GEOCOL − A FORTRAN−program for Gravity Field Approximation by Collocation.

by

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Abstract: The corrections, updates, improvements and planned changes of a FORTRAN program for gravity field approximation published in its first version in 1974 are described. The most important changes made in 1984 have been the use of the subroutines COVAX and GPOTDR for the computation of ’signal’−covariances and contributions from a spherical harmonic expansion, respectively. This makes it possible to use and predict for example gravity gradients. Furthermore, the estimation of several types of parameters, including datum shift and satellite altimetry track biases, is now possible. Also in 1985 H.Suenkel’s covariance function interpolation routines have been incorporated in the program, geodetic datums may be defined from various combinations of GM, A, J2, 1/F, gamma−e and omega and the mean gravity anomaly functional may be evaluated by numerical integration. In 1986 possiblities for calculating density anomaly estimates and for producing and using solutions on binary form have been implemented. New possibilities for using covariance functions tabulated for fixed height and data types have been implemented in 1987, and a modification of the covariance function interpolation subroutine has been made in 1988 in order to assure the necessary precision on computers which use less then 12 digit floating point calculations. The arrays for storing the observations and the normal equations have been entlarged, and the possibility of using a satellite−oriented reference frame has been added in 1989, 1991. The use of along−track means was implemented in 1992. Along−track deflections of the vertical can be used after Apr. 95. In oct. 95, provisions were made for output with 4 digits in case the signal variance is below 0.1. In the spring of 1996 the use of finite covariance functions is implemented as well as output statistics concerning the actual prediction error relative to the estimated error of prediction.

In 1997 preparations for improved handling of airborne gravity was implemented: adjustment of track biases, and correlated errors. In march 1998 the program was modified to enable the use of spherical harmonic expansions up to degree and order 1800, and in june 1999 the prediction of spherical harmonic coefficients was implemented. A throughout tested version, geocol15a, was ready january 2000.

In Feb. 2002, a new version with the possibility of not using spherical

approximation was released. If this is used, the observations, except geoid heights, must be associated with the angles of the rotation matrix.

The use of multi−processor computers was enabled in 2007 with the several new sub−routines written by M.Veicherts. This requieres the use of a FORTRAN90 compilor with multiprocessing build in.

This report will be updated each time a new version of the program is released, and the present version describes the changes made up to 2009−01−19. Corrections are implemented both in geocol17.for and in geocol18.for, because geocol18.for can not be run under Windows due to the use of multiprocessing. Both versions are under SVN control in pyGravsoft.

1. Introduction.

GEOCOL is an updated version of the FORTRAN−program published in Tscherning (1974). However, there exist intermediate versions of the program (1 APR 1975, 6 JULY, 22 NOV 1984, 25 MAR, 8 JULY 1985, 20 OCT 1986, 7 JULY 1988 and 8 JULY 1989, 1994) which includes some of the changes described below. There also exist single and double−precision editions of the individual versions, prepared for running under CDC and IBM FORTRAN 77 compilers, respectively. With the use of Microsoft PowerFortran or the LAHEY compiler it is now possible to run the program in a Windows environment. Version 18 requires the use of a FORTRAN90 compilor.

There also exist a corresponding algol version of the program named "runcoll", "runcoll1", "runcoll2" etc., described in Tscherning (1978). GEOCOL includes nearly all the features of the algol version. However, some of the features found in the algol version have not been implemented in GEOCOL, because experience has shown that they were never used.

With the published 1974 version of the program was also an input and output example. It may still be used with the new version, after a few minor changes. The output will be nearly the same, but not exactly the same, because some errors have been corrected since the first version, see section 2.

New examples are given with this report, which also illustrate some of the new features of the program. It is the intention to keep this report updated, so it may also exist in several versions.

2. Corrected and suspected errors.

2.1. The program has the possibility of defining a datum−shift as a combination of a translation, rotation and scale change or as a change of the deflections of the vertical and the height anomaly at a given origin. A combination of the two types of shifts is also permitted. In the versions dated earlier than 22 NOV 1984, the change given at an origin was used to compute only the corresponding changes in deflections of the vertical and height anomalies, and the coordinates of the points were not changed. This error has been corrected, so that the change at the origin is converted to a corresponding translation vector cf. Heiskanen and Moritz (1967), eq. (5−56).

2.2. The 1 APR 1975 version used a simplified method of computing the derivative of cosine to the spherical distance with respect to latitude, which contained an error (SUBROUTINE PRED). This error has been corrected, since the computation of the mentioned quantity now takes place in the subroutine COVAX, which does not contain this error.

2.3. The 20 APRIL 1974 and the 1 APRIL 1975 versions contained an error related to the facility which permits two columns to be computed simultaneously for example in case pairs of deflections of the vertical were used. The error occurred when two columns had to be stored in different blocks of the normal equations, i.e. when the logical variable LBST was true. The error has been corrected. However, a new error was found and corrected May, 1, 1986.

2.4. In versions earlier than 22 NOV 1984 an error in the description of the input sequence of the rotation angles used for datum shift occurred. They (EPS1, EPS2, EPS3) were described as being the rotation around the X, Y and Z axes, respectively, where the correct description is that they are the rotation angles around the Z, Y and X axes, respectively.

2.5. Some variables had in version 1 APR 1975 undefined values, (DL, GM1, INDEX(2), SREF, OBS(1), K21). These variable are now initialized, some by the BLOCK DATA module.

2.6. Errors may occur if the program is used on the southern hemisphere or close to the equator (subroutine TRANS).
The prediction of parameter defined quantities (such as changes in geodetic coordinates caused by a datum−shift) has not been tested in all cases.

2.7. When a restart−file is created (LWRSOL is true) and LAREA is true it may happen, that the terminating "T" on the data−sections is an "F". This must then be changed 'manually' on the file.

2.8. In the versions up to and including version 22 NOV 1984 it was supposed, that if the pointer was outside the range in a computed GO TO − statement, then the first or the last label was selected, depending on whether the pointer was below or above the range. Since this seems not to be standard (e.g. on UNIVAC 1100), the use of this facility is avoided in version 7 FEB 1985 and subsequent versions.

2.9. When creating the restart file on unit 17, it was supposed, that it was a "printer−like" device, i.e. that a record change was executed depending on the very first character output during a WRITE−operation. Since unit 17 generally not will be "printer−like" , the output formats have been changed, so that a record (line) change now is executed at the end of a WRITE−operation. The 7 FEB 1985 version includes this change.

2.10. The 25 MAR and 8 JULY versions contained an RC8000 statement "LONG NO", which should be deleted. Also a data−statement contained more than 19 continuation lines, which is not acceptable for some compilers. The statement is easily split into several separate ones.

2.11. In order to read and write normal−equation blocks exceeding the maximal buffersize in IBM FORTRAN 77 the subroutines NREAD and and NWRITE was introduced in 1985. These subroutines updates the the block−counter as also done when using IBM FORTRAN IV direct access. This was not taken into account when also correcting the restart−facility, i.e. the value of the block−counter (NBT) did not obtain its correct value. This has been corrected in SEPT 1987.

2.12. Versions before 7 July 1988 had an error in the restart file, in case the original data did not include an explicit height value in the data record. This had no consequence if the restart file was used unchanged, but if it was used as a basis for a new computation, then an error occurred.

2.13. In versions before 7 july 1988, Suenkels covariance function interpolation routine BSFC was used for the interpolation of cross−covariances between gravity and deflections, when LTABEL was true. If too few significant digits was used (like on the RC8000), then this gave wrong results. Therefore a modifications has been made, which uses simple linear interpolation instead directly in the subroutine COVCG.

2.14. In Nov. 1990 the subroutine RGRAV was changed erroneously, so that the calculation of gravity at heights different from 0 became wrong in GEOCOL. Corrected 1991.03.19.

2.15. In aug. 92 errors were found in the interface between pred.f and covcx.f. The value of ISAT was not transferred correctly.

2.16. In oct. 92 an error was found in the calculation of mean values. The stepsize was calculated as size/5 and not size/4.

2.17. In june 1993 an error corrected related to the re−use of a solution in geocolh.

2.18. In Nov. 93, the variable LMEAN1 was not put FALSE after use. Sideeffect was that two observations were input simultaneously.

2.19. In sept. 95 it was found that the paging of the parameter matrix was working also when it was not needed. When LPOT is true, and parameters are to be determined, the matrix CX is paged to unit 2. This need not to be done when LPOT is false. An error in the implementation of this feature was detected in April 1996, and corrected.

2.20. In dec. 96 it was found that the calculation of mean−values of gravity anomalies only was possible when two datums were used.

2.21. In july 2001 it was detected that 1−D means (airborne gravity) could not be used when predicting other quantities. Corrected.

2.22 In Feb. 2002 it was found that the number of of variables associated with parameters should not exceed about 300. This is now extended, so that now up to 100000 can be used with one parameter or 50000 with 2 parameters (bias+tilt).

2.23 In nov. 2002 severe errors were found in the subroutine COVCX for cases where the data were Tyy and Tyz. Corrected.

2.24. In nov. 2002 it was found that when LSAT was true and 1−order derivatives were used, unreduced data could not be used.

2.25. In mar. 2003 it was found that the rotation matrix in the point Q was initialized to zero when no rotation was needed in Q but a rotation was needed in P. It is now initialized to be the unit matrix.

2.26. In June 2004 it was found that prediction of data depending on parameters made a variable MP decrease so the array−bounds were exceeded. Correction tried 2004−07−02.

2.27. On July 7, 2004 it was found that the subroutine PRED did not read the data−file when it was called first time for an observation which was not the first. (This happens when LRESOL=LT). A new logical variable, LSTART, was introduced in the common blick /PR/, to handle this situation, so that the data were transferred at the first time the subroutine was called. The problem occurred only when the number of data exceeded MAXO=5600, since in this case data are paged to disk.

2.28. On 2004−08−17 an error was corrected which occurred when error−estimates for spherical harmonic coefficients were computed, when parameters were determined. The sign was wrong.

2.27. It was detected that two logical variables LGRERR and LGRERS were not initialized to .FALSE. before first use. Corrected 2004−11−05.

2.28. The determination of tilt−parameters were erroneous. Corrected in connection with general revision 2004−12−21.

2.29. The variable HPP was not assigned a value if TRAPOT was not called.

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Corrected 2005-01-30.

2.30. When parameters were to be determined and correlated data
errors were used, the identification of parameters was erroneous.
Corrected 2005-03-12.

2.31. The variable LNTRAN in the subroutine COUT was not assigned
a correct value. Corrected 2005-09-07.

2.32. When calculating error-covariances with LPARAM=true, it was not
taken into account that the sign must be changed in the summation
when the row number exceeds the number of data. Partly corrected
2005-10-30.

2.33. It must be checked if there are problems using a spherical
harmonic expansion of vey high degree (subroutine gpotdr). 2005-10-30.
Solved June 2008, see  3.64.

2.34. An error was detected when geocentric coordinates were used as
input. If the subroutine TRAPOT was not called and spherical approximation
was not used, the altitude was referring to the ellipsoid and not to the
mean Earth sphere. Corrected 2005-11-12.

2.35 An error in subroutine gpotdr was found when computing second order
derivatives. Corrected 2008-09-12 and 2009-01-18.

2.36. An error in subroutine COPRED corrected related to the computation
of error-estimates of multiple gradients or gravity gradients. 2008-10-02.

2.37. In the subroutine GPOTDR the content of the array SU8 was not
saved correctly and the array SU in the call, which is REAL*8 was
declared as REAL*8 in the calling modules (TRANS and MAIN). Corrected
Dec. 2008. Also the value of NNSU was incorrect in TRANS.

2.38. When an observed quantity not is an anomaly, the reference
value is subtracted in the subroutine TRAPOT. Here the reference
value for gravity gradients was earlier not converted to Eoetvoes
units. This was corrected 2009-01-15.

2.39. When a quantity was corrected (LADMU true), the error estimate
was not corrected simultaneously. This is in a situation where the
error-estimate is reproduced in output, for example (LERNO=true)
Corrected 2010-11-23.

2.40. There seems to be an error in the calculation of COVCX of the
covariance between TYY and first order derivatives like the gravity
anomaly or disturbance. 2010-11-28. Corrected 2010-12-01. Error
caused by changes where SIGMAX had dimension changed to 2200 and
the equivalence with SIGMA0 was skipped. SIGMAX is now in the
common block CMCOV. Other errors were found in the evaluation of
covariances between TYY and gravity anomalies or disturbances. For
the latter, the sign must be revesed.

2.41. When computing errors for gridded values, and having output
on GRAVSOFT grid format an error occurred. This had to do with
preparations for using multiprocessing when calculating the error-estimates
(LMAP7E=true). This was corrected 2010-12-07.

2.42. A newer version of the IFORT compiler caused the program to terminate
in a run. It was found that it was caused by having a fixed quantity (0),
in the call of NES_MP. Corrected 2011-01-08.

2.43. The limit on integer*4 was exceeded in the subroutine RESTORE. The
pertinent variables was redefined as INTEGER*8. 2011-04-04. (Not yet tested
fully).


3. Modifications.
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3.1. A (modified) version of COVAX (cf. Tscherning (1976a), Krarup and
Tscherning (1984)) is now used to compute the 'signal' covariances.
This permit (1) covariances to be evaluated at the actual heights
of the individual points instead of at the mean heights of points
and (2) the calculation of covariances of gravity gradients, torsion
balance observations and gravity disturbances.

Consequently, the codes for the degree-variance models and data kinds
used in COVAX must now be used. In order to preserve backward
compatability new codes are used equal to the codes used in COVAX
with 10 added, and the old codes, which are in the range from 1 to 7
can still be used. A new function IKC converts the codes to the
codes used in COVAX.

This change was first introduced in 1984.

3.2. The subroutine GRAVC (with several (sub-) entries) has been
split in two separate subroutines GRAVC and RGRAV. The latter now
permits the computation of second order derivatives of the normal
potential. This function was introduced in the 6 JULY 1984 version
but the 22 NOV 1984 version is the first one fully tested.

3.3. The subroutine IGPOT with (sub-) entry GPOT has been split
into two separate subroutines SETCS and GPOTDR, both published
in Tscherning et al. (1984). This permit the use of spherical
harmonic expansions to high degree and order, presently 180, and
the evaluation of second order derivatives.

The coefficients do not anymore need to be in the input-stream,
but may be read from a separate file (9) using a new subroutine
LOADCS. The coefficients are supposed to be on the form
degree (n), order (m), C(n,m), S(n,m) with S(n,0) = 0.
The coefficients do not anymore need to be multiplied by
10**6. If the coefficient C(0,0) is input and different from 1.0,
then its value will be used to scale the coefficients. Otherwise
the coefficients are supposed not to be scaled.

The change was introduced with the 6 JULY 1984 - version.

If coefficient sets of degree larger than 180 are used, it will be
necessary to change the dimension of the array COFF in common block
/GPOTC0/ and ROOT in common block /SQROOT/. A dimension check in the
main program must also be changed (approximatly at label 1009).


3.4. Already the 1 APRIL 1975 version permitted the determination
of parameters, namely the values of the change of the deflections
of the vertical and the height anomaly at a (datum) point, cf.
Tscherning (1976).

This feature has now been changed (version 17 OCT 1984), so that
any of the three mentioned parameters or any of these of a 7-parameter
datum transformation may be determined. Also one or more bias
parameters may be determined.

The partials with respect to the parameters are now treated as if
they were a kind of covariances. The bordered normal-equations are
solved using the modified Cholesky-algorithm, see Tscherning (1984).
This algorithm is also used to determine the error-estimates.

The parameters to be determined are identified by codes (integers
> 0) given in a specific sequence, for example 8  9  10. If a set
of data depends on or contribute to the parameters, then this is
identified by giving the codes (at the proper place in the input
stream) in an arbitrary sequence. If any other code is used, it is
supposed, that the data does not depend on this parameter. Example
2 in the appendix shows how this is implemented.

In the 25 MAR 85 version, it has been made possible to define
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parameters for each individual observation. This may be used for satellite altimetry observations, which each are associated with a specific track, or cross-over observations, which are associated with two tracks. Details are given in Tscherning & Knudsen (1985). Also up to 240 parameters may be used. The extra space needed for this has been obtained by using the core area reserved for potential coefficients also for this purpose. While the coefficients are not used, they are stored on a scratch file 2. The contribution from the parameters are stored on a scratch file 3. Such files must then be established if parameters are to be determined.

3.5. As a consequence of the change described in 3.4, it has been necessary to change the subroutine NES, which reduces and solves the normal-equations. A fully tested version is found in version 22 NOV 1984.

Furthermore, the data-set on unit 8 used to hold the normal-equations formed by the signal-covariances only (C), now holds the coefficients of the A-matrix and the P-matrix. The file, which earlier was established by a DEFINE FILE - statement , may now be established by an OPEN - statement. This necessitates, that the record-pointer, associated with the DEFINE FILE - statement is updated seperatly, and this is now done (22 NOV 1984).

3.6. The subroutine PRED has as a consequence of 3.1. and 3.4 been changed considerably. Last change 22 NOV 1984.

3.7. Data within a specific area may now be selected from a set of data or prediction points. This option is used when the logical variable LAREA is true. The limits must be given separatly for each set of points. The change is implemented in the 22 NOV 84 version.

3.8. In case the heights for a set of points are all equal, this height was earlier given implicitly as the ratio between the mean earth radius (RE) plus the height (HP) and RE, RP = (RE+HP)/RE. It must now be given by the value of HP, only. Note, that this height is also used in order to simulate mean values (as being equivalent to a point in the height HP). The change is implemented in the 22 NOV 84 version.

3.9. In versions earlier than 22 NOV 84, the input data, the results and the solutions could be punched-out, when LPUNCH and LWRSOL, respectively, were true. The solutions could be input in a later run, when LRESOL was true, and a solution could in this manner be reestablished. Unfortunatly error estimates could then not be computed, because it was not possible to save the reduced normal-equations.

This has now been changed, so that a whole file is created on unit 17, which may be used as input in a later run. This file also functions as a 'restart'-file, making it possible to add new data, correct data or request parameters to be determined. The file is created, if the logical variable LWRSOL is set true in the very beginning of the run. If a part or all of the reduced normal-equations is to be re-used, then the value of LSANEQ must be set true and the value of the total number of reduced columns must be input (integer variable IFC). If IFC is equal to the original number of observations plus one, then the beforehand computed solutions must be input.

3.9. Since it with the RC-8000 FORTRAN-compiler not is possible to use variable input format, several standard formats have been introduced. New formats have been introduced latest in the 7 NOV 85 version. If variable formats are to be used, then the logical variable LFORM must be set true.

3.10. The program calculates effects of datum shifts and contributions from spherical-harmonic expansions. Since this sometimes is the only

functions needed, a logical variable LNCOL has been introduced, so that the collocation part is not used. Implemented with 22 NOV 1984 version.

3.11. Since some compilers do not permit DATA-statements in the main program, a BLOCK DATA module has been implemented, valid 22 NOV 1984.

3.12. It is now possible to compare predicted values in a grid with values given in the same grid, without giving the coordinates explicitly for each point. (Change 17 DEC 84).

3.13. Since the error-degree-variances for potential coefficients sometimes are given on parametric form (as a function of the degree), it is now possible to specify that such a model should be used. A present only one simple model can be used, where the model simply is (2*i+1)*(VG*9.81)**2, where VG is a scale factor and i the degree. However, the explicit error degree-variances associated with Rapp's 1981 and Wenzels GPM2 coefficient sets are now available in the dimensioned variables DRAPP and DGPM2, initialized by the BLOCK DATA module.

3.14. For large data files it is inconvenient to have these files as a part of the input stream. Furthermore, the use of a terminating F or T at each data record to signal end of data is sometimes inconvenient. From the 25 Mar 85 version it is now possible to use unit 4 (file 4) for input and use a negative station number to signal end of data.

3.15. Suenkel's 1979 covariance interpolation procedures have been incorporated in the JULY 85 version. Several new subroutines have been added (BILDEC, CTABLE, COVGC, DPOL, BSFC). Consequently changes in the input have been necessary (input (7)). Also a few changes have been made in COVAX (common /CMCOV/).

3.16. Instead of specifying the ratio RB/RE between the radius of the Bjerhammar-sphere and the Earth mean radius, it is possible to specify the depth to the Bjerhammar-sphere, RE-RB, a negative number, if this value is less than 10 km. This change is made in the JULY 85 version.

3.17. In order to identify the files used as restart-files and as storage for the normal-equations, the file-names must be input as (new) records 2 and 3. If parameters are to be determined, names of two scratch-files (connected to units 2 and 3) must be input. If unit 17 is used for output (LPUNCH true) then the name of the as- sociated file must be given first time it is used. These changes are valid from the JULY 85 version.

3.18. It is now possible to define the normal potential from various combinations of GM, a, J2, gamma-e, 1/f, e**2 and omega. Parameters for several standard systems (GRS1967, 1980, NWL9D) may now be obtained by calling a new subroutine ICOSYS. (Effective 7 NOV 1985).

3.19. Use of free-format and END-option in READ have been implemented in some versions distributed since NOV 1985.

3.20. Observations of mean values of blocks may be treated as if they were equivalent to a point observation in a certain height. However, the computation of mean gravity anomalies by numerical integration (mean of 5*5 points) have been implemented in the 7 NOV 1985 version.

3.21. I many cases it is convenient to pre-calculate contributions from potential coefficients and terrain or density-models. It is now possible to input such values. Their position in the input record must be given using the relative position of the quantity in the record with respect to (a possibly fictitious) observed value, see the program for details. This has been implemented in release 3 of the NOV 85 version.

3.22. It is now possible to compute quasi-harmonic density estimates

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and to use these estimates as observations. The power, n, of the
weight function r**n and the radius of the sphere, which include
all masses must be given, (new input (9J)).

3.23. It is with the versions after OCT 1986 possible to create
and use a set of binary solutions, each valid inside an equal-
angular geographical block. Also covariance function parameters
and potential coefficients may also be stored and retrieved on
binary form.

3.24. After OCT 1987 it is possible to tabulate covariance functions
for fixed heights and functionals. Initialization by the sub-
routine INTABH and interpolation by TABH.

3.25. After SEPT 1987, coordinates of grids (LGRID is true) in
a non-geocentric coordinate system will not be transformed, but
only the transformation will be computed. This assures the fast
evaluation of spherical harmonic series also in this case.

3.26. After SEPT 1987 it is possible to store potential coefficients
as integers. This gives only an advantage on certain computers,
where it may be better to use REAL *4 variales for the coefficients.

3.27. In the 7 July 1988 version the function of one of the logical
variables in input (9) has been changed. Consequently at input (9F)
an additive and multiplicative constant is input, togetger with the
the value of LMEGR, true if data are measured values and not anomalies.

3.28. In the 7 july 1988 version, a logical variable LTEST has been
introduced in input (1) instead of the variable LONEQ. If LTEST is true,
input in (1D) will enable timing and testoutput. The RC8000 timing
routine rystime must be changed on other computers.

3.29. The calculation of the second order derivative in eastern and
and northern direction in GPOTDR has been corrected 1988.08.24. A
factor M21 was missing right after label 2000.

3.30. Two new error-degree variance models have been introduced. Model
4 is linear, and model 5 is quadratic in the degree. This change was
introduced 1988.11.30.

3.31. In order to permit timing in a UNIX evironment, a subroutine
cctime has been introduced. In order to use it, remove contingently
the characters C UNIX. For more details, contact the author.

3.32. Different values of Omega (angular velocity) may now be
used. (April, 1989).

3.33. In order to take advantage of vector processors, the array
holding the normal equations has been expanded to 19800. (/NESOL/).
A subroutine SETCAT has been introduced, in order to have greather
flexibility when setting up the normal equations. (July, 1989).

3.34. In order to make more room for observations, the arrays in
common /PR/ have been expanded. The PARAMETER-statement is now used
to specify the actual sizes (Nov. 1991).

Preparations for using a satellite orbit oriented coordinate system
has been made, using a logical variable LSAT, with data-kind codes
added 40 to indicate the situation. Also a right handed coordinate
system (East, North, Up) is now used as output from GPOTDR in the
arrays G1 and G2. (July, 1989).

3.35. From Sept. 1989 it is possible to determine bias as well as
tilts for satellite altimeter data and gradiometer data. Modifications
have been made in the main program, APARM, WRPAR, BLOCK DATA, and
subroutines holding the common block /CPARM/. Warning will now be
given, if there are too few observations. If there is only one
observation, the parameters will not be determined.
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3.36. From Jan. 90 it is possible to input error degree-variances
by indicating that MODEL=0. File name must be input to unit 5.

3.37. From May 1991, it is possible to run the program interactivly.
However, logical variables get their value as T/F and not as yes/no.

3.38. From June, 1991, a rotated coordinate system may be used.
Input (9L) is used to specify whether the rotation is only horizontal
or free. Major modifications (cf. Tscherning(1991)) has been made in
COVBX, COVCX, and a new subroutine COVROT has been added. Azimuth,
height angle and tilt must be input with each observation. In an
experimental version, there is only made room for 200 points. (May
be changed in the PARAMETER statement).

3.39. In order to use potential coefficients up to a high degree
and order on a PC, the program will now check whether there is
room for the coefficients. Otherwise it will be expected that they
are stored on binary form, blocked. A preprocessing program LOADC
will do the necessary formatting.

3.30. In order to be able to use more data, data may now be blocked
if necessary (1992.06.06).

3.31. Along-track mean values may now be calculated and used. The
length of the track-segment is supposed to be constant, and the
azimuth variable. The length is input as equal to the blocksize in
northern direction. Azimuth is input individually for each point.
(1992.10.07).  In Dec. 1992 the use of filtered means was implemented.
5 weights may now be used with equidistant spacing. A new subroutine
mean1 to input the weights was written.  In 1996 11 weights were permitted.

3.32. Values are now output with layout F8.4 when the signal variance
is small (< 0.1) in the collocation mode. (Sept. 1995).

3.33. When prediction errors are computed, and oberved values are
compared with predicted, walues larger than X times the error estimate
may be output to a file. If X is < 0, only a histogram showing the
distribution of the ratio between "error" and error-estimates is printed.
Added 1995.11.15.

3.34. If LTEST is selected true, it is now possible to specify that
finite covariances (i.e. covariances for points at a distance larger
than a certain value must be set equal to zero) are to be used for
a specific data-type and a fixed altitude. (See Sanso & Schuh, 1987).
Added 1995.11.15 and corrected 1996.04.30.

3.35. Covariances of equal-angular mean values has been implemented
so that a weighting is used using cosine of the latitude. Dec. 1996.

3.36. In July 1997 the determination of along-track biases for
gravity has been introduced. The track number must be element 1 or
2 on an additional record after the observation. Also correlated
errors (along-track) can now be specified. A global variable LCOERR
must be set true when LTEST is true. The error-covariance function is
at present (july 1997) a finite covance function  (see 3.34) given
by its variance and half-length to zero. For eash dataset the value
of a logical LLCOER must be input to tell if the data have correlated
errors. In march 1998 the possibility for using correlated errors
was extended so that such ones can be used for more quantities.

3.37. In april 1998 the program was changed as to enable the use of
spherical harmonic expansions to degree 1800. This involved a new option
to read spherical harmonic coefficient files, where the first lines
had to be skipped.

3.38. In june 1999 a possibility for predicting spherical harmonic
coefficients was implemented. This required large modifications of
the subroutines PRED, COVXB amd COVXC. Test  were completed
```

January 2000. See (Tscherning, 2000).

3.39. In Nov. 2000 the program was modified so that the normal equation matrix could be spread over different files. This was made in order to be able to exceed the DOS (and at this time LINUX) maximal file size of 2**8 bytes.

3.40. The possibility for continuing the reduction from a specific column was also implemented. This will enable the program to be stopped in the course of a Cholesky reduction of the normal−equations, and then restarted. It requires that the number of reduced colum is given as a number with minus in front. (2000−07−25).

3.41. The subroutine COMPA as modified so that min, max of values are also output. (July 2001).

3.42. The program was modified, so that spherical approximation optionally was not used. The major change is that the distance from the origin, r, is not calculated anymore as r=R+h, but from X, Y, Z using Pytagoras. All data, except the geoid height must now be associated with attitude data (Euler−angles). For gravity anomalies e.g. the difference between geodetic and geocentric latitude.

3.43. The procedure for identifying which parameters are associated with which observations (INPUT(10A)) has been modified. Final solution is not yet found.

3.44. A new data type, the anomalous potetial T, has bee introduced having the integer 8 as an identifier.

3.45. An error−covariance function may be specified as a fourier series in time.cov(dt)=sum i=(0:nfouri)foucof(i)*cos(i*pi/nfouri*dt).(2002−09−12) (Not fully implemented 2005−03−12).

3.46. Output of full vector of 1−order derivatives or 3x3 matrix of 2−order derivatives is now possible both in the ENU frame and in a rotated frame. New input variable if LTEST is true. 2002−10−10.

3.47. A modification was introduced to take into account correlated errors associated with individual tracks. This is done by reading in a value ITRGAP which size gives the minimum gap in /time) between tracks. This requires that the "station number" is used as "time". 2003−03−19.

3.48. "IMPLICIT NONE" is now used in all routines (2003−10−01).

3.49. Parameters associated with height anomalies may now be specified using the time interval of one segment of data (e.g. a revolution) and the start time of the first revolution. This enables parameters to be associated with each individual track. 2003−04−03.

3.50. Output of predicted spherical harmonic coefficients to a fixed file "pcoeff" has been implemented 2004−08−17.

3.51. It is as of 2004−10.01 possible to input the attitude information in the form of the rotation matrix between the instrument frame and the East−North−Radially up frame. Simultaneously a check of the rotation matrix properties were build in.

3.52. A major revision of the program has been done, so that very few "go to" jumps are used. Simultaneously the determination of scale−factor parameters has been introduced. This required the introduction of "parameter codes", as a new input item.

3.53. Computation of error−covariances implemented 2005−03−01.

3.54. It is possible to use time−difference and not spherical distance as an argument for the error−covariance function. 2005−04−05.

3.55. Output of predicted spherical harmonic coefficients and error−estimates to file implemented fully 2005−04−27.

3.56. The input of coefficients in subroutine LOADCS changed to permit unformateed input. Effective 2005−07−26.

3.57. Two versions of geocol: geocol17.f and geocol17a.f are now maintained simultaneously. The latter one uses very large blocking of the normal−equations and may therefore not run on computers with central memory less than 2 GB. 2005−07−26.

3.58. If geocentric coordinates are used for input (IANG=6) the output will now also be in geocentric coordinates. Major changes in the subroutine COUT. 2005−09−06.

3.59. The computation of error−estimates will us a lot of execution time if the normal equations are stored in several blocks, due to block−transfer time. It has now become possible to defer the computation of the error−estimates until the last predicitio "point" or spherical harmonic coefficient. This is the case when LGRID is true. But it is required that the vectors of covariances are stored on a direct access file, the name of which must be input. Change 2005−10−06 and 2007−12−11.

3.60. If the scale−facter on the degree−variances becomes negative in the subroutine INCOV will the execution terminate. 2006−01−20.

3.61. In 2006 the possibility for predicting simultaneously all first or all second order derivatives was implemented. A new COMMON block denoted CALLCO was introduced in order to facilitate the transfer of the derivatives between the MAIN program and the subroutines DEFDAT, INP10, TRAPOT, COPRED and COUT. The feature takes advantage of the fact that all covariances are computed for each order of derivatives in order to enable the use of attitude information.

3.62. The program may now itself generate names for the files used to hold the normal equations. (Subroutine FILRNAMEGENERATOR). July 2007.

3.63. In 2007 the use of multiprocessors was implemented using a number of subroutines written by M.Veicherts. However, it was also necessary to use FORTRAN90 features, so the version of the program must be compiled using a F90 compiler. Multiprocessors may be used both for the reduction of the normal−equations as well as for the computation of error−estimates and error−covariances. The latter feature is only of effective use when when many error−estimates need to be computed such as when values in a grid are computed or spherical harmonic coefficients are predicted with LGRID=true. See also 3.59. Finalized Dec. 2007.

3.64. The subroutine gpotdr was changend so that REAL*16 are used for degree larger than 512 and abs(lat) greather than 60 degrees. The option for using integer coefficients was abolished.

3.65. The dimension of arrays used to hold empirical degree variances has been changed to 2200 in order to hold values derived from EGM2008.

3.66. Open−MP implemented for Clenshaw summation, with new subroutine VMSUM to calculate sums for each order. 2008−07−09.

3.67. geocol18.for now under SVN control in directory pyGravsoft/src. 2008−08−20.

3.68. If singularities are detected during the Cholesky reduction, in the subroutine factorizeA, the diagonal term is fixed to 1.0D4 experimentally. 2009−02−10.

3.69. In order to make room for EGM08 error−degree variances, the dimensions of SIGMA, SIGMA0, SIGMAX and SIGMAP was changed to 2200. 2010−11−23.

4. Planned improvements or changes.

4.1. In the subroutine COVAX, the user may (July 85) define a functional by giving the number of derivatives with respect to radial or spherical distance etc. This requires new possibilities for input of the values in GEOCOL, and also that the same functionals may be applied on the normal potential and on the potential given by the spherical harmonic expansion. (Partly implemented with the use of the attitude matrix 2004).

4.6. An improved algorithm should be used for the computation of geodetic coordinates from euclidian coordinates in "TRANS".

4.7. If two nearly identical observations occur (e.g. with slightly different values and standard−deviations) then it would be nice to give these observations a special treatment, such as the subsequent use of the sum and the difference of the observations.

4.9. It should be possible to have the program calculate optimal intervals used for the covariance function interpolation, cf. 3.15.

4.10. It should be possible to compute error−covariances. This requires some small modifications in NES and in the setting up of the catalogue of columns. (See 3.36 for along−track airborne error correlations implemented July 1997). Implemented 2005, see 3.53.

4.11. Atmospheric corrections should be applied.

4.12. It should be possible to update the error estimates using the computed normalized square−sum of the observations divided by the number of observations as a (squared) scale factor.

4.13. The identification of tracks associated with one parameter or where the error−correlation is non−zero need to be improved. (Partly implemented, see 3.49.)

4.14. It should be possible to store the unreduced normal equation matrix without the noise added. This would mean that simulations where the noise is changed can be made much more effective. (2003−12−14).

4.15. In the actual version, two observations may be used in the same point for certain data combinations like the deflections of the vertical. It would be a good idea to make it possible to use other combinations and more than 2 observations, such as e.g Tee, Tnn and Trr. (2003−12−14).

4.16. A new datatype being the difference between two values of the same kind but having different spatial location should be introduced (in order to handle GRACE potential difference data). (2003−12−14).

4.17. It should be possible to use data in an inertial reference system when the UTC is given and the transformation is a simple rotation.

4.18. It should be possible to use weighted means of data which are not on a greath−circle. This is needed for filtered GOCE gravity gradients. (2005−04−25). This would require that the coordinates of all points which are used are stored somewhere. This could be used also if multi−point functionals (GRACE) are to be used.

4.19. When computing error−estimates, this is done for one functional at a time. If the reduced normal equations are stored on disk, then disk transfers have to be done for all functionals. Alternatively the covariances could be stored on disk for several prediction functionals, and the part of the column could be reduced block after block. 2005−04−25. Implemented 2005−10−06, see 3.59.

4.20. When using a very large blocking factor the performance is reduced. Maybe a division of the blocks (for normal equations) is sammler blocks which are transferred could help. 2005−10−30.

4.21. When predicting spherical harmonic coefficients, the spherical harmonics are for each degree and order computed using forward recursion. This may be improved when LGRID is true, because then the coefficients are predicted in a loop for increasing degree and order. The solution is to save the contribution from the two last steps in the loop for each observation. This is already implemented in sphgric.f. 2008−01−11.

5. Creation of program version for other computers or compilers.

The GEOCOL program was in its original version developed for an IBM model 360/370 FORTRAN IV compiler. This version was in double precision (REAL *8) and used the DEFINE FILE statement, which is a special IBM feature. Also it was here possible to use variable format input to the program in a real, dimensioned quantity.

The use of FORTRAN 77 on most computers have made the conversion to other computers easy. Most standard functions are now intrinsic (except ALOG), so names do not need to be changed when converting from single to double precision. One problem remains, namely that integers on some computers are half the size of the reals in single precision. A careful check of the common blocks NESOL and CRW must therefore always be made, because these includes both reals and integers. It also influences the calculation of record sizes for the direct access file 8. However, most of these problems have been solved using logical variables LCDC, LIBM66, LIBM77, RC8000 true or false according to the computer on which GEOCOL is executed. Be sure to check, that the correct variable is set true.

A similar problem occurs using the A−format. On some computers, one real variable holds 4, and others hold 6 characters. Also the use of run−time FORMAT input, may cause problems.

In order to run the UNIX version, at different computers, a modification of the timing routines may be needed.
This is easily changed by modifying the subroutine sytime. For the PC−DOS version DATE and TIME are used. They must be deactivated if DOS is not used.

The program, three test examples and GPM2 set of coefficients, cf. the Appendix are distributed on diskettes or by anonymous ftp.

At 2005−04−01 two versions geocol17.f and geocol17a.f are created. The 17a version should only be run on computers with more than 2 GB internal memory.

The new version geocol18.f is created 2007−12−11.
It uses openmp features and real*16 variables, so some compilers can’t be used. IFORT works fine under LINUX and Lahey fl95 for Windows. 2008−09−14.

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Appendix.   WARNING NOT UPDATED to comply with geocol12 (july 1997).
=========

Example 1.

The following example shows a two step collocation solution similar to the one in Tscherning(1974). The main difference is that the restart file (file PUNX) is created and subsequently executed.

Input data:

```
 F
 T T T F F F T
 T F F F F
1
PUNX
22 1
NEQ
T T F
 0
GSFC
 3 3.986012200E+14 6.378143000E+06 2.982500000E+02
 5 9.780490000E+00 6.378388000E+06 2.970000000E+00
 −111.10 −111.50 −142.60  1.05  0.19  1.57  5.20E−06 T
 55 30 00.00 10 00 00.00  −1.00   1.00   0.00
’ R.H.RAPP, THE GEOPOTENTIAL TO (14,14) ETC., IUGG, LUCERNE, 1967.’
 3.98601220E+14  6378143.0 −484.1803   8 T F F F
  0.0000  0.0000  2.3241 −1.3106  0.9025  1.7842  0.2601  0.7224 −0.5755
  0.7240  1.3860  0.5608 −0.5289 −0.4290  0.1966  0.5120  0.8804 −0.2317
  0.1861  0.3065  0.0296 −0.0670 −0.0161  0.3934 −0.1339 −0.1203 −0.0209
  0.1371  0.2119  0.0317 −0.5727 −0.0703 −0.0834 −0.0062  0.0153 −0.2185
 −0.0486  0.0774 −0.0300 −0.4660 −0.2760 −0.4555 −0.0124 −0.2009  0.0890
  0.0996  0.0062  0.2632  0.0832  0.1540 −0.0391 −0.2898 −0.0145  0.0612
  0.0634 −0.1685  0.1512  0.0897 −0.0672 −0.0195 −0.0738  0.0017  0.0621
  0.2200  0.0262  0.0907 −0.0029  0.0568 −0.0757  0.0702 −0.0859  0.2170
  0.0246  0.0668 −0.0948 −0.1090
 2
  24
 0.9998  1600.00  12 F F F F
    0.0     0.0     0.0     0.0     0.0     0.0     0.0    15.1
   17.7    13.7     8.4
  1  2  3  2  4  5  0  2  0   9913.91 F F T T F F F F F F
 T T     60.00    120.00     55.30
   4.00
    937269  56 30.00   9 00.00    0.00   18.00 F
    937271  56 30.00  11 00.00    0.00   10.00 F
    937273  56 30.00  13 00.00    0.00   27.00 F
    937289  55 30.00   9 00.00    0.00   26.00 F
    937291  55 30.00  11 00.00    0.00   12.00 F
    937293  55 30.00  13 00.00    0.00    6.00 F
    937309  54 30.00   9 00.00    0.00    5.00 F
    937311  54 30.00  11 00.00    0.00   10.00 F
    937313  54 30.00  13 00.00    0.00    2.00 T
T F
T F
 0.999800 170.00  90 T F F F
  1  2  3  1  0  4  5  5  0      0.00 F F F T F F F F F F
  0.30
40216  55 58 39.68   9 49 54.90   −5.13    3.61 F
40621  55 57 56.16  12 02 20.37   −2.20   −0.37 F
40058  54 58 01.40   9 58 32.48   −5.13    1.11 F
40606  54 42 54.22  11 55 55.39   −1.34    1.00 T
F F
  1  2  3  1  0  4  0  1  0      0.00 F F F F F F F F F F
   28  55 52 38.51  12 50 38.93   20.40    0.00 T
F F
  1  2  3  2  4  5  0  2  0      0.00 F F F T F T F F F F
      1.00 981000.00 T
  0.20
    261301  56 04.90  10 00.34   70.60  621.54 F
    700181  56 07.10  11 57.00    0.00  603.20 F
      4413  54 51.49   9 59.55    6.94  517.58 F
      3163  54 50.23  12 00.01   17.63  510.18 T
T F
F T T F
  1  2  3  1  0  4  5  5  0      0.00 F F F F F F T F F F
      0.10
```

```
      -1.0
40216  55 58 39.68   9 49 54.90   -5.13    3.61 F
40606  54 42 54.22  11 55 55.39   -1.34    1.00 T
F
F T T F
  1  2  3  2  4  5  0  2  0      0.00 F F F T F T F F F F
      1.00 981000.00 T
      4413  54 51.49   9 59.55    6.94  517.58 F
      3163  54 50.23  12 00.01   17.63  510.18 T
T

File to be added to restart file (PUNX):

T t F F
  54.5  55.0  9.0 10.0  0.5 1.0 13 0 5000.0 F F F
t
T T F F
   54.5 55.0  9.0 10.0  0.5 1.0 13 0 5000.0 F F F
F
T T F F
 54.5   55.0  9.0 10.0  0.5 1.0  5 0 5000.0 F F F
F
T T F  F
54.5   55.5  9.0 10.0  0.5 1.0  1 0      0.0 T F F
T

Output from first run:


 GEODETIC COLLOCATION, VERSION 13 JUL 2001 RELEASE 15f  (LINUX)
 Mon Jul 16 14:22:02 2001


 NOTE THAT THE FUNCTIONALS ARE IN SPHERICAL APPROXIMATION
 MEAN RADIUS = RE = 6371 KM AND MEAN GRAVITY 981 KGAL USED.
 MAX NUMBER OF OBS= 5600, MAX NUMBER OF PARAMETERS=239
 MAX NUMBER OF OBS IN GIVEN REF. FRAME =5600
 SIZE OF NORMAL EQ. BLOCKS= 399120, SIZE OF POT.COFF. BLOCK= 3243602
  INTERACTIVE INPUT (T/F)
  BUFFER SIZE MAXO9 =       403200
 NAME OF RESTART FILE=PUNX

          21 BLOCKS IN EACH FILE NEEDED
 NAME OF FILE HOLDING NORMAL EQUATIONS=NEQ

          12           1

 REFERENCE SYSTEM:
 GSFC
+                   USER DEFINED SYSTEM.

 A   = 6378143.00 M
 1/F = 298.2500000
 GM= 0.3986012200E+15
 REF.GRAVITY AT EQUATOR =   978032.6783 MGAL
 POTENTIAL AT REF.ELL.  = 62636916.8409 M**2/SEC**2

 PARAMETERS FOR
+                   USER DEFINED SYSTEM.

  NEW A      NEW GM         NEW 1/F
 6378388.0  0.3986329E+15 297.00000

    DL       DX      DY      DZ
  0.52E-05 -111.1 -111.5 -142.6

  EPS3  EPS2  EPS1
  1.05  0.19  1.57
```



```
  NEW REF. GRAVITY AT EQUATOR=   978048.99 MGAL
  NEW POTENTIAL AT ELLIPSOID = 62639787.0 M**2/SEC**2

 ADDITIONAL DATUM-SHIFT COMPONENTS OR INITIAL PARAMETERS FOR DATUM SHIFT
 DETERMINATION, GIVEN IN:
   LATITUDE      LONGITUDE BY DKSI  DETA  DZETA
  55 30  0.00  10  0  0.00  -1.00   1.00   0.00
 THE CHANGE OF DEFLECTIONS AND HEIGHT ANOMALY CORRESPOND TO A
 TRANSLATION VECTOR: (DX,DY,DZ) =(  19.72,  34.95, -17.52), (METERS).


 SOURCE OF THE POTENTIAL COEFFICIENTS USED:
 ' R.H.RAPP, THE GEOPOTENTIAL TO (14,14) ETC., IUGG, LUCERNE, 1967.'

     GM             A       COFF(5)  MAX.DEGREE
 0.39860122E+15  6378143.0 -484.1803    8

 START OF COLLOCATION I:

 THE MODEL ANOMALY DEGREE-VARIANCES ARE EQUAL TO
 A*(I-1)
+        /((I-2)*(I+  24)).
  HCMAX =    100000.0000000000
  12 EMPIRICAL ANOMALY DEGREE-VARIANCES FOR DEGREE > 1,
 IN UNITS OF MGAL**2 :
    0.00    0.00    0.00    0.00    0.00    0.00    0.00   15.10
   17.70   13.70    8.40

 RATIO R/RE                             =       0.999800
 DEPTH TO BJERHAMMAR SPHERE (R-RE)      =   -1274.20 M
 VARIANCE OF POINT GRAVITY ANOMALIES    =    1600.00 MGAL**2
 THE FACTOR A, DIVEDED BY RE**2 IS      =     412.71 MGAL**2

 TIME USED=    0.000 SEC, ELAPSED TIME =     0.000 SEC

  OBSERVATIONS:

 =   4.0000

 SYSTEM USED:
+                  USER DEFINED SYSTEM.

 THE FOLLOWING QUANTITIES ARE MEAN-VALUES, AND ARE REPRESENTED
 AS POINT VALUES IN THE HEIGHT H.
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
                D  M          D  M     M
+                                             ST.DEV.=   27.981991
                      TRA   POT   POT-TRA
+  OBS    DIF    ERR
    937269   56 30.00       9  0.00   9913.9
  18.00  -5.29  4.00  -6.83  16.46  23.29
    937271   56 30.00      11  0.00   9913.9
  10.00 -13.22  4.00  -6.83  16.39  23.22
    937273   56 30.00      13  0.00   9913.9
  27.00   3.90  4.00  -6.83  16.27  23.10
    937289   55 30.00       9  0.00   9913.9
  26.00   3.47  4.00  -6.61  15.92  22.53
    937291   55 30.00      11  0.00   9913.9
  12.00 -10.46  4.00  -6.61  15.86  22.46
    937293   55 30.00      13  0.00   9913.9
   6.00 -16.35  4.00  -6.61  15.74  22.35
    937309   54 30.00       9  0.00   9913.9
   5.00 -16.70  4.00  -6.38  15.32  21.70
    937311   54 30.00      11  0.00   9913.9
  10.00 -11.65  4.00  -6.38  15.26  21.65
    937313   54 30.00      13  0.00   9913.9
   2.00 -19.54  4.00  -6.39  15.16  21.54

 TIME USED=    0.000 SEC, ELAPSED TIME =     0.000 SEC
```

```
  FILE          12 OPENED FOR NEQ
           1 FILE(S) OPENED FOR NEQ
 BLOCK-CATALOGUE:    0   10

 COEFFICIENTS OF NORMAL-EQUATIONS, BLOCK    1
 (FIRST 200 ELEMENTS AND LAST FULL BLOCK)
     798.9918004    370.3390984    798.9918004    207.4125012
     370.3390104    798.9918004    394.7116730    295.7418411
     185.2099379    798.9918004    295.7418588    394.7115819
     295.7417555    363.9677878    798.9918004    185.2099480
     295.7417720    394.7114950    201.8201154    363.9676975
     798.9918004    229.1563343    198.7176797    143.0498391
     394.7118632    292.3421414    180.7749916    798.9918004
     198.7176923    229.1562508    198.7176018    292.3421592
     394.7117698    292.3420538    357.8385971    798.9918004
     143.0498503    198.7176136    229.1561710    180.7750015
     292.3420704    394.7116805    196.4780497    357.8385047
     798.9918004     -5.2879270    -13.2212360      3.9014670
       3.4742949    -10.4638482    -16.3500936    -16.7005133
     -11.6455378    -19.5430345      1.7922652
 TIME USED=   0.000 SEC, ELAPSED TIME=   0.130 SEC
  REDUCED BLOCK            1 WRITTEN, LAST CO.          10

 SOLUTIONS TO NORMAL EQUATIONS:

 -0.352581863E-02-0.204216085E-01 0.274768869E-01 0.286372986E-01
 -0.158881387E-02-0.181047089E-01-0.255596794E-01 0.181459416E-02
 -0.181112469E-01

 NUMBER OF EQUATIONS =      9
 NORMALIZED SQUARE-SUM OF OBSERVATIONS        = 0.179227E+01
 NORMALIZED DIFFERENCE BETWEEN SQUARE-SUM OF
 OBSERVATIONS AND NORM OF APPROXIMATION       = 0.224612E+00

 TIME USED=   0.000 SEC, ELAPSED TIME=   0.130 SEC

 START OF COLLOCATION II:

  HCMAX =    100000.0000000000
  90 ERROR DEGREE-VARIANCES EQUAL TO ZERO

 RATIO R/RE                              =       0.999800
 DEPTH TO BJERHAMMAR SPHERE (R-RE)       =   -1274.20 M
 VARIANCE OF POINT GRAVITY ANOMALIES     =     170.00 MGAL**2
 THE FACTOR A, DIVEDED BY RE**2 IS       =      65.80 MGAL**2

 TIME USED=    0.000 SEC, ELAPSED TIME =     0.000 SEC

  OBSERVATIONS:

 =   0.3000
0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
             D  M  S       D  M  S     M
+                                            ST.DEV.=    1.948958
                            TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
   40216   55 58 39.68    9 49 54.90      0.0
  -5.13  -3.99  0.30   0.86  -0.07  -0.21  -0.27  -1.14
   3.61   4.22  0.30   3.93   1.71   1.62   3.33  -0.61
   40621   55 57 56.16   12  2 20.37      0.0
  -2.20   0.66  0.30   0.78  -0.13  -1.96  -2.08  -2.86
  -0.37   1.91  0.30   3.74   1.99  -0.52   1.46  -2.28
   40058   54 58  1.40    9 58 32.48      0.0
  -5.13  -2.43  0.30   1.00  -0.25  -1.45  -1.70  -2.70
   1.11   2.33  0.30   3.96   1.72   1.01   2.73  -1.22
   40606   54 42 54.22   11 55 55.39      0.0
  -1.34   0.28  0.30   0.97  -0.33  -0.32  -0.65  -1.62
   1.00   2.05  0.30   3.79   1.96   0.78   2.74  -1.05
0   NO      LATITUDE     LONGITUDE     H    ZETA (M)
```



```
             D  M  S       D  M  S     M
+                                            ST.DEV.=    0.370809
                            TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
      28   55 52 38.51   12 50 38.93      0.0
  20.40  -0.06  0.00  22.55  46.20  -3.19  43.01  20.46
 =   0.2000
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
             D  M          D  M        M
+                                            ST.DEV.=   13.038405
                            TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
   261301   56  4.90      10  0.34     70.6
  37.49  21.62  0.20  -6.74  16.21  -7.07   9.14  15.88
   700181   56  7.10      11 57.00      0.0
  -5.69 -19.90  0.20  -6.75  16.14  -8.69   7.45  14.20
     4413   54 51.49       9 59.55      6.9
  17.21   5.70  0.20  -6.46  15.52 -10.47   5.04  11.51
     3163   54 50.23      12  0.01     17.6
  14.89   8.68  0.20  -6.46  15.42 -15.67  -0.25   6.21

 TIME USED=    0.000 SEC, ELAPSED TIME =     0.000 SEC
  FILE          12 OPENED FOR NEQ
           1 FILE(S) OPENED FOR NEQ
 BLOCK-CATALOGUE:    0   14

 COEFFICIENTS OF NORMAL-EQUATIONS, BLOCK    1
 (FIRST 200 ELEMENTS AND LAST FULL BLOCK)
       3.8884353      0.0000000      3.8884353      0.1944857
       0.0120711      3.8884353      0.0018075     -0.5158458
       0.0000000      3.8884353     -0.5044878      0.0690912
      -0.1484685     -0.2512848      3.8884353      0.0687605
       0.3445430     -0.2401545     -0.2265733      0.0000000
       3.8884353     -0.1819524      0.1855236     -0.5121260
      -0.0341386      0.2079654      0.1670791      3.8884353
       0.1751510     -0.1618996     -0.0336338      0.1832417
       0.1593344     -0.4853048      0.0000000      3.8884353
       0.0006510     -0.0173193      0.0538771     -0.2842803
       0.0071300      0.0121577     -0.1089554     -0.0478257
       0.1374995     -7.0652220     -6.5800743     -0.2671358
       2.2831235     -2.4606847     -0.0368871      0.2025547
      -0.1576162     -0.4671453    170.0400000     -0.2690982
      -2.0010649     -9.1608375      2.9752201     -0.1306381
      -0.1232105     -0.9594207     -0.0068250      1.1799365
      -5.0712644    170.0400000      2.4022219     -0.1984156
       0.1199899      0.1296504      9.5121597     -0.8454982
      -0.3353485      2.3614906     -0.4240238     -7.0184059
      -7.8539122    170.0400000     -0.0364326      0.0405799
       2.3778217      0.0470777      0.2056880     -2.1217498
      -9.1768369     -2.9474984     -0.1868119     -7.8411522
      -7.5395371     -6.2034501    170.0400000     -3.9942539
       4.2157260      0.6629322      1.9068600     -2.4261095
       2.3325604      0.2801768      2.0510436     -0.0642252
      21.6154827    -19.8954287      5.7014308      8.6840650
      19.8037653
 TIME USED=   0.000 SEC, ELAPSED TIME=   0.130 SEC
  REDUCED BLOCK            1 WRITTEN, LAST CO.          14

 SOLUTIONS TO NORMAL EQUATIONS:

 -0.102642525E+01 0.135200854E+01-0.194133454E+00 0.970475534E+00
 -0.981425763E+00 0.688602850E+00 0.293599350E+00 0.777365983E+00
  0.444607946E+01 0.126807385E+00-0.146249137E+00 0.110340909E+00
  0.100346866E+00

 NUMBER OF EQUATIONS =     13
 NORMALIZED SQUARE-SUM OF OBSERVATIONS        = 0.198038E+02
 NORMALIZED DIFFERENCE BETWEEN SQUARE-SUM OF
 OBSERVATIONS AND NORM OF APPROXIMATION       =-0.424719E+01
```

```
 TIME USED=   0.000 SEC, ELAPSED TIME=   0.120 SEC
  file 17 closed at label 3111
  PREDICTIONS: <

 =   0.5000
0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
             D  M  S       D  M  S     M
+                                              ST.DEV.=    1.948958
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  OBS    DIF    ERR
   40216   55 58 39.68    9 49 54.90      0.0
  -5.13  -0.09  0.58   0.86  -0.07  -0.21  -3.90  -4.18  -5.04
   3.61   0.12  0.58   3.93   1.71   1.62   4.09   7.42   3.49
   40606   54 42 54.22   11 55 55.39      0.0
  -1.34   0.03  0.58   0.97  -0.33  -0.32   0.25  -0.40  -1.37
   1.00   0.07  0.58   3.79   1.96   0.78   1.98   4.72   0.93
0COMPARISON OF PREDICTIONS AND OBSERVATIONS
0LATITUDE COMPONENT OF DEFLECTION OF THE VERTICAL (KSI)
 NUMBER:     2
0         OBSERVATIONS     PREDICTIONS     DIFFERENCE
 MEAN           -3.235000       -3.202023       -0.032977
 ST.DEV.         2.679935        2.595929        0.084006
 MAX            -1.340000       -1.366424        0.026424
 MIN            -5.130000       -5.037622       -0.092378
0DISTRIBUTION OF DIFFERENCES, UNITS:  0.100000
   0  0  0  0  0  0  0  0  0  1  1  0  0  0  0  0  0  0  0  0  0       0
 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1  0  1  2  3  4  5  6  7  8  9 10 OUTSIDE


0LONGITUDE COMPONENT OF DEFLECTION OF THE VERTICAL (ETA)
 NUMBER:     2
0         OBSERVATIONS     PREDICTIONS     DIFFERENCE
 MEAN            2.305000        2.209178        0.095822
 ST.DEV.         1.845549        1.808979        0.036570
 MAX             3.610000        3.488319        0.121681
 MIN             1.000000        0.930037        0.069963
0DISTRIBUTION OF DIFFERENCES, UNITS:  0.100000
   0  0  0  0  0  0  0  0  0  0  0  2  0  0  0  0  0  0  0  0  0       0
 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1  0  1  2  3  4  5  6  7  8  9 10 OUTSIDE


 HISTOGRAM RATIO ERROR/ERROR ESTIMATE IN 0.5 INTERVALS .
      4       0       0       0       0       0       0       0
  1.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
                D  M          D  M     M
+                                              ST.DEV.=   13.038405
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  OBS    DIF
      4413   54 51.49       9 59.55      6.9
  17.21   0.00
+                     -6.46  15.52 -10.47   5.70  10.74  17.21
  9.8151939106
      3163   54 50.23      12  0.01     17.6
  14.89   0.00
+                     -6.46  15.42 -15.67   8.68   8.43  14.89
  9.8151189618

 TIME USED=    0.000 SEC, ELAPSED TIME =     0.590 SEC
 TOTAL CPU TIME USED=        0.000 SEC
  GEOCOL TERMINATED AT:
 Mon Jul 16 14:22:03 2001

Restart file:

F
 T T F F F F F
```



```
1
NEQ
22    1
    0
GSFC
 3 0.398601220E+15 0.637814300E+07 0.298250000E+03
 5 0.978049000E+01 0.637838800E+07 0.297000000E+01
 -111.10 -111.50 -142.60  1.05  0.19  1.57  0.52E-05 T
 55 30  0.00 10  0  0.00 -1.00  1.00  0.00
' R.H.RAPP, THE GEOPOTENTIAL TO (14,14) ETC., IUGG, LUCERNE, 1967.'
 0.39860122E+15  6378143.0 -484.1803   8 T F F F
  0.0000  0.0000  2.3241 -1.3106  0.9025  1.7842  0.2601  0.7224 -0.5755
  ---  see start of example  ---
  0.0246  0.0668 -0.0948 -0.1090
 2
  24   0
 0.99980 1600.00  12 F F F F
    0.00    0.00    0.00    0.00    0.00    0.00    0.00   15.10
   17.70   13.70    8.40
 -1  2  3  2  4  5   0  -2   0   9913.91 F F T F F F F F F F
 T T     60.00    120.00     55.30
    937269  56 30.00   9  0.00 9913.91   -5.28    4.00 F
    937271  56 30.00  11  0.00 9913.91  -13.21    4.00 F
    937273  56 30.00  13  0.00 9913.91    3.91    4.00 F
    937289  55 30.00   9  0.00 9913.91    3.48    4.00 F
    937291  55 30.00  11  0.00 9913.91  -10.46    4.00 F
    937293  55 30.00  13  0.00 9913.91  -16.34    4.00 F
    937309  54 30.00   9  0.00 9913.91  -16.69    4.00 F
    937311  54 30.00  11  0.00 9913.91  -11.64    4.00 F
    937313  54 30.00  13  0.00 9913.91  -19.54    4.00 T
 T T
 T   10
    9   10   45    1    1  0.2233679E+00  0.4327523E+02
-0.352187842E-02 -0.204196198E-01  0.274808272E-01  0.286392157E-01
-0.158875713E-02 -0.181027918E-01 -0.255556509E-01  0.181673344E-02
-0.181072184E-01  0.179056528E+01
    0   10
 T F
 0.99980  170.00  90 T F F F
 -1  2  3  1  4  5   6  -5   0      0.00 F F F F F F F F F F
40216  55 58 39.68   9 49 54.90    0.00   -3.99    4.22    0.30    0.30 F
40621  55 57 56.16  12  2 20.37    0.00    0.66    1.91    0.30    0.30 F
40058  54 58  1.40   9 58 32.48    0.00   -2.43    2.33    0.30    0.30 F
40606  54 42 54.22  11 55 55.39    0.00    0.28    2.05    0.30    0.30 T
 F T
 -1  2  3  1  4  5   0  -1   0      0.00 F F F F F F F F F F
   28  55 52 38.51  12 50 38.93    0.00   -0.07    0.00 T
 F T
 -1  2  3  2  4  5   0  -2   0      0.00 F F F F F F F F F F
    261301  56  4.90  10  0.34   70.60   21.61    0.20 F
    700181  56  7.10  11 57.00    0.00  -19.90    0.20 F
      4413  54 51.49   9 59.55    6.94    5.69    0.20 F
      3163  54 50.23  12  0.01   17.63    8.68    0.20 T
 T T
 T   14
    9   14   91    1    1 -0.4222046E+01  0.1481002E+03
-0.102661803E+01  0.135160624E+01 -0.193436561E+00  0.968496435E+00
-0.981155376E+00  0.688599253E+00  0.292767007E+00  0.777057585E+00
 0.442095026E+01  0.126693792E+00 -0.146074317E+00  0.110220386E+00
 0.100210582E+00  0.198050511E+02
    0   14
T t F F
  54.5  55.0  9.0 10.0  0.5 1.0 13 0 5000.0 F F F
t
T T F F
   54.5 55.0  9.0 10.0  0.5 1.0 13 0 5000.0 F F F
F
T T F F
 54.5   55.0  9.0 10.0  0.5 1.0  5 0 5000.0 F F F
```

```
F
T T F  F
54.5   55.5  9.0 10.0  0.5 1.0  1 0      0.0 T F F
T

Output from edited restart file:

 GEODETIC COLLOCATION, VERSION 17 JUL 2001 RELEASE 15f  (LINUX)
 Wed Jul 18 10:23:00 2001

Only last part shown, since it is identical to the output
from the start run:

 OBSERVATIONS:

 SYSTEM USED:
+                   USER DEFINED SYSTEM.

 THE FOLLOWING QUANTITIES ARE MEAN-VALUES, AND ARE REPRESENTED
 AS POINT VALUES IN THE HEIGHT H.
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
                D  M          D  M     M
+                                            ST.DEV.=   27.981991
                       TRA   POT   POT-TRA
+  OBS    DIF    ERR
 ONLY STATION NUMBERS OUTPUT:
      937269     937271     937273     937289     937291     937293
      937309     937311     937313
  FILE          32 OPENED FOR NEQ
            1 FILE(S) OPENED FOR NEQ

 SOLUTIONS TO NORMAL EQUATIONS:

 -0.352581863E-02-0.204216085E-01 0.274768869E-01 0.286372986E-01
 -0.158881387E-02-0.181047089E-01-0.255596794E-01 0.181459416E-02
 -0.181112469E-01

 THE SOLUTIONS HAVE BEEN COMPUTED IN A PREVIOUS RUN.

 NUMBER OF EQUATIONS =      9
 NORMALIZED SQUARE-SUM OF OBSERVATIONS        = 0.179228E+01
 NORMALIZED DIFFERENCE BETWEEN SQUARE-SUM OF
 OBSERVATIONS AND NORM OF APPROXIMATION       = 0.224612E+00


 START OF COLLOCATION II:

  HCMAX =    100000.0000000000
  90 ERROR DEGREE-VARIANCES EQUAL TO ZERO

 RATIO R/RE                              =       0.999800
 DEPTH TO BJERHAMMAR SPHERE (R-RE)       =   -1274.20 M
 VARIANCE OF POINT GRAVITY ANOMALIES     =     170.00 MGAL**2
 THE FACTOR A, DIVEDED BY RE**2 IS       =      65.80 MGAL**2

  OBSERVATIONS:

0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
             D  M  S       D  M  S     M
+                                            ST.DEV.=    1.948958
                       TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
 ONLY STATION NUMBERS OUTPUT:
       40216      40621      40058      40606
0   NO      LATITUDE     LONGITUDE     H    ZETA (M)
             D  M  S       D  M  S     M
+                                            ST.DEV.=    0.370809
                       TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
```



```
 ONLY STATION NUMBERS OUTPUT:
          28
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
                D  M          D  M     M
+                                            ST.DEV.=   13.038405
                       TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
 ONLY STATION NUMBERS OUTPUT:
      261301     700181       4413       3163
  FILE          32 OPENED FOR NEQ
            1 FILE(S) OPENED FOR NEQ

 SOLUTIONS TO NORMAL EQUATIONS:

 -0.102642525E+01 0.135200854E+01-0.194133454E+00 0.970475534E+00
 -0.981425763E+00 0.688602850E+00 0.293599350E+00 0.777365983E+00
  0.444607946E+01 0.126807385E+00-0.146249137E+00 0.110340909E+00
  0.100346866E+00

 THE SOLUTIONS HAVE BEEN COMPUTED IN A PREVIOUS RUN.

 NUMBER OF EQUATIONS =     13
 NORMALIZED SQUARE-SUM OF OBSERVATIONS        = 0.198039E+02
 NORMALIZED DIFFERENCE BETWEEN SQUARE-SUM OF
 OBSERVATIONS AND NORM OF APPROXIMATION       =-0.424719E+01

  PREDICTIONS: <

  GRID CONSIST OF            2 *            2 POINTS
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
            DEGREES       DEGREES      M
+                                            ST.DEV.=    8.818779
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  ERR
          1   55.000000     9.000000    5000.0
   8.11
+                     -6.47  15.56  -6.77   2.98  11.77  18.24
          2   55.000000    10.000000    5000.0
   5.59
+                     -6.47  15.53  -8.90   6.33  12.97  19.43
          3   54.500000     9.000000    5000.0
   8.45
+                     -6.35  15.26 -18.32  -1.85  -4.92   1.44
          4   54.500000    10.000000    5000.0
   7.92
+                     -6.35  15.23 -12.61  -3.75  -1.13   5.23
  GRID CONSIST OF            2 *            2 POINTS
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
            DEGREES       DEGREES      M
+                                            ST.DEV.=    8.818779
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  ERR
          1   55.000000     9.000000    5000.0
   8.11
+                     -6.47  15.56  -6.77   2.98  11.77  18.24
          2   55.000000    10.000000    5000.0
   5.59
+                     -6.47  15.53  -8.90   6.33  12.97  19.43
          3   54.500000     9.000000    5000.0
   8.45
+                     -6.35  15.26 -18.32  -1.85  -4.92   1.44
          4   54.500000    10.000000    5000.0
   7.92
+                     -6.35  15.23 -12.61  -3.75  -1.13   5.23
  GRID CONSIST OF            2 *            2 POINTS
0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
            DEGREES       DEGREES      M
+                                            ST.DEV.=    1.323493
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
```

```
+  ERR
          1   55.000000     9.000000    5000.0
   1.23
+                    1.03  -0.22  -2.21  -0.88  -3.30  -4.34
   1.22
+                    4.04   1.61   1.05  -0.57   2.08  -1.96
          2   55.000000    10.000000    5000.0
   0.65
+                    1.00  -0.24  -1.34  -1.19  -2.77  -3.77
   0.61
+                    3.95   1.72   1.03   1.43   4.19   0.24
          3   54.500000     9.000000    5000.0
   1.26
+                    1.10  -0.30  -0.83  -0.64  -1.77  -2.87
   1.26
+                    4.06   1.61   0.98  -0.03   2.55  -1.51
          4   54.500000    10.000000    5000.0
   1.17
+                    1.07  -0.32  -0.55  -0.54  -1.41  -2.48
   1.19
+                    3.97   1.72   0.33   0.19   2.25  -1.72
  GRID CONSIST OF           3 *          2 POINTS
0   NO      LATITUDE     LONGITUDE     H    ZETA (M)
            DEGREES       DEGREES      M
+                                              ST.DEV.=    0.370809
                     TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  ERR
          1   55.500000     9.000000       0.0
   0.31
+                   27.23  48.33  -2.44   0.37  46.26  19.03
          2   55.500000    10.000000       0.0
   0.27
+                   26.01  47.82  -3.01   0.18  44.99  18.98
          3   55.000000     9.000000       0.0
   0.32
+                   27.50  48.28  -3.03   0.17  45.42  17.92
          4   55.000000    10.000000       0.0
   0.24
+                   26.27  47.77  -3.37   0.20  44.60  18.32
          5   54.500000     9.000000       0.0
   0.34
+                   27.80  48.21  -3.58  -0.10  44.54  16.74
          6   54.500000    10.000000       0.0
   0.31
+                   26.55  47.69  -3.67  -0.15  43.88  17.32
  54.500000   55.500000    9.000000   10.000000    0.500000    1.000000
    19.03   18.98
    17.92   18.32
    16.74   17.32
  GEOCOL TERMINATED AT:
 Wed Jul 18 10:23:05 2001
```

Example 2:

Here is shown the determination of 3 datum shift parameters, covariance interpolation (in step II) and use of numerically integrated mean gravity anomalies.

Input data:

```
 F
 T T T F F F F
NEQ
 T F F
 0
' GSFC '
 3 3.986012200E+14 6.378143000E+06 2.982500000E+02
 5 9.780490000E+00 6.378388000E+00 2.970000000E+02
```



```
 -111.10 -111.50 -142.60  1.05  0.19  1.57  5.20E-06 F
' R.H.RAPP, THE GEOPOTENTIAL TO (14,14) ETC., IUGG, LUCERNE, 1967.'
 3.98601220E+14  6378143.0 -484.1803   8 T F F F
  0.0000  0.0000  2.3241 -1.3106  0.9025  1.7842  0.2601  0.7224 -0.5755
  ----  see example 1  ----
  0.0246  0.0668 -0.0948 -0.1090
 2
  24
 0.9998  1600.00  12 F F F F
    0.0     0.0     0.0     0.0     0.0     0.0     0.0    15.1
   17.7    13.7     8.4
  1  2  3  2  4  5  0  2  0      0.00 F F T T F F F F F F
 F T     60.00    120.00     55.30
  4.00
    937269  56 30.00   9 00.00    0.00   18.00 F
    937271  56 30.00  11 00.00    0.00   10.00 F
    937273  56 30.00  13 00.00    0.00   27.00 F
    937289  55 30.00   9 00.00    0.00   26.00 F
    937291  55 30.00  11 00.00    0.00   12.00 F
    937293  55 30.00  13 00.00    0.00    6.00 F
    937309  54 30.00   9 00.00    0.00    5.00 F
    937311  54 30.00  11 00.00    0.00   10.00 F
    937313  54 30.00  13 00.00    0.00    2.00 T
T F
T T
 0.999800 170.00  90 T T F F
   2    0.000    200.00   2
   120.000  1920.000
        12        12
 T
CXF
POTF
 3
     1     2     3
  1  2  3  1  0  4  5  5  0      0.00 F F F T F F F F F F
 T   3
     1     2     3
  0.30
40621  55 57 56.16  12 02 20.37   -2.20   -0.37 F
40058  54 58 01.40   9 58 32.48   -5.13    1.11 F
40606  54 42 54.22  11 55 55.39   -1.34    1.00 T
F F
  1  2  3  1  0  4  5  5 -1      0.00 F F F T F F F F F F
 T   0
  0.30
40216  55 58 39.68   9 49 54.90   -5.13    3.61 T
F F
  1  2  3  1  0  4  0  1  0      0.00 F F F F F F F F F F
 T   3
     1     2     3
   28  55 52 38.51  12 50 38.93   20.40    0.00 T
F F
  1  2  3  1  0  4  0  1 -1      0.00 F F F F F F F F F F
 T   0
  201  55 45 00.00  11 00 00.00   43.87    0.44 T
F F
  1  2  3  1  0  4  5  7  0      0.00 F F F T F F F F F F
 T   3
     1     2     3
  0.10
  210  55 45 00.00  11 00 00.00   -1.82   -1.54 F
10000  55 30 00.00  10 00 00.00   -1.86   -1.62 T
F F
  1  2  3  1  0  4  0  6  0      0.00 F F F F F F F F F F
 T   3
     1     2     3
20000  55 30 00.00  10 00 00.00  -24.08    1.00 T
F F
  1  2  3  2  4  5  0 13  0      0.00 F F F T F T F F F F
```

```
 T   0
      1.00 981000.00 T
  0.20
    261301  56 04.90  10 00.34   70.60  621.54 F
    700181  56 07.10  11 57.00    0.00  603.20 F
      4413  54 51.49   9 59.55    6.94  517.58 F
      3163  54 50.23  12 00.01   17.63  510.18 T
T F
F T T F F
  1  2  3  1  0  4  5  5 -1      0.00 F F F F F F F F F F
 T   0
40216  55 58 39.68   9 49 54.90   -5.13    3.61 T
F
F T T F F
  1  2  3  1  0  4  5  5  0      0.00 F F F F F F F F F F
 T   3
     1     2     3
40606  54 42 54.22  11 55 55.39   -1.34    1.00 T
F
F T T F F
  1  2  3  1  4  5  0  1  0      0.00 F F F F F F F F F F
 T   3
     1     2     3
   28  55 52 38.51  12 50 38.93    0.00   20.40 T
F
F T T F F
  1  2  3  2  4  5  0 13  0      0.00 F F F F F T T F F F
      1.00
 T   0
      1.00 981000.00 T
 -1.0
      4413  54 51.49   9 59.55    6.94  517.58 F
      3163  54 50.23  12 00.01   17.63  510.18 T
F
T T F F
  54.5  55.0    9.0 10.0 0.5000 1.0000  13  0   9000.00 F F F
     0
F
T T F F
  54.5  55.0    9.0 10.0 0.5000 1.0000   5  0 100000.00 F F F
     3     1     2     3
F
T T F F
  54.5  55.0    9.0 10.0 0.5000 1.0000   1  0 100000.00 F F F
     3     1     2     3
F
T T F F
   54.5 55.5    9.0 11.0 1.0 2.0    2  0      0.00 F F T
     0
 F T     60.00    120.00     55.30
T

Output from example 2, only last part shown, since first
part is identical to output from example 1.

 GEODETIC COLLOCATION, VERSION 17 JUL 2001 RELEASE 15f  (LINUX)
 Wed Jul 18 10:31:54 2001


  OBSERVATIONS:

 =   4.0000

 SYSTEM USED:
+                   USER DEFINED SYSTEM.

 THE FOLLOWING QUANTITIES ARE MEAN VALUES, WITH
 BLOCKSIZE=     60.00 *     120.00 MINUTES
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
```



```
                D  M          D  M     M
+                                              ST.DEV.=   28.021315
                       TRA   POT   POT-TRA
+  OBS    DIF    ERR
    937269   56 30.00       9  0.00      0.0
  18.00  -5.26  4.00  -6.81  16.45  23.26
    937271   56 30.00      11  0.00      0.0
  10.00 -13.19  4.00  -6.81  16.38  23.19
    937273   56 30.00      13  0.00      0.0
  27.00   3.93  4.00  -6.81  16.26  23.07
    937289   55 30.00       9  0.00      0.0
  26.00   3.50  4.00  -6.58  15.91  22.50
    937291   55 30.00      11  0.00      0.0
  12.00 -10.44  4.00  -6.59  15.85  22.44
    937293   55 30.00      13  0.00      0.0
   6.00 -16.32  4.00  -6.59  15.73  22.32
    937309   54 30.00       9  0.00      0.0
   5.00 -16.68  4.00  -6.36  15.32  21.68
    937311   54 30.00      11  0.00      0.0
  10.00 -11.62  4.00  -6.36  15.26  21.62
    937313   54 30.00      13  0.00      0.0
   2.00 -19.52  4.00  -6.36  15.16  21.52
  FILE          32 OPENED FOR NEQ
           1 FILE(S) OPENED FOR NEQ
 BLOCK-CATALOGUE:    0   10

 COEFFICIENTS OF NORMAL-EQUATIONS, BLOCK    1
 (FIRST 200 ELEMENTS AND LAST FULL BLOCK)
     707.8942542    409.3060542    707.8943147    219.3687277
     409.3059516    707.8943700    428.0667531    319.0932842
     194.8268423    703.6107357    319.0933616    428.0666925
     319.0932080    402.8863912    703.6107933    194.8268312
     319.0932788    428.0666341    213.5169086    402.8862871
     703.6108460    240.7522956    208.4012009    148.8295000
     426.6559213    315.3863489    190.1824240    699.4461680
     208.4012195    240.7522312    208.4011386    315.3864553
     426.6558588    315.3862722    396.7057187    699.4462228
     148.8294871    208.4011555    240.7521698    190.1824223
     315.3863695    426.6557985    207.9286328    396.7056131
     699.4462729     -5.2585529    -13.1908798      3.9327491
       3.5011330    -10.4359391    -16.3211605    -16.6763384
     -11.6201976    -19.5165666      1.7813314
  REDUCED BLOCK           1 WRITTEN, LAST CO.           10

 SOLUTIONS TO NORMAL EQUATIONS:

 -0.665751823E-02-0.336123566E-01 0.438002011E-01 0.470808248E-01
 -0.127627680E-02-0.273047403E-01-0.417781898E-01 0.114732619E-01
 -0.212056257E-01

 NUMBER OF EQUATIONS =      9
 NORMALIZED SQUARE-SUM OF OBSERVATIONS        = 0.178133E+01
 NORMALIZED DIFFERENCE BETWEEN SQUARE-SUM OF
 OBSERVATIONS AND NORM OF APPROXIMATION       =-0.470356E+00


 START OF COLLOCATION II:

  HCMAX =    100000.0000000000
  90 ERROR DEGREE-VARIANCES EQUAL TO ZERO

 RATIO R/RE                               =       0.999800
 DEPTH TO BJERHAMMAR SPHERE (R-RE)        =   -1274.20 M
 VARIANCE OF POINT GRAVITY ANOMALIES      =     170.00 MGAL**2
 THE FACTOR A, DIVEDED BY RE**2 IS        =      65.80 MGAL**2

 TABEL OF COVARIANCES GENERATED USING
 NS=   2, HMIN=     0.000, HMAX=   200.000
  MAX-PSI (ARCSEC)   N-INTERVALS.
```

```
   120.000                12
  1920.000                12
 NUMBER OF BLOCKS NEEDED FOR CX =          1
         81 POT. COFF. WRITTEN TO UNIT 3
 start writing CX
 end writing CX
 start reading COFF
 end   reading COFF
0NUMBER OF PARAMETERS=  3
 DELTA X
 DELTA Y
 DELTA Z

 OBSERVATIONS:


 OBSERVATIONS CONTRIBUTE TO/DEPEND ON   3 PARAMETERS     1     2     3
 =   0.3000
0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
             D  M  S       D  M  S     M
+                                              ST.DEV.=    1.948958
                       TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
   40621   55 57 56.16   12  2 20.37      0.0
  -2.20   2.15  0.30   1.81  -0.13  -2.41  -2.54  -4.35
  -0.37   1.30  0.30   2.77   1.99  -0.88   1.10  -1.67
   40058   54 58  1.40    9 58 32.48      0.0
  -5.13  -0.71  0.30   2.00  -0.25  -2.17  -2.42  -4.42
   1.11   1.45  0.30   2.96   1.72   0.89   2.61  -0.34
   40606   54 42 54.22   11 55 55.39      0.0
  -1.34   1.28  0.30   1.99  -0.33  -0.29  -0.62  -2.62
   1.00   0.67  0.30   2.82   1.96   1.19   3.15   0.33
 =   0.3000

 SELECTED GEOCENTRIC SYSTEM USED.
0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
             D  M  S       D  M  S     M
+                                              ST.DEV.=    1.948958
                       POT    COLL   PRED
+  OBS    DIF    ERR
   40216   55 58 39.68    9 49 54.90      0.0
  -5.13  -5.47  0.30  -0.07   0.41   0.34
   3.61  -0.20  0.30   1.71   2.10   3.81

 OBSERVATIONS CONTRIBUTE TO/DEPEND ON   3 PARAMETERS     1     2     3
 SYSTEM USED:
+                   USER DEFINED SYSTEM.
0   NO      LATITUDE     LONGITUDE     H    ZETA (M)
             D  M  S       D  M  S     M
+                                              ST.DEV.=    0.370809
                       TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
      28   55 52 38.51   12 50 38.93      0.0
  20.40   0.56  0.00  23.19  46.20  -3.17  43.03  19.84

 SELECTED GEOCENTRIC SYSTEM USED.
0   NO      LATITUDE     LONGITUDE     H    ZETA (M)
             D  M  S       D  M  S     M
+                                              ST.DEV.=    0.370809
                       POT    COLL   PRED
+  OBS    DIF    ERR
     201   55 45  0.00   11  0  0.00      0.0
  43.87  -0.05  0.44  47.29  -3.37  43.92

 OBSERVATIONS CONTRIBUTE TO/DEPEND ON   3 PARAMETERS     1     2     3
 =   0.1000
 SYSTEM USED:
+                   USER DEFINED SYSTEM.
0   NO      LATITUDE     LONGITUDE     H    LAT.,LONG*COS(LAT) DIFF.
```



```

   NO      LATITUDE     LONGITUDE     H    GRA.DIST. MGAL
             D  M  S       D  M  S     M
                       TRA    PRED PRED-TRA
+  OBS    DIF    ERR
     210   55 45  0.00   11  0  0.00      0.0
  -1.82   0.04  0.10   1.86   0.00  -1.86
  -1.54   1.32  0.10   2.86   0.00  -2.86
   10000   55 30  0.00   10  0  0.00      0.0
  -1.86   0.06  0.10   1.92   0.00  -1.92
  -1.62   1.32  0.10   2.94   0.00  -2.94
  UNIT 2 WRITTEN

 OBSERVATIONS CONTRIBUTE TO/DEPEND ON   3 PARAMETERS     1     2     3
0   NO      LATITUDE     LONGITUDE     H    HEIGHT DIF.
             D  M  S       D  M  S     M
                       TRA    PRED PRED-TRA
+  OBS    DIF    ERR
   20000   55 30  0.00   10  0  0.00      0.0
 -24.08   1.93  1.00  26.01   0.00 -26.01
  UNIT 2 WRITTEN
 =   0.2000
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
                D  M          D  M     M
+                                              ST.DEV.=   13.038405
                       TRA    POT    COLL   PRED  PRED-TRA
+  OBS    DIF    ERR
   261301   56  4.90      10  0.34     70.6
  37.49  22.13  0.20  -6.71  16.21  -7.56   8.65  15.37
   700181   56  7.10      11 57.00      0.0
  -5.69 -19.21  0.20  -6.72  16.14  -9.35   6.79  13.51
     4413   54 51.49       9 59.55      6.9
  17.21   5.56  0.20  -6.44  15.52 -10.31   5.21  11.65
     3163   54 50.23      12  0.01     17.6
  14.89   9.82  0.20  -6.44  15.42 -16.78  -1.36   5.08

 PARAMETER CATALOGUE:
      13       3       1       2       3      14       0      15       3
       1       2       3      16       0      20       0
  FILE          32 OPENED FOR NEQ
          1 FILE(S) OPENED FOR NEQ
 BLOCK-CATALOGUE:    0   18

 COEFFICIENTS OF NORMAL-EQUATIONS, BLOCK    1
 (FIRST 200 ELEMENTS AND LAST FULL BLOCK)
       3.8884353      0.0000000      3.8884353     -0.1484651
      -0.2512843      3.8884353     -0.2401540     -0.2265767
       0.0000000      3.8884353     -0.5121256     -0.0341434
       0.2079632      0.1670838      3.8884353     -0.0336385
       0.1832413      0.1593392     -0.4853025      0.0000000
       3.8884353      0.1949499      0.0021294     -0.5046967
       0.0680089     -0.1821828      0.1752083      3.8884353
       0.0123743     -0.5159390      0.0683372      0.3442822
       0.1855750     -0.1617183      0.0000000      3.8884353
       0.0538815     -0.2842926      0.0071299      0.0121577
      -0.1089551     -0.0478264      0.0006632     -0.0174792
       0.1374995      0.0947058      0.2624535     -0.1625602
      -0.1191302     -0.1335166      0.0673139      0.0856672
      -0.2535131      0.0061017      0.3310995     -0.2669152
       2.2811017     -2.4584315     -0.0368704      0.2019467
      -0.1571410     -7.2510692     -6.7301804     -0.4665442
       0.8663031    166.7013038     -9.1974994      2.9870562
      -0.1306374     -0.1232115     -0.9594210     -0.0068315
      -0.2690128     -2.0060023      1.1799366      0.8754155
      -5.0600913    170.0400000      0.1200147      0.1296790
       9.8163228     -0.8724658     -0.3353345      2.3612796
       2.3995149     -0.1962875     -0.4239774     -0.0716992
      -7.0055194     -7.8530210    169.7029327      2.3772873
```

```
       0.0470835      0.2056592     -2.1212980     -9.3833758
      -3.0139052     -0.0358378      0.0398708     -0.1867014
      -0.0934319     -7.8298613     -7.5366115     -6.1994151
     169.1877165     -0.0262051     -0.0067290     -0.0260789
      -0.0055888     -0.0258281     -0.0066705      0.0000000
       0.0000000     -0.5469398      0.0000000      0.0000000
       0.0000000      0.0000000      0.0000000      0.4557865
      -0.0055880      0.0315554     -0.0045863      0.0317790
      -0.0054573      0.0315701      0.0000000      0.0000000
      -0.1246914      0.0000000      0.0000000      0.0000000
       0.0000000      0.0000000      0.0430792      0.2156969
       0.0180967      0.0000000      0.0185640      0.0000000
       0.0186810      0.0000000      0.0000000      0.0000000
      -0.8278339      0.0000000      0.0000000      0.0000000
       0.0000000      0.0000000      0.3638936      0.0632929
       0.7458371      2.1476542      1.2998482     -0.7126340
       1.4540514      1.2756679      0.6717057     -5.4690865
      -0.1967283      0.5551686     -0.0475378     22.1266046
     -19.2050112      5.5584183      9.8157589     -2.9088139
       8.1055114     -1.3925999     18.8373623
  REDUCED BLOCK            1 WRITTEN, LAST CO.          18

 SOLUTIONS TO NORMAL EQUATIONS:

  0.428284779E+00-0.220972193E-01-0.581793281E+00 0.127193510E+00
  0.533410117E+00-0.469300108E-01-0.141748972E+01 0.833873603E-02
 -0.142016029E-01 0.187513266E+00 0.675661856E-01-0.797430411E-01
  0.908094274E-01 0.857426181E-01-0.979231107E+01 0.396649281E+02
 -0.430490866E+00
OLAST   3 ELEMENTS OF SOLUTION VECTOR
 ARE THE VALUES OF THE ESTIMATED PARAMETERS


 NUMBER OF EQUATIONS =     17
 NORMALIZED SQUARE-SUM OF OBSERVATIONS        = 0.188374E+02
 NORMALIZED DIFFERENCE BETWEEN SQUARE-SUM OF
 OBSERVATIONS AND NORM OF APPROXIMATION       =-0.317504E+03

 ELEMENTS OF (AT*C**-1*A)**-1.
  REDUCED BLOCK            1 WRITTEN, LAST CO.          18
    3.3539   -0.3068   -2.1189
  REDUCED BLOCK            1 WRITTEN, LAST CO.          18
   -0.3068    4.7038   -0.4664
  REDUCED BLOCK            1 WRITTEN, LAST CO.          18
   -2.1189   -0.4664    1.5568
  PREDICTIONS: <


 SELECTED GEOCENTRIC SYSTEM USED.
0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
             D  M  S       D  M  S     M
+                                              ST.DEV.=    1.948958
                       POT   COLL1  COLL2  PRED
+  OBS    DIF    ERR
   40216   55 58 39.68    9 49 54.90      0.0
  -5.13  -0.13  0.30  -0.07   0.41  -5.34  -5.00
   3.61   0.00  0.30   1.71   2.10  -0.20   3.61

 OBSERVATIONS CONTRIBUTE TO/DEPEND ON   3 PARAMETERS     1     2     3
 SYSTEM USED:
+                   USER DEFINED SYSTEM.
0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
             D  M  S       D  M  S     M
+                                              ST.DEV.=    1.948958
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  OBS    DIF    ERR
   40606   54 42 54.22   11 55 55.39      0.0
  -1.34   0.05  0.33   1.99  -0.33  -0.29   1.23   0.61  -1.39
   1.00   0.00  0.33   2.82   1.96   1.19   0.68   3.83   1.00
```



```
 OBSERVATIONS CONTRIBUTE TO/DEPEND ON   3 PARAMETERS     1     2     3
0   NO      LATITUDE     LONGITUDE     H    ZETA (M)
             D  M  S       D  M  S     M
+                                              ST.DEV.=    0.370809
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  OBS    DIF    ERR
      28   55 52 38.51   12 50 38.93      0.0
  20.40   0.00  0.59  23.19  46.20  -3.17   0.56  43.59  20.40
 =   0.1000
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
                D  M          D  M     M
+                                              ST.DEV.=   13.038405
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  OBS    DIF    ERR
     4413   54 51.49       9 59.55      6.9
  17.21   0.00  0.22  -6.44  15.52 -10.31   5.55  10.77  17.21
  9.8153412347
     3163   54 50.23      12  0.01     17.6
  14.89   0.00  0.22  -6.44  15.42 -16.78   9.81   8.46  14.89
  9.8152627120
0COMPARISON OF PREDICTIONS AND OBSERVATIONS
0DATA TYPE = 13
 NUMBER:     2
0         OBSERVATIONS     PREDICTIONS     DIFFERENCE
 MEAN           16.052279       16.048748        0.003531
 ST.DEV.         1.636873        1.636729        0.000143
 MAX            17.209723       17.206090        0.003632
 MIN            14.894835       14.891405        0.003430
0DISTRIBUTION OF DIFFERENCES, UNITS:  1.000000
   0  0  0  0  0  0  0  0  0  0  2  0  0  0  0  0  0  0  0  0  0       0
 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1  0  1  2  3  4  5  6  7  8  9 10 OUTSIDE


 HISTOGRAM RATIO ERROR/ERROR ESTIMATE IN 0.5 INTERVALS .
       2       0       0       0       0       0       0       0
  1.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

  GRID CONSIST OF           2 *           2 POINTS
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
            DEGREES       DEGREES      M
+                                              ST.DEV.=    7.335262
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  ERR
        1   55.000000     9.000000    9000.0
   6.62
+                     -6.42  15.50  -6.00  -1.50   8.01  14.42
        2   55.000000    10.000000    9000.0
   4.52
+                     -6.42  15.48  -7.57   2.31  10.21  16.63
        3   54.500000     9.000000    9000.0
   6.95
+                     -6.31  15.20 -16.53  -1.94  -3.27   3.03
        4   54.500000    10.000000    9000.0
   6.46
+                     -6.31  15.18 -13.47  -1.84  -0.13   6.18
  GRID CONSIST OF           2 *           2 POINTS

 OBSERVATIONS CONTRIBUTE TO/DEPEND ON   3 PARAMETERS     1     2     3
  4 DIGIT LAYOUT IN USE
  PW   0.1396894688819975
0   NO      LATITUDE     LONGITUDE     H    KSI/ETA (ARCSEC)
            DEGREES       DEGREES      M
+                                     K
+                                              ST.DEV.=    0.139689
                       TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  ERR
        1   55.000000     9.000000     100.0
 0.1391
```

```
+                    2.0195-0.1037-0.6743 0.0403-0.7377-2.7573
   0.14
+                    3.0252 1.5715 0.5961 1.2729 3.4405 0.4153
          2   55.000000    10.000000     100.0
 0.1275
+                    1.9957-0.1272-0.6100 0.0385-0.6987-2.6945
   0.13
+                    2.9529 1.6856 0.4963 1.2617 3.4435 0.4906
          3   54.500000     9.000000     100.0
 0.1419
+                    2.0903-0.1808-0.4318 0.0839-0.5287-2.6190
   0.14
+                    3.0418 1.5721 0.5685 1.2838 3.4245 0.3827
          4   54.500000    10.000000     100.0
 0.1332
+                    2.0667-0.2032-0.3603 0.0611-0.5023-2.5691
   0.14
+                    2.9695 1.6844 0.3990 1.2379 3.3213 0.3518
  GRID CONSIST OF            2 *            2 POINTS

 OBSERVATIONS CONTRIBUTE TO/DEPEND ON   3 PARAMETERS     1     2     3
  4 DIGIT LAYOUT IN USE
  PW   5.5825591961524808E-002
0   NO      LATITUDE     LONGITUDE     H    ZETA (M)
            DEGREES       DEGREES      M
+                                     K
+                                            ST.DEV.=    0.055826
                      TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  ERR
          1   55.000000     9.000000     100.0
 0.3000
+                   27.460046.6799-2.4617 2.320446.538619.0786
          2   55.000000    10.000000     100.0
 0.2941
+                   26.540846.1668-2.6345 1.921645.453918.9131
          3   54.500000     9.000000     100.0
 0.3050
+                   28.020846.6389-2.6190 2.337746.357618.3367
          4   54.500000    10.000000     100.0
 0.2968
+                   27.090246.1195-2.7719 1.935645.283218.1930
  GRID CONSIST OF            2 *            2 POINTS

 THE FOLLOWING QUANTITIES ARE MEAN VALUES, WITH
 BLOCKSIZE=     60.00 *     120.00 MINUTES
0   NO      LATITUDE     LONGITUDE     H   DELTA G (MGAL)
            DEGREES       DEGREES      M
+                                            ST.DEV.=    6.559727
                      TRA    POT   COLL1  COLL2  PRED PRED-TRA
+  ERR
          1   55.500000     9.000000       0.0
   4.25
+                     -6.63  15.91   2.75  -1.94  16.72  23.35
          2   55.500000    11.000000       0.0
   3.68
+                     -6.63  15.85 -10.42  -1.62   3.81  10.44
          3   54.500000     9.000000       0.0
   4.80
+                     -6.41  15.32 -16.00  -1.70  -2.38   4.03
          4   54.500000    11.000000       0.0
   4.10
+                     -6.41  15.26 -11.80   0.95   4.41  10.81
  GEOCOL TERMINATED AT:
 Wed Jul 18 10:32:05 2001


  COVCG OR TABH CALLED    112 TIMES WITH INIT.
  COVCG OR TABH CALLED      8 TIMES WITHOUT INIT.
  COVCX CALLED           1105 TIMES.
```



```
Example 3.

The example shows the use of the program for the computation
of reference values from a spherical harmonic expansion, and the
computation of density values using quasi-harmonic inversion.

Input data:

F
F T F T F T F
 5
 WENZELS GPM2 TO DEGR. 180.
 3.98600500E+14  6378135.0 -484.1803 180 F F F F
COGPM2
F F T F F
  1  2  3  1  0  4  5 30  3    300.00 F F F F F T T F F F
      5.00
      1.00      0.00 T
1100   39 39 41.70 -83 10 18.60   16.74  -24.78 F
1101   39 40 16.80 -83 09 35.50   20.45  -34.45 F
1102   39 39 03.60 -83 09 44.50   23.57  -33.58 F
1103   39 40 00.20 -83 08 30.80    6.19  -60.43 T
F
F F T F F
  1  2  3  1  0  4  5 35  3    300.00 F F F F F T T F F F
      5.00
      1.00      0.00 T
1100   39 39 41.70 -83 10 18.60    8.76    0.73 F
1101   39 40 16.80 -83 09 35.50  -16.82    0.67 F
1102   39 39 03.60 -83 09 44.50  -23.40  -18.35 F
1103   39 40 00.20 -83 08 30.80   20.93  -18.29 T
F
T F F F F
    5.00000   80.00000 1.0000 1.0000   1   1 10 -7      0.00 F F F
  0 6371000.0    1000.0 F
COGPM2.BIN
T

Output:


 GEODETIC COLLOCATION, VERSION 13 JUL 2001 RELEASE 15f  (LINUX)
 Mon Jul 16 14:25:00 2001


 NOTE THAT THE FUNCTIONALS ARE IN SPHERICAL APPROXIMATION
 MEAN RADIUS = RE = 6371 KM AND MEAN GRAVITY 981 KGAL USED.
 MAX NUMBER OF OBS= 5600, MAX NUMBER OF PARAMETERS=239
 MAX NUMBER OF OBS IN GIVEN REF. FRAME =5600
 SIZE OF NORMAL EQ. BLOCKS= 399120, SIZE OF POT.COFF. BLOCK= 3243602
  INTERACTIVE INPUT (T/F)
  BUFFER SIZE MAXO9 =       403200

 LEGEND OF TABLES OF OBSERVATIONS AND PREDICTIONS:
 OBS = OBSERVED VALUE (WHEN AN OBSERVATION IS A VECTOR
       QUANTITY, THEN ONE BELOW THE OTHER)
 DIF = DIFFERENCE BETWEEN OBSERVED AND PREDICTED VALUE
       WHEN PREDICTION ARE COMPUTED AND ELSE THE RESIDUAL
       OBSERVATION.
 ERR = STANDARD DEVIATION OF OBSERVATION OR ESTIMATE OF
       PREDICTION ERROR.
 TRA = CONTRIBUTION FROM DATUM TRANSFORMATION.
 TERR= CONTRIBUTION FROM TERRAIN
 POT = CONTRIBUTION FROM POTENTIAL COEFFICIENTS.
 COLL= CONTRIBUTION FROM COLLOCATION DETERMINED PART.
 COLL1=CONTRIBUTION FROM FIRST SET OF OBSERVATIONS.
```

```
 COLL2=CONTRIBUTION FROM SECOND SET OF OBSERVATIONS.
 PRED= PREDICTED VALUE IN GEOCENTRIC SYSTEM.
 PRED-TRA= PREDICTED VALUE IN SELECTED COORDINATE SYSTEM.

 REFERENCE SYSTEM:
+                   GRS1980.

 A   = 6378137.00 M
 1/F = 298.2572204
 GM= 0.3986005000E+15
 REF.GRAVITY AT EQUATOR =   978032.6772 MGAL
 POTENTIAL AT REF.ELL.  = 62636860.8504 M**2/SEC**2


 SOURCE OF THE POTENTIAL COEFFICIENTS USED:
  WENZELS GPM2 TO DEGR. 180.

     GM              A       COFF(5)  MAX.DEGREE
 0.39860050E+15  6378135.0 -484.1803  180
 NAME OF FILE HOLDING COEFFICIENTS: COGPM2

  COEFFICIENTS UP TO N=5
    0   0  0.100000000E+01  0.000000000E+00
    1   0  0.000000000E+00  0.000000000E+00
    2   0 -0.484165010E-03  0.000000000E+00
    3   0  0.957653010E-06  0.000000000E+00
    4   0  0.540946640E-06  0.000000000E+00
    1   1  0.000000000E+00  0.000000000E+00
    2   1 -0.122337420E-08 -0.230018360E-08
    3   1  0.203089730E-05  0.250573750E-06
    4   1 -0.532396430E-06 -0.475613860E-06
    2   2  0.243887440E-05 -0.139975070E-05
    3   2  0.900259070E-06 -0.616907760E-06
    4   2  0.354211950E-06  0.659978300E-06
    3   3  0.718245700E-06  0.142322390E-05
    4   3  0.983652510E-06 -0.207454700E-06
    4   4 -0.193606230E-06  0.309325510E-06
         101 DEG FINISHED READING


 SYSTEM USED:
+                   NAD1927, NEW MEXICO VALUES, DLON=-0.7".
0   NO      LATITUDE     LONGITUDE     H KIND= 30
           D  M  S       D  M  S     M
                     TRA   POT   POT-TRA
+  OBS    DIF
    1100   39 39 41.70  -83 10 18.60    300.0
   8.79   9.58
+                   -0.06  -0.85  -0.79
 -24.78 -23.21
+                    0.00  -1.57  -1.57
    1101   39 40 16.80  -83  9 35.50    300.0
  12.50  13.31
+                   -0.06  -0.87  -0.81
 -34.45 -32.85
+                    0.00  -1.60  -1.60
    1102   39 39  3.60  -83  9 44.50    300.0
  15.62  16.33
+                   -0.06  -0.77  -0.71
 -33.58 -31.92
+                    0.00  -1.66  -1.66
    1103   39 40  0.20  -83  8 30.80    300.0
  -1.76  -1.02
+                   -0.06  -0.80  -0.74
 -60.43 -58.73
+                    0.00  -1.70  -1.70
0COMPARISON OF PREDICTIONS AND OBSERVATIONS
0DATA TYPE = 30
 NUMBER:     4
```



```
0         OBSERVATIONS     PREDICTIONS     DIFFERENCE
 MEAN             8.788867       -0.762333        9.551200
 ST.DEV.          7.565820        0.045106        7.569132
 MAX             15.621975       -0.711324       16.333299
 MIN             -1.758845       -0.809442       -1.019810
0DISTRIBUTION OF DIFFERENCES, UNITS:  5.000000
   0  0  0  0  0  0  0  0  0  0  1  0  1  2  0  0  0  0  0  0  0       0
 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1  0  1  2  3  4  5  6  7  8  9 10 OUTSIDE


0DATA TYPE = 31
 NUMBER:     4
0         OBSERVATIONS     PREDICTIONS     DIFFERENCE
 MEAN           -38.310000       -1.633874      -36.676126
 ST.DEV.         15.379941        0.057359       15.328630
 MAX            -24.780000       -1.574939      -23.205061
 MIN            -60.430000       -1.703819      -58.726181
0DISTRIBUTION OF DIFFERENCES, UNITS:  5.000000
   0  0  0  1  1  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0       1
 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1  0  1  2  3  4  5  6  7  8  9 10 OUTSIDE


0   NO      LATITUDE     LONGITUDE     H KIND= 35
           D  M  S       D  M  S     M
                     TRA   POT   POT-TRA
+  OBS    DIF
    1100   39 39 41.70  -83 10 18.60    300.0
   2.56   3.04
+                    0.07  -0.40  -0.47
   0.73  -1.34
+                    0.00   2.07   2.07
    1101   39 40 16.80  -83  9 35.50    300.0
 -23.02 -22.56
+                    0.07  -0.39  -0.46
   0.67  -1.50
+                    0.00   2.17   2.17
    1102   39 39  3.60  -83  9 44.50    300.0
 -29.60 -29.09
+                    0.07  -0.44  -0.51
 -18.35 -20.41
+                    0.00   2.06   2.06
    1103   39 40  0.20  -83  8 30.80    300.0
  14.73  15.22
+                    0.07  -0.41  -0.48
 -18.29 -20.52
+                    0.00   2.23   2.23
0COMPARISON OF PREDICTIONS AND OBSERVATIONS
0DATA TYPE = 35
 NUMBER:     4
0         OBSERVATIONS     PREDICTIONS     DIFFERENCE
 MEAN            -8.829244       -0.480414       -8.348831
 ST.DEV.         20.957316        0.022553       20.952482
 MAX             14.733983       -0.456109       15.216502
 MIN            -29.598833       -0.510011      -29.088822
0DISTRIBUTION OF DIFFERENCES, UNITS:  5.000000
   0  0  0  0  1  1  0  0  0  0  0  1  0  1  0  0  0  0  0  0  0       0
 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1  0  1  2  3  4  5  6  7  8  9 10 OUTSIDE


0DATA TYPE = 36
 NUMBER:     4
0         OBSERVATIONS     PREDICTIONS     DIFFERENCE
 MEAN            -8.810000        2.135706      -10.945706
 ST.DEV.         10.981257        0.080569       10.995636
 MAX              0.730000        2.231100       -1.343200
 MIN            -18.350000        2.064826      -20.521100
0DISTRIBUTION OF DIFFERENCES, UNITS:  5.000000
   0  0  0  0  0  2  0  0  0  2  0  0  0  0  0  0  0  0  0  0  0       0
 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1  0  1  2  3  4  5  6  7  8  9 10 OUTSIDE
```

```
 GRID CONSIST OF            2 *            2 POINTS
WEIGHT FACTOR ON HARMONIC DENSITIES IS R**(  0)*    1000.0
DENSITY DISTRIBUTION IS WITHIN SPHERE WITH RADIUS 6371000.00 M

HARMONIC COEFFICIENTS FROM C(0,0) TO C(4,0)
 0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00
 0.3667083E-07 -0.3385068E-07 -0.6364592E-07  0.6748348E-04
-0.3873100E-04  0.3990596E-04  0.1196830E-03  0.1476659E-04
 0.5305326E-04 -0.3635506E-04  0.4232701E-04  0.8387215E-04
-0.1851479E-04


SELECTED GEOCENTRIC SYSTEM USED.
0   NO      LATITUDE     LONGITUDE     H KIND= 10
            DEGREES       DEGREES      M
                                                                  POT
          1    5.000000    80.000000       0.0
+                                                                  -27.06
          2    5.000000    81.000000       0.0
+                                                                  -31.47
          3    4.000000    80.000000       0.0
+                                                                   -3.76
          4    4.000000    81.000000       0.0
+                                                                   -8.22
 GEOCOL TERMINATED AT:
Mon Jul 16 14:25:01 2001
```