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

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### **Authors**

### • Jiaze Cao≌

· 🕥 JiazeCLeo

Department of Civil and Environmental Engineering, University of Illinois Urbana-Champaign; WRES

#### • Yuyao Huang

Yuyao-Huang

 $Department of {\it Civil and Environmental Engineering, University of Illinois {\it Urbana-Champaign; EWES}}$ 

#### Yue Wan

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

### Hsing-Yu Huang <sup>™</sup>

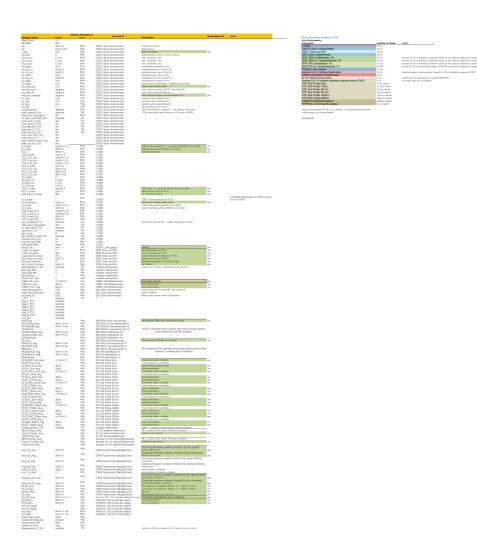
· 🞧 <u>Hsing-Yu</u>

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>.

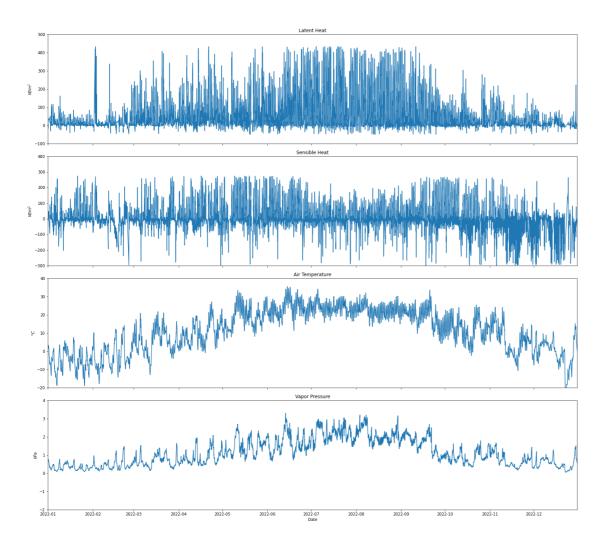
# **Dataset Description**

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 [fig2]: 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: <a href="https://www.hydroshare.org/resource/c276c71e8d1246e29d8502f5b2054668/">https://www.hydroshare.org/resource/c276c71e8d1246e29d8502f5b2054668/</a>





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		Sample, Averaged,
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RECORD	RN	
Hs	W/m^2	Smp
tau	$kg/(m s^2)$	Smp
u_star	m/s	Smp
Ts_stdev	С	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
Llx Llv cov	(m/s)^2	Smp

Ux_Uz_cov Uy_stdev Uy_Uz_cov Uz_stdev wnd_spd rslt_wnd_spd wnd_dir_sonic std_wnd_dir wnd_dir_compass Ux_Avg Uy_Avg Uz_Avg Ts_Avg sonic_azimuth sonic_samples_Tot diag_sonic_aggregate no_new_sonic_data_Tot sonic_amp_l_f_Tot sonic_amp_h_f_Tot sonic_aq_sig_f_Tot sonic_low_volt_f_Tot sonic_intrnl_hmdty_f_Tot	(m/s)^2 m/s m/s (m/s)^2 m/s m/s m/s m/s degrees degrees degrees m/s m/s C degrees samples arb samples arb	Smp Smp Smp Smp Smp Smp Smp Smp Avg Avg Avg Avg Smp Tot Smp Tot Tot Tot Tot
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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
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Solar_Batt_Min	V	Min
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mean_wind_speed	m/s	
mean_wind_direction	Deg	Avg
std_wind_dir	Deg	Avg
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diag_1_TOT	samples	
diag_2_TOT	samples	
diag_4_TOT	samples	
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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	VV/111 2 11111	Smp
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PRIDown570_Avg	W/m^2 nm	Avg
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	m^3/m^3	Avg
D5TE_VWC_5cm_Avg	111/3/111/3	Avg
D5TE_P_5cm_Avg	dC/	Avg
D5TE_EC_5cm_Avg	dS/m	
D5TE_T_5cm_Avg	Deg C	Avg
D5TE_VWC_15cm_Avg	m^3/m^3	Avg
D5TE_P_15cm_Avg	10.4	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
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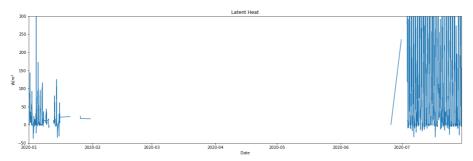
DSTE_VVVC_ZUUCIII_AVG D5TE_P_200cm_Avg D5TE_EC_200cm_Avg D5TE_T_200cm_Avg slowsequence_2_Tot SB121TempC_Avg Targ121TempC_Avg Targ121mV_Avg SB1H1TempC_Avg Targ1H1TempC_Avg Targ1H1TempC_Avg	dS/m Deg C samples	Avg Avg Avg Tot Avg Avg Avg Avg Avg Avg
short_up_Avg	W/m^2	Avg
short_dn_Avg	W/m^2	
long_up_Avg	W/m^2	Avg
long_dn_Avg cnr4_T_C_Avg cnr4_T_K_Avg	W/m^2 deg_C K	Avg Avg Avg
long_up_corr_Avg	W/m^2	Avg
long_dn_corr_Avg Rs_net_Avg Rl_net_Avg albedo_Avg Rn_Avg SQ_110_Avg SQ_110_Avg shf_Avg(1) shf_Avg(2) shf_mV_Avg(1) shf_cal(1) shf_cal(2) board_temp_Avg board_humidity_Avg incline_pitch_Avg slowsequence_3_Tot	W/m^2 W/m^2 W/m^2 W/m^2 W/m^2 W/m^2 W/m^2 W/m^2 W/m^2 w/mpan w degC percent deg deg samples	Avg

## **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 (<a href="https://etdata.org/">https://etdata.org/</a>). 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<sub>2</sub>O is a liquid

superscript: 2<sup>10</sup> is 1024.

unicode superscripts<sup>0123456789</sup>

unicode subscripts<sub>0123456789</sub>

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



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	3.141592653589793238462643383 27950	288419716939937510582097494 459230	781640628620899862803482534 211706	piday.org
e	2.718281828459045235360287471 35266	249775724709369995957496696 762772	407663035354759457138217852 516642	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:

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

### **1** Blue Banner

useful for important information - manubot.org

### **○** Light Red Banner

useful for warnings - manubot.org

### References

#### Sci-Hub provides access to nearly all scholarly literature 1.

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

#### 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: <u>10.1038/nbt.3780</u> · PMID: <u>28288103</u> · PMCID: <u>PMC6103790</u>

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Douglas Heaven

Nature (2019-02) https://www.ncbi.nlm.nih.gov/pubmed/30718888

DOI: 10.1038/d41586-019-00447-9 · PMID: 30718888

#### Plan S: Accelerating the transition to full and immediate Open Access to scientific publications

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(2018-09-04) https://www.wikidata.org/wiki/Q56458321

#### Open access

Peter Suber MIT Press (2012) ISBN: 9780262517638

#### Open collaborative writing with Manubot 6.

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/

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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

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DOI: <u>10.1098/rsif.2017.0387</u> · PMID: <u>29618526</u> · PMCID: <u>PMC5938574</u>

#### Open collaborative writing with Manubot

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