Technische Universität Braunschweig

The influence of Level of Details (LoD0-2) and buffer sizes on parameter effectiveness for fine dust distribution modelling

Marc-O. Löwner & Yahya Ghassoun

Technische Universität Braunschweig
Technische Universität Braunschweig

Original paper: https://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/IV-4-W6/41/2018/isprs-annals-IV-4-W6-41-2018.pdf

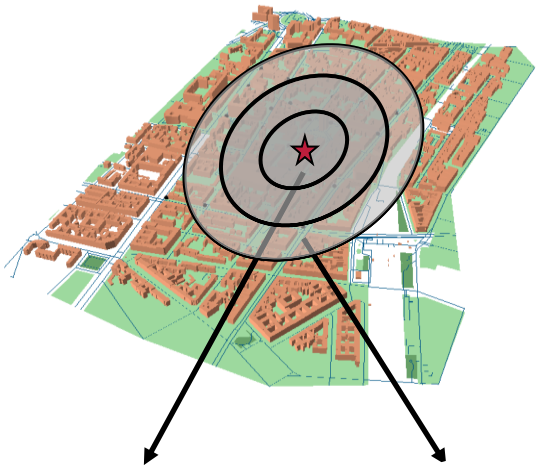
Fine dust – an urban system failure

www.inforadio.de/

Foto: imago/Christian Mang

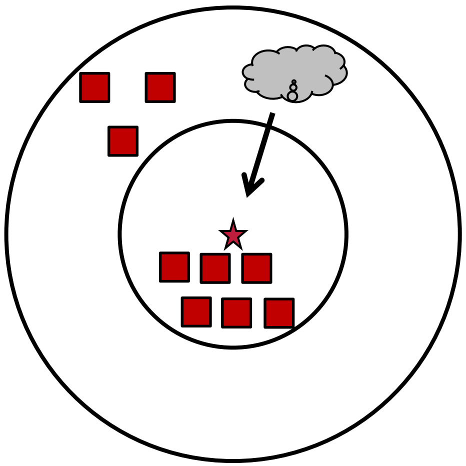
- Traffic generated fine and Ultra Fine Particles (UFP, 10nm - 420nm) significantly increase health risks in urban areas (WHO, 2013)
- brought to the focus by the Volkswagen emissions scandal (germ.: Dieselaffäre)
- Fast and preferably accurate now-cast of UFP is needed to plan, optimize, and evaluate counter measures
  - short term: smart traffic management system (diversion)
  - mid term: greenery
  - long term: urban planning
- Land Use Regression model (LUR)
  - geostatistical method
  - parameter extensive
  - easy to use
  - supports fast to instantaneous now-cast
  - useful for the implementation as a service

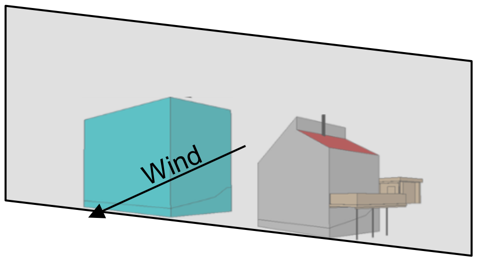
Modelling the urban fine dust distribution – the LUR approach



- Measuring the pollution concentration at a certain location
- Analyzing spatial parameters within certain buffers
- Determine the correlation between measured values and the parameters
- Performing an enhanced multilinear regression analysis (Henderson 2007, Ghassoun & Löwner 2017)
- We divide parameters representing
  - Production
  - Deposition
  - Dilution
    - the local wind field and therefore
    - the urban morphology

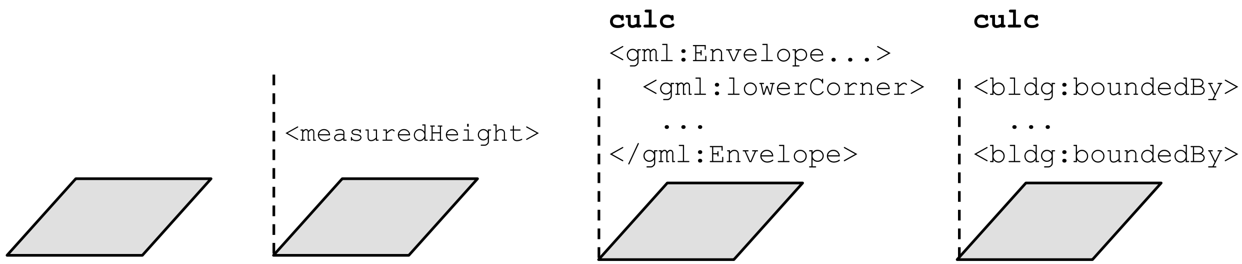
Estimated effects of LoD and buffer sizes on parameter correlation

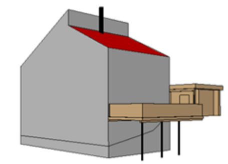




- Influence of buffer sizes on the correlation between parameter and measured values
  - averaging effect of the calculated parameter in large buffers
  - overestimation of effects (production) in close vicinity in small buffers
- Influence of LoD on the correlation between parameter an measured values
  - change of dimension when defining the parameter (from surface to volume to more volume)
  - different volume calculations because of f.i. building installations
  - different shape (including roof shape) of projected surface f.i. shielding the wind

Parameters and buffer widths



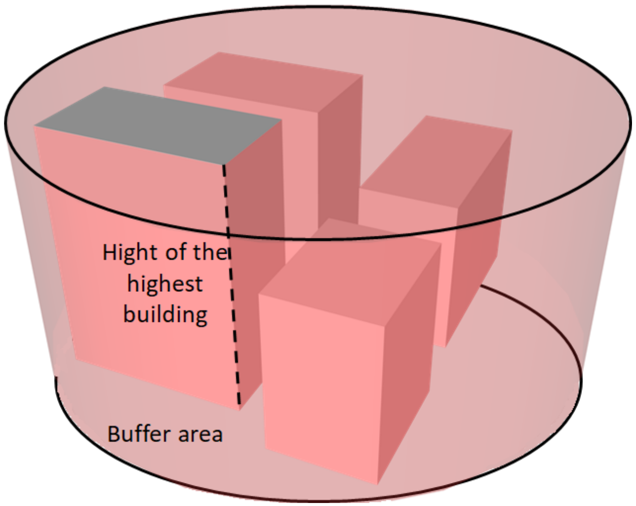


pic from Löwner et al. 2013

	LoD0	**LoD1** extruded using <measuredHeight>	**LoD1** extruded using LoD1 envelope height	**LoD1** extruded using LoD2 boundarySurfaces height	**LoD2**
averaged heights of buildings		X	X	X	
Height-width ratio		X	X	X	
Porosity	X	X	X	X	
Frontal Area Index	X	X	X	X	X
Building surfaces		X	X	X	X

Buffers from 50m and 100m, 200m,…1000m were analyzed, except for the frontal area index analysis (50m and 100m – 500m)

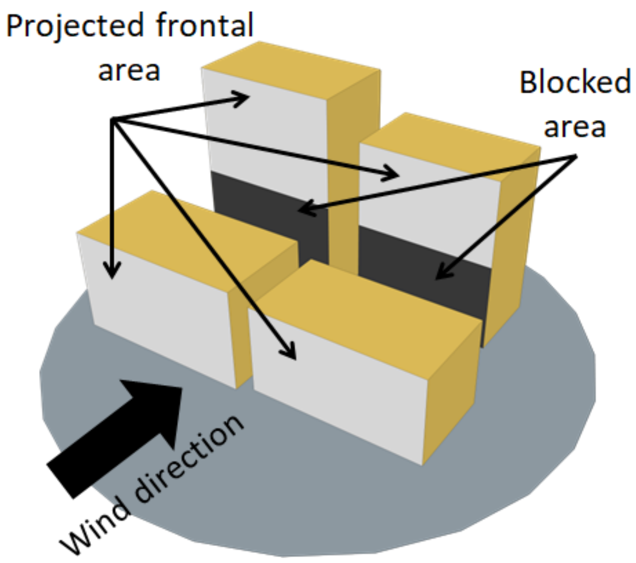
Porosity in 3D



- General information about the ventilation capacity of an area
  - descriptive parameter for the dilution capacity
  - high values should result in lower UFP values

1. Identify every building within a certain buffer
2. Get the height of the highest building in the buffer (according to different height information)
3. Calculate the volume of the 3D-buffer
4. Sum all the volumes of all the buildings within the buffer according to different height information
5. Calculate porosity

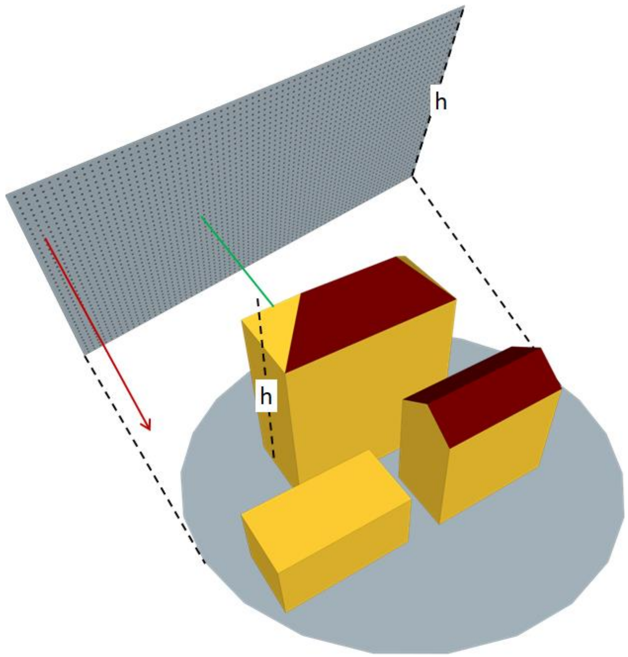
Frontal Area Index from LoD1



- Descriptive concept to describe the effect of buildings shielding the wind. The higher it is, the less the wind is expected to pass through an area.
  - descriptive parameters for the dilution capacity
  - low values should result in higher UFP values
- Area of the buffer divided by the total blocking area perpendicular to the wind direction of all buildings within a buffer (Frontal Area Surface)
- Represents the deteriorating ventilation effect
- Again, different height information was applied

- For LoD1: Calculated with the Urban Roughness Toolbox (ArcGIS 10.5) from René Burghard

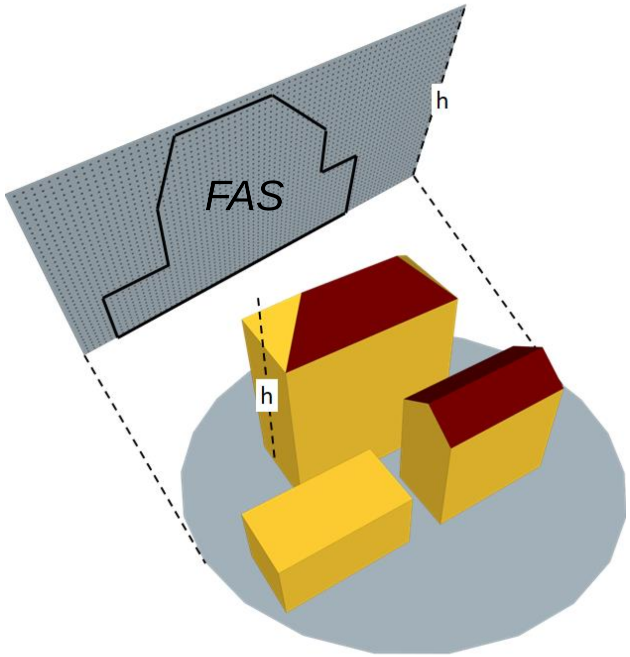
Frontal Area Index from LoD2



- Total blocking area perpendicular to the wind direction of all buildings within a buffer (Frontal area Surface) is expected to be represented in a more realistic way
- Correlation with UFP values should be better

1. Select all (LoD2) buildings in a corresponding buffer
2. Get all surfaces of all buildings within the buffer and cut them into triangles applying a fan triangulation
3. Create a point array with 1 m resolution, arranged perpendicular to the wind direction filling an area of the width of the buffer time the height of the highest building
4. Complete every point in the point array with a direction vector towards the wind direction
5. Compute revealing half ray line against every triangle applying the Möller-Trumbore intersection algorithm (Möller and Trumbore, 1997).

Frontal Area Index from LoD2



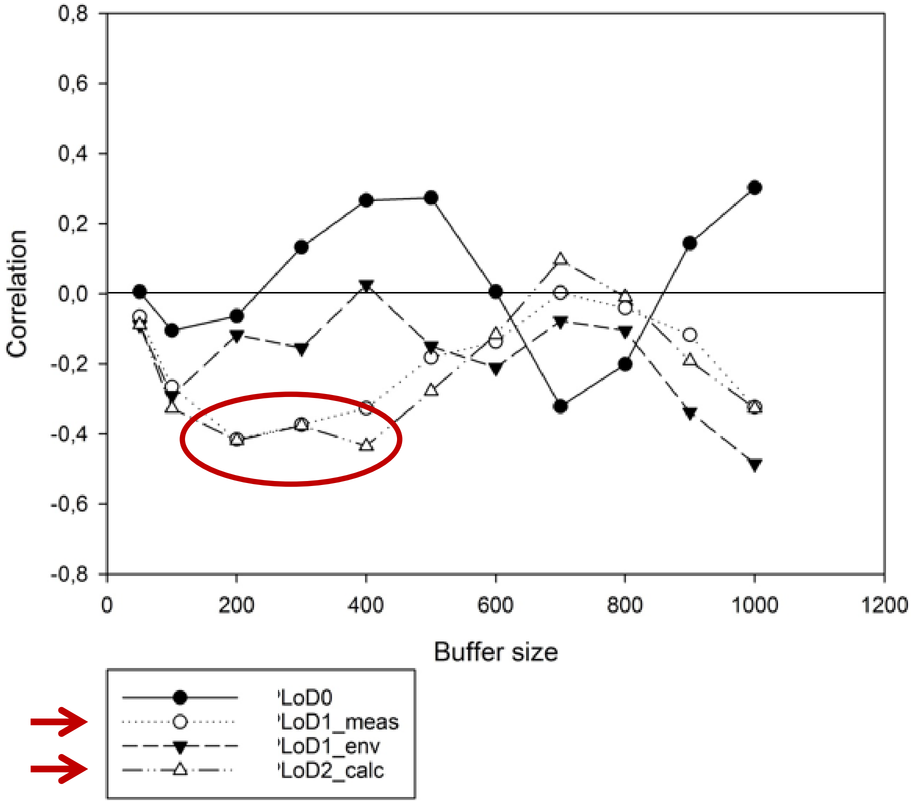
- Total blocking area perpendicular to the wind direction of all buildings within a buffer (Frontal area Surface) is expected to be represented in a more realistic way
- Correlation with UFP values should be better

1. Select all (LoD2) buildings in a corresponding buffer
2. Get all surfaces of all buildings within the buffer and cut them into triangles applying a fan triangulation
3. Create a point array with 1 m resolution, arranged perpendicular to the wind direction filling an area of the width of the buffer time the height of the highest building
4. Complete every point in the point array with a direction vector towards the wind direction
5. Compute revealing half ray line against every triangle applying the Möller-Trumbore intersection algorithm (Möller and Trumbore, 1997).

Research area and data

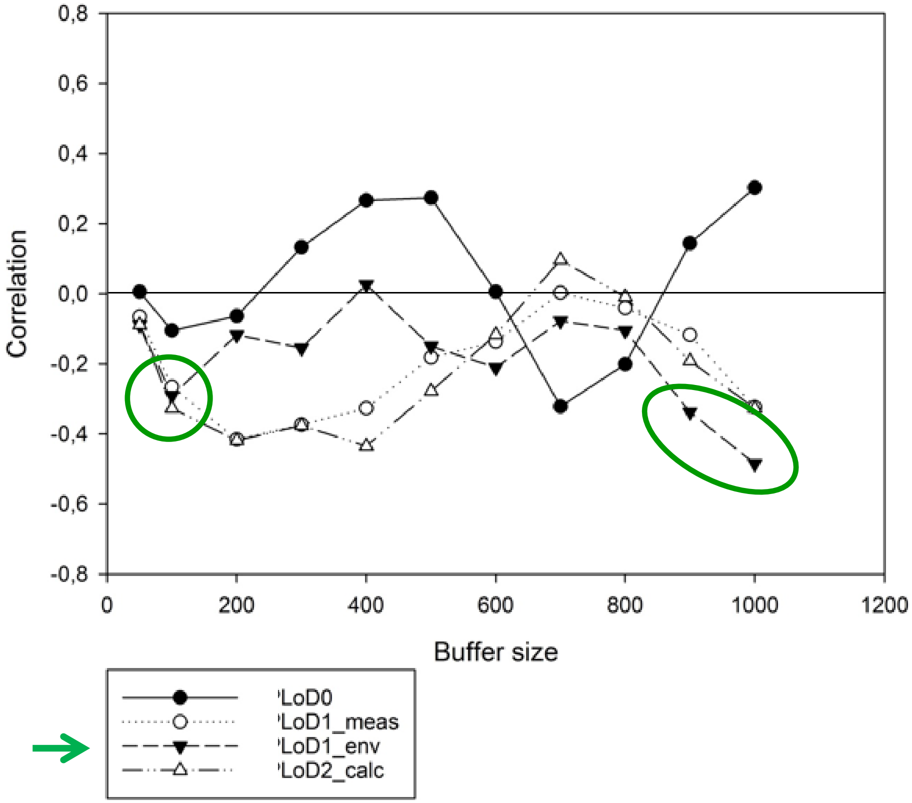
- Research Area: 1×2 km in Berlin, Germany
- 25 measuring points for Total number concentrations (TNC) with a hand-held particle counter device (TSI 3007) (size from 10 to about 1000 nm, range 0 to 100,000 particle per cm^3.
- CityGML data *(LoD1 and LoD2) from the open data portal of the city of Berlin (https://fbinter.stadt-berlin.de/fb/index.jsp)*
- *LoD0 representation was extracted from LoD1 data*
- Data extraction performed directly from CityGML files on pure Python scripting with no interconnected database or spatial packages
- Parameter calculation was performed either in ArcGIS for LoD0 and LoD1 representations or
- with self-programmed Python Scripts for LoD1 and LoD2 representations

Results on the Porosity



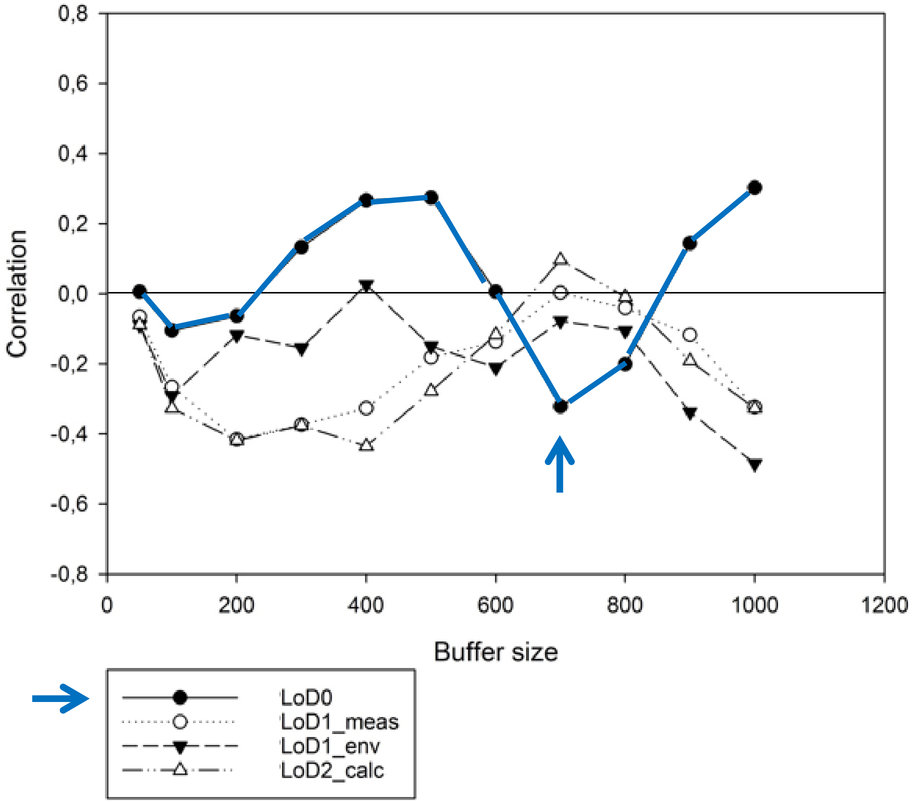
- 'Porosity': a **value of how penetrable** an are is for the wind
- Expected: negative correlation with high fine dust values
- Best performers: **LoD2_culc and Lod1_meas** showing parallel behaviour with an high negative correlation of approx. *0.435 in 200m-400m buffers*

Results on the Porosity



- 'Porosity': a **value of how penetrable** an are is for the wind
- Expected: negative correlation with high fine dust values
- Best performers: **LoD2_culc and Lod1_meas** showing parallel behaviour with an high negative correlation of approx. *0.435 in 200m-400m buffers*
- **LoD1_env** shows expected high negative correlations only in a buffer of 100m, 900m, and 1000m

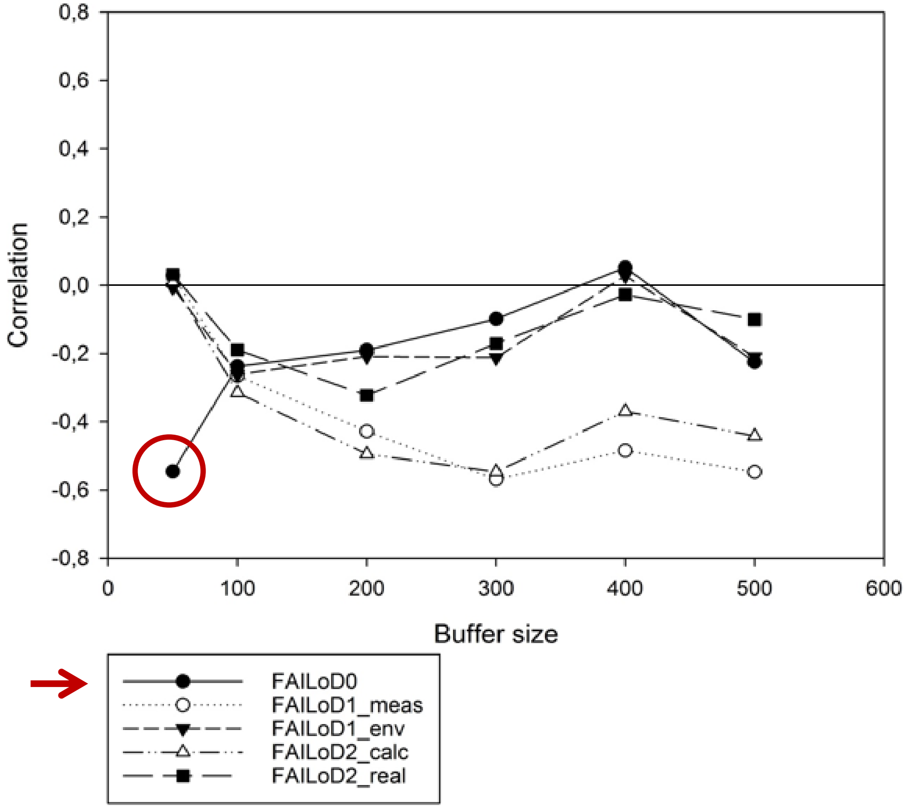
Results on the Porosity



- 'Porosity': a **value of how penetrable** an are is for the wind
- Expected: negative correlation with high fine dust values

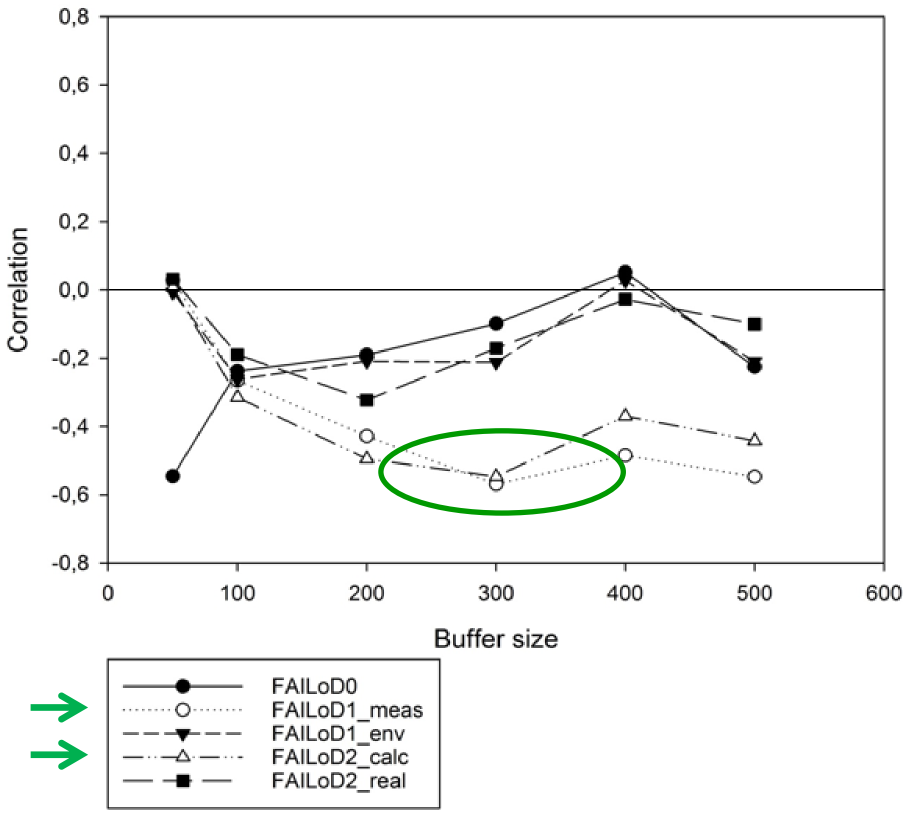
- Best performers: **LoD2_culc and Lod1_meas** showing parallel behaviour with an high negative correlation of approx. *0.435 in 200m-400m buffers*
- **LoD1_env** shows expected high negative correlations only in a buffer of 100m, 900m, and 1000m
- **LoD0** seems not to perform, even correlation in buffer of 700m is not really high

Results on the Frontal Area Index



- 'Frontal Area Index': a **value of the deteriorating ventilation** effect through wind shielding surfaces
- Expected: **negative correlation** with high fine dust values (because of using its reciprocal)
- Best performer: **LoD0** showing highest negative correlation in a 50m buffer but bad correlations in other buffers

Results on the Frontal Area Index

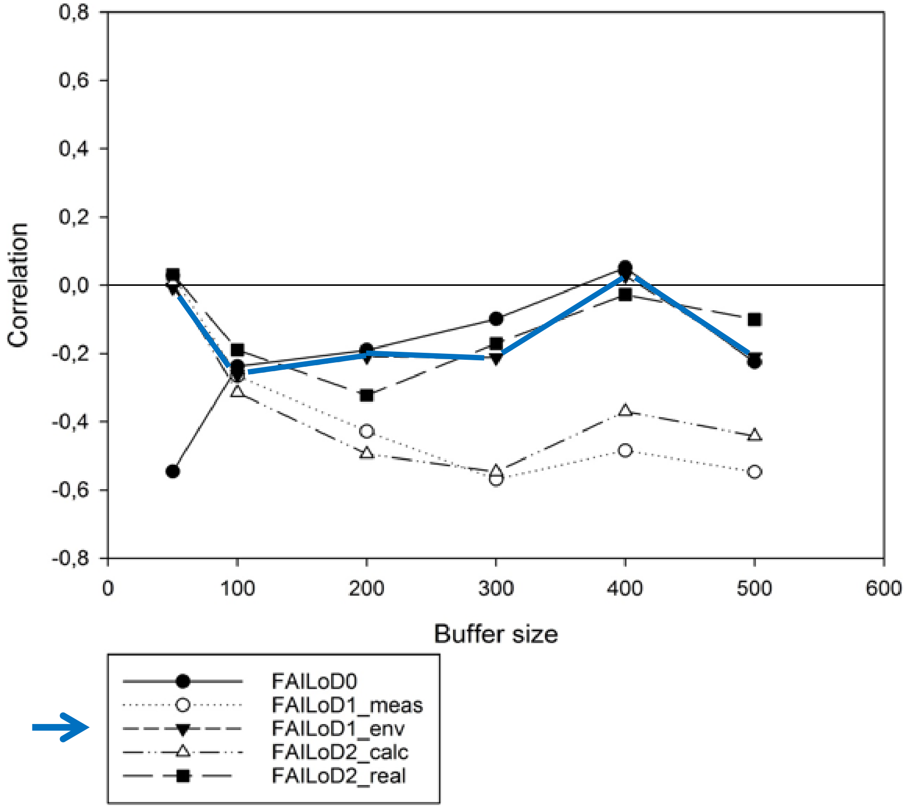


- ‘Frontal Area Index’: a **value of the deteriorating ventilation** effect through wind shielding surfaces
- Expected: **negative correlation** with high fine dust values (because of using its reciprocal)
- Best performer: **LoD0** showing highest negative correlation in a 50m buffer but bad correlations in other buffers
- Good performers: **LoD2_culc and Lod1_meas** again showing parallel behaviour with an high negative correlation of approx. 0.56 in a 300m buffer

Technische Universität Braunschweig

igp

Results on the Frontal Area Index



- 'Frontal Area Index': a **value of the deteriorating ventilation** effect through wind shielding surfaces
- Expected: **negative correlation** with high fine dust values (because of using its reciprocal)

- Best performer: **LoD0** showing highest negative correlation in a 50m buffer but bad correlations in other buffers
- Good performers: **LoD2_culc and Lod1_meas** again showing parallel behaviour with an high negative correlation of approx. 0.56 in a 300m buffer
- Non performer: **LoD1_env** shows weak correlation over all buffer sizes

Conclusion

- Influence of buffer sizes and different LoD representations on the correlation between parameter and measured values
- Target: We need the smallest buffer and the simplest data representation possible to fasten our modelbuilding in the context of Web-services
- Mainly focusing on parameters representing dilution processes
  - Porosity
  - Frontal area index
- LoD1 models extruded from LoD1 `<measuredHeight>` and LoD2 `<bldg:boundedBy>` calculation showed almost parallel behavior
- Best performers are found along all different LoD representation, except LoD1 extruded from LoD1 `Envelope calculation`
- General statements for best performing buffer sizes cannot be made
- Work should be extended in terms of different urban system (compare more cities)

Thank you for your attention…

Bedankt voor je aandacht!

Heb je vragen?
schrijf dan een e-mail: m-o.loewner@tu-bs.de

Get the paper:

https://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/IV-4-W6/41/2018/isprs-annals-IV-4-W6-41-2018.pdf

Related Topics:

Ghassoun, Y., Löwner, M.-O. (2017): Land use regression models for total particle number concentrations using 2D, 3D and semantic parameters, Atmospheric Environment. PDF

Ghassoun, Y. & Löwner, M.-O. (2017): Comparison of 2D & 3D parameter-based models in urban fine dust distribution modelling. In: A. Abdul-Rahman (ed.), Advances in 3D Geoinformation, Lecture Notes in Geoinformation and Cartography, DOI 10.1007/978-3-319-25691-7_13, 2017, 231-246. PDF

Löwner, M.-O., Gröger, G., Benner, J., Biljecki, F., and Nagel, C. (2016): Proposal for a new LoD and multi-representational concept for CityGML, ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-2/W1, 3-12, doi:10.5194/isprs-annals-IV-2-W1-3-2016. PDF