



NEW USAGE OF MULTI-OBJECTIVE CALIBRATION: MODEL COMPARISON

Case study of flow and sediment calibration on a small Danish catchment

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OUTLINE

Introduction

- › **Multi-objective calibration**
- › **Objective**

Material and Methods

- › **NSGAX SWAT Integration**
- › **Study area**
- › **Model set-ups**

Results and discussion

- › **Trade-off curves**
- › **Flow and sediment results**

Conclusion



INTRODUCTION

What is Multi-objective calibration

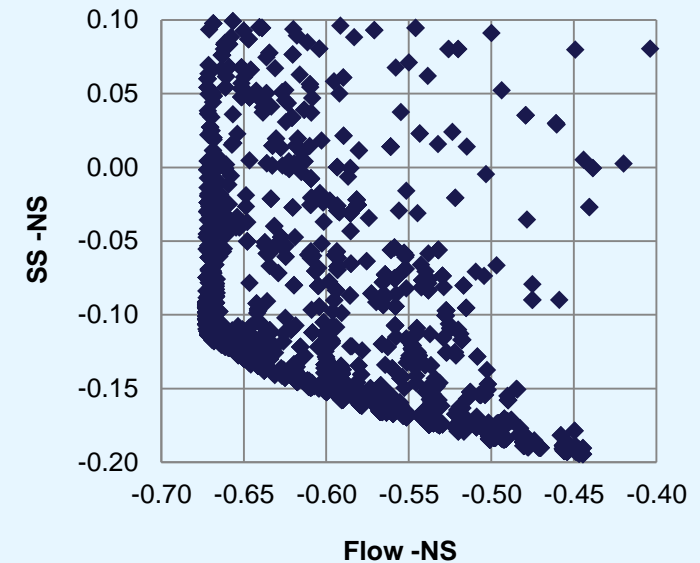
- › Optimize multiple objectives
- › Pareto front

Why use Multi-objective calibration

- › Provides trade-off information
- › Generates multiple solutions

Objective

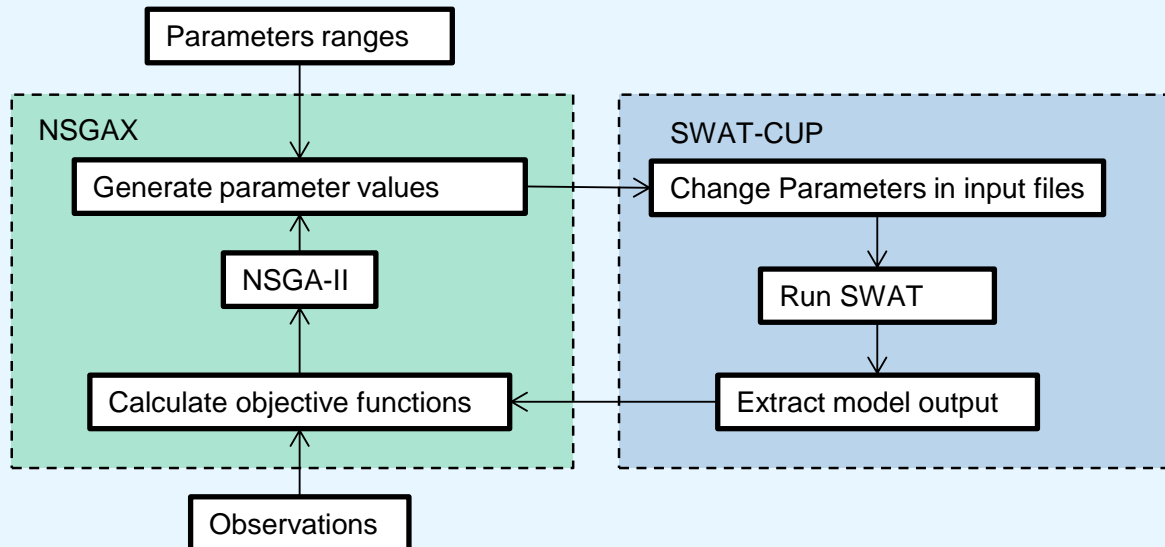
- › Compare 'goodness' of different model:
 - › Two sediment routing methods
 - › SWAT2009 and SWAT2005



MATERIAL AND METHODS

NSGAX SWAT INTEGRATION

- › Auto-calibration tool based on NSGA-II
- › Use SWAT-CUP to
 - › Change parameter (swat_edit.exe)
 - › Extract model output (swat_extrac_rch.exe)





MATERIAL AND METHODS

NSGAX Interface

- › Define input using SWAT-CUP input file format
 - › Parameters and range
 - › Observations
 - › Calibration period and sites
- › Select objective function
- › Define algorithm relate parameters

The screenshot shows the NSGAX software interface. The window title is "NSGAX". The menu bar includes "Project", "Set parameters", "Run", and "Help". The "Working folder" is set to "desktop\nsgax_loop4\loop4_mxgax.Glue.SwatCup\14PA_EQN0_6.in".

The "Input data" section contains several input fields:

- Populations: 80
- Generations: 50
- Obj. Functions: 2
- Constrains: 0
- Real Var.: 14
- Prob. Crossover: 0.90
- Prob. Mutation: 0.10
- Dis. index Cross: 15.00
- Dis. index Mutat: 20.00
- Binary Var.: 0
- Prob. Crossover Bin: 1.00
- Prob. Mutation Bin: 1.00
- Objective func.: NS

The "No. of Parameters" is set to 14. A table lists the parameters with their minimum and maximum values:

Name	Minimum	Maximum
r_CN2.mgt	-0.3	0
r_DEP_IMP.hru	-0.2	0
r_TDRAIN.mgt	0	2
v_ESCO.hru	0.85	0.95
v_ALPHA_BF.g	0.5	0.95
v_GW_DELAY	20	40
v_Usle_P.mgt	0.05	0.3
v_Spcon.bsn	0.0001	0.001
v_Spexp.bsn	1	1.5
V_PRF.bsn	0.05	0.3
v_CH_COV1.rte	0	0.6
v_CH_COV2.rte	0	1
r_CH_D.rte	1	3

The "Seed" is 0.50. The "Objective X axis" is "q_1.ou" and the "Objective Y axis" is "S_1.ou". A "Randomize" button is present.

The "Options" section includes:

- Update axes every 5 generations
- Plot Dominated individuals
- Plot All Domain

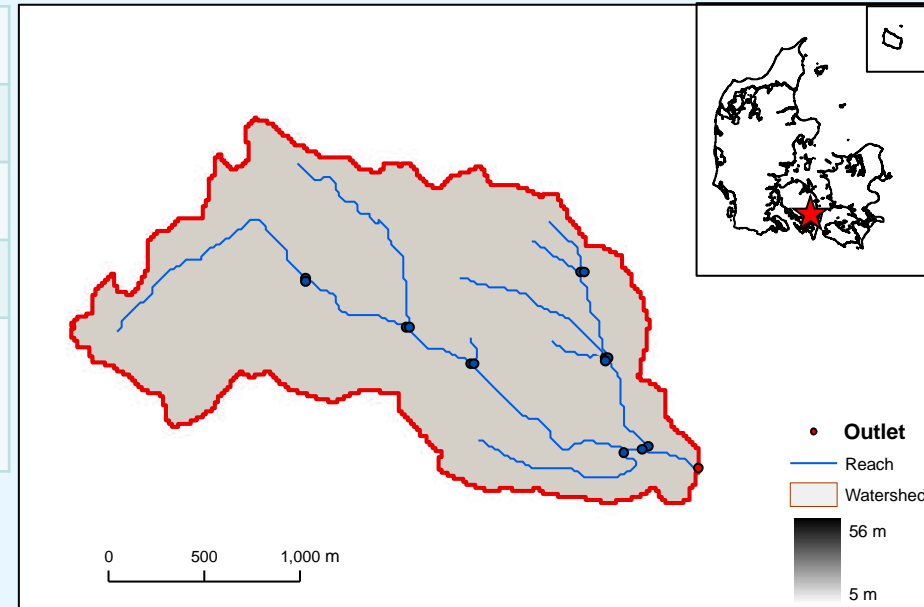
The status bar shows "Reading configuration file". The "External Input File" is "\G.pin", the "External Output File" is "\GM.rsp", and the "External Function Executable" is empty.

Buttons at the bottom: Run, Stop, Close.

MATERIAL AND METHODS

Study Area: Lillebæk

Location	Southeast coast of Fyn
Area	3.67 km ²
Land use	Agriculture 88%
Soil type	Sandy loam 86%
Climate 1995-2006	Annual precipitation: 654mm Temperature: warmest in Aug. 22°C coldest in Jan. -0.4°C



Limited surface runoff:

- › High infiltration capacity soil
- › Low rainfall intensity
- › Lowland topography



MATERIAL AND METHODS

Model set-ups:

SWAT2009 EQN-0 / SWAT2009 EQN-1 / SWAT2005 EQN-0

- › **Different Sediment routing methods:**
 - › EQN-0: **simplified Bagnold Equation**
 - › EQN-1: **improved simplified Bagnold Equation**
 - › **river bank and river bed routing**
 - › **SS only from silt, clay**
 - › **settling velocity**
- › **SWAT2009 and SWAT2005**

All 3 models share same:

- › Catchment delineation
- › HRU definition
- › Weather and management inputs



MATERIAL AND METHODS

Calibration

› Parameters

- › **Select after sensitivity analysis**
- › **Range defined by physical bound and experience**

SWAT2005 EQN-0	Same parameters and range
SWAT2009 EQN-0	
SWAT2009 EQN-1	Extra SS parameters

› **Model run**

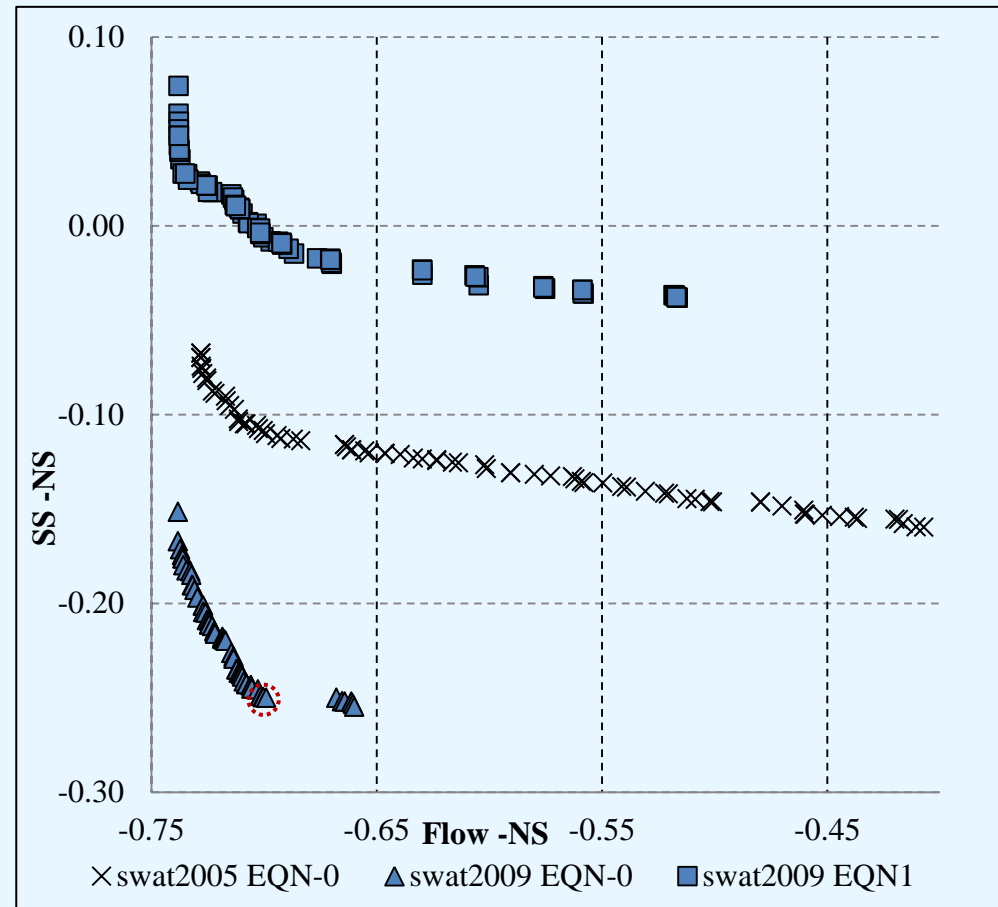
Warm up	Calibration	Validation
1995-1997	1998-2002	2003-2006

- › **Objective function: Nash-Sutcliffe (NS) efficiency**
- › **Calibrate on daily flow & weekly SS value**

RESULTS AND DISCUSSION

Trade-off curves

- › SWAT2009 EQN-1 best
- › All good at flow
- › Significant trade-off
- › Complex EQN-1 not suitable for the case



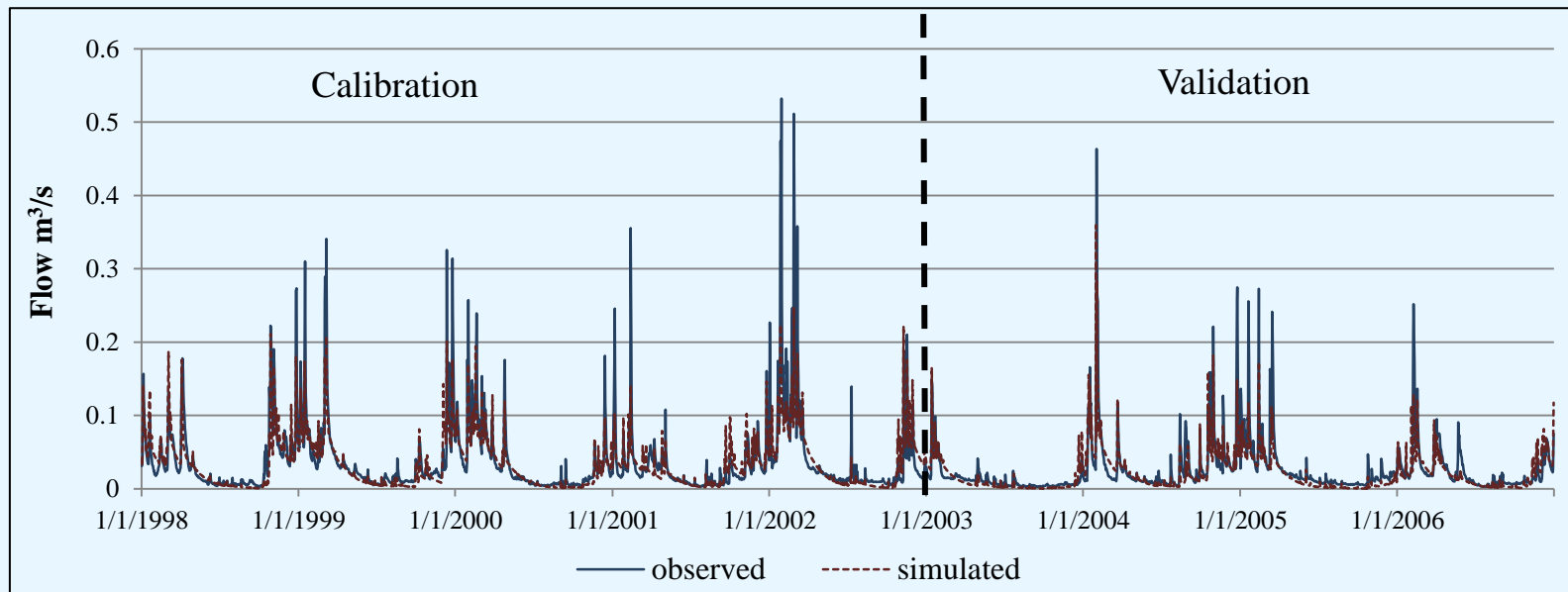


RESULTS AND DISCUSSION

Daily Flow

- › **Good in both calibration and validation**
- › **Good in both wet and dry period**
- › **Under estimate peak flows**

Period	Flow	
	NS	RMSE
Calibration 1998-2002	0.71	0.026
Validation 2003-2006	0.60	0.022



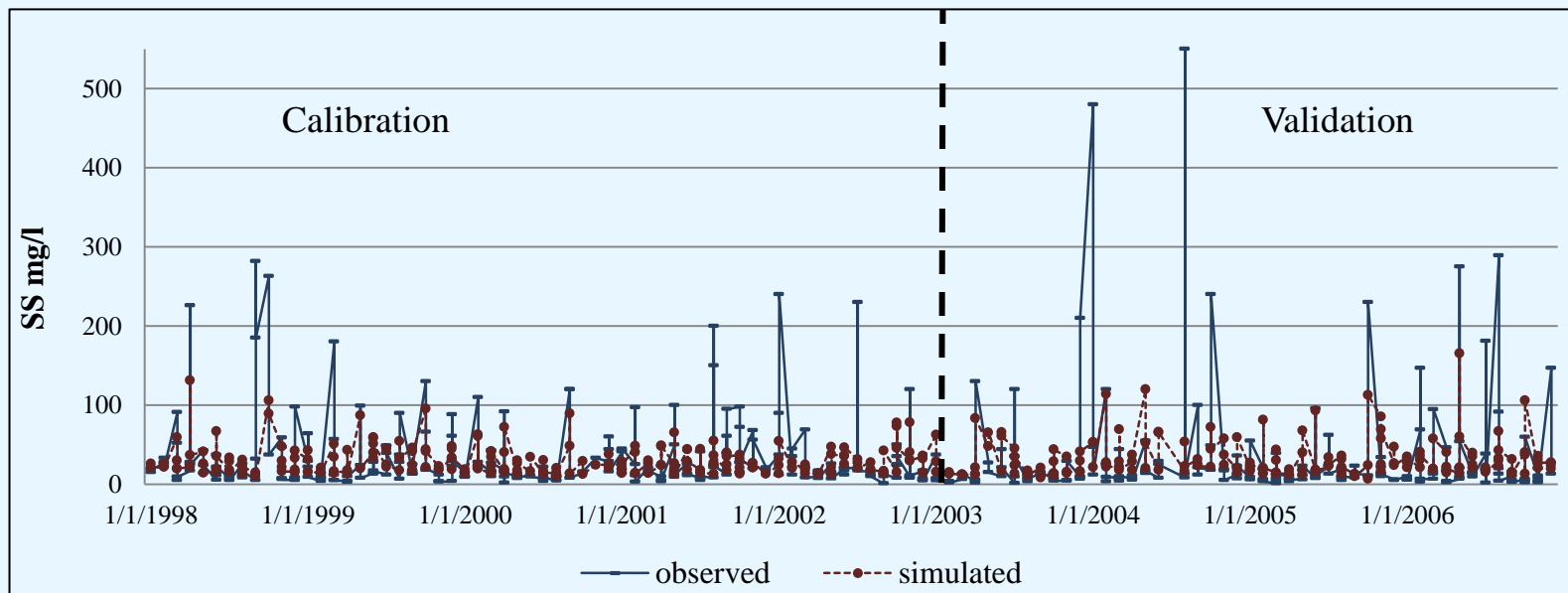


RESULTS AND DISCUSSION

Weekly SS

- › **Acceptable at low concentration**
- › **Cannot simulate high concentrations**

Period	Sediment	
	NS	RMSE
Calibration 1998-2002	0.21	40.41
Validation 2003-2006	0.15	65.27





CONCLUSION

- › **SWAT2009 EQN-0 most suitable for the case**
- › **Auto-calibrated parameters generates**
 - › **Good results for daily flow**
 - › **Acceptable results for SS**
- › **Further study on**
 - › **Correction of peak under estimation**
 - › **Sediment routing methods**

Thank you for your attention!
Questions? Or lunch!

MATERIAL AND METHODS

Calibration Parameters

Parameters	Symbol	Range	SWAT2009 EQN-1	SWAT2009 EQN-0**	SWAT2005 EQN-0
Curve number for moisture condition II	CN2	-0.3 – 0*	√	√	√
Depth to the impervious layer in the soil (mm)***	DEP_IMP	1200 – 1500	√	√	√
Time to drain to field capacity (h)	TDRAIN	24 – 72	√	√	√
Soil evaporation compensation factor	ESCO	0.85 -0.95	√	√	√
Base flow factor	ALPHA_BF	0.5 – 0.9	√	√	√
Ground water delay time (day)	GW_DELAY	20 – 40	√	√	√
USLE equation support practice factor	USLE_P	0.05 - 0.3	√	√	√
Linear parameter for calculation the maximum amount of sediment	SPCON	0.0001 – 0.001	√	√	√
Exponent parameter for calculation sediment reentrained in channel	SPEXP	1 – 1.5	√	√	√
Peak adjustment factor for sediment routing	PRF	0.05 – 0.3	√	√	√
Channel depth (m)	CH_D	0 – 3*	√	√	√
Channel width (m)	CH_W2	-0.5 – 0*	√	√	√
Channel erodibility factor	CH_COV1	0.1 – 0.6	√	√	√/CH_EROD ***
Channel cover factor	CH_COV2	0 – 1		√	√/CH_COV ***
Erodibility of channel bank sediment by jet test (cm ³ /N-s)	CH_BNK_KD	0.001 – 3.75	√		
Erodibility of channel bed sediment by jet test (cm ³ /N-s)	CH_BED_KD	0.001 – 3.75	√		