Lecture 3.5. Statistical analysis of gravity data.

Histogram

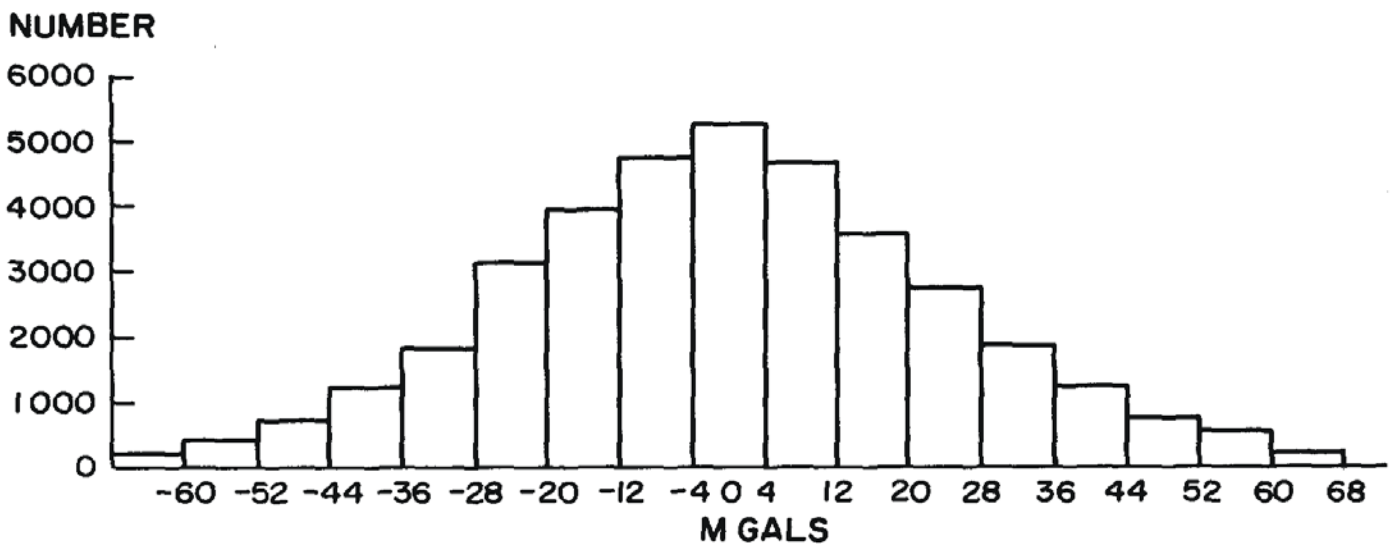
Auto-covariance function

Analytic representation

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.

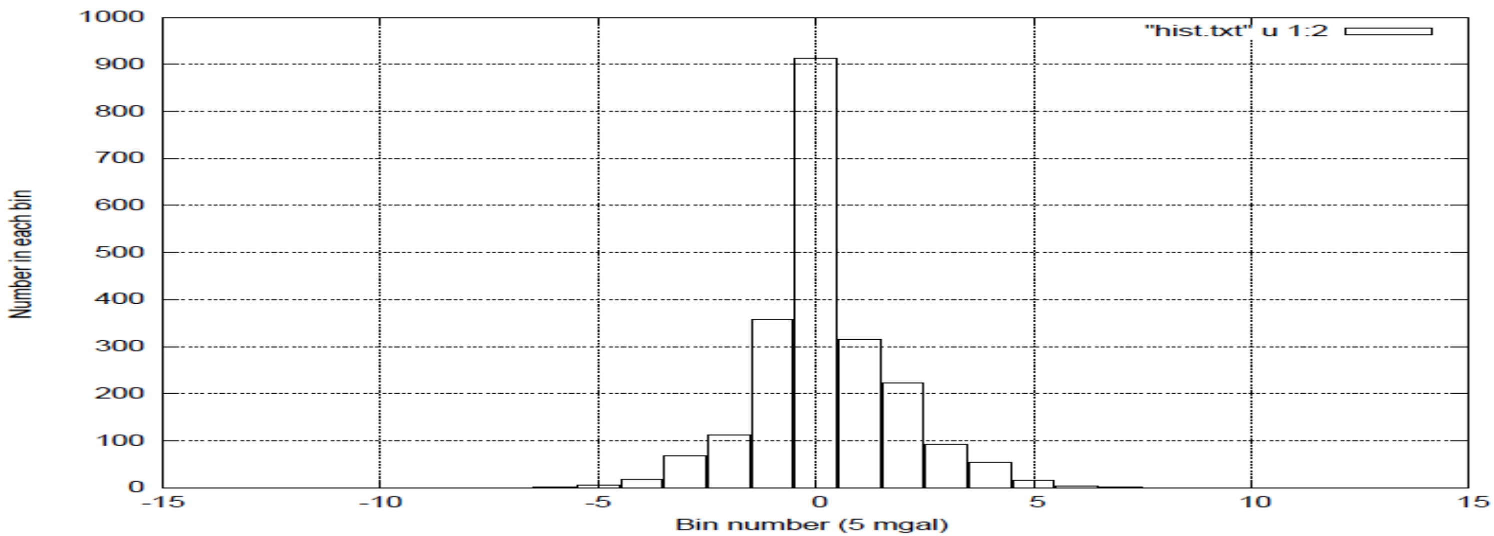
Output from GRAVSOFT module EMPCOV:

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 !.

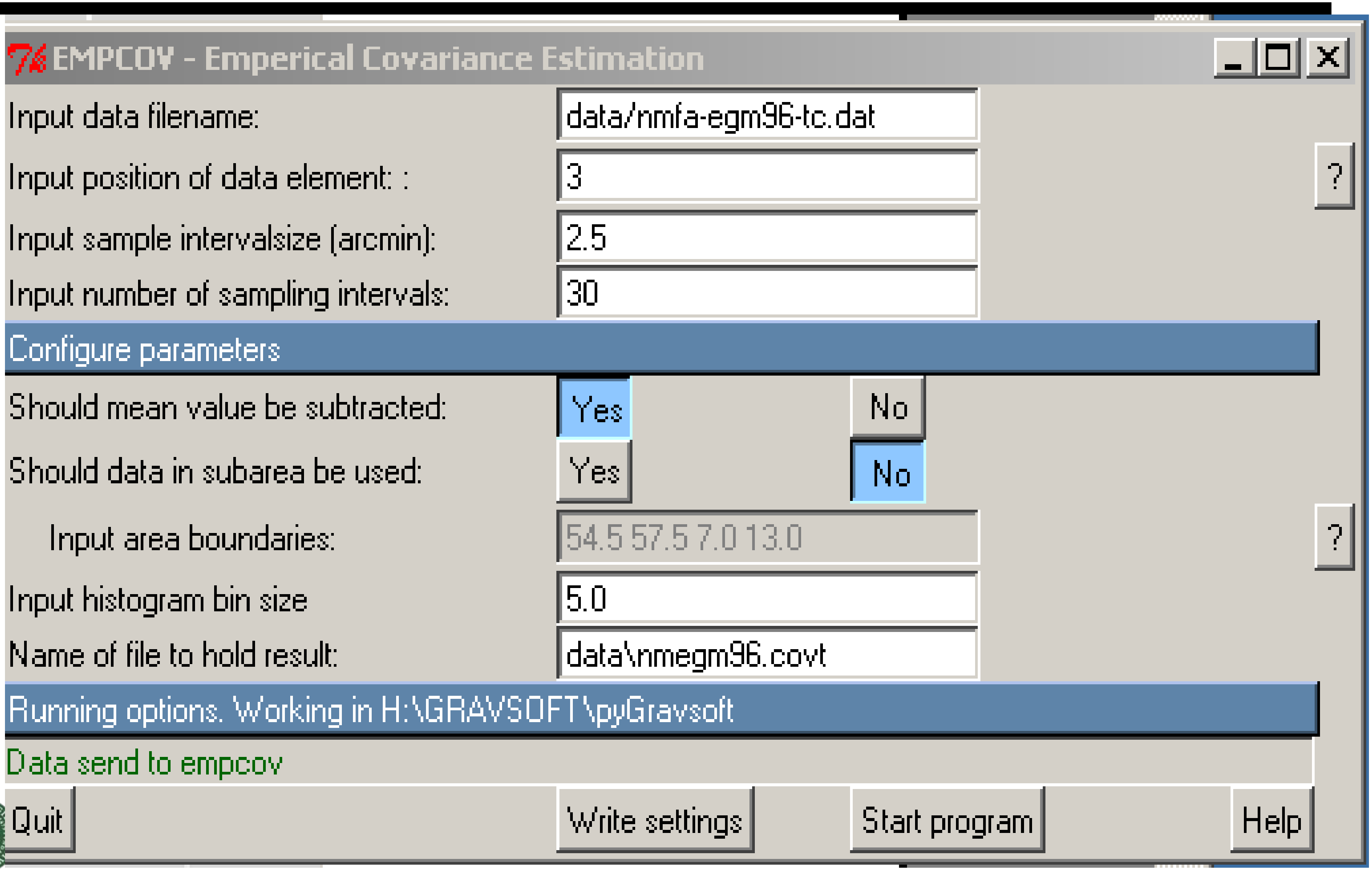
The following data must be used, with format: number, latitude, longitude, altitude and gravity anomaly in mgal.

```
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



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 49118248372887357343233127 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:

$$cov_{\Delta g}(\psi) = AA \sum_{i=2}^{N} \sigma_i{}^e \cdot \frac{(i-1)^2}{R_E{}^2} P_i(\cos(\psi)) +$$

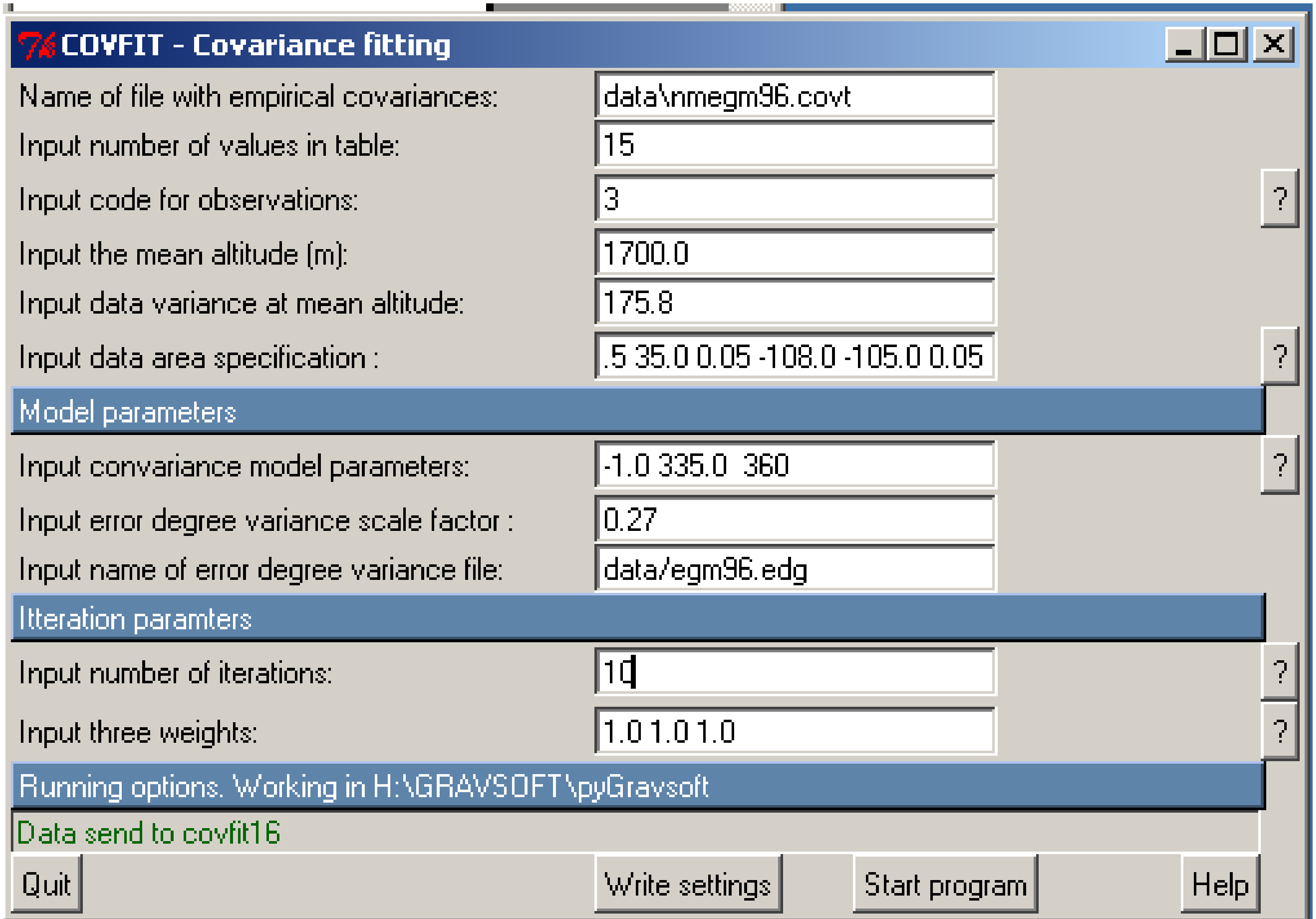
$$\sum_{i=N+1}^{\infty} \left(\frac{R_B{}^2}{r_P{}^2}\right)^{(i+1)} \frac{A \cdot (i-1)^2}{(i-1)(i+2)(i+4)} P_i(\cos(\psi))$$

AA: scale factor on EGM error-degree variances,

A and R_B determined from emperical covariances

Using a non-linear adjustment with 3 unknowns !

Analytic Covariance fitting by COVFIT

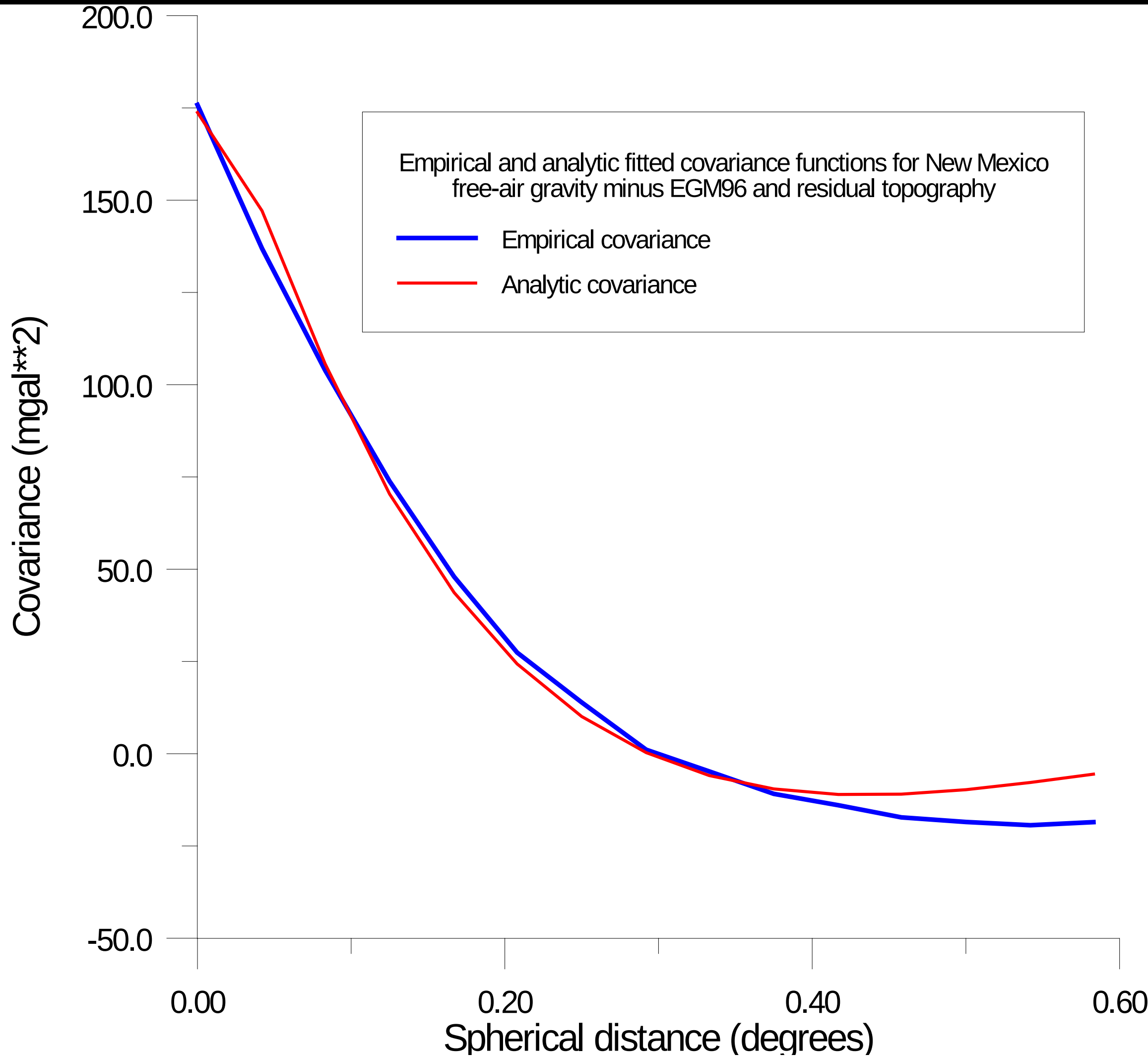


Output from COVFIT -> input to GEOCOL:.

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.



Covariances at 1700 m.

Ψ (deg)	ζ,ζ	Δg,Δg	Δg,ζ	ξ,ξ	ξ,Δg	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