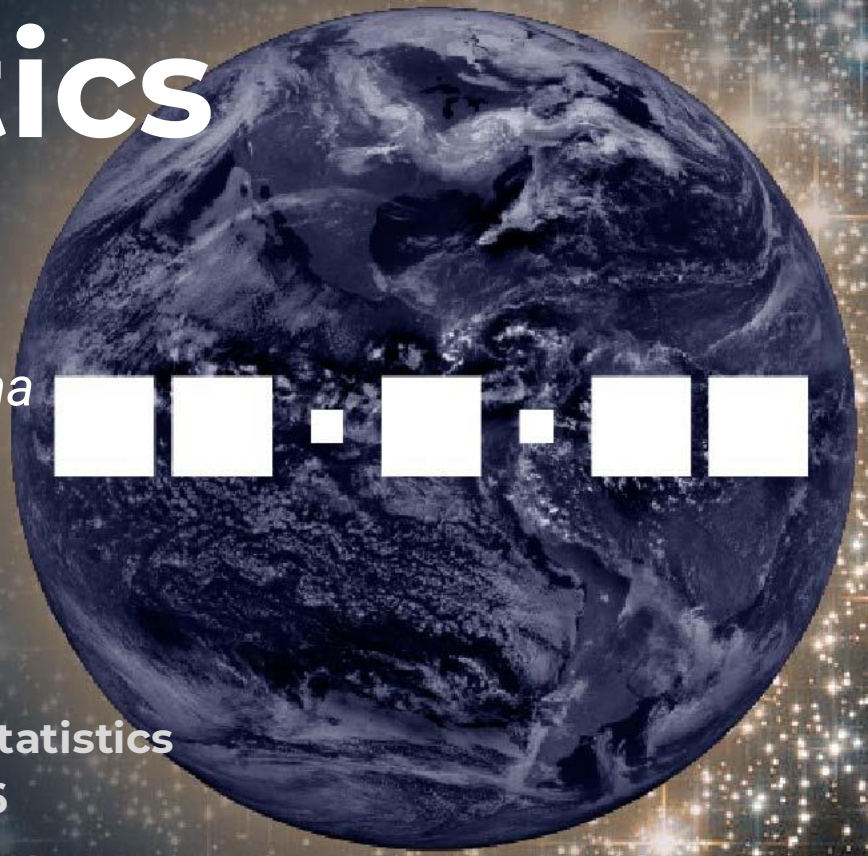
Task Force for the Format of Combination Statistics

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IGS INTERNATIONAL GNSS SERVICE

The 3rd meeting for the format of combination statistics
Wuhan Combination Center (WCC) October 2026

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Current status

- 【Completed】 Finalize the objectives of the task force
- 【Completed】 Discuss and compare the JSON, SINEX and YAML formats
- 【Completed】 Discuss possible contents for product combination statistics
- 【Completed】 Design preliminary combination statistics in YAML format
- 【Completed】 Draft specification for the combination statistics file and accompanying YAML format. First and second round of community feedback collected
- 【In progress】 Continue refining the draft specification and YAML format based on first and second round community feedback
- 【In progress】 Improve the auxiliary plotting scripts for combination statistics file

Sections of combination statistics

- META
  - COMBINATION, PRODUCTS, COMMENTS
- ALIGNMENT
  - ORBIT, CLOCK, BIAS
- WEIGHT
  - ERP, ORBIT, CLOCK, BIAS
- CONSISTENCY
  - ERP, ORBIT, CLOCK, BIAS
- BOUNDARY
  - ORBIT, CLOCK
- OUTLIER
  - ORBIT, CLOCK, BIAS

```
%YAML 1.2
---
META:
  COMBINATION: ···
  PRODUCTS: ···
  COMMENTS: ···
ALIGNMENT:
  ORBIT: ···
  CLOCK: ···
  BIAS: ···
WEIGHT:
  ERP: ···
  ORBIT: ···
  CLOCK: ···
  BIAS: ···
CONSISTENCY:
  ERP: ···
  ORBIT: ···
  CLOCK: ···
  BIAS: ···
BOUNDARY:
  ORBIT: ···
  CLOCK: ···
OUTLIER:
  ORBIT: ···
  CLOCK: ···
  BIAS: ···
...
```

COMB_YAML format structure

esp. Floating-Point Format Specification

- Decimal digits to meet physical resolution requirements

- One decimal digit: mm, µas, ps, µs, and %; Other: ppb (2), ps/d (4), µas/d (3)

Block	Fields	Unit	Format
ALIGNMENT:ORBIT	DX/DY/DZ; RX/RY/RZ; SCALE	mm; µas; ppb	%.1f; %.1f; %.2f
ALIGNMENT:CLOCK	OFFSET ; DRIFT	ps ; ps/d	%.1f; %.4f
ALIGNMENT:BIAS	OFFSET	ps	%.1f
CONSISTENCY:ERP	POLE; RATE; LOD	µas; µas/d; µs	%.1f; %.3f; %.1f
CONSISTENCY:ORBIT	RMS_RADIAL; RMS_ALONG_TRACK; RMS_CROSS_TRACK	mm	%.1f
CONSISTENCY:CLOCK	RMS	ps	%.1f
CONSISTENCY:CLOCK	RMS	ps	%.1f
All others	WEIGHT	%	%.1f

META:COMBINATION Block

- Basic information of the combined products
  - Start and end epoch of the combined products
  - Satellite systems and reference signals
  - Reference GNSS used for receiver clocks
  - Antenna phase center (APC) model
  - List of contributing Analysis Centers (ACs)

```
META:
  COMBINATION:
    START_EPOCH: 2026-01-01 00:00:00
    END_EPOCH: 2026-01-02 00:00:00
    SATELLITE_SYSTEM: GPS GLONASS GALILEO
    REFERENCE_SIGNALS: {GPS: C1W C2W, GLONASS: C1P C2P, GALILEO: C1C C5Q}
    RECEIVER_CLOCK_REFERENCE_GNSS: GPS
    APC: IGS20_2361
    ANALYSIS_CENTERS: COD EMR ESA GFZ GRG HUS IGS JGX JPL MIT NGS SIO
```

META:COMBINATION Block snapshot

META:PRODUCTS Block

- List of the products provided by each AC and their file names
  - Product type and satellite systems
  - File names of the orbit, clock, attitude, bias, ERP and APC model
  - An empty field indicates that the corresponding product type is not provided

```
PRODUCTS:
 - {AC: COD, TYPE: OPSFIN, SYS: GRE, ORBIT: COD0OPSFIN_20260010000_01D_05M_ORB.SP3, CLOCK: COD0OPSFIN_20260010000_01D_30S_CLK.CLK, ATTITUDE:
 COD0OPSFIN_20260010000_01D_30S_ATT.OBX, BIAS: COD0OPSFIN_20260010000_01D_01D_OSB.BIA, ERP: COD0OPSFIN_20260010000_01D_01D_ERP.ERP, APC:      igs20.atx}
 - {AC: EMR, TYPE: OPSFIN, SYS: G  , ORBIT: EMR0OPSFIN_20260010000_01D_05M_ORB.SP3, CLOCK: EMR0OPSFIN_20260010000_01D_30S_CLK.CLK, ATTITUDE:
 EMR0OPSFIN_20260010000_01D_30S_ATT.OBX, BIAS: EMR0OPSFIN_20260010000_01D_01D_OSB.BIA, ERP: EMR0OPSFIN_20260010000_01D_01D_ERP.ERP, APC: igs20_2388.atx}
 - {AC: ESA, TYPE: OPSFIN, SYS: GRE, ORBIT: ESA0OPSFIN_20260010000_01D_05M_ORB.SP3, CLOCK: ESA0OPSFIN_20260010000_01D_30S_CLK.CLK,
 ATTITUDE:                                , BIAS:                                , ERP: ESA0OPSFIN_20260010000_01D_01D_ERP.ERP, APC: esa23_2391.atx}
 - {AC: GFZ, TYPE: OPSFIN, SYS: GRE, ORBIT: GFZ0OPSFIN_20260010000_01D_05M_ORB.SP3, CLOCK: GFZ0OPSFIN_20260010000_01D_30S_CLK.CLK,
 ATTITUDE:                                , BIAS:                                , ERP: GFZ0OPSFIN_20260010000_01D_01D_ERP.ERP, APC: igs20_2375.atx}
 - {AC: GRG, TYPE: OPSFIN, SYS: GRE, ORBIT: GRG0OPSFIN_20260010000_01D_05M_ORB.SP3, CLOCK: GRG0OPSFIN_20260010000_01D_30S_CLK.CLK, ATTITUDE:
 GRG0OPSFIN_20260010000_01D_30S_ATT.OBX, BIAS: GRG0OPSFIN_20260010000_01D_01D_OSB.BIA, ERP: GRG0OPSFIN_20260010000_01D_01D_ERP.ERP, APC: igs20_2388.atx}
 - {AC: HUS, TYPE: MGXFIN, SYS: GRE, ORBIT: HUS0MGXFIN_20260010000_01D_05M_ORB.SP3, CLOCK: HUS0MGXFIN_20260010000_01D_30S_CLK.CLK, ATTITUDE:
 HUS0MGXFIN_20260010000_01D_30S_ATT.OBX, BIAS: HUS0MGXFIN_20260010000_01D_01D_OSB.BIA, ERP: HUS0MGXFIN_20260010000_01D_01D_ERP.ERP, APC: igs20_2388.atx}
 - {AC: IGS, TYPE: OPSFIN, SYS: G  , ORBIT: IGS0OPSFIN_20260010000_01D_15M_ORB.SP3, CLOCK: IGS0OPSFIN_20260010000_01D_30S_CLK.CLK,
 ATTITUDE:                                , BIAS:                                , ERP:                                , APC:      igs20.atx}
```

META:PRODUCTS Block snapshot

META:COMMENTS Block

- Other information on the COMB_YAML file
  - File version, the agency that created the file, the creation time
  - Organization(s) that gathered or altered the file contents
  - Description of the file contents, contact information
  - Software and hardware environments used to generate the file
  - FTP URLs, and literature references

```yaml
COMMENTS:
  COMB_VERSION: 0.01
  CREATED_BY: SKLPG
  CREATED_ON: 2026-09-16 08:42:33
  DESCRIPTION: "PRIDE Lab, State Key Laboratory of Precision Geodesy, APM, CAS"
  OUTPUT: The quality information for each AC in Comb-YAML format
  CONTACT: pride@apm.ac.cn
  SOFTWARE: ckcom
  HARDWARE: "CentOS: Linux, x86_64"
  URL: "ftps://bdspride.com/wcc/"
  ARTICLES:
    - "Geng J, Yan Z, Wen Q, et al. Integrated satellite clock and code/phase bias combination in the third IGS reprocessing campaign.
    GPS Solutions, 2024, 28(3): 150."
    - "Geng J, Wen Q, Wang B, and Zhang Y, and the The IGS Task Force to Standardize GNSS Product Combination Statistics. The IGS task
    force for a standardized format of GNSS satellite product combination statistics, EGU General Assembly 2026, Vienna, Austria, 3-8
    May 2026, EGU26-2264, https://doi.org/10.5194/egusphere-egu26-2264, 2026."
```

META:COMMENTS Block snapshot

ALIGNMENT:ORBIT Block

- Helmert transformation parameters from each AC to the combined orbit
  - Three translation parameters [mm] and three rotation parameters [μas]
  - One scale parameter [ppb]
  - Seven-parameter transformation supported for each GNSS system

```
ALIGNMENT:
  ORBIT:
    - {AC: COD, SYS: G, DX:  -1.0, DY:   0.0, DZ:   3.0, RX: -23.0, RY:   2.0, RZ: -13.0, SCALE: -0.02}
    - {AC: COD, SYS: R, DX:  -1.0, DY:   0.0, DZ:   3.0, RX: -11.0, RY:  -5.0, RZ:  10.0, SCALE: -0.04}
    - {AC: COD, SYS: E, DX:  -1.0, DY:   0.0, DZ:   5.0, RX:  -1.0, RY:  14.0, RZ:  -6.0, SCALE:  0.08}
    - {AC: EMR, SYS: G, DX:   1.0, DY:  -2.0, DZ:  -3.0, RX:  16.0, RY:  16.0, RZ: -15.0, SCALE: -0.01}
    - {AC: ESA, SYS: G, DX:   0.0, DY:   0.0, DZ:  -1.0, RX:  14.0, RY:   4.0, RZ: -28.0, SCALE: -0.00}
    - {AC: ESA, SYS: R, DX:  -1.0, DY:   0.0, DZ:  -3.0, RX:  -6.0, RY:  18.0, RZ:  32.0, SCALE: -0.29}
    - {AC: ESA, SYS: E, DX:   1.0, DY:   1.0, DZ:   0.0, RX:  19.0, RY:  11.0, RZ: -29.0, SCALE: -0.61}
    - {AC: GFZ, SYS: G, DX:  -1.0, DY:   1.0, DZ:   2.0, RX:  13.0, RY:  25.0, RZ: -17.0, SCALE:  0.14}
    - {AC: GFZ, SYS: R, DX:   0.0, DY:   2.0, DZ:   1.0, RX:  41.0, RY:  22.0, RZ:  35.0, SCALE: -0.01}
    - {AC: GFZ, SYS: E, DX:   0.0, DY:   2.0, DZ:  -6.0, RX:  32.0, RY:  29.0, RZ: -23.0, SCALE:  0.10}
    - {AC: GRG, SYS: G, DX:   0.0, DY:   1.0, DZ:   1.0, RX:   0.0, RY:   7.0, RZ: -30.0, SCALE: -0.00}
    - {AC: GRG, SYS: R, DX:   0.0, DY:  -1.0, DZ:   0.0, RX:  17.0, RY:  13.0, RZ: -69.0, SCALE:  0.14}
    - {AC: GRG, SYS: E, DX:   0.0, DY:   0.0, DZ:   2.0, RX:  -3.0, RY:  20.0, RZ: -23.0, SCALE:  0.31}
    - {AC: JGX, SYS: G, DX:   0.0, DY:   0.0, DZ:  -2.0, RX:  -6.0, RY:  27.0, RZ: -19.0, SCALE:  0.04}
```

ALIGNMENT:ORBIT Block snapshot

ALIGNMENT:CLOCK Block

- Alignment of ACs' clock products
  - Offset/drift: aligning AC's satellite/receiver clocks to the combined clock [ps, ps/d]
  - Note: a linear fitting is needed in the case of epoch-wise alignment

```
CLOCK:
  - {AC: GRG, SYS: G, SVN: G080, PRN: G01, STATION: -------  , OFFSET:      -6328.5, DRIFT:   450.1955}
  - {AC: GRG, SYS: G, SVN: G061, PRN: G02, STATION: -------  , OFFSET:      -9896.1, DRIFT:   450.1955}
  - {AC: GRG, SYS: G, SVN: G069, PRN: G03, STATION: -------  , OFFSET:       1520.1, DRIFT:   450.1955}
  - {AC: GRG, SYS: G, SVN: G074, PRN: G04, STATION: -------  , OFFSET:      -3474.5, DRIFT:   450.1955}
  - {AC: GRG, SYS: G, SVN: G050, PRN: G05, STATION: -------  , OFFSET:      -2761.0, DRIFT:   450.1955}
  - {AC: GRG, SYS: -, SVN: ----, PRN: ---, STATION: ALIC00AUS, OFFSET:      -3026.4, DRIFT:   449.6432}
  - {AC: GRG, SYS: -, SVN: ----, PRN: ---, STATION: AREG00PER, OFFSET:      -6002.6, DRIFT:   449.6432}
  - {AC: GRG, SYS: -, SVN: ----, PRN: ---, STATION: AREQ00PER, OFFSET:      -7922.2, DRIFT:   449.6432}
  - {AC: GRG, SYS: -, SVN: ----, PRN: ---, STATION: ASCG00SHN, OFFSET:      -5388.6, DRIFT:   449.6432}
  - {AC: GRG, SYS: -, SVN: ----, PRN: ---, STATION: BAKE00CAN, OFFSET:      -3927.3, DRIFT:   449.6432}
  - {AC: GRG, SYS: -, SVN: ----, PRN: ---, STATION: BHR400BHR, OFFSET:      -7249.7, DRIFT:   449.6432}
  - {AC: GRG, SYS: -, SVN: ----, PRN: ---, STATION: BJFS00CHN, OFFSET:      -4394.1, DRIFT:   449.6432}
```

ALIGNMENT:CLOCK Block snapshot

ALIGNMENT:BIAS Block

- The (code) bias alignment
  - Offset between the AC solution and the combined solution [ps]
  - Both OSB and DCB are supported

```
BIAS:
  - {AC: GRG, SYS: G, OBSERVABLE_1: C1W, OBSERVABLE_2: C2W, OFFSET:  -0.0}
  - {AC: EMR, SYS: G, OBSERVABLE_1: C1W, OBSERVABLE_2: C2W, OFFSET: 421.5}
  - {AC: COD, SYS: G, OBSERVABLE_1: C1W, OBSERVABLE_2: C2W, OFFSET: 417.2}
  - {AC: HUS, SYS: G, OBSERVABLE_1: C1W, OBSERVABLE_2: C2W, OFFSET: 420.1}
  - {AC: GRG, SYS: G, OBSERVABLE_1: C1W, OBSERVABLE_2: C1C, OFFSET:  -0.0}
  - {AC: EMR, SYS: G, OBSERVABLE_1: C1W, OBSERVABLE_2: C1C, OFFSET:   1.1}
  - {AC: COD, SYS: G, OBSERVABLE_1: C1W, OBSERVABLE_2: C1C, OFFSET:   0.3}
  - {AC: HUS, SYS: G, OBSERVABLE_1: C1W, OBSERVABLE_2: C1C, OFFSET:   4.4}
  - {AC: GRG, SYS: E, OBSERVABLE_1: C1C, OBSERVABLE_2: C5Q, OFFSET:  -0.0}
  - {AC: COD, SYS: E, OBSERVABLE_1: C1C, OBSERVABLE_2: C5Q, OFFSET: 455.2}
  - {AC: HUS, SYS: E, OBSERVABLE_1: C1C, OBSERVABLE_2: C5Q, OFFSET: 290.0}
```

ALIGNMENT:BIAS Block snapshot

WEIGHT Section

- AC's product contribution in different product combinations (4 Blocks: ERP/ORBIT/CLOCK/BIAS)
- Support AC-, system- and satellite-specific weighting strategies

```
WEIGHT:
  ERP:
    - {AC: COD, PERCENT:  13.7}
    - {AC: EMR, PERCENT:   6.8}
    - {AC: ESA, PERCENT:  17.0}
  ORBIT:
    - {AC: COD, SYS: G, SVN: ----, PRN: ---, PERCENT:  13.7}
    - {AC: COD, SYS: R, SVN: ----, PRN: ---, PERCENT:  32.0}
    - {AC: COD, SYS: E, SVN: ----, PRN: ---, PERCENT:  16.1}
    - {AC: EMR, SYS: G, SVN: ----, PRN: ---, PERCENT:   6.8}
    - {AC: ESA, SYS: G, SVN: ----, PRN: ---, PERCENT:  17.0}
  CLOCK:
    - {AC: COD, SYS: ----, SVN: ----, PRN: ---, STATION: -------, PERCENT:  17.6}
    - {AC: EMR, SYS: ----, SVN: ----, PRN: ---, STATION: -------, PERCENT:  14.2}
    - {AC: ESA, SYS: ----, SVN: ----, PRN: ---, STATION: -------, PERCENT:  15.4}
    - {AC: GFZ, SYS: ----, SVN: ----, PRN: ---, STATION: -------, PERCENT:  10.7}
    - {AC: GRG, SYS: ----, SVN: ----, PRN: ---, STATION: -------, PERCENT:  13.2}
  BIAS:
    - {AC: COD, SYS: G, SVN: ----, PRN: ---, STATION: -------, OBSERVABLE_1: C1W, OBSERVABLE_2: C2W, PERCENT:  25.0}
    - {AC: EMR, SYS: G, SVN: ----, PRN: ---, STATION: -------, OBSERVABLE_1: C1W, OBSERVABLE_2: C2W, PERCENT:  25.0}
    - {AC: GRG, SYS: G, SVN: ----, PRN: ---, STATION: -------, OBSERVABLE_1: C1W, OBSERVABLE_2: C2W, PERCENT:  25.0}
    - {AC: HUS, SYS: G, SVN: ----, PRN: ---, STATION: -------, OBSERVABLE_1: C1W, OBSERVABLE_2: C2W, PERCENT:  25.0}
```

Weight section snapshot

CONSISTENCY:ERP Block

- RMSE between each AC's ERP and the combined ERP
  - Start and end epoch of the data, and number of total epochs
  - RMSE of X pole and Y pole differences [μas] and their rate differences [μas/d]
  - RMSE of LOD differences [μs]

```
ERP:
  - {AC: COD, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS_X_POLE:   2.0, RMS_Y_POLE:  22.0,
  RMS_X_POLE_RATE: 94.000, RMS_Y_POLE_RATE: 143.000, RMS_LOD:  14.0}
  - {AC: EMR, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS_X_POLE:  15.0, RMS_Y_POLE:  13.0,
  RMS_X_POLE_RATE: 46.000, RMS_Y_POLE_RATE:  79.000, RMS_LOD:  33.0}
  - {AC: ESA, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS_X_POLE:   1.0, RMS_Y_POLE:   4.0,
  RMS_X_POLE_RATE: 22.000, RMS_Y_POLE_RATE:  64.000, RMS_LOD:   2.0}
  - {AC: GFZ, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS_X_POLE:  29.0, RMS_Y_POLE:  30.0,
  RMS_X_POLE_RATE: 93.000, RMS_Y_POLE_RATE:  88.000, RMS_LOD:  13.0}
  - {AC: GRG, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS_X_POLE:  28.0, RMS_Y_POLE:  30.0,
  RMS_X_POLE_RATE: 66.000, RMS_Y_POLE_RATE: 121.000, RMS_LOD:  17.0}
  - {AC: JGX, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS_X_POLE:   3.0, RMS_Y_POLE:  36.0,
  RMS_X_POLE_RATE:  6.000, RMS_Y_POLE_RATE:  47.000, RMS_LOD:   7.0}
```

CONSISTENCY:ERP Block snapshot

CONSISTENCY:ORBIT Block

- RMSE between each AC's orbit and the combined orbit
  - Start and end epoch of the data, and number of total epochs
  - RMSE of satellite orbit differences in the radial, along-track, and cross-track directions [mm]

```
ORBIT:
  - {AC: COD, SYS: E, SVN: E211, PRN: E02, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288,
  RMS_RADIAL:   9.5, RMS_ALONG_TRACK:  10.5, RMS_CROSS_TRACK:   8.0}
  - {AC: COD, SYS: E, SVN: E212, PRN: E03, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288,
  RMS_RADIAL:  13.9, RMS_ALONG_TRACK:  11.0, RMS_CROSS_TRACK:   8.0}
  - {AC: COD, SYS: E, SVN: E213, PRN: E04, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288,
  RMS_RADIAL:  11.3, RMS_ALONG_TRACK:  10.2, RMS_CROSS_TRACK:   6.0}
  - {AC: COD, SYS: E, SVN: E214, PRN: E05, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288,
  RMS_RADIAL:   7.5, RMS_ALONG_TRACK:  14.1, RMS_CROSS_TRACK:   7.0}
  - {AC: COD, SYS: E, SVN: E227, PRN: E06, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288,
  RMS_RADIAL:   7.1, RMS_ALONG_TRACK:   9.0, RMS_CROSS_TRACK:   5.4}
  - {AC: COD, SYS: E, SVN: E207, PRN: E07, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288,
  RMS_RADIAL:   8.1, RMS_ALONG_TRACK:   7.0, RMS_CROSS_TRACK:  11.4}
  - {AC: COD, SYS: E, SVN: E208, PRN: E08, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288,
  RMS_RADIAL:  15.6, RMS_ALONG_TRACK:  11.8, RMS_CROSS_TRACK:  12.1}
  - {AC: COD, SYS: E, SVN: E209, PRN: E09, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288,
  RMS_RADIAL:   9.6, RMS_ALONG_TRACK:  12.5, RMS_CROSS_TRACK:   8.9}
```

CONSISTENCY:ORBIT Block snapshot

CONSISTENCY:CLOCK Block

- RMSE between each AC's clock and the combined clock
  - Start and end epoch of the data, and number of total epochs
  - RMSE of satellite and receiver clock differences[ps]

```
CLOCK:
 - {AC: COD, SYS: E, SVN: E211, PRN: E02, STATION: -------  , START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00,
NUM_EPOCH:  2881, RMS:   5.0}
 - {AC: COD, SYS: E, SVN: E212, PRN: E03, STATION: -------  , START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00,
NUM_EPOCH:  2881, RMS:   4.0}
 - {AC: COD, SYS: E, SVN: E213, PRN: E04, STATION: -------  , START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00,
NUM_EPOCH:  2881, RMS:   6.0}
 - {AC: COD, SYS: E, SVN: E214, PRN: E05, STATION: -------  , START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00,
NUM_EPOCH:  2881, RMS:   5.0}
 - {AC: COD, SYS: -, SVN: ----, PRN: ---, STATION: ABMF00GLP, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-01 23:55:00,
NUM_EPOCH:   288, RMS:  12.0}
 - {AC: COD, SYS: -, SVN: ----, PRN: ---, STATION: AC2400USA, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-01 23:55:00,
NUM_EPOCH:   288, RMS:   4.0}
 - {AC: COD, SYS: -, SVN: ----, PRN: ---, STATION: ADIS00ETH, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-01 23:55:00,
NUM_EPOCH:   288, RMS:   6.0}
 - {AC: COD, SYS: -, SVN: ----, PRN: ---, STATION: AIRA00JPN, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-01 23:55:00,
NUM_EPOCH:   288, RMS:   0.0}
```

CONSISTENCY:CLOCK Block snapshot

CONSISTENCY:BIAS Block

- RMSE between each AC's bias and the combined code bias
  - Start and end epoch of the data, and number of total epochs
  - RMS of the bias difference [ps]
  - Both OSB and DCB are supported

```
BIAS:
  - {AC: COD, SYS: G, SVN: G080, PRN: G01, STATION: -------, OBSERVABLE_1: C1C, OBSERVABLE_2: ----, START_EPOCH: 2026-01-01 00:00:00,
  END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS:   40.2}
  - {AC: COD, SYS: G, SVN: G080, PRN: G01, STATION: -------, OBSERVABLE_1: C1W, OBSERVABLE_2: ----, START_EPOCH: 2026-01-01 00:00:00,
  END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS:    2.0}
  - {AC: COD, SYS: G, SVN: G080, PRN: G01, STATION: -------, OBSERVABLE_1: C2W, OBSERVABLE_2: ----, START_EPOCH: 2026-01-01 00:00:00,
  END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS:    3.3}
  - {AC: COD, SYS: G, SVN: G061, PRN: G02, STATION: -------, OBSERVABLE_1: C1C, OBSERVABLE_2: ----, START_EPOCH: 2026-01-01 00:00:00,
  END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS:   11.1}
  - {AC: COD, SYS: G, SVN: G061, PRN: G02, STATION: -------, OBSERVABLE_1: C1W, OBSERVABLE_2: ----, START_EPOCH: 2026-01-01 00:00:00,
  END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS:   49.4}
  - {AC: COD, SYS: G, SVN: G061, PRN: G02, STATION: -------, OBSERVABLE_1: C2W, OBSERVABLE_2: ----, START_EPOCH: 2026-01-01 00:00:00,
  END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS:   81.1}
  - {AC: COD, SYS: G, SVN: G069, PRN: G03, STATION: -------, OBSERVABLE_1: C1C, OBSERVABLE_2: ----, START_EPOCH: 2026-01-01 00:00:00,
  END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS:  259.1}
  - {AC: COD, SYS: G, SVN: G069, PRN: G03, STATION: -------, OBSERVABLE_1: C1W, OBSERVABLE_2: ----, START_EPOCH: 2026-01-01 00:00:00,
  END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1, RMS:  237.3}
```

CONSISTENCY:BIAS Block snapshot

BOUNDARY Section

- Day-boundary discontinuity between consecutive daily products
  - ORBIT: Discontinuity in R/A/C components [mm]
  - CLOCK: Discontinuity of the clocks [ps]
  - A missing record means the 24:00 epochs are not all available

```
BOUNDARY:
  ORBIT:
    - {AC: WCC, SYS: E, SVN: E211, PRN: E02, EPOCH: 2026-01-02 00:00:00, DIFF_RADIAL:   2.0, DIFF_ALONG_TRACK: -13.0, DIFF_CROSS_TRACK:  19.0}
    - {AC: WCC, SYS: E, SVN: E212, PRN: E03, EPOCH: 2026-01-02 00:00:00, DIFF_RADIAL:   4.0, DIFF_ALONG_TRACK:   0.0, DIFF_CROSS_TRACK:   0.0}
    - {AC: WCC, SYS: E, SVN: E213, PRN: E04, EPOCH: 2026-01-02 00:00:00, DIFF_RADIAL:   9.0, DIFF_ALONG_TRACK:   3.0, DIFF_CROSS_TRACK:   0.0}
    - {AC: WCC, SYS: E, SVN: E214, PRN: E05, EPOCH: 2026-01-02 00:00:00, DIFF_RADIAL:   3.0, DIFF_ALONG_TRACK:  11.0, DIFF_CROSS_TRACK:   5.0}
  CLOCK:
    - {AC: WCC, SYS: E, SVN: E211, PRN: E02, STATION: -------, EPOCH: 2026-01-02 00:00:00, DIFF:   5.0}
    - {AC: WCC, SYS: E, SVN: E212, PRN: E03, STATION: -------, EPOCH: 2026-01-02 00:00:00, DIFF:   0.0}
    - {AC: WCC, SYS: E, SVN: E213, PRN: E04, STATION: -------, EPOCH: 2026-01-02 00:00:00, DIFF:   0.0}
    - {AC: WCC, SYS: E, SVN: E214, PRN: E05, STATION: -------, EPOCH: 2026-01-02 00:00:00, DIFF: -11.0}
    - {AC: WCC, SYS: E, SVN: E227, PRN: E06, STATION: -------, EPOCH: 2026-01-02 00:00:00, DIFF:   3.0}
    - {AC: WCC, SYS: E, SVN: E207, PRN: E07, STATION: -------, EPOCH: 2026-01-02 00:00:00, DIFF:   6.0}
    - {AC: WCC, SYS: E, SVN: E208, PRN: E08, STATION: -------, EPOCH: 2026-01-02 00:00:00, DIFF:   2.0}
    - {AC: WCC, SYS: E, SVN: E209, PRN: E09, STATION: -------, EPOCH: 2026-01-02 00:00:00, DIFF:  -3.0}
```

BOUNDARY section snapshot

OUTLIER Section

- Outliers detected during combination for orbit, clock and bias products
  - Start and end epoch of the outlier parts, and the number of outliers
  - In the CLOCK block, station clocks are also allowed

```
OUTLIER:
  ORBIT:
    - {AC: COD, SYS: R, SVN: R804, PRN: R06, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288}
    - {AC: ESA, SYS: R, SVN: R804, PRN: R06, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288}
    - {AC: GFZ, SYS: R, SVN: R804, PRN: R06, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288}
    - {AC: GFZ, SYS: R, SVN: R808, PRN: R20, START_EPOCH: 2026-01-01 00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:   288}
  CLOCK:
    - {AC: COD, SYS: -, SVN: ----, PRN: ---, STATION: ABMF00GLP, START_EPOCH: 2026-01-01 10:55:00, END_EPOCH: 2026-01-01
    11:00:00, NUM_EPOCH:     2}
    - {AC: COD, SYS: -, SVN: ----, PRN: ---, STATION: AREQ00PER, START_EPOCH: 2026-01-01 01:15:00, END_EPOCH: 2026-01-01
    02:05:00, NUM_EPOCH:    11}
    - {AC: COD, SYS: -, SVN: ----, PRN: ---, STATION: AREQ00PER, START_EPOCH: 2026-01-01 02:15:00, END_EPOCH: 2026-01-01
    02:15:00, NUM_EPOCH:     1}
  BIAS:
    - {AC: COD, SYS: E, SVN: E211, PRN: E02, STATION: -------, OBSERVABLE_1: C1C, OBSERVABLE_2: C5Q, START_EPOCH: 2026-01-01
    00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1}
    - {AC: COD, SYS: E, SVN: E212, PRN: E03, STATION: -------, OBSERVABLE_1: C1X, OBSERVABLE_2: C5X, START_EPOCH: 2026-01-01
    00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1}
    - {AC: COD, SYS: E, SVN: E214, PRN: E05, STATION: -------, OBSERVABLE_1: C1C, OBSERVABLE_2: C1X, START_EPOCH: 2026-01-01
    00:00:00, END_EPOCH: 2026-01-02 00:00:00, NUM_EPOCH:     1}
```

OUTLIER section snapshot

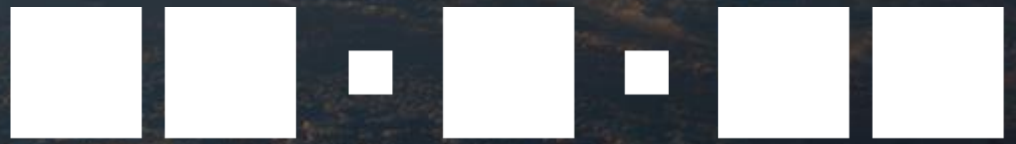
Python Parser

- Read the COMB_YAML statistics file
- Released alongside the COMB_YAML format
- Supports command-line plotting in Python (e.g., heat maps)

Parser	Input	Output	Key Features
Comb_YAML_parser.py	*_CMB.YML combination file path	Python nested dictionary structure; print human-readable summary; export selected fields	Rapid prototyping; convenient for statistics & plotting

Next steps

- Continue to improve the specification for the combination statistics in Google Docs
  - Collect and respond to the community feedback on the YAML format
- Develop auxiliary python tools to visualize the YAML format
- Prepared to submit the format proposal to the Governing Board in December



IGS INTERNATIONAL GNSS SERVICE

Thank You!

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Community Feedback & Responses

No.	Contributor	Revision Suggestion	Response
1	Sylvain Loyer Lotfi Massarweh	**Clarification for all epoch-related quantities**: Timestamps should preferably use GNSS Time, in phase with SP3 products.	**Adding a timestamp specification in Section 3.2** (Advanced features): All timestamps follow GNSS time, consistent with IGS SP3 products.
2	Sylvain Loyer	Clarify the possible causes of missing BOUNDARY: Orbit/Clock records.	Adding a note in the specification stating that "an absent BOUNDARY record means the boundary epoch was unavailable in at least one solution, with no extrapolation performed"
3	Sylvain Loyer	**Rename the "BIAS" boundary term to avoid naming ambiguity**, recommend using alternative formal expressions like Equivalent Pseudo-Range Continuity as the substitute.	**Chapter 5 Revision**: The BOUNDARY section has been restructured into two sub-blocks BOUNDARY: ORBIT and BOUNDARY: CLOCK **Chapter 6 Update**: Accordingly, the formal definition and descriptive text of BOUNDARY have been updated to align with the revised terminology framework.
4	Lotfi Massarweh	**About Chapter BOUNDARY: ORBIT/BIAS block** (mandatory), Note clock/bias-induced discontinuities in orbit consistency assessment, and specify RAC coordinate definition (DOY boundary epoch + velocity term) for reproducibility.	

Community Feedback & Responses

No.	Contributor	Revision Suggestion	Response
5	Sylvain Loyer	**Besides pseudorange OSB results, additionally present the consistency or boundary information of DCB**, which are the core output quantities in the combination process.	**OBS1/OBS2 in CONSISTENCY: BIAS block**, supporting OSB/DCB product consistency verification.
6	Lotfi Massarweh	**Check the consistency between the Helmert parameters formula in Section 6 and Table 8**, and supplement the units description for the dimensionless quantities in the formula definition of Section 6.1. **The accompanying executable scripts in Chapter 8 are recommended to be stored in a Git repository**. **Replace the current image-based equations with native LaTeX-formatted equations in the offline Word version** after the document is finalized. **Add a practical YAML syntax example, as implemented in RINEX documentation.**	**Helmert parameters:** Corresponding unit descriptions will be added in the parameter annotation part of the formula in Section 6.1. **How to use the file and the scripts in Appendix:** This section will add function descriptions for plotting scripts and the corresponding Git repository address, with all files hosted on GitHub. **Formula**: Google Docs formula rendering has limitations, and will implement native LaTeX formatting for all equations in Word after the manuscript is completed. **YAML syntax example:** Figure 1 with intuitive YAML syntax example has been supplemented in this section for clearer structure reading

Community Feedback & Responses

No.	Contributor	Revision Suggestion	Response
7	Lotfi Massarweh	**About the YAML file.** a) **OBS2/OSB2** naming appears mixed in text and figures, further clarification required. b) **Replace ambiguous 24:00:00 timestamp** notation for BOUNDARY/SISRE end epochs, ensure full compatibility with YAML 1.2 specifications. c) **Check and unify the definition consistency of Day Boundary Discontinuity** (DBD) in Section 6.3, and replace DISCONTINUITY/SISRE with 4 signed DBD components (R/A/C/T, field BOUNDARY/DBD) for users to calculate SISRE independently.	**OSB2/OBS2 mismatch**: Rename all ambiguous shorthand OBS to full OBSERVABLE in docs and YAML to eliminate OSB/OBS confusion. **24:00:00 epoch issue**: Verified YAML 1.2 rejects 24:00:00 notation, all end epochs will be adjusted to equivalent YYYY-MM-DD+1 00:00:00 for full compatibility. **DBD rework**: BOUNDARY outputs signed DBD components RADIAL / ALONG_TRACK / CROSS_TRACK (mm) plus clock DISCONTINUITY (ps), enabling users to derive any SISRE variant locally.
8	Michael J. Coleman	**Recommend ending the document at Chapter 5.** Post-Chapter 5 content (implementation-specific solution/combination particulars and user-developed tools) should be separated from the pure format definition and hosted in an independent standalone documentation file.	**All post-Chapter 5 non-format-definition content would be split**: general references stay in the main doc's appendix, all implementation-specific parts are moved to an independent standalone document.

Community Feedback & Responses

No.	Contributor	Revision Suggestion	Response
9	Pascal Stebler	a) **Add example data section** to YAML specification (following RINEX standard convention) b) **Explicitly note that ordered lists** (- ...) are used to preserve sequence of entries c) **Clarify applicable scope of ordered list blocks** (all blocks except META:?) d) **Add concise explanation of inline dictionary** {...} and its usage rules e) **Specify YAML mapping order limitation**: Standard YAML does not guarantee map sequence retention; list order (- ...) is stable, while inline dict {...} may lose order across different parsing tools	**Add a standalone example data section to the YAML specification**, formatted following standard RINEX conventions. **Add specs notes**: ordered lists (-) are required for all blocks except META, to strictly preserve entry sequence. **Add a short guide in docs for inline mappings** ({...}), clarifying it is only a human-friendly concise formatting option for single-line parameter sets. **Explicitly document that YAML 1.2 does not preserve mapping key order** — but all our fields use explicit named keys (not positional parsing), so reordered inline mappings will never cause data misreading.

Community Feedback & Responses

No.	Contributor	Revision Suggestion	Response
10	Paul Rebischung	**a) YAML Timestamp Compatibility** Resolve 24:00:00 epoch YAML parsing error: Remove ENEPOCH in BOUNDARY/SISRE block, rename STEPOCH to EPOCH for YAML standard compliance. **b) Consistency & Helmert Transformation (Section 6.1/6.2)** Extend Helmert transformation to pole coordinates, add corresponding formulas for xp/yp alignment Update Consistency definition: Consistency refers to post-Helmert difference between AC and combined pole coordinates/orbits Align rotation sign convention with IERS Conventions Equation 4.3 **c) Format Scope Discussion** The current format is tailored to satellite product combination statistics, extending it to SINEX combination statistics may introduce unnecessary complexity.	**YAML Timestamp**: Remove invalid ENEPOCH, rename STEPOCH to EPOCH, to avoid YAML parsing error, epochs will be adjusted to equivalent YYYY-MM-DD+1 00:00:00 for full compatibility. **Consistency & Helmert update**: Clarify Section 6.2 that consistency refers to Helmert-aligned differences between AC and combined orbits/pole coordinates, add the provided pole coordinate transform formulas in Section 6.1. IERS convention alignment: Unify all Helmert rotation signs to strictly match IERS Conventions 4.3. **Format Scope Discussion:** Keep the current format focused exclusively on satellite product combination statistics, SINEX-related extensions will be reserved for future independent discussion.

Community Feedback & Responses

No.	Contributor	Revision Suggestion	Response
11	Simon Banville	**Section 6.4 (Outlier): "with a recommended value of 3"** Note that the 3σ threshold will retain ~0.3% distribution-tail points; marking these as outliers is not appropriate. **Section 6.2 (Consistency): Aligned DCB converted back to OSB** Recommend reporting directly computed raw statistics for DCBs and MWU instead. **Section 5.10.2 (Consistency: BIAS, Table13 OBS2)** Propose replacing OBS1/OBS2 with an extensible OBS array to support Melbourne-Wubbena signals (L1W, L2W, C1W, C2W). **Section 5.9.1 (Consistency: CLOCK, integer clock)** Request explicit specification on which clocks/biases have integer properties, and whether integer offsets are resolved.	**Outliers:** MAD-based robust processing can be adopted, and related documentation will be updated. **DCB/OSB:** Raw statistics of DCBs will be directly reported, and DCB-to-OSB back-conversion is also retained to demonstrate OSB consistency. **OBS fields**: Currently only code OSBs (instead of phase OSBs) are considered for dual-frequency clocks. **Integer clock**: A dedicated integer-clock flag is not introduced, since the integer property can be inferred from the presence or absence of phase bias in the corresponding bias file. Integer clocks are full-cycle adjusted, and non-integer clocks are calibrated relative to the reference integer clock.

Community Feedback & Responses

No.	Contributor	Revision Suggestion	Response
12	Simon Banville	**Section 5.7.2 (Consistency: ERP, Table10 STEPOCH)** Suggest replacing all compressed abbreviations (e.g. STEPOCH) with full names, e.g. START_EPOCH across the document. **Section 5.13.1 (Outlier: CLOCK, clock jump handling)** Recommend adding clock jump magnitude reporting, and explicitly record jump epochs even when corresponding data is not excluded. **General comment on Table 1 (file format & CNT field)** Propose adopting YAML as the standard file format, aligned with current usage. Request clarification on CNT field options, to support single-type outputs (e.g. orbit-only, clock-only, bias-only files). **General comment on the mandatory property of blocks:** OUTLIER (BIAS, CLOCK, ORBIT), BOUNDARY: SISRE, CONSISTENCY (BIAS, CLOCK, ORBIT, ERP), and COMB: HELMERT should be optional, if an orbit/clock/bias combination was not computed.	**Naming convention**: All compressed abbreviations (e.g. STEPOCH) across the document will be replaced with full names (e.g. START_EPOCH). **Clock jump:** it should be sufficient to identify and report the epochs affected by outliers, allowing users to exclude those epochs during data processing. Estimating the actual magnitude of the outliers is challenging and may not be necessary. **File naming**: the combination file uses the "_CMB" product type with the ".YML" extension. A content-type field identifies the combination content (orbit / clock / bias or combinations), supporting single-product files. **General structural blocks:** To maintain format consistency, we recommend keeping all listed blocks in their designated positions. While their presence remains required, the content fields may be left empty if no orbit/clock/bias combination is computed.

Community Feedback & Responses

No.	Contributor	Revision Suggestion	Response
13	Simon Banville	**Define a consistent float format across all providers**: Would it be worth specifying a format for the float values that would make the number of digits consistent across all providers of YAML files?	A fixed-width format is proposed for all floating-point values, with each field specifying both total width and decimal places. Precision follows the physical target plus one redundant digit: 1 decimal place for mm, µas, µs, ps and %, 2 for scale (ppb), 3 for ERP polar motion rates (µas/d), and 4 for clock drift (ps/d). All clock and bias quantities are expressed in ps. This is a formatting convention only, and parsed values are unaffected.