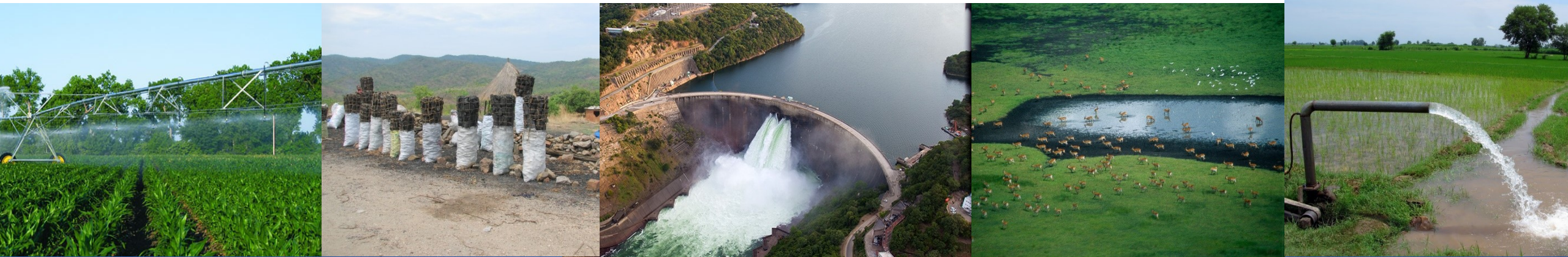
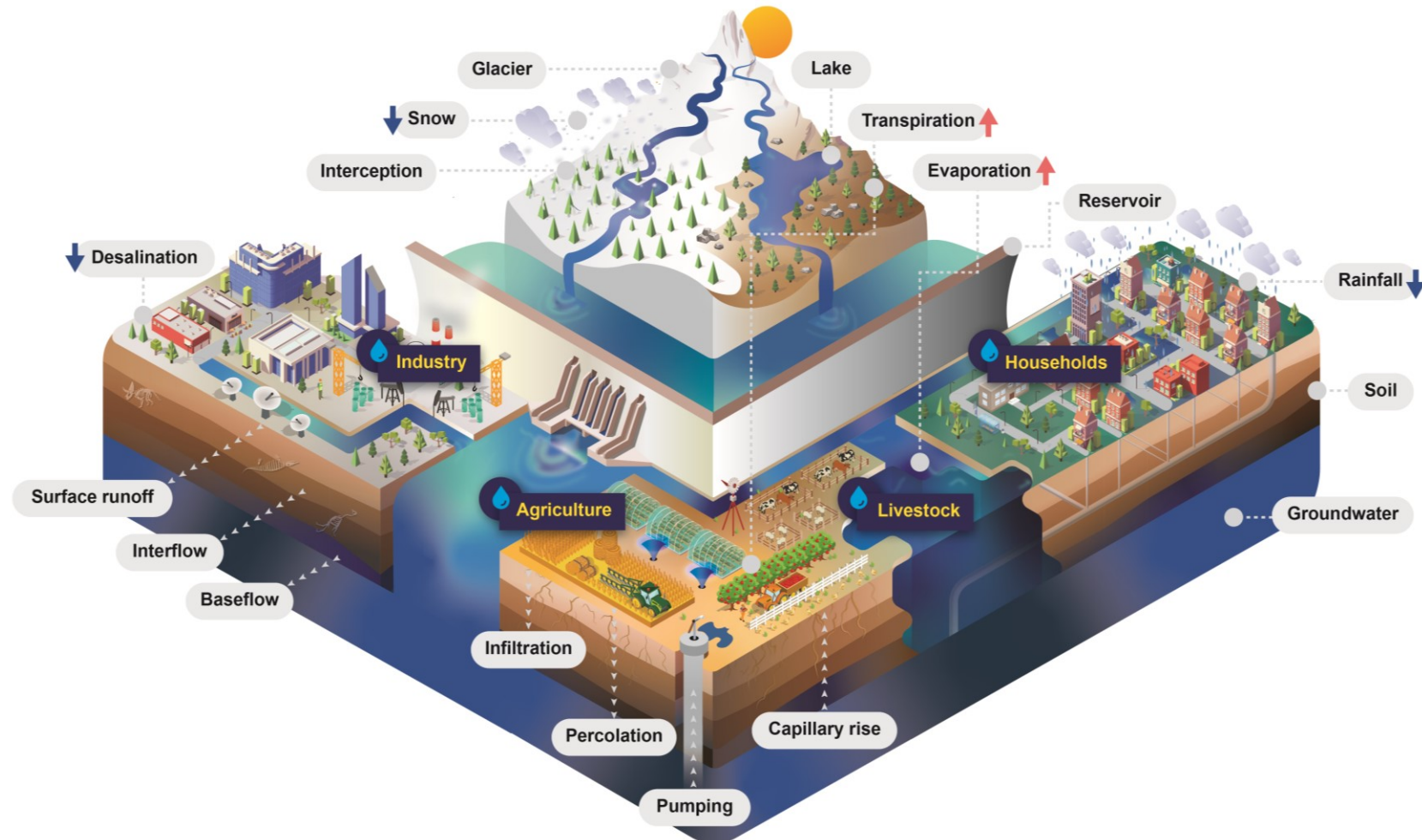


Hands on CWatM

Peter Burek, Mikhail Smilovic
International Institute for Applied Systems Analysis
Research Scholars at
Water Program
15th Oct 2020

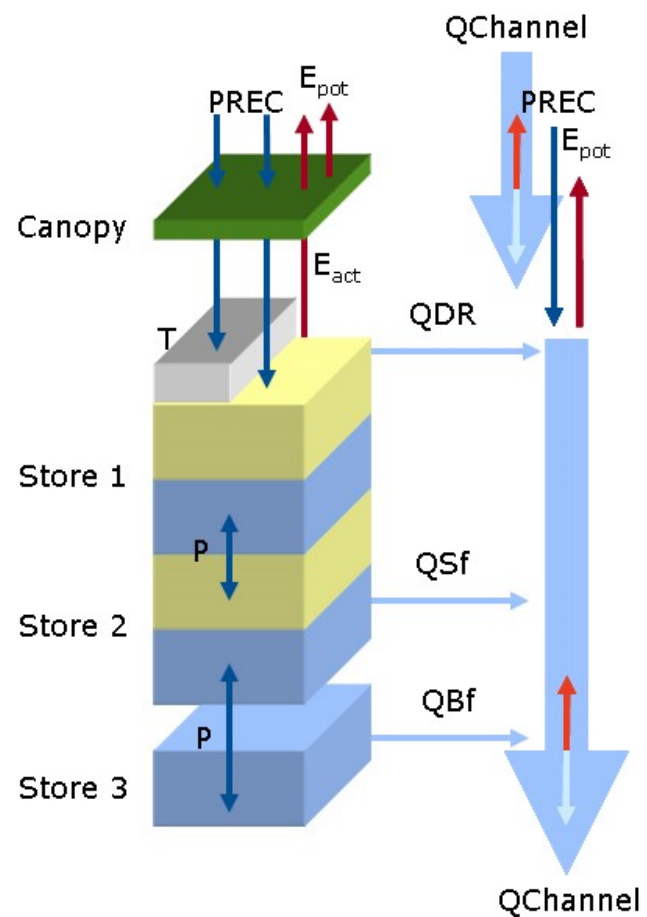


Community Water Model (CWatM)

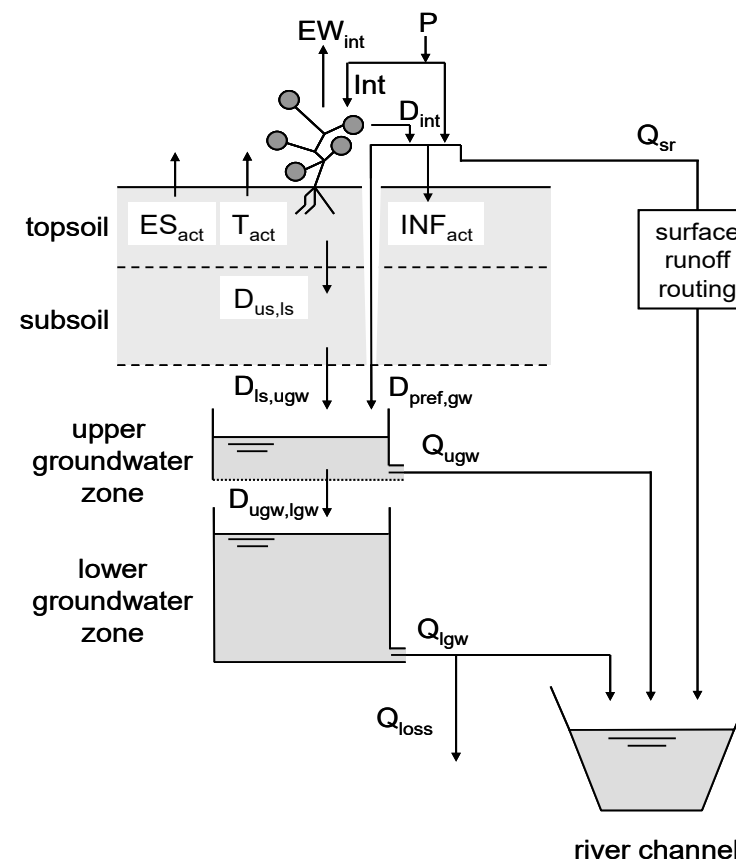


<http://www.iiasa.ac.at/cwatm>
<https://cwatm.iiasa.ac.at/>

IIASA Community Water Model



PCR-GLOBWB

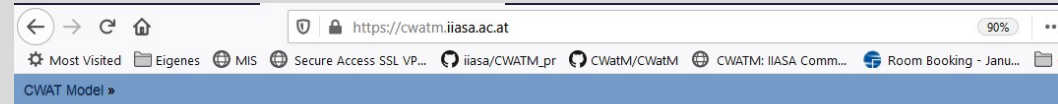


LISFLOOD

Comm

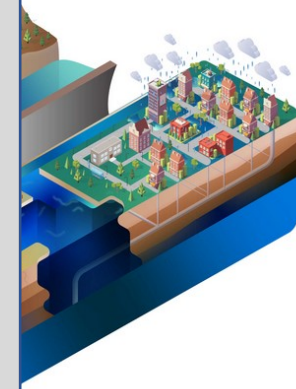
Community Model on the web

<https://cwatm.iiasa.ac.at/>

A screenshot of the CWatM GitHub repository page. The page header shows the GitHub logo, a search bar, and navigation links for 'Pull requests', 'Issues', and 'Gist'. The repository name 'CWatM' is displayed with a blue water drop logo. The 'Overview' tab is selected, showing 'Popular repositories' with 'CWatM' and 'cwatm.github.io' listed. A '34 contributions in the last year' section shows a calendar grid with green squares indicating contributions. The repository description reads 'Community Water Model CWatM'.

Open source on Github

<https://github.com/CWatM/CWatM>



Community Water Model

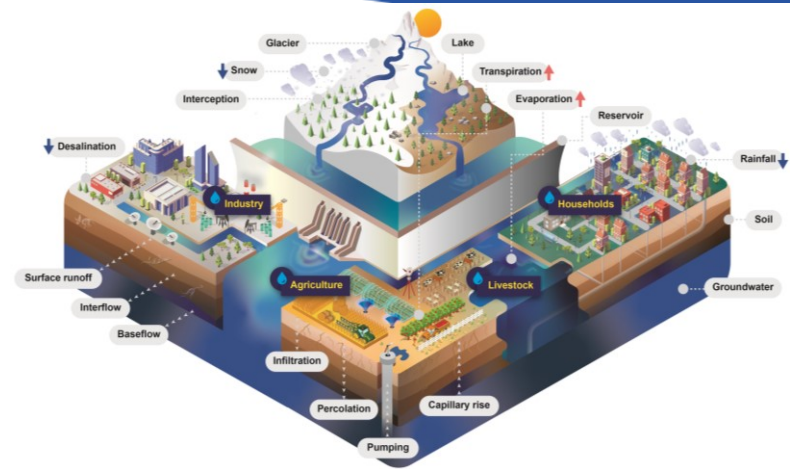


Feature	Description
Flexible	different resolution, different processes for different needs, links to other models, across sectors and across scales
Adjustable	to be tailored to the needs at IIASA i.e. collaboration with other programs/models, including solutions and option as part of the model
Multi-disciplinary	including economics, environmental needs, social science perspectives etc.
Sensitive	Sensitive to the option / solution
Fast	Global to regional modeling – a mixture between conceptual and physical modeling – as complex as necessary but not more
Comparable and exchangeable	Planned to be part of the ISI-MIP community, part of capacity development

Modules in CwatM

Cwatm_init

...



Cwatm_dynamic

readmeteo_module



evaporatePot_module



inflow_module



lakes_reservoirs_module



snowfrost_module

landcoverType_module

evaporation_module

interception_module

waterdemand_module

soil_module

actTrans

dirctRunoff

interflow

gwRecharge

sealed_water_module

groundwater_module



runoff_concentration



lakes_res_small_module



routing_kinematic_module



environmentalflow



output_module

Installation of software 1

Texteditor

CWatM information (settingsfile) is stored in a text file, which can be read by Windows notepad.

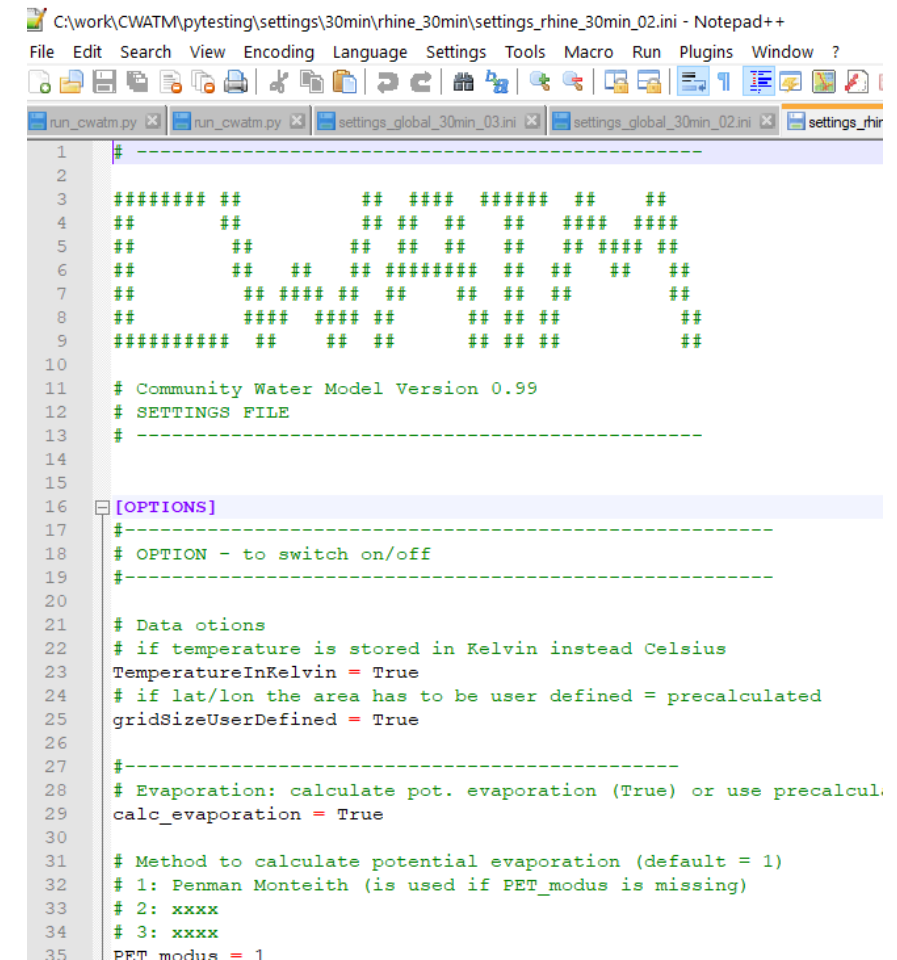
But we strongly recommend a better text editor!

You can use any text editor you are familiar with.

In case you do not have a texteditor

Install notepad++ in the Dropbox folder cwatm_exercise1/tools
or from

<https://notepad-plus-plus.org>



```
C:\work\CWATM\pytesting\settings\30min\rhine_30min\settings_rhine_30min_02.ini - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
run_cwatm.py run_cwatm.py settings_global_30min_03.ini settings_global_30min_02.ini settings_rhir

1  # -----
2
3  #####  ##          ##  ###  #####  ##  ##
4  ##      ##          ##  ##  ##  #####  ##
5  ##      ##          ##  ##  ##  ##  ##  ##
6  ##      ##  ##  ##  #####  ##  ##  ##  ##
7  ##      ##  ##  ##  ##  ##  ##  ##  ##
8  ##      ###  ##  ##  ##  ##  ##  ##
9  #####  ##  ##  ##  ##  ##  ##
10
11  # Community Water Model Version 0.99
12  # SETTINGS FILE
13  # -----
14
15
16  [OPTIONS]
17  # -----
18  # OPTION - to switch on/off
19  # -----
20
21  # Data options
22  # if temperature is stored in Kelvin instead Celsius
23  TemperatureInKelvin = True
24  # if lat/lon the area has to be user defined = precalculated
25  gridSizeUserDefined = True
26
27  #-----
28  # Evaporation: calculate pot. evaporation (True) or use precalcul
29  calc_evaporation = True
30
31  # Method to calculate potential evaporation (default = 1)
32  # 1: Penman Monteith (is used if PET_modus is missing)
33  # 2: xxxx
34  # 3: xxxx
35  PET_modus = 1
```

Installation of software 2

Texteditor

CWatM data and output can be quite large

Therefore we store our data as compressed as possible as netCDF files

NetCDF is a nice format but not so easy to handle as this is mostly used by meteorologist on there Linux systems

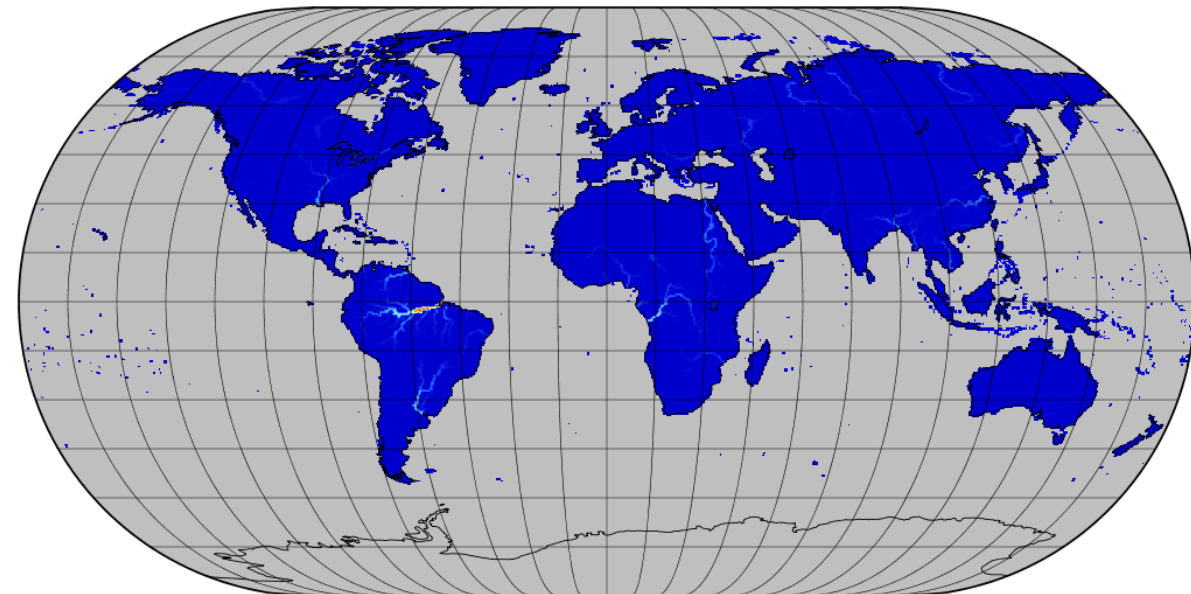
To view input and output data on Windows you can use the Panoply netCDF viewer

Install panoply from the Dropbox in the folder cwatm_exercise1/tools or from:

<https://www.giss.nasa.gov/tools/panoply/>



Discharge in cubic meter per second: average over the whole time period



Discharge in cubic meter per second: average over the whole time period (m3/s)



Data Min = 0.0, Max = 183284.3, Mean = 640.0

Installation of software 3

CWatM GitHub

Our software is open source.

We use a public repository to store our software – Github

<https://github.com/CWatM/>

As CWatM is a living software, we add thing, change things, remove bugs

And we put our changes alive on GitHub

This workshop gives a short introduction into GitHub

Therefore it would be good if you:

- subscribed to a GitHub account
- install GitHub Desktop (<https://desktop.github.com/>)

<https://github.com/>

<https://docs.github.com/en/free-pro-team@latest/github/getting-started-with-c>

<https://www.wikihow.com/Create-an-Account-on-GitHub>



Installation of software 5

CWatM + Exercises

Please download all the files in:

<https://www.dropbox.com/sh/gvzg2ucbybkf0q1/AAANxK-JfH6lrWqh2FsM33UTa?dl=0>

And unzip the three zipped folders:

- CWatM_05102020.zip (CWatM Python version)
- CWatMexe_05102020.zip (CWatM executable version)
- rhine30min.zip (test catchment and data)

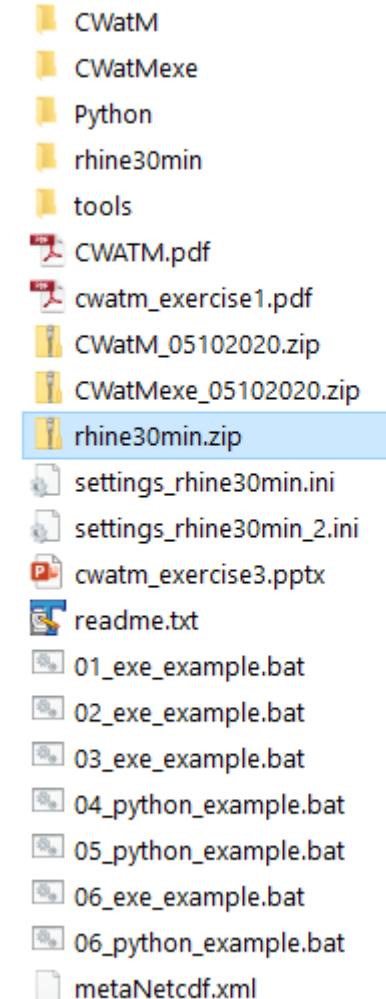
With:

Extract here

The folder structure should look likes this

(You need some diskpace – the whole folder structure needs around 2GB)

Name



- CWatM
- CWatMexe
- Python
- rhine30min
- tools
- CWATM.pdf
- cwatm_exercise1.pdf
- CWatM_05102020.zip
- CWatMexe_05102020.zip
- rhine30min.zip
- settings_rhine30min.ini
- settings_rhine30min_2.ini
- cwatm_exercise3.pptx
- readme.txt
- 01_exe_example.bat
- 02_exe_example.bat
- 03_exe_example.bat
- 04_python_example.bat
- 05_python_example.bat
- 06_exe_example.bat
- 06_python_example.bat
- metaNetcdf.xml

Hands on CWatM

1. Running CWatM for the first time
2. Run CWatM with a settings file
3. Test the options `-l` , `-t`
4. Take a look at the settings file
5. Take a look at the dataset
6. Have a look at the documentation <https://cwatm.iiasa.ac.at/>
7. Have a look at github <https://github.com/CWatM/CWatM>
8. Installing Python, libraries and CWatM



Hands on CWatM

1. Running CWatM for the first time

- Go to folder CWATM_exercise1
- Look into directory rhine30min
- Start: 01_exe_example.bat

```
F:\CWATM_exercise2\rhine30min>..\CWatMexe\cwatmexe\cwatm.exe
CWatM - Community Water Model
Authors: WATER Program, IIASA
Version: Version: 1.04
Date: 06/08/2019
Status: Development

Arguments list:
settings.ini      settings file

-q --quiet        output progression given as .
-v --veryquiet    no output progression is given
-l --loud         output progression given as time step, date and discharge
-c --check        input maps and stack maps are checked, output for each input map BUT no model run
-h --noheader     .tss file have no header and start immediately with the time series
-t --printtime    the computation time for hydrological modules are printed
-w --warranty     copyright and warranty information
```

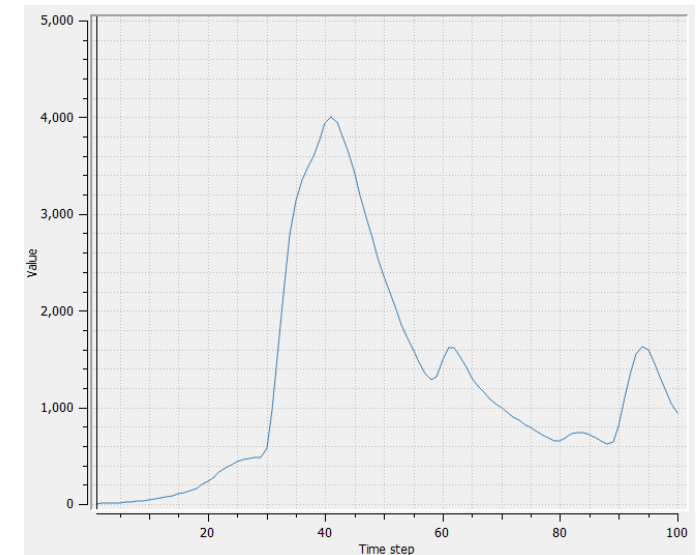
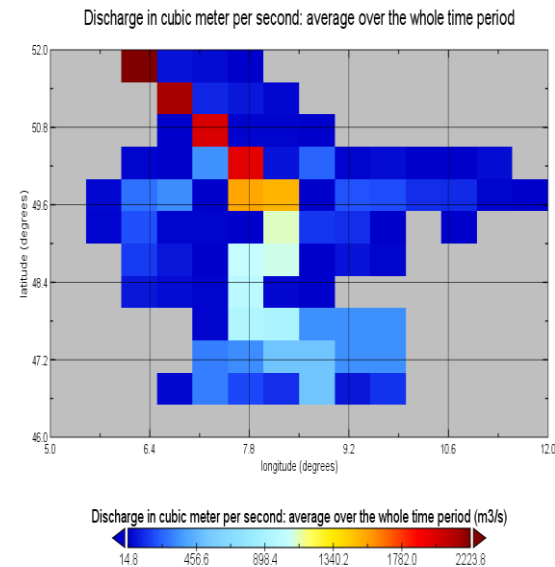
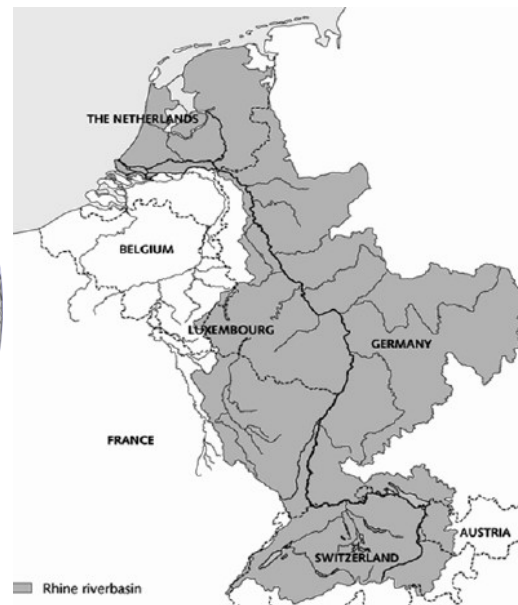
Name

- CWatM
- CWatMexe
- Python
- rhine30min
- tools
- CWATM.pdf
- cwatm_exercise1.pdf
- CWatM_05102020.zip
- CWatMexe_05102020.zip
- rhine30min.zip
- settings_rhine30min.ini
- settings_rhine30min_2.ini
- cwatm_exercise3.pptx
- readme.txt
- 01_exe_example.bat
- 02_exe_example.bat
- 03_exe_example.bat
- 04_python_example.bat
- 05_python_example.bat
- 06_exe_example.bat
- 06_python_example.bat
- metaNetcdf.xml

Hands on CWatM

2. Run CWatM with a settings file

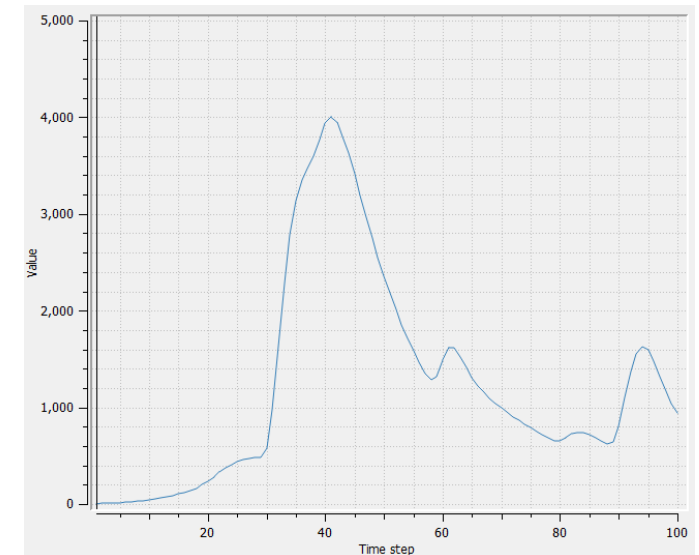
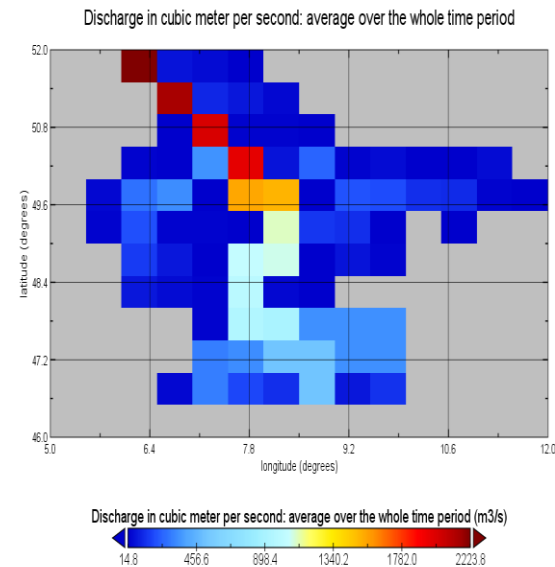
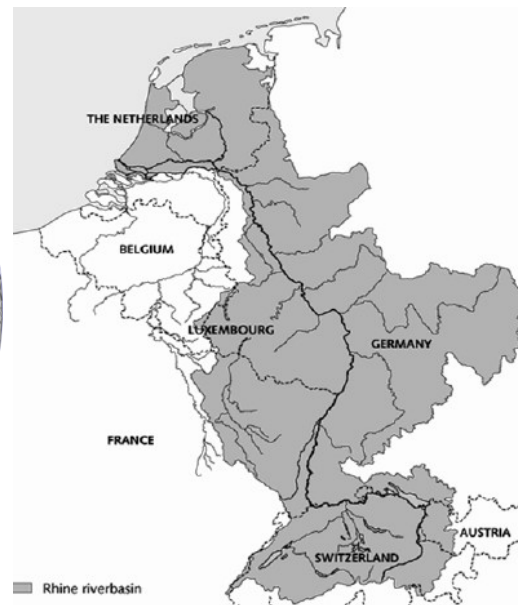
- Start 02_exercise.bat
`..\CWatMexe\cwatmexe\cwatm.exe settings_rhine30min.ini -l`
- Use a text editor e.g. notepad, textpad, notepad++
- Look at rhine30min\output\discharge_daily.tss



Hands on CWatM

3. Run CWatM with a settings file

- Start 03_exercise.bat
`..\CWatMexe\cwatmexe\cwatm.exe settings_rhine30min.ini -l -t`
- Use a text editor e.g. notepad, textpad, notepad++ to change 03_exercise.bat

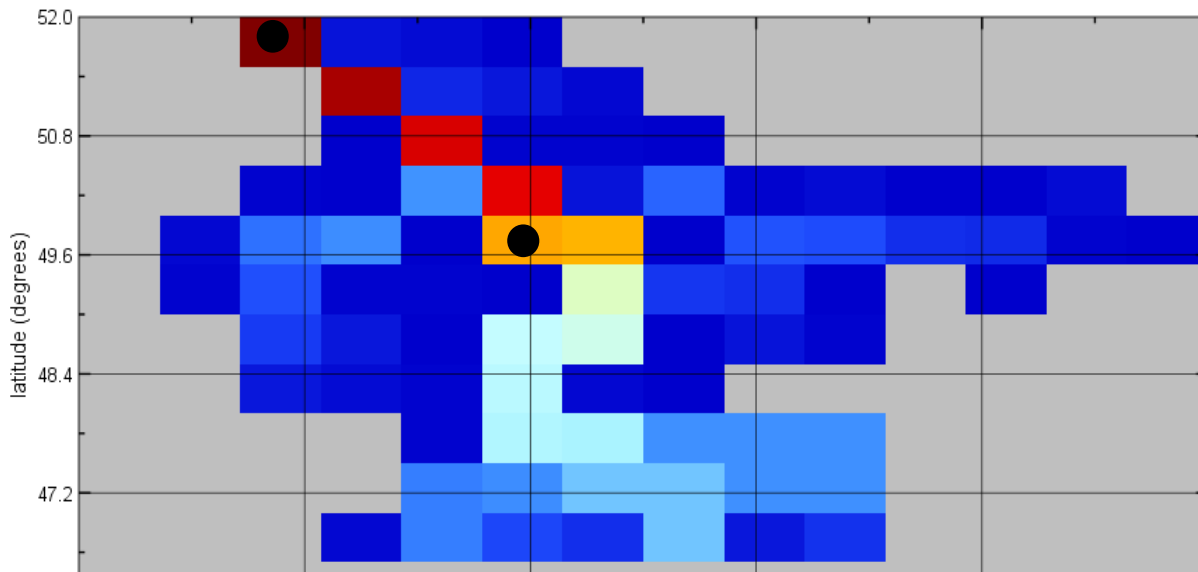


Exercise 3: Hands on CWatM

4. Take a look at the settings file

- Change settings_rhine30min.ini with a text editor
- Look for gauges in settings_rhine30min.ini
- Change it to Gauges = 6.25 51.75 7.75 49.75
- Change StepEnd = 100
- Start 02_exercise.bat

Discharge in cubic meter per second: average over the whole time period



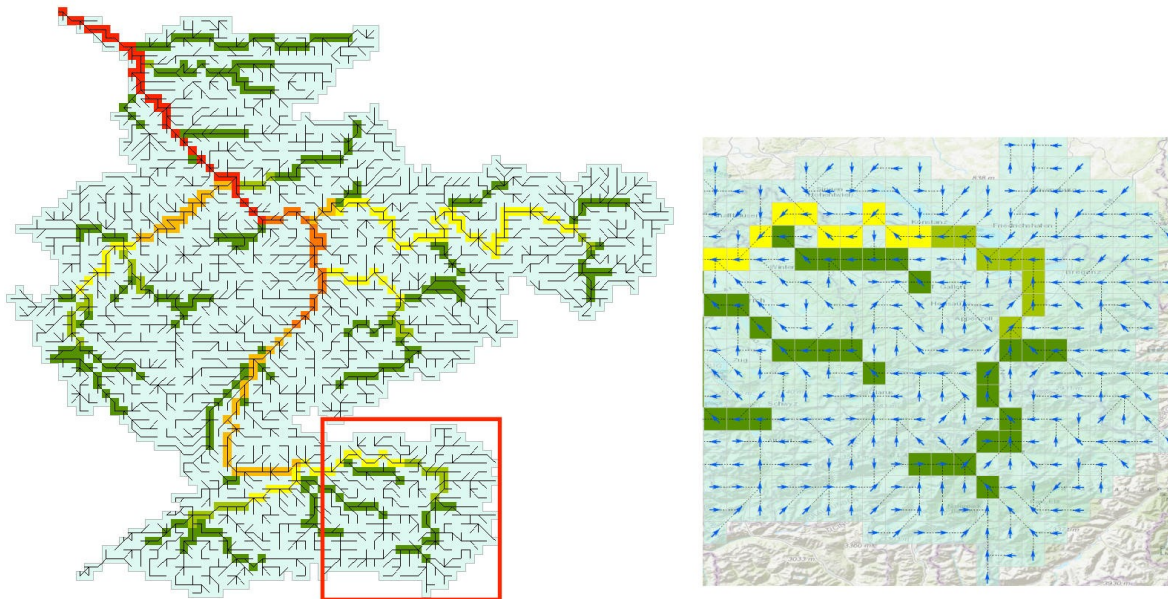
```
*C:\work\CWATM\source\settings1.ini - Notepad++
File Edit Search View Encoding Language Settings Macro Run Plugins Window ?
settings1.ini
1 # -----
2
3 ##### ##      ## ### ##### ##
4 ##      ##      ## ## ##      ##
5 ##      ##      ## ## ##      ##
6 ##      ##      ## ##### ##      ##
7 ##      ##      ## ## ##      ##
8 ##      ##      ## ## ##      ##
9 ##### ##      ## ##      ##
10
11 # Community Water Model Version 0.99
12 # SETTINGS FILE
13 # -----
14 #
15 # OPTION - to switch on/off
16 # -----
17
18 [OPTIONS]
19 [NETCDF_ATTRIBUTES]
20 [BASICS]
21 PathRoot = C:\work
22
23 # -----
24 # AREA AND OUTLETS
25 # -----
26
27 [MASK_OUTLET]
28
29 # Area mask
30 # A pcraster map e.g. $(BASICS:PathRoot)\data\areamaps\area_indus.map
31 # or a rectangle: Number of Cols, Number of rows, cellsize, upper left corner X, upper left corner Y
32
33 MaskMap = $(BASICS:PathRoot)\data\areamaps\area3.map
34 # Indus
35 #MaskMap = 30 20 0.5 65 38
36 #MaskMap = $(BASICS:PathRoot)\data\areamaps\area_indus.map ; Cut out Indus only
37 # Rhine
38 #MaskMap = 30 20 0.5 3 54
39
40 # Station data
41 # either a map e.g. $(BASICS:PathRoot)\data\areamaps\area3.map
42 # or a location coordinates (X,Y) e.g. 5.75 52.25 9.25 49.75 )
43
44 #Gauges = $(BASICS:PathRoot)\data\areamaps\station8.map
45 # Rhine
46 Gauges = 5.75 52.25 9.25 49.75
47
48 # -----
49
50 [TIME-RELATED_CONSTANTS]
51 # -----
52
53 # StepStart and StepEnd either dates e.g. 01/06/1990
```

Exercise 3: Hands on CWatM

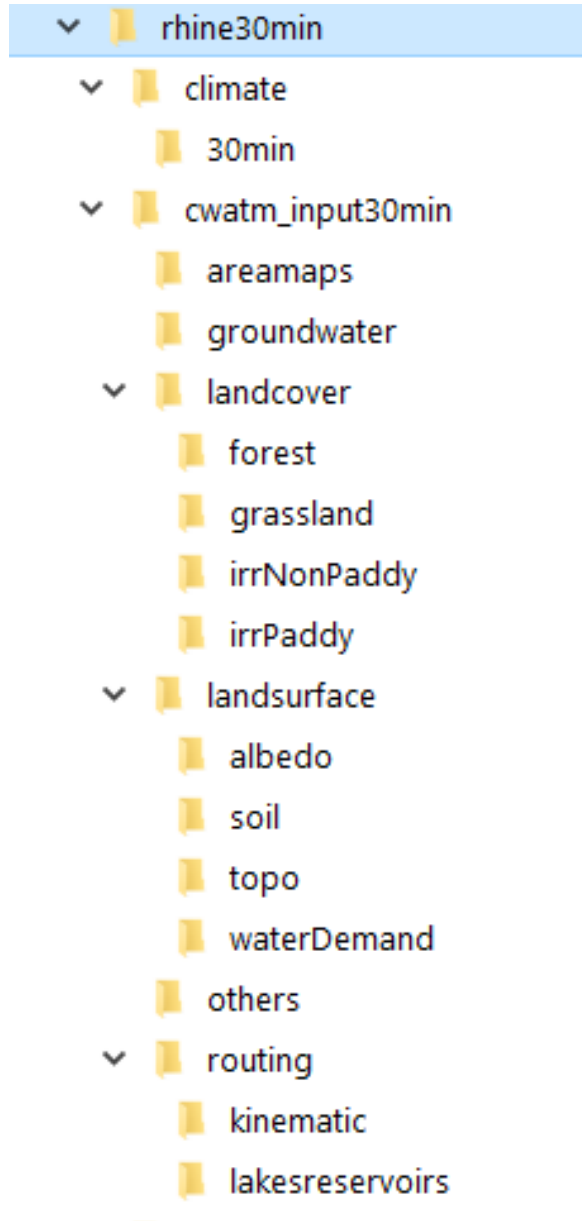
5. Take a look at dataset

- Take a look at folder rhine30min
- Take a look at:

<https://cwatm.iiasa.ac.at/data.html>



River network at 5 arcmin for the Rhine basin



Exercise 3: Hands on CWatM

6. Have a look at the documentation

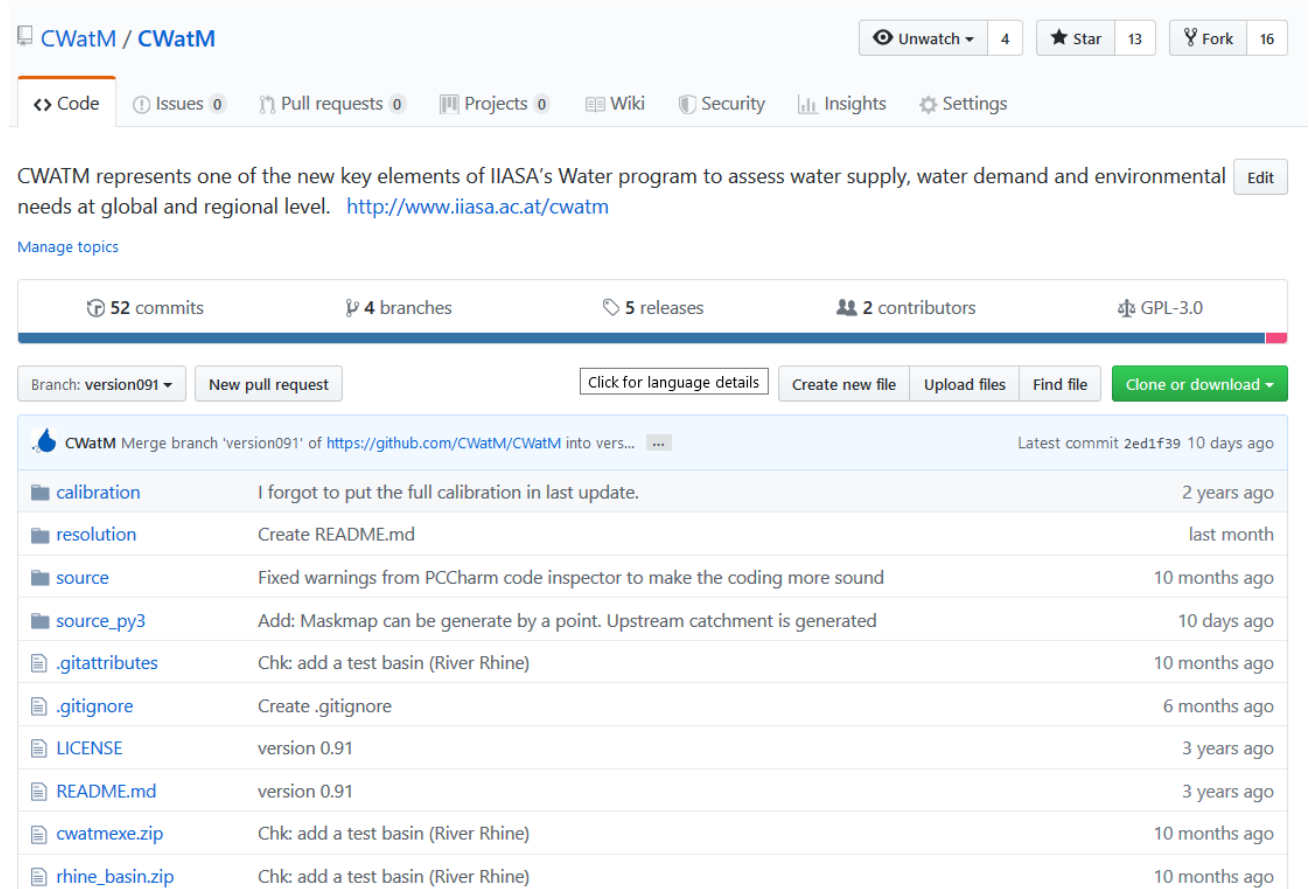
<https://cwatm.iiasa.ac.at/>

Hands on CWatM

7. Have a look at github

<https://github.com/CWatM/CWatM>

- Modular structure of CWatM
- Subversion system



The screenshot shows the GitHub repository page for CWatM/CWatM. The repository is owned by CWatM and has 4 stars, 13 forks, and 16 watchers. It is a public repository with 52 commits, 4 branches, 5 releases, 2 contributors, and is licensed under GPL-3.0. The repository is currently on the 'version091' branch. The repository description states: 'CWatM represents one of the new key elements of IIASA's Water program to assess water supply, water demand and environmental needs at global and regional level. <http://www.iiasa.ac.at/cwatm>'. The repository contains several files and folders, including 'calibration', 'resolution', 'source', 'source_py3', '.gitattributes', '.gitignore', 'LICENSE', 'README.md', 'cwatmexe.zip', and 'rhine_basin.zip'. The commit history shows that the repository was created by CWatM, with the latest commit '2ed1f39' made 10 days ago. The commit messages include: 'I forgot to put the full calibration in last update.', 'Create README.md', 'Fixed warnings from PCCharm code inspector to make the coding more sound', 'Add: Maskmap can be generate by a point. Upstream catchment is generated', 'Chk: add a test basin (River Rhine)', 'Create .gitignore', 'version 0.91', 'version 0.91', 'Chk: add a test basin (River Rhine)', and 'Chk: add a test basin (River Rhine)'.

Installation of software 4a

CWatM Python

Our software is mainly programmed as Python3.x source code

- One of the easiest programming language
- The source code is freely available: <https://cwatm.iiasa.ac.at/sourcecode.html>
- The way to contribute to CWatM is to get familiar with Python

Here we give NO Python course, as CWatM also runs without any programming skills!

But we strongly recommend to install Python (Version 3.7 or 3.8 as 64 bit) and the necessary libraries to be up to date with our newest versions on GitHub

In case you are not able to install Python + libraries we also provide a Windows executable

Installation of software 4b

CWatM Python

Python 3.8 64 bit you can find:

On our Dropbox: CWATM_exercise1/Python/python-3.8.6-amd64.exe

Or on:

<https://www.python.org/downloads/release/python-386/>

(we know that Python 3.9 is out now, but we did not test it!)

You can use also Anaconda Python.

To run CWatM you need also some libraries

We have limited the use of libraries to a minimum but those one you need:

- Numpy
- Scipy
- netCDF4
- GDAL

Please read: <https://cwatm.iiasa.ac.at/setup.htm>

Installation of software 4c

CWatM Python libraries

Please read: <https://cwatm.iiasa.ac.at/setup.htm>

We provide some libraries on (not numpy because it is too big):
CWATM_exercise1/Python/

But in most cases you can install them with pip (or conda if you use anaconda)

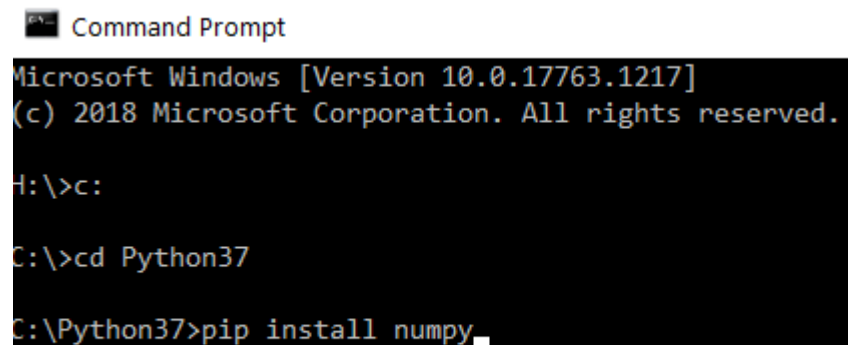
pip install numpy

pip install scipy

pip install netCDF4

In case you see some errors you can also try:

pip install your_path\to\ netCDF4-1.5.4-cp38-cp38-win_amd64.whl

A screenshot of a Windows Command Prompt window. The title bar reads 'Command Prompt'. The text inside shows the Windows version and copyright information, followed by directory navigation and a pip command.

```
Microsoft Windows [Version 10.0.17763.1217]
(c) 2018 Microsoft Corporation. All rights reserved.

H:\>cd C:

C:\>cd Python37

C:\Python37>pip install numpy_
```

Installation of software 4d

CWatM Python libraries

Troublemaker GDAL library

In most cases

Pip install GDAL will not work!

We provide the GDAL library for Python 3.8 in CWATM_exercise1/Python/
GDAL-3.1.3-cp38-cp38-win_amd64.whl

If you use another version you can download the library:

<https://www.lfd.uci.edu/~gohlke/pythonlibs/#gdal>

Please install

```
pip install your_path_to/GDAL-3.1.3-cp38-cp38-win_amd64.whl
```

Exercise 3: Hands on CWatM

8. Installing Python, libraries and CWatM

- Install python 3.8.5 (in folder CWATM_exercise1/python)
- Install libraries with pip (you may have to change to the python directory)
 - pip install numpy-1.17.3+mkl-cp38-cp38m-win_amd64.whl
 - Pip install scipy-1.3.1-cp38-cp38m-win_amd64.whl
 - ...
- Test python 3.8 (you may have to change to the python directory)
 - Type python

```
F:\CWATM_exercise2\rhine30min>python
Python 3.7.0 (v3.7.0:1bf9cc5093, Jun 27 2018, 04:59:51) [MSC v.1914 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> import numpy
>>> import netCDF4
>>> import scipy
>>> import gdal
>>> _
```

- If an error occurs it might be handled on
<https://cwatm.iiasa.ac.at/tutorial.html#test-the-python-model-version>

Hands on CWatM

8. Installing Python, libraries and CWatM

- Start 04_python_example.bat
python ./CWatM/run_cwatm.py settings_rhine30min.ini -l
- Start 05_python_example.bat
python ./CWatM/run_cwatm.py settings_rhine30min.ini -l

- If an error occurs it might be handled on

<https://cwatm.iiasa.ac.at/tutorial.html#test-the-python-model-version>

```
F:\CWATM_ECHO\CWATM_exercise1>python ./CWatM/run_cwatm.py
CWatM - Community Water Model
Authors: Peter Burek, Yusuke Satoh, Peter Greve, Mikhail Smilovic, Jens de Bruijn
Version: 1.4
Date: 19/02/2020
Status: Development

Arguments list:
settings.ini    settings file

-q --quiet      output progression given as .
-v --veryquiet no output progression is given
-l --loud      output progression given as time step, date and discharge
-c --check     input maps and stack maps are checked, output for each input map BUT no model run
-h --noheader  .tss file have no header and start immediately with the time series
-t --printtime the computation time for hydrological modules are printed
-w --warranty  copyright and warranty information
```


9. Homework

- Play around with the Rhine catchment

change the settings file: settings_rhine30min.ini

- Run for different times
 - Produce different outputs
- What catchment are you interested?
 - Find out the coordinates (lat/lon) of the outlet point
 - Find out coordinates of gauges
 - Send me the coordinates for next lesson

10. Outlook for next session

- Dive deeper into the settings file
- Compare simulated with observed discharge
- Set up your own catchment

“Water is a precious resource, crucial to realizing the sustainable development goals, which at their heart aim to eradicate poverty.”

UN Secretary-General Ban Ki-moon

21th January 2016, Davos



Thank you