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Results from IGS Workshop on GNSS Biases, 18–19 January 2012 in Bern

Stefan Schaer

Swiss Federal Office of Topography (swisstopo)

Workshop on GNSS Biases

18–19 January 2012
University of Bern, Switzerland (Hauptgebäude Universität Bern, Hörsaal HS 115)
www.biasws2012.unibe.ch/programme.pdf

Programme and oral presentations

Wednesday 18 January

08:30–09:00 Workshop check-in
09:00–09:30 Welcome and Introduction – A. Jäggi, R. Dach
09:30–10:30 **Participants' short introductions (part 1) – R. Dach**
3 slides presented by each participant (in alphabetical order)
10:30 Break
11:00–12:00 **Participants' short introductions (part 2) – R. Dach**
3 slides presented by each participant (in alphabetical order)
12:00–12:30 **Overview of GNSS biases (part 1) – S. Schaer**
GPS/GLONASS differential code biases – S. Schaer

12:35–12:40 Photo session
12:45 Lunch

14:00–15:00 **Overview of GNSS biases (part 2) – S. Schaer**
(30') CODE's DCB specialties, GLONASS ambiguity resolution, intersystem phase biases, GLONASS-GPS station-specific intersystem translations, IGS ANTEX model – S. Schaer
(10') DCB estimation at NRCan – R. Ghoddousi-Fard
(10') PRN22/SVN47 DCB anomaly – A. Hauschild
15:00–15:30 **GLONASS biases and clock corrections (part 1) – R. Dach**
Introduction and current status (CODE) – R. Dach
15:30 Break
16:00–17:00 **GLONASS biases and clock corrections (part 2) – R. Dach**
Presentations by IGS AC representatives:
(10') GFZ: Current status and plans – M. Uhlemann
(10') CNES/CLS: Experience from CNES-CLS IGS AC – S. Loyer
(10') Comparison of IGS AC GLONASS clock correction results – R. Dach
(10') GLONASS inter-channel biases in high-end receivers – J.-M. Sleewaegen & A. Simsky
17:00–17:30 **GNSS phase biases (part 1) – N. Teferle / S. Loyer**
(20') Integer clocks and integer PPP issues – S. Loyer
(10') GLONASS Carrier Phase biases for RTK operation – G. Zyryanov

19:00 Dinner

Thursday 19 January

09:00–09:30 **GLONASS biases and clock corrections (part 3) – R. Dach**
(15') Comparison of AC GLONASS biases – S. Schaer, M. Meindl
Discussions concerning definition of "GLONASS reference biases" and proceeding towards an IGS-combined GLONASS clock product
09:30–10:30 **GNSS phase biases (part 2) – N. Teferle / S. Loyer**
(15') Uncalibrated Phase Biases for Precise Point Positioning Integer Ambiguity Resolution – N. Teferle & X. Meng
(15') Estimation of uncalibrated hardware delays for single-difference ambiguity resolution – J. Tegedor
(15') GLONASS carrier-phase inter-frequency biases – L. Wanninger
(15') Biases in GLONASS carrier phase observables – A. Zinoviev
10:30 Break
11:00–12:30 **New GNSS signals and related issues – J.-M. Sleewaegen / O. Montenbruck**
Presentations by representatives of receiver manufacturers:
(25') New GNSS signals: how to deal with the plethora of observables? – J.-M. Sleewaegen
(25') Line bias variations in GPS L1/L2/L5 signals – O. Montenbruck
(10') GLONASS RTK interoperability issues with 3rd party receivers – F. Takac & P. Alves
(10') Compass/Beidou: system status and initial service – J. Chen (presented by X. Meng)
(10') Status of IGS M-GEX – R. Weber
Discussion

12:45 Lunch

14:00–15:30 **Bias calibration, combination, harmonization, exchange and formats – H. van der Marel / G. Petit**
(10') Bias-SINEX – L. Agrotis
(10') RTCM / Special Committee 104, RINEX Status – J. Sass
(10') RTCM-SSR strategy of bias treatment – G. Wübbena
(10') Real-time calibration of GLONASS FDMA biases – A. Cartmell
(10') Biases between BIPM's PPP clock solutions and IGS clock solution for NIST – G. Petit
(10') Absolute calibration of P1-P2 biases and comparison with DCB determination – G. Petit
(10') From differential to absolute code bias values – S. Schaer
Discussion
15:30 Break
16:00–16:30 **Closing session – S. Schaer**
Key issues, recommendations, action items

Keeping of the workshop minutes by Y. Jean (AIUB)

Last updated 2 February 2012/ss

37 participants on 18 January 2012 in front of the main building of the University of Bern, Switzerland

Presentations available at: www.biasws2012.unibe.ch

International GNSS Service
Formerly the International GPS Service

Workshop on GNSS Biases

- Main
- Program
- Registration
- List of participants
- Supporting documents
- Travel and accommodation
- Presentations etc.
- Email contact

Presentations

as held at the IGS Workshop on GNSS Biases at the University of Bern, Switzerland on:

- 18 January 2012
- 19 January 2012

Please click on the title-author line of the presentation of interest to get the desired pdf file.

Programme and oral presentations (final version)

Key issues, recommendations, action items (preliminary version as approved by the workshop participants)
Key issues, recommendations, action items (version to be completed/finalized)

Group photo of all workshop participants taken on 18 January 2012 in front of the main building of the University of Bern

Collection of completed questionnaires

Collection of related papers

Collection of GLONASS bias values as computed by IGS ACs

List of GNSS biases

- GNSS differential code biases (DCB)
- CODE's DCB specialties (e.g., DCB multiplier estimation)
- GLONASS interfrequency code biases (relevant to GNSS clock estimation, or PPP)
- Intersystem code biases
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- GLONASS-GPS station-specific intersystem translations as considered in CODE's GNSS analysis (IGS ANTEX model)
- (GPS) quarter-cycle issue (again crucial)

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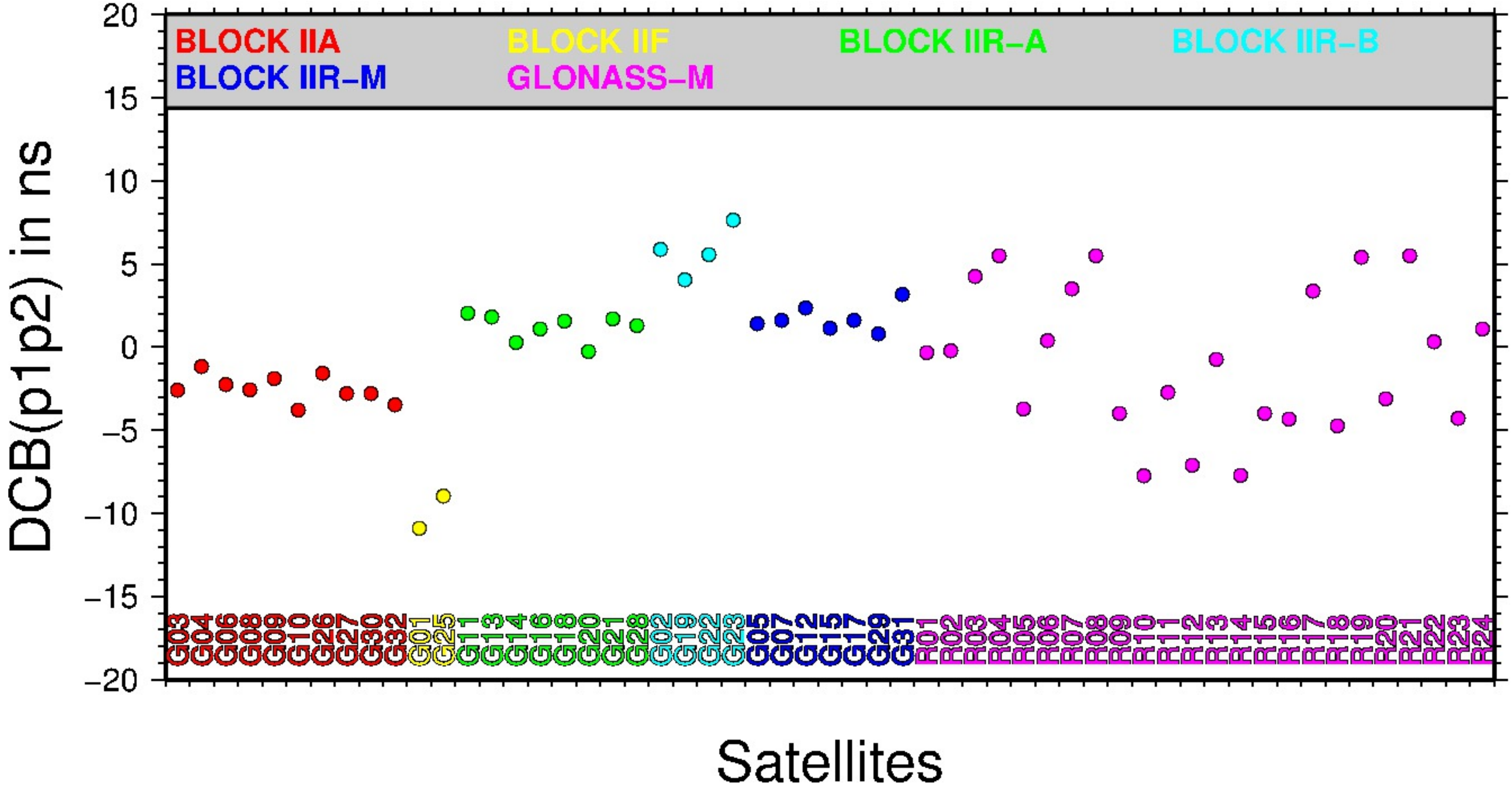
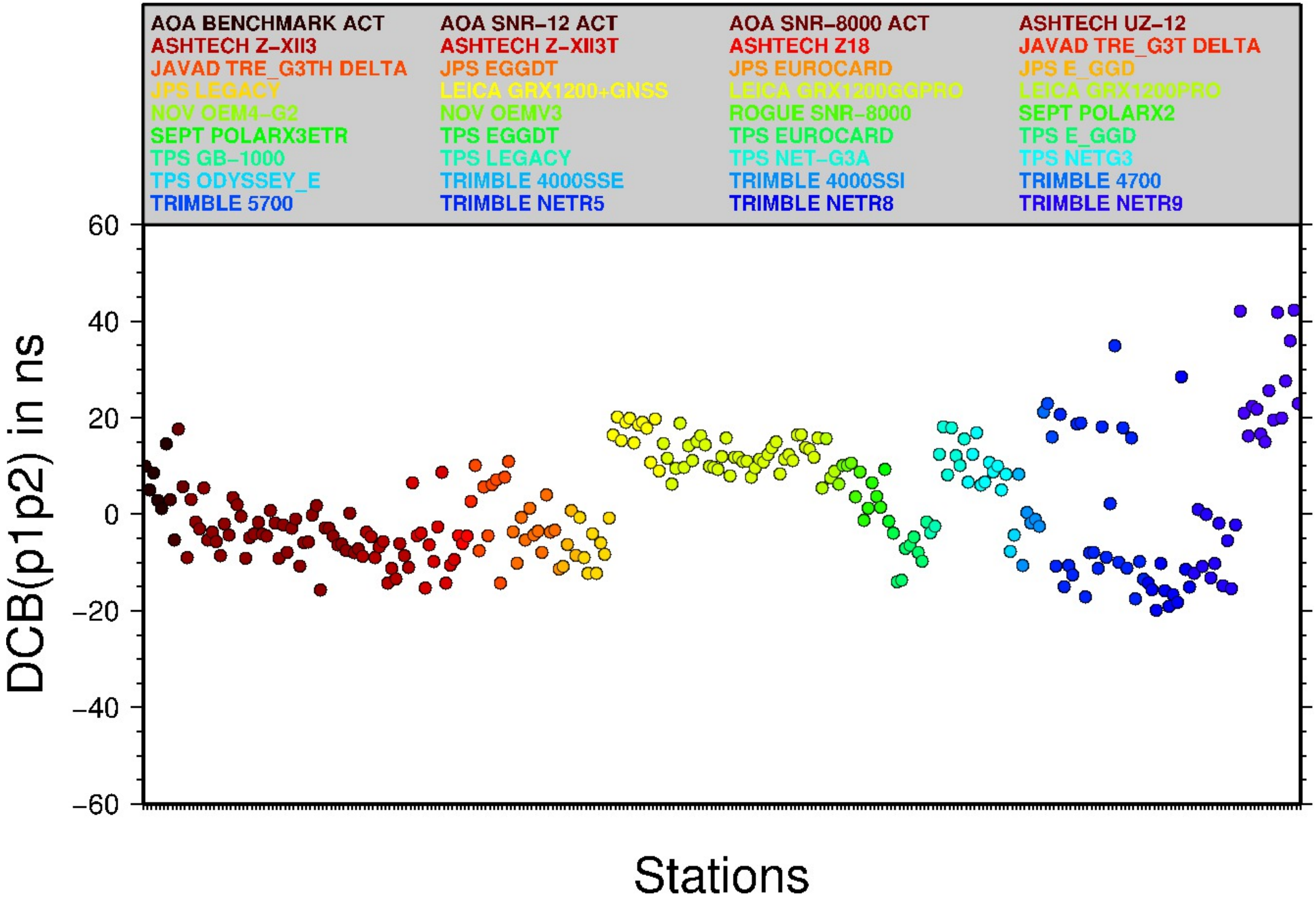
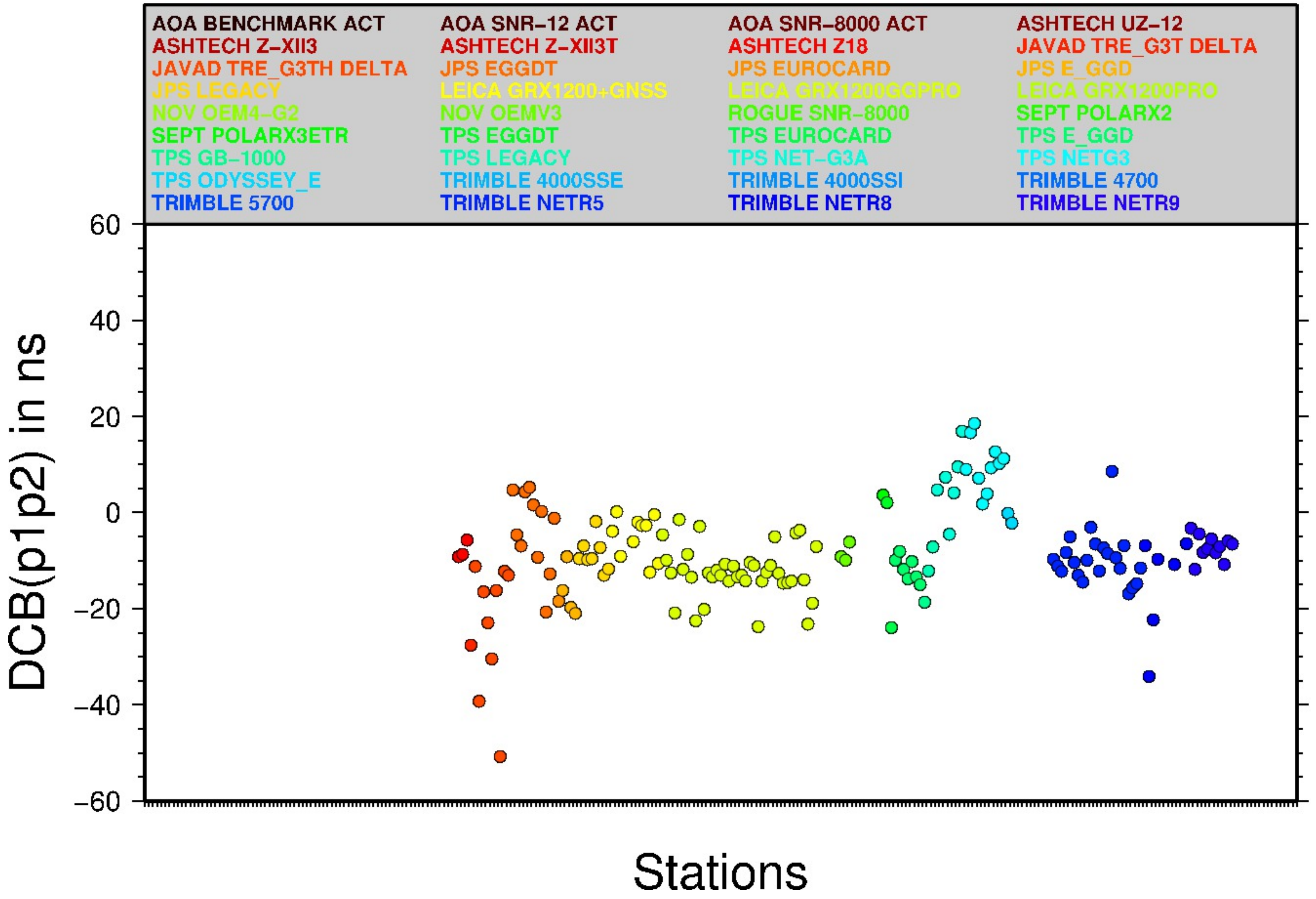
CODE's GPS/GLONASS P1-P2 DCB monthly solution, computed for December 2011



CODE's GPS P1-P2 DCB monthly solution, computed for December 2011



CODE's GLONASS P1-P2 DCB monthly solution, computed for December 2011



Indirect and direct GPS P1-C1 DCB determination (1/3)

GPS receiver classes commonly distinguished:

P1/P2:	C1	P1	P2	
C1/P2:	C1		P2	
C1/X2:	C1			X2

Indirect and direct GPS P1-C1 DCB determination (2/3) → indirect

GPS receiver classes commonly distinguished:

P1/P2:	C1	P1	P2	
C1/P2:	C1		P2	
C1/X2:	C1			X2

Indirect and direct GPS P1-C1 DCB determination (3/3) → direct

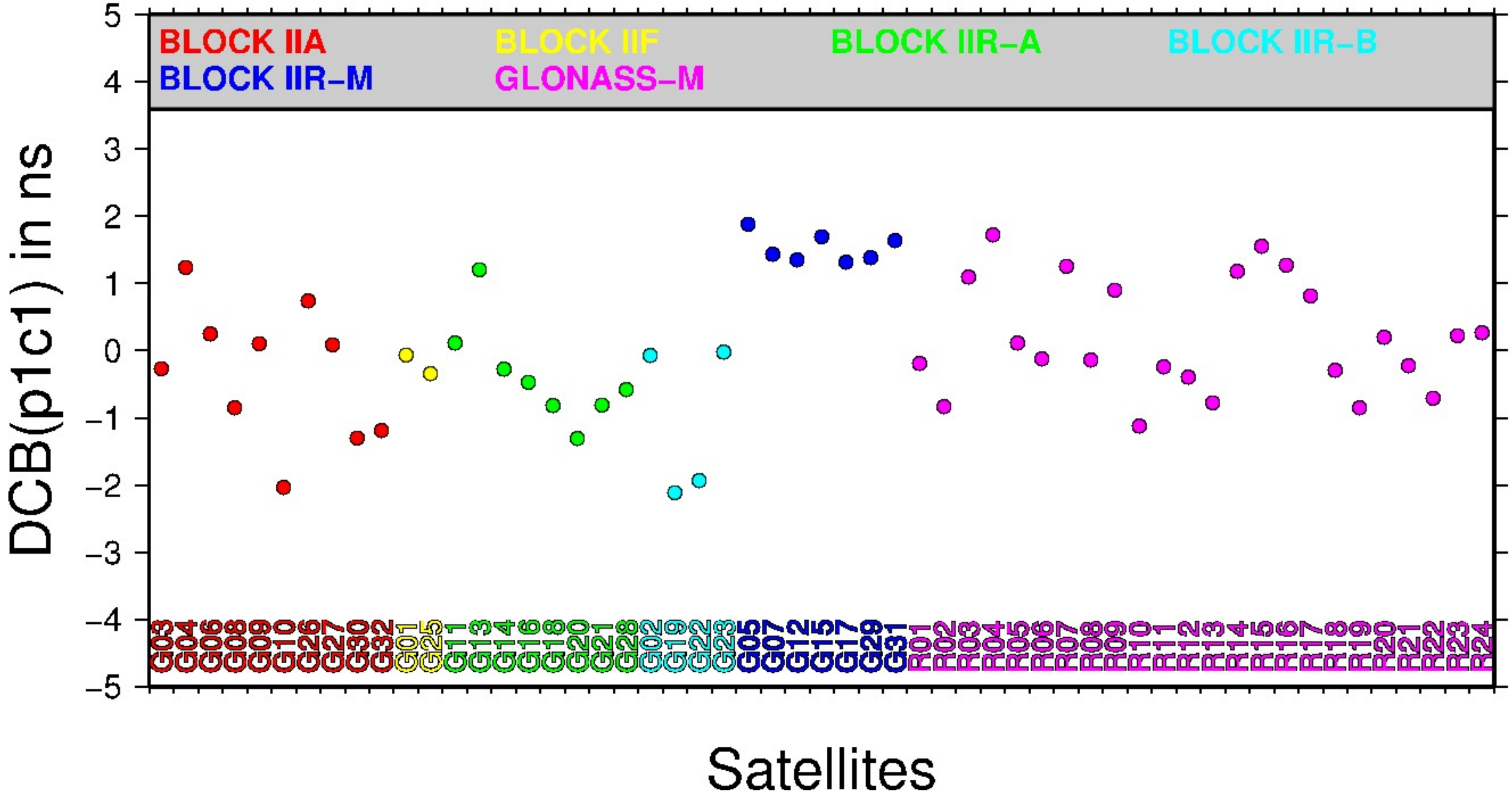
GPS receiver classes commonly distinguished:

P1/P2:	C1	P1	P2	
C1/P2:	C1		P2	
C1/X2:	C1			X2

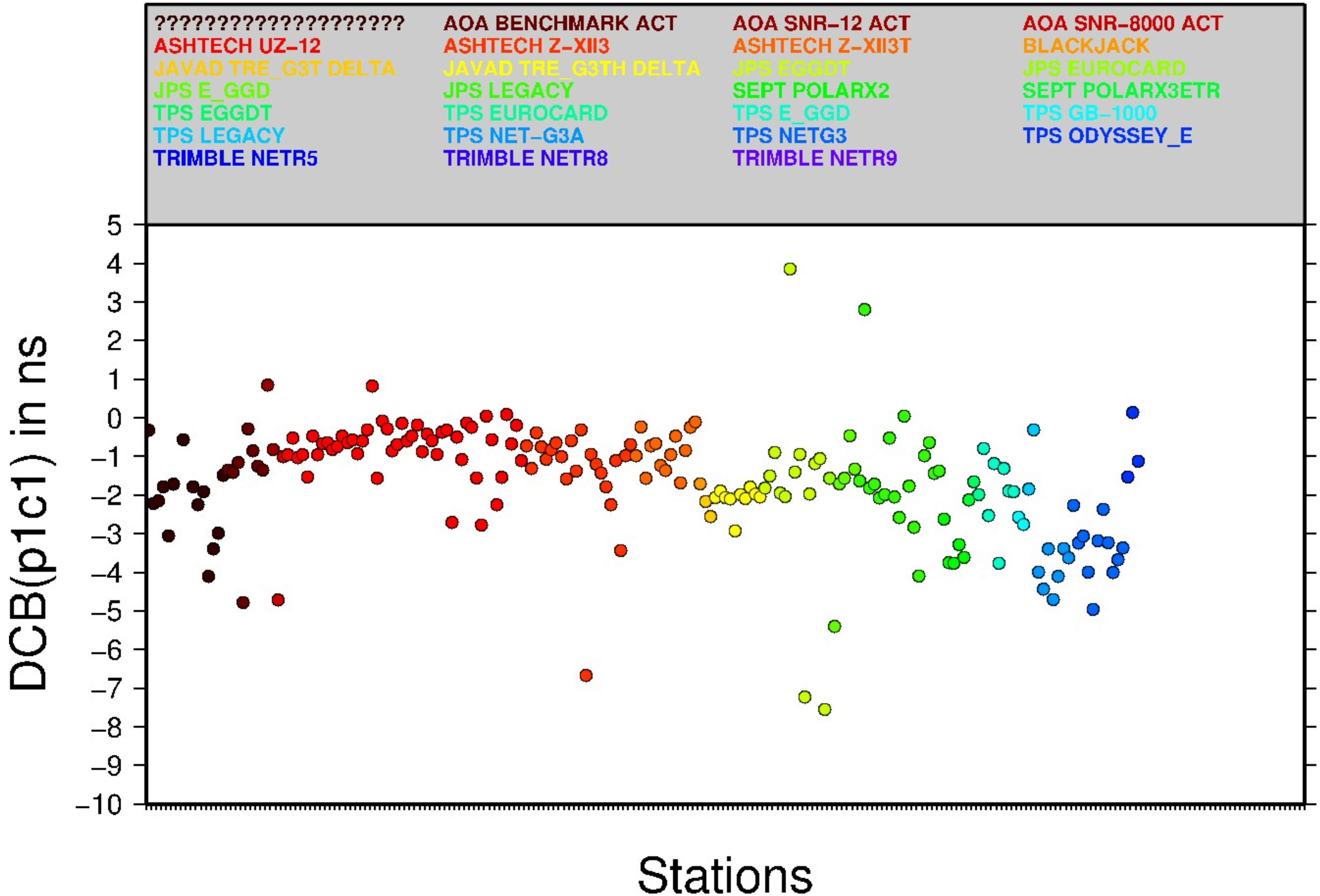
Direct GNSS DCB estimation for P1-C1 and P2-C2 based on RINEX data

- P1-C1 and P2-C2 observation differences are analyzed file by file (typically station by station for a particular day) and stored for:
  - overall combination
  - combinations may be actually recalled/retrieved for:
    - selected receiver types
    - selected receiver groups
    - all considered receivers/stations (=overall combination)
- Sophisticated outlier detection scheme using quantities responding to IQR (interquartile range IQR=$Q_{0.75}$-$Q_{0.25}$) → just one scalar quantity to be selected to cope with observation data with most various noise levels and characteristics, respectively
- Overall (LS) combination performed (with an outlier detection scheme concerning station-specific, or file-specific DCB determinations)

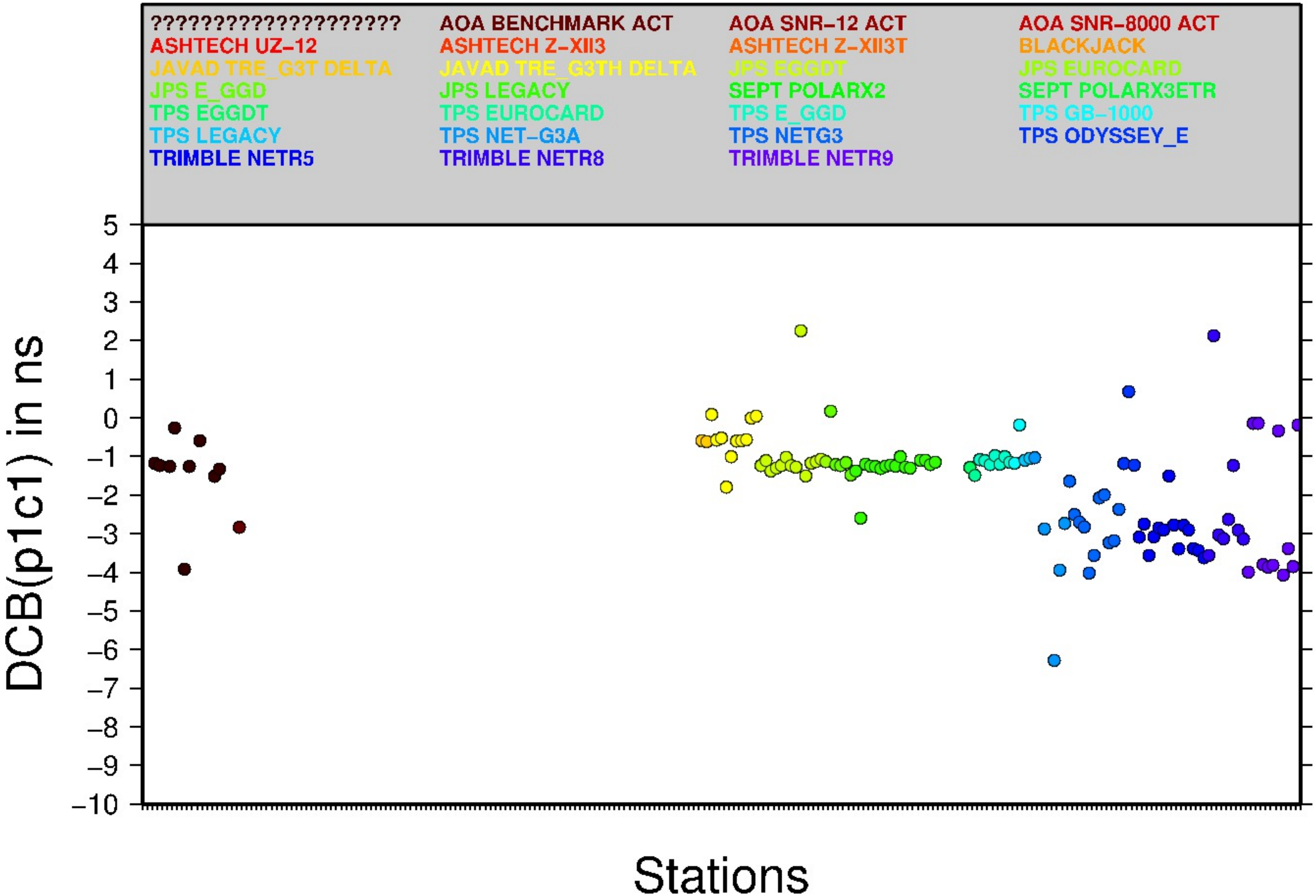
CODE's GNSS P1-C1 DCB monthly solution, computed for December 2011 (directly from RINEX)



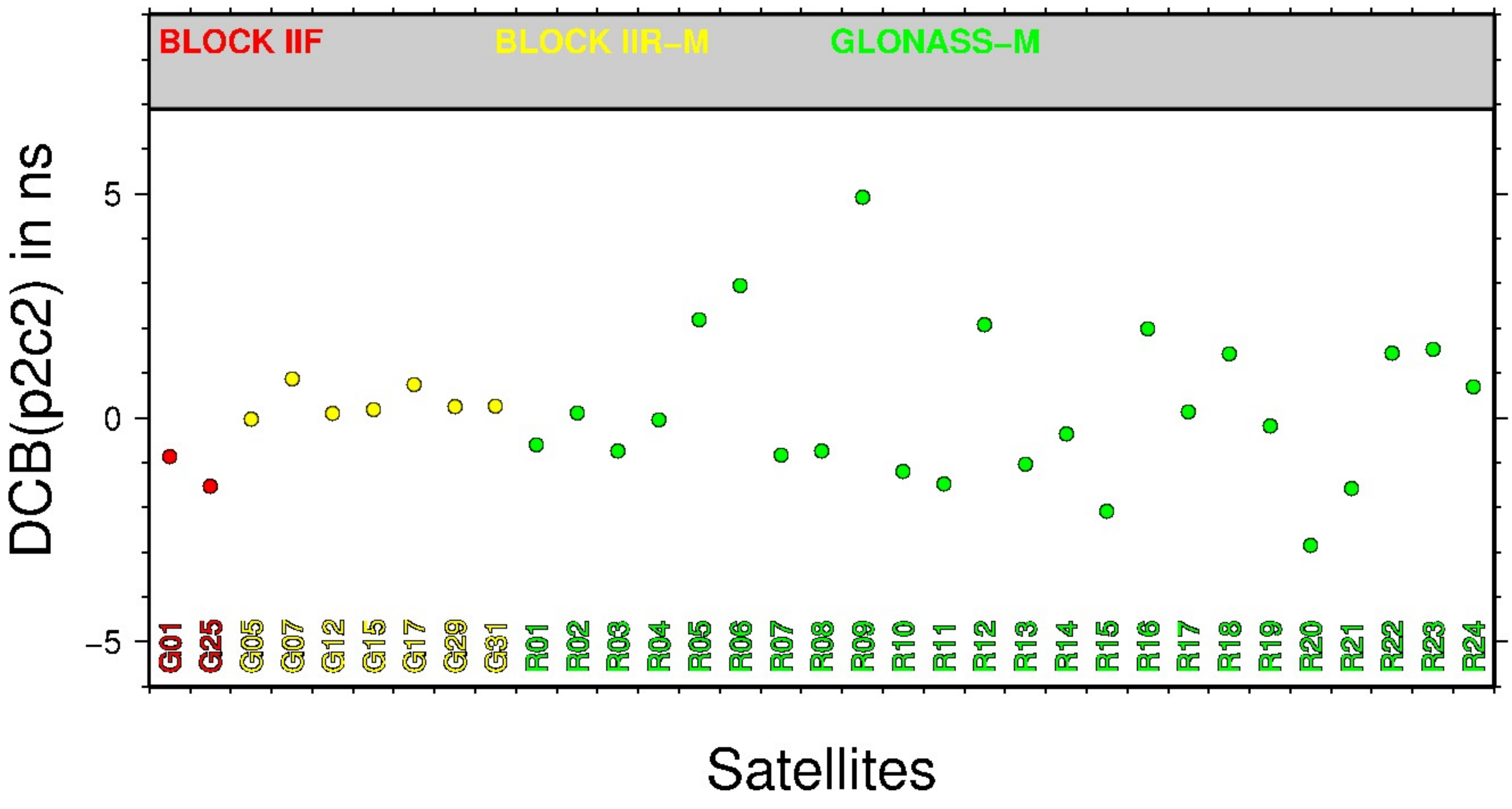
CODE's GPS P1-C1 DCB monthly solution, computed for December 2011 (directly from RINEX)



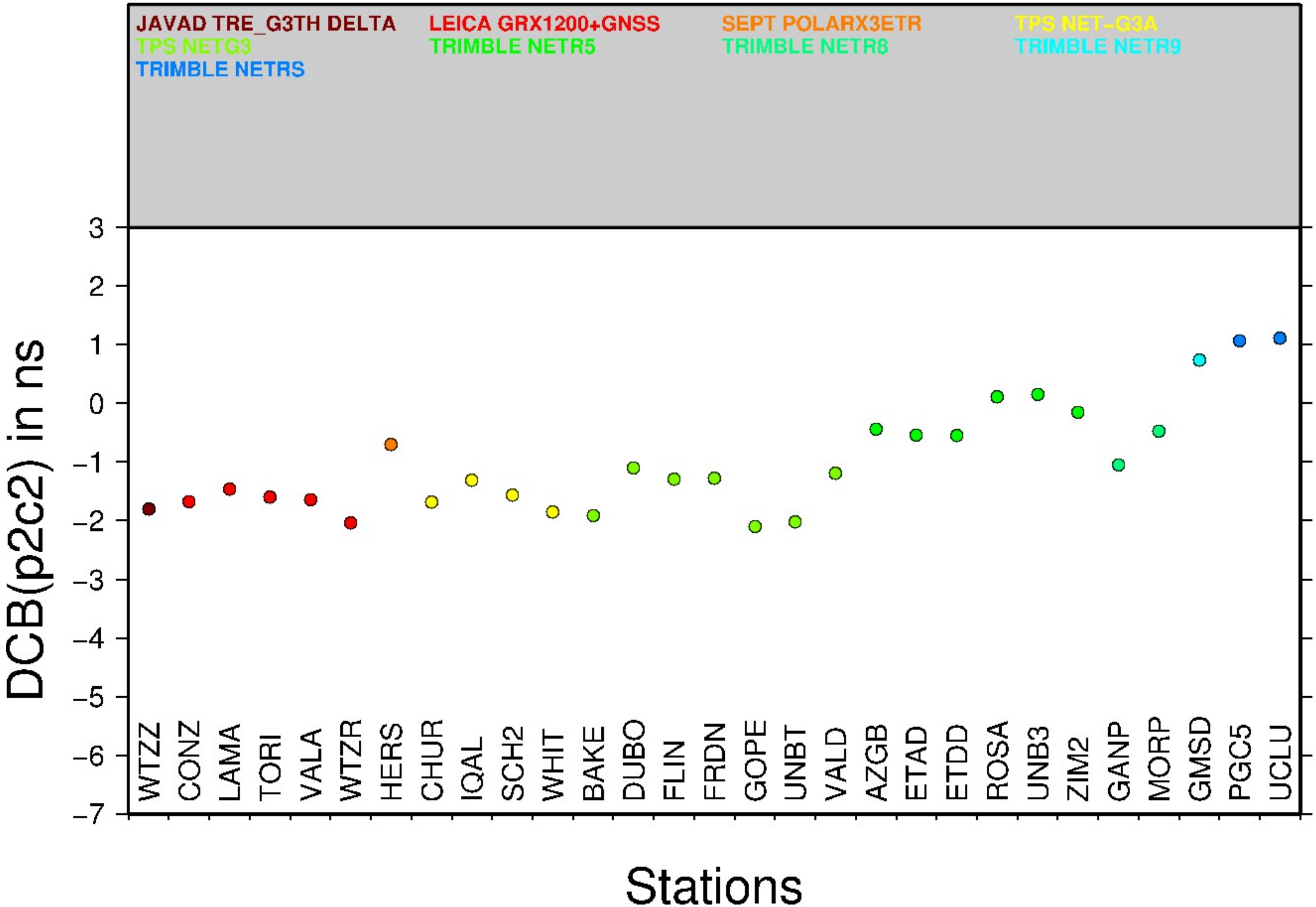
CODE's GLONASS P1-C1 DCB monthly solution, computed for December 2011 (directly from RINEX)



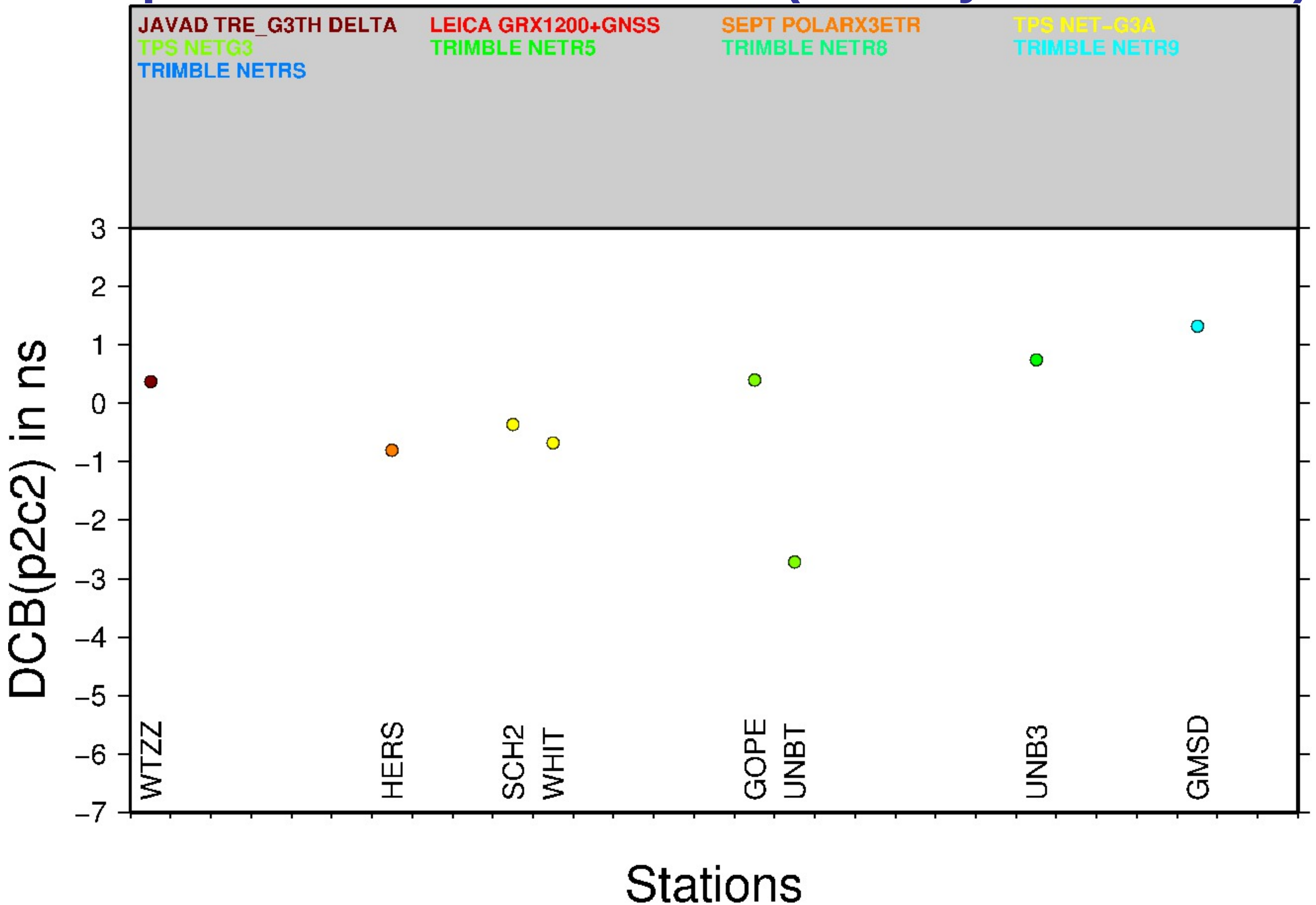
CODE's GNSS P2-C2 DCB monthly solution, computed for December 2011 (directly from RINEX)



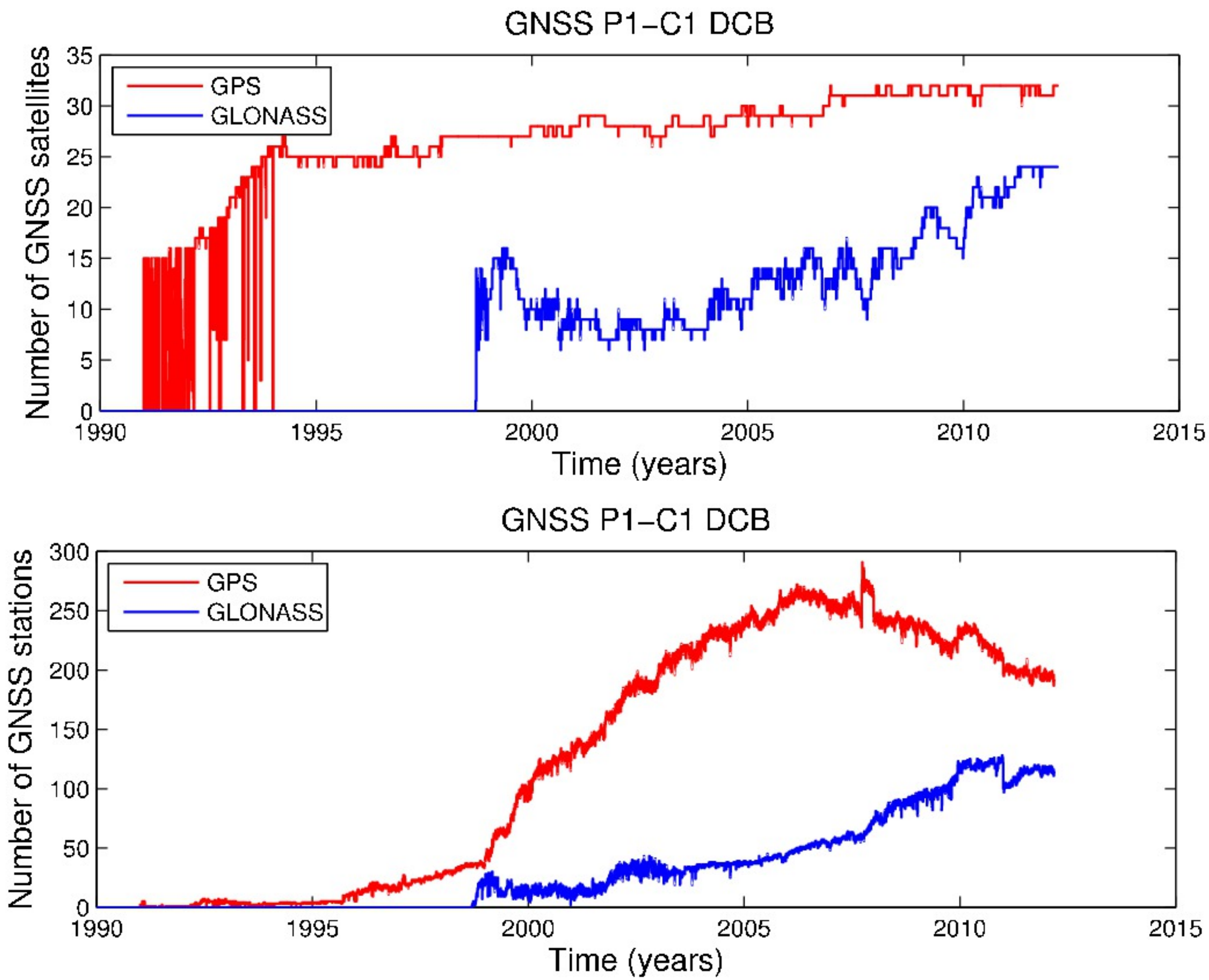
CODE's GPS P2-C2 DCB monthly solution, computed for December 2011 (directly from RINEX)



CODE's GLONASS P2-C2 DCB monthly solution, computed for December 2011 (directly from RINEX)



Statistics on GNSS DCB reprocessing from RINEX



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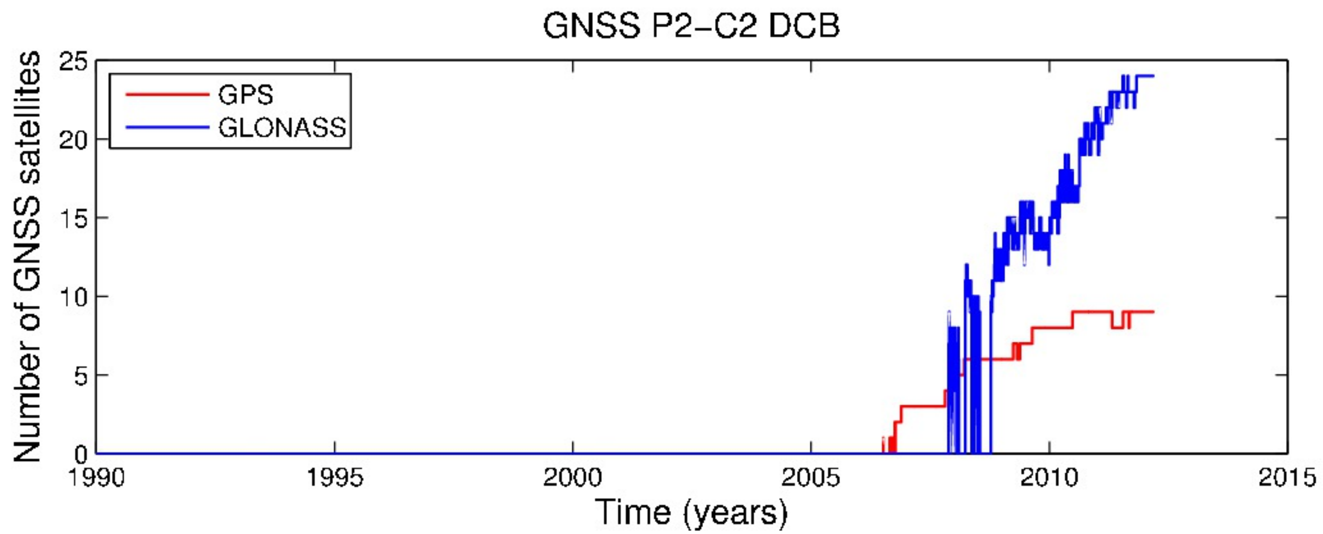

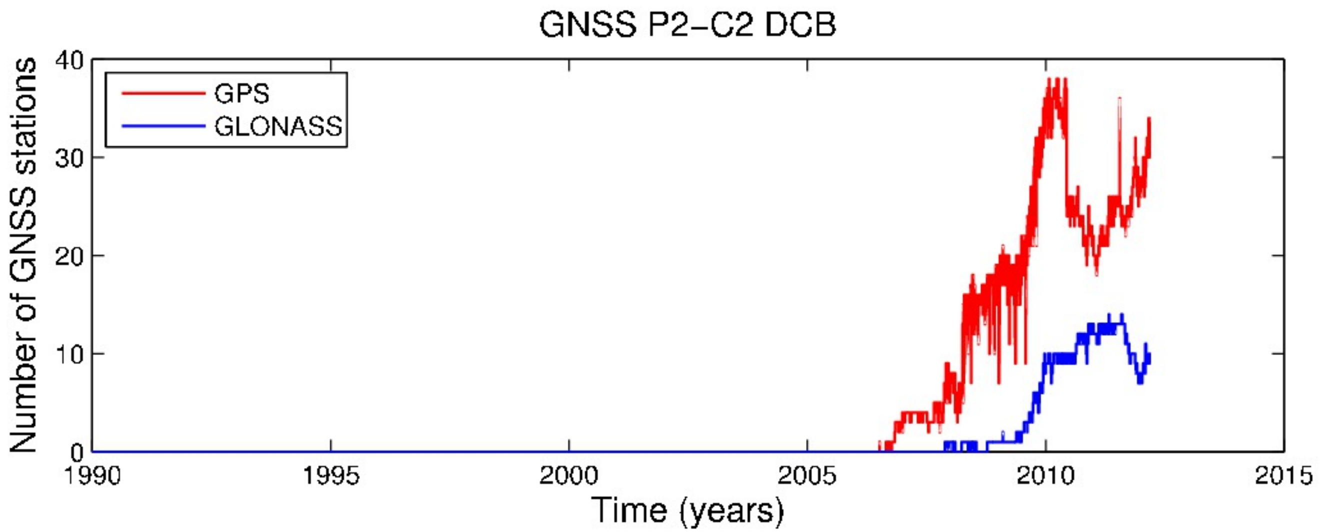

List of GNSS biases

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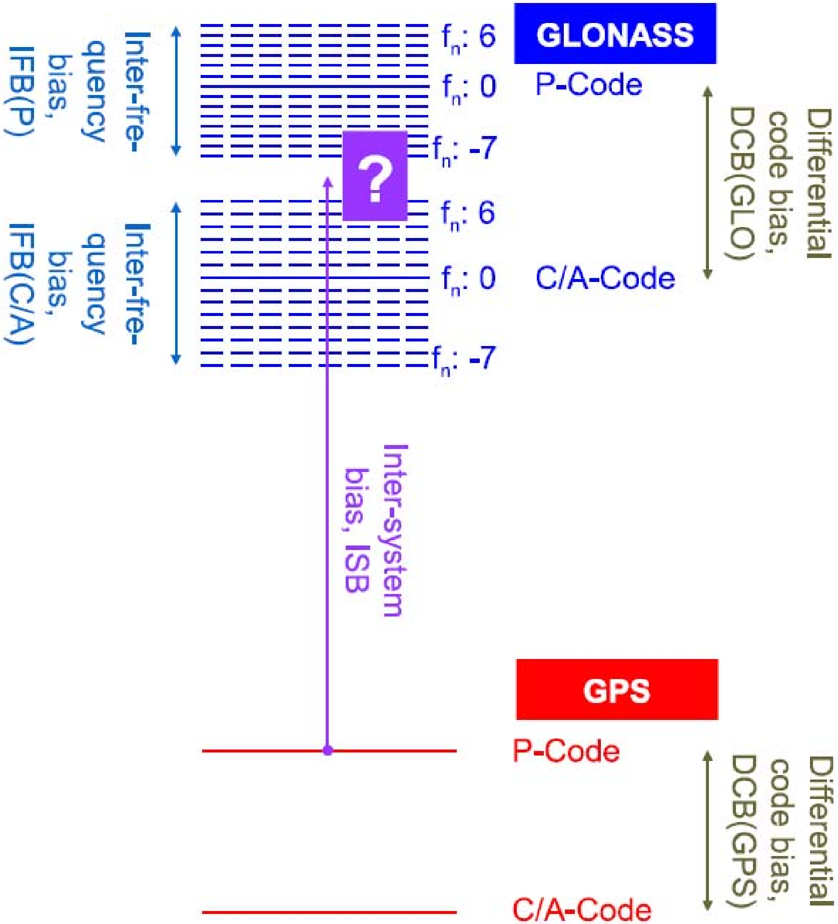
AC GLONASS bias files collected for comparison (GPS weeks 1666-1667)

- **COD** Center for Orbit Determination in Europe, AIUB, Switzerland
  - Bernese DCB
- **EMR** Natural Resources Canada, Canada
  - no GLONASS bias information (GLONASS biases ignored in GNSS clock analysis)
- **ESA** European Space Operations Center, ESA, Germany
  - bias-SINEX (first two days of GPS week 1666 missing)
- **GFZ** GeoForschungsZentrum, Germany
  - bias-SINEX
- **GRG** GRGS-CNES/CLS, Toulouse, France
  - modified Bernese DCB
- **IAC** Information-Analytical Centre, Russia
  - PBS format
- **JPL** Jet Propulsion Laboratory, USA
  - GIPSY time dependent parameter format (wrong weeks)

Biases in GPS/GLONASS (Clock) Processing

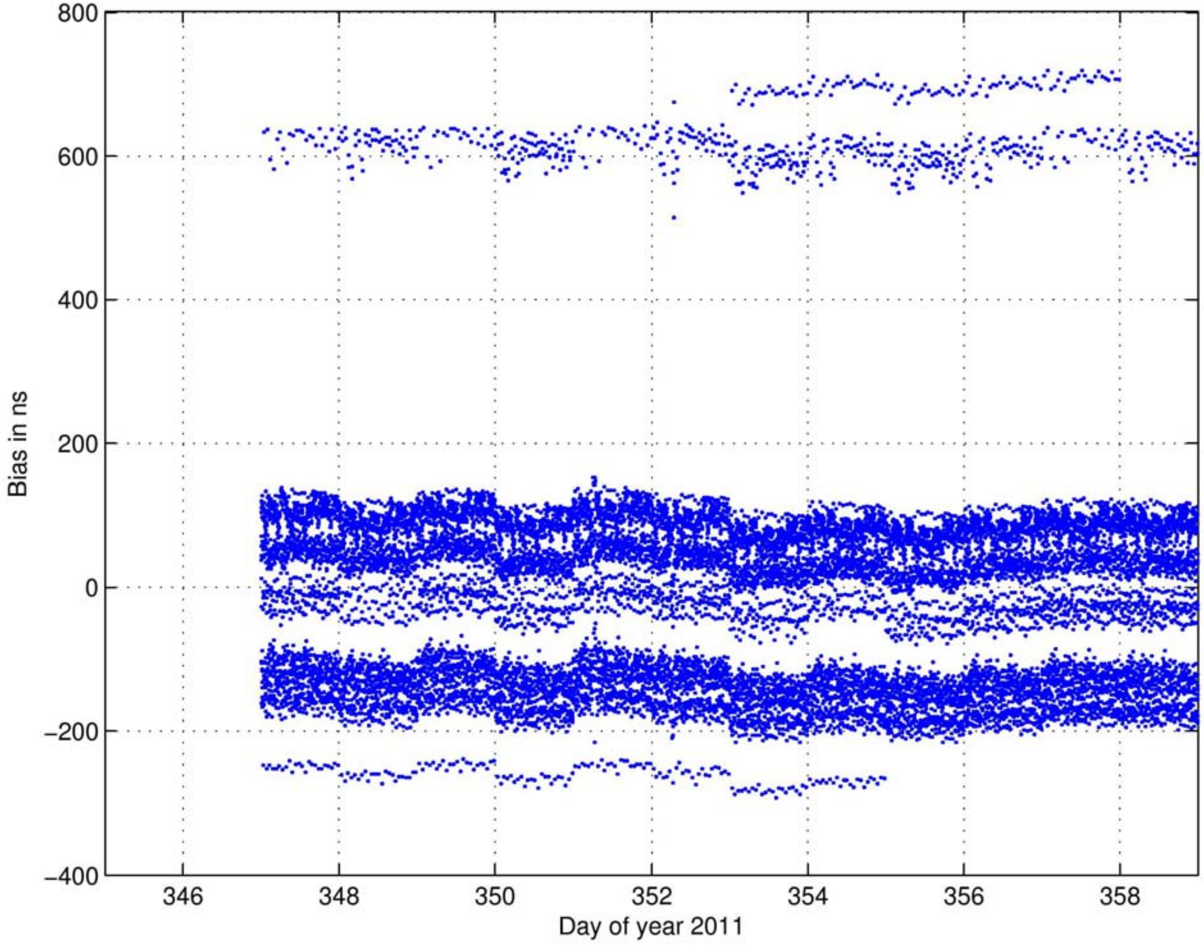


- **DCB: differential code bias**
  different hardware delays for P– and C–Code
- **ISB: inter–system bias**
  different hardware delays for measurements of different GNSS
- **IFB: inter–frequency bias**
  frequency–dependent hardware delays for the different GLONASS–signals

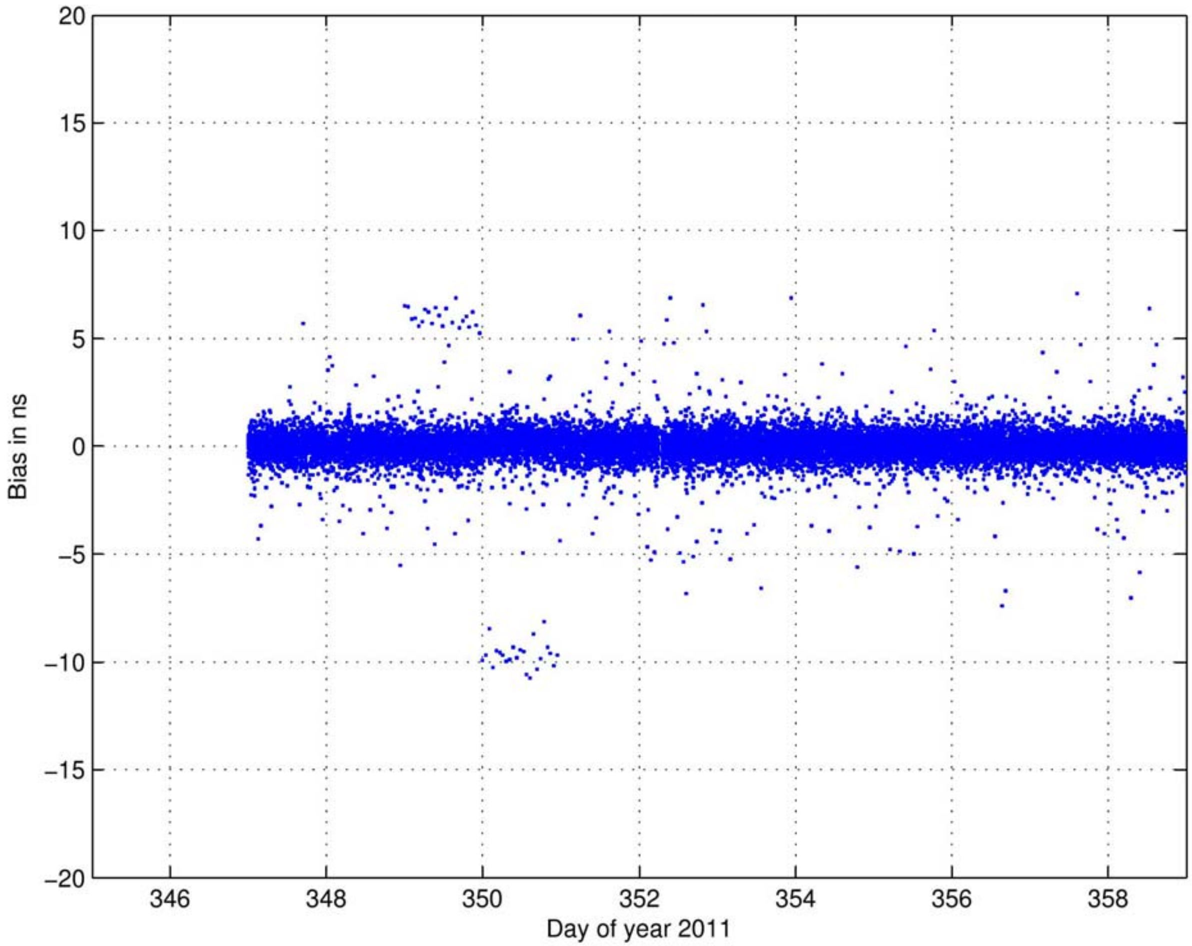
We can only extract the sum of delays from a GPS/GLONASS data processing.

AIUB

AC GLONASS bias comparison: COD-ESA (1)



AC GLONASS bias comparison: COD-ESA (3) → P1-C1 DCB corrected



Summary of AC GLONASS bias comparison

AC	Median (ns)	Mean (ns)	Std (ns)
COD-ESA	0.01	0	0.79
COD-GFZ	0.02	0	1.33
COD-GRG	5.63	1.87	23.12
ESA-GFZ	0.01	0	1.34
ESA-GRG	4.14	1.29	20.63
GFZ-GRG	6.00	1.72	25.23

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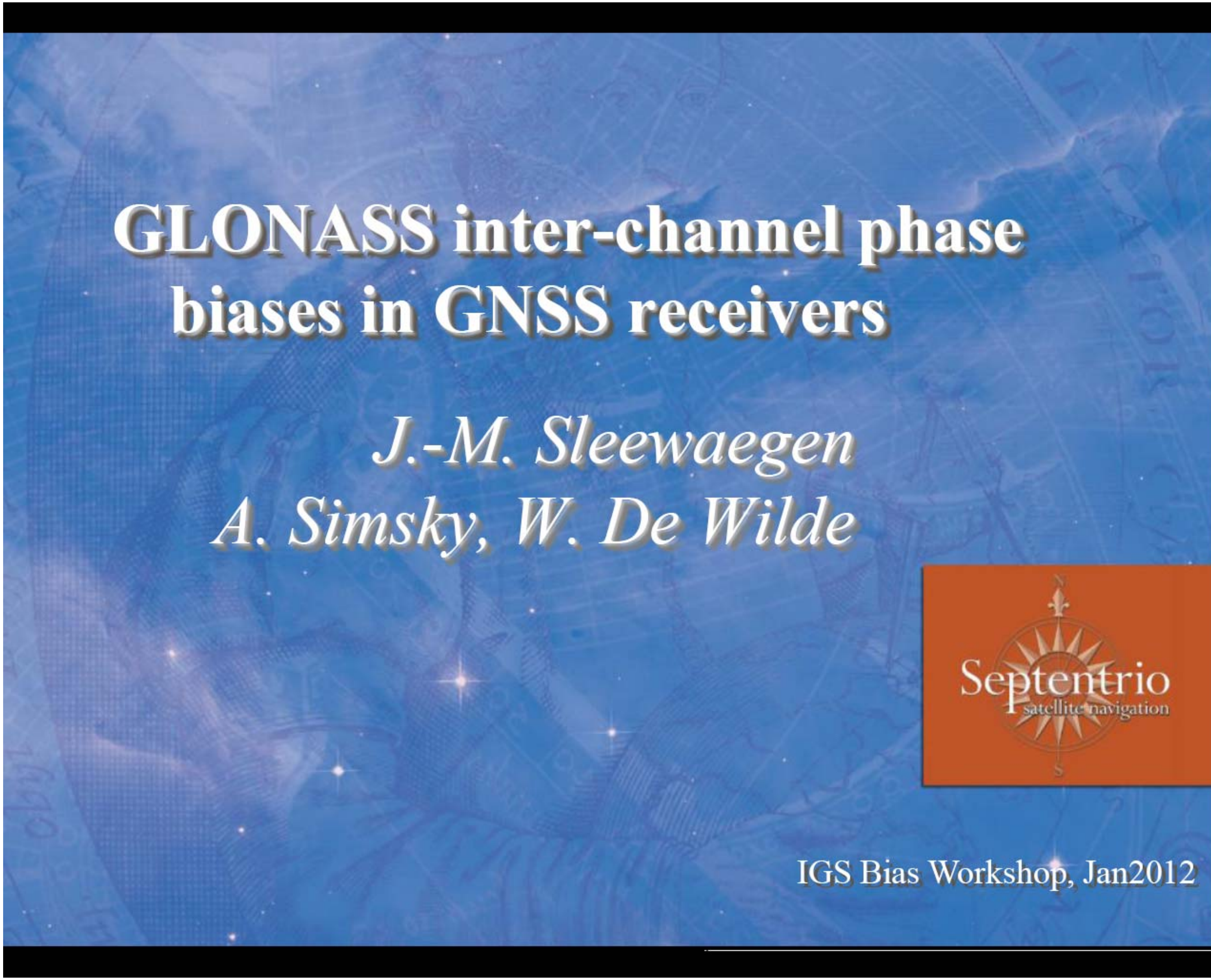
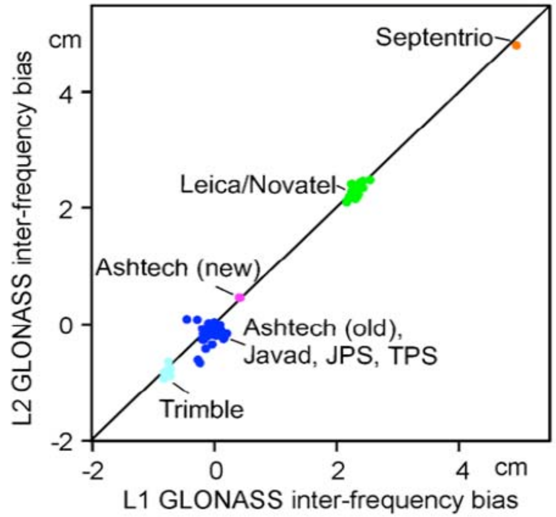

GLONASS inter-channel phase biases in GNSS receivers
J.-M. Sleewaegen
A. Simsky, W. De Wilde
Septentrio
satellite navigation
IGS Bias Workshop, Jan2012

GLONASS Carrier Phase Biases



Wanninger, L. (2011): Carrier-Phase Inter-Frequency Biases of GLONASS receivers.
http://www.gpsworld.com/tech-talk-blog/carrier-phase-inter-frequency-biases-glonass-receivers-12013

- Analog RF filters cannot account for these biases:
  - RF filter bias would not be the same on L1 and L2
  - RF filter bias would not be such linear function of GLO fn

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Phase Bias from Digital Signal Processing

- The effect is that the clock biases for code and carrier slightly differ (typically by <1µs):

$$PR[m] = \rho + c\Delta\tau + \Delta PR + \ldots$$

$$\Phi[m] = \rho + c\Delta\phi + \ldots = PR[m] + c(\Delta\phi - \Delta\tau) - \Delta PR + \ldots$$

Phase bias term

- Only the sub-cycle part of the phase bias term is causing a problem:

$$GLOPhaseBias[m] = \mathrm{mod}\left(c(\Delta\phi - \Delta\tau) - \Delta PR, \lambda_{fn}\right)$$

with λ_{fn} the carrier wavelength for GLONASS frequency number fn, expressed in meters

IGS Bias Workshop, Jan 2012 (c) Septentrio 6

LS combination of CODE's accumulated IGSFINAL and EPNFINAL SDByyssss.LST results (WL)

Receiver type		SD bias	RMS error (ns)
ASHTECH Z18	:	22.120	2.268
JAVAD TRE_G3TH DELTA	:	218.901	0.675
JPS EGGDT	:	58.271	0.606
JPS E_GGD	:	128.505	0.565
JPS LEGACY	:	111.921	0.609
LEICA GRX1200+GNSS	:	-269.900	0.753
LEICA GRX1200GGPRO	:	-242.546	0.484
NOV OEMV3	:	-247.286	0.516
SEPT POLARX3ETR	:	-501.984	0.533
TPS EGGDT	:	70.275	0.726
TPS EUROCARD	:	155.776	0.652
TPS E_GGD	:	121.529	0.868
TPS LEGACY	:	92.682	0.517
TPS NETG3	:	52.682	0.507
TPS ODYSSEY_E	:	57.586	0.611
TRIMBLE NETR5	:	96.551	0.515
TRIMBLE NETR8	:	74.919	0.908

GLONASS RTK Interoperability Issues Involving 3rd Party Receivers

Frank Takac, Leica Geosystems, Heerbrugg, Switzerland

Paul Alves, NovAtel, Calgary, Canada

- when it has to be **right**

Estimating the SD Ambiguity Bias

- In practice, the SD ambiguity bias can be estimated with the aid of code observations. For example, SD phase minus SD code.

$$\phi^p_{mk,i} = \rho^p_{mk} + cdt_{mk} + \lambda^p_i n^p_{mk,i} + b_{mk} + \varepsilon^p_{mk,i} \qquad P^p_{mk,i} = \rho^p_{mk} + cdt_{mk} + B_{mk} + E^p_{mk,i}$$

$$\begin{aligned}\lambda^p_i a^p_{mk,i} &= \phi^p_{mk,i} - P^p_{mk,i} \\ &= \lambda^p_i n^p_{mk,i} + \underbrace{b_{mk} - B_{mk}}_{\beta_{mk}} + E^p_{mk,i}\end{aligned}$$

β_{mk} - Differential code-phase receiver bias (DCPB)

- For a homogeneous receiver pair, the differential code-phase receiver bias (DCPB) effectively cancels.

- when it has to be **right**

Leica Geosystems

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Intersystem phase biases (or drifts)

Biases and clock modelling in the frame of ambiguity resolution

International GNSS Service
Workshop 2012
23 - 27 July 2012, Olsztyn, Poland

E. Orliac[1], R. Dach[1], K. Wang[2], M. Rothacher[2],
D. Voithenleitner[3], U. Hugentobler[3], M. Heinze[3], and D. Svehla[4]
[1] Astronomical Institute, University of Bern, Switzerland
[2] Institute of Geodesy and Photogrammetry, Swiss Federal Institute of Technology Zurich, Switzerland
[3] Institut für Astronomische und Physikalische Geodäsie, Technische Universität München, Munich, Germany
[4] European Space Operations Centre, European Space Agency, Darmstadt, Germany

OVERVIEW

In the frame of the ESA project "Satellite and Station Clock Modelling for GNSS" we carried out a review of the code and phase biases in and between existing GNSS. The stability of these biases and opportunities for their modeling were investigated and compared to the requirements for successful ambiguity resolution on the zero- and single-difference levels.
Based on both simulated and real data, the track-to-track ambiguity resolution was investigated, with a special focus set on the impact of clock modeling.

INTER-SYSTEM PHASE BIASES

GPS/GLO mixed baselines only as formed in the CODE final 1-day solution are used in this investigation, i.e. GPS only baselines are not considered. Only preprocessed phase ionosphere-free (L3) observations are used. Estimated parameters are daily coordinates and troposphere parameters, plus (float) ambiguities.
The mixed baselines are processed 7 times:

1. in GPS-only mode (**G**)
2. in GLO-only mode (**R**)
3. in GPS/GLO mode (**RG00**)
4. in GPS/GLO mode, correcting for station inter-system translation biases (**RG10**)
5. in GPS/GLO mode, correcting for station inter-system troposphere biases (**RG01**)
6. in GPS/GLO mode, correcting for both station inter-system translation and troposphere biases (**RG11**).
7. in GPS/GLO mode, estimating a phase inter-system bias, modelled as a piece-wise linear function with a knot spacing of 1 hour (**RGI**)

Table 1: Statistics on the distribution of the baseline L3 DD phase normalized residuals RMS. Values are given in mm and are based on residuals from DOYs 170-172 of 2012.

Solution	Q00% (min)	Q25%	Q50% (median)	Q75%	Q100% (max)	Size
G	0.16	1.06	1.23	1.42	1.90	566
R	0.13	1.09	1.27	1.43	2.11	566
GG00	0.17	1.06	1.24	1.43	1.89	566
GG10	0.20	1.21	1.42	1.60	2.01	566
GG01	0.17	1.06	1.24	1.43	1.89	566
GG11	0.17	1.06	1.23	1.43	1.89	566
GGI	0.17	1.06	1.24	1.42	1.89	566
RR00	0.14	1.12	1.30	1.47	2.08	566
RR10	0.15	1.11	1.29	1.47	2.05	566
RR01	0.15	1.12	1.30	1.48	2.07	566
RR11	0.14	1.11	1.29	1.47	2.05	566
RRI	0.14	1.10	1.28	1.46	2.05	566
RG00	0.20	1.23	1.42	1.60	2.01	566
RG10	0.20	1.21	1.42	1.60	2.01	566
RG01	0.20	1.23	1.42	1.60	2.01	566
RG11	0.20	1.21	1.42	1.60	2.01	566
RGI	0.20	1.21	1.40	1.57	1.99	566

The main point from Tab. 1 is that the G and R solutions (single-GNSS) show the smallest residuals overall, with, comparable performances.
For mixed solutions (3. to 7.) the DD residuals were analyzed in three groups: GPS/GPS (GG), GLO/GLO (RR), and GPS/GLO (RG). The RMS of the DD residuals between satellites of the same GNSS (GGxx and RRxx) are only slightly higher than the residuals from the single-GNSS solutions (1. and 2.) whereas the residuals accross the systems (RGxx) are significantly higher.
In solutions 4. to 7. attempts were made to identify the potential source of the degradation. Correcting for coordinate and/or troposphere bias (to handle GLO antenna calibration bias from a GPS only based calibration, solutions 4. to 6.) did not help. Only estimating a inter-system time-varying phase bias seems to have a little effect (solution 7.).

We now investigate the role of the receiver type, or more precisely the role fo the receiver type combination. Receivers from a same brand were grouped together. Here we focus on the difference between the residuals RMS from the GG and RG DD in solutions RG00, RG11 and RGI.

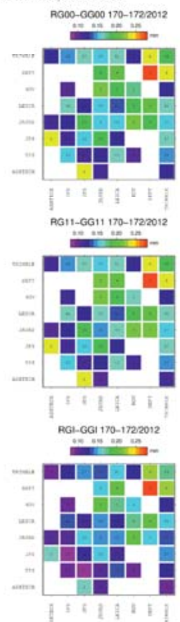

Figure 1: Mean of the difference of baseline residual RMS when grouped by receiver class between the RG and GG residuals for mixed-GNSS solutions RG00 (top), RG11 (middle), and RGI (bottom). Values were computed residuals from baselines from DOY 170-172 of 2012. The numbers in each square indicate the number of contributing baselines to a specific receiver class combination.

Summary on inter-system phase bias

Fig. 1 shows that correcting for station-wise GLONASS translation and troposphere bias does not impact the performances of any receiver class pair. However, when estimating a time-varying inter-system phase bias, the degradation of the RG residuals compared to the GG or RR one is reduced (colder colors in Fig. 1). This effect is not yet fully understood and needs to be further investigated.

TRACK-TO-TRACK AMBIGUITY RESOLUTION

Fig. 2 shows the histograms of the fractional wide-lane ambiguities (left) and the fractional track-to-track wide-lane ambiguities (right) for station USN3 on February 1st, 2011. We see that most of the receiver- and satellite-related biases, which still remain in the zero-difference wide-lane ambiguities, were significantly reduced by forming track-to-track ambiguities.

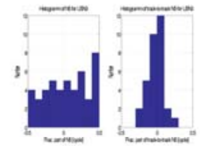

Figure 2: Histograms of the fractional wide-lane ambiguities (left) and the fractional track-to-track wide-lane ambiguities from Melbourne-Wübbena linear combination for station USN3 on February 1st, 2011.

Fig. 3 shows the relationship between the fractional N5 and N1 ambiguities and the weighted track lengths on the zero-difference level. The data for 10 stations in February 2011 was used for plotting. We see that track-to-track ambiguities with small fractional parts are more likely to be generated by the ones with long track lengths.

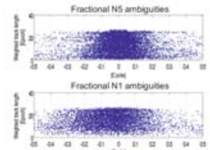

Figure 3: Relationship between the fractional N5 (top) and N1 (bottom) ambiguities and the weighted track lengths on the zero-difference level.

Fig. 4 shows the track-to-track N1 ambiguities with an absolute fractional part below 0.1 cycle. The resolved track-to-track ambiguities were constrained with a strong weight on the normal equation level iteratively. We see that the constraining has increased the number of the good track-to-track ambiguities significantly.

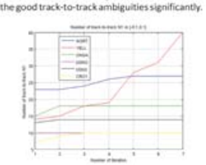

Figure 4: Number of track-to-track N1 ambiguities with a fractional part in [-0.1, 0.1] cycle after seven iterations of constraining the resolved ones on the normal equation level.

ACKNOWLEDGEMENTS

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AIUB Poster compiled by E.Orliac, July 2012
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IAPG ETH

List of GNSS biases

- GNSS differential code biases (DCB)
- CODE's DCB specialties (e.g., DCB multiplier estimation)
- GLONASS interfrequency code biases (relevant to GNSS clock estimation, or PPP)
- Intersystem code biases
- "DCPB" crucial for GLONASS ambiguity resolution
- Intersystem phase biases (or drifts)
- Uncalibrated phase delays (UPD) relevant to undifferened integer fixing for PPP
- GLONASS-GPS station-specific intersystem translations as considered in CODE's GNSS analysis (IGS ANTEX model)
- (GPS) quarter-cycle issue (again crucial)

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Un-calibrated Phase Biases for Precise Point Positioning Integer Ambiguity Resolution

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2) Now at: Scripps Institution of Oceanography, University of California, San Diego

3) Geophysics Laboratory, University of Luxembourg

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Workshop on GNSS Biases,
18-19 January 2012, Bern, Switzerland

UNIVERSITÉ DU LUXEMBOURG

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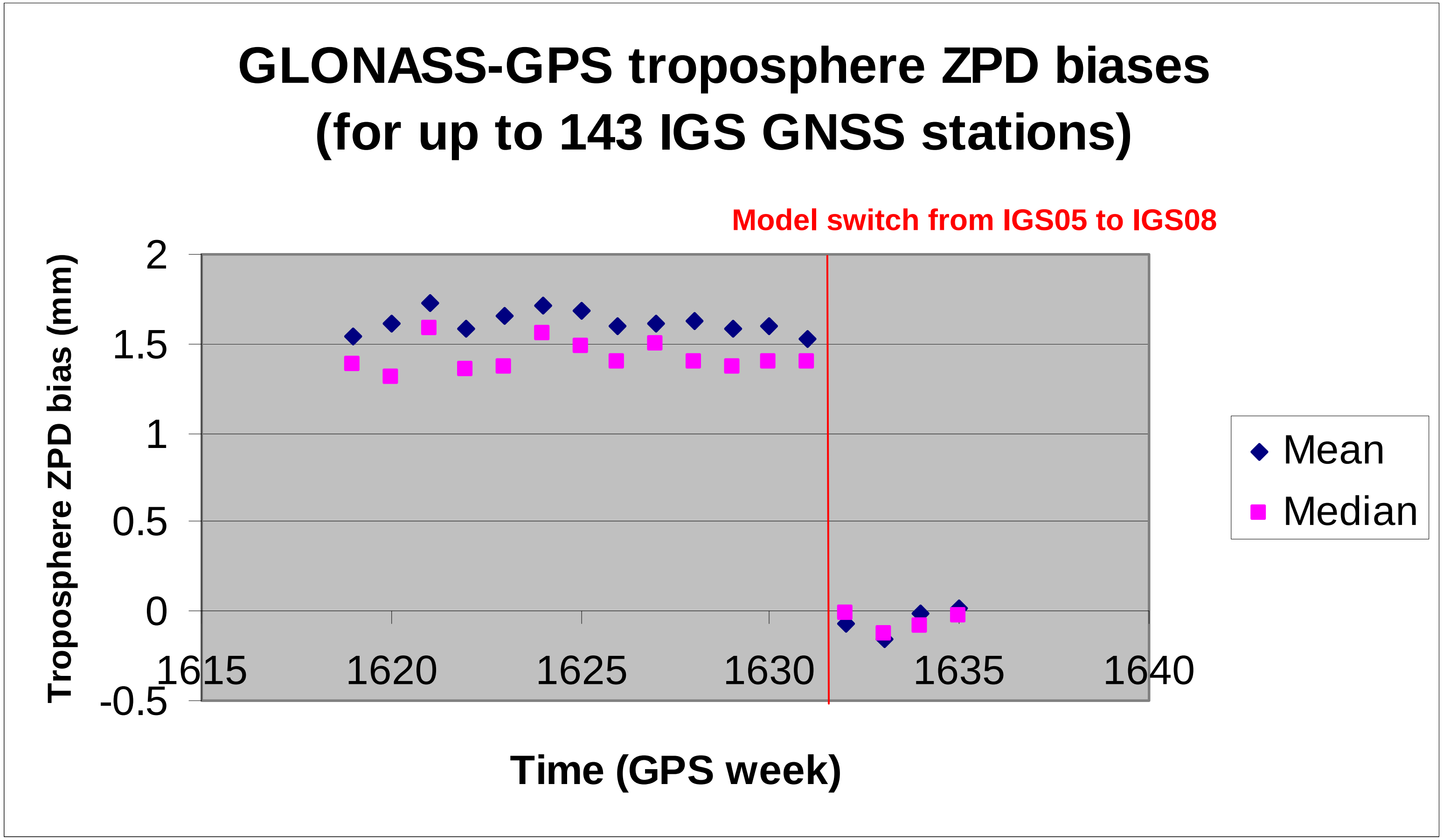
Mean GLONASS-GPS troposphere ZPD biases: CODE IGS (global) weekly results



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[IGSMAIL-6583] GPS quarter-cycle biases

Until recently, we did expect GPS quarter-cycle biases between L2(P) and L2(C) only for Leica and NovAtel receivers. As a consequence, ambiguity resolution was not permitted between modernized GPS satellites (specifically Block IIR-M and IIF) and older generations as soon as a receiver type belonging to the mentioned receiver group gets involved.

We could recognize, however, three additional characteristics that must be taken into account:

1. Javad receivers obviously also belong to this receiver group (potentially revealing quarter-cycle biases). We could verify corresponding biases for the JAVAD TRE_G3TH DELTA receivers operated at AREV, DGAV, TABV, WTZZ. It is worth mentioning that AREV, DGAV, TABV started to provide C2 and thus implicitly L2(C) on February 3, 2012. Quarter-cycle biases started to occur exactly in coincidence with that date (day 034 of 2012) for these Javad receivers. Verification was possible on the zero baselines AREV-AREQ (wrt ASHTECH UZ-12), DGAV-DGAR (wrt ASHTECH UZ-12), and ultimately on the 50km baseline TABV-JPLV (wrt JPS EGGDT).

2. Moreover, we realized that there are certain time periods for particular modernized GPS satellites where C2 and L2(C) seem to be commonly unavailable (no receiver model was able to provide C2 and L2(C) at all). SVN49 is a prominent candidate in the table of such time periods:

PRN01/SVN49: 54951 <= MJD < 54970
PRN25/SVN62: 55353 <= MJD < 55375
PRN01/SVN49: 55677 <= MJD < 55688
PRN24/SVN49: 55959 <= MJD < 56001

3. Finally, we noticed cases, where L2(C) was not observed by particular receivers for one (or a subset) of the modernized GPS satellites.

As a consequence of the above observations, we changed our analysis software in a way that ambiguity resolution is generally not permitted between modernized GPS satellites as soon as a Javad, Leica, or a NovAtel receiver type gets involved.

Line bias variations in GPS L1/L2/L5 signals

O. Montenbruck

DLR/GSOC

Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Slide 1
IGS Bias Workshop > Bern > 18-19 Jan. 2011

Summary and Conclusion

- Triple frequency carrier phase combination provides evidence for thermally dependent line bias variations in GPS IIF satellites
- Apparent L1/L2 clock is affected by similar variations despite highly stable Rubidium Frequency Standard (→ all frequencies are affected)
- Need
  - independent L1/L5 clock product or
  - L1/L5-L1/L2 bias product (with e.g. 15-min sampling) or
  - Empirical L1/L5-L1/L2 model
- Problem most evident in GPS; other GNSSs are less affected (or not at all)

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in der Helmholtz-Gemeinschaft

Slide 10
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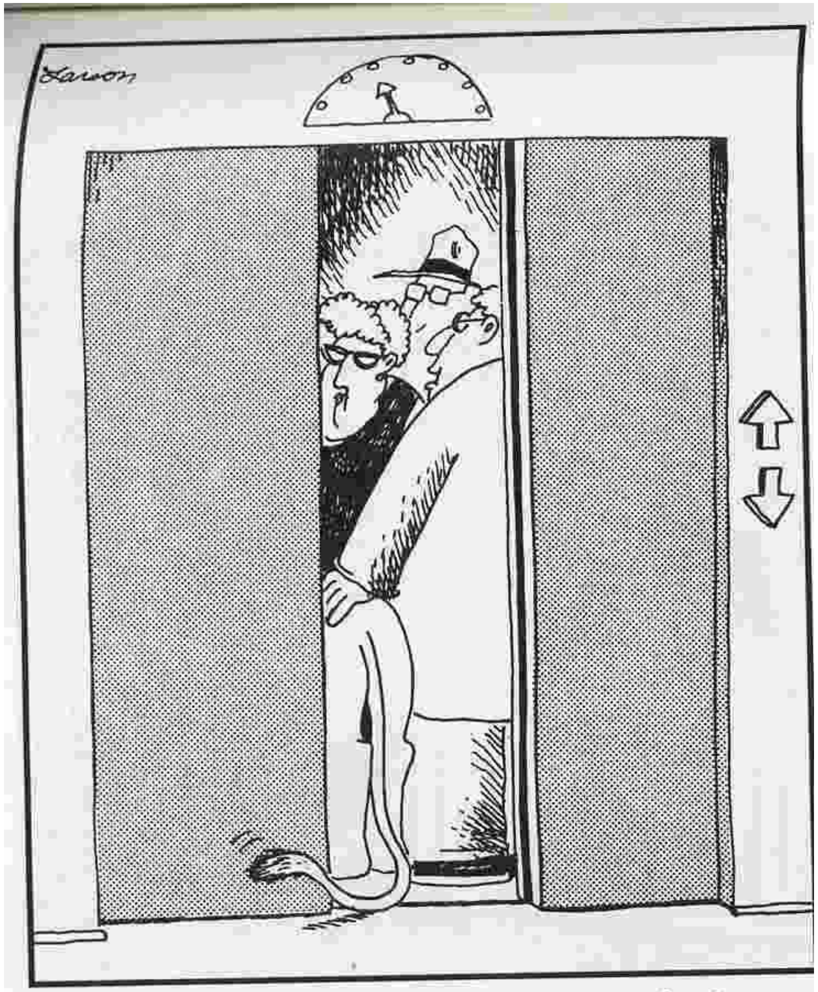
We may summarize that …

- **GNSS biases** become relevant when
  - different observable types,
  - different frequencies,
  - different GNSS (or satellite generations),
  - different receiver antenna types,
  - different receiver antenna mountings,
  - different receiver antenna environments,
  - different receiver types,
  - different receiver firmware versions,
  - or, ultimately, different observation techniques

  are involved.

Thank you for your attention …



“Don’t be alarmed, folks—he’s completely harmless unless something startles him.”

IGS BCWG Splinter Meeting Agenda

- Results from IGS Workshop on GNSS Biases, 18–19 January 2012 in Bern
  - Key issues, recommendations, action items
  - See www.biasws2012.unibe.ch
- New bias products generated at CODE
  - P1-C1 and P2-C2 for GPS and GLONASS
  - See IGS Technical Report 2011
- Discussion/feedback concerning bias handling in IGS AC analysis software
  - From cc2noncc to …
  - Priority list of GNSS observable types
  - See poster on *Availability and Completeness of IGS Tracking Data*
- GLONASS clock estimation and treatment of GLONASS pseudorange biases
  - IGS combined GLONASS clock product
- Bias SINEX
- Additional discussion items:
  - Discussion concerning GLONASS-GPS intersystem bias parameters for station coordinates and troposphere ZPD
  - Remarks on CODE's GLONASS ambiguity resolution scheme

Plethora of GNSS observables: different GPS/GLONASS receiver tracking (1/3)

```
AOA BENCHMARK ACT    (  10) .    G:P1 G:P2 .    .    .    .    .
AOA BENCHMARK ACT    (  88) G:C1 G:P1 G:P2 .    .    .    .    .
AOA SNR-12 ACT       (  22) G:C1 G:P1 G:P2 .    .    .    .    .
AOA SNR-8000 ACT     (  31) G:C1 G:P1 G:P2 .    .    .    .    .
ASHTECH PF500        (  11) G:C1 .    G:P2 .    R:C1 .    R:P2 .
ASHTECH UZ-12        ( 513) G:C1 G:P1 G:P2 .    .    .    .    .
ASHTECH Z-XII3       (   8) G:C1 .    G:P2 .    .    .    .    .
ASHTECH Z-XII3       ( 229) G:C1 G:P1 G:P2 .    .    .    .    .
ASHTECH Z-XII3T      ( 129) G:C1 G:P1 G:P2 .    .    .    .    .
ASHTECH Z18          (  24) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
BLACKJACK            (   4) G:C1 G:P1 G:P2 .    .    .    .    .
DICOM GTR50          (  11) G:C1 G:P1 G:P2 .    .    .    .    .
IFEN SX_NSR_RT_400   (  11) G:C1 .    G:P2 .    .    .    .    .
JAVAD TRE_G3T DELTA  (  11) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
JAVAD TRE_G3TH DELTA (   1) G:C1 .    G:P2 .    .    .    .    .
JAVAD TRE_G3TH DELTA ( 131) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
JPS EGGDT            ( 141) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
JPS EUROCARD         (  10) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
JPS E_GGD            (  55) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
JPS LEGACY           (   4) G:C1 G:P1 G:P2 .    .    .    .    .
JPS LEGACY           ( 192) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
LEICA GRX1200+GNSS   ( 172) G:C1 .    G:P2 .    R:C1 .    R:P2 .
LEICA GRX1200GGPRO   (   1) G:C1 .    G:P2 .    .    .    .    .
LEICA GRX1200GGPRO   ( 452) G:C1 .    G:P2 .    R:C1 .    R:P2 .
LEICA GRX1200PRO     (  44) G:C1 .    G:P2 .    .    .    .    .
NOV OEM4-G2          (  11) G:C1 .    G:P2 .    .    .    .    .
NOV OEMV3            (  44) G:C1 .    G:P2 .    R:C1 .    R:P2 .
ROGUE SNR-8000       (  23) G:C1 .    G:P2 .    .    .    .    .
ROGUE SNR-8100       (  11) G:C1 .    G:P2 .    .    .    .    .
```

Plethora of GNSS observables: different GPS/GLONASS receiver tracking (2/3)

```
SEPT POLARX2         (  71) G:C1 G:P1 G:P2 .    .    .    .    .
SEPT POLARX3ETR      (  11) G:C1 G:P1 G:P2 .    R:C1 .    .    R:C2
SEPT POLARX3ETR      (  11) G:C1 G:P1 G:P2 .    R:C1 .    R:P2 .
SEPT POLARX4TR       (   5) G:C1 G:P1 G:P2 .    R:C1 .    .    R:C2
SEPT POLARX4TR       (   4) G:C1 G:P1 G:P2 .    R:C1 .    R:P2 .
TPS EGGDT            (  11) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TPS EUROCARD         (   9) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TPS E_GGD            (  79) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TPS GB-1000          (  33) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TPS LEGACY           (  13) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TPS NET-G3A          (  17) G:C1 G:P1 G:P2 .    .    .    .    .
TPS NET-G3A          (  88) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TPS NETG3            (  11) G:C1 G:P1 G:P2 .    .    .    .    .
TPS NETG3            ( 121) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TPS ODYSSEY_E        (  44) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TRIMBLE 4000SSE      (  11) G:C1 .    G:P2 .    .    .    .    .
TRIMBLE 4000SSI      (  65) G:C1 .    G:P2 .    .    .    .    .
TRIMBLE 4700         (  33) G:C1 .    G:P2 .    .    .    .    .
TRIMBLE 5700         (  21) G:C1 .    G:P2 .    .    .    .    .
TRIMBLE NETR5        (  13) G:C1 .    G:P2 .    .    .    .    .
TRIMBLE NETR5        (  96) G:C1 .    G:P2 .    R:C1 .    R:P2 .
TRIMBLE NETR5        ( 120) G:C1 .    G:P2 .    R:C1 R:P1 R:P2 .
TRIMBLE NETR8        (  29) G:C1 .    G:P2 .    .    .    .    .
TRIMBLE NETR8        (  32) G:C1 .    G:P2 .    R:C1 R:P1 .    .
TRIMBLE NETR8        (  62) G:C1 .    G:P2 .    R:C1 R:P1 R:P2 .
TRIMBLE NETR8        (  18) G:C1 G:P1 G:P2 .    R:C1 R:P1 R:P2 .
TRIMBLE NETR9        (  18) G:C1 .    G:P2 .    .    .    .    .
TRIMBLE NETR9        (  53) G:C1 .    G:P2 .    R:C1 .    R:P2 .
TRIMBLE NETR9        ( 110) G:C1 .    G:P2 .    R:C1 R:P1 R:P2 .
TRIMBLE NETRS        ( 244) G:C1 .    G:P2 .    .    .    .    .
TRIMBLE NETRS        (   9) G:C1 G:P1 G:P2 .    .    .    .    .
```

Plethora of GNSS observables: different GPS/GLONASS receiver tracking (3/3)

AOA BENCHMARK ACT	(2)
ASHTECH Z-XII3	(2)
JAVAD TRE_G3TH DELTA	**(2)**
JPS LEGACY	(2)
LEICA GRX1200GGPRO	(2)
SEPT POLARX3ETR	**(2)**
SEPT POLARX4TR	**(2)**
TPS NET-G3A	(2)
TPS NETG3	(2)
TRIMBLE NETR5	**(3)**
TRIMBLE NETR8	**(4)**
TRIMBLE NETR9	**(3)**
TRIMBLE NETRS	**(2)**