

CG6TOOL User's manual (vers. 2022.12)



Interactive computer program to process Scintrex CG3/CG5/CG6 gravity data

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CONTEXT

CG6TOOL is an interactive computer program to process Scintrex CG3/CG5/CG6 gravity data. The program is based on an interactive user JAVA interface and uses GMT (Generic Mapping Tools) facilities. CG6TOOL is an updated and extended version of the CG3TOOL software initially developed in 1996 by the authors for processing Scintrex CG3 gravity data. The aim of CG3TOOL was to allow for an objective evaluation of data and to provide a higher resolution in data reduction. The main functions included the reduction of daily data files by applying standard or accurate corrections (earth-tide, free-air gradient, and instrumental drift). The interactive procedures and the program output have been designed to ease data handling and as well as to provide useful information for further purposes of data interpretation or modeling. As CG3TOOL was only running on Unix Sun workstations, the authors started in 2014 the development of a new version (CG5TOOL) based on Eclipse platform. Later, the following updates have been done :

- 2019 : With the release of CG6 instruments and new formats, CG5TOOL become CG6TOOL
- 2020 : The new version of CG6TOOL run under Windows NT OS (but only with gmt6)
- 2021 : New graphics formats are available (jpg, png and pdf) but only with gmt6 version
- 2022 : File names no longer have to respect a particular coding, and observations files can concern a circuit over several consecutive days. Alphanumeric station names are accepted. Possibility to process profiles that do not loop (e.g. between two bases with known values).

Citation : G. Gabalda and S. Bonvalot (2022). CG6TOOL: An interactive computer program to process Scintrex CG6 gravity data. Bureau Gravimetrique International. BGI Software. DOI :XXX

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Original paper : Gabalda, G., Bonvalot, S., Hipkin, R., 2003. Interactive computer program to process Scintrex CG-3/3M gravity data for high resolution applications. Computers & Geosciences, 29, 2, pp. 155–171. <u>https://doi.org/10.1016/S0098-3004(02)00114-0</u>

DISCLAIMER OF WARRANTY

CG6TOOL is provides "AS IS", with no warranty. The authors and their belonging institutions assume no responsibility. CG6TOOL is provided as free software to the scientific community and you are no allowed to distribute CG6TOOL without the permission of the authors.

PREREQUISITES

In order to use CG6TOOL, it is necessary to install **Java**, **GMT** (the graphical and mathematical "Generic Mapping Tool" free library, available from the web), and initialize environment variables:

- **CG6TOOL**: Java Archive file and CG6TOOL script must be installed into \$CG6TOOL. Don't forget to set your **PATH** to include \$CG6TOOL.
- CG6VIEWER: A Postscript viewer. Only gv or gs (Ghostscript) have been tested. This variable isn't used with GMT6
- CG6READER: To read the *pdf* files (evince by default). Not used on Windows NT
- **GMT_VERSION** : GMT4, GMT5 or GMT6 (default)
- **DIR_GSHHG** : Path to the coastlines database directory

CG6TOOL.gmt

In order to initialize its variables and depending on the version used (gmt4, gmt5 or gmt6), GMT needs a configuration file, respectively **.gmtdefaults4**, **gmt.conf** and **gmt.conf**. These files are respectively created using the files CG6TOOL.gmt4, CG6TOOL.gmt5 and CG6TOOL.gmt6 which must also be present in the *\$CG6TOOL/init* directory. There are automatically created when needed and can be modified by the user.

Starting CG6TOOL

• Linux environment

If your PATH includes \$CG6TOOL then run CG6TOOL or you can create a Desktop *launcher* (with the *CG6TOOL.jpg* icon) with the command: *java –jar <jar_full path>*

• Windows NT environment

Double-click the JAR file or using a shortcut (associate with CG6TOOL.ico) on your desktop.

INPUT DAILY DATA FILES

CG6TOOL directly handles Scintrex digital data files acquired in the operating 'field' mode and uploaded from the instrument through the serial port.

All observations must be stored in files (containing both one header and time series). Other data type may exist:

- s-file [site] created by the user
- c-file [computed] and r-file [result] produced by CG6TOOL.

Scintrex CG3/3M file

SCINTREX V/.2 AUT	JGRAV / Fleid	Mode	R/.21 1	Ser No:	S 110193
Line: 0. Grid:	1. Job:	1. Dat	e: 02/04/11	Operator:	1.
GREF.:	-3000. mGals		Tilt x sens:	it.:	293.2
GCAL.1:	6015.752		Tilt y sens:	it.:	296.5
GCAL.2:	0.		Deg.Lat.:		-33.45
TEMPCO.:	-0.1253mGal/	nK	Deg.Long.:		70.66
Drift const.:	0.		GMT Differe	nce:	0.hr
Drift Correction Start	Time: 23:24:1	2	Cal.after x	samples:	12
	Date: 02/03/0	6	On-Line Til	t Corrected	= "*"
Station Grav SD	 Tilt y Tilt	v Temp	 Е. Т. С	Dur # Rei	 Time
1. 2289.7584* 0.048	-0.3 -1	-2.01	0.015	100 2	13:37:20
1. 2290.2210* 0.026	-2.5 -2	.2 1.05	-0.067	100 2	23:28:00
2. 2231.5532* 0.042	-0.6 1	.2 0.22	0.062	100 0	14:56:56
3. 2232.8674* 0.040	-3.9 2	.0 0.24	0.068	100 3	15:11:14
4. 2230.3552* 0.075	0.8 -0	.9 0.47	0.077	100 2	15:43:18
5. 2227.6992* 0.078	1.6 0	.2 0.35	0.080	100 0	16:00:48
5. 2227.7088* 0.067	-3.9 -0	.1 0.34	0.080	100 2	16:03:27
6. 2226.3028* 0.072	1.4 0	.7 0.29	0.080	100 0	16:16:21
6. 2226.2930* 0.070	-0.2 -1	.7 0.31	0.080	100 2	16:18:32
7. 2226.7656* 0.047	-4.5 -0	.6 0.36	0.079	100 4	16:36:08

Header parameters required :

- *File type:* ---- (*First line*)
- SER No: Serial number of the instrument
- *Date:* Date of data acquisition
- *Deg.Lat.*: Latitude
- *Deg.Long.*: Longitude (+ to the West)
- *GMT Difference : Difference between UTC and measurement time*

Scintrex CG5 file

1	CG-5 SURVEY										
/	Survey name:	Pyrope									
1	Instrument S/N:	9136									
/	Client:	Default									
/	Operator:	Default									
/	Date:	2014/ 6/ 2									
/	Time:	07:56:56									
1	LONG:	1.5000000 E									
1	LAT:	42.8000000 N									
/	ZONE:	31									
/	GMT DIFF.:	0.0									
,											
1,	CG-5 SETUP PARAM	VIETERS	~								
1,	Gref:	0.00	0								
/,		9109.393									
/	Tiltus:	670.647									
1	TiltyO:	84 648									
1	TiltyO:	61 302									
1	Tempco:	-0.141									
1	Drift:	0.000									
1	DriftTime Start:	01:06:34									
/	DriftDate Start:	2000/01/01									
/	CG-5 OPTIONS										
1	Tide Correction:	YES									
/	Cont. Tilt: NO										
1	Auto Rejection:	YES									
/	Terrain Corr.: N	10									
1	Seismic Filter: YE	ES									
/	Raw Data: YE	5									
/LIN	ESTATIONALL.	GRAVSD	IILIX	· I IL I Y·	-TEMP	- IIDE	DUR	-REJIIIVIE-	DEC. HIME+I	JAIEIEI	KRAINDAT
1.000	245.000 0.0000 4	4253.907 0.034	-25.4	-24.4	-17.38	-0.001	90	23 07:30:35	5143.31240	0.0000	2014/06/05
1.000	245.000 0.0000 4	4253.909 0.016	-5.4	-11.4	-17.43	-0.001	90	7 07:33:31	5143.31444	0.0000	2014/06/05
1.000	246.000 0.0000 4	4308.860 0.035	72.0	32.4	-17.34	-0.005	90	22 08:54:40	5143.37070	0.0000	2014/06/05
1.000	246.000 0.0000 4	4308.835 0.014	27.3	11.2	-17.35	-0.006	90	22 08:57:13	5143.37220	0.0000	2014/06/05
1.000	246.000 0.0000 4	4308.833 0.010	18.0	11.9	-17.40	-0.006	90	6 09:00:04	5143.37445	0.0000	2014/06/05
1.000	262.000 0.0000 4	4240.207 0.017	-2.2	8.0	-17.36	0.025	90	10 16:24:03	5143.68227	0.0000	2014/06/05
1.000	262.000 0.0000 4	4240.222 0.011	-6.5	0.6	-17.34	0.025	90	0 16:26:21	5143.68387	0.0000	2014/06/05
1.000	262.000 0.0000 4	4240.225 0.009	-0.3	-4.6	-17.35	0.025	90	0 16:28:39	5143.68546	0.0000	2014/06/05
1.000	245.000 0.0000 4	4253.972 0.051	-5.9	-12.4	-17.29	0.025	90	3 16:49:53	5143,70019	0.0000	2014/06/05
1 000		1253 979 0 068	3.6	-1 9	-17 29	0.025	90	4 16.52.41	5143 70213	0.0000	2014/06/05
1.000	240.000 0.0000 2	+233.313 0.008	5.0	-1.9	-11.23	0.023	30	4 10.32.41	5145.70213	0.0000	2014/00/05

Header parameters required :

•	File type:	CG-5 SURVEY
•	Instrument S/N :	Serial number of the instrument
•	Date:	Date of data acquisition
•	LAT:	Latitude
•	LONG:	Longitude (+ to the East)
•	GMT DIFF.:	Difference between UTC and measurement time
•	Tide Correction :	Earth tide correction (available or not)

WARNING: Files with coordinates are not accepted but it is possible to transform them using the tool "Import Data" (*cf p.49*)

Scintrex CG6 file

/	CG-6 SURVEY	
/	Survey name:	AZER_AA
/	Instrument Serial N	umber: 018100125
/	Created:	2019-05-07-10:32:20
/		
/	CG-6 Calibration	
/	Operator:	GG
/	Gcal1 [mGal]:	7996.315000
/	Goff [ADU]:	-8388608.000000
/	Gref [mGal]:	0.0000
/	X Scale [arc-sec/ADU	J]: 0.031125
/	Y Scale [arc-sec/ADL	J]: 0.031014
/	X Offset [ADU]:	-85356.959885
/	Y Offset [ADU]:	-75699.919233
/	Temperature Coeffic	cient [mGal/mK]: -0.128600
/	Temperature Scale [mK/ADU]: -0.000111
/	Drift Rate [mGal/day	ı]: -0.119628
/	Drift Zero Time:	2018-10-31 12:00:18
/	Firmware Version:	R-20170705-1
/Station	Date Time	CorrGrav Line StdDev// LatGPS LonGPS ElevGPS Corrections[drift-temp-na-tide-tilt]
1001	2019-05-07 10:32:2	0 3370.5900 0 0.0797// 40.378101 48.973633 544.1 11011
1001	2019-05-07 10:33:2	0 3370.5901 0 0.0724// 40.378105 48.973633 544.2 11011

Observation: Below all the parameters of the CG6 format:

Station Date Time CorrGrav Line StdDev StdErr RawGrav X Y SensorTemp TideCorr TiltCorr TempCorr DriftCorr MeasurDur InstrHeight LatUser LonUser ElevUser LatGEXT LonGEXT ElevGEXT Corrections[drift-temp-na-tide-tilt

Header parameters required:

•	File type:	CG-6 SURVEY
•	Instrument Serial Number:	Serial number of the instrument

When you run CG6TOOL (and CG6TOOL environment variable defined) ...

	CG6TOOL - jv2022.12 (2022-12-01) - BGI/IRD – 🗆
Field 9	Survey Tools About Help
	INPUT INFORMATIONS Directory : Observed File : Site File : Gravimeter :
	OUTPUT INFORMATIONS Directory Computed File : Result File :
	OK
	TIME : UTC-Local = DRIFT : Linear (Least Square Adjustment) SITE : Height (mGal/m) : 0.00000 Reset REOC : Time Delay (min) = 15 +
	POSITION Directory : Position File : Load Infos
	GRAVITY BASE Base 1: mGal
	Base 2: mGal
GRA Di Pla	Base 2: mGal APPLY PHIC irectory ot #1: ps
GRA Di Plo Ac	Base 2: mGal APPLY PHIC irectory ot #1:ps ot #2: dvanced Graphic ParametersTo save temporary directory

1. Select raw data file

Click the **<Load>** button and select an observation file.

As soon as a file is selected, CG6TOOL is updated with the output files names.

	CG6TOOL - jv2022.12 (2022-12-01) - BGI/IRD
Field Surv	rey Tools About Help
F INPUT IN Direct Obser Site Fi Gravin	IFORMATIONS ory: /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202 ved File: CG6_2019137.dat Load Edit le: Unknown meter: CG6 #18100125 ERR =
Ουτρυτ	INFORMATIONS Directory SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST Computed File: C_CG6_2019137.dat Result File: R_CG6_2019137.dat
	ок
F	CORRECTIONS E.T.C.: © CG6 © Common Longman © Precise Long TIME : UTC-Local = DRIFT : Linear (Least Square Adjustment) SITE : Height (mGal/m) : 0.00000 Reset REOC : Time Delay (min) = 15÷ POSITION Directory : Position File : Load Infos GRAVITY BASE Base 1 : mGal
	Base 2: mGal
GRAPHI	
Direct	tory 'home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/TE
Plot #	1: Plot1_CG6_2019137.ps
Plot # Advar	2: Plot2_CG6_2019137.ps ced Graphic Parameters To save temporary directo
	PLOT

At this step the raw data file can be edited by pressing the **<Edit>** button.

		СG6ТО	OL : Observe	d Data File			- 🛛
Save Double clie	/home/gabalda/ c to activate/d	Z_SOFTS/grav	/i_cg6tool/new(a measureme	CG6TOOLv202	212/TEST/CG6/	/CG6_2019	137.dat
/ / / / / / / / / / / / / / / / / / /	Date 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17 2019-05-17	CG-6 Survey Survey Nam Instrument Created: CG-6 Calibra Operator: Gcall [mGa Goff [ADU]: Gref [mGal] X Scale [arc Y Scale [arc Y Scale [arc Y Offset [AD Temperatur Drift Zero T Firmware Ve Time 08:23:06 08:28:02 08:29:02 08:29:02 08:39:28 08:40:28 08:54:15 08:54:15 08:56:10 09:04:04 09:05:04 09:05:04 09:05:04 09:27:48 09:27:48 09:39:07 09:39:07 09:39:07 09:39:07	<pre></pre>	000000018 08:17:20 000000 0.031125 0.031014 -85356.953 -75699.919 mGal/mK]: DU]: -0.119628 2018-10-33 R-2017070 Line 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	8100125 9885 9233 -0.128600 -0.000111 1 12:00:18 5-1 StdDev 0.1032 0.1425 0.0741 0.0864 0.0931 0.1223 0.1354 0.1137 0.1955 0.1381 0.0834 0.1360 0.0342 0.0259 0.0552 0.0866 0.0467 0.1311 0.0866	StdErr 0.0133 0.0184 0.0096 0.0112 0.0120 0.0158 0.0175 0.0147 0.0252 0.0178 0.0178 0.0176 0.0044 0.0033 0.0071 0.0112 0.0060 0.0171	

• Double click to deactivate/activate a measurement (insert/remove "#").

✤ <Save> to keep the changes

2. Load the selected file

Click the **<OK>** button. If there are errors while loading several messages can appears else the **<APPLY>** button will be available.

CG6TOOL - jv2022.12 (2022-12-01) - BGI/IRD – 🗆 🔇
Field Survey Tools About Help
INPUT INFORMATIONS Directory : /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST/CG6 Observed File : CG6_2019137.dat Load Edit Site File : Unknown Gravimeter : CG6 #18100125 ERR -
OUTPUT INFORMATIONS Directory SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST/CG6 Computed File: C_CG6_2019137.dat Result File: R_CG6_2019137.dat OK
CORRECTIONS E.T.C.: © CG6 © Common Longman © Precise Longman TIME: UT UTC-Local = 0 DRIFT: Linear (Least Square Adjustment) SITE: Height (mGal/m): 0.00000 Reset REOC: Time Delay (min) = 15÷ POSITION Directory: Position File: Load Infos GRAVITY BASE Base 1: BASE 0.000 mGal
Base 2: BASE 0.000 mGal
GRAPHIC Directory 'home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST/CG6 Plot #1: Plot1_CG6_2019137.ps Plot #2: Plot2_CG6_2019137.ps Advanced Graphic Parameters To save temporary directory PLOT

3. Processing

Several corrections (Earth tide correction, height correction, reoccupation time delay) and options (coordinates file, gravity base value) are proposed:

- <u>E.T.C.: CG6 / Common Longman / Precise Longman</u>
 - ✓ CG6 : CG6TOOL use the value computed by the gravimeter
 - ✓ **Common Longman** : a new value is computed from the Longman (1959) algorithm and the header coordinates
 - ✓ **Precise Longman** permits to calculate a correction for each site with coordinates read in a "position" file (see below).
- <u>SITE : Height</u>

Height correction is also applied to remove the height variations in the instrument leveling or to reduce the height to benchmark level. These corrections use a site file (one site file by observation file). This file can be created in the "Tools" page (Create/Modify Site File). By default the gradient is 0.3086 mGal/m.

• <u>REOC : Time Delay</u>

The instrumental linear drift correction is calculated from the reoccupied sites when the time between two measurements on the same site is beyond this delay (15 minutes by default).

• **<u>POSITION</u>** (See chapter "POSITION FILE for more explanations)

This option allows loading a file with precise station coordinates in order to compute the earth tide correction in each site when the common header coordinates is not adequate. At this step, the user must initialize the format of the file. After this information are available with the **<Infos>** button.

CG6TOOL : PC	DSITION FILE : INITIALISATION
/home/gabalda/Z_SOFTS/gravi_co	g6tool/newCG6T00Lv202212/TEST/CG6/CG6.stations
HEADER (Number of lines) :	2 -
RECORD : Fix the file fields's	number and choice unity
Station Number :	2
Longitude & Latitude :	8 [★] 4 [★] +DD.DDD ▼
Elevation :	12÷ M 💌
	ок

• <u>GRAVITY</u>

This option allows you to assign a gravity value to 1 or 2 stations in the circuit. By default *Base 1* is the first station of the circuit and *Base 2* the last. In the case of profiles that do not loop, the use of 2 bases makes it possible to obtain a "realistic" drift and so "acceptable" results.

Once validated processing options, click on <APPLY> button.

If the **Precise Longman** earth tide correction has been selected and no "position" file was loaded, the user must upload a "position file".

Then, CG6TOOL will provide information about the instrumental drift correction.

	CG6TOOL 🛛 😣
i	LINEAR REGRESSION PARAMETERS
	Number of differences used : 22
	Correlation Coefficient = 95.10 %
	Goodness-of-fit Believable (Q = 1.0000)
	Gravity[i] = K x Time[i] + B + Error[i]
	K (mGal/Day) = 0.170 + -0.067
	B (mGal) = 0.003 +/- 0.003
	SD(Error) = 0.002 mGal
	MAX(Error) = 0.006 mGal
	OK

Click **<OK>** button to continue.

CG6TOOL will produce two files:

- c-file [computed] with all corrected measurement sorted by time.
- r-file [result] with one record per station

```
CG6TOOL Computed file: C < Observed File>
```

```
: CG6TOOL 2022.12 (2022-12-01) - FIELD COMPUTED FILE
# INFO
# CREATOR : gabalda
# DATE
         : Thu Nov 24 17:49:52 CET 2022
# GRAVIMETER : CG6 #18100125
# DATA
        : Observed = 37 / Used = 37
# CORRECTION : Earth Tide = Precise Longman / Height = No
# FORMAT : STATION / VALUE (mGal) / ERR (mGal) / DUR (s) / # REJ / X (Arc s) / Y (Arc s) / TEMP (mK)
# FORMAT
           : ETC (mGal) / JUL DAY / TIME (mn) / DDMMYY / HHMMSS / UT-Local (h) / SC (mGal) / GRAV (mGal)
BASE 3426.150 0.013 60 0 -8.4 -1.3 2.51 0.124 137 503.1000 170519 082306 0 0.000
                                                                                      0.0000
BASE 3426.152 0.018 60 0 -7.8 -1.8 2.45 0.123 137 508.0333 170519 082802 0 0.000
                                                                                      -0.0002
BASE 3426.154 0.010 60 0 -6.3 -1.3 2.44 0.123 137 509.0333 170519 082902 0 0.000
                                                                                      0.0024
7002 3421.201 0.011 60 0 10.6 -4.5 2.61 0.120 137 519.4667 170519 083928 0 0.000
                                                                                      -4.9552
7002 3421.209 0.012 60 0 10.0 -7.5 2.57 0.120 137 520.4667 170519 084028 0 0.000
                                                                                      -4.9470
... / ...
7015 3423.639 0.013 60 0 13.9 -17.2 2.54 0.007 137 688.3167 170519 112819 0 0.000
                                                                                      -2.6503
BASE 3426.311 0.016 60 0 3.2 -9.1 2.54 -0.011 137 709.1500 170519 114909 0 0.000
                                                                                       0.0024
BASE 3426.312 0.009 60 0 4.4 -13.4 2.52 -0.011 137 710.1500 170519 115009 0 0.000
                                                                                       0.0027
BASE 3426.313 0.017 60 0 -2.6 -7.7 2.47 -0.012 137 711.4333 170519 115126 0 0.000
                                                                                       0.0023
BASE 3426.314 0.009 60 0 -3.9 -13.2 2.46 -0.013 137 712.4333 170519 115226 0 0.000
                                                                                       0.0027
```

CG6TOOL Result file: R_<Observed File>

INFO : CG6TOOL 2022.12 (2022-12-01) - FIELD RESULT FILE
CREATOR : gabalda
DATE : Thu Nov 24 17:49:52 CET 2022
GRAVIMETER : CG6 #18100125
DATA : Total = 37 / Used = 37 / Station = 15 / Reoccupation (DT>15mn) = 1
CORRECTION : Earth Tide = Precise Longman / Height = No
REFERENCE : Station BASE (980041.400 mGal)
DRIFT : Value (mGal/Day) = 0.170 +/- 0.067 / Offset (mGal) = 0.003 +/- 0.003
: Standard Deviation (mGal) = 0.002 / Maximum Deviation (mGal) = 0.006
: Correlation = 95 % / Goodness-of-fit (Q) = 1.000 Believable
FORMAT : STATION / VALUE (mGal) / ERROR (mGal) / REITERATION / REOCCUPATION
BASE 980041.4000 0.0010 7 1
7002 980036.4465 0.0048 2 0
7003 980036.4919 0.0040 3 0
7004 980036.8292 0.0025 2 0
7005 980037.2676 0.0025 2 0
7006 980039.0663 0.0028 2 0
7007 980042.0468 0.0031 2 0
7008 980042.5147 0.0039 3 0
7009 980036.5543 0.0026 2 0
7010 980036.5085 0.0026 2 0
7011 980037.3576 0.0026 2 0
7012 980039.3811 0.0038 2 0
7013 980041.7948 0.0026 2 0
7014 980038.9337 0.0025 2 0
7015 980038.7466 0.0025 2 0

And update CG6TOOL page.

<PLOT> and <Advanced Graphic Parameters> buttons will be available.

CG6TOOL - jv2022.12 (2022-12-01) - BGI/IRD – 🗆 😣
Field Survey Tools About Help
INPUT INFORMATIONS Directory: /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST/CG6 Observed File: CG6_2019137.dat Site File: Unknown Gravimeter: CG6 #18100125 ERR
OUTPUT INFORMATIONS Directory SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST/CG6 Computed File : C_CG6_2019137.dat Result File : R_CG6_2019137.dat
E.T.C. : CG6 Common Longman Precise Longman TIME : UT UTC-Local = 0 DRIFT : Linear (Least Square Adjustment) SITE : Height (mGal/m) : 0.00000 Reset REOC : Time Delay (min) = 15 +
POSITION Directory : /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST/CG6 Position File : CG6.stations Load Infos
GRAVITY BASE Base 1: BASE 980041.400 mGal Base 2: BASE 0.000 mGal APPLY
GRAPHIC Directory 'home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST/CG6 Plot #1: Plot1_CG6_2019137.ps Plot #2: Plot2_CG6_2019137.ps Advanced Graphic Parameters To save temporary directory
PLOT

4. Drawing

The user can produce results graphics clicking the **<PLOT>** button. **CG6TOOL** uses the standard graphical and mathematical **Generic Mapping Tools** (GMT) free library to create well-documented plot files automatically generated by a script.

All the parameters are automatically calculated but it is possible to change them through the graphic interface clicking the <**Advanced Graphic Parameters**> button as well as through the script.

Indeed, this script created with a generic name expressed in the following form: _tmp_cg6tool_GMT_*o-file.ext* where *o-file* is the raw data file and *ext* the extension file-name (**csh** under Linux and **bat** under Windows NT).

The script can also be customized by the user.

The script and all the temporary files used for the GMT drawing are stored in a temporary directory whose generic name is _tmp_user_yyyy-mm-dd-hhnnss where user is the operator name, yyyy-mm-dd and hhnnss the script creation date and time.

This temporary directory can be saved by checking the checkbox "To save temporary directory".

The two (or three) output graphic files are automatically displayed using the viewer define by **CG6VIEWER** variable or according the extension (ext, jpg, png or pdf).



The first plot contains the time series related to a single gravity survey (corrected measures, error, tilts and temperatures). The repeatability of consecutive measurements and the histogram of the standard errors are also displayed for a quick evaluation of short-term repeatability and the noise level, respectively. General information on the survey are also displayed in the header.



The second Plot file displays the final gravity value computed for each site after the userdefined corrections have been applied. The upper graph shows the actual values of the repeated measurements at the same locations and the best model of the instrument drift obtained by a linear least-squares fitting of the observed data. Statistics and solutions for the drift model are provided to evaluate the goodness of fit and the data quality. The lower graph contains the table of the mean corrected gravity value for each station with the corresponding gravity profile.

CG6TOOL allows correcting the height variations in the instrument leveling or for reducing the height to benchmark level.

This correction uses a site file (one *s-fil*e by o-file) which can be created in the "**Tools**" tab. It contains the following information:

- ✓ Station name
- ✓ Date
- ✓ Time (hh:mm)
- ✓ Height (m)

CG6TOOL - jv2022.12 (2022-12-01) - BGI/IRD	-	8
Field Survey Tools About Help		
SITE FILE Create/Modify Site File Add a constant (m) = ADJUSTMENT Gravity Network Adjustment		
IMPORT DATA CG5wGEO> CG5 + GEO		

At this step, three options are possible:

- Create a s-file from an observation file with different height values for each station
- Modify an existing s-file
- Create a s-file from an observation file with the same height value for all station

- 1. Creation of new s-file with different height values for each station
 - Click on the <**Create/Modify Site file**> button and select *o-file*.

Open 😣
Look in: CG6
📑 ori 🚺 R CG6 2019137.dat
C_CG6_2019137.dat
CG6.stations
CG6_2019137.dat
🗋 gmt.conf
Plot1_CG6_2019137.png
Plot2_CG6_2019137.png
File <u>N</u> ame:
Files of Type: Observation file or Site File [S_])
Open Cancel

• Provide a valid height value for each measurement and valid with **OK** button.

	CG6TOO	L:TOOLS:	SITE FILE	- 😣
Directory : Site File :	/home/gabalda/Z_S0/ S_CG6_2019137.dat	TS/gravi_cg6	itool/newCG6T00Lv2022	212/TEST/CG6
STATION	DATE	TIME	HEIGHT(m)	
BASE	2019-05-17	08:23	0.000	ок
Previous	Next		Save & Quit	

• The end of the o-file is notified after the last measurement



• At this step all the entered height values can be changed. Press **Previous** or **Next** buttons to display the measurements and **OK** button to validate.

	CG6TOO	L : TOOLS :	SITE FILE	- 😣
Directory : Site File :	/home/gabalda/Z_SOI S_CG6_2019137.dat	FTS/gravi_cg6 (Creation)	itool/newCG6T00Lv2022	12/TEST/CG6
STATION BASE	DATE 2019-05-17	TIME 11:52	HEIGHT(m) 0.000	ок
Previous	Next		Save & Quit	

• Do not forget to save the site file before leaving with Save & Quit

2. Modification of old s-file

• Click on the <**Create**/**Modify Site file**> button and select *s-file*.

	CG6TOO	L : TOOLS :	SITE FILE	- 😣
Directory : Site File :	/home/gabalda/Z_SO S_CG6_2019137.dat	-TS/gravi_cg6 (Existing)	tool/newCG6T00Lv202	212/TEST/CG6
STATION BASE	DATE 2019-05-17	TIME 08:23	HEIGHT(m) 0.000	ок
Previous	Next		Save & Quit	

- At this step all the entered height values can be changed. Press **Previous** or **Next** buttons to display the measurements and **OK** button to validate.
- Do not forget to save the site file before leaving with Save & Quit
- If you quit without saving, the following dialog box is displayed to confirm the choice:



- 3. Creation of new s-file with the same height value for all stations
 - Check < Add a constant (m)> and initialize the field with a correct value

CG6TOOL - jv2022.12 (2022-12-01) - BGI/IRD	-		8
Field Survey Tools About Help			
SITE FILE Create/Modify Site File ✓ Add a constant (m) = ADJUSTMENT Gravity Network Adjustment	0.23]	
IMPORT DATA CG5wGEO> CG5 + GEO			

• Click on the <**Create/Modify Site file**> button and select *o-file*.

	CG6TOO	L : TOOLS :	SITE FILE	- 🙁
Directory : Site File :	/home/gabalda/Z_SOI S_CG6_2019137.dat	-TS/gravi_cg6 (Existing)	tool/newCG6T00Lv2022	212/TEST/CG6
STATION BASE	DATE 2019-05-17	TIME 08:23	HEIGHT(m) 0.230	ок
Previous	Next		Save & Quit	

- The same value entered (here 0.23m) is assigned to all observations.
- **Previous** and **Next** are used to scan all the heights entered, which can be modified again and then validated by **OK**.
- If a height is modified without validation, a confirmation is requested:



• As before, **Save & Quit** button to save the file.

With the aim to bring together a large number of observations acquired during survey using one or several instruments CG6TOOL include an adjustment program.

The program is designed to estimate the gravity values at each site connected by relative measurements using one or several instruments. It requires processed data files (*c-file* or *r-file*) containing the reduced gravity observations (earth tide, instrumental drift and optionally height corrections) and also one (or more) *absolute value*.

In order to compute the free-air and simple Bouguer anomaly in various reference systems (IAG80, IGSN71 or Potsdam 1930) and also to create maps a *coordinates file is needed*.

This program "Gravity Network Adjustment" is available in the "Tools" tab

CG6TOOL - jv2022.12 (2022-12-01) - BGI/IRD 🛛 🗆 🗆	8
Field Survey Tools About Help	
SITE FILE Create/Modify Site File Add a constant (m) = ADJUSTMENT Gravity Network Adjustment IMPORT DATA	
CGSWGEO> CGS + GEO	

1. Configuration file : config-file

In order to process an adjustment, CG6TOOL needs to load a configuration file. This text file must be created by the user with the name extension "**config**".

It provides all the information necessary for the adjustment data.

- Each command is recognized by the **keyword** at the beginning of the line. They must begin in column one and the keywords answers must begin after one or several blank.
- The order of the commands in the file is not important.
- The character "#" is used in order to disable a keyword or comment a line.
- Only two keywords are required to adjust data:
 - ✓ **IRELFIL** *full filename* CG6TOOL c-file or r-file file
 - ✓ ABSOLUT *number measure error* Absolute station
- Two others keywords are required to create maps and compute anomalies:
 - ✓ **IPOSFIL** *full filename* Coordinates filename
 - ✓ **IPOSFMT** *n sta lon lat alt [tc] lonlat_unit alt_unit [tc_unit]* Format

See below for a complete list of keyword and the chapter "**POSITION FILE**" for more explanation about the coordinates file format.

2. Keywords used in the configuration file

Below we consider that the "config" full filename is: dir/gna.config.

The code entered in the last column below indicates the maximum possible number of occurrences of the keyword: unique (1) or several (n)

In [**bold**], the default value

2.1.	Netwo	rk Informat	ion		
\checkmark	COMMENT	text		Commentary used as a title in the drawing	1
\checkmark	REPORT	filename	Ou	tput report filename [dir/gna.pdf by default]	1
2.2.	Input	Information			
\checkmark	IRELFIL	filename		CG6TOOL c-file or r-file	N
\checkmark	IPOSFIL	filename		Coordinates file	1
\checkmark	IPOSFMT	n1 i2 i3 i4 i5	5 fmt1 fmt2	Coordinates file format	1
\checkmark	ABSOLUT	station measu	re error	Absolute station parameters	N
✓	GRAVPAR	serialnumber	scalingfactor	Gravimeter parameters	Ν
2.3.	Adjus	tment Inforn	nation		
\checkmark	OADJFIL	rootname	Ro	ot of the result file name [dir/gna by default]	1
~	ADJNSIG	filter	Te	b keep only residues less than ADJNSIG x σ	1
2.4.	Free-a	ir and Boug	uer anomal	ies	
\checkmark	ANODENS	density	Mean density	y of the earth's crust (g/cm ³) [2.67 by default]	1
\checkmark	ANOGRAD	gradient	Vertical grad	lient of gravity (mGal/m) [0.3086 by default]	1
✓	ANOGEOS	system Geo	detic system (]	AG8, IGSN71, POTS30) [IAG80 by default]	1
2.5.	Drawi	ng Informat	ion		
\checkmark	PLOTCMD	script	script name	used to draw [dir/gna.csh or .bat by default]	1
\checkmark	PLOTFIL	rootname		Root of the graphic files [dir/gna by default]	1
\checkmark	PLOTREG	wesn		Coordinates of the data region	1
\checkmark	PLOTSFK	flag	To plot the	scaling factor k (0=No/1=Yes) [1 by default]	1
\checkmark	PLOTERR	flag	To plot the e	rrors (0=No/1=only post/2=all) [2 by default]	1
\checkmark	PLOTRES	flag	Γo plot the res	idues (0=No/1=extremes/2=all) [2 by default]	1
\checkmark	PLOTFAA	<i>flag</i> Fla	ag to plot the f	ree-air anomaly (0=No/1=Yes) [1 by default]	1
\checkmark	PLOTBGA	<i>flag</i> Flag	g to plot the B	ouguer anomaly (0=No/1=Yes) [1 by default]	1
\checkmark	PLOTANO	size	Anomaly s	quare size in .gmtdefault unit [1.0 by default]	1
\checkmark	GCPTFAA	table Free-	air GMT Colo	r palette [dir/gna_haxby_faa.cpt by default]	1
\checkmark	GCPTBGA	table Bougu	er GMT Colo	r palette [dir/gna_haxby_bga.cpt by default]	1
\checkmark	CONTFAA	flag [Aannot]	[Ccont]	To specify the free-air contour [1 by default]	1
\checkmark	CONTBGA	flag [Annot] [0	Ccont] T	o specify the Bouguer contours [1 by default]	1
\checkmark	BOUGUER	type		S(imple) or (Complete) [1 by default]	1

3. Configuration file loading

3.1. Select the configuration file

• Click the <Gravity Network Adjustment> button and select a *config-file*.

	Open 😣
Look <u>i</u> n: 🗖 A	Dj_Dolomieu 🔻 🗟 🛱 🛱 📴 📴
📑 archive	
C_file	
📑 ori	
Dolomieu.c	onfig
File Name:	Dolomieu config
Files of <u>T</u> ype:	Adjustment configuration File (*.config.)
	Open Cancel

As soon as a file is selected, information about the processing is saved in a **log file** whose generic name is CG6TOOL_ADJ_*user_yyyy-mm-dd-hhhnnmss*s.log where *user* is the operator name, *yyyy-mm-dd* and *hhnnss* the creation date and time.

CG6TOOL provide a new window:

CG6TOOL : TOOLS : GRAVITY NETWORK ADJUSTMENT		×
CONFIGURATION FILE /home/gabalda/Z_S0FTS/gravi_cg6tool/newCG6T00Lv202212/TEST/ADJ_Dolomieu/Dolomieu.config Edit LOAD	Infos	

- At this step, three possibilities are proposed:
 - ✓ To edit the configuration file which name is displayed (<**Edit**> button)
 - ✓ To display information about the usable keywords (<Infos> button)
 - ✓ To load and verify the configuration file (<LOAD> button)
- From now CG6TOOL does not allow to run a new adjustment by clicking <Gravity Network Adjustment> button.



3.2. Edit the configuration file

CG6TOOL : Adjustment : Configuration File	- 😣
Save /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/TEST/ADJ_Dolomieu/D Double clic to activate/desactivate a measurement.)olomieu.config
<pre># TITRE COMMENT DOLOMIEU 95 (Piton de la Fournaise) # GRAVITY FILE IRELFIL /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/templates/ADJ_Dolomieu IRELFIL /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/templates/ADJ_Dolomieu IRELFIL /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/templates/ADJ_Dolomieu IRELFIL /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/templates/ADJ_Dolomieu IRELFIL /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/templates/ADJ_Dolomieu IRELFIL /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/templates/ADJ_Dolomieu IRELFIL /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/templates/ADJ_Dolomieu IPOSFNL /home/gabalda/Z_SOFTS/gravi_cg6tool/newCG6T00Lv202212/templates/ADJ_Dolomieu IPOSFNL 7 2 1 2 3 4 DMS M # ABSOLUTE STATION ABSOLUT 9 978469.925 0.010 #ABSOLUT 35 978414.428 0.012 # GRAVPAR 9002136 1.000000 GRAVPAR 9408267 0.998400 # ADJUSTMENT #OADJFIL #ADJINSIG 2.85 # PLOT #PLOTSK 0 #PLOTSK 0 #PLOTFR 0 #PLOTFR 0 #PLOTFR 0 #PLOTRR 0 #PLOTRR 0 #PLOTRR 0 #PLOTRR 0 #PLOTRR 0 #PLOTRR 0 #PLOTRR 0 #PLOTRR 0 #PLOTRA 0 #PLOTRA 0</pre>	
	•

- In the editor, double click on a line to deactivate/activate a keyword. When a keyword is deactivate (or missing) the default value is used.
- Save button to keep the modifications

3.3. Display the information about the keywords

CG6TOOL : Adjustment : Key name inform	nations – 😣
Network Informations	
COMMENT Commentary (also used as a title in the drawing) REPORT Output report filename	Chilean network in Lastarria volcano (2005-2010) /CG6T00L/Lastarria_adj/Lastarria.report
Input Informations	
IRELFIL C66T00L c-file (computed) or r-file (result) IPOSFIL Position file name with coordinates IPOSFMT #lines (Head), field (Sta,Lon,Lat,Alt,TCo), [DD D.MS DMS EOL], [M KM EOL], [MGAL 6 ABSOLUT Absolute station (number measure error) GRAVPAR Gravimeter parameter (Serial_Number Scaling_Factor)	/CG6T00L/c_Data/fist1c95.256 /CG6T00L/posf/Lastarria.xy E0L]) 0 1 3 2 4 0 DD M MGAL 315 978038.114 0.007 9002136 1.000054
Adjustment Informations	
OADJFIL Root of the result file name with adjusted data ADJNSIG Adjustment filter (only residues < ADJNSIG * sigma)	/CG6T00L/Lastarria_adj/Lastarria 3.0
Free-air and Bouguer anomalies	
ANODENS Mean Density of the earth's crust (g/cm3) [2.67 by default] ANOGRAD Vertical gradient of gravity (mGal/m) [0.3086 by default] ANOGEOG Geodetic System [IAG80 (default) / IGSN71 / POTS30] BOUGUER S(imple) or C(omplete) Bouguer [5 (default) / C]	2.670 0.3 IAG80 S
Drawing Informations	
PLOTCMD Root of the C-shell script or command name to draw PLOTFIL Root of the Plot file name PLOTER w e s n (min/max coordinates of data region) PLOTSFK Scaling Factor k: 0 (No plot) / 1 (Yes by default) PLOTERR Error: 0 (No plot) / 1 (only after adjustment) / 2 (all by default) PLOTERR Residues: 0 (No plot) / 1 (only extremes) / 2 (all by default) PLOTERA Free-air anomaly: 0 (No plot) / 1 (Yes by default) PLOTBGA Bouguer anomaly: 0 (No plot) / 1 (Yes by default) PLOTBGA Bouguer anomaly: 0 (No plot) / 1 (Yes by default) PLOTBGA Bouguer anomaly: 0 (No plot) / 1 (Yes by default) GCPTFAA Free-air anomaly (GMT Color Palette Table) GCPTBGA Bouguer anomaly (Contour map): 0 (No) / 1 (Yes by default) [Aannotation] [Ccont CONTBGA Bouguer anomaly (Contour map): 0 (No) / 1 (Yes by default) [Aannotation] [Ccont	/CG6T00L/Lastarria_adj/csh_visu_Lastarria_Netw /CG6T00L/Lastarria_adj/Lastarria -68.80 -68.25 -25:25 -25.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

On the first column the **keyword** written in bold Then some explanations of the usefulness of the keyword At the end of the line, an example of the used

Only these keywords are "understood" by CG6TOOL

3.4. Load the configuration file

Click on **<OK>** button to process. CG6TOOL reads the *config-file*, verifies the keywords and load all the data. At this step, if the keywords used to initialize the file names are missing, CG6TOOL will provide a message:

	CG6TOOL 😣
?	Output file(s) missing ! Default(s) file(s) names(s) will be used
	Please see CG6TOOL messages
	Do you want continue ?
	<u>Y</u> es <u>N</u> o

If the user is agree to continue, the graphic interface is updated with all the known information about the data to be adjusted.

From now if the *config-file* is edited and saved, CG6TOOL makes disappear these information and it is necessary reload the data by clicking **LOAD** button.

CONFIGURATION FILE - /home/gabalda/Z_SOFTS,	/gravi_cg6tool/newC0	6TOOLv202212	2/TEST/ADJ_Dolomi	ieu/Dolomieu	.config Edit	Infos
ADJUSTMENT						
Input Informations –						
Relative Data :	Files :	6	Stations :	49	Observations :	333
	Gravimeters :	2	S/N #	9002136	6/9408267	
Absolute Data :	Stations :	1	Names :	9		
Scaling Factor :	2	S/N #	9002136/94	08267		
Position file :	alda/Z_SOFTS/gra	vi_cg6tool/new	CG6T00Lv202212	/templates/A	DJ_Dolomieu/ori/GEOPDN_	98_CG6T00L.txt
Output Informations						
Report file : /ho	me/gabalda/Z_SOFTS	6/gravi cg6tool	/newCG6T00Lv202	2212/TEST/A) Dolomieu/Dolomieu rep	ort.pdf
Result file : om	e/gabalda/7_SOFTS/g	aravi co6tool/n	ewCG6T00Iv2022	12/TEST/ADI	Dolomieu/Dolomieu.adi.re	esult (1
Command file : /ho	me/gabalda/Z_SOFT	5/gravi cg6tool	/newCG6T00Lv20	2212/TEST/A	DI Dolomieu/Dolomieu [].c	sh
					-)(1	
	me/gabalda/7_SOFT	5/gravi cg6tool	/newCG6T00Lv202	2212/TEST/AI	DJ_Dolomieu/Dolomieu_[].p	os ps 🗆
Plot file : /ho	inc/gabalaa/2_00111					

4. Scaling Factor

Click on **SCALING FACTOR**> button to continue the processing.

CG6TOOL updates the graphic interface with information about scaling factors:

- Calculated with the relative data only if more than one gravimeter is used and if there are common stations.
- Read from the *config-file* (keyword **GRAVPAR**)
- Calculated with relative and absolute data (keyword **ABSOLUT**)

The correction factors of the gravity meters with respect to the primary instrument (if exist) read from the *config-file* or from the instrument used in the first relative file (**IRELFIL**) are determined by a least-square adjustment procedure.

CONFIGURATI			CG6TOOL	: TOOLS	: GRAVITY NETWO	RK ADJUS	TMENT	-
/home/gabalda	VZ SOFTS/d	ravi co6t	ool/newCG6	T001v202	21.2/TEST/ADL Dolomie	u/Dolomieu	config Edit	Infos
/nonic/gabaiae	./2_30113/g	run_egot	000,11040000	10020202		a, bolonnica.	comy Luit	intos
					LOAD			
ADJUSTMENT								
Input Inform	ations —							
Relative D	ata :	Files :		6	Stations :	49	Observations :	333
		Gravime	eters :	2	S/N #	9002136	6/9408267	
Absolute [Data :	Station	s :	1	Names :	9		
Scaling Fa	ctor:	2		S/N #	9002136/940	8267		
Position fi	le :	balda/Z	_SOFTS/gra	vi_cg6tool/	newCG6T00Lv202212	/templates//	ADJ_Dolomieu/ori/GEOPDI	V_98_CG6T00L.txt
Report file Result file Command Plot file :	e: /hom : ome/ file: /hom /hom	e/gabalda/ gabalda/ e/gabald e/gabald	a/Z_SOFTS/(Z_SOFTS/gra a/Z_SOFTS/ a/Z_SOFTS/	gravi_cg6to avi_cg6too gravi_cg6t gravi_cg6t	ool/newCG6T00Lv2022 il/newCG6T00Lv20221 ool/newCG6T00Lv2022 ool/newCG6T00Lv2022	212/TEST/AD 2/TEST/ADJ_1 212/TEST/AD 212/TEST/AD	J_Dolomieu/Dolomieu_rej Dolomieu/Dolomieu.adj_r J_Dolomieu/Dolomieu_[]. J_Dolomieu/Dolomieu_[].	oort.pdf esult_[] csh png png
					SCALING FACTOR			
Scaling Fact	ors Inform	ations -						
Id	S/Numbe	r Ref	From g-f	les only	Read in configura	tion file	g-files and absolutes	values
1	9002136	Х	▶ 1.000	000	1.000000			
2	9408267		0.998	329	0.998400			

To help the Scaling factors choice used in the adjustment, CG6TOOL will produce graphic files (using GMT library) automatically generated by a script.

Scripts and grafic files are created with a generic name expressed in the following form: *gna*_sf_Gc*snc*vsGr*snr.ext* where *gna*, *snc*, *snr* and *ext are* the configuration base name file, the serial number of the calibrated instrument, the serial number of the reference instrument and the extension (csh, bat, ext, jpg, png ou pdf), respectively. The script can also be customized by the user.

- * These files are not created if **PLOTSFK** keyword value is zero
- ★ A star (*) after a scaling factor indicate than the hypothesis (*Intercept equal to zero*) has been rejected with a significance level of 5% (Student Test).



This plot contains the successive parameters of the correction factor of the gravity meter #9408267 with respect to the instrument #90023136 (scaling factor, intercept, number of rejection and rms). Twenty iterations are calculated and the data outliers (*residual greater than 3 standard deviation*) are rejected.

The lower graph contains the result of applying the final scaling factor calculated with an intercept equal to zero.

For the red dots, the residual is less than 3 standard deviation.

5. Adjustment

Click on **<ADJUSTMENT>** button to continue the processing.

- Gravity data are adjusted (one, two or three iterations)
 - ✓ Only one iteration if CG6TOOL can provide an gravity value for each station of the network before the adjustment
 - \checkmark Two iteration when a first initialization adjustment is necessary
 - ✓ Another iteration is realized if ADJNSIG keyword is defined
- Adjusted file is created (*see below*)
 - ✓ The adjusted data filename has a generic name : *adjfile*.adj_result_*filter* where *adjfile* is OADJFIL value (or *gna* by default) and *filter* is "nofilter" or "filtered" (if ADJNSIG value)

CG6TOOL can display an information windows if **PLOTREG** defines a region smaller than the region defined by the data:



• The graphic interface is updated with the region of interest:

					LOAD			
DJUSTMENT								
Input Informati	ions							
Relative Data	a:	Files :		6	Stations :	49	Observations :	333
		Gravime	eters :	2	S/N #	900213	6 / 9408267	
Absolute Dat	a:	Station	5.7	1	Names :	9		
Scaling Facto	or: 3	2		S/N #	9002136/9408	3267		
Position file :	: I	balda/Z	SOFTS/gra	avi_cg6tool	/newCG6T00Lv202212/	templates/	ADJ_Dolomieu/ori/GE0PDI	N_98_CG6T00L.txt
Report file : Result file : Command file Plot file :	/home/ ome/ga e: /home/ /home/	'gabalda abalda/2 'gabalda 'gabalda	a/Z_SOFTS/ Z_SOFTS/gr a/Z_SOFTS, a/Z_SOFTS,	/gravi_cg6t ravi_cg6toc /gravi_cg6t /gravi_cg6t	ool/newCG6T00Lv2022 ol/newCG6T00Lv20221 ool/newCG6T00Lv2022 ool/newCG6T00Lv2022	12/TEST/AD 2/TEST/ADJ_ 12/TEST/AD 12/TEST/AD	0]_Dolomieu/Dolomieu_rej Dolomieu/Dolomieu.adj_ 0]_Dolomieu/Dolomieu_[]. 0]_Dolomieu/Dolomieu_[].	port.pdf result_[] .csh .png png
Report file : Result file : Command file Plot file : Scaling Factors	/home/ ome/ga : /home/ /home/	gabalda abalda/2 gabalda gabalda	a/Z_SOFTS/ Z_SOFTS/gr a/Z_SOFTS/ a/Z_SOFTS/	/gravi_cg6t ravi_cg6toc /gravi_cg6t /gravi_cg6t	ool/newCG6T00Lv2022 ol/newCG6T00Lv20221 ool/newCG6T00Lv20222 ool/newCG6T00Lv2022 SCALING FACTOR	12/TEST/AD 2/TEST/ADJ_ 12/TEST/AD 12/TEST/AD	D_Dolomieu/Dolomieu_rej Dolomieu/Dolomieu.adj_ Dolomieu/Dolomieu_[]. D_Dolomieu/Dolomieu_[].	port.pdf result_[] .csh .png png
Report file : Result file : Command file Plot file : Scaling Factors	/home/ ome/ga : /home/ /home/ s Informat	gabalda abalda/2 gabalda gabalda gabalda gabalda Ref	a/Z_SOFTS/ Z_SOFTS/gr a/Z_SOFTS/ a/Z_SOFTS/ From g- 1	/gravi_cg6t ravi_cg6toc /gravi_cg6t /gravi_cg6t /gravi_cg6t files only	ool/newCG6T00Lv2022 bl/newCG6T00Lv20221 ool/newCG6T00Lv2022 sool/newCG6T00Lv2022 SCALING FACTOR Read in configural	12/TEST/AD 2/TEST/ADJ_ 12/TEST/AD 12/TEST/AD 12/TEST/AD	D_Dolomieu/Dolomieu_rej Dolomieu/Dolomieu.adj_r D_Dolomieu/Dolomieu_]). D_Dolomieu/Dolomieu_[]. g-files and absolutes	port.pdf result_[] .csh png png s values
Report file : Result file : Command file Plot file : Scaling Factors Id S, 1 9	/home/ ome/ga : /home/ /home/ s Informati /Number 002136	gabalda abalda/2 (gabalda gabalda tions – Ref X	a/Z_SOFTS/ Z_SOFTS/gr a/Z_SOFTS/ a/Z_SOFTS/ From g-1 1.000	/gravi_cg6t ravi_cg6toc /gravi_cg6t /gravi_cg6t /gravi_cg6t	ool/newCG6T00Lv2022 ool/newCG6T00Lv20222 ool/newCG6T00Lv2022 SCALING FACTOR Read in configural	12/TEST/AD 2/TEST/ADJ_ 12/TEST/AD 12/TEST/AD 12/TEST/AD)]_Dolomieu/Dolomieu_rej Dolomieu/Dolomieu.adj_r)]_Dolomieu/Dolomieu_[].)]_Dolomieu/Dolomieu_[]. g-files and absolutes	port.pdf result_[] .csh .png png svalues
Report file : Result file : Command file Plot file : Scaling Factors Id S, 1 99 2 99	/home/ ome/ga : /home/ /home/ s Informat /Number 002136 408267	gabalda abalda/2 /gabalda /gabalda /gabalda /gabalda /gabalda / gabalda / / / / / / / / / / / / / / / / / / /	a/Z_SOFTS/ Z_SOFTS/gr a/Z_SOFTS/ a/Z_SOFTS/ a/Z_SOFTS/ From g-1 1.000	/gravi_cg6t ravi_cg6toc /gravi_cg6t /gravi_cg6t /gravi_cg6t /gravi_cg6t	ool/newCG6T00Lv2022 ool/newCG6T00Lv20221 ool/newCG6T00Lv2022 sool/newCG6T00Lv2022 SCALING FACTOR Read in configurat 1.000000 v 0.998400	12/TEST/AU 2/TEST/ADJ_ 12/TEST/AU 12/TEST/AU 12/TEST/AU	Dolomieu/Dolomieu_rej Dolomieu/Dolomieu.adj_r Dolomieu/Dolomieu.adj_r D_Dolomieu/Dolomieu_[]. D_Dolomieu/Dolomieu_[]. g-files and absolutes	port.pdf result_[] .csh .png png svalues

CG6TOOL adjusted file: Dolomieu.adj_result_nofilter

INFO : CG6TOOL 2022.12 (2022-12-01) - ADJUSTMENT RESULT FILE
CREATOR : gabalda
DATE : Mon Nov 28 16:48:21 CET 2022
LOG FILE : /home/gabalda/2_SOF15/gravi_cgbtool/CG61OOLv202212/ADJ_Dolomieu/CG61OOL_ADJ_gabalda_2022-11-28-15h53m42s.log
CONFIGURATION FILE
/nome/gabaida/2_SOFIS/gravi_cg6tool/CG61OOLV202212/ADJ_Dolomieu/Dolomieu.config
Input informations
- A helitve Data - Files# 07 Glavineters# 27 Stations# 497 Observations# 555
- Absolute Station - [2]
- Position file : /home/gabalda/2 SOFTS/gravi co6tool/CG6TOOLy202212/ADL Dolomieu/ori/Reseau GEOPDN 98
Output informations
- Result file : /home/gabalda/Z_SOFTS/gravi_cg6tool/CG6TOOLv202212/ADJ_Dolomieu/ori/Dolomieu.adi_result_nofilter
- Script file : /home/gabalda/Z SOFTS/gravi_cg6tool/CG6TOOLv202212/ADJ Dolomieu/ori/Dolomieu [].csh
- Graphic file : /home/gabalda/Z SOFTS/gravi cg6tool/CG6TOOLv202212/ADJ Dolomieu/ori/Dolomieu [].ps
Absolute station informations
- Station 9 = 978469.9250 +/- 0.0100 mgal
Scaling Factors informations
- Meter #1 [s/n 9002136] 1.000000 < read in configuration file (Reference)
- Meter #2 [s/n 9110193] 0.998400 < read in configuration file
Result informations
- Root-Mean-Square residual : 0.040 mGal
- Filter : No
- Errors (mGal) : Min= 0.009 / Max= 0.033 / Mean= 0.025
- Residues (mGal) : Min= -0.117 / Max= 0.251 / Mean= 0.001
Mono density 12 G70 s/cm2
- Medi defisity = 2.070 g/cm3
- Condition current - 10.5000 mildar/m
- Octuber System : IAG 1980
- free-air anomaly (mGal) : Min= 475 986 / Max= 493 1592 / Mean= 487 348
- Bouguer anomaly (mGa) : Min= 196.080 / Max= 223.977 / Mean= 209.525
#
FORMAT : Gravity, Error, Free-air, Bouguer (mGal), Coordinates (DD, m)
Sta Gravity Error Reit Longitude Latitude Altitude Free-air Bouguer
#
550 978416.0095 0.0120 6 55.7219647 -21.2278319 2520.000 483.734 201.645
551 978417.7471 0.0229 4 55.7196333 -21.2275817 2525.500 487.184 204.479
552 978411.4271 0.0217 4 55.7178622 -21.2284867 2557.600 490.715 204.417
553 978405 3228 0.0216 4 55 7158503 -21 2294914 2585 500 493 159 203 738
554 978388 9882 0 0197 5 55 7131353 -21 2307136 2630 000 490 483 196 080
/
529 970430.0300 0.0202 9 53.7230123 21.2340017 2403.470 402.407 203.374
518 9/8437.3177 0.0306 4 55.7229053 -21.2327619 2461.230 486.605 211.095
<u>34</u> 978417.9166 0.0297 2 55.7205872 -21.2278153 2519.660 485.537 203.486

6. Drawing

CG6TOOL can produce results graphics clicking the **<PLOT>** button. CG6TOOL uses the standard graphical and mathematical **Generic Mapping Tools** (GMT) free library to create graphic files automatically generated by scripts that can be customized by the user. The generic script name is *cshfile_type.ext* where *cshfile* is **PLOTCMD** value (or *gna* by default) and *ext* is *csh* (Linux) or *bat* (Windows). See below for the different *type* values

West, east, south and north specify the map limits and the user may specify them in **decimal degrees** or in **D:M:S** (degrees, minute and second) format.

By default CG6TOOL will produce:

• 9 graphic files. The generic name is *plotfile_type.ext* where *plotfile* is **PLOTFIL** value (or *gna* by default) and *ext* the graphic format (ext, jpg, png or pdf).

√	<i>plotfile</i> _info_histo.ext :	Information and histogram	(see figure 6.1)
✓	<pre>plotfile_err_raw.ext :</pre>	Network with errors bars (before adjustment)	(see figure 6.2)
√	<pre>plotfile_err_adj.ext :</pre>	Network with errors bars (after adjustment)	(see figure 6.3)
✓	<i>plotfile</i> _res_max. <i>ext</i> :	Network with residues extremes	(see figure 6.4)
√	<pre>plotfile_res_mean.ext :</pre>	Network with residues means	(see figure 6.5)
✓	<i>plotfile</i> _faa_dot. <i>ext</i> :	Network with free-air anomaly (point)	(see figure 6.6)
✓	<i>plotfile</i> _faa_grd. <i>ext</i> :	Network with free-air anomaly (grid)	(see figure 6.7)
✓	<pre>plotfile_bga_dot.ext :</pre>	Network with simple Bouguer anomaly (point)	(see figure 6.8)
✓	<i>plotfile</i> _bga_grd. <i>ext</i> :	Network with simple Bouguer anomaly (grid)	(see figure 6.9)

- 2 grid files. The generic name is *gna*_[faa,grd].grd where *gna* is the base name of the configuration file.
 - ✓ gna_faa.grd : grid file created with the GMT command surface and free-air data
 - ✓ gna_bga.grd : grid file created with the GMT command surface and Bouguer data
- 2 GMT Color Palette Table. The generic name is *gna*_haxby_[faa,grd].cpt.
 - ✓ gna_haxby_faa.cpt : cpt file created with the GMT command makecpt and free-air data
 - ✓ gna_haxby_bga.cpt : cpt file created with the GMT command makecpt and Bouguer data
- Maps with errors are not created if **PLOTERR** keyword value is zero
- ♦ Maps with residues are not created if **PLOTRES** keyword value is zero
- * Maps with free-air are not created if **PLOTFAA** keyword value is zero
- ♦ Maps with Bouguer are not created if **PLOTBGA** keyword value is zero
- ✤ Free-air CPT file is not created if GCPTFAA keyword is used
- Souguer CPT file is not created if GCPTBGA keyword is used
- ♦ No «free-air» levels (gridded values) if CONTFAA keyword value is zero
- ♦ No **«Bouguer**» levels (gridded values) if **CONTBGA** keyword value is zero



Figure 6.1: Information and histogram



Figure 6.2: Network with errors bars (before adjustment)



Figure 6.3: Network with errors bars (after adjustment)



Figure 6.4: Network with residues extremes



Figure 6.5: Network with residues means



Figure 6.6: Network with free-air gravity anomaly (point values)



Figure 6.7: Network with free-air gravity anomaly (gridded values)



Figure 6.8: Network with Bouguer gravity anomaly (point values)



Figure 6.9: Network with Bouguer gravity anomaly (gridded values)

7. Adjustment report

Adjustment report in **PDF format** can be automatically generated when the user closes the adjustment windows by clicking the X icon on the tab (*figure 7.1*) or when he want to begin a new adjustment by clicking the **LOAD** button (*figure 7.2*).



Figure 7.1: The confirmation dialog after clicking the X icon

	To create a report	8
? Do yo	ou want to create a report on the previous adjustme	nt ?
	Yes No	

Figure 7.2: The confirmation dialog before a new adjustment (LOAD button)

By checking Yes, CG6TOOL produces a report with the generic name is *reportfile*_report.pdf where *reportfile* is **REPORT** value (or *gna* by default).

The report contains the following information:

- ✤ User, date and time of the adjustment
- Title (COMMENT) if exist
- ✤ Log file name
- Configuration file
- ✤ Adjustment information (input, output, absolute station, ...)
- Adjusted values (station, gravity, error, coordinates, faa, simple Bouguer)
- All the graphics

In some case, the user needs precise coordinates for each station. They are imported in a file named "**Position file**" in CG6TOOL with a format defined by the user:

• with a dialog box in *Field Survey* (Position file : Load button):

CG6TOOL : POSITION FILE : INITIALISATION
/home/gabalda/Z_S0FTS/gravi_cg6tool/newCG6T00Lv202212/TEST/CG6/CG6.stations
HEADER (Number of lines): $2\frac{1}{2}$
RECORD : Fix the file fields's number and choice unity Station Number : 2 Longitude & Latitude : 8 4 +DD.DDD
Elevation : 12 M
οκ

• with keywords in *Adjustment Tool* (IPOSFILE and IPOSFMT in *config-file*). IPOSFMT can accept 7 or 9 parameters depending on whether or not the position file contains a column with *Terrain Correction* (necessary for the calculation of the complete Bouguer anomaly).

IPOSFMT 2 2 8 4 12 16 DD M MGAL

The two cases require the following information:

- \checkmark header's lines number (0 if no header)
- ✓ position of the fields (station, longitude, latitude, elevation, [terrain correction])
- ✓ longitudes and latitudes format:

Field Survey	Adjustment	01°26'37.15" East
DD.DDD	DD	1.4436528
DD.MMSSSS	D.MS	1.263715
DDMMSS.SS	DMS	012637.15
0.00001D	EOL	144365.28

✓ elevation unit:

Field Survey	Adjustment	150 m
СМ	EOL	15000
М	М	150
KM	KM	0.15

 \checkmark terrain correction unit:

Field Survey	Adjustment	40.88 mGal
Non disponible	MGAL	40.88
Non disponible	EOL	4088

Above the two formats (graphic interface and command line) are almost identical :

- Position file with a header of two lines (2)
- Station (field 2), longitude (field 8), latitude (field 4) and elevation (field 12)
- Longitude and latitude in Decimal Degrees (DD.DDD / DDD)
- Elevation in meters (**M**)
- Terrain Correction (field 16) in mGal (only IPOSFMT)

While a *<Field Survey>* this information are available with the *<*Infos> button:

	CG6TOOL: POSITION FILE ×
i	NUMBER OF STATIONS : 16
	HEADER [2 lines] :
	# Position file (CG6 templates)
	RECORD DESCRIPTION : #2 : Station number #8 : Longitude [dd.dd] #4 : Latitude [dd.dd] #12 : Elevation [m]
	ОК

En this example we have the following informations :

- \checkmark The coordinates file contains 16 stations
- ✓ With 2 header lines
- ✓ In first the station number (field 2 in the origin file)
- ✓ Field 2 : longitud in decimal degrees (field 8 in the origin file)
- ✓ Field 3 : latitud in decimal degrees (field 4 in the origin file)
- ✓ Field 4 : altitud in meters (field 12 in the origin file)

CG6TOOL - jv2022.12 (2022-12-01) - BGI/IRD -	-	×
Field Survey Tools About Help		
SITE FILE Create/Modify Site File Add a constant (m) =		
ADJUSTMENT Gravity Network Adjustment		
IMPORT DATA CG5wGEO> CG5 + GEO		

"CG5wGEO \rightarrow CG5 + GEO" available from <Tools> can import the gravity observations acquired using Scintrex CG-5 gravimeter with the GEXT option GEXT which contains geographic coordinates (*see example below*).

1	CG-5 SLIBVEV	
1		
1	Instrument S/N	
1	Client:	+6005
1	Operator:	
1	Dato:	NL 2015/9/14
1	Time:	
1	LONG:	70 5025278 W/
1		/3.3032-40 W
1		
1	GMT DIFE ·	
/	GIVIT DITT	
1	CG-5 SETUP PARAM	IETERS
/	Gref:	0.000
/	Gcal1:	8757.598
/	TiltxS:	665.577
/	TiltyS:	708.322
/	TiltxO:	-1.292
/	TiltyO:	15.236
/	Tempco:	-0.127
1	Drift:	-0.008
1	DriftTime Start:	19:04:46
/	DriftDate Start:	2015/08/14
/	CG-5 OPTIONS	
/	Tide Correction:	YES
/	Cont. Tilt:	YES
/	Auto Rejection:	YES
/	Terrain Corr.:	NO
/	Seismic Filter:	YES
/	Raw Data:	NO
Line	1.000	
/L	_ATLON	ALTGRAVSDTILTXTILTYTEMPTIDEDUR-REJTIMEDEC.TIME+DATETERRAINDAT
43.79024	10-79.5035400 160.	000 5491.907 0.034 -25.4 -24.4 17.38 -0.001 30 3 19:04:54 42198.79380 0.0000 2015/08/14
43.79024	08-79.5035400 170.	000 5491.910 0.033 -25.3 -24.6 17.38 -0.001 30 0 19:05:29 42198.79420 0.0000 2015/08/14
43.79024	18 - 79.5035400 165.	000 5491.906 0.026 -25.1 -24.7 17.38 -0.002 30 1 19:06:04 42198.79461 0.0000 2015/08/14
Line	2.000	
/L	AILUN	ALIUKAVSUIILIXIILIYIEMPIIDEDUK-KEJIIMEDEC.IIME+DATEIERRAINDAT
43.79051	.19 - /9.5034710 255.	000 5491.628 0.046 -15.4 -14.4 17.58 -0.005 30 2 19:07:30 42198.79560 0.0000 2015/08/14
43.79051	.21 - 79.5034714 257.	000 5491.632 0.030 -15.0 -10.6 17.59 -0.006 30 0 19:08:05 42198.796000 0.0000 2015/08/14

Warning, only this format above is recognized by CG6TOOL:

- ✓ Only one header with « CG-5 SURVEY », « CG-5 SETUP » and « CG-5 OPTIONS »
- \checkmark the **Line** parameter is used as an indicator of the station number
- ✓ the first fields of the time series are LAT and LONG or NORTHING and EASTING

Two output files are created, one containing the gravity observations in a usable format for **CG6TOOL** and another containing the geographic coordinates.

Click the $\langle CG5wGEO \rightarrow CG5 + GEO \rangle$ button and select one Scintrex CG-5 data file.

CG6TOOL / IMPORT DATA : Select CG5 file with coordinates 🛛 😣		
Look <u>I</u> n: 📑 IM	IPORT_DATA	
🗂 ori	T190931.TXT.xyz	
CG-5_T1909	31.TXT 🗋 T190931.xyz	
🗋 р.тхт	T190931_NE.TXT	
🗋 D.xyz	T1_NE.TXT	
🗋 т1.тхт	T1_NE.TXT.xyz	
T1.xyz	T1_NE.xyz	
🗋 Т190931.ТХ	Г	
File <u>N</u> ame:	T190931.TXT	
Files of <u>T</u> ype:	Scintrex CG5 Observation file	▼
		Open Cancel

CG5 + GEO (LAT/LONG or NORTHING/EASTING coordinates)		
Directory : /home/gabalda/Z_SOFTS/JAVA/JAVA_WS/DATA/new_cg6tool/IMPORT_DATA CG5 File : T190931.TXT		
/home/gabalda/Z_SOFTS/JAVA/JAVA_WS/DATA/new_cg6tool/IMPORT_DATA CG-5_T190931.TXT		
[/] home/gabalda/Z_SOFTS/JAVA/JAVA_WS/DATA/new_cg6tool/IMPORT_DATA F190931.TXT.xyz		
ок		

- ✓ The user has the possibility to choose the output directory. By default the output directory is identical to the input directory. Names of the output files are also editable.
- $\checkmark\,$ Click « **OK** » button to verify the parameters and continue the processing.
- \checkmark The coordinates are averaged per station

CG6TOOL can display windows information (or dialog) . See examples below :

✓ If an output file exist the user has the choice between interrupting the process (to change his choice) or continue (and destroy the existing file).



✓ An error has prevented the process to unfold properly until its completion. In this case it is also desirable to take knowledge of the more explicit information displayed in "CG6TOOL messages".



As long as the main GUI is displayed, the user can exit the program by right-clicking the program's icon \boxtimes , and choose Yes to exit or No to continue :

CG6TOOL / IMPORT DATA	×
? Are you sure you want to q	uit ?
<u>Y</u> es <u>N</u> o	

The "CG6TOOL messages" window allows you to monitor the operations and especially contains explicit information in the event of errors.

Example of CG5 File

/ CG-5 SURVEY			
/ / CG6TOOL - IMPORT DATA - CG5wGEO> CG5 + GEO - Proccessing by gabalda (28/11/2022)			
/			
, / CG5 INPUT : /home/gabald	/ / CG5 INPUT : /home/gabalda/Z_SOFTS/JAVA/JAVA_WS/DATA/new_cg6tool/IMPORT_DATA/T190931.TXT		
1			
/ CG5 OUTPUT : /home/gaba	Ida/Z_SOFTS/JAVA/JAVA_WS/DATA/new_cg6tool/IMPORT_DATA/CG-5_T190931.TXT		
/ XYZ OUTPUT : /nome/gabai	da/2_SUFTS/JAVA/JAVA_WS/DATA/new_cgbtool/IMPORT_DATA/T190931.1XT.xyz		
/ CG-5 SOFTWARE W	/FR · 4 2		
/ CG-5 SURVEY			
/ Survey name:	LAT LONG		
/ Instrument S/N:	9601323		
/ Client:			
/ Operator:	RL		
/ Date:	2015/ 8/14		
/ Time:	19:04:43		
/ LONG:	79.5035248 W		
/ LAT: 43.7902	2756 N		
/ ZONE: U	0.0		
/ CG-5 SETLIP PARAL	0.0 METERS		
/ Gref:	0.000		
/ Gcal1:	8757.598		
/ TiltxS:	665.577		
/ TiltyS:	708.322		
/ TiltxO:	-1.292		
/ TiltyO:	15.236		
/ Tempco:	-0.127		
/ Drift:	-0.008		
/ DriftTime Start:	19:04:46		
/ DriftDate Start:	2015/08/14		
/ CG-5 OPTIONS			
/ Ide Correction:	YES		
/ Cont. Tilt: YES	VEC		
/ Auto Rejection.	10		
/ Seismic Filter: Y			
/ Raw Data: N	0		
/LINESTATIONAL	rGRAVSDTILTXTILTY-TEMPTIDEDUR-REJTIMEDEC.TIME+DATETERRAINDATE		
1 1 160.00	00 5491.609 0.030 -0.3 3.5 -0.05 0.070 30 0 19:04:54 42198.79380 0.0000 2015/08/14		
1 1 170.00	00 5491.610 0.033 -0.4 4.1 -0.05 0.070 30 0 19:05:29 42198.79420 0.0000 2015/08/14		
1 1 165.00	00 491.610 0.026 -0.5 4.3 -0.05 0.069 30 6 19:06:04 42198.79461 0.0000 2015/08/14		
1 2 255.000	00 5491.628 0.046 -0.8 4.9 -0.04 0.069 30 0 19:06:55 42198.79520 0.0000 2015/08/14		
1 2 257.000	00 5491.609 0.032 -1.3 4.7 -0.04 0.069 30 0 19:07:30 42198.79560 0.0000 2015/08/14		

Example of "coordinates" File

CG6TOOL - IMPORT DATA - CG5wGEO --> CG5 + GEO - Proccessing by gabalda (28/11/2022)
#
CG5 INPUT : /home/gabalda/Z_SOFTS/JAVA/JAVA_WS/DATA/new_cg6tool/IMPORT_DATA/T190931.TXT
CG5 OUTPUT : /home/gabalda/Z_SOFTS/JAVA/JAVA_WS/DATA/new_cg6tool/IMPORT_DATA/CG-5_T190931.TXT
XYZ OUTPUT : /home/gabalda/Z_SOFTS/JAVA/JAVA_WS/DATA/new_cg6tool/IMPORT_DATA/CG-5_T190931.TXT.xyz
STATION------LATITUDE----LONGITUDE----ALTITUDE
1 43.7902412 -79.5035400 165.0000
2 43.7905120 -79.5034712 256.0000

The '*About*' tab contains some general information on CG6TOOL (current version, summary,...) as well as a history on the main contributions of each version.

CG0100C - JV2022.12 (2022-12-01) - BG	уік о <u>–</u>
d Survey Tools About Help	
CG6TOOL	
Version : CG6TOOL 2022.12 (2022-12-01)	
Interactive Scintrex CG3/CG5/CG6 data pro	ocessing
CG6TOOL is an interactive computer program of	ledicated
to the processing of the gravity data acquired	by the
Corminal Cabalda (garminal gabalda Gird fr)	
Sylvain Bonvalot (sylvain.bonvalot@ird.fr)	
ABSTRACT	
The aim of CG6TOOL is to allow for an objective evaluate	on of data
and to provide a higher resolution in data reductions. 7	The program
reads the gravity data acquired in either field and then	downloaded
out interactively through a user friendly interface. It all	ows the user to :
(1) load, edit the observed gravity time series,	
(2) compute by applying standard or accurate correction	ons
(3) VISUALIZE and evaluate the results. (4) adjust a network and compute free-air and Bouque.	r anomaly
CG6TOOL was developped in JAVA and uses the standar	rd graphical and
mathematical Generic Mapping Tools (GMT) free library	
In the Beginning was	
CG3TOOL	
An interactive computer program to process Scintre»	CG-3/3M
gravity data for high-resolution applications,	
Gabalda Germinal, Bonvalot Sylvain, Hipkin R.,	77
Computers & Geosciences, vol. 29, issue 2, pp. 155-1	/1, March 2003
HISTORIC	
2022.12 (2022-12-01) Java-11	
Java version based on CG6TOOL (v2022.11 / Novemb	er 2022)
 available under Linux and windows (with gmt6 only observation files produces by Scintrex CG5 or CG6 	,
- single (one day) or complex survey (several days)	_
 observation with or without tide correction 	
 data with stations name alphanumeric absorved data file see be adited and medified 	
 observed data file can be edited and modified earth tide and instrumental drift corrections 	
- correction of height variations due to the levelling	
 precise coordinates can be used for long distance 	
 choice of the reference station and its value 	
 survey or unclosed loop available (between 2 base C file (calculated) with all corrected measurement 	s known)
- Chie (Calculated) with all confected measurement	T

The 'Help' tab allows access to the documentation in french, English and Spanish..

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Field Survey Tools	About Help		

- ✤ Documentation ("pdf" files) must be present in the directory \$CG6TOOL/pdf.
- Under *Linux*, if the \$CG6READER (PDF Reader) environment variable is not set then 'evince' is used by default.

1. Field survey processing

1.1. Gravity raw data with error (g_m, e)

- g_m is computed from GRAV (measured in DUR-REJ) and TIDE (respectively Grav, Dur #Rej and E.T.C. for a CG3 gravimeter).
- e is SD or estimated from SD and DUR-REJ.

$\mathbf{g}_{\mathbf{m}} = \mathbf{GRAV} - \mathbf{TIDE}$	$\mathbf{e} = SD \text{ or } SD \frac{SD}{\sqrt{DUR - REJ}}$
---	--

1.2. Earth tide correction ($\Delta Getc$)

• By default (CG6 option) CG6TOOL uses the *Earth Tide Correction* generated via the Longman formula and the header coordinates. With "Common Longman" or "Precise Longman" options, CG6TOOL computes new values. This is interesting if the header coordinates are false or if you want a different value per station.

1.3. Site correction (ΔGheight)

• To remove the height variations in the instrument leveling

$\Delta Gheight (mGal) = Hgrad . \Delta H (m)$	<i>Hgrad</i> = -0.3086 mGal/m (<i>default</i>)
	ΔH = height to benchmark

1.4. Drift correction (ΔG*drift*)

• **R**_{ij} is the **i** repetition at the station **j**

 t_{1j} (t_{ij}) the time at the **first** (i) measure at the station j

 $g_{1j}\left(g_{ij}\right) \text{ corrected gravity (etc,site) computed at time } t_{1j}\left(t_{ij}\right)$

 $e_{1j}(e_{ij})$ the error associated to $g_{1j}(g_{ij})$

$$\mathbf{R}_{ij} \{ \Delta T_{ij} = t_{ij} - t_{1j}, \ \Delta G_{ij} = g_{ij} - g_{1j}, \ E_{ij} = \sqrt{e_{ij}^2 + e_{1j}^2} \}$$

• The drift rate is defined by a least-squares fitting with all weighted gravity observations R_{ij} at reoccupied sites.

$$\begin{split} \sum_{\substack{1 \le i \le \text{iterations} \\ 1 \le j \le \text{stations}}} \left(\frac{\Delta G_{ij} - B - K \Delta T_{ij}}{Er_{ij}} \right)^2 &= \chi^2_{(K,B)} \text{ minimal} \\ S &= \sum_{\substack{1 \le j \le \text{stations}}} S_x = \sum_{\substack{1 \le i_j \\ E_{ij}^2}} S_y = \sum_{\substack{1 \le i_j \\ E_{ij}^2}} S_{xx} = \sum_{\substack{1 \le i_j \\ E_{ij}^2}} S_{xy} = \sum_{\substack{1 \le i_j \\ E_{ij}^2}}$$

• Drift correction

 $\Delta G drift = K \cdot \Delta T + B \qquad \Delta T = \text{Time with the first measure}$

1.6. Corrected gravity values (ΔG *cal*)

• The last column of the « c-file » (calculated file) contains for each measures the corrected gravity value $\Delta Gcal$.

```
\Delta Gcal = Gm + \Delta Getc + \Delta Gheight + \Delta Gdrift - \Delta Gcal_0
```

with $\Delta Gcal_{\theta}$ the first corrected value of the field survey

1.7. Averaged values of gravity (Gres)

• The «r-file » (result file) contains for each station a unique value averaged over all repetitions ($\Delta Gcal_i$, e_i).

$$Gres_{j} = \frac{\sum_{i}^{N} w_{i} \Delta Gcal_{i}}{\sum_{i}^{N} w_{i}} + G_{0} \quad with w_{i} = \frac{1}{e_{i}^{2}} \text{ and } G_{0} = Gravity Base$$

$$EP_{j} = \sqrt{\frac{\sum_{i}^{N} w_{i} \Delta Gcal_{i}^{2}}{\sum_{i}^{N} w_{i}}} - Gres_{j}^{2} = \text{weighted error}$$

$$No \text{ reiteration of the station j} : \qquad Eres_{j} = \sqrt{e_{i}^{2} + SD^{2}}$$

$$\underline{Reitered \text{ station j but no reoccupied}} : \qquad Eres_{j} = \sqrt{EP_{j}^{2} + SD^{2}}$$

$$\underline{Reoccupied \text{ station j } (\exists \Delta \underline{Ti} > \underline{REOCDT})} : \quad Eres_{j} = \sqrt{EP_{j}^{2}}$$

2. Gravity Network Adjustment

1.1. Scaling factors computing

- Absolute data read in « *config-file* »
- Relative data read in *«c-file »* or *«r-file »*
- Gravity variation between stations are computed for each file.
- The segments $(\Delta G_i, \Delta E_i)$ reoccupied are averaged (by gravimeter)

$$\overline{\Delta G}_{j} = \frac{\sum_{1}^{N} w_{i} \Delta G_{i}}{\sum_{1}^{N} w_{i}} \quad avec \ w_{i} = \frac{1}{\Delta E_{i}^{2}} \quad for \ N \ identicals \ segments$$
$$\overline{\Delta E}_{j} = \sqrt{\frac{\sum_{1}^{N} w_{i} \Delta G_{i}^{2}}{\sum_{1}^{N} w_{i}} - \overline{\Delta G}_{j}^{2}}$$

• **STEP 1** : The set of common segments to two gravimeters allows to compute by least-squares method the scaling factors : **Gr** (*reference*) = **b** + **k** . **Gc** (*calibrated*).

We calculate
$$\mathbf{X} = \begin{bmatrix} \mathbf{k} \\ \mathbf{b} \end{bmatrix} = (\mathbf{G}\mathbf{c}^{\mathsf{T}}\mathbf{W}\mathbf{G}\mathbf{r})^{-1} \mathbf{G}\mathbf{c}^{\mathsf{T}} \mathbf{W} \mathbf{G}\mathbf{r}$$

$$\mathbf{W} = \begin{bmatrix} \frac{1}{\Delta \mathbf{F}\mathbf{r}_{1}^{2} + \Delta \mathbf{E}\mathbf{c}_{1}^{2}} & \cdots & \mathbf{0} \\ \vdots & \ddots & \vdots \\ \mathbf{0} & \cdots & \frac{1}{\Delta \mathbf{E}\mathbf{r}_{n}^{2} + \Delta \mathbf{E}\mathbf{c}_{n}^{2}} \end{bmatrix} = weight \ matrix$$

$$\mathbf{G}\mathbf{c} = \begin{bmatrix} \frac{\Delta \mathbf{G}\mathbf{c}_{1} & \mathbf{1}}{\Delta \mathbf{G}\mathbf{c}_{2} & \mathbf{1}} \\ \vdots & \vdots \\ \Delta \mathbf{G}\mathbf{c}_{n} & \mathbf{1} \end{bmatrix} \quad \mathbf{G}\mathbf{r} = \begin{bmatrix} \frac{\Delta \mathbf{G}\mathbf{r}_{1}}{\Delta \mathbf{G}\mathbf{r}_{2}} \\ \vdots \\ \Delta \mathbf{G}\mathbf{r}_{n} \end{bmatrix} \quad \mathbf{R} = \mathbf{G}\mathbf{c} \cdot \mathbf{X} - \mathbf{G}\mathbf{r} = residues$$

$$\widehat{\sigma}_{0}^{2} \text{ the variance estimation} : \widehat{\sigma}_{0}^{2} = \frac{R^{T}WR}{n-2}$$

$$\overline{W} \text{ the "normalized" weight matrix } \overline{W} = \frac{W}{\widehat{\sigma}_{0}^{2}}$$

$$\mathbf{C} = \begin{bmatrix} \sigma_{k}^{2} & \mathbf{0} \\ \mathbf{0} & \sigma_{b}^{2} \end{bmatrix} = (\mathbf{G}\mathbf{c}^{\mathsf{T}}\overline{W}\mathbf{G}\mathbf{c})^{-1} = Normalized \ covariance \ matrix$$

$$\sigma = \sqrt{\frac{R^{T}R}{n-2}} = Standard \ deviation$$

• **STEP 2** : To eliminate the "outliers" observations

Step 1:	Scaling factors $k_1,\ b_1$ and the standard deviation σ_1
Step 2:	19 repetition of « Step 1 » to eliminate the observations ($\overline{\Delta Gr}, \overline{\Delta Gc}$)
	if $Residues_{i+1} = \overline{\Delta Gr} - k_i \overline{\Delta Gc} - b_i \ge 3 \sigma_i$

• STEP 3 : Student test to evaluate the hypothesis $b_{20}=0$ (greater than 95%)

• STEP 4 : To compute the scaling factor k only with observations selected in the Step 2 and b=0 : Gr (*reference*) = k . Gc (*calibrated*).

$$\mathbf{K} = [\mathbf{k}] = (\mathbf{G}\mathbf{c}^{\mathrm{T}}\mathbf{W}\mathbf{G}\mathbf{c})^{-1} \mathbf{G}\mathbf{c}^{\mathrm{T}} \mathbf{W} \mathbf{G}\mathbf{r}$$

$$\mathbf{W} = \begin{bmatrix} \frac{1}{\Delta \mathbf{E}\mathbf{r}_{1}^{2} + \Delta \mathbf{E}\mathbf{c}_{1}^{2}} & \cdots & \mathbf{0} \\ \vdots & \ddots & \vdots \\ \mathbf{0} & \cdots & \frac{1}{\Delta \mathbf{E}\mathbf{r}_{n}^{2} + \Delta \mathbf{E}\mathbf{c}_{n}^{2}} \end{bmatrix} = weight \ matrix$$

$$\mathbf{G}\mathbf{c} = \begin{bmatrix} \overline{\Delta \mathbf{G}\mathbf{c}}_{1} \\ \overline{\Delta \mathbf{G}\mathbf{c}}_{2} \\ \vdots \\ \overline{\Delta \mathbf{G}\mathbf{c}}_{n} \end{bmatrix} \quad \mathbf{G}\mathbf{r} = \begin{bmatrix} \overline{\Delta \mathbf{G}\mathbf{r}}_{1} \\ \overline{\Delta \mathbf{G}\mathbf{r}}_{2} \\ \vdots \\ \overline{\Delta \mathbf{G}\mathbf{c}}_{n} \end{bmatrix} \quad \mathbf{R} = \mathbf{G}\mathbf{c} \cdot \mathbf{K} - \mathbf{G}\mathbf{r} = residues \ matrix$$

$$\widehat{\boldsymbol{\sigma}}_{0}^{2} \ \text{the variance estimation} : \ \widehat{\boldsymbol{\sigma}}_{0}^{2} = \frac{R^{T}WR}{n-1}$$

$$\overline{W} \ \text{the "normalized" weight matrix } \overline{W} = \frac{W}{\overline{\sigma}_{0}^{2}}$$

$$\boldsymbol{\sigma}_{k}^{2} = (\mathbf{G}\mathbf{c}^{\mathrm{T}}\overline{W}\mathbf{G}\mathbf{c})^{-1} \qquad \boldsymbol{\sigma} = \sqrt{\frac{R^{T}R}{n-1}}$$

1.2. Network adjustment

The gravity network contains n_{sta} stations. We have n_{seg} relative observations and n_{abs} absolute stations known :

• STEP 1 : Calculate a value for the <u>base</u> (first station) of each file (or traverse). <u>Only are used</u> the absolutes measures **a**_i and the traverses which base is an **absolute stations** (read in *config_file*).

To compute
$$[\mathbf{S}_k]$$
 with $[\mathbf{W}_{ii}] [\mathbf{C}_{ik}] [\mathbf{S}_k] = [\mathbf{W}_{ii}] [\mathbf{G}_i]$
 \mathbf{S}_k absolute station : $\mathbf{G}_i = (\mathbf{a}_i, \mathbf{e}_i)$ with $(\mathbf{a}_i, \mathbf{e}_i)$ read in *config_file*
 $\mathbf{C}_{ik} = \mathbf{1}$ and $\mathbf{C}_{ij} = \mathbf{0} (\mathbf{j} \neq \mathbf{k})$ $\mathbf{W}_{kk} = \frac{1}{e_i^2}$ and $\mathbf{W}_{ii} = \mathbf{0} (\mathbf{i} \neq \mathbf{k})$
Segment $\mathbf{S}_b(\mathbf{g}_{i1,}\mathbf{e}_{i1}) \equiv \mathbf{S}_k(\mathbf{g}_{i2,}\mathbf{e}_{i2})$: $\mathbf{W}_{ii} = \frac{1}{e_{i1}^2 + e_{i2}^2}$ and $\mathbf{W}_{ij} = \mathbf{0} (\mathbf{i} \neq \mathbf{j})$
 \mathbf{S}_b an absolute station $(\mathbf{a}_b, \mathbf{e}_b)$ read in *config_file*
 $\mathbf{S}_k = \mathbf{S}_b(\text{Reocupation})$: $\mathbf{G}_i = \mathbf{S}_b(\mathbf{a}_b, \mathbf{e}_b) + \Delta \mathbf{g}_{i1i2} \times \mathbf{k}_g$
 $\mathbf{C}_{ib} = \mathbf{1}$ and $\mathbf{C}_{ij} = \mathbf{0} (\mathbf{j} \neq \mathbf{b})$
 $\mathbf{S}_b \neq \mathbf{S}_k$: $\mathbf{G}_i = \Delta \mathbf{g}_{i1i2} \times \mathbf{k}_g$ with \mathbf{k}_g scaling factor
 $\mathbf{C}_{ib} = \mathbf{1}$, $\mathbf{C}_{ib} = -\mathbf{1}$ and $\mathbf{C}_{ij} = \mathbf{0} (\mathbf{j} \neq \mathbf{b} \neq \mathbf{k})$
 $[\mathbf{R}_i] = [\mathbf{C}_{ik}] [\mathbf{S}_k] - [\mathbf{G}_i]$ $\sigma = \sqrt{\frac{\mathbf{R}^T \mathbf{R}}{n_{seg} - n_{stg}}}$

• **STEP 2** : <u>Only if all stations have not been determined in step 1</u>. All the network bases have a value (absolute or adjusted in step 1) and we use all the observations.

To compute $[\mathbf{S}_k]$ with $[\mathbf{W}_{ii}] [\mathbf{C}_{ik}] [\mathbf{S}_k] = [\mathbf{W}_{ii}] [\mathbf{G}_i]$ S_k absolute station : $G_i = (a_i, e_i)$ with (a_i, e_i) read in *config_file* $\mathbf{C}_{ik} = \mathbf{1}$ and $\mathbf{C}_{ij} = \mathbf{0}$ (j \neq k) $\mathbf{W}_{kk} = \frac{1}{e_i^2}$ and $\mathbf{W}_{ii} = \mathbf{0}$ (i \neq k) Segment $S_b(g_{i1}, e_{i1}) \equiv S_k(g_{i2}, e_{i2})$: $S_k = S_b$ (reoccupation) and S_b absolute station (a_b, e_b) : $\mathbf{G}_{\mathbf{i}} = \mathbf{S}_{\mathbf{b}}(\mathbf{a}_{\mathbf{b}},\mathbf{e}_{\mathbf{b}}) + \Delta \mathbf{g}_{\mathbf{i}\mathbf{1}\mathbf{i}\mathbf{2}} \times \mathbf{k}_{\mathbf{g}}$ (scaling factor) $\mathbf{C}_{ib} = \mathbf{1}$ and $\mathbf{C}_{ii} = \mathbf{0}$ (j \neq b) $W_{ii} = \frac{1}{e_{i1}^2 + e_{i2}^2}$ and $W_{ij} = 0$ (i \neq j) $S_k = S_b$ (reoccupation) and S_b ajusted station (g_a, e_a): $\mathbf{G}_{\mathbf{i}} = \mathbf{S}_{\mathbf{b}}(\mathbf{g}_{\mathbf{a}},\mathbf{e}_{\mathbf{a}}) + \Delta \mathbf{g}_{\mathbf{i}\mathbf{1}\mathbf{i}\mathbf{2}} \times \mathbf{k}_{\mathbf{a}}$ (scaling factor) $\mathbf{C}_{ib} = \mathbf{1}$ and $\mathbf{C}_{ii} = \mathbf{0}$ (j \neq b) $W_{ii} = \frac{1}{e_{i1}^2 + e_{i2}^2 + e_a^2}$ and $W_{ij} = 0$ (i \neq j) $\mathbf{S_b} \neq \mathbf{S_k}: \ \mathbf{G_i} = \Delta \mathbf{g_{i1i2}} \times \mathbf{k_g} \qquad \mathbf{W_{ii}} = \frac{1}{e_{i1}^2 + e_{i2}^2} \text{ and } \mathbf{W_{ij}} = \mathbf{0} \ (i \neq j)$ $C_{ib} = 1$, $C_{ib} = -1$ and $C_{ij} = 0$ (j \neq b \neq k) $\sigma = \sqrt{\frac{R^T R}{n_{seg} - n_{sta}}}$ $[\mathbf{R}_i] = [\mathbf{C}_{ik}] [\mathbf{S}_k] - [\mathbf{G}_i]$

• **STEP 3**: Another iteration can be realized <u>only</u> if the **ADJNSIG** keyword is initialized in the *config_file*.

Step 1 (and Step 2): $\sigma = \sqrt{\frac{R^T R}{n_{seg} - n_{sta}}}$ We compute $[\mathbf{S}_k]$: $[\mathbf{W}_{ii}] [\mathbf{C}_{ik}] [\mathbf{S}_k] = [\mathbf{W}_{ii}] [\mathbf{G}_i]$ All the *relative* observations \mathbf{G}_i with residue $[\mathbf{R}_i] = [\mathbf{C}_{ik}] [\mathbf{S}_k] - [\mathbf{G}_i]$

are eliminated if $R_i > ADJNSIG * \sigma$

- [1] Germinal Gabalda, Sylvain Bonvalot, and Roger Hipkin. CG3TOOL: an interactive computer program to process Scintrex CG3/3M gravity data for high-resolution applications. *Computer & Geosciences*, 29 (2003) 155-171. DOI:<u>10.1016/S0098-3004(02)00114-0</u>
- [2] Longman, I.M., 1959, Formulas for computing the tidal acceleration due to the moon and the sun. *Journal of Geophysical Research* 64, 2351-2355
- [3] Scintrex, CG-3/3M Autograv, Automated Gravity Meter, Operator Manual, PN:858700, Version 5.0, August 1995, Scintrex Ltd., Concord, Ontario
- [4] Scintrex, CG-5, Scintrex Autograv System, Operation Manual, part #867711 Rev. 2, August 2009, Concord, Ontario
- [5] CG-6 Autograv[™] Gravity Meter, Operation Manual, p/n 115370001 Rev. B, March 2, 2018, Concord, Ontario
- [6] Wessel, P., W. H. F. Smith, R. Scharroo, J. F. Luis, and F. Wobbe, Generic Mapping Tools: Improved version released, *EOS Trans. AGU*, 94, 409-410, 2013. <u>doi:10.1002/2013EO450001</u>.