SIMHYD with routing - SRG

SIMHYD with routing is a conceptual rainfall-runoff model that estimates daily stream flow from daily rainfall and areal potential evapotranspiration data. SIMHYD with routing is similar to the standard SIMHYD model but has an additional store to simulate routing of surface flows.

The model contains stores for interception loss, soil moisture, groundwater and routing. The model has nine parameters.
Scale

SIMHYD with routing operates at a functional unit scale and daily time-step.
Principal developer

Cooperative Research Centre for Catchment Hydrology. SIMHYD is a simplified version of the daily conceptual rainfall-runoff model, HYDROLOG, that was developed in 1972 (see Porter 1972; and Porter & McMahon 1975) and the more recent MODHYDROLOG (Chiew & McMahon 1991).

The SIMHYD with routing model has nine parameters as compared to the 17 parameters required for HYDROLOG and the 19 for MODHYDROLOG.

The SIMHYD model was developed by Francis Chiew in Fortran and converted to C# in TIME by Jean-Michel Perraud. Routing was added by Jai Vaze and Phillip Jordan.
Scientific provenance

SIMHYD has been widely applied to a large number of Australian catchments by several hydrologists (Peel et al., 2000; Chiew et al., 2008). The extent of its use outside of Australia is unknown but the conceptual structure is not particularly limited to Australian catchments and with appropriate calibration and testing it is likely that it could be successfully applied in other countries.
Version

Source v3.8.10
Dependencies

None
Availability/conditions

SIMHYD is automatically installed with Source. SIMHYD is also available through the Rainfall Runoff Library on eWater Toolkit http://www.toolkit.net.au/Tools/RRL.
Flow phase

The structure of the simple lumped conceptual daily rainfall-runoff model, SIMHYD, is shown in Figure 1.

Figure 1. Structure of the SIMHYD with routing rainfall-runoff model
In SIMHYD, daily rainfall first fills the interception store, which is emptied each day by evaporation. The excess rainfall is then subjected to an infiltration function that determines the infiltration capacity. The excess rainfall that exceeds the infiltration capacity becomes infiltration excess runoff.

Moisture that infiltrates is subjected to a soil moisture function that diverts the water to the stream (interflow), groundwater store (recharge) and soil moisture store. Interflow is first estimated as a linear function of the soil wetness (soil moisture level divided by soil moisture capacity). The equation used to simulate interflow therefore attempts to mimic both the interflow and saturation excess runoff processes (with the soil wetness used to reflect parts of the catchment that are saturated from which saturation excess runoff can occur).

Groundwater recharge is then estimated, also as a linear function of the soil wetness. The remaining moisture flows into the soil moisture store.

Evapotranspiration from the soil moisture store is estimated as a linear function of the soil wetness, but cannot exceed the atmospherically-controlled rate of areal potential evapotranspiration. The soil moisture store has a finite capacity and overflows into the groundwater store. Base flow from the groundwater store is simulated as a linear recession from the store.

The model therefore estimates runoff generation from three sources - infiltration excess runoff, interflow (and saturation excess runoff) and base flow. Surface flows are routed through a storage.

The fundamental equations of the model are shown in Equation 1 through Equation 10.

| Equation 1              | \[
|                         | imperviousET = \min \left( \frac{PET}{(1 - perviousFraction) \cdot perviousThreshold}, \frac{imperviousIncident}{imperviousIncident} \right) \]
| Equation 2              | \[
|                         | interceptionET = \min \left( \frac{perviousIncident}{perviousIncident}, \frac{PET}{PET}, \frac{rainfallInterceptionStoreCapacity}{rainfallInterceptionStoreCapacity} \right) \]
| Equation 3              | infiltrationCapacity = \[
|                         | \frac{perviousFraction}{perviousFraction} \cdot \frac{infiltrationCoefficient}{infiltrationCoefficient} \cdot \exp(- infiltrationShape \cdot soilMoistureFraction) \]
| Equation 4              | infiltration = \min(throughfall, infiltrationCapacity) \]
| Equation 5              | interflowRunoff = interflowCoefficient \cdot soilMoistureFraction \cdot infiltration \]
| Equation 6              | infiltrationAfterInterflow = infiltration − interflowRunoff \]
| Equation 7              | recharge = rechargeCoefficient \cdot soilMoistureFraction \cdot infiltrationAfterInterflow \]
| Equation 8              | soilInput = infiltrationAfterInterflow − recharge \]


Equation 9

\[ \text{surfaceStorageVolume} = K \bullet \\
( x \bullet \text{unroutedSurfaceRunoff} + \\
(1 - x) \bullet \text{routedSurfaceRunoff} ) \]

Equation 10

\[ \text{surfaceStorageVolume}_{\text{current timestep}} = \\
\text{surfaceStorageVolume}_{\text{previous timestep}} + \\
\text{unroutedSurfaceRunoff} - \\
\text{routedSurfaceRunoff} \]
Input data

The model requires daily rainfall and potential evapotranspiration data. The rainfall and evaporation data sets need to be continuous (no gaps) and overlapping. Catchment area in km$^2$ is required to provide flow output volumes.

Daily rainfall data may be obtained from rain gauges or rainfall surfaces but will need to be converted to a time series record that is spatially representative of the whole catchment. Note that the time that rainfall data is collected may be important. Very often rainfall data is collected in the morning, the usual time is 9 am, and may be more representative of the previous day’s rainfall.

Daily evaporation is an estimate of the spatially averaged evaporation rate of the catchment being modelled. This estimate is subject to the types of land uses that are in the catchment. This may be estimated by applying a crop/land use factor to daily pan or potential evapotranspiration surface data.

Daily flow data in ML/day, m$^3$/s or mm/day may be required to calibrate the model.

Selecting stream flow data to use in a river-basin-scale simulation study needs information about the reliability of the data. It is best to use data which are most representative of the stream flow from the catchment. Observed data would normally be selected, except where the data are of poor quality or of unknown reliability.
Parameters or settings

Model parameters are summarised in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Units</th>
<th>Default</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseflow coeff.</td>
<td>Base flow Coefficient</td>
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<td>1.0</td>
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</tr>
<tr>
<td>Impervious Threshold</td>
<td>Impervious Threshold</td>
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<td>n.a.</td>
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<td>5.0</td>
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<tr>
<td>Infiltration Coeff.</td>
<td>Infiltration Coefficient</td>
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<td>400</td>
<td></td>
</tr>
<tr>
<td>Infiltration shape</td>
<td>Infiltration Shape</td>
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<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Interflow Coef.</td>
<td>Interflow Coefficient</td>
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<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Perv. Fraction</td>
<td>Pervious Fraction</td>
<td>n.a.</td>
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<td>1.0</td>
<td></td>
</tr>
<tr>
<td>RISC</td>
<td>Rainfall Interception Store Capacity</td>
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<tr>
<td>Recharge coefficient</td>
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<td>1.0</td>
<td></td>
</tr>
<tr>
<td>SMSC</td>
<td>Soil Moisture Store Capacity</td>
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<td>K</td>
<td>Surface delay parameter</td>
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<td>x</td>
<td>Inflow to outflow bias parameter</td>
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<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

The relative sensitivity of parameters will vary between catchments but generally the model is most sensitive to the soil moisture store capacity, pervious fraction and base flow index.
Output data

The model outputs daily surface and base flow. This may be saved in ML/day, m³/s or mm/day.
Configuration

This model requires calibration and validation.
Reference list

Porter, JW 1972, The synthesis of continuous streamflow Department of Civil Engineering, Monash University, Melbourne, p. 222.


Bibliography


