

The IGS, the IAG, and the ICG

G. Beutler

*Astronomical Institute, University of Bern
IAG representative on PNT Advisory Board*

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**University Corporation for Atmospheric Research
(UCAR)**

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Boulder, Colorado 80301**

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- **The IAG, the IGS, the GGOS, the GIAC, and the ICG**
- **The UN GGRF Working Group and the UN resolution on reference frames, February 26, 2015.**
- **IGS: present and future**

IAG, IGS, GGOS, GIAC and ICG

IAG, the **International Association of Geodesy** is a scientific organization in the field of geodesy promoting scientific cooperation and research [...] on a global scale [...].

GGOS, IAG's **Global Geodetic Observing System**, working with the other IAG components to provide the geodetic infrastructure necessary for monitoring the Earth system and for global change research.

GIAC is the GGOS Inter-Agency Committee (GIAC).

IGS, the **International GNSS Service**, is a scientific service of the IAG, enabling highest-accuracy applications, including scientific applications.

IERS is the **International Earth Rotation and Reference System Service** (of IUGG and IAU) using the IGS products to generate technique-overarching geodetic & astronomical products.

The IGS is an associate member of the **ICG**, the **International Committee on Global Navigation Satellite Systems**.

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UN-GGRF & resolution of reference frames

UN-GGRF (UN-Global Geodetic Reference Frames) is a working group of the UN Committee of Experts on Global Geospatial Information Management (UN GGIM).

GGRF members are in part members of the aforementioned IAG entities.

On February 26, 2015, **the first UN resolution about global geodetic reference frames** was adopted.

→ The resolution is an **astonishing example** of the **science-driven community and decision makers from politics**, in particular from the **UN working together** to the benefit of society.

The IGS: present

Today, the IGS archives

- archives all globally relevant GNSS observations since 1991, generates and provides
 - **ephemerides** (accurate to 2-4 cm) for ~32 GPS satellites and for ~24 GLONASS satellites (accurate to 5-8 cm), and other GNSS being deployed,
 - **satellite and receiver clock corrections** (sub-ns accuracy)
 - **polar motion (PM)** and **length of day (LOD)** (cm accuracy)
 - **coordinates and velocities** for 200+ sites (cm / mm/y accuracy)
 - **atmosphere information**, in particular **Global Ionosphere Models (GIMs)**.
 - **Satellite clock corrections & corresponding orbits** are also provided in „real time“ based on the IGS Real Time Network of 150+ sites.

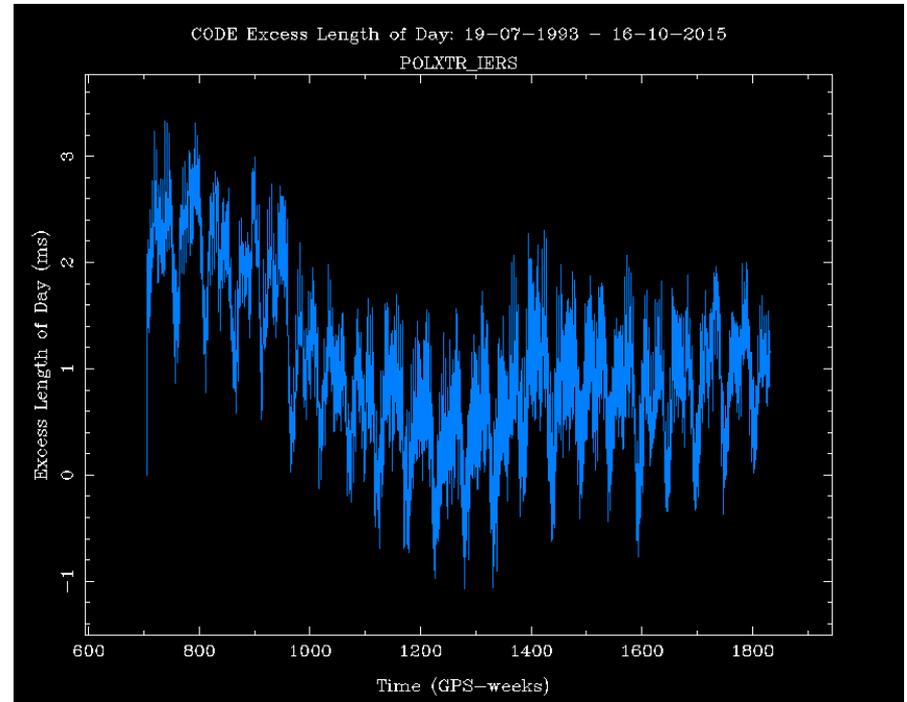
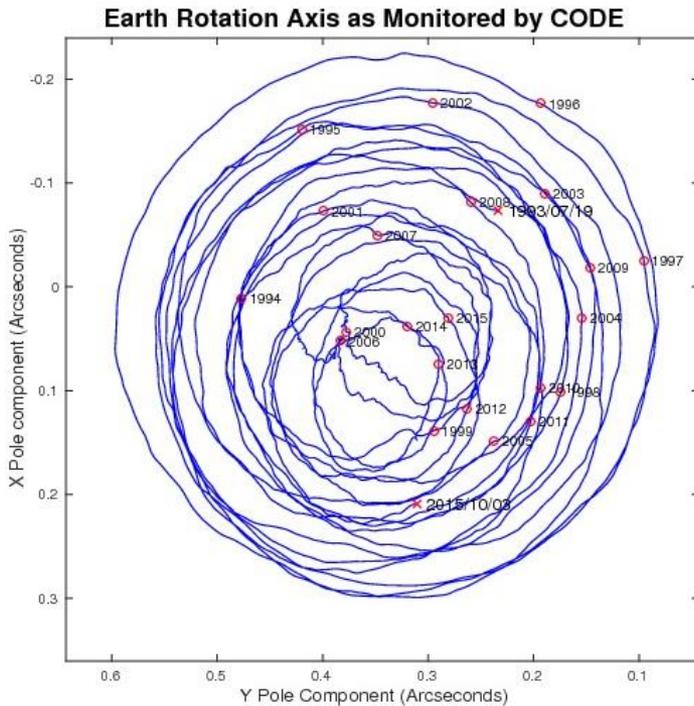
IGS products are **accurate**, **reliable** and **validated**.

- **Combined products** are formed by **Coordinators** and made publicly available in a **timely** manner.

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IGS products: Earth Rotation

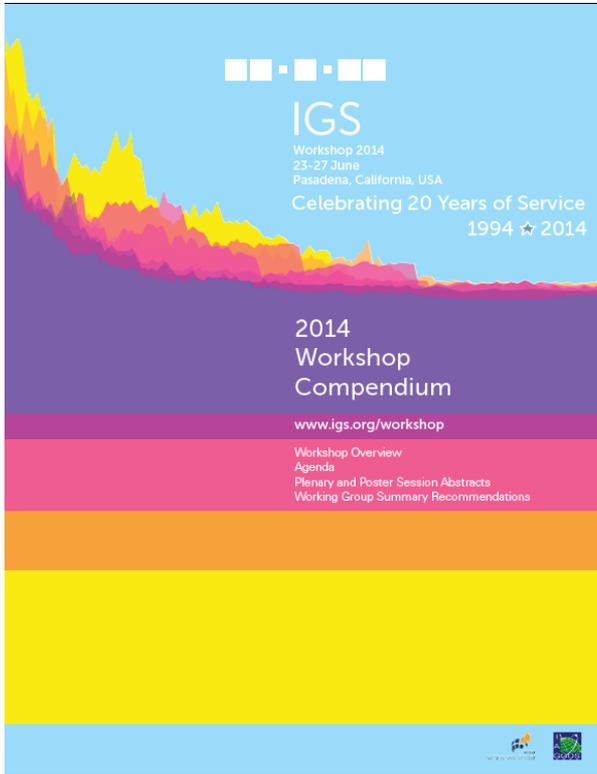


Left: Polar motion since 1993, Right: Excess Length of Day since 1993. Time resolution of IGS time series: 1 day. “millimetric” accuracy on Earth’s surface

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IGS Workshop 2014: 20th Anniversary



<http://kb.igs.org/hc/en-us/articles/2048>

Compendium. The IGS is regularly questioning and improving its performance and products.

Message from the Director of the IGS Central Bureau

Dear Workshop Attendee,

Thank you for participating in the IGS Workshop 2014, held on the campus of the California Institute of Technology (Caltech) in Pasadena, California, USA. This special twentieth anniversary workshop was hosted by the IGS Central Bureau, with support from the NASA Jet Propulsion Laboratory (JPL) and Caltech.

The week-long workshop featured plenary presentations and posters presented by our colleagues from around the world – illustrating how the IGS is truly an international organization serving science, engineering, and society in general.

The local organizing committee was led by Ruth Neilan (JPL) and Steve Fisher (JPL), with support from members of the IGS Central Bureau. The scientific program committee was led by Rolf Dach (AIUB), Shailen Desai (JPL), and Andrzej Krankowski (UWM).

In addition to plenary and poster presentations, we were able to celebrate twenty years of service with a special Anniversary Colloquium. This event featured many of our colleagues reflecting on various points in IGS history, as well as their own thoughts on the future of the IGS and geodesy.

All plenary session presentations were videorecorded, and are available to view on the "Presents" section of the IGS website: www.igs.org/presents. All presentations and posters are available in PDF format for download from the IGS website, as well.

Thank you for attending, and we look forward to seeing you again in 2016!

Ruth Neilan
IGS Central Bureau Director
Head of the Local Organizing Committee

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Future in GNSS: the science perspective

Until about 2007/08 GNSS was synonymous to GPS + minor contributions from other systems.

Today, we have two fully operational systems, namely GPS and GLONASS, which are both capable of generating geodetic products.

A combined analysis may result in better products for science and the wider user community.

>2018 there will be 3+ fully operational systems.

The future has already begun in the IGS with the MGEX (Multi-GNSS Experiment)

MGEX: Why Multi-GNSS?

More Satellites

- Improved PPP convergence
- More pierce points for atmospheric sounding
- De-correlation of height, clock, troposphere

Improved Signals

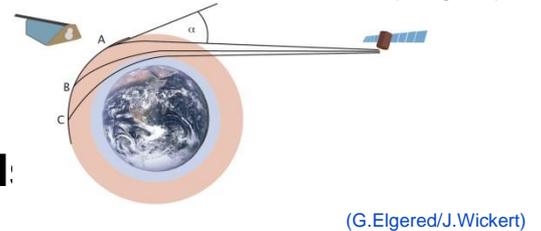
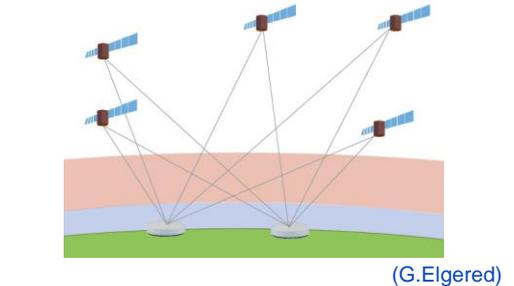
- Less multipath
- Increased robustness (scintillation, weak signal)

Stable clocks

- Improved Real-time PPP
- Orbit improvement / prediction

Diversity

- Different orbital periods and commensurabilities
- Decorrelation of estimated parameters (orbits, Earth rotation)



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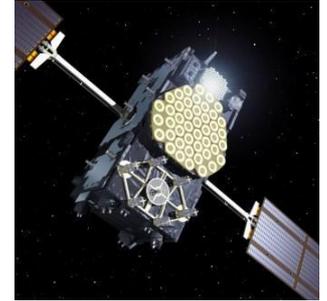
IGS-MGEX Products

Post-processed

Precise orbits and clocks
Broadcast ephemerides
Differential code biases

Real-time

Broadcast ephemerides
Orbit and clock corrections (Galileo)



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MGEX: Today's „System of Systems“

System	Blocks	Signals	Sats ^{*)}
GPS 	IIA	L1 C/A, L1/L2 P(Y)	3
	IIR	L1 C/A, L1/L2 P(Y)	12
	IIR-M	+L2C	7
	IIF	+L5	9
GLONASS 	M	L1/L2 C/A+P	23
	M+	L1/L2 C/A+P, L3 (CDMA)	1
	K1	L1/L2 C/A+P, L3 (CDMA)	(2)
BeiDou 	GEO	B1, B2, B3	5
	IGSO	B1, B2, B3	5
	MEO	B1, B2, B3	3
	3 rd generation	(B1,B3)	(1)
Galileo 	IOV	E1, (E6), E5a/b/ab	3+(1)
	FOC	E1, (E6), E5a/b/ab	(2)+(2)
QZSS 	IGSO	L1 C/A, L1C, SAIF L2C, E6 LEX, L5	1
IRNSS 	IGSO	L5, S	4

*) Status June 2015; brackets indicate satellites not declared healthy/operational

Modeling GNSS Orbits



- Lageos (LAser GEodetic Satellite); spherical, diameter 60cm, mass 405kg
- GNSS satellite: Body $2 \times 2 \times 2 \text{ m}^3$, “wings” $20 \times 2 \text{ m}^2$, mass 500-1000kg

Modeling GNSS Orbits



Ferraris are built to minimize non-gravitational forces, trucks not really (only “to some extent”).

From the p.o.v. of orbitography the Lageos is a Ferrari, the GNSS satellite is a truck.

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Wishes ...

All GNSS satellites equipped with **Laser Reflectors**

Information needed: The IGS is only capable of generating integrated and highest quality GNSS products, **provided the information on**

- satellite properties (mass, surface, reflectivities),
- Attitude,
- Satellite clock properties,

is available from system providers. ICG is the ideal platform for that purpose.

IGS acknowledged by PNT, ICG as provider for highest accuracy GNSS products.

IGS-internal:

Include LEO GNSS receivers for product generation.

Acknowledgement

The slides on MGEX stem from Oliver Montenbruck's presentation on the occasion of the 15th PNT Advisory Board Meeting.