GGOS Working Group Conventions, Models, Analysis Status Report February 2007

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General objectives of WG CMA

1) To ensure the consistency between all geodetic (**geometric and gravimetric**) products by using common constants, conventions and models in data analysis, parameterisation and representation.

2) To improve the geodetic algorithms, parameterisation and physical models to the point, where an overall accuracy and consistency of **products better than 1 ppb** can be achieved.

3) To stimulate and coordinate efforts aiming at a **combined** analysis of all (**geometric and gravimetric**) space geodetic observation techniques, integrating all parameters common to more than one space geodetic technique.

Σ) To obtain all geodetic products (deformation of the Earth's continental and ocean surfaces, variations of Earth's rotation and gravity field, time dependent atmosphere parameters, ...) with highest accuracy, consistency, temporal and spatial resolution, and referring to a unique reference frame stable over decades.

1) Common constants, conventions and models

Controversial definitions of fundamental constants
in IAG resolutions (GRS80) and IERS conventions (2003):

GM [10^8 m^3s^{-2}]	3 986 005	$\leftrightarrow$	3 986 004.418
Semi-major axis [m]	6378137.0	$\leftrightarrow$	6378136.6
Reciprocal flattening	298.25722	$\leftrightarrow$	298.25642
Normal potential [m^2s^{-2}]	62636860.85	$\leftrightarrow$	62636856.0

The **geodetic use** is even different from both (e.g., EGM96, EIGEN, ..)

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ff) Common constants, conventions and models

- **Controversial conventions defined** by IERS (2003), the gravity community (no official IGFS conventions) and IAG resolutions, e.g.:
  - Time system: defined to be geocentric (TCG) but in use is TT
  - Tide system: zero tide (IAG1981) in IGFS, tide free in IERS

- **Controversial conventions** for reducing **or not** the observations:
  - Ocean loading
  - Atmosphere loading
  - Hydrosphere loading
  - Second (& third) order ionosphere effects
  - Troposphere refraction (troposphere gradients)
  - Gravity variations (short period, seasonal, secular)
  - Geo-centre / coordinate origin / centre of network variations
  - Relativity effects

ff) Common constants, conventions and models

Controversial geophysical models used in data analysis

- Solid Earth tide models
- Ocean tide models
- Pole tide models
- Ocean loading models
- Ionosphere models
- Troposphere models and mapping functions
- Relativity models
- Nutation models
- (Sub-daily) ERP models
- Gravity field models
- Earth mass (density) models
- (Digital) Terrain (Earth surface) models

There are other models required for specific techniques (instrumental)

2) Improve algorithms and parameterisation

Controversial parameterisation

- Station coordinates and their time evolution
  (reference epoch, linear and non-linear velocities, accelerations, ...)
- Satellite orbits (Kepler, gravitational & non-gravitational forces)
- Quasar coordinates and their time evolution
- Nutation, UT1, polar motion and its time evolution
- Gravity values and its time evolution
  (reference epoch, linear and non-linear gravity change, ...)
- Gravity field parameters and its time evolution
  (spherical harmonics, grid values, wavelets, splines, grid values, ...)
- Reference surfaces and its time evolution
  (ellipsoid, geoid/quasi-geoid, sea surface, height reference surface ...)
- Troposphere parameters (dry & wet, mapping functions gradients)
- Ionosphere parameters

Actual Activities on 1) and 2)

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Review of used Constants, Conventions, Models and Parameters

Name	Hermann Drewes	*Institution*	DGFI
Technique	SLR	*Software*	Example

1 Fundamental Constants	**Released by**	**Value**	**Comment**
Geoc. grav. Constant GM	IERS2003	$3\,986\,004.418 \cdot 10^{-14}$	
Speed of light c	IERS2003	299792458 m/s	
Earth rotation velocity ω	IERS2003	$7292115 \cdot 10^{-11}$ rad/s	
Semi-major axis a	IERS2003	6378136.6 m	
Normal potential U_0	GRS80	62636860.850 $m^2 s^{-2}$	
Normal gravity γ	GRS80	9.78032677 m s^{-2}	
Geometric flattening 1:f	GRS80	298.257222101	
Dynamic form factor J_2	GRS80	$108263 \cdot 10^{-8}$	
Others			
...			

Form to be filled by all WG members (i.e. analysis coordinators of all the services and corresponding person of the commissions) for software packages used in their field.

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Actual Activities on 1) and 2)

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Review of used Constants, Conventions, Models and Parameters

2 Geodetic Conventions	**Type**	**Applied**	**Comment**
Time system	TT	Yes	
Tide system	Tide free	Yes	Permanent tide reduced from obs.
Ocean loading reduction	Model	Yes	
Atmosphere loading red.	-	No	
Hydrosphere loading red.	-	No	
$2^{nd}/3^{rd}$ order ionosphere	-	No	
Troposphere refraction	Model paramet.	Yes	
Troposphere gradients	Parameterised	Yes	
Gravity variations	-	Yes	
Geocentre/origin variation	-	Yes	
Relativity effects	Model	Yes	
Others			
...			

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Actual Activities on 1) and 2)

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Review of used Constants, Conventions, Models and Parameters

3 Geophysical Models	Type	Applied	Comment
Solid Earth tides (orbits)	IERS2003	Yes	
Solid Earth tides (stations)	IERS2003	Yes	
Ocean tides (orbits)	FES2004	Yes	
Ocean tides (stations)	FES2004	Yes	
Pole tides (orbits)	IERS2003 lin.	Yes	
Pole tides (stations)	IERS2003 lin.	Yes	
Ocean loading	FES2004'	Yes	
Ionosphere	-	No	
Albedo	Heurtel	Yes	
Solar radiation	3-hourly	Yes	
Infrared radiation	Heurtel	No	
Troposphere (dry)	Murray-Marini	Yes	
Troposphere (wet)	Mendes	Yes	
Tropos. mapping function	Mendes	Yes	
Relativity (orbits)		Yes	
Relativity (observations)	Shapiro effect	Yes	
Nutation	IAU2000A	Yes	
ERP	C04	Yes	As a priori values
Sub-daily ERP	IERS2003	No	
Gravity field	EIGEN-GL04S1	Yes	
Earth mass density	PREM	No	
(Digital Earth) Terrain	-	No	No DEM necessary
Others			
...			

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Actual Activities on 1) and 2)

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Review of used Constants, Conventions, Models and Parameters

4 Estimated Parameters	**Type**	**Estimate**	**Comment**
Station coordinates	Epoch 2000.0	Yes	
Linear station velocities		Yes	Only stations t > 2 years
Non-linear station veloc.	seasonal	No	
Satellite orbits	Numerical	Yes	
Non-gravitational forces	ILRS	Yes	
Quasar coordinates	CRF-Ext. 2	No	
Quasar motions	-	No	
Nutation	IAU2000A	Yes	
UT1 (and rates)	Offset+rate/day	No	
Polar motion (and rates)	Offset+rate/day	Yes	
Point gravity values	-	No	
Gravity anomalies	-	No	
Gravity variations	-	No	
Gravity field model param.	< deg/order 4	Yes	
Gravity field variations	-	No	
Ellipsoid parameters (a, f)	-	No	
Level ellipsoid (U_0, J_2)	-	No	
Sea surface / sea level	-	No	
Sea surface topography	-	No	
Dry troposphere parameter	-	No	
Wet troposphere parameter	2^h zenit delays	No	
Mapping function / grads.	Tilting	No	
Ionosphere parameters	-	No	
Others			
...			

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Actual Activities on 1) and 2)

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Review of used Constants, Conventions, Models and Parameters

5 Urgent Requirements	**Comment**
Do we need more conventions?	
Do we need other recommendations?	
Do we need a new GRS?	
Others	

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In the next step we shall analyse the used CMA and study the **effects** produced by the use of different CMA on the different parameters.

There is a German project (GGOS-D) concentrating on similar investigations:

- GeoForschungsZentrum Potsdam (GFZ, Chair: M. Rothacher)
- Deutsches Geodätisches Forschungsinstitut (DGFI)
- Bundesamt für Geodäsie und Kartographie (BKG)
- Institut für Geodäsie und Geoinformation Univ. Bonn (IGGB)

3) Other Objectives of WG CMA

- Promote processing strategies and analysis beyond the services' work, i.e., combining geometric and gravimetric observations, etc.
- Study the interactions and relationship between all the parameters of the three fields of geodesy, including reference frame issues.
- Define constants and conventions (for modelling, parameterisation and processing) for areas that go beyond the existing conventions.
- Estimation of station coordinates, Earth rotation and gravity field parameters using all the space geodetic observations.
- Promote the development of software packages that jointly process (on the observation level) or combine (on the solution level) all types of space geodetic techniques.
- Analyse Earth models that integrate the three fields of geodesy.
- Unify the models, parameters and formats used by the services and define consistent sets of GGOS products.
- Encourage and promote discussions between all IAG services and commissions by organizing workshops, etc.

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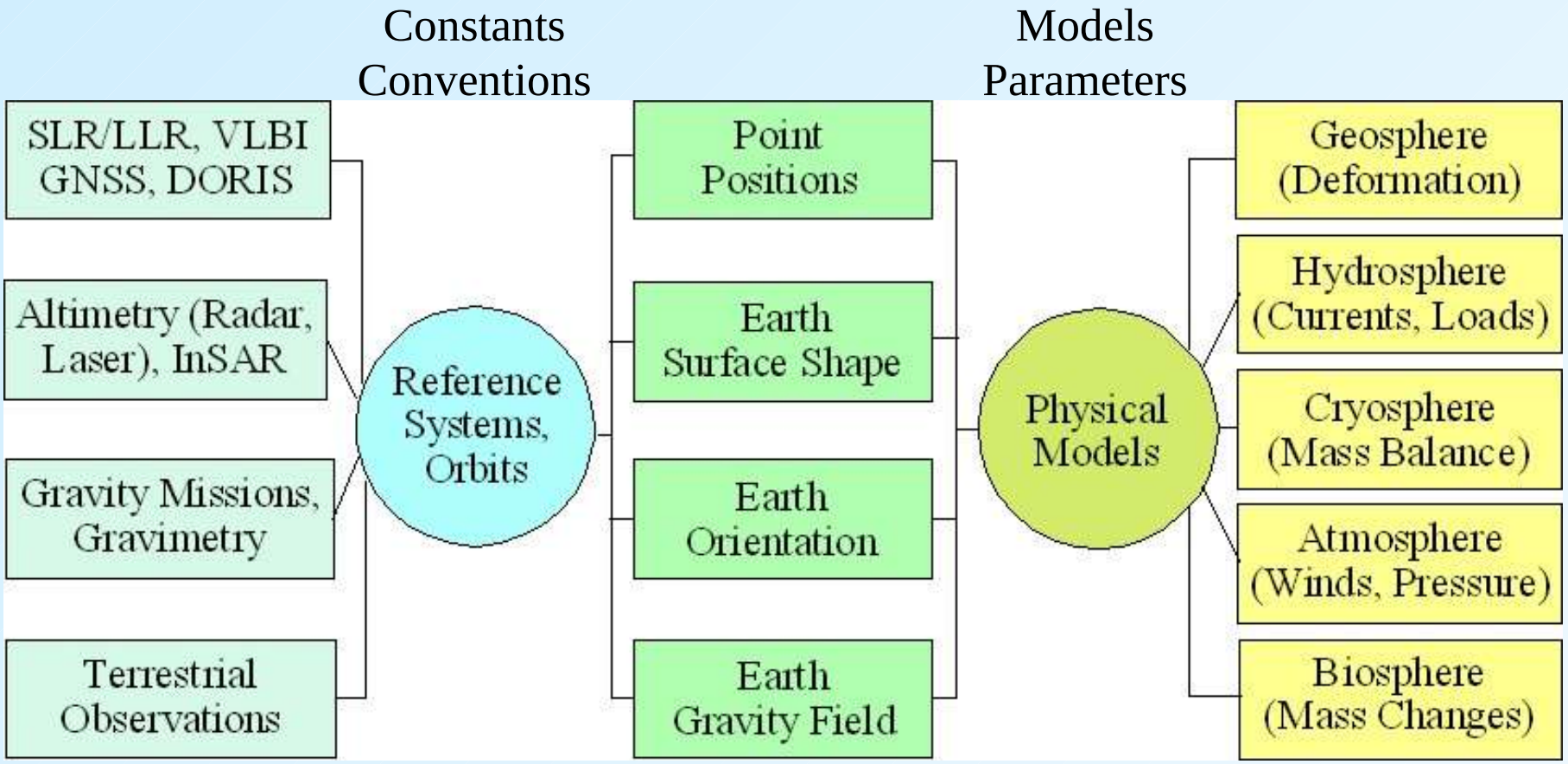
Combining Geometry and Gravimetry Integrating all Models and Parameters



There is a German DFG project (MaSiS) dealing with this problem (DGFI)

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Summary and Conclusion

- The work of WG CMA goes beyond the work of the services by looking after identical constants and conventions, and consistent models and parameters used in all data processing and analysis procedures, and in all geometric and physical products.
- WG CMA shall give input to IUGG and IAG Executive Committees to release and control the compliance of consistent resolutions in order to enhance the reliability and acceptance of geodetic products.
- The cooperation with the other GGOS WG (Data and Information Systems, Ground Networks and Communication, Missions) is indispensable and shall be intensified in the future.

Thank you !

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