



## GGP Newsletter #4 - 20 June 1997

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Prepared by David Crossley, June, 1997.

### GGP Observing Period About to Begin

The official start of GGP is only days away. This is the real thing; no more delays, no more extensions. All SG groups will be receiving a short questionnaire on the state of health of their installation, which you should return. A summary status report will be placed on the GGP Home Page and updated regularly.

It is now too late to do any major overhaul of installations before July 1, but upgrades to the data acquisition systems and other improvements should still be planned, even though they will downgrade the quality of the data. Data interruptions of more than a day or two should be avoided wherever possible.

### Calibration of the Electronics

One item that should be considered even now is to determine the phase delay of your electronics. This parameter has been under emphasised in some of the GGP discussions, but, together with the absolute calibration of the instrument, remains an extremely important measurement to be made.

The preferred method, as we have recommended in the past, is using the step response, or equivalent harmonic response, of the system, as described in Richter & Wenzel (1991) and Wenzel (1995). Failing that, beg, borrow or steal a good quality spectrum analyzer and do check of the electronics before July 1.

Some of the implications of this measurement are outlined below.

Richter, B., & Wenzel, H.G., 1991. Precise instrumental phase lag determination by the step response method, Bull. Inf. Marées Terrestres, **111**, 8032-8052.

Wenzel, H.G., 1995. Accurate instrumental phase lag determination for feedback gravimeters, in Proc. 12th Int. Symp. Earth Tides, ed. H.T. Hsu, Science Press, Beijing, New-York, 191-198.

### Phase Response & Group Delay

The overall amplitude gain of the electronic analog anti-aliasing filter should be unity for most of the installations, up to the corner frequency. The phase response will depend on the configuration of the filter; for most installations the assumption of a linear phase response is made. In the new GGP tide filter boards, an 8-pole Bessel filter is used. Bessel filters have the desirable quality of linearity in their phase response (at least theoretically). This means the phase after the anti-aliasing filter is given by

$$f(w) = -aw \quad (1)$$

where  $a$  is a constant. Usually  $f$  is measured in degrees and  $w$  in cycles per day. This condition is only an assumption and may not be true of your system. In any case, one has to know  $f(w)$  accurately in order to do high quality data analysis (particularly when involving the ocean tide loading) which is the hallmark of the GGP network.

Once  $f(w)$  is known, it is simple to find the group delay of the filter (thanks to my seismological friends at Saint Louis University for a reference to this):

$$t = -df/dw \quad (2)$$

Usually,  $t$  is measured in seconds. Obviously, for a **linear phase filter**, one can combine (1) and (2) to arrive at the relation

$$t = 240 a = \text{constant} \quad (3)$$

provided  $t$  is measured in sec and  $a$  is in *degrees / cycle per day*.

So as examples:

Instrument	a deg/cpd	t sec
GWR IDA tidal filter	0.1500	36.00
GWR new board (1 sec sampling)	0.0350	8.40
GWR new board (2 sec sampling)	0.6500	156.00
Cantley T012 (1990-1993)	0.0060	1.44
Boulder CO24	0.1250	30.00

### Accuracy

The target timing accuracy for GGP data is  $\pm 10$  ms, thus we must know  $t$  to an accuracy of  $\pm 0.01$  s. This is stringent and requires careful measurement. As discussed in the last Newsletter, this accuracy can be achieved by the step response method. Note that other delays in the instrument and electronics must also be included.

It is worth emphasizing that this time delay **cannot be obtained by a comparison with a theoretical tide model**, because of the uncertainty in factors such as the ocean tidal loading. Such a situation pertains to the absolute calibration of the instrument, **which also cannot be obtained using a theoretical tide model**. Obviously the tidal model can be used as a gross check of the correctness of the calibration and phase delay, but it is useless at the level of the desired GGP accuracy.

### Theoretical Tides

Note that the Group Delay must be considered in any computer program you use to estimate the theoretical tides at a station. In tidal fitting programs such as ETERNA, this parameter is specified on input as DTLAG (assuming a linear phase condition).

The only exception is when you use local delta factors to synthesize the tides at a station. In this case one possibility is to analyze several years of data at station with a program that does not use the group delay (e.g. ETERNA with DTLAG = 0.0) so the fitted (d,k) factors contain an adjustment for the group delay (as well as ocean loading of course). Then a synthetic tide based on these local delta factors will automatically include the correct time delay for the station, and this synthetic tide might then be used to fill gaps or to be subtracted from the observed data.

### Modified GGP Headers

In order to accommodate the phase shift / group delay into the GGP data processing, we suggest it should be added to the GGP header files, in a way that makes it machine readable. To avoid confusion, the result should be quoted as **deg / cycle per day**, rather than the group delay. Following the suggestion in the previous Newsletter, the GGP header should now be as follows:

Line	Text (a20)	Parameter 1	Parameter 2
Line 1:	Filename	[name of file] (a20)	
Line 2:	Station	[name of station] (a20)	
Line 3:	Instrument	[name of instrument] (a20)	
Line 4:	Phase Lag (deg/cpd)	[phase lag] (f10.5)	[error] (f10.5)
Line 5:	N. Latitude (deg)	[latitude] (f10.5)	[error] (f10.5)
Line 6:	E. Longitude (deg)	[longitude] (f10.5)	[error] (f10.5)
Line 7:	Height (m)	[height] (f10.5)	[error] (f10.5)
Line 8:	Gravity Cal (ugal/v)	[g calibration] (f10.5)	[error] (f10.5)

Line 9:	Pressure Cal (mbar/v)	[p calibration] (f10.5)	[error] (f10.5)
Line10:	Author	[email address of author] (a40)	
Lines 11	<i>other information</i>		
C****	<i>end of header</i>		

The readable parameters, either 1 or 2 per line, now all begin in column 21 of lines 1-9. Other information on lines 11 ..., will be for supplemental use only.

Below we show the new recommended header for a CSGI data file:

```

Filename          ca891100.ggp
Station           Cantley, Canada
Instrument         TT70 GWR 012
Phase Lag (deg/cpd) 0.00640 0.00010
N Latitude (deg)   45.58500 0.00010
E Longitude (deg)  284.19290 0.00010
Height (m)        269.00000 1.00000
Gravity Cal (ugal/v) -63.94000 0.01000
Pressure Cal (mbar/v) 60.82105 0.00005
Author            (crossley@eas.slu.edu)
yyyyymmdd hhmmss gravity(V) pressure(V)
C*****
77777777 000000 0.0 0.0
19891107 000000 3.006837 2.986827
...

```

## Update on Earthquake Data

The original list of candidate earthquakes for SG groups to practice with is now supplemented by the following recent events:

```

1996/08/02 12:55:29.3 10.769S 161.445E 33.0 7.1Ms WHDF SOLOMON ISLANDS
1996/08/05 22:38:22.0 20.690S 178.310W 550.0 7.3M1 WHDF FIJI ISLANDS REGION
1996/09/05 08:14:14.4 22.118S 113.436W 10.0 7.0Ms WHDF EASTER ISLAND REGION
1996/11/12 16:59:44.0 14.993S 75.675W 33.0 7.7M1 WHDF NEAR COAST OF PERU
1996/11/19 10:44:46.0 35.345N 78.133E 33.0 7.1Ms WHDF EASTERN KASHMIR
1997/01/11 20:28:26.0 18.219N 102.756W 33.0 7.0M1 WHDF MICHOACAN, MEXICO
1997/01/23 02:15:22.9 21.999S 65.719W 276.0 7.1M1 WHDF SOUTHERN BOLIVIA
1997/02/27 21:08:02.3 29.976N 68.208E 33.0 7.3Ms WHDF PAKISTAN
1997/04/21 12:02:26.4 12.584S 166.676E 33.0 7.9Ms WHDF SANTA CRUZ ISLANDS
1997/05/01 11:37:36.1 18.993N 107.350W 33.0 7.1M1 WHDF COAST OF JALISCO, MEXICO
1997/05/10 07:57:29.7 33.825N 59.809E 10.0 7.3Ms WHDF NORTHERN IRAN
1997/05/25 23:22:33.7 31.984S 179.695E 333.0 7.1Mw QED KERMADEC ISLANDS REGION

```

ICET's directory where earthquake data may be sent and saved is:

```

address:  ftpserver.oma.be
login:    anonymous
password: your email address
directory: /pub/astro/ggp/bigquakes

```

## GGP Workshop

Many thanks in advance to Olivier Francis and the Staff of the Observatoire Royal de Belgique for organizing the GGP Workshop. By now everyone should have received the program by email. For planning purposes, and as a courtesy to the ICET organizers, **It is essential that you register for the Workshop in advance; don't just turn up on the day!**

Please note the following:

(1) If you are scheduled to lead a discussion, please notify either Jacques Hinderer or myself in the event you will be **unable** to make the presentation or attend the GGP Workshop.

(2) The title of the presentation by T. Sato has been changed to ``GGP-Japan Network".

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### **New GWR Filter Board**

The board should be available by the time you receive this Newsletter. Please contact GWR immediately to receive shipment.

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