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New ambiguity-fixed IGS clock analysis products at CODE

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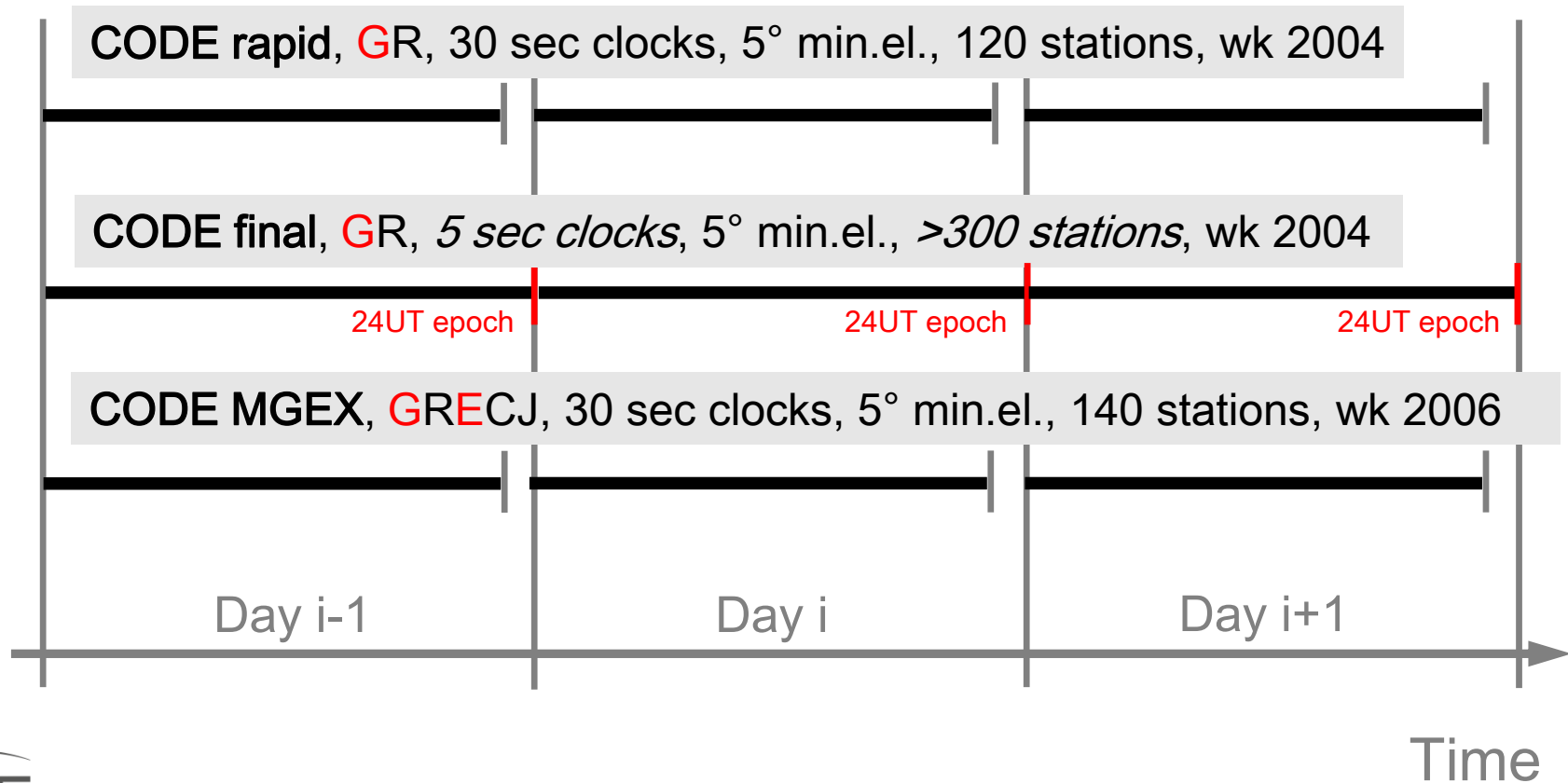
Outline

- New clock products at CODE
- GPS and Galileo widelane fractional biases
- Clock generation procedure
- Phase bias representation
- Properties of the new clock and phase bias products
- Validation
- Summary and conclusions



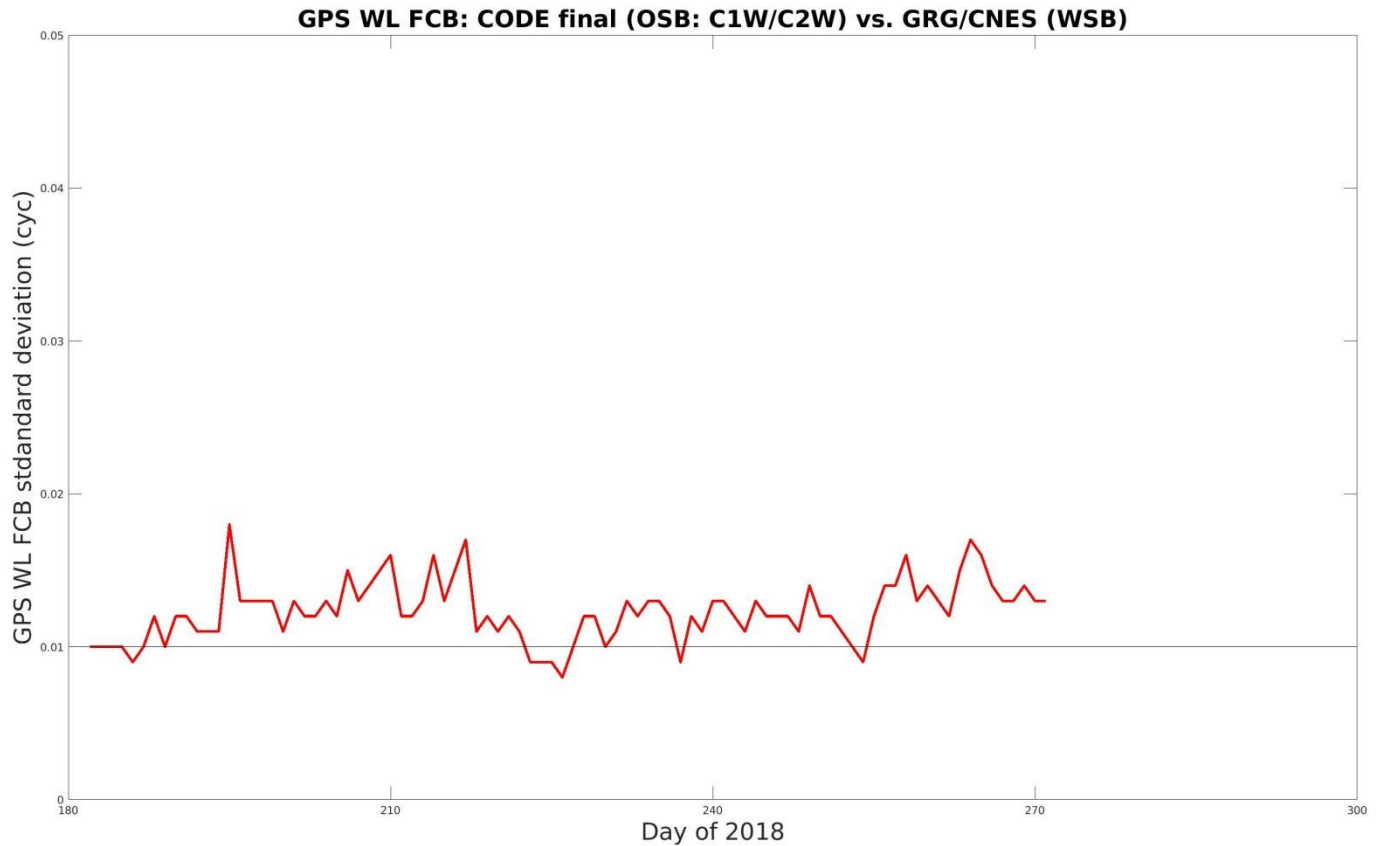


New GNSS clock analysis products and their characteristics



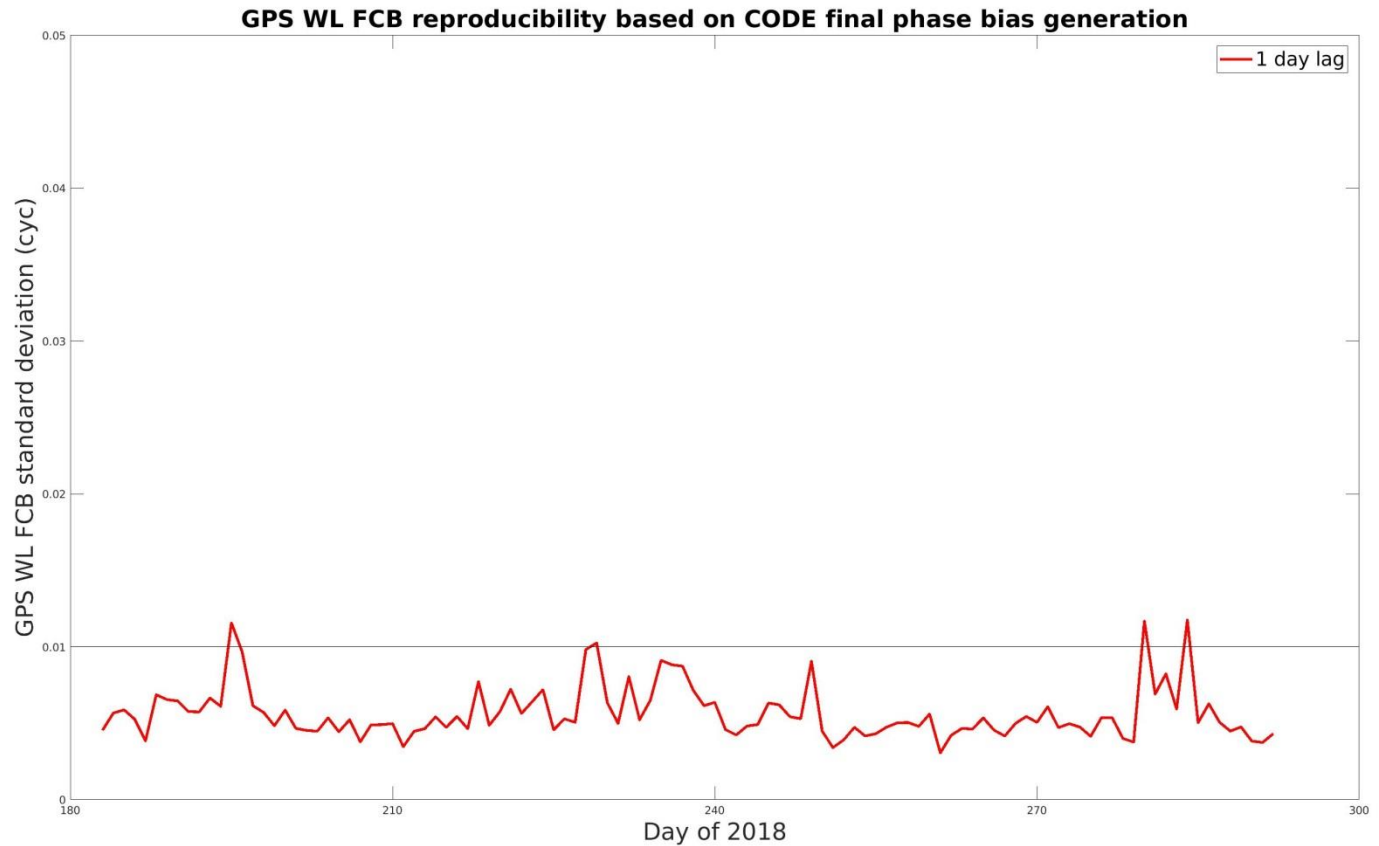


GPS and Galileo satellite widelane fractional bias results



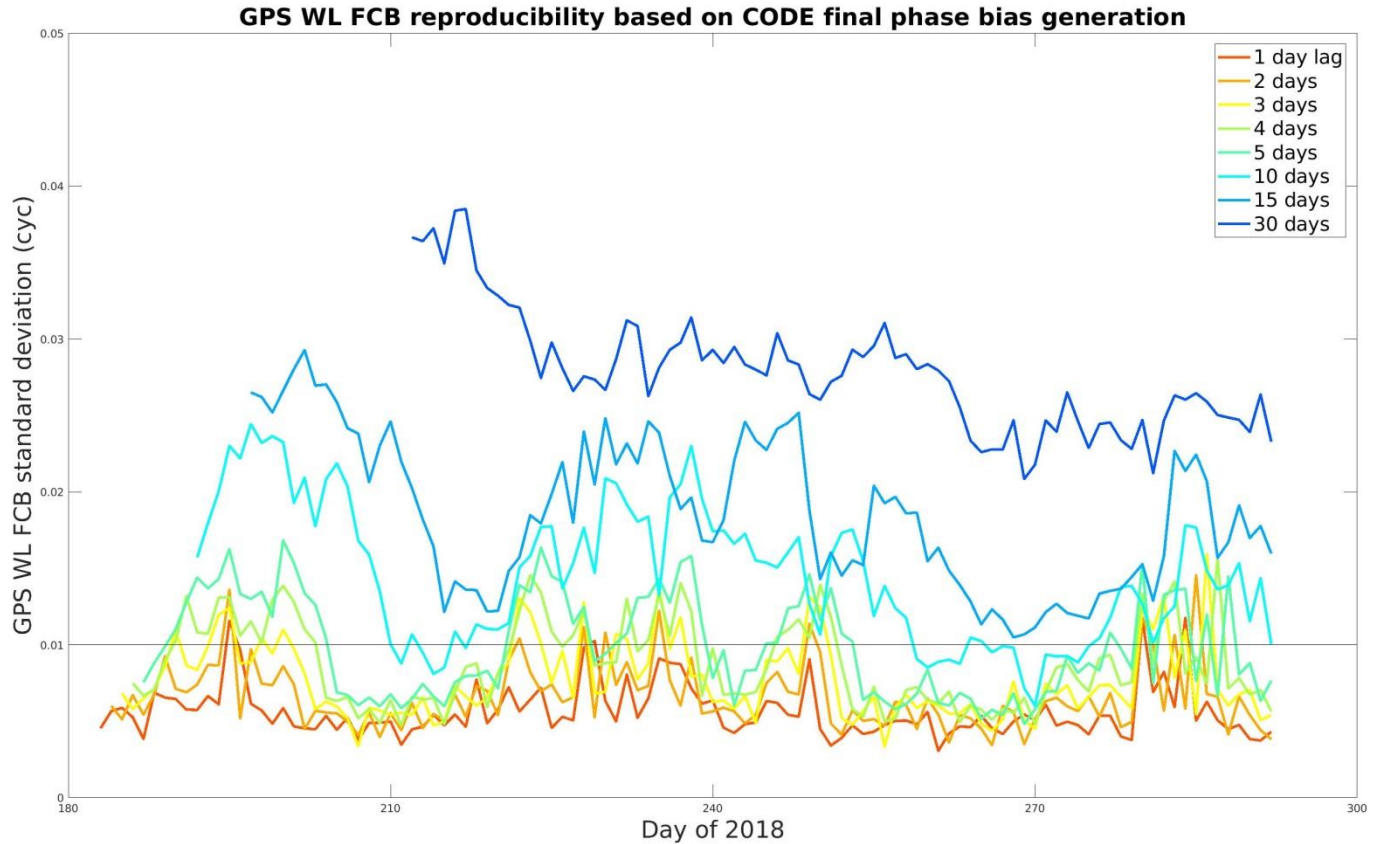


GPS and Galileo satellite widelane fractional bias results



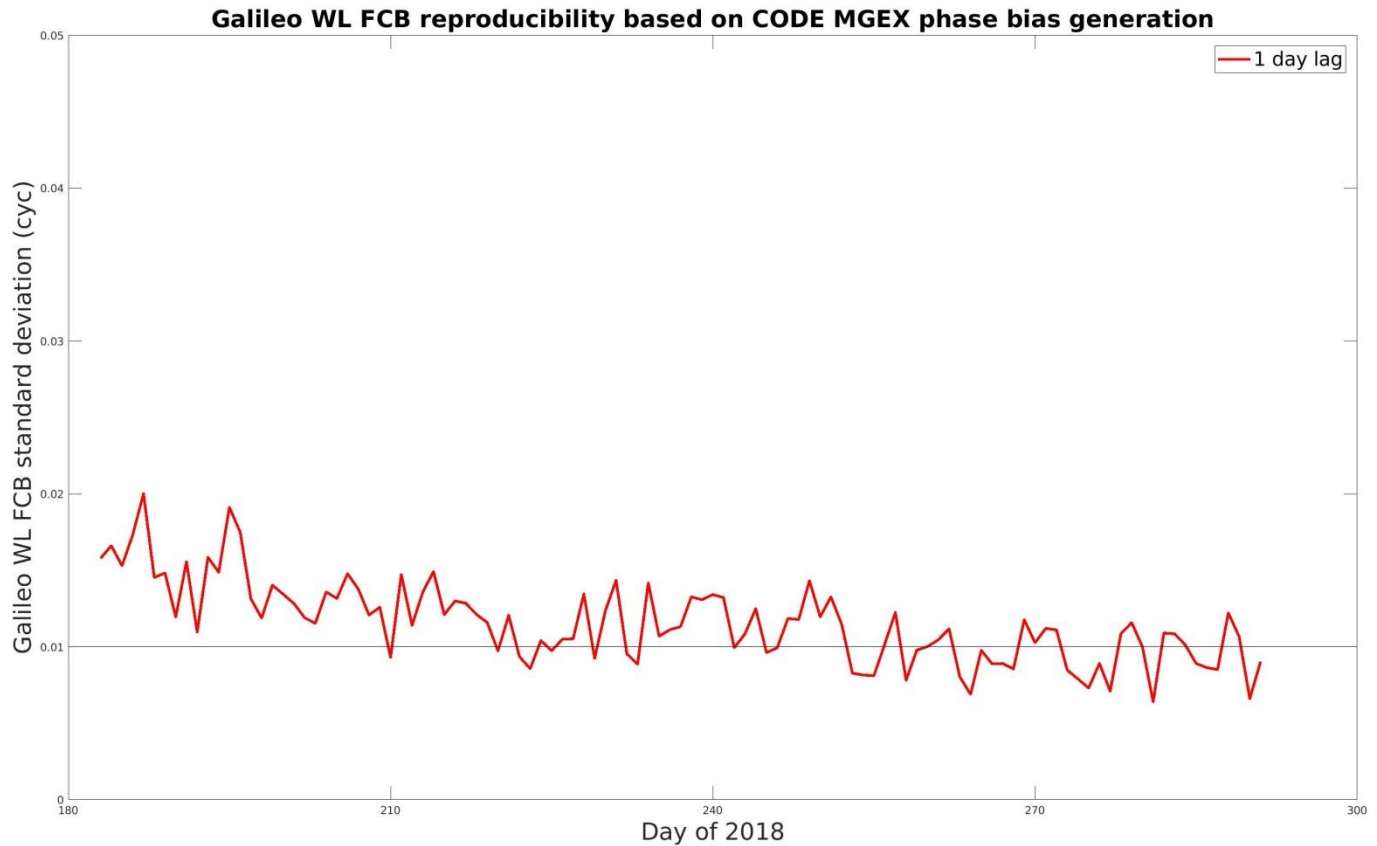


GPS and Galileo satellite widelane fractional bias results



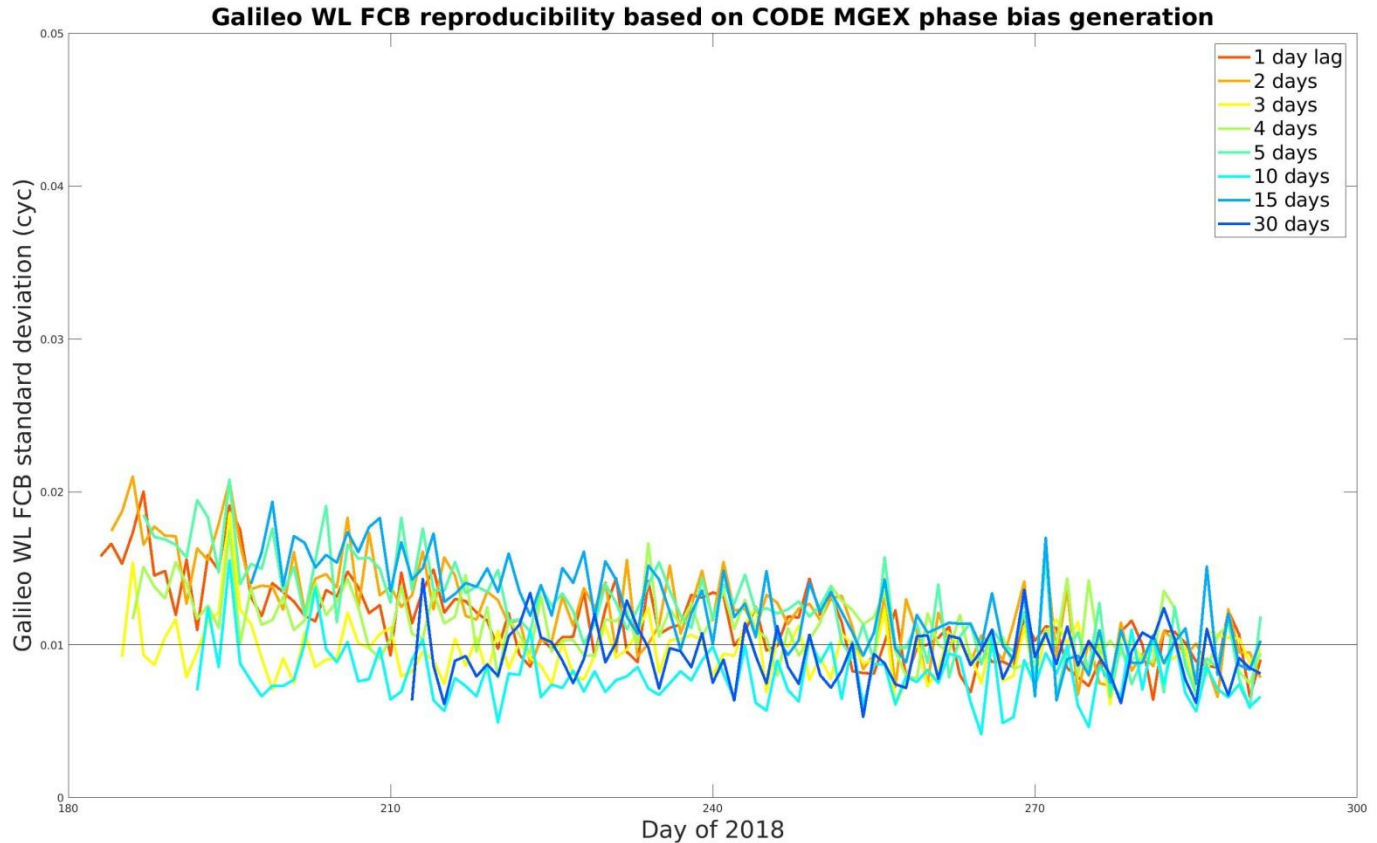


GPS and Galileo satellite widelane fractional bias results



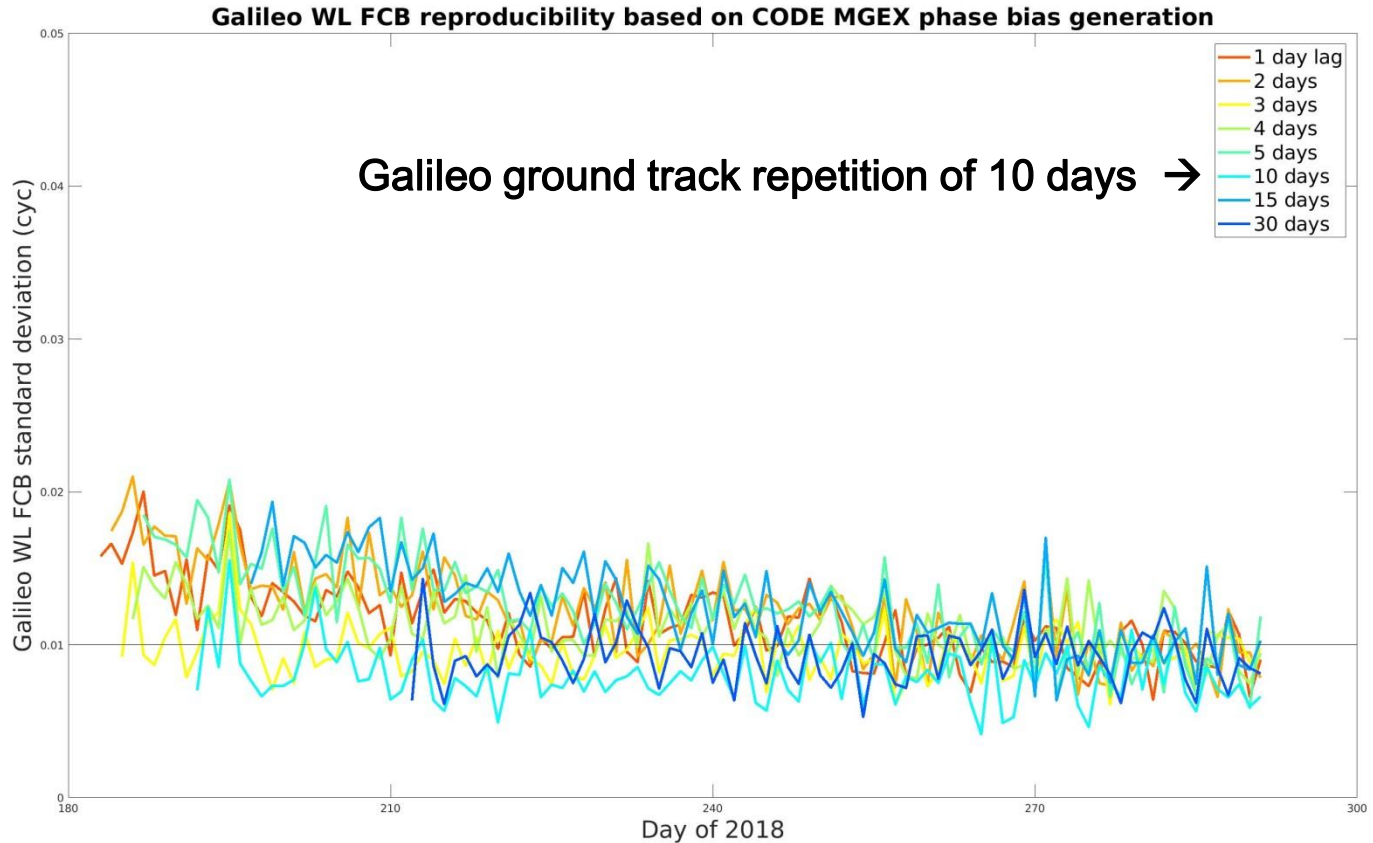


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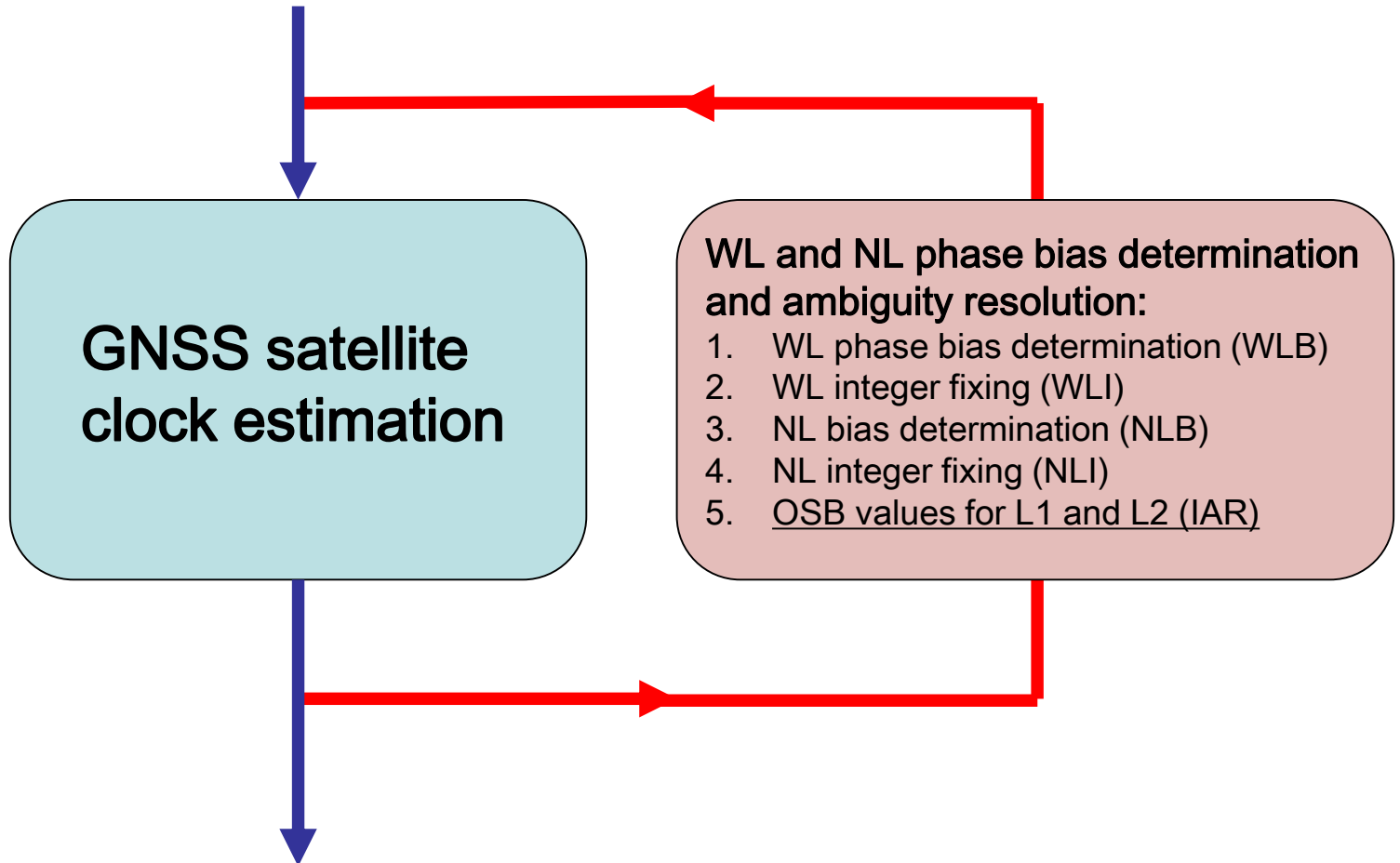


GPS and Galileo satellite widelane fractional bias results



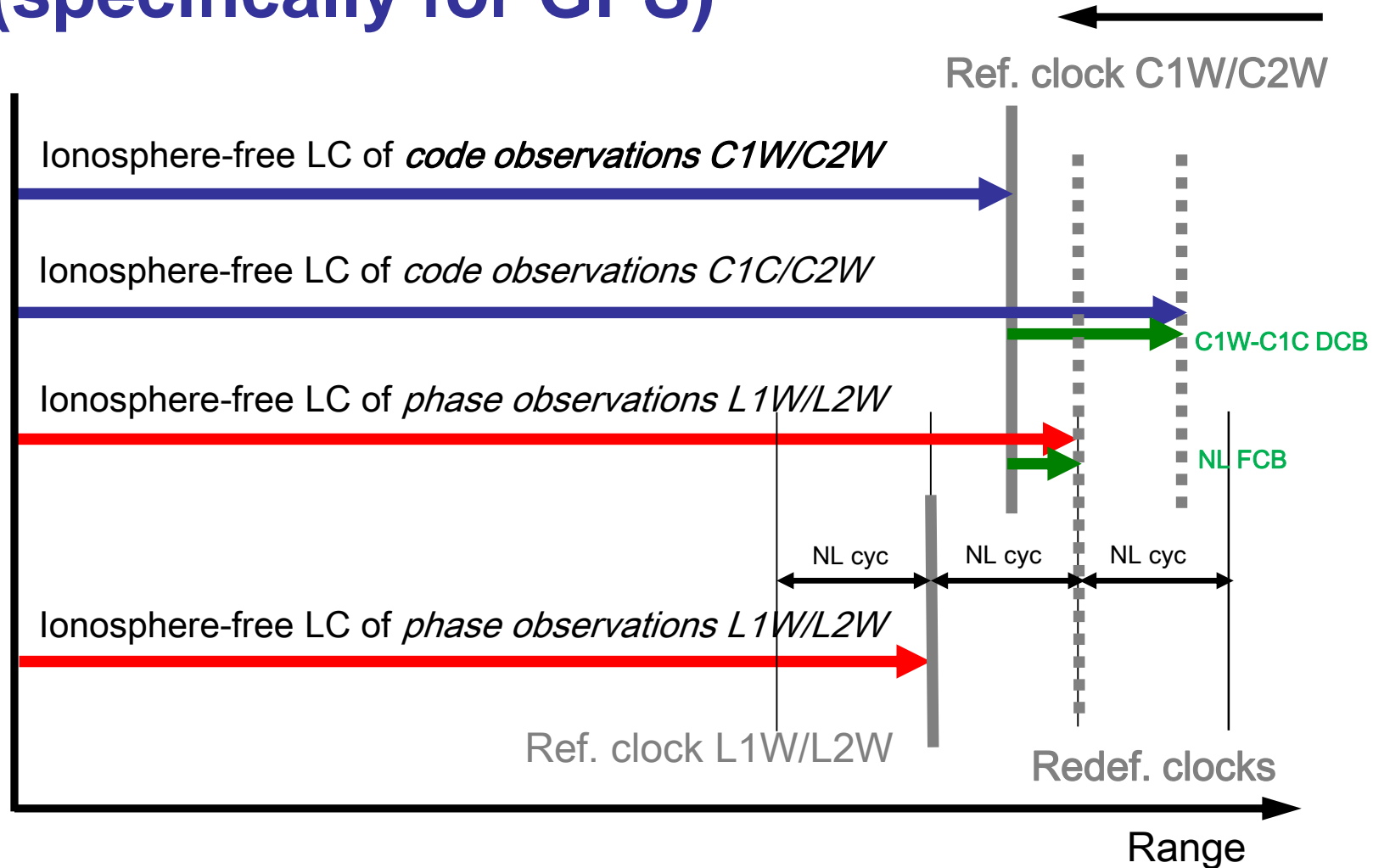


WL and NL phase bias determination, between-satellite ambiguity resolution (AR), and generation of ambiguity-fixed clock products



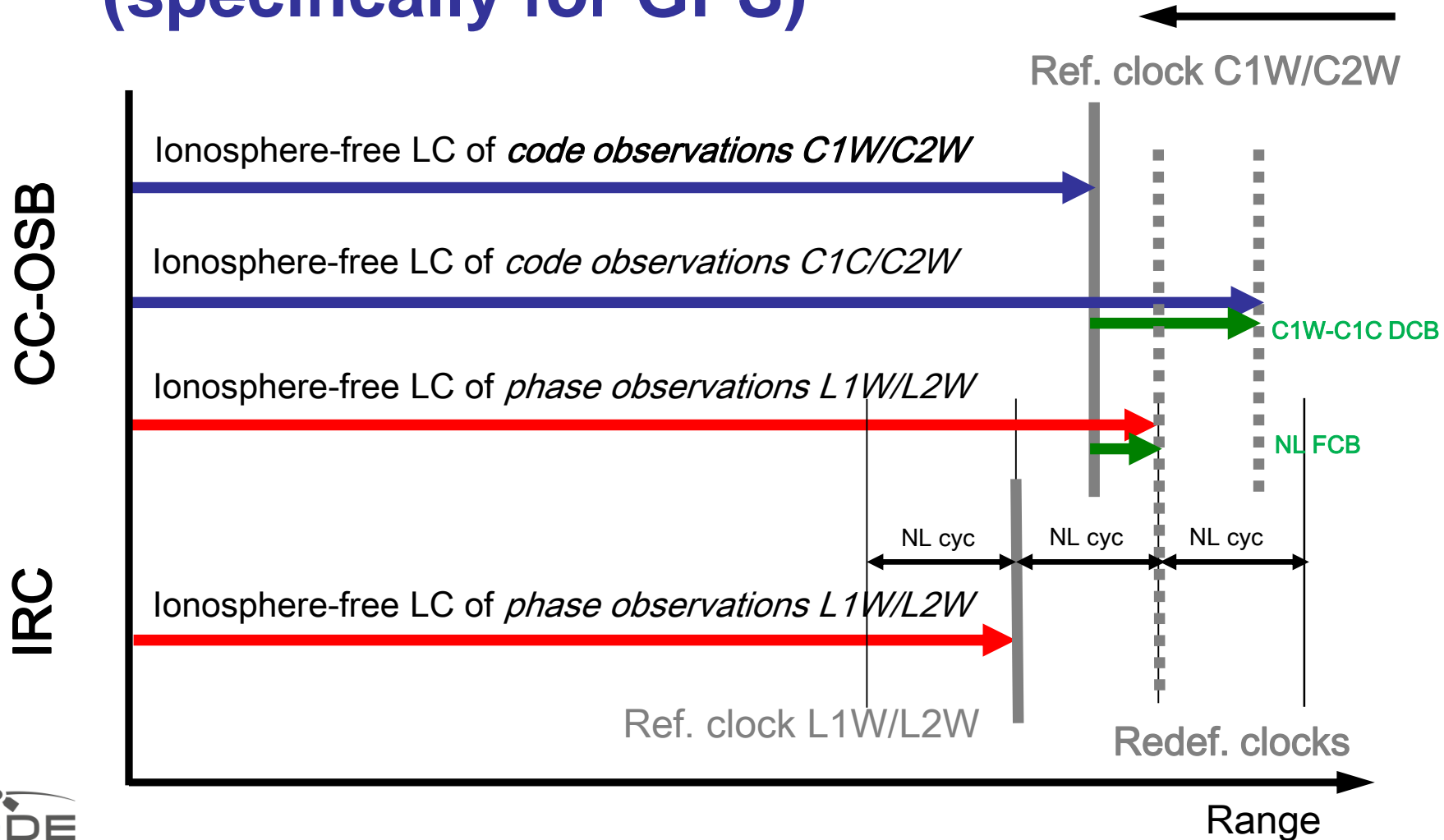


Narrowlane phase bias representation (specifically for GPS)



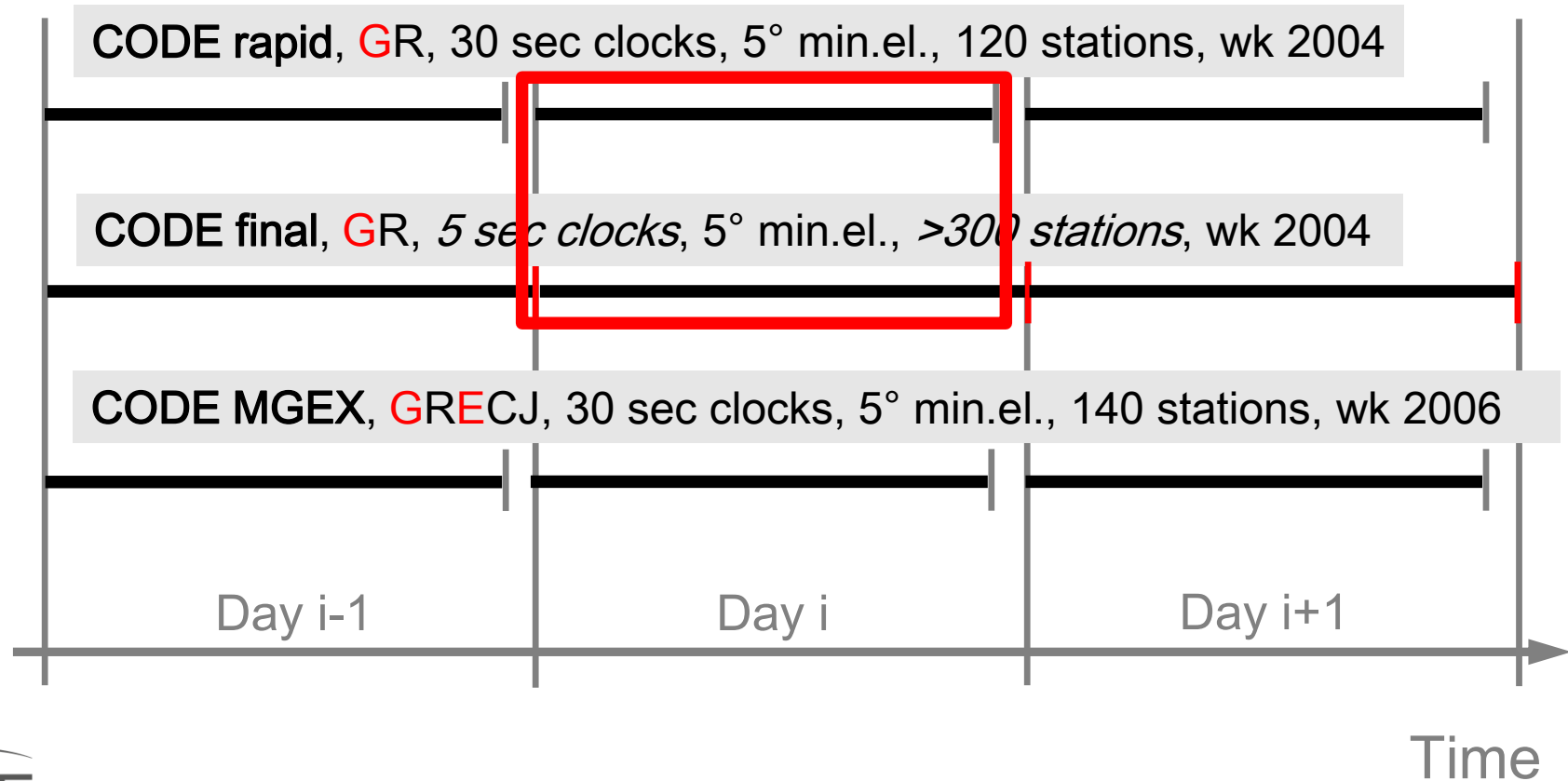


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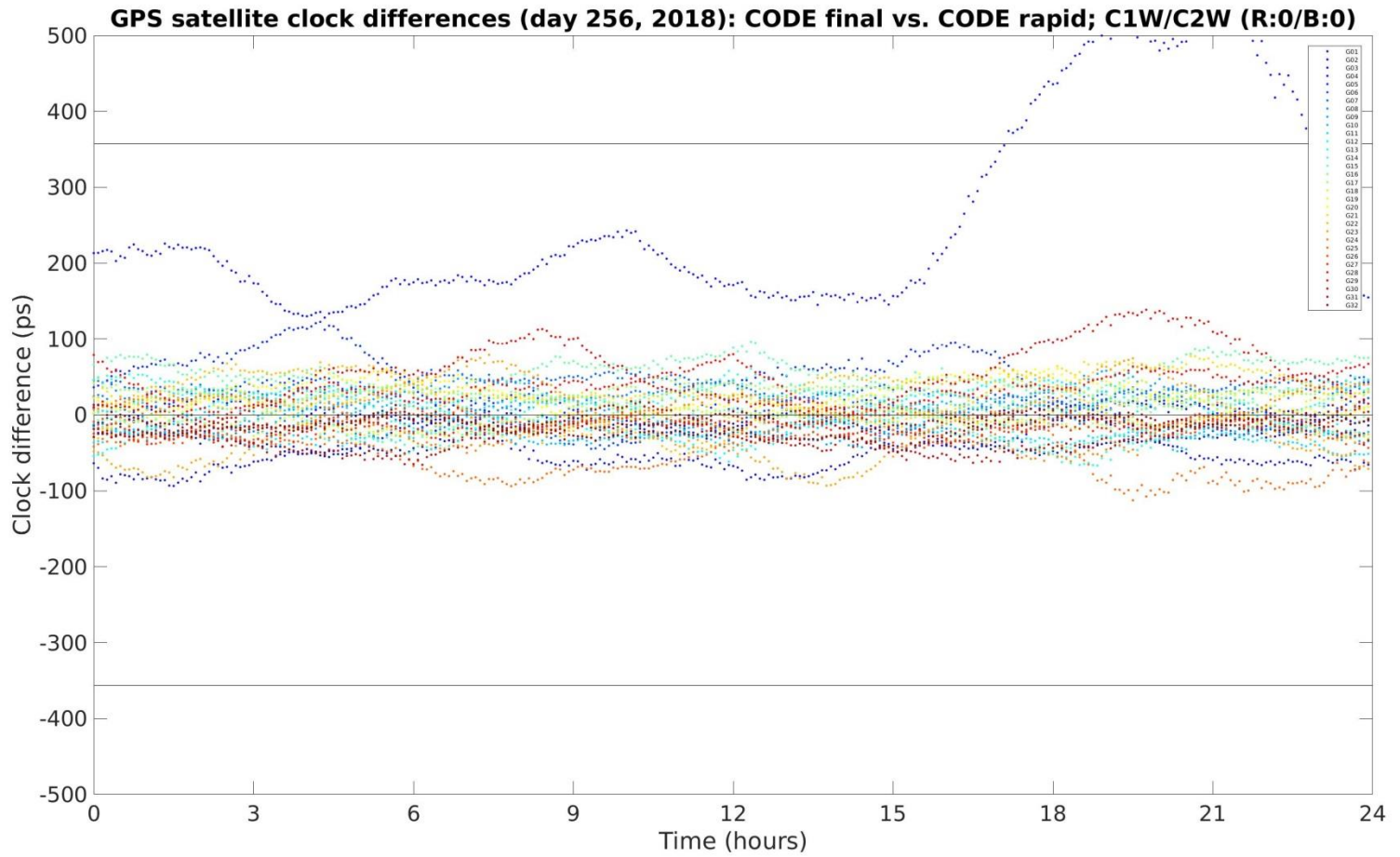


New GNSS clock analysis products and their characteristics



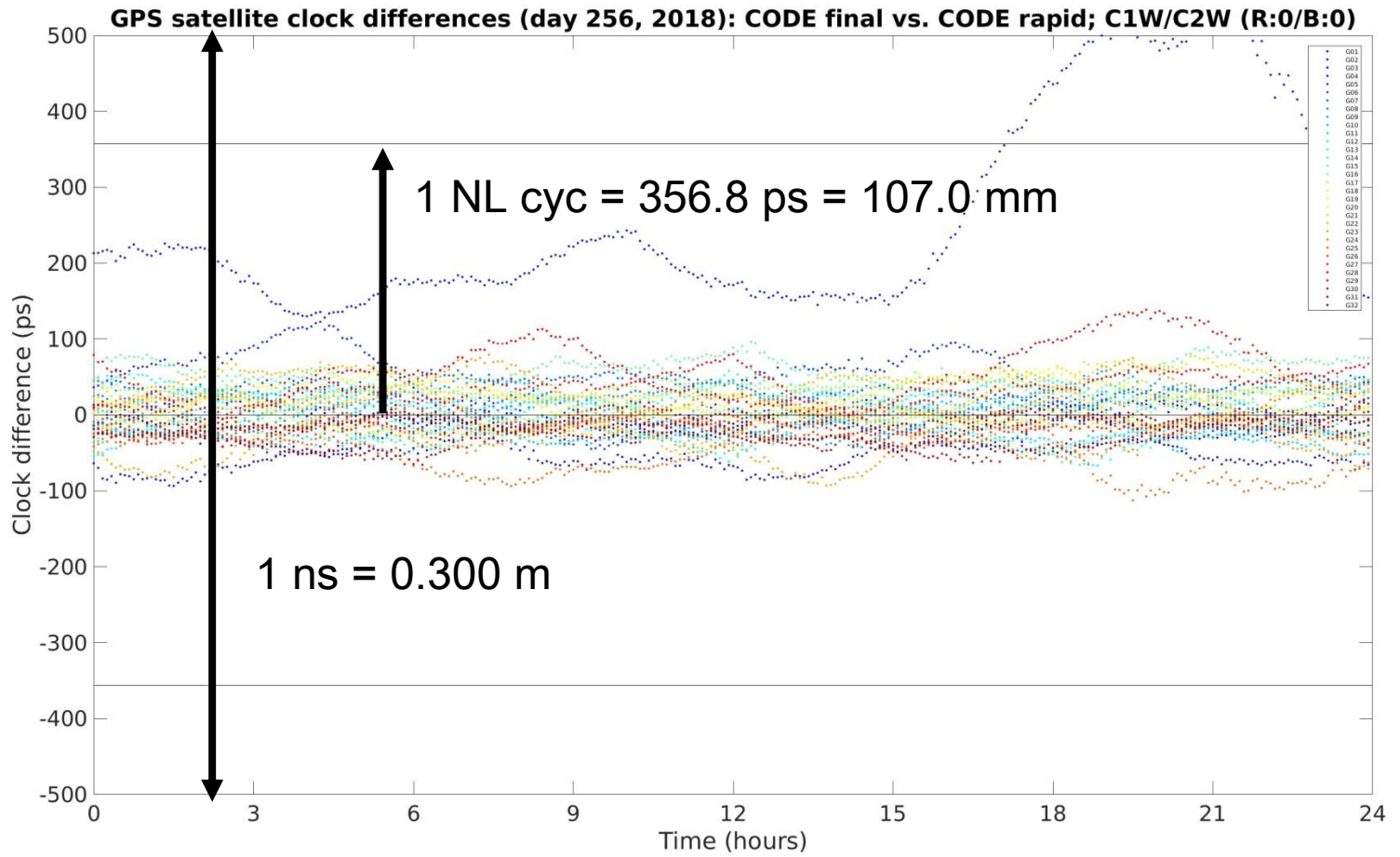


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



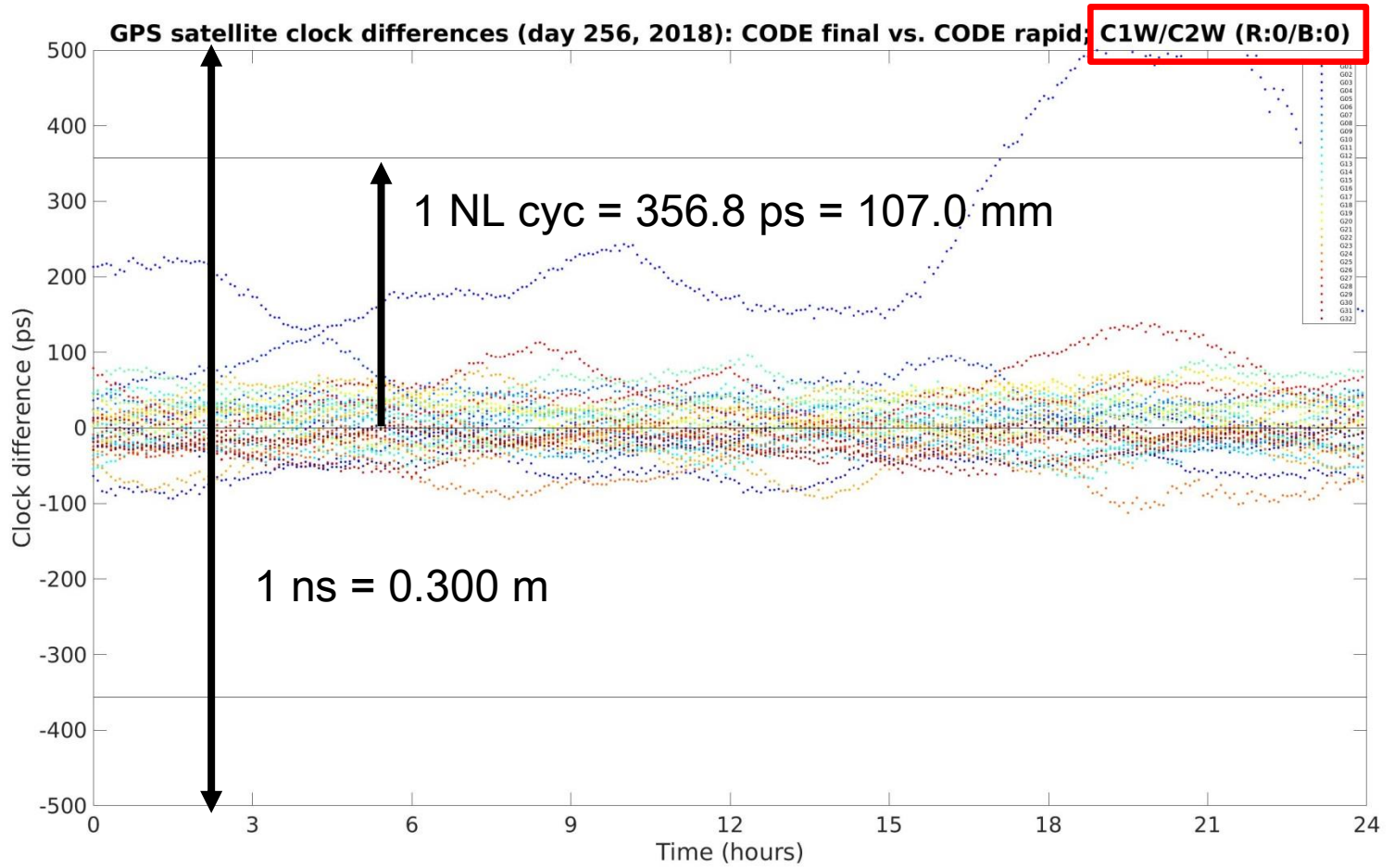


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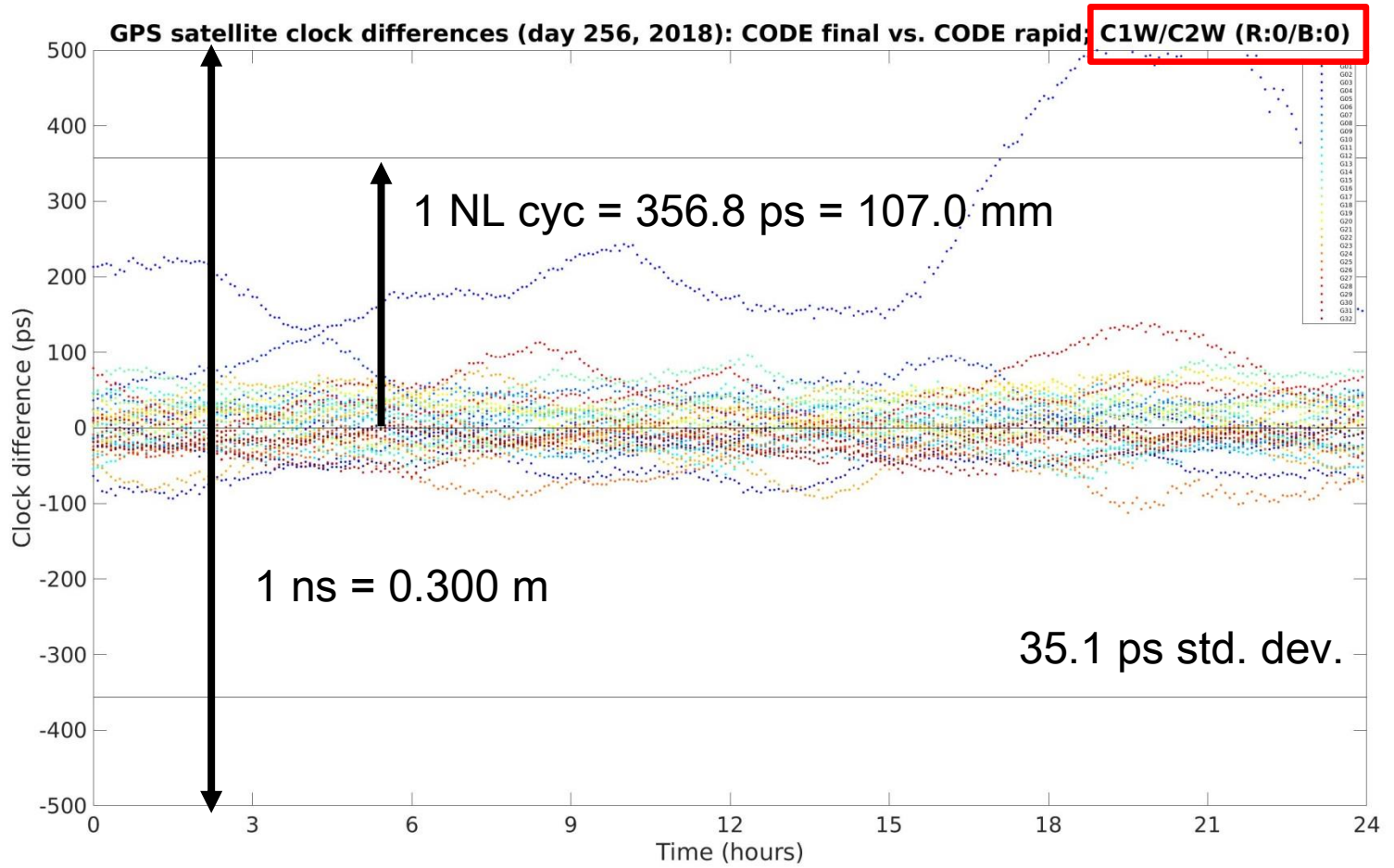


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



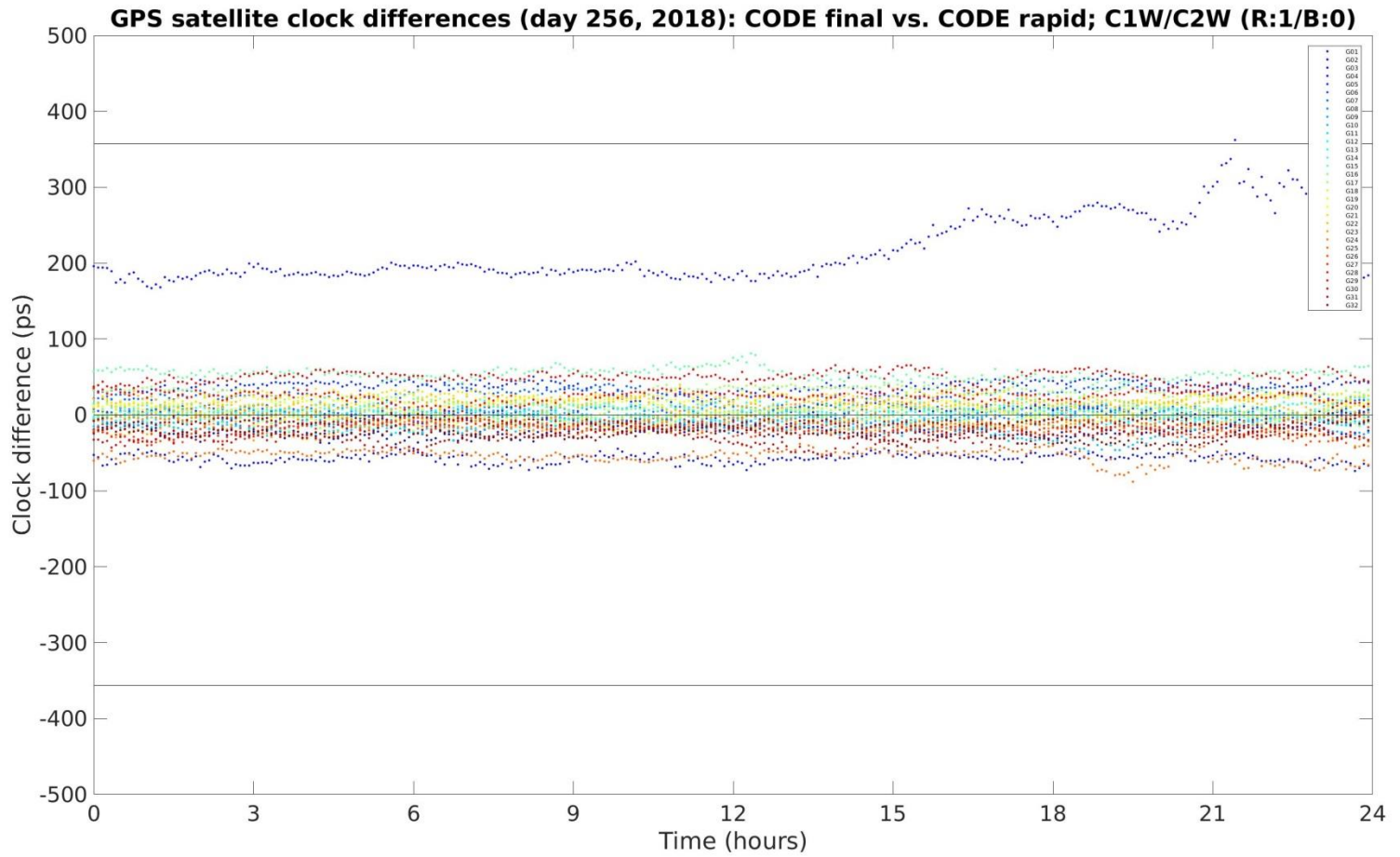


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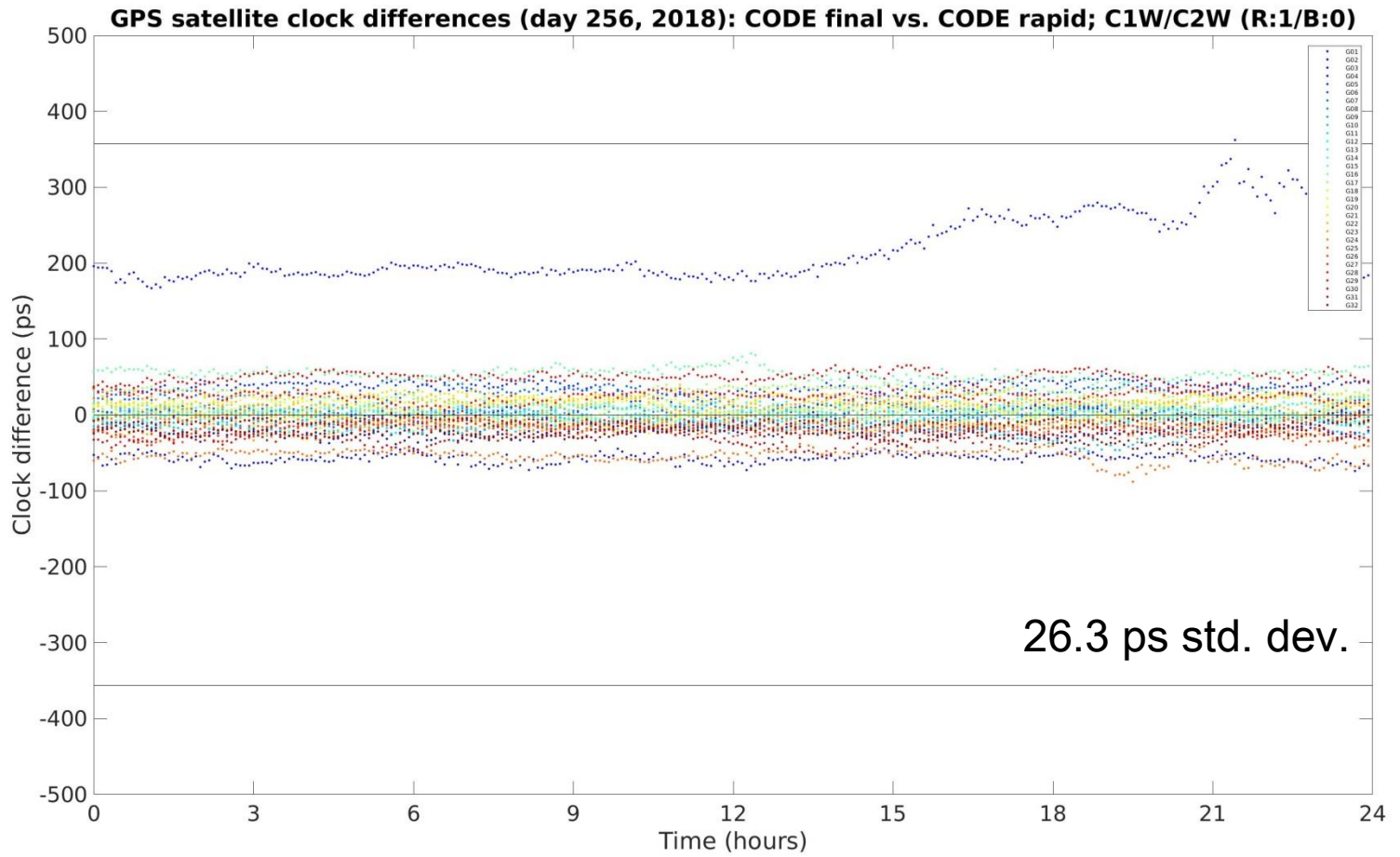


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



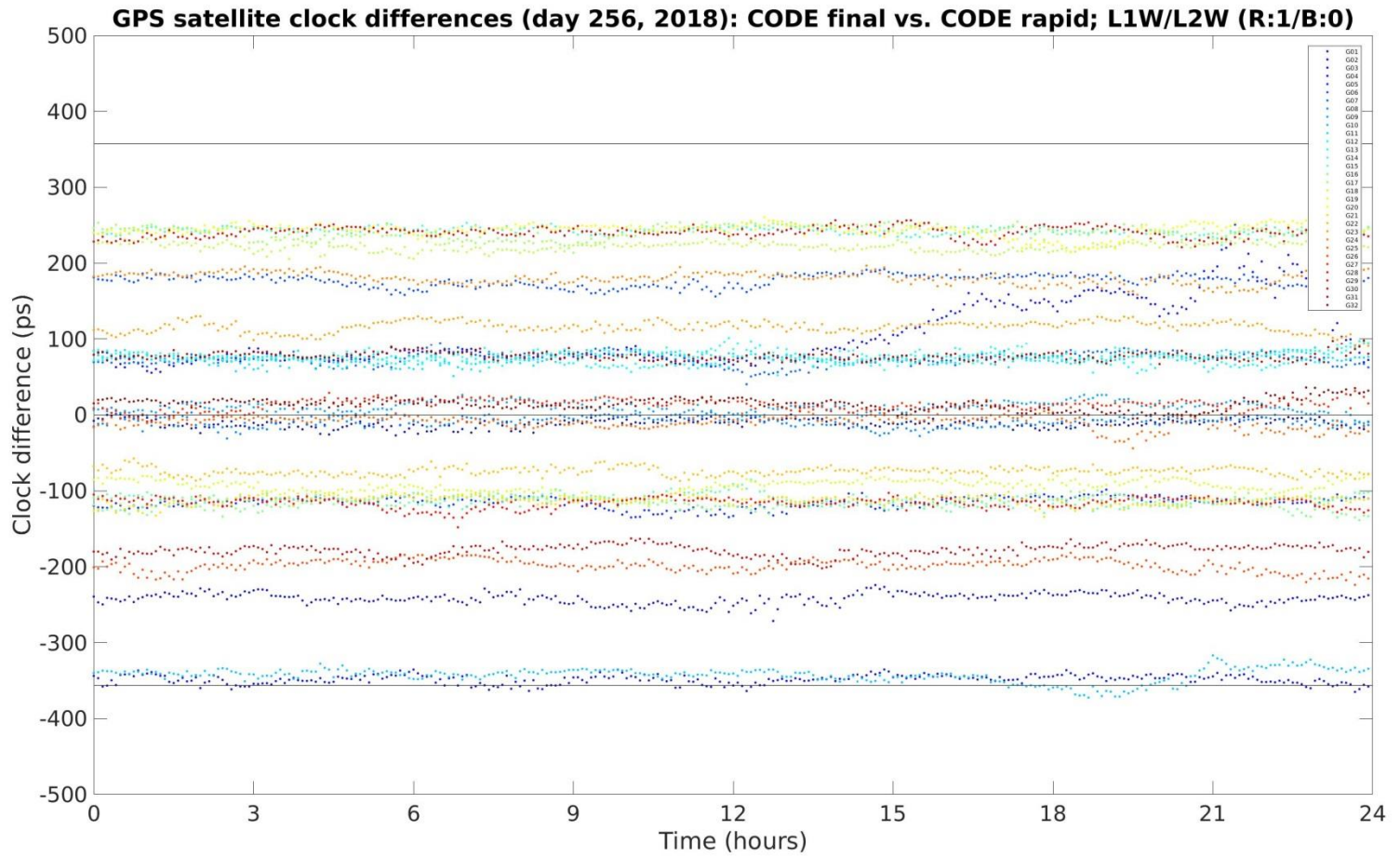


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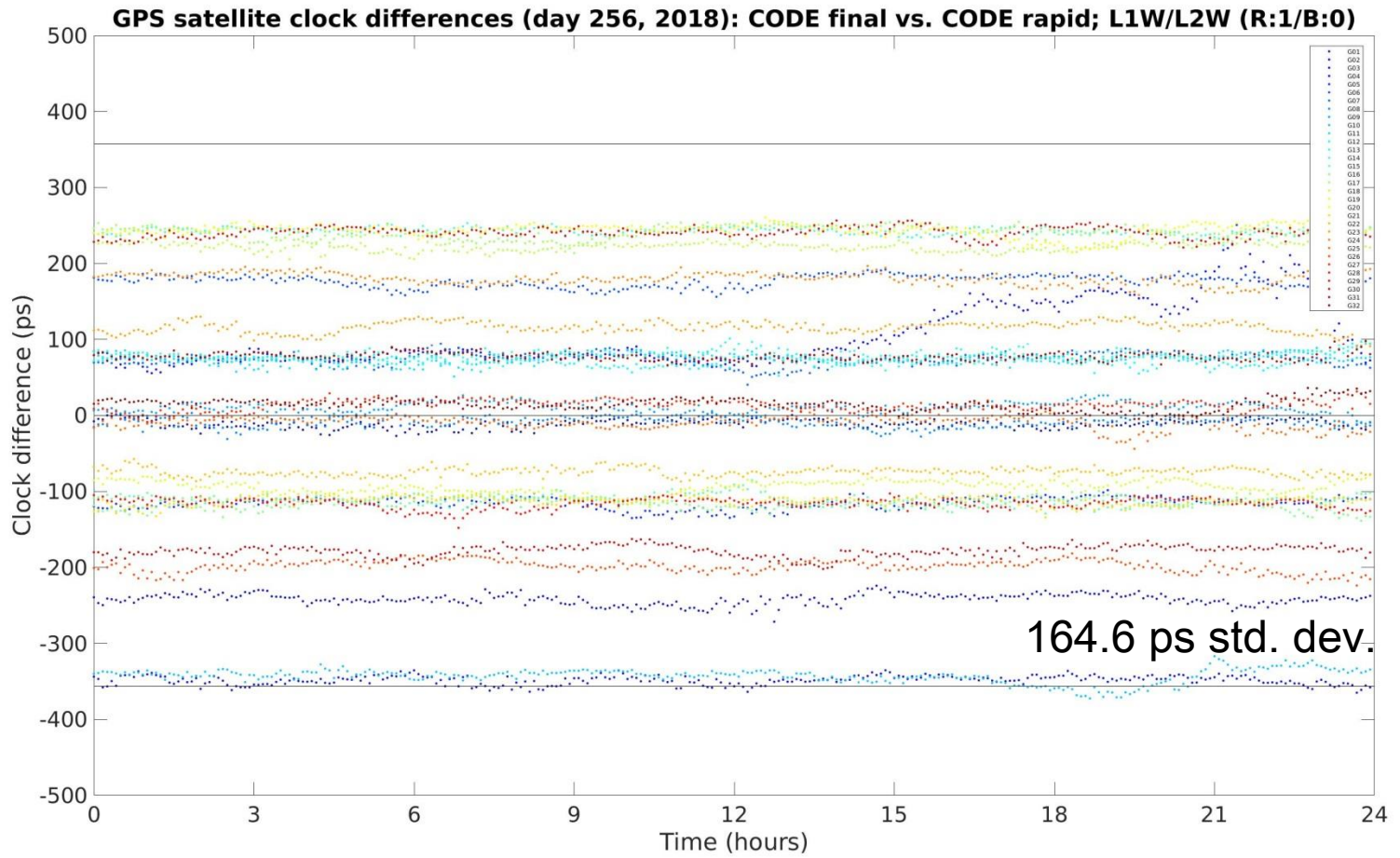


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



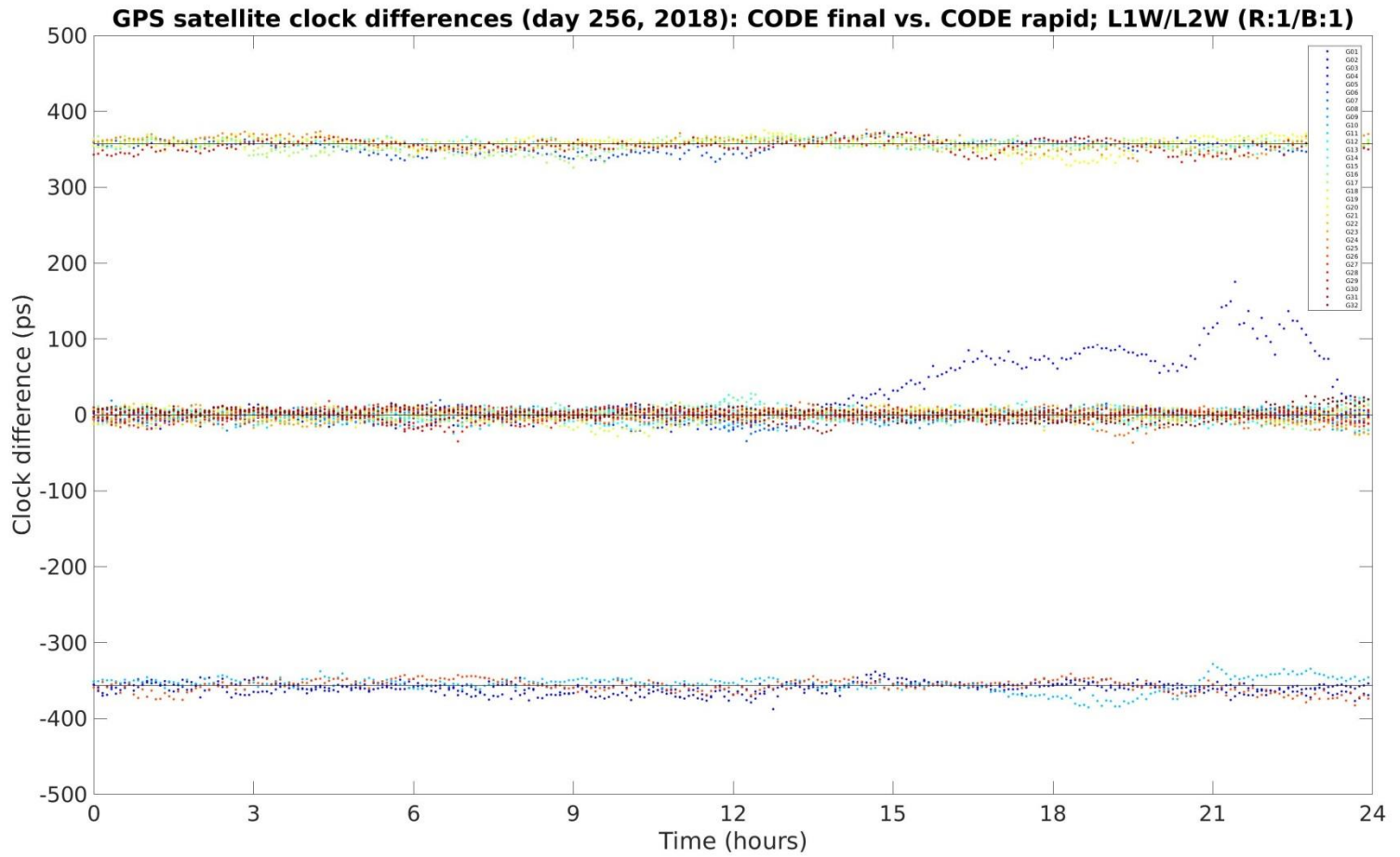


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



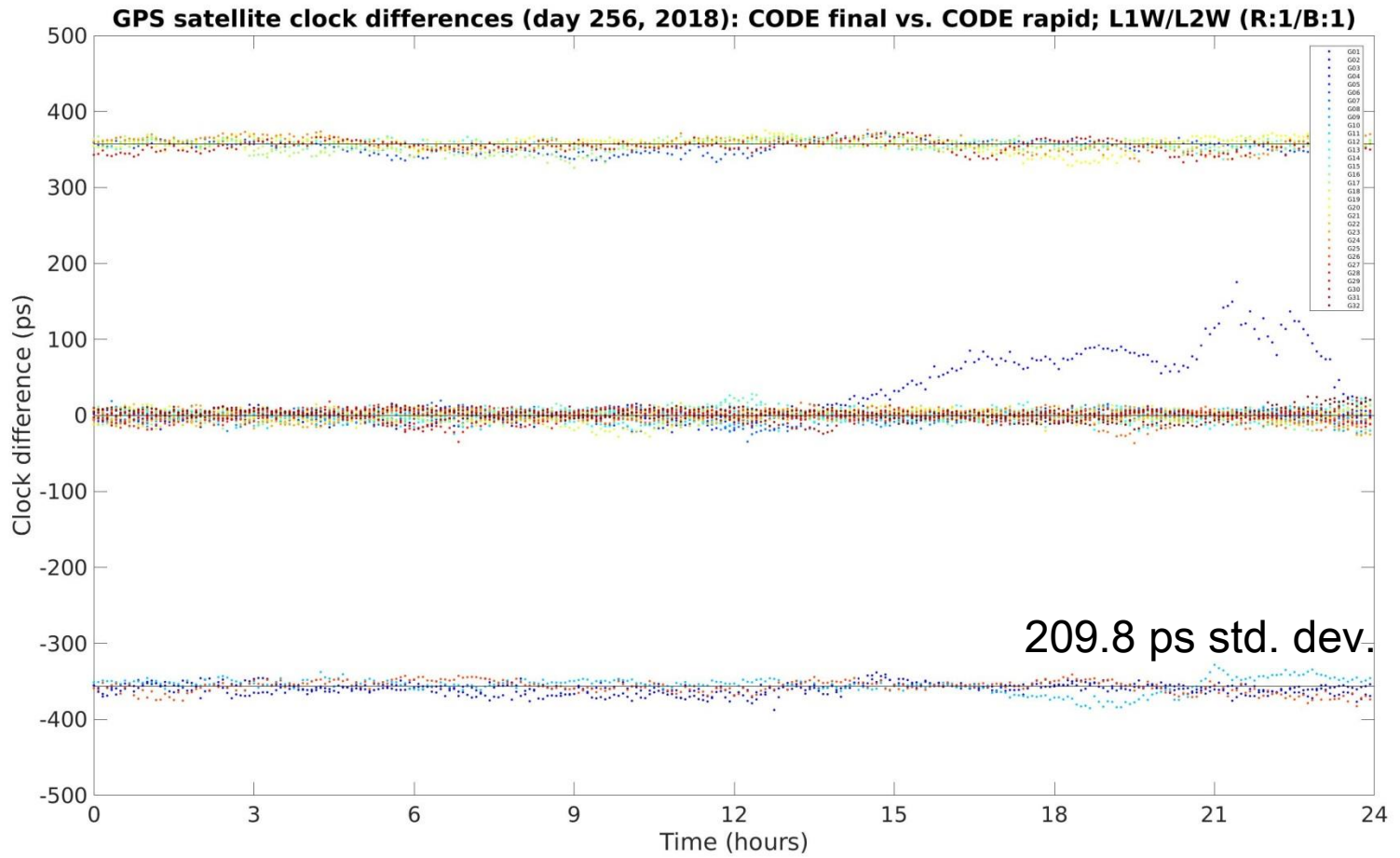


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



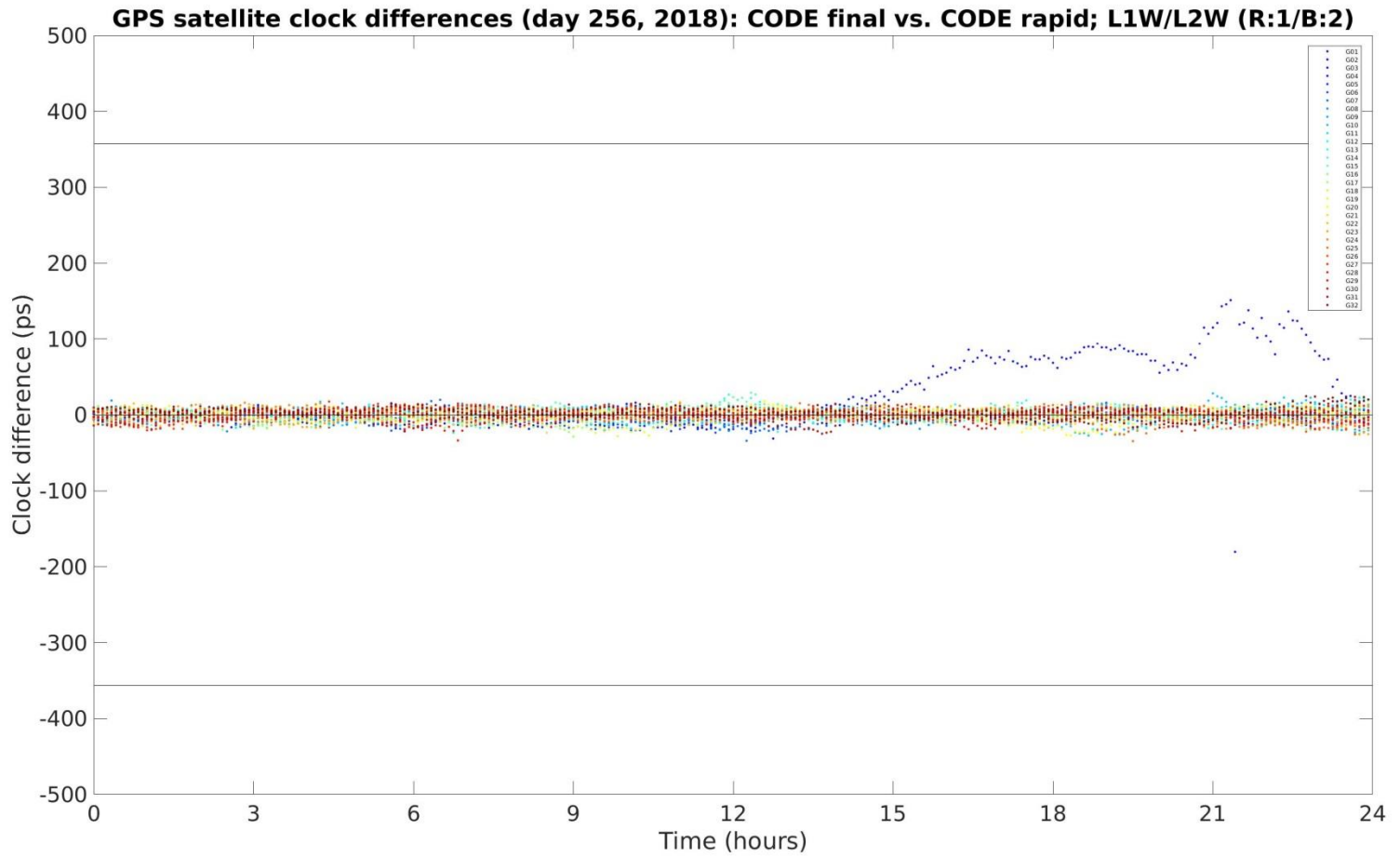


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



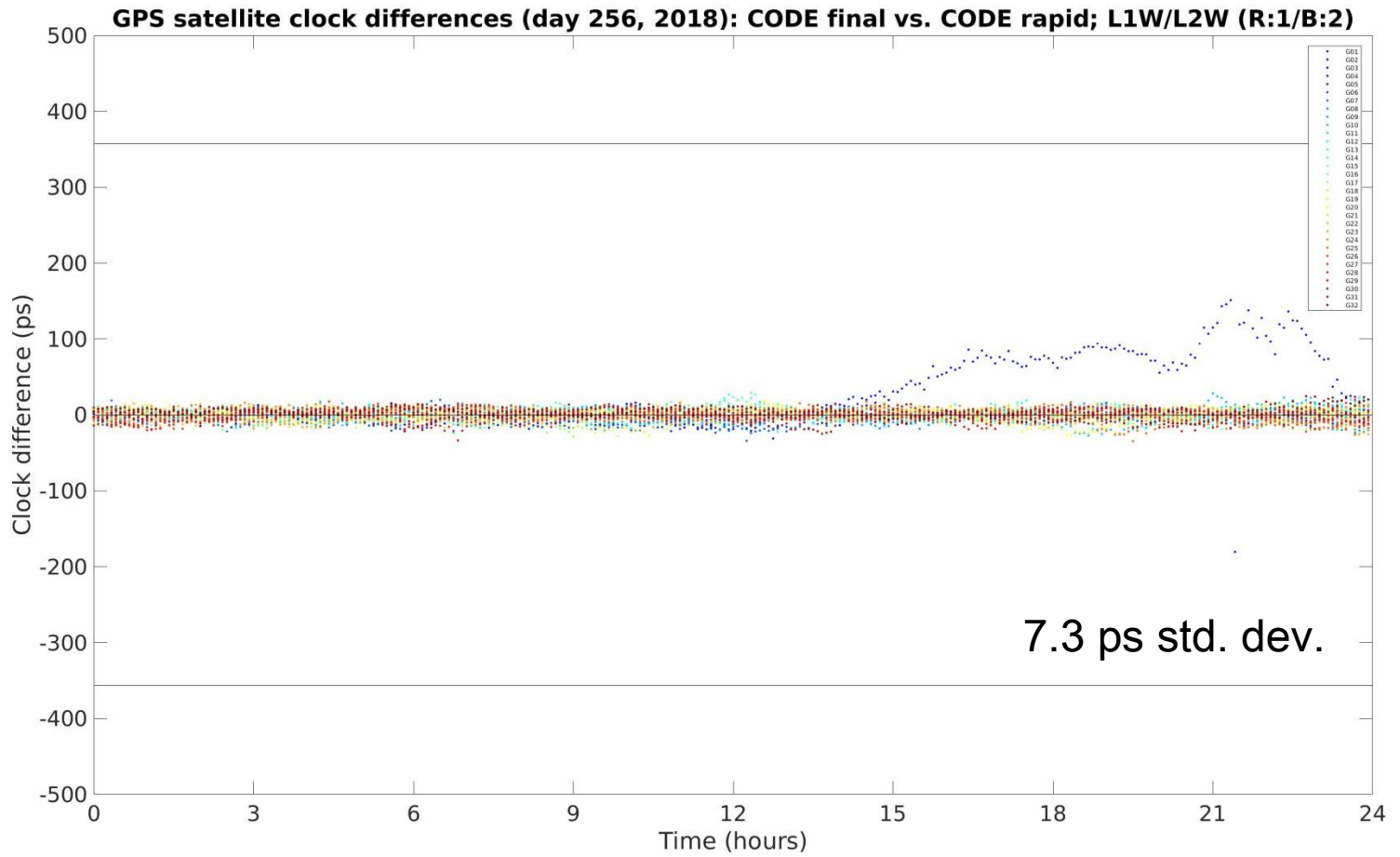


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



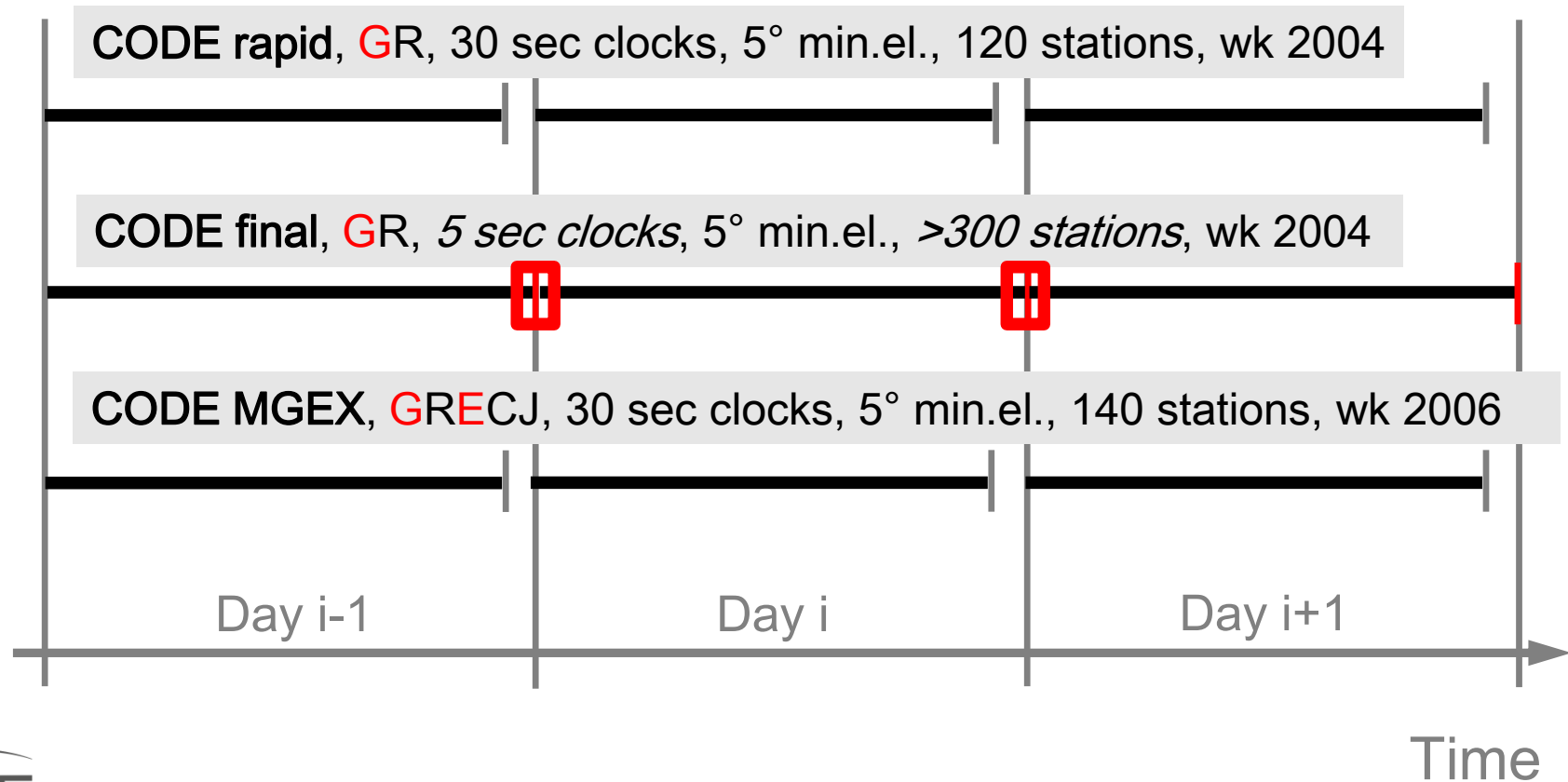


GPS satellite clock properties (1/2): Comparison CODE final vs. CODE rapid



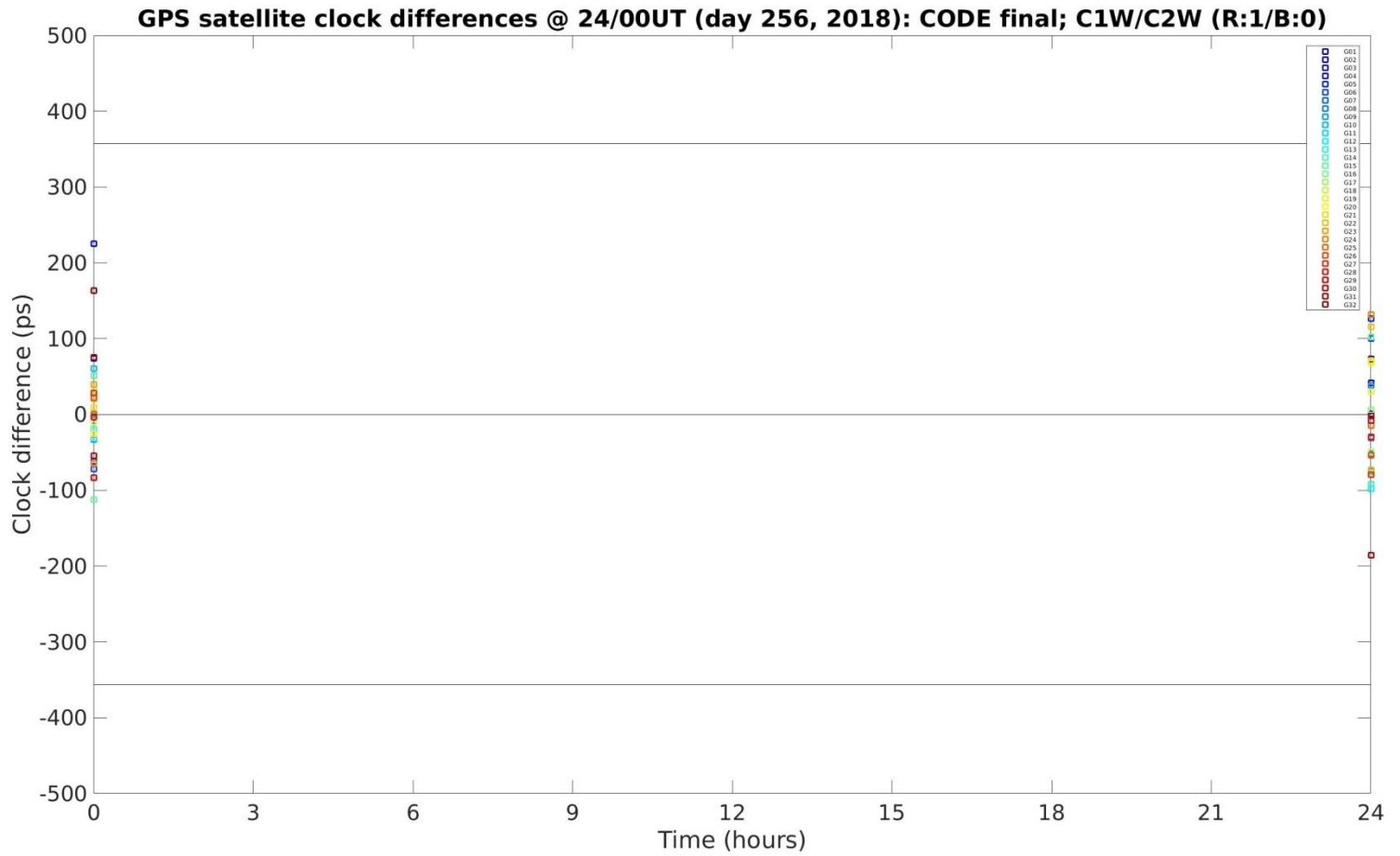


New GNSS clock analysis products and their characteristics



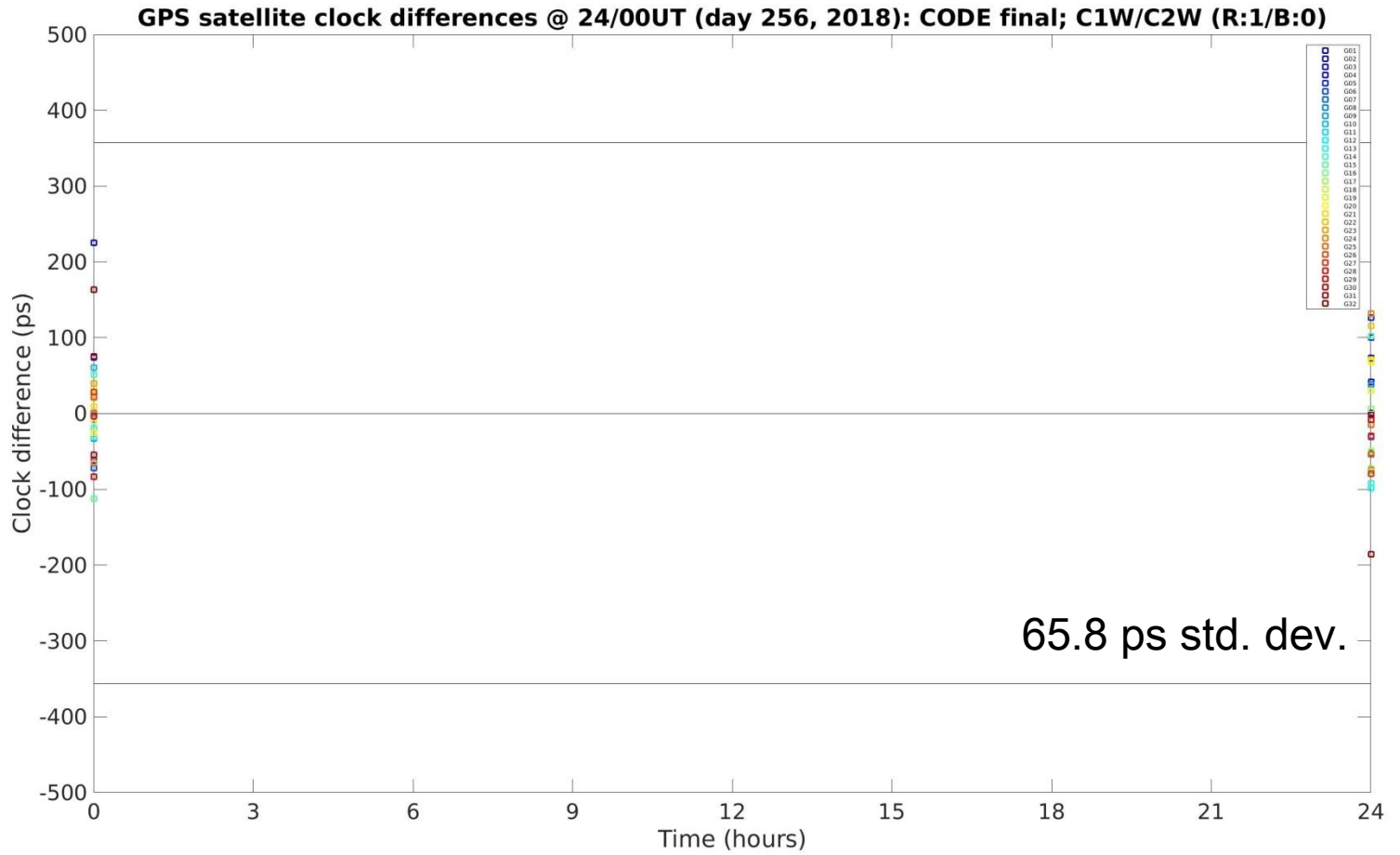


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries



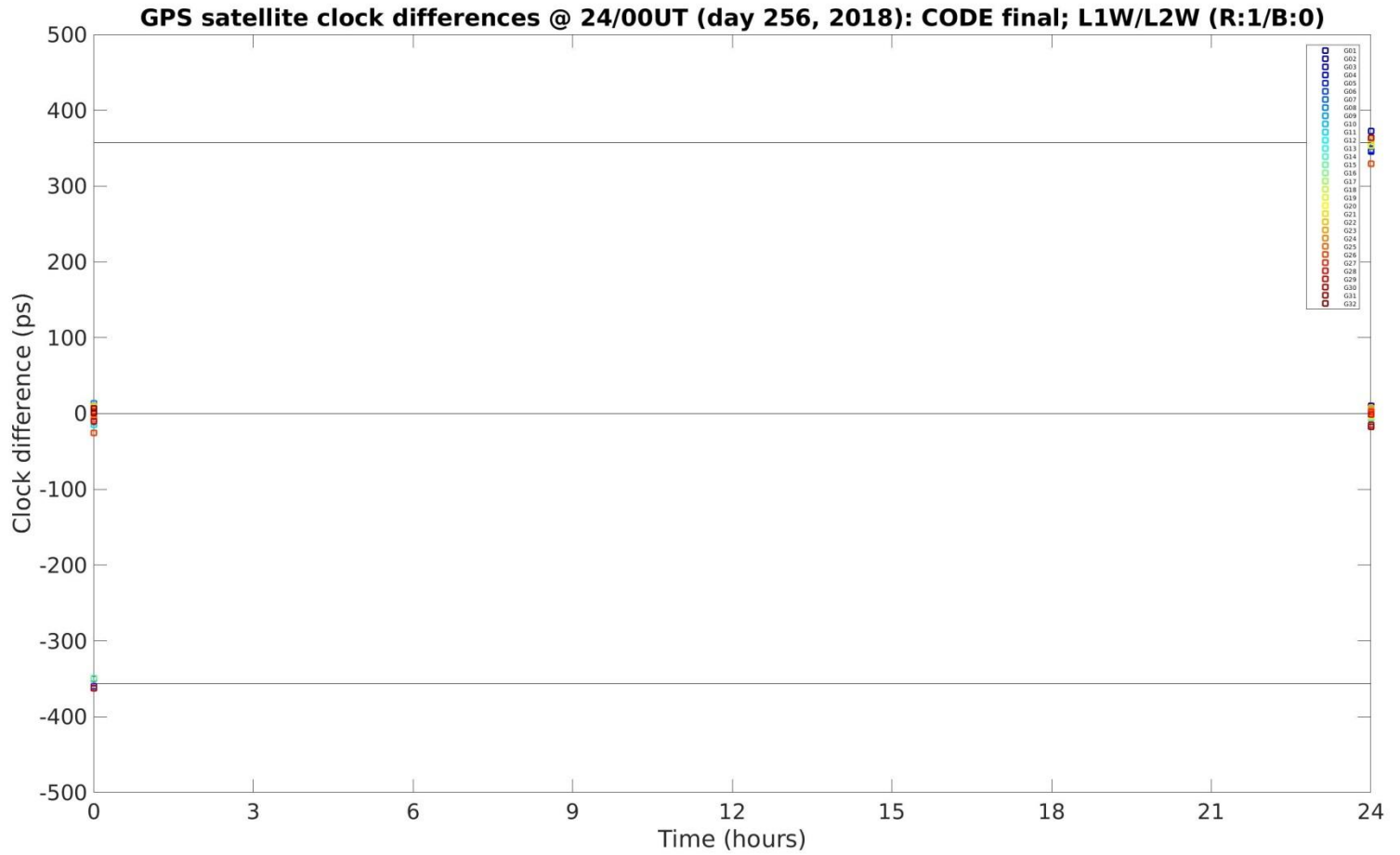


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries



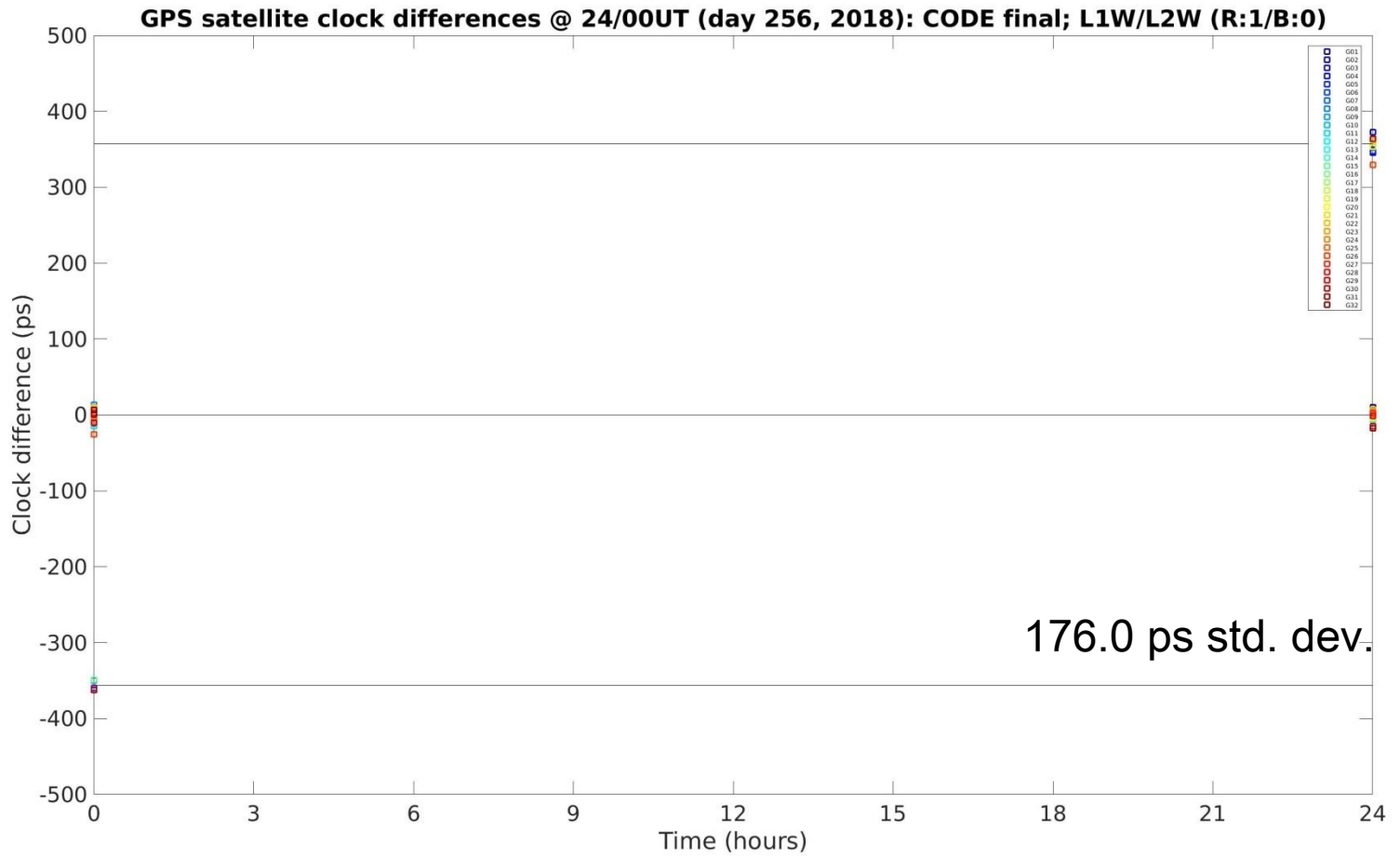


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries



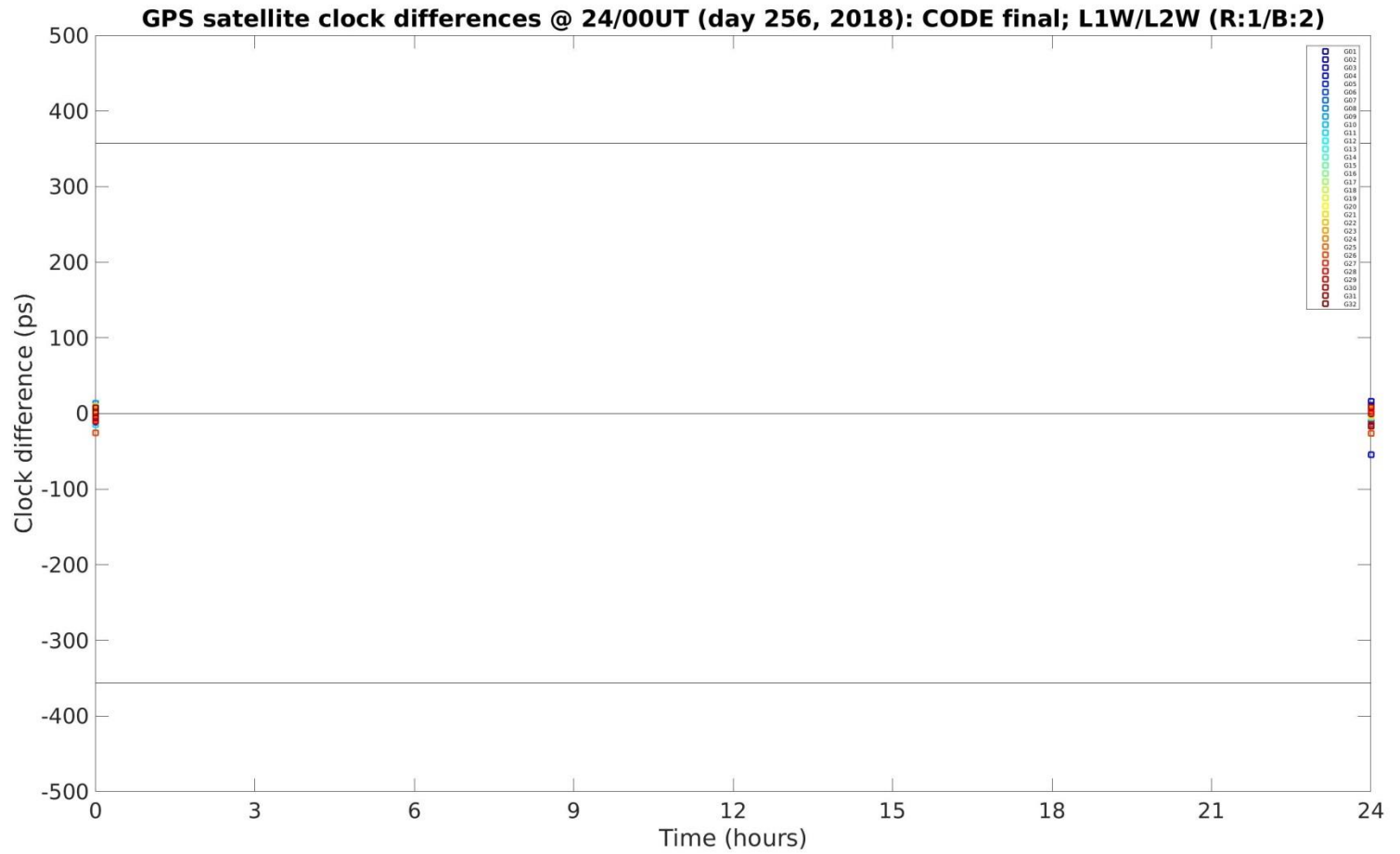


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries



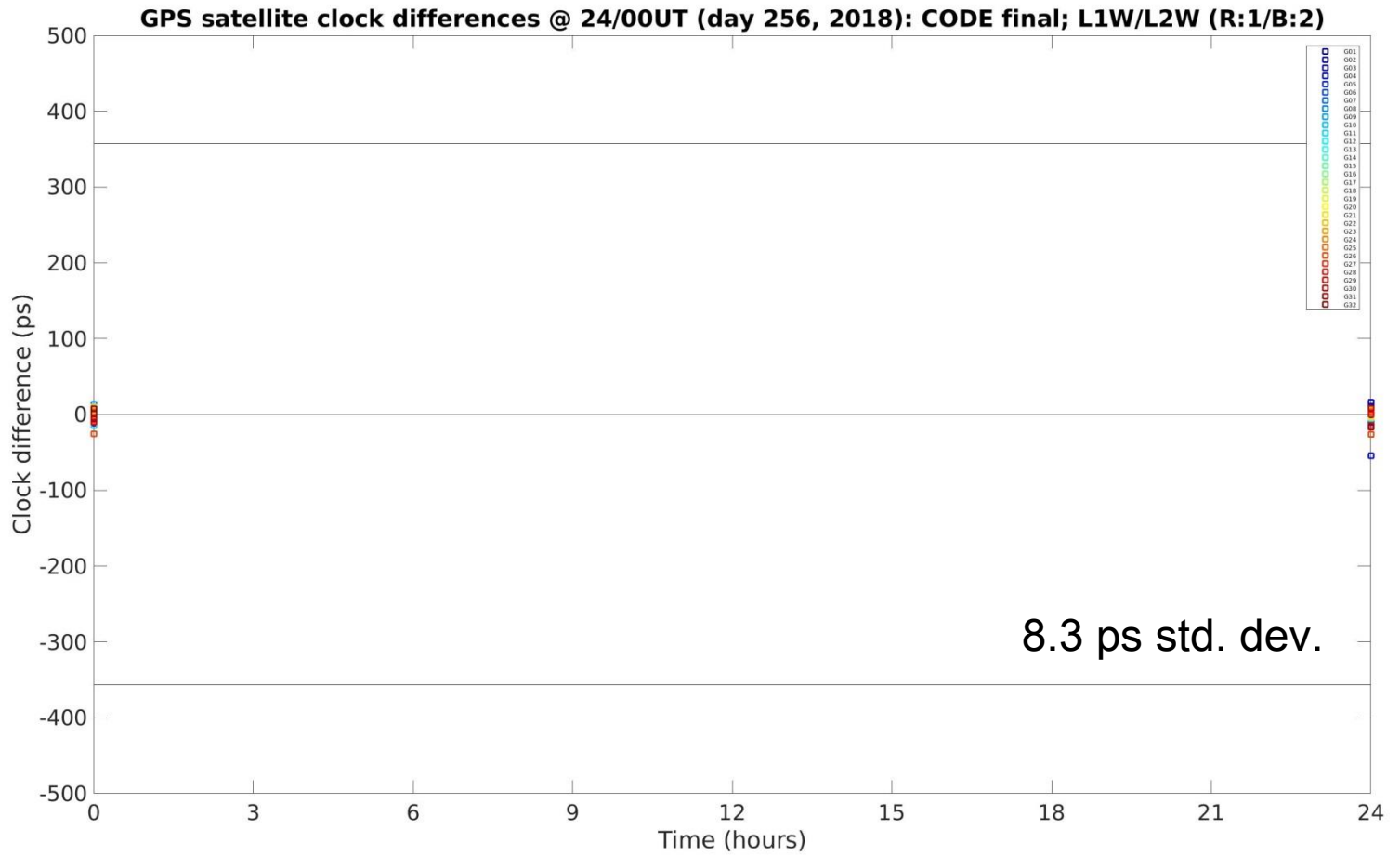


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries



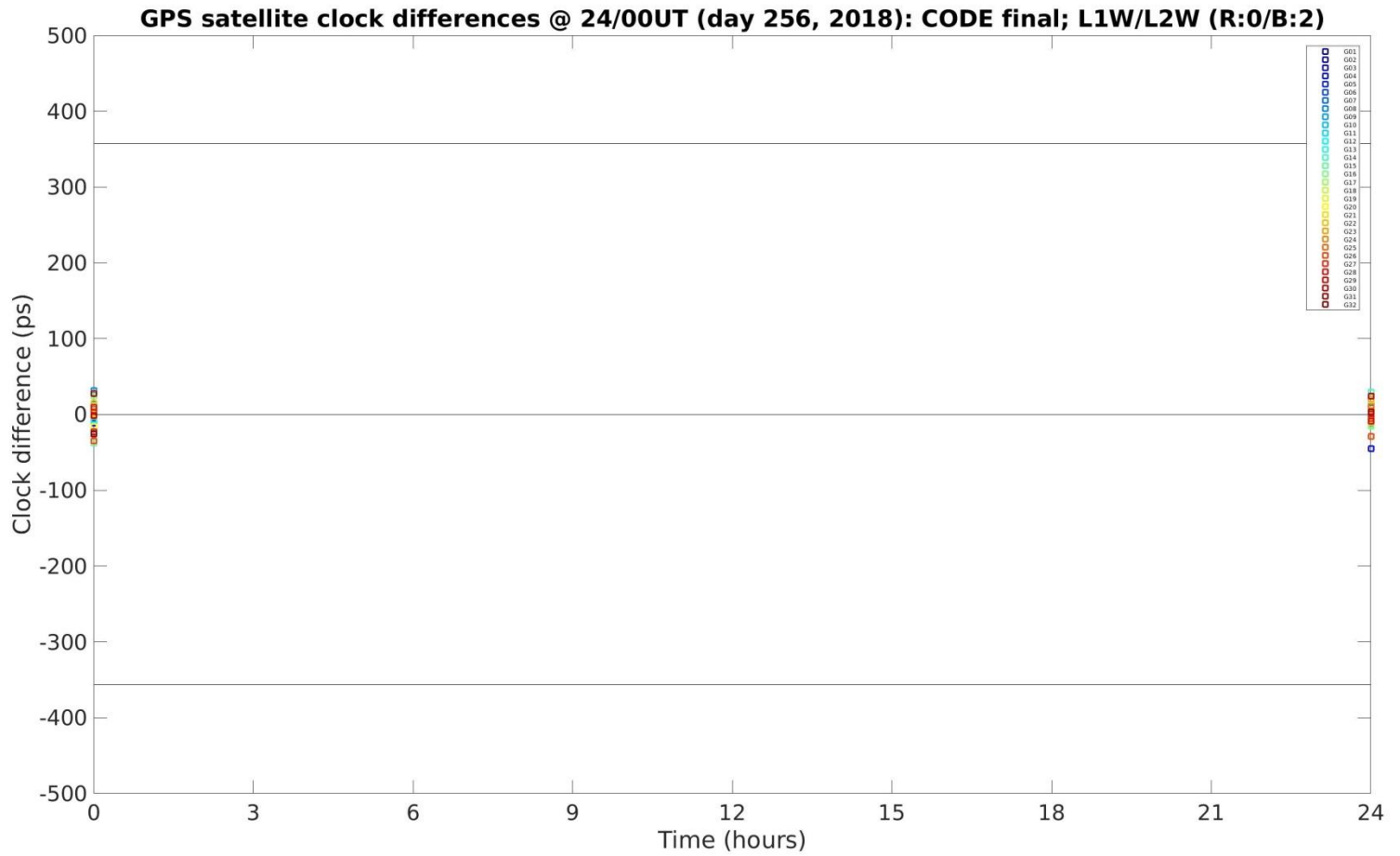


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries



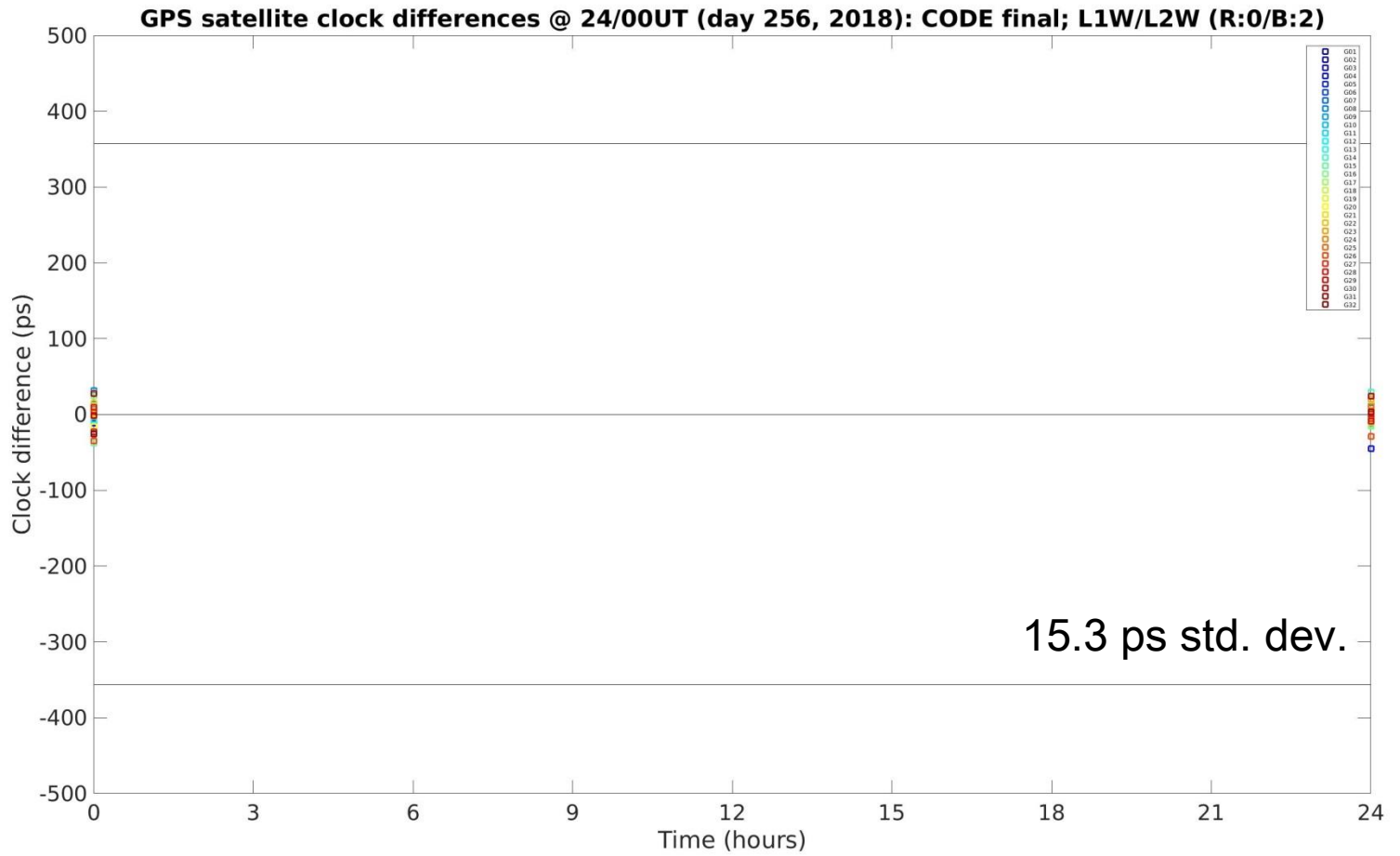


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries



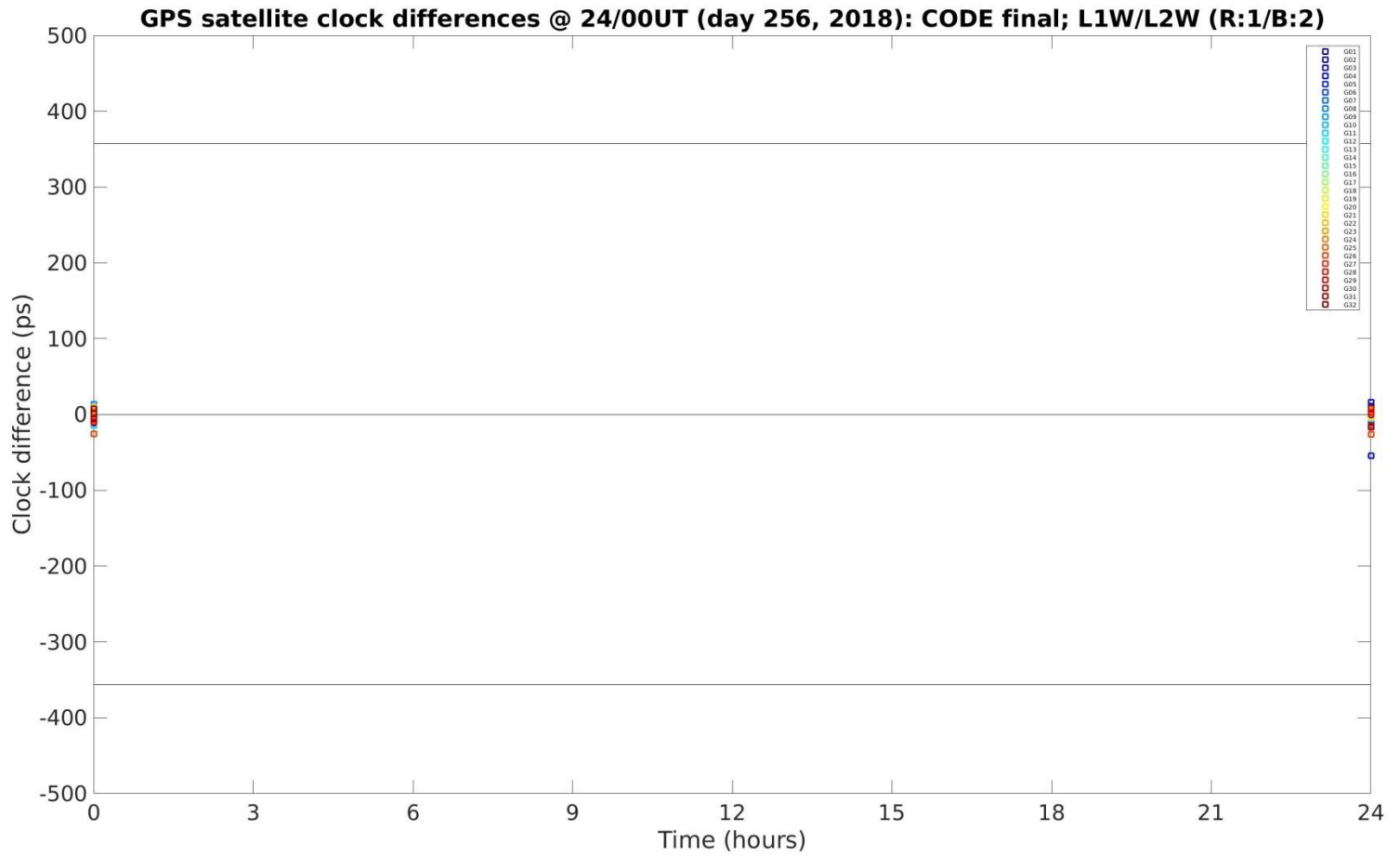


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries



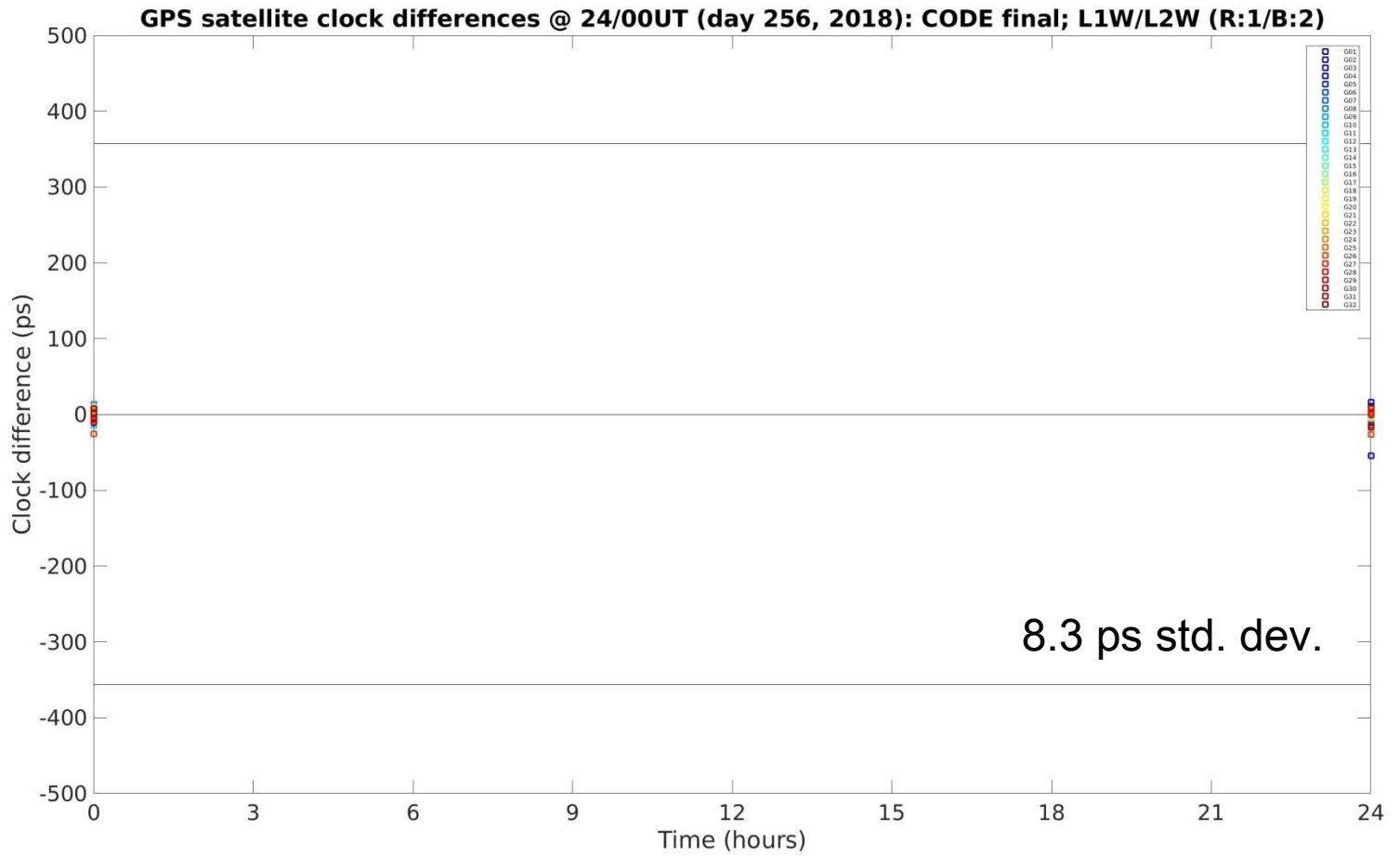


GPS satellite clock properties (2/2): Comparison CODE final at day boundaries





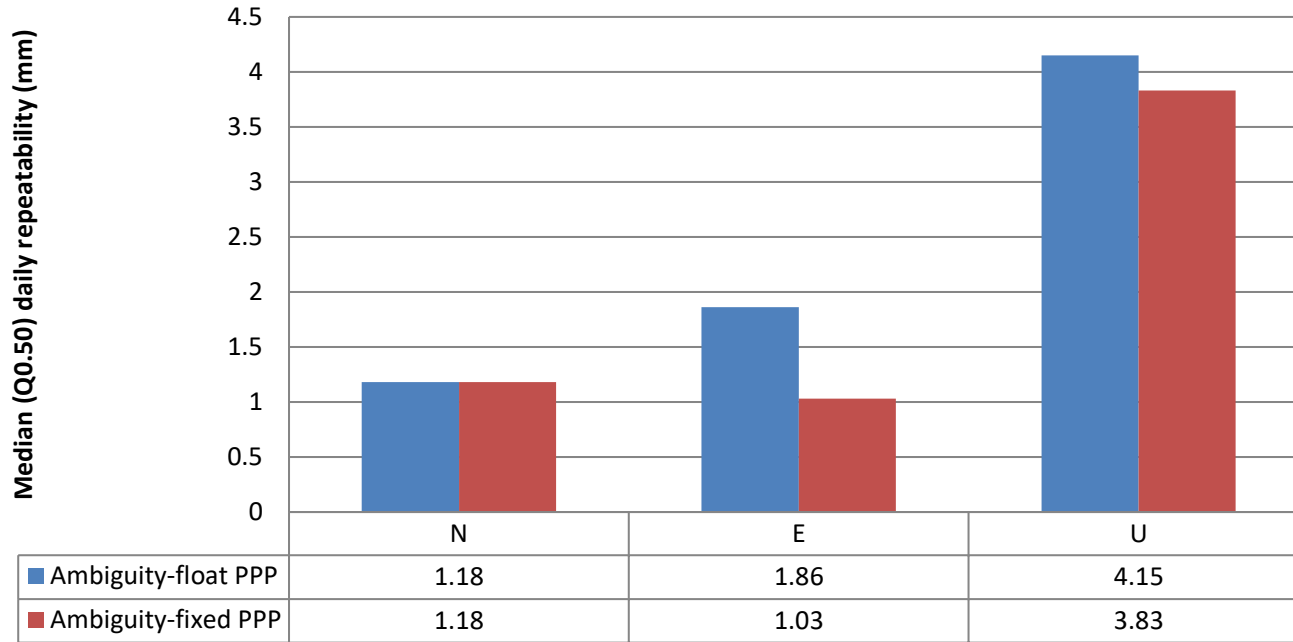
GPS satellite clock properties (2/2): Comparison CODE final at day boundaries





Validation 1/3: Daily PPP vs. daily IPPP

Daily PPP; CODE final product; September 2018;
295 (of 337) stations

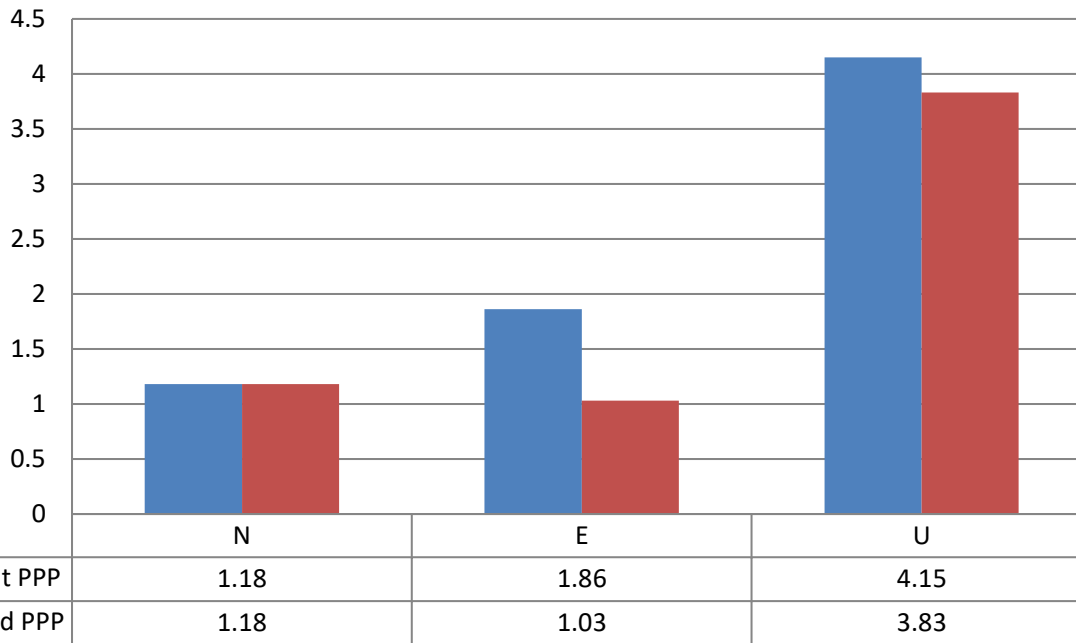




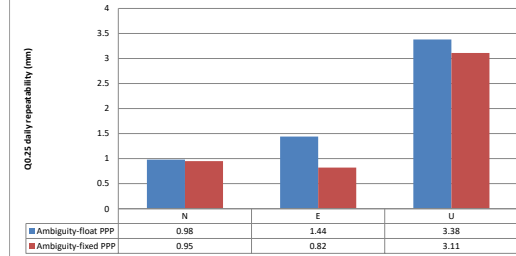
Validation 1/3: Daily PPP vs. daily IPPP

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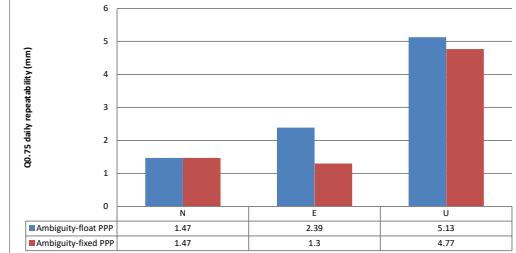
Median (Q0.50) daily repeatability (mm)



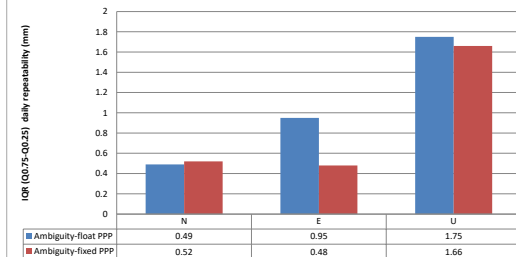
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Daily PPP; CODE final product; September 2018; 295 (of 337) stations



Daily PPP; CODE final product; September 2018; 295 (of 337) stations





Validation 2/3: K-band range (KBR) performance comparison using GRACE data (of April 2007)

Please be referred to the poster PS13-07 by Arnold et al. on:

Undifference ambiguity resolution for GPS-based precise orbit determination of low Earth orbiters using the new CODE clock and phase bias products

IGSWS2018 – PS13

International GNSS Service
Workshop 2018 29 Oct.-02 Nov. 2018, Wuhan, China

D. Arnold¹, S. Schaer^{1,2}, A. Villiger¹, R. Dach¹, A. Jäggi¹

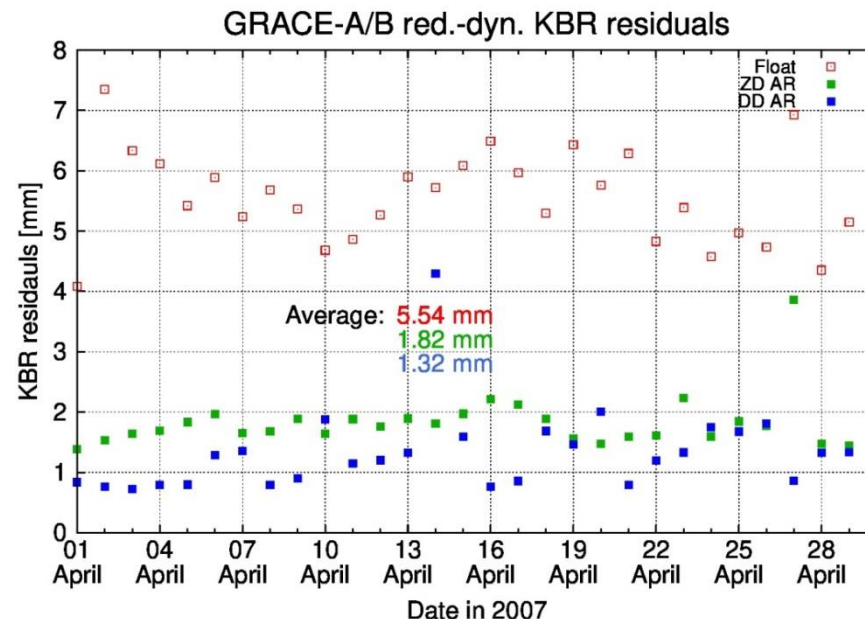
¹Astronomical Institute, University of Bern, Bern, Switzerland

²Swiss Federal Office of Topography, Wabern, Switzerland

Introduction

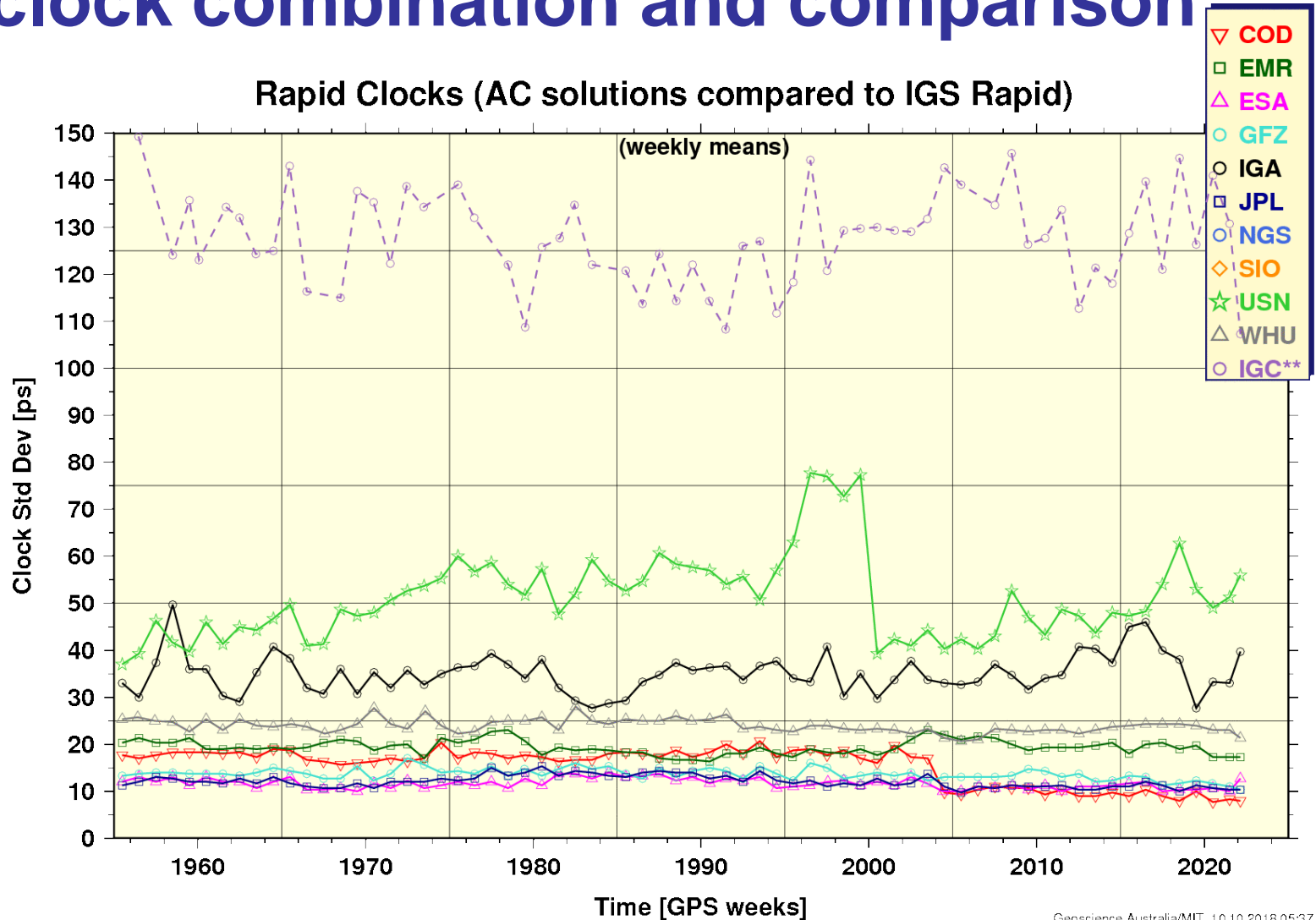
Ambiguity resolution

Reduced-dynamic vs. kinematic solutions





Validation 3/3: IGS **rapid** and final clock combination and comparison

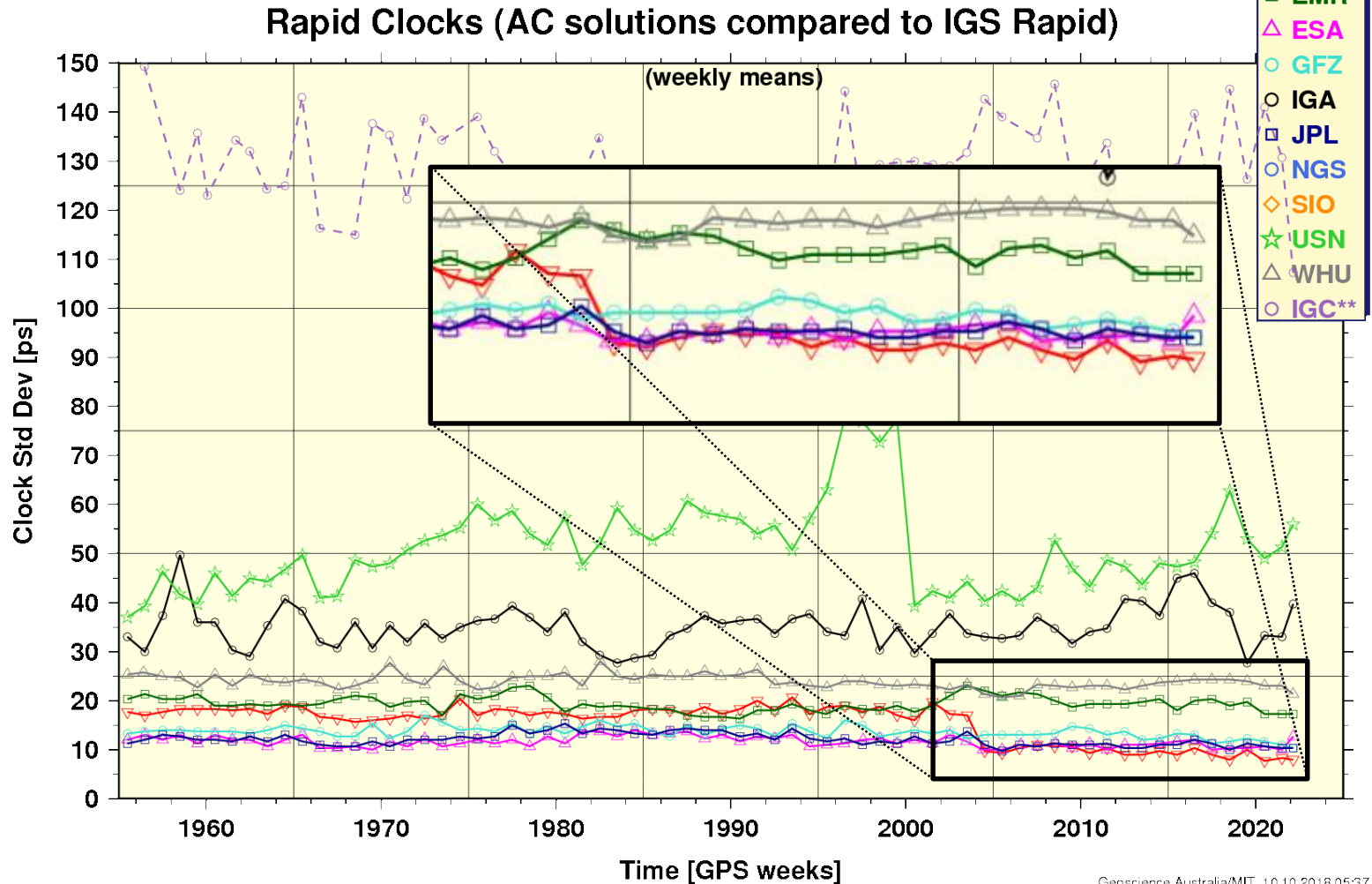


Geoscience Australia/MIT, 10.10.2018 05:37 (GMT)





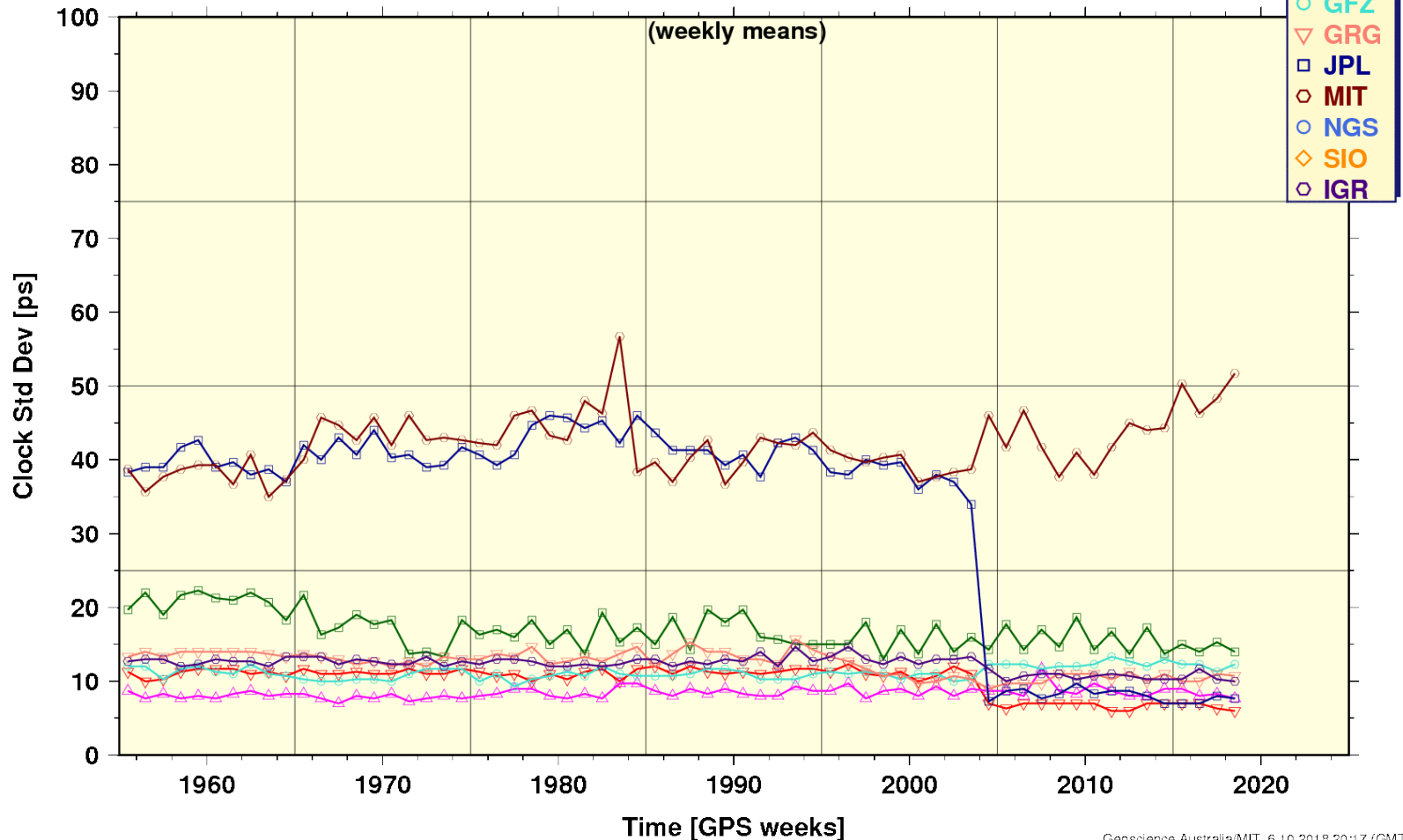
Validation 3/3: IGS **rapid** and final clock combination and comparison





Validation 3/3: IGS rapid and **final** clock combination and comparison

Final Clocks (AC solutions compared to IGS Final)



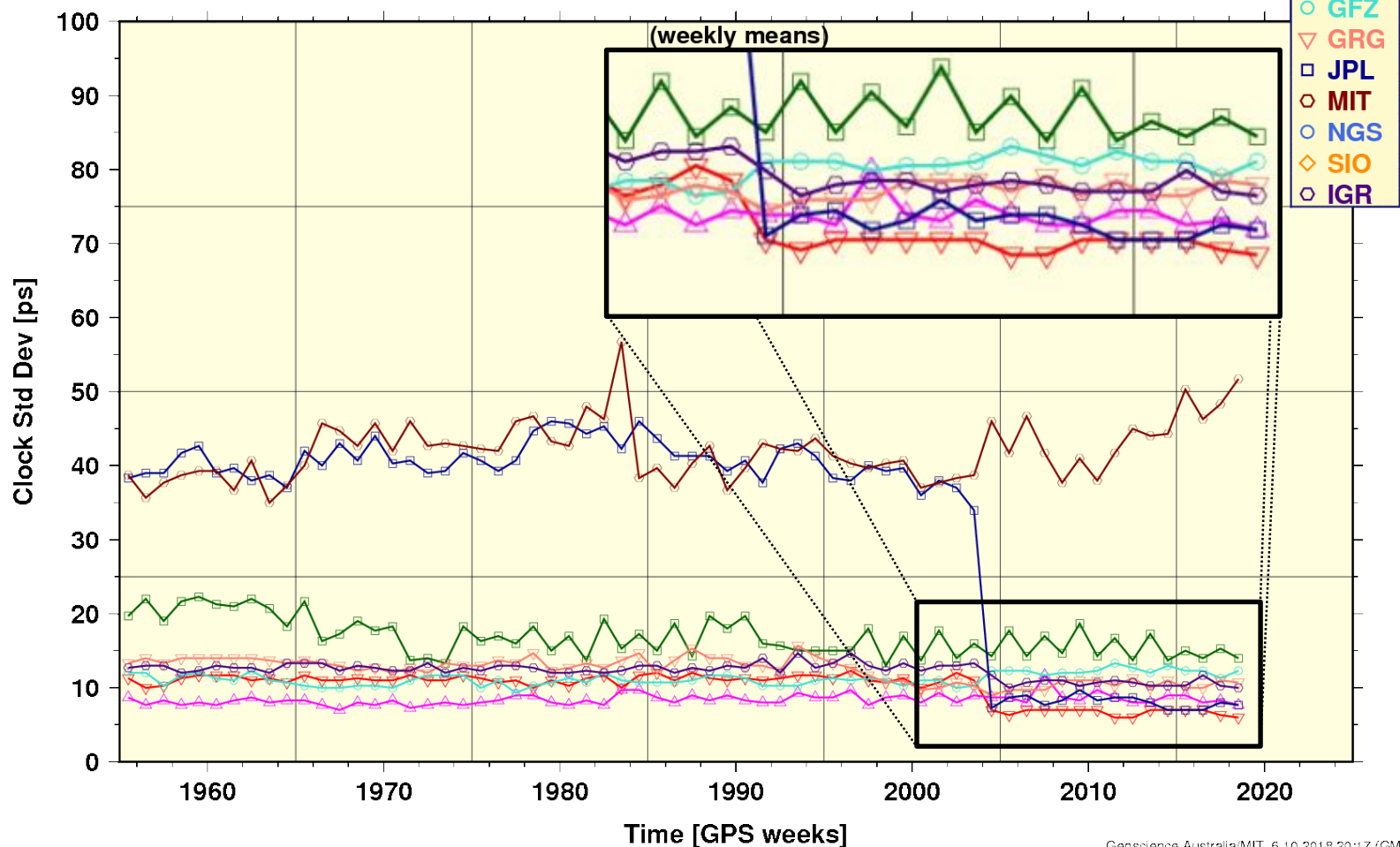
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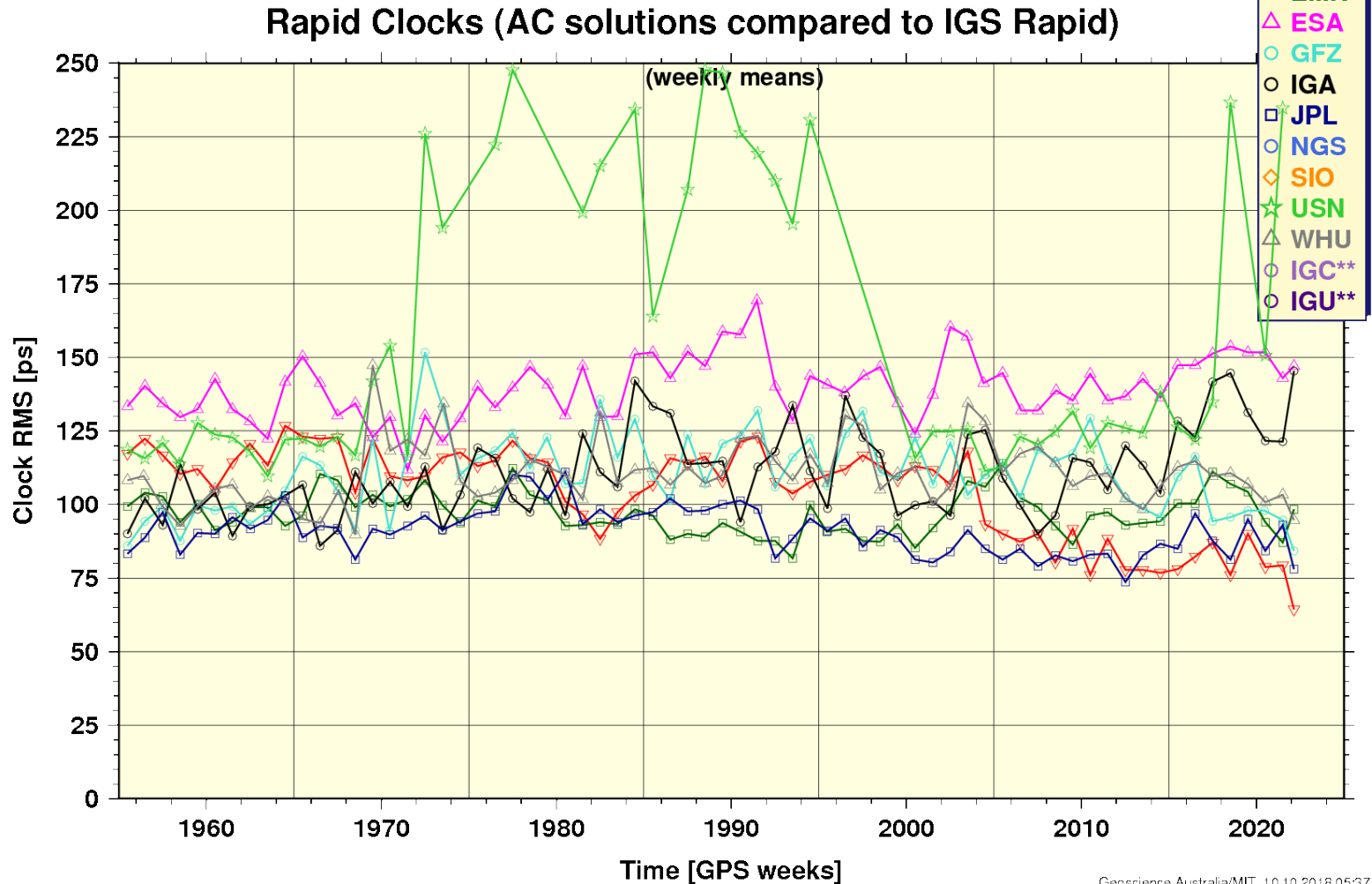
Validation 3/3: IGS rapid and **final** clock combination and comparison

Final Clocks (AC solutions compared to IGS Final)





Validation 3/3: IGS rapid and final clock combination and comparison

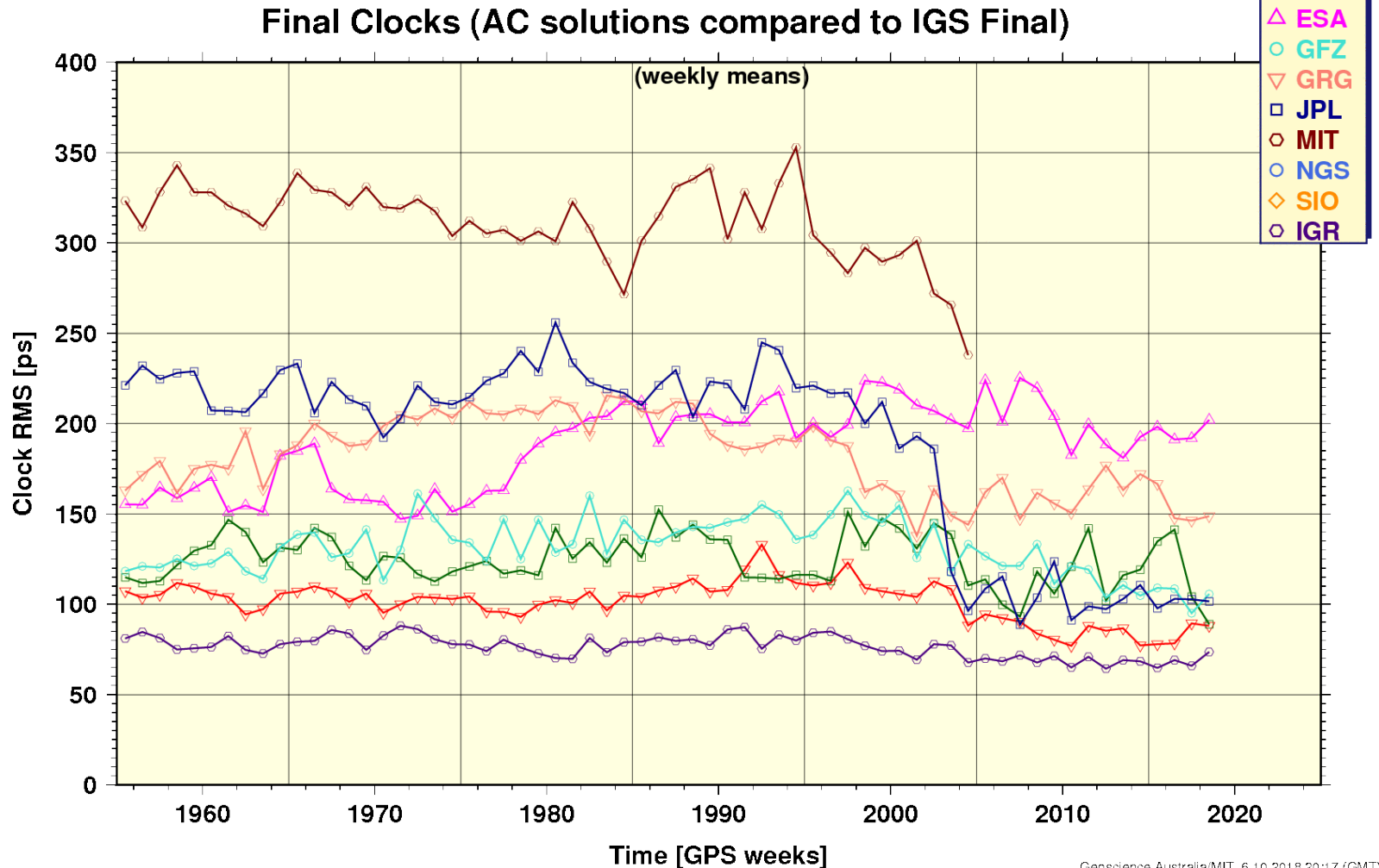


Geoscience Australia/MIT, 10.10.2018 05:37 (GMT)





Validation 3/3: IGS rapid and final clock combination and comparison





Summary and conclusions (1/2)

- CODE has established the generation of a high-quality signal-specific phase bias (OSB) product and a fully consistent ambiguity-fixed clock product within its rapid and final IGS-related processing (since wk 2004/2006). Our multi-GNSS clock product contribution to MGEX (covering GRECJ) does include ambiguity fixing not only for GPS but also for Galileo.





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- All presented developments are part of the current development version of the Bernese GNSS Software.





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- All presented developments are part of the current development version of the Bernese GNSS Software.
- This quantum leap in GNSS clock analysis at CODE could be accomplished due to successful *between-satellite ambiguity fixing* using undifferenced observation data of IGS receiver network. The new CODE clock products reveal a notably improved quality and, in the end, allow for single-receiver ambiguity resolution, thus enabling *integer-PPP (IPPP)*.





Summary and conclusions (2/2)

- Our new clock and bias products are conditioned in a way that maximum consistency may be ensured for *(i) ambiguity-float*, *(ii) ambiguity-fixed*, and *(iii) pseudorange-supported* (or pseudorange-only) PPP applications.





Summary and conclusions (2/2)

- Our new clock and bias products are conditioned in a way that maximum consistency may be ensured for *(i) ambiguity-float*, *(ii) ambiguity-fixed*, and *(iii) pseudorange-supported* (or pseudorange-only) PPP applications.
- In any case, the clock product (following a CC-OSB representation strategy) has to be used in conjunction with the *associated phase and pseudorange bias product* in order to achieve best possible performance.





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- 24UT clock values permit (NLC-)integer-corrected connection of subsequent days of CODE final clock information (48/72 hours or more).





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- 24UT clock values permit (NLC-)integer-corrected connection of subsequent days of CODE final clock information (48/72 hours or more).
- **Redefined clock (Obs1/Obs2) = Reference clock (C1W/C2W) – IF LC OSB correction (Obs1/Obs2)**





How to use the CODE clock and phase bias analysis products → Bias-SINEX V1.00

Code biases

Phase biases

OSB	G063	G01	C1C	2018:256:00000	2018:257:00000	ns	11.0960	0.0065
OSB	G063	G01	C2C	2018:256:00000	2018:257:00000	ns	18.2463	0.0103
OSB	G063	G01	C1W	2018:256:00000	2018:257:00000	ns	12.1990	0.0064
OSB	G063	G01	C2W	2018:256:00000	2018:257:00000	ns	20.1247	0.0084
OSB	G061	G02	C1C	2018:256:00000	2018:257:00000	ns	-12.8302	0.0066
OSB	G061	G02	C1W	2018:256:00000	2018:257:00000	ns	-14.1435	0.0065
OSB	G061	G02	C2W	2018:256:00000	2018:257:00000	ns	-23.2726	0.0084
OSB	G069	G03	C1C	2018:256:00000	2018:257:00000	ns	7.3892	0.0065
OSB	G069	G03	C2C	2018:256:00000	2018:257:00000	ns	14.5950	0.0103
OSB	G069	G03	C1W	2018:256:00000	2018:257:00000	ns	8.3351	0.0064
OSB	G069	G03	C2W	2018:256:00000	2018:257:00000	ns	13.8998	0.0084
OSB	G063	G01	L1C	2018:256:00000	2018:257:00000	ns	-0.40989	0.00000
OSB	G063	G01	L1W	2018:256:00000	2018:257:00000	ns	-0.40989	0.00000
OSB	G063	G01	L2C	2018:256:00000	2018:257:00000	ns	-0.67184	0.00000
OSB	G063	G01	L2W	2018:256:00000	2018:257:00000	ns	-0.67184	0.00000
OSB	G063	G01	L2X	2018:256:00000	2018:257:00000	ns	-0.67184	0.00000
OSB	G061	G02	L1C	2018:256:00000	2018:257:00000	ns	-0.86212	0.00000
OSB	G061	G02	L1W	2018:256:00000	2018:257:00000	ns	-0.86212	0.00000
OSB	G061	G02	L2C	2018:256:00000	2018:257:00000	ns	-1.31564	0.00000
OSB	G061	G02	L2W	2018:256:00000	2018:257:00000	ns	-1.31564	0.00000
OSB	G061	G02	L2X	2018:256:00000	2018:257:00000	ns	-1.31564	0.00000
OSB	G069	G03	L1C	2018:256:00000	2018:257:00000	ns	-0.32326	0.00000
OSB	G069	G03	L1W	2018:256:00000	2018:257:00000	ns	-0.32326	0.00000
OSB	G069	G03	L2C	2018:256:00000	2018:257:00000	ns	-0.43774	0.00000
OSB	G069	G03	L2W	2018:256:00000	2018:257:00000	ns	-0.43774	0.00000
OSB	G069	G03	L2X	2018:256:00000	2018:257:00000	ns	-0.43774	0.00000





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Code biases

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OSB	G063	G01	C1W	2018:256:00000	2018:257:00000	ns	12.1990	0.0064
OSB	G063	G01	C2W	2018:256:00000	2018:257:00000	ns	20.1247	0.0084
OSB	G061	G02	C1C	2018:256:00000	2018:257:00000	ns	-12.8302	0.0066
OSB	G061	G02	C1W	2018:256:00000	2018:257:00000	ns	-14.1435	0.0065
OSB	G061	G02	C2W	2018:256:00000	2018:257:00000	ns	-23.2726	0.0084
OSB	G069	G03	C1C	2018:256:00000	2018:257:00000	ns	7.3892	0.0065
OSB	G069	G03	C2C	2018:256:00000	2018:257:00000	ns	14.5950	0.0103
OSB	G069	G03	C1W	2018:256:00000	2018:257:00000	ns	8.3351	0.0064
OSB	G069	G03	C2W	2018:256:00000	2018:257:00000	ns	13.8998	0.0084
OSB	G063	G01	L1C	2018:256:00000	2018:257:00000	ns	-0.40989	0.00000
OSB	G063	G01	L1W	2018:256:00000	2018:257:00000	ns	-0.40989	0.00000
OSB	G063	G01	L2C	2018:256:00000	2018:257:00000	ns	-0.67184	0.00000
OSB	G063	G01	L2W	2018:256:00000	2018:257:00000	ns	-0.67184	0.00000
OSB	G063	G01	L2X	2018:256:00000	2018:257:00000	ns	-0.67184	0.00000
OSB	G061	G02	L1C	2018:256:00000	2018:257:00000	ns	-0.86212	0.00000
OSB	G061	G02	L1W	2018:256:00000	2018:257:00000	ns	-0.86212	0.00000
OSB	G061	G02	L2C	2018:256:00000	2018:257:00000	ns	-1.31564	0.00000
OSB	G061	G02	L2W	2018:256:00000	2018:257:00000	ns	-1.31564	0.00000
OSB	G061	G02	L2X	2018:256:00000	2018:257:00000	ns	-1.31564	0.00000
OSB	G069	G03	L1C	2018:256:00000	2018:257:00000	ns	-0.32326	0.00000
OSB	G069	G03	L1W	2018:256:00000	2018:257:00000	ns	-0.32326	0.00000
OSB	G069	G03	L2C	2018:256:00000	2018:257:00000	ns	-0.43774	0.00000
OSB	G069	G03	L2W	2018:256:00000	2018:257:00000	ns	-0.43774	0.00000
OSB	G069	G03	L2X	2018:256:00000	2018:257:00000	ns	-0.43774	0.00000

Thank you for your attention

