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Including hillslope sediment connectivity in SWAT – the Siret Basin case study

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Current SWAT modelling of hillslope erosion

Daily sediment yields in SWAT are assessed with the Modified Universal Soil Loss Equation (MUSLE):

$$SY = 11.8\left(QQ_pA\right)^{0.56}(CPKLS) \qquad (1)$$

where *SY* = sediment yield (t); *Q* = volume of runoff (mm); Q_p = runoff peak (m^3/s); *A* = unit area (ha); *C*, *P*, *K*, and *LS* are dimensionless factors accounting for crop cover, soil protection, soil erodibility (adjusted for coarse fragment cover), and topography as in the original USLE. The MUSLE equation implies that $SY \sim A^{1.12}$ (Chen and Mackay, 2004). This scale dependency is undesirable, as it means that: (i) Hydrologic Response Units (HRUs) that are similar for soil, land use and topography, but different in size will result in different specific sediment yields (t/ha); and (ii) SWAT sediment predictions are very sensitive to spatial discretization.

An alternative approach to incorporate hillslope sediment connectivity. We aim at developing an alternative approach to assess daily hillslope sediment yield with SWAT by introducing spatially (and temporally) variable Sediment Delivery Ratios (*SDRs*) that account for sediment connectivity (Box 1).

Box 1. Better accounting for sediment connectivity

$SY = SL * SDR$	SL = daily soil loss (t/ha), SDR = (daily) sediment delivery ratio
$SL = \frac{f_C KPLSQ}{10}$	*K*, *P*, *LS* : USLE factors for erodibility, soil protection, and topography; *Q* = daily runoff (mm/ha); f_C is a function of crop and residue cover. (Freebairn and Wockner, 1986; ww.howleaky.net)
SDR (two potential approaches):	
Flux Connectivity (Borselli et al., 2008)	Residence Time (Lu et al., 2006)
$SDR_{IC} = f(IC)$ where *IC* = Flux Connectivity index	$SDR_{RT} = f(t_t, t_{er}, \upsilon)$ where t_t = travel time; t_{er} = effective storm duration; υ = particle settling velocity.
+ upstream accumulation + distance to stream + spatial variability	+ distance to stream + climate gradient + spatial variability + (potentially) temporal variability

The Siret Basin

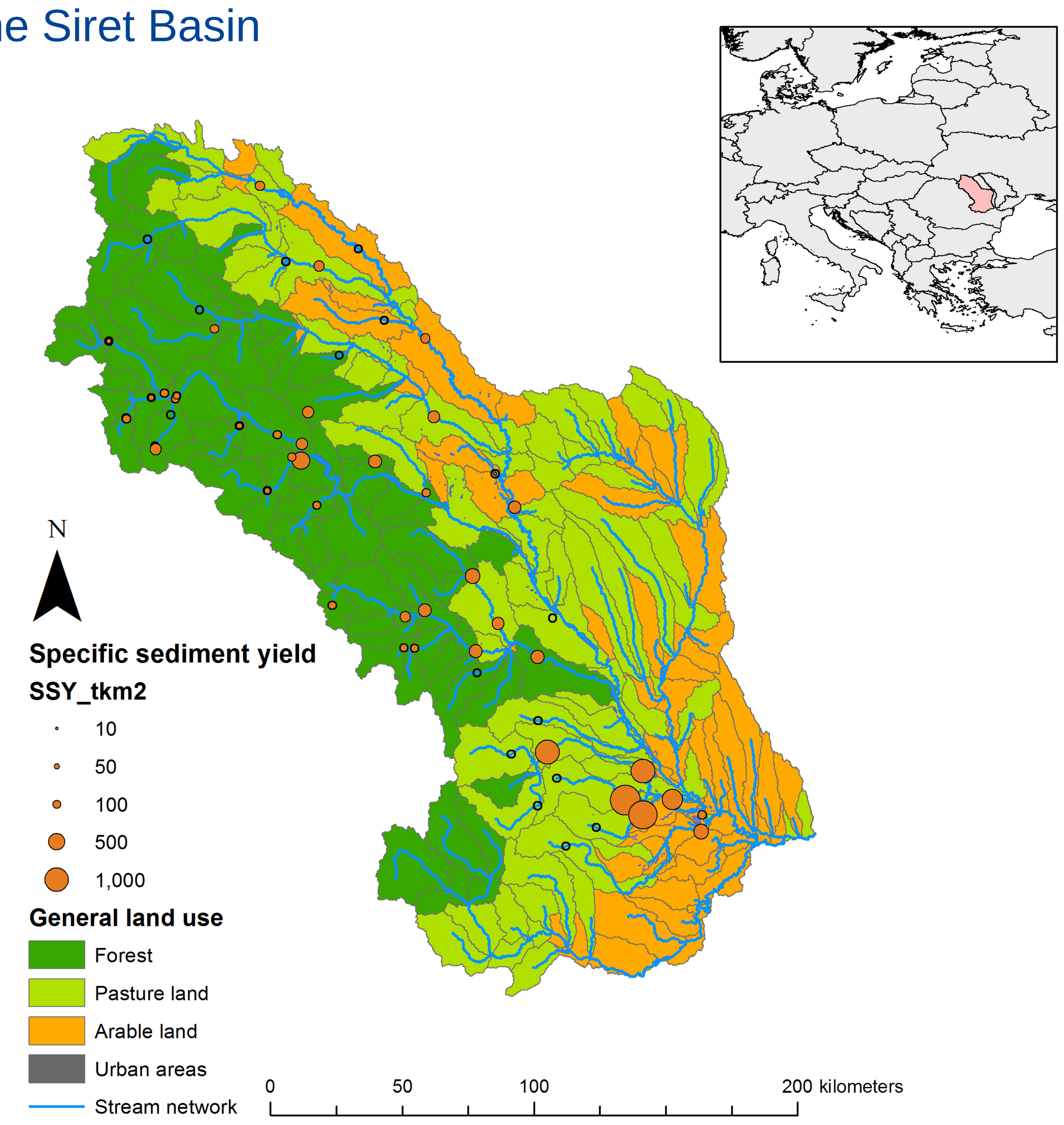

Figure 1. Location, land use, and mean annual specific sediment yields of the Siret Basin.

The Siret Basin extends on ~44900 km^2, across Ukraine and Romania. Altitude ranges from ~10 to ~2100 m a.s.l. with relief decreasing from West to East and from North to South. The climate is temperate continental, with mean annual rainfall ranging from 650 to 1000 mm. Data for model calibration and validation comprise daily discharge and sediment load measured at 41 monitoring stations from 1980 to 2011. Mean annual specific sediment loads range from 24 to more than 1000 $t/km^2/y$ (Fig. 1). The highest sediment yields in the South-east of the Basin are related to seismic activities (Vanmaercke et al., 2014). The SWAT model of the Siret Basin comprises 229 subbasins with 195 km^2 mean area. A regionalized calibration and validation of water discharge will be completed prior to sediment modelling.

References

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