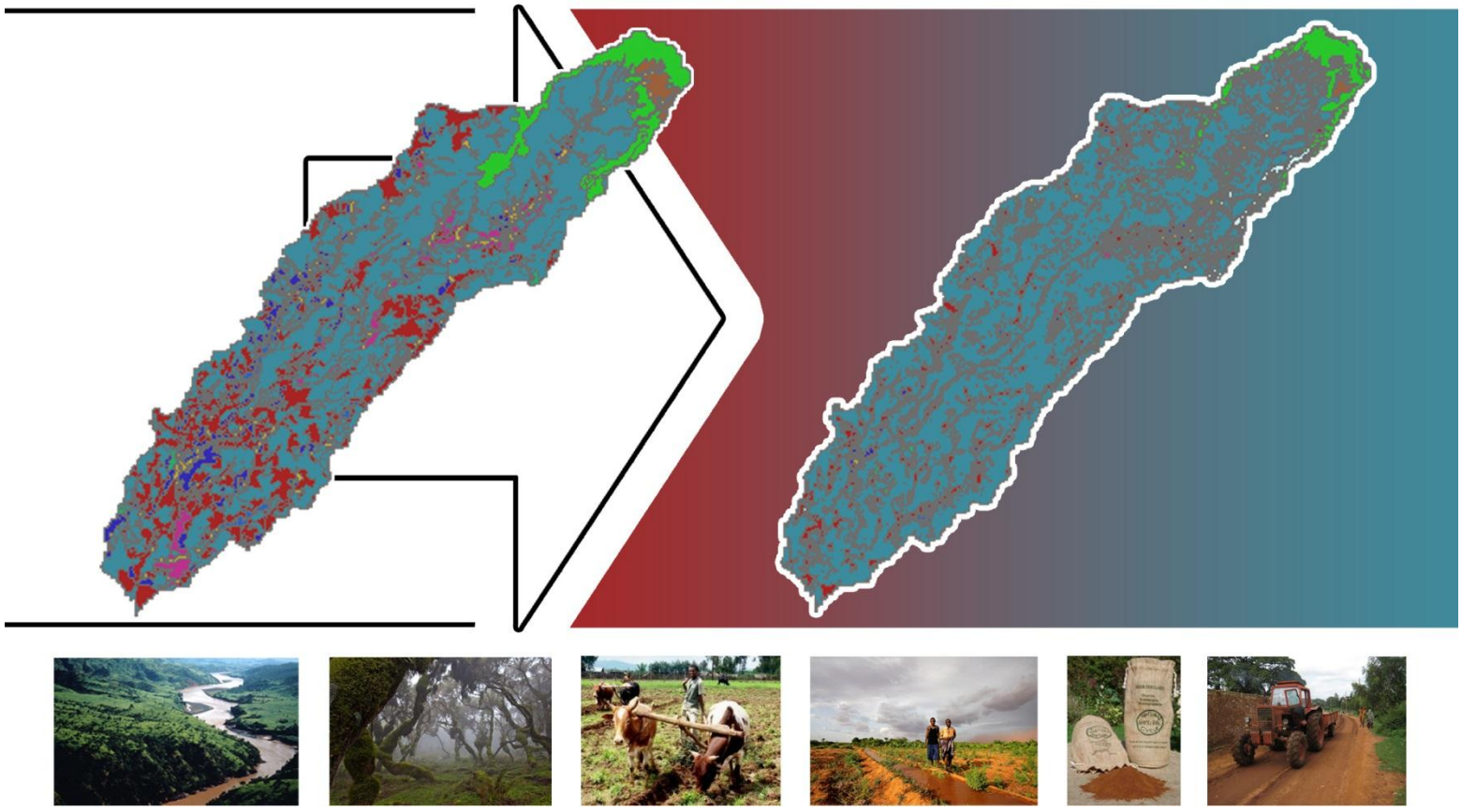
Leibniz Institute of Agricultural Development in Central and Eastern Europe

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

UNESCO-IHE Institute for Water Education



Integration of dynamic land use change into SWAT using the LUP.dat file and an advanced setup tool

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LUPSA

Test Case & LUPSA app.

Conclusions & Prospects

SWAT Input

Dynamics of SWAT Input						
Input Type	Static				Dynamic	
SWAT Input	Terrain	Soil	Land Use		Climate	
Scale	Geological	Centuries	Decades	Years	Days	Hours

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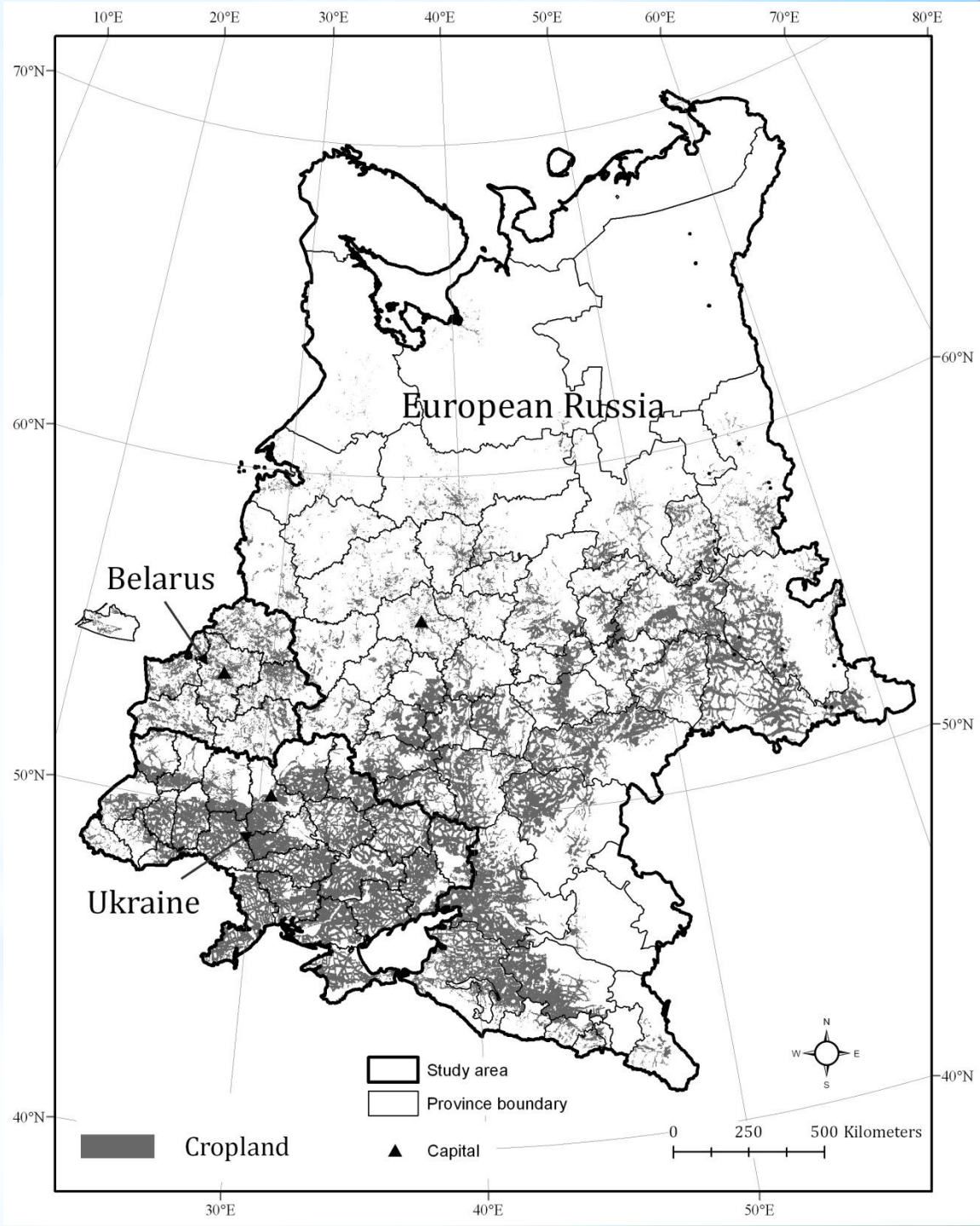
Actual Cropland in Eastern Europe



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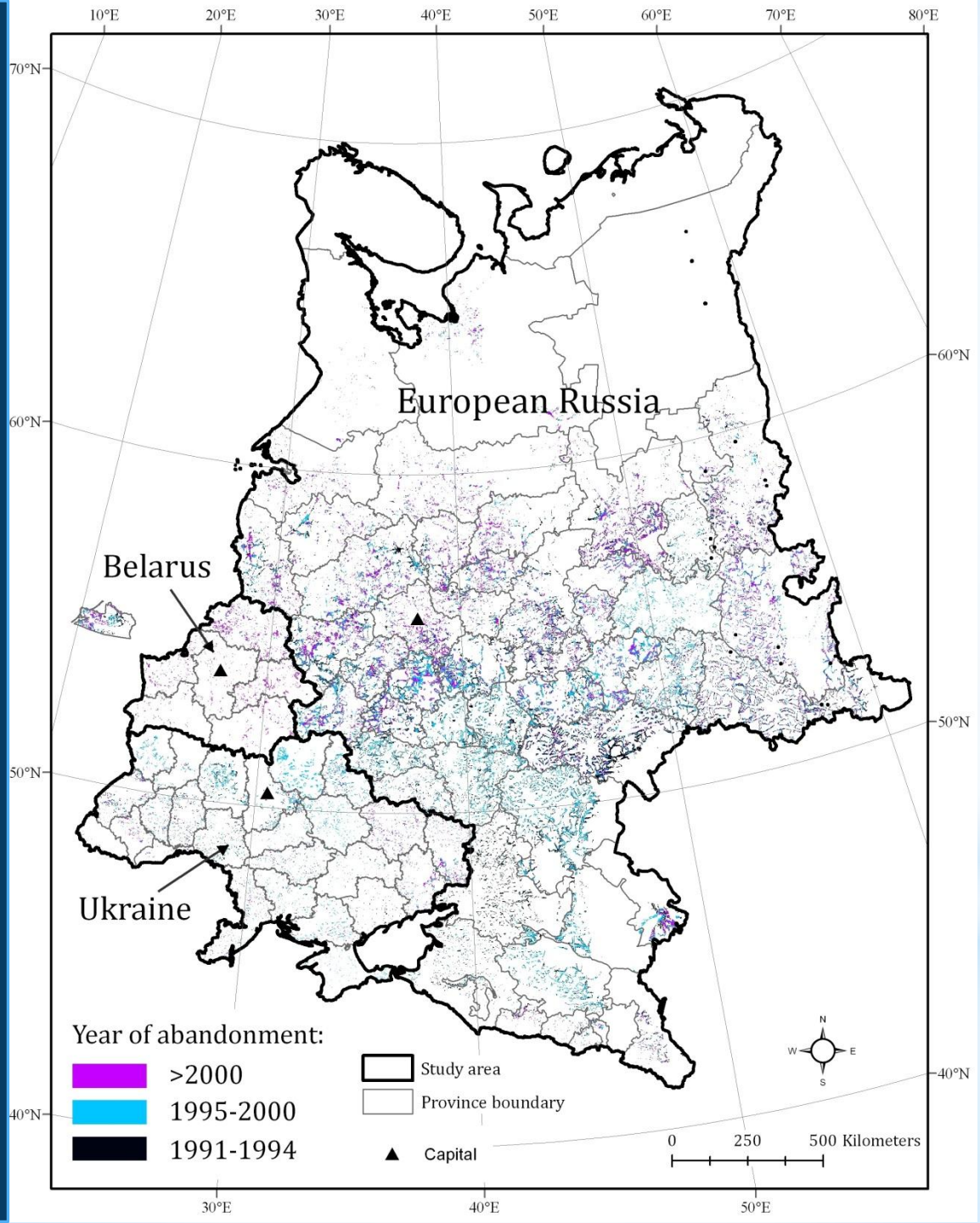

Abandonment of cropland in Eastern Europe

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Dynamics of SWAT Input						
Input Type	Static				Dynamic	
SWAT Input	Terrain	Soil		Land Use	Climate	
Scale	Geological	Centuries	Decades	Years	Days	Hours

- Impact on Calibration/Validation once a model is calibrated for several years?
- Impact on projections? What if I want information on a shifting process projected by a single future scenario
- What if I would like to use the model for scenario optimization effected by land use dynamics? (e.g. using a Pareto optimum)

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SWAT and Land Use Change - the lup.dat file

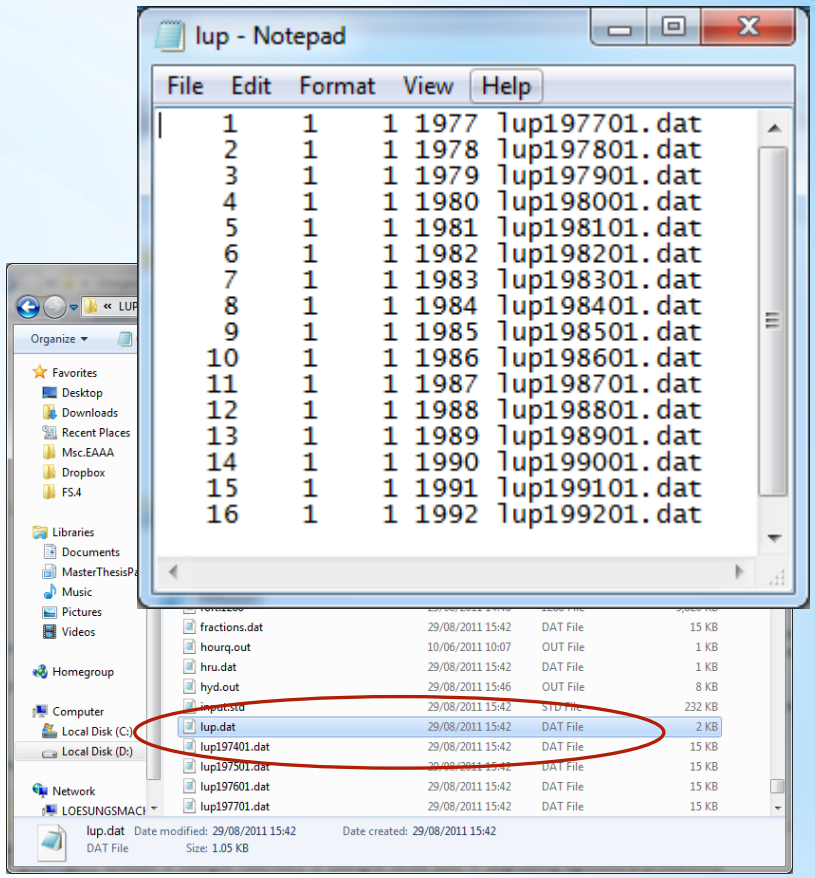
lup.dat:

- optional SWAT input file

- HRU fraction update during simulation

- Covers only existing HRUs

- Manually very time consuming for larger models



→ A 10y simulation for a 500 HRU test case with monthly updates means 120 update files with max. 60,000 update fractions

→ What if new land uses shall be introduced? How to update/include not existing HRUs

SWATLUPSA for Land Use Change

LUPSA - Land Use Update and Slope Adjustment

- Interpolates HRUs of different SWAT setups based on different land use inputs

e.g.:

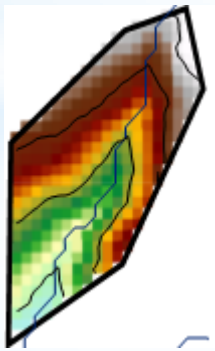
Input A		UP!	UP!	UP!	UP!	UP!	UP!			LU2
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
		Simulation Period								

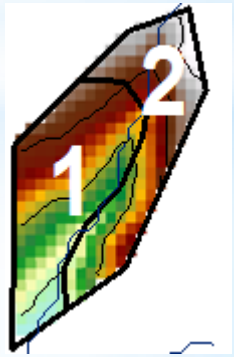
- Accounts also for HRUs unique in only one setup

- Additionally updates HRU slopes

Why Slope Change Implementation?

HRU:
Fraction: 0.13
Slope: 22%





HRU_1 =
Fraction: 0.06
Slope: 18%

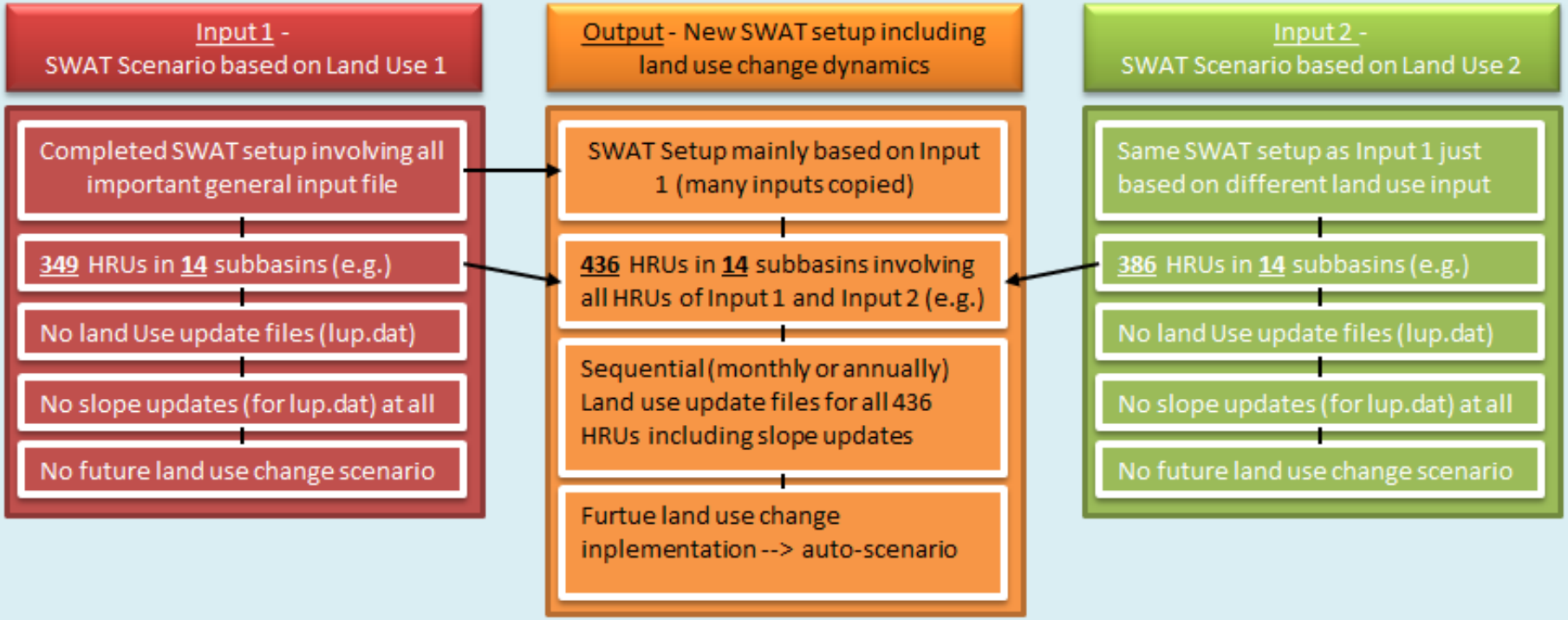
HRU_2 =
Fraction: 0.07
Slope: 25%

LUPSA Process:

1. HRU identification, fraction and slope extraction, renaming/rewriting
2. lup.dat and update file generation → fraction and slope linear interpolation
3. Checking + adjusting total subcatchment HRU fractions

For One Subbasin (e.g. subbasin 1 as it is here)							
Attribute	Scenario 1			Scenario 2			New Scn
	HRU	frc1 array	slp1 array	slp2 array	frc2 array	HRU	HRU
match	000010001	frc1	slp1	slp2	frc2	000010001	000010001
uniqe in 1	000010002	frc1	slp1	slp1	0.0000007	-	000010002
match	000010003	frc1	slp1	slp2	frc2	000010002	000010003
match	000010004	frc1	slp1	slp2	frc2	000010004	000010004
uniqe in 1	000010005	frc1	slp1	slp1	0.0000007	-	000010005
...	...	...	...	...	...	...	...
match	000010018 (last scn1)	frc1	slp1	slp2	frc2	000010015	000010018
uniqe in 2	-	0.0000007	slp2	slp2	frc2	000010003	000010019
uniqe in 2	-	0.0000007	slp2	slp2	frc2	000010016	000010020
...	...	...	...	...	...	...	...

Example: 2 setups based on 2 LU inputs but one parameterisation



Common HRUs = 286
Unique HRUs 1 = 56
Unique HRUs 2 = 94
Unique HRUs: 34%

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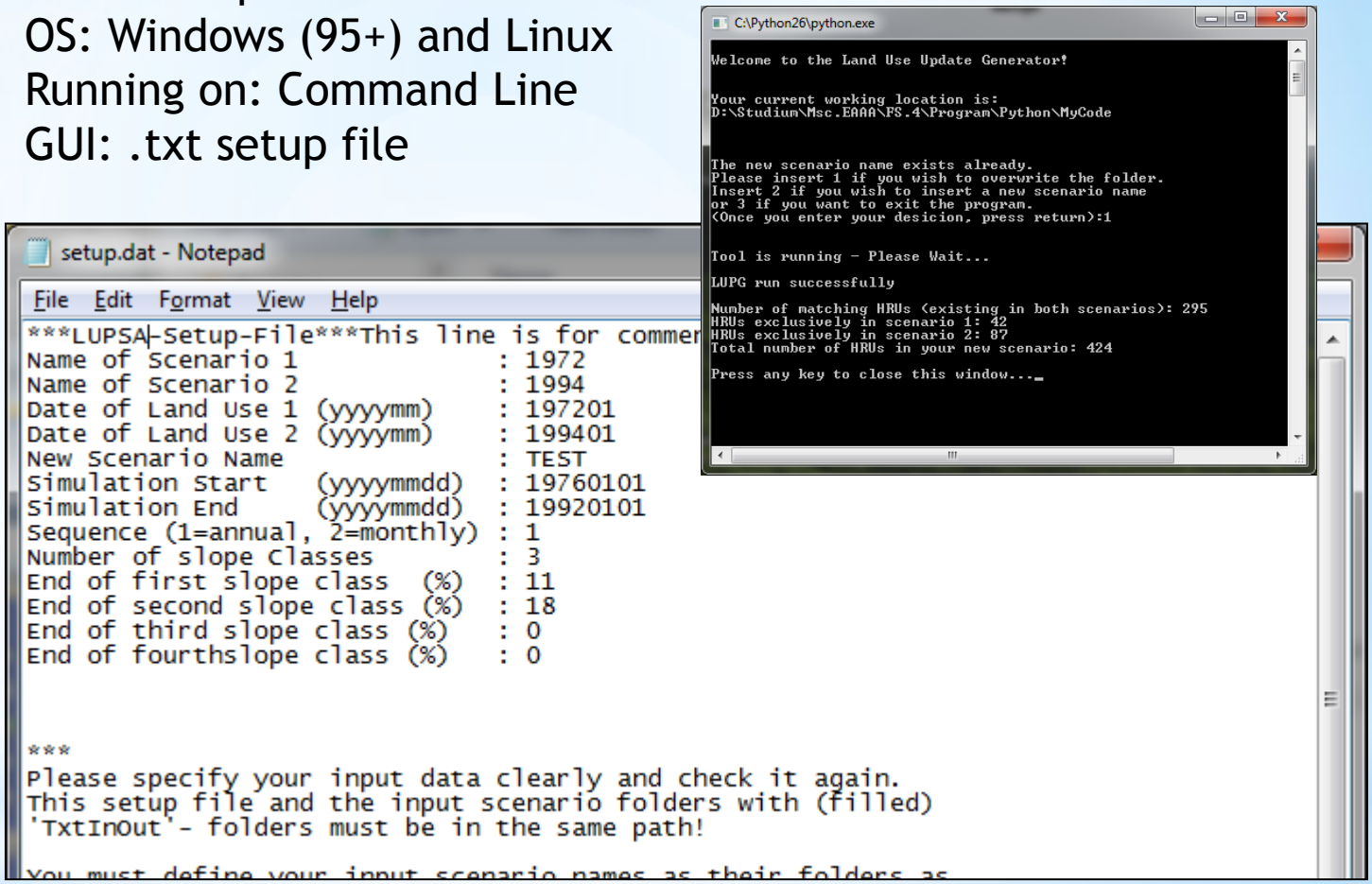
Program Language: Python
License: Open Source
OS: Windows (95+) and Linux
Running on: Command Line
GUI: .txt setup file



Related modified SWAT Versions (by Ann van Griensven)

SWAT2009lu-slope.exe	Fraction + slope update
SWAT2009lu-noslope.exe	fraction update
SWAT2009lu-slope-slopelength.exe	Fraction + slope + slope length update

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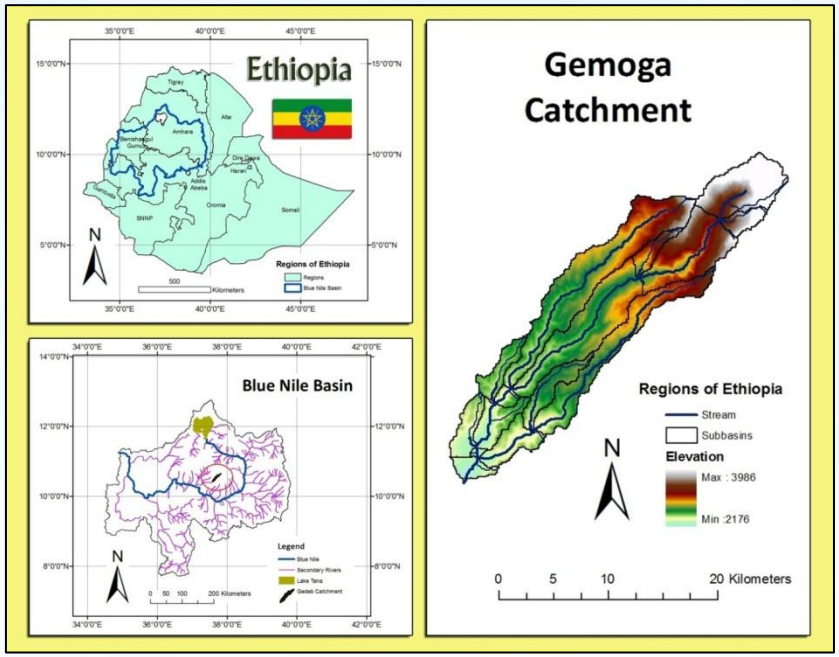
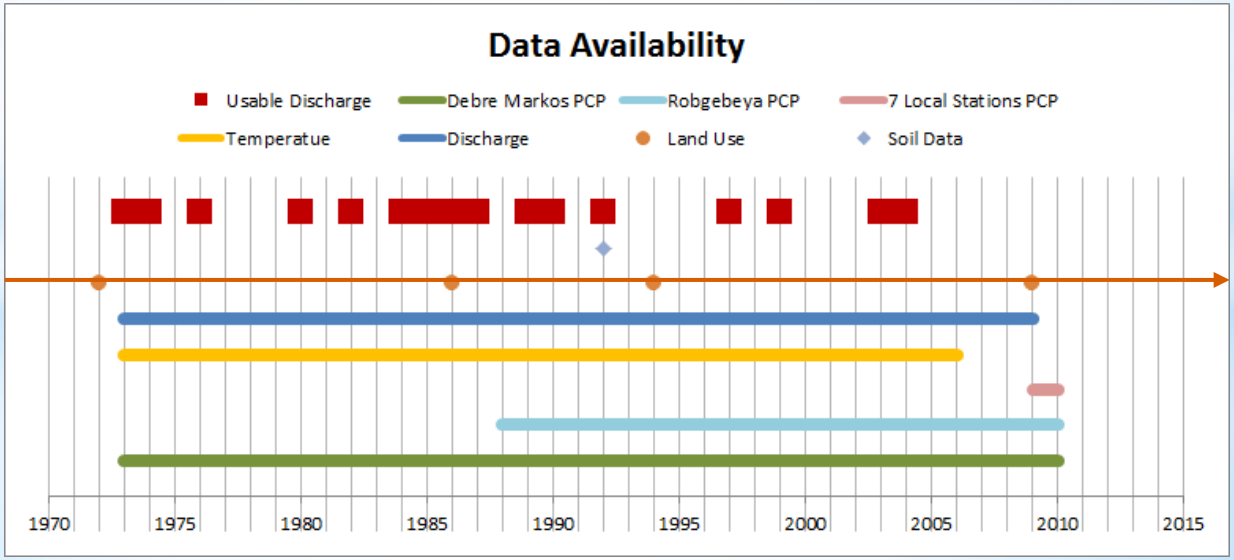


- Size: ~285 km²
- Elevation: 2176m-3986m
- Slope: up to 84%, ø = 16%

Data:

- Minor relation between Rainfall Stations
- Poor Elevation – Rainfall Relation
- Overrated discharge measurements
- Fast Catchment response



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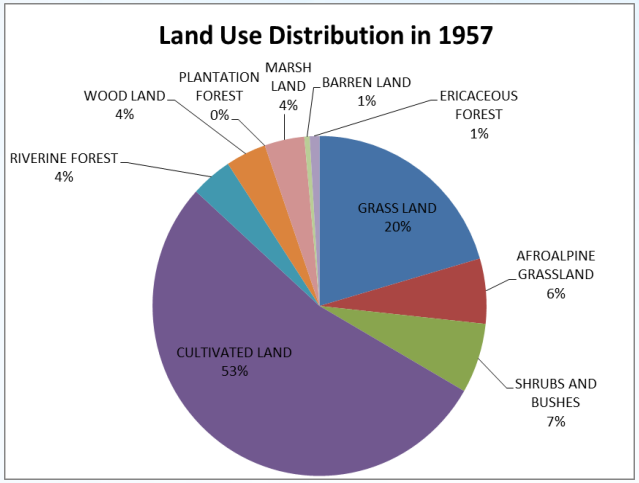
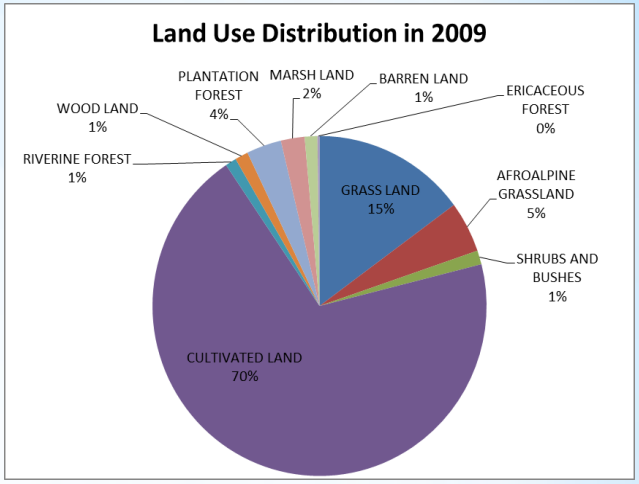
Land use dynamics onwards artificial land use:





LUPSA application setup:

- Simulation period 1983-1993
- Annual land use updates from 1984 to 1993
- Land use inputs: remote sensing based shapes from 1972 and 2009

Results:

Calibration

Simulation	Calibration			Validation	
	R2	NS		R2	NS
Daily 89/90/92	0.39	0.39		0.26	0.24
Daily 84-87	0.53	0.52		0.43	0.41
Daily 73/74	0.49	0.36		0.25	0.22
Monthly 89/90/93	0.85	0.63		0.66	0.55
Monthly 84-87	0.8	0.8		0.79	0.77

Flow

Annual Average - Daily Flow	Basic Model	Fraction Change	Slope and Fraction Change
Maximum	195.000	197.700	197.700
Arith. Mean	5.930	6.070	6.071
Median	3.111	3.246	3.246
Maximum Difference		8.170	8.170
Average Difference		0.331	0.332

Hydrology

Annual Average of Hydrological Components [mm]			
	LUPSA NoSlope	LUPSA Slope	Basic Model
Precipitation	1313.9	1313.9	1313.9
Surface Runoff	137.12	137.11	132.99
Lateral Flow	113.48	113.73	106.45
Groundwater Flow	442.86	442.65	438.05
REVAP	9.66	9.65	9.77
Deep Aquifer Recharge	24.06	24.05	23.57
Evapotranspiration	592.3	592.3	604.9

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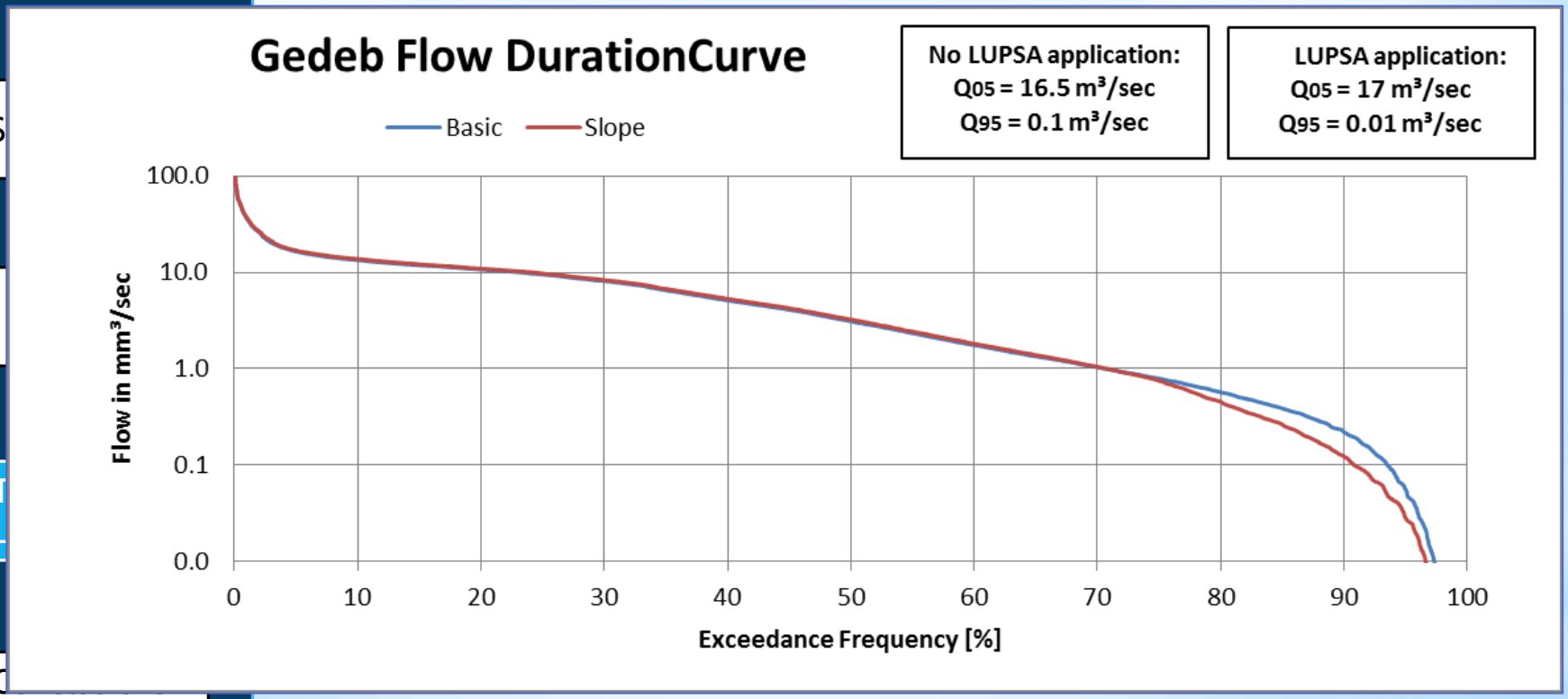
Results:



Conclusions

Achievements:

1. An automated lup.dat generation helps the implementation of LUC in SWAT

2. To fully address LUC in SWAT, arising HRUs (due to LUC) should be addressed

3. Land use change might have a considerable impact (case dependent) on the hydrology also within decades

Prospective

1. Applying the tool in European Russia on agricultural production

2. Checking the impact of dynamic LUC implementation on the calibration of the new model

What else is going on

Alternative:
Another tool was developed by at the University of Arkansas which uses another approach of setting up the luc.dat file (SWAT2009_LUC)
Advantage: Setup directly based on land use input grid

Disadvantage:
- accounting only for matching HRUs
- no slope change implemented
- Abrupt updates on the dates of the input grids which may causes problems with the amount of water an nutrients in the HRU storages

Other works:
A on going research about the impact of land use change on the model calibration at the UNESCO-IHE applying both tools supervised by Ann van Griensven

Thank you for your attention!