Hydrological challenges in the Rhine- and Meuse basins

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Introduction

Society is facing more and more socio-economic problems as result of flood occurrences in western Europe. One of the world's largest re-insurance companies, Munich Re, describes in its Annual Review of Natural Catastrophe 2002 that floods account for 30% of all loss events and 42% of all fatalities due to natural catastrophes in 2002 (Munich Re, 2003). The total economic loss by floods was estimated at US$ 27 bn in that year. Furthermore, Munich Re (2003) ranked Rotterdam-Amsterdam (Randstad) metropolis in the hazard index at position 18 of the 50 megacities in the world. Although this is a first attempt to index hazard risk of metropolis, and in case of the Randstad the hazard is based on flood and wind, it shows that there is a major economic and societal risk, partly induced by floods.

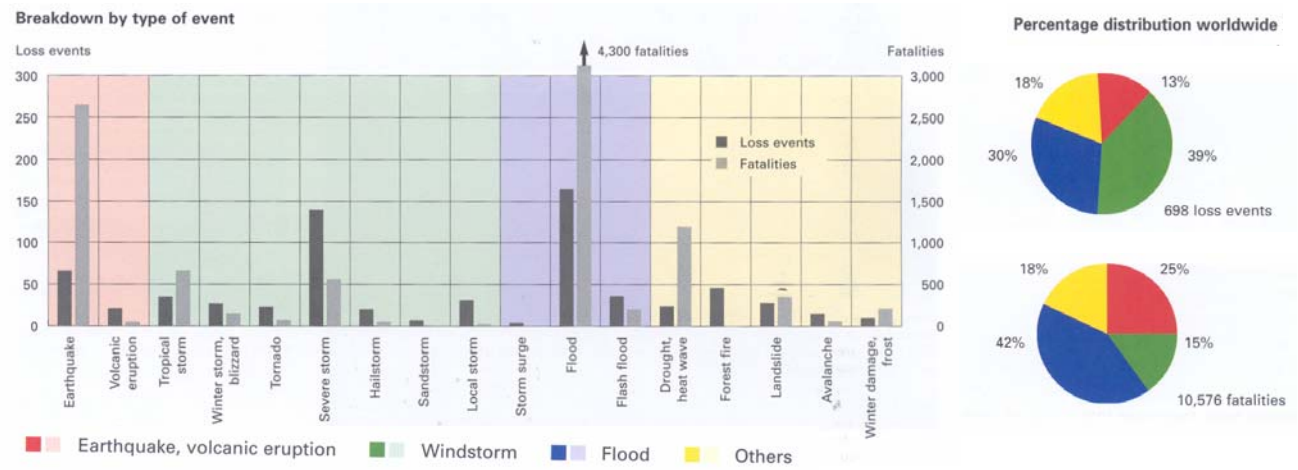


Figure 1: Statistics of natural hazards in 2002, according to the Munich Re (2003).

NCR initiatives: 'Hydrological Triangle' and 'Genesis of Flood' theme

For Dutch water management, knowledge of the hydrological processes in the Rhine and Meuse basins upstream of the Netherlands is essential. Both for flood forecasting as for long term spatial planning. In 2003 at least two reconnaissance of hydrological research were made and published; the Dutch 'foresight committee on Hydrology' (KNAW 2003) and Geosciences, the future (IUGG 2003). Both reports were written after several discussions and meetings. Although different from set-up both reports come up with similar scientific bottlenecks and challenges for hydrology: 1) incomplete understanding of the hydrological processes; 2) incomplete theory and data sets for modelling; 3) data integration and model calibration; 4) scale issues.

The NCR has stimulated two initiatives. First of all, a NCR hydrological working group (Hydrological Triangle) was initiated by RIZA in order to stimulate and tune the hydrological research in the Rhine and Meuse basins within the Netherlands. A number of Dutch universities, technical institutes, and governmental institutes participate in this working group. Main aims of the group are to bring together skills, knowledge and man-power of different research groups and stimulate data-sharing and collaboration and define those research questions that are both relevant for water management and challenging for scientists.

Furthermore, NCR defined the 'Genesis of Floods' theme which aims at studying the genesis of floods, or more broadly, discharge generation in upstream areas. The 'Genesis of Flood' theme now resides under the Hydrological Triangle. The overall objective of 'Genesis of Floods' is to improve our understanding of the spatial and temporal controls of discharge generation under changing

hydrometeorological behaviour and land use management. The research questions have been grouped into: i) discharge forecasting, ii) determination of design discharge, iii) influence of climate change, and iv) influence of land use change. Some examples will be given of ongoing projects on these topics. Besides some research topics will be listed that have potential for further joint study.

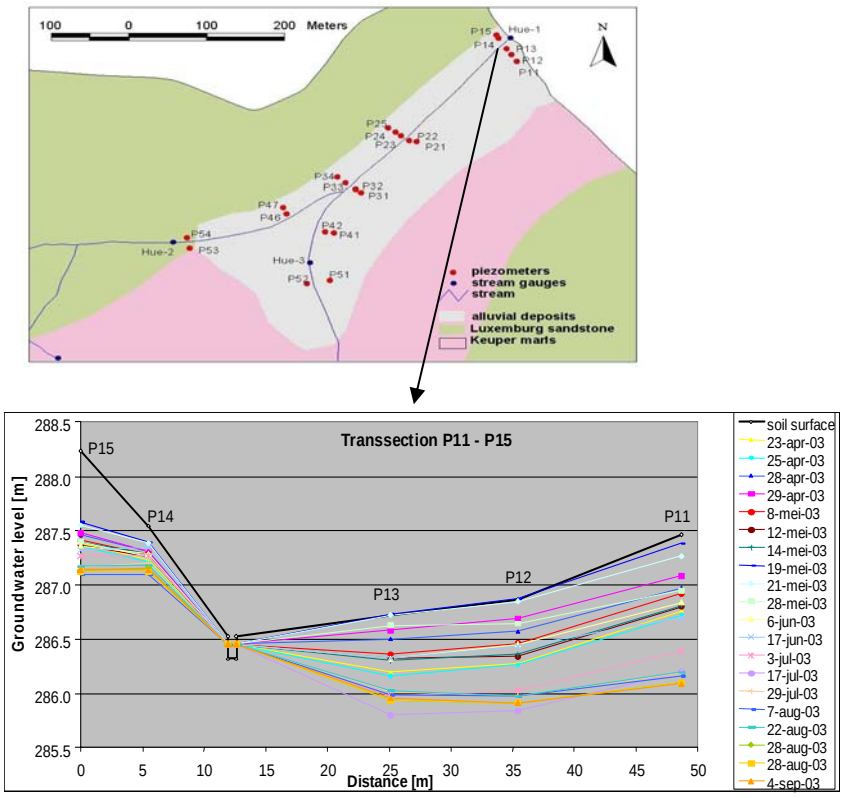
Examples

It is generally accepted that continuation of the engineering approach of controlling the natural river system is not sustainable. More and more it is discussed that river systems should get more room to allow for their natural behaviour. The reasoning is that a river stream can (temporarily) store more water and diminishes flood related problems along a river. Besides storage of discharge in the river system itself, the discussion also focuses on retardation of rainfall in the upstream area of the river catchments. Land use has changed enormously during the last century, especially with urbanisation and an intensification of agriculture and forestry. The overall believe is that these activities result in an accelerated drainage of the upstream areas. The WWF has initiated a discussion on combining nature restoration and water storage with their report 'Mountains of water' (WWF, 2000). This 'enhancing the natural sponginess of river basins' could provide an enjoyable network of rivers, water and nature, solve floods and droughts and stimulate business in tourism and recreation. As the public was told that deforestation, soil drainage, and sealing of surfaces was the cause for the increased flood frequency and magnitude, why should doing the reversed not have the opposite effect?

However, the Munich Re (2003) report is very clear about the effects of river restoration: *River restoration measures make sense and are very welcome; but their effectiveness in extreme cases is often overestimated or misrepresented. As a rule, they are incapable of preventing really catastrophic floods and in many cases will not even bring about any significant reduction. The volumes of water that amass in extreme events are simply too huge.*

De Wit et al. (2003) focused on the Meuse and discussed the limited effects of reforestation, re-meandering, increased inundation of floodplains, nature recovery and uncontrolled retention on the peak discharge of the Meuse at Borgharen.

But this is all based on the extreme events, when storage is already or otherwise quickly used. What are the effects of the proposed measures on floods of lower return periods and lower magnitudes? It is challenging to try to quantify in what cases the water storage could be beneficial for flood prevention, or to quantify the criticism on the WWF report.



In the field of process knowledge the challenges are to be found in the temporal and spatial dynamics of soil moisture and the interaction between the hydrological cycle and terrestrial ecosystems. Another research item is the quantification of groundwater effects on discharge generation in the Ardennes. An example of this research is given in Figure 2. Here one sees the groundwater dynamics in only 6 months of a small catchment in Luxemburg.

Figure 2: Fluctuation of piezometric level Huelerbach catchment Apr 2003 - Sep. 2003

Challenging new model concepts like there are the Hillslope-storage Boussinesq formulation and the Representative Elementary Watershed concept are brought forward in the last few years that also describe the questions of water storage and water flow, but tackle the problems with the Richards equation based, distributed, models.

On the operational side of the discharge forecast there is a clear trend from modelling towards data processing: from point data towards spatial time series and from one forecast towards several forecasts and uncertainty. This is a logical trend, more and more attention should be given to all available data sources. This asks for powerful data assimilation tools to integrate observations and model predictions. Also the post-processing needs attention as model outputs shifts from one output towards output ensembles which should lead to insight and quantification of the uncertainty of the model results.

The scale issues relate to all hydrological sciences and include the research of dominant processes and interaction between processes that occur at different spatial scales. How to come from process knowledge to a flood forecasting?

In the above, the NCR initiatives of the Hydrological Triangle and Genesis of Flood were presented and discussed. The overall aim is bring together skills, knowledge and man-power of different research groups and stimulate data-sharing and collaboration and define those research questions that are both relevant for water management and challenging for scientists. The objectives of the NCR theme Genesis of Floods fit perfectly within this network. The meetings that were organised by the Hydrological Triangle can already be called a success. Different research groups were brought together and different research topics have been addressed and discussed. Initiatives have seen daylight like a field excursion to the Ardennes to look for collaborative field research site in the framework of the Genesis of Flood theme. For further information the reader is referred to the authors or to the NCR web page: http://www.ncr-web.org

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