GGP Newsletter #2 - 21 November 1996

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Prepared by David Crossley and Jacques Hinderer, November 1996.

Recent Meetings

(1) Bonn. There was a GGP report and discussion on Wednesday 18 September within the Working Group Meeting 'High Precision Tidal Data Processing', held at the Technical University of Bonn 16-19 September 1996. Those in attendance were: *Casula, Crossley, Ducarme, Francis, Hinderer, Hsu, Jentzsch, Kääriäinen, Meurers, Neumeyer, Richter, Van Camp, Virtanen and Wenzel*.

(2) Tokyo. There was a GGP meeting on Wednesday 2 October at 12:00-14:00 in B1001 Sanjo Hall, University of Tokyo, within the International Symposium on Gravity, Geoid and Marine Geodesy in Tokyo, 30 September - 4 October, 1996. The GGP meeting was organized by Takemoto, Imanishi and Crossley. Those in attendance were: *Crossley, Francis, Fukuda, Higashi, Hinderer, Hsu, Imanishi, Kaminuma, Makinen, Marson, Mukai, Nawa, Richter, Sato, Segawa, Shibuya, Takemoto, Tamura, Warburton and Wenzel*.

As a result of these two meetings, a number of proposals and recommendations were discussed. It was agreed that if no further communications or comments are received by either of the GGP officers (Crossley, Hinderer) before 15 December 1996, then the agreements and recommendations contained in this Newsletter would remain in effect until the Working Group Meeting on 21 July 1997 in Brussels (see below).

Review of Questionnaire

The Questionnaire circulated in the previous Newsletter attracted almost complete agreement between the groups on the proposed timetable for GGP and on the cooperation of the groups in providing data as stipulated. In answer to Question 1 (will you have one or more functioning SGs at the start of the Observing Period?), it appears clear that at least 15 instruments should be in operation on a quasi-permanent basis. Considering that the original GGP proposal hoped to be able to field a minimum of 6-8 instruments, the delay in implementation of the Observing Period has had the benefit of allowing an increased number of sites to be prepared.

Acceptance of Time Periods

All groups accepted that from now until 1 July 1997 would constitute the Pilot Study period. This enables groups to perform a number of important tasks that are essential for the successful operation of the project:

(a) installation and preparation of instruments, upgrades to equipment, modifications to the data acquisition systems (where appropriate).

(b) performance of calibration procedures for the instruments and data acquisition systems.

(c) practise in the exchange of data by electronic means and according to the agreed upon formats and conventions.

All groups accepted that 1 July 1997 would be the start of the Observing Period . This will run for a minimum of 6 years until 30 June 2003.

ICET as the GGP Data Centre

All groups accept ICET (International Centre for Earth Tides, Brussels) as the center for the archive, exchange and processing of GGP data. Through agreement with the Director (B. Ducarme) and Vice Director (O. Francis), ICET agrees to receive data according to the GGP standards. A letter (attached) to ICET further stipulates that ICET be consulted with respect to changes in GGP data and formats.

Station Review

A number of changes to the station configuration are indicated on the attached List of GGP Stations. Most important are the following:

(a) Strasbourg has acquired a new compact dewar.
(b) Richmond, Florida, has stopped operation.
(c) Fairbanks, Alaska, has stopped operation.
(d) The Chinese instrument in Wuhan will shortly be upgraded.
(e) We welcome the new site in Vienna, Austria under the direction of Bruno Meurers.
(f) Some discussion has taken place on assisting the site in Thessaloniki.
(g) New stations are to be established shortly in Bandung, Indonesia and Canberra, Australia, thanks to the efforts of our Japanese colleagues (Takemoto, Sato et al.)
(h) It is recognized that sites are needed in certain under-represented parts of the world. In particular, new SG sites in S. America, S. Africa and Central Asia would be extremely beneficial in improving global coverage.

The current list of stations is shown below:

Table 1. SG Station Locations

Code	Instrument	Location	Lat °N	Long °E	Height(m)	Status*
BA	GWR T008	Bandung, Indonesia	-6.89638	107.63167	714	N
BE	GWR T003	ROB Belgium	50.7986	4.3581	98	A
BO	GWR CO24	Boulder, USA	40.1308	254.7672	1682	A
BR	GWR T015	Brasimone, Italy	44.121	11.413	840	A
CA	GWR T012	Cantley, Canada	45.5850	284.1929	269	A
CB	GWR CO**	Canberra, Australia	-35.1	149.2	??	N
ES	GWR T007	Esashi, Japan	39.148	141.335	393	A
KY	GWR T009	Kyoto, Japan	35.03	135.786	57.6	A
MA	GWR T011	Matsushiro, Japan	36.543	138.207	405.9	A
MB	GWR CO21	Membach, Belgium	50.617	6.00	250	A
ME	GWR T020	Metsahovi, Finland	60.2172	24.3958	55.6	A
PO	GWR T018	Potsdam, FRG	52.3806	13.0682	81	A
ST	GWR C026	Strasbourg, France	48.6220	7.6840	180	A

SY	GWR T016	Syowa, Antarctica	-69.0	39.6	??	A
VI	GWR CO25	Vienna, Austria	48.2493	16.3579	192.44	A
TH	GWR T017	Thessaloniki, Greece	40.38	22.56		B
WE	GWR CO23	Wettzell, FRG	49.1458	12.8794	612	A
WU	GWR T004	Wuhan, China	30.53	114.30	??	A

*Status: A = GGP Site

B = Instrument not operational

C = New Station or new instrument to be installed for GGP

Test Format

The primary data to be exchanged is 1 minute gravity and pressure data in PRETERNA format. The file naming format currently proposed is given in Table 2. **All SG groups should examine this format immediately to see if it meets their needs, and if not, to suggest improvements** to Crossley and/or Hinderer.

Filename Convention

The following is an example of how to construct the filename for gravity and pressure data for the month of December, 1989 from the station in Cantley, Canada. The raw data at 1s sampling data are decimated to 1 min:

Table 2. GGP Filenames

Station	Year	Month	Repair Code		File Extension	Content
CA	89	12	00	.	ggp	gravity / pressure
CA	89	12	00	.	aux	auxiliary data
CA	89	12	00	.	log	log file
CA	89	12	00	.	zip	compressed version of all files

1. The latest version of the ZIP (formerly PKZIP) program should be used. Older versions cannot handle the newer zipped file formats.

2. If the auxiliary and log files are not available, the zip file will contain only the gravity and pressure data file.

3. SG Groups should experiment with the construction and sending of files according to the GGP Agreements.

Data Repair Codes

Table 3. GGP Data Repair Codes

(a) repair done on raw data, before decimation to 1 min

Code	significance
00	raw data, decimated but untreated
01	gaps and disturbances filled with synthetic signal
02	as 01 + offsets adjusted

(b) repair done on data after decimation to 1 min

Code	significance
11	gaps and disturbances filled with synthetic signal
12	as 11 + offsets adjusted

(c) One hour data, decimated from 1 min

Code	significance

h1	data processed by ICET
h2	data processed by user

Notes:

1. Gaps and disturbances are defined as loss of data, spikes, earthquakes, helium refills, calibrations and other interruptions to the data stream.

2. SG groups should send 00 files, as defined in Table 3, to ICET. The raw data provides useful information on the site conditions and state of health of the instrument and data acquisition system.

3. Additionally, all groups are strongly encouraged to send repaired data (either 02 or 12 files) processed according to local data repair experience and practise.

Example 1 min File

Each one month file should be in the form of a header, followed by time stamped data for each minute. Figure 1 shows the file structure that corresponds to the filename in Table 2. The header information in this file shows **the minimum** information necessary to process the data. Headers may be longer. This ASCII (.ggp) file takes 1.66 MB of disk space and 0.44 MB when compressed with ZIP.EXE.

```
Filename     : ca891200.ggp
Station      : Cantley, Canada
Instrument   : TT70 GWR 012
N Latitude   : 45.5850
E Longitude  : 284.1929
Height m     : 269
Gravity      : -63.94    microgal / V
Pressure     :  60.82105 millibar / V
Author       : Crossley (crossley@eas.slu.edu)
yyyymmdd hhmmss   gravity(V)  pressure(V)
C*********************************************
77777777 000000   0.0         0.0
19891201 000000   2.711686    2.984059
19891201 000100   2.680915    2.984405
19891201 000200   2.578493    2.984734
19891201 000300   2.730598    2.985076
19891201 000400   3.296396    2.985428
...
19891231 235500   2.814888    2.723250
19891231 235600   2.795676    2.722451
19891231 235700   2.790064    2.721816
19891231 235800   2.791065    2.721525
19891231 235900   2.790888    2.721012
99999999
```

Figure 1. Example 1 min Data File

Earthquake Data

SG groups have indicated willingness to make available raw data 1-2 weeks following selected large teleseismic events (moment magnitudes of order 7.5 or greater). A broadcast Email message to all groups will be sent by Hinderer (Strasbourg) indicating events whose data should be prepared for sending to ICET.

Earthquake Data Format

A suggestion for the file name convention is given in Table 4.

Table 4. Earthquake Data Filename

Station	Year	Month	Day		File Extension	Content
CA	93	07	12	.	10g	gravity at 10s sampling

CA	93	07	12	.	10p	pressure at 10s sampling
CA	93	07	12	.	zip	compressed version of all files

Example Earthquake Data File

An example file is given in Figure 2. This is 10 days of 10s gravity data following the magnitude 7.7 event under Hokkaido, Japan, beginning 12 July 1993. Note that to conserve disk space, each sample is not time stamped, rather the (UT) time of the initial sample is given, the number of samples and sampling interval. Missing values should be designated by 99.0. The end of file is designated by 99999999, as for the 1m files. This file take 1.02 MB in ASCII format and 0.36 MB when compressed using ZIP.EXE.

NB: Because ZIP files loose their DOS filename extensions, 1 min and earthquake data might be confused (or overwritten) in their zipped form if stored in the same directory.

```
Filename    : ca930712.10g
Station     : Cantley, Canada
Instrument  : TT70 GWR 012
N Latitude  : 45.5850
E Longitude : 284.1929
Height m    : 269
Gravity     : -63.94    microgal / V
yyyymmdd    : 19930712
hhmmss      : 000000
No. samples :  86400
Sampling    :  10.0sec
Data format : (6f12.7)
Author      : Crossley (crossley@eas.slu.edu)
C*************************************************************
  -0.5061047  -0.5031543  -0.5026706  -0.5043538  -0.5067025  -0.5064495
  -0.5051077  -0.5067879  -0.5092642  -0.5094902  -0.5084866  -0.5074243
  -0.5077556  -0.5106755  -0.5126884  -0.5121571  -0.5118811  -0.5125290
  -0.5137124  -0.5142505  -0.5136628  -0.5140121  -0.5152020  -0.5157181
  -0.5168655  -0.5182320  -0.5179317  -0.5183780  -0.5193126  -0.5182234
...
  -1.1738826  -1.1783767  -1.1807186  -1.1800373  -1.1815287  -1.1822327
  -1.1822515  -1.1831082  -1.1846977  -1.1876949  -1.1874323  -1.1868742
  -1.1903643  -1.1911156  -1.1906251  -1.1938142  -1.1950426  -1.1941563
  -1.1957331  -1.1975970  -1.2003344  -1.2015472  -1.2005579  -1.2032920
  -1.2045080  -1.2044385  -1.2066984  -1.2068674  -1.2073495  -1.2099165
99999999
```

Figure 2. Example Earthquake Data File

Recommended Earthquakes for Data Exchange

The following list of earthquakes should be used to select events that can be exchanged during the Pilot Study periods. The columns are date, time, latitude, longitude, depth and magnitude (l for local, s for surface wave). Courtesy of the IRIS WWW Site.

```
1990/06/20 21:00:09.9  36.957N   49.409E  19.0 7.7Ms  MHDF WESTERN IRAN
1990/07/16 07:26:34.6  15.679N  121.172E  25.0 7.8Ms  MHDF LUZON, PHILIPPINE ISLANDS
1993/07/12 13:17:11.9  42.851N  139.197E  17.0 7.7Ml  MHDF HOKKAIDO, JAPAN  REGION
1993/08/08 08:34:24.9  12.982N  144.801E  59.0 8.0Ms  MHDF SOUTH OF MARIANA ISLANDS
1994/06/02 18:17:34.0  10.477S  112.835E  18.0 7.8Ml  MHDF SOUTH OF JAWA, INDONESIA
1994/06/09 00:33:16.2  13.841S   67.553W 631.0 8.2Ml  MHDF NORTHERN BOLIVIA
1994/10/04 13:22:55.8  43.773N  147.321E  14.0 8.3Ml  MHDF KURIL ISLANDS
1994/12/28 12:19:23.0  40.525N  143.419E  27.0 7.8Ml  MHDF EAST COAST OF HONSHU, JP
1995/04/07 22:06:56.8  15.199S  173.529W  21.0 8.0Ms  MHDF TONGA ISLANDS
1995/05/16 20:12:44.2  23.008S  169.900E  20.0 7.7Ms  MHDF LOYALTY ISLANDS REGION
1995/08/16 10:27:28.6   5.799S  154.178E  30.0 7.8Ms  MHDF SOLOMON ISLANDS
1995/12/03 18:01:08.9  44.663N  149.300E  33.0 7.9Ms  MHDF KURIL ISLANDS
1996/01/01 08:05:11.9   0.724N  119.981E  33.0 7.8Ml  WHDF MINAHASSA PENINSULA, SULAW
1996/02/17 05:59:29.7   0.950S  137.027E  33.0 8.1Ms  WHDF IRIAN JAYA REGION, INDON
1996/06/17 11:22:18.5   7.137S  122.589E 587.0 7.8Ml  WHDF FLORES SEA
```

SG Calibration

Methods

There are several methods to calibrate a superconducting gravimeter:

- the inertial method based on the generation of artificial accelerations from an oscillating platform; this technique was developed for SG calibration by IFAG (Richter 1995; Richter et al., 1995) and was shown to be able to provide calibration accuracy better than 0.1% ;

- the gravitational method based on the Newtonian attraction of a known distribution of masses (e.g. ring torus); this method was developed by the Physics Department of the University of Bologna and the precision is close to 0.3% (Achilli et al., 1995);

- the comparison with absolute gravity measurements made in parallel at the same site for a period of some days; different SG groups are using this technique and the accuracy ranges from values slightly better than 1% for the older JILAG type instruments (Hinderer et al. 1991; Hinderer et al. 1995) to 0.1% for the new FG-5 instruments (Francis 1996).

In addition there are calibration methods using parallel registration with other 'calibrated' relative spring meters, vertical or horizontal gravity gradients (calibration lines) or electrostatic or electromagnetic forces (this last one is merely for the check of the stability in time of the calibration factor).

It is strongly recommended that every SG station which will take part of the GGP does a calibration experiment before the official starting time of July 1, 1997 using one of the 3 previous techniques and, in any case, leading to a calibration accuracy at least better than 1% which is needed in any attempt of geophysical interpretation of tidal results in terms of mantle inelasticity (e.g. Dehant & Zschau 1989), ocean loading (e.g. Francis & Melchior 1996, Llubes & Mazzega 1996) or other phenomena (Rydelek et al. 1991; Melchior 1995).

Instrument Phase Lag

The phase lag of the recording system of the SG (gravimeter sensor + feedback + analogue anti-aliasing filter) should be verified experimentally. Again, every group should check the phase lag of its system before July 1, 1997 and it is suggested to use the so-called 'step response method' (Richter & Wenzel 1991; Wenzel 1995) which consists in applying through a parallel adder a specific step as in put and to measure the response of the system as output function. The Fourier transform of this response function leads then to the frequency-dependent transfer function as well as to the phase lag of the system. The accuracy resulting from the phase lag determination with the help of this method is smaller than 10^{-4} degree for the semi-diurnal wave M_2 . This is much smaller than what is needed to study phase lags due to anelasticity in the mantle (e.g. Dehant & Zschau 1989).

Loading Parameters

Ocean Loading

ICET has agreed to provide ocean loading parameters for all the stations of the GGP network. This will be done for a selection of the most recent and widely available ocean loading models and for the major tidal waves only. The parameters will not be time dependent, but new sets of parameters will be calculated as new ocean tide models are introduced by the community.

More accurate regional ocean load models will be necessary for some GGP stations and these should be computed by the appropriate groups and individuals.

Atmospheric Loading

There is no provision at present for global atmospheric pressure data through ICET or any other data center. In future it may be possible to provide global pressure data for the GGP Observing Period. This possibility is being considered at Saint Louis University which already has direct access to global surface pressure data though NCAR.

In order to provide a standard processing of the 1 minute data, ICET will use the ETERNA tidal processing package with a single scalar admittance between the atmospheric pressure and gravity at the observing station.

GWR Anti-Aliasing Filter

Agreement was reached on the form of the anti-aliasing filter for high rate sampling. GWR Instruments has agreed to provide a replacement tide filter board containing the following items:

(1) A modified tide output filter, according to agreed-upon specifications (see below).

(2) An adder input for injecting a step response for calibration checks (see Calibration).

(3) Passive components with reduced temperature sensitivity, especially important for installations where the electronics units are not in thermally controlled environments.

It is highly recommended that SG groups consider the benefit of this upgrade before the start of GGP. The cost is projected to be under $2K US.

Filter Design

The analog filter should incorporate the following design elements:

(1) For a sampling interval of either 1s or 2s, the Nyquist frequency should be 0.25Hz.

(2) Simple (i.e. as few elements) as possible, to avoid an unpleasant impulse response.

(3) Flat (± 1%) from 0 frequency to a minimum of 0.02Hz (50s period). If possible this should be extended to higher frequencies such as 0.04Hz (25s period).

(4) Amplitude roll-off of 100 dB between the corner frequency and the Nyquist frequency.

(5) Phase Shift < 0.05 deg / cpd. Linear with frequency f.

GWR is currently designing a compromise filter, possibly a 4-pole or 6-pole standard Butterworth design.

Workshops

It is considered essential that GGP participants meet on a yearly basis to discuss the technical aspects of the instrumentation, data acquisition and methods of interpretation for all aspects of high precision gravimetry. The format for these Workshops should be detailed technical exchanges, conducted informally, perhaps stimulated by a small number of seed presentations to initiate discussion.

A GGP Workshop is not intended to duplicate the format of a conference or even an IAG Working Group Meeting. Therefore Workshops should be held in conjunction with major international conferences at which GGP members could submit a formal presentation and receive travel assistance.

The First GGP Workshop is Scheduled for **Monday, 21 July 1997 in Brussels**, just prior to the International Symposium on Earth Tides. Details of this Workshop will be discussed with ICET and information will be distributed early in the new year by the GGP Secretariat.

At each Workshop the location of the next Workshop, the following year, will be agreed upon. Future International Conferences that might be suitable are: 1998 either Tours (SEDI) or Trieste (IGC); 1999 Birmingham (IUGG); 2000 ?; 2001 ? (Earth Tides Symposium); 2002 ?; 2003 ? (IUGG).

WWW Home Pages

An administrative Home Page for GGP has been started at Saint Louis University (http://www.eas.slu.edu/). It will be updated to include a Bulletin Board and to set up links to ICET and to other Home Pages. Each SG group is encouraged to set up its own Home Page, describing the site, instrument and other pertinent information.

As part of the GGP Home Page, a list of GGP publications has been initiated. SG Groups are asked to check these and to contribute publications that may have been omitted.

Publicity

We agree there should be an article on GGP for one of the June issues of EOS, just prior to the start of the Observing Period. At the same time a Special Issue of BIM will commemorate the launch of GGP.

Relations with IAG

There has been some dialogue between GGP and representative of IAG concerning future relations both with IAG and with the new Working Group on Intercomparison between SG and Absolute Gravimeters (G-Gramophone).

Inasmuch as GGP began life as part of SEDI, an inter-union project of IUGG, GGP does not formally belong to any one section of IUGG. Nonetheless, the connections with IAG tend to dominate GGP due to the inclusion of the tidal community within GGP.

The goals of GGP and G-Gramophone are mutually supportive, since GGP embraces all time scales of relative gravity, including long term variations where absolute gravity measurements are essential as an intercomparison. Further, absolute gravimeters are widely used as a calibration device for SGs, so that absolute gravimetry is integral to GGP.

For the moment, GGP members are content with the status quo, i.e. no formal ties to IAG, though GGP is grateful to IAG for supporting the goals of the project. It remains to be seen if this situation continues or whether there may emerge some benefits for GGP to establish closer links to IAG, e.g. as a Special Interest Group.

Mailing List

A master email address ggpmail@eas.slu.edu has been created for GGP including all those on the Mailing List with email addresses. All members of the list may send mail to the list.

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