

INTERPOLATION - ON THE EXAMPLE OF THE INTRA-URBAN HEAT ISLAND EFFECT IN BERLIN

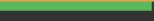
FOSSGIS SEMINAR

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Ruprecht-Karls-Universität Heidelberg

AGENDA



Introduction

Interpolation Methods

Project

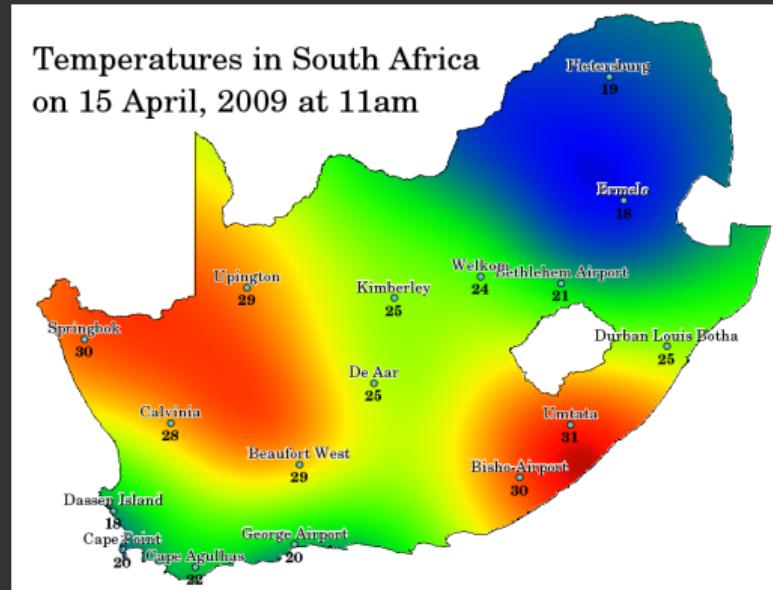
Results

Outlook

Introduction

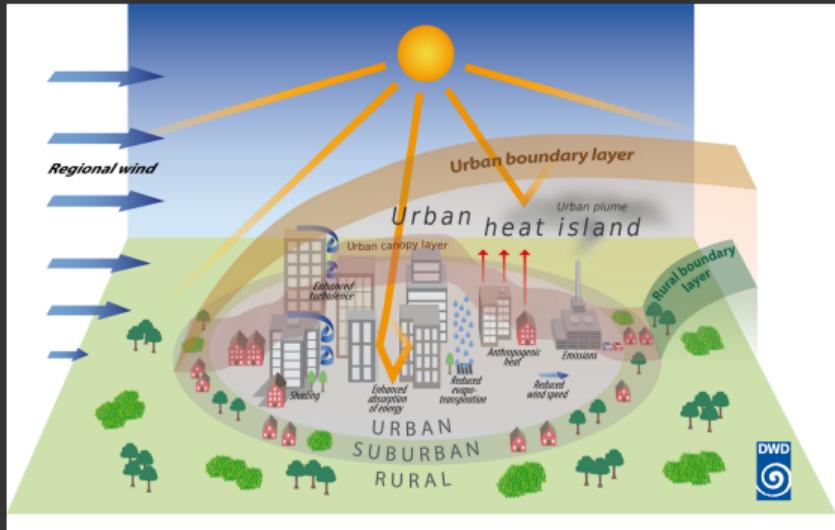
INTERPOLATION OVERVIEW

- Calculation of missing points using neighboring known points
- Vector to raster
- Raster to raster (Resampling)
- Spatial and spatio-temporal distributions of physical but also socioeconomic phenomena
- Deterministic vs Statistical



Source: QGis Documentation
11. Spatial Analysis (Interpolation)

THE INTRA-URBAN HEAT ISLANDS EFFECT

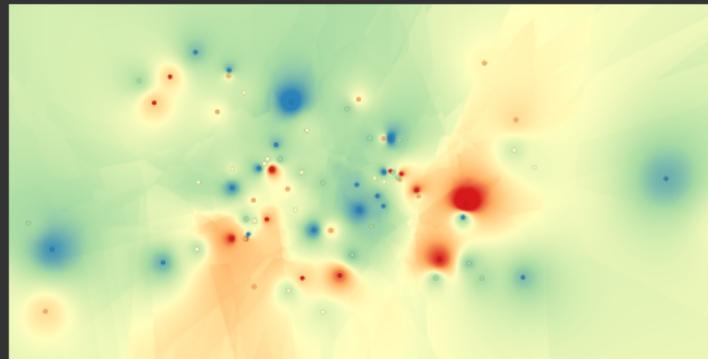


Source: Deutscher Wetterdienst
Urban climate - urban heat islands

- „[...] an urban area or metropolitan area is significantly warmer than its surrounding rural areas due to human activities“[TM20]
- Infrastructure, such as buildings, roads and other sealed surfaces absorb and re-emit the sun's radiation in the form of heat
- natural landscapes, such as forests and water bodies have a cooling effect[US 14]

PROJECT GOALS

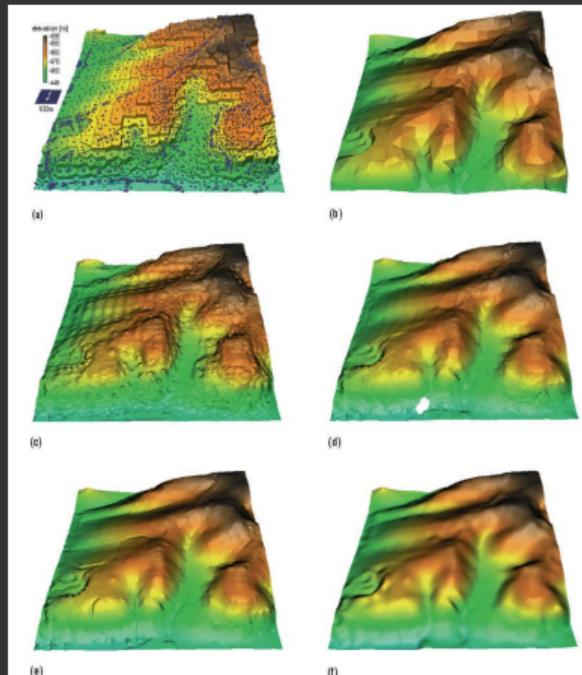
- Analyze temperature data from a citizen science project (openSenseMap)
- Visual product of the intra-urban heat islands effect
- Development over the course of the day
- Animation



*Interpolation of temperatures between measurement stations
(Berlin, 2020-08-09 12:00)*

Interpolation Methods

INTERPOLATION METHODS OVERVIEW

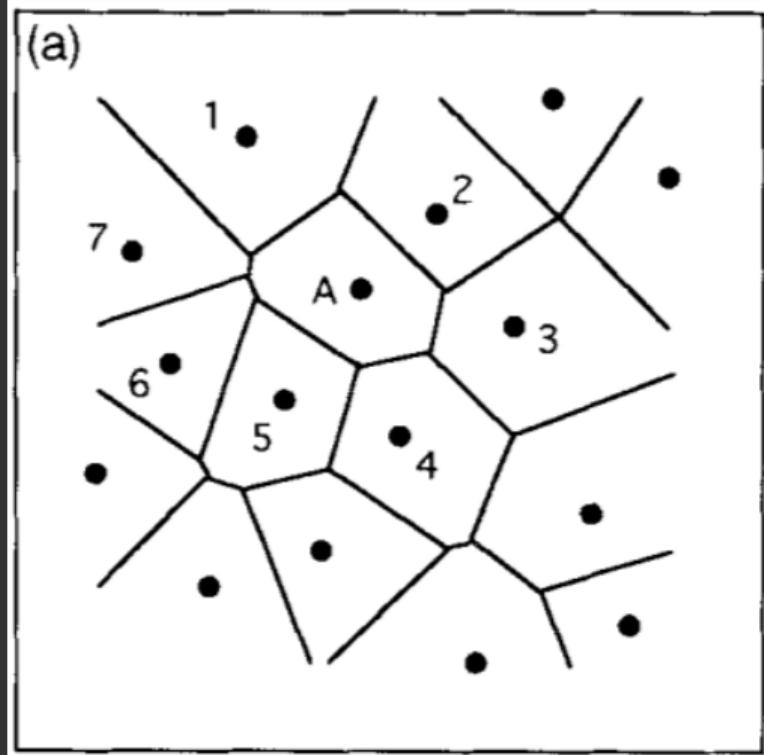


- Nearest Neighbor (deterministic)
<a>
- Linear/TIN (deterministic)
- IDW (deterministic) <c>
- Spline (deterministic) <e & f>
- Kriging (statistical) <d>

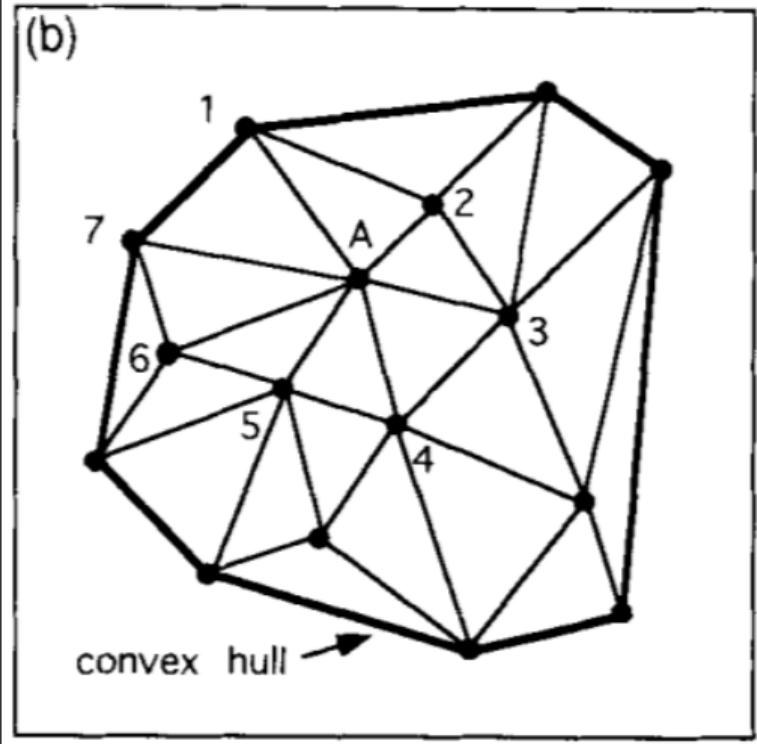
Interpolation with different methods [MM99]

NEAREST NEIGHBOR

- Voronoi diagrams
- Value is exactly the value of its nearest neighbor
- Sharp edges
- Inaccurate if known points have a great distance



Voronoi diagram [SBM95]

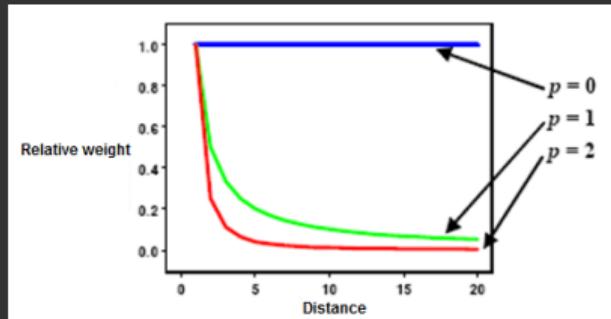


- Delaunay triangulation
- Surfaces formed by triangles
- Sharp edges
- Linear relationship
- Not suitable for data points outside the convex hull of the known points

Delaunay triangulation [SBM95]

INVERSE DISTANCE WEIGHTING

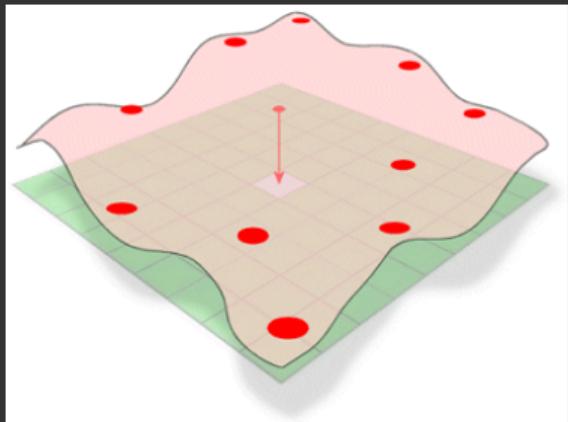
- N neighbors (within search radius)
- Weighting according to neighbor's distance to interpolation point
- Weighting function: $w_i(x) = \frac{1}{d(x, x_i)^p}$
- Higher power values \Rightarrow farther neighbors have less weight
- Useful for dense and equally distributed data points
- Not good for clustered or points following a trend



Source: ArcGIS Pro Help

How inverse distance weighted interpolation works

SPLINE

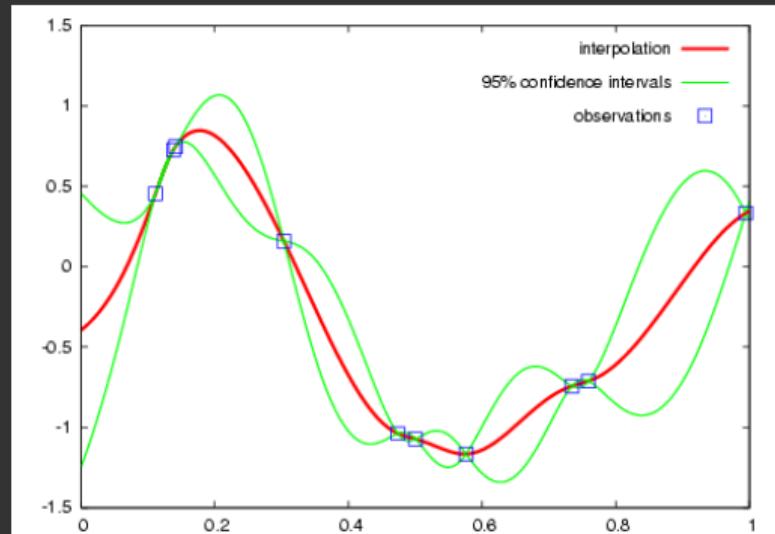


Spline “rubber sheet” fit to known data points [Alb05]

- Distortion through splines
- Minimizes overall surface curvature
- Creates a smooth continuous surface
- Bad for dense points with relatively high value differences
- Can estimate values outside of the measurement area

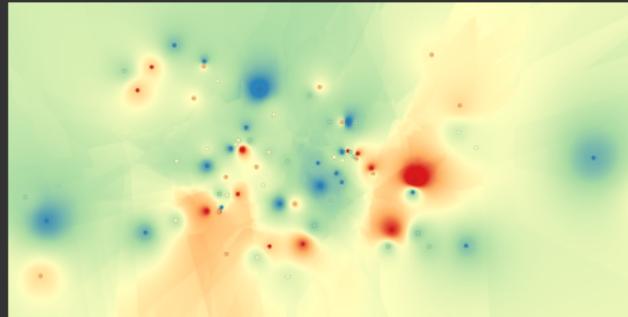
KRIGING

- Geo-statistical approach
- Based on auto-correlation
- Produces a prediction surface
- Measure of certainty: error estimation and a confidence interval for every unknown point



Kriging in two dimensions [Git16]

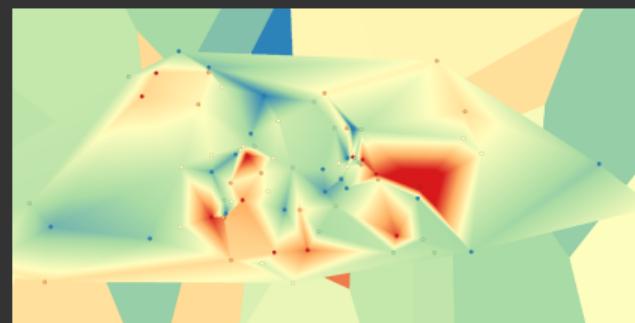
COMPARISON QUIZ



Method 1

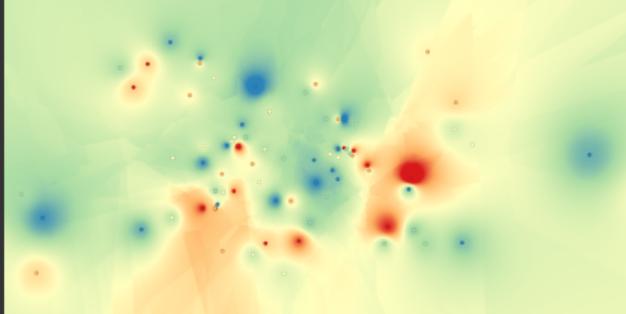


Method 2



Method 3

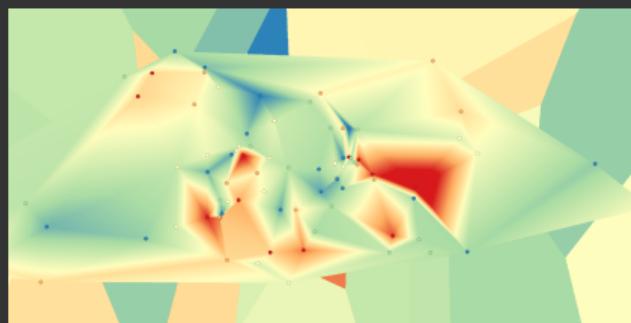
COMPARISON QUIZ



IDW

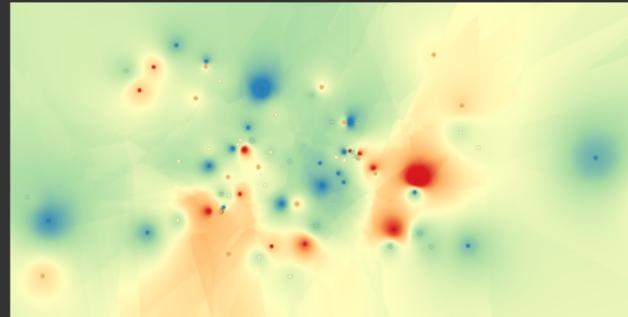


Method 2



Method 3

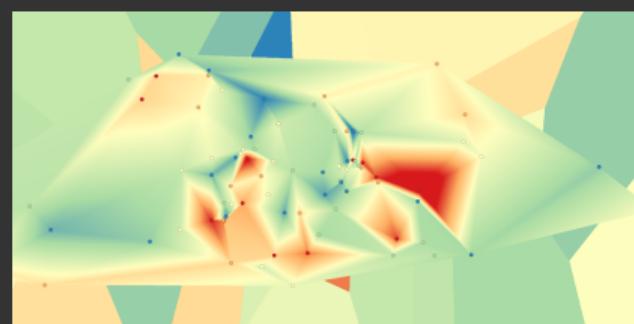
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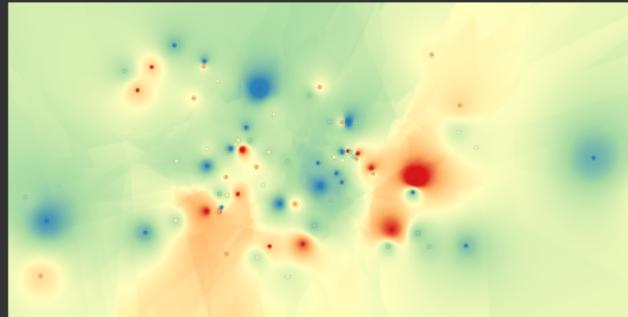


Nearest Neighbor



Method 3

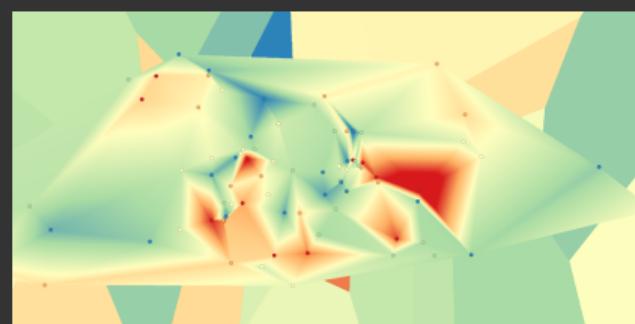
COMPARISON QUIZ



IDW



Nearest Neighbor



TIN

SUPPORT IN FOSSGIS TOOLS

Interpolation method	QGIS	GRASS GIS	SAGA	GDAL
Nearest neighbor	✗	✓	✓	✓
TIN	✓	✓	✓	✓
IDW	✓	✓	✓	✓
Spline	✗	✓	✓	✗
Kriging	✗	✓	✓	✗

Project

INITIAL SITUATION



- Use openSenseMap
- Get urban temperature sensors for Berlin
- Interpolate data using different methods
- Create animation
- Compare results

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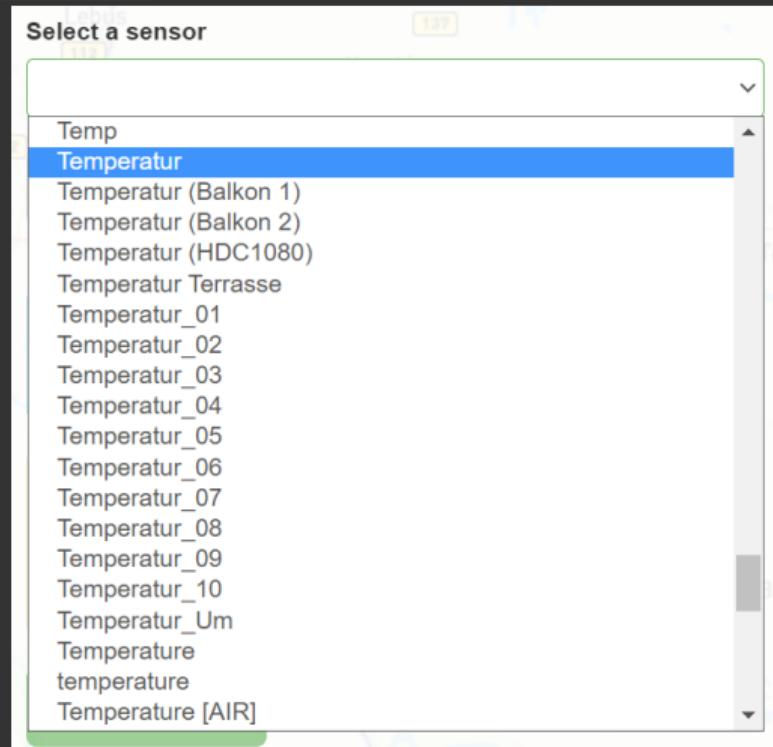
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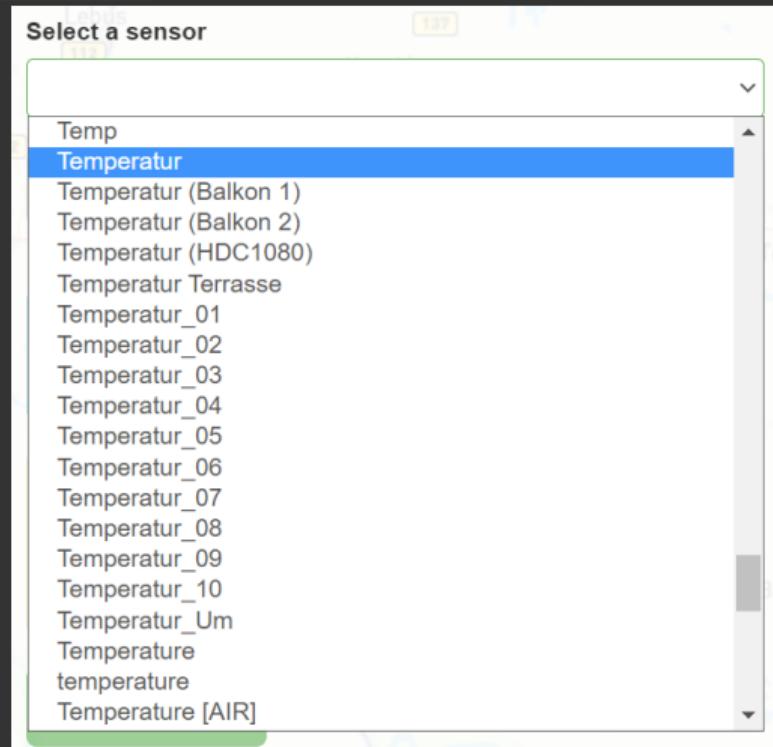
PROBLEMS: GETTING THE DATA

- openSenseMap offers API access
- For bbox sensor data a phenomenon name must be given
- Phenomenon/Sensor name is a free-text field
- Different notations



PROBLEMS: GETTING THE DATA

- openSenseMap offers API access
- For bbox sensor data a phenomenon name must be given
- Phenomenon/Sensor name is a free-text field
- Different notations
- Most common one (Temperatur) was chosen



PROBLEMS: AGGREGATING DATA



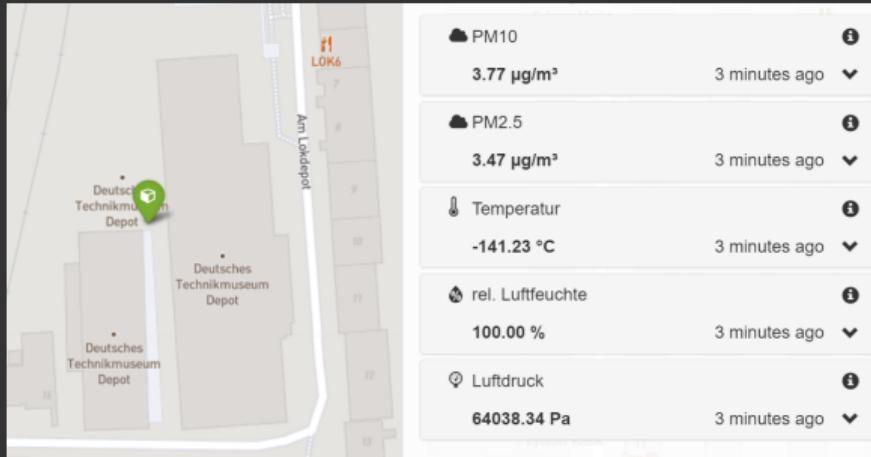
- Aggregated export does not cover full day
- Raw data may not include measurements throughout the day

PROBLEMS: AGGREGATING DATA



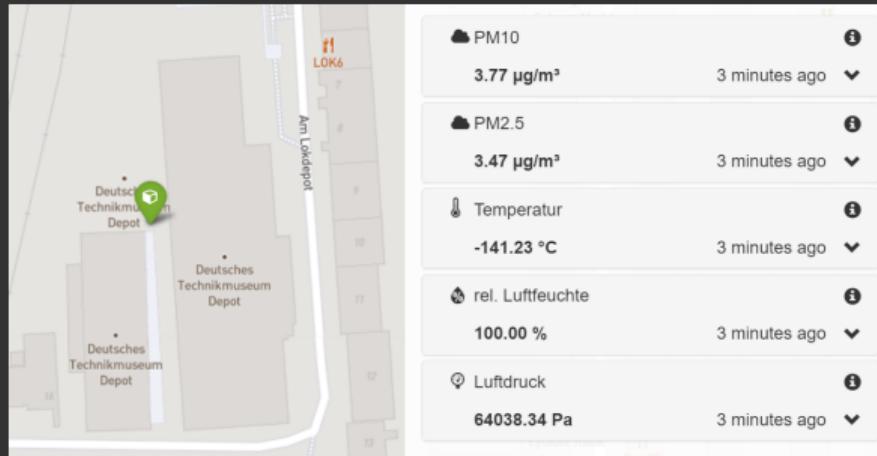
- Aggregated export does not cover full day
- Raw data may not include measurements throughout the day
- Manually aggregate raw data into 10 minute averages
- Filter out all stations that didn't provide measurements for every 10 minute interval

PROBLEMS: DATA QUALITY



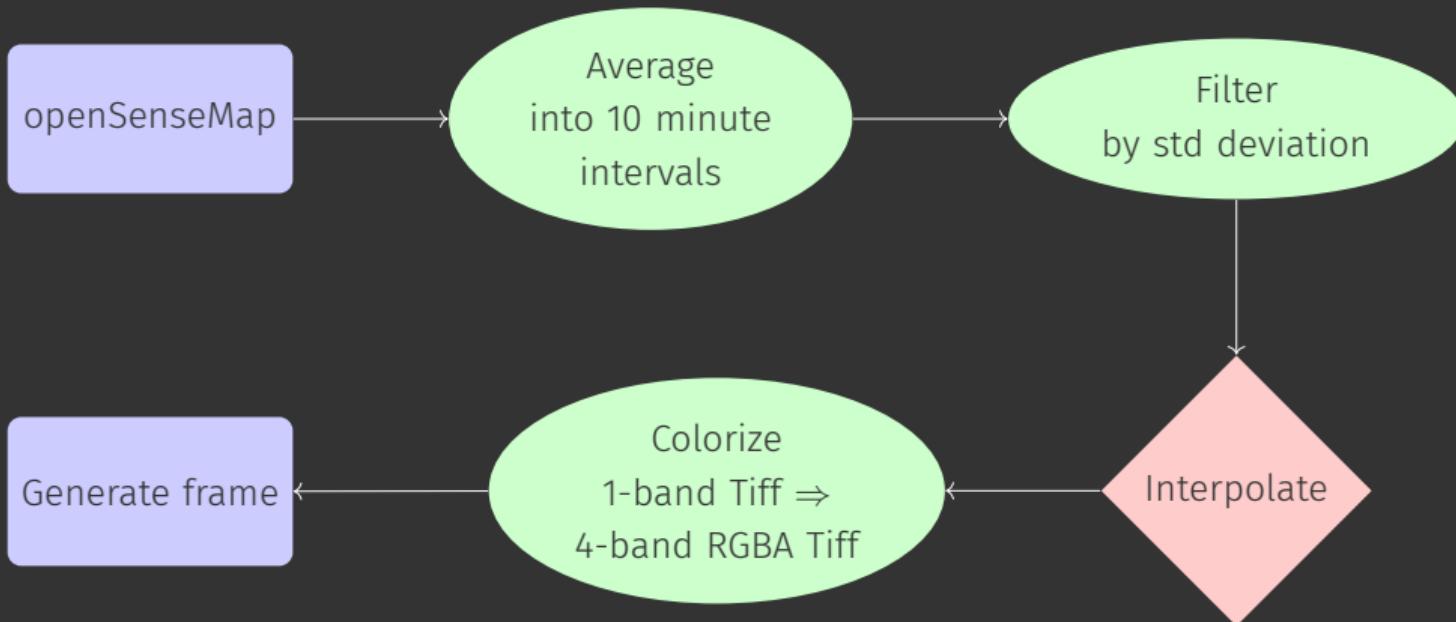
- Citizen-science project
- No validation of submitted data
- Do you spot any issues with the measurements?

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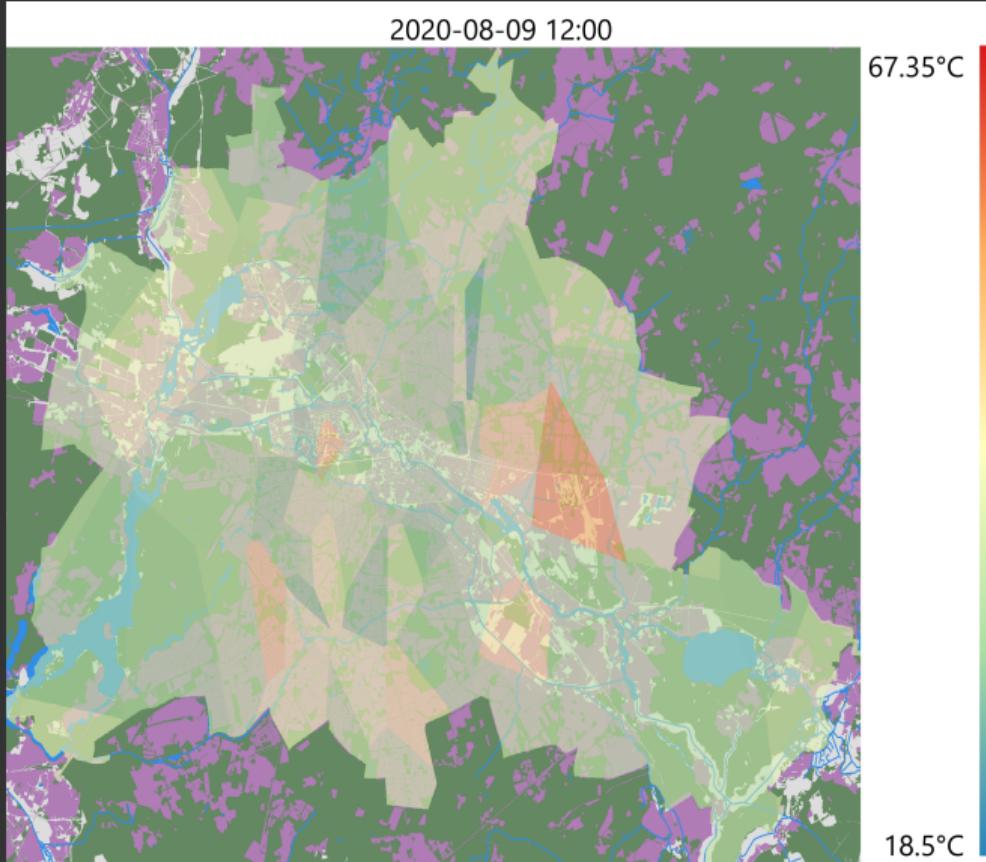
- Citizen-science project
- No validation of submitted data
- Do you spot any issues with the measurements?
- Filter all measurements that are more than double standard deviation from mean

FINAL WORKFLOW

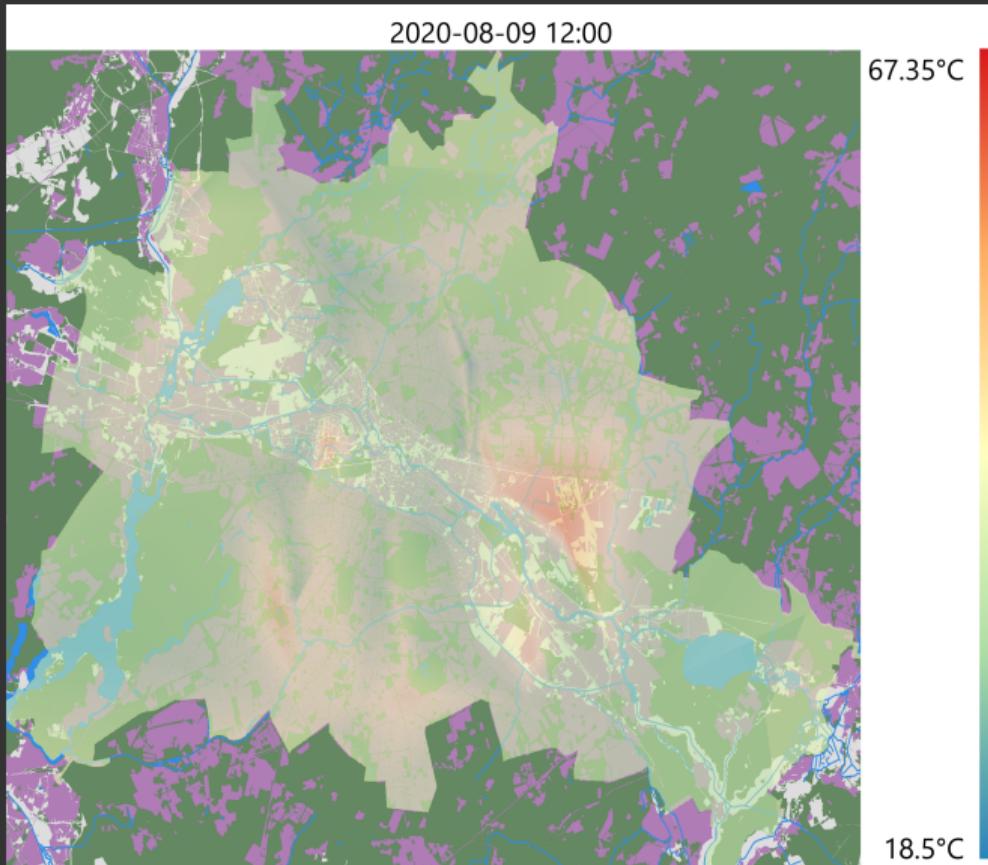


Results

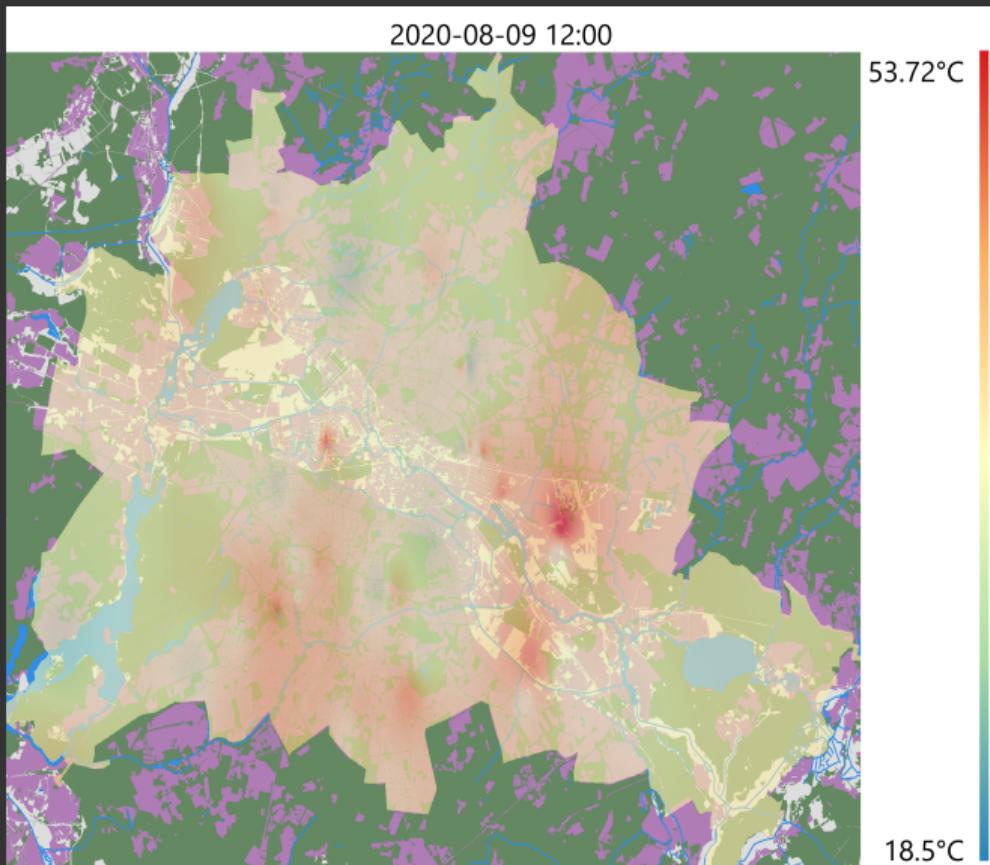
NEAREST NEIGHBOR INTERPOLATION



TIN INTERPOLATION



IDW INTERPOLATION



DISCUSSION

- Why did we choose GDAL?
- Why did we choose Nearest Neighbor, TIN and IDW?

Outlook

OUTLOOK: VALIDATION

- Validate data internally
 - Sample sets to check their accuracy
- Validate data externally
 - E.g. using DWD data

OUTLOOK: FOSSGIS COMPARISON

- Check if implementation differs in different FOSSGIS tools
- Check for differences in default settings
 - Which are better suited for our use case?

References

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