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New York State Mesonet Flux Network Data

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The data described here are created by New York State Mesonet at University at Albany. In the event that the data are used for any form of publications, please cite Brotzge et al. (2020) and Covert (2019) and use the following statement in the acknowledgement:

"This research is made possible by the New York State (NYS) Mesonet. Original funding for the NYS Mesonet was provided by Federal Emergency Management Agency grant FEMA-4085-DR-NY, with the continued support of the NYS Division of Homeland Security & Emergency Services; the state of New York; the Research Foundation for the State University of New York (SUNY); the University at Albany, SUNY; the Atmospheric Sciences Research Center (ASRC) at SUNY Albany; and the Department of Atmospheric and Environmental Sciences (DAES) at SUNY Albany."

Details about the Flux Network, instruments and their retrieval methods can also be found at Covert (2019), "Design and Implementation of the New York State Mesonet Flux Tower Network".

1. Introduction

The New York State (NYS) Mesonet (http://nysmesonet.org) is an advanced, statewide weather station network that provides unprecedented weather information across the state. This network is the first of its kind in New York. In addition to the 126 "standard" weather stations, the NYSM operates three sub-networks: 17 profiler sites, 20 snow sites, and 18 flux sites (Fig. 1). The flux network consists of 18 enhanced surface energy budget stations with sensors that directly measure both incoming and outgoing shortwave and longwave radiation, soil heat flux, and turbulent fluxes of momentum, sensible and latent heat, and carbon dioxide (Table 1). Turbulent fluxes are computed on the station datalogger every 30 minutes using EasyFlux DL (Campbell Scientific Inc). Radiation and soil heat fluxes are sampled at 1Hz and reported every 5 minutes. Flux station locations were selected based upon their surrounding topography, land use, and fetch characteristics, and include a wind farm, vineyards, orchards, farmland, and urban areas. Table 2 lists flux site metadata including latitude, longitude, elevation, land cover type and install date.

2. Site Design and Instruments

A photo of a standard site that was enhanced with flux instrumentation is shown in Fig. 2. The site consists of a 10 ×10 m fenced in area with a 10-meter tall Rohn 25 fold-over tower at the center. Each flux site includes an InfraRed Gas Analyzer (IRGA), a three-dimensional ultrasonic (sonic) anemometer, a four-component net radiometer, and four soil heat flux plates. Flux site instrumentation is described in Table 3. The IRGA, net radiometer, and sonic are installed at roughly 8.3 meters above ground level. Exact heights are noted in Table 4. The HFP01 soil heat flux plates are buried 6 cm sub-surface at the northwest corner of the fenced in an area. Soil heat flux plates were buried 1 meter south of the NYSM soil temperature/moisture sensors. NYC sites QUEE, BKLN, and STAT are on rooftops and do not have soil heat flux plates installed.

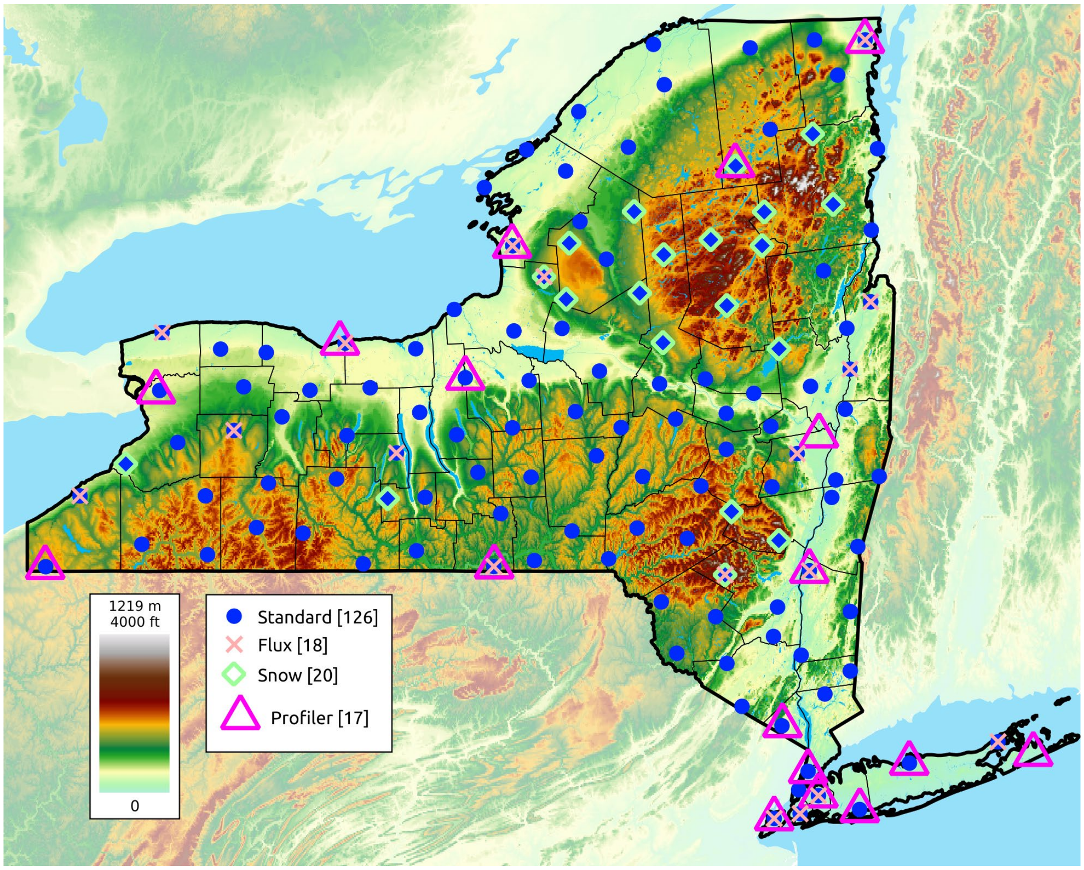

Fig. 1: New York State Mesonet site locations for standard, flux, snow and profiler networks.

3. Data format and availability

The flux data are available every 30 minutes in comma delimited (CSV) format. The available variables for flux data are listed in Table 5. Raw 10 Hz sonic and IRGA data can be provided upon special request. Raw 1 Hz sonic, IRGA, net radiometer, and soil heat flux plate data are also available by special request.

Winter power management: Though the standard site's power system is well under its capacity for most of the year, snow build-up on solar panels and reduced daylight hours during the winter occasionally limit the ability of the battery bank to fully recharge during the day. In addition, colder air temperatures require that some heating be performed to keep instruments within their operating temperature. If energy needs to be conserved to keep the standard site operating, the IRGA and sonic are disabled. This is most apparent on cold winter nights and consecutive cloudy days. Soil heat flux plates and net radiometer data are unaffected by power saving measures. Generally, sites further south and east have the highest data availability in the winter.

Sign conventions: Signs for flux measurements can be inconsistent in textbooks and literature. Table 1 clarifies the sign convention of NYSM flux data.

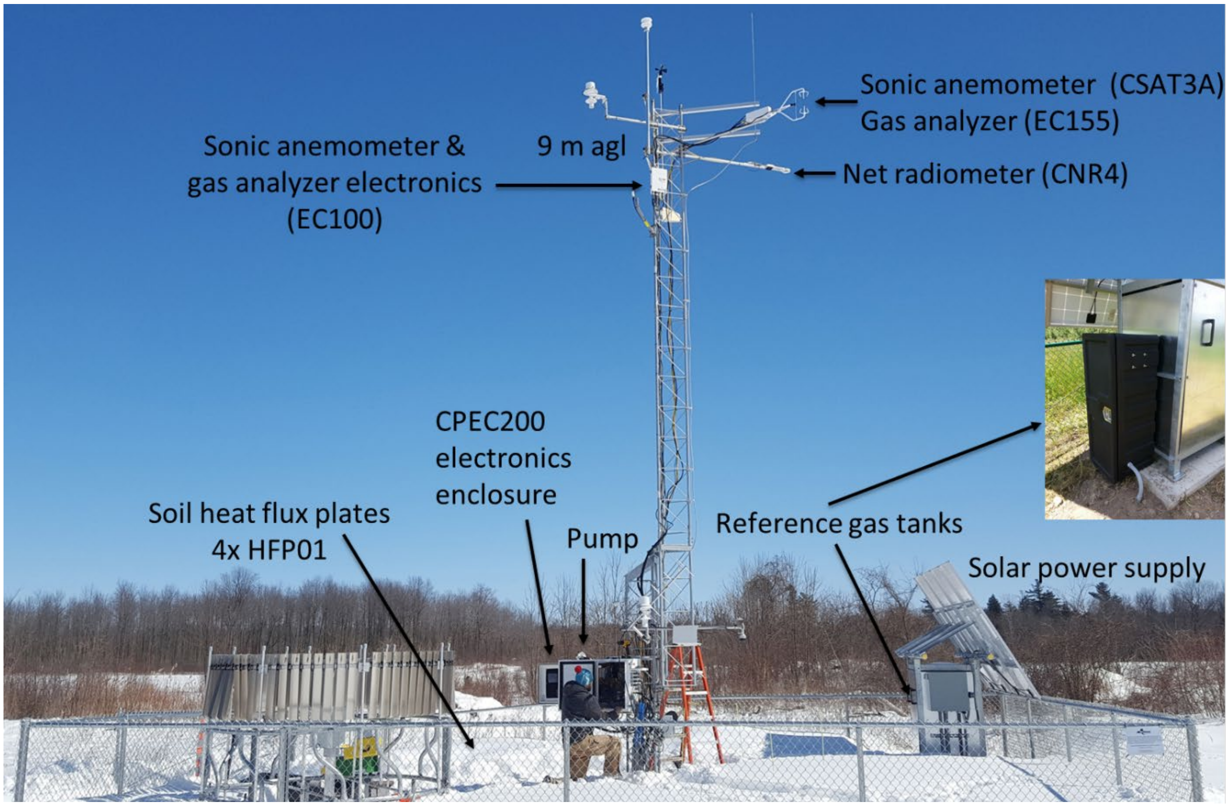

Fig 2. A typical NYSM flux site on the fold-over tower. Chazy (CHAZ) site shown.

Table 1: Direction of flux relative to the earth's surface based on sign of data.

Flux	**Variables**	**Positive data (+)**	**Negative data (–)**
Turbulent fluxes	FC, LE , H, TAU	↑	↓
Soil heat flux	G_6cm G_HFP01_1/2/3/4	↓	↑
Net radiation	Rn	↓	↑
Incoming shortwave and longwave radiation	SW_IN LW_IN	↓	Set negative values to zero
Outgoing shortwave and longwave radiation	SW_OUT LW_OUT	↑	Set negative values to zero

4. Filtering turbulent fluxes for quality

The quality of the turbulent flux data is partially dependent on how well the atmosphere aligns to the assumptions of the eddy covariance method. Flow distortion introduced by the tower and sonic anemometer design is also a factor. Quality control "QC" grades calculated by EasyFlux DL attempt to quantify flux data quality based on these factors. In general, QC grades between 1 and 3 are sufficient for research applications. A grade between 4 and 6 indicates that the data are appropriate for more general applications where accuracy is less critical (i.e. exploratory analysis, seasonal trends). Data with grades of 7 and 8 should be avoided, except where they may be useful for filling gaps in the data record. Data with a grade of 9 should not be used. Do not rely solely on the QC grade to determine if a flux measurement is trustworthy. Effort should be made to understand how terrain, obstructions, weather conditions, and positioning of the instruments play a role in the measured fluxes.

5. Special notes on the data:

a) Sensor and/or system failures are not uncommon as the flux equipment are sensitive to a variety of environmental factors. Data gaps may be due to sensor failures; calibration errors; power failures; and/or communication failures.

b) Only manufacturer-developed QA/QC procedures are applied to the turbulent flux data and there might still be some undetected errors. No QA/QC is currently applied to the soil heat flux plate and net radiometer data. Please make your own judgement on questionable data.

c) We remotely calibrate CO_2 and H_2O zero and CO_2 span daily around 5:00 UTC using known concentrations of CO_2 stored on site. We encourage the use of daily calibrations to determine how much the IRGA has drifted since its last field calibration.

d) NYC sites, QUEE, BKLN, and STAT are subject to significant flow distortion from all wind directions due to their locations on rooftops. The turbulent flux measurements are taken well below the constant flux layer (i.e. inertial sublayer) and are therefore not comparable to those collected on traditional urban flux towers. We encourage users of these data to explore unconventional uses for these flux measurements and to exercise caution when interpreting them.

Table 2: Flux site metadata.

STID	**Date of change**	**Net radiometer height (m)**		**IRGA height (m)**	
		Before	**After**	**Before**	**After**
BELL	5/14/2020	8.44	8.65	8.55	8.36
BKLN*	-	8.41	-	8.52	-
BURT	6/9/2020	8.43	8.64	8.55	8.36
CHAZ	5/6/2020	8.47	8.64	8.56	8.34
CLAR	4/14/2020	8.59	8.59	8.51	8.33
FRED	6/9/2020	8.46	8.64	8.55	8.37
ONTA	5/13/2020	8.43	8.62	8.55	8.35
OWEG	5/22/2020	8.45	8.64	8.53	8.34
PENN	6/10/2020	8.41	8.65	8.53	8.36
QUEE*	-	8.49	-	8.62	-
REDF	5/21/2020	8.46	8.65	8.55	8.36
REDH	5/20/2020	8.45	8.64	8.56	8.36
SCHU	4/29/2020	8.46	8.64	8.54	8.36
SOUT	7/14/2020	7.23	7.23	7.32	7.19
STAT*	-	8.34	-	8.57	-
VOOR	5/5/2020	8.39	8.60	8.55	8.34
WARS	6/10/2020	8.46	8.74	8.55	8.48
WHIT	5/4/2020	8.45	8.64	8.55	8.36

*Ground level is considered the height of the instruments above the rooftop

Table 3: NYSM flux instrument specifications

Measurement	Instrument	Units	Accuracy	Resolution	Sampling interval
Shortwave radiation Longwave radiation	Kipp & Zonen CNR4	Wm^{-2} Wm^{-2}	< 5% [1] <10% [1]	- -	1 s
CO2 molar concentration H2O molar concentration	Campbell Scientific EC155	$\mu mol \cdot mol^{1}$ $mmol \cdot mol^{-1}$	±1% [2] ±2% [2]	0.15 0.006	0.1 s
U axis wind velocity V axis wind velocity W axis wind velocity Sonic temperature	Campbell Scientific CSAT3A	ms^{-1} ms^{-1} ms^{-1} °C	±0.08 ±0.08 ±0.04 -	0.01 0.01 0.005 0.025	0.1 s
Soil heat flux (x4)	Hukseflux HFP01	Wm^{-2}	-	-	1 s
Leaf wetness	Decagon dielectric Leaf Wetness Sensor	mV	no standard	-	1 s

[1] reflects maximum achievable accuracy under ideal conditions with frequent calibrations.
[2] ±15 mm from 0 to 300 mm; ±15 % from 300 to 600 mm

Table 4: Instrument installation height above ground level

Site Name	ID	Latitude	Longitude	Site Description	Mesonet Site Type	Install date (dd/mm/yyyy)
Belleville	BELL	43.78962	-76.11373	Grass/ Crop field	Profiler (350 m WSW *)	05/15/2017
Brooklyn	BKLN	40.63176	-73.95368	Urban	NYC Standard	05/18/2017
Burt	BURT	43.31699	-78.74903	Vineyard/ Crop field	Standard	03/10/2017
Chazy	CHAZ	44.89565	-73.46461	Crop field	Profiler (752 m SE*)	03/17/2017
Claryville	CLAR	41.9792	-74.5171	Pasture	Snow	01/09/2020
Fredonia	FRED	42.41817	-79.3666	Vineyard	Standard	06/28/2017
Ontario	ONTA	43.25941	-77.37331	Orchard	Profiler (3.2 km E*)	03/08/2017
Owego	OWEG	42.02571	-76.25543	Grassy field	Profiler (213 m SE*)	04/05/2017
Penn Yan	PENN	42.65578	-76.98746	Crop field	Standard	05/23/2017
Queens	QUEE	40.73434	-73.81586	Urban	NYC Profiler (10 m*)	04/18/2017
Redfield	REDF	43.62218	-75.87769	Grassy field	Snow	04/11/2017
Red Hook	REDH	42.00168	-73.88391	Grass/ Orchard	Profiler (206 m S*)	03/06/2017
Schuylerville	SCHU	43.11700	-73.57828	Grassy field/ Canal	Standard	02/27/2017
Southold	SOUT	41.04018	-72.46586	Vineyard	Profiler (23.6 km SE*)	05/10/2017
Staten Island	STAT	40.60401	-74.1485	Suburban	NYC Profiler (10 m*)	05/03/2017
Voorheesville	VOOR	42.65242	-73.97562	Orchard	Profiler (17.4 km NE*)	02/13/2017
Warsaw	WARS	42.77993	-78.20889	Crops/ Wind farm	Standard	06/29/2017
Whitehall	WHIT	43.48507	-73.42307	Grassy field/ Canal	Standard	02/27/2017

*Distance between flux tower and co-located vertical profiler

Table 5: Variables in 30 minute flux table

Variable	Example	Units	Data source	Description
stid	FLUX_BURT		Loggernet	site id
datetime	00:00.0		CR6	timestamp
TIMESTAMP_START	2.02E+11	yyyymmdd HHMM	Program	Start of eddy covariance averaging period
TIMESTAMP_END	2.02E+11	yyyymmdd HHMM	Program	End of eddy covariance averaging period
FC	1.079181	umolCO2/(m^2 s)	CSAT3A + EC155	CO2 flux after coordinate rotations and frequency corrections
FC_mass	0.047495	mg m-2 s-1	CSAT3A + EC155	CO2 flux after coordinate rotations and frequency corrections
FC_QC	3	grade	CSAT3A + EC155	Results of the Steady State and Integral Turbulence Characteristics for FC according to Foken et al (2004)
FC_samples_Tot	18000	samples	CSAT3A + EC155	Total data records used to compute FC
LE	47.81122	W m-2	CSAT3A + EC155	Latent heat flux after coordinate rotations and freq corrections
LE_QC	3	grade	CSAT3A + EC155	Results of the Steady State and Integral Turbulence Characteristics for LE according to Foken et al (2004)
ET	0.068939	mm/hr	CSAT3A + EC155	Evapotranspiration
ET_interval	0.03447	mm/30 min	CSAT3A + EC155	Total Evaporation over table interval
ET_QC	3	adimensional	CSAT3A + EC155	Results of the Steady State and Integral Turbulence Characteristics for LE according to Foken et al (2004)
LE_samples_Tot	18000	samples	CSAT3A + EC155	Total data records used to compute LE
H	-47.93	W m-2	CSAT3A + EC155	Sensible heat flux derived from sonic temperature flux with SND correction after coordinate rotations and freq corrections
H_QC	3	grade	CSAT3A + EC155	Results of the Steady State and Integral Turbulence Characteristics for H according to Foken et al (2004)
H_samples_Tot	18000	samples	CSAT3A + EC155	Total data records used to compute H
TAU	0.628524	kg m-1 s-2	CSAT3A + EC155	Momentum flux after coordinate rotations and freq corrections
TAU_QC	1	grade	CSAT3A + EC155	Results of the Steady State and Integral Turbulence Characteristics for TAU according to Foken et al (2004)
Bowen_ratio	-1.00248	adimensional	CSAT3A + EC155	H/LE
USTAR	0.702051	m s-1	CSAT3A	Friction velocity after coordinate rotations and freq corrections
TSTAR	0.053202	deg C	CSAT3A	Scaling temperature after coordinate rotations and freq corrections
TKE	3.10322	m2 s-2	CSAT3A	Specific turbulence kinetic energy after coordinate rotations
ZL	0.013408	adimensional	Calfile + CSAT3A	Atmospheric boundary-layer stability
MO_LENGTH	671.217	m	CSAT3A	Monin-Obukhov Length

CO2	419.2776	umolCO2 mol-1 (ppm)	EC155	CO2 mixing ratio
CO2_SIGMA	0.131497	umolCO2 mol-1 (ppm)	EC155	CO2 mixing ratio standard deviation
CO2_density_Avg	810.2849	mg m-3	EC155	CO2 mass density
CO2_density_SIGMA	0.52054	mg m-3	EC155	CO2 mass density standard deviation
CO2_sig_strgth_Min	1.006637	fraction	EC155	Signal strength for CO2 (0 to 1 with 1 being the strongest)
H2O	3.895578	mmolH2O mol-1	EC155	H2O mixing ratio
H2O_SIGMA	0.094436	mmolH2O mol-1	EC155	H2O mixing ratio standard deviation
H2O_density_Avg	3.08188	g m-3	EC155	Ambient H2O density
H2O_density_SIGMA	0.074921	g m-3	EC155	Ambient H2O density standard deviation
H2O_sig_strgth_Min	0.957082	fraction	EC155	Signal strength for H2O (1 indicates the best possible signal)
PA	100.7833	kPa	EC155 barometer + EC100 barometer	Atmospheric pressure
PA_SIGMA	0.012421	kPa	EC155 + EC100	Atmospheric pressure standard deviation
Tc	1.822898	deg C	CSAT3A + EC155	Air temperature calculated using sonic temperature and H2O mixing ratio
Tc_SIGMA	0.117463	deg C	CSAT3A + EC155	Standard deviation of air temperature calculated using sonic temperature and H2O mixing ratio
RH	55.88391	percent	EC155 + EC100	Relative humidity calculated using sonic temperature, H2O mixing ratio, and ambient pressure
T_DP	-6.04998	deg C	EC155 + EC100	Dew point temperature calculated using H2O mixing ratio and ambient pressure
e	0.391086	kPa	EC155 + EC100	Water vapor pressure calculated from H2O mixing ratio and ambient pressure
e_sat	0.699901	kPa	EC155 + EC100	Saturation water vapor pressure calculated from Tc and ambient pressure
VPD	3.088154	hPa	EC155 + EC100	Air vapor pressure deficit
q	2.33677	g kg-1	EC155	Specific humidity
rho_d	1272.135	g m-3	EC155	Dry air density
rho_d_SIGMA	0.537607	g m-3	EC155	Dry air density standard deviation
rho_a	1.275217	kg m-3	EC155	Moist air density
Cp	1006.291	J/(kg K)	EC155	Specific heat of moist air at constant pressure
Lv	2496.689	J g-1	EC155	Latent heat of vaporization
WS	6.765692	m s-1	CSAT3A	Wind speed
WS_RSLT	6.589509	m s-1	CSAT3A	Resultant wind speed
WS_MAX	14.13025	m s-1	CSAT3A	Maximum wind speed
WD	293.9193	degrees	CSAT3A	Average wind direction (compass bearing)
WD_SONIC	276.0807	degrees	CSAT3A	Wind direction in the sonic anemometer's coordinate system
WD_SIGMA	13.07107	degrees	CSAT3A	Wind direction standard deviation
U	6.596907	m s-1	CSAT3A	Average wind speed in stream-wise direction after coordinate rotations

U_SIGMA	1.71798	m s-1	CSAT3A	Standard deviation of wind speed in stream-wise wind direction after coordinate rotations
V	0	m s-1	CSAT3A	Average wind speed in cross-stream direction after coordinate rotations
V_SIGMA	1.546412	m s-1	CSAT3A	Standard deviation of wind speed in cross-stream direction after coordinate rotations
W	2.98E-08	m s-1	CSAT3A	Average vertical wind speed after coordinate
W_SIGMA	0.929297	m s-1	CSAT3A	Standard deviation of vertical wind after coordinate rotations
Ts	2.163069	deg C	CSAT3A	sonic temperature
Ts_SIGMA	0.115956	deg C	CSAT3A	Standard deviation of sonic temperature
Rn	-51.1029	W m-2	CNR4: all sensors	Net radiation
ALB	0	fraction	CNR4: top and bottom pyranometers	Surface albedo
SW_IN	-1.80233	W m-2	CNR4: top pyranometer	Downwelling shortwave radiation
SW_OUT	1.027853	W m-2	CNR4: bottom pyranometer	Upwelling shortwave radiation (reflected)
LW_IN	270.575	W m-2	CNR4: top pyrgeometer + thermistor	Downwelling longwave radiation (corrected for sensor temperature)
LW_OUT	318.8477	W m-2	CNR4: bottom pyrgeometer + thermistor	Upwelling longwave radiation (corrected for sensor temperature)
T_surf_eff	2.056368	deg C	CNR4: bottom pyrgeometer + thermistor	Effective surface temperature based on upwelling longwave radiation
T_nr	274.7545	Kelvin	CNR4: thermistor	Net radiometer sensor body temperature (used to correct LW measurements)
LWS_volt	268.9687	Volts	leaf wetness sensor	Voltage output related to mass of standing water on a leaf
G_6cm	-17.9284	W m-2	HFP01x4	Soil heat flux measured at 6 cm depth. Average of GHFP01-1, GHFP01-2, GHFP01-3, and GHFP01-4 which are distributed at the corners of a 1x1 meter square.
G_HFP01_1	-17.0025	W m-2	HFP01 #1	Soil heat flux measured by a single heat flux plate, GHFP01-1
G_HFP01_2	-16.6131	W m-2	HFP01 #2	Soil heat flux measured by a single heat flux plate, GHFP01-2
G_HFP01_3	-19.8104	W m-2	HFP01 #3	Soil heat flux measured by a single heat flux plate, GHFP01-3
G_HFP01_4	-18.2875	W m-2	HFP01 #4	Soil heat flux measured by a single heat flux plate, GHFP01-4
PBLH	592.1487	m	EC155	Estimate of planetary boundary layer height
FETCH_MAX	94.4881	m	CSAT3A + EC155	Upwind location of source/sink that contributes most to the measured flux
FETCH_90	272.1551	m	CSAT3A + EC155	Upwind range within which sources/sinks contribute 90% the measured flux

FETCH_55	136.144	m	CSAT3A + EC155	Upwind range within which sources/sinks contribute 55% the measured flux
FETCH_40	102.8582	m	CSAT3A + EC155	Upwind range within which sources/sinks contribute 40% the measured flux
UPWND_DIST_INTRST	900	m	CSAT3A	User-entered upwind distance of interest for the average upwind direction in this averaging interval
FTPRNT_DIST_INTRST	98.47598	m	CSAT3A + EC155	Percentage of measured scalar flux from upwind range of interest
FTPRNT_EQUATION	Kljun et al	Authors (string)	CSAT3A + EC155	Type of footprint equation: Kljun et al or KormannMeixner
sonic_azimuth	210	m	Calfile	Direction the sonic anemometer is facing
alpha	-2.71591	m	CSAT3A	Sonic anemometer pitch angle from coordinate rotation
beta	0	m	CSAT3A	Sonic anemometer roll angle from coordinate rotation
gamma	276.0807	m	CSAT3A	Sonic anemometer yaw angle from coordinate rotation
height_measurement	9	m	Calfile	Measurement height
height_canopy	1.5	m	Calfile	Assumed height of the canopy
displacement_user	0	m	Calfile	Displacement height input by a user as priority for use (0 is default. If default, d is auto calculated and is used)
d	0	m	Calfile	Assumed displacement height
roughness_user	0	m	Calfile	Roughness length input by a user as priority for use (0 is default. If default, z0 is auto calculated)
z0	0.191845	m	Calfile	Assumed roughness length
z	9	m	Calfile	Assumed aerodynamic height