Assessment of the vulnerability and the climate change impact on the water resources of an insular Mediterranean Watershed

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Adapt to Climate Conference
Heraklion, June 2019
Presentation Layout

• Quiz about intermittent rivers
• Methodology
• Calibration/validation of SWAT model, Sensitivity analysis, CC models prediction, Low and high flows Indicators (IHA & SMIRES TOOLS)

• Results
• Recommendations
Do you want to assess your expertise in river flow intermittence?

Ready for the Quiz? Let’s play!
Question 1

Where is the gauging station with the highest proportion of zero?

- In Italy
- In France
- In Cyprus
Question 2

Are intermittent rivers well monitored in France?

Which proportion of gauging stations is monitoring intermittent streams?

- Less than 1%
- Between 1 and 10%
- More than 10%

Next question
Question 3

What could the maximum value of the mean annual flow ($m^3/s$) within the dataset?

- Less than 0.1 $m^3/s$
- Between 0.1 and 1 $m^3/s$
- Between 1 and 10 $m^3/s$
- More than 10 $m^3/s$

Next question
Question 4

Where was this picture taken?

- In Italy
- In Spain
- In Cyprus
- In the UK

Next question
Question 5

Can you click on the picture related to a perennial river?
This catalogue is one of the deliverables of the COST Action CA15113 (SMIRES, Science and Management of Intermittent Rivers and Ephemeral Streams, www.smires.eu), supported by COST (European Cooperation in Science and Technology).
Flood alert system of North Aegean

Meteorological station in Stypsi

Automatic telemetric station in Kalloni village
Flood alert system of North Aegean

Levellogger operation in Agia Paraskevi

Measuring the flow to extract rating-curve
Continuous, physically based, and distributed Model

The hydrology

Water balance

\[ SW_t = SW_0 + \sum_{i=1}^{t}(R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw}) \]

- \( SW_t \) is the final soil water content (mm),
- \( SW_0 \) is the initial soil water content on day \( i \) (mm),
- \( t \) is the time (days),
- \( R_{day} \) is the amount of precipitation on day \( i \) (mm),
- \( Q_{surf} \) is the amount of surface runoff in day \( i \) (mm),
- \( E_a \) is the amount of evapotranspiration on day \( i \) (mm),
- \( W_{seep} \) is the amount of water entering the vadose zone from the soil profile on day \( i \) (mm),
- \( Q_{gw} \) is the amount of return flow on day \( i \) (mm).

Sediment yield

Watershed

Subbasin

Hydrological response
• **Hydrology** (runoff, interception by the canopy, evapotranspiration, drainage, percolation, subsurface runoff, reservoirs, wetlands)

• **Climate** (soil temperature, snow, climate generator)

• **Crop growth,**

• **Farm management** (irrigation, rotation, pesticides)

• **Transfer of water into the main reach**

• **Sedimentation,**

• **Nutrients.**

**Objectif of the research**

**Watershed Delineation**

**HRUs definition**

**Input Tables**

**SWAT run**

**Precipitation, Temperature**
Meteorological data from (1955-2016) (Tmin, Tmax, Prec), Flow (2014-16)
The SWAT model performance to be evaluated using:

• **R²** (the coefficient of determination that evaluates the correlation between two series),

• **RMSE** (the root mean squared error, which evaluates the deviation),

• **Percent bias (PBIAS)** measures the average tendency of the simulated values to be larger or smaller than their observed ones.

The optimal value of PBIAS is 0.0, with low-magnitude values indicating accurate model simulation. Positive values indicate overestimation bias, whereas negative values indicate model underestimation bias.

• **the Nash–Sutcliffe Efficiency (NSE)** (the goodness of-fit criterion for the predicted and observed values)
The graph on the left shows the precipitation (mm) for different years from 1979-80 to 2009-10, with bars representing the precipitation data for 'Agia Paraskevi' and 'Stipsi'.

The graph on the right illustrates the temperature (°C) over the years from 1955 to 2015, with a fitted linear regression line given by the equation $f(x) = -0.01x + 17.81$. The data points and trend line are highlighted for 'Agia Paraskevi'.

Below the graphs, there is a graph showing the streamflow (CMS) for different months and subbasins, with lines representing the simulated flow for subbasins 25, 24, 22, and 19.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Range</th>
<th>Initial values</th>
<th>Adjusted values</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESCO</td>
<td>Soil evaporation compensation factor</td>
<td>0-1</td>
<td>0.95</td>
<td>0.95</td>
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<tr>
<td>EPCO</td>
<td>Plant uptake compensation factor</td>
<td>0-1</td>
<td>1.0</td>
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<td>lat_time(days)</td>
<td>Lateral flow travel time</td>
<td>0-800</td>
<td>0.2</td>
<td>0.2</td>
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<tr>
<td>GW_DELAY(days)</td>
<td>Ground water delay time</td>
<td>0-1000</td>
<td>31</td>
<td>0</td>
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<tr>
<td>ALPHA_BF(days)</td>
<td>Base flow travel time</td>
<td>0-1</td>
<td>0.048</td>
<td>0.8</td>
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<tr>
<td>RCHRG_DP(fraction)</td>
<td>Deep aquifer percolation fraction</td>
<td>0-1</td>
<td>0.05</td>
<td>0.3</td>
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<tr>
<td>GWQMIN (mm)</td>
<td>Threshold depth of water in the shallow aquifer required for return flow</td>
<td>0-1000</td>
<td>1000</td>
<td>400</td>
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<tr>
<td>GW_REVAP</td>
<td>Ground water revap coefficient</td>
<td>0.02-0.2</td>
<td>0.2</td>
<td>0.2</td>
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<tr>
<td>REVAPMN (mm)</td>
<td>Threshold depth of water in the shallow aquifer for revap to occur</td>
<td>0-1000</td>
<td>750</td>
<td>1000</td>
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<td>CN2</td>
<td>Initial SCS runoff curve number for moisture condition</td>
<td>35-98</td>
<td>72-74-77-83-85-87</td>
<td>36-45-54</td>
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<tr>
<td>Sol_Z(mm)</td>
<td>Depth from soil surface to bottom layer</td>
<td>0-3500</td>
<td>300-600-900</td>
<td>150</td>
</tr>
<tr>
<td>Sol_AWC(mm/mm)</td>
<td>Available water capacity of the soil layer</td>
<td>0-1</td>
<td>0.38-0.41-0.42-0.44-0.48</td>
<td>0.2-0.3-0.4</td>
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<tr>
<td>SOL_K (mm/hr)</td>
<td>Saturated hydraulic conductivity</td>
<td>0-2000</td>
<td>36-136-236-336-360</td>
<td>2.2-2.6-3.6</td>
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<tr>
<td>CH-K2 (mm/hr)</td>
<td>Effective hydraulic conductivity in tributary channel alluvium</td>
<td>-0.01-0.150</td>
<td>0</td>
<td>5</td>
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</tbody>
</table>
Calibration results:

\[ f(x) = 1.22x - 0.03 \]

\[ R^2 = 0.95 \]

Monthly observed flow (m$^3$/s)

- Jul-14
- Oct-14
- Jan-15
- Apr-15
- Jul-15
- Oct-15
- Jan-16

Simulated flow

Daily Statistics of Goodness of Fit:

- Nash-Sutcliffe Efficiency:
  - NSE: 0.53
  - >0.5

- Percent Bias:
  - PBIAS: -15.5
  - 25%

- RMSE Standard Deviation Error:
  - RSR: 0.75
  - <0.7

- RMSE/STDEV: 15.5

- Date:
  - 2014-07
  - 2015-01
  - 2015-07
  - 2016-01

- Flow (m$^3$/s)
<table>
<thead>
<tr>
<th>RCM institution name</th>
<th>RCM institution acronym</th>
<th>RCM model name</th>
<th>GCM model name</th>
<th>GCM Institution Acronym</th>
<th>Abbreviation</th>
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CC models flow simulation results
The **Range of Variability Approach (RVA)** compares the variation in the IHA parameters from the pre-impact period to the variation in the post-impact period (or reference vs. alternative scenarios) to determine the extent of the changes. Each IHA parameter is analyzed to determine the frequency with which it falls into one of three RVA categories (Low, Middle, High), as defined by the RVA Category Boundaries. RVA requires at least two years of pre-impact data.
Low and high flow indicators

• **Quantiles of flow**

The Quantile of flow is defined as the flow value, which exceeds a specific time interval (i.e. 90 % 95). Q90 and Q95 are defined as discharges that exceeded 90% and 95% of the time, respectively, over the full duration of record at each measurement location. For example the 95 percentile of flow or Q95, the flow that is exceeded for 95% of the period of record. They represent warning levels and limiting conditions (Q90) as well as the bases for biological and ecological indices (Q95) and for limits for surface- and effluent discharges.
High flow indicators

• Flow Exceedance Probability
Temporal regime plot - SMIRES toolset
RCP45
Groundwater predominantly contributes to the drinking water supply and surface water to irrigation needs in Lesvos. However, increasing demand for water in irrigation and industrial application has led to the displacement of previously sustainable practices in water consumption. Furthermore, although the potential for reclaiming water from wastewater exists in the Aegean, current water resource programs have failed to realize sustainability in their management by not integrating them into practice. Since 2015, the island of Lesvos have been used as a popular gateway for migrant crossing into the European Union creating additional pressure on its resources. An essential issue in addition to that of water supply lies in the threat posed by the water quality deterioration through nutrients concentration and saltwater intrusion.
A significant decrease of the annual flow in the river of almost 40% during the next 100 years is predicted by the various CC scenarios. This phenomena can result in droughts, harming both the local agricultural, ecological system and the social-economic one.

**Soft and hard adaptation solutions**

Water retention measures have to be taken such as the construction of a reservoir to store water and nature based solutions to prevent from flood phenomena. Meanwhile, there is the need of public consultation, in order to increase acceptability of water sources management solutions and incorporate public perspectives in planning and decision making.
Thank you