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LatPos System for Ionosphere Monitoring and RTK Applications

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Contents:

LatPos System for Ionosphere Monitoring and RTK Applications

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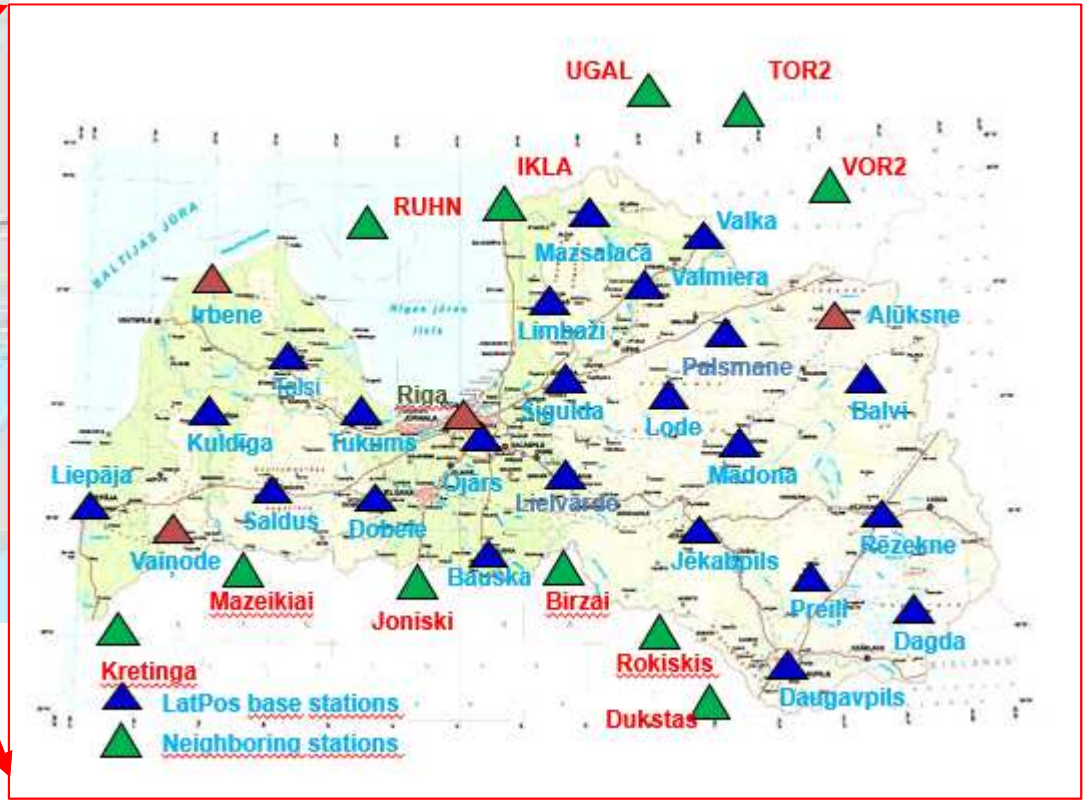
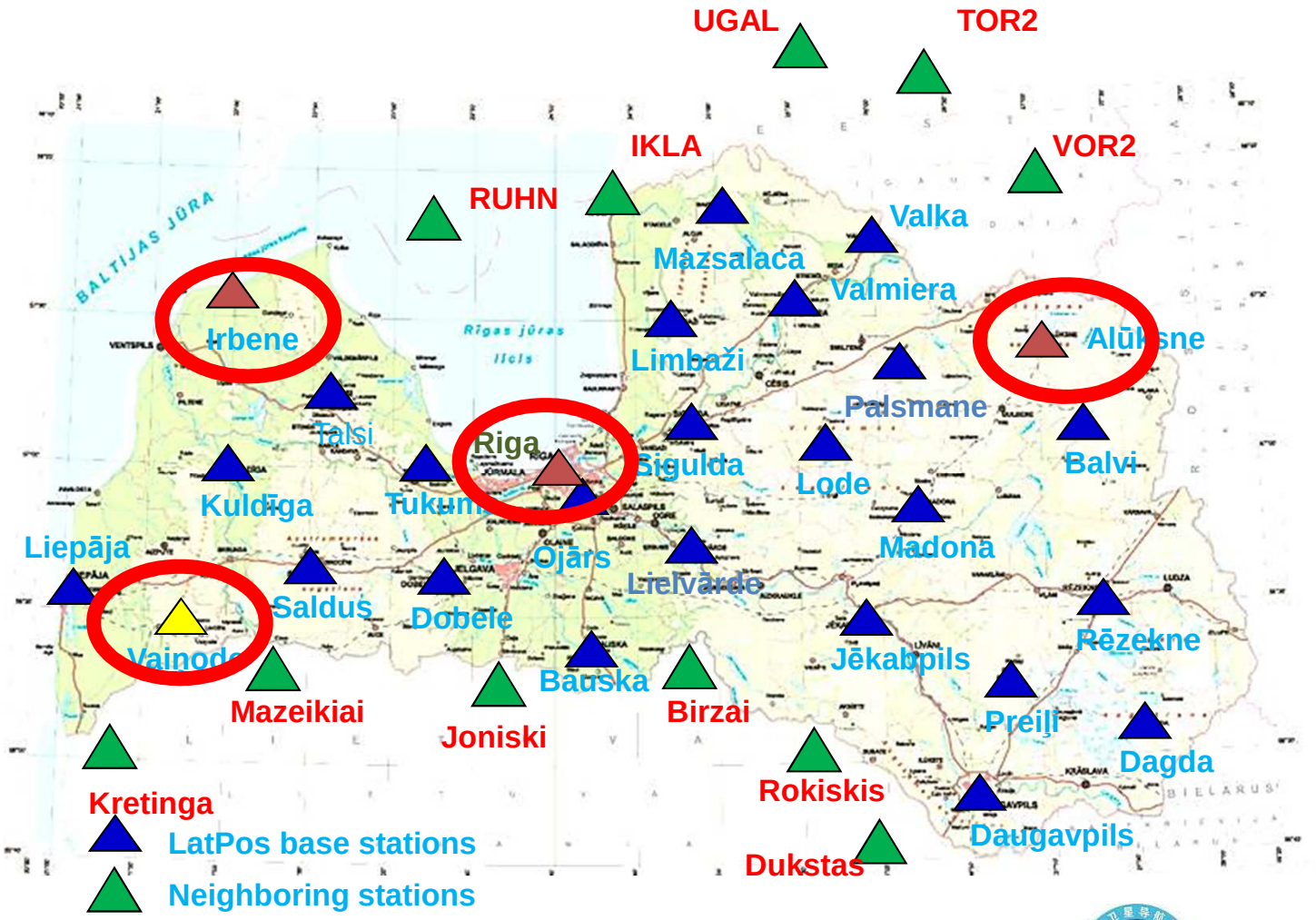
GNSS CORS Network of Latvia - LatPos

- 1,957,200 inhabitants
- territory of 64,589 km2
- Capital - Riga



GNSS used in LatPos

System Established: 2005



Riga, Irbene, Vainode, Aluksne

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LatPos Services and Data

cm level positioning

REAL-TIME

Submeter positioning

→ **RTK and Network RTK**
- Surveying and Mapping
- Precise Agriculture
- etc

→ **Handheld DGNSS**
- Forestry etc

Post processing data

→ **RINEX 2.11** (Ready 3.x)
1 sec data - 2 Years
30 sec data – all (from 2005)

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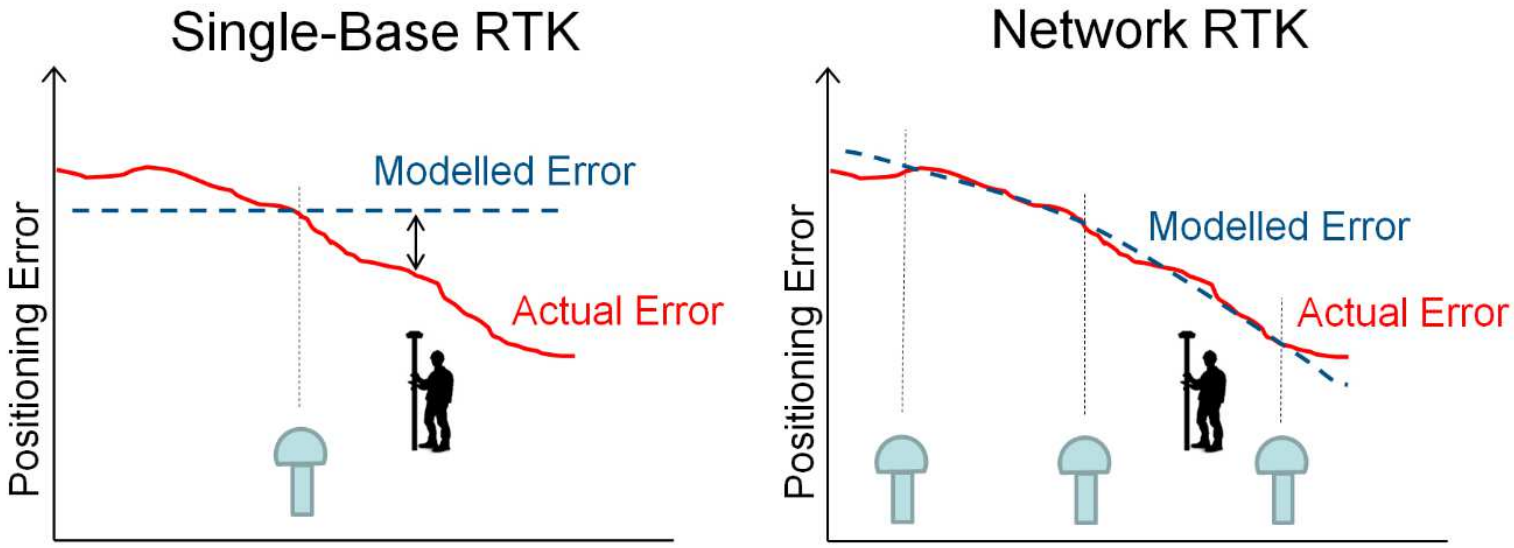
RTK Solutions:

LatPos provides:

- ✓ **Single-Base RTK**
- **Network RTK**
  - ✓ MAX
  - ✓ iMAX
  - ✓ VRS
  - ✗ FKP



Resource: Janssen, V and Haasdyk, J and McElroy, S (2011) *Network RTK: Same look and feel... only better.* Position (56). pp. 20-24. ISSN 1447-2635

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LatPos for Ionosphere Monitoring

TEC (Total Electron Content) estimation

BERNESE GNSS Software Version 5.2

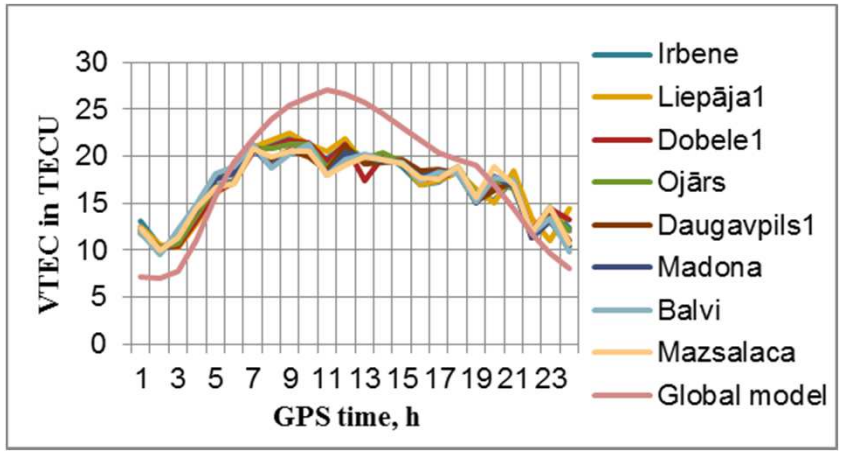
INPUT

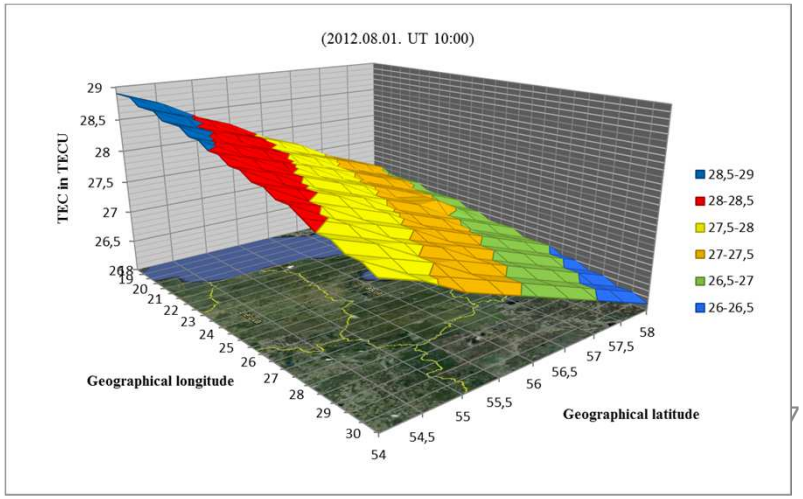
RINEX data
Coordinates
Orbit information
etc.

OUTPUT

TEC estimates

IONEX





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Yearly LatPos test procedure

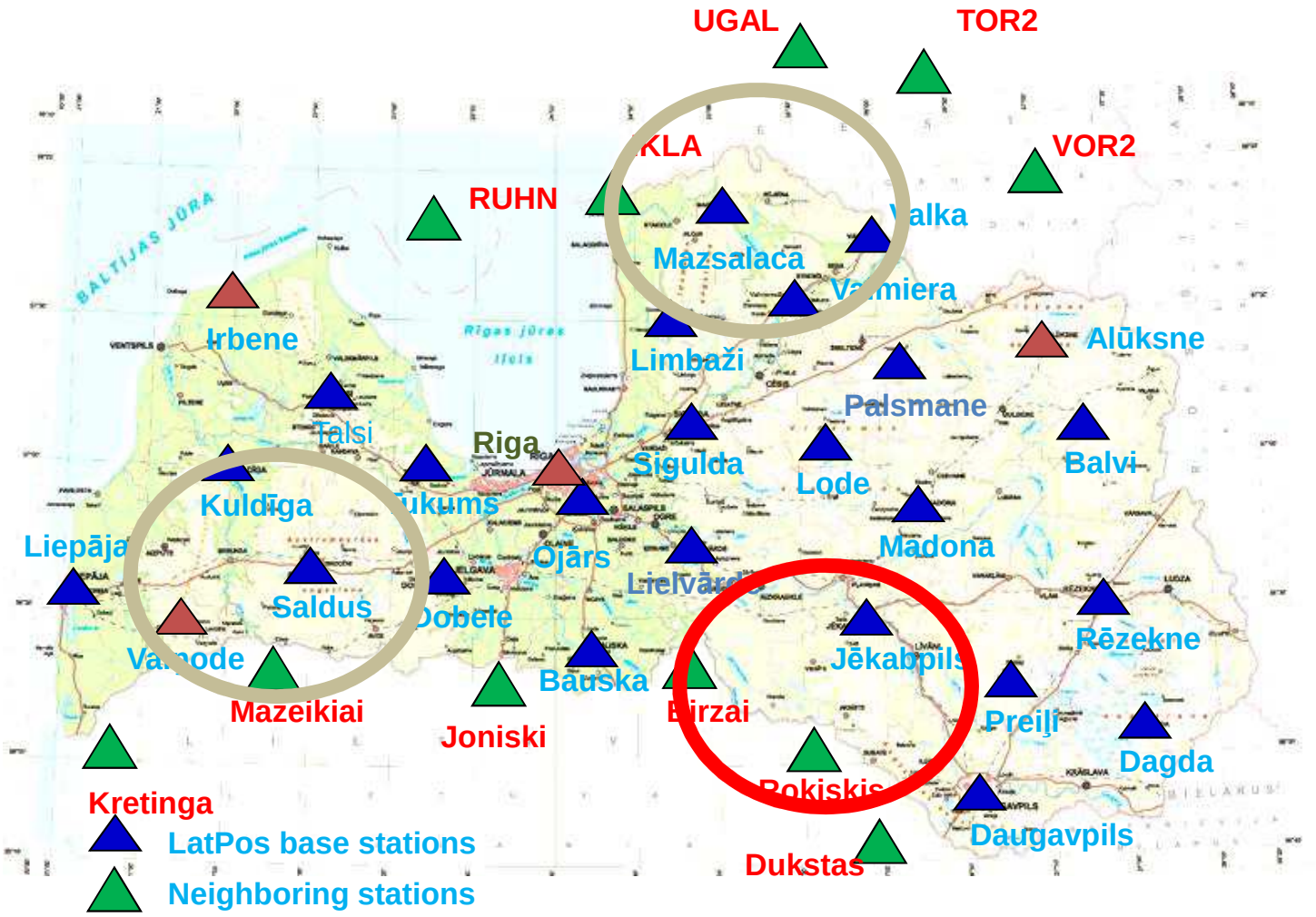
1. **Initialization time – Time to FIX**

2. **Initialization repeating – number of measurements**
   - in same point with different FIX
   - different TYPE of FIX (MAX,iMAX,SINGLE-SITE,VIRTUAL-RS)
   - In time span up to HOUR

3. **RTK stability in time span – Hour (1 sec rate)**

4. **Post processing data collection**

Yearly LatPos test procedure



- Area for test measurements - **6 points** (2nd order Geodetic network)
- Measurements done in October 11-13, (2 points per day)

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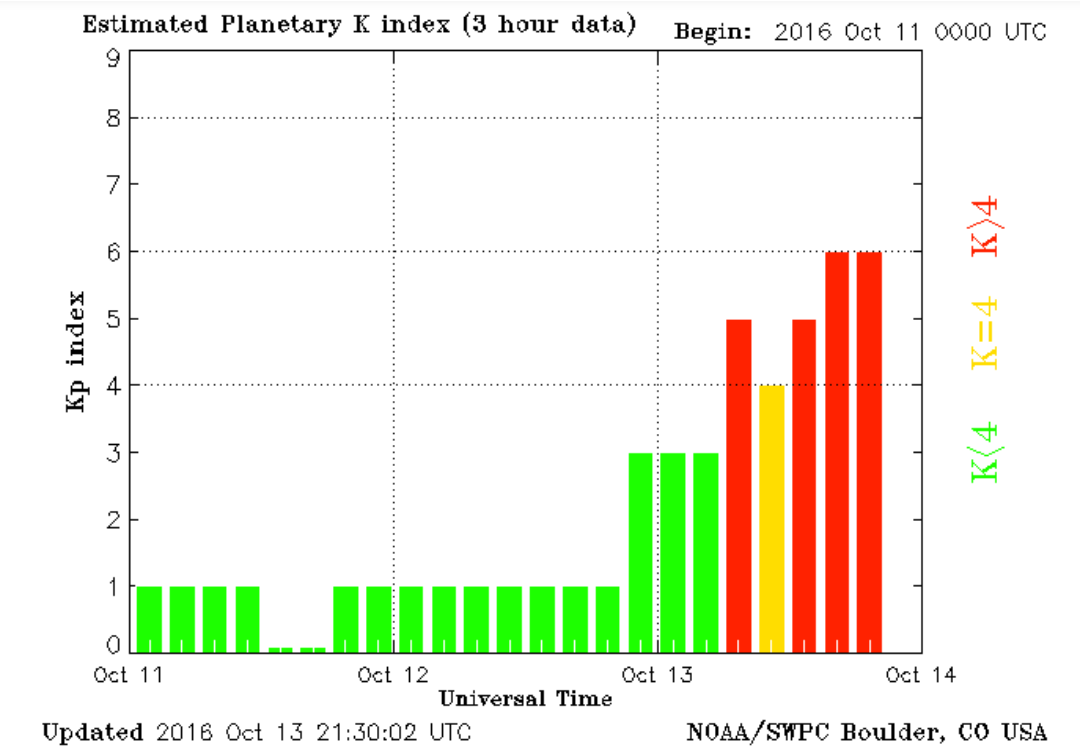
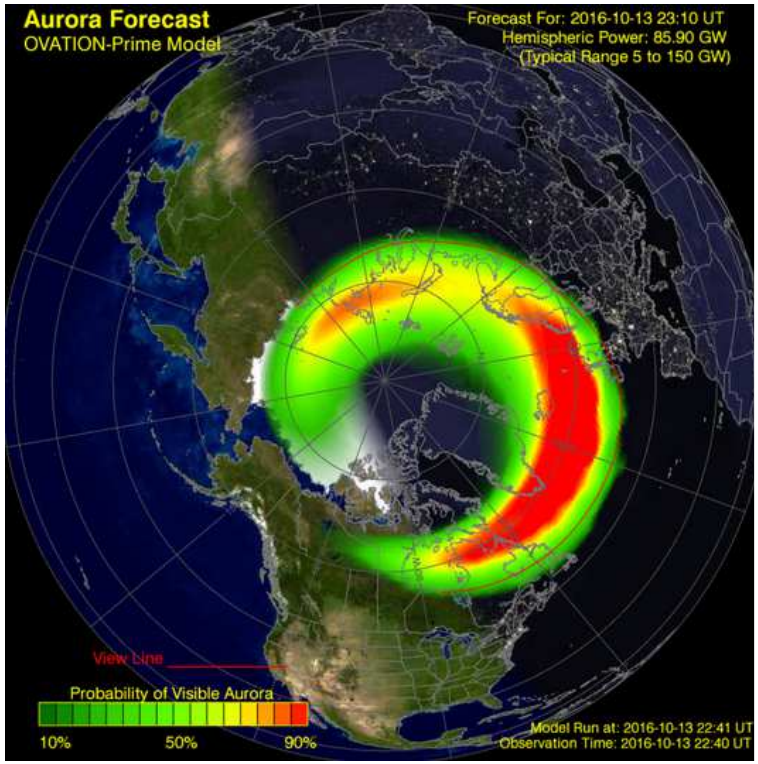
What happened on October 13?

A filament in Sun's northeast quadrant erupted between 15:00 and 17:00 UTC on Saturday, October 8, 2016, producing an asymmetric, partial-halo CME. The CME, although faint, was first observed in LASCO C2 imagery beginning 00:48 UTC on October 9.



Geomagnetic K-index of 5 (G1 - Minor geomagnetic storm) threshold was first reached at 08:15 UTC.



Source: NOAA/SWPC Boulder, CO USA

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What happened?

Figure 2: VTEC extracting locations

Source: Royal Observatory of Belgium
GNSS Research Group

http://gnss.be/Atmospheric_Maps/ionospheric_event.

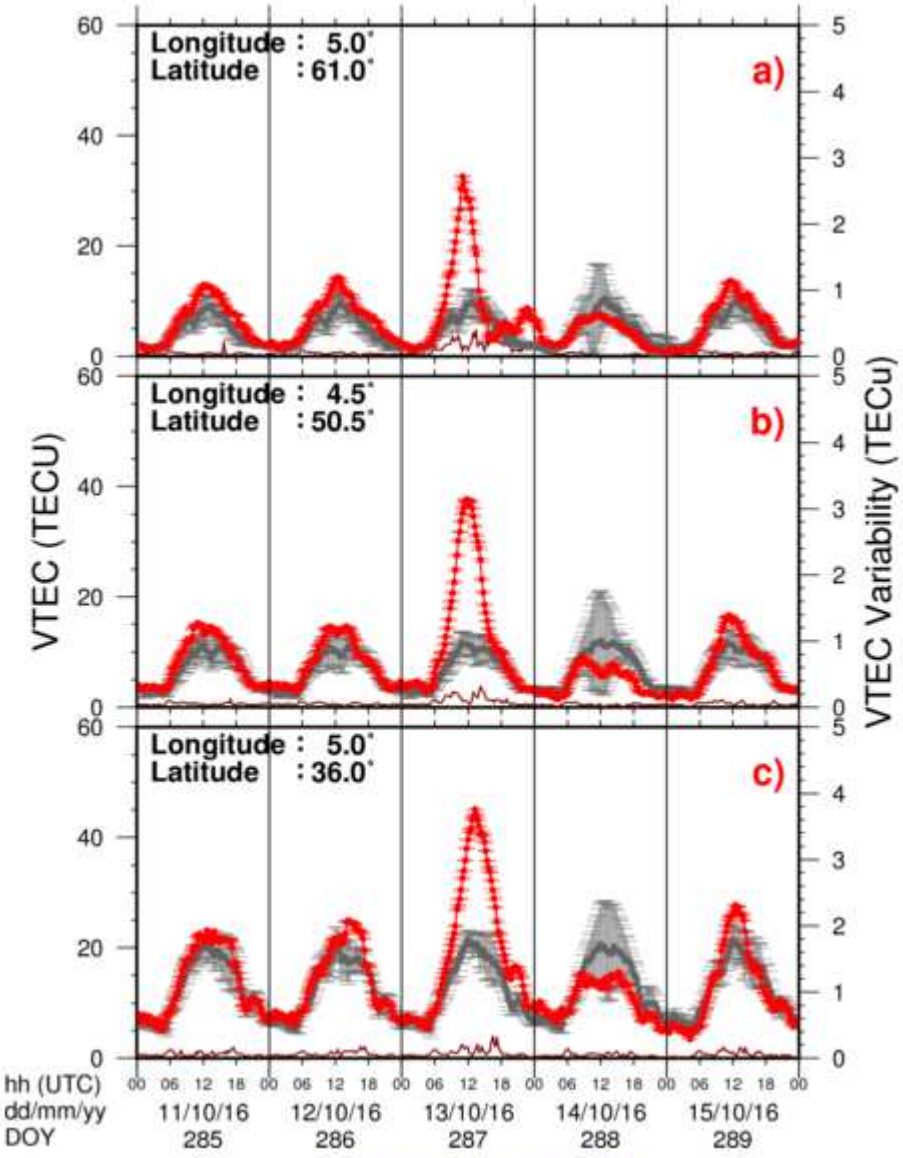
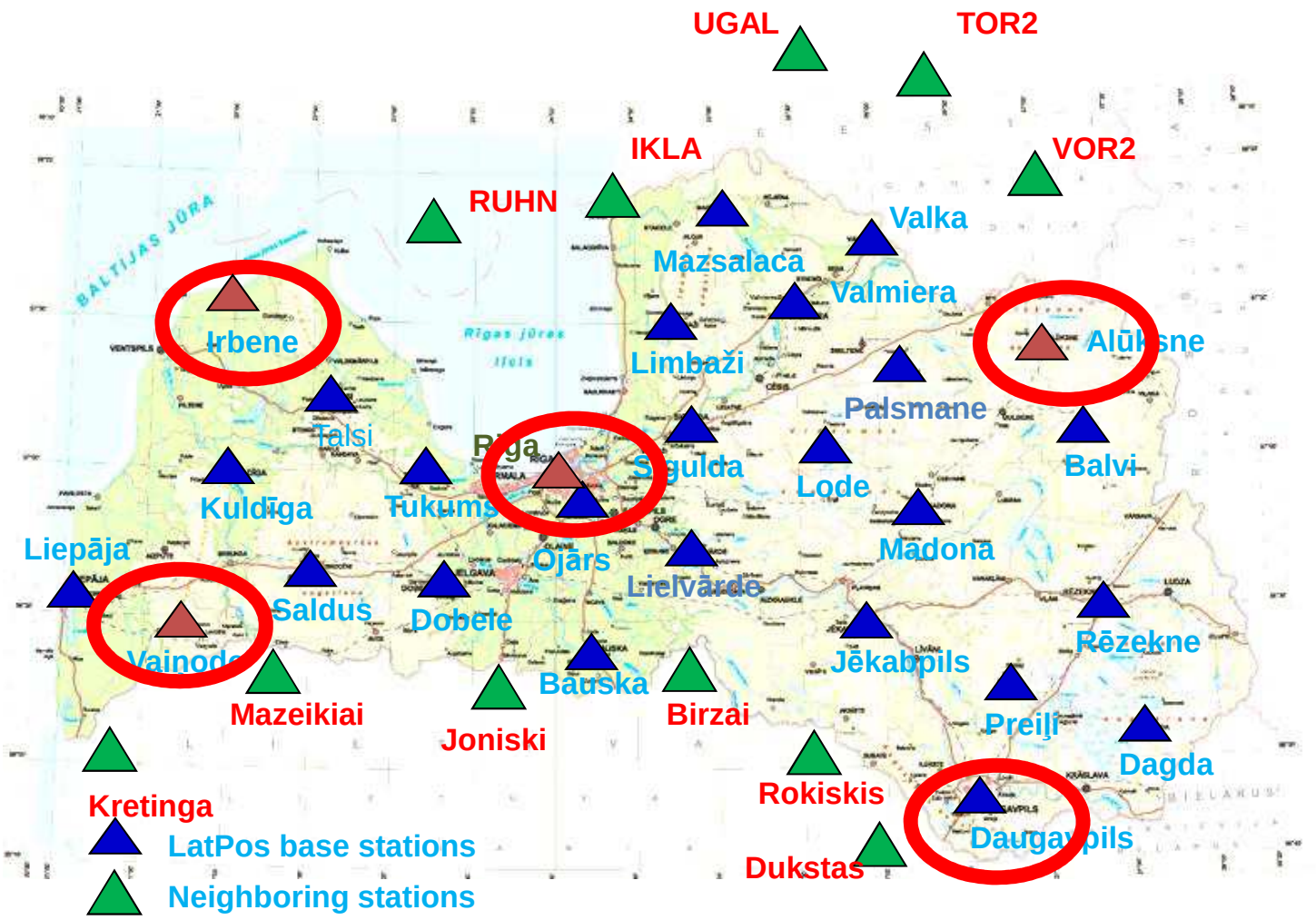


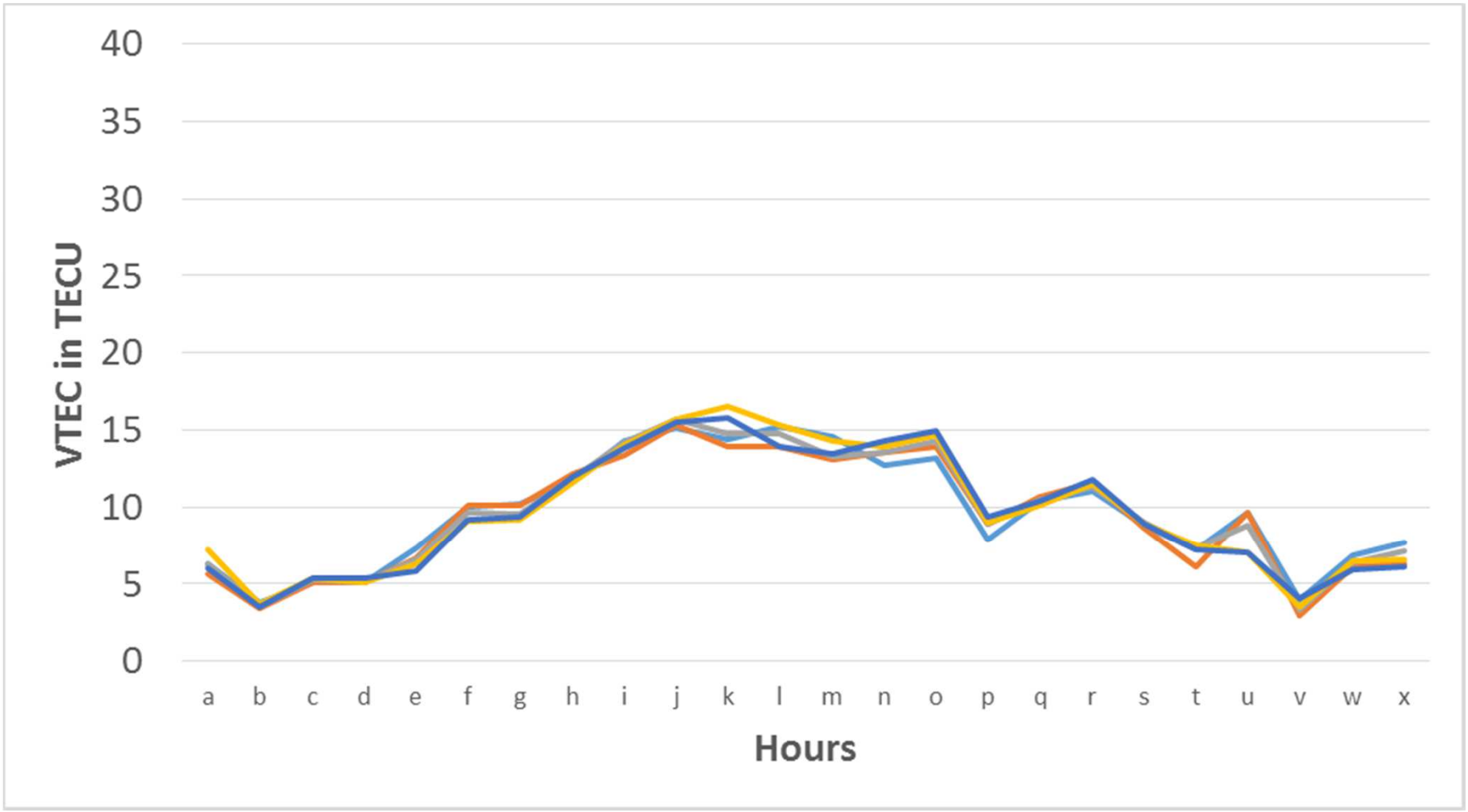
Figure 1: VTEC Time Series

LatPos stations used for VTEC calculations

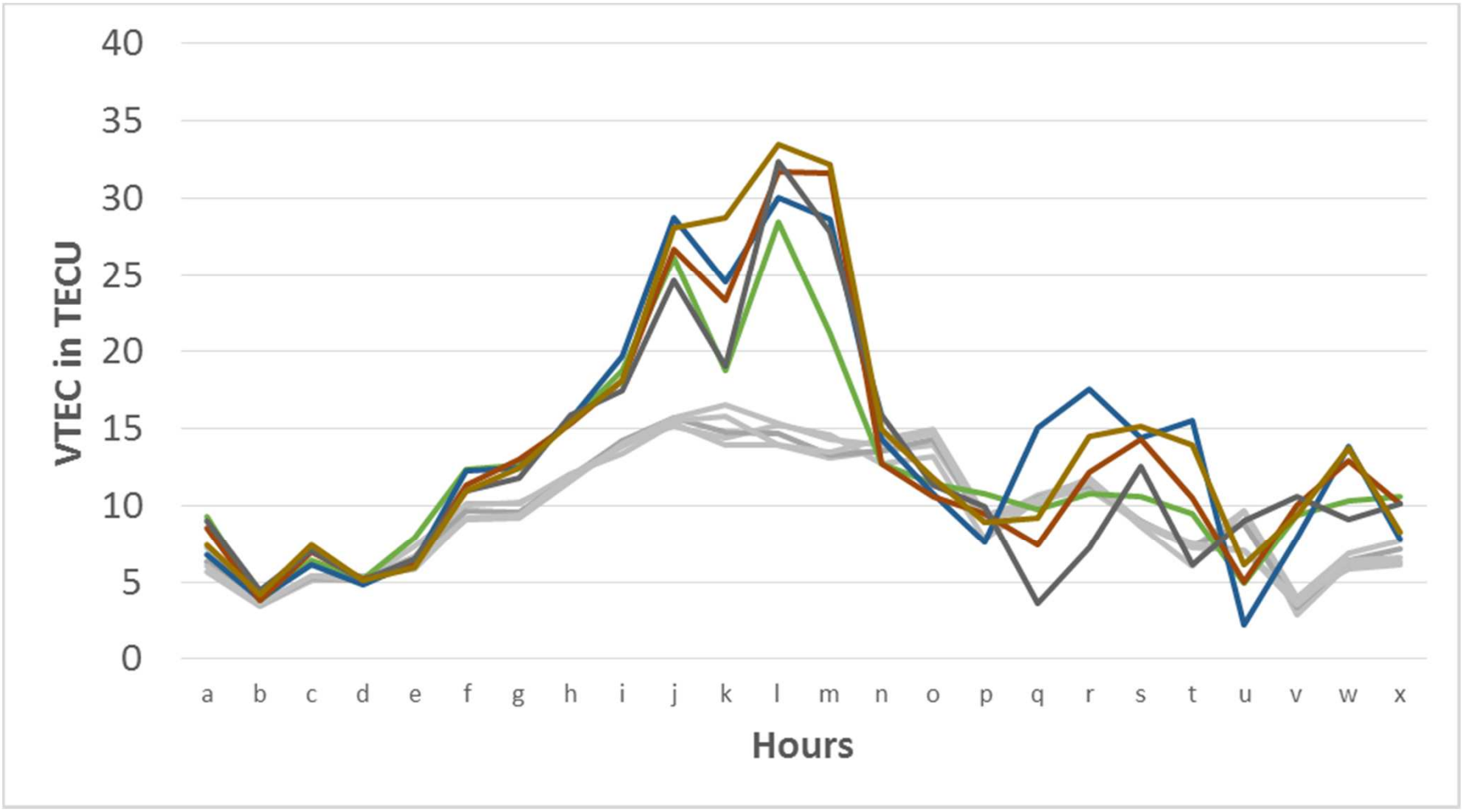


Ojars, Irbene, Vainode, Aluksne, Daugavpils

Calculated VTEC October 12, 2016

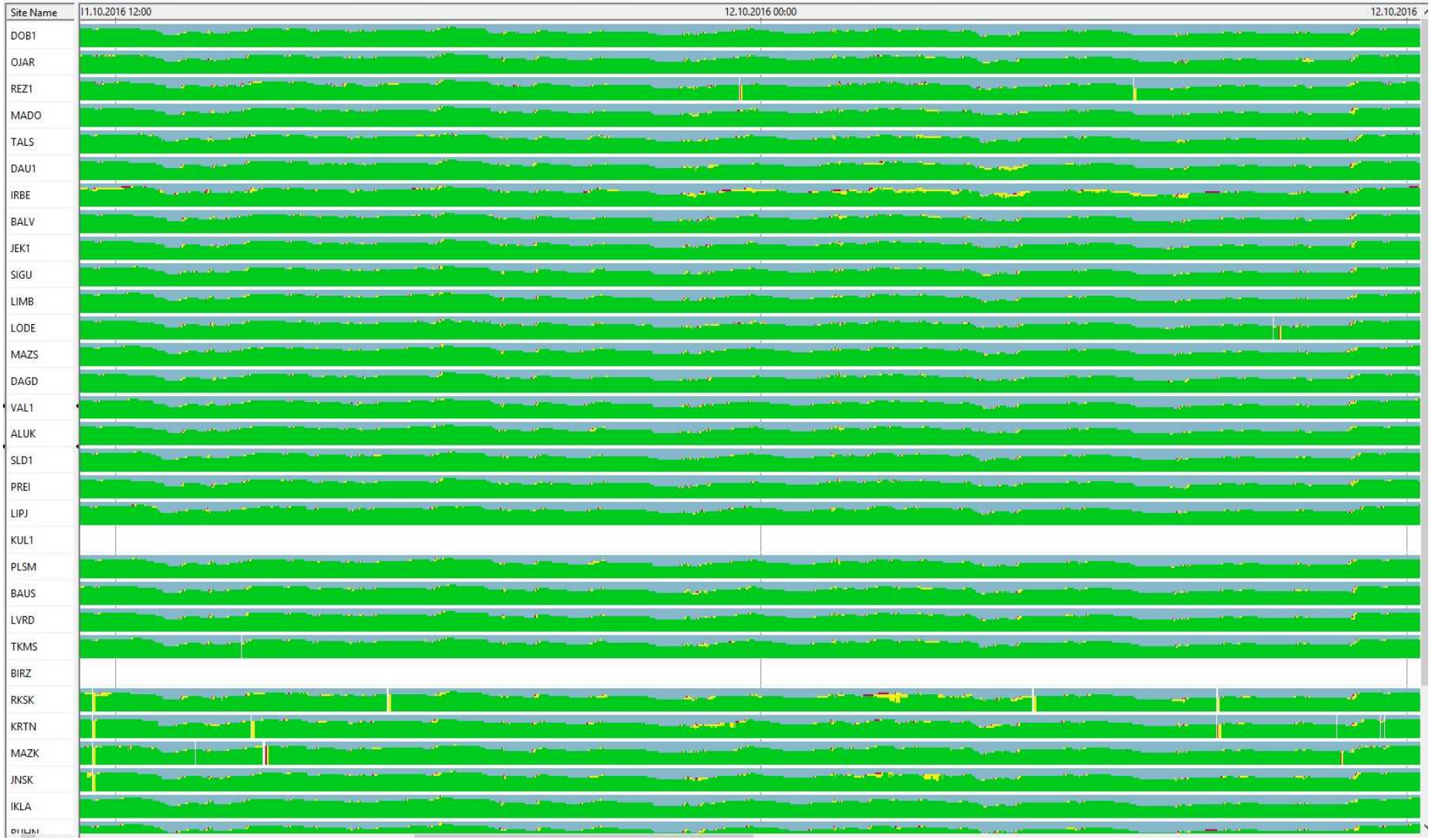


Calculated VTEC October 12 and 13, 2016



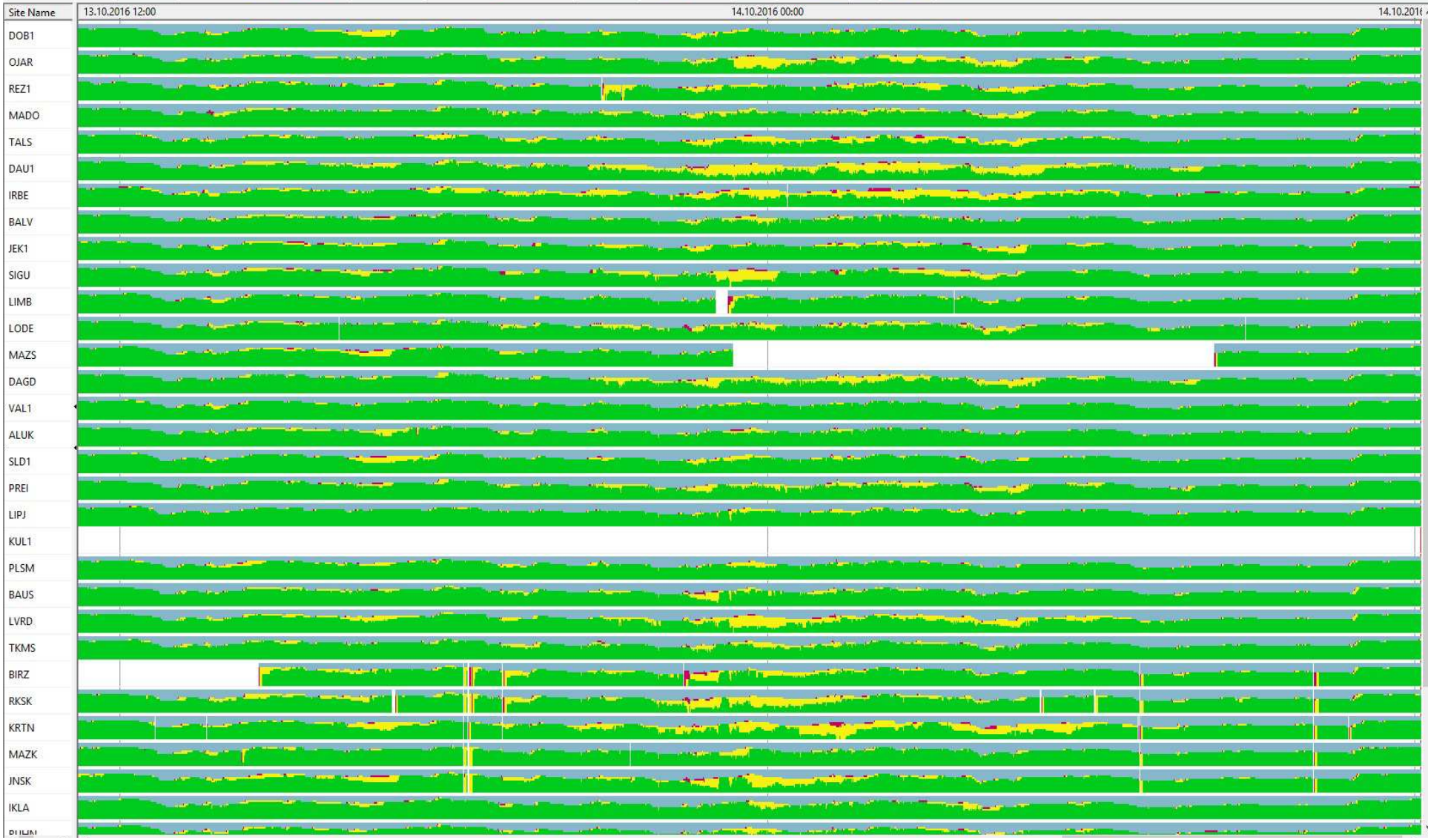
LatPos Network server

Fixed ambiguities October 12, 2016



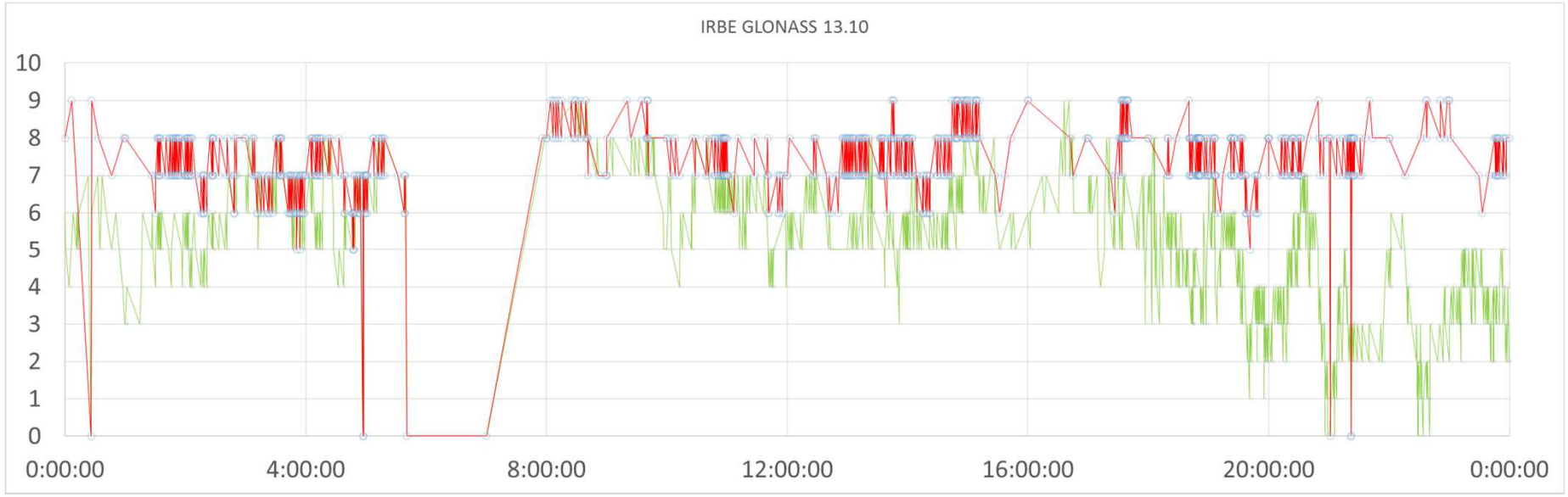
LatPos Network server

Fixed ambiguities October 13-14, 2016



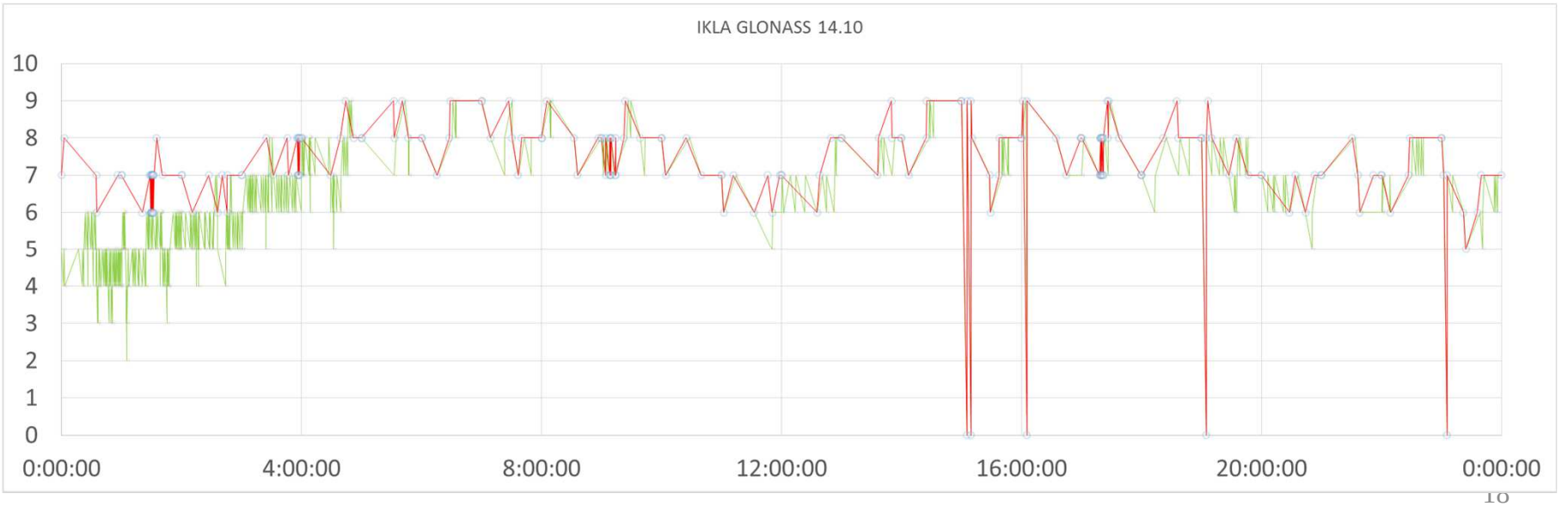
LatPos Network server **Tracked satellites and Fixed satellites**

Station IRBE (13.10)



LatPos Network server **Tracked satellites and Fixed satellites**

Station IKLA (14.10.)



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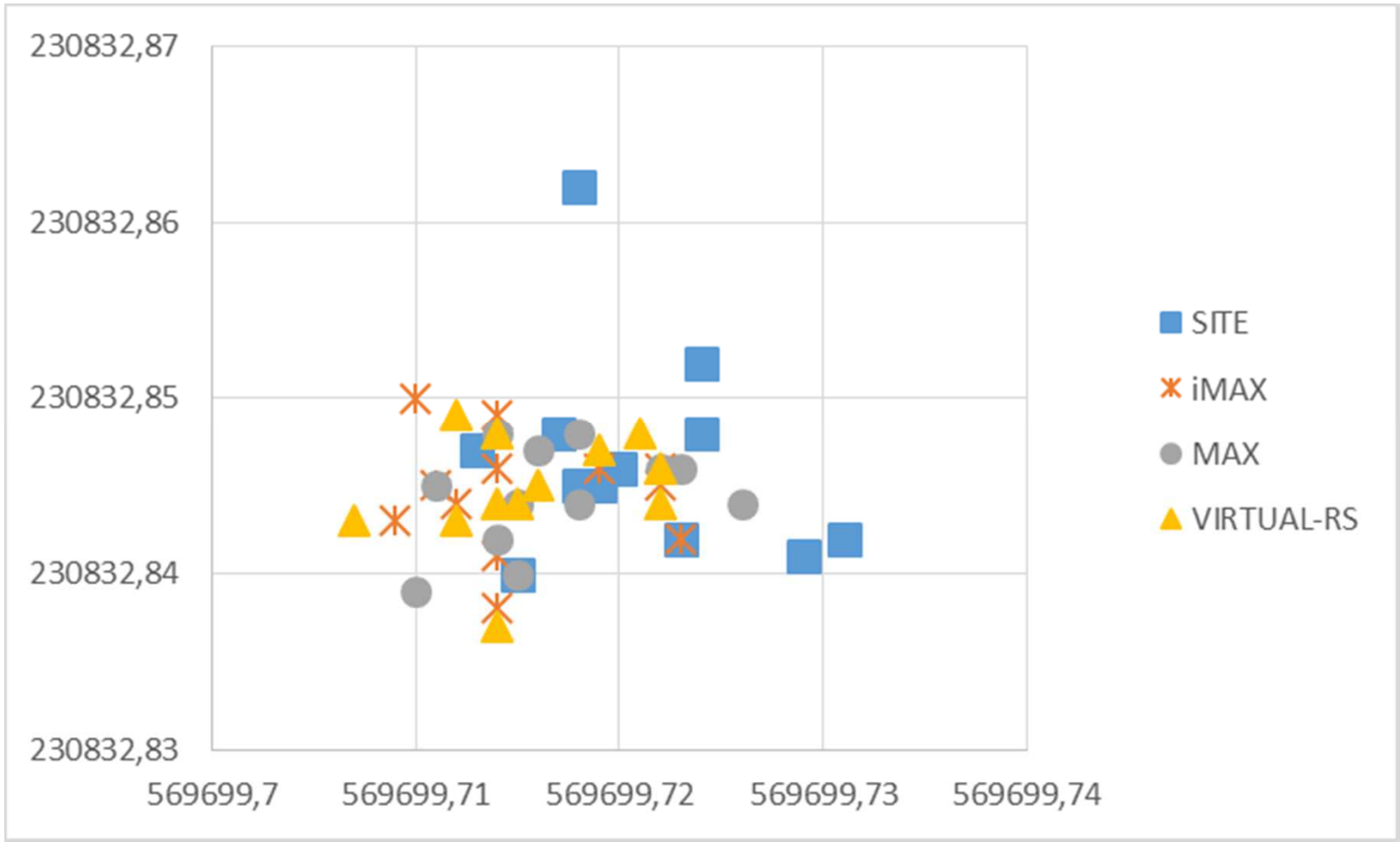
FIX results on point ”Gricgale”

average time-to-FIX: 18 sec (12 sessions)



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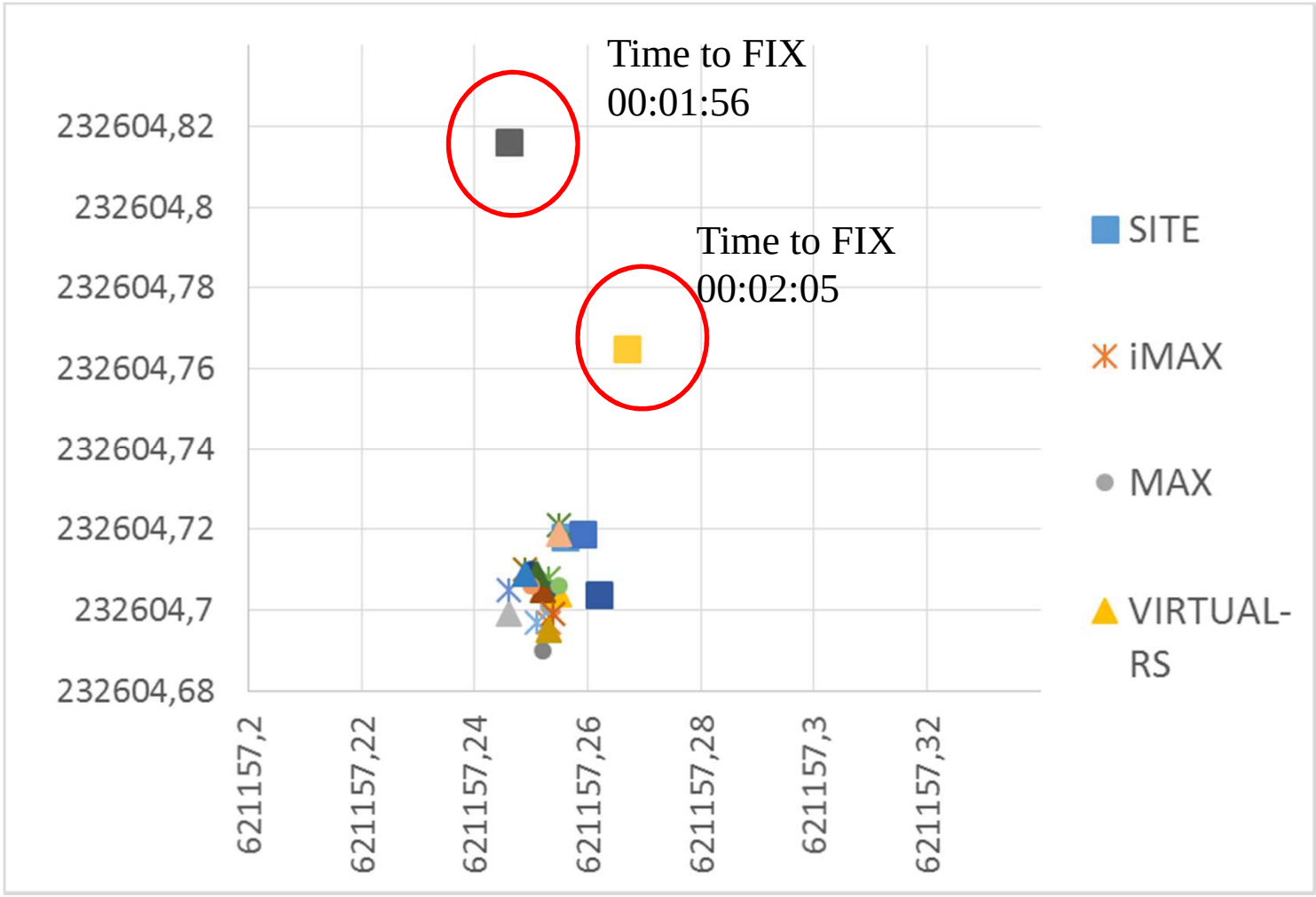
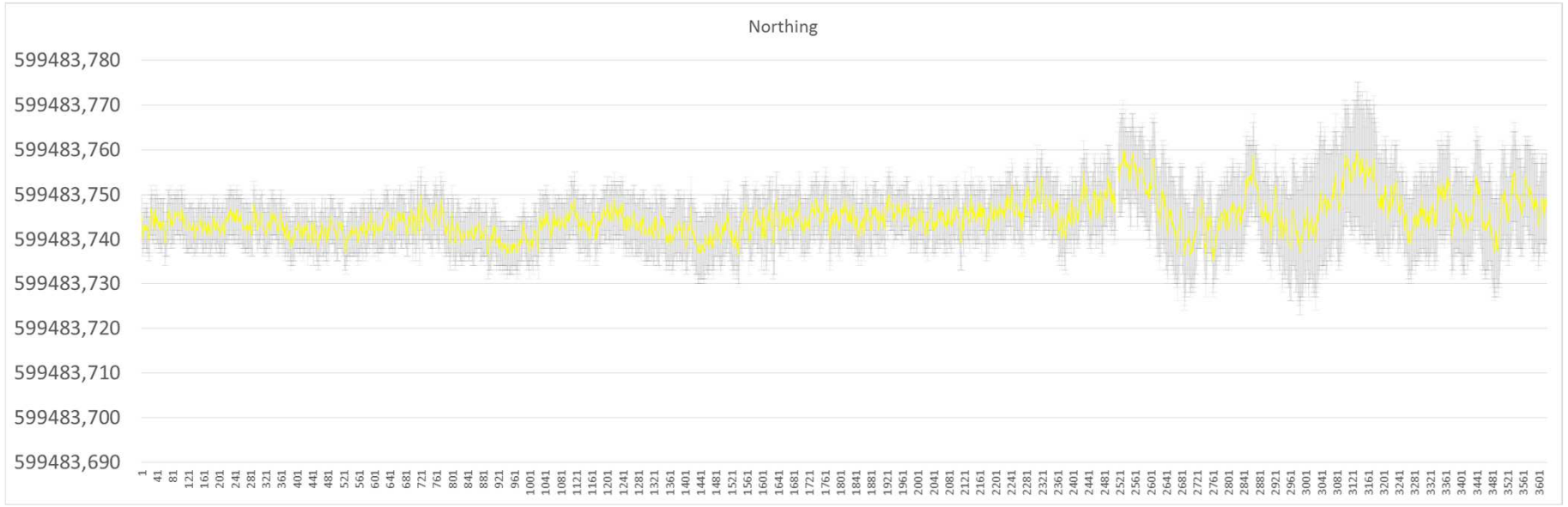
FIX results on point ”Slāte”

average time-to-FIX: 42 sec (7 sessions)



RTK Stability ”Vižuļi” (MAX solution)



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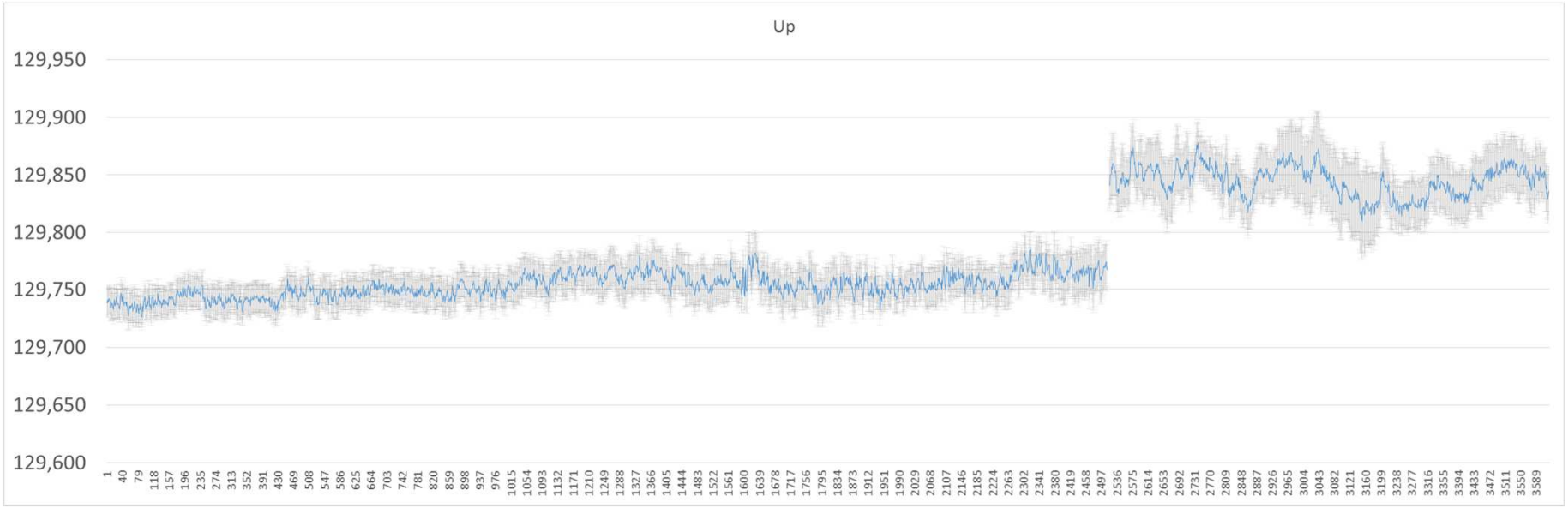
RTK Stability ’’Vižuļi’’ (MAX)

Up component



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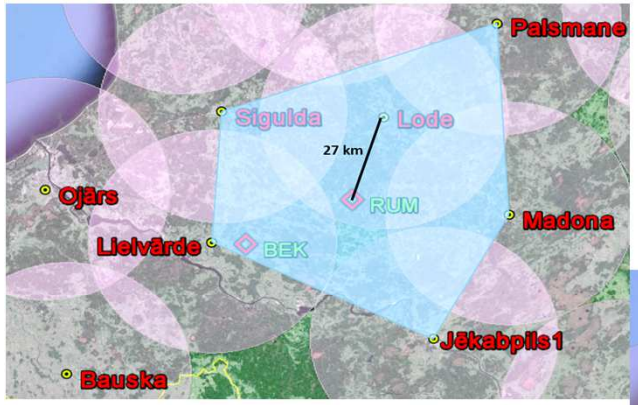
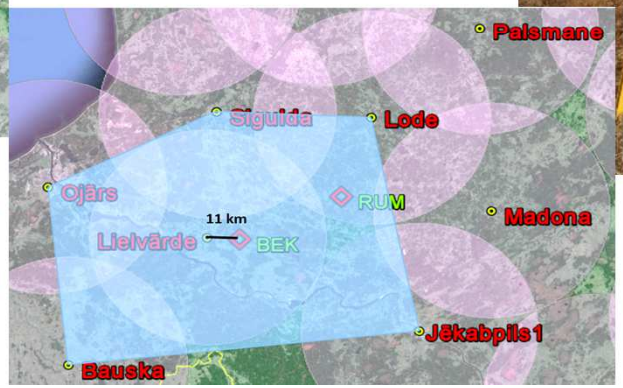
Research on RTK solutions

Method:

- 3 GNSS receivers simultaneously(2 Leica, 1 Trimble)
- 2 different places for observations(baseline lenghts)
- 5 observation sessions 40 min each
- 1 sec rate (2400 measurements per session)
- Different elevation cut-off angle setting





Research method

- 3 GNSS receivers (2 Leica, 1 Trimble)
- 5 observation sessions 40 min each
- Different elevation cut-off angle setting

S. No.	Rover receiver		
	Leica Viva*1	Leica Viva*2	Trimble R8
1.	SITE(0)	SITE(0)	SITE(10)
2.	SITE(10)	SITE(0)	NETW-iMAX(10)
3.	NETW-MAX(10)	NETW-iMAX(10)	VRS(10)
4.	VRS(10)	SITE(15)	SITE(15)
5.	VRS(0)	NETW-MAX(0)	VRS(10)

*SITE – Single site correction from nearest base station
NETW-MAX – MAC concept network RTK correction
NETW-iMAX – Individualized MAX concept network RTK correction
VRS – Virtual Reference Station network RTK correction
*(0,10 or 15) – elevation cut-off angle

Results

Leica Viva*1

S.No.		Location - RUM N	E	H	Location - BEK N	E	H
1.	σ	4,1	4,3	8,1	4,1	2,2	7,2
	A	33	28	52	20	12	42
2.	σ	6,2	3,3	15,0	3,4	2,2	6,0
	A	37	24	77	20	14	40
3.	σ	4,4	2,5	9,1	3,3	2,1	4,2
	A	25	16	49	19	12	27
4.	σ	2,4	3,7	6,7	3,0	2,1	5,1
	A	17	18	38	18	14	38
5.	σ	4,3	2,4	5,0	3,8	1,9	4,6
	A	27	15	32	24	14	25

Leica Viva*2

S.No.		Location – RUM N	E	H	Location - BEK N	E	H
1.	σ	4,9	3,7	9,4	4,1	3,2	6,9
	A	30	25	55	24	14	43
2.	σ	5,7	4,3	11,6	3,5	2,5	6,1
	A	39	26	73	22	13	37
3.	σ	3,8	2,4	6,1	2,2	1,6	5,2
	A	23	15	34	14	11	33
4.	σ	6,2	3,6	10,3	2,4	1,5	4,7
	A	34	26	65	15	9	31
5.	σ	3,7	2,4	5,3	2,6	1,8	4,4
	A	31	12	35	14	11	29

Trimble R8

S.No.		Location - RUM N	E	H	Location - BEK N	E	H
1.	σ	6,9	3,9	10,7	8,9	3,9	19,2
	A	43	24	76	46	27	97
2.	σ	9,6	4,7	9,1	6,3	4,3	14,0
	A	58	29	55	56	50	97
3.	σ	3,7	3,8	7,7	8,0	3,4	11,2
	A	24	24	50	48	20	64
4.	σ	7,7	3,7	10,8	4,9	3,0	11,5
	A	42	23	68	36	18	72
5.	σ	6,7	3,5	10,8	4,1	2,7	8,7
	A	47	21	64	32	16	54

All values in table are given in millimeters

Similar performance;
Dependency of baseline lenght

S. No.	Rover receiver		
	Leica Viva*1	Leica Viva*2	Trimble R8
1.	SITE(0)	SITE(0)	SITE(10)
2.	SITE(10)	SITE(0)	NETW-iMAX(10)
3.	NETW-MAX(10)	NETW-iMAX(10)	VRS(10)
4.	VRS(10)	SITE(15)	SITE(15)
5.	VRS(0)	NETW-MAX(0)	VRS(10)

Results

Leica Viva*1

S.No.		Location - RUM N	E	H	Location - BEK N	E	H
1.	σ	4,1	4,3	8,1	4,1	2,2	7,2
	A	33	28	52	20	12	42
2.	σ	6,2	3,3	15,0	3,4	2,2	6,0
	A	37	24	77	20	14	40
3.	σ	4,4	2,5	9,1	3,3	2,1	4,2
	A	25	16	49	19	12	27
4.	σ	2,4	3,7	6,7	3,0	2,1	5,1
	A	17	18	38	18	14	38
5.	σ	4,3	2,4	5,0	3,8	1,9	4,6
	A	27	15	32	24	14	25

Leica Viva*2

S.No.		Location – RUM N	E	H	Location - BEK N	E	H
1.	σ	4,9	3,7	9,4	4,1	3,2	6,9
	A	30	25	55	24	14	43
2.	σ	5,7	4,3	11,6	3,5	2,5	6,1
	A	39	26	73	22	13	37
3.	σ	3,8	2,4	6,1	2,2	1,6	5,2
	A	23	15	34	14	11	33
4.	σ	6,2	3,6	10,3	2,4	1,5	4,7
	A	34	26	65	15	9	31
5.	σ	3,7	2,4	5,3	2,6	1,8	4,4
	A	31	12	35	14	11	29

Trimble R8

S.No.		Location - RUM N	E	H	Location - BEK N	E	H
1.	σ	6,9	3,9	10,7	8,9	3,9	19,2
	A	43	24	76	46	27	97
2.	σ	9,6	4,7	9,1	6,3	4,3	14,0
	A	58	29	55	56	50	97
3.	σ	3,7	3,8	7,7	8,0	3,4	11,2
	A	24	24	50	48	20	64
4.	σ	7,7	3,7	10,8	4,9	3,0	11,5
	A	42	23	68	36	18	72
5.	σ	6,7	3,5	10,8	4,1	2,7	8,7
	A	47	21	64	32	16	54

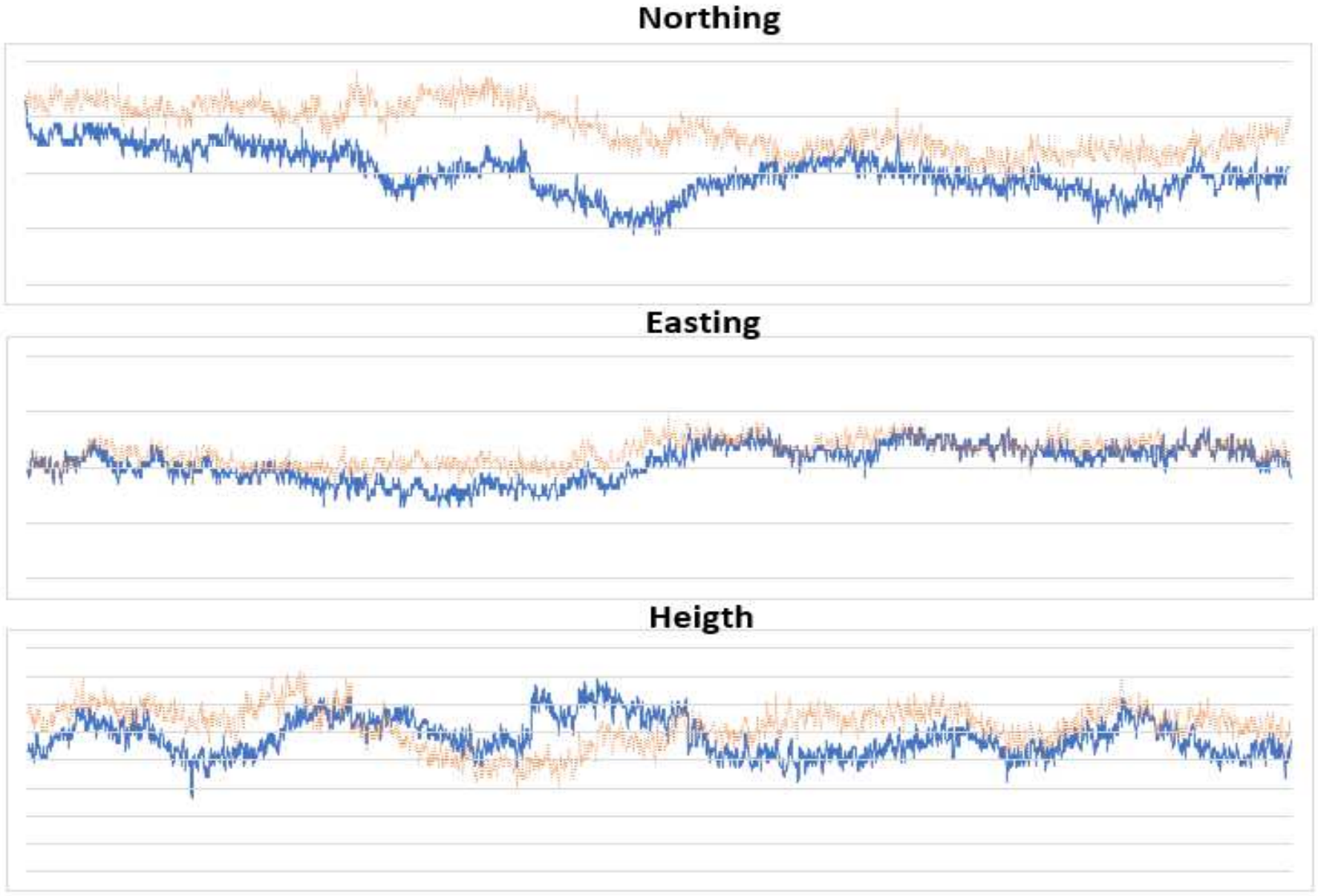
All values in table are given in millimeters

Results of Trimble receiver in all sessions worse. Due to old firmware?

S. No.	Rover receiver		
	Leica Viva*1	Leica Viva*2	Trimble R8
1.	SITE(0)	SITE(0)	SITE(10)
2.	SITE(10)	SITE(0)	NETW-iMAX(10)
3.	NETW-MAX(10)	NETW-iMAX(10)	VRS(10)
4.	VRS(10)	SITE(15)	SITE(15)
5.	VRS(0)	NETW-MAX(0)	VRS(10)

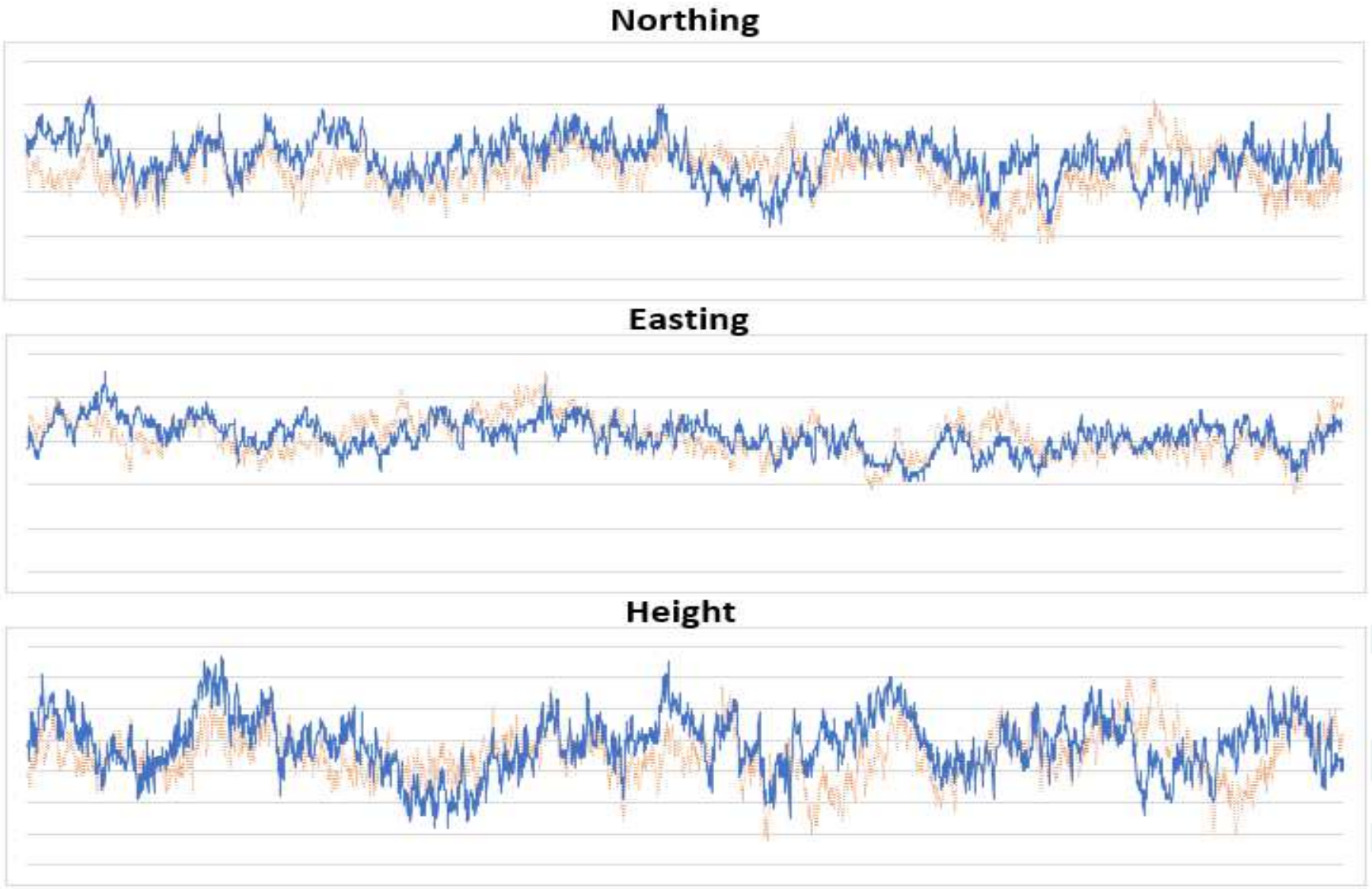
Results

- Location BEK, Session 1.
- Leica receivers



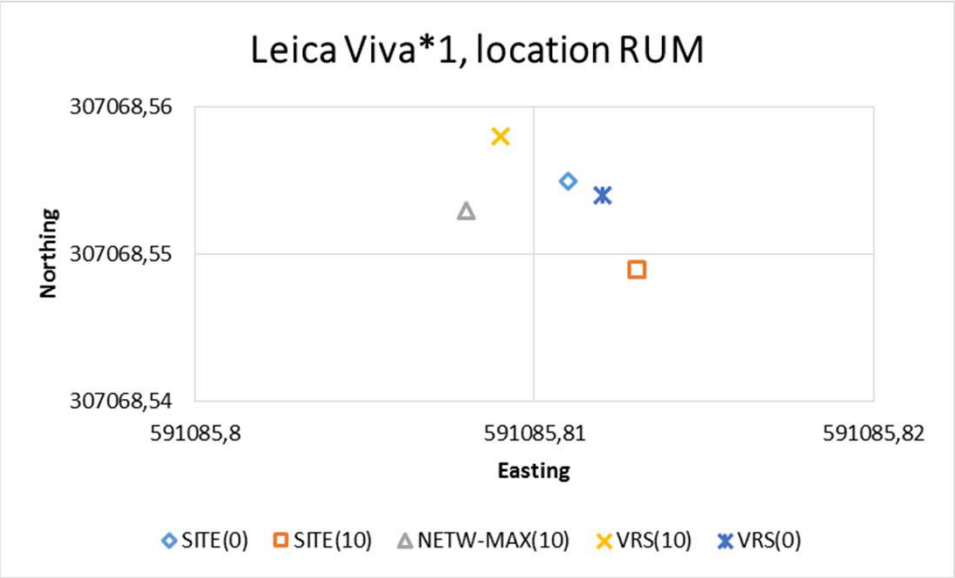
Results

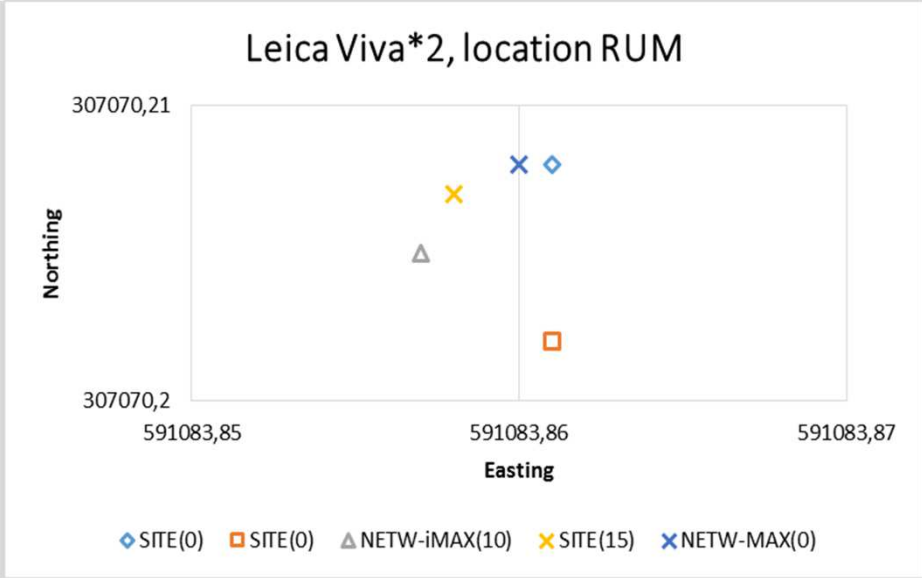
- Location RUM, Session 1.
- Leica receivers

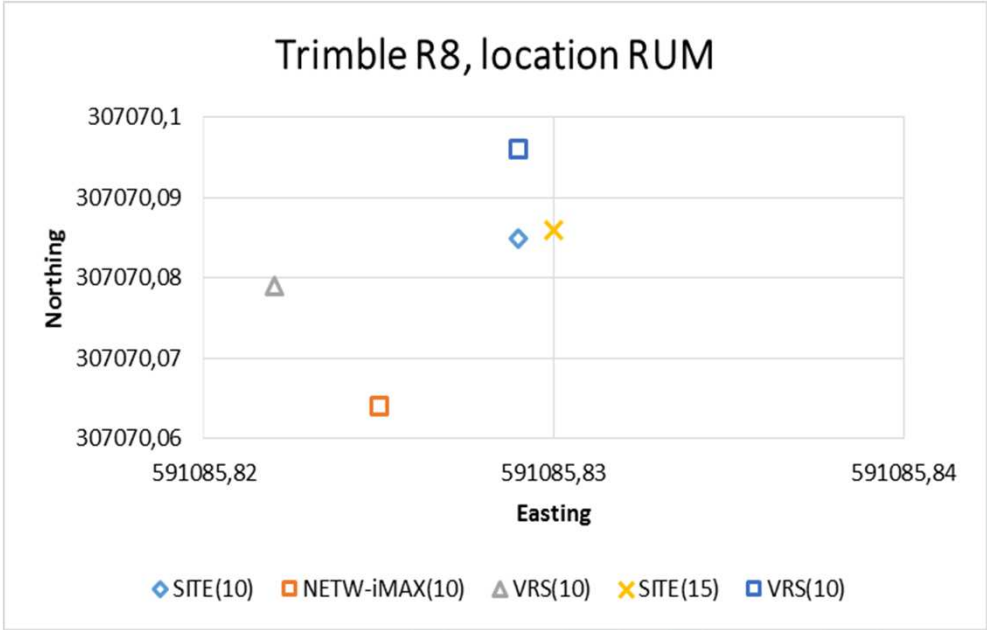


Results

- Mean values of RTK solutions

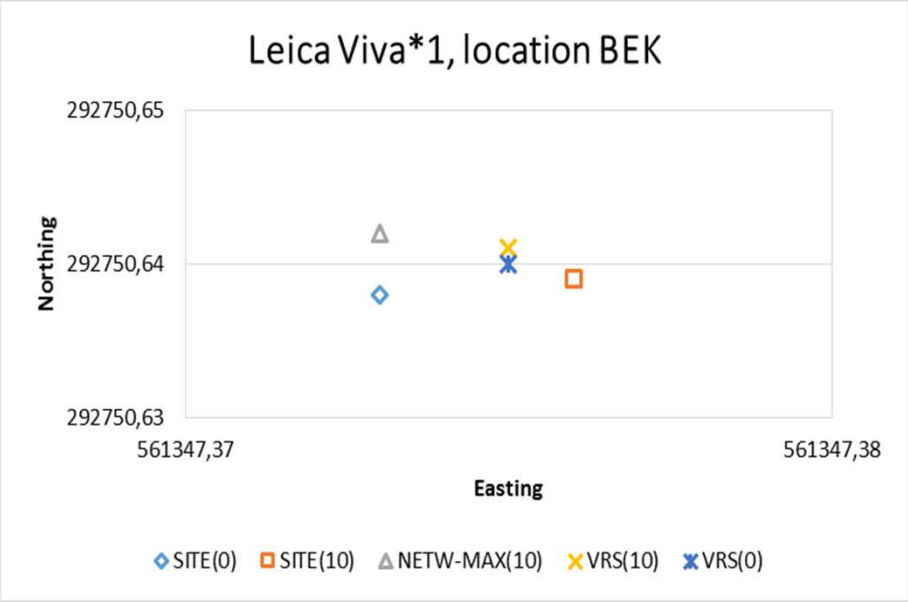


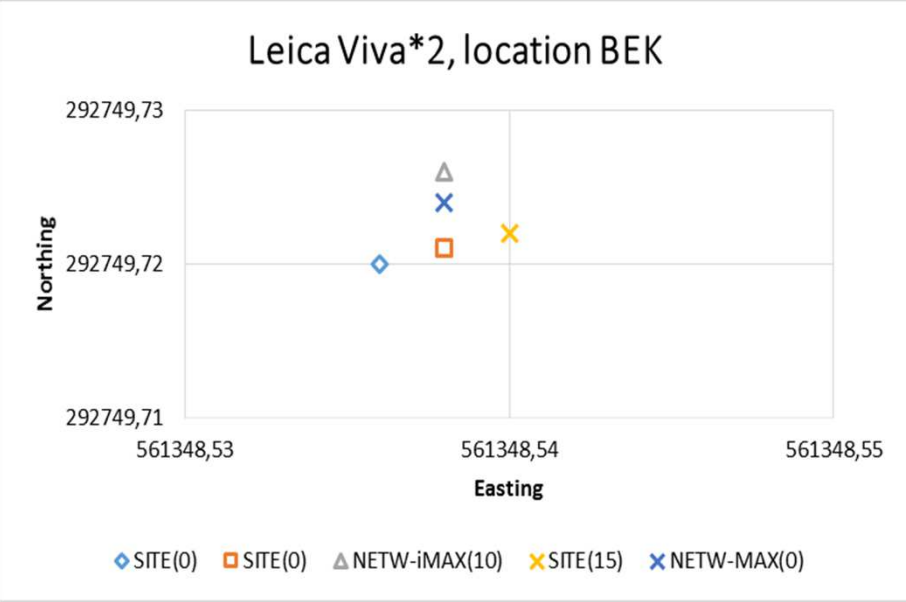


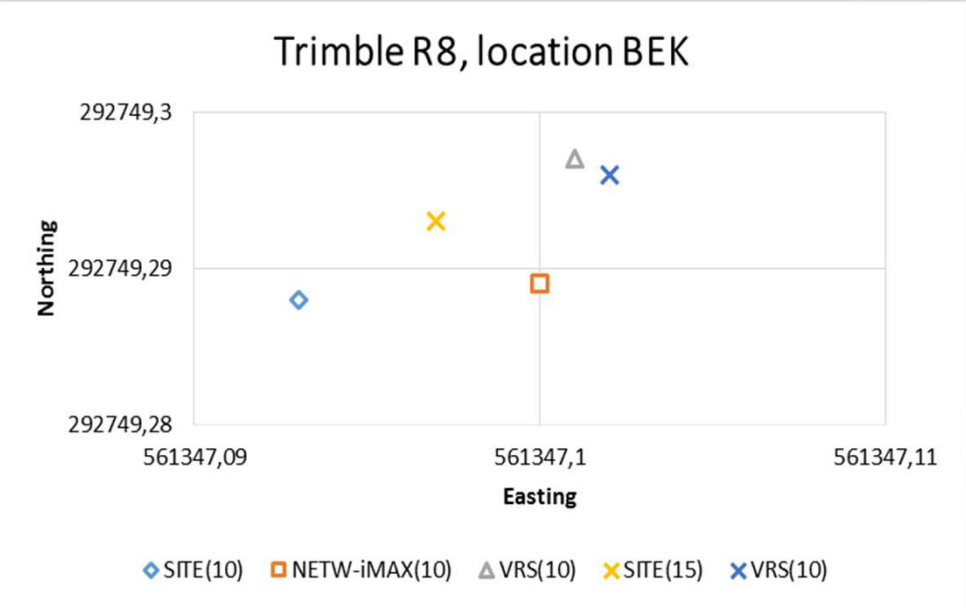


Results

- Mean values of RTK solutions

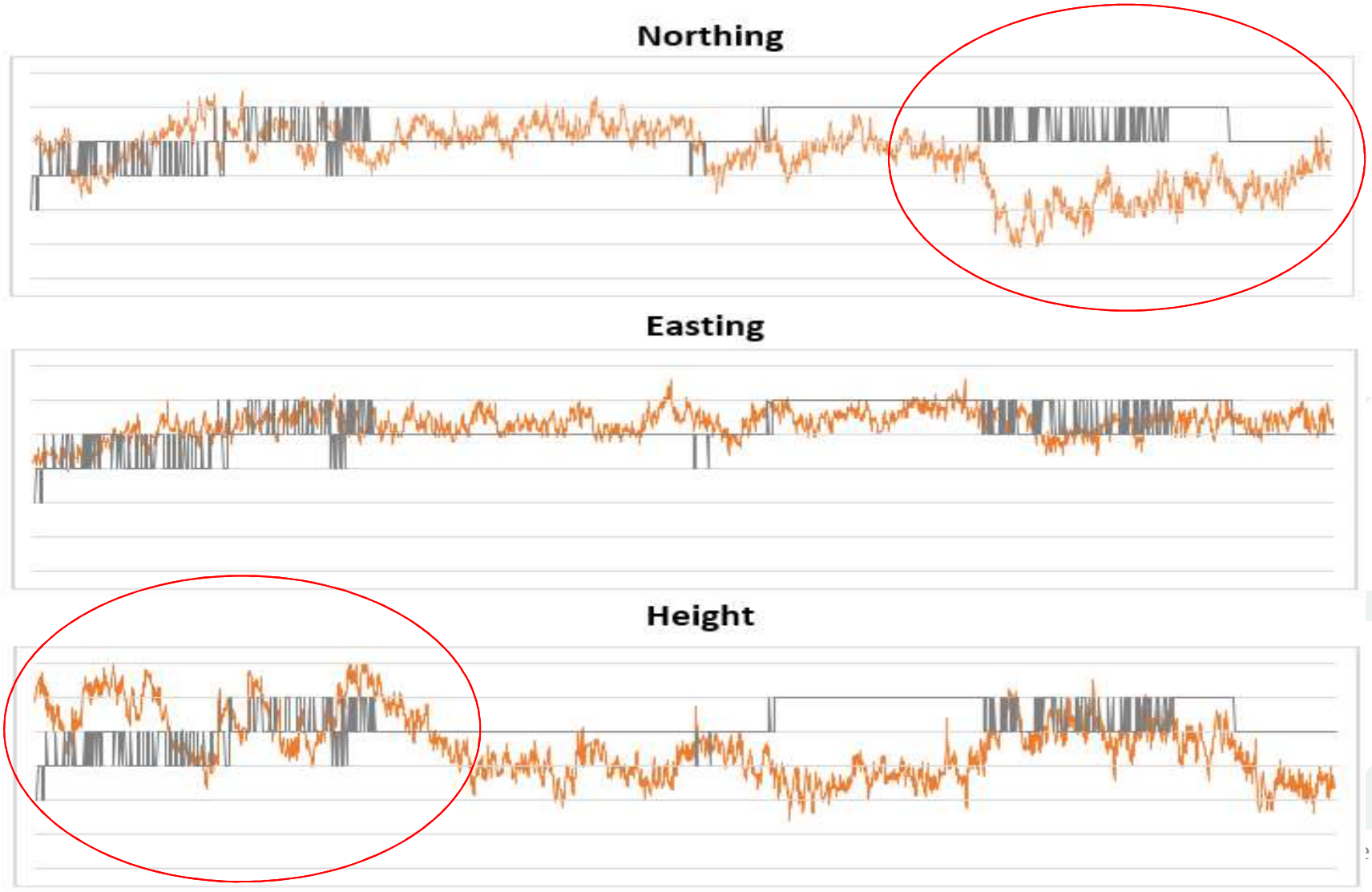






Results

- Coordinate shifts due to satellite changes
- Location BEK, Session 1 (Trimble R8, SITE(0))



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Conclusions:

1. LatPos System	Powerfull infrastructure for economics and also for scientific studies;
2. Yearly LatPos test procedure	Must continue – process could be automated;
3. Performance of LatPos during high ionospheric activity;	More research has to be done and come-up with possible improvements;
4. RTK Applications	Used in many sectors of economy, number of users is expected to increase;
5. Performance of LatPos RTK services	Horizontal accuracy meets requirements, Vertical accuracy could be improved.

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Thank You for attention!

QUESTIONS?

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