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Comparative analysis of the atmospheric correction results for inter- and cross-sensor application in LUCC studies

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Background

- Remote sensing enables continuous Earth observations and change detection
- Satellite data archives provide great records for multi-temporal analysis
- An increasing number of new remote sensing datasets offer opportunities for multi-scale and cross-sensor applications
- These applications can be hindered due to differences in surface reflection products, causing uncertainties in the retrieval of biophysical parameters or spectral indices across image frames
- In order to achieve reliable and comparable results in land change studies **atmospheric correction and radiometric normalization** of satellite imagery is a prerequisite.

Atmospheric correction:

- reduces effects of scattering and absorption by gases and aerosols in the atmosphere between the Earth's surface and the sensor
- minimizes the influence of solar illumination and topography on the registered signal

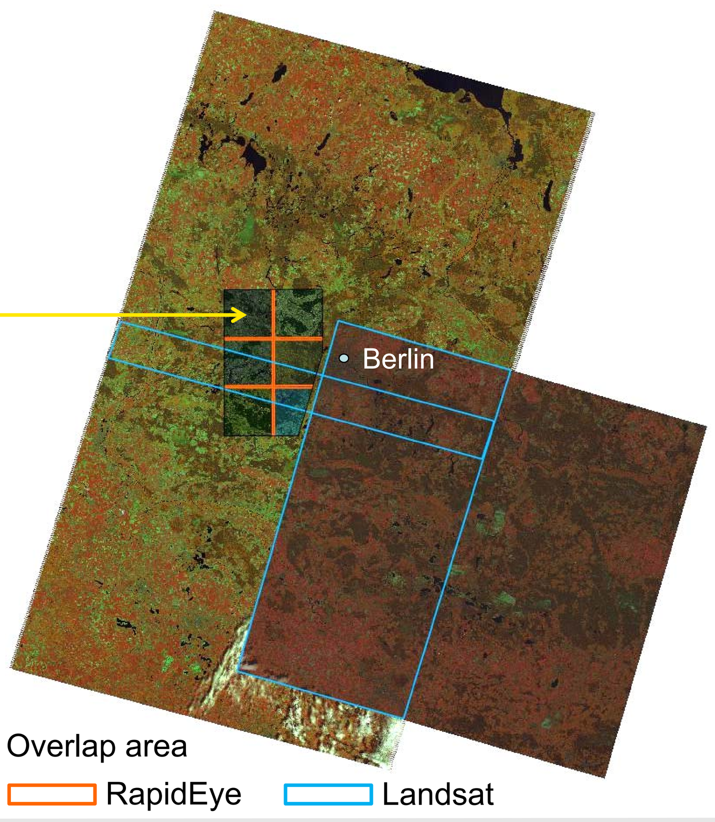
Specific objectives:

- compare atmospheric correction results from Landsat TM, ETM+, OLI, and RapidEye imagery
- validate aerosol optical thickness (AOT) derived from the satellite imagery with ground-truth measurements (simultaneous to the satellite overpass).

Analysis

Data:

- 42 satellite images:
  RapidEye (27),
  Landsat TM (6),
  Landsat ETM+ (5),
  Landsat OLI (4)
- Ground-truth AOT550 measurements (14)

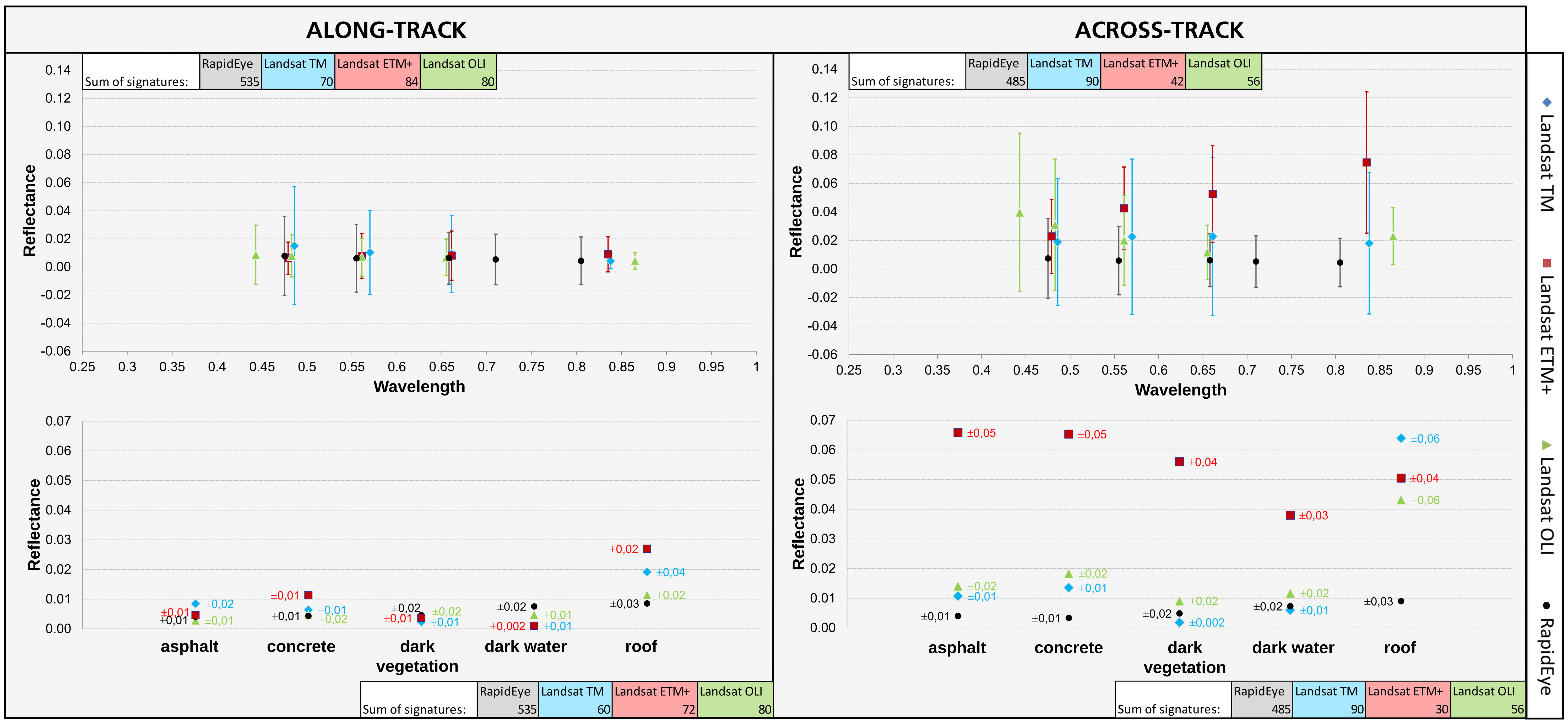


Methods:

- Atmospheric correction using the ATCOR software version 8.2.1. for flat terrain, settings: variable visibility over the scene, rural aerosol type *[Richter, R., Schläpfer, D., (2013)]*
- Extraction of the intra-sensor overlap areas for along-track (the same acquisition date) and across-track (different acquisition dates within 6 months) comparison
- Identification of pseudo-invariant features (asphalt, concrete, dark vegetation, dark water, roof) and collection of its spectral signatures by 3x3 pixel for all Landsat and 5x5 pixel for RapidEye images
- Extraction of the ATCOR-derived AOT values by 3x3 pixel for Landsat and 5x5 pixel for RapidEye images acquired simultaneously to the ground-truth AOT measurements

Results and Conclusions

Mean differences in spectral signatures after atmospheric correction:



ALONG-TRACK

- mean difference in reflectance for the overlap area of two successive scenes (along-track) was less than 0.01
- larger disparities of above 0.04 (maximally) were observed for all sensors
- the highest differences occurred in visible blue spectral range (disparities above 0.08 for Landsat TM) and for very bright features (roof)

ACROSS-TRACK

- mean difference in reflectance for the overlap area of two scenes in time-series (across-track) was around 0.03
- larger disparities above 0.08 were observed for all sensors beyond RapidEye
- results for Landsat ETM+ revealed increasing disparities with the wavelength
- for all sensors the highest differences occurred for very bright features (roof)
- maximal disparities of above 0.1 were registered for aerosol band of Landsat OLI (0.443µm), and green (0.57µm) and red bands (0.661µm) of Landsat TM

Mean differences in AOT retrieval:

- atmospheric correction was validated on the level of aerosol retrieval uncertainties
- ATCOR-derived AOT values were mostly overestimated when compared to the ground-truth measurements
- mean differences in AOT were about 0.04 (RapidEye), 0.05 (Landsat TM), 0.06 (Landsat ETM+), and 0.04 (Landsat OLI); $\Delta AOT_{550} = 0.04$ corresponds to $\Delta\rho \approx 0.004$

CONCLUSIONS:

- Mean uncertainties in surface reflectance meets the requirements on the processing of EnMAP data, but standard deviations (mean and maximum) for along- and across-analysis were significantly exceeded *[EN-DLR-RS-006, p. 55-56]*
- Uncertainties in AOT retrieval are tightly in line with the EnMap-Requirements
- However, AOT uncertainties confirm the limitations of atmospheric correction found for the reflectance retrieval
- To overcome retrieval limitations our results underline the need for relative radiometric normalization performed additionally to atmospheric correction of imagery, particularly for intra- and cross-sensor data integration, and multi-temporal applications.

References: *Richter, R., and D. Schlaepfer, (2013), Atmospheric / topographic correction for satellite imagery: ATCOR-2/3 User Guide, DLR IB 565-01/13, Wessling, Germany.*
V, Bargen, A,, Grosser, J, (2010), Environmental Mapping & Analysis Program (EnMAP), Ground Segment Requirements Document, GRD, EN-DLR-RS-006

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