Geophysical models and numerical standards in ETideLoad4.5

ETideLoad4.5 is mainly based on the geophysical models and numerical standards recommended by IERS conventions (2010). You can update them by the program [System configs for the geophysical models and numerical standards]. These geophysical models and numerical standards are stored in file form in the folder C:\ETideLoad4.5_win64en\iers.

7.4.1 The surface atmosphere tidal load spherical harmonic coefficient model file

The 360-degree surface atmosphere tidal load spherical harmonic coefficient model file ECMWF2006.dat is stored in the folder C:\ETideLoad4.5_win64en\iers in FES2004 format, which were constructed by the spherical harmonic analysis programs of ETideLoad4.5 using 0.5°× 0.5° global harmonic constant grids of four atmosphere tidal constituents, to meet the basic needs of centimeter-level geodesy. The four tidal constituents are respectively the diurnal, semi-diurnal, semi-annual and annual periodic tidal constituents (S_1, S_2, Ss_a, Sa) whose harmonic constant grids come from ECMWF-DCDA2006 of European Centre for Medium-Range Weather Forecasts.

ECMWF2006.dat

```
Atmospheric tide model: ECMWF-DCDA2006 normalized model up to (360,360) in hPa
半日/周日/半年/年周期
Doodson   Darw   n    m      Csin+        Ccos+        Csin-        Ccos-        C+          eps+        C-          eps-
 164.556   S1    1    0   -0.01055351   0.00555959  -0.01055351   0.00555959  0.01192835  297.7803  0.01192835  297.7803
 164.556   S1    2    0   -0.00898730   0.02713172  -0.00898730   0.02713172  0.02858149  341.6727  0.02858149  341.6727
 164.556   S1    3    0    0.02416514   0.01232573   0.02416514   0.01232573  0.02712707   62.9756  0.02712707   62.9756
 164.556   S1    4    0    0.01971779  -0.01808456   0.01971779  -0.01808456  0.02675523  132.5261  0.02675523  132.5261
 164.556   S1    5    0    0.00538826  -0.01556217   0.00538826  -0.01556217  0.01646859  160.9021  0.01646859  160.9021
 164.556   S1    6    0   -0.01896560  -0.00055330  -0.01896560  -0.00055330  0.01897366  268.3289  0.01897366  268.3289
 164.556   S1    7    0    0.00163224   0.00711629   0.00163224   0.00711629  0.00730108   12.9183  0.00730108   12.9183
 164.556   S1    8    0    0.00341644   0.00607435   0.00341644   0.00607435  0.00696920   29.3550  0.00696920   29.3550
 164.556   S1    9    0   -0.00469730  -0.00311697  -0.00469730  -0.00311697  0.00563739  236.4331  0.00563739  236.4331
 164.556   S1   10    0    0.00442735  -0.01563001   0.00442735  -0.01563001  0.01624496  164.1847  0.01624496  164.1847
 164.556   S1   11    0    0.00941838  -0.00082619   0.00941838  -0.00082619  0.00945455   95.0132  0.00945455   95.0132
 164.556   S1   12    0   -0.00454013   0.00688423  -0.00454013   0.00688423  0.00824654  326.5953  0.00824654  326.5953
 164.556   S1   13    0   -0.01227672   0.00310149  -0.01227672   0.00310149  0.01266243  284.1781  0.01266243  284.1781
 164.556   S1   14    0    0.00203678   0.00166923   0.00203678   0.00166923  0.00263340   50.6638  0.00263340   50.6638
 164.556   S1   15    0    0.00253994   0.00381849   0.00253994   0.00381849  0.00458608   33.6306  0.00458608   33.6306
 164.556   S1   16    0    0.00613602  -0.00041704   0.00613602  -0.00041704  0.00615017   93.8882  0.00615017   93.8882
 164.556   S1   17    0   -0.00113104  -0.00413462  -0.00113104  -0.00413462  0.00428652  195.2992  0.00428652  195.2992
 164.556   S1   18    0   -0.00311700   0.00136741  -0.00311700   0.00136741  0.00340375  293.6868  0.00340375  293.6868
 164.556   S1   19    0   -0.00217138   0.00053937  -0.00217138   0.00053937  0.00223737  283.9498  0.00223737  283.9498
 164.556   S1   20    0   -0.00017645   0.00369644  -0.00017645   0.00369644  0.00370065  357.2671  0.00370065  357.2671
 164.556   S1   21    0    0.00068441  -0.00165216   0.00068441  -0.00165216  0.00178831  157.4980  0.00178831  157.4980
 164.556   S1   22    0    0.00100221  -0.00214635   0.00100221  -0.00214635  0.00236881  154.9703  0.00236881  154.9703
 164.556   S1   23    0    0.00461395  -0.00179653   0.00461395  -0.00179653  0.00495136  111.2744  0.00495136  111.2744
 164.556   S1   24    0   -0.00143873   0.00014453  -0.00143873   0.00014453  0.00144597  275.7366  0.00144597  275.7366
 164.556   S1   25    0   -0.00083151  -0.00001238  -0.00083151  -0.00001238  0.00083160  269.1470  0.00083160  269.1470
 164.556   S1   26    0   -0.00272792  -0.00095240  -0.00272792  -0.00095240  0.00288940  250.7543  0.00288940  250.7543
 164.556   S1   27    0   -0.00183890   0.00217563  -0.00183890   0.00217563  0.00284868  319.7946  0.00284868  319.7946
```

The surface atmospherical pressure, tidal constituent harmonic constants and tidal load spherical harmonic coefficients are all in unit of hPa or mbar.

7.4.2 The ocean tidal load spherical harmonic coefficient model file

The 100-degree ocean tidal load spherical harmonic coefficient model file FES2004S1.dat is stored in the folder C:\ETideLoad4.5_win64en\iers in FES2004 format. The relationship expression between the ocean tidal load normalized spherical harmonic coefficients and the geopotential coefficients is as the formula (6.15) in the IERS conventions (2010).

In order to meet the basic needs of satellite, coastal zone and ocean gravity gradient data processing, we adopted AVISO FES2014b global tidal height harmonic constant grid models to construct the 720-degree ocean tidal height spherical harmonic coefficient model file FES2014b720cs.dat in FES2004 format by the spherical harmonic analysis programs of ETideLoad4.5.

ECMWF2006.dat FES2004S1.dat

```
Ocean tide model: FES2004 normalized model (fev. 2004) up to (100,100) in cm
(long period from FES2002 up to (50,50) + equilibrium Om1/Om2, atmospheric tide NOT included)
Doodson Darw   n   m    Csin+     Ccos+       Csin-     Ccos-      C+    eps+    C-     eps-
  55.565 Om1   2   0 -0.540594  0.000000   0.000000  0.000000   0.5406 270.000 0.0000   0.000
  55.575 Om2   2   0 -0.005218  0.000000   0.000000  0.000000   0.0052 270.000 0.0000   0.000
  56.554 Sa    1   0  0.017233  0.000013   0.000000  0.000000   0.0172  89.957 0.0000   0.000
  56.554 Sa    2   0 -0.046604 -0.000903   0.000000  0.000000   0.0466 268.890 0.0000   0.000
  56.554 Sa    3   0 -0.000889  0.000049   0.000000  0.000000   0.0009 273.155 0.0000   0.000
  56.554 Sa    4   0  0.012069 -0.000413   0.000000  0.000000   0.0121  91.960 0.0000   0.000
  56.554 Sa    5   0 -0.009780 -0.000421   0.000000  0.000000   0.0098 267.535 0.0000   0.000
  56.554 Sa    6   0  0.006895  0.000043   0.000000  0.000000   0.0069  89.643 0.0000   0.000
  56.554 Sa    7   0 -0.010515 -0.000287   0.000000  0.000000   0.0105 268.437 0.0000   0.000
  56.554 Sa    8   0  0.002067 -0.000011   0.000000  0.000000   0.0021  90.305 0.0000   0.000
  56.554 Sa    9   0 -0.004236 -0.000110   0.000000  0.000000   0.0042 268.512 0.0000   0.000
  56.554 Sa   10   0 -0.001781 -0.000085   0.000000  0.000000   0.0018 267.268 0.0000   0.000
  56.554 Sa   11   0 -0.001372 -0.000068   0.000000  0.000000   0.0014 267.163 0.0000   0.000
  56.554 Sa   12   0 -0.004081 -0.000048   0.000000  0.000000   0.0041 269.326 0.0000   0.000
  56.554 Sa   13   0 -0.000116 -0.000041   0.000000  0.000000   0.0001 250.534 0.0000   0.000
  56.554 Sa   14   0 -0.003043 -0.000007   0.000000  0.000000   0.0030 269.868 0.0000   0.000
  56.554 Sa   15   0  0.001109 -0.000028   0.000000  0.000000   0.0011  91.446 0.0000   0.000
  56.554 Sa   16   0 -0.002596 -0.000034   0.000000  0.000000   0.0026 269.250 0.0000   0.000
  56.554 Sa   17   0 -0.000674  0.000022   0.000000  0.000000   0.0007 271.870 0.0000   0.000
  56.554 Sa   18   0  0.000546  0.000006   0.000000  0.000000   0.0005  89.370 0.0000   0.000
  56.554 Sa   19   0 -0.000024  0.000023   0.000000  0.000000   0.0000 313.781 0.0000   0.000
  56.554 Sa   20   0  0.000867  0.000014   0.000000  0.000000   0.0009  89.075 0.0000   0.000
```

FES2014n720cs.dat includes spherical harmonic coefficients of the 36 tidal constituents (Ω1, Ω2; 2N2, Eps2, J1, K1, K2, L2, La2, M2, M3, M4, M6, M8, Mf, MKS2, Mm, MN4, MS4, MSf, MSqm, Mtm, Mu2, N2, N4, Nu2, O1, P1, Q1, R2, S1, S2, S4, Sa, Ssa, T2), in which the spherical harmonic coefficients of the two equilibrium tidal constituents (Ω1, Ω2) come from FES2004S1.dat.

The ocean tidal height, harmonic constant of the tidal constituent and tidal load spherical harmonic coefficients are all in unit of cm.

7.4.3 The Earth's Load Love number file

The Earth's load Love numbers also called the load deformation coefficients (LDC) can be calculated using the spherically symmetric non-rotating elastic Earth model REF6371. The load Love numbers in ETideLoad4.5 come from a Regional ElAstic Rebound calculator (REAR1.0, 2015.11). The load Love number file Love_load_cm.dat were stored in the folder C:\ETideLoad4.5_win64en\iers, which includes the load Love numbers of the radial displacement, horizontal displacement and geopotential $(h'_n, l'_n, k'_n), n = 0, \cdots, 32768$ from 0 to 32768 degree, $k'_0 = k'_1 = 0$, as shown in the figure.。

In order to suppress the high-degree oscillations of the load Green's function, the load Green's function is calculated to 54000 degrees in ETideLoad, and the load Love numbers exceeding 32768 degrees (n>32768) are calculated with the following asymptotic formulas:

h'_n =-6.209114, l'_n =1.890061$/n$, k'_n =-2.682697$/n$.

```
Love_load_cm.dat
The load Love numbers from the REAR package are attached. There are no
more of these oscillations at high degree, and they go up to degree 32768.
November 20, 2015. Jean-Paul
CM: center of mass reference frame
     n      h' (vert)          l' (horiz)          k' (potent)
     0    0.0000000000D+00  0.0000000000D+00   0.0000000000D+00
     1   -0.0287112988D+01  0.1045044062D+00   0.0000000000D+00
     2   -0.9945870591D+00  0.2411251588D-01  -0.3057703360D+00
     3   -0.1054653021D+01  0.7085493677D-01  -0.1962722363D+00
     4   -0.1057783895D+01  0.5958723183D-01  -0.1337905897D+00
     5   -0.1091185915D+01  0.4702627503D-01  -0.1047617976D+00
     6   -0.1149253656D+01  0.3940811757D-01  -0.9034958051D-01
     7   -0.1218363201D+01  0.3499400649D-01  -0.8205733906D-01
     8   -0.1290473661D+01  0.3225123202D-01  -0.7652348967D-01
     9   -0.1361847865D+01  0.3038562458D-01  -0.7239287690D-01
    10   -0.1430981761D+01  0.2902258995D-01  -0.6907768441D-01
    11   -0.1497377458D+01  0.2798156018D-01  -0.6629382122D-01
    12   -0.1560934855D+01  0.2716367080D-01  -0.6388475059D-01
    13   -0.1621715593D+01  0.2650554043D-01  -0.6175536119D-01
    14   -0.1679770379D+01  0.2596800569D-01  -0.5983856019D-01
    15   -0.1735198310D+01  0.2551661917D-01  -0.5808965155D-01
    16   -0.1788088250D+01  0.2512667367D-01  -0.5647488828D-01
    17   -0.1838448069D+01  0.2478452380D-01  -0.5496610314D-01
    18   -0.1886440474D+01  0.2447083426D-01  -0.5354901315D-01
    19   -0.1932084480D+01  0.2417919471D-01  -0.5220607051D-01
    20   -0.1975465902D+01  0.2389862142D-01  -0.5092726303D-01
    21   -0.2016677975D+01  0.2362510597D-01  -0.4970406011D-01
    22   -0.2055800328D+01  0.2335504487D-01  -0.4853059813D-01
    23   -0.2092911079D+01  0.2308664225D-01  -0.4740132374D-01
    24   -0.2128152865D+01  0.2281672671D-01  -0.4631386954D-01
```

7.4.4 The IERS Earth orientation parameter time series file

The IERS Earth orientation parameters (EOP) time series file IERSeopc04.dat (ITRF2008) were stored in the folder C:\ETideLoad4.5_win64en\iers. You can update the EOP time series from the IERS website. For future time epochs, the forecast EOP products can be employed. Considering the non-tidal nature of the polar shift, the forecast time should be controlled within half a year.

```
ECMWF2006.dat | FES2004S1.dat | IERSeopc04.dat


                   INTERNATIONAL EARTH ROTATION AND REFERENCE SYSTEMS SERVICE
                        EARTH ORIENTATION PARAMETERS
                          EOP (IERS) 14 C04


              FORMAT(3(I4),I7,2(F11.6),2(F12.7),2(F11.6),2(F11.6),2(F11.7),2(F12.6))
##################################################################################

      Date      MJD      x          y        UT1-UTC       LOD         dX        dY        x Err      y Err   UT1-UTC Err  LOD Err     dX Err      dY Err
                         "          "           s           s          "         "           "          "          s          s          "           "
     (0h UTC)

2001   1   1  51910  -0.073506   0.398095   0.0931626   0.0006630   0.000150  -0.000109   0.000061   0.000048  0.0000107  0.0000131   0.000028    0.000030
2001   1   2  51911  -0.072651   0.399806   0.0924546   0.0007596   0.000141  -0.000092   0.000061   0.000048  0.0000070  0.0000131   0.000028    0.000031
2001   1   3  51912  -0.071557   0.401864   0.0916573   0.0008515   0.000132  -0.000074   0.000061   0.000047  0.0000034  0.0000131   0.000028    0.000031
2001   1   4  51913  -0.071024   0.403840   0.0907195   0.0008969   0.000149  -0.000084   0.000061   0.000047  0.0000084  0.0000132   0.000029    0.000031
2001   1   5  51914  -0.070723   0.405333   0.0897667   0.0008872   0.000174  -0.000103   0.000060   0.000047  0.0000163  0.0000132   0.000029    0.000031
2001   1   6  51915  -0.070378   0.406725   0.0889292   0.0008068   0.000199  -0.000122   0.000060   0.000047  0.0000221  0.0000132   0.000029    0.000031
2001   1   7  51916  -0.070068   0.408041   0.0882375   0.0006463   0.000224  -0.000141   0.000060   0.000047  0.0000163  0.0000132   0.000029    0.000031
2001   1   8  51917  -0.070205   0.409479   0.0876861   0.0004933   0.000250  -0.000160   0.000060   0.000047  0.0000104  0.0000132   0.000029    0.000031
2001   1   9  51918  -0.070220   0.410814   0.0872445   0.0004441   0.000275  -0.000179   0.000060   0.000046  0.0000046  0.0000132   0.000029    0.000032
2001   1  10  51919  -0.069861   0.412336   0.0868199   0.0004186   0.000270  -0.000158   0.000060   0.000046  0.0000043  0.0000133   0.000029    0.000031
2001   1  11  51920  -0.069330   0.414004   0.0864003   0.0004447   0.000155  -0.000180   0.000059   0.000046  0.0000039  0.0000133   0.000029    0.000031
2001   1  12  51921  -0.068456   0.416120   0.0858451   0.0005855   0.000106  -0.000203   0.000059   0.000046  0.0000088  0.0000133   0.000028    0.000030
2001   1  13  51922  -0.067463   0.418251   0.0851161   0.0007422   0.000095  -0.000222   0.000059   0.000046  0.0000138  0.0000133   0.000028    0.000030
2001   1  14  51923  -0.066479   0.420226   0.0842390   0.0008823   0.000084  -0.000241   0.000059   0.000046  0.0000112  0.0000134   0.000028    0.000029
2001   1  15  51924  -0.065406   0.422044   0.0833100   0.0009404   0.000072  -0.000259   0.000059   0.000046  0.0000086  0.0000134   0.000027    0.000028
2001   1  16  51925  -0.063999   0.423541   0.0824180   0.0009155   0.000061  -0.000278   0.000059   0.000046  0.0000060  0.0000134   0.000027    0.000028
2001   1  17  51926  -0.062602   0.425076   0.0816384   0.0007815   0.000050  -0.000297   0.000059   0.000046  0.0000034  0.0000135   0.000027    0.000027
2001   1  18  51927  -0.061434   0.426438   0.0809369   0.0005717   0.000307  -0.000078   0.000060   0.000046  0.0000060  0.0000135   0.000026    0.000026
2001   1  19  51928  -0.060301   0.428009   0.0803992   0.0004021   0.000387  -0.000005   0.000060   0.000046  0.0000114  0.0000135   0.000026    0.000025
2001   1  20  51929  -0.059175   0.429380   0.0801026   0.0002618   0.000335  -0.000045   0.000060   0.000046  0.0000197  0.0000136   0.000025    0.000025
2001   1  21  51930  -0.058122   0.430418   0.0799970   0.0000786   0.000284  -0.000085   0.000060   0.000046  0.0000198  0.0000136   0.000025    0.000024
2001   1  22  51931  -0.056745   0.431190   0.0799904  -0.0000387   0.000232  -0.000124   0.000060   0.000047  0.0000199  0.0000136   0.000024    0.000023
2001   1  23  51932  -0.055378   0.432515   0.0800354  -0.0000794   0.000180  -0.000164   0.000061   0.000047  0.0000200  0.0000137   0.000024    0.000022
2001   1  24  51933  -0.054038   0.434299   0.0801054  -0.0000531   0.000189  -0.000183   0.000061   0.000047  0.0000090  0.0000137   0.000024    0.000022
2001   1  25  51934  -0.052227   0.436048   0.0801105   0.0000481   0.000130  -0.000240   0.000061   0.000047  0.0000025  0.0000137   0.000023    0.000021
2001   1  26  51935  -0.050435   0.438026   0.0799589   0.0001715   0.000101  -0.000252   0.000062   0.000048  0.0000160  0.0000137   0.000023    0.000021
2001   1  27  51936  -0.049130   0.439812   0.0796787   0.0002940   0.000094  -0.000242   0.000062   0.000048  0.0000312  0.0000137   0.000022    0.000020
2001   1  28  51937  -0.047602   0.441607   0.0792944   0.0004503   0.000086  -0.000232   0.000062   0.000048  0.0000276  0.0000137   0.000022    0.000019
2001   1  29  51938  -0.045537   0.443509   0.0788172   0.0005621   0.000079  -0.000221   0.000063   0.000048  0.0000239  0.0000138   0.000021    0.000019
2001   1  30  51939  -0.043660   0.444974   0.0782782   0.0006019   0.000072  -0.000211   0.000063   0.000048  0.0000203  0.0000138   0.000021    0.000018
2001   1  31  51940  -0.042067   0.446396   0.0777060   0.0005437   0.000254  -0.000159   0.000063   0.000049  0.0000063  0.0000138   0.000021    0.000019
2001   2   1  51941  -0.040683   0.447325   0.0772066   0.0004689   0.000298  -0.000141   0.000064   0.000049  0.0000064  0.0000138   0.000022    0.000020
2001   2   2  51942  -0.039012   0.448060   0.0767917   0.0003692   0.000290  -0.000134   0.000064   0.000049  0.0000143  0.0000138   0.000022    0.000020
```

7.4.5 The Earth's mass centric variation time series file

The Earth's mass centric variation time series file Monthly_geocenter_MK.txt (ITRF2014) from Center for Space Research in University of Texas in USA (UT/CSR) from LAGEOS-1/2, Stella, Starlette, AJISAI, BEC and LARES Satellite Laser Ranging (SLR) measured. For future time epochs, the forecast products can be employed, but the forecast time should be controlled within three months.

Monthly_geocenter_MK.txt

```
Description for Geocenter variations from SLR
Column 1: Year equivalent of first day of month
Column 2-4: Lower Pass Filtered X,Y,Z (mm)
Column 5-7: SLR estimated X,Y,Z (mm)
Column 8-10: Sigma for X,Y,Z (mm)
Usage: (C11,S11,C10) = (X,Y,Z)/sqrt(3.0)/6378136000.0
Remark: Monthly station range bias and zenith delay adjusted
FORMAT(F9.1,F12.4,6F9.3,3F7.2)
1993.0000    5.077   -2.796   -1.605    6.477    1.797   -6.338   0.11   0.12   0.31
1993.0849    4.639   -3.300   -1.244    1.922   -2.697    2.723   0.10   0.10   0.29
1993.1615    3.765   -3.384   -1.106    5.188   -4.895    0.714   0.09   0.10   0.26
1993.2464    2.562   -2.788   -1.336    1.450   -6.692   -3.054   0.11   0.12   0.26
1993.3285    1.198   -1.521   -1.911    2.230   -4.670   -4.583   0.11   0.10   0.25
1993.4134   -0.126    0.137   -2.656   -0.187    3.425    0.901   0.10   0.10   0.25
1993.4956   -1.214    1.754   -3.323   -0.585    2.945   -1.864   0.10   0.09   0.21
1993.5804   -1.920    2.913   -3.678   -0.832    3.154   -1.596   0.09   0.08   0.21
1993.6653   -2.178    3.347   -3.579   -4.795    3.621  -10.809   0.09   0.08   0.20
1993.7474   -2.004    2.991   -3.037   -4.289    2.258   -4.667   0.08   0.07   0.21
1993.8323   -1.466    1.952   -2.253    2.444    3.179    2.852   0.09   0.09   0.27
1993.9144   -0.645    0.449   -1.614    0.122    1.610    1.299   0.09   0.09   0.22
1994.0000    0.397   -1.237   -1.600   -0.654   -4.129   -7.715   0.08   0.09   0.19
1994.0849    1.612   -2.802   -2.625    1.034   -5.735    1.035   0.09   0.09   0.20
1994.1615    2.931   -3.928   -4.840    2.030   -1.856   -5.718   0.08   0.08   0.21
1994.2464    4.228   -4.321   -7.998    3.979   -2.408   -5.872   0.09   0.08   0.20
1994.3285    5.313   -3.784  -11.461    8.049   -1.572  -11.862   0.10   0.09   0.20
1994.4134    5.965   -2.309  -14.360    5.917   -3.452  -22.300   0.09   0.10   0.24
1994.4956    6.014   -0.151  -15.860    2.151   -2.927  -10.555   0.09   0.10   0.25
```

7.4.6 Ocean tidal constituent harmonic constant grid model files

(1) The ocean tidal height model is composed of multiple grid models of all tidal constituent harmonic constants. Each tidal constituent harmonic constants are stored as a vector grid file.

(2) All the tidal constituent grid files from an ocean tidal height model should be in a folder with the same grid specifications.

(3) The 10 vector grid files in the folder C:\ ETideLoad4.5_win64en\OceanTide represent the ocean tide model GOT4.8 with 10 global grid models of 10 tidal constituent harmonic constants.

(4) The type of the tidal constituent is identified by the seventh attribute (Doodson constant) in its grid file header. These files can be named at will.

M2_got4.8.dat

```
0.000000  360.000000  -90.000000   90.000000  0.50000000  0.50000000    255555
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
```

(5) The ocean tidal height model can be global or regional. The ocean tidal height and the harmonic constants are all in unit of cm.

7.4.7 The JPL Planetary Ephemeris DE440 file

The JPL Planetary Ephemeris DE440 file JEPH.440 (from 1850 to 2201) was stored in the folder C:\ETideLoad4.5_win64en\iers.

7.4.8 The Love number correction file for frequency dependence

The correction file frqadjlovekhl.txt for frequency dependence was generated from Table 6.5a, 6.5b, 6.5c, 7.2, 7.3a and 7.3b in IERS conventions (2010) can be employed to calculate the Love number corrections for frequency dependence to obtain the high-accuracy solid tidal effects on all-element geodetic variations.

frqadjlovekhl.txt

doodson	°/hr	l	l'	F	D	Ω	(δR	δI)[2~72,e-5;73~120,e-4]	H(e-5m)
245655	28.43973	1	0	2	0	2	2	0	12099
255555	28.98410	0	0	2	0	2	2	0	63192
125755	12.85429	2	0	2	0	2	-29	3	-664
127555	12.92714	0	0	2	2	2	-30	3	-802
135645	13.39645	1	0	2	0	1	-45	5	-947
135655	13.39866	1	0	2	0	2	-46	5	-5020
137455	13.47151	-1	0	2	2	2	-49	5	-954
145545	13.94083	0	0	2	0	1	-82	7	-4946
145555	13.94303	0	0	2	0	2	-83	7	-26221
147555	14.02517	0	0	0	2	0	-91	9	343
153655	14.41456	1	0	2	-2	2	-168	14	194
155445	14.48520	-1	0	2	0	1	-193	16	137
155455	14.48741	-1	0	2	0	2	-194	16	741
155655	14.49669	1	0	0	0	0	-197	16	2062
155665	14.49890	1	0	0	0	1	-198	16	414
157455	14.56955	-1	0	0	2	0	-231	18	394
157465	14.57176	-1	0	0	2	1	-233	18	87

7.4.9 The Desai ocean pole tide coefficient file

The ocean pole tide is generated by the centrifugal effect of polar motion on the oceans. Desai (2002) present a self-consistent equilibrium model of the ocean pole tide. This model accounts for continental boundaries, mass conservation over the oceans, self-gravitation and load of the ocean floor. Using this model, the ocean pole tide produces the following perturbations to the normalized geopotential coefficients, as a function of the polar shift parameters (m_1, m_2).

ECMWF2006.dat | FES2004S1.dat | IERSeopc04.dat | GCN_L1_L2_30d_CF-CM.txt | desaiscopolecoef.txt

n	m	Anm(Real)	Bnm(Real)	Anm(Imaginary)	Bnm(Imaginary)
1	0	1.8736759805448e-02	0.0000000000000e+00	2.9688884960424e-02	0.0000000000000e+00
1	1	2.8258913146935e-02	2.1774643075236e-02	2.3898264393684e-02	5.6771602236635e-02
2	0	-3.9555099024374e-03	0.0000000000000e+00	6.8390464271953e-04	0.0000000000000e+00
2	1	-2.4325330521304e-01	5.4680741193318e-03	5.4680741193318e-03	-1.9252111185300e-01
2	2	1.9102047023374e-02	1.1158297399424e-02	-1.5123770169928e-02	-2.4857839911518e-04
3	0	-2.0869478248378e-02	0.0000000000000e+00	-1.0775272844125e-02	0.0000000000000e+00
3	1	3.0809252024501e-02	7.4552838003486e-03	5.5937937407386e-03	6.6496877724041e-02
3	2	2.3295703062692e-02	3.7984356463618e-02	-2.1678456242839e-03	1.1232359168959e-02
3	3	7.9776020803848e-03	1.2502542787182e-02	-2.2341399966187e-02	-2.2979590161975e-02
4	0	-1.0612668622736e-02	0.0000000000000e+00	-1.5569196271270e-02	0.0000000000000e+00
4	1	1.3606306893006e-04	2.2051992576636e-03	2.0130037501025e-03	1.6323514549038e-02
4	2	1.1139374002795e-02	1.7031544962514e-02	-7.9621127289889e-03	-8.4440848505132e-04
4	3	-1.6100794768731e-02	1.4681986705593e-02	9.5178410813713e-03	-2.1017136590507e-02
4	4	4.3132021252707e-03	-4.6836271624465e-03	-2.9309550249205e-03	1.3175690530653e-02
5	0	7.0731357453056e-03	0.0000000000000e+00	-1.8023029843730e-03	0.0000000000000e+00
5	1	2.5644907587134e-03	-1.0076857169607e-02	-9.6273922883022e-03	-1.1684145258283e-02
5	2	-7.9615162895536e-03	2.0820461332209e-03	-3.0274671879191e-03	-1.0475800274156e-02
5	3	-1.1818705609675e-02	1.2063416189422e-02	-1.6584597520384e-02	-2.8253596831795e-02
5	4	9.2731253376468e-03	1.8353138561674e-02	-1.0870088052722e-02	4.7120935900411e-03
5	5	1.4460712839068e-02	-8.5510747244577e-03	8.9167437380844e-04	1.6048852898081e-02
6	0	7.4439256593180e-03	0.0000000000000e+00	-1.0670986469176e-03	0.0000000000000e+00
6	1	1.8261459881891e-02	-3.7775168887123e-03	-3.6768761254667e-03	-1.4329108864964e-03
6	2	-8.4568708595335e-03	2.5640802224787e-03	8.0976103423504e-03	-6.3983905389798e-03
6	3	-1.5355186088842e-02	1.8642889355748e-03	-9.6956523287846e-03	-2.2353328754893e-02

The Desai calculating formula of the ocean pole tide adopts the formula (6.23) in the IERS conventions (2010), and the 360-degree ocean polar tide coefficient file desaiscopolecoef.txt were stored in the folder C:\ETideLoad4.5_win64en\iers.

7.4.10 First-degree ocean tidal load spherical harmonic coefficient file

The file OtideOne.dat could be employed to forecast of ocean tidal load effects on Earth's mass centric variations or all-element geodetic variation effects due to Earth's mass centric variation of ocean tide.

The file is output by the function [Spherical harmonic analysis on ocean tidal constituent harmonic constants]. The following figure is the first-degree ocean tidal load spherical harmonic coefficient file generated by the spherical harmonic analysis of 34 tidal constituent harmonic constants in the FES2014b ocean tide model.

frqadjlovekhl.txt | OtideOne.dat

3.986004418 6378137.00

name	Doodson	C10+	C10-	C11+	C11-	S11+	S11-
2N2	247.455	0.14379190E-08	0.72446933E-09	0.45556662E-09	0.50261431E-09	0.98234968E-09	0.28806626E-08
J1	175.455	0.22805765E-08	-0.14599680E-07	0.11146859E-07	0.31354016E-08	0.49073923E-08	0.50239288E-08
K1	165.555	0.65903198E-07	-0.23618735E-06	0.15240517E-06	0.54510351E-07	0.57951321E-07	0.91115166E-07
K2	275.555	0.58820344E-08	0.78223673E-09	0.82634785E-08	0.17098158E-07	0.28274727E-08	0.95641986E-09
L2	265.455	0.99527541E-09	0.43369491E-10	0.27208849E-08	0.18838893E-08	-0.93316186E-09	-0.31242492E-09
M2	255.555	0.64086749E-07	0.33741274E-07	0.82092113E-07	0.76976307E-08	-0.39331272E-07	0.74234937E-07
M3	355.555	0.51159035E-10	0.26216133E-10	0.20622631E-10	-0.16737336E-10	-0.74054752E-10	-0.32502465E-10
M4	455.555	-0.12877739E-09	-0.82078020E-09	0.21241775E-09	0.89312487E-09	-0.11238411E-09	-0.11882183E-08
M6	655.555	0.18174228E-08	0.30921490E-09	0.36600543E-09	0.36841599E-09	-0.72147727E-09	-0.13743491E-09
M8	855.555	-0.59854172E-10	-0.29503418E-11	0.41858427E-10	0.58809710E-10	-0.34465624E-10	0.81925459E-11
Mf	75.555	0.23994538E-07	0.23160661E-08	0.14961765E-07	-0.19050356E-07	0.57231952E-08	-0.38155669E-08
Mm	65.455	0.12211587E-07	-0.10619733E-08	-0.13680094E-08	-0.93454574E-08	0.34149364E-08	-0.61740212E-09
N2	245.655	0.16604395E-07	0.24692742E-08	0.10060051E-07	0.75631673E-09	-0.49125733E-09	0.20845840E-07
N4	435.755	-0.11170849E-09	-0.41029169E-10	0.37178942E-10	-0.10703469E-09	-0.53442667E-10	-0.19926918E-10
O1	145.555	0.23239277E-07	-0.16830188E-06	0.86481239E-07	0.11802879E-07	0.58555768E-07	0.34726677E-07
P1	163.555	0.16600812E-07	-0.74602430E-07	0.48235157E-07	0.14146460E-07	0.16888410E-07	0.27904988E-07
Q1	135.655	0.40244812E-08	-0.29117940E-07	0.15908436E-07	0.77164577E-09	0.12770867E-07	0.14909422E-08
R2	274.554	0.21029138E-09	0.96276767E-10	0.25728894E-09	0.46084038E-09	0.53716115E-10	0.14500876E-09
S1	164.556	-0.40129653E-08	0.48653114E-08	-0.48716881E-08	0.11419251E-07	0.74509139E-08	-0.34899535E-09
S2	273.555	0.22430236E-07	0.94564697E-08	0.30377828E-07	0.49157638E-07	-0.61338730E-08	0.76805145E-08
S4	491.555	0.32089047E-09	0.14407638E-09	0.12925319E-11	0.14038268E-09	0.10308541E-09	0.11742749E-09
Sa	56.554	0.21793187E-09	0.12972260E-09	0.71714382E-10	0.49927099E-10	-0.42733149E-10	-0.53422994E-10
T2	272.556	0.13719484E-08	0.73425584E-09	0.20944307E-08	0.29614380E-08	0.13767437E-09	0.10318216E-08
MN4	445.655	-0.70793273E-09	-0.76823301E-10	0.24279253E-09	-0.66374018E-09	-0.14062685E-09	0.16716883E-09
MS4	473.555	0.32582237E-09	-0.10684852E-08	0.10873236E-08	0.38092589E-09	-0.40703836E-09	-0.28009461E-09
Msf	73.555	0.52032006E-09	0.12958178E-08	0.20898774E-09	0.69234415E-09	0.16108594E-08	0.36734674E-09
Mtm	85.455	0.38057222E-08	0.89028662E-09	0.47545363E-08	-0.16109463E-08	0.13034435E-08	0.46197838E-10
mu2	237.555	0.27230195E-08	-0.54548861E-09	0.80856645E-09	0.28475772E-08	0.30945151E-08	0.39961507E-08
nu2	245.655	0.31512988E-08	0.13274377E-08	0.16643629E-08	0.77176190E-09	-0.34369557E-09	0.49489633E-08
Ssa	57.555	0.85592993E-08	-0.21041028E-09	-0.85777470E-08	-0.10849053E-08	0.38854237E-09	-0.73333943E-09
eps2	227.655	0.15232320E-08	-0.54284574E-09	0.18709319E-08	-0.17678032E-09	0.14037532E-08	-0.64291979E-09
lam2	263.655	0.77975910E-09	-0.46145888E-09	0.29230225E-08	-0.81098933E-09	-0.68691816E-09	-0.10714953E-08
MKS2	257.555	-0.76338045E-11	-0.81694611E-10	0.81955321E-10	0.53313693E-09	0.52931064E-09	0.23733568E-09
Msqm	93.555	0.17382639E-09	-0.21085098E-11	0.98864729E-10	0.18391545E-09	-0.15315104E-09	-0.66456652E-11

The file header inludes the geocentric gravitational constant GM ($\times 10^{14} m^3/s^2$) and equatorial radius a (m) of the Earth. The record (starting from the third row) includes the tidal constituent's name, Doodson constant, the degree-1 order-0 spherical harmonic coefficient C_{10}+ from in-phase amplitude, that C_{10}- from out-of-phase amplitude, and the degree-1 order-1 spherical harmonic coefficient C_{11}+ from in-phase amplitude, that C_{11}- from out-of-phase amplitude, and the degree-1 order-1 spherical harmonic coefficient S_{11}+ from in-phase amplitude, that S_{11}- from out-of-phase amplitude.

7.4.11 First-degree atmosphere tidal load spherical harmonic coefficient file

The file AirtdOne.dat could be employed to forecast of surface atmosphere tidal load effects on Earth's mass centric variations or all-element geodetic variation effects due to Earth's mass centric variation of surface atmosphere tide.

The file is output by the function [Spherical harmonic analysis on atmosphere tidal constituent harmonic constants]. The following figure is the first-degree atmosphere tidal load spherical harmonic coefficient file generated by the spherical harmonic analysis of 4 tidal constituent harmonic constants in the ECMWF-DCDA2006 atmosphere tide model.

frqadjlovekhl.txt | OtideOne.dat | AirtdOne.dat

```
  3.986004418    6378137.00
name Doodson          C10+            C10-            C11+            C11-            S11+            S11-
  S1 164.556 -0.32743062E-08  0.17656303E-08 -0.73961700E-08 -0.43747341E-07 -0.53408107E-07 -0.10739535E-08
  S2 273.555 -0.63038465E-09  0.13745086E-08  0.76856572E-10  0.52369957E-08  0.33909106E-08 -0.10867279E-08
  Sa  56.565  0.82104410E-07 -0.16159641E-06 -0.35242403E-07 -0.82907617E-08  0.35038132E-07 -0.12165492E-06
 Ssa  57.555  0.65276776E-08  0.64836812E-07 -0.35849594E-07 -0.25040842E-07  0.12768923E-07  0.24915570E-07
```

The file header inludes the geocentric gravitational constant GM ($\times 10^{14} m^3/s^2$) and equatorial radius a (m) of the Earth. The record (starting from the third row) includes the tidal constituent's name, Doodson constant, the degree-1 order-0 spherical harmonic coefficient C_{10}+ from in-phase amplitude, that C_{10}- from out-of-phase amplitude, and the degree-1 order-1 spherical harmonic coefficient C_{11}+ from in-phase amplitude, that C_{11}- from out-of-phase amplitude, and the degree-1 order-1 spherical harmonic coefficient S_{11}+ from in-phase amplitude, that S_{11}- from out-of-phase amplitude.