2010 SWAT Korea

# *Evaluation of Streamflow and Water Quality in an Agricultural Watershed of South Korea using SWAT and KOMPSAT-2 Detailed Land Use Information*


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  - ✓ The study area description
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# Introduction

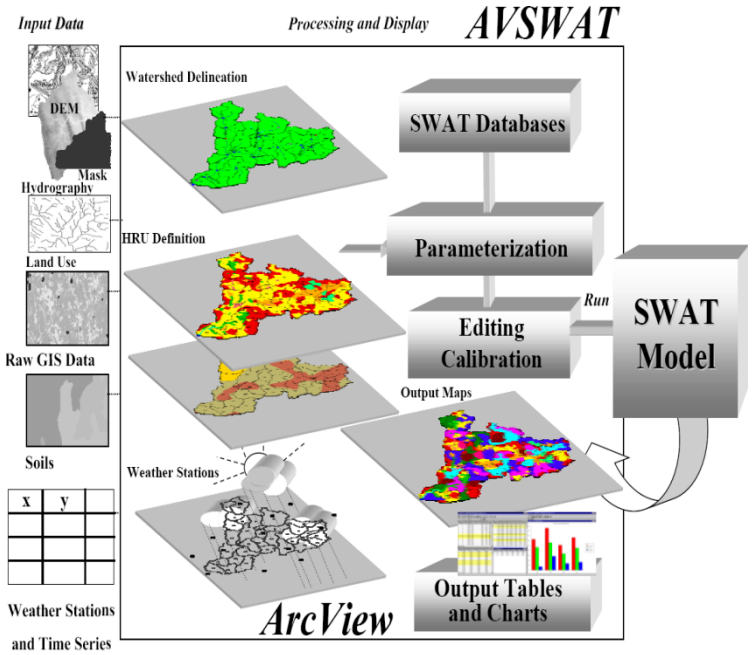
- Land use is the essential information in NPS assessment.
  - ✓ The effects of land use are directly linked to changes in streamflow and NPS pollution loads such as sediment, T-N (Total Nitrogen) and T-P (Total Phosphorus).
  - ✓ Recently, a practical use of high spatial resolution image such as IKONOS, QuickBird, and KOMPSAT (KOrea MultiPurpose SATellite)-2 is accommodated in various land use related application field.

- Environmental problem by Non Point Source (NPS) pollution in our country is a big issue for the healthy watershed management.
  - ✓ The accurate NPS evaluation can improve efficient watershed management which will eventually improve the stream water quality.

- The precise and accurate information of land use data enhances the evaluation of NPS pollution loads from a watershed .

# SWAT model Description

- SWAT (Soil and Water Assessment Tool)




- ✓ SWAT model operations on daily time step and based on the concept of hydrologic response units (HRUs)
- ✓ HRUs are portion of a sub watershed that possess unique land use / management / soil attributes
- ✓ SWAT is able to simulate surface and subsurface flow, sediment generation and deposit, and nutrient late and movement through the landscape and river

Soil & Water Assessment Tool | SWAT

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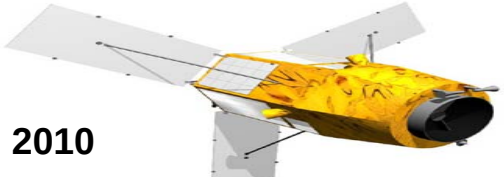
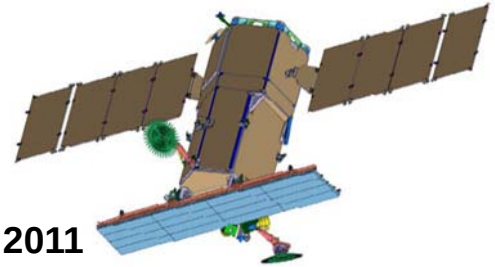
# KOMPSAT-2

- KOMPSAT-2 (KOrea Multi-Purpose SATellite-2)

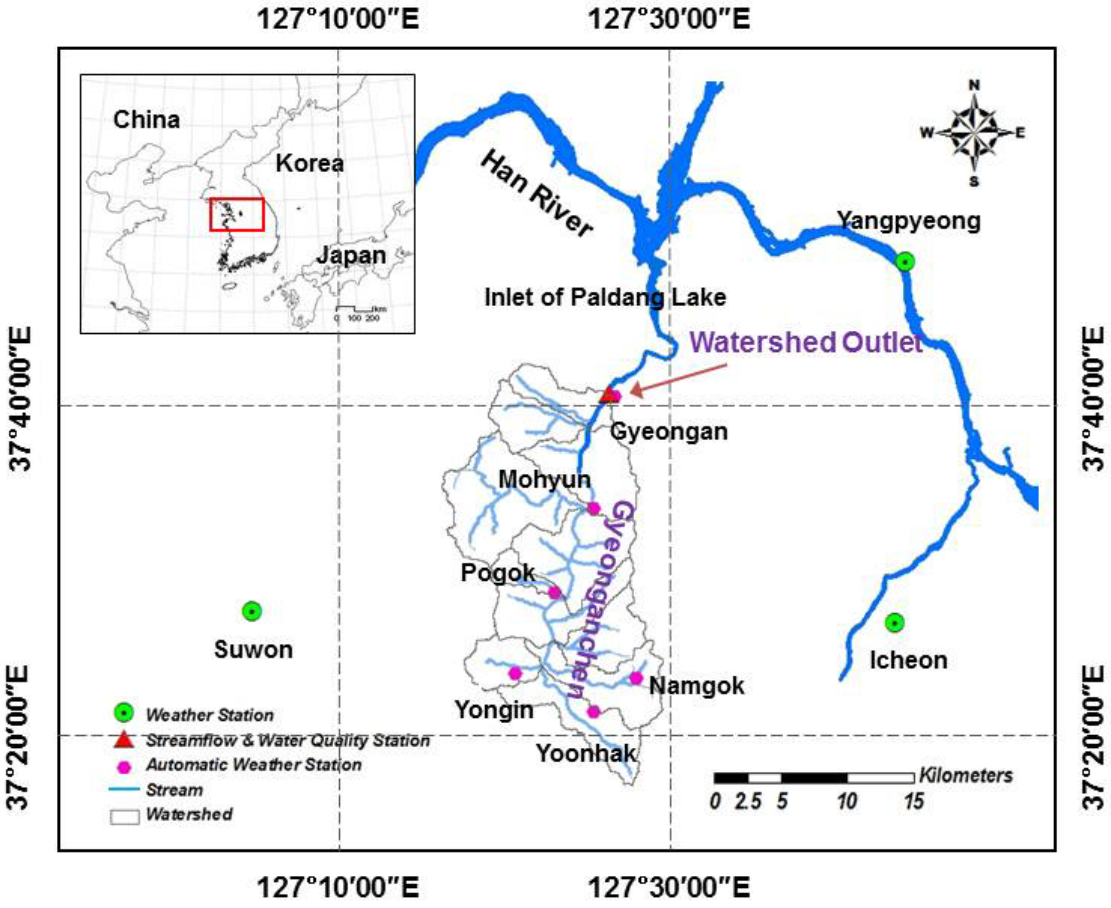





- ✓ KOMPSAT (KOrea Multi Purpose SATellite)-2 is a lightweight earth observation satellite developed by the KARI (Korea Aerospace Research Institute).
- ✓ KOMPSAT-3 that will have spatial resolution of 1 m panchromatic and 2.8 m multi-spectral images is scheduled to launch in 2010. (KOMPSAT-1: 1999, 6.6 m, KOMPSAT-2: 2006, 1.0 m)
- ✓ KOMPSAT-5 with an active sensor of Synthetic Aperture Radar (SAR),had a launch in 2011.
- ✓ KOMPSAT-2 image can produce USGS (United States Geological Survey) Level IV (0.25 - 1.0 m spatial resolution) land use data.

# The study Area




- ✓ The study area is 251.7 km$^2$ agricultural watershed located in the northwestern part of south Korea
- ✓ Gyeongan-Cheon is the main tributary of Han River directly linked to Paldang Lake.

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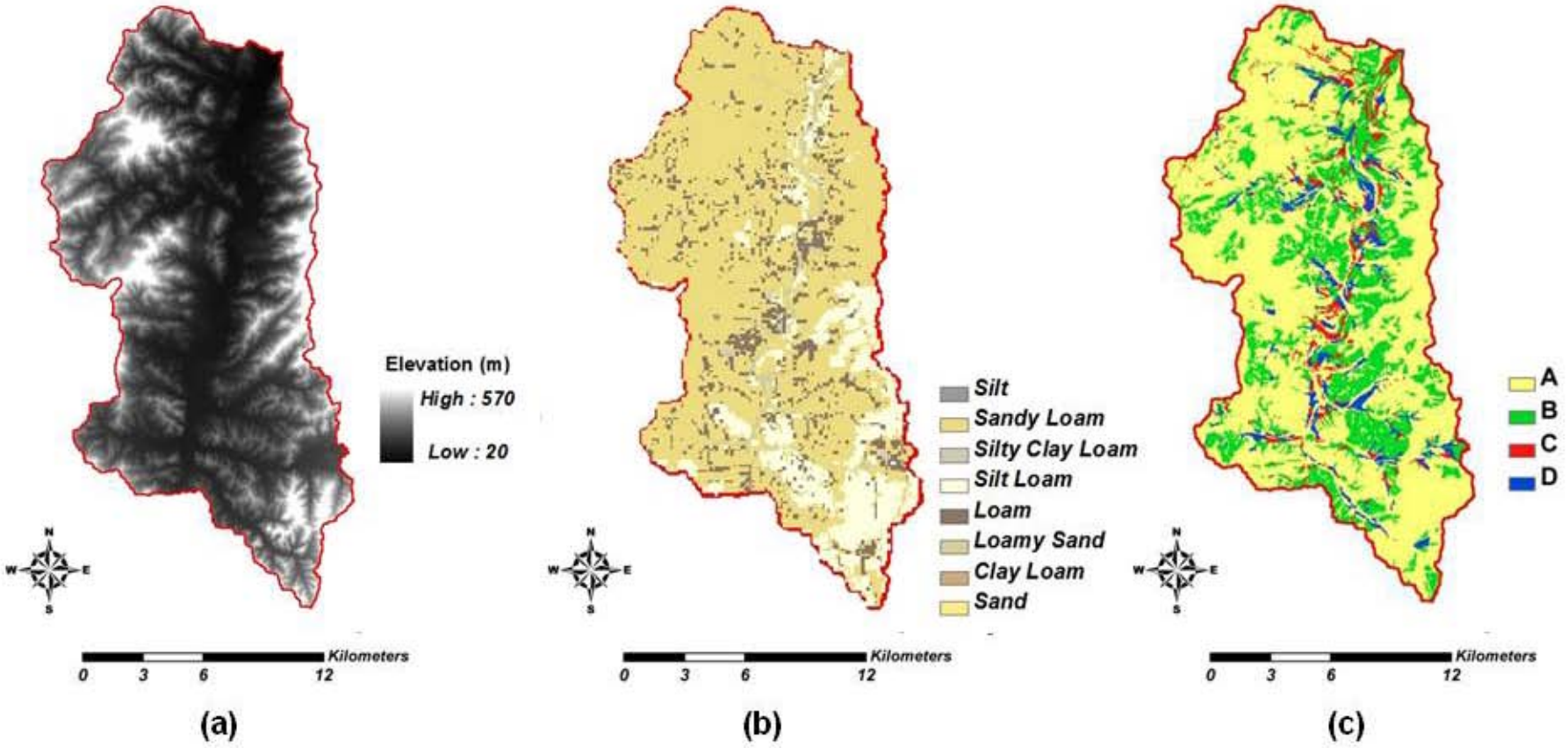
# SWAT model Data set

| Data Set | Source | Scale | Data Description / Properties |
|---|---|---|---|
| **Terrain** | Korea National Geography Institute | 1:5,000 | Digital Elevation Model (DEM) – **2 m, 30 m** |
| **Soil** | Korea Rural Development Administration | **1:25,000** | Soil classifications and physical properties such as bulk density, texture, and saturated conductivity. |
| **Land use** | **KOMPSAT-2** Satellite Image | 2 m | Land use classifications such as paddy, grass, and forest. |
| | **Landsat TM** Satellite Image | 30 m | |
| **Weather** | Korea Meteorological Administration | Daily | precipitation, minimum and maximum temperature, mean wind speed and relative humidity data from 1995 to 2007 |
| **Streamflow** | Han River Flood Control Office | Daily | streamflow data from 2001 to 2007 |
| **Water Quality** | Ministry of Environment | Monthly | water quality (SS, T-N and T-P) data from 2001 to 2007 |

# SWAT model Data set




**DEM** **Soil type** **Hydrological soil group**

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# Land use from KOMPSAT-2

- KOMPSAT-2 land use of study area
  - ✓ 30 GCP 30 GCPs (Ground Control Points) acquired from SOKKIA GPS (Global Positioning System) equipment
  - ✓ The KOMPSAT land use was produced by on-screen digitizing method with GPS field investigation data.
  - ✓ The land use was classified with more than 26 categories.

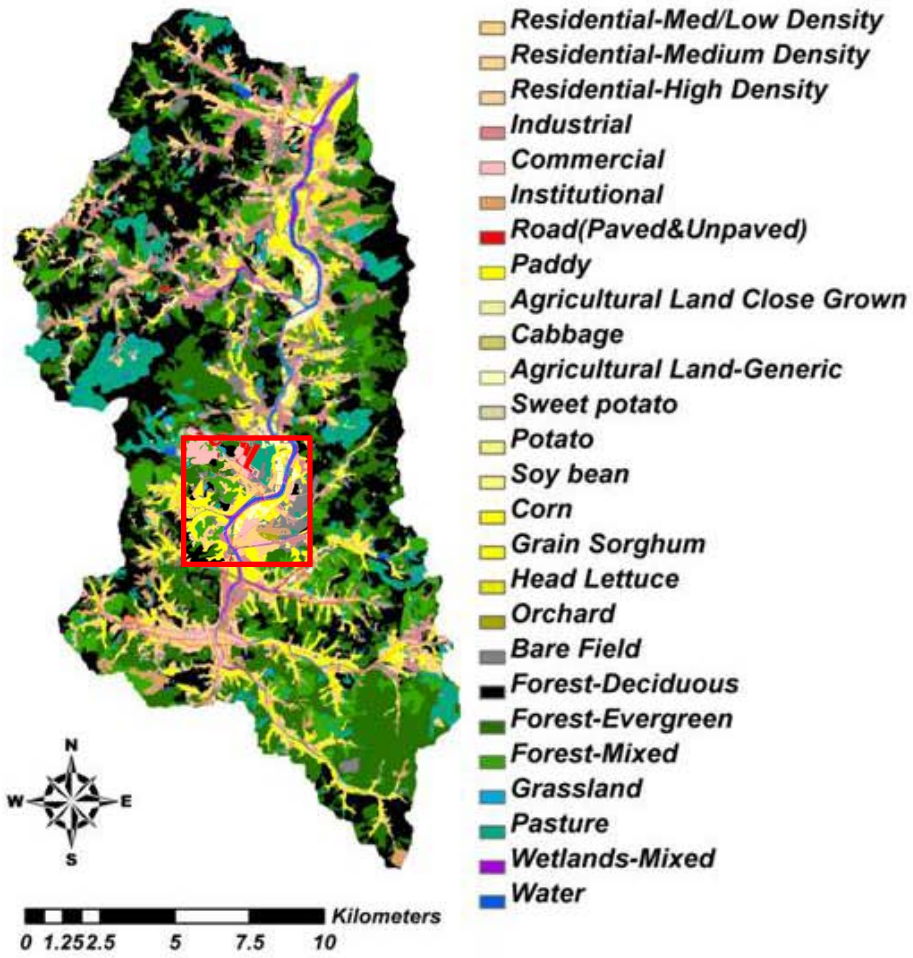
KOMPSAT (2007/09/17)


Ortho-rectification using GCPs and Land use investigation

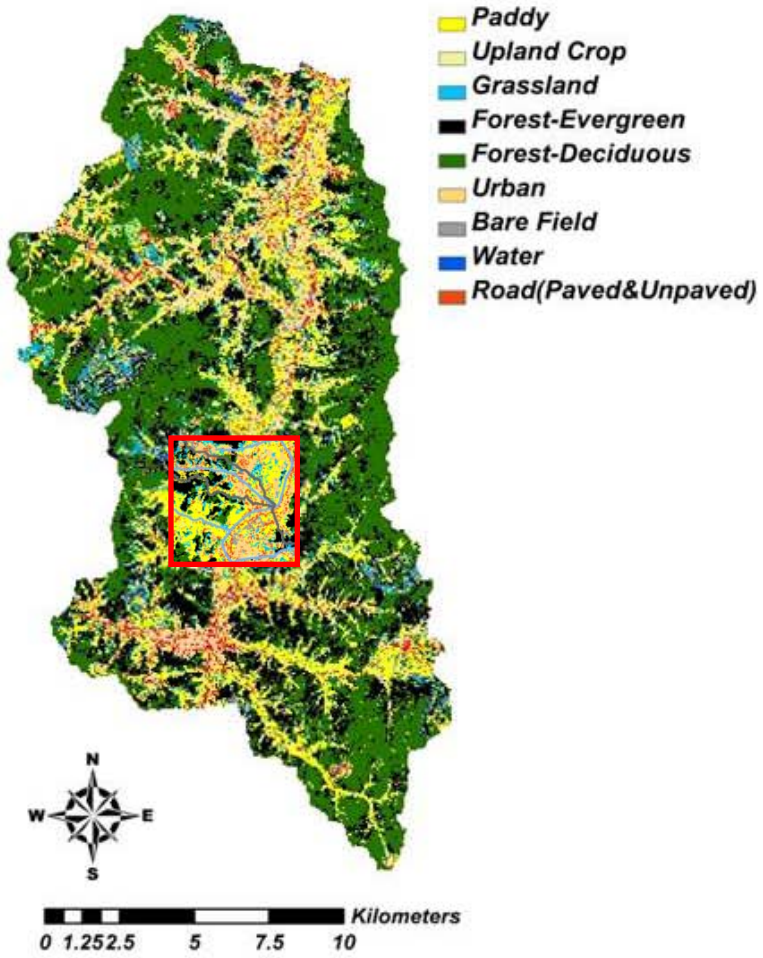
Land use

# Land Use Data

**KOMPSAT (2 m)**




**Landsat (30 m)**



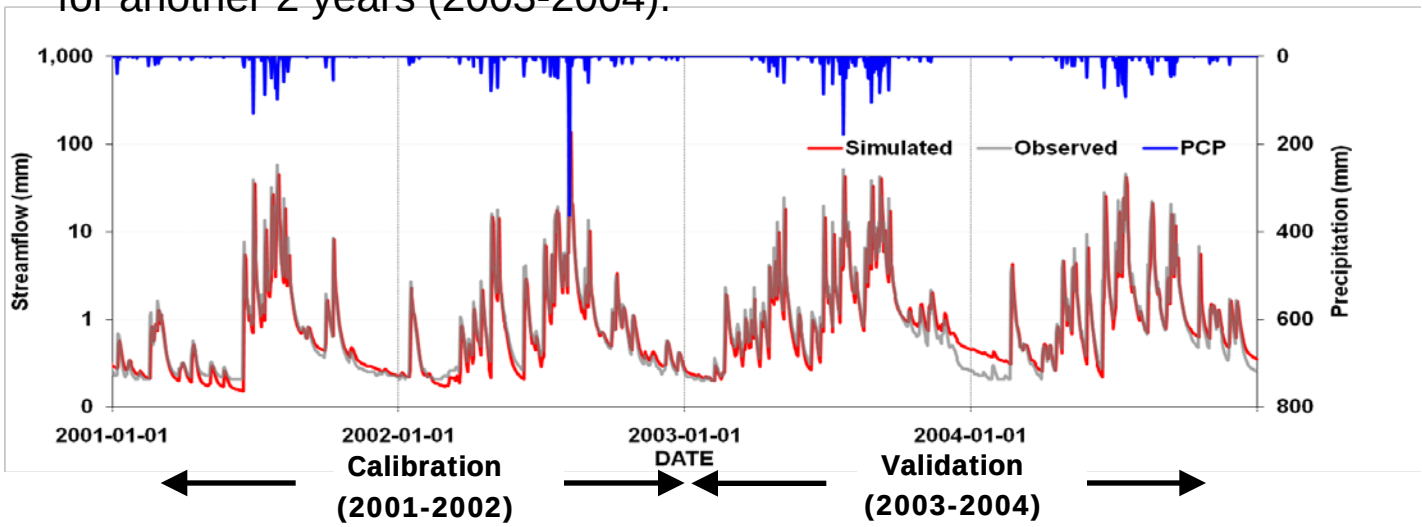
| KOMPSAT (2 m) | | | | Landsat (30 m) | | | |
|---|---|---|---|---|---|---|---|
| **Class** | **Area ($km^2$)** | **[%]** | **CN** | **Class** | **Area ($km^2$)** | **[%]** | **CN** |
| **Residential-Med/Low Density** | 16.62 | [6.54] | 76.1 | **Urban** | 21.12 | [8.39] | 77 |
| **Residential-Medium Density** | 0.05 | [0.02] | 71.0 | | | | |
| **Residential-High Density** | 0.40 | [0.16] | 75.3 | | | | |
| **Industrial** | 12.01 | [4.73] | 85.2 | | | | |
| **Commercial** | 5.03 | [1.98] | 90.5 | | | | |
| **Institutional** | 4.50 | [1.77] | 43.1 | | | | |
| **Road** | 4.49 | [1.77] | 89.4 | **Road** | 11.00 | [4.37] | 89.4 |
| ***Sub Total*** | ***43.10*** | ***[16.96]*** | ***75.8*** | ***Sub Total*** | ***32.12*** | ***[12.76]*** | ***83.6*** |
| **Paddy** | **18.99** | **[7.47]** | **78.0** | | **46.56** | **[18.50]** | **78.0** |
| **Agricultural Land-Close-grown** | 0.04 | [0.02] | 67.5 | | 8.41 | [3.34] | 72.3 |
| **Cabbage** | 0.42 | [0.17] | 71.0 | | | | |
| **Agricultural Land-Generic** | 4.12 | [1.62] | 75.5 | | | | |
| **Sweet potato** | 0.23 | [0.09] | 71.5 | | | | |
| **Potato** | 0.23 | [0.09] | 71.8 | | | | |
| **Soybean** | 0.16 | [0.06] | 70.3 | | | | |
| **Corn** | 0.56 | [0.22] | 69.7 | | | | |
| **Grain Sorghum** | 0.08 | [0.03] | 67.9 | | | | |
| **Head Lettuce** | 0.02 | [0.01] | 71.3 | | | | |
| **Orchard** | 0.39 | [0.15] | 58.6 | | | | |
| ***Sub Total*** | ***25.23*** | ***[9.93]*** | ***70.3*** | | ***54.97*** | ***[21.84]*** | ***75.2*** |
| **Forest-Deciduous** | 63.61 | [25.04] | 50.5 | **Forest-Deciduous** | 94.33 | [37.48] | 50.5 |
| **Forest-Evergreen** | 58.81 | [23.15] | 53.0 | **Forest-Evergreen** | 48.10 | [19.11] | 53.0 |
| **Forest-Mixed** | 21.04 | [8.28] | 53.3 | | | | |
| **Grassland** | 1.56 | [0.62] | 40.7 | **Grassland** | 18.70 | [7.43] | 40.7 |
| **Pasture** | 19.16 | [7.54] | 57.0 | | | | |
| **Wetlands-Mixed** | 2.56 | [1.01] | 98.0 | | | | |
| ***Sub Total*** | ***166.75*** | ***[65.63]*** | ***58.8*** | ***Sub Total*** | ***161.13*** | ***[64.02]*** | ***48.5*** |
| **Bare Field** | 16.33 | [6.43] | 98.0 | **Bare Field** | 3.12 | [1.24] | 98.0 |
| **Water** | 0.27 | [0.11] | 100.0 | **Water** | 0.38 | [0.15] | 100.0 |
| **Total** | **251.7** | **[100]** | **63.0** | **Total** | **251.7** | **[100]** | **60** |

# Calibrated parameters

| Component | Parameter | Min. | Max. | Calibrated value |
|---|---|---|---|---|
| Streamflow | CN2 | 0 | 100 | ▼ 6 |
| | ESCO | 0 | 1 | 0.8 |
| | ALPHA_BF | 0 | 1 | 1 |
| | SOL_AWC | 0 | 1 | ▲ 0.2 |
| | CH_K2 | -0.01 | 500 | 100 |
| Sediment | USLE_P | 0 | 1 | 0.7 |
| | Spcon | 0 | 0.01 | 0.0003 |
| | CH_Erod | -0.05 | 0.6 | ▲ 0.5 |
| T-N | ERORGN | 0 | 5 | 2.5 |
| T-P | PHOSKD | 100 | 200 | ▲ 25 |
| | SOL_OrgP | 0 | 100 | 50 |
| | GWSOLP | 0 | 1000 | 1 |

# Model Calibration : *Streamflow*

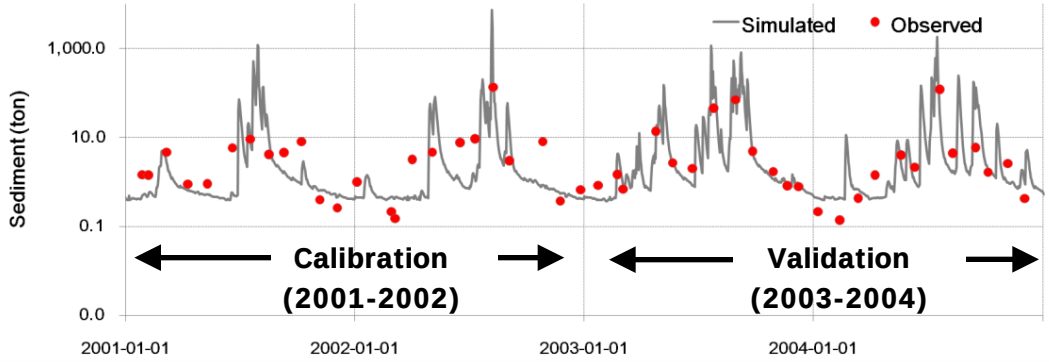
- Hydrology (streamflow) and Water quality (sediment, T-N, and T-P)
  - ✓ The SWAT model was calibrated for 2 years (2001-2002) using daily streamflow and monthly water quality records from 2001 to 2002, and validated for another 2 years (2003-2004).

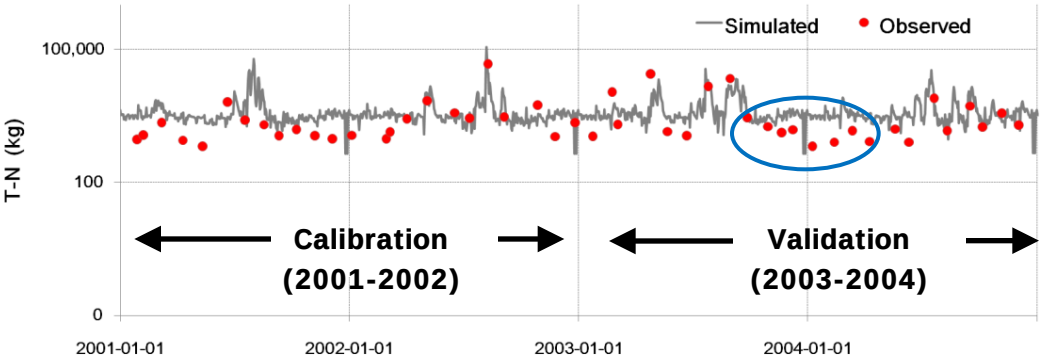


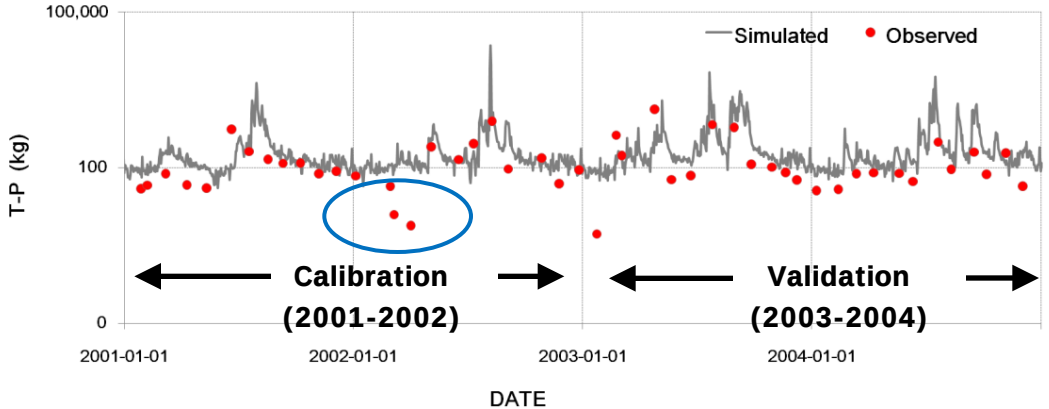

- ✓ The error of runoff may come from the withdrawal through the paddy field drainage during irrigation period from the middle of May to the early period of September and the uncertainty of groundwater contribution to streamflow

| Year | $R^2$ | *RMSE* (mm/day) | *ME* |
|---|---|---|---|
| 2001 | 0.62 | 3.16 | 0.51 |
| 2002 | 0.95 | 3.13 | 0.89 |
| 2003 | 0.81 | 2.42 | 0.74 |
| 2004 | 0.79 | 2.30 | 0.63 |
| Mean | 0.79 | 2.75 | 0.69 |

# Model Calibration : *Water quality*




| Year | $R^2$ | | |
|---|---|---|---|
| | *Sediment* | T-N | *T-P* |
| 2001 | 0.66 | 0.63 | 0.61 |
| 2002 | 0.94 | 0.92 | 0.68 |
| 2003 | 0.85 | 0.60 | 0.87 |
| 2004 | 0.95 | 0.69 | 0.56 |
| Mean | 0.85 | 0.71 | 0.68 |

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| KOMPSAT (2 m) | | | | Landsat (30 m) | | | |
|---|---|---|---|---|---|---|---|
| Class | Area ($km^2$) | [%] | CN | Class | Area ($km^2$) | [%] | CN |
| Residential-Med/Low Density | 16.62 | [6.54] | 76.1 | Urban | 21.12 | [8.39] | 77 |
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| *Sub Total* | *43.10* | *[16.96]* | *75.8* | *Sub Total* | *32.12* | *[12.76]* | *83.6* |

| YEAR | PCP (mm) | Average. Runoff (mm) | | | Runoff Ratio (%) | | |
|---|---|---|---|---|---|---|---|
| | | Obs. | KOMPSAT | Landsat | Obs. | KOMPSAT | Landsat |
| 2001 | 1036.0 | 469.2 | 548.2 | 619.7 | 45.3 | 52.9 | 59.8 |
| 2002 | 1463.5 | 933.7 | 818.7 | 892.0 | 63.8 | 55.9 | 60.9 |
| 2003 | 1597.0 | 984.6 | 927.2 | 961.5 | 61.7 | 58.1 | 60.2 |
| 2004 | 1136.0 | 573.2 | 729.9 | 810.7 | 50.5 | 64.2 | 71.4 |
| Mean | 1272.9 | 740.1 | 756.0 | 820.9 [-8.58] | 55.3 | 57.7 | 63.1 [-9.17] |

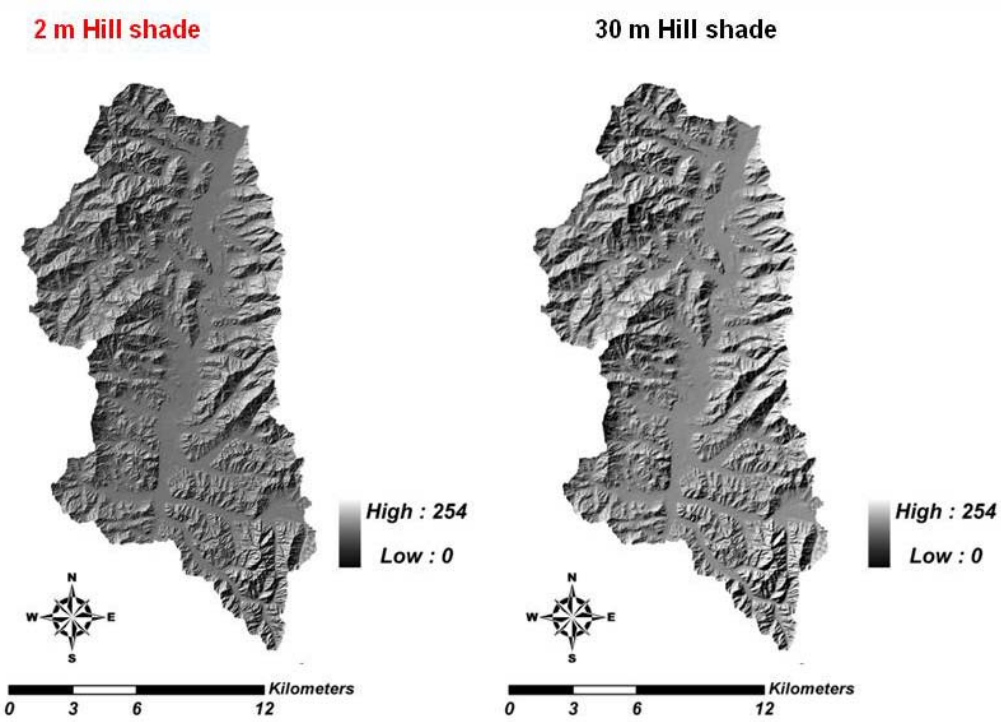
Watershed average CN
KOMPSAT : 63
Landsat : 60

[ ] :Percent of decrease based on KOMPSAT

# Results

- Sediment generation
  - ✓ The different spatial resolution of land use and DEM affected the mean values of USLE K, C, LS and CFRG

| LandUse | KOMPSAT | Landsat |
|---|---|---|
| DEM | 2 m | 30 m |
| Soil | | |
| Watershed Area (km2) | | |
| Number of Subwatershed | | |
| Number of HRUs | | |
| Mean K Factor | | |
| Mean C Factor | | |
| Mean LS Factor | | |
| Mean CFRG Factor | | |
| Mean K×C×LS×CFRG at the HRU | | |



# Results

- The NPS loadings from the model prediction
  - ✓ As the sediment yields increased, the T-N, T-P loads increased.
  - ✓ The sediment, T-N, and T-P of KOMPSAT land use showed 2.3 %, 2.1 %, and 12.2 % higher than those of Landsat land use

| Year | Average. Sediment (ton/day) | | | Average. T-N (kg/day) | | | Average. T-P (kg/day) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Obs. | KOMPSAT | Landsat | Obs. | KOMPSAT | Landsat | Obs. | KOMPSAT | Landsat |
| 2001 | 3.5 | 3.6 | 2.4 | 1805.7 | 2762.1 | 2697.2 | 129.1 | 135.8 | 121.2 |
| 2002 | 14.5 | 11.3 | 13.0 | 6505.4 | 6737.3 | 6303.0 | 166.0 | 125.7 | 141.9 |
| 2003 | 12.2 | 28.7 | 27.7 | 7367.9 | 5720.9 | 5541.0 | 307.4 | 394.3 | 299.5 |
| 2004 | 12.0 | 8.2 | 7.5 | 2341.9 | 2471.1 | 2764.2 | 106.0 | 126.2 | 123.8 |
| Mean | 10.5 | 12.9 | 12.6 [2.32] | 4505.2 | 4422.8 | 4329.6 [2.10] | 177.1 | 195.5 | 171.6 [12.22] |

[ ] :Percent of decrease based on KOMPSAT

# Summary & Conclusions

- In this study, we tried to evaluate the SWAT streamflow, sediment, T-N, and T-P in case of using a quite detailed land use data of a 257.1km$^2$ agricultural watershed of South Korea.

- Even though the two results could not be compared directly, we found that the 2m KOMPSAT land use detected the impervious areas unrevealed in 30m Landsat land use and the increased impervious area increase the watershed CN and runoff.

- The high resolution satellite images such as KOMPSAT-2 and KOMPSAT-3 are expected to be understanding of detail landuse data effects on water quality.

# “ Thank You ”

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