Chapter 1

Introductory Chapter: The Philosophy Behind the Accuracy Assessment of GNSS Methods

Dogan Ugur Sanli

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.81288

1. Introduction

Satellite geodesy was developed to overcome the tasks which cannot be accomplished using traditional geodetic techniques, for instance, to measure the motion of continents more precisely, to eliminate the difficulty in line of site problems, to gain performance in all weather conditions, and to be able to monitor global deformations of the earth leading to the contribution in the emerge of a terrestrial reference frame (TRF) which is compatible with the geodynamic events of the earth.

Today, global navigation satellite system (GNSS) data are used for various purposes, not only in geodesy but also in all earth science disciplines such as geophysics, geology, meteorology, oceanography, and others. In geodesy, applications range from establishing geodetic control networks to detail surveys. The GNSS instrumentation is designed according to various purposes. Cost-effective instrumentation, hardware, and software are preferred suitable to application and accuracy expectations. The accuracy expectation of users according to their aims is multifold. The instrumentation and the GNSS products are always improved with the developments in technology and analysis methodologies, coding, etc. Hence the user, the GNSS community, needs to be updated in terms of accuracy of the positioning results, orbital products, TRF quality, etc. with continuous research.

2. Positioning accuracy of GNSS

The accuracy of GNSS was studied by many researchers; however, the first organized study in which the accuracy prediction formulas for coordinate components were developed for the user was produced by [1] based on an experiment using only GPS data. There the authors emphasized that the accuracy of GNSS positioning was mainly dependent on observation session duration. The dependency on baseline length, which for instance was the essence as emphasized in [2–4], was mainly changed with the release of the IGS precise orbit (i.e., with the improvement in orbit quality).

Eckl et al. [1] were targeting GPS studies at the national level with Continuously Operating Reference Station (CORS) inter-station distances of up to 300 km. Sanli and Engin [5] changed the angle to tectonic studies in which GPS processing was handled using baseline lengths of up to thousands of kilometers. Again, the dependency on baseline length came back to the agenda. From these studies the authors produced prediction formulas for north, east, and up positioning components. The formulas were useful for the GPS community with various accuracy expectations for various applications. Before field works, they were able to obtain a priory accuracy levels and hence taking necessary precautions in the field to guarantee the desired position accuracy.

Then, the research continued to present details in the accuracy assessment of point positions. For instance, Ozturk and Sanli [6] made an attempt to unify accuracy models for baselines of 1–3000 km resulting in a complete accuracy model. Sanli and Kurumahmut [7] took into account the effect of large height difference on positioning and extended the traditional formulation. Ghoddousi-Fard and Dare [8] were among those who studied the accuracy of GPS positioning for web-based GPS software. Schwarz et al. [9] and Hastaoglu and Sanli [10] assessed the accuracy of GPS rapid static positioning. At the end of the day, GPS positioning accuracy prediction formulas from static GPS surveys were produced for three major GNSS software, Bernese, GIPSY/OASIS II, and GAMIT by [11–13], respectively.

3. Scope of book

Besides the GPS positioning accuracy efforts that are well documented in the literature and discussed above, this book embraces the present day work documenting the performance evaluation of GNSS systems and new receiver designs to improve GNSS signal quality before the processing. The up-to-date experiment results on positioning accuracy are also evaluated for online GNSS software which is freely available to user community. In addition, the positioning accuracy under severe atmospheric disturbances is evaluated for single-frequency receivers which are widespread in surveying practice today. The structure of the sections and chapters is as in the following:

In the first section, the performance of the two GNSS systems, GPS and BeiDou, is evaluated. Referring to well-established standards developed for the GPS, the performance assessment of BeiDou satellite navigation system is performed. The available signal in space (SIS) model is improved based on the reliability theory using exponential distribution and Gauss-Markov process, and constellation models are refined taking into consideration satellite failure rate, repair rate, and backup situation.

The second section reviews the quality of the GNSS measurements. In the first chapter, a new GNSS receiver design in which the GNSS signal is repaired using a new vector tracking architecture is proposed. In the second chapter, how the GNSS signal is degraded under severe atmospheric disturbances such as ionospheric scintillations is investigated. A calibration model improving single-frequency PPP results is presented.

The third section is devoted to GNSS positioning assessments:

Chapter 1 in Section 3 assesses GPS relative positioning accuracy for a single-frequency GPS receiver. Single-frequency receivers are economic and suitable for nationwide surveying practices. Therefore, researchers are eager to develop methodologies in which single-frequency receivers are employed. Here the positioning accuracy is assessed taking into consideration the mode of surveying, baseline, and precision dilution of position (PDOP), signal-to-noise ratio (SNR), and occupation time. Chapters 2 and 3 in this section assess results from online GNSS software. Results from available software are compared. Chapter 2 presents results in ITRF14 and Chapter 3 in a national grid system.

The fourth section is devoted to the construction of national spatial reference systems by combining terrestrial geodetic networks with GNSS networks. A recurrent adjustment methodology which uses GPS data from GNSS methods is presented applying sparse matrix operations, outlier detection, and simplified subsystem of observation equations. Namely, present day accuracy of establishing national spatial reference systems based on GNSS is presented.

Author details

Dogan Ugur Sanli

Address all correspondence to: usanli@yildiz.edu.tr

Yildiz Technical University, Turkey

References

[1] Eckl MC, Snay RA, Soler T, Cline MW, Mader GL. Accuracy of GPS-derived relative positions as a function of inter-station distance and observing-session duration. Journal of Geodesy. 2001;**75**:633-640

[2] Dong DN, Bock Y. Global positioning system network analysis with phase ambiguity resolution applied to crustal deformation studies in California. Journal of Geophysical Research. 1989;**94**(B4):3949-3966

[3] Larson KM, Agnew DC. Application of the global positioning system to crustal deformation measurement, 1, precision and accuracy. Journal of Geophysical Research. 1991;**96**(B10):16547-16565

[4] Feigl KL, Agnew DC, Bock Y, Dong D, Donellan A, Hager BH, et al. Space geodetic measurement of crustal deformation in central and Southern California, 1984-1992. Journal of Geophysical Research. 1993;**98**(B12):21677-21712

[5] Sanli DU, Engin C. Accuracy of GPS positioning over regional scales. Survey Review. 2009;**41**:192-200

[6] Ozturk D, Sanli DU. Accuracy of GPS positioning from local to regional scales: A unified prediction model. Survey Review. 2011;**43**:79-589

[7] Sanli DU, Kurumahmut F. Accuracy of GPS positioning in the presence of large height differences. Survey Review. 2011;**43**(320):162-176

[8] Ghoddousi-Fard R, Dare P. Online GPS processing services: An initial study. GPS Solutions. 2006;**10**:12-20

[9] Schwarz CR, Snay RA, Soler T. Accuracy assessment of the national geodetic survey's OPUS-RS utility. GPS Solutions. 2009;**13**:119-132

[10] Hastaoglu KO, Sanli DU. Monitoring Koyulhisar landslide using rapid static GPS: A strategy to remove biases from vertical velocities. Natural Hazards. 2011;**58**:1275-1294

[11] Doğan U. Accuracy analysis of relative positions of permanent GPS stations in the Marmara region, Turkey. Survey Review. 2007;**39**:156-165

[12] Sanli DU, Tekic S. Accuracy of GPS precise point positioning: A tool for GPS accuracy prediction. Saarbrücken: LAP Lambert Academic Publishing; 2010. 60 p

[13] Firuzabadi D, King RW. GPS precision as a function of session duration and reference frame using multi-point software. GPS Solutions. 2012;**16**:191-196