The need of common standards and conventions for homogeneous data processing and consistent geodetic products

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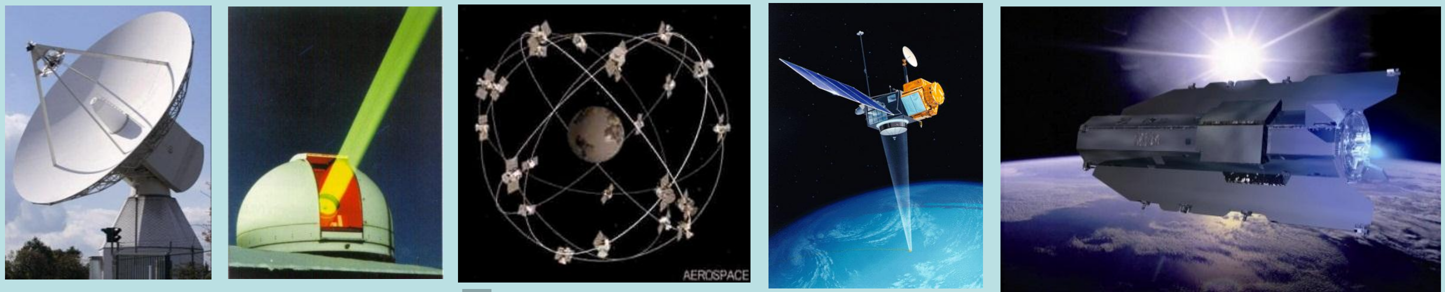
Introduction

Space geodetic observation techniques



Data Analysis Centres

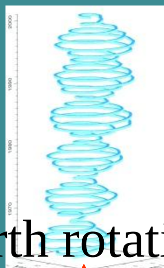
Combination Centres

Modelling Centres

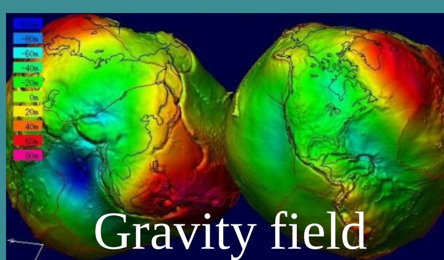
Geodetic products

Z

Geokinematic



Earth rotation



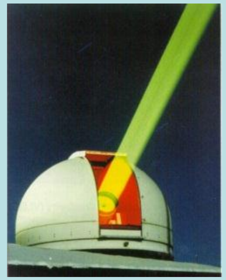
Gravity field

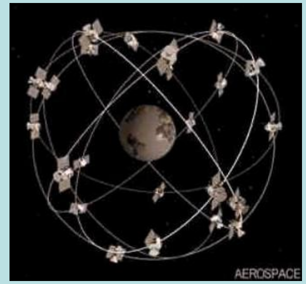
Geodetic reference frames

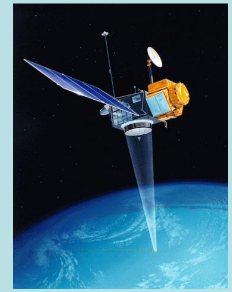
X

Introduction

Space geodetic observation techniques







Data Analysis Centres

Combination Centres

Modelling Centres

Geodetic products

Z

Are the geodetic products really consistent ?

Geokinematic

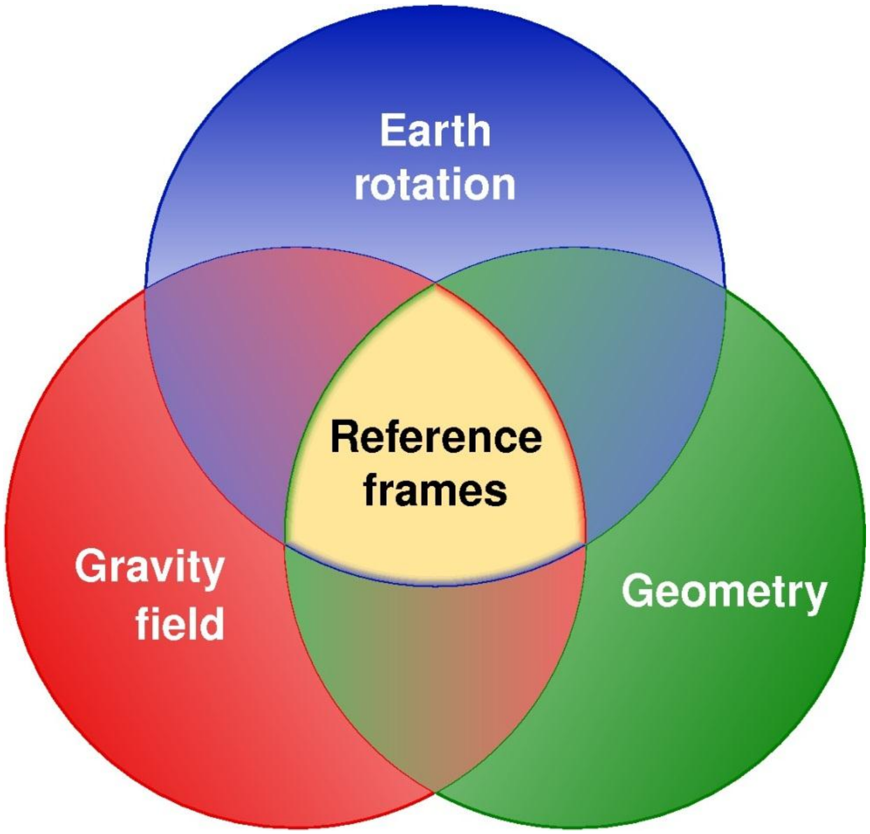
Earth rotation

Gravity field

Geodetic reference frames

X

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

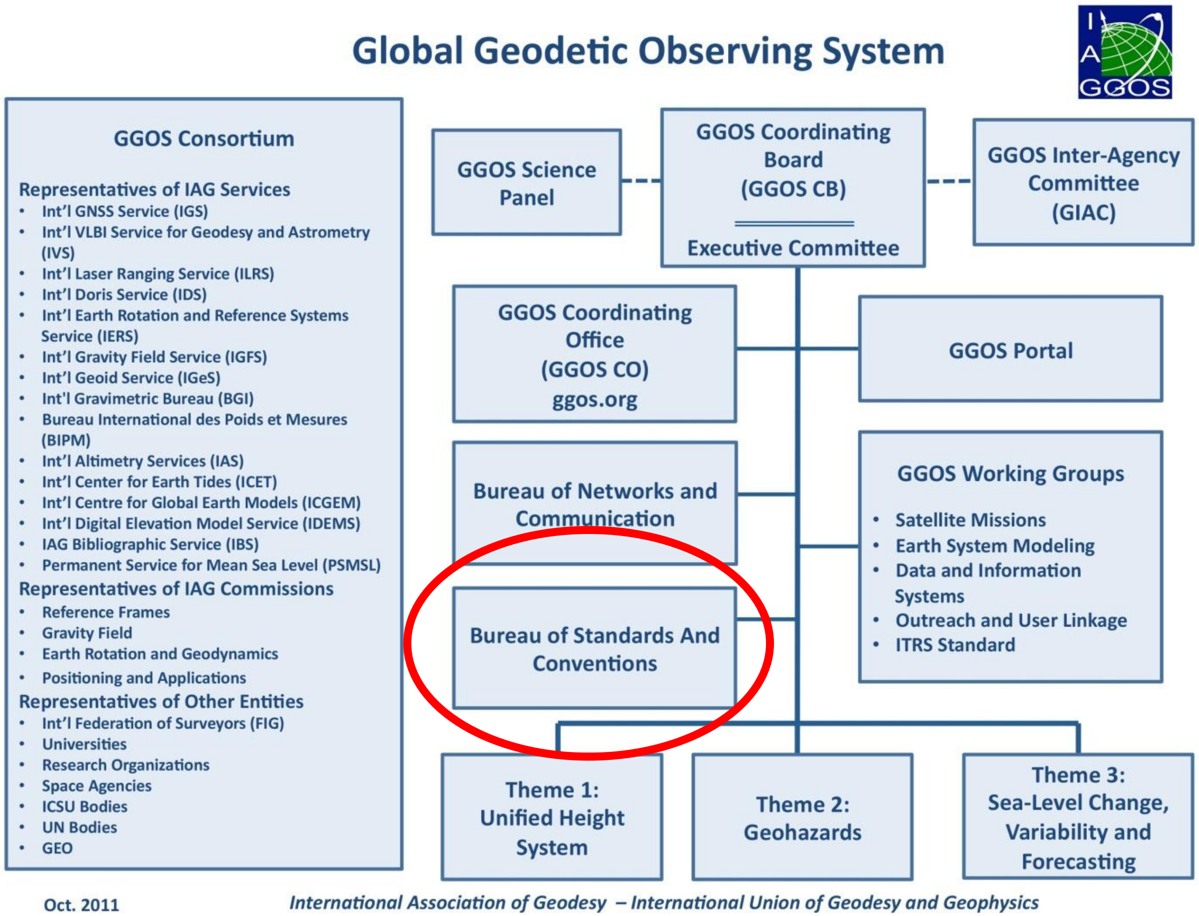


(from Plag and Pearlman 2009)

What do we need ?

- Consistency among the data sets from all geodetic space techniques
- Common standards and conventions (across all IAG components)
- Refined analysis and procedures to generate consistent products

GGOS Structure



Bureau for Standards and Conventions (BSC)

- The BSC has been installed as a GGOS component in 2009
- It is jointly 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 (IAU representative)
  - Gravity, height systems: T. Gruber, L. Sánchez
- Associated members: J. Ádám, M. Craymer, J. Ihde, J. Kusche
- Representation of IAG Services:
  - Geometry: G. Pétit (IERS Conventions), E. Pavlis (ILRS), J. Gibson (IVS), U. Hugentobler (in personal union for the IGS)
  - Gravity: F. Barthelmes (ICGEM), R. Bazarghi (IGeS), S. Bonvalot (BGI)
- Representation of BSC to IAU:
  - WG “Numerical Standards for Fundamental Astronomy”: R. Heinkelmann

Objectives and tasks of the BSC

- The key objective of the BSC is to ensure that **common standards and conventions** are adopted and implemented by all IAG components as a fundamental basis for the generation of **consistent IAG/GGOS products**.

- Major tasks of the BSC 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.

Activities of the BSC

Major topics …

- Inventory of constants, standards, conventions used across all IAG Services (i.e., numerical standards, resolutions of IAG, IAU and IUGG, IERS conventions, conventions of gravity missions (CHAMP, GRACE, GOCE), satellite altimetry, …)
- Focus on geodetic products: All IAG Service products are also GGOS products (e.g., ICRF, ITRF, EOP, GNSS orbits, gravity fields, geoid, height systems, …)
  - How are the products derived (procedures, organizational structures, ...) ?
  - What is the 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

BSC-publication in progress …

Title: "GGOS Bureau for Standards and Conventions: Inventory of standards and conventions used for the generation of IAG/GGOS products"

0. Preface and scope of the document
1. Introduction
   - 1.1 Global Geodetic Observing System (GGOS): Mission, goals and structure
   - 1.2 Standards and conventions: Basics and nomenclature
   - 1.3 Standards and conventions relevant for geodesy
2. GGOS Bureau for Standards and Conventions
   - 2.1 Mission and objectives
   - 2.2 Tasks
   - 2.3 BSC staff members, representation of IAG components and other entities
3. Product-based review of standards and conventions
   - 3.1 General remarks
   - 3.2 Celestial reference systems and frames
   - 3.3 Terrestrial reference systems and frames
   - 3.4 Earth orientation parameters
   - 3.* GNSS orbits, gravity field, height systems, interactions between products
4. Deficits, gaps and recommendations
5. Summary

Numerical standards for geodesy

- … are officially defined by the Geodetic Reference System 1980 (GRS80, Moritz 2000) and by the corresponding IAG resolutions.
- Best estimates of the fundamental parameters (Groten, 2004)
- IERS Conventions 2010 (Pétit and Luzum, 2010)
- Different standards for gravity (e.g., EIGEN, GOCE, EGM2008)

Quantitiy	GRS80	Fund. param.	IERS 2010	Unit
GM_{Earth}	398.6005	398.6004418	398.6004418	[10^{12} m^3 s^{-2}]
Equatorial radius (a) - zero-tide - mean-tide - tide-free	6378137	637836.62 637836.72 637836.59	6378136.6	[m]
Flattening factor (1/f) - zero-tide - mean-tide - tide-free	298.25722	298.25642 298.25231 298.25765	298.25642	
Dyn. form factor (J_2)	1082.63	1082.6359	1082.6359	[10^{-6}]
Ang. rot. velocity (ω)	7.292115	7.292115	7.292115	[rad s^{-1}]
Potential geoid (W_0)	62636860.85	62636856.4	62636856.0	[m^2 s^{-2}]

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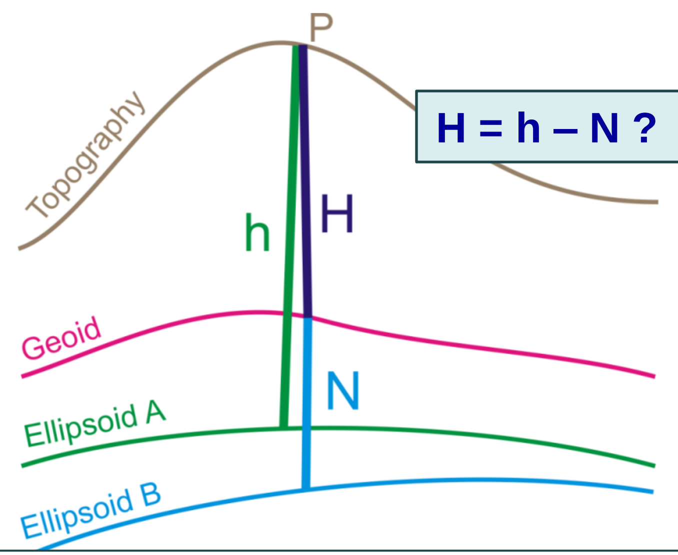
Contradictory definitions of geodetic standards !

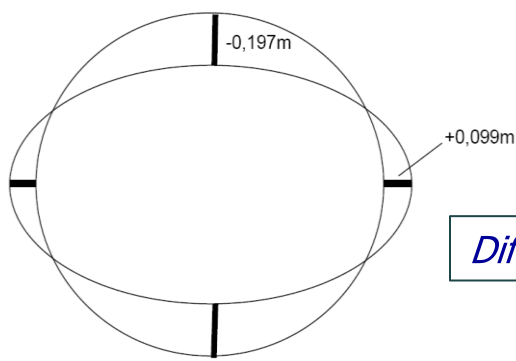
Time and Tide Systems

- Time System TT (practice) vs. TCG (IAU & IUGG Resolutions, 1991)
  GM = 398.600 44 $\boxed{18}$ [10^{12} m^3s^{-2}] (TCG value, IERS 2010)
  398.600 44 $\boxed{15}$ (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

Bureau for Standards and Conventions

ITRS – Definition vs. realization

- It is geocentric, its origin being the centre of mass for the whole Earth, including oceans and atmosphere;

  definition (CM) – realization (SLR origin)

- The unit of length is the meter (SI). The scale is consistent with the TCG time coordinate (IAU & IUGG Resolutions, 1991);

  definition (TCG) - realization (TT) -> Δ Scale = 0.7 10^{-9}

- Its orientation was initially given by the Bureau International de l'Heure (BIH) orientation at 1984.0;

  definition (conventional) - realization (transformations)

- The time evolution of the orientation is ensured by using a no-net-rotation condition with regards to horizontal tectonic motions over the whole Earth.

  definition (NNR-condition) - realization (NNR-NUVEL1A)

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)** (see IERS Conventions)

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

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

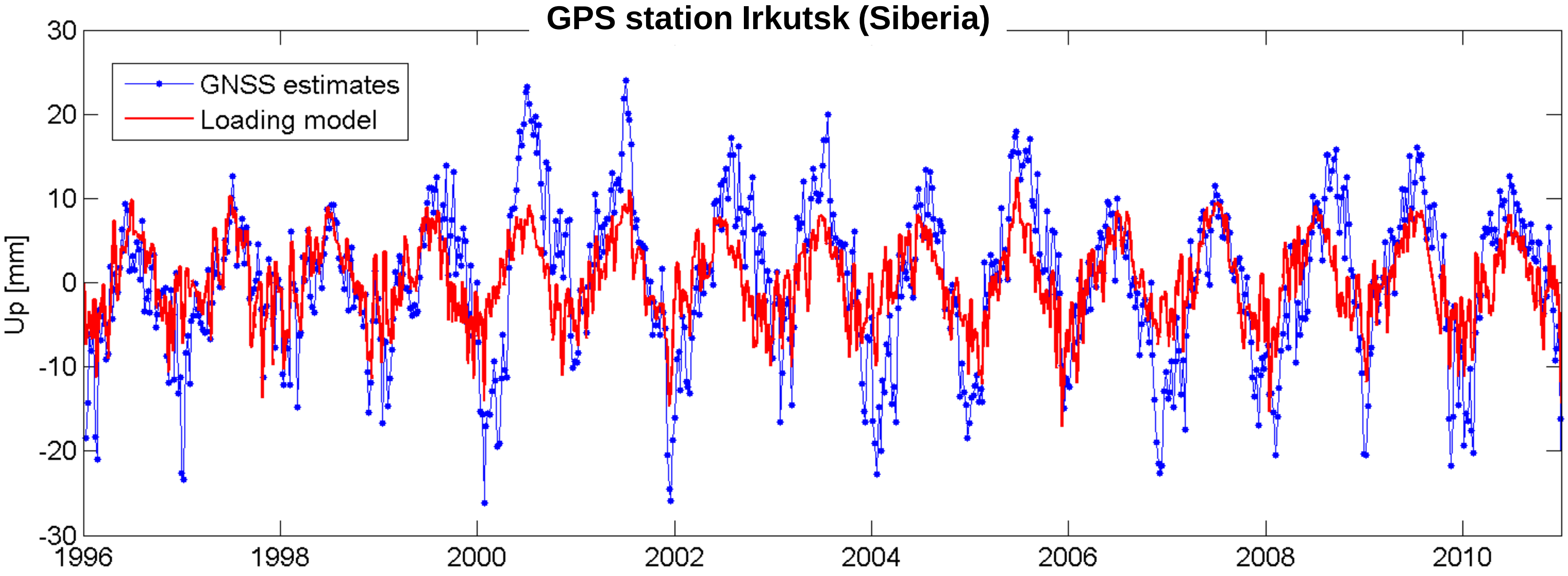
$$X_R(t) = X_o + V(t - t_o)$$

- **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 ITRF
  - 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

Impact of correction models on ITRF‘s

- Example: Models for non-tidal atmospheric pressure loading are not applied for ITRF input data (recommended by IERS Conventions)
- Season variations are visible in station positions (primarily heights)



Conclusions

- Common standards and conventions are of crucial importance for the generation of consistent GGOS products.
- All analysis centers supporting geometric and gravimetric GGOS products shall apply common standards for the processing of the different space geodetic observations.
- The BSC is compiling an inventory of standards and conventions in use for generating IAG/GGOS products (e.g., ICRF, ITRF, EOP, gravity field, …)
- This inventory presents the status regarding standards and conventions for these products, identifies gaps and inconsistencies, etc.
- A major outcome are recommendations to resolve existing inconsistencies, which will be distributed within IAG/GGOS and other entities involved.

Back up slides …

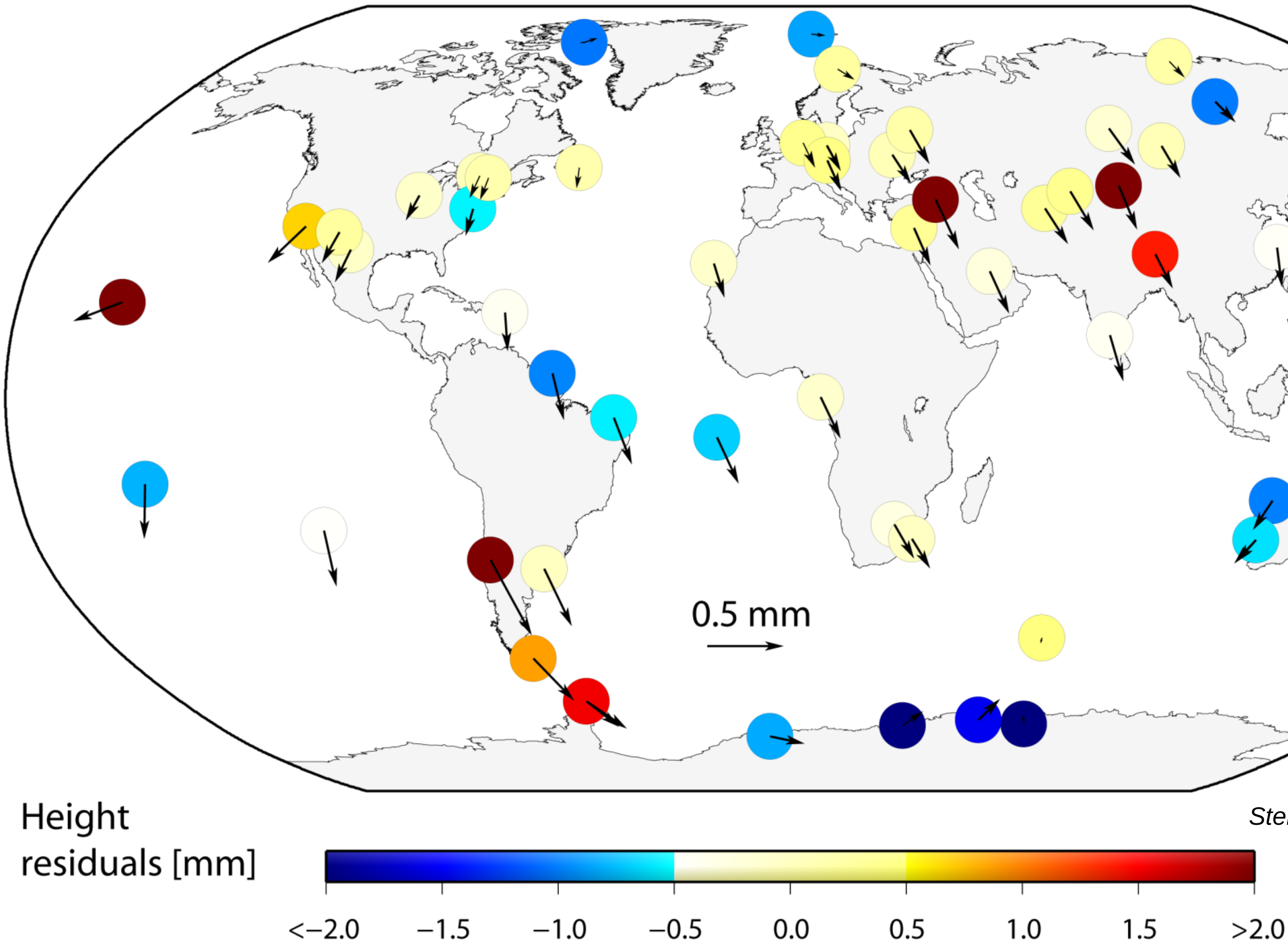
Review of models used in data analysis

- 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

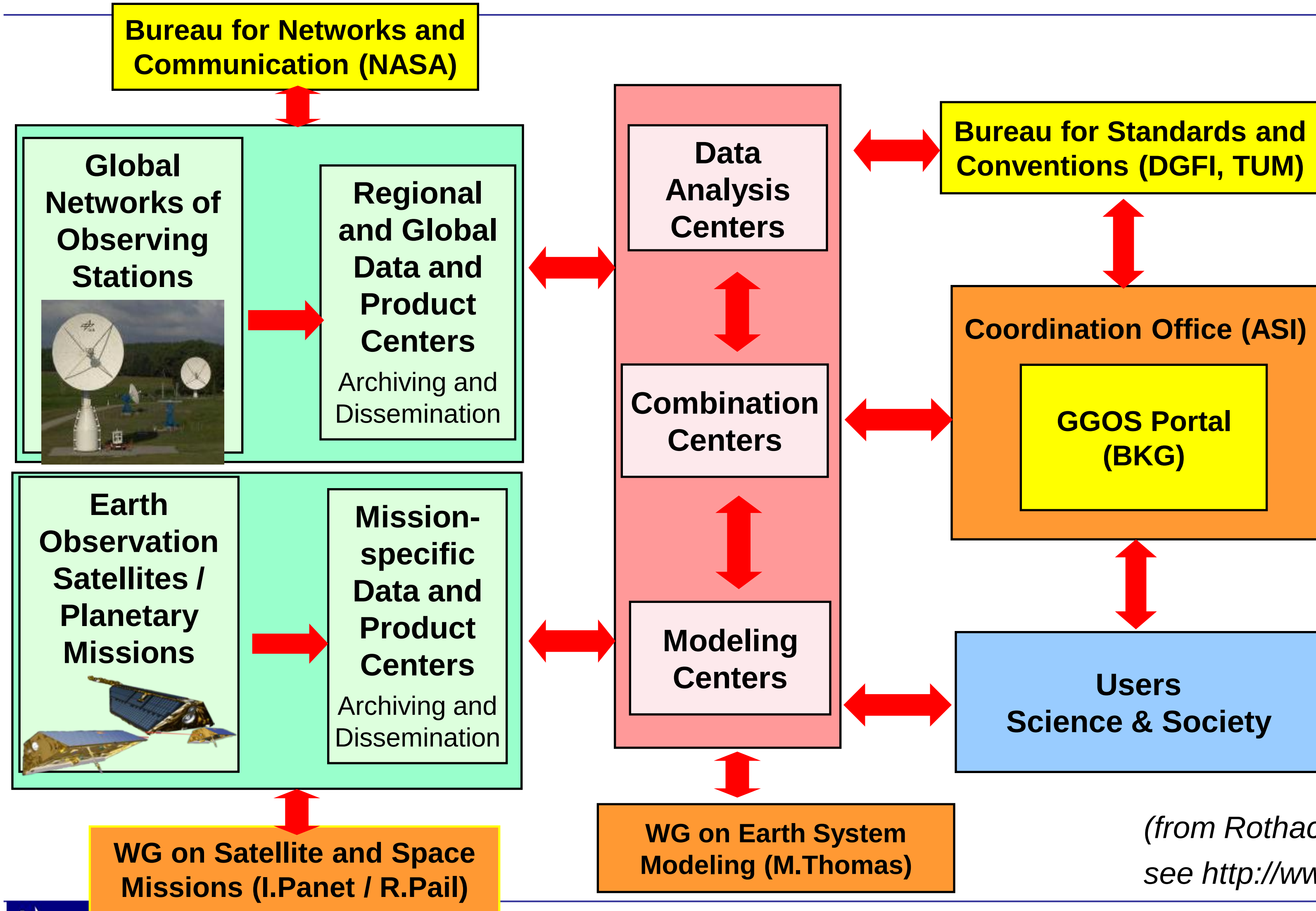
Table compiled by P. Steigenberger, Sept. 2012

Station position residuals GMF/GPT vs. VMF1/ECMWF



Steigenberger et al., 2009, J Geod

Global Geodetic Observing System (GGOS)



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

GGOS Structure