Improvement of the resilience of the City of Luebeck to heavy rainfall: the RainAhead project

Amélioration de la résilience de la ville de Luebeck à des pluies importantes : le projet RainAhead

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RÉSUMÉ

Des pluies importantes peuvent, à un niveau local, engendrer de graves dégâts consécutifs à des inondations. Le Ministère Fédéral Allemand de l'Environnement a attribué une subvention au projet RainAhead ayant comme objectif la réduction des risques d'inondation en cas de fortes pluies affectant la ville de Luebeck. L'outil principal est un outil web qui facilite, d'une part, la planification de mesures de protection contre les inondations pluviales en ville et, d'autre part, donne des alertes de pluie aux pompiers. Dans le cadre de ce projet, le changement climatique est pris en compte dans les pluies de projet. Celles-ci sont utilisées comme base de modélisation, et donc pour la détermination de mesures protectrices contre des inondations. Le module d'alerte est basé sur l'expérience historique des pompiers, les résultats de modèles de ruissellement et d'assainissement, et sur la situation météorologique actuelle. Le système d'alerte a été mis en place en Mai 2015 et sa performance a été évaluée.

ABSTRACT

Heavy rainfall events can cause severe damage on a local scale due to urban flash floods. The project RainAhead, funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, was conceived to reduce potential risks caused by urban flash floods for the city of Luebeck. The project's main objective was to develop a planning and warning tool to improve flood damage mitigation and the emergency service's effectiveness. The project included an assessment of potential climate change impacts concerning heavy rainfall. The warning tool combined emergency service experiences, modelling results and the current weather situation and issued real-time warnings for urban quarters that would be subject to flooding. The warning system was implemented in May 2015 and has been evaluated since.

KEYWORDS

Heavy Rainfall, Urban Flooding, Hydrodynamic modelling, Urban planning, Warning system

1 INTRODUCTION

The City of Luebeck had to manage several heavy rainfall events in the past (e.g. 2001, 2002 and 2011). The project RainAhead (Integrated planning and warning tool for heavy rain in urban areas, www.rainahead.de) was designed to mitigate flood damage and reduce potential risks due to climate change in the City of Luebeck. The main objective was to identify locations prone to urban flash floods and to use this information for improvement of urban planning as well as flash flood emergency warning. Together with the project partners - hydro & meteo GmbH & Co. KG, Luebeck University of Applied Sciences and the Hanseatic City of Luebeck - further parties involved such as the fire brigade, the municipal service for waste and wastewater, urban planning and citizens were working on innovative, transparent and sustainable practices. The project will be completed in May 2016.

2 METHODS

2.1 Concept

Within RainAhead a tool for urban planning and warning related to heavy rain events for local communities based on a vulnerability analysis was developed. The resulting map comprised areas, objects, natural resources or dangerous goods susceptible to urban flooding. The warning tool combined those known vulnerable areas with short-term forecast precipitation information provided by weather radar.

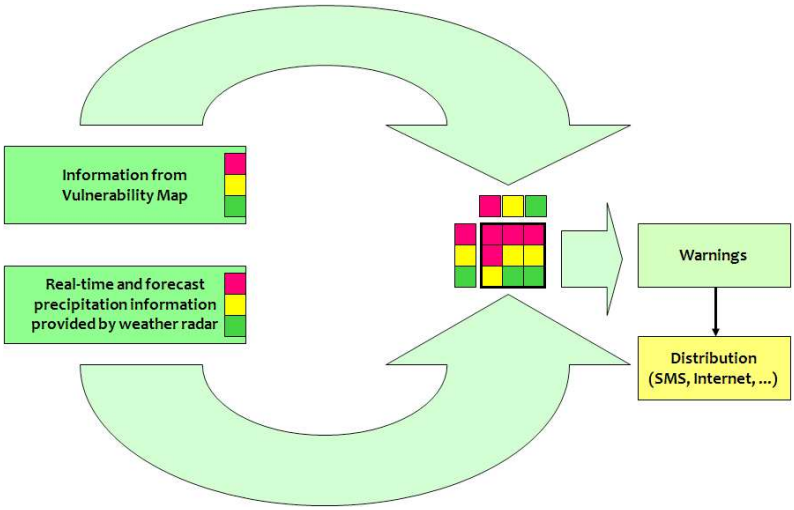

Figure 1. The warning tool: basic design.

Additionally, a planning tool proposed measures for urban planning in order to mitigate flood damage. The decision-making process was accompanied by a multi-day workshop with different stakeholders. To reduce information overload and include opinions of all participants, a sensitivity model (sensitivity model by Prof. Vester®) was used to help analyse complex issues during the process (Ulrich, 2005). During the workshop, the question “How can negative impacts of heavy rain events be reduced in St. Lorenz Sued?” was discussed to get an overall picture of the current state and to develop the most appropriate measures for flood protection. The methodology was applied to two districts. A detailed analysis was conducted in St. Lorenz Sued district and validated in the “University district” of Luebeck.

2.2 Pragmatic approach

An analysis of fire brigade operations of the Luebeck city fire brigade as function of rainfall amounts was conducted. For this, radar data between 2009 and 2014 were screened and compared to emergency operations with a water-related keyword. Overall, 174 emergency operations took place at different locations of the city during 22 rainfall events. In order to have a basic data volume, events with only one action in one area were skipped from the data base, resulting in 163 operations during 15 rainfall events. Of these, 137 operations took place during 3 events in 2008 and 2011. Those were taken as investigation data base.

Since the different locations within the city show a different response profile to rainfall, a spatially varying assessment of rainfall response was required to be developed for those areas with a sufficient

data base at hand. For the remaining areas, a summary approach was carried out. As a result, a “typical duration” of 20 minutes was determined, and rainfall thresholds ranging between 13 mm and 18 mm for the investigated areas, representing return periods between 3.3 years and 10 years. The latter value corresponds well with a previous analysis (Einfalt et al., 2012), whereas the former value has to be used for an area which is known to be sensitive to heavy rainfall.

Therefore, the warning system based on the web-based HydroNET-SCOUT platform (Behnken et al., 2013) and the nowcasting module within SCOUT (Tessendorf and Einfalt, 2011) was prepared for the area of the city of Luebeck (Figure 2), producing an email alert for the fire brigade. The change rate for a possible alert is every 5 minutes.

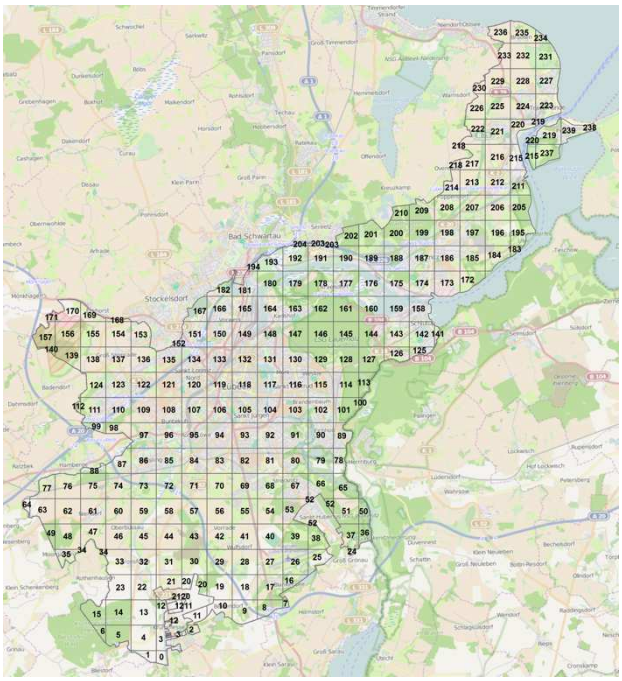

Figure 2. The warning system: pixels covering the city of Luebeck..

3 RESULTS

3.1 Warning system

After a heavy precipitation event, the warning system was made operational in May 2015.

In the course of summer 2015, overall 10 warnings were produced – none of them was during catastrophic rainfall. The analysis of the false alarms revealed that too high forecast values were produced due to

- an overestimation of growth effects of the observed rain cells.
- “hopping values”, i.e. the forecast time step of 5 minutes produced overestimations at peak points and underestimations between peaks due to the instantaneous character of radar images.

While the first effect was quickly eliminated in the SCOUT precipitation data software, the second one needs more fundamental software extensions and will be ready for the 2016 summer period. In the meantime, the warning thresholds were raised by approximately 30% to improve warning system reliability.

3.2 Planning module: evaluation of planning

The planning module includes analyses on sensitivity to heavy precipitation and on discrepancies between original planning and final result after construction for two pilot areas in Luebeck: St. Lorenz-Sued and Hochschulstadtteil. Both areas were simulated with a hydrodynamic sewer model (MIKE Urban), coupled with a two-dimensional surface flow model (MIKE21). The rainfall input also included climate change scenarios produced from downscaling of regional climate model results (BASt, 2014). Results yielded a detailed view on areas prone to flooding which then could be compared to other geographical information e.g. on the location of schools and hospitals, but also on oil tanks and other

potentially dangerous installations.

The analysis showed that there is room for improvement of the current status in both pilot areas. In particular, potentially flooded areas can be protected by low cost measures – if the danger is known to the responsible persons or institutions.

3.3 Other effects

In late 2015 and based on the experience with the use of the web-based detailed precipitation information in HydroNET-SCOUT, the city of Luebeck commissioned a study on the connection between heavy rainfall and bathing water pollution for the municipal bathing locations. The objective was the feasibility of a warning based on precipitation information. Results show locally varying effects and also a mix of different contributing influences to pollution cases. Conclusions will be drawn in early 2016.

4 CONCLUSIONS

The project RainAhead is part of Luebeck's adaptation initiative to climate change. The attention of the municipal administration for the project is high, but some administrational obstacles for a smooth data exchange persist. The project is tailored for practical use in municipal routine processes and can contribute to bridging the gap between urban planning and urban water management.

The warning system within the HydroNET-SCOUT implementation has proven to be operationally functional and reliable. The forecast procedure will be extended to produce smooth forecasts from 2016 onwards.

The planning module results will result in structural changes for some locations in the pilot areas.

As the methodological approach is easily transferable to other communities, an implementation in other cities' administration and emergency management is envisaged.

ACKNOWLEDGEMENT

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