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

This manuscript (permalink) was automatically generated from uiceds/project-team-wres@5ff428e on September 25, 2024.

Authors

- **Jiaze Cao** ✉
  · JiazeCLeo
  Department of Civil and Environmental Engineering, University of Illinois Urbana-Champaign; WRES

- **Yuyao Huang**
  · Yuyao-Huang
  Department of Civil and Environmental Engineering, University of Illinois Urbana-Champaign; EWES

- **Yue Wan**
  · clarawan
  Department of Civil and Environmental Engineering, University of Illinois Urbana-Champaign; EWES · Funded by Grant XXXXXXXX

- **Hsing-Yu Huang** ✉
  · Hsing-Yu
  Department of Civil and Environmental Engineering, University of Illinois Urbana-Champaign; WRES

✉ — Correspondence possible via GitHub Issues or email to Jiaze Cao <jiazec2@illinois.edu>, Hsing-Yu Huang <jane.roe@whatever.edu>.

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	stat covariance: (ux)		
Ts_Uy_cov	C m/s	Smp	CSAT3 Sonic Anemometer	stat covariance: (uy)		
Ts_Uz_cov	C m/s	Smp	CSAT3 Sonic Anemometer	stat covariance: (uz)		
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 stdev of 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)		
wnd_spd	m/s	Smp	CSAT3 Sonic Anemometer	wind speed (horizontal) - different from 2m?		
std_wnd_dir	degrees	Smp	CSAT3 Sonic Anemometer	wind direction from CSAT3, dev from NP		
wnd_dir_compass	degrees	Smp	CSAT3 Sonic Anemometer	wind direction from compass (from NP)	yes	
Ua_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average horiz windspeed u		
Va_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average horiz windspeed v		
Wa_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average vertical windspeed w		
Ta_Avg	C	Avg	CSAT3 Sonic Anemometer	air temperature at 2% m		
sonic_azimuth	degrees	Smp	CSAT3 Sonic Anemometer	180 is direction is nowhere - can change this value		
sonic_samples_Tot	samples	Smp	CSAT3 Sonic Anemometer	10 Hz samples rate bodes per 15 mins = 9000		
diag_sonic_aggregate	arb	Smp	CSAT3 Sonic Anemometer			
no_new_sonic_data_Tot	samples	Tot	CSAT3 Sonic Anemometer			
sonic_amp_1_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_amp_2_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_amp_3_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_del_T_1_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_del_T_2_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_del_T_3_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_aq_sig_1_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_aq_sig_2_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_aq_sig_3_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_low_volt_1_Tot	arb		CSAT3 Sonic Anemometer			
sonic_low_volt_2_Tot	arb		CSAT3 Sonic Anemometer			
sonic_low_volt_3_Tot	arb		CSAT3 Sonic Anemometer			
sonic_int_temp_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 onward (+ = onward) 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^2 s)	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			
Ts_li_stdev	C	Smp	LI7500			
Ts_li_Ux_cov	C m/s	Smp	LI7500			
Ts_li_Uy_cov	C m/s	Smp	LI7500			
Ts_li_Uz_cov	C m/s	Smp	LI7500			
CO2_li_mean	mg/m^3	Smp	LI7500	CO2 conc --> used to convert to mole units	yes	
H2O_li_mean	g/m^3	Smp	LI7500	water vapor conc at 2% m	yes	
amb_press_li_mean	kPa	Smp	LI7500	air pressure at 2% m	yes	
						corrected temp based on CSAT, not as used as 3969
Ts_li_mean	C	Smp	LI7500	CSAT air temperature at 2% m		
rho_a_li_mean	kg/m^3	Smp	LI7500	density of air with water vapor	yes	
Fc_li_sig	mg/(m^2 s)	Smp	LI7500	carbon flux without Webb et al Term		
LE_li_sig	W/m^2	Smp	LI7500	latent heat flux without Webb et al Term		
CO2_li_sat_f_t_li	mg/(m^2 s)	Smp	LI7500			
H2O_li_sat_f_t_li	mg/(m^2 s)	Smp	LI7500			
H2O_li_sat_f_t	W/m^2	Smp	LI7500			
agc_li_samples_Tot	samples	Tot	LI7500	should be around 60 - quality indicator of LI-Cor		
diag_irga_li_aggregate	arb	Tot	LI7500			
no_new_data_li_Tot	samples	Tot	LI7500			
agc_li_Avg	%	Avg	LI7500			
agc_li%dt_oscillat_Tot	samples	Tot	LI7500			
process_time_Avg	us	Max	LI7500			
process_time_Max	us	Max	LI7500			
Precip_Tot	mm	Tot	TE525-L rain gauge	rainfall	yes	
T_tmpr_m_mean	C	Smp	865E Temp and RH	air temperature at 2% m	yes	
e_tmpr_m_mean	kPa	Smp	865E Temp and RH	vapor pressure at 2% m	yes	
e_sat_tmpr_m_mean	kPa	Smp	865E Temp and RH	saturated vapor pressure at 2% m	yes	
RH_tmpr_m_mean	%	Smp	865E Temp and RH	Relative Humidity at 2% m (min sat)	yes	
Rh_tmpr_m_mean	%	Smp	865E Temp and RH	Relative Humidity at 2% m (min sat)	yes	
rho_a_tmpr_m_mean	kg/m^3	Smp	865E Temp and RH	air density	yes	
downsyncsrc_1_Tot	samples	Min	multiplx instruments	radios over 1% mark, - scanrates every 10 secs		
Batt_Volt_Min	V	Min	multiplx instruments			
Batt_Volt_Avg	V	Avg	multiplx instruments			
Box_Rh_Avg		Avg	multiplx instruments			
Panel Tmpr Avg	C	Avg	multiplx 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_Ts_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 sonicos?		
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_6_TOT	samples					
diag_9_TOT	samples					
diag_10_TOT	samples					
dist_Tot	samples					
NDVI_Avg		Avg	SRS NDVI (both instruments)	Normalized Difference Vegetative Index	yes	
NDVIUpNIR_Avg	W/m^2 nm	Avg	SRS NDVI (h: hemispherical) Ni			
NDVIUpVIS_Avg	W/m^2 nm	Avg	SRS NDVI (h: hemispherical) Ni	NDVI is calculated from upward and canopy facing sensors		
NDVIUpNIR_Avg		Avg	SRS NDVI (a:fieldstop) Ni	that measure IR and NIR radiation		
NDVIDownNIR_Avg	W/m^2 nm	Avg	SRS NDVI (a:fieldstop) Ni			
NDVIVisDown		Avg	SRS NDVI (a:fieldstop) Ni			
PRI_Avg		Avg	SRS PRI (both instruments)	Photochemical Reflectance Index	yes	
PRIUpNIR_Avg	W/m^2 nm	Avg	SRS PRI (h: hemispherical) Pi			
PRIUpVIS_Avg	W/m^2 nm	Avg	SRS PRI (h: hemispherical) Pi	PRI calculated from upward and canopy facing sensors that		
PRIBeUp		Sinc	SRS PRI (b: hemispherical) Pi	measure 2 wavelengths of radiation		
PRIDownNIR_Avg	W/m^2 nm	Avg	SRS PRI (a:fieldstop) Pi			
PRIDownVIS_Avg	W/m^2 nm	Avg	SRS PRI (a:fieldstop) Pi			
PRIBeDown		Avg	SRS PRI (b: hemispherical) Pi			
DSTE_VWC_5cm_Avg	m^3/m^3	Avg	STE Soil Probe 5cm	volumetric water content	yes	
DSTE_P_5cm_Avg		Avg	STE Soil Probe 5cm	bulk dielectric permittivity		
DSTE_EC_5cm_Avg	dS/m	Avg	STE Soil Probe 5cm	soil electrical conductivity	yes	
DSTE_T_5cm_Avg	Deg C	Avg	STE Soil Probe 5cm	soil temperature	yes	
DSTE_VWC_15cm_Avg	m^3/m^3	Avg	STE Soil Probe 15cm	volumetric water content	yes	
DSTE_P_15cm_Avg		Avg	STE Soil Probe 15cm	bulk dielectric permittivity		
DSTE_EC_15cm_Avg	dS/m	Avg	STE Soil Probe 15cm	soil conductivity	yes	
DSTE_T_15cm_Avg	Deg C	Avg	STE Soil Probe 15cm	soil temperature	yes	
DSTE_VWC_30cm_Avg	m^3/m^3	Avg	STE Soil Probe 30 cm	volumetric water content	yes	
DSTE_P_30cm_Avg		Avg	STE Soil Probe 30 cm	bulk dielectric permittivity		
DSTE_EC_30cm_Avg	dS/m	Avg	STE Soil Probe 30 cm	soil conductivity	yes	
DSTE_T_30cm_Avg	Deg C	Avg	STE Soil Probe 30 cm	soil temperature	yes	
DSTE_VWC_50cm_Avg	m^3/m^3	Avg	STE Soil Probe 50 cm	volumetric water content	yes	
DSTE_P_50cm_Avg		Avg	STE Soil Probe 50 cm	bulk dielectric permittivity		
DSTE_EC_50cm_Avg	dS/m	Avg	STE Soil Probe 50 cm	soil conductivity	yes	
DSTE_T_50cm_Avg	Deg C	Avg	STE Soil Probe 50 cm	soil temperature	yes	
DSTE_VWC_100cm_Avg	m^3/m^3	Avg	STE Soil Probe 100cm	volumetric water content	yes	
DSTE_P_100cm_Avg		Avg	STE Soil Probe 100cm	bulk dielectric permittivity		
DSTE_EC_100cm_Avg	dS/m	Avg	STE Soil Probe 100cm	soil conductivity	yes	
DSTE_T_100cm_Avg	Deg C	Avg	STE Soil Probe 100cm	soil temperature	yes	
DSTE_VWC_200cm_Avg	m^3/m^3	Avg	STE Soil Probe 200cm	volumetric water content	yes	
DSTE_P_200cm_Avg		Avg	STE Soil Probe 200cm	bulk dielectric permittivity		
DSTE_EC_200cm_Avg	dS/m	Avg	STE Soil Probe 200cm	soil conductivity	yes	
DSTE_T_200cm_Avg	Deg C	Avg	STE Soil Probe 200cm	soil temperature	yes	
SBTIRTemp_C_Tot	samples	Tot	SI-111 Infrared Radiometer	SBR --> temp in body (number times scanned)		
SBTIRTemp_C_Avg		Avg	SI-111 Infrared Radiometer	surface body temp of body of canopy		
Targ1IRTemp_Avg		Avg	SI-121 Infrared Radiometer	surface temperature	yes	
Targ1IRTemp_Avg		Avg	SI-121 Infrared Radiometer			
SBTIRTemp_C_Avg		Avg	Apogee SI-1H1 Infrared Radiometer	SB --> temp body temp of body of canopy		
Targ2IRTemp_Avg		Avg	Apogee SI-1H1 Infrared Radiometer	surface temperature	yes	
Targ2IRTemp_C_Avg		Avg	Apogee SI-1H1 Infrared Radiometer			
Targ2IRTemp_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		
surf_T_Avg	K	Avg	CNR4 Pyranometer (Kipp&Zonen)	temperature of sensor		
cnrt_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 radiance (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	
PAR_Den_Avg	umol/s/m^2	Avg	SQ-110 PAR (photosynthetically active radiation)	number of photons in the wavelength range	yes	
shf_Avg(1)	W/m^2	Avg	HPFO1SC-L50 (2 heat flux plates)	Ground heat flux	yes	
shf_Avg(2)	W/m^2	Avg	HPFO1SC-L50 (2 heat flux plates)	Ground heat flux	yes	
shf_mV_Avg(1)		Avg	HPFO1SC-L50 (2 heat flux plates)			
shf_mV_Avg(2)		Avg	HPFO1SC-L50 (2 heat flux plates)			
shf_Cal(1)	W/(m^2 mV)	Smp	HPFO1SC-L50 (2 heat flux plates)			
shf_Cal(2)	W/(m^2 mV)	Smp	HPFO1SC-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				
downsyncsrc_3_Tot	samples	Tot		number of times scanned in 15 mins (room rev min)		

most instruments installed in 2016

List of Instruments

Instrument	Location on Tower	notes
LI7500	2% m	
CSAT3 Sonic Anemometer	2% m	
083E Temp and RH	2% m	
CS2 Sonic Anemometer	1.0 m	
SRS NDVI (a fieldstop): Nr	2% m	moved to 2% m height in summer 2020 to see canonv instead of roass
SRS NDVI (b: hemisphericall): Ni	2% m	moved to 2% m height in summer 2020 to see canonv instead of roass
SRS PRI (a fieldstop): Pr	2% m	moved to 2% m height in summer 2020 to see canonv instead of roass
SRS PRI (b: hemisphericall): Pi	2% m	moved to 2% m height in summer 2020 to see canonv instead of roass
TE525-L rain gauge	1.5 m	
Apogee SI-1H1 Infrared Radiometer	2% m	nentino canonv temperature: moved to 2% m height in summer 2020
CNR4 Pyranometer (Kipp&Zonen)	10 m	
SI-121 Infrared Radiometer	2 m	reointed at ornund heat flux 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 rlenth	
5TE Soil Probe 15cm	15 cm rlenth	
5TE Soil Probe 30 cm	30 cm rlenth	
5TE Soil Probe 50 cm	50 cm rlenth	
5TE Soil Probe 100cm	100 cm rlenth	
5TE Soil Probe 200cm	200 cm rlenth	
CS655-L50 Reflectometer	shallow rlenth	
HFP01SC-L50 (2 heat flux plates)	8 cm rlenth	

+new anemometer???? at 10 m height - a ramrobell anemometer
main course 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	stat covariance: (ux)		
Ts_Uy_cov	C m/s	Smp	CSAT3 Sonic Anemometer	stat covariance: (uy)		
Ts_Uz_cov	C m/s	Smp	CSAT3 Sonic Anemometer	stat covariance: (uz)		
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 met?		
std_wnd_spd	m/s	Smp	CSAT3 Sonic Anemometer	wind speed (horizontal)	yes	
wnd_dir_sonic	degrees	Smp	CSAT3 Sonic Anemometer	wind direction from CSAT3, dev from NP		
std_wnd_dir	degrees	Smp	CSAT3 Sonic Anemometer	met stdev of wind direction		
wnd_dir_compass	degrees	Smp	CSAT3 Sonic Anemometer	wind direction from compass (from NP)	yes	
Ua_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average horiz windspeed u		
Va_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average horiz windspeed v		
Wa_Avg	m/s	Avg	CSAT3 Sonic Anemometer	average vertical windspeed w		
Ta_Avg	C	Avg	CSAT3 Sonic Anemometer	air temperature at 2% m		
sonic_azimuth	degrees	Smp	CSAT3 Sonic Anemometer	180 is direction is nowhere - can change this value		
sonic_samples_Tot	samples	Smp	CSAT3 Sonic Anemometer	10 Hz samples rate bodes per 15 mins = 9000		
diag_sonic_aggregate	arb	Smp	CSAT3 Sonic Anemometer			
no_new_sonic_data_Tot	samples	Tot	CSAT3 Sonic Anemometer			
sonic_amp_1_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_amp_2_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_amp_3_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_aq_sig_1_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_aq_sig_2_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_aq_sig_3_Tot	arb	Tot	CSAT3 Sonic Anemometer			
sonic_low_volt_1_Tot	arb		CSAT3 Sonic Anemometer			
sonic_low_volt_2_Tot	arb		CSAT3 Sonic Anemometer			
sonic_low_volt_3_Tot	arb		CSAT3 Sonic Anemometer			
sonic_int_temp_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 onward (+ = onward) 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			

most instruments installed in 2016

List of Instruments

Instrument	Location on Tower	notes
LI7500	2% m	
CSAT3 Sonic Anemometer	2% m	
083E Temp and RH	2% m	
CS2 Sonic Anemometer	1.0 m	
SRS NDVI (a fieldstop): Nr	2% m	moved to 2% m height in summer 2020 to see canonv instead of roass
SRS NDVI (b: hemisphericall): Ni	2% m	moved to 2% m height in summer 2020 to see canonv instead of roass
SRS PRI (a fieldstop): Pr	2% m	moved to 2% m height in summer 2020 to see canonv instead of roass
SRS PRI (b: hemisphericall): Pi	2% m	moved to 2% m height in summer 2020 to see canonv instead of roass
TE525-L rain gauge	1.5 m	
Apogee SI-1H1 Infrared Radiometer	2% m	nentino canonv temperature: moved to 2% m height in summer 2020
CNR4 Pyranometer (Kipp&Zonen)	10 m	
SI-121 Infrared Radiometer	2 m	reointed at ornund heat flux 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 rlenth	
5TE Soil Probe 15cm	15 cm rlenth	
5TE Soil Probe 30 cm	30 cm rlenth	
5TE Soil Probe 50 cm	50 cm rlenth	
5TE Soil Probe 100cm	100 cm rlenth	
5TE Soil Probe 200cm	200 cm rlenth	
CS655-L50 Reflectometer	shallow rlenth	
HFP01SC-L50 (2 heat flux plates)	8 cm rlenth	

+new anemometer???? at 10 m height - a ramrobell anemometer
main course is at a new height

Apogee SQ

H2O_li_cal_Avg	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 mmm units	yes
H2O_li_mean	g/m^3	Smp	LI7500	water vapor conc at 75 m	yes
amb_press_li_mean	kPa	Smp	LI7500	air pressure at 75 m	yes
		Smp			
Tc_li_mean	C	Smp	LI7500	CSAT air temperature at 75 m	
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_threhld_exceed_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 75 m	yes
e_tmpr_rh_mean	kPa	Smp	083E Temp and RH	vapor pressure at 75 m	yes
e_sat_tmpr_rh_mean	kPa	Smp	083E Temp and RH	saturated vapor pressure at 75 m	yes
H2O_tmpr_rh_mean	g/m^3	Smp	083E Temp and RH	water vapor conc at 75 m	yes
RH_tmpr_rh_mean	%	Smp	083E Temp and RH	Relative Humidity at 75 m (w/r to?)	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 - scannios 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 minchumahs	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_3_TOT	samples				
diag_8_TOT	samples				
diag_9_TOT	samples				
diag_10_TOT	samples				
NDVI_Avg	samples	Avg	SRS NDVI (both instruments)	Normalized Difference Vegetation Index	yes
NDVIUpRad_Avg	W/m^2 nm	Avg	SRS NDVI (b: hemispherical): Ni		
NDVIUpNIR_Avg	W/m^2 nm	Avg	SRS NDVI (b: hemispherical): Ni		
NDVIRx3.0		Smp	SRS NDVI (b: hemispherical): Ni	NDVI is calculated from upward and canopy facing sensors that measure IR and NIR radiation	
NDVIDownRad_Avg	W/m^2 nm	Avg	SRS NDVI (a:fieldstop): Nr		
NDVIDownNIR_Avg	W/m^2 nm	Avg	SRS NDVI (a:fieldstop): Nr		
NDVIRx3Down		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): Pr		
PRIUp570_Avg	W/m^2 nm	Avg	SRS PRI (b: hemispherical): Pr		
PRIrdx570		Smp	SRS PRI (b: hemispherical): Pr	PRI calculated from upward 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		
PRIrdx5Down		Avg	SRS PRI (a:fieldstop): Pr		
DSTE_VWC_5cm_Avg	m^3/m^3	Avg	STE Soil Probe 5cm	volumetric water content	yes
DSTE_P_5cm_Avg		Avg	STE Soil Probe 5cm	bulk dielectric permittivity	
DSTE_EC_5cm_Avg	dS/m	Avg	STE Soil Probe 5cm	soil electrical conductivity	yes
DSTE_T_5cm_Avg	Deg C	Avg	STE Soil Probe 5cm	soil temperature	yes
DSTE_VWC_15cm_Avg	m^3/m^3	Avg	STE Soil Probe 15cm	volumetric water content	yes
DSTE_P_15cm_Avg		Avg	STE Soil Probe 15cm	bulk dielectric permittivity	
DSTE_EC_15cm_Avg	dS/m	Avg	STE Soil Probe 15cm	soil minchumahs	yes
DSTE_T_15cm_Avg	Deg C	Avg	STE Soil Probe 15cm	soil temperature	yes
DSTE_VWC_30cm_Avg	m^3/m^3	Avg	STE Soil Probe 30 cm	volumetric water content	yes
DSTE_P_30cm_Avg		Avg	STE Soil Probe 30 cm	bulk dielectric permittivity	
DSTE_EC_30cm_Avg	dS/m	Avg	STE Soil Probe 30 cm	soil minchumahs	yes
DSTE_T_30cm_Avg	Deg C	Avg	STE Soil Probe 30 cm	soil temperature	yes
DSTE_VWC_50cm_Avg	m^3/m^3	Avg	STE Soil Probe 50 cm	volumetric water content	yes
DSTE_P_50cm_Avg		Avg	STE Soil Probe 50 cm	bulk dielectric permittivity	
DSTE_EC_50cm_Avg	dS/m	Avg	STE Soil Probe 50 cm	soil minchumahs	yes
DSTE_T_50cm_Avg	Deg C	Avg	STE Soil Probe 50 cm	soil temperature	yes
DSTE_VWC_100cm_Avg	m^3/m^3	Avg	STE Soil Probe 100cm	volumetric water content	yes
DSTE_P_100cm_Avg		Avg	STE Soil Probe 100cm	bulk dielectric permittivity	
DSTE_EC_100cm_Avg	dS/m	Avg	STE Soil Probe 100cm	soil minchumahs	yes
DSTE_T_100cm_Avg	Deg C	Avg	STE Soil Probe 100cm	soil temperature	yes
DSTE_VWC_200cm_Avg	m^3/m^3	Avg	STE Soil Probe 200cm	volumetric water content	yes
DSTE_P_200cm_Avg		Avg	STE Soil Probe 200cm	bulk dielectric permittivity	
DSTE_EC_200cm_Avg	dS/m	Avg	STE Soil Probe 200cm	soil minchumahs	yes
DSTE_T_200cm_Avg	Deg C	Avg	STE Soil Probe 200cm	soil temperature	yes
slowsequence_2_Tot	samples	Tot	multiple instruments	rules - 1 minute (runs fourther times scannerl)	
SB121TempC_Avg		Avg	SI-121 Infrared Radiometer	TR = 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	TR = 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		
		Avg		Incoming shortwave radiation detected by the upward facing instrument	
short_up_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	factory instrument	yes
		Avg		Outgoing shortwave radiation detected by the downward facing instrument	
short_dn_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	factory instrument	yes
		Avg		incoming longwave radiation detected by upward facing instrument	
long_up_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)		
		Avg		outgoing longwave radiation detected by downward facing instrument	
long_dn_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	temperature of sensor	
cnr4_T_C_Avg	deg_C	Avg	CNR4 Pyranometer (Kipp&Zonen)	temperature of sensor in Kelvin	
cnr4_T_K_Avg	K	Avg	CNR4 Pyranometer (Kipp&Zonen)	Incoming longwave radiation detected by the upward facing instrument (corrected)	
		Avg		Outgoing longwave radiation detected by the downward	
long_up_cor_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	factory instrument - corrected	yes
		Avg		Shortwave net radiation (Rshort up - Rshort down)	
long_dn_cor_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Shortwave net radiation (Rlong up - Rlong down)	yes
Rs_net_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Longwave net radiation (Rlong up - Rlong down)	yes
Rl_net_Avg	W/m^2	Avg	CNR4 Pyranometer (Kipp&Zonen)	Albedo	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
PQ_110_Avg	(?mol) m-2	Avg	LI-190SB Quantum Sensor	PAR (photosynthetically active radiation)	yes
shf_Avg(1)	W/m^2	Avg	HPD15C-L50 (2 heat flux plates)	Ground heat flux	yes
shf_Avg(2)	W/m^2	Avg	HPD15C-L50 (2 heat flux plates)	Ground heat flux	yes
shf_mV_Avg(1)		Avg	HPD15C-L50 (2 heat flux plates)		
shf_mV_Avg(2)		Avg	HPD15C-L50 (2 heat flux plates)		
shf_cal(1)	W/m^2 mV	Smp	HPD15C-L50 (2 heat flux plates)		
shf_cal(2)	W/m^2 mV	Smp	HPD15C-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)	

corrected temp based on CSAT, not as need as ORIF

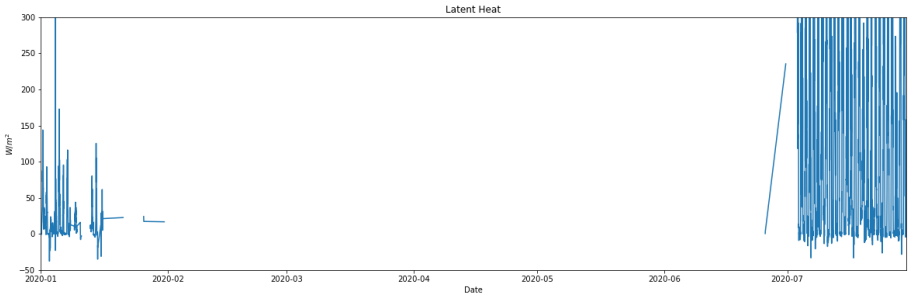
Proposal

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 1

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:

```
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

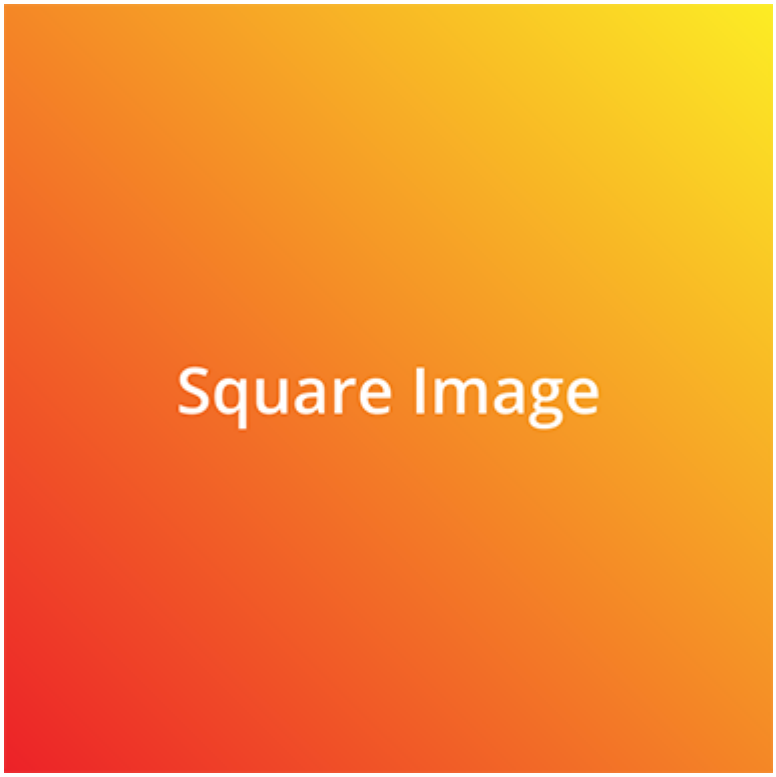


Figure 1: A square image at actual size and with a bottom caption. Loaded from the latest version of image on GitHub.

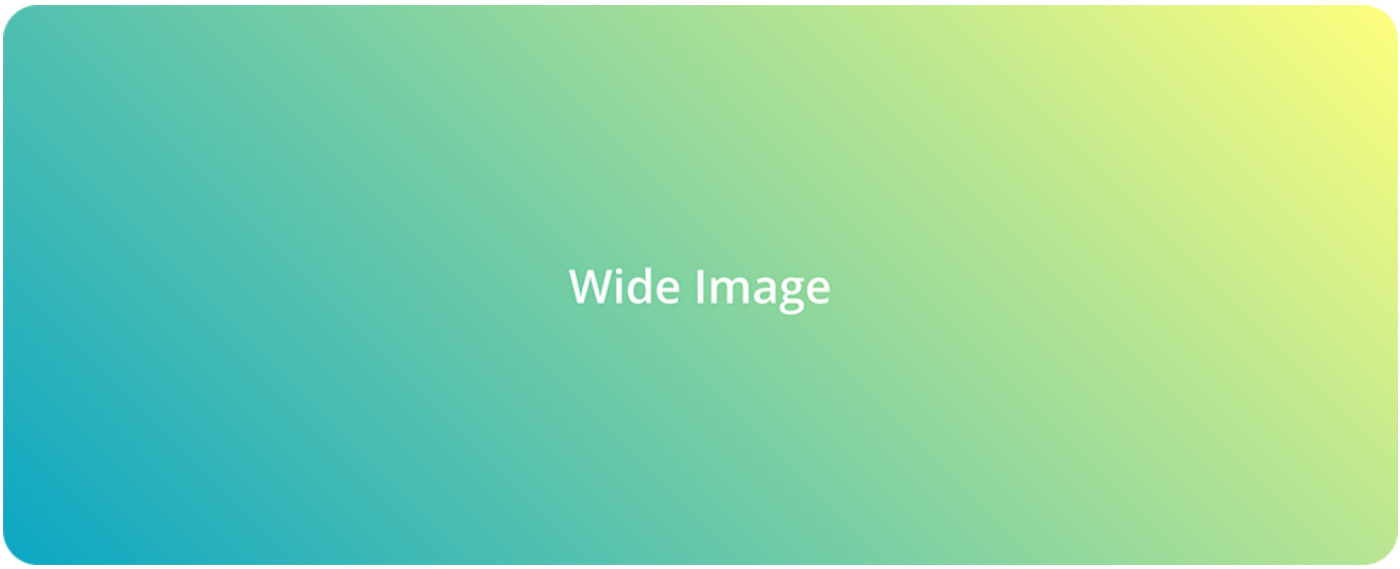


Figure 2: An image too wide to fit within page at full size. Loaded from a specific (hashed) version of the image on GitHub.

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 1: 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 2: A table too wide to fit within page.

	Digits 1-33	**Digits 34-66**	**Digits 67-99**	**Ref.**
pi	3.14159265358979323 846264338327950	28841971693993751 0582097494459230	78164062862089986 2803482534211706	`piday.org`
e	2.71828182845904523 536028747135266	24977572470936999 5957496696762772	40766303535475945 7138217852516642	`nasa.gov`

Table 3: 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:

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

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 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

References

1. **Sci-Hub provides access to nearly all scholarly literature**
Daniel S Himmelstein, Ariel Rodriguez Romero, Jacob G Levernier, Thomas Anthony Munro, Stephen Reid McLaughlin, Bastian Greshake Tzovaras, Casey S Greene
eLife (2018-03-01) https://doi.org/ckcj
DOI: 10.7554/elife.32822 · PMID: 29424689 · PMCID: PMC5832410

2. **Reproducibility of computational workflows is automated using continuous analysis**
Brett K Beaulieu-Jones, Casey S Greene
Nature biotechnology (2017-04) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6103790/
DOI: 10.1038/nbt.3780 · PMID: 28288103 · PMCID: PMC6103790

3. **Bitcoin for the biological literature.**
Douglas Heaven
Nature (2019-02) https://www.ncbi.nlm.nih.gov/pubmed/30718888
DOI: 10.1038/d41586-019-00447-9 · PMID: 30718888

4. **Plan S: Accelerating the transition to full and immediate Open Access to scientific publications**
cOAlition S
(2018-09-04) https://www.wikidata.org/wiki/Q56458321

5. **Open access**
Peter Suber
MIT Press (2012)
ISBN: 9780262517638

6. **Open collaborative writing with Manubot**
Daniel S Himmelstein, Vincent Rubinetti, David R Slochower, Dongbo Hu, Venkat S Malladi, Casey S Greene, Anthony Gitter
Manubot (2020-05-25) https://greenelab.github.io/meta-review/

7. **Opportunities and obstacles for deep learning in biology and medicine**
Travers Ching, Daniel S Himmelstein, Brett K Beaulieu-Jones, Alexandr A Kalinin, Brian T Do, Gregory P Way, Enrico Ferrero, Paul-Michael Agapow, Michael Zietz, Michael M Hoffman, … Casey S Greene
Journal of The Royal Society Interface (2018-04) https://doi.org/gddkhn
DOI: 10.1098/rsif.2017.0387 · PMID: 29618526 · PMCID: PMC5938574

8. **Open collaborative writing with Manubot**
Daniel S Himmelstein, Vincent Rubinetti, David R Slochower, Dongbo Hu, Venkat S Malladi, Casey S Greene, Anthony Gitter
PLOS Computational Biology (2019-06-24) https://doi.org/c7np
DOI: 10.1371/journal.pcbi.1007128 · PMID: 31233491 · PMCID: PMC6611653