Use of HYPROM to assess the Moraca river water potential

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Integrated modelling system

**Atmosphere:**
NMM E non-hydrostatic model

**Land:**
NOAH land surface model

**Hydrology:**
HYPROM 2D – surface runoff
HYPROM 1D – river routing

**DATASETS:**
HYDRO1k USGS topography
FAO soil texture data
USGS land use data
**HYdrology PROgnostic Model**

**Governing equations:**

\[
\begin{align*}
\frac{\partial u}{\partial t} &+ u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + g \left[ \frac{\partial h}{\partial x} + S_{fx} - S_{0,x} \right] = 0 \\
\frac{\partial v}{\partial t} &+ u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + g \left[ \frac{\partial h}{\partial y} + S_{fy} - S_{0,y} \right] = 0 \\
\frac{\partial h}{\partial t} &+ \frac{\partial (hu)}{\partial x} + \frac{\partial (hv)}{\partial y} + H = 0
\end{align*}
\]

- Dynamically treatment of an overland flow (NO kinematic approximation!)
- Numerically stable implicit time scheme for the friction term
- New numerical technique for preventing grid decoupling noise
- Suitable for long term and flash flood simulations
- Computationally efficient

NOAH Land Surface Model

Liquid water content forecast: Darcy’s Law

\[
\frac{\partial W_l}{\partial t} = \frac{\partial}{\partial z} \left( K_w \frac{\partial W_l}{\partial z} + \gamma_w \right) + R_{ex}
\]

**diffusivity**

\[
K_w = K_{ws} \left( \frac{W_l}{W_s} \right)^{b+2}
\]

**conductivity**

\[
\gamma_w = \gamma_{ws} \left( \frac{W_l}{W_s} \right)^{2b+3}
\]

- \(K_{ws}\) saturated diffusivity
- \(\gamma_{ws}\) saturated conductivity
- \(W_s\) porosity (max. soil moisture content)
- \(b\) Clapp-Horneberger constant
The Moraca river (Montenegro)

Moraca basin: 3200 km²
Podgorica sub-basin: 2600 km²

Heavy rain event on 5th Feb. 2003
Surface runoff and streamlines valid at: 052005FEB2003

Surface runoff and streamlines valid at: 072005FEB2003
Water budget components (NMM E)
six months accumulations: November 2002 – April 2003
Sensitivity to soil type

<table>
<thead>
<tr>
<th>parameter</th>
<th>Clay Loam (09)</th>
<th>Bedrock (15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sat. diffusivity</td>
<td>$0.113 \times 10^{-4}$</td>
<td>$0.136 \times 10^{-3}$</td>
</tr>
<tr>
<td>sat. conductivity</td>
<td>$2.45 \times 10^{-6}$</td>
<td>$1.41 \times 10^{-4}$</td>
</tr>
<tr>
<td>porosity</td>
<td>0.465</td>
<td>0.20</td>
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<tr>
<td>CH constant</td>
<td>8.17</td>
<td>2.79</td>
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</table>
The Moraca river discharge – Podgorica sub-basin

**case 2003**

**model vs. observations discharge 2003**

<table>
<thead>
<tr>
<th>BIAS</th>
<th>MAE</th>
<th>RMSE</th>
<th>CC</th>
<th>FEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.43</td>
<td>35.48</td>
<td>55.48</td>
<td>0.94</td>
<td>0.87</td>
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</tbody>
</table>
case 2008

water budget components
2008 accumulations

- precipitation
- surface runoff
- base runoff
- evapotranspiration
- snow melt

model vs. observations discharge 2008

- HYPROM
- Podgorica station

Days vs. discharge (m³/s)
Instead of the conclusions – future work

HYPROM + NCEP’s NMM-B

large river basins

climate studies

Hyprom NCEP's NMM-B

Dynamical ground water flow

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