Australian Water Balance Model (AWBM) - SRG

The Australian Water Balance Model (AWBM) is a catchment water balance model that relates daily rainfall and evapotranspiration to runoff, and calculates losses from rainfall for flood hydrograph modelling. The model contains five stores; three surface stores to simulate partial areas of runoff, a base flow store and a surface runoff routing store.
Scale

AWBM operates at the functional unit scale and at a daily time-step.
Principal developer

Cooperative Research Centre for Catchment Hydrology. The original model was developed by Dr Walter Boughton.
Scientific provenance

AWBM has been applied in many Australian catchments by the original author (Boughton) and by several other hydrologists. The extent of its use outside Australia is unknown but it is not expected to have been widely applied outside of Australia. There is nothing particularly unique to Australia in the conceptual structure of AWBM but it would require calibration and testing to catchments outside of Australia to confirm its suitability.
Version

Source v3.8.10
Rainfall Runoff Library v1.0.5, June 25, 2004
http://www.toolkit.net.au/Tools/RRL
Dependencies

None.
Availability and conditions

AWBM is automatically installed with Source. AWBM is also available through the Rainfall Runoff Library on eWater Toolkit: [http://www.toolkit.net.au/Tools/RRL](http://www.toolkit.net.au/Tools/RRL).
Structure and processes

AWBM uses three surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others (Figure 1). The model calculates the moisture balance of each partial area at daily time-steps. At each time-step, rainfall is added to each of the three surface moisture stores and evapotranspiration is subtracted from each store.

Figure 1. Structure of the AWBM rainfall-runoff model

If the value of moisture in the store becomes negative, it is reset to zero, as the evapotranspiration demand is superior to the available moisture. If the value of moisture in the store exceeds the capacity of the store, the moisture in excess of the capacity becomes runoff and the store is reset to the capacity.

The catchment area is divided into 3 subareas, A1, A2 and A3, each representing user defined land use or soil classifications as proportions of the area of the catchment. Thus the sum of A1, A2 and A3 must be 1. Only A1 and A2 can be set by the user and the remaining area proportion, A3, is calculated internally as A3 = 1 - (A1 + A2). The default parameter values are A1 = 0.134, A2 = 0.433 and A3 = 0.433. If the user enters values of A1 and A2 that do not satisfy the constraints, then the AWBM model will rescale these parameters to ensure that A1 + A2 + A3 = 1 (the rescaled values are not reported to the user). The rescaling method used by AWBM is:
\[ A1_{\text{new}} = \max(0, \min(A1, 1)) \]
\[ A2_{\text{new}} = \begin{cases} A2 & \text{if } A1_{\text{new}} + A2 \leq 1 \\ 1 - A1_{\text{new}} & \text{otherwise} \end{cases} \]
\[ A3 = 1 - A1_{\text{new}} - A2_{\text{new}} \]

where \( A1 \) and \( A2 \) are the values entered by the user and \( A1_{\text{new}}, A2_{\text{new}} \) and \( A3 \) are the values used by AWBM.

When runoff occurs from any store, part of the runoff becomes recharge of the base flow store if there is base flow in the stream flow. The fraction of the runoff used to recharge the base flow store is \( \text{BFI} \times \text{runoff} \), where \( \text{BFI} \) is the base flow index, i.e., the ratio of base flow to total flow in the stream flow. The remainder of the runoff, i.e., \( (1.0 - \text{BFI}) \times \text{runoff} \), is surface runoff. The base flow store is depleted at the rate of \( (1.0 - K) \times \text{BS} \) where \( \text{BS} \) is the current moisture in the base flow store and \( K \) is the base flow recession constant of the time-step being used (typically daily).

The surface runoff can be routed through a store if required to simulate the delay of surface runoff reaching the outlet of a medium to large catchment. The surface runoff store acts in the same way as the base flow store, and is depleted at the rate of \( (1.0 - K_S) \times \text{SS} \), where \( \text{SS} \) is the current moisture in the surface runoff store and \( K_S \) is the surface runoff recession constant of the time-step being used.
**Input data**

The model requires daily rainfall and potential evapotranspiration data (PET). The rainfall and PET data sets need to be continuous and overlapping.

**Note:** AWBM cannot be used at sub-daily time-steps in Source.

Compared to rainfall, evapotranspiration has little influence on the water balance at a daily time scale and thus areal potential evapotranspiration is used (Boughton & Chiew 2003).

Daily rainfall data may be obtained from rain gauges or rainfall represented as a spatial layer, e.g., rainfall grids, 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 9am, and may be more representative of the previous day’s rainfall.

Daily PET is an estimate of the spatially averaged areal potential evapotranspiration rate of the catchment being modelled. This estimate is subject to a number of climatic and land use/land cover variables. This may be estimated by applying a crop/land use factor to daily pan data or extracted directly from maps of calculated areal potential evapotranspiration data.

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.
The relative sensitivity of parameters will vary between catchments but generally the model is most sensitive to the recession constants 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.

The variables listed in Table 2 can be recorded.

Table 2. Recorded variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseflowrecharge</td>
<td>Baseflow recharge in each time step</td>
<td>time step</td>
</tr>
<tr>
<td>Baseflowstore</td>
<td>Baseflow store contents in each time step</td>
<td>time step</td>
</tr>
<tr>
<td>Effectiverainfall</td>
<td>Effective rainfall at each time step</td>
<td>time step</td>
</tr>
<tr>
<td>Routedsurfacerunoff</td>
<td>Routed surface runoff at each time step</td>
<td>time step</td>
</tr>
<tr>
<td>Surfacerunoff</td>
<td>Surface runoff in current time step – before routing</td>
<td>time step</td>
</tr>
<tr>
<td>Excess</td>
<td>Rainfall excess in each time step</td>
<td>time step</td>
</tr>
<tr>
<td>PartialExcess</td>
<td>Partial excess in each time step</td>
<td>time step</td>
</tr>
<tr>
<td>S1</td>
<td>Soil moisture contents in first surface store</td>
<td>time step</td>
</tr>
<tr>
<td>S2</td>
<td>Soil moisture contents in second surface store</td>
<td>time step</td>
</tr>
<tr>
<td>S3</td>
<td>Soil moisture contents in third surface store</td>
<td>time step</td>
</tr>
</tbody>
</table>
Configuration

Daily flow data in ML/day, m³/s or mm/day may be required to calibrate the model.

This model requires calibration and validation.
References