

IAG SECTION V: GEODYNAMICS

Report to the General Assembly, Budapest, 2001

1. Overview

Clark R. Wilson, President Section V

This document describes the activities of various commissions and services organized within IAG Section V. A description of these activities, including links to websites, is at the Section V website <http://www.astro.oma.be/IAG/index.html>. Sections of this report are therefore summaries of the more complete information to be found at the website.

2. Commision V: Earth Tides

Shuzo Takemoto, President

Program of Activities

The objective of the Commission is to promote international cooperation and coordination of investigations related to the observation, preprocessing, analysis and interpretation of earth tides. By earth tides, we understand all phenomena related to the variation of the Earth's gravity field and to the deformation of the Earth's body induced by the tide generating forces, i.e. the forces acting on the Earth due to differential gravitation of the celestial bodies as the Moon, the Sun and the nearby planets. The Commission makes standard software for the prediction of earth tide phenomena and for the processing of earth tide observations available to the scientific community by an Electronic Information Service, started in November 1st 1995. Note that the ftp information service is no longer available, because since May 1997, the Electronic Information Service of the Earth Tide Commission is directly accessible from the www home page. The Commission supports the activities of the International Center for Earth Tides (ICET) in collecting, analyzing and distributing earth tide observations. The ICET is considered as the executive office of the Earth Tide Commission. The Commission provides an Electronic Information Service with data and software files on its website.

International Symposium on Earth Tides

The 14th International Symposium on Earth Tides (ETC2000) was held in Mizusawa, Iwate, Japan from August 28th to September 1st, 2000. The Symposium sessions were: Tidal instrumentation; Results of ground based observations; Tidal observations using space techniques; Modeling of solid earth tides and related problems; Atmospheric and oceanic loading effects; Data processing; Superconducting gravimeters; Tidal studies in tectonic active regions; Tides on planet; Proceedings were published in the Journal of the Geodetic Society of Japan V. 47, No. 1, 2001.

The Earth Tide Commission Medal

The Earth Tide Commission normally awards the Earth Tide Commission Medal to a scientist for her/his outstanding contribution to international cooperation in earth tide research, on the occasion of the International Symposium on Earth Tides. At the opening session of the 13th International Symposium on Earth Tides on July 22nd, 1997, the Earth Tide Commission Medal was awarded for the first time to Baron Paul Melchior for his outstanding contribution to international cooperation in earth tide research. In May 2000, the ETC steering committee decided to award the ETC Medal 2000 to the late Prof. H.- G. Wenzel for his outstanding contribution to international cooperation in earth tide research. The ETC awarded the Medal to Ms Marion Wenzel at the Opening Session of ETS2000 on August 28 2000 at Mizusawa, Japan.

Working Groups:

Working Group 4: Calibration of Gravimeters (Michel Van Ruymbeke, Closed in 2000)

Working Group 5: Global Gravity Monitoring Network (Bernd Richter, Closed in 2000)

Working Group 6: Earth Tides in Geodetic Space Techniques (Harald Schuh / Wu Bin)

Working Group 7: Analysis of Environmental Data for the Interpretation of Gravity Measurements (Gerhard Jentzsch / Corinna Kroner)

Working Group 8: Gravitational Physics (Lalu Mansinha)

3. Commission XIV: Crustal Deformation

Suzanna Zerbini, Chairperson

The primary general objectives of the Commission XIV, Crustal Deformation, as confirmed by the Commission Bureau Meeting in San Fernando in September 2000, are: to study 3-D motions, in active tectonic regions, post-glacial rebound and sea-level fluctuations and changes in relation to vertical tectonics along many parts of the coastlines and in relation to environmental fluctuations/changes affecting the geodetic observations; to promote, develop and coordinate international programs related to observations, analysis and data interpretation for the three fields of investigation mentioned above; to promote the development of appropriate models. The structure of Commission XIV is entirely new because the Commission was created at the General Assembly in Birmingham. Details are at web site <http://www.df.unibo.it/commXIV/> Generally, Commission XIV coordinates the activities of the IAG related to crustal deformation, including the work through its regional commissions for Africa, North America, Central and South America and the Caribbean, Antarctica, Asia via APSG, Geodetic and Geodynamics programs of the Central European Initiative (CEI), and WEGENER.

Commission XIV held 4 meetings during this period: San Fernando, Spain, September 21, 2000, San Francisco, CA, U.S.A., December 17, 2000, Miami, FL., U.S.A., December 15, 2000, Nice, France, March 29, 2001. Reports for these are given on the Commission XIV website noted above. In addition, two upcoming meetings related to Commission activities are scheduled for May 14 in Shanghai (APSG), and the end of August 2001 (Helsinki, Finland)

4. Special Commission 3: Fundamental Parameters

Erwin Groten, Chairman

There are two fundamental aspects which affect the policies of SC-3 and will subsequently also affect IAG and IUGG: The first is the recently adopted IAU reference systems which are fully relativistic and are based on accuracy assumptions of the sub-microarcsecond range which implies that actions has to be taken by us. In Birmingham IAG was still hesitating. Consequently, the existing reference systems of IAG, such as the inconsistent WGS 84 (updated in 1997) and the GRS 80, no longer represent the present state of the art. The roles of ellipsoidal systems, as those by Somigliana-Pizzetti, have to be discussed in detail and their use and applications together with other reference frames, such as ITRF, ICRF etc., have to be clarified. SC-3 has delivered a variety of studies and investigations. The second aspect is the progress in measurement techniques and the feasibility studies on forthcoming high-precision gravity and other space projects, such as GRACE, GOCE, CHAMP, JASON, ENVISAT etc., give way to more detailed investigations of the gravity field and its regional and temporal variations as well as variations of the shape and structure of the earth. Substantial improvements of tidal and other time-dependent variations of the earth (solid, load and fluid models) justify deeper and far reaching studies of those space-time variations, also in view of the aforementioned relativistic aspects.

One particular aspect of those variations is global vertical changes which demand unified global vertical reference systems or frames. In the past, global tectonics and geodynamics were dominated by horizontal motion and movement. SC-3 has produced and published impressive and far reaching studies and results in this connection which are not yet incorporated into IAG products and standards. All significant global trends and well documented variations need to be incorporated in the associated reference models. Variability of earth's rotation, global sea level changes, variations in the ocean-ice-atmosphere budget as well as recent crustal movements are only a small part of global geodynamics where precise unified reference frames are now needed and where physical and dynamical aspects need to be incorporated in (partly) kinematic reference frames such as IGS, ITRF etc. Two recently discussed details are the incorporation of a unified vertical global datum in ITRF and the addition of physical and dynamical aspects to IGS. With almost three quarters of the earth's surface being of oceanic type, long periodic dynamics, such as El Nino, La Nina etc. besides shorter periodic and even shortest periodic (subdiurnal etc.) variations deserve more attention than in the past.

From the triaxiality of the earth, to core-mantle-boundary effects and earth's core dynamics SC-3 has substantially contributed to recent developments. The same holds true for surface phenomena. Recently, also critical reviews of the newly adopted IAU-systems in view of their consequences for geodesy were formulated by SC-3. It appears that IAG has not properly involved SC-3 in badly needed discussions on improved reference systems and consistent systems of fundamental constants and parameters in strictly relativistic frames and systems. Nevertheless, SC-3 is continuing its contributions to and studies of highly-precise reference frames and systems and related theoretical investigations. The titles of numerous studies and publications of SC-3 since 1999 can be found in the circular letters of SC-3 from

that time on. The most important contributions were presented at various meetings and appeared in international journals such as *J. of Geodesy*, *Studia Geophysica et Geodaetica* etc. The main contributions to the Somigliana-Pizzetti field originated from Prof. Grafarend and associates, the principal studies on unified vertical datums were published by Prof. Bursa and his group.

5. Special Commission 8: Sea Level and Ice Sheets

Michael Bevis, Chairman

IAG SC 8 has so far focused on continuous geodetic positioning of tide gauges. It led the formation of the CGPS@TG Working Group, which is a joint working group of IAG (SC 8), IAPSO, PSMSL, and the IGS, to provide a technical forum to discuss and disseminate technical standards, and to promote the transition from studying the problem to actual operational activity. The main vehicle for doing this is the CGPS@TG website http://www.soest.hawaii.edu/cgps_tg.

The CGPS@TG group also ran a one day Workshop at the Hawaii GLOSS GE7 meeting in Hawaii on 26 April, 2000. Here The IGS announced the imminent formation of a new pilot project, called TIGA, that will take on operational responsibility for collecting and processing CGPS data obtained at tide gauges.

6. Joint Working Group on Geodetic effects of non-tidal oceanic processes

Richard Gross, Chairman

The IAG/IAPSO Joint Working Group (JWG) on Geodetic Effects of Nontidal Oceanic Processes was formed at the XXII General Assembly of the IUGG held in Birmingham during July, 1999 for the purpose of: (1) promoting investigations of the effects of nontidal oceanic processes on the Earth's rotation, deformation, gravitational field, and geocenter; and (2) fostering interactions between the geodetic and oceanographic communities in order to gain greater understanding of these effects. In the two years since it was formed, three meetings-of-opportunity of the JWG have been held: (1) on December 15, 1999 in conjunction with the 1999 Fall Meeting of the AGU held in San Francisco, California; (2) on April 27, 2000 in conjunction with the XXV General Assembly of the EGS held in Nice, France; and (3) on March 29, 2001 in conjunction with the XXVI General Assembly of the EGS held in Nice, France. Summaries of the latter two meetings have been or will soon be published in the IAG Newsletter (*J. Geodesy*, 74, 500-501, 2000; *J. Geodesy*, 75, in press, 2001). In the last few years a number of exciting developments have occurred in the area of ocean / solid Earth interactions. As global ocean general circulation models continue to improve, and as ocean data assimilation systems are developed, even more progress can be expected to be made in this field in the future. In the last few years the effect of oceanic mass redistribution on the orbits of satellites have also been studied. The launch of CHAMP and the imminent launch of GRACE will enable even more detailed studies of the influence of the oceans on the Earth's gravitational field. Furthermore, CHAMP and GRACE will directly measure the mass term of the Earth rotation excitation functions (Gross 2001) as well as fluctuations in ocean-bottom pressure (Ponte 1999). Thus, the next few years should prove as exciting as

the last few years in studying the geodetic effects of nontidal oceanic processes. Reports from individual JWG members on their activities are given below.

Report from S. Dickman: Continued work on the dynamic barometer to include pressure forcing of the oceans by harmonics of higher degrees and orders. The goal is to produce a more accurate 'DB' correction for analysis of tidal signals in I.o.d., and the expansion should be useful for applications of greater interest to the JWG, relating to the removal of a barometric pressure-driven component from GRACE data. A master's student of mine has just begun investigating the correlations between atmospheric/oceanic processes and rapid polar motion. Our goal is to develop a more efficient and optimal correction to rotational data for the effects of AAM. The differences between such a correction and the traditional AAM subtraction has implications for oceanic excitation of polar motion.

Report from J. Nastula: Velocity and mass fields from a constant-density ocean model driven by observed surface wind stresses and atmospheric pressure were used to estimate the equatorial excitation functions for the ocean for the period 1993-1995. The results of this paper confirm findings that oceanic excitation when added to atmospheric excitation, leads to substantial improvements in the agreement with observed polar motion excitation at seasonal and intraseasonal periods. In addition the results point to the role of Oceanic Angular Momentum (OAM) signals in exciting polar motion at period between 5 and 10 days. The combined oceanic-atmospheric excitation does not explain, however, all the observed polar motion excitation, especially for c2. It is also clear that there is still a drop in coherence between geophysical and geodetic excitation series at about 8 or 9 days. The similarity in the OAM series calculated from the barotropic and full stratified ocean models indicates the relevance of barotropic dynamics to the treatment of the variable vertically integrated circulation and associated mass fluxes. The comparisons of geophysical and geodetic excitations at rapid time scales seem to favour an ocean with stronger friction.

To better understand the nature of the high frequency Atmospheric Angular Momentum (AAM) and OAM signals and to try to reduce the uncertainties in their estimated values, it is useful to analyse their regional variability characteristics and how different regions may contribute to the globally-integrated values. Regional analysis of AAM and OAM signals have been performed for monthly and longer periods and for periods shorter than 10 days (Nastula et al. 2000b) and have revealed the importance of specific areas for polar motion excitation. The results also confirm findings that oceans supplement the atmosphere as an important source of polar motion excitation. Regional characteristics of short period excitation are generally in agreement with those obtained from analyses performed for signals at monthly and longer periods. The AAM and OAM signals associated with pressure terms were found to be of the same order of magnitude while signals associated with winds were substantially larger than those associated with ocean currents. The strongest polar motion excitation due to variability of atmospheric pressure, oceanic pressure and wind terms is connected with areas over northern and southern midlatitudes. The spatial pattern of pressure + inverted barometer (IB) term is dominated, however, by maxima over land areas. Oceanic excitation due to currents is strong in the North Pacific and the Southern Oceans. For ocean current terms, maxima in variability and fractional covariances do not strictly coincide, indicating that

areas of large variability may not always contribute the most to the variability in the global excitation function.

Report from R. Ponte: In two papers, Ponte and Stammer successfully demonstrated the important ocean role on polar motion excitation at seasonal and Chandler periods, and confirmed the measurable but weak oceanic influence on LOD at seasonal and shorter timescales. Seasonal signals in OAM were traced to changes in the oceanic gyre and circumpolar circulation and mass fields. Positive impact of data assimilation on the estimation of OAM was examined by Ponte et al. (2001). Analysis by Ponte and Rosen of a newly available 40-year torque data set revealed strong atmospheric stress torques on the ocean and a truly three-way interaction among atmosphere, oceans, and solid Earth at seasonal periods. Short delays expected in the transfer to the solid Earth of the angular momentum exchanged with the atmosphere could not explain the observed phase lead of LOD over AAM at monthly and longer periods. Besides continuing to examine possible non-isostatic signals in the oceanic response to atmospheric pressure at high frequencies, other ongoing efforts have focused on extending the coverage and temporal resolution of existing OAM series.

7. International Earth Rotation Service

Jan Vondrak, Chairman of the Directing Board

During past years the International Earth Rotation Service (IERS) has undergone a fundamental re-organization that was led by its Directing Board under the efficient chairmanship of Chris Reigber (1995-2000). The re-organization of the IERS was initiated at the IERS Workshop, Paris 1996, that endorsed corresponding recommendations, and the discussions that followed at the next IERS Workshop at Potsdam, 1998, namely during the 'IERS Retreat'. Shortly afterwards, the new IERS Terms of Reference were formulated and endorsed in March 1999 by the IERS Directing Board; the document is available on the IERS web site (www.iers.org). The main 'driving force' of the proposed changes was the ever increasing complexity of the service since its establishment in 1988, and the efforts to make it less centralized and even more international, with tasks and responsibilities clearly defined and distributed among many institutions all over the world.

New IERS Terms of Reference define the following components of the new IERS: Technique Centers (TC) that are generally autonomous independent services, cooperating with the IERS. There is typically only one TC per technique, and it provides its operational products to the IERS. At the moment, these are the following: International VLBI Service (IVS); International GPS Service (IGS); International Laser Ranging Service (ILRS); International DORIS Service (IDS) that has not yet been formed, and the technique serves as a Pilot Experiment of the CSTG.

Product Centers (PC) that are responsible for the products of the IERS. They are as follows: Earth Orientation PC, responsible for monitoring longterm orientation parameters, publications for time dissemination and announcements of leap seconds. It is placed at Observatoire de Paris, under the leadership of Daniel Gambis. Rapid Service/Prediction PC, responsible for providing Earth orientation parameters on a rapid basis, primarily for realtime users. It is placed at U.S. Naval Observatory,

Washington D.C., and is headed by Jim Ray. Conventions PC is responsible for the maintenance of the IERS conventional models, constants and standards. Joint proposal of U.S. Naval Observatory (Washington D.C.) and Bureau International des Poids et Mesures (Sevres) was accepted, under the guidance of Dennis McCarthy and Gerard Petit, respectively. International Celestial Reference System PC, responsible for the maintenance of ICRS and its realization, ICRF. Joint proposal of Observatoire de Paris and U.S. Naval Observatory was accepted, both groups being represented by Jean Souchay and Ralph Gaume, respectively. IGN was designed to become the ITRS Product Center, with Claude Boucher as its representative, and both IGN and DGFI as ITRF Combination Centers. The IERS is open for additional ITRF Combination Centers. Global Geophysical Fluids PC, responsible for providing relevant geophysical data sets and related results. This center, having seven subcenters, was established only in 1998, and consequently no new Call for Participation was issued. It is headed by Ben Chao of GSFC.

Combination Research Centers that are responsible for the development of combinations from data (or products) coming from different techniques. They are expected to provide their solutions to Analysis Coordinator. There are ten of them (the names of leading scientists are given in brackets):

- AICAS & CTU, Prague (J. Vondrak);
- FGS & DGFI, Munich (D. Angermann);
- FGS & FESG, Munich (M. Rothacher);
- FGS & GIUB, Bonn (A. Nothnagel);
- GFZ, Potsdam (S.Y. Zhu);
- FFI, Kjeller (P.H. Andersen);
- GRGS, Toulouse (R. Biancale);
- IGN, Marne-la-Vallee (P. Sillard);
- JPL, Pasadena (R. Gross);
- IAA, St. Petersburg (Z. Malkin).

Analysis Coordinator that is responsible for long-term and internal consistency of the IERS reference frames and other products, for ensuring the appropriate combination of the TC products into a single set of official IERS products and for archiving them.

The designated Analysis Coordinator is Markus Rothacher but, because of his new position and teaching responsibilities at the Technical University Munich, he will be able to take over his new IERS office only in summer 2001. Therefore Tom Herring (MIT) was appointed as the interim Analysis Coordinator.

Central Bureau that is the administrative center of the IERS; it is responsible for the general management (according to the directives given by the Directing Board), for coordinating the activities, IERS publications, archiving the products and it also serves as its communication center with the users. It is placed at Bundesamt fuer Kartographie und Geodäsie in Frankfurt, under the direction of Bernd Richter.

Directing Board that exercises general control over the activities of the IERS; its chairperson (elected by the Board from its members) is the official representative of

the IERS to external organizations. It consists of two representatives of each of the Technique Centers, one for each of the Product Centers, one for all Combination Research Centers together, a representative of the Central Bureau, Analysis Coordinator, and representatives of the IAU, IAG/IUGG and FAGS. Most of the new IERS components were operational by the end of 2000, and the new IERS as a whole will be fully operational in summer 2001.

8. Permanent Service for Mean Sea Level (PSMSL)

Phil Woodworth, Director

Introduction

This year the Permanent Service for Mean Sea Level (PSMSL) has continued with its primary task of assembly of the global data set of sea level change information and its dissemination to the research community. It has also contributed strongly to the further development of the Global Sea Level Observing System (GLOSS), and has participated in important international conferences and working groups concerned with sea level and climate change. These and other activities are reviewed briefly in the following report. In the period since the last Annual Report (i.e. since mid-December 1999), almost 1300 station-years of data were entered into the PSMSL database which is approximately 400 more than in 1999. This is a creditable achievement, given the local difficulties referred to in last year's PSMSL Report, with the number of station-years this year similar to those obtained on average prior to 1999.

GLOSS

The Global Sea Level Observing System (GLOSS) is an Intergovernmental Oceanographic Commission (IOC) project, one of the aims of which is to improve the quality and quantity of data supplied to the PSMSL. GLOSS can be considered as one of the first components of the Global Ocean Observing System (GOOS). In brief, the status of the programme at the present time is near-identical to that one year ago. GLOSS can be considered approximately two-thirds operational, if one uses data receipts by the PSMSL as a guide to operational status, or somewhat better if one considers several factors discussed in detail in the PSMSL 1999 Report. However, these status summaries hide major problems in several regions, with expenditure in new tide gauge equipment in a number of countries, and the network improvements which result, balanced against the fact that many GLOSS stations in other countries are being terminated or require major upgrades. In addition, the investments made in gauges for international programs (notably WOCE) are unlikely to be repeated in future. Consequently, it is possible that GLOSS status, measured in terms of PSMSL receipts, may have reached a plateau. This pessimism is contradicted to some extent by the stated requirements for investment in regional networks of coastal tide gauges by, for example, the GOOS COOP (Coastal Oceans Observations Panel). Therefore, GLOSS status may receive a boost in the long term from 'coastal', rather than 'climate' or 'oceanographic', applications. The PSMSL maintains a list of reports relevant to the development of GLOSS

<http://www.pol.ac.uk/psmsl/training/gloss.pub.html> An updated version of the third

volume of the IOC Manuals and Guides No.14 on sea level measurement and interpretation has been completed and can be down-loaded from the PSMSL training web page: <http://www.pol.ac.uk/psmsl/training/training.html>

New WOCE Sea Level Data CD-ROM Version 2.0 of the WOCE Sea Level Data set is now available. In addition to the 'Fast-delivery' and 'Delayed-mode' WOCE sea level data sets, the CD-ROM contains tidal constants from the WOCE sea level data set, PSMSL monthly and annual mean sea level data set, and the GLOSS Station Handbook (Version 4.1). Copies are available from PSMSL, BODC or the University of Hawaii Sea Level Center. At the recent IOC International Oceanographic Data and Information Exchange (IODE) XVI Committee meeting several extensions to the Global Ocean Data Archaeology and Rescue (GODAR) project led by Mr. Syd Levitus (Ocean Climate Laboratory, WDC-A) were suggested. Dr. Lesley Rickards represented the PSMSL at this meeting and proposed a data archaeology project for historical sea level records with the aim of extending existing time series and gaining access to observations which are not in digital form. In many countries there are considerable amounts of historical sea level data in paper form such as charts or tabulations. These need to be computerised to provide electronic access, as backup for data security, and so that they can be subject to modern quality control and analysis. The original records would not be destroyed, as they may contain further information which is not captured by the computerised version (for example, charts digitised to hourly values might miss tsunami or seiche information) and also, in some cases, they are historic documents.

GLOUP

The PSMSL is responsible to the IAPSO Commission on Mean Sea Level and Tides for the maintenance of the database of pelagic (bottom pressure recorder) information. This data base, now called GLOUP (Global Undersea Pressures), was significantly enhanced during the year by Dr. Chris Hughes and can be inspected at: <http://www.pol.ac.uk/psmslh/gloup/gloup.html>.

Current holdings consist of 279 records at 149 sites, of which 62 are deeper than 200 m and longer than 25 days (20 longer than 300 days). Currently, all sites are in the Atlantic and Indian Ocean sectors, with none in the Pacific, and work is underway to acquire Pacific records. High frequency and daily data are available from the web site, as well as tidal analyses. The latter will be input to the IAPSO Pelagic Tidal Constants data set, which is also maintained by Dr. Hughes on behalf of the PSMSL and IAPSO.

9. BIPM Time Section

Felicitas Arias, Head

International time scales

Reference time scales International Atomic Time (TAI) and Universal Coordinated Time (UTC) have been computed regularly and have been published in the monthly Circular T. Definitive results for 1999 and 2000 have been available, in the form of

computer-readable files in the BIPM home-page and on printed volumes of the respective Annual Reports of the BIPM Time Section. Work is done to automate the calculation of TAI and UTC, this allowing a shorter delay in the publication of Circular T.

Algorithms for time scales

Research concerning time scale algorithms includes studies to improve the long-term stability of the free atomic time scale EAL and the accuracy of TAI. Studies are undertaken to evaluate the feasibility of providing a prediction of UTC in quasi-real time. Some 80 % of the clocks are now either commercial caesium clocks of the type HP5071A or active, auto-tuned active hydrogen masers, and together they contribute 86 % of the total weight with consequent improvement in the stability of EAL. Since most HP5071A clocks have at present the maximum relative weight, the weighting procedure of clocks in TAI is under revision. The medium-term stability of EAL, expressed in terms of the Allan deviation, is estimated to be 0.6×10^{-15} for averaging times of 20 to 40 days over the period. Nine primary frequency standards reported their measures to the BIPM. The global treatment of these individual measurements led to a relative departure of the duration of the TAI scale unit from the SI second on the geoid ranging, in the last year, from $+2 \times 10^{-15}$ to $+6 \times 10^{-15}$, with an uncertainty of 4×10^{-15} . Following the recommendations of the Consultative Committee on Time and Frequency, changes were implemented to render the data used in TAI, as well as the results, more accessible to the users and to make the procedures of calculation even more transparent and traceable. Since April 2000 two modifications were implemented: a new model to characterise the instability of the free atomic scale EAL, and a more complete representation of the uncertainty of the deviation of the TAI scale interval relative to that of the Terrestrial Time TT.

Time links

In the last decade the time links computed at the BIPM used the classical GPS common-view technique based on C/A-code measurements obtained from one-channel receivers. The commercial availability of newly developed receivers has stimulated interest in extending the classical common-view technique for use of multichannel dual-code dual-system (GPS and GLONASS) observations, with the aim of improving the accuracy of time transfer. The two-way time and frequency transfer via geostationary satellites (TWSTFT) has a performance comparable to that of GPS. Since July 1999 GPS multichannel links and TWSFTF links are being progressively introduced in TAI. Even if the calculation of TAI relies mostly on single channel GPS links, GPS multichannel and TWSTFT links are also included. Ionospheric parameters and precise ephemerides provided by the IGS (International GPS Service) are routinely used to correct all links in regular TAI calculations since May 2000. In addition, the BIPM Time section carries on research on new techniques of time transfer, such as the utilisation of geodetic type receivers. These activities are developed in the frame of the IGS/BIPM pilot project to study accurate time and frequency comparison using GPS phase and code measurements.

Space-time references

The BIPM/IAU Joint Committee on general relativity for space-time reference systems and metrology (JCR), created in 1997, continued its work. Two studies have been conducted at the BIPM in collaboration with other members of the JCR. One

concerns the extension of the relativistic framework to allow a correct treatment for time transformations and the realisation of barycentric coordinate time at the full post Newtonian level. The second study concerns the realisation of geocentric coordinate times. Following a Call for Participation of the IERS, the BIPM, jointly with the USNO, will provide its Conventions Product Centre since January 2001.

10. International Center for Earth Tides

B.Ducarme, Director

The staff of ICET, which is completely supported by the Royal Observatory of Belgium, 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” , for the tidal data processing and more recently for the maintenance of the ICET/GGP data base.

Ongoing activities

The tasks of the Centre are continuously updated and ICET decided : to become the computing centre and the data bank of the Global Geodynamics Project (GGP) which is a six years world wide campaign of tidal gravity observations using a network of more than 15 cryogenic gravimeters, to organise training sessions in tidal data preprocessing and analysis using up to date software and procedures, and to improve the diffusion of these software, to develop its web page www.astro.oma.be/ICET/

As the groups interested by tidal phenomena are always very small and often only marginally involved in tidal research and as the papers dealing specifically with tidal studies are not fitting so well to international journals, it is still 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 publishing two eighty-pages issues per year. Starting from BIM 133 an electronic version is available from ICET web site.

We receive regularly requests for information. The most common requests concerns tidal predictions or general information. We receive more or less one request per week. Since ICET is charged, thanks to Marion Wenzel courtesy, to distribute freely the ETERNA34 tidal analysis package we had to sent 40 copies of the CD-rom within the first year. ICET web site 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 the most recent issues of the BIM 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.

The 14th International Symposium on Earth Tides

ICET Director presented his report to the Earth Tides Commission (ETC) at the 14th International Symposium on Earth Tides (ETS2000) which took place at Mizusawa (Japan) from August 28 to September 1st. The ICET Directing Board met on August 29 under the chairmanship of Prof. S. Takemoto, ETC President. Unhappily several members were not present. Following the decease of Prof. H.G.Wenzel, it was decided to propose the cooptation of additional members i.e. Prof. R.Vieira Diaz from Spain and Dr. H. Schuh from Austria. The main subject of discussion was the proposal of creating a new confederated service inside IAG, discussed below.

Data processing

Several Institutes continue to send regularly earth tides data to ICET. All data received have been checked and recompiled. East European countries are still sending clinometric and extensometric records but most of the activity is now devoted to gravity tides. Most of our computing activities are now connected to the GGP project. According to the internal GGP rules we produced already the 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. The CD-ROM of the third year is due on July 2001.

Proposed 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 draft proposal was established during meetings of the three directors in Milan on May 3, 2000 and on March 22nd in Nice. Other entities could join this group. The proposed name of this new composite body is Gravity Field and Figure of the Earth Service (GFFS). 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 GFFS may obtain the status of « Fellows » and will be represented inside the Advisory Board. The Directing board of ICET agreed on the principle of joining GFFS. The same holds for IGB and IGeS. The IAG Executive Committee set up a provisory board to report at the General Assembly in Budapest. As a first action ICET was decided to organise jointly with IGB a summer school on gravity measurements and data processing, including the tidal signal.