Urban RoGeR: Merging process-based high-resolution flash flood model for urban areas with long-term water balance predictions

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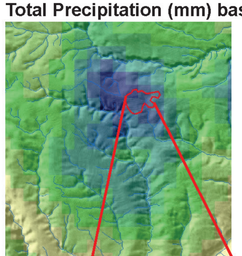
Background and Approach

Heavy rain induced flash floods are still a serious hazard and generate high damages in urban areas. In particular in the spatially complex urban areas, the temporal and spatial pattern of runoff generation processes at a wide spatial range during extreme rainfall events need to be predicted including the specific effects of green infrastructure and urban forests.
The initial conditions (soil moisture pattern, water storage of green infrastructure) and the effect of lateral redistribution of water (run-on effects and re-infiltration) have to be included in order realistically predict flash flood generation. We further developed the distributed, process-based model RoGeR (Runoff Generation Research) to include the relevant features and processes in urban areas in order to test the effects of different settings, initial conditions and the lateral redistribution of water on the predicted flood response.

Flash Flood Modelling

The model framework was applied to several case studies in Southern Germany where intense rainfall events produced flash floods causing high damage. The case of the township of Bonndorf is shown as an example, showing the overall modelling extend, the detailed dynamic modelling of surface runoff including reinfiltartion during an extreme rainfall event (Return intervall = 200-500 years).
The simulations shows the relevance of re-infiltration of surface runoff from areas with a low infiltration (lateral redistribution) and its effect of reducing the flood peaks by over 90% in certain areas and situations. In addition, we could reporduce the damage history for this event and can use the model to evaluate certain measures to reduce damages in the future.

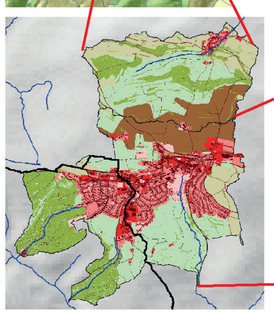
Total Precipitation (mm) based on Radar

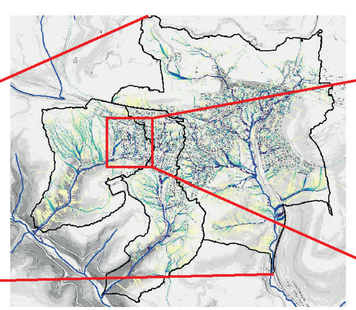


0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90

Land cover and land use

Land use	Degree of sealing [%]
Pasture	1 - 20
Coniferous forest	21 - 40
Mixed forest	41 - 60
Water	61 - 80
Crop land	81 - 100

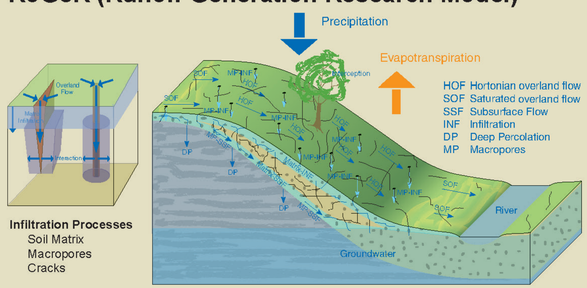




Water Balance and Green Infrasturcture

The model framework was also applied to the long-term research catchment in an urban setting (Vauban, Freiburg), where a variety of green infrastructures dominates the hydrology and modifies the water balance and runoff generation processes. We have observed the different structures and different water balance components in this experimental watershed since 2010. The long-term observations allowed us to apply Urban-RoGeR to a variety of situation and settings and also to develop a web-base interface (FraWaB), allowing the user to assess the influence of different green infrastructures on reducing flood peaks, but also its effect on the water balance components (evapotranspiration and groundwater recharge).

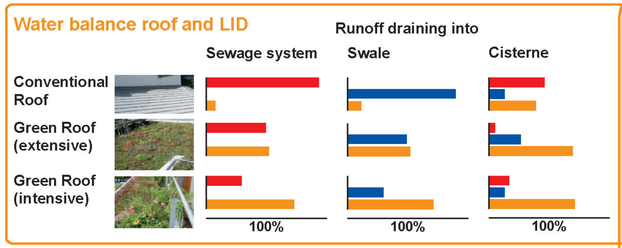
RoGeR (Runoff Generation Research Model)



Infiltration Processes
Soil Matrix
Macropores
Cracks

The uncalibrated model RoGeR runs at a spatial resolution of 1*1m² (LiDAR, degree of sealing, landuse), soil properties and geology (1:50.000). In addition, different green infrastructures are included into the model as well as the effect of trees on interception and transpiration. A hydraulic model was included into RoGeR to predict surface runoff, water redistribution, and re-infiltration. During rainfall events, RoGeR predicts at 5 min temporal resolution, but the model also simulates evapotranspiration and groundwater recharge during rain-free periods at a longer time step.

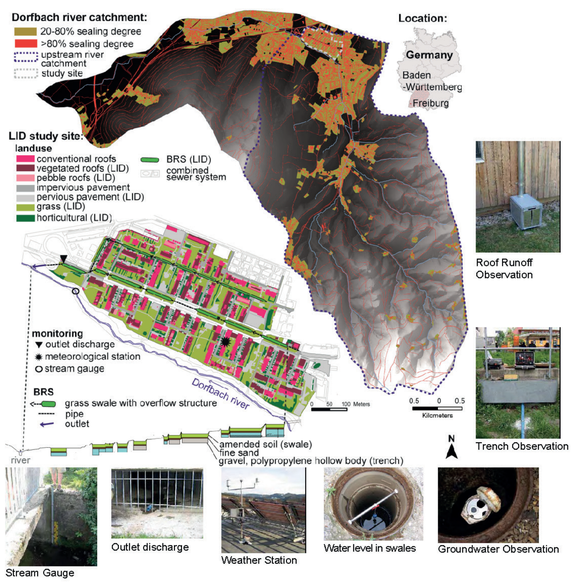
Water balance roof and LID



Precipitation =
Runoff into sewage +
Recharge +
Evapotranspiration

Water balance and runoff for property in Vauban

Long-term Urban Research Catchment Vauban



Roof Runoff Observation

Trench Observation

Stream Gauge

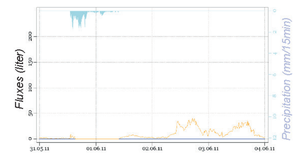
Outlet discharge

Weather Station

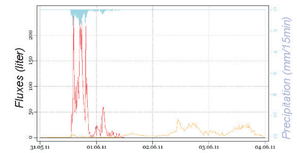
Water level in swales

Groundwater Observation

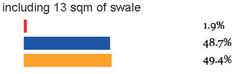
Reference Simulation
Lawn (grassland) above a loamy soil
Water balance between 26.2.2010 and 31.12.2012
Precipitation event (26 mm) from 31.05.- 04.06.2011

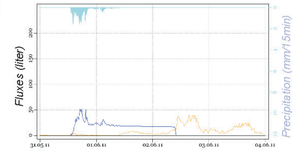


Conventional Infrastructure
1) Conventional roof draining into sewage system
2) Green roof draining into sewage system
3) Deciduous tree above lawn
4) Deciduous tree above impermeable pavement
5) Lawn

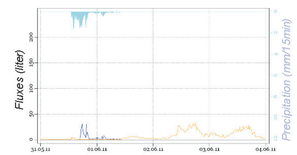


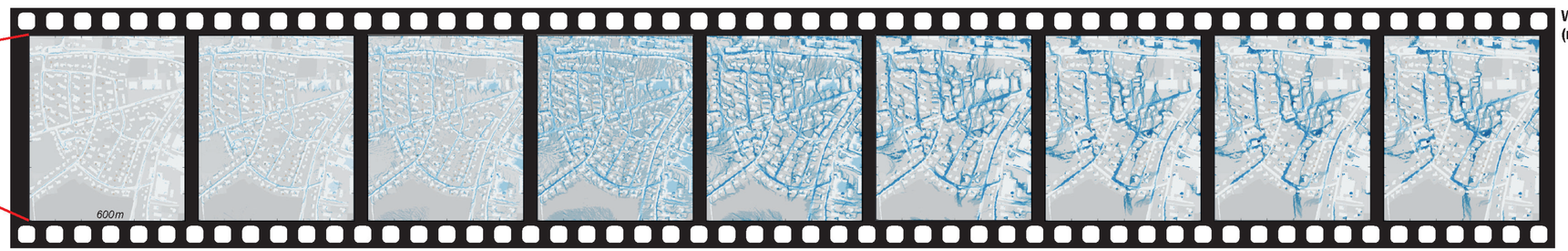
Conventional Infrastructure with swales
1) Conventional roof draining into swale
2) Green roof (intensive) draining into swale
3) Deciduous tree above lawn
4) Deciduous tree above permeable pavement
5) Lawn including 13 sqm of swale





LID Infrastructure with cistern
1) Conventional roof draining into cistern
2) Green roof (intensive) draining into cistern
3) Deciduous tree above lawn
4) Deciduous tree above green permeable pavement
5) Lawn





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