Using SWAT to understand the eco-hydrological response to droughts of a dry Mediterranean agro-forested catchment, southern Portugal

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Climate change is expected to increase aridity in the Mediterranean rim of Europe, leading to concerns on consequences for water resources availability in a region already under water stress.

- Understanding how streamflow availability and vegetation growth have responded to past droughts.
- How this might reflect future water availability conditions.
GUADALUPE:
Agro-forested catchment
Area: 446 ha
Elevation: 260 to 380 meters
Mediterranean inland climate with hot and dry summers and mild winters:
  Mean annual precipitation (1973-2012): 533 mm
  Mean annual temperature: 15.5°C

Representative of the dry regions of southern Portugal
The catchment is representative of the streamflow sources for a network of reservoirs in the Évora region which provide water for irrigation and hydroelectric power generation.

**Study Site: Guadalupe**

**Data Collection:**

Discharge:

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow (stream flow) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set/12</td>
<td></td>
</tr>
<tr>
<td>Out/12</td>
<td></td>
</tr>
<tr>
<td>Nov/12</td>
<td></td>
</tr>
<tr>
<td>Dez/12</td>
<td></td>
</tr>
<tr>
<td>Jan/13</td>
<td></td>
</tr>
<tr>
<td>Feb/13</td>
<td></td>
</tr>
<tr>
<td>Mar/13</td>
<td></td>
</tr>
</tbody>
</table>

Soil Moisture:

<table>
<thead>
<tr>
<th>Date</th>
<th>SWC_mm</th>
<th>PP_mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mai/11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set/11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan/12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mai/12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set/12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan/13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Study Site: Guadalupe

Data Collection:

Climate Data:
- Rainfall
- Wind Speed
- Solar Radiation
- Temperature
- Relative Humidity

Total Annual Rainfall (mm)

Mean = 533 mm
Study Site: Guadalupe

Data Collection:

2 Eddy covariance flux towers:
Carbo Euro Flux
1999-2008

Precipitation (mm)  PET_mm/d  EET_mm/d_Mitra2

Evapotranspiration:

- Soil Moisture
- Plant Type
- Stage of the plant development
- Weather conditions
• HRU definition

10 subbasins

107 HRUs

Classes of Slope
- Green: 0-10%
- Red: > 10%

Land Uses
- FRSS
- OLVG
- URM D
- WCRL
- WPSR
- WPST

Soil Type
- SROASBL
- SROAPmn
- SROAPMG
- SROAPGD
- SROAPG
SWAT

- Parameterization

**Legend**

- SROASBL: Coluvisols
- SROAPmn: Brown Mediterranean Soils - Schists
- SROAPMG: Brown Mediterranean Soils - Plutonic Rocks
- SROAPGD: Non-Humic Litholic Soils - Granite (shallow)
- SROAPG: Non-Humic Litholic Soils - Granite

**LANDUSES**

- Cork/holm oak (>50%) + pasture: 52.9%
- Olive groves: 2.6%
- Urban: 0.3%
- Annual Crops: 10.7%
- Cork/holm oak (30-50%) + pasture: 28.1%
- Pasture: 5.4%
Observed Data:

MITRA 2 - PASTURE

SWAT
Observed Data:

PASTURE

Figure: Pasture production curve in rainfed Mediterranean conditions

Management Operations - PASTURE

<table>
<thead>
<tr>
<th>Year</th>
<th>OP_NUM</th>
<th>Operation</th>
<th>Crop</th>
<th>Heat Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Plant/begin growing season</td>
<td>WPST</td>
<td>0.07</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Auto fertilization initialization</td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>Grazing operation</td>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>Harvest and kill operation</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

LAI sim (m²/m²) | LAI obs (m²/m²)
Preliminary Results:

PASTURE - Daily

- LAI sim (m²/m²)
- LAI obs (m²/m²)
- EET obs PT-Mi2 (mm)
- EET sim (mm)

Dates:
- Abr/04, Jun/04, Aug/04, Out/04, Dez/04, Feb/05, Abr/05, Jun/05, Aug/05, Out/05, Dez/05, Feb/06, Abr/06, Jun/06, Aug/06, Out/06, Dez/06, Feb/07, Abr/07, Jun/07, Aug/07, Out/07, Dez/07, Feb/08, Abr/08, Jun/08, Jul/08, Set/08, Nov/08, Jan/09
Preliminary Results:

**PASTURE - monthly**

- **R² = 0.59**
- NSE = 0.41
- PBIAS = 11.1

<table>
<thead>
<tr>
<th>Year</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004/05</td>
<td>0.85</td>
</tr>
<tr>
<td>2005/06</td>
<td>0.66</td>
</tr>
<tr>
<td>2006/07</td>
<td>0.36</td>
</tr>
<tr>
<td>2007/08</td>
<td>0.84</td>
</tr>
</tbody>
</table>
Baseflow Separation

- Baseflow separation with filter
- Recession curve analysis (Arnold et al, 1995)

\[ \text{AlphaBf} = \left( -\frac{1}{N} \right) \ln \left( \frac{Q_n}{Q_o} \right) \]

- \( N = \text{Number of day} \)
- \( Q_o = Q \) at the beginning of the recession
- \( Q_n = Q \) at the end of the recession

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>mean</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha_Bf</td>
<td>(day)</td>
<td>0.09</td>
<td>0.02</td>
<td>0.58</td>
</tr>
</tbody>
</table>
Preliminary Results:

- Observed Flow (mm)
- Simulated Flow out (mm)
Conclusions

• The Evapotranspiration is a very important parameter to understand the water balance and can be simulated in SWAT

• The most sensitive parameter to calibrate LAI and evapotranspiration was heat unit

Ongoing:
• Compare the data with satellite data
• Future work will include the upscaling of the model for regional catchments, and its application to evaluate the impacts of climate change scenarios
Thank you for your attention