Simulating the Impact of the 2003 Flood Event of the Rhone River on the Gulf of Lions, France

Albert J. Kettner 1,2, Eric W.H. Hutton 1 and James P.M. Syvitski 1

1 Environmental Computation and Imaging Group, Institute of Arctic and Alpine Research (INSTAAR), University of Colorado, Boulder, USA.
2 Department of Applied Earth Sciences, Delft University of Technology, Delft, The Netherlands.

Kettner@colorado.edu

Outline

This project is part of the EuroSTRAFORM and has two key objectives: 1) Modeling the routing of water and sediment into the Gulf of Lions; 2) Determine the impact of changes in climate since the Last Glacial Maximum and the impact of humans for the Rhone River (figure 1).

Rhone flood background

To determine the short-term climate impact on the routing of water and sediment the December 2003 Rhone flood was chosen to simulate. The consequence of the heavy rainfall was that the flooding was characterized by a sudden, large increase in discharge. In less than 30 hours discharge increased from 2,400 m³/s to 10,000 m³/s in Beaucaire. All the Rhone’s tributaries downstream of Lyon suffered flooding (Figure 2). The peak discharge of this flood was 13,000 m³/s (return period of 100 - 350yrs), which was caused by an already saturated ground by autumn rain and 48 hours of heavy rainfall in the south of the Rhone River basin, locally up to 500mm (Figure 2).

Applied Models

Two models are applied to simulate: 1) river discharge and sediment flux on a day by day basis, 2) the routing of water and sediment into the Gulf of Lions.

SedFlux3D is a 3-dimensional process-based stratigraphic model. The model distributes the loads (before and after major damming of the river) are similar as described in literature. 2003 storm simulation

HydroTrend was adjusted to simulate single storm events (figure 5). Measurements of sediment load are during storm events hardly possible. However, relatively short storm event carry the bulk of the annual sediment load to the ocean. Models are indispensable to get a better understanding of the magnitude of the impact on the strata formation (figure 6).

Plume deposition was modeled with SedFlux3D. In these initial runs we impose a current velocity of 0.2 - 0.5 m/s. No wave refraction or long-shore transport was taking into account.

Conclusions

HydroTrend is able to simulate 100yrs mean monthly discharge accurately ($R^2 = 0.99$) compared to observed data. Using real time climate data, HydroTrend is able to predict discharge, even for the peak flood which was not possible to measure (figure 5).

Simulations show how important flood events are in terms of the impact of strata formation. 42% of the annual sediment load (2.8 Mt) and 12% of the bedload (0.06 Mt) was moved to the ocean during the 10days storm event (Table 2).

Based on the simulated fluvial sediment flux, SedFlux3D is able to simulate the same plume dimensions (figure 8) as observed from satellite images (figure 7).

SedFlux3D predicts that the 2003 single storm event shows a plume that reaches a maximum width of 10 km.

Over 90% of the sediment is deposited within 10 km of the river mouth and has a maximum thickness of 29 cm.

References


Table 1. Rhone River characteristics

<table>
<thead>
<tr>
<th>River Length</th>
<th>Drainage basin area</th>
<th>Relief</th>
<th>Average annual precipitation</th>
<th>Trapping efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>(km)</td>
<td>(km²)</td>
<td>(m)</td>
<td>(mm)</td>
<td>(%)</td>
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<tr>
<td>812</td>
<td>95,000</td>
<td>4,800</td>
<td>920</td>
<td>78</td>
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</tbody>
</table>

Table 2. Rhone River simulation results

<table>
<thead>
<tr>
<th>100yr simulation</th>
<th>Observed</th>
<th>Modeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long term average discharge (m³/s)</td>
<td>1708</td>
<td>1718</td>
</tr>
<tr>
<td>100 yr peak flood (m³/s)</td>
<td>11,200</td>
<td>12,600</td>
</tr>
<tr>
<td>Average suspended sediment load before major dams (Mt/yr)</td>
<td>22.31</td>
<td>29.8</td>
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<tr>
<td>Average suspended sediment load after major dams (Mt/yr)</td>
<td>7.4</td>
<td>6.5</td>
</tr>
<tr>
<td>Average bedload (Mt/yr)</td>
<td>---</td>
<td>0.6</td>
</tr>
</tbody>
</table>

2003 STORM simulation

(100-350yrs) Peak flood at Beaucaire (m³/s) 13,000 | 13,353 |
Total suspended sediment load (Mt/10days) | --- | 2.8 |
Total bedload (Mt/10days) | --- | 0.06 |