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INTERNATIONAL SWAT CONFERENCE 2015:

UTILIZATION OF SOIL AND WATER ASSESSMENT TOOL IN INDONESIA

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Background

Hydrological model is a simple presentation of a complex hydrologic system → climate, soil, land use and land management → process in a watershed

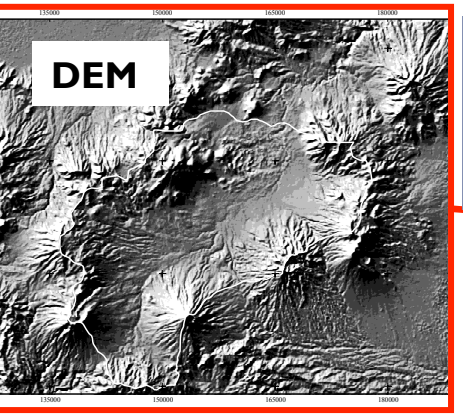
SWAT model :

- to predict the effect of land management on water yield, sediment, pesticides and chemical of agricultural products that enter the river or body of water in a watershed which complex with soil, land use and various management over a long time (Neitsch *et al.*, 2005) ➔

determining a watershed management activities ➔

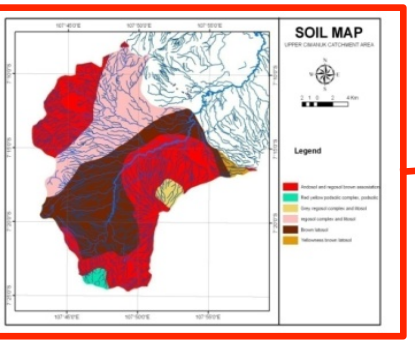
Scenarios ➔ Statisfatory calibration and validation

SWAT modeling

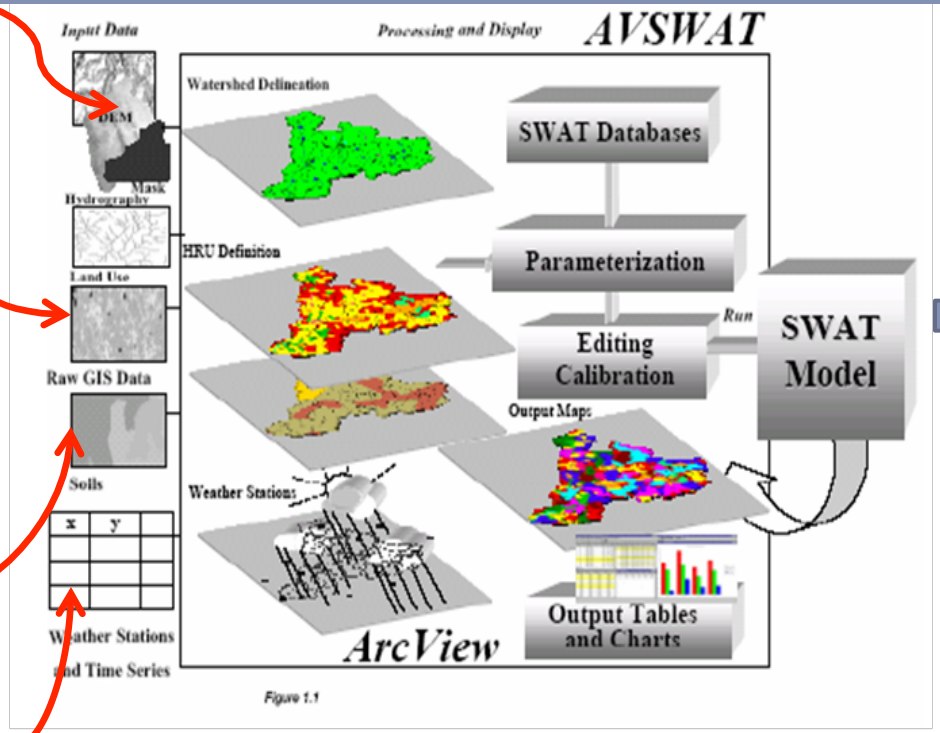


Predicting impact of climate, vegetation, dam, ground water and water use management on water yield, sedimentation and water quality

Landuse



Climate



Calibration and Validation

R^2
NSE

0,75<NSE<1,00 (very good),
0,65<NSE<0,75 (good),
0,5<NSE<0,65 (satisfied)
NSE≤ <0,50 (not satisfied).
Moriasi *et al.*, (2007)

$$NSE = 1 - \frac{\sum_{i=1}^{n}(Q_{obs,i} - Q_{Sim,i})^2}{\sum_{i=1}^{n}(Q_{obs,i} - \bar{Q}_{Sim,i})^2}$$

The aim of this study

- to understand the process of calibration and uncertainty factors that affect the processes occurring in hydrological modeling
- to identify sensitive input parameters and calibration techniques according to Indonesian condition, especially West Java Province using SWAT Model

SWAT ➔ a lot of parameters

➔determining the specific parameters which really affect the hydrology of a watershed

- a) the absolute sensitivity analysis in which the value of one parameter is vary while the other parameters remains constant
- b) the relative sensitivity analysis in which all parameters vary simultaneously

Calibration, Validation & Verification

- CALIBRATION: model testing with known input and output used to adjust or estimate factors
- VALIDATION: comparison of model results with an independent data set (without further adjustment).
- VERIFICATION: examination of the numerical technique in the computer code to ascertain that it truly represents the conceptual model and that there are no in here

Calibration/Validation Periods :

- distinct time period
- similar range of conditions
- adequate time period to simulate conditions

Model Configuration

- Land use categories : land use types in watershed, existing and future land uses, management techniques employed, management questions
- Subwatersheds : location, physical characteristics/soils, gaging station locations, topographic features, management questions.
- Reaches : topographic features, stream morphology, cross-section data available

Calibration Issues :

- individual land use parameter determination
- location of gaging station data
- location of water quality monitoring information
- available information on stream systems

Calibration/Validation Procedures

- Hydrology
- Sediment
- Water quality : nitrogen, phosphorus, pesticides, DO, bacteria

Calibration/Validation Common Problems

- too little data
- small range of conditions : only small storms or storms during the spring etc
- prediction of future conditions which are outside the model conditions
- calibration/validation does not adequately test separate pieces of model
- adjusment of the wrong parameters
- calibration adjustments destroy physical representation of system by model

Key consideration in calibration : water balance , storm sequence

SCIENTIFIC JOURNAL-BASED SWAT RESEARCH IN INDONESIA

- As per June 2015, there are only 3 papers discussing about SWAT, where all of the applications are concentrated in the Java Island.
  1. Prasena and Shrestha (2013): *Indonesian Journal of Geography*
  2. Othman and Sholichin (2008): *International Association for Environmental Hydrology Vol. 16*
  3. Ridwansyah *et al* (2014): *International Journal of Science and Engineering Vol. 6*

- ArcSWAT 2009 was the interface that was used to perform runoff simulation in Bedog Sub Watershed, Jogjakarta, Indonesia.

- The most sensitive parameter is the Available Water Capacity (SOL_AWC).

- The parameters which were considered to be sensitive in runoff production are:
  1. Available water capacity (SOL_AWC),
  2. Soil evaporation compensation factor (ESCO),
  3. Depth from soil surface to bottom of layer (SOL_Z).

- Runoff generation was also found to be sensitive to groundwater parameters:
  1. Threshold depth of water in the shallow aquifer required for return flow to occur (GWQMN) in mm,
  2. Base flow alpha factor (ALPHA_BF) in days.

- The value of R^2 for the year 2001, 2006, and 2010 was 0.7, 0.57, 0.51 respectively.

- The value of Nash-Sutcliffe Coefficient of Efficiency (NSE) for the year 2001 and 2010 was 0.64 and 0.43 respectively.

JOURNAL OF ENVIRONMENTAL HYDROLOGY
The Electronic Journal of the International Association for Environmental Hydrology
On the World Wide Web at http://www.hydroweb.com

Othman and Sholichin (2008): *International Association for Environmental Hydrology Vol. 16*

- AVSWAT was the interface that was used to assess the effect of fertilizer application rates on nutrient transport to the Sutami reservoir within Brantas River Basin in East Java, Indonesia.

- Stream-flow parameters calibration include:
  1. CN2,
  2. ESCO and
  3. SOL_AWC

- The values of sediment parameters calibrated include:
  1. USLE_C,
  2. USLE_P,
  3. SLSUBBBSN,
  4. SLOPE and
  5. SPEXP.

- Nutrient value parameters calibrated include:
  1. PPERCO,
  2. PHOSKD,
  3. SOL-OrgP,
  4. SOL-OrgN and
  5. RS5.

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Parameter Name	Model Process	Description	Model Range	Actual Value
CN2	Flow	Curve number	± 10%	-6
ESCO	Flow	Soil evaporation compensation factor	0.00 t0 1.00	1
SOL_AWC	Flow	Soil available water capacity	± 0.04	+0.02
USLE_C	Sediment	Universal Soil Loss Equation C factor	0.0001 to 1	0.150
USLE_P	Sediment	Universal Soil Loss Equation P factor	0.1 to 1.0	0.6
SLSUBBSN	Sediment	Average slope length (m)	NA	-10%
SLOPE	Sediment	Average slope steepness (m/m)	NA	-10%
SPEXP	Sediment	Exponential factor channel sediment routing	1.0 to 1.5	1.0
PPERCO	Mineral P	Phosphorous percolation coefficient	10 to 17.5	10
PHOSKD	Mineral P	Phosphorous soil partitioning coefficient	100 to 200	200
FRY_LY1	Nutrient	Fraction of fertilizer applied to top 10mm soil layer	0.0 to 1.0	0.2
SOL_ORGP	Organic P	Initial organic P concentration in the upper soil layer	NA	0.2 mg/kg
SOL_ORGN	Organic N	Initial organic N concentration in the upper soil layer	NA	0.2 mg/kg
RS5	Total P	Settling rate organic P at 20^0C	0.001 to 0.1	0.1

- AVSWAT calibration parameters and their final values for the Sutami Reservoir

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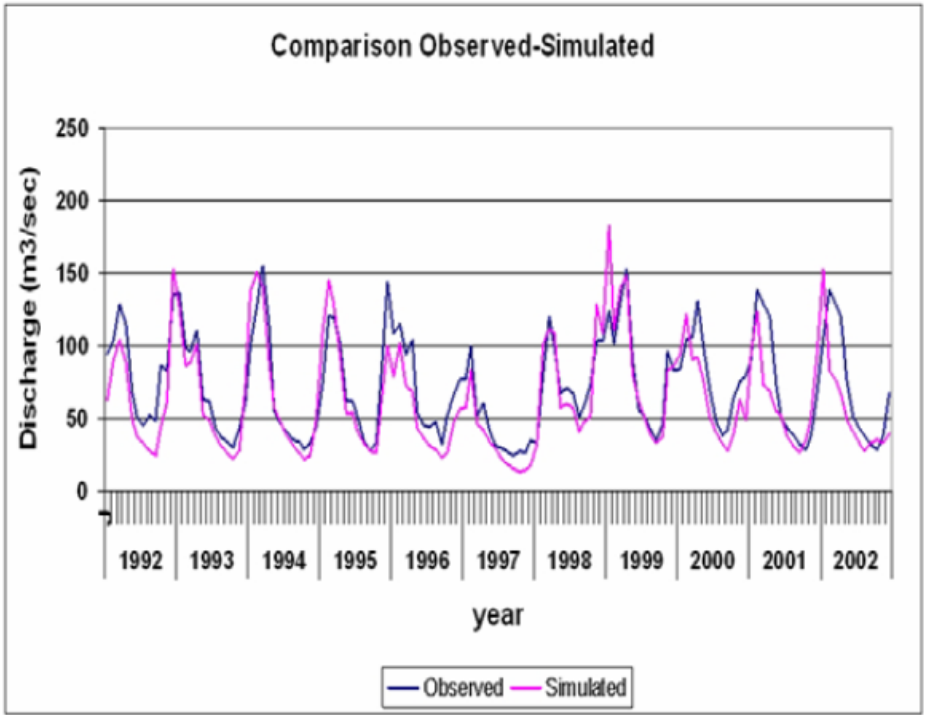
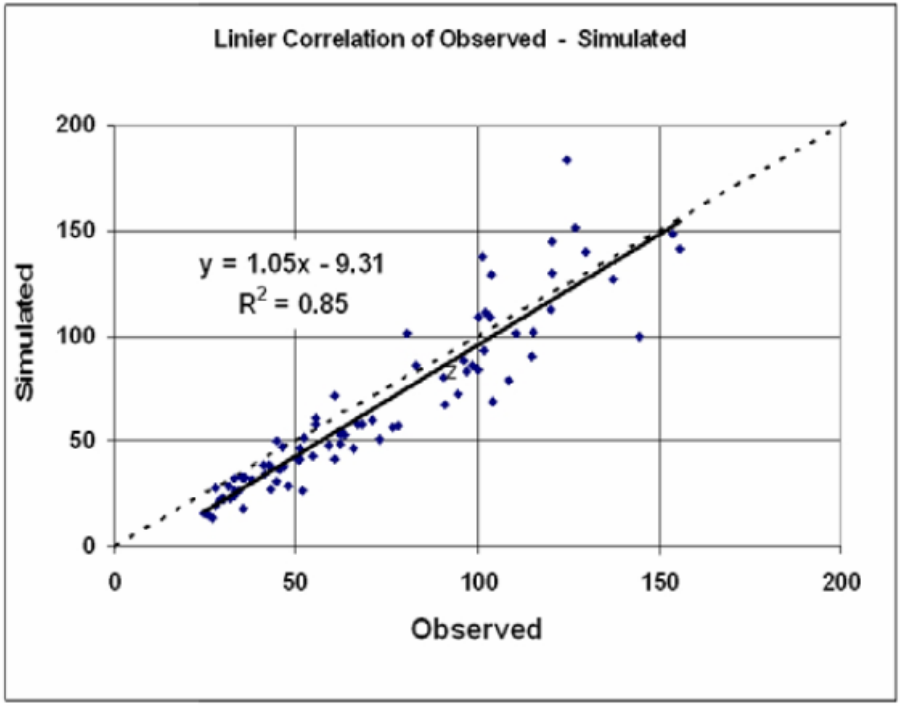
- The resulting statistical goodness-of-fit was evaluated with the Nash-Sutcliffe coefficient, $R^2_{NS} = 0.32$ and the linear correlation was found to be $R^2 = 0.85$.

(a)



(b)



(a) Comparison between observed and simulated flow; (b) Linear correlation of observed and simulated flows

- ArcSWAT and SUFI2 was used to perform a comprehensive watershed modeling in predicting river flow in Cisadane Catchment Area, Indonesia.

- Using SUFI2, 12 parameters during the calibration were found to be more sensitive, where CN2 was considered the most sensitive among the others.

- The parameters include: CN2, ALPHA_BF, GW_DELAY, GWQMN, GW_REVAP, ESCO, CH_N2, CH_K2, ALPHA_BNK, SOL_AWC, SOL_K, and SOL_BD

- The parameters below have given ranks for their sensitivity to the model calibration.

No	Parameter_Name	Fitted_Value	Min_value	Max_value
1	R__CN2.mgt	-0.14	-0.2	0.2
2	V__ALPHA_BF.gw	0.35	0	1
3	V__GW_DELAY.gw	32.5	10	60
4	V__GWQMN.gw	0.7	0	2
5	V__GW_REVAP.gw	0.01	0	0.2
6	V__ESCO.hru	0.89	0.8	1
7	V__CH_N2.rte	0.135	0	0.3
8	V__CH_K2.rte	111.25	5	130
9	V__ALPHA_BNK.rte	0.45	0	1
10	R__SOL_AWC(..).sol	0.17	0.2	0.4
11	R__SOL_K(..).sol	0.24	0.1	0.8
12	R__SOL_BD(..).sol	0.5	0.1	0.6

- Fitted value, and minimum and maximum ranges of parameters in the SUFI-2 uncertainty techniques

- The most sensitive parameters recorded after sensitivity analysis for daily calibration in SUFI-2 procedures is presented below:

Parameter Name	rank	t-Stat	P-Value
R__CN2.mgt	1	1.324272387	0.227013
V__ALPHA_BF.gw	2	0.232031793	0.823151
V__GW_DELAY.gw	3	2.051756529	0.079324
V__GWQMN.gw	4	0.585847879	0.576371
V__GW_REVAP.gw	5	1.236567016	0.256124
V__ESCO.hru	6	1.049884034	0.328661
V__CH_N2.rte	7	1.565833881	0.161369
V__CH_K2.rte	8	-6.67780619	0.000283
V__ALPHA_BNK.rte	9	2.618492264	0.034485
R__SOL_AWC(..).sol	10	-0.955975391	0.370926
R__SOL_K(..).sol	11	3.552908082	0.009307
R__SOL_BD(..).sol	12	1.84147118	0.108111

- Parameter sensitivities for SUFI-2

- CONCLUSION
- * In the hydrology modeling, both the input parameters and the model is something that is not definite - each input reflect the condition of a watershed at a particular moment/time that cannot be compared to any other time.
- * Sensitive input parameters were vary and manual calibration is very helpful in understanding the process and uncertainty parameter in a model for small watershed scale.

THANK YOU