

Centre International des Marées Terrestres  
**International Centre for Earth Tides**



(ICET)

**Report to the  
 Earth Tides Commission  
 for the years 1997- 2000**

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

Prof. B.Ducarme, Director(part time)  
 Dr. O.Francis, Vice-Director(part time, until November 1998)  
 Mrs. L.Vandercoilden, technician(full time)  
 Mr. M.Hendrickx, technician(part time)

The Royal Observatory of Belgium is hosting ICET since its creation and continues to provides numerous administrative and scientific facilities especially for the publication of the “ Bulletin d’Information des Marées Terrestres” , for the tidal data processing and more recently for the maintenance of the ICET/GGP data bank.

## **Introduction**

This XIV<sup>th</sup> International Symposium on Earth Tides is a good opportunity to recall the challenges ICET has been facing since its creation more than 40 years ago and the new perspectives for the XXI century.

Earth Tide is affecting gravity and positions at the surface of the Earth at the  $10^{-7}$ - $10^{-8}$  level and requires a multidisciplinary approach including Astronomy, Geodesy, physics of the Earth interior, physical Oceanography, atmospheric sciences...

The tidal observations are providing information for the study of the Earth nutations as well as of the anelasticity in the mantle. Tidal prediction is required to correct gravity observations as well as precise positioning.

The beginning of concerted observations goes back to the International Geophysical Year. At that time one thought that it would be possible to determine the Love numbers from ground observations. It was indeed too optimistic due to the well known perturbing effects such as :

- the indirect effect of the oceanic tides that can reach 10% of the observed tidal phenomena;
- a coloured aperiodic geophysical noise mainly from atmospheric origin (more than 5%);
- the limited accuracy of the calibration of the instruments (typically 1%);
- site effects such as strain-tilt coupling.

It was thus necessary to work on all these problems in a concerted way and it was the task of ICET through:

- the dissemination of information by means of the "Bulletin d'Information des Marées Terrestres" (BIM);
- the constitution of data banks;
- a technical support to users including data reduction, analysis and interpretation, improvement of observation techniques (VM pendulum, calibration) and tidal prediction;
- its participation to coordinated observation campaigns such as Astro-Geo Project Spitsbergen (1969-70), Trans European tidal gravity Profiles(1971-1973) and finally Trans World tidal gravity Profiles(1973-1993).

The main goal of these observation campaigns was to check the validity of the oceanic tidal loading corrections (Schwiderski, 1979) and of the models for the Earth response to the tidal forces ( Molodenskii, 1965; Wahr, 1981).

Since 1990 there is a renewed interest from seismologist and volcanologist for continuous gravity, tilt and strain recording as part of a multiparameter approach. Monitoring of the tidal signal is requested to see if the transfer function is modified on one hand or to eliminate properly the tides in order to obtain clean records in search for aperiodic signals. For ICET it means a renewed pedagogic effort involving technical help for the calibration of instruments and the elimination of perturbing effects from the records as well as the organisation of training sessions for data preprocessing, analysis and interpretation.

The Brussels symposium in 1997 coincides with the opening of new perspectives in tidal research:

- The different models describing the Earth response to the tidal forces achieve an agreement at the level of a few parts in  $10^{-3}$ .
- Thanks to satellite altimetry, several new and more precise oceanic tides models are now available.
- Improved methods have been developed to correct the atmospheric attraction and loading effects.
- Efficient software for tidal data preprocessing are now available such as PRETERNA or T-soft and it becomes thus easy to work directly on minute sampled data.

Moreover the Global Geodynamics Project (GGP consortium) was launched in July 1997 for a 6 years time span. More than 15 superconducting gravimeters located all around the world (figure 1) are recording tidal gravity changes following standard procedures. Much attention is paid to the calibration as well in amplitude as in phase. The world-wide coverage will help to discriminate the global phenomena.

For ICET It was an unique opportunity to handle high quality tidal data that will help for example to

- improve the determination of the core resonance and compare the results with the models;
- recover global phenomena of very tiny amplitude ( $10^{-11}g$ );
- evaluate the quality of the new cotidal maps for tidal loading correction;
- determine the so called "pole tide" due to the polar motion.

ICET proposed thus to keep the GGP data bank and assist GGP as computing centre for data preprocessing and routine data analysis in order to check the quality of the stations (integrity monitoring). The main advantage is that a standard procedure is applied to the data. Moreover each year ICET is preparing a CD-ROM with the raw and preprocessed data.

### **Diffusion of Information**

From 1997 to 2000 eight issues of the "Bulletin d'Information des Marées Terrestres" (BIM) have been published, numbers 126 to 133. We wish to thank here Dr. Olivier Francis who acted as editor up to number 130. The ICET director resumed this task.

The ICET WEB site is continuously improved. It contains now:

- 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 published BIM and starting from BIM 133 an electronic version of the papers;
- tidal analysis and preprocessing softwares available from different WEB sites or on request from ICET.

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 softwares. 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 have been requested from ICET since May 2000. Other softwares such as Tsoft for tidal data processing and VEN98 for tidal data analysis are currently available from the WEB.

## Data processing

ICET is still receiving regularly earth tides data. *All data received are checked and recompiled.* Some Institutes are still sending clinometric and extensometric records but most of the activity is now devoted to gravity tides. Among the recently participating countries we should mention, besides GGP member countries : Belgium, China, Czech Republic, France, Germany, Hungary, Indonesia, Italy, Grand Duchy of Luxembourg, Poland, Russia and Spain.

Most of our computing activities are now connected to the GGP project. ICET is responsible of the "Global Geodynamics Project-Information System and Data Centre" (GGP-ISDC). The GGP original minute sampled data are carefully preprocessed at ICET using T-soft. The data are corrected for tares and spikes. The data are then decimated to one hour and analysed. This is the main task of Mrs.L.Vandercoilden. 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 sets and insure their homogeneity.

The archiving of the data is rather complex as 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 software provided for the gestion of this data bank by the GeoForschungZentrum Potsdam is fully operational since April 1999. The implementation of this software required to purchase new informatic equipments. Although he resigned his position in ICET, Dr. O. Francis from the Royal Observatory of Belgium agreed to supervise the installation of the software. The routine work is assumed by Mr. M.Hendrickx.

The one minute sampled raw data of each gravimeter represents 1.6 Mbytes per month. For fifteen operational stations we have thus 24 Mbytes per month or 300 Mbytes per year. It represents only one CD-ROM. We do also archive the preprocessed minute data ready for tidal analysis.

According to the internal GGP rules we produced already 4 CD-ROMS containing the raw(#1 and #2) and processed(#1a and #2a) minute data of the two first years, 97/07 to 99/07, of the project.

## New structures inside IAG

In the framework of the reorganisation of the IAG structures a proposal has been put forward by Prof. F.Sanso, director of the IGeS to create a confederation of the IAG Services dealing with the gravity vector i.e. the International Centre for Earth Tides(ICET), the International Gravimetric Bureau(IGB) and the International Geoid Service(IGeS). A first draft proposal was established during a meeting of the three directors in Milan on May 3. Other entities, such as new IAG Service dealing with Digital Terrain Modelling, could join this group. The official name of this new composite body will be International Gravity Field (IGFS).

As the statutes of the contributing entities are very different, some being FAGS member or WDC other not, each partner will keep his own governing bodies and structures. There will be an « Advisory board » organising the co-operation between Centres and their representation at IAG level. Individuals wishing to contribute actively to the IGFS may obtain the status of « Fellows » and will be represented inside the Advisory Board.

At the meeting of the Gravity and Geoid Commission in Banff(CDN) in August 2000 it was decided that IGB and IGeS will unite inside IGFS. At the meeting of ICET Directing Board during the 14<sup>th</sup> International Symposium on Earth Tides it was stressed that the advantages of IGFS for ICET are not evident, the most obvious one being a better representation at IAG level. The new structures seemed unduly complicated. Directing Board members insisted on the fact that in any case the publication of BIM should continue under its present form. Finally, after additional consultations, it was decided that the ICET director

was allowed to appreciate by himself the opportunity of joining IGFS.

## Visitors

### Year 1997

We welcomed as trainees Dr. J.J.Alonso del Rosario(Cadiz, Spain), Dr. U.Riccardi(Napoli, Italy), Mrs. S.H.Schwab(Curitiba, Brasil), Dr. T.Van Dam(Boulder, USA). Each participant brought his own data to process using the new preprocessing software T-SOFT.

Dr. H.P.Sun(Wuhan, China) was staying three months to work on superconducting gravimeters data and atmospheric pressure effects.

### Year 1998

Prof. A.P.Venedikov of the Geophysical Institute, Academy of Sciences of Bulgaria, stayed from February 9 to March 2. He developed a new version NSV98 of his tidal analysis program. He also worked on the long series of data of the superconducting gravimeter of Brussels.

Dr.V.Timofeev, Geophysical Institute, UIGGM, RAS (Siberian branch) at Novosibirsk, stayed from November 15 to December 5. He reanalysed the clinometric and extensometric data registered since 15 years at the Talaya underground laboratory near Baikal lake. He also worked on the transformation by electromagnetic feedback of the Russian made Gridniev horizontal pendulums.

Dr. Ph.Jousset, in postdoctoral stay in Japan, visited us on April 22-23 to prepare the publication in BIM of the gravimetric tidal records made on Mount Merapi in Indonesia.

Geophysicist Maria M.Caamaño, Observatorio Astronomico de la Plata, Argentina, came for training from April 27 to June 19. She worked on the tidal gravimetric data of Buenos Ayres in connexion with the swells in the Rio de la Plata estuary. She was trained in the use of the Tsoft for data processing and got informations concerning the oceanic tides along the coasts of Argentina.

### Year 1999

Dr. Mark Davis from the Open University, Great Britain came from May 17 to 20 to get training on tidal data preprocessing and analysis. He brought with him the tidal gravity observations registered on Mount Etna. His main goal is to get rid from tidal, pressure and other environmental effects in order to try to identify the effects of volcanic activity on the gravity residuals.

Dr. G. Casula was staying from May 27 to July 10. He brought his data of the Brasimone cryogenic gravimeter in order to practice with TSOFT and the new softwares of Prof. A.P. Venedikov.

Dr. H.P.Sun stayed at ROB from beginning of September to end of November. He treated the observations obtained at the GGP station Wuhan using the softwares developed at ROB(T-soft). He also prepared communications presented at ETS2000.

Dr. V.Timofeev stayed at ROB from October 20 to December 23, 1999.

During these two months at ROB we finished the analysis of the tidal data recorded at Talaya, (Baikal, Siberia) and at Ala-Archa/Bishkek (Kirghizstan). At Talaya we have now analysed ten years(1988-1998) of clinometric records in NS and EW direction as well as five extensometers.

### Year 2000

Dr. Alexander Kopaev from Sternberg Astronomical Observatory, Moscow University, stayed one month to work on the ICET data bank and prepare papers presented at the ETS2000.

Prof. David Crossley and Jacques Hinderer, respectively President and Secretary of the GGP consortium, visited ICET to discuss of the current status of the GGP data bank at ICET. They met Dr. Bernd Ritschel who is developing the GGP data base software.

Dr. Ernst Boyarski and Ludmila Latinina, from Institute of Physics of the Earth of Moscow will stay from September 22 to 29. They bring clinometric and extensometric data from stations Medevo/Almaty(Kazakstan) Protvino/Serpoukov(Russia).

