Determination of atmospheric aerosol particles using digital photography

University of Natural Resources and Applied Life Sciences, Vienna
Department of Water, Atmosphere and Environment
Institute of Meteorology (BOKU-Met)

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Institute of Meteorology and Climatology (BOKU-Met)

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Overview

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Department of Water, Atmosphere and Environment
Institute of Meteorology (BOKU-Met)

1. Motivation and Background
2. Research Question
3. Topic
4. Hypotheses
5. Material and Methods
6. Results and Discussion
7. Conclusion and Outlook

1. Motivation and Background

29.09.2018

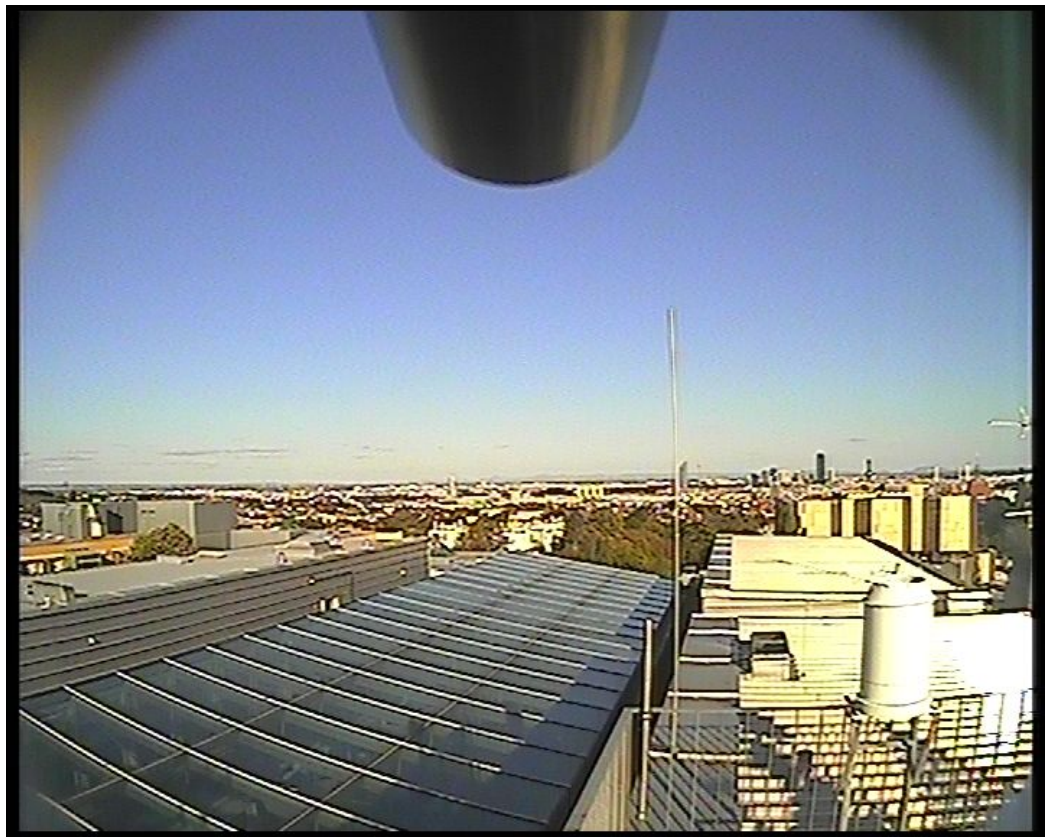


Fig. 1: Webcam image direction 74°, unpolluted day

19.10.2018

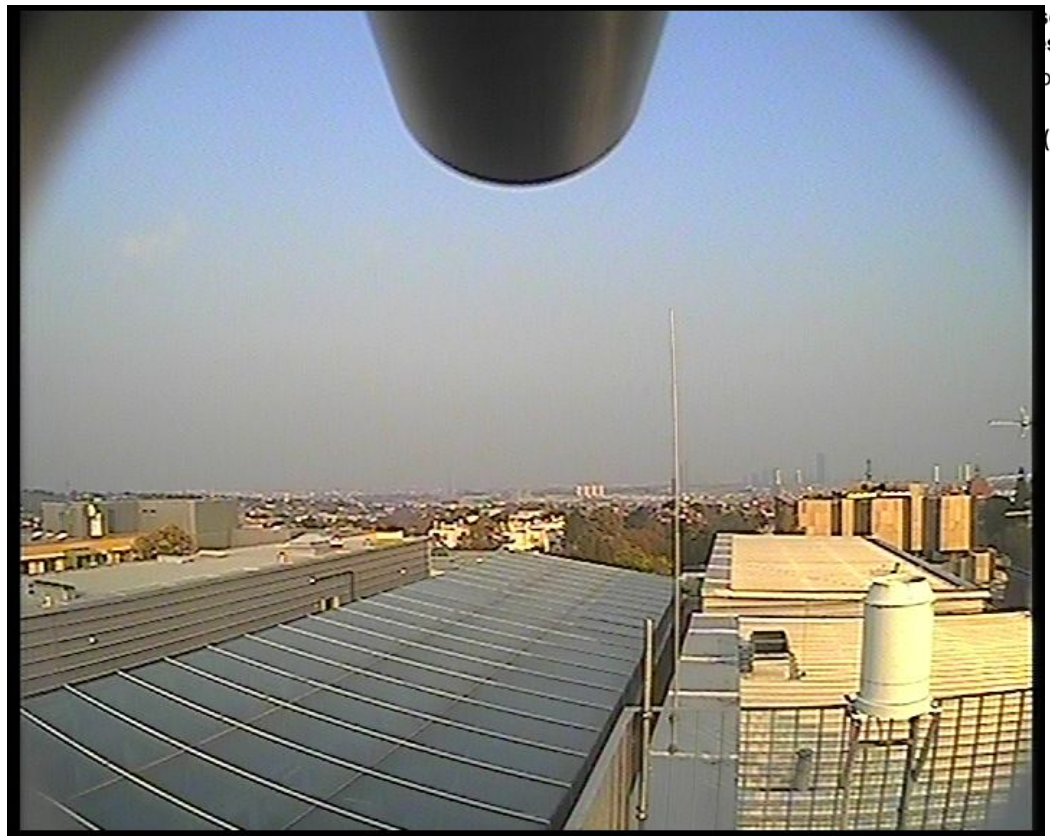


Fig. 2: Webcam image direction 74°, polluted day

2. Research Question

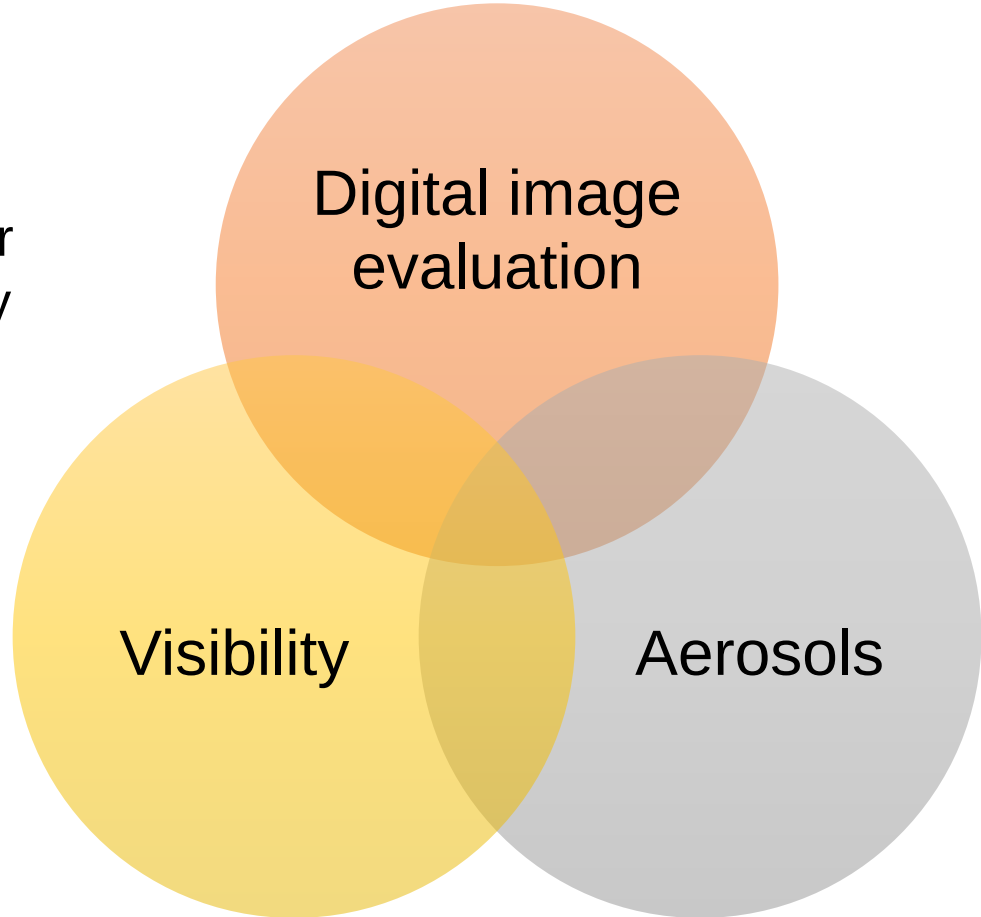
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Is it possible to determine atmospheric aerosol particles by means of digital photography?

3. Topic

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Malm et al., 2018:
Use of cameras for monitoring visibility impairment



Carretas et al., 2015:
Atmospheric visibility and Angström exponent measurements through digital photography

4. Hypotheses

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The difference in contrast in a horizontal line can be used to determine aerosol amounts in the atmosphere.

The difference in the ratio of blue to red in a vertical line can be used to determine the aerosol amounts in the atmosphere.

The difference in the ratio of blue to red in a horizontal line can be used to determine the aerosol amounts in the atmosphere.

5. Material and Methods (1)

Data:

- Webcam Images – BOKU MAX-DOAS

  Standard resolution mini bullet camera
  Bosch VTC-204F03-3
  Study Period 01.05.2017 to 30.04.2019
  2 Directions: 74° and 213°

- AOD – Cimel Sun Photometer AERONET
- PM10 – Umweltbundesamt und Amt der Wiener Landesregierung
- Global Radiation, Relative Humidity – BOKU Weather Station

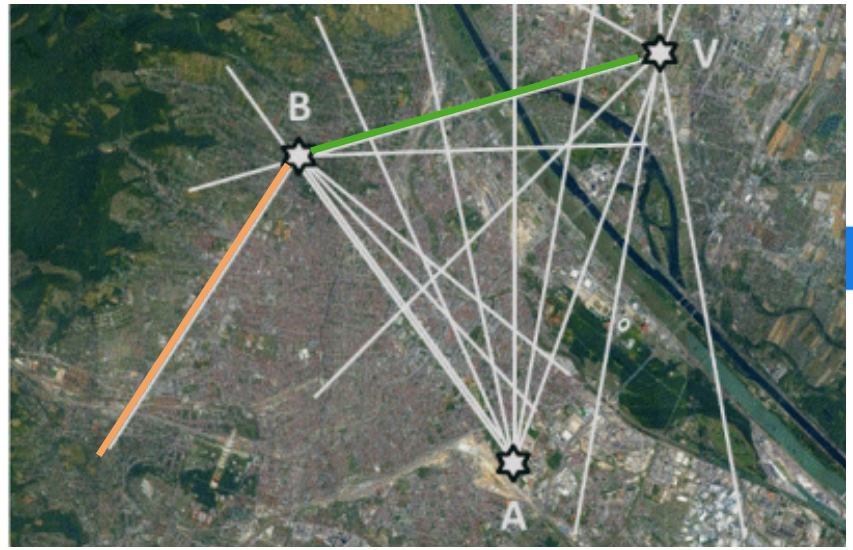


Fig. 3: Webcam directions MAX-DOAS



Fig. 4: Webcam

5. Material and Methods (2)

Data:

- Webcam Images – BOKU MAX-DOAS
  - Standard resolution mini bullet camera
  - Bosch VTC-204F03-3
  - Study Period 01.05.2017 to 30.04.2019
  - 2 Directions: 74° and 213°
- AOD – Cimel Sun Photometer AERONET
- PM10 – Umweltbundesamt und Amt der Wiener Landesregierung
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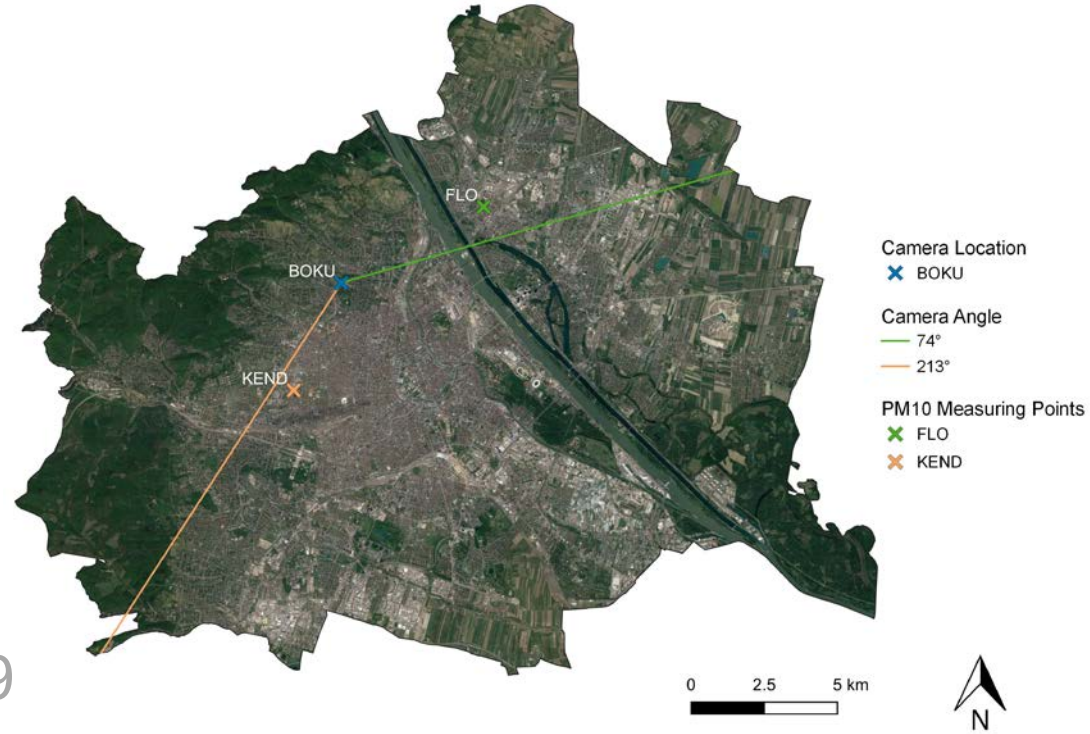
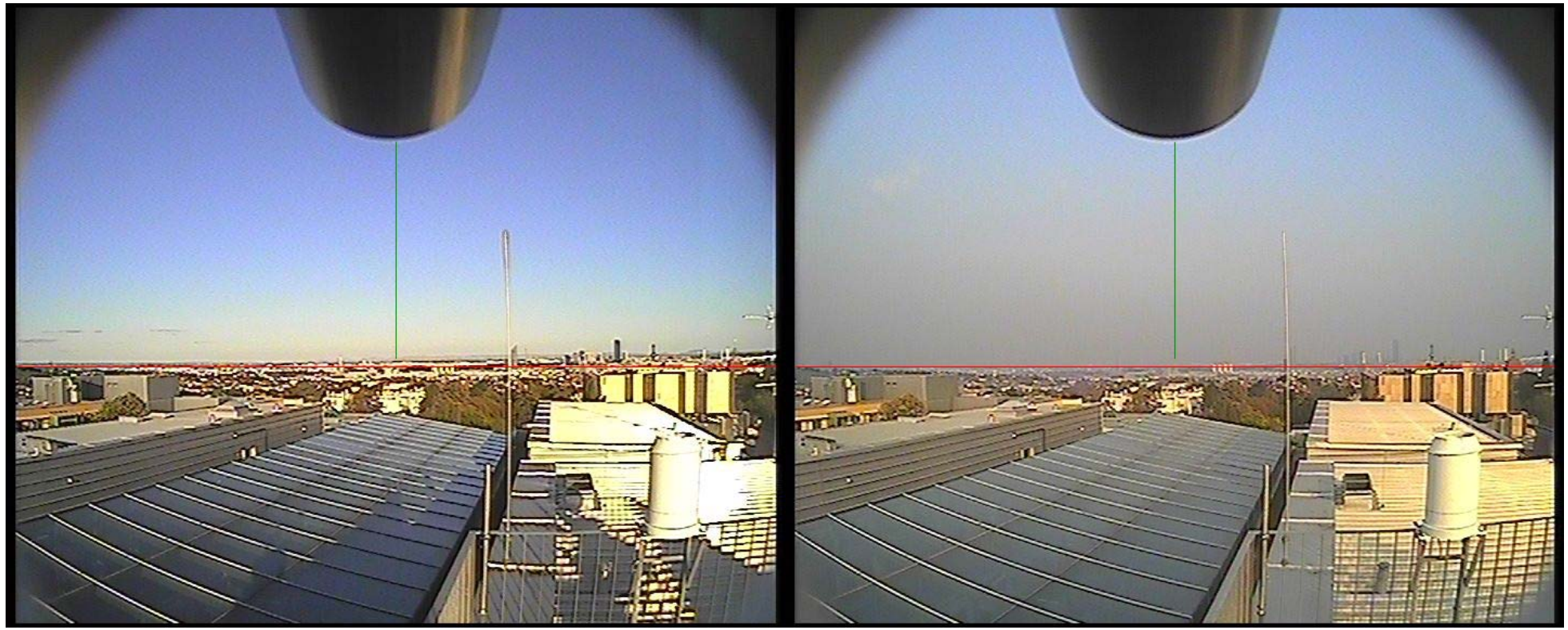


Fig. 5: Map of web cam image directions 74° and 213° and corresponding PM10 measuring points Floridsdorf (FLO) and Kendlerstraße (KEND).

5. Material and Methods (3) – Direction 74°

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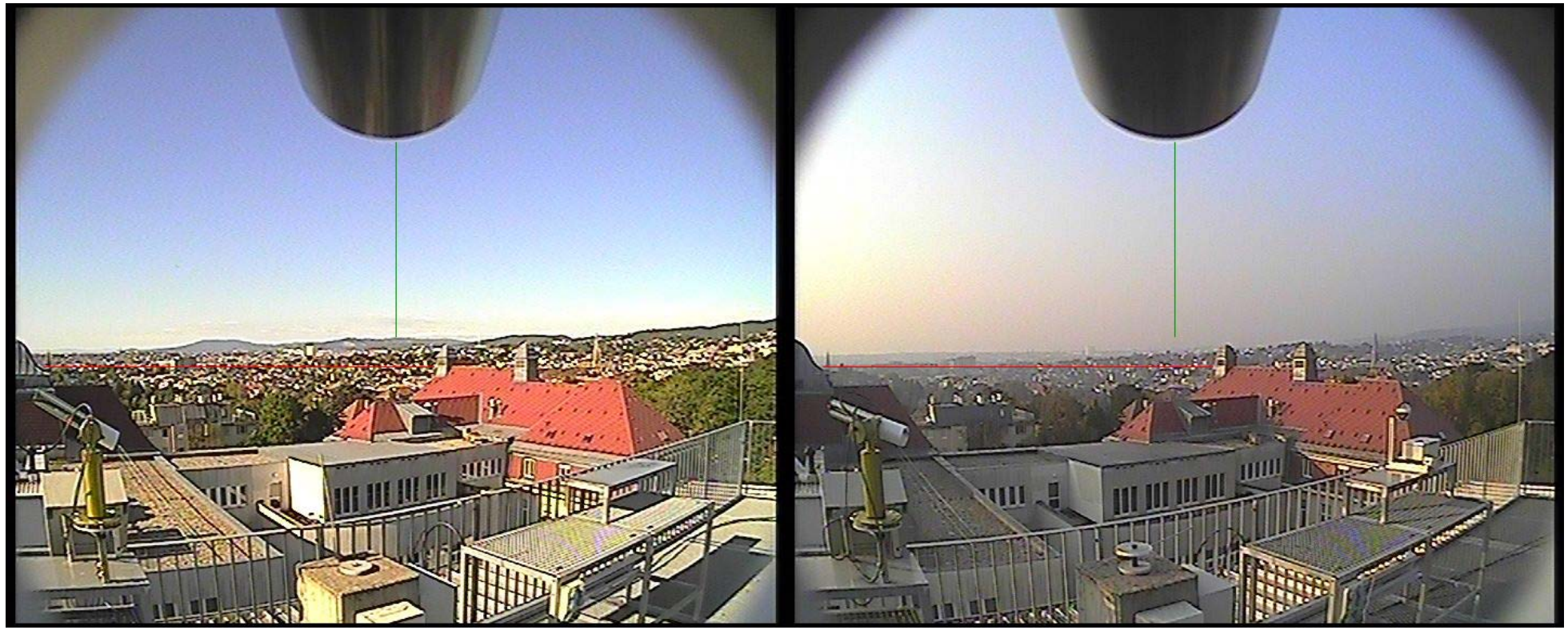


(a) (b)

Fig. 6: Direction 74° vertical (green) and horizontal (red) pixel lines. (a) unpolluted day 29.09.2018. (b) polluted day 19.10.2018.

5. Material and Methods (4) – Direction 213°

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(a) (b)

Fig. 7: Direction 213° vertical (green) and horizontal (red) pixel lines. (a) unpolluted day 14.05.2017. (b) polluted day 19.10.2018.

5. Material and Methods (5)

Only Clear Sky Days

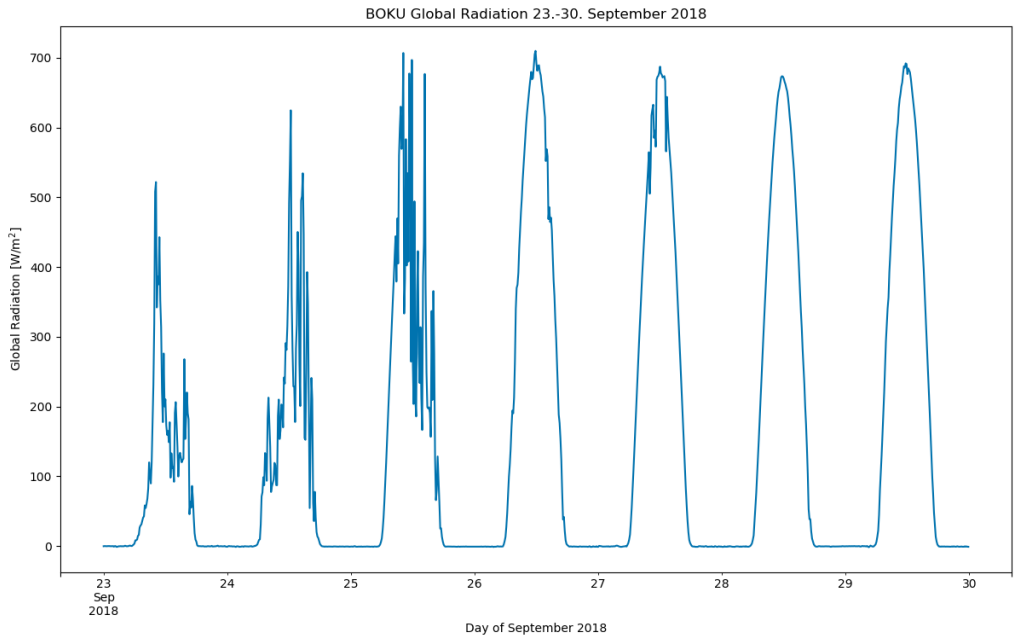


Fig. 8: Global Radiation example, 23.-30. September 2018

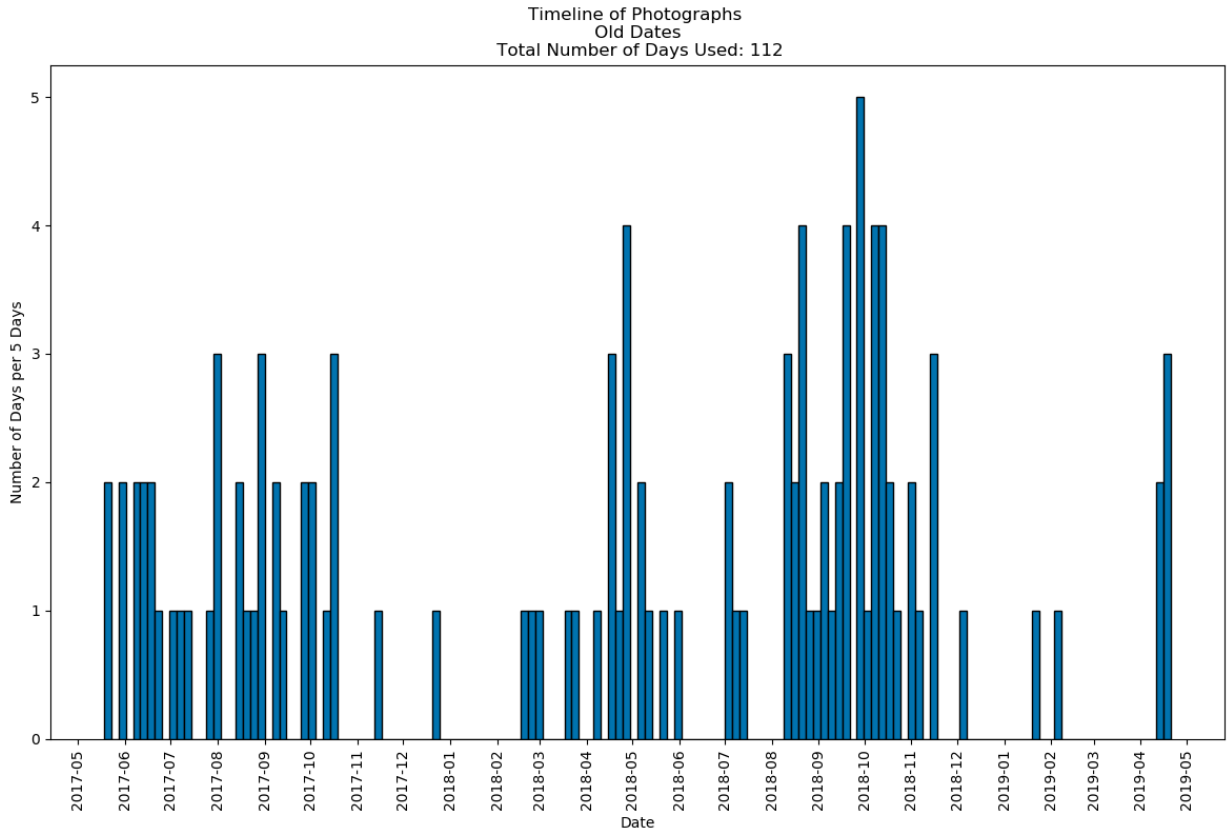


Fig. 9: Timeline of used photographs of the first selection of dates

5. Material and Methods (6)

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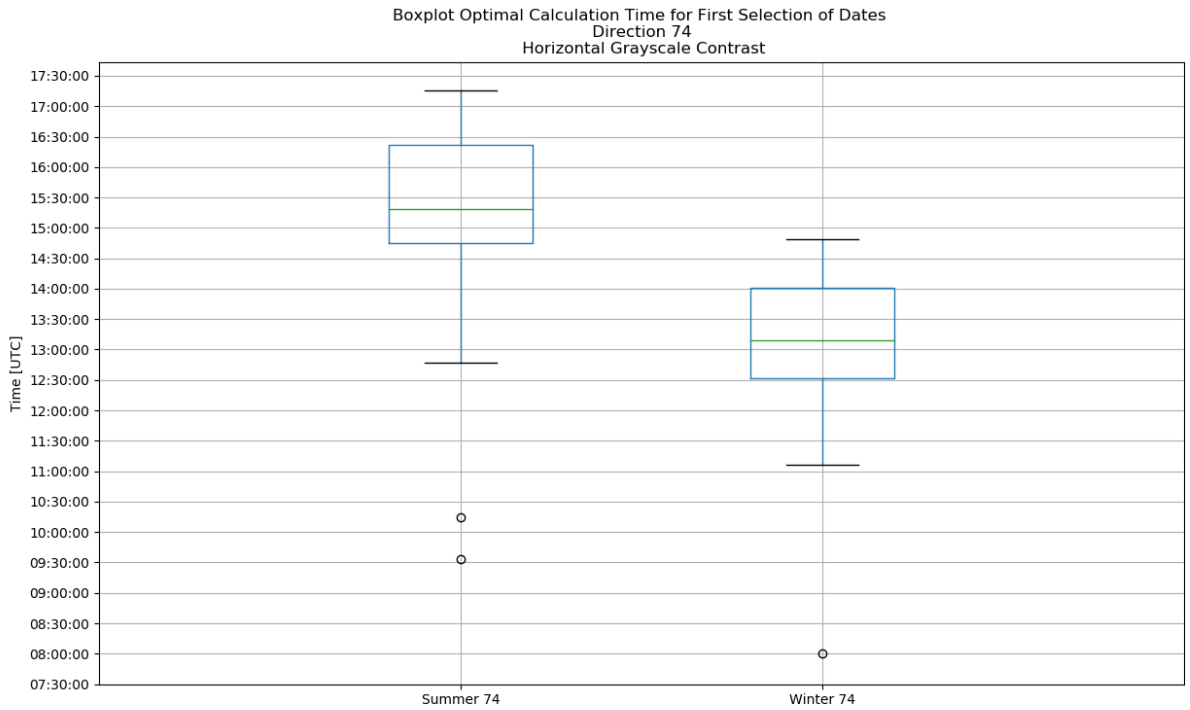


Fig. 10: Boxplots for optimal calculation time for first selection of dates in direction 74° for horizontal grayscale contrast for summer and winter time

25% and 75% Quantile as boundary or more narrow

e.g. Direction 74° horizontal grayscale:

Table 1: Selection of optimal calculation time for first selection of dates in direction 74° for horizontal grayscale contrast for summer and winter time

Summer	Start	14:45:02 UTC
	End	16:22:19 UTC
Winter	Start	12:31:49 UTC
	End	14:00:34 UTC

5. Material and Methods (5)

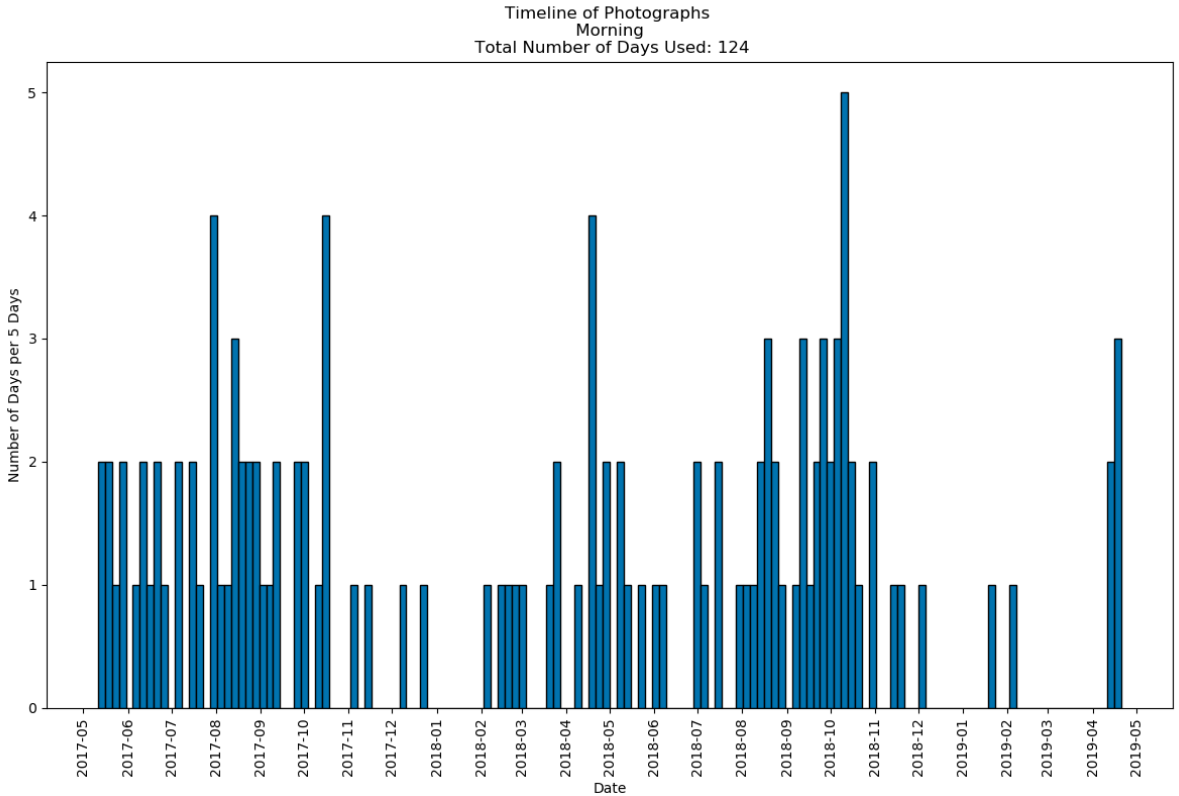


Fig. 11: Timeline of used photographs of the second selection morning dates

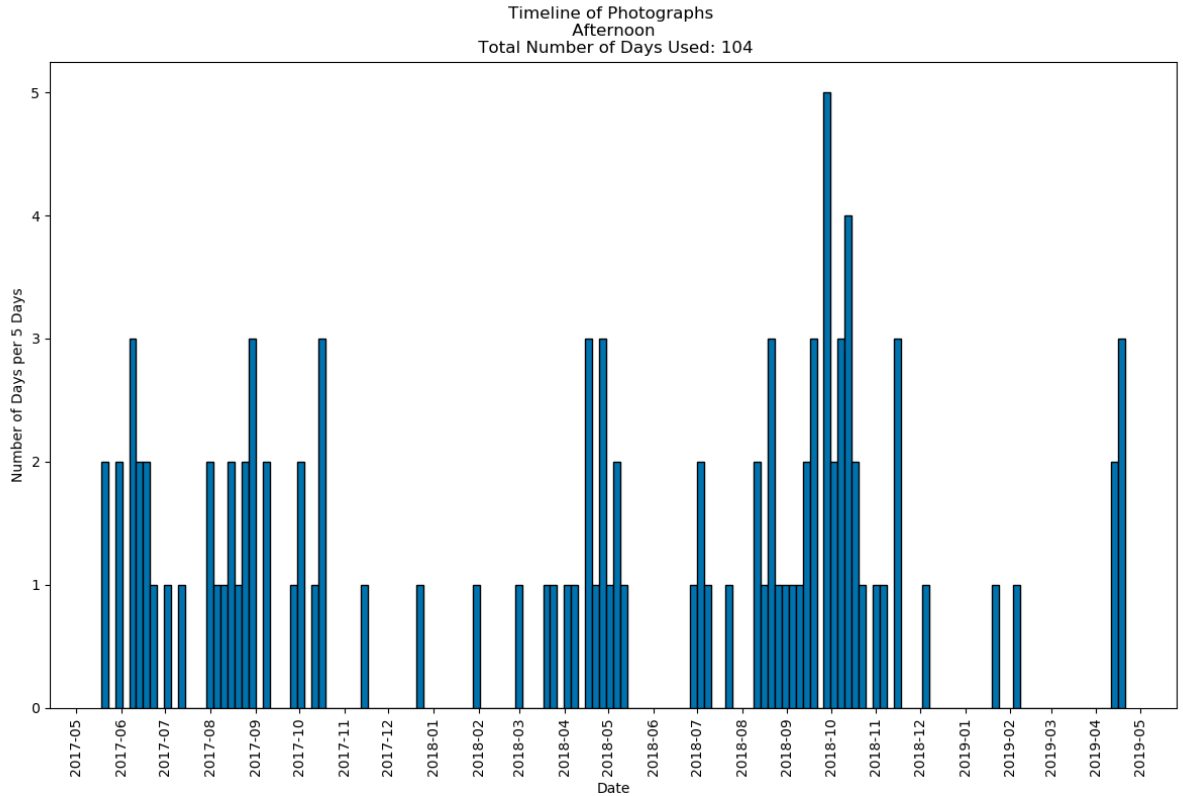


Fig. 12: Timeline of used photographs of the second selection afternoon dates

6. Results and Discussion (1)

Table 2: Optimal calculation time, direction 74°, horizontal grayscale contrast, winter, first and second selection.

First Selection	Start	12:31:49 UTC
	End	14:00:34 UTC
Second Selection	Start	12:41:57 UTC
	End	14:05:36 UTC

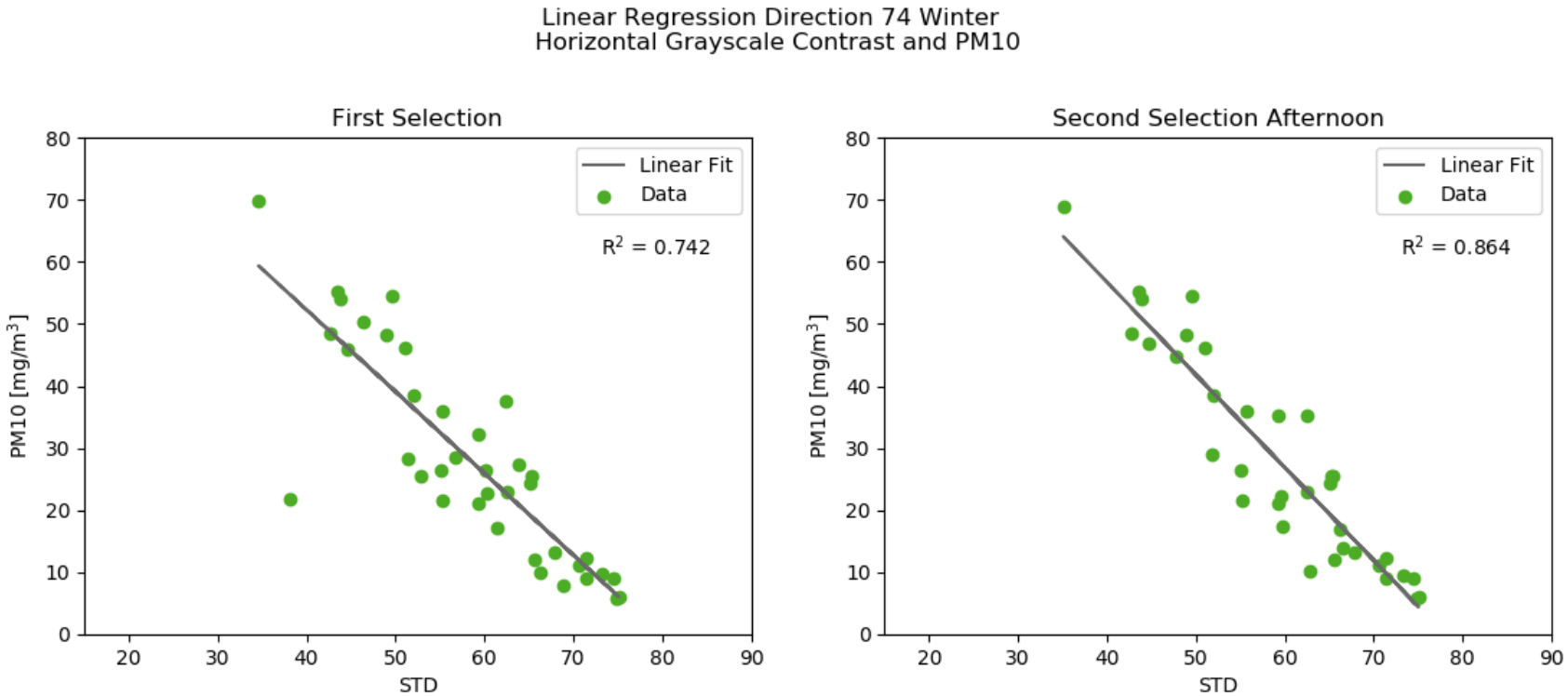


Fig. 13: Simple linear regression between the horizontal grayscale standard deviation and PM10 in direction 74°; winter months; First selection (left) where R^2 = 0.742 and second selection afternoon (right) where R^2 = 0.864

6. Results and Discussion (2)

Table 3: Optimal calculation time, direction 74°, vertical B:R ratio, summer, first and second selection.

First Selection	Start	04:47:21 UTC
	End	09:51:39 UTC
Second Selection	Start	04:44:44 UTC
	End	08:36:57 UTC

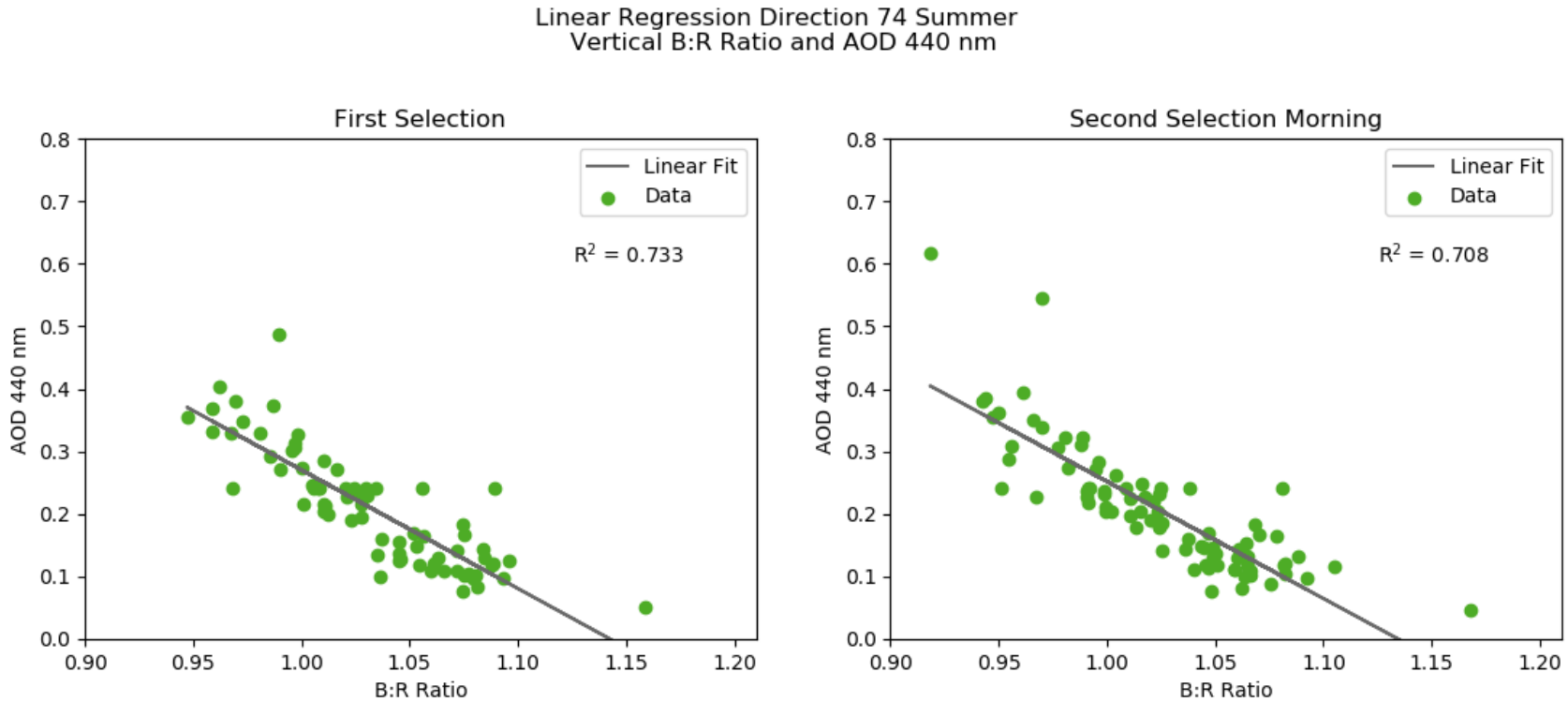


Fig. 14: Simple linear regression between the vertical B:R ratio and AOD 440 nm in direction 74; summer months; First selection (left) where R^2 = 0.733 and second selection morning (right) where R^2 = 0.708.

6. Results and Discussion (3)

Table 4: Optimal calculation time, direction 213°, vertical B:R ratio, summer, first and second selection.

First Selection	Start	08:30:12 UTC
	End	12:50:04 UTC
Second Selection	Start	09:44:50 UTC
	End	12:07:55 UTC

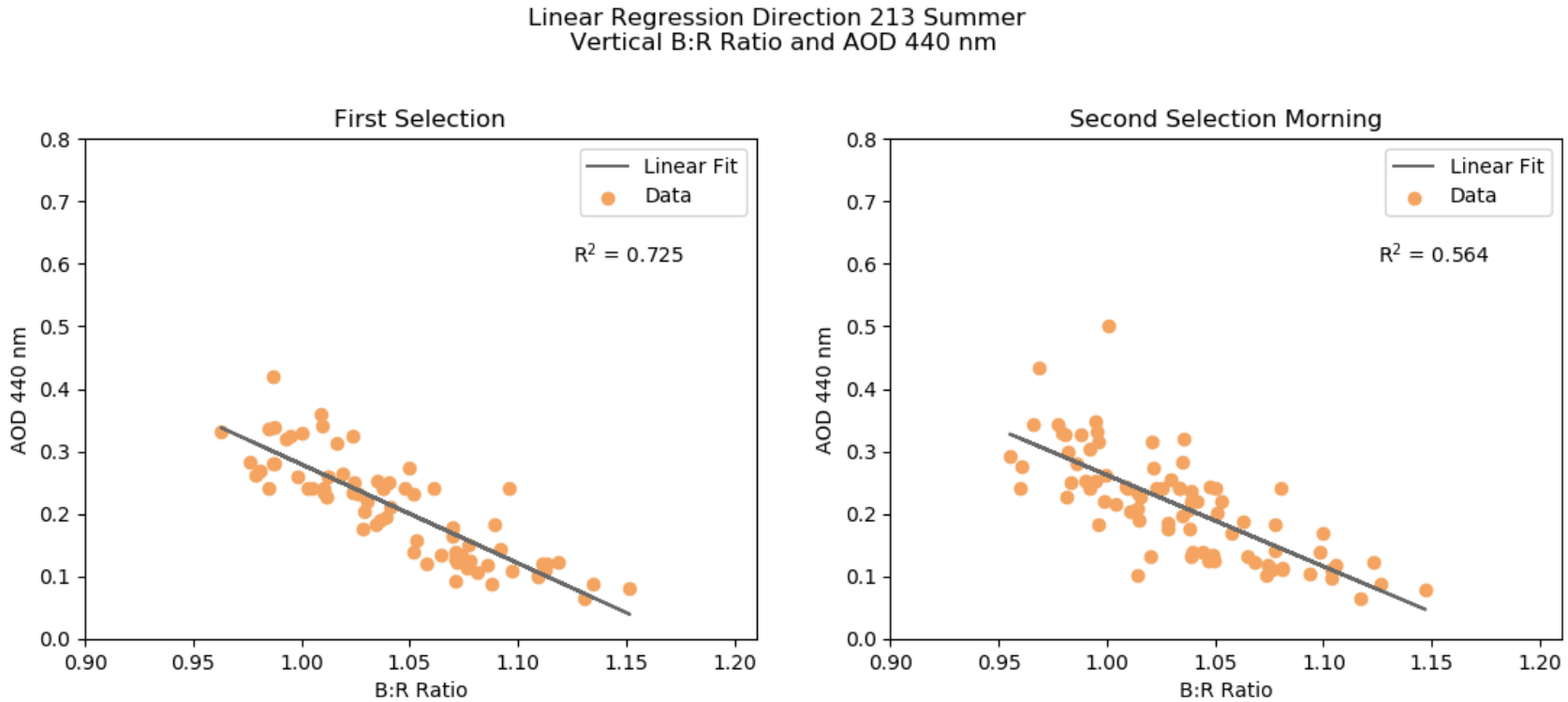


Fig. 15: Simple linear regression between the vertical B:R ratio and AOD 440 nm in direction 213°; summer months; First selection (left) where R2 = 0.725 and second selection morning (right) where R2 = 0.564.

7. Conclusion and Outlook (1)

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Table 5: Overview results R^2

			AOD 440 nm		PM10	
			First Selection	Second Selection	First Selection	Second Selection
74°	Vertical B:R	Summer	0.733	0.708	0.103	0.123
	Horizontal Grayscale Contrast	Summer	0.135	0.265	0.317	0.4
		Winter	0.609	0.653	0.742	0.864
213°	Vertical B:R	Summer	0.725	0.564	0.079	0.042
	Horizontal Grayscale Contrast	Summer	0.175	0.258	0.004	0.075
		Winter	0.345	0.432	0.286	0.359

7. Conclusion and Outlook (2)

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- Water vapor plays important role → Multiple linear regression with RH
- Automatic selection of clear sky days
- Model to make approximations of PM10 and AOD values

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Thank you for your attention!

Any questions?

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Master’s thesis seminar WS 2019/20

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References

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Malm, W., Cismoski, S., Prenni, A., Peters, M., 2018. Use of cameras for monitoring visibility impairment. Atmospheric Environment 175, 167–183. https://doi.org/10.1016/j.atmosenv.2017.12.005