IAG Commission 1 „Reference Frames“ and the Global Geodetic Observing System

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GGOS

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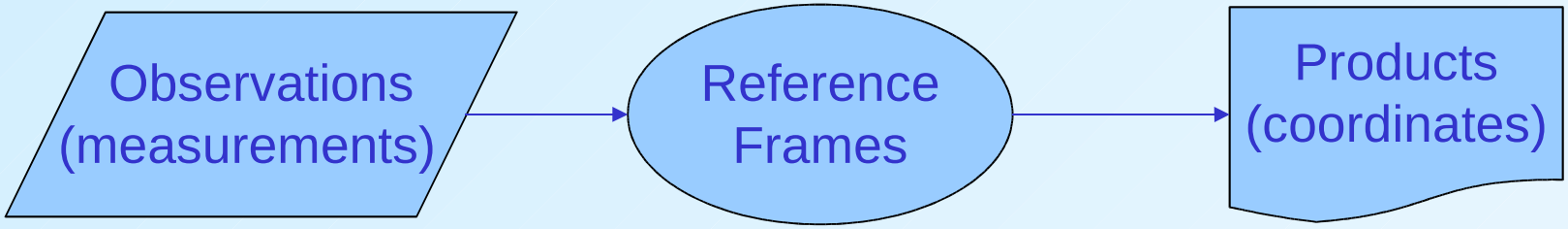
Introduction

Reference Frames form central research objectives and products of the IAG Commissions, Services (IERS, IGS, ILRS, IVS, IDS) and of GGOS.



- What is the role of Commission 1 in this environment ?
- What will Commission 1 contribute to GGOS ?
- What can Commission 1 receive from GGOS ?

It has become familiar to refer „reference frames“ only to geometry.
Of course there are also gravity reference frames: IGSN71, IAGBN ...

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IAG Commissions and Services

(IAG Bylaws)

- **1.2 COMMISSIONS** shall promote the advancement of science, technology and international cooperation in their field. They establish the necessary links with sister disciplines and with the relevant Services. Commissions shall represent the Association in all scientific domains related to their field of geodesy.

  The Commissions are one of the main components of the IAG structure. In addition to their main tasks they are also responsible for their sub-components: the Sub-commissions, Commission-Projects, Study-Groups, and Joint Sub-components.

- **1.3 SERVICES** are part of the Association's work and generate products, using their own observations and/or observations of other services, relevant for geodesy and for other sciences and applications. ...

Objectives of IAG Commission 1

(Geodesist‘s Handbook 2004)

The principal objective of the scientific work is the **basic** research on:

- Definition, establishment, maintenance, and improvement of geodetic reference frames.
- Advanced development of terrestrial and space observation techniques for this purpose.
- Analysis and processing methods for parameter estimation related to reference frames.
- Theory and coordination of astrometric observations for reference frame purposes.

Additional objectives are the international collaboration:

- for the definition and deployment of networks of observatories,
- with related scientific organizations, institutions, agencies, and IAG Services.

Commission 1 and Services

Reference System

- Definition of a set of constants models, parameters as basis for the representation of time dependent quantities.

Reference Frame

- Fundamentals for realization of the reference systems by sets of physical objects.
- **No** product generation

Reference Frame

- Realization of the reference systems from observations by numerical values along with their uncertainties.
- Provision of the reference frame as a product to the user communities
- Maintenance of consistency and reliability of all provided components.

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Structure of IAG Commission 1

SC1.1 Coordination of Space Techniques

SC1.2 Global Reference Frames

SC1.3 Regional Reference Frames
(Europe, S. America, N. America, Africa, Asia-Pacific, Antarctic)

SC1.4 Interaction of Celestial and Terrestrial Reference Frames

ICP1.1 Satellite Altimetry

ICP1.2 Vertical Reference Frames

SG1.1 Ionosphere Modelling and Analysis

SG1.2 Use of GNSS for Reference Frames

Joint Projects and Working Groups hosted by other Commissions and the Inter-Commission Committee on Theory

SC1.1 Coordination of Space Techniques

Sub-Commission 1.1 coordinates efforts that are common to more than one space geodetic technique, such as models, standards and formats.

- Study systematic effects of or between space geodetic techniques.
- Develop common modelling standards and processing strategies.
- Comparison and combination of orbits.
- Explore and develop innovative combination aspects.
- Establish methods to validate the combination results.
- Explore interactions between gravity, EOPs and reference frames.
- Study combination aspects of GPS and InSAR.

→ Enters directly into GGOS WG on Conventions, Models, Analysis.

SC1.2 Global Reference Frames

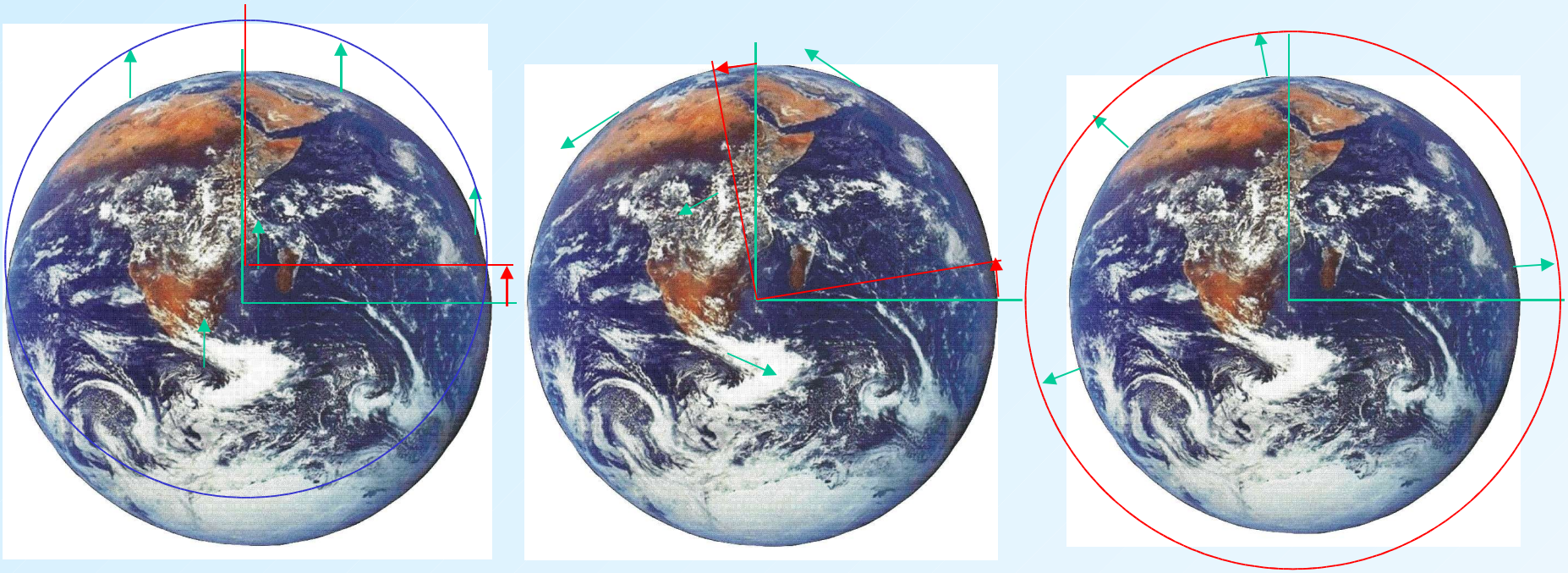
Sub-Commission 1.2 is engaged in scientific research and practical aspects of the global reference frames.

- Definition of the terrestrial reference frame (origin, orientation, scale),
- Fundamentals of the realization of the terrestrial reference frame,
- Analysis of strengths and weaknesses of individual techniques,
- Combination methodology of individual techniques' solutions,
- Definition of common standards and models for all techniques,
- Implementation of the concept of Global Geodetic Observatories,
- Propagation of ITRS/ITRF to national and international organizations.

→ Enters into GGOS WG on Networks and Communication and into WG on Conventions, Models, Analysis.

SC1.2 Example of Definition and Realization

Motions of individual stations of the reference frame may have the same effect as a change of the datum (origin, orientation and scale).



→ We must not mix the definition and the realization, i.e., change the definition by the procedure of its realization.

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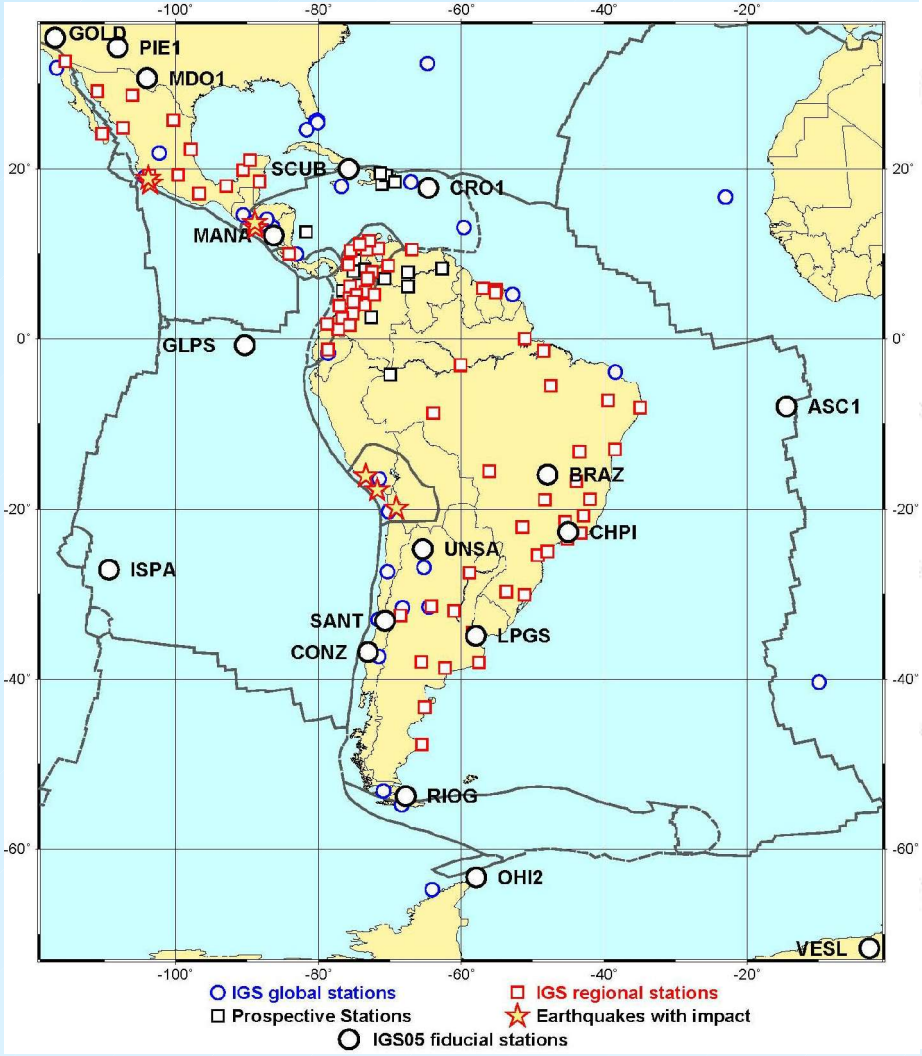
SC1.3 Regional Reference Frames

Sub-Commission 1.3 is concerned with definitions and realizations of regional reference frames and their connection to (and densification of) the global International Terrestrial Reference Frame (ITRF).

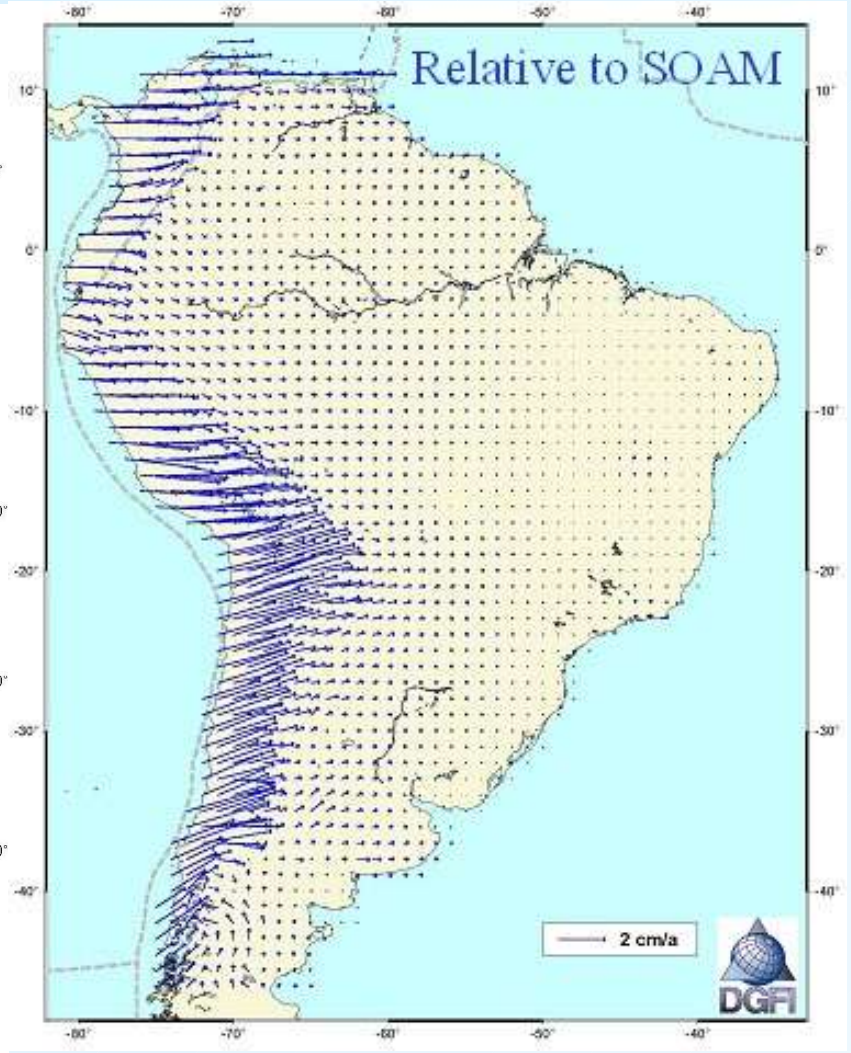
- Develop specifications for the definition and realization of regional reference frames.
- Develop and promote operation of GPS permanent stations.
- Coordinate activities of the regional sub-commissions (EUREF, SIRGAS, NAREF, AFREF, PCGIAP, SCAR).
- Encourage and stimulate the emerging development of the AFREF.
- Encourage and assist countries to re-define and modernize their national geodetic systems, compatible with the ITRF.

→ The ITRF is not only a scientific product but it is used in most countries of the world as a (national) reference for positioning and navigation.

SC1.3 Example of a Regional Reference Frame



IGS2005 and regional stations



Deformation model

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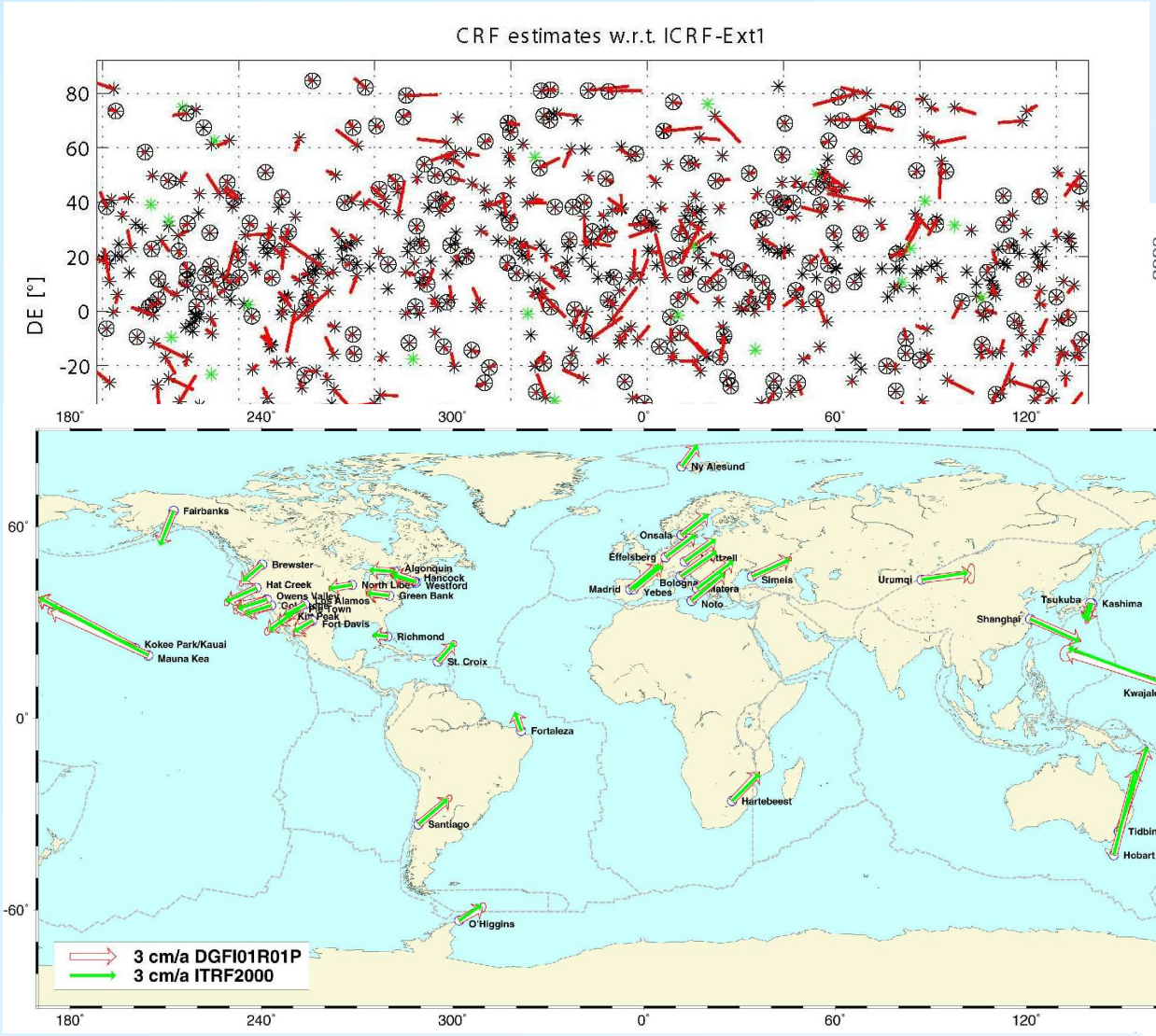
SC1.4 Interaction of Celestial and Terrestrial Reference Frames

The major objective of SC1.4 is to study the interaction of the celestial and the terrestrial reference frame which are linked by observations of the celestial sources or satellites from the terrestrial stations.

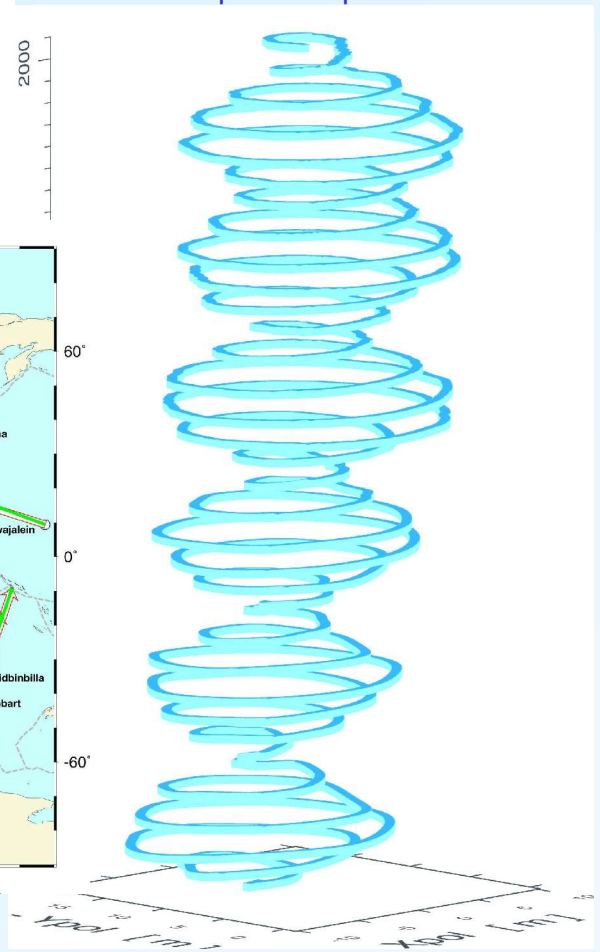
- Theoretical aspects of the Celestial Reference System.
- Realization of Celestial Reference Frames (CRF & transformations).
- Systematic effects in the CRF determination.
- Interaction Between Celestial and Terrestrial Reference Frame.
- Satellite Gravity Theory (with Commission 2 and ICCT).

→ Is an interface to neighbouring sciences (astrometry, IAU)

SC1.4 Example of Interaction of CRF and TRF



Simultaneous computation of CRF, EOP (X_{pole}, Y_{pole}, LOD)



and TRF

ICP1.1 Satellite Altimetry

The primary objective of the Inter-Commission Project is to identify the scientific requirements to ensure a long and precise time series of utmost consistent altimeter observations with up-to-date geophysical corrections, consolidated geocentric reference and long-term stability.

- To study the contribution of satellite altimetry to the realization and stability of the vertical component of the ITRF.
- To investigate by an interdisciplinary working group the rationale, feasibility and scope of an International Altimeter Service in order to serve scientific and operational applications of satellite altimetry. The group shall strive for a broad support by other scientific entities.

→ The IAS is being installed as a new IAG Service in 2007.

ICP1.2 Vertical Reference Frames

Based on the classical and modern observations, the Project on Vertical Reference Frames shall study the consistent modeling of both, geometric and gravimetric parameters, and provide the fundamentals for the installation of a unified global vertical reference frame.

- To elaborate a proposal for the definition and realization of a global vertical reference system (World Height System – WHS).
- To derive transformation parameters between regional vertical reference frames.
- To establish an information system describing the various regional vertical reference frames & their relation to a world height frame (WHF).

→ The realization of a WHS is in progress (see next page).

ICP1.2 Vertical Reference Level W_0

Table 1. W_0-values derived from different GGMs and MSS-models [in m^2s^{-2}].

MSS	n	EIGEN-CG03C	EGM96	TEG4	GGM02S	φ [N/S]
CLS01	120	62 636 853,35	62 636 853,37	62 636 853,38	62 6368 53,36	60/60
	200	53,35	53,37	53,37		60/60
	360	53,35	53,36			60/60
KMS04	360	53,24	53,26			60/60
GSFC00.1	360	53,58	53,59			60/60
CLS01	120	62 636 854,61	62 636 854,62	62 636 854,65	62 636 854,61	82/80
	200	54,61	54,62	54,64		82/80
	360	54,61	54,61			82/80
KMS04	360	54,46	54,45			82/82
GSFC00.1	360	54,93	54,93			80/80

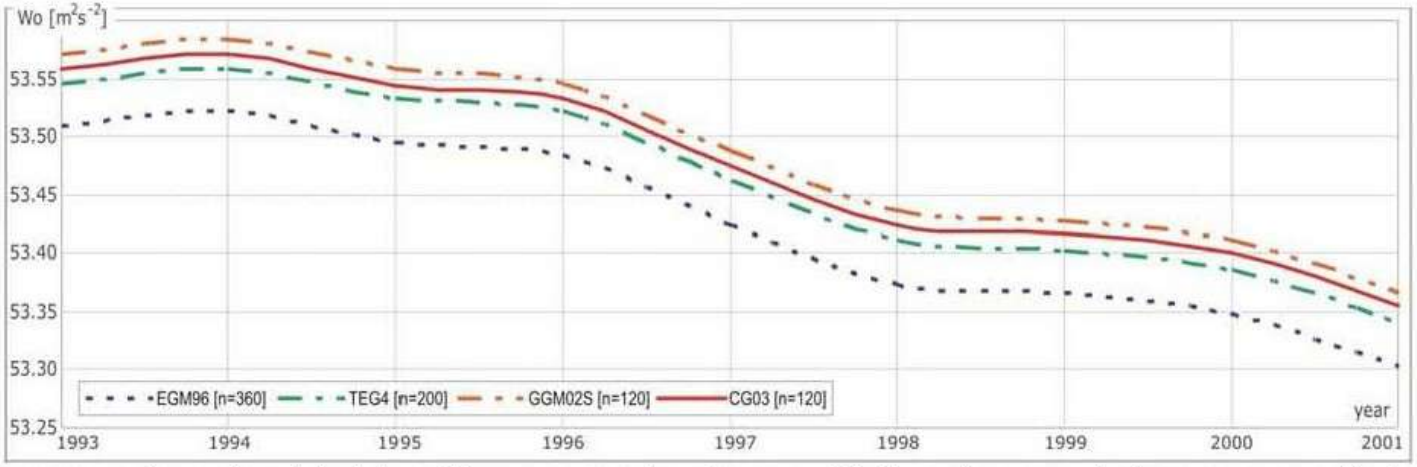


Fig. 4 Annual W_0-values derived from different GGMs and yearly MSS-models from T/P 1-365 cycles (1° x 1°, $\varphi = 60°N/S$), the value 62 636 800 m^2s^{-2} should be added.

Gravity potential of the mean sea level (W_0) from three altimetry models and four global gravity models.

Time evolution of the gravity potential of the mean sea level.

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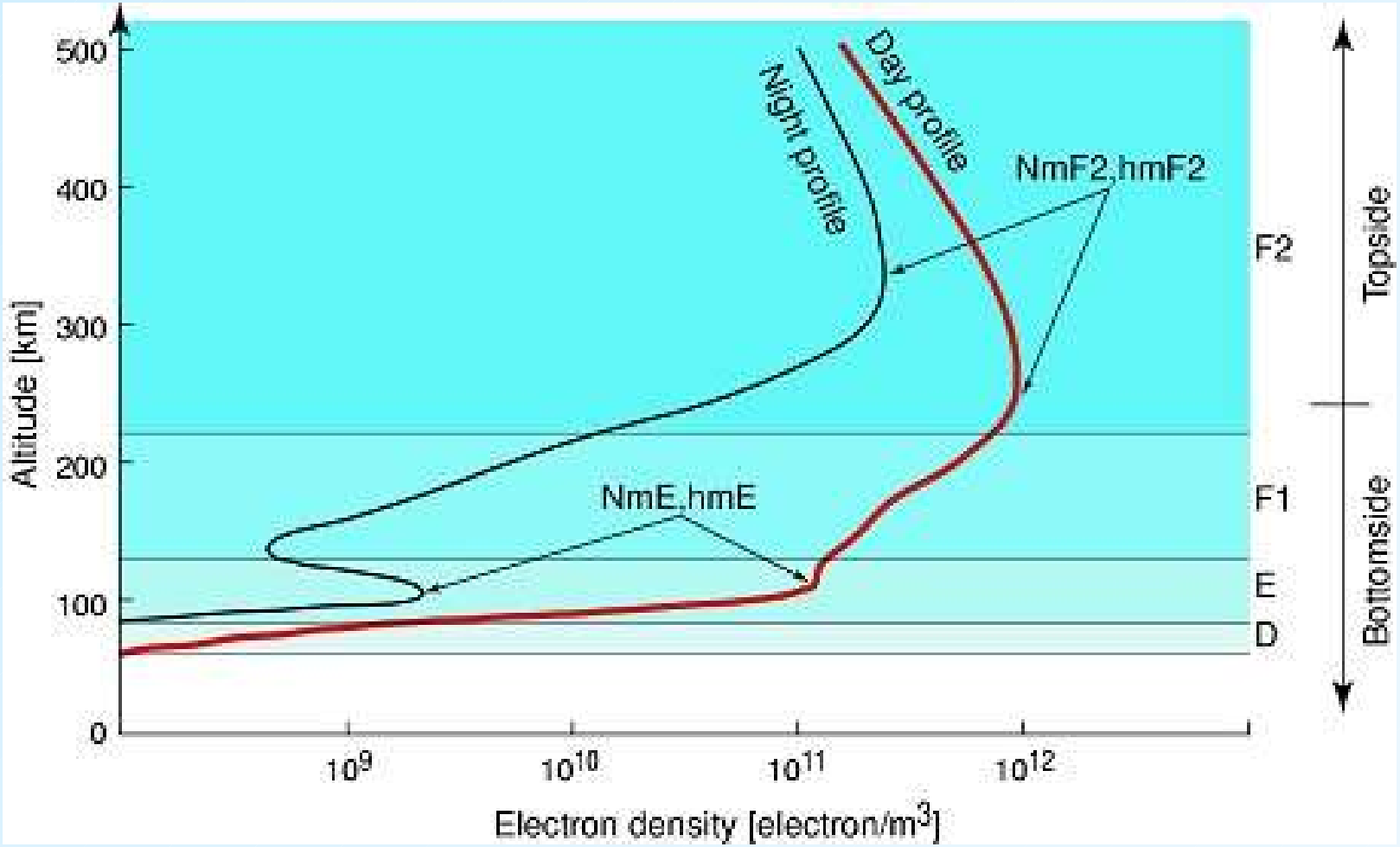
ICSG1.1 Ionosphere Modelling and Analysis

The Inter-Commission Study Group shall investigate the possibilities to derive parameters of physical ionosphere models (e.g. International Reference Ionosphere, IRI) from geodetic microwave observations.

- To collect and validate existing physical ionosphere models.
- To represent them by different methods, e.g., spherical harmonics and wavelets.
- To compare the models with geodetic observations.
- To derive model parameters from geodetic observables (e.g., GNSS, satellite altimetry).

→ This is a study of a possibly new product of geodesy.

ICSG1.1 Example of an Ionosphere Model



Ionosphere model NeQuick to be parameterised and estimated 4D

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ICSG1.2 Use of GNSS for Reference Frames

The goal of Inter-Commission Study Group 1.2 is to evaluate and support the use of Global Navigation Satellite Systems for the definition and densification of the ITRF.

- Document the potential contributions of Global Navigation Satellite Systems to reference frame establishment and maintenance.
- Investigate the ties between GNSS Broadcast Frames like WGS84, PZ-90 and the upcoming GALILEO Reference Frame, and the ITRF.
- Examine deficiencies in the stability of the global GNSS network, especially focusing on stations contributing to the ITRF.
- Prepare a consolidated feedback concerning GPS, GLONASS and GALILEO receiver site selection, installation and maintenance.
- Investigate the strengths and shortcomings of GPS, GLONASS and GALILEO for Reference System Realisation and work out synergies.
- Study the ties of regional and local frames realized by a permanently increasing number of active real-time GNSS networks.

Conclusion

- IAG Commission 1 contributes basic research to the definition and realization of celestial, and global and regional terrestrial reference frames.
- It studies eventual gaps in international scientific services (IAS) and products (VRS - WHS - WHF).
- It studies new representation methods of physical models (IRI).
- Commission 1 expects from GGOS an improved information and propagation of results in the interdisciplinary community and in society in general.

Thank you !