

ESA Code Bias Reference Frame

Volker Mayer², Tim Springer³, Francesco Gini¹, Frank Zimmermann¹, Erik Schönemann¹

¹ ESA/ESOC, Darmstadt, Germany

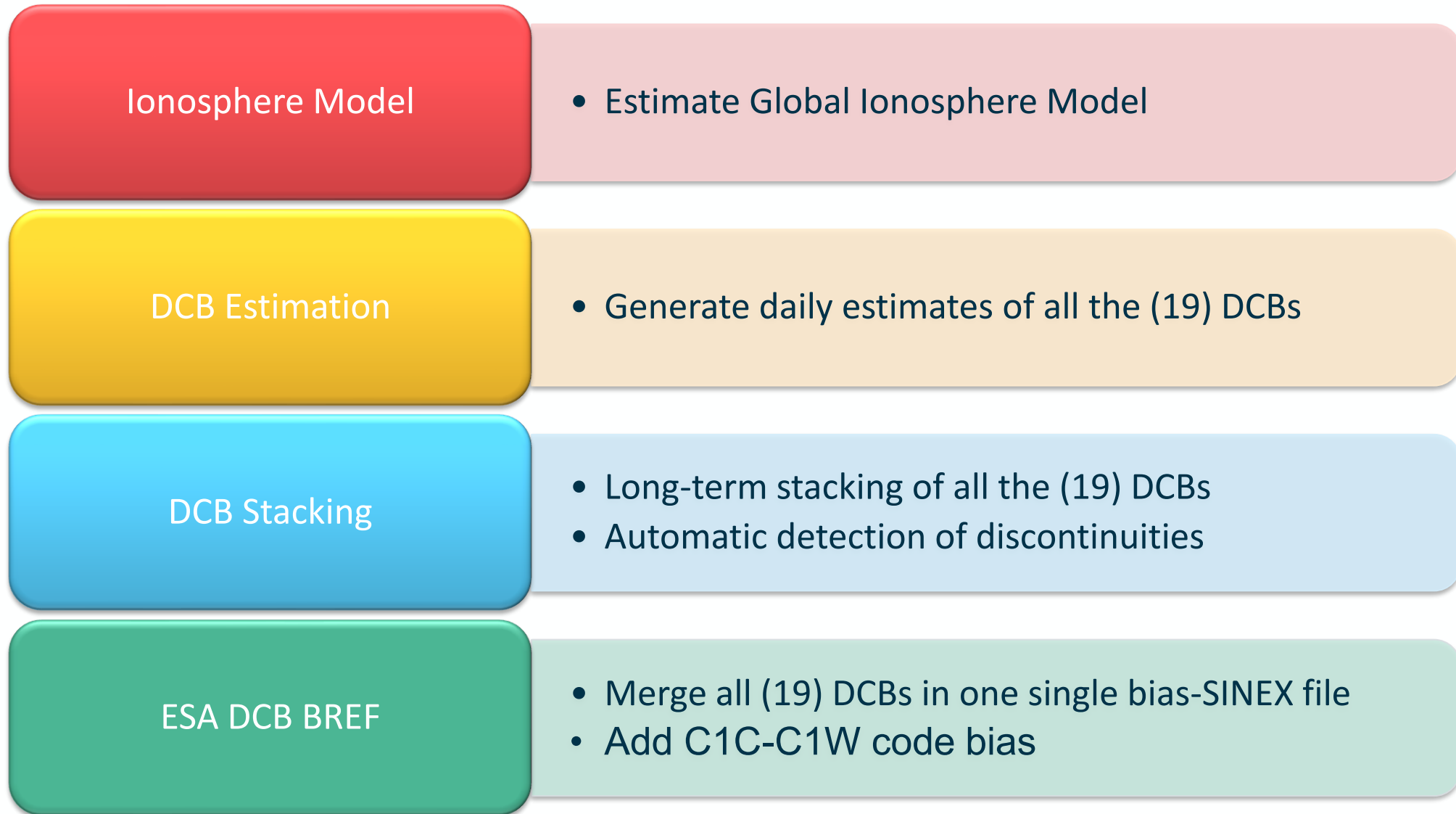
² SSC Space GmbH for ESA, Navigation Support Office

³ PosiTim UG for ESA, Navigation Support Office

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- GNSS signals often consist of a Data and a Pilot component:
 - Data component is navigation-message modulated.
 - Pilot component is unmodulated yielding a lower noise level.
- Components can be tracked individual or jointly (providing the X component).
- Past ESA analysis suggested that identical signal delays for data and pilot components can be assumed.
 - Estimating a single code bias per signal is sufficient.

	Frequencies	Component	Equal to
Galileo	L1, L6	B, C, X	C
	L5, L7, L8	I, Q, X	Q
GPS	L1, L2	P	W
	L1, L2	S, L, X	L
	L5	I, Q, X	Q
BeiDou	L1, L5, L8	D, P, X	P
	L7	D, P, Z	D
QZSS	L1, L2, L6	S, L, X	L
	L5	I, Q, X	Q
	L5s	D, P, Z	P
	L8	D, P, X	X
GLONASS	L3	I, Q, X	Q



Preview



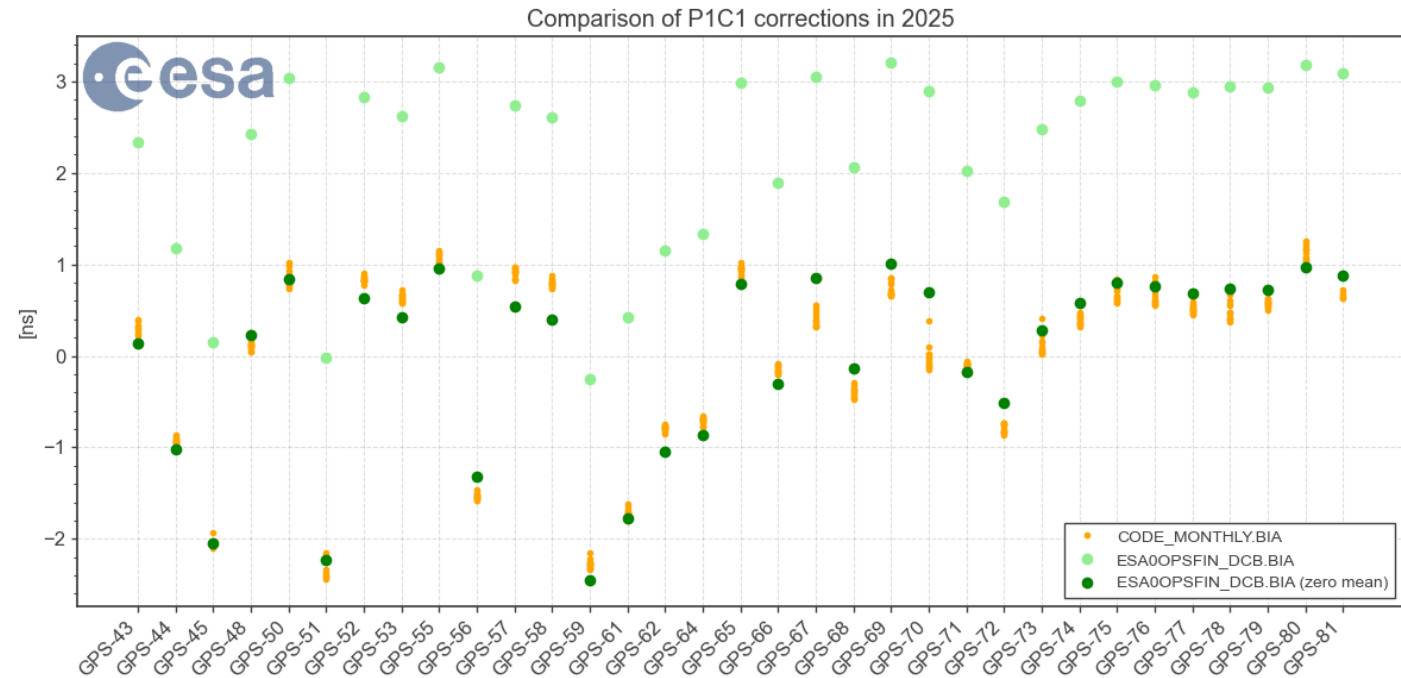
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1 %=BIA 1.000 ESA 2026:078:49431 IGS 2017:001:00000 2026:078:00000 R 00000629
2 *-----*
3 * Bias Solution INdependent EXchange Format (Bias-SINEX)
4 *-----*
5 +FILE/REFERENCE
6 DESCRIPTION          European Space Operations Centre(ESOC)
7 INPUT                CHAMP MGNSS DCBIAS estimates in normal equation format
8 OUTPUT              MGNSS DCB estimates in BIAS SINEX format
9 CONTACT              Navigation-Office@esa.int
10 HARDWARE            SLES15
11 SOFTWARE            EPNS 1.3 02/07/2025
12 -FILE/REFERENCE
13 *-----*
14 +FILE/COMMENT
15 Products available from:
16   https://navigation-office.esa.int
17 The following signals are considered equal
18 - GPS P      equal to W for L1, L2
19   S/L/X equal to L for L1, L2
20   I/Q/X equal to Q for L5
21 - GLO I/Q/X equal to Q for L3
22 - GAL B/C/X equal to C for L1, L6
23   I/Q/X equal to Q for L5, L7, L8
24 - BEI D/P/X equal to P for L1, L5, L8
25   D/P/Z equal to D for L7
26 - QZS S/L/X equal to L for L1, L2, L6
27   I/Q/X equal to Q for L5
28   D/P/Z equal to P for L5s
29   D/P/X equal to X for L8
30 -FILE/COMMENT
31 *-----*
32 +INPUT/ACKNOWLEDGMENTS
33 ESA European Space Agency
34 ESOC European Space Operations Centre
35   Navigation Support Office
36 IGS International GNSS Service
37 -INPUT/ACKNOWLEDGMENTS
38 *-----*
39 +BIAS/DESCRIPTION
40 OBSERVATION_SAMPLING          300
41 BIAS_MODE                     RELATIVE
42 TIME_SYSTEM                   G
43 RECEIVER_CLOCK_REFERENCE_GNSS G
44 SATELLITE_CLOCK_REFERENCE_OBSERVABLES G
45 SATELLITE_CLOCK_REFERENCE_OBSERVABLES E
46 SATELLITE_CLOCK_REFERENCE_OBSERVABLES C
47 SATELLITE_CLOCK_REFERENCE_OBSERVABLES J
48 APC_MODEL                     ESA23
49 *SATELLITE_ANTENNA_PCC_APPLIED_TO_MW_LC YES
50 -BIAS/DESCRIPTION
51 *-----*
52 +BIAS/SOLUTION
53 *BIAS SVN PRN STATION OBS1 OBS2 BIAS_START BIAS_END UNIT ESTIMATED_VALUE STD_DEV
54 DSB E210 E01 C1C C5Q 2017:001:00000 2023:120:00000 ns -0.360307531411484E+00 .124448E-01
55 DSB E211 E02 C1C C5Q 2017:001:00000 2026:078:00000 ns 0.808882941249843E+00 .124355E-01
56 DSB E208 E08 C1C C5Q 2017:001:00000 2026:078:00000 ns 0.276361779176073E+01 .124355E-01
57 DSB E209 E09 C1C C5Q 2017:001:00000 2026:078:00000 ns -0.140435980590626E+01 .124355E-01
58 DSB E101 E11 C1C C5Q 2017:001:00000 2026:078:00000 ns 0.104703035440027E+02 .124359E-01
59 DSB E102 E12 C1C C5Q 2017:001:00000 2026:078:00000 ns 0.823780778417171E+01 .124358E-01
60 DSB E202 E14 C1C C5Q 2017:001:00000 2019:077:00018 ns -0.303123504462416E+02 .125409E-01
61 DSB E201 E18 C1C C5Q 2017:001:00000 2019:049:00018 ns -0.152822820659627E+02 .125480E-01
62 DSB E103 E19 C1C C5Q 2017:001:00000 2026:078:00000 ns 0.250631587619431E+01 .124361E-01
63 DSB E204 E22 C1C C5Q 2017:001:00000 2017:342:00000 ns 0.137349003393180E+01 .126696E-01
```

Publicly available:
https://navigation-office.esa.int/products/gnss-products/ESA0OPSFIN_DCB.BIA



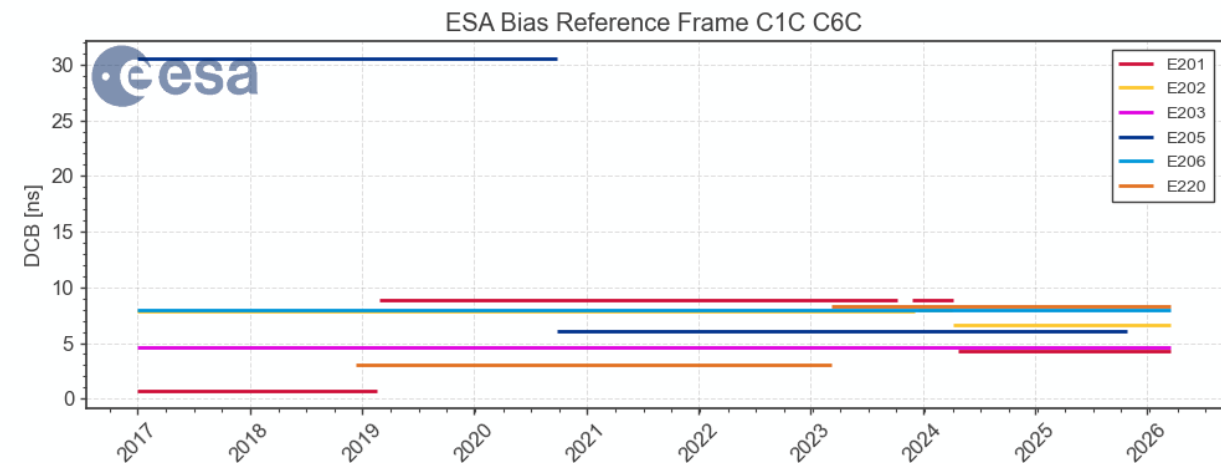
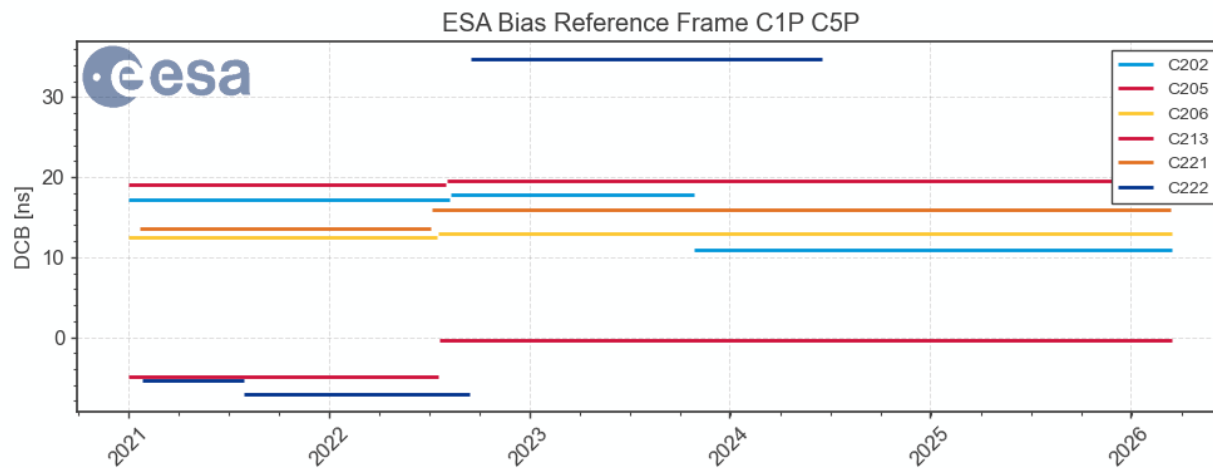
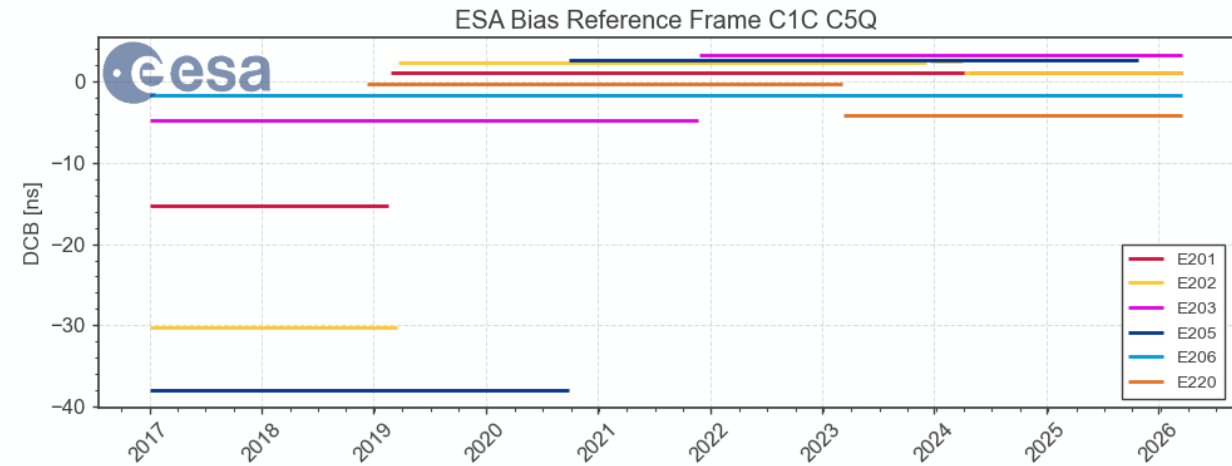
GPS P1C1 Correction using ESA BREF

- ESAAC uses in-house data for P1C1 correction.
 - Started September 2025
 - Reduction of external dependencies
- Computed by combining BREF
 - $[C1C-C2W] - [C1W-C2W] = C1C-C1W$
 - Constellation zero-mean applied
- Impact on ESAAC solution in IGS0OPSFIN
 - Increasing satellite clock RMS
 - Stable satellite clock STD



Differential Code Bias Jumps

- Numerous DCB jumps could be observed over the past decade.
- In particular, when constraining the biases to a code Reference frame such as BREF the jumps needs to be closely monitored.



- ESA generates supporting products for PPP-AR using fractional phase biases since many years.
 - For GPS phase biases make use of 1W-2W observations
 - For Galileo phase biases make use of 1C/X - 5Q/I
 - For BeiDou phase biases make use of 1P/X - 5P/X
 - and QZSS of 1L/X/S - 5Q/I/X
- The latest Sentinel satellites provide Galileo 1C-5Q and GPS 1W-2W but also GPS 1C-2L observations.
 - How can GPS 1W-2W based products (orbit, clock and phase biases) be used to process that data!?
- When correcting the code observations, it must be ensured that the phase biases remain usable.
- For many years GPS 1C has been converted to 1W like observations, which has been proven to work perfectly fine when doing PPP-AR of 1C-2W data with 1W-2W based products.
 - Logically it should be possible to produce 2L-2W biases similarly, which could make the 2L observations compatible with the 2W phase biases.
 - Disadvantage: These 1C-1W and 2L-2W biases cannot be part of a set of an internally consistent set of bias products, because the implicit assumption was that the 1W and 2W observations were bias free.
 - But it works very well!



- We generate and maintain a long-term differential code bias product:
 - The ESA Bias Reference Frame (BREF)
 - Available from our web-site <https://navigation-office.esa.int/products/>
- We generate phase biases for all GNSS systems:
 - GPS, Galileo, BeiDou and QZSS (GLONASS excluded for obvious reasons (FDMA))
 - Not (yet) publicly available
- Our code and phase bias products are state-of-the-art.
 - Using our phase biases requires special biases when used with other code signals.
 - For C1C one would need the well know C1C-C1W biases.
 - For C2L one would need the C2L-C2W biases.
- Our ESA BREF is currently containing only DSBs.
 - We will generate and maintain an OSB version of it (soon).
 - We will generate phase biases consistent with our ESA OSB BREF.

Thank you for your Attention



ESA-ESOC Navigation Support Office team
based in Darmstadt, Germany

<https://navigation-office.esa.int>

navigation-office@esa.int

Join us at the
poster session:

P1 05	EGON: The ESA/ESOC GNSS Observation Station Network
P1 08	GSSC: GNSS Science Support Centre – ESA’s IGS Global Data Centre
P2 05	ESA IGS Analysis Centre – Status Update
P2 17	An Update on Genesis Mission Status

