File : ETERNA34.HLP, Status 1997.09.21  4746 records

```
#######    ########    #######     #######      ##    ##        ####
##            ##       ##          ##    ##     ###   ##       ##  ##
##            ##       ##          ##    ##     ####  ##      ##    ##
######        ##       ######      #######      ## ## ##      ##    ##
##            ##       ##          ##  ##       ##  ####      ########
##            ##       ##          ##   ##      ##   ###      ##    ##
#######       ##       #######     ##    ##     ##    ##      ##    ##
```

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```
***************************************************
*                                                 *
*    EARTH TIDE DATA PROCESSING PACKAGE ETERNA    *
*                                                 *
*                  Version 3.40                   *
*                                                 *
*               Manual ETERNA34.HLP               *
*                                                 *
***************************************************
```

Contents of the manual ETERNA34.HLP:
------------------------------------ record

## Section 1: General description of the ETERNA package

The Earth tide data processing package ETERNA 3.40 (e.g. Wenzel 1996) allows the recording, preprocessing and analysis of earth tide observations, the prediction of earth tide signals and the computation of ocean tide loading under MS-DOS operating system on a personal computer 80386/387 upwards. The computing kernels DETIDE, DESPIKE, DECIMATE, ANALYZE, PREDICT and OCELOAD are written in standard Fortran 77/90 and can also be compiled and executed on a workstation under UNIX operating system. The new international standard format for the storage and exchange of high resolution earth tide data (Wenzel 1995) is used in all parts of the ETERNA 3.40 package.

Compared to previous versions, we have included into the ETERNA earth tide data processing package the most accurate tidal potential catalogue of Hartmann and Wenzel (1995a,b), and the DUT1 correction due to the Earth's variable rotation. The DUT1 values provided by the International Earth Rotation Service (IERS) are used in the relevant programs. These upgrades enable the computation of synthetic earth tide signals with a model accuracy better than 1 ngal (1 ngal = 0.01 nm/s**2).

Several parts of the ETERNA earth tide data proceesing package have been rewritten, several programs have been added, and a few programs have been renamed. For the computation of the earth tide signals we have implemented recursion formulas which reduce the computation time for some data sets up to 35% compared to previous versions without loss of accuracy. The ETERNA package has been given a new and better structure (see below) in order to avoid multiple storage of data files. We have added an online manual with program HELMPE33, which enables the reading of the manual, searching and extraction of text from the online manual. The former program ETERNA has been renamed to ANALYZE, the former program PRETERNA has been splitted into the programs DETIDE, DESPIKE and DECIMATE, and the former program ETGTAB has been rewritten and renamed to PREDICT. O. Francis from the International Center for Earth Tides (ICET) was so kind to provide his program LOAD89 (and associated data files for ocean tide loading computation), which has been added to the ETERNA package in order to provide the users the possibility to compute ocean tide loading effects by themselves. Thanks to O. Francis !

We believe that a substantial improvement with respect to accuracy, flexibility and operational comfort has been achieved compared to previous versions of the package. ETERNA 3.40 is currently the only earth tide data processing package with a model accuracy better than 1 ngal !

The ETERNA 3.40 package is delivered on a CD-rom together with a short manual printed on paper. Because the total package needs about 158 MByte when installed, there is no diskette version of the package available. The package is divided into several pieces and will be installed in 7 directories, if you use the installation program SETUP34 given on the CD-rom:

```
+-------------+       +------------------+
|  eterna34   |---+---| eterna34/rectid  |  data acquisition
+-------------+   |   +------------------+
                  |
                  |   +------------------+
                  +---| eterna34/bin     |  executable files
                  |   +------------------+
                  |
                  |   +------------------+
                  +---| eterna34/commdat |   common data files
                  |   +------------------+
                  |
                  |   +------------------+
                  +---| eterna34/1mindat |   1 min data files
                  |   +------------------+
                  |
                  |   +------------------+
                  +---| eterna34/hourdat |   hourly data files
                  |   +------------------+
                  |
                  |   +------------------+
                  +---| eterna34/oceload |   ocean tide loading
                  |   +------------------+
                  |
                  |   +------------------+
                  +---| eterna34/iers    |   earth orientation
                      +------------------+
```

The ETERNA 3.40 package contains the following 21 programs (including the necessary data files to run these programs plus examples):

| name | length [records] | purpose |
|---|---|---|
| ANALYZE: | 6374 | analysis of earth tide data. |
| BENCHMAR: | 3913 | comparison of model tides with benchmark series. |
| DETIDE: | 4079 | calibration and detiding of earth tide data. |
| DESPIKE: | 2166 | despiking of earth tide data. |
| DECIMATE: | 1034 | decimation of earth tide data. |
| ETSTEP: | 1028 | evaluation of a recorded stepresponse. |
| IERS: | 179 | transformation of earth rotation data. |
| SETUP34: | 267 | installation of the ETERNA 3.40 package. |
| HELPME34: | 356 | display of the online manual. |
| LOAD97: | 554 | ocean tide loading computation. |
| PREDICT: | 3718 | computation of synthetic model tides. |
| PREGRED: | 4067 | graphical editing of earth tide data. |
| PREPLOT: | 361 | visualization of earth tide data. |
| PRINTGL: | | hard copy of a plot. |
| PLOTDATA: | 2054 | plot of earth tide data. |
| PLOTFILT: | 1568 | plot of numerical filter gain. |
| PLOTSPEC: | 1519 | plot of spectra of earth tide residuals. |
| PLOTHIST: | 1570 | plot of histograms of earth tide residuals. |
| RECTIDE: | 2511 | recording of earth tide data. |
| TRANS: | 983 | transformation of old international format |
| WPAREX: | 231 | interpolation of gravity tide parameters |

in total 38525 program records

Please note that - except for very few programs - we do not supply the source code for the programs of the ETERNA 3.40 package. The experience experience with previous versions of the package has shown that few users only are able to recompile the programs, because generally the users do not own the necessary compilers. Additionally, we want to avoid user generated modifications of the programs.

## Section 1.1: How to start

Attention:

Your personal computer should have an 80386/387 upwards processor (i.e. an 80486 or PENTIUM) with at least 8 MBytes of RAM adressable the programs. Although the Fortran programs have been compiled using the Lahey virtual memory manager, these programs can be executed with a few MBytes of RAM only. The computation speed is however severely degraded under such conditions. From the ETERNA 3.40 package, only the programs RECTIDE and PREPLOT can be executed on an 80286/287 processor.

You should have more than 157 MByte empty space on your hard disk available when starting the installation program INSTALCD for a complete installation of the ETERNA 3.40 package. All program and data files in directory oceload need about 120 MByte of your hard disk. If you have less free disk space on your hard disk available, you may decide during the execution of program INSTALCD on the installation of directories "rectide" and "oceload", which saves about 126 MByte disk space.

To perform the installation of the ETERNA 3.40 package, use an 80386/387, 80486 or PENTIUM personal computer operating under MS-DOS 5.0...6.20 operating system. Insert the CD-rom into the CD-rom drive (supposed this is e:), and make the CD-rom drive your active drive by entering

<e:>

You have to define the hard disk partition on which the directory eterna33 and all subdiretories shall be installed (supposed this is d:). Attention: If there exists already a directory named "eterna33" on the chosen hard disk, the next step will probably ne dangerous and you should carefully read the manual before continuing!

Start the installation program INSTALCD provided on the CD-rom by entering

<instalcd d:>

and follow the instructions. The installation program INSTALCD will establish the diretory eterna33 at your chosen hard disk and all necessary subdiretories under this directory (for some subdirectories, the installation program will ask for your advice to install a sub-directory or not). At its last step, the installation program will execute an earth tide analysis for five different data sets with program ANALYZE. This will take several minutes (depending on the speed of your processor). You should see on your screen the following printout (except for the execution time on the right column):

```
*******************************************************
*                                                     *
*  Program ANALYZE, version 3.40 970921 Fortran 90.   *
*                                                     *
*        Analysis of earthtide observations.          *
*                                                     *
*    The  Black  Forest  Observatory  Schiltach       *
*    wishes you much success when using ANALYZE.      *
*                                                     *
*******************************************************


1 HAL29901: Analysis started                                    0.00 s
1 HAL29901: Tidal potential catalogue:Hartmann+Wenzel (1995)    0.00 s
1 HAL29901: Input of observations completed                     1.76 s
1 HAL29901: Normal equations computed                           3.63 s
1 HAL29901: Normal equations solved                             3.68 s
1 HAL29901: Residuals computed                                  4.34 s
1 HAL29901: Spectrum of residuals computed                      4.84 s
1 HAL29901: Analysis finished,    stdv.=    6.945 nm/s**2       4.84 s

2 BFL24903: Analysis started                                    0.00 s
2 BFL24903: Tidal potential catalogue:Hartmann+Wenzel (1995)    0.00 s
2 BFL24903: Input of observations completed                     2.64 s
2 BFL24903: Normal equations computed                          12.31 s
2 BFL24903: Normal equations solved                            12.42 s
2 BFL24903: Residuals computed                                 14.72 s
2 BFL24903: Spectrum of residuals computed                     15.49 s
2 BFL24903: Analysis finished,    stdv.=    0.746 nm/s**2      15.49 s

3 BFD00801: Analysis started                                    0.00 s
3 BFD00801: Tidal potential catalogue:Hartmann+Wenzel (1995)    0.00 s
3 BFD00801: Input of observations completed                     1.92 s
3 BFD00801: Normal equations computed                           9.55 s
3 BFD00801: Normal equations solved                             9.61 s
3 BFD00801: Residuals computed                                 10.49 s
3 BFD00801: Spectrum of residuals computed                     11.20 s
3 BFD00801: Analysis finished,    stdv.=    1.554  nstr        11.20 s

4 BFET1907: Analysis started                                    0.00 s
4 BFET1907: Tidal potential catalogue:Hartmann+Wenzel (1995)    0.00 s
4 BFET1907: Input of observations completed                     5.21 s
4 BFET1907: Normal equations computed                          34.16 s
4 BFET1907: Normal equations solved                            34.27 s
4 BFET1907: Residuals computed                                 45.09 s
```

```
4 BFET1907: Spectrum of residuals computed                        47.07 s
4 BFET1907: Analysis finished,    stdv.=    0.558 nm/s**2         47.07 s

5 BHTT4003: Analysis started                                       0.00 s
5 BHTT4003: Tidal potential catalogue:Hartmann+Wenzel (1995)       0.00 s
5 BHTT4003: Input of observations completed                       10.49 s
5 BHTT4003: Normal equations computed                             46.25 s
5 BHTT4003: Normal equations solved                               46.63 s
5 BHTT4003: Residuals computed                                    76.07 s
5 BHTT4003: Spectrum of residuals computed                        83.00 s
5 BHTT4003: Analysis finished,    stdv.=    6.884 nm/s**2         83.00 s

    **********************************************
    *   Program ANALYZE finished the execution.  *
    **********************************************

    Total execution time:    161.870  seconds
```

When the installation program INSTALCD has finished its execution, you should modify in the "autoexec.bat" file of your pc the record containing the path statement by adding the path to directory \eterna34\bin. Change the already existing path statement to e.g.

```
path c:\dos;d:\eterna34\bin
```

After rebooting your pc, you should be able to execute all programs of the ETERNA 3.40 package from the directories which contain the relevant data files.

After the installation of the ETERNA 3.40 package, you should carefully study the manual and the relevant publications given in the list of references. If you feel familiar with the capabilities and restrictions of the programs, you should e.g. start program ANALYZE from directory "\eterna33\hourdat" by entering

```
<analyze>
```

You should receive a small part of the printout on the screen and the complete printouts in the files "hal2901.prn", "bfl24903.prn", "bfd00801.prn" and "bhtt4003.prn" in directory "\eterna33\hourdat". The contents of these files should be almost the same as in this manual under section 10 (except for the printed jobtimes, because this depends on the speed of your computer).

If you want to run programs from the ETERNA package on a workstation under UNIX operating system, you should at first install the package on a pc under MS-DOS operating system using the installation program INSTALCD and afterwards transfer the relevant files to your work-station. You have to enable at the Fortran 90 programs those records, which are currently disabled by comment C HP-UX and you have to disable the relevant statements for the MS-DOS operating system. You have to re-compile the programs with your own Fortran 90 compiler (most of the programs can be compiled with a Fortran 77 compiler). You should not transfer the unformatted files with suffix ".uft" to your workstation, but have these files established by the first execution of the relevant programs.

There is little hope that you will be able to re-compile under operating system UNIX e.g. the powerfull graphical editor PREGRED, which is written for the Microsoft Visual C++ compiler. Instead of spending much time to transform some of the programs of the ETERNA 3.40 package to a workstation, the better procedure is to buy a cheap PENTIUM 100 MHz pc which most probably executes the programs faster than your workstation !

## Section 1.2: Distribution of the ETERNA package

The programs including data files and result files are distributed on a CD-rom, together with sections 1 and 2 of this program manual printed on paper. Please remind that the programs may only be used within your institution, but should not be copied or given in loan to anybody outside your institution. Requests for the program package ETERNA should be forwarded directly to the program author. If you experience any error in the programs or failure of the programs during execution, which are not due to an error in input data or a misuse of the programs, please report these errors to the program author. If you have any proposal for a significant improvement of the handling and performance of the ETERNA package, please do not hesitate to contact the author.

## Section 1.3: Platforms

All programs have been installed and tested on different personal computers (80486 DX2 66 MHz, 80486 DX4 100 MHz, PENTIUM 90 MHz ... 166 MHz), using a standard VGA graphics adapter and different super VGA graphics adapters (Spea V7 Mirage, Spea V7 Mercury, Miro Crystal 20SD PCI). Some programs have been executed for timing purpose on several different platforms. The programs DETIDE, DESPIKE, DECIMATE, ANALYZE, ETSTEP, PREDICT and LOAD89 are written in standard Fortran, and have been tested additionally on a SUN sparc 2 workstation under operating system SOLARIS 2.3. However, it is recommended to use ETERNA 3.40 on a high speed PENTIUM processor under MS-DOS operating system, because the overall performance of the ETERNA package is much superior under MS-DOS than under UNIX or SOLARIS operating systems. This is mainly because the ETERNA package does not supply programs for graphical visualization under UNIX or SOLARIS operating systems.

## Section 1.4: Contents of the CD-rom

| file name | kbytes | date | description |
|---|---|---|---|
| instalcd.exe | 286.612 | 22.08.96 | installation program |

directory \eterna33\rectide (15 files, 772.367 kB):

| file name | kbytes | date | description |
|---|---|---|---|
| autoexec.bat | 473 | 13.08.96 | sample AUTOEXEC.BAT file |
| etcpot.dat | 112.983 | 22.01.96 | tidal potential catalogues |
| etstep.exe | 304.949 | 14.08.96 | program ETSTEP, executable file |
| etstep.ini | 571 | 13.08.96 | control parameter file for ETSTEP |
| etstep.prn | 62.841 | 14.08.96 | print file of program ETSTEP |
| n20m1s01.nlf | 25.832 | 04.09.96 | numerical lowpass filter 1s |
| n20m5s02.nlf | 6.172 | 04.09.96 | numerical lowpass filter 5s |
| project | 9 | 22.01.96 | project file |
| recsimul.ini | 2.775 | 14.08.96 | control parameter file for RECTIDE |
| kal68601.ini | 2.779 | 14.08.96 | control parameter file for RECTIDE |
| rectide.bas | 132.950 | 11.09.96 | program RECTIDE, source code |
| rectide.exe | 108.385 | 11.09.96 | program RECTIDE, executable file |
| st299v81.dat | 8.977 | 14.08.96 | step response sample data file |
| plotdata.ini | 1.658 | 22.08.96 | control parameters for PLOTDATA |
| plotfilt.ini | 1.108 | 22.08.96 | control parameters for PLOTFILT |

directory \eterna33\bin (27 files, 5 012.852 kB):

| name | kbytes | date | description |
|---|---|---|---|
| analyze.exe | 401.925 | 09.09.96 | executable file of program ANALYZE |
| benchmar.exe | 352.117 | 09.09.96 | executable file of program BENCHMAR |
| decimate.exe | 301.429 | 06.09.96 | executable file of program DECIMATE |

| | | | |
|---|---|---|---|
| detide.exe | 351.493 | 09.09.96 | executable file of program DETIDE |
| despike.exe | 324.053 | 06.09.96 | executable file of program DESPIKE |
| iers.exe | 280.645 | 15.08.96 | executable file of program IERS |
| instalcd.exe | 269.028 | 03.09.96 | executable file of program INSTALCD |
| helpme33.exe | 419.381 | 11.08.96 | executable file of program HELPME33 |
| hpno.bin | 927 | 05.08.94 | driver for HPGL plot files |
| hpyes.bin | 1.167 | 02.08.94 | driver for HPGL plot files |
| hplsr3.bin | 1.123 | 08.08.94 | driver for HP-laser printer |
| eps-p.bin | 1.764 | 30.06.93 | driver for Postcript plotfiles |
| eps-l.bin | 1.796 | 30.06.93 | driver for Postcript plotfiles |
| lf90.eer | 40.736 | 19.10.95 | error message file from Lahey |
| oem08.fon | 4.752 | 16.09.94 | font file for PREGRED |
| oem10.fon | 5.264 | 16.09.94 | font file for PREGRED |
| plotdata.exe | 336.661 | 22.09.96 | executable file of program PLOTDATA |
| plotfilt.exe | 329.637 | 22.09.96 | executable file of program PLOTFILT |
| plothist.exe | 334.101 | 08.09.96 | executable file of program PLOTHIST |
| plotraus.bat | 26 | 05.08.96 | batch file for hardcopy of a plot |
| plotspec.exe | 327.045 | 22.09.96 | executable file of program PLOTSPEC |
| predict.exe | 346.437 | 09.09.96 | executable file of program PREDICT |
| pregred.exe | 110.874 | 06.09.96 | executable file of program PREGRED |
| preplot.bas | 15.295 | 27.08.96 | sourcecode file of program PREPLOT |
| preplot.exe | 67.059 | 27.08.96 | executable file of program PREPLOT |
| printgl.exe | 75.376 | 01.09.91 | executable file of program PRINTGL |
| trans.exe | 312.725 | 27.08.96 | executable file of program TRANS |

directory \eterna33\commdat (50 files, 7 486.977 kB):

| name | kbytes | date | description |
|---|---|---|---|
| buellehw.dat | 75.609 | 28.06.95 | Buellesfeld catalogue, ASCII |
| buellehw.uft | 74.005 | 24.05.96 | Buellesfeld catalogue, binary |
| cted73hw.dat | 61.186 | 28.06.95 | Cartwright et al. catalogue, ASCII |
| cted73hw.uft | 60.107 | 20.03.96 | Cartwright et al. catalogue, binary |
| doodsehw.dat | 46.036 | 28.06.95 | Doodson catalogue, ASCII |
| doodsehw.uft | 45.265 | 28.03.96 | Doodson catalogue, binary |
| eopc04.96 | 17.200 | 13.08.96 | IERS ftp file, ASCII |
| etddt.dat | 11.316 | 23.03.96 | TDT-UTC, ASCII |
| eterna33.hlp | 325.009 | 11.09.96 | ETERNA33 manual, ASCII |
| etpolut1.dat | 603.131 | 13.08.96 | IERS polar motion and DUT1, ASCII |
| etpolut1.uft | 718.560 | 13.08.96 | IERS polar motion and DUT1, binary |
| hw95s.dat | 1 401.137 | 04.08.96 | Hartmann + Wenzel catalogue, ASCII |
| hw95s.uft | 1 363.319 | 04.08.96 | Hartmann + Wenzel catalogue, binary |
| ratgp95.dat | 700.818 | 13.03.96 | Roosbeek catalogue, ASCII |
| ratgp95.uft | 681.677 | 24.05.96 | Roosbeek catalogue, binary |
| tamurahw.dat | 133.823 | 25.05.96 | Tamura catalogue, ASCII |
| tamurahw.uft | 130.667 | 25.05.96 | Tamura catalogue, binary |
| xi1989hw.dat | 319.604 | 13.03.96 | Xi catalogue, ASCII |
| xi1989hw.uft | 311.175 | 24.05.96 | Xi catalogue, binary |
| n14h5m01.nlf | 4.425 | 29.08.96 | lowpass (old) 5 min / 60 min old |
| n2h1m001.nlf | 3.748 | 29.08.96 | lowpass (old) 1 min / 5 min old |
| n01s1m01.nlf | 32.878 | 29.08.96 | lowpass 1 s / 1 min |
| n02s1m01.nlf | 17.556 | 29.08.96 | lowpass 2 s / 1 min |
| n03s1m01.nlf | 17.578 | 29.08.96 | lowpass 3 s / 1 min |
| n05s1m01.nlf | 8.397 | 29.08.96 | lowpass 5 s / 1 min |
| n10s1m01.nlf | 5.275 | 29.08.96 | lowpass 10 s / 1 min |
| n20s1m01.nlf | 3.653 | 29.08.96 | lowpass 20 s / 1 min |
| n30s1m01.nlf | 3.083 | 29.08.96 | lowpass 30 s / 1 min |
| n02s5m02.nlf | 79.053 | 29.08.96 | lowpass 2 s / 5 min |
| n03s5m02.nlf | 53.548 | 29.08.96 | lowpass 3 s/ 5 min |
| n05s5m02.nlf | 33.143 | 29.08.96 | lowpass 5 s / 5 min |
| n10s5m02.nlf | 17.705 | 29.08.96 | lowpass 10 s / 5 min |
| n20s5m02.nlf | 10.199 | 29.08.96 | lowpass 20 s / 5 min |
| n30s5m02.nlf | 7.423 | 29.08.96 | lowpass 30 s / 5 min |
| n60s5m02.nlf | 4.729 | 29.08.96 | lowpass 60 s / 5 min |
| n1h1h001.nlf | 1.128 | 29.08.96 | lowpass for ANALYZE, 1 h sampl. |
| n1h1h002.nlf | 1.362 | 29.08.96 | lowpass for ANALYZE, 1 h sampl. |
| n1h1h003.nlf | 2.927 | 29.08.96 | lowpass for ANALYZE, 1 h sampl. |
| n1h1h004.nlf | 4.557 | 29.08.96 | lowpass for ANALYZE, 1 h sampl. |

```
n1h1h005.nlf      1.328  29.08.96  lowpass for ANALYZE, 1 h sampl.
n1h1h006.nlf      1.334  29.08.96  lowpass for ANALYZE, 1 h sampl.
n1h1h007.nlf      2.965  29.08.96  lowpass for ANALYZE, 1 h sampl.
n1h1h008.nlf      4.598  29.08.96  lowpass for ANALYZE, 1 h sampl.
n05m05m2.nlf     36.342  06.09.96  lowpass for ANALYZE,  5 min sampl.
n10m10m2.nlf     19.342  05.09.96  lowpass for ANALYZE, 10 min sampl.
n20m20m2.nlf     10.839  05.09.96  lowpass for ANALYZE, 20 min sampl.
n30m30m2.nlf      8.017  05.09.96  lowpass for ANALYZE, 30 min sampl.
n60m60m2.nlf      5.249  05.09.96  lowpass for ANALYZE, 60 min sampl.
```

directory \eterna33\1mindat (26 files, 10 856.083 kB):

```
name             kbytes     date   description

preplot.bas      15.295  27.08.96  source code file of PREPLOT
kal299tt.cal      1.045  04.09.96  calibration data        kal299tt
kal299tt.raw    129.480  04.09.96  raw 1 min data          kal299tt
kal299tt.ini      3.995  06.09.96  control parameter       kal299tt
kal299tt.tid    199.696  06.09.96  detided 1 min data      kal299tt
kal299tt.cor    199.861  06.09.96  despiked 1 min data     kal299tt
kal299tt.fil     40.076  06.09.96  preprocessed 5 min data kal299tt
kal299tt.dec      4.583  06.09.96  preprocessed 1 h   data kal299tt
sg102tes.ini      4.149  06.09.96  control parameter       sg102tes
sg102tes.raw   1102.905  06.09.96  raw data                sg102tes
sg102tes.cal      1.059  05.09.96  calibration data        sg102tes
sg102tes.tid   1560.448  06.09.96  detided data            sg102tes
sg102tes.pro      6.322  06.09.96  PREGRED protocol        sg102tes
sg102tes.cor   1560.408  06.09.96  manually edited data    sg102tes
sg102tes.des   1560.488  07.09.96  despiked data           sg102tes
sg102tes.fil    311.194  07.09.96  preprocessed 5 min data sg102tes
sg102tes.dec     25.982  09.09.96  preprocessed 1 h   data sg102tes
bfhw9502.rrr   1109.811  07.09.96  raw synthetic data      bfhw9502
bfhw9502.ini      8.184  07.09.96  control parameter       bfhw9502
bfhw9502.cal      1.465  07.09.96  calibration data        bfhw9502
bfhw9502.tid   1398.255  07.09.96  detided data            bfhw9502
bfhw9502.cor   1398.340  07.09.96  manually edited data    bfhw9502
bfhw9502.fil    278.199  07.09.96  preprocessed 5 min data bfhw9502
bfhw9502.dec     23.341  07.09.96  preprocessed 1 h   data bfhw9502
plotdata.ini      1.493  07.09.96  control parameters for PLOTDATA
project               9  05.09.96  project file
```

directory \eterna33\hourdat (54 files, 23 364.605 kB):

```
name             kbytes     date   description

analyze.prn       3.879  09.09.96  logfile of program ANALYZE
bfde403f.dat  1 898.359  08.09.96  benchmark gravity tides bfde403f
bfde403f.dif  3 296.611  08.09.96  differences bfde403f - HW95
bfde403f.ini      5.427  08.09.96  control parameter for    bfde403f
bfde403f.prn     44.810  08.09.96  print file of ANALYZE for bfde403f
bfde403f.res  2 602.404  08.09.96  residuals  of ANALYZE for bfde403f
bfde403f.far     25.094  08.09.96  spectrum of residuals for bfde403f
bfde403f.par      3.840  08.09.96  adjusted tidal params.for bfde403f
bfd00801.ini      5.123  07.09.96  control parameters for    bfd00801
bfd00801.dat     73.375  06.09.96  observed hor. strain      bfd00801
bfd00801.prn     35.285  07.09.96  print file of ANALYZE for bfd00801
bfd00801.res     88.664  07.09.96  residuals  of ANALYZE for bfd00801
bfd00801.far     19.436  07.09.96  spectrum of residuals for bfd00801
bfd00801.par      1.920  07.09.96  adjusted tidal params.for bfd00801
bfet1907.ini      6.141  07.09.96  control parameters for    bfet1907
bfet1907.dat    259.448  06.09.96  observed gravity data     bfet1907
bfet1907.prn     38.436  07.09.96  print file of ANALYZE for bfet1907
bfet1907.res    322.370  07.09.96  residuals  of ANALYZE for bfet1907
bfet1907.far     23.946  07.09.96  spectrum of residuals for bfet1907
bfet1907.par      2.720  07.09.96  adjusted tidal params.for bfet1907
bfhw9501.ini      6.920  08.09.96  control parameters for    bfhw9501
bfhw9501.prd  3 738.177  08.09.96  synthetic gravity signal  bfhw9501
bfhw9501.dat  3 738.275  08.09.96  synthetic gravity signal  bfhw9501
```

| | | | |
|---|---|---|---|
| bfhw9501.prn | 37.393 | 08.09.96 | print file of ANALYZE for bfhw9501 |
| bfhw9501.res | 3 739.268 | 08.09.96 | residuals of ANALYZE for bfhw9501 |
| bfhw9501.far | 20.666 | 08.09.96 | spectrum of residuals for bfhw9501 |
| bfhw9501.par | 3.840 | 08.09.96 | adjusted tidal params.for bfhw9501 |
| bfl24903.ini | 5.581 | 05.09.96 | control parameters for bfl24903 |
| bfl24903.dat | 111.915 | 06.09.96 | oberserved gravity data bfl24903 |
| bfl24903.prn | 38.971 | 09.09.96 | print file of ANALYZE for bfl24903 |
| bfl24903.res | 125.406 | 09.09.96 | residuals of ANALYZE for bfl24903 |
| bfl24903.far | 21.814 | 09.09.96 | spectrum of residuals for bfl24903 |
| bfl24903.par | 2.240 | 09.09.96 | adjusted tidal params.for bfl24903 |
| bhtt4003.ini | 6.892 | 07.09.96 | control parameters for bhtt4003 |
| bhtt4003.dat | 895.331 | 06.09.96 | observed gravity data bhtt4003 |
| bhtt4003.prn | 37.258 | 09.09.96 | print file of ANALYZE for bhtt4003 |
| bhtt4003.res | 1 618.588 | 09.09.96 | residuals of ANALYZE for bhtt4003 |
| bhtt4003.far | 20.748 | 09.09.96 | spectrum of residuals for bhtt4003 |
| bhtt4003.par | 3.520 | 09.09.96 | adjusted tidal params.for bhtt4003 |
| deafult.ini | 6.293 | 07.08.96 | default control parameter file |
| hal29901.ini | 5.141 | 07.09.96 | control parameters for hal29901 |
| hal29901.dat | 119.234 | 05.09.96 | observed gravity data hal29901 |
| hal29901.prn | 33.124 | 09.09.96 | print file of ANALYZE for hal29901 |
| hal29901.res | 72.446 | 09.09.96 | residuals of ANALYZE for hal29901 |
| hal29901.far | 20.584 | 09.09.96 | spectrum of residuals for hal29901 |
| hal29901.par | 1.920 | 09.09.96 | adjusted tidal params.for hal29901 |
| plotdata.ini | 1.484 | 07.09.96 | control parameters for PLOTDATA |
| plotspec.ini | 2.010 | 07.09.96 | control parameters for PLOTSPEC |
| plothist.ini | 1.127 | 08.09.96 | control parameters for PLOTHIST |
| project | 51 | 07.09.96 | project file |
| trans.dat | 46.387 | 22.01.96 | example input file for TRANS |
| trans.prn | 8.813 | 27.08.96 | print file of TRANS |
| trans.ini | 3.950 | 27.08.96 | output file of TRANS |
| trans.out | 111.950 | 27.08.96 | output file of TRANS |

directory \eterna33\oceload (42 files, 126.135.507 kB):

| name | kbytes | date | description |
|---|---|---|---|
| load89.f | 15.541 | 08.05.96 | source code file of program LOAD89 |
| load89.for | 15.604 | 08.05.96 | source code file of program LOAD89 |
| mascor.csr | 312 | 08.05.96 | mass cons. param.s for CSR3.0 |
| mascor.scw | 114 | 08.05.96 | mass cons. param.s for Schwiderski |
| para.bxl | 431 | 08.05.96 | |
| prem | 2.001 | 08.05.96 | Green function for PREM earth model |
| scw80.mf | 1 439.393 | 08.05.96 | Schwiderski model for wave MF |
| scw80.q1 | 1 442.308 | 08.05.96 | Schwiderski model for wave Q1 |
| scw80.o1 | 1 467.149 | 08.05.96 | Schwiderski model for wave O1 |
| scw80.p1 | 1 446.210 | 08.05.96 | Schwiderski model for wave P1 |
| scw80.k1 | 1 476.612 | 08.05.96 | Schwiderski model for wave K1 |
| scw80.m2 | 1 520.343 | 08.05.96 | Schwiderski model for wave M2 |
| scw80.n2 | 1 454.624 | 08.05.96 | Schwiderski model for wave N2 |
| scw80.s2 | 1 485.849 | 08.05.96 | Schwiderski model for wave S2 |
| scw80.k2 | 1 446.142 | 08.05.96 | Schwiderski model for wave K2 |
| csr3.q1 | 5 344.414 | 07.05.96 | CSR3.0 model for wave Q1 |
| csr3.o1 | 5 325.820 | 07.05.96 | CSR3.0 model for wave O1 |
| csr3.p1 | 5 323.618 | 07.05.96 | CSR3.0 model for wave P1 |
| csr3.k1 | 5 362.966 | 07.05.96 | CSR3.0 model for wave K1 |
| csr3.n2 | 5 331.767 | 07.05.96 | CSR3.0 model for wave N2 |
| csr3.m2 | 5 406.137 | 07.05.96 | CSR3.0 model for wave M2 |
| csr3.s2 | 5 373.547 | 07.05.96 | CSR3.0 model for wave S2 |
| csr3.k2 | 5 330.499 | 07.05.96 | CSR3.0 model for wave K2 |
| fes952.q1 | 4 447.496 | 08.05.96 | Grenoble 95 model for wave Q1 |
| fes952.o1 | 4 477.472 | 08.05.96 | Grenoble 95 model for wave O1 |
| fes952.p1 | 4 403.049 | 08.05.96 | Grenoble 95 model for wave P1 |
| fes952.k1 | 4 513.484 | 08.05.96 | Grenoble 95 model for wave K1 |
| fes952.phi | 5 114.332 | 08.05.96 | Grenoble 95 model for wave PHI1 |
| fes952.pi1 | 5 023.486 | 08.05.96 | Grenoble 95 model for wave PI1 |
| fes952.j1 | 4 675.572 | 08.05.96 | Grenoble 95 model for wave J1 |
| fes952.sgi | 4 884.838 | 08.05.96 | Grenoble 95 model for wave SIGMA1 |
| fes952.n2 | 4 416.500 | 08.05.96 | Grenoble 95 model for wave N2 |

```
fes951.m2     4 682.982  08.05.96  Grenoble 95 model for wave M2
fes952.s2     4 548.218  08.05.96  Grenoble 95 model for wave S2
fes952.k2     4 400.315  08.05.96  Grenoble 95 model for wave K2
fes952.t2     4 573.182  08.05.96  Grenoble 95 model for wave T2
fes952.2n2    4 491.611  08.05.96  Grenoble 95 model for wave 2N2
wparm.dat     5 174.490  07.09.96  world wide grid of Timmen and Wenzel
wparex.for       10.947  07.09.96  interpolation program WPAREX
wparex.exe      283.429  07.09.96  interpolation program WPAREX
wparex.dat          155  07.09.96  input data file for program WPAREX
wparex.prn        2.548  07.09.96  print file of program WPAREX
```

## Section 2: Description of program INSTALCD

The automatic installation program INSTALCD is provided in the root of the CD-rom. If you insert the CD-rom into the CD-rom drive and start program INSTALCD from the root of the CD-rom, program INSTALCD will install the ETERNA 3.40 package on your hard disk. The hard disk partition ond which the ETERNA 3.40 package shall be installed can be input into program INSTALCD. Program INSTALCD will ask for the installation of subdirectories "rectide" and "oceload", in order to save hard disk space. The use of program INSTALCD is selfexplaining.

After having installed the ETERNA 3.40 package, you should add the path to \eterna33\bin to the path statement of your "autoexec.bat" file, e.g.

```
path=c:\dos;c:\eterna33\bin;
```

and define the MS-DOS environment variable MSCFONTS by adding in your "autoexec.bat" file the line

```
set MSCFONTS=c:/eterna33/bin
```

provided you have installed the ETERNA 3.40 package on drive c:

## Section 3: Description of program HELPME33

The program HELPME33.FOR is supplied in order to on-line display the manual for the ETERNA 3.40 earth tide data processing package, given in file "eterna34\commdat\eterna34.hlp". The executable program is given in file "\eterna34\bin\helpme34.exe". The program is written in non-standard Fortran 90 (it uses special statements for the Lahey starter-interacter kit LISK and can only be compiled using the Lahey 2.00 Fortran 90 compiler with option -lisk). After entering

```
<helpme34>
```

from any subdirectory, the program displays the first 20 records of this manual on the screen. To exit the program, you can either press the escape-key or function key 4. You can use function key 1 to see the on-line help window of the program. You can use function key 2 to to search for a certain string within the manual. You can use function key 3 to export the contents of the manual currently shown on the screen to file "helpme34.prn", which will be established in the current directory. You can use the up- and down-cursor keys to scroll through the file. You can use the next and previous page keys to see the next or previous page of the manual.

## Section 4: Description of the ETERNA standard format

The data files of the ETERNA 3.40 package use the same standard format which is described in Wenzel (1995) and has been adopted for the exchange of high precision and high rate earth tide data by the Working Group on High Precision Tidal Data Processing at its meeting in Bonn 1994. Data files to be used within ETERNA consist of one file header, and at least one parameter section and one file body. A file body may be followed by another parameter section plus another file body.

## Section 4.1: File header

A data file used in ETERNA must have an alphanumeric file header containing some information to describe the file and the processing which has eventually been done with these files. The length of a header record is restricted to 80 characters (FORMAT A80). The number of header records is not restricted. Please try to enter as much information as possible in the file header, because this might be of some value for you when looking into the file after some time has gone, and for other people (e.g. your successor).

The alphanumeric file header ends with a record having C********* in columns 1...10.

## Section 4.2: Parameter section

A parameter section is allowed before each file body. The parameter section ends with flag 77777777 in cols. 1...8. A parameter section is currently used with program ANALYZE only (see the description of program ANALYZE).

## Section 4.3: File body

The file body starts with an offset record (flag 77777777 in columns 1...8), with offsets at all data channels. These offsets might be added to all subsequent data records. Offset records are allowed also also within the file body at all positions in the data set. Offset records use the standard data format (I8,7X, 4F10.3) and are defined by flag 77777777 in columns 1...8. The first offset record defines initial offsets for all data channels. These offsets are added to the samples for all subsequent records when reading the data file, and may be used to glue two or more data sets together by removing eventual steps between the data sets. The units of the offsets are identical to the units of the samples in the corresponding channels.

### Data records:

```
All subsequent records have the same format (I8,1X,I6,4F10.3):
IDAT    = data of the record, 19931125 means year = 1993,
          month = 11 = November, day = 25.
ITIM    = time of the sample in UTC, 140800 means 14 hours,  08  min.,
          00 seconds. Please remind that the samples have to be  given
          at full minute if e.g. the sample interval is 60 s.
DCIN(1..NC) = samples for channels 1...NC. The number NC of channels is
             restricted to 7.
             Channel 1      is generally the earth tide observation.
             Channel 2...NC may contain samples of meteorological
                            parameters.
             Channel NC+1   may contain the model tide computed by
                            e.g. program DETIDE.
             Channel NC+2   may contain the residual signal computed
                            by e.g. program DETIDE.

             The residual signal is computed by linear multiple
             regression:
             ch(NC+2)= ch1 - ch(NC+1) + sum{FAC(i) * ch(i)}
```

The end of a the data block is defined by IDAT = 99999999.

A step correction may be carried out by using an offset record (flag IDAT = 777777777) between two data records. In this case, ITIM is ignored in the offset record, and the samples for the individual channels are interpreted as corrections to the offset, which will be added for all subsequent data records.

A gap in the data may be defined by putting the undefined data values of the channels to 99999.999. It is allowed to have gaps in all data channels.

We list in the following the first 50 records of file "kal299tt.tid" given in directory "\eterna33\1mindat" for a better understanding of the structure of ETERNA data files:

```
File             : kal299tt.tid
Status           : 19941101
Start            : 19921125 14:08
End              : 19921227 23:59
Contents         : Detide 1 min data from BFO-TLD1 data
                   acquisition, station Karlsruhe.
                   Channel 1 is LCR-G299-SW02    in nm/s**2,
                   Channel 2 is barometer BMS5   in hPa,
                   Channel 3 is model tide       in nm/s**2,
                   Channel 4 is residual signal  in nm/s**2.

                  Chan. 1   Chan. 2   Chan. 3   Chan. 4
C*************************************************************
77777777             0.000     0.000     0.000     0.000
19921125 140800   1226.128     6.870   803.679   467.678
19921125 140900   1227.583     6.903   805.466   467.568
19921125 141000   1228.986     6.941   807.252   467.432
19921125 141100   1230.650     6.954   809.037   467.401
19921125 141200   1232.677     6.935   810.819   467.520
19921125 141300   1234.756     6.899   812.599   467.579
19921125 141400   1236.523     6.867   814.377   467.360
19921125 141500   1237.978     6.855   816.152   466.962
19921125 141600   1239.538     6.875   817.924   466.877
19921125 141700   1241.461     6.931   819.693   467.402
19921125 141800   1243.540     7.012   821.458   468.247
19921125 141900   1245.359     7.089   823.220   468.810
19921125 142000   1246.867     7.133   824.978   468.852
19921125 142100   1248.374     7.125   826.731   468.552
19921125 142200   1250.037     7.062   828.480   468.052
19921125 142300   1251.752     6.973   830.224   467.441
19921125 142400   1253.676     6.907   831.963   467.186
19921125 142500   1255.651     6.887   833.697   467.298
19921125 142600   1257.522     6.899   835.425   467.519
19921125 142700   1259.289     6.912   837.148   467.651
19921125 142800   1261.004     6.912   838.864   467.647
19921125 142900   1262.720     6.897   840.574   467.557
19921125 143000   1264.487     6.871   842.277   467.451
19921125 143100   1266.254     6.842   843.973   467.332
19921125 143200   1268.073     6.824   845.662   467.341
19921125 143300   1270.204     6.824   847.344   467.791
19921125 143400   1272.284     6.838   849.018   468.286
19921125 143500   1273.947     6.854   850.684   468.389
```

## Section 5: References

---------------------


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## Section 6: List of enclosures

```
001: Gain of filter n20m1s01.nlf for online decimation 1 s / 1 min
002: Gain of filter n20m5s02.nlf for online decimation 5 s / 1 min
003: Step response recorded in file st299v81.dat
004: Differences benchmark series bfde403f - HW95
005: Histogram of differences bfde403f - HW95
006: Predicted gravity variation "bfhw9501.prd"
007: Predicted gravity pole tides "bfhw9501.prd"
008: Predicted gravity LOD  tides "bfhw9501.prd"
009: Gain of filter n01s1m01.nlf for decimation  1 s / 1 min
010: Gain of filter n02s1m01.nlf for decimation  2 s / 1 min
011: Gain of filter n03s1m01.nlf for decimation  3 s / 1 min
012: Gain of filter n05s1m01.nlf for decimation  5 s / 1 min
013: Gain of filter n10s1m01.nlf for decimation 10 s / 1 min
014: Gain of filter n20s1m01.nlf for decimation 20 s / 1 min
015: Gain of filter n30s1m01.nlf for decimation 30 s / 1 min
016: Gain of filter n02s5m02.nlf for decimation  2 s / 5 min
017: Gain of filter n03s5m02.nlf for decimation  3 s / 5 min
018: Gain of filter n05s5m02.nlf for decimation  5 s / 5 min
019: Gain of filter n10s5m02.nlf for decimation 10 s / 5 min
020: Gain of filter n20s5m02.nlf for decimation 20 s / 5 min
021: Gain of filter n30s5m02.nlf for decimation 30 s / 5 min
022: Gain of filter n60s5m02.nlf for decimation 60 s / 5 min
023: Gain of filter n2h1m001.nlf for decimation  1 min /  5 min (old)
024: Gain of filter n14h5m01.nlf for decimation  5 min / 60 min
025: Observed gravity signal kal299tt.tid (1 min)
026: Detided  gravity signal kal299tt.tid (1 min)
027: Despiked detided gravity signal kal299tt.cor (1 min)
028: Despiked gravity signal kal299tt.cor (1 min)
029: Preprocessed gravity signal kal299tt.fil (5 min)
030: Preprocessed detided gravity signal kal299tt.fil (5 min)
031: Observed gravity signal sg102tes.tid (1 min)
032: Detided  gravity signal sg102tes.tid (1 min)
033: Detided  gravity signal sg102tes.tid 19940607
034: Detided and edited gravity signal sg102tes.cor 19940607
035: Detided gravity signal sg102tes.tid (1 min)
```

```
036: Detided despiked gravity signal sg102tes.des (1 min)
037: Detided despiked gravity signal sg102tes.des (1 min)
038: Manually edited detided gravity signal sg102tes.des (1 min)
039: Despiked gravity signal sg102tes.des (1 min)
040: Preprocessed detided gravity signal sg102tes.fil (5 min)
041: Preprocessed gravity signal sg102tes.fil (5 min)
042: Synthetic gravity signal bfhw9502.tid (1 min)
043: Detided synthetic gravity signal bfhw9502.tid (1 min)
044: Despiked detided synthetic gravity signal bfhw9502.cor (1 min)
045: Preprocessed detided synthetic gravity signal bfhw9502.fil (5 min)
046: Gain of ANALYZE highpass filter n1h1h001.nlf (Pertzev 1957)
047: Gain of ANALYZE highpass filter n1h1h002.nlf (Pertzev 1959)
048: Gain of ANALYZE highpass filter n1h1h003.nlf (Wenzel 143 h)
049: Gain of ANALYZE highpass filter n1h1h004.nlf (Wenzel 239 h)
050: Gain of ANALYZE highpass filter n1h1h005.nlf (HYCON-MC)
051: Gain of ANALYZE highpass filter n1h1h006.nlf (Wenzel 49 h)
052: Gain of ANALYZE highpass filter n1h1h007.nlf (Wenzel 145 h)
053: Gain of ANALYZE highpass filter n1h1h008.nlf (Wenzel 241 h)
054: Gain of ANALYZE highpass filter n05m05m2.nlf  5 min sampling int.
055: Gain of ANALYZE highpass filter n10m10m2.nlf 10 min sampling int.
056: Gain of ANALYZE highpass filter n20m20m2.nlf 20 min sampling int.
057: Gain of ANALYZE highpass filter n30m30m2.nlf 30 min sampling int.
058: Gain of ANALYZE highpass filter n60m60m2.nlf 60 min sampling int.
059: Plot of observed gravity tide data hal29901.dat
060: Analysis results for file          hal29901.dat
061: Residuals after analysis           hal29901.res
062: Histogram of residuals             hal29901.res
063: Amplitude spectrum of residuals    hal29901.far
064: Plot of observed gravity tide data bfl24903.dat
065: Analysis results for file          bfl24903.dat
066: Residuals after analysis           bfl24903.res
067: Histogram of residuals             bfl24903.res
068: Amplitude spectrum of residuals    bfl24903.far
069: Plot of observed strain tide data  bfd00801.dat
070: Analysis results for file          bfd00801.dat
071: Residuals after analysis           bfd00801.res
072: Histogram of residuals             bfd00801.res
073: Amplitude spectrum of residuals    bfd00801.far
074: Plot of observed gravity tide data bfet1907.dat
075: Analysis results for file          bfet1907.dat
076: Residuals after analysis           bfet1907.res
077: Histogram of residuals             bfet1907.res
078: Amplitude spectrum of residuals    bfet1907.far
079: Plot of observed gravity tide data bhtt4003.dat
080: Analysis results for file          bhtt4003.dat
081: Residuals after analysis           bhtt4003.res
082: Histogram of residuals             bhtt4003.res
083: Amplitude spectrum of residuals    bhtt4003.far
084: Plot of synthetic gravity tides    bfhw9501.dat
085: Analysis results for file          bfhw9501.dat
086: Residuals after analysis           bfhw9501.res
087: Histogram of residuals             bfhw9501.res
088: Amplitude spectrum of residuals    bfhw9501.far
089: Plot of benchmark gravity tides    bfde403f.dat
090: Analysis results for file          bfde403f.dat
091: Residuals after analysis           bfde403f.res
092: Histogram of residuals             bfde403f.res
093: Amplitude spectrum of residuals    bfde403f.far
094: Printout of program WPAREX
```

****** This ends the startup section of the ETERNA 3.40 manual.
****** The rest of the manual is available on thd CD-rom only.

Section 7: Description of program RECTIDE
-----------------------------------------

The program RECTIDE is a pc-based earth tide data acquisition program for gravimeters, which enables simultaneously a high sampling rate and high precision data recording and the graphical display of the recorded data, reduced for computed model tides. The source code of the program is given in file "\eterna33\rectid\rectid.bas", the executable program is given in file "\eterna33\rectid\rectid.exe".

The data sampling and the model tide computation is carried out at 1 s interval using one of four different available tidal potential catalogs (Doodson 1921, Cartwright-Tayler-Edden 1973, Buellesfeld 1985, Tamura 1987). Because the computed model tides are only used to online display the difference between the observation and the model tide, we dont need the highest accuracy for the model tides (i.e. we dont need the Hartmann and Wenzel 1995 catalogue). With RECTIDE it is possible to display on-line the reduced data with a very high resolution of up to 1 nm/s**2 per cm on the screen of the pc (depending on the short periodic noise level). The 1 s samples are numericall filtered on-line by a symmetric FIR (finite impulse response) lowpass filter with 5 min cutoff period and decimated to 1 min interval. The data decimated to 1 min interval are stored on the hard disk of the pc. The program can also be used to record data from other sensors, e.g. tiltmeters.

Section 7.1: Hardware requirements
---------------------------------

The hardware you need to record earth tide data with program RECTIDE consists of

- a personal computer with a built-in AD-converter card,
- a clock providing a 1 pulse per second TTL signal.

The current version of the RECTID earth tide data acquisition program with a sampling interval of 1 s needs a high speed 80486 66 MHz or PENTIUM P60 processor, a EGA or VGA color screen, and a hard disk of about 200 MByte capacity. Pricipl y, the program can be executed (and has been with the BFO-TLD-1 and BFO-TLD-2 data acquisition system for several years) on an 80286/287 pc, with a larger sampling interval of e.g. 5 s. To increase the sampling interval to 5 s, a clock with a 5 s TTL pulse must be available, and some modifications have to be made in program RECTID. For this purpose, the lowpass filter N20M5S02 for 5 s sampling interval is still available with file N20M5S02.NLF.

The currently used AD-converter card RTI870 built by Analog Devices has a capacity of 4 channels and a resolution of 22 bits. The AD-converter may be purchased by

Analog Devices
One Technology Way
P.O. Box 9106
Norwood, MA 02062-9106, U.S.A.
Fax: ++1-617-326-8703

If you want to use a different AD-converter card, you have to modify the routines RTI870TE and RTI870AD within program RECTID and you have to re-compile program RECTID.

The triggering of the AD-conversion has to be provided by a 1 pps TTL clock pulse (between 0 and +5 V) at digital input terminal D1 of the AD-converter. The AD-conversion is triggered by the downgoing pulse flank, which should be synchronized to Universal Time Coordinated (UTC).

Section 7.2: Program description
--------------------------------

The data recording is done with program RECTIDE.BAS under operating system MS-DOS 5.0 using Microsoft Quick Basic 4.0. The raw sampling interval is 1 s, using the 1 s TTL pulse of the PZF535 radio controlled clock at digital input channel 1 of the RTI870 AD-converter card to trigger the analog to digital conversion of up to 4 channels.

The range of the analog input channels is set to +/- 5 V within the program, the resolution of the analog input channels is set to 22 bit which corresponds to about 2 microvolt.

With program RECTIDE, the graphic screen and the text screen is available simultaneously. The program is usually switched to the graphic screen, but may be switched by the user to the text screen by entering

    <text>

from keyboard during the operation of the program. You have available the on-line option to print the raw data or the filtered data to the text screen. For a description of the available keyboard commands, hit function key no. 1 to print the help-screen:

```
           Help-screen of Program RECTIDE
           ------------------------------

           to print a list of data files enter    <files>
           to print raw 1 s samples enter         <praw>
           to print filtered 1 min samples enter  <pfil>
           to switch to graphic screen enter      <graph>
           to switch to text    screen enter      <text>
           to increase clock reading enter         <+>
           to decrease clock reading enter         <->
           to stop the program enter              <end>
```

After reading the help-screen, you have to enter

        <graph>

to continue with the graphic screen.

The data sampled at 1 s interval are smoothed by taking a moving average over 60 s and the smoothed data are displayed on the VGA colour graphic screen with a horizontal extension of 1 day (ticks have an x-spacing of 1 hour). The screen starts at 00:00:00 UTC. For the gravimeter channels, the model tide of the station computed with routine TIDE5 (one of four different tidal potential catalogs may be chosen by the user with observed/predicted tidal parameters) is subtracted. The computed model tide is displayed in red on the graphic screen with +/- 1250 nm/s**2 vertical range. The residual signal of the gravimeters (recorded signal minus computed model tide) is displayed with a user-defined vertical range; we recommend +/- 100 nm/s**2 vertical range. The recorded barometer signal is displayed on the screen with a user-defined vertical range; we recommend +/- 10 hPa vertical range. In the plot program, a screen stepper takes care that the recorded or residual signal will always be visible on the screen of the pc.

The data sampled at 1 s interval are numerically lowpass filtered using a symmetrical FIR lowpass filter with zero phase shift with 1225 coefficients and a length of about 20 minutes. The filter has been supplied by Dr. J. Neumeyer from GFZ Potsdam. The filter coefficients are defined with file "n20m1s01.nlf" and the filter gain is given below. Note that the filter gain can be plotted with program PLOTFILT. The filter gives a damping of more than 78 dB for periods shorter than 120 s. For periods larger than 1 hour, the gain of the filter is 1 with a maximum deviation of 1.4*10**-6.

The gain of numerical filter "n20m1s01.nlf" (see encl. 1) is:

| Frequ. [cps] | Gain [dB] | Frequ. [cps] | Gain [dB] | Frequ. [cps] | Gain [dB] |
|---|---|---|---|---|---|
| 0.002 | 0.00 | 0.02 | -121.64 | 0.22 | -141.08 |
| 0.003 | -0.02 | 0.03 | -124.98 | 0.23 | -144.53 |

| | | | | | |
|---|---|---|---|---|---|
| 0.004 | -0.59 | 0.04 | -137.90 | 0.24 | -170.16 |
| 0.005 | -3.95 | 0.05 | -135.68 | 0.25 | -144.22 |
| 0.006 | -13.29 | 0.06 | -132.34 | 0.26 | -141.60 |
| 0.007 | -32.73 | 0.07 | -136.92 | 0.27 | -144.77 |
| 0.008 | -77.88 | 0.08 | -150.08 | 0.28 | -173.40 |
| 0.009 | -133.53 | 0.09 | -135.36 | 0.29 | -145.91 |
| 0.010 | -118.68 | 0.10 | -133.68 | 0.30 | -142.99 |
| 0.011 | -113.08 | 0.11 | -137.24 | 0.31 | -146.26 |
| 0.012 | -118.43 | 0.12 | -157.27 | 0.32 | -176.47 |
| 0.013 | -121.07 | 0.13 | -140.71 | 0.33 | -146.08 |
| 0.014 | -119.58 | 0.14 | -137.92 | 0.34 | -143.30 |
| 0.015 | -130.61 | 0.15 | -141.68 | 0.35 | -146.41 |
| 0.016 | -121.61 | 0.16 | -162.46 | 0.36 | -179.71 |
| 0.017 | -123.83 | 0.17 | -141.12 | 0.37 | -147.06 |
| 0.018 | -124.32 | 0.18 | -138.77 | 0.38 | -144.09 |
| 0.019 | -129.52 | 0.19 | -142.05 | 0.39 | -147.24 |
| | | 0.20 | -166.62 | 0.40 | -183.30 |
| | | 0.21 | -143.95 | 0.41 | -147.15 |

After numerical filtering, the data are resampled at 1 min resampling interval. The data resampled at 1 min interval are recorded on the hard disk in ETERNA standard format with 1 microvolt resolution.

## Section 7.3: Description of the project file "project"

The ASCII project name file "project" for program RECTIDE contains one single variable only, the project name which is abbreviated as "pn" in this manual. The project name is an alphanumerical string consisting of 8 characters at maximum. The project name is read from the first 8 characters of the first record of project name file "project". The project name is used to define the control parameter file name "pn".ini for program RECTIDE.

## Section 7.4: Description of control parameter file "pn".ini

The control parameter file "pn".ini (where "pn" stands for the project name defined in file "project") defines several control parameters necessary for the operation of program RECTIDE. This control parameter file has an identical structure to the control parameter files used by programs ANALYZE, DETIDE, DESPIKE, DECIMATE, PREGRED and PREDICT. Some of the variables are identical to those used by programs ANALYZE, DETIDE, DESPIKE, DECIMATE, PREGRED and PREDICT. Thus it may be possible to use the same control parameter file for data recording, data preprocessing and data analysis.

All control parameter statements must begin with the control parameter name (column 1...10) which ends with an equal sign. The control parameter names must be spelled exactly with uppercase letters as defined below. Control parameters with unknown names will be ignored by program RECTIDE. The control parameter variables must be input after the equal sign following the control parameter name, with appropriate format. The control parameter statements must not have a specific sequence. A record starting with # in column 1 will be ignored and may be used to comment the control parameters. All characters following # in a record will be ignored and may be used to comment the control parameters.

STATIONAME= station name, 10 characters (col. 12...21) following the equal sign. The station name will be displayed on the graphics screen during data recording.
STATLATITU= ellipsoidal latitude of the station in degree referring to WGS84 reference system (col.12...26).
STATLONITU= ellipsoidal longitude of the station in degree referring to WGS84 reference system (col.12...26).
STATELEVAT= ellipsoidal height of the station in meter referring to WGS84 reference system (col.12...26).

```
STATGRAVIT= gravity of the station in m/s**2, necessary for tidal tilt
            only (col. 12...26,  real  with  decimal  point).  If  the
            gravity is unknown, use a value of less than 1.0  and  the
            program will  compute  and  subsequently  use  the  normal
            gravity value referring to GRS80 reference system.
STATAZIMUT= azimuth of the  instrument  in  degree  decimal,  reckoned
            clockwise from north (col. 12 ... 26,  real  with  decimal
            point). This parameter is used for tidal tilt,  horizontal
            displacement and horizontal strain only.
TIDALPOTEN= parameter for the tidal potential catalog to be used.
            1 = Doodson (1921) tidal potential catalog,
            2 = Cartwright-Tayler-Edden (1973) tidal potential catalog
            3 = Buellesfeld (1985) tidal potential catalog.
            4 = Tamura (1987) tidal potential catalog,
TIDALCOMPO= defines component of model tides which will be computed.
            0 = gravity tides in nm/s**2,
            1 = tilt tides in mas in azimuth STATAZIMUT.
RECTIDNUMC= number of analog input channels which will be recorded.
            The number of analog channels is restricted to 4.
RECTIDSIMU= simulation parameter. For RECTIDSIMU=0 signals from the
            analog input channels will be recorded. For RECTIDSIMU=1,
            a program test with simulated data (computed model tides)
            will be carried out.
RECTIDLOWP= name of the data file, from which the numerical lowpass
            filter for the decimation of the recorded data will be
            read. RECTIDLOWP is restricted to 12 characters.
RECTIDCHAN= definition of analog input channels. For each analog input
            channel, the following variables have to be input:
            Col.12..14: IC%  = analog input channel number
            Col.15..17: ICOL%= screen plot color for the channel
                         0 = black              1 = dark blue
                         2 = green              3 = light blue
                         4 = dark red           5 = dark pink
                         6 = brown              7 = light grey
                         8 = dark grey          9 = bright dark blue
                        10 = bright green      11 = bright light blue
                        12 = bright red        13 = bright pink
                        14 = yellow            15 = bright white
            Col.18..20: IRED%= 0 for plot of calibrated signal,
                        IRED%= 1 for plot of calibrated  signal  minus
                        computed model tides (residual signal).
            Col.21..30: CAL#= scale factor for calibration of recorded
                         signal before being plotted.
            Col.31..40: SR#= Range of screen plot of calibrated signal
                        or residual signal. Plot range is +/-SR#.
TIDALPARAM= wave group selection for a priori model tide  computation.
            The number of wavegroups is restricted to  85.  The  tidal
            parameters may be taken from an  earth  tide  analysis  of
            another data set in the same station,  or  from  a  neigh-
            bouring station, or from synthetic gravity tide parameters
            (Timmen and Wenzel 1994, 1995), or from a guess only.
            Col.12..21: DFRA#=  start frequency of the wave  group  in
                                cpd (real).
            Col.22..31: DFRE#=  end   frequency of the wave  group  in
                                cpd (real).
            Col.32..41: DGAM0#= amplitude factor  of  the  wave  group
                                (real).
            Col.42..51: DPHI0#= phase lead of the wave  group  in  deg
                                (real).

The wave group selection for model tide  computation  should  be  made
according to the wave group selection for the analysis of  Earth  tide
data (see the program manual for ANALYZE); the list given below  is  a
proposal only). The frequencies are given in cycles per day (cpd).

group        > 1 month            > 6 months          > 1 year
              from      to         from      to        from      to
             [cpd]   [cpd]        [cpd]   [cpd]       [cpd]   [cpd]
```

| | | | | | | |
|---|---|---|---|---|---|---|
| SA | - | - | - | - | 0.001379 | 0.004107 |
| SSA | - | - | 0.004108 | 0.020884 | 0.004108 | 0.020884 |
| MM | 0.020885 | 0.054747 | 0.020885 | 0.054747 | 0.020885 | 0.054747 |
| MF | 0.054748 | 0.091348 | 0.054748 | 0.091348 | 0.054748 | 0.091348 |
| MTM | 0.091349 | 0.501369 | 0.091349 | 0.501369 | 0.091349 | 0.501369 |
| Q1 | 0.501370 | 0.911390 | 0.501370 | 0.911390 | 0.501370 | 0.911390 |
| O1 | 0.911391 | 0.947991 | 0.911391 | 0.947991 | 0.911391 | 0.947991 |
| M1 | 0.947992 | 0.981854 | 0.947992 | 0.981854 | 0.947992 | 0.981854 |
| P1 | - | - | 0.981855 | 0.998631 | 0.981855 | 0.998631 |
| S1 | - | - | - | - | 0.998632 | 1.001369 |
| K1 | 0.981855 | 1.023622 | 0.998632 | 1.023622 | 1.001370 | 1.004107 |
| PSI1 | - | - | - | - | 1.004108 | 1.006845 |
| PHI1 | - | - | - | - | 1.006846 | 1.023622 |
| J1 | 1.023623 | 1.057485 | 1.023623 | 1.057485 | 1.023623 | 1.057485 |
| OO1 | 1.057486 | 1.470243 | 1.057486 | 1.470243 | 1.057486 | 1.470243 |
| 2N2 | 1.470244 | 1.880264 | 1.470244 | 1.880264 | 1.470244 | 1.880264 |
| N2 | 1.880265 | 1.914128 | 1.880265 | 1.914128 | 1.880265 | 1.914128 |
| M2 | 1.914129 | 1.950419 | 1.914129 | 1.950419 | 1.914129 | 1.950419 |
| L2 | 1.950420 | 1.984282 | 1.950420 | 1.984282 | 1.950420 | 1.984282 |
| S2 | 1.984283 | 2.451943 | 1.984283 | 2.002736 | 1.984283 | 2.002736 |
| K2 | - | - | 2.002737 | 2.451943 | 2.002737 | 2.451943 |
| M3M6 | 2.451944 | 7.000000 | 2.451944 | 7.000000 | 2.451944 | 7.000000 |

In the following we show the control parameter file kal68601.ini given on the CD-rom. For your actual recording setup, you should modify the parameters according to your instruments and to your station!

```
# this is file KAL68601.INI version 1996.08.06 for program RECTID 3.40

STATIONAME= KARLSRUHE      #stations name
STATLATITU=  49.0121       #stations latitude  in degree
STATLONITU=   8.4126       #stations longitude in degree
STATELEVAT=  114.000       #stations ellipsoidal height in m
TIDALPOTEN=  4             #Tamura (1987) tidal potential catalogue
TIDALCOMPO=  0             #tidal component
RECTIDNUMC=  4             #number of channels for RECTID
RECTIDSIMU=  0             #simulation without A/D conversion if = 1
RECTIDLOWP=N20M1S01.NLF    #numerical lowpass filter

# plot colors: 0 = black                    1 = dark blue
#              2 = green                    3 = light blue
#              4 = dark red                 5 = dark pink
#              6 = brown                    7 = light grey
#              8 = dark grey                9 = bright dark blue
#             10 = bright green            11 = bright light blue
#             12 = bright red #            13 = bright pink
#             14 = yellow                  15 = bright white

# next lines RECDTIDCHAN: col. 12..14: channel number
#                              15..17: plot color
#                              18..20: 1 for reduction of model tides
#                              21..30: scale factor
#                              31..40: plot range

RECTIDCHAN=  1 14  1    4785.4    100.00            #gravimeter
RECTIDCHAN=  2 11  0      10.00     10.00            #barometer
RECTIDCHAN=  3 10  0   1000.00      2.00            #beam position
RECTIDCHAN=  4  9  0      10.00      2.00            #voltage standard

TIDALPARAM=  0.000000  0.249951   1.15000    0.0000 LONG
TIDALPARAM=  0.721500  0.906315   1.13980   -0.1700 Q1
TIDALPARAM=  0.921941  0.940487   1.14790    0.1560 O1
TIDALPARAM=  0.958085  0.974188   1.14340    0.5290 M1
TIDALPARAM=  0.989049  1.011099   1.13520    0.2560 P1K1
TIDALPARAM=  1.013689  1.044800   1.14960   -1.6760 J1
TIDALPARAM=  1.064841  1.216397   1.14560    0.8600 OO1
TIDALPARAM=  1.719381  1.872142   1.15850    4.4470 2N2
```

```
TIDALPARAM=  1.888387  1.906462   1.17330    3.0360 N2
TIDALPARAM=  1.923766  1.942754   1.18100    1.9920 M2
TIDALPARAM=  1.958233  1.976926   1.18990    1.5590 L2
TIDALPARAM=  1.991787  2.182843   1.18440    0.6590 S2K2
TIDALPARAM=  2.753244  3.081254   1.05680    0.9260 M3
TIDALPARAM=  3.791964  3.937897   1.02000    0.0000 M4
```

## Section 7.5: Description of output files

The data output files of program RECTIDE use the ETERNA standard format for exchange of high resolution and high rate tidal data (Wenzel 1995). The format of these files is

```
Col.01...08: date in year, month, day; e.g. 900328  means  year  1990,
             month 03 = March, day 28th.
Col.10...15: time in hour, minute, second,  given  in  Universal  Time
             Coordinated (UTC); e.g. 231200 means 23 hours 12  minutes
             00 seconds. The seconds  are assumed to be exact, e.g. 00
             seconds means 0.000 seconds.
Col.16...25: Sample of channel 1 in Volt.
Col.26...35: Sample of channel 2 in Volt.
Col.36...45: Sample of channel 3 in Volt.
Col.46...55: Sample of channel 4 in Volt.
  ...
```

As an example, a part of the output file 96081500.10 recorded with program RECTIDE at station Karlsruhe August 15th, 1996 (filtered feedback output of gravimeter LCR-G686 at channel 1, barometer BS05 at channel 2, beam position of gravimeter LCR-G686 at channel 3, 4 V voltage reference at channel 4) using the control parameter file "kal68601.ini"given on the CD-rom are shown below:

File 96981500.10:

```
Date      Time    Channel1  Channel2  Channel3


19960814      0 -0.759007  0.078377 -0.000543 -4.000112
19960815    100 -0.759616  0.078571 -0.000554 -4.000112
19960815    200 -0.759109  0.078542 -0.000581 -4.000112
19960815    300 -0.758253  0.078165 -0.000581 -4.000112
19960815    400 -0.758292  0.077714 -0.000555 -4.000112
19960815    500 -0.758696  0.077609 -0.000553 -4.000111
19960815    600 -0.758454  0.077102 -0.000572 -4.000111
19960815    700 -0.757854  0.075946 -0.000579 -4.000111
19960815    800 -0.757493  0.075523 -0.000571 -4.000112
19960815    900 -0.757573  0.075894 -0.000558 -4.000112
19960815   1000 -0.757887  0.075801 -0.000558 -4.000112
19960815   1100 -0.757769  0.075235 -0.000572 -4.000111
19960815   1200 -0.757349  0.074995 -0.000569 -4.000111
19960815   1300 -0.757452  0.074869 -0.000555 -4.000111
19960815   1400 -0.757757  0.074162 -0.000557 -4.000111
19960815   1500 -0.757678  0.073639 -0.000564 -4.000111
19960815   1600 -0.757610  0.074012 -0.000560 -4.000111
19960815   1700 -0.757729  0.074505 -0.000557 -4.000111
19960815   1800 -0.757810  0.074733 -0.000561 -4.000112
19960815   1900 -0.757751  0.075035 -0.000567 -4.000113
19960815   2000 -0.757467  0.075400 -0.000570 -4.000113
19960815   2100 -0.757117  0.075520 -0.000566 -4.000113
19960815   2200 -0.757027  0.075070 -0.000562 -4.000114
19960815   2300 -0.757072  0.074139 -0.000563 -4.000115
19960815   2400 -0.756957  0.073641 -0.000564 -4.000115
19960815   2500 -0.756690  0.073838 -0.000567 -4.000115
19960815   2600 -0.756294  0.073682 -0.000572 -4.000114
19960815   2700 -0.756127  0.072732 -0.000566 -4.000114
19960815   2800 -0.756247  0.071956 -0.000565 -4.000113
19960815   2900 -0.755843  0.072568 -0.000583 -4.000112
```

19960815   3000 -0.755032  0.074007 -0.000585 -4.000112

Section 7.6:  Program tests
---------------------------

Previous versions of program RECTIDE have been used since 1990 to record gravity tides with the transportable data acquisition system BFO-TLD-1 (80286/287 pc with Strawberry Tree Inc. 16 bit/8 channel AD-converter card in stations Karlsruhe, Potsdam, Hannover, Berggiesshuebel and Bonn. There is built into the program the test variable ISIM%, which can be enabled by using RECTIDSIMU= 1 in the control parameter file "pn".INI. This internal program test has been used intensively to check and to increase the performance of program RECTIDE.

Long term program tests with program RECTIDE version 3.00 ... 3.40 has been performed with data acquisition BFO-TLD-3 (80486 66 MHz pc with RTI870 22 bit/4 channel ADC-card) using feedback gravimeter LCR-G686F and an electronic barometers between August 8th and 29th, 1996.

Section 8:   Description of program ETSTEP
------------------------------------------

The program ETSTEP computes the frequency transfer function of a linear dynamic causal system with constant parameters by Fourier transform of differentiated step response (e.g. Wenzel 1976, Richter and Wenzel 1991, Wenzel 1994).

The recommended method to carry out a step response experiment is to input an electronic step into a parallel adder to the gravimeter's feedbeck (e.g. Wenzel 1994) and to record the gravimeter's output with a high resolution and high rate data acquisition. The time given in the sample files has to be counted in seconds from the step.

The principal method of program ETSTEP is that the sample data (not necessarily given at equidistant instants) are normalized to a unity step and subsequently used to fit a 2nd degree least squares polynomial to the data collected within a certain time window from the complete set of sample data. The least squares polynomial is subsequently used to differentiate the recorded step response. The differentiated step response is finally transformed into frequency domain by Discrete Fourier Transform (DFT), and the complex transfer function of the gravimeter is given by the real and imaginary part of the DFT. The system's gain is given by the SQRT(real**2 + imag**2), and the system's phase lag is given by ATAN(imag/real).

The recorded step response may be visualized and plotted on paper with program PLOTDATA (see encl.003). Remember that program ETSTEP does not subtract the tides from the recorded step response. The tides contained always in signals recorded with earth tide instruments can significantly influence the step response evaluation, if the tidal signal during the step response experiment is significant. However, you can remove to a large part the tidal signal contained in the recorded step response data using program DETIDE, provided you know the necessary parameters.

To evaluate the step response, you have to record the step response with high rate (e.g. 1 s) using a suitable data acquisition in ETERNA standard format on a file. The samples are assumed to be equidistant at exact full seconds. The program ETSTEP reads the necessary control parameters from a file called "etstep.ini". This file must be located in the same directory as file "etstep.exe" and the file containing the recorded step response.

All control parameter statements given in file "etstep.ini" must begin with the control parameter name (column 1...10) which ends with an equal sign. The control parameter names must be spelled exactly with uppercase letters as defined below. Control parameters with unknown names will be ignored by program ETSTEP. The control parameters must be input after the equal sign following the control parameter name, with appropriate format. The control parameter statements must not have a specific sequence. A record starting with # in column 1 will be ignored and may be used to comment the control parameters. All characters following # in a record will be ignored and may be used to comment the control parameters. The control parameter file for program ETSTEP has the same structure as other control parameter files for the ETERNA 3.40 package.

The following control parameters have to be defined in the control parameter file "etstep.ini":

```
DATFILNAME= alphanumeric name of the file, in which the recorded  step
            response is given.
STEPCHANIS= Integer channel number at which the step response has been
            recorded. Remember that the  data  acquisition may  record
            parameters in more than one channel.
STARTTIMIS= Integer start time of the data which will be used for  the
            step  response  evaluation  in  hours,  minutes,  seconds
            (hhmmss). E.g. 162000  means 16 hours,  20 min, 0 sec.
STEPTIMEIS= Integer time at which the input step  to  the  system  has
            been generated, in hours, minutes, seconds  (hhmmss). E.G.
            162000 means 16 hours, 20 minutes, 0 seconds.
STOPTIMEIS= Integer stop time of the data which will be used  for  the
            step response evaluation in hours, minutes,  seconds. E.g.
            162500 means 16 hours, 25 minutes, 0 seconds.
STEPFITINT= Intervall in seconds, at which the step response  will  be
            fitted by the polynomial  adjustments.  The  fit  interval
            should be in the order of the average sampling interval.
STEPCOLRAD= Collection radius in seconds for the data, which  will  be
            used around the fit epoch to adjust  the  coefficients  of
            the polynomial. This interval should be 2 to 3  times  the
            the average sampling interval.
```

We list below as an example the control parameter file "etstep.ini" provided on the CD-rom:

```
# this is file etstep.ini version 1996.08.13 containing control
# parameters for program  ETSTEP

DATFILNAME=st299v81.dat    # input data file name
STEPFITINT=   0.500        # fit interval in secs
STEPCOLRAD=   2.500        # collection radius in sec
STARTTIMIS=  162000        # start time of the data set in hh mm ss
STEPTIMEIS=  162000        # step  time                 in hh mm ss
STOPTIMEIS=  162500        # end   time of the data set in hh mm ss
STEPCHANIS=       1        # data channel at which the step was recorded

# end of file etstep.ini
```

The data file to be used for the step response evaluation (e.g. file "st299v81.dat") has to be defined in the control parameter file "estep.ini" and to be provided in the directory from which program ETSTEP will be executed. We give in the following the first part of file "st299v81.dat" as example. The step response data file must contain a file header, which gives an alphanumeric description of the file contents, and a file body, which must contain the data. The file header ends with 'C*********' in columns 1 ... 10. The file body contains the date, time and recorded channels in standard ETERNA format. The file body must end with 99999999 in columns 1 ... 8.

```
File: ST299V81.DAT           Status: 1996.08.14

Step response of gravimeter LCR-G299-SW02 feedback,
step by electronic step into parallel adder, computer controlled
by BFO-TLD1 data acquisition, program STEPRES.BAS.
!!! Modified version of program STEPRES.BAS, feedback voltage at ADC
```

```
!!! channels 4 and 5.

Re-sampled at full second from original file ST299V80.DAT,
which was sampled  at irregularly intervals opf about 0.3 s.

Calibration function of the gravimeter is
            linear calibration factor:    51902.71 nm/s**2 per V
            quadratic calibration factor:    36.39 nm/s**2 per V**2
            cubic calibration factor:        -0.22 nm/s**2 per V**3

Step at 930329 16:20:00 UTC, 20. experiment
C*********************************************************************
77777777         0.000000
19930329 162000  0.062601
19930329 162001  0.062568
19930329 162002  0.062575
19930329 162003  0.062578
19930329 162004  0.062476
19930329 162005  0.062122
19930329 162006  0.060227
19930329 162007  0.055921
19930329 162008  0.045564
19930329 162009  0.027073
19930329 162010 -0.004299
19930329 162011 -0.050774
19930329 162012 -0.114854
19930329 162013 -0.196773
19930329 162014 -0.294235
19930329 162015 -0.404705
19930329 162016 -0.521605
19930329 162017 -0.640638
19930329 162018 -0.753298
19930329 162019 -0.857758
19930329 162020 -0.948130
19930329 162021 -1.022431
19930329 162022 -1.080996
19930329 162023 -1.123435
19930329 162024 -1.153067
19930329 162025 -1.171148
19930329 162026 -1.180805
19930329 162027 -1.185414
19930329 162028 -1.186197
19930329 162029 -1.185607
19930329 162030 -1.184291
   .
   .
```

The computed gain, phase lag and time lag of the system under consideration is provided in file "etstep.prn." We give below a part of the printout for sample file "st299v81.dat" provided on the CD-rom:

```
####################################################
# Program ETSTEP, gain and phase lag of the system #
# Normalization factor:  0.999981                  #
####################################################

frequency  real part imag.part      gain     phase  time lag
     [cps]                               [degree]       [s]


  0.000001  1.000000  0.000103  1.000000     0.006    16.381
  0.000002  1.000000  0.000206  1.000000     0.012    16.381
  0.000003  1.000000  0.000309  1.000000     0.018    16.381
  0.000004  1.000000  0.000412  1.000000     0.024    16.381
  0.000005  1.000000  0.000515  1.000000     0.029    16.381
  0.000006  1.000000  0.000618  1.000000     0.035    16.381
  0.000007  1.000000  0.000720  1.000000     0.041    16.381
  0.000008  1.000000  0.000823  1.000000     0.047    16.381
  0.000009  1.000000  0.000926  1.000000     0.053    16.381
```

| | | | | | |
|---|---|---|---|---|---|
| 0.000010 | 0.999999 | 0.001029 | 1.000000 | 0.059 | 16.381 |
| 0.000020 | 0.999998 | 0.002058 | 1.000000 | 0.118 | 16.381 |
| 0.000030 | 0.999995 | 0.003088 | 1.000000 | 0.177 | 16.381 |
| 0.000040 | 0.999991 | 0.004117 | 0.999999 | 0.236 | 16.381 |
| 0.000050 | 0.999986 | 0.005146 | 0.999999 | 0.295 | 16.381 |
| 0.000060 | 0.999980 | 0.006175 | 0.999999 | 0.354 | 16.381 |
| 0.000070 | 0.999972 | 0.007205 | 0.999998 | 0.413 | 16.381 |
| 0.000080 | 0.999964 | 0.008234 | 0.999998 | 0.472 | 16.381 |
| 0.000090 | 0.999954 | 0.009263 | 0.999997 | 0.531 | 16.381 |
| 0.000100 | 0.999943 | 0.010292 | 0.999996 | 0.590 | 16.381 |
| 0.000200 | 0.999773 | 0.020583 | 0.999985 | 1.179 | 16.381 |
| 0.000300 | 0.999490 | 0.030871 | 0.999967 | 1.769 | 16.381 |
| 0.000400 | 0.999093 | 0.041155 | 0.999941 | 2.359 | 16.381 |
| 0.000500 | 0.998584 | 0.051433 | 0.999908 | 2.948 | 16.380 |
| 0.000600 | 0.997961 | 0.061705 | 0.999867 | 3.538 | 16.380 |
| 0.000700 | 0.997226 | 0.071968 | 0.999819 | 4.128 | 16.380 |
| 0.000800 | 0.996377 | 0.082221 | 0.999764 | 4.717 | 16.380 |
| 0.000900 | 0.995417 | 0.092464 | 0.999702 | 5.307 | 16.380 |
| 0.001000 | 0.994344 | 0.102694 | 0.999633 | 5.897 | 16.379 |
| 0.002000 | 0.977492 | 0.204045 | 0.998561 | 11.791 | 16.376 |
| 0.003000 | 0.949717 | 0.302793 | 0.996818 | 17.684 | 16.374 |
| 0.004000 | 0.911401 | 0.397713 | 0.994398 | 23.575 | 16.372 |
| 0.005000 | 0.863102 | 0.487619 | 0.991321 | 29.465 | 16.369 |
| 0.006000 | 0.805503 | 0.571466 | 0.987627 | 35.354 | 16.368 |
| 0.007000 | 0.739326 | 0.648266 | 0.983286 | 41.245 | 16.367 |
| 0.008000 | 0.665453 | 0.717035 | 0.978246 | 47.137 | 16.367 |
| 0.009000 | 0.584979 | 0.776970 | 0.972565 | 53.024 | 16.365 |
| 0.010000 | 0.498994 | 0.827528 | 0.966332 | 58.910 | 16.364 |
| 0.020000 | -0.406528 | 0.772176 | 0.872651 | 117.765 | 16.356 |
| 0.030000 | -0.733380 | 0.043879 | 0.734691 | 176.576 | 16.350 |
| 0.040000 | -0.325935 | -0.472524 | 0.574032 | 235.403 | 16.347 |
| 0.050000 | 0.169341 | -0.376246 | 0.412598 | 294.232 | 16.346 |
| 0.060000 | 0.265793 | -0.033230 | 0.267862 | 352.874 | 16.337 |
| 0.070000 | 0.098245 | 0.117282 | 0.152994 | 410.048 | 16.272 |
| 0.080000 | -0.016037 | 0.073423 | 0.075154 | 462.321 | 16.053 |
| 0.090000 | -0.028304 | 0.018132 | 0.033614 | 507.356 | 15.659 |
| 0.100000 | -0.014532 | -0.000944 | 0.014563 | 543.718 | 15.103 |
| 0.200000 | 0.000167 | -0.000033 | 0.000170 | 708.942 | 9.846 |
| 0.300000 | 0.000015 | 0.000052 | 0.000054 | 433.630 | 4.015 |
| 0.400000 | 0.000164 | 0.000085 | 0.000185 | 387.336 | 2.690 |
| 0.500000 | 0.000015 | 0.000051 | 0.000053 | 433.625 | 2.409 |
| 0.600000 | 0.000109 | -0.000051 | 0.000120 | 695.049 | 3.218 |
| 0.700000 | 0.000012 | 0.000029 | 0.000032 | 427.361 | 1.696 |
| 0.800000 | 0.000062 | 0.000011 | 0.000063 | 370.085 | 1.285 |
| 0.900000 | -0.000853 | 0.000054 | 0.000855 | 536.362 | 1.655 |

```
####################################################
# Program ETSTEP, gain and phase lag of the system #
# Normalization factor:  0.999981                  #
####################################################
```

| wave | freq. [deg/h] | freq. [cpd] | gain | phase [deg] | time lag [s] |
|---|---|---|---|---|---|
| MM | 0.544375 | 0.036292 | 1.000000 | 0.0025 | 16.381 |
| MF | 1.098033 | 0.073202 | 1.000000 | 0.0050 | 16.381 |
| MTM | 1.642408 | 0.109494 | 1.000000 | 0.0075 | 16.381 |
| Q1 | 13.398661 | 0.893244 | 1.000000 | 0.0610 | 16.381 |
| O1 | 13.943036 | 0.929536 | 1.000000 | 0.0634 | 16.381 |
| M1 | 14.496694 | 0.966446 | 1.000000 | 0.0660 | 16.381 |
| P1 | 14.958931 | 0.997262 | 1.000000 | 0.0681 | 16.381 |
| S1 | 15.000002 | 1.000000 | 1.000000 | 0.0683 | 16.381 |
| K1 | 15.041069 | 1.002738 | 1.000000 | 0.0684 | 16.381 |
| PSI1 | 15.082135 | 1.005476 | 1.000000 | 0.0686 | 16.381 |
| PHI1 | 15.123206 | 1.008214 | 1.000000 | 0.0688 | 16.381 |
| J1 | 15.585443 | 1.039030 | 1.000000 | 0.0709 | 16.381 |
| OO1 | 16.139102 | 1.075940 | 1.000000 | 0.0734 | 16.381 |

```
2N2  27.968208  1.864547  1.000000    0.1273    16.381
N2   28.439730  1.895982  1.000000    0.1294    16.381
M2   28.984104  1.932274  1.000000    0.1319    16.381
L2   29.528479  1.968565  1.000000    0.1344    16.381
S2   30.000000  2.000000  1.000000    0.1365    16.381
K2   30.082137  2.005476  1.000000    0.1369    16.381
M3   43.476156  2.898410  1.000000    0.1978    16.381
M4   57.968208  3.864547  0.999999    0.2638    16.381


######################################
# Program ETSTEP finished execution. #
######################################
```

The instrumental time lag of the system is 16.381 s, the instrumental phase lag of the system is 0.0634 deg for tidal wave O1 and 0.1319 deg for tidal wave M2.

Section 9: Description of program IERS
--------------------------------------

The program IERS.FOR is supplied in order to transform an earth orientation parameter file, as e.g. "eopc04.96" available from the International Earth Rotation Service (IERS) via ftp into the format necessary for the ETERNA package. The source code of the program is provided in file "\eterna33\sourcef\iers.for", the executable program is provided in file "\eterna33\bin\iers.exe". The program is written in standard Fortran 90.

The IERS earth rotation parameters can be transferred from IERS Central Bureau at Paris via FTP:

```
adress:     149.238.2.21
login:      anonymous
password:   your e-mail adress
directory:  cd iers cd old
files:      eopc04.xx where xx stands for the year.
```

The program IERS assumes the input data in IERS format on file "eopc04.96", and provides the output on the print file "iers.prn". The data from this output have to be added at the end of the ASCII file "etpolut1.dat" and the unformatted file "etpolut1.uft" in directory "eterna33\commdat" has to be deleted in order to update the pole coordinates and DUT1 corrections for the ETERNA package. The program IERS has to be updated and re-compiled after 1996 or when a new leap second has been introduced in UTC. When a new leap second has been introduced, you should also update file "etddt.dat" in directory "eterna33\commdat".

Section 10: Description of program BENCHMARK
--------------------------------------------

The Fortran 90 program BENCHMAR reads data from a tidal benchmark series (e.g. bfde403f.dat, see Wenzel 1996), computes model tides from a tidal potential catalogue and computes the differences between the benchmark series and the model tides. Program BENCHMAR is a modification of program PREDICT. There can be used seven different tidal potential catalogues (Doodson 1921, Cartwright-Tayler-Edden 1973, Buellesfeld 1985, Tamura 1987, Xi 1989, Roosbeek 1996, Hartmann and Wenzel 1995). Program BENCHMAR reads the project name "pn" from file "project", the control parameters from file "pn.ini and the benchmark series from file "pn.dat". Program BENCHMAR writes the benchmark series, the computed model tide and the difference in standard ETERNA format on file "pn.dif". For a description of the control parameters see the description of program PREDICT.

Section 11: Description of program PREDICT

The Fortran 90 program PREDICT can be used for the computation of earth tide signals with constant time interval for one station in order to generate a table of synthetic model tides (tidal potential, gravity tides, tilt tides, vertical or horizontal displacement, vertical strain, horizontal strain, areal strain, shear strain, volume strain, and oceanic tides). There can be used seven different tidal potential catalogs (Doodson 1921, Cartwright-Tayler-Edden 1973, Buellesfeld 1985, Tamura 1987, Xi 1989, Roosbeek 1996, Hartmann and Wenzel 1995) together with observed tidal parameters. Additionally, gravity pole tides (gravity variation due to polar motion, see encl. 007) and gravity LOD tides (gravity variation due to variation of length of day, see encl. 008) can be computed for those periods, where the necessary data are given in file "etpolc.dat".

## Section 11.1: Description of the project file "project"

The ASCII project name file "project" for program PREDICT contains one single variable only, the project name which is abbreviated as "pn" in this manual. The project name is an alphanumerical string consisting of 8 characters at maximum. The project name is read from the first 8 characters of the first record of project name file "project". The project name is used to define the control parameter file name "pn".ini for program PREDICT.

## Section 11.2: Description of control parameter file "pn".ini

The control parameter file "pn".ini (where "pn" stands for the project name defined in file "project") defines several control parameters necessary for the operation of program PREDICT. This control parameter file has an identical structure to the control parameter files used by programs RECTIDE, DETIDE, DESPIKE, DECIMATE, PREGRED and ANALYZE. Some of the variables are identical to those used by programs RECTIDE, DETIDE, DESPIKE, DECIMATE, PREGRED and ANALYZE. Thus it may be possible to use the same control parameter file for data recording, data preprocessing and data analysis.

All control parameter statements must begin with the control parameter name (column 1...10) which ends with an equal sign. The control parameter names must be spelled exactly with uppercase letters as defined below. Control parameters with unknown names will be ignored by program RECTIDE. The control parameter variables must be input after the equal sign following the control parameter name, with appropriate format. The control parameter statements must not have a specific sequence. A record starting with # in column 1 will be ignored and may be used to comment the control parameters. All characters following # in a record will be ignored and may be used to comment the control parameters.

```
STATIONAME= station name, 10 characters (col. 12...21)  following  the
            equal sign. The station name  will  be  displayed  on  the
            graphics screen during data recording.
STATLATITU= ellipsoidal latitude of the station in degree referring to
            WGS84 reference system (col.12...26).
STATLONITU= ellipsoidal longitude of the station in  degree  referring
            to WGS84 reference system (col.12...26).
STATELEVAT= ellipsoidal height of the station in meter referring to
            WGS84 reference system (col.12...26).
STATGRAVIT= gravity of the station in m/s**2, necessary for tidal tilt
            only (col. 12...26,  real  with  decimal  point).  If  the
            gravity is unknown, use a value of less than 1.0  and  the
            program will  compute  and  subsequently  use  the  normal
            gravity value referring to GRS80 reference system.
STATAZIMUT= azimuth of the  instrument  in  degree  decimal,  reckoned
            clockwise from north (col. 12 ... 26,  real  with  decimal
```

```
              point). This parameter is used for tidal tilt,  horizontal
              displacement and horizontal strain only.
TIDALPOTEN=   parameter for the tidal potential catalog to be used.
              1 = Doodson (1921) tidal potential catalog,
              2 = Cartwright-Tayler-Edden (1973) tidal potential catalog
              3 = Buellesfeld (1985) tidal potential catalog,
              4 = Tamura (1987) tidal potential catalog,
              5 = Xi (1989) tidal potential catalog,
              6 = Roosbeek (1996) tidal potential catalog,
              7 = Hartmann and Wenzel (1995) tidal potential catalog.
              As default, TIDALPOTEN= 7 is used.
SAMPLERATE=   Data sample interval in s (col. 12 ... 26, integer).
INITIALEPO=   Initial epoch, used to compute the Fourier development  of
              the specific earth tide component. The initial epoch  con-
              sists  of  the  integer  year (col. 12 ... 16, e.g. 1992),
              integer month (col. 17 ... 21), and integer day (col.
              22 ... 26).
PREDICSPAN=   Time span for the  prediction  in  hours  (col. 12 ... 26,
              integer). The model tide series will start at the  initial
              epoch INITIALEPO and the  time  span  will  be  PREDICSPAN
              hours.
TIDALCOMPO=   Earth tide component (col. 12 ... 26, integer).
              = -1 for tidal potential in m**2/s**2.
              =  0 for tidal gravity in nm/s**2.
              =  1 for tidal tilt in mas, at azimuth STATAZIMUT.
              =  2 for tidal vertical displacement in mm.
              =  3 for tidal horizontal displacement in mm at
                   azimuth STATAZIMUT.
              =  4 for tidal vertical   strain in 10**-9 = nstr.
              =  5 for tidal horizontal strain in 10**-9 = nstr,
                   at azimuth STATAZIMUT.
              =  6 for tidal areal  strain in 10**-9 = nstr.
              =  7 for tidal shear  strain in 10**-9 = nstr.
              =  8 for tidal volume strain in 10**-9 = nstr.
              =  9 for ocean tides in mm.
              The computed model  tides  will  be  given  in  the  units
              defined above.
AMTRUNCATE=   Amplitude threshold for the tidal potential  catalogue  in
              m**2/s**2. Only tidal waves with amplitudes exceeding  the
              amplitude threshold are used  for  the  computation.  This
              reduces the execution time, but also the accuracy  of  the
              computed tidal signales. For mean latitudes, the  relation
              between amplitude threshold and gravity tide accuracy   is
              for the Hartmann and Wenzel (1995) tidal potential catalog

                       threshold            rms error
                                           [nm/s**2]

                         1.D-01               88.40
                         1.D-02               14.40
                         1.D-03                2.25
                         1.D-04                0.44
                         1.D-05                0.068
                         1.D-06                0.011
                         1.D-07                0.002
                         1.D-08                0.001
                         1.D-09                0.001
                         1.D-10                0.001

POLTIDECOR=   Amplitude factor for gravity pole  tide. If  the amplitude
              factor is greater zero, gravity pole tides will be  compu-
              ted using the IERS daily pole  coordinates  and  stored as
              additional channel of the ouput file "pn".prd.
LODTIDECOR=   Amplitude factor for gravity LOD tide.  If  the  amplitude
              factor is greater zero, gravity LOD tides will be computed
              using  the IERS  daily  pole  coordinates  and  stored  as
              additional channeld of the output file "pn".prd.
TIDALPARAM=   wave group selection for a priori model tide  computation.
```

The number of wavegroups is restricted to 85. The tidal parameters may be taken from an earth tide analysis of another data set in the same station, or from a neighbouring station, or from synthetic gravity tide parameters (Timmen and Wenzel 1994, 1995), or from a guess only.

Col.12..21: DFRA#= start frequency of the wave group in cpd (real).
Col.22..31: DFRE#= end frequency of the wave group in cpd (real).
Col.32..41: DGAMO#= amplitude factor of the wave group (real).
Col.42..51: DPHIO#= phase lead of the wave group in deg (real).

The wave group selection for model tide computation should be made according to the wave group selection for the analysis of Earth tide data; the list given below is a proposal only. The frequencies are given in cycles per day (cpd).

| group | > 1 month from [cpd] | to [cpd] | > 6 months from [cpd] | to [cpd] | > 1 year from [cpd] | to [cpd] |
|---|---|---|---|---|---|---|
| SA | - | - | - | - | 0.001379 | 0.004107 |
| SSA | - | - | 0.004108 | 0.020884 | 0.004108 | 0.020884 |
| MM | 0.020885 | 0.054747 | 0.020885 | 0.054747 | 0.020885 | 0.054747 |
| MF | 0.054748 | 0.091348 | 0.054748 | 0.091348 | 0.054748 | 0.091348 |
| MTM | 0.091349 | 0.501369 | 0.091349 | 0.501369 | 0.091349 | 0.501369 |
| Q1 | 0.501370 | 0.911390 | 0.501370 | 0.911390 | 0.501370 | 0.911390 |
| O1 | 0.911391 | 0.947991 | 0.911391 | 0.947991 | 0.911391 | 0.947991 |
| M1 | 0.947992 | 0.981854 | 0.947992 | 0.981854 | 0.947992 | 0.981854 |
| P1 | - | - | 0.981855 | 0.998631 | 0.981855 | 0.998631 |
| S1 | - | - | - | - | 0.998632 | 1.001369 |
| K1 | 0.981855 | 1.023622 | 0.998632 | 1.023622 | 1.001370 | 1.004107 |
| PSI1 | - | - | - | - | 1.004108 | 1.006845 |
| PHI1 | - | - | - | - | 1.006846 | 1.023622 |
| J1 | 1.023623 | 1.057485 | 1.023623 | 1.057485 | 1.023623 | 1.057485 |
| OO1 | 1.057486 | 1.470243 | 1.057486 | 1.470243 | 1.057486 | 1.470243 |
| 2N2 | 1.470244 | 1.880264 | 1.470244 | 1.880264 | 1.470244 | 1.880264 |
| N2 | 1.880265 | 1.914128 | 1.880265 | 1.914128 | 1.880265 | 1.914128 |
| M2 | 1.914129 | 1.950419 | 1.914129 | 1.950419 | 1.914129 | 1.950419 |
| L2 | 1.950420 | 1.984282 | 1.950420 | 1.984282 | 1.950420 | 1.984282 |
| S2 | 1.984283 | 2.451943 | 1.984283 | 2.002736 | 1.984283 | 2.002736 |
| K2 | - | - | 2.002737 | 2.451943 | 2.002737 | 2.451943 |
| M3M6 | 2.451944 | 7.000000 | 2.451944 | 7.000000 | 2.451944 | 7.000000 |

As an example for the control parameter file for program PREDICT, we list below file "bfhw9501.ini", which is provided on the CD-rom:

```
# This file BFHW9501.INI status 1996.08.15 containing control parameters
# for program package ETERNA 3.40

# !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
# ! NOTE: The datalines have to start with their names.       !
# !       An additional comment may follow after the values,  !
# !       delimited by a whitespace                           !
# ! Values of 0 or less causes PREGRED to calculate the       !
# ! range(s) automatically resp. to use default values        !
# !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

# a commentline starts with an '#', it may appear at any position
# in this file. Empty lines may appear too

TEXTHEADER=  1.15000   0.0000 long   1.14673   -0.2474 Q1
TEXTHEADER=  1.14882   0.0804 O1     1.13070   0.2132 M1
TEXTHEADER=  1.13899   0.2062 P1     1.13000   0.0000 S1
TEXTHEADER=  1.13600   0.2070 K1     1.25000   0.5000 PSI1
```

```
TEXTHEADER=  1.18000   0.3000 PHI1   1.15354   0.0801 J1
TEXTHEADER=  1.14851  -0.0251 OO1    1.15205   2.4463 2N2
TEXTHEADER=  1.17054   2.5425 N2     1.18705   2.0327 M2
TEXTHEADER=  1.22450   4.1630 L2     1.18963   0.6271 S2
TEXTHEADER=  1.18947   0.8226 K2     1.06234   0.3783 M3
TEXTHEADER=  1.02000   0.0000 M4     1.01500   0.0000 M5M6

SENSORNAME=PREDICT         # earth tide sensor name
SAMPLERATE=   3600         # sampling interval in seconds
STATLATITU=     48.3306    # stations latitude  in degree
STATLONITU=      8.3300    # stations longitude in degree
STATELEVAT=    589.000     # stations elevation in meter
STATGRAVIT=      0.        # stations gravity in m/s**2
STATAZIMUT=      0.        # stations azimuth in degree from north
INITIALEPO= 1987    1    1 # start epoch for PREDICT
PREDICSPAN=  65544         # time span in hours for PREDICT
TIDALCOMPO=      0         # tidal component, see manual
TIDALPOTEN=      7         # HW95 tidal potential development
AMTRUNCATE=  1.D-10        # amplitude threshold
POLTIDECOR=   1.16         # poletide amplitude factor
LODTIDECOR=   1.17         # LOD tide amplitude factor
POLTIDEREG=      1         # ANALYZE pole tide regression adjustment

TIDALPARAM=  0.000000  0.501369   1.15000    0.0000 long   #tidal param.
TIDALPARAM=  0.501370  0.911390   1.14673   -0.2474 Q1     #tidal param.
TIDALPARAM=  0.911391  0.947991   1.14882    0.0804 O1     #tidal param.
TIDALPARAM=  0.947992  0.981854   1.13070    0.2132 M1     #tidal param.
TIDALPARAM=  0.981855  0.998631   1.13899    0.2062 P1     #tidal param.
TIDALPARAM=  0.998632  1.001369   1.13000    0.0000 S1     #tidal param.
TIDALPARAM=  1.001370  1.004107   1.13600    0.2070 K1     #tidal param.
TIDALPARAM=  1.004108  1.006845   1.25000    0.5000 PSI1   #tidal param.
TIDALPARAM=  1.006846  1.023622   1.18000    0.3000 PHI1   #tidal param.
TIDALPARAM=  1.023623  1.057485   1.15354    0.0801 J1     #tidal param.
TIDALPARAM=  1.057486  1.470243   1.14851   -0.0251 OO1    #tidal param.
TIDALPARAM=  1.470244  1.880264   1.15205    2.4463 2N2    #tidal param.
TIDALPARAM=  1.880265  1.914128   1.17054    2.5425 N2     #tidal param.
TIDALPARAM=  1.914129  1.950419   1.18705    2.0327 M2     #tidal param.
TIDALPARAM=  1.950420  1.984282   1.22450    4.1630 L2     #tidal param.
TIDALPARAM=  1.984283  2.002736   1.18963    0.6271 S2     #tidal param.
TIDALPARAM=  2.002737  2.451943   1.18947    0.8226 K2     #tidal param.
TIDALPARAM=  2.451944  3.381478   1.06234    0.3783 M3     #tidal param.
TIDALPARAM=  3.381379  4.347615   1.02000    0.0000 M4     #tidal param.
TIDALPARAM=  4.347616  7.000000   1.01500    0.0000 M5M6   #tidal param.

# End of file BFHW9501.INI
```

Section 11.3: Description of output file "pn".prd
-------------------------------------------------

The data output file of program PREDICT uses the ETERNA standard format for exchange of high resolution and high rate tidal data (Wenzel 1995). The output file is divided into a file header giving an alphanumeric description of the file (provided with control parameters TEXTHEADER of the "pn".ini file) and the file body containing the computed tidal signal. The format of the file body is

```
Col.01...08: date in year, month, day; e.g. 19900328  means year 1990,
             month 03 = March, day 28th.
Col.10...15: time in hour, minute, second,  given  in  Universal  Time
             Coordinated (UTC); e.g. 231200 means 23 hours 12  minutes
             00 seconds. The seconds  are assumed to be exact, e.g. 00
             seconds means 0.000 seconds.
Col.16...25: Channel 1 in units of the tidal component. This channel
             contains the sum of the tidal signal and the gravity
             pole tide and LOD tide signals.
Col.26...35: Channel 2 in units of the tidal component. This channel
             usually conatins the gravity tide.
Col.36...45: Channel 3 in units of the tidal component. This channel
```

contains the gravity pole tide, if computed.
Col.46...55: Channel 4 in units of the tidal component. This channel contains the gravity LOD tide, if computed.

The file ends with 99999999 as date.

As an example, a part of the output file "bfhw9501.prd" computed with program PREDICT using the control parameter file "bfhw9501.ini" is given below. This files contains gravity tides, gravity pole tides and gravity LOD tides.

```
77777777            0.000     0.000     0.000     0.000
19870101      0 -1630.338 -1649.708    18.906     0.464
19870101  10000 -1544.612 -1563.988    18.909     0.467
19870101  20000 -1253.944 -1273.327    18.913     0.469
19870101  30000  -811.681  -831.070    18.917     0.472
19870101  40000  -295.698  -315.093    18.921     0.474
19870101  50000   208.593   189.191    18.925     0.477
19870101  60000   626.498   607.090    18.929     0.479
19870101  70000   909.354   889.939    18.933     0.482
19870101  80000  1043.335  1023.914    18.937     0.485
19870101  90000  1049.655  1030.227    18.941     0.487
19870101 100000   976.094   956.660    18.944     0.490
19870101 110000   881.969   862.529    18.948     0.492
19870101 120000   820.439   800.992    18.952     0.495
```

The data stored in the output file of program PREDICT can be plotted using program PLOTDATA (see encl. 006...008).

## Section 11.4: Execution time of program PREDICT

The execution time of program PREDICT depends mainly on the number of waves of the chosen tidal potential catalogue, on the amplitude threshold of the tidal potential, and on the number of samples to be computed. The execution time given below has been measured on a 100 MHz PENTIUM pc with operating system MS-DOS 6.22 for 8760 hourly gravity signals including pole tide and LOD tide. The rms error has been determined by comparison with gravity tide benchmark series BFDE403F.DAT.

| catalogue | threshold | nwave | rms error [nm/s**2] | exec.time [s] |
|---|---|---|---|---|
| Tamura (1987) | 1.D-06 | 1200 | 0.070 | 11.86 |
| Hartmann+Wenzel (1995) | 1.D-01 | 9 | 88.40 | 3.90 |
| Hartmann+Wenzel (1995) | 1.D-02 | 42 | 14.40 | 4.06 |
| Hartmann+Wenzel (1995) | 1.D-03 | 155 | 2.25 | 4.94 |
| Hartmann+Wenzel (1995) | 1.D-04 | 434 | 0.44 | 7.20 |
| Hartmann+Wenzel (1995) | 1.D-05 | 1248 | 0.068 | 13.51 |
| Hartmann+Wenzel (1995) | 1.D-06 | 3268 | 0.011 | 33.01 |
| Hartmann+Wenzel (1995) | 1.D-07 | 7761 | 0.002 | 83.82 |
| Hartmann+Wenzel (1995) | 1.D-08 | 11462 | 0.001 | 132.86 |
| Hartmann+Wenzel (1995) | 1.D-09 | 12000 | 0.001 | 139.95 |
| Hartmann+Wenzel (1995) | 1.D-10 | 12011 | 0.001 | 140.11 |

## Section 12: Description of program PREGRED

PREGRED is an interactive graphical editor for digital recorded earth tide data (Vetter and Wenzel 1995), written in Microsoft Visual C++ 1.52 language to supplement the batch programs DETIDE, DESPIKE and DECIMATE (see below). Problems which cannot automatically be solved by program DESPIKE (e.g. several steps within short time interval, small slow glitches) can be managed with the graphical editor PREGRED under graphical control of the user. PREGRED uses the standard ETERNA format (Wenzel 1995). The creation of the graphical editor PREGRED was initi-ated by Dr. J. Neumeyer, Geoforschungszentrum Potsdam, who supplied his programs ALPHA and BETA to us.

The graphical editor PREGRED is able to plot simultaneously data from two channels for a predefined time window (e.g. one day) on the screen of the pc. Vertical and/or horizontal zooming is possible. The user can manually delete disturbed data, interpolate gaps and correct steps in all channels. PREGRED has originally been designed for 1 min data, but can be applied to data with 1 s ... 1 h sampling interval (the sampling interval has to be an integer number of seconds equal to 3600 divided by an integer n). Recommended sampling intervals are 1 s, 2 s, 3 s, 5 s, 10 s, 20 s, 30 s or 1 min. PREGRED can be applied to data from 9 channels at maximum, but can display simultaneously on the screen data from two channels only.

PREGRED runs on an IBM-compatible personal computer with at least 640 kB RAM, preferably with a color screen. Although PREGRED could in principle be executed with a monochromatic screen, it will be very difficult to distinguish the traces of the different channels (for this situation, PREGRED has the built-in option to display one channel only). The graphics adapter should be EGA-, VGA-standard or higher. Due to the high processing effort of graphical editing, a PENTIUM cpu is recommended.

PREGRED needs the two font files "oem08.fon" and "oem10.fon", supplied on the CD-rom. These two font files have either to be copied to the working directory from which PREGRED is executed, or the path to these files has to be defined with the MS-DOS environment variable MSCFONTS by adding in your "autoexec.bat" file the line

```
set MSCFONTS=c:/eterna34/bin
```

provided you have installed the ETERNA 3.40 package on drive c:

The combination of programs DETIDE, DESPIKE, DECIMATE and PREGRED is shown in the following diagram:

```
           ---------------
           I  Raw data   I
           ---------------
                  Y
           ---------------
           I   PREGRED   I      <---- find and flag gaps
           ---------------
                  Y
           ---------------
           I   DETIDE    I      <---- calibrate and detide data
           ---------------
                  Y
           ---------------
           I   PREGRED   I      <---- flag disturbances, destep data
           ---------------
  --------------->Y
  I        ---------------
  I        I   DESPIKE   I      <---- destepping, despiking, degapping
  I        ---------------
  ----------------Y
           ---------------
           I   PREGRED   I      <----- final check
           ---------------
                  Y
           ---------------
           I   DECIMATE  I      <---- decimation to 5 min samples
           ---------------
                  Y
           ---------------
           I   DECIMATE  I      <---- decimation to hourly samples
           ---------------
```

It is in any case recommended to store the original data files to be edited on a backup medium, e.g. magneto-optical disk, before starting the graphical editing with PREGRED.

PREGRED may be executed by entering

<pregred projectname.suffix>

If you enter <pregred -h>, you will see a help screen showing the command line options. If you have a high resolution graphics adapter and screen, you may want to work with a high resolution image by entering

```
<pregred projectname.suffix -r800>  for  800 x  600 pixel resolution,
<pregred projectname.suffix -r1024> for 1024 x  768 pixel resolution.
<pregred projectname.suffix -r1280> for 1280 x 1024 pixel resolution.
```

PREGRED overwrites the original file with the edited data, but saves the original data in a backup file. If you edit e.g. the file "sg102tes.tid", the original data are saved in file "sg102tes.#ti", whereas the edited data are stored in file "sg102tes.tid" after finishing the execution of program PREGRED. You should never input a backup file to PREGRED, because in this case it may be impossible for PREGRED to save the backup file. If you have made a mistake during the editing with PREGRED, you should finish the execution of PREGRED, copy the backup file to a file having the original name, and restart the editing procedure.

PREGRED reports the modification which have been made at the data file in a report file with name "filename".PRO. As an example, we give in directory "\eterna33\1mindat" the report file "sg102tes.pro" which was established by PREGRED when editing file "sg102tes.cor".

For the execution of PREGRED, there must exist a control parameter file with name "projectname.ini" and a calibration parameter file with name "projectname.cal" in the directory, from which PREGRED has been executed and in which the data file to be edited is stored. This control parameter file defines the control parameters necessary to execute PREGRED. The structure of the control parameter file used by PREGRED is identical to the structure of the control parameter files used in the ETERNA 3.40 package by other programs (e.g. PREDICT). For the execution of PREGRED, the following control parameters have to be defined:

SAMPLERATE= data sample interval in s (col. 12...26, free format). The program PREGRED is designed for 60 s raw data sampling interval, but may also be used for another sampling interval (between 1 s and 3600 s). Recommended sample rates are 1 s, 2 s, 3 s, 5 s, 10 s, 20 s, 30 s, 1 min, 5 min, 10 min, 20 min, 30 min and 60 min.

NUMRAWCHAN= number of raw data channels (before calibration and detiding). This parameter is valid only for files with suffix "raw".

NUMBCHANEL= number of final channels (after detiding) for all files where the suffix is not equal to "raw".

HPERPAGE= displayed hours per page on the original (unzoomed) screen (col. 12...26, free format).

PGUPPGDN= time shift between successive windows in hours (col. 12... 26, free format).

RANGETCx= vertical range for channel x in units of channel 1, when editing calibrated files with suffix CAL, TID, COR or FIL (col. 12...26, free format). x denotes the channel number and is restricted to 1...9.

ASSOC_LTO1= parameter for copying modifications made with PREGRED in the last channel (detide signal) to channel 1 (col. 12 ... 26, free format, 1 = yes). If you interpolate gaps in the last channel and ASSOC_LTO1 is set to 1, the data in channel is computed by:

```
             ch(1) = ch(last) + sum over [channel(i)*METCORFACT(i)],
                                                      i=2,last-1
```

RANGRAWx= vertical range for channel x in Volt, when editing an un-calibrated file with suffix RAW (col. 12 ... 26, free format).
INTEPOCx= Number of samples to be averaged before and after a gap for gap interpolation in channel x (col. 12 ... 26, free format). By default, 10 samples will be used. x denotes the channel number and is restricted to 1...9.
MAXGAP= Maximum number of hours of a gap to be interpolated by PREGRED. Gaps exceeding MAXGAP cannot be interpolated.

The calibration parameter file contains a file header and a a file body. The file header contains alphanumeric information to describe the file contents, and ends with C********* in cols. 1...10.

```
The first record of the file body contains
in cols.  1..11:  RAWCHAUNIT=
in cols. 12..14:  blanks
in cols. 15..24:  unit of raw data in channel 1 (CHARACTER*10)
in cols. 25..34:  unit of raw data in channel 2 (CHARACTER*10)
in cols. 35..44:  unit of raw data in channel 3 (CHARACTER*10)
in cols. 45..54:  unit of raw data in channel 4 (CHARACTER*10) ...

The second record of the file body contains
in cols.  1..11:  CALCHAUNIT=
in cols. 12..14:  blanks
in cols. 15..24:  unit of calibrated data in channel 1 (CHARACTER*10)
in cols. 25..34:  unit of calibrated data in channel 2 (CHARACTER*10)
in cols. 35..44:  unit of calibrated data in channel 3 (CHARACTER*10)
in cols. 45..54:  unit of calibrated data in channel 4 (CHARACTER*10) ...

The third record of the file body contains
in cols. 1...11: METCORFACT=
in cols. 12..14: blanks
in cols. 15..24: correction factor for channel 1 (has to be 1.0)
in cols. 25..34: correction factor for channel 2
in cols. 35..44: correction factor for channel 3
in cols. 45..54: correction factor for channel 4 ....
```

The calibration parameter file to be used with PREGRED is identical to the calibration parameter file for programs DETIDE and DESPIKE. PREGRED reads however only the chanel units and correction factors for the meteorological channels from this file.

We give below a copy of file "sg102tes.cal" provided in directory "\eterna33\1mindat":

```
File             : sg02tes.cal
Status           : 1996.09.02
Contents         : calibration parameters for data file sg02tes.raw
                   cryogenic gravimeter SG102 and barometer BMG3
                   at BFO Schiltach.

Sequence is:
raw data:         unit       unit
detided data:     unit       unit       unit    unit
correction:       fact.1     fact.2    fact.3
calib.param:     linear     linear
                 quadratic  quadratic
                 cubic      cubic
                 time lag   time lag
C***********************************************************
RAWCHAUNIT=        Volt        Volt
CALCHAUNIT=        nm/s**2      hPa    nm/s**2   nm/s**2
METCORFACT=         1.0000   -3.2000    1.0000
```

```
19940602 120000 3439.7000  -23.0424
19940602            0.0000    0.0000
19940602            0.0000    0.0000
19940602           57.6000   21.0300
19940622 120000 3439.7000  -23.0424
19940622            0.0000    0.0000
19940622            0.0000    0.0000
19940622           57.6000   21.0300
99999999
```

While reading data from the input file, PREGRED performs a sequence test that checks for gaps in the data file. In case of gaps or faults in the date and time of the observation, the user is requested to decide either to terminate the execution of PREGRED or to allow PREGRED to fill the gaps with flags. Please have in mind that the samples should be given at full minutes if the sample interval is e.g. 60 s, because otherwise PREGRED will start to correct the time of the observation.

After having performed the sequence check, PREGRED shows the data of the first page on the graphical screen. Using function key 1 shows the on-line help screen of program PREGRED, which explains the operations allowed with PREGRED.

We give in the following the help screen of PREGRED version 3.40:

```
  PgUp      = save gaps, display prev. page
  Ctrl+PgUp = save gaps, display first page
  PgDn      = save gaps, display next page
  Ctrl+PgUp = save gaps, dosplay last page
  ESC     = save gaps and EXIT program
  a,A     = switch active channel RED-WHITE
  Arrows = move cursor, move slow use Ctrl-key additional
  g,G     = start gap
  e,E     = end   gap
  f,F     = fill gaps for this channel by linear interpolation.
  c,C     = save gaps, display next channel as active
  d,D     = display both channels <-> only the active channel
  u,U     = UNDO gaps for active day

  s,S     = save gaps and define shift for active channel
            to actual cursor position
  r,R     = save gaps, refresh screen
  z,Z     = save gaps, zoom in both axis
  o,O     = save gaps, zoom out in both axis
  T       = save gaps, zoom in Time-axis
  t       = save gaps, zoom out in Time-axis
  V       = save gaps, zoom in value axis
  v       = save gaps, zoom out in value axis
  1       = save gaps, zoomfactor 1 for both axis
  i,I     = switch ranges from INI-File - calculated ranges

  Continue PREGRED - Hit RETURN
```

Description of the on-line commands:
-----------------------------------

ESC : By hitting the "ESC" key, the program PREGRED terminates the operation. Eventual modifications which have been made to the data and are not yet saved are now saved in the data file. The program checks and lists remaining gaps in the data.

PgUp : Switch screen to previous page (if it exists). If there have been made any modifications to the data on the current page, these modifications are now stored permanently in the data file. The modifications cannot be undone after hitting the "PgUp" key.

Ctrl+PgUp: Switch to first screen. If there have been made any changes in the data on the current page, these modifications are now stored permanently in the data file. The modifications cannot be undone after hitting the "Ctrl+PgUp" key.

PgDn : Switch screen to next page (if it exists). If there have been made any modifications to the data on the current page, these modifications are now stored permanently in the data file. The modifications cannot be undone after hitting the "PgDn" key.

Ctrl+PgDn: Switch to last screen. If there have been made any changes in the data on the current page, these modifications are now stored permanently in the data file. The modifications cannot be undone after hitting the "Ctrl+PgDn" key.

Pos1(Home): Move cursor to left border of the screen.

End: Move cursor to the right border of the screen.

d,D : There are usually displayed two channels simultaneously on the page by PREGRED. The decision of PREGRED which two channels (of the up to four channels available) are displayed depends on the suffix of the file which is edited: for suffixes RAW and CAL (and suffixes unknown to PREGRED), channel 1 is initially the active channel plotted in red and channel 2 is initially the inactive channel plotted in white. For suffixes TID, COR, FIL and DEC, channel 4 is initially the active channel plotted in red and channel 2 is initially the inactive channel plotted in white. Which data channel is currently plotted as red or white channel is displayed at the left side of the page. By hitting key "d" or "D", the active channel is displayed only and the inactive channel is deleted from the page. This may help the editing in case of larger disturbances or crossings of red and white traces. The "d" and "D" command is valid for all pages of the session.

a,A : There are usually two channels plotted simultaneously on the page, one in white and one in red. One of both channels is called the "active channel", which means that modifications to the data (deleting data of destepping data) are made to this channel only. Which one of the channels is currently active, is displayed in the lower right part of the page. For each session, initially the red channel is active. If you hit the "a" or "A" key, the active channel is switched to the white channel, which was previously inactive. If you hit again the "a" or "A" key, the active channel is again the red channel. The "a" and "A" command is valid for all pages of the session.

c,C : The current active channel is replaced by the next available channel with higher number of the current file to be edited. If the active channel is 1 and you hit the "c" or "C" key, the channel 2 will be plotted as active channel (except if channel 2 is already plotted as inactive channel; in this case, channel 3 will be displayed). If the active channel is already the last channel available for the file and you hit the "c" or "C" key, channel 1 will be displayed as active channel.

Arrows : The cursor keys may be used to change the position of the cursor (white cross, being positioned initially in the center of the page). By using simultaneously the "Cntrl" key and the cursor keys, you have a low speed motion with minimum increment of 1 pixel resp. the sample interval. The date and time corresponding to the current cursor position are shown in the upper left part of the page; the numerical value of the active channel corresponding to the current cursor position is shown at the upper right part of the page.

z,Z : The trace of the active channel of the page (plotted in red) is zoomed around the current cursor position by a factor of 2 in both vertical and horizontal directions (in fact both channels are zoomed in horizontal direction, but in vertical direction the active channel is zoomed only). If you hit n times the "z" or "Z" key, the active channel is zoomed by a factor of 2**n. The "z" and "Z" command is valid for the current page only.

T : The trace of both channels of the page is zoomed around the current cursor position by a factor of 2 in horizontal direction only. If you hit n times the "T" key, the screen is zoomed by a factor of 2**n in horizontal direction. The "T" command is valid for the current page only.

```
t      : The trace of both channels of the page is de-zoomed around the
         current cursor position by a factor of 2 in horizontal  direc-
         tion only (this works only, if the page  has  previously  been
         zoomed in horizontal direction by hitting "z","Z" or "T" key).
         If you hit n times the "t" key, the page  is  de-zoomed  by  a
         factor of 2**n in horizontal direction.
V      : The trace of the active channel of the page is  zoomed  around
         the current cursor position by  a  factor  of  2  in  vertical
         direction only. If you hit n times the "V" key, the  trace  of
         the active channel is zoomed by a factor of 2**n  in  vertical
         direction. The "V" command is valid for the current page only.
v      : The trace of the active channel  of  the  page  is   de-zoomed
         around the current  cursor  position  by  a  factor  of  2  in
         vertical direction only (this works  only,  if  the  page  has
         previously been zoomed in vertical direction by  hitting  "z",
         "Z" or "V" key). If you hit n times the "v" key, the  page  is
         de-zoomed by a factor of 2**n in vertical direction.
o,O    : The trace of the active  channel  of  the  page  is  de-zoomed
         around the current cursor position by a factor of  2  in  both
         vertical and horizontal directions (this works  only,  if  the
         page has previously been zoomed). If you hit n times  the  "o"
         or the "O" key, the trace of the active channel  is  de-zoomed
         by a factor of 2**n.
1      : The page is plotted  with  the  initial  ranges;  any  zooming
         which may have been performed is removed.
g,G    : Start of a gap at the current (horizontal) cursor position. To
         flag (delete) disturbed data, you move the cursor in  horizon-
         tal direction to the start of the gap you want to create,  and
         you hit the "g" or "G" key if the cursor  is  at  the  correct
         position.
e,E    : End of a gap at the current (horizontal) cursor  position.  To
         flag (delet) disturbed data, you move the cursor in horizontal
         direction to the end of the gap you want to  create,  and  you
         hit the "e" or "E"  key  if  the  cursor  is  at  its  correct
         position. These keys work only if the start  of  the  gap  has
         already been defined on the same screen!
f,F    : Linear interpolation of the current gap in the active channel.
         This key works only if the cursor is positioned inside  a  gap
         (in time direction). The last n samples before the gap and the
         first n samples after the gap are  used  to  linearily  inter-
         polate the gap, if the length of the gap is less  than  MAXGAP
         hours. The number of samples to be averaged can be defined  by
         parameter INTEPOCx. By default, INTEPOCx is 10.
u,U    : A gap which has been created on  the  current  screen  may  be
         undone (if the data of the current screen have  not  yet  been
         saved) by hitting the "u" or "U" key.
s,S    : Step correction. To correct the data of the active channel for
         the complete data file, move the cursor to the position at the
         right hand side of a step,  where  the  trace  of  the  active
         channel before the step would be located  if  the  step  would
         not exist. Before using the "s" or "S" keys, it is recommended
         to zoom the screen around the step in vertical direction.

                                step
                                 -----------------------

         ---------------------  x= cursor position

         Hit the "s" or "S" key, and the program PREGRED will show  you
         how the step will be removed, if you agree with  the  proposed
         shift (the program asks you to confirm the step removal opera-
         tion by entering either "y" for yes or "n" for no).

                                 --
                                   <------ spike to be deleted
         ---------------------  x--------------------
```

It is usually necessary, to delete a small part of the data around the step after its removal by using the "g" and "e" keys, see above.

Error messages of program PREGRED:
----------------------------------

| Message: | Description / Action |
|---|---|
| Wrong samplingrate xxx - consult manual | Check the parameter SAMPLERATE= in the INI-File. The Samplingrate has to be between 1 and 3600 and 3600 must be divisible by Samplingrate without a rest. |
| Can't find font oem10.fon | Copy the font-files into your working-directory or define a directory in your AUTOEXEC.BAT which contains the font-files. Use SET MSCFONTS=<directory> e.g. SET MSCFONTS=C:/eterna33/bin !! DON'T use a backslash "\" as seperator !! |
| channel numbers not allowed and channels have to be different | If you use a command-line-option to choose the channels to be displayed, the channel numbers have to be different and they have to be between 1 and the number of channels in the data-file |
| Unknown Parameter -x | You used an unknown command-line-parameter |
| File xxx not found | PREGRED could not find your input-file |
| Can't open xxx-File | PREGRED could not open a file for writing. May be your filesystem is full. |
| Wrong RANGETC-Number at INI-File | The number of Channels is limited to 11. Check your parameters in the INI-File |
| Wrong RANGRAW-Number at INI-File | The number of Channels in RAW-Files is limited to 9. Check your Parameters in the INI-File. |
| Wrong INTEPOC-Number at INI-File | The number of Channels is limited to 11. Check your Parameters in the INI-File |
| AIRPCORFAC, METCORFACx are not supported any more METCORFACT has to be defined in the CAL-File | Delete the AIRPCORFAC and METCORFACx parameters in the INI-File and define them in the CAL-File |
| No INI-File found.... | Generate a INI-File or copy the existing INI-File to the working directory |
| No CAL-File found.... | Generate a CAL-File or copy the exsiting CAL-File to the working directory |
| CAL-File uncomplete - Program aborted | One of the following parameters is NOT defined in the CAL-File: METCORFACT, RAWCHAUNIT, CALCHAUNIT Define the missing Parameter. |
| Number of Chanels in INI-File different from number of first offsets | In the datafile, the number of offsets from the number of channels, described in the INI-File (NUMBCHANEL or NUMRAWCHAN) |
| Max. xx channels allowed | For RAW-Files, only 9 channels are allowed and for other files the limit is 11 channels |
| ASSOC_LT01 ignored in | In RAW-Files, the last channel can't be |

| | |
|---|---|
| RAW-Files | associated to channel no. 1 |
| Data error | No data found in the file |
| First Data-Line contains not enough channels | The first line of data contains less channels than described in the INI-File |
| Found Data-Line containing not enough channels | A single data record contains less channels than described in the INI-File |
| Wrong time data detected. Please select action Correct time by program (=1) abort Program (=2) | The detected time doesn't fit to the sampling interval |
| At <time> additional Offsets in Rawfile ignored | Offsets with code 77777 may not occur in a RAW-file and are not processed |
| Not enough memory | Take care to have at least 500kB of free memory in the lower memory section or decrease the parameter HPERPAGE in the INI-File |
| Can't interpolate data No gap at actual cursor-position - Hit RETRUN | PREGRED only interpolates data if there is a gap at the current cursor position. Move the cursor to a gap or delete some data before gap interpolation. |
| This is already the FIRST Page<br>or<br>This is already the LAST Page | You tried to go forward/backward at the end/start of the datafile |
| xxx gaps detected - see PRO-File | After terminating the program, PREGRED detected xxx gaps in the data, described in the PRO-File |
| No data at the END of gap | You tried to interpolate a gap, but there are no data at the end of the gap |
| No data at the BEGIN of gap | You tried to interpolate a gap, but there are no data at the beginning of the gap |
| Gap exceeds maximum length of xxx hours - See Parameter MAXGAP in INI-File | You tried to interpolate a gap with a length exceeding the MAXGAP-Parameter in the INI-file |
| Gap in Meteorological Data Can't calculate Channel 1 - run DETIDE first - run DETIDE first | You tried to interpolate a gap in the channel with parameter ASSOC_LTO1 = 1. PREGRED can't calculate the data for channel 1 if there are gaps in any meteorological data at the same time. Interpolate the meteo-channels first and run DETIDE-Program. |
| Gap (99999.999) at act. Position - Can't calculate an offset | You tried to correct an offset but at the current cursorposition are no data. Move the cursor to a position containing data and repeat the step-correction. |
| Gap detected at <time> xxx records missing - Fill gap with flags(=1) abort Program (=2) | PREGRED detected a gap of xxx records. Select the action, which PREGRED shall perform. |

| | |
|---|---|
| You decided to fill a large gap of more than 10 hours | Be shure to fill such a large gap with flags. |

## Section 13: Description of program DECIMATE

Program DECIMATE can be used to decimate data stored in standard ETERNA format after numerical lowpass filtering to a lower resampling interval. If data have e.g. been recorded with 10 s sampling interval, program DECIMATE can be used to numerically lowpass filter the data and to resample the data at 60 s resampling interval. After data pre-processing with DETIDE and DESPIKE, the preprocessed data can again be decimated to hourly interval using DECIMATE. Program DECIMATE uses FIR zero phase numerical lowpass filters; the apropriate filter can be chosen by the user from a variety of available filters.

### Section 13.1: Decimation of data

For program DETIDE, there are in principle allowed sampling intervals between 1 and 3600 s. However, we have provided numerical lowpass filters for the following sampling / resampling intervals only:

| filter name | sampling / resampling interval | enclosure |
|---|---|---|
| n01s1m01.nlf | 1 s / 1 min | 009 |
| n02s1m01.nlf | 2 s / 1 min | 010 |
| n03s1m01.nlf | 3 s / 1 min | 011 |
| n05s1m01.nlf | 5 s / 1 min | 012 |
| n10s1m01.nlf | 10 s / 1 min | 013 |
| n20s1m01.nlf | 20 s / 1 min | 014 |
| n30s1m01.nlf | 30 s / 1 min | 015 |
| n02s5m02.nlf | 2 s / 5 min | 016 |
| n03s5m02.nlf | 3 s / 5 min | 017 |
| n05s5m02.nlf | 5 s / 5 min | 018 |
| n10s5m02.nlf | 10 s / 5 min | 019 |
| n20s5m02.nlf | 20 s / 5 min | 020 |
| n30s5m02.nlf | 30 s / 5 min | 021 |
| n60s5m02.nlf | 60 s / 5 min | 022 |
| n2h1m001.nlf | 1 min / 5 min | 023 |
| n14h5m01.nlf | 5 min / 60 min | 024 |

The filter gain of these lowpass filters can be plotted with program PLOTFILT.

Program DECIMATE reads the project name "pn" from file "project" and the necessary control parameters from file "pn".ini from the directory from which DECIMATE is called. The data to be decimated have to be provided in the same directory; the name of the input data file has to be defined in the control parameter file "pn".ini. The decimated data are written in standard ETERNA format to a file in the same directory. The name of the data output file has to be defined in the control parameter file "pn".ini. The length of the data files to be decimated with DECIMATE is restricted to 10000 days = 30 years. The length of the numerical filters to be used with DECIMATE is restricted to 4501 coefficients.

### Section 13.2: Description of the project file "project"

The ASCII project name file "project" for program DECIMATE contains one single variable only, the project name which is abbreviated as "pn" in this manual. The project name is an alphanumerical string consisting of 8 characters at maximum. The project name is read from the first 8 characters of the first record of project name file "project". The project name is used to define the control parameter file name "pn".ini for program DECIMATE.

## Section 13.3: Description of control parameter file "pn".ini

The control parameter file "pn".ini (where "pn" stands for the project name defined in file "project") defines several control parameters necessary for the operation of program DECIMATE. The control parameter file has an identical structure to the control parameter files used by programs RECTIDE, PREDICT, DETIDE, DESPIKE, PREGRED and ANALYZE. Some of the variables are identical to those used by programs RECTIDE, DETIDE, DESPIKE, DECIMATE, PREGRED and ANALYZE. Thus it is usually possible to use the same control parameter file for data recording, data preprocessing and data analysis.

All control parameter statements must begin with the control parameter name (column 1...10) which ends with an equal sign. The control parameter names must be spelled exactly with uppercase letters as defined below. Control parameters with unknown names will be ignored by program DESPIKE. The control parameter variables must be input after the equal sign following the control parameter name, with appropriate format. The control parameter statements must not have a specific sequence. A record starting with # in column 1 will be ignored and may be used to comment the control parameters. All characters following # in a record will be ignored and may be used to comment the control parameters.

The following control parameters are valid for program DECIMATE:

```
DECFILNAME= lowpass filter file name (CHARACTER*12). Valid lowpass
            filter file names are

            n01s1m01.nlf   n02s1m01.nlf   n03s1m01.nlf  n05s1m01.nlf
            n10s1m01.nlf   n20s1m01.nlf   n30s1m01.nlf  n02s5m02.nlf
            n03s5m02.nlf   n05s5m02.nlf   n10s5m02.nlf  n20s5m02.nlf
            n30s5m02.nlf   n60s5m02.nlf   n2h1m001.nlf  n14h5m01.nlf

INPFILNAME= input data file name (CHARACTER*12).
OUTFILNAME= output data file name (CHARACETR*12).
SAMPLERATE= sampling interval in s.
NUMBCHANEL= number of data channels to be decimated. NUMBCHANEL is
            restricted to 9.
DECIMATION= integer decimation factor. The decimation factor is
            restriced by the filter cutoff period.
```

## Section 14: Description of program DETIDE

The program DETIDE is a Fortran 90 program for the preprocessing of high rate earth tide observations (1 s ... 30 min sampling interval). DETIDE was a part of the larger program PRETERNA developed by H.-G. Wenzel in 1991, and is described in Wenzel (1994). Program DETIDE uses the ETERNA standard format for the storage and exchange of high resolution and high rate earth tide data described in Wenzel (1995). The output file of program DETIDE may directly be used to input into the graphical editor PREGRED or the despiking program DESPIKE or the decimation program DECIMATE or the earth tide analysis program ANALYZE.

The earth tide preprocessing programs DETIDE, DESPIKE, DECIMATE and PREGRED allow the preprocessing of high rate earth tide data. The data preprocessing is carried out using a remove-restore technique (similar to the remove-restore technique known from gravity field transformation). We at first remove all known signals (i.e. computed model tides and influences of meteorological parameters (e.g. air pressure). The remaining residual signal (including the earth tide sensor's drift) is then cleaned (destepped, despiked and degapped), and the known signals are subsequently added back to the cleaned residual signal. Errors in the model earth tide signal and model meteorological parameter contribution will by this procedure be cancelled to a large extend (naturally except for the gaps, where we use the model earth tide and model meteorological parameter contribution to interpolate the data during the gap). The corrected samples at the original sampling interval may finally be numerically filtered and decimated to a lower sampling interval. The data preprocessing should be carried out in different steps, and one should check the result of the different steps by plotting the data using programm PLOTDATA or PREGRED.

There exist several different procedures for the preprocessing of one data set; the ETERNA 3.40 package should be flexible enough to allow to establish very special data preprocessing preocdures.

The experience of several groups with PRETERNA has shown, that an optimal data preprocessing my be the following procedure:

- Decimate the raw data for e.g. one month from e.g. 1 s sampling interval to 1 min sampling interval using DECIMATE,
- Check the 1 min observations with the graphical editor PREGRED, especially for the meteorological channels. Remove spikes and steps and interpolate gaps in the meteorological channels with PREGRED.
- Calibrate and detide the earth tide data with DETIDE,
- Check the detided earth tide data with the graphical editor PREGRED. Parts of the data with large distortions e.g. due to earth quakes should be eliminated (make a gap). Slow steps and parts with several steps in short time should be removed.
- Despike the earth tide data with program DESPIKE.
- Check the despiked earth tide data with the graphical editor PREGRED.
- Decimate the despiked earth tide data with DECIMATE to e.g. 5 min resampling interval.
- Collect several 5 min data sets and merge these data together,
- Decimate the merged data set to e.g. 1 hours resamling interval,
- Perform an analysis of the 1 hour data set using program ANALYZE.

There may be used with program DETIDE:

- as observations:
  tidal potential, gravity tides, tilt tides, vertical displacements, horizontal displacements, vertical strain tides, horizontal strain tides, areal strain tides, shear strain tides, volume strain tides, and oceanic tides.

- high rate earth tide data for up to 100 days, containing up to 500 gaps at maximum (with a maximum length of 30 000 samples),

- up to 85 tidal wave groups,

- up to 6 additional meteorological parameter,

- 7 different tidal potential catalogues (Doodson 1921, Cartwright - Tayler-Edden-Doodson 1973, Buellesfeld 1985, Tamura 1987, Xi 1989, Roosbeek 1996 and Hartmann and Wenzel 1995),

There have been made significant improvements and changes over previous program versions. Program DETIDE has been extensively tested using model data and observed data sets for gravity only. However, many routines are identical in DETIDE, PREDICT and ANALYZE, and have been tested with gravity, tilt, strain, and ocean tides.

The structure of the data files is identical for programs DECIMATE, DETIDE, DESPIKE, PREGRED and PLOTDATA.

The project file PROJECT is described in section B5.6 and the control parameter file "project name".INI is described in section B5.7.

## Section 14.1: Calibration of data

The name of the formatted data input file to program DETIDE has to be defined in the control parameter file "pn".ini. When reading the data from the data input file, the sequence of the data is checked. No gap in the sequence of the data is allowed; if there exist gaps in the sequence of the data, these gaps have to be filled with flagged data which means that a sample value of 99999.999 has to be put in the data input file at the proper positions. The flagging of gaps may be carried out using an alphanumerical standard editor, which is a very tedious task for longer gaps. We recommend to use the graphical editor PREGRED to check for gaps and to flagg gaps.

We use 3rd degree polynomials with time dependent coefficients (see below) to calibrate the earth tide signal from the raw data unit (e.g. Volt) to the component dependent earth tide signal unit

```
   m**2/s**2          for tidal potential,
   nm/s**2            for tidal gravity,
   mas                for tidal tilt,
   mm                 for tidal vertical displacement,
   mm                 for tidal horizontal displacement,
   nstr = 10**-9 str  for tidal vertical strain,
   nstr = 10**-9 str  for tidal horizontal strain,
   nstr = 10**-9 str  for tidal areal strain,
   nstr = 10**-9 str  for tidal shear strain,
   nstr = 10**-9 str  for tidal volume strain, and
   mm                 for ocean tides.
```

The meteorological signals have to be calibrated from the raw data unit to the proper unit of the meteorological parameter (e.g. hPascal for air pressure, deg Celsius for temperature), where a 3rd degree calibration polynomial (with time variable parameters, see below) may be used. If there is known a linear calibration factor only for a specific meteorological sensor, set the 2nd and 3rd degree polynomial calibration coefficients simply to zero. The calibrated earth tide observation will be stored as channel 1 and the calibrated meteorological observations will be stored as channels 2..NRAW in the formatted data output file of program DETIDE.

## Section 14.2: Computation of model tides and residual signal

The calibrated data are used for this computation step. DETIDE will compute model earth tides for the specified earth tide component at the specified sampling interbal, delayed for the instrumental time lag of the earth tide sensor (read from the calibration parameter file). These model earth tides are stored as channel NRAW+1 in the output output data file "pn".TID of computation step 3. The model earth tides are computed using one of seven available tidal potential catalogues, with observed amplitude factors and phase leads defined in the control parameter file "pn".INI. As tidal potential catalogue,

- the Doodson (1921) tidal potential catalogue with 379 waves,
- the Cartwright-Tayler-Edden-Doodson (1973) tidal potential catalogue with 505 waves,
- the Buellesfeld (1985) tidal potential catalogue with 656 waves
- the Tamura (1987) tidal potential catalogue with 1200 waves,
- the Xi (1989) tidal potential catalogue with 2934 waves,
- the Roosbeek (1996) tidal potential catalogue with 6499 waves,
- the Hartmann and Wenzel (1995) tidal potential catalogue with 12935 waves

may be selected. For the contribution of meteorological parameters, we use a linear regression model with regression parameters defined in the calibration data file. The residual signal is computed by ch(last) = ch(1) - sum over [chanel(i)*METCORFACT(i)], i=2,NRAW+1

and stored as last channel in the output data file of program DETIDE.

## Section 14.3: Description of the project file "project"

The ASCII project name file "project" for program DETIDE contains one single variable only, the project name which is abbreviated as "pn" in this manual. The project name is an alphanumerical string consisting of 8 characters at maximum. The project name is read from the first 8 characters of the first record of project name file "project". The project name is used to define the control parameter file name "pn".ini for program DETIDE.

## Section 14.4: Description of control parameter file "pn".ini

The control parameter file "pn".ini (where "pn" stands for the project name defined in file "project") defines several control parameters necessary for the operation of program DETIDE. The control parameter file has an identical structure to the control parameter files used by programs RECTIDE, PREDICT, DECIMATE, DESPIKE, PREGRED and ANALYZE. Some of the variables are identical to those used by programs RECTIDE, PREDICT, DECIMATE, DESPIKE, PREGRED and ANALYZE. Thus it is usually possible to use the same control parameter file for data recording, data preprocessing and data analysis.

All control parameter statements must begin with the control parameter name (column 1...10) which ends with an equal sign. The control parameter names must be spelled exactly with uppercase letters as defined below. Control parameters with unknown names will be ignored by program DETIDE. The control parameter variables must be input after the equal sign following the control parameter name, with appropriate format. The control parameter statements must not have a specific sequence. A record starting with # in column 1 will be ignored and may be used to comment the control parameters. All characters following # in a record will be ignored and may be used to comment the control parameters.

The following control parameters are valid for program DECIMATE:

```
SENSORNAME= name of the earth tide sensor (CHARACTER*10)
INPFILNAME= name of the raw data input file (CHARACTER*12)
CALFILNAME= name of the calibration data file (CHARACTER*12)
OUTFILNAME= name of the output data file (CHARACTER*12)
NUMRAWCHAN= number of raw data channels (INTEGER)
SAMPLERATE= Data sample interval in s (col. 12 ... 26, integer).
STATLATITU= ellipsoidal latitude of the station in degree referring to
            WGS84 reference system (col.12...26).
STATLONITU= ellipsoidal longitude of the station in  degree  referring
            to WGS84 reference system (col.12...26).
STATELEVAT= ellipsoidal height of the station in meter referring to
            WGS84 reference system (col.12...26).
STATGRAVIT= gravity of the station in m/s**2, necessary for tidal tilt
            only (col. 12...26,  real  with  decimal  point).  If  the
            gravity is unknown, use a value of less than 1.0  and  the
            program will  compute  and  subsequently  use  the  normal
            gravity value referring to GRS80 reference system.
STATAZIMUT= azimuth of the  instrument  in  degree  decimal,  reckoned
            clockwise from north (col. 12 ... 26,  real  with  decimal
            point). This parameter is used for tidal tilt,  horizontal
            displacement and horizontal strain only.
TIDALCOMPO= Earth tide component (col. 12 ... 26, integer).
            = -1 for tidal potential in m**2/s**2.
            =  0 for tidal gravity in nm/s**2.
            =  1 for tidal tilt in mas, at azimuth STATAZIMUT.
```

```
              =  2 for tidal vertical displacement in mm.
              =  3 for tidal horizontal displacement in mm at
                   azimuth STATAZIMUT.
              =  4 for tidal vertical   strain in 10**-9 = nstr.
              =  5 for tidal horizontal strain in 10**-9 = nstr,
                   at azimuth STATAZIMUT.
              =  6 for tidal areal  strain in 10**-9 = nstr.
              =  7 for tidal shear  strain in 10**-9 = nstr.
              =  8 for tidal volume strain in 10**-9 = nstr.
              =  9 for ocean tides in mm.
              The computed model  tides  will  be  given  in  the  units
              defined above.
TIDALPOTEN= parameter for the tidal potential catalog to be used.
              1 = Doodson (1921) tidal potential catalog,
              2 = Cartwright-Tayler-Edden (1973) tidal potential catalog
              3 = Buellesfeld (1985) tidal potential catalog,
              4 = Tamura (1987) tidal potential catalog,
              5 = Xi (1989) tidal potential catalog,
              6 = Roosbeek (1996) tidal potential catalog,
              7 = Hartmann and Wenzel (1995) tidal potential catalog.
              As default, TIDALPOTEN= 7 is used.
AMTRUNCATE= Amplitude threshold for the tidal potential  catalogue  in
              m**2/s**2. Only tidal waves with amplitudes exceeding  the
              amplitude threshold are used  for  the  computation.  This
              reduces the execution time, but also the accuracy  of  the
              computed tidal signales. For mean latitudes, the  relation
              between amplitude threshold and gravity tide accuracy   is
              for the Hartmann and Wenzel (1995) tidal potential catalog

                        threshold             rms error
                                             [nm/s**2]

                          1.D-01               88.40
                          1.D-02               14.40
                          1.D-03                2.25
                          1.D-04                0.44
                          1.D-05                0.068
                          1.D-06                0.011
                          1.D-07                0.002
                          1.D-08                0.001
                          1.D-09                0.001
                          1.D-10                0.001
RIGIDEARTH= Parameter for using a rigid earth model for  the  adjusted
              earth  tide  parameters (col. 12...26, integer,  1 = yes).
              For program DETIDE, parameter RIGIDEARTH should, always be
              1.0000 except for the processing of benchmark series.
TIDALPARAM= wave group selection for a priori model tide  computation.
              The number of wavegroups is restricted to  85.  The  tidal
              parameters may be taken from an  earth  tide  analysis  of
              another data set in the same station,  or  from  a  neigh-
              bouring station, or from synthetic gravity tide parameters
              (Timmen and Wenzel 1994, 1995), or from a guess only.
              Col.12..21: DFRA#=  start frequency of the wave  group  in
                                  cpd (real).
              Col.22..31: DFRE#=  end   frequency of the wave  group  in
                                  cpd (real).
              Col.32..41: DGAM0#= amplitude factor  of  the  wave  group
                                  (real).
              Col.42..51: DPHI0#= phase lead of the wave  group  in  deg
                                  (real).

The wave group selection for model tide  computation  should  be  made
according to the wave group selection for the analysis of  Earth  tide
data (see the program manual for ANALYZE); the list given below  is  a
proposal only). The frequencies are given in cycles per day (cpd).

group         > 1 month            > 6 months          > 1 year
              from      to         from      to        from      to
```

| | [cpd] | [cpd] | [cpd] | [cpd] | [cpd] | [cpd] |
|---|---|---|---|---|---|---|
| SA | - | - | - | - | 0.001379 | 0.004107 |
| SSA | - | - | 0.004108 | 0.020884 | 0.004108 | 0.020884 |
| MM | 0.020885 | 0.054747 | 0.020885 | 0.054747 | 0.020885 | 0.054747 |
| MF | 0.054748 | 0.091348 | 0.054748 | 0.091348 | 0.054748 | 0.091348 |
| MTM | 0.091349 | 0.501369 | 0.091349 | 0.501369 | 0.091349 | 0.501369 |
| Q1 | 0.501370 | 0.911390 | 0.501370 | 0.911390 | 0.501370 | 0.911390 |
| O1 | 0.911391 | 0.947991 | 0.911391 | 0.947991 | 0.911391 | 0.947991 |
| M1 | 0.947992 | 0.981854 | 0.947992 | 0.981854 | 0.947992 | 0.981854 |
| P1 | - | - | 0.981855 | 0.998631 | 0.981855 | 0.998631 |
| S1 | - | - | - | - | 0.998632 | 1.001369 |
| K1 | 0.981855 | 1.023622 | 0.998632 | 1.023622 | 1.001370 | 1.004107 |
| PSI1 | - | - | - | - | 1.004108 | 1.006845 |
| PHI1 | - | - | - | - | 1.006846 | 1.023622 |
| J1 | 1.023623 | 1.057485 | 1.023623 | 1.057485 | 1.023623 | 1.057485 |
| OO1 | 1.057486 | 1.470243 | 1.057486 | 1.470243 | 1.057486 | 1.470243 |
| 2N2 | 1.470244 | 1.880264 | 1.470244 | 1.880264 | 1.470244 | 1.880264 |
| N2 | 1.880265 | 1.914128 | 1.880265 | 1.914128 | 1.880265 | 1.914128 |
| M2 | 1.914129 | 1.950419 | 1.914129 | 1.950419 | 1.914129 | 1.950419 |
| L2 | 1.950420 | 1.984282 | 1.950420 | 1.984282 | 1.950420 | 1.984282 |
| S2 | 1.984283 | 2.451943 | 1.984283 | 2.002736 | 1.984283 | 2.002736 |
| K2 | - | - | 2.002737 | 2.451943 | 2.002737 | 2.451943 |
| M3M6 | 2.451944 | 7.000000 | 2.451944 | 7.000000 | 2.451944 | 7.000000 |

## Section 14.5: Description of the calibration parameter file

The calibration parameter file contains a file header and a file body. The file header contains alphanumeric information to describe the file contents, and ends with C********* in cols. 1...10.

```
The first record of the file body contains
in cols.  1..11:  RAWCHAUNIT=
in cols. 12..14:  blanks
in cols. 15..24:  unit of raw data in channel 1 (CHARACTER*10)
in cols. 25..34:  unit of raw data in channel 2 (CHARACTER*10)
in cols. 35..44:  unit of raw data in channel 3 (CHARACTER*10)
in cols. 45..54:  unit of raw data in channel 4 (CHARACTER*10) ...

The second record of the file body contains
in cols.  1..11:  CALCHAUNIT=
in cols. 12..14:  blanks
in cols. 15..24:  unit of calibrated data in channel 1 (CHARACTER*10)
in cols. 25..34:  unit of calibrated data in channel 2 (CHARACTER*10)
in cols. 35..44:  unit of calibrated data in channel 3 (CHARACTER*10)
in cols. 45..54:  unit of calibrated data in channel 4 (CHARACTER*10) ...

The third record of the file body contains
in cols. 1...11: METCORFACT=
in cols. 12..14: blanks
in cols. 15..24: correction factor for channel 1 (has to be 1.0)
in cols. 25..34: correction factor for channel 2
in cols. 35..44: correction factor for channel 3
in cols. 45..54: correction factor for channel 4 ....
```

Following the third record, there has to be given a table of time depnendent 3rd degree calibration coefficients for all raw data channels. For each calibration epoch, you have to enter four records.

```
First calibration table record:
in cols. 1... 8: date of the calibration in yyyymmdd (year,month,day).
in cols.10...15: time of the calibration in hhmmss (hour,min,sec).
in cols.16...25: 1st degree calibration coefficient for channel 1.
in cols.26...35: 1st degree calibration coefficient for channel 2.
in cols.36...45: 1st degree calibration coefficient for channel 3.
in cols.46...55: 1st degree calibration coefficient for channel 4.
Second calibration table record:
```

```
in cols. 1... 8: date of the calibration in yyyymmdd (year,month,day).
in cols.10...15: time of the calibration in hhmmss (hour,min,sec).
in cols.16...25: 2nd degree calibration coefficient for channel 1.
in cols.26...35: 2nd degree calibration coefficient for channel 2.
in cols.36...45: 2nd degree calibration coefficient for channel 3.
in cols.46...55: 2nd degree calibration coefficient for channel 4.
Third calibration table record:
in cols. 1... 8: date of the calibration in yyyymmdd (year,month,day).
in cols.10...15: time of the calibration in hhmmss (hour,min,sec).
in cols.16...25: 3rd degree calibration coefficient for channel 1.
in cols.26...35: 3rd degree calibration coefficient for channel 2.
in cols.36...45: 3rd degree calibration coefficient for channel 3.
in cols.46...55: 3rd degree calibration coefficient for channel 4.
Fourth calibration table record:
in cols. 1... 8: date of the calibration in yyyymmdd (year,month,day).
in cols.10...15: time of the calibration in hhmmss (hour,min,sec).
in cols.16...25: time lag in sec of earth tide sensor.
in cols.26...35: time lag in sec of meteorological sensor 1.
in cols.36...45: time lag in sec of meteorological sensor 2.
in cols.46...55: time lag in sec of meteorological sensor 3.
```

After the first calibration table epoch, there might follow up to 299 other calibration epochs.

Program DETIDE will linearily interpolate the calibration parameters and time lags from the table. If you dont know one of the calibration parameters, it might make sense to simply put the parameter to zero (e.g. if your sensor is perfectly linear, you can set the 2nd and 3rd degree coeffcients to zero). If the calibration parameters are stable with time, you can use one calibration epoch only. If an observation is taken before the date of the first calibration, DETIDE will use the calibration parameters of the first calibration epoch to calibrate this observation. If an observation is taken after the last calibration epoch, DETIDE will use the calibration parameters of the last epoch to calibrate this observation.

The calibration parameter file to be used with DETIDE is identical to the calibration parameter file for programs PREGRED and DESPIKE.

We give below a copy of file "sg102tes.cal" provided in directory "\eterna33\1mindat":

```
File             : sg02tes.cal
Status           : 1996.09.02
Contents         : calibration parameters for data file sg02tes.raw
                   cryogenic gravimeter SG102 and barometer BMG3
                   at BFO Schiltach.

Sequence is:
raw data:         unit       unit
detided data:     unit       unit       unit    unit
correction:       fact.1     fact.2    fact.3
calib.param:     linear     linear
                 quadratic  quadratic
                 cubic      cubic
                 time lag   time lag
C****************************************************************
RAWCHAUNIT=        Volt        Volt
CALCHAUNIT=        nm/s**2      hPa    nm/s**2   nm/s**2
METCORFACT=         1.0000   -3.2000    1.0000
19940602 120000 3439.7000  -23.0424
19940602            0.0000    0.0000
19940602            0.0000    0.0000
19940602           57.6000   21.0300
19940622 120000 3439.7000  -23.0424
19940622            0.0000    0.0000
19940622            0.0000    0.0000
19940622           57.6000   21.0300
```

99999999

Section 15: Description of program DESPIKE
------------------------------------------

The program DESPIKE is a Fortran 90 program for the preprocessing of high rate earth tide observations (1 s ... 30 min sampling interval). DESPIKE was a part of the larger program PRETERNA developed by H.-G. Wenzel in 1991, and is described in Wenzel (1994). Program DESPIKE uses the ETERNA standard format for the storage and exchange of high resolution and high rate earth tide data described in Wenzel (1995). The output file of program DESPIKE may directly be used to input into the graphical editor PREGRED or the plotting program PLOTDATA or the decimation program DECIMATE or the earth tide analysis program ANALYZE.

The earth tide preprocessing programs DETIDE, DESPIKE, DECIMATE and PREGRED allow the preprocessing of high rate earth tide data. The data preprocessing is carried out using a remove-restore technique (similar to the remove-restore technique known from gravity field transformation). We at first remove all known signals (i.e. computed model tides and influences of meteorological parameters (e.g. air pressure). The remaining residual signal (including the earth tide sensor's drift) is then cleaned (destepped, despiked and degapped), and the known signals are subsequently added back to the cleaned residual signal. Errors in the model earth tide signal and model meteorological parameter contribution will by this procedure be cancelled to a large extend (naturally except for the gaps, where we use the model earth tide and model meteorological parameter contribution to interpolate the data during the gap). The corrected samples at the original sampling interval may finally be numerically filtered and decimated to a lower sampling interval. The data preprocessing should be carried out in different steps, and one should check the result of the different steps by plotting the data using programm PLOTDATA or PREGRED.

The project name for program DESPIKE is read from the project file "project", which has to be stored in the directory from which DESPIKE is executed. The control parameters for DESPIKE are read from the control parameter file "pn".ini, which has to be stored in the directory from which DESPIKE is executed.

Section 15.1: Destepping, despiking and degapping
-------------------------------------------------

DESPIKE tries at first to destep the data (i.e. to find steps and to remove these steps). Half hourly averages of the residual signal are computed together with their standard deviations. With these half hourly averages, an iterative search for steps is carried out. We use a 1st degree least squares polynomial fitted to the half hourly mean values over 10 hours, with two different zero degree coefficients (one for the first half of the samples and one for the second half of the samples) being adjusted. The standard deviations of the half hourly averages estimated from the averaging are used to derive weights for the step adjustment. The difference between the two zero degree coefficients is the estimated step. A step is assumed to be found, if it exceeds three times its estimated standard deviation, and if it exceeds the threshold STEPDETLIM read from control parameter file "pn".INI (we don't want to correct very small steps in case of very small noise). Within one iteration loop for the step search, the data window for the fit is moved over the recorded time span with half an hour shift between successive adjustments. For the iteration loop, the step with the maximum signal to noise ratio is assumed to be found and subsequently corrected at the half hourly averages and the sample data. The iteration is continued until no more steps are found.

```
<-    half hourly averages          ->

x x x x x x x x x x o o o o o o o o o o        1st fit
```

```
x x x x x x x x x x x o o o o o o o o o o o     2nd fit
  x x x x x x x x x x x o o o o o o o o o o o   3rd fit
    x x x x x x x x x x x o o o o o o o o o o o 4th fit
```

It should be noted that the automatic destepping procedure described above can generally detect and correct single large steps only. For the correction of small steps or of several large steps, the use of the graphical editor PREGRED is recommended.

After destepping, program DESPIKE is starting the despiking loop. The despiking is carried out in an iterative search for and removal of spikes using the original samples of the residual signal from the last input data channel. A 2nd degree polynomial is fitted to the residual signal over 120 min time span, and the maximum residual inside a central window of +/- 30 min around the central time of the fit is tested against a threshold. This threshold is determined by the despiking limit SPIKDETLIM read from control parameter file "pn".INI, if it exceeds three times the rms of fit of the previous iteration. The maximum residual inside the central window exceeding the threshold is then corrected at the sample data, and the fit is repeated with the time span for the fit shifted by 15 min.

The threshold is initially set to 64 times the parameter SPIKDETLIM read from control parameter file "pn".INI, and then subsequently divided by two for each despiking loop. Within a despiking loop, this threshold remains constant. Within each despiking loop, the time span for the fit is shifted over the whole record of 1 min samples. If we for instance input as despiking threshold SPIKDETLIM= 2 nm/s**2 for a gravimeter record, the first despiking loop uses 128 nm/s**2 as threshold and removes spikes exceeding 128 nm/s**2 only. In the second despiking loop, we use 64 nm/s**2 as threshold and we remove spikes exceeding 64 nm/s**2 only. The threshold is divided by two for each despiking loop, until it is below the parameter SPIKDETLIM and below 3 times the rms of fit of the previous despiking loop. This procedure enables an automatic adaption of the despiking limit to the noise of the record for normal recording periods. But for periods containing large disturbances (e.g. earthquakes), these disturbances would not allow the despiking threshold to become normal. Therefore the input of a hard despiking limit enables the despiking of periods containing large disturbances. Another good procedure is to delete the gravity data during large disturbances, and to interpolate the artificial gap later on during the degapping.

Shifting of the despiking time span:

```
         central window
--------xxxxxxxxxxxxxxxx--------                        1st fit
    --------xxxxxxxxxxxxxxxx--------                    2nd fit
        --------xxxxxxxxxxxxxxxx--------                3rd fit
            --------xxxxxxxxxxxxxxxx--------            4th fit
                --------xxxxxxxxxxxxxxxx--------        5th fit
                    --------xxxxxxxxxxxxxxxx--------    6th fit
```

After despiking, DESPIKE looks for gaps in the data and tries to interpolate data in the gaps. For the degapping, DESPIKE looks at first for gaps in the meteorological channels record and subsequently interpolate the gaps in these channels by a 1st degree polynomial. For the gaps in the residual signal, we use a least squares 1st degree polynomial, where samples over 10 min are used on both sides of the gap. The number of gaps is restricted to 500, and the maximum length of a gap is restricted to 30 000 samples. Thus, the maximum gap length depneds on the sampling interval.

## Section 15.2: Description of the project file "project"

The ASCII project name file "project" for program DESPIKE contains one single variable only, the project name which is abbreviated as "pn" in this manual. The project name is an alphanumerical string consisting of 8 characters at maximum. The project name is read from the first 8 characters of the first record of project name file "project". The project name is used to define the control parameter file name "pn".ini for program DESPIKE.

## Section 15.3: Description of control parameter file "pn".ini

The control parameter file "pn".ini (where "pn" stands for the project name defined in file "project") defines several control parameters necessary for the operation of program DESPIKE. This control parameter file has an identical structure to the control parameter files used by programs RECTIDE, PREDICT, DECIMATE, DETIDE, PREGRED and ANALYZE. Some of the variables are identical to those used by programs RECTIDE, DETIDE, DESPIKE, DECIMATE, PREGRED and ANALYZE. Thus it is usually possible to use the same control parameter file for data recording, data preprocessing and data analysis.

All control parameter statements must begin with the control parameter name (column 1...10) which ends with an equal sign. The control parameter names must be spelled exactly with uppercase letters as defined below. Control parameters with unknown names will be ignored by program DESPIKE. The control parameter variables must be input after the equal sign following the control parameter name, with appropriate format. The control parameter statements must not have a specific sequence. A record starting with # in column 1 will be ignored and may be used to comment the control parameters. All characters following # in a record will be ignored and may be used to comment the control parameters.

The following are valid control parameters for program DESPIKE:

```
NUMBCHANEL= integer number of data channels, including the model
            tide channel and the residual signal channel (col. 12..
            21).
INPFILNAME= input  data file name (col.12..23, 12 characters).
OUTFILNAME= output data file name (col.12..23, 12 characters).
CALFILNAME= calibration data file name (col.12..23, 12 characters).
SENSORNAME= alphanumeric name of the earth tide sensor (col 12 ... 21,
            left bounded). SENSORNAME is restricted to 10  characters.
SAMPLERATE= input data sample interval in s (col. 12 ... 26, integer).
            The program DESPIKE is designed for 60 s sampling interval
            but may also be used for  other  sampling  intervals.  The
            sampling interval should however not exceed 30 min. Please
            note that  the  samples  have  to  be  given  e.g. at full
            minutes if the sample interval is 60 s.
STEPDETLIM= Step detection threshold in earth tide units (col. 22  ...
            26, real with decimal point). There will be removed  steps
            exceeding STEPDETLIM and three times their estimated stan-
            dard deviation.
SPKIDETLIM= Despiking threshold in earth tide  units  (col. 22 ... 26,
            real with decimal point).
```

## Section 15.4: Examples for data preprocessing

In directory "\eterna33\1mindat" we give several example files for data preprocessing for the three projects "kal299tt", "sg102tes" and "bfhw9502".

Project "kal299tt" contains gravity data recorded with gravimeter LCR-G299 at station Karlrsuhe using 5 s sampling interval with program RECTIDE and online decimation to 1 min data. The raw data are stored in file "kal299tt.raw". In the raw data file, several large spikes and one large step has been introduced in order to test data processing software. The detided data using program DETIDE (see encl. 025 and

026) are stored in file "kal299tt.tid". The despiked data using program DESPIKE (see encl. 027 and 028) are stored in file "kal299tt.cor". The data decimated to 5 min resampling interval using program DECIMATE are stored in file "kal299tt.fil" (see encl. 029 and 030). The data decimated to 1 h sampling interval using a second time program DECIMATE (but with a different filter, naturally) are stored in file "kal299tt.dec".

Project "sg102tes" contains gravity data recorded with gravimeter GWR-SG102 (courtesy of Institut fuer Angewandte Geodaesie, Frankfurt) at BFO Schiltach in 1994 using 5 s sampling interval. The data were numerically filtered and decimated to 1 min resampling interval after recording: these 1 min data are stored in file "sg102tes.raw". The detided data using program DETIDE are stored in file "sg102tes.tid" (see encl. 031, 32 amd 33). Please note a very small step of 1.4 nm/s**2 in encl. 033, which could not be detected with the automatic despiking program DESPIKE, but has been (together with other steps and spikes) edited with program PREGRED (encl. 034). The output data of the automatic despiking of the manually edited file "sg102tes.cor" using program DESPIKE is stored in file "sg102tes.des". The despiking of disturbances during a large earthquake (see encl. 035 and 036) shows good supression of short periodic noise, but reveals also a step and long periodic disturbances (perhaps due to clipping of large voltages in the data aquisition). These longperiodic disturbances have to be removed with program PREGRED (see encl. 037) before decima-tion ofthe data. The data decimated to 5 min resampling interval (see encl. 038 and 039) are stored
in file "sg102tes.fil", the data decimated to 1 h resampling interval are stored in file "sg102tes.dec".

Project "bfhw9502" contains sythetic gravity data computed with program PREDICT at 1 min sampling interval. The gravity signal includes gravity tides using the Hartmann and Wenzel (1995) tidal potential catalogue, pole tides, LOD tides, plus three additional channels (sine waves with periods 5.0 h, 5.5 h and 7.0 h). We have built into the data one step, several spikes and several gaps. The synthetic gravity signal (see encl. 042) is stored in file "bfhw9502.rrr" and the detided gravity signal using program DETIDE (see encl. 043) is stored in file "bfhw9502.tid". The despiked detided data after application of program DESPIKE (see encl. 044) is stored in file "bfhw9502.cor". The data decimated to 5 min resampling interval (encl. 046, please have in mind the quantization interval of 0.001 nm/s**2 = 0.1 ngal) using program DECIMATE are stored in file "bfhw9502.fil", and the data decimated to hourly sampling interval using a second time program DECIMATE are stored in file "bfhw9502.dec".

## Section 16: Description of program PREPLOT

The program PREPLOT has been written in Microsoft QuickBasic 4.0 and may be used to plot the data of individual channels of selected data files on the screen of the pc. There might be visualized raw, cali-brated, detided or preprocessed 1 min data. The executable file "preplot.exe" stored in directory "\eterna33\bin" may be executed by entering

<preplot>

from any directory. The program may be (modified and) interpreted by by calling the Microsoft QuickBasic interpreter available under MS-DOS 4.0 upwards by entering

<qbasic preplot>

from keyboard. The program asks for the input of some parameters to be entered into the program via keyboard. The data of one individual channel is displayed in white color, whereas the numerically differen-tiated data of the channel is displayed in red on the same screen. The initial time window is 1 day, but the screen may be zoomed in either horizontal or vertical direction. The screen may be dumped to a matrix printer (e.g. EPSON LQ850) by initializing the MS-DOS routine GRAPHICS in the start file AUTOEXEC.BAT and hitting keys

SHIFT and PRNT

from keyboard.

## Section 17: Description of program ANALYZE

The program ANALYZE is a Fortran 90 program for the analysis of earth tide observations. It follows a combination of the ideas of Chojnicki (1973), Schueller (1976) and Wenzel (1976, 1977, 1994). ANALYZE is the successor of the former program ETERNA.

There have been made significant improvements and changes compared to previous versions of ANALYZE. The program has been tested extensively using model data and observed data sets for tidal gravity, tilt, vertical strain, horizontal strain, volume strain, and ocean tides.

The program allows the adjustment of tidal parameters, meteorological regression parameters and pole tide regression parameters, and the computation of a Fourier amplitude spectrum of the residuals. To care for instrumental drifts, either drift elimination by highpass filtering or drift modelization by Tschebyscheff polynomials is possible. The stacking of instruments with different precision and instrumental characteristics at the same station is possible by applying individual instrumental time lag corrections, scale factors and weights for individual observation blocks. For the least squares adjustment of tidal parameters, the unity and Hann window may be applied as weighting function (e.g. Schueller 1976). For the tidal waves of different degree and order, a priori amplitude factors from an approximation to the Wahr-Dehant-Zschau model (Dehant, V. 1987) for an elliptical, uniformly rotating oceanless Earth with liquid outer core and viscous mantle may be used to represent the different response of the elastic Earth to tidal waves of different degree and order (but nearly the same frequency) within one wave group. For these a priori amplitude factors, the nearly diurnal free wobble resonance in the diurnal band is taken into account from Wahr's 1981 model. The printed adjusted tidal parameters are scaled by the a priori body tide amplitude factors of the main wave in the group, just as they would have been obtained referring to a rigid Earth model.

When using unfiltered observations, tidal parameters from long- to shortperiodic waves may be adjusted. Observations of meteorological parameters (e.g. air pressure) may be input, which will be used to fit a simple linear regression model to the earth tide observation. Additionally, Tschebyscheff polynomial bias parameters of varying degree for the individual data blocks may be adjusted in order to approximate the drift. The Tschebyscheff polynomials have been chosen, because they are orthogonal with respect to normalized time (range +/- 1) and have much better numerical properties than ordinary polynomials. The degree of bias polynomials is not restricted, except from the total number of unknowns. The number of polynomial bias parameters per individual block should not exceed the blocklength divided by the longest period of the tidal wave, for which parameters will be adjusted. For a block with N observations, numbered from J=1...N, the adjusted drift for observation no. J may be computed from the adjusted Tschebyscheff polynomial bias parameters DBIAS(1...NBIAS) (listed in the print file, containing the parameters for degree 0... NBIAS-1) by

```
DTN=(DBLE(J-1)-DBLE(N-1)*0.5D0)/(DBLE(N-1)*0.5D0)
DAK(1)=1.D0
DAK(2)=DTN
DRIFT=DBIAS(1)*DAK(1)+DBIAS(2)*DAK(2)
```

```
      DO 4560 I=3,NBIAS
      DAK(I)=2.D0*DTN*DAK(I-1)-DAK(I-2)
4560  DRIFT=DRIFT+DBIAS(I)*DAK(I)
```

Although the adjustment of Tschebyscheff polynomials has been tested with simulated data up to degree 100, it is recommended to use low degree polynomials only, especially when using the Hann window for the least squares adjustment. In any case, the drift approximation should be controlled by e.g. plotting the residuals after adjustment.

When using highpass filtered observations, the earth tide observations are splitted into a low frequency part (below about 0.8 cycles per day) and a high frequency part (above about 0.8 cycles per day) by numerical filtering. The least squares adjustment of tidal parameters for diurnal to sixthdiurnal wave groups is carried out by using the highpass filtered earth tide observations. Observations of meteorological parameters (e.g. air pressure) may be input as additional channels, which will (after highpass filtering equivalent to the earth tide observations) be used to fit a simple linear regression model to the earth tide observations. For the adjusted tidal parameters, the frequency transfer function of the used highpass filter is corrected.

The highpass filtering is in fact done in the program by application of a symmetrical numerical lowpass (or bandreject) filter, and subtracting the lowpass filtered observation from the original observation. This is equivalent to highpass (or bandpass) filtering. There are supplied different symmetrical numerical non-recursive FIR (finite impulse response) filters for different sampling intervals (see below), which - due to their exact symmetry - do not generate any phase shift. The quality of the filters may be estimated from the transfer function of the filters, which can be plotted using program PLOTFILT.

In contrast to all previous tidal analysis programs, which were restricted to hourly sampling interval, we allow for program ANALYZE for artificial smapling intervals, e.g. 1 min ... 1 hour. The recommended sampling intervals for ANALYZE simply depend on the numerical filters which are available in the current version, and are 1 min, 5 min, 10 min, 20 min, 30 min and 1 hour.

The following numerical filters are available for ANALYZE:

```
n1h1h001.nlf      lowpass for ANALYZE, 1 h sampl. (old filter no. 1)
n1h1h002.nlf      lowpass for ANALYZE, 1 h sampl. (old filter no. 2)
n1h1h003.nlf      lowpass for ANALYZE, 1 h sampl. (old filter no. 3)
n1h1h004.nlf      lowpass for ANALYZE, 1 h sampl. (old filter no. 4)
n1h1h005.nlf      lowpass for ANALYZE, 1 h sampl. (old filter no. 5)
n1h1h006.nlf      lowpass for ANALYZE, 1 h sampl. (old filter no. 6)
n1h1h007.nlf      lowpass for ANALYZE, 1 h sampl. (old filter no. 7)
n1h1h008.nlf      lowpass for ANALYZE, 1 h sampl. (old filter no. 8)
n05m05m2.nlf      lowpass for ANALYZE,  5 min sampling interval
n10m10m2.nlf      lowpass for ANALYZE, 10 min sampling interval
n20m20m2.nlf      lowpass for ANALYZE, 20 min sampling interval
n30m30m2.nlf      lowpass for ANALYZE, 30 min sampling interval
n60m60m2.nlf      lowpass for ANALYZE, 60 min sampling interval
```

In general, the tidal parameters adjusted from highpass filtered data do not change significantly when using different filters; but there exist small changes at the residuals and the estimated standard deviations of the tidal parameters.

The error estimation for the adjusted tidal parameters is done in two different ways with ANALYZE:

- by least squares adjustment procedure, which generally gives too optimistic estimates due to the neglection of error correlations,

- by Fourier amplitude spectrum of the residuals of the adjustment, using average spectral amplitudes over individual tidal bands (e.g. Wenzel 1976, 1977). Please have in mind, that the Fourier amplitude spectrum at frequencies below 0.8 cpd (the filter cut-off frequency) is of no meaning when using the highpass filter option!

The error estimation by Fourier amplitude spectrum of the residuals is known to give more realistic error estimations (Wenzel 1976, 1977), especially when adjusting simultaneously long- and shortperiodic tidal parameters. The error estimation procedure uses average noise amplitudes from the computed residual spectrum in 0.1 deg/h = 0.00666 cpd interval :

```
 0.1... 2.9 deg/h = 0.007...0.193 cpd for longperiodic waves,
12.0...17.9 deg/h = 0.800...1.193 cpd for diurnal tidal waves,
26.0...31.9 deg/h = 1.733...2.127 cpd for semidiurnal waves,
42.0...47.9 deg/h = 2.800...3.193 cpd for terdiurnal  waves,
57.0...62.9 deg/h = 3.800...4.193 cpd for quaterdiurnal waves.
```

For longperiodic waves, we use the frequency dependent noise model

$$\text{noise}(f) = \frac{\text{DMSE0}}{f}$$

with f = frequency in cycles per day. The constant DMSE0 is computed by taking the average of

noise(f)*f

between 0.1 ... 2.9 deg/h = 0.007 ... 0.193 cpd.

The standard deviations computed by the least squares adjustment are scaled (up or down) by the relation

$$\text{scale} = \frac{\text{noise}(f)}{\text{wn}} ,$$

where wn is the estimated Fourier amplitude of white noise in the frequency band 0.01...6.0 cpd.

There has been built in a quick-look option, which carries out the adjustment of parameters and error estimation by least squares method, but computes neither residuals nor the spectrum of residuals. In any case, this option should only be used for a quick-look of the data, and the final analysis should be made using the full computation option (QUICKLOOKA=0).

There may be used with ANALYZE

- up to 500 projects, whith the names of the projects to be defined in file "project".

- as observations:
  tidal potential, gravity tides, tilt tides, vertical displacements, horizontal displacements, vertical strain tides, horizontal strain tides, areal strain tides, shear strain tides, volume strain tides, and oceanic tides.

- unlimited number of hourly earth tide observations within one block (i.e. without gap),

- up to 300 blocks of data (i.e. data spans without interruption),
- up to 175 unkown parameters,
- up to 85 tidal wave groups (i.e. up to 170 tidal parameters),
- up to 6 additional meteorological parameters,
- either no highpass filtering or highpass filtering,
- different numerical filters of different length and quality, there can even be used numerical filters computed by the user,
- 7 different tidal potential catalogs (Doodson 1921, Cartwright-Tayler-Edden-Doodson 1973, Buellesfeld 1985, Tamura 1987, Xi 1989, Roosbeek 1996 and Hartmann and Wenzel 1995 tidal potential catalog).

## Section 17.1: Description of project name file "project"

The ASCII project name file "project" contains the project names for program ANALYZE. There might be defined one single project only, or up to 500 projects within one "project" file. In this case, ANALYZE performs subsequently the earth tide analyses for all the projects within one batch run. The project name is abbreviated as "pn" in this manual. The project name is an alphanumerical string consisting of 8 characters at maximum. The project names are read from the first 8 characters of the non-empty records of project name file "project". The project names are used in ANALYZE to define the control parameter file names and the names of data input and output files.

The program ANALYZE uses the following file name convention:

```
- control parameter file:          "project name".ini
- hourly data input file:          "project name".dat
- print file:                      "project name".prn
- hourly residuals of adjustemnt:  "project name".res
- spectrum of residuals:           "project name".far
- adjusted parameters:             "project name".par
- normal equation system file:     "project name".new
```

## Section 17.2: Description of the control parameter files "pn".INI

For program ANALYZE, there might be defined a group of common control parameters for all analyses in file "default.ini" containing the common default control parameters, and there might be defined individual control parameters for each project in the individual control parameter file "pn".ini. The control parameter files "pn".ini are used by programs RECTIDE, DECIMATE, DETIDE, DESPIKE, PREGRED, PREDICT and ANALYZE. Because these programs use partly the same control parameters but are written in different languages, we use a common simple structure to input the control parameters to the individual programs. A control parameter file may consist of control parameter records and and of comment records. A comment record starts with symbol # in column 1, and gives just an explanation. A control parameter record starts with the name of the control parameter in columm 1, which must be written in capital letters and must be followed by an equal sign. The length of the control parameter name is restricted to 10 characters excluding the equal sign. After the control parameter name, the value of the control parameter(s) have to be given. There is a format specified for the control parameters, and a real parameter has naturally to be input with a point (e.g. 3.1415962) and an integer parameter has to be input without a point. If there is given a control parameter which is not valid for the used program but valid for another program, the control parameter record is simply neglected by the used program. The sequence of the control parameter records is in general of no importance with the exception of the TEXTHEADER control parameters. The latter have to be input in their proper sequence.

The following control parameters are valid for program ANALYZE:

```
TEXTHEADER= Alphanumeric text, which will  be  printed  as  header  at
            the print file of ANALYZE. The number of header records is
            records is restricted to 10.
STATLATITU= Ellipsoidal latitude of the  station  in  degree  decimal,
            positive north of the equator, referring to World Geodetic
            System 1984 (col. 12...26, real with decimal point).
STATLONITU= Ellipsoidal longitude of the station  in  degree  decimal,
            positive east of Greenwhich, referring to  World  Geodetic
            System 1984 (col. 12...26, real with decimal point).
STATELEVAT= Ellipsoidal height of the station in  meter  referring  to
            World  Geodetic  System  1984  (col.  12...26,  real  with
            decimal point).
STATGRAVIT= Gravity of the station in m/s**2, necessary for tilt only.
            (col. 12...26, real with decimal point). If the gravity is
            unknown, use a value of less than 1. and the program  will
            compute and subsequently use the normal gravity value.
STATAZIMUT= Azimuth of the  instrument  in  degree  decimal,  reckoned
            clockwise from north (col. 12 ... 26,  real  with  decimal
            point). This parameter is used for tilt,  horizontal  dis-
            placement and horizontal strain only.
TIDALCOMPO= Earth tide component (col. 12 ... 26, integer).
            = -1 for tidal potential in m**2/s**2.
            =  0 for tidal gravity in nm/s**2.
            =  1 for tidal tilt in mas, at azimuth STATAZIMUT.
            =  2 for tidal vertical displacement in mm.
            =  3 for tidal horizontal displacement in mm at
                 azimuth STATAZIMUT.
            =  4 for tidal vertical   strain in 10**-9 = nstr.
            =  5 for tidal horizontal strain in 10**-9 = nstr,
                 at azimuth STATAZIMUT.
            =  6 for tidal areal  strain in 10**-9 = nstr.
            =  7 for tidal shear  strain in 10**-9 = nstr.
            =  8 for tidal volume strain in 10**-9 = nstr.
            =  9 for ocean tides in mm.
            The earth tide observations must be  input  in  the  units
            given above!!!
TIDALPOTEN= parameter for the tidal potential catalog to be used.
            1 = Doodson (1921) tidal potential catalog,
            2 = Cartwright-Tayler-Edden (1973) tidal potential catalog
            3 = Buellesfeld (1985) tidal potential catalog,
            4 = Tamura (1987) tidal potential catalog,
            5 = Xi (1989) tidal potential catalog,
            6 = Roosbeek (1996) tidal potential catalog,
            7 = Hartmann and Wenzel (1995) tidal potential catalog.
            As default, TIDALPOTEN= 7 is used.
PRINTDEVEL= Parameter for printout of the tidal waves for the specific
            component (col. 12...26, integer).
            = 1 : tidal waves will be printed.
SEARDATLIM= Parameter for testing the  observations  on  gross  errors
            (col. 12...26, real with decimal point).
            For positive SEARDATLIM, the observations will  be  tested
            on gross errors using a filter of 23 hours length  (Wenzel
            1976). SEARDATLIM is the threshold for testing the  obser-
            vations on gross errors in units of the  observations.  If
            any computed test value exceeds  SEARDATLIM,  the  program
            will list the first 20 test values  exceeding  SEARDATLIM.
            It is however not recommended to use this method of  gross
            error detection, because  in  the  case  of  multi-channel
            input, the influence of the  additional  channels  on  the
            earth tide signal is not  taken  into  account  with  this
            method of gross error detection.
```

```
NUMHIGPASS= Parameter deciding on numerical highpass filtering of  the
            data before analysis (col. 12 ... 26, integer, 1  =  yes).
            We do highpass filtering by subtracting the lowpass filte-
            red signal from the observation. This is because  we gene-
            rate less algebraic correlation than  by  direct  highpass
            filtering. We use  symmterical  filters  with  zero  phase
            shift only.

            = 0: no filtering will be applied. In this case, bias
                 parameters may be adjusted for each block of data.
            = 1: highpass filtering will be applied. In this case,
                 the input of a valid name for the high pass filter
                 file (see below) is necessary.


NUMFILNAME= alphanumeric name of the highpass filter file, CHARACTER*12.
            The following numerical filters are available for ANALYZE
            (in directory \eterna33\commdat):

            file name     coeff. lenght   sampling     gain
                                          intvl.
            n1h1h001.nlf    37    37 h    1 h          encl. 046
            n1h1h002.nlf    51    51 h    1 h          encl. 047
            n1h1h003.nlf   143   143 h    1 h          encl. 048
            n1h1h004.nlf   239   239 h    1 h          encl. 049
            n1h1h005.nlf    49    49 h    1 h          encl. 050
            n1h1h006.nlf    49    49 h    1 h          encl. 051
            n1h1h007.nlf   145   145 h    1 h          encl. 052
            n1h1h008.nlf   241   241 h    1 h          encl. 053
            n05m05m2.nlf  2001   167 h     5 min       encl. 054
            n10m10m2.nlf  1001   167 h    10 min       encl. 055
            n20m20m2.nlf   501   167 h    20 min       encl. 056
            n30m30m2.nlf   335   167 h    30 min       encl. 057
            n60m60m2.nlf   167   167 h    60 min       encl. 058

            The first eight filters are the "old" filters already
            used in previous versions of the program. The mnemotic
            of the filter names is "n1h1h00x" is old filter no. x.
            We recommend to use one of the last 5 filters, because
            they all have approximately the same filter gain (which
            is partly much better than the gain of the first eight
            filters).

PRINTOBSER= Parameter for writing the original observations  to  print
            file "pn".PRN (col. 12...26, integer, 1 = yes).
PRINTLFOBS= Parameter for writing the lowpass filtered observations to
            print file "pn".PRN (col. 12...26, integer, 1 = yes).
RIGIDEARTH= Parameter for using a rigid earth model for the adjustment
            of earth tide parameters (col. 12...26, integer, 1 = yes).
            A priori amplitude factors 1.0000 are used for  all  tidal
            waves, independent of their degree and order. RIGIDEARTH =
            1 should  be  used  for  analyzing  computed  model  tides
            referring to a rigid Earth model (e.g.  benchmark  series)
            only. For analyzing observed tides, RIGIDEARTH=0 should be
            used. In the latter case, a  priori  body  tide  amplitude
            factors for the tidal waves of different degree and  order
            from an approximation to the Wahr-Dehant earth model  will
            be used, including Wahr's model of the nearly diurnal free
            wobble resonance.
HANNWINDOW= Parameter for applying a Hann-window  (see Schueller 1976)
            to the weights of the observations  before  least  squares
            adjustment (col. 12...26, integer, 1 = yes).  This  option
            may be  used  to  reduce  leakage  effects.  However,  the
            application of the Hann-window has been found to be dange-
            rous if bias parameters are adjusted together  with  tidal
            parameters in case of NUMHIGPASS = 0 (no highpass  filter-
            ing).
QUICKLOOKA= Parameter for carrying out a quick look  adjustment  (col.
```

12...26, integer, 1 = yes). For QUICKLOOKA = 1, the parameters will be adjusted, but neither residuals nor the Fourier spectrum of residuals will be computed. Please have in mind that the error estimation is in this case purely from least squares adjustment techniques neglecting correlations and thus generally being too optimistic. The quick-look mode needs about 30% of the execution time for a complete analysis only.

POLETIDCOR= Correction for pole tide (gravity only) with amplitude factor 1.164 and no phase lead (col. 12 ... 26, integer, 1 = yes). This option is useful only if the NUMHIGPASS parameter is set to zero (no highpass filtering). To compute the pole tide, we use pole coordinates given in file PUTC7294.DAT for each day at 0 UTC between January 1st 1972 and October 30th 1994. The pole coordinates are named EOPC04 and taken from the International Earth Rotation Service IERS. We quadratically interpolate the daily pole coordinates to derive the pole tide at each sample.

POLETIDREG= Adjustment of a linear regression model between gravity observations and gravity pole tides computed for a rigid Earth model (col. 12 ... 26, integer, 1 = yes). This option is useful only if the NUMHIGPASS parameter is set to zero (no highpass filtering). To compute the gravity pole tide, we use pole coordinates given in file PUTC7294.DAT for each day at 0 UTC between January 1st 1972 and October 30th 1994. The pole coordinates are named EOPC04 and taken from the International Earth Rotation Service IERS. We quadratically interpolate the daily pole coordinates to derive the pole tide and its time derivative at each sample. A regression parameter in amplitude and time lag is adjusted. For the error estimation of these pole tide regression parameters, we use the same frequency dependent noise model as is used for the error estimation of long periodic tidal parameters.

LODTIDECOR= LOD correction of gravity (gravity variations due to variation in length of day = LOD) will be applied (col. 12 ... 26, integer, 1 = yes). This option is useful only if the NUMHIGPASS parameter is set to zero (no highpass filtering). To compute the LOD-tide, we use the differences DTAI = TAI minus UT1 (International Atomic Time minus Universal Time 1) given in file PUTC7294.DAT for each day at 0 UTC between January 1st 1972 and October 30th 1994. The DTAI's are taken from the International Earth Rotation Service IERS. We quadratically interpolate the daily DTAI to compute the length of day at each sample. The LOD correction of gravity is computed in routine ETPOLC by

$$dg = 1.164 * \frac{2 * omega^2 * dLOD * a * \cos^2(psi)}{86400} * 1.D9$$

with dg = LOD correction of gravity in nm/s**2, to be subtracted from observed gravity,
omega= 7.292115D-5 = rotation speed of the Earth,
dLOD = d(DTAI)/dt = time derivative of the length of day,
a = 6378137 m = major semi axis of the Earth,
psi = geocentric latitude.

The LOD correction of gravity is however relatively small and may be significant for very precise observations only.

STORENEQSY= parameter for storage of the normal equation system.
= 1: normal equation system will be stored on file "pn".NEQ. The normal equations may be used to stack data sets of different instruments at different stations.

WAVEGROUPI= wave group definition for the adjustment of tidal parameters. The number of wavegroups is restricted to 85. There have to be input the five parameters DFRA, DFRE, DFTFD, DFTFP and CNSY for each wave group in the same record.

col. 12...21: DFRA = frequency of first tidal wave in the wave group, in cpd (real).

col. 22...31: DFRE = frequency of last tidal wave in the wave group, in cpd (real).

col. 32...41: DFTFD= instrumental gain for the wave group, (real), should be approx. 1.

col. 42...51: DFTFP= instrumental phase lag for the wave group in degree decimal (real). For instruments with linear phase lag with respect to frequency, it is recommended to input the instrumental time lag in secs in the block header record in file "pn".DAT. In this case, DFTFD should be set to 1.000 and DFTFP should be set to 0.000.

col. 52...60: CNSY = alphanumeric name of the wave group (8 characters max.).

Standard wave groups for analysis of earth tide data (the list given below is a proposal only). The frequencies are given in cycles per day (cpd).

| group | > 1 month | | > 6 months | | > 1 year | |
|---|---|---|---|---|---|---|
| | from [cpd] | to [cpd] | from [cpd] | to [cpd] | from [cpd] | to [cpd] |
| SA | - | - | - | - | 0.001379 | 0.004107 |
| SSA | - | - | 0.004108 | 0.020884 | 0.004108 | 0.020884 |
| MM | 0.020885 | 0.054747 | 0.020885 | 0.054747 | 0.020885 | 0.054747 |
| MF | 0.054748 | 0.091348 | 0.054748 | 0.091348 | 0.054748 | 0.091348 |
| MTM | 0.091349 | 0.501369 | 0.091349 | 0.501369 | 0.091349 | 0.501369 |
| Q1 | 0.501370 | 0.911390 | 0.501370 | 0.911390 | 0.501370 | 0.911390 |
| O1 | 0.911391 | 0.947991 | 0.911391 | 0.947991 | 0.911391 | 0.947991 |
| M1 | 0.947992 | 0.981854 | 0.947992 | 0.981854 | 0.947992 | 0.981854 |
| P1 | - | - | 0.981855 | 0.998631 | 0.981855 | 0.998631 |
| S1 | - | - | - | - | 0.998632 | 1.001369 |
| K1 | 0.981855 | 1.023622 | 0.998632 | 1.023622 | 1.001370 | 1.004107 |
| PSI1 | - | - | - | - | 1.004108 | 1.006845 |
| PHI1 | - | - | - | - | 1.006846 | 1.023622 |
| J1 | 1.023623 | 1.057485 | 1.023623 | 1.057485 | 1.023623 | 1.057485 |
| OO1 | 1.057486 | 1.470243 | 1.057486 | 1.470243 | 1.057486 | 1.470243 |
| 2N2 | 1.470244 | 1.880264 | 1.470244 | 1.880264 | 1.470244 | 1.880264 |
| N2 | 1.880265 | 1.914128 | 1.880265 | 1.914128 | 1.880265 | 1.914128 |
| M2 | 1.914129 | 1.950419 | 1.914129 | 1.950419 | 1.914129 | 1.950419 |
| L2 | 1.950420 | 1.984282 | 1.950420 | 1.984282 | 1.950420 | 1.984282 |
| S2 | 1.984283 | 2.451943 | 1.984283 | 2.002736 | 1.984283 | 2.002736 |
| K2 | - | - | 2.002737 | 2.451943 | 2.002737 | 2.451943 |
| M3M6 | 2.451944 | 7.000000 | 2.451944 | 7.000000 | 2.451944 | 7.000000 |

METEOPARAM= regression to meteorological parameter will be adjusted. The number of meteorological parameters is restricted to 8. There have to be input the four parameters IREG, DMECOR, CFY1 and CFY2 for each meteorological channel in the same record.

col. 12...21: IREG = number of meteorological channel (integer).

col. 22...31: DMECOR = a priori regression parameter (real). DMECOR is currently unused.

col. 32...41: CFY1 = alphanumerical description of the meteorological parameter.

col. 42...51: CFY2 = alphanumerical description of the unit in which the meteorological parameter is given.

We give in the following a listing of the file HAL29901.INI, which is provided in directory "\eterna33\hourdat":

```
# This file HAL29901.INI status 1996.09.05 containing control parameters
# for program package ETERNA 3.40

# !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
# ! NOTE: The datalines have to start with their names.        !
# !       An additional comment may follow after the values,   !
# !       delimited by a whitespace                            !
# ! Values of 0 or less causes PREGRED to calculate the        !
# ! range(s) automatically resp. to use default values         !
# !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

# a commentline starts with an '#', it may appear at any position
# in this file. Empty lines may appear too

TEXTHEADER=Gravimetric Earth tide station Hannover no.709 Germany
TEXTHEADER=Institut fuer Erdmessung, Universitaet Hannover
TEXTHEADER=52.387N   9.712E  H50M  P2M  D180KM    VERTICALCOMPONENT
TEXTHEADER=GRAVIMETER LACOSTE-ROMBERG NR.G299     DR.BREIN IFAG FRANKFURT
TEXTHEADER=ZERO METHOD INSTRUMENT WITH ELECTROMAGNETIC FEEDBACK
TEXTHEADER=1973.05.29 - 1973.07.31      63.5 DAYS
TEXTHEADER=INSTALLATION       DR.BREIN,SCHREINER FRANKFURT
TEXTHEADER=MAINTENANCE        H.G.WENZEL HANNOVER
TEXTHEADER=CALIBRATED TO IGSN71
TEXTHEADER=INSTRUMENTAL LAG CORRECTED FOR 0.59 DEG O1 AND 1.23 DEG M2

SENSORNAME=LCR-G299-BR     #earth tide sensor name
SAMPLERATE=   3600         #sampling interval in seconds
STATLATITU=     52.387     #stations latitude  in degree
STATLONITU=      9.712     #stations longitude in degree
STATELEVAT=     50.000     #stations elevation in meter
STATGRAVIT=      0.        #stations gravity in m/s**2
STATAZIMUT=      0.        #stations azimuth in degree from north
TIDALCOMPO=      0         #tidal component, see manual
AMTRUNCATE=     5.D-5      #truncation threshold for tidal waves
STEPDETLIM=      5.        #DESPIKE limit for step detection  (nm/s**2)
SPIKDETLIM=      2.        #DESPIKE limit for spike detection (nm/s**2)

TIDALPARAM=  0.000000  0.600000   1.15000    0.0000 long #tidal param.
TIDALPARAM=  0.600001  0.910000   1.14972   -0.7206 Q1   #tidal param.
TIDALPARAM=  0.910001  0.949000   1.15182    0.1099 O1   #tidal param.
TIDALPARAM=  0.949001  0.980000   1.11863    1.0176 M1   #tidal param.
TIDALPARAM=  0.980001  1.012000   1.13894    0.1373 K1   #tidal param.
TIDALPARAM=  1.012001  1.050000   1.14967   -0.3844 J1   #tidal param.
TIDALPARAM=  1.050001  1.500000   1.13796    2.1804 OO1  #tidal param.
TIDALPARAM=  1.500001  1.875000   1.15147    1.8050 2N2  #tidal param.
TIDALPARAM=  1.875001  1.910000   1.16998    2.0400 N2   #tidal param.
TIDALPARAM=  1.910001  1.950000   1.18803    1.6049 M2   #tidal param.
TIDALPARAM=  1.950001  1.985000   1.21930    1.7852 L2   #tidal param.
TIDALPARAM=  1.985001  2.500000   1.19502    0.1603 S2   #tidal param.
TIDALPARAM=  2.500001  7.000000   1.25291   -5.7544 M3M6 #tidal param.

PRINTDEVEL=      0      #ANALYZE print param. for tidal development
(1=yes)
SEARDATLIM=     -1.     #ANALYZE search for data error threshold
NUMHIGPASS=      1      #ANALYZE highpass filtering = 1
NUMFILNAME=n1h1h002.nlf #ANALYZE Pertzev (1959) highpass filter
PRINTOBSER=      0      #ANALYZE print parameter for observations (1=yes)
PRINTLFOBS=      0      #ANALYZE print parameter fo lowpass filtered obs.
RIGIDEARTH=      0      #ANALYZE parameter for rigid earth model (1=yes)
HANNWINDOW=      0      #ANALYZE parameter for Hann-window (1=yes)
QUICKLOOKA=      0      #ANALYZE parameter for quick look analysis (1=yes)

WAVEGROUPI=  0.501370  0.911390   1.00000     0.000 Q1
WAVEGROUPI=  0.911391  0.947991   1.00000     0.000 O1
WAVEGROUPI=  0.947992  0.981854   1.00000     0.000 M1
WAVEGROUPI=  0.981855  1.023622   1.00000     0.000 K1
```

```
WAVEGROUPI=  1.023623  1.057485   1.00000     0.000 J1
WAVEGROUPI=  1.057486  1.470243   1.00000     0.000 OO1
WAVEGROUPI=  1.470244  1.880264   1.00000     0.000 2N2
WAVEGROUPI=  1.880265  1.914128   1.00000     0.000 N2
WAVEGROUPI=  1.914129  1.950419   1.00000     0.000 M2
WAVEGROUPI=  1.950420  1.984282   1.00000     0.000 L2
WAVEGROUPI=  1.984283  2.451943   1.00000     0.000 S2
WAVEGROUPI=  2.451944  7.000000   1.00000     0.000 M3M6

METEOPARAM=         1      3.20airpress. hPa        #ANALYZE meteorol.

HPERPAGE=24         #PREGRED displayed hours per page

PGUPPGDN=12         #New hours per Pageup / Pagedown

RANGETC1=8000       #PREGRED range for Channel 1 in nm/s^2
RANGETC2=30         #PREGRED range for Channel 2 in hPascal
RANGETC3=2500       #PREGRED range for Channel 3 in nm/s^2
RANGETC4=250        #PREGRED range for Channel 4 in nm/s^2

# ranges for RAW-Files

RANGRAW1=2          #PREGRED range for Channel 1 in Volts
RANGRAW2=2          #PREGRED range for Channel 2 in Volts

# End of file HAL29901.INI
```

Section 17.3: Description of the data input files "pn".dat
----------------------------------------------------------

The first part of the data file may contain a general alphanumeric file header of 80 columns per record, which is used as a description of the data given in the file only. The header is not used by any program but simply read and eventually written to the print file. In any case, the file header must finish with

C********* starting at the first column.

Now the first data block of earth tide observations follows, starting with a header record and an offset record.

Header record FORMAT (A10,5X,2F10.4,F10.3,I10):
-----------------------------------------------

CINSTR = Alphanumeric name of the instrument (cols.1..10).
DCAL = Calibration factor for the earth tide observations of this data block, which will be multiplied to the hourly samples in order to get proper calibration. (cols. 16...25).
DSAPR = A priori standard deviation of the earth tide observations of this data block in proper unit. The parameter DSAPR will be used to give the observations of the current data block a proper statistical weight for the least squares adjustment. If DSAPR is unknown, use 1.0 as standard deviation. (cols. 26...35).
DTLAG = Instrumental time lag of the instrument in sec (including filter, recording system). The input of a time lag per block makes sense only for instruments with linear phase lag versus frequency and should be preferred in those cases. (cols. 36...45).
NBIAS = Number of Tschebyscheff polynomial bias parameters to be adjusted for the current data block. This information is required for parameter NUMHIGPASS = 0 only. The number of bias parameters should not exceed the length of the data block divided by the longest period of the tidal waves to be adjusted. Otherwise, ETERNA will print a warning. If NBIAS is set to a negative value, this block will not be used for the analysis, independent of the parameter NUMHIGHPASS.

```
         (cols.46..55).

Offset record FORMAT I8,7X,6F10.3):
-----------------------------------

IDUMMY       = 77777777 dummy parameter (cols. 1...7).
DOFFS(1...9) = Offset values (cols.  16...25,  26...35,...).  DOFFS(1)
               will be added to all following earth tide  observations
               (after having calibrated the earth  tide observations).
               DOFFS(2) will be added to  all  following  observations
               of the first meteorological parameter, and so on.

Data records FORMAT = I8,1X,I6,8F10.3:
-------------------------------------

IDAT    =    Date of the observations of  the  record (cols. 1 ... 8).
             IDAT = 19891214 means year = 1989, month = 12, day = 14.
ITIM    =    Time of the observations of the record in  UTC  (cols. 10
             ...15). ITIM = 130000 means  13  hours,  00  minutes,  00
             seconds.
DCIN(1) =    Earth tide sample (cols. 16...25). The earth tide  sample
             DCIN(1) will be scaled with DCAL  before  being  used  in
             program ANALYZE.
DCIN(2..8) = meteorological samples (cols. 26...35, 36...45, 46...55,
             ....).

The end of a data block is defined by 999999999 as  date  IDAT.  After
the end of a data block, a new data block may follow  starting with  a
block header record and an offset record, or the  end  of  earth  tide
data flagged by 888888888 as date IDAT. We list in  the  folllowing as
example for input data a part of file BFL24903.DAT  (1  meteorological
parameter):

L249              1.0000     0.977   139.400         0   BLOCK 1
77777777           0.000     0.000
19881208      0 -672.700    16.130
19881208  10000 -342.500    16.210
19881208  20000   79.600    16.610
19881208  30000  523.100    16.440
19881208  40000  912.100    16.970
19881208  50000 1198.800    17.150
19881208  60000 1355.300    17.450
19881208  70000 1391.400    17.720
19881208  80000 1343.700    17.770
19881208  90000 1258.700    18.490
19881208 100000 1191.300    18.930
19881208 110000 1179.700    18.210
....
99999999
88888888


Section 17.4: Description of the residual output files "pn".res
---------------------------------------------------------------

The ASCII output data files with suffix "res" have the same  structure
and use the same standard format as the data input files  with  suffix
"dat". If the data input file has NC channels, the corresponding resi-
dual output file has NC + n channels, where n = 1 in case of POLTIDREG
= 0 and n  =  3 in case of POLTIDREG = 1. The first NC channels of the
residual output file contain highpass filtered observations in case of
NUMHIGPASS greater zero. In case of POLTIDREG = 1, the channel  NC + 1
contains the computed gravity pole tide referring  to  a  rigid  earth
model and channel NC + 2 contains the time derivative of  the  gravity
pole tide in nm/s**2 per day. The  residuals  of  the  adjustment  are
always stored in the last channel. We list in the folllowing  a  short
example for a residual file, taken from file BFL24903.RES (1  meteoro-
logical parameter):
```

```
L249              1.0000    0.8500   139.400         0RESIDUALS
77777777           0.000     0.000     0.000
19881211      0 -1647.100    0.427    -0.519
19881211  10000 -1635.102    0.177    -0.367  <----- residual
19881211  20000 -1432.571   -0.124    -0.172
19881211  30000 -1077.091   -0.432    -0.111
19881211  40000  -631.130   -0.690    -0.207
19881211  50000  -168.266   -0.835    -0.345
19881211  60000   242.645   -0.833    -0.431
19881211  70000   551.564   -0.687    -0.476
19881211  80000   736.371   -0.453    -0.516
19881211  90000   804.971   -0.239    -0.489
19881211 100000   790.014   -0.165    -0.270
19881211 110000   737.602   -0.283     0.130
19881211 120000   692.827   -0.526     0.500
19881211 130000   685.977   -0.738     0.652
19881211 140000   723.432   -0.778     0.691
.......
```

Section 17.5: Description of the residual amplitude spectrum file "pn".far
------------------------------------------------------------------

The ASCII output data files with suffix "far" contain the Fourier amplitude spectrum of residuals to be plotted with program PLOTSPEC. It starts with the file header of the corresponding data input file with suffix DAT. The file header is finished with

C********* starting at the first column.

The following records contain in each record the frequency in cpd and the Fourier amplitude in the unit of the tidal component.

Section 17.6: Description of examples
-------------------------------------

In directory "\eterna33\hourdat" we have given files for seven different examples (see also encl 059... 093). The individual examples are also described in the header of their data file (with suffix dat).

| example | station | data type | length | epoch |
|---|---|---|---|---|
| hal29901 | Hannover | observed gravity | 63.5 d | 1973 |
| bfl24903 | BFO Schiltach | observed gravity | 121.0 d | 1991 |
| bfd00801 | BFO Schiltach | observed strain | 110.0 d | 1974 |
| bfet1907 | BFO Schiltach | observed gravity | 286.0 d | 1991 |
| bhtt4003 | Bad Homburg | observed gravity | 1004.5 d | 1982 |
| bfhw9501 | BFO Schiltach | synthetic gravity | 2731.0 d | 1990 |
| bfde403f | BFO Schiltach | benchmark gravity | 2922.0 d | 1990 |

Example hal29901 contains gravity tide observations with electromagnetic feedback gravimeter CLR-G299 (transformed by Dr. R. Brein, IfAG) at station Hannover in 1973, 63.5 days, analog recording, together with air pressure observations. Plots to example hal29901 are given in encl. 059...063.

Example bfl24903 contains gravity tide observations with SWR electrostatic feedback gravimeter LCR-G249F at station BFO Schiltach in 1988-1989, 121 days, digitally recorded, together with air pressure observations. Plots for this example are given in encl. 064...068.

Example bfd00801 contains horizontal strain tides from 10 m invar wire strainmeter D008 at station BFO Schiltach azimuth 2 deg from north to east, at position 190, analog recording.
Reference: Beavan, J., R. Bilham, D. Emter and G. King (1979): Observations of strain enhancement across a fissure. In: Bonatz, M. (editor): Beitraege zur Erdgezeitenforschung des Arbeitskreises

Geodaesie/Geophysik der Bundesrepublik Deutschland, Deutsche Geodaetische Kommission, Reihe B, Heft Nr. 231, 47 - 58, Muenchen 1979. Plots for this example are given in encl. 069...073.

Example bfet1907 contains gravity tide observations with LaCoste-Romberg earth tide gravimeter ET19 with Larson electrostatic feedback at station BFO Schiltach in 1991, 286 days, together with air pressure observations. The data have been digitally recorded with 5 s sampling interval and 21 bit resolution, and decimated to hourly samples after preprocessing with program PRETERNA. Plots for this example are given in encl. 074...078.

Example bhtt4003 contains gravity tide observations with superconducting gravimeter GWR-TT40 at station Bad Homburg 1981-1984, 1004.5 days, together with air pressure observations (Richter 1987). This data set is included in the ETERNA package with kind permission of Dr. B. Richter, IfAG Frankfurt. The analysis of this data set has been carried out without highpass filtering by adjusting longperiodic and and shortperiodic tidal parameters, pole tide parameters and drift parameters. Please have in mind that the noise level is generally much lower when applying highpass filtering. Plots to this example are given in encl. 079...083.

Examnple bfhw9501 contains synthetic (i.e. computed) gravity tides from Hartmann and Wenzel (1995) tidal potential catalogue using program PREDICT for station BFO Schiltach, 1987...1994, 2731 days. The analysis of this data set with program ANALYZE demonstrates the consistency between programs PREDICT and ANALYZE (standard deviation of residuals 0.000 nm/s**2), even when solving for longperiodic tidal parameters. Plots to this examples are given in encl. 084...088.

Example bfde403f contains a gravity tide benchmark series computed from DE403 ephemerides (Wenzel 1996) for station BFO Schiltach, 1987 - 1994, 2922 days. The analysis of this benchmark series with program ANALYZE when using the Hartmann and Wenzel (1995) tidal potential catalogue shows the very small errors of the Hartmann and Wenzel (1995) tidal potential catalogue of 0.001 nm/s**2 rms. You can verify yourself that the other tidal potential catalogues have much larger errors. Plots to this example are given in encl. 089...093.

## Section 17.7: Execution time for the example files

The cpu execution time of ANALYZE mainly depends on the number of data to be processed, the tidal potential to be used and the number of parameters to be adjusted. The execution time has been measured for different data sets provided on the CD-rom using different cpu's.

| operating system: | | MS-DOS | MS-DOS | MS-DOS |
|---|---|---|---|---|
| processor: | | 486DX2 | PENTIUM | PENTIUM |
| speed: | | 66 MHz | 90 MHz | 100 MHz |
| sample file | days | | | |
| hal29901 | 63.5 | 23.29 s | s | 4.84 s |
| bfl24903 | 121.0 | 78.59 s | s | 15.49 s |
| bfd00801 | 110.0 | 54.05 s | s | 11.20 s |
| bfet1907 | 286.0 | 261.61 s | s | 47.07 s |
| bhtt4003 | 1004.5 | 479.45 s | s | 83.00 s |
| bfhw9501 | 2731.0 | 13915.54 s | s | 2384.81 s |
| bfde403f | 2922.0 | 14850.26 s | s | 2531.41 s |

## Section 18: Description of program TRANS

The program TRANS transforms old ETERNA version 2.3 data input files (international format and 6 sample per record format) into the ETERNA standard format (Wenzel 1995). The program TRANS has been written in

Fortran 90 and has been compiled using the Lahey Fortran 90 compiler. After entering

    <trans>

the program asks for the data file to be transformed. The data file must be an ETERNA 2.3 data input file, as given e.g. in file "trans.dat". The program generates the control parameter file under filename "trans.ini" and the ETERNA 3.40 data input file under name "trans.out". A protocol file is available under name "trans.prn".

There is no transformation program for ETERNA 3.0 data input files to ETERNA 3.21 data input files, because we believe that this transformation can easily be done using a standard alphanumeric editor.

## Section 19: Description of program PLOTDATA

The program PLOTDATA performs a plot of data files containing time dependent equally spaced data in standard ETERNA format (e.g. Wenzel 1995). The plot can either be visualized on the screen of the pc or printed on paper (after establishing file "plotdata.hpg" containing plot commands in HPGL-plotter language or file "plotdata.lsr" containing plotcommands for HP-Laser printer). The program is written in Fortran 90 but contains calls to non-standard Fortran 90 Calcomp plot routines, which have been compiled using the Lahey Graphoria package. Program PLOTDATA reads the necessary control parameters from file "plotdata.ini". PLOTDATA can be called from any directory, but expects the driver files in directory \eterna33\bin.

The following control parameters are valid for program PLOTDATA:

```
DATFILNAME= name of file containing the data to be plotted
            (CHARACTER*12).
PLOT-TITEL= titel of the plot (CHARACTER*64).
X-PLOTSIZE= size of inner frame in x-direction in inch (2.52 cm).
Y-PLOTSIZE= size of inner frame in y-direction in inch (2.52 cm).
Y-AXISUNIT= y-axis unit (CHARACTER*15).
Y-PMINIMUM= y-minimum of the plot, in world y-coordinates.
Y-PMAXIMUM= y-maximum of the plot, in world y-coordinates.
Y-TICKDIST= y-tick difference, in world y-coordinates.
X-GRIDLINE= plots grid lines in x-direction at y-axis ticks.
Y-GRIDLINE= plots grid lines in y-direction at date/time ticks.
PLOTCHANEL= plot channel number (INTEGER).
PLOTCOLOUR= plot colour number (INTEGER, 0...15).
             0 = black.             1 = dark blue.
             2 = green.             3 = light blue.
             4 = red.               5 = dark magenta.
             6 = brown.             7 = light grey.
             8 = dark grey.         9 = bright dark blue.
            10 = bright light green. 11 = bright light blue.
            12 = bright red.        13 = bright magenta.
            14 = bright yellow.     15 = bright white.
STARDATEIS= start date of the plot in yyyymmdd (year, month, day).
            E.g. 19870101 is January 1st, 1987.
STARTIMEIS= start time of the plot in hhmmss (hours, minutes, seconds).
            E.g. 131214 is 13 hours 12 minutes 14 seconds.
STOPDATEIS= stop date of the plot in yyyymmdd.
STOPTIMEIS= stop time of the plot in hhmmss.
TICKDATEIS= x-tick difference in yyyymmdd.
TICKTIMEIS= x-tick difference in hhmmss.
NUMDIFFERN= numerically differentiation of the signal. For NUMDIFFERN=
            1, the differences of subsequent samples will be plotted.
```

For an example of control parameters for program PLOTDATA, see file "plotdata.ini" in directory \eterna33\hourdat.

On option, program PLOTDATA establishes the file "plotdata.hpg", which can be used with batch file PLOTRAUS.BAT (contained in directory \eterna33\bin) to print the plot on paper. PLOTRAUS can be used for different printers (see below).

## Section 20: Description of program PLOTFILT

The program PLOTFILT performs a plot of the gain of a numerical FIR zero phase filter, as e.g. used in program ANALYZE. The plot can either be visualized on the screen of the pc or printed on paper (after establishing file "plotfilt.hpg" containing the plot commands in HPGL-plotter language of file "plotfilt.lsr" containing plotcommans for HP-Laser printer). The program is written in Fortran 90 but contains calls to non-standard Fortran 90 Calcomp plot routines, which have been compiled using the Lahey Graphoria package. Program PLOTFILT reads the necessary control parameters from file "plotfilt.ini". PLOTFILT can be executed from any directory, but expects the driver driver files on directory \eterna33\bin.

The following control parameters are valid for program PLOTFILT:

```
DATFILNAME= name of data file containing the numerical filter
            (CHARACTER*12).
PLOT-TITEL= titel of the plot (CHARACTER*64).
INVERSEFIL= plots the gain of the inverse filter if INVERSEFIL=1.
X-FREQUNIT= frequency unit for the x-axis, in cps.
X-PLOTSIZE= plot size (inner frame) in x-direction in inch.
Y-PLOTSIZE= plot size (inner frame) in y-direction in inch.
X-PMINIMUM= x-minimum of the plot in world x-coordinates.
X-PMAXIMUM= x-maximum of the plot in world x-coordinates.
X-TICKDIST= x-tick distance in world x-coordinates.
X-AXISUNIT= x-axis unit (CHARACTER*15).
Y-PMINIMUM= y-minimum of the plot in world y-coordinates.
Y-PMAXIMUM= y-maximum of the plot in world y-coordinates.
Y-TICKDIST= y-tick distance in world y-coordinates.
Y-AXISUNIT= y-axis unit (CHARACTER*15).
X-GRIDLINE= plots horizontal gridlines if X-GRIDLINE=1.
Y-GRIDLINE= plots vertical   gridlines if Y-GRIDLINE=1.
```

For an example of control parameters for program PLOTFILT, see file "plotfil.ini" in directory \eterna33\commdat.

On option, program PLOTFILT establishes the file "plotfilt.hpg", which can be used with batch file PLOTRAUS.BAT (contained in directory \eterna33\bin) to print the plot on paper. PLOTRAUS can be used for different printers (see below).

## Section 21: Description of program PLOTHIST

Program PLOTHIST computes and plots a histogram of samples stored in standard ETERNA format. E.g., a histogram of residuals after least squares adjustment with program ANALYZE can be plotted. The plot can either be visualized on the screen of the pc or printed on paper (after establishing file "plothist.hpg" containing the plot commands in HPGL-plotter language or file "plothist.lsr" containing the plot commands for an HP-Laser printer). The program is written in Fortran 90 but contains calls to non-standard Fortran 90 Calcomp plot routines, which have been compiled using the Lahey Graphoria package. Program PLOTHIST reads necessary control parameters from file "plothist.ini". PLOTFILT can be executed from any directory, but expects the driver driver files on directory \eterna33\bin.

The following control parameters are valid for program PLOTHIST:

The following control parameters are valid for PLOTHIST:

```
DATFILNAME= name of file containing the sample data (CHARACTER*12).
```

```
PLOT-TITEL= title of the plot (CHARACTER*64).
X-PLOTSIZE= size of inner frame in x-direction in inch (2.52 cm).
Y-PLOTSIZE= size of inner frame in y-direction in inch (2.52 cm).
X-AXISUNIT= x-axis unit (CHARACTER*15).
X-PMINIMUM= x-minimum of the histogram in units of the samples.
X-PMAXIMUM= x-maximum of the histogram in units of the samples.
X-TICKDIST= x-tick distance in units of the samples.
PLOTCHANEL= channel numer in which samples are stored.
PLOTCOLOUR= plot colour number (INTEGER, 0...15).
             0 = black.              1 = dark blue.
             2 = green.              3 = light blue.
             4 = red.                5 = dark magenta.
             6 = brown.              7 = light grey.
             8 = dark grey.          9 = bright dark blue.
            10 = bright light green. 11 = bright light blue.
            12 = bright red.        13 = bright magenta.
            14 = bright yellow.     15 = bright white.
Y-PMAXIMUM= y-maximum of the plot in %.
Y-TICKDIST= y-tick distance in %.
```

For an example of control parameters for program PLOTHIST, see file "plothist.ini" in directory \eterna33\hourdat.

On option, program PLOTHIST establishes the file "plothist.hpg", which can be used with batch file PLOTRAUS.BAT (contained in directory \eterna33\bin) to print the plot on paper. PLOTRAUS can be used for different printers (see below).

## Section 22: Description of program PLOTSPEC

Program PLOTSPEC performs a plot of the Fourier amplitude spectrum of residuals after least squares adjustment, as stored in an output file of program ANALYZE with suffix "far". The plot can either be visuali-zed on the screen of the pc or printed on paper (after establishing file "plotspec.hpg" containing the plot commands in HPGL-plotter language or file "plotspec.lsr" containing the plot commands for HP-laser printer). The program is written in Fortran 90 but contains calls to non-standard Fortran 90 Calcomp plot routines, which have been compiled using the Lahey Graphoria package. Program PLOTSPEC reads the necessary control parameters from file "plotspec.ini". PLOTSPEC can be executed from any directory, but expects the driver files in directory \eterna33\bin.

The following control parameters are valid for program PLOTSPEC:

```
DATFILNAME= name of the data file containing the spectrum to be
            plotted (CHARACETR*12).
PLOT-TITEL= titel of the plot (CHARACETR*64).
X-PLOTSIZE= size of inner frame in x-direction in inch (2.52 cm).
Y-PLOTSIZE= size of inner frame in y-direction in inch (2.52 cm).
X-AXISUNIT= x-axis unit (CHARACTER*15).
Y-AXISUNIT= y-axis unit (CHARACTER*15).
Y-PLOTLOGS= 0 for linear, 1 for logarithmic y-axis.
X-PMINIMUM= x-minimum of the plot, in world x-coordinates.
X-PMAXIMUM= x-maximum of the plot, in world x-coordinates.
X-TICKDIST= x-tick distance, in world x-coordinates.
Y-PMINIMUM= y-minimum of the plot, in world y-coordinates.
Y-PMAXIMUM= y-maximum of the plot, in world y-coordinates.
Y-TICKDIST= y-tick distance, in world y-coordinates.
X-GRIDLINE= plot of vertical gridlines    if X-GRIDLINE=1.
Y-GRIDLINE= plot of horizontal gridlines  if Y-GRIDLINE=1.
```

For an example of control parameters for program PLOTSPEC, see file "plotspec.ini" in directory \eterna33\hourdat.

On option, program PLOTSPEC establishes the file "plotspec.hpg", which can be used with batch file PLOTRAUS.BAT (contained in directory

\eterna33\bin) to print the plot on paper. PLOTRAUS can be used for different printers (see below).

Section 23: Description of program PRINTGL
------------------------------------------

Program PLOTRAUS is a batch file in directory "\eterna33\bin" which calls program PRINTGL from Ravitz Software Inc. to make a preview or a hardcopy from a HPGL-plotfile. You should edit file "plotraus.bat" in order to set the correct options for your printer.

The call of PRINTGL is

PRINTGL [/P]plotfile [/option1] [/option2] ...

Valid options are

```
/A[O][x,y]  puts plot center or x,y (inches) at print center or
            Origin
/Cc..       up to 8 pen colors of B C G K M R W Y or shade mixed colors.
/D[+]f      destination printer port|file|device, +append

/Fc[-|+[b]|*][!][~][x,y]  format, -lo|+hi|*max, !comprs, ~no clr,
                          x,y dpi
```

The following printers may be chosen:

```
 J=Canon BJ130                   G=GEM IMG ~
 Q=HP QJ                         6=IBM X24 +*
 9=NEC 24 +*                     C=CGA
 7=Canon BJ                      8=HP-GL
 4=IBM LP                        5=X24 alt1 +
 S=PostScript                    E=EGA screen
 D=Canon LBP                     L=HP LJ
 1=IBM Pro +                     X=X24 alt2 +
 O=Tosh 24 +*                    M=EGAmono
 N=Epson 9 +*                    I=HP LJ3
 2=IBM QW2                       K=Kodak C4
 Z=ZS PCX                        H=HGC
 T=Epson 24 +*                   P=HP PJ
 3=IBM QW3                       A=MT MT92C
 V=VGA +b
```

Other options of PRINTGL are displayed on the screen by entering <printgl>

Section 24: Description of program LOAD89
-----------------------------------------

Program LOAD89 has kindly been provided by Dr. O. Francis from International Center for Earth Tides (ICET) Bruxelles. It computes ocean tide loading for a different ocean tide models provided in directory "\eterna33\oceload". Unfortunetely, we were unable to write a detailed program manual for program LOAD89 with this version of the ETERNA package; but we have included two Fortran source code files (load89.f for a Sun workstation, load89.for for a pc using the Lahey compiler).

Section 25: Description of program WPAREX
-----------------------------------------

Program WPAREX interpolates synthetic gravity tide parameters from the 1 by 1 degree grid computed by Timmen and Wenzel (1994) using Schwiderski (1980) ocean tide model. The coordinates (latitude and longitude) of the stations to be interpolated have to be stored in file "wparex.dat" before execution of program WPAREX, and the interpolated gravity tide parameters will be stored in file "wparex.prn" after execution of program WPAREX. Program WPAREX can only be executed from directory "\eterna33\oceload". The print file of program WPAREX for the example input file is given in encl. 094.

end end end end end end end end end end end end end end end end end end