Simulation of Heavy Rainfalls in Berlin

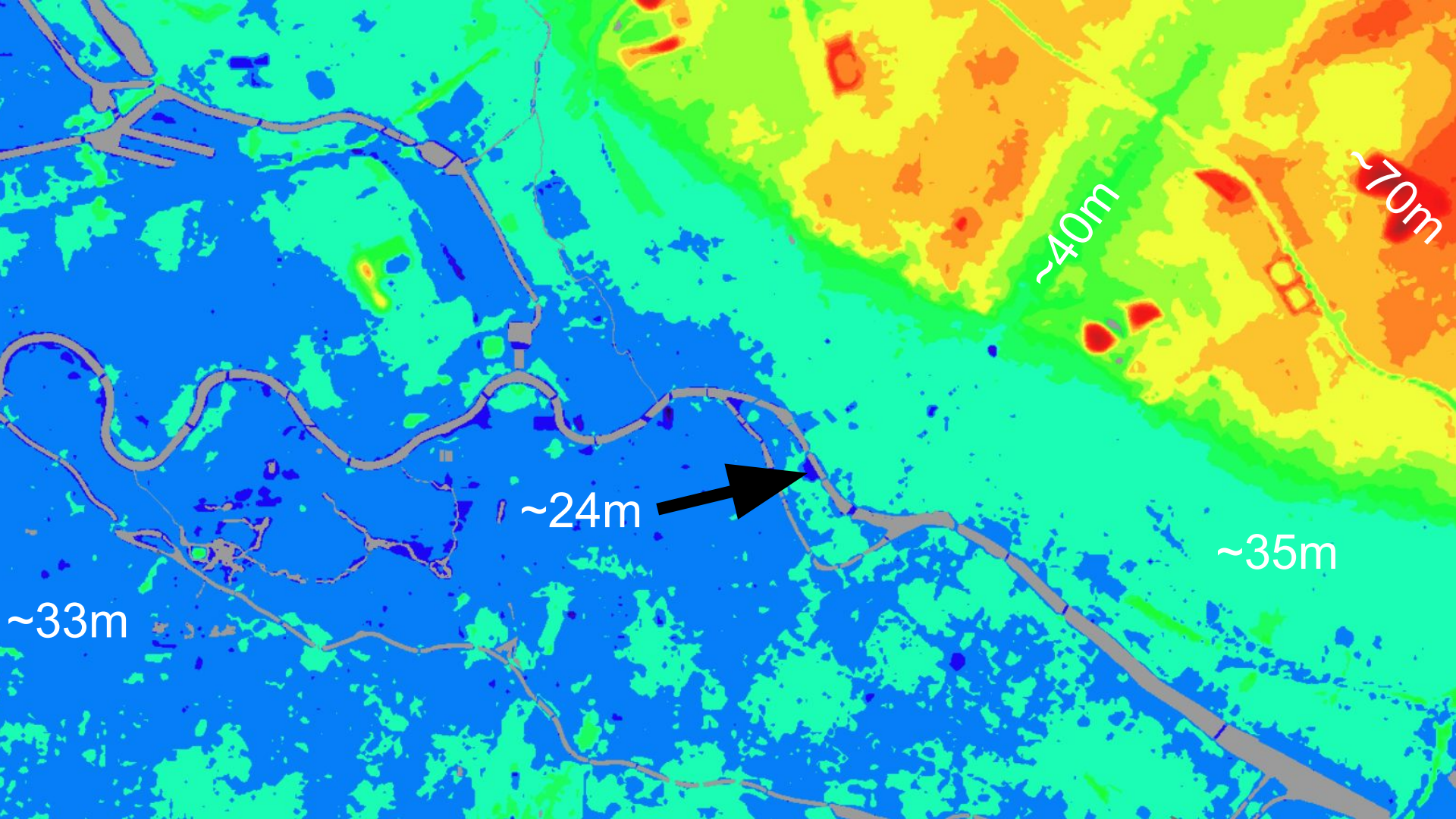
Sebastian Jäger

Customer: City of Berlin

Goal: Simulate dangerous areas

Data: BERLIN OPEN DATA (daten.berlin.de)

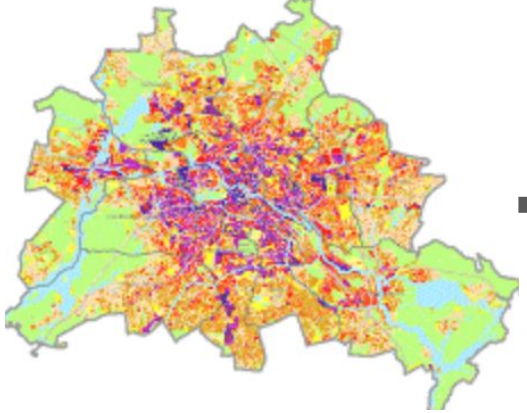

Low Sealing
High Sealing
No Sealing
SPRENGELKIEZ
MITTE
MOABIT
HANSAVIERTEL
BRUNNENVIERTEL
PRENZLAUER BERG
WINSVIERTEL
KOLLWITZKIEZ
FRIEDRICHSHAIN
KREUZBERG
BEZIRK FRIEDRICHSHAIN-KREUZBERG
Berlin
Mauerpark
Gedenkstätte Berliner Mauer
Kollwitzplatz
Zeiss-Großplanetarium
Museum für Naturkunde
Berliner Medizinhistorisches...
Volkspark Friedrichshain
Alexanderplatz
Pergamonmuseum
Madame Tussauds Berlin
Schloss Bellevue
Brandenburger Tor
Denkmal für die ermordeten Juden...
Gendarmenmarkt
Märkisches Museum
Ernst-Reuter-Platz
Großer Tiergarten
Potsdamer Platz
Checkpoint Charlie
Museum für Fotografie
Zoologischer Garten Berlin
Kaiser-Wilhelm-Gedächtnis-Kirche
Topographie des Terrors
Berlin Story Bunker
Jüdisches Museum Berlin
Kaufhaus des Westens
Deutsches Technikmuseum
East Side Gallery
Markthalle Neun
Boxhagener Platz
RAW-Gelände
Spree


~70m
~40m
~24m
~35m
~33m

Sealing

Versiegelung 2016 (Ausgabe 2017)

Sealing 2016 (issue 2017)



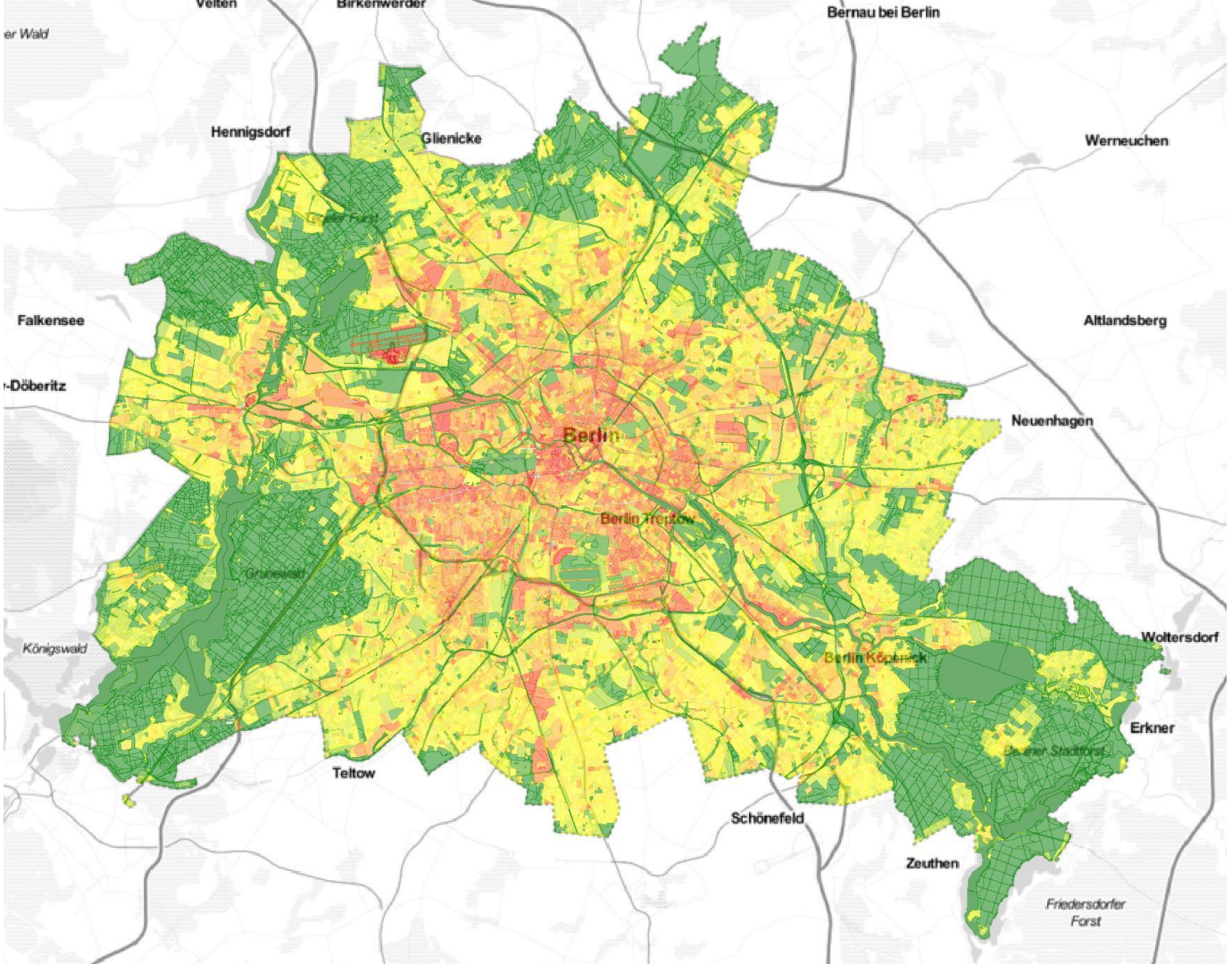
Web Feature Service (WFS)

QGIS

GeoJSON

GeoPandas +
Feature Selection

	sealing	geometry
0	69.30	POLYGON ((389326.214 5821756.291, 389374.948 5...
1	38.56	POLYGON ((389261.965 5821859.562, 389326.214 5...
2	83.53	POLYGON ((389261.965 5821859.562, 389326.319 5...
3	73.07	POLYGON ((389382.276 5821858.150, 389605.756 5...
4	76.37	POLYGON ((389382.276 5821858.150, 389488.086 5...


Velten
Birkenwerder
Bernau bei Berlin
Hennigsdorf
Glienicke
Werneuchen
Falkensee
Altlandsberg
Döberitz
Neuenhagen
Berlin
Berlin Treptow
Grunewald
Königswald
Berlin Köpenick
Woltersdorf
Erkner
Teltow
Schönefeld
Zeuthen
Friedersdorfer Forst

Ground Level

Digitale Geländemodelle – ATKIS DGM

Digital terrain models - ATKIS DGM

ATKIS: Amtliches Topographisches-Kartographisches Informationssystem (Official Topographic Cartographic Information System)

ATKIS® DGM (1m-Rasterweite)

Granularity

Kurzbeschreibung:	Das ATKIS DGM ist ein Teil des Amtlichen Topographisch-Kartographischen Informationssystem (ATKIS).
Koordinatensysteme:	EPSG:25833
Grafikformate:	text/csv
Nutzungsbedingungen:	Nutzungsbedingungen: Für die Nutzung der Daten ist die Datenlizenz Deutschland - Namensnennung - Version 2.0 anzuwenden. Die Lizenz ist über https://www.govdata.de/dl-de/by-2-0 abrufbar. Der Quellenvermerk gemäß (2) der Lizenz lautet "Geoportal Berlin / [Titel des Datensatzes]".
Zugriffsbeschränkungen:	Es gelten keine Bedingungen

Technische Angaben

ATOM-Feed-Url:	https://fbinter.stadt-berlin.de/fb/feed/senstadt/a_dgm
Standard:	ATOM-Feed
Version:	1.0

Explanation

Direkter Download des Datensatzes

ATKIS® DGM (1m-Rasterweite) - Download-Service - EPSG25833 - [illegible], gezippt.

Erläuterung	Blattschnittübersicht 2x2 Km
ATKIS® Basis-DGM1 370_5806	http://fbinter.stadt-berlin.de/fb/atom/DGM1/370_5806.zip
ATKIS® Basis-DGM1 370_5808	http://fbinter.stadt-berlin.de/fb/atom/DGM1/370_5808.zip
ATKIS® Basis-DGM1 370_5810	http://fbinter.stadt-berlin.de/fb/atom/DGM1/370_5810.zip
ATKIS® Basis-DGM1 370_5812	http://fbinter.stadt-berlin.de/fb/atom/DGM1/370_5812.zip
ATKIS® Basis-DGM1 370_5814	http://fbinter.stadt-berlin.de/fb/atom/DGM1/370_5814.zip
ATKIS® Basis-DGM1 372_5804	http://fbinter.stadt-berlin.de/fb/atom/DGM1/372_5804.zip

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279 files
~24GB

"Structured"


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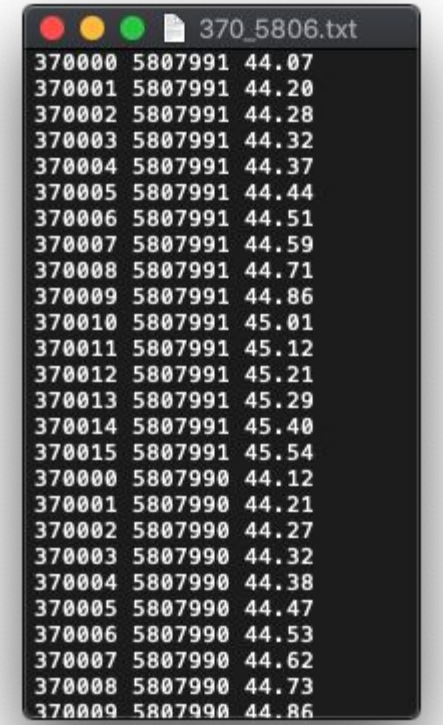
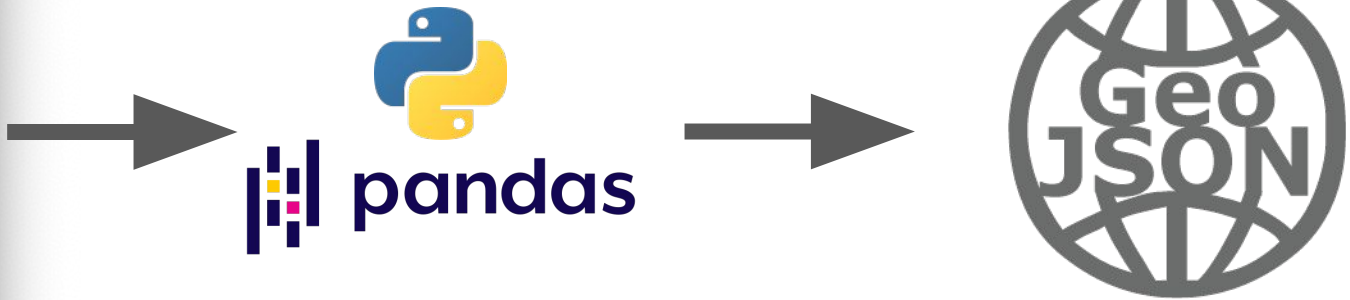
BERLIN
FALKENSEE
SPANDAU
REINICKENDORF
PANKOW
CHARLOTTENBURG-WILMERSDORF
FRIEDRICHSHAIN-KREUZBERG
NEUKÖLLN
TEMPELHOF-SCHÖNEBERG
STEGLITZ-ZEHLENDORF
TREPTOW-KÖPENICK
MARZAHN-HELLERSDORF
LICHTENBERG
MITTE
Ahrensfelde
ALTLANDSBERG
Hoppegarten
Neuenhagen b. Berlin
Fredersdorf-Vogelsdorf
Schöneiche b. Berlin
Woltersdorf
Kleinmachnow
TELTOW
Stahnsdorf
Schönefeld
POTSDAM





⇒ ~125GB GeoJSON 🤯

pandas

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Mean ground level

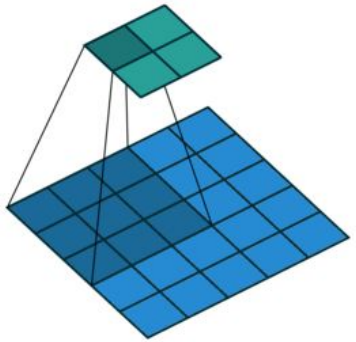
25x “compression”

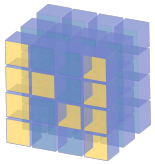
1	2
3	4

⇒ 3.5 h/file 🤯

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Convolution





NumPy

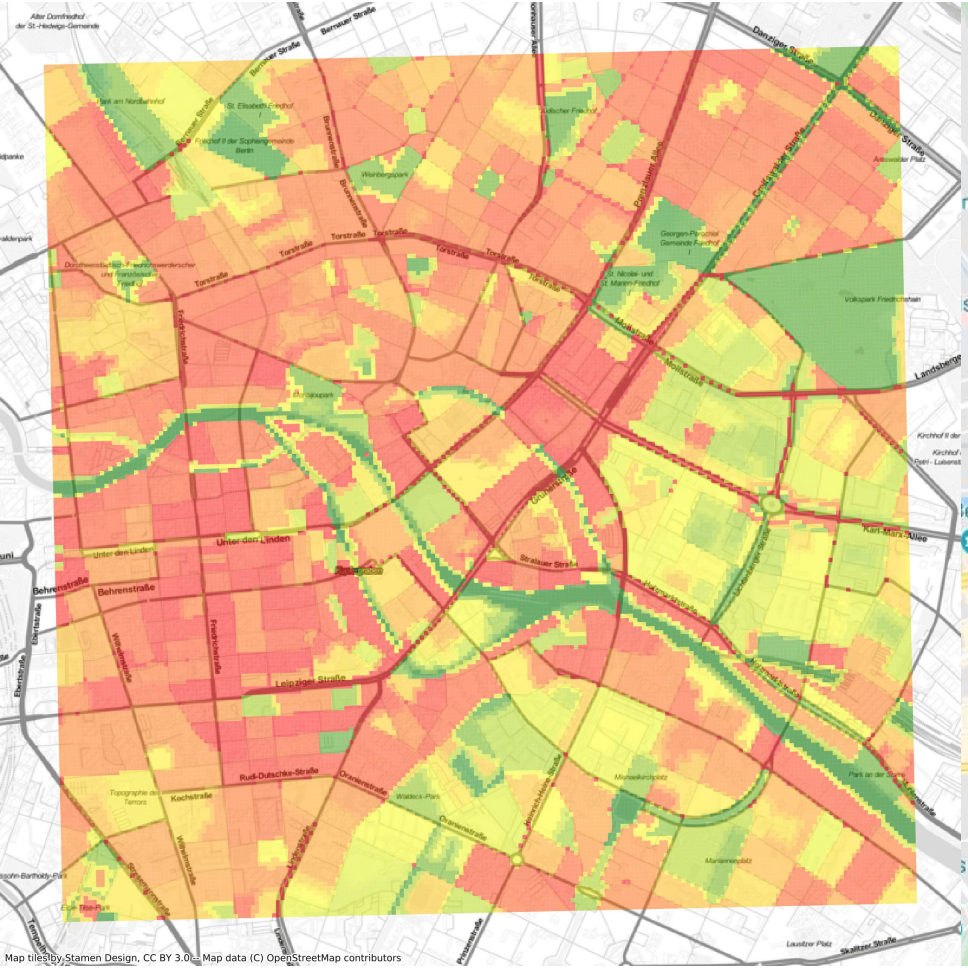
Downloader Package

https://github.com/se-jaeger/berlin-gelaendemodelle-downloader

```
> pip3 install berlin-opendata-downloader

> berlin_downloader download ~/berlin_height --compress 5 --file-format geojson
```

⇒ Download + “Compress” in ~2.5h 😉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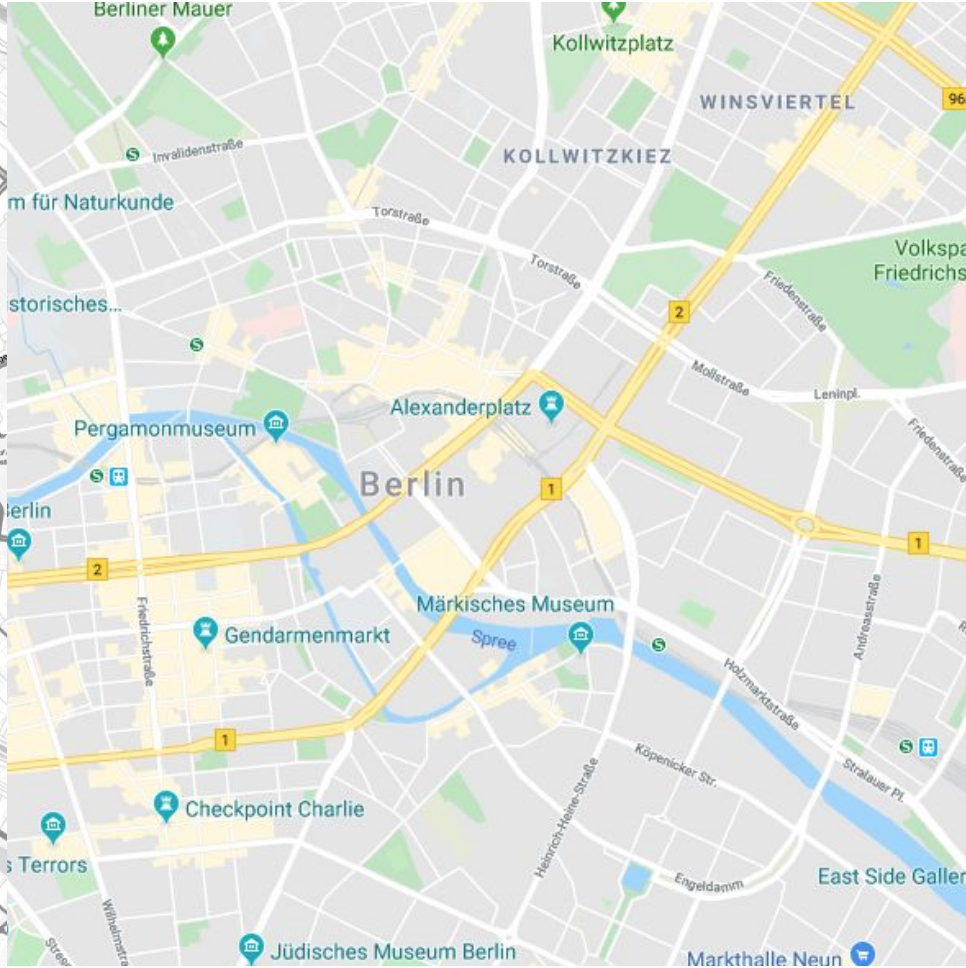
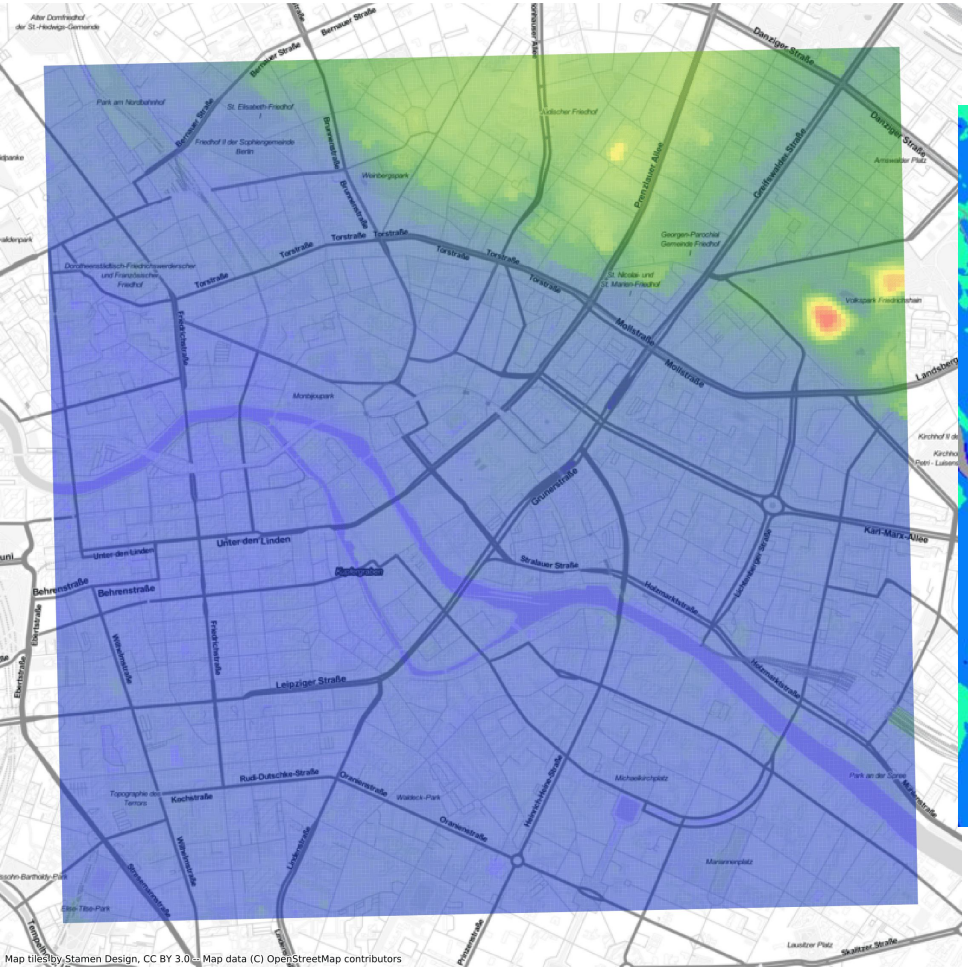
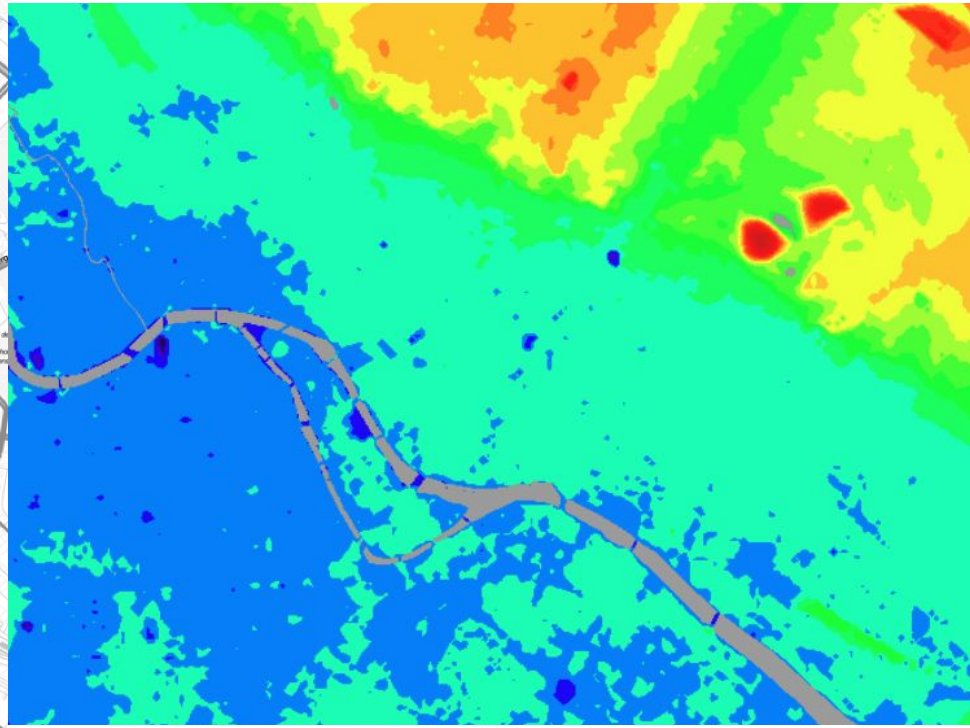

Berliner Mauer
Kollwitzplatz
WINSVIERTEL
KOLLWITZKIEZ
Invalidenstraße
Torstraße
Pergamonmuseum
Alexanderplatz
Berlin
Märkisches Museum
Gendarmenmarkt
Spree
Checkpoint Charlie
Jüdisches Museum Berlin
East Side Galler
Markthalle Neun


Berliner Straße
Danziger Straße
Torstraße
Prenzlauer Allee
Greifswalder Straße
Mollstraße
Landsberger Allee
Gründerstraße
Unter den Linden
Behrenstraße
Leipziger Straße
Karl-Marx-Allee
Stralauer Straße
Heinrich-Heine-Straße
Ruså-Dutschke-Straße
Kochstraße
Oranienstraße
Lindenstraße
Wilhelmstraße
Friedrichstraße
Wadzeck-Park
Michaelkirchplatz
Mariannenplatz
Lausitzer Platz
Skalitzer Straße
Map tiles by Stamen Design, CC BY 3.0 – Map data (C) OpenStreetMap contributors



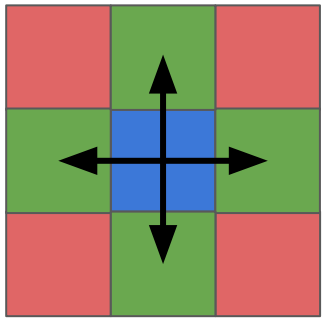
Part 2

The Simulation

Assumptions/Simplifications

- Pixel-based
- Discrete timesteps
- Rainfall is constant in time and geographical dimension
- Water only flows parallel to the axis +

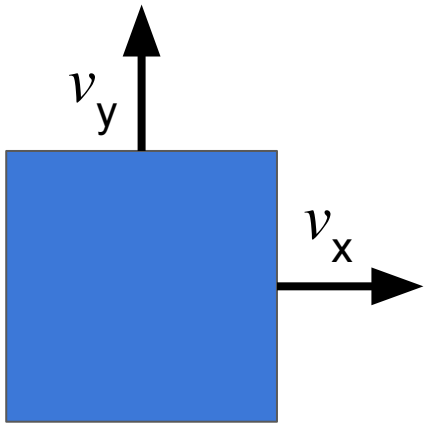
  Max. distance of 1 pixel



Goal: Calculate spatial water levels during time.

```
for n timesteps do:
   add rainfall;
   subtract infiltrated water;
   calculate water movement;
   update water level;
```

How many % water leaves a pixel in which direction?



$\text{distance}_x = v_x * \text{timestep}$

$\text{distance}_y = v_y * \text{timestep}$

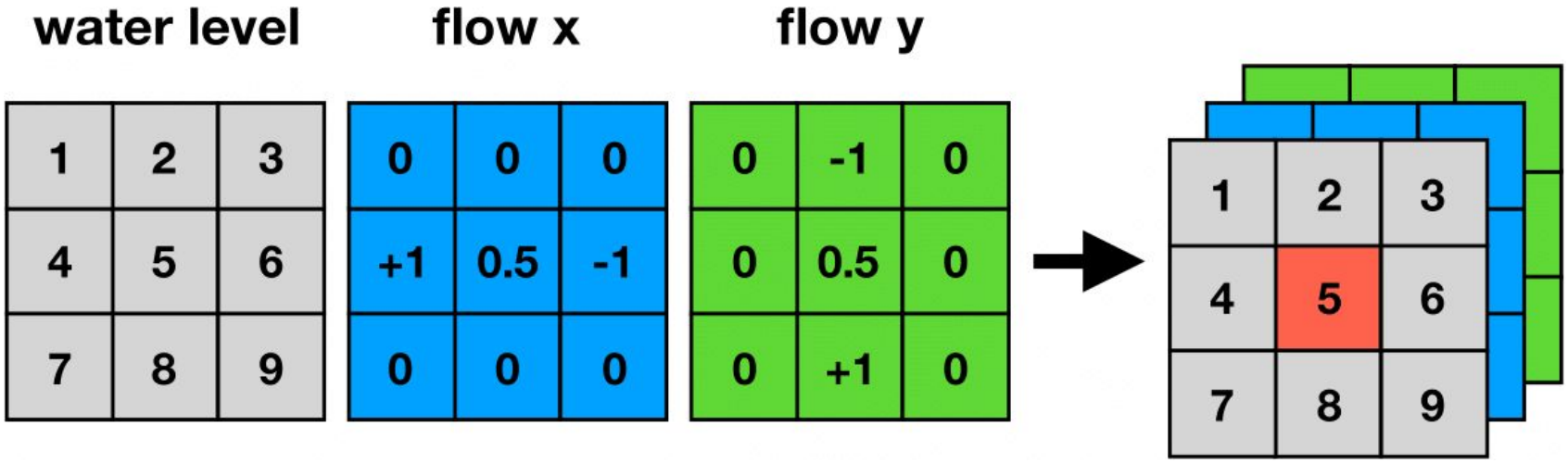
Water Flow According to Gauckler-Manning-Strickler

$$v_{\mathrm{m}} = k_{\mathrm{st}} \cdot \sqrt[3]{R^2} \cdot \sqrt{I}$$

Surface	k_{st} as $\frac{m^{\frac{1}{3}}}{s}$
Smooth concrete	100
Stright watercourse	30 - 40
Meandering riverbed with ground vegetation	20 - 30
Torrent with scree	10 - 20
Torrent with undergrowth	< 10

$$R = \frac{water\ level\ (l)}{length * width * 1000} = \frac{water\ level\ (l)}{pixel\ square\ meter * 1000}$$

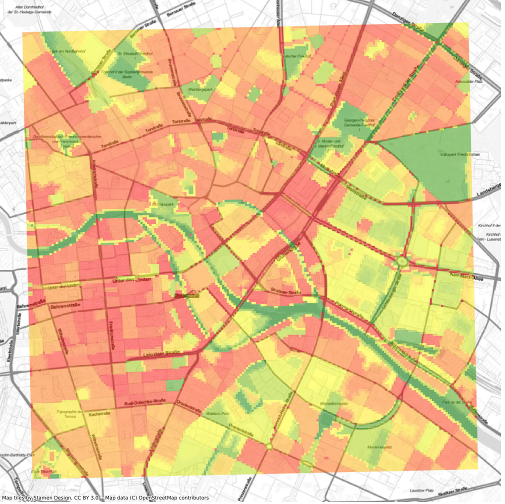
Source: https://de.wikipedia.org/wiki/Fließformel#Fließformel_nach_Gauckler-Manning-Strickler


water level
flow x
flow y
1 2 3
4 5 6
7 8 9
0 0 0
+1 0.5 -1
0 0 0
0 -1 0
0 0.5 0
0 +1 0
1 2 3
4 5 6
7 8 9

Berlin ‘17 - Precipitation >200l/sqm/24h

Simulation: https://bit.ly/2RkmnB2

Code: https://github.com/se-jaeger/urban-technologies-berlin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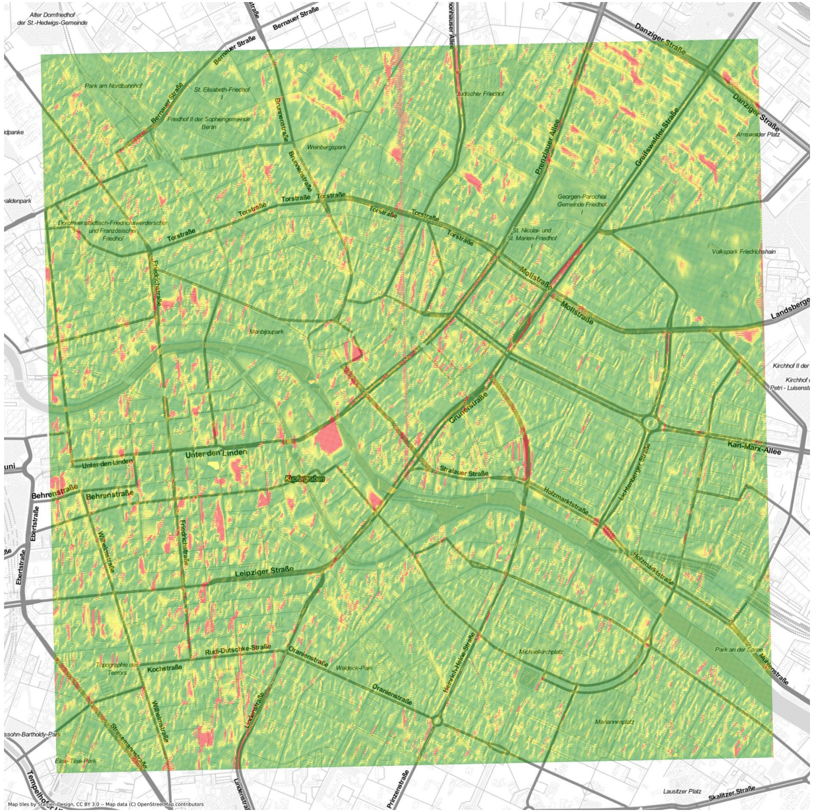
Alter Domfriedhof
der St.-Hedwigs-Gemeinde
Bernauer Straße
Danziger Straße
Park am Nordbahnhof
St. Elisabeth-Friedhof
Friedhof II der Sophiengemeinde
Berlin
Jüdischer Friedhof
Weinbergspark
Prenzlauer Allee
Greifswalder Straße
Amswalder Platz
Torstraße
Georgen-Parochial
Gemeinde Friedhof
St. Nicolai- und
St. Marien-Friedhof
Volkspark Friedrichshain
Mollstraße
Landsberger
Monbijoupark
Kirchhof II der
Grunerstraße
Karl-Marx-Allee
Unter den Linden
Behrenstraße
Stralauer Straße
Holzmarktstraße
Leipziger Straße
Friedrichstraße
Wilhelmstraße
Rudi-Dutschke-Straße
Kochstraße
Oranienstraße
Waldeck-Park
Michaelkirchplatz
Park an der Spree
Topographie des
Terrors
Mariannenplatz
Elise-Tilse-Park
Lindenstraße
Prinzenstraße
Lausitzer Platz
Skalitzer Straße
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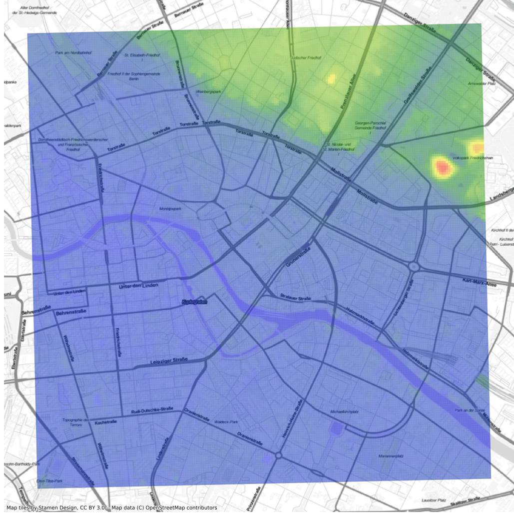
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Thank You!

Questions?