

METADATA

Swamp Angel Study Plot

Swamp Angel Study Plot (SASP) data: <https://snowstudies.org/swamp-angel-study-plot/>
Senator Beck Basin Study Area (SBBSA), Red Mountain Pass, San Juan Mountains
Center for Snow and Avalanche Studies (CSAS)

I. Swamp Angel Study Plot (SASP)

- 1) Type of Site
 - a) Study Plot: this large generally 'flat' and planar subalpine meadow is very well sheltered from wind by the surrounding terrain and, therefore, provides an excellent site for measuring precipitation and monitoring snowpack properties minimally influenced by wind redistribution of snow. Snow cover is conserved, undisturbed, within a 30m x 30m plot surrounding the instrumentation for a time series of snowpack profiles throughout the snow season and for researchers requiring undisturbed snowcover for their projects. See our [archived data](#) for SASP snow profiles, by season.
- 2) Site Datum
 - a) Location: August 2008 GPS Lat 37° 54' 24.89088", Lon -107° 42' 40.75924"
 - i) Originally estimated as 37° 54' 25" N, 107° 42' 41" W; per USGS Ironton, Colorado quadrangle 1955, NAD 1927
 - b) Elevation: August 2008 GPS 11,059.6 feet (3371 meters)
 - i) Originally estimated as 11,050 feet (3368 meters) per USGS Ironton, Colorado quadrangle 1955, NAD 1927
 - c) Aspect & Slope: study plot generally slopes 3 degrees NNE
 - d) Soils: deep, colluvial gravels; shallow "A" horizon; minimal 'O' horizon
 - e) Vegetation: grasses and vascular annual plants; no shrubs, no trees within study plot
 - f) Ownership: SASP is located on public lands and authorized by the Uncompahgre National Forest under a Special Use Permit issued to the CSAS
 - g) Changes to site: no trees or brush cleared from site; no changes to ground surface
 - h) Photographs: see CSAS website at <https://snowstudies.org/swamp-angel-study-plot/>
- 3) System Operation
 - a) SASP began operating in Winter 2003/2004, on November 8, 2003
 - b) SASP performs continuous collection of 'Winter' and 'Summer' datasets spanning the 'Water Year' (October 1 through September 30)
 - i) 'Winter' datasets begin October 1 (start of 'Water Year') through midnight of the last day of Spring (through the day before summer solstice)
 - ii) 'Summer' datasets extend from Summer Solstice through September 30 (through the day before start of new 'Water Year')
 - c) All data are collected on Mountain Standard Time, by day-of-year (DOY)
 - i) Datalogger clocks are not switched from/to Mountain Daylight Time
 - ii) 24-hour summary datasets are calendar day, ending at midnight.

d) Total precipitation (from Noah II precipitation gauge) is reset to 0 mm H₂O on October 1st each season, the start of the Water Year

4) System Operation Notes (see also Sensor History notes for individual sensors):

a) Notable changes in operations (additions of sensors, recalibrations, etc.), or sensor or system malfunctions with extended periods of missing data, are listed below. Other, brief periods of missing data exist.

Year	Date(s)	Day of Year	Note
2024	June-November		Comprehensive station upgrades took place over the summer/autumn of 2024. Some new sensors added to system, some sensors replaced, some sensors kept as is.

5) Power

a) Solar powered by 40-watt photovoltaic panel providing regulated charge to four 12V gel DC batteries. Battery bank has total 320-amp hours nominal capacity.

- i) DC supply from datalogger to Noah II regulated at 13.0 volts maximum
- ii) 320-amp hour battery bank installed Fall 2004
- (a) Entire battery bank replaced (four new batteries) October, 2009

6) Measurements and Sensors

a) Upper Wind Speed and Direction

- i) Properties
 - (a) Make: RM Young
 - (b) Model: #05103-5
 - (c) Serial Number: 61999
 - (d) Type: Wind Monitor
 - (e) Specifications: [CSI_RMYoung_WindMonitor_05103_manual.pdf](#)
- ii) Installation
 - (a) Height above ground: 6.0 m
 - (i) Refer to [Sensor Status Workbooks](#), by winter season, for sensor height above snowpack surface
 - (b) Distance from tower or obstacle: 1.0 m
 - (c) Data begin: October 22, 2004
 - (d) Comments: Data recorded on 'Slave' Campbell Scientific CR-10 datalogger, SDI-12 linked to the SASP Primary datalogger.
 - (e) Comments: Sensor initially programmed to collect only scalar average wind speed; programming was changed on Jan 25, 2005 to calculate both scalar and resultant average speed (and resultant direction) data; see table of programming instructions at end of metadata.

iii) Sensor History:

Serial #	Date	Action	Condition
61999	Oct 2, 2019	Sent in for calibration	Replaced bearings, etc
61999	Aug 25, 2011	Installed as SASP Upper	Refurbished Aug 2011, CSI
61653	Aug 25, 2011	Removed for refurbishing	Good, on CSI inspect
61653	Oct 22, 2004	Replaced #12387	New, calibrated Jun 2004
12387	Nov 8, 2003	Installed as SASP Upper	Used, operating normally

b) Lower Wind Speed and Direction

- i) Properties
 - (a) Make: RM Young
 - (b) Model: #05103-5
 - (c) Serial Number: 22659
 - (d) Type: Wind Monitor
 - (e) Specifications: [CSI_RMYoung_WindMonitor_05103_manual.pdf](#)
- ii) Installation
 - (a) Height above ground: 3.8 m
 - (i) Refer to [Sensor Status Workbooks](#), by winter season, for sensor height above snowpack surface
 - (b) Distance from tower or obstacle: 1 m
 - (c) Data begin: January 29, 2005
 - (d) Comments: Data recorded on secondary Campbell Scientific CR-10 datalogger (Ser. #14652, recalibrated December 2004), SDI-12 linked to the SASP primary datalogger.
 - (e) Comments: programmed on Jan 29, 2005 to calculate both scalar and resultant average speed (and resultant direction) data; see table of programming instructions at end of metadata.
- iii) Sensor History:

Serial #	Date	Action	Condition
22659	Oct 2, 2019	Sent in for calibration	Replaced bearings, etc
22659	Sep 19, 2011	Installed as SASP Lower	Refurbished Aug 2011, CSI
no sensor installed 7/12/2011 to 9/19/2011 – data gap			
12387	July 12, 2011	Removed for refurbishing	Good, on CSI inspect
12387	Jan 29, 2005	Installed as SASP Lower	Refurbished Nov 2004

c) [Lower Air Temperature and Humidity](#)

- i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: HygroVue10
 - (c) Serial Number: One of the following: E5776, E5854, E5891, E5754, E5862
 - (d) Type: SHT35 (CMOSens® Digital Sensor), capacitive RH sensor
 - (e) Specifications: [online manual](#)
- ii) Installation
 - (a) Height above ground: 3.4 m above ground
 - (i) Refer to [Sensor Status Workbooks](#), by winter season, for sensor height above snowpack surface

- (b) Distance from tower or obstacle: 0.12 m
- (c) Data begin: 7/26/2024
- (d) Comments: Enclosed in a Campbell Scientific air temperature radiation shield, serial number: 32360

iii) Sensor History:

Serial #	Date	Action	Condition
One of the following: E5776, E5854, E5891, E5754, E5862	Summer 2024	Replaced Campbell/Vaisala HMP60	New

d) Upper Air Temperature and Humidity

- i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: HygroVue10
 - (c) Serial Number: One of the following: E5776, E5854, E5891, E5754, E5862
 - (d) Type: SHT35 (CMOSens® Digital Sensor), capacitive RH sensor
 - (e) Specifications: [online manual](#)
- ii) Installation
 - (a) Height above ground: 5.95 m above ground
 - (i) Refer to [Sensor Status Workbooks](#), by winter season, for sensor height above snowpack surface
 - (b) Distance from tower or obstacle: 0.15 m
 - (c) Data begin: 7/26/2024
 - (d) Comments: Enclosed in a Campbell Scientific air temperature radiation shield, serial number: 32360
- iii) Sensor History:

Serial #	Date	Action	Condition
One of the following: E5776, E5854, E5891, E5754, E5862	Summer 2024	Replaced Campbell Scientific HMP-50YA A4210022	New

e) Snow Depth

- i) Properties
 - (a) Make: Sommer Messtechnik
 - (b) Model: USH-9
 - (c) Serial Number: 05241687 or 05241691
 - (d) Type: Ultrasonic sensor

- (e) Specifications: [PDF on website](#)
- ii) Installation
 - (a) Height above ground: 4 m
 - (b) Distance from tower or obstacle: 2.4 m; sensor mounted at end of arm extending south from mast

- iii) Sensor History:

Serial #	Date	Action	Condition
05241687 or 05241691	Summer 2024	Installed, replaced SR50 with Sommer USH-9	New

- iv) Spring date of “snow all gone” (SAG), by winter season
 - (a) Data begin ~October 1 each season, regardless of presence of snow on the ground, and may reflect plant heights until snow cover begins to accumulate. Early season snowfalls may melt and reveal bare ground or plants until persistent snow cover develops.
 - (b) Date of SAG refers to total loss of snowcover directly under sensor in spring; snowpack depth data are discontinued thereafter and sensor is removed for summer, then reinstalled in early fall.

Winter	Date of Spring SAG	DOY
2024/2025	May 2025	150
2023/2024	June 3, 2024	155
2022/2023	June 10, 2023	161
2021/2022	May 16, 2022	136
2020/2021	June 4, 2021	155
2019/2020	May 28, 2020	149
2018/2019	June 25, 2019	177
2017/2018	May 17, 2018	132
2016/2017	June 10, 2017	161
2015/2016	June 9, 2016	161
2014/2015	June 15, 2015	166
2013/2014	June 6, 2014	157
2012/2013	May 18, 2013	138
2011/2012	May 11, 2012	132
2010/2011	June 23, 2011	174
2009/2010	May 29, 2010	149
2008/2009	May 21, 2009	141
2007/2008	June 16, 2008	168
2006/2007	June 5, 2007	156
2005/2006	May 26, 2006	146
2004/2005	June 18, 2005	169
2003/2004	June 5, 2004	157

- f) Precipitation Sensor
 - i) Properties

- (a) Make: Lufft
- (b) Model: [Lufft WS100 Precipitation Radar](#)
- (c) Serial Number:
- (d) Type: 24-GHz Doppler radar
- (e) Specifications: [Manual online under 'Resources'](#)
- ii) Installation
 - (a) Height above ground: [REDACTED]
 - (b) Distance from tower or obstacle: [REDACTED]
 - (c) Data begin: No data
 - (d) Comments: Precipitation sensor installed but not yet collecting data.

Serial #	Date	Action	Condition
xxxx	July 2024	Installed	New, not operational

- g) Precipitation
 - i) Properties
 - (a) Make: ETI Instrument Systems
 - (b) Model: Noah II
 - (c) Serial Number: #144
 - (d) Type: 'TBO' simulating gauge
 - (e) Specifications: [ETI_NoahII_precip_gauge_manual.pdf](#)
 - ii) Installation
 - (a) Height above ground: 4.5 m
 - (b) Distance from tower or obstacle: free standing 0.30 m diameter standpipe located approx. 8 m from primary instrument mast, 15 m from nearest (lone) tree
 - (c) Data begin: November 8, 2003
 - (d) Comments: gauge utilizes alcohol antifreeze covered with oil skim and transducer to collect and weigh precipitation in 12" orifice collection chamber; ETI-style vinyl windscreens; gauge automatically cycles (dumps fluid into storage standpipe) and self-charges with fresh antifreeze
 - (e) Sensor History:

Serial #	Date	Action	Condition
144	Jan 13, 2004	Reinstalled	Operating normally
144	Dec xx, 2003	Malfunction, removed	Sent to ETI for test, repair
144	Nov 8, 2003	SASP Startup	Used, operating normally

- h) Solar Flux & Albedo Sensors (six total)
 - i) Properties
 - (a) Make: all units Kipp & Zonen
 - (b) Model: CM21 (all five pyranometers) and CG4 (pyrgeometer)
 - (c) Serial Numbers, by unit/location:
 - (i) Up-looking broad band CM21 pyranometer: Ser. #041359
 - (ii) Up-looking NIR to SWIR CM21-RG695 filtered pyranometer: Ser. #041354
 - (iii) Up-looking shadowed broad band CM21 pyranometer: Ser. #041360
 - (iv) Up-looking CG4 pyrgeometer: Ser. #040743

- (v) Down-looking broad band CM21 pyranometer: Ser. #041358
- (vi) Down-looking NIR to SWIR CM21-RG695 filtered pyranometer: Ser. #041353
- (d) Type: spectral response, by types:
 - (i) Broad band CM21 pyranometer: 305-2800 nm (50% points)
 - (ii) NIR to SWIR CM21-RG695 pyranometer: 780-2800 nm (50% points)
 - (iii) CG4 pyrgeometer: 4.5-42 μm (50% points)
- (e) Specifications
 - (i) CM21 (including RG695): [Kipp_Zonen_cm21_pyranometer.pdf](#)
 - (ii) CG4: [Kipp_Zonen_cg4_pyrgeometer_manual.pdf](#)
- ii) Installation
 - (a) Height above ground:
 - (i) Up-looking array: 5.7 m
 - (ii) Down-looking array: 3.1m above ground
 - (b) Distance from tower or obstacle:
 - (i) Up-looking array: 0.8 - 1.0 m
 - (ii) Down-looking array: 1.5 - 1.6 m
 - (c) Data begin: January 25, 2005 (DOY 25)
 - (i) Single up-looking LiCor LI200S (S# PY16599) utilized for Winter 2003/2004 only; contact CSAS for data
 - (d) Comments: snow surface albedo calculations are influenced by the slope and aspect of the reflective (snow) surface. In order to monitor the slope and aspect of the snowpack surface within the domain of the SASP downlooking pyranometers, arrays of manually observed, 3m “height of snow” (HS) stakes are installed around the SASP tower, as described in a separate [HS Stake Array Metadata](#) document. SASP HS Stake Array data are contained in [Sensor Status Workbooks](#), by winter season.
 - (e) Comments: no ventilation units are installed; up-looking radiometers at SASP are routinely buried by new snow and subsequently swept clean; CSAS suggests referencing SBSP up-looking radiometer data during and immediately after periods of precipitation, since wind consistently prevents SBSP up-looking radiometers from being buried, and riming is extremely rare in our continental snow climate; [Sensor Status Workbooks](#) for each winter season detail the state (buried, swept, AOK(clear)) of up-looking radiometers at both SASP and SBSP sites.
 - (f) Comments: up-looking shadowed CM21 pyranometer is deployed in Swiss ASRB-style array for approx. 5 minutes of shadowing at/about solar noon each day. See “312” Solar Noon arrays.
 - (g) Comments: spring snow albedo data are valid up to the date of “snow all gone” (SAG) underneath the downlooking pyranometers, after which those sensors are viewing bare soil and/or vegetation until snowcover redevelops in the fall (see SAG dates table under e) *Snowpack Depth* section above)
 - (h) Sensor History:
 - (i) Contact CSAS for intercalibration and recalibration results
 - (ii) Recalibrations by AccuFlux per Annex A.3.1 of the ISO-9847 Standard
 - (iii) Recalibrations on all sensors by Iso-Cal were performed summer 2025.

Date of Calibration	Sensor	Calibration Constant	Calibration Uncertainty
July 21, 2025	Pyranometer (041353)	10.669 $\mu\text{V}/\text{W}\cdot\text{M}$ -2 @ 19°C	±0.56%
July 21, 2025	Pyranometer (041359)	11.178 $\mu\text{V}/\text{W}\cdot\text{M}$ -2 @ 20°C	±0.55%
July 22, 2025	Pyranometer (041354)	10.768 $\mu\text{V}/\text{W}\cdot\text{M}$ -2 @ 20°C	±0.56%
July 22, 2025	Pyranometer (041358)	10.607 $\mu\text{V}/\text{W}\cdot\text{M}$ -2 @ 19°C	±0.55%
July 22, 2025	Pyranometer (041360)	10.882 $\mu\text{V}/\text{W}\cdot\text{M}$ -2 @ 19°C	±0.55%
July 19, 2025	Pyrgeometer (040743)	9.716 $\mu\text{V}/\text{W}\cdot\text{M}$ -2 @ 19°C	±3.5%

Sensors	Date	DOY	Action
All	July 4 th , 2025 – August 23 rd , 2025	186-236	All pyranometers and pyrgeometer removed for recalibration; restored to service on August 23 rd , 2025. No data during this period.
All	July 1, 2016 – Sept 7, 2016	183-251	All pyranometers and pyrgeometer removed for recalibration; restored to service on Sept 7 2016 (DOY 251). No radiation data during this period.
All	Nov 3, 2012	308	All sensors reinstalled; data resume
All	Sep 15 – Nov 2, 2012	259 - 307	Sensors removed for recalibration by Accuflux; no radiation data during this period
Pyranometers	Aug 10-Sep 5, 2011	222-248	Intercalibrated in-situ, on mast; no down-looking data available for this period
Pyranometers	Aug 10-Sep 3, 2009	222-246	Intercalibrated in-situ, on mast; no down-looking data available for this period
Pyranometers	Jul-Sep 2007	201-258	All units recalibrated by Accuflux; periods of missing data, by sensor
Pyrgeometer	Jul 2007	188-198	Intercal'd, in-situ, to new CG4
Pyranometers	Sep 2006	245-260	Intercalibrated in-situ, on mast; no down-looking data available for this period
Up #041354	Jun 22 – Sep 1, 2006	173-244	Removed for testing
Pyranometers	Sep 2005	262-273	Intercalibrated in-situ, on mast; no down-looking data available for this period
All	Jan 25, 2005	25	All units installed, new

All	Nov 2004	Original calibration by K&Z
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- i) Infrared Snow Surface Temperature
 - i) Properties
 - (a) Make: AlpuG GmbH
 - (b) Model: AlpuG SnowSurf
 - (c) Serial Number: #6004
 - (d) Type: millivolt output type
 - (e) Specifications: [AlpuG_SnowSurf_manual.pdf](#)
 - ii) Installation
 - (a) Height above ground: 3.2m
 - (i) Refer to [Sensor Status Workbooks](#), by winter season, for sensor height above snowpack surface
 - (b) Distance from tower or obstacle: 1.3m
 - (c) Comments: AlpuG sensors emissivity fixed at 0.98 for snow surfaces, and cannot be reset for soil or plant ground cover (i.e., prior to and after snowcover).
 - (d) Comments: sensor is removed for summer and reinstalled in early fall. Periods of measurements above 0.0 C occur during episodic exposure of bare ground during early winter until persistent snow cover develops. Spring snow surface temperature data are valid until bare ground begins emerging in field of view of sensor; data discontinued thereafter.

Winter	End of Valid Spring Data	DOY
2016/2017	June 8, 2017	159
2015/2016	June 6, 2016	158
2014/2015	June 11, 2015	162
2013/2014	June 4, 2014	155
2012/2013	May 16, 2013	136
2011/2012	May 9, 2012	130
2010/2011	June 21, 2011	172
2009/2010	May 28, 2010	149
2008/2009	May 18, 2009	138
2007/2008	June 13, 2008	165
2006/2007	June 5, 2007	156
2005/2006	May 23, 2006	143
2004/2005	June 10, 2005	161

- (e) Sensor History:

Serial #	Date	Action	Condition
6004	May 12, 2006	Installed	New, AlpuG cal Mar 2006

- j) [Vertical Snow Temperature Sensor](#)
 - i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: CSC Temperature Profiler CS230
 - (c) Serial Number: Part number 32279-187
 - (d) Type: 21 thermistors at 10 cm intervals, 2 m rigid probe

- (e) Specifications: Manual on Campbell Scientific website
- ii) Installation
 - (a) Installed with two metal supports parallel to vertical sensor and two painted (white) wooden dowels attached horizontally to metal supports. 13m cable.
 - (b) Distance from tower or obstacle: Approximately 15 feet
 - (c) Date originally installed at SASP: July 4th, 2024
 - (i) Replaced Campbell Scientific model: #107 (five sensor array)
 - (d) Comments:
 - (e) Sensor History:

Serial #	Date	Action	Condition
1412	July 4 th , 2024	Installed	New Sensor

k) Barometric Pressure

- i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: BaroVUE10
 - (c) Serial Number: 39204
 - (d) Type: Digital transducer
 - (e) Specifications: [Online manual](#)
- ii) Installation
 - (a) Instrument elevation used in measurement instruction: 
 - (b) Height above ground surface, on tower: 4 m
 - (c) Distance from tower or obstacle: located in datalogger enclosure
 - (d) Date originally installed at SASP: Summer 2024
 - (e) Comments:
 - (f) Sensor History:

Serial #	Date	Action	Condition
39204	Summer 2024	Installed	New

- iii) Data Units
 - (a) Data are reported as hPa

l) Soil Heat Flux

- i) Properties
 - (a) Make: Hukseflux (through Campbell Scientific)
 - (b) Model: HFP01
 - (c) Serial Number: 22022 or 22963
 - (d) Type: thermopile
 - (e) Calibration uncertainty for 22022: $\pm 1.98 \times 10^{-6} \text{ V}/(\text{W}/\text{m}^2)$
22963: $\pm 1.93 \times 10^{-6} \text{ V}/(\text{W}/\text{m}^2)$
 - (f) Sensitivity for 22022: $66.15 \times 10^{-6} \text{ V}/(\text{W}/\text{m}^2)$
22963: $64.47 \times 10^{-6} \text{ V}/(\text{W}/\text{m}^2)$
 - (g) Specifications: [Online manual](#)

ii) Installation

- (a) Height below ground surface ("A" horizon; no "O" horizon present): 2 cm
- (b) Distance from tower or obstacle: 1.8 m
- (c) Date originally installed at SASP: Summer 2024
- (d) Comments: Sensor located at shallow depth to facilitate measurement of snowpack/ground heat flux; sensor collocated with soil temperature array (underneath), volumetric water content sensor, and nearby snow temperature array.
- (e) Sensor History:

Serial #	Date	Action	Condition
22022 or 22963	Summer 2024	Replaced H043140	New

a) Soil Temperature and Volumetric Water Content

i) Properties

- (a) Make: Campbell Scientific
- (b) Model: [SoilVUE10](#)
- (c) Serial Number: 3822
- (d) Type: Campbell TrueWave™TDR technology
- (e) Specifications: [Online manual](#)

ii) Installation: Drill and 2 in auger, then screwed it into the hole.

- (a) Height below ground surface: 50 cm
- (b) Distance from tower or obstacle: 2.4 m
- (c) Date originally installed at SASP: Summer 2024
- (d) Service/calibration dates: new units upon installation
- (e) Comments:

Serial #	Date	Action	Condition
3822	Summer 2024	Replaced Volumetric Water Content model CS616 and Campbell Scientific soil temperature sensor model #107 (no longer co-located with heat flux and vertical snow temperature)	New

m) Snow Scale (SWE)

i) Properties

- (a) Make: Sommer-Messtechnik
- (b) Model: SSG2
- (c) Serial number: 45210219
- (d) Type: snow scale
- (e) Specifications: [Online manual](#)

ii) Installation

- (a) Height: 0-4 cm above ground surface, level
- (b) Distance from tower or obstacle: 11.2 m
- (c) Date originally installed at SASP: July 5th, 2024

- (d) Service/calibration dates: new units upon installation
- (e) Comments: Consists of seven perforated plates, each plate measuring 31.44" x 47.16"(inches), total dimensions of 110.24 x 94.49 x 4.06 inches.

Year	Date(s)	Day of Year	Note
2024	October 9	282	Tested the snow scale with a known weight (person).
2024	July 5	187	Snow scale panels installed.
2024	July 4	186	Beginning of snow scale install. Dug into the ground to level.

Serial #	Date	Action	Condition
45210219	July 5 th 2024	Frame and outer panels installed; center panel and scale not installed	New

- n) Camera
 - i) Properties
 - (1) Make: Cambell Scientific
 - (2) Model: CCFC-RS232
 - (3) Serial Number: 2721, 2754, or 2717
 - ii) Specifications: [Online Manual](#)
 - iii) Sensor History: Installed at the end of the summer 2024 approx. 15 ft above ground.

Year	Date(s)	Day of Year	Note
2024	Summer		Installed camera on precipitation gage

Serial #	Date	Action	Condition
2721, 2754, or 2717	Summer 2024	Installed	New

- 7) Primary Datalogger
 - a) Make: Campbell Scientific
 - b) Model: CR1000X
 - c) Serial Number: One of the following 57762, 57761, 53649, 53654, 53651, 53660, 53648
 - d) Specifications: [Online manual](#)
 - e) PakBus address: 50
 - f) Comments:
 - g) Sensor History:

Serial #	Date	Action	Condition
One of the following 57762, 57761, 53649, 53654,	Summer 2024	Installed and replaced CR10X	New

53651, 53660, 53648			
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8) 'Slave' Datalogger

- Make: Campbell Scientific
- Model: CR1000X
- Serial Number: One of the following 57762, 57761, 53649, 53654, 53651, 53660, 53648
- Specifications: [Online manual](#)
- Comments: 'slave' datalogger required for input channels for wind monitors; connected to primary datalogger using SDI-12 link. Used during CG4 pyrgeometer intercalibrations.
- PakBus address: 55
- Sensor History:

Serial #	Date	Action	Condition
CR1000X	Summer 2024	Installed, replaced CR10X	New
CR10X 39210	Aug 2007	Installed, replaced 14652	Recal by CSI Aug 2007
CR10 14652	Jan 2005	Installed	Recal by CSI Dec 2004

9) Multiplexer

- Make: Campbell Scientific
- Model: AM16/32
- Serial Number: 6695
- Type: relay
- Specifications: [CSI_am16-32a_manual.pdf](#)
- Comments: housed in own enclosure
- Sensor History:

Serial #	Date	Action	Condition
6695	Oct 2004	Installed	New

10) Data Retrieval

- RF Station ID = 3
- Radio telemetry using phone-to-RF; direct link to base station; no repeater utilized
 - Modem, [COM220-US \(CSI\)](#), serial number: 18896-12
 - Radios, RF452, serial numbers: 5979, 5978, 5973, 5980, 5981
 - Omni Antenna 3 dBd Gain, item no.: 14221

11) Software

- Campbell Scientific LoggerNet 2.1c
- Contact CSAS for specific Winter or Summer season Loggernet programming

12) Observer Contact Information

- Name: Jeff Derry - Executive Director
- Organization: Center for Snow and Avalanche Studies
- Address: PO Box 190, Silverton, CO, USA 81433

- d) Telephone: (970) 387-5080
- e) Email: jderry@snowstudies.org
- f) Website: <http://www.snowstudies.org>

13) Data processing and output methods:

- a) Loggernet program execution interval: initially set at 5 seconds from original 2003 startup until February 17, 2012, when interval was increased to 6 seconds. This change was required to reduce increasing volume of “table overrun” errors triggered by the recent addition of experimental snow moisture sensors. Data processing for those sensors often exceeded the 5 second allowance, effectively resulting in a doubling of the 5 second execution interval to 10 seconds. Discontinuing those measurements and increasing the execution interval for the remaining sensors to 6 seconds in February 2012 effectively eliminated table overrun errors.
- b) Revised measurements of snow depth: instruction P73 (Maximize) used during early Winters 2003/2004 and 2004/2005 changed to P70 (Sample) beginning Winter 2005/2006, sampling once at the end of all arrays to minimize bad data during storms caused by blowing snow
- c) Measurements and Loggernet instructions: see table on following page
 - (1) Location # in the table below refers to position in data file string (within a given array) as well as column number in relevant Excel spreadsheet header

Data processing and output methods (data points as labeled in Excel workbooks):
 Scan length = 6 seconds (Logger scans the data every 6 seconds).

<i>Spreadsheet Labels (some abbreviations expanded)</i>	<i>Loc'n #</i>	<i>Type of Measurement</i>	<i>Notes</i>
TIMESTAMP	1	na	Mountain Standard Time, in military time; previous day at midnight, 2400 at midnight
RECORD	2		
LoAIR_C_Min	3		
LoAIR_C_TMn	4	Minimize	Array lower air temperature (C) sensor minimum, time of minimum
LoAIR_C_Max	5		
LoAIR_C_TMx	6	Maximize	Array lower air temperature (C) sensor maximum, time of maximum
LoRH_pct	7		
<i>Upper Wind Monitor</i>			
MS_UPWND_Max	8	Maximize	<i>CRBasic programming WindVector()</i> Sensor maximum
MS_UPWND_TMx	9		Time of sensor maximum
MS_UP_Avg	10		Mean horizontal wind speed (WVc(1))
MS_UP_ReslntAvg	11		Mean wind vector magnitude (WVc(2))
DIR_UP_ReslntAvg	12		Resultant mean wind direction (WVc(3))
DIR_UP_STD	13		Standard deviation of wind direction (WVc(4))
<i>Lower Wind Monitor</i>			
MS_LOWND_Max	14	Maximize	<i>CRBasic programming WindVector()</i> Sensor maximum
MS_LOWND_TMx	15		Time of sensor maximum
MS_LOW_Avg	16		Mean horizontal wind speed (WVc(1))
MS_LOW_ReslntAvg	17		Mean wind vector magnitude (WVc(2))
DIR_LOW_ReslntAvg	18		Resultant mean wind direction (WVc(3))
DIR_LOW_STD	19		Standard deviation of wind direction (WVc(4))
PyDWN_UNF_Avg	20	Average	Down-looking broadband pyranometer, in average watts/m ²
PyDWN_FIL_Avg	21	Average	Down-looking NIR & SWIR filtered pyranometer, in average watts/m ²
PyUP_UNF_Avg	22	Average	Up-looking broadband pyranometer, in average watts/m ²
PyUP_FIL_Avg	23	Average	Up-looking NIR & SWIR filtered pyranometer, in average watts/m ²
PyUP_SH_Avg	24	Average	Up-looking shadowed broadband pyranometer, in average watts/m ²
PYRG_WATT_Avg	25	Average	Up-looking pyrgeometer, in average watts/m ²
SNOSURF_C_Avg	26	Average	Average infra-red snow surface temp (C)
SOILSURF_Avg	27	Average	Average soil surface temp (C)
SOIL10_C_Avg	28	Average	Average temperature (C) at 10 cm below ground surface
SOIL20_C_Avg	29	Average	Average temperature (C) at 20 cm below ground surface
SOIL40_C_Avg	30	Average	Average temperature (C) at 40 cm below ground surface
SnowDepth_mtr	31	Sample	Height-of-snow sampled once at end of array

<i>Spreadsheet Labels (some abbreviations expanded)</i>	<i>Loc'n #</i>	<i>Type of Measurement</i>	<i>Notes</i>
SYS_VOLTS	32	Sample	Voltage at datalogger (prior to regulation) sampled once at end of array
Rain_in_Tot	33	Totalize	Total mm precipitation during array
DAY_H2O	34	Sample	Running daily total mm of precipitation, 0000 hrs through 2400 hrs
SEASN_H2O	35	Sample	Running water year total mm of precipitation, beginning October 1
BARO_InHg_Avg	36	Average	Average barometric pressure, hPa
LoAIR_C_Avg	37	Average	Averages all measurements of air temperature collected during a day, from 0000 hrs through 2400 hrs
SOILFLUX_Avg	38	Average	Average heat flux (watts) entering or exiting soil
VWC_H2OGD_Avg	39	Average	Volumetric water content (scale 0.0 to 1.0) of soil at 10 cm below ground surface
UpAIR_C_Min	40	Minimize	Upper air temperature (C) sensor array minimum, time of minimum
UpAIR_C_TMin	41		
UpAIR_C_Max	42	Maximize	Upper air temperature (C) sensor array maximum, time of maximum
UpAIR_C_TMax	43		
UpRH_pct	44	Sample	Upper RH sensor; samples relative humidity (%) once at end of array
SSG2_SWE	45	Sample	Snow scale (SWE) mm; sampled once at end of array
WS1_NewDif_in_Tot	46	Totalize	Total mm precipitation during array
SnoT_GndC_Avg	47	Average	Mean temperature (C) of snow temperature sensor at ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_10C_Avg	48	Average	Mean temperature (C) of snow temperature sensor at 10 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_20C_Avg	49	Average	Mean temperature (C) of snow temperature sensor at 20 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_30C_Avg	50	Average	Mean temperature (C) of snow temperature sensor at 30 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_40C_Avg	51	Average	Mean temperature (C) of snow temperature sensor at 40 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_50C_Avg	52	Average	Mean temperature (C) of snow temperature sensor at 50 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_60C_Avg	53	Average	Mean temperature (C) of snow temperature sensor at 60 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler

<i>Spreadsheet Labels (some abbreviations expanded)</i>	<i>Loc'n #</i>	<i>Type of Measurement</i>	<i>Notes</i>
SnoT_70C_Avg	54	Average	Mean temperature (C) of snow temperature sensor at 70 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_80C_Avg	55	Average	Mean temperature (C) of snow temperature sensor at 80 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_90C_Avg	56	Average	Mean temperature (C) of snow temperature sensor at 90 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_100C_Avg	57	Average	Mean temperature (C) of snow temperature sensor at 100 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_110C_Avg	58	Average	Mean temperature (C) of snow temperature sensor at 110 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_120C_Avg	59	Average	Mean temperature (C) of snow temperature sensor at 120 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_130C_Avg	60	Average	Mean temperature (C) of snow temperature sensor at 130 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_140C_Avg	61	Average	Mean temperature (C) of snow temperature sensor at 140 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_150C_Avg	62	Average	Mean temperature (C) of snow temperature sensor at 150 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_160C_Avg	63	Average	Mean temperature (C) of snow temperature sensor at 160 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_170C_Avg	64	Average	Mean temperature (C) of snow temperature sensor at 170 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_180C_Avg	65	Average	Mean temperature (C) of snow temperature sensor at 180 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_190C_Avg	66	Average	Mean temperature (C) of snow temperature sensor at 190 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler
SnoT_200C_Avg	67	Average	Mean temperature (C) of snow temperature sensor at 200 cm above ground in a 21-thermistor (2 m) rigid probe temperature profiler

<i>Spreadsheet Labels (some abbreviations expanded)</i>	<i>Loc'n #</i>	<i>Type of Measurement</i>	<i>Notes</i>
VWC_5cm_Avg	68	Average	Volumetric water content (scale 0.0 to 1.0) of soil at 5 cm below ground surface
SoilTmpC5cm_Avg	69	Average	Average temperature (C) at 5 cm below ground surface
VWC_10cm_Avg	70	Average	Volumetric water content (scale 0.0 to 1.0) of soil at 10 cm below ground surface
SoilTmpC10cm_Avg	71	Average	Average temperature (C) at 10 cm below ground surface
VWC_20cm_Avg	72	Average	Volumetric water content (scale 0.0 to 1.0) of soil at 20 cm below ground surface
SoilTmpC20cm_Avg	73	Average	Average temperature (C) at 20 cm below ground surface
VWC_30cm_Avg	74	Average	Volumetric water content (scale 0.0 to 1.0) of soil at 30 cm below ground surface
SoilTmpC30cm_Avg	75	Average	Average temperature (C) at 30 cm below ground surface
VWC_40cm_Avg	76	Average	Volumetric water content (scale 0.0 to 1.0) of soil at 40 cm below ground surface
SoilTmpC40cm_Avg	77	Average	Average temperature (C) at 40 cm below ground surface
VWC_50cm_Avg	78	Average	Volumetric water content (scale 0.0 to 1.0) of soil at 50 cm below ground surface
SoilTmpC50cm_Avg	79	Average	Average temperature (C) at 50 cm below ground surface

Web Links for CSAS Metadata and Supplemental Documents:

- CF Standard Name Table for each variable measured (pre-2024 upgrades):
http://snowstudies.org/data/metadata/SASP_Variable_Table.xlsx
- Archived Datasets by Season, Snow Profiles, and Storm Reports including Sensor Status Workbooks: <https://snowstudies.org/archival-data/>
- Metadata and Photographs of all Study Plots located:
Swamp Angel Study Plot: <https://snowstudies.org/swamp-angel-study-plot/>
Senator Beck Study Plot: <https://snowstudies.org/senator-beck-study-plot/>
Putney Study Plot: <https://snowstudies.org/putney-study-plot/>
Senator Beck Stream Gauge: <https://snowstudies.org/sb-stream-gauge/>
- Height of Snow (HS) Stake Array Metadata:
http://snowstudies.org/data/metadata/HS_Stake_Array_Metadata.pdf

ARCHIVE**** Data file names and locations prior to summer 2024 ****

<i>Spreadsheet Labels (some abbreviations expanded)</i>	<i>Loc'n #</i>	<i>LoggerNet 2.1c Instruction</i>	<i>Type of Measurement</i>	<i>Notes</i>
ArrayID	1	P80	na	301 = 1 hour array 303 = 3 hour array 312 = solar noon array 324 = 24 hour array
Year	2	P77	Na	Calendar year
DOY	3	P77	na	Sequential day of calendar year
Hour	4	P77	na	Mountain Standard Time at end of array period, in military time; previous day at midnight, 2400 at midnight
LoAir_Min_C LoAir_Min_Time	5 6	P74	Minimize	Array lower air temperature (C) sensor minimum, time of minimum
LoAir_Max_C LoAir_Max_Time	7 8	P73	Maximize	Array lower air temperature (C) sensor maximum, time of maximum
Lo_RH	9	P70	Sample	Lower RH sensor; samples relative humidity (%) once at end of array
<i>Upper Wind Monitor</i> UpWind_PGust_MS UpWind_PGust_Time UpWind_SAvg_MS UpWind_Uavg_MS UpWind_Dir_Uavg UpWind_Dir_StDev	10 11 12 13 14 15	P73 P69	Maximize Wind vector	P69 output option '2': scalar mean horizontal wind speed S; resultant mean wind speed U; resultant mean wind direction; standard deviation wind direction using Campbell Scientific algorithm.
<i>Lower Wind Monitor</i> LoWind_PGust_MS LoWind_PGust_Time LoWind_SAvg_MS LoWind_Uavg_MS LoWind_Dir_Uavg LoWind_Dir_StDev	16 17 18 19 20 21	P73 P69	Maximize Wind vector	P69 output option '2': scalar mean horizontal wind speed S (ms); resultant mean wind speed U (ms); resultant mean wind direction; standard deviation wind direction using Campbell Scientific algorithm.
PyDwn_Unfilt_W	22	P71	Average	Down-looking broadband pyranometer, in average watts/m ²
PyDwn_Filt_W	23	P71	Average	Down-looking NIR & SWIR filtered pyranometer, in average watts/m ²
PyUp_Unfilt_W	24	P71	Average	Up-looking broadband pyranometer, in average watts/m ²
PyUp_Filt_W	25	P71	Average	Up-looking NIR & SWIR filtered pyranometer, in average watts/m ²
PyUp_Shad_W	26	P71	Average	Up-looking shadowed broadband pyranometer, in average watts/m ²
Pyrgeom_W	27	P71	Average	Up-looking pyrgeometer, in average watts/m ²
Sno_IR_C	28	P71	Average	Average infra-red snow surface temp (C)
Sno_Gd_C	29	P71	Average	Mean temperature (C) of lowest snow temperature sensor in five-sensor array
Sno_10cm_C	30	P71	Average	Mean temperature (C) of 2 nd lowest snow temperature sensor in five-sensor array
Sno_20cm_C	31	P71	Average	Mean temperature (C) of center snow temperature sensor in five-sensor array
Sno_30cm_C	32	P71	Average	Mean temperature (C) of 2 nd highest snow temperature sensor in five-sensor array
Sno_40cm_C	33	P71	Average	Mean temperature (C) of highest snow temperature sensor in five-sensor array

Table continued next page

Spreadsheet Labels (some abbreviations expanded)	Loc'n #	LoggerNet 2.1c Instruction	Type of Measurement	Notes
Sno_Height_M	34	P70	Sample	Height-of-snow sampled once at end of array
Sys_Volts	35	P70	Sample	Voltage at datalogger (prior to regulation) sampled once at end of array
Array Tot H2O	36	P72	Totalize	Total mm precipitation during array
Day Tot H2O	37	P70	Sample	Running daily total mm of precipitation, 0000 hrs through 2400 hrs
Season Tot H2O	38	P70	Sample	Running water year total mm of precipitation, beginning October 1
Baro In HG	39	P71	Average	Average barometric pressure, in inches of mercury, sampling the last five minutes of 301 (1 hour) arrays only
LoAir_Avg_C	40	P71	Average	Averages all measurements of air temperature collected during a day, from 0000 hrs through 2400 hrs
Soil_Flux_W	41	P71	Average	Average heat flux (watts) entering or exiting soil
Soil_Surf_C	42	P71	Average	Average temperature (C) at soil/air interface (sensor exposed to direct light)
Soil_10cm_C	43	P71	Average	Average temperature (C) at 10 cm below ground surface
Soil_20cm_C	44	P71	Average	Average temperature (C) at 20 cm below ground surface
Soil_40cm_C	45	P71	Average	Average temperature (C) at 40 cm below ground surface
Soil_VWC	46	P71	Average	Volumetric water content (scale 0.0 to 1.0) of soil at 10 cm below ground surface
UpAir_Min_C UpAir_Min_Time	47 48	P74	Minimize	Upper air temperature (C) sensor array minimum, time of minimum
UpAir_Max_C UpAir_Max_Time	49 50	P73	Maximize	Upper air temperature (C) sensor array maximum, time of maximum
Up_RH	51	P70	Sample	Upper RH sensor; samples relative humidity (%) once at end of array
UpAir_Avg_C	52	P71	Average	Averages all measurements of air temperature collected during a day, from 0000 hrs through 2400 hrs
Ground-Snow Moisture	53	P71	Average	'Period' measurement of moisture at ground/snowpack interface – DISCONTINUED 2/17/2012 Experimental data collected <i>Winter 2007/2008 to Feb 17, 2012 only; contact CSAS</i>
Mid-Pack Snow Moisture	54	P71	Average	'Period' measurement of moisture at mid-snowpack DISCONTINUED – experimental data collected Winters 2007/2008 to 2010/2011 only; contact CSAS
See also: Table of variables, CF standard names and attributes: snowstudies.org/data/metadata/SASP_Variable_Table.xlsx				

REPLACED SENSORS

- a) Lower Air Temperature and Humidity
 - i) Properties
 - (a) Make: Campbell/Vaisala
 - (b) Model: HMP60 (replaced CS500-U Ser #P4810054))

- (c) Serial Number: HMP60
- (d) Type: thermistor
- (e) Specifications: [CSI_HMP60_manual.pdf](#)
- ii) Installation
 - (a) Height above ground: 3.4 m above ground (see Feb 2005 Note in Operations Notes above)
 - (i) Refer to [Sensor Status Workbooks](#), by winter season, for sensor height above snowpack surface
 - (b) Distance from tower or obstacle: 1.2 m
 - (c) Data begin: November 8, 2003
 - (d) Comments: none
- iii) Sensor History:

Serial #	Date	Action	Condition
HMP60	Sept 10, 2016	HMP60 replaced CS500	New sensor
P4810054	Oct 22, 2004	Replaced HMP35-C	Refurbished Jul 2004, CSI
7063	Nov 8, 2003	SASP startup	Used, calibrated Aug 1996

Upper Air Temperature and Humidity

- ii) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: HMP-50YA
 - (c) Serial Number: A4210022
 - (d) Type: platinum resistance temp detector (PRT) and capacitive RH sensor
 - (e) Specifications: [CSI_hmp50_manual.pdf](#)
- iii) Installation
 - (a) Height above ground: 5.95 m above ground
 - (i) Refer to [Sensor Status Workbooks](#), by winter season, for sensor height above snowpack surface
 - (b) Distance from tower or obstacle: 0.15 m
 - (c) Data begin: February 8, 2006 (DOY 39)
 - (d) Comments: property of NSIDC
- iv) Sensor History:

Serial #	Date	Action	Condition
A4210022	Sept 22, 2018	Replaced Temp/RH chip at on 265 at 1400	Temp and RH data erroneous for that time
A4210022	Feb 8, 2006	Installed	New

- b) Snow Temperature (five sensors)
 - i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: #107 (five sensor array)
 - (c) Serial Number: na
 - (d) Type: thermistor
 - (e) Specifications: [CSI_107_temp_probe_manual.pdf](#)
 - ii) Installation

- (a) Height above ground, not including any downward displacement caused by settlement of the overlying snowcover (unknown).
 - (i) SnoT Lo sensor at the ground surface
 - (ii) SnoT 2Lo sensor 10 cm above the ground
 - (iii) SnoT Ctr sensor 20 cm above the ground
 - (iv) SnoT 2Hi sensor 30 cm above the ground
 - (v) SnoT Hi sensor 40 cm above the ground
- (b) During the first four winters (2004/2005 – 2007/2008), sensor deployed relative to snowpack surface was observed during field sessions. Contact CSAS for array’s “floating” position within the snowpack for those seasons.
- (c) Distance from tower or obstacle: approx 3m.
- (d) Date originally installed at SASP: January 25, 2005 (DOY 25)
 - (i) Replaced three-sensor array used for Winter 2003/2004
- (e) Comments: all measurements corrected with small offsets derived from calibrating the sensors to isothermal, wet snow at 0.0 C. Comments: values above 0.0 C occurred during exposure of sensors to air during early winter, prior to full burial of the array, and during spring snowmelt as array became exposed to air; data discontinued after SnoT Lo sensor at the ground surface is exposed to air.
- (f) Comments: Sensor array stored on mast for summer.
- (g) Sensor History:

Serial #	Date	Action	Condition
na	January 2005	Installed	New Sensors

- c) Barometric Pressure
 - i) Properties
 - (a) Make: Vaisala (Campbell Scientific supplier)
 - (b) Model: PTB101B (CS105)
 - (c) Serial Number: B2730009
 - (d) Type: silicon capacitive pressure sensor
 - (e) Specifications: [CSI CS105 barometer manual.pdf](#)
 - ii) Installation
 - (a) Instrument elevation used in measurement instruction (see below)
 - (i) From Fall 2003 – Spring 2012
 - 1. Est., from USGS Ironton Park Quadrangle, at 11,050' (3368m)
 - (ii) Summer 2012 – present
 - 1. Measured, with Survey Grade GPS, at 11,070' (3374m)
 - (b) Height above ground surface, on tower: 3 m
 - (c) Distance from tower or obstacle: located in datalogger enclosure
 - (d) Date originally installed at SASP: November 8, 2003
 - (e) Comments: recalibrated August 8, 2006 by Vaisala
 - (f) Sensor History:

Serial #	Date	Action	Condition
B2730009	Aug 16, 2006	Reinstalled	Operating normally

B2730009	Aug 8, 2006	Recalibrated by Vaisala	Error was -0.03 in Hg
B2730009	Aug 2, 2006	Removed for recalibration	Operating normally
B2730009	Nov 8, 2003	Installed	Used, operating normally

iii) Data Units

- (a) Data are reported as inches of mercury (in Hg), using a multiplier of 0.02953 to convert mb to inches of mercury within the measurement instruction
- (b) Data are corrected to sea level pressure using the following offset values (see method in box below, from Campbell Scientific manual):
 - (i) Winter 2003/2004 – Winter 2011/2012: offset = 344.36 mb
 - (ii) Summer 2012 – present: offset = 344.88 mb
- (c) To calculate actual pressure at the Swamp Angel Study Plot, in mb
 - (i) Multiply reported value by 33.86 to convert inches of mercury to mb, then
 - (ii) Subtract offset (344.36 mb through Winter 2011/2012, or 344.88 mb thereafter) from that result to obtain actual pressure, in mb

From Campbell Scientific manual

The weather service, most airports, radio stations, and television stations adjust the atmospheric pressure to a common reference (sea level). Equation 1 can be used to find the difference in pressure between the sea level and the site. That value (dP) is then added to the offset (500 mb in our example programs) in the measurement instruction. U. S. Standard Atmosphere and dry air were assumed when Equation 1 was derived (Wallace, J. M. and P. V. Hobbes, 1977: *Atmospheric Science: An Introductory Survey*, Academic Press, pp. 59-61).

$$dP = 1013.25 \left\{ 1 - \left(1 - \frac{E}{44307.69231} \right)^{5.25328} \right\} \quad (1)$$

The value dP is in millibars and the site elevation, E , is in meters. Add dP value to the offset in the measurement instruction.

d) Soil Heat Flux

i) Properties

- (a) Make: REBS (Campbell Scientific)
- (b) Model: HFT-3.1
- (c) Serial Number: H043140
- (d) Type: thermopile
- (e) Specifications: [CSI REBS hft-3.1 manual.pdf](#)

ii) Installation

- (a) Height below ground surface ("A" horizon; no "O" horizon present): 3 cm
- (b) Distance from tower or obstacle: approx. 10 feet
- (c) Date originally installed at SASP: July 11, 2005
- (d) Comments: sensor located at shallow depth to facilitate measurement of snowpack/ground heat flux; sensor collocated with soil temperature array

(underneath), volumetric water content sensor, and nearby snow temperature array

(e) Sensor History:

Serial #	Date	Action	Condition
H043140	Jul 11, 2005	Installed	Operating normally
H043140	Oct 7, 2004	Calibrated by REBS	New

d) Soil Temperature (four sensors)

- i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: #107
 - (c) Serial Number: na (none)
 - (d) Type: thermistor
 - (e) Specifications: [CSI_107_temp_probe_manual.pdf](#)
- ii) Installation
 - (a) Height below ground surface ("A" horizon; no "O" horizon present): at surface, -10 cm, -20 cm, -40 cm
 - (b) Distance from tower or obstacle: approx. 10 feet
 - (c) Date originally installed at SASP: July 11, 2005
 - (d) Service/calibration dates: new units upon installation; sensors not serviceable;
 - (e) Comments: sensor array collocated with soil heat flux sensor (above), volumetric water content sensor, and nearby snow temperature array

e) Soil Volumetric Water Content

- i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: CS616
 - (c) Serial Number: na (none)
 - (d) Type: water content reflectometer
 - (e) Specifications: [CSI_cs616_manual.pdf](#)
- ii) Installation
 - (a) Height *below* ground surface ("A" horizon; no "O" horizon present): -10 cm
 - (b) Distance from tower or obstacle: approx. 10 feet
 - (c) Date originally installed at SASP: July 11, 2005
 - (d) Service/calibration dates: new units upon installation; sensors not serviceable;
 - (e) Comments: the sensor is horizontally deployed, with both tines at the same level below, and parallel with, the ground surface. Rocky soils required excavating a trench in which to place the sensor in order to assure a constant distance between the sensor's tines. A soil block was kept intact, the sensor was placed in the trench and covered with loose soil, then the soil block was replaced over the sensor.

f) Snowpack Depth

- i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: SR50 (replaced UDG01 in Oct 2005)
 - (c) Serial Number: C3852

- (d) Type: ultrasonic depth sensor
- (e) Specifications: [CSI_sr50_manual.pdf](#)
- ii) Installation
 - (a) Height above ground: 3.2 m above ground
 - (i) February 16, 2005 (DOY 47): raised to 4.3 m above ground for remainder of season due to depth of snowpack
 - (b) Distance from tower or obstacle: 2.0 m; sensor mounted at end of arm extending south from mast
 - (c) Data begin: November 8, 2003
 - (d) Comments: wherever possible, bad data for short intervals (1-3 hours) are corrected by interpolation (for all interpolated data since fall 2011 see our [Data Notes](#)). When bad data occur over longer time periods no interpolation is performed and bad data are removed resulting in missing data.

- iii) Sensor History:

Serial #	Date	Action	Condition
C3852	Sep 2015	Maintenance	New transducer by CSI
C3852	Sep 2014	Maintenance	New transducer by CSI
C3852	Jul 2013	Maintenance	New transducer by CSI
C3852	Jul 2011	Maintenance	New transducer by CSI
C3852	Aug 2008	Maintenance	New transducer by CSI
C3852	Oct 2007	Maintenance	New transducer by CSAS
C3852	Mar 23, 2005	Re-installed	Repaired by CSI
C3852	Feb 26, 2005	Unit failed, removed	Replaced by loaner SR50
C3852	Oct 22, 2005	SR50 Installed (replaced UDG01)	New unit
C1374	Nov 8, 2003	SASP Startup w/UDG01	Used, operating normally

- g) Ground/Snowpack Interface Moisture Content
 - i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: CS616
 - (c) Serial Number: na (none)
 - (d) Type: water content reflectometer
 - ii) Experimental data begin in Winter 2007/2008 and discontinued Winter 2011/2012; contact CSAS
- h) Mid-Snowpack Moisture Content
 - i) Properties
 - (a) Make: Campbell Scientific
 - (b) Model: CS616
 - (c) Serial Number: na (none)
 - (d) Type: water content reflectometer
 - ii) Experimental data begin in Winter 2007/2008 and discontinued Winter 2010/2011; contact CSAS

14) Primary Datalogger

- a) Make: Campbell Scientific
- b) Model: CR10X
- c) Serial Number: 40363 (replaced #14652 in Oct, 2005)
- d) Type: fully programmable measurement and control system with ring memory
- e) Specifications: [CSI_cr10x_specs.pdf](#)
- f) Comments: none
- g) Sensor History:

Serial #	Date	Action	Condition
CR10X	Aug 18, 2020	Swapped out logger	Operating normally
CR10X 08006	Nov 20, 2016	Installed, replaced #40363	#40363 was resetting itself
CR10X 40363	Feb 17, 2011	Recal by CSI, w/out certify	Operating normally
CR10X 40363	Feb 11, 2011	Removed for testing by CSI	Malfunction Feb 10-11
CR10X 40363	Jul 30, 2007	Recal by CSI, with certif	Operating normally
CR10X 40363	Oct 22, 2004	Installed, replaced #14652	New, orig calib Sep 2004
CR10 14652	Nov 8, 2003	SASP startup	Operating normally