Effects of input data resolution on SWAT simulations –
a case study at the Ems river Basin (Northwest Germany)

Gerd Schmidt, Martin Volk, Stefan Liersch and Martin Steinert
UFZ – Centre for Environmental Research, Department of Applied Landscape Ecology,
Permoserstraße 15, 04318 Leipzig, Germany
BACKGROUND AND MOTIVATION

• Research Programme River Basin Management
  Funding - German Ministry of Education and Research
  Goal - Strategies for Implementation of the EU WFD

• Main Goal
  good ecological situation of all waterbodies at the
  territory of the EU - surface and groundwater

• FLUMAGIS
  Development of DSS tool for river basin management
  Visualisation of Management Measures and their effects to
  water bodies http://www.flumagis.de

• Integration of simulation models in a DSS tool (visualisation)
  participation of all stakeholders
  calculation time
  scale specific data requirements
OUR CONTRIBUTIONS

• Derivation of indicators to assess hydrological situation

• Development of a scale system and methods for scale transfer

• Water and Nutrient Balance
description and assessment of current situation

• Developing future land use scenarios
  Landscape planning programs, EU Funding, Nature Conservation plans......

• Predicting effects of land use change to hydrological situation and water quality
SCALE DEFINITION

- EU WFD - „Report Scale“ 1 : 500,000
- River Basin Management – Planning Measures an Efficiency control?
- Scale definitions in Geography, Hydrology, Landscape Ecology, Biology, Regional Planning – different ideas!
QUESTIONS

• What are the scale equivalent/appropriate input data sets?
• Leads higher input data resolution to better simulation results?
• Which spatial resolution is suitable for derivation of different hydrological indicators? (seasonal, monthly averages; peaks, yields….)
• Can be figured out a critical catchment size for SWAT modelling?

Spatial resolution of input data

Temporal resolution of simulation

km² ha a m²

Increasing simulation quality
UPPER EMS RIVER BASIN

Area: 3740 km²  
Elevation: 27m – 350m asl

- Poor sandy soils, high ground water influence
- Rainfall 600mm SW
  1200mm E
Land use characteristics

- Tillage: food production
- Stock farming
- Milk and meat production
- Highest live stock numbers
- High amount of liquid manure

Land use distribution

- Arable Land: 77
- Forest: 9.9
- Pasture: 3.9
- Urban: 8.9
- Water: 0.4
HYDROLOGICAL AND WATER QUALITY MONITORING

- 17 Gauges 10 Usable for Calibration
- 600 sampling points only two with 2-weeks random sampling mostly not connected with gauges

- Main problem: N – input 14 mg/l TIN
- Target for “good ecological quality” 3 mg/l TIN
DATA BASE AND METHODS

- Official available data collected by the governmental departments and the national surveys, but...
- Comfortable situation - two data sets with different spatial resolution for the same area (DEM, SOIL, LAND USE)
- Using SWAT with the AVS2000 extension watershed delineation and HRU distribution with the same settings
- Parametrisation of land use and plant parameters with regional information
- Simulations at different temporal resolution
- Comparing efficiency
DATA BASE AND METHODS

<table>
<thead>
<tr>
<th>Data set</th>
<th>Low resolution</th>
<th>High resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEM</td>
<td>200m grid</td>
<td>50m grid</td>
</tr>
<tr>
<td>Soil</td>
<td>BÜK1000 – 1:1,000,000, 21 soil types, (Federal Institute for Geoscience and Mineral Ressources)</td>
<td>BK50 1:50,000, 854 soil types (Geological Survey of NRW and LS)</td>
</tr>
<tr>
<td>Land use</td>
<td>Corine Land Cover – aggregated 5 land use types</td>
<td>Topographic Information system 24 land use types (ATKIS-DLM)</td>
</tr>
<tr>
<td>Climate</td>
<td>regional stations of German weather survey 5 fully equipped 21 precipitation stations</td>
<td>regional stations of German weather survey 5 fully equipped 21 precipitation stations</td>
</tr>
</tbody>
</table>

- Agricultural management practice, crop rotations
- Waste water input 256 (urban and industrial)
WATERSHED DELINEATION

<table>
<thead>
<tr>
<th></th>
<th>Low resolution</th>
<th>High resolution</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment size in km²</td>
<td>3695</td>
<td>3785</td>
<td>90</td>
</tr>
<tr>
<td>Number of subbasins</td>
<td>62</td>
<td>76</td>
<td>10</td>
</tr>
</tbody>
</table>
GAUGED SUBCATCHMENTS

<table>
<thead>
<tr>
<th>River</th>
<th>Gauge</th>
<th>Area km²</th>
<th>Diff in %</th>
<th>Area in km²</th>
<th>Diff in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ems</td>
<td>0.89</td>
<td>-3.0</td>
<td>-16.1</td>
<td>1,485.8</td>
<td>1,502.3</td>
</tr>
<tr>
<td>Ems</td>
<td>1.29</td>
<td>-5.7</td>
<td>-8.47</td>
<td>1,616.0</td>
<td>1,620.2</td>
</tr>
<tr>
<td>Ems</td>
<td>1.203,784.8</td>
<td>-18.74</td>
<td>1,806.3</td>
<td>1,845.0</td>
<td>1,816.7</td>
</tr>
<tr>
<td>Ems</td>
<td>1.485.0</td>
<td>11.6</td>
<td>2,006.9</td>
<td>3,749.0</td>
<td>3,784.8</td>
</tr>
<tr>
<td>Ems</td>
<td>3,695.3</td>
<td>0.89</td>
<td>41.20</td>
<td>3,784.8</td>
<td>3,784.8</td>
</tr>
</tbody>
</table>

- Uncertainties in Hydrological characteristics (specific yields)
- Prediction of ungauged catchments?
HRU GENERATION

<table>
<thead>
<tr>
<th></th>
<th>Low resolution</th>
<th>High resolution</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil types</td>
<td>21</td>
<td>854</td>
<td>833</td>
</tr>
<tr>
<td>Land use classes</td>
<td>5</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Number of HRU’s</td>
<td>387</td>
<td>1950</td>
<td>1563</td>
</tr>
</tbody>
</table>

- Soil parametrization
- Management practices, crop rotation
SIMULATION RESULTS

GAUGE RHEINE

Land use change at hydromorphic soils from arable land to extensive pasture

![Graph showing concentration changes](image-url)
Monthly Hydrographs

- Good description of monthly dynamic

Average discharge at Gauge Rheda (342 km²) based on monthly calculations

Average discharge at Gauge Rheine (3740 km²) based on monthly calculations
DYNAMIC AT DAILY SIMULATION

Gauge Rheda (342 km²)

Gauge Haskenau (1616 km²)
Comparison of model efficiencies at main gauges based on monthly simulations

Comparison of model efficiencies at main gauges based on daily simulations
• Relation between catchment size and simulation quality
CONCLUSIONS

- Effects of input data resolution to simulation quality depends on time steps – daily, monthly, yearly.

- Use of data sets and parametrisation efforts should focus on the questions to be answered.

- Decreasing of model efficiency with catchment size, but it could vary on physical conditions of the catchments and unknown management operations.

- Including more gauged catchments with other physical conditions and of different size.
GAUGED SUBCATCHMENTS