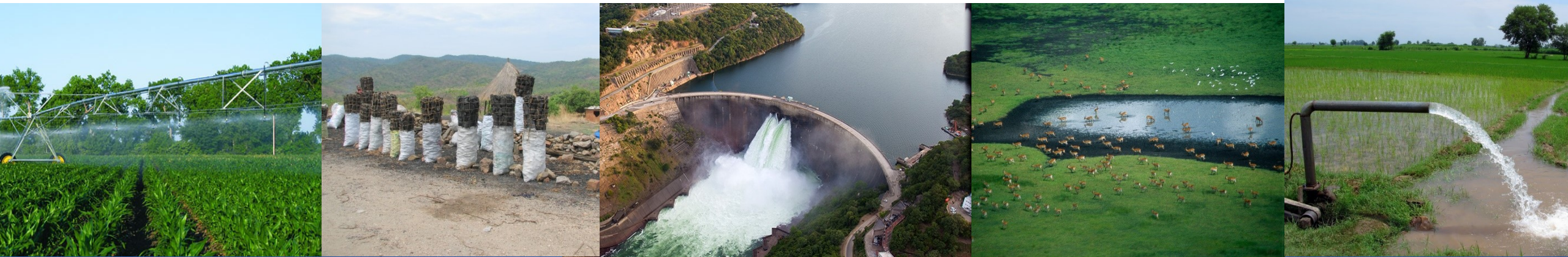


Exercise 7: Options of CWatM

Peter Burek, Mikhail Smilovic, Luca Guillaumot
International Institute for Applied Systems Analysis
Research Scholars at
Water Program



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 demand
3. Landcover options
4. Reservoir options

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 three possibilities:

1. 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.
2. The initial state is known from a previous run, where the variables are stored at a certain time step. This is called **warm start**
3. A spin up time, all output is only generated after this day

The **warm start** is useful 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>

1. Running a warm start

Starting with different initial conditions of soil moisture

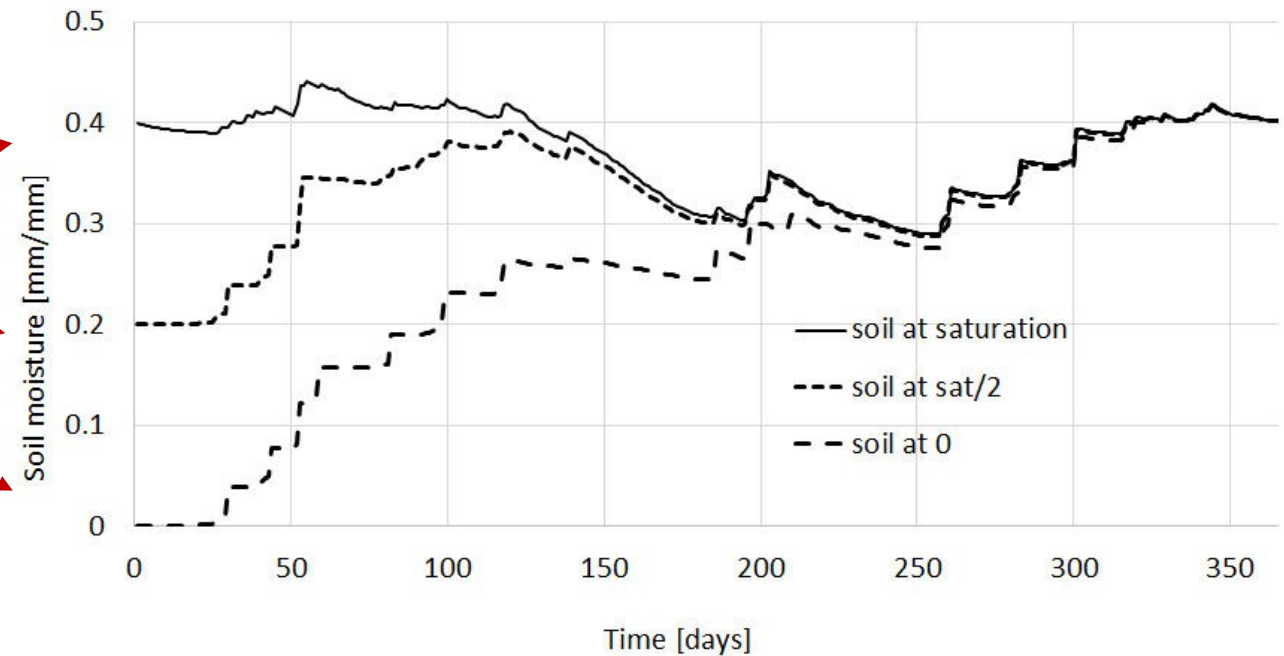
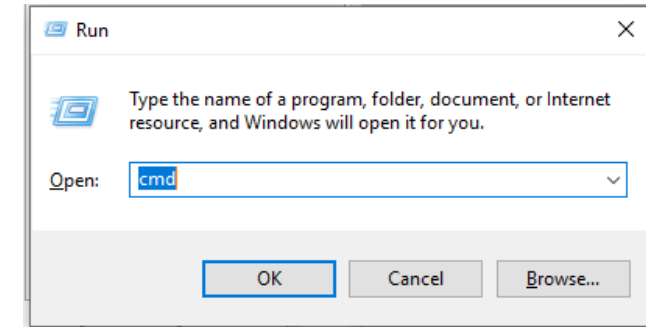


Figure shows the impact of different initial condition on the soil moisture of the lower soil.

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

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  
149 |
```

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>

1. Running a warm start

Defining a spin up date:

Only after this date output variables are generated

```
121 #-----
122 [TIME-RELATED_CONSTANTS]
123 #-----
124
125 # StepStart has to be a date e.g. 01/06/1990
126 # SpinUp or StepEnd either date or numbers
127 # SpinUp: from this date output is generated (up to this day: warm up)
128
129 StepStart = 1/1/1998
130 SpinUp = None
131 StepEnd = 31/12/1999
132
```

Spin up date is defined to 1/1/1999

From this date all output timeseries and netCDFs are generated

```
129 StepStart = 1/1/1998
130 SpinUp = 1/1/1999
131 StepEnd = 31/12/1999
```

For calibration warm up and spinup is used together:

- warm up of a few decades to have a long time for groundwater and lakes to get into steady state
- For each calibration run a spinup of a few years to get used to the change of calibration parameter

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`

```
33
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_environtflow = 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 abstraction
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 distinguish where the water
is taken from:
Groundwater or surface water
Either a fixed fraction or a fraction from
longterm baseflow / discharge

Options of CWatM

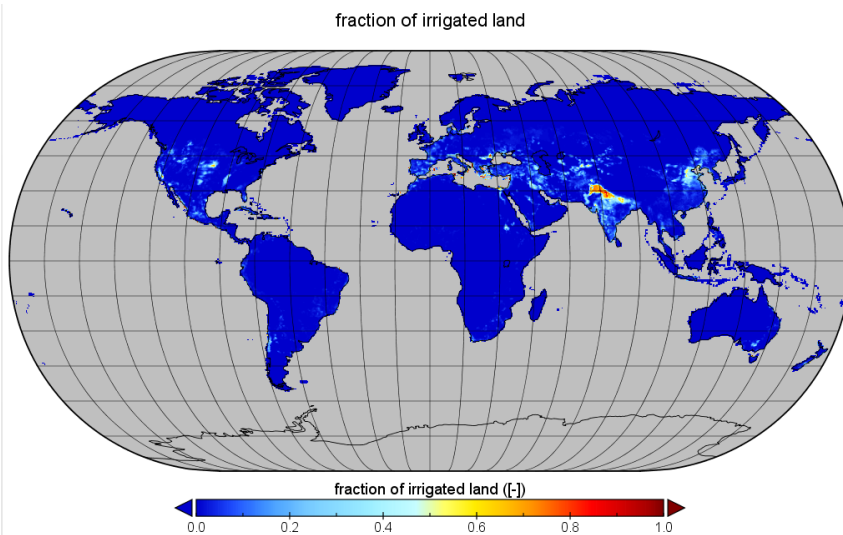
3. Changing land cover option

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

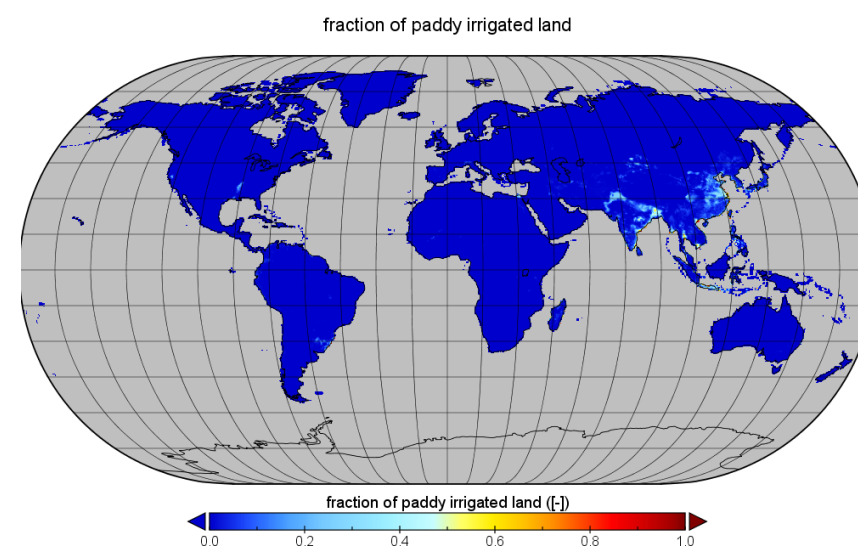
- cities are growing (more sealed area)
- Agricultural area is growing (more irrigation, maybe less forest)

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`

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

Start: 75_exe_example.bat for a fixed 1961 landcover
or type

`..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_75.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
384
```

```
L#-----
[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
```

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
61 # kinematic wave routing, if False no routing is calculated
```

Start: 76_exe_example.bat for a run without waterbodies
or type

`..\CWATM_model\CWatMexe\cwatm.exe settings_rhine30min_76.ini -l`

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

Difference are shown in rhine7.xlsx sheet: Rhine_reservoir

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 and
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

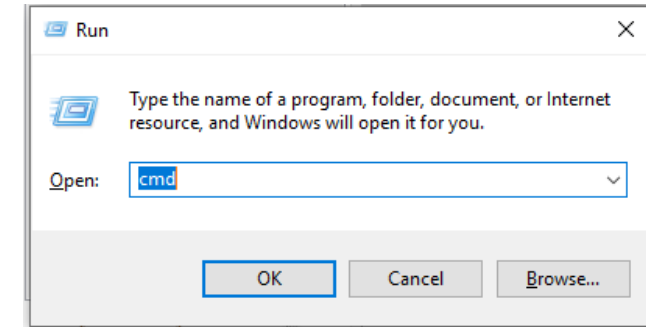
For the Rhine we did not include a reservoir in the 30 arcmin setting

Therefore no exercise

Hands on CWatM

Starting a dos box

- Go to folder CWATM_exercise7
- Start: 31_exe_example.bator 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`



Problems

Most problems come from different file systems, folder structures

We try to set up everything with relative path.

1. Please make sure that your folders have a similar structure like in slide 3 in `cwatm_exercise1.ppt`

2. The settings file has a part:

[FILE_PATHS]

PathRoot = ../cwatm_data

PathOut = ./output

PathMaps = \$(PathRoot)/cwatm_input30min

PathMeteo = \$(PathRoot)/climate/rhine

../ jumps back to the previous folder

./ uses the folder output in the same folder as the settings file or the directory you are in

3. If this is not working you can use also absolute path (also with white space)

PathRoot = C:/root directory/second.root/cwatm/cwatm_data

4. If you execute `cwatm` you can also use absolute path

instead

../CWATM_model/CWatMexe/cwatm.exe settings_rhine30min.ini -l

"C:/root directory/second.root/cwatm/CWATM_model/CWatMexe/cwatm.exe" settings_rhine30min.ini -l (mind the " if there are white spaces)

5. Some other errors we address in:

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