Title: Sandy Creek Snow Study Station

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Dataset Overview:

The Sandy Creek Snow Study Station provided stationary, in situ measurements of meteorological variables (temperature, relative humidity, wind speed and direction, precipitation) and automated snow depth measurements (total snow depth and interval snow depth). An automated camera also took photos of the interval snow depth board. Manual snow depth and snow water equivalent measurements were performed in the same location during IOPs (see readme file in manual-snow-obs directory).

Time period covered by the data:

December 5, 2013 – January 29, 2014 (full suite of instruments)
October 17 – December 4, 2013 (no precipitation or interval snow depth measurements)

Time period covered by the snow depth camera:

December 10 – December 21, 2013
January 07 – January 29, 2014

Location of station:

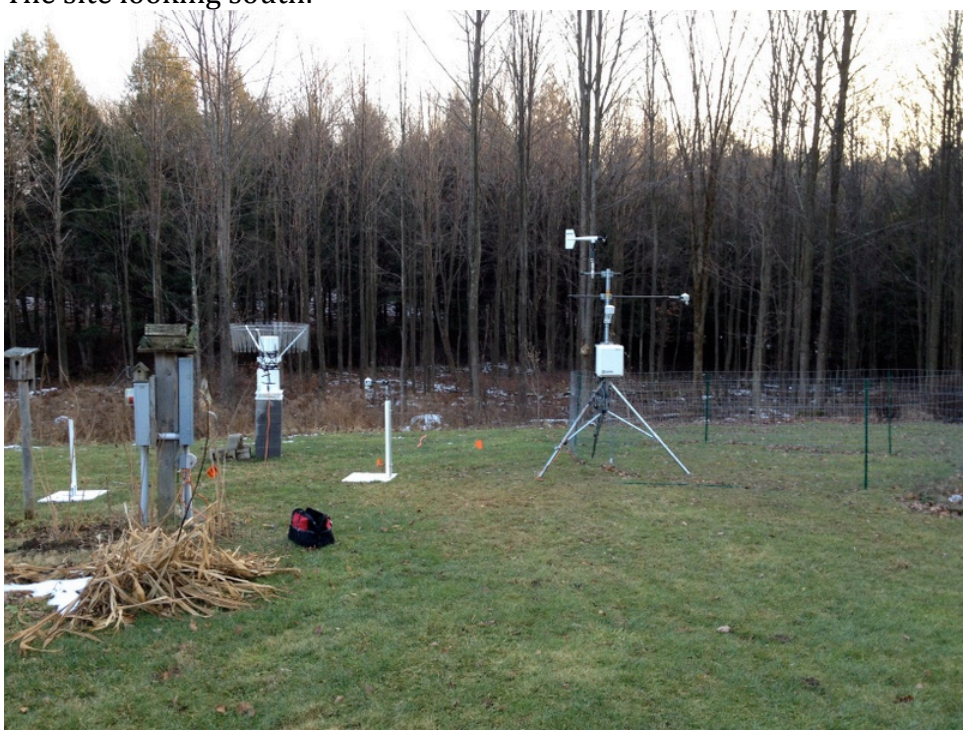
43.6402 N, 76.09715 W
Elevation: 143 m MSL

Instrument Description:

Location:

The Sandy Creek Snow Study Station was located in a clearing surrounded by dense forest. The clearing had a large enough sky view factor that tree intercept of precipitation was not observed but was sheltered enough by surrounding trees to prevent snow transport during all but the most windy periods of the OWLeS program.

The site looking south:

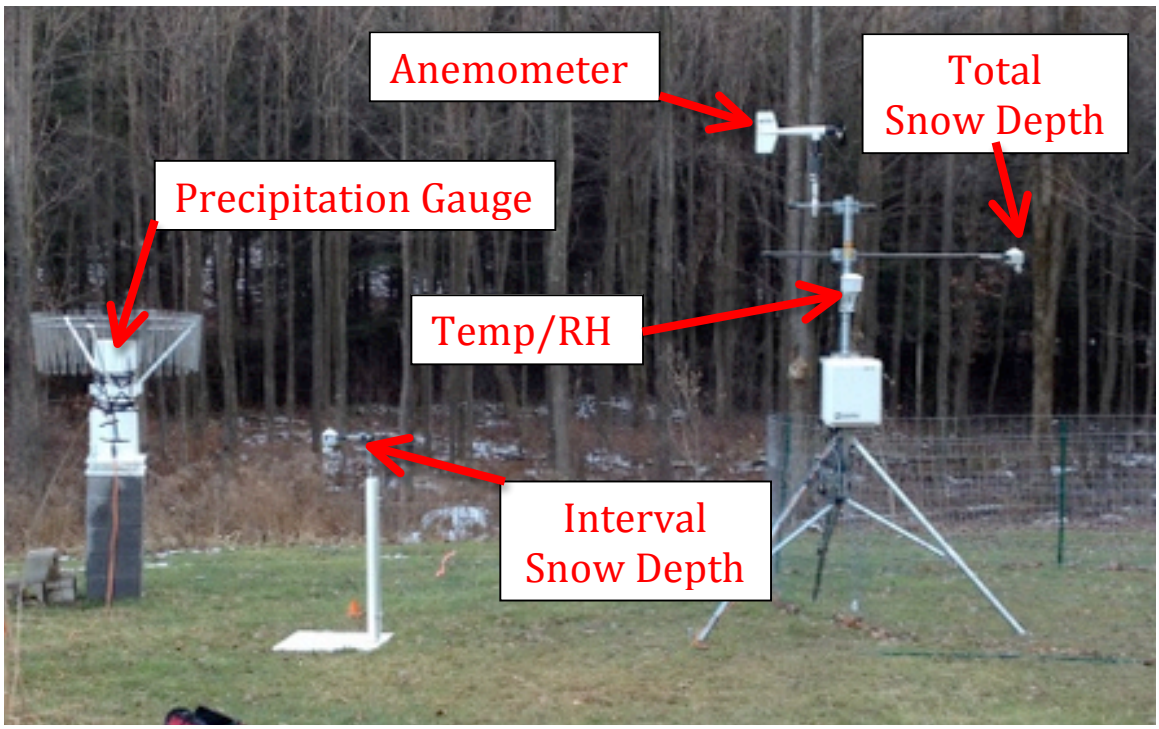


The site looking east:

The site looking north:

The site looking west:

Sensor specifications and additional information:
A tripod held the anemometer, temperature and relative humidity sensor, and total snow depth sensor. The precipitation gauge was located about 5 m away from the tripod, and the interval snow depth sensor was attached to a snow board that could be moved around within about 2 m of the tripod. The snow depth camera was mounted on a stake and positioned facing the interval snow depth sensor.



Anemometer: *RM Young 05103*

The anemometer was mounted on top of the tripod at a height of approximately 3.2 m above the ground and was oriented to true north (about 13.5° from magnetic north). The purpose of mounting the anemometer in this location was primarily to provide information about wind conditions that might affect the precipitation gauge and depth sensor measurements.

Temperature and relative humidity probe: *Vaisala HMP60*

The temperature and relative humidity probe was mounted in a radiation shield on the north side of the tripod at approximately 1.5 m above the ground.

Weighing precipitation gauge: *ETI NOAH II*

The precipitation gauge was mounted on a levelable board on top of a 1 meter tall tower of cement cinder blocks. The gauge was surrounded by an

Alter shield to reduce undercatch. The precipitation gauge was filled with a few inches of an antifreeze/hydraulic oil mixture on December 4th, 2013, and this liquid, along with captured precipitation, was drained and refilled on December 19, 2013. The body of the precipitation gauge was wrapped in heat tape to keep the liquid in the chamber from freezing at very cold temperatures and/or during high snowfall rates.

Interval Snow Depth sensor: *Judd Communications Ultrasonic Snow Depth Sensor*

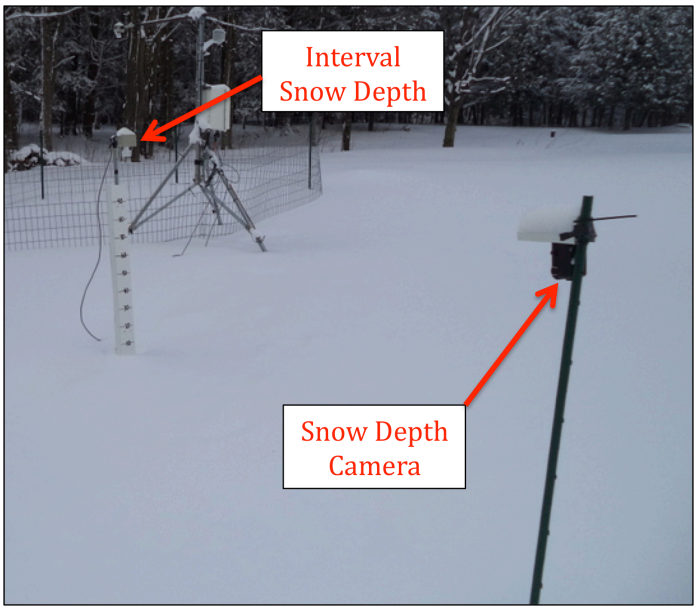
This depth sensor was mounted 1.2 m above a 2'x2' snow board. Manual snow depth measurements were performed at approximately 6 hour intervals on this snow board during IOPs. After each manual measurement, the snow board would be swept, effectively resetting the interval depth. The board was not swept during non-IOP periods and IOPs in which the Utah team did not take manual snow measurements (i.e. short-axis events).

Total Snow Depth sensor: *Judd Communications Ultrasonic Snow Depth Sensor*

The total snow depth sensor was mounted on a cross-arm extending out from the tripod, at a height of 2.5 m above the ground. This sensor provided a record of the total snowpack depth throughout the field program. A wire fence was placed around the area surveyed by the depth sensor to keep deer from disturbing the snow. The wire fence did not appear to cause drifting or settlement effects that might detract from the quality of the depth sensor data.

Snow Depth Camera: *Bushnell Trophy Cam HD*

Originally designed to take automated pictures of animals, this camera has a motion sensor that triggers the camera, in addition to the capability to automatically take photos at a set interval. The battery-powered camera was programmed to snap a photo every 5 minutes, day and night. The camera was pointed at the automated interval snow depth sensor board to provide a quality check on the automated depth measurements, as well as a picture of the weather conditions as viewed by the naked eye.



Sensor specifications*:*

Anemometer: *RM Young 05103*

- Wind speed: 0-224 mph
- Wind direction: 0 to 360 degrees
- Operating temperature: -50C to +50C

Temperature and relative humidity probe: *Vaisala HMP60*

- Temp range: -40C to -60C
- Relative humidity 0% to 100%

Weighing precipitation gauge: *ETI NOAH II*

- Capacity: 12 inch
- Accuracy: +/- 0.01 in
- Operating temperature: -30C to +50C

Snow Depth sensors: *Judd Communications Ultrasonic Snow Depth Sensor*

- Accuracy: +/- 1 cm or 0.4% distance to target
- Resolution: 3 mm (0.12 in)
- Operating temperature: -40C to +70C

Snow Depth Camera: *Bushnell Trophy Cam HD*

- Resolution: 5 megapixel
- Wavelength spectrum: visible (day), near-infrared (night)

Data Collection and Processing:

Snow depth camera photos were logged on a memory card in the camera, and all weather station data was logged on a Campbell Scientific CR1000 datalogger for the duration of the field program. Data was collected following IOPs for redundancy.

Weather station data is available in both raw (sandy-creek/data/raw/) and processed (sandy-creek/data/processed/) format. Processing involved the following:

- Total snow depth:
  - Values > 200 cm set to NaN
  - Values < 0 cm set to 0
- Interval snow depth:
  - Values > 65 cm set to NaN
  - Values < 0.2 cm set to 0
  - Values that increased more than 8 cm in one five minute period set to NaN
  - Individual unrealistic values identified manually and set to NaN
- Wind direction:
  - Values <= 0 or >= 360 set to NaN
- All other variables passed basic quality control measures (i.e. checking for realistic values) and were not changed.

Data Format:

Weather station data is available in comma delimited (.csv) format.

The processed data is available in five minute intervals only and is named:
/sandy-creek/data/processed/sandycreek_processed_all.csv.
This file contains all the data collected during the entire OWLeS period.

The raw data is available in either five minute or hourly intervals, and files are named as follows:
/sandy-creek/data/raw/sandycreek_datainterval_YYYYMMDD_HHMMSSUTC.csv
Where the time stamp represents date and time (UTC) that data was collected from the data logger. Each data file includes data from December 4th to the date of collection.

Five Minute Data Interval Header:
array ID, year, day of year, time (UTC), seconds, air temperature (°F), air temperature (°C), relative humidity (%), windvector (m s^{-1}), wind direction, wind speed (m s^{-1}), battery voltage, panel temperature (°C), interval snow depth (cm), total snow depth (cm), five minute precipitation (cm)

Hourly Data Interval Header:
array ID, year, day of year, time (UTC), seconds, interval snow depth (cm), total snow depth (cm), hourly precipitation (cm), interval depth sensor temperature (°F), total depth sensor temperature (°F), total precipitation since last reset (in)

* These headers are also available at /sandycreek/data/headers.txt

Sampling and Averaging Times:

Variable	Sampling Interval	Averaging or Reporting Interval	Quantity Reported
Wind speed (m s^{-1})	10 sec	5 min	Mean horizontal wind speed
Wind direction	10 sec	5 min	Unit vector mean wind direction
Max wind gust (m s^{-1})	10 sec	5 min	Maximum instantaneous horizontal wind speed
Air temperature (°C)	10 sec	5 min	Mean air temperature
Relative humidity (%)	10 sec	5 min	Mean relative humidity

Interval snow depth (cm)	10 sec	5 min	Instantaneous depth
Total snow depth (cm)	10 sec	5 min	Instantaneous depth
Precipitation (cm)	10 sec	5 min	Total interval snow water equivalent

Snow depth camera photos are available in .jpg format at five minute intervals. Files are named as follows:
/sandy-creek/snow-depth-camera/YYYYMMDD_HHMMSSEST_sandycreek.jpg
Where the time stamp represents date and time (EST) that the photo was taken. The images are automatically stamped with time in EST as well as the temperature provided by some sort of temperature sensor of unknown accuracy built into the camera.

Data Remarks:

• Overall, data quality from this station appeared to be quite good.
• There may be some undercatch of precipitation by the ETI gauge. Refer to fieldnotes for more information about the impact of wind during specific events.
• The shields around ultrasonic snow depth sensor temperature probes would get filled with snow during periods of high snowfall rates. This snow was removed when noted. There was some concern that this might affect the accuracy of the snow depth measurements, but this has not been apparent when comparing the automated measurements to the manual snow depth measurements conducted on the same board.
• Interval snow depth data during IOP3 was affected by small flags used to mark the edges of the snow board. The inaccurate readings have been quality controlled and removed, and replaced with NaN values in the processed data.
• During heavy snowfall rates there were some periods where the snow depth camera lens became covered with snow, making the images blurry or useless.
• Additional notes on the Sandy Creek Snow Study Station are available in the /sandy-creek/fieldnotes/ folder