Sediment

Introduction

Sediments are simulated as suspended sediments (SS) and nitrogen in algae (AE). The sum of the two **substances** is an additional output (total suspended sediments, TS). Suspended sediments are not simulated in the soil of HYPE. Suspended sediments are first introduced into the runoff of the soil by soil erosion.

The main **states** are concentration of SS and AE in all water stores of HYPE, i.e. soil, river, lakes, but also snow, aquifers (in the store and on the move there or away), irrigation water, floodplain water, and water transfer (that is delayed one time step) could hold suspended sediments and algae. In the current model though, concentration of SS and AE is only positive in river and lakes, and flows originating from them. In addition two pools of settled sediment are simulated; a pool of delayed sediment in runoff, and a pool of (temporarily) settled sediment in river. Note: No store of “settled sediment” of the soil is simulated, i.e. HYPE has an unlimited source of soil for erosion.

Figure 1: Schematic figure of sediment model.

Sources of sediment load

Soil erosion

The main source of sediment in HYPE is from soil erosion. Soil erosion is modelled in several steps. **First** particles are mobilized from the soil by rain or surface runoff. The result is here called “mobilized sediments”. The mobilized sediments are assumed suspended in an “eroding flow”, which is surface runoff plus macropore flow. **Secondly**, if there is surface runoff, the mobilized sediments is transported away from the field with the surface runoff and macropore flow (“eroded sediment”). A filtering can be applied to reduce the amount of eroded sediment. If there is no surface runoff, there will be no transport of eroded sediments. For SS, the eroded sediments are taken from an infinite pool. For PP, the eroded particulate phosphorus is taken from the soil pools. **Thirdly**, the eroded sediments in macropore flow and surface runoff (and tile runoff though that is generally zero) are delayed in a temporary pool. The release of suspended sediments from this pool is determined by the total runoff from the class, and is following the total runoff off the land.

Step 1: Mobilization of particles from soil.

HYPE has two alternative models for mobilization; soil erosion model 1 and soil erosion model 2.

Soil erosion model 1 (MMF-based model): The first model is based on Morgan-Morgan-Finney erosion model (Morgan et al., 1984) and calculates particles mobilized by rainfall energy and surface runoff. The kinetic energy in rainfall is calculated as a function of rainfall (*rain*, mm/ts) and day of the year (*dayno*). If the precipitation falls as snow, or if it falls on snow-covered ground or if it is smaller than 5 mm/day no mobilization occurs in the model. Some of the raindrop's energy can be absorbed by vegetation. Crop cover is defined as the portion of land that is sheltered from raindrops; for a description of how this is calculated, see Chapter Crop cover and ground cover. The factor

$common_{cropcover}$ is the sheltering effect that the main and secondary crops give together. It varies over the year due to crop growth and management. The mobilization by rain (*MobilisedRain*, g/m2/ts) is also influenced by soil erodibility (soil dependent parameter *soilerod* (g/J)).

$$Rainfall_{energy} = rain \times \left(8.95 + 8.44 \times LOG_{10}\left(rain \times 2 \times \left(0.257 + 0.09 \times \sin\left(2\pi \times \left(dayno - 70 \right) / 365 \right) \right) \right) \right)$$

$$MobilisedRain = Rainfall_{energy} \times \left(1. - common_{cropcover} \right) \times soilerod$$

When surface runoff occurs, soil particles are eroded and carried away as the soil surface is exposed to shear forces. The mobilization (*MobilisedSR*, g/m2/day) is calculated from the surface runoff (*sflow*, mm/day), subbasin average slope, a parameter for soil cohesion (*soilcoh* (kPa) soil type dependent), and a general parameter (*sreroexp*). This type of erosion can be mitigated by protective vegetation or vegetation residues that are in contact with the ground. The calculation of this reducing factor (*groundcover*) is described in Chapter Crop cover and ground cover. The factor $common_{groundcover}$ is the combined effect of the main and secondary crops.

$$MobilisedSR = \frac{\left(sflow \times 365 \right)^{sreroexp} \times \left(1 - common_{groundcover} \right) \times \frac{1}{0.5 \times soilcoh} \times \sin\left(\frac{slope}{100} \right)}{365}$$

All mobilized particles are not staying mobilized, because sometimes the transport capacity of the particle-bearing water (*eflow*) will not suffice for the task. If this is the case, a *transportfactor* reduces the particle amount mobilized:

$$transportfactor = MIN\left(1.0, \left(eflow / 4 \right)^{1.3} \right)$$

Finally mobilized sediment (*mobilSed*, kg/km2/day) is calculated as the sum of rain and surface runoff caused mobilization as:

$$mobilSed = 1000 \times \left(MobilisedRain + MobilisedSR \right) \times transportfactor$$

Soil erosion model 2 (HBV-SED based model): The second model is based on HBV-SED model (Lidén, 1999; Lidén et al., 2001) and calculates particles mobilized by rain (*rain*). It also depends on soil and land characteristics in the form of model parameters and data on subbasin characteristics.