XIII International forum
«INTEREXPO GEO-Siberia 2017»

PERSPECTIVES OF FREE GNSS POST-PROCESSING SOFTWARE USING

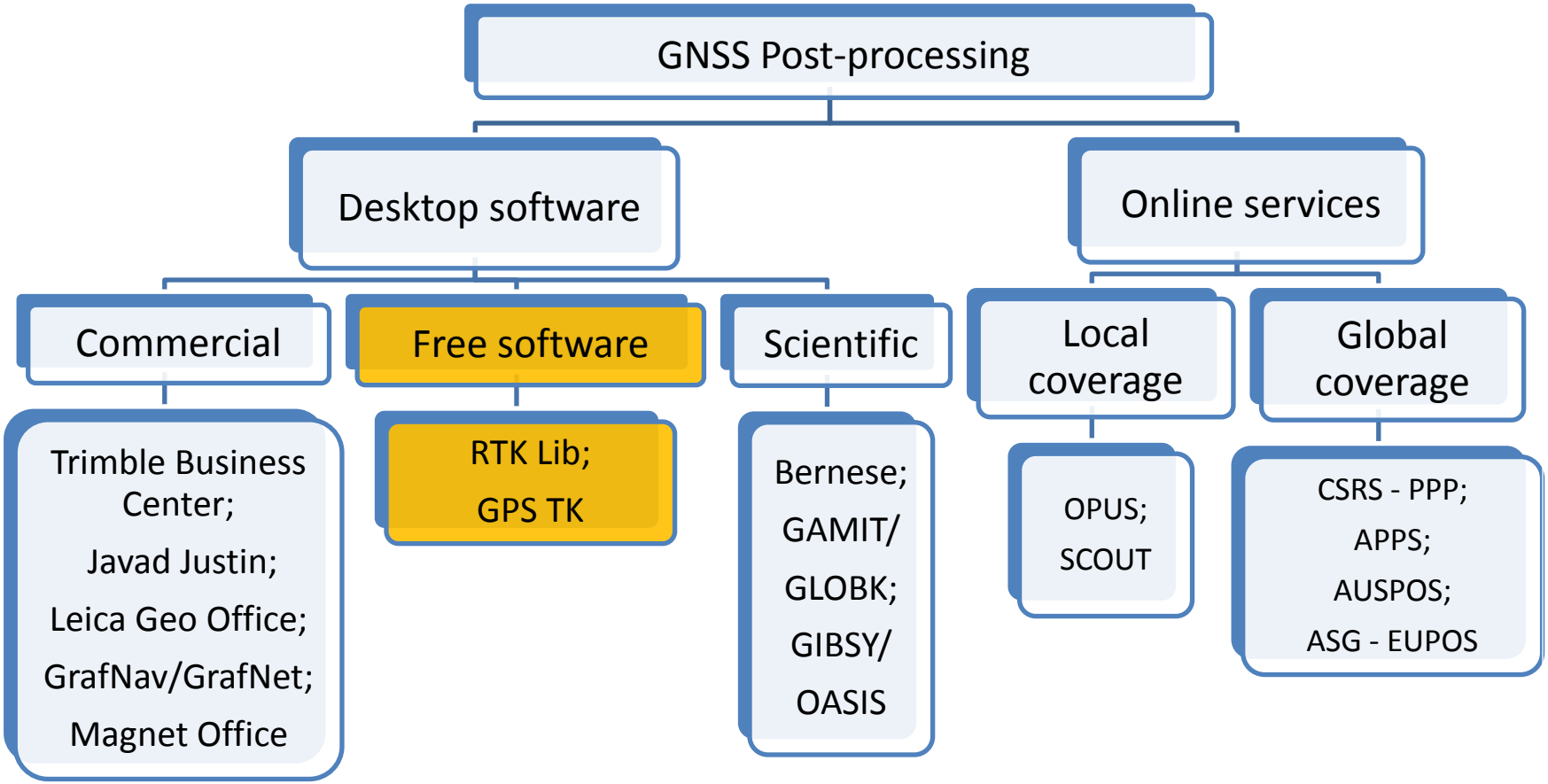
S. Shevchuk, L. Lipatnikov, K. Malyutina
(Siberian State University of Geosystems and Technologies)

Research objectives

Today **Free and open software** for GNSS Post-Processing is increasingly used, and improved for a wide range of purposes.

Free and open software using can make geodetic measurements noticeably more financially effective (especially in the case of severe budget constraints). Also this kind of software can be used when there is a failure in commercial software.

Means of GNSS Post-processing



Free GNSS Post-processing software features

Free GNSS Post-processing software distribution is based on freeware licenses (often with open source code). This kind of software has more of commercial GNSS software features but often with some limitations.

Such programs are financed by grants or third-party investments.

Desktop Software and Online Services were compared

- Free software:
  - RTKLib.
- Commercial:
  - WayPoint GrafNav;
  - Magnet Tools;
  - Justin.
- Free online services:
  - CSRS-PPP.

Canada

Desktop Software and Online Services were compared

Specifications		Desktop software				Online services
		Waypoint GrafNav	Magnet Office Tools	Justin	**RTKLib**	CSRS-PPP
Kind		Commercial software			Free software	Free global (PPP) online service
Developer		NovAtel, Inc	Topcon Position Systems, Inc	Javad GNSS	T. Tacasu	IGS, Government Canada
Version used		8.2	2.5	2.121	2.4.2	1.05
Year of version used release		2009	2013	2015	2013	2014
User manual		+	+	+	+	+
Post Processing L1/L2		+	+	+	+	+
Kinematic mode		+	+	+	+	+
GLONASS support		+	+	+	+	Not specified
Glonass-only processing possibility		-	+	+	-	-
Baseline length limitation, km	For fixed solution	30	Not specified	Not specified	Not specified	-
	Maximum	1500	Not specified	Not specified	Not specified	-
Support of RINEX 2.11 (or higher)		+	+	+	+	+
Geoid Model support		+	+	+	+	CGVD only
Possibility of net solution		+	+	+	-	-
Precise Point Positioning support		+	-	-	+	+
Default tropospheric model		Saastamoinen	Goad and Goodman	Justin	Saastamoinen	Hopfield + Davis (GPT)

Static-mode experiment

The experiment was conducted in June 2016.
The measurements were made at the Geodetic Polygon of Siberian Research institute of Geology, Geophysics and mineral resources.
The duration of the measurements was: 10 min, 30 min and 60 min.
Data record period was set at 1 second.

Leica Viva GS10 GNSS receiver with AS-10 antenna was used

Specifications		Values
Common		
Receiver type		Dual-frequency
Country manufacturer		Switzerland
GNSS included (with options)		GPS, GLONASS
Static-mode accuracy		
Rapid static	plane, mm	5 mm +0,5 ppm
	height, mm	10 mm +0,5 ppm
Satellite number		
Channels	All	120
	GPS	16 L1, 16 L2, 16 L5
	GLONASS	14 L1, 14 L2
	SBAS	4

Measurement sites

Spartak

064

Morskoy

4976

Site (point) name	Site terrain conditions	Baseline length, km	A priori instructive errors, m	
			Plane	Height
Potaninsky	Open	*Base station*		
Spartak	Open	12.7	0.01	0.02
064	Forest border	20.6	0.02	0.02
Morskoy	Leafy forest	17.8	0.01	0.02
4976	Pine forest	24.5	0.02	0.02

Potaninsky

Processing options

- Elevation mask 10°
- Measuring data was imported from RINEX 2.11 format;
- Used default troposphere models (for relative Post-processing) and computed model (for PPP);
- Used WGS-84 datum.

Software compared

Relative method

- GrafNav
- Magnet OT
- Justin
- RTKLib

Precise Point Positioning

- GrafNav
- CSRS-PPP
- RTKLib

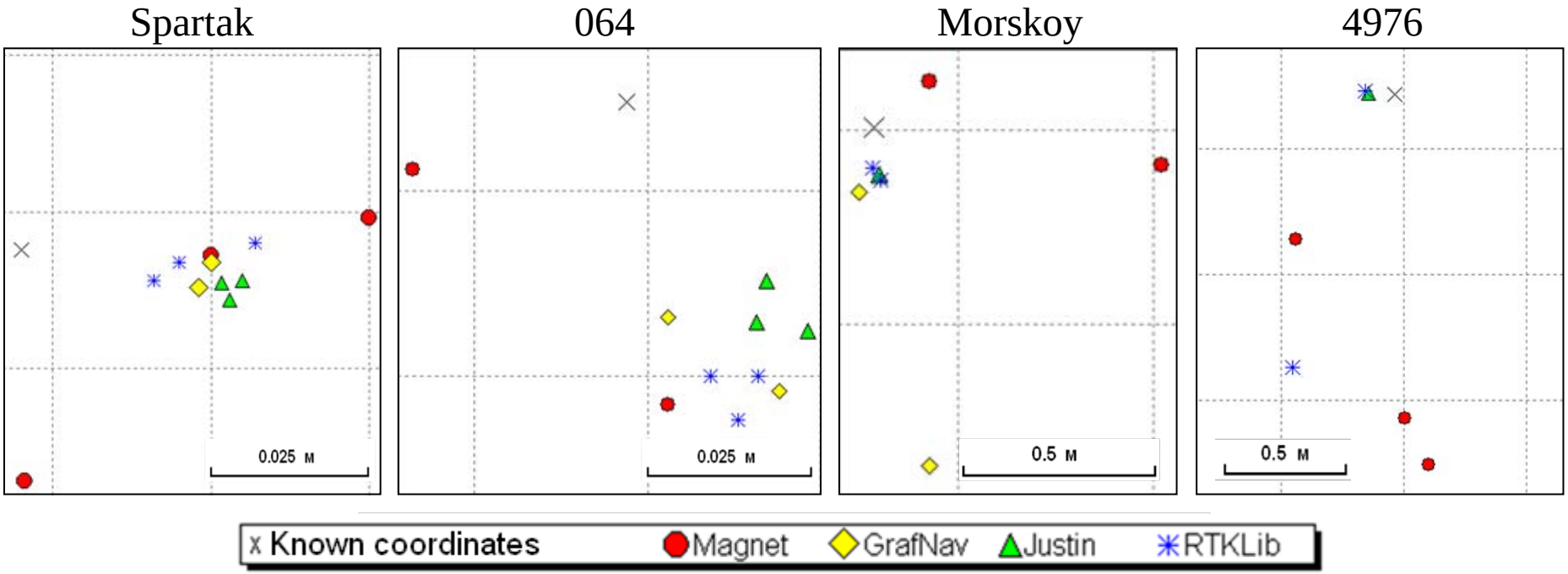
Static-mode experiment results

Relative method

Site name, kind of terrain	Duration, min	Absolute residuals, m							
		GrafNav		Magnet OT		Justin		**RTKLib**	
		plane	height	plane	height	plane	height	plane	height
Spartak (open site)	10	0.03	0.02	0.08	0.07	0.03	0.77	0.03	0.11
	30	0.03	0.01	0.06	0.06	0.04	0.06	0.04	0.10
	60	0.03	0.01	0.03	0.00	0.03	0.09	0.02	0.08
064 (forest border)	10	0.04	0.02	0.04	0.00	0.04	0.12	0.04	0.10
	30	0.03	0.06	0.19	0.16	0.04	0.13	0.04	0.08
	60	0.03	0.06	0.03	0.01	0.03	0.10	0.05	0.05
Morskoy (leafy forest)	10	0.88	0.03	0.74	0.66	**1.20**	**1.74**	0.14	0.09
	30	0.17	0.10	0.19	0.16	0.12	0.14	0.10	0.05
4976 (pine forest)	10	-	-	0.71	**1.50**	0.11	0.04	0.12	0.46
	30	**6.48**	**9.23**	**1.48**	**1.58**	-	-	**1.17**	**1.59**
	60	**23.72**	**43.94**	**1.29**	**2.36**	-	-	0.12	0.48

Static-mode experiment results

Relative method



Open horizon-site and forest border: solution differences were less than 2 cm (plane coordinates) and 4-5 cm (heights).

Forest conditions: RTKLib solutions were on the same accuracy level with commercial software or even better(!)

Static-mode experiment results

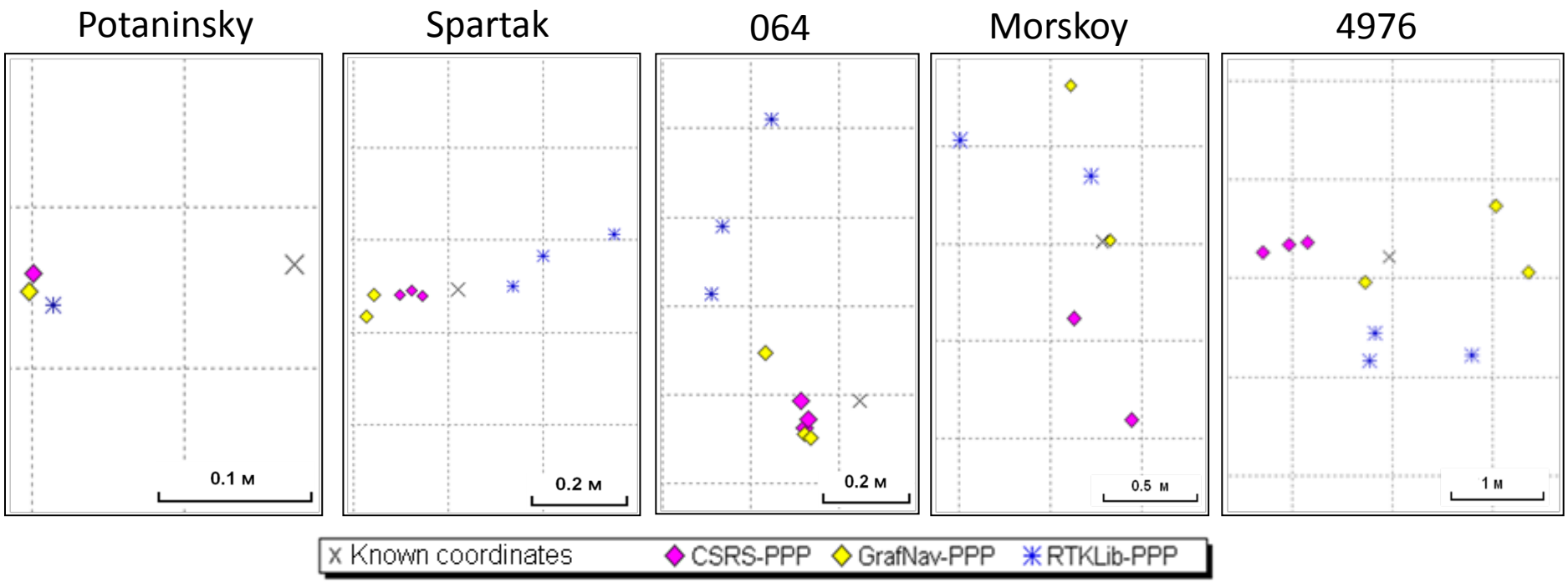
Precise Point Positioning

Site name, kind of terrain	Duration, min	Absolute residuals, m					
		GrafNav		CSRS-PPP		RTKLib	
		plane	height	plane	height	plane	height
Potaninsky (open site)	360	0.17	0.25	0.18	0.23	0.16	0.27
Spartak (open site)	10	0.20	0.12	0.08	0.13	0.35	0.25
	30	0.20	0.15	0.10	0.12	0.19	0.03
	60	0.18	0.11	0.12	0.15	0.12	0.10
064 (forest border)	10	0.15	0.05	0.14	0.09	0.67	0.94
	30	0.14	0.07	0.13	0.06	0.50	0.83
	60	0.14	0.04	0.12	0.05	0.41	0.31
Morskoy (leafy forest)	10	0.04	0.11	0.93	**1.26**	0.93	**3.14**
	30	0.82	0.02	0.42	0.65	0.35	0.79
4976 (pine forest)	10	**1.40**	**1.09**	**1.83**	**1.37**	**1.30**	**2.09**
	30	0.35	0.56	**1.26**	**1.68**	**1.07**	0.20
	60	**1.19**	0.84	**1.01**	**1.09**	0.79	**2.64**

*The duration of measurements in the experiment wasn't quite enough for PPP processing. Also the coordinates of the sites were known on 2004-2006 year epoch and changed. The experiment may be repeated with another initial data.

Static-mode experiment results

Precise Point Positioning



Coordinates and heights computed by RTKLib with using PPP method, have accuracy characteristics close to CSRS-PPP and GrafNav (0.1 -0.3 m in open sites and 1-2 m in leafy/pine forest). Exceptions were for short-term (10 min) measurements when RTKLib received coarser coordinates.

Kinematic-mode experiment

For the kinematic experiment the data measured at aerial geophysical works was used. The aerial electro-magnetic survey was made in June 2013 in Central Siberia, (Kuraginskyi region, Krasnoyarskyi Kray, Russia) by Aerogeophysical Survey, CSJC

Data record period was set at 0.2 second (5 Hz).

Javad Sigma G3T GNSS receiver with AirAnt antenna was used

Specifications		Values
Common		
Receiver Type		Dual-frequency
Country manufacturer		USA
GNSS included (with options)		GPS, GLONASS
Kinematic-mode accuracy		
Kinematic with initialization	plane, mm	10 mm + 1 ppm
	height, mm	15 mm + 1 ppm
Количество отслеживаемых спутников		
Channels	All	216
	GPS	All-in-view (все видимые)
	GLONASS	
	SBAS	

Kinematic-mode experiment

Measurement conditions. «Impulse-Aero» aero-geophysical complex

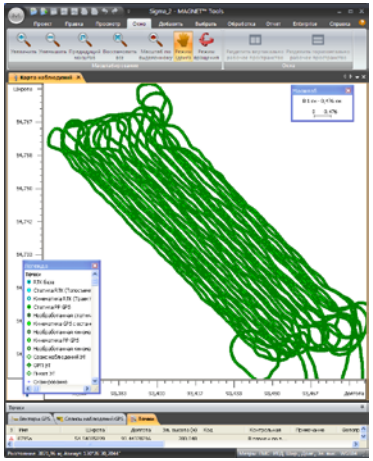
a) «Impulse A7» platform on the fly;
b) Platform ground mount;
c) GNSS-receiver and other measuring equipment inside the capsule of the platform;
d) Antenna AirAnt of Javad Sigma G3T receiver on the top of the capsule;
e) Experimental devices mounted on the platform.

Kinematic-mode experiment results

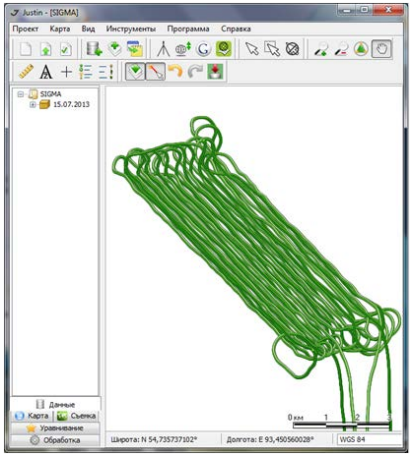
Kinematic track processed by different software

Relative method

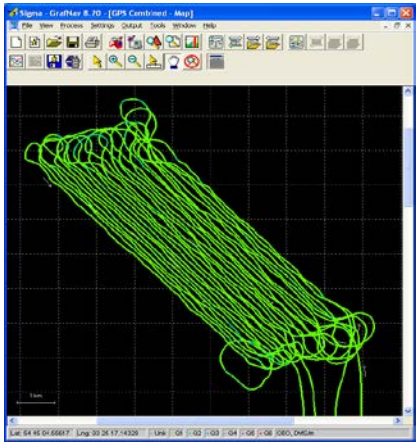
Magnet OT



Justin



GrafNav

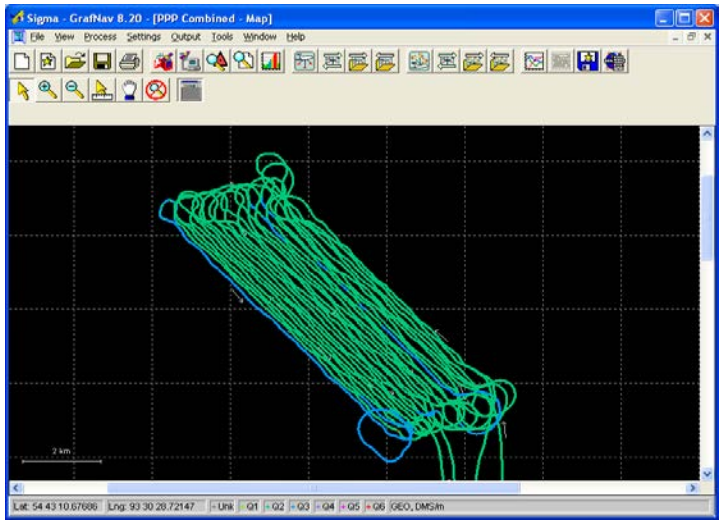


RTKLib

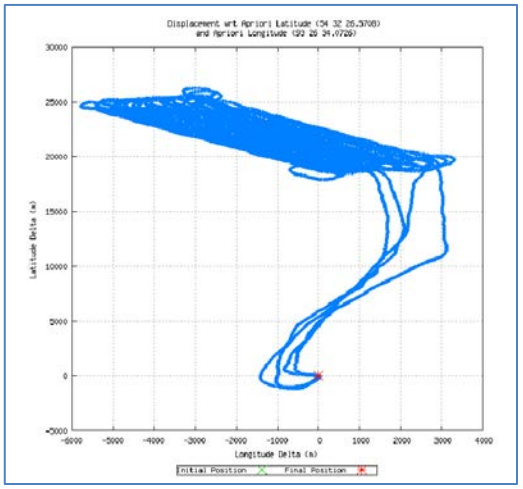
Kinematic-mode experiment results

Kinematic track processed by different software

GrafNav

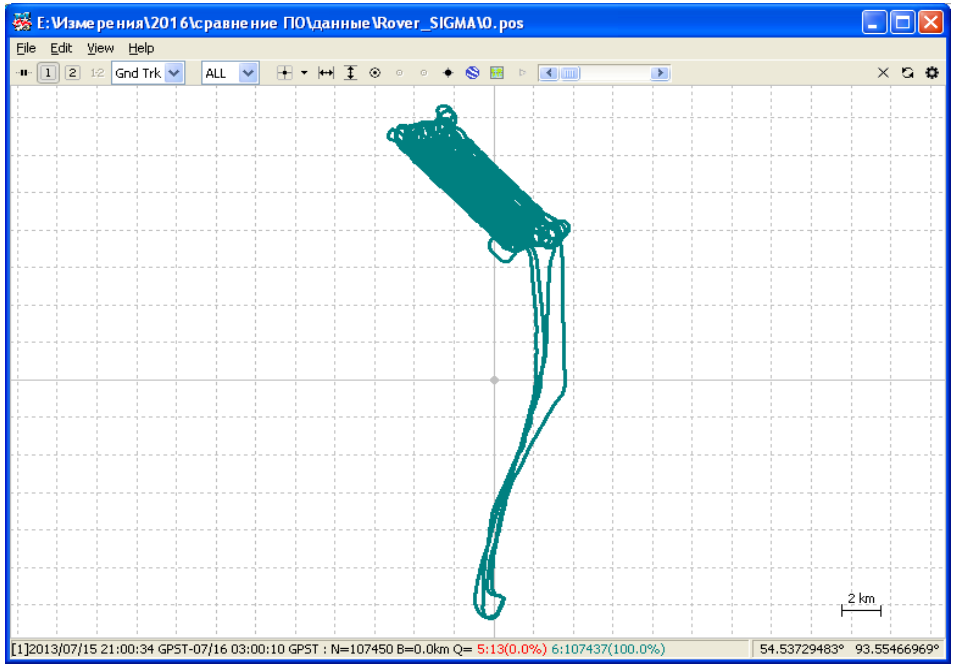


CSRS-PPP



Precise Point Position

RTKLib



Kinematic-mode experiment results

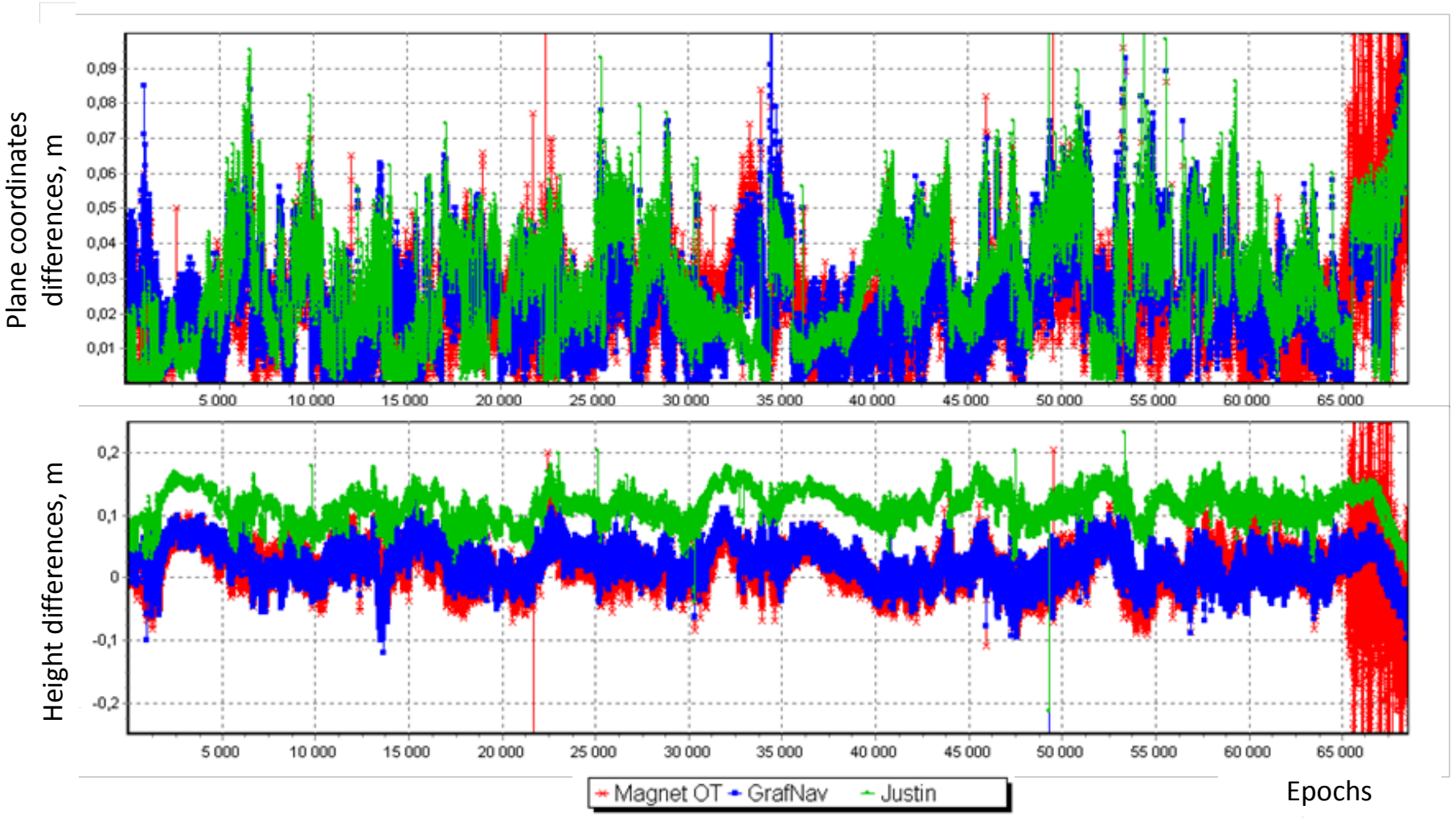
Processing reports analysis

Specifications		Relative method				PPP		
		GrafNav	Magnet OT	Justin	RTKLib	GrafNav	CSRS-PPP	RTKLib
Processing time		10	> 60	15	45	15	~25	10
Ambiguity resolution quality, %	Fixed	**94.4**	**65.5**	**100.0**	**68.9**	**0**	**100.0**	**100.0**
	Float	5.6	34.45	-	31.1	100.0		
	Code/DGPS	-	0.05	-	-	-	-	-
	No solution	-	-	-	-	-	-	-
Residuals (RMS or Standard Deviations): plane, m		0.02	0.04	0.02	0.04	0.11	0.02	0.3
Residuals (RMS or Standard Deviations): height, m		0.04	0.06	0.02	0.08	0.16	0.05	0.4

Notice: 68500 epochs were analyzed (3 hours 50 minutes) that was pure fly time. Full measuring session duration was 6 hours (including ground static initialization and refueling).

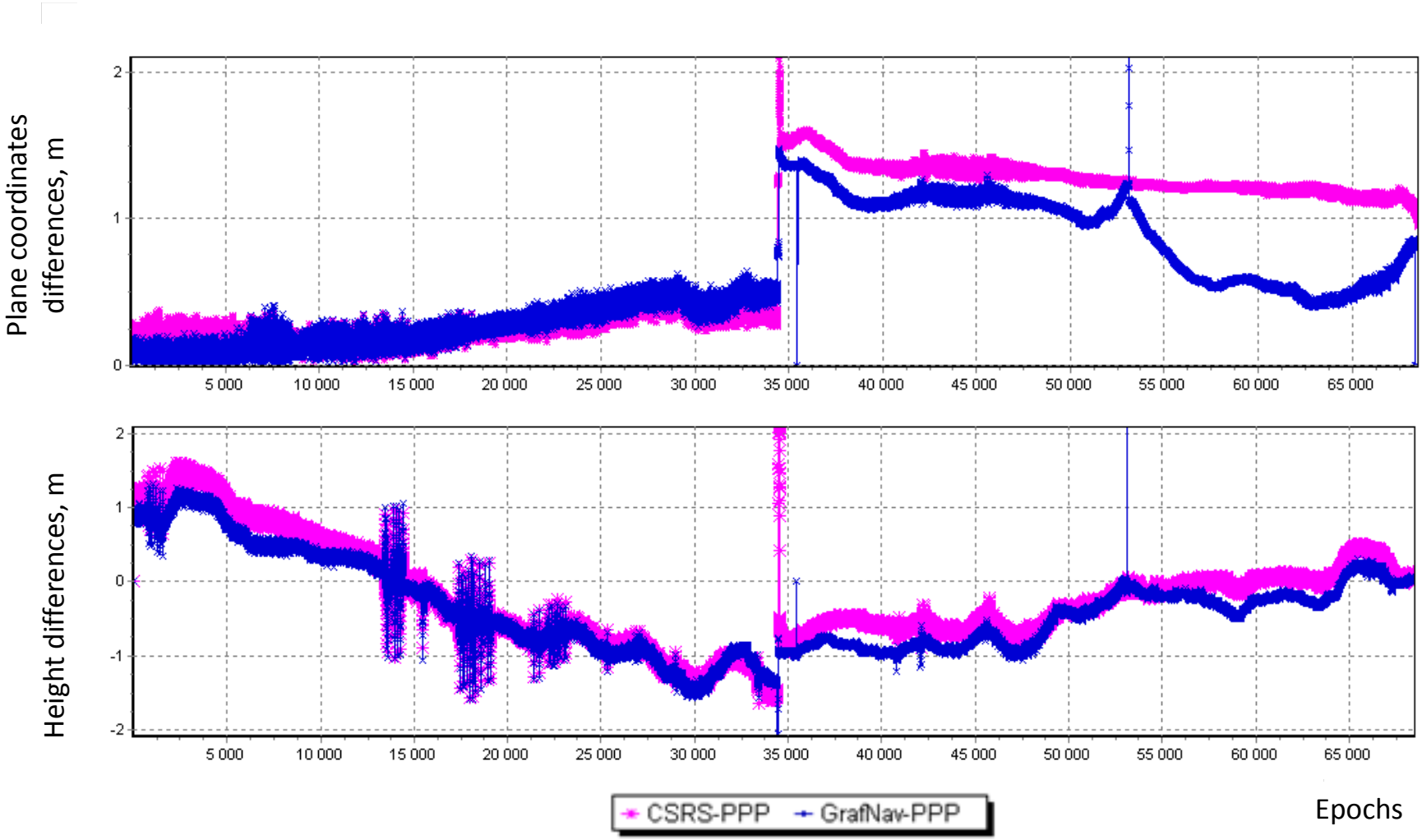
Kinematic-mode experiment results

RTKLib with the other software comparison: relative method



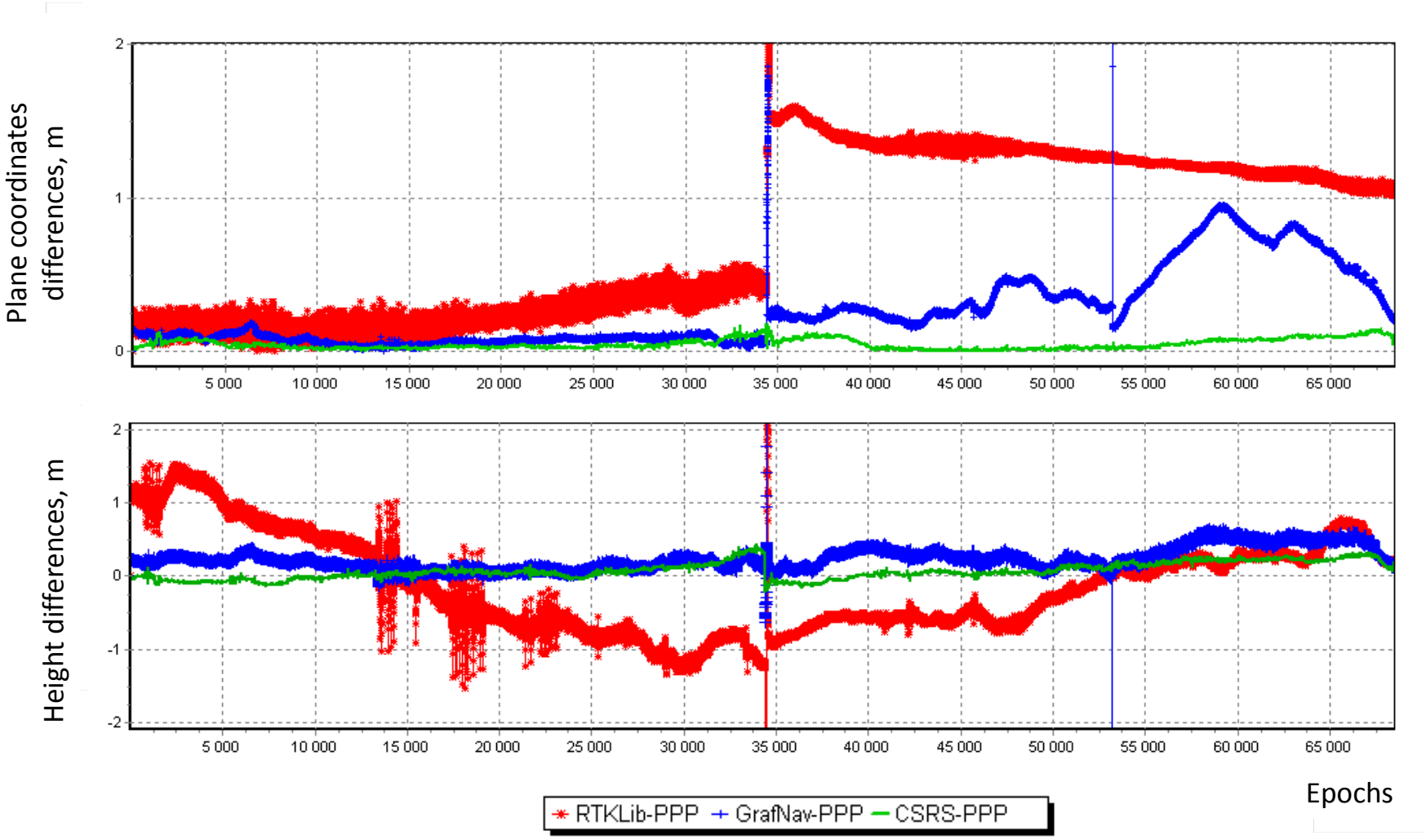
Kinematic-mode experiment results

RTKLib with the other software comparison: Precise Point Positioning



Kinematic-mode experiment results

Additionally: PPP and relative method comparison



Kinematic-mode experiment results

Coordinates and heights comparison summary

Parameter	Relative method			PPP	
	GrafNav	Magnet OT	Justin	GrafNav	CSRS-PPP
Difference RMS, m (plan; height)	0.03; 0.04	0.04; 0.07	0.04; 0.13	0.83; 0.87	0.71; 0.93
Average difference, m (plan; height)	0.03; 0.02	0.02; 0.02	0.03; 0.11	0.58; 0.35	0.51; 0.15

Kinematic-mode experiment conclusions

- Coordinates and heights for each epoch of trajectories processed with **relative method** by different software have differences 0.03 – 0.04 m RMS (except of Justin tracks heights with 0.05 – 0.08 m additional systematic difference).

- Solutions by **PPP method** by RTKLib have differences with CSRS-PPP and GrafNav on 0.7 – 1.3 m level (both plan and height).

Conclusions

Disadvantages of RTKLib (2.4.2) in comparison with commercial software:

- User interface is not enough user-friendly;
- Processing can be done just for one rover and one base station;
- Low flexibility of settings for coordinate systems (default WGS-84 only available);
- Long duration of processing (especially, for relative kinematic processing);
- Lacking «Stop-and-Go» processing support.

Advantages RTKLib:

- More of commercial GNSS software features are available;
- Most of GNSS data formats are supported (provided by TEQC);
- PPP method is available (with additional data downloading utility);
- forward/backward/combined processing and filtering;
- Open source with improvement by user possibility;
- Free-ware distribution license.

Conclusions

(continue)

- ***GNSS Post-processing by RTKLib free software with relative method provide high-quality solutions with the commercial software accuracy level*** (despite some lacking features) both in static and kinematic mode.

- ***Kinematic trajectories processed by RTKLib with PPP method had serious differences with the trajectories got with the other software and services (0.7 – 1.3 m differences for the same-time epochs)***. The causes of this problems may be in high frequency of data record (5 Hz). In fact, using of this mode with conditions that showed in the experiment is very limited.

Conclusions

(Final)

RTKLib currently used for the some engineering, research and production tasks instead or with commercial GNSS software.

Soon free GNSS software (with the further improvements) will be able to compete with commercial software for wide range of tasks and provide the same (or little bit lower) quality of processing solutions.

THANK YOU FOR ATTENTION!