IAG and GALILEO-Science Events in 2009

G. Beutler

Astronomical Institute, University of Bern
Member of **IAG Executive Committee**
IGS Governing Board
GSAC (ESA)

National Space-Based Positioning, Navigation, And Timing (PNT) Advisory Board

Hilton Alexandria Old Town

1767 King Street, Alexandria VA, USA 22314

November 5-6, 2009

International Association of Geodesy

IAG and Galileo Science-related Events

- ➢ **The IAG Scientific Assembly in 2009**
- ➢ **2nd International Colloquium on Scientific Aspects of the Galileo Program in Padua and the GSAC**
- ➢ **The Frankfurt Meeting on GGOS**

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IAG Scientific Assembly 2009

**The IAG scientific assembly (quadrennual event) took place Aug 31 to Sep 4 in Buenos Aires, Argentina.**

- ➢ **Gravity field determination,**
- ➢ **the establishment of reference frames (global, regional),**
- ➢ **positioning and navigation,**
- ➢ **propagation of electromagnetic signals through the Earth's atmosphere,**
- ➢ **geodynamcs and**
- ➢ **the establishment of IAG's Global Geodetic Observing System (GGOS)**

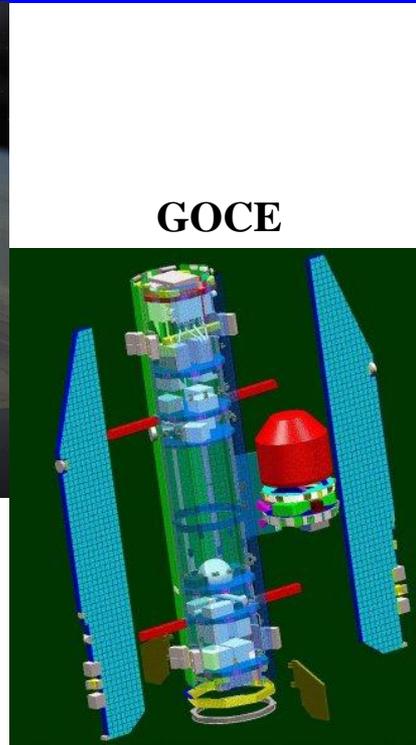**were the major issues – and GPS plays a key role in all of them.**
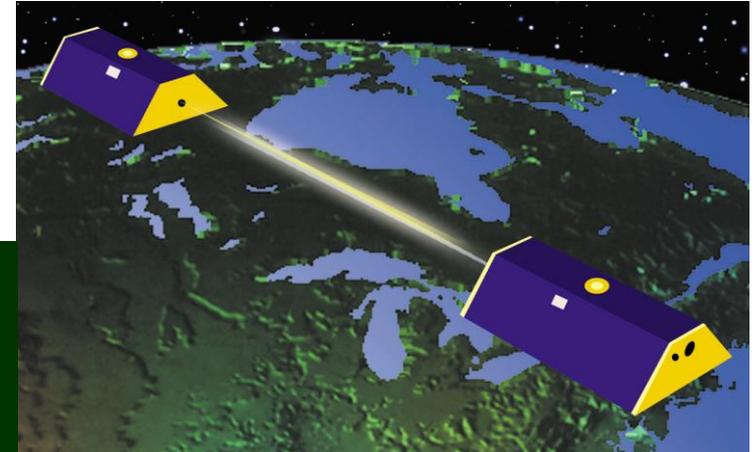
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Gravitaty field determination
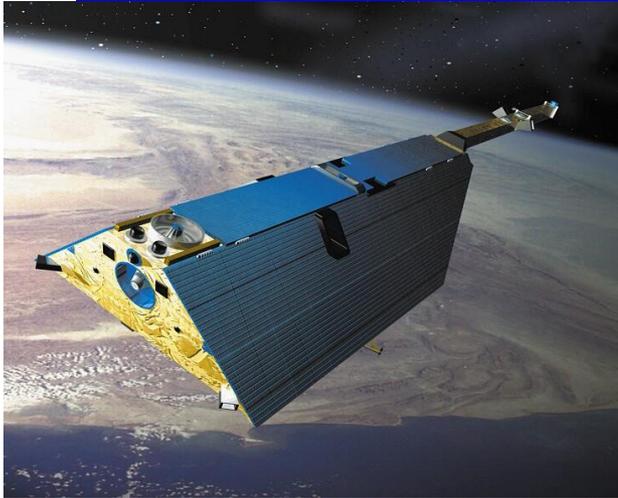
GOCE

CHAMP

GRACE A and B

CHAMP (left) determinates the gravity field from kinematic positions established with a spaceborne GPS receiver, GRACE (right) uses in addition μm-precise inter-satellite distances, GOCE (center) the measurements of a so-called gradiometer – in addition to GPS.

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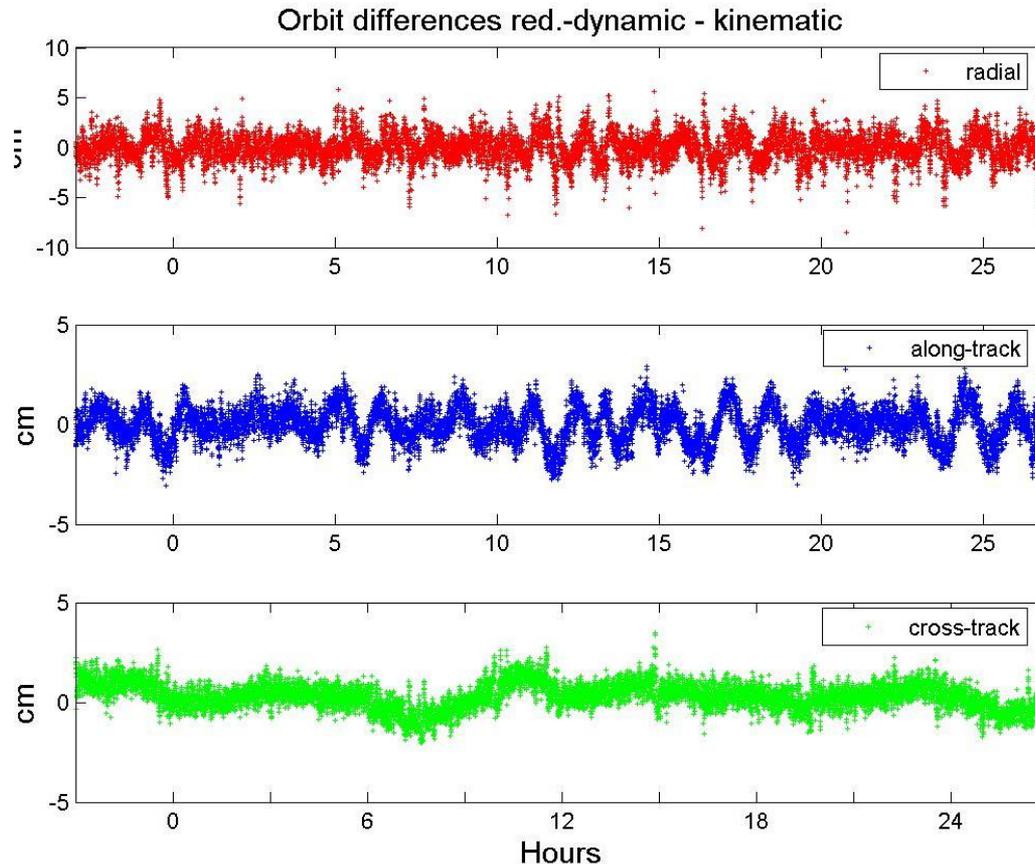# Gravitaty field determination

Protagonists of the missions: CHAMP: Christoph Reigber, GRACE: Byron Tapley & Ch. Reigber, GOCE: Reinhard Rummel
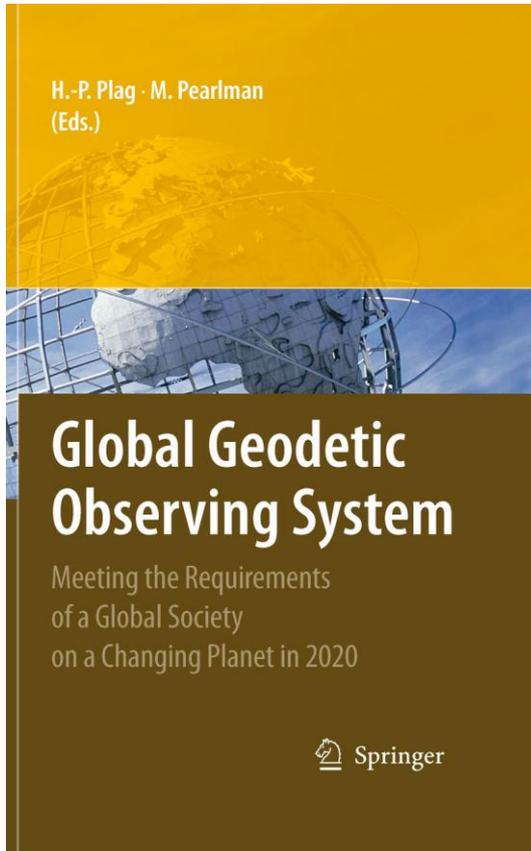
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Gravitaty field determination

Accuracy of GPS- derived kinematic GOCE orbit of the GOCE science orbit (by AIUB/ HPF from ESA, with permission).

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GGOS Mission

GGOS is

➢ the **global observing system of the IAG**,

➢ its **flagship** component that advances the use of geodetic observing methods for Earth system and planetary science and applications.

GGOS accomplishes its mission by **defining the geodetic infrastructure** that is needed to meet scientific and societal requirements,

➢ by advocating for the establishment and maintenance of this geodetic infrastructure,

➢ by coordinating interaction between the IAG Services, Commissions, and stakeholders,

➢ by improving the quality of and accessibility to geodetic observations and products, and

➢ by educating the scientific community about the benefits of geodetic research and the public about the fundamental role that geodesy plays in society.

H.-P. Plag · M. Pearlman (Eds.)

Global Geodetic Observing System

Meeting the Requirements of a Global Society on a Changing Planet in 2020

Springer

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GGOS: The near future: 2009-....

Prof. Dietmar Grünreich, President of the Federal Agency for Cartography and Geodesy (BKG) invited the key agencies contributing to the IAG services and GGOS components for a conference on Nov 2-3 2009 to Frankfurt to

> ➢ **sign up to the GGOS concept laid down in GGOS 2020 document,**

> ➢ **take note of the situation crated by the GGOS CfP and to develop a strategy to fill the GGOS gaps**

> ➢ **to consider the creation of an Intergovernmental Committee for GGOS to take over political responsibility for the GGOS long-term stability**

It goes without saying that the scientific home of and the scientific responsibility for GGOS must remain at IAG.

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Galileo Science-related Events

2nd International Colloquium on

Scientific Aspects of the Galileo Program **(3 days, parallel sessions)**

Sessions:

Ionosphere, Clocks

Remote Sensing, Relativity

Troposphere, Time

Geodesy, Advanced Topics

More information: http://www.congrex.nl/09c10/

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Galileo Science-related Events

2nd **International Colloquium on**

Scientific Aspects of the Galileo Program **(3 days, papallel sessions)**

Round table:

Community anxious to get GIOVE obs

Research related to GALILEO space clocks, multi-GNSS, real time satellite clocks/ephemerides, satellite/receiver antenna issues, independent orbit validation should be stimulated.

SLR reflectors will be on Galileo spacecrafts of IOV and FOC phases.

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Galileo Science-related Events

GSAC stands for Galileo Science Advisory Committee. The members of GSAC shall -

Recommend improvements to Galileo and EGNOS for scientific applications

Maintain a GNSS Science Opportunity Document (SOD), highlighting scientific priorities

Support the preparation of announcements of opportunity (AO) for scientific studies

Advise on the use of Galileo and EGNOS data for scientific applications.

Consider and review ESA-furnished documents related to the scientific use of GNSS signals

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Galileo Science-related Events

➢ **The members of the GSAC are appointed by the ESA Director General upon recommendation of the ESA member countries.**

➢ **The Committee has a Chair (one of its members) and a Secretary (from ESA).**

➢ **Secretary: Dr. Bertram Arbesser-Rastburg.**

➢ **The GSAC was created in fall 2008 and met three times since.**

➢ **Third meeting took place October 13, 2009 in Padua**

➢ **A GSAC web-page is under construction.**

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Frankfurt GGOS Meeting

The major GGOS funding agencies and IAG/GGOS develop a strategy to preserve and improve global geodetic infrastructure.

Results of the meeting on November 2-3:

- ➢ **The GGOS2020 document is adopted as the reference for all GGOS-related activities.**
- ➢ **The IAG services' products also labeled GGOS products**
- ➢ **Decision to create GGOS Intergovernmental Committee (GIC) (first step Inter-agency agreement)**
- ➢ **GIC will be represented in the top level GGOS Governing Entity (requires revision of GGOS structure)**
- ➢ **Frankfurt declaration adopted.**

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GLONASS-Status November 2009 / Re-Iteration on SLR Reflectors

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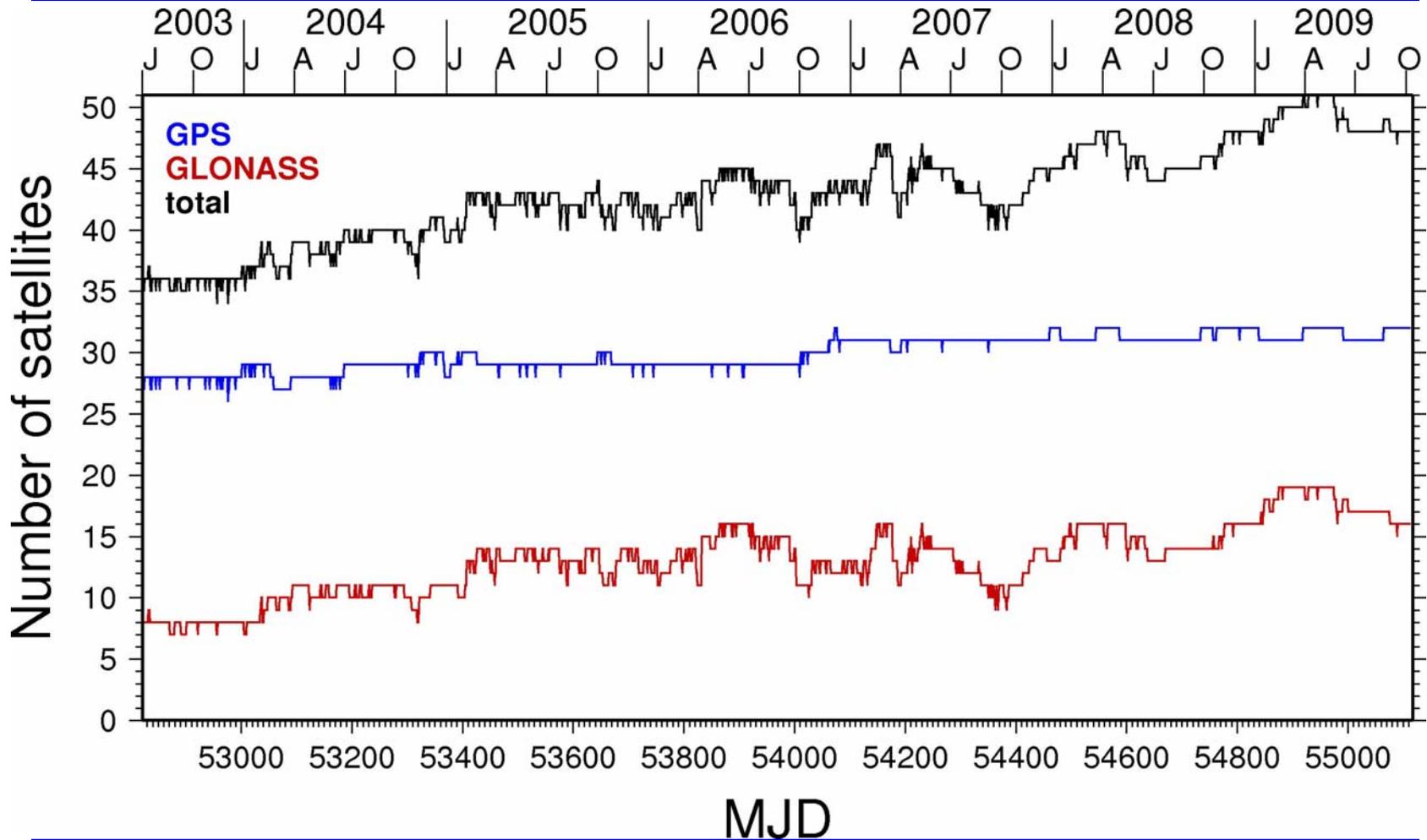
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Multi-GNSS Analysis at CODE

Multi-GNSS Analysis at CODE

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                    GLONASS Constellation Status
                        ( November 5, 2009)

|GLONASS|Cosmos|Plane/|Frequ.|   Launch    |    Intro    |   Status   |   Outage    |
|number |number| slot |chann.|    date     |    date     |            |    date     |
|-------|------|------|------|-------------|-------------|------------|-------------|
|  728  | 2448 | 1/02 |  -4  | 25.12.2008  | 20.01.2009  | operating  | ..........  |
|  727  | 2447 | 1/03 |  05  | 25.12.2008  | 17.01.2009  | operating  | ..........  |
|  701  | 2404 | 1/06 |  01  | 10.12.2003  | 09.12.2004  |  unusable  | 18.06.2009  |
|  712  | 2413 | 1/07 |  05  | 26.12.2004  | 22.12.2005  | operating  | ..........  |
|  729  | 2449 | 1/08 |  06  | 25.12.2008  | 12.02.2009  | operating  | ..........  |
|  722  | 2435 | 2/09 |  -2  | 25.12.2007  | 25.01.2008  | operating  | ..........  |
|  717  | 2426 | 2/10 |  -7  | 25.12.2006  | 03.04.2007  | operating  | ..........  |
|  723  | 2436 | 2/11 |  00  | 25.12.2007  | 22.01.2008  | operating  | ..........  |
|  721  | 2434 | 2/13 |  -2  | 25.12.2007  | 08.02.2008  | operating  | ..........  |
|  715  | 2424 | 2/14 |  -7  | 25.12.2006  | 03.04.2007  | operating  | ..........  |
|  716  | 2425 | 2/15 |  00  | 25.12.2006  | 12.10.2007  | operating  | ..........  |
|  718  | 2431 | 3/17 |  04  | 26.10.2007  | 04.12.2007  | operating  | ..........  |
|  724  | 2442 | 3/18 |  -3  | 25.09.2008  | 26.10.2008  | operating  | ..........  |
|  720  | 2433 | 3/19 |  03  | 26.10.2007  | 25.11.2007  | operating  | ..........  |
|  719  | 2432 | 3/20 |  02  | 26.10.2007  | 27.11.2007  | operating  | ..........  |
|  725  | 2443 | 3/21 |  04  | 25.09.2008  | 05.11.2008  | operating  | ..........  |
|  726  | 2444 | 3/22 |  -3  | 25.09.2008  | 13.11.2008  |  unusable  | 31.08.2009  |
|  714  | 2419 | 3/23 |  03  | 25.12.2005  | 31.08.2006  | operating  | ..........  |
|  713  | 2418 | 3/24 |  02  | 25.12.2005  | 31.08.2006  |  unusable  | 02.11.2009  |
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Three GLONASS-M Satellites dropped out summer/fall 2009, among them the oldest GLONASS-M. September triple launch postponed to Feb 2009. Status of Christmas launch unclear.
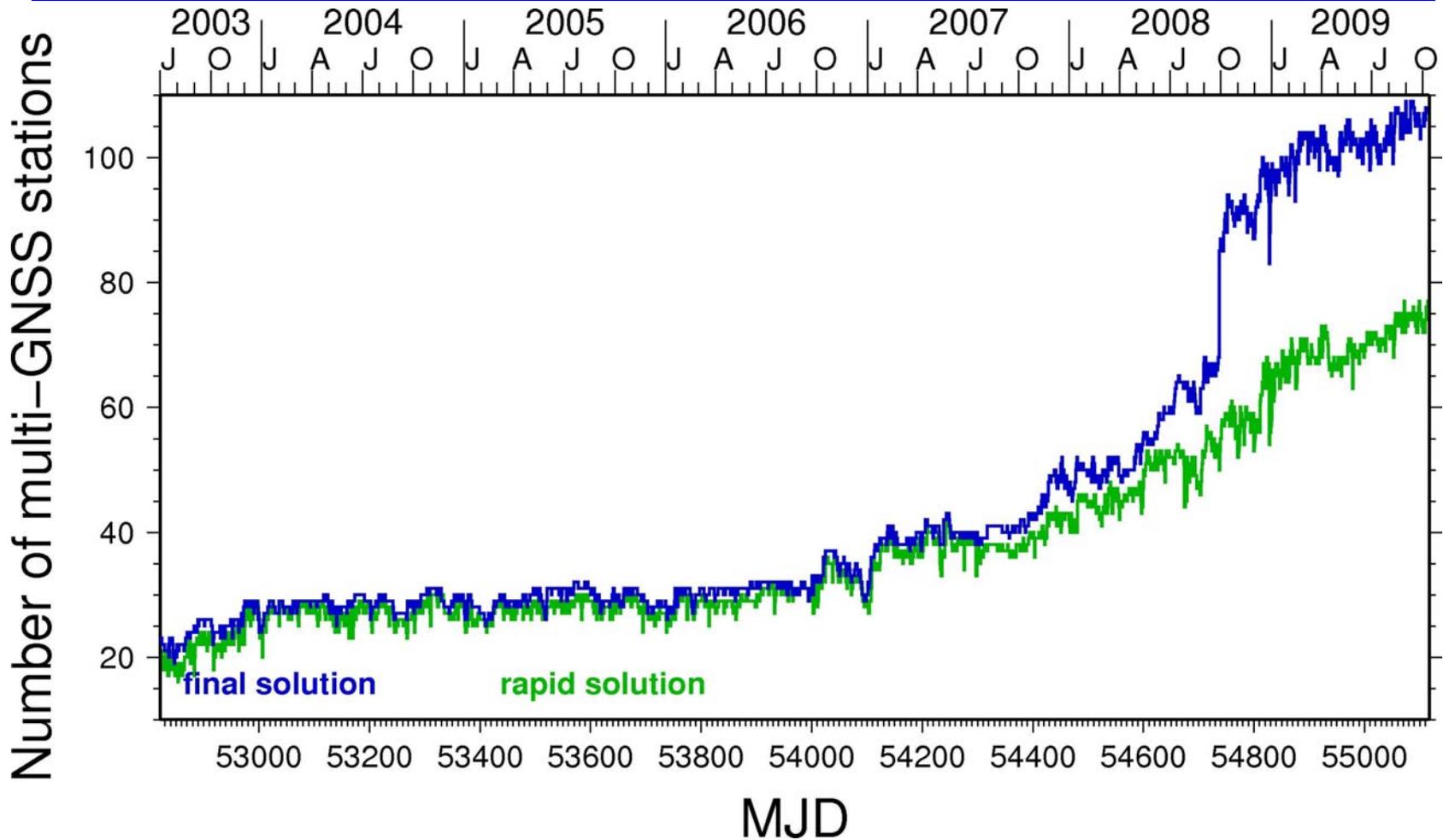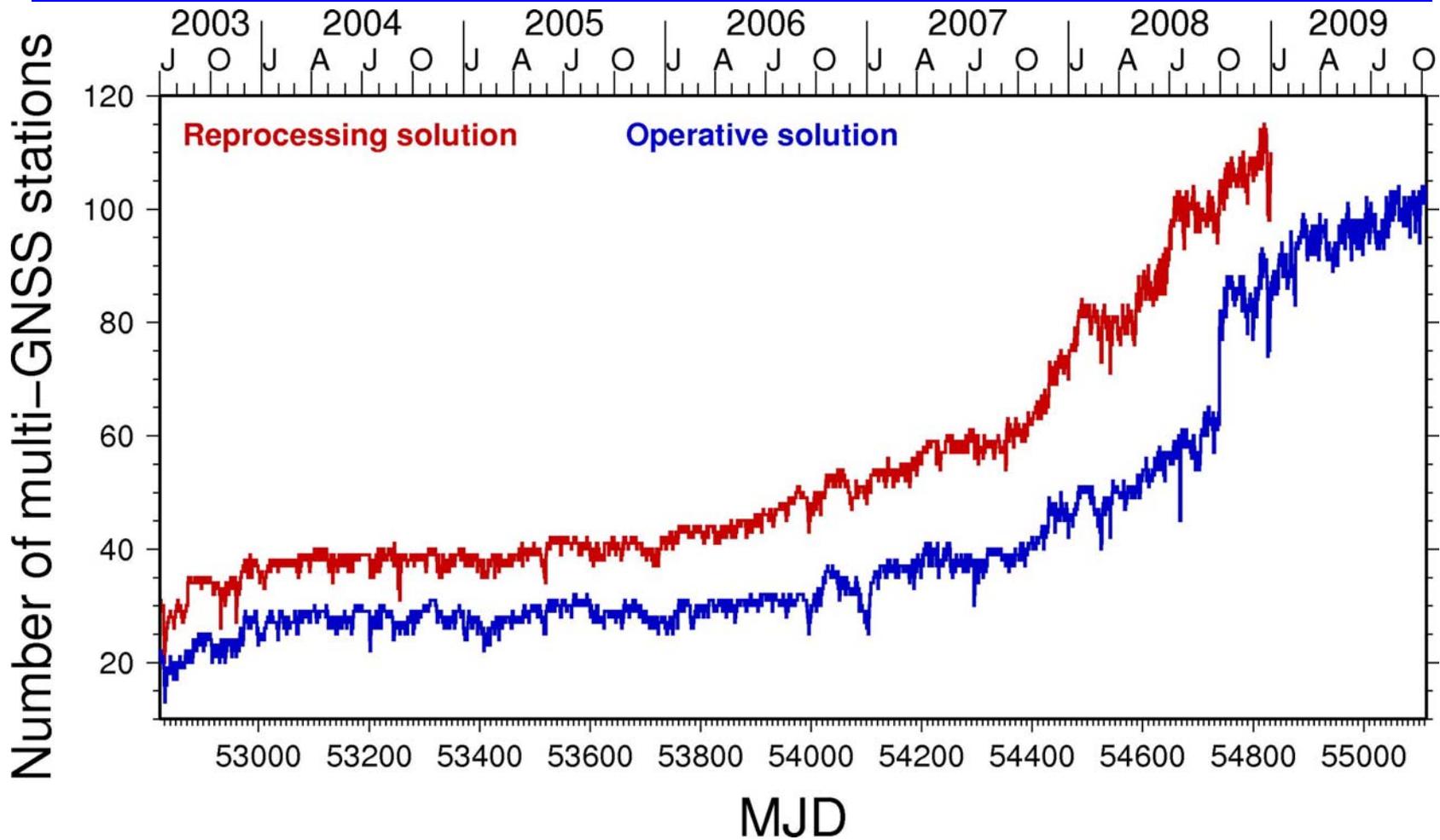
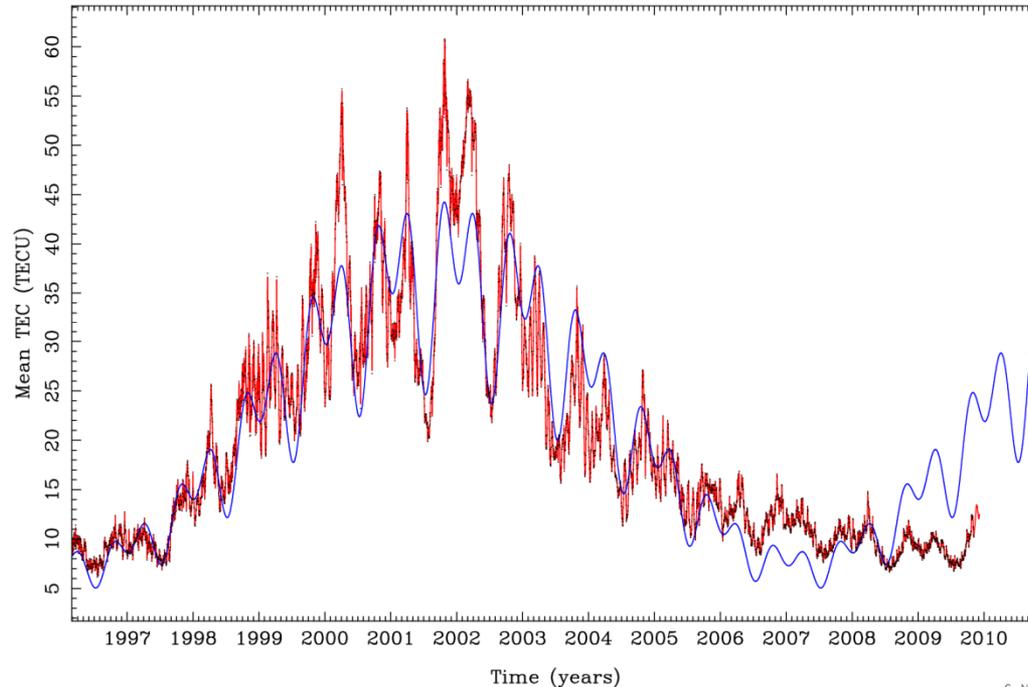International Association of Geodesy

Multi-GNSS Analysis at CODE

Multi-GNSS Analysis at CODE

Mean TEC Development since 1996

CODE GIM time series from 01-Jan-1995 to 05-Nov-2009

Mean TEC Values as established by the IGS.

Current cycle of solar activity unusually long.

SLR for Precise GNSS Orbits

The following example underlines that system-specific systematic errors on the level of few cm

- ➢ **in fact do occur**
- ➢ **can only be detected if there are independent checks**
  - ▪ **using other space geodetic techniques or**
  - ▪ **using measurements from independent GNSS (such as GALILEO, GLONASS)**

The example uses SLR (Satellite Laser Ranging observations) to validate GPS orbits.

The illustrations are taken from a Ph.D. Thesis by Mrs. Claudia Flohrer (former Ms. Claudia Urschl).

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SLR for Precise GNSS Orbits

Eclipsing seasons
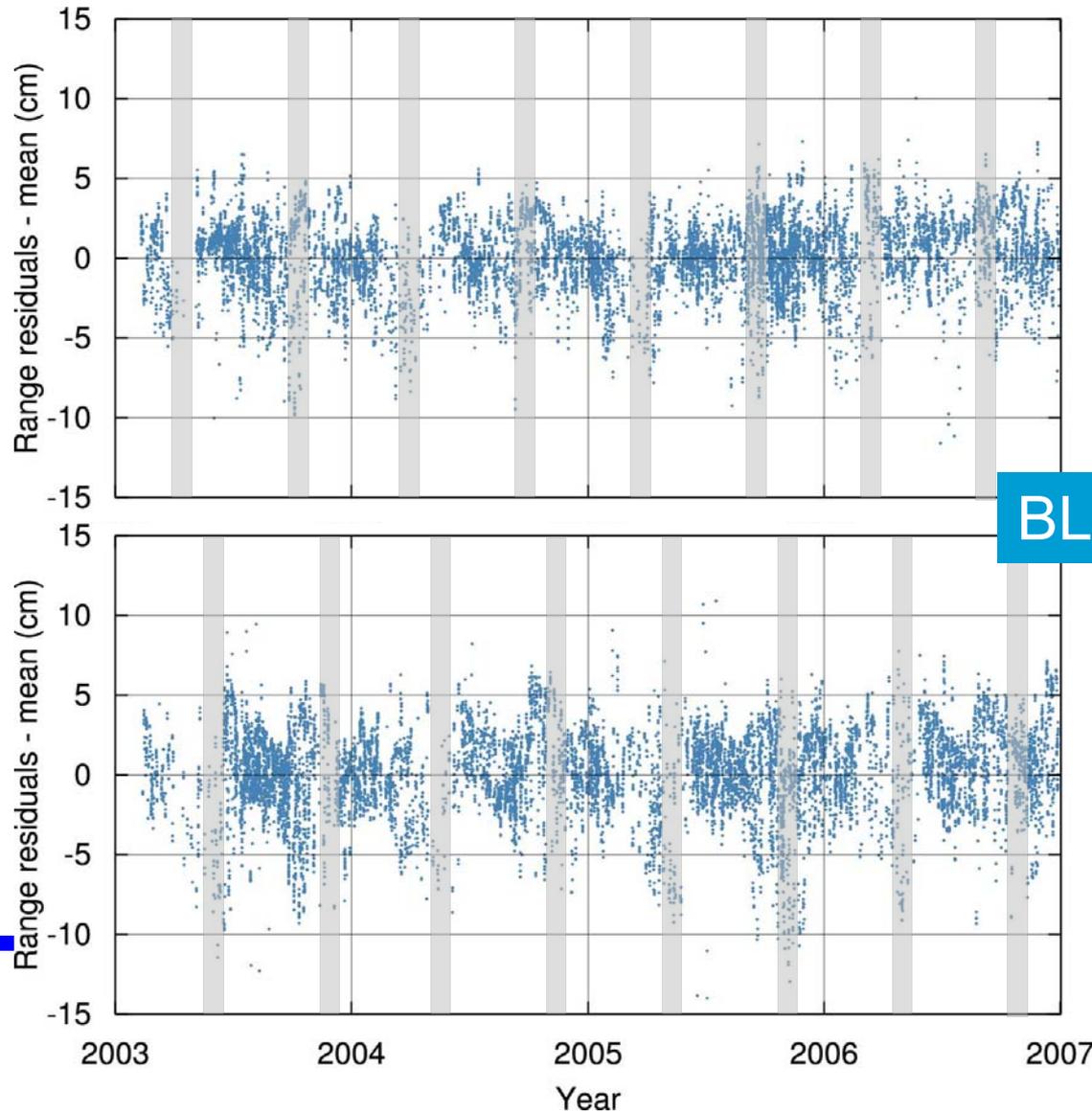
G05

BLOCK II

G06

International

9-Nov-09

SLR for Precise GNSS Orbits
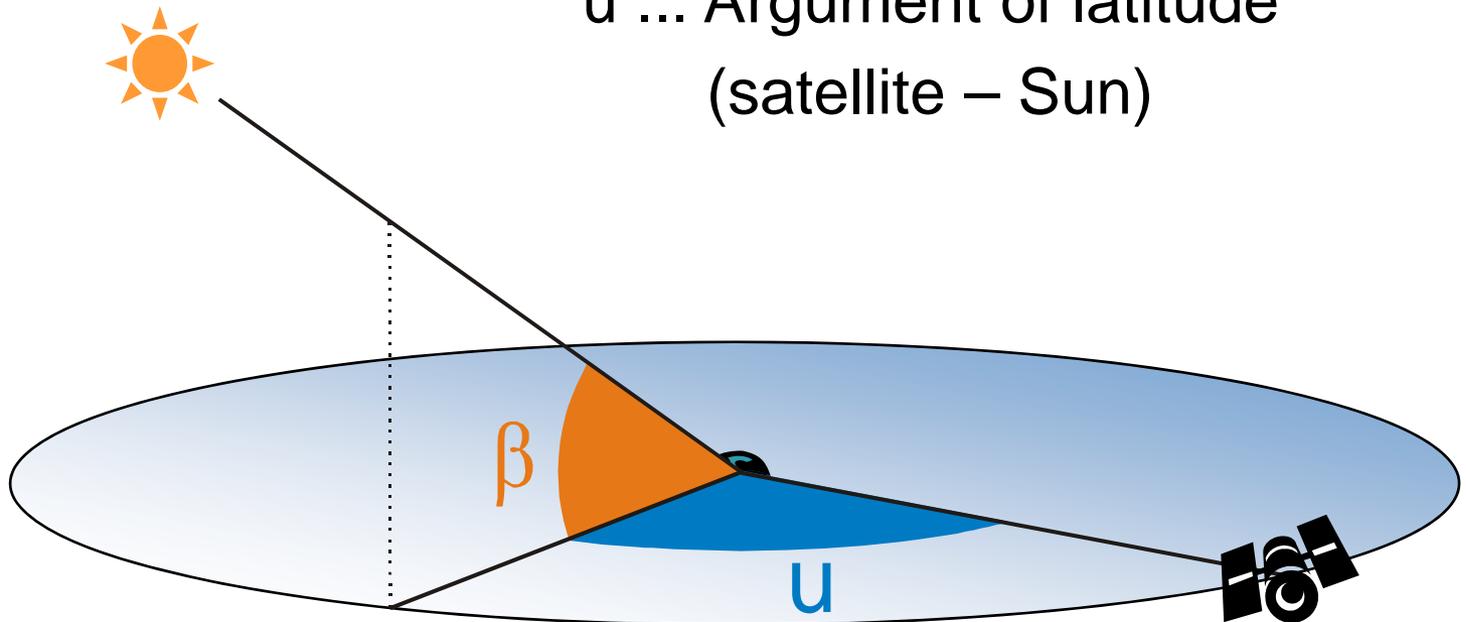
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Coordinate system (β,u)

β ... Elevation of the Sun
above the orbital plane
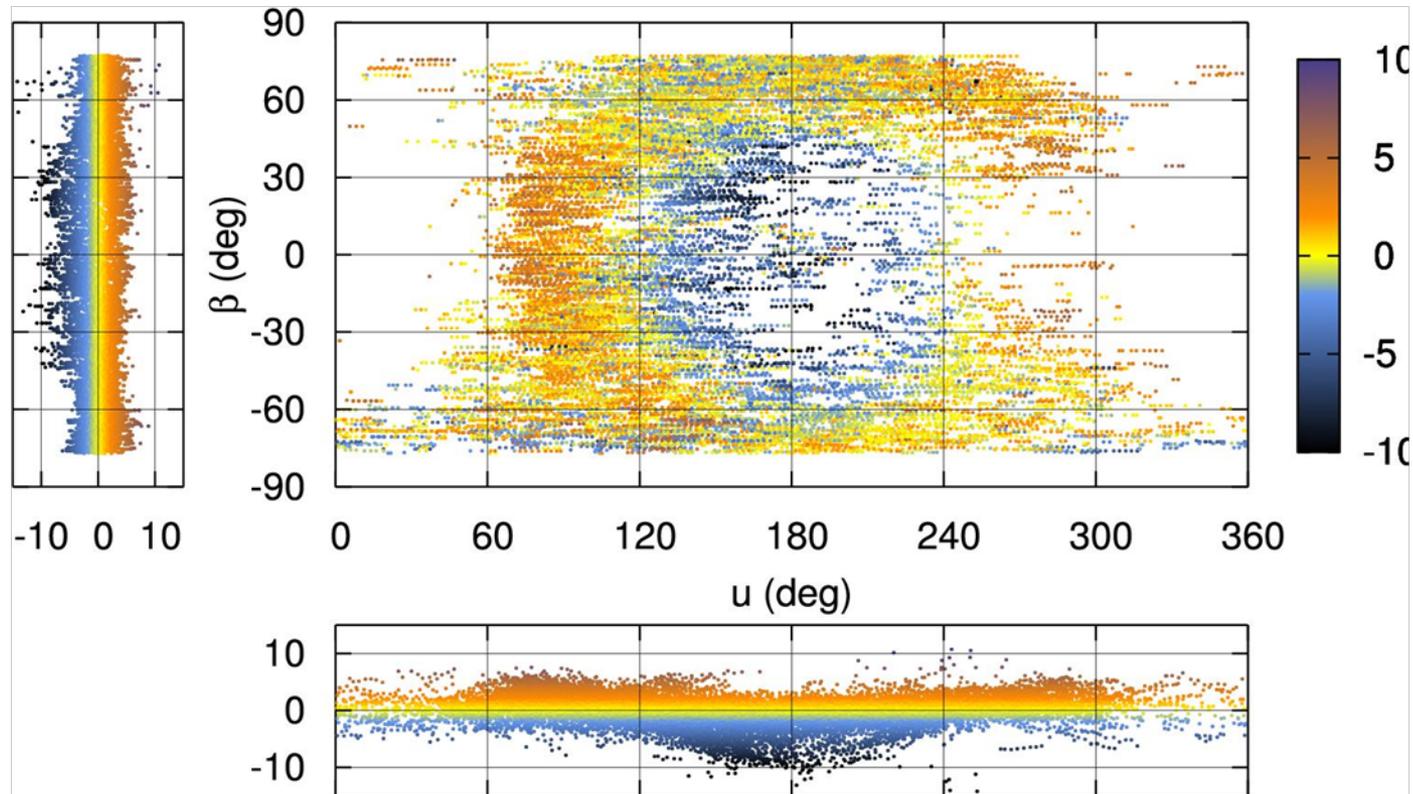
u ... Argument of latitude
(satellite – Sun)

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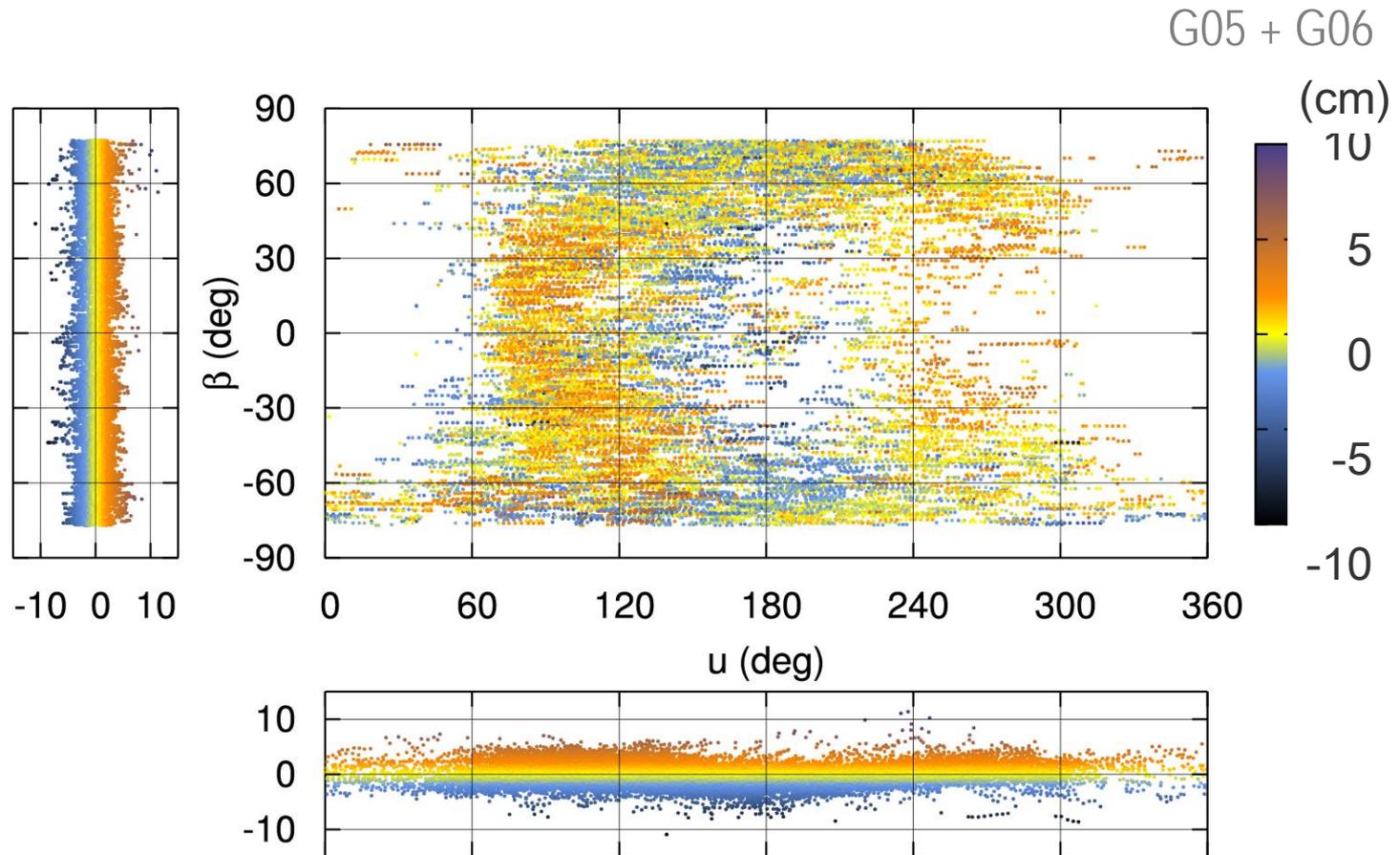
SLR for Precise GNSS Orbits

G05 + G06

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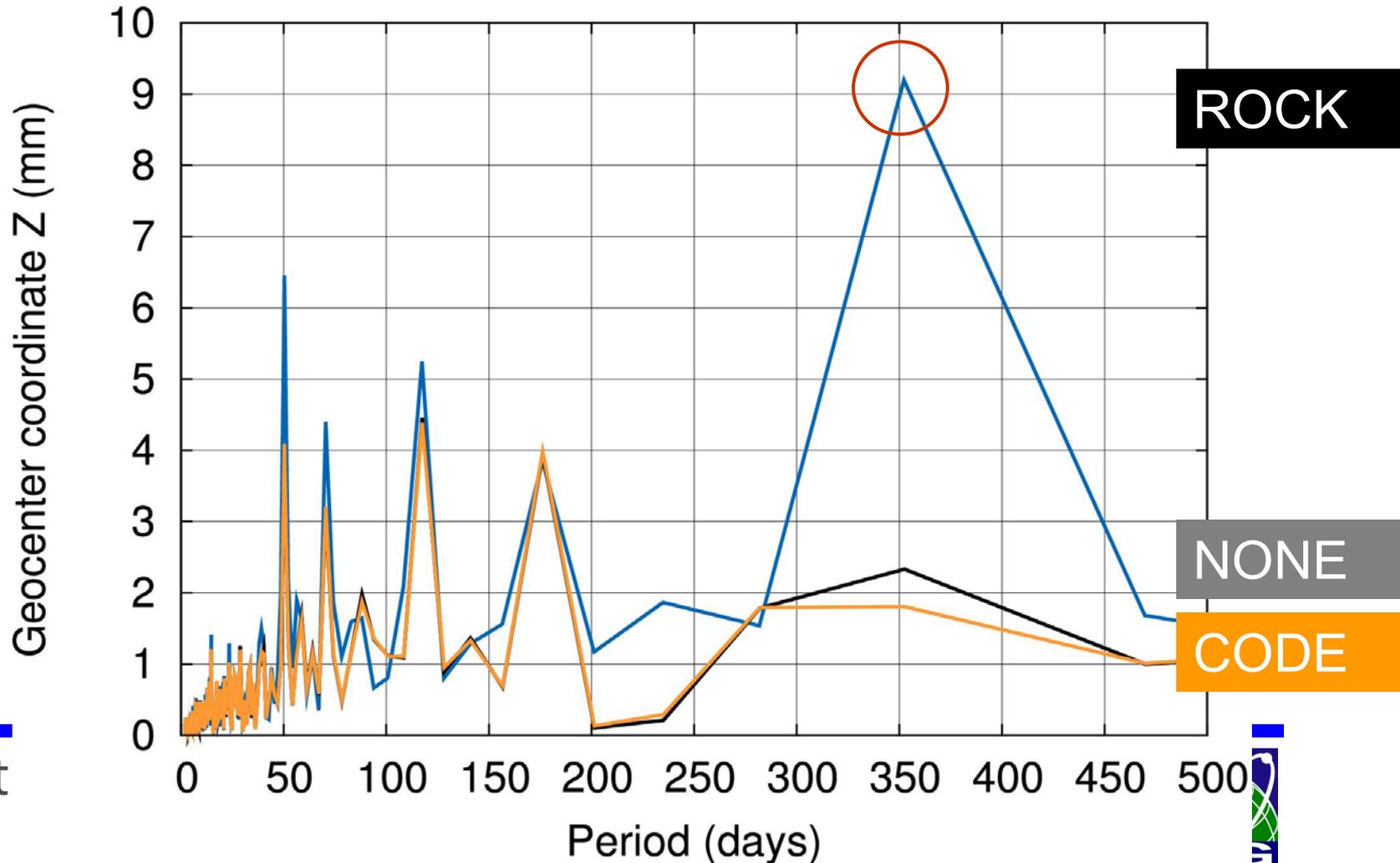
11

SLR for Precise GNSS Orbits

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12

SLR for Precise GNSS Orbits

352 days → draconitic GPS year

ROCK

NONE

CODE

Int