

Lecture 3.5. Statistical analysis of gravity data.

Histogram

Auto-covariance function

Analytic representation

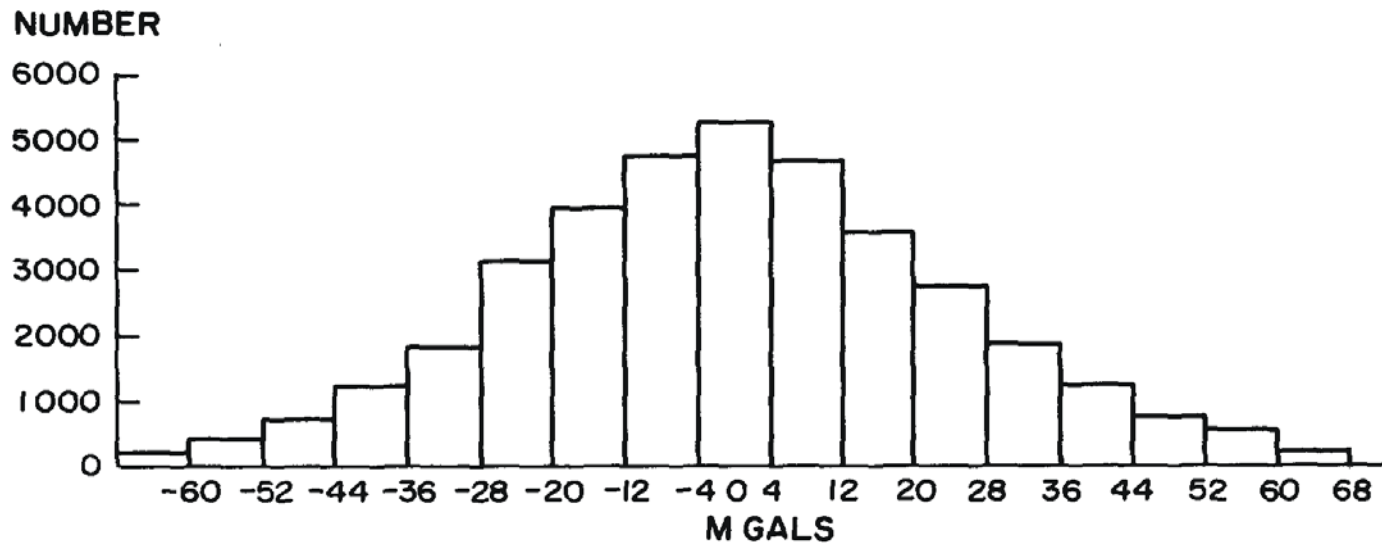


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Histogram: Global distribution.

Describes distribution of repeated observations. Repeated at different times or locations.

Example: Distribution of Global 1 deg. X 1 deg. Mean gravity anomalies: Normally distributed.



Histogram: local distribution.

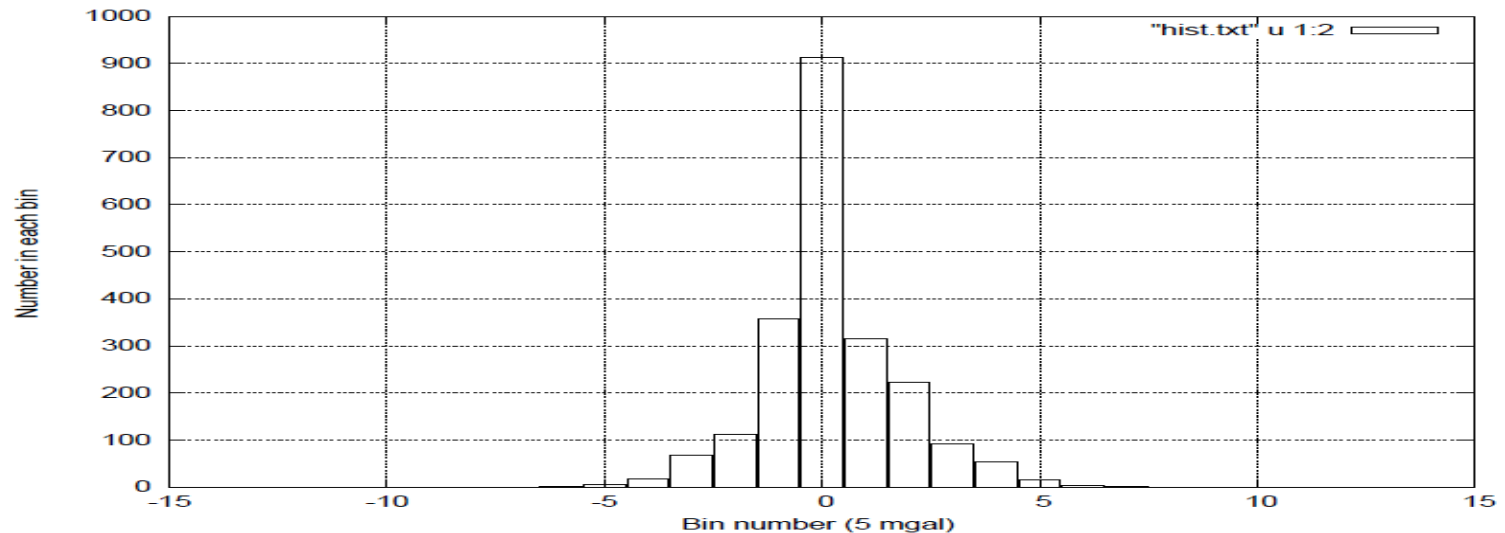
Output from GRAVSOF module EMPCOV:

Example of using KSA dataset, from which has been subtracted EGM2008 and residual topography (RTM):

NUMBER OF OBS 1= 2181 MEAN = -1.29 VAR. = 92.05

HISTOGRAM, USING BIN SIZE= 5.000

0 0 0 0 0 2 6 18 67 112 357 912 316 223 93 54 16 3 2 0 0 0 0



Preparation: Covariance estimation by hand !.

The following data must be used, with format: number, latitude, longitude, altitude and gravity anomaly in mgal.

11	56.0	10.0	0.0	4.0
12	56.1	10.0	0.0	2.0
13	56.2	10.0	0.0	0.0
14	56.3	10.0	0.0	-2.0
15	56.4	10.0	0.0	-4.0
16	56.5	10.0	0.0	-6.0
17	56.6	10.0	0.0	-8.0
18	56.7	10.0	0.0	-9.0
19	56.8	10.0	0.0	-7.0
20	56.9	10.0	0.0	-5.0
21	57.0	10.0	0.0	-3.0
22	57.1	10.0	0.0	-1.0
23	57.2	10.0	0.0	1.0
24	57.3	10.0	0.0	5.0
25	57.4	10.0	0.0	4.0



Preparation: Covariance estimation exercise.

- Compute the empirical gravity anomaly covariance function using the program **EMPCOV** for the New Mexico area both for the anomalies minus EGM96 and for the anomalies from which also RTM-effects have been subtracted (input files nmfa-egm96.dat and nmfa-egm96-tc.dat).



Preparation: Covariance estimation by EMPCOV

EMPCOV - Emperical Covariance Estimation

Input data filename:

data/nmfa-egm96-tc.dat

Input position of data element :

3

Input sample intervalsize (arcmin):

2.5

Input number of sampling intervals:

30

Configure parameters

Should mean value be subtracted:

Yes

No

Should data in subarea be used:

Yes

No

Input area boundaries:

54.5 57.5 7.0 13.0

Input histogram bin size

5.0

Name of file to hold result:

data\nmegm96.covt

Running options. Working in H:\GRAVSOFT\pyGravsoft

Data send to empcov

Quit

Write settings

Start program

Help



Preparation: Covariance estimation: empcov.log

2920 VALUES INPUT FROM FILE data/nmfa-egm96-tc.dat
NUMBER OF OBS 1= 2920 MEAN = 0.3066 VAR. = 173.53

HISTOGRAM, USING BIN SIZE= 5.000

0 0 0 0 3 9 34 49 118 248 372 887 357 343 233 127 59 35 18 18 10 0 0
OUT-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9' 10OUT
PSI COVA(1, 1) PROD. STDV OF COV..

O	M	(UNIT)**2	NUMB	(UNIT)**2	
0	0.00	175.509014	3132	4.9	0.330449
0	2.00	145.042029	4762	3.4	20.163033
0	4.00	119.317243	9487	2.3	45.463833
0	6.00	90.458667	14003	1.8	75.421001
0	8.00	67.998329	17995	1.5	101.052568
0	10.00	48.805606	21731	1.3	119.723639
0	12.00	31.054065	25167	1.2	136.020523
0	14.00	18.040267	28540	1.1	149.844158

Important value: Half correlation distance, 6'.

Preparation: Covariance Fitting.

We need expressions for covariances between ALL gravity field quantities. This can be done using a reproducing kernel.

We must fit the empirical values with an analytic expression derived from a reproducing kernel:

$$\text{cov}_{\Delta g}(\psi) = AA \sum_{i=2}^N \sigma_i^e \cdot \frac{(i-1)^2}{R_E^2} P_i(\cos(\psi)) + \sum_{i=N+1}^{\infty} \left(\frac{R_B}{r_P}\right)^{2(i+1)} \frac{A \cdot (i-1)^2}{(i-1)(i+2)(i+4)} P_i(\cos(\psi))$$

AA: scale factor on EGM error-degree variances,

A and R_B determined from empirical covariances

Using a non-linear adjustment with 3 unknowns !



Analytic Covariance fitting by COVFIT

74 COVFIT - Covariance fitting

Name of file with empirical covariances:

Input number of values in table:

Input code for observations: ?

Input the mean altitude (m):

Input data variance at mean altitude:

Input data area specification : ?

Model parameters

Input covariance model parameters: ?

Input error degree variance scale factor :

Input name of error degree variance file:

Iteration parameters

Input number of iterations: ?

Input three weights: ?

Running options. Working in H:\GRAVSOFT\pyGravsoft

Data send to covfit16

Quit Write settings Start program Help



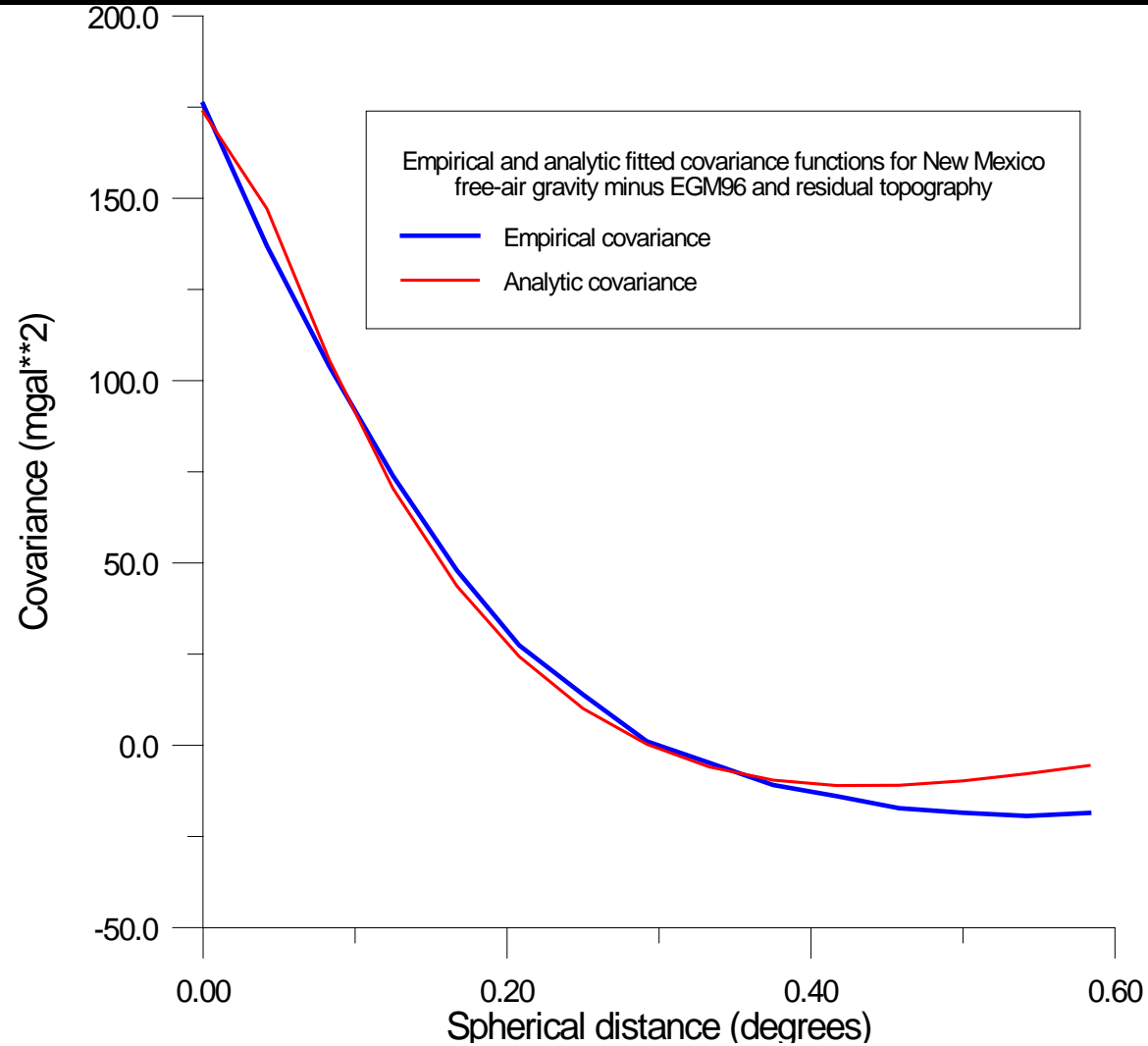
Output from COVFIT -> input to GEOCOL:.

TAU(J) USED IN THE CX MATRIX 0.10E+01 0.10E+01 0.10E+01
RESULTS IN VARIANCE OF GRAVITY ANOMALIES:
1'TH ROW OF INVERSE MATRIX 0.4132E-01 -0.1243E-01 -0.3080E-01
2'TH ROW OF INVERSE MATRIX -0.1243E-01 0.1211E-01 0.4449E-01
3'TH ROW OF INVERSE MATRIX -0.3080E-01 0.4449E-01
0.1782E+00
STD.DEV. 0.576779E-01 0.732173E+05 0.334610E+03
STD.DEV.*RMS 0.329951E-01 0.418845E+05 0.191416E+03
RESULTS IN VARIANCE OF GRAVITY ANOMALIES: 334.36 MGAL**2.

N	RATIO	AA	A	RE-RB	VARG	IT
360	0.5721D+00	0.2837	0.6654D+06	-792.72	334.36	10



Covariance fit.



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Covariances at 1700 m.

Ψ (deg)	ζ, ζ	$\Delta g, \Delta g$	$\Delta g, \zeta$	ξ, ξ	$\xi, \Delta g$	ξ, ζ
0.00	0.0476	174.15	2.058	3.878	0.000	0.000
0.05	0.0463	139.00	1.885	2.749	-11.167	-0.092
0.10	0.0430	90.20	1.535	1.307	-13.884	-0.146
0.15	0.0387	53.43	1.167	0.318	-13.132	-0.167
0.20	0.0342	27.60	0.837	-0.309	-11.188	-0.167
0.25	0.0298	10.08	0.566	-0.678	-8.886	-0.153
0.30	0.0260	-1.15	0.358	-0.860	-6.597	-0.132
0.40	0.0201	-10.61	0.112	-0.857	-2.730	-0.084
0.50	0.0167	-9.71	0.038	-0.593	-0.233	-0.044
0.60	0.0150	-4.53	0.062	-0.264	0.885	-0.021
0.70	0.0141	0.91	0.115	0.004	0.939	-0.014
0.80	0.0133	4.40	0.152	0.153	0.377	-0.019
0.90	0.0120	5.20	0.152	0.174	-0.353	-0.028
1.00	0.0102	3.75	0.117	0.100	-0.910	-0.036
1.10	0.0081	1.11	0.061	-0.014	-1.117	-0.038
1.20	0.0061	-1.51	0.003	-0.121	-0.961	-0.035

