Software to Generate Weather Files for Urban Physics Modelling: Final Report

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Contents

List of Figures

1 Introduction

As a part of the Atmospheric Innovation Research (AIR) Laboratory, our goal is to understand the impact of climate change and weather conditions and how that relates to energy consumption and sustainable land use development. The research is focused on the development of Urban Physics Models (UPMs) that can be used to investigate urban development alternatives under different future climate scenarios.

Professor Amir A. Aliabadi developed a program named the Vertical City Weather Generator (VCWG), a computationally-fast UPM that predicts temporal and vertical variation of meteorological variables in the urban environment, building envelope temperatures, and temporal variation of building performance metrics, such as indoor air temperature, indoor specific humidity, building thermal and electricity loads, and natural gas and electricity consumptions [Aliabadi et al., 2021, Moradi et al., 2021, Moradi et al., 2022, Aliabadi et al., 2023].

UPMs often require weather files (for instance in EnergyPlus Weather (EPW) or International Weather for Energy Calculations (IWEC) formats) for each region with at least hourly time resolution. For instance VCWG takes weather files in the EPW format. EPW files can be generated using the ERA5 dataset from the European Centre for Medium-Range Weather Forecasts (ECMWF). The ERA5 dataset provides the required variables for the EPW file format at an hourly resolution. The spatial horizontal resolution of the ERA5 dataset is 31 km. Quality-checked monthly updates of ERA5 dataset are available since 1979 until present, and they are published within three months of real time. ERA5 dataset combines historical observations into global estimates using advanced modeling and data assimilation systems [Aliabadi et al., 2023].

Two programs are used that can assist in processing the EPW Files required for the VCWG. The Virtous File Bot (VWFB) requests and downloads datasets from the ECMWF servers. I have also further developed Amir A. Aliabadi's Veracious Weather File Processor VWFP1.0.0 program to be able to process datasets in a time efficient manner.[1] This document will give a brief overview of the programs I developed and will provide a step by step procedure in how to operate both programs. It is important that you read this document in its entirety before using the programs as they require an understanding of are reliant on the file management of ERA and EPW files.

If no other package for these programs has been provided for you, you can find the package here [2]

2 Virtuous Weather File Bot (VWFB)

2.1 Intorduction

In order to develop Urban Physics Models we must first gather weather data. Since the Vertical City Weather Generator (VCWG) requires EnergyPlus Weather (EPW) Files in order to develop models, it is our job to generate these EPW files. To generate EPW files, we can use the Veracious Weather File Processor. In this documentation, VWFP refers to the current version (VWFP2.0) unless mentioned otherwise. The Veracious Weather File Processor requires ERA5 Land and ERA5 files to generate EPW Files. ERA5 data can be found at ERA5 data.

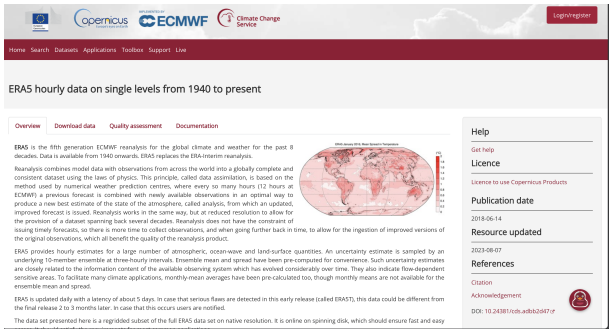

Figure 1.1: An overview of the ERA5 data.

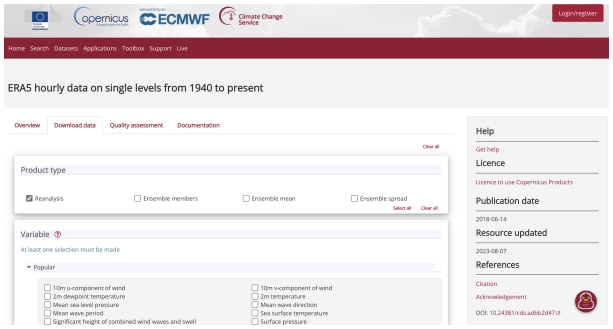

Figure 1.2: The download data request page for ERA5 data.

Manually requesting and downloading ERA5 data can be a tedious and time consuming process . This led to the development of the Virtuous Weather File Bot (VWFB). The VWFB is a program that can automatically request and download ERA5 and some ERA5Land data from the ECMWF servers with the help from human input. There

[1] https://github.com/AmirAAliabadi/VWFPv1.0.0
[2] https://github.com/judge787/ERA5-Processor

might be some learning curves when using the VWFB program, but this guide will provide a step by step procedure in how to operate the program.

This program is only designed for one user in it's current form as the program requires the user to input their username and password for the ECMWF servers. The accounts made are detached from me personally and are ready to use for anyone. If multiple users start using the program, the program will just require some variables to change with the updated nine emailAddresses assciated accounts and the password. The nine accounts can be creating here.

Before delving into the intricacies of the Virtuous Weather File Bot (VWFB), one should familiarize themselves with Amir A. Aliabadi's comprehensive documentation for the The Veracious Weather File Processor 1.0 (VWFP1.0).[3]. Central to downloading data, is the task of requesting and downloading thousands of files. This task is inherently vulnerable to human errors, which can lead to a significant degree of frustration. What further compounds the issue is the possibility that these errors might only become apparent after a substantial investment of time in requesting, downloading, and processing the ERA5 data with the VWFP. Consequently, a single oversight could lead to hours of precious time wasted. To tackle this challenge effectively, the VWFB emerges as the solution, automating the majority of the process of requesting ERA5 data and significantly reducing the potential for errors. By employing the power of Chrome automation, the VWFB seamlessly handles the requests for ERA5 and ERA5Land data. Once the files finish processing, the ERA5 data can be automatically downloaded, increasing effiemncy. However, it is essential to note that the user must manually download the ERA5Land data. Utilizing the VWFB not only optimizes efficiency but also ensures a more accurate and reliable approach to managing vast amounts of weather-related data.

2.2 File Management

Before we get started with the VWFB, it is crucial that we practice organized file management. You will download a folder called ERA5 Processor that contains the content in Figure 2. Each region's EPW, ERA5 and ERA5Land files should be stored in their own folder. The folder should be named after the city followed by a comma, space and then the province/state in abbreviation form. For example, the folder for Guelph, Ontario would be named `Guelph, ON` (caps sensitive). Inside the folder, we should create two folders named `ERA5` and `ERA5Land`. The `ERA5` folder will contain the ERA5 files and the `ERA5Land` folder will contain the ERA5Land files. The `EPW Files` and `Modified EPW Files` directories (folders) will be automaticlaly created by the VWFP later on. Now in the same parent directory as the region folder (`ERA5 Processor`), the folder `ERA5bot` must be there as well. The `era5bot` folder contains `VWFB.py` and other dependceis such as the `chromedriver` package that must be in the same folder as `VWFB.py` as we will discuss in the next sections of the guide.

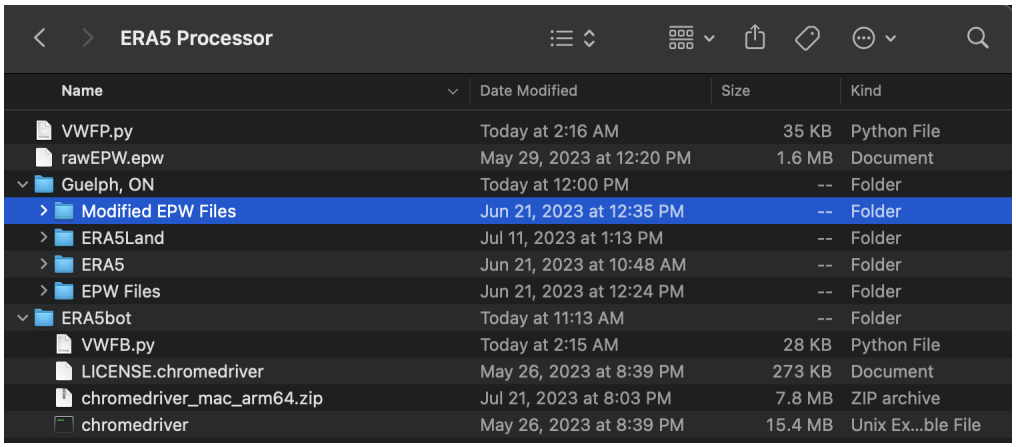

Figure 2: Correct file management for the VWFB.py and VWFP.py programs.

2.3 Installing Visual Studio Code and Python

Before we can operate the program there are a few things we must first download and install. Firstly, I highly reccommend that you use `Visual Studio Code (VSC)`, which is a free IDE (Integrated Development Environment)

[3] https://github.com/AmirAAliabadi/VWFPv1.0.0

that is easy to use and has a lot of plugins with a pleasant user interface that can be very helpful for new and experienced users. To download VSC, we can go to the VSC website [4] and download the latest version of VSC.

Since `VWFB.py` is a python program, we must first download and install python. To install python, we can go to the python website [5] and download the latest version of python. Once python is installed, the python program also has a few dependencies that we must install. To install the dependencies, we first need to open up VSC, afterwards click `File` in the upper left corner of VSC and then click open folder and proceed to open up `ERA5 Processor`. Your VSC should look similar to Figure 3.

It is important to note that I have auto save on. Auto save can be turned on by clicking `File` in the upper left corner of VSC and then clicking `Auto Save`. Auto save is not necessary but I will assume that the user has it enabled on for the rest of the guide. The VWFB program has a lot of instances where the user must change variables and then restart the program, each time the user changes a variable they would be requireed to save the file and then restart the program. Auto save will save the user a lot of time, however, it is good practice to back up files.

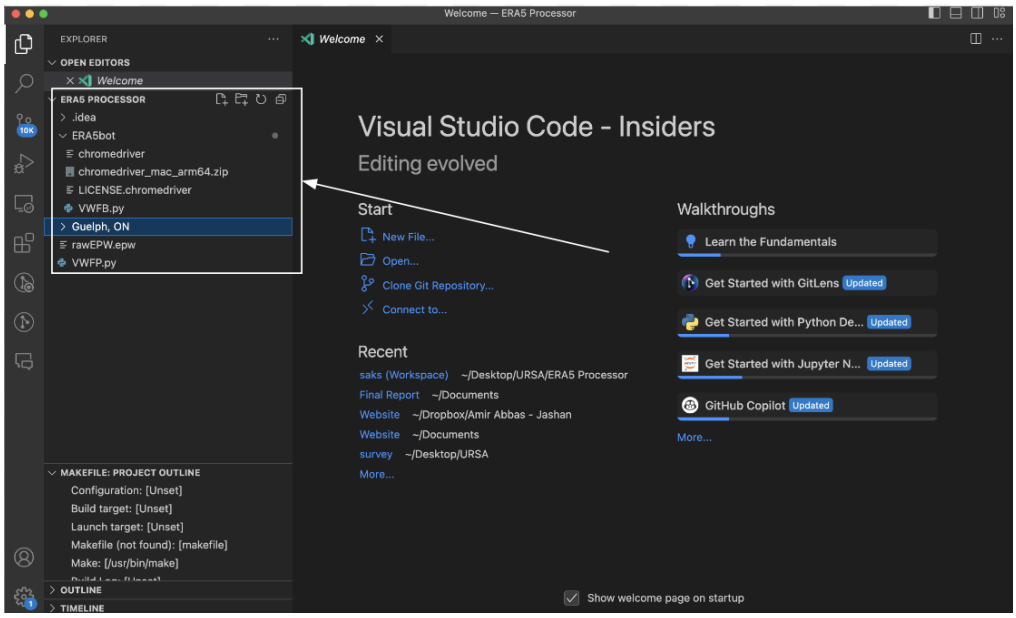

Figure 3: VSC with the `ERA5 Processor` folder open.

2.4 Using the Terminal and Installing Dependencies

The terminal is a very powerful tool that we will be using to run commands. The terminal can be used to run commands such as installing software, running programs, and much more. For this documentation the terminal will be accessed via VSC by clicking on the terminal tab at the top left of the screen in VSC. There are a few commands that we should be familiar with before we can use the `VWFB` and then the `VWFP`. The first command is

```
cd
```

This command is used to change the directory. For example, if we wanted to change the directory from `ERA5 Processor` to `era5bot` we would type in

```
cd era5bot
```

Only the `VWFB.py` program can run in the era5bot directory. If we want to return to the parent directory (`era5 processor`) to run the `VWFP.py` program then we can use the follwing command:

```
cd ..
```

[4] https://code.visualstudio.com/download
[5] https://www.python.org/downloads/

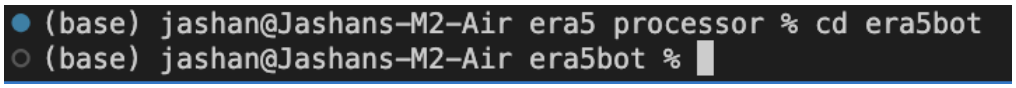

Figure 4: The directory has been changed from era5 processor to era5bot.

The `VWFB.py` has dependencies that must be installed before we can use the program. One dependency is `selenium`. To install `selenium`, ensure that you are in the era5bot directory and type the following command:

```
pip install selenium
```

If pip is not installed, install pip. [6] To verify that selenium and python have been installed correctly you can look at Figure 5 for similar results after you and type the following commands in the era5bot directory:

```
python --version
```

```
pip show selenium
```

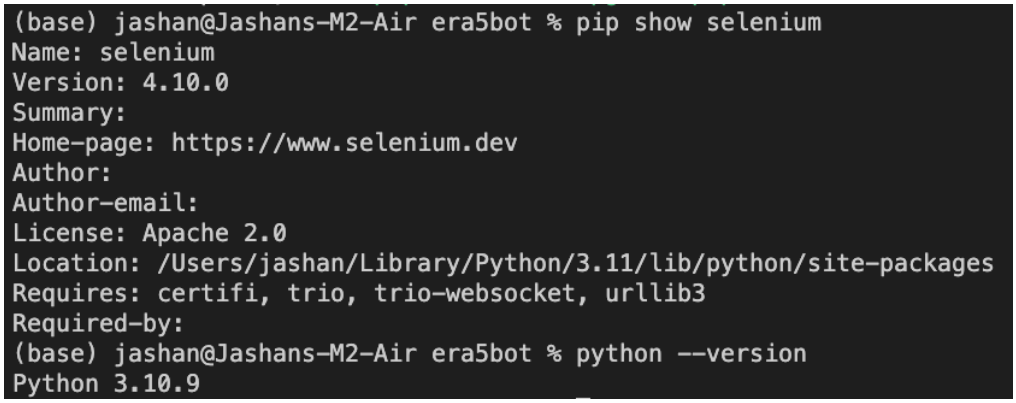

Figure 5: messages confirming that python and selenium have been installed correctly.

Another dependency you must download and extract in the `era5bot` directory is the chrome driver that can be found at the chromedriver website. [7] Moreover, the user must also download google chrome which can be downloaded here. [8] After downloading, ensure that all of the contents from the chromedriver are moved into the `era5bot` directory (refer to Figure 3, the directory should look similar) you are ready to use the `VWFB.py` program. To run any python code in the terminal you type `python` followed by the filename, for the `VWFB.py` program you would type the command:

```
python VWFB.py
```

2.5 Variables and Program Setup

To begin with the user must ensure that they understand and have completed all prior steps to each section and the user must also be connected to the wifi. A few variables require user adjustment before each program run, prompting the necessity for users to familiarize themselves with these variables beforehand. These values can be found in Figure 6 and are `city`, `province`, `northCoordinate`, `southCoordinate`, `westCoordinate`, `eastCoordinate`, `downloadingStartingNumber`, `group`, and `choice` which is located approximately ten lines below the group variable.

[6] https://pip.pypa.io/en/stable/installation/
[7] https://chromedriver.chromium.org/downloads
[8] https://www.google.com/intl/en_ca/chrome/

The coordinate, `city`, and `province` variables should only be changed once you start a new region as they do not change for the entire region.

The group variable is the group that the user wants to request data for. The group variable can be changed to 1-9 so that each gorup has there own emails, startYears and EndYears for requesting data. The `group` variable should be changed each time the user wants to download/request different data for different time ranges. Moreover, there are different groups because each group has its own data to request so that time can be minimized for processing our requests and we can avoid files being unavaible to download. Some files can become unavaible to download after around 20 hours.

The `downloadStartingNumber` should be changed for groups 1 and 2 before you attempt to download data that you requested usig `choice = 3`

The last variable you will be using is `choice` which should only be changed if you want to download the era5 data that you requested for groups 1 and 2. For more information on the `downloadStartingNumber` variable refer to in Section 2.7.

```
12  city = "Charlottetown" #enter the city
13  province = "PE" #enter the province in abbreviation
14  location = f"{city}, {province}"
15
16  #enter all the coordinates
17  northCoordinate = 46.38
18  southCoordinate = 46.12      You, 2 days ago • added VWFP.py
19  westCoordinate = -63.60
20  eastCoordinate = -63.19
21
22  downloadButtonStartingNumber = 168 #the number of the first download button on the page, you can find it in the xpath
23
24  group = 9 #change the group number to the group number you are working on (different gorups have different years and different logins)
```

Figure 6: Variables to remember in the VWFB program

The ERA5 Land data processing time for each year may take up to 25 minutes, resulting in a cumulative processing duration of up to 5 hours. To optimize data retrieval efficiency, groups request ERA5 Land data for four to five years at once. This approach enables users to download most of the required data promptly within 24 hours.

Conversely, the ERA5 data, which includes monthly records, generally takes up to 3 minutes until it is available for download. Accordingly, there are only two dedicated groups responsible for requesting and downloading this data. These groups cover the years 1980-1999 and 2007-2020.

The `choice` variable allows the user to select from three options: Choice 1 enables the user to request ERA5 data. Choice 2 facilitates the request for ERA5 Land data. Choice 3 allows the user to download ERA5 data. However, please note that there is no option to download ERA5 Land data automatically; the user must manually download all ERA5 Land data. For groups 1 and 2, the only occasion where manual modification of the `choice` variable is necessary is when transitioning from requesting to downloading data. Once the requested data is ready for download, the user should change the `choice` variable accordingly. Beginners are advised to request data for one group at a time. It is essential to confirm the successful completion of the data request from group 1 before proceeding to group 2, and so forth. After the data is requested for all groups, the user should return after 24 hours to download the requested data.

2.6 Requesting Data

When you start this program for the first time it is important that you change all the variables discussed in Section 2.5 and set the `group` variable to the range of years that you wish to request. If you have installed all the dependcies for the program to run as discussed in the previous sections, ensure you are in the terminal and are in the era5bot directory. To run the program enter the follwoing command in the terminal:

```
python3 VWFB.py
```

The program should launch google chrome, open the ECMWF website and login. The program should then take the user to their view requests page for the first time and then the program will prompt the user to enter `y` when you have deleted all previous requests. The user should ensure that all requests have been deleted before entering `y` as the program will not automtaically delete the old requests. As forgetting to delete old requests results in the

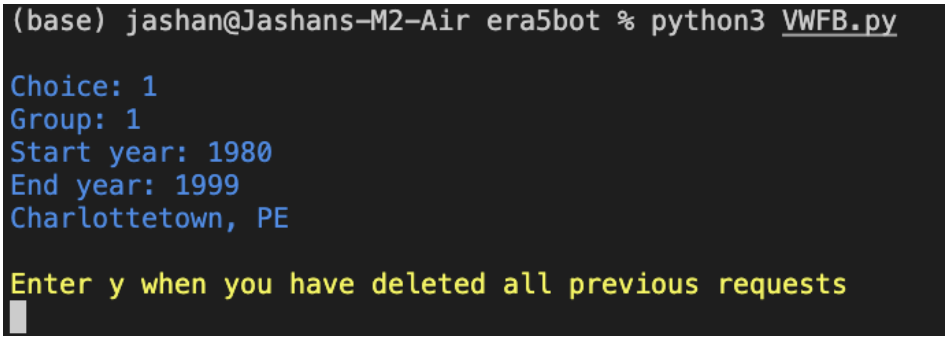

Figure 7: After a successful run of the program the user should see a message with their choosen values for the variables in less then twenty seconds

program not being able to automatically download all ERA5 data for that group. Once the old requests have been deleted enter `y` in the terminal.

Now the program should proceed to the ERA5 data request page. The program will ask the user to ensure all the correct values are checked. The program will automatically check and enter most of the correct values. However there are some values the user must check manually each time for requesting ERA5 Data. Under radiation and heat, check the following values in Figure 8.

- `Surface solar radiation downwards`
- `Surface thermal radiation downwards`
- `Total sky direct solar radiation at surface`

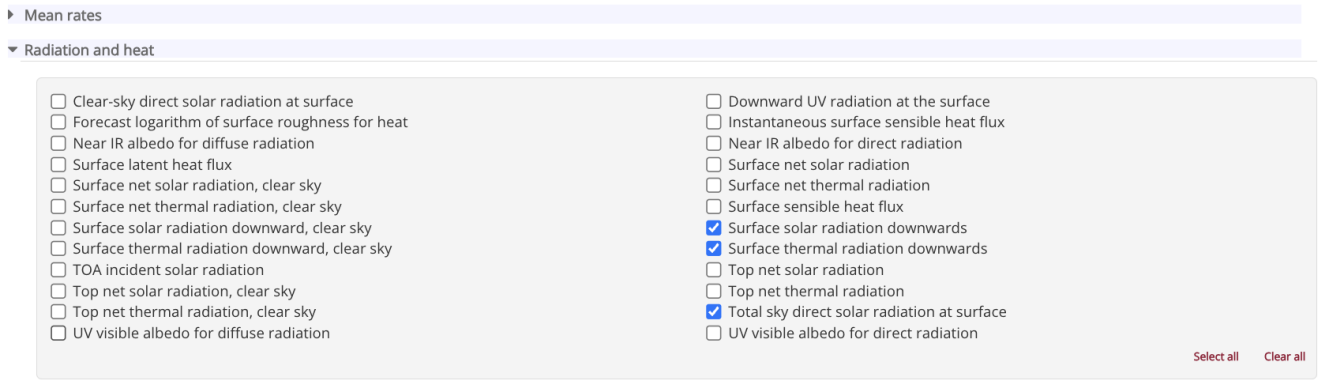

Figure 8: The user must manually check these values when requesting ERA5 data

After the values are checked enter `y` in the terminal and the program should start requesting data. If all the output in the terminal is green and it says requested ERA5 for all the months and years then the program has successfully requested all the data for that group. The user should ensure that all the data has been requested correctly. The program automatically provides the user with three minutes to verify the data requests. The user should scroll to the bototm of the chrome page and confirm that the data starts at january of the first year of that group and increments the month for the request above it. It is a frequent error that the program requests a duplicate of the first request. This can be resolved by first verifying if there is a duplicate. If there is a duplicate Janurary for the first year, delete the first request and keep the second request. Clear the terminal by holding `ctrl + c`, and change the group variable to the next group and repeat the process until all ERA5 groups are done.

For ERA5Land data the process is similar however after running the program and entering `y` to confirm that all the files have been deleted. The program will ask the user to review documentation and confirm if all the correct values are checked. The program will automatically check and enter most of the correct values. However sometimes

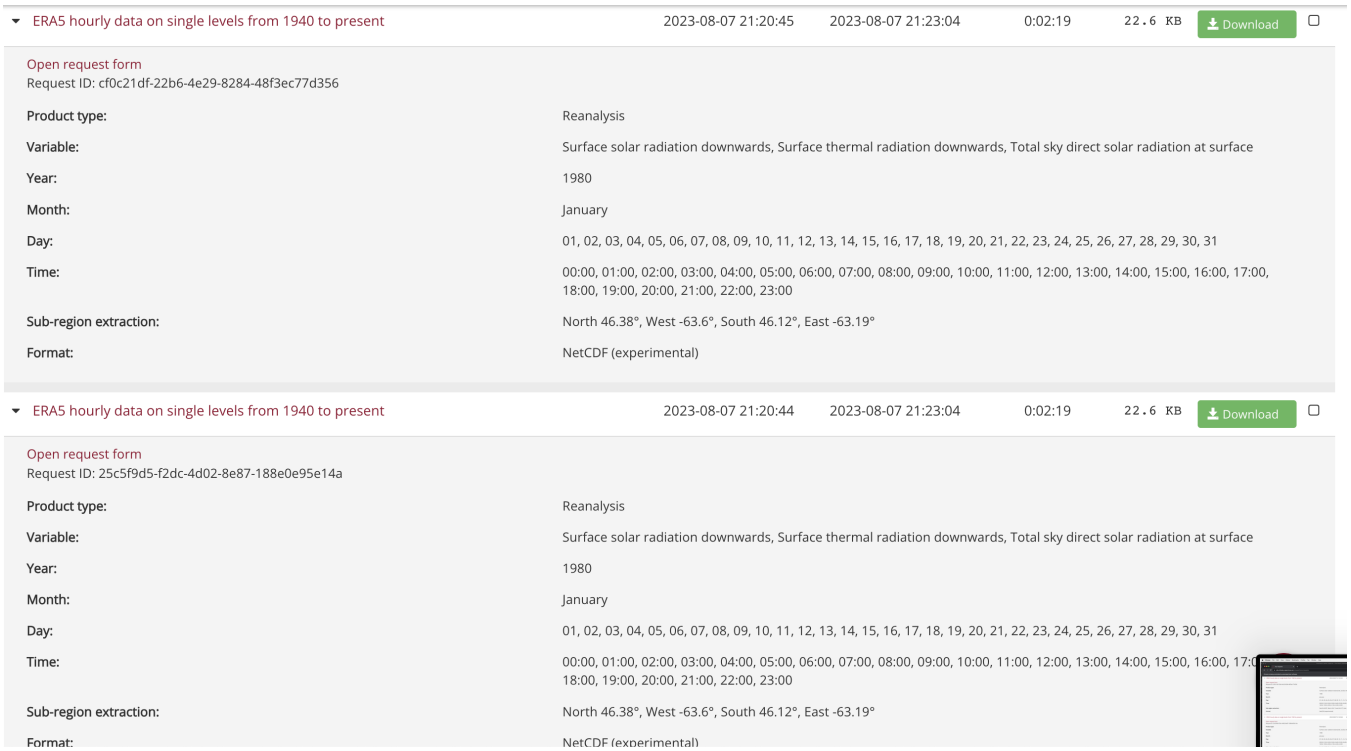

Figure 9: A duplicate request for the January of the first year of the group

the program does not. Please ensure that these values are checked. If they are not the user must manually check each of the following values in Figure 11 before entering `y` in the terminal to proceed with the requests. Repeat this for every ERA5Land group and then proceed to the downloading section.

2.7 Downloading Data

Once the user has requested all the data for all the groups and it has been around 24 hours since the user has requested their data, the user can now begin to download the data. It is important that ERA5 Land cannot be automatically downloaded. The optional first step that I do is re rquest all the ERA5 and ERA5Land data. This is because the ECMWF servers already have your ready to download requests saved. Re requesting data ensures that you likley will not have any unavailable files when you are ready to download as re requesting only has to process requests that are unavailabe. After re requesting, and when all data is ready to download, download the data for group 1 or 2. To do this the user must change the `choice` variable to 3 and run the program. The program will then take the user to the view requests page where the user must ensure that the data is accurate. Now is a good time to check for the duplicate request discussed in the previous section. If the data requested is correct then the user has to find the xpath value for the download button for the first request.

The program uses this value to locate the first download so it can start downloading all the data. To locate the xpath value the user must right click on the download button for the first request and then click inspect. This will open up a new window in the browser. The user must make sure that the elements tab is open and click the button in the upper top left corner of the new window as seen in the red box in Figure 11. Once the cursor button is blue, it indicates that it has been activated. Click on the download button when the button is highlighted in blue exactly like it is seen in Figure 12. If it did not appear highlighted as in Figure 12, click the cursor selctor in the top left of the insepction window to activate the cursor selector again. If you clicked it correctly, the code should appear similar to the white box in Figure 12. Right click the code and copy the xpath as seen in Figure 13. Paste the xpath into a empty docuement or even in the code(delete the entire xpath after using it). The xpath should look like this:

```
//*[@id="cdsapp"]/div/div/table/tbody[241]/tr[1]/td[7]/span/a
```

The value in Square brackets after tbody is the number that should be assigned for the `downloadStartingNumber` variable. After the variable has been changed, terminate the program by holding ctrl + c in the terminal until it

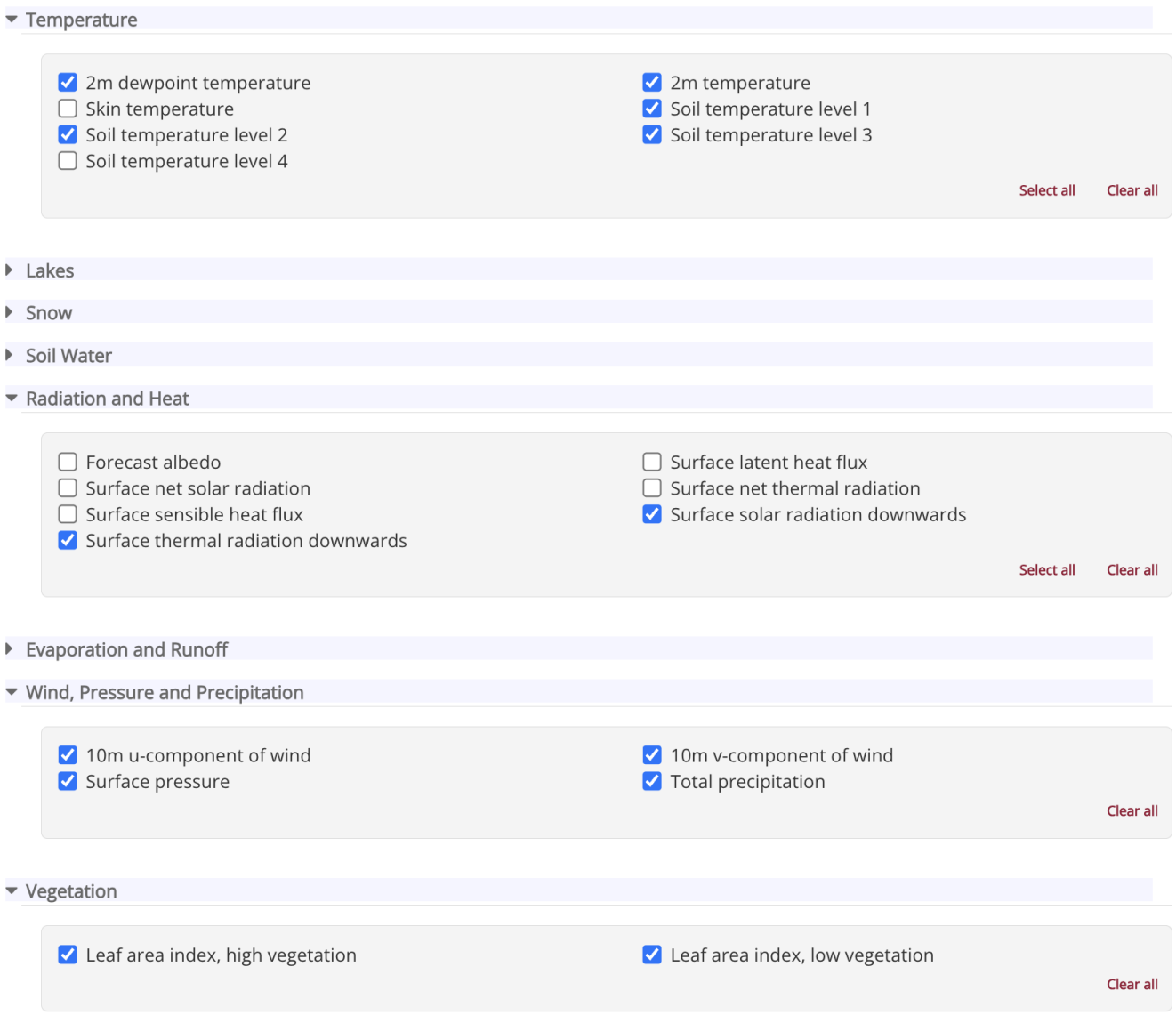

Figure 10: All the variables that the user must check before entering `y` to request ERA5Land data

ends or terminate. Run VWFB.py again and enter `y` to confirm that the downloadStartingNumber is correct and that you have restarted the program. The program will now download and rename all the data for that group. The files will be downloaded into your downloads drive. Some files will have a .nc extension and a random name. Delete those files and move all the correctly fomratted files (Ex.`ERA5_Jan_1980_May.nc`) Some files will most likley not be downloaded therfore, the user must terminate the program (holding ctrl + c) once it is done attempting to download all the ERA5 data for that group. Run the program again but instead of entering y just open up the google chrome browser and search for the missing files as indicated in the terminal output from the last time the program ran. Download the files and save them in the ERA5 directory for it's region. Ensure to name the files with the correct format of the rest of the files or else the EPW files will not process.

2.8 Manually Downloading Data

The next step is to download the ERA5Land data. To do this the user can start at group 3 run the program but remember not to enter "y" in the terminal as that would start requesting the data again, just stay on the view requests page for this step. Once google chrome opens, click the thee dots in the top right corner of the google page,

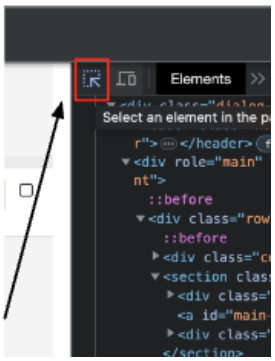

Figure 11: Click this button to assist in finding the xpath value

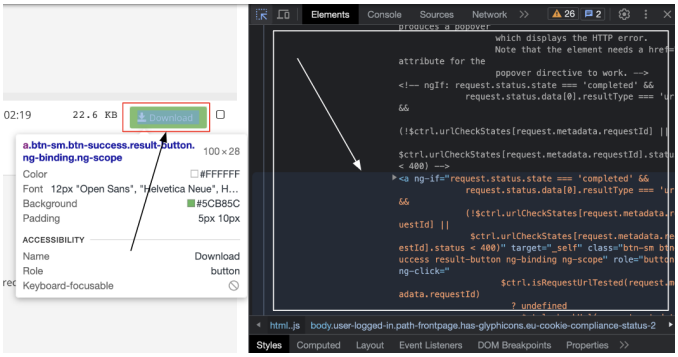

Figure 12: Click this button and the code on the right should appear

go to the downloads menu, and turn on the option to `ask where to save each file before downloading`. As this will allow the user to name the file with the correct file name which would be (Ex.`ERA5Land_Jan_1980_May.nc`) Now the user can go to the view requests page and click the download button for the first request. A pop up will appear asking the user the location to save the file. The user must save the file in the ERA5Land directory for it's region and name the file with the correct file name. Repeat this step for the remaining requests.

The files downloaded will be zipped files please keep them zipped as the program in the next step, the VWFP will unzip and rename all the files for you. Repeat these steps for the remaining groups. If any files are unable to be downloaded please re request the files by deleting all th old requests from the view requests page and then enter `y` and follow all the steps for requesting data again.

Do not worry that the files that you requested will take another 24 hours to be ready as the files that are avaible will still be ready to download after you re request. Those files are already ready to be downloaded but the files that are unavialbe will still take time to download. Once all the files have been downloaded for all the groups move on to the next step which involves using the VWFP program.

2.9 Trouble Shooting

When requesting data using the VWFB program there are a few common errors that can occur. The most common error is that the user forgets to delete a duplicate file for the first month of the first year. It is essential that the program user ensure that the coordinates are correct for each city.

Another common human error is that when the user is using the program to download ERA5 data for groups 1 and the 2, the user forgets to change the downloadStartingNumber variable to the new number. Another similar erroror is that the user starts the program and changes the downloadStartingNumber but forgets to terminate the program and run it again so that the program can update the code with the new downloadStartingNumber. For most of the other errors while requesting or downloaing data the program should be terminated and restarted by holding ctrl + c and then running the program again.

If there a is a red message while requesting data, you must restart the program. The problem will always get fixed (unless the user manually created new accounts for ECMWF in which they must manually click the accept

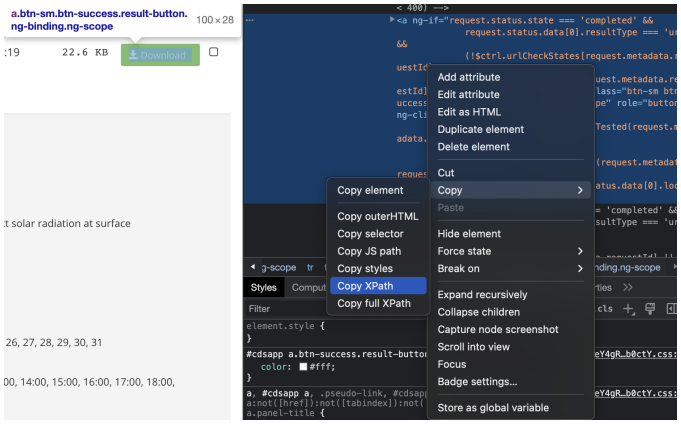

Figure 13: Right click on the highlighted line of code and then click copy xpath

terms button on the page where they are checking if the values are correct before requesting data.)

If there is a yellow message while requesting data, you can still resolve the issue by deleting the duplicate file after the program has finished running.

Other errors such as selectAlldays and deleteAllMonths (red errors) can not be ignored as they are not requesting the correct data and require the program to be restarted. Another cause for errors can be deleting the wrong duplicate file, when there are duplicates, ensure that the earliest version is deleted to allow the bot to request files properly. When using the VWFB ensure that you are not utilizing the computer's resources as that can cause the program to not function properly. If the program is not functioning properly ensure that the computer is not being used for other tasks and that the computer is not in sleep mode.

If you require further guidance, a video on how to use the program can be found here. [9] or contact me at jashanjudge87@gmail.com.

3 The Veracious Weather File Processor (V2.0.0)

3.1 Introduction

The Veracious Weather File Processor (VWFP) is a program designed to generate EPW (EnergyPlus Weather) files from ERA5 and ERA5Land files, which originate from the VWFB program. The VWFP program serves a specific purpose: it becomes relevant once users have successfully acquired all ERA5 and ERA5Land files pertinent to their chosen city.

The primary function of VWFP revolves around processing EPW Files. These processed files are tailored for utilization within the Vertical City Weather Generator (VCWG) program, specializing in Urban Physics Modelling. In contrast to the VWFB program, VWFP is streamlined and user-friendly, demanding only minor variable adjustments before program execution. However, it's important to note that its simplicity is dependent on the proper acquisition of ERA5 and ERA5Land files. A majority of the errors are a result of missing or unamed ERA5 and ERA5Land Files. Consequently, the program is programmed to manage the processing of ERA5 and ERA5Land files for the specified city, culminating in the creation of EPW Files for each year.

3.2 Variables and Setting up the Program

After you have download all the files for ERA5 and ERA5Land you can now proceed to the next step which is to use the VWFP program to process the ERA5 and ERA5Land data to generate EPW Files. To start the program since we are in the ERA5bot directory after using VWFB.py we have to go back to the parent directory by entering

```
cd ..
```

Once in the `ERA5 Proccessor` directory, open the program file VWFP.py in VSC (Visual Studio Code). Once the file is open you must familiarize yourself with the follwing varibales in Figure 14. The `startYear` and `endYear`

[9] `https://www.youtube.com/playlist?list=PLMI8H8m6BygqmDINaONmzU4V14uI7hyXy`

are the start and end years for the range of EPW Files that will be generated. It is reccomended that you generate the files in two ranges 1980-1999 and 2007-2020 as all these years must be processed. The `latrural` and `lonrural` are the coordinates for the city that you are generating the EPW Files for. The `GMT` and `timeOffset` are the GMT offset for the city that you are generating the EPW Files for. NOTE: the `GMT` must be one digit and `timeOffset` must two digits. The `city` is the name of the city that you are generating the EPW Files for and the `province` is the province that the city is located in. It muust be the same spelling and caps senstive as the directory of the region as shown in Figure 2.

```
33  startYear = 1980      You, now • Uncommitted changes
34  endYear = 1999
35  lat_rural = 46.25  #latitude
36  lat = str(lat_rural) #converts lat to string of the variable lat_rural
37  lon_rural = -63.38 #longitude
38  lon = str(lon_rural) #converts lon to string of the variable lon_rural
39  GMT = -3
40  timeOffset = "-3.0"
41  city = "Charlottetown"
42  province = "PE"
43  location = f"{city}, {province}"
44
```

Figure 14: All variables that require user familiarity.

3.3 Running the Program

Once the varaibles are changed to meet the needs of your city you can now run the program. To run the program you must first save the file by clicking the save button in the top left corner of the VSC Application. I would reccomend having autosave on as it can help reduce time to save the file after each change, however if autosave is on the user must ensure they backup all their files frequenctly incase something happens. Once the file is saved you can now run the program by entering the following command in the terminal:

```
python3 VWFP.py
```

Once the program is running you will be prompted to enter `1` to generate EPW Files for the range you set, `2` to Fix all EPW files data for years 1980-1999 and 2007-2020, `3` to unzip and rename all ERA5Land files in the directory of your region, or `4` to exit the program.

Firstly, we need to enter `3` to unzip and rename the files for the city. The correct number should be 408 files extracted and renamed in the terminal. Once the files are extracted and renamed, if there are less files please check your ERA5Land files to ensure that you download the missing files. Even if all the files are not in the ERA5Land directory, entering `1` to generate EPW Files will process EPW Files for the months and years that have the correct files. If a specific year does not have the correct files it generates EPW Files chronologically for the months starting at Janauray and lets the user know which ERA5 or ERA5Land file is missing or needs to be renamed. It is important to check if all the files for that error year are missing. Keep on trying until it generates all the EPW Files for both ranges (1980-1999 and 2007-2020). Once all the files have been successfully created for all ranges, enter `2` to fix all the EPW files data for all years. Now you should check the modified EPW files directory that has been created in the region's directory to ensure there is a file for each year for both ranges.

3.4 Trouble Shooting

The most common errors are that there are missing or incorrectly named ERA5 or ERA5Land Files. Please ensure that you have downloaded and moved each file into the correct directory.

Please ensure that you have 408 files extracted and renamed after running program choice 3 in the VWFP.py program. If you are missing files please download them and ensure they are named properly.

Another common error is one similar to Figure 15 where each year's january ERA5 or ERA5Land files are incorrect. There are several reasons why this can happen; the rawEPW file is not in the era5processor directory which is the same directory as the VWFP.py program. Also ensure that all the directories are named properly and

that the city and provicne variables match the spelling and case sensitive letters as the directory name. Another reason is that it is caused by automatically downloading ERA5 data without deleteing the duplicate January for the first year of the range which can be resolved with the user re requesting and downloading the data again for those groups in those speciifc years.

If you require further guidance, a video on how to use the program can be found here. [10] or contact me at jashanjudge87@gmail.com.

```
Enter 1, 2, 3, or 4: 1
Processing EPW Files for Charlottetown, PE for years 1980 to 1999...

ERROR: with year1980, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1981, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1982, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1983, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1984, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1985, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1986, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1987, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1988, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
ERROR: with year1989, please ensure that rawEPW.epw is in the current working directory or please check if Charlottetown's J
anuary ERA5Land and ERA5 data have been named and downloaded correctly and try again.
```

Figure 15: Error for VWFP.py program

4 Conclusion

Over the course of my summer research experience, I had the incredible opportunity to immerse myself in interesting projects that help the world learn more about climate change. My reserach focused primarily around The Veracious Weather File Processor (VWFP v2.0.0) Software and the Virtuous Weather File Bot (VWFB v.1.0.0). Collaborating closely with my research partner, William Childs, and under the guidance of Professor Amir A. Aliabadi, our focus was to delve into the vast realm of building energy consumption and weather data. I was able to contribute significantly to the research by enhancing Amir A. Aliabadi's Veracious Weather File Processor (VWFP v1.0.0) and developing the Virtuous Weather File Bot (VWFB v1.0.0). These programs proved instrumental in the efficiency of data processing, paving the way for a more robust and streamlined approach. Throughout this research term, I delved into the intricacies of the environment, and building energy consumption trends.

The summer research served as a profound learning experience for me. It broadened my horizons and exposed me to novel aspects of environmental studies. Ultimately, the knowledge gained and the skills honed during this research work has improved my work ethics, and helped me gain an deeper understanding of how to write computer programs and scientific documentation. I am grateful to have had the opportunity to work on this project with William Childs and want to thank Amir A. Aliabadi for his guidance and support throughout this research term.

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[10] https://www.youtube.com/playlist?list=PLMI8H8m6BygqmDINaONmzU4V14uI7hyXy

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