Modelling human interventions in the Rhine basin using the hydrological model SIMGRO

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Contents

• Introduction
  framework of the study
• Simgro model application to the Rhine basin
  Climate and land use scenarios
• Adaptation measures
• Conclusions
Objective of the study

• How does a physical based hydrological model perform for a basin as the Rhine (snow module)
• Quantify the effect of land use and climate change on river flows
• What are the changes on droughts or low flows
Hydrological model SIMGRO

- Subcatchment boundary
- Sprinkling from surface water
- Supply capacity
- Aquitard
- 1st Aquifer
- 2nd Aquifer
- Aquitard
- Hydrological base
- Surface runoff
- Land use
- Root zone
- Subsurface irrigation or drainage
- Sprinkling from groundwater
- Capillary rise or percolation
- Public water supply
- Phreatic level
- Node point finite element grid
Aim of model SIMGRO

- Physical based model
- For practical problems and hydrological research
Modelling the Rhine basin

Basin area: 160 000 km\(^2\)
Mainly Switzerland, Germany, France, Luxemburg, Belgium >> Netherlands

Finite element network:
5 x 5 km; 8144 cells

Surface water:
Larger rivers > 400 km\(^2\)
630 sub catchments

Groundwater:
data Rhine Commission (CHR)
Land use: CORINE
Soil map FAO
Surface water

Drainage network is derived from DTM (Voigt e.a., 2007)

Important for interaction between groundwater – surface water
Gauging stations

42 gauging stations used

Procedure to compare calculated-measured discharges in term of Nash-Sutcliffe model efficiency
Lobith – compare measured and calculated
<table>
<thead>
<tr>
<th>Location</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lobith</td>
<td>0.90</td>
</tr>
<tr>
<td>Main</td>
<td>0.74</td>
</tr>
<tr>
<td>Neckar</td>
<td>0.65</td>
</tr>
<tr>
<td>Moselle</td>
<td>0.79</td>
</tr>
<tr>
<td>Switzerland (5 stat)</td>
<td>0.30</td>
</tr>
<tr>
<td>Downstr. Switzerl. (13 stat)</td>
<td>0.79</td>
</tr>
</tbody>
</table>
Scenarios

• Land use change (extreme)
  
  all crops to grass \(\sim 33\%\) area changed
  
  all crops to forest

• Climate change

  scenarios from Dutch Meteorological Institute
  (standardized)
Climate scenarios for the Netherlands

- Moderate (G)
- Warm (W)
- Extreme scenario (G+ and W+)

Air circulation patterns:
- Changed
- Unchanged

Global temperature in 2050 compared to 1990:
- +1°C
- +2°C

Conform IPCC
## Climate scenarios: some details

<table>
<thead>
<tr>
<th>Global temperature rise</th>
<th>G</th>
<th>G+</th>
<th>W</th>
<th>W+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in air circulation patterns</td>
<td>+1°C</td>
<td>+1°C</td>
<td>+2°C</td>
<td>+2°C</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

| Winter^3 | average temperature | +0.9°C | +1.1°C | +1.8°C | +2.3°C |
|          | average precipitation amount | +4% | +7% | +7% | +14% |
| Summer^3 | average temperature | +0.9°C | +1.4°C | +1.7°C | +2.8°C |
|          | average precipitation amount | +3% | -10% | +6% | -19% |

| potential evaporation | +3% | +8% | +7% | +15% |
Lobith - Climate scenarios

Discharge (m³/s)

- Reference
- Threshold (1265 m³/s)
- Scenario G+
- Scenario W+

Lower than threshold:
- 88 days
- 139
- 153

Threshold (navigation, water use agric., etc)
Scenario – land use

Discharge (m$^3$/s)

- Reference
- Crop to Grass
- Crop to Forest

Lobith

% change from reference situation

year 1992

- Reference
- G+
- W+
- Crop > grass
- Crop > forest
Strategy to follow

Is it acceptation or adaptation

Note the mark on high water levels (Moselle)
In the past: use of flood levees

There is an end in raising dikes
Strategy: analysis concept

- Reduce floods and droughts
- Further implications of climate change

Reduced range is also favourable in terms of WFD
• Make use of the groundwater system (retain water in the ground)
  Before the wet season have enough storage cap. available to cope with peak flows
  After the wet period save water for the dry period

• Natural flood defenses
  The Ecoflood report gives guidelines on how to restore flood plains
Conclusions

- SIMGRO model: has the ability to model practical situations (scenarios like land use and climate change)

- Climate change has a much larger impact on discharges and droughts than extreme changes in land use

- Consider natural flood defence measures
Is this the challenge we are facing?

Is this Acceptation or Adaptation?
Thank you