GROUND-BASED MEASUREMENTS FOR VALIDATION OF L2A-PRODUCTS

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LPVE23 - WORKSHOP ON LAND PRODUCT VALIDATION AND EVOLUTION

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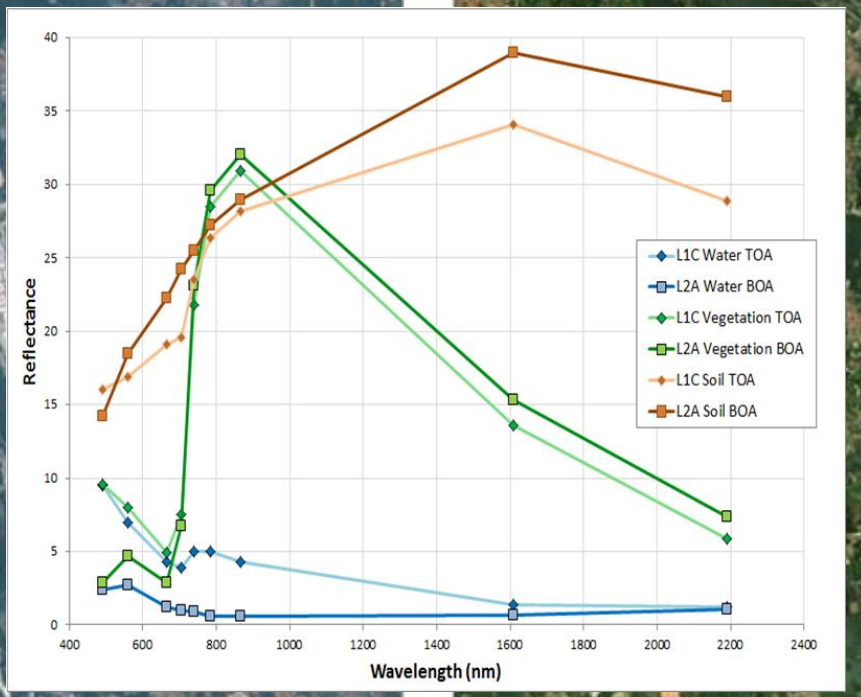
Motivation

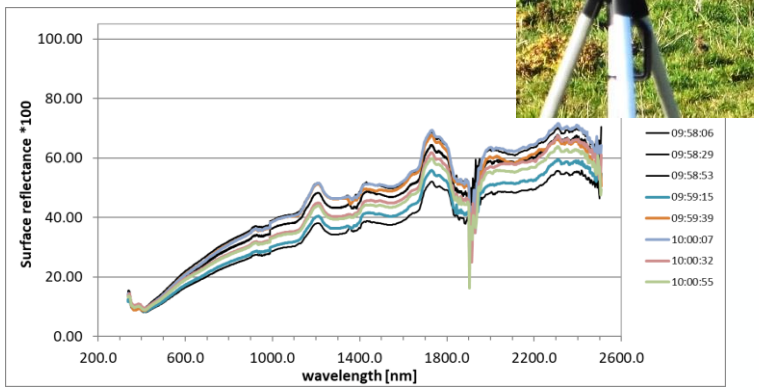
Top of Atmosphere (TOA) → Atmospheric correction → Bottom of Atmosphere (BOA)



- Validation need reference data with (low) uncertainty as close as possible to FRM
- Reference data sources: AERONET, RadCalNet, (Hypernets), **Campaigns**

Instruments

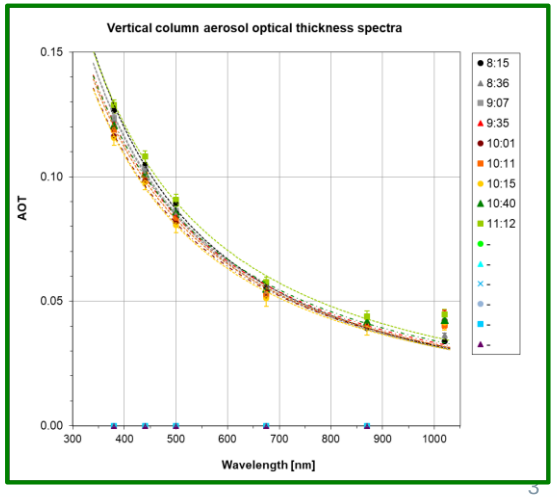
SVC with white disk (and WEDI-sensor)



SVC	V-NIR	SWIR-1	SWIR-2
Detector Technology (Photo-diode-array)	Silicon (512)	InGaAs (256)	Ext. InGaAs (256)
	337.6 - 1010.5 nm	975.4 - 1908.1 nm	1903.9-2507.1 nm
Band width (sampling Interval)	≤ 1.5 nm	≤ 3.8 nm	≤ 2.5 nm
Spectral Resolution (FWHM)	≤ 3.3 nm	≤ 9.5 nm	≤ 6.5 nm

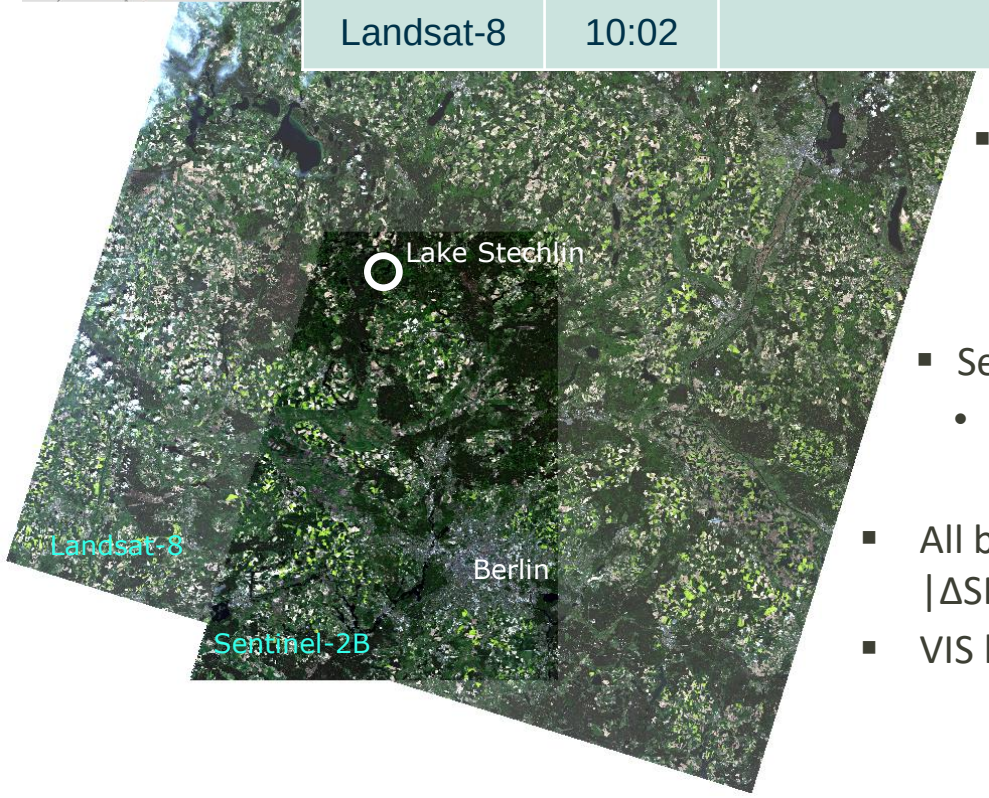
Microtops

Spectral range:	305, 312, 320,	936, 1020 nm 380, 440, 500, 675, 870 nm
Bandwidth:	2.4 nm,	10 nm
FOV:	2.5° (Sun)	

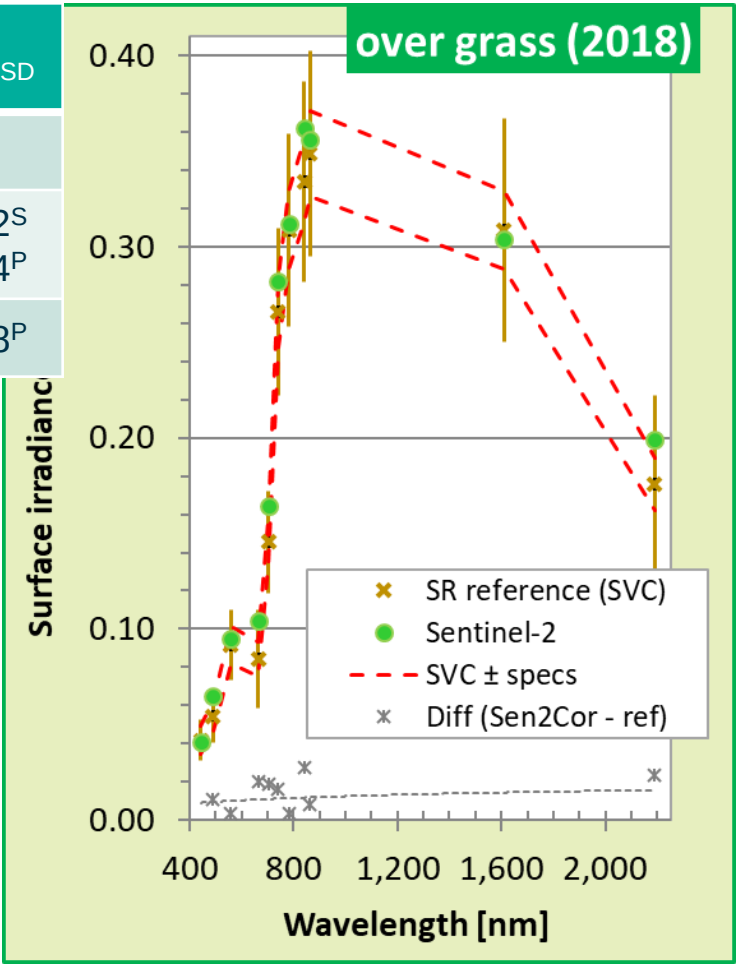


2018 Lake Stechlin

04.05.2018	UTC	(θ_s,φ_s)	(θ_v,φ_v)	AOT_{550}	WV [kg/m^2]	SR_{RMSD}
Microtops	±15 min	---	---	0.07 ±0.0	5.9 ±0.1	---
Sentinel-2B	10:10	(38.4°, 160.9°)	(10.9°, 111.7°)	0.06 ±0.0 0.09 ±0.0	4.8 ±1.0 5.7 ±1.0	0.022^S 0.014^P
Landsat-8	10:02			0.10 ±0.0	---	0.018^P



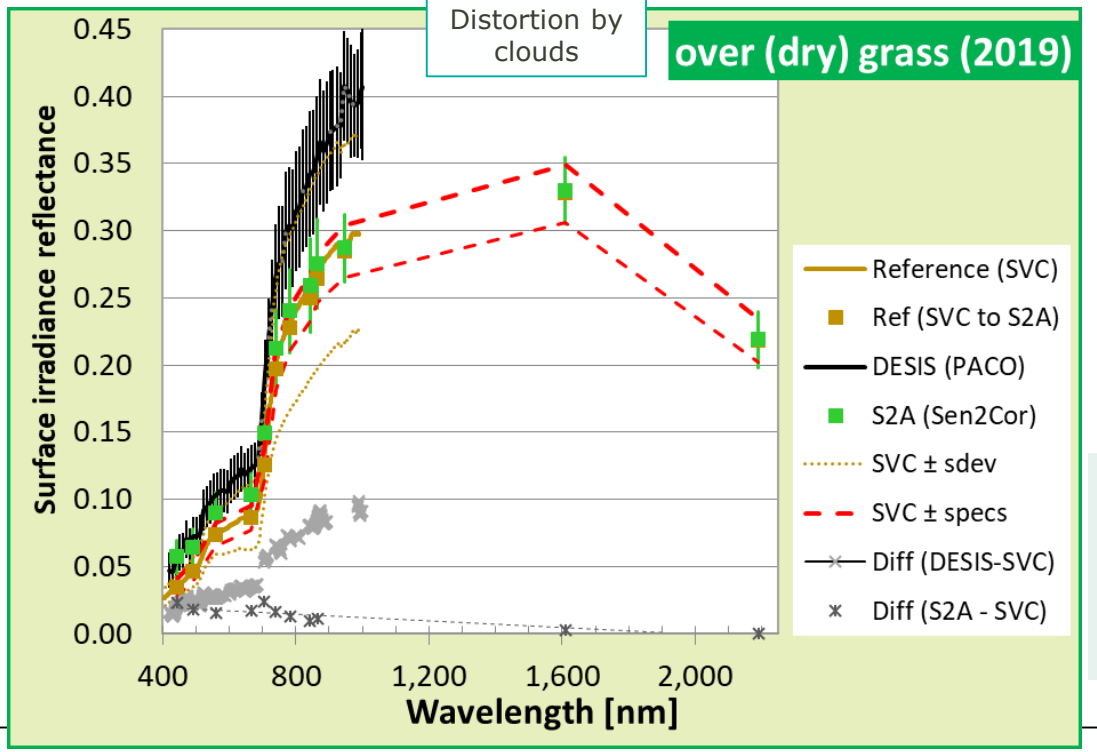
- Processing:
  - Sentinel: Sen2Cor 2.8, PACO
  - Landsat: PACO
  - SVC: Reference panel reflectance corr.
- Set up on ground:
  - mean over randomly distributed points in 2x2 m^2 area
- All bands are within or slightly outside $|\Delta SR| \leq 0.05 * SR_{ref} + 0.005$
- VIS bands undercorrected



- Lessons learnt
  - Ground area too close to forest
  - High natural variability
  - Improve set up on ground

2019 Wesenberg

22.08.2019	UTC	(θ_s,φ_s)	(θ_v,φ_v)	AOT_{550}	WV [kg/m²]	SR_{RMSD}
Microtops	±15 min	---	---	0.18 ±0.0	12.8 ±0.1	---
Sentinel-2A	10:11	(42.9°, 159.9°)	(11.4°, 110.7°)	0.17 ±0.0	13.8 ±1.3	0.017^S
DESIS	10:08	(43.3°, °)	(29.9°, °)	(0.42 ±0.0)	(21.0 ±1.0)	0.056^P

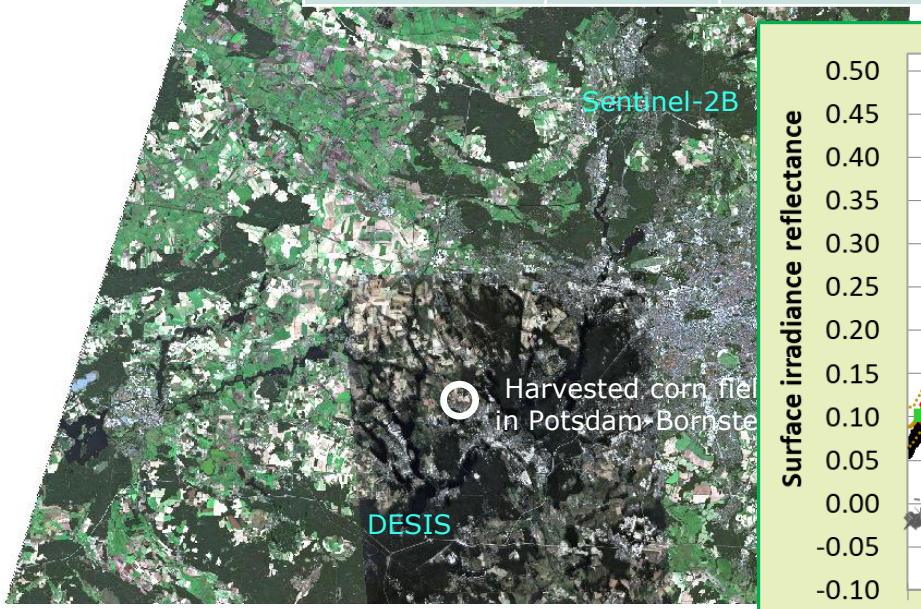


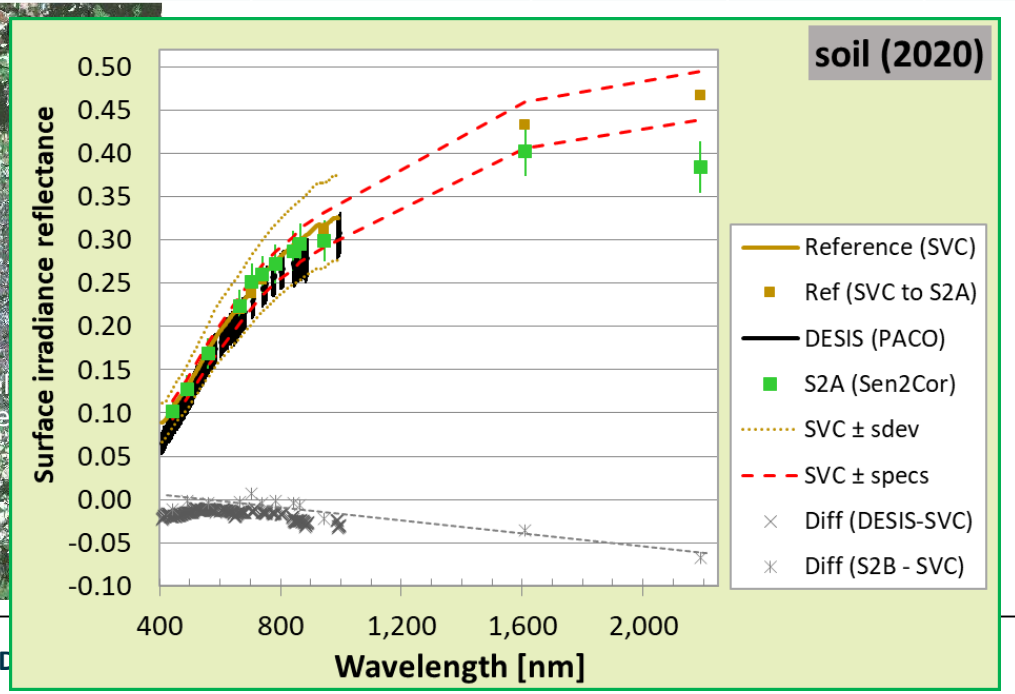
- Processing:
  - Sentinel: Sen2Cor 2.8
  - DESIS: PACO
  - SVC: Reference panel reflectance corr.
- Set up on ground:
- mean over multiple 20m long lines
- Bands for S2 are within or slightly outside specification $|\Delta SR| \leq 0.05*SR_{ref} + 0.005$
- VIS bands undercorrected
- Bands for DESIS outside specification (BRDF-effect, clouds?)

- Lessons learnt
  - High natural variability
  - set up lines in S2-flight direction
  - Need of BRDF-correction

2020 Potsdam-Bornstedt

01.08.2020	UTC	(θ_s,φ_s)	(θ_v,φ_v)	AOT_{550}	WV [kg/m²]	SR_{RMSD}
Microtops	±15 min	---	---	0.06 ±0.0	14.0 ±0.0	---
Sentinel-2B	10:06	(36.4°, 156.4°)	(9.1°, 97.3°)	0.08 ±0.0	17.2 ±1.8	0.020
06.08.2020						
Microtops	±15 min	---	---	0.07 ±0.0	13.5 ±0.0	---
DESIS[06.08]	14:27	(52.2°, °)	(9.9°, °)	0.09 ±0.0	21.0 ±1.0	0.020



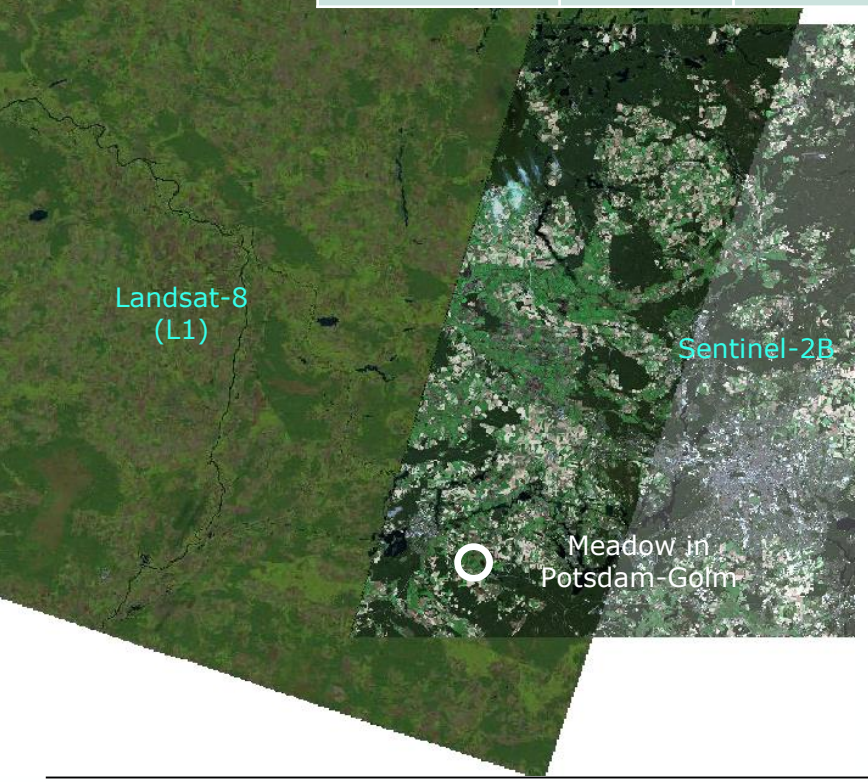


- Processing:
  - Sentinel: Sen2Cor 2.8
  - DESIS: PACO
  - SVC: Reference panel reflectance corr.
- Set up on ground:
  - mean over multiple 20m long lines along S2 flight direction
- VNIR bands are within $|\Delta SR| \leq 0.05*SR_{ref} + 0.005$
- SWIR bands (little) outside

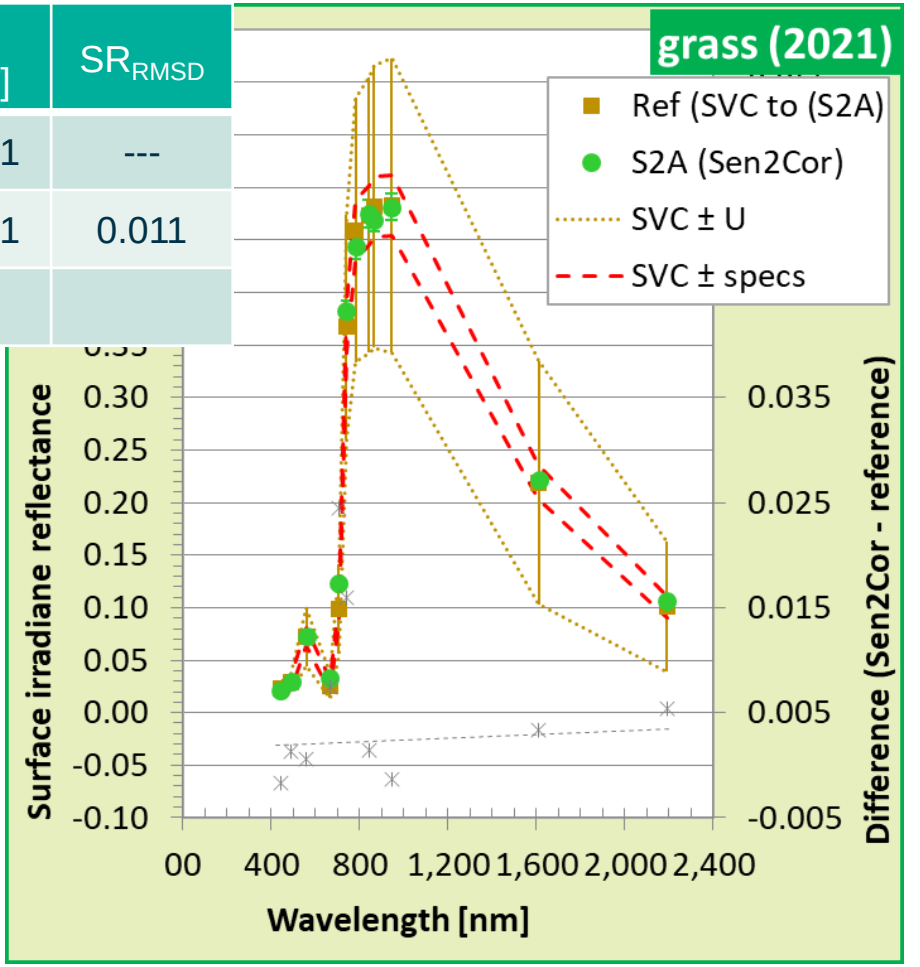
- Lessons learnt
  - very dirty, keep white panel clean!
  - Uncertainties? → best practices (Malthus. T. et.al., 2019; SVC-Field-Guide, 2019)
  - Optimizing measurement protocol

2021 Potsdam-Golm

10.10.2021	UTC	(θ_s,φ_s)	(θ_v,φ_v)	AOT_{550}	WV [kg/m²]	SR_{RMSD}
Microtops	±15 min	---	---	0.07 ±0.0	6.3 ±0.1	---
Sentinel-2A	10:10	(59.8°, 168.8°)	(9.3°, 96.7°)	0.07 ±0.0	6.3 ±0.1	0.011
Landsat-8	10:09					



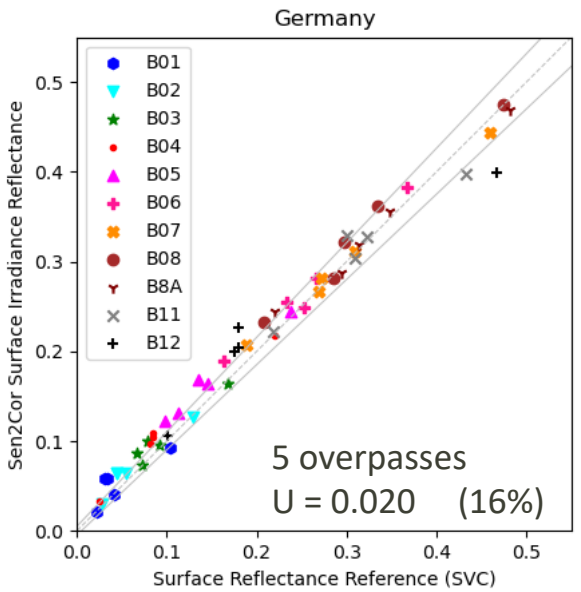
- Processing:
  - Sentinel: Sen2Cor 2.8
  - SVC: Ref. panel reflectance corr.
- Set up on ground:
  - mean over multiple 20m long lines along S2 flight direction
  - Added special measurements to estimate uncertainty
- Almost all bands are within $|\Delta SR| \leq 0.05 * SR_{ref} + 0.005$



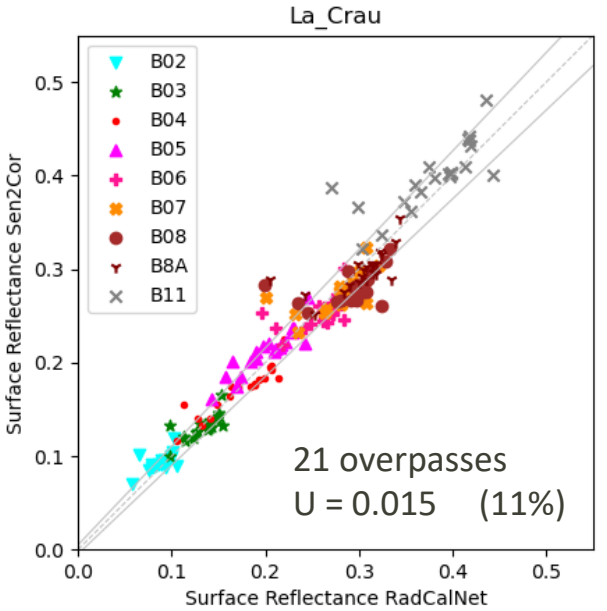
- Lessons learnt
  - Measurements while moving?
  - procurement of additional equipment like tablet for controlling SVC, WEDI sensor, weather logger and fisheye objective for smartphone

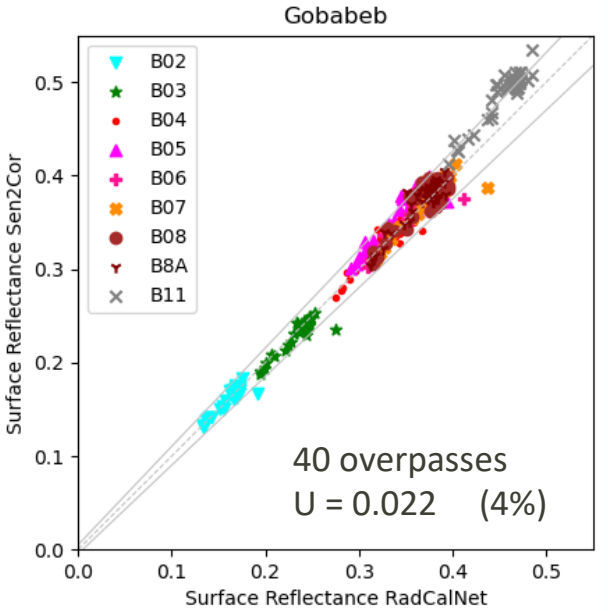
Sentinel-2: Campaigns 2018 -2021 <-> RadCalNet

Campaigns in Germany

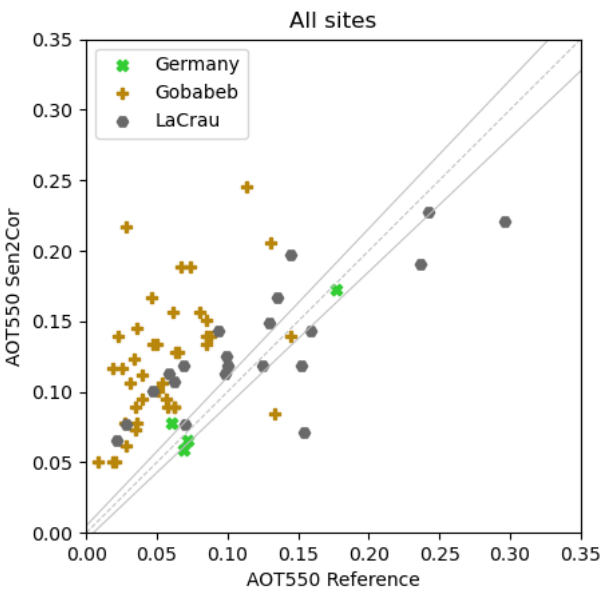


RadCalNet





AOT-retrieval



- Within uncertainty goal $U(SR) = 0.05 * SR + 0.005$

√	44% of 55 values	71% of 189 values	88% of 360 values	Gobabeb: No DDV in area

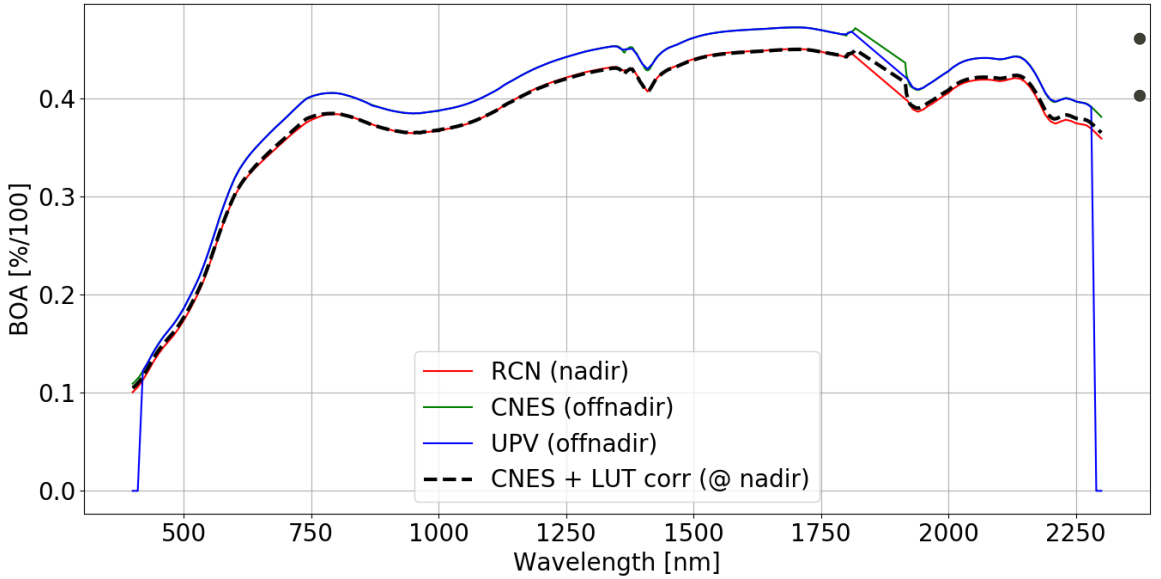
- Data set too small to give statistical reliable information
- Results comparable, but brighter (RadCalNet) sites represent a different situation than darker sites
- We need more reference measurements for darker (vegetated) sites, with uncertainties of reference measurements.
- Available data dominated by quite low AOT

Off-nadir overpasses

Hyperspectral sensors: DESIS and EnMAP off-nadir 30 - 40 deg.

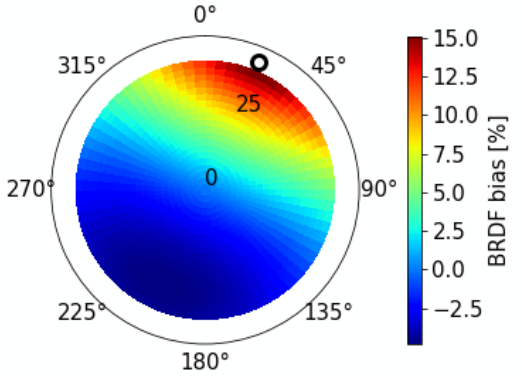
Need for accounting for BRDF effects results @ CalVal sites -> **$BRDF_{site} = f(\theta_{v,sensor}, \phi_{v,sensor})$**
Comparison of BRDF LUTs versus in-situ simulations at Gobabeb RadCalNet site:

CNES simulation by Meygret A. & Farges M.



Example:

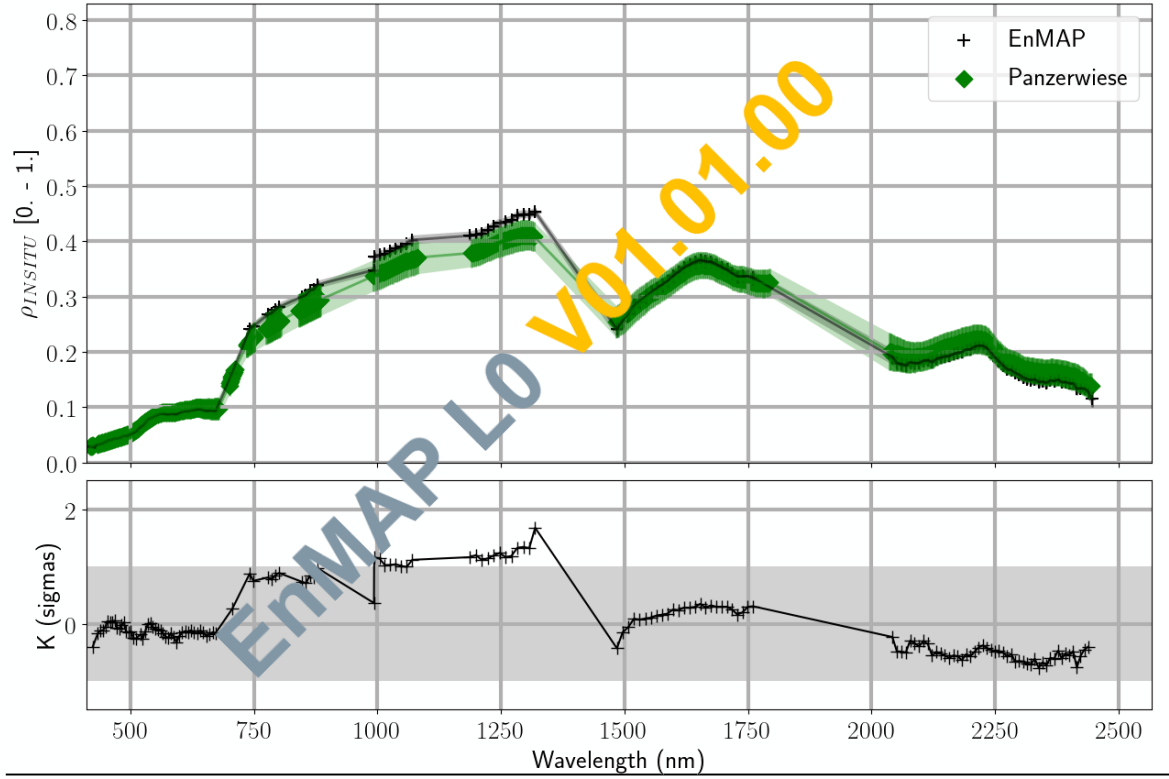
- $(\theta_{sun}, \phi_{sun})$ = (42.7, 22.6) deg
- $(\theta_{v,sensor}, \phi_{v,sensor})$ = (16.4, 12.2) deg -> $BRDF_{bias}$ (645 nm) ~ 5%

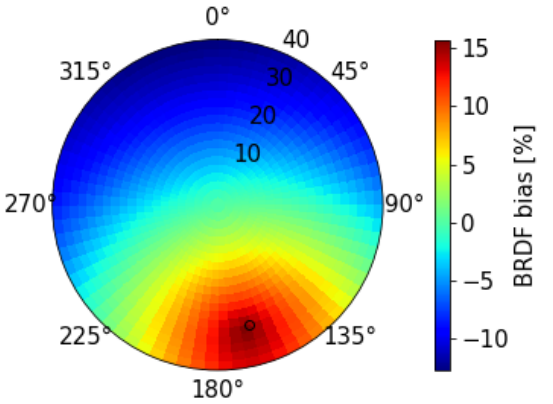


UPV BRDF LUTs (Gorrono, J.)

2022 Munich / Panzerwiese – EnMAP overpass

28.07.2022	UTC	(θ_s,φ_s)	(θ_v,φ_v)	AOT_{550}	WV (kg/m^2)	$BRDF_{bias}$ [% @ 645 nm]
AERONET (> 9 km)	10:48±1h	---	---	0.09±0.01	18.6±0.5	---
EnMAP	10:48	(29.9°, 165.6°)	(1.0°, 284.5°)	0.09±0.00	24.5±13.	- 0.2





UPV BRDF LUTs (Gorrono, J.)

Lessons learnt

- RadCalNet is not sufficient for validation of L2A-products (talk R. de los Reyes et al)
- Need of additional sites under non-ideal atmospheric conditions (AOT > 0.1-0.2)
  - with enough vegetation (DDV) required for some algorithms
  - Covered by darker targets

- Take time for extra measurements
  - Pre- and post campaign investigations characterizing instrument and site
  - Special measurements for estimation of uncertainty budget and BRDF contribution

- Great benefit from joint discussion of people familiar with instruments and people going to take field data
- Work started on harmonized, unified data analysis

  (Check ambient light stability | Check S/N ratio | Check overlapped data matching between VNIR-SWIR1-SWIR2 sensors | Reference Panel Reflectance Correction | Verify spectral / wavelength calibration | account for BFDF effects | uncertainty)