Conference Paper

Assessment of Different Real Time Precise Point Positioning Correction Over the Sea Area

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Abstract

In a global scale, the accuracy of Real Time Precise Point Positioning (RT-PPP) method in Global Navigation Satellite System (GNSS) point positioning is within cm to dm level. Unlike other conventional method in GNSS point positioning which used differential data to minimize the error sources, RT-PPP used additional orbit correction, clock correction and other atmospheric correction to minimize the error since RT-PPP is an absolute point positioning method. Currently, there are several providers who give the orbit correction and clock correction in real-time. Not only in the land area, this service can be also used in sea area. Thus, this research aims to analyse the differences in point determination derived from RT-PPP method by using several service providers in sea area. The RT-PPP data acquisition used three different receivers with unique service correction, namely RTX correction from Trimble Net R9 receiver, ATLAS correction from Hemisphere receiver and Veripos correction from Hemisphere receiver. All these antennas were set up on the ship with a controlled distance and the point coordinates were estimated from Seribu Island to Ancol, Jakarta with a different time interval for each receiver due to the technical limitations. To assess the point positioning stability, the distance between each antenna derived from point positioning then evaluated by comparing to its controlled distance. The results indicate that a time lag is found in Trimble Net R9 compared with the others, and it should be corrected first before applying the further analysis. In general, after removing the outliers, the distance and the precision between each antenna between Veripos-ATLAS is 4.472 ± 0.040 m, RTX-ATLAS is 2.054 ± 0.077 m and RTX-Veripos is 3.947 ± 0.060 m. Therefore, RT-PPP method can be used as an alternative in precise point positioning in sea area.

Keywords: distance, java Sea, ATLAS, veripos, RTX, leap second

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1. Introduction

Nowadays, absolute positioning methods are developing that can provide accurate positioning of fractions up to 5 cm known as Real Time Precise Point Positioning (RT-PPP) [1]. Basically, RT-PPP is the development of Precise Point Positioning (PPP) method, where PPP use phaserange and pseudorange in ionospheric-free linear combination. In order to get high accuracy and precision of position, PPP needs a precise orbit and clock accuracy which can be downloaded from the International GNSS Service (IGS), while RT-PPP will get its correction from global Satellite Based Augmentation System (SBAS) that computed from global ground reference station [2]. Currently, there are several providers who give the orbit correction and clock correction in real-time. Not only in the land area, this service can be also used in sea area. The performance of Real-Time (RT) Precise Point Positioning (PPP) ambiguity resolution can be further improved by incorporating multiple Global Navigation Satellite System (GNSS) observations [3, 4].

The applications of RT-PPP method are being used in land and mapping survey activities, including: land parcel surveying, topographical surveying, and Ground Control Point (GCP) survey. For the surveying activities on the sea, RT-PPP is started being used for research to determine geodetic height of sea level [5].In addition, there are several other applications on the sea including, Marine surveys, ocean buoy positioning for tsunami detection, in marine applications for sensor positioning of sea floor mapping and marine construction, for precise hydrographic surveying, dredging, attitude control of ships, buoys and floating platforms, and crustal deformation monitoring [6].

GNSS positioning at sea, by any means in general, and by RT-PPP method, would improve the practicability of modern hydrographic surveys [7]. By such mean, ellipsoidal-based vertical positioning at sea --as advised by the International Federation of Surveyors-- can be performed (Mills & Dodd 2014). This, however, needs the availability of the so-called hydrographic separation model, i.e. transformation among various vertical datum, mainly between the ellipsoid and tidal datum, such as LAT and MSL, as well as the geoid and/or another Chart Datum [8--10]. One should bear in mind that the application of GNSS-heighting in hydrographic surveys requires thorough concerns. [5] has shown that independent from the precision of GNSS-heighting, vertical positioning by using RT-PPP or any other SBAS-based devices at sea demand precise monitoring of antenna attitude. It is therefore necessary to further assess the performance of precise point positioning for vertical positioning at sea. Thus, this research aims to analyze the differences in point determination derived from RT-PPP method by using several service providers in Java Sea area.

2. Data and Method

2.1. Data and research area

The comparison of the position determination derived from RT-PPP is carried out during a cruise from Seribu Island to Ancol, Jakarta. The cruise occupies about 50 km of travel. Three GNSS set with its own correction were utilized in this research, namely Trimble NetR9 (RTX), Hemisphere (Veripos) and Hemisphere S321 (ATLAS). The terminology of correction provider (RTX, Veripos and ATLAS) is used in this paper instead of the receiver type. These sets were set up in a controlled distance between antenna. The distance between Veripos and ATLAS antenna, RTX and ATLAS antenna, RTX and Veripos antenna were 4.43, 2.04 and 3.94 meter respectively (Figure 2).

Ideally, the time interval for the data acquisition for each system should be same, however, due to some technical issues, this ideal condition could not be applied in this research. Thus, the positioning performance was evaluated by comparing the distance between two GNSS sets on the same time observation with the controlled distance. The distance between two GNSS sets is expected to be the same as the controlled distance.

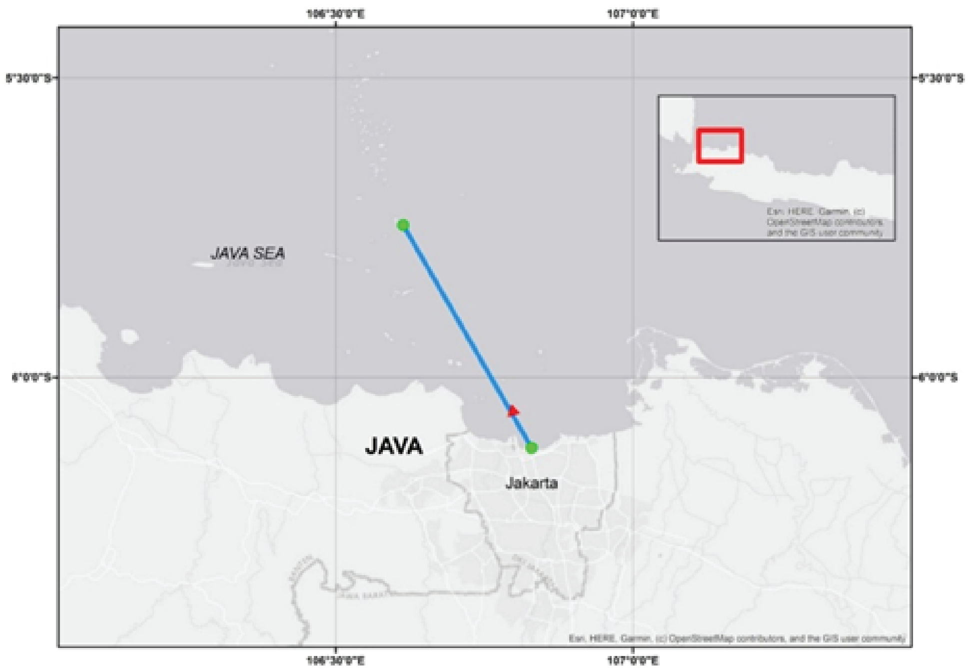

Figure 1: Research area.

Figure 2: GNSS antennas configuration on the ship, Veripos (left), RTX (middle), ATLAS (right) correction provider.

Table 1: Comparison of controlled distance and estimated distance for each system.

	Mean distance (m)	*Controlled distance (m)*	*Differences (m)*
Veripos-ATLAS	4.472 ± 0.040	4.46	0.012
RTX-ATLAS	2.054 ± 0.077	2.06	-0.006
RTX-Veripos	3.947 ± 0.060	3.96	-0.013

2.2. Real-Time Precise Point Positioning

Precise Point Positioning (PPP) is an advance absolute point positioning method that assure of high accuracy of position determination. PPP is mainly done in post processing data scheme by eliminate the errors using additional correction (i.e. precise ephemeris and clock) and specific procedures. Since the high demand of rapid precise positioning determination, in early 2013, IGS officially launched the Real-Time Service (RTS) to provide the precise ephemeris and clock [11] as a pilot project of RT-PPP. Currently, several providers (i.e RTX, ATLAS, Veripos) compute the precise ephemeris and satellite clock data on their control segment and transmit it through their L-Band satellites to users. This section will describe the GNSS signal propagation and PPP in general. Result and Discussion

This section will be divided into two sub-section. First sub-section will describe the data consistency while the second sub-section will describe the RT-PPP positioning performance.

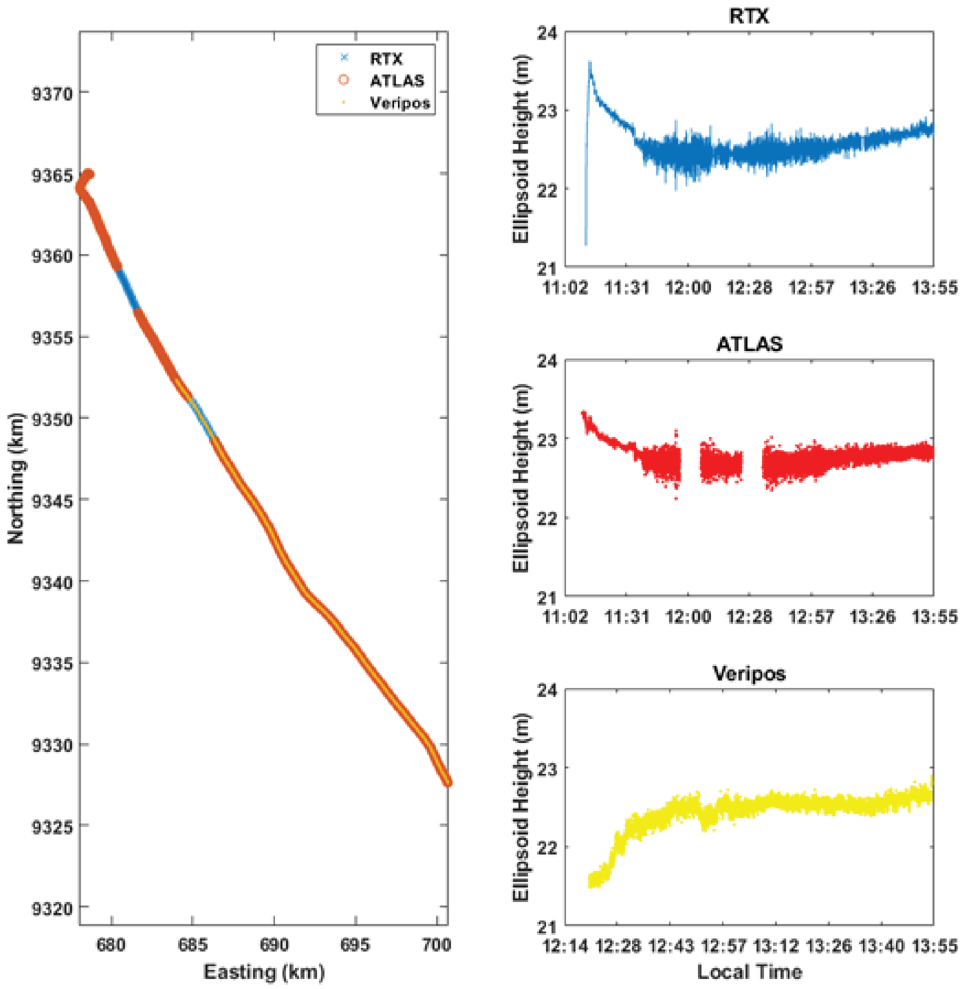

Figure 3: Horizontal and elevation position for each system.

To check the consistency of RT-PPP performance and to evaluate any systematic error, the position estimation from each system were plotted in the same figure (Figure 3). Take a closer look into the elevation data for each RT-PPP system, it could be interfered that the position derived from RT-PPP method took approximately 30 minutes to achieve its claimed precision or solved ambiguity solution. However, due to the ocean current and the ship movement, the precision became larger than in its ideal condition (static or not moving) especially in height determination, however, this error could be compensated by using a gyro or Inertial Measurement Unit (IMU).

By evaluating Figure 3, there was no further information that could be obtained, hence, the horizontal positions were analyse in 1D approach. Figure 4 shows the easting and northing component for ATLAS and RTX. It could be seen that there was a time delay between ATLAS and RTX estimated position. 18 seconds of time delay was estimated

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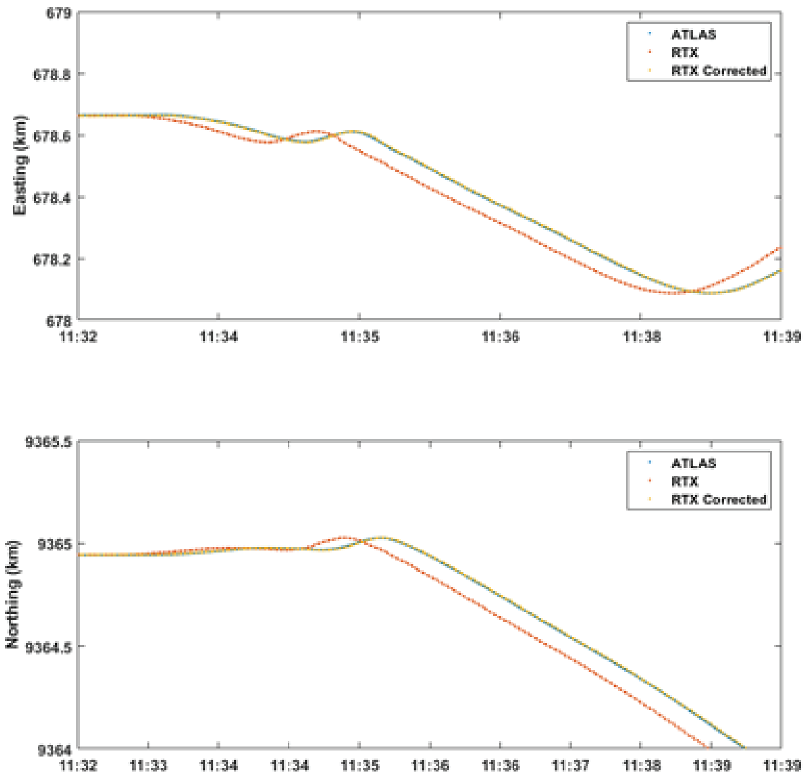

Figure 4: Easting and northing component of ATLAS and RTX.

using cross correlation method between ATLAS and RTX position. This result is in accordance with current GPS time leap second. This leap second error will not be affected in the terrestrial topographic mapping application, however, in a condition where accurate time information and position is needed, such as UAV PPK/RTK mapping [15], it leads a systematic shifting in the produced maps. The typical flight speed of UAV is around 10 m/s, thus, the produced map will be shifted around 180 meters in the opposite direction of flight trajectory. Further analysis should be done to solve the time leap problem in GNSS data or by updating the firmware of the receiver.

2.2.1. RT-PPP positioning performance

The distance between each system was computed by using estimated 3D coordinate. As a result, three sets of distance were analysed in this research, namely Veripos-ATLAS, RTX-ATLAS and RTX-Veripos. Tabel 1 and Figure 5 show the statistic and time series of computed distance for each system after removing the outliers and the initiation condition. Although the precision of estimated position (Figure 3) was more than 10 cm,

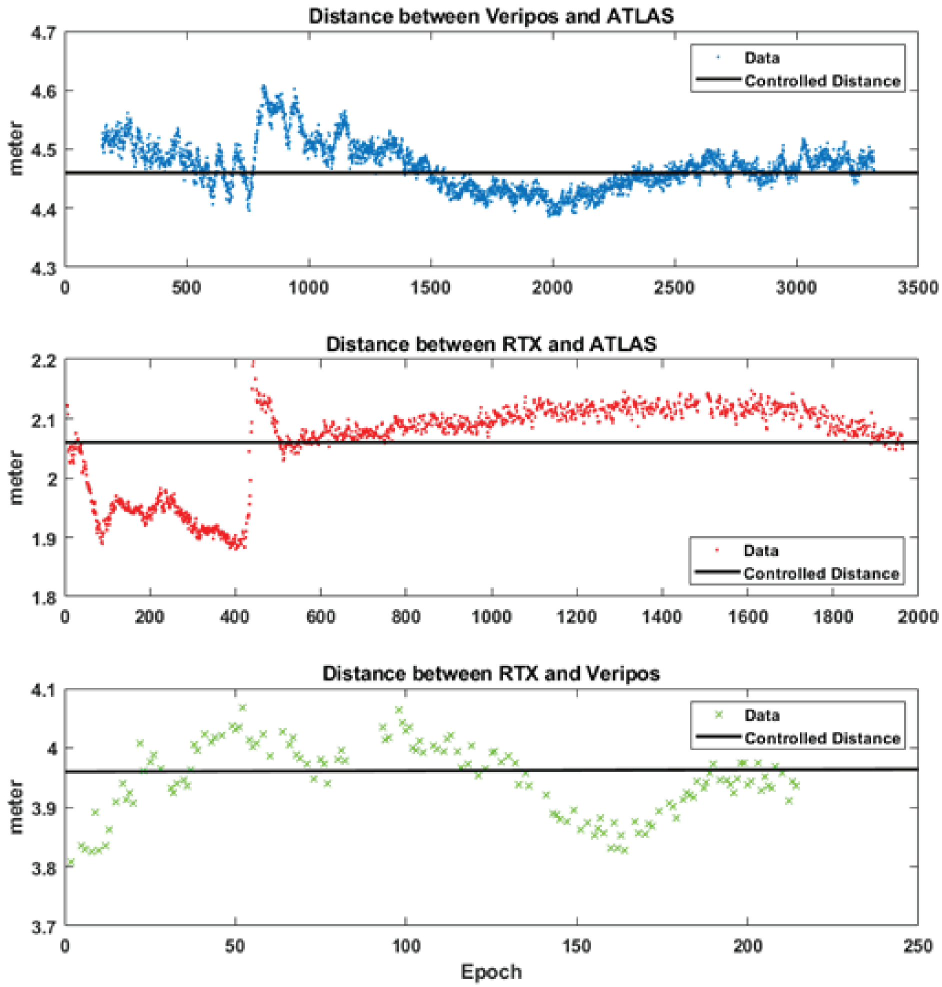

Figure 5: Estimated distance between each system.

especially in height coordinate, all these combinations achieve its accuracy in cm level and the precision for under 10 cm. It indicates that the estimated position accuracy was good, however, due to the ocean current and ship movement, the precision of time series data became worse.

3. Conclusion

This study examines the performance of RT-PPP method using three correction provides for estimating the coordinates on the sea area. The results indicated that there was a leap second problem that need to be concerned. In general, after removing the outliers, the distance and the precision between each antenna between Veripos-ATLAS is 4.472 $\pm$ 0.040 m, RTX-ATLAS is 2.054 $\pm$ 0.077 m and RTX-Veripos is 3.947 $\pm$ 0.060 m. It found that the differences between estimated distance and the controlled distance for Veripos-ATLAS, RTX-ATLAS and RTX-Veripos were 0.012 m, -0.006 m and -0.013 m respectively.

References

[1] B. Bramanto, I. Gumilar and W. Kuntjoro, "RT-PPP: Concept and Performance in Indonesia Region," in FIT ISI 2015, Batu, 2015.

[2] C. Rizos, C. R. V. Janssen and T. Grinter, "Precise Point Positioning: Is the era of differential GNSS positioning drawing to an end?," in FIG Working Week 2, Rome, Italy, 2012.

[3] C. Cai, Y. Gao, L. Pan and J. Zhu, "Precise point positioning with quad-constellations: GPS,BeiDou, GLONASS and Galileo," Advances in Space Research, vol. 56, pp. 133-143, 2015.

[4] H. Li, LiaoX., B. Li and L. Yang, "Modeling of the GPS satellite clock error and its performance evaluation in precise point positioning," Advances in Space Research, vol. 62, pp. 845-854, 2018.

[5] Poerbandono, K. Prijatna and I. Gumilar, "racking of geodetic height of sea level in the west of Java Sea, Indonesia: A preliminary assessment.," E3S Web of Conferences, vol. 94, no. 01003, 2019.

[6] S. Bisnath and Y. Gao, "Precise point positioning, a powerful technique with a promising future," GPS World, vol. 20, no. 4, pp. 44-50, 2009.

[7] M. Berber and W. Wright, "Online kinematic GNSS data processing for small hydrographic surveys," Ocean Engineering, vol. 112, pp. 335-339, 2016.

[8] D. Slobbe, R. Klees, M. Verlaan, L. L. Dorst and H. Gerritsen, "Lowest astronomical tide in the North Sea derived from a vertically referenced shallow water model, and an assessment of its suggested sense of safety," Marine Geodesy, vol. 36, no. 1, pp. 31-71, 2012.

[9] D. Dodd and J. Mills, "Ellipsoidally referenced surveys: Issues and solutions," International Hydrographic Review, vol. 6, pp. 19-30, 2011.

[10] J. C. Iliffe, M. K. Ziebart and J. F. Turner, "A new methodology for incorporating tide gauge data in sea surface topography models," Marine Geodesy, vol. 30, no. 4, pp. 271-296, 2007.

[11] G. Weber, L. Mervart, Z. Lukes, C. Rocken and J. Dousa, "Real-time clock and orbit corrections for improved point positioning via NTRIP," in ION-GNSS-2007, Fort Worth, TX, USA, 2007.

[12] J. Tomaštík, M. Mokroš, P. Surový, A. Grznárová and J. Merganic, "UAV RTK/PPK Method---An Optimal Solution for Mapping Inaccessible Forested Areas?," Remote sensing, vol. 11, no. 721, 2019.