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

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Dataset Description

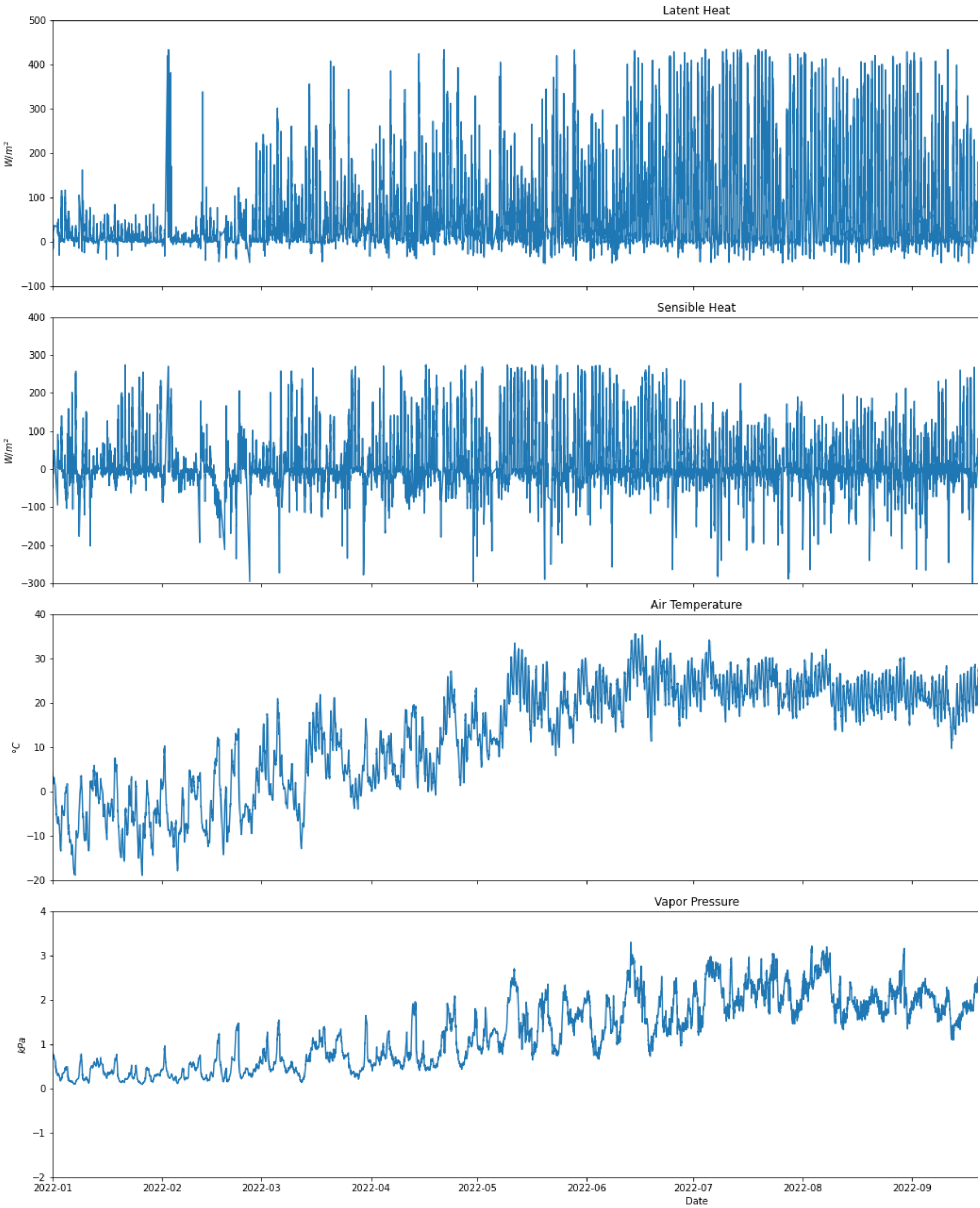
We propose to use Goose Creek Eddy Covariance Flux Tower Sensor Data[**kumar2024?**]. The data is collected from the Eddy Covariance Flux Tower in Goose Creek, Piatt County. The dataset consists of time series data spanning from Spring 2016 to Spring 2023 with 15 minutes time interval. Dataset involves 167 variables shown in Fig 1 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, 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_P_200cm_Avg		Avg
D5TE_EC_200cm_Avg	dS/m	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	(F°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



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: PCA 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 PCA analysis to find out variables related 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.

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.

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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.

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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

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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:

```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.

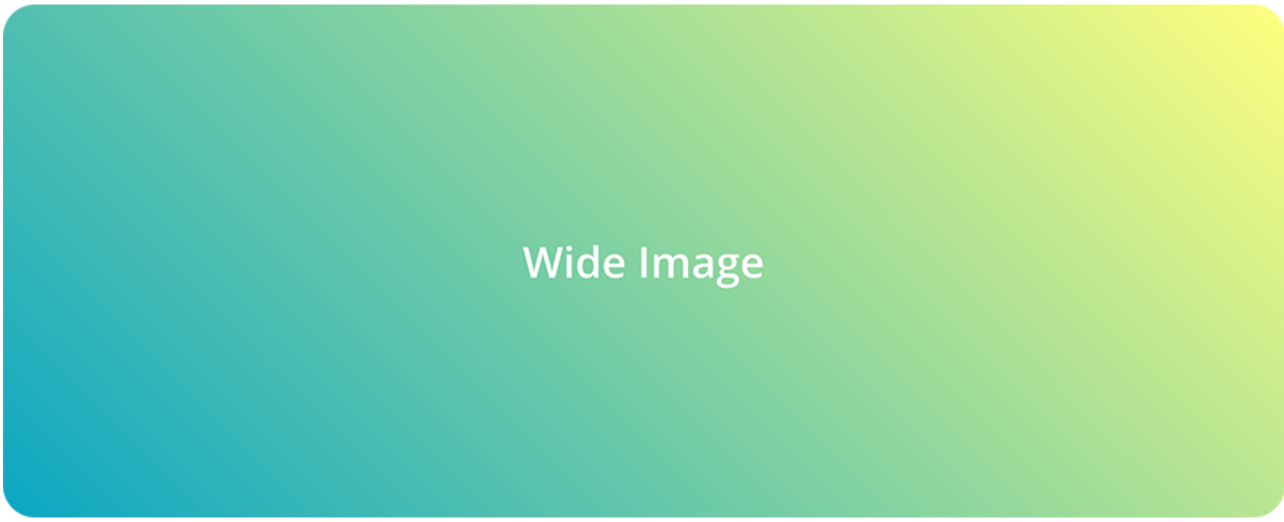

Figure 2: An image too wide to fit within page at full size. Loaded from a specific (hashed) version of the image on GitHub.

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 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	3.14159265358979323846264338327950	288419716939937510582097494459230	781640628620899862803482534211706	`piday.org`
e	2.71828182845904523536028747135266	249775724709369995957496696762772	407663035354759457138217852516642	`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:

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

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⚠ 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`.*

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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):

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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`

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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