EOL
LAND DATA FORMAT
RECORD DESCRIPTION
126 characters

EOL files are made of fixed-length ASCII records. Each record is separated into space-padded fields. When a field has no known value (for example, anomalies are not always provided), it contains only spaces.

ISOURCE 1-8 B.G.I. source number (8 char.)

LATI 9-16 Latitude (unit : 10^{-5} degree) (8 char.)

LONGI 17-25 Longitude (unit : 10^{-5} degree) (9 char.)

POSIAC 26-27 Accuracy of position (2 char.)
The site of the gravity measurements is defined in a circle of radius R
0 = no information
1 = R <= 5 m
2 = 5 < R <= 20 m (approximately 0'01)
3 = 20 < R <= 100 m
4 = 100 < R <= 200 m (approximately 0'1)
5 = 200 < R <= 500 m
6 = 500 < R <= 1000 m
7 = 1000 < R <= 2000 m (approximately 1')
8 = 2000 < R <= 5000 m
9 = 5000 m < R
10 ...

POSISYS 28-29 System of positioning (2 char.)
0 = no information
1 = topographical map
2 = trigonometric positioning
3 = satellite

OBSERTYP 30 Type of observation (1 char.)
1 = current observation of detail or other observations of a 3rd or 4th order network
2 = observation of a 2nd order national network
3 = observation of a 1st order national network
4 = observation being part of a nation calibration line
5 = coastal ordinary observation (harbour, bay, seaside ...)
6 = harbour base station

ALTI 31-38 Elevation of the station (unit : 10^{-2} m) (8 char.)

ALTITYP 39-40 Elevation type (2 char.)
1 = Land
2 = Subsurface
3 = Lake surface (above sea level)
4 = Lake bottom (above sea level)
5 = Lake bottom (below sea level)
6 = Lake surface (above sea level with lake bottom below sea level)
7 = Lake surface (below sea level)
8 = Lake bottom (surface below sea level)
9 = Ice cap (bottom below sea level)
10 = Ice cap (bottom above sea level)
11 = Ice cap (no information about ice thickness)

ALTIAC	41-42	Accuracy of elevation 0 = no information 1 = E <= 0.02 m 2 = .02 < E <= 0.1 m 3 = .1 < E <= 1 4 = 1 < E <= 2 5 = 2 < E <= 5 6 = 5 < E <= 10 7 = 10 < E <= 20 8 = 20 < E <= 50 9 = 50 < E <= 100 10 = E > 100 m	(2 char.)
ALTIDET	43-44	Determination of the elevation 0 = no information 1 = geometrical levelling (bench mark) 2 = barometrical levelling 3 = trigonometrical levelling 4 = data obtained from topographical map 5 = data directly appreciated from the mean sea level 6 = data measured by the depression of the horizon 7 = satellite	(2 char.)
ALTISUP	45-52	Supplemental elevation (unit : 10^{-2} m) if ALTITYP = 1, ALTISUP=0 if ALTITYP > 1 and ALTITYP <= 8, ALTISUP = lake depth if ALTITYP > 8, ALTISUP = ice width	(8 char.)
GVALUE	53-61	Observed gravity (unit : 10^{-3} mGal)	(9 char.)
FREEAIR	62-67	Free air anomaly (unit : 10^{-2} mGal)	(6 char.)
BOUGUER	68-73	Bouguer anomaly (unit : 10^{-2} mGal) Simple Bouguer anomaly with a mean density of 2670 kg/m^3. No terrain correction	(6 char.)
FREEAST	74-76	Estimation standard deviation free-air anomaly (unit : 0.1 mGal)	(3 char.)
BOUGST	77-79	Estimation standard deviation bouguer anomaly (unit : 0.1 mGal)	(3 char.)
TERCOR	80-85	Terrain correction (unit : 10^{-2} mGal) computed according to the next mentioned radius & density	(6 char.)
TERCORINF	86-87	Information about terrain correction 0 = no topographic correction 1 = tc computed for a radius of 5 km (zone H) 2 = tc computed for a radius of 30 km (zone L) 3 = tc computed for a radius of 100 km (zone N) 4 = tc computed for a radius of 167 km (zone 02) 11 = tc computed from 1 km to 167 km 12 = tc computed from 2.5 km to 167 km 13 = tc computed from 5.2 km to 167 km 14 = tc (unknown radius) 15 = tc computed to zone M (22 km) 16 = tc computed to zone G 17 = tc computed to zone K (18.8 km) 25 = tc computed to 48.6 km on a curved Earth 26 = tc computed to 64. km on a curved Earth	(2 char.)
DENSITY	88-91	Density used for terrain correction (unit : 10^1 kg/m^3 ; e.g. 267)	(4 char.)
GACCU	92-93	Accuracy of gravity 0 = no information 1 = E <= 0.01 mGal	(2 char.)

		2 = .01 < E <= 0.05 mGal 3 = .05 < E <= 0.1 mGal 4 = 0.1 < E <= 0.5 mGal 5 = 0.5 < E <= 1. mGal 6 = 1. < E <= 3. mGal 7 = 3. < E <= 5. mGal 8 = 5. < E <= 10 mGal 9 = 10. < E <= 15. mGal 10 = 15. < E <= 20. mGal 11 = 20. < E mGal	
GCOR	94-99	Correction of observed gravity (unit : 10^{-3} mGal)	(6 char.)
REFSTA	100-105	Reference station This station is the base station (BGI number) to which the concerned station is referred.	(6 char.)
APPARAT	106-108	Apparatus used for the measurement of G 0.. no information 1.. pendulum apparatus before 1960 2.. latest pendulum apparatus (after 1960) 3.. gravimeters for ground measurements in which the variations of G are equilibrated or detected using the following methods : 30 = torsion balance (Thyssen ...) 31 = elastic rod 32 = bifilar system 34 = Boliden (Sweden) 4.. Metal spring gravimeters for ground measurements 41 = Frost 42 = Askania (GS-4-9-11-12), Graf 43 = Gulf, Hoyt (helical spring) 44 = North American 45 = Western 47 = Lacoste-Romberg 48 = Lacoste-Romberg, Model D (microgravimeter) 5.. Quartz spring gravimeter for ground measurements 51 = Norgaard 52 = GAE-3 53 = Worden ordinary 54 = Worden (additional thermostat) 55 = Worden worldwide 56 = Gak 57 = Canadian gravity meter, sharpe 58 = GAG-2 59 = SCINTREX CG2 6.. Gravimeters for under water measurements (at the bottom of the sea or of a lake) 60 = Gulf 62 = Western 63 = North American 64 = Lacoste-Romberg 9.. Absolute gravimeter 91 = JAEGER GA60	(3 char.)
PAYS	109-111	Country code (BGI)	(3 char.)
CONFID	112	Confidentiality 0 = no restriction 1 = with authorization 2 = classified	(1 char.)
VALID	113	Validity 0 = no validation	(1 char.)

		1 = good 2 = doubtful 3 = lapsed	
NBORIGI	114-120	Numbering of the station (original)	(7 char.)
NBSEQ	121-126	Sequence number	(6 char.)

EOS
SEA DATA FORMAT
RECORD DESCRIPTION
150 characters

EOS files are made of fixed-length ASCII records similar to EOL records.

ISOURCE	1-8	B.G.I. source number	(8 char.)
LATI	9-16	Latitude (unit : 10^{-5} degree)	(8 char.)
LONGI	17-25	Longitude (unit : 10^{-5} degree)	(9 char.)
POSIAC	26-27	Accuracy of position The site of the gravity measurements is defined in a circle of radius R 0 = no information 1 = R <= 5 m 2 = 5 < R <= 20 m (approximately 0'01) 3 = 20 < R <= 100 m 4 = 100 < R <= 200 m (approximately 0'1) 5 = 200 < R <= 500 m 6 = 500 < R <= 1000 m 7 = 1000 < R <= 2000 m (approximately 1') 8 = 2000 < R <= 5000 m 9 = 5000 m < R 10 ...	(2 char.)
POSISYS	28-29	System of positioning 0 = no information 1 = Decca 2 = visual observation 3 = radar 4 = loran A 5 = loran C 6 = omega or VLF 7 = satellite 8 = solar/stellar (with sextant) 9 = GPS 10 = Kinematic navigation 11 = ARGOS	(2 char.)
OBSERTYP	30	Type of observation 1 = individual observation at sea 2 = mean observation at sea obtained from a continuous recording	(1 char.)
ALTI	31-38	Elevation of the station (unit : 10^{-2} m)	(8 char.)
ALTITYP	39-40	Elevation type 1 = ocean surface 2 = ocean submerged 3 = ocean bottom	(2 char.)
ALTIAC	41-42	Accuracy of elevation 0 = no information 1 = E <= 0.02 m 2 = .02 < E <= 0.1 m	(2 char.)

3 = .1 < E <= 1
4 = 1 < E <= 2
5 = 2 < E <= 5
6 = 5 < E <= 10
7 = 10 < E <= 20
8 = 20 < E <= 50
9 = 50 < E <= 100
10 = E > 100 m

ALTIDET 43-44 Determination of the elevation (2 char.)

0 = no information
1 = depth obtained with a cable (meters)
2 = manometer depth
3 = corrected acoustic depth (corrected from Mathew's tables, 1939)
4 = acoustic depth with correction obtained with sound speed 1500 M/sec. (or 820 fathom/s)
5 = acoustic depth obtained with sound speed 1463 m/s (800 fathom/s)
6 = depth interpolated on a magnetic record
7 = depth interpolated on a chart

ALTISUP 45-52 Supplemental elevation (unit : 10^{-2} m) (8 char.)

GVALUE 53-61 Observed gravity (unit : 10^{-3} mGal) (9 char.)

FREEAIR 62-67 Free air anomaly (unit : 10^{-2} mGal) (6 char.)

BOUGUER 68-73 Bouguer anomaly (unit : 10^{-2} mGal) (6 char.)

Simple Bouguer anomaly with a mean density of 2670 kg/m^3. No terrain correction

FREEAST 74-76 Estimation standard deviation free-air anomaly (unit : 0.1 mGal) (3 char.)

BOUGST 77-79 Estimation standard deviation bouguer anomaly (unit : 0.1 mGal) (3 char.)

TERCOR 80-85 Terrain correction (unit : 10^{-2} mGal) (6 char.)

computed according to the next mentioned radius & density

TERCORINF 86-87 Information about terrain correction (2 char.)

0 = no topographic correction
1 = tc computed for a radius of 5 km (zone H)
2 = tc computed for a radius of 30 km (zone L)
3 = tc computed for a radius of 100 km (zone N)
4 = tc computed for a radius of 167 km (zone 02)
11 = tc computed from 1 km to 167 km
12 = tc computed from 2.5 km to 167 km
13 = tc computed from 5.2 km to 167 km
14 = tc (unknown radius)
15 = tc computed to zone M (22 km)
16 = tc computed to zone G
17 = tc computed to zone K (18.8 km)
25 = tc computed to 48.6 km on a curved Earth
26 = tc computed to 64. km on a curved Earth

DENSITY 88-91 Density used for terrain correction (unit : 10^1 kg/m^3 ; e.g. 267) (4 char.)

MATHZONE 92-93 Mathew's zone (2 char.)

When the depth is not corrected depth, this information is necessary. For example : zone 50 for the Eastern Mediterranean Sea.

GACCU 94-95 Accuracy of gravity (2 char.)

0 = no information
1 = E <= 0.01 mGal
2 = .01 < E <= 0.05 mGal
3 = .05 < E <= 0.1 mGal
4 = 0.1 < E <= 0.5 mGal

		5 = 0.5 < E <= 1. mGal 6 = 1. < E <= 3. mGal 7 = 3. < E <= 5. mGal 8 = 5. < E <= 10 mGal 9 = 10. < E <= 15. mGal 10 = 15. < E <= 20. mGal 11 = 20. < E mGal	
GCOR	96-101	Correction of observed gravity (unit : 10^{-3} mGal)	(6 char.)
JDATE	102-110	Date of observation In Julian day (unit : 1/10 000 of day) - 2 400 000	(9 char.)
VELOCY	111-113	Velocity of the ship (unit : 0.1 knot)	(3 char.)
EOTVOS	114-118	Eötvös correction (unit : 0.1 mGal)	(5 char.)
PAYS	119-121	Country code (BGI)	(3 char.)
CONFID	122	Confidentiality 0 = no restriction 1 = with authorization 2 = classified	(1 char.)
VALID	123	Validity 0 = no validation 1 = good 2 = doubtful 3 = lapsed	(1 char.)
NBORIGI	124-130	Numbering of the station (original)	(7 char.)
NBSEQ	131-136	Sequence number	(6 char.)
NBLEG	137-139	Leg number	(3 char.)
REFSTA	140-145	Reference station	(6 char.)
NUMDEG	146-150		(5 char.)

Whenever given, the theoretical gravity (γ_0), free-air anomaly (FA), Bouguer anomaly (BO) are computed in the 1967 geodetic reference system.

The approximation of the closed form of the 1967 gravity formula is used for theoretical gravity at sea level :

$$\gamma_0 = 978031.85 * \left[1 + 0.005278895 * \sin^2\Phi + 0.000023462 \sin^4\Phi\right] \text{ mGal}$$

where Φ is the geographic latitude.

The formulas used in computing FA and BO are summarized in the next pages.

Formulas used in computing free-air and Bouguer anomalies

Symbols used :

g	*: observed value of gravity*
γ	*: theoretical value of gravity (on the ellipsoid)*
Γ	*: vertical gradient of gravity (approximated by 0.3086 mGal/m)*
H	*: elevation of the physical surface of the land, lake or glacier (H = 0 at sea surface), positive upward*
D_1	*: depth of water, or ice, positive downward*
D_2	*: depth of a gravimeter measuring in a mine, in a lake, or in an ocean, counted from the surface, positive downward*
G	*: gravitational constant* ($667.2\ 10^{-13}\ m^3\ kg^{-1}\ s^{-2}$) $\Rightarrow k = 2\ \pi\ G$
ρ_c	*: mean density of the Earth's crust (taken as 2670 kg* m^{-3}*)*
ρ_w^f	*: density of fresh water (1000 kg* m^{-3}*)*
ρ_w^s	*: density of salted water (1027 kg* m^{-3}*)*
ρ_i	*: density of ice (917 kg* m^{-3}*)*
FA	*: free-air anomaly*
BO	*: Bouguer anomaly*

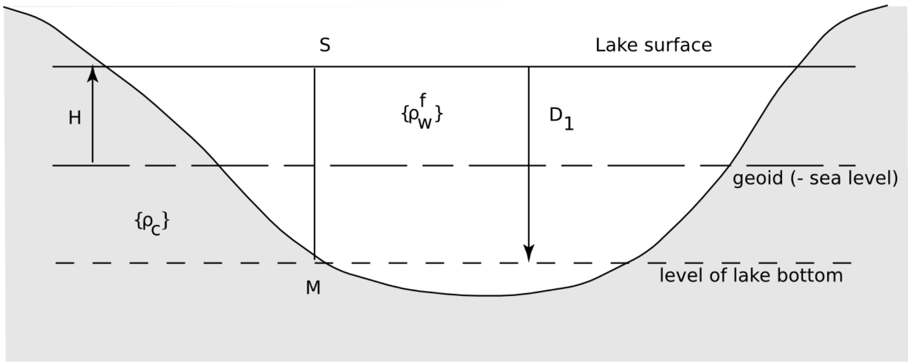
Formulas :

* *FA : The principle is to compare the gravity of the Earth at its surface with the normal gravity, which first requires in some cases to derive the surface value from the measured value. Then, and until now, FA is the difference between this Earth's gravity value reduced to the geoid and the normal gravity* γ_o *computed on the reference ellipsoid (classical concept). The more modern concept* in which the gravity anomaly is the difference between the gravity at the surface point and the normal (ellipsoidal) gravity on the telluroid corresponding point may be adopted in the future depending on other major changes in the BGI data base and data management system.*

* *BO : The basic principle is to remove from the surface gravity the gravitational attraction of one (or several) infinite plate(s) with density depending on where the plate is with respect to the geoid. The conventional computation of BO assumes that parts below the geoid are to be filled with crustal material of density* ρ_c *and that the parts above the geoid have the density of the existing material (which is removed).*

<u>For example,</u> if a measurement g_M *is taken at the bottom of a lake, with the bottom being below sea level, we have :*

* cf. "On the definition and numerical computation of free air gravity anomalies", by H.G. Wenzel. Bulletin d'Information, BGI, n° 64, pp. 23-40, June 1989.



$$g_s = g_M + 2k\rho_w^f D_1 - \Gamma D_1$$
$$FA = g_S + \Gamma H - \gamma_O$$

Removing the (actual or virtual) topographic masses as said above, we find :

$$\begin{aligned}\delta g_s &= g_s - k\rho_w^f D_1 + k\rho_c (D_1 - H) \\ &= g_s - k\rho_w^f [H + (D_1 - H)] + k\rho_c (D_1 - H) \\ &= g_s - k\rho_w^f H + k(\rho_c - \rho_w^f)(D_1 - H)\end{aligned}$$

$$BO = \delta g_s + \Gamma H - \gamma_0$$

The table below covers the most frequent cases. It is an update of the list of formulas published before.

It may be noted that, although some formulas look different, they give the same results. For instance BO (9) and BO (10) are identical since :

$$\begin{aligned}-k\rho_{iH} + k(\rho_c - \rho_i)(D_1 - H) &\equiv -k\rho_i (H - D_1 + D_1) - k(\rho_c - \rho_i)(H - D_1) \\ &\equiv -k\rho_i D_1 - k\rho_c (H - D_1)\end{aligned}$$

Similarly, BO (3), BO (4) and BO (5) are identical.

Elev. Type	Situation	Formulas
EOL land data format		
1	Land Observation-surface	$FA = g + \Gamma H - \gamma_O$ $BO = FA - k\,\rho_C\,H$
2	Land Observation-subsurface	$FA = g + 2\,k\,\rho_C\,D_2 + \Gamma(H - D_2) - \gamma_O$ $BO = FA - k\,\rho_C\,H$
3	Lake surface above sea level with bottom above sea level	$FA = g + \Gamma H - \gamma_O$ $BO = FA - k\,\rho_w^f\,D_1 - k\,\rho_C\,(H - D_1)$
4	Lake bottom, above sea level	$FA = g + 2\,k\,\rho_w^f\,D_1 + \Gamma(H - D_1) - \gamma_O$ $BO = FA - k\,\rho_w^f\,D_1 - k\,\rho_C\,(H - D_1)$
5	Lake bottom, below sea level	$FA = g + 2\,k\,\rho_w^f\,D_1 + \Gamma(H - D_1) - \gamma_O$ $BO = FA - k\,\rho_w^f\,H + k(\rho_c - \rho_w^s)\,(D_1 - H)$
6	Lake surface above sea level with bottom below sea level	$FA = g + \Gamma H - \gamma_O$ $BO = FA - k\,\rho_w^f\,H + k(\rho_c - \rho_w^s)\,(D_1 - H)$
7	Lake surface, below sea level (here $H < 0$)	$FA = g + \Gamma H - \gamma_O$ $BO = FA - k\,\rho_C H + k(\rho_c - \rho_w^f)\,D_1$
8	Lake bottom, with surface below sea level ($H < 0$)	$FA = g + (2\,k\,\rho_w^f - \Gamma)\,D_1 + \Gamma H - \gamma_O$ $BO = FA - k\,\rho_C H + k(\rho_c - \rho_w^f)\,D_1$
9	Ice cap surface, with bottom below sea level	$FA = g + \Gamma H - \gamma_O$ $BO = FA - k\,\rho_i\,H + k\,(\rho_C - \rho_i)\,(D_1 - H)$
10	Ice cap surface, with bottom above sea level	$FA = g + \Gamma H - \gamma_O$ $BO = FA - k\,\rho_i\,D_1 - k\,\rho_C\,(H – D_1)$
EOS sea data format		
1	Ocean Surface	$FA = g - \gamma_O$ $BO = FA + k(\rho_c - \rho_w^s)\,D_1$
2	Ocean submerged	$FA = g + (2k\,\rho_w^s - \Gamma)\,D_2 - \gamma_O$ $BO = FA + k(\rho_c - \rho_w^s)\,D_1$
3	Ocean bottom	$FA = g + (2k\,\rho_w^s - \Gamma)\,D_1 - \gamma_O$ $BO = FA + k(\rho_c - \rho_w^s)\,D_1$