3rd ClimEd Online Training on Digital Tools and Datasets for Climate Change Education

A3 Group HWA

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12-11-2021

Main Theme: Water management

Project: Efficiency of green roofs in urban areas for stormwater retention under climate change

Areas: Kyiv, Kharkiv, Odessa cities





Green roofs advantages:

- retain storm water
- reduce peak flow and increase time-to-peak flow
- reduce total runoff volume
- decrease of load to stormwater drainage system
- prevent streets flooding
- air purification
- carbon sequestration
- decrease of building heating
- mitigation of urban heat island effects
- additional habitat for wildlife
- aesthetic appeal



Norway



Poland





Kyiv region

Historical and forecasted climate indices

Annual precipitation, monthly precipitation, monthly min/max precipitation, heavy precipitation, number of rainless days, duration of consecutive rainless days, duration of vegetation period, min/max temperature

Additional data

Urban built-up areas, roofs areas

Data sources

Copernicus Climate Change Service (CDS)

Expected outcomes

Feasibility assessment of green roof implementation in three Ukrainian cities (Kyiv, Kharkiv, Odessa) under different scenarios of climate change



The work is based on tenyear experience of observations on the author's "green roof" in steppe climate in Donetsk by Tetiana Tkachenko.

Main influencing factors (averaged by year):

- temperature *t*, °C
- relative humidity rh, %
- cloud coverage c, %
- wind speed w, m /s



Calculating climatologies 2011-2021 for Kyiv, Kharkiv, Odessa

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Toolbox Editor Applications Data Documentation Search for app or example your workspace & 00 Hello World	12_calculate_climatologies Console ① History Your queue Runtime profile Import cdstoolbox as ct 2 3 * layout = { 'input_ncols': 3, 'output_align': 'bottom'	← Calculate climatologies 2011-2021 Kharkiv Variable Frequency Start Total precipitation ♥ month ♥ 1 ♥ ♥ Climatology mean and standard deviation Starting from month n. 1
03 Extract time series and plot graph Kharkiv 1 12_calculate_climatologies 21 Calculate regional mean and anomalies 3_extract_time_series_and_plot_graph_HWA1 D1 plot_time series part1_Kharkiv max monthly prcp D1 plot_time series part1_Kharkiv max monthly prcp-loop forum_daily_max green roofs max PRCP Kharkiv 04 Hollo World 01 Retrieve data 02 Plot map 03 Extract time series and plot graph 11 Calculate time mean and standard deviation 12 Calculate regional mean and anomalies 31 Calculate trends 41 Calculate GDD	<pre>/ variables = { 'Near-Surface Air Temperature': '2m_temperature', 'Eastward Near-Surface Wind': '10m_u_component_of_wind', 'Westward Near-Surface Wind': '10m_u_component_of_wind', 'Total precipitation': 'total_precipitation', 'Total precipitation': 'total_precipitation', 'Eastward Near-Surface Localet climatologies 2011-2021 Kharkiv', layout=layout) @ct.input.dropdown('var', label='Variable', values=variables.keys()) @ct.input.dropdown('freq', label='Frequency', default='month', values= ['dayofyear', 'weekofyear', 'month'], link=True,</pre>	The second secon

Calculating climatologies 2011-2021

Kyiv



Kharkiv

ariable	Frequency		Start		
Near-Surface Air Temperature 🗸 🗸	month		1	\sim	





Climatology mean and standard deviation Starting from month n. 1



Odessa



Estimation of plant development conditions based on wind speed, relative humidity, temperature, cloud cover

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	state at	Tetiana Tkachenko
e Search Datasets Applications Your requests Toolbox Support Live		
5 monthly averaged data on single levels from 1979 to pres	int	
الالام 2021-06-25: Variable "Orography" is now named "Geopotential". No change in the da	a themselves. Previous API requests asking for "Orography" will fail now. To download the corresponding data the API request should ask for	"Geopotential".
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ariable 🔞		References
		Citation
Popular		DOI: 10.24381/cds.f17050d7cr
Temperature and pressure		Related data
2m dewpoint temperature loe temperature layer 1	2m temperature lee temperature layer 2	ERAS hourly data on pressure levels from 1950 to 1978 (preliminary version)
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100m u-component of wind 10m u-component of neutral wind	100m v-component of wind 10m u-component of wind	ERAS monthly averaged data on pressure levels from 1979 to present
10m v-component of neutral wind 2 10m wind speed	I tom v-component of wind Instantaneous 10m wind gust	FRAS monthly averaged data on single levels from 1050 to 1078 (preliminary version)
		Sector Contrary are type and an angle areas from 150 to 1570 (Pelininiary Vetsion)
Mean rates		
Radiation and heat Clouds		
Cloud base height Low cloud cover	High cloud cover Medium cloud cover	
Total cloud cover	Total column cloud ice water	

Calculation of relative humidity by air temperature and dew point

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	Расчётные формулы [править править код]
0	Формула для приблизительного расчёта точки росы T_p в градусах Цельсия (только для положительных
٩	температур):
0	$T = b \gamma(T, RH)$
Ø	$T_p=rac{1}{a-\gamma(T,RH)},$
\triangleright	где
\bigcirc	a = 17.27.
()	$b = 237,7 ^{\circ}C,$
ŝ	
Ç	$\gamma(T,KH)=rac{1}{b+T}+\ln KH,$
	T — температура в градусах Цельсия,
	RH — относительная влажность в объёмных долях (0 < RH < 1,0).
	Формула обладает погрешностью ±0,4 °С в следующем диапазоне значений:
	0 °C < T < 60 °C
	0,01 < RH < 1,00
	0 °C < T_n < 50 °C
	P

The formula should be transformed to find relative humidity



 $RH = \frac{4105.079(td-t)}{(t+237.7)(td+237.7)}$

The next step is to write the software for calculations using CDS Toolbox and Python language:

- retreiving data;
- resampling the data for year-averaged one;
- calculating the regression equation,

which describes the observations results;

- plotting.

Regression equations for estimation of plant development (phenotype) for the following plant groups:

GROUP I - armeria, aster alpinus, dianthus deltoides, iris, centaurea:

FT1 = 5.31 + 0.144 *t* - 5.926 *rh* + 0.0477 *c* - 0.38 *w*

GROUP II - stipa, aster, alyssum, gypsophila, saponaria, tanacetum, lysimachia, deschampsia, leymus, helictotrichon, filipendula, euphorbia:

FT2 = 4.49 + 0.157 *t* - 1.836 *rh* - 0.00064 *c* - 0.0795 *w*

GROUP III - festuca valesiaca, salvia, phlomoides tuberosa, polygonum, hypericum, iberis, iris sibirica, artemisia, thymus serpyllum, melica, carex, scutellaria:

FT3 = 7.526 + 0.188 *t* – 5.6 *rh* + 0.0159 *c* – 0.603 *w*



GROUP I - armeria, aster alpinus, dianthus deltoides, iris, centaurea;

ROUP II - stipa, aster, alyssum, gyosophila, saponaria, tanzoetum, lysimachia, deschampsia, leymus, helictöhrihon, filipendula, euphorbia; ROUP III - festuca valesiaca, salvia, phiomoides tuberósa, polygonum, hypericum, iberia, ińs sibirica, artemisia, thymus senpyltum, melica, carex, scutellari

	time		Group 1	
2016		4.15		
2017		4.19		
2018		4.10		
2019		4.21		
2020		4.34		
	time		Group 2	
2016		4.24		
2017		4.33		
2018		4.29		
2019		4.46		
2020		4.52		
	time		Group 3	
2016		4.07		
2017		4.13		
2018		4.22		-
2019		4.36		2
2020		1.46		

The software code

1	# EN ##################################	****
2	# APPLICATION FOR CALCULATION OF	#
3	# PLANT DEVELOPMENT ON "GREEN ROOFS"	#
4	#	#
5	# It is based on a mathematical regression	#
6	# model of plant development after	#
7	# more than ten years of observations	#
8	# by Tetiana TKACHENKO for "green roofs"	#
0	# in Ukraine	#
10	# IN OKIAINE.	# #
10	# PENELOPER DV.	#
11	# DEVELOPED BY:	#
12	# Tetiana TKACHENKO, Dr hab, prof.,	#
13	# Viktor MILEIKOVSKYI, Dr hab, prof.	#
14	# Kyiv National University	#
15	# of Construction and Architecture	#
16	***************************************	#####
17	# UA ##################################	#####
18	# ЗАСТОСУНОК ДЛЯ РОЗРАХУНКУ РОЗВИТКУ	#
19	# РОСЛИН НА "ЗЕЛЕНИХ ПОКРІВЛЯХ"	#
20	#	#
21	# Базується на математичній регресійній	#
22	# молелі розвитку рослин на пілставі	#
23	# почал лесяти років спостережень	#
24	# Тотани ТКАЧЕНКО за "започними	#
24	# тегяни полныто за зеленими	# #
25	# покрівлями в Україні.	#
20	#	#
27	# РОЗРОБНИКИ:	#
28	# Тетяна ТКАЧЕНКО, д.т.н., проф.,	#
29	# Віктор МІЛЕИКОВСЬКИИ, д.т.н., проф.	#
30	# Київський національний університет	#
31	# будівництва і архітектури	#
32	***************************************	#####
33		
34	import cdstoolbox as ct	
35		
36 🔻	layout = {	
37	'input ncols': 2,	
38	'output align': 'bottom'	
39	}	
40		
41	#Defining the application	
12	#Визначения застосунку	
13 -	Act application(title='Plant Development on	"Green Boofs"
4.0 4	description="UN Department of	Green Roors ,
44	description= DA: POSBNICK po	слин на зелених покрівлях ,
45	Layout=Layout)	
46	#Input of the calculation city	
47	#Увід розрахункового міста	
48 •	<pre>@ct.input.city('CityToCalc',</pre>	
49	label='City',	
50	description='UA: Micro')	
51	#Output of the plot	
52	#Вивід графіка	
53	<pre>@ct.output.livefigure()</pre>	
54	#Output of the plant groups	
55	#Вивід груп рослин	
56	Oct.output.markdown()	
57	#Output of the tables	
58	#Вивід таблиць	
50	Act autput table()	
59	(ect.output.table()	
60	MCT.OUTDUT.TADLE[]	

	<pre>@ct.output.table()</pre>
	#Main function
	#Головна функція
۳	<pre>def plot_time_series(CityToCalc):</pre>
	Арріїсаціон шалі steps: Основні пії попатку:
	ochobni dii dodanky.
٠	 retreiving data;
	отримуємо дані;
۲	 resampling the data for year-averaged one Machine for the second se
	масштабуемо далі до середпоорічних
٣	 calculating the regression equation
	розраховуємо рівняння регресії
	-1-++/
٠	- plotting
	креслимо
	#Input data
	#Вхідні дані
	years=['2016','2017','2018','2019','2020']
	lat=lityToCalc.get('lat')
	# Retrieving the weather data around the city
	# Отримуємо погодні дані навколо міста
٠	<pre>wind,dew,temp,cloud = ct.catalogue.retrieve(</pre>
	'reanalysis-era5-single-levels-monthly-means',
۳	{
	'product_type': 'monthly_averaged_reanalysis'
*	'lOm wind speed'.
	'2m dewpoint temperature'.
	'2m_temperature',
	'total_cloud_cover',
],
	'time': '00:00',
	'month': [
	'01', '02', '03',
	'04', '05', '06',
	'07', '08', '09',
	'10', '11', '12',
٠	dred ; [lat+1 lon_1 lat-1
	lon+1
],
	}
)
	#Extracting the data for the city.
	# IL CANNOL DE RESAMPLED UNTIL # relative bumidity calculation
	#Вилобуваємо пані для міста.
	# Вони не можуть бути масштабовані
	# до розрахунку відносної вологості
	<pre>wind = ct.cube.interpolate(wind,lon=lon,lat=lat)</pre>
	<pre>dew = ct.cube.interpolate(dew.lon=lon.lat=lat)-273.15</pre>

121		<pre>dew = ct.cdm.update attributes(dew, attrs={'units': '°C'})</pre>
122		<pre>temp = ct.cube.interpolate(temp,lon=lon,lat=lat)-273.15</pre>
123		<pre>temp = ct.cdm.update_attributes(temp, attrs={'units': '°C'})</pre>
124		<pre>cloud = ct.cube.interpolate(cloud,lon=lon,lat=lat)</pre>
125		#Calculating relative humidity using dew point
126		#Розраховуємо відносну вологість
127		# з використанням точки роси
128		<pre>rh = ct.math.exp((4105.079*(dew-temp))/((temp+237.7)*(dew+237.7)));</pre>
129		<pre>rh = ct.cdm.update_attributes(rh, attrs={'units': ''})</pre>
130		#Averaging the data by each year
131		#Усереднюємо дані за кожним роком
132		wind=ct. cube.resample (wind,freq='year',skipna= True)
133		<pre>dew=ct.cube.resample(dew,freq='year',skipna=True) #not necessary</pre>
134		temp=ct. cube.resample (temp,freq='year',skipna= True)
135		cloud=ct. cube.resample (cloud,freq='year',skipna= True)
136		<pre>rh=ct.cube.resample(rh,freq='year',skipna=True)</pre>
137		#Simulating the plant development
138		#Моделюємо розвиток рослин
139		FT1=5.31+0.144*temp-5.926*rh+0.0477*cloud-0.38*wind #
140	#	
141		FIZ=4.49+0.15/*Temp-1.836*Fh-0.00064*Cloud-0.0/95*Wind
142		F13=7.520+0.188*temp-5.6*Fn+0.0159*Cloud-0.005*Wind
143		rii = ct.com.update attributes(rii, attrs=[units: ', long name: Group 1})
144		riz = ct.com.upoate attributes(riz, attrs=[units: ', long name: Group 2 })
145		ris = ct.com.upoate_attributes(ris, attis={ units : , tong_name : Group 5 })
140		#Processing
147		The state of the second state of the state o
140		'name': 'Group 1'
150		'showleagend': True.
151		'marker': {'color': 'red'}.
152		'texttemplate': '%v'}.
153 .	,	<pre>layout kwargs = {'xaxis': {'title':'Year'},</pre>
154		'yaxis': {'title':"Points on the Tumanov
	so	ale"}})
155 •		<pre>fig = ct.chart.bar(FT2,fig=fig,bar_kwargs={</pre>
156		'name': 'Group 2',
157		'showlegend': True,
158		'marker': {'color': 'green'},
159		'texttemplate': '%y'
160		})
161 1	1	<pre>tig = ct.cnart.bar(F13,f1g=f1g,bar_Kwargs={</pre>
162		name : Group 3',
163		snowledgend : True,
104		marker: { color: blue },
165		Lexttemptate . sy
167		
168	**	grp — GROUP I** , *armeria*, *aster alninus*, *dianthus deltoides*, *iris*, *centaurea*;
169		under 1 - uniteria, aster atprinas, utantinas activides, iris, centaurea,
170	**	GROUP II** - *stipa*, *aster*, *alvssum*, *gvpsophila*, *saponaria*, *tanacetum*.
	1	vsimachia. *deschampsia*. *levmus*. *helictótrichon*. *filipendula*. *euphorbia*:
171	1	,
172	**	GROUP III** - *festuca valesiaca*, *salvia*, *phlomoides tuberósa*, *polvgonum*,
	h	ypericum, *iberis*, *iris sibirica*, *artemisia*, *thymus serpyllum*, *melica*,
	c	arex, *scutellaria*.
173 .		•
174		<pre>return fig, grp, ct.chart.table(FT1, dim_format='%Y'), ct.chart.table(FT2,</pre>
	di	m format='%Y'), ct. <mark>chart.table</mark> (FT3, dim format='%Y')

Kyiv

Group 2

Plant Development on "Green Roofs"

UA: Розвиток рослин на "зелених покрівлях"

City UA: Місто



time	Group 1
2016	4.15
2017	4.19
2018	4.10
2019	4.21
2020	4.34
time	Group 2
2016	4.24
2017	4.33
2018	4.29
2019	4.46
2020	
2020	4.52
time	4.52 Group 3
2016 time	4.52 Group 3 4.07
time 2016 2017	4.52 Group 3 4.07 4.13
time 2016 2017 2018	4.52 Group 3 4.07 4.13 4.22
time 2016 2017 2018 2019	4.52 Group 3 4.07 4.13 4.22 4.36

GROUP I - armeria, aster alpinus, dianthus deltoides, iris, centaurea;

GROUP II - stipa, aster, alyssum, gypsophila, saponaria, tanacetum, lysimachia, deschampsia, leymus, helictótrichon, filipendula, euphorbia;

GROUP III - festuca valesiaca, salvia, phlomoides tuberósa, polygonum, hypericum, iberis, iris sibirica, artemisia, thymus serpyllum, melica, carex, scutellaria.

Plant Development on "Green Roofs"

UA: Розвиток рослин на "зелених покрівлях"



time	Group 1
2016	3.99
2017	4.13
2018	4.03
2019	4.28
2020	4.44
time	Group 2
2016	4.15
2017	4.31
2018	4.27
2019	4.46
2020	4.56
time	Group 3
2016	3.94
2017	4.10
2018	4.14
2019	4.40

GROUP I - armeria, aster alpinus, dianthus deltoides, iris, centaurea;

GROUP II - stipa, aster, alyssum, gypsophila, saponaria, tanacetum, lysimachia, deschampsia, leymus, helictótrichon, filipendula, euphorbia;

GROUP III - festuca valesiaca, salvia, phlomoides tuberósa, polygonum, hypericum, iberis, iris sibirica, artemisia, thymus serpyllum, melica, carex, scutellaria.

Kharkiv

Group 2

Odessa

Group 1 Group 2 Group 3

Plant Development on "Green Roofs"

UA: Розвиток рослин на "зелених покрівлях"



time	Group 1
2016	3.94
2017	3.84
2018	4.10
2019	4.12
2020	4.24
time	Group 2
2016	4.65
2017	4.71
2018	4.80
2019	4.92
2020	4.99
time	Group 3
2016	Group 3 4.14
2016 2017	Group 3 4.14 4.16
2016 2017 2018	Group 3 4.14 4.16 4.44
2016 2017 2018 2019	4.14 4.44 4.56

GROUP I - armeria, aster alpinus, dianthus deltoides, iris, centaurea;

GROUP II - *stipa, aster, alyssum, gypsophila, saponaria, tanacetum, lysimachia, deschampsia, leymus, helictótrichon, filipendula, euphorbia;*

GROUP III - festuca valesiaca, salvia, phlomoides tuberósa, polygonum, hypericum, iberis, iris sibirica, artemisia, thymus serpyllum, melica, carex, scutellaria.

Results

Year	Plant development (phenotype) estimation [points on the Tumanov scale] at city								
	Kyiv			Kharkiv		Odessa			
	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
2020	4,34	4,52	4,46	4,44	4,56	4,55	4,24	4,99	4,71
2019	4,21	4,46	4,36	4,28	4,46	4,40	4,12	4,92	4,56
2018	4,10	4,29	4,22	4,03	4,27	4,14	4,1	4,80	4,44
2017	4,19	4,33	4,13	4,13	4,31	4,10	3,84	4,71	4,16
2016	4,15	4,24	4,07	3,99	4,15	3,94	3,94	4,65	4,14
Ave- rage	4,198	4,368	4,248	4,174	4,35	4,226	4,048	4,814	4,402

Green – the best; Brown – medium; Red – the worse

During the last five full years, the plants of group II are the leaders of phenotype. In other groups, the situation was changed in 2018. This year, group III won the second place. In Kharkiv, the group take approximately the same mark as the leader.