NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE
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NEW USAGE OF MULTI-OBJECTIVE CALIBRATION: MODEL COMPARISM

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

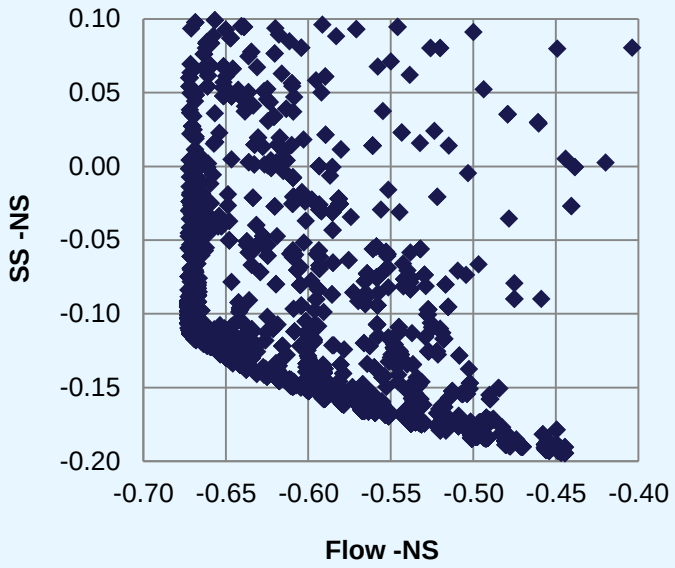
INTRODUCTION

What is Multi-objective calibration

- Optimize multiple objectives
- Pareto front

Why use Multi-objective calibration

- Provides trade-off information
- Generates multiple solutions



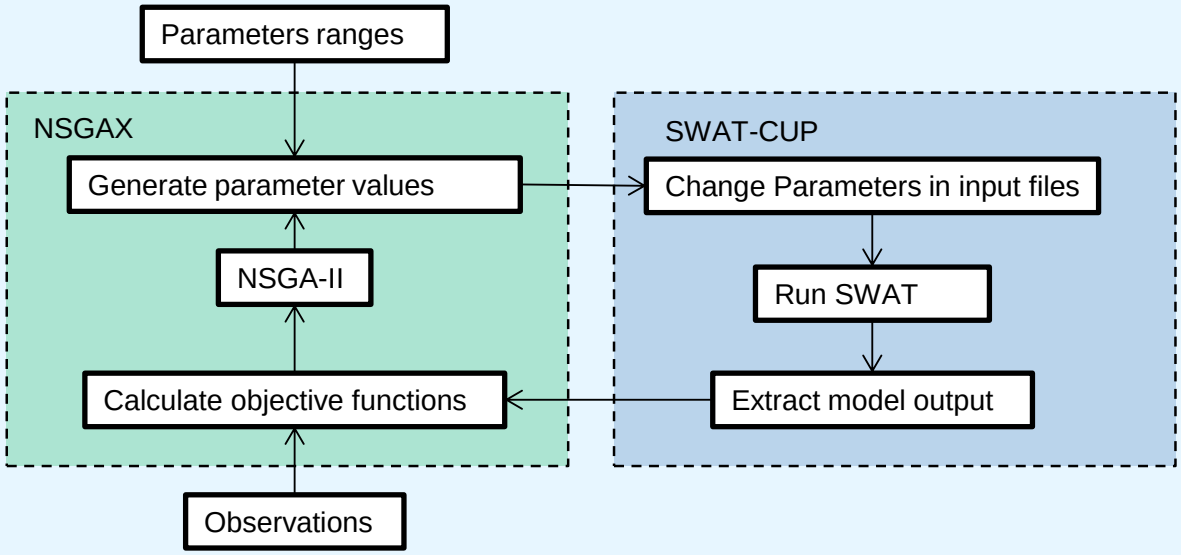
Objective

- 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)

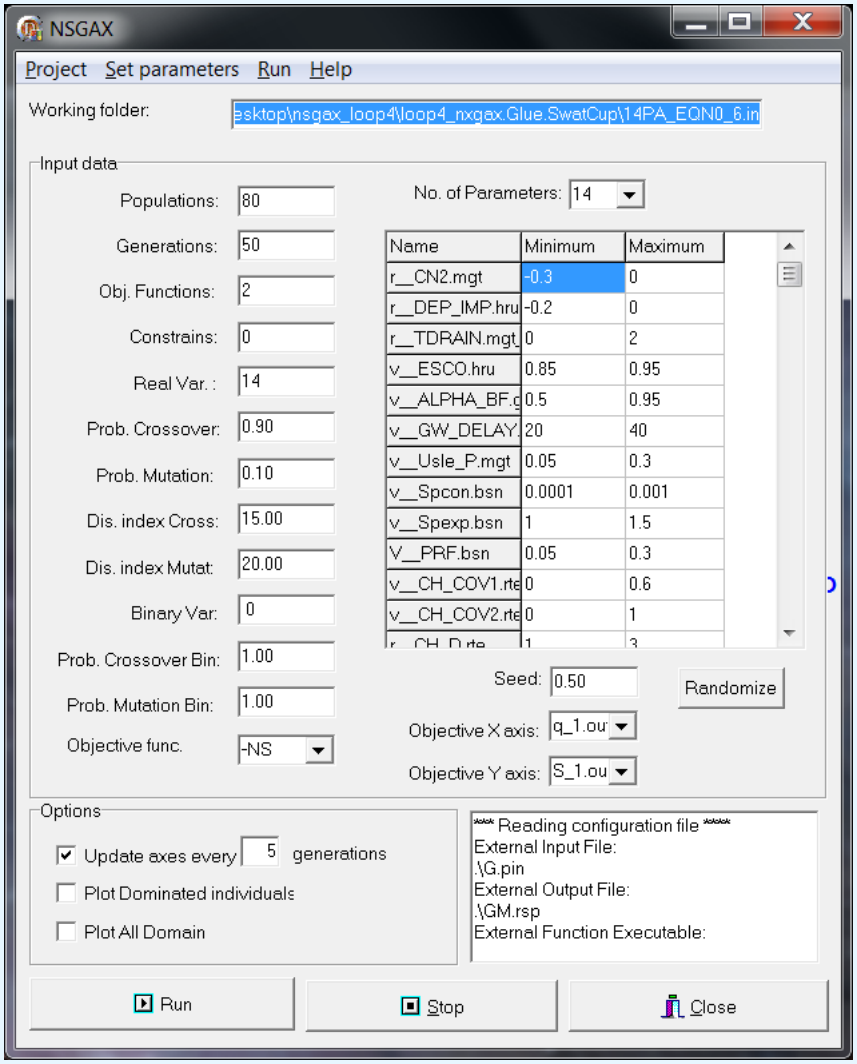


Linked by Kayastha et al. 2011

MATERIAL AND METHODS

NSGAX Interface

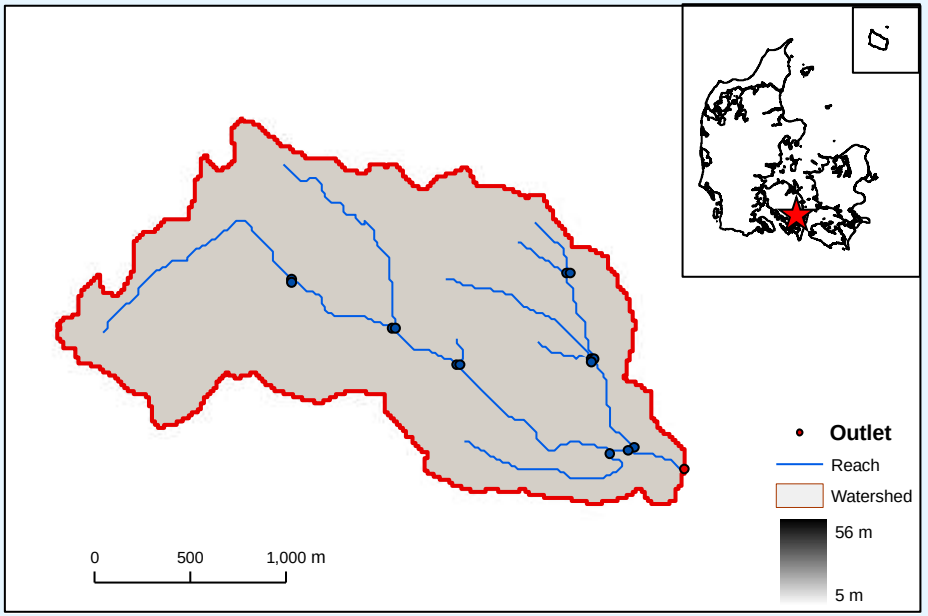
- Define input using SWAT-CUP input file format
  - Parameters and range
  - Observations
  - Calibration period and sites
- Select objective function
- Define algorithm relate parameters



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**

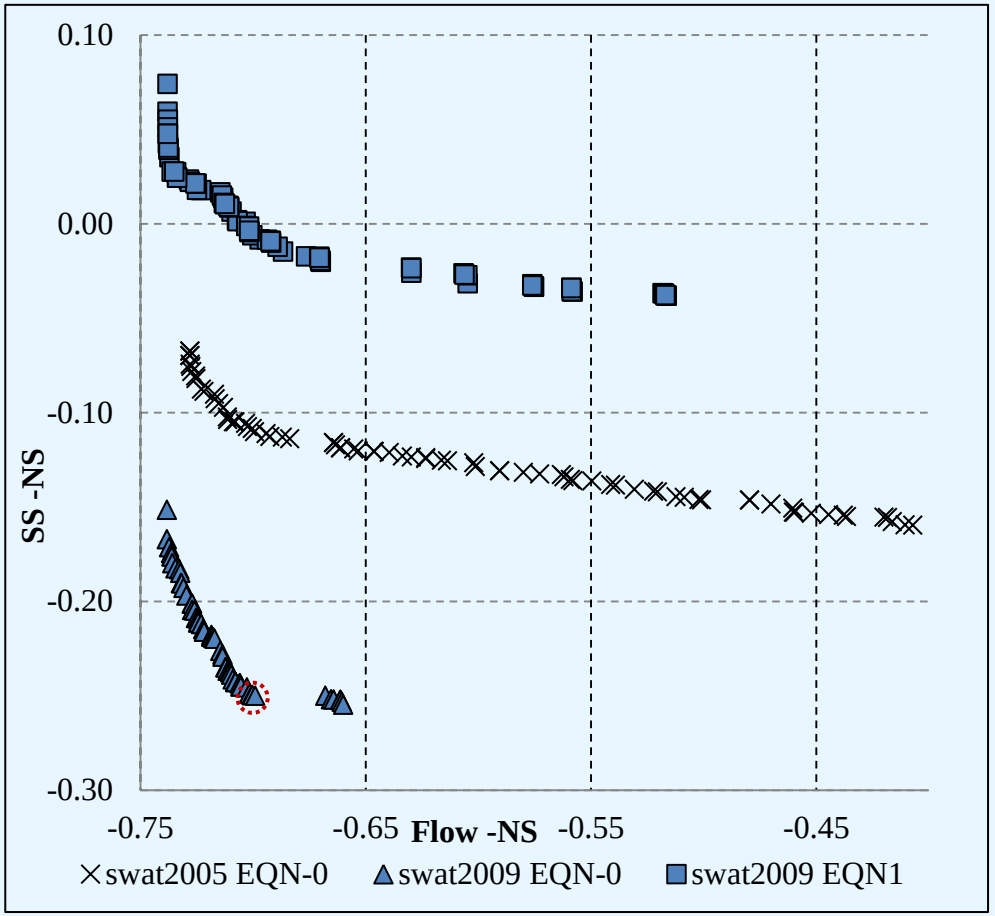
Warm up	Calibration	Validation
1995-1997	1998-2002	2003-2006

- **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

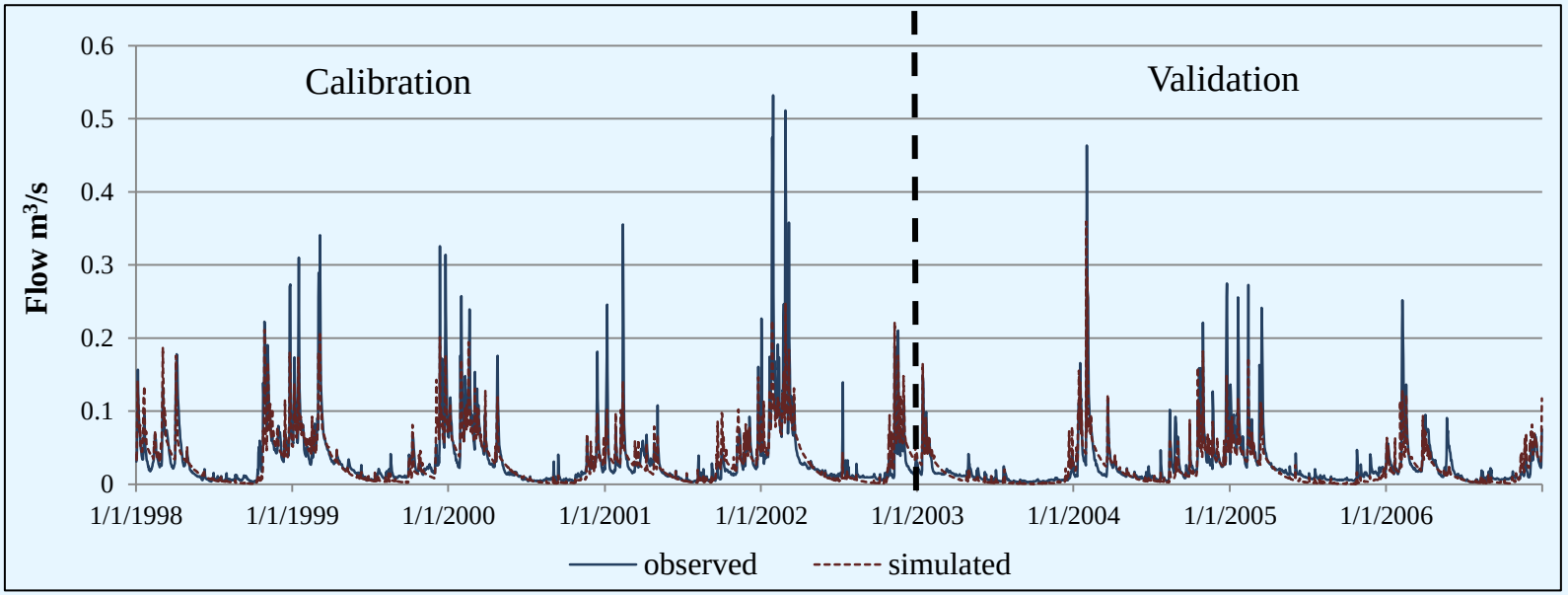


RESULTS AND DISCUSSION

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

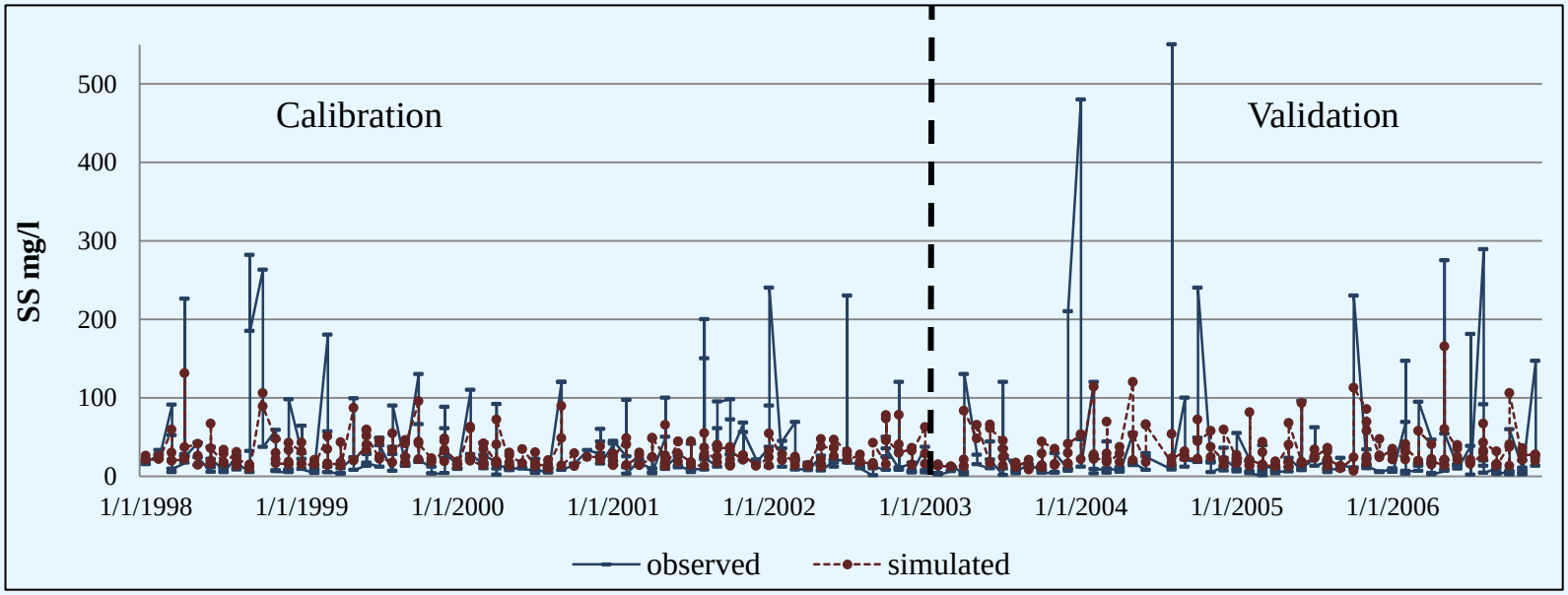


RESULTS AND DISCUSSION

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 filed 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	√		