Flood forecasting with uncertainty using a fully automated flood model chain: A case study for the City of Kulmbach

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Introduction/Motivation

Floods in Heinsberg, Germany, 22 May 2018. Photo: Feuerwehr Gangelt via Twitter

Floods in San Polo, Tuscany, Italy, 08 May 2018. Photo: Region of Tuscany Government

Disruption traffic

Disruption navigable waterways

Disruption City’s services...

Sewer Overflows...

Early Warning Systems

Swollen Seine river, Paris, January 2018. Photo: Julien Colin
Flood forecasting

- Bayerisches Landesamt für Umwelt
  - Flood Forecast Center

- Predicting High discharges (statistical approach)
Methodology: Flood forecasting

- Forecast flood discharges
- Forecast 2D flood extents
- Include uncertainty
- Automatic calibration

FloodEvac Tool
Methodology: Flood forecasting
Methodology: Flood forecasting

- Forecast flood discharges
- Include uncertainty
- Model Parameter
- Rainfall

FloodEvac Tool

Operational Modus

Hindcast
Methodology: Flood forecasting

- Checks observed or forecasted rainfall data
- Distribute the data within the whole catchment area considering **sequential conditional geospatial simulation**.
- Spatial resolution of 1 km x 1 km. (whole catchment as 4000 km²)

*Include uncertainty*

- **Rainfall**
  - \( P_1 \)
  - \( P_2 \)
  - \( \ldots \)
  - \( P_m \)
Methodology: Flood forecasting

- Sensitivity analysis on the parameters
- 8 out of 34 are selected
- Monte Carlo for generation of ensemble of models
- LARSIM Model from Flood Forecast Center – LFU

Include uncertainty

Model Parameter

Rainfall
Methodology: Flood forecasting

- forecast flood discharges
- Include uncertainty

FloodEvac Tool
Methodology: Flood forecasting

FloodEvac Tool

**Operational Modus**

**Inclue uncertainty**

**Forecast flood discharges**

**Hindcast**

<table>
<thead>
<tr>
<th>MP</th>
<th>P₁.MP₁</th>
<th>P₁.MP₂</th>
<th>...</th>
<th>P₁.MPₖ</th>
<th>P₂.MPₖ₊₁</th>
<th>P₂.MPₖ₊₂</th>
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<th>Pₘ.MPₙ</th>
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</table>
Methodology: Flood forecasting

- one year warm-up period
- forecast is repeated every hour, length of 12 hours
- 50 MP (parameter sets) and 10 P (rainfall sets)
- 25 minutes (3 core desktop in parallel)
Case study: Upper Main catchment, Kulmbach

- Germany, Bavaria
- Area = 4244 km$^2$
- December, 2012
- January, 2011
- January, 2012
Results: flood forecasting Dec-2012
Results: flood forecasting Dec-2012
Methodology extension

\[ \Delta Q \]

\begin{align*}
Q_1 & \quad Q_2 \\
Q_3 & \quad Q_4 \\
\Delta Q & \\
t &
\end{align*}

<table>
<thead>
<tr>
<th>∆Q</th>
<th>up</th>
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<tbody>
<tr>
<td>0-Q_1</td>
<td>MP_2</td>
<td>MP_{10}</td>
</tr>
<tr>
<td>Q_1-Q_2</td>
<td>MP_1</td>
<td>MP_{10}</td>
</tr>
<tr>
<td>Q_3-Q_4</td>
<td>MP_5</td>
<td>MP_2</td>
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Chair of Hydrology and River Basin Management
Prof. Dr.-Ing. Markus Disse
TUM Department of Civil, Geo and Environmental Engineering
Technical University of Munich
Validation: Event 1 Dec-2012

Forecast for station Ködnitz

Date and Time

Dec 12  Dec 13  Dec 14  2012

Q (m3/s)

0  20  40  60  80  100  120

Observed Data

Date and Time

Dec 12  Dec 13  Dec 14  2012

Q (m3/s)

0  20  40  60  80  100  120

Observed Data
Validation: Event 2 Jan-2011
Validation: Event 3 Jan-2012
Conclusions

• Flood forecasting with uncertainty using a fully automated flood model chain: FloodEvac tool
• A case study: City of Kulmbach
• Possible to reduce the uncertainty band in the forecasts
• Possible to improve computational time
• Validated in 3 Events
Acknowledgement

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Thank for your attention!