Description of the Climate Change Data Service Portal

Climate Services for Infrastructure

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1 INTRODUCTION

Due to the severe impacts of climate change, the Nile Basin Initiative (NBI) aims to provide Nile Basin Countries with climate services which will support decision-makers in carrying out climate risk assessments particularly with regards to infrastructure planning. In addition to that, the NBI developed a Climate Proofing Guideline that is intended to serve the NB countries, project developers and consultants, to include climate resilience in project identification, preparation, construction and operation.

The climate services provided by the NBI can be accessed through a data service database portal and entails downscaled CORDEX Data from 4 scenarios which represent the minimum and maximum signal changes of climate in terms of temperature (minimum and maximum) and precipitation. Those four selected datasets were used to derive Intensity-Duration-Frequency (IDF) matrices, and the Probable Maximum Precipitation (PMP).

2 DATA SERVICE PORTAL

2.1 Home page

The data service database portal is available on the following website: "http://5.175.16.252:8002/". Figure 1 shows the homepage of the website where users can find a description of the main purpose of the portal. Additionally different links: query (where users can query for a certain location based on the spatial information) CSV, ASCII, and MAP (where users can get access to the CSV, ASCII, and MAP file formats) are also listed.

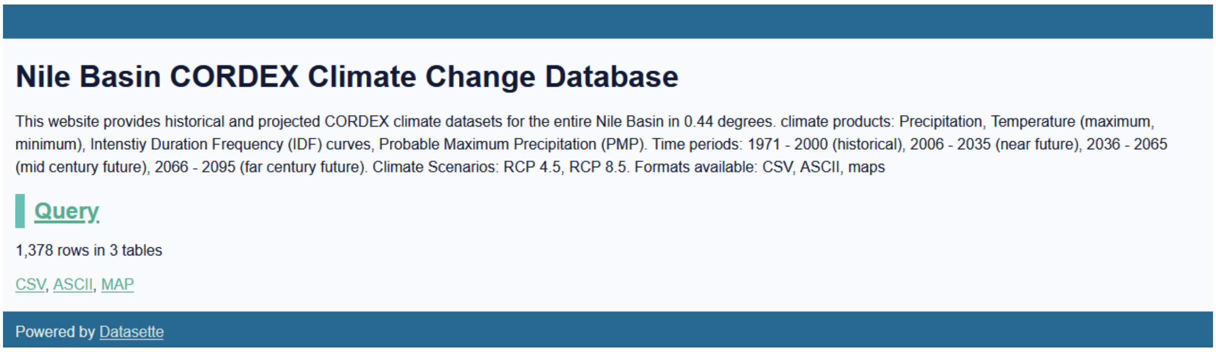


Figure 1: Data service portal homepage.

2.2 CSV

On the CSV page the datasets which are saved in a CSV file format can be viewed and downloaded. Users can click on the "CSV" link to reach the page showing a map with the locations of all available datasets as shown in Figure 2. The datasets consist of the following columns: rowid, longitude, latitude, and a URL link. By clicking on the URL link, the user can access a google drive folder containing different folders structured by climate change scenario and period. The user has the choice to download a selected file or the entire folder. The structure of the google drive will be explained in the upcoming sections.

Figure 2: CSV page.

Additionally, users can utilize the web map where they can zoom to a certain location and easily access the data by clicking on the point feature as seen in Figure 3. A small window will appear listing the information of the chosen point feature. To have an overview on the CORDEX cells, a key map is provided in this page through a link in the header of the page.

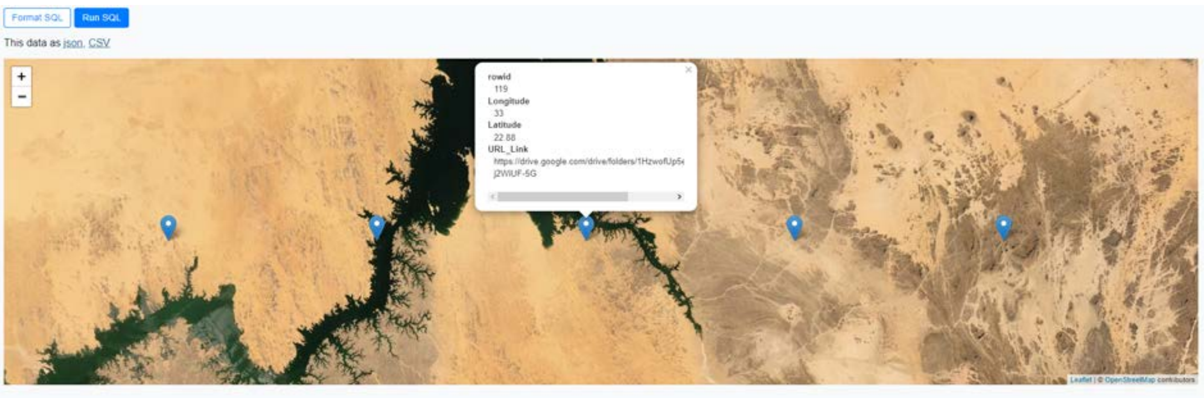


Figure 3: Web map application.

When a record is selected, users can get access to a google drive folder by clicking on the URL link. The google folder entails 6 folders which are divided by time period (1971-2000, 2006-2035, 2036-2065, 2066-2095) and climate scenario (historical, rcp4.5, rcp8.5) as shown in Figure 4.

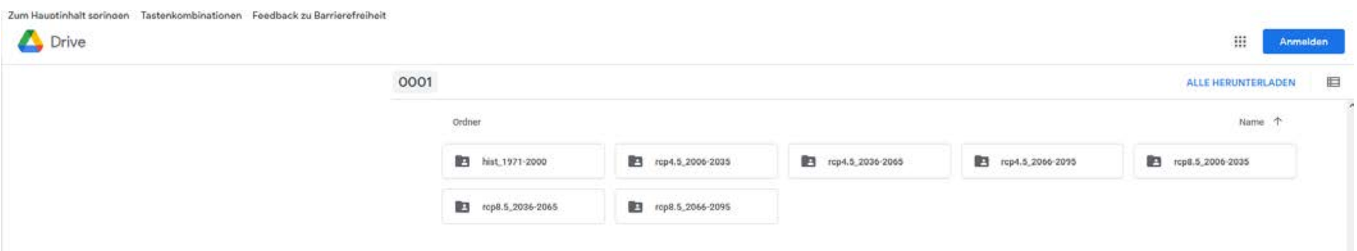


Figure 4: Main google drive folder entailing the different scenarios and different period.

Clicking on one of the folders in Figure 4, users will be diverted to a page (Figure 5) where the available climate models are listed. The available climate models are:

1. SMHI_RCA4MOHC_HadGEM2 (represents minimum precipitation)
2. BCCR_WRF331NCC_NorESM1_M (represents maximum precipitation)

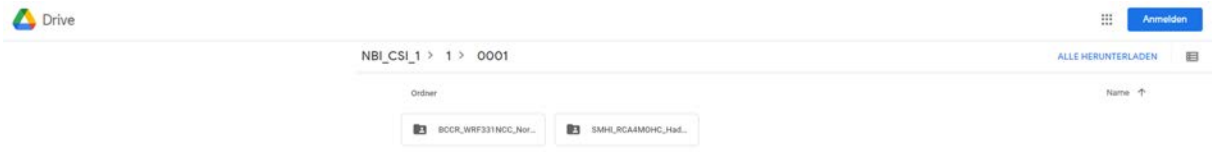


Figure 5: Climate Model folder encompassing the different models.

Users get access to 4 datasets according to minimum and maximum signal changes in terms of precipitation and temperature. The names of the 4 datasets are as follows:

1. rcp45SMHI_RCA4MOHC_HadGEM2 (represents minimum precipitation and minimum temperature)
2. rcp85SMHI_RCA4MOHC_HadGEM2 (represents minimum precipitation and maximum temperature)
3. rcp45BCCR_WRF331NCC_NorESM1_M (represents maximum precipitation and minimum temperature)
4. rcp85BCCR_WRF331NCC_NorESM1_M (represents maximum precipitation and maximum temperature)

Users can click on the desired model and thereby access different csv files such as:

2.2.1 pr.csv

This file contains a precipitation timeseries. The precipitation timeseries can be applied as data input for a simulation model such as precipitation-runoff models or hydrological mass balance models. The first column represents the time stamp, whereas the second column represents the daily precipitation value in mm.

2.2.2 tasmax.csv, tasmin.csv

These 2 files contain temperature timeseries including maximum temperature (tasmax) and minimum temperature (tasmin). The temperature timeseries can be utilized to calculate the potential evapotranspiration and different crop requirements prior to being applied in water allocation models and hydrological mass balance models. The first column represents the time stamp, whereas the second column represents the maximum temperature value in °C.

2.2.3 IDF.csv

This file contains an IDF table. IDF curves represent the rainfall at a certain location taking into consideration the following parameters: rainfall Intensity, duration of rainfall event and frequency of occurrence. The available IDF curves were calculated using the widely used German Weather Service (DWD) approach. IDF curves are means to identify climate change and can be used in the design phase of water infrastructures, as floods with different return periods can be derived from them.

To extract the values from the file (Figure 6), users can specify two variables (e.g. duration and frequency) and follow the matrix to extract the third (intensity). The first left column represents the duration in minutes, whereas the upper row represents the frequency in years.

	A	B	C	D	E	F	G	H	I	J	K
1	Duration [min] (Left column) - Frequency [yr] (upper row) - Intensity [mm] (matrix)										
2	0	0.5	1	2	5	10	20	50	100	1000	10000
3	5	0	0	0.7	1.6	2.3	3	3.9	4.6	6.9	9.3
4	10	0	0	0.7	1.6	2.3	3	3.9	4.6	6.9	9.3
5	15	0	1.6	5.3	10.1	13.7	17.4	22.2	25.9	38.2	50.5
6	20	0	1.9	5.8	10.9	14.8	18.7	23.8	27.7	40.7	53.6
7	30	0	2.4	6.7	12.3	16.5	20.7	26.3	30.6	44.9	59.2
8	45	0	3	7.7	13.8	18.4	23	29.2	33.8	49.1	64.4
9	60	0	3.6	8.5	15	19.9	24.9	31.4	36.3	52.6	68.9
10	90	0	4.5	9.9	17	22.4	27.8	34.9	40.2	57.8	75.4
11	120	0	5.3	11	18.6	24.3	30.1	37.6	43.3	62.2	81.2
12	180	0.4	6.7	12.9	21.2	27.4	33.7	42	48.2	68.8	89.4
13	240	1.2	7.9	14.5	23.3	30	36.6	45.4	52.1	74.4	96.6
14	360	2.6	9.9	17.2	26.8	34	41.3	50.9	58.2	82.5	106.7
15	540	4.5	12.5	20.4	30.9	38.8	46.7	57.2	65.2	91.8	118.4
16	720	6.2	14.7	23.1	34.3	42.7	51.2	62.3	70.8	99	127.3
17	1080	9.3	18.5	27.7	39.9	49.1	58.3	70.5	79.7	110.3	140.8
18	1440	12	21.8	31.6	44.5	54.3	64.1	77.1	86.9	119.5	152
19	2880	20.8	32.2	43.6	58.7	70.1	81.5	96.6	108	145.9	183.7
20	4320	28.1	40.6	53	69.5	81.9	94.4	110.8	123.3	164.8	206.3
21	5760	34.5	47.8	61	78.5	91.8	105	122.5	135.8	180	224.2
22	7200	40.3	54.2	68.1	86.5	100.4	114.3	132.7	146.6	192.8	238.9
23	8640	45.7	60.1	74.6	93.7	108.2	122.6	141.7	156.2	204.4	252.5
24											

Figure 6: IDF file.

2.2.4 PMP.csv

This file consists of a PMP table. The PMP is the greatest precipitation depth that could occur at a particular location and time. It can be used by hydrologists to determine the PMF which is usually applied in designing large water infrastructures such as dams. In this project, the PMP was calculated by applying the statistical method adopted by the WMO.

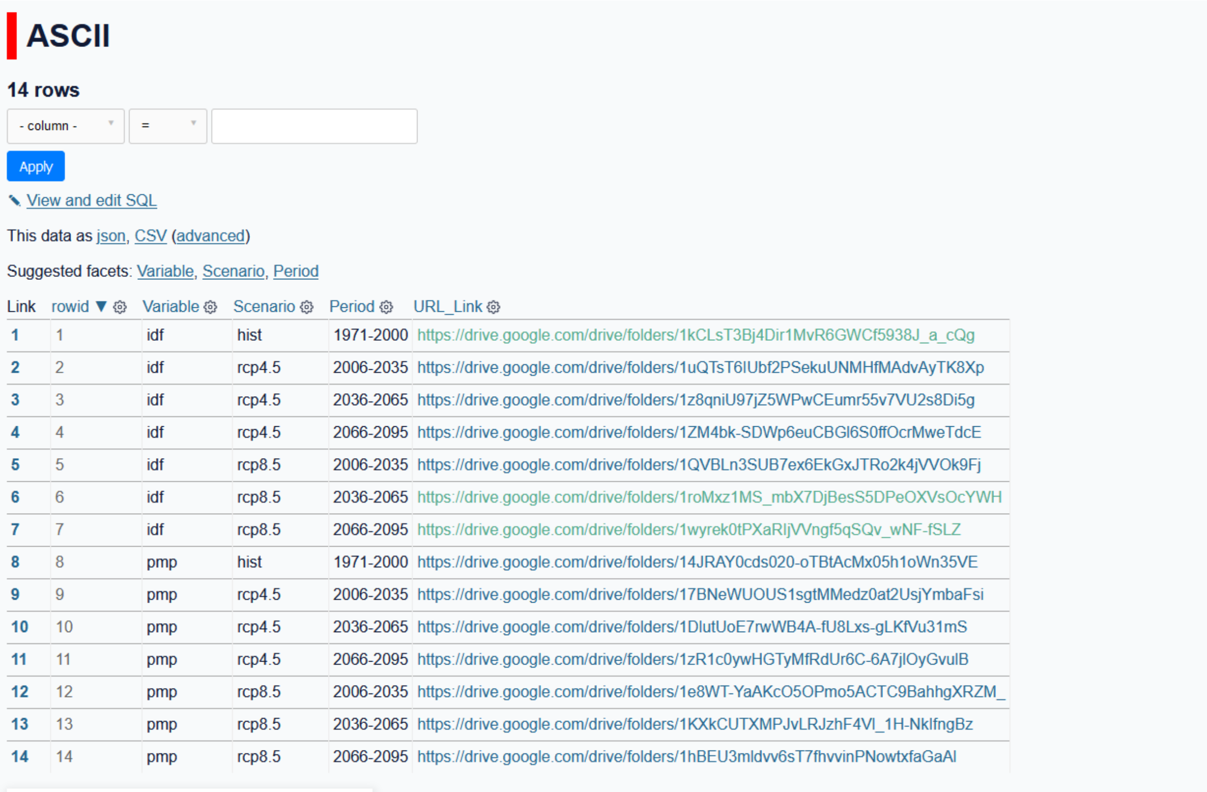
Users can extract PMP values by choosing a storm duration (Figure 7). Different design storm profiles with different distribution patterns of the PMP have to be tested to obtain a set of potential design floods. Each of those storm profiles must be simulated in a precipitation runoff model to obtain maximum conditions (PMF) at the respective water infrastructure.

	A	B
1	Duration [min]	PMP [mm]
2	5	4.68
3	10	9.38
4	15	14.05
5	20	18.74
6	30	28.11
7	45	42.17
8	60	56.22
9	90	78.71
10	120	118.07
11	180	171.49
12	240	210.84
13	360	227.71
14	540	264.26
15	720	269.88
16	1080	278.32
17	1440	281.13

Figure 7: PMP file.

2.3 ASCII

The ASCII page encompasses the datasets saved in the form of ASCII file format. Clicking on the "ASCII" link in the home page, users can get access to the window shown in Figure 8. The dataset entails the following columns: rowid, variable, scenario, period, and URL link. Users can choose the folder to be downloaded by specifying the variable (IDF, PMP), scenario (hist, rcp4.5, rcp8.5), and period (1971-2000, 2006-2035, 2036-2065, 2066-2095).



ASCII

14 rows

- column - =

Apply

View and edit SQL

This data as json, CSV (advanced)

Suggested facets: Variable, Scenario, Period

Link	rowid ▼	Variable	Scenario	Period	URL_Link
1	1	idf	hist	1971-2000	https://drive.google.com/drive/folders/1kCLsT3Bj4Dir1MvR6GWCf5938J_a_cQg
2	2	idf	rcp4.5	2006-2035	https://drive.google.com/drive/folders/1uQTsT6IUbf2PSekuUNMHfMAdvAyTK8Xp
3	3	idf	rcp4.5	2036-2065	https://drive.google.com/drive/folders/1z8qniU97jZ5WPwCEumr55v7VU2s8Di5g
4	4	idf	rcp4.5	2066-2095	https://drive.google.com/drive/folders/1ZM4bk-SDWp6euCBGl6S0ffOcrMweTdcE
5	5	idf	rcp8.5	2006-2035	https://drive.google.com/drive/folders/1QVBLn3SUB7ex6EkGxJTRo2k4jVVOk9Fj
6	6	idf	rcp8.5	2036-2065	https://drive.google.com/drive/folders/1roMxz1MS_mbX7DjBesS5DPeOXVsOcYWH
7	7	idf	rcp8.5	2066-2095	https://drive.google.com/drive/folders/1wyrek0tPXaRIjVVngf5qSQv_wNF-fSLZ
8	8	pmp	hist	1971-2000	https://drive.google.com/drive/folders/14JRAY0cds020-oTBtAcMx05h1oWn35VE
9	9	pmp	rcp4.5	2006-2035	https://drive.google.com/drive/folders/17BNeWUOUS1sgtMMedz0at2UsjYmbaFsi
10	10	pmp	rcp4.5	2036-2065	https://drive.google.com/drive/folders/1DlutUoE7rwWB4A-fU8Lxs-gLKfVu31mS
11	11	pmp	rcp4.5	2066-2095	https://drive.google.com/drive/folders/1zR1c0ywHGTyMfRdUr6C-6A7jlOyGvulB
12	12	pmp	rcp8.5	2006-2035	https://drive.google.com/drive/folders/1e8WT-YaAKcO5OPmo5ACTC9BahhgXRZM_
13	13	pmp	rcp8.5	2036-2065	https://drive.google.com/drive/folders/1KXkCUTXMPJvLRJzhF4Vl_1H-NklfngBz
14	14	pmp	rcp8.5	2066-2095	https://drive.google.com/drive/folders/1hBEU3mldvv6sT7fhvvinPNowtxfaGaAl

Figure 8: ASCII page.

Users can get access to the climate model folder by clicking on the URL link (Figure 9). The available climate models are as follows:

1. SMHI_RCA4MOHC_HadGEM2 (represents minimum precipitation)
2. BCCR_WRF331NCC_NorESM1_M (represents maximum precipitation)

After selecting the model, users can download the ascii data when they click on the required model folder. To download the IDF ASCII file, the following durations are available (in minutes): 5, 10, 15, 20, 30, 45, 60, 120, 180, 240, 360, 540, 720, 1080, 1440, 2880, 5760, 7200, 8640. Additionally, the following return periods are available (in years): 0.5, 1, 2, 5, 10, 20, 50, 100, 1000, 10000.

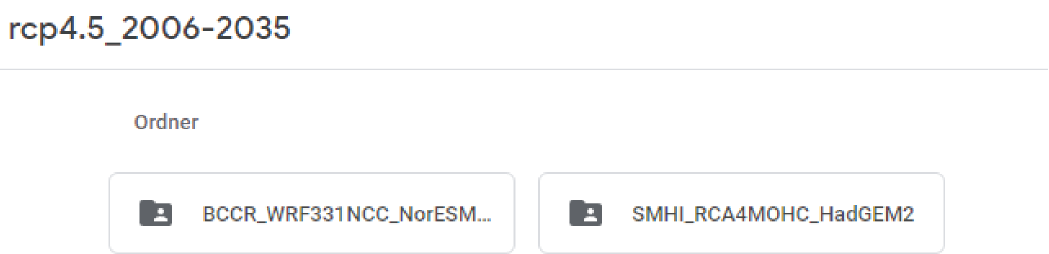
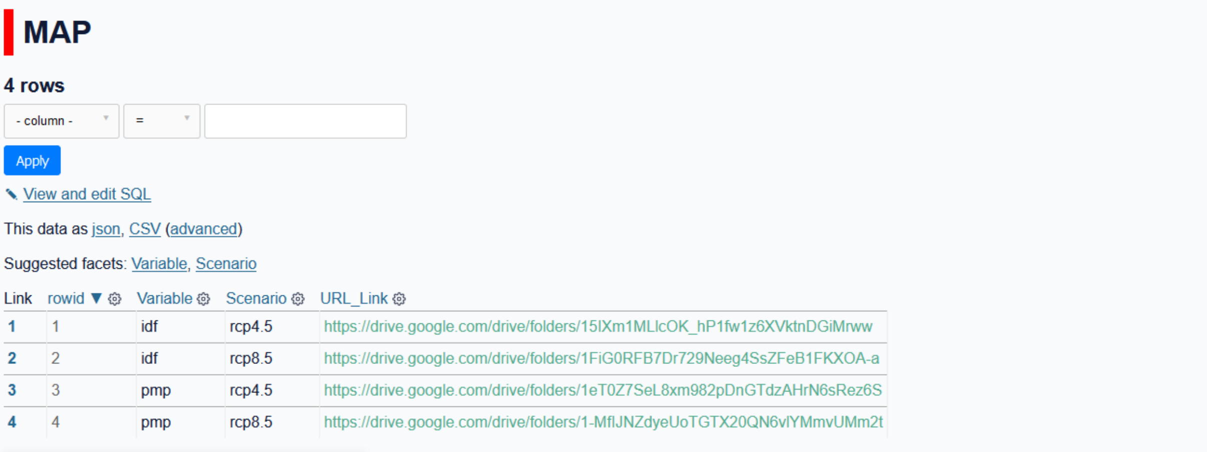


Figure 9: Climate Model folder encompassing the different models.

2.4 MAP

The MAP page consists of the datasets which are saved in form of GIS maps, which are generated to visualize the results of the entire Nile Basin. Users can download the map by clicking on the “MAP” link and specify the folder to be downloaded by selecting the variable (IDF, PMP) and scenario (rcp4.5, rcp8.5). Figure 10 shows the overview of the MAP page.



MAP

4 rows

- column - =

Apply

View and edit SQL

This data as json, CSV (advanced)

Suggested facets: Variable, Scenario

Link	rowid ▼	Variable	Scenario	URL_Link
1	1	idf	rcp4.5	https://drive.google.com/drive/folders/15lXm1MLlcOK_hP1fw1z6XVktnDGiMrww
2	2	idf	rcp8.5	https://drive.google.com/drive/folders/1FiG0RFB7Dr729Neeg4SsZFeB1FKXOA-a
3	3	pmp	rcp4.5	https://drive.google.com/drive/folders/1eT0Z7SeL8xm982pDnGTdzAHrN6sRez6S
4	4	pmp	rcp8.5	https://drive.google.com/drive/folders/1-MflJNZdyeUoTGTX20QN6vlYMmvUMm2t

Figure 10: MAP page

Same as ASCII file datasets, Users can get access to the climate model folders by clicking on the URL link. The available climate models are:

1. SMHI_RCA4MOHC_HadGEM2 (represents minimum precipitation)
2. BCCR_WRF331NCC_NorESM1_M (represents maximum precipitation)

The model folder entails the following folders: cluster maps, grid maps (Figure 11).

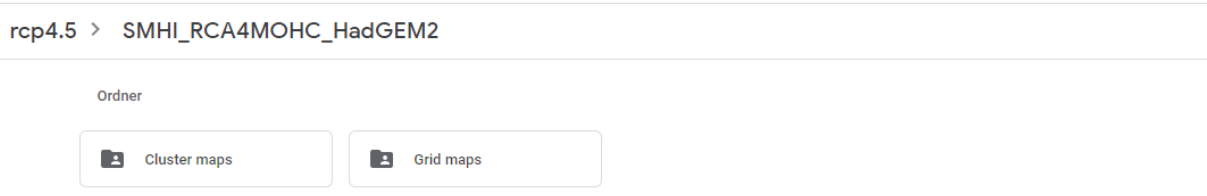


Figure 11: Map folder.

Cluster maps represent the change in intensity, duration, frequency by comparing the historical and future IDF values. The data is represented as a radar diagram for each cluster. The folder entails the maps for different periods: 2006-2035, 2036-2065, 2066-2095. On the other hand, the grid maps show the IDF and PMP values at different periods representing different statistics and histogram graphs for each period. The maps demonstrate the change in values beginning from the historical period to the far future.

2.5 Query page

Clicking on the “Query” in the homepage, will lead to a page with a text field where the SQL query can be entered. The user can easily query on finding a certain record based on the longitude/latitude values or the ID values. Additionally, the user can easily select one or multiple records using queries as shown in the following figures. After writing the query, the user can click on the "run SQL" button and the results will appear.

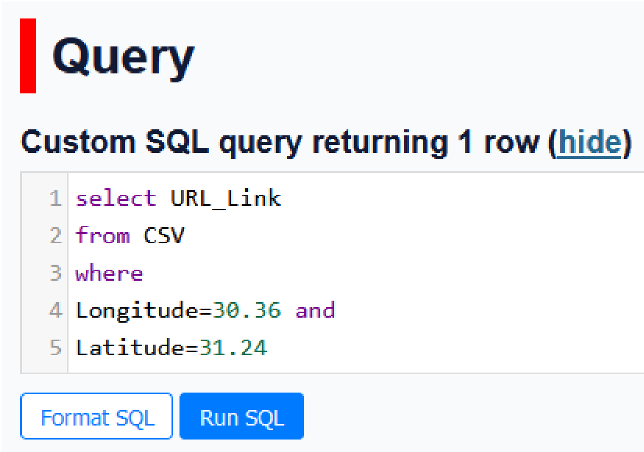


Figure 12: SQL query for one record to download data in CSV format. Note: querying at a certain location using longitude and latitude input value.

Figure 13: SQL query for one record to download a CSV files. Note: querying at certain location using rowed input value.

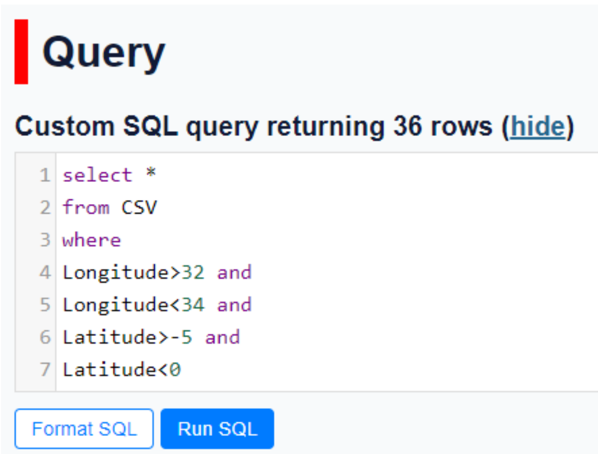


Figure 14: SQL query for multiple records. Note: the user can search for datasets located inside Lake Victoria by specifying the longitude and latitude ranges.

Query

Custom SQL query returning 1 row (hide)

```
select *
from ASCII
where
Variable="idf" and
Scenario="rcp4.5" and
Period="2006-2035"
```

Format SQL | Run SQL

Figure 15: SQL query for one record to download ASCII files. Note: querying using variable, scenario, and period as input.

Query

Custom SQL query returning 1 row (hide)

```
select *
from MAP
where
Variable="idf" and
Scenario="rcp4.5"
```

Format SQL | Run SQL

Figure 16: SQL query for one record to download maps. Note: querying using variable and scenario as input.

3 APPLICATION OF DATABASE PORTAL

To train users how they can apply the database portal, several examples have been prepared in this section. The Ngono basin, which is located in the south-western part of the Nile Basin has been selected out of the 7 case studies to demonstrate these examples.

3.1 Example 1: Data preparation for a precipitation runoff model

If users want to set-up a precipitation runoff model including water infrastructures for Ngono the following data is required:

- Precipitation timeseries
- Temperature timeseries
- IDF table

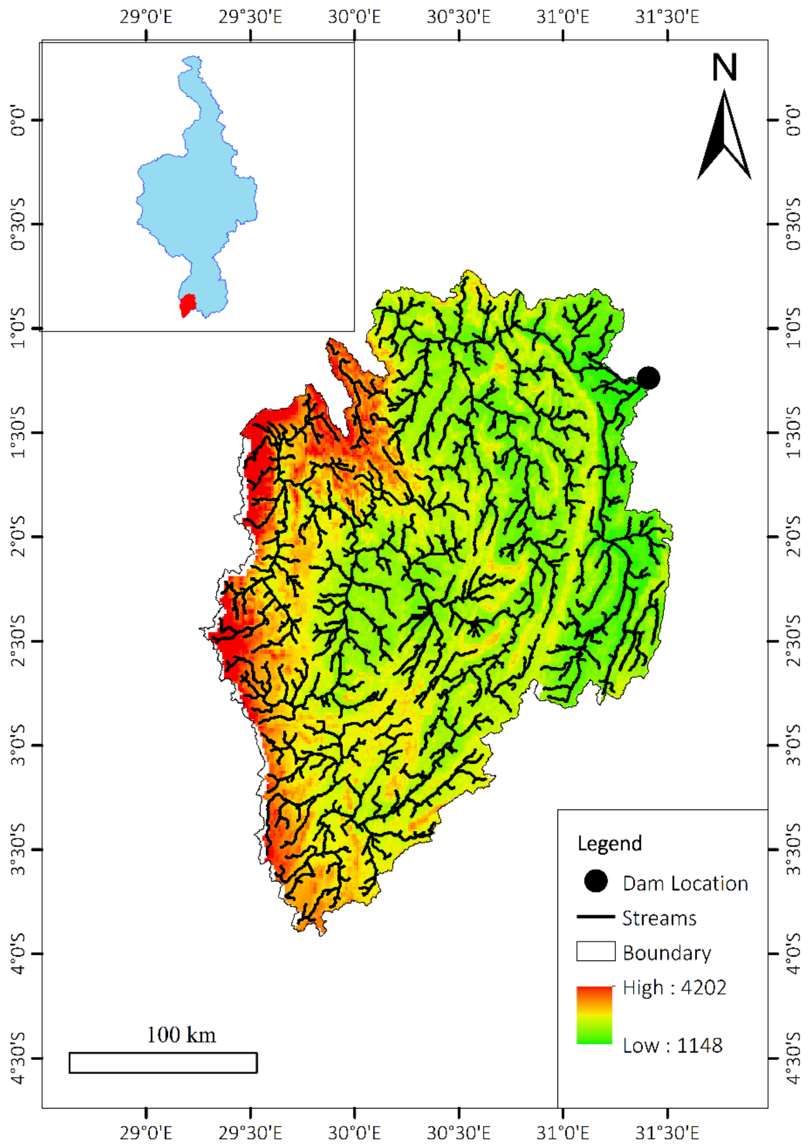


Figure 17: Ngono basin (Example).

Prior to extracting the required data from the website, users have to follow the following steps:

- Specify the location extension (upper-left and lower-right coordinates).

- Conduct the query process in the website
- Download the data
- Process the data

3.1.1 Step 1: Specify the location boundary

Users have to specify the spatial extent prior to determining the data files to be downloaded using the database portal. This can be done by specifying the coordinates of the lower-left boundary and the upper-right boundary. In this example the lower-left corner of the basin is around (29°15' E, 4° S) and the upper-right corner is approximately (31°30' E, 0°45' S).

In case the users want to download only the data located inside the basin they can divide the basin into smaller rectangles and specify the lower-left and upper-right corner coordinates as shown in Figure 18.

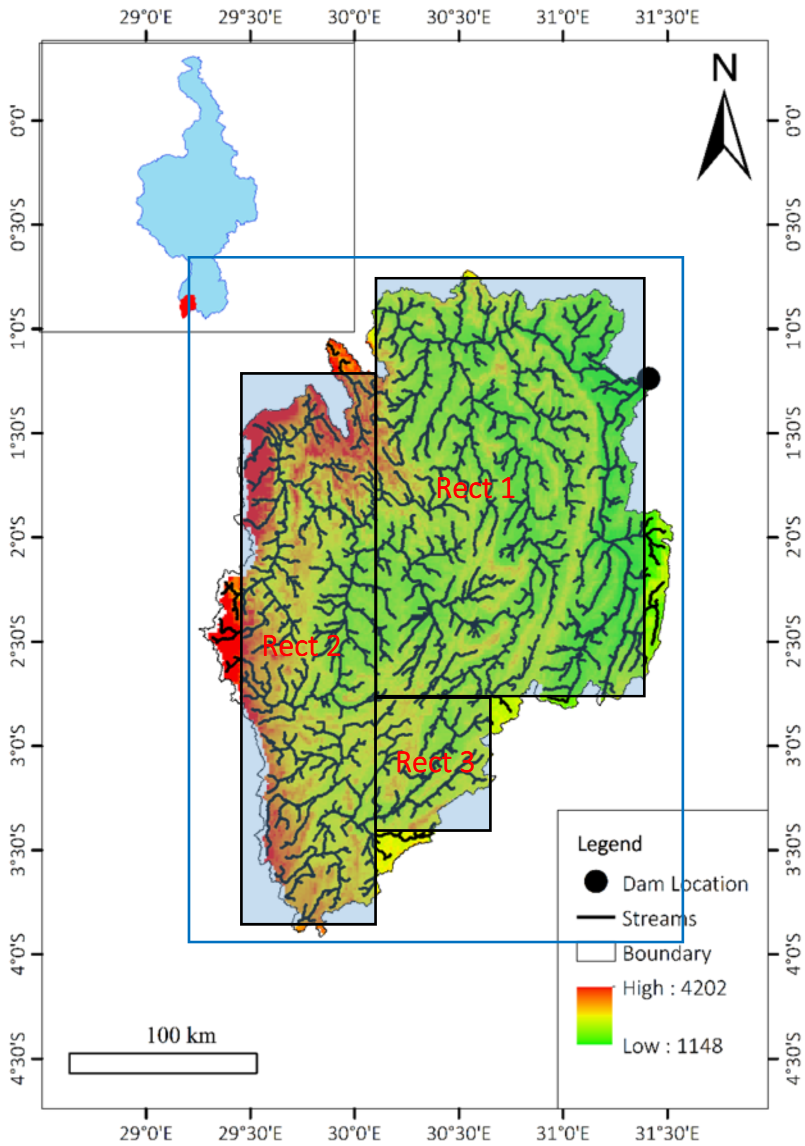


Figure 18: Illustrating dividing the basin into smaller portions. The blue frame represents the spatial extent without dividing the basin into smaller rectangles. The black frame rectangles represent the location extension after dividing the basin into smaller rectangles.

The following table shows the lower-left and upper-right corner coordinate values for the 3 rectangles. The coordinates were determined using the aforementioned approach. Users have to convert the geographical projection coordinates from degrees to decimals. The table shows the values in both formats: degrees and decimals.

	Lower-left corner		Upper-right corner	
	Degree format	Decimal format	Degree format	Decimal format
Rect 1	30°10′ E, 2°15′ S	30.16, -2.25	31°30′ E, 0°45′ S	30.50, -0.75
Rect 2	29°30′ E, 3°50′ S	29.50, -3.83	30°10′ E, 1°15′ S	30.16, -1.25
Rect 3	30°10′ E, 3°25′ S	30.16, -3.42	30°40′ E, 2°50′ S	30.67, -2.83

3.1.2 Step 2: Conduct the query process in the website

After specifying the spatial extent in decimals, the database portal "http://5.175.16.252:8002" can be opened and a query can be started by clicking on the "query" link. A new window will open encompassing a text field where an SQL query can be entered. Using the following SQL query as shown in Figure 19, users can specify the cells which lie within the basin.

```
select *
from CSV
Where
/*Rect 1*/
(Longitude between 30.16 and 30.5
 and
 Latitude between -2.25 and -0.75)
```

```
select *
from CSV
Where
/*Rect 2*/
(Longitude between 29.5 and 30.16
 and
 Latitude between -3.83 and -1.25)
```

```
select *
from CSV
Where
/*Rect 3*/
(Longitude between 30.16 and 30.67
 and
 Latitude between -3.42 and -2.83)
```

Figure 19: SQL query to extract the required cells for rectangle 1, 2, and 3.

After querying process users can just click on run SQL, the results will appear as shown in Figure 20 and Figure 21 in the form of a web map and a table. In the web map, the selected cells are represented as point feature. Users can easily click on the feature where a new pop up window will appear listing all the information related to this cell. Additionally, users can get access to all the selected cells through the table (11 cells) and can get access to the data by clicking on the URL link.

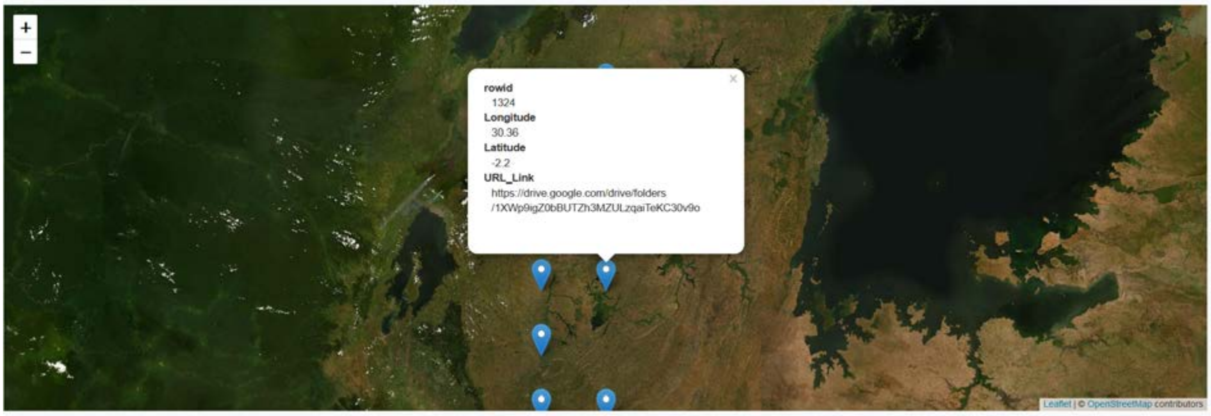


Figure 20: Query results (web map).

rowid	Longitude	Latitude	URL_Link
1280	30.36	-0.88	https://drive.google.com/drive/folders/15Wc3nwH0tu8sHRX687qJtf-cXL6ClBFt
1293	29.92	-1.32	https://drive.google.com/drive/folders/1f7aN2XjZ2G8pND6vz5v-ANReQKbCAwrs
1294	30.36	-1.32	https://drive.google.com/drive/folders/1enZ7Up-Dmrk3Tn3DFvuRtTNVQqEg0lez
1308	29.92	-1.76	https://drive.google.com/drive/folders/1JT4SL4CkrqY4Ma2HY0aGBte_KC7GkS9d
1309	30.36	-1.76	https://drive.google.com/drive/folders/1uGWTbF4BW2xDT9U1TOb_yChvDgAsINxE
1323	29.92	-2.2	https://drive.google.com/drive/folders/1zDmsoGjo9oPrFlJbcZRi9pSZCdyls-b4
1324	30.36	-2.2	https://drive.google.com/drive/folders/1XWp9igZ0bBUTZh3MZULzqaiTeKC30v9o
1337	29.92	-2.64	https://drive.google.com/drive/folders/1M4qLqoLxjMPrwlf5lYMDgHrUHYt21pnh
1350	29.92	-3.08	https://drive.google.com/drive/folders/1Sd3RjV7a6lZ0-bCP6lFfvPRS1s_GuSPr
1351	30.36	-3.08	https://drive.google.com/drive/folders/1tXhlxRR5O10tlDUAkCh01l3v5cPOFy5P
1358	29.92	-3.52	https://drive.google.com/drive/folders/1vNkFZMdyOXWHQ8e5JYJDHc9_u-i039Oq

Figure 21: Query results (Table).

3.1.3 Step 3: Download the data

Clicking on URL link, users can get access to google drive folder for this record/cell. The google folder entails different folders structured by the time period (1971 - 2000, 2006 - 2035, 2036 – 2065, 2066 - 2095), the climate emission scenario (historical, rcp4.5, rcp8.5) and climate model (BCCR, SMHI). Let's suppose that users would like to choose the data characterized by maximum temperature and minimum precipitation for the far future period (2006-2095). In this case, users have to download the following scenario "rcp85SMHI_RCA4MOHC_HadGEM2". The description of all scenarios in this database is described in section 2.2.

To obtain the data for this scenario, users can choose "rcp8.5_2066-2095" from the main folder, then they can choose "SMHI_RCA4MOHC_HadGEM2". Afterwards, 5 CSV format files will appear representing the different climate variables: pr.csv (precipitation timeseries), tasmax.csv (maximum temperature timeseries), tasmin.csv (minimum temperature timeseries), IDF.csv (IDF table), PMP.csv (PMP table). Users can repeat the previous steps to download the other cells (in this example 11 cells). To save time, user can download the whole folder instead of downloading each file.

3.1.4 Step 4: process the data

Lumped precipitation runoff models usually require one timeseries per basin. However, in this case 11 timeseries are representing the basin. To overcome this issue, users can calculate the mean value of the timeseries. This could be done in Microsoft Excel, where users can create multiple sheets named by the cell number and copy the data to these sheets. Using the “mean” function in Excel, users can easily calculate the mean for the required climate variable (precipitation, temperature, etc).

3.2 Example 2: IDF and PMP extraction for a basin.

Suppose that the users want to extract the IDF and PMP values at a certain duration and frequency for a certain basin. First of all, a polygon shape file has to be obtained for Ngono basin. To extract the files from the website. The following steps should be followed:

- Conduct the query process in the website
- Download the data
- Process the data

3.2.1 Step 1: Conduct the query process in the website

Users can access the database portal “http://5.175.16.252:8002”. By clicking on “query” a new window will open encompassing a text field where an SQL query can be entered to specify the required variable, scenario, and period. In this example, it is required to choose for example the IDF values for “rcp4.5” scenario and the “2006-2035” period. Thus, the users have to enter the following SQL query as shown in Figure 22. After writing the query, users can click on “run SQL” button and results will appear including the URL link for the files.

Custom SQL query returning 1 row (hide)

```
select *
from ASCII
where
Variable="idf" and
Scenario="rcp4.5" and
Period="2006-2035"
```

Format SQL Run SQL

Figure 22: SQL query to extract the IDF values for rcp4.5 scenario and 2006-2035 period.

3.2.2 Step 2: Download the data

Users can get access to the IDF folder by clicking on the URL link. A google folder window where users can choose the required climate model will appear. To download for example the intensity values at duration = 1440 min and frequency = 1000 yr, users have to search for the file “rcp4.5_2006-2035_1440min_1000yr.asc” and download the ASCII file.

3.2.3 Step 3: Process the data

Using ArcGIS, users can import the basin polygon shape file and the downloaded ASCII file format to ArcMap using the “add data” tool. Users should define the coordinate projection system of the ASCII file using the “define projection” tool. The coordinate projection system for this file is “GCS_WGS_1984”. Afterwards the “clip” data management tool can be applied to extract the cells located inside the basin. The output file can represented as shown in Figure 23. The output files can be exported as ASCII format or other format prior to being utilized in other spatially distributed hydrological models such as HecGeoHMS.

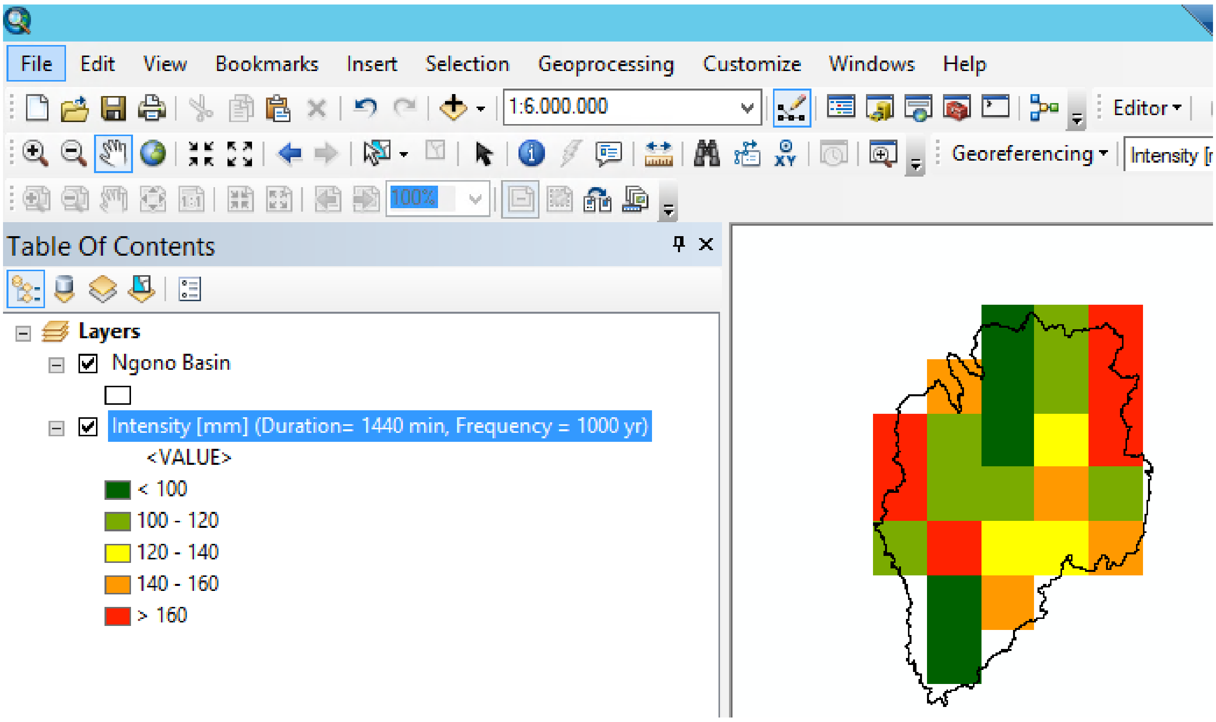


Figure 23: ArcGIS output showing the clipped ASCII file format.

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