

MGA Webinar Series : 9

Updates on GNSS Raw Data Measurement from Android Device

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Purpose

- Provide updates related with Android GNSS Raw Data
 - Results from Raw Data Processing
 - Tokyo, Japan
 - Suva, Fiji
 - Melbourne, Australia
 - Florida, USA
 - Sharing of Raw Data to practice
- Please refer MGA Webinar #8 for additional information
 - <https://home.csis.u-tokyo.ac.jp/~dinesh/WEBINAR.htm>

Android Device for GNSS Raw Data

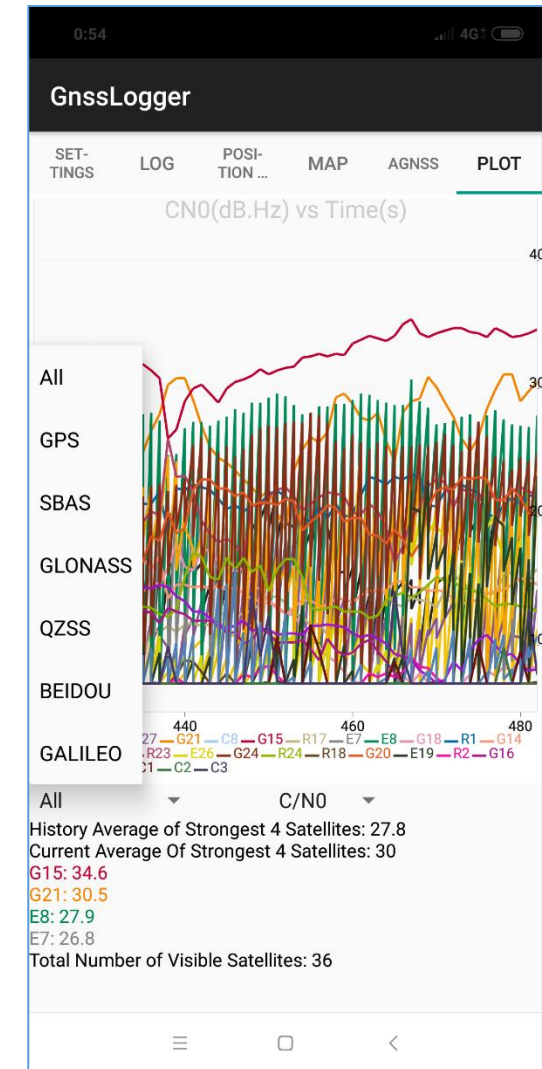
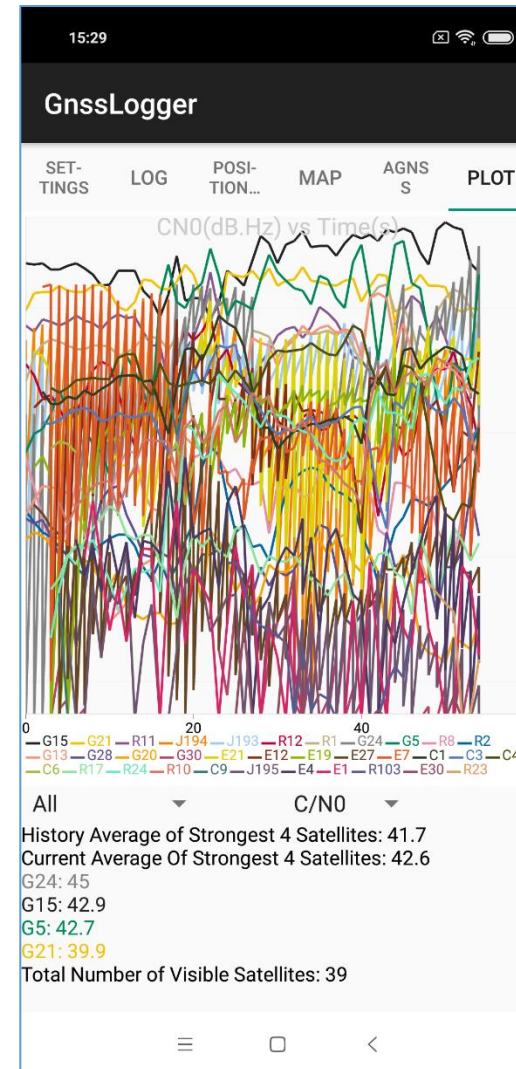
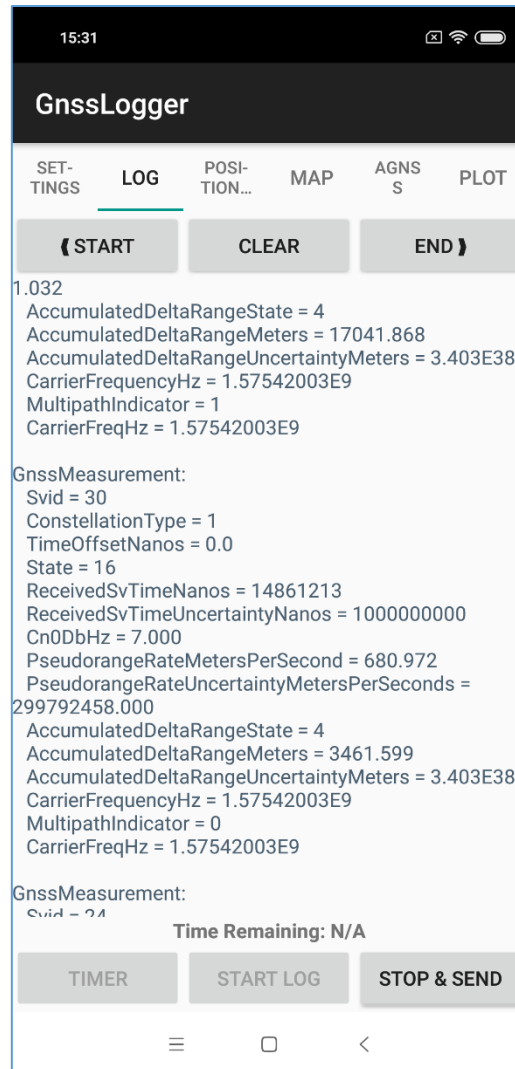
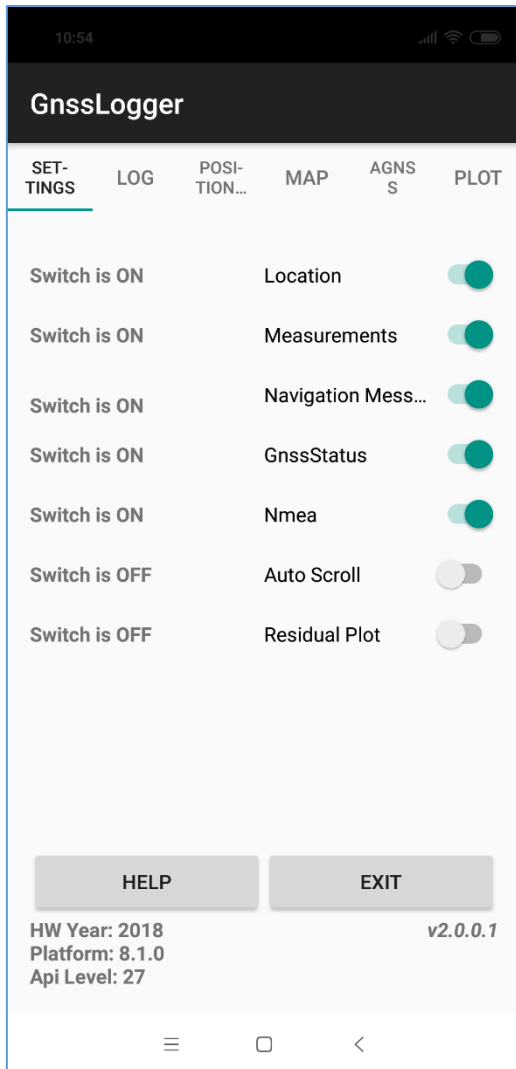
- Many Android devices with OS 7.0 or higher can output GNSS Raw Data
 - These data can be used for RTK post-processing
- Some devices have Multi-Frequency (L1/L5) GNSS receiver
 - Multi-System (GPS, GLONASS, GALILEO, BEIDOU, QZSS)
 - Multi-Frequency (L1/E1/B1, L5/E5)
 - Outputs more than 40 channels
 - Some devices output NAV BIT Data and/or AGC values

GNSS Raw Data Compatible Smart-Phones

S. No.	Model	Android version	System Score Max: 6 (D)	Function Score Max: 5 (E)	Total Score (D + E)	Raw Data output used in System Score					Satellite Systems used in System Score					
						AGC	NAV MSG	Accumulated delta range	HW clock	L5 Support	GPS	GLO	GAL	BDS	QZSS	SBAS
4	Xiaomi Mi 8	8.1	5	4	9	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
31	Samsung S8	7	5	3	8	no	yes	yes	yes	no	yes	yes	yes	yes	yes	no
33	Huawei P10	7	5	3	8	no	yes	yes	yes	no	yes	yes	yes	yes	yes	no
42	Huawei Mate 20 X	9	4	4	8	no	yes	yes	yes	yes	yes	yes	yes	no	yes	no
19	Google Pixel 2 XL	8	5	2	7	yes	no	no	yes	no	yes	yes	yes	yes	yes	no
20	Google Pixel 2	8	5	2	7	yes	no	no	yes	no	yes	yes	yes	yes	yes	no
22	Samsung Note 8	7.1	4	3	7	no	yes	yes	yes	no	yes	yes	yes	yes	no	no
1	Pixel 3 XL	9	4	3	7	yes	no	yes	yes	no	yes	yes	yes	yes	no	no
2	Pixel 3	9	4	3	7	yes	no	yes	yes	no	yes	yes	yes	yes	no	no
43	Huawei Mate 20 RS	9	4	3	7	no	no	yes	yes	yes	yes	yes	yes	yes	no	no
44	Huawei Mate 20 Pro	9	4	3	7	no	no	yes	yes	yes	yes	yes	yes	yes	no	no
45	Huawei Mate 20	9	4	3	7	no	no	yes	yes	yes	yes	yes	yes	yes	no	no
10	Huawei P20	8.1	3	3	6	no	yes	yes	yes	no	yes	yes	no	no	yes	no
11	Samsung Galaxy S9	8	3	3	6	no	yes	yes	yes	no	yes	yes	no	no	yes	no
18	Huawei Mate 10 Pro	8	3	3	6	no	yes	yes	yes	no	yes	yes	no	no	yes	no

Check → <https://developer.android.com/guide/topics/sensors/gnss> for Latest Updates

Android Raw Data Logging Tool – 1: GnssLogger



GNSS Raw Data Output Format from Smart Phone Device

- #
- # Header Description:
- # Version: v2.0.0.1 Platform: 9 Manufacturer: Xiaomi Model: MI 8
- **# Raw,**
 - ElapsedRealtimeMillis,TimeNanos,LeapSecond,TimeUncertaintyNanos,FullBiasNanos,
 - BiasNanos,BiasUncertaintyNanos,DriftNanosPerSecond,DriftUncertaintyNanosPerSecond,
 - HardwareClockDiscontinuityCount,Svid,TimeOffsetNanos,State,ReceivedSvTimeNanos,
 - ReceivedSvTimeUncertaintyNanos,Cn0DbHz,PseudorangeRateMetersPerSecond,
 - PseudorangeRateUncertaintyMetersPerSecond,AccumulatedDeltaRangeState,
 - AccumulatedDeltaRangeMeters,AccumulatedDeltaRangeUncertaintyMeters,CarrierFrequencyHz,
 - CarrierCycles,CarrierPhase,CarrierPhaseUncertainty,MultipathIndicator,
 - SnrInDb,ConstellationType,AgcDb,CarrierFrequencyHz
- **# Fix,**
 - Provider,Latitude,Longitude,Altitude,Speed,Accuracy,(UTC)TimeInMs
- **# Nav,**
 - Svid,Type,Status,MessageId,Sub-messageId,Data(Bytes)

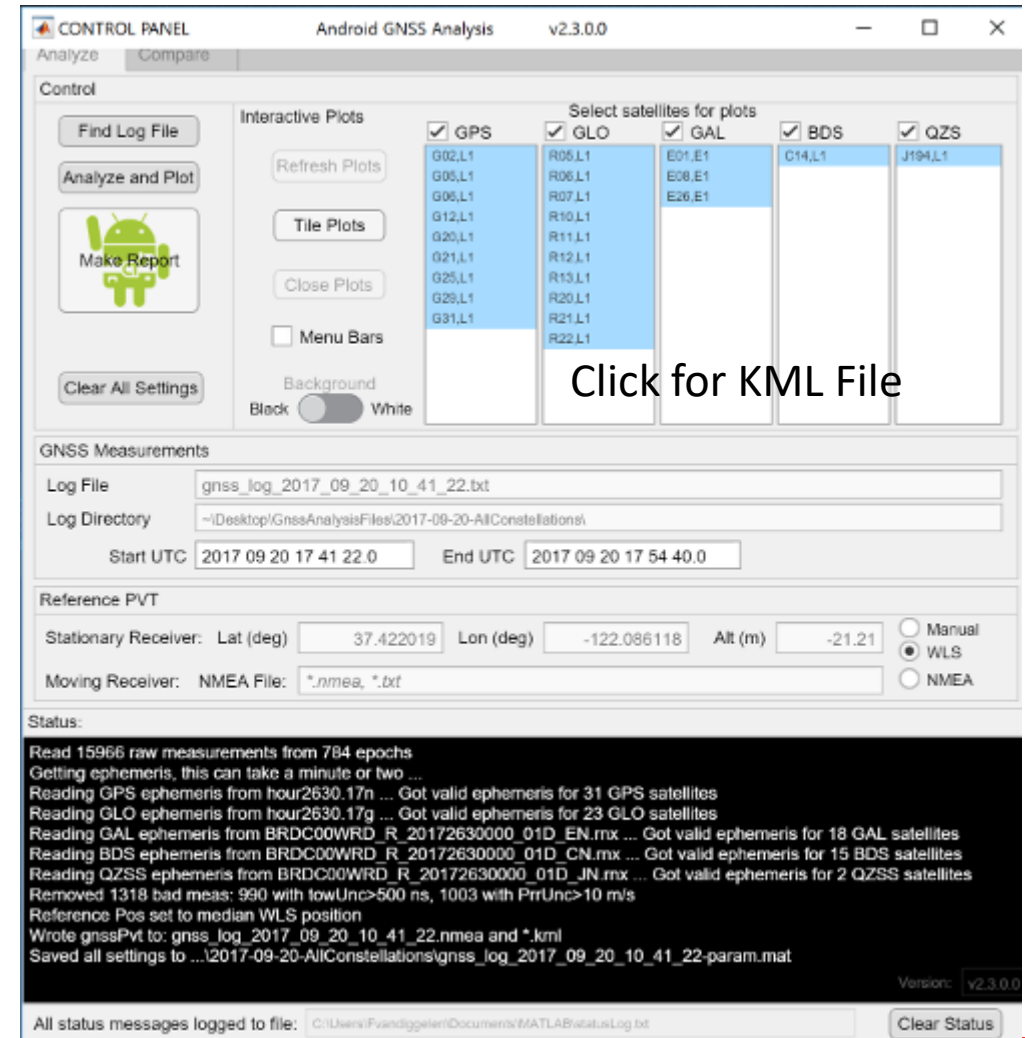
Sample GNSS Raw Data Output

```
13 # Nav, Svid, Type, Status, MessageId, Sub-messageId, Data (Bytes)
14
15 Nav, 96, 769, 1, -1, 13, 110, 121, 9, 58, -100, 116, -65, -32, -96, 100, 32
16
17 Raw, 86394315, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 1, 0.0, 16431, 303193919524422, 20, 33.86
18 Raw, 86394315, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 3, 0.0, 16431, 303193916939667, 33, 27.52
19 Raw, 86394315, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 10, 0.0, 16431, 303193928480980, 27, 29.8
20 Raw, 86394315, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 11, 0.0, 16392, 303193914305357, 1000000
21 Raw, 86394315, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 12, 0.0, 16431, 303193918153504, 44, 23.9
22 Raw, 86394316, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 14, 0.0, 16431, 303193929357084, 15, 37.3
23 Raw, 86394316, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 16, 0.0, 16392, 303193914613478, 1000000
24 Raw, 86394316, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 20, 0.0, 16431, 303193920851248, 58, 20.6
25 Raw, 86394316, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 22, 0.0, 16431, 303193921837227, 16, 36.6
26 Raw, 86394316, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 25, 0.0, 16431, 303193926177270, 14, 38.1
27 Raw, 86394316, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 26, 0.0, 16431, 303193924152390, 31, 28.4
28 Raw, 86394316, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 31, 0.0, 16431, 303193932611146, 17, 35.4
29 Raw, 86394316, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 1, 0.0, 16393, 303193919524421, 9, 29.583
30 Raw, 86394317, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 3, 0.0, 16393, 303193916939680, 11, 31.84
31 Raw, 86394317, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 10, 0.0, 16393, 303193928480980, 8, 34.70
32 Raw, 86394317, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 25, 0.0, 16393, 303193926177261, 8, 33.51
33 Raw, 86394317, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 26, 0.0, 16393, 303193924152389, 24, 24.9
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38 Raw, 86394318, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 1, 0.0, 16491, 1927826124, 73, 26.4779949
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40 Raw, 86394318, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 23, 0.0, 16431, 303179924679079, 11, 32.4
41 Raw, 86394318, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 24, 0.0, 16431, 303179914451366, 11, 32.7
42 Raw, 86394318, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 25, 0.0, 16431, 303179927268994, 9, 34.37
43 Raw, 86394318, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 2, 0.0, 19498, 303193919524625, 31, 28.40
44 Raw, 86394319, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 3, 0.0, 19498, 303193912298358, 25, 30.87
45 Raw, 86394319, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 7, 0.0, 19498, 303193916212787, 14, 37.91
46 Raw, 86394319, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 8, 0.0, 19498, 303193927835139, 26, 32.68
47 Raw, 86394319, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 13, 0.0, 16392, 303193906638380, 1000000
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49 Raw, 86394319, 73386000000, -1238933520614358644, 0.0, 6.103678716954078, 0, 26, 0.0, 19498, 303193910514372, 39, 25.8
```

GNSS Raw Data Analysis Tool for GnssLogger

- GNSS Analysis APP

- Matlab-based Tool
- Linux, Windows, MacOS
- Version 2.6.3.0
- Release Notes:
[https://developer.android.com/guide/topics/sensors/gnss#releaseGNSS Analysis app v2.6.3.0 release notes.](https://developer.android.com/guide/topics/sensors/gnss#releaseGNSS Analysis app v2.6.3.0 release notes)

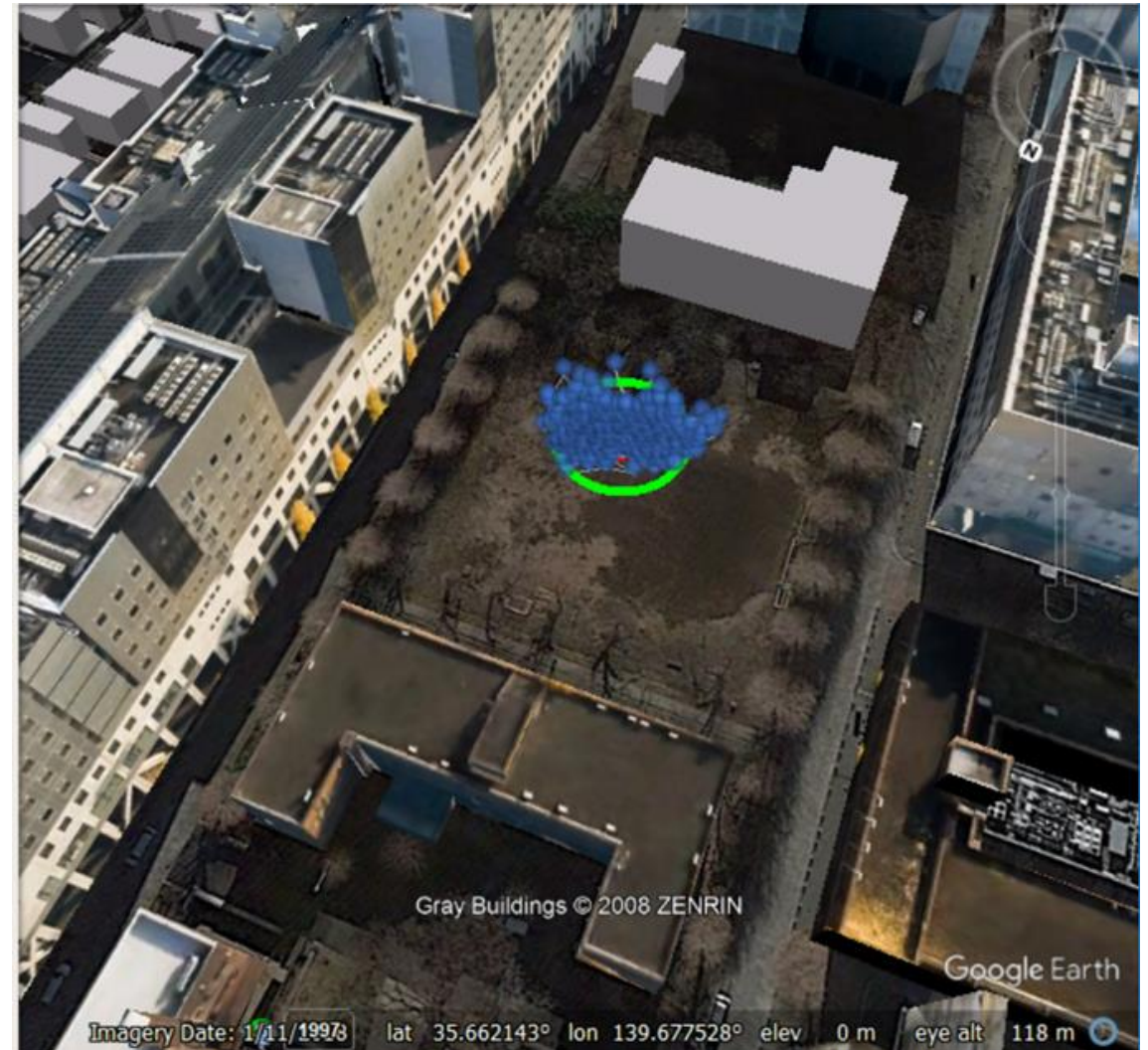


The GNSS Analysis app is built on [MATLAB](#), but you don't need to have MATLAB to run it. The app is compiled into an executable that installs a copy of the MATLAB Runtime.

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Position Output from Android GNSS Receiver, Komaba

- Standard Position Computation
 - No DGPS or RTK Corrections
 - All visible GNSS Satellites are used
 - Frequency : L1/L5/E5
 - Surrounding : Tall Buildings around



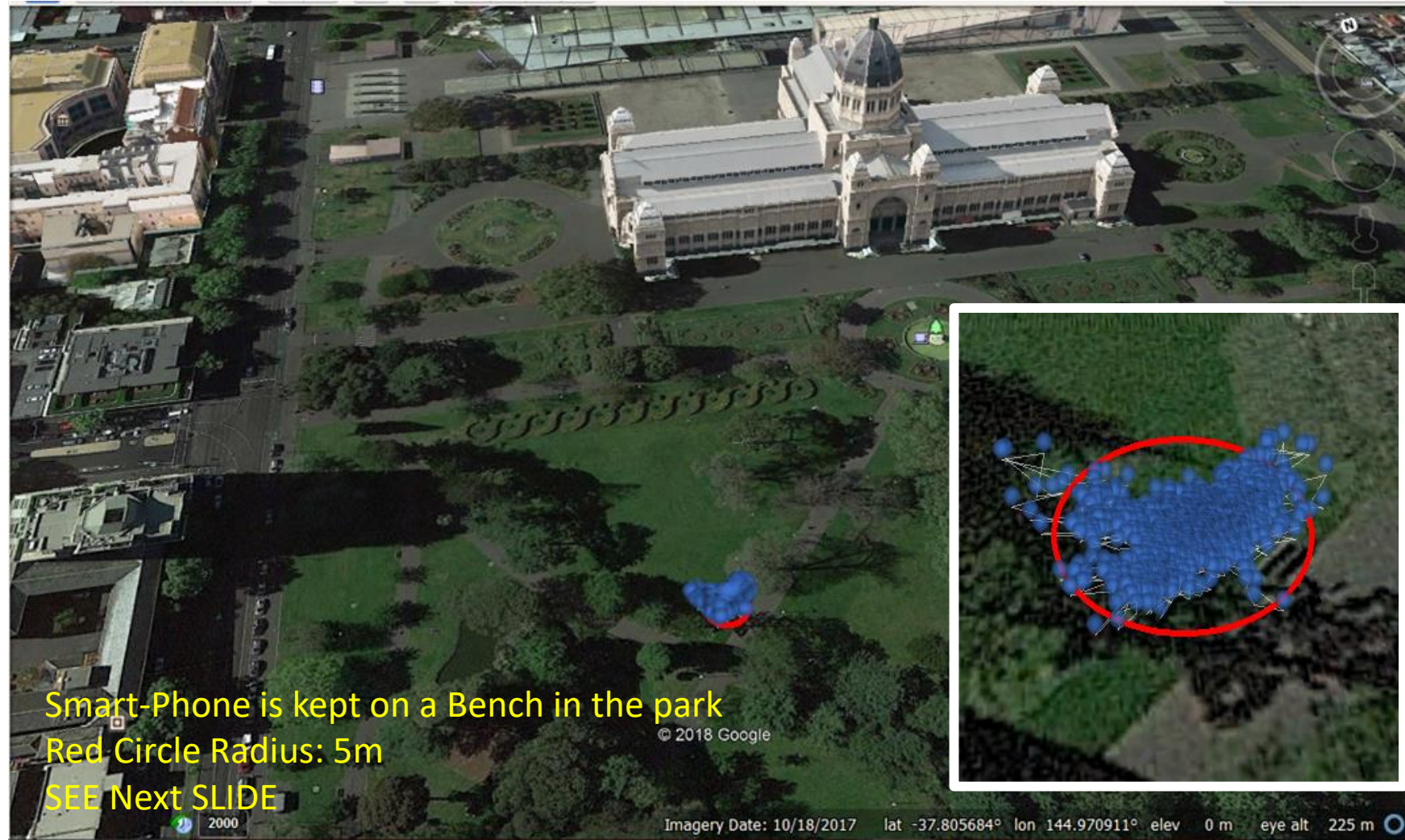
Position Output from Android GNSS Receiver, Hongo



Position Output from Android GNSS Receiver



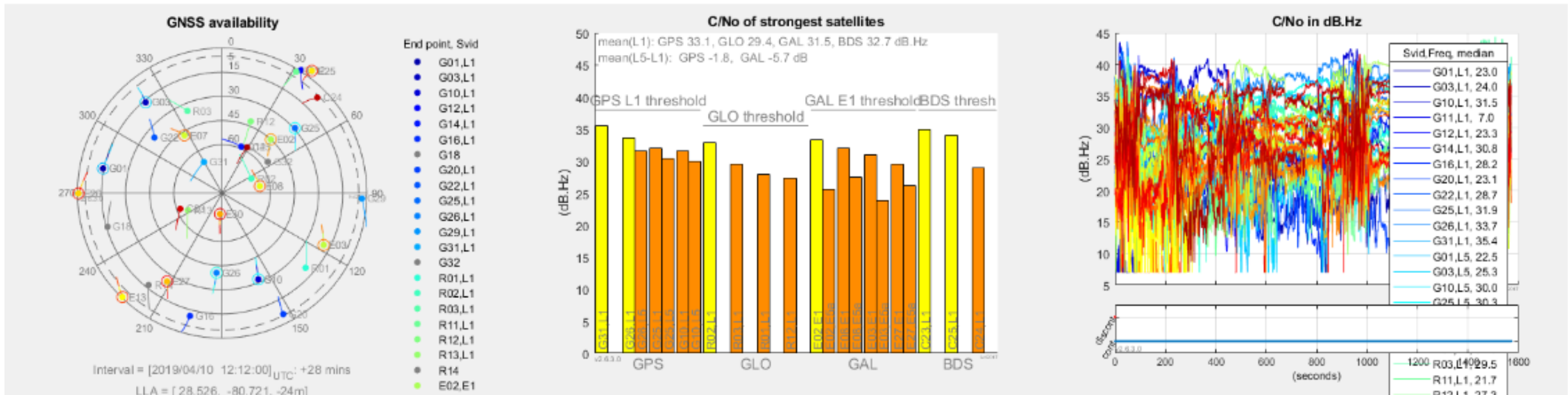
Position Output from Android GNSS Receiver, Melbourne





Smart-Phone is kept on a Bench in the park
Red Circle Radius: 5m

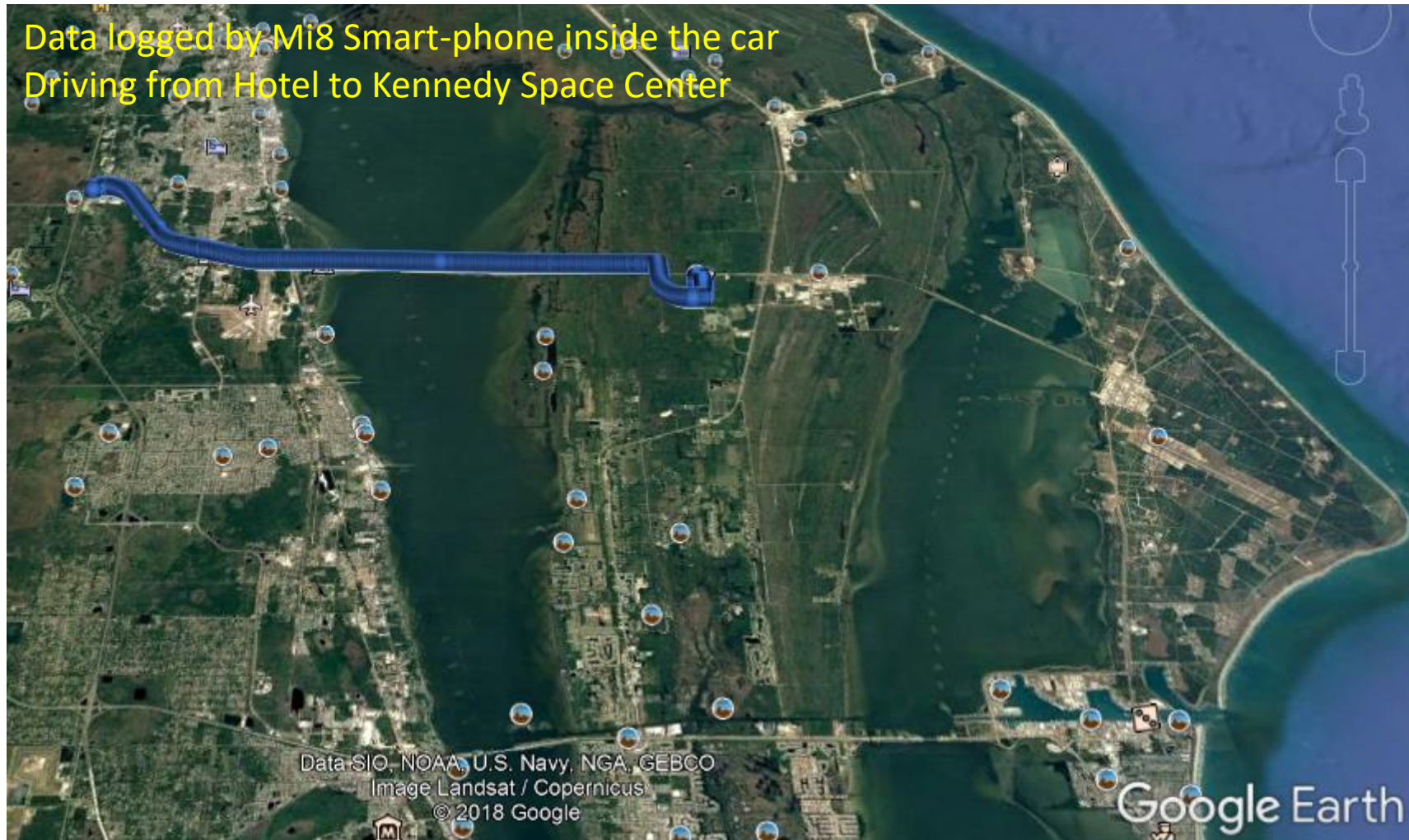
Output from GNSS Analysis Tool, Data Logged by GNSSLogger



Data logged by Mi8 Smart-phone inside the car

Output from GNSS Analysis Tool, Data Logged by **GNSSLogger**

Location:
Kennedy Space Center
Florida



Output from GNSS Analysis Tool, Data Logged by **GNSSLogger**



GNSS Position Data from Mi8 Android Device

Yellow Circles : Mi8 Device
White Circle : 5m Radius



Location: SUVA, FIJI

GNSS Position Data from P20 Android Device

Red Circles : P20 Device
White Circle : 5m Radius



Location: SUVA, FIJI

GNSS Position Data from Mi8 & P20 Android Devices

Red Circles : P20 Device
Yellow Circles : Mi8 Device
White Circle : 5m Radius

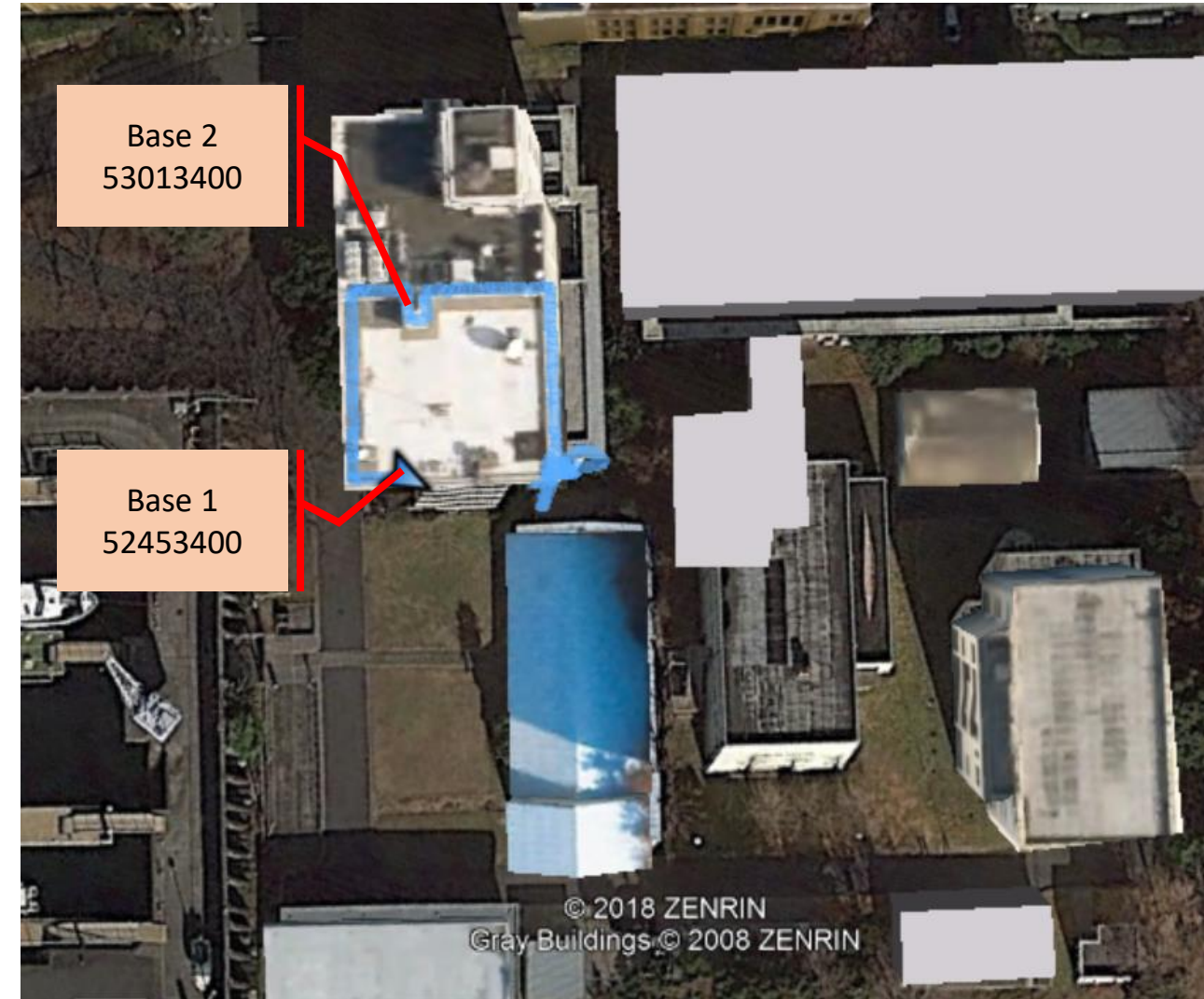


Location: SUVA, FIJI

Position Output from Android GNSS Receiver 海洋大学 (TUMSAT)

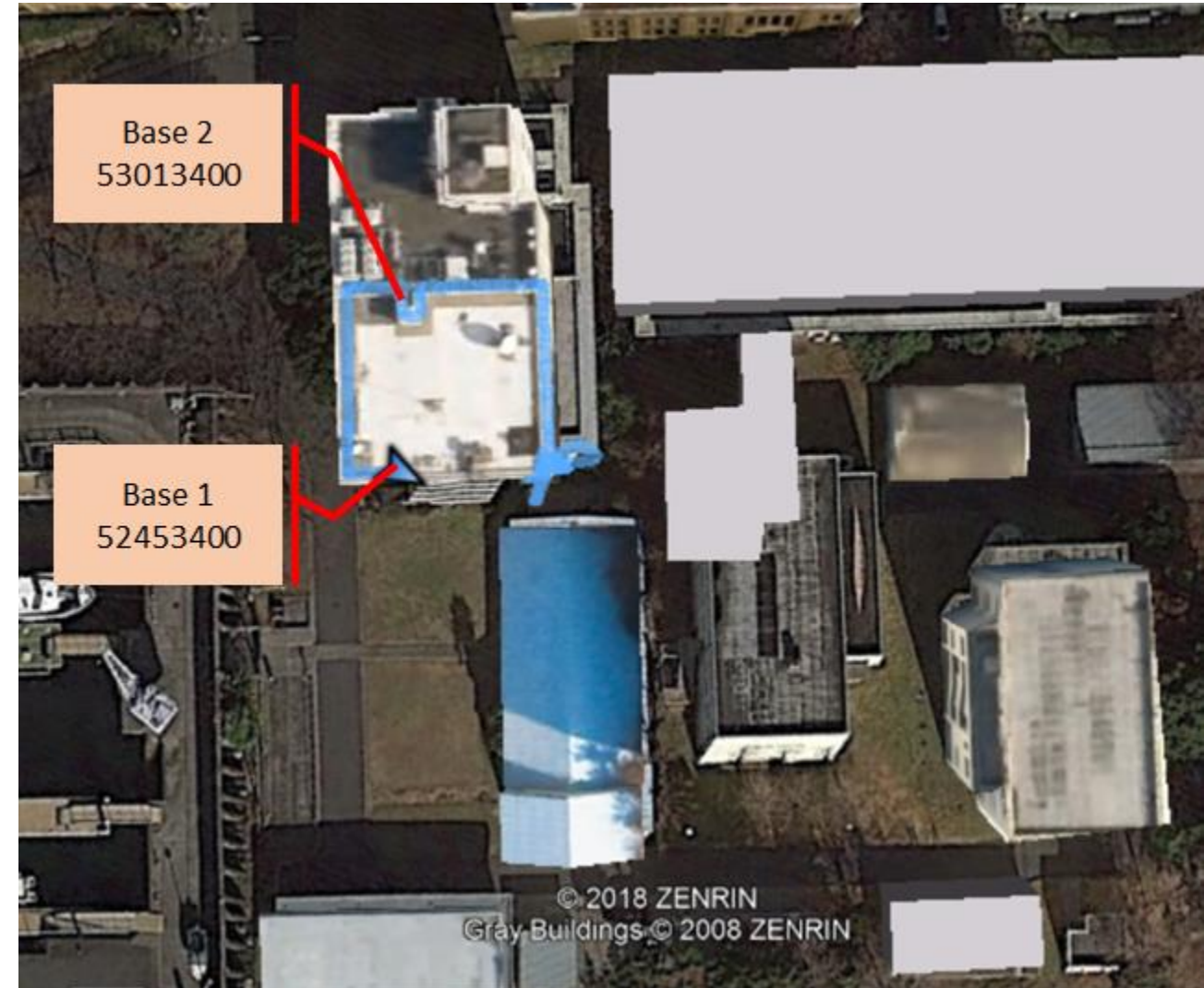
- Mobile-phone is kept static for about 60min then moved around the roof.
- A GNSS base-station (Trimble NetR9) on the roof is used to collect correction data.

These data were logged at TUMST, Dr. Yize

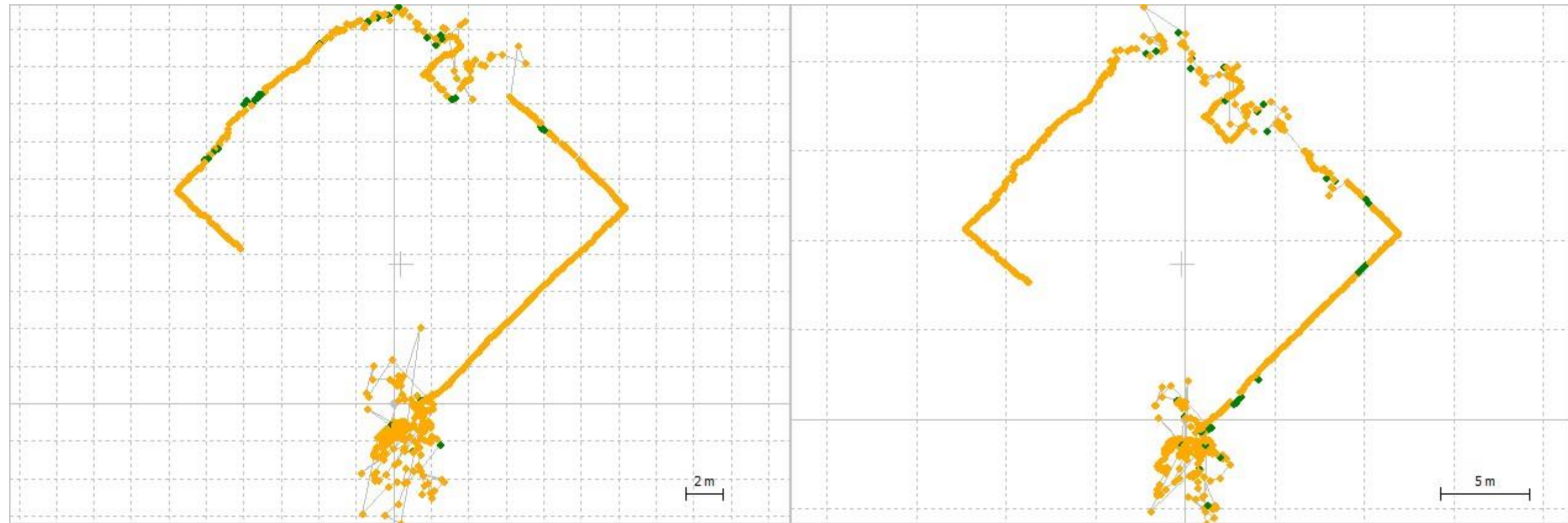


Android GNSS Raw Data Information

1	Base-Station File 1	53013400.18o	Trimble NetR9
2	Base-Station File 2	52453400.18o	Trimble NetR9
3	Android GNSS Data	GEOP3400	Device Mi8 Logger: Geop++
4	RINEX NAV File	brdm3400.18p	

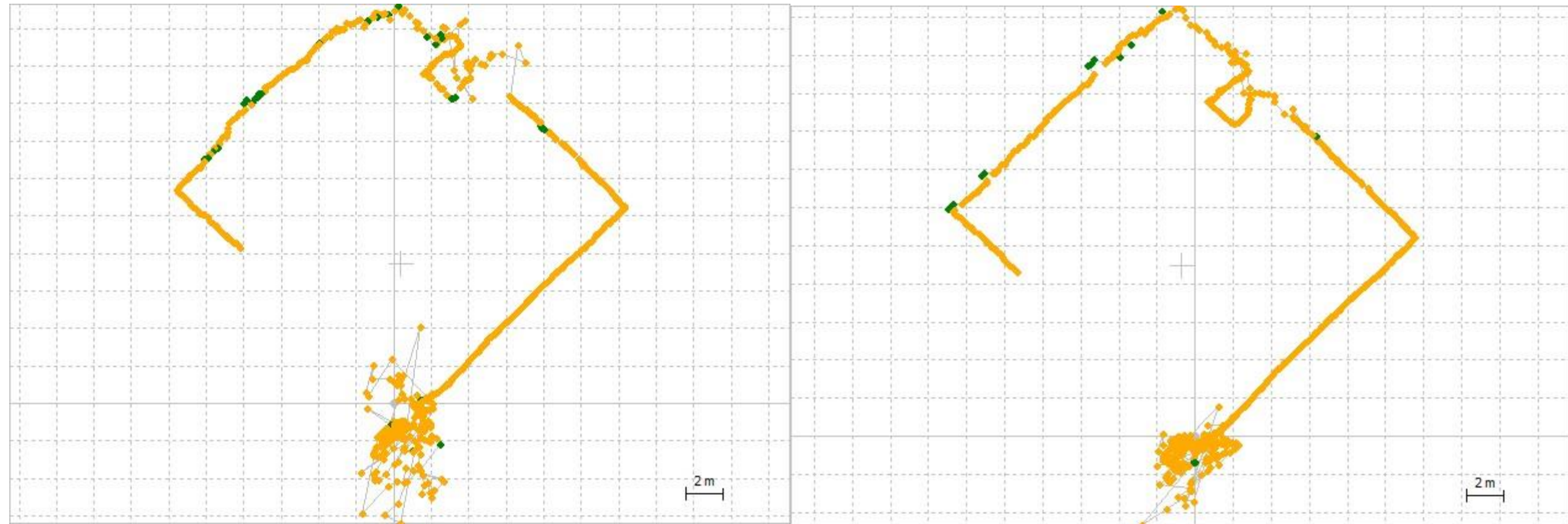


GPS L1 vs GPS L1/L5



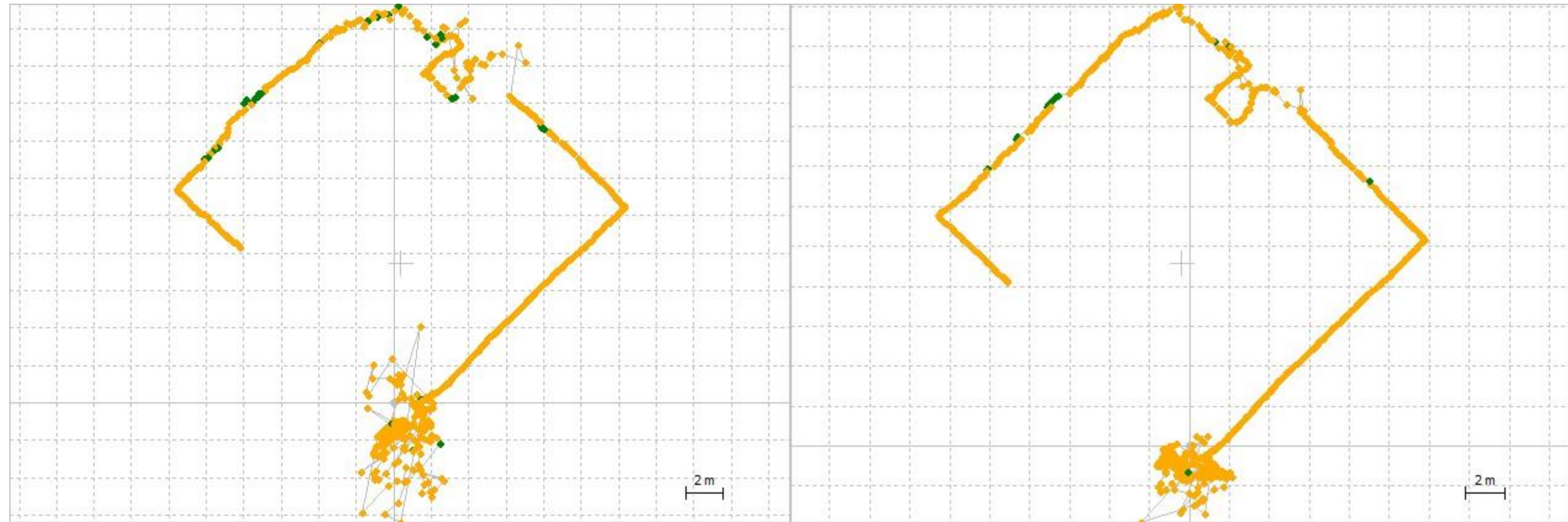
Data logged by Mi8 Smart-phone

GPS L1 vs GPS + QZS L1



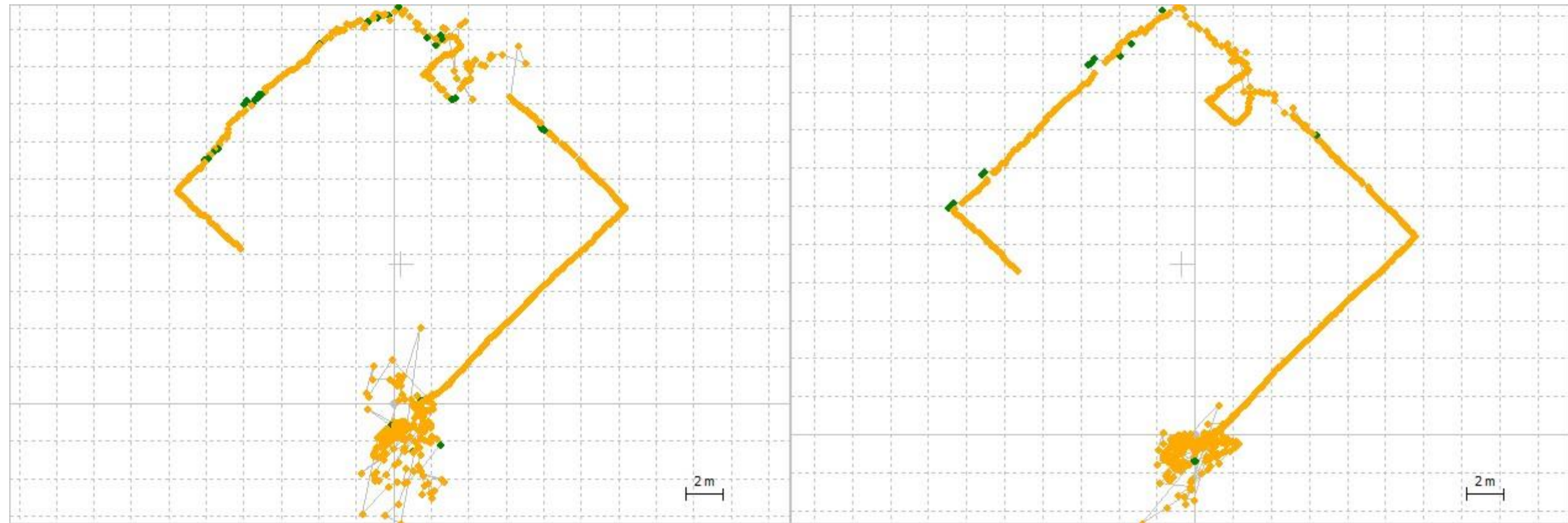
Data logged by Mi8 Smart-phone

GPS L1 vs GPS + QZS L1/L5



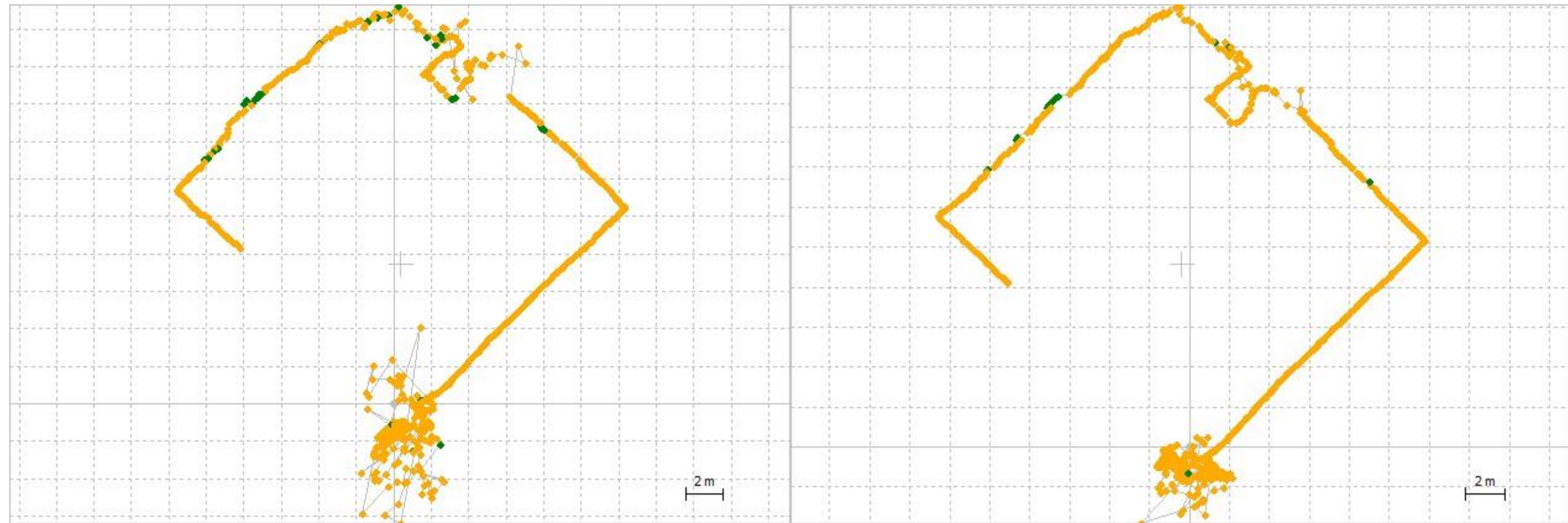
Data logged by Mi8 Smart-phone

GPS L1 vs GPS + QZS + BDS L1



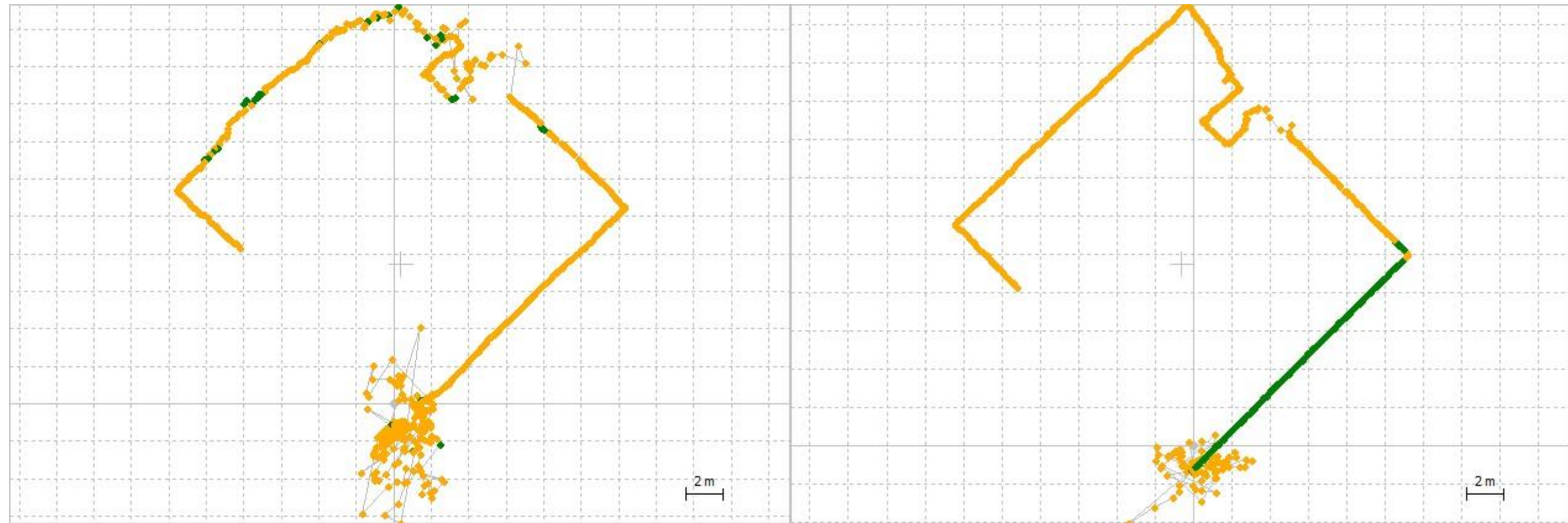
Data logged by Mi8 Smart-phone

GPS L1 vs GPS + BDS + QZS L1/L5



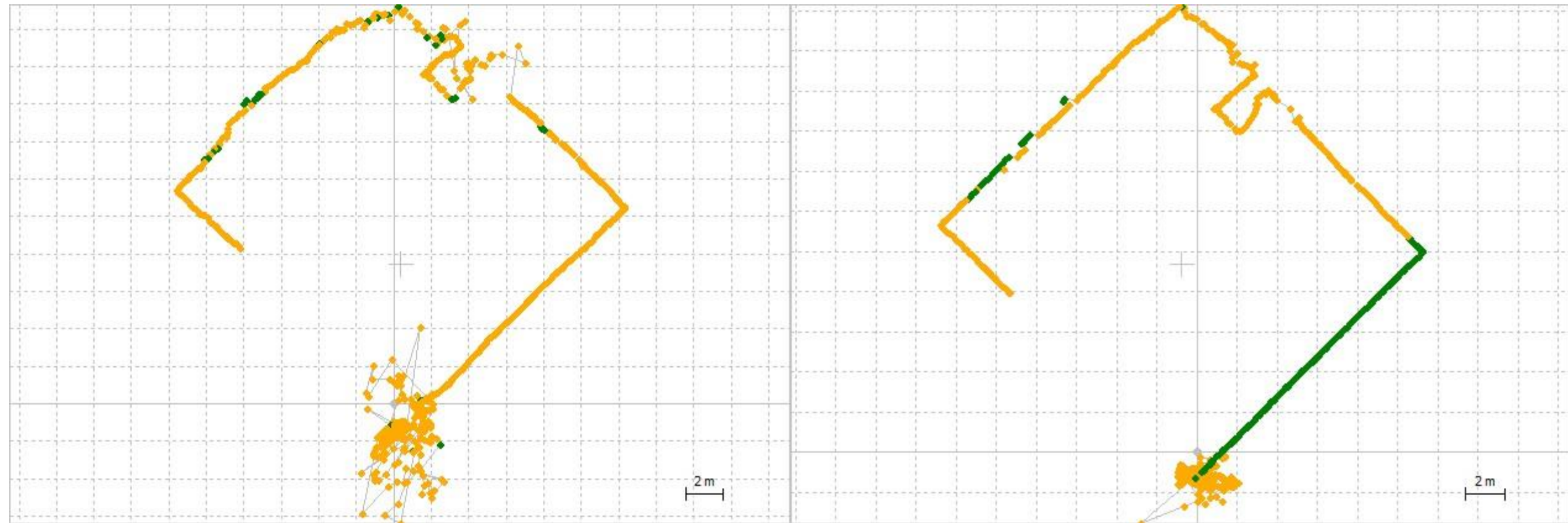
Data logged by Mi8 Smart-phone

GPS L1 vs GPS + GAL+ BDS + QZS L1

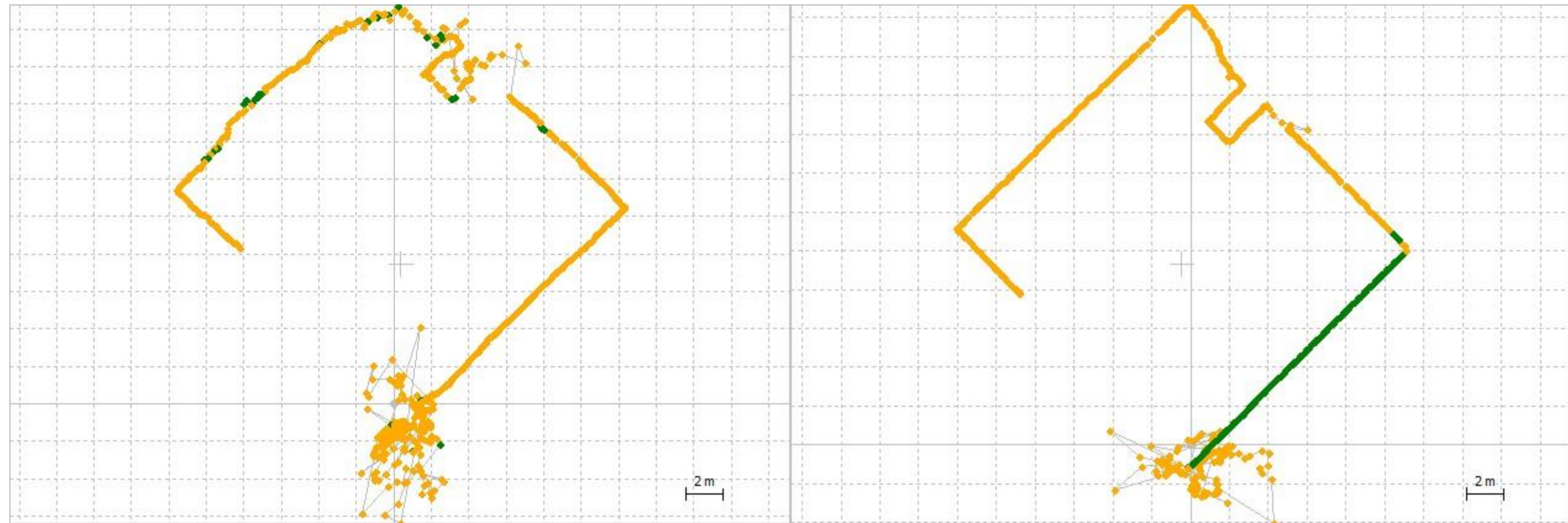


Data logged by Mi8 Smart-phone

GPS L1 vs GPS + GAL+ BDS + QZS L1/L2/L5

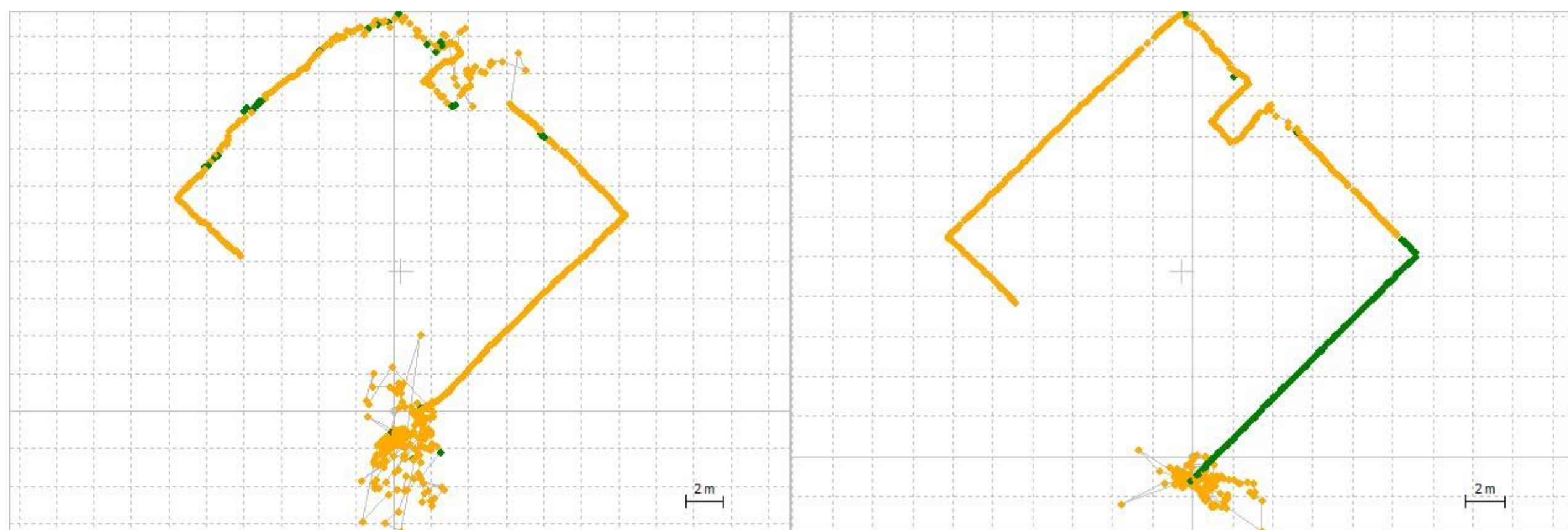


GPS L1 vs GPS + GLO + GAL+ BDS + QZS L1



Data logged by Mi8 Smart-phone

GPS L1 vs GPS + GAL+ BDS + QZS L1/L5



Data logged by Mi8 Smart-phone

(Possible) Applications of Android GNSS Raw Data

- High-Accuracy Positioning
 - Multi-System, Multi-Frequency
- Interference and Jamming Detection
 - Crowd Sourcing
- Spoofing Detection
- Signal Authentication
- Atmospheric Parameter Estimations
 - Ionosphere and Troposphere
- Space Weather
- Scientific Applications

White Paper on GNSS Raw Data Measurement



USING GNSS RAW MEASUREMENTS ON ANDROID DEVICES 3

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<http://galileognss.eu/wp-content/uploads/2018/05/Using-GNSS-Raw-Measurements-on-Android-devices.pdf>

GNSS Raw Measurements Taskforce Workshop

GNSS Raw Measurements Taskforce Workshop was held on
26th June 2019, Prague, *GSA European Agency* Headquarters

Refer <https://www.gsa.europa.eu/gnss-raw-measurements-taskforce-workshop> for more information

References

- GNSS Raw Data Measurement Tutorial File by Dr, Frank Van Diggelen, Google Inc.
 - https://home.csis.u-tokyo.ac.jp/~dinesh/GNSS_Raw_files/GNSS%20102%20Measurements%20from%20Phones%20Short%20Course%20Slides.pdf
- GPS Receiver Signal Processing background information file:
 - https://home.csis.u-tokyo.ac.jp/~dinesh/WEBINAR_files/MGA_W08_RawDataMeasurement_Background.pdf
- Video record of GNSS Raw Signal Measurement MGA WEBINAR held on 6th DEC 2018.
 - https://www.youtube.com/watch?v=S217xg--O_Q&feature=youtu.be
- Sample Data
 - [Sample GNSS Raw Data from Android Device](#)
 - <https://home.csis.u-tokyo.ac.jp/~dinesh/WEBINAR.htm>