# Low-cost GNSS applications to area surveying under forest canopy: possibilities and limitations

Tetsuhiko Yoshimura, Faculty of Life and Environmental Science, Shimane University, Japan
Yasushi Suzuki, Faculty of Agriculture and Marine Science, Kochi University, Japan

## Introduction

Large positional errors when using GNSS receivers in dense-canopy forests, which block and attenuate GNSS signals, have posed a significant challenge since the 1990s. This study focused on the use of low-cost GNSS receivers for area measurement in forestland because GNSS receivers with post-processing differential correction (DGNSS) functions are relatively unaffordable for small-scale forest owners in Japan.

## Study site

The study site was located in the Tane block of Sanbe University Forest, Shimane University, Japan. The field trials were conducted on November 8, 2013, in a Japanese cedar (Cryptomeria japonica) plantation forest (planted in 1956). The average tree height and diameter at breast height were 21.1 m and 26.6 cm, respectively. The stand density was 975 trees/ha. As shown in Figure 1, the stand conditions of the study site, and as shown, standing trees limited the visibility in the horizontal direction as well as in the vertical direction.

Figure 1. Stand conditions of the study site

## GNSS measurements

The low-cost GNSS receivers used in this study were two sets of Garmin GPSMAP 62SJ (Figure 2), which receives L1 signals from the GPS, GLONASS, QZSS and multi-functional satellite augmentation system (MSAS) satellites and does not have post-processed differential correction functionality. The MSAS is a Japanese satellite-based augmentation system that supports real-time DGPS and is designed to supplement the GPS system. With the two devices on one tripod, we measured a polygonal area of 0.24 ha surrounded by 13 vertex points (Figure 3). At each of the 13 vertex points, we conducted the GNSS measurements for five minutes with the logging interval of one second. One of the two devices was with the MSAS correction while the other was without the MSAS correction.


Figure 2. Garmin GPSMAP 62SJ

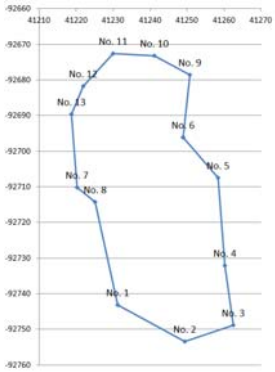


Figure 3. Polygonal area (unit: m)

## Results and discussion

Figures 4 and 5 show the results of GNSS measurements at the 13 vertex points and those of area measurements with and without the MSAS correction, respectively. The areas measured with the MSAS and without the MSAS were 0.226 ha and 0.278 ha corresponding to 95.2 % and 117.9 % of the actual area (0.24 ha), respectively. Furthermore, this study used the Monte Carlo simulation for area measurements in a four times larger virtual polygon with an area of 0.95 ha (Figure 6). As a result, the error rates of area estimation could be -9.0 to +3.6 % of the true area, and that these error rates could be improved to be -5.2 to +2.2 % when the measured area was four times larger than the true area (Table 1).

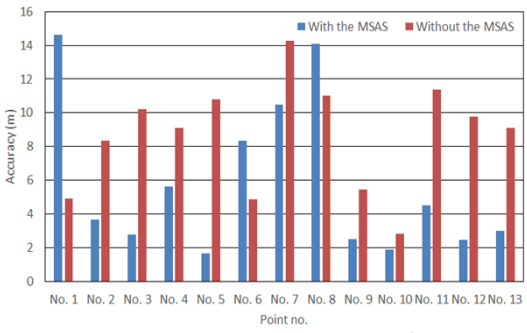


Figure 4. Accuracy comparison of GNSS measurements at the 13 vertex points

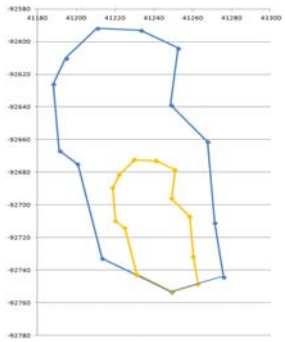

Figure 6. Actual (small) and virtual (large) polygons

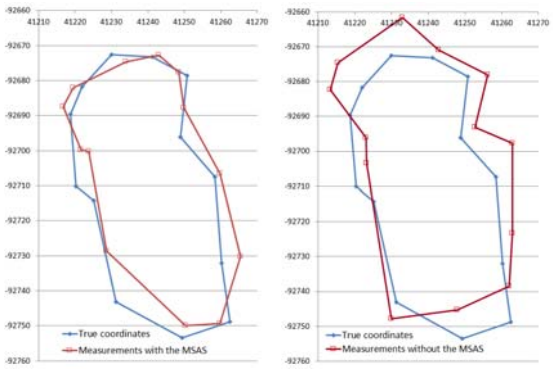


Figure 5. Results of area measurements with and without the MSAS correction

Table 1. Results of the Monte Carlo simulation

| | Actual (small) | Virtual (large) |
|---|---|---|
| True | 2373.67㎡ | 9494.67㎡ |
| Average | 2297.28㎡ | 9339.57㎡ |
| Max. | 2614.63㎡ | 9941.40㎡ |
| Min. | 1963.88㎡ | 8650.54㎡ |
| 95% interval | -9.0～+3.6% | -5.2～+2.2% |