Estimating snow depth with GNSS reflectometry

Kegen Yu
China University of Mining and Technology, Xuzhou, China

Abstract

Statement of the Problem: Snow depth is a key measure of snowfall which is an important parameter in the management of water resource and the study of climate change. The conventional snow depth measurement is made by manually sampling at a rather limited number of locations or using dedicated devices fixed at selected positions. To improve the spatial and temporal resolution of snow depth measurement, GNSS reflectometry (GNSS-R) can be exploited. The purpose of this study is to describe the fundamentals of estimating snow depth based on GNSS-R and evaluate the performance of the different GNSS-R schemes.

Methodology & Theoretical Orientation: The SNR, carrier phase and pseudorange measurements generated by typical GNSS receivers are employed. Time series of the characteristics of reflected signals are obtained and their main frequencies are estimated, which are related to snow depth. SNR method and carrier phase and pseudorange combination method can be applied to single-frequency receivers, while carrier phase combination methods use data collected by dual-frequency or triple-frequency receivers. SNR method needs to remove the SNR component of direct signals, while dual-frequency phase combination method and signal-frequency phase and pseudorange combination method need to exclude the ionospheric effect.

Findings: Results demonstrate that the SNR method, the carrier phase combination method and the carrier phase and pseudorange combination method achieve different accuracies in snow depth estimation, depending on the quality of the data and satellite signal structure (Figure 1). A higher antenna height is beneficial to the carrier phase and pseudorange combination method.

Conclusion & Significance: The use of GNSS-R for snow depth estimation is feasible as demonstrated by theoretical studies and experimental results. The different snow depth estimation methods may be combined to obtain an accuracy gain. The spatial and temporal resolutions of snow depth measurement can be significantly improved by exploiting GNSS-R.

Image

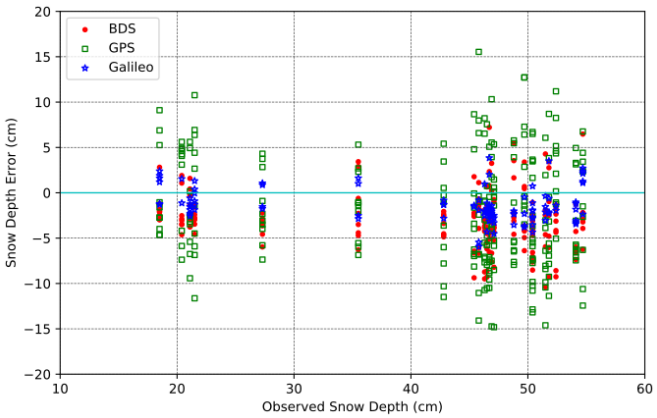


Figure 1: Effects of satellite signals of different constellations on snow depth estimation accuracy with dual-frequency carrier phase and pseudorange combination.

Recent Publications

1. Larson KM, Gutmann ED, Zavorotny VU, Braun JJ, Williams MW, Nievinski FG (2009) Can we measure snow depth with GPS receivers? *Geophysical Research Letters*, 36: L17502.
2. Ozeki M, Heki K (2012) GPS snow depth meter with geometry-free linear combinations of carrier phases. Journal of Geodesy 86(3):209-219
3. Nievinski FG, Larson KM (2014) Inverse modeling of GPS multipath for snow depth estimation—Part II: Application and validation. IEEE Transactions on Geoscience and Remote Sensing 52(10):6564–6573
4. Yu K, Ban W, Zhang X, Yu X (2015) Snow depth estimation based on multipath phase combination of GPS triple-frequency signals. IEEE Transactions on Geoscience and Remote Sensing 53(9): 5100-5109
5. Yu K, Li Y, Chang X, (2018) Snow depth estimation based on combination of pseudorange and carrier phase of GNSS dual-frequency signals. IEEE Transactions on Geoscience and Remote Sensing doi.org/10.1109/TGRS.2018.2869284



Biography

Kegen Yu received the Ph.D. degree from the University of Sydney, Australia, in 2003. He was awarded Hubei “One Hundred Talents Program” in 2015. He was with a number of universities and research organizations, including the University of Oulu, Oulu, Finland; the CSIRO ICT Centre, Sydney, Australia; Macquarie University, Sydney; the University of New South Wales, Sydney; and Wuhan University, Wuhan, China. He is currently a Professor with the School of Environmental Science and Spatial Informatics, China University of Mining and Technology, Xuzhou, China. He has co-authored the book *Ground-Based Wireless Positioning* (Wiley-IEEE Press, 2009) and another book *Wireless Positioning: Principles and Practice* (Springer, 2018), and has authored or co-authored over 100 refereed journal and conference papers including more than 50 SCI journal papers. He edited the book *Positioning and Navigation in Complex Environments* (IGI Global, 2018) and another book *Indoor Positioning and Navigation* (Science Press, 2018).

Email: kegen.yu@foxmail.com
Phone:

Notes/Comment