

# The ICGEM-format

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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 **comment-section** which starts at the beginning and ends with the keyword "begin\_of\_head" (as a separator between the comment section and the header). The keyword "begin\_of\_head" is optional (to stay compatible with earlier versions). Without "begin\_of\_head" no explicit comment section is defined.
2. The **header** which contains 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). Without any keyword "begin\_of\_head" the header starts at the beginning of the file.
3. The **data section** with the list of degree- and order-dependent parameters.

The records in the header and the data section have the following basic structure:

- The record lines are 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 beginning with non-defined keywords are comments (for longer comments it is safer to define a separate comment section using the keyword "begin\_of\_head").
- In any line, additional characters and/or numbers beyond the last parameter are allowed as comments.
- Leading and trailing blanks are ignored.

## Earth Gravity Field Models

### Header section:

mandatory keywords	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
radius	1	reference radius of the spherical harmonic development
max_degree	1	maximum degree of the spherical harmonic development
errors	1	either "no", "calibrated", "formal" or both "calibrated_and_formal" errors are included
end_of_head	0	The position of this keyword defines the end of the header

optional keywords	number of parameters	meaning of parameters
begin_of_head	0	position of keyword defines the begin of the header (all previous lines are comments; such comments are safer than comments within the keyword-section which simply do not start with a keyword sequence)
tide_system	1	either "zero_tide", "tide_free" or "unknown" (default)
norm	1	either "fully_normalized" (=default) or "unnormalized"

### **Data section:**

optional keyword	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)
trnd <sup>1</sup>	6(*)	degree, order, trend_C, trend_S, sigma_trend_C, sigma_trend_S
trnd <sup>1</sup>	8(**)	degree, order, trend_C, trend_S, sigma_trend_C_cal, sigma_trend_S_cal, sigma_trend_C_formal, sigma_trend_S_formal,
trnd <sup>1</sup>	4(***)	degree, order, trend_C, trend_S
asin	7(*)	degree, order, sine_amplitude_C, sine_amplitude_S, sigma_sine_amplitude_C, sigma_sine_amplitude_S, period
asin	9(**)	degree, order, sine_amplitude_C, sine_amplitude_S, sigma_sine_amplitude_C_cal, sigma_sine_amplitude_S_cal, sigma_sine_amplitude_C_formal, sigma_sine_amplitude_S_formal, period
asin	5(***)	degree, order, sine_amplitude_C, sine_amplitude_S, period
acos	7(*)	degree, order, cosine_amplitude_C, cosine_amplitude_S, sigma_cosine_amplitude_C, sigma_cosine_amplitude_S, period
acos	9(**)	degree, order, cosine_amplitude_C, cosine_amplitude_S, sigma_sine_amplitude_C_cal, sigma_sine_amplitude_S_cal, sigma_sine_amplitude_C_formal, sigma_sine_amplitude_S_formal, period
acos	5(***)	degree, order, cosine_amplitude_C, cosine_amplitude_S, period

(\*) – 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 – knn

<sup>1</sup> – the keyword "dot" is still allowed due to backward compatibility

The keywords "trnd", "asin" and "acos" require a corresponding keyword "gfct".

**Example:**

This is an example.  
Here could be some comment, e.g. references and/or description of  
the calculation method of the model

For each gravity parameter G of degree l and order m  
(i.e. for each spherical harmonic coefficient Clm or Slm)  
until degree l=50 six mean parameters has been estimated:

coefficient at reference time t=t0: G(t0)  
linear trend: trnd  
amplitude for sine oscillation with period p1: asin1  
amplitude for cosine oscillation with period p1: acos1  
amplitude for sine oscillation with period p2: asin2  
amplitude for cosine oscillation with period p2: acos2  
  
p1 is the annual period: p1 = 1.0 y  
p2 is the semiannual period: p2 = 0.5 y

The final, cumulated equation, contains six parameters for each coefficient  
until degree 50: G(t0), trnd, asin1, acos1, asin2, acos2);  
and one parameter per coefficient from degree 51 to 370.  
All parameters are solved-for in one run.

To calculate a gravity field functional from this model, the coefficients G=G(t)  
up to degree 50 have to be calculated for the corresponding time point t  
by the formula:

$$G(t)=G(t_0) + trnd*(t-t_0) + asin1*\sin(2\pi/p_1 * (t-t_0)) + acos1*\cos(2\pi/p_1 * (t-t_0)) + asin2*\sin(2\pi/p_2 * (t-t_0)) + acos2*\cos(2\pi/p_2 * (t-t_0))$$

The reference time t0 is: t0 = 2005.0 y

begin\_of\_head =====

```
product_type    gravity_field
modelname       EXAMPLE_MODEL
earth_gravity_constant  0.3986004415E+15
radius          0.6378136460E+07
max_degree      370
errors          formal
```

key	L	M	C	S	sigma C	sigma S	t0 [yyyymmdd] period [y]
end_of_head	=====						
gfc	0	0	1.000000000000e+00	0.000000000000e+00	0.0000e+00	0.0000e+00	
gfc	1	0	0.000000000000e+00	0.000000000000e+00	0.0000e+00	0.0000e+00	
gfct	2	0	-4.84165299806e-04	0.000000000000e+00	1.9482e-13	0.0000e+00	20050101
trnd	2	0	-1.26060242677e-11	0.000000000000e+00	3.2284e-14	0.0000e+00	
acos	2	0	4.10012162817e-11	0.000000000000e+00	1.8915e-13	0.0000e+00	1.0
asin	2	0	5.32328946063e-11	0.000000000000e+00	1.9618e-13	0.0000e+00	1.0
acos	2	0	3.33917546745e-11	0.000000000000e+00	1.8829e-13	0.0000e+00	0.5
asin	2	0	-2.44339926664e-11	0.000000000000e+00	1.9158e-13	0.0000e+00	0.5
gfct	3	0	9.57211211877e-07	0.000000000000e+00	1.6575e-13	0.0000e+00	20050101
trnd	3	0	-8.37409795344e-12	0.000000000000e+00	5.0047e-14	0.0000e+00	
acos	3	0	-1.76060539636e-11	0.000000000000e+00	2.2776e-13	0.0000e+00	1.0
asin	3	0	9.47586646659e-11	0.000000000000e+00	2.2725e-13	0.0000e+00	1.0
acos	3	0	1.06250666438e-11	0.000000000000e+00	1.8607e-13	0.0000e+00	0.5
asin	3	0	-9.12652655373e-12	0.000000000000e+00	1.8757e-13	0.0000e+00	0.5
gfct	4	0	5.39990171043e-07	0.000000000000e+00	6.2820e-14	0.0000e+00	20050101
trnd	4	0	1.24828057445e-12	0.000000000000e+00	2.8139e-14	0.0000e+00	
acos	4	0	-7.55236874480e-12	0.000000000000e+00	7.4141e-14	0.0000e+00	1.0
asin	4	0	-3.50320360424e-12	0.000000000000e+00	7.2096e-14	0.0000e+00	1.0
acos	4	0	8.17774288320e-12	0.000000000000e+00	7.4031e-14	0.0000e+00	0.5
asin	4	0	-1.53703748172e-11	0.000000000000e+00	7.3160e-14	0.0000e+00	0.5
gfct	5	0	6.86846086922e-08	0.000000000000e+00	4.4587e-14	0.0000e+00	20050101
trnd	5	0	-5.03351696812e-12	0.000000000000e+00	2.0154e-14	0.0000e+00	
acos	5	0	5.08662560512e-12	0.000000000000e+00	5.2391e-14	0.0000e+00	1.0
asin	5	0	-1.05985537206e-10	0.000000000000e+00	5.1024e-14	0.0000e+00	1.0
acos	5	0	2.22624185397e-12	0.000000000000e+00	5.2349e-14	0.0000e+00	0.5
asin	5	0	8.82192224350e-13	0.000000000000e+00	5.1716e-14	0.0000e+00	0.5.
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gfct	27	27	8.06120329239e-09	1.06608226493e-09	2.2844e-13	2.2826e-13	20050101
trnd	27	27	3.67098016238e-13	2.27158968548e-13	7.3838e-14	7.3724e-14	
acos	27	27	8.91937468847e-14	7.77803575847e-13	1.7863e-13	1.7852e-13	1.0
asin	27	27	-8.51683023418e-13	4.34767822873e-13	1.7514e-13	1.7498e-13	1.0
acos	27	27	5.06913063717e-13	-2.32657020141e-13	1.7766e-13	1.7742e-13	0.5
asin	27	27	1.89774541915e-13	-1.45928916924e-13	1.7583e-13	1.7582e-13	0.5
gfct	28	27	-8.03143232828e-09	1.20703195531e-09	2.7913e-13	2.7915e-13	20050101
trnd	28	27	-2.00166443528e-13	-3.93373011285e-13	1.0621e-13	1.0623e-13	
acos	28	27	7.34123111437e-13	-6.81259850564e-13	2.5327e-13	2.5322e-13	1.0
asin	28	27	4.90821907582e-13	-1.59350550219e-13	2.4966e-13	2.4972e-13	1.0
acos	28	27	1.08483587687e-12	-1.72429171568e-13	2.5241e-13	2.5231e-13	0.5
asin	28	27	-7.06527907663e-13	1.53301500544e-12	2.5024e-13	2.5035e-13	0.5
gfct	29	27	-7.73381038494e-09	-7.12599251556e-10	2.2397e-13	2.2400e-13	20050101
trnd	29	27	7.45731672960e-14	-1.88010301771e-13	7.8838e-14	7.8851e-14	
acos	29	27	1.26344942042e-14	-1.71165107390e-14	1.8983e-13	1.8991e-13	1.0
asin	29	27	-7.34314665050e-13	-4.01985361372e-13	1.8657e-13	1.8667e-13	1.0
acos	29	27	2.49158864776e-16	1.10238884087e-13	1.8895e-13	1.8908e-13	0.5
asin	29	27	-1.02102111285e-12	-5.40708657982e-13	1.8721e-13	1.8722e-13	0.5
gfct	30	27	-7.72874025980e-09	1.25541295052e-08	1.8714e-13	1.8715e-13	20050101
trnd	30	27	-1.87538029519e-13	1.82696340981e-13	7.2002e-14	7.2011e-14	
acos	30	27	7.59741523741e-13	-8.97191941982e-14	1.7319e-13	1.7315e-13	1.0
asin	30	27	6.03260716490e-13	3.53437864527e-13	1.7051e-13	1.7057e-13	1.0
acos	30	27	1.03533466862e-12	2.86879182500e-13	1.7253e-13	1.7248e-13	0.5
asin	30	27	7.07570156865e-14	3.97615584293e-13	1.7097e-13	1.7105e-13	0.5
gfct	31	27	-1.13744297023e-09	1.10316027212e-08	2.3031e-13	2.3047e-13	20050101
trnd	31	27	7.40871533735e-14	1.21037257769e-13	6.8705e-14	6.8737e-14	
acos	31	27	5.71415899456e-13	4.20057832732e-14	1.6117e-13	1.6128e-13	1.0
asin	31	27	4.58757750487e-13	-5.00999874499e-14	1.5886e-13	1.5903e-13	1.0
acos	31	27	-6.77760455270e-14	-2.62483376992e-13	1.6062e-13	1.6071e-13	0.5
asin	31	27	-1.60638948013e-13	-4.30190569712e-13	1.5925e-13	1.5941e-13	0.5
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gfc	80	53	-6.98612520806e-10	-8.15476908997e-10	1.2825e-12	1.2831e-12	
gfc	81	53	1.92170808521e-09	-3.28956589348e-09	1.2497e-12	1.2506e-12	
gfc	82	53	9.31735484272e-10	9.51657560255e-10	1.3631e-12	1.3640e-12	
gfc	83	53	-4.49512933539e-10	2.35684623894e-09	1.3869e-12	1.3880e-12	
gfc	84	53	5.08987212551e-10	-4.97988534071e-11	1.4527e-12	1.4538e-12	
gfc	85	53	4.17659273146e-11	-1.13197887747e-09	1.5374e-12	1.5387e-12	
gfc	86	53	-2.70028498118e-10	4.50284895284e-10	1.5580e-12	1.5595e-12	
gfc	87	53	-1.41103157756e-10	1.64767302491e-10	1.6992e-12	1.7006e-12	
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gfc	370	366	-1.55480023415e-11	1.93505587305e-11	7.2077e-11	7.2076e-11	
gfc	367	367	-2.89431310483e-11	2.37374959911e-11	7.3543e-11	7.3542e-11	
gfc	368	367	9.03717109323e-13	6.91852047933e-13	7.3142e-11	7.3143e-11	
gfc	369	367	-1.14492738762e-11	2.63952107639e-11	7.2747e-11	7.2748e-11	
gfc	370	367	-3.64375144637e-12	1.15893956997e-11	7.2335e-11	7.2337e-11	
gfc	368	368	-2.54244519773e-11	-1.55400024226e-11	7.3386e-11	7.3385e-11	
gfc	369	368	8.26779522399e-13	1.90002206374e-11	7.2987e-11	7.2987e-11	
gfc	370	368	-6.27441636505e-12	2.23015857612e-11	7.2593e-11	7.2593e-11	
gfc	369	369	1.07090530321e-11	3.17611923497e-11	7.3230e-11	7.3232e-11	
gfc	370	369	2.44645105996e-11	-1.24447844022e-11	7.2832e-11	7.2833e-11	
gfc	370	370	-2.53164796379e-11	-1.72931830167e-11	7.3077e-11	7.3076e-11	

## Ocean/Atmosphere Tides

### Header section:

mandatory keywords	number of parameters	meaning of parameters
product_type	1	"ocean_tides"
modelname	1	name of the model
earth_gravity_constant	1	gravitational constant times mass of the earth
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" errors given
end_of_head	0	position of keyword defines the end of the header

optional keywords	number of parameters	meaning of parameters
begin_of_head	0	position of keyword defines the begin of the header (all previous lines are comments; such comments are safer than comments within the keyword-section which simply do not start with a keyword sequence)
norm	1	either "fully_normalized" (=default) or "unnormalized"
water_density	1	density of sea water [kg/m3] (default = 1025.0 )

### Data section:

optional keywords	number of parameters	meaning of parameters
lovr	2	degree, load love number
ocs	8(*)	degree, order, "pro" or "retro", Doodson number, Clm-coefficient, SIm-coefficient, sigmaC, sigmaS
ocs	6(**)	degree, order, "pro" or "retro", Doodson number, Clm-coefficient, SIm-coefficient
acs	8(*) / 6(**)	(dto. for atmosphere tide coefficients)
ccs	8(*) / 6(**)	(dto. for combined ocean/atmosphere tide coefficients)
oap	8(*)	degree, order, "pro" or "retro", Doodson number, Alm (amplitude), Plm (phase), sigmaA, sigmaP
oap	6(**)	degree, order, "pro" or "retro", Doodson number, Alm (amplitude), Plm (phase)
aap	8(*) / 6(**)	(dto. for atmosphere tide amplitude/phase)
cap	8(*) / 6(**)	(dto. for combined ocean/atmosphere tide amplitude/phase)

(\*) – in the case of errors = "calibrated" or "formal" in the header

(\*\*) – in the case of errors = "no" in the header

**Example:**

```
product_type      ocean_tides
modelname         EXAMPLE-MODEL
earth_gravity_constant 0.3986030000E+15
radius           0.6378160000E+07
water_density     1025.0
max_degree       6
errors           formal
norm             fully_normalized
```

end\_of\_head

```
=====
lovr 0  0.0000
lovr 1  -0.3075
lovr 2  -0.1950
lovr 3  -0.1320
lovr 4  -0.1032
lovr 5  -0.0892
lovr 6  -0.0820
ocs  2  1 pro  +135.655  -.699279379E+00  0.616931102E+00  0.1048E+00  0.1035E+00
oap  2  1 pro  +135.655  .933000000E+00  0.311400000E+03  0.0210E+00  0.1200E+01
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ocs  6  2 pro  +275.555  -.102235651E+00  0.489852820E-02  0.3575E-02  0.3308E-02
oap  6  2 pro  +275.5552 .102240000E+00  0.272700000E+03  0.1000E-03  0.4000E+00
```