FIG WORKING WEEK 2017

Helsinki Finland

29 May - 2 June 2017

Experimental Assessment of Achievable Accuracy of GNSS-Derived Heights from Carrier Phase-Based Positioning Techniques for Ellipsodially Referenced Hydrographic Surveys

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OUTLINE

Introduction

ONE OF THE MOST SIGNIFICANT ISSUES IN HYDROGRAPHY TODAY IS TO USE THE ELLIPSOID AS THE REFERENCE FOR MEASURING WATER DEPTH.

- Hydrographic survey has traditionally been performed for establishing nautical charts for safety of navigation, **but has now a vital role in costal zone management.**
- Costal zone encompasses a wide belt along the shoreline including the land and sea.
- **Integration of hydrographic and topographic data is essential for the analysis of coastal processes and management decision.**
- GNSS derived-heights on land and seas can be readily related to one another by **GEOID, HYDRODYNAMIC & TTS MODELS.**
- The ellipsoid is convenient surface for field surveying, but it has only geometrical meaning.
- **The ellipsoidally referenced spatial information should be transformed to geodetic or chart datum.**

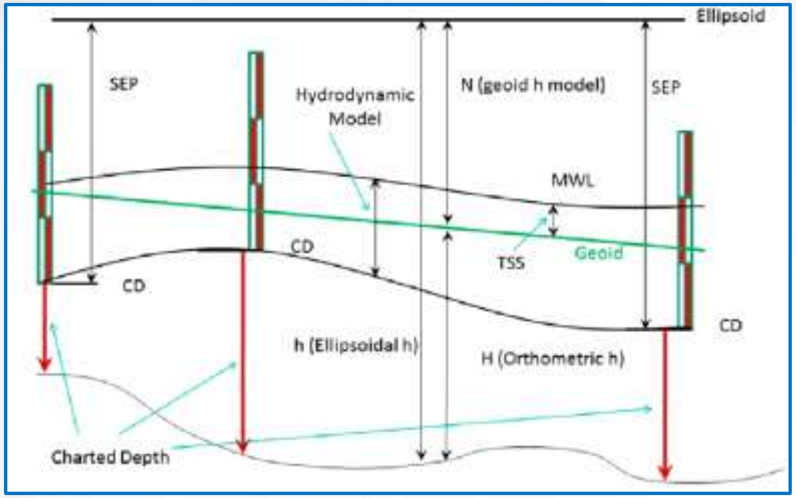


FIG (2014) Ellipsoidally reference surveying for hydrography, Publication No. 62, 62pp.

Some Technical Issues in ERS

- I Data acquisition of high accuracy of GNNS
- II GNSS data processing scheme and its accuracy (uncertainty)
- III Vertical separation model (SEP) development and application
- IV Quality control of vertical offset, GNSS, motion, SEP.
- V Uncertainty associated with offset, GNSS, motion and SEP
- VI Data archive reference

FIG (2014) Ellipsoidally reference surveying for hydrography, Publication No. 62, 62pp.

Background & Objectives

KHOA is currently preparing to introduce the ERS concept to its bathymetric surveys.

Development of a best practice for the GNSS vertical positioning is a prerequisite.

Field trials were performed to collect satellite observables in static and kinematic modes.

The measurements were processed in medium-ranage PPK and PPP modes by two commonly used software (i.e., GrafNav & RTKLib).

To gain some experience and understanding of CPH-based techniques.

To access potential accuracy of the geometric height derived by the techniques.

GNSS Measurement & Methodology

GNSS Positioning Techniques for Hydrography

1 Pseudo-Range (PR)

$$R_i^s = \rho_i^s + d\rho_i^s + c(dt^s\text{-}dT_i) + di_i^s + dr_i^s + \boxed{dm_{i,R}^s + \varepsilon_{i,R}^s}$$

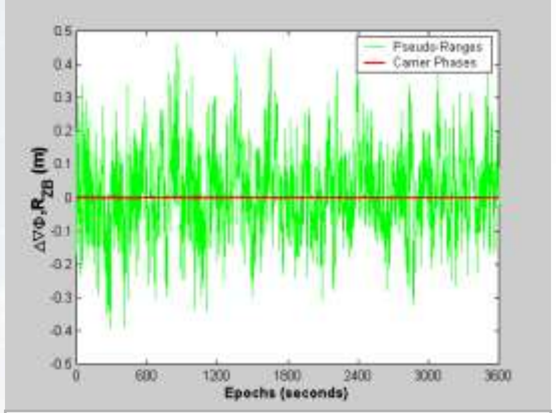
2 Carrier-Phase (CPH)

$$\lambda_G \cdot \phi_i^s = \rho_i^s + d\rho_i^s + c(dt^s - dT_i) + \boxed{\lambda_G \cdot N_i^s} - di_i^s + dr_i^s + \boxed{dm_{i,\phi}^s + \varepsilon_{i,\phi}^s}$$

GNSS Techniques depend upon

- Type of measurements used for estimation of coordinates (PR Vs. CPH);
- Method how errors boxed in the equations are corrected (Point Vs. Relative).

To maximize positioning accuracy, CPH should be used for estimation process.

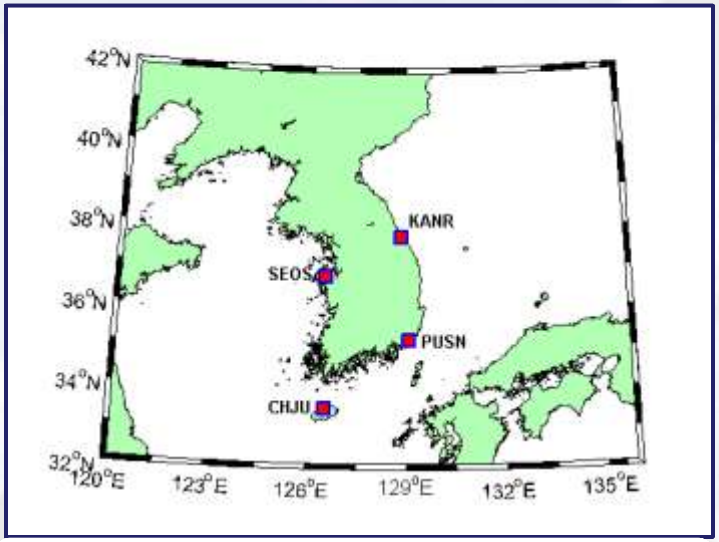


Comparison of noise level of PR and CPH

GNSS Measurements

Static Case

- Five CORS stations in Korea
- 24 hours GPS data
- Over 250km of baseline length



Precise satellite orbit and clock were used for the data analysis.

Kinematic Cases

Turn-table Test

- Sokkia GRS2600 (dual-frequency)
- 1Hz sampling rate
- 70 min. including 10 min. static session

Survey Vessel Test

- Three of Sokkia GRX1
- 1Hz sampling rate for 2 hours
- Two hours kinematic session

Software and Methodology of Accuracy Evaluation

Software#1(SW-1)

- An open source program for GNSS positioning
- Standard and precise positioning algorithms with **GPS, GLONASS, SBAS, QZSS**
- Positioning mode for **real-time and post-processing: Single, SBAS, DGPS, RTK, PPP**

Software#2 (SW-2)

- Commercial post-processing software by Novatel
- Highly configurable processing engine that allows for **the best possible static or kinematic accuracy.**
- Differential and PPP processing
- Support for GPS L1/L2/L2C, GLONASS, BeiDou

Evaluation of achievable accuracy of ellipsoidal height estimated by medium-range PPK and PPP

Medium-Range Baseline PPK

- ✓ CODE precise satellite orbit
- ✓ Estimation of Iono. & trop.
- ✓ Ambiguity float solutions
- ✓ Combination of forward & backward processing

Short Baseline PPK

- ✓ Generation of reference for accuracy evaluation
- ✓ Ambiguity fixed solutions
- ✓ Usage of the nearest base station (e.g., shorter than 3km)

PPP - Kinematic

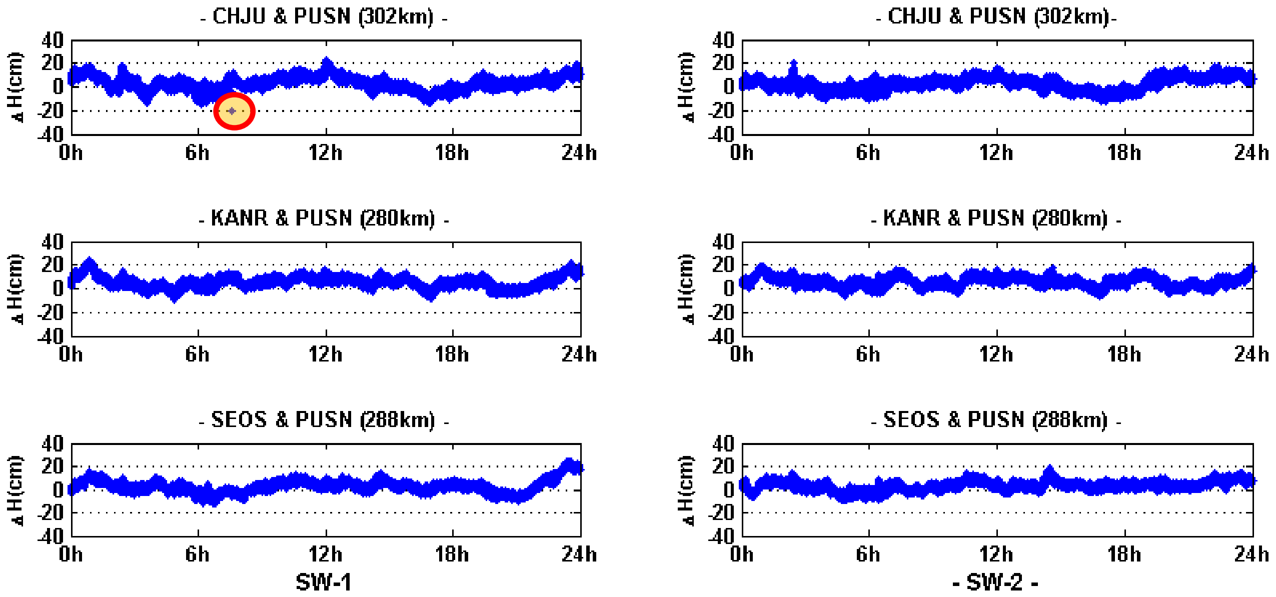
- ✓ CODE precise satellite orbit
- ✓ CODE 5 sec. satellite clock
- ✓ Ambiguity float solutions
- ✓ Combination of forward & backward processing

Comparison!

Comparison!

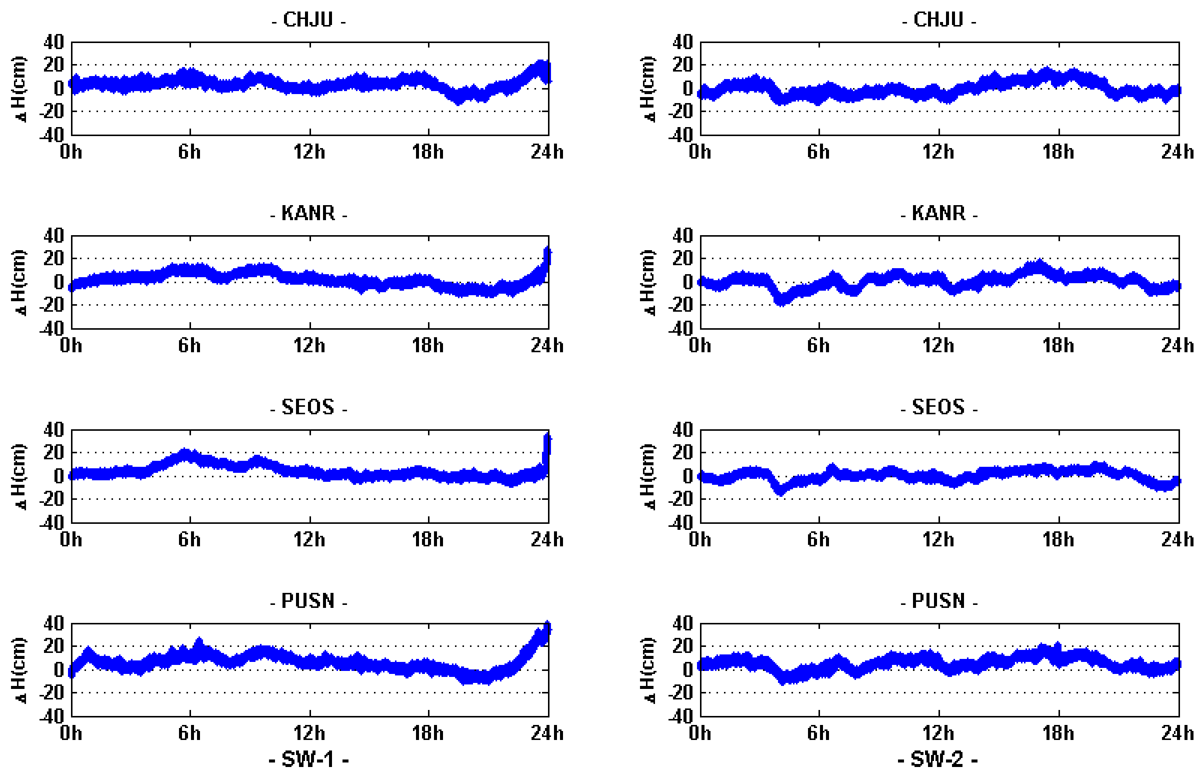
Test Results & Discussion

STATIC TESTS: MEDIUM-RANGE PPK

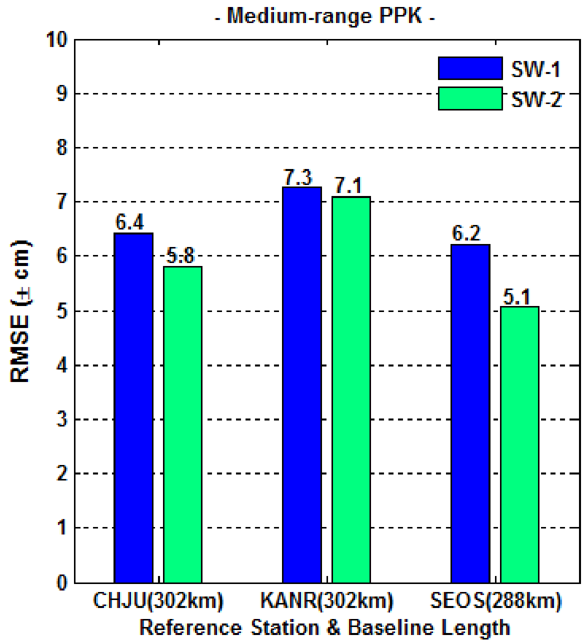


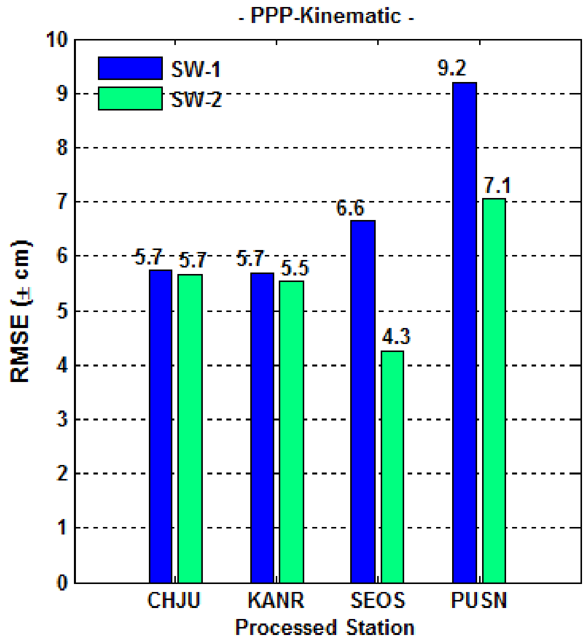
- ✓Three baseline solutions were generated by each software.
- ✓Time-series of coordinate differences between PPK-derived and published height.

Static Tests: PPP-Kinematic



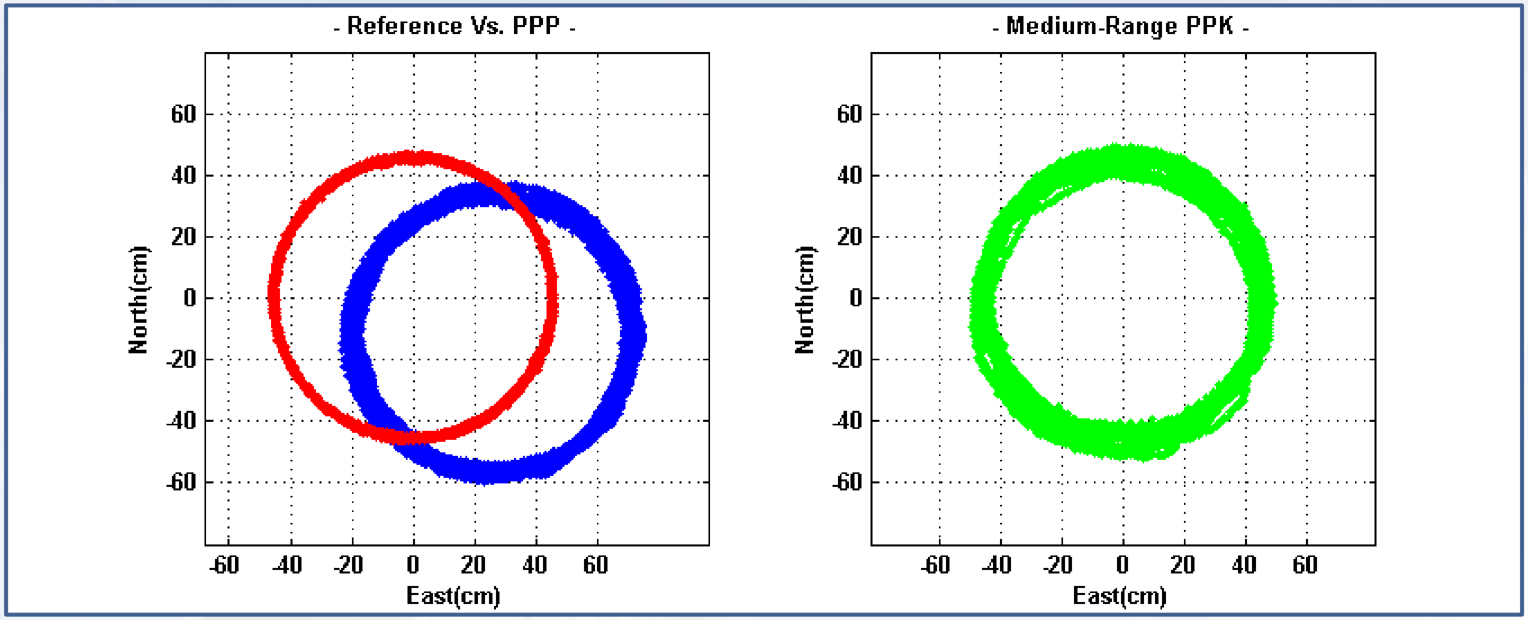
Static Tests: Comparison of RMSE





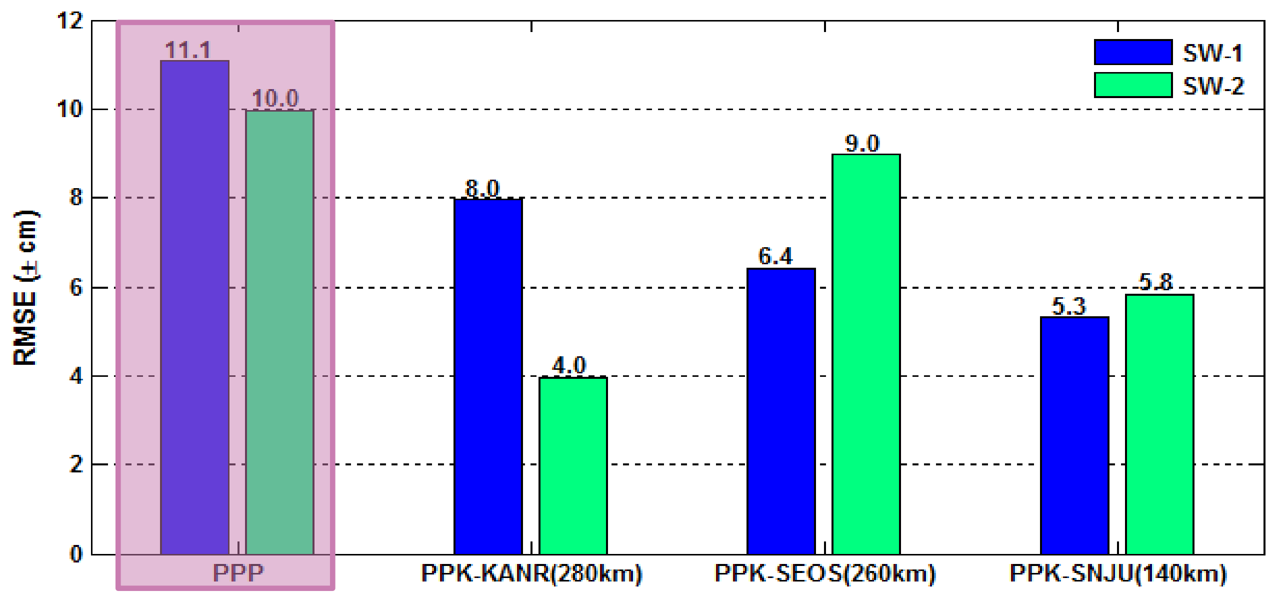
- ✓ Accuracy of PPK and PPP is almost equivalent (PPK: ±5 - ±7cm, PPP: ±4 – 7cm except for PPP at PUSN).
- ✓ Solutions from SW-2 are slightly more accurate than those of SW-1.

Turntable Trial: An Example of SW-1



- ✓PPK results was derived with respect to SEOS station: baseline length was about 260Km.
- ✓Bias is observed in PPP solution; it seems to be caused by reference epoch difference between IGS08 and KGD 2002.

Turntable Trial: Comparison of RMSE

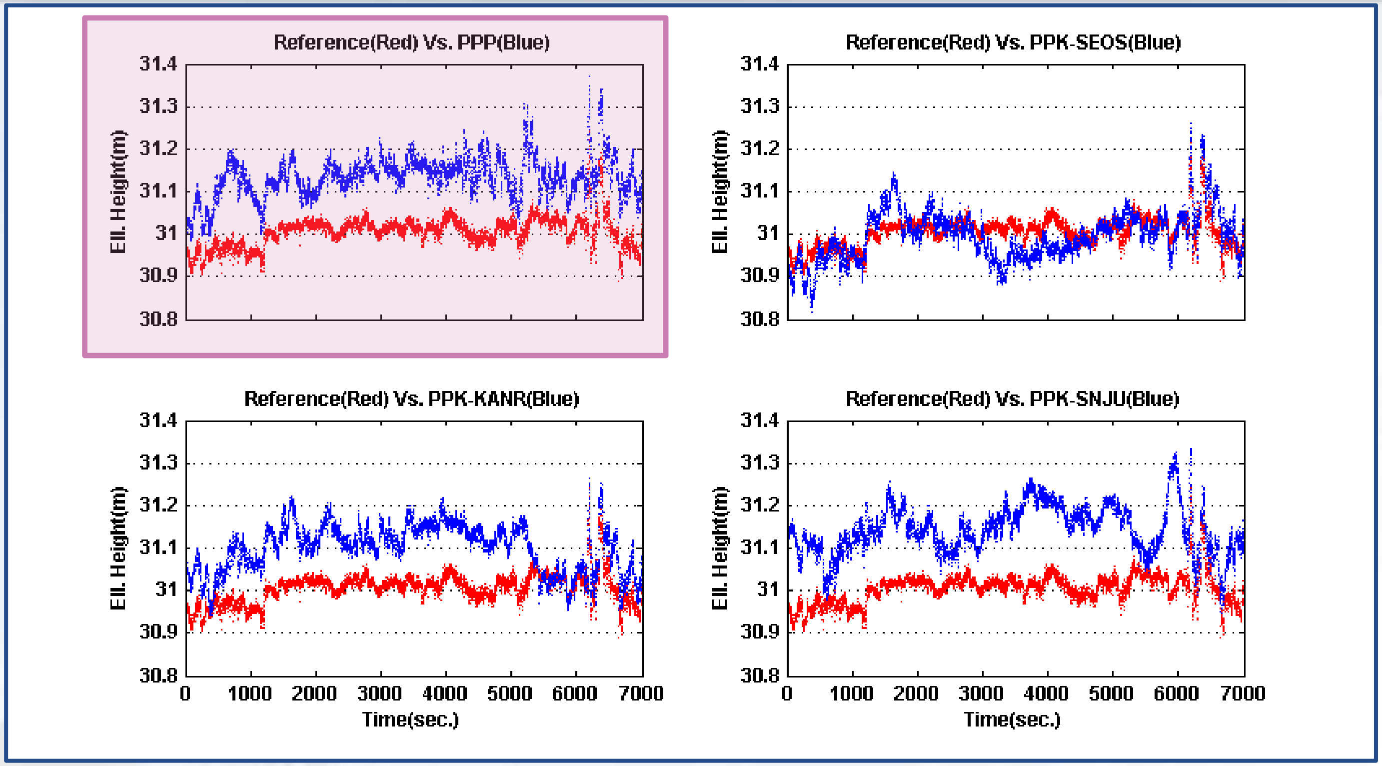


- PPK solutions are slightly more accurate than that of PPP.
- Accuracy of PPP is around ±10cm; that of PPK is better than ±10 cm
- Accuracy of PPK-KANR from SW-2 is superior to that of SW-1, but in other two cases SW-1 is a little bit better.

Survey Vessel Test - Introduction

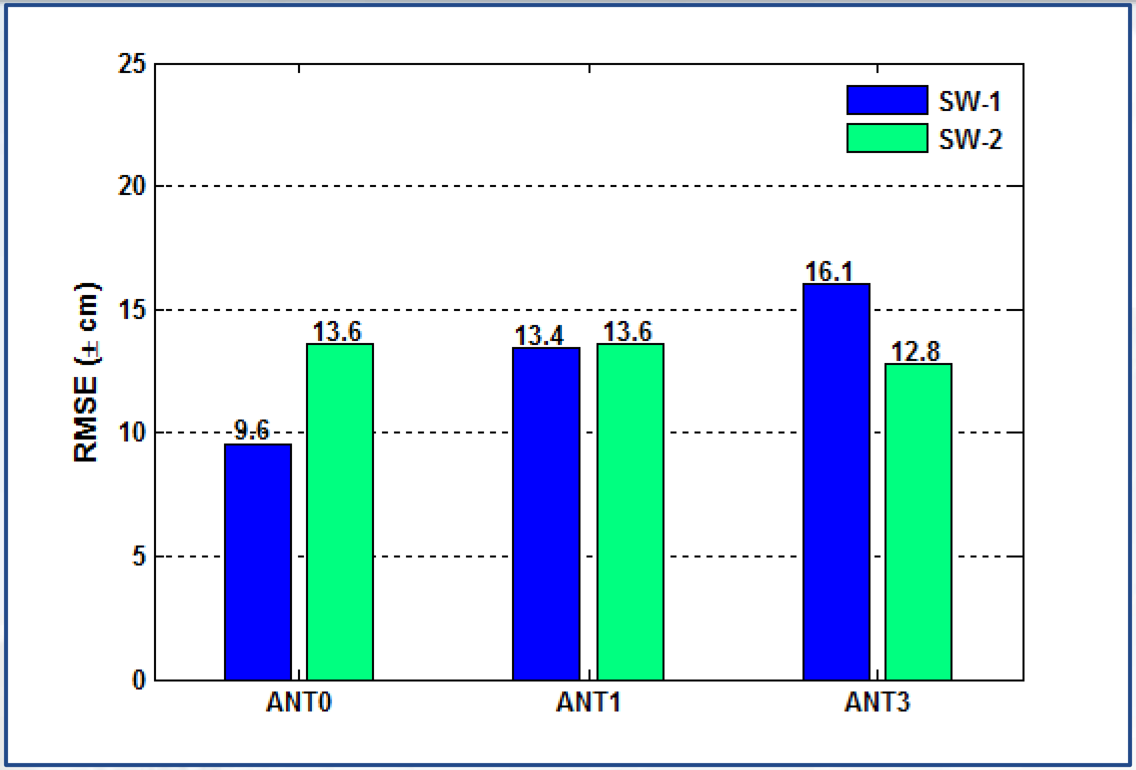
- ✓ The experiment was conducted around West Nakdong River in Busan, Korea.
- ✓ GPS observation was made for approximate 2 hours by 3 rover receivers

Survey Vessel Test – Comparison with Reference



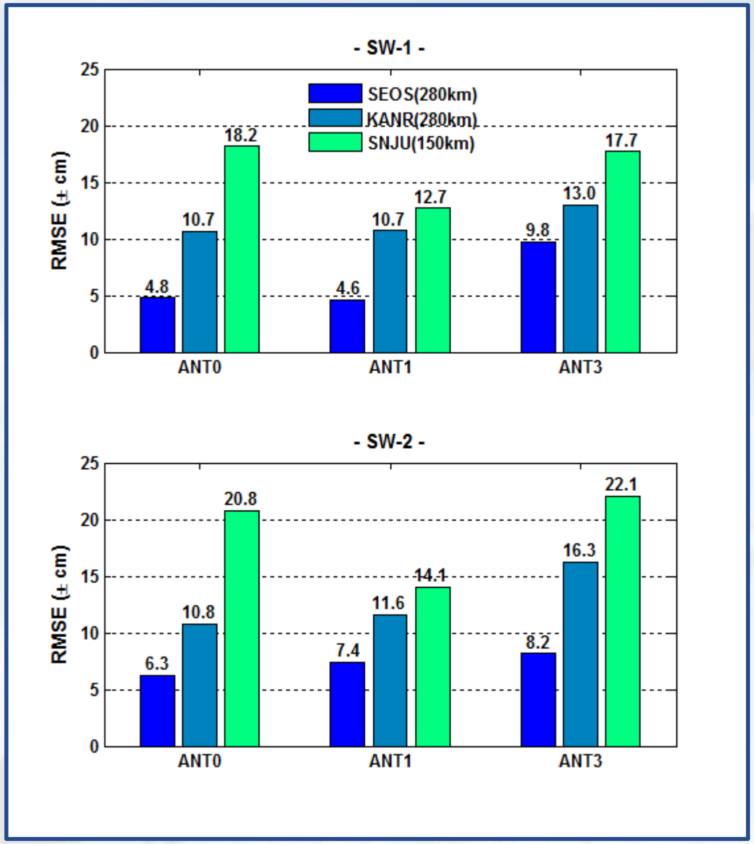
- ✓ Bias is clearly seen in these results, expect for PPK-SEOS.
- ✓ Considering characteristics of errors in measurement models, it seems to be induced by residual troposphere

Survey Vessel Test: RMSE of PPP-Kinematic



- ✓ S/W does not much impact into accuracy, but SW-2 provides more stable solutions.
- ✓ GNSS-derived height accuracy by PPP ranges from about ±10cm to 15 cm.

Survey Vessel Test: RMSE of Medium-Rnage PPK



- ✓ Accuracy highly depends on selection of reference.
- ✓ PPK is less stable than PPP.
- ✓ Baseline distance is not coupled with accuracy.
- ✓ This might be residual relative troposphere caused by meteorological condition.

Some meteorological parameters during the test

Site	Temp. (°C)	Humid. (%)
KANR	25 - 26	68 – 75
SEOS	28 - 29	84 – 90
SNJU	31 - 32	59 – 61
Testing Area	27- 30	79 - 86

Concluding Remarks

CONCLUDING REMARKS

- ✓ For future adaptation the ERS concept in Korean hydrographic society, the CPH-based GNSS positioning techniques have been tested in terms of accuracy on static and kinematic mode by using the two software packages.
- ✓ Performance of the two software packages is comparable in both the CPH-based techniques as the accuracy differs only few centimetres level.
- ✓ Although results of the static test is more accurate than those of the kinematic, it is somewhat overestimated because temporal residual tropospheric delay for 24 hours evened out in the RMSE computation.
- ✓ Comparing the medium-range PPK to the PPP, the latter's accuracy is more consistent, and that of the former varies against selection of the reference station.
- ✓ As a consequence of the tests, achievable accuracy of the PPP with 1-σ confidence level is better than ± 16.1 cm, whereas that of the medium-range PPK is around ± 22.0 cm.
- ✓ Because the experiments performed in this study are limited to the number and the size of testing samples, more intensive analysis under various survey conditions are highly recommenced in future for more reliable accuracy assessment.

Thank you for your attention .....