GIS 환경시스템 연구실

GIS Environmental Systems Lab.

KNU http://www.EnvSys.co.kr

Development of Integrated SWAT-VFSMOD model

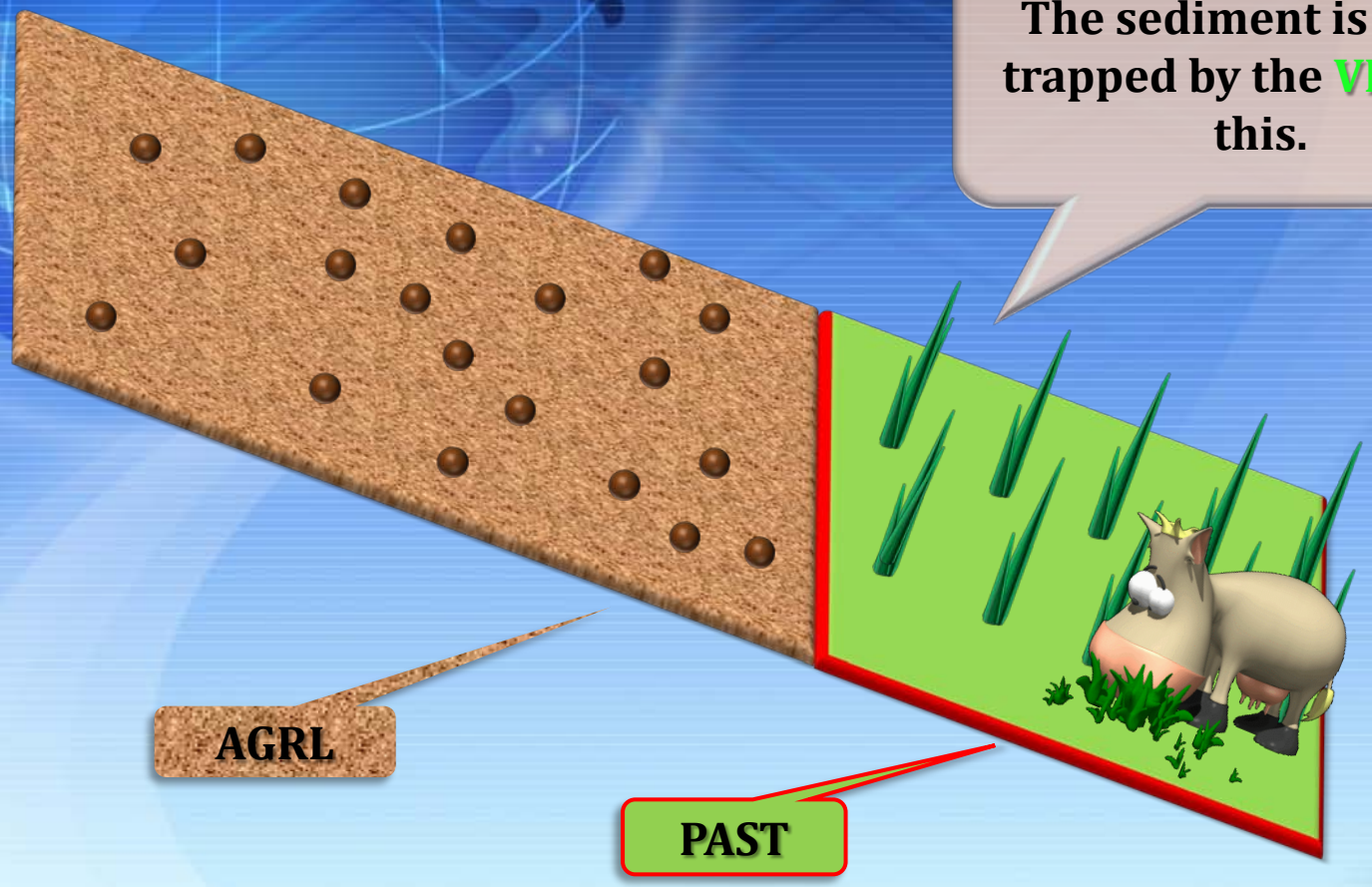
SWAT Conference
Aug. 4-6, 2010

Youn Shik Park
Kangwon National Univ. in South Korea

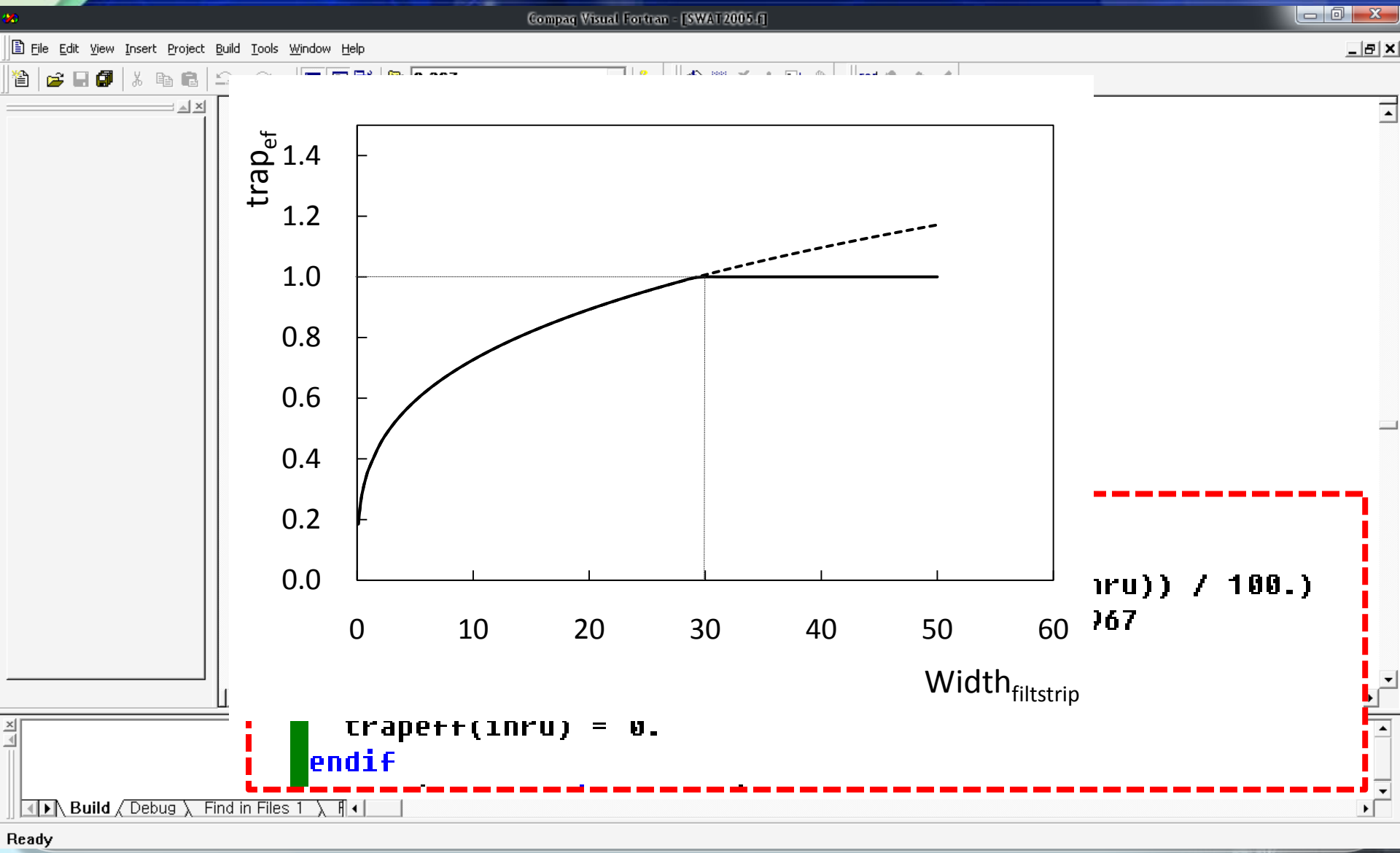
About Vegetative Filter Strip..

- The muddy water is not that simple problem.
- To prevent and management this, there are some methods.
- The **VFS** is deemed as one of the good methods against this sediment-laden water problem.

How does it work ??



Limitation of Current SWAT..



VFSMOD – W MOD

Hydrology and Water Quality - Dr. Rafael Muñoz-Carpena - Windows Internet Explorer

http://carpena.ifas.ufl.edu/

Hydrology and Water Quality - Dr. Rafael Muñoz-Car...

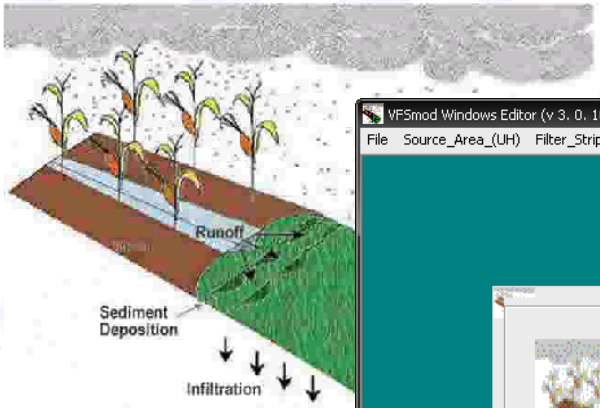
UF|IFAS|ABE : Hydrology & Water Quality

RESEARCH EXTENSION PUBLICATIONS UF-HydroBase SOFTWARE STAFF CONTACT HOME

VFSMOD Vegetative Filter Strip Modeling System

- Abstract
- Draft Users Guide (pdf) - Old Users Guide
- History of changes - Last Update 01/28/2007
- Registration, Download Source Code and Available Executables *(NEW: version 4.0.xx is now in the install package)*
- Updates *(for the current version - Last change 1/28/2007)*
- Feedback - questions, suggestions, etc
- Citings of VFSMOD in journal articles, on the Web, and in User Applications
- Disclaimer and Other Items

- Frequently Asked Questions NEW



In memory of John E. Parsons (1952-2005)
our mentor and friend

last update 01/28/2008 ; created 2/28/1997
Questions or Comments... *Rafael Muñoz-Carpena*

http://carpena.ifas.ufl.edu/research.html

VFSmod Windows Editor (v 3. 0. 10)

File Source_Area_(UH) Filter_Strip_(VFS) D

VFSMOD Vegetative Filter Strip Modeling System

Citings of VFSMOD in journal articles, on the Web, and in user applications

(Please e-mail us to add other papers to this list!)

- Refereed journal articles about VFSMOD or citing VFSMOD use:
  - Effectiveness of Vegetative Filter Strips in Reducing Pesticide Loading: Quantifying Pesticide Trapping Efficiency. 2008. Sabbagh, G.J., G.A. Fox, A. Kamanu, B. Roepke and J. Z.Tang. J. ENV. QUALITY. Accepted for pub. Q08_0266.
  - A Design Aid for Determining Width of Filter Strips. 2008. M.G. Dosskey, M.J. Helmers, and D.E. Eisenhauer. JOURNAL OF SOIL AND WATER CONSERVATION 63(4):232-241.
  - Evaluation of water quality models through global sensitivity and uncertainty analyses techniques: application to the vegetative filter strip model VFSMOD-W. 2007. Muñoz-Carpena, R., Z. Zajac and Yi-Ming Kuo. TRANS. OF ASABE 50(5):1719-1732.
  - Uncertainty in TMDL models. 2006. Shamsudduha, A. I. Chaubey, R.D. Harmel, D.D. Bosch, R. Muñoz-Carpena, C. Dharmasri, A. Sexton, M. Arabi, M.L. Wolfe, J. Frankenberger, C. Graff and T.M. Sohrabi. TRANS. OF ASABE 49(4):1033-1049.
  - Establishing conservation buffers using precision information. 2005. M.G. Dosskey, D.E. Eisenhauer, and M.J. Helmers. JOURNAL OF SOIL AND WATER CONSERVATION. 60(6):349-354.
  - Suspended sediment removal by vegetative filter strip treating highway runoff. 2005. J. Han, S. Wu and C. Allan. JOURNAL OF ENVIRONMENTAL SCIENCE AND HEALTH. 40:1637-1649.
  - Modeling sediment trapping in a vegetative filter accounting for converging overland flow. 2005. M.J. Helmers, D. E. Eisenhauer, M. G. Dosskey, T. G. Franti, J. M.G. Dosskey. TRANS. OF THE ASABE Vol. 48(2): 541-555.
  - Flow pathways and sediment trapping in a field-scale vegetative filter. 2005. M. J. Helmers, D. E. Eisenhauer, M. G. Dosskey, T. G. Franti, J. M. Brothers, M. C. McCullough. TRANS. OF THE ASABE Vol. 48(3): 955-968.
  - A design procedure for vegetative filter strips using VFSMOD-W. 2004. Muñoz-Carpena, R, Parsons, JE. TRANS. OF THE ASAE vol 47 (6):1933-1941.
  - Cost-effective Targeting of Riparian Buffers. 2004. Yang, W. and A. Weersink. CANADIAN JOURNAL OF AGRICULTURAL ECONOMICS 52:17-34.
  - Assessment of concentrated flow through riparian buffers. 2002. Dosskey, MG, Helmers, MJ, Eisenhauer, DE, Franti, TG, Hoagland, KD. JOURNAL OF SOIL AND WATER CONSERVATION. vol 57(6):336-343.
  - Effectiveness of vegetation barriers for nearly sediment trapping. 2004. Rey, F. EARTH SURFACE PROCESSES AND LANDFORMS. vol (29):1161-1169.
  - Factors affecting sediment trapping in vegetated filter strips: simulation study using VFSMOD. 2001. Abu-Zreig, M. HYDROLOGIC PROCESSES. vol 15(8):1477-1488.
  - Validation of a vegetated filter strip model (VFSMOD). 2001. Abu-Zreig, M, Rudra, RP, Whitely, HR. HYDROLOGIC PROCESSES. vol 15(5):729-742.
  - Modeling overland flow and sediment transport in vegetative filter strips: model development and application. 1999. Muñoz-Carpena, R., J. E. Parsons, and J. W. Gilliam. 1999. JOURNAL OF HYDROLOGY. 214(1-4):111-129.
  - Numerical approach to the overland flow process in vegetative filter strips. 1993. Muñoz-Carpena, R., J. E. Parsons, and J. W. Gilliam. 1993. TRANS. OF ASAE. 36(3):761-770.
  - A quadratic Petrov-Galerkin solution for kinematic wave overland flow. 1993. Muñoz-Carpena, R., C. T. Miller, and J. E. Parsons. WATER RESOURCES RESEARCH. 29(8):2615-262.
- Proceedings:
  - 1999 ASAE Paper - Using VFSMOD for Developing Design Guides for Vegetative Filter Strips
  - 2001 ASAE Paper - Impact of Uncertainty on the Design of Vegetative Filter Strips
  - 2001 Conference on Environmental Research, Kansas State University- VFSMOD is used as the base model to predict transport of *Cryptosporidium parvum* oocysts in VFS overland flow (pdf)
  - 2002 TMDL Papers -
    - Paper 1 - VFSMOD-W a graphical Windows system for the evaluation and design of vegetative filter strips for sediment trapping
    - Paper 2 - A normalized design procedure to meet sediment TMDL with vegetative filter strips
  - 2004 ASABE Paper - Evaluation of Green-Ampt parameters for riparian buffers (pdf)
  - 2006 ASABE paper - Modeling Water and Sediment Trapping by Vegetated Filters Using VFSMOD: Comparing Methods for Estimating Infiltration Parameters (pdf)
  - 2007 ASABE paper - An Inverse Calibrator For VFSMOD-W Using The Global Multilevel Coordinate Search/ Nelder-Mead Simplex Algorithm (pdf)
  - 2008 ASABE Paper - Development of Web GIS based VFSMOD System to Simulate Sediment Reduction Efficiency with Vegetative Filter Strip (pdf)
  - 2008 ASABE Paper - Enhancement and Evaluation of SWAT Filter Strip Module reflecting Field Runoff Volume and Filter Strip Width (based on VFSMOD) (pdf)
- Handbooks, reports and manuals:
  - VFSMOD is listed for Analysis of Management Practices in the US-EPA's "Handbook for Developing Watershed Plans to Restore and Protect Our Waters/Contents" (draft October 2005) (pdf).
  - VFSMOD is discussed in the Chapter on Buffer strips by M.J. Helmers et al. in the "Gulf Hypoxia and local water quality concerns" workshop to assess nutrient losses to water resources in the Corn Belt. Iowa State University, Sept. 26-28, 2005 (pdf)
  - A linkage of VFSMOD with SWAT is proposed as part of the "Great Lakes Tributary Modeling Program: Status Report", U.S. Army Corps of Engineers Great Lakes & Ohio River Division Cincinnati, Ohio (pdf)
  - The VFSMOD development work is referenced in the New Jersey Stormwater Best Management Practices Manual (February 2004) (pdf)
  - USDA-ARS is using VFSMOD-W as the Optimization of Buffer-Grass Criteria As Part of National P-Index Evaluation (web page)
  - Project using VFSMOD for education on the effectiveness of vegetative filter strips in Iowa (pdf)
  - VFSMOD was used in a project to evaluate performance of vegetative filters to remove highway pollutants (pdf)
  - US-EPA lists VFSMOD as a model that can be used in determing vegetative filter lengths (pdf) (In Chapter 6 of National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution)
  - Reference to VFSMOD in US-EPA report " Evaluation of Sediment Transport Models and Comparative Application of Two Watershed Models" (pdf)
  - Cited as a model for use in sizing VFS by USGS Report (pdf)
  - VFSMOD is used as a basis for testing and evaluating their field project at U. of Guelph (pdf)
  - VFSMOD is used as the base model for U. of Guelph's phosphorus modeling effort (see pdf & pdf for details)
- Web tools:
  - Web GIS (Google Earth) based VFSMOD, Kangwon National University, Chuncheon, Gangwon, Republic of Korea [html]
- Training and other efforts:
  - VFSMOD-W Training Workshop at the Universidad Politécnica de Madrid, ETSI Agrónomos (Spain). July 2-6, 2007 [Programa, PDF]

last update 11/02/2008 ; created 7/30/2005
Questions or Comments... Rafael Muñoz-Carpena

What does VFSMOD – w model need..??

Source Area

Rainfall event and Runoff
(Rainfall, Storm Duration, Curve Number, Strom Type)

Source Area
(Length along slope, Slope as a fraction, Area)

Erosion Parameters
(Soil Erodibility, Soil Type, Percent organic matter, Particle Class Diameter, Crop Factor, Practice Factor)

Filter Strip

Overland Flow Inputs
(Buffer Length, Width of the Strip)

Soil Properties
(Vertical Saturated K, Initial Water Content, Saturated Water Content)

Buffer Vegetation Properties
(Spacing for grass stems, Height of Grass, Roughness)

Improvement of SWAT model – Old Study

SWAT2005_oF - Compaq Visual Fortran - [SWAT2005_oF.f]

File Edit View Insert Project Build Tools Window Help

trapeff_vfs

Workspace 'SWAT200!
SWAT2005_oF fil

```
      subroutine trapeff_vfsmod
!!    ~ ~ ~ LOCAL DEFINITIONS ~ ~ ~
!!    name          |units        |definition
!!    ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~
!!    j             |none         |HRU number
!!    filterw       |m            |filter strip width of subbasins
!!    surfq         |mm H2O       |surface runoff generated on day in HRU
!!    trapeff_vfs(:)              |revised trapping efficiency using vfsmod-w
!!    wf            |m**3         |inflow water yield into VFS.. EnvSys
!!    ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~

!!    ~ ~ ~ ~ ~ ~ END SPECIFICATIONS ~ ~ ~ ~ ~ ~

      use parm

      real :: wf
      integer :: j

      j = 0
      j = ihru

      wf = 0.
      wf = surfq(ihru) * hru_ha(ihru) * 10
          !!   mm      *     ha       * = m**3   !!EnvSys

      if (filterw(ihru) > 0. .and. wf > 1) then
       trapeff_vfs(ihru) = (-0.0000734504 6*filterw(ihru)**3
     & +0.001558*filterw(ihru)**2-0.006376*filterw(ihru)-0.001189)
     & *(log(wf))**3+(0.0009688469*filterw(ihru)**3
     & -0.020779*filterw(ihru)**2+0.095153*filterw(ihru)+0.019348)
```

FileView

SWAT2005_oF.obj - 0 error(s)

Build Debug Find in Fi

Ready

```
if (filterw(ihru) > 0. .and. wf > 1) then
 trapeff_vfs(ihru) = (-0.0000734504 6*filterw(ihru)**3
& +0.001558*filterw(ihru)**2-0.006376*filterw(ihru)-0.001189)
& *(log(wf))**3+(0.0009688469*filterw(ihru)**3
& -0.020779*filterw(ihru)**2+0.095153*filterw(ihru)+0.019348)
& *(log(wf))**2+(-0.004274*filterw(ihru)**3
& +0.092846*filterw(ihru)**2-0.487355*filterw(ihru)-0.10563)
& *(log(wf))+(0.006381*filterw(ihru)**3
& -0.140713*filterw(ihru)**2+0.869293*filterw(ihru)+0.19386)
```

2008).

http://www.envsys.co.kr/~vfsmod

Improvement of SWAT model – Old Study

READMGT

- Read : **FILTERW**
- Calculate : **Sediment Trapping Efficiency using Equation (1)**

READMGT

- Read : **FILTERW**
- Calculate : **Sediment Trapping Efficiency using Equation (1)**

FILTER

- Calculate : **Reduced Water and Non-Point Source Pollutants**

FILTER

- Calculate : **Reduced Water and Non-Point Source Pollutants**

TRAPEFF_VFSMOD

- Calculate : **Sediment Trapping Efficiency using Equation (2)**

To Simulate VFS effect..

- VFS needs to be simulated before it's installation to fields.
- There are many factors, that VFS has, affecting sediment trapping efficiency.
- Moreover, the condition of source area is also important.
- The current SWAT model considers only filter strip width.
- Not only VFS width, but various VFS conditions need to be considered.
- Thus, the VFSMOD model has been integrated to SWAT model.

SWAT model

Subroutine Filter
...
"call VFSMOD"
...

Subroutine VFSMOD
Prepare Input Parameters
for VFSMOD-w model

vfsmoddb1.knu
: sol_clay(1,i), silt(1,i)

vfsmoddb2.knu
: usle_c

vfsmoddb3.knu
: usle_p(i)

vfsmoddb4.knu
: cnday(j)

vfsmoddb5.knu
filterw(ihru), hru_ha(ihru), hru_slp(ihru)

vfsmoddb6.knu
: precipday

TE.txt

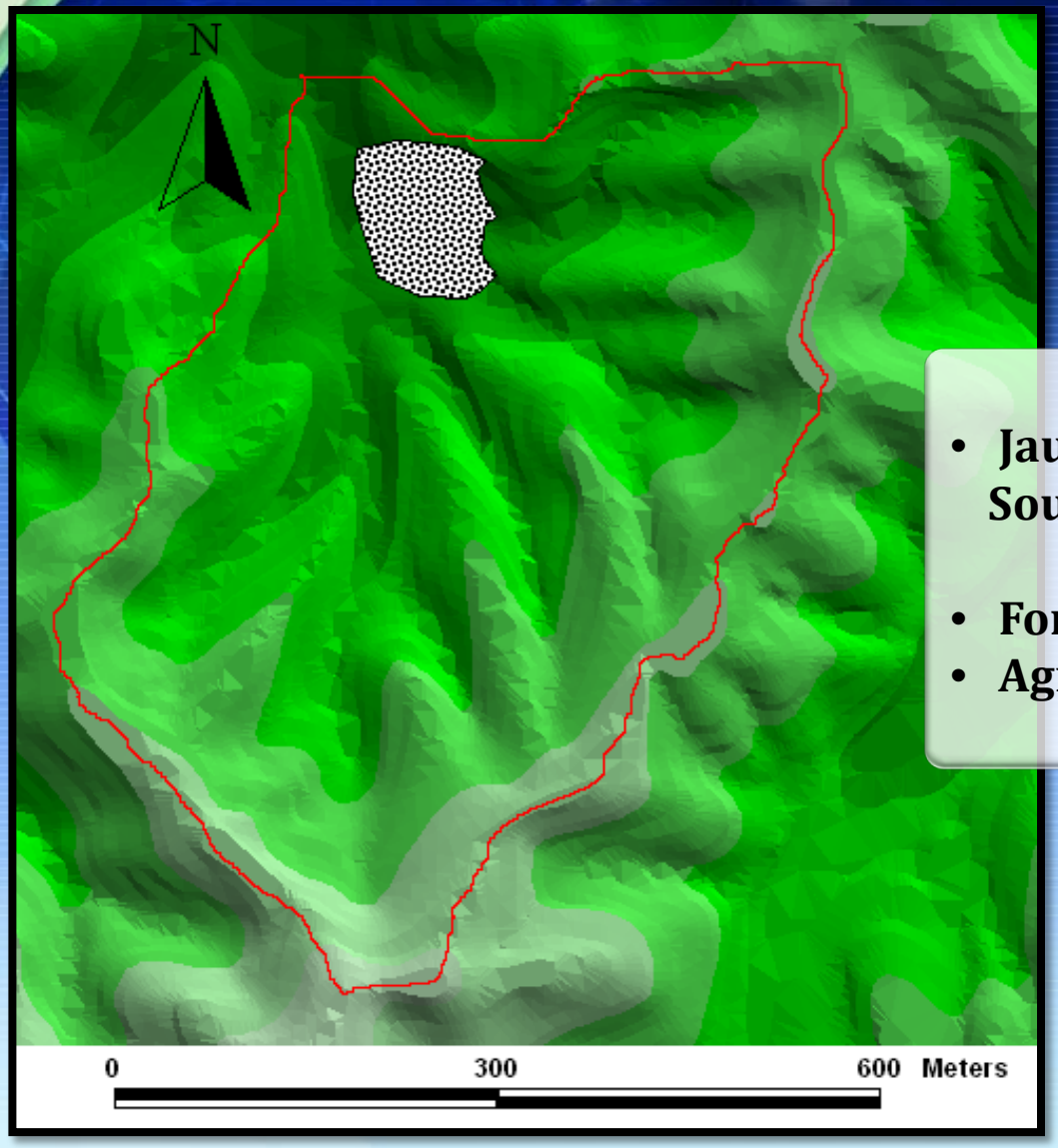
VFSMOD model

Calculation
sediment trapping efficiency

vfsmod.cio

precipitation ranges,
Ratio of width and length of HRU
Storm type

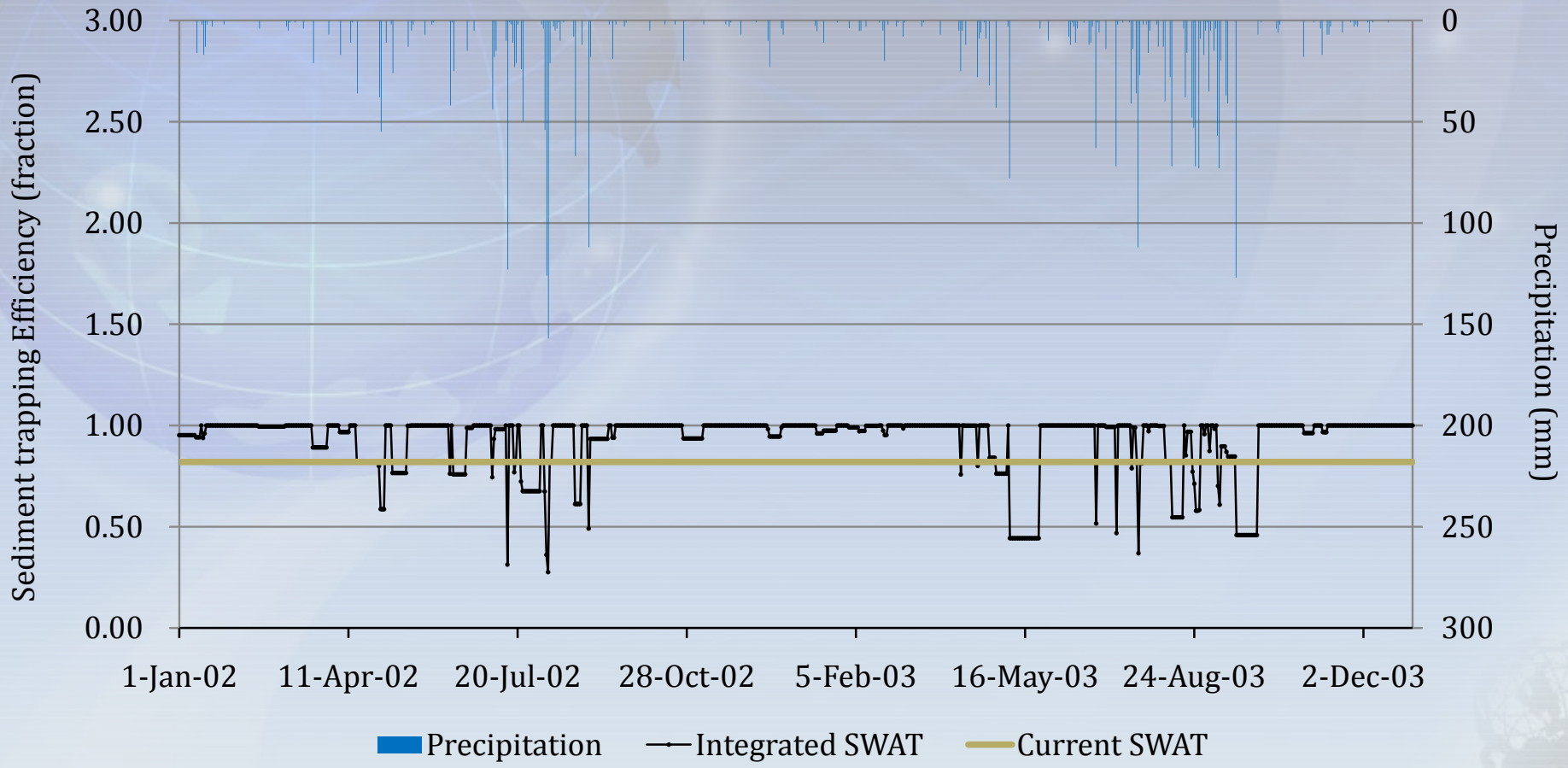
Application of Integrated SWAT to Small Watershed



- **Jaun-ri, Gangwon province, South-Korea**

- **Forest :** 23.83 ha, 96.17 %
- **Agricultural Area :** 1.06 ha, 3.83 %

Comparison of Sediment Trapping Efficiencies (2002-2003)



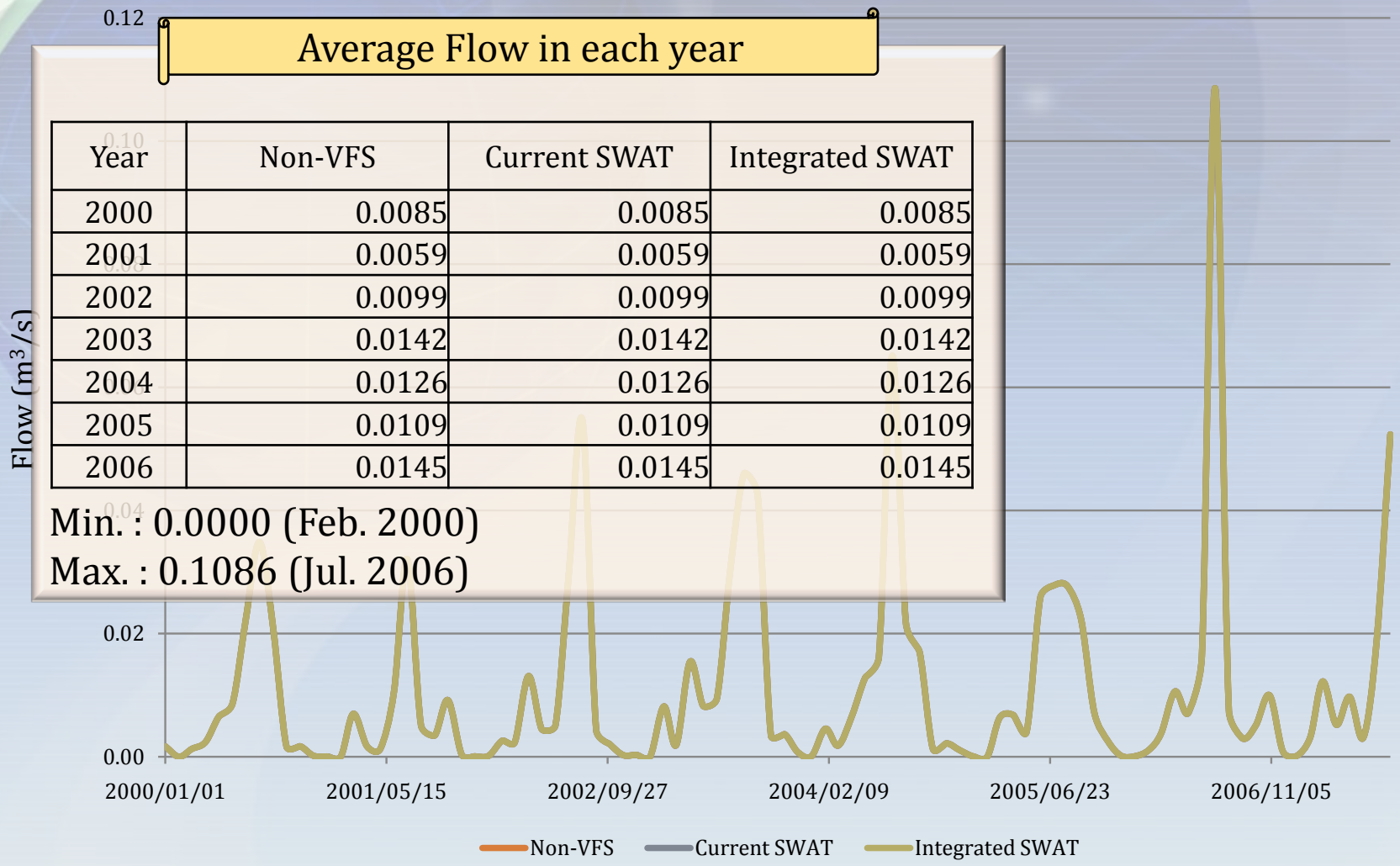
Comparison of Flow (2000. 01. – 2007. 08.)

Average Flow in each year

Year	Non-VFS	Current SWAT	Integrated SWAT
2000	0.0085	0.0085	0.0085
2001	0.0059	0.0059	0.0059
2002	0.0099	0.0099	0.0099
2003	0.0142	0.0142	0.0142
2004	0.0126	0.0126	0.0126
2005	0.0109	0.0109	0.0109
2006	0.0145	0.0145	0.0145

Min. : 0.0000 (Feb. 2000)

Max. : 0.1086 (Jul. 2006)



Comparison of Sediment (2000. 01. – 2007. 08.)

Average Sediment in each year

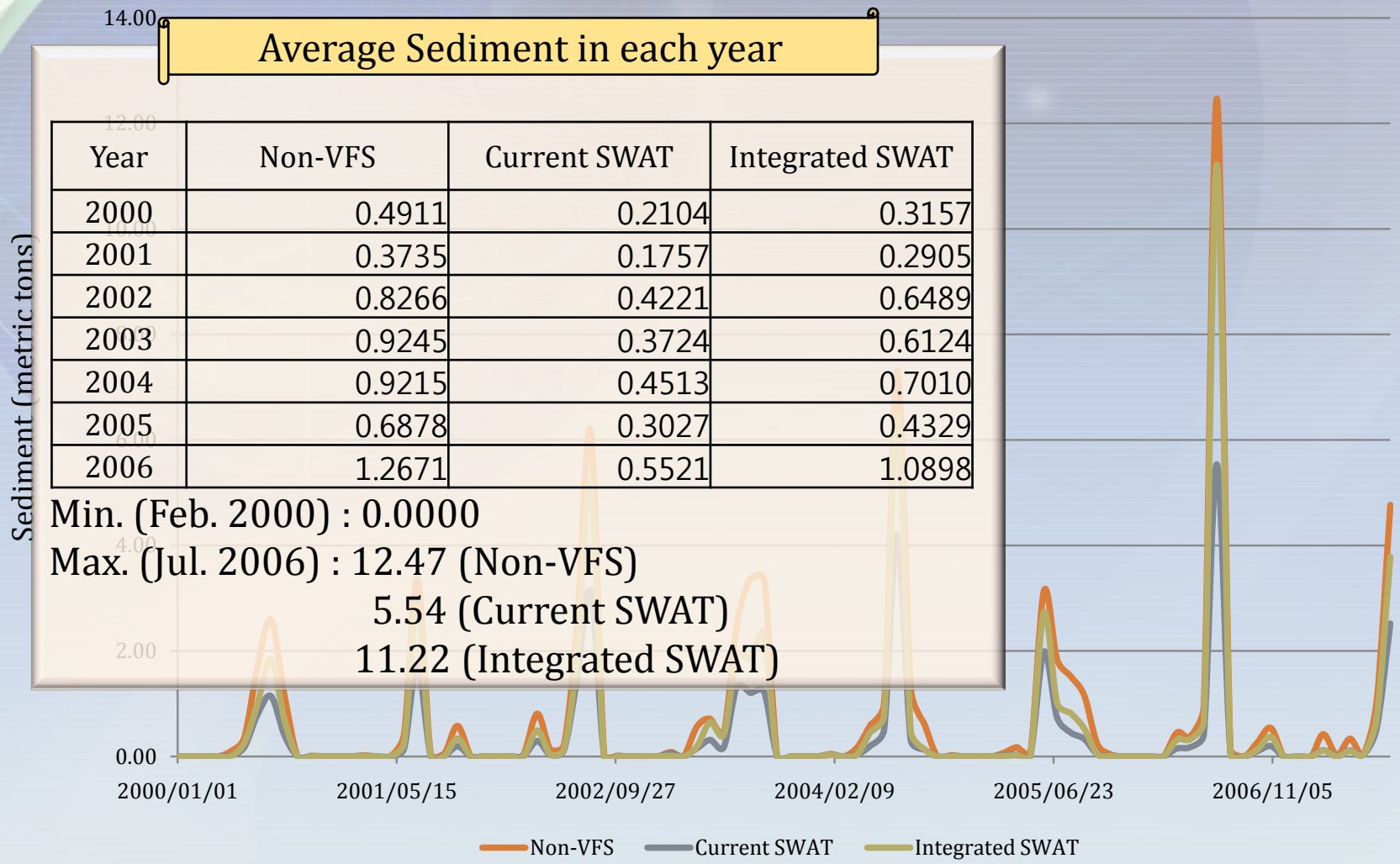
Year	Non-VFS	Current SWAT	Integrated SWAT
2000	0.4911	0.2104	0.3157
2001	0.3735	0.1757	0.2905
2002	0.8266	0.4221	0.6489
2003	0.9245	0.3724	0.6124
2004	0.9215	0.4513	0.7010
2005	0.6878	0.3027	0.4329
2006	1.2671	0.5521	1.0898

Min. (Feb. 2000) : 0.0000

Max. (Jul. 2006) : 12.47 (Non-VFS)

5.54 (Current SWAT)

11.22 (Integrated SWAT)



Do you remember what I said..??

- The **SWAT** model is deemed as the one of good watershed model .
- The model, however, has limitation to simulate **VFS**.
- Although the VFSMOD model is available to **VFS** simulation effectively, the model is field scale model.
- Thus, the VFSMOD model has been integrated to **SWAT** model.
- The integrated model shows non-constant sediment trapping efficiency, reflecting time-variant conditions.
- The integrated model is expected as a useful model for **VFS** simulations.

Welcome to any Question..

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Bigger Wings, Powerful Leap
Kangwon National University