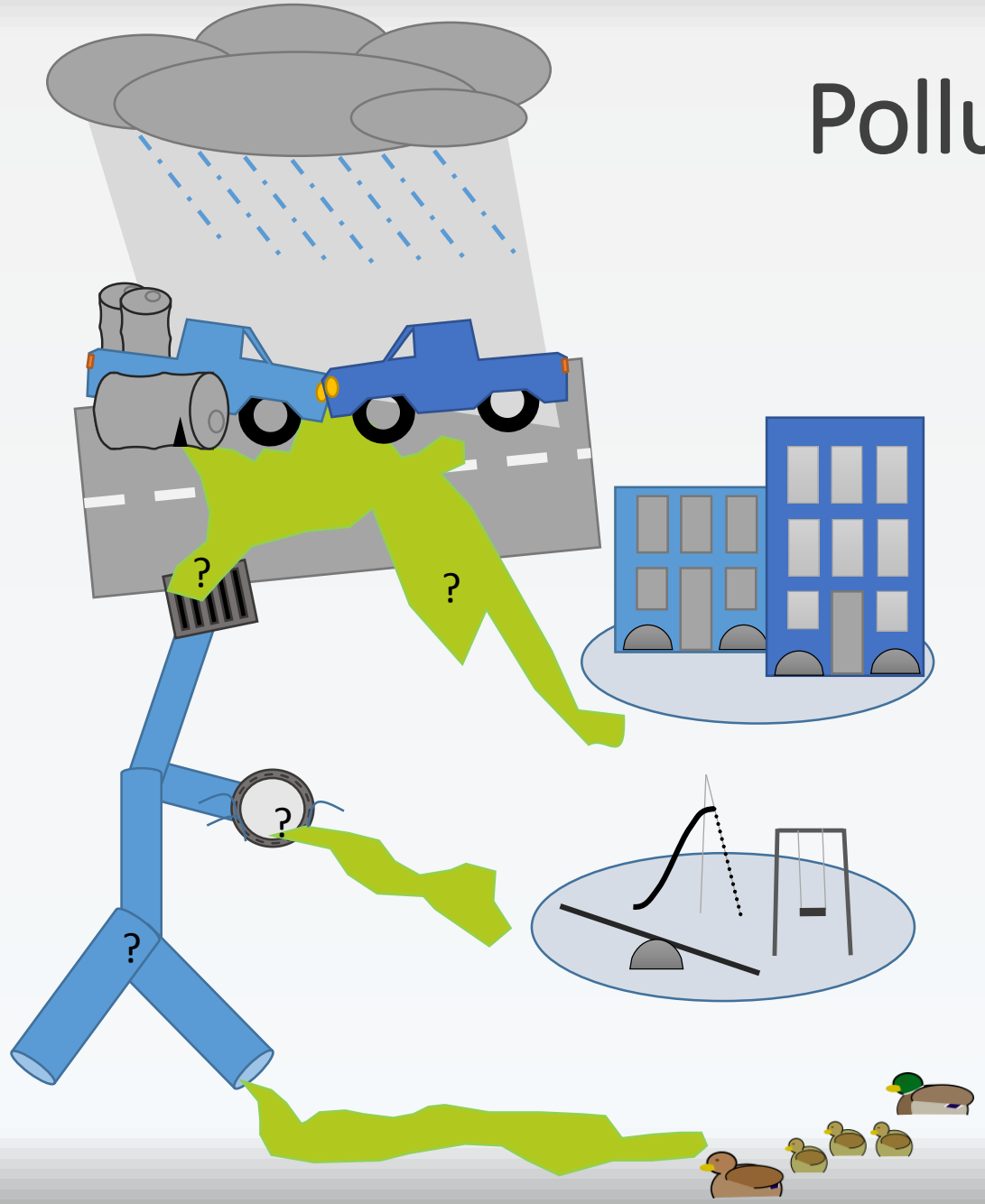


Pollution transport forecast during pluvial flood events

Robert Sämann, Thomas Graf, Insa Neuweiler

Institute of Fluid Mechanics and Environmental Physics in Civil Engineering

Leibniz University of Hannover, Germany

Leibniz Universität Hannover

ISU Institute of Fluid Mechanics and Environmental Physics in Civil Engineering

Project EVUS

SPONSORED BY THE Federal Ministry of Education and Research

Agenda:

1. Pollution Transport Model
2. Pluvial Flood Forecast

Dynamic solute transport in multiple domains

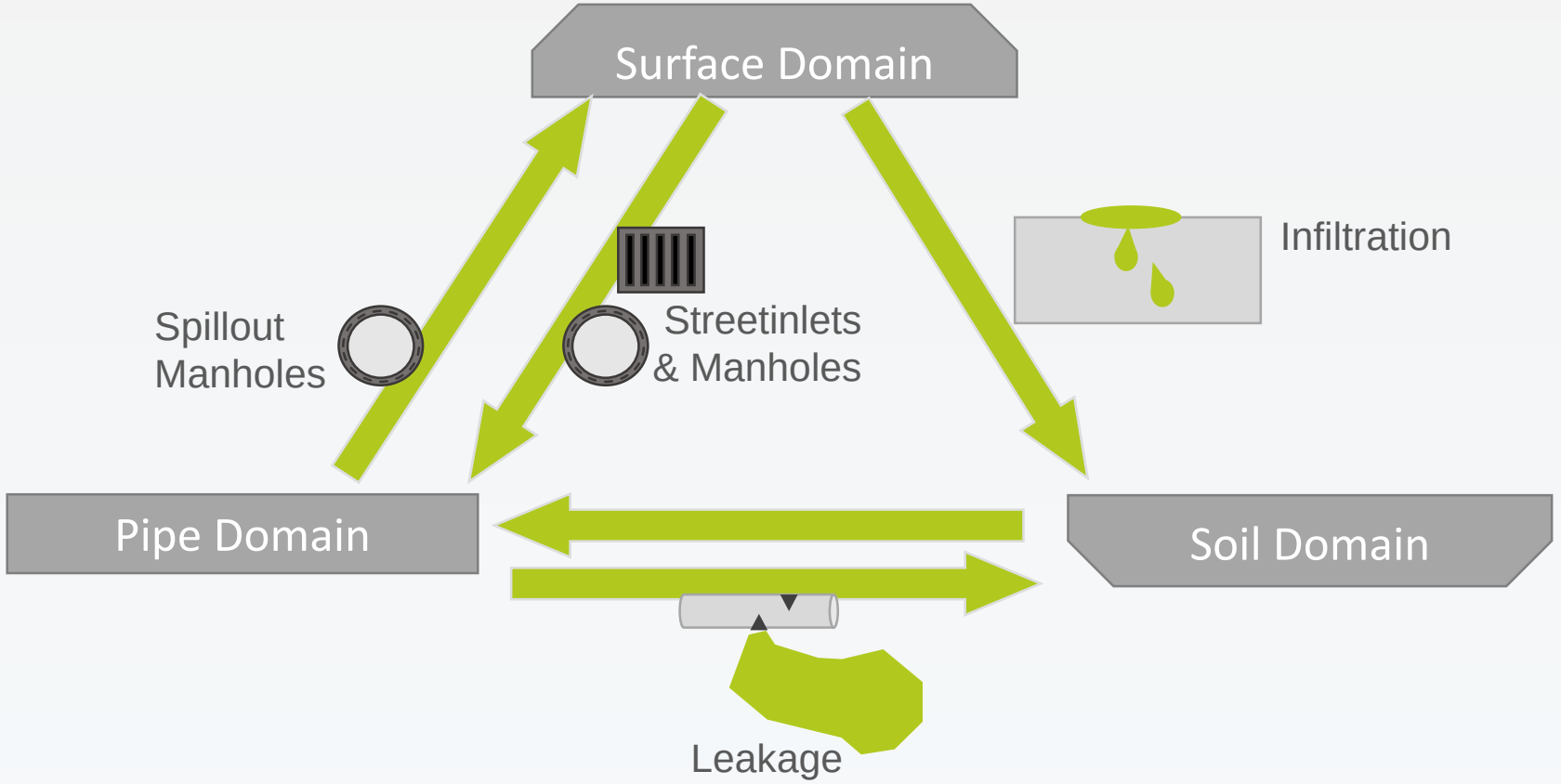
Accident with
hazardous injection spill

2D Surface

Inlets
Manholes

1D Pipe system

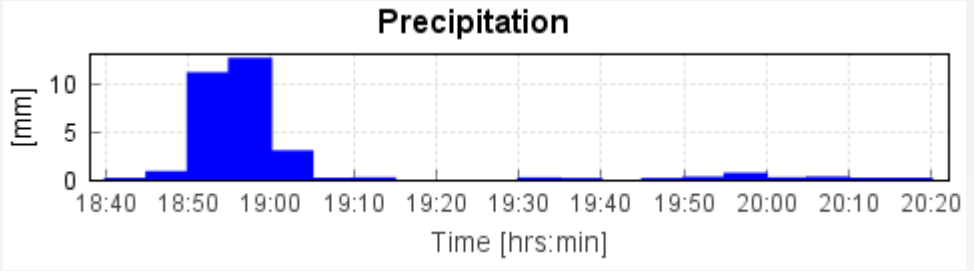
Cross domain transport paths

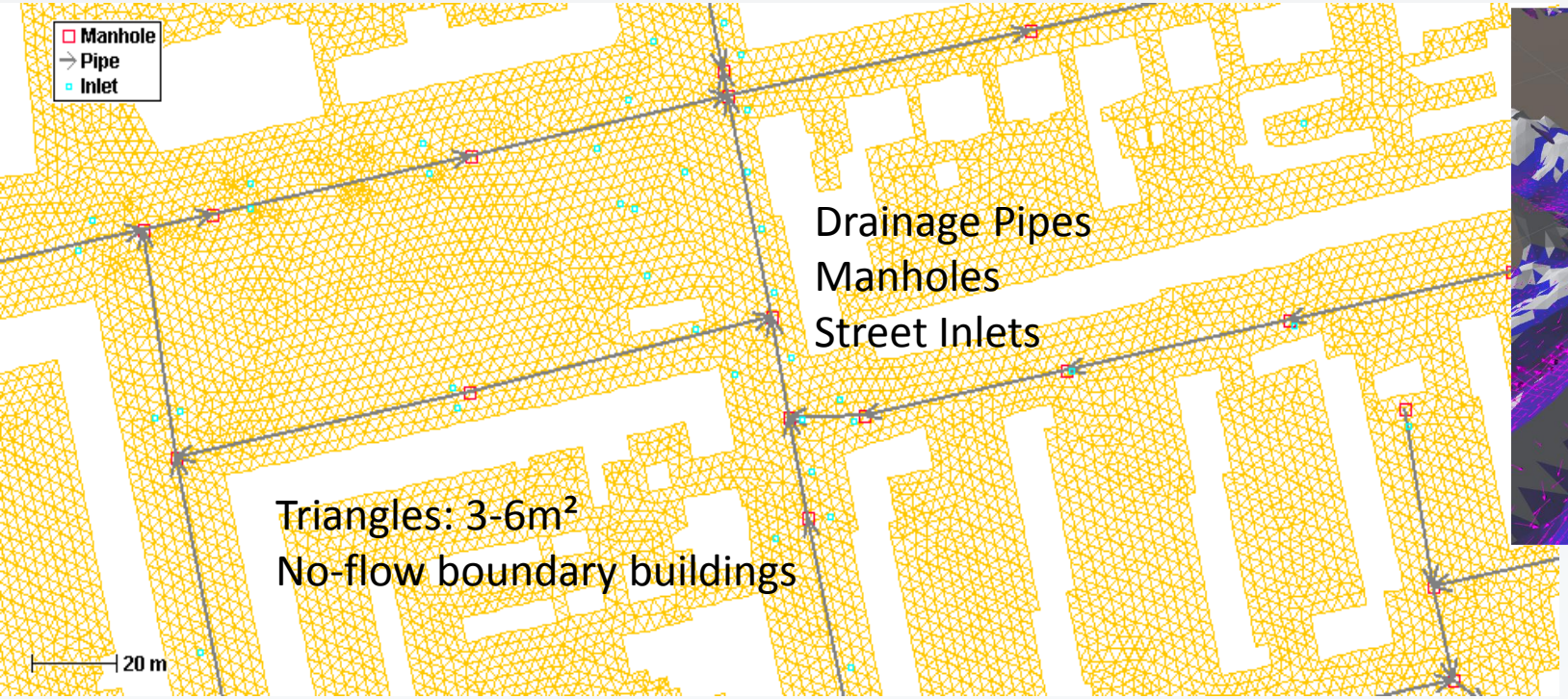


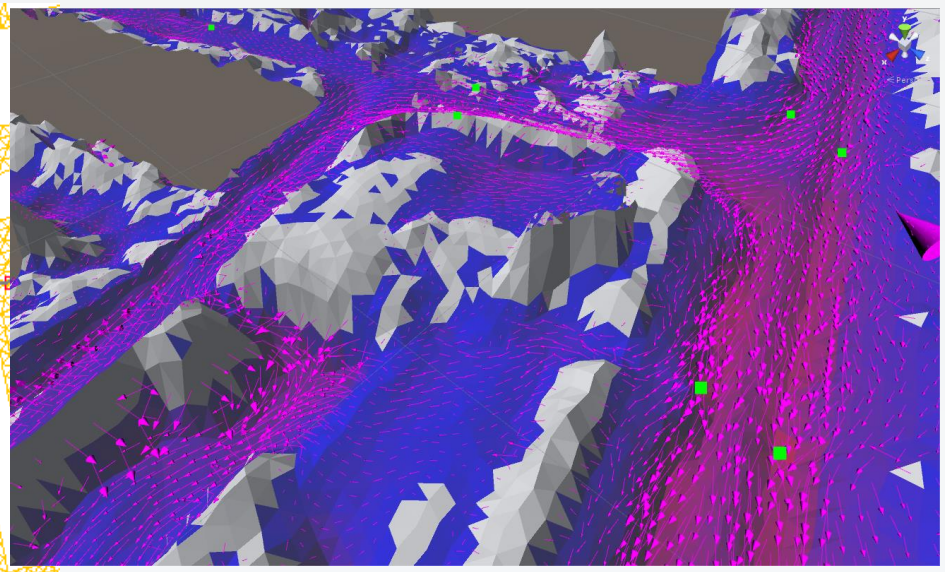
Hydrodynamic runoff model

Hystem Extran 2D (1D-2D runoff & routing) creates

dynamic velocities and water levels based on precipitation pattern







Dynamic velocity and waterlevel in pipe and on surface.

itwh (2015). Modellbeschreibung HYSTEM EXTRAN 2D, Institut für technisch-wissenschaftliche Hydrologie GmbH, Hannover.

Solute transport model

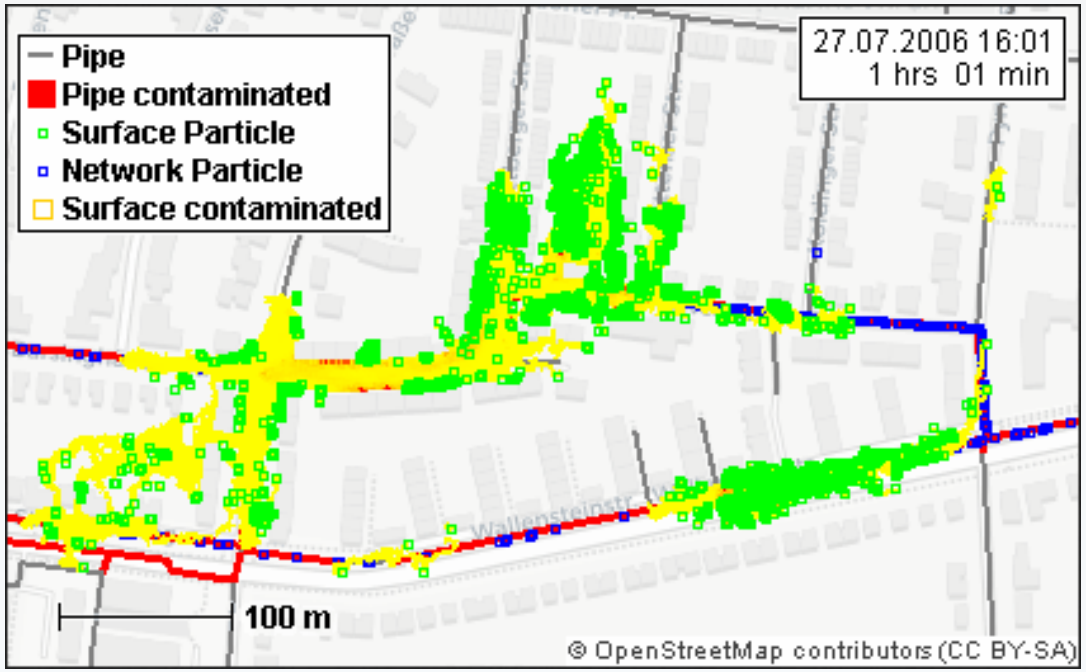
Lagrangian Particles, Random Walk apporach for diffusion

$$x(t+\Delta t) = x(t) + u(x(t)) \cdot \Delta t + \sqrt{2 \cdot D(x(t)) \cdot \Delta t} \cdot \xi$$

+ No numerical diffusion
+ Easy to track
+ Scalable
+ Parallelization

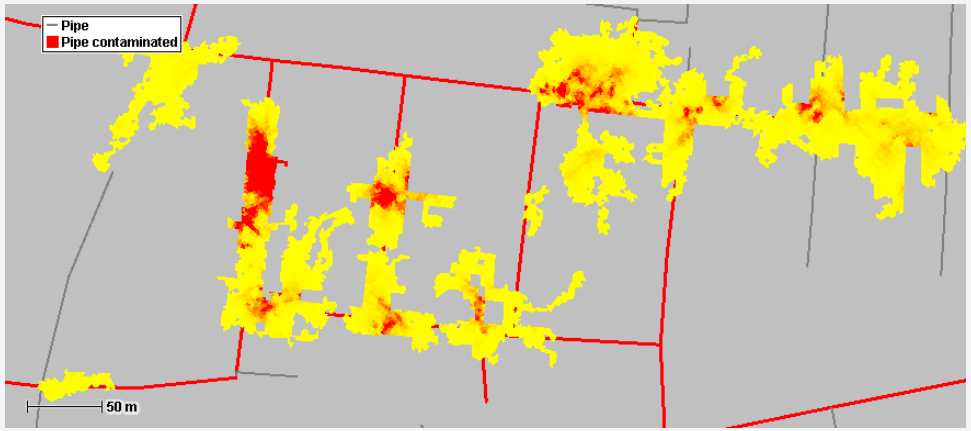
o No reaction / deposition so far (prepared in code)

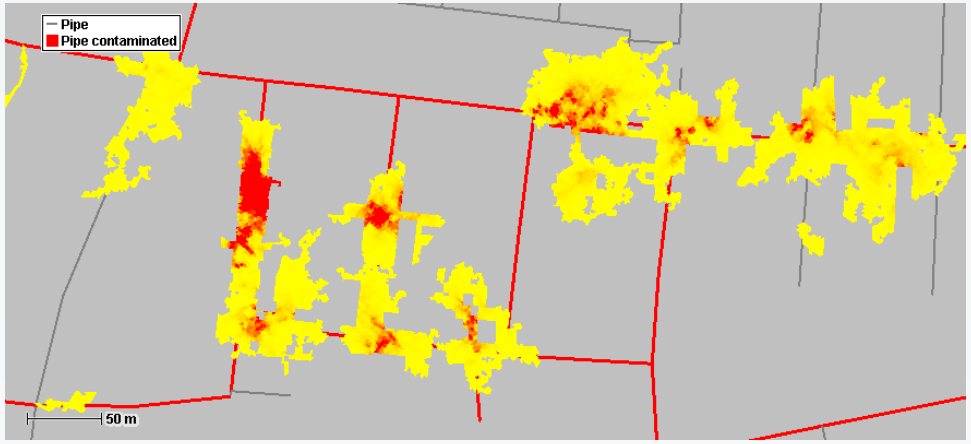
- Concentration calculation
- Many particles needed

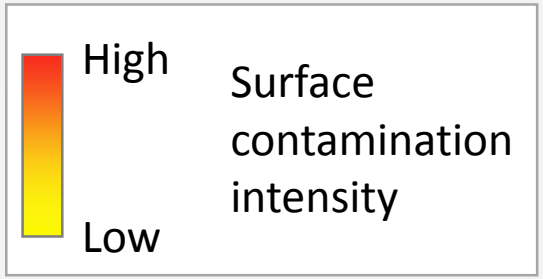


Influence of routing uncertainty

Same
- Injection location
- Injection time
- Flow field





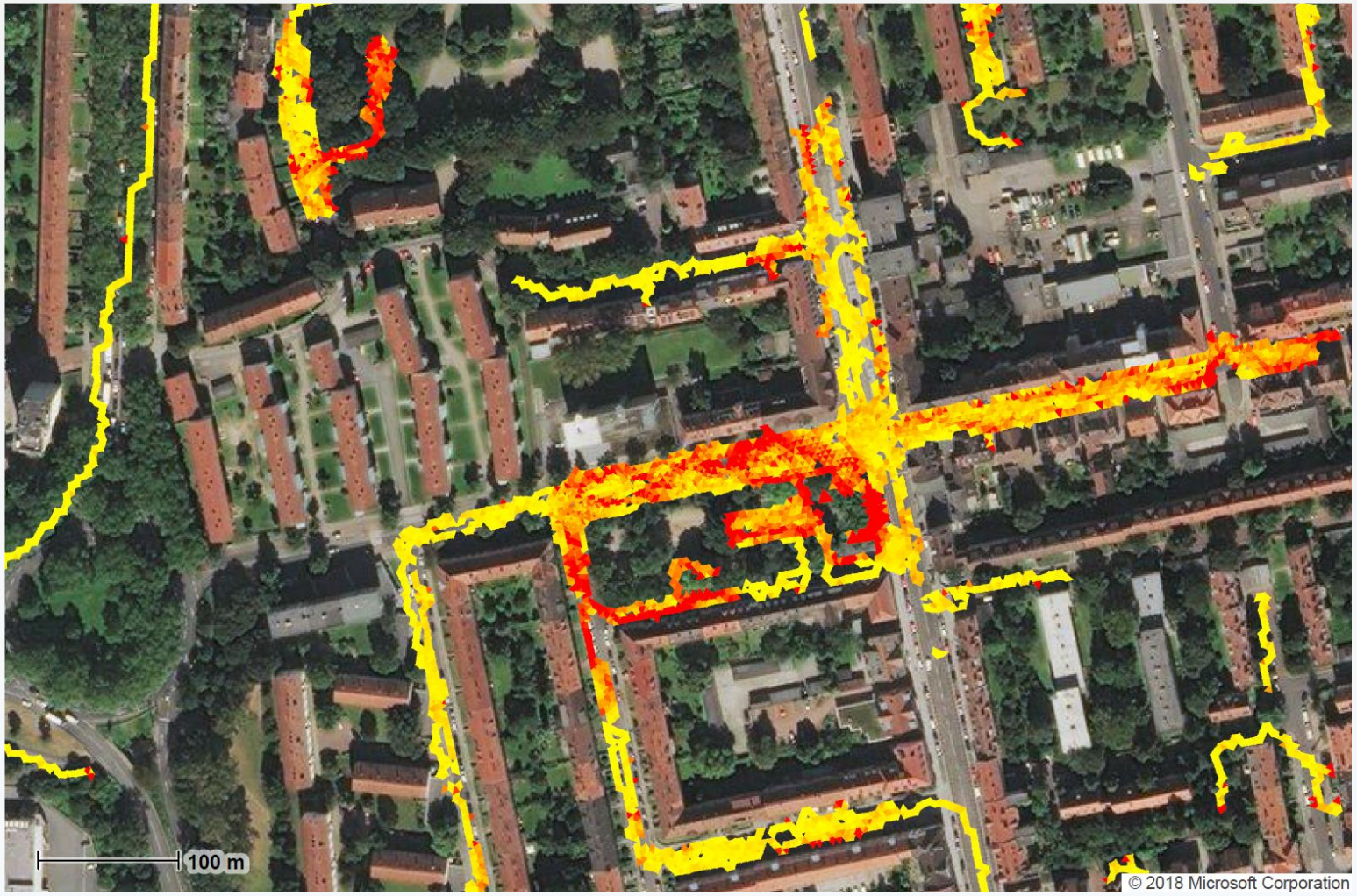


Area of low intensity with high variation

Area of high intensity with low variation

→ Create **Risk Maps** for accumulation locations

Surface contamination risk map



Risk Maps for accumulation locations

Red colour: Area of high concentration or long retention time

Source injection: uniform distribution over whole surface domain

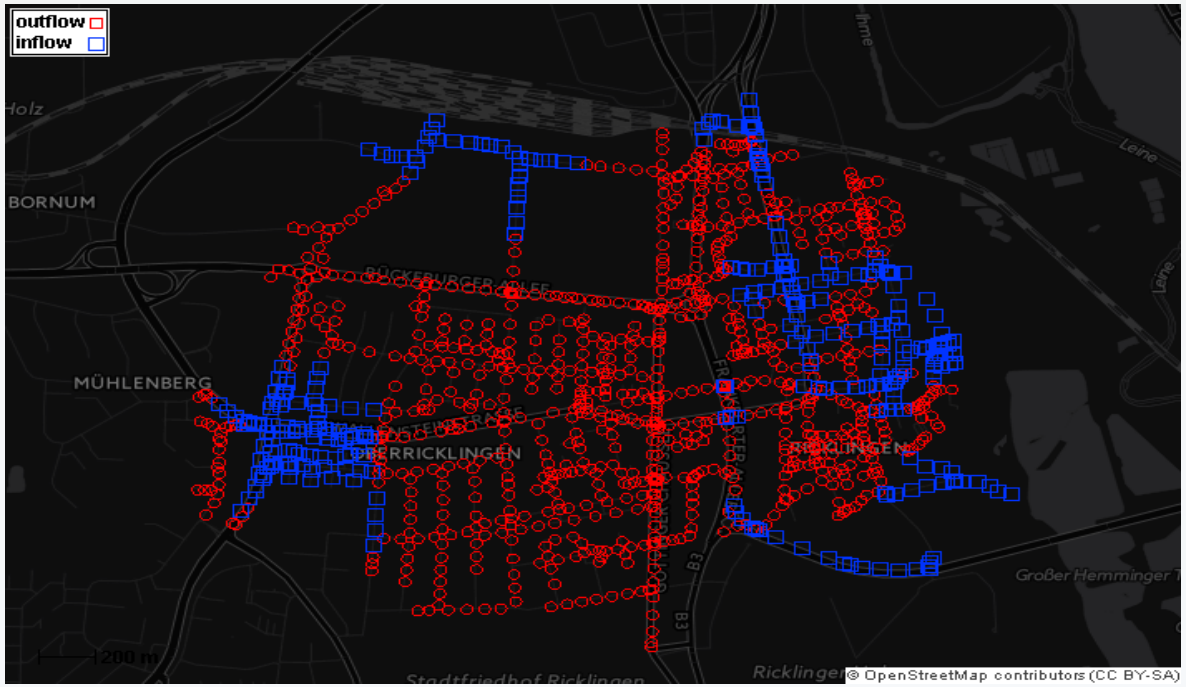
Tracking only after particles moved more than 50 m.

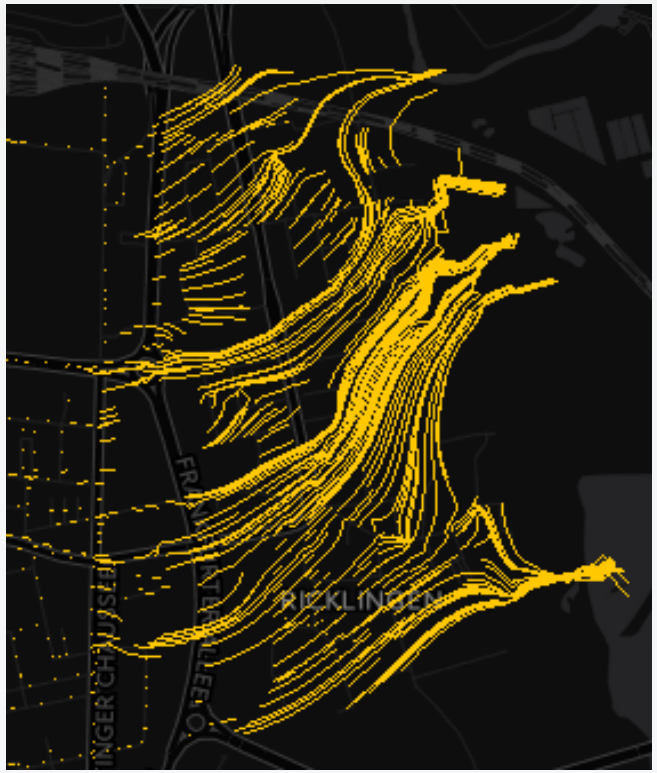
Sämann, R., T. Graf, and I. Neuweiler (2019) Modeling of contaminant transport during an urban pluvial flood event–The importance of surface flow, Journal of Hydrology 568, 301-310.

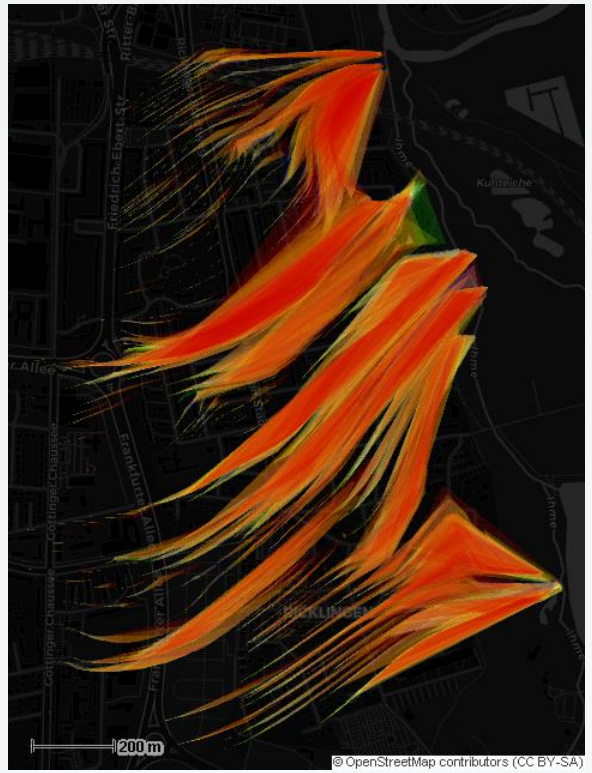
Soil domain transport

3D movement in soil

Exfiltration from pipesystem
when above groundwater level







Outlook: 3D contamination output / visualisation ,
Direct coupling from pipe leakage

Peche, A., T. Graf, L. Fuchs, I. Neuweiler (2017) A coupled approach for the three-dimensional simulation of pipe leakage in variably saturated soil, Journal of Hydrology 555, 569-585, DOI: 10.1016/j.jhydrol.2017.10.050

Transport model JAVA code

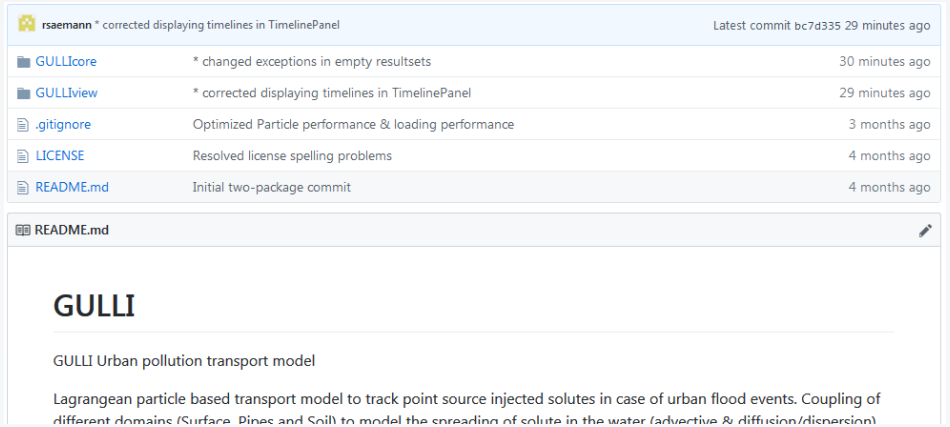
Input: Various formats (HYSTEM EXTRAN 2D, SWMM, OpenGeoSys)

Export: Contamination shapes as GeoJSON, SHP

90 seconds calculation time for 3,5 hours flow field with 100,000 particles on Intel i7 8x3.6GHz, uses 2 GByte RAM

Optimized for multithreading, low RAM cost, dynamic loading of network database resources

	Pipe	Surface		Soil
Dimension	1D	1D	2D	3D
Transport	Advection +Diffusion	Advection +Diffusion		Advection +Dispersion
Coupling	Direct			Post-Pipe-Run
Timestep	0,1-1 s			14 d

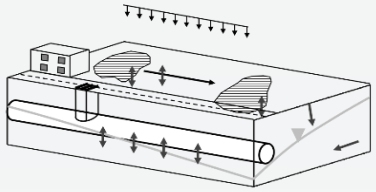


Check out https://github.com/rsaemann/GULLI

Contact saemann@hydromech.uni-hannover.de

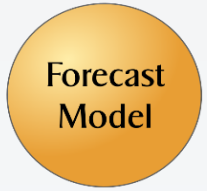
EVUS Research project

Rain Forecast, increasing leadtime



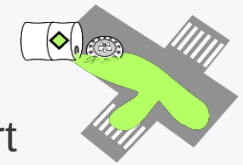
High definition surface model for hydrodynamic modelling of pluvial floods

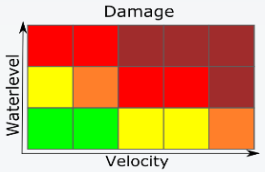
Time & location extraction of rain events from social media



Historic flood database
800 dynamic flood simulations

Forecasting pollution transport





Loss estimation model

Collect Information / Send warnings via App

EVUS Research project

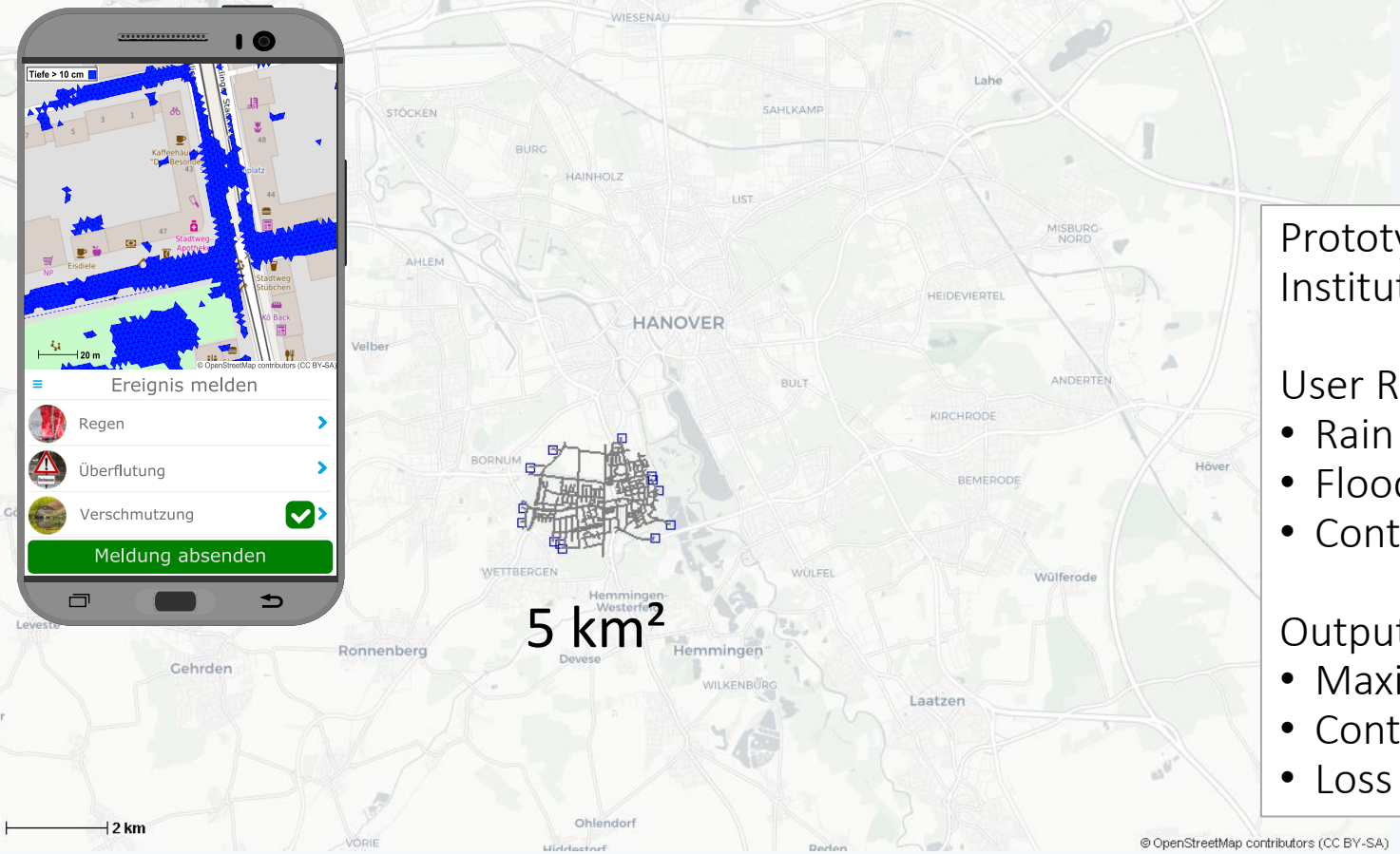
Project EVUS

2015-2018

Leibniz Universität Hannover

Institut für Strömungsmechanik und Umweltphysik im Bauwesen

Stadtentwässerung Hannover Wir klären das.



5 km²

Prototype Web-Application
Institute Server Host

User Report Input:
- Rain intensity
- Flooding
- Contamination

Output:
- Maximum water level
- Contamination boundary
- Loss estimation

itwh

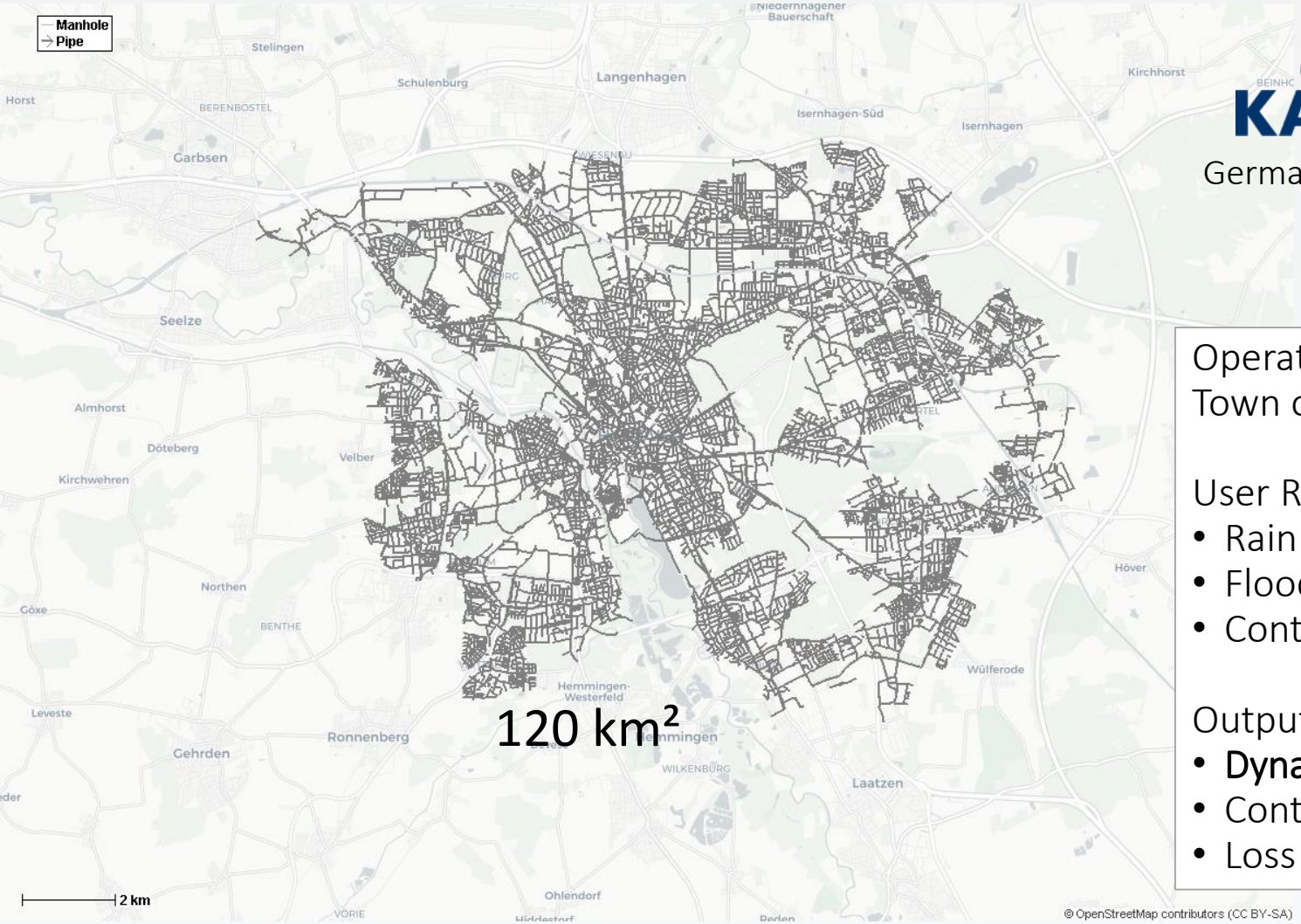
GFZ Helmholtz-Zentrum Potsdam

IP SYSCON

wawi

ikg

Outlook



120 km²

Implementation link to

KATWARN

German Hazard Warn App

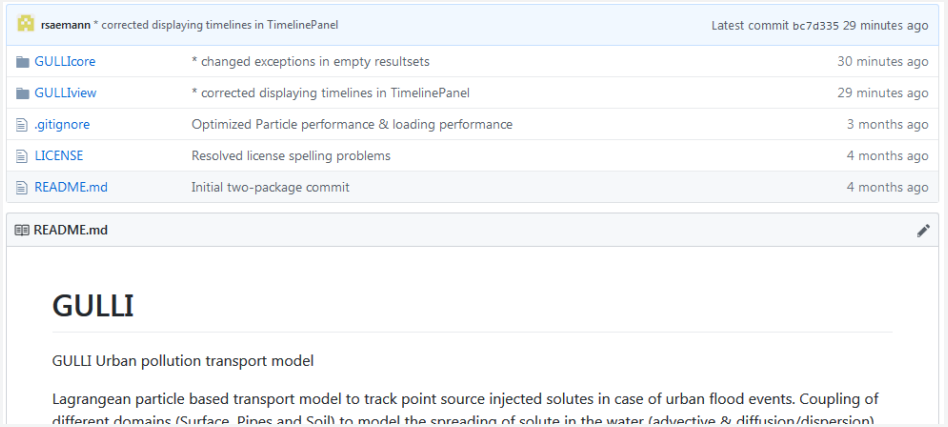
Operational Web-Application
Town of Hannover Server

User Report Input:
- Rain intensity ?
- Flooding ?
- Contamination ?

Output:
- **Dynamic** water level
- Contamination **intensity**
- Loss estimation

Questions?

Verification?	Yes, against a high resolution numerical code
Validation?	No. If you know of a tracer experiment in large scale urban areas during a pluvial flood, please let me know.



Check out https://github.com/rsaemann/GULLI

Contact saemann@hydromech.uni-hannover.de

Thanks for your attention.

Questions from the audience:

Applicable for other scenarios?	Yes, internal structure for millions of cells. Only flow field is needed (dynamic or static)
Do particles have a volume?	No, particles only have a mass. Particle injection do not change the flow field. Passive tracer approach. Swim “on top” of the flow field.
How many people used the App?	App was available but not public announced. Only project member used the App to report findings.