

# Fluxes Over Snow Surfaces (FLOSS)

Looking east toward Medicine Bow mountains from FLOSS site.

## News

## Introduction

This document describes the first phase of the FLOSS project, which studied the surface meteorology of snow-covered rangeland in the North Park region of Colorado, near Walden, from December 2001 to March 2002.

The second phase of that project, FLOSSII, is described in a [separate document](#).

If you reached this page from a search engine, click [here](#) to see the full report, with frames.

This document is a standard product of [NCAR/ATD/RTF](#) and gives an overview of the measurements taken using the [Integrated Surface Flux Facility \(ISFF\)](#) and conditions during the FLOSS field experiment.

The [ISFF Request](#) is available to describe the scientific goals and experiment design.

## Location

Near Walden, Colorado, in the Arapahoe Wildlife Refuge near the old Case Ranch. Through [MapQuest.com](#), we've obtained an [overhead](#) aerial photograph of this area. A year later, we took oblique aerial photos looking SW from the NCAR C-130 ([A](#),[B](#)). We've produced a [map](#) using Topo of the site, with tower locations for FLOSS01 and FLOSSII indicated with red dots. Note that the labels are to the NE of the corresponding dot -- not necessarily the closest.

I have written a set of [driving directions](#) for the convenience of the many visitors we expect to see! Also, see my [contact list](#) for our phone numbers, etc.

## Chronology

The request was modified in August, 2001 to extend the measurement period.

- 9-10 Oct, 2001: 24m tower erected
- 26-30 Nov, 2001: Instrumentation set-up
- 1-15 Dec, 2001: First manned observation period
- 17 Dec, 2001: Third station installed at sagebrush site
- 18 Feb -2 Mar, 2002: Second manned observation period
- 26 March, 2002: Data acquisition systems removed from bare and sage sites.

Radiometers and soil sensors removed from all three sites.

- 1-2 Apr, 2002: Equipment teardown.
- October 2002 Setup begins for [FLOSSII](#)

Between the periods of manned observations, data was taken in a minimal maintenance mode, with short service visits and remote data monitoring.

## Measurement Sites

NCAR ISFF sensors were installed at three sites during FLOSS.

### **24 meter walkup tower**

- profiles of mean air temperature and RH at 0.5, 1, 2, 5, 10, 15 and 20 meters
- profiles of mean wind speed and direction at 1, 2, 5, 10, 15 and 20 meters
- barometer
- eddy correlation sensors (sonic anemometer, fast water vapor) at 2, 10 and 20 meters. The 2 meter level also had two fast CO<sub>2</sub> sensors.
- OSU and NCAR MMM also installed 20 thermocouples on this tower from 0.2 to 20 meters.
- nearby radiation stand with up-and-down-looking long and short wave radiometers, net radiation sensor, and soil temperature, moisture and heat flux sensors
- precipitation and snow depth gauges

### **bare site**

- mean air temperature and RH at 2 meters
- barometer
- one level of eddy correlation sensors (sonic anemometer, fast water vapor) at 2 meters
- Up to Dec 17th, the bare site also had a 4 component radiation stand and soil sensors like the tower. After Dec 17th the radiation stand was moved to the sagebrush site, keeping only net radiation and soil sensors.

### **sagebrush site**

Installed Dec 17th.

- mean air temperature and RH at 2 meters
- barometer
- one level of eddy correlation sensors (sonic anemometer, fast water vapor) at 2 meters
- 4 component radiation stand and soil sensors like the tower.

## Site Locations

Site	Latitude (N)	Longitude (W)
24 meter tower	40° 39' 32" 40° 39.53'	106° 19' 26" 106° 19.43'
bare	40° 39' 56" 40° 39.93'	106° 19' 11" 106° 19.18'
sagebrush	40° 40' 11" 40° 40.18'	106° 19' 3" 106° 19.05'

## Sensors

The layout of the sensors on the 24 meter tower and bare/sagebrush sites is shown [here](#) (and [PostScript version](#)).

OSU also had a hot-film and a 3-D sonic anemometer close to the surface near the SE guy wires of the 24m tower. OSU also deployed 2-D sonic anemometers and thermocouples to the west of the 24m tower. Contact them for these data.

## Sonic Anemometers

These were all Campbell CSAT3 anemometers, which generally performed well. They were all nominally on booms pointing to the West. The bare sonic was lowered from 2.9 to ~2m on 2 Dec 2001.

## Krypton Hygrometers

Krypton hygrometers were used for water vapor fluctuation measurements. Like in FLOSSII, they probably went offscale frequently due to ice fog. Also, the wiring in the electronic boxes became corroded due to moisture infiltration in the middle of this project, which I think is indicated by a diurnal variation in the offset with respect to the T/RHs.

The kryptons were mounted horizontally, with the sensing volume almost directly underneath the front of the junction box of the sonic arms, and even with the bottom arm of the sonic. This is far enough displaced that any flux data should be corrected. The source tube was usually mounted to the North, to avoid having the detector view the sun, however this was switched (only at the sage site?) for a period of testing when we were trying to figure out the problem which turned out to

be corrosion.

## CO2 sensors

NCAR deployed a LiCor 6251 CO2 sensor with an inlet tube near the 2m sonic anemometer at the 24m tower. It ran from 1 Dec 2001 to 1 Apr 2002. Three different pairs of calibration gases were used to characterize its calibration. The "low cal" cylinders typically lasted for 3 weeks and the "high cal" cylinders lasted for about 6 weeks (apparently, there was a small leak on the "low cal" side), so there are periods when there were 0, 1, or 2 calibration gases.

The sensor was calibrated using the procedure developed for FLOSSII, which fits the analyzer output  $V$  to CO2 density computed using the cylinder concentration  $M$ , analyzer pressure  $P$  and temperature  $T$ ,  $V = a1 + a2 * M * P / (T + 273.15) + a3 * P$ . During FLOSS01, the pressure in the analyzer was not monitored, so the nearest atmospheric pressure sensor (at the base of the 24m tower) was used instead. (The data from this barometer were corrected for temperature -- see below.) Since  $P/P_{atmos}$  is a function of flow rate and the flow rates were adjusted when the calibration gases were changed, separate calibrations were made for each calibration gas pair. The fits are:

	a1	a2	a3
1 Dec 2001 to 4 Jan 2002:	-0.07692321	0.001657638	0.0007069289
4 Jan 2002 to 20 Feb 2002:	0.3992281	0.001586562	0.0001679215
20 Feb 2002 to 1 Apr 2002:	0.1187805	0.001498741	0.0005661472

A plot of these fits is shown [here](#), where "mpot" is  $M * P / (T + 273.15)$  and "mpotc" is  $(V - (a1 + a3 * P)) / a2$ .

OSU also deployed a LiCor7500 open-path sensor from 10 Dec 2001 - 27 Feb 2002. This particular sensor was an early production unit which had a light leak. Thus, the data have a diurnal cycle artifact.

## Propeller-vane Anemometers

The prop-vanes were mounted pointing South from the South side of the 24m tower, to measure velocity profiles. We had several failures of these sensors during FLOSS01 due to icing-related propeller breakage and electronics which caused either the chopper wheel (wind speed) counts to read zero or the encoder (direction) to read constant. Electronics, propellers, vanes, and processors were all swapped at various times with various sensors. By the end of the project, we no longer had spare parts, so the top? sensor was not used. (For FLOSSII, we used only sonic anemometers for both flux and velocity profile measurements.)

## T/RH Sensors

The data from the T/RH sensors generally were good, though we had the usual fan outages

during the project and inlets probably were clogged with ice/snow from time to time.

## Barometers

We had our standard barometers at each site. The bare and sage sites both had Vaisala PTB220 sensors which work fine. The PTB100 at the 24m site has a temperature dependence. For FLOSS01, this was reasonably fit by:  $P = P_{\text{ptb100}} + 0.126 * T - 3.4$ . Since the sensor was mounted in the ADAM, Tbox.cosmos was used to characterize its temperature. This correction will be applied to the data.

## Precipitation

Precipitation was measured at the 24m site using our ETI weighing precipitation gauge. This appeared to give some spurious tips.

As with FLOSSII, we also deployed an ultrasonic snow depth gauge, but have found the data from it to be useless (except as an indicator of snow in the air).

## Radiometers

Our standard 4-component sensor suite (PSP up and down, PIR up and down, and net) was deployed initially at the 24m and bare sites. As mentioned above, when the sage site was established, the sensors at the bare site were moved to sage, but a new net radiometer was installed at the bare site. Since high accuracy was not needed from these sensors, our standard calibration was used. All of the PSP and PIR sensors (probably!) were aspirated, but undoubtedly, there still were periods when they were covered with ice/frost/snow. We also ran "dummy" radiometers as icing detectors at the main tower site. These data have not been examined yet.

From logbook:

- sage fans disconnected 2 March 2002 to save power.
- main Rsw.out was bad until the sensor was replaced on 10 Dec.
- Even after the change, main Rsw.in varied at night more than others (at least all of Dec 2001)

## Soil Sensors

Our standard sensors were used at each site: 1 REBS heat flux plate at 5cm, 1 REBS temperature probe slanted from 1-4cm, and 1 CS615 soil moisture probe at 5cm. These sensors were deployed in late November when the ground was frozen, so thermal coupling to the soil was not

great. Also, we now know that the CS615 probes do not "see" frozen moisture. We also took several manual moisture measurements with our handheld TRIME probe, but it probably suffers from the same "ice blindness". Thus, the only reliable moisture measurements were those done gravimetrically. We did take over 20 gravimetric samples at various depths at the 3 sites. All the "reliable" soil moisture measurements are plotted [here](#). There aren't many values. CS615 data are only shown when Tsoil is greater than 0. Also, the main site CS615 data have been multiplied by 1.4 to agree with the (2!) gravimetric samples in the non-frozen period. Unfortunately, no gravimetric samples were taken at bare and sage with non-frozen soil so that similar adjustments could be made.

## Daily QC Plots

This [table](#) displays all available QC plots, by day. These plots are of the 5-minute statistics, covering 48 hours, centered on local noon of each day. These are preliminary plots for data quality control.

## Variables

This [table of variables](#) is generated from the header of a NetCDF file of 5 minute statistics.

## FLOSS Data Access

The NCAR FLOSS data is available for download in the following forms:

- [5-minute statistics in NetCDF form](#)

## FLOSS Field Logbook

A computer-readable [field logbook](#) of comments noted by NCAR and other personnel is available in html form.

## FLOSS Photographs

[Photographs](#) are available from site survey and during operations. Note the repeated views of some shots to characterize the snow cover.

On Jan 17th, an [Axis 2420](#) network camera was installed on the tower at about 21 meters, looking south. Photos are taken and saved in JPEG form every 15 minutes from 05:00 to 20:00 local time (MST=GMT-7). [Photos at 08:00, 12:00 and 16:00 local time](#) each day are available here.

Network camera photo history:

- Jan 17-Feb 7: VGA resolution photos (704x480 pixels), but due to bug in camera software, detailed images were truncated at 55 Kbytes.
- Feb 7-Feb 22: Low resolution photos (352x240). Due to operator error, photos were lost from Feb 14 thru Feb 16.
- Feb 23-April 1: Camera software upgraded. Photos are 704x480 resolution, without truncation.

Also, [here is a link](#) to photographs taken by Sean Burns (NCAR/MMM).

## Other FLOSS Links

- [Oregon State University](#)
- [NCAR MMM Report](#)
- [NCAR MMM Summary](#)

This page was prepared by [Steven Oncley](#), NCAR Research Technology Facility