An Analysis of Intersystem Biases for multiGNSS Positioning

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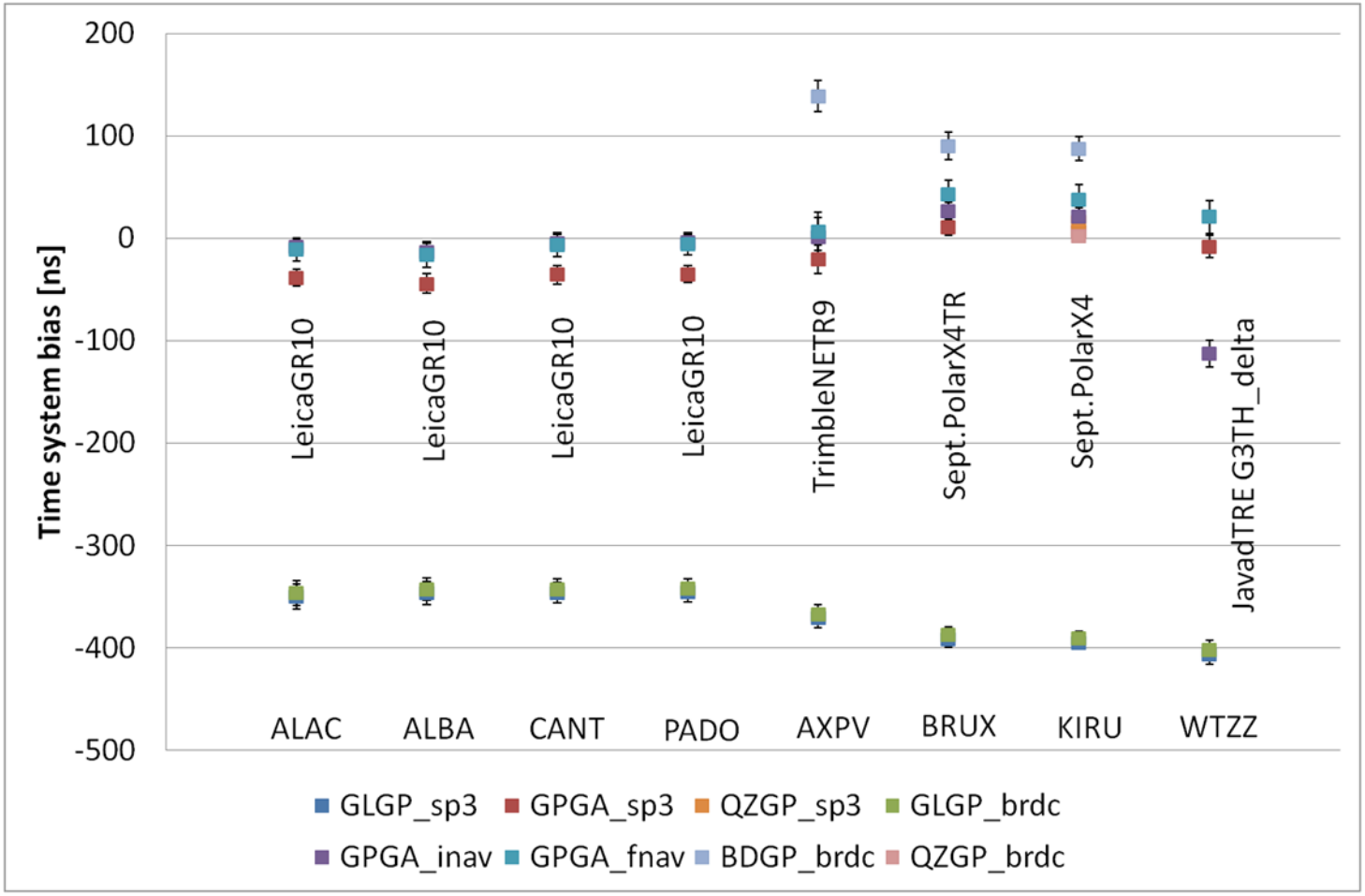
- Galileo Nav message: HS/DVS set to zero since 2013-12-03
- Systematic monitoring of Coordinates, TZD, Time Offsets : results for January 2014
- disalignment to GPS of Glonass, BeiDou is non random and receiver dependent
- How the IGS DCB can be used

Time system biases and receiver dependent biases in 2013 data



Dalla Torre and Caporali, GPS Solutions 2014 (in press)

The data validity status bit has the values shown in Table 75:

Data Validity Status	Definition
0	Navigation data valid (tbc)
1	Working without guarantee

Table 75. Data validity Status Bit Values

The signal status bits have the values shown in Table 78.

Signal Health Status	Definition (tbc)
0	Signal OK
1	Signal out of service
2	Signal will be out of service
3	Signal Component currently in Test

Table 78. Signal Health Status Bit Values (definitions are tbc)

Message Type	5.Record 2. Word	Bits set	6.Record 2.Word	Bits set
I/NAV (E5b-E1)	513	9,0	E5b 390 (HS=3) 384 (HS=0)	6,7,8
F/NAV (E5a-E1)	258	8,1	E5a 48	3,4,5

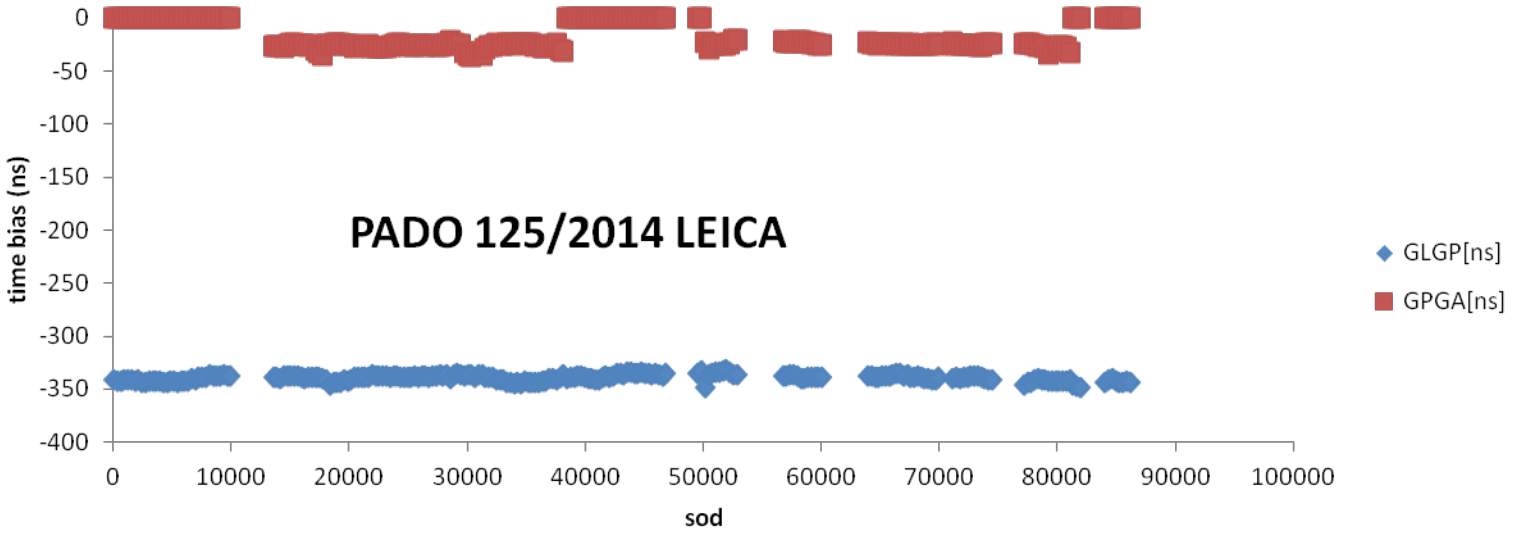
Since 2013-12-03 the 6.record 2.word is set to zero

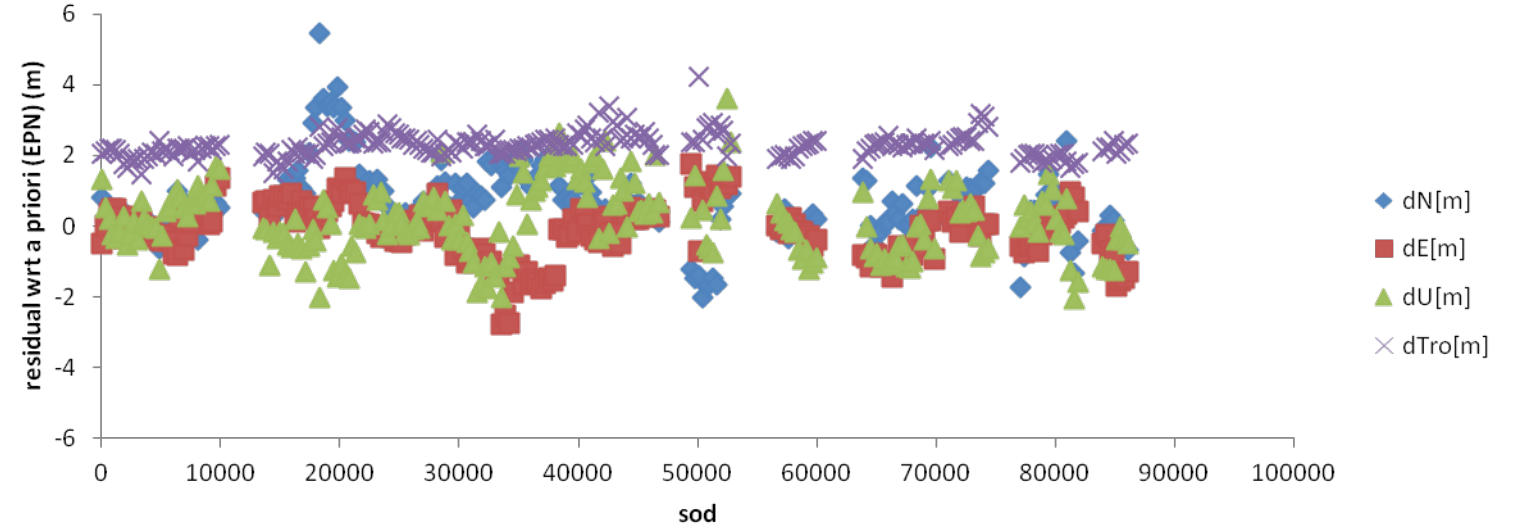
T ORBIT - 5	- IDOT (radians/sec) - Data sources (FLOAT --> INTEGER) Bit 0 set: I/NAV E1-B Bit 1 set: F/NAV E5a-I Bit 2 set: I/NAV E5b-I Bits 0-2 : non-exclusive Bit 3 reserved for Galileo internal use Bit 4 reserved for Galileo internal use Bit 8 set: af0-af2, Toc, SISA are for E5a,E1 Bit 9 set: af0-af2, Toc, SISA are for E5b,E1 - GAL Week # (to go with Toe) - spare	4X,4D19.12 ****)
BROADCAST ORBIT - 6	- SISA Signal in space accuracy (meters) Undefined/unknown: -1.0 - SV health (FLOAT converted to INTEGER) Bit 0: E1B DVS Bits 1-2: E1B HS	4X,4D19.12 *****)

TABLE A8
GNSS NAVIGATION MESSAGE FILE - GALILEO DATA RECORD DESCRIPTION

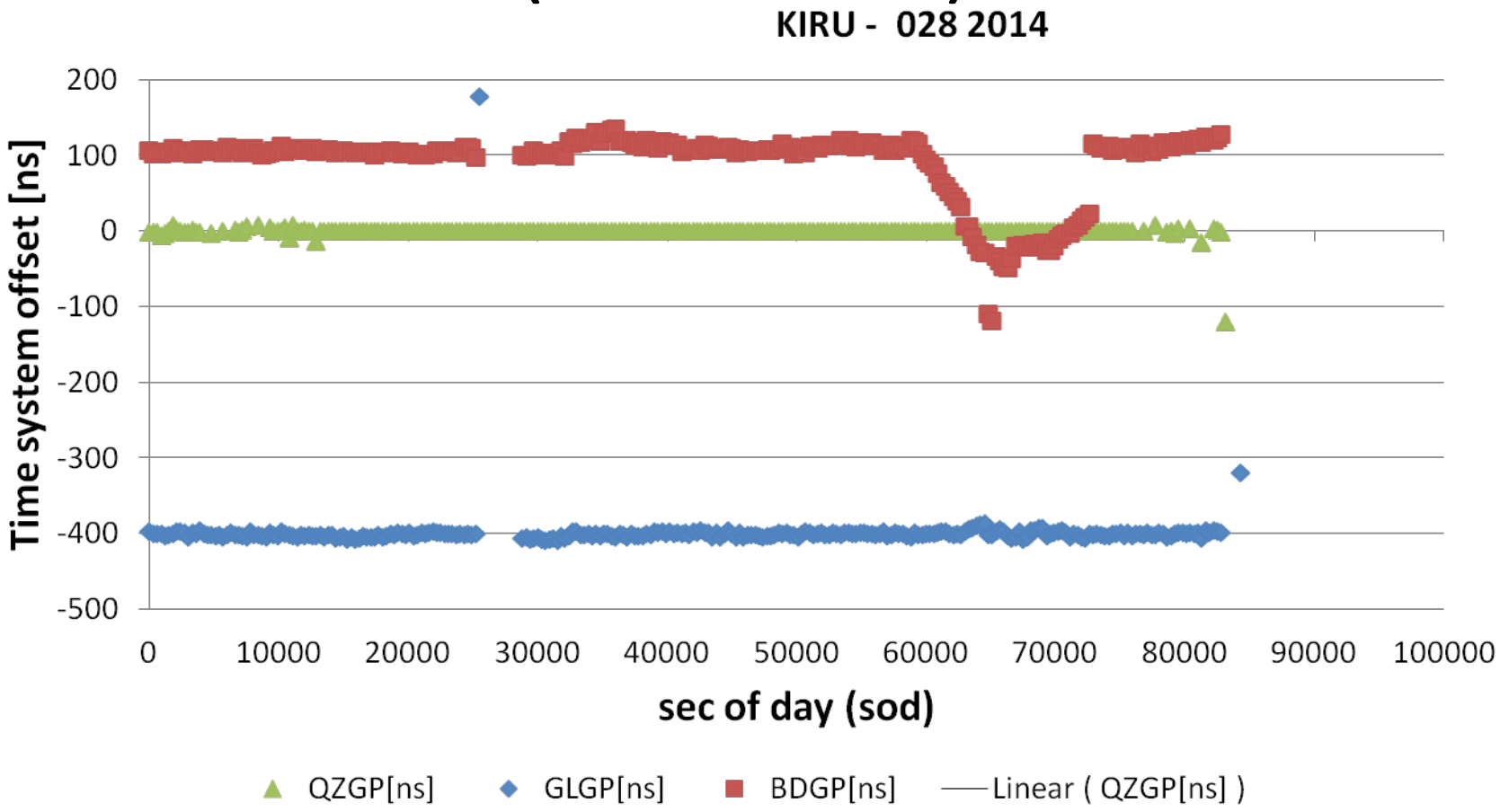
OBS. RECORD	DESCRIPTION	FORMAT
	Bit 3: E5a DVS Bits 4-5: E5a HS Bit 6: E5b DVS Bits 7-8: E5b HS - BGD E5a/E1 (seconds) - BGD E5b/E1 (seconds)	

Ignore NULL HS and DVS and treat message data as valid



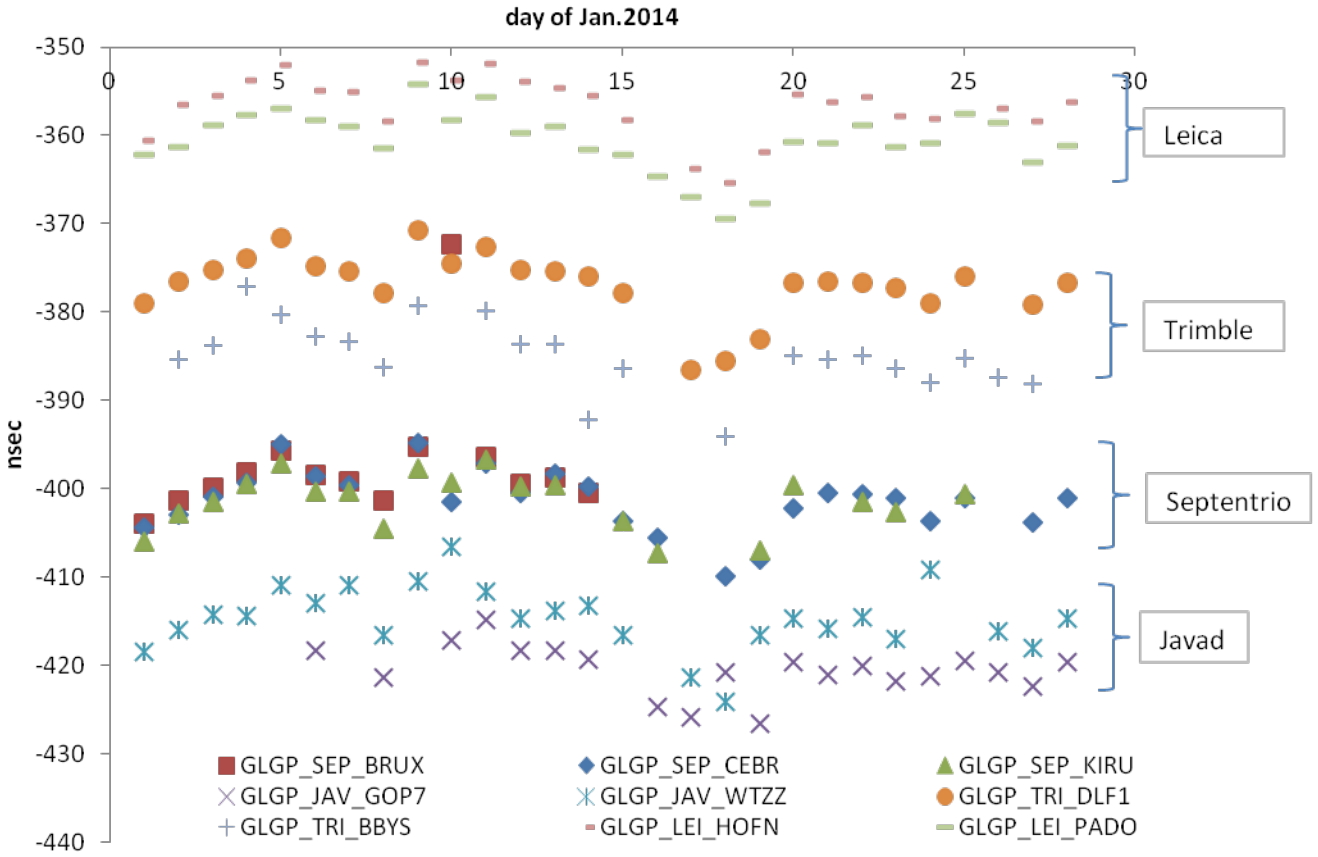


Example of a day with synch problems of BeiDou, Glonass relative to GPS (3ns → 1m)

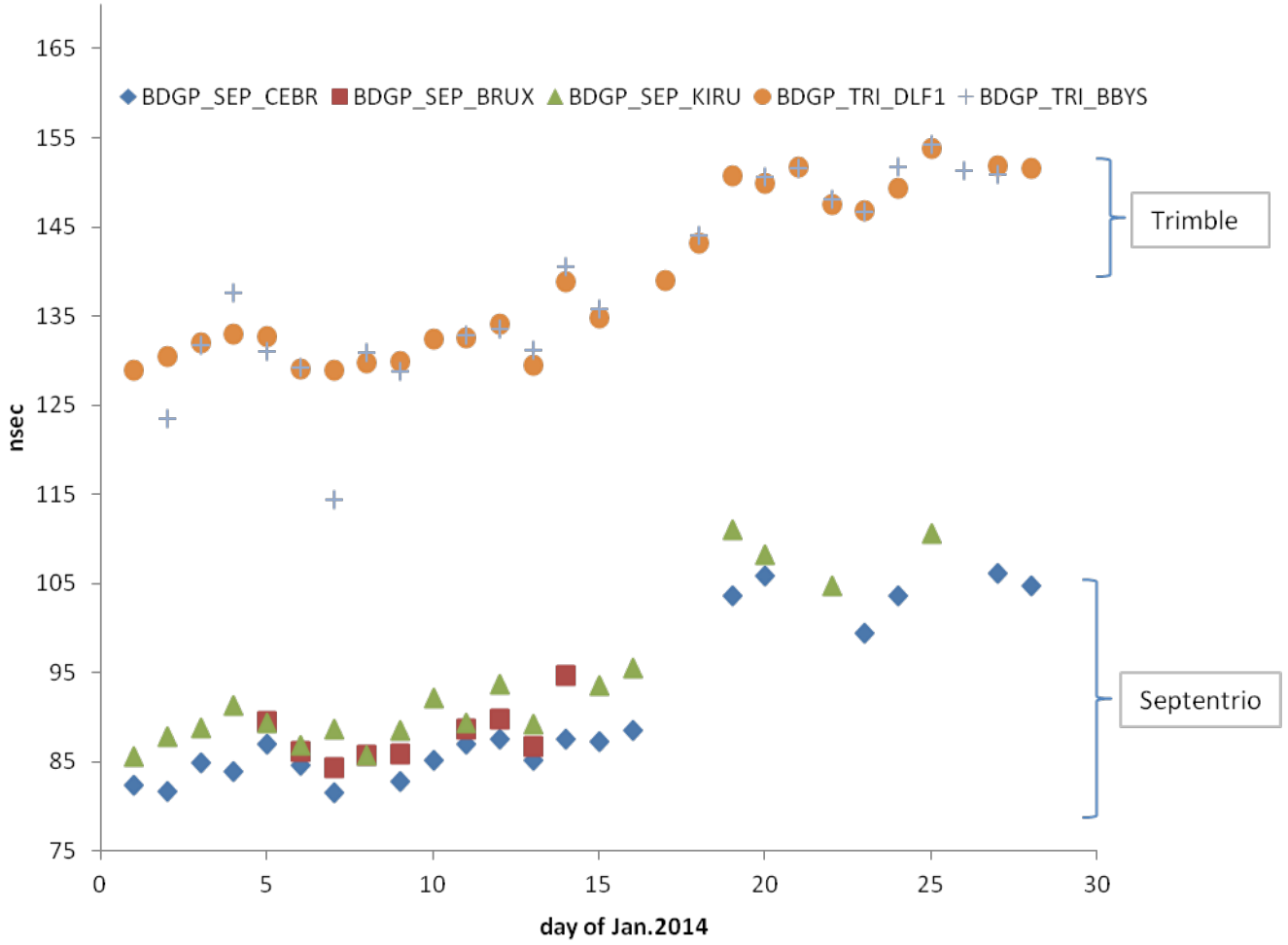


Glonass to GPS Time Offset: varies from day to day, depends on receiver type

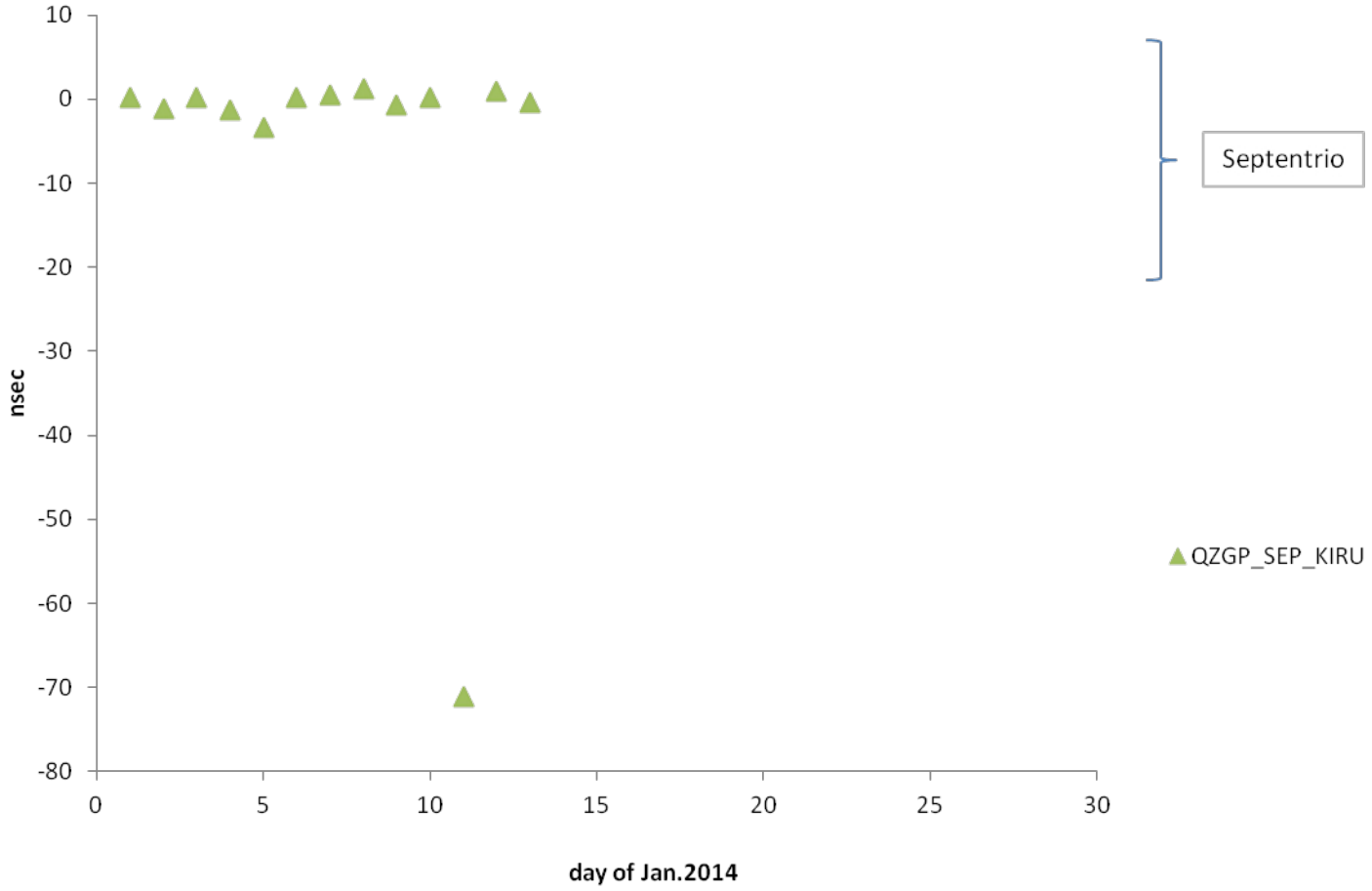
(error bars not shown; differences within each receiver group are negligible DCB's for satellites and MGEX stations and not applied: their size is <15-20 ns max)



BeiDou to GPS Time Offset: systematic drift, depends on receiver type

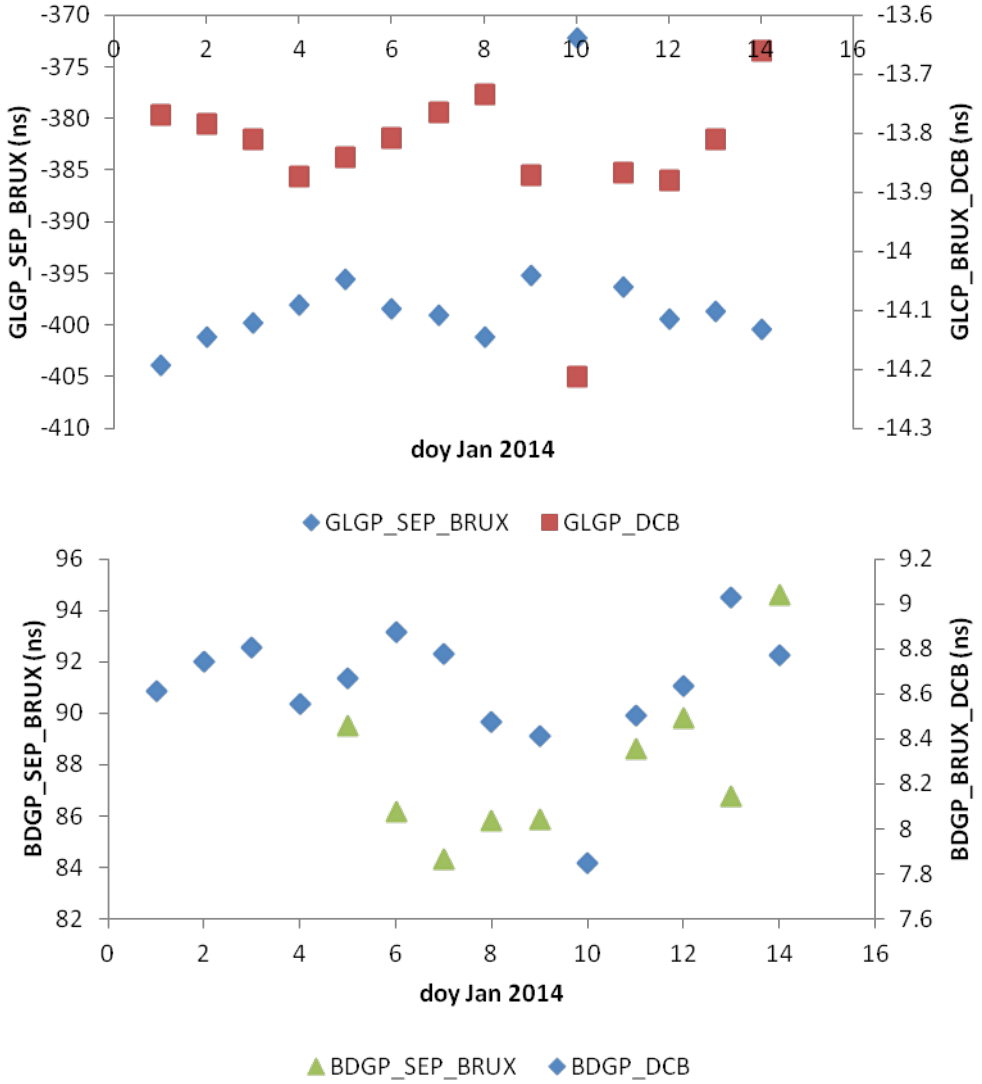


QZSS to GPS Time Offset: close to zero, only KIRU data

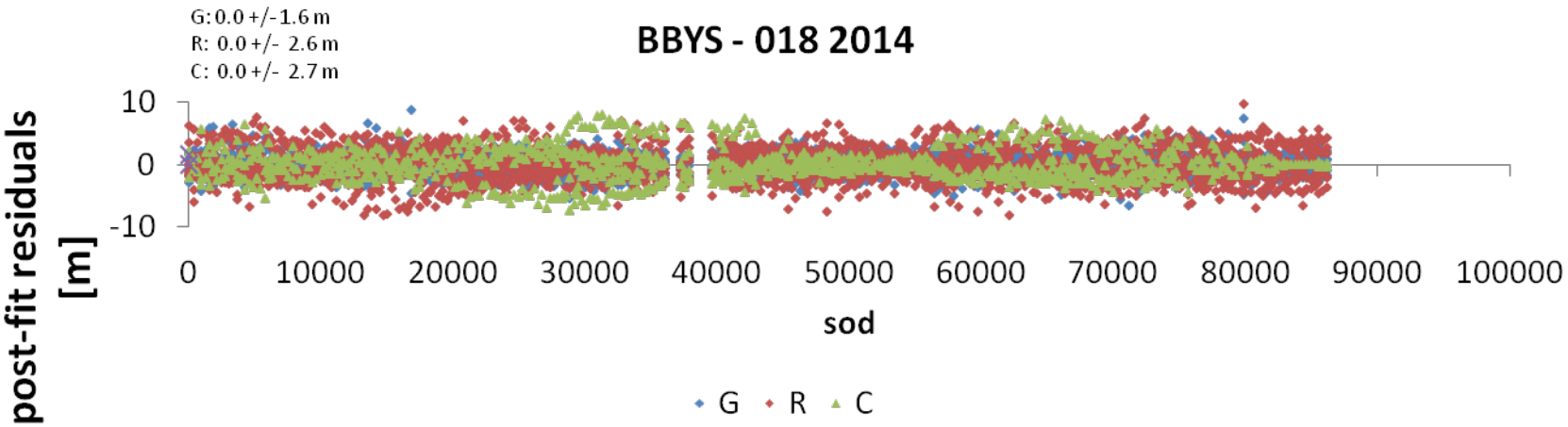


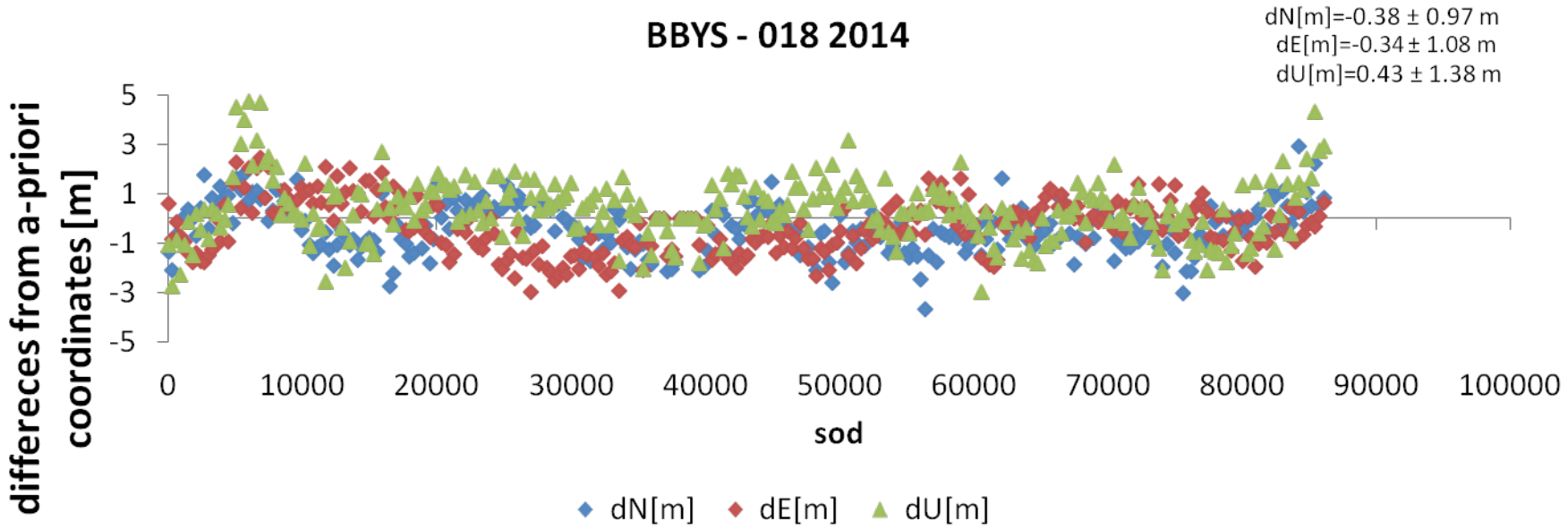
Understanding the new DCB Sinex from IGS

* - Multi-GNSS differential code biases (DCBs) in this product have been derived from observations of the IGS MGEX network. Details of the DCB estimation process are described in Montenbruck O., Hauschild A., Steigenberger P., "Differential Code Bias Estimation using Multi-GNSS Observations and Global Ionosphere Maps"; ION International Technical Meeting, 26-28 Jan. 2014, San Diego (2014).
* - A zero-mean constellation condition is applied to separate satellite and receiver biases on a daily basis.
* - Standard deviations reflect the uncertainty of individual satellite and station biases adjusted from the observed set of satellite+station biases.
* - This product may contain redundant, but potentially conflicting, bias information (e.g. GPS C1C-C1W and C1W-C2W along with C1C-C2W). Since individual biases are based on different sets of monitoring stations, consistency of these biases cannot be ensured, i.e. DCB(C1C-C2W) will typcially differ from the sum of DCB(C1C-C1W) +DCB(C1W-C2W). Where available, direct use of a DCB for a given signal pair is expected to better represent GNSS pseudorange observations than chaining of multiple DCBs.

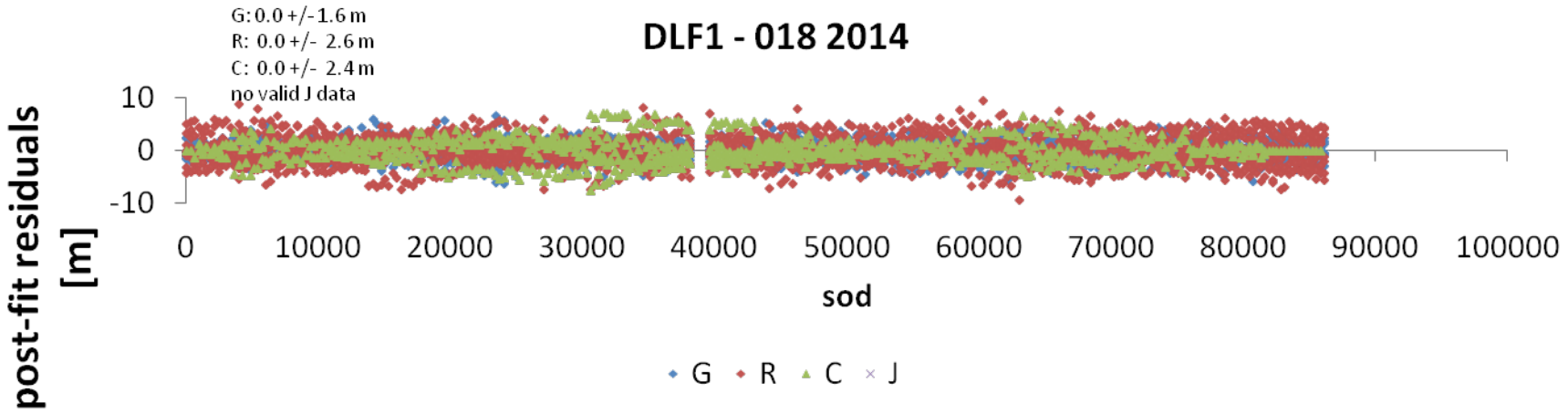


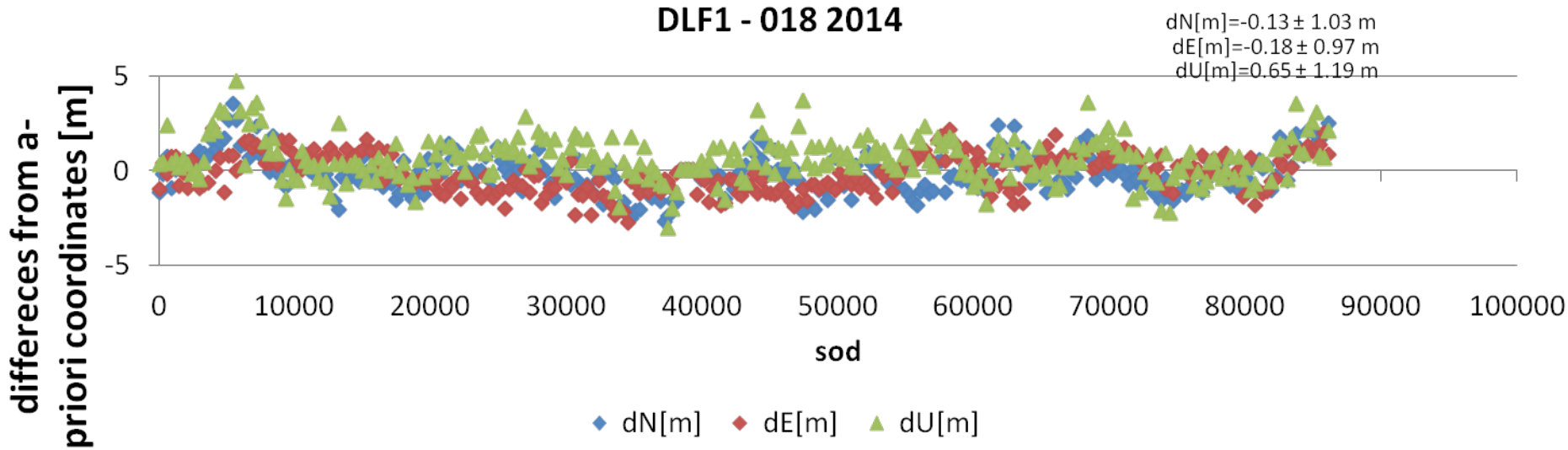
Postfit and time series of coordinates Trimble (1/2)



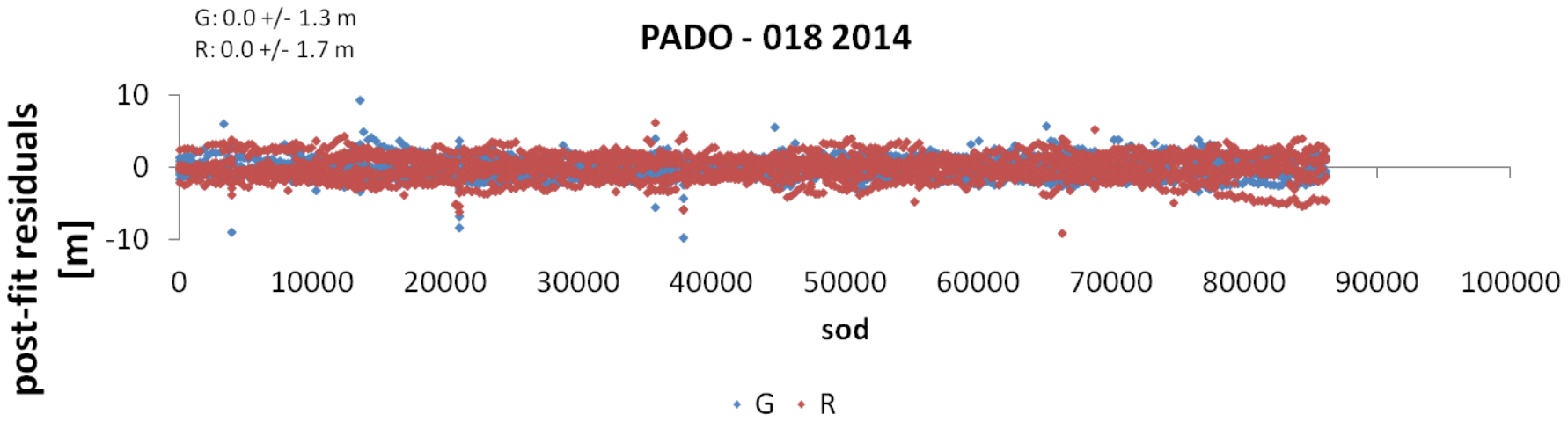


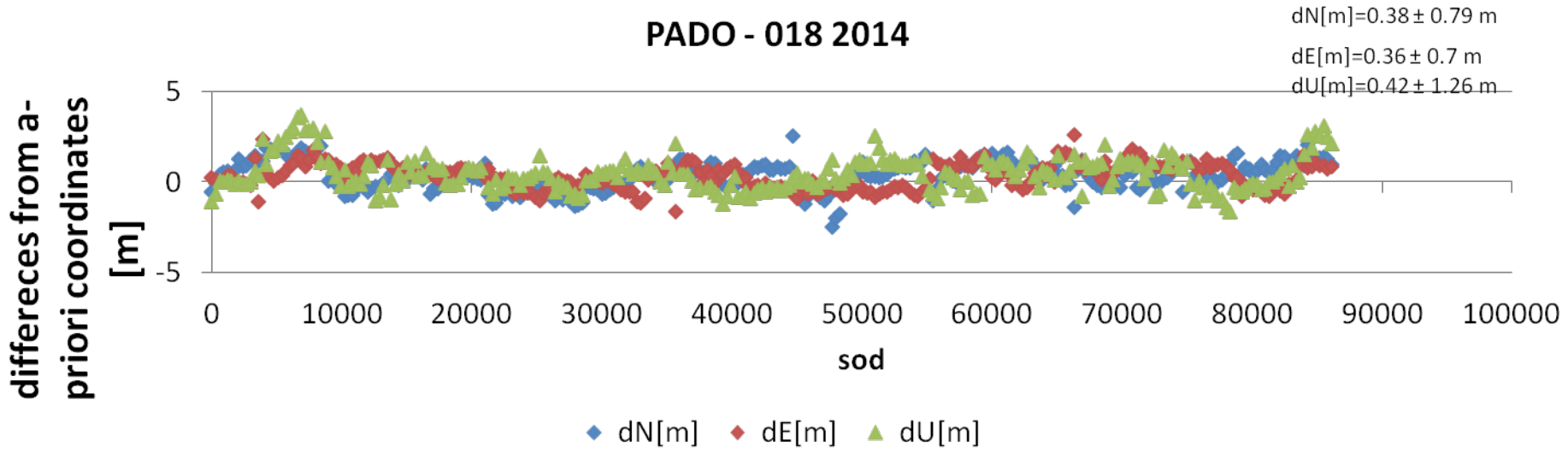
Postfit and time series of coordinates Trimble (2/2)



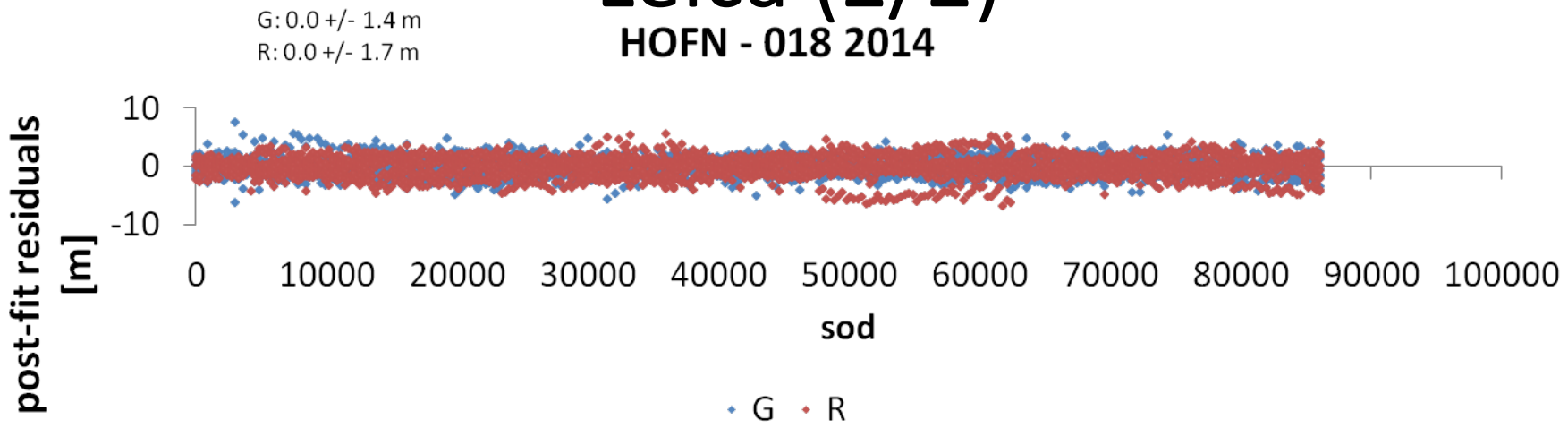


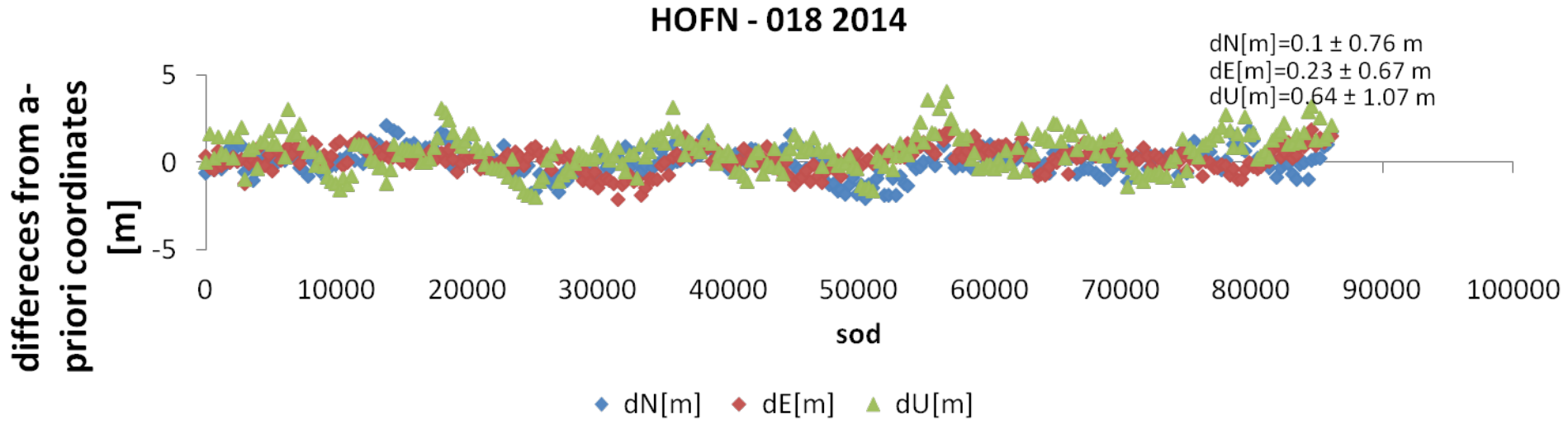
Postfit and time series of coordinates Leica (1/2)



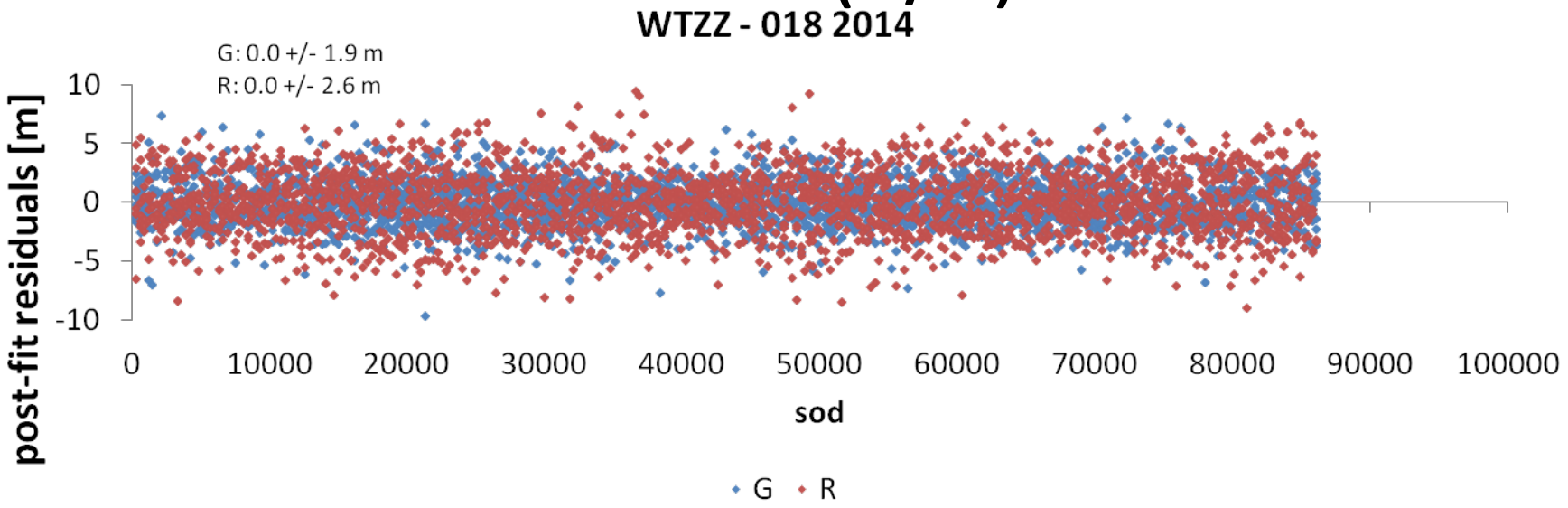


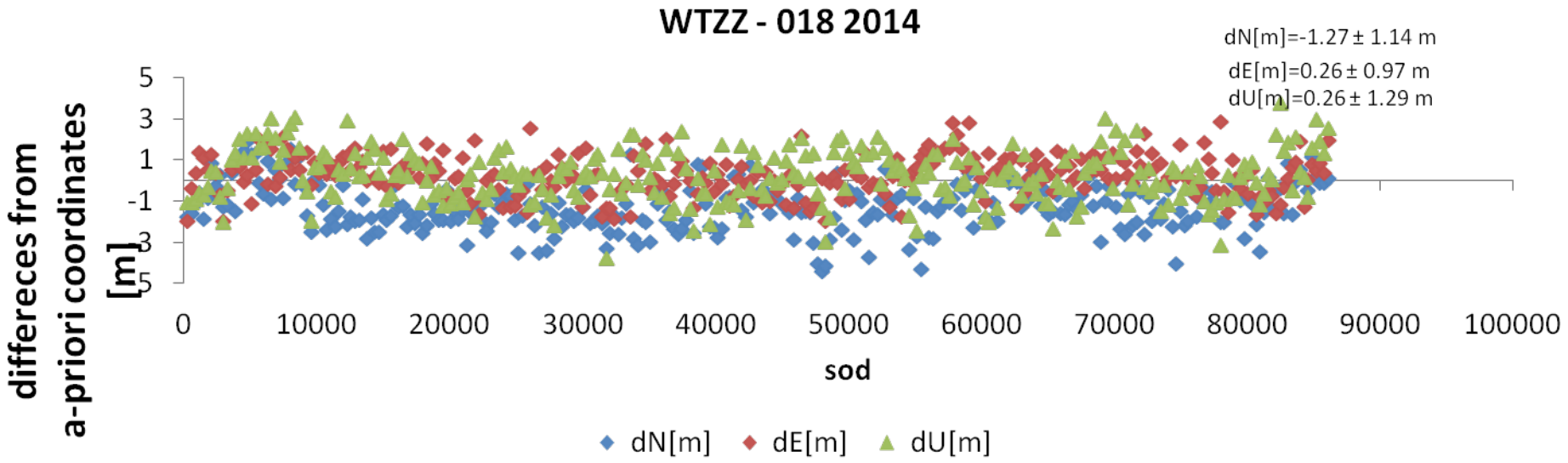
Postfit and time series of coordinates Leica (2/2)



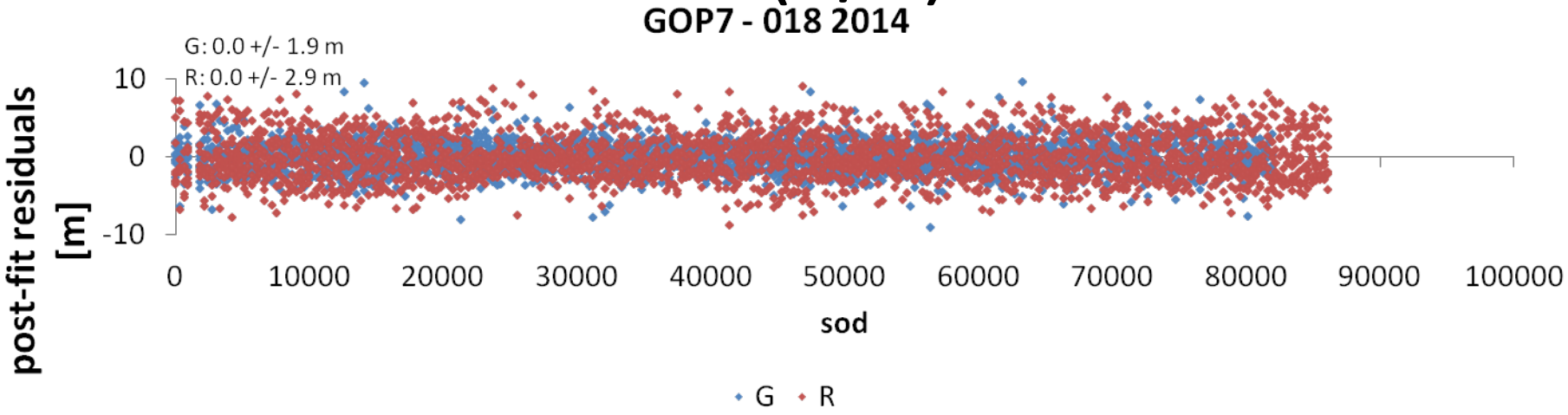


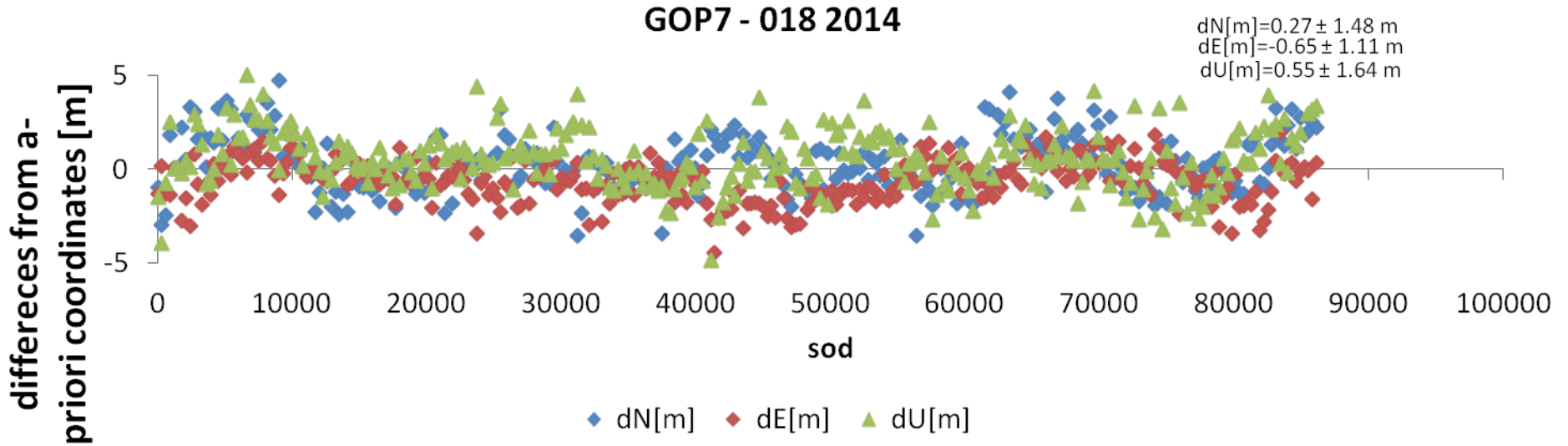
Postfit and time series of coordinates Javad (1/2)



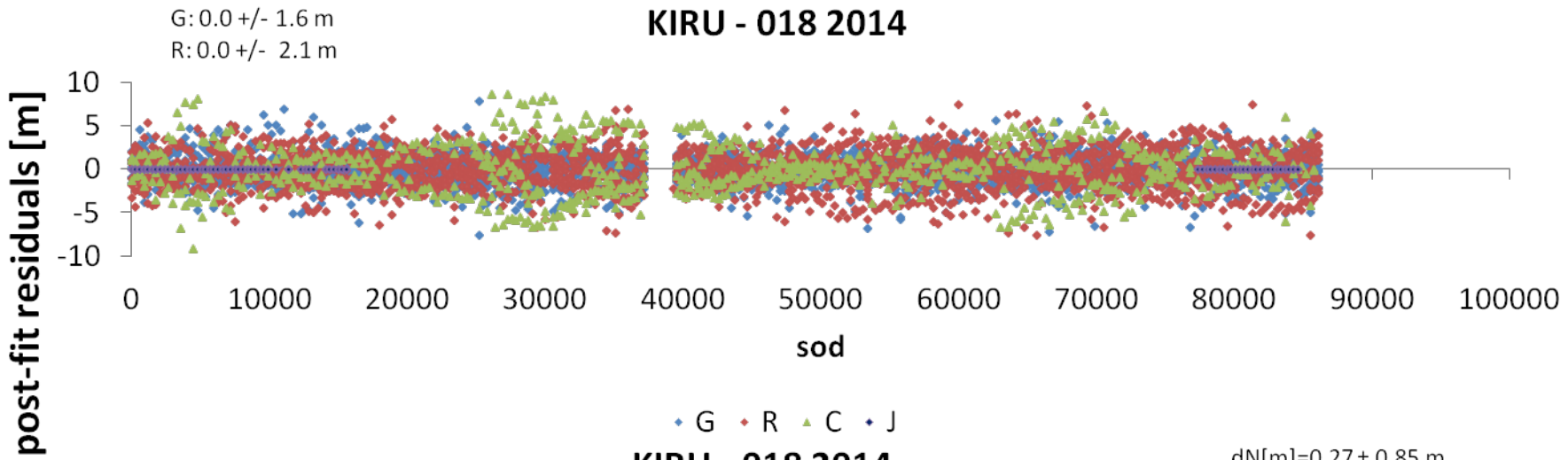


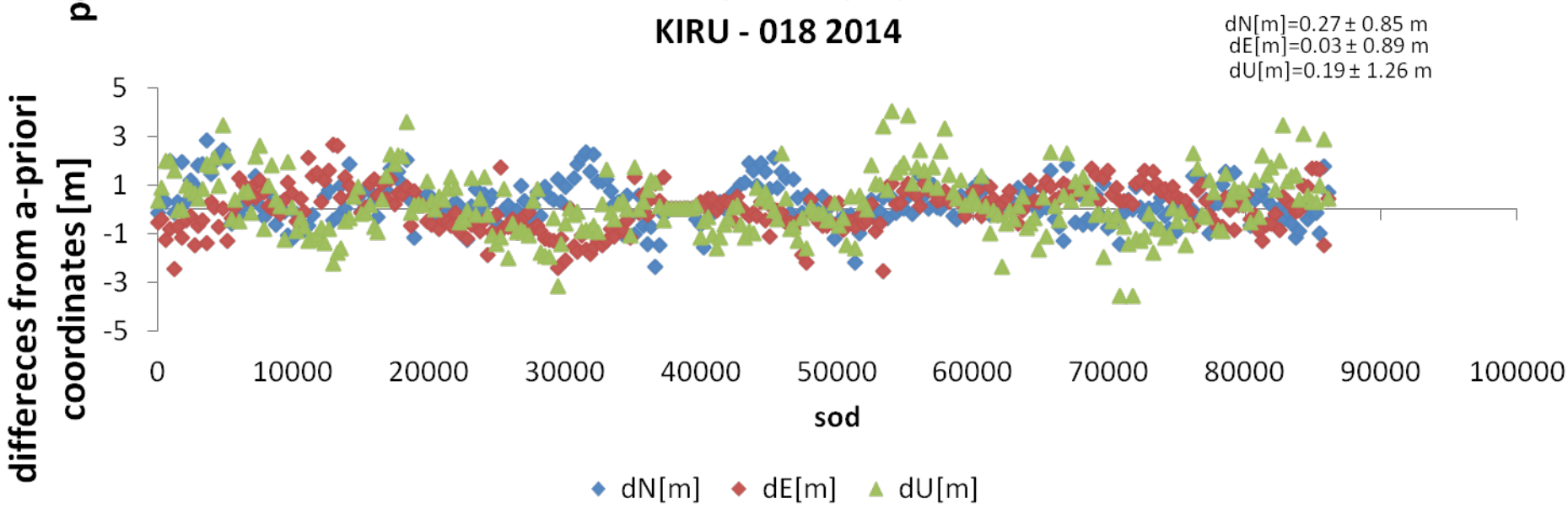
Postfit and time series of coordinates Javad (2/2)



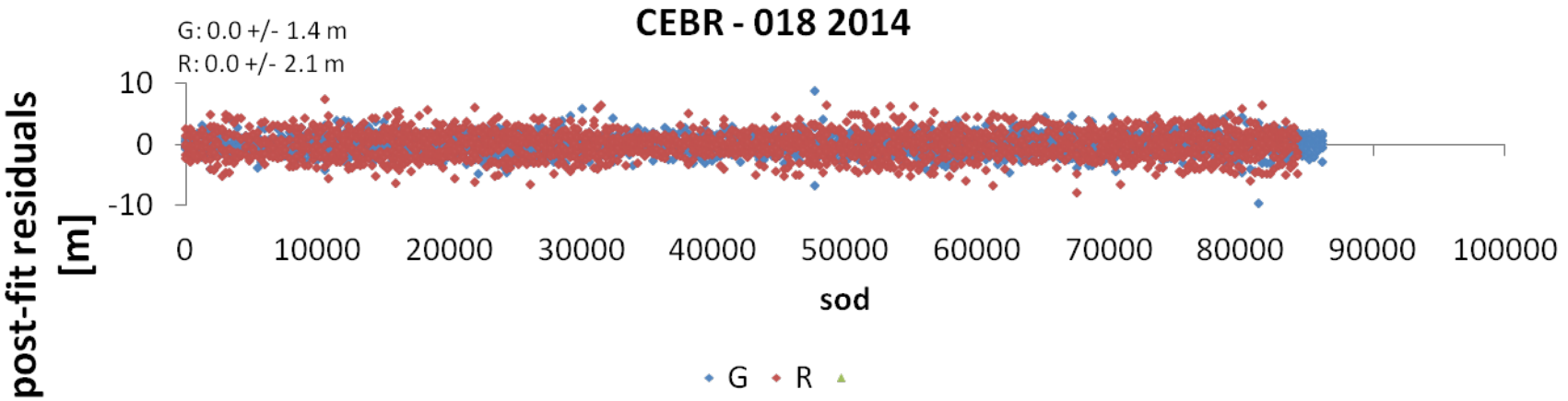


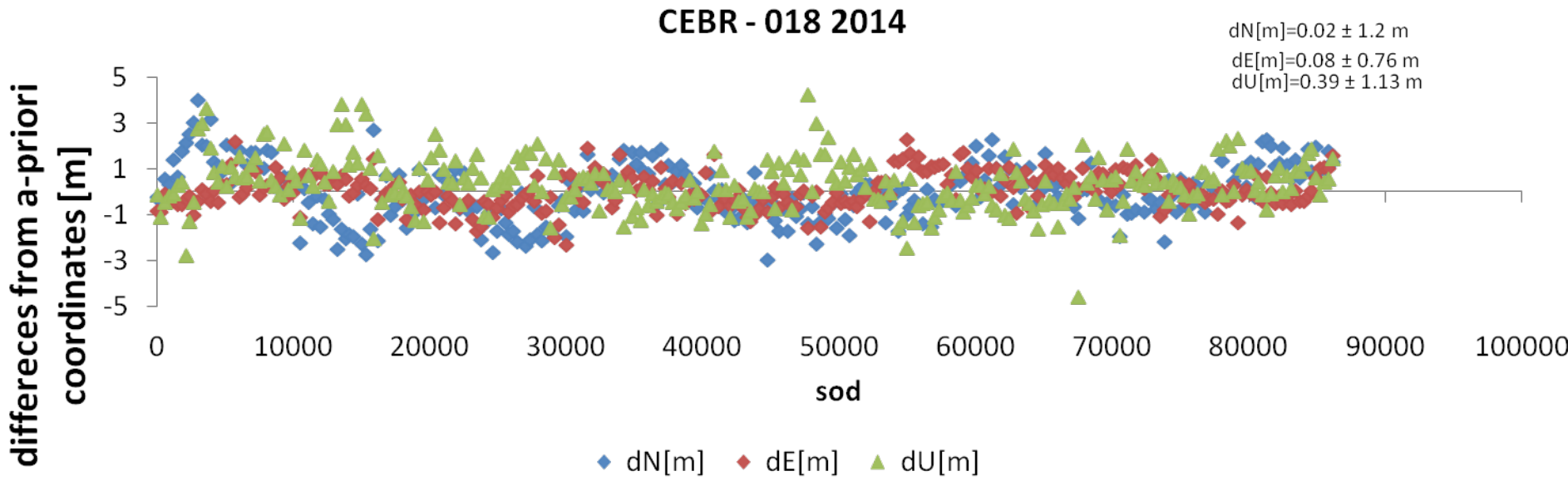
Postfit and time series of coordinates Septentrio (1/2)



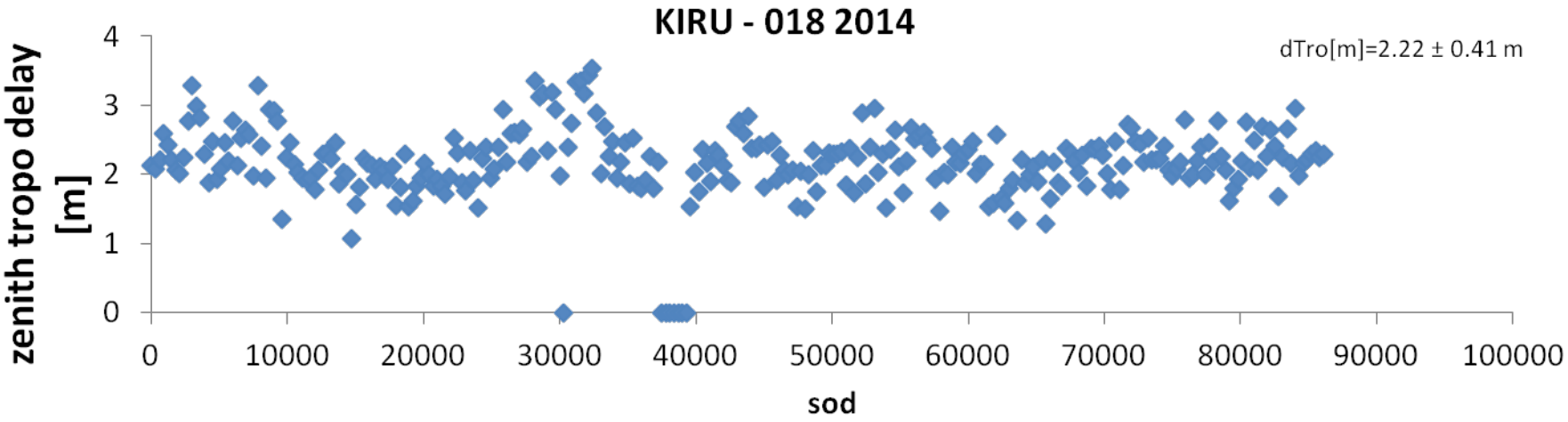


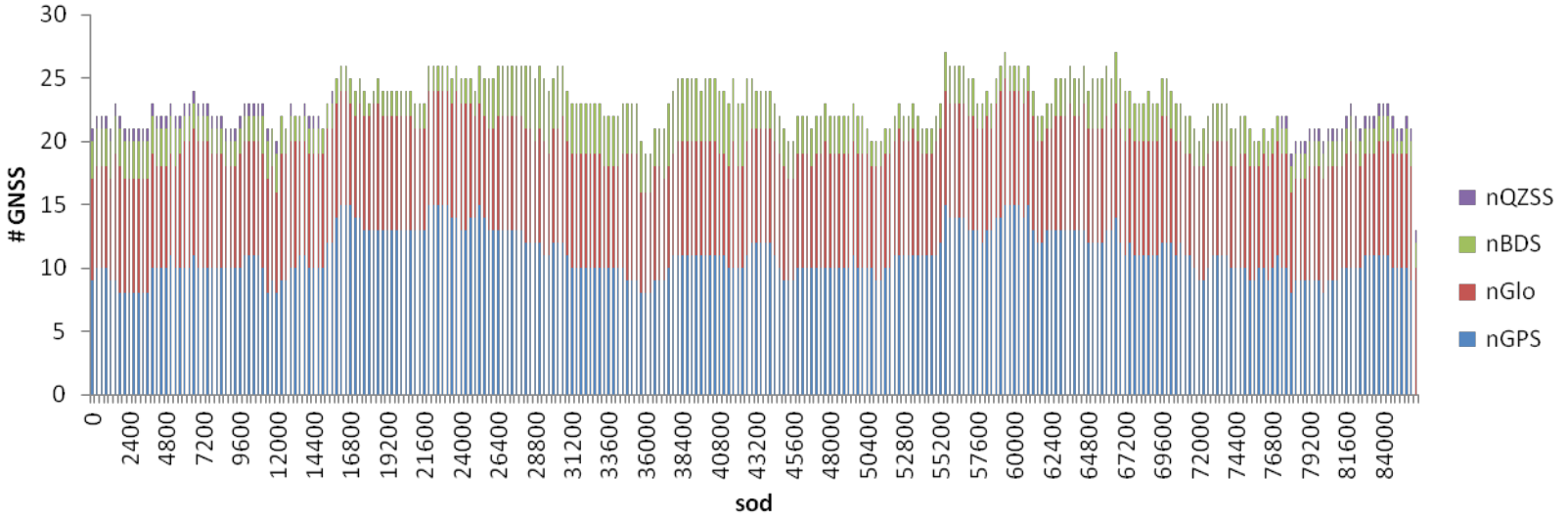
Postfit and time series of coordinates Septentrio (2/2)





TZD estimated epochwise from pseudoranges to multiple GNSS





Conclusions

- Interoperability of GNSS is demonstrated, **but** has an obstacle in:
  - Time Scales of GNSS are offset relative to GPS; offset may not be time independent
  - Offset depends on the receiver type
  - For Galileo we have data in 2014 with invalid HS and DVS, but maybe the data are acceptable anyway; GGTO is made more complicated by the presence of F/NAV and I/NAV clock models, and irregular upload of the message (especially F/NAV)
- Disadvantage for user: needs to solve for separate satellite time offsets (one for each GNSS)
- Possible improvements: phase smoothed pseudoranges; Sp3 instead of brdc (but which SP3? Several agencies publish theirs); adopt IGS DCB's (but first we must understand them in full detail)
- Proposal (offline and/or Real Time):
  - Monitor Time Offset for several GNSS sites and receivers
  - Estimate mean values which could serve as reference for future calibration
  - TZD epochwise with <0.5 m rms