GROWTH OF FOREST FLOOR VEGETATION OBSERVED FROM SNOW DEPTH MEASUREMENTS IN SODANKYLÄ, FINLAND

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The results show that annual growth of forest floor vegetation can be observed from snow depth measurements by using fixed stakes and reference measurements. Finnish Meteorological Institute has research station in Sodankylä in northern Finland, and the main snow measurement site is in sparse pine forest and clearing in it. Automatic countinuous snow depth measurements has been made since 2006 with two Campbell Scientific SR50 sensors installed to forest and clearing. Snow depth is also measured manually on weekly with fixed stakes from clearing since 2009 and from forest since 2010. Annually growing bias has been observed in comparison of manual and automatic measurements, so that value of the manual measurements is larger than the automatic, on average. This trend is more visible in the forest than in the clearing, and average bias grows approximately 0.7 cm per year. We suggest that the bias is caused by growth of forest floor vegetation around the fixed stakes. The results show that level of forest floor vegetation is an error source in snow depth observations made with fixed stakes.

Keywords: snow depth, forest floor vegetation, lichen and moss growth

INTRODUCTION

The growth of forest floor vegetation is used in Finland for example to research impact of reindeer hearding (Herder et al., 2003, Köster et al., 2013 and Köster et al., 2017), soil CO_2 flux (Laurila et al., 2000 and Aurela et al., 2013), and pollution accumulation to plants (Monni et al., 2000 and Zverev et al., 2008).

The growth is slower in taiga forest in northern Finland than in areas closer to the oceans with longer growth seasons, and growth of lichen is observed to be 0.30-0.43 cm per year in pine forest in northern Finland (Helle et al., 1983). Traditionally, forest floor vegetation growth is measured by measuring length of plant or change in biomass (Hunt, 1990). We propose that growth of forest floor vegetation can be estimated from the snow depth measurements made with both fixed stakes and reference measurements.

On the other hand, fixed stakes has a long history as the main instrument to measure snow depth in Finland, which are still used for research purposes. Therefore, vegetation based error of the snow depth measurements is important but poorly researched in taiga snowpack.

This paper includes description of the used data set from Sodankylä, comparison of fixed stakes with automatic reference measurements and conclusions.

MATERIALS AND METHODS

Finnish Meteorological Institute's research station in Sodankylä in northern Finland has measurement site with extent measurements for calibration and validation of satellite observations of snow and soil in addition to satellite receiving activities. Operational manual snow depth measurements were performed daily in Sodankylä in 1908-2008, when automatic measurements replaced them. Snow measurements has been made for research purposes since 2006. Detail description of snow conditions, manual snow measurements and measurement sites in Sodankylä is in paper Leppänen et al., 2016.

The main snow measurement site, Intensive Observation Area (IOA), is in sparse pine forest and clearing in it (Figure 1). Vegatation of the forest floor mainly consists of moss (*Pleurozium schreberi*), lichen (*Cladonia rangiferina and Cladonia mitis*), heather (*Calluna vulgaris*), lingonberry (*Vaccinium vitis-idaea*) and crowberry (*Empetrum nigrum*). The area is fenced so that reindeers have no access to it. IOA has several instruments for validation and development of snow and soil remote sensing instruments and interpretation algorithms. Additionally, several automatic reference snow, soil and meterological measurements are installed. Weekly manual snow measurements are also performed at IOA during the snow cover.

In this paper is used snow depth data from manually measured fixed stakes and automatic stations in clearing and forest. Measurements at clearing are side by side, while measurements at forest are approximately 25 m away from each other.

Figure 1. Intensive observation area, IOA. Location of fixed stakes are marked with red circles and automatic stations with yellow circles.

Fixed stakes

Snow depth is measured manually from clearing and forest at IOA (Figure 1) with fixed stakes (Figure 2). The stakes are installed so that zero point is in level of ground surface. Five fixed stakes was installed in 2009 to the clearing and two stakes was added in 2010. Measurements are made from the forest with ten fixed stakes since 2010. The fixed stakes in forest were removed for the maintenance work and reinstalled in 2015.

Measurements are made usually on weekly basis during the snow cover, except in winter 2014-2015 when observations were performed every two weeks. Observation is made visually by estimating average snow depth around the stake.

Automatic sensors

Continuous automatic snow depth measurements are made since 2006 with two SR50 sensors (Campbell Scientific) installed in automatic weather stations to forest and clearing at IOA (Figure 1). Below the automatic sensors is an artificial turf and sensors are calibrated so that vegetation has no affect to observations (Figure 3).

a)

b)

Figure 2. a) Seven fixed stakes in clearing and b) ten fixed stakes in forest at IOA.

a) b)

Figure 3. Automatic snow depth measurement with SR50 sensor a) in clearing and b) in forest at IOA. Green artificial turf is installed below the sensors.

RESULTS

Annually growing bias is observed in comparison of manual and automatic measurements, so that value of the manual measurements is larger than the automatic, on average. This trend is more visible in forest than in clearing. Bias between average of fixed stakes and automatic measurements from 09:00 UTC is calculated for clearing and forest separately (Figure 4). The regression lines with positive slopes are fitted to the values.

Bias is estimated to grow linearly, and difference between beginning and end of the regression lines are 7.1 cm for forest and 3.6 cm for clearing. We suggest that the bias is caused by growth of forest floor vegetation around the fixed stakes. That means average growth rate of 1.0 cm per year for forest and 0.4 cm per year for clearing.

Growth rate of lichen is measured to be lower in clear-felled areas than shadowed maximum 60 years old pine forests, because of the differing environmental conditions (Helle et al., 1983). However, growth rate of lichen (Helle et al., 1983) is lower than observed growth rates, due to other plants are growing in the measurement area. Vegetation is also slightly different in forest than in clearing, which cause the difference in growth rates.

During the melting seasons bias is smaller than during mid-winter or negative at clearing (Figure 4). That is caused by melting of the snow around the stakes. This is less visible in the forest, where shadows reduces warming of the stakes. To reduce errors, biases with values smaller than -5 cm and for forest larger than 20 cm and for clearing larger than 15 cm were removed from the data set.

CONCLUSION

A new method to evaluate growth rate of forest floor vegetation is to compare snow depth measurements of manual fixed stake and automatic reference instrument. The method does not measure growth rate of a single plant, but gives an average growth rate for the area.

Snow depth is measured manually from fixed stakes and with automatic SR50 sensors in sparse pine forest and clearing in it in Sodankylä, northern Finland. Data from total 17 fixed stakes are used, seven in clearing and ten in forest, and average values are calculated for both separately. The values from fixed stakes are compared to automatic observations of Campbell Scientfic SR50 sensors. The bias between those is annually growing, and it is possible to fit line to the values. In Sodankylä average growth rate of forest floor vegetation is approximately 1.0 cm per year for forest and 0.4 cm per year for clearing, and on average 0.7 cm per year, based on analysis of snow depth data.

Accordingly, growth of forest floor vegetation is related to measurement bias of snow depth observations from fixed stakes. That error source needs to be accounted when using snow depth data from fixed stakes at area where forest floor vegetation is growing.

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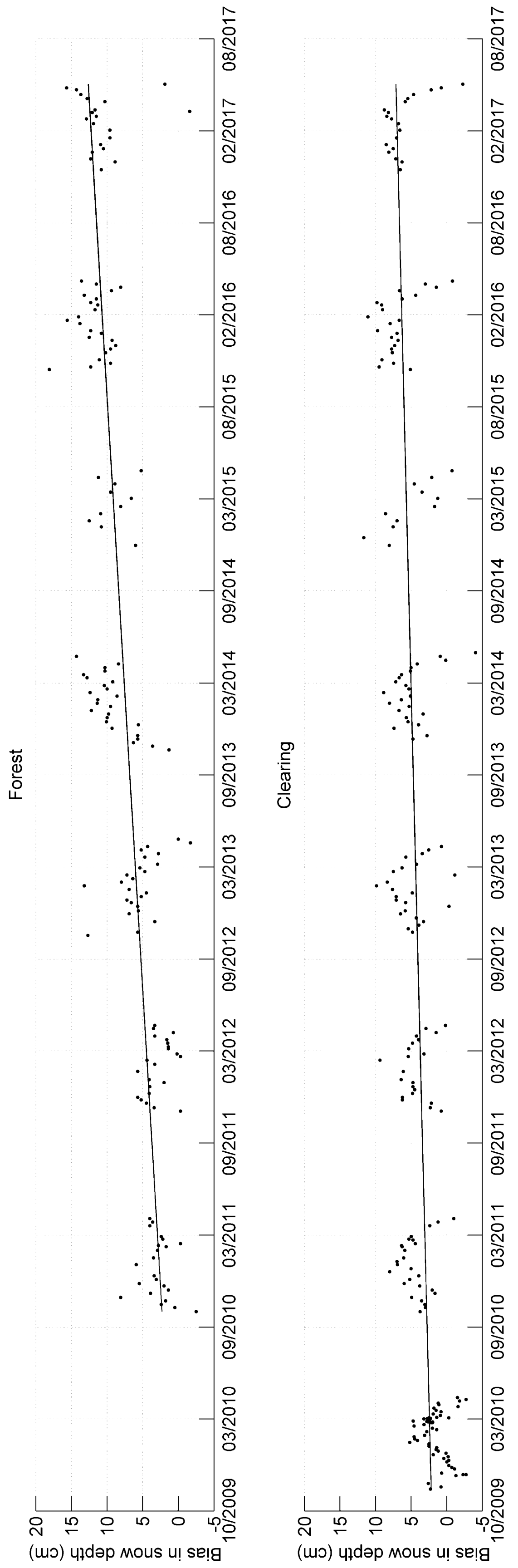

Figure 4. Bias in snow depth between automatic measurements and fixed stakes for forest and clearing for the dates when both measurements were available. The linear regression lines are fitted to the values.

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