International Institute for Applied Systems Analysis
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Exercise 7: Options of CWatM

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Options of CWatM

0. What you need
1. What is netCDF
2. Display netCDF files
3. Change ksat2 (saturated soil conductivity layer 2) in ArcGIS

Option of CWatM

0. What you need

- We go back to the Rhine basin on 30 arcmin because it is fast to execute

Options of CWATM

1. Running a warm start
2. Running with and without water demnd
3. Landcover options
4. Reservoir options

Options of CWATM

1. Running a warm start

CWatM needs to have estimates of the initial state of the internal storage variables, e.g. the amount of water stored in snow, soil, groundwater etc.:

There are two possibilities:

The initial state of the internal storage variables are unknown and a **first** guess has to be used e.g. all storage variables are half filled.

The initial state is known from a previous run, where the variables are stored at a certain time step. This is called **warm start**

The **warm start** is usful for:

- using a long pre-run to find the steady-state storage of the groundwater storage and use it as initial value
- using the stored variables to shorten the warm-up period
- using the stored variables to restart every day with the values from the previous day (forecasting mode)

See also: https://cwatm.iiasa.ac.at/setup.html#initialisation

Options of CWATM

1. Running a warm start

Starting with different initial conditions of soil moisture

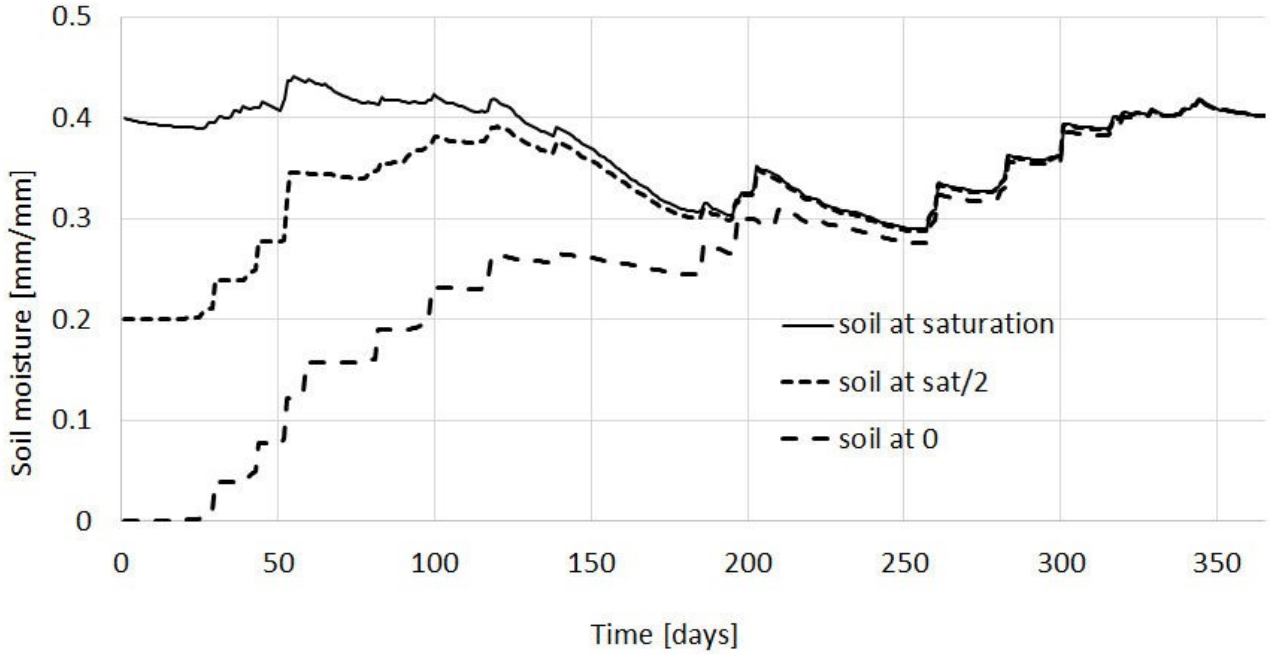


Figure shows the impact of different initial condition on the soil moisture of the lower soil.

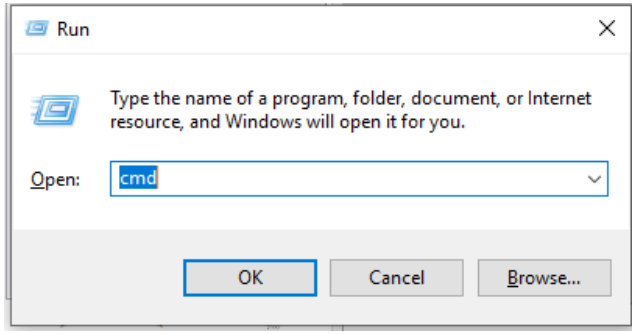
Options of CWatM

1. Running a warm start

- Go to folder CWATM_exercise7
- Start: 71_exe_example.bat

  or open a DOS command prompt

  - press Windows+R
  - type cmd + return
  - change directory: e.g. cd c:/CWATM/CWATM_exercise7
    (or cd "c:/directory with white space/CWATM/CWATM_exercise7")



- Type ..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_71.ini -l

```
F:\CWATM.ECHO\CWATM_exercise7>..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_71.ini -l
CWATM - Community Water Model  1.04  Date:  version 1.04
International Institute of Applied Systems Analysis (IIASA)
Running under platform:  Windows
------------------------------------------------------------

CWATM Simulation Information and Setting
The simulation output as specified in the settings file: ./output can be found in settings_rhine30min_71.ini

Step         Date   Discharge
 1      01/01/1998        5.27
2       02/01/1998        6.50
3       03/01/1998        8.25
4       04/01/1998       10.56
5       05/01/1998       13.61
6       06/01/1998       17.36
7       07/01/1998       21.84
8       08/01/1998       27.08
9       09/01/1998       32.86
10      10/01/1998       39.01
```

Cold start:
You see the outlet of the Rhine basin has really low discharge, because it needs time to fill up

Options of CWATM

1. Running a warm start

```
135 #-----------------------------------------------------
136 [INITIAL CONDITIONS]
137 #-----------------------------------------------------
138
139 # for a warm start initial variables a loaded
140 # e.g for a start on 01/01/2010 load variable from 31/12/2009
141 load_initial = False
142 initLoad = $(FILE_PATHS:PathOut)/Rhine_19991231.nc
143
144 # saving variables from this run, to initiate a warm start next run
145 # StepInit = saving date, can be more than one: 10/01/1973 20/01/1973
146 save_initial = True
147 initSave = $(FILE_PATHS:PathOut)/Rhine
148 StepInit = 31/12/1999
149
```

Important part in settings_rhine30min_71.ini

- save_initial is set to true
- initSave points to outlet folder
- StepInit is set to 31.12.1999
  (an init file for the date 31/12/1999 is created)

```
139 # for a warm start initial variables a loaded
140 # e.g for a start on 01/01/2010 load variable from 31/12/2009
141 load_initial = True
142 initLoad = $(FILE_PATHS:PathOut)/Rhine_19991231.nc
143
144 # saving variables from this run, to initiate a warm start next run
145 # StepInit = saving date, can be more than one: 10/01/1973 20/01/1973
146 save_initial = False
147 initSave = $(FILE_PATHS:PathOut)/Rhine
148 StepInit = 31/12/1999
```

Important part in settings_rhine30min_71.ini

- load_initial is set to true
- save_initial is set to false
- initLoad is set to the initial file in ./outlet

Options of CWatM

1. Running a warm start

- Start: 72_exe_example.bat
  or type ..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_72.ini -l

```
F:\CWATM.ECHO\CWATM_exercise7>..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_72.ini -l
CWATM - Community Water Model  1.04  Date:  version 1.04
International Institute of Applied Systems Analysis (IIASA)
Running under platform:  Windows
-----------------------------------------------------

CWATM Simulation Information and Setting
The simulation output as specified in the settings file: ./output can be found in settings_rhine30min_72.ini

Step         Date    Discharge
 1      01/01/2000     8163.15
2       02/01/2000     7168.01
3       03/01/2000     6236.38
4       04/01/2000     5537.56
5       05/01/2000     5114.96
6       06/01/2000     4699.51
7       07/01/2000     4234.66
8       08/01/2000     3817.04
9       09/01/2000     3479.93
10      10/01/2000     3211.58
```

Warm start:
You see the outlet of the Rhine basin has regular discharge, because it uses the stored values from the run before

See also: https://cwatm.iiasa.ac.at/setup.html#initialisation

Options of CWatM

2. Running with and without water demand

Start: 73_exe_example.bat
or type ..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_73.ini -l

```
34  # if irrigation is included, otherwise paddy and non paddy is put into 'grassland'
35  includeIrrigation = False
36  # if water demand from irrigation, industry and domestic is included
37  includeWaterDemand = False
```

Start: 74_exe_example.bat
or type ..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_74.ini –l

```
34  # if irrigation is included, otherwise paddy and non paddy is put into 'grassland'
35  includeIrrigation = True
36  # if water demand from irrigation, industry and domestic is included
37  includeWaterDemand = True
```

Difference are shown in rhine7.xlsx sheet: Rhine_waterdemand

Options of CWatM

2. Running with and without water demand

Further options on water demand

```
544 [WATERDEMAND]
545 #------------------------------------------------------
546
547 PathWaterdemand = $(FILE_PATHS:PathMaps)/landsurface/waterDemand
548 # For water demand vs. availability: areas have to be aggregated
549 # Allocation map
550 allocSegments = $(PathWaterdemand)/catchx.nc
551
552 domesticWaterDemandFile = $(PathWaterdemand)/domesticWaterDemand.nc
553 industryWaterDemandFile = $(PathWaterdemand)/industryWaterDemand.nc
554
555 irrNonPaddy_efficiency = $(FILE_PATHS:PathMaps)/landsurface/waterDemand/efficiency.nc
556 irrPaddy_efficiency = $(FILE_PATHS:PathMaps)/landsurface/waterDemand/efficiency.nc
557
558 # using environmental flow (EF) (per month) as input value
559 # EF will be treated as one part of overall water demand
560 use_environflow = False
561 EnvironmentalFlowFile = $(FILE_PATHS:PathOut)/MQ90_12month.nc
562
563 irrigation_returnfraction = 0.5
564
565 # ------------------------------------------------------------
566 # Estimate of fractions of groundwater and surface water abstractions
567 # Either a fixed fraction for surface water abstration
568 # based on fraction of average baseflow and upstream average discharge
569 # if swAbstractionFrac < 0: fraction is taken from baseflow / discharge
570 # if swAbstractionFrac > 0 this value is taken as a fixed value
571 swAbstractionFrac = 0.9
572 averageDischarge = $(FILE_PATHS:PathOut)/discharge_totalavg_rhine30min.nc
573 # in [m3/s]
574 averageBaseflow  = $(FILE_PATHS:PathOut)/baseflow_totalavg_rhine30min.nc
575 # in [m3/s]
576 baseflowInM = True
577 # if baseflow is in [m] instead of [m3/s] it will be converted
578
579
```

Return flow fraction of irrigation:
This fraction of the difference between Irrigation withdrawal and irrigation consumption will be returned to rivers

Surface water abstraction
This value is used to distinguise where the water is taken from:
Groundwater or surface water
Either a fixed fraction or a fraction from longterm baseflow / discharge

Options of CWatM

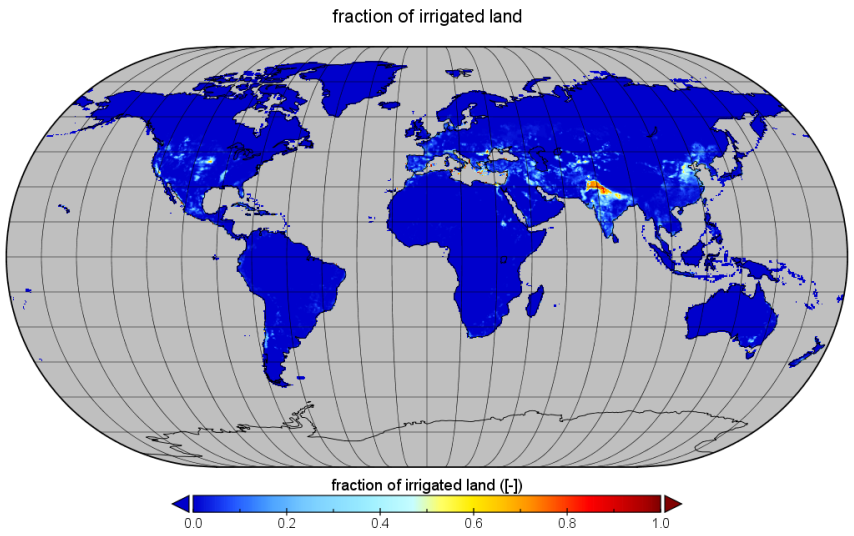
3. Changing land cover option

Land cover i.e. the fraction of different land use in a grid cell is varying over time

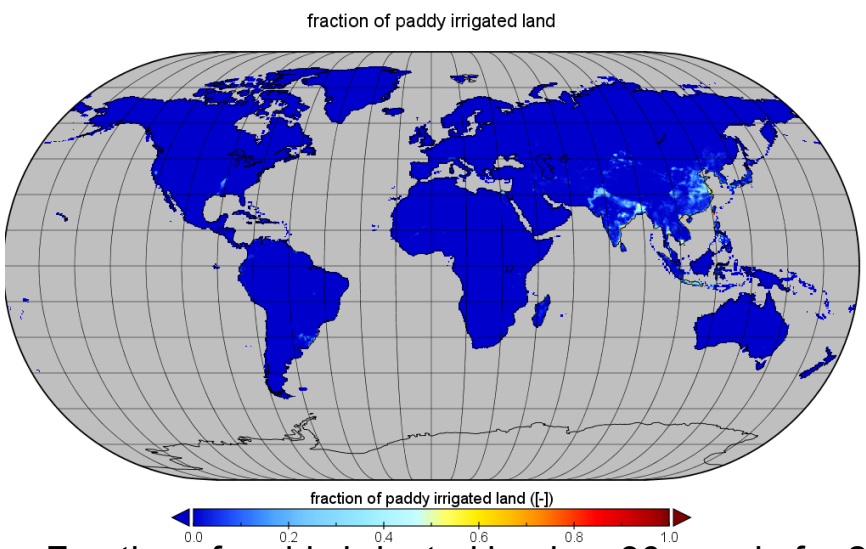
- cities are growing (more sealed area)
- Agricultural area is growing (more irrigation, maybe less forest)

CWatM accounts for that, and has a land cover fraction map for each year:

./cwatm_input30min/landsurface/fractionLandcover.nc



Fraction of non paddy irrigated land on 30 arcmin for 2010



Fraction of paddy irrigated land on 30 arcmin for 2010

Options of CWatM

3. Changing land cover option

In the settingsfile in section [LANDCOVER]

Land cover can be dynamically changing every year

Like in:

cwatm.exe settings_rhine30min_74.ini –l

```
373 [LANDCOVER]
374 PathLandcover = $(FILE_PATHS:PathMaps)/landsurface
375
376 coverTypes = forest, grassland, irrPaddy, irrNonPaddy, sealed, water
377 coverTypesShort = f, g, i, n, s, w
378 fractionLandcover = $(PathLandcover)/fractionLandcover.nc
379
380 # Landcover can vary from year to year
381 dynamicLandcover = True
382 # if landcover cannot vary, which year should be taken as fixed year
383 fixLandcoverYear = 1961
```

Or land cover is fixed constant for a specific year
e.g. 1961

```
#----------------------------------------------------------
[LANDCOVER]
PathLandcover = $(FILE_PATHS:PathMaps)/landsurface

coverTypes = forest, grassland, irrPaddy, irrNonPaddy, sealed, water
coverTypesShort = f, g, i, n, s, w
fractionLandcover = $(PathLandcover)/fractionLandcover.nc

# Landcover can vary from year to year
dynamicLandcover = False
# if landcover cannot vary, which year should be taken as fixed year
fixLandcoverYear = 1961
```

Start: 75_exe_example.bat for a fixed 1961 landcover
or type
..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_75.ini –l

Difference are shown in rhine7.xlsx sheet: Rhine_landcover

Options of CWatM

4. Changing lakes reservoir option

In the settingsfile in section [Option]

Lakes and reservoirs can put in or off, to show the effect of waterbodies

As in: settings_rhine30min_74.ini

```
54  #-----------------------------------------------
55  # Routing
56
57  # if runoff concentration to the edge of a cell is included
58  includeRunoffConcentration = True
59  # Waterbodies like lakes and reservoirs
60  includeWaterBodies = True
```

Start: 76_exe_example.bat for a run without waterbodies
or type
..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_76.ini –l

```
59  # Waterbodies like lakes and reservoirs
60  includeWaterBodies = False
```

Difference are shown in rhine7.xlsx sheet: Rhine_reservoir

Options of CWatM

4. Changing lakes reservoir option

In the same way as for land cover, reservoirs can be put in dynamically
- depending on the year they are build, they are in

Or fixed
- only the reservouirs are in, which are build until this year

```
634  [LAKES_RESERVOIRS]
635
636  PathLakesRes = $(FILE_PATHS:PathMaps)/routing/lakesreservoirs
637
638  # Use reservoirs and lakes (otherwise use only lakes Lake ID=1 an
639  useResAndLakes = True
640  # Reservoirs do have a year of implementation
641  dynamicLakesRes = True
642  # if Reservoirs does not have a year of implemtation, which year
643  fixLakesResYear = 1950
644
```

In the settingsfile in section [LAKES_RESERVOIRS]

Reservoirs can be dynamically changing every year

Or reservoirs are fixed constant for a specific year
e.g. 1950

For the Rhine we did not include a reservoir in the 30 arcmin setting
Therefore no exercise