The importance of common standards and conventions for consistent GGOS products

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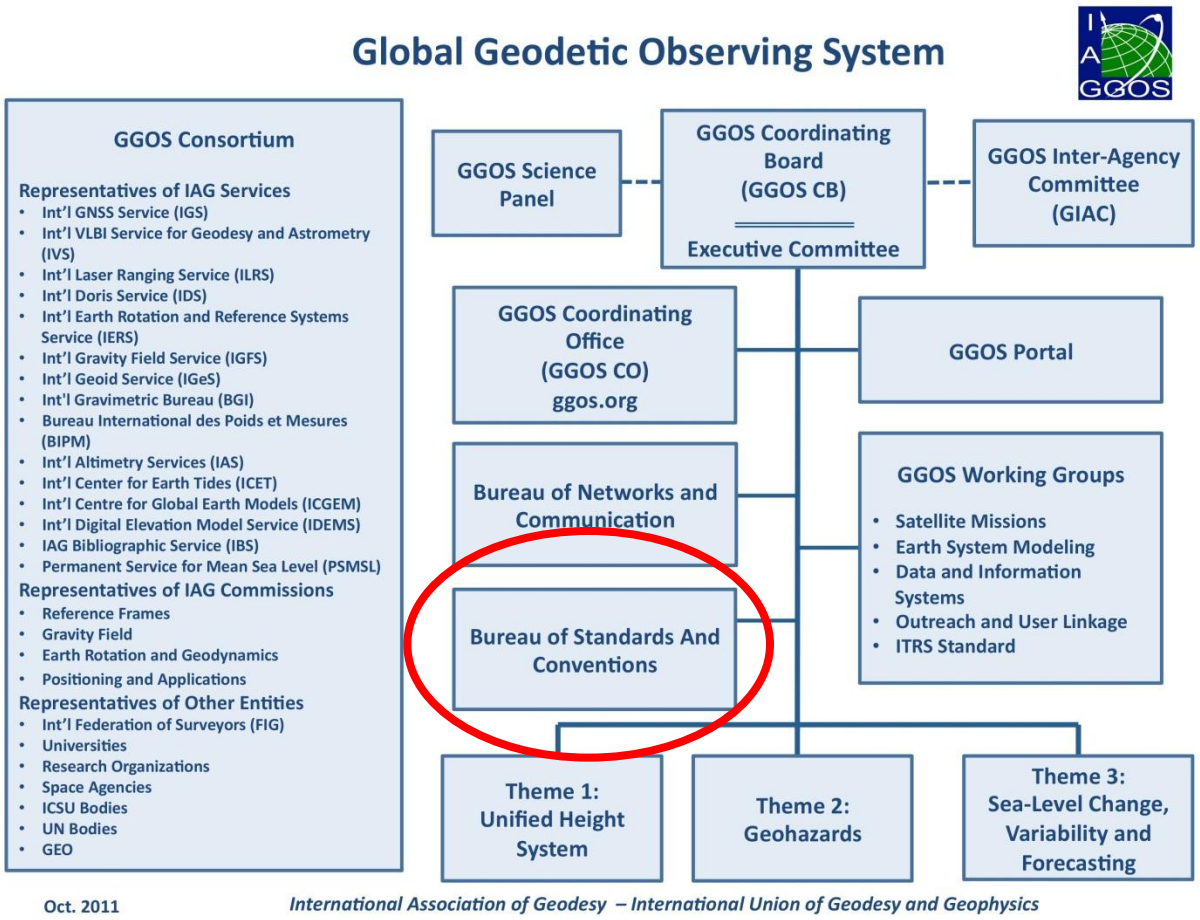
Motivation and tasks of the BSC

- For the generation of highly accurate GGOS products **consistency** among the data sets from the different (geometric and gravimetric) observation techniques is of **crucial importance**.
- 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.

GGOS Structure



GGOS Bureau for Standards and Conventions (BSC)

- The BSC is operated by DGFI and IAPG, TU München
- Director: D. Angermann (successor of U. Hugentobler since April 2011)
- Deputy director: T. Gruber
- BSC-Team:
  - Geometry, TRF: U. Hugentobler, P. Steigenberger, D. Angermann
  - Earth Orientation, CRF: M. Gerstl, R. Heinkelmann
  - Gravity: J. Bouman, T. Gruber
  - Vertical reference systems: L. Sánchez
- Associated: J. Ádám, M. Craymer, J. Ihde, J. Kusche
- Representation of all IAG Services needs to be established

Geodetic constants

- … are officially defined by the Geodetic Reference System 1980 (GRS80) and by the corresponding IAG resolutions.
- IERS conventions for geometric applications
- Different standards for gravimetric applications (e.g., EIGEN, GOCE, EGM2008)

	GRS80	IERS2010	
GM	398.600 5	398.600 411 8	[10^{12} m^3s^{-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} rad s^{-1}]
W_0	62 636 860.85	62 636 856.0	[m^2s^{-2}]

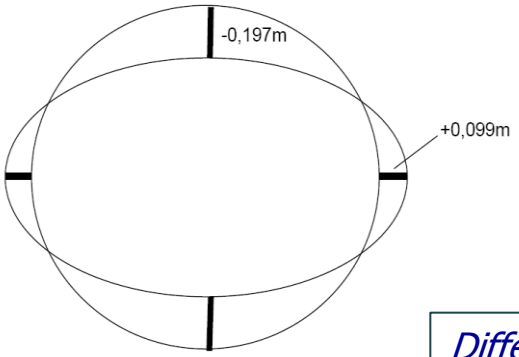
⇒ Controversial definitions of geodetic standards

Time and Tide Systems

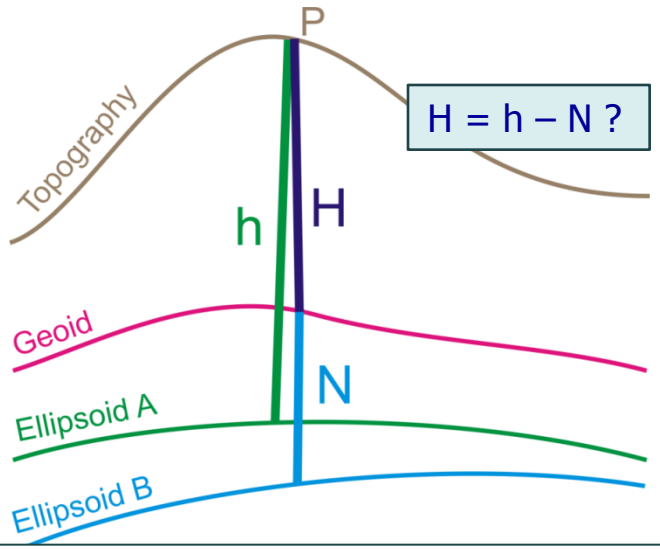
- Time System TT (practice) vs. TCG (IAU & IUGG Resolutions, 1991)
  GM = 398.600 44 18 [10^{12} m^3s^{-2}] (TCG value, IERS 2010)
  398.600 44 15 (TT value, GOCE Standards)
- Tide system, IAG Resolution No. 16 of 18th General Assembly (1983)
  - zero-tide for geopotential quantities
  - mean-tide for station displacement quantities,

  In practice: conventional tide-free for ITRF

⇒ Source for confusion when combining **geometric and gravimetric** quantities

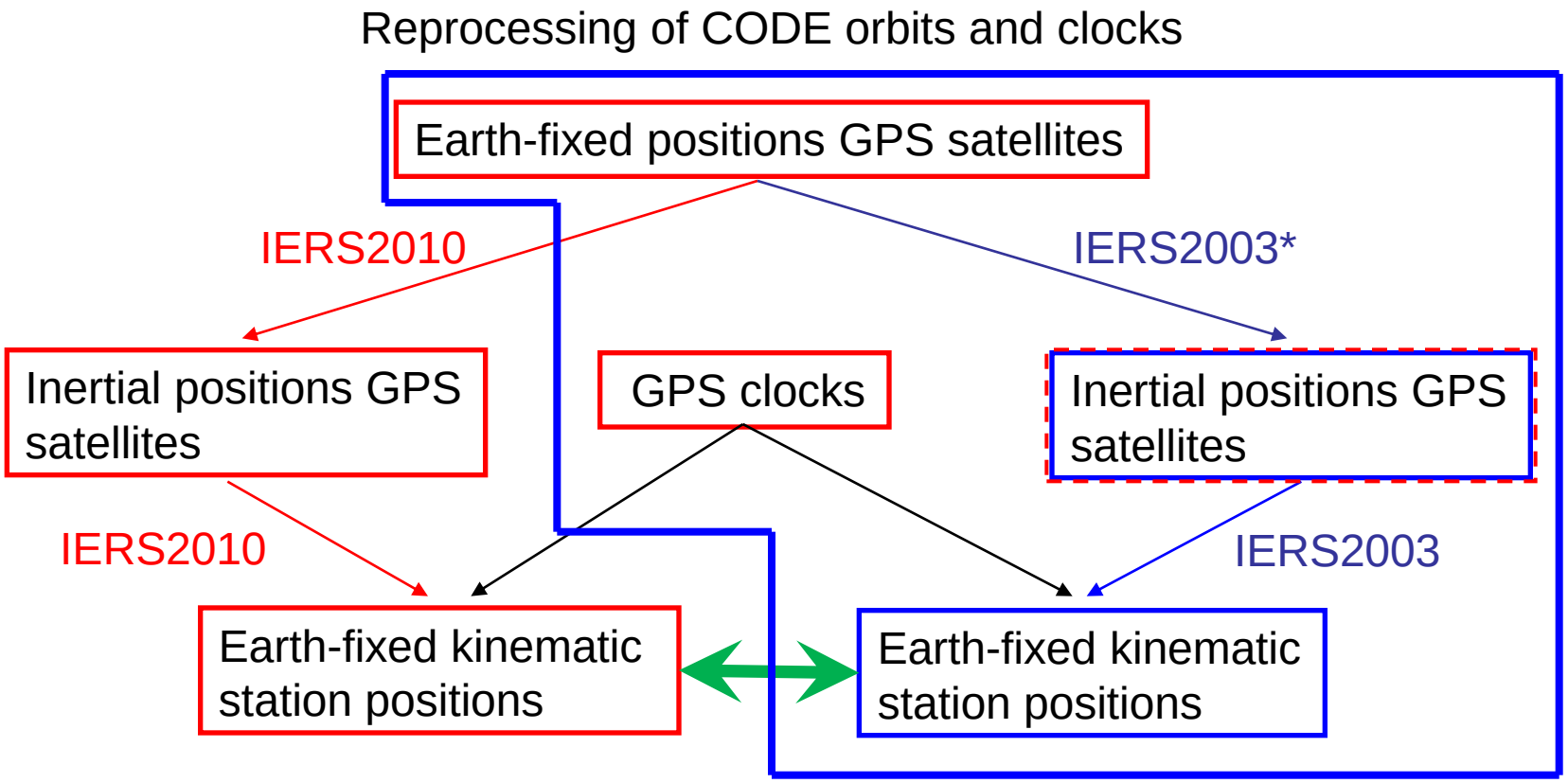


Differences between mean and zero geoids (Heck 2010)



Different ellipsoid parameters in geometry and gravity

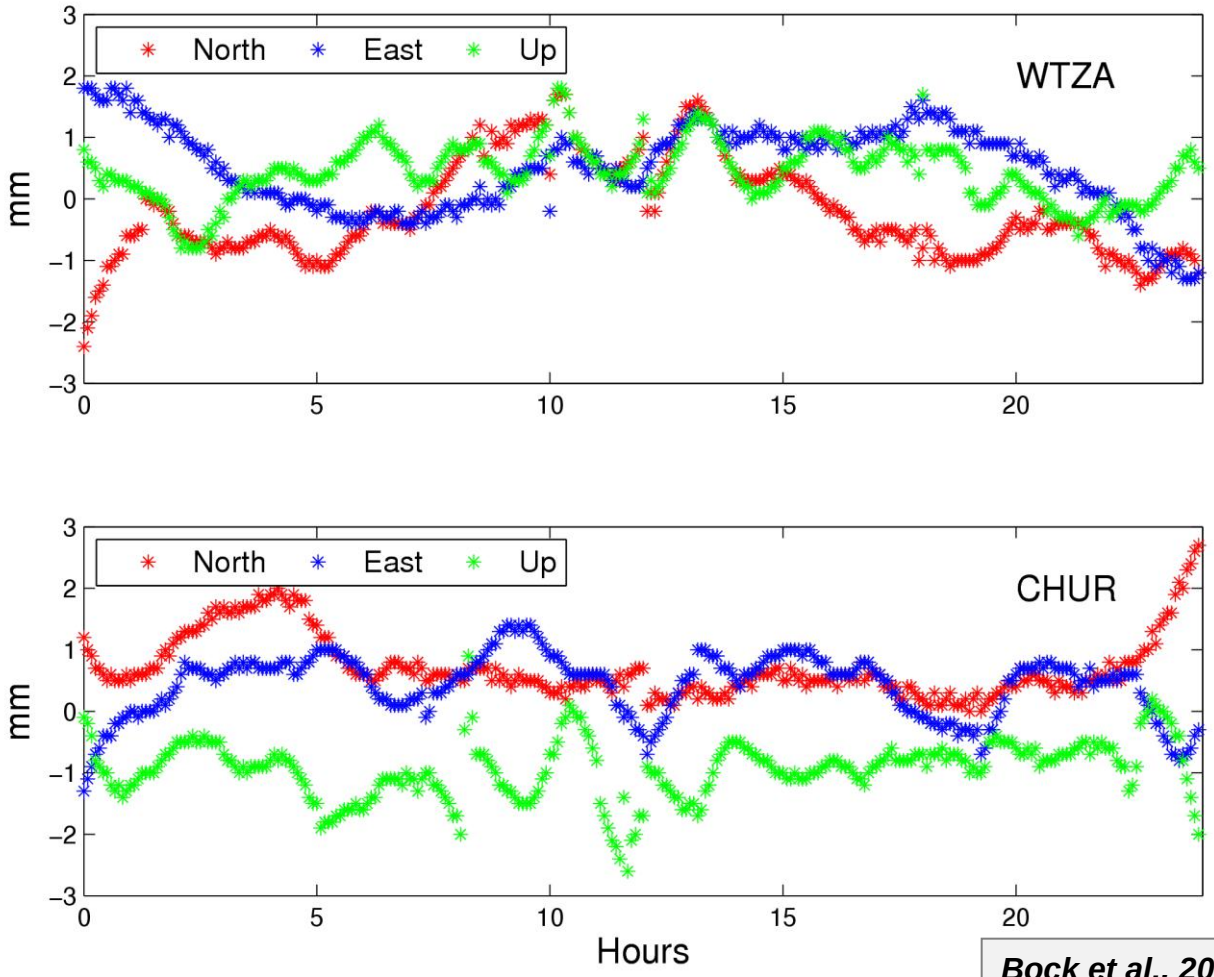
IERS2003 / GOCE Standards vs. IERS2010 Conventions



IERS2003* - EGM2008 gravity field is used

Bock et al., 2011: GOCE HPF Meeting, Potsdam

IERS2003 / GOCE Standards vs. IERS2010 Conventions



Differences in kinematic station positions

Bock et al., 2011: GOCE HPF Meeting, Potsdam

Geophysical background and correction models

- Conventional models (IERS Conventions 2010)
  - Solid Earth tides and pole tide
  - Geopotential (EGM2008)
  - Tidal loading
    - ocean tidal loading (FES2004, EOT11a, ...)
    - atmospheric S1/S2
- Non-tidal loading (not applied for ITRF)
  - hydrological loading
  - atmospheric pressure loading
- Technique-specific correction models (IAG Services)
  - propagation corrections
  - antenna effects
  - …

⇒ The models shall be applied consistently by all IAG Services

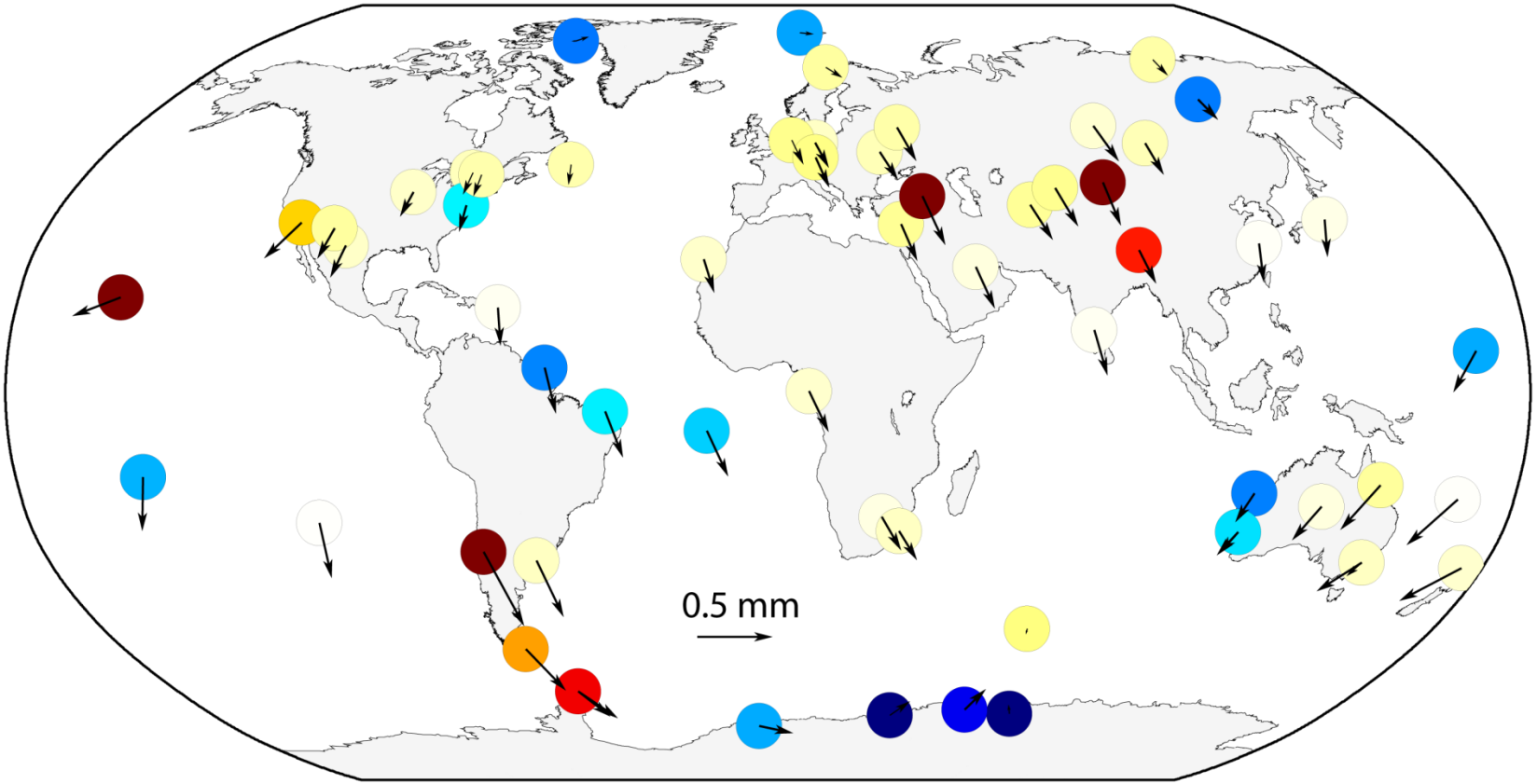
Review of geophysical models used in data analysis

- The geophysical models are **not fully consistently** applied among the Analysis Centers (AC) of the IAG Services.
- The Table shows the status for the IGS (the information is obtained from the IGS AC logs), the situation is similar (or even worse) for the other Services

	COD	EMR	ESA	GFZ	GRG	JPL	MIT	NOAA	SIO
Date	05/2008	10/2009	06/2011	01/2009	04/2011	09/2010	02/2008	05/2011	10/2005
TRP MF	GMF	GMF	GMF	GMF	GMF	GMF	GMF	GMF	NMF
TRP a priori	Saastamoinen/GPT	ECMWF	Saastamoinen/GPT	Saastamoinen/GPT	GPT	Davis/GPT	Saastamoinen/GPT	Saastamoinen/GPT	???
Solid Earth tides	IERS2003	IERS2003	IERS2003	IERS2003	IERS2003	IERS2003	IERS2003	IERS2003	???
Ocean tidal loading	FES2004	FES2004	FES2004	FES2004	FES2004	FES2004	FES2004	FES2004	???
Geopotential	JGM3	JGM3	EIGEN-GLO5C	EIGEN-GL04S1	EIGEN-GL04S	GGM02C	EGM96	EGM2008	EGM96
Solid Earth Tides (orbit)	IERS2003	IERS2003	IERS2003	IERS2003	IERS2003	IERS2003	IERS92	IERS2010	???
Ocean tides (orbit)	CSR 3.0	IERS2003	FES2004	IERS2003	FES2004	FES2004	none	IERS2003	none

Table compiled by P. Steigenberger, August 2011

Station position residuals GMF/GPT vs. VMF1/ECMWF



Height residuals [mm]

Impact of geophysical models on ITRF results

- The general ITRF model connects the **instantaneous position X(t)** of a station at epoch t, and a **regularized position $X_R(t)$** by applying **conventional geophysical correction models $\sum \Delta X_i(t)$**

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

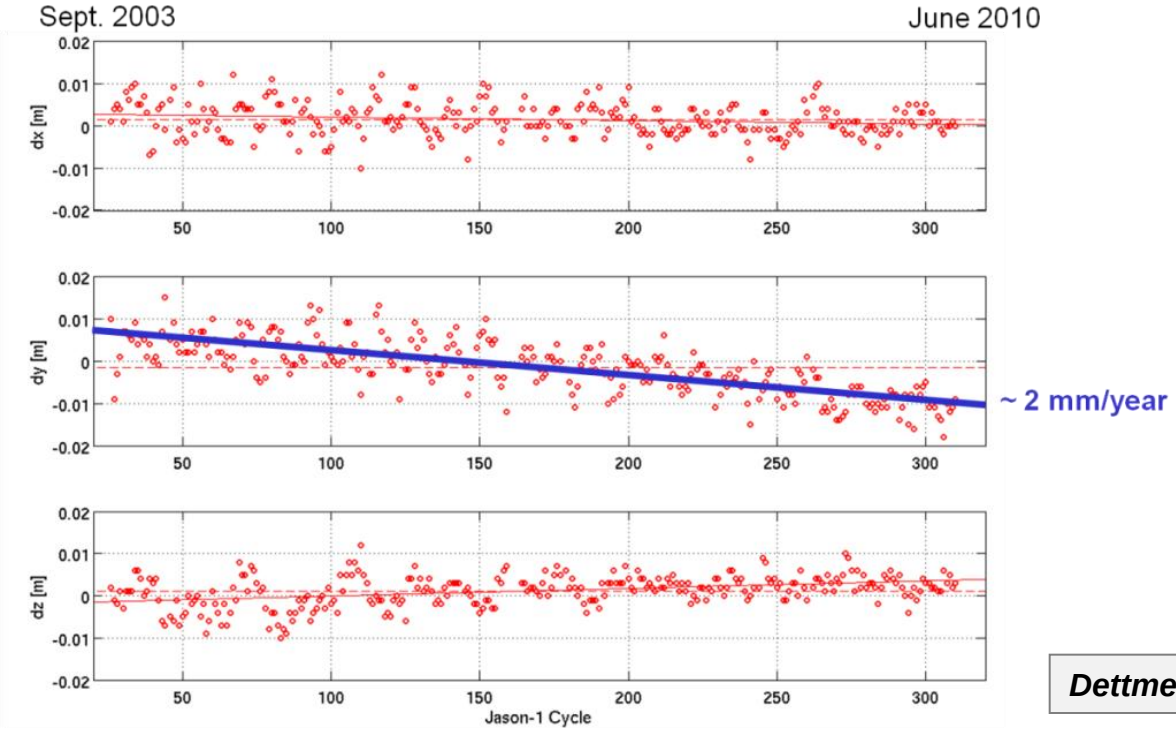
- The regularized station position $X_R(t)$ at an epoch t is expressed by a **linear model** as

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

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

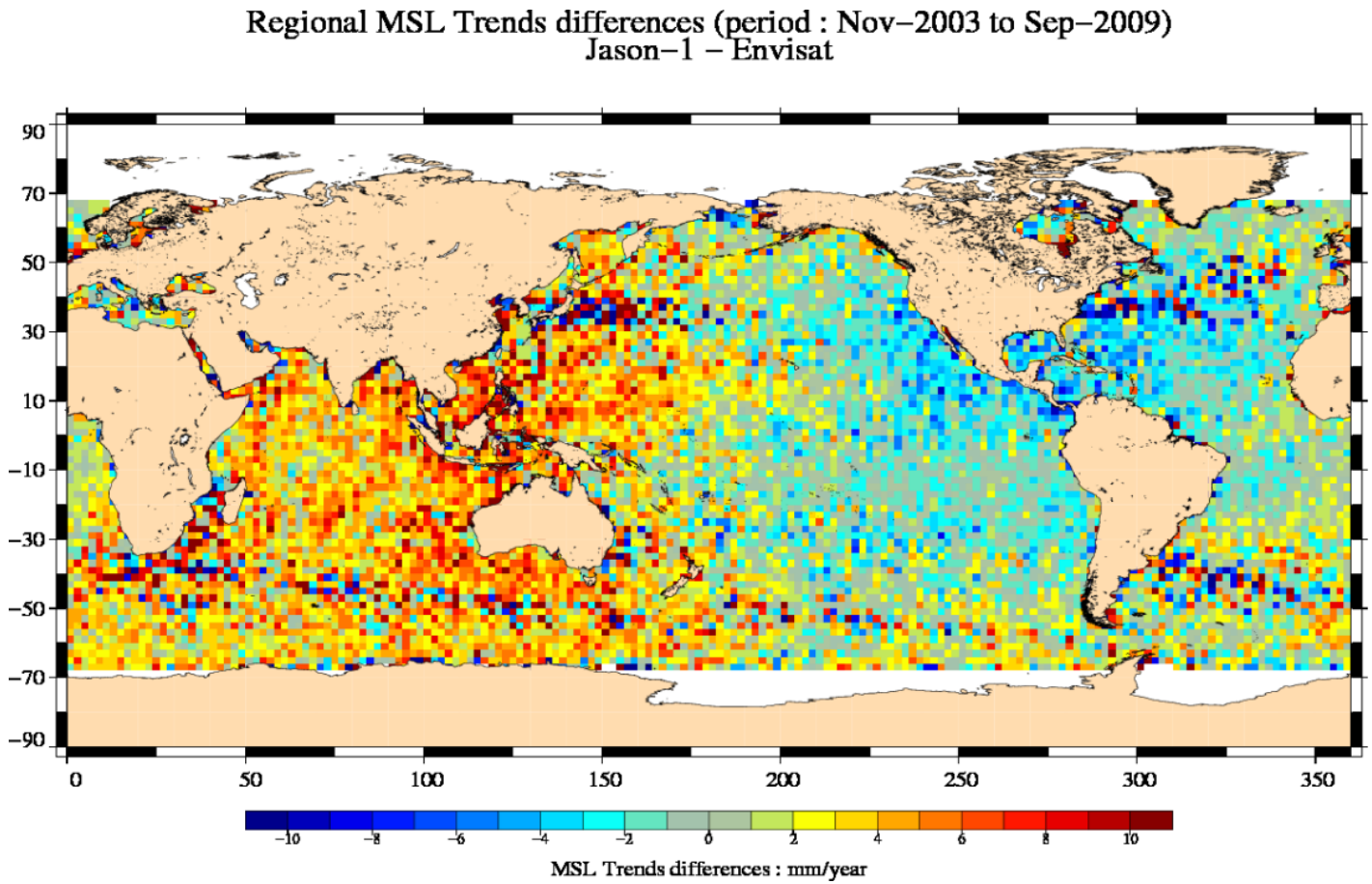
Impact of orbits (geopotential) on satellite altimetry

- Method: Global multi-mission cross-calibration of altimeter missions
  - time series of radial errors for each mission
  - differences in origin, i.e. between Envisat and Jason
- Processing with GDR-C orbit standard -> significant drift in y-comp.



Dettmering et al., 2010

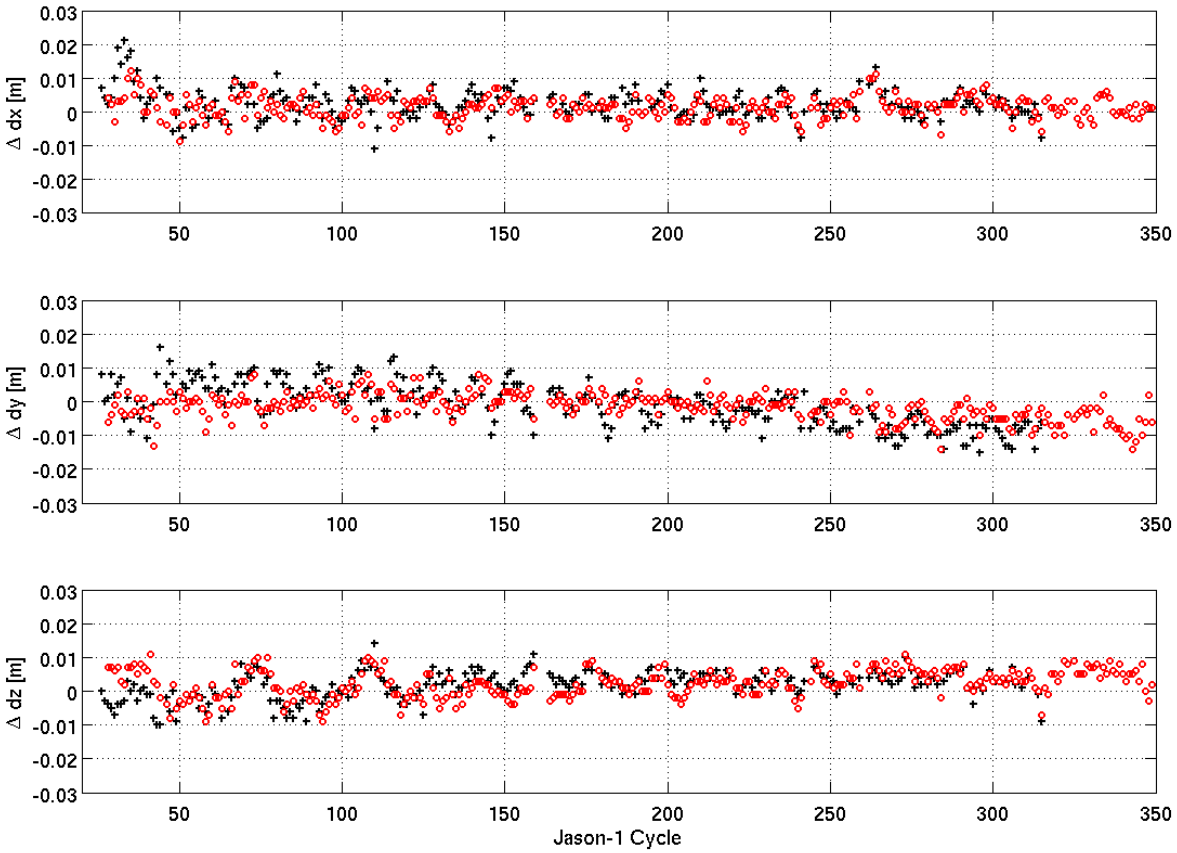
Systematic effects in mean sea level trends



Faugere et al. (2010): Envisat ocean altimetry performance assessment, Living Planet Symposium, Bergen

New orbits (GDR-D standard)

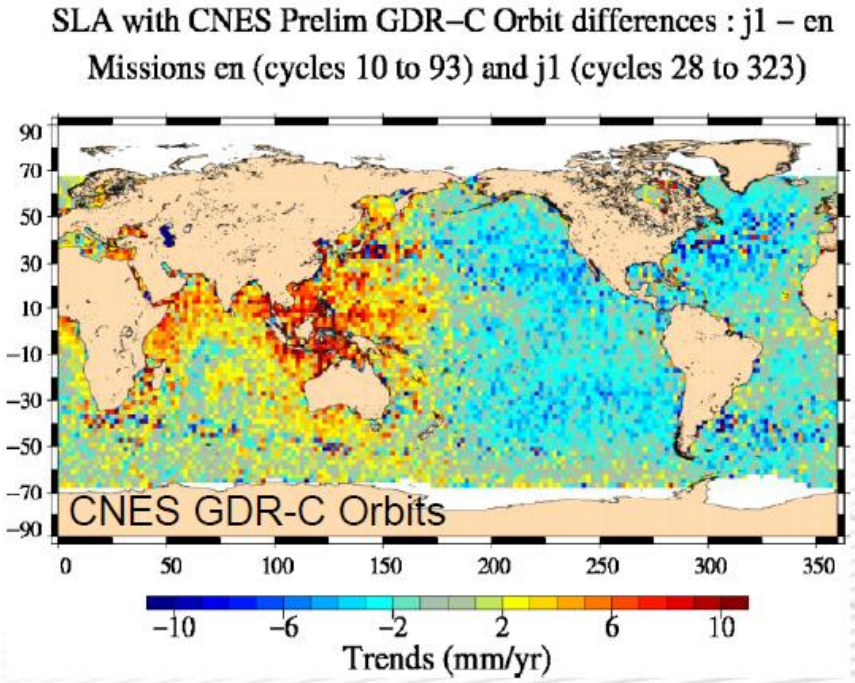
- Different handling/impact of **time varying gravity field** used for orbit computation reduces/removes the trend

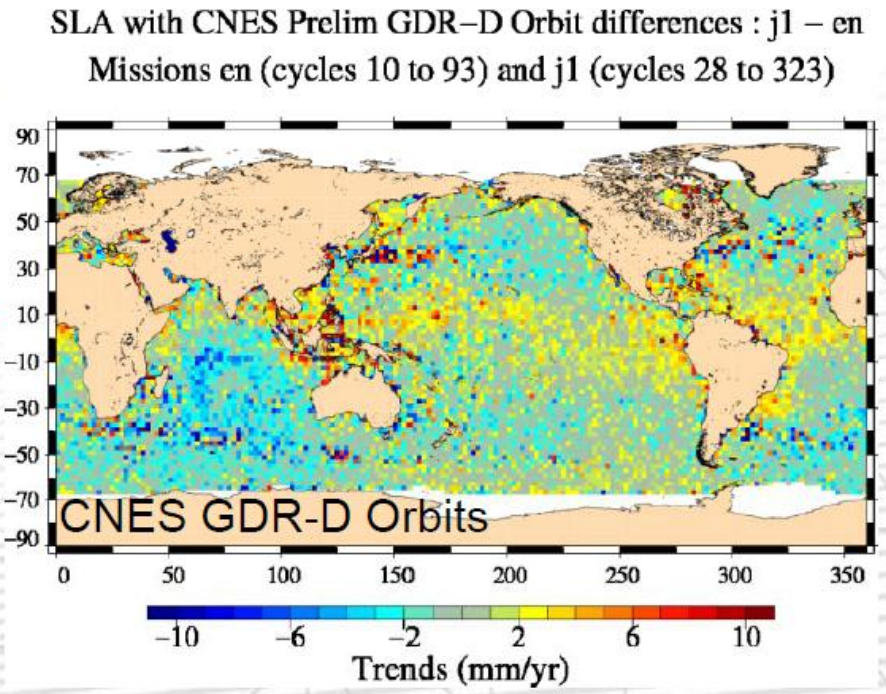


- 2mm/yr (GDR-C)
- 0.7 mm/yr (GDR-D)

Dettmering et al., 2011

Impact of orbits on mean sea level trends





Ablain et al. 2011: Regional MSL trends – OSTST San Diego 2011

Conclusions

- The definition of common standards and conventions is of crucial importance for the generation of consistent GGOS products.
- Existing gaps and inconsistencies have to be identified, and steps shall be initiated to resolve them.
- All analysis centers supporting geometric and gravimetric GGOS products shall apply common standards, conventions and models for the processing of the different space geodetic observations.
- The users of such products must exactly know, whereupon they are based on, to fully exploit their accuracy and to allow for a coherent interpretation.