Integration of MOHID model and tools with SWAT model

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Like the contracts the small letters have the important things

www.mohid.com
Overview

• Why are watershed models important for us:
  – Mondego Case Study

• SWAT-MOHID
  – MOHID Time Series editor
  – MOHID Time Series Analyzer
  – MOHID HDF
  – Coupling SWAT with Mohid River Network

• SWAT-MOHID application
  – Mondego Case Study

• Conclusions
Mondego Case Study
Nutrient Loads to Estuary
HARP guidelines (OSPAR)

Annual quantities

• Values in tons/year

• Source Oriented Approach
  – Nitrogen - 4121
  – Phosphorous - 646

• Load Oriented Approach (river)
  – Nitrogen - 3469
  – Phosphorous - 404
Preliminary results show agriculture is responsible for 25% of total nitrogen and 13% of total phosphorous.
Estuary modeling - Water quality

Fitoplancton

Amonium

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Other Case Studies

- Case studies used mainly publicly available internet data:
  - NASA DEM
  - Corine LU/LC
  - Europe soil map
  - National Water Institute Precipitations and flows
What is MOHID about?

• Object oriented programing:
  – Models - Fortran 95
  – Interfaces – dot Net, VB, C#, etc

• Models:
  – Grid based
  – Variable Time Step
  – Water and properties mass conservation

• Solving water related problems
Why to link MOHID & SWAT?

• SWAT is the sum of many simple solved processes => Complex model
• Mohid tools allow exploring easily SWAT results to find:
  – Input errors
  – Concept errors
  – Compare with data
  – Trends
  – Study in high detail some processes
Connection of SWAT and MOHID River Network
MOHID Time Series Viewer

Example MOHID Time serie.txt - Notepad

SERIE_INITIAL_DATA : 2006 8 1 12 15 30
TIME_UNITS : MINUTES
time temperature salinity
<BeginTimeSerie>
0 10.2 35.4
10 10.3 35.2
20 10.3 35.3
30 10.1 35.5
40 10.0 35.6
<EndTimeSerie>
# MOHID Time Series Analyzer

![Image of MOHID Time Series Analyzer](image.png)

## Table

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Average</td>
<td>88.29403</td>
</tr>
<tr>
<td>Modeled Average</td>
<td>125.14259</td>
</tr>
</tbody>
</table>

## Graph

![Graph of Time Series](graph.png)

- **Observed Data**
- **Modeled Data**

**Notes:**
- Statistics from Daily and Monthly averages.
- For each observed parameter, a time series analysis is performed.
- The data values are plotted over time with a window width of 3500 days.

**Data Values Range:**
- Time: 03-06-1963 to 20-08-1971
- Data Values: 0 to 1000

<table>
<thead>
<tr>
<th>Data Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>03-06-1963</td>
</tr>
<tr>
<td>27-02-1966</td>
</tr>
<tr>
<td>23-11-1968</td>
</tr>
<tr>
<td>20-08-1971</td>
</tr>
</tbody>
</table>

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MOHID GIS

- **Layers of spatial information**
- **Rain Indicator**
- **Subbasin results**
- **Time control**
- **Frame Date & Time**

MOHID GIS - C:tempMohid GIS Project.mp - [XY View]

Mondego Watershed - Portugal
SWAT results

03-11-1931
00:00
Aplication of SWAT-MOHID

• Land Use Land Cover – CORINE

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Agriculture census data

% of agriculture area

- 0.000 - 0.200
- 0.201 - 0.400
- 0.401 - 0.600
- 0.601 - 0.800
- 0.801 - 1.000
Animal Pressures

N Kg / hectar / year

- 0.0 - 50.0
- 50.1 - 100.0
- 100.1 - 150.0
- 150.1 - 200.0
- 200.1 - 250.0
- 250.1 - 300.0

www.mohid.com
Some round numbers

- Area of 6700 km²
- 1000 mm of precipitation
- 2000 meters mountain
- Agriculture area, Corine-35% Census-20%
- About 600 000 people
- 40 000 cattle, 150 000 pigs, 200 000 sheep, 50 000 goats and 6 000 000 poultry
- 700 year old University (Coimbra)
## Flow results

![Graph showing observed vs modeled data over time](https://www.mohid.com)

<table>
<thead>
<tr>
<th>Flow gage station</th>
<th>Coimbra</th>
<th>Tabua</th>
<th>Mucela</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily</td>
<td>Monthly</td>
<td>Daily</td>
</tr>
<tr>
<td>RMSE - Root Mean Squared Error [m³/s]</td>
<td>88</td>
<td>51</td>
<td>37</td>
</tr>
<tr>
<td>R² - Pearson Product-Moment Correlation Coefficient [-]</td>
<td>0.78</td>
<td>0.91</td>
<td>0.76</td>
</tr>
<tr>
<td>E - Model efficiency (Nash-Sutcliffe) [-]</td>
<td>0.69</td>
<td>0.82</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Weather generator vs independently measured temperature
Conclusion

• MOHID and SWAT have free access source code. This has allowed the integration of some aspects of both models.
• The advantage of application of SWAT-MOHID is mainly the improved capabilities to analyze results.
• SWAT seems to be underestimation flows, though the simulation results in the most downstream station (Coimbra) has an monthly Efficiency of 0.82 and of 0.69 for daily results.
• The preliminary results show agriculture as responsible for 25% of total nitrogen and 13% of total phosphorous loads to the estuary.
Future work

• Code development:
  – Check-In code changes in to Temple-Texas
  – Design a way to maintain new versions of SWAT and MOHID code compatible

• SWAT application:
  – Improve data inputs
  – Comparison with Mohid-Land model
  – Detailed studies with Mohid-Land model

www.mohid.com
MOHID – LAND model

Bacia Hidrográfica do Rio Trancão
Evento de Chuva
13-11-2002
0:01
Integrated Catchment Modelling

Catchment Models

Reservoir Model

Integrated Catchment Modelling
Coupled Watershed / Reservoir Model

31/10/2002
1:00 PM
Integrated Catchment Modelling

MOHID
Integrated Catchment Modelling
Coupled Watershed / Reservoir Model
1/10/2002
12:00 AM
MOHID
Modelling Water Resources

MOHID
Water Modelling System

Additional Applications

<table>
<thead>
<tr>
<th>Operational Modelling</th>
<th>Operational Model for the Tagus Estuary (Portuguese)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IST - Wave Forecast</td>
</tr>
<tr>
<td>WebGIS Applications</td>
<td>GIS Web Portal (Portuguese; restricted area)</td>
</tr>
<tr>
<td>Modelling Support</td>
<td>MOHID Modelling Discussion Group</td>
</tr>
</tbody>
</table>

NEW => MOHID Users Meeting / Course II <= (Lisbon, June 25th to 28th (2007)
Members Area

Login

For registered members, there is available information about keywords used by MOHID, as well as a download section, with MOHID manuals, software, etc.

But first, you will need to login:

Username(email): [Blank]
Password: [Blank]

login
change password
forgot password

First time? Please register
Register

After you submit your register information, you will receive an email from us (register@mohid.com) with your username and password.

* The password will be sent to you by e-mail
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOHID Installer 4.9</td>
<td>Mohid Installer (Complete Package - GUI, GIS &amp; Numerics)</td>
</tr>
<tr>
<td>MOHID Installer 4.8</td>
<td>Mohid Installer (Complete Package - GUI, GIS &amp; Numerics)</td>
</tr>
<tr>
<td>Mohid Installer v4.7</td>
<td>Mohid Installer (Complete Package - GUI, GIS &amp; Numerics)</td>
</tr>
<tr>
<td>Mohid Source Code (v4.9)</td>
<td>Mohid Water and Mohid Land Source Code (version 4.9)</td>
</tr>
<tr>
<td>SWAT-MOHID</td>
<td>This Package includes the MOHID-SWAT2000 and MOHID-SWAT2005, the main input files ready to use and small help manual</td>
</tr>
<tr>
<td>HDF5Extractor</td>
<td>Software to extract subsets of data in HDF5 format from HDF5 files</td>
</tr>
<tr>
<td>Bathymetry Filter</td>
<td>Tool to filter bathymetry</td>
</tr>
</tbody>
</table>