Abstract.

A methodology for evaluating the accuracy of snow depth measurement are demonstrated in this study 1) by applying the equation of error propagation into the manual snow depth measurements and automatic sensors of the same type and 2) by comparing autimatic measurement with manual observation. The snow depth measurement system at the Centre for Atmospheric Research Experiments (CARE) site of the Environment Canada (EC) was comprised of three bases and three snow depth targets during the 2013-2014 winter experiment. Three ultrasonic and one laser snow depth sensors and twelve snow stakes located at the corner of snow target were placed on each base. Data from snow depth sensors are quality-controlled by range check and step test to eliminate erroneous data such as outliers and discontinuities before quantifying uncertainty of snow depth sensors.

Bias errors were calculated in manual measurements to show the spatial variability of snow depth at CARE site by considering snow depth measured from four snow stakes located on the easternmost side of the site as reference. The bias error of snow stakes on the west side of the site was largest (maximum: 7.99 cm). The uncertainty of all pairs of stakes (36 stakes), the average uncertainty for each base (12 stakes), and that for each snow depth target (4 stakes) were 1.81 cm, 1.52 cm, and 1.33 cm. These values could be smaller when taking into accounting the temporal variation of manual observations. The bias error and normalized bias removed root mean square error (NBRRMSE) for each snow depth sensor were calculated to quantify the systematic error and random error in comparison of snow depth sensors with manual observations that share the same snow depth target. The snow depth sensors on base 12A (11A) measured snow depth larger (less) than manual observation up to 10.7 cm (5.21 cm) although they were set to zero value before snow season (not shown). NBRRMSEs ranged from 5.10% to 16.5 % and these values depended on location rather than sensor types. Finally, the instrumental uncertainties of each snow depth sensor were quantified by comparing three

sensors of the same type installed at the different bases and ranged from 0.62 cm to 3.08cm.