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11-15 September 2022 in Warsaw, Poland

Data Quality and Outdoor Positioning Accuracy of Recent Smartphones with Dual Frequency GNSS Receivers

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Paper No. 11575, Session TS04G

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Original Intention: Student Projects Spring 2021

- Kinematic Positioning Experiments
  Continuous, Stop & Go
- Precise Point Positioning (PPP), DGNSS
- Google Pixel 5 Android Smartphone with
  Dual Frequency Receiver L1/L5 Band
- Spectra SP 80 RTK GNSS Receiver as Reference
- Experiments: LBS Course
  Andreas Slateff, Henri Schauer, Katharina Fehn
- BSc-Thesis
  Till Weigert

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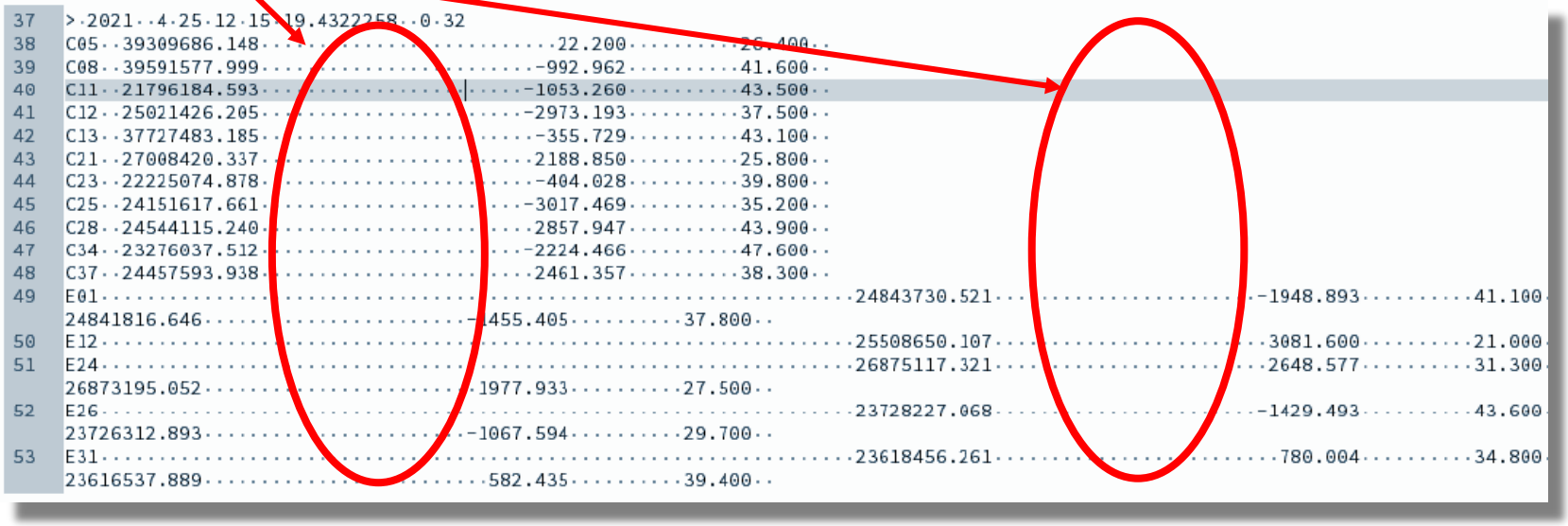
FIRST FINDINGS with Pixel 5

Missing Carrier Phase Data in All Bands



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38  C05  39309686.148                    22.200          26.400
39  C08  39591577.999                  -992.962          41.600
40  C11  21796184.593                 -1053.260          43.500
41  C12  25021426.205                 -2973.193          37.500
42  C13  37727483.185                  -355.729          43.100
43  C21  27008420.337                  2188.850          25.800
44  C23  22225074.878                  -404.028          39.800
45  C25  24151617.661                 -3017.469          35.200
46  C28  24544115.240                  2857.947          43.900
47  C34  23276037.512                 -2224.466          47.600
48  C37  24457593.938                  2461.357          38.300
49  E01                                                 24843730.521                  -1948.893          41.100
    24841816.646                 -1455.405          37.800
50  E12                                                 25508650.107                   3081.600          21.000
51  E24                                                 26875117.321                   2648.577          31.300
    26873195.052                  1977.933          27.500
52  E26                                                 23728227.068                  -1429.493          43.600
    23726312.893                 -1067.594          29.700
53  E31                                                 23618456.261                    780.004          34.800
    23616537.889                   582.435          39.400
```

RINEX file created by Geo++Rinex-Logger app on Pixel5 smartphone, Karlsplatz 2021-Apr-25

FIRST FINDINGS with Pixel 5 (cont'd)

Often No Useable or Missing L5-Band Data

```
> 2022  4 21 15 23 58.4482378  0 33
99  38422238.871                                  NaN          29.500
C08  40751375.943                              -983.800          28.000
C13  39303822.963   204665319.9891             -801.110          36.700
C20  24517799.614   127670616.1011             3271.679          30.900
C26  25362504.737   132069217.6311              818.171          42.000
C27  26064928.659                             -2660.300          28.200
C29  22034856.420   114741278.9321             1613.180          36.300
C30  22133186.547   115253310.0651            -1256.995          34.100
C32  23379042.759   121740810.2831              594.930          38.000
C36  26652750.019   138787863.3851            -2958.450          34.100
E02                                                      28158852.166                -3087.400          23.900
E05                                                      26878376.221                 2608.950          23.600
E09                                                      26892906.861   141323179.6481  542.783          38.300   26890983.993   105525996.6541
     405.401          24.400
E15                                                      24503797.507   128768324.7211 1864.277          43.900   24501888.729    96150673.7401
     1392.142          37.000
E21                                                      28623178.220                 2812.300          21.900   28621235.864
     2100.450          23.000
E27                                                      25171333.982   132276253.3091  704.764          40.200   25169429.400    98770246.4741
     526.371          41.300
E30                                                      25174359.487   132292151.8041 -2159.387          45.000   25172448.910    98782096.1571
     -1612.496          36.300
E36                                                      26571795.862   139635730.0291 -2151.664          37.400   26569886.784   104265941.7241
     -1606.632          34.100
G07  25063318.459   131708627.2371            -201.875          29.600
G08  22566826.145   118589471.2141            3042.967          38.800   22564470.975    88547830.4731  2272.214          44.400
G10  21207178.609   111444475.1721            1785.858          40.300   21204820.142    83212268.0781  1333.538          31.900
G15  23868054.024   125427470.1731            -258.686          39.600
G16  21594666.657   113480738.3931           -2152.649          43.400
G18  22923639.728   120464539.2521           -2780.084          38.300
G21  24029513.248                             2974.100          22.400
G23  21001485.008   110363547.6471            -491.041          28.500
G26  23416122.289   123052552.8191           -3337.426          32.600   23413703.264    91880572.2824  2422.140          26.700
G27  20285631.283   106601711.5171            1207.950          43.200   20283277.013    79595934.7341   901.928          44.000
R06  20977995.369                             -190.400          25.000
R12  21884553.372                            -3352.800          28.400
R13  21227232.626   113352237.9051             -91.581          32.400
```

Pixel 5 Rinex File Karlsplatz 2022-Apr-21, also some carrier phase data missing

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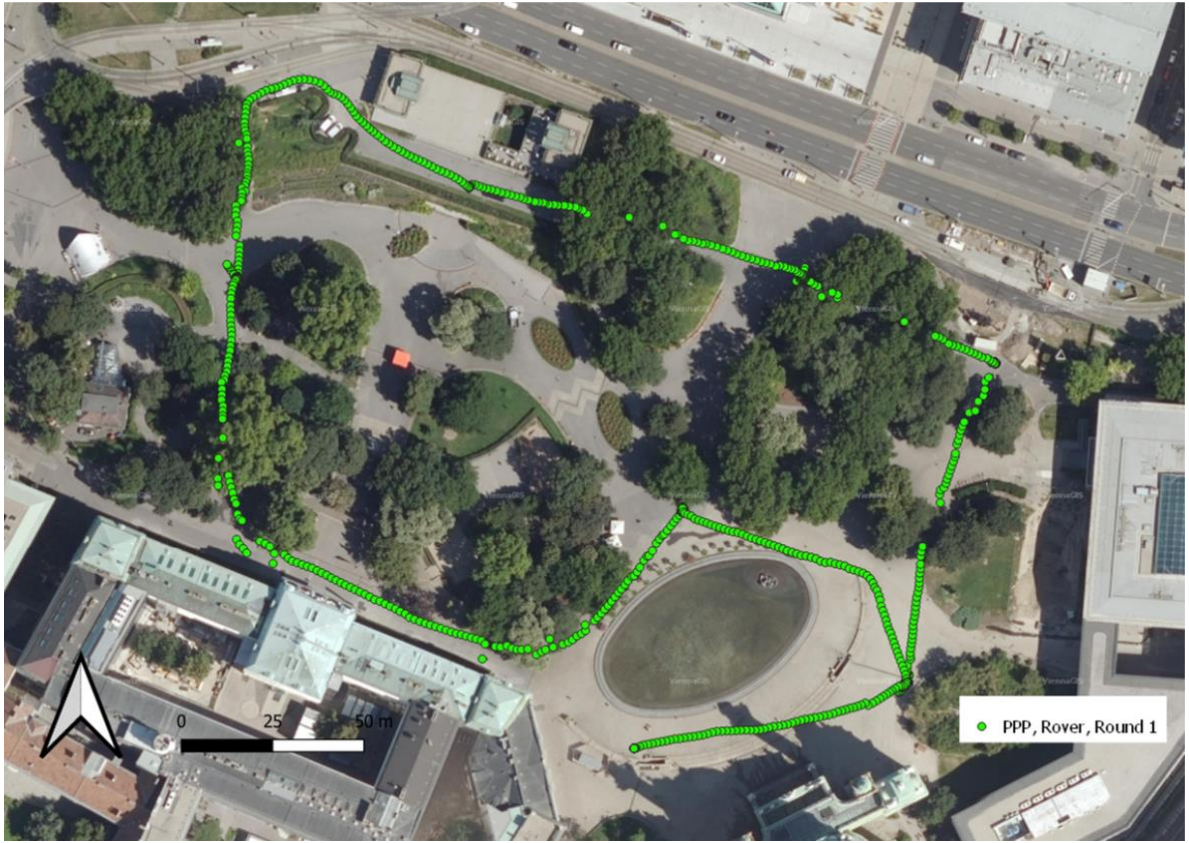
SP80 Reference Trajectory



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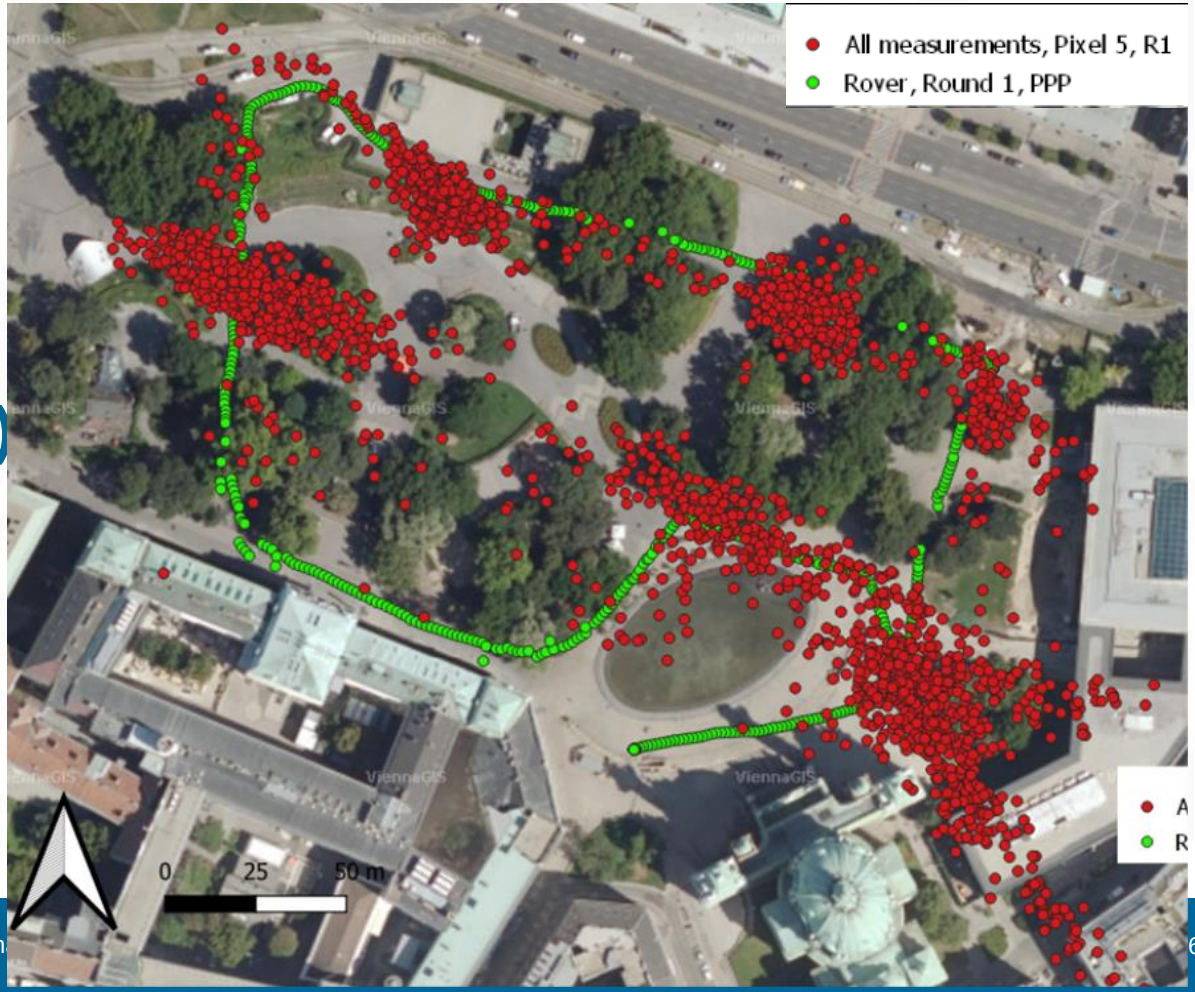
Stop & Go Pixel 5 and Spectra SP80

(7 Stop Points)

Large Scattering of Positioning Solutions!



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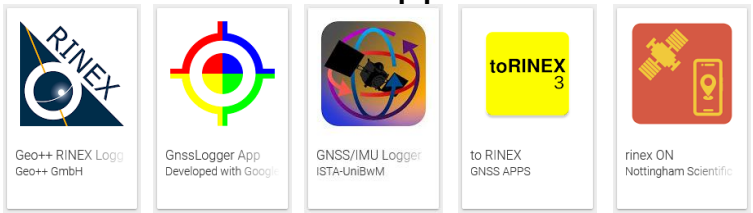
Back to the Start:

- Static Measurements
- Try to Identify Influencing Factors
- Google Pixel 5 and Samsung S21 5G
- Permute Positions & Orientation
- Permute Configurations
- Test Several Apps



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Results of Static Measurements:

- Android Apps Unstable and Crash
- Smartphone Display Timeout Sometimes Kills Apps
- Sometimes Carrier Phase Data Recorded, Sometimes Not
- L5/E5 Band Data Scarcely Recorded
- General Low Data Quality (Low S/N-Ratio)
- Positioning Accuracy in Decimeter Range Only (15-30 minutes static)
  if Carrier Phase Data Available
- Positioning Accuracy in Meters or Worse Only
  if Carrier Phase Data Not Available or of Too Low Quality
  or of Too Little Frequency

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GNSS Literature: “Publication Bias?”

- In literature, results on technological progress published –
  at the frontline of available technology
- Studies concentrate on particular devices (e.g. Xiaomi Mi 8, Huawei P30)
- Centimeter to decimeter accuracy claimed, e.g.
  Wanninger et al. 2020
  Psychas et al. 2019
  Wu et al. 2019
- Almost no papers address reliability of Android GNSS apps
  or Smartphone configuration

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Results of Smartphone GNSS-Experiments:

Reproducible?
Transferable?

- Further investigation necessary!
- Extensive calibration required? (Antenna phase centre variations…)

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Some Topics to Consider for GNSS Smartphone-Experiments and Publications:

- Airplane Mode active: Yes/No?
- Developer Mode active: Yes/No?
- Display Timeout (how long?) or Always On Display?
- Other Receivers (e.g. WirelessLAN, Bluetooth,...) active: Yes/No?
- Which Apps Used for Collecting the Data?
- Other Apps Running in the Background?
- Power Supply Active (which one? USB? Magnetic?) or Battery?
- Orientation of the Device in Space?
- … (to be extended)

Thank You for Your Attention!
Any Questions?

Literature

FREEDEN, W., RUMMEL, R. (eds.), **2017**. *Erdmessung und Satellitengeodäsie. Handbuch der Geodäsie.* Springer Spektrum, Berlin.
GLEASON, S., GEBRE-EGZIABHER, D., **2009**. *GNSS applications and methods*. Boston, Mass.: Artech House.
PSYCHAS, D., BRUNO, J., MASSARWEH, L., DARUGNA, F. , **2019**. *Towards Sub-meter Positioning using Android Raw GNSS Measurements.* Conference Paper. doi:10.33012/2019.17077.
WANNINGER, L., HESSELBARTH, A., **2020**. *GNSS code and carrier phase observations of a Huawei P30 smartphone: quality assessment and centimeter-accurate positioning.* GPS Solutions, 24(2).
WU, Q., SUN, M., ZHOU, C., ZHANG, P., **2019**. *Precise Point Positioning Using Dual-Frequency GNSS Observations on Smartphone.* Sensors, 19(9), p.2189.

FEHN, K., SCHAUER, H., SLATEFF, A., **2021**. *Stop and Go Measurements with the Google Pixel 5.* Report Location Based Systems VU, TU Wien (not published)
WEIGERT, T., **2021**. *Untersuchung verschiedener Anwendungsszenarien für Smartphones mit Dual-Frequenz GNSS Empfänger im Vermessungswesen.* BSc-Thesis TU Wien, April 2021 (not published)
RETSCHER, G. et. al., **2021**. *Performance Analysis of Static and Stop-and-Go Observations Using a Dual Frequency Multi-GNSS Smartphone.* submitted to Appl. Geomatics (under review)