Identification and Prediction of Flux Tower Latent Heat Data and Their Source Variables (Time Series Imputation)

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Dataset Description

We propose to use Goose Creek Eddy Covariance Flux Tower Sensor Data[**kumar2024?**]. The data is collected from the Eddy Covariance Flux Tower in Goose Creek, Piatt County. The dataset consists of time series data spanning from Spring 2016 to Spring 2023 with 15 minutes time interval. Dataset involves 167 variables shown in Figure [**fig?**]: Data including latent heat, sensible heat, wind speed, temperature, and changes in the ecosystem with respect to water, carbon, and temperature. Figure 2 illustrates part of variables in 2022. The data collected by flux tower provides a foundation for further investigation into hydrological, meteorological, and environmental phenomena. The format of dataset is CSV file (generated from raw PICKLE file). The dataset can be found through link: https://www.hydroshare.org/resource/c276c71e8d1246e29d8502f5b2054668/

Variable Name	Units	Sample, Averaged, or Total	Instrument	Description	Geodashboard?	notes
TIMESTAMP	TS					
RECORD	RN					
Hs	W/m^2	Smp	CSAT3 Sonic Anemometer	sensible heat flux		
tau	kg/(m s^2)	Smp	CSAT3 Sonic Anemometer	shear stress		
u_star	m/s	Smp	CSAT3 Sonic Anemometer	friction velocity	yes	
Ts_stdev	C	Smp	CSAT3 Sonic Anemometer	instantaneous stdev of temperature		
Ts_Ux_cov	C m/s	Smp	CSAT3 Sonic Anemometer	inst. cov(temp, Ux)		
Ts_Uy_cov	C m/s	Smp	CSAT3 Sonic Anemometer	inst. cov(temp, Uy)		
Ts_Uz_cov	C m/s	Smp	CSAT3 Sonic Anemometer	inst. cov(temp, Uy)		
Ux_stdev	m/s	Smp	CSAT3 Sonic Anemometer	instantaneous stdev of Ux		
Ux_Uy_cov	(m/s)^2	Smp	CSAT3 Sonic Anemometer	instantaneous cov of (Ux,Uy)		
Ux_Uz_cov	(m/s)^2	Smp	CSAT3 Sonic Anemometer	instantaneous cov of (Ux,Uz)		
Uy_stdev	m/s	Smp	CSAT3 Sonic Anemometer	instantaneous stdev of Uy		
Uy_Uz_cov	(m/s)^2	Smp	CSAT3 Sonic Anemometer	instantaneous cov of (Uy,Uz)		
Uz_stdev	m/s	Smp	CSAT3 Sonic Anemometer	instantaneous stdev of Uz		
wnd_spd	m/s	Smp	CSAT3 Sonic Anemometer	wind speed (horizontal) - different from next?		
rslt_wnd_spd	m/s	Smp	CSAT3 Sonic Anemometer	wind speed (horizontal)	yes	
wnd_dir_sonic	degrees	Smp	CSAT3 Sonic Anemometer	wind direction from CSAT3, deg from N?		
std_wnd_dir	degrees	Smp	CSAT3 Sonic Anemometer	inst. stdev of wind direction		
wnd_dir_compass	degrees	Smp	CSAT3 Sonic Anemometer	wind direction from compass (from N?)	yes	
Ux_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average horiz windspeed x		
Uy_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average horiz windspeed y		
Uz_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average vertical windspeed z		
Ts_Avg	C	Avg	CSAT3 Sonic Anemometer	air temperature at 25 m		
sonic_azimuth	degrees	Smp	CSAT3 Sonic Anemometer	180 is direction is pointing - can change this value		
sonic_samples_Tot	samples	Tot	CSAT3 Sonic Anemometer	10 Hz sampling rate (cycles per 15 mins = 9000)		
diag_sonic_aggregate	arb	Smp	CSAT3 Sonic Anemometer			
no_new_sonic_data_Tot	samples	Tot	CSAT3 Sonic Anemometer			
sonic_amp_l_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_amp_h_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_sig_lck_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_del_T_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_aq_sig_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_low_volt_f_Tot	arb		CSAT3 Sonic Anemometer			
sonic_trig_f_Tot	arb		CSAT3 Sonic Anemometer			
sonic_intml_hmdty_f_Tot	arb		CSAT3 Sonic Anemometer			
sonic_cal_err_f_Tot	arb		CSAT3 Sonic Anemometer			
Fc_li_wpl	mg/(m^2 s)	Smp	Li7500	carbon flux upward (+ = upward) with Webb et al Term	yes	
LE_li_wpl	W/m^2	Smp	Li7500	latent heat flux with Webb et al term	yes	
Hc_li	W/m^2	Smp	Li7500	sensible heat flux	yes	
CO2_li_stdev	mg/m^3	Smp	Li7500			
CO2_li_Ux_cov	mg/(m^2 s)	Smp	Li7500			
CO2_li_Uy_cov	mg/(m^2 s)	Smp	Li7500			
CO2_li_Uz_cov	mg/(m^2 s)	Smp	Li7500			
H2O_li_stdev	g/m^3	Smp	Li7500			
H2O_li_Ux_cov	g/(m^2 s)	Smp	Li7500			
H2O_li_Uy_cov	g/(m^2 s)	Smp	Li7500			
H2O_li_Uz_cov	g/(m^2 s)	Smp	Li7500			
Tc_li_stdev	C	Smp	Li7500			
Tc_li_Ux_cov	C m/s	Smp	Li7500			
Tc_li_Uy_cov	C m/s	Smp	Li7500			
Tc_li_Uz_cov	C m/s	Smp	Li7500			
CO2_li_mean	mg/m^3	Smp	Li7500	CO2 conc --> need to convert to ppm units	yes	
H2O_li_mean	g/m^3	Smp	Li7500	water vapor conc at 25 m	yes	
amb_press_li_mean	kPa	Smp	Li7500	air pressure at 25 m	yes	
Tc_li_mean	C	Smp	Li7500	CSAT air temperature at 25 m		corrected temp based on CSAT, not as good as 083E
rho_a_li_mean	kg/m^3	Smp	Li7500	density of air with water vapor	yes	
Fc_li_irga	mg/(m^2 s)	Smp	Li7500	carbon flux without Webb et al. Term		
LE_li_irga	W/m^2	Smp	Li7500	latent heat flux without Webb et al. Term		
CO2_li_wpl_LE_li	mg/(m^2 s)	Smp	Li7500			
CO2_li_wpl_H_li	mg/(m^2 s)	Smp	Li7500			
H2O_li_wpl_LE_li	W/m^2	Smp	Li7500			
H2O_li_wpl_H_li	W/m^2	Smp	Li7500			
irga_li_samples_Tot	samples	Tot	Li7500	should be around 60 - quality indicator of LiCor		
diag_irga_li_aggregate	arb	Tot	Li7500			
no_new_data_li_Tot	samples	Tot	Li7500			
sig_error_li_Tot	samples	Tot	Li7500			
agc_li_Avg	%	Avg	Li7500			
agc_thrshld_excded_Tot	samples	Tot	Li7500			
process_time_Avg	us	Avg	Li7500			
process_time_Max	us	Max	Li7500			
buff_depth_Max	scans	Max	Li7500			
Precip_Tot	mm	Tot	TE525-L rain gauge	rainfall	yes	
T_tmpr_rh_mean	C	Smp	083E Temp and RH	air temperature at 25 m	yes	
e_tmpr_rh_mean	kPa	Smp	083E Temp and RH	vapor pressure at 25 m	yes	
e_sat_tmpr_rh_mean	kPa	Smp	083E Temp and RH	saturated vapor pressure at 25 m	yes	
H2O_tmpr_rh_mean	g/m^3	Smp	083E Temp and RH	water vapor conc at 25 m	yes	
RH_tmpr_rh_mean	%	Smp	083E Temp and RH	Relative Humidity at 25 m (e/e_sat)	yes	
rho_a_tmpr_rh_mean	kg/m^3	Smp	083E Temp and RH	air density	yes	
slowsequence_1_Tot	samples	Tot	multiple instruments	cycles per 15 mins - scanning every 10 secs		
Batt_Volt_Min	V	Min	multiple instruments			
Solar_Batt_Min	V	Min	multiple instruments			
Box_Rh_Avg		Avg	multiple instruments			
Panel_Tmpr_Avg	C	Avg	multiple instruments			
CS655_Wcr_Avg	m^3/m^3	Avg	CS655-L50 Reflectometer	soil water content	yes	
CS655_Ec_Avg	dS/m	Avg	CS655-L50 Reflectometer	soil conductivity	yes	
CS655_Tmpr_Avg	Deg C	Avg	CS655-L50 Reflectometer	soil temperature	yes	
mean_wind_speed	m/s	Avg	DS2 Sonic Anemometer	wind speed at 10 m height--not average?		
mean_wind_direction	Deg	Avg	DS2 Sonic Anemometer	wind direction		
std_wind_dir	Deg	Avg	DS2 Sonic Anemometer	mean wind vector stdev of direction		
n_TOT	samples	Tot	?			
diag_1_TOT	samples					
diag_2_TOT	samples					
diag_4_TOT	samples					
diag_8_TOT	samples					
diag_9_TOT	samples					
diag_10_TOT	samples					
one_Tot	samples					
NDVI_Avg		Avg	SRS NDVI (both instruments)	Normalized Difference Vegetation Index	yes	
NDVIUpRed_Avg	W/m^2 nm	Avg	SRS NDVI (b: hemispherical): Ni	NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation		
NDVIUpNIR_Avg	W/m^2 nm	Avg	SRS NDVI (b: hemispherical): Ni			
NDVIIndUp		Smp	SRS NDVI (b: hemispherical): Ni			
NDVIDownRed_Avg	W/m^2 nm	Avg	SRS NDVI (a:fieldstop): Nr			
NDVIDownNIR_Avg	W/m^2 nm	Avg	SRS NDVI (a:fieldstop): Nr			
NDVIIndDown		Avg	SRS NDVI (a:fieldstop): Nr			
PRI_Avg		Avg	SRS PRI (both instruments)	Photochemical Reflectance Index	yes	
PRIUp531_Avg	W/m^2 nm	Avg	SRS PRI (b: hemispherical): Pi	PRI calculated from updward and canopy facing sensors that measure 2 wavelengths of radiation		
PRIUp570_Avg	W/m^2 nm	Avg	SRS PRI (b: hemispherical): Pi			
PRIIndUp		Smp	SRS PRI (b: hemispherical): Pi			
PRIDown531_Avg	W/m^2 nm	Avg	SRS PRI (a:fieldstop): Pr			
PRIDown570_Avg	W/m^2 nm	Avg	SRS PRI (a:fieldstop): Pr			
PRIIndDown		Avg	SRS PRI (a:fieldstop): Pr			
D5TE_VWC_5cm_Avg	m^3/m^3	Avg	5TE Soil Probe 5cm	volumetric water content	yes	
D5TE_P_5cm_Avg		Avg	5TE Soil Probe 5cm	bulk dielectric permittivity		
D5TE_EC_5cm_Avg	dS/m	Avg	5TE Soil Probe 5cm	soil electrical conductivity	yes	
D5TE_T_5cm_Avg	Deg C	Avg	5TE Soil Probe 5cm	soil temperature	yes	
D5TE_VWC_15cm_Avg	m^3/m^3	Avg	5TE Soil Probe 15cm	volumetric water content	yes	
D5TE_P_15cm_Avg		Avg	5TE Soil Probe 15cm	bulk dielectric permittivity		
D5TE_EC_15cm_Avg	dS/m	Avg	5TE Soil Probe 15cm	soil conductivity	yes	
D5TE_T_15cm_Avg	Deg C	Avg	5TE Soil Probe 15cm	soil temperature	yes	
D5TE_VWC_30cm_Avg	m^3/m^3	Avg	5TE Soil Probe 30 cm	volumetric water content	yes	
D5TE_P_30cm_Avg		Avg	5TE Soil Probe 30 cm	bulk dielectric permittivity		
D5TE_EC_30cm_Avg	dS/m	Avg	5TE Soil Probe 30 cm	soil conductivity	yes	
D5TE_T_30cm_Avg	Deg C	Avg	5TE Soil Probe 30 cm	soil temperature	yes	
D5TE_VWC_50cm_Avg	m^3/m^3	Avg	5TE Soil Probe 50 cm	volumetric water content	yes	
D5TE_P_50cm_Avg		Avg	5TE Soil Probe 50 cm	bulk dielectric permittivity		
D5TE_EC_50cm_Avg	dS/m	Avg	5TE Soil Probe 50 cm	soil conductivity	yes	
D5TE_T_50cm_Avg	Deg C	Avg	5TE Soil Probe 50 cm	soil temperature	yes	
D5TE_VWC_100cm_Avg	m^3/m^3	Avg	5TE Soil Probe 100cm	volumetric water content	yes	
D5TE_P_100cm_Avg		Avg	5TE Soil Probe 100cm	bulk dielectric permittivity		
D5TE_EC_100cm_Avg	dS/m	Avg	5TE Soil Probe 100cm	soil conductivity	yes	
D5TE_T_100cm_Avg	Deg C	Avg	5TE Soil Probe 100cm	soil temperature	yes	
D5TE_VWC_200cm_Avg	m^3/m^3	Avg	5TE Soil Probe 200cm	volumetric water content	yes	
D5TE_P_200cm_Avg		Avg	5TE Soil Probe 200cm	bulk dielectric permittivity		
D5TE_EC_200cm_Avg	dS/m	Avg	5TE Soil Probe 200cm	soil conductivity	yes	
D5TE_T_200cm_Avg	Deg C	Avg	5TE Soil Probe 200cm	soil temperature	yes	
slowsequence_2_Tot	samples	Tot	multiple instruments	cyles - 1 minute loops (number times scanned)		
SB121TempC_Avg		Avg	SI-121 Infrared Radiometer	SB = sensor body, temp of body of sensor		
Targ121TempC_Avg		Avg	SI-121 Infrared Radiometer	surface temperature	yes	
Targ121mV_Avg		Avg	SI-121 Infrared Radiometer			
SB1H1TempC_Avg		Avg	Apogee SI-1H1 Infrared Radiometer	SB = sensor body, temp of body of sensor		
Targ1H1TempC_Avg		Avg	Apogee SI-1H1 Infrared Radiometer	surface temperature	yes	
Targ1H1mV_Avg		Avg	Apogee SI-1H1 Infrared Radiometer			
short_up_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Incoming shortwave radiation detected by the upward facing instrument	yes	
short_dn_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Outgoing shortwave radiation detected by the downward facing instrument	yes	
long_up_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	incoming longwave radiation detected by upward facing instrument		
long_dn_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	outgoing longwave radiation detected by downward facing instrument		
cnr4_T_C_Avg	deg_C	Avg	CNR4 Pyranometer (Kipp&Zonen)	temperature of sensor		
cnr4_T_K_Avg	K	Avg	CNR4 Pyranometer (Kipp&Zonen)	temperature of sensor in Kelvin		
long_up_corr_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Incoming longwave radiation detected by the upward facing instrument, corrected	yes	
long_dn_corr_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Outgoing longwave radiation detected by the downward facing instrument , corrected	yes	
Rs_net_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Shortwave net radiation (Rshort_up - Rshort_down)	yes	
Rl_net_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Longwave net radiation (Rlong_up - Rlong_down)	yes	
albedo_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Albedo	yes	
Rn_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Net radiation (Rs_net + Rl_net)	yes	
SQ_110_Avg	(F°mol m-2	Avg	Apogee SQ-110 sunlight calibrated quant	PAR (photosynthetically active radiation)	yes	
shf_Avg(1)	W/m^2	Avg	HFP01SC-L50 (2 heat flux plates)	Ground heat flux	yes	
shf_Avg(2)	W/m^2	Avg	HFP01SC-L50 (2 heat flux plates)	Ground heat flux	yes	
shf_mV_Avg(1)		Avg	HFP01SC-L50 (2 heat flux plates)			
shf_mV_Avg(2)		Avg	HFP01SC-L50 (2 heat flux plates)			
shf_cal(1)	W/(m^2 mV	Smp	HFP01SC-L50 (2 heat flux plates)			
shf_cal(2)	W/(m^2 mV	Smp	HFP01SC-L50 (2 heat flux plates)			
board_temp_Avg	degC	Avg				
board_humidity_Avg	percent	Avg				
incline_pitch_Avg	deg	Avg				
incline_roll_Avg	deg	Avg				
slowsequence_3_Tot	samples	Tot		number of times scanned in 15 mins (once per min)		

most instruments installed in 2016

List of Instruments

Instrument	Location on Tower	notes
Li7500	25 m	
CSAT3 Sonic Anemometer	25 m	
083E Temp and RH	25 m	
DS2 Sonic Anemometer	10 m	
SRS NDVI (a:fieldstop): Nr	25 m	moved to 25 m height in summer 2020 to see canopy instead of grass
SRS NDVI (b: hemispherical): Ni	25 m	moved to 25 m height in summer 2020 to see canopy instead of grass
SRS PRI (a:fieldstop): Pr	25 m	moved to 25 m height in summer 2020 to see canopy instead of grass
SRS PRI (b: hemispherical): Pi	25 m	moved to 25 m height in summer 2020 to see canopy instead of grass
TE525-L rain gauge	1.5 m	
Apogee SI-1H1 Infrared Radiometer	25 m	getting canopy temperature, moved to 25 m height in summer 2020
CNR4 Pyranometer (Kipp&Zonen)	10 m	
SI-121 Infrared Radiometer	2 m	pointed at ground heat fux plates (HFP01SC)
Apogee SQ-110 sunlight calibrated quantum sensor (PAR)	2 m	on tower arm at 2 m height
5TE Soil Probe 5cm	5 cm depth	
5TE Soil Probe 15cm	15 cm depth	
5TE Soil Probe 30 cm	30 cm depth	
5TE Soil Probe 50 cm	50 cm depth	
5TE Soil Probe 100cm	100 cm depth	
5TE Soil Probe 200cm	200 cm depth	
CS655-L50 Reflectometer	shallow depth	
HFP01SC-L50 (2 heat flux plates)	8 cm depth	

*new anemometer???? at 10 m height - a campbell anemometer

*rain gauge is at a new height

Apogee SQ

Variable Name	Units	Sample, Averaged, or Total	Instrument	Description	Geodashboard?	notes
TIMESTAMP	TS					
RECORD	RN					
Hs	W/m^2	Smp	CSAT3 Sonic Anemometer	sensible heat flux		
tau	kg/(m s^2)	Smp	CSAT3 Sonic Anemometer	shear stress		
u_star	m/s	Smp	CSAT3 Sonic Anemometer	friction velocity	yes	
Ts_stdev	C	Smp	CSAT3 Sonic Anemometer	instantaneous stdev of temperature		
Ts_Ux_cov	C m/s	Smp	CSAT3 Sonic Anemometer	inst. cov(temp, Ux)		
Ts_Uy_cov	C m/s	Smp	CSAT3 Sonic Anemometer	inst. cov(temp, Uy)		
Ts_Uz_cov	C m/s	Smp	CSAT3 Sonic Anemometer	inst. cov(temp, Uy)		
Ux_stdev	m/s	Smp	CSAT3 Sonic Anemometer	instantaneous stdev of Ux		
Ux_Uy_cov	(m/s)^2	Smp	CSAT3 Sonic Anemometer	instantaneous cov of (Ux,Uy)		
Ux_Uz_cov	(m/s)^2	Smp	CSAT3 Sonic Anemometer	instantaneous cov of (Ux,Uz)		
Uy_stdev	m/s	Smp	CSAT3 Sonic Anemometer	instantaneous stdev of Uy		
Uy_Uz_cov	(m/s)^2	Smp	CSAT3 Sonic Anemometer	instantaneous cov of (Uy,Uz)		
Uz_stdev	m/s	Smp	CSAT3 Sonic Anemometer	instantaneous stdev of Uz		
wnd_spd	m/s	Smp	CSAT3 Sonic Anemometer	wind speed (horizontal) - different from next?		
rslt_wnd_spd	m/s	Smp	CSAT3 Sonic Anemometer	wind speed (horizontal)	yes	
wnd_dir_sonic	degrees	Smp	CSAT3 Sonic Anemometer	wind direction from CSAT3, deg from N?		
std_wnd_dir	degrees	Smp	CSAT3 Sonic Anemometer	inst. stdev of wind direction		
wnd_dir_compass	degrees	Smp	CSAT3 Sonic Anemometer	wind direction from compass (from N?)	yes	
Ux_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average horiz windspeed x		
Uy_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average horiz windspeed y		
Uz_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average vertical windspeed z		
Ts_Avg	C	Avg	CSAT3 Sonic Anemometer	air temperature at 25 m		
sonic_azimuth	degrees	Smp	CSAT3 Sonic Anemometer	180 is direction is pointing - can change this value		
sonic_samples_Tot	samples	Tot	CSAT3 Sonic Anemometer	10 Hz sampling rate (cycles per 15 mins = 9000)		
diag_sonic_aggregate	arb	Smp	CSAT3 Sonic Anemometer			
no_new_sonic_data_Tot	samples	Tot	CSAT3 Sonic Anemometer			
sonic_amp_l_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_amp_h_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_sig_lck_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_del_T_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_aq_sig_f_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_low_volt_f_Tot	arb		CSAT3 Sonic Anemometer			
sonic_trig_f_Tot	arb		CSAT3 Sonic Anemometer			
sonic_intml_hmdty_f_Tot	arb		CSAT3 Sonic Anemometer			
sonic_cal_err_f_Tot	arb		CSAT3 Sonic Anemometer			
Fc_li_wpl	mg/(m^2 s)	Smp	Li7500	carbon flux upward (+ = upward) with Webb et al Term	yes	
LE_li_wpl	W/m^2	Smp	Li7500	latent heat flux with Webb et al term	yes	
Hc_li	W/m^2	Smp	Li7500	sensible heat flux	yes	
CO2_li_stdev	mg/m^3	Smp	Li7500			
CO2_li_Ux_cov	mg/(m^2 s)	Smp	Li7500			
CO2_li_Uy_cov	mg/(m^2 s)	Smp	Li7500			
CO2_li_Uz_cov	mg/(m^2 s)	Smp	Li7500			
H2O_li_stdev	g/m^3	Smp	Li7500			
H2O_li_Ux_cov	g/(m^2 s)	Smp	Li7500			

most instruments installed in 2016

List of Instruments

Instrument	Location on Tower	notes
Li7500	25 m	
CSAT3 Sonic Anemometer	25 m	
083E Temp and RH	25 m	
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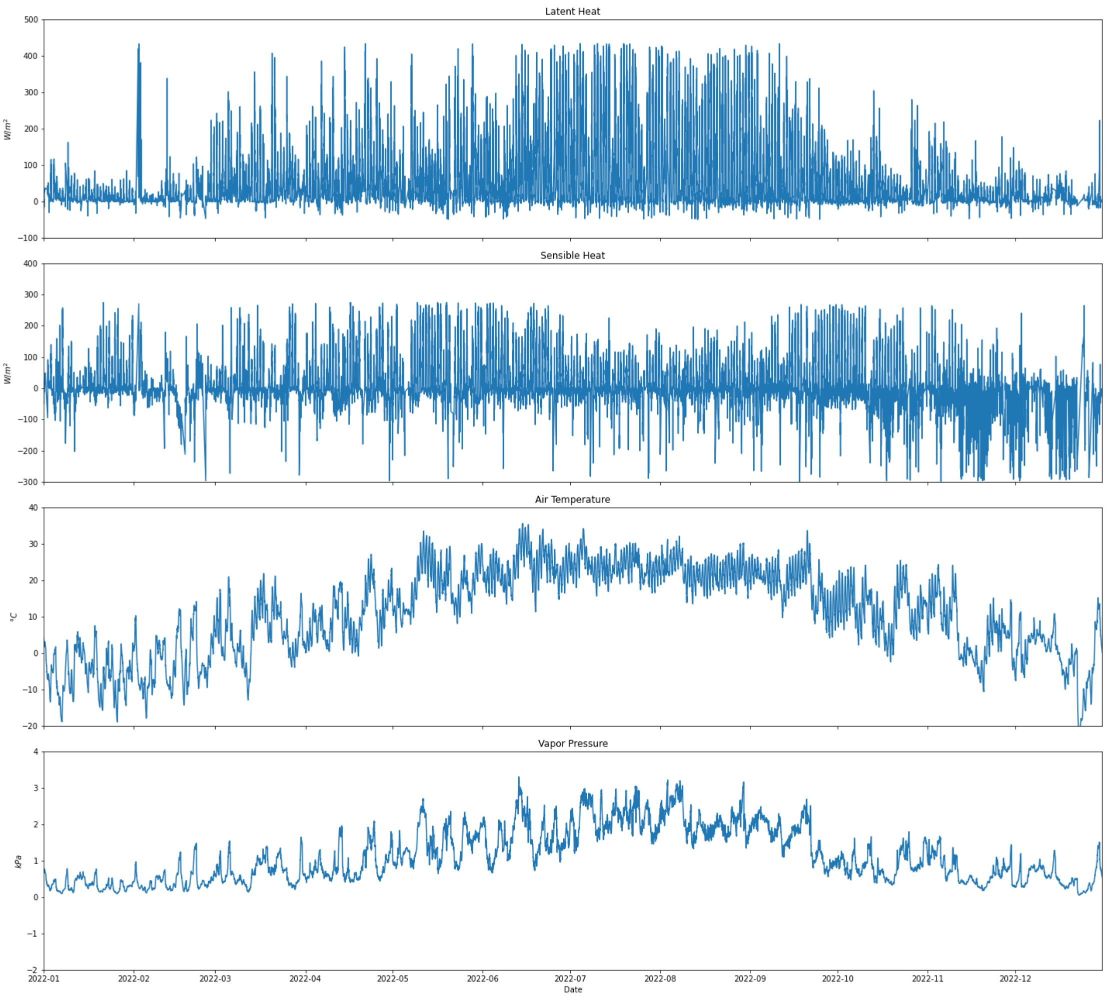
Apogee SQ-110 sunlight calibrated quantum sensor (PAR)	2 m	on tower arm at 2 m height
5TE Soil Probe 5cm	5 cm depth	
5TE Soil Probe 15cm	15 cm depth	
5TE Soil Probe 30 cm	30 cm depth	
5TE Soil Probe 50 cm	50 cm depth	
5TE Soil Probe 100cm	100 cm depth	
5TE Soil Probe 200cm	200 cm depth	
CS655-L50 Reflectometer	shallow depth	
HFP01SC-L50 (2 heat flux plates)	8 cm depth	

*new anemometer???? at 10 m height - a campbell anemometer

*rain gauge is at a new height

Apogee SQ

H2O_li_Uy_cov	g/(m^2 s)	Smp	Li7500			
H2O_li_Uz_cov	g/(m^2 s)	Smp	Li7500			
Tc_li_stdev	C	Smp	Li7500			
Tc_li_Ux_cov	C m/s	Smp	Li7500			
Tc_li_Uy_cov	C m/s	Smp	Li7500			
Tc_li_Uz_cov	C m/s	Smp	Li7500			
CO2_li_mean	mg/m^3	Smp	Li7500	CO2 conc --> need to convert to ppm units	yes	
H2O_li_mean	g/m^3	Smp	Li7500	water vapor conc at 25 m	yes	
amb_press_li_mean	kPa	Smp	Li7500	air pressure at 25 m	yes	
Tc_li_mean	C	Smp	Li7500	CSAT air temperature at 25 m		corrected temp based on CSAT, not as good as 083E
rho_a_li_mean	kg/m^3	Smp	Li7500	density of air with water vapor	yes	
Fc_li_irga	mg/(m^2 s)	Smp	Li7500	carbon flux without Webb et al. Term		
LE_li_irga	W/m^2	Smp	Li7500	latent heat flux without Webb et al. Term		
CO2_li_wpl_LE_li	mg/(m^2 s)	Smp	Li7500			
CO2_li_wpl_H_li	mg/(m^2 s)	Smp	Li7500			
H2O_li_wpl_LE_li	W/m^2	Smp	Li7500			
H2O_li_wpl_H_li	W/m^2	Smp	Li7500			
irga_li_samples_Tot	samples	Tot	Li7500	should be around 60 - quality indicator of LiCor		
diag_irga_li_aggregate	arb	Tot	Li7500			
no_new_data_li_Tot	samples	Tot	Li7500			
sig_error_li_Tot	samples	Tot	Li7500			
agc_li_Avg	%	Avg	Li7500			
agc_thrshld_excded_Tot	samples	Tot	Li7500			
process_time_Avg	us	Avg	Li7500			
process_time_Max	us	Max	Li7500			
buff_depth_Max	scans	Max	Li7500			
Precip_Tot	mm	Tot	TE525-L rain gauge	rainfall	yes	
T_tmpr_rh_mean	C	Smp	083E Temp and RH	air temperature at 25 m	yes	
e_tmpr_rh_mean	kPa	Smp	083E Temp and RH	vapor pressure at 25 m	yes	
e_sat_tmpr_rh_mean	kPa	Smp	083E Temp and RH	saturated vapor pressure at 25 m	yes	
H2O_tmpr_rh_mean	g/m^3	Smp	083E Temp and RH	water vapor conc at 25 m	yes	
RH_tmpr_rh_mean	%	Smp	083E Temp and RH	Relative Humidity at 25 m (e/e_sat)	yes	
rho_a_tmpr_rh_mean	kg/m^3	Smp	083E Temp and RH	air density	yes	
slowsequence_1_Tot	samples	Tot	multiple instruments	cycles per 15 mins - scanning every 10 secs		
Batt_Volt_Min	V	Min	multiple instruments			
Solar_Batt_Min	V	Min	multiple instruments			
Box_Rh_Avg		Avg	multiple instruments			
Panel_Tmpr_Avg	C	Avg	multiple instruments			
CS655_Wcr_Avg	m^3/m^3	Avg	CS655-L50 Reflectometer	soil water content	yes	
CS655_Ec_Avg	dS/m	Avg	CS655-L50 Reflectometer	soil conductivity	yes	
CS655_Tmpr_Avg	Deg C	Avg	CS655-L50 Reflectometer	soil temperature	yes	
mean_wind_speed	m/s	Avg	DS2 Sonic Anemometer	wind speed at 10 m height…not average?		
mean_wind_direction	Deg	Avg	DS2 Sonic Anemometer	wind direction		
std_wind_dir	Deg	Avg	DS2 Sonic Anemometer	mean wind vector stdev of direction		
n_TOT	samples	Tot	?			
diag_1_TOT	samples					
diag_2_TOT	samples					
diag_4_TOT	samples					
diag_8_TOT	samples					
diag_9_TOT	samples					
diag_10_TOT	samples					
one_Tot	samples					
NDVI_Avg		Avg	SRS NDVI (both instruments)	Normalized Difference Vegetation Index	yes	
NDVIUpRed_Avg	W/m^2 nm	Avg	SRS NDVI (b: hemispherical): Ni			
NDVIUpNIR_Avg	W/m^2 nm	Avg	SRS NDVI (b: hemispherical): Ni			
NDVIIndUp		Smp	SRS NDVI (b: hemispherical): Ni	NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation		
NDVIDownRed_Avg	W/m^2 nm	Avg	SRS NDVI (a:fieldstop): Nr			
NDVIDownNIR_Avg	W/m^2 nm	Avg	SRS NDVI (a:fieldstop): Nr			
NDVIIndDown		Avg	SRS NDVI (a:fieldstop): Nr			
PRI_Avg		Avg	SRS PRI (both instruments)	Photochemical Reflectance Index	yes	
PRIUp531_Avg	W/m^2 nm	Avg	SRS PRI (b: hemispherical): Pi			
PRIUp570_Avg	W/m^2 nm	Avg	SRS PRI (b: hemispherical): Pi			
PRIIndUp		Smp	SRS PRI (b: hemispherical): Pi	PRI calculated from updward and canopy facing sensors that measure 2 wavelengths of radiation		
PRIDown531_Avg	W/m^2 nm	Avg	SRS PRI (a:fieldstop): Pr			
PRIDown570_Avg	W/m^2 nm	Avg	SRS PRI (a:fieldstop): Pr			
PRIIndDown		Avg	SRS PRI (a:fieldstop): Pr			
D5TE_VWC_5cm_Avg	m^3/m^3	Avg	5TE Soil Probe 5cm	volumetric water content	yes	
D5TE_P_5cm_Avg		Avg	5TE Soil Probe 5cm	bulk dielectric permittivity		
D5TE_EC_5cm_Avg	dS/m	Avg	5TE Soil Probe 5cm	soil electrical conductivity	yes	
D5TE_T_5cm_Avg	Deg C	Avg	5TE Soil Probe 5cm	soil temperature	yes	
D5TE_VWC_15cm_Avg	m^3/m^3	Avg	5TE Soil Probe 15cm	volumetric water content	yes	
D5TE_P_15cm_Avg		Avg	5TE Soil Probe 15cm	bulk dielectric permittivity		
D5TE_EC_15cm_Avg	dS/m	Avg	5TE Soil Probe 15cm	soil conductivity	yes	
D5TE_T_15cm_Avg	Deg C	Avg	5TE Soil Probe 15cm	soil temperature	yes	
D5TE_VWC_30cm_Avg	m^3/m^3	Avg	5TE Soil Probe 30 cm	volumetric water content	yes	
D5TE_P_30cm_Avg		Avg	5TE Soil Probe 30 cm	bulk dielectric permittivity		
D5TE_EC_30cm_Avg	dS/m	Avg	5TE Soil Probe 30 cm	soil conductivity	yes	
D5TE_T_30cm_Avg	Deg C	Avg	5TE Soil Probe 30 cm	soil temperature	yes	
D5TE_VWC_50cm_Avg	m^3/m^3	Avg	5TE Soil Probe 50 cm	volumetric water content	yes	
D5TE_P_50cm_Avg		Avg	5TE Soil Probe 50 cm	bulk dielectric permittivity		
D5TE_EC_50cm_Avg	dS/m	Avg	5TE Soil Probe 50 cm	soil conductivity	yes	
D5TE_T_50cm_Avg	Deg C	Avg	5TE Soil Probe 50 cm	soil temperature	yes	
D5TE_VWC_100cm_Avg	m^3/m^3	Avg	5TE Soil Probe 100cm	volumetric water content	yes	
D5TE_P_100cm_Avg		Avg	5TE Soil Probe 100cm	bulk dielectric permittivity		
D5TE_EC_100cm_Avg	dS/m	Avg	5TE Soil Probe 100cm	soil conductivity	yes	
D5TE_T_100cm_Avg	Deg C	Avg	5TE Soil Probe 100cm	soil temperature	yes	
D5TE_VWC_200cm_Avg	m^3/m^3	Avg	5TE Soil Probe 200cm	volumetric water content	yes	
D5TE_P_200cm_Avg		Avg	5TE Soil Probe 200cm	bulk dielectric permittivity		
D5TE_EC_200cm_Avg	dS/m	Avg	5TE Soil Probe 200cm	soil conductivity	yes	
D5TE_T_200cm_Avg	Deg C	Avg	5TE Soil Probe 200cm	soil temperature	yes	
slowsequence_2_Tot	samples	Tot	multiple instruments	cyles - 1 minute loops (number times scanned)		
SB121TempC_Avg		Avg	SI-121 Infrared Radiometer	SB = sensor body, temp of body of sensor		
Targ121TempC_Avg		Avg	SI-121 Infrared Radiometer	surface temperature	yes	
Targ121mV_Avg		Avg	SI-121 Infrared Radiometer			
SB1H1TempC_Avg		Avg	Apogee SI-1H1 Infrared Radiometer	SB = sensor body, temp of body of sensor		
Targ1H1TempC_Avg		Avg	Apogee SI-1H1 Infrared Radiometer	surface temperature	yes	
Targ1H1mV_Avg		Avg	Apogee SI-1H1 Infrared Radiometer			
short_up_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Incoming shortwave radiation detected by the upward facing instrument	yes	
short_dn_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Outgoing shortwave radiation detected by the downward facing instrument	yes	
long_up_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	incoming longwave radiation detected by upward facing instrument		
long_dn_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	outgoing longwave radiation detected by downward facing instrument		
cnr4_T_C_Avg	deg_C	Avg	CNR4 Pyranometer (Kipp&Zonen)	temperature of sensor		
cnr4_T_K_Avg	K	Avg	CNR4 Pyranometer (Kipp&Zonen)	temperature of sensor in Kelvin		
long_up_corr_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Incoming longwave radiation detected by the upward facing instrument, corrected	yes	
long_dn_corr_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Outgoing longwave radiation detected by the downward facing instrument , corrected	yes	
Rs_net_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Shortwave net radiation (Rshort_up - Rshort_down)	yes	
Rl_net_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Longwave net radiation (Rlong_up - Rlong_down)	yes	
albedo_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Albedo	yes	
Rn_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Net radiation (Rs_net + Rl_net)	yes	
SQ_110_Avg	(Ê°mol m-2	Avg	Apogee SQ-110 sunlight calibrated quant	PAR (photosynthetically active radiation)	yes	
shf_Avg(1)	W/m^2	Avg	HFP01SC-L50 (2 heat flux plates)	Ground heat flux	yes	
shf_Avg(2)	W/m^2	Avg	HFP01SC-L50 (2 heat flux plates)	Ground heat flux	yes	
shf_mV_Avg(1)		Avg	HFP01SC-L50 (2 heat flux plates)			
shf_mV_Avg(2)		Avg	HFP01SC-L50 (2 heat flux plates)			
shf_cal(1)	W/(m^2 mV	Smp	HFP01SC-L50 (2 heat flux plates)			
shf_cal(2)	W/(m^2 mV	Smp	HFP01SC-L50 (2 heat flux plates)			
board_temp_Avg	degC	Avg				
board_humidity_Avg	percent	Avg				
incline_pitch_Avg	deg	Avg				
incline_roll_Avg	deg	Avg				
slowsequence_3_Tot	samples	Tot		number of times scanned in 15 mins (once per min)		



Variable Name	Units	Sample, Averaged, Total
TIMESTAMP	TS	
RECORD	RN	
Hs	W/m^2	Smp
tau	kg/(m s^2)	Smp
u_star	m/s	Smp
Ts_stdev	C	Smp
Ts_Ux_cov	C m/s	Smp
Ts_Uy_cov	C m/s	Smp
Ts_Uz_cov	C m/s	Smp
Ux_stdev	m/s	Smp
Ux_Uy_cov	(m/s)^2	Smp

Ux_Uz_cov	(m/s)^2	Smp
Uy_stdev	m/s	Smp
Uy_Uz_cov	(m/s)^2	Smp
Uz_stdev	m/s	Smp
wnd_spd	m/s	Smp
rslt_wnd_spd	m/s	Smp
wnd_dir_sonic	degrees	Smp
std_wnd_dir	degrees	Smp
wnd_dir_compass	degrees	Smp
Ux_Avg	m/s	Avg
Uy_Avg	m/s	Avg
Uz_Avg	m/s	Avg
Ts_Avg	C	Avg
sonic_azimuth	degrees	Smp
sonic_samples_Tot	samples	Tot
diag_sonic_aggregate	arb	Smp
no_new_sonic_data_Tot	samples	Tot
sonic_amp_l_f_Tot	arb	Tot
sonic_amp_h_f_Tot	arb	Tot
sonic_sig_lck_f_Tot	arb	Tot
sonic_del_T_f_Tot	arb	Tot
sonic_aq_sig_f_Tot	arb	Tot
sonic_low_volt_f_Tot	arb	
sonic_trig_f_Tot	arb	
sonic_intrnl_hmdty_f_Tot	arb	
sonic_cal_err_f_Tot	arb	
Fc_li_wpl	mg/(m^2 s)	Smp
LE_li_wpl	W/m^2	Smp
Hc_li	W/m^2	Smp
CO2_li_stdev	mg/m^3	Smp
CO2_li_Ux_cov	mg/(m^2 s)	Smp
CO2_li_Uy_cov	mg/(m^2 s)	Smp
CO2_li_Uz_cov	mg/(m^2 s)	Smp
H2O_li_stdev	g/m^3	Smp
H2O_li_Ux_cov	g/(m^2 s)	Smp
H2O_li_Uy_cov	g/(m^2 s)	Smp
H2O_li_Uz_cov	g/(m^2 s)	Smp
Tc_li_stdev	C	Smp
Tc_li_Ux_cov	C m/s	Smp
Tc_li_Uy_cov	C m/s	Smp
Tc_li_Uz_cov	C m/s	Smp
CO2_li_mean	mg/m^3	Smp
H2O_li_mean	g/m^3	Smp
amb_press_li_mean	kPa	Smp
Tc_li_mean	C	Smp
rho_a_li_mean	kg/m^3	Smp
Fc_li_irga	mg/(m^2 s)	Smp
LE_li_irga	W/m^2	Smp
CO2_li_wpl_LE_li	mg/(m^2 s)	Smp
CO2_li_wpl_H_li	mg/(m^2 s)	Smp
H2O_li_wpl_LE_li	W/m^2	Smp
H2O_li_wpl_H_li	W/m^2	Smp
irga_li_samples_Tot	samples	Tot
diag_irga_li_aggregate	arb	Tot
no_new_data_li_Tot	samples	Tot
sig_error_li_Tot	samples	Tot
agc_li_Avg	%	Avg
agc_thrshld_excded_Tot	samples	Tot
process_time_Avg	us	Avg
process_time_Max	us	Max

buff_depth_Max	scans	Max
Precip_Tot	mm	Tot
T_tmpr_rh_mean	C	Smp
e_tmpr_rh_mean	kPa	Smp
e_sat_tmpr_rh_mean	kPa	Smp
H2O_tmpr_rh_mean	g/m^3	Smp
RH_tmpr_rh_mean	%	Smp
rho_a_tmpr_rh_mean	kg/m^3	Smp
slowsequence_1_Tot	samples	Tot
Batt_Volt_Min	V	Min
Solar_Batt_Min	V	Min
Box_Rh_Avg		Avg
Panel_Tmpr_Avg	C	Avg
CS655_Wcr_Avg	m^3/m^3	Avg
CS655_Ec_Avg	dS/m	Avg
CS655_Tmpr_Avg	Deg C	Avg
mean_wind_speed	m/s	Avg
mean_wind_direction	Deg	Avg
std_wind_dir	Deg	Avg
n_TOT	samples	Tot
diag_1_TOT	samples	
diag_2_TOT	samples	
diag_4_TOT	samples	
diag_8_TOT	samples	
diag_9_TOT	samples	
diag_10_TOT	samples	
one_Tot	samples	
NDVI_Avg		Avg
NDVIUpRed_Avg	W/m^2 nm	Avg
NDVIUpNIR_Avg	W/m^2 nm	Avg
NDVIIndUp		Smp
NDVIDownRed_Avg	W/m^2 nm	Avg
NDVIDownNIR_Avg	W/m^2 nm	Avg
NDVIIndDown		Avg
PRI_Avg		Avg
PRIUp531_Avg	W/m^2 nm	Avg
PRIUp570_Avg	W/m^2 nm	Avg
PRIIndUp		Smp
PRIDown531_Avg	W/m^2 nm	Avg
PRIDown570_Avg	W/m^2 nm	Avg
PRIIndDown		Avg
D5TE_VWC_5cm_Avg	m^3/m^3	Avg
D5TE_P_5cm_Avg		Avg
D5TE_EC_5cm_Avg	dS/m	Avg
D5TE_T_5cm_Avg	Deg C	Avg
D5TE_VWC_15cm_Avg	m^3/m^3	Avg
D5TE_P_15cm_Avg		Avg
D5TE_EC_15cm_Avg	dS/m	Avg
D5TE_T_15cm_Avg	Deg C	Avg
D5TE_VWC_30cm_Avg	m^3/m^3	Avg
D5TE_P_30cm_Avg		Avg
D5TE_EC_30cm_Avg	dS/m	Avg
D5TE_T_30cm_Avg	Deg C	Avg
D5TE_VWC_50cm_Avg	m^3/m^3	Avg
D5TE_P_50cm_Avg		Avg
D5TE_EC_50cm_Avg	dS/m	Avg
D5TE_T_50cm_Avg	Deg C	Avg
D5TE_VWC_100cm_Avg	m^3/m^3	Avg
D5TE_P_100cm_Avg		Avg
D5TE_EC_100cm_Avg	dS/m	Avg
D5TE_T_100cm_Avg	Deg C	Avg
D5TE_VWC_200cm_Avg	m^3/m^3	Avg

D5TE_VWC_200cm_Avg	m^3/m^3	Avg
D5TE_P_200cm_Avg		Avg
D5TE_EC_200cm_Avg	dS/m	Avg
D5TE_T_200cm_Avg	Deg C	Avg
slowsequence_2_Tot	samples	Tot
SB121TempC_Avg		Avg
Targ121TempC_Avg		Avg
Targ121mV_Avg		Avg
SB1H1TempC_Avg		Avg
Targ1H1TempC_Avg		Avg
Targ1H1mV_Avg		Avg
short_up_Avg	W/m^2	Avg
short_dn_Avg	W/m^2	Avg
long_up_Avg	W/m^2	Avg
long_dn_Avg	W/m^2	Avg
cnr4_T_C_Avg	deg_C	Avg
cnr4_T_K_Avg	K	Avg
long_up_corr_Avg	W/m^2	Avg
long_dn_corr_Avg	W/m^2	Avg
Rs_net_Avg	W/m^2	Avg
Rl_net_Avg	W/m^2	Avg
albedo_Avg	W/m^2	Avg
Rn_Avg	W/m^2	Avg
SQ_110_Avg	(E°mol m-2	Avg
shf_Avg(1)	W/m^2	Avg
shf_Avg(2)	W/m^2	Avg
shf_mV_Avg(1)		Avg
shf_mV_Avg(2)		Avg
shf_cal(1)	W/(m^2 mV	Smp
shf_cal(2)	W/(m^2 mV	Smp
board_temp_Avg	degC	Avg
board_humidity_Avg	percent	Avg
incline_pitch_Avg	deg	Avg
incline_roll_Avg	deg	Avg
slowsequence_3_Tot	samples	Tot

Table 1: A table with a variables.

Variable Name	Units	Description
TIMESTAMP	TS	
RECORD	RN	
Hs	W/m^2	sensible heat flux
tau	kg/(m s^2)	shear stress
u_star	m/s	friction velocity
Ts_stdev	C	instantaneous stdev of temperature
Ts_Ux_cov	C m/s	inst. cov(temp, Ux)
Ts_Uy_cov	C m/s	inst. cov(temp, Uy)
Ts_Uz_cov	C m/s	inst. cov(temp, Uv)
Ux_stdev	m/s	instantaneous stdev of Ux
Ux_Uy_cov	(m/s)^2	instantaneous cov of (Ux,Uy)
Ux_Uz_cov	(m/s)^2	instantaneous cov of (Ux,Uz)
Uy_stdev	m/s	instantaneous stdev of Uy
Uy_Uz_cov	(m/s)^2	instantaneous cov of (Uy,Uz)
Uz_stdev	m/s	instantaneous stdev of Uz
wnd_spd	m/s	wind speed (horizontal) - different from next?
rslt_wnd_spd	m/s	wind speed (horizontal)
wnd_dir_sonic	degrees	wind direction from CSAT3, deg from N?
std_wnd_dir	degrees	inst. stdev of wind direction
wnd_dir_compass	degrees	wind direction from compass (from N?)
Ux_Avg	m/s	average horiz windspeed x
Uy_Avg	m/s	average horiz windspeed y
Uz_Avg	m/s	average vertical windspeed z
Ts_Avg	C	air temperature at 25 m
sonic_azimuth	degrees	180 is direction is pointing - can change this value
sonic_samples_Tot	samples	10 Hz sampling rate (cycles per 15 mins = 9000)
Fc_li_wpl	mg/(m^2 s)	carbon flux upward (+ = upward) with Webb et al Term
LE_li_wpl	W/m^2	latent heat flux with Webb et al term
Hc_li	W/m^2	sensible heat flux
CO2_li_mean	mg/m^3	CO2 conc –> need to convert to ppm units
H2O_li_mean	g/m^3	water vapor conc at 25 m
amb_press_li_mean	kPa	air pressure at 25 m
Tc_li_mean	C	CSAT air temperature at 25 m
rho_a_li_mean	kg/m^3	density of air with water vapor
Fc_li_irga	mg/(m^2 s)	carbon flux without Webb et al. Term
LE_li_irga	W/m^2	latent heat flux without Webb et al. Term
irga_li_samples_Tot	samples	should be around 60 - quality indicator of LiCor
Precip_Tot	mm	rainfall
T_tmpr_rh_mean	C	air temperature at 25 m
e_tmpr_rh_mean	kPa	vapor pressure at 25 m
e_sat_tmpr_rh_mean	kPa	saturated vapor pressure at 25 m
H2O_tmpr_rh_mean	g/m^3	water vapor conc at 25 m
RH_tmpr_rh_mean	%	Relative Humidity at 25 m (e/e_sat)
rho_a_tmpr_rh_mean	kg/m^3	air density
slowsequence_1_Tot	samples	cycles per 15 mins - scanning every 10 secs
CS655_Wcr_Avg	$m^{3/m}3$	soil water content
CS655_Ec_Avg	dS/m	soil conductivity
CS655_Tmpr_Avg	Deg C	soil temperature
mean_wind_speed	m/s	wind speed at 10 m height...not average?
mean_wind_direction	Deg	wind direction
std_wind_dir	Deg	mean wind vector stdev of direction

Variable Name	Units	Description
NDVI_Avg		Normalized Difference Vegetation Index
NDVIUpRed_Avg	W/m^2 nm	NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation
NDVIUpNIR_Avg	W/m^2 nm	NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation
NDVIIndUp		NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation
NDVIDownRed_Avg	W/m^2 nm	NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation
NDVIDownNIR_Avg	W/m^2 nm	NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation
NDVIIndDown		NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation
PRI_Avg		Photochemical Reflectance Index
PRIUp531_Avg	W/m^2 nm	PRI calculated from updward and canopy facing sensors that measure 2 wavelengths of radiation
PRIUp570_Avg	W/m^2 nm	PRI calculated from updward and canopy facing sensors that measure 2 wavelengths of radiation
PRIIndUp		PRI calculated from updward and canopy facing sensors that measure 2 wavelengths of radiation
PRIDown531_Avg	W/m^2 nm	PRI calculated from updward and canopy facing sensors that measure 2 wavelengths of radiation
PRIDown570_Avg	W/m^2 nm	PRI calculated from updward and canopy facing sensors that measure 2 wavelengths of radiation
PRIIndDown		PRI calculated from updward and canopy facing sensors that measure 2 wavelengths of radiation
D5TE_VWC_5cm_Avg	$m^{3/m}3$	volumetric water content
D5TE_P_5cm_Avg		bulk dielectric permittivity
D5TE_EC_5cm_Avg	dS/m	soil electrical conductivity
D5TE_T_5cm_Avg	Deg C	soil temperature
D5TE_VWC_15cm_Avg	$m^{3/m}3$	volumetric water content
D5TE_P_15cm_Avg		bulk dielectric permittivity
D5TE_EC_15cm_Avg	dS/m	soil conductivity
D5TE_T_15cm_Avg	Deg C	soil temperature
D5TE_VWC_30cm_Avg	$m^{3/m}3$	volumetric water content
D5TE_P_30cm_Avg		bulk dielectric permittivity
D5TE_EC_30cm_Avg	dS/m	soil conductivity
D5TE_T_30cm_Avg	Deg C	soil temperature
D5TE_VWC_50cm_Avg	$m^{3/m}3$	volumetric water content
D5TE_P_50cm_Avg		bulk dielectric permittivity
D5TE_EC_50cm_Avg	dS/m	soil conductivity
D5TE_T_50cm_Avg	Deg C	soil temperature
D5TE_VWC_100cm_Avg	$m^{3/m}3$	volumetric water content
D5TE_P_100cm_Avg		bulk dielectric permittivity
D5TE_EC_100cm_Avg	dS/m	soil conductivity
D5TE_T_100cm_Avg	Deg C	soil temperature
D5TE_VWC_200cm_Avg	$m^{3/m}3$	volumetric water content
D5TE_P_200cm_Avg		bulk dielectric permittivity
D5TE_EC_200cm_Avg	dS/m	soil conductivity
D5TE_T_200cm_Avg	Deg C	soil temperature
slowsequence_2_Tot	samples	cyles - 1 minute loops (number times scanned)
SB121TempC_Avg	Deg C	SB = sensor body, temp of body of sensor
Targ121TempC_Avg	Deg C	surface temperature
Targ121mV_Avg	Deg C	
SB1H1TempC_Avg	Deg C	SB = sensor body, temp of body of sensor
Targ1H1TempC_Avg	Deg C	surface temperature
Targ1H1mV_Avg	Deg C	
short_up_Avg	W/m^2	Incoming shortwave radiation detected by the upward facing instrument
short_dn_Avg	W/m^2	Outgoing shortwave radiation detected by the downward facing instrument
long_up_Avg	W/m^2	incoming longwave radiation detected by upward facing instrument
long_dn_Avg	W/m^2	outgoing longwave radiation detected by downward facing instrument
cnr4_T_C_Avg	deg_C	temperature of sensor
cnr4_T_K_Avg	K	temperature of sensor in Kelvin
long_up_corr_Avg	W/m^2	Incoming longwave radiation detected by the upward facing instrument, corrected
long_dn_corr_Avg	W/m^2	Outgoing longwave radiation detected by the downward facing instrument , corrected
Rs_net_Avg	W/m^2	Shortwave net radiation (Rshort_up - Rshort_down)
Rl_net_Avg	W/m^2	Longwave net radiation (Rlong_up - Rlong_down)

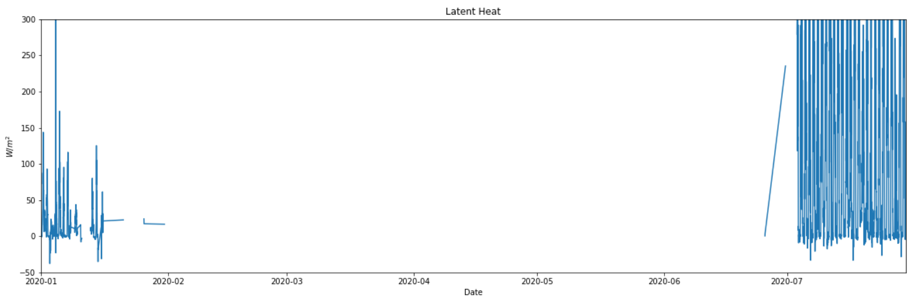
Variable Name	Units	Description
albedo_Avg	W/m^2	Albedo
Rn_Avg	W/m^2	Net radiation (Rs_net + Rl_net)
SQ_110_Avg	Œ°mol m-2s-1	PAR (photosynthetically active radiation)
shf_Avg(1)	W/m^2	Ground heat flux
shf_Avg(2)	W/m^2	Ground heat flux
slowsequence_3_Tot	samples	number of times scanned in 15 mins (once per min)

Proposal

Background

Evapotranspiration (ET) is the process of water transferring from land to the atmosphere, accompanying the phase change of water from liquid to gas. This process plays a critical role in the ecohydrological system and profoundly affects the hydrological cycle. The processes of evapotranspiration and energy exchange are interdependent. Both latent heat (LE) and evapotranspiration (ET), from the perspective of energy and water flux, are key terms for anticipating weather conditions, simulating climate, and diagnosing climate change. However, the measurement of evapotranspiration is challenging because the process itself is invisible and complex.

Figure 3 shows the latent heat data gap in 2020 due to covid-19 and overhaul of equipment. Our project goal is to fill in these missing data. The ground truth data is collected from satelite sensors (https://etdata.org/). Despite the existence of numerous classical evapotranspiration simulation models, such as Bowen Ratio, Priestley-Taylor and Penman-Monteith models, the predictive accuracy of these models is inferior to that of deep learning models. Therefore, we plan to use RNN and LSTM deep learning models to predict latent heat and fill the gap.



Step 1: Regression analysis

We have 167 variables in the dataset. Although we can filter some ET related variables based on empirical models, these variables may not accurate and AI models tend to obtain adequate information. Therefore, we propose to conduct regression analysis to find out variables highly correlated to latent heat. These variables will be input variables in deep learning model.

Step 2: Deep Learning Time Series Forecast (Time Series Imputation)

Once we confirm the input variables, we plan to use RNN or LSTM forecast models to predict latent heat in 2020. All the input are divided into training datasets and the validation datasets. After the RNN model is trained, the validation datasets are used to verify the model. At last, the missing data are generated by the model.

Source

This manuscript is a template (aka “rootstock”) for Manubot, a tool for writing scholarly manuscripts. Use this template as a starting point for your manuscript.

The rest of this document is a full list of formatting elements/features supported by Manubot. Compare the input (`.md` files in the `/content` directory) to the output you see below.

Basic formatting

Bold text

Semi-bold text

Centered text

Right-aligned text

Italic text

Combined *italics and **bold***

~~Strikethrough~~

1. Ordered list item
2. Ordered list item
    a. Sub-item
    b. Sub-item
        i. Sub-sub-item
3. Ordered list item
    a. Sub-item

- List item
- List item
- List item

subscript: H_2O is a liquid

superscript: 2^{10} is 1024.

unicode superscripts^{0123456789}

unicode subscripts$_{0123456789}$

A long paragraph of text. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Putting each sentence on its own line has numerous benefits with regard to editing and version control.

Line break without starting a new paragraph by putting
two spaces at end of line.

Document organization

Document section headings:

Heading 1

Heading 2

Heading 3

Heading 4

Heading 5

Heading 6

A heading centered on its own printed page

Horizontal rule:

`Heading 1`'s are recommended to be reserved for the title of the manuscript.

`Heading 2`'s are recommended for broad sections such as *Abstract*, *Methods*, *Conclusion*, etc.

`Heading 3`'s and `Heading 4`'s are recommended for sub-sections.

Links

Bare URL link: https://manubot.org

Long link with lots of words and stuff and junk and bleep and blah and stuff and other stuff and more stuff yeah

Link with text

Link with hover text

Link by reference

Citations

Citation by DOI [1].

Citation by PubMed Central ID [2].

Citation by PubMed ID [3].

Citation by Wikidata ID [4].

Citation by ISBN [5].

Citation by URL [6].

Citation by alias [7].

Multiple citations can be put inside the same set of brackets [1,5,7]. Manubot plugins provide easier, more convenient visualization of and navigation between citations [2,3,7,8].

Citation tags (i.e. aliases) can be defined in their own paragraphs using Markdown's reference link syntax:

Referencing figures, tables, equations

Figure 1

Figure 2

Figure 3

Figure 4

Table 2

Equation 1

Equation 2

Quotes and code

> Quoted text

> Quoted block of text
>
> Two roads diverged in a wood, and I—
> I took the one less traveled by,
> And that has made all the difference.

Code `in the middle` of normal text, aka `inline code`.

Code block with Python syntax highlighting:

```python
from manubot.cite.doi import expand_short_doi

def test_expand_short_doi():
    doi = expand_short_doi("10/c3bp")
    # a string too long to fit within page:
    assert doi == "10.25313/2524-2695-2018-3-vliyanie-enhansera-copia-i-insulyatora-gypsy-na-sintez-ernk-
        modifikatsii-hromatina-i-svyazyvanie-insulyatornyh-belkov-vtransfetsirovannyh-geneticheskih-konstruktsiyah"
```

Code block with no syntax highlighting:

```
Exporting HTML manuscript
Exporting DOCX manuscript
Exporting PDF manuscript
```

Figures

Figure 1: A square image at actual size and with a bottom caption. Loaded from the latest version of image on GitHub.

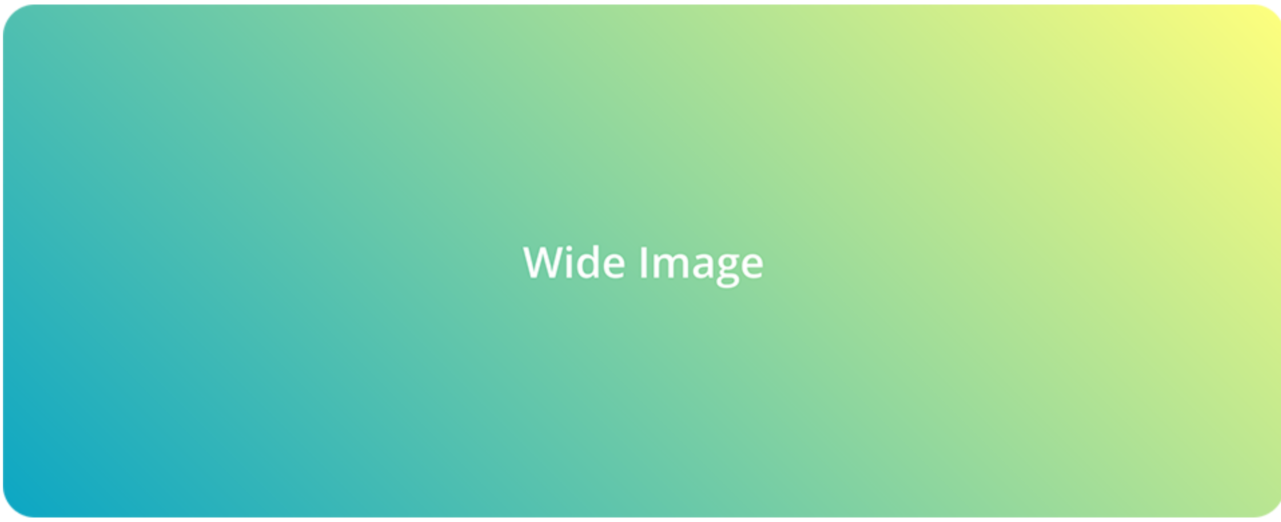


Figure 2: An image too wide to fit within page at full size. Loaded from a specific (hashed) version of the image on GitHub.

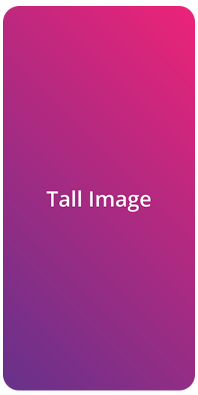


Figure 3: A tall image with a specified height. Loaded from a specific (hashed) version of the image on GitHub.

Figure 4: A vector `.svg` image loaded from GitHub. The parameter `sanitize=true` is necessary to properly load SVGs hosted via GitHub URLs. White background specified to serve as a backdrop for transparent sections of the image. Note that if you want to export to Word (`.docx`), you need to download the image and reference it locally (e.g. `content/images/vector.svg`) instead of using a URL.

Tables

Table 2: A table with a top caption and specified relative column widths.

Bowling Scores	**Jane**	**John**	**Alice**	**Bob**
Game 1	150	187	210	105
Game 2	98	202	197	102
Game 3	123	180	238	134

Table 3: A table too wide to fit within page.

	Digits 1-33	**Digits 34-66**	**Digits 67-99**	**Ref.**
pi	3.14159265358979323846264338327950	288419716939937510582097494459230	781640628620899862803482534211706	[`piday.org`]
e	2.71828182845904523536028747135266	249775724709369995957496696762772	407663035354759457138217852516642	[`nasa.gov`]

Table 4: A table with merged cells using the `attributes` plugin.

	Colors	
Size	**Text Color**	**Background Color**
big	blue	orange
small	black	white

Equations

A LaTeX equation:

$$\int_0^\infty e^{-x^2} dx = \frac{\sqrt{\pi}}{2} \tag{1}$$

An equation too long to fit within page:

$$\begin{aligned} x = a + b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s + t \\ + u + v + w + x + y + z + 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 \end{aligned} \tag{2}$$

Special

⚠ WARNING *The following features are only supported and intended for `.html` and `.pdf` exports. Journals are not likely to support them, and they may not display correctly when converted to other formats such as `.docx`.*

LINK STYLED AS A BUTTON

Adding arbitrary HTML attributes to an element using Pandoc's attribute syntax:

> Manubot Manubot Manubot Manubot Manubot. Manubot Manubot Manubot Manubot. Manubot Manubot Manubot. Manubot Manubot. Manubot.

Adding arbitrary HTML attributes to an element with the Manubot `attributes` plugin (more flexible than Pandoc's method in terms of which elements you can add attributes to):

> Manubot Manubot Manubot Manubot Manubot. Manubot Manubot Manubot Manubot. Manubot Manubot Manubot. Manubot Manubot. Manubot.

Available background colors for text, images, code, banners, etc:

`white` `lightgrey` `grey` `darkgrey` `black` `lightred` `lightyellow` `lightgreen` `lightblue` `lightpurple` `red` `orange` `yellow` `green` `blue` `purple`

Using the [Font Awesome](https://fontawesome.com/) icon set:

Light Grey Banner
useful for *general information* - manubot.org

Blue Banner
useful for *important information* - manubot.org

Light Red Banner
useful for *warnings* - manubot.org

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DOI: 10.1371/journal.pcbi.1007128 · PMID: 31233491 · PMCID: PMC6611653