Uncertainties in calibrating SWAT for a semi-arid catchment in NSW (Australia)

“A work in progress”

Willem Vervoort
w.vervoort@usyd.edu.au

McCaughey Senior Lecturer
Hydrology Research Laboratory

Faculty of Agriculture, Food & Natural Resources
Calibration and catchment models

- Large catchment scale models are used extensively for management scenarios
- Calibration is used to match observed to predicted data
- Implies background conceptual model
  - Calibration is non-unique
- Impacts subsequent management scenario

Semi-arid Hydrology

- Semi-arid and arid rivers have high flow variability
- Many no-flow days
- Lateral flows, valley/bank storage
- Dynamic transmission losses
- Difficult to predict/model
Salinity and water sharing

- Key issues for Australia’s food bowl: The Murray Darling Basin (~1 mln km²)
- Salinity levels have been rising in rivers
- Continued extraction of water for irrigation
- Mooki catchment has been recognised as an area prone to salinisation in earlier work

Source: wikipedia.org

Faculty of Agriculture, Food & Natural Resources
Australia:
Data poor, large spaces
Mooki catchment relative
DEM, soils map, landuse

Rainfall: 550 mm/year
But highly variable
spatial and temporal!
SWAT 2000 used for Mooki catchment: 4500 km²

Three gauging stations with 10 years of data
- Ruvigne
- Breeza
- Caroona

PEST to calibrate 38 parameters
Partly tied using PAR2PAR
Other parameters estimated from data

Dominant landuses: wheat, sorghum, grazing, irrigated cotton
Dominant soils: Vertosols

Faculty of Agriculture, Food & Natural Resources
Earlier work assumed connected system

GW in many places well below river

Baseflow behaviour, or only ephemeral?

Extraction from irrigators

Several parameters in SWAT:
– EPCO/ESCO, RCHG_DP, GWQMIN, SHALLST, REVAP, REVAPMIN

Interdependent

Simplify? Or make more complex?

Connected System?

Ruvigne

Logflow Mt.(day)

date

Faculty of Agriculture, Food & Natural Resources
For example

- High connectivity deep and shallow groundwater
- High capillary rise
- Result is no baseflow

- Or:
- Low connectivity
- Low capillary rise
- Result is high baseflow
SWAT conceptual model

But, relative magnitude of arrows and buckets is important for economic modelling and water quality.
### Parameters calibrated

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curvenumbers</td>
<td>10 different soil and landuses</td>
</tr>
<tr>
<td>REVAP</td>
<td>4 subcatchments</td>
</tr>
<tr>
<td>Transmission K, Mannings n</td>
<td>4 subcatchments</td>
</tr>
<tr>
<td>GW threshold</td>
<td>4 subcatchments</td>
</tr>
<tr>
<td>EPCO</td>
<td>ET damping in soil, 10 soils</td>
</tr>
</tbody>
</table>

Based on SENSAN analysis in PEST  
Also calibrated the CMD version of IHACRES (Croke and Jakeman 2004) with only 6 parameters to the data at each of the stations (max simplification)
## Conceptual models

<table>
<thead>
<tr>
<th>Run</th>
<th>SHALLST</th>
<th>RCHRG_DP</th>
<th>REVAPMIN</th>
<th>GWQMNN</th>
<th>ESCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run 1</td>
<td>500</td>
<td>0.5</td>
<td>200</td>
<td>500</td>
<td>0.95</td>
</tr>
<tr>
<td>Run 2</td>
<td>500</td>
<td>0.01</td>
<td>500</td>
<td>Calibrated</td>
<td>0.95</td>
</tr>
<tr>
<td>Run 3</td>
<td>500</td>
<td>0.1</td>
<td>500</td>
<td>Calibrated</td>
<td>0.95</td>
</tr>
<tr>
<td>Run 4</td>
<td>1</td>
<td>0.1</td>
<td>10</td>
<td>1</td>
<td>0.95</td>
</tr>
<tr>
<td>Run 5</td>
<td>500</td>
<td>0.1</td>
<td>510, Calibrated, tied to GWQMNN</td>
<td>500, Calibrated</td>
<td>0.001</td>
</tr>
<tr>
<td>Run 6</td>
<td>500</td>
<td>0.25</td>
<td>510, Calibrated, tied to GWQMNN</td>
<td>500, Calibrated</td>
<td>0.95</td>
</tr>
<tr>
<td>Run 7</td>
<td>500</td>
<td>0.25</td>
<td>300, Calibrated, tied to GWQMNN</td>
<td>600, Calibrated</td>
<td>0.95</td>
</tr>
<tr>
<td>Station</td>
<td>Ruvigne</td>
<td>Breeza</td>
<td>Caroona</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td>--------</td>
<td>---------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model run</td>
<td>NSE</td>
<td>$r^2$</td>
<td>NSE</td>
<td>$r^2$</td>
<td></td>
</tr>
<tr>
<td>run 1</td>
<td>0.25</td>
<td>0.52</td>
<td>0.26</td>
<td>0.37</td>
<td>0.16</td>
</tr>
<tr>
<td>run 2</td>
<td>0.12</td>
<td>0.48</td>
<td>0.34</td>
<td>0.48</td>
<td>0.34</td>
</tr>
<tr>
<td>run 3</td>
<td>0.09</td>
<td>0.54</td>
<td>0.35</td>
<td>0.49</td>
<td>0.40</td>
</tr>
<tr>
<td>run 4</td>
<td>-0.13</td>
<td>0.46</td>
<td>0.24</td>
<td>0.44</td>
<td>0.17</td>
</tr>
<tr>
<td>run 5</td>
<td>-0.10</td>
<td>0.47</td>
<td>0.23</td>
<td>0.43</td>
<td>0.23</td>
</tr>
<tr>
<td>run 6</td>
<td>-0.24</td>
<td>0.38</td>
<td>0.15</td>
<td>0.42</td>
<td>0.14</td>
</tr>
<tr>
<td>run 7</td>
<td>-0.11</td>
<td>0.49</td>
<td>0.28</td>
<td>0.48</td>
<td>0.29</td>
</tr>
<tr>
<td>IHACRES</td>
<td>0.40</td>
<td>0.40</td>
<td>0.38</td>
<td>0.38</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Clear differences in flow. Both peak and baseflow
But similar calibrations

Extraction for irrigation?

Behaviour of high and low flows

Caroona
• Semi-arid hydrology is difficult for SWAT: dynamic transmission losses and connectivity
  – Should we increase complexity? – How can we manipulate the groundwater algorithms

• Calibrations not the same for all stations, and do not distinguish between conceptual models

• Other data (Water quality) would be needed (but not very available)

• Validation still to be attempted (2003 – 2006), but drought

• Equifinality? Should we look at average predicted flow for all “calibrated” conceptual models
Equifinality

Ruvigne

Observed
Average predicted
95% confidence

Log flow (M3/day)

Date

2002

Faculty of Agriculture, Food & Natural Resources
Further discussion

- Care should be taken when interpreting the results of a “calibrated” catchment model:
  - Conceptual model drives calibration direction due to interdependence of parameters
  - If conceptual model is unknown or uncertain, how do we interpret results?
  - Bayesian averaging? And include in calibration
- Calibrate on monthly values?