Report on All Tutorials and Excel Exercises

Course: Urban Climatology – Basic Concepts and Microclimatological Modelling with ENVI-met

SUBMITTED TO
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By

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ACKNOWLEDGEMENTS

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1. Basic introduction about Envi-Met:

Envi-Met is a software for modelling and examining microclimates in both urban and outdoor settings. It is a useful tool for those researching the thermal comfort and air quality of cities as well as for architects, academics, and urban planners.

Envi-Met simulates the interactions between the atmosphere and urban surfaces, such as buildings, roads, and trees, using a three-dimensional modelling technique. It considers a number of environmental elements, including temperature, humidity, wind direction and speed, and sun radiation. The user-friendly software interface makes setting up and using the simulator easy. Also, it provides images of the simulation's results, which can aid in understanding the changes in microclimate experienced across a city or in a natural environment.

The fundamentals of microclimate modelling and simulation were covered in the first Envi-Met lesson for students. Also, we have learned how to construct and execute simulations using the Envi-Met programme, as well as how to decipher and evaluate the outcomes. During this course the following topics has been covered:

- Introduction to Envi-Met and microclimate modeling
- Setting up a simulation in Envi-Met
- Defining boundary conditions and meteorological input data
- Creating urban geometry and surface properties
- Running a simulation and analyzing the results
- Visualization and interpretation of simulation results

2. Basic microclimatic information and Excel calculations (Reports are based on PPTs which were provided by Mr. Nils Eingrüber):

The climatic conditions in a small area or location, such as a street canyon, a park, or a structure, are referred to as the microclimate. Microclimatic conditions are impacted by a variety of elements, such as terrain, vegetation, structures, and human activities, and can differ dramatically from the larger-scale regional or global climate. Understanding and forecasting microclimatic conditions in various situations requires the use of microclimate modelling and simulation. It is possible to simulate the conditions and interactions between numerous elements inside an environment by building a virtual model of it and entering different meteorological and physical data.

2.1 microclimatological modelling:

The act of building a virtual representation of an environment and replicating the microclimatic conditions inside that environment is known as microclimatological modelling. It includes entering several meteorological and physical factors, such as temperature, humidity, wind speed and direction, sun radiation, and air quality, into specialist software tools, such as Envi-Met, to generate a three-dimensional model of an urban or natural environment.

2.3 Error and error propagation in sums

Errors in the individual values might affect the sum or difference when adding or removing items. The size of the mistakes in the individual numbers and how they combine determine the extent of the inaccuracy in the total or difference. This process is called error propagation.

Sources of error- 1) Sampling error, 2) Measurement error, 3) Model error etc.

2.4 Gap filling methods

Gap filling methods are used to estimate missing data in a time series or spatial dataset.

2.4.1 Arithmetic Mean: The arithmetic mean method is a simple approach to gap filling that involves calculating the mean value of the available data and using it to fill in the missing values. This method is straightforward and easy to implement, but it may not be appropriate for datasets with significant variability or outliers.

C4 =(B4+D4+E4)/3

A	B	C	D	E	F
Timezone : Europe/Berli	Temp (Z1.1	Temp (Z1.2	Temp (Z1.	Temp (A	Humidity (Z1
2022-09-06 00:15	22.3	22.5	22.4	22.8	47
2022-09-06 00:45	22.5	22.5	22.4	22.5	47
2022-09-06 01:15	22.4	22.3	22.3	22.3	47
2022-09-06 01:45	21.8	21.9	21.7	22.1	48
2022-09-06 02:15	21.5	21.6	21.4	21.8	49
2022-09-06 02:45	19.2	19.4	18.9	20.2	58
2022-09-06 03:15	18.6	18.7	18.4	19	65
2022-09-06 03:45	18.6	18.6	18.5	18.6	67
2022-09-06 04:15	18.6	18.5	18.5	18.5	69
2022-09-06 04:45	18.6	18.6	18.5	18.5	70
2022-09-06 05:15	18.9	18.8	18.9	18.6	70
2022-09-06 05:45	18.9	18.8	18.8	18.8	71
2022-09-06 06:15	18.2	18.3	18.2	18.5	72
2022-09-06 06:45	17.9	18.0	17.8	18.2	73
2022-09-06 07:15	17.7	17.8	17.7	17.9	74
2022-09-06 07:45	17.8	17.8	17.8	17.9	74
2022-09-06 08:15	18.5	18.5	18.4	18.5	74
2022-09-06 08:45	19.5	23.3	19.4	19.5	72
2022-09-06 09:15	20.6	20.5	20.4	20.6	70
2022-09-06 09:45	21.7	21.6	21.4	21.6	67
2022-09-06 10:15	22.8	22.7	22.6	22.7	64
2022-09-06 10:45	23.8	23.7	23.5	23.9	61
2022-09-06 11:15	24.9	24.9	24.7	25	58
2022-09-06 11:45	25.8	25.8	25.7	26	55
2022-09-06 12:15	26.7	26.7	26.5	26.8	53
2022-09-06 12:45	27.4	27.5	27.3	27.8	51
2022-09-06 13:15	28.1	33.8	28	28.5	49
2022-09-06 13:45	28.7	33.4	28.6	29.2	47

Arithmetic Mean Method

2.4.2 Regression: Regression, a more complex gap-filling technique, bases the estimation of missing values on the connection between the known data and other factors. To estimate missing values, for instance, based on the correlation between the available data and time or other factors like temperature or precipitation, a linear regression model may be utilised. While it needs more information and could be more to execute, this approach can offer estimates that are more precise than those obtained using the arithmetic mean.

C5 =-0.1510687806+(0.9068033586*D5)

	A	B	C	D	E
1	Timezone : Europe/Berlin	Temp (Z1.1)	Temp (Z1.2)	Temp (Z1.3)	Temp (A1)
2	2022-09-06 00:15	22.3	22.5	22.4	22.8
3	2022-09-06 00:45	22.5	20.2	22.4	22.5
4	2022-09-06 01:15	22.4	20.1	22.3	22.3
5	2022-09-06 01:45	21.8	19.5	21.7	22.1
6	2022-09-06 02:15	21.5	19.3	21.4	21.8
7	2022-09-06 02:45	19.2	17.0	18.9	20.2
8	2022-09-06 03:15	18.6	16.5	18.4	19
9	2022-09-06 03:45	18.6	16.6	18.5	18.6
10	2022-09-06 04:15	18.6	16.6	18.5	18.5
11	2022-09-06 04:45	18.6	18.6	18.5	18.5
12	2022-09-06 05:15	18.9	17.0	18.9	18.6
13	2022-09-06 05:45	18.9	16.9	18.8	18.8
14	2022-09-06 06:15	18.2	18.3	18.2	18.5
15	2022-09-06 06:45	17.9	16.0	17.8	18.2
16	2022-09-06 07:15	17.7	15.9	17.7	17.9
17	2022-09-06 07:45	17.8	16.0	17.8	17.9
18	2022-09-06 08:15	18.5	16.5	18.4	18.5
19	2022-09-06 08:45	19.5	23.3	19.4	19.5
20	2022-09-06 09:15	20.6	18.3	20.4	20.6
21	2022-09-06 09:45	21.7	21.6	21.4	21.6
22	2022-09-06 10:15	22.8	22.7	22.6	22.7
23	2022-09-06 10:45	23.8	21.2	23.5	23.9
24	2022-09-06 11:15	24.9	22.2	24.7	25
25	2022-09-06 11:45	25.8	23.2	25.7	26
26	2022-09-06 12:15	26.7	23.9	26.5	26.8
27	2022-09-06 12:45	27.4	24.6	27.3	27.8
28	2022-09-06 13:15	28.1	33.8	28	28.5

	H	I	J
5	Temp (Z1.3)	slope	intercept
6	Coefficients	0.906803359	-0.151068781
7	SE	0.015709446	0.211936941
8	R square SE	0.457440691	4.85157741
9	F stat/ Degree of Freedom	3331.996302	3952
10	Regression SS/Residual SS	78427.87376	93021.39889
13	Temp (A1)	slope	intercept
14	Coefficients	0.883195361	0.147627792
15	SE	0.015202138	0.205894854
16	R square SE	0.460642516	4.837240834
17	F stat/ Degree of Freedom	3375.236785	3952
18	Regression SS/Residual SS	78976.82425	92472.4484
23	Temp (Z1.3)	slope	intercept
24	Coefficients	0.996369036	0.111506808
25	SE	0.001029078	0.013883349
26	R square SE	0.995801962	0.317812188
27	F stat/ Degree of Freedom	937440.1492	3952
28	Regression SS/Residual SS	94685.75493	399.1701271

Figure 2: Regression method in excel

2.5. Root Mean Square Error (RMSE):

The difference between a set of observed values and the equivalent values projected by a model or estimator is measured by the term "Root Mean Square Error" (RMSE). RMSE is frequently used to assess the accuracy of a model or estimating approach across a variety of disciplines, including statistics, machine learning, and environmental sciences.

The RMSE is calculated by taking the square root of the mean of the squared differences between the observed values and the predicted values.

The formula for calculating RMSE is:

RMSE = sqrt[(1/n) * sum(i=1 to n) (yi - yi_hat)^2]

H3 {=SQRT(SUMSQ(D3:D3956-E3:E3956)/COUNT(E3:E3956))}

	A	B	C	D	E	F	G	H
1								
2		**Timezone : Europe/Berlin**	**Temp (Z1.1)**	**Temp (Z1.2)**	**Temp (Z1.3)**			
3		2022-09-06 00:15	22.3	22.5	22.4		**RMSE**	**1.295280527**
4		2022-09-06 00:45	22.5	20.2	22.4		**NSE**	**1.22715E+16**
5		2022-09-06 01:15	22.4	20.1	22.3		**Correlation**	**0.972108406**
6		2022-09-06 01:45	21.8	19.5	21.7		**Squared Correlation Coefficient**	**0.944994753**
7		2022-09-06 02:15	21.5	19.3	21.4			
8		2022-09-06 02:45	19.2	17	18.9			
9		2022-09-06 03:15	18.6	16.5	18.4			
10		2022-09-06 03:45	18.6	16.6	18.5			
11		2022-09-06 04:15	18.6	16.6	18.5			
12		2022-09-06 04:45	18.6	18.6	18.5			
13		2022-09-06 05:15	18.9	17	18.9			
14		2022-09-06 05:45	18.9	16.9	18.8			
15		2022-09-06 06:15	18.2	18.3	18.2			
16		2022-09-06 06:45	17.9	16	17.8			
17		2022-09-06 07:15	17.7	15.9	17.7			
18		2022-09-06 07:45	17.8	16	17.8			
19		2022-09-06 08:15	18.5	16.5	18.4			
20		2022-09-06 08:45	19.5	23.3	19.4			
21		2022-09-06 09:15	20.6	18.3	20.4			
22		2022-09-06 09:45	21.7	21.6	21.4			
23		2022-09-06 10:15	22.8	22.7	22.6			
24		2022-09-06 10:45	23.8	21.2	23.5			
25		2022-09-06 11:15	24.9	22.2	24.7			
26		2022-09-06 11:45	25.8	23.2	25.7			

where yi is the ith observed value, yi_hat is the ith predicted value, and n is the total number of observations.

The average difference between the observed values and the expected values is represented by the RMSE value. A lower RMSE number denotes a model or estimator that is more accurate in forecasting observed values, whereas a greater RMSE value denotes a model or estimator that is less accurate.

2.6. Potential Evapotranspiration:

Evapotranspiration (ET) is the process of losing water from the soil's surface through both evaporation and plant transpiration. For many applications, including irrigation management, water resource planning, and climate modelling, accurate prediction of ET is crucial.

Potential Evapotranspiration (PET) is the amount of water that would evaporate and transpire from a vegetated surface if water were unlimited. PET is primarily determined by the available energy at the land surface, which is driven by solar radiation, air temperature, wind speed, and humidity.

```
=IF(Temperature!M4>0,40.9*(0.611*EXP((17.3*Temperature!M4)/(Temperature!M4+237.3))),0)
```

Potential Evapotranspiration (mm) according to Malmstrom (1969)

Month	year	Alandi	Budhawad	Katrajtunnel	Kumbheri	Mulshi	Pune	Paud	Nighoje	Velhe	Khandala	Ghisar
1	1995	87	85	71	80	82	87	86	87	79	85	73
2	1995	111	109	91	102	105	111	110	111	102	109	94
3	1995	131	128	108	121	125	132	130	131	121	129	111
4	1995	158	155	131	146	150	158	156	158	145	156	134
5	1995	167	164	139	154	159	168	165	167	154	164	142
6	1995	164	161	136	152	156	165	162	164	151	162	140
7	1995	137	134	113	126	130	137	135	137	126	135	116
8	1995	134	131	111	124	128	134	133	134	123	132	114
9	1995	129	126	106	119	123	130	128	129	119	127	109
10	1995	130	127	107	120	123	130	128	130	119	128	110
11	1995	109	107	90	100	104	109	108	109	100	107	92
12	1995	100	98	82	92	95	100	99	100	92	98	84
1	1996	105	103	86	97	100	106	104	105	96	103	89
2	1996	113	111	93	104	108	114	112	113	104	111	96
3	1996	142	140	118	132	136	143	141	143	131	140	121
4	1996	157	153	130	145	149	157	155	157	144	154	133
5	1996	168	164	139	155	160	168	166	168	154	165	143
6	1996	153	150	127	141	146	154	152	153	141	151	130
7	1996	134	131	111	124	128	135	133	134	123	132	114

Instructions:

The method of Malmstrom (1969) uses air temperature to drive the potential evapotranspiration.

Potential Evapotranspiration (columns C till M)

- Use the functions WENN (IF) and EXP to calculate the potential evapotranspiration according to Malmstrom (1969).
- Air temperature is given on the sheet 'temperature'.

Calculation of PET: Example

Estimation of PET based on vapor pressure according to Malmstrom (1969):

$$PET_m = \begin{cases} 40.9 \bullet e_a^*(T_a) & \text{for } T_a > 0 \\ 0 & \text{otherwise} \end{cases}$$

T_a: mean monthly air temperature (°C)
e_a^*: saturation vapor pressure (kPa):

$$e_a^*(T_a) = 0.611 \bullet \exp\left(\frac{17.3 \bullet T_a}{T_a + 237.3}\right) \quad \textit{Magnus-Formel}$$

2.7 Albedo Calculation: Albedo is the fraction of solar radiation that is reflected by a surface. It is an important parameter in climate modeling, as it influences the energy balance of the Earth's surface and affects global climate patterns. The calculation of albedo depends on the type and condition of the surface, as well as the angle and intensity of the incident solar radiation. [9_CL_UHI_Radiation.pdf, Nils Engruber]

J8 =G8/H8

TIMESTAMP	RECORD	SWUpper_	SWLower_	LWUpper_	LWLower_	RsNet_Avg	RlNet_Avg	Rtotal_Net_Avg	Albedo_Avg
TS	RN	W/m^2	W/m^2	W/m^2	W/m^2	W/m^2	W/m^2	W/m^2	W/m^2
		Avg	Avg	Avg	Avg	Avg	Avg	Avg	Avg
#############	13093	-0.67	0.67	-5.212	2.815	-1.34	-8.027	-9.367	0.16693659
#############	13094	-0.665	0.67	-5.826	2.933	-1.335	-8.759	-10.094	0.15241466
#############	13095	-0.76	0.681	-6.586	2.854	-1.441	-9.44	-10.881	0.15264831
#############	13096	-1.045	0.765	-9.35	2.614	-1.81	-11.964	-13.774	0.15128719
#############	13097	-1.341	0.972	-12.4	2.424	-2.313	-14.824	-17.137	0.15603076
#############	13098	-1.369	1.162	-12.76	2.536	-2.531	-15.296	-17.827	0.1654681
#############	13099	-0.67	1.017	-7.731	3.128	-1.687	-10.859	-12.546	0.15535501
#############	13100	-0.637	0.911	-7.899	3.084	-1.548	-10.983	-12.531	0.1409451
#############	13101	-0.665	0.743	-8.6	2.882	-1.408	-11.482	-12.89	0.12262672
#############	13102	-1.38	1.078	-17.54	2.525	-2.458	-20.065	-22.523	0.12250187
#############	13103	-2.614	1.318	-21.59	1.424	-3.932	-23.014	-26.946	0.17085252
#############	13104	-2.827	1.363	-21.36	0.966	-4.19	-22.326	-26.516	0.18767356
#############	13105	-2.039	1.341	-18.58	1.922	-3.38	-20.502	-23.882	0.16486196
#############	13106	-1.637	1.397	-15.62	1.877	-3.034	-17.497	-20.531	0.17340115
#############	13107	-1.363	1.341	-16.07	2.207	-2.704	-18.277	-20.981	0.14794551
#############	13108	-1.525	1.341	-19.59	2.056	-2.866	-21.646	-24.512	0.13240322
#############	13109	-1.531	1.469	-20.07	2.005	-3	-22.075	-25.075	0.13590034
#############	13110	-1.687	1.424	-19.26	1.989	-3.111	-21.249	-24.36	0.14640689
#############	13111	-1.525	1.469	-17.99	2.212	-2.994	-20.202	-23.196	0.14820315
#############	13112	-0.832	1.709	-15.88	2.704	-2.541	-18.584	-21.125	0.13673052
#############	13113	-0.743	1.62	-12.99	2.843	-2.363	-15.833	-18.196	0.14924525
#############	13114	-0.246	1.665	-12.47	3.095	-1.911	-15.565	-17.476	0.12277546
#############	13115	-0.302	1.581	-13.25	2.698	-1.883	-15.948	-17.831	0.11807123
#############	13116	-0.637	1.413	-12.31	2.698	-2.05	-15.008	-17.058	0.13659382
#############	13117	-0.67	1.346	-11.81	2.676	-2.016	-14.486	-16.502	0.13916885

A: Calculate the Albedo: Determine the shortwave radiation balance, the longwave radiation balance, and the overall radiation balance at the 4 component radiation sensor at our weather station in the Volksgarten of Cologne Südstadt. You can download the measurements from the Excel file RADIATION.xlsx from ILIAS.

V25

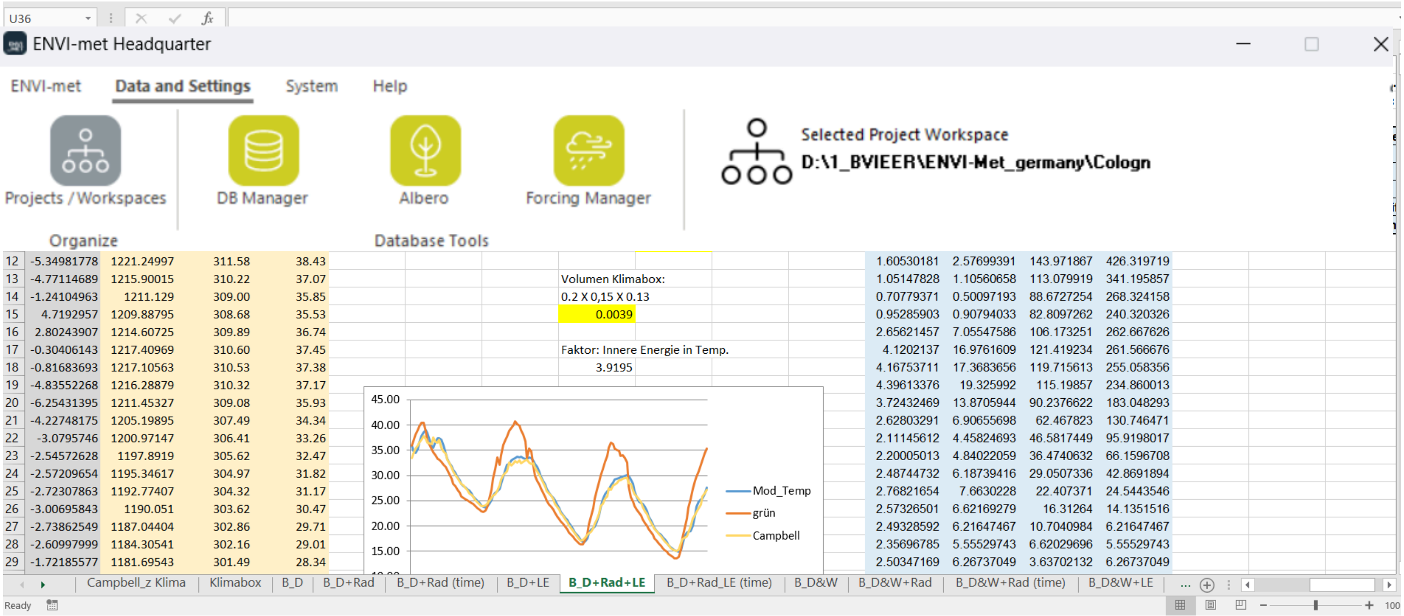
TIMESTAMP	RECORD		Diffuse_Sl	Global_Slr	Direct_uncorrected_SlrkW_Av	Correction	Diffuse_corrected_SlrkW_Avg	Direct_corrected_SlrkW_Avg
TS	RN		kW/m^2	kW/m^2	kW/m^2	factor	kW/m^2	kW/m^2
			Avg	Avg	Avg	n	Avg	Avg
###############	13093		0	0	0	1.02	0	0
###############	13094		0	0	0	1.02	0	0
###############	13095		0	0	0	1.02	0	0
###############	13096		0	0	0	1.02	0	0
###############	13097		0	0	0	1.02	0	0
###############	13098		0	0	0	1.02	0	0
###############	13099		0	0	0	1.02	0	0
###############	13100		0	0	0	1.02	0	0
###############	13101		0	0	0	1.02	0	0
###############	13102		0	0	0	1.02	0	0
###############	13103		0	0	0	1.02	0	0
###############	13104		0	0	0	1.02	0	0
###############	13105		0	0	0	1.02	0	0
###############	13106		0	0	0	1.02	0	0
###############	13107		0	0	0	1.02	0	0
###############	13108		0	0	0	1.02	0	0
###############	13109		0	0	0	1.02	0	0
###############	13110		0	0	0	1.02	0	0
###############	13111		0	0	0	1.02	0	0
###############	13112		0	0	0	1.02	0	0
###############	13113		0	0	0	1.02	0	0
###############	13114		0	0	0	1.02	0	0
###############	13115		0	0	0	1.02	0	0
###############	13116		0	0	0	1.02	0	0

B: Correct the measurements for diffuse irradiation of the diffusometer (shadow ring) at our weather station in the Volksgarten of Cologne Südstadt by using the instrcuctions and the correction formula in the "DeltaOHM_LPPYRA13_manual_ENG.PDF" file in the ILIAS Literature folder. Calculate the direct irradiation based on the measurements of the diffuse radiation and global radiation.

2.8 Klimabox und Sensor Vergleich - Gras, Humus:

It was an excel sheet where every calculation was already calculated. We had to form a hypothesis and change some value to check our hypothesis.

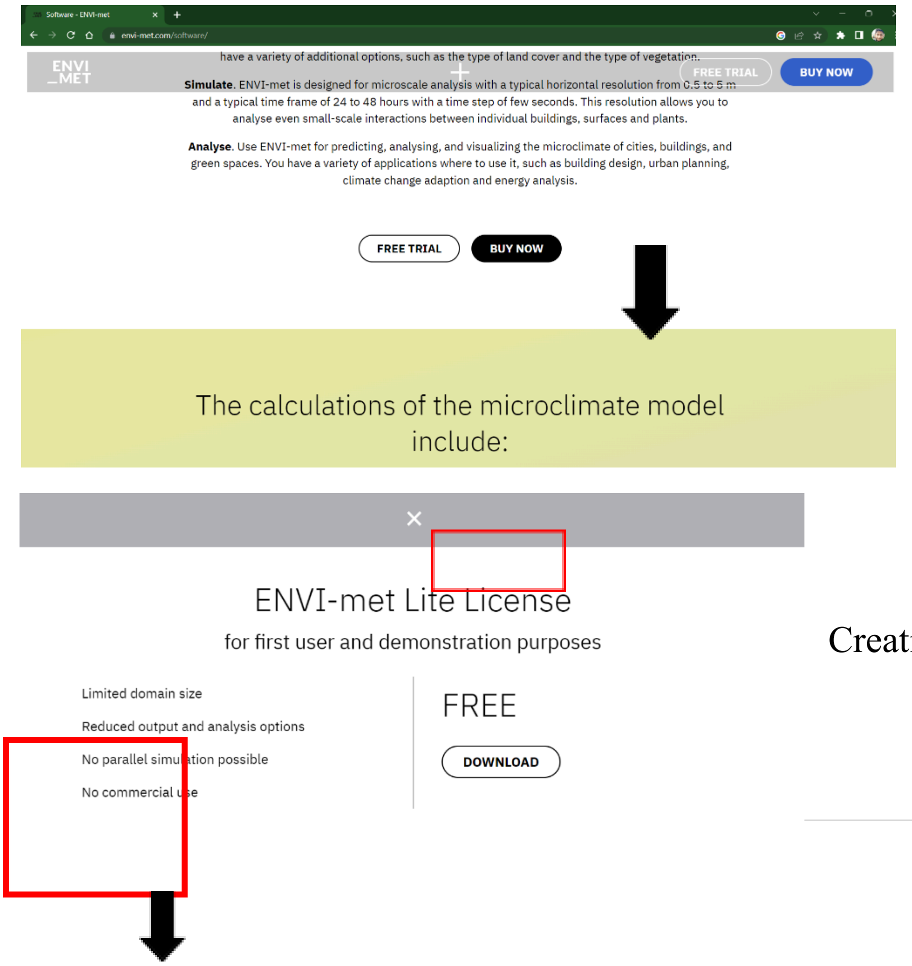
3.Nearpod Tutorials (Reports is based on Nearpod Tutorials, Mr. Nils Eingrüber):



An interactive, cloud-based learning tool called Nearpod enables teachers to design and present captivating multimedia classes to pupils.The platform has a variety of engaging elements that let students actively engage in the learning process, including surveys, quizzes, virtual reality field excursions, and interactive simulations.

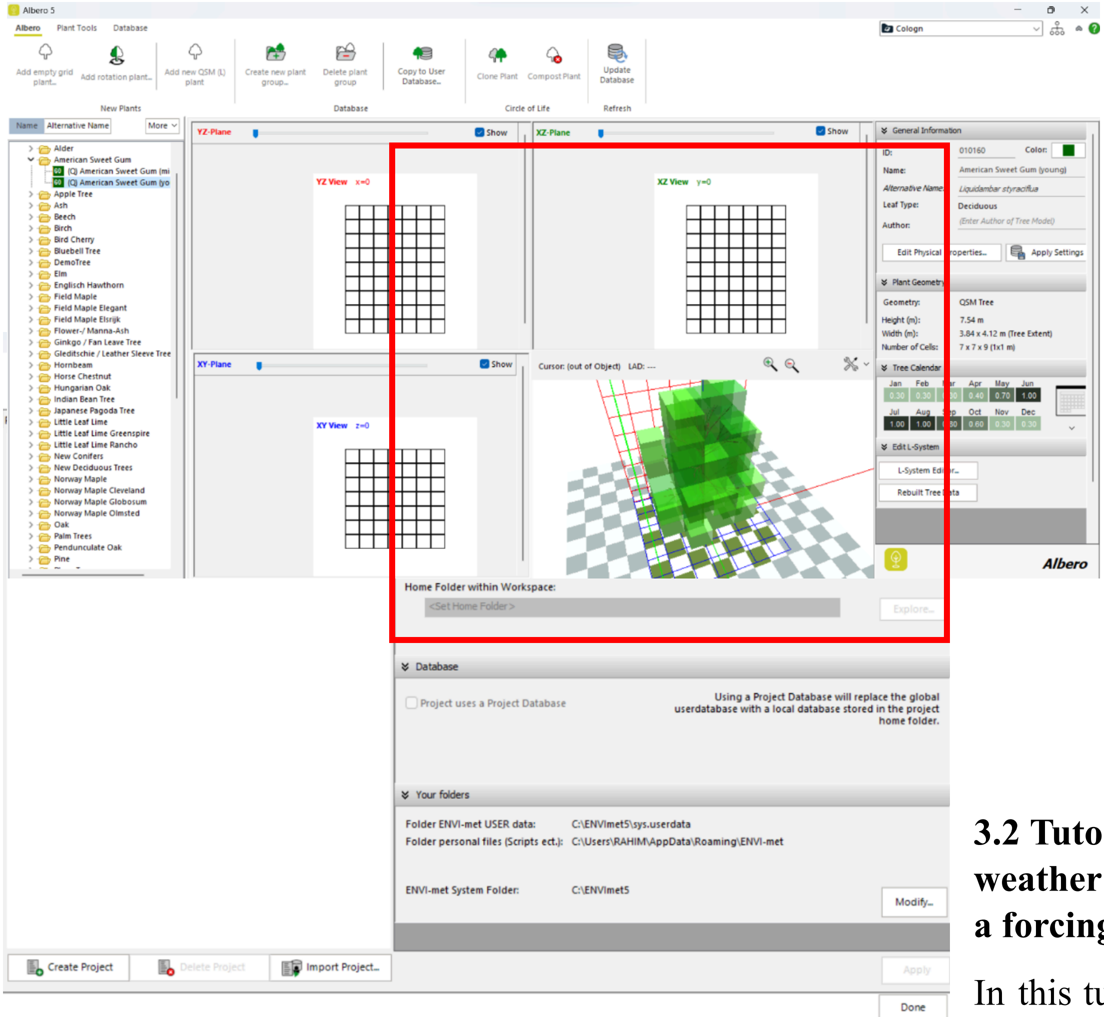
3.1 Tutorial 01: Introduction

In first tutorial we have learned how to download env-imet and how we can create a project.



All the screenshots are taken by me

Creating a project:



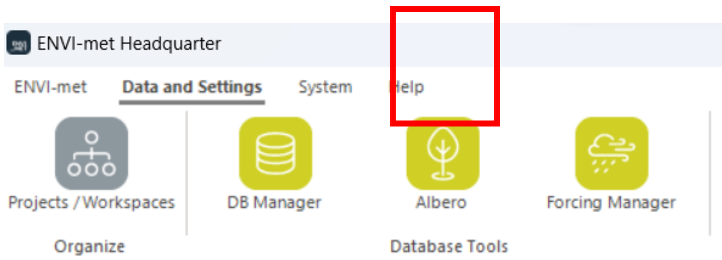
3.2 Tutorial 02: Importing weather data and creating a forcing file

In this tutorial I have learned about three types of LBCs and also how we can import .csv data in Envi-met software. Tutorial two is mainly focused on downloading the climatological data from appropriate sources.

3.3 Tutorial 03: Gridding 3D Vegetation in Albero

In order to accurately depict the vertical distribution of vegetation within the simulation region, gridding 3D vegetation in Albero is a crucial step in ENVI-met microclimate simulations.

In the gridding process, the vegetation is divided into tiny, three-dimensional cells, or voxels, and vegetation attributes are assigned to each cell.



3.3.1 L-System:

The scientist Aristid Lindenmayer created the L-System, often known as the Lindenmayer system, as a mathematical model to describe the growth and development of plants in 1968.

It is a system for rewriting strings that is based on a set of production rules that specify how a string may be changed into a new string by swapping out particular symbols for other symbols or groups of symbols. [wikipwdia]

L-Systems have been widely used in computer graphics and animation to model the branching patterns of trees and other vegetation. By interpreting the production rules as instructions for generating 3D structures, L-Systems can create complex and realistic models of plants.

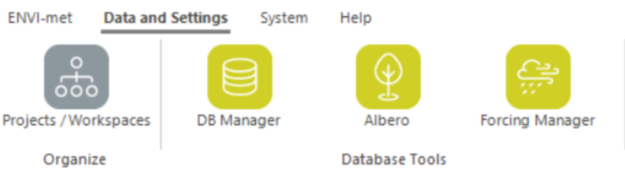
3.3.2 Turtle logic:

Turtle logic is a type of computer programming that is used in graphics and animation to create shapes and patterns based on a virtual turtle that moves around a screen or canvas. The turtle is an object that can move forward or backward, turn left or right, and draw lines as it moves.

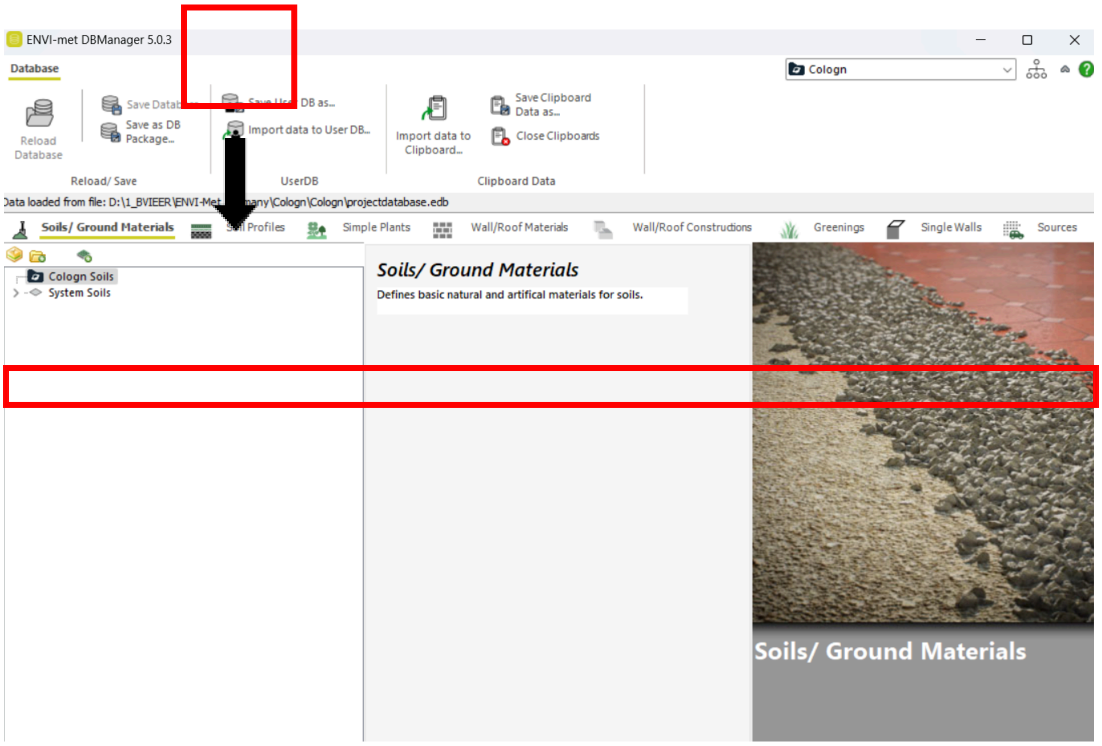
Turtle logic is a simple and intuitive way to introduce programming concepts to beginners, as it provides immediate visual feedback and allows for experimentation and creativity. It is often used in educational settings to teach basic programming concepts and has also been used in art and design to create intricate and visually stunning patterns and shapes. [Wikipedia]

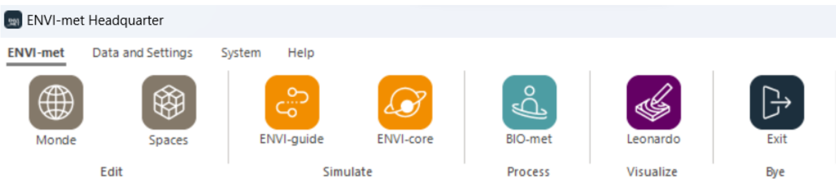
3.4 Tutorial 04: DB Manager

Users of the Envi-met programme may construct and maintain databases containing soil, vegetation, and dust source characteristics for use in their simulations. This tool is called the



Database Manager. With the use of this tool, these characteristics may be modified to fit the particulars of a certain project or area.





3.5 Tutorial 05: Monde

Monde is a geographical information system (GIS) in which shapefiles or layer files can be imported, georeferenced and edited as well as new layers created.

All the screenshots are taken by me

3.6 Tutorial 06: Spaces

Using Spaces, the model domain can be defined, created and modified to be used for an ENVI-met simulation. [PPT, Mr. Nils Engruber] Envi-met "Space" tool is used to construct spaces. Users may choose the space's dimensions, geometry, and orientation, as well as its surface characteristics and surrounding circumstances. Setting criteria like surface abrasiveness, albedo, emissivity, and plant cover fall under this category.

3.7 Tutorial 07: Envi Guide

A component of the Envi-met programme called Envi-Guide offers users a step-by-step interface for creating, simulating, and analysing microclimatic conditions in various urban and natural contexts. Envi-Guide was created to make it simpler for new users to begin using Envi-met by guiding them through the challenging process of setting up simulations and assessing the results.

We can change these sections according to our purpose.

In this tutorial we have created SIMX file for final simulation.

3.8 Tutorial 08: ENVI-core:

In ENVI-core, the different features and properties of the urban microclimate that are represented in an ENVI-met model will be calculated based on various physical processes. For every grid cell in the model domain, the energy balance and the mass balance is calculated based on the fluxes of the adjoining six grid cells. [Mr.Nils Engruber]. According to our purpose and computational power of machine will decide the duration of the simulation tome.

3.9 Tutorial: Leonardo, DataStudio and Python

Leonardo, DataStudio, and Python are software tools that can be used in conjunction with Envi-met for advanced data visualization, analysis, and automation.

Powerful software tools like Python, DataStudio, and Leonardo may be utilised to speed up the data processing and visualisation process and improve Envi-met simulations. With the help of these tools, users may construct simulations that are more accurate and effective and obtain a greater understanding of microclimatic conditions. They also have access to a range of sophisticated capabilities for data analysis, visualisation, and automation.

3.10. Tutorial 10: BIO-met

Out of the simulation results, BIO-met is used to produce bio-thermal indices, which may then be utilised to study and compare the thermal (outdoor) comfort, for example, of pedestrians.

In contrast to the primary ENVI-met software, which uses physical differential equations to determine the microclimate, BIO-met is based on empirical data combined with outputs from the atmospheric model.

The idea of Thermal (Outdoor) Comfort is heavily debated in the scientific community for many reasons:

- What is an average human?

- Which class borders should be used to categorize the results?

- The empirical basis of the concept limits the possibilities to calculate and compare results. [Mr. Nils Engruber]

Field Excursion:

During this course we had two filed excursions one trip was conducted in cologne for German students and virtually for Indian students.

Similarly, one excursion was conducted here in pune, India. Virtually for German students through Xpert eye device.

Photo captured during excursion by me