GNSS Online Lecture # 1
Lecture ID: WT-103-401
Lecture Topic: GNSS Data Processing in RTKLIB

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11th May 2018

Webinar Information

- Lecture Type : Webinar
- Webinar ID : WT-103-401
- Webinar Topic : GNSS Data Processing in RTKLIB
- Technical Level : Intermediate
- Pre-Requisite (Recommended):
  - Webinar ID : WT-101-101: Introduction to GNSS
  - Webinar ID : WT-102-302: GNSS Field Survey
  - Or general knowledge about GNSS, field survey and data collection.
- Date : 11th MAY 2018 Friday, Time : 18:00 (JST) 09:00 (UTC)
- Duration : 75 minutes
- Resource Person : Dinesh Manandhar, Associate Professor, The University of Tokyo
- This Webinar is Technical. We discuss the followings:
  (1) How to setup u-blox receiver to collect raw data for RTK
  (2) How to convert u-blox data into RINEX format
  (3) How to download base-station data from our ABN stations (NetR9)
  (4) How to process raw data for RTK using RTKLIB
- Registration : https://gnss.peatix.com or https://s-gnss.peatix.com

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u-center Software Installation

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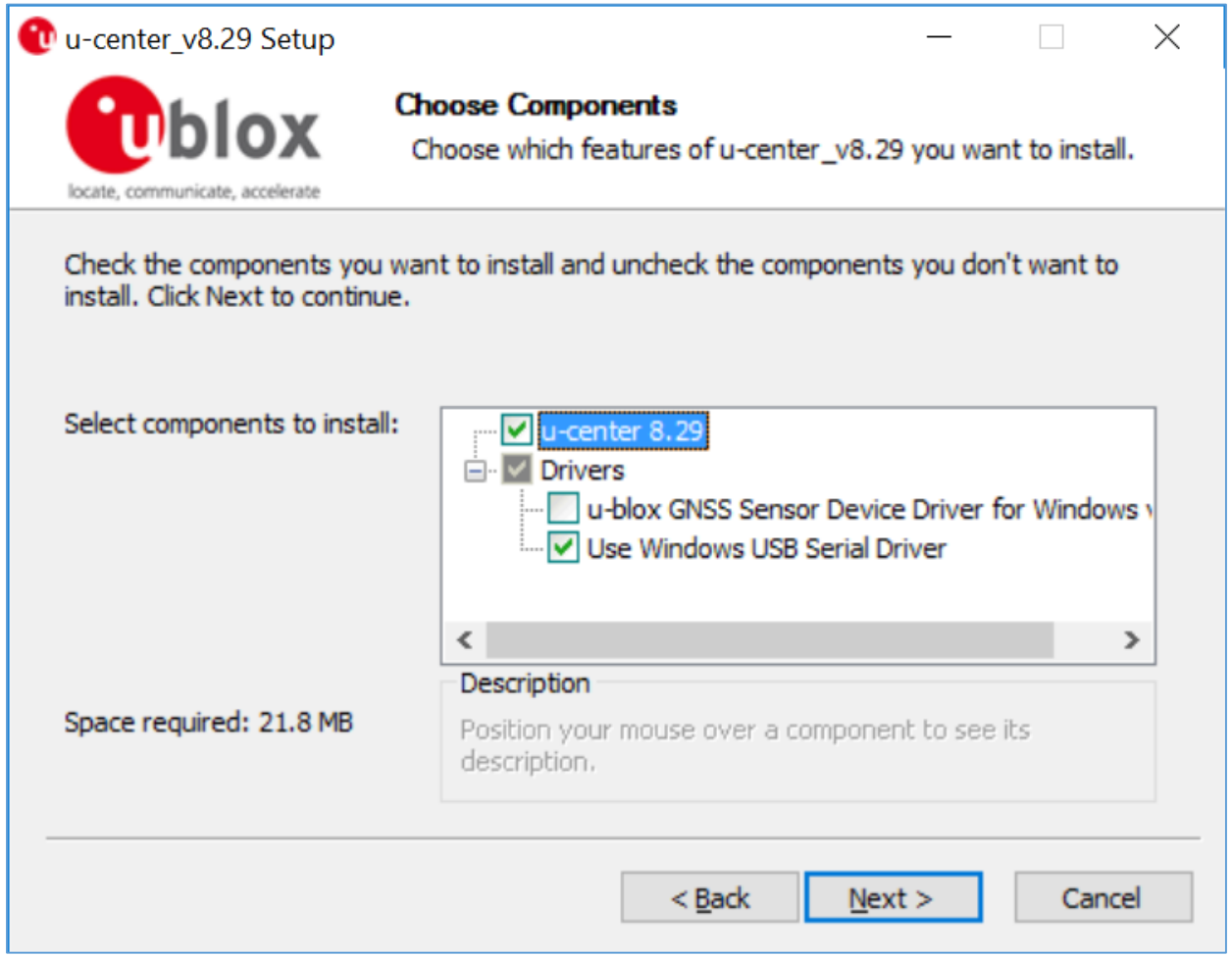
Install u-center Software

- u-center is a software for u-blox receivers
  - Available for Windows and Android Device
  - It can also be used with other receivers that output NMEA data
- Download the software from
  - https://www.u-blox.com/en/evaluation-software-and-tools
- Install the software with driver
  - Select “Use Windows USB Serial Driver”
  - Follow the instructions
- Connect u-blox receiver to one of the USB ports. The device is now ready for use.



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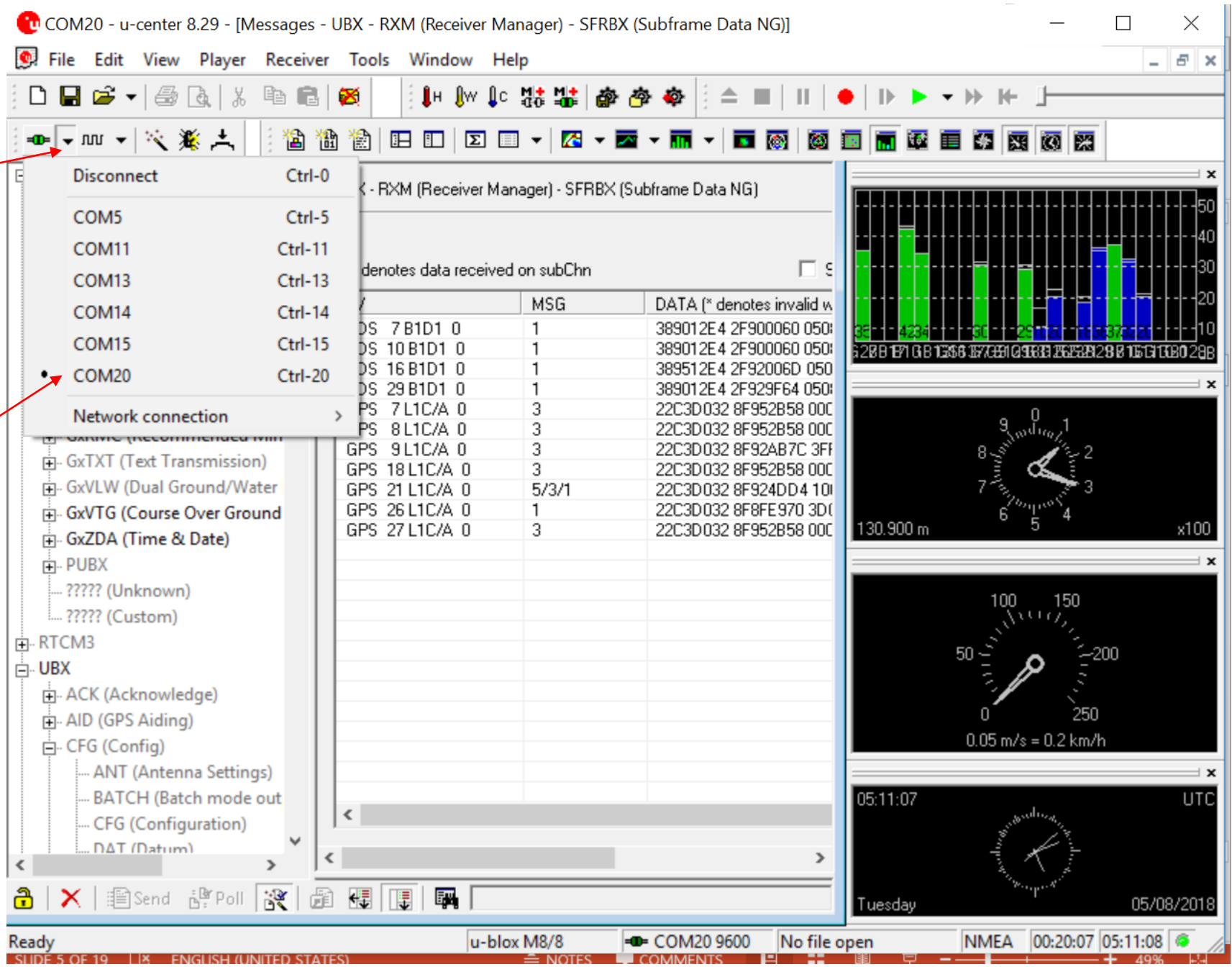
Select COM Port to Connect the Receiver

Click here
This will show the COM port on which u-blox receiver is connected
Select the port which is connected to u-blox
Hint:
If you don't know which COM port is used for u-blox:
* disconnect the receiver
* check COM ports now
- Re-connect the receiver
- check the COM ports

You will see one new COM port now.
Select this COM port to connect the receiver



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Troubleshooting COM Port Setting

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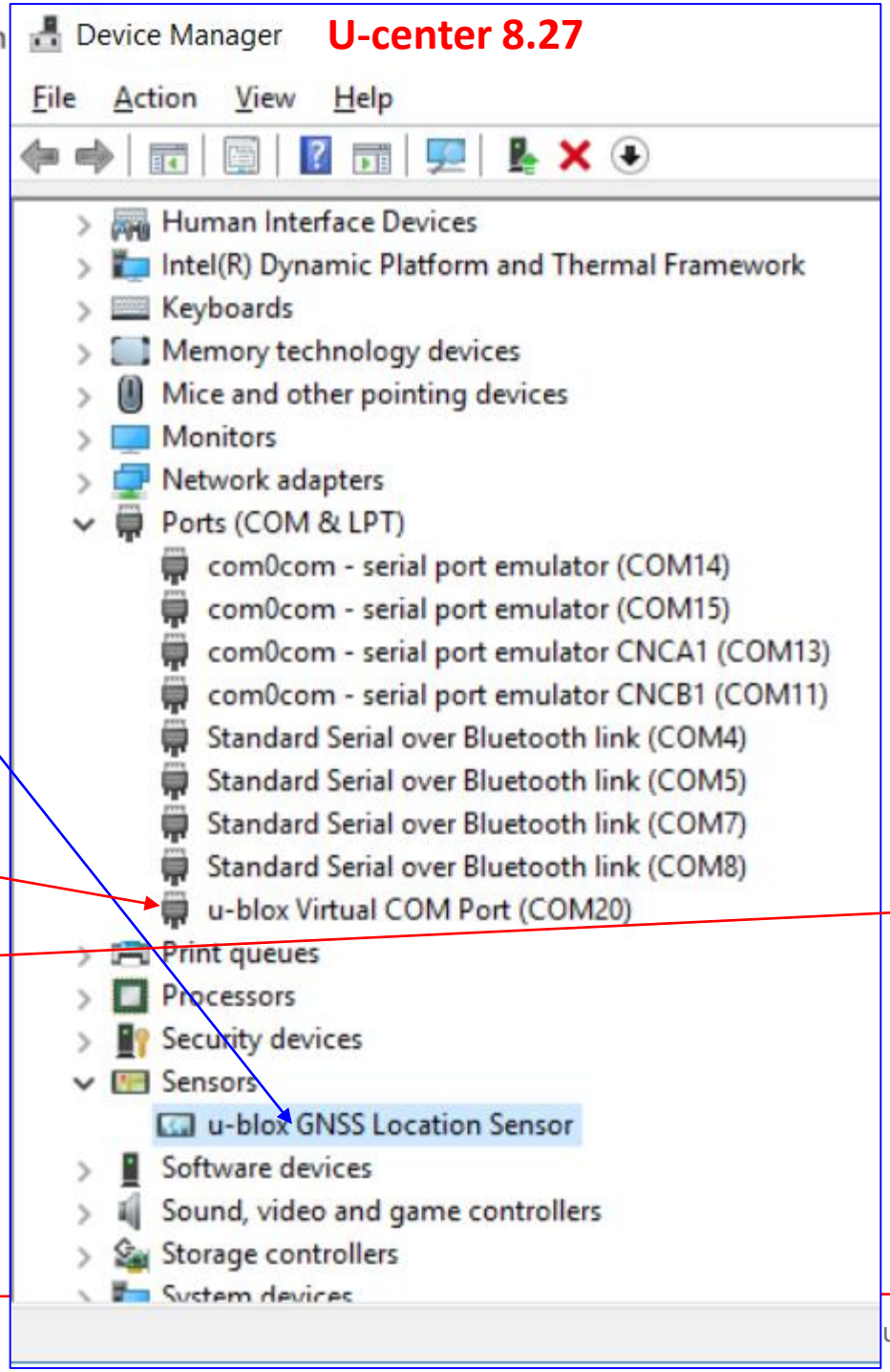
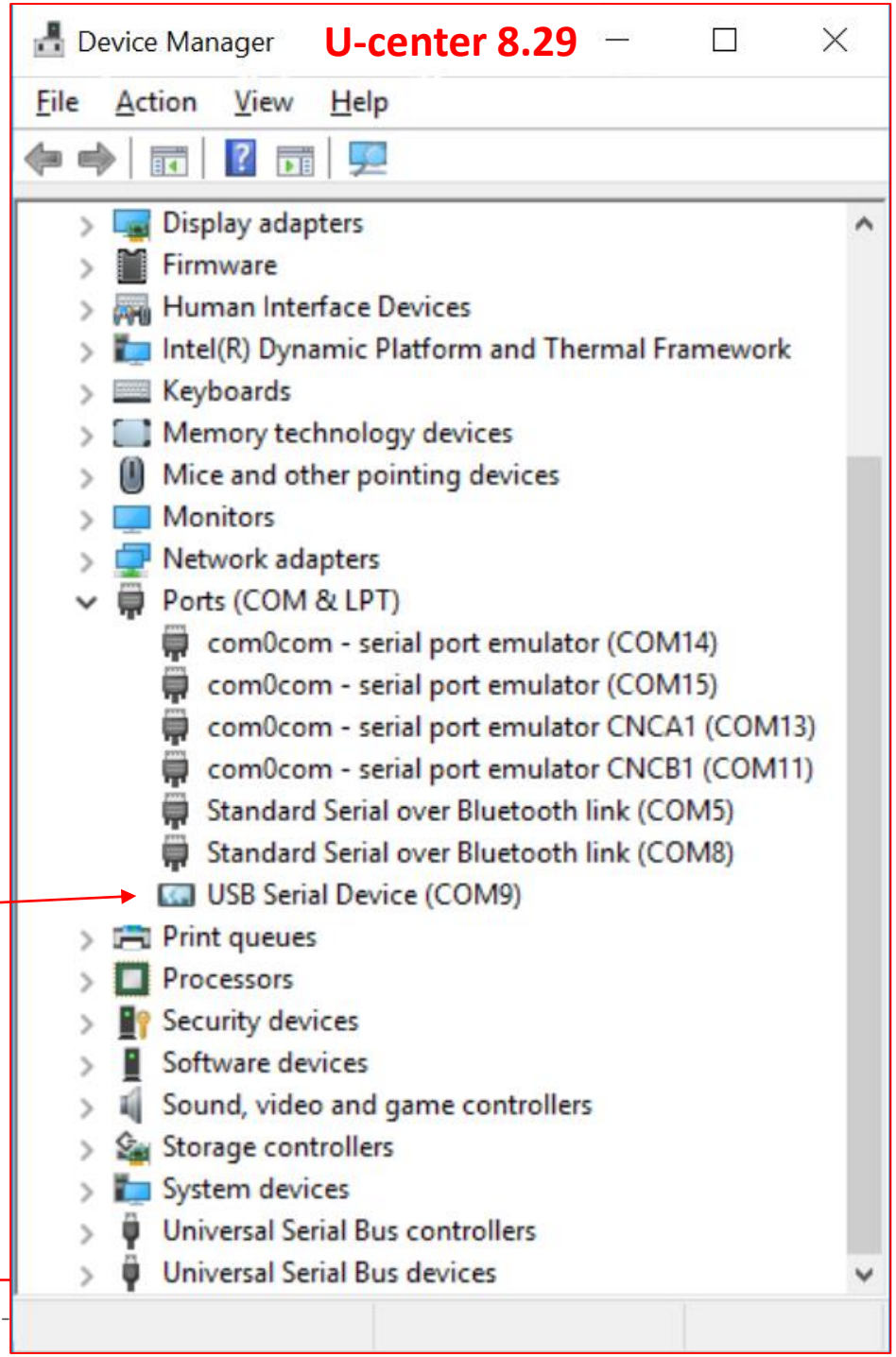
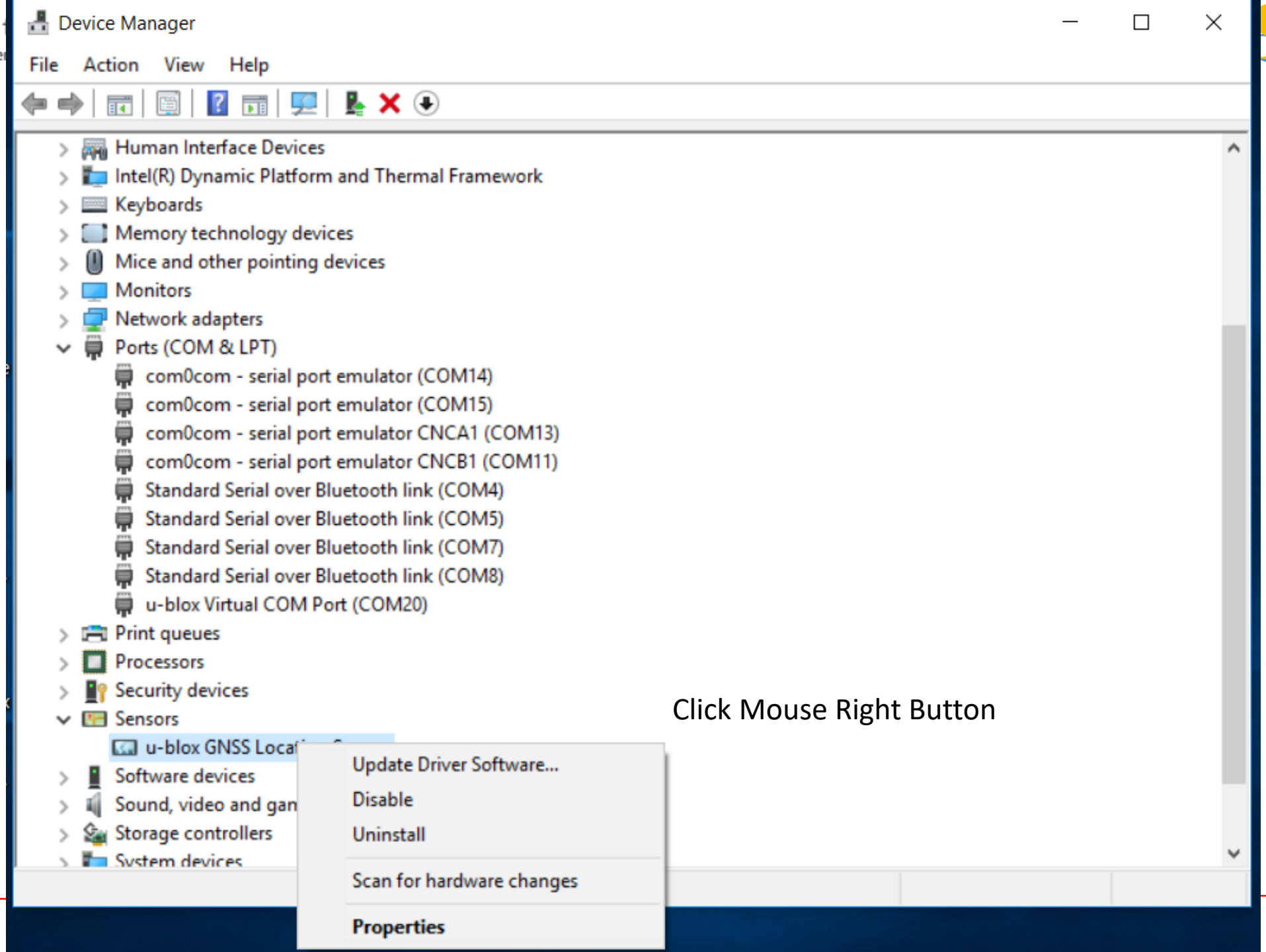
Run Device Manager
You will see SENSORS
– u-blox GNSS Location Sensor
If your receiver doesn't work with this setting, update this driver

Instructions for update are given in the next few slides

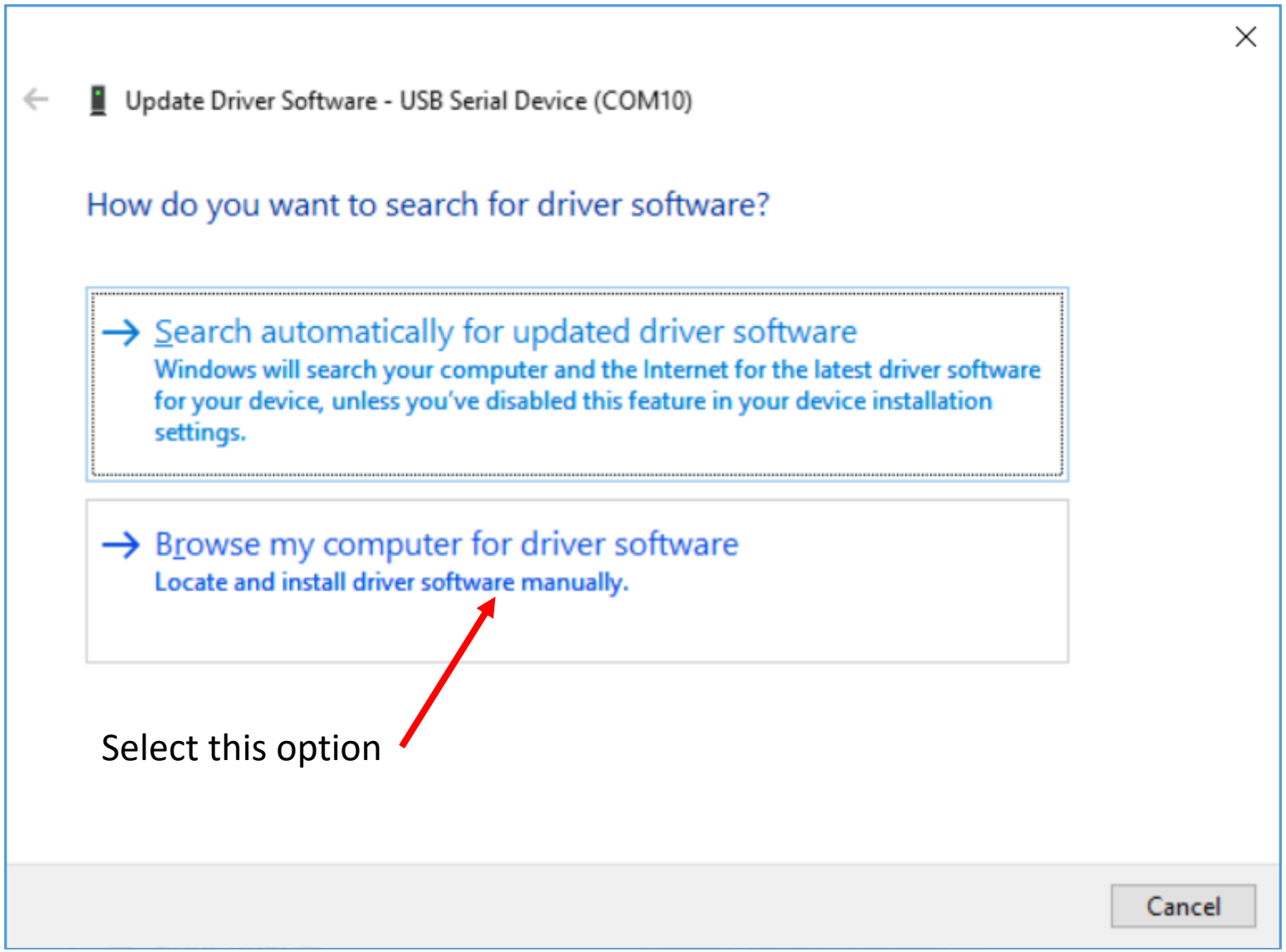
After update you will see
(1) U-blox Virtual COM Port (COM ID) OR
(2) USB Serial Device (COM ID)
(3) Repeat update process for all USB ports that you want to connect the u-blox receiver
(4) Otherwise it will use Virtual COM port







Click Mouse Right Button



Select this option

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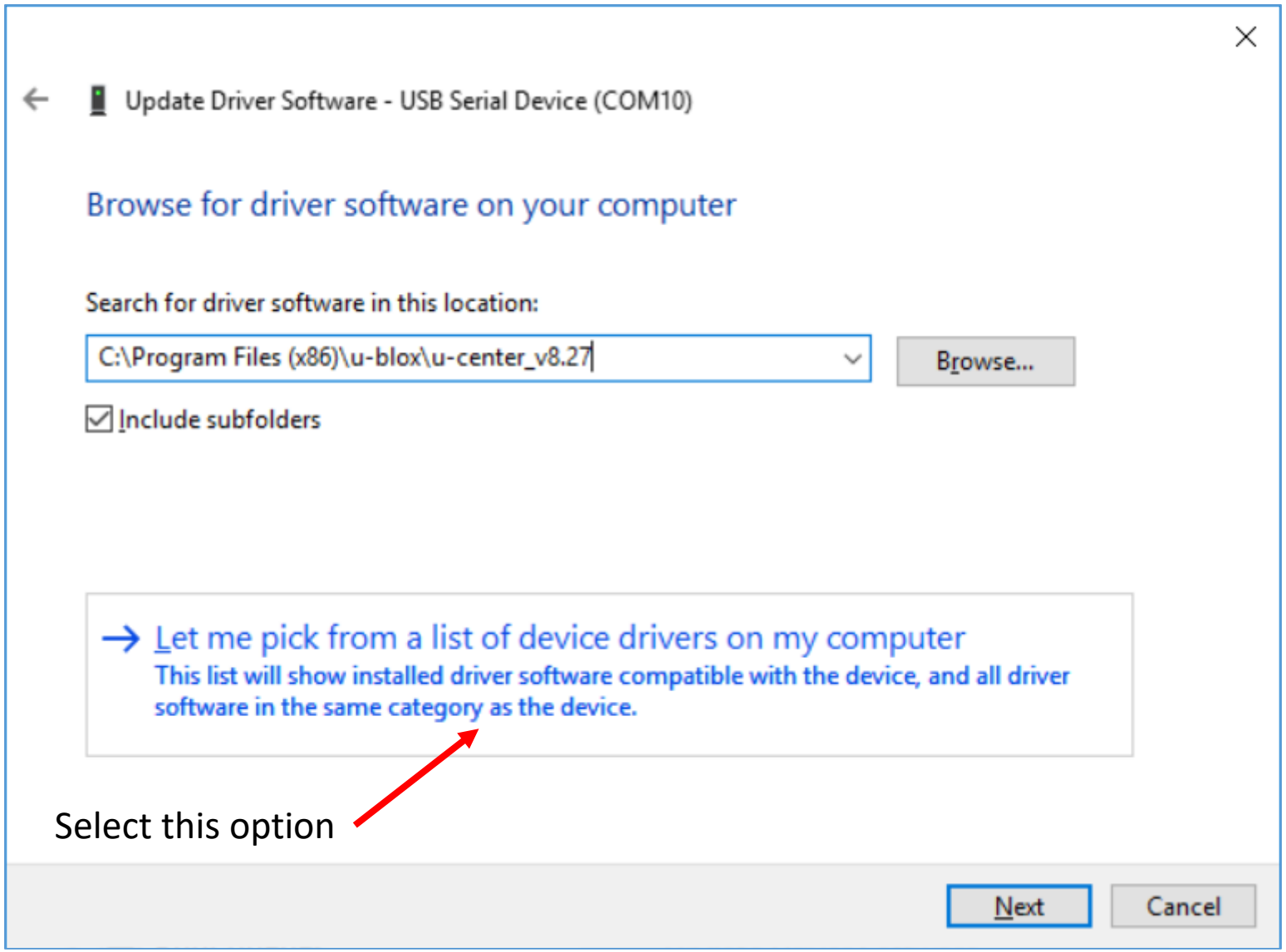

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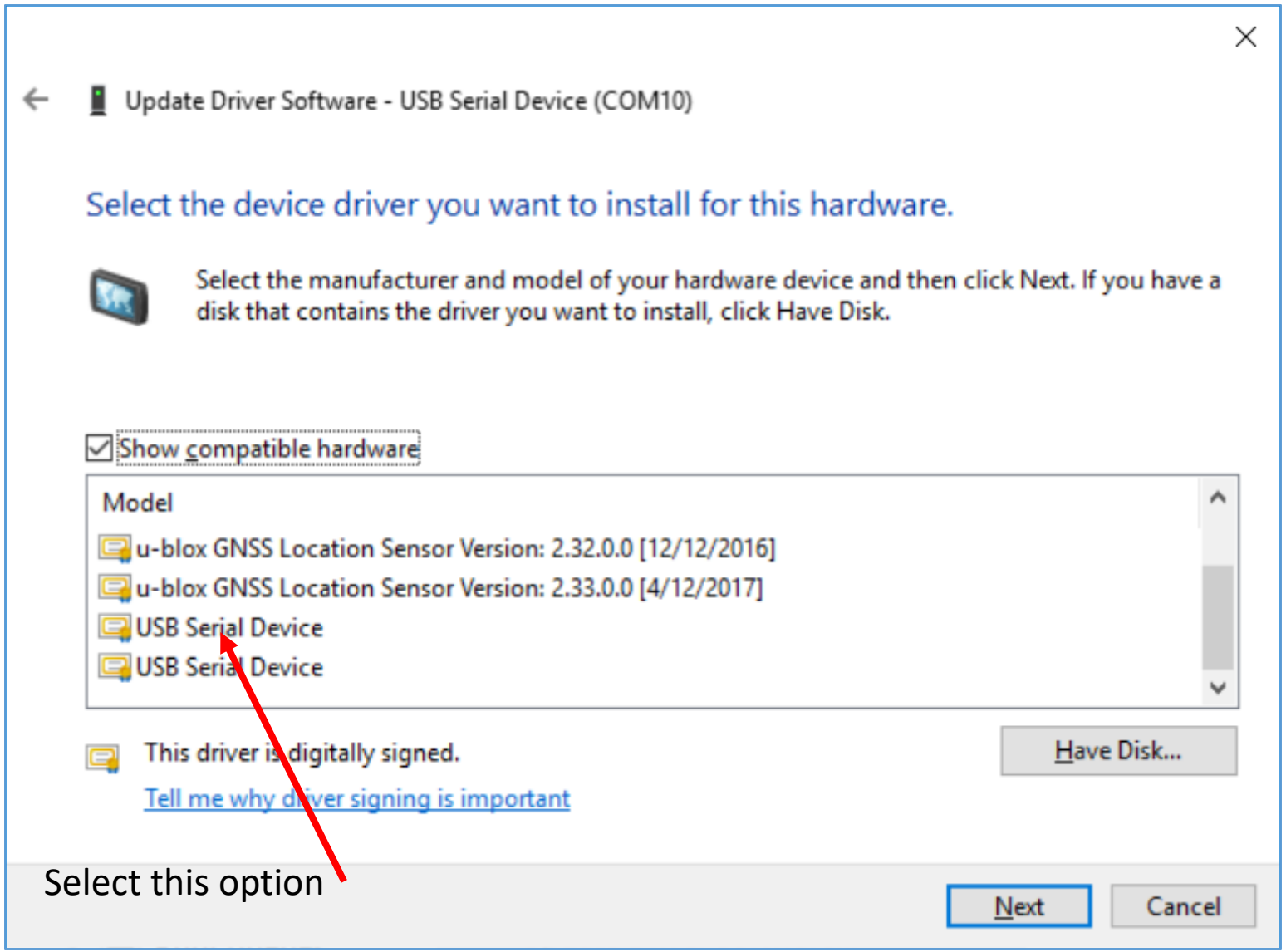

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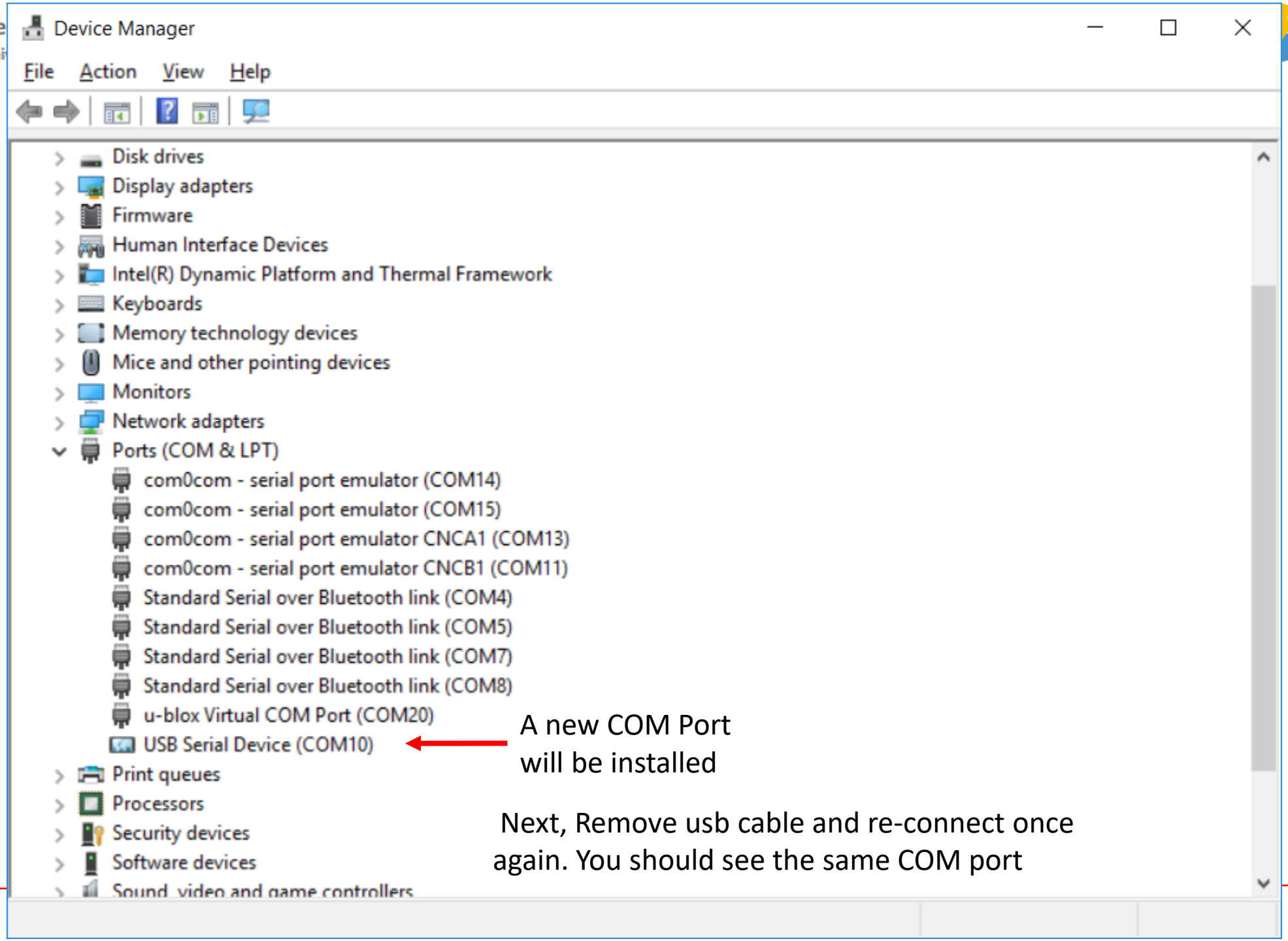
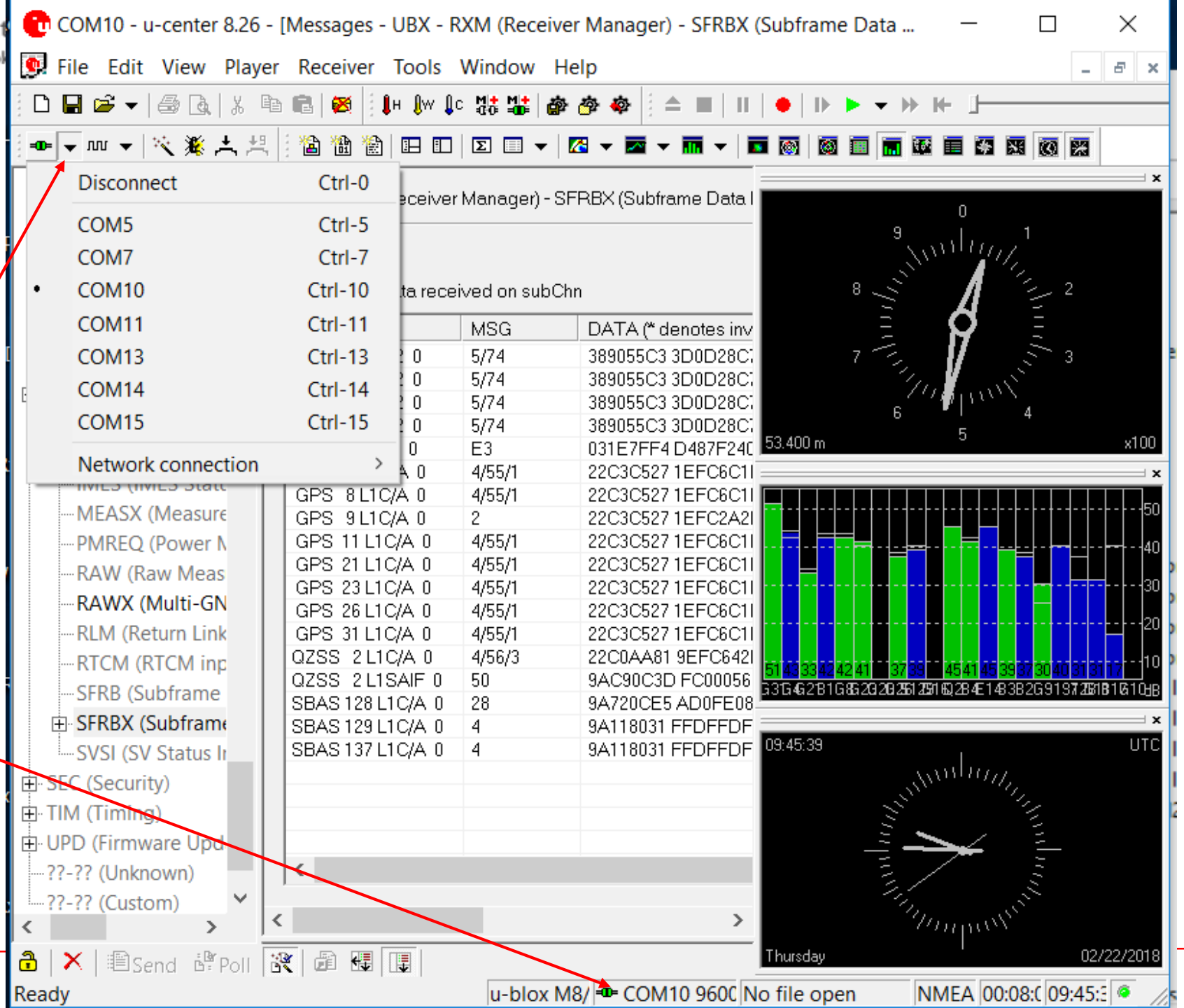


A new COM Port will be installed

Next, Remove usb cable and re-connect once again. You should see the same COM port

Run u-center and select COM Port. You will see the New COM port here. Select it.

It should work now See the COM Port and green light blinking here



u-Blox Receiver Setup to Log Raw Data for RTK

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Output Data Types from a GPS Receiver

- PVT Data
  - Position, Velocity and Time
  - All receivers output these data
  - Data format is NMEA
- Raw Data
  - Pseudorange, Carrier-phase and Doppler
    - Required for RTK
    - Some receivers output these data
    - File format may be proprietary or RINEX Observation File
- Navigation Message Data
  - Satellite Ephemeris, Almanac and Clock Data, Satellite Health Status etc.
  - Required for RTK
  - File format may be proprietary or RINEX Navigation File
- Satellite Related Data
  - Number and Type of Satellites, Azimuth, Elevation, Satellite Types and Signals
  - Many Receivers output these data
  - Data Format is NMEA
- Signal Quality Data
  - C/No or SNR
- Other Data
  - Noise related data
  - Receiver specific proprietary information

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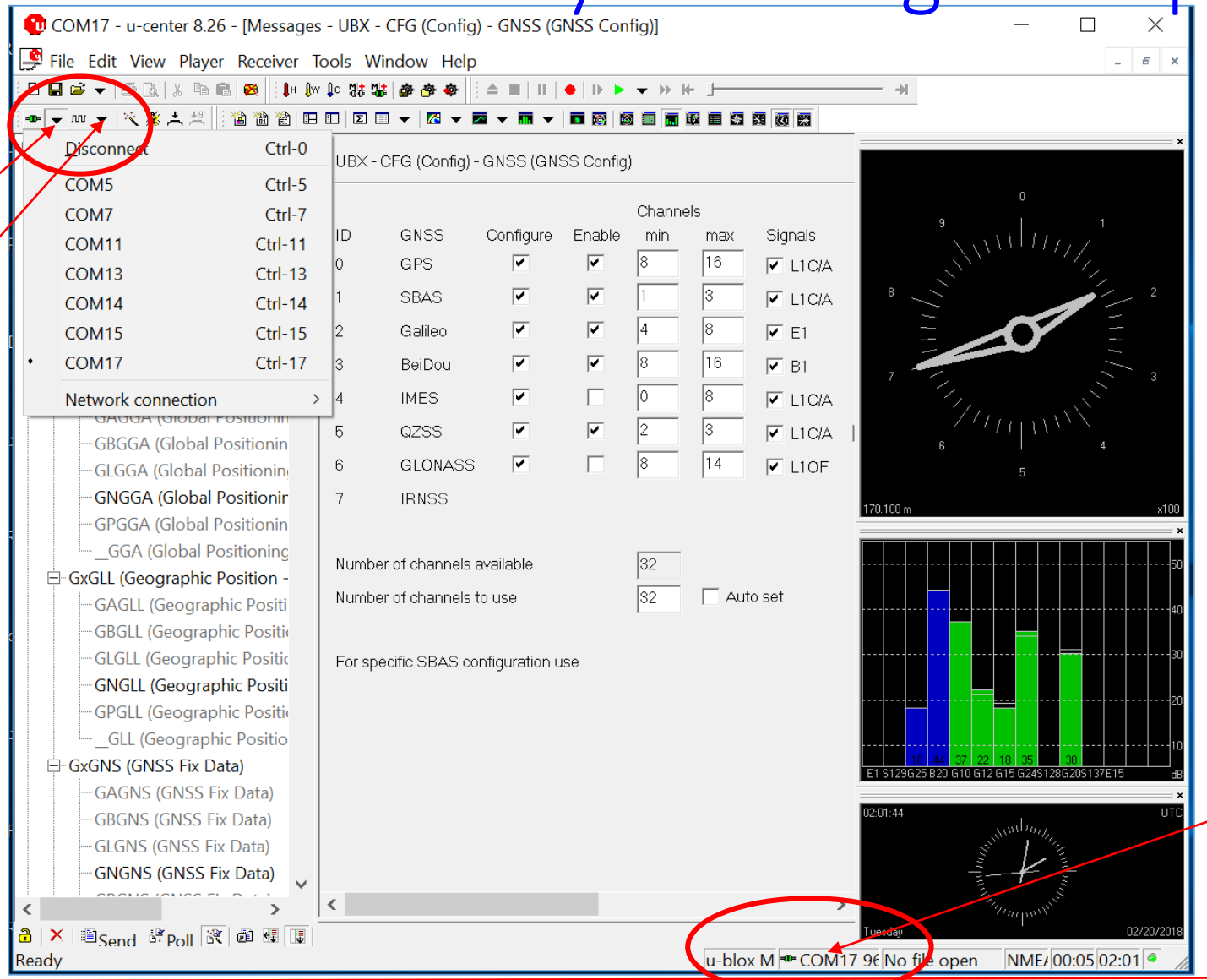
Connect receiver by selecting COM port

Select COM Port

Select Speed 115200



If COM port is open properly, You will see Green color flashing

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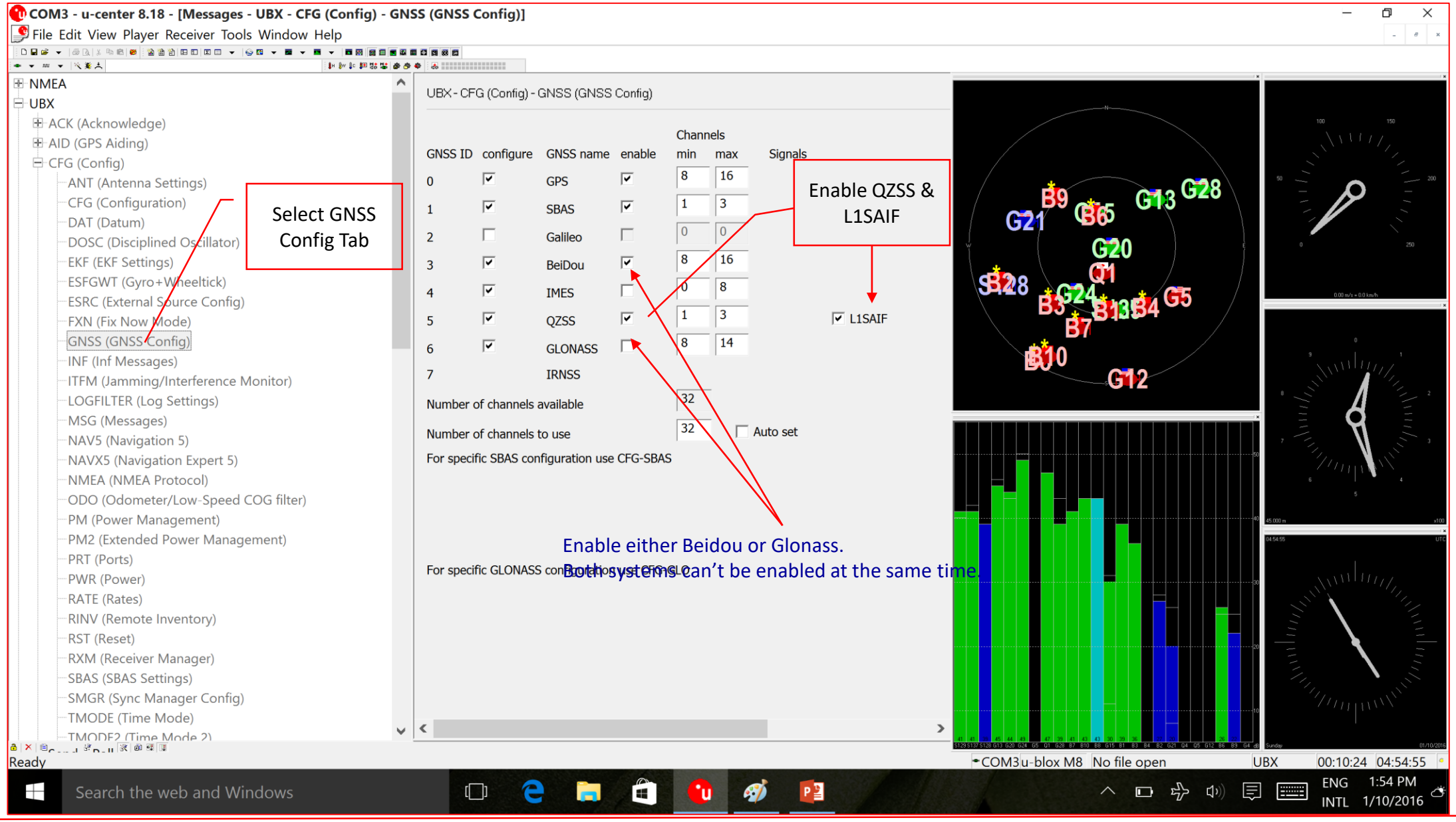

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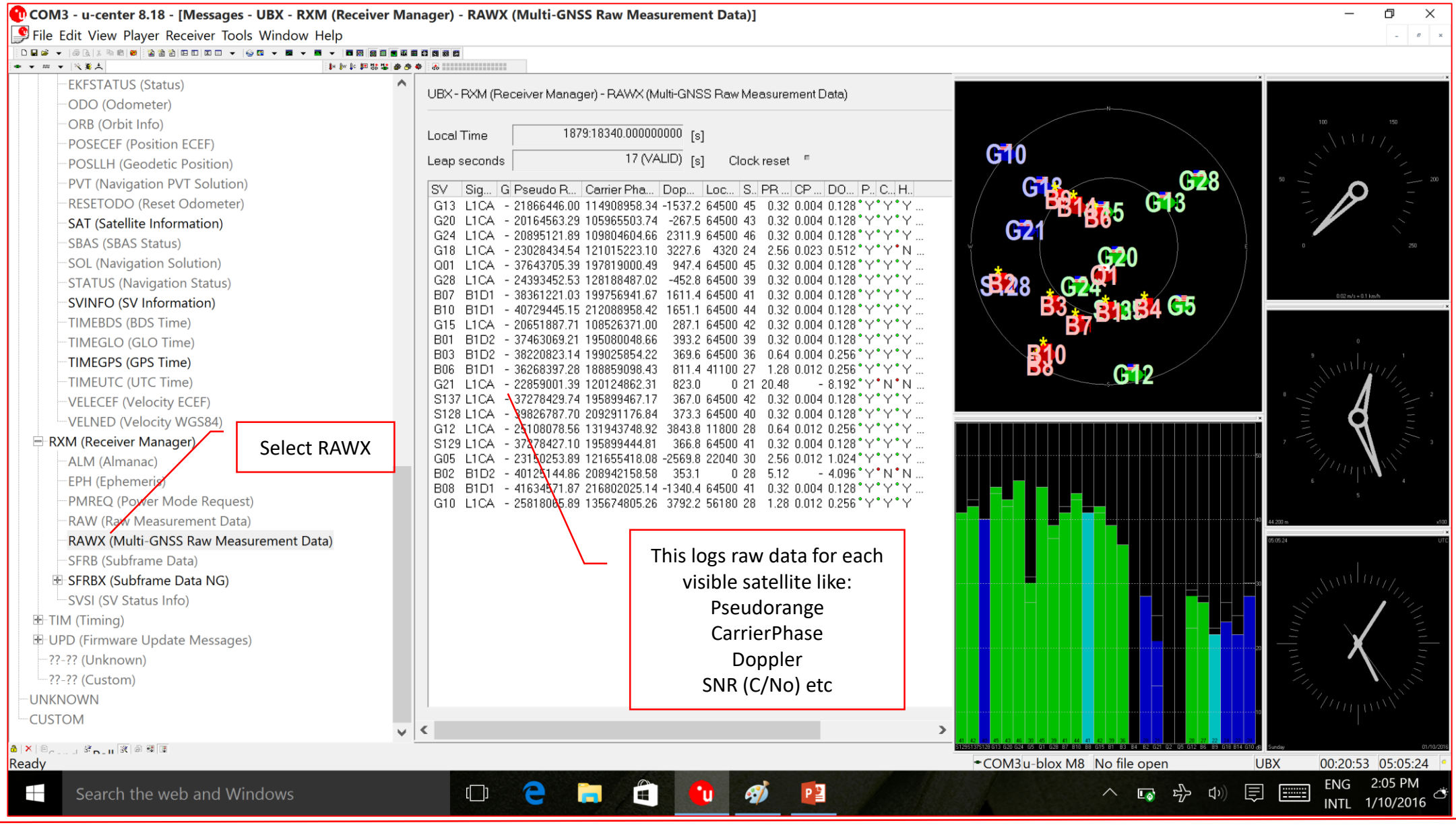

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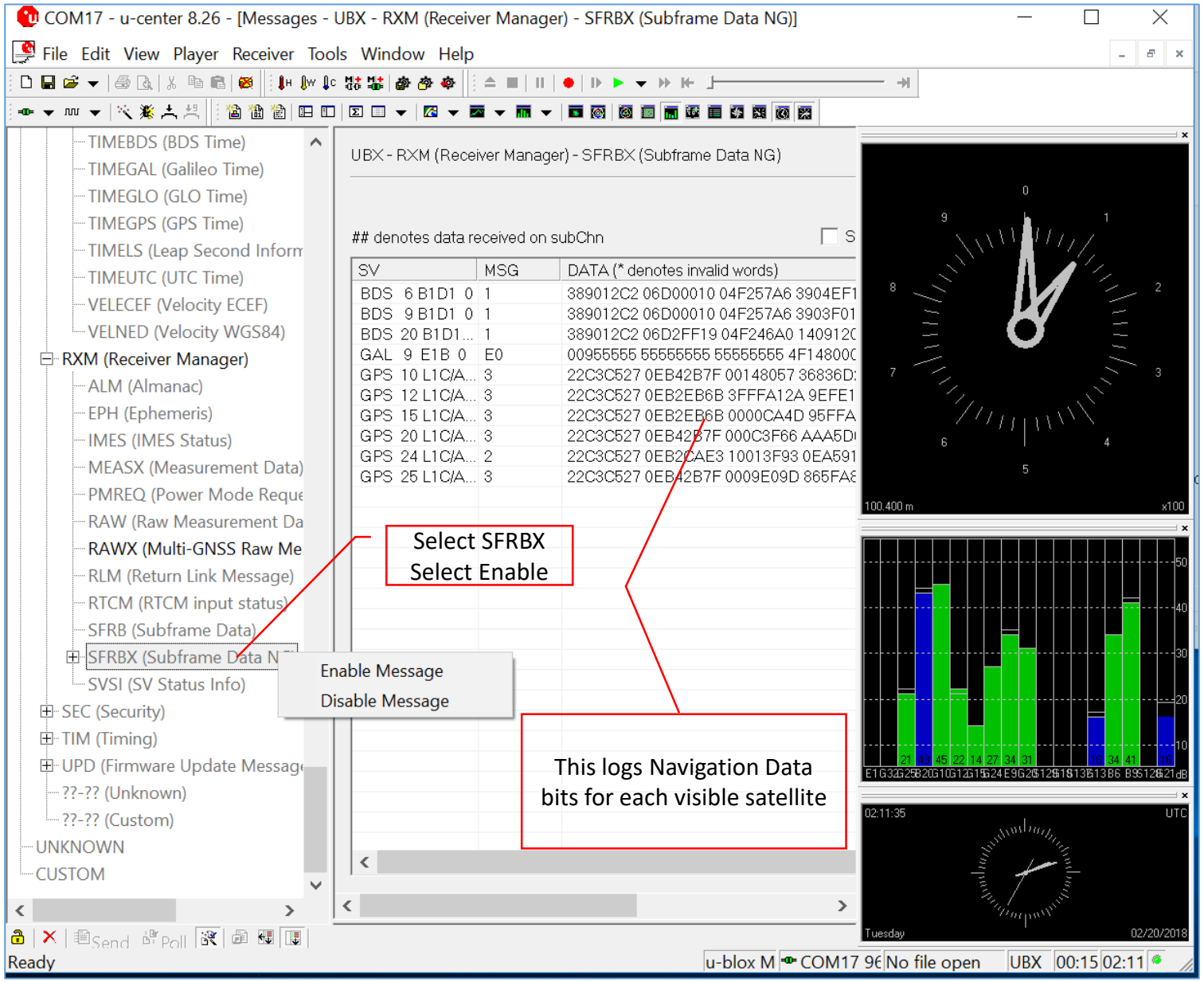

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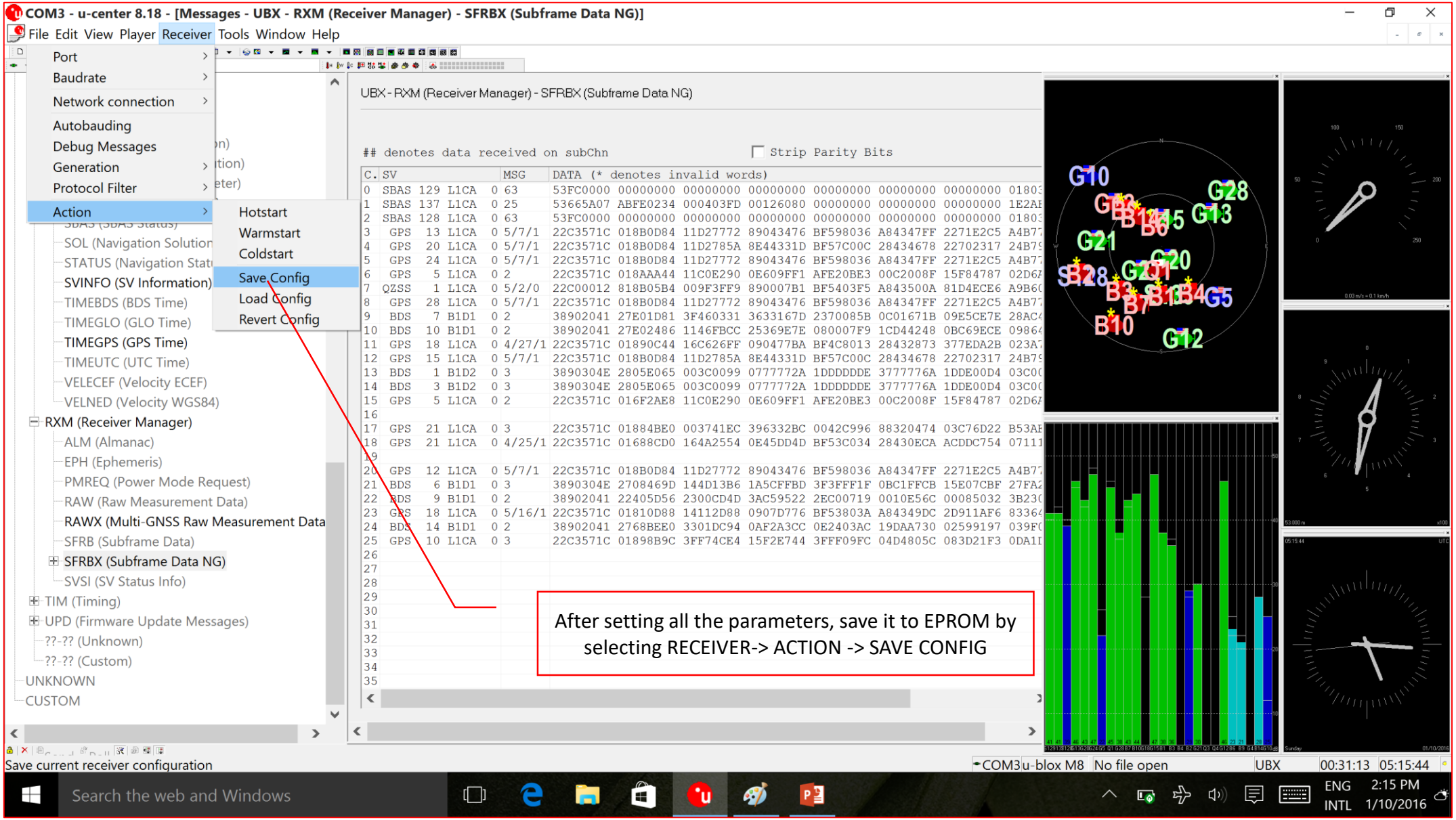

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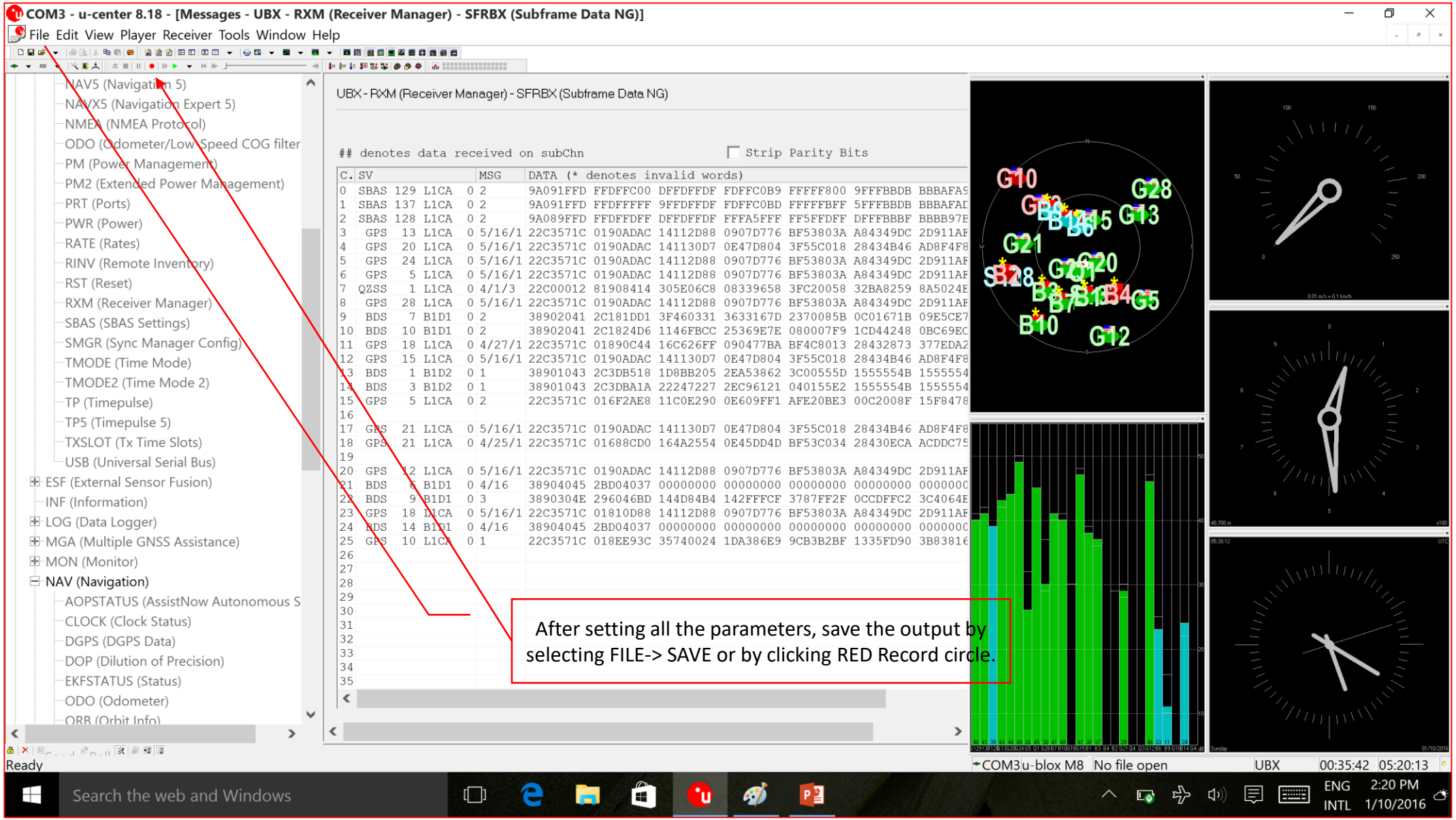

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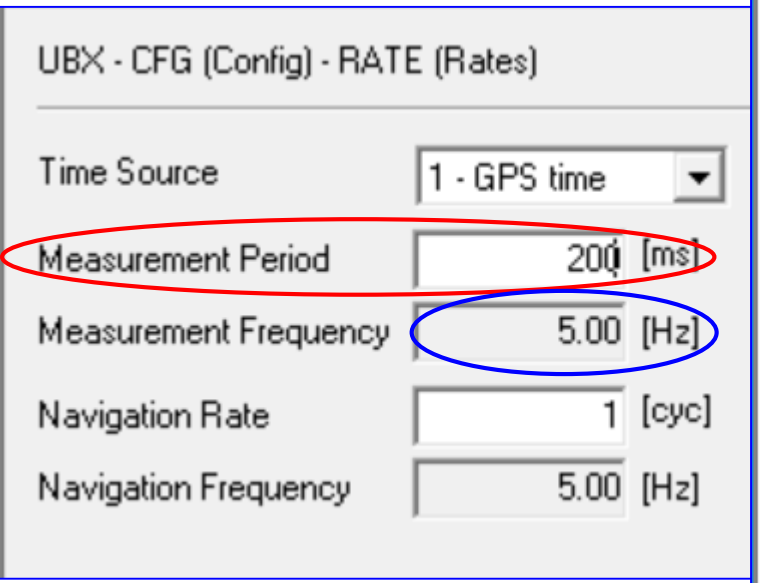
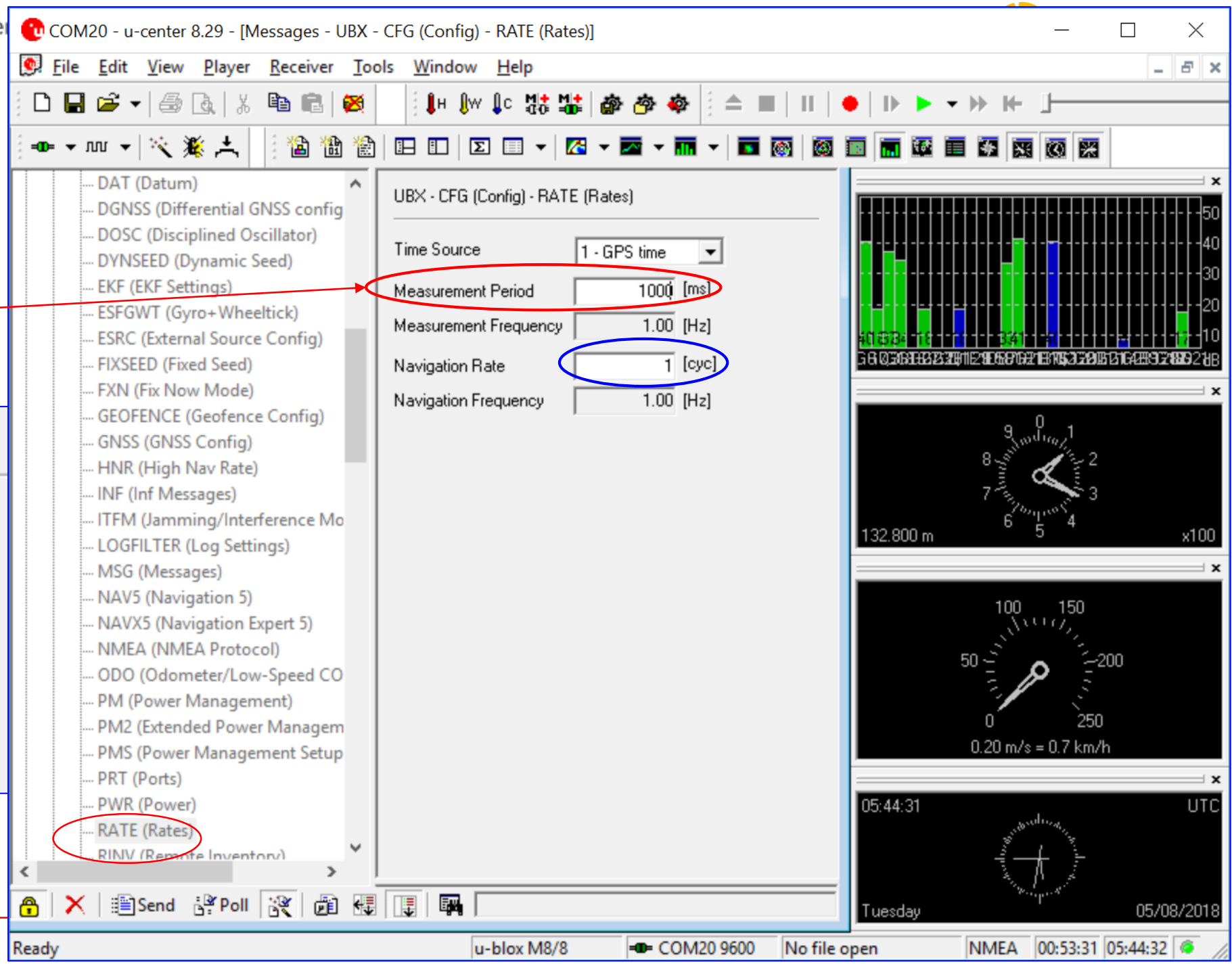
Output rate can be changed from 1Hz to 5Hz or 10Hz

Change UBX-CFG-RATE parameter
Change
Measurement Period to 200 [ms] for 5[Hz] output





Convert from UBX format to RINEX

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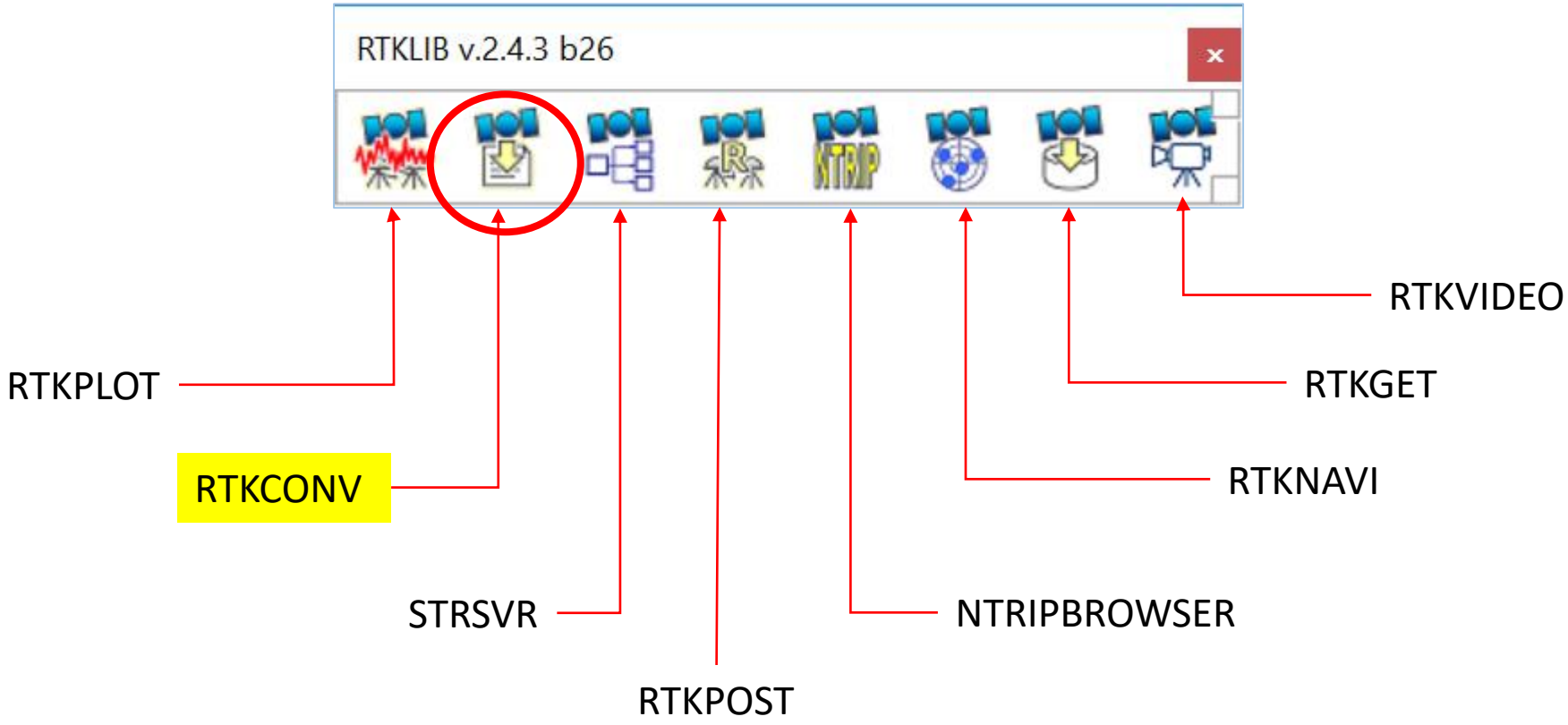
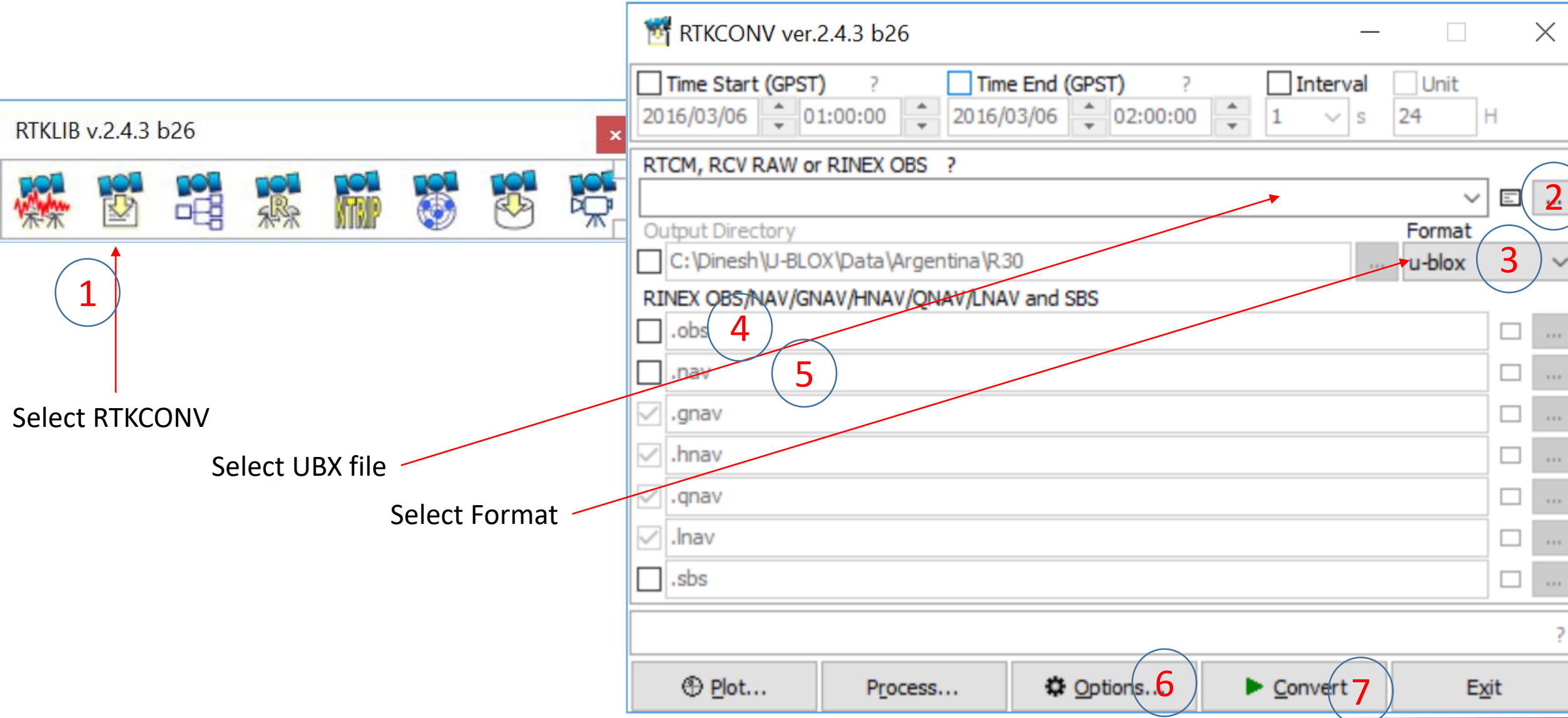
RTKLIB Main Menu, Ver 2.4.3 b26



Convert from UBX to RINEX



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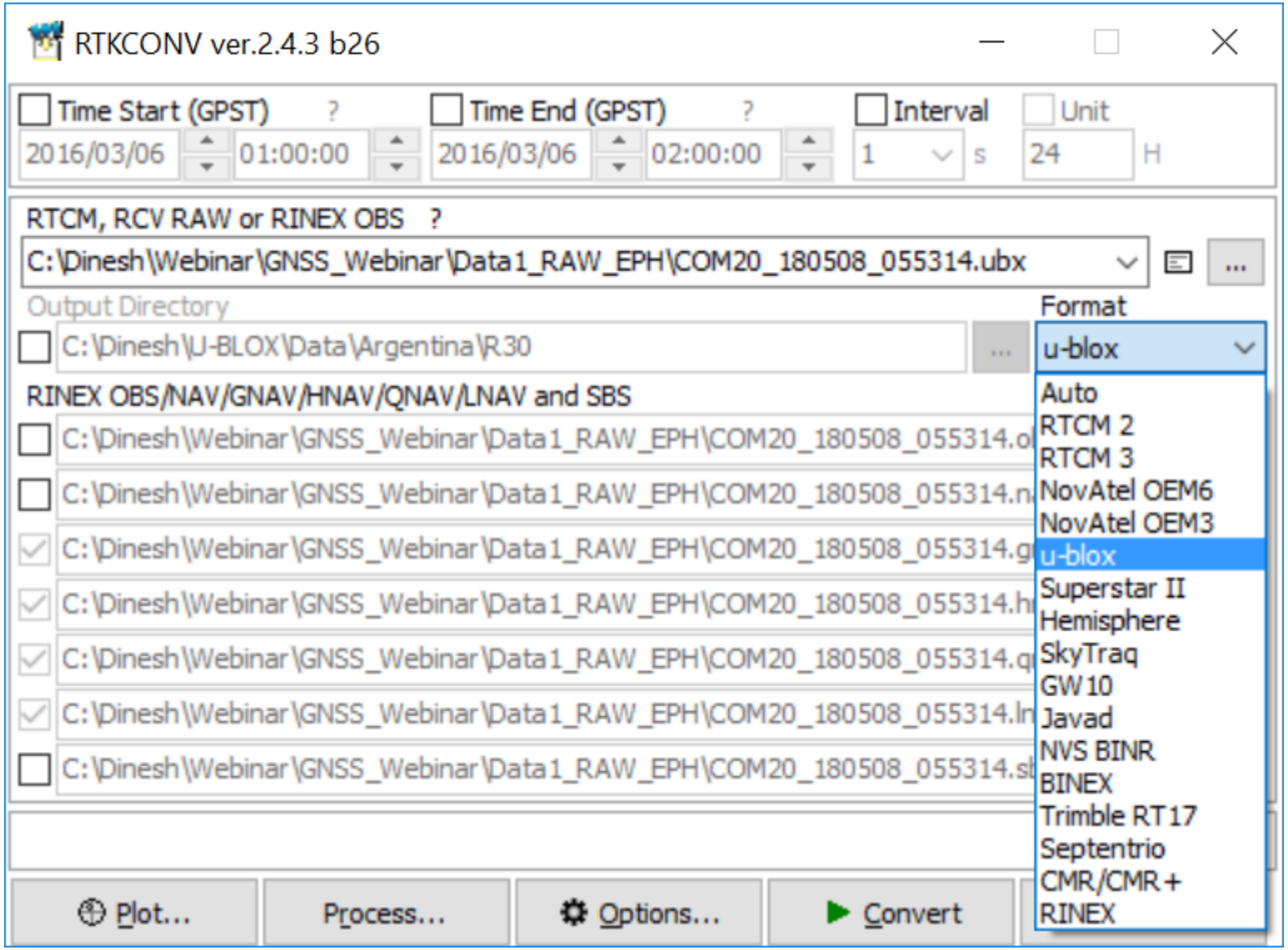

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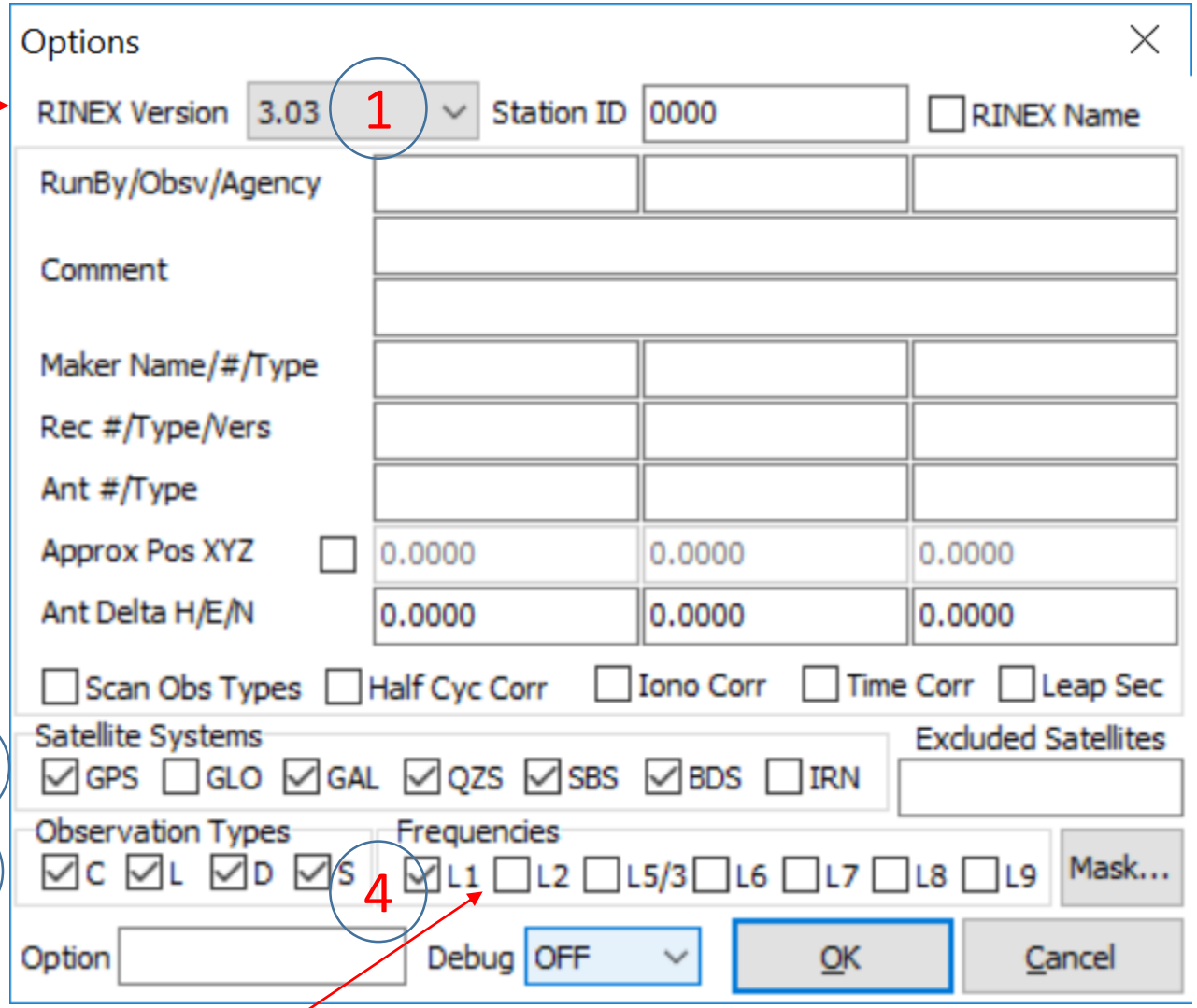
Select RINEX Version



Select Satellite Types

2

Select RAW Data Types
C: Codephase
L: Carrierphase
D: Doppler
S: SNR

3

4

Select Frequencies

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C:\Dinesh\Webinar\GNSS_Webinar\Data1_RAW_EPH\COM20_180508_055314....

File Edit Search View Encoding Language Settings Macro Run Plugins Window ? X

WebRefInfo.txt | new 1 | Weblink.txt | new 2 | new 3 | new 4 | COM20_180508

```
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RTKCONV 2.4.3 b26                       20180508 063741 UTC PGM / RUN BY / DATE
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format: u-blox                                              COMMENT
                                                            MARKER NAME
                                                            MARKER NUMBER
                                                            MARKER TYPE
                                                            OBSERVER / AGENCY
                                                            REC # / TYPE / VERS
                                                            ANT # / TYPE
 -3958743.6815  3329014.4044  3719521.8668                  APPROX POSITION XYZ
        0.0000        0.0000        0.0000                  ANTENNA: DELTA H/E/N
G    4 C1C L1C D1C S1C                                      SYS / # / OBS TYPES
E    4 C1C L1C D1C S1C                                      SYS / # / OBS TYPES
J    4 C1C L1C D1C S1C                                      SYS / # / OBS TYPES
S    4 C1C L1C D1C S1C                                      SYS / # / OBS TYPES
C    4 C1I L1I D1I S1I                                      SYS / # / OBS TYPES
  2018     5     8     5    53   53.8020000     GPS         TIME OF FIRST OBS
  2018     5     8     5    58   39.8020000     GPS         TIME OF LAST OBS
G                                                           SYS / PHASE SHIFT
E                                                           SYS / PHASE SHIFT
J                                                           SYS / PHASE SHIFT
S                                                           SYS / PHASE SHIFT
C                                                           SYS / PHASE SHIFT
  0                                                         GLONASS SLOT / FRQ #
 C1C    0.000 C1P    0.000 C2C    0.000 C2P    0.000       GLONASS COD/PHS/BIS
                                                            END OF HEADER
> 2018  5  8  5 53 53.8020000  0 11
G 8  21422159.747   112574213.209         443.982          47.000
G 7  22980603.593                        1962.350          25.000
J 3  39409862.656   207100226.953         -537.128          36.000
G18  22521155.170   118349454.925         3152.973          29.000
G27  21412034.625                        -1696.892          23.000
G16  22340686.030                        -2003.634          17.000
G10  24698675.041                         1297.075          19.000
C 7  36340268.883   189233234.024           72.968          37.000
C10  37625862.965   195927711.819          474.266          42.000
G 1  24489851.016   128695035.3342        3704.419          28.000
C16  37772326.978   196690397.959          474.114          38.000
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C:\Dinesh\Webinar\GNSS_Webinar\Data1_RAW_EPH\COM20_180508_055314....

File Edit Search View Encoding Language Settings Macro Run Plugins Window ? X

new 2 | new 3 | new 4 | COM20_180508_055314.obs | COM20_180508_055314.nav

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format: u-blox                                              COMMENT
                                                            END OF HEADER
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       .900000000000E+01  .160000000000E+02  .428910722996E-08  .147692161388E+01
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       .194400000000E+06  .726431608200E-07  .284651424308E+01  .782310962677E-07
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       .194046000000E+06  .400000000000E+01
G18 2018  5  8  6  0  0  .637071207166E-05  .466116034659E-11  .000000000000E+00
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      -.302866101265E-05  .770077644847E-02  .601634383202E-05  .515366776085E+04
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       .578351318836E-05  .744588590460E-01 -.409223139286E-05  .649349954605E+04
       .194400000000E+06 -.288709998131E-06  .276081194061E+01 -.815838575363E-06
       .708645506593E+00  .282750000000E+03 -.156176460704E+01 -.222580699951E-08
      -.173221501085E-09  .200000000000E+01  .200000000000E+04  .100000000000E+01
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C 7 2018  5  8  5  0  0  .158527866006E-03 -.152864387815E-10  .000000000000E+00
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```

length : 5354 lines : 70 Ln : 1 Col : 1 Sel : 0 | 0 Dos\Windows UTF-8 INS

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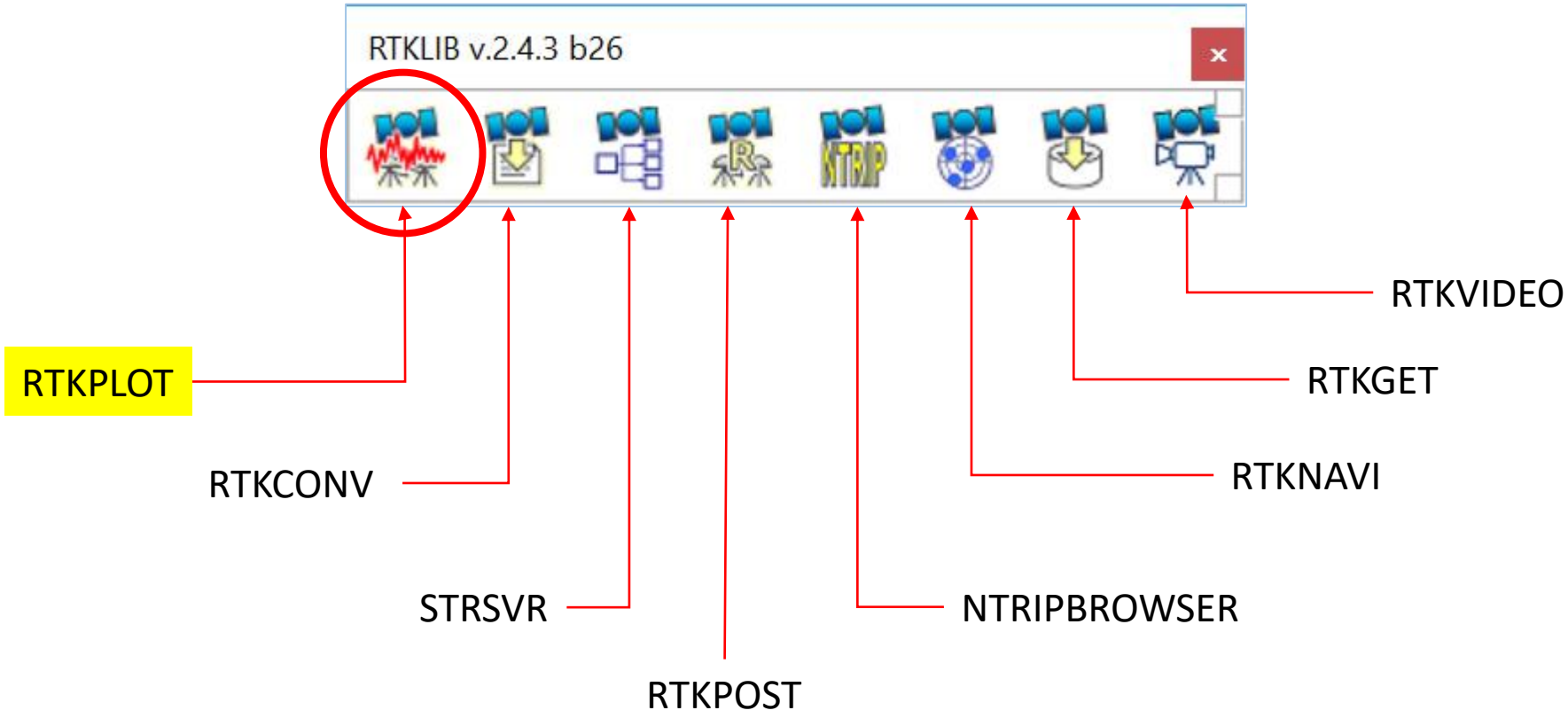
Check RINEX Data



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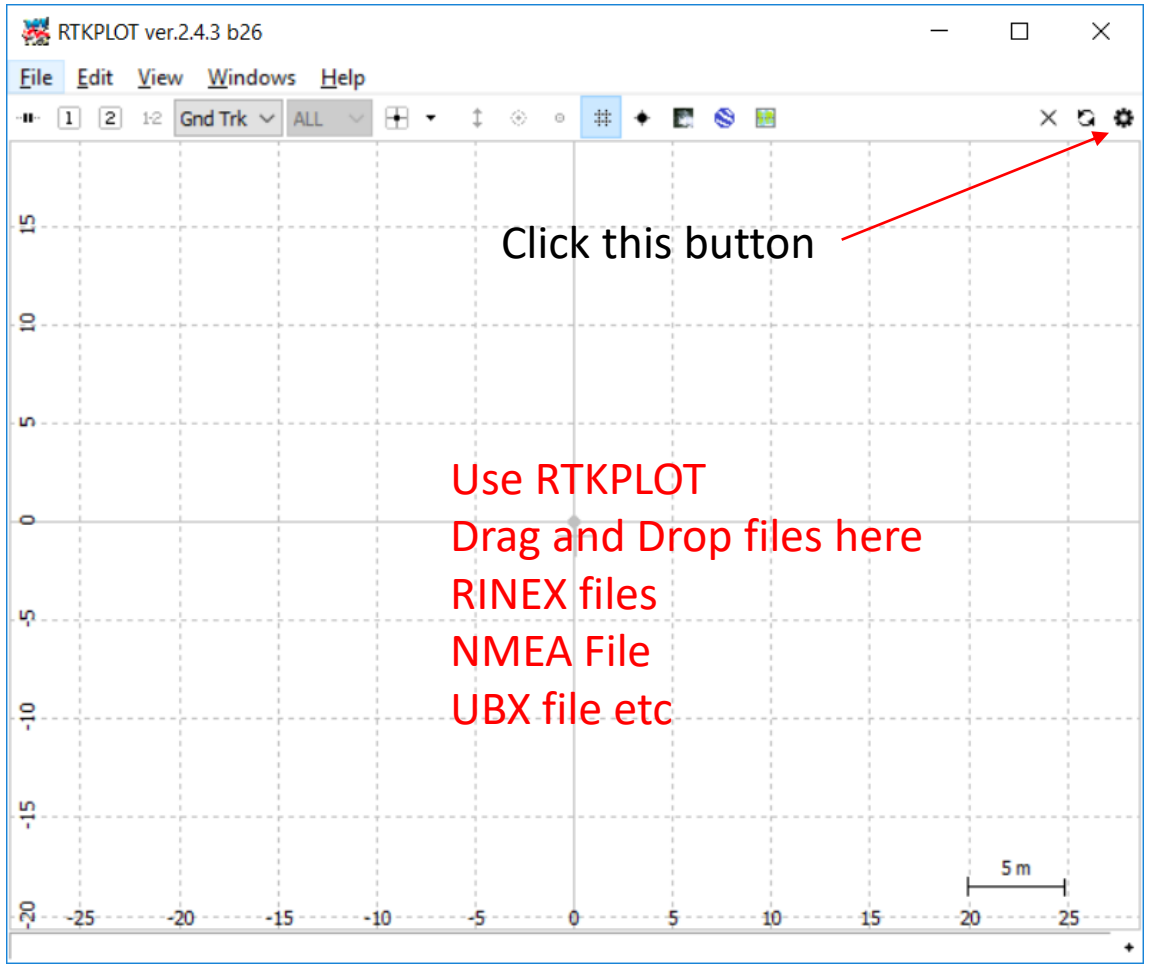
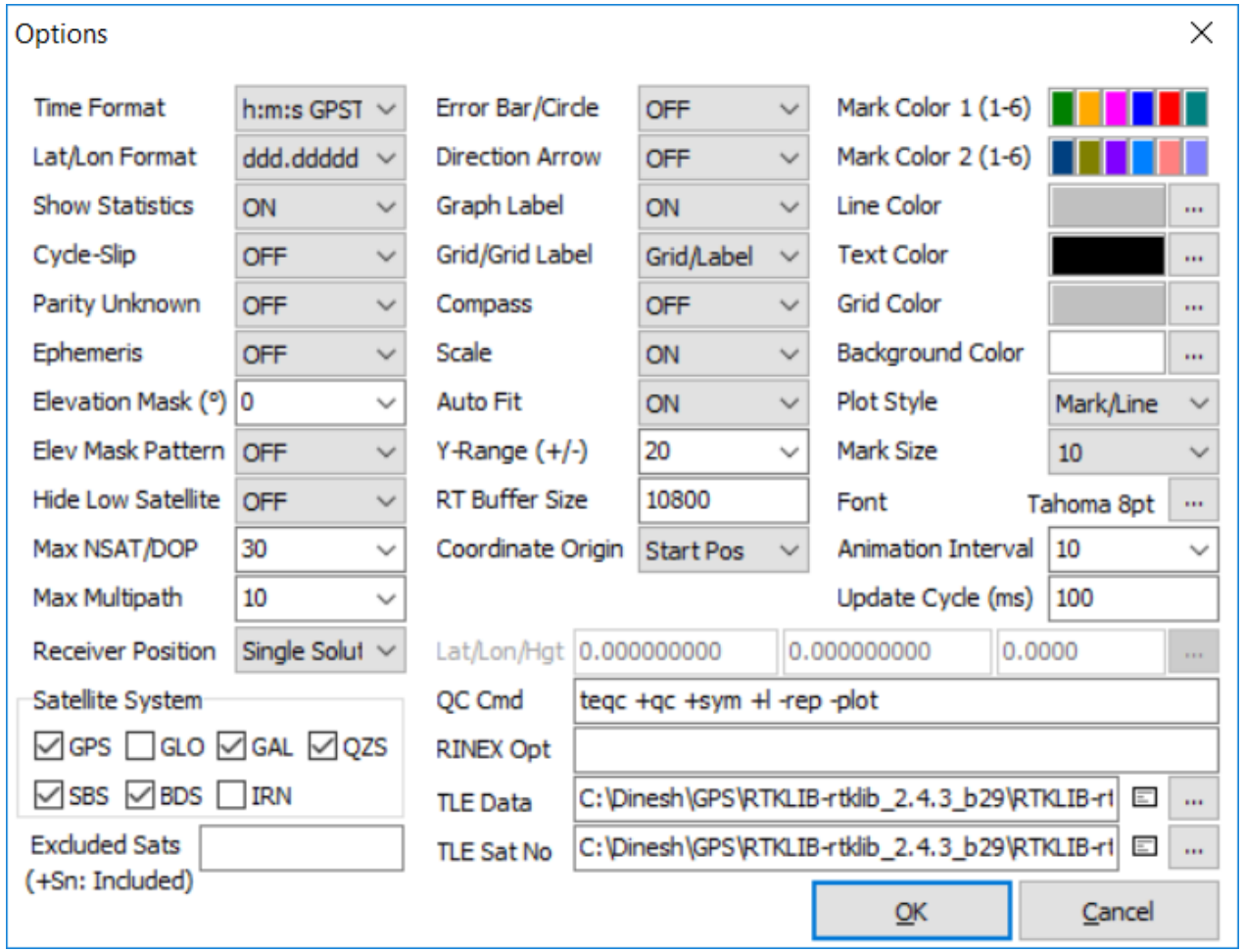
RTKPLOT to Check Data





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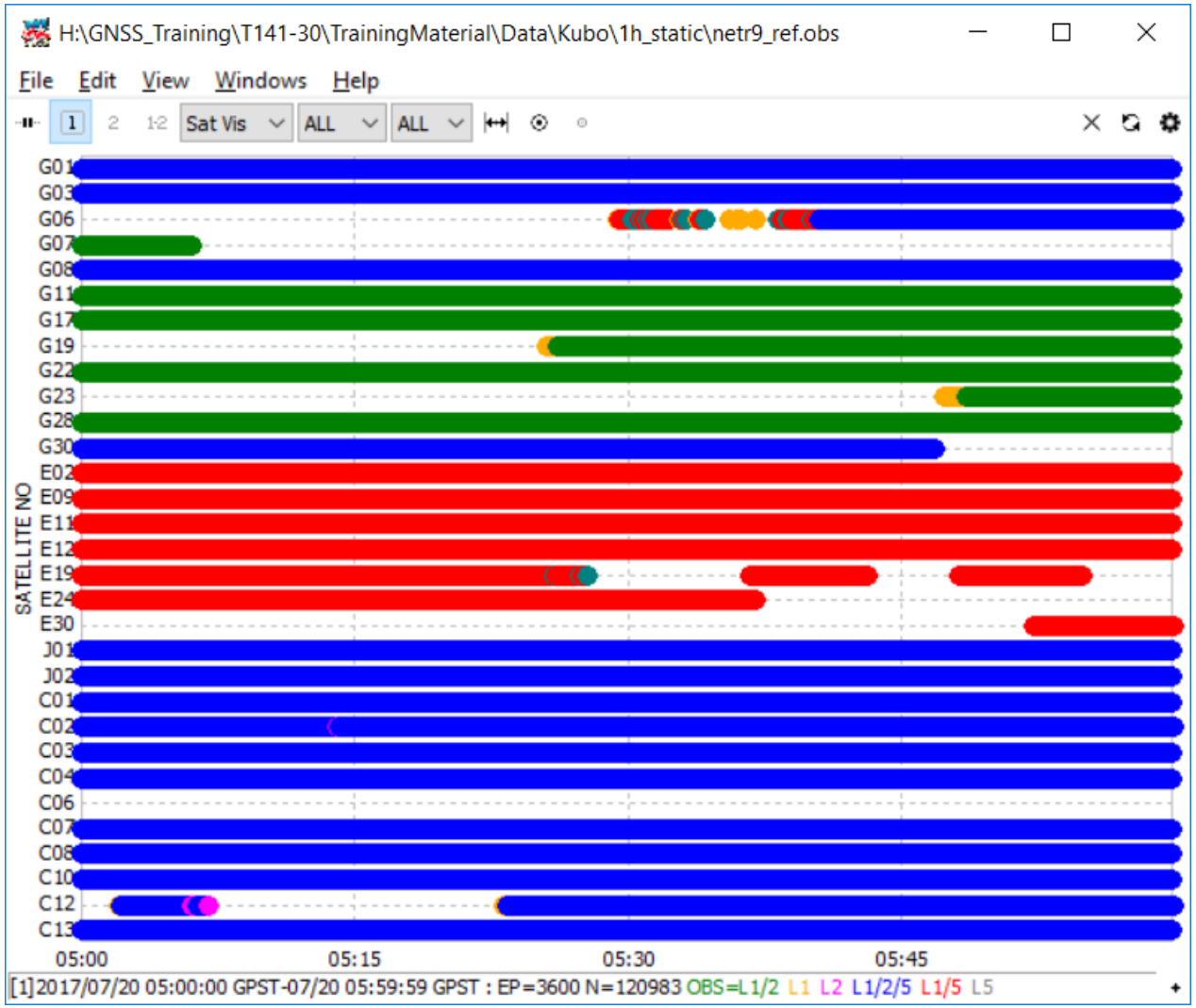
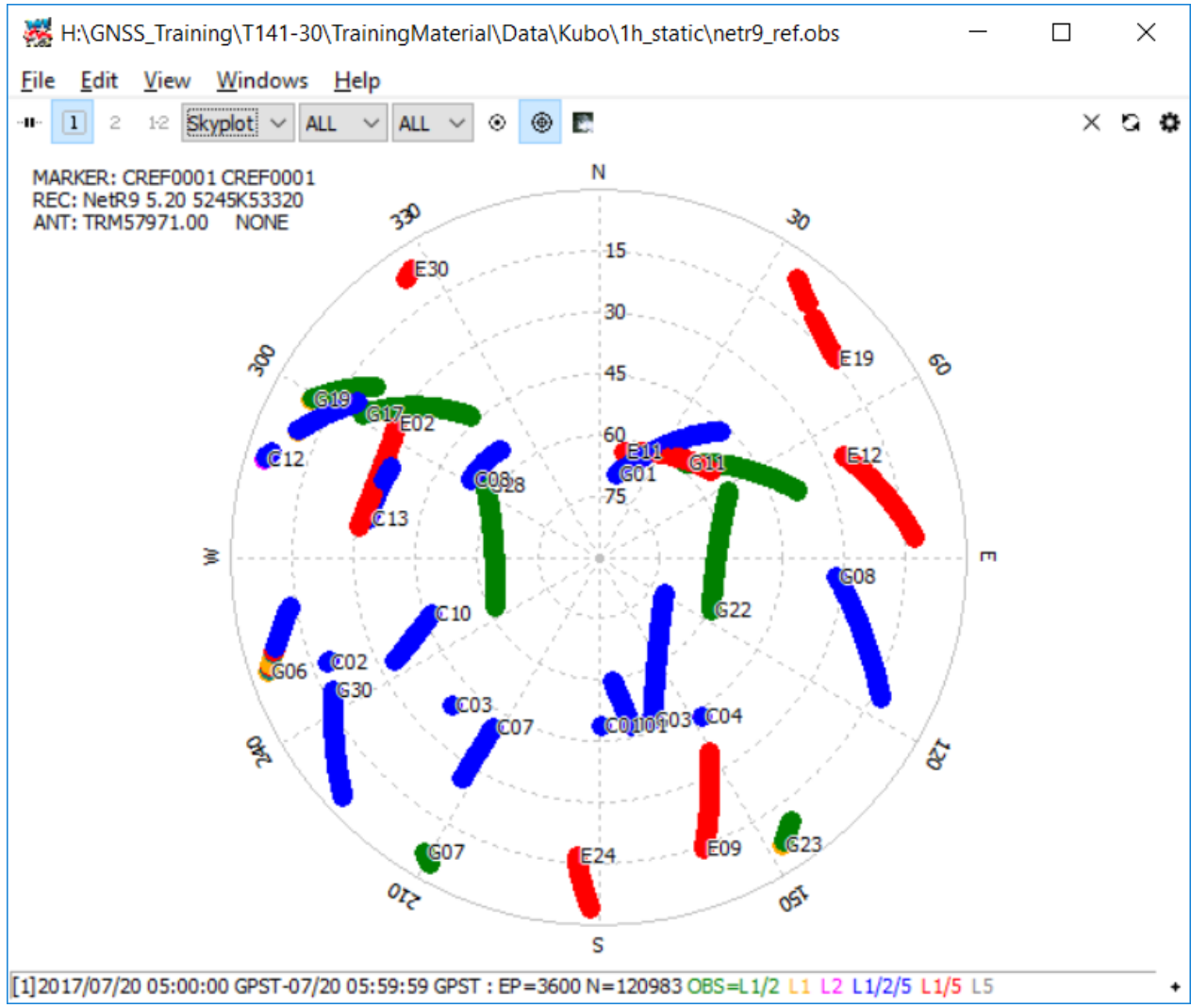
Visible Satellites and Skyplot





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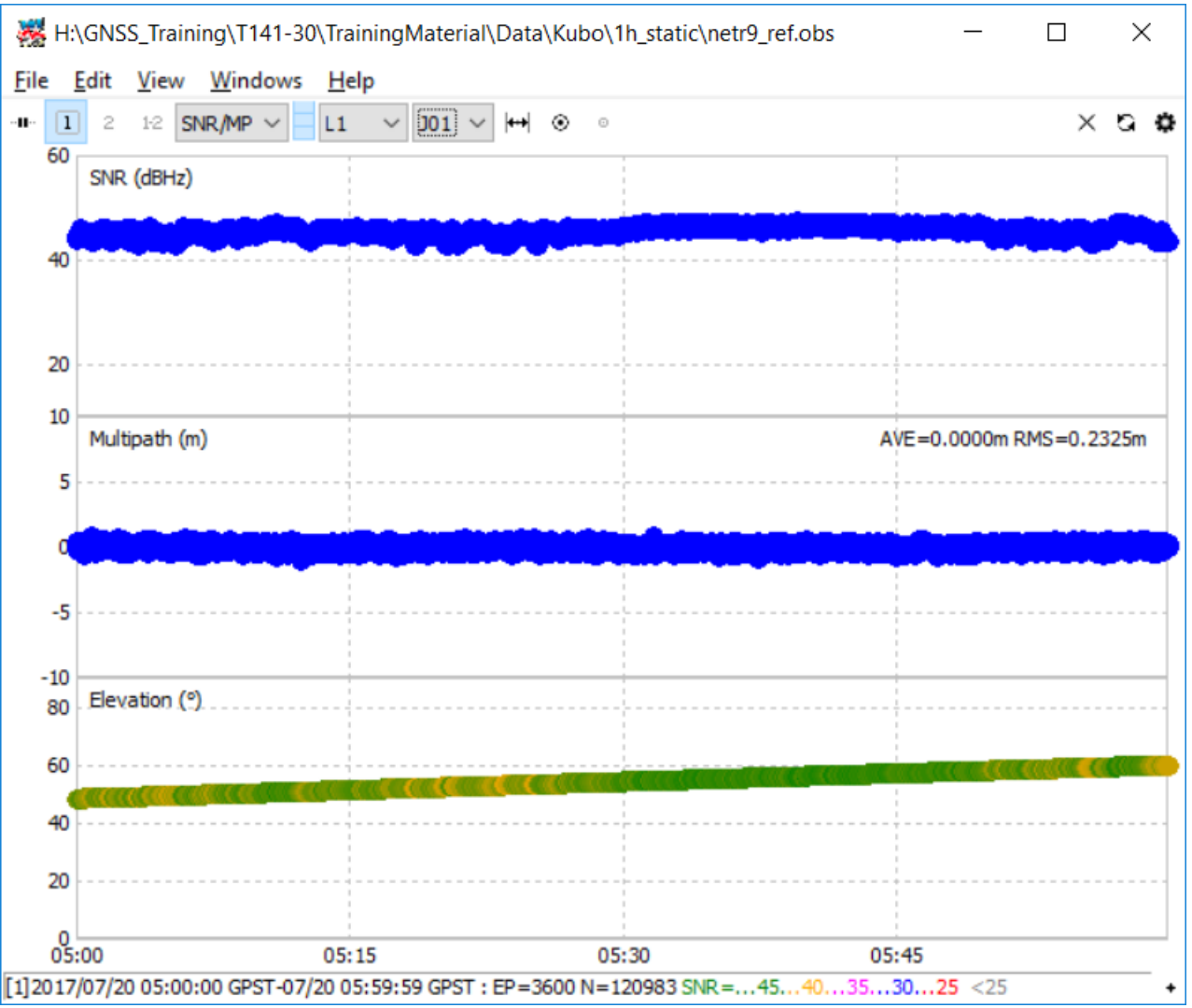
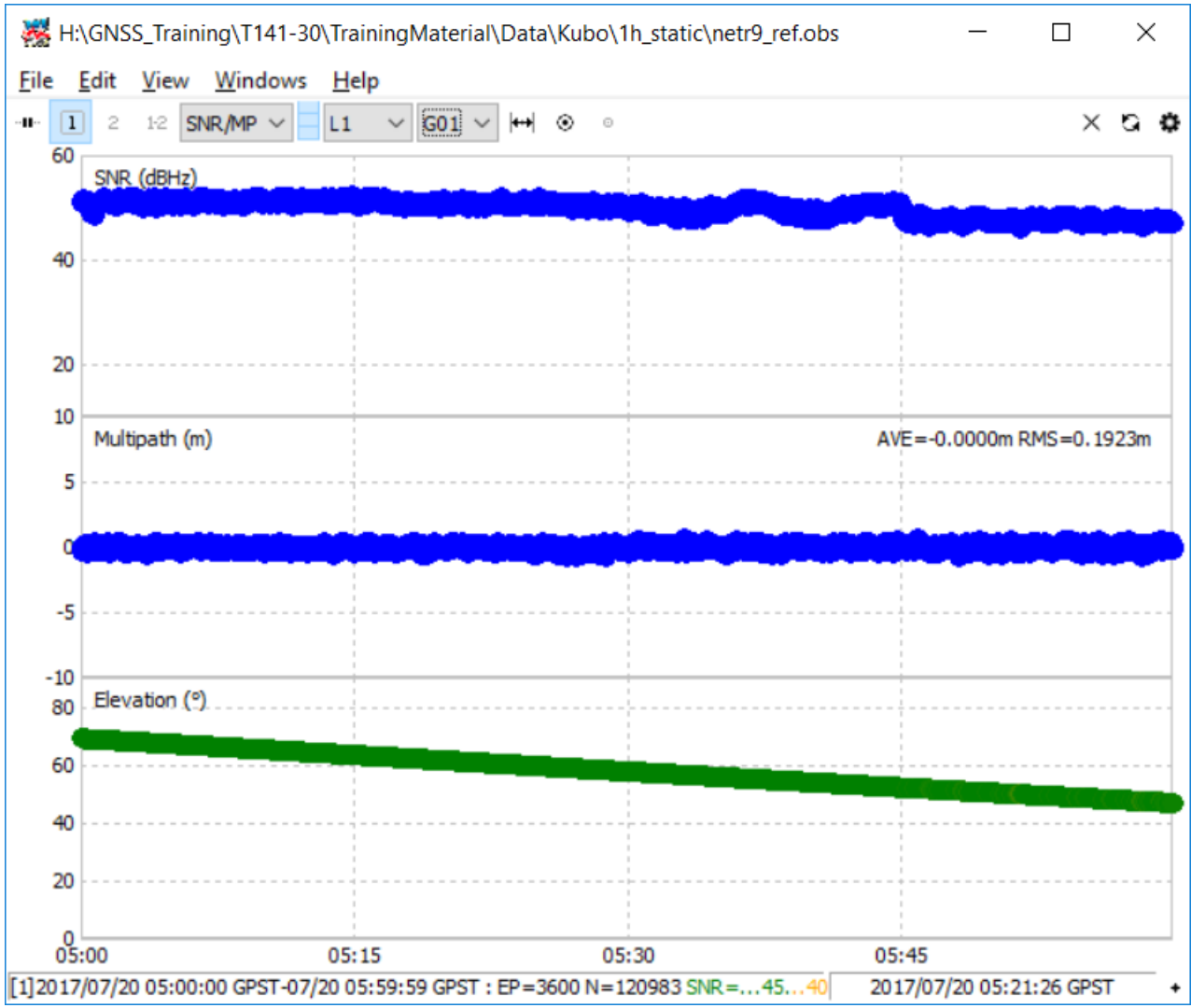
SNR, Multipath and Elevation for J03 and G01 Satellites





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How to Get Base-Station Data

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Accessing Base-Station Data

- For Real-Time RTK
  - Get NTRIP Address
    - IP Address
  - Port ID
  - Mount Point
  - Login ID
  - Password

- For Post-Processing RTK
  - IP Address
  - Login ID
  - Password
- Select the files
- Select the data format
- Download the files

Always request Base-station data in RINEX format if possible.
This will save your time in pre-processing of proprietary data formats

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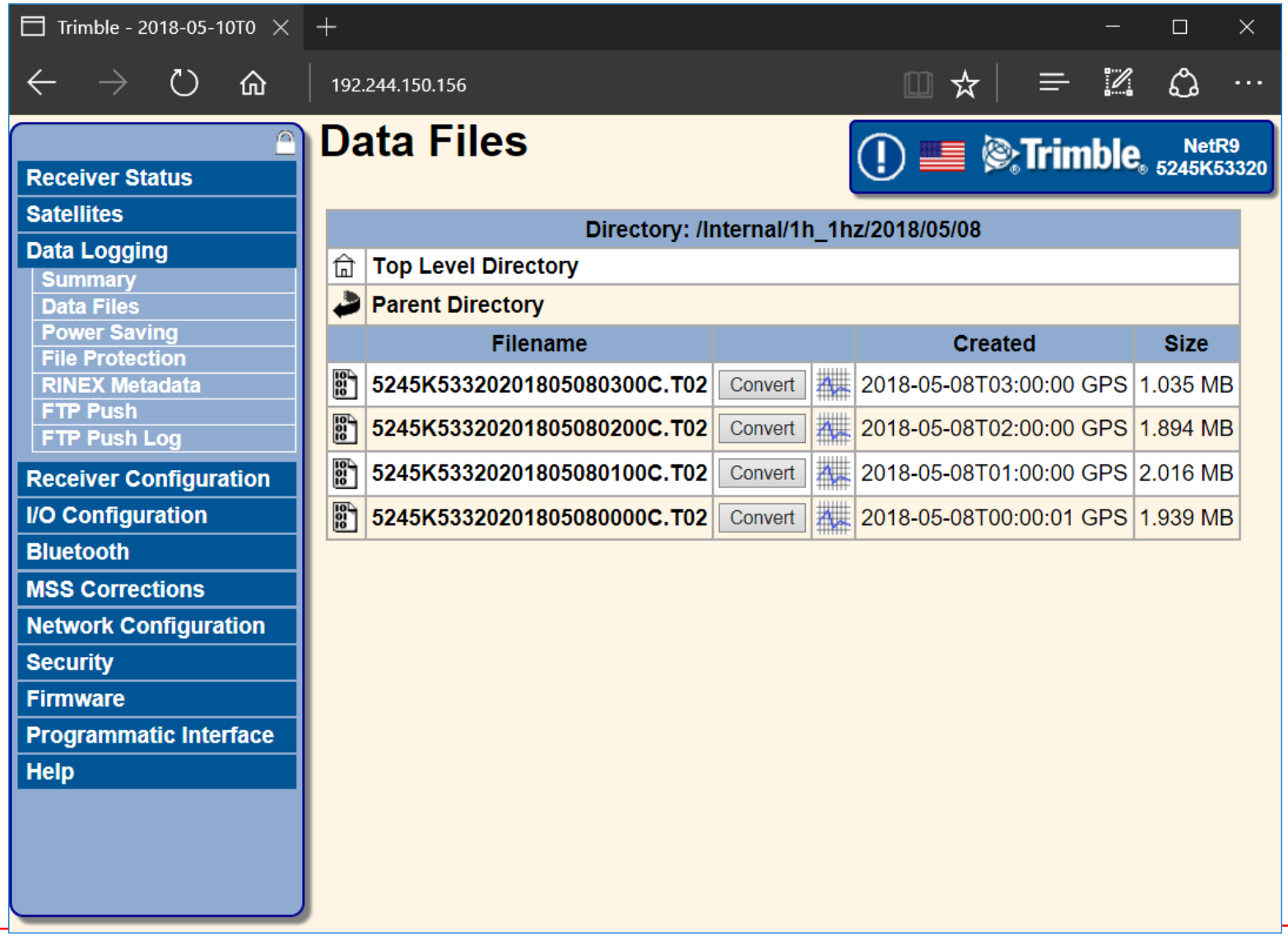
Sample of Data Files in NetR9



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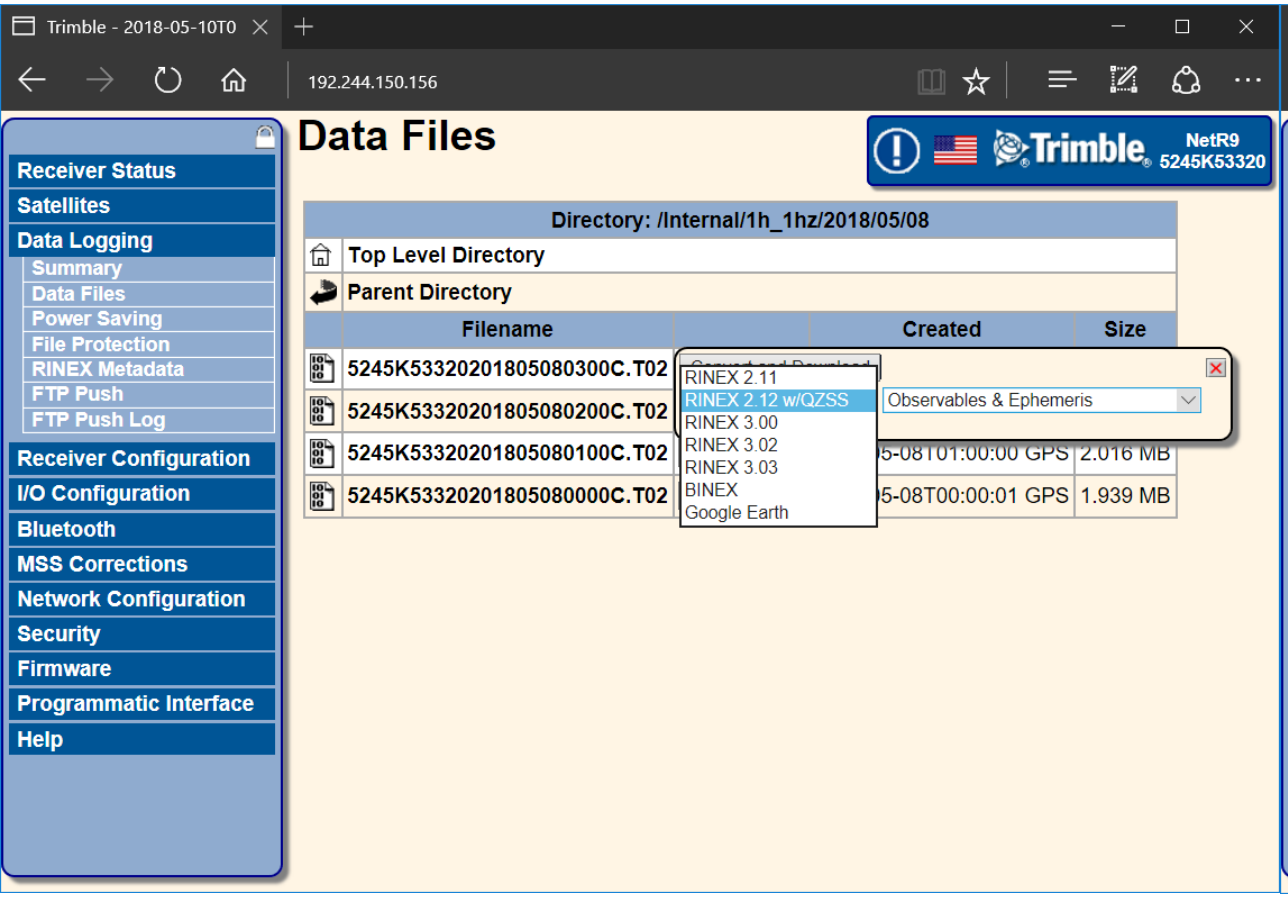
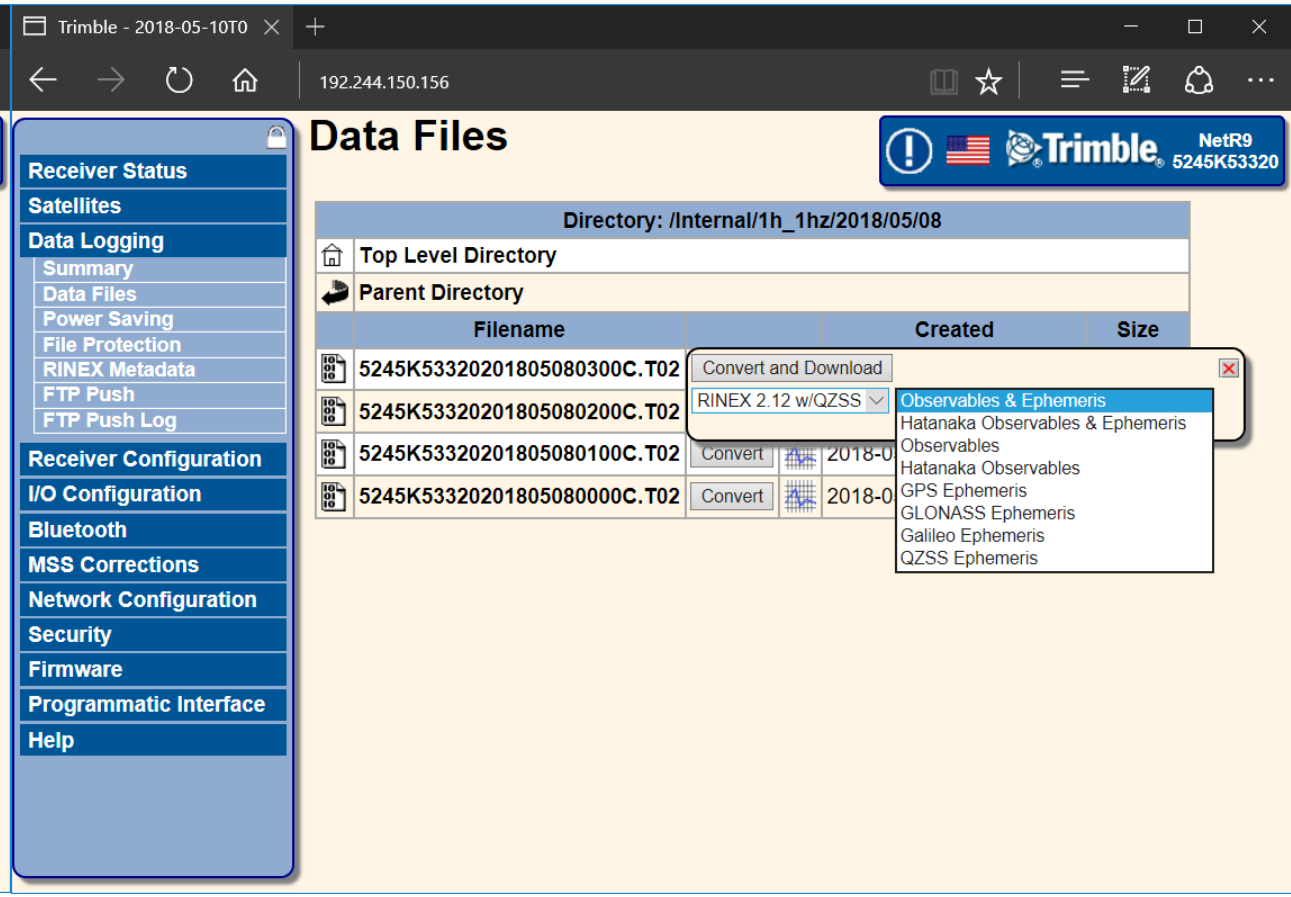
Select Required Data Type and Data





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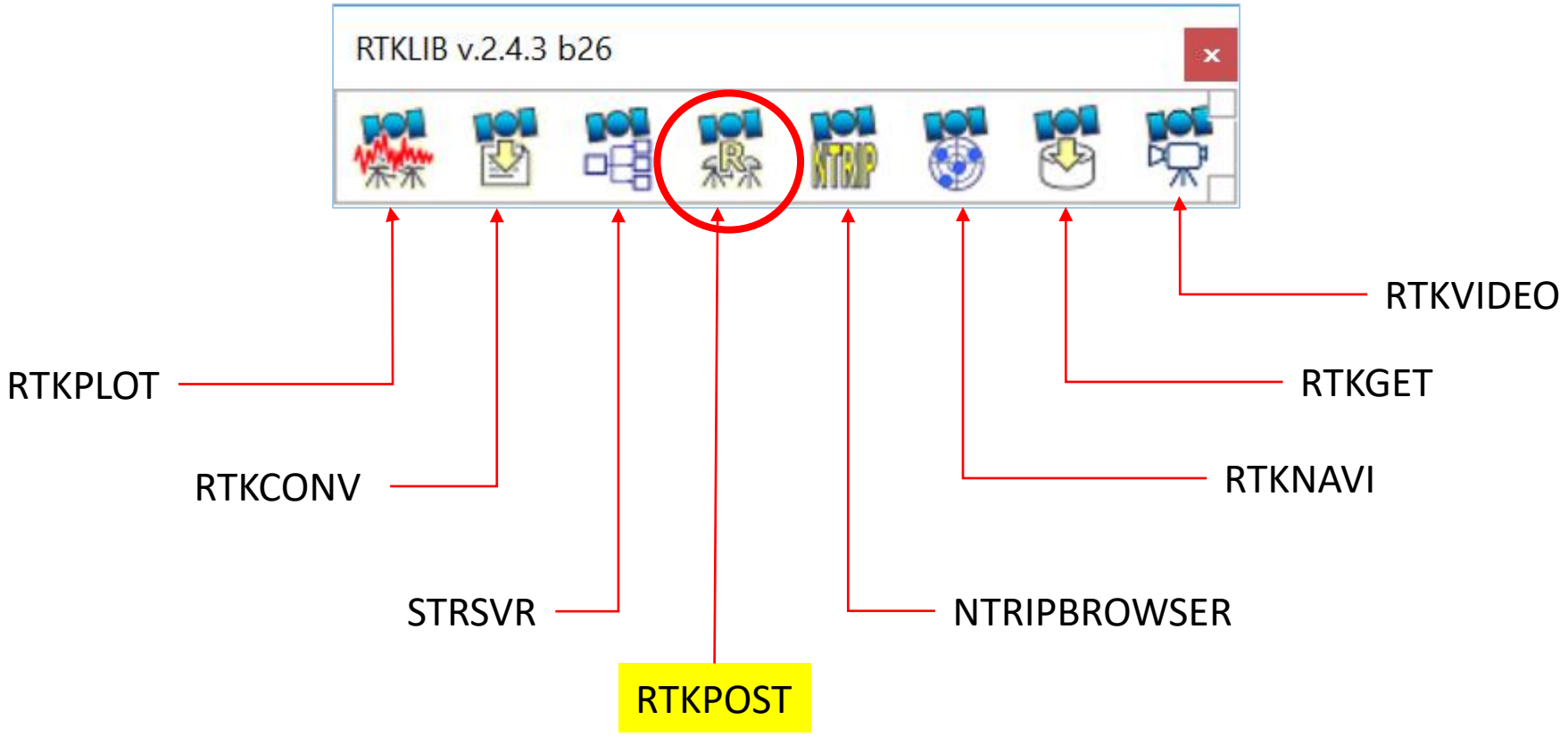
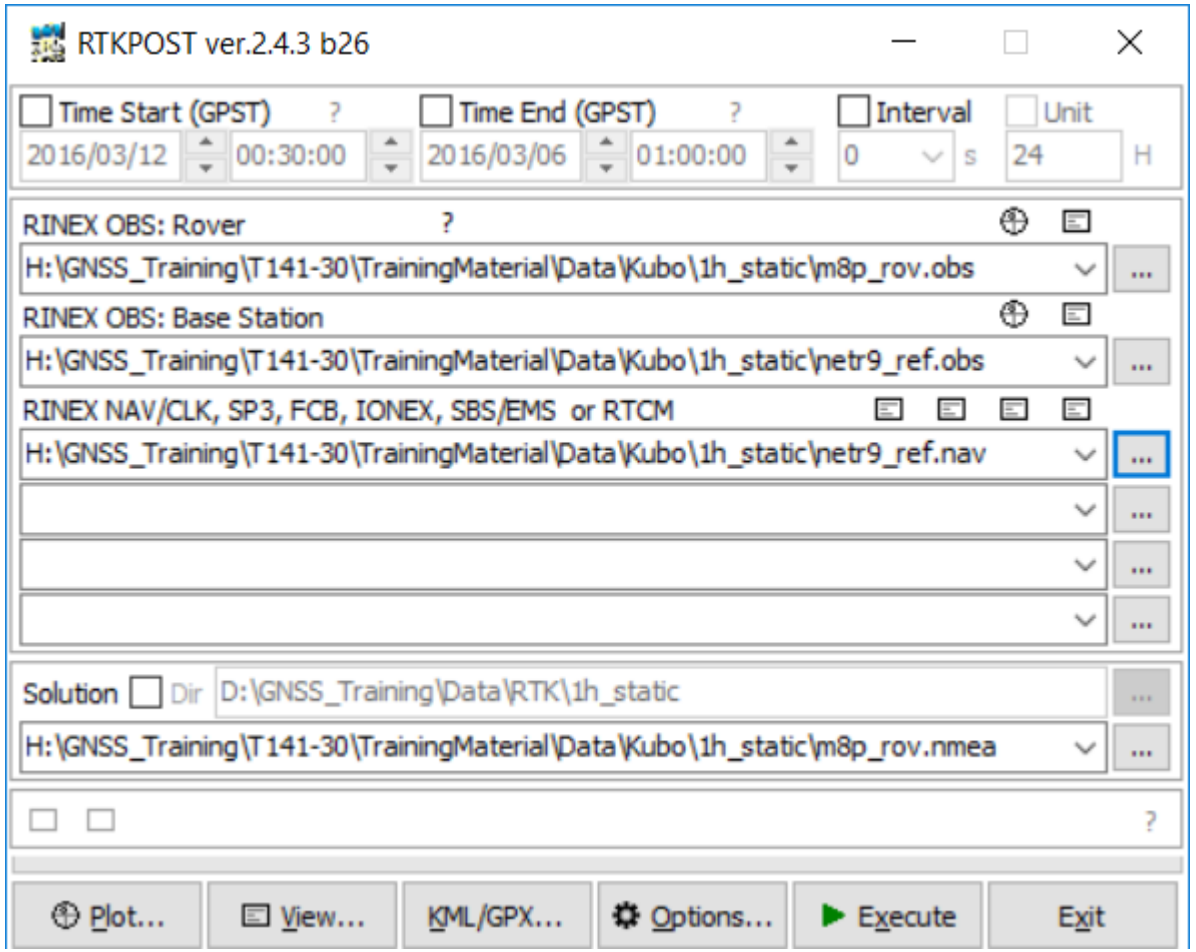
RTK Post-Processing



RTK Post-Processing

- Prepare Data
  - Base Station Data
    - RINEX OBS File
    - RINEX NAV File
  - Rover (User) Data
    - RINEX OBS File
- Select Rover Observation Data
- Select Base Observation Data
- Select Navigation Data



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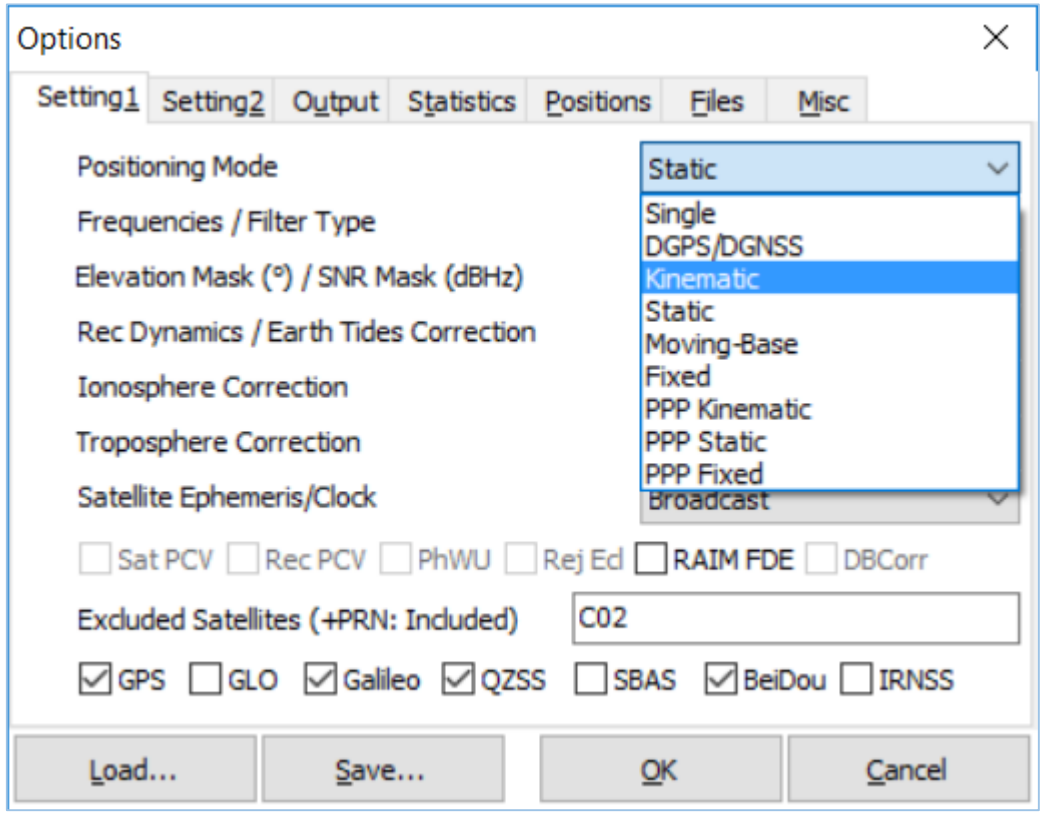

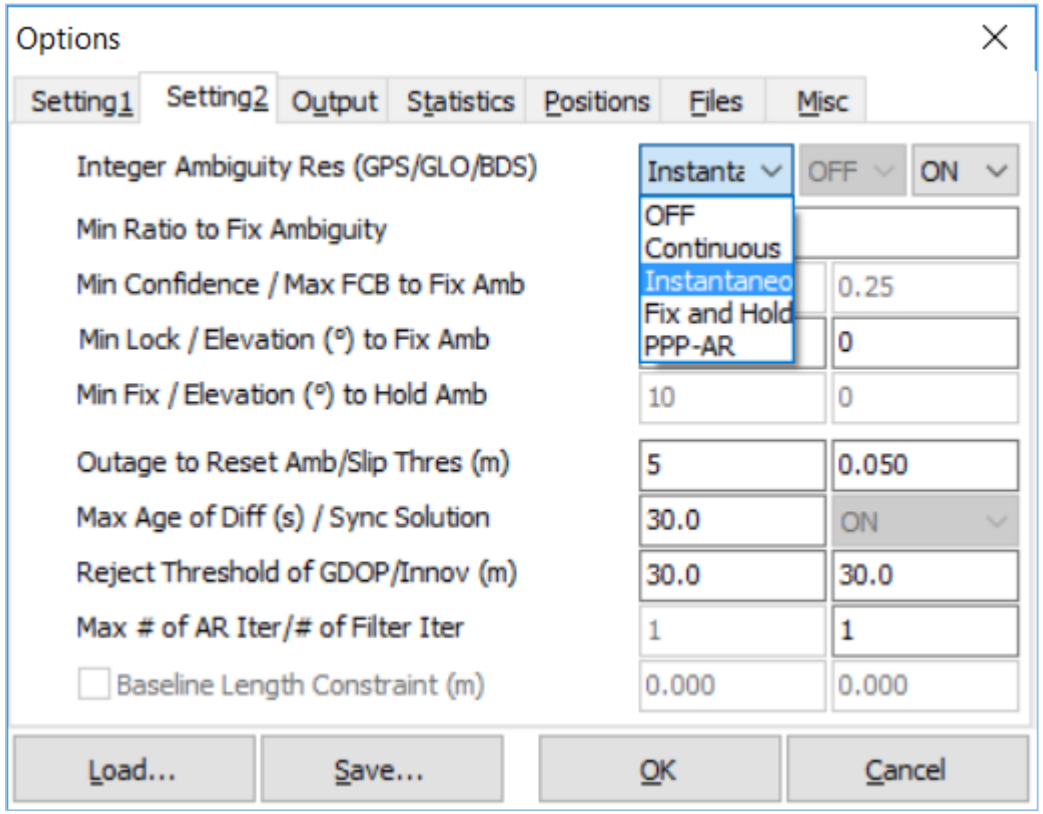

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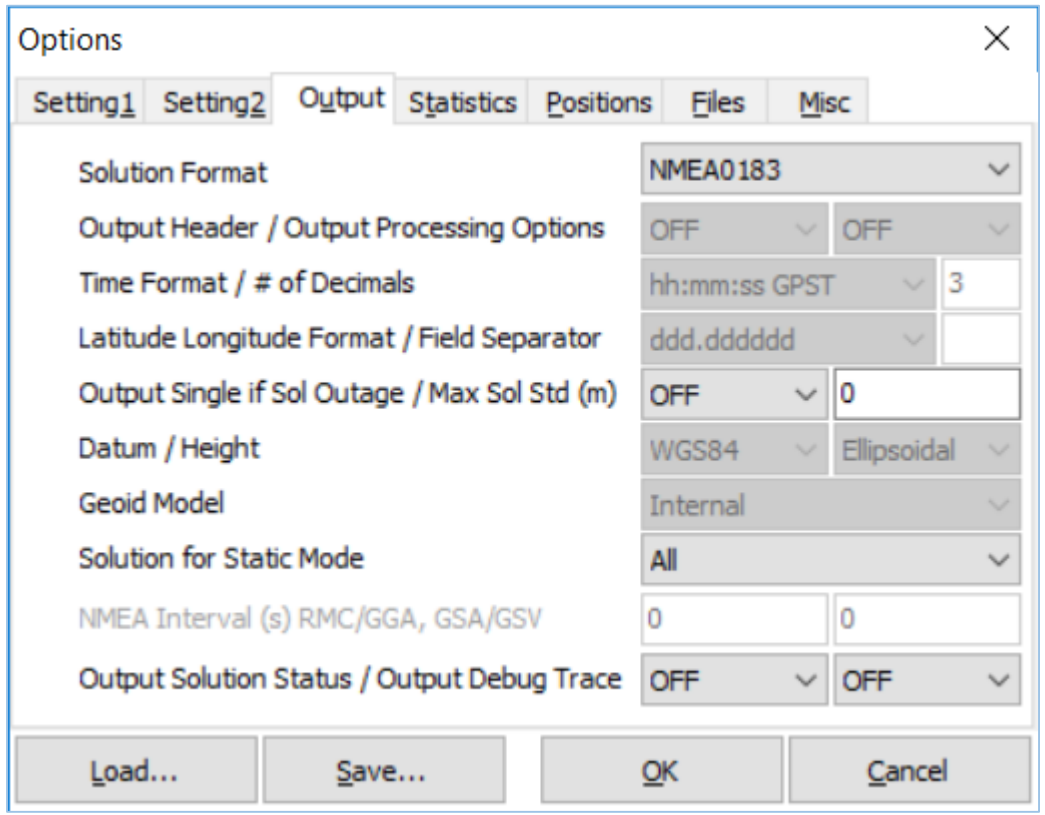

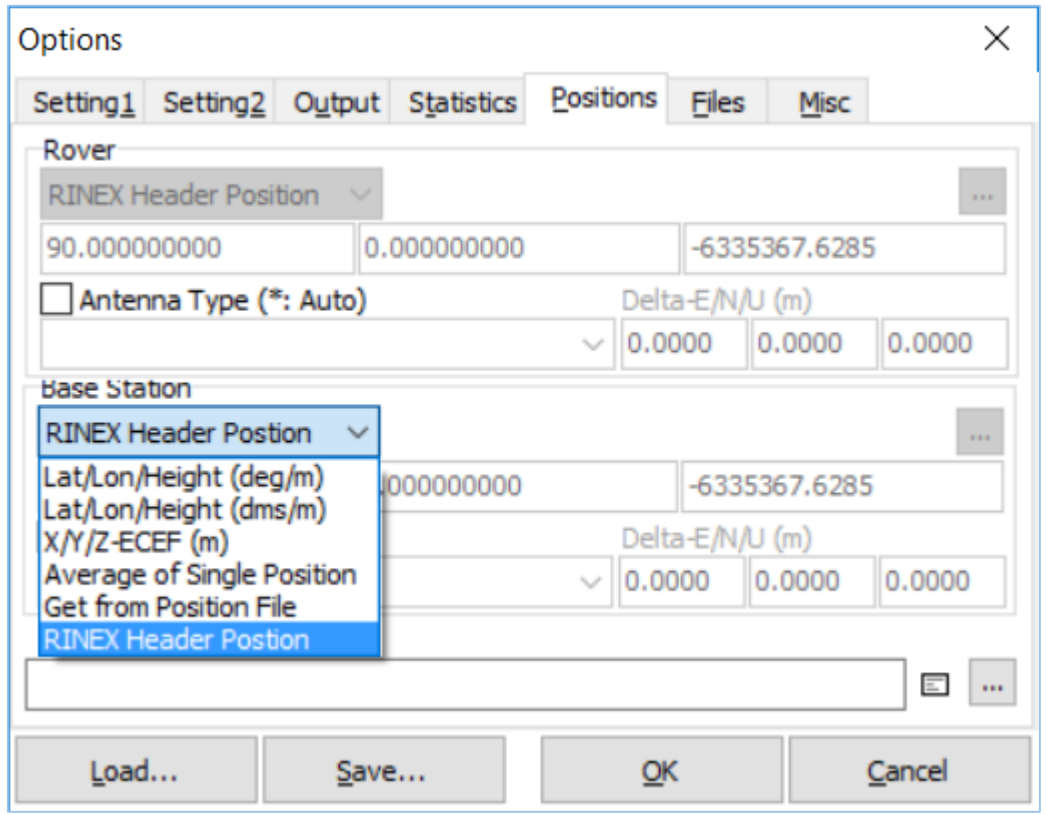

35.66633461 139.7922008 59.741

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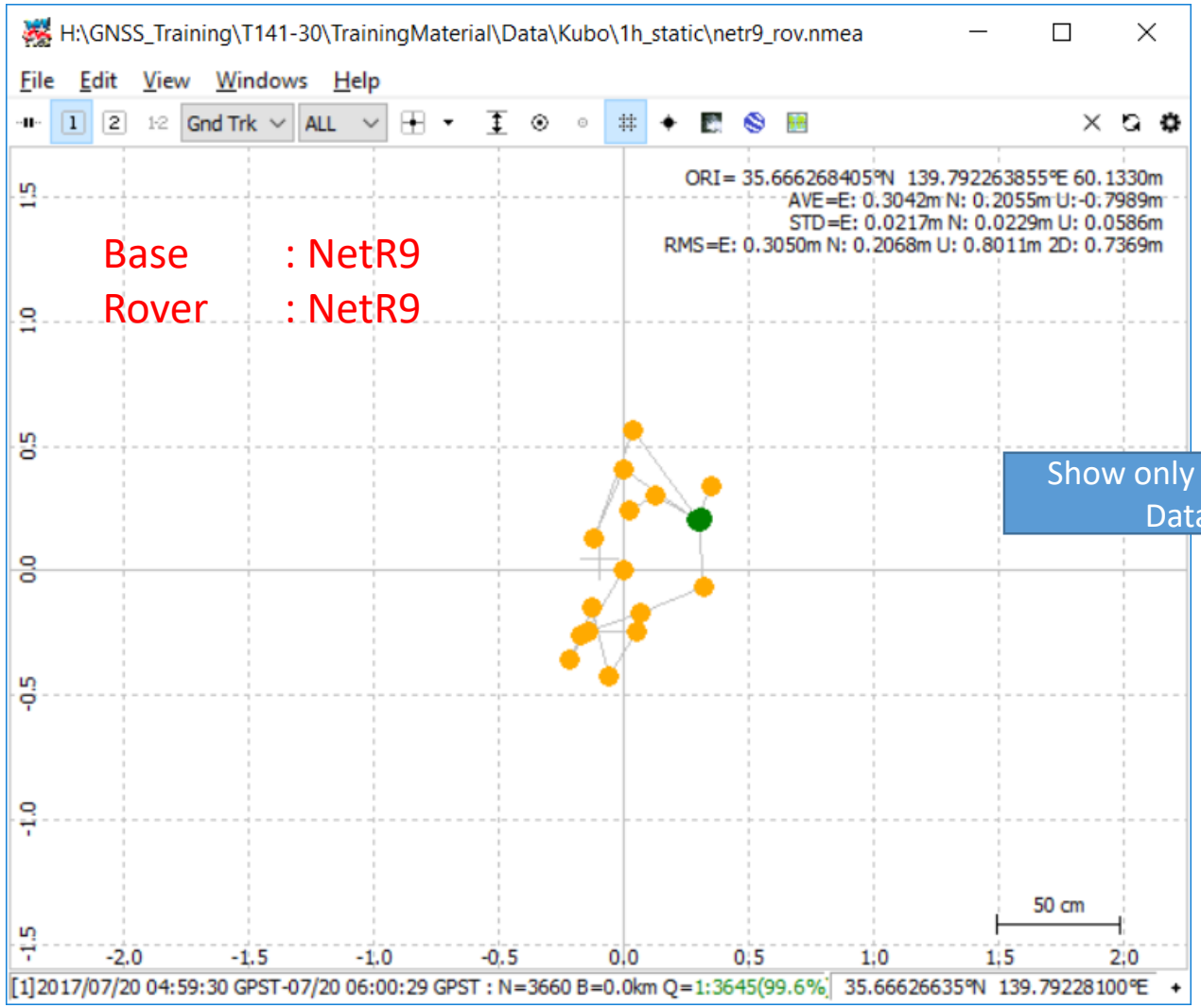
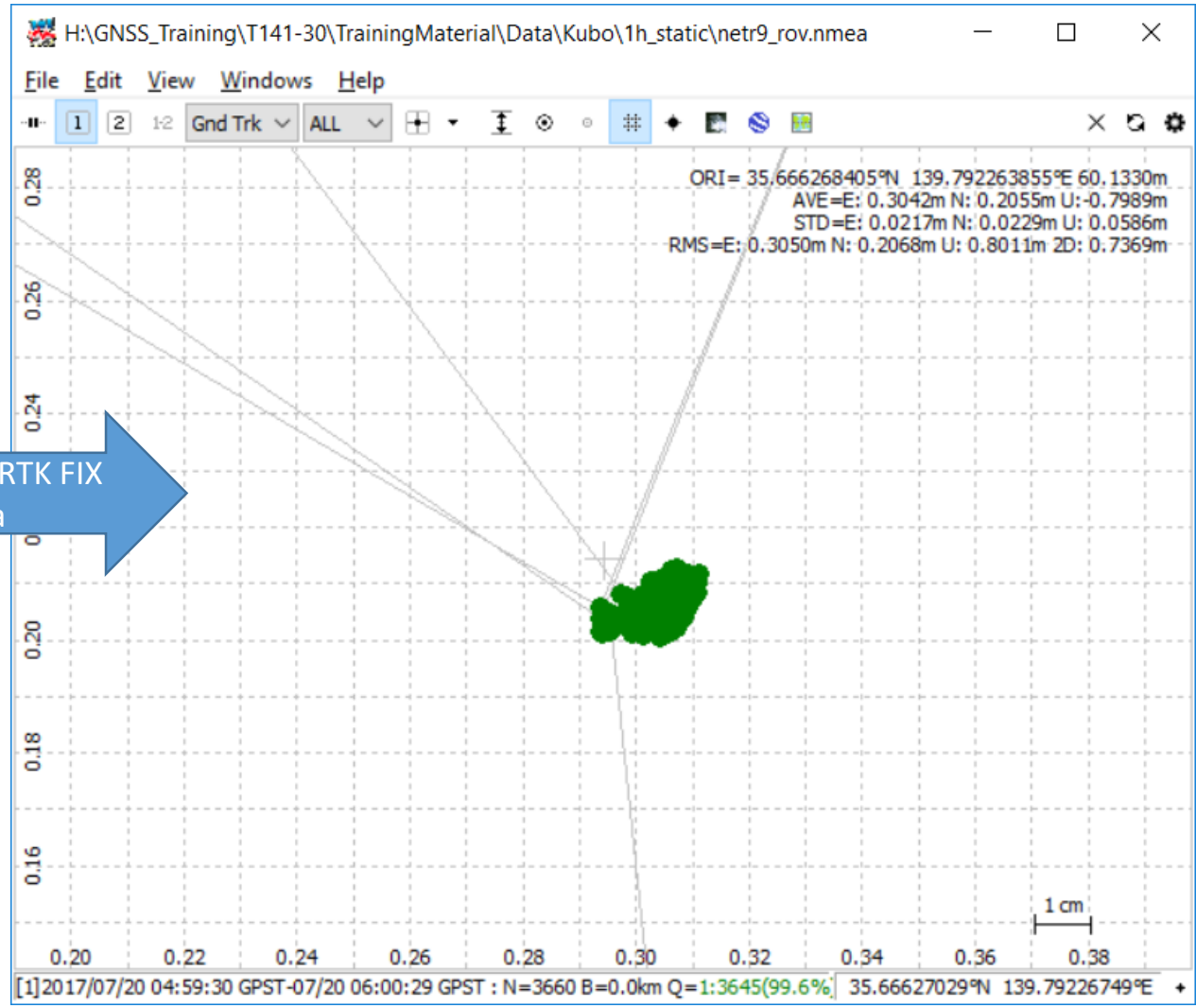
One Hour RTK Post-processing output



Show only RTK FIX Data



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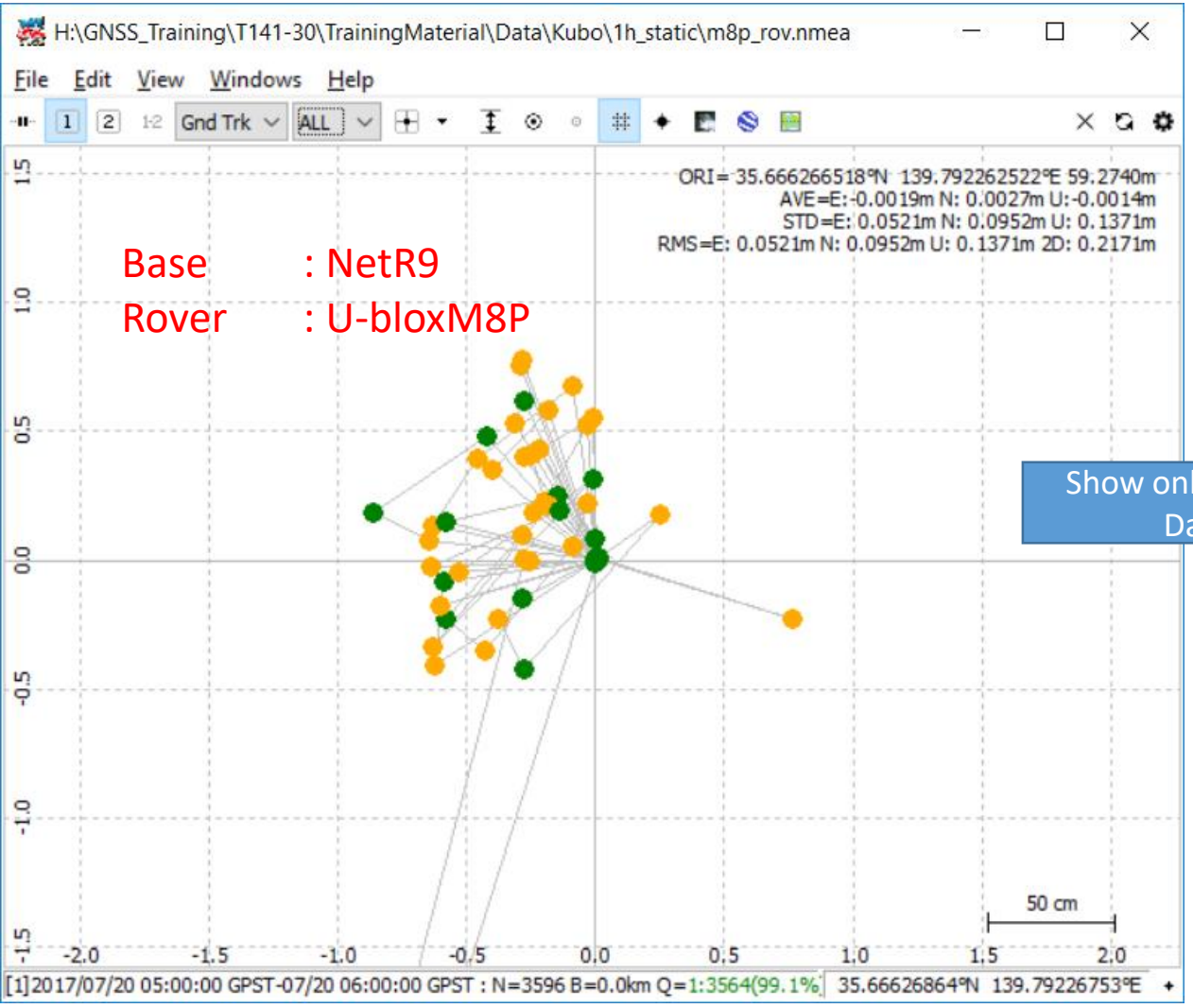
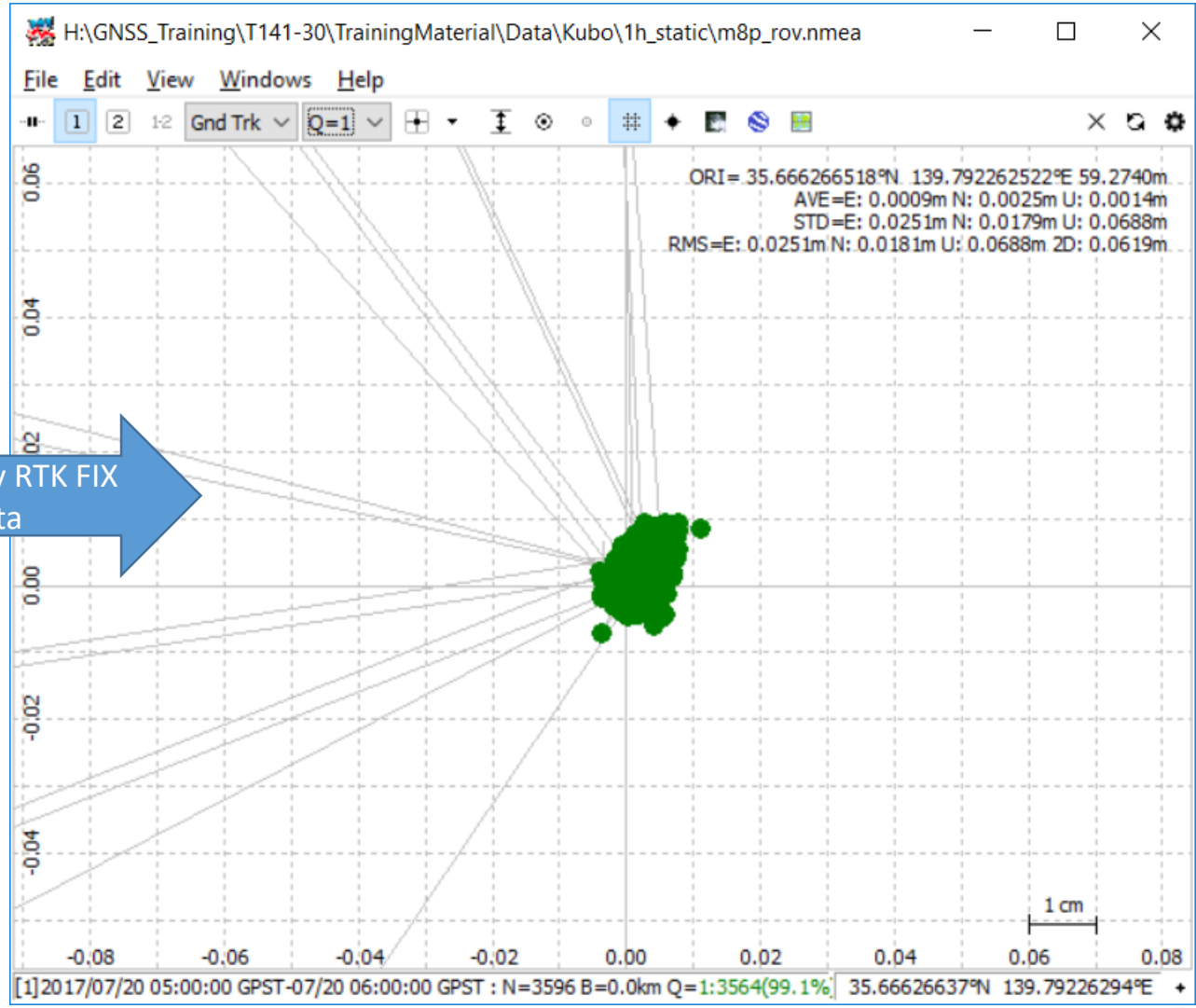
One Hour RTK Post-processing output



Show only RTK FIX Data



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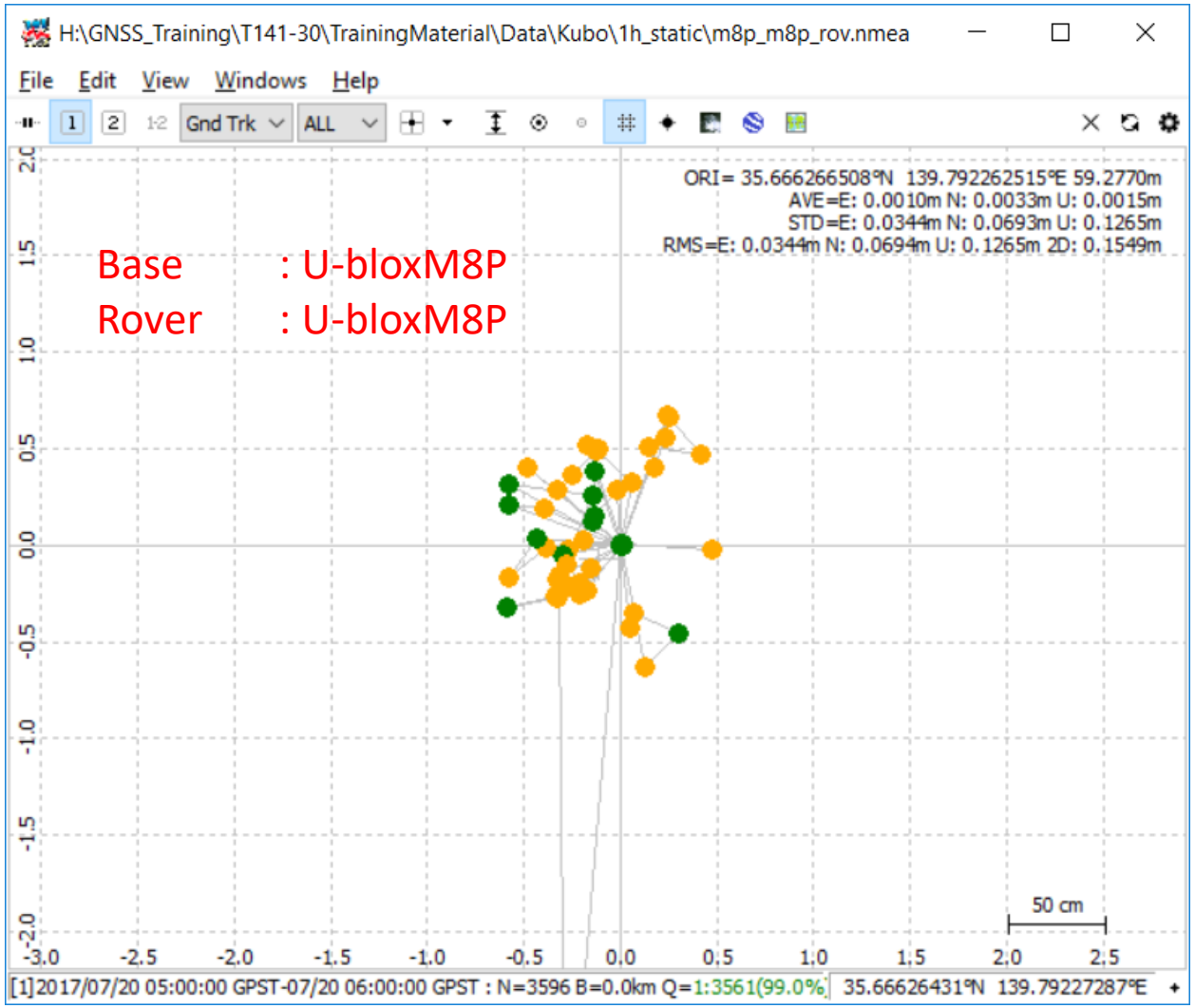

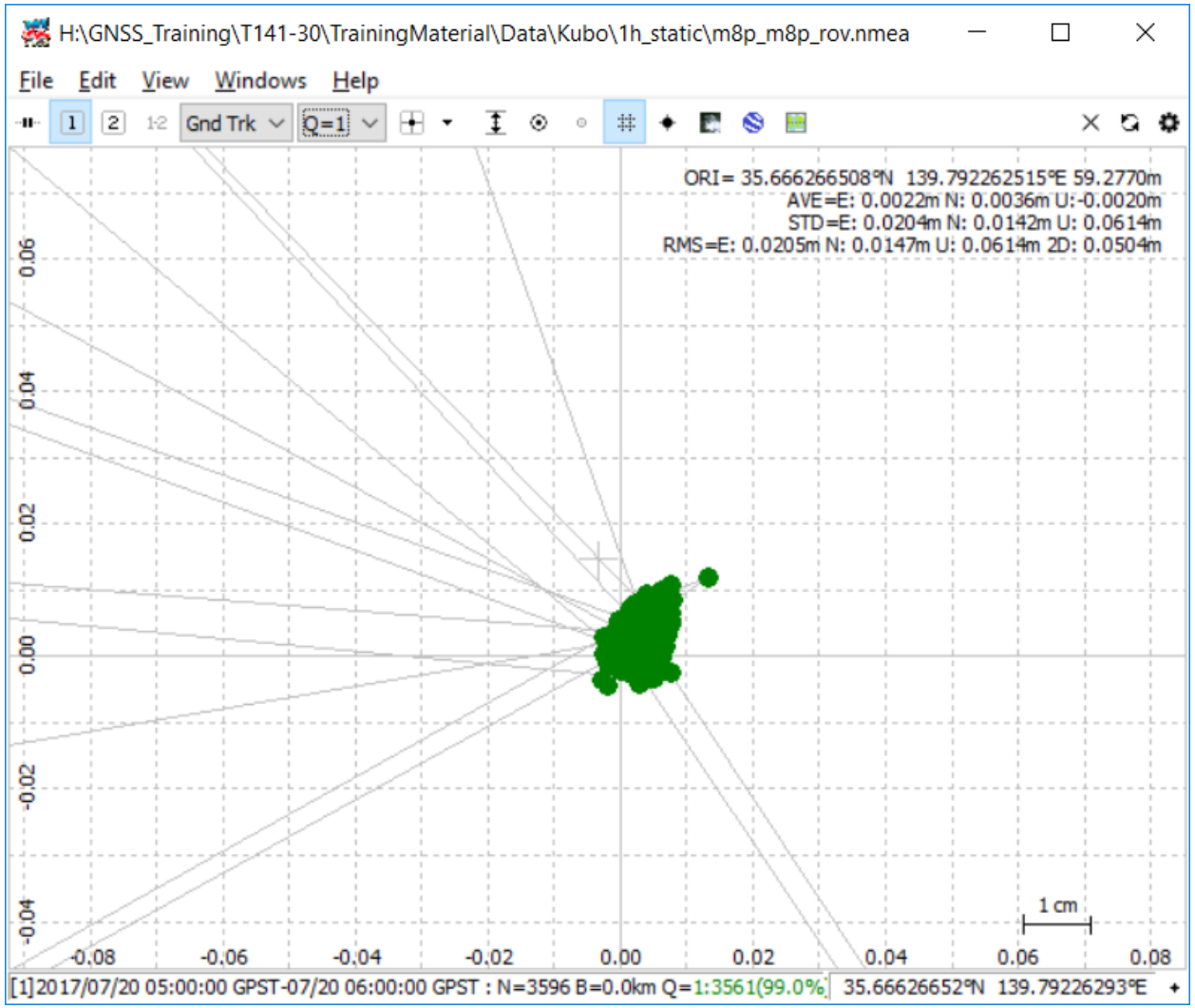

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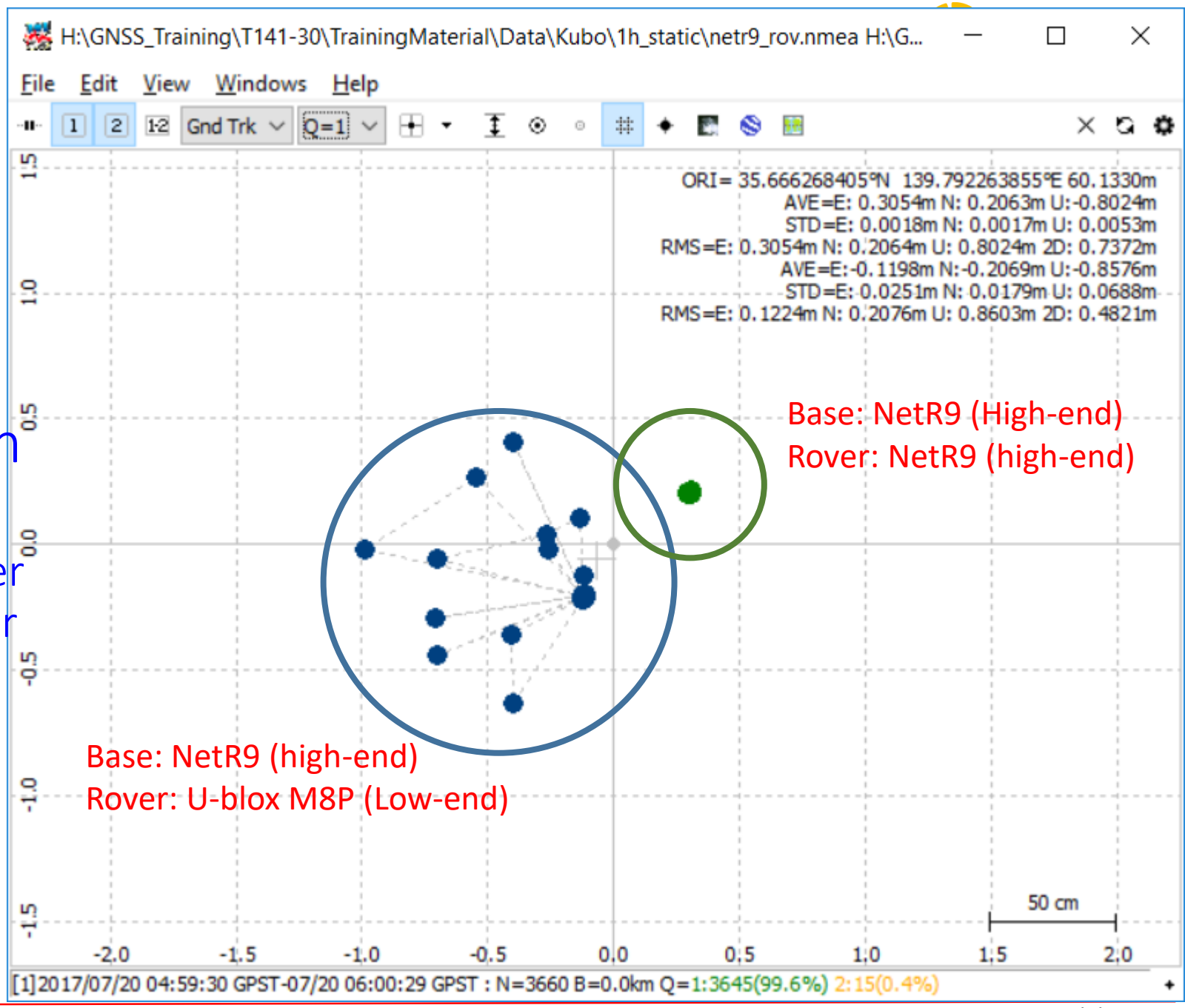
Position Output Comparison between

(a) High-end Base and High-end Rover

(b) High-end Base and Low-end Rover



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Reference Slides

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Data Formats: NMEA, RINEX

References: https://www.nmea.org/
http://freenmea.net/docs

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National Marine Electronics Association (NMEA) Format

- NMEA is format to output measurement data from a sensor in a pre-defined format in ASCII
- In the case of GPS, It output GPS position, velocity, time and satellite related data
- NMEA sentences (output) begins with a “Talker ID” and “Message Description”
  - Example: $GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47
  - “$GP” is Talker ID
  - “GGA” is Message Description to indicate for Position Data

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NMEA Data Format

GGA - Fix data which provide 3D location and accuracy data.

$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47

Where: GGA Global Positioning System Fix Data

123519	Fix taken at 12:35:19 UTC
4807.038, N	Latitude 48 deg 07.038' N
01131.000, E	Longitude 11 deg 31.000' E
1 Fix quality:	
	0 = invalid ,
	1 = GPS fix (SPS),
	2 = DGPS fix,
	3 = PPS fix,
	4 = Real Time Kinematic
	5 = Float RTK
	6 = estimated (dead reckoning) (2.3 feature)
	7 = Manual input mode
	8 = Simulation mode
08	Number of satellites being tracked
0.9	Horizontal dilution of position
545.4,M	Altitude, Meters, above mean sea level
46.9,M	Height of geoid (mean sea level) above WGS84 ellipsoid
(empty field)	time in seconds since last DGPS update (empty field) DGPS station ID number
*47	the checksum data, always begins with *

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RINEX Data Format

- Receiver Independent Exchange Format (RINEX) is a data exchange format for raw satellite data among different types of receivers.
  - Different types of receivers may output position and raw data in proprietary formats
  - For post-processing of data using DGPS or RTK it is necessary to use data from different types of receivers. A common data format is necessary for this purpose.
  - Example: How to post process data from Trimble, Novatel and Septenrtio receivers to compute a position?
- RINEX only provides Raw Data. It does not provide position output.
  - User has to post-process RINEX data to compute position
  - Raw data consists of Pseudorage, Carrierphase, Doppler, SNR
- RINEX basically consists of two data types
  - "*.*N" file for Satellite and Ephemeris Related data.
    - Also called Navigation Data
  - "*.*O" file for Signal Observation Data like Pseudorange, Carrier Phase, Doppler, SNR
    - Also called Observation Data

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RINEX "N" File for GPS

```
     2.11           NAVIGATION DATA     GPS(GPS)             RINEX VERSION / TYPE
cnvtToRINEX 2.90.0  convertToRINEX OPR  05-Jul-17 03:38 UTC PGM / RUN BY / DATE
------------------------------------------------------------ COMMENT
    0.8382D-08  0.2235D-07 -0.5960D-07 -0.1192D-06           ION ALPHA
    0.8602D+05  0.6554D+05 -0.1311D+06 -0.4588D+06           ION BETA
   -0.931322574615D-09-0.355271367880D-14   405504     1947 DELTA-UTC: A0,A1,T,W
    18                                                       LEAP SECONDS
                                                             END OF HEADER
32 17 05 01 00 00  0.0-0.400723423809D-03-0.110276232590D-10 0.000000000000D+00
    0.370000000000D+02-0.806250000000D+01 0.455840416154D-08-0.192420920137D+01
   -0.353902578354D-06 0.111064908560D-02 0.826455652714D-05 0.515371503258D+04
    0.864000000000D+05-0.782310962677D-07 0.675647076441D-01-0.838190317154D-07
    0.958529124300D+00 0.221156250000D+03-0.265074890978D+01-0.796390315710D-08
   -0.389659088008D-09 0.100000000000D+01 0.194700000000D+04 0.000000000000D+00
    0.240000000000D+01 0.000000000000D+00 0.465661287308D-09 0.370000000000D+02
    0.795120000000D+05 0.400000000000D+01 0.000000000000D+00 0.000000000000D+00
24 17 05 01 00 00  0.0-0.341213308275D-04-0.454747350886D-12 0.000000000000D+00
    0.100000000000D+02 0.787812500000D+02 0.459340561950D-08 0.167267059468D+01
    0.404566526413D-05 0.564297637902D-02 0.102464109659D-04 0.515370226479D+04
    0.864000000000D+05-0.782310962677D-07 0.108986675687D+01 0.484287738800D-07
    0.945651423640D+00 0.170906250000D+03 0.490563049326D+00-0.815641117584D-08
   -0.128933942045D-09 0.100000000000D+01 0.194700000000D+04 0.000000000000D+00
    0.240000000000D+01 0.000000000000D+00 0.279396772385D-08 0.100000000000D+02
    0.792180000000D+05 0.400000000000D+01 0.000000000000D+00 0.000000000000D+00
```


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RINEX "O" File GPS, GLONASS, GALILEO, QZSS, SBAS

```
     2.11           OBSERVATION DATA    Mixed(MIXED)         RINEX VERSION / TYPE
cnvtToRINEX 2.90.0  convertToRINEX OPR  05-Jul-17 03:38 UTC PGM / RUN BY / DATE
------------------------------------------------------------ COMMENT
KMBA                                                         MARKER NAME
KMBA                                                         MARKER NUMBER
DM                  UT                                       OBSERVER / AGENCY
5536R50102          TRIMBLE NETR9       5.20                 REC # / TYPE / VERS
                    UNKNOWN EXT                              ANT # / TYPE
 -3955510.8982  3357111.6791  3697796.5495                   APPROX POSITION XYZ
        0.0000        0.0000        0.0000                   ANTENNA: DELTA H/E/N
     1     1     0                                           WAVELENGTH FACT L1/2
     8    C1    C2    C3    L1    L2    L3    P1    P2       # / TYPES OF OBSERV
     1.000                                                   INTERVAL
  2017     5     1     0     0    0.0000000     GPS          TIME OF FIRST OBS
  2017     5     1    23    59   59.0000000     GPS          TIME OF LAST OBS
     0                                                       RCV CLOCK OFFS APPL
    18                                                       LEAP SECONDS
    59                                                       # OF SATELLITES
   G01 23351 23350     0 23350 46694     0     0 23344      PRN / # OF OBS
   G02 22293     0     0 22293 22286     0     0 22286      PRN / # OF OBS
   G03 19633 19632     0 19632 39259     0     0 19627      PRN / # OF OBS
   G05 25303 25302     0 25299 50599     0     0 25297      PRN / # OF OBS
   G06 24709 24708     0 24709 49411     0     0 24703      PRN / # OF OBS
   G07 27766 27764     0 27764 55505     0     0 27741      PRN / # OF OBS
```


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RINEX "O" File, Continued from previous slide

```
   S37 86400      0      0 86400      0      0      0      0       PRN / # OF OBS
   S40 56700      0      0 56700      0      0      0      0       PRN / # OF OBS
CARRIER PHASE MEASUREMENTS: PHASE SHIFTS REMOVED                  COMMENT
                                                                  END OF HEADER
 17  5  1  0  0  0.0000000  0 19G10G12G14G15G18G24G25G31G32R01R02R03
                               R11R12R13S28S29S37S40
  21375379.406 7  21375388.078 9                  112328384.475 7  87528640.180 9
                                  21375388.41448
  20991588.469 7  20991594.418 9                  110311559.942 7  85957091.970 9
                                  20991594.71548
  23097788.500 6                                  121379711.146 6  94581624.25147
                                  23097793.85247
  24539464.648 6  24539473.480 8                  128955722.954 6 100484989.893 8
                                  24539473.66046
  21890081.000 6                                  115033147.870 6  89636240.02147
                                  21890086.53547
  22760846.398 6  22760855.313 9                  119609048.681 6  93201876.319 9
                                  22760854.86347
  20303284.266 7  20303294.227 9                  106694510.219 7  83138615.317 9
                                  20303294.01248
  23440741.258 6  23440748.211 8                  123181935.734 6  95985961.100 8
                                  23440748.62147
  21395760.742 7  21395769.145 9                  112435502.496 7  87612113.685 9
                                  21395769.30548
```


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Additional Information

Please visit websites

For Webinar: http://www.csis.u-tokyo.ac.jp/~dinesh/WEBINAR.htm

https://gnss.peatix.com

Main Page : http://www.csis.u-tokyo.ac.jp/~dinesh/

Other: https://www.youtube.com/watch?v=JaicV8egzFo

Contact:

dinesh@iis.u-tokyo.ac.jp

Sample Raw Data can be downloaded to Check Accuracy of RTK Processing

1. High-End Base (NetR9) Data vs Low-End Rover (u-blox M8T) Data
2. Low-End Base (u-blox M8T) Data vs Low-End Rover (u-Blox M8T) Data