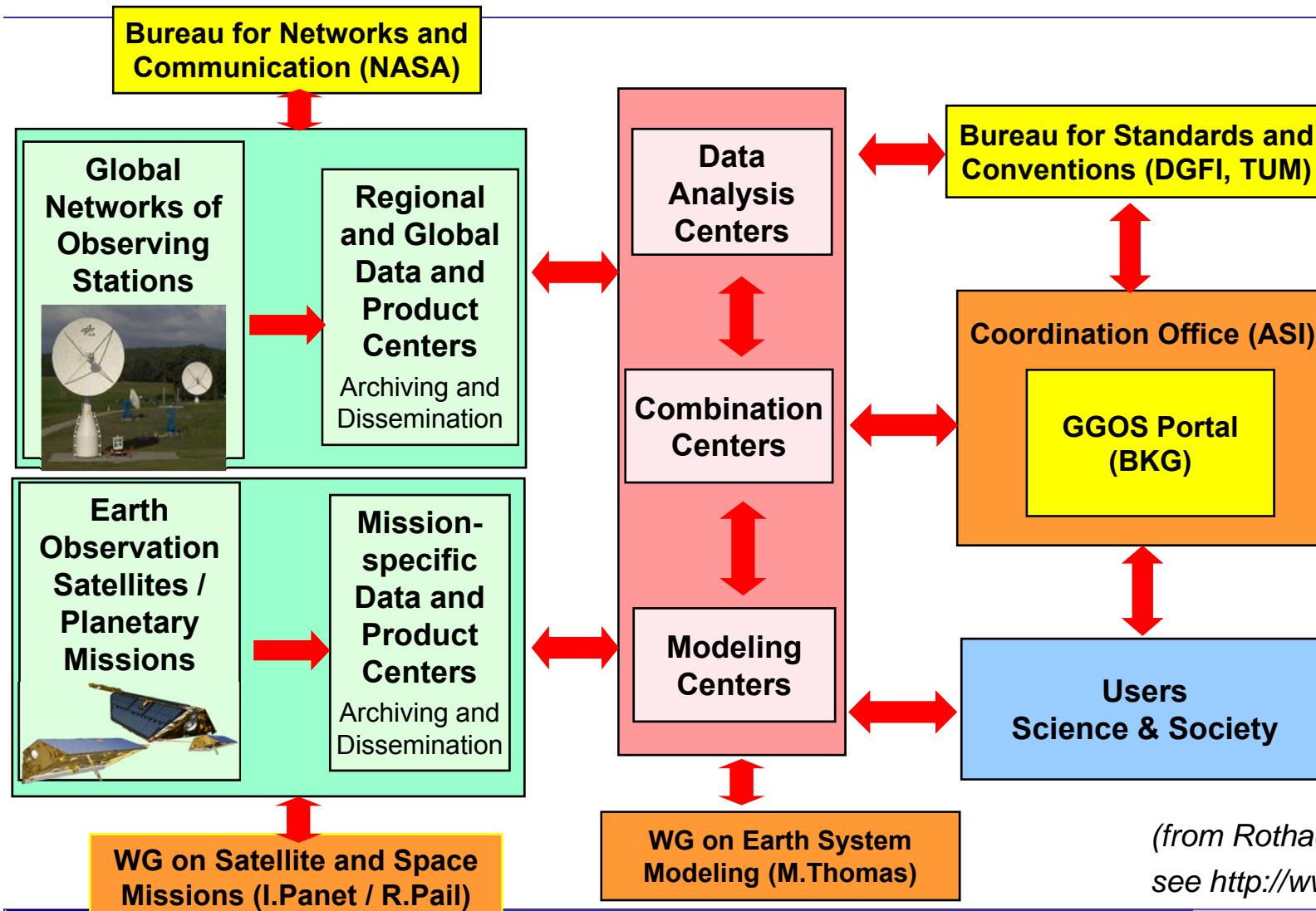


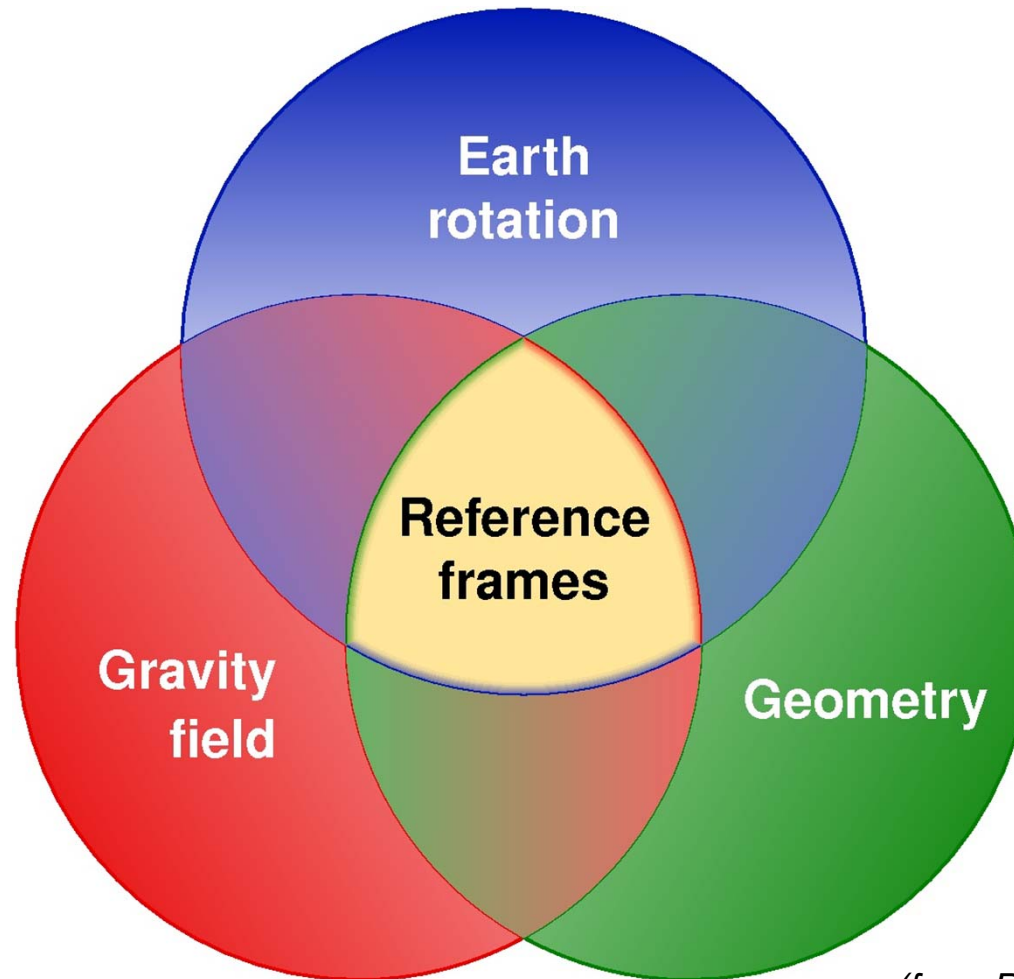
Global Geodetic Observing System (GGOS)



(from Rothacher 2011, see <http://www.ggos.org>)



A key GGOS goal: Integration of the “three pillars”



(from Plag and Pearlman 2009)

Motivation and tasks of the BSC

- **Consistency** among the data sets from the different (geometric and gravimetric) observation techniques is of **crucial importance** for the generation of highly accurate GGOS products.
- The analysis of the geodetic observations shall be based on the definition of **common standards** and a **unique representation and parameterization** of the relevant quantities.
- The Bureau for Standards and Conventions (BSC) has been installed as a GGOS component in 2009, major tasks are
 - to **keep track of the observance** of adopted geodetic standards and conventions applied by the IAG Services,
 - to **review and evaluate** all actual standards and conventions,
 - to **identify gaps** and to initiate steps to close them,
 - to **propagate** geodetic standards and conventions to the wider scientific community and promote their use.



Bureau for Standards and Conventions (BSC)

- The BSC is operated by DGFI and IAPG/TUM (members of CGE)
- Director: D. Angermann, deputy director: T. Gruber
- BSC-Team:
 - Geometry, Orbits, TRF: U. Hugentobler, P. Steigenberger, D. Angermann
 - Earth Orientation, CRF: M. Gerstl, R. Heinkelmann
 - Gravity: T. Gruber
 - Vertical reference systems: L. Sánchez
- Associated members: J. Ádám, M. Craymer, J. Ihde, J. Kusche
- Representation of IAG Services (still in progress, so far are nominated):
 - Geometry: G. Petit (IERS Conventions Centre), E. Pavlis (ILRS)
 - Gravity: F. Barthelmes (ICGEM), R. Bazarghi (IGeS)
- Representation of BSC to IAU:
 - WG “Numerical Standards for Fundamental Astronomy”: R. Heinkelmann



Geodetic constants

- ... are officially defined by the Geodetic Reference System 1980 (GRS80) and by the corresponding IAG resolutions.
- IERS conventions for geometry and Earth rotation
- Different standards for gravity (e.g., EIGEN, GOCE, EGM2008)

	GRS80	IERS2010	
GM	398.600 5	398.600 411 8	$[10^{12} \text{ m}^3\text{s}^{-2}]$
J2	1082.63	1082.635 9	$[10^{-6}]$
a_e	6 378 137	6 378 136.6	[m]
1/f	298.257 22	298.256 42	
ω	7.292 115	7.292 115	$[10^{-5} \text{ rad s}^{-1}]$
W_0	62 636 860.85	62 636 856.0	$[\text{m}^2\text{s}^{-2}]$

➔ Controversial definitions of geodetic standards

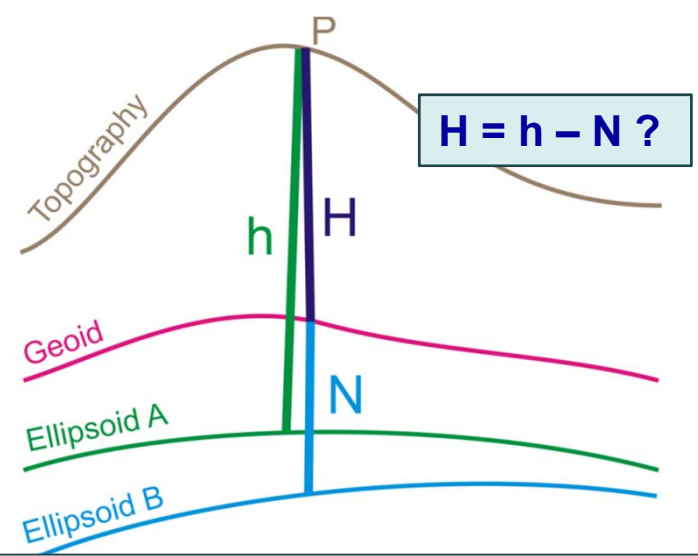
Time and Tide Systems

- Time System TT (practice) vs. TCG (IAU & IUGG Resolutions, 1991)

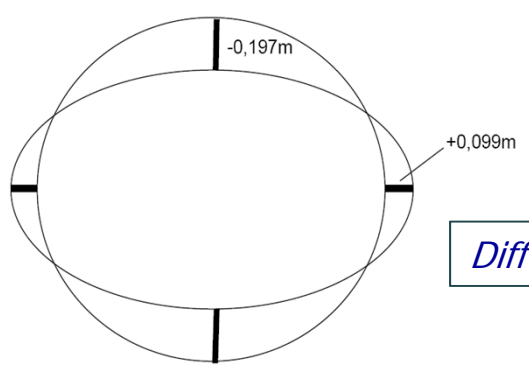
GM = 398.600 44 18	[10 ¹² m ³ s ⁻²]	(TCG value, IERS 2010)
398.600 44 15		(TT value, GOCE Standards)
- Tide system, IAG Resolution No. 16 of 18th General Assembly (1983)
 - zero-tide for gravity field quantities
 - mean-tide for 3-D positions,

In practice: conventional tide-free for ITRF

→ Source for errors and inconsistencies when combining **geometric and gravimetric** quantities



Differences between mean and zero geoids (Heck 2010)



Different ellipsoid parameters in geometry and gravity

Activities of the BSC

Major topics ...

- Inventory of constants, standards, conventions used across all IAG Services (i.e., numerical standards, IERS conventions, conventions of gravity missions (CHAMP, GRACE, GOCE), satellite altimetry, ...)
- Focus on geodetic products (i.e., celestial and terrestrial reference frames, EOP, gravity field, GNSS orbits, vertical reference frames, ...)
 - What is the present status w.r.t. standards and conventions ?
 - Discussion and identification of shortcomings / deficiencies
 - Recommendations to resolve inconsistencies and gaps
- Interaction with IAG Services and other entities involved in standards and conventions

Conventional modelling of station positions

- The general model connects the **instantaneous position $X(t)$** of a point at epoch t , and a **regularized position $X_R(t)$**

$$X(t) = X_R(t) + \sum \Delta X_i(t)$$

- The regularized position is described by a **linear model**

$$X_R(t) = X_0 + V(t - t_0)$$

- **Correction models $\sum \Delta X_i(t)$** , e.g.,
 - Solid Earth tides, permanent tide, ocean tides
 - Non-tidal pressure loading (atmosphere, hydrology) not applied for ITRF2008
 - Technique specific models (e.g., propagation corrections, antenna effects)



The definition and choice of the **correction models $\sum \Delta X_i(t)$** has a direct impact on the ITRF results

ITRS Realizations

- The ITRS is realized through 3-D coordinates and velocities of GNSS, VLBI, SLR and DORIS stations
- ITRFs are obtained from a combination of space-technique solutions generated by the Services (IGS, ILRS, IVS and IDS)
- Processing standards are defined by the Services and their AC's
 - IGS proc. standards AC1, AC2, ... → Intra-Tech.-Comb.
 - ILRS proc. standards AC1, AC2, ... → Intra-Tech.-Comb.
 - IVS proc. standards AC1, AC2, ... → Intra-Tech.-Comb.
 - IDS proc. standards AC1, AC2, ... → Intra-Tech.-Comb.
- Combination of technique-specific solutions or normal equations
- Generation of final ITRS realization (e.g., ITRF2008)



Review of models used in data analysis

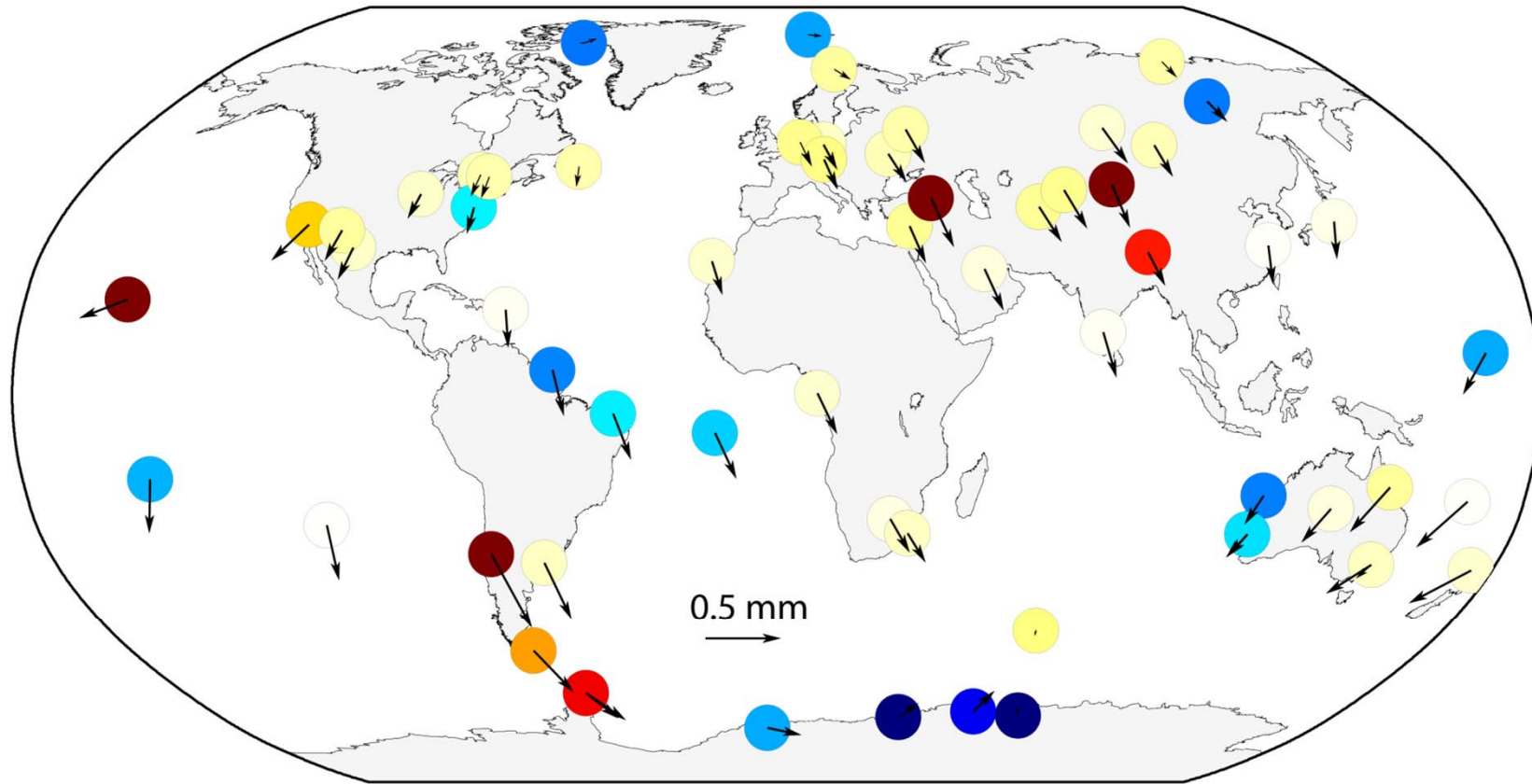
- Models applied by the Analysis Centres (AC) of the IGS
- This table shows the current status obtained from the IGS AC logs

	COD	EMR	ESA	GFZ	GRG	JPL	MIT	NOAA	SIO
Date	05/2008	10/2009	06/2011	12/2011	04/2011	04/2012	02/2008	08/2012	10/2005
TRP MF	GMF	GMF	GMF	GMF	GMF	GMF	GMF	GMF	NMF
TRP a priori	Saastamoinen/GPT	ECMWF	Saastamoinen/GPT	Saastamoinen/GPT/H=60%	??*/GPT	Davis/GPT/10 cm wet	Saastamoinen/GPT/H=50%	Saastamoinen/GPT/H=50%	??*
Solid Earth tides	IERS2003	IERS2003	IERS2003	IERS2003	IERS2003	IERS2010	IERS2003	IERS2003	??*
Ocean tidal loading	FES2004	FES2004	FES2004	FES2004	FES2004	FES2004	FES2004	FES2004	??*
Geopotential	JGM3	JGM3	EIGEN-GLO5C	EIGEN-GL04S1	EIGEN-GL04S	EGM2008	EGM96	EGM2008	EGM96
Solid Earth Tides (orbit)	IERS2003	IERS2003	IERS2003	IERS2003	IERS2003	IERS2010	IERS92	IERS2010	??*
Ocean tides (orbit)	IERS2003 CSR 3.0	IERS2003 ??*	IERS2003 FES2004	IERS2003 ??*	IERS2003 FES2004	IERS2010 FES2004	none	IERS2010 FES2004	none

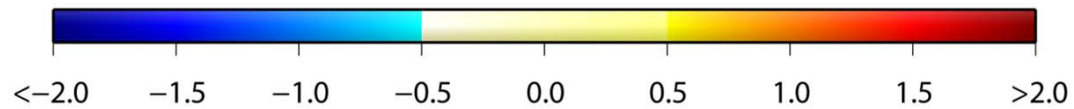
Table compiled by P. Steigenberger, Sept. 2012



Station position residuals GMF/GPT vs. VMF1/ECMWF



Height residuals [mm]



Steigenberger et al., 2009, J Geod

Station position time series obtained from ITRF2008

Models for non-tidal pressure loading (e.g., atmosphere) were not applied for ITRF2008/DTRF2008

-> seasonal variations in station positions (primarily heights)

