Estimating Plot Scale Impacts on Watershed Scale Management

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INTRODUCTION AND OBJECTIVE

Land and resource use and climate change reduce ecosystem services (ie: high quality water yield, biodiversity, agricultural and forest products). However, ecosystem services have become increasingly important to watershed management approaches. These complex policy and management decisions require integration of physical, economic, and social data over multiple scales to assess water resource and ecological effects.

Multi-disciplinary field-based monitoring and modeling scenarios are used to examine spatial and temporal changes in land use and climate on water quantity, quality, and sediment transport. The study area is located in a monsoonal environment with extreme weather events. The catchment has a unique "punchbowl" topography that aids in parameter characterization with elevation.

Accurate modeling scenarios require not only physical information but the socio-economic relationship between individuals and policy managers and the value of ecosystem services. Our objective is to examine how physical environmental processes are affected by land use changes. Simulation scenarios are driven by social interactions between farmers and policy regulators and the value that each places on individual ecosystem services.

STUDY AREA

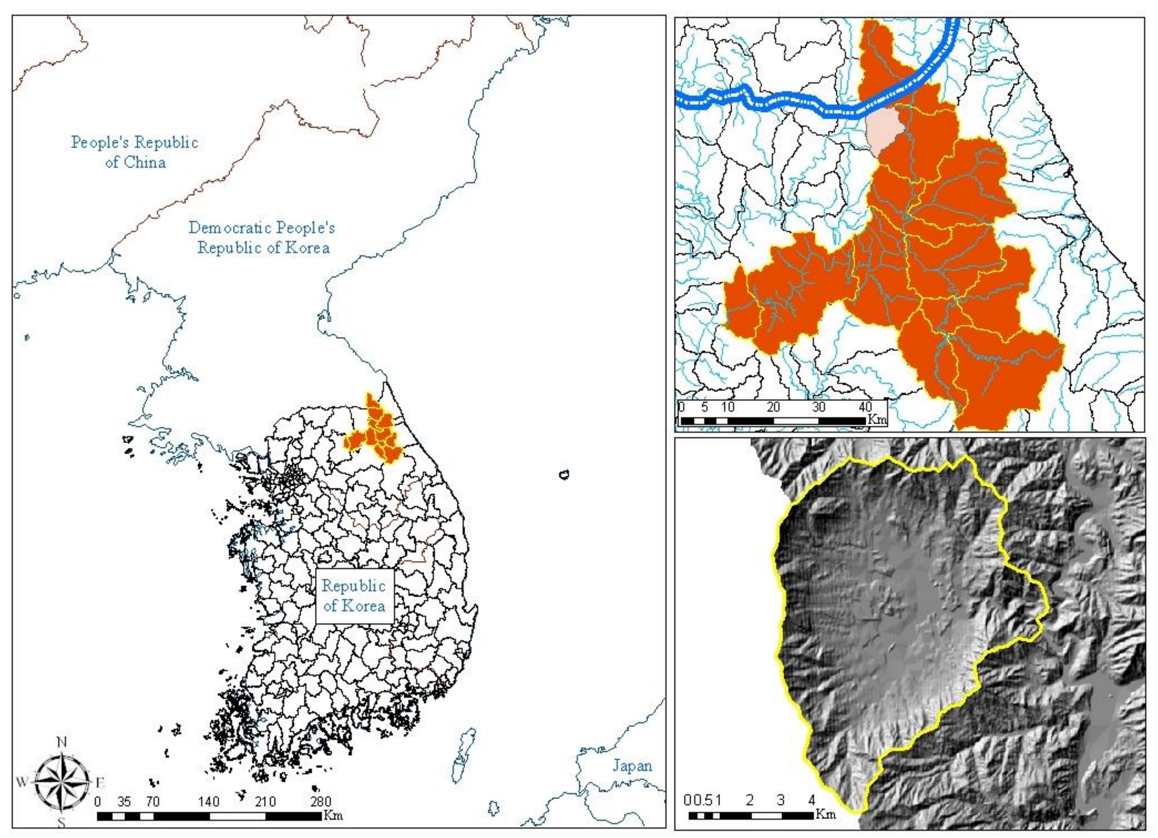

Fig. 1 – The study location is the Haean Catchment on the border between North Korea and South Korea (38.281164, 128.124742). The catchment is a primary sediment load for the Soyang Lake watershed.

- •Haean Catchment, Yanggu, South Korea
- •On De-Militarized Zone (DMZ) between North and South Korea.
- •64 km^2 catchment area
- •Elevation range 340-1310 m.
- •Monsoonal climate.
- •Average annual precipitation of 1520 mm ,up to 70 % in June and July, 80 mm/hr.
- •Haean is 2nd highest sediment load to 2700 km^2 Soyang Lake.
- •Low population, heavy agricultural, steep sloge, high erosion.

APPLICATIONS

- The Soil Water Assessment Tool (SWAT) model is used to analyze land management impacts on water, sediment, and chemical yields in a complex watershed.
- Local process-based models (Hydrus-2D, Erosion-3D, PIXGRO, VS2DH, HBV-Light, DNDC, TOPMODEL, The INVEST Tool, and others) for parameter assignment and comparison.
  - Plot-scale investigations of soil properties, growth rates, gas fluxes, subsurface hydraulics
  - Individual parameters (ie: anisotropy, matric potential) estimated on local-scale and evaluated at increased spatial area for comparison with watershed model.
  - Comparison of plot-scale results (ie: sediment yield, grain size distribution, plant growth rate) to those estimated in watershed level results.
  - Higher resolution interpolation and interpretation of model inputs (ie: meteorological data gaps, solar radiation distribution).

LOCAL ANALYSES

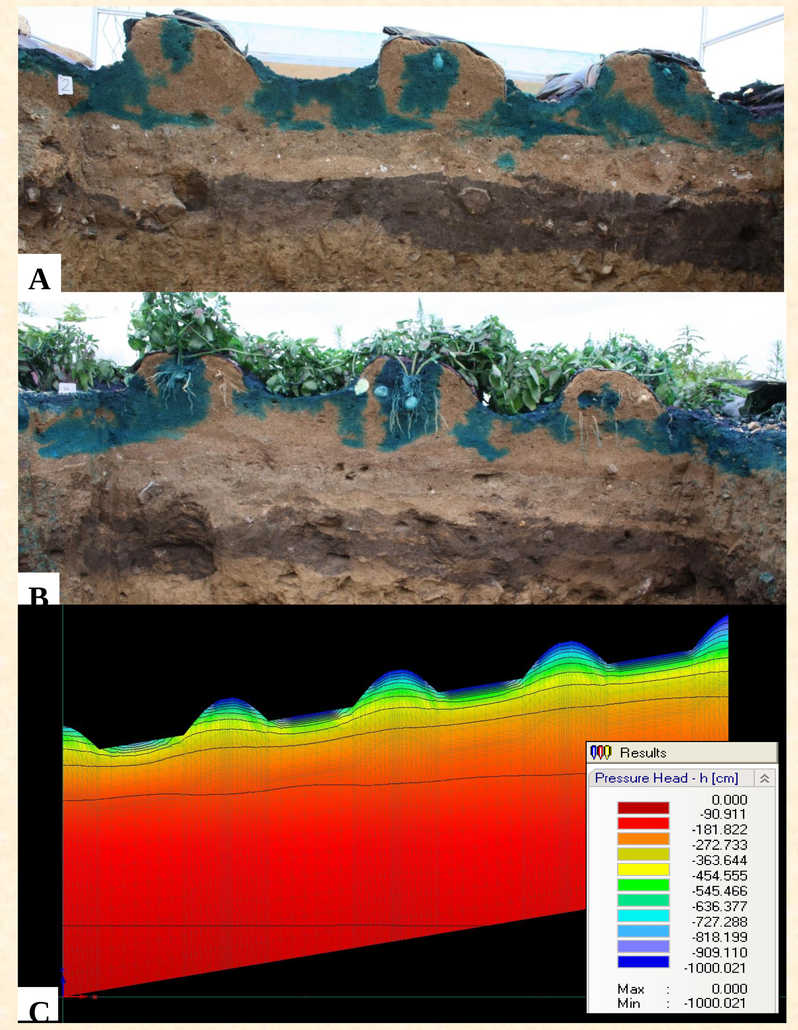

Fig. 3– Photographs of a typical row/inter-row potato field (A) prior to planting and (B) at harvest. Brilliant blue dye tracer experiments indicated predominately vertical infiltration to approximately 30 cm below inter/row. Plant introduction and growth caused local sinks toward plant roots, severely impacting lateral fluid flow. (C) A 2D Inter-Row-Cultivation simulation with Hydrus 2/3D. Inverse modeling of water flow based on 3D field monitoring network (including tensiometer and FDR/TDR measurements) indicated strong differences between inter-row and row positions. Both Hydrus 3D and Hydrogeosphere are being utilized for flow and transport simulations.

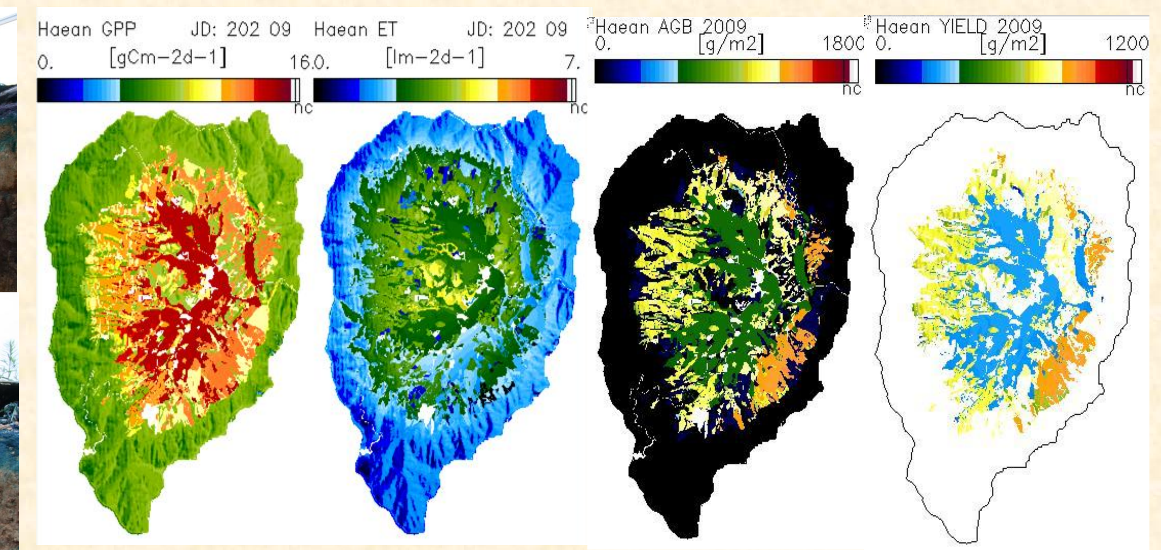

Fig. 2 – The PIXGRO model is used to examine canopy fluxes and vegetation structure effects on net ecosystem gas exchange and growth. The example data shows the spatial discretization for Solar Radiation input and Gross Primary Production, Evapotranspiration, and Leaf Area Index outputs.

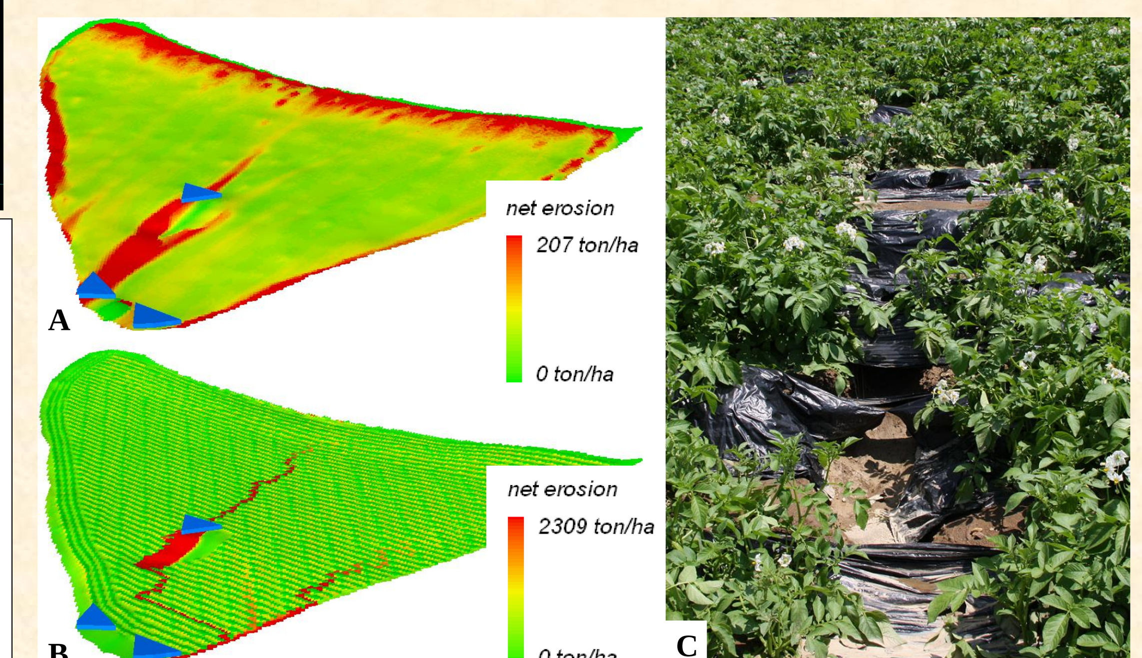

Fig. 4 – (A) Erosion without row/inter-row contouring leads to large-scale sheet erosion and general accumulation in depressions. (B) Typical row/inter-row contours reduced sheet erosion; however, flow accumulation is much higher leading to higher soil loss by rill erosion. (the blue triangles in A and B show the location of runoff collectors for erosion measurements during the monsoon period in 2010) (C) This pattern was observed with field measurements.

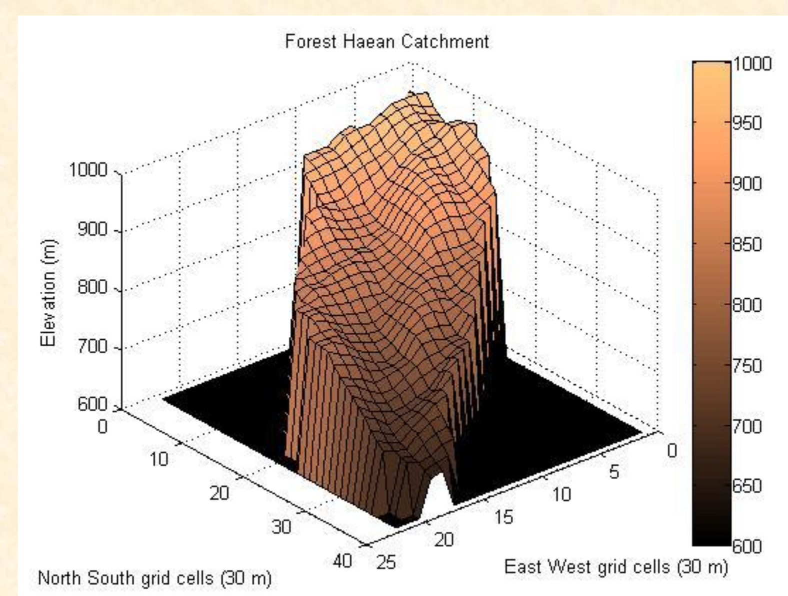

Fig. 5– DEM based TOPMODEL configuration of a small forest subcatchment of the Haean watershed used to predict contributing areas. Simulations of flow patterns were necessary because land mines throughout the forest prevented in-field observations. Simulation results were consistent with forest area outlet discharge, other parts of the catchment, and with similar modeling scenarios.

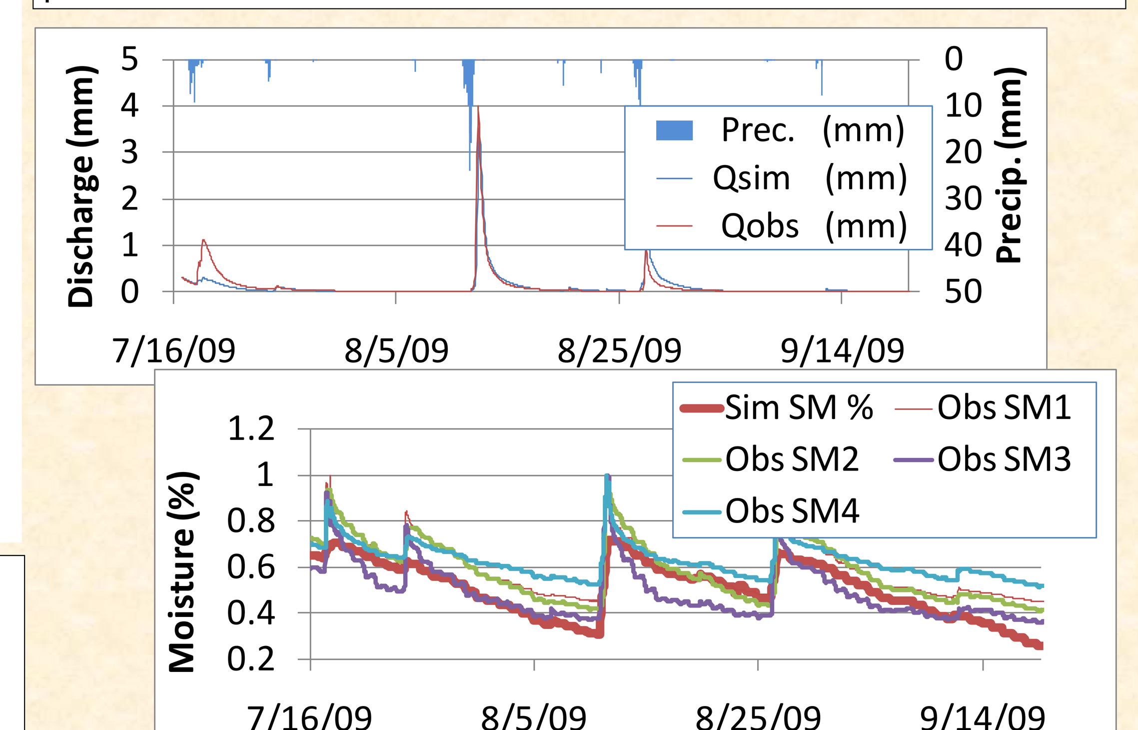

Fig. 6– HBV-Light calibration discharge and soil moisture output for a forested subcatchment. Daily soil moisture dynamics consistent with measured range at multiple locations.

WATERSHED ANALYSIS

- 13 weather stations within catchment (precipitation, temperature, relative humidity, wind speed, solar radiation).
- 21 surface water/chemistry monitoring locations
- 121 groundwater well locations
- 31 individual student and post-doctoral projects with field research and investigations (soil sampling, plant physiology, fluid flow and transport, N cycling, trace gas emissions, ecosystem services, etc.).
- 16 current land use types, 35 soil classifications, and 3 slope classes.
- 111 simulation subbasins and ~3500 HRUs.
- Management database.

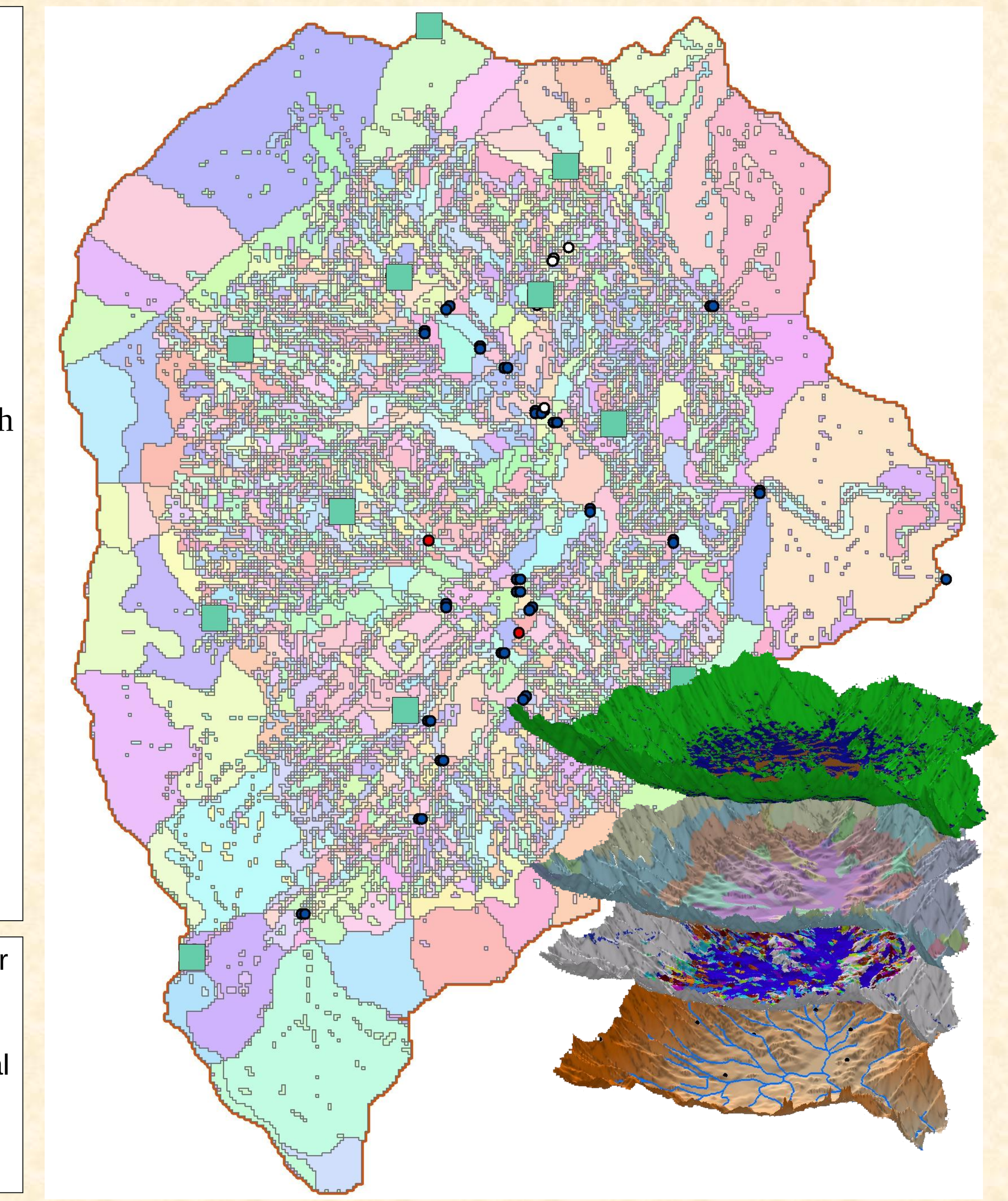

Fig. 7 –SWAT2005 HRU discretization for the Haean Catchment based on 16 land use types, 35 soil classes, and 3 slope gradients. The model uses these 3 spatial features and DEM to characterize individual HRUs as shown in inset. The "punchbowl" shape is easily identified.

MAJOR CONCLUSIONS

- Local-scale field experiements and process-based models useful in parameterizing the watershed scale SWAT model and understanding complex flow, sediment transport and nutrient loadings within the Haean catchment, South Korea.
- Local scale predications used to weight HRU-scale parameter behavior in larger watershed model. The local-scale enables comparison of average or pixel specific responses and to compare mathematical estimations at the watershed-scale.
- Parameter sensitivity was analyzed wth the ArcSWAT interface for the entire catchment area. The parameters with the highest calibration sensitivity were the soil layer depth (mm), the base flow alpha factor (days), the groundwater return flow to the reach (mm water), the maximum canopy storage (mm water), and the soil evaporation compensation factor.
- Initial comparison of observed and simulated streamflow at several locations indicate a good agreement between the observed and simulated in-stream discharge. The results are verified by coefficient of determination (R2) and Nash Sutcliffe efficiency (NSE) greater than 0.5.

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