Task Force for the Format of Combination Statistics

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The 2nd meeting for the format of combination statistics
Wuhan Combination Center (WCC) April 2026

Agenda

- Review of action items
- Discussion of SINEX_Comb file format and contents
- The next steps

Status of action items

- 【Complete】Finalize the goals of the task force
- 【Complete】Discuss and compare the JSON, SINEX and YAML formats
- 【Complete】Possible contents for product combination statistics
- 【In progress】Investigate the YAML format for the combination statistics
- 【In progress】ERP and station position combination statistics into the format

YAML file format for the combination statistics

- Open-source python script 'snx2yaml.py' has been developed (B. Wang)
  - Python standard library is used, no third-party libraries
  - SINEX file can be converted into the yaml format
  - Tabular format, and easily human and machine readable

SINEX format COMB/DESCRIPTION → YAML format COMB: DESCRIPTION

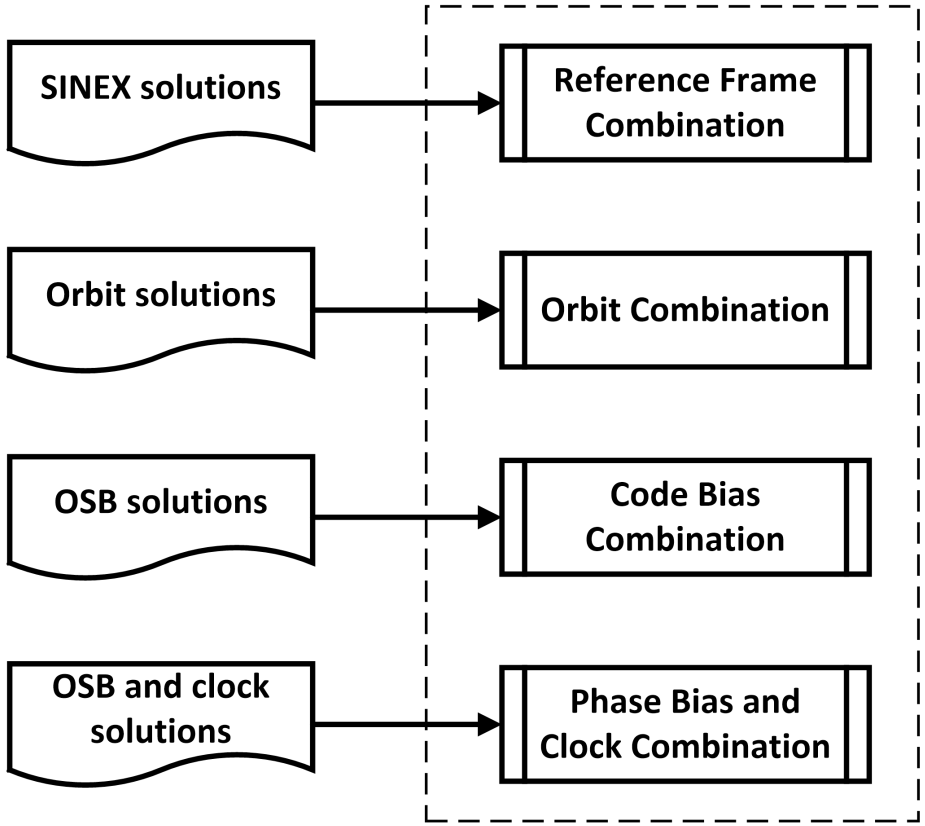
```
COMB:
  DESCRIPTION:
    - {ORBIT_SAMPLING: 300}
    - {CLOCK_SAMPLING: 30}
    - {RECEIVER_CLOCK_SAMPLING: 
    - {COMBINATION_INTERVAL: 864(
    - {"SATELLITE SYSTEM": G/R/E/C}
    - {ANALYSIS_CENTERS_NUMBER: 12}
    - {ANALYSIS_CENTERS_NAMES: ['cod', 'emr', 'esa', 'gfz', 'grg', 'hus', 'igs', 'jgx', 'jpl', 'mit', 'ngs', 'sio']}
  INFORMATION:
    - {AC: COD, LABEL: OPSFIN, SYS: GRE , ORBs: 300, CLKs:  30, ATTs:   1, OBSd:   1, ERPd:   1, ATX: IGS20, ORBEPOCH:  289, CLKEPOCH: 2881, RCVCLKEPOCH:  289, CLKTOTNUM: 304889, CLKBADNUM: 2981}
    - {AC: EMR, LABEL: OPSFIN, SYS: G   , ORBs: 300, CLKs:  30, ATTs:   1, OBSd:   1, ERPd:   1, ATX: IGS20, ORBEPOCH:  288, CLKEPOCH: 2880, RCVCLKEPOCH:  288, CLKTOTNUM: 123108, CLKBADNUM:   22}
    - {AC: ESA, LABEL: OPSFIN, SYS: GRE , ORBs: 300, CLKs:  30, ATTs:   0, OBSd:   0, ERPd:   1, ATX: IGS20, ORBEPOCH:  289, CLKEPOCH: 2880, RCVCLKEPOCH:  289, CLKTOTNUM: 272594, CLKBADNUM:  242}
    - {AC: GFZ, LABEL: OPSFIN, SYS: GRE , ORBs: 300, CLKs:  30, ATTs:   0, OBSd:   0, ERPd:   1, ATX: IGS20, ORBEPOCH:  288, CLKEPOCH: 2880, RCVCLKEPOCH:  288, CLKTOTNUM: 257878, CLKBADNUM:  305}
    - {AC: GRG, LABEL: OPSFIN, SYS: GRE , ORBs: 300, CLKs:  30, ATTs:   1, OBSd:   1, ERPd:   1, ATX: IGS20, ORBEPOCH:  289, CLKEPOCH: 2881, RCVCLKEPOCH:  289, CLKTOTNUM: 260484, CLKBADNUM:   83}
  HELMERT:
    - {AC: COD, SYS: G, DXmm:    0.0, DY:    0.0, DZmm:    4.0, RXuas:   24.0, RYuas:   19.0, RZuas:    5.0, SCLppb:    0.0}
    - {AC: COD, SYS: R, DXmm:    0.0, DY:    2.0, DZmm:    4.0, RXuas:    6.0, RYuas:   22.0, RZuas:   17.0, SCLppb:   -0.0}
    - {AC: COD, SYS: E, DXmm:    0.0, DY:    0.0, DZmm:    3.0, RXuas:   19.0, RYuas:   21.0, RZuas:   13.0, SCLppb:    0.1}
    - {AC: EMR, SYS: G, DXmm:   -2.0, DY:    0.0, DZmm:   -2.0, RXuas:   15.0, RYuas:   15.0, RZuas:    4.0, SCLppb:    0.0}
    - {AC: HUS, SYS: E, DXmm:    1.0, DY:   -1.0, DZmm:    5.0, RXuas:  -18.0, RYuas:   -7.0, RZuas:  -12.0, SCLppb:   -0.0}
  ERP:
    - {AC: EMR, STEPOCH: 2025-04-16 00:00:00, ENEPOCH: 2025-04-17 00:00:00, XPuas:  -15.0, YPuas:   37.0, XRTuas_d:  -97.0, YRTuas_d:  -68.0, LODRES:  -14.0}
    - {AC: ESA, STEPOCH: 2025-04-16 00:00:00, ENEPOCH: 2025-04-17 00:00:00, XPuas:   18.0, YPuas:  -17.0, XRTuas_d:   22.0, YRTuas_d:   13.0, LODRES:   -6.0}
    - {AC: GFZ, STEPOCH: 2025-04-16 00:00:00, ENEPOCH: 2025-04-17 00:00:00, XPuas:   20.0, YPuas:  -32.0, XRTuas_d:   45.0, YRTuas_d:  -57.0, LODRES:   28.0}
    - {AC: GRG, STEPOCH: 2025-04-16 00:00:00, ENEPOCH: 2025-04-17 00:00:00, XPuas:   30.0, YPuas:   12.0, XRTuas_d:  -68.0, YRTuas_d:   74.0, LODRES:  -23.0}
    - {AC: NGS, STEPOCH: 2025-04-16 00:00:00, ENEPOCH: 2025-04-17 00:00:00, XPuas:   -5.0, YPuas:   38.0, XRTuas_d:   16.0, YRTuas_d:  -42.0, LODRES:    9.0}
```

SINEX format for the combination statistics

- **What statistics** should be formatted in the SINEX
- Combination products
  - Reference frame (ERP and station coordinates), advised by P. Rebischung
  - Satellite products: orbit, clock, phase and code biases
- Combination statistics information
  - meta data (AC-specific information, combination strategies, etc.)
  - reference frame (Helmert, ERP, consistency of station, weights and outliers)
  - orbit (Helmert, ERP, consistency among ACs, weights and outliers, discontinuity)
  - clock (Consistency among ACs, weights and outliers , discontinuity)
  - bias (Observable codes, consistency across ACs, discontinuity)

Workflow of the combination process

- Four combinations
  - Reference frame, orbit, bias, clock
- Combination sequence
  - Reference frame and satellite product combinations are independent at the moment
- What is the output of the combination?
  - Which statistics



Discussion I

- Headings for each SINEX_Comb block
  - StatisticType/ProductType is OK?
    - **StatisticType**: COMB, CONSISTENCY, OUTLIER, DAY_BOUNDARY
    - **ProductType**: ERP, SITE, WEIGHT, ORBIT, BIAS, CLOCK, etc.

```
*
+CONSISTENCY/CLOCK
*
*AC_ SYS SVN_ PRN STA_ DATA_START____ DATA_END______ UNIT NEPO_ NBAD_ _OFFSET_ __RMSE__
*
 GFZ   G G061 G02      2025:300:00000 2025:300:86370 ps    2880    26    45.00    10.00
 GFZ   R R747 R02      2025:300:00000 2025:300:86370 ps    2880          72.00    10.00
 COD   E E213 E04      2025:300:00000 2025:300:86400 ps    2881          54.00     3.00
 COD              ABMF 2025:300:00000 2025:300:86100 ps     288     5    27.00     9.00
 COD              ACRG 2025:300:00000 2025:300:86100 ps     288          67.00     6.00
 COD              ADIS 2025:300:00000 2025:300:86100 ps     288         -25.00     7.00
*
-CONSISTENCY/CLOCK
```

SINEX_Comb Keywords

- Header Keywords
  - COMB/DESCRIPTION
  - COMB/HELMERT_ORBIT
  - COMB/HELMERT_FRAME
  - COMB/WEIGHT

- Data body keywords
  - CONSISTENCY/ERP
  - CONSISTENCY/SITE
  - CONSISTENCY/ORBIT
  - CONSISTENCY/BIAS
  - CONSISTENCY/CLOCK
  - BOUNDARY/ORBIT
  - BOUNDARY/BIAS
  - BOUNDARY/CLOCK
  - OUTLIER/ORBIT
  - OUTLIER/BIAS
  - OUTLIER/CLOCK
  - OUTLIER/SITE

Discussion 2: contents of SINEX_Comb

- meta data for Header Keywords
  - Combination description
    - Sampling of orbit/clock, period, reference frequency, APC model, AC numbers
  - AC-specific product information
    - Helmert information of orbit/frame: AC name, system, 7-transform parameters
    - Weight: product type, AC name, sys, svn/prn, site name, weight value

COMB/DESCRIPTION

```
*KEYWORD_____________________________________ VALUE(S)_____________
*
 ORBIT_COMBINATION_SAMPLING                   300
 SATELLITE_CLOCK_COMBINATION_SAMPLING         30
 RECEIVER_CLOCK_COMBINATION_SAMPLING          300
 COMBINATION_PERIOD                           86400
 SATELLITE SYSTEM                             G/R/E/C
 REFERENCE FREQUENCY                          G  C1W  C2W
 REFERENCE FREQUENCY                          R  C1W  C2W
 REFERENCE FREQUENCY                          E  C1W  C2W
 REFERENCE FREQUENCY                          C  C1W  C2W
 RECEIVER_CLOCK_REFERENCE_GNSS                G
 APC_MODEL                                    IGS20_2361.ATX
 ANALYSIS_CENTERS_NUMBER                      12
 ANALYSIS_CENTERS_NAMES                       cod emr esa gfz grg
*
-COMB/DESCRIPTION
```

COMB/HELMERT

```
*AC_ SYS DX_mm_ DY_mm_ DZ_mm_ RX_uas_ RY_uas_ RZ_uas_ SCL_ppb_
*
 COD   G   0.00   0.00   4.00   24.00   19.00    5.00    0.02
 COD   R   0.00   2.00   4.00    6.00   22.00   17.00   -0.03
 COD   E   0.00   0.00   3.00   19.00   21.00   13.00    0.09
 EMR   G  -2.00   0.00  -2.00   15.00   15.00    4.00    0.02
 ESA   G   0.00   0.00  -1.00   -1.00   19.00   -8.00   -0.12
 ESA   R  -3.00  -1.00  -1.00   37.00    5.00   42.00   -0.14
 ESA   E   1.00   0.00   4.00   -3.00   10.00    2.00   -0.69
 GFZ   G   3.00   1.00   5.00   14.00   -4.00  -20.00    0.08
 GFZ   R   2.00   1.00  -3.00   32.00    7.00  -52.00   -0.13
 GFZ   E  -1.00  -2.00   6.00   15.00   16.00   -3.00    0.04
 GRG   G   0.00  -1.00  -3.00  -29.00   -8.00  -13.00   -0.02
 GRG   R   3.00  -2.00   0.00  -46.00  -18.00  -29.00    0.16
 GRG   E   0.00   0.00   1.00  -31.00  -14.00    2.00    0.37
 JGX   G   0.00  -1.00   0.00   26.00   -7.00   -7.00   -0.04
 JGX   R   2.00  -1.00   6.00    0.00    6.00  -54.00   -0.38
 JGX   E   0.00  -1.00   8.00    9.00  -22.00  -15.00   -0.41
```

COMB/WEIGHT

```
*TYPE_ AC_ SYS SVN_ PRN STA_ WEIGHT_%
*
 ORBIT COD   G                  17.30
 ORBIT COD   R                  28.70
 ORBIT COD   E                  17.80
 ORBIT EMR   G                   8.40
 ORBIT ESA   G                  13.20
 ORBIT ESA   R                  16.20
 ORBIT ESA   E                  19.80
 ORBIT GFZ   G                   4.80
 ORBIT GFZ   R                  14.10
 ORBIT GFZ   E                   3.00
 ORBIT GRG   G                  11.20
 ORBIT GRG   R                  26.40
 ORBIT GRG   E                  16.50
 ORBIT JGX   G                   0.00
```

Discussion 2: contents of SINEX_Comb

- **meta data for Header Keywords**
  - Combination description
    - Sampling of orbit/clock, period, reference frequency, APC model, AC numbers
  - AC-specific product information
    - Helmert information of orbit/frame: AC name, system, 7-transform parameters
    - Weight: product type, AC name, sys, svn/prn, site name, weight value

? How to deal with the **'repetition' of different combination processes**, especially the **Helmert and ERP** from reference frame and orbit combination?

Discussion 2: contents of SINEX_Comb

- **reference frame (ERPs & station coordinates)**
  - Helmert: 7-parameters
  - Consistency of ERP: AC name, date, residual of xp and yp, xp rate, yp rate, LOD
  - Consistency of station: AC name, site name, date, residual of E/N/U
  - Outliers of station: AC name, site name, date

```
+CONSISTENCY/ERP
*
*AC_ DATA_START____ DATA_END______ XP_uas YP_uas XRT_uas/d YRT_uas/d LODRES
*
 EMR 2025:106:00000 2025:107:00000 -15.00  37.00    -97.00    -68.00 -14.00
 ESA 2025:106:00000 2025:107:00000  18.00 -17.00     22.00     13.00  -6.00
 GFZ 2025:106:00000 2025:107:00000  20.00 -32.00     45.00    -57.00  28.00
 GRG 2025:106:00000 2025:107:00000  30.00  12.00    -68.00     74.00 -23.00
 NGS 2025:106:00000 2025:107:00000  -5.00  38.00     16.00    -42.00   9.00
 HUS 2025:106:00000 2025:107:00000  13.00   2.00      2.00     65.00  -4.00
 JGX 2025:106:00000 2025:107:00000  51.00  10.00     -3.00     98.00   6.00
 JPL 2025:106:00000 2025:107:00000 -18.00  -9.00     23.00    -14.00  20.00
*
-CONSISTENCY/ERP
```

Discussion 2: contents of SINEX_Comb

- **reference frame (ERPs & station coordinates)**
  - Helmert: 7-parameters
  - Consistency of ERP: AC name, date, residual of xp and yp, xp rate, yp rate, LOD
  - Consistency of station: AC name, site name, date, residual of E/N/U
  - Outliers of station: AC name, site name, date

CONSISTENCY/SITE

```
*
*AC_ STA_ DATA_START____ DATA_END______   ERES_mm    NRES_mm    URES_mm
*
 COD ABMF 2025:106:00000 2025:107:00000     1.938      0.218     -1.403
 COD AC24 2025:106:00000 2025:107:00000     0.891     -0.364      0.006
 EMR ABMF 2025:106:00000 2025:107:00000    -1.095     -0.607      3.534
```

OUTELIER/SITE

```
*
*AC_ SITE DATA_START____ DATA_END______
*
 COD MARS 2025:300:00000 2025:300:86400
 MIT LCK4 2025:300:00000 2025:300:86400
*
-OUTLIER/SITE
```

Discussion 2： contents of SINEX_Comb

- **orbit**
  - Helmert: 7-parameters
  - Consistency of ERP: AC name, date, residual of xp and yp, xp rate, yp rate, LOD
  - Consistency of orbit: AC name, system, svn/prn, date, unit, epoch, offset and std of X/Y/Z
  - Outliers of orbit: AC name, svn/prn, date

CONSISTENCY/ORBIT

```
*
*AC_ SYS SVN_ PRN DATA_START____ DATA_END______ UNT NEPO BAD OFFSx OFFSy OFFSz STDX SRDY STDZ
*
 COD   E      E02 2025:300:00000 2025:300:86400 mm   288   0   3.4   3.6  -3.7 18.0 14.2 10.4
 COD   E      E03 2025:300:00000 2025:300:86400 mm   288   0  -3.1  -
 COD   E      E04 2025:300:00000 2025:300:86400 mm   288   0   3.5  -
 COD   E      E05 2025:300:00000 2025:300:86400 mm   288   0  -2.1
```

OUTLIER/ORBIT

```
*
*AC_ SVN_ PRN YY_DOY_SODST YY_DOY_SODEN
*
 ESA R803 R26 25:300:00000 25:300:86400
 ESA R804 R27 25:300:00000 25:300:86400
```

Discussion 2: contents of SINEX_Comb

- clock
  - Consistency of clock: AC name, satellite, site, date, unit, epoch, bad epoch, offset and RMSE
  - Outliers of clock: AC name, satellite, station, date

CONSISTENCY/CLOCK

```
*
*AC_ SYS SVN_ PRN STA_ DATA_START____ DATA_END______ UNIT NEPO_ NBAD_ _OFFSET_ __RMSE__
*
 COD   E E211 E02      2025:300:00000 2025:300:86400 ps     2881           40.00      4.00
 COD   E E212 E03      2025:300:00000 2025:300:86400 ps     2881            2.00
 COD   E E213 E04      2025:300:00000 2025:300:86400 ps     2881           54.00
 COD   E E214 E05      2025:300:00000 2025:300:86400 ps     2881           35.00
 COD   E E227 E06      2025:300:00000 2025:300:86400 ps     2881            7.00
```

OUTLIER/CLOCK

```
*
*AC_ SVN_ PRN STA_ YY_DOY_SODST YY_DOY_SODEN
*
 COD          ABMF 25:300:17400 25:300:18600
 COD          CHUR 25:300:54000 25:300:54000
 COD          CUSV 25:300:00900 25:300:01200
 COD          CUSV 25:300:03600 25:300:04200
 COD          CZTG 25:300:80400 25:300:81900
 COD          CZTG 25:300:84300 25:300:86100
 COD E215 E21      25:300:86370 25:300:86370
```

Discussion 2： contents of SINEX_Comb

- bias
  - Consistency of bias: AC name, observation, date, offset, RMSE
  - Outliers of bias: AC name, satellite, observation, date

CONSISTENCY/BIAS

```
*
*AC_ SVN_ PRN OBS1 OBS2 DATA_START____ DATA_END______ UNIT   _OFFSET_ __RMSE__
*
 COD G080 G01 C1X       2025:106:00000 2025:107:00000 ns      0.02410  0.00000
 COD G080 G01 C1L       2025:106:00000 2025:107:00000 ns      0.02271  0.00000
 COD G080 G01 C1C       2025:106:00000 2025:107:00000 ns      0.07687  0.00000
 COD G080 G01 C1W       2025:106:00000 2025:107:00000 ns      0.07637  0.00000
 COD G080 G01 L2S       2025:106:00000 2025:107:00000 ns     -0.0343
 COD G080 G01 L2L       2025:106:00000 2025:107:00000 ns     -0.0343
 COD G080 G01 L2W       2025:106:00000 2025:107:00000 ns     -0.0343
*
-CONSISTENCY/CODE_BIAS
```

OUTLIER/BIAS

```
*AC_  SVN_ PRN OBS1 OBS2 DATA_START____ DATA_END______
*
 COD  G080 G01 C1X       2025:106:00000 2025:107:00000
 COD  G080 G01 C1L       2025:106:00000 2025:107:00000
 COD  G080 G01 C1C       2025:106:00000 2025:107:00000
 COD  G080 G01 C1W       2025:106:00000 2025:107:00000
 COD  G080 G01 C2X       2025:106:00000 2025:107:00000
```

Plan for the following steps …

- Algorithms to compute such statistics
- Document to describe the format and the relevant algorithms

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Thank You!

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