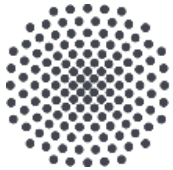
E-GVAP 2019 expert teams meeting
Deutscher Wetterdienst (DWD),
28-29 November 2019

WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES



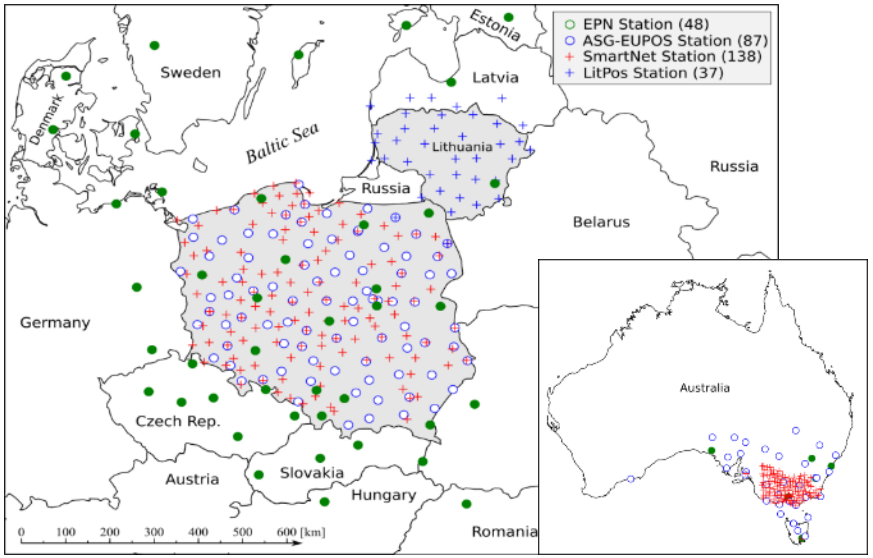
University of Stuttgart

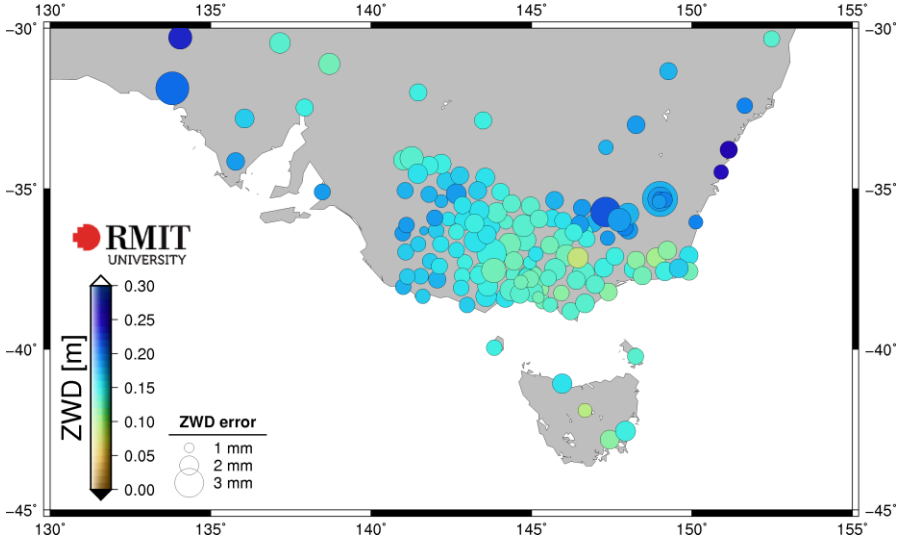
STATUS AND UPDATES OF WUELS, POLAND

Piotr BRYŁKA[(1)], Damian TONDAŚ[(1)], Tomasz HADAŚ[(2,1)], Jan KAPŁON[(1)]

1) Wroclaw University of Environmental and Life Sciences
2) Institute of Navigation, University of Stuttgart

Maintaining the WUEL/WLIT (E-GVAP) and VICNET NRT





- BSW 5.2 DD solutions,
- GPT/GMF a priori ZTD, GMF MF,
- 6-hour window of 30s GPS data,
- 1 h interval of processing,
- ZTD + gradients estimated in 30 min intervals
- VICNET ZTDs assimilated each hour by BoM.
- Data from: ASG-EUPOS, Leica SmartNet, NadowskiNet, GPSnet.

RMIT UNIVERSITY

Post-Processing DD ZTD solution – low-cost

Piksi Multi

GNSS Characteristics

GNSS Signal Tracking

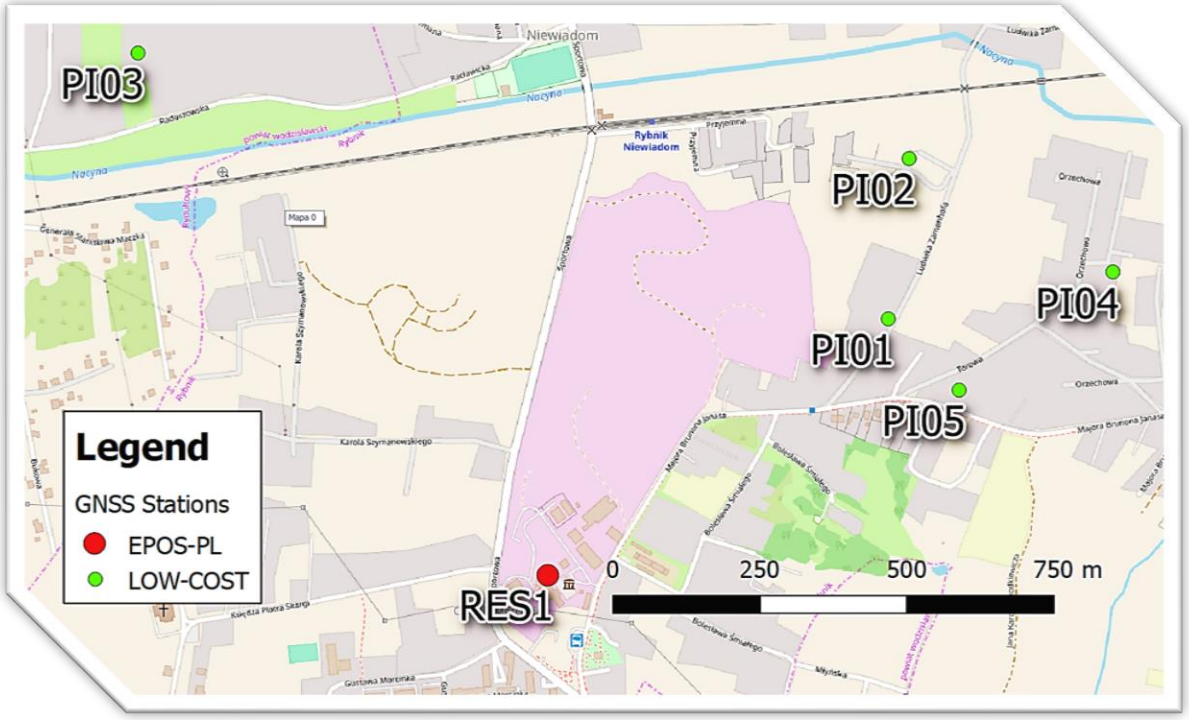
GPS L1/L2, GLONASS G1/G2,
BeiDou B1/B2, Galileo E1/E5b
SBAS[1]

GNSS Data Rates

Measurements (Raw Data)	Up to 10 Hz
Standard Position Outputs	Up to 10 Hz
RTK Position Outputs	Up to 10 Hz[2]
Swift Binary Protocol (SBP) and NMEA-0183	

Maximum Operating Limits[3]

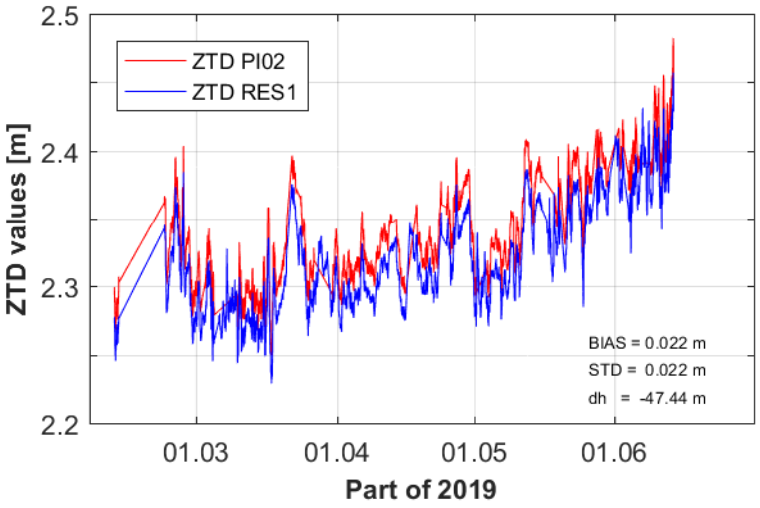
Velocity	515 m/s

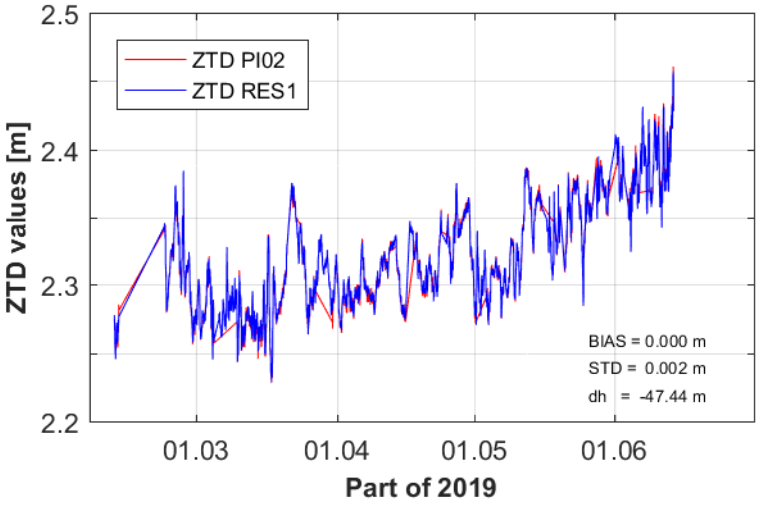


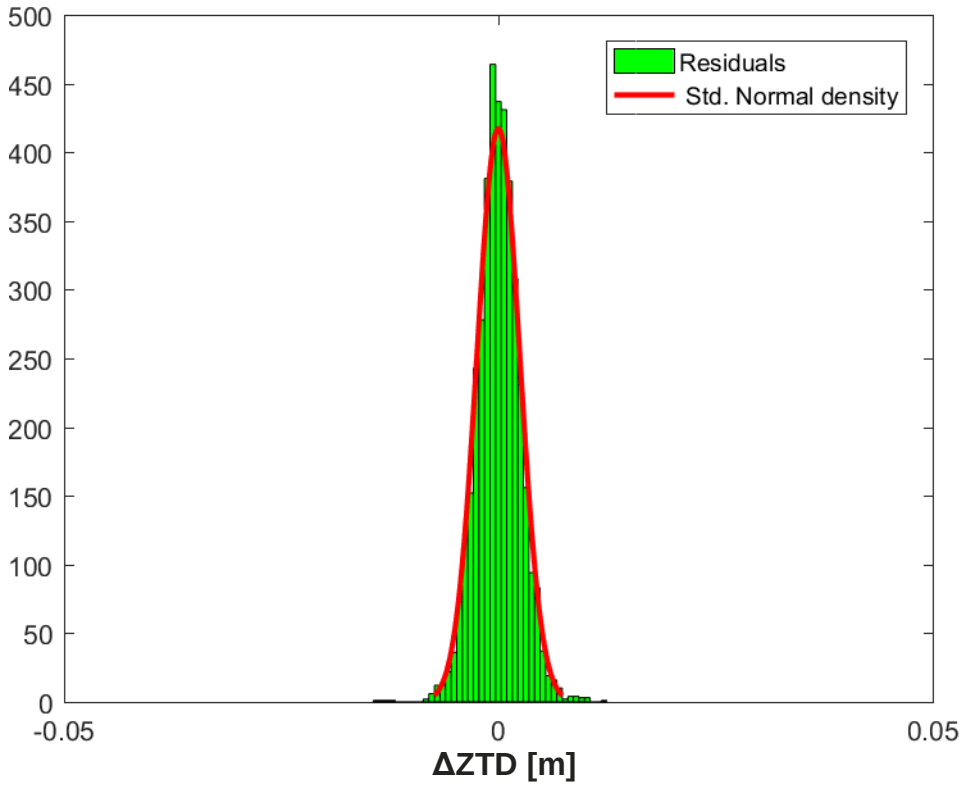
Technical Specifications

Antenna Specification	
Frequency Range	GPS L1/L2 GLONASS L1/L2 BeiDou B1/B2/ B3
Impedance	50 ohm
Polarization	RHCP
Axial Ratio	≤ 3 dB
Azimuth Coverage	360°
Output VSWR	≤ 2.0
Peak Gain	5.5 dBi
Phase Center Error	± 2 mm
LNA Specification	
LNA Gain	40 ± 2 dB
Noise Figure	≤ 2.0 dB
Output VSWR	≤ 2.0
Operation Voltage	3.3 ~ 12V DC
Operation Current	≤ 45 mA
Group Delay	≤ 5 ns
Mechanical Specification	
Dimension	φ 152*62.2 mm
Connector	TNC Female
Weight	435 g
Environment Specification	
Storage Temp	-55° C to +85° C
Operating Temp	-45 °C to +85° C
Humidity	95% No-condensing

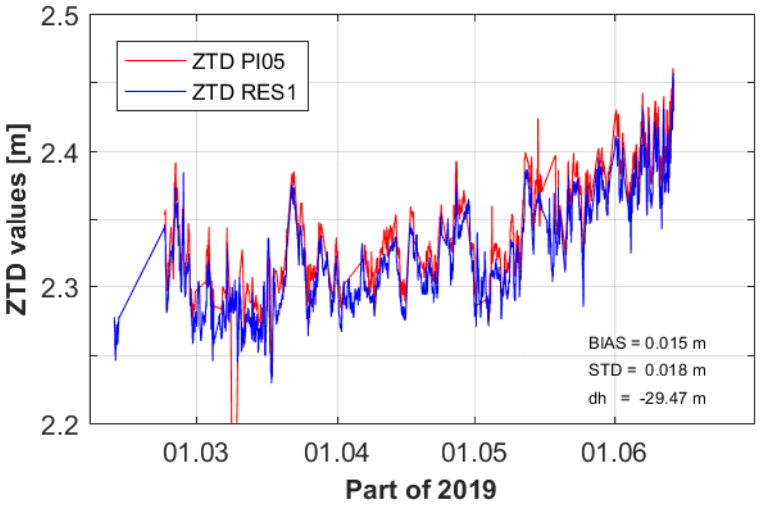
Post-Processing DD solution (PI02)

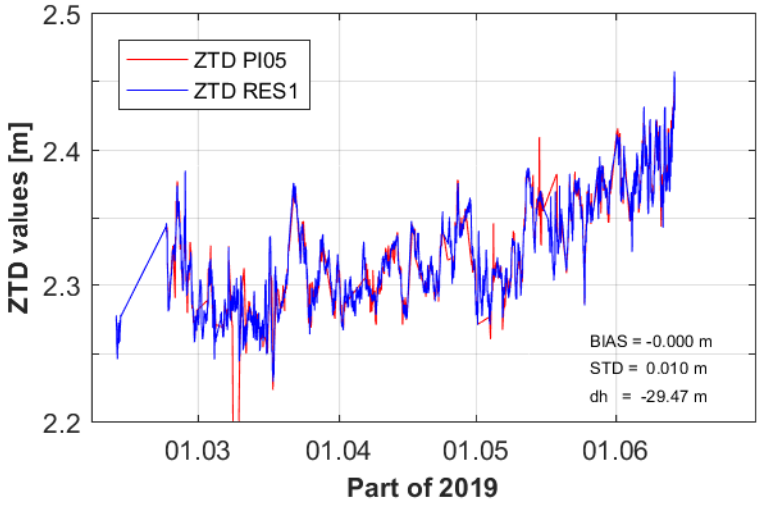


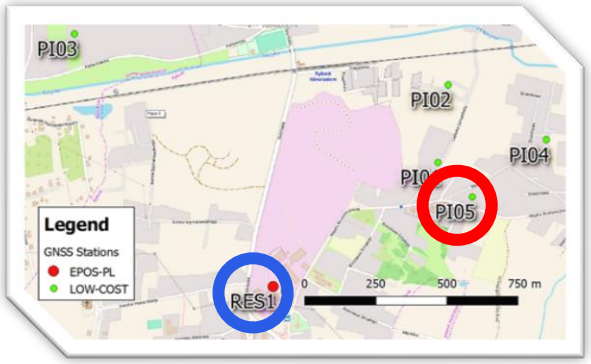


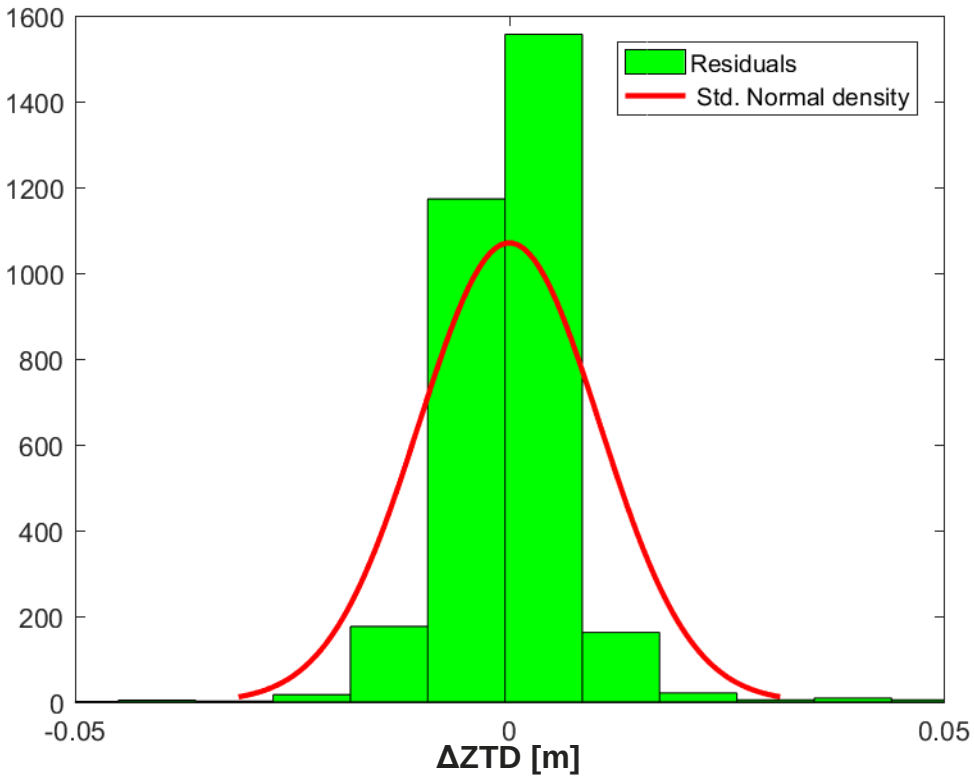


Post-Processing DD solution (PI05)

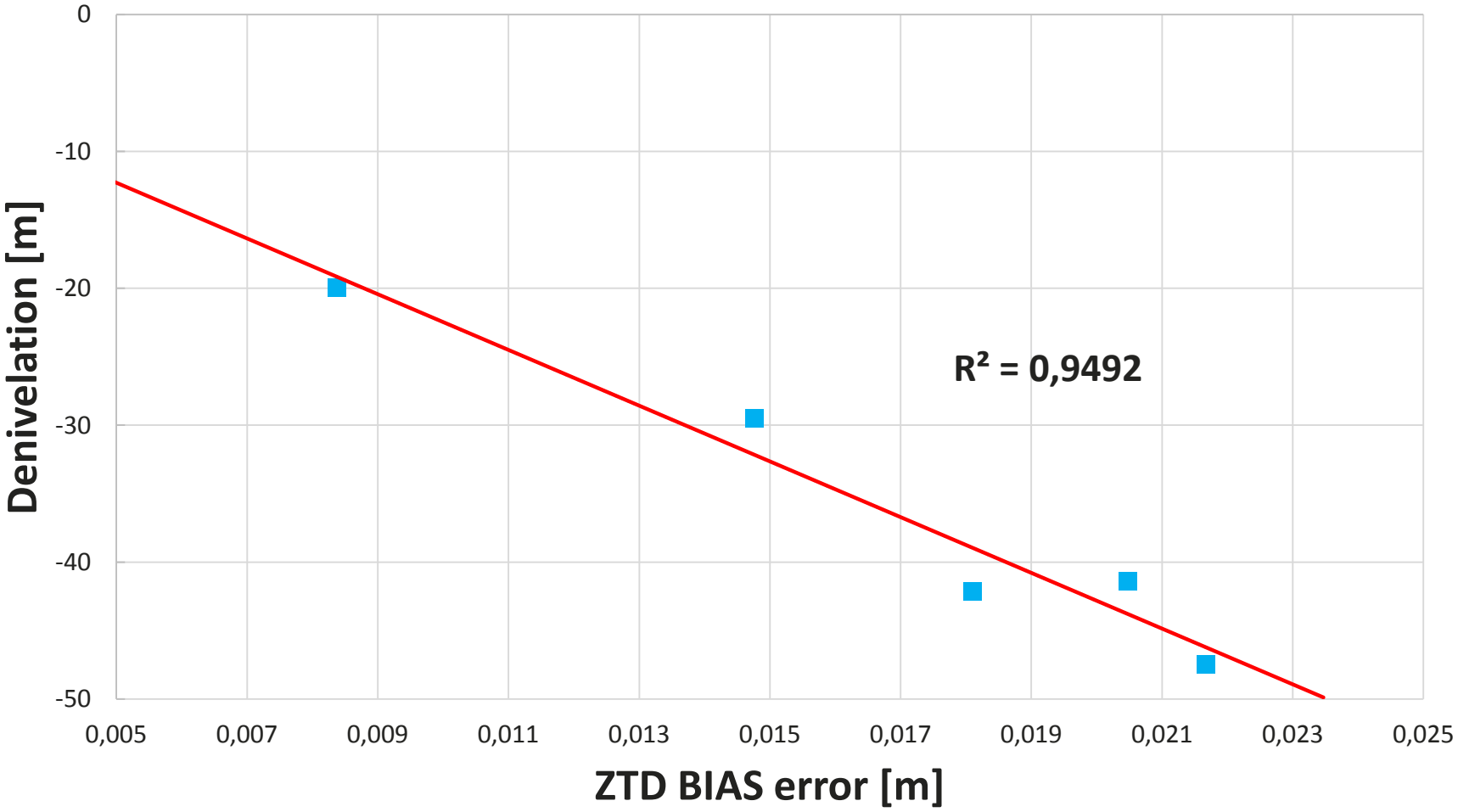






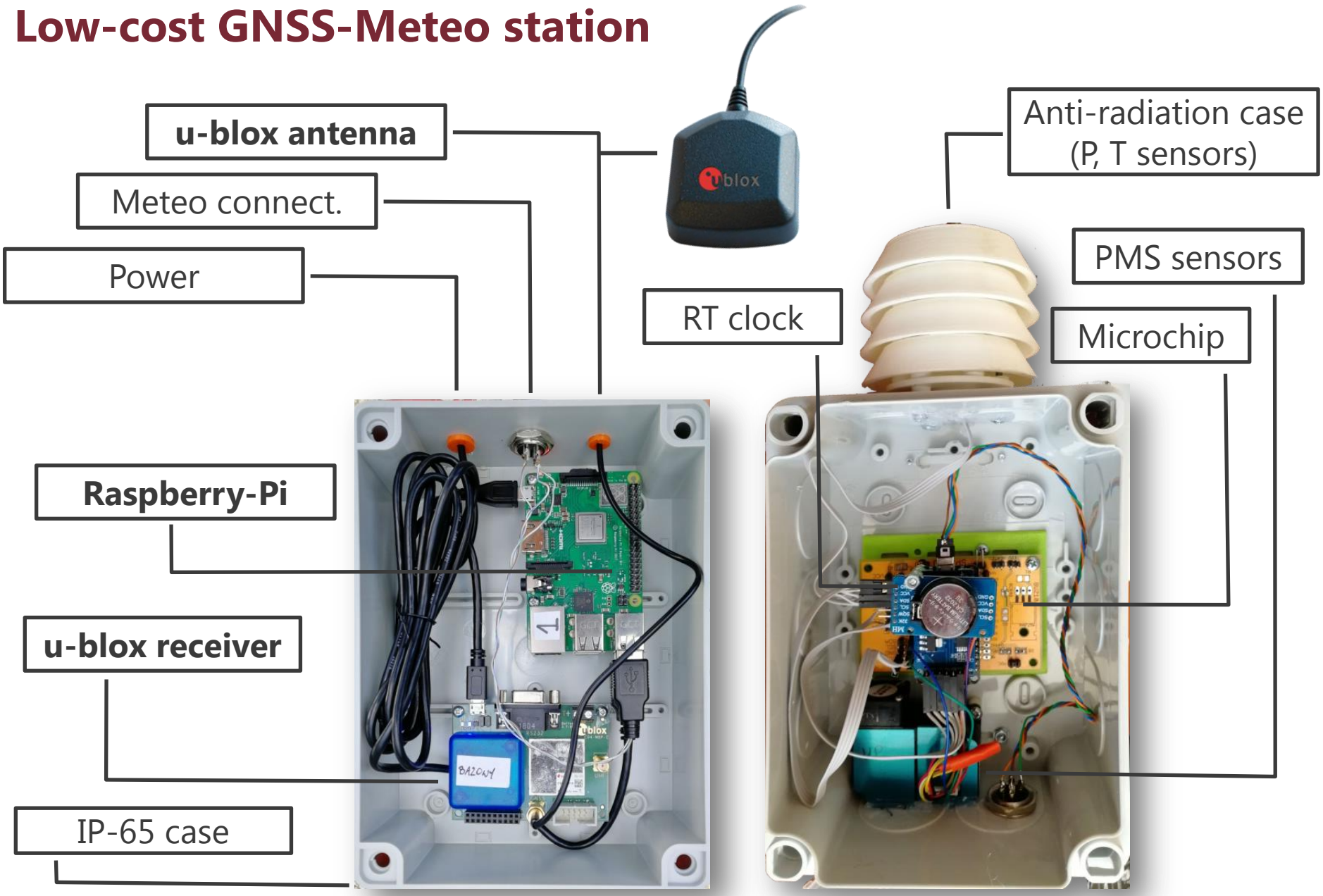


Bias reduction

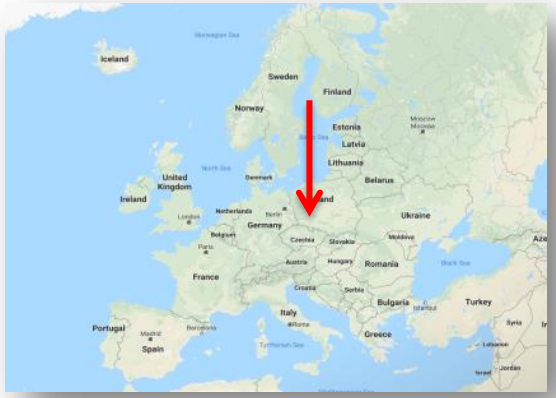


Mean bias after denivelation corrections < 2mm

Low-cost GNSS-Meteo station

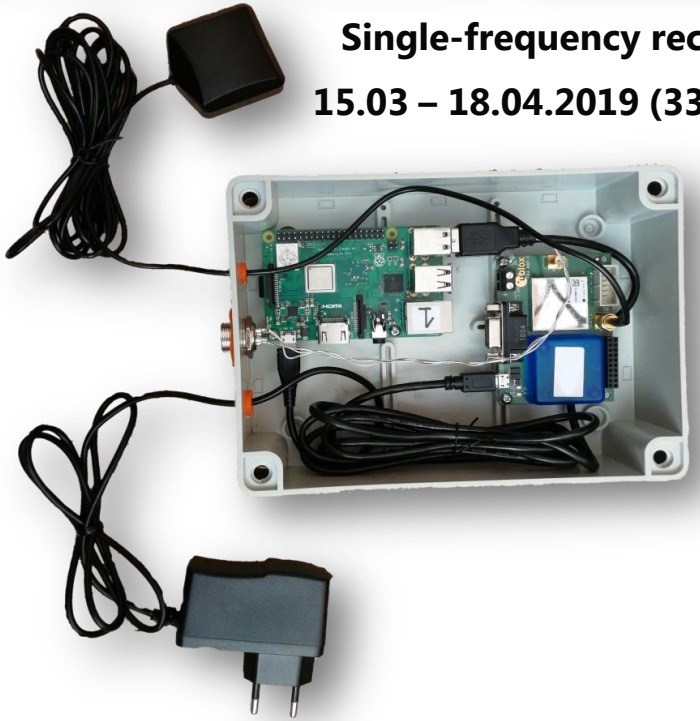


Experiment



Single-frequency receiver

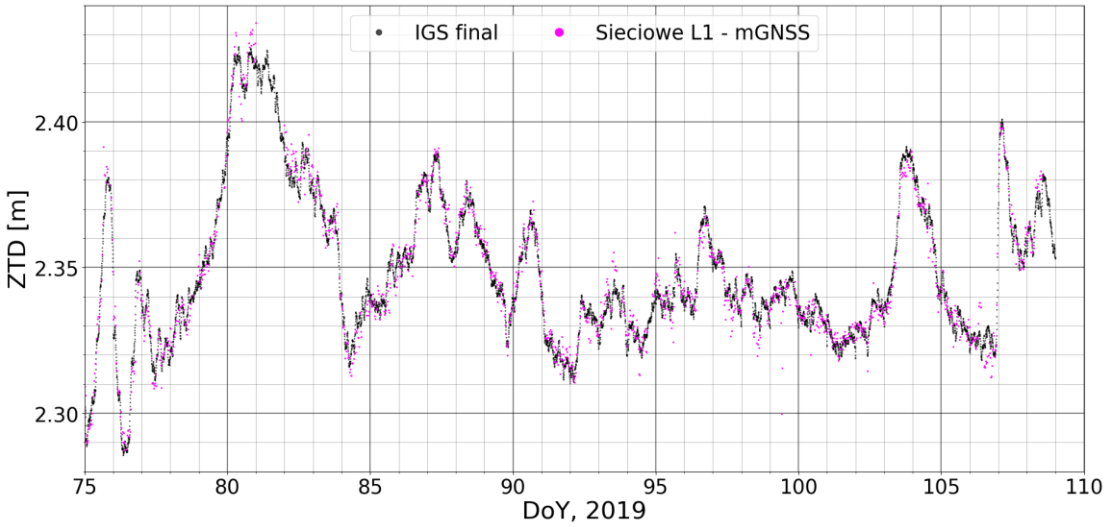
15.03 – 18.04.2019 (33 days)



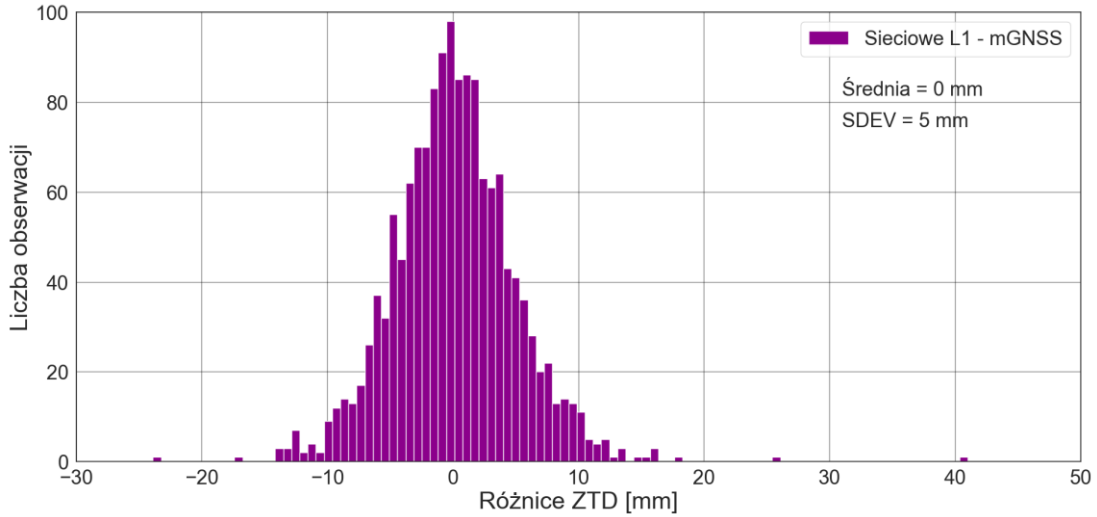
Dual-frequency receiver

30.04 – 10.05.2019 (11 days)

L1: Network NRT solution



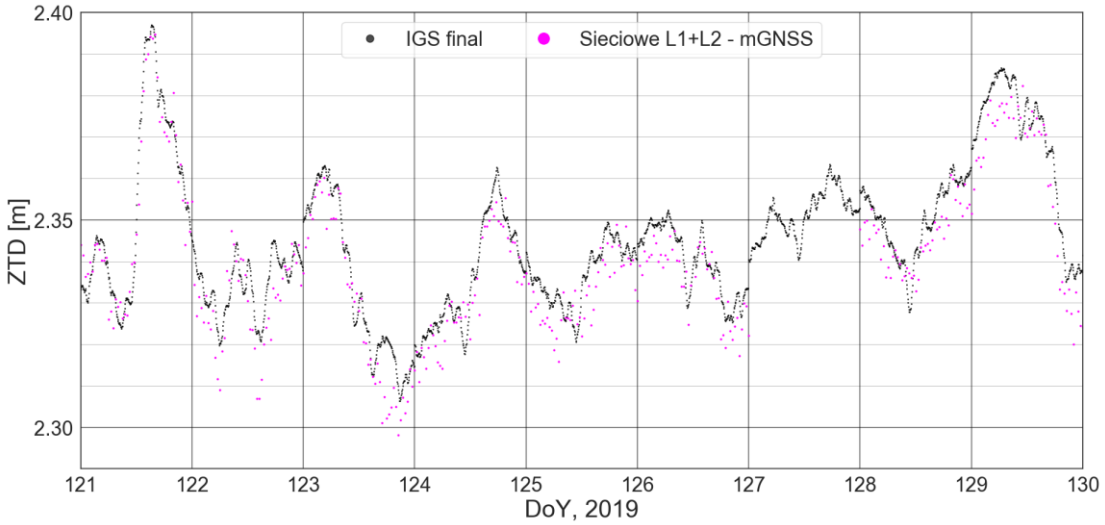
15.03 – 18.04.2019
(33 days)



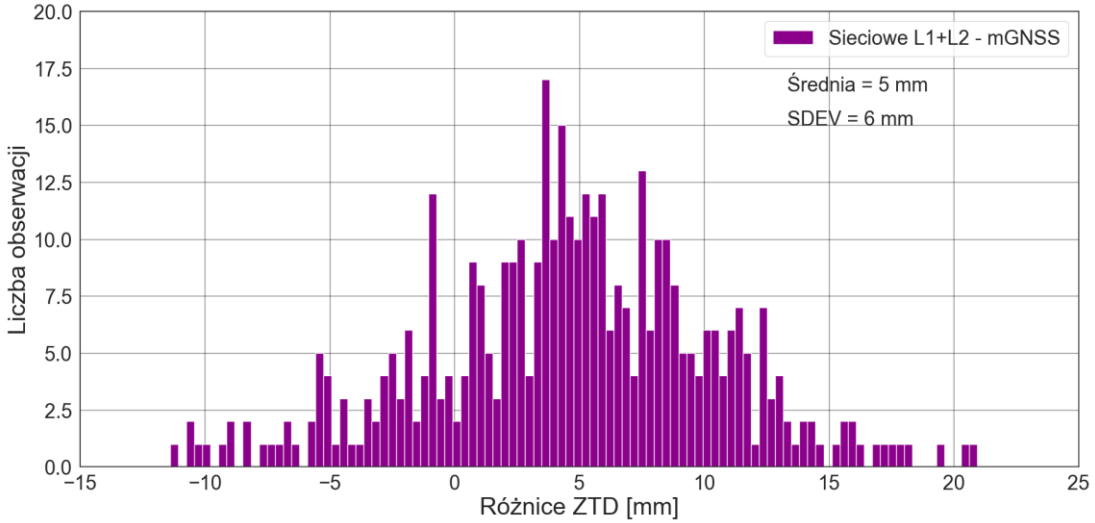
NRT vs. Final (IGS)

	[mm]
RMSE	5
Mean	0
StdDev	5
Median	0

L1/L2: Network NRT solution



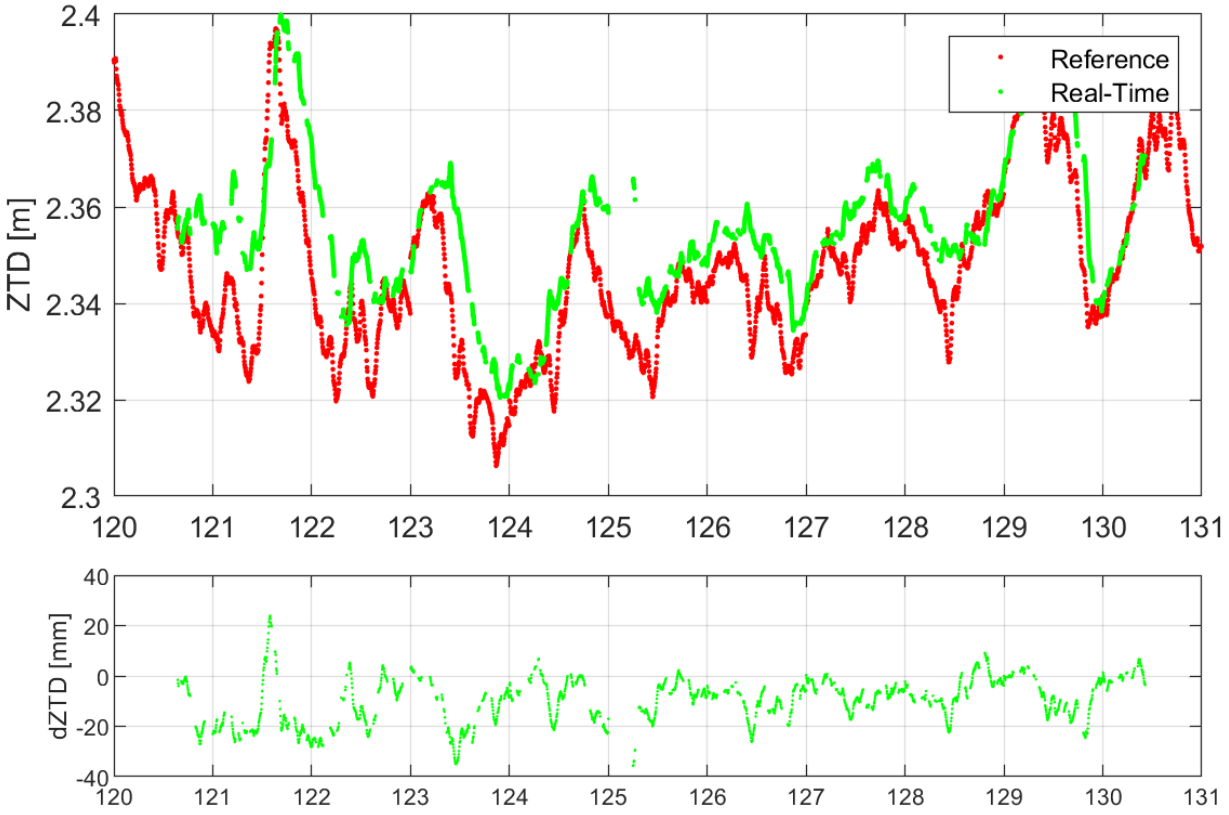
30.04 – 10.05.2019
(11 days)

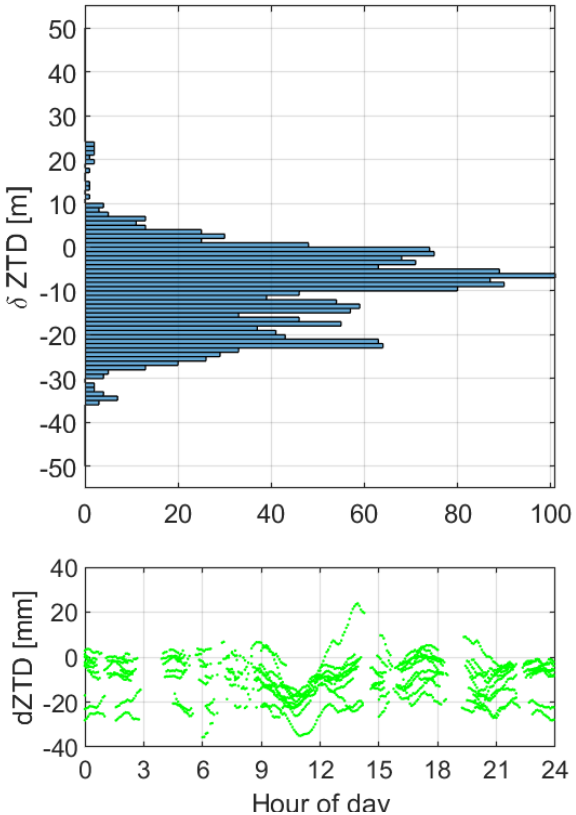


NRT vs. Final (IGS)

	[mm]
RMSE	7
Mean	5
StdDev	6
Median	5

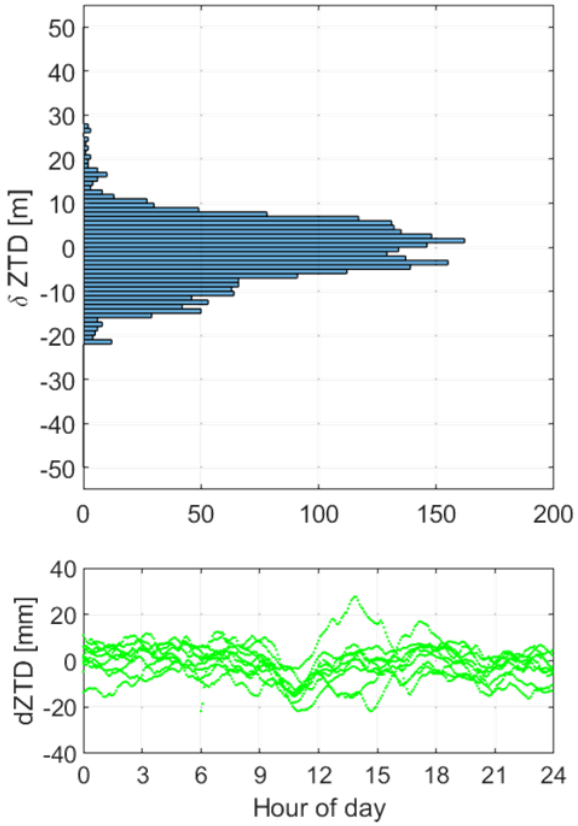
L1/L2: Real-time PPP solution (G-only)





RMS = 14 mm
Mean = 10 mm
S.Dev. = 9 mm
Max = 36 mm
R2 = 0.84
Avail.: 65%

L1/L2: Real-time PPP solution (G+R+E)



RMS = 14 mm
Mean = 10 mm
S.Dev. = 9 mm
Max = 36 mm
R2 = 0.84
Avail.: 65%

RMS = 7 mm
Mean = -1.0 mm
S.Dev. = 7 mm
Max = 28 mm
R2 = 0.91
Avail.: 97%

Low-cost summary

Time	Mode	GNSS:	Receiv.	Freq:	StdDev
Final	DD	GR	Piksi M.	L1/L2	2 – 10 mm
NRT	DD	GR	M8P	L1	5 mm
NRT	DD	GR	F9P	L1/L2	6 mm
Real-time	PPP	G	F9P	L1/L2	9 mm
Real-time	PPP	GRE	F9P	L1/L2	7 mm

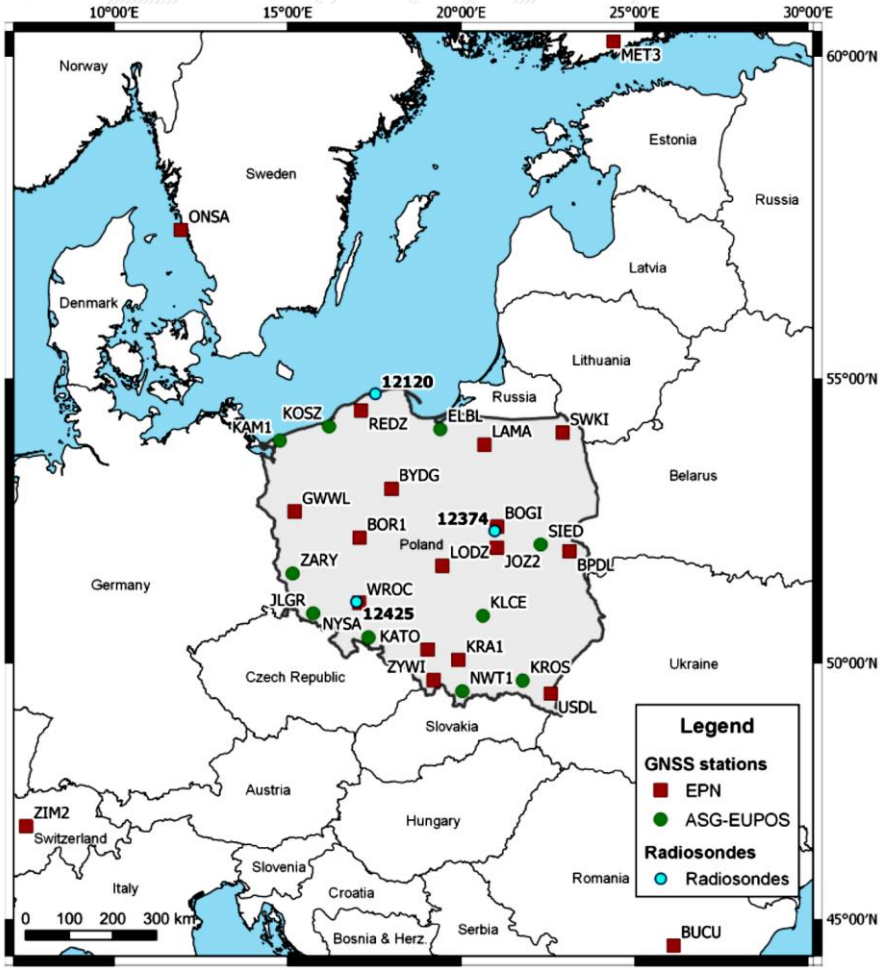
ZTD accuracy depends on:

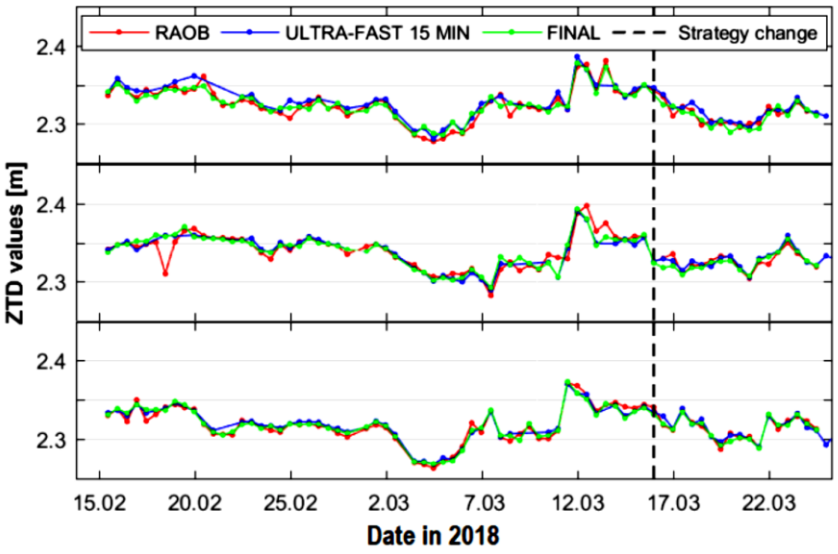
- receiver / antenna ($$ > $)
- time regime (Final =~ NRT > RT)
- strategy (PPP =? DD)
- #SV (GNSS > GPS only)

StdDev <10mm (~2kg/m² IWV)

Ultra-fast NRT tests

28 stations, NRT 6-hour window, 15 min int., VMF1-FC as a priori model and MF



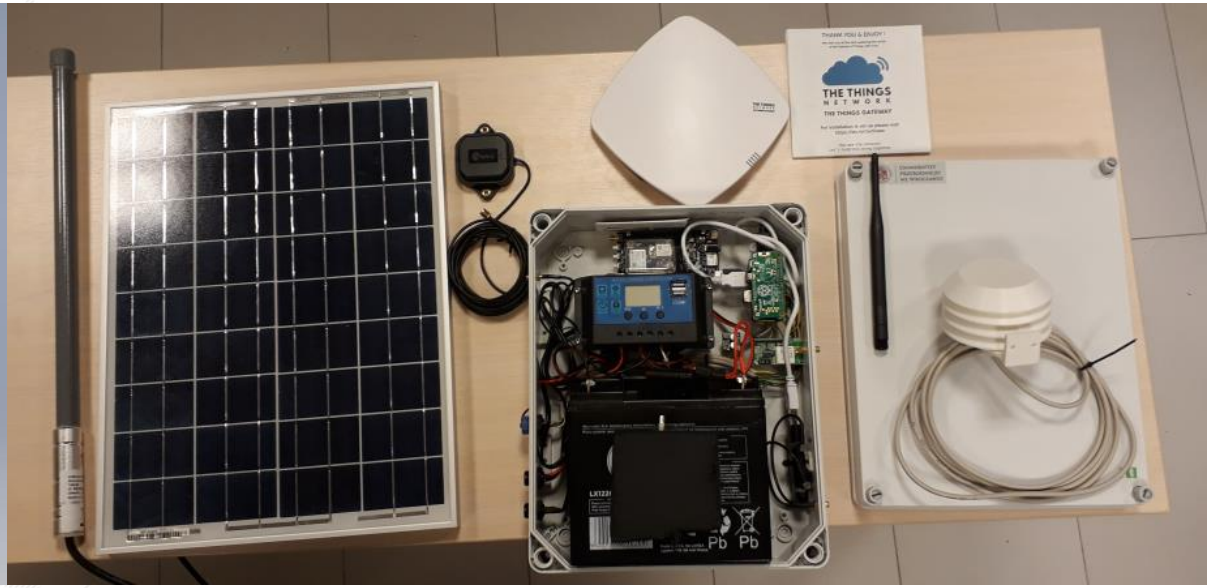


Site	GNSS - Radiosonde distance [km]	Strat. I (2880)		Strat. I (1056)		Strat. II (1056)	
		NRT	FINAL	NRT	FINAL	NRT	FINAL
BOGI	15	5.9	6.5	5.8	6.3	8.0	7.3
REDZ	50	10.4	10.4	10.1	10.3	4.8	5.8
WROC	12	5.0	5.1	5.2	5.1	5.4	3.8

Mean latency of NRT solutions: < 4 m 15 s

The low-cost GNSS-Meteo network

Design and build of 22 u-blox based GNSS-meteo stations (2 L1-only, 20 multi-GNSS, multi-frequency), to establish the network for low-cost NRT ZTD estimation and ground deformation monitoring



- **Data transmission options: GSM/LTE, RJ45, LoRa (long range, low-power, wide area network)**
- **Power supply options: ~230V + solar panel with 12V battery,**
- **No external power source needed – low power consumption,**
- **Equipped with meteo T, P, RH, and PM10 sensors,**
- **2 G+R L1-only M8P u-blox, 20 multi-GNSS u-blox F9P,**
- **Free RTCM 3.X data packages transmission with LoRa in 30 [s] intervals.**

1000 € / station !

Other activities

1. **Very recent installation of 2 Radiometers belonging to WUELS (funded by EPOS-PL project) for IWV and slant delay studies :**
   - ✓ **in Wrocław < 10 m to the WROC EPN/IGS station,**
   - ✓ **in Borowa Góra < 100m to the EPN station BOGI (Warsaw area).**

STATUS AND UPDATES OF WUELS AC

WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES

University of Stuttgart

Thank you!

jan.kaplon@upwr.edu.pl

E-GVAP 2019 expert teams meeting
Deutscher Wetterdienst (DWD),
28-29 November 2019