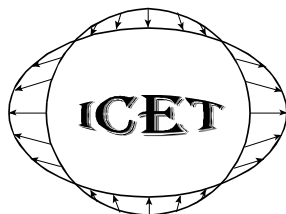


Centre International des Marées Terrestres
International Centre for Earth Tides



**SCIENTIFIC ACTIVITY REPORT
for the period 2000-2004**

by
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The staff of ICET, which is completely supported by the Royal Observatory of Belgium, our host Institution, is composed as follows:

Prof. B.Ducarme, Director(part time)
Mrs. L.Vandercoilden, technician(full time)
Mr. M.Hendrickx, technician(part time)

The Royal Observatory of Belgium is hosting ICET since 1958 and continues to provides numerous administrative and scientific facilities especially for the publication of the “ Bulletin d’Information des Marées Terrestres” (BIM), for the tidal data processing and, between 1997 and 2004, for the maintenance of the ICET/GGP data base.

1. Terms of reference

The terms of reference of the International Centre for Earth Tides(ICET) can be summarised as follows:

- as *World Data Centre C*, to collect all available measurements on Earth tides;
- to evaluate these data by convenient methods of analysis in order to reduce the very large amount of measurements to a limited number of parameters which should contain all the desired and needed geophysical information;
- to compare the data from different instruments and different stations distributed all over the world, evaluate their precision and accuracy from the point of view of internal errors as well as external errors;
- to help solving the basic problem of calibration by organising reference stations or realising calibration devices;
- to fill gaps in information and data;
- to build a data bank allowing immediate and easy comparison of earth tides parameters with different Earth models and other geodetic and geophysical parameters ;
- to ensure a broad diffusion of the results and information to all interested laboratories and individual scientists.

These goals are achieved essentially by the diffusion of information and software, the data processing, the training of young scientists and the welcome of visiting scientists.

2. Main Commitments

It appears first that most geodetic measurements are affected by earth tides, as at the centimetric level the tidal displacement of the station is no more negligible. It will thus remain an important task for ICET to provide algorithms for tidal computation or analysis. For example the geophysicists, such as seismologists or volcanologists, who are measuring crustal deformations for natural hazards monitoring, are now conscious of the necessity of dealing properly with the tidal signals. In a similar way absolute gravity measurements require accurate tidal corrections that should take into account the local tidal parameters. These parameters have to be computed including oceanic tidal loading effects or even require in situ tidal gravity observations.

On the other hand the earth tidal scientific community is limited. The last International Symposium on Earth Tides, held in Mizusawa, Japan from August 28 to September 1st, 2000, brought together only a bit more than one hundred and twenty participants. The groups are always very small and often marginally involved in tidal research. The papers dealing specifically with tidal studies are not fitting so well to international journals. It is thus very important to keep a specialised diffusion and information medium. It is the vocation of the "Bulletin d'Information des Marées Terrestres"(BIM). ICET is generally publishing two eighty pages issues per year.

Besides this basic activity, which is the scientific challenge for the beginning of this century?

The mathematical modelisation of the astronomical tidal forces as well as the elastic response of the Earth made decisive progress. It is now possible to model the astronomical tidal forces to within 5 nanogal in the time domain. The different mathematical techniques for the evaluation of the tidal response of the Earth do agree now to better than 0.1%. The most recent models include inelasticity in the mantle.

The last problems to be solved are linked to the fluid elements of our planet: liquid core resonance, oceanic loading, meteorological effects, underground water.

Among the ground based observations only gravity tides are able to give informations valid at the regional level. The other components (tilt, strain, volume change) are heavily depending of the local parameters of the crust, including cavity or topography effects. These observations should be mostly used to monitor tectonic deformations after removing the tidal phenomena.

Tidal gravity observations are able to provide constrains on the liquid core resonance by means of very precise observations in selected sites. The same is valid also for the selection of the most realistic model for the elastic or inelastic response of the Earth. For that purpose it is essential to improve the calibration methods in order to achieve a 0.1% accuracy in amplitude and a 0.01° accuracy in the phase determination. It is also necessary to use up to date oceanic tides models for tidal loading corrections. Recently it became possible to determine precisely the frequency of the NDFW and its Q factor using superconducting gravimeters data. The determination of the amplitude factor of the polar motion effect on gravity will constrain the Earth viscosity at low frequency.

To achieve these goals it will be necessary to tackle three main questions: oceanic tidal loading, atmospheric pressure effects, underground water. It is only possible through a coordinated effort and a multidisciplinary approach including Astronomy, Geodynamics, physical Oceanography, Hydrology and Climatology.

3. Ongoing project

These objectives are now directly addressed by the "Global Geodynamic Project"(GGP). A network of 20 stations equipped with cryogenic gravimeters is in operation

since July 1997, using a similar hardware and the same procedures for data acquisition. It is an unique opportunity to obtain high quality well calibrated tidal observations. It is a reason why ICET fully supported GGP activities since the beginning and considers GGP as an ICET "project". A first 6 years term finished in July 2003 (GGP-Phase 1) and a second term 2003-2007 (GGP-Phase 2) started immediately after.

Besides tidal research, an important objective of GGP is to study the residues after elimination of the tidal contribution in order to detect inertial accelerations such as free oscillations of the Earth core and mantle with periods larger than 50 minutes, which are difficult to observe by means of conventional seismometers. In fact the cryogenic gravimeters are extra-large band instruments covering phenomena with period ranging from one second to more than one year.

- During the Phase 1 of the project, ICET was responsible of the "Global Geodynamics Project-Information System and Data Centre" (GGP-ISDC, <http://etggp.oma.be/>), with the technical support of the Royal Observatory of Belgium. The software provided for the management of GGP-ISDC by the GeoForschungZentrum Potsdam was continuously updated.

The data owners can upload themselves the original minute sampled data. The data are carefully preprocessed at ICET using a standard procedure, to correct for tares and spikes. The data are then decimated to one hour and analysed. The analysis results are directly communicated to the data owners. This follow up is required to detect quickly the anomalies that could affect the data. Each year CD-ROM's are edited with the raw and corrected minute data as well as the log files and the auxiliary data, when available.

The data are only released according to a strict time table. The data are sent to ICET only one year after their production. During one additional year the data are only available to the GGP members and can be freely accessed only after two years. The second GGP observation period started immediately after the first one. This GGP Phase 2 is limited to a four years period starting July 1,2003.

- During Phase 2 the GGP groups producing data agree to send to ICET for access by other GGP groups their uncorrected 1-minute data within a 6 month period from the time of its collection and to release it for open access within a 1-year period. During Phase 2 the GGP data Centre is administrated jointly by ICET and the GFZ-Potsdam. An official agreement was signed between ICET and GFZ for that purpose. The data base is physically at GFZ but ICET will continue its task of data evaluation and analysis.

With the collaboration of guest scientists ICET pushed forward researches using the GGP data sets and concerning the liquid core resonance, the determination of the pole tide and the detection of the inner core oscillations known as Slichter's mode. We have now more than 20 high quality data sets with a minimum length of three year and we can provide on request not only tidal parameters, oceanic loading corrections according to different models but also tidal residues to study non tidal effects such as core modes. These series, if they are well constrained by absolute measurements, will be also useful in the interpretation of satellite gravity data.

4. Ongoing Activities

The "Bulletin d'Information des Marées Terrestres"(BIM) is printed in 300 copies. Some 275 copies are sent to libraries and individual scientists all over the world. It is devoted to scientific papers concerning tidal research. From May 2000 until the end of 2003, six issues n° 132 to 138 have been published with a total number of 770 pages. BIM139 is under

preparation. In 2002 we had the opportunity to publish the proceedings of the "Third Workshop of the Global Geodynamics Project (GGP) on superconducting Gravimetry" and of the "Meeting of the ETC-Working Group 7 on Analysis of Environmental Data", held in Jena, Germany, from March 11 to 15, 2002. For the first time all the published papers were immediately available on the ICET WEB site.

ICET made an agreement with Marion Wenzel, wife of late Prof. H.G. Wenzel, who inherited the property rights on the ETERNA tidal analysis and prediction software. ICET is now authorised to distribute freely this software among the scientific community for non commercial purposes. This initiative met a great success as some forty CD-ROMS with ETERNA software are requested from ICET each year since May 2000.

The ICET WEB site (<http://www.astro.oma.be/ICET/>) has been updated and developed. Besides general information including historical aspect and last ICET reports, it proposes to the visitors an access to:

- the general bibliography on Earth Tides from 1870-1997 either by alphabetical order of the first author or following the decimal classification introduced by Prof. P. Melchior;
- the table of content of all the previous BIM, n° 1-138, and starting from BIM 133 an electronic version of the papers;
- tidal analysis and preprocessing software available from different WEB sites or on request from ICET.

Most of the information requests (one per week minimum) concerned softwares. Most of them followed the consultation of the WEB site. This site is one of the most frequently consulted among the pages of the Royal Observatory of Belgium (ROB), which is the host agency.

According to the internal GGP rules ICET is preparing annually CD-ROM's, with the raw and processed minute data. We already edited CD-ROM's for the 5 first years, 1997/07 to 2002/06, of the project. We are now preparing the sixth year.

5. Visitors

ICET welcomed more than 25 visitors. Besides visitors coming only for a short stay we must consider also guest scientists and trainees.

The guest scientists bring their own know how or data to work at ICET during several weeks or even months. Some of them worked on the ICET and GGP data banks, as Dr. A. Kopaev (Sternberg Astronomical Institute, Moscow), Prof. H.P. Sun and his assistants (Institute of Geodesy and Geophysics, CAS, Wuhan, China), Prof. V. Timofeev (Institute of Geophysics, UIGGM, Novosibirsk, Russia) and Prof. A.P. Venedikov (Institute of Geophysics Sofia). Others brought their own data sets to perform tidal analyses using the ICET software and computing facilities, as Dr. E. Boyarski and Prof. L. Latynina (Institute of Physics of the Earth, RAS, Moscow), Prof. L. Brimich (Geophysical Institute, SAS, Bratislava Slovakia), Prof. Silvia S. Schwab ("Universidade Federal de Parana", Curitiba, Brazil), Dr. V. Timofeev (Institute of Geophysics, UIGGM, Novosibirsk, Russia). Mrs P. Beddows (School of Geographical Sciences, Bristol University, UK), Mr. M. Harrop (Open University, UK) and Mrs. E. Zapreeva (Institute of Geophysics, UIGGM, Novosibirsk, Russia) came to receive intensive training on earth tide data processing and analysis.

5. Schools

In the framework of the International Gravity Field Service (IGFS) recently created inside IAG, a summer course on "Terrestrial Gravity Data Acquisition Techniques" has been organised jointly by ICET and the "Bureau Gravimétrique International" (BGI), with the

support of IAG and FAGS. Some 45 students from 27 countries took part to this school that took place on the campus of the Catholic University of Louvain in Louvain-la-Neuve, Belgium from September 4 to 11. A CD-ROM with all the teaching material was published. The aim of this summer school was the training in *gravimetric techniques* of people involved in geodesy, geodynamics, geophysics or geology. At the end of the school, they were able to operate relative gravimeters and handle gravity data in order to realise gravity networks, densification surveys or microgravimetric studies. Special attention was paid to the tidal gravity corrections. There were three different types of activities: lectures, field practice and case studies. The case studies were talks given by specialists who are using the gravimetric techniques in Geodesy and Geophysics or for civil engineering applications.

The ICET Director took part to the "International Seminary on the Applications of the Computer Program VAV-03 for Tidal Data Processing" organised in Madrid from October 21 to 24 by the "Instituto de Astronomia y Geodesia" (CSIC-UCM). He presented two lectures. A CD-ROM will be edited and a manual of VAV method, including applications, will be printed in BIM139 with a CD-ROM attached.

6. Implementation of the new IAG structures

During the 23rd General Assembly of the IUGG, the new IAG structures have been implemented. As a member of the of the International Gravity Field Service (IGFS), ICET has a strong link to the new Commission 2 (Gravity Field), but it is also associated with Commission 3 (Geodynamics and Earth Rotation), to which the new Earth Tides Sub-commission is attached. In the new structure the Services will be represented at the level of the IAG Executive Committee. For ICET this representation will become effective through the IGFS.

A new Directing Board for ICET has been installed (Annex 1). Besides the ex-officio members, the other members have been elected during the last meeting of the former Earth Tides Commission

The Global Geodynamics Project (GGP) is now recognised as an Inter-commission Project between Commissions 1 and 3, reporting to Commission 3.

After the common organisation of the 2002 Summer School, ICET continued to tighten its links with the "Bureau Gravimétrique International" (BGI) in the framework of the "International Gravity Field Service (IGFS). The two services made a common bid for funding to the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) for the merging of their bibliographic data bases. This work is in progress.

7. Future Perspectives

Besides its usual activities for the diffusion of information, the training of young scientists, or the management of the GGP data bank, ICET wants to pay more attention to the development of its WEB site by putting on line the results of all the stations kept in our data bank.

ICET asked to the Earth Tides sub-commission to create a working Group on "Precise Tidal Prediction Methods" in order to be able to provide updated tidal prediction programs on its WEB site.

With an improved WEB site it will be possible also to convert partly the "Bulletin d'Information des Marées Terrestres" into an electronic journal. It will speed up the

publication of the papers, which are generally dedicated to ongoing researches, and reduce drastically the costs.

Following the creation inside IAG of the International Gravity Field Service (IGFS), ICET will deepen its cooperation with the other confederated bodies. ICET will continue its cooperation with BGI for the preparation of a CD-ROM with standard software for gravity measurements, including tidal gravity predictions and for the organisation of a second summer school on "Micro-gravimetric techniques: static and dynamics aspects".

Another possibility offered inside IGFS is to appoint "Fellows", who are individual scientists wishing to contribute to the Service activities. It will be possible to develop a network of contributors who can provide their expertise to ICET in answering to very specialised questions, developing new software and so on.

ANNEX 1

ICET DIRECTING BOARD

ICET Directing Board is composed as follows

Ex officio members

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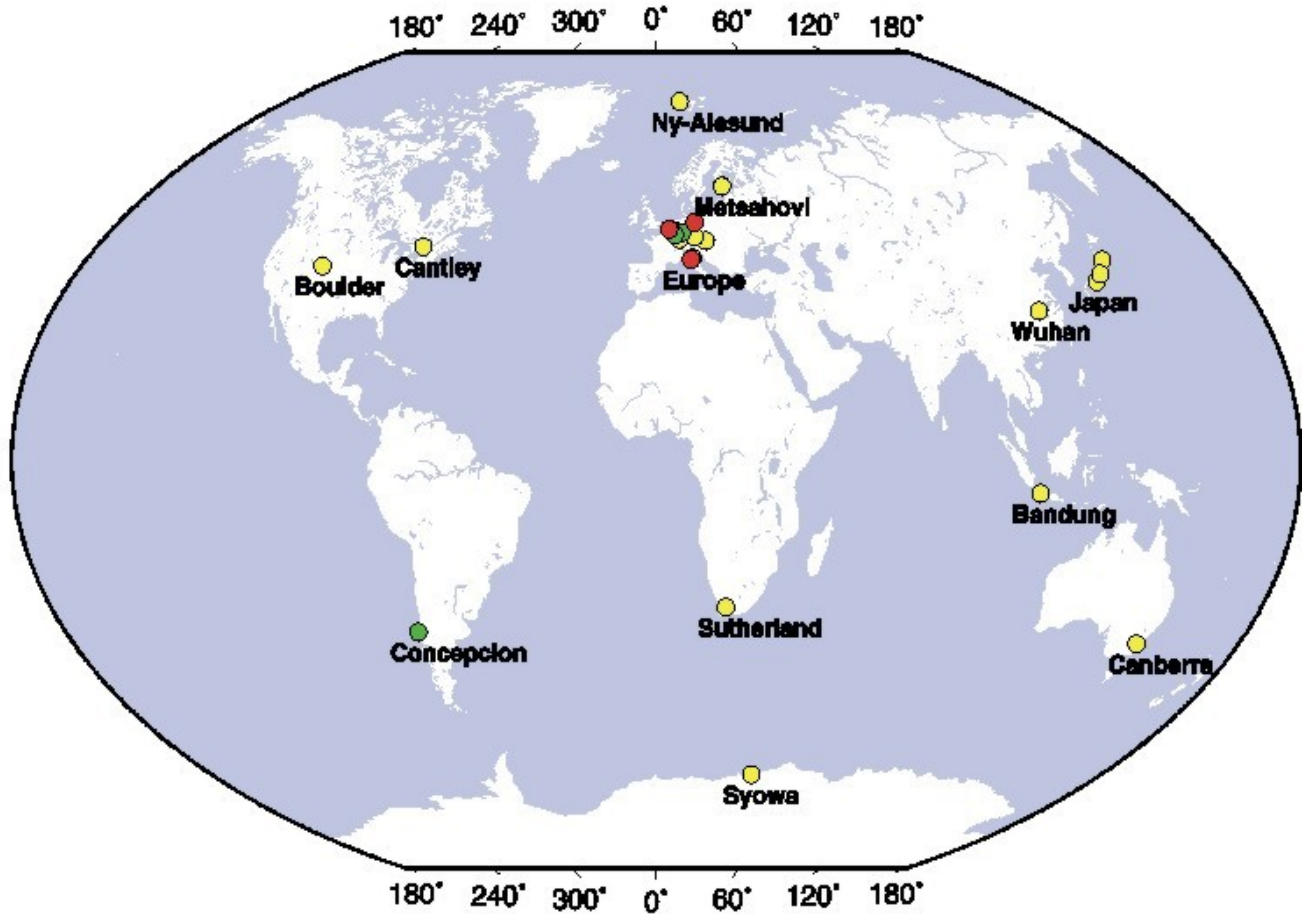
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GGP Stations 1997 - 2003



GMT 2003 Jan 31 10:20:44

Figure 1 : Network of stations equipped with superconducting gravimeters and contributing to the Global Geodynamics Project
Red dots: closed stations Brasimone (I), Brussels (B) and Potsdam (D)
Yellow dots: active stations
Europe Membach (B), Moxa (D), Strasbourg (F), Vienna (A) and Wettzell (D)
Japan Esashi, Kyoto and Matsushiro
Green dots: stations recently implemented Conception (Chile) and Walferdange (Luxembourg)