Fluxnet-Canada
Groundhog River Flux Station

Fluxnet-Canada Metadata Documentation

Version 1.0

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Queen's University

Department of Geography

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Please Note: This Document is an evolving one.

Fluxnet-Canada Metadata Documentation Guidelines

Table of Contents
This is an outline of the required data set documentation for Fluxnet-Canada. It is based on the BERMS and BOREAS models. The data documentation includes:

1. Data Set Overview

Fluxnet Canada ON-OMW Mixed Wood Tower Flux Data.

1.1 Data Set Identification
This site is known as ON-OMW Tower Flux data from the Groundhog River Station.

1.2 Study Overview

The large area of boreal mixed woods makes it the largest potential C sink of the central boreal forest. As part of Fluxnet-Canada, the Groundhog River Station was established in August of 2003 to study the carbon cycling of boreal mixed wood forest ecosystems in Canada. An important issue for C cycling in boreal mixed woods is whether management practices should encourage retention of mixed wood stands or conversions (or partial conversion) to conifers. Thus, one objective of this study is to help inform management practices on C exchange for this important forest type. The measurements described in this document are specifically aimed at measuring the net ecosystem exchange of carbon dioxide and water vapour exchange between the forest and atmosphere at the Groundhog River Station. The aim of this project is also to continuously measure the fluxes of carbon dioxide, sensible and latent above a boreal mixed wood stand over multiple years to provide valuable information on the role of climate variability; to obtain estimates of gross ecosystem photosynthesis and ecosystem respiration; to compare EC-based and chamber-based measurements of respiration; to determine the effects of environmental factors on stand NEP and evapotranspiration; to study the processes controlling turbulent transfer of CO_2 and water vapour within the stand; and to evaluate methods of estimating nocturnal carbon dioxide in and above the stand.

1.3 Data Set Introduction

The Groundhog River site measures carbon dioxide, sensible heat, latent heat and meteorological variables above and throughout the canopy. These variables are used to calculate net ecosystem exchange (NEE), respiration (R), and storage fluxes.

The data from Groundhog River is stored in the Fluxnet-Canada DIS. Data sets are ASCII comma delimited and are broken down into six categories. The categories are Ecological, Ancillary, Main, Summarized, Computed Fluxes and NEP (net ecosystem productivity). The ecological data sets provide information/data about forest composition. Ancillary files contain raw data used to derive carbon, water, energy fluxes and NEP. This category contains Met1 and Flx1 data sets. Main files contain the most complete subset of meteorological variables where most have been corrected and some have been derived, but none have been gap-filled. This category contains Met2 data sets. The summarized files are meteorological variables that have been aggregated and gap-filled. Computed flux files contain carbon, water, and energy flux and storage information. This category contains flx2 data sets. Finally, NEP files contain NEE, NEP, gross ecosystem productivity (GEP) and R information. This category contains flx3 data sets. For further details about the instruments used and nature of the data please refer to sections 4 and 7 respectively.

1.4 Related Data Sets
[*Note any similar or related data collected by the investigator, other investigators, or other data centres. Something like five or six related data sets is a good number to provide.*]

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2.5 Acknowledgements
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3. Theory of Measurements

Measurements of the fluxes of momentum, sensible heat, water vapour, and CO_2 were made with the eddy covariance technique that describes the vertical flux (F_x) of an entity, x, as equal to the covariance of the vertical velocity (w) and the concentration of x. This is expressed as

$$F_x = \overline{w'x'} \qquad (3.1)$$

Where the prime is the difference in the means from the mean and the overbar is the time average over a period of a half hour. When F_x is positive, the flux is upwards. Velocity components, air temperature, water vapour density, and CO_2 concentration in the air are sampled at 20 hz, and from this half hour fluxes are computed. Eddy covariance measurements are performed at 41.148 m. Three rotations in the coordinate transformation were applied to the flux data to make the lateral component (v) and vertical component (w) of the wind vector, and the covariance, cov(w v), equal to zero. Mixing ratios were used following Webb, Pearman, and Leuning (1980) and were measured using the closed-path LI-COR 7000 infrared gas analyzer (IRGA). The broadening correction was done online (see Chen et al.,1999, for summary of theory). The rate of change in CO_2 storage (the "storage flux") in the air column below the EC measurement level was calculated from the mole fraction measurements of the LI-6262 IRGA that sampled eight profile levels. The mole fraction was determined by

$$F_s = \overline{j(\partial h_{(i,j)}\rho_{(i,j)}(\partial \chi_{c(i,j)} / \partial t} \ , \qquad (3.2)$$

where ∂h is the thickness of the j-th air layer centered around each measurement height, and ρ is the mean molar air density in the layer. Then, $\partial \chi_{c(i,j)} / \partial t$ was calculated for half-hour i using

$$\partial \chi_{c(i,j)} / \partial t = \frac{\chi_{(i+1j)} - \chi_{(i-1j)}}{\partial t} \qquad (3.3)$$

where ∂t = 3600s. When mixing ratio was available from the LI-6262, it was used instead of mole fraction, and the mean air density was replaced by mean dry air density ρ_a in the equation above.

Net ecosystem exchange (NEE) of C was calculated as

$$\mathrm{NEE} = F_c + Fs \qquad (3.4)$$

With this definition, positive values of NEE correspond to C losses from the ecosystem.
Storage fluxes of latent and sensible heat, the soil surface heat flux, biomass heat storage, and energy used in photosynthesis were calculated from meteorological measurements using the method described by Oliphant et al. (2004).

4. Equipment

Figures 4.1 and 4.2 show the experimental layout of the Groundhog River Station.

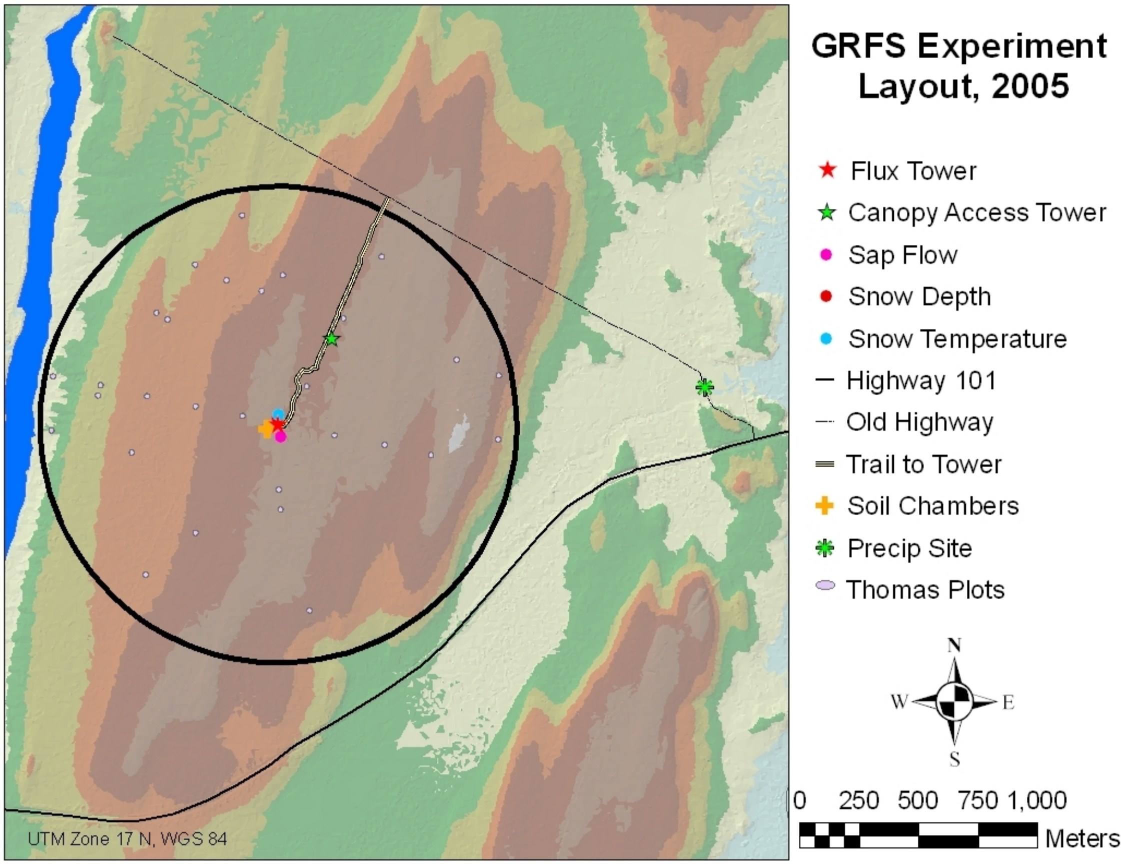

Figure 4.1. Experimental layout of the Groundhog River Station

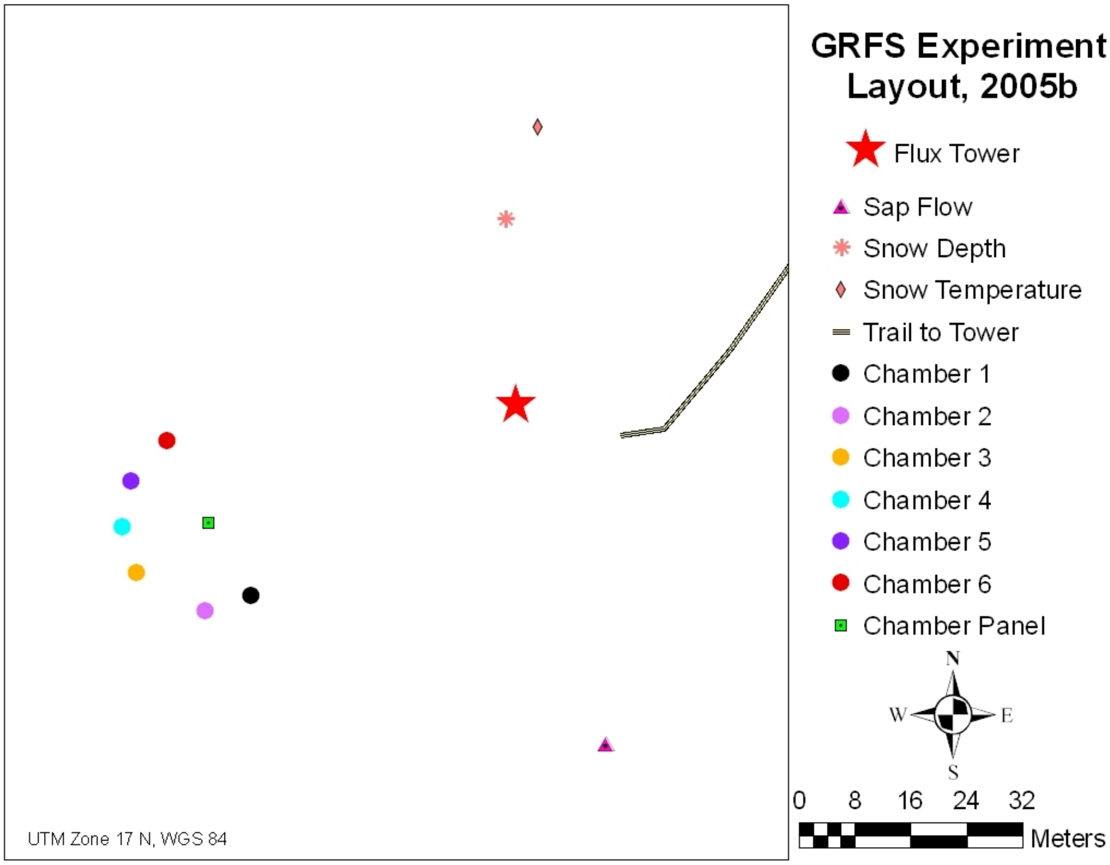

Figure 4.2. Experimental layout around the Groundhog River Station tower.

4.1.1 Sensor/Instrument Description

Instrument: Omega RTD-810
Measures: air temperature
Location: Above canopy 43 m agl
Characteristic of Instrument: Aspirated in a MetOne 076B-1 Shield; 100 Ohm, Alpha=0.00385 Pt RTD Sensor: measurement range: -200 to 750°C

Instrument: Vaisala HMP45C
Measures: air temperature and humidity
Location: Above canopy 43 m agl
Characteristic of Instrument: Aspirated in a Met One Shield; temperature range: -40 to 60°C; relative humidity range: 0.8 to 100%; Accuracy is ±2% over 10-90% RH; ±3% over 90-100% RH; Response time of the RH sensor is 15 seconds at 20°C with the Teflon membrane filter; The voltage drop along the leads will cause an error of about 0.56°C and 1.56% in the temperature and RH measurements with every 30 metres of additional cable length

Instrument: Vaisala HMP45C
Measures: air temperature and humidity
Location: In canopy at 21.3m agl; In canopy at 11m agl; Below canopy at 1.5m agl; Precipitation site at 2.74 m agl
Characteristic of Instrument: Radiation shielded; for more detail please see above.

Instrument: Omega Chromel-Constantan Thermocouple
Measures: air temperature
Location: Above canopy 43 m agl
Characteristic of Instrument: Bare wire; Temperature range: -40°C to 149°C; Accuracy: 1°C

Instrument: Omega fine wire 0.005 Cu-Co thermocouple
Measures: air temperature
Location: In canopy at 21.3m agl; In canopy at 11m agl; Below canopy at 1.5m agl
Characteristic of Instrument: Radiation shielded with an RM YOUNG 12 plate shield; Accuracy: 1°C

Instrument: RM Young 05103 wind monitor anemometer
Measures: Wind speed and direction
Location: Above canopy at 43m agl
Characteristic of Instrument: Wind speed range: 0 to 60 m/s (216 kph); Gust survival: 100 m/s (360 kph); Azimuth range: 360 degress mechanical, 355 degree electrical (5 degree open); Wind speed Accuracy: +-0.3 m/s; Wind direction Accuracy: +- 3 degrees; Threshold Propeller: 1m/s; Threshold Vane: 1.1 m/s

Instrument: Campbell Scientific SR-50 Ultrasonic Depth Gauge
Measures: snow depth
Location: Below canopy at 221m agl
Characteristic of Instrument: Measurement range: 0.5 to 10 m; Accuracy: +-1cm or 0.4 % of distance to target (whichever is greater) requires external temperature compensation; Resolution 0.1 mm; Beam acceptance angle is approximately 22 degrees; operating temperature: -30°C to 50°C

Instrument: Li-Cor LI-190SA Quantum Sensor
Measures: PAR
Location: Above canopy at 37m agl (downwelling and upwelling PAR); Below canopy at 1.5m agl (downwelling PAR)
Characteristic of Instrument: Absolute Calibration: ± 5% traceable to the National Institute of Standards and Technology (NIST); Sensitivity: Typical 5 u A per 1000 umol s-1 m-2; Linearity: Maximum deviation of 1% up to 10,000 µmol s-1 m-2.; Stability: Typically < ± 2% change over a 1 year period; Response Time: 10 µs; Temperature Dependence: 0.15% per °C maximum; Cosine corrected up to 80° angle of incidence; Azimuth: < ± 1% error over 360° at 45° elevation. Operating Temperature**:** -40 to 65°C, Relative Humidity: 0 to 100%.

Instrument: NR LITE net radiometer
Measures: net radiation
Location: Below canopy at 1.5m agl
Characteristic of Instrument: Blackened thermopile; Spectral response: 0 to 100 um; Response time (e-1): 20 seconds (nominal); Sensitivity: 10 µV W-1 m2 (nominal); Output range: ±25 mV; Range: ±2000 W m-2; Temperature range: -30° to 70°C

Instrument: BF2 sunshine sensor
Measures: downwelling Diffuse PAR
Location: Above canopy at 37m agl
Characteristic of Instrument: Accuracy: +-15% or +-10 umol/m2/s; Resolution 0.6 umol/m2/s; Range 0-2500 umol/m2/s; Output sensitivity 1mV = 1 umol/m2/s; Accuracy of cosine correction; +-10 of incoming radiation over 0-90 degree zenith angle; Azimuthal accuracy: +-5% over 360 degree rotation; temperature range -20 to 50°C

Instrument: Kipp & Zonen CNR1
Measures: Measures both up and downwelling solar and longwave radiation
Location: Above canopy at 37m agl

Characteristic of Instrument: Sensor: Kipp & Zonen's CM3 ISO-class-, thermopile pyranometer, CG3 pyrgeometer, PT100 RTD; Spectral response: 305 to 2800 nm (pyranometer), 5000 to 50,000 nm (pyrgeometer); Response time: 18 seconds; Typical sensitivity range: 7 to 15 uV /Wm2; Output range: 0 to 25 mV (pyranometer), ±5 mV (pyrgeometer); Expected accuracy for daily totals: ±10%; Directional error: < 25 W m-2 (pyranometer); Heating resistor: 24 Ohms, 6 W at 12 Vdc; Operating temperature: -40° to 70°C

Instrument: 24 gauge Cu-Co thermocouple
Measures: soil temperature
Location: 2cm bgl in a pit W of tower; 5cm bgl in a pit W of tower; 10cm bgl in a pit W of tower; 20cm bgl in a pit W of tower; 50cm bgl in a pit W of tower; 100cm bgl in a pit W of tower; 2cm bgl in a pit N of tower; 5cm bgl in a pit N of tower; 10cm bgl in a pit N of tower; 20cm bgl in a pit N of tower; 50cm bgl in a pit N of tower; 100cm bgl in a pit N of tower
Characteristic of Instrument: –250°C to 350°C; Special Limits of Error +/- 1ºF or 0.4% of reading whichever is greater.

Instrument: 24 gauge Cu-Co thermocouple
Measures: snow temperature
Location: on rod near W soil temp pit, 1cm agl; on rod near W soil temp pit, 2cm agl; on rod near W soil temp pit, 5cm agl; on rod near W soil temp pit, 10cm agl; on rod near W soil temp pit, 20cm agl; on rod near W soil temp pit, 30cm agl; on rod near W soil temp pit, 50cm agl; on rod near W soil temp pit, 100cm agl; on rod near N soil temp pit, 1cm agl; on rod near N soil temp pit, 2cm agl, on rod near N soil temp pit, 5cm agl; on rod near N soil temp pit, 10cm agl; on rod near N soil temp pit, 20cm agl; on rod near N soil temp pit, 30cm agl; on rod near N soil temp pit, 50cm agl; on rod near N soil temp pit, 100cm agl
Characteristic of Instrument: Bare wire; –250°C to 350°C; Special Limits of Error +/- 1ºF or 0.4% of reading whichever is greater.

Instrument: 24 gauge Cu-Co thermocouple
Measures: Tree bole temperature
Location: Aspen - 1.5 m agl and 57mm North; 1.5 m agl and 114mm Central; 1.5 m agl and 57mm South; 3.1 m agl and 57mm North; 3.1 m agl and 114mm Central; 3.1 m agl and 57mm South; 6.1 m agl and 57mm North; 6.1 m agl and 114mm Central; 6.1 m agl and 57mm South; Black spruce - 1.5 m agl and 57mm North; 1.5 m agl and 114mm Central; 1.5 m agl and 57mm South; 6.1 m agl and 57mm North; 6.1 m agl and 114mm Central; 6.1 m agl and 57mm South; 10.6 m agl and 57mm North; 10.6 m agl and 114mm Central; 10.6 m agl and 57mm South;
Characteristic of Instrument: Bare wire: –250°C to 350°C; Special Limits of Error +/- 1ºF or 0.4% of reading whichever is greater.

Instrument: HFT3 heat flux plates
Measures: Soil heat flux
Location: West of tower at 10cm bgl; West of tower at 10cm bgl; North of tower at 10cm bgl; North of tower at 10cm bgl
Characteristic of Instrument: Operating temperature: -40°C to 55°C; Plate thickness: 3.91 mm; Plate diameter: 38.2 mm; Sensor: Thermopile; Measurement Range +-100 W/m2; Signal Range: +-2.4 mV for the above range; Accuracy: better than +-5% of reading; Thermal conductivity: 1.22 W/m/K

Instrument: Campbell Scientific CS615 water content reflectometer
Measures: Volumetric soil moisture
Location: in a pit North of the tower 15cm blg; in a pit North of the tower 30cm blg; in a pit North of the tower 45cm blg; in a pit North of the tower 60cm blg; in a pit North of the tower 60cm blg; in a pit North of the tower 100cm blg; in a pit West of the towerapproximately 5 cm blg; in a pit West of the tower 5 cm blg

Characteristic of Instrument: Indirectly measures soil volumetric water content via dielectric constant; Accuracy: ±3% typical; Rod Length: 30.0 cm; Rod Diameter: 3.2 mm; Rod Spacing: 3.2 cm

Instrument: Geonor T-200B precipitation gauge
Measures: Cumulative Precipitation
Location: Precipitation site 2.11 m asl (surface to orifice); un-forested area
Characteristic of Instrument: Capacity 0-600 mm; collecting area: 200 cm2; Sensitivity: 0.1 mm; Accuracy 0.1% FS; repeatability 0.1 mm; Temperature range: -25°C to 60°C; Temperature drift: 0.001% FS/°C

Instrument: Hydrological Services CS700 tipping bucket rain gauge
Measures: Rain over a 30min period
Location: Precipitation site 0.27 m asl (surface to orifice); un-forested area
Characteristic of Instrument: Funnel is 200 mm; Measurement range: 0 to 700 mm/hr; Accuracy: better than 2% at 500 mm/hr; Resolution: 0.254 mm; Temperature range: -20°C to 70°C; Siphon capacity 0.3 mm

Instrument: Licor closed path LI-7000 CO_2/H_2O analyzer
Measures: Eddy covariance; CO_2 concentration; Set up November 12, 2003
Location: above canopy at 41m agl
Characteristic of Instrument: Temperature Range: 0-50 °C ambient, 0-55 °C bench; Range: 0-3000 ppm; Accuracy: 1% nominal

Instrument: CSAT3 three dimensional sonic anemometer
Measures: Vertical and horizontal wind speeds and directions
Location: above canopy at 41m agl
Characteristic of Instrument: Operating temperature range -30°C to 50°C; Noise equivalent wind: ux and uy is 1 mm/s, uz is 0.5 mm/s, c is 1 mm/s (0.002°C). Values are the standard deviations of instantaneous measurements made of a constant signal. The noise is unaffected the sample rate; Wind measurement offset: less than +-4 cm/s over operating range; Measurement path length: 10 cm vertical; 5.8 cm horizontal; Transducer path angle from horizontal: 60 degrees

Instrument: Vaisala CS105
Measures: Surface atmospheric pressure
Location: below canopy at 1.5m agl
Characteristic of Instrument: Operating Range for pressure is 600 mb to 1060 mb; temperature range: -40°C to 60°C, humidity range: non-condening; Total Accuracy (defined as the root of squares of end-point non linearity, hysteresis error, repeatability error and calibration uncertainty at room temperature): +-0.5 mb at 20°C, -+2mb at 0°C to 40°C, -+4 mb at -20°C to 45°C, +-6mb at -40°C to 60°C; Linearity*: +-0.45mb at 20°C; Hysteresis*:0.05mb at 20°C; Repeatability*: 0.05 mb at 20°C; Calibration uncertainty (Defined as +-2 standard deviation limits of inaccuracy of the working standard at 1000 mb in comparision to international standards (NIST): +-0.15mb at 20°C; Long-Term Stability: +-0.1 mb per year.
*Defined as +-2 standard deviation limits of end-point non-linearity, hysteresis error, of repeatability error)

Instrument: Licor closed path LI-6262 CO_2/H_2O analyzer
Measures: Eddy covariance; CO_2 concentration
Location: above canopy at 41m; in the canopy at 32m, 22.9m, 16.8m and 10.7m; below canopy at 1.5m and 0.8m agl
Characteristic of Instrument: Solid state detector, filtered for detection at 4.26 microns. No sensitivity to motion. Differential, non-dispersive infrared gas analyzer functioning in differential mode; Calibration: factory linearized over 0 to 3000 ppm range using NIST-traceable standard gases; Temperature range: 0°C to 50°C ambient, 0°C to 52°C optical bench temperature; typical

noise level (ppm, peak-to-peak) is 0.2 ppm and maximum noise level is 0.4 ppm; Accuracy: +-1ppm at 350 ppm (<3ppm maximum). +-2 ppm at 1000 ppm (<6 ppm maximum)

Instrument: Licor open path LI-7500 CO2/H2O analyzer
Measures: Eddy covariance; CO2 concentration; in operation from August to November, 11 2003
Location: above canopy at 41 m agl
Characteristic of Instrument: Absolute, open-path, non-dispersive infrared gas analyzer; Bandwidth: 5, 10, or 20 Hz software selectable; Operating Temperature Range: -25 °C to 50 °C; Path Length: 12.5 cm; Calibration range for CO2: 0 to 3000 umol/mol; Calibration range for H2O: 0 to 60 umol/mol; CO2 RMS noise at ambient (370 ppm) with 20 Hz bandwidth: 0.16 umol/mol; H20 RMS noise in moist air (10 mmol/mol) with 20 Hz bandwidth: 0.0067 umol/mo

Instrument: Campbell Scientific CR23X dataloggers
Measures: 4 dataloggers recording radiation, soil, CO2 profile and chamber data
Characteristic of Instrument: for details please refer to the following website www.campbellsci.com/documents/lit/s_cr23x.pdf

Instrument: Campbell Scientific CR10X datalogger
Measures: 2 dataloggers; one records measurements made at the precipitation site and the other records diagnostic measurements such at battery voltages, tube temperatures etc.
Characteristic of Instrument: for details please refer to the following website http://www.campbellsci.com/documents/lit/s_cr10x.pdf

Instrument: Campbell Scientific CR7X datalogger
Measures: Records meteorological measurements from the tower
Characteristic of Instrument: for details please refer to the following website http://www.campbellsci.com/documents/lit/s_cr7.pdf

Instrument: Campbell Scientific CR5000 datalogger
Measures: Records above canopy HMP, sonic, LI-7000 and below canopy atmospheric pressure
Characteristic of Instrument: for details please refer to the following website http://www.campbellsci.com/documents/lit/s_cr5000.pdf

Instrument: R.M. Young 12002/12005 3-cup gill anemometer
Measures: Wind speed
Location: In canopy at 21.3m agl; In canopy at 11m agl; Below canopy at 1.5m agl; At precipitation gauge at 2.74 m agl
Characteristic of Instrument: Range: 0 to 50 m/s, gusts survival to 60 m/s; Dynamic response: 2.3 m cup wheel distance constant; Threshold Sensitivity: 0.5 m/s tach-generator, 0.3 m/s photochopper

Instrument: SDM-CD16AV 16 Channel AC/DC controller
Characteristic of Instrument: Arrangement: Single pole double throw, Break before make; Individual contact rating: 5 A at 30 VDC, 0.3 A at 110 VDC, 5 A 1/10 HP at 125 VAC, 5 A 1-6 HP at 277 VAC; Actuation release time: approximately 4 ms; Operating temperature -40°C to 70°C

4.1.2 Manufacturer of Sensor/Instrument

Instrumentation: CNR1
Contact: Kipp and Zonen
US Office Kipp & Zonen USA Inc.
125, Wilbur Place
Bohemia, NY 11716 USA
telephone number: 631 589 2065

Instrumentation: SR-50, NR LITE , HFT3 heat flux plates, CS615 water content reflectometer, CS700 tipping bucket rain gauge, CSAT3, SDM and all dataloggers
Contact: Campbell Scientific (Canada) Corp.
11564 - 149 Street NW
Edmonton, AB T5M 1W7 Canada
Telephone number: 780 454 2505

Instrumentation: HMP45C and CS105
Contact: Vaisala
37 De Tarascon
Blainville, Que J7B 6B7 Canada
Telephone number: 450 430 0880

Instrumentation: LI-190SA Quantum Sensor, LI-7000, LI-6262 and LI-7500
Contact: LI-COR Biosciences
4421 Superior St.
Lincoln, NE 68504 USA
Telephone number: 800-447-3576

Instrumentation: 05103 wind monitor anemometer and 3-cup anemometer
Contact: R.M. Young Company
2801 Park Drive
Traverse City, Michigan 49686 USA
Telephone number: 231 946 3980

Instrumentation: RTD-810 and all thermocouples
Contact: OMEGA Engineering, INC.
One Omega Drive
Stamford, Connecticut 06907-0047 USA
P.O. Box 4047
Telephone number: 800 848 4286 or 203 359 1660

Instrumentation: BF2 sunshine sensor
Contact: Delta-T Devices Ltd
128 Low Road, Burwell, Cambridge CB5OEJ England.
Telephone number: 01638 742922 (international + 44 1638 742922)

Instrumentation: T-200B precipitation gauge
Contact: Geonor Inc.
PO Box 903
Milford, PA 18337-0903 USA
Telephone number: 570 296 4884

4.1.3 Principles of Operation

Data collection was automated, where the environmental measurements were converted to electrical signals and recorded by dataloggers. The majority of these electronic signals were then converted online into concentrations, fluxes, temperatures etc. Electronic signals that were not processed online were converted by Matlab functions.

The EC system measures windspeed, temperature, CO_2 flux and CO_2 concentration. The sonic anemometer/thermometers measures the wind speed and temperature with a pair of transducers that act alternately as transmitters and receivers, sending pulses of high frequency ultrasound back and forth between the pair. The 3-D sonic has three pairs of transducers arranged in nonparallel axes to measure wind the u, w, and z direction. The LI-COR CO2/H2O analyzers are based on the difference in absorption of infrared radiation passing through two gas sampling cells. The reference cell is used for a gas of known CO_2 or H_2O density, and the sample cell is used for a gas of unknown density. Infrared radiation is transmitted through both cell paths, and the output of the analyzer is proportional to the difference in the absorption between the two.

For detail on how individual meteorological instrumentation operators, please refer the manufacture's manual.

4.1.4 Source/Platform

<u>TOWER</u>
The majority of equipment is located on a dual-section scaffold walk-up tower. The design is based on the towers at the mature BERMS sites (e.g. OJP). Each section is 1.542 by 2.756 m, and the dimensions of the tower are 1.542 by 4.248 m. The scaffolding components used are standard 1.969 by 1.969 m frames. The stairs occupy the south section of the tower, while the work platforms occupy the north section. Most work platforms are located at 6.096 m height intervals. However, the penultimate work platform is located 5.906 m from the top. The top work platform is approximately 41.148 m above the ground. The long axis of the tower runs north to south, while the short axis runs east to west (Figure 4.3).

View of SE Corner of Flux Tower

View of NE Corner of Flux tower

View of Flux Tower Base from Hut

Figure 4.3. Various views of the flux tower at the Groundhog River Flux Station.

The booms at Groundhog River are all made of square aluminium tubing. The booms have 3 main components: a boom mounting bracket, a boom sleeve, and a boom arm. The boom sleeve is attached to the tower via the mounting brackets. The boom arm slides in an out in the sleeve on nylon bearings. Locking pins hold the boom arm in place. Adjustable strain lines allow the boom to be levelled. The dimensions of the cylindrical tower members are 41.275 mm O.D. The dimensions of the square aluminium boom sleeve is 63.5 mm O.D. The dimensions of the boom arm are 50.8 mm O.D. The aluminium tubing has a wall diameter of 0.3175 mm. The boom arms are all 6.096 m in length. The instrumentation on each boom are:

Level 1 at 1.5 m agl: NR LITE, LI-190, HMP, Cu-Co 0.003 fine wire thermocouple, 3-cup anemometer
Level 2 at 11 m agl: HMP, Cu-Co fine wire 0.005 thermocouple, 3-cup anemometer
Level 3 at 21 m agl: HMP, Cu-Co fine wire 0.005 thermocouple, 3-cup anemometer
Level 4 at 43 m agl: HMP, Cu-Co fine wire 0.005 thermocouple, 3-cup anemometer

Level 4 at 41.148m agl: CSAT3, LI-7000, Cu-Co fine wire 0.003 thermocouple
Level 4 at 38 m agl: Kipp and Zonen CRN1, LI-190 PAR sensor, BF2 sunshine sensor

Off the west side of the tower, 8 profile inlet tubes are drawing in air to measure CO_2 concentrations. Their heights are 0.762 m, 1.524 m, 4.572 m, 10.668 m, 16.764 m, 22.86 m, 32.004 m and 41.148 m agl.

Ground Level
SR50 – In the center of a metal crossbar 2.21 m agl.

At the precipitation site – unforested and 1.6 km east of the tower
All instruments are on metal posts (Figure 4.4). For instrument heights refer to section 4.1.1

Figure 4.4. The precipitation site at Groundhog River

4.1.5 Sensor/Instrument Measurement Geometry
The eddy covariance instruments are located on a boom extending from the northwest corner of the tower bearing approximately 42º from true north (Figure 4.5). The air temperature and relative humidity sensor associated with the EC system is located in the Met One shield on a boom extending from the southwest corner. The pressure sensor associated with the EC system is located in the hut, with a pressure port extending to the outside. The EC and above canopy meteorological sensors are situated approximately 43 m agl. Radiation variables are located on a boom extending to the south at approximately 38 m above ground level.

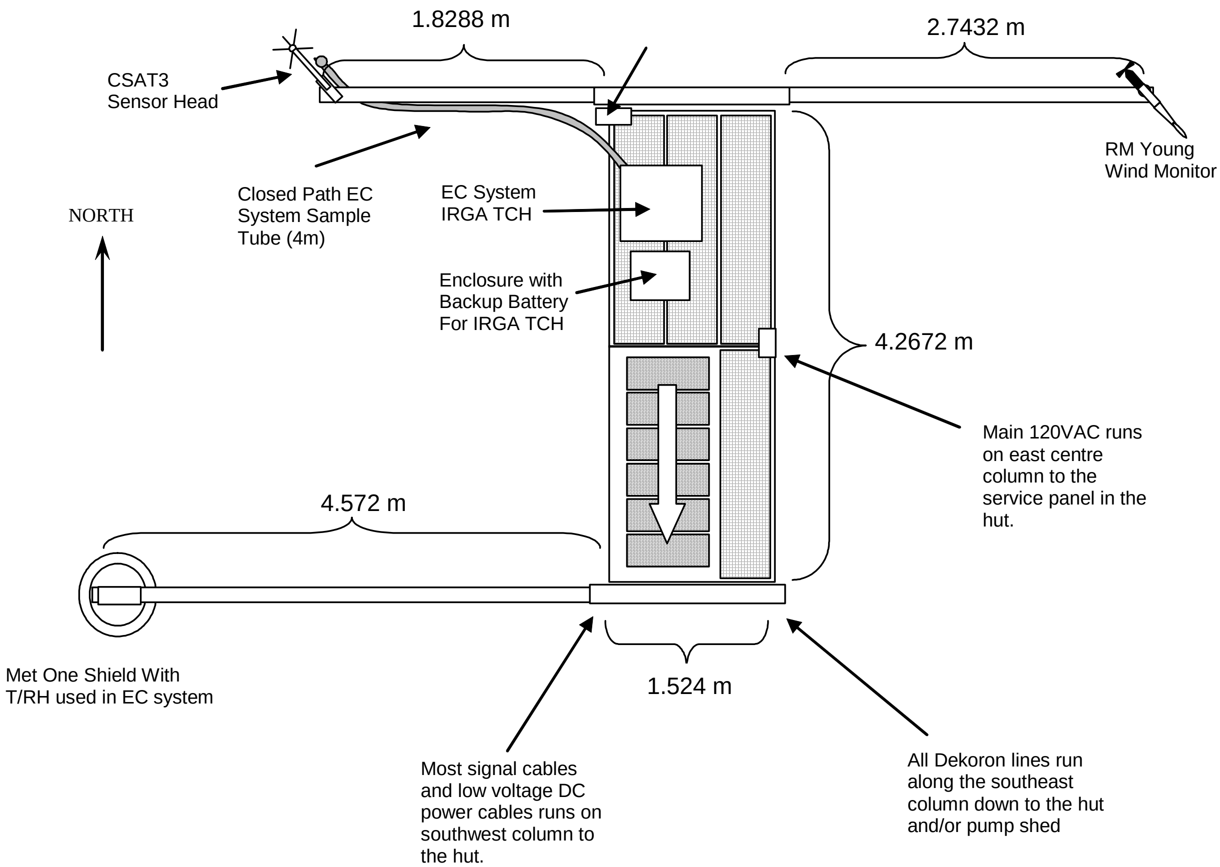

Figure 4.5. A plan view of the sensor layout at the top of the Groundhog River tower (not to scale).

The CSAT3 is mounted on the 19.05 mm horizontal arm provided by the manufacturer (Figure 4.5). This arm is inserted and secured into an aluminium block that is attached to a vertical piece of aluminium pipe. The vertical pipe is connected to the main boom arm via two U-bolts. The sample tube for the closed-path EC system is attached to the lower arm of the CSAT3 via cable ties.

Closed Path EC Configuration **Open Path EC Configuration**

Figure 4.5. Eddy Covariance system configurations at the Groundhog River Station. The CSAT3 mount allows both an open path IRGA and a closed path system to run simultaneously, however this configuration is not currently used.

Booms on levels 1 through 3 face north and are horizontal. The 8 profile inlet tubes facing west are tilted approximately -30º from horizontal to prevent precipitation from entering the unit.

4.1.6 Collection Environment
Except for the respiration chambers, data is collected year-round. The temperature ranges from approximately -45ºC to 38ºC with an average of 831.3 mm of precipitation falling annually.

4.2 Calibration
All calibrations are conducted as outlined by the Fluxnet protocol and as suggested by the manufactures of the instrumentation. For further details please refer to sections 4.2.1 to 4.2.3.

4.2.1 Specifications
There are no special circumstances that affect the calibration of the device, its operation, or the analysis of the data with it. Any special corrections or adjustments to the data are outlined in section 9.2

4.2.1.1 Tolerance
Refer to section 4.1.1

4.2.2 Frequency of Calibration
Calibrations for closed path CO_2 systems were done once a day. The eddy covariance system is calibrated at 0:06 UTC, and the profile system is calibrated at 1:30 UTC from March to November 2004 and 6:30 UTC from December 1, 2004 to present. Calibrations were also conducted several times after IRGA replacement. Water vapour mole fraction measurements were annually confirmed by laboratory-based calibrations using a dew point generator (LI-COR LI-610 Portable Dew Point Generator). The open path CO_2 system(used in 2003) was only calibrated before deployment.

All instrumentation is sent to the factory for re-calibration as suggested by the manufacture, or as determined by the Flux-net protocol. For these details please refer to the instruction manual of the sensor of interest and the Flux-net protocol.

A field comparison the top of tower meteorological equipment (Kipp and Zonen CNR1 net radiometer, LICOR LI-190 Quantum sensor, HMP45C temperature and humidity sensor inside an aspirated 12 plate radiation shield, and RTD-810 temperature probe inside MetOne shield) was conducted in August of 2005. For further details please contact Dan Finch at Queens University.

The Cross Site comparison of the CSAT and LI-7000 was conducted in Late July through early August of 2005. For the results of this study please contact the Queens Climatology group.

4.2.3 Other Calibration Information

Sensor: LI-6262
Serial number: IRG3-1233
Factory Calibration Date(s): 05/12/2002
Calibration values: CO2 calibration values: T = 39.22; K = 18800; A = 1.40097E-1; B = 1.00644E-5 ;C = 6.09682E-9; D = -6.95252E-13; E = 4.33756E-17
$H_2$0 calibration values: T = 39.73;   K = 18371; A = 6.24114E-3; B = 2.58047E-6; C = -1.65588E-11
Pressure calibration values (PX-1036, 17 September 2002): FCT_71 = 58.975; FCT_72 = 0.01518; FCT_73 = 43; FCT_75 = 0

Sensor: LI-7500
Serial number: 75H-0197
Factory Calibration Date(s): 03/23/2001
Calibration values: CO2 Calibration values: A = 1.45314E2; 2.02121E4; D = -1.05076E10; E = 1.57247E12; XS = 0.0066; Z = 0.0017
H2O calibration values: A = 4.64976E3; B = 3.18832E6; C = 1.14654E8; XS = -0.0037; Z = -0.0006; CO2 Zero = 0.8660; CO2 span = 1.0010 at 1000 ppm; H2O Zero = 0.9290; H2O span = 0.9940 at 15ºC

Sensor: LI-7000
Serial number: IRG4-0260
Factory Calibration Date(s): 10/23/2002
Calibration values: CO2 values: a1 = 9.59879E2; a2 = 1.36527E5; a3 = 1.89613E8; a4 = -4.41624E10; a5 = 5.75364E12; Zt = 4.31E-05; WO'_d = 1403232; AGC = 0.54
Pressure values (S/N is PX-1028 last calibrated 18/07/2002): a0 = 58.930; a1 = 30.460
H2O values: a1 = 3.20983E1; a2 = 2.22149E4; a3 = 1.35161E6; Zt = -8.60E-05; WO'_d = 1393873; AGC = 0.58

Sensor: LI-7000
Serial number: IRG4-0261
Factory Calibration Date(s): 12/04/2002
Calibration values: CO2 values: a1 = 938.613; a2 = 189284; a3 = 1.39233E08; a4 = -2.62083E10; a5 = 3.49838e12; Zt = -8.53E-05; WO'_d = 1.40139E06; AGC = 0.54
Pressure values (S/N is PX-1019 last calibrated 18/07/2002): a0 = 58.646; a1 = 30.46
H2O values: a1 = 31.1637; a2 = 22784.5; a3 = 1.14753E6; Zt = 5.02E-05; WO'_d = 1.31768E06; AGC = 0.58

5 Site Description

The Groundhog River Flux Station is located in the boreal mixed wood forest of north eastern Ontario (48° 3' 37'' N 82° 2' 36'' W, 345 m asl, Figure 5.1). The forest has a heterogeneous mixture of five main species: trembling aspen, white birch, white spruce, black spruce, and balsam fir. These species make up the largest identifiable association of the central boreal forest, occupying over 50% of the total forest land base in northern Ontario. Canopy height is quite variable, but in the region of the tower it is generally 15 to 18 m. Ostensibly, a serial stage in a complex succession from intolerant hardwood to tolerant conifer, they are maintained as an almost permanent component of the landscape by disturbance agents, i.e., spruce budworm infestations and wildfire. More recently, harvesting has had significant influence on their composition. Mixed woods are commercially exploited throughout their range. Past logging consisted of high-grading white and black spruce for the lumber and pulp and paper industries. Currently, the dominant management practice is clear-cutting. Without intervention, sites frequently revert to almost pure stands of aspen. Over their lifetime, a conifer understory (often balsam fir) may develop. More intensive management generally includes planting followed by competition suppression though the use of herbicides. Shelter-wood cutting (i.e., partial harvesting) is being tried in some areas.

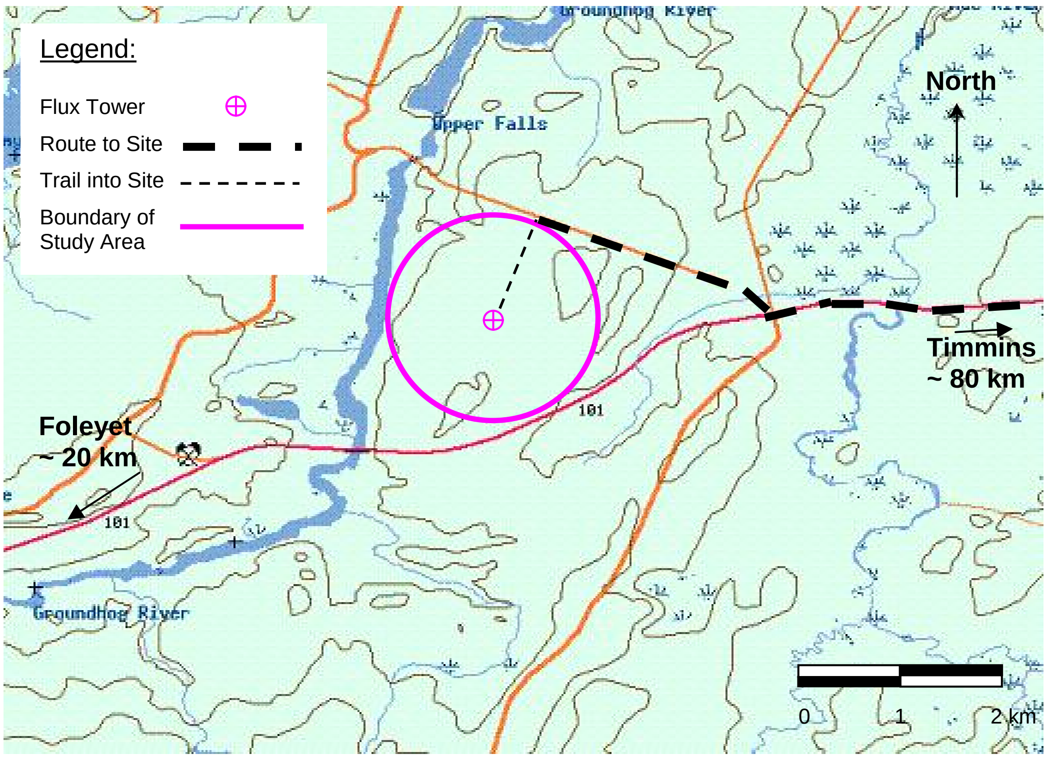

Figure 5.1. Map of the Groundhog River Flux Station and the surrounding area.

6. Data Acquisition Methods

The closed-path eddy covariance system at Groundhog River (GR) uses a Campbell Scientific CR5000 (S/N 1435) to measure the following sensors at a 20 Hz scan interval:

1 CSI CSAT3 Sonic Anemometer (S/N 0705)
1 LICOR LI-7000 Infrared Gas Analyzer (S/N IRG4-0260)
1 Fine Wire Thermocouple (0.003)
1 CSI/Vaisala HMP45C Temperature and RH Probe
1 CSI CS105 barometric pressure sensor
1 Motorola Gage pressure sensor in IRGA TCH
4 Omega PX212 Pressure Transducers for Gas Cylinders

All sensors are measured as analogue signals by the CR5000, except the CSAT3. The CSAT3 is measured by the SDM protocol. The CSAT3 is configured for 20 Hz sampling and does not employ over-sampling. The SDM address of the CSAT3 on the tower is “3”.

Signal cables are run from the sensors at the top, down the tower and into the instrumentation hut where the CR5000 is located. The CS105 pressure sensor is located in the hut with a pressure port extending to the outside. The signal cables from the EC system at the top of the tower are about 60.96 m in length. An anti-aliasing filter was not used in the EC system until July 23, 2005.

The inlet for the air sample tube is positioned in accordance with the FCRN EC protocols. The tube is 4m long and is connected to the TCH. The sample tube is designed and constructed in accordance with the FCRN EC protocols. A CR10 at the top of the tower measures four T-type thermocouples in the sample tube.

There are four 0.635 cm O.D. Dekoron tubing lines running from compressed gas cylinders located within the hut up the tower and into the IRGA TCH. There are 3 calibration lines (Cal 0, 1 and 2), and one reference line (EC REF) (Table 6.1). Each of these lines is approximately 60.96 m long. All connections are standard brass or stainless steel 0.635 cm Swagelok fittings.

The sample line that runs from the TCH, down the tower, to the diaphragm pump is 1.27 cm O.D. Dekoron. Swagelok adapters and reducing unions are used at each end of this line. The sample pump is a GAST DOA V722-AA 115VAC diaphragm pump. The pump is housed in a small shed located near the hut. There is a valve connected to the sample pump that is used to control the EC system flow rate.

Table 6.1. Gas flow rates used in the Closed-Path EC System at Groundhog River

Gas Line	Gas	Flow Rate	Flow Rate Control
EC Reference	N2	60-80 cc/min	Needle valve in hut used to adjust flow rate but the meter in the TCH is the one used to set and monitor the flow rate.
EC Sample	Air	9-10 LPM	Valve attached to the pump is used to control the flow rate but the meter in the TCH is the one used to set and monitor the flow rate.
Cal 0	N2	14 LPM	Flow is set at the tank but the flow rate is determined in the TCH
Cal 1	CO2 (360 ppm)	14 LPM	Flow is set at the tank but the flow rate is determined in the TCH
Cal 2	CO2 (450 ppm)	14 LPM	Flow is set at the tank but the flow rate is determined in the TCH

A profiles system measuring CO_2 concentrations at 41m, 32m, 22.9 m, 16.8m and 10.7m, 1.5m and 0.8 m was set-up in March 2004 (Figure 6.1). The inlets for air are made up of eight Coglan's stove and lantern funnels with strainer screen that are attached to O.D. Dekoron (outside diameter of 1.27 cm). The funnels are attached to the tubing with rubber splicing tape. At each height, every 315 seconds, the CO_2 concentration is measured for 45 seconds. This is because the air is drawn down into a sub sample manifold where a SDM-CD16AV 16 Channel AC/DC controller opens one of eight solenoid values every 45 seconds. The air from the manifold is drawn into a LI-6262 infrared gas analyzer where the CO_2 concentration of air is measured. Concentrations are measured and recorded every second and a 30 minute average is also computed online. Once daily the calibration values for the IRGA are recorded by purging the instruments with nitrogen and a known concentration of CO_2. For more information on calibrations please refer to section 4.2.

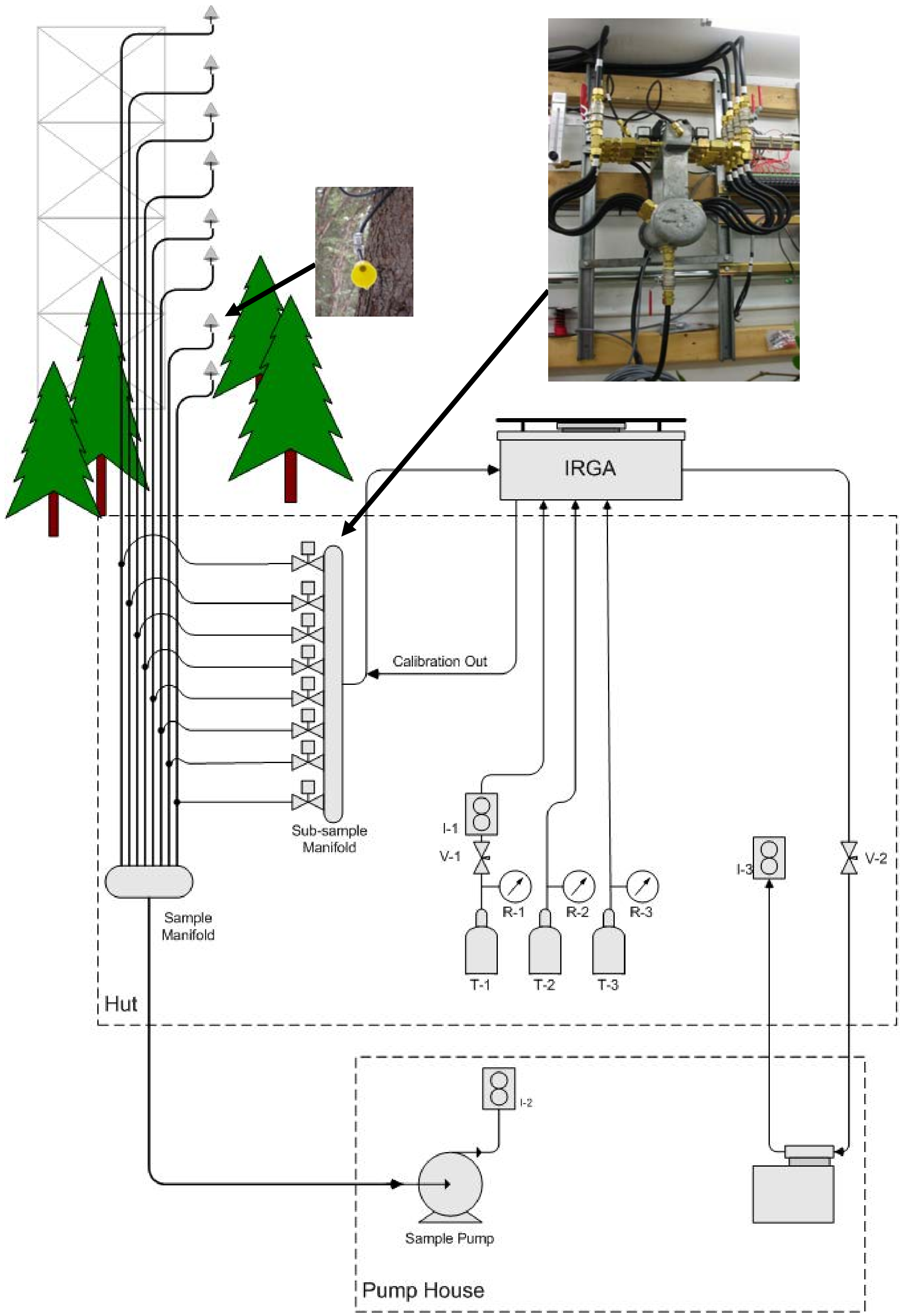

Figure 6.1. A schematic diagram of the profile system

At four levels on the tower (1.5, 11, 21 and 43 m), temperature, relative humidity and wind speed are measured every 10 seconds and a 30 minute average, maximum, minimum and standard deviation are recorded. At the very top of the tower wind direction is also measured (for more details please refer to section 4.1.3).

Above the canopy, at approximately 38 m, measurements of shortwave radiation, longwave radiation, net radiation, PAR and diffuse PAR are measured and recorded every second with a 1 and 30 minute output of the average, maximum, minimum and standard deviation (Figure 6.2). Short and longwave radiation is measured by a Kipp & Zonen CNR1, and from this net radiation is computed online. PAR and diffuse PAR are measured by a Licor LI-190SA Quantum Sensor and BF2 sunshine sensor respectively. Both the CNR1 and BF2 are heated. Below the canopy at 1.5 m net radiation and PAR are measured every second, and 5 and 30 minute outputs of the average, maximum, minimum and standard deviation are recorded. Net radiation is measured by an NR LITE net radiometer and PAR is measured with a Licor LI-190SA Quantum Sensor.

Figure 6.2. Photos of radiation sensors - looking down onto the 1.5 m boom (left) and looking south over the radiation Sensors at 38 m (right).

Ground heat flux, soil temperature and soil moisture are measured at two locations within 30 meters of the tower. The ground heat fluxes and temperatures are measured every 10 seconds and 30 minute averages, maximum, minimum and standard deviations were recorded. Volumetric soil moistures are measured once every four hours. Location 1 is west of the tower, and location 2 is north of the tower. At each location, soil temperature is measured at 2, 5, 50 and 100 cm below ground by 24 gauge Co-Cu thermocouples. For support, these thermocouples are attached to dowels. Volumetric soil moisture was measured at cluster 2 by CS615 water content reflectometers, and the probes were placed 15, 30, 45, 60, 80 and 100 cm below ground. Also, at each location, two heat flux plates were installed 10 cm below ground.

Snow temperature is also measured in the vicinity of soil temperature and moisture probes. Again, measurements are made every second and 30 minute averages, maximum, minimum and standard deviations are recorded. At each location, bare wire Co-Cu thermocouples were placed on a rod that measured snow temperature at 1, 2, 5, 10, 20, 30, 50 and 100cm (Figure 6.3). Just east of northern soil cluster, snow depth is recorded by Campbell Scientific SR-50 Ultrasonic Depth Gauge at 221 cm asl.

Figure 6.3. The Co-Cu thermocouples measuring snow temperatures at 1, 2, 5, 10, 20, 30, 50 and 100cm.

Two trees were chosen to measure tree bole temperatures with CO-Cu 24 gauge thermocouples. Measurements were on the north and south side of the tree bole and in the heartwood (i.e. central). A black spruce tree, just east of location 1 had 9 Co-Cu thermocouples placed in the treebole at 1.5 m agl and 57mm North, 1.5 m agl and 114mm Central, 1.5 m agl and 57mm South, 3.1 m agl and 57mm North, 3.1 m agl and 114mm Central, 3.1 m agl and 57mm South, 6.1 m agl and 57mm North, 6.1 m agl and 114mm Central, and 6.1 m agl and 57mm South. An aspen just West of the tower was also selected to measure tree bole temperatures and had 9 Co-Cu thermocouples placed in the treebole at 1.5 m agl and 57mm North, 1.5 m agl and 114mm Central, 1.5 m agl and 57mm South, 6.1 m agl and 57mm North, 6.1 m agl and 114mm Central, 6.1 m agl and 57mm South, 10.6 m agl and 57mm North, 10.6 m agl and 114mm Central, and 10.6 m agl and 57mm South.

The precipitation site is un-forested and approximately 1.6 km east of the main tower. At this site rainfall was measured with a Hydrological Services CS700 tipping bucket at 0.27 m agl, and cumulative precipitation was measured with a Geonor T-200B precipitation gauge at 2.11 m agl,. Precipitation is measured every ten seconds and totals for each half hour are recorded. In addition to precipitation, a 3-cup gill anemometer measures wind speed at 2.74 m agl, and an HMP measured temperature and humidity at 2.74 m agl. These measurements were captured by the datalogger every 10 seconds and a 30 minute average, maximum, minimum and standard deviation were recorded.

For more information about each sensor and its orientation please refer to section 4.

6.1 Methods of data acquisition

All instrumentation was installed according to the Fluxnet management protocol.

6.2 Sampling

6.2.1 Spatial Coverage/Geographic Location

29 large tree plots were established within the 1 km radius surrounding the flux tower. The plots had a radius of 11.3 m, with the centre points as follows in UTM Zone 17 North projection:

Plot 1: 414401.3 E, 5341061.4 N
Plot 2: 414015.1 E, 5341143.8 N

Plot 3: 413818.9 E, 5341183.2 N
Plot 4: 414285.1 E, 5341268.3 N
Plot 5: 413220.8 E, 5341309.1 N
Plot 6: 413420.0 E, 5341272.1 N
Plot 7: 413409.1 E, 5341229.4 N
Plot 8: 413615.1E, 5341226.2 N
Plot 9: 414013.5 E, 5341984.6 N
Plot 10: 413948.9 E, 5341712.6 N
Plot 11: 414095.7 E, 5341667.8 N
Plot 12: 414185.1 E, 5341734.2 N
Plot 13: 414611.2 E, 5341021.5 N
Plot 14: 414806.1 E, 5340980.1 N
Plot 15: 414166.9 E, 5340834.5 N
Plot 16: 414175.3 E, 5340751.4 N
Plot 17: 413816.7 E, 5341778.3 N
Plot 18: 413653.7 E, 5341575.9 N
Plot 19: 413700.5 E, 5341548.8 N
Plot 20: 414598.9 E, 5341811.6 N
Plot 21: 414439.7 E, 5341552.8 N
Plot 22: 414913.9 E, 5341379.6 N
Plot 23: 415090.8 E, 5341313.3 N
Plot 24: 415088.0 E, 5341045.5 N
Plot 25: 413214.2 E, 5341083.2 N
Plot 26: 413551.5 E, 5340990.1 N
Plot 27: 414164.8 E, 5341107.7 N
Plot 28: 413818.7 E, 5340652.9 N
Plot 30: 414296.7 E, 5340327.7 N

Airborne light detection and ranging (LiDAR) data was collected over the site in 2003 and 2004. These data cover slightly more than the full 1 km radius around the tower (centre coordinate approximately 414164.8 E, 5341107.7 N).

A CASI airborne hyperspectral image was collected over the site in 2004. These data cover the 1 km radius surrounding the tower (centre coordinate approximately 414164.8 E, 5341107.7 N).

An EO-1 Hyperion image was collected over the site on July 15, 2005. The extent of the image is as follows (in Latitude and Longitude (DMS)): NW Corner: 48'36'46'N, 82'03'29'W, NE Corner: 48'35'44'N, 81'57'23'W, SW Corner: 47'46'48'N, 82'22'29'W, SE Corner: 47'45'46'N, 82'16'29'W.

6.2.2 Spatial sampling

Existing forest inventory maps provided a rough spatial outline of the vegetative strata. These were used to define a stratified sampling scheme for the site, in which 29 large tree plots were distributed across the range of tree species associations. Each plot had a radius of 11.3 m. The UTM coordinates for centre of each plot are listed in 6.2.1.

6.2.3 Temporal coverage

Large tree mensuration data was collected in 2003. Hemispherical photographs were collected at each plot in 2003 and at multiple times in 2004.

6.2.4 Temporal sampling

Hemispherical photographs were taken under diffuse light conditions, which include dawn, dusk, and overcast conditions with no precipitation.

7 . Observations

7.1 Procedural Notes

- Numerous data gaps existed in the high frequency and half-hour EC system data from September to December 2004 (Table 7.1). Most of these gaps were due to communication problems between the computer's operating system, loggernet and the datalogger.

Month	Percentage gaps in half hour data	Percentage gaps, after filling using the high frequency
September	66%	48% Note: High frequency data up to Sept 16 (DOY 260) was in good shape. Following this, the high frequency data is missing data points.
October	81%	56% Note: The majority of high frequency data, though available, is non-continuous (missing several data points).
November	44% (in Fc cp, Le_cp, Hs, Hc)	0.3%
December	34% Gaps Due to program modifications	34%

- Due to profile system calibration issues from July 29, 2004 to April 27 2005, Profile system data has not yet been submitted for the July 29, 2004 to December 31, 2005 period. This data will be recalculated, and added at a later date.

To be completed via Field Notes.txt

8 . Data Description

8.1 Data Organization
Data are stored in monthly data files according to the Fluxnet-Canada Data Management Plan and is explained in section 1.3 and 8.3.

8.2 Image and Data Format
1.) OMW05015EO1HY.PIX
Radiance (W/m^2/µm/SR) image. The data are 16-bit signed integer in ".pix" format (PCI Geomatica). The SWIR and VNIR bands have scaling factors of 80 and 40, respectively.

VNIR radiance = Digital Number/40; SWIR radiance = Digital Number/80

2.) OMW04015CASI_rad.PIX
Geocorrected radiance (W/m^2/µm/SR) image with a scaling factor of 100 applied (radiance = Digital Number/100). The data are 16-bit signed integer in ".pix" format (PCI Geomatica). Coordinate system is UTM (Zone 17 N).

3.) OMW04015CASI_ref.PIX
Geocorrected reflectance with scaling applied ((%ref + 10)*500). The data are 16-bit signed

integer in “.pix” format (PCI Geomatica). Coordinate system is UTM (Zone 17 N).
4.) OMW03010lidar.txt
This is point cloud data in ascii text format. First and last returns are included. There are 4 columns of data, including: X location (UTM Easting, m); Y location (UTM Northing, m); Z location (Height above ellipsoid (m)); and intensity. The coordinate system is UTM (Zone 17 N).

5.) OMW04021lidar.txt
This is point cloud data in ascii text format. First and last returns are included. There are 3 columns of data, including: X location (UTM Easting, m); Y location (UTM Northing, m); and Z location (Height above ellipsoid (m)). The coordinate system is UTM (Zone 17 N).

8.3 Numerical Data Characteristics
The following tables illustrate the data structure of each file type.

ON-OMW_FlxTwr_Flx1_yyyy-mm-00

	Variable	Unit	Description
1	DataType	(n/a)	First subset of Flux data corrections applied but gaps not filled.
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	Day	(UTC)	Day of Year UTC.
6	End_Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	EddyCovariance_CO2	(umol/m2/s)	EddyCovariance; Licor 7000; above canopy at 41m agl.
8	CO2	(ppm)	CO2 concentration; Licor 7000; above canopy at 41m agl.
9	TreeTemp_W_1.5m_57mmN	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 1.5 m agl and 57mm North
10	TreeTemp_W_1.5m_114mmC	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 1.5 m agl and 114mm Central
11	TreeTemp_W_1.5m_57mmS	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 1.5 m agl and 57mm South
12	TreeTemp_W_3.1m_57mmN	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 3.1 m agl and 57mm North
13	TreeTemp_W_3.1m_114mmC	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 3.1 m agl and 114mm Central
14	TreeTemp_W_3.1m_57mmS	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 3.1 m agl and 57mm South
15	TreeTemp_W_6.1m_57mmN	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 6.1 m agl and 57mm North
16	TreeTemp_W_6.1m_114mmC	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 6.1 m agl and 114mm Central
17	TreeTemp_W_6.1m_57mmS	(degC)	Treebole temperature; Black spruce; Cu-Co thermocouple at 6.1 m agl and 57mm South
18	TreeTemp_N_1.5m_57mmN	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 1.5 m agl and 57mm North
19	TreeTemp_N_1.5m_114mmC	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 1.5 m agl and 114mm Central

20	TreeTemp_N_1.5m_57mmS	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 1.5 m agl and 57mm South
21	TreeTemp_N_6.1m_57mmN	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 6.1 m agl and 57mm North
22	TreeTemp_N_6.1m_114mmC	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 6.1 m agl and 114mm Central
23	TreeTemp_N_6.1m_57mmS	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 6.1 m agl and 57mm South
24	TreeTemp_N_10.6m_57mmN	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 10.6 m agl and 57mm North
25	TreeTemp_N_10.6m_114mmC	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 10.6 m agl and 114mm Central
26	TreeTemp_N_10.6m_57mmS	(degC)	Treebole temperature; Aspen; Cu-Co thermocouple at 10.6 m agl and 57mm South
27	SoilHeatFlux_W_10cm_#1	(W/m2)	Soil heat flux; HFT3 heat flux plates; West of tower at 10cm bgl.
28	SoilHeatFlux_W_10cm_#2	(W/m2)	Soil heat flux; HFT3 heat flux plates; West of tower at 10cm bgl.
29	SoilHeatFlux_N_10cm_#1	(W/m2)	Soil heat flux; HFT3 heat flux plates; North of tower at 10cm bgl.
30	SoilHeatFlux_N_10cm_#2	(W/m2)	Soil heat flux; HFT3 heat flux plates; North of tower at 10cm bgl.
31	CertificationCode	(n/a)	CPI: checked by PI; PRE: preliminary.
32	RevisionDate	(dymoyear)	Date of latest revision

ON-OMW_FlxTwr_Met1_yyyy-mm-00

	Variable	Unit	Description
1	DataType	(n/a)	First subset of meteorological data corrections applied but gaps not filled.
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	Day	(UTC)	Day of Year UTC.
6	End_Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	DownLongwave_Thermopile	(W/m2)	Downwelling Longwave Rad; Uncorrected from thermopile; Kipp & Zonen CNR1 at 37m agl.
8	Longwave_BodyTemp	(degC)	Instrument body temperature; Kipp & Zonen CNR1 at 37 agl.
9	UpLongwave_Thermopile	(W/m2)	Upwelling Longwave Rad; Uncorrected from thermopile; Kipp & Zonen CNR1 at 37m agl.
10	WindSpd_AtPrecipGauge	(m/s)	Wind speed; RMY05103 wind monitor anemometer at precipitation gauge 2.74 m agl.
11	AirTemp_AtSnowdGauge	(degC)	Air temperature; Radiation Shield; Vaisala HMP below canopy at 1.5 m agl.
12	RadLogger_Temp	(degC)	Panel temperature; cr23X datalogger.
13	RadLogger_Battery	(Volts)	Battery voltage; cr23X datalogger.
14	CertificationCode	(n/a)	CPI: checked by PI; PRE: preliminary.
15	RevisionDate	(dymoyear)	Date of latest revision

ON-OMW_FlxTwr_Met2_yyyy-mm-00

	Variable	Unit	Description
1	DataType	(n/a)	Second subset of meteorological data corrections applied but gaps not filled.
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	Day	(UTC)	Day of Year UTC.
6	End_Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	FourWay_NetRad_AbvCnpy_37m	(W/m2)	Derived by: (DownShort - UpShort)+(DownLong-UpLong).
8	CNR1_GlobalShortwaveRad_AbvCnpy_37m	(W/m2)	Global Shortwave Rad.; Kipp & Zonen CNR1 at 37m agl.
9	CNR1_UpShortwaveRad_AbvCnpy_37m	(W/m2)	Upwelling Shortwave Rad.; Kipp & Zonen CNR1 at 37m agl.
10	CNR1_DownLongwaveRad_AbvCnpy_37m	(W/m2)	Downwelling Longwave Rad.; Kipp & Zonen CNR1 at 37m agl.
11	CNR1_UpLongwaveRad_AbvCnpy_37m	(W/m2)	Upwelling Longwave Rad.; Kipp & Zonen CNR1 37m agl.
12	LI-190_DownPAR_AbvCnpy_37m	(umol/m2/s)	Downwelling PAR Rad.; Li-Cor LI190 at 37m agl.
13	BF2_DownDiffusePAR_AbvCnpy_37m	(umol/m2/s)	Downwelling Diffuse PAR Rad; BF2 at 37m agl.
14	LI-190_UpPAR_AbvCnpy_37m	(umol/m2/s)	Upwelling PAR Rad.; Li-Cor LI190 at 37m agl.
15	LI-190_DownPAR_BlwCnpy_1.5m	(umol/m2/s)	Downwelling PAR Rad.; Li-Cor LI190 at 1.5m agl.
16	TC_AirTemp_AbvCnpy_43m	(degC)	Non-Aspirated Air Temperature; Bare Wire Chromel-Constantan Thermocouple at 43m agl.
17	AspiratedTC_AirTemp_AbvCnpy_43m	(degC)	Aspirated Air Temperature; Thermocouple at 43m agl.
18	AspiratedHMP_AirTemp_AbvCnpy_43m	(degC)	Aspirated Air Temperature; Vaisala HMP at 43m agl.
19	AspiratedRTD_AirTemp_AbvCnpy_43m	(degC)	Aspirated Air Temperature; RTD at 43m agl.
20	TC_AirTemp_Cnpy_11m	(degC)	Air Temperature; Radiation Shielded; Copper-Constantan Thermocouple in canopy at 11m agl.
21	HMP_AirTemp_Cnpy_11m	(degC)	Air Temperature; Radiation Shielded; Vaisala HMP in canopy at 11m agl.

22	TC_AirTemp_BlwCnpy_1.5m	(degC)	Air Temperature; Radiation Shielded; Cu-Co Thermocouple below canopy at 1.5 agl.
23	HMP_AirTemp_BlwCnpy_1.5m	(degC)	Air Temperature; Radiation Shielded; Vaisala HMP below canopy at 1.5m.
24	AspiratedHMP_RelHum_AbvCnpy_43m	(%)	Aspirated Relative Humidity; Vaisala HMP above canopy at 43m.
25	HMP_RelHum_Cnpy_11m	(%)	Relative Humidity; Radiation Shielded; Vaisala HMP in canopy at 11m agl.
26	HMP_RelHum_BlwCnpy_1.5m	(%)	Relative Humidity; Radiation Shielded; Vaisala HMP below canopy at 1.5m.
27	WindSpd_AbvCnpy_43m	(m/s)	Wind Speed; RMY 05103 wind monitor anemometer above canopy at 43m agl.
28	WindDir_AbvCnpy_43m	(deg)	Wind Direction; RMY 05103 wind monitor anemometer above canopy at 43m agl.
29	StdDev_WindDir_AbvCnpy_43m	(deg)	Standard Deviation of Wind Direction; RMY 05103 wind monitor anemometer above canopy at 43m agl.
30	SurfPress_1.5m	(kPa)	Surface Atmospheric Pressure; CS105 at 1.5m agl.
31	Geonor_CumPrec_AtPrecipGauge	(mm)	Cumulative Precipitation; Geonor T-200B precipitation gauge.
32	CS700_TBRG_Rain_AtPrecipGauge	(mm)	Rain over 30min period; CS700 tipping bucket rain gauge.
33	SnowDepth_Cnpy	(cm)	Snow Depth; SR50 Ultrasonic Depth Gauge within canopy.
34	SoilTemp_W_2cm	(degC)	Soil temperature; Cu-Co thermocouple 2cm bgl in a pit W of tower.
35	SoilTemp_W_5cm	(degC)	Soil temperature; Cu-Co thermocouple 5cm bgl in a pit W of tower.
36	SoilTemp_W_10cm	(degC)	Soil temperature; Cu-Co thermocouple 10cm bgl in a pit W of tower.
37	SoilTemp_W_20cm	(degC)	Soil temperature; Cu-Co thermocouple 20cm bgl in a pit W of tower.
38	SoilTemp_W_50cm	(degC)	Soil temperature; Cu-Co thermocouple 50cm bgl in a pit W of tower.
39	SoilTemp_W_100cm	(degC)	Soil temperature; Cu-Co thermocouple 100cm bgl in a pit W of tower.

40	SoilTemp_N_2cm	(degC)	Soil temperature; Cu-Co thermocouple 2cm bgl in a pit N of tower.
41	SoilTemp_N_5cm	(degC)	Soil temperature; Cu-Co thermocouple 5cm bgl in a pit N of tower.
42	SoilTemp_N_10cm	(degC)	Soil temperature; Cu-Co thermocouple 10cm bgl in a pit N of tower.
43	SoilTemp_N_20cm	(degC)	Soil temperature; Cu-Co thermocouple 20cm bgl in a pit N of tower.
44	SoilTemp_N_50cm	(degC)	Soil temperature; Cu-Co thermocouple 50cm bgl in a pit N of tower.
45	SoilTemp_N_100cm	(degC)	Soil temperature; Cu-Co thermocouple 100cm bgl in a pit N of tower.
46	SnowTemp_W_1cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near W soil temp pit, 1cm agl.
47	SnowTemp_W_2cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near W soil temp pit, 2cm agl.
48	SnowTemp_W_5cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near W soil temp pit, 5cm agl.
49	SnowTemp_W_10cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near W soil temp pit, 10cm agl.
50	SnowTemp_W_20cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near W soil temp pit, 20cm agl.
51	SnowTemp_W_30cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near W soil temp pit, 30cm agl.
52	SnowTemp_W_50cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near W soil temp pit, 50cm agl.
53	SnowTemp_W_100cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near W soil temp pit, 100cm agl.
54	SnowTemp_N_1cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near N soil temp pit, 1cm agl.
55	SnowTemp_N_2cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near N soil temp pit, 2cm agl.
56	SnowTemp_N_5cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near N soil temp pit, 5cm agl.
57	SnowTemp_N_10cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near N soil temp pit, 10cm agl.
58	SnowTemp_N_20cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near N

			soil temp pit, 20cm agl.
59	SnowTemp_N_30cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near N soil temp pit, 30cm agl.
60	SnowTemp_N_50cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near N soil temp pit, 50cm agl.
61	SnowTemp_N_100cm	(degC)	Snow Temp; Cu-Co thermocouple on rod near N soil temp pit, 100cm agl.
62	CertificationCode	(n/a)	CPI: checked by PI; PRE: preliminary.
63	RevisionDate	(dymoyear)	Date of latest revision.

ON-OMW_FlxTwr_VWC3_yyyy-mm-00

	Variable	Unit	Description
1	DataType	(n/a)	Third subset of flux data corrections applied.
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	Day	(UTC)	Day of Year UTC.
6	End_Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	AvgCS615_VWC_15cm	(m3/m3)	Volumetric soil moisture; Campbell Scientific CS615 water content reflectometer in a pit North of the tower .15cm blg
8	AvgCS615_VWC_30cm	(m3/m3)	Volumetric soil moisture; Campbell Scientific CS615 water content reflectometer in a pit North of the tower 30cm blg.
9	AvgCS615_VWC_45cm	(m3/m3)	Volumetric soil moisture; Campbell Scientific CS615 water content reflectometer in a pit North of the tower 45cm blg.
10	AvgCS615_VWC_60cm	(m3/m3)	Volumetric soil moisture; Campbell Scientific CS615 water content reflectometer in a pit North of the tower 60cm blg.
11	AvgCS615_VWC_80cm	(m3/m3)	Volumetric soil moisture; Campbell Scientific CS615 water content reflectometer in a pit North of the tower 60cm blg.
12	AvgCS615_VWC_100cm	(m3/m3)	Volumetric soil moisture; Campbell Scientific CS615 water content reflectometer in a pit North of the tower 100cm blg.
13	Certification Code	(n/a)	CPI: checked by PI; PRE: preliminary.
14	RevisionDate	(dymoyear)	Date of latest revision

ON-OMW_FlxTwr_Flx2_yyyy-mm-00

	Variable	Unit	Description
1	DataType	(n/a)	Second subset of flux data corrections applied but gaps not filled.
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	Day	(UTC)	Day of Year UTC.

6	End_Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	NetEcosystemExchange	(umol/m2/s)	Sum of turblent and storage CO2.
8	CO2Flux_AbvCnpy_37m	(umol/m2/s)	Turbulant CO2 flux; Licor 7000; above canopy at 41m agl.
9	FourWay_NetRad_AbvCnpy_37m	(W/m2)	Derived by: (DownShort - UpShort)+(DownLong-UpLong).
10	LatentHeatFlux_AbvCnpy_37m	(W/m2)	Latent heat flux (sum of eddy and storage flux).
11	SensibleHeatFlux_AbvCnpy_37m	(W/m2)	Sensible heat flux (sum of eddy and storage flux).
12	SoilHeatFlux_0cm	(W/m2)	Heat flux at the soil surface.
13	BiomassHeatStorage_AbvCnpy_37m	(W/m2)	Biomass heat storage rate of change.
14	PhotosyntheticHeatFlux_AbvCnpy_37m	(W/m2)	Energy used in photosynthesis.
15	FrictionVelocity_AbvCnpy_37m	(W/m2)	Friction velocity above canopy 37m.
16	OneLevel_CO2StorageFlux_37m	(umol/m2/s)	CO2 storage rate of change calculated assuming 41 m mixing ratio change is representative for the whole profile.
17	CO2StorageFlux_0to37m	(umol/m2/s)	CO2 storage rate of change calculated using the CO2 profile measurements.
18	LatentHeatFlux_AbvCnpy_37m	(W/m2)	Turbulent latent heat flux above canopy.
19	LatentHeatStorageFlux_Sfc to Top	(W/m2)	Rate of change of latent heat storage in the air column.
20	SensibleHeatFlux_AbvCnpy_37m	(W/m2)	Turbulent sensible heat flux above canopy.
21	SensibleHeatStorageFlux_0to37m	(W/m2)	Rate of change of sensible heat storage in the air column.
22	Gapfilled_FourWay_NetRad_AbvCnpy_37m	(W/m2)	Gapfilled; Derived by: (DownShort - UpShort)+(DownLong-UpLong).
23	Gapfilled_LatentHeatFlux_AbvCnpy_37m	(W/m2)	Gapfilled; Turbulent latent heat flux above canopy.
24	Gapfilled_SensibleHeatFlux_AbvCnpy_37m	(W/m2)	Gapfilled; Turbulent sensible heat flux above canopy.
25	CertificationCode	(n/a)	CPI: checked by PI; PRE: preliminary.
26	RevisionDate	(dymoyear)	Date of latest revision

ON-OMW_FlxTwr_Met3_yyyy-mm-00

	Variable	Unit	Description
1	DataType	(n/a)	Third subset of meteorological data corrections applied and gaps filled.
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	Day	(UTC)	Day of Year UTC.
6	End_Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	FourWay_NetRad_AbvCnpy_37m	(W/m2)	Gapfilled; Derived by: (DownShort - UpShort)+(DownLong-UpLong).
8	CNR1_GlobalShortwaveRad_AbvCnpy_37m	(W/m2)	Gapfilled; Global Shortwave Rad.; Kipp & Zonen CNR1 at 37m agl.
9	LI-190_DownPAR_AbvCnpy_37m	(umol/m2/s)	Gapfilled; Downwelling PAR Rad.; Li-Cor LI190 at 1.5m agl.
10	AirTemp_AbvCnpy_43m	(degC)	Gapfilled; Derrived (Average of all air temperatures measured at 43m agl).
11	AspiratedHMP_RelHum_AbvCnpy_43m	(%)	Gapfilled; Aspirated Relative Humidity; Vaisala HMP above canopy at 43m.
12	SpecificHum_AbvCnpy	(g/g)	Gapfilled; Derived from Lowe (1977)
13	Windspeed_AbvCnpy_43m	(m/s)	Wind Speed; RMY 05103 wind monitor anemometer above canopy at 43m agl.
14	SoilTemp_2cm	(degC)	Gapfilled; Average soil temperature at 2cm; Cu-Co thermocouple 2cm bgl in a pit W and N of tower.
15	SoilTemp_5cm	(degC)	Gapfilled; Average soil temperature at 5cm; Cu-Co thermocouple 5cm bgl in a pit W and N of tower.
16	SoilTemp_10cm	(degC)	Gapfilled; Average soil temperature at 10cm; Cu-Co thermocouple 10cm bgl in a pit W and N of tower.
17	SoilTemp_20cm	(degC)	Gapfilled; Average soil temperature at 20cm; Cu-Co thermocouple 20cm bgl in a pit W and N of tower.
18	SoilTemp_50cm	(degC)	Gapfilled; Average soil temperature at 50cm; Cu-Co thermocouple 50cm bgl in a pit W and N of tower.

19	SoilTemp_100cm	(degC)	Gapfilled; Average soil temperature at 100cm; Cu-Co thermocouple 100cm bgl in a pit W and N of tower.
20	Geonor_CumPrec_ATPrecipGauge	(mm)	Cumulative Precipitation; Geonor T-200B precipitation gauge.
21	EventPrec_ATPrecipGauge	(mm)	Event precipitation
22	CertificationCode	(n/a)	CPI: checked by PI; PRE: preliminary.
23	RevisionDate	(dymoyear)	Date of latest revision

ON-OMW_FlxTwr_Flx3_yyyy-mm-00

	Variable	Unit	Description
1	DataType	(n/a)	Third subset of flux data corrections applied.
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	DOY	(UTC)	Day of Year UTC.
6	Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	NEP	(umol/m2/s)	Net ecosystem productivity (Barr et al, 2005)
8	R	(umol/m2/s)	Ecosystem respiration (Barr et al, 2005)
9	GEP	(umol/m2/s)	Gross ecosystem photosynthesis (Barr et al, 2005)
10	GapFilled_NEP	(umol/m2/s)	Gapfilled; Net ecosystem productivity (Barr et al, 2005)
11	GapFilled_R	(umol/m2/s)	Gapfilled; Ecosystem respiration (Barr et al, 2005)
12	GapFilled_GEP	(umol/m2/s)	Gapfilled; Gross ecosystem photosynthesis (Barr et al, 2005)
13	Modelled_R	(umol/m2/s)	Modelled; Ecosystem respiration (Barr et al, 2005)
14	Modelled_GEP	(umol/m2/s)	Modelled; Gross ecosystem photosynthesis (Barr et al, 2005)
15	EClosure_NEP	(umol/m2/s)	Energy balance closure of NEP (Barr et al, 2005)
16	EClosure_R	(umol/m2/s)	Energy balance closure of R (Barr et al, 2005)
17	EClosure_GEP	(umol/m2/s)	Energy balance closure of GEP (Barr et al, 2005)
18	GapfilledEClosure_NEP	(umol/m2/s)	Gapfilled; Energy balance closure of NEP (Barr et al, 2005)
19	GapfilledEClosure_R	(umol/m2/s)	Gapfilled; Energy balance closure of R (Barr et al, 2005)
20	GapfilledEClosure_GEP	(umol/m2/s)	Gapfilled; Energy balance closure of GEP (Barr et al, 2005)
21	ModelledEClosure_R	(umol/m2/s)	Modelled; Energy balance closure of R (Barr et al, 2005)
22	ModelledEClosure_GEP	(umol/m2/s)	Modelled; Energy balance closure of GEP (Barr et al, 2005)
23	GapfilledPref_NEP	(umol/m2/s)	Gapfilled with perfered method; NEP
24	GapfilledEClosurePref_NEP	(umol/m2/s)	Gapfilled with perfered method; Energy balance closure of NEP

25	CertificationCode	(n/a)	CPI: checked by PI; PRE: preliminary.
26	RevisionDate	(dymoyear)	Date of latest revision

ON-OMW_FoliarNutrients-SLA_yyyy

	Variable	Unit	Description
1	DataType	(n/a)	Ecological data; foliar nutrients - SLA
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	Day	(UTC)	Day of Year UTC.
6	End_Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	Plot	(n/a)	Plot number
8	Species	(n/a)	Tree species
9	Tree_Number	(n/a)	Tree number
10	Analytical_Replicate_Number	(n/a)	Analytical Replicate Number
11	N	(%)	Nitrogen
12	P	(ppm)	Phosphorous
13	K	(ppm)	Potassium
14	Ca	(ppm)	Calcium
15	Mg	(ppm)	Magnisum
16	Specific_leaf_area	(cm2/g)	Specific leaf area
17	CertificationCode	(n/a)	CPI: checked by PI; PRE: preliminary.
18	RevisionDate	(dymoyear)	Date of latest revision

ON-OMW_SiteChar-LargeTrees_yyyy

	Variable	Unit	Description
1	DataType	(n/a)	Ecological; Large tree attributes
2	Site	(n/a)	Ontario Old Mixed Wood (Groundhog R.) site.
3	SubSite	(n/a)	Flux Tower sub-site.
4	Year	(UTC)	4 digit year UTC.
5	Day	(UTC)	Day of Year UTC.
6	End_Time	(UTC)	End of 30min time period, in hours and minutes UTC.
7	ThomasPlot	(n/a)	Plot identifier
8	CenX	(m)	Plot centre Easting, UTM coordinates, Zone 17 North
9	CenY	(n)	Plot centre Northing, UTM coordinates, Zone 17 North
10	Tree_Number	(n/a)	Tree idendifier
11	Species	(n/a)	Genus and species
12	DBH	(cm)	Diameter at breast height (1.3 m)
13	Height	(m)	Height to the top of the crown
14	HLC	(m)	Height to the live canopy
15	LCL	(m)	Live Crown Length (i.e. crown depth)
16	Distance	(m)	Distance from plot centre to stem
17	Azimuth	(degree)	Bearing from plot centre to stem
18	MajCW	(m)	Major crown axis width
19	BearMajCW	(m)	Bearing of the major crown axis
20	MinCW	(m)	Minor crown axis with (perpendicular to major axis)
21	StemE	(m)	Easting coordinate of the stem centre, UTM, Zone 17N
22	StemN	(m)	Northing coordinate of the stem centre, UTM, Zone 17N

23	StemArea	(cm^2)	Area of the stem
24	SWBio	(kg)	Stem wood biomass (Alemdag, 1983;1984)
25	SBBio	(kg)	Stem bark biomass (Alemdag, 1983;1984)
26	LBBio	(kg)	Live branch biomass (Alemdag, 1983;1984)
27	FBio	(kg)	Foliage (twigs and leaves) biomass (Alemdag, 1983;1984)
28	AGBio	(kg)	Total Above Ground biomass (Alemdag, 1983;1984)
29	CertificationCode	(n/a)	CPI: checked by PI; PRE: preliminary.
30	RevisionDate	(dymoyear)	Date of latest revision

8.3.1 Sample Data Record

ON-OMW_FlxTwr_Flx1_yyyy-mm-00

```
DataType,Site,SubSite,Year,Day,End_Time,EddyCovariance_CO2,CO2,TreeTemp
_W_1.5m_57mmN,TreeTemp_W_1.5m_114mmC,TreeTemp_W_1.5m_57mmS,TreeTemp_W_3
.1m_57mmN,TreeTemp_W_3.1m_114mmC,TreeTemp_W_3.1m_57mmS,TreeTemp_W_6.1m_
57mmN,TreeTemp_W_6.1m_114mmC,TreeTemp_W_6.1m_57mmS,TreeTemp_N_1.5m_57mm
N,TreeTemp_N_1.5m_114mmC,TreeTemp_N_1.5m_57mmS,TreeTemp_N_6.1m_57mmN,Tr
eeTemp_N_6.1m_114mmC,TreeTemp_N_6.1m_57mmS,TreeTemp_N_10.6m_57mmN,TreeT
emp_N_10.6m_114mmC,TreeTemp_N_10.6m_57mmS,SoilHeatFlux_W_10cm_#1,SoilHe
atFlux_W_10cm_#2,SoilHeatFlux_N_10cm_#1,SoilHeatFlux_N_10cm_#2,Certific
ationCode,RevisionDate
(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(umol/m2/s),(ppm),(degC),(degC),(de
gC),(degC),(degC),(degC),(degC),(degC),(degC),(degC),(degC),(degC),(deg
C),(degC),(degC),(degC),(degC),(degC),(W/m2),(W/m2),(W/m2),(W/m2),(n/a)
,(dymoyear)
Flx1,ON-OMW,FlxTwr,2004,215,1730,
5.12,351.67,19.4,17.17,17.63,19.72,18.35,17.97,20.29,18.89,19.09,19.07,
16.59,16.49,20.1,17.96,18.29,22.37,20.89,21.73,11.52,9.19,10.19,7.72,PR
E,30052005
Flx1,ON-OMW,FlxTwr,2004,215,1800,-
0.46,352.83,19.87,17.56,18.03,20.19,18.77,18.36,20.78,19.35,19.51,19.45
,16.75,16.68,20.55,18.3,18.64,23.07,21.56,22.58,12.27,10.01,11.03,8.22,
PRE,30052005
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ON-OMW_FlxTwr_Met1_yyyy-mm-00

```
DataType,Site,SubSite,Year,Day,End_Time,DownLongwave_Thermopile,Longwav
e_BodyTemp,UpLongwave_Thermopile,WindSpd_AtPrecipGauge,AirTemp_AtSnowdG
auge,RadLogger_Temp,RadLogger_Battery,CertificationCode,RevisionDate
(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(W/m2),(degC),(W/m2),(m/s),(degC),(
degC),(Volts),(n/a),(dymoyear)
Met1,ON-OMW,FlxTwr,2003,244,30,-109.03,15.661,-
13.529,0.2,15.95,17.45,13.04,PRE,30052005
Met1,ON-OMW,FlxTwr,2003,244,100,-106.29,14.772,-
14.733,0.2,14.6,16.67,13.3,PRE,30052005
```

ON-OMW_FlxTwr_Met2_yyyy-mm-00

```
DataType,Site,SubSite,Year,Day,End_Time,FourWay_NetRad_AbvCnpy_37m,CNR1
_GlobalShortwaveRad_AbvCnpy_37m,CNR1_UpShortwaveRad_AbvCnpy_37m,CNR1_Do
wnLongwaveRad_AbvCnpy_37m,CNR1_UpLongwaveRad_AbvCnpy_37m,LI-
190_DownPAR_AbvCnpy_37m,BF2_DownDiffusePAR_AbvCnpy_37m,LI-
190_UpPAR_AbvCnpy_37m,LI-
190_DownPAR_BlwCnpy_1.5m,TC_AirTemp_AbvCnpy_43m,AspiratedTC_AirTemp_Abv
Cnpy_43m,AspiratedHMP_AirTemp_AbvCnpy_43m,AspiratedRTD_AirTemp_AbvCnpy_
```

43m,AspiratedTC_AirTemp_Cnpy_11m,AspiratedHMP_AirTemp_Cnpy_11m,AspiratedTC_AirTemp_BlwCnpy_1.5m,AspiratedHMP_AirTemp_BlwCnpy_1.5m,AspiratedHMP_RelHum_AbvCnpy_43m,AspiratedHMP_RelHum_Cnpy_11m,AspiratedHMP_RelHum_BlwCnpy_1.5m,WindSpd_AbvCnpy_43m,WindDir_AbvCnpy_43m,StdDev_WindDir_AbvCnpy_43m,SurfPress_1.5m,Geonor_CumPrec_AtPrecipGuage,CS700_TBRG_Rain_AtPrecipGuage,SnowDepth_Cnpy,SoilTemp_W_2cm,SoilTemp_W_5cm,SoilTemp_W_10cm,SoilTemp_W_20cm,SoilTemp_W_50cm,SoilTemp_W_100cm,SoilTemp_N_2cm,SoilTemp_N_5cm,SoilTemp_N_10cm,SoilTemp_N_20cm,SoilTemp_N_50cm,SoilTemp_N_100cm,SnowTemp_W_1cm,SnowTemp_W_2cm,SnowTemp_W_5cm,SnowTemp_W_10cm,SnowTemp_W_20cm,SnowTemp_W_30cm,SnowTemp_W_50cm,SnowTemp_W_100cm,SnowTemp_N_1cm,SnowTemp_N_2cm,SnowTemp_N_5cm,SnowTemp_N_10cm,SnowTemp_N_20cm,SnowTemp_N_30cm,SnowTemp_N_50cm,SnowTemp_N_100cm,CertificationCode,RevisionDate
(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(W/m2),(W/m2),(W/m2),(W/m2),(W/m2),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(degC),(degC),(degC),(degC),(degC),(degC),(degC),(degC),(%),(%),(%),(m/s),(deg),(deg),(kPa),(mm),(mm),(cm),(degC),(n/a),(dymoyear)
Met2,ON-OMW,FlxTwr,2003,244,30,-88.452,0.77,1.35,306.65,394.52,9.16,10.92,0.32,0.59,18.2,17.87,17.98,-999,16.94,17.24,15.78,15.95,60.2,64.3,76.6,3.4,238.4,8.442,97.7,52.3,0,0,14.93,14.12,12.47,11.18,10.59,9.91,14.82,13.98,12.49,11.63,11.06,10.39,15.16,15.14,15.14,15.18,15.2,15.23,15.28,15.36,15.23,15.13,15.13,15.17,15.15,15.21,15.21,15.24,PRE,31052005
Met2,ON-OMW,FlxTwr,2003,244,100,-66.647,-1.64,0.99,327.19,391.2,0.16,1.69,0.01,-0.22,17.56,17.15,17.22,-999,16.1,16.25,14.55,14.6,63.1,67.9,81.2,3.5,242.1,8.793,97.7,52.6,0,0,14.44,13.86,12.4,11.2,10.6,9.9,14.29,13.72,12.44,11.65,11.06,10.38,14.38,14.35,14.35,14.37,14.38,14.39,14.43,14.47,14.36,14.27,14.23,14.25,14.2,14.24,14.22,14.23,PRE,31052005

ON-OMW_FlxTwr_VWC3_yyyy-mm-00

DataType,Site,SubSite,Year,Day,End_Time,AvgCS615_VWC_15cm,AvgCS615_VWC_30cm,AvgCS615_VWC_45cm,AvgCS615_VWC_60cm,AvgCS615_VWC_80cm,AvgCS615_VWC_100cm,CertificationCode,RevisionDate
(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(m3/m3),(m3/m3),(m3/m3),(m3/m3),(m3/m3),(m3/m3),(n/a),(dymoyear)
SM3,ON-OMW,FlxTwr,2003,221,2000,0.47508,0.41217,0.37725,0.37719,0.43433,0.4403,PRE,10082004
SM3,ON-OMW,FlxTwr,2003,221,2400,0.47366,0.41203,0.37747,0.3774,0.43445,0.44033,PRE,10082004

ON-OMW_FlxTwr_Flx2_yyyy-mm-00

DataType,Site,SubSite,Year,Day,End_Time,NetEcosystemExchange,CO2Flux_AbvCnpy_37m,FourWay_NetRad_AbvCnpy_37m,LatentHeatFlux_AbvCnpy_37m,SensibleHeatFlux_AbvCnpy_37m,SoilHeatFlux_0cm,BiomassHeatStorage_AbvCnpy_37m,PhotosyntheticHeatFlux_AbvCnpy_37m,FrictionVelocity_AbvCnpy_37m,OneLevel_CO2StorageFlux_37m,CO2StorageFlux_0to37m,LatentHeatFlux_AbvCnpy_37m,LatentHeatStorageFlux_Sfc to Top,SensibleHeatFlux_AbvCnpy_37m,SensibleHeatStorageFlux_0to37m,Gapfilled_FourWay_NetRad_AbvCnpy_37m,Gapfilled_LatentHeatFlux_AbvCnpy_37m,Gapfilled_SensibleHeatFlux_AbvCnpy_37m,CertificationCode,RevisionDate

(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(umol/m2/s),(umol/m2/s),(W/m2),(W/m2),(W/m2),(W/m2),(W/m2),(W/m2),(W/m2),(umol/m2/s),(umol/m2/s),(W/m2),(W/m2),(W/m2),(W/m2),(W/m2),(W/m2),(W/m2),(n/a),(dymoyear)
Flx2,ON-OMW,FlxTwr,2004,1,30,0.46,0.91,-73.59,14.2,-36.3,-2.01,-8.15,0.23,-999,-0.45,-999,20.84,-6.64,-11.05,-25.25,-73.59,20.84,-11.05,PRE,5072005
Flx2,ON-OMW,FlxTwr,2004,1,100,-0.38,0.51,-48.27,4.84,-31.13,-5.8,-8.77,-0.19,-999,-0.89,-999,8.18,-3.34,-13.57,-17.56,-48.27,8.18,-13.57,PRE,5072005
Flx2,ON-OMW,FlxTwr,2004,1,130,0.5,0.96,-46.04,11.22,-16.92,-5.62,-8.23,0.25,-999,-0.46,-999,13.73,-2.51,-7.33,-9.59,-46.04,13.73,-7.33,PRE,5072005

ON-OMW_FlxTwr_Met3_yyyy-mm-00
DataType,Site,SubSite,Year,Day,End_Time,FourWay_NetRad_AbvCnpy_37m,CNR1_GlobalShortwaveRad_AbvCnpy_37m,LI-190_DownPAR_AbvCnpy_37m,AirTemp_AbvCnpy_43m,AspiratedHMP_RelHum_AbvCnpy_43m,SpecificHum_AbvCnpy,Windspeed_AbvCnpy_43m,SoilTemp_2cm,SoilTemp_5cm,SoilTemp_10cm,SoilTemp_20cm,SoilTemp_50cm,SoilTemp_100cm,Geonor_CumPrec_ATPrecipGauge,EventPrec_ATPrecipGauge,CertificationCode,RevisionDate
(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(W/m2),(W/m2),(umol/m2/s),(degC),(%),(g/g),(m/s),(degC),(degC),(degC),(degC),(degC),(degC),(mm),(mm),(n/a),(dymoyear)
Met3,ON-OMW,FlxTwr,2004,1,30,-73.592,-4.94,0.08,-11.8,91.4,0.001,5.4,0.48,0.94,1.41,2.85,3.16,3.75,0,-999,PRE,8062005
Met3,ON-OMW,FlxTwr,2004,1,100,-48.265,-4.84,0.1,-12.34,94,0.001,3.9,0.46,0.91,1.37,2.86,3.18,3.76,-999,-999,PRE,8062005

ON-OMW_FlxTwr_Flx3_yyyy-mm-00
DataType,Site,SubSite,Year,DOY,Time,NEP,R,GEP,GapFilled_NEP,GapFilled_R,GapFilled_GEP,Modelled_R,Modelled_GEP,EClosure_NEP,EClosure_R,EClosure_GEP,GapfilledEClosure_NEP,GapfilledEClosure_R,GapfilledEClosure_GEP,ModelledEClosure_R,ModelledEClosure_GEP,GapfilledPref_NEP,GapfilledEClosurePref_NEP,CertificationCode,RevisionDate
(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(umol/m2/s),(n/a),(dymoyear)
Flx3,ON-OMW,FlxTwr,2004,1,30,-0.46,0.46,0,-0.46,0.46,0,0.492,0,-0.489,0.489,0,-0.489,0.489,0,0.519,0,-0.46,-0.489,PRE,19072005
Flx3,ON-OMW,FlxTwr,2004,1,100,0.38,-0.38,0,0.38,-0.38,0,0.486,0,0.404,-0.404,0,0.404,-0.404,0,0.511,0,0.38,0.404,PRE,19072005

ON-OMW_FoliarNutrients-SLA_yyyy
DataType,Site,SubSite,Year,Day,End_Time,Plot,Species,Tree_Number,Analytical_Replicate_Number,N,P,K,Ca,Mg,Specific_leaf_area,CertificationCode,RevisionDate
(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(n/a),(n/a),(n/a),(n/a),(%),(ppm),(ppm),(ppm),(ppm),(cm2/g),(n/a),(dymoyear)
Ecological,On-OMW,FlxTwr,2004,225,-999,21,Populus_tremuloides,1,1,2.29,1569,11689,12162,2276,128.7,PRE,03052005
Ecological,On-OMW,FlxTwr,2004,225,-999,21,Populus_tremuloides,2,1,2.20,1295,8490,15444,3008,165.6,PRE,03052005

ON-OMW_SiteChar-LargeTrees_yyyy

```
DataType,Site,SubSite,Year,Day,End_Time,ThomasPlot,CenX,CenY,Tree_Numbe
r,Species,DBH,Height,HCL,LCL,Distance,Azimuth,MajCW,BearMajCW,MinCW,Ste
mE,StemN,StemArea,SWBio,SBBio,LBBio,Fbio,AGBio,CertificationCode,Revisi
onDate
(n/a),(n/a),(n/a),(UTC),(UTC),(UTC),(n/a),(m),(m),(n/a),(n/a),(cm),(m),
(m),(m),(m),(degrees),(m),(degrees),(m),(m),(m),(cm^2),(kg),(kg),(kg),(
kg),(kg),(n/a),(dymoyear)
SiteChar,On-OMW,FlxTwr,2003,189,-
999,1,414401.37,5341061.43,1,Betula_papyrifera,13,15.5,8.6,6.9,1.4,47,3
.3,250,2.9,414402.44,5341062.43,132.7,42.5,7.5,9.2,2.3,61.5,PRE,2906200
5
SiteChar,On-OMW,FlxTwr,2003,189,-
999,1,414401.37,5341061.43,2,Betula_papyrifera,20.9,13,7,6,4,23,4.3,197
,3.9,414402.97,5341065.21,343.1,92.1,16.3,20,4.9,133.3,PRE,29062005
```

8.4 Image Data

Identifier:OMW05015EO1HY.PIX
Date of Acquisition (UTC):15 July 2005
Time of Acquisition (UTC):16:05
Sensor / Mode:EO-1 Hyperion
Wavelength (nm) / Frequency (GHz): 400-2500 nm
Platform Altitude: N/A
Spatial Ground Resolution (m):30
Incidence Angle – Average: -4.4249
Incidence Angle – Minimum: N/A
Incidence Angle – Maximum: N/A
Polarization: N/A
Gain Control:
Flight Azimuth: Descending
Scene Centre:48.217° N, 82.156° W

Identifier: OMW04015CASI_rad.PIX
Date of Acquisition (UTC): 15 August 2004
Time of Acquisition (UTC): 16:38
Sensor / Mode: Compact Airborne Spectrographic Imager (CASI), Spectral Mode
Wavelength (nm) / Frequency (GHz): 400 – 950 nm
Platform Altitude (m): 1886.9 m
Spatial Ground Resolution (m): 4
Incidence Angle – Average: 0
Incidence Angle – Minimum: n/a
Incidence Angle – Maximum: n/a
Polarization: n/a
Gain Control:
Flight Azimuth: 328.857^{o} true
Scene Centre:48.217° N, 82.156° W

Identifier: OMW04015CASI_ref.PIX
Date of Acquisition (UTC): 15 August 2004
Time of Acquisition (UTC): 16:38
Sensor / Mode: Compact Airborne Spectrographic Imager (CASI), Spectral Mode
Wavelength (nm) / Frequency (GHz): 400 – 950 nm
Platform Altitude (m): 1886.9 m
Spatial Ground Resolution (m): 4
Incidence Angle – Average: 0
Incidence Angle – Minimum: n/a

Incidence Angle – Maximum: n/a
Polarization: n/a
Gain Control:
Flight Azimuth: 328.857° true
Scene Centre:48.217° N, 82.156° W

Identifier:OMW03010lidar.txt
Date of Acquisition (UTC): 10 August 2004
Time of Acquisition (UTC):
Sensor / Mode: Optech ALTM 2050, first and last return mode
Wavelength (nm) / Frequency (GHz): 50kHz
Platform Altitude (m):
Spatial Ground Resolution (m): 0.25 m (3-8 pulses/m^2)
Incidence Angle – Average: n/a
Incidence Angle – Minimum: 0
Incidence Angle – Maximum: 25
Polarization: N/A
Gain Control:
Flight Azimuth:
Scene Centre:48.217° N, 82.156° W

Identifier:OMW04021lidar.txt
Date of Acquisition (UTC):21 August 2004
Time of Acquisition (UTC):
Sensor / Mode:M7 Visual Intelligence Leica ALS-40, first and last return mode
Wavelength (nm) / Frequency (GHz): 1064 nm / 25 kHz
Platform Altitude (m): 1066.8 m
Spatial Ground Resolution (m): 5 m (0.035 pulses/m^2)
Incidence Angle – Average: n/a
Incidence Angle – Minimum: 0
Incidence Angle – Maximum: 20
Polarization: N/A
Gain Control:
Flight Azimuth:
Scene Centre:48.217° N, 82.156° W

9 Data Manipulations

The data were recorded on several dataloggers in various formats. Some calibrations and data manipulations were completed on-line and the rest were completed in Matlab functions. For example the LI-7000 data was corrected on-line daily (refer to section 4.2.2). Except for the profile system electrical outputs were converted on-line to temperatures, fluxes etc. The profile data was converted from electrical outputs to concentrations with a series of Matlab function created by the UBC group and Queens climatology group.

9.1 Post Processing and Calculated Variables

All data is processed according to the Fluxnet-Canada management and measurement protocols (please refer to the protocols for details). For instance, the integrity of the data is ensured by rejected bad data points and setting them to -999. In general, data is rejected when maintenance is being done on a sensor, if the sensor is malfunctioning and when unexplained outliers occur. Further, carbon dioxide concentrations, eddy covariance, latent heat and sensible heat data is rejected when data capture is poor (for example during a heavy rainstorm eddy covariance measurements are poor).

Corrections are also applied to the data. For relative humidity measurements, when the relative humidity is reads above 100%, the value is set to 100%. As suggested in the Fluxnet-Canada protocol, the cumulative precipitation, measured by the Geonor precipitation gauge, is corrected for fluctuations that arise from in changes in temperature by determining a maximum accumulated precipitation value and then disallowing this value to decrease. However, a shortcoming in this technique is that small precipitation events (<1mm) maybe missed. The Geonor precipitation gauge is also wind correct as outlined by Campbell and Smith (2005). The wind correction for snow is

$$CE(\%) = 0.49u^2 - 13.10u + 107.23 \tag{9.1}$$
$$\text{Corrected precipitation} = \text{measured precipitation}/CE \tag{9.2}$$

where CE is the ratio of the catch of a Geonor-Alter to a Geonor-Double fenced, u is windspeed (m/s) and precipitation is in mm. The measured precipitation was converted from hz to mm (Geonor, 2003). The wind correction for rain is

$$CE(\%) = -1.46u + 105.38 \tag{9.3}$$
$$\text{Corrected precipitation} = \text{measured precipitation}/CE. \tag{9.4}$$

An offset is applied to the snow depth measurement as the sensor reads approximately 1.5 cm of snow in the summertime. The offset is determined by taking the mean snow depth measurement the summer before and after the winter and subtracting this mean value to winter snow depth measurements. When snow is not present, all snow depth measurements are set to 0.

Event precipitation was determined from both the tipping bucket and the Geonor precipitation gauge. Essentially, half hour precipitation values were established from the Geonor and compared to the tipping bucket. When the Geonor appeared to miss small rain events (see discussion above), or underestimate the catch, measurements from the tipping bucket were used.

Several variables are gap filled. Small gaps less than or equal to 2 hours are filled by linear interpolation. Larger gaps are filled according to the Fluxnet-Protocols. Presently, there are no Fluxnet protocols for gap filling meteorological variables, such as temperature, and several standards were established to gap fill meteorological data. Where possible, a relationship is established between two sensors or measurements a few days before and after the gap, and the gap is filled by via the relationship with the other sensor. If a relationship with another sensor cannot be established, the gap is filled by a 5 day diurnal mean pattern before and after the gap occurred. For gaps larger than a week, a five day diurnal mean maybe too small, and the number of days included in the diurnal mean pattern is increased.

Storage terms were computed using Fluxnet-Protocols and Oliphant (2004). Both the soil heat storage flux and Biomass heat storage flux contain site specific estimated and measured constants. The soil heat storage flux $Q_{g_{(o)}}$ was estimated as:

$$Q_{g_{(o)}} = Q_{g_{(z)}} + Cs\frac{\partial T_s}{\partial t}z \tag{9.5}$$

where $Q_{g_{(z)}}$ is the average ground heat flux from the four flux heat plates at 0.1 m bgl, Cs is the specific heat capacity of the soil, ∂T_s half-hour difference in the average soil temperature above the heat flux plates (K), ∂t is the difference in time (1800 seconds) and z is the depth below ground (0.1 m). The heat capacity of soil was estimated from

$$Cs = \rho_b Cs_d + \theta_v Cs_w \tag{9.6}$$

where ρ_b is the bulk density of the soil estimate to be 13000 kg/kg, Cs_d is specific heat of dry mineral soil estimated to be 1500 J/kg/K, Cs_w is the specific heat of soil water estimated to be 4190 J/kg/K, θ_v is the measured volumetric water content from the CS615 water content reflectometers. The biomass heat storage was determined by

$$Q_v = M_{veg} C_{veg} \frac{\partial T_{veg}}{\partial t}, \tag{9.7}$$

where M_{veg} is mass of vegetation per unit horizontal area of the forest and was determined to be 12.76 kg/m2, C_{veg} is a representative specific heat of the vegetation and was estimated to be 2928 J/Kg/K and ∂T_{veg} is the change in the average tree bole temperatures (2 trees; 9 measurements per tree).

2005 Data

It should be noted that in 2005, we have improved upon our data screening procedures for meteorology and flux data, and time was spent in the development of QC and QA software tools for these tasks. These changes will be reflected in the 2005 set. As well, a detailed soil analysis has been conducted and this will improve the quality of our soil heat flux calculation.

Changes to the 2004 screening procedures are as follows:

-RH sensor values up to 103% have not been rejected, as this falls within the accuracy of the sensor. RH sensors have undergone QC through first rejecting values that fall outside of limits set at 0 and 150%. The remaining cleaning was done through visual inspection of the sensor's max, min, and average values, and standard deviation. Neighbouring HMP sensors were compared and top of canopy values were compared to the EC system.

-Offsets in shortwave and PAR data have been corrected. This has been done through finding the mean value of the offset during the night, and applying this mean offset value to the latter half of the previous day, and the first half of the following day.

-C-Sat values are first screened on the basis of data capture. Calibration currently takes 6 minutes, and this was used as a cut-off threshold for missing data. It should be noted that when there was an issue of data capture, a large majority of the time, we are missing 90-100% of the half hour. Data capture between 10-80% outside of calibration periods was not common and only occurred when the C-Sat was going through a transition phase between completely malfunctioning and functioning normally. These transition values were rejected. Further screening was done through comparison with the RMYoung.

-For the EC system, Licor values were first screened using gage pressure. Following this, values were rejected when < 340 ppm, and >480 ppm. Both measurement values and standard deviations were visually inspected, and some values on the cusp of a pump failure, maintenance period were removed. Points were also removed when standard deviations were seasonally very high. Through visual inspection, the EC system was compared with the top of canopy profile measurement, and the majority of points were within 1 ppm. H_20 values were compared with the top of canopy HMP values.

-Profile system was screened both on the basis of gage pressure and through agreement with EC system.

-All flux values have undergone rotation.

-Soil bulk density values have become available from NFI. A spacial average of six of the NFI plots closest to the tower is currently being used.
-For Biomass Heat Storage, there was an update to the M_{veg} value. This new value was determined by using a special average of 8 sectors where estimated of above ground biomass was determined through remote sensing.

-Soil Heat Flux had been calcuated using a bulk density of 1739.4 kg/m^3. This was determined through using a mean of the bulk density values at a depth of 0-15 cm at the 6 NFI plots closest to the tower. 840 J/(m^3K) was used as the average specific heat of mineral soils as specified in Mayocchi and Bristow (1995).

-Below canopy PAR measurement have been screened for snow. This was done through manual inspection of max, min and average data PAR data, snow fall data, and air temperature. There are periods during the winter where the data shows no sign of snow cover, and this data has been retained. It should be noted, however, that being a remote site, it is difficult to tell with absolute certainty whether or not there is ice or snow cover on the sensor, and this should be taken into consideration when looking at the winter data.

Gap Filling of H and Le(2004 and 2005)

Le Gap Filling

1. Small Gaps (gaps less than 2 hours) are filed using linear interpolation. This is done using LeGapFill.m

2. Gaps at night are set to “0”

3. Gaps during the growing season are filled using first order polynomial regression relationship between Net Radiation and LE. This is done using LeGapFill, and the regression relationship is done using 100 points (approximately 2 days) of data. The growing season is defined as between May 15 and September 15.

4. Gaps during the non-growing season are filled using an ensemble average of the same half hour 5 days prior to and 5 days following the gap. Should half hour values to compute the average be missing, the average is made using as many values as available.

H Gap Filling

1. Small Gaps (gaps less than 2 hours) are filed using linear interpolation. This is done using HGapFill.m

2. Large gaps are filled using first order polynomial regression relationship between Net Radiation and H. This is done using HGapFill.m, and the regression relationship uses 100 points (approximately 2 days) of data.

9.2 Special Corrections/Adjustments

DOY 1 to 235, 2004 - Soil and snow temperatures were biased by a heater in the datalogger’s temperature controlled housing. The temperature oscillated from the heater turning on and off. The temperature was corrected by sequencing a running mean through the data series to remove the oscillations in the data series.

DOY 1 to 235, 2004 - The multiplexer controlling the west soil and snow sensors was not working properly (i.e. produced erroneous values such as temperatures of 35 degrees C in the winter). These values were rejected.

DOY 357, 2004 at 7:30 to DOY 60, 2005 at 0:30 - The span (cal 1) values for the EC system above the canopy were incorrect. The data was manually corrected during this period by using and cal 2 to span and zero the co2 data.

DOY 1 to 117 2005
There was a calibration issue in the Profile system between Jan 1, and April 27. The raw data has been recalculated through approximating the span and zero values for the period. There is good agreement with EC system during this period.

Precipitation-November, 2005

Three collumns of precipitation data are included in the 2005 data set. The reason for this is that a discrepancy was found between our wind corrected November data, and precipitation data from the Timmins airport. Uncorrected data showed no discrepancy,and we beleive this discrepancy has been introduced through use of wind correction for snow. Because of this discrepancy, we have included the following sets:

-wind corrected precipitation data
-uncorrected precipitation data
-Data that has been wind corrected, except for the month of November(PI preferred). We beleive this set is
the most accurate.

DOY 1-98
There was a noise induced heater effect from DOY 1-98. Through inspection, this noise was not evident in the min values. Because the variability of soil temperature is very low, the min value was used during this period.

10 . Errors and Limitations
[This section describes an error analysis for the data.]

Error analysis needs to be done

10.1 Sources of Error
[Describe what factors of the instrument or environment may introduce errors in the observations.]

10.2 Quality Assessment

10.2.1 Data Validation by Source

Data were quality assured by comparing similar variables at the same site daily to ensure that problems were flagged and fixed in a timely manner.

10.2.2 Confidence Level/Accuracy Judgment

The data submitted are of good quality with minimal amount of errors. However, any measurement is not perfect, and the user must be aware of the limitations of the instrumentation.

10.2.3 Measurement Error for Parameters

[Quantitative error estimates.]

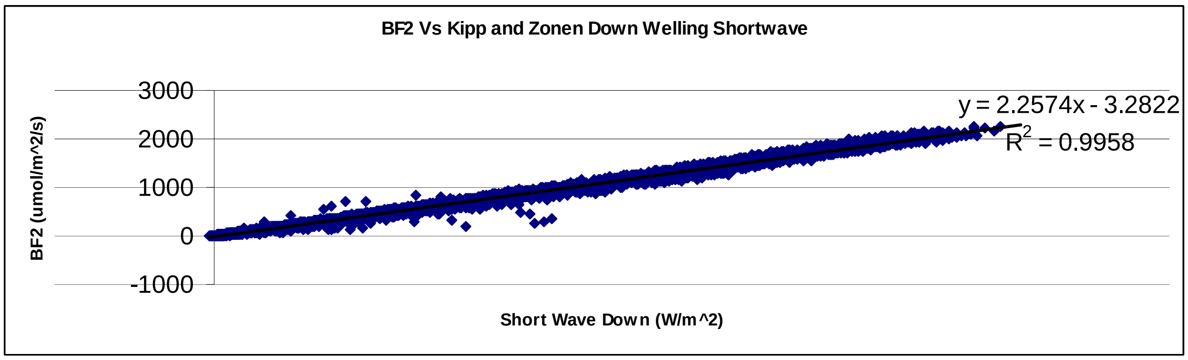
10.2.4 Additional Quality Assessments

Both Cross Site and Roving Met were conducted during August 2005. The Roveing Met found that no additional corrections were required. Also our flux system measurements results were comparable to the Cross Site system.

10.3 Limitations and Representativeness

2005

Analysis of BF2 sensor indicated that it's performance is at the outside limits of the manufacture Indicated accuracy(12%). This should be taken into account when using the Diffuse PAR data.



10.4 Known Problems with the Data

2003

There appears to be a calibration problem with the CO_2 values. Additional screening is required. This data will be updated, and this document revised.

2004

The soil heat storage is currently an estimate, as the flux contains estimated soil bulk density and heat capacities. Once these parameters are measured at the groundhog site the soil heat capacity will need to be recalculated.

No rotation correction has been applied to fluxes or variables using the sonic anemometer (e.g. eddy covariance, latent heat flux, sensible heat flux and u*).

Fc Data for November and December are effected by the noise issue mentioned below. This issue was discovered through analysis of the 2005 data, and will corrected. In the interim, this data can be used for the purpose of daily totals, but should not be used when looking at changes on a half hourly basis.

2005

There was a noise issue in the EC CO_2 signal between January 1 and July 2005. The issue was due to an electrical jumper wired into the CR5000 logger that was advised by Campbell Scientific Senior Applications Engineer in late 2004 when we switched from open to closed path systems.

This jumper was found to be an issue during the UBC Cross Site comparison, and was then removed. The noise was most evident in Fc measurements for the first four months of 2005, and it is for this reason that daily mean values have been submitted into the DIS. We do not have confidence in the half hour measured Fc data for the first four months of 2005, but there is an Fc signal that has been preserved here, and by using daily means for this period, we can obtain very reasonable values for the purpose of annual totals.

There were Profile system calibration issues from the January 1, 2005 to April 27 2005. The Span on a Li 6262 is quite stable, and with estimated Li 6262 zero values, we obtained above canopy CO2 levels within 1-2 ppm with the EC system. Because we can compare values with the EC system, we do have confidence in the absolute CO_2 values, and have an even higher degree of confidence in the storage values as they are based on the change of CO_2 over time.

11. Software

11.1 Software Description

Data was processed online (i.e. in by the Campbell scientific data loggers) and with Matlab functions created by Queens Climatology, UBC Biomet group, Alan Barr and group. Data was also processed in Excel.

11.2 Software Access

Excel and Matlab are available commercially. For Matlab functions please contact the Queens Climatology group.

12 . References

12.1 Platform/Sensor/Instrument/Data Processing Documentation
[List any published documentation relevant to the data collected, such as manufacturer's instruction manuals, government technical manuals, user's guides, etc.]

12.2 Journal Articles and Study Reports
[List technical reports and scientific publications that concern the methods, instruments, or data described in this document. Publications by the Principal Investigator or investigating group that would help a reader understand or analyze the data are particularly important.]

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13. Glossary of Terms and Acronyms

DIS – Data information system
EC – Eddy correlation or eddy covariance
GR – Groundhog River Station
IRGA - Infrared gas analyser
PAR – Photosynthetic active radiation
NEE – Net ecosystem exchange
NEP - Net ecosystem productivity
R - Ecosystem respiration

14 . Document Information

14.1 Document Revision Date

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14.2 Document Author

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14.3 Keywords

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