Validation examples of ATCOR haze removal of Rapid-Eye images

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Outline

1. Introduction
2. AOT validation
3. Validation of deHazing
4. Outlook
5. Summary

References:

1. Richter, R., Schläpfer, D., & Müller, A. (2006), An automatic atmospheric correction algorithm for visible / NIR imagery, International Journal of Remote Sensing, 27(10), 2077–2085, doi:10.1080/01431160500486690
2. Pflug, B., (2012), Ground based measurements of aerosol properties using Microtops instruments, AIP Conf. Proc. 1531, 588 (2013); doi: 10,1063/1,4804838, View online: http://dx.doi.org/10.1063/1.4804838
3. Makarau, Aliaksei und Richter, Rudolf und Müller, Rupert und Reinartz, Peter (2014) Haze detection and removal in remotely sensed multispectral imagery. IEEE Transactions on Geoscience and Remote Sensing, 52 (9), Seiten 5895-5905. IEEE Xplore. DOI: 10.1109/TGRS.2013.2293662. ISSN 0196-2892.

Motivation

- Atmospheric correction of satellite data is necessary for many applications of remote sensing.
- Application of atmospheric correction algorithms requires knowledge about the uncertainty of the correction process.

Validation procedure and Test sites

(total 16 samples)

Validation procedure:

- ground-based sunphotometer measurements in parallel to satellite overpasses
  - In-situ vertical column AOT-spectra
    → reference AOT@550 nm
- Processing the satellite images with ATCOR
  → ATCOR-AOT@550 nm
- Comparison of ATCOR-AOT@550 nm with reference AOT@550 nm

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Algorithm for ground-based data

- Coupled analysis of sunphotometer and ozonometer measurements

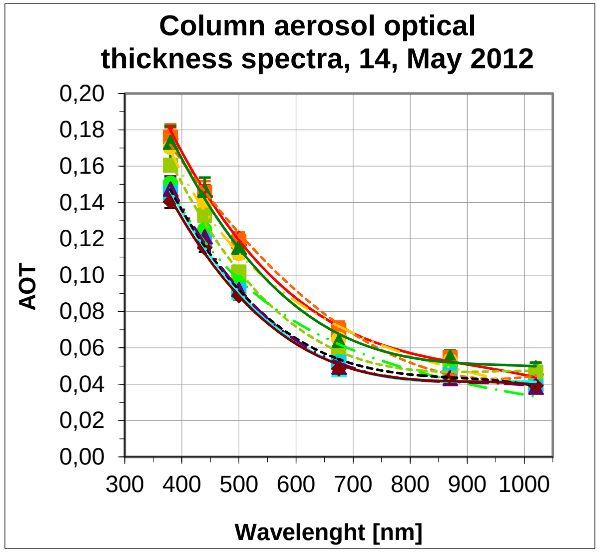
[Pflug, B., (2012)]

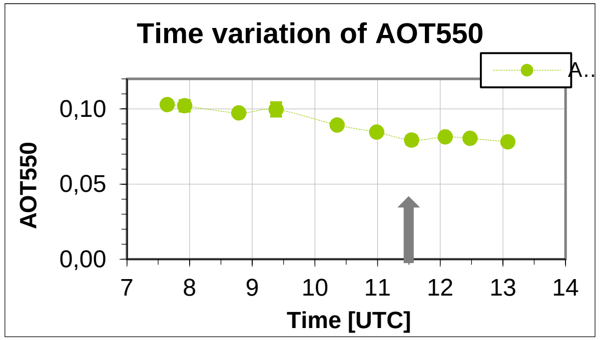
- Results:

  Vertical column
  - AOT-spectra -> AOT550 -> VIS
  - Ångstrœm-exponent α $\{ \tau_\lambda = \tau_{1\,\mu m} \cdot \lambda^{-\alpha} \}$

Aerosol type	Ångstrœm-exponent α	
	at RH 99%	at RH 0%
Maritime model	0.07	0.56
Rural model	1.13	1.54
Urban model	1.00	1.44
Desert model	-0.1 (wind 30 m/s)	1.6 (wind 0 m/s)

  - Effective particle radius [µm]
  - ozone content [DU]
  - water vapour content [cm precipitable water column]

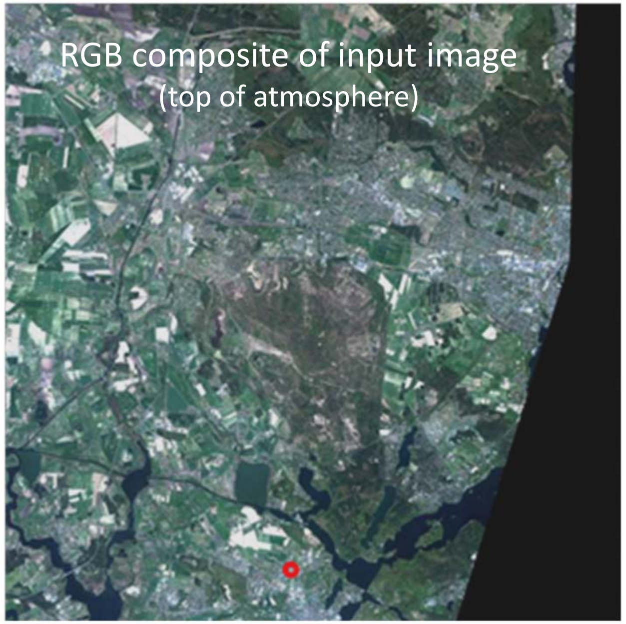




Processing of RapidEye data

input

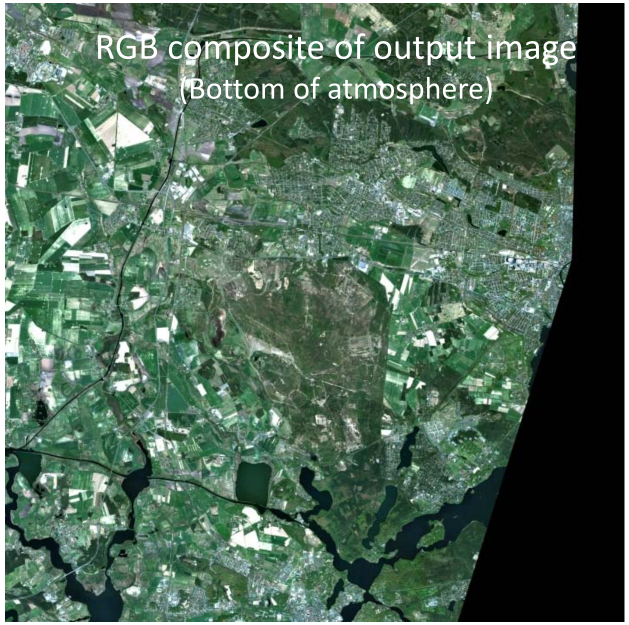
output



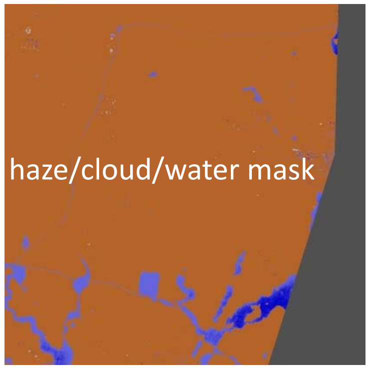
ATCOR2

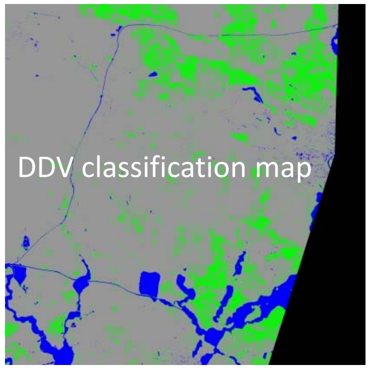
[Richter, R. et.al., (2012)]

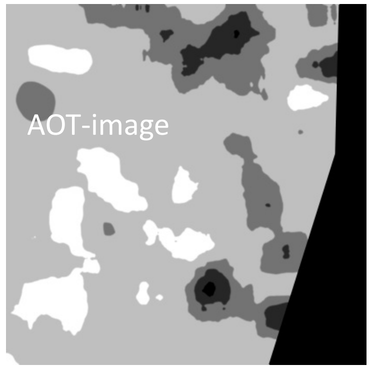
Rural atmosphere



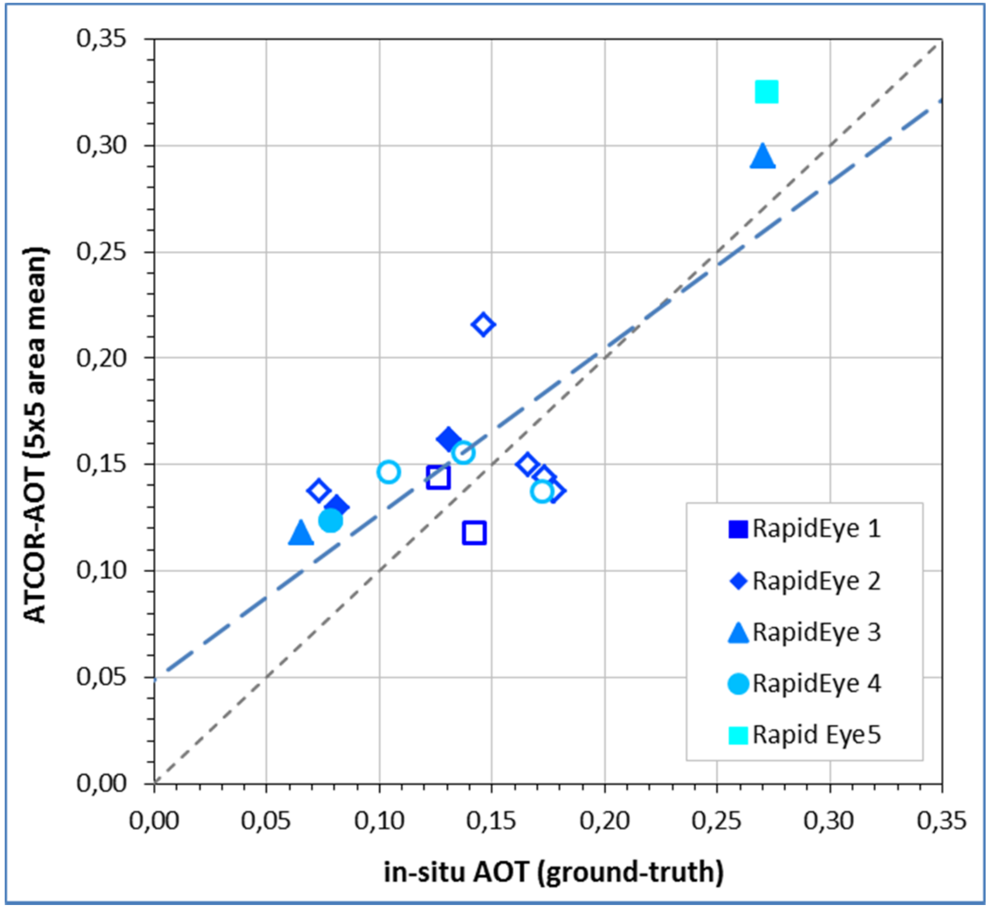
Red circle marks the sunphotometer location (Test site Potsdam Bornstedt).







ATCOR AOT (Tile average) <-> ground-truth AOT

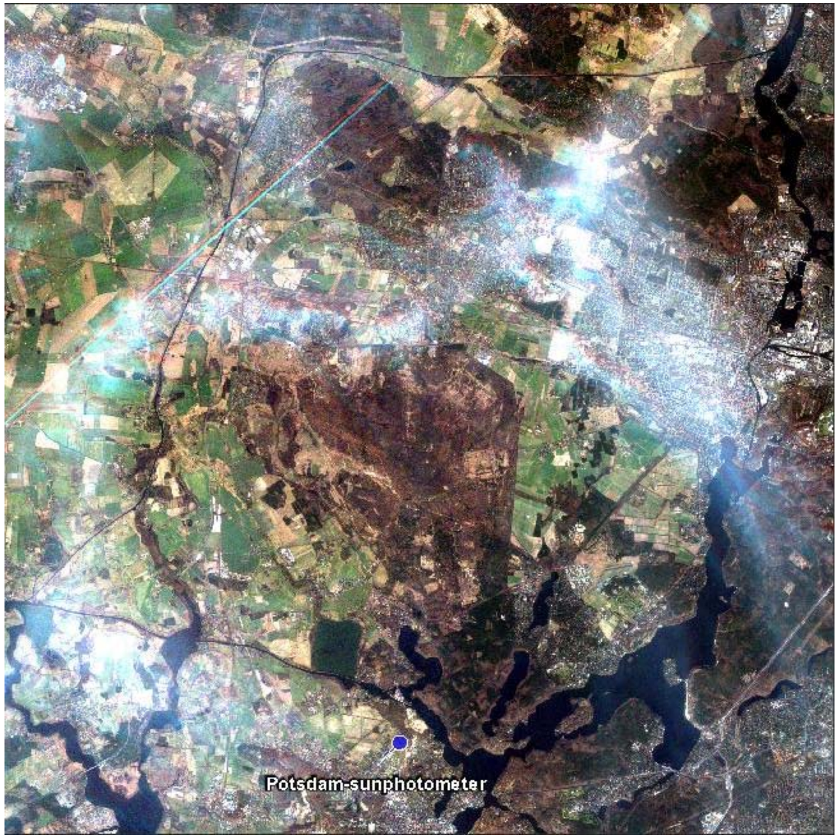


Filled points: cloudiness > 1%
Unfilled points: cloudiness ≤1%

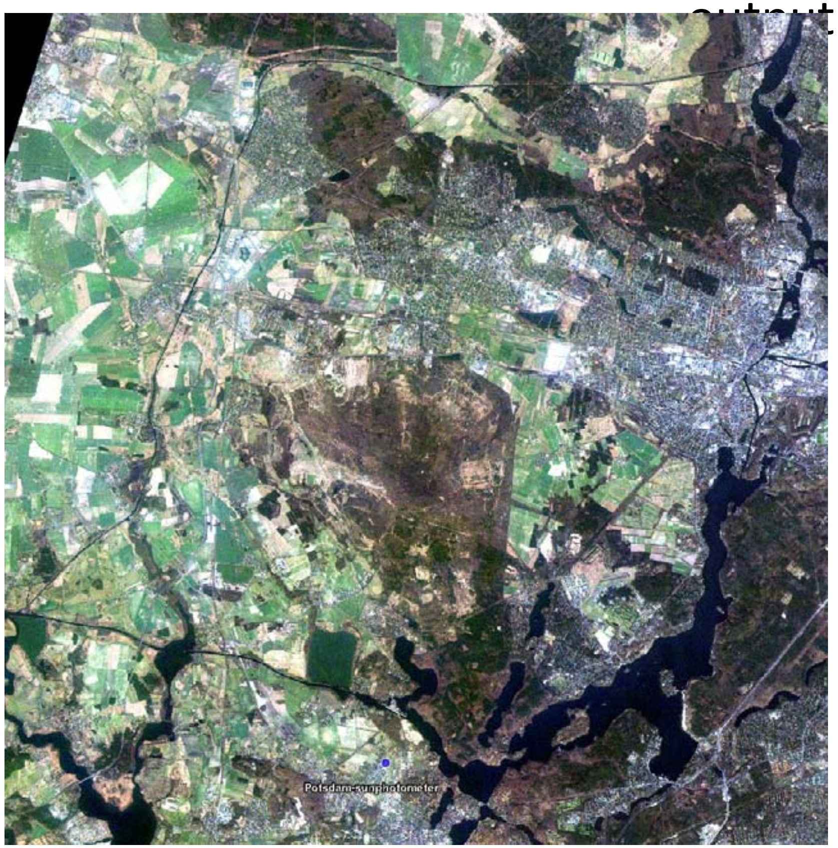
Uncertainty (AOT difference)		
	Mean ±sdev	samples
RapidEye 1	0.018 ± 0.006	2
RapidEye 2	0.041 ± 0.016	8
RapidEye 3	0.040 ± 0.016	2
RapidEye 4	0.027 ± 0.009	4
RapidEye 5	0.052	1
all together	**0.036 ± 0.016**	17

- **Mean AOT difference = 0.04**
- **Maximum difference = 0.06**

RGB composites of RapidEye-TOA images (top of atmosphere)



March 07, 2014

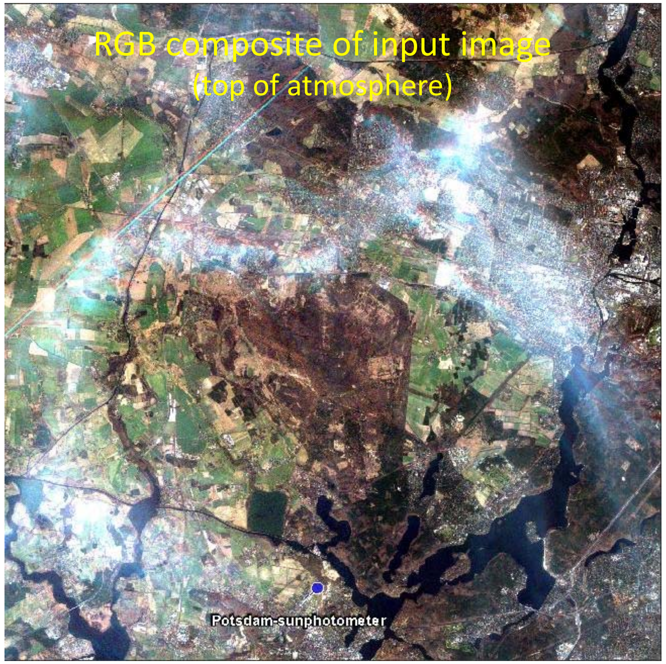


March 09, 2014

(with sunphotometer data) [AOT = 0.17]

ATCOR [AOT = 0.14]

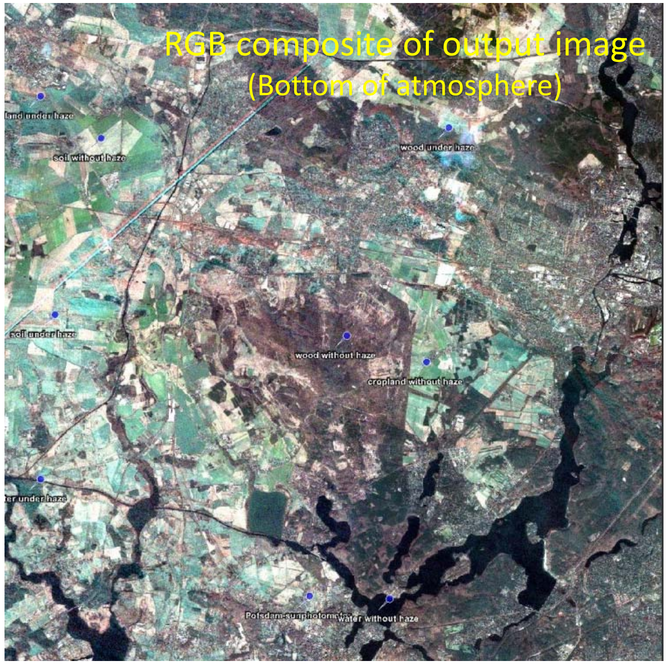
ATCOR deHazing

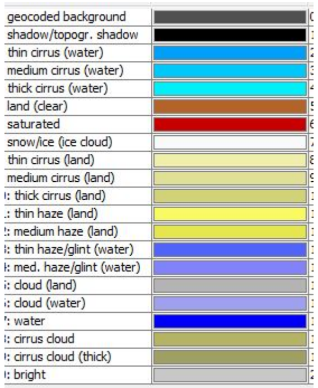


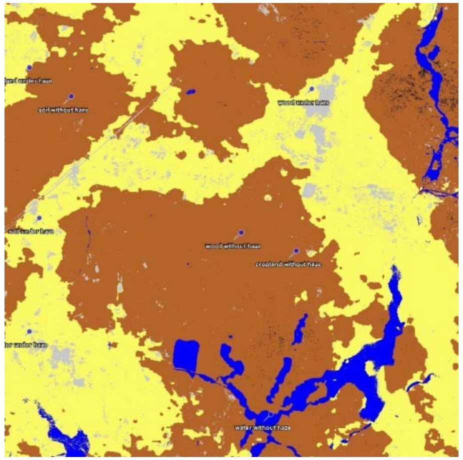
ATCOR2

[Makarau, A. et.al., (2014)]
[Richter, R. et.al., (2012)]

Rural atmosphere







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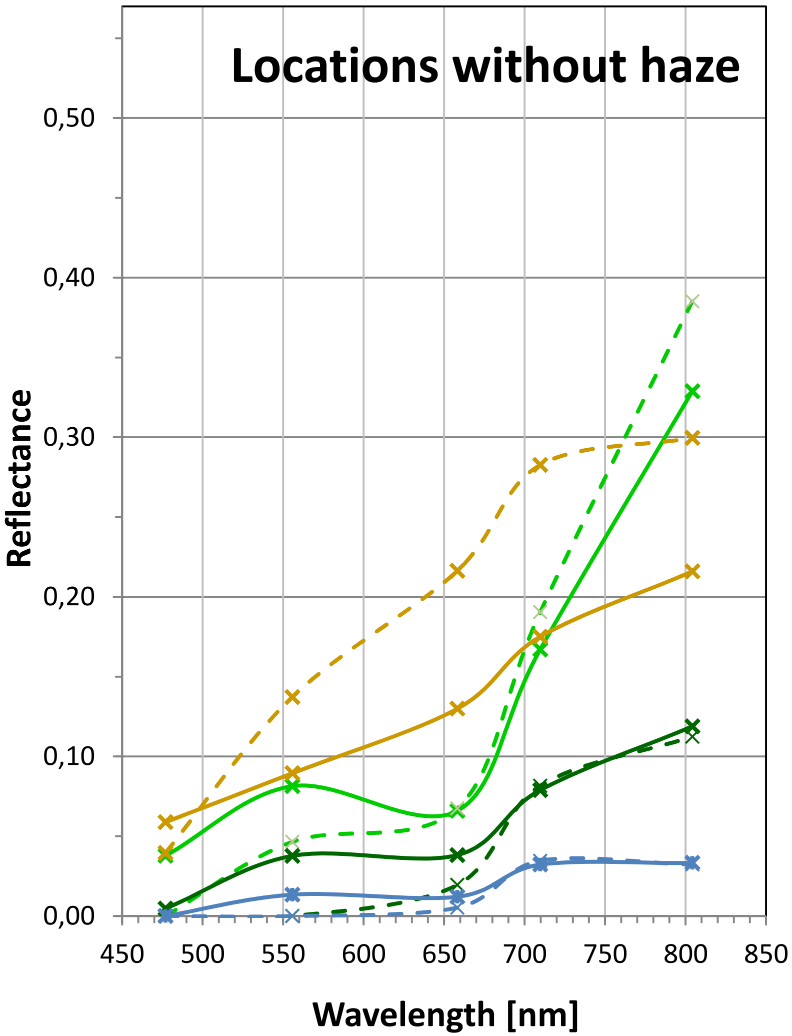
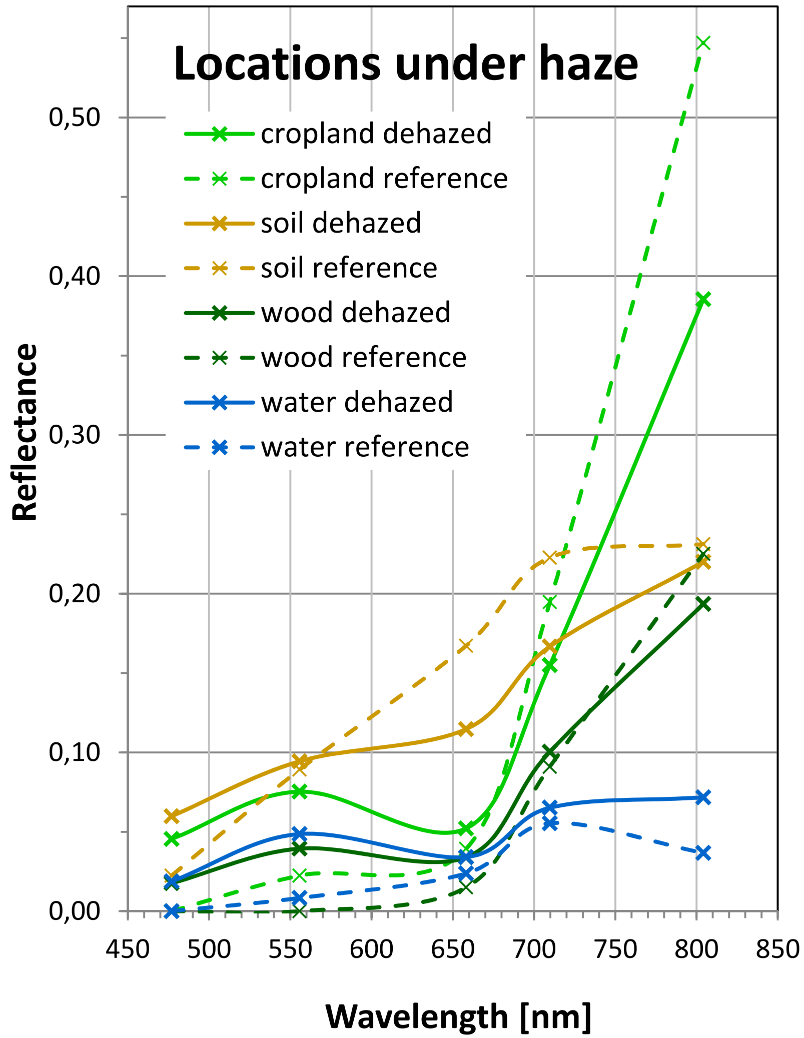
Example spectra





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NDVI

NDVI = (NIR-red)/NIR+red), red = 658 nm, NIR = 804 nm

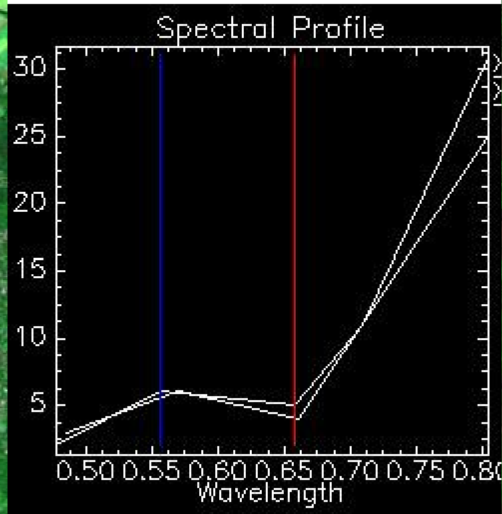
	Region free of haze on 07.03				
	water	soil	wood	cropland	Potsdam-sunphotometer
reference 09.03.2015	0,72	0,16	0,70	0,70	0,37
deHaze 07.03.2015	0,47	0,25	0,51	0,67	0,37
Difference	0,25	0,09	0,19	0,04	0,00

	Region under haze on 07.03			
	water	soil	wood	cropland
reference 09.03.2015	0,21	0,16	0,88	0,87
deHaze 07.03.2015	0,36	0,31	0,76	0,31
	0,14	0,15	0,11	0,55

Outlook: Cross-sensor comparison

Landsat-8, 2011-09-06, 09:51,
resampled, ATCOR-AOT = 0.12

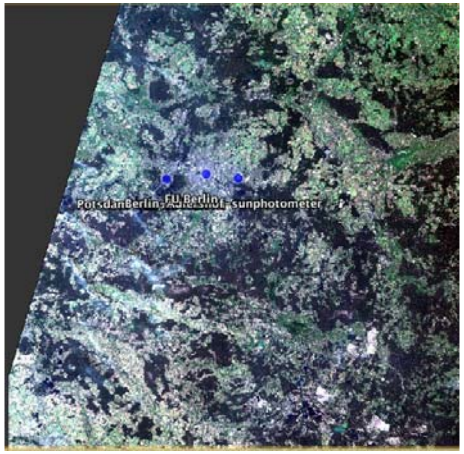
In-situ-AOT = 0.08

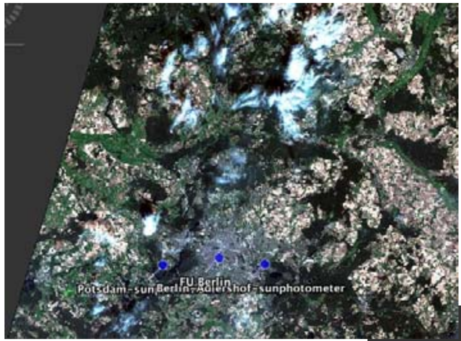


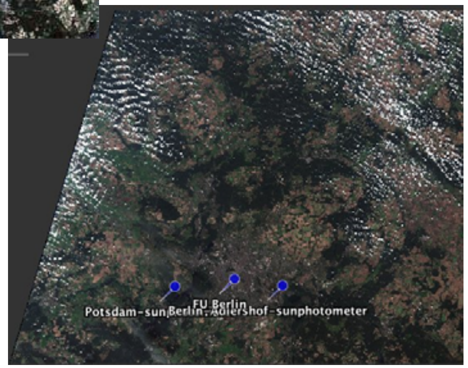
RapidEye, 2011-09-06, 11:13,
Resampled, ATCOR-AOT = 0.12

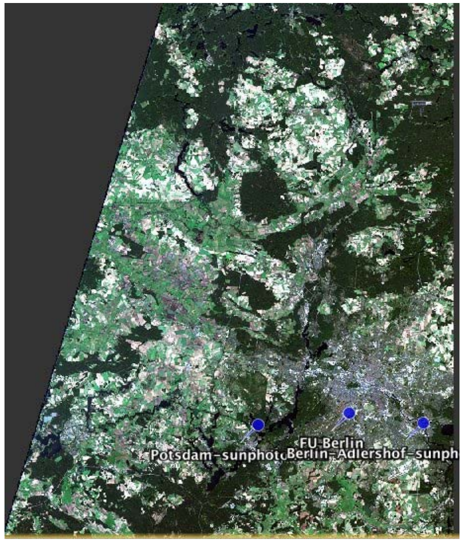
Outlook: Cross-sensor comparison

RapidEye and Sentinel-2, acquisitions over Potsdam/Berlin in parallel









Sentinel-2 04.07.2015	Sentinel-2 03.08.2015	Sentinel-2 12.09.2015	Sentinel-2 12.10.2015
AERONET sunphotometer RapidEye	AERONET sunphotometer RapidEye	DLR sunphotometer RapidEye	DLR sunphotometer RapidEye

Summary

<u>ATCOR validation:</u>

- Aerosol retrieval: Mean uncertaintiy is **ΔAOT550 ≈ 0.04**
- Results are stable until at least 20% cloud cover.
- deHazing preprocessing works for images partly covered by haze
- gives improved results, error assessment to be continued

<u>Outlook:</u>

- Validation for RapidEye **continued**: AOT and BOA-reflectance
- **Cross-sensor** comparison with Sentinel-2 and Landsat-8
- RapidEye acquisitions for selected ad-hoc **campaigns**?

Publications

Publications:

1. Main-Knorn, Magdalena und Pflug, Bringfried (2014) Comparative analysis of the atmospheric correction results for inter- and cross-sensor application in LUCC studies. In: 5th Workshop of the EARSeL Special Interest Group on Land Use and Land Cover (Abstract Book). 5th Workshop of the EARSeL Special Interest Group on Land Use and Land Cover, 17.-18. März 2014, Berlin, Germany.
2. Mannschatz, Theresa und Pflug, Bringfried und Borg, Erik und Feger, K.-H. und Dietrich, P. (2014) Uncertainties of LAI estimation from satellite imaging due to atmospheric correction. Remote Sensing of Environment, 153, Seiten 24-39. Elsevier. DOI: 10.1016/j.rse.2014.07.020. ISSN 0034-4257.
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4. Pflug, Bringfried und Main-Knorn, Magdalena und Makarau, Aliaksei und Richter, Rudolf (2015) Validation of aerosol estimation in atmospheric correction algorithm ATCOR. In: Proceedings of International Symposium on Remote Sensing of Environment (ISRSE) 2015. 36th International Symposium on Remote Sensing of Environment (ISRSE), 11.-15. Mai 2015, Berlin, Germany.
5. Makarau, Aliaksei und Richter, Rudolf und Schläpfer, Daniel und Reinartz, Peter (2016) Combined haze and cirrus removal for multispectral imagery. IEEE Geoscience and Remote Sensing Letters, PP (99). IEEE Xplore. DOI: 10.1109/LGRS.2016.2515110. ISSN 1545-598X. (im Druck)
6. Makarau, Aliaksei und Richter, Rudolf und Müller, Rupert und Reinartz, Peter (2014) Spectrally consistent haze removal in multispectral data. In: Image and Signal Processing for Remote Sensing XX, 9244, Seiten 1-7. SPIE. SPIE Remote sensing Europe, 22-25 September 2014, Amsterdam, Netherlands. ISBN 9781628413076. Volltext nicht frei. file
7. Makarau, Aliaksei und Richter, Rudolf und Müller, Rupert und Reinartz, Peter (2014) Haze detection and removal in remotely sensed multispectral imagery. IEEE Transactions on Geoscience and Remote Sensing, 52 (9), Seiten 5895-5905. IEEE Xplore. DOI: 10.1109/TGRS.2013.2293662. ISSN 0196-2892.