ICGEM

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ICGEM - The International Centre for Global Earth Models

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ICGEM is one of six centres of the International Gravity Field Service (IGFS) of the International Association of Geodesy (IAG).
IGFS was established by theIAG-Executive Board at the General Assembly, 2003, and is an IAG “level-2” Service under IAG Commission 2

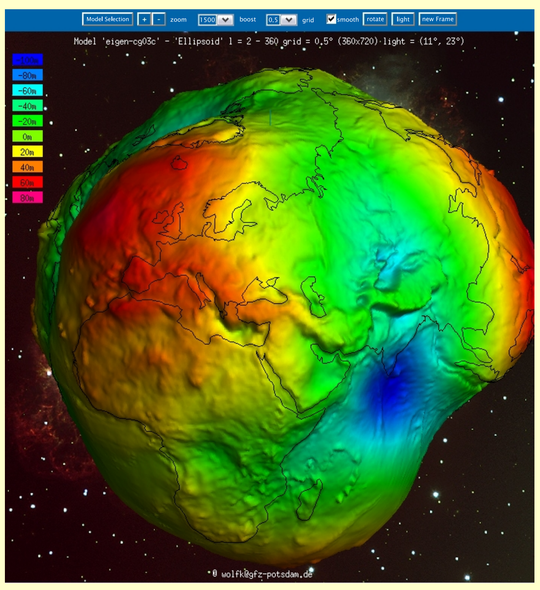
The main tasks of ICGEM
- collecting and archiving of global gravity field models of the Earth
- interactive visualisation of functionals of the models and differences of models
- interactive visualisation of time variation (e.g. monthly solutions of global models)
- calculation of functionals on arbitrary grids and providing the grids and plots
- evaluation of models

Models

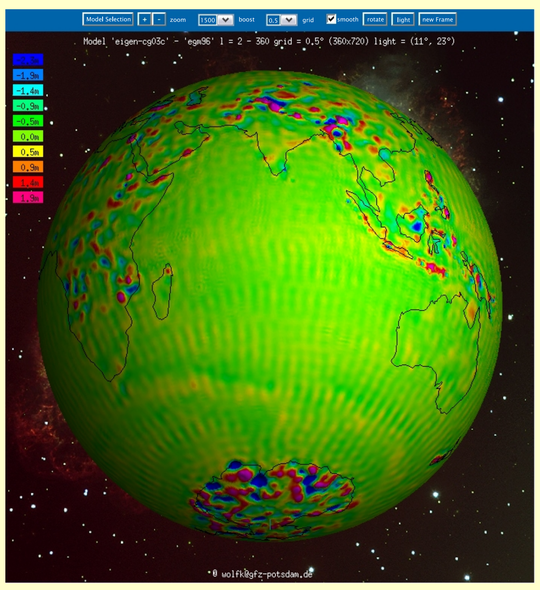
Model	Year	Degree	Data	Reference	d-load
GGM03S	2008	180	S(Grace)	Tapley et al, 2007	X
AIUB-GRACE01S	2008	120	S(Grace)	Jäggi et al, 2008	X
EIGEN-05S	2008	150	S(Grace,Lageos)	Förste et al, 2008	X
EIGEN-05C	2008	360	S(Grace,Lageos),G,A	Förste et al, 2008	X
EGM2008	2008	2190	S(Grace),G,A	Pavlis et al, 2008	X
ITG-Grace03	2007	180	S(Grace)	Mayer-Gürr et al, 2007	X
AIUB-CHAMP01S	2007	90	S(Champ)	Prange, L. et al, 2007	X
ITG-Grace02s	2006	170	S(Grace)	Mayer-Gürr et al, 2006	X
EIGEN-GL04S1	2006	150	S(Grace,Lageos)	Förste et al, 2006	X
EIGEN-GL04C	2006	360	S(Grace,Lageos),G,A	Förste et al, 2006	X
EIGEN-CG03C	2005	360	S(Champ,Grace),G,A	Förste et al, 2005c	X
GGM02C	2004	200	S(Grace),G,A	UTEX CSR, 2004	X
GGM02S	2004	160	S(Grace)	UTEX CSR, 2004	X
EIGEN-CG01C	2004	360	S(Champ,Grace),G,A	Reigber et al, 2006	X
EIGEN-CHAMP03S	2004	140	S(Champ)	Reigber et al, 2005b	X
EIGEN-GRACE02S	2004	150	S(Grace)	Reigber et al, 2005a	X
TUM-2S	2004	70	S(Champ)	Wermuth et al., 2004	X
DEOS_CHAMP-01C	2004	70	S(Champ)	Ditmar et al, 2006	X
ITG_Champ01K	2003	70	S(Champ)	Ilk et al, 2003	X
ITG_Champ01S	2003	70	S(Champ)	Ilk et al, 2003	X
ITG_Champ01E	2003	75	S(Champ)	Ilk et al, 2003	X
TUM-2Sp	2003	60	S(Champ)	Földvary et al, 2003	X
TUM-1S	2003	60	S(Champ)	Gerlach et al, 2003	X
GGM01C	2003	200	TEG4,S(Grace)	UTEX CSR, 2003	X
GGM01S	2003	120	S(Grace)	Tapley et al, 2003	X
EIGEN-GRACE01S	2003	140	S(Grace)	Reigber et al, 2003c	X
EIGEN-CHAMP03Sp	2003	140	S(Champ)	Reigber et al, 2004a	X
EIGEN-2	2003	140	S(Champ)	Reigber et al, 2003b	X
EIGEN-1	2002	119	S(Champ)	Reigber et al, 2003a	X
EIGEN-1S	2002	119	GRIM5,S	Reigber et al, 2002	X
PGM2000A	2000	360	S,G,A	Pavlis et al, 2000	X
TEG4	2000	180	S,G,A	Tapley et al, 2000	X
GRIM5C1	1999	120	S,G,A	Gruber et al, 2000	X
GRIM5S1	1999	99	S	Biancale et al, 2000	X
GRIM4S4G	1999	100	GRIM4S4,S(GFZ-1)	König et al, 1999	X
GFZ97	1997	359	PGM062w,G,A	Gruber et al, 1997b	
EGM96	1996	360	EGM96S,G,A	Lemoine et al, 1998	X
GFZ96	1996	359	PGM055,G,A	Gruber et al, 1997a	X
TEG3	1996	70	S,G,A	Tapley et al, 1997a	X
EGM96S	1996	70	S	Lemoine et al, 1998	X
GFZ95A	1995	360	GRIM4C4,G,A	Gruber et al, 1996	X
GRIM4C4	1995	72	S,G,A	Schwintzer et al, 1997	
GRIM4S4	1995	70	S	Schwintzer et al, 1997	X
JGM3	1994	70	S,G,A	Tapley et al, 1996	X
JGM2	1994	70	S,G,A	Nerem et al, 1994a	X
JGM2S	1994	60	S	Nerem et al, 1994a	X
GFZ93B	1993	360	GRIM4C3,G,A	Gruber et al, 1993b	
GFZ93A	1993	360	GRIM4C3,G,A	Gruber et al, 1993b	X
JGM1	1993	70	S,G,A	Nerem et al, 1994a	
JGM1S	1993	60	S	Nerem et al, 1994a	X
OGE12	1992	360	GRIM4C2,G,A	Gruber et al, 1993a	
GRIM4C3	1992	60	S,G,A	Schwintzer et al, 1993	
GRIM4S3	1992	60	S	Schwintzer et al, 1993	X
OSU91A	1991	360	GEMT2,G,A	Rapp et al, 1991	X
GRIM4C2	1991	50	S,G,A	Schwintzer et al, 1992	X
GRIM4S2	1991	50	S	Schwintzer et al, 1992	X
GEMT3	1991	50	S,G,A	Lerch et al, 1992	X
GEMT3S	1991	50	S	Lerch et al, 1992	X
TEG2B	1991	54	S,G,A	Tapley et al, 1991	
TEG2	1990	54	S,G,A	Tapley et al, 1991	
GRIM4C1	1990	50	S,G,A	Schwintzer et al, 1991	X
GRIM4S1	1990	50	S	Schwintzer et al, 1991	X
GEMT2	1989	50	S,G,A	Marsh et al, 1990	X
GEMT2S	1989	50	S	Marsh et al, 1990	
TEG1	1988	50	S,G	Tapley et al, 1991	
OSU89B	1989	360	GEMT2,G,A	Rapp et al, 1990	X
OSU89A	1989	360	GEMT2,G,A	Rapp et al, 1990	X
GEMT1	1987	36	S	Marsh et al, 1988	X
OSU86F	1986	360	GEML2,G,A	Rapp et al, 1986b	X
OSU86E	1986	360	GEML2,G,A	Rapp et al, 1986b	X
OSU86D	1986	250	GEML2,G,A	Rapp et al, 1986a	
OSU86C	1986	250	GEML2,G,A	Rapp et al, 1986a	
GPM2	1984	200	GEML2,G,A	Wenzel, 1985	X
GRIM3L1	1984	36	S,G,A	Reigber et al, 1985	X
HAJELA84	1983	250	G	Hajela, 1984	
GPM1	1983	200	GEM9,G,A	Wenzel, 1985	
GRIM3B	1983	36	S,G,A	Reigber et al, 1983b	
GEML2	1982	20	S	Lerch et al, 1983	X
GRIM3	1981	36	S,G,A	Reigber et al, 1983a	X
OSU81	1981	180	GEM9,G,A	Rapp, 1981	X
GEM10C	1981	180	GEM10B,G,A	Lerch et al, 1981	
OSU78	1978	180	GEM9,G,A	Rapp, 1978	
GEM10B	1978	36	GEM10,A	Lerch et al, 1978	X
GEM10A	1978	30	GEM10,A	Lerch et al, 1978a	X
GEM10	1977	22	S,G	Lerch et al, 1979	X
GEM9	1977	20	S	Lerch et al, 1979	X
GRIM2	1976	23	S,G	Balmino et al, 1976b	X
GEM8	1976	25	S,G	Wagner et al, 1976	X
GEM7	1976	16	S	Wagner et al, 1976	X
HARMOGRAV	1975	36	G	Dimitrijevich, 1975	
GRIM1	1975	10	S	Balmino et al, 1976a	X
KOCH74	1974	15	S,G	Koch, 1974	X
GEM6	1974	16	S,G	Lerch et al, 1974	X
GEM5	1974	12	S	Lerch et al, 1974	X
OSU73	1973	20	GEM3,G	Rapp, 1973	X
SE3	1973	18	S,G	Gaposchkin, 1973	X
GEM4	1972	16	S,G	Lerch et al, 1972b	X
GEM3	1972	12	S	Lerch et al, 1972b	X
GEM2	1972	16	S,G	Lerch et al, 1972a	
GEM1	1972	12	S	Lerch et al, 1972a	
KOCH71	1971	11	S,G	Koch and Witte, 1971	X
KOCH70	1970	8	S,G	Koch and Morrison, 1970	X
SE2	1969	16	S,G	Gaposchkin and Lambeck, 1970	X
OSU68	1968	14	S,G	Rapp, 1968	X
SE1	1966	8	S	Lundquist and Veis, 1966	X

Visualisation

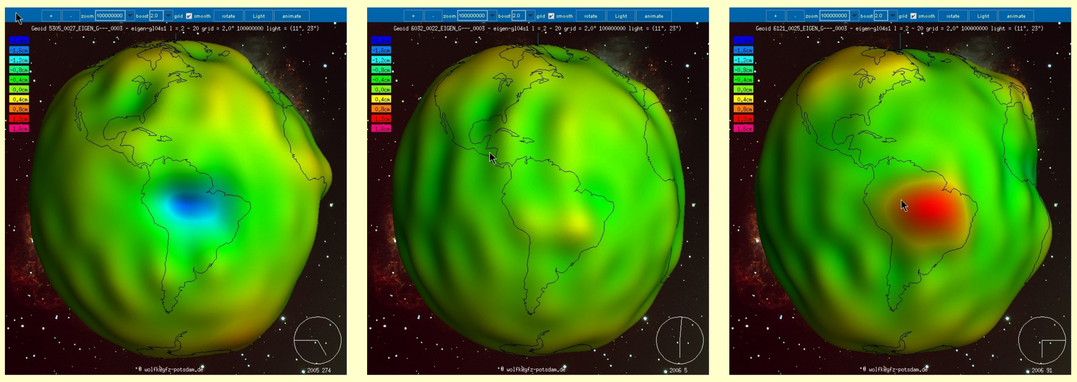
Models



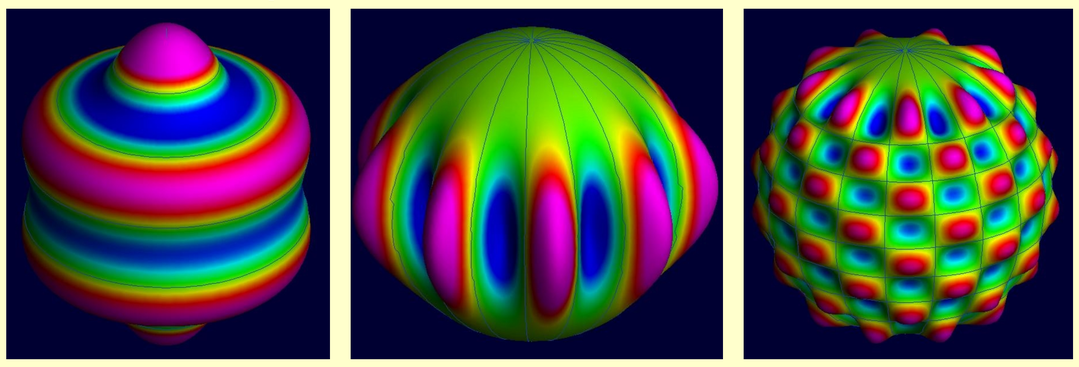
Differences



Animated Visualisation of Monthly Solutions



Spherical Harmonics as Tutorial



zonal: l = 6, m = 0 | sectorial: l = 9, m = 9 | tesseral: l = 16, m = 9

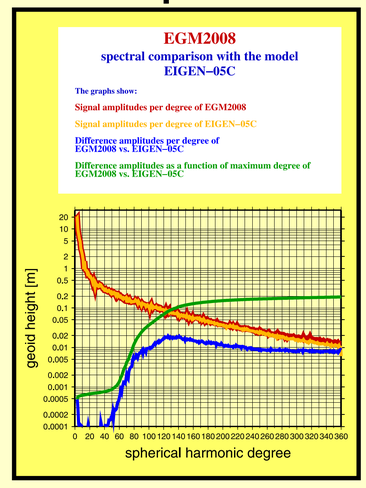
Evaluation

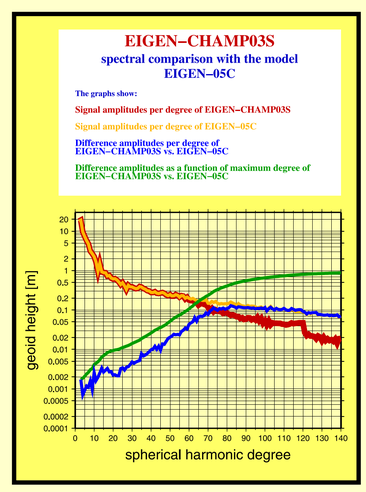
GPS / Levelling

Root mean square (rms) about mean of GPS / levelling minus gravity field model derived geoid heights [m]

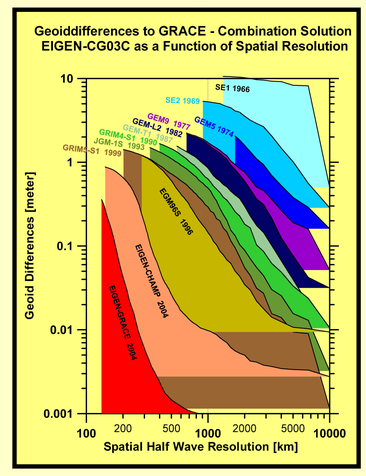
Model	Nmax	USA 6169	Canada 1930	Europe 1235	Australia 201
GGM03S-UPTO150	150	0.641	0.521	0.710	0.494
EIGEN-05C	360	0.341	0.251	0.303	0.244
AIUB-GRACE01S	120	0.724	0.628	0.930	0.563
EGM2008	2190	0.248	0.126	0.208	0.217
EIGEN-05S	150	0.630	0.547	0.737	0.475
ITG-GRACE03	180	0.633	0.557	0.658	0.603
AIUB-CHAMP01S	70	0.843	0.906	1.513	0.893
ITG-GRACE02S	170	0.623	0.511	0.639	0.489
EIGEN-GL04C	360	0.339	0.253	0.336	0.244
EIGEN-GL04S1	150	0.630	0.576	0.748	0.464
EIGEN-CG03C	360	0.346	0.306	0.355	0.260
GGM02C	200	0.473	0.378	0.515	0.376
GGM02S	160	0.977	1.116	1.416	1.356
EIGEN-CG01C	360	0.351	0.270	0.370	0.263
EIGEN-CHAMP03S	140	0.816	0.842	1.451	0.849
EIGEN-GRACE02S	150	0.739	0.643	0.828	0.538
TUM2S	60	0.864	0.963	1.639	1.101
DEOS_CHAMP-01C	70	0.813	0.887	1.499	0.886
ITG_CHAMP01K	70	0.841	0.881	1.574	0.944
ITG_CHAMP01S	70	0.908	0.941	1.529	0.979
ITG_CHAMP01E	75	0.802	0.839	1.470	0.806
TUM2SP	60	0.866	0.973	1.641	1.089
TUM1S	60	0.860	1.004	1.636	1.165
GGM01C	200	0.477	0.381	0.555	0.398
GGM01S	120	0.748	0.719	0.964	0.636
EIGEN-GRACE01S	140	0.765	0.705	0.936	0.553
EIGEN-CHAMP03SP	140	0.823	0.861	1.440	0.853
EIGEN2	140	0.966	1.080	1.655	1.074
EIGEN1	119	0.973	1.067	1.793	1.397
EIGEN1S	119	0.935	1.073	1.659	1.221
PGM2000A	360	0.381	0.364	0.483	0.286
TEG4	200	0.467	0.465	0.692	0.445
GRIM5C1	120	0.727	0.646	1.050	0.543
GRIM5S1	99	1.079	1.208	1.808	1.514
GRIM4S4G	70	1.313	1.174	2.053	1.783
EGM96	360	0.379	0.357	0.478	0.297
GFZ96	359	0.500	0.859	0.652	0.403
TEG3	70	0.828	1.059	1.506	0.949
EGM96S	70	1.118	1.122	1.927	1.507
GRIM4C4	72	0.859	1.051	1.595	0.923
GRIM4S4	70	1.371	1.268	2.069	1.771
JGM3	70	0.829	1.059	1.506	0.949
JGM2	70	0.824	1.072	1.509	0.930
JGM2S	70	1.300	1.199	2.141	1.787
GFZ93A	360	0.500	1.104	0.785	0.404
JGM1S	60	1.299	1.202	2.145	1.754
GRIM4S3	60	1.463	1.228	2.131	2.097
OSU91A	360	0.534	0.738	0.712	0.453
GRIM4C2	50	1.068	1.106	1.778	1.403
GRIM4S2	50	1.441	1.219	2.135	2.035
GEMT3	50	1.047	1.064	1.788	1.456
GEMT3S	50	1.440	1.253	2.345	2.042
GRIM4C1	50	1.097	1.167	1.778	1.390
GRIM4S1	50	1.617	1.299	2.235	2.201
GEMT2	50	1.474	1.303	2.373	2.112
OSU89B	360	0.637	0.905	0.806	0.434
OSU89A	360	0.624	0.867	0.795	0.429
GEMT1	36	1.710	1.462	2.639	2.394
OSU86E	360	0.470	1.458	1.219	0.459
OSU86F	360	0.490	1.501	1.292	0.465
GPM2	200	0.696	1.773	0.919	1.061
GRIM3L1	36	1.242	2.136	2.776	2.005
GEML2	30	2.181	2.343	3.115	2.367
GRIM3	36	1.683	3.953	2.965	2.700
OSU81	180	0.914	1.656	1.529	0.821
GEM10B	36	1.539	1.606	2.416	2.288
GEM10A	30	1.526	1.609	2.533	2.190
GEM10	30	2.207	1.892	2.690	2.509
GEM9	30	2.352	2.276	3.042	2.386
GRIM2	23	5.541	6.394	3.254	4.219
GEM8	25	1.619	2.052	2.436	1.826
GEM7	16	2.805	3.051	3.512	2.336
HARMOGRAV	36	2.251	2.772	3.871	6.993
GRIM1	31	4.030	7.214	9.112	6.885
KOCH74	15	18.039	10.880	10.670	9.566
GEM6	16	3.326	3.463	5.038	2.231
GEM5	12	4.548	4.531	3.473	4.227
OSU73	20	2.140	2.199	3.027	2.209
SE3	24	7.758	9.246	3.011	3.723
WGS72	28	2.971	2.237	3.529	2.984
GEM4	16	3.467	2.863	2.880	3.314
GEM3	12	5.225	4.443	3.336	3.954
GEM2	22	2.909	3.226	3.724	3.002
GEM1	22	4.180	4.692	3.166	3.447
KOCH71	11	17.180	10.335	12.103	11.822
KOCH70	8	15.781	12.880	10.682	13.335
SE2	22	3.898	4.986	4.434	3.326
OSU68	14	4.261	9.115	3.654	5.097
WGS66	24	3.205	5.325	3.361	3.983
SE1	15	3.895	4.851	8.351	3.833

Spectral Comparison



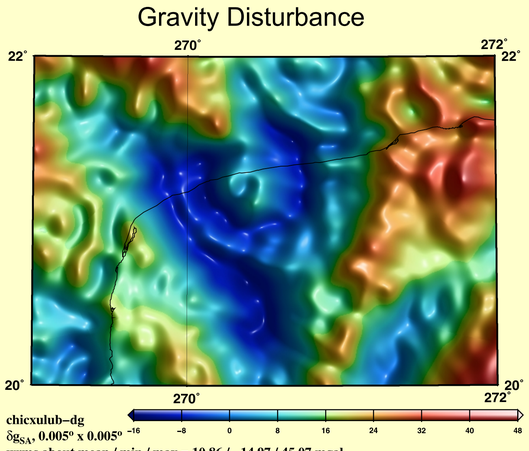


Accuracy Development of Satellite-only Models



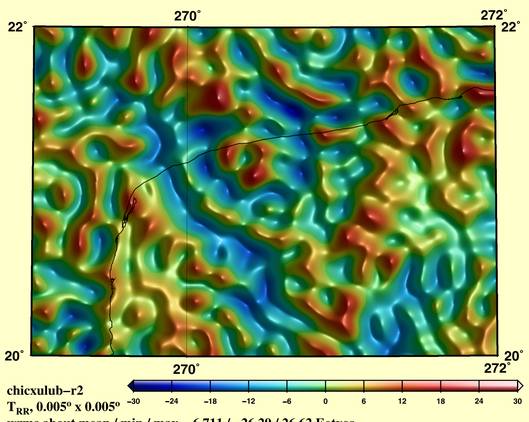
Calculation of Grids and Plots → Region of Interest - Different Functionals - Filtering - Adapted Plot-Projection

Gravity Disturbance



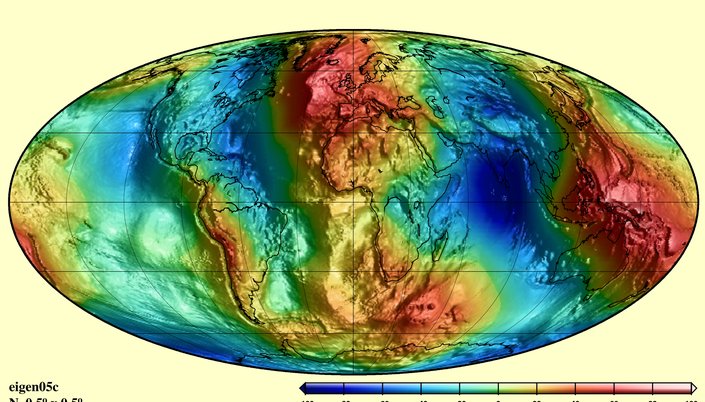
chicxulub–dg
δg_{SA}, 0.005° x 0.005°
wrms about mean / min / max = 10.86 / −14.97 / 45.07 mgal

Second Radial Derivative



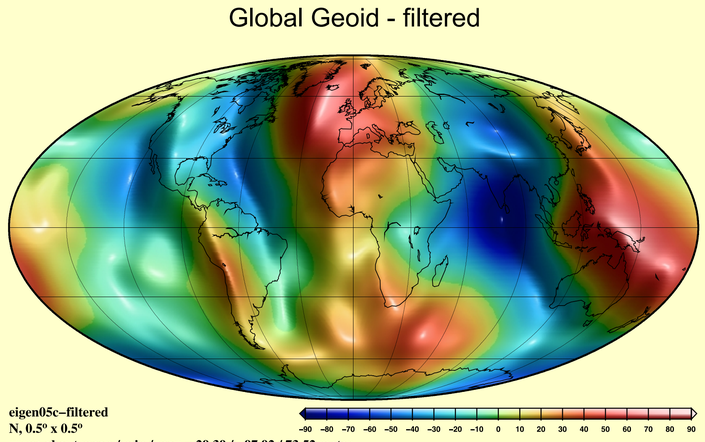
chicxulub–r2
T_{RR}, 0.005° x 0.005°
wrms about mean / min / max = 6.711 / −26.29 / 26.62 Eotvos

Global Geoid



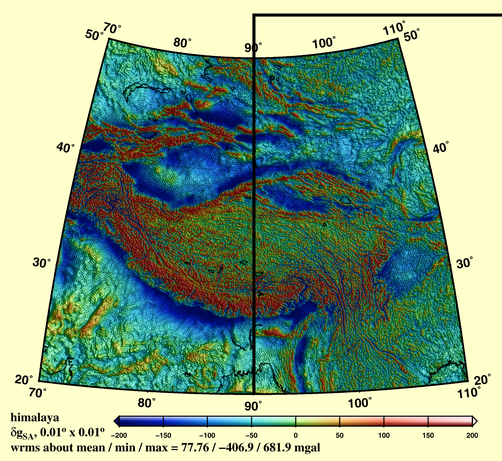
eigen05c
N, 0.5° x 0.5°
wrms about mean / min / max = 30.59 / −106.4 / 85.43 meter

Global Geoid - filtered



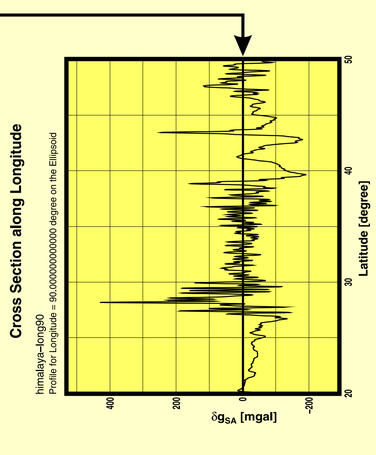
eigen05c–filtered
N, 0.5° x 0.5°
wrms about mean / min / max = 29.39 / −97.92 / 73.52 meter

Regional



himalaya
δg_{SA}, 0.01° x 0.01°
wrms about mean / min / max = 77.76 / −406.9 / 681.9 mgal

Cross Section



Self-explanatory Grid Format

```
********** Grid on the Ellipsoid **********
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   generating_date       2008/10/07
     product_type        gravity_field
         modelname       eigen-cg03c
  max_used_degree        360
       tide_system       tide_free
        functional       geoid
              unit       meter
         refsysname      wgs84
 zero_degree_term        included
           gmrefpot      3.986004418OOE+14 m**3/s**2
        radiusrefpot     6378137.000 m
        flatrefpot       3.352810664747480E-03   (1/298.257223563OO)
        omegarefpot      7.292115OOOOOE-05 1/s
      long_lat_unit      degree
     latitude_north      90.000000000000
     latitude_south      -90.000000000000
     longimit_west       0.500000000000
     longimit_east       360.000000000000
           gridstep      0.500000000000
 latitude_parallels      361
longitude_parallels      720
number_of_gridpoints     259920
          gapvalue       999.0000
     weighted_mean       -5.70110E-02 meter
          maxvalue       8.54289E+01 meter
          minvalue       -1.06417E+02 meter
       signal_wrms       1.05918E+01 meter
       grid_format       long_lat_value

        longitude    latitude      geoid
          [deg.]       [deg.]      [meter]
end_of_head ================================
            0.5000     90.0000     15.354123
            1.0000     90.0000     15.354123
            1.5000     90.0000     15.354123
   .
   .
   .
          359.5000      0.0000     17.665284
          360.0000      0.0000     17.671109
            0.5000     -0.5000     17.833854
            1.0000     -0.5000     17.734532
            1.5000     -0.5000     17.574483
   .
   .
   .
          359.0000    -90.0000    -29.008275
          359.5000    -90.0000    -29.008275
          360.0000    -90.0000    -29.008275
```

Functionals available in the Calculation Service

- height anomaly on the ellipsoid
- height anomaly
- geoid height
- gravity anomaly (in spherical approximation)
- gravity anomaly (classical and Molodensky)
- gravity disturbance in spherical approximation
- gravity disturbance (on the Earth's surface)
- gravity (on the Earth's surface)
- second r-derivative of the potential
- equivalent water height (water column)

OSTST Meeting, 10-12 November 2008, Nice - France