DEVELOPERS

JSWMM - Runoff component

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Abstract

This pages teaches JSWMM-Runoff component as OMS3 component. Some preliminary knowledge and installation of OMS is mandatory (see @Also useful). This component replicates the EPA SWMM runoff module. See Hydrology Manual at https://www.epa.gov/water-research/storm-water-management-model-swmm for more.

@Version:
0.1

@License:
GPL v.3

@Inputs:
HashMap<Integer, LinkedHashMap<Instant, Double>> adaptedRainfallData;

@Outputs:
HashMap<Integer, LinkedHashMap<Instant, Double>> runoffFlowRate;

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Code Information

Code repository

This points to the source code https://github.com/geoframecomponents/jswmm

Executables

This points to the jar file that, once downloaded can be used in the OMS console.
../build/libs

Also useful

Dependency of the source code:

- inpparser-all.jar
- oms-all.jar

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Component Algorithms and internals

Governing equations

Overland flow is generated by modeling the subcatchment as a nonlinear reservoir, as sketched in Figure 1.

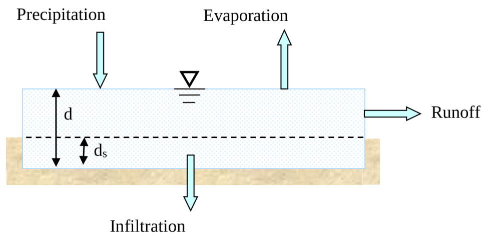


Figure 1 SWMM runoff processes. Credit:[1]

The non linear reservoir means to solve the equation:

$$\frac{\partial d}{\partial t} = i - e - f - q \tag{1}$$

where i is the rate of rainfall, e is the surface evaporation rate, f is the infiltration rate and q the runoff rate.

Subcatchment partitioning

The different sub-area have same approach, so the equations are the same. The only change to take care of is the depth factor. So the sub-areas that model the subcatchment are:

A1 (pervious area)

$$\alpha_P = \frac{W \cdot S^{1/2}}{A_1 \cdot n_P} \tag{2}$$

A2 (impervious area with depression storage):

$$\alpha_I = \frac{W \cdot S^{1/2}}{(A_2 + A_3) \cdot n_I} \tag{3}$$

A3 (impervious area without depression storage): same equation as **A2**.

Computational scheme

The computational scheme directly from the SWMM manual follows the step:

1 If currently there is no precipitation, no snow melt, and no runoff occurring within the entire study area then set the current time step Δt equal to the user-specified dry time step. Otherwise set it to the user-specified wet time step. If necessary, reduce the time step to the next time at which either rainfall or evaporation changes.

2 For each subcatchment, retrieve its current precipitation rate i and evaporation rate e from the data sources.

3 For each subarea within each subcatchment:
   (a) If snow melt is being simulated is necessary to adjust the precipitation rate i to reflect any snow accumulation (which decreases i) or snow melt (which increases i).
   (b) Set the available moisture volume d_a to $i \cdot \Delta t + d$ where d is the current ponded depth and limit the evaporation rate e to be no greater than $d/\Delta t$.
   (c) If the subarea is pervious, then determine the infiltration rate f and if groundwater is being simulated consider the possible reduction in f that can occur due to fully saturated conditions. Otherwise set $f = 0$.
   (d) If losses exceed the available moisture volume (i.e.,$(e + f)\Delta t \geq d_a$) then $d = 0$ and the runoff rate $q = 0$. Otherwise, compute the rainfall excess i_x as:

$$i_X = i - e - f.$$

   (e) If the rainfall excess is not enough to fill the depression storage depth d_s over the time step (i.e. $d + i_X \cdot \Delta t \leq d_S$) then update d to $d + i_X \Delta t$ and set $q = 0$. Otherwise update d and q by solving equation 1 as described below.

4 Compute the total runoff Q from subcatchment at the end of the time step:

$$Q = \sum_{j=1}^{3} q_j \cdot A_j \tag{4}$$

where q_j is the runoff per unit area in each subarea j (eq. 6) and A_j is the area of subarea j.

To evaluate runoff per unit area in each subarea q_j SWMM follow the steps above:

1 If ponded depth is currently below the depression storage depth ($d < d_s$) and the rainfall excess is positive then determine the time step Δt_x during which the depth will exceed d_s: $\Delta t_X = \Delta t - (d_s - d)/i_X$ and set $d = d_s$. Otherwise set $\Delta t_x = \Delta t$.

2 Use a standard fifth-order Runge-Kutta integration routine with adaptive step size control ([2]) to solve the equivalent of equation 1:

$$\frac{\partial d}{\partial t} = i_X - \alpha \cdot d_X^{5/3} \tag{5}$$

for d over Δt_X. Here $d_X = d - d_S$ for $d > d_s$ and is 0 otherwise while α is α_P (equation 2) if the subarea is pervious or is α_I (equation 3) if the subarea is impervious.

3 Compute the runoff per unit area q at the end of the time step:

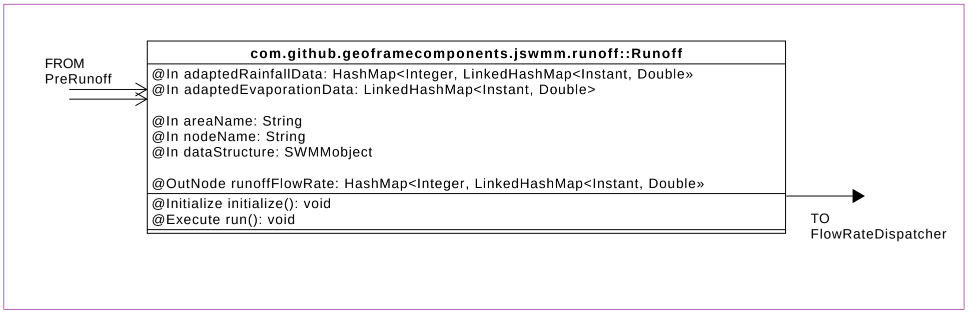
$$q = \alpha \cdot d_X^{5/3} \tag{6}$$

Recall that the depression storage d_s can have different user-supplied values for subareas $A1$ (pervious) and $A2$ (impervious) while it is zero by definition for subarea $A3$. Also note that initially at time zero the ponded depth d on each subarea of each subcatchment is zero.

Sofware specifications

To evaluate runoff using EPA SWMM algorithm.

Class UML diagram



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References

1. Rossman, L.A.: Storm Water Management Model User's Manual, Version 5.0. National Risk Management Research Laboratory, Office of Research and . . . , ??? (2010)
2. Press, W.H., Teukolsky, S.A., Vetterling, W.T., Flannery, B.P.: Numerical Recipes in C: The Art of Scientific Computing. Second Edition (1992)