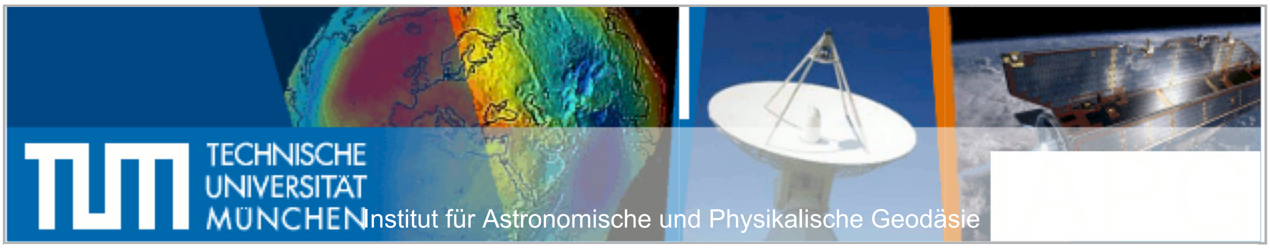
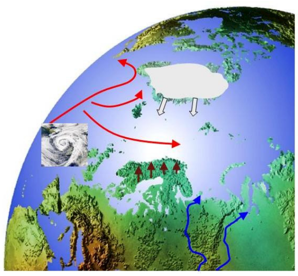


Monitoring and Modelling individual Sources of Mass Distribution and Transport in the Earth System by Means of Satellites

Project Partners

- Institute of Astronomical and Physical Geodesy, Technical University Munich, Germany
- Bristol Glaciology Centre, University of Bristol, United Kingdom
- Department of Physical Geography, Utrecht University, The Netherlands
- Deutsches GeoForschungsZentrum Potsdam, Germany
- University of Luxembourg, Luxembourg
- Delft Institute of Earth Observation and Space Systems, Delft University of Technology, The Netherlands

Introduction:



In 2006 the European Space Agency (ESA) initiated a study on “Monitoring and Modelling individual Sources of Mass Distribution and Transport in the Earth System by Means of Satellites”. The goal of this interdisciplinary study was to create as realistic as possible simulated time variable gravity fields based on coupled geophysical models, which could be used in the simulation processes in a controlled environment. For this purpose global atmosphere, ocean, continental hydrology and ice models were used. The coupling was performed by using consistent forcing throughout the models and by including water flow between the different domains of the Earth system. In addition gravity field changes due to solid Earth processes like continuous glacial isostatic adjustment (GIA) and a sudden earthquake with co-seismic and post-seismic signals were modelled. All individual model results were combined and converted to gravity field spherical harmonic series, which is the quantity commonly used to describe the Earth's global gravity field. The result of this study is a twelve-year time-series (1995 to 2006) of 6-hourly time variable gravity field spherical harmonics up to degree and order 180 corresponding to a global spatial resolution of 1 degree in latitude and longitude. On this Website the resulting time series is made available to the public.

Data Files:

Various combinations of mass fields were computed and converted to gravity field spherical harmonics. Details are described in the reference given below. 6-hourly gravity potential spherical harmonics for each data combination scenario are combined to yearly batches (see following table). All together 60 files are available.

Data Combination	Identifier Data Archive
Atmosphere only	[yyyy]_A.tar.gz
Atmosphere & Ocean	[yyyy]_AO.tar.gz
Atmosphere & Ocean & Hydrology	[yyyy]_AOH.tar.gz
Atmosphere & Ocean & Hydrology & Ice	[yyyy]_AOHI.tar.gz

Atmosphere & Ocean & Hydrology & Ice & Solid-Earth	[yyyy]_AOHIS.tar.gz

[yyyy] = Year (e.g. 1995)

Format Description:
The format of the gravity potential spherical harmonic series follows the conventions used by the International Center for Global Earth Models (ICGEM) see: http://icgem.gfz-potsdam.de/ICGEM/ICGEM.html

The ICGEM-format accommodates

- Earth Gravity Field models in terms of spherical harmonic coefficients and
- Ocean and Atmosphere Tides.

Each individual data file consists of two sections:

1. The header containing parameters which do not depend on degree l and order m. The end of the header is marked by the keyword "end_of_head" (as a separator between header and data section)
2. The data section with the list of degree- and order-dependent parameters

The records have the following basic structure:

- The basic structure of the record lines is unformatted, i.e. separators are blanks and/or tabs
- Each record consists of one keyword followed by one or more parameters (numbers or characters), which are separated by one or an arbitrary number of blanks and/or tabs,
- The number of parameters depends on the corresponding keyword as defined below,
- There are mandatory and optional records,
- All lines led by non-defined keywords are comments,
- In any line, additional characters and/or numbers beyond the last parameter are allowed as comments.
- Leading and trailing blanks are ignored.

File name convention:

shs_XXXXX_YYYYMMDD_HH.NNN

- XXXXX = A, AO, AOH, AOHI, or AOHIS
- YYYY = Year (4 digits)
- MM = Month (2 digits)
- DD = Day (2 digits)
- HH = Hour (2 digits: 00, 06, 12, or 18)
- NNN = Maximum Degree and Order

Header section:

keyword (mandatory records)	number of parameters	meaning of parameters
product_type	1	"gravity_field"
modelname	1	name of the model

earth_gravity_constant	1	gravitational constant times mass of the earth [m^3/s^2]
radius	1	reference radius of the spherical harmonic development [
max_degree	1	maximum degree of the spherical harmonic development
errors	1	either "no", "calibrated" or "formal" or “calibrated_and_formal” errors included
norm	1	either "fully_normalized" or "unnormalized"
tide_system	1	either "zero_tide", "tide_free" or "unknown"
end_of_head	0	Position of keyword defines the end of the header

Data section:

There are defined three types of spherical harmonic series coefficients in this format:

- gfc: static coefficient
- gfct: coefficient valid for a specific time
- dot: time derivative of coefficient

Spherical harmonic series for the mass variations are valid for a specific time. The date is implicitly defined by the file name convention. Therefore these products only contain coefficients with keyword “gfc”.

keyword (optional records)	**number of parameters**	**meaning of the parameters**
gfc	6(*)	degree, order, Clm, Slm, sigmaC sigmaS
gfc	8(**)	degree, order, Clm, Slm, sigmaC_cal, sigmaS_cal, sigmaC_formal, sigmaS_formal
gfc	4(***)	degree, order, Clm, Slm
gfct	7(*)	degree, order, Clm, Slm, sigmaC, sigmaS, time (yyyymmdd)
gfct	9(**)	degree, order, Clm, Slm, sigmaC_cal, sigmaS_cal, sigmaC_formal, sigmaS_formal, time (yyyymmdd)
gfct	5(***)	degree, order, Clm, Slm, time (yyyymmdd)
dot	6(*)	degree, order, dClm/dt, dSlm/dt, sigmaCdot, sigmaSdot
dot	8(**)	degree, order, dClm/dt, dSlm/dt, sigmaCdot_cal, sigmaSdot_cal, sigmaCdot_formal, sigmaSdot_formal,
dot	4(***)	degree, order, dClm/dt, dSlm/dt

(*) = in the case of errors = "calibrated" or "formal" in the header
(**) = in the case of errors = “calibrated_and_formal” in the header
(***) = in the case of errors = "no" in the header

Example for file shs_A_19950117_06.180:

```
product_type                 gravity_field
modelname                    dealias_ecmwf_ocm_date
earth_gravity_constant        0.39860050000000D+15
radius                       6378137.0000
max_degree                    180
errors                       no
```

```
norm                          fully normalized
tide_system                   unknown
end_of_head
gfc      0    0  0.61909736798767D-10  0.00000000000000D+00
gfc      1    0  0.20081137834687D-09  0.00000000000000D+00
gfc      1    1  0.42153249840457D-09 -0.10001823909712D-09
gfc      2    0 -0.13263906448879D-09  0.00000000000000D+00
gfc      2    1 -0.68851368409159D-10  0.33706748997037D-09
gfc      2    2  0.34980032669709D-10  0.17818798083341D-09
gfc      3    0 -0.37024758943344D-10  0.00000000000000D+00
gfc      3    1  0.31339897801848D-09  0.88054066930472D-10
gfc      3    2 -0.54893227913781D-10  0.28623592343905D-10
gfc      3    3 -0.53538457820075D-10 -0.21608783842442D-11
gfc      4    0 -0.11561953966016D-09  0.00000000000000D+00
gfc      4    1  0.31520927511642D-10  0.11144809694184D-09
gfc      4    2  0.17763664102010D-10  0.34430620707771D-10
gfc      4    3 -0.61268626447738D-11 -0.21843447625585D-10
.
.
```

Downloads:
Each file is a compressed tar archive with about 480 MB file size:

1995				
1995_A	1995_AO	1995_AOH	1995_AOHI	1995_AOHIS
1996				
1996_A	1996_AO	1996_AOH	1996_AOHI	1996_AOHIS
1997				
1997_A	1997_AO	1997_AOH	1997_AOHI	1997_AOHIS
1998				
1998_A	1998_AO	1998_AOH	1998_AOHI	1998_AOHIS
1999				
1999_A	1999_AO	1999_AOH	1999_AOHI	1999_AOHIS
2000				
2000_A	2000_AO	2000_AOH	2000_AOHI	2000_AOHIS
2001				
2001_A	2001_AO	2001_AOH	2001_AOHI	2001_AOHIS
2002				
2002_A	2002_AO	2002_AOH	2002_AOHI	2002_AOHIS
2003				
2003_A	2003_AO	2003_AOH	2003_AOHI	2003_AOHIS
2004				
2004_A	2004_AO	2004_AOH	2004_AOHI	2004_AOHIS
2005				
2005_A	2005_AO	2005_AOH	2005_AOHI	2005_AOHIS
2006				
2006_A	2006_AO	2006_AOH	2006_AOHI	2006_AOHIS

Reference:
A complete description of the geophysical models implementation and the data combination is given in:

Th. Gruber, J. L. Bamber, M.F.P. Bierkens, H. Dobslaw, M. Murböck, M. Thomas, L.P.H. van Beek, T. van Dam, L.L.A. Vermeersen, P.N.A.M Visser (2011), Simulation of the time-variable gravity field by means of coupled geophysical models; submitted to Earth System Science Data; Discussion Paper available at: http://www.earth-syst-sci-data-discuss.net/4/27/2011/essdd-4-27-2011.html