Supplementary Material to

"Soil Erosion Assessment – Mind the Gap"

Jongho Kim[1,2], Valeriy Y. Ivanov[1], and Simone Fatichi[3]

[1]Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI

[2]Department of Civil and Environmental Engineering, Sejong University, Seoul, Republic of Korea

[3]Institute of Environmental Engineering, ETH Zurich, Zurich, Switzerland

Corresponding author: Valeriy Y. Ivanov, Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI 48109, tel: 734-763-5068, email: ivanov@umich.edu.

SM.1. Types of Intrinsic Variability

To properly frame the results in the context of geo-science literature, one needs to consider that variations of properties intrinsic to the system or caused by factors external to the system have been considered in various disciplines. They are referred to as ‘endogenous’ and ‘exogenous’ in geology, ‘autogenic’ and ‘allogenic’ in sedimentary geology, and ‘internal’ and ‘external’ in climate science. However, the meaning is different in each discipline. For example, focusing on the former type of variations, ‘endogenous’ processes in geology relate to the earth’s internal dynamics, referring to phenomena such as earthquakes, emergence and development of continents, ocean troughs and mountain ridges, generation of volcanic activity, changes in pre-existing rocks, etc. [*Jain*, 2013]. ‘Autogenic’ processes refer to morphologic changes that arise from the system's internal dynamics, but the term puts an emphasis on self-organized complexity, such as pattern formation occurring in alluvial channels, shoreline, sea level rise and fall, and avulsion [*Paola et al.*, 2009]. ‘Internal’ variability in climate studies refers to variations that are either purely related to the chaotic nature of the climate system or those that are not well understood and thus remain unexplained, such as El Niño–Southern Oscillation, Atlantic Multidecadal Oscillation, and Pacific Decadal Oscillation [*Deser et al.*, 2012; *Swanson et al.*, 2009]. In watershed erosion research, variability due to internal factors has been sometimes referred to as ‘natural’ variability, although this has not been consistent across the discipline and has never been rigorously defined. Here, we propose the use of the term ‘geomorphic internal variability’ introduced to unequivocally distinguish from variations caused by external factors.

SM.2. Model Description: tRIBS-VEGGIE-FEaST

Numerical experimentation relies on a two-dimensional model of overland flow and sediment transport coupled with a formulation of variably saturated flow in porous media. Specifically, this model solves 2D Saint-Venant and Hairsine-Rose equations for surface flow and sediment, and 1D Richards and Boussinesq equations for subsurface flow. The model therefore computes essential hydro-geomorphic processes such as infiltration, lateral subsurface moisture exchange, interrill and rill flow, and multi-size sediment detachment, entrainment, transfer, and deposition. The coupled flow, erosion, and sediment transport processes enable particle size selectivity by erosion and deposition and formation of soil surface shielding during event [*Kim and Ivanov*, 2014]. These dynamics, resolved with a modeling approach based on physical laws of conservation of mass and momentum, play a fundamental role in transforming the initial soil surface conditions. They markedly contrast conventional assumptions of static erodibility accepted in majority of soil erosion models.

SM.3. Soil Loss Regression Equations

An equation reflecting the characteristics of the 10,001 simulation results is obtained with a regression model that fits a linear relationship between the initial cover fraction of deposited materials (H) and soil loss (SL) and differentiates the effect of each particle on SL. The model is

$$\frac{SL - SL_0}{H} = \sum_{i=1}^{6} w_i f_i \tag{S1}$$

where the coefficient SL_0 is the soil loss (intercept) for the case of soil surface that is entirely "intact", i.e., H is zero, and equals to 0.0299 [kg m^{-2}], computed from the model, tRIBS-VEGGIE-FEaST. The coefficients w_i represent weights for the partition fractions (f_i) of the six particle size classes composing the antecedent fraction of deposited materials. The coefficients are calculated using the linear, least-squares multiple regression method: 1.8525, 0.8261, 0.1285, -0.0186, -0.0261, -0.0278 [kg m^{-2}], listed here sequentially from the finest ('P1') to the coarsest particle size classes ('P6').

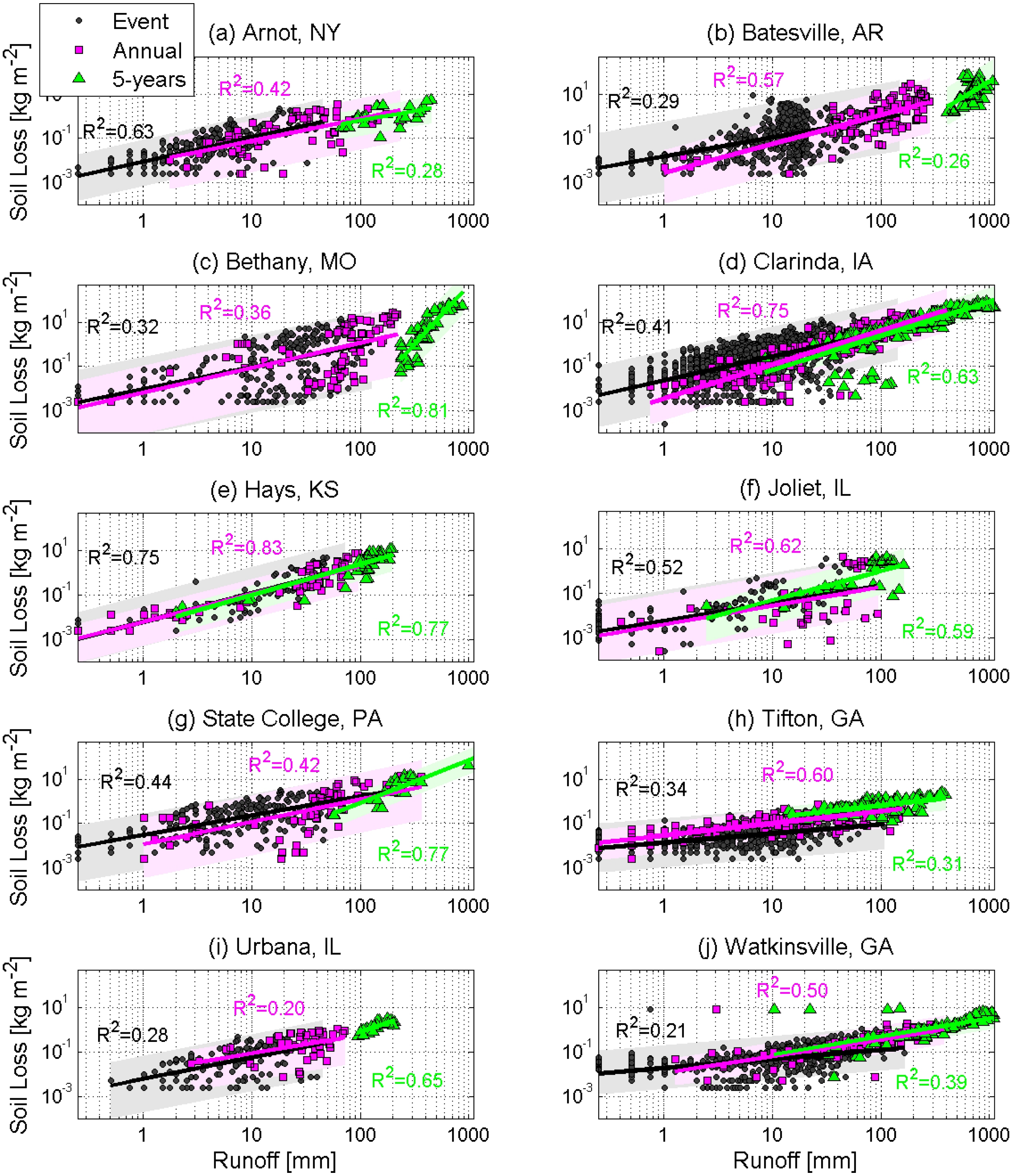

Figure S1. Measured runoff vs. soil loss represented at several temporal scales: event (black), annual (magenta), and 5-year (green) from the USLE database for ten locations. The shaded areas in light grey, magenta, and green illustrate the order of magnitude differences with respect to each regression line (thick lines).

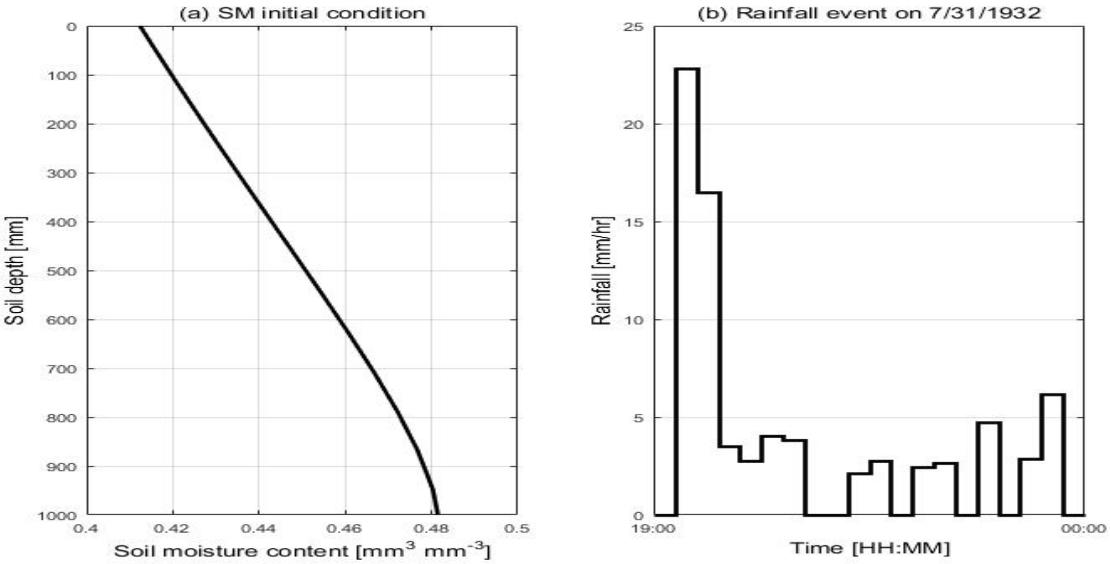

Figure S2. The initial condition of soil moisture distribution (a) and rainfall event (b) used in numerical experimentation of Section 3.1.

Table S1. Parameters used to represent hydrologic, hydraulic, and sediment erosion-transport dynamics for Clarinda, IA. This is an excerpt from the Supplementary Material in *Kim et al.* [2016a].

Description	**Value**	**Unit**	**Source**	**Usage**
Manning coefficient	0.03	s m$^{-1/3}$	*Kim and Ivanov* [2014]	Flow
Detachability of original soil	20	kg m^{-3}	*Kim and Ivanov* [2014]	Erosion
Detachability of deposited soil	2000	kg m^{-3}	*Kim and Ivanov* [2014]	Erosion
Effective fraction of excess stream power	0.01	-	*Kim and Ivanov* [2014]	Erosion
Critical stream power	0.0439	W m^{-2}	*Heng et al.* [2011]	Erosion
Specific energy of entrainment	750	m^2 s^{-2}	*Heng et al.* [2011]	Erosion
Deposited mass needed to sheild original soil	2.7	kg m^{-2}	*Kim and Ivanov* [2014]	Erosion
Saturated hydraulic conductivity	4.279	mm hr^{-1}	ROSETTA	Soil-hydraulic
Volumetric soil moisture at saturation	0.4815	m^3 m^{-3}	ROSETTA	Soil-hydraulic
Volumetric residual soil moisture	0.0913	m^3 m^{-3}	ROSETTA	Soil-hydraulic
Pore-size distribution index	1.5093	-	ROSETTA	Soil-hydraulic
Air entry bubbling pressure	-0.00085	mm	ROSETTA	Soil-hydraulic

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