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Level 2 product: GOCE Precise Science Orbits

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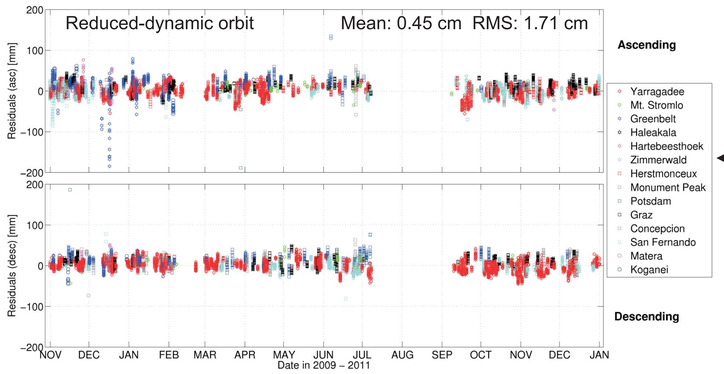
Introduction

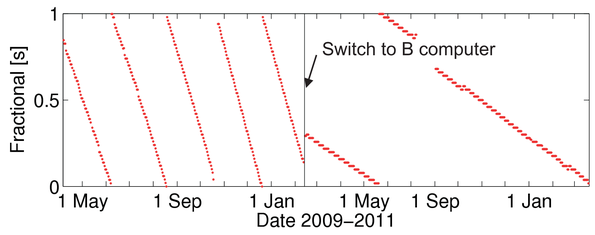
ESA's first Earth Explorer Core Mission GOCE is equipped with a 12-channel, dual-frequency GPS receiver (SSTI - satellite-to-satellite tracking instrument) for precise orbit determination, instrument time-tagging, and the determination of the long wavelength part of the Earth's gravity field. A precise science orbit (PSO) product with 2-cm accuracy is provided by the GOCE High-level Processing Facility (HPF) with a latency of one week for final analyses. Orbit validation results for the reduced-dynamic PSO obtained from almost two years of operations are presented. Characteristics of the GOCE GPS data are briefly discussed and the sub-products of the PSO are described.

Orbit quality - validation with SLR

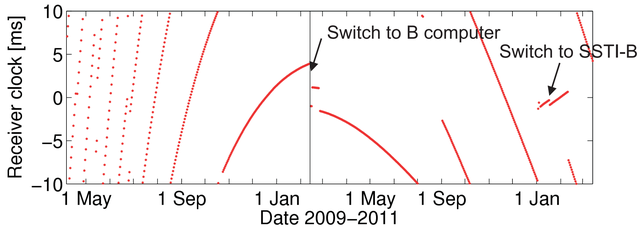


More details on orbit results and validation can be found at the poster "**Orbit validation for GOCE**" by Heinze et al.(2011)

Observation epochs and receiver clock



The internal clock is not steered to integer seconds and the observation epochs have, therefore, fractional offsets (shown at the midnight epochs). These fractional offsets stayed constant for about 25-27h and then jumped by 20ms. This behaviour changed after the switch to the redundant onboard computer B mid of Feb 2010. The time interval for a constant fractional offset is extended to 5-6 days.



The receiver clock (shown at the midnight epochs) varies between -10ms and +10ms. The variations from one day to the next have been larger at the beginning of the mission. The switch to SSTI-B from 6 Jan to 9 Feb, 2011 is clearly visible.

Sub-products of the SST_PSO

SST_PRD: reduced-dynamic orbit, 10 s sampling, sp3-format

SST_PKI: kinematic orbit, 1 s sampling

SST_PCV: covariance matrix of kinematic orbit, covariances over +/- 4 epochs

SST_PRM: quaternions for the rotation from Earth fixed to Inertial reference frame

SST_PRP: quality report (pdf-format)

SST_PRD

```
#cV2010 12  1  0  0  0.00000000    8640 u     IGS05 FIT AIUB
## 1612 259200.00000000   10.00000000 55531 0.0000000000000
+    1   L15  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
%c L  cc GPS ccc cccc cccc cccc cccc cccc cccccc cccccc cccccc cccccc
%c cc cc ccc ccc cccc cccc cccc cccc cccccc cccccc cccccc cccccc
%f  1.2500000  1.025000000  0.00000000000  0.000000000000000
%f  0.0000000  0.000000000  0.00000000000  0.000000000000000
%i    0    0    0    0      0      0      0      0         0
%i    0    0    0    0      0      0      0      0         0
/* GOCE Precise Science Orbit
/* Reduced-dynamic orbit, day 335, year 2010
/* IAPG/AIUB
/*
*  2010 12  1  0  0  0.00000000
PL15   1105.300921  -6534.696237   -365.828354 999999.999999
VL15 -12909.952645  -6414.077953  76889.218128 999999.999999
*  2010 12  1  0  0 10.00000000
PL15   1092.311666  -6540.656438   -288.915846 999999.999999
VL15 -13068.042901  -5506.145400  76934.046359 999999.999999
...
```

GOCE position in x,y,z [km] Earth-fixed reference frame

GOCE velocity in x,y,z [dm/s] Earth-fixed reference frame

SST_PKI

```
#cP2010 12  1  0  0  0.38220000   85920 ZERO  IGS05 KIN AIUB
## 1612 259200.38220000     1.00000000 55531 0.0000044236111
+    1   L15  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
+          0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
++         0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
%c L  cc GPS ccc cccc cccc cccc cccc cccc cccccc cccccc cccccc cccccc
%c cc cc ccc ccc cccc cccc cccc cccc cccccc cccccc cccccc cccccc
%f  1.2500000  1.025000000  0.00000000000  0.000000000000000
%f  0.0000000  0.000000000  0.00000000000  0.000000000000000
%i    0    0    0    0      0      0      0      0         0
%i    0    0    0    0      0      0      0      0         0
/* GOCE Precise Science Orbit
/* Kinematic orbit, day 335, year 2010
/* IAPG/AIUB
/*
*  2010 12  1  0  0  0.38217773
PL15   1104.807420  -6534.940713   -362.889775-382177.732082
*  2010 12  1  0  0  1.38217774
PL15   1103.515017  -6535.574115   -355.200415-382177.734736
*  2010 12  1  0  0  2.38217774
PL15   1102.221021  -6536.198436   -347.510570-382177.737405
*  2010 12  1  0  0  3.38217774
PL15   1100.925444  -6536.813690   -339.820247-382177.740047
...
```

SSTI measurement epoch + clock correction*10^{-6} = nominal epoch

2010 12 1 0 0 0.000

GOCE position in x,y,z [km] Earth-fixed reference frame

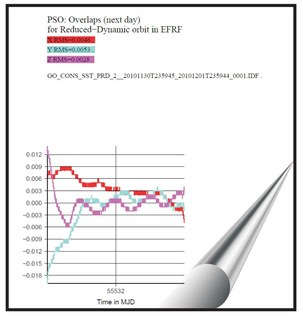
The epochs given in the SST_PKI-file are the true SSTI measurement epochs.

SST_PRM

```
# TRANSFORMATION:                GO_CONS_SST_PRM_2__20101130T235945_20101201T235944_0001.IDF
# Program that created the file: BERNESE/ROTMAT
# Date of creation:              2011-01-05 07:06:47
# Reference epoch:               2010-12-01 00:00:00 GPS
# First epoch:                   2010-12-01 00:00:00 GPS
# Transformation direction:      Earth-fixed to inertial
# Pole file:                     G3_10335
# Nutation model:                IAU2000
# Nutation offsets:              not applied
# Subdaily model:                IERS2000
# End of header
       0 -0.0003107872919878 -0.0004476827755134 -0.5702893699800141  0.8214436909972551
       1 -0.0003108036683785 -0.0004476714284237 -0.5703193199103925  0.8214228973727984
       2 -0.0003108200443559 -0.0004476600807388 -0.5703492690826034  0.8214021026563639
       3 -0.0003108364199201 -0.0004476487324587 -0.5703792174966080  0.8213813068479786
       4 -0.0003108527950712 -0.0004476373835834 -0.5704091651523652  0.8213605099476710
       5 -0.0003108691698090 -0.0004476260341128 -0.5704391120498349  0.8213397119554687
       6 -0.0003108855441335 -0.0004476146840472 -0.5704690581889785  0.8213189128713989
       7 -0.0003109019180447 -0.0004476033333863 -0.5704990035697554  0.8212981126954896
       8 -0.0003109182915427 -0.0004475919821303 -0.5705289481921262  0.8212773114277683
       9 -0.0003109346646273 -0.0004475806302792 -0.5705588920560514  0.8212565090682622
      10 -0.0003109510372986 -0.0004475692778329 -0.5705888351614898  0.8212357056170000
      11 -0.0003109674095565 -0.0004475579247917 -0.5706187775084069  0.8212149010740056
.....
```

Quaternions q1, q2, q3, q4=scalar

SST_PRP



Example page from the SST_PRP

SST_PCV

```
# VARIANCE-COVARIANCE MATRIX: GO_CONS_SST_PCV_2__20101130T235945_20101201T235944_0001.IDF
# Corresponding kinematic orbit: GO_CONS_SST_PKI_2__20101130T235945_20101201T235944_0001.IDF
# Program that created the file: BERNESE/CUTCOV
# Date of creation:              2011-01-05 07:06:35
# First epoch:                   2010-11-30 23:59:51 GPS
# Time step size (seconds):                  1
# RMS of unit weight:                   0.0017
# Parameters:                    X, Y, Z
# End of header
     1     1 8.1724549E-06
     2     1-2.2601333E-06
     2     2 4.3979666E-05
     3     1-6.2950148E-07
     3     2 4.7807501E-06
     3     3 6.8161925E-06
     5    -3 7.2347980E-07
     5    -2-5.1435469E-08
     5    -1-1.3695615E-07
     5     1 7.2355086E-07
     ...
    33    17 7.2433735E-07
    33    18-5.1267767E-08
    33    19-1.3730200E-07
    33    21 7.2440900E-07
    33    22-5.1133519E-08
    33    23-1.3729992E-07
    33    25 7.2448076E-07
    33    26-5.0999348E-08
    33    27-1.3729786E-07
    33    29 7.2455261E-07
    33    30-5.0865255E-08
    33    31-1.3729583E-07
    33    33 8.1866694E-06
    34    17-5.0443214E-08
    34    18 1.1585541E-06
    34    19 1.1852921E-07
    34    21-5.0515136E-08
    34    22 1.1585987E-06
    34    23 1.1867129E-07
    ...
```

iepo =1

=> icomp 1,2,3

iepo =10 => 2010-12-01 00:00:00

icomp = 1 => X

index = 4*(iepo-1)+icomp

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The epochs in the SST_PCV-file have to be interpreted as 'nominal epochs'. These 'nominal epochs' are obtained by adding back the clock correction to the estimated SSTI measurement epoch.

Poster compiled by H. Bock, March 2011
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