



Surface reflectance validation for multi- and hyperspectral air- and spaceborne sensors using in-situ data from the CARMA campaign in Puch, Germany

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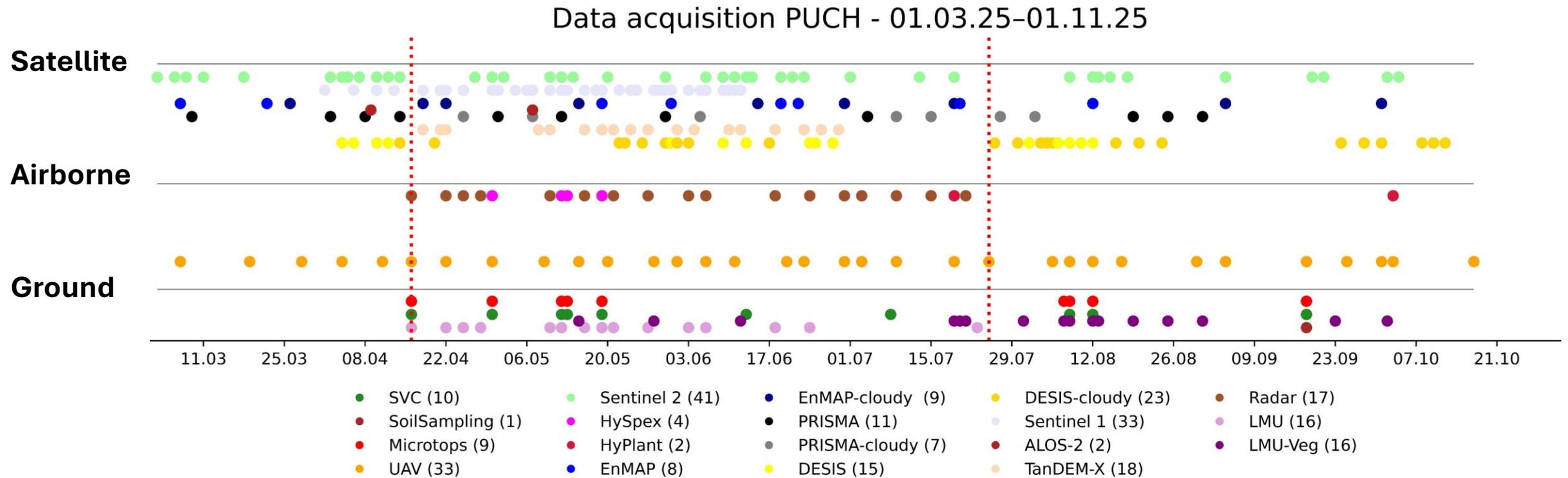
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VH-RODA 2025

17 – 21 November 2025 | ESA-ESRIN | Frascati (RM), Italy



- Upcoming Copernicus Sentinel satellites from ESA ([Press release](#))
 - **ROSE-L** (Radar Observing System for Europe at L-band)
 - **CHIME** (Copernicus Hyperspectral Imaging Mission for the Environment)
- Fields campaigns organized from March to July 2025 in preparation for future missions
 - **Agri4ROSE-L**
 - **23 airborne overflights** from airborne high performance radar system F-SAR (DLR) with 6 day frequency to match ROSE-L cycle and four radar frequencies (X-, C-, S- and L-bands)
 - **Field measurements** conducted by LMU München to collect data on soil moisture, surface roughness, plant water content and biomass
 - **Ground-based scatterometer** installed on a tower in a growing wheat field
 - **CARMA**
 - **6 airborne overflights** with high resolution hyperspectral imaging from HySpex (DLR) and HyPlant (CzechGlobe)
 - **EnMAP, PRISMA, DESIS and Sentinel 1/2** observations acquired
 - **Field measurements** from drones and spectrometers conducted by DLR, GFZ and LMU
- Aim:
 - **build a comprehensive dataset** that will help guide the mission development
 - **support future in-orbit validation activities**
 - **combine observations** from fieldwork, airborne and satellite
 - **track soil and vegetation parameters** across multiple sensors and platforms and at different scales



- Validation is important to assess the **accuracy of the products** to the mission requirements
- **Reference data** is required with (low) uncertainties. For L2A products, typical sources include:
 - **dedicated networks** (AERONET, RadCalNet, Hypernets)
 - **field campaigns**

The CARMA field campaign represents a unique opportunity to validate observations from **multiple hyperspectral and multispectral sensors** from a **single region** over **multiple months** in an **application setting** (non-ideal atmospheric conditions, partially cloudy skies, darker targets)

HySpex TOA



HySpex BOA

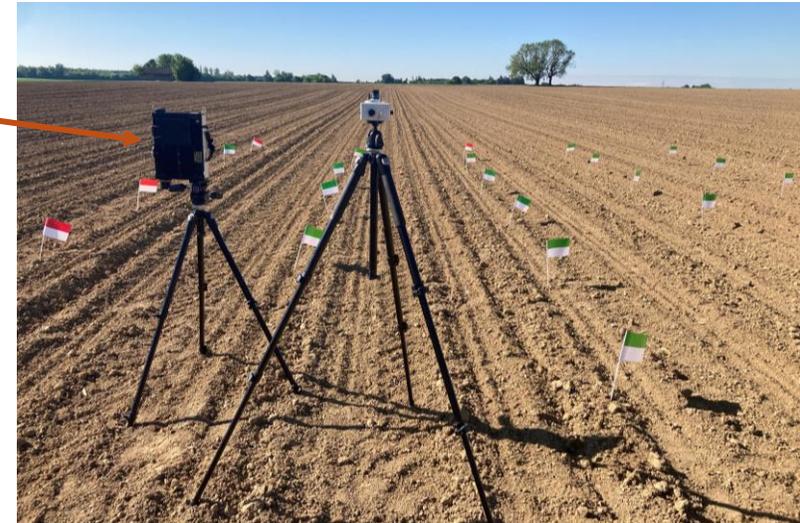


- Select large fields
- Measure in centre to minimise adjacency effects
- Make 3x3 pixel grid with at least measurement 16 points
- Use appropriate spacing
 - 30m (for EnMAP, PRISMA, DESIS) 20m (Sentinel-2) or 2m (HySpex) spacing
- Align to overflight path
- Take multiple measurements at each grid point



- Spectra Vista Corporation Spectrometer (SVC HR-1024i)
 - Ground measurements in raw digital numbers
 - Calibrated in lab

	SVC HR-1024i
Spectral channels	1024
Spectral resolution (FWHM) for 350 – 1000 nm	4.5 nm
Spectral resolution (FWHM) for 1000 – 1890 nm	13 nm
Spectral resolution (FWHM) for 1890 – 2500 nm	10 nm
Field of View	4° (lens)
Radiometric uncertainty (k = 2)	< 3 % (VNIR), < 4 % (SWIR)

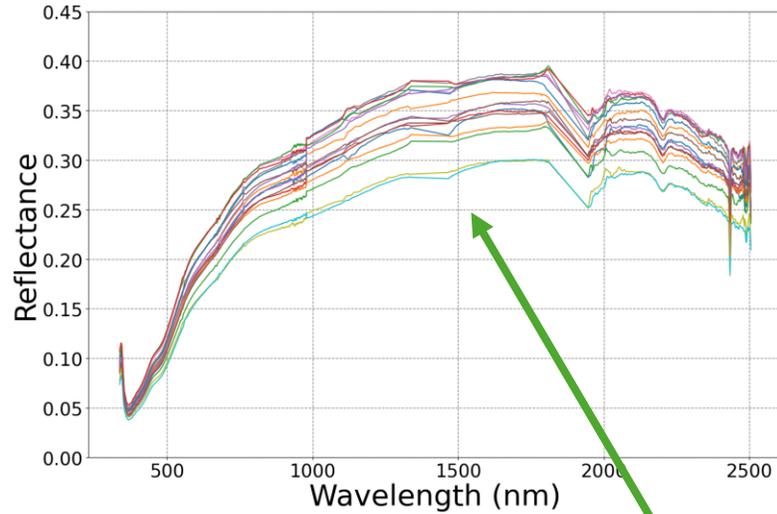


- Wireless External Data Interface (WEDI) sensor
 - Monitor downwelling irradiance
- Spectralon® reflectance panel
 - 50% reflectance for reference
 - Calibrated in lab
- Microtops sun photometers
 - AOT and Ozone measurements



Campaign	Date	Field	Overpasses	Notes
1	16.04.2025	Wheat		Campaign start, no overpass
2	30.04.2025	Wheat	HySpex, Sentinel-2A	Sentinel-2A cloudy
3	12.05.2025	Maize (soil)	HySpex, Sentinel-2C, PRISMA	
4	13.05.2025	Wheat	HySpex	BRDF airborne campaign
5	19.05.2025	Maize (soil)	HySpex, EnMAP	
6	13.06.2025	Barley, Maize, Wheat, Triticale	Sentinel-2A, DESIS	Many fields measured for spectral library, not intended for SR validation
7	07.08.2025	Barley (harvested)		No overpass
8	08.08.2025	Barley (harvested)	Sentinel-2B, DESIS	
9	12.08.2025	Wheat (harvested)	Sentinel-2A, EnMAP, DESI	
10	18.09.2025	Wheat (harvested)	EnMAP	

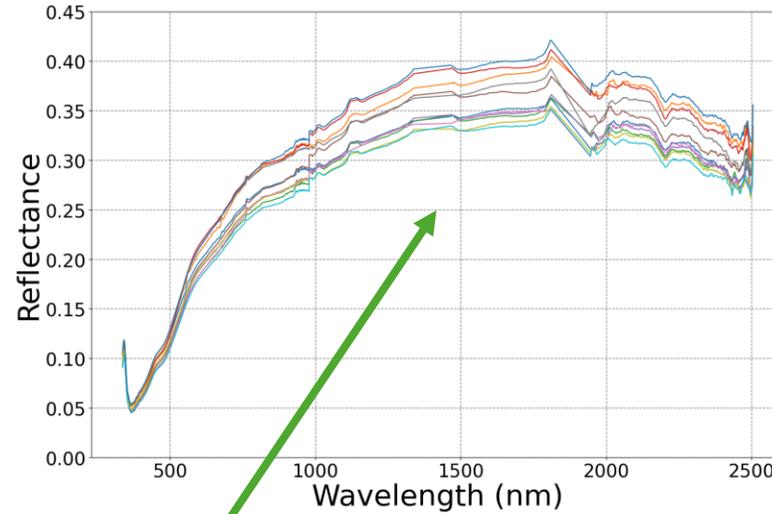
12.05.2025



Small variability in in-situ measurements

Good for validation

19.05.2025

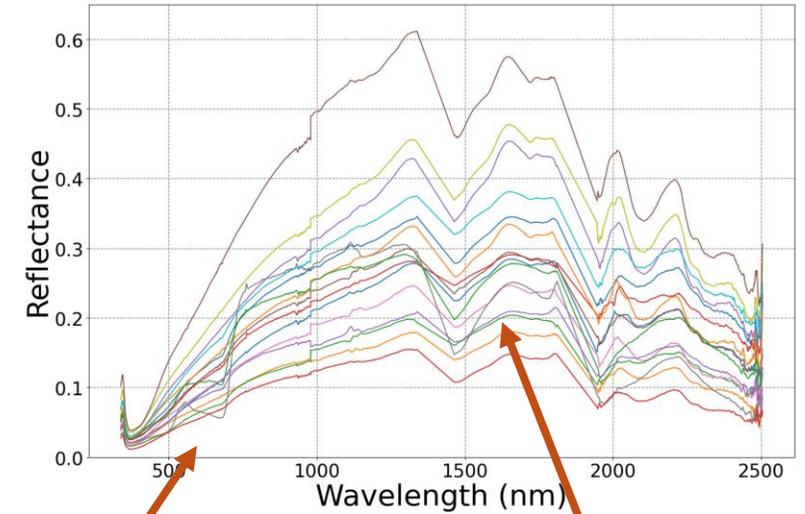


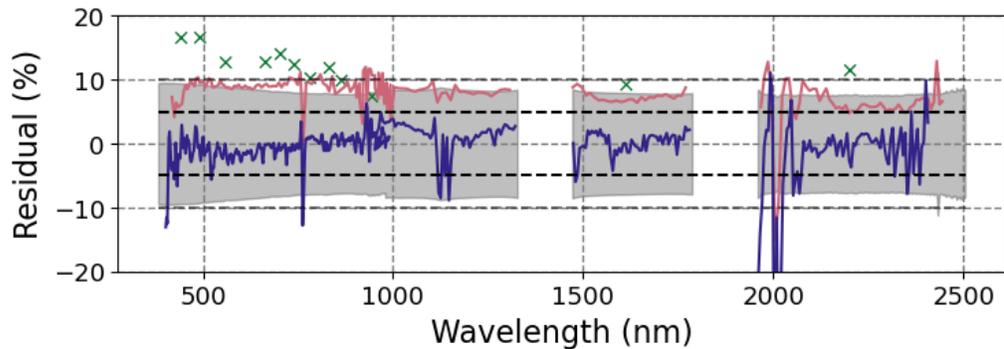
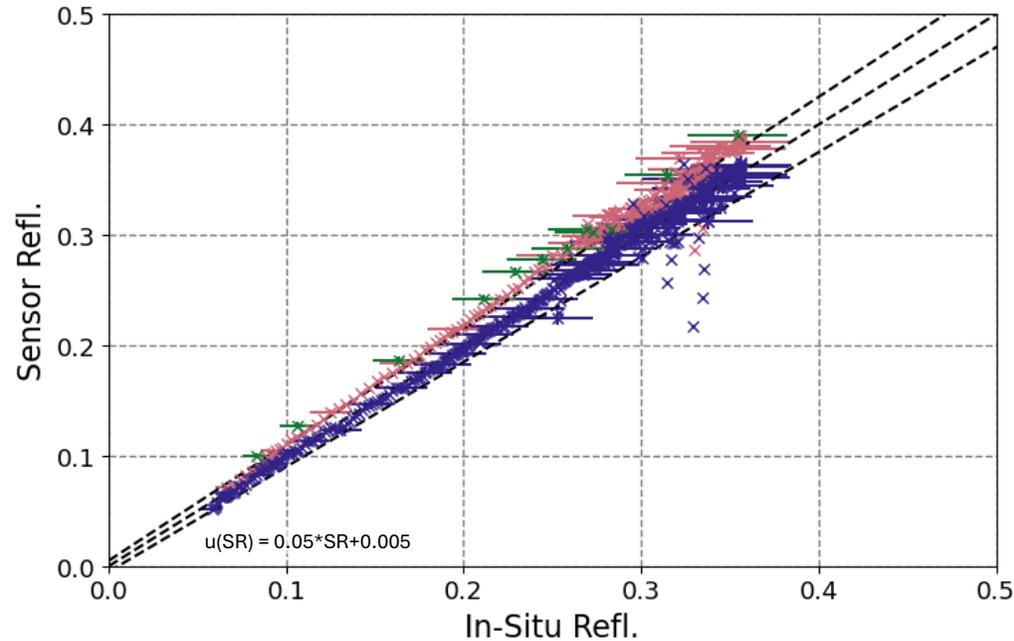
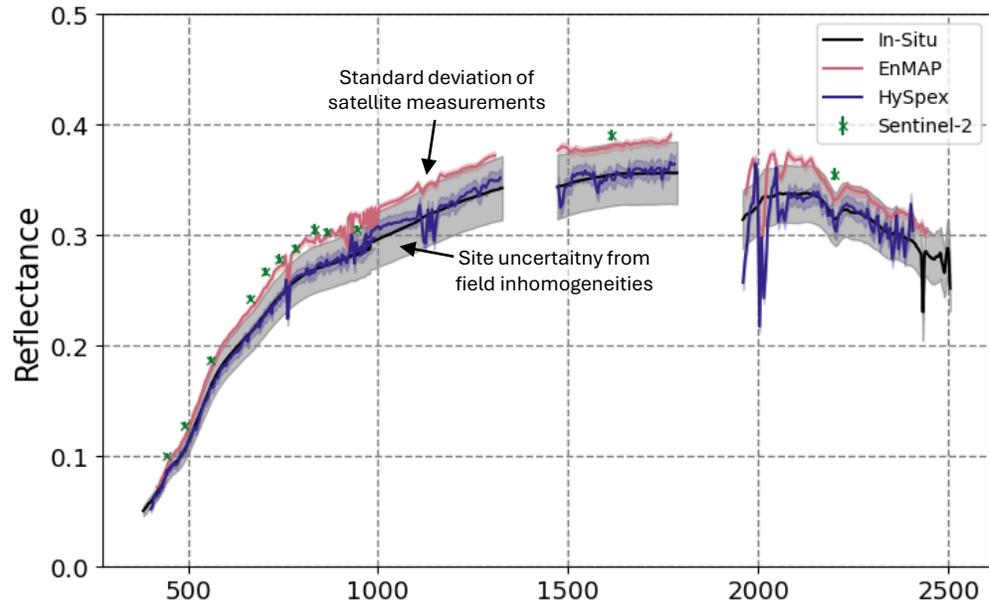
Inhomogeneous mixture of surfaces

Large variability in in-situ measurements

Requires further study on inhomogeneity for use in validation study

12.08.2025

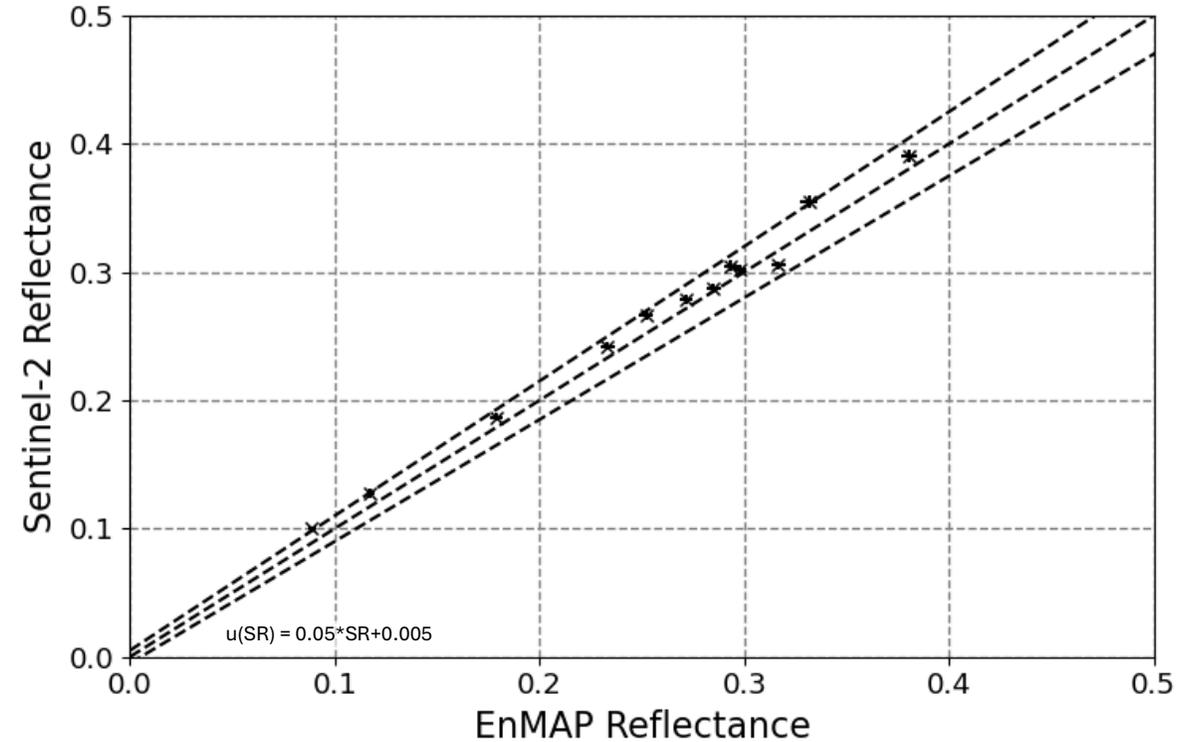
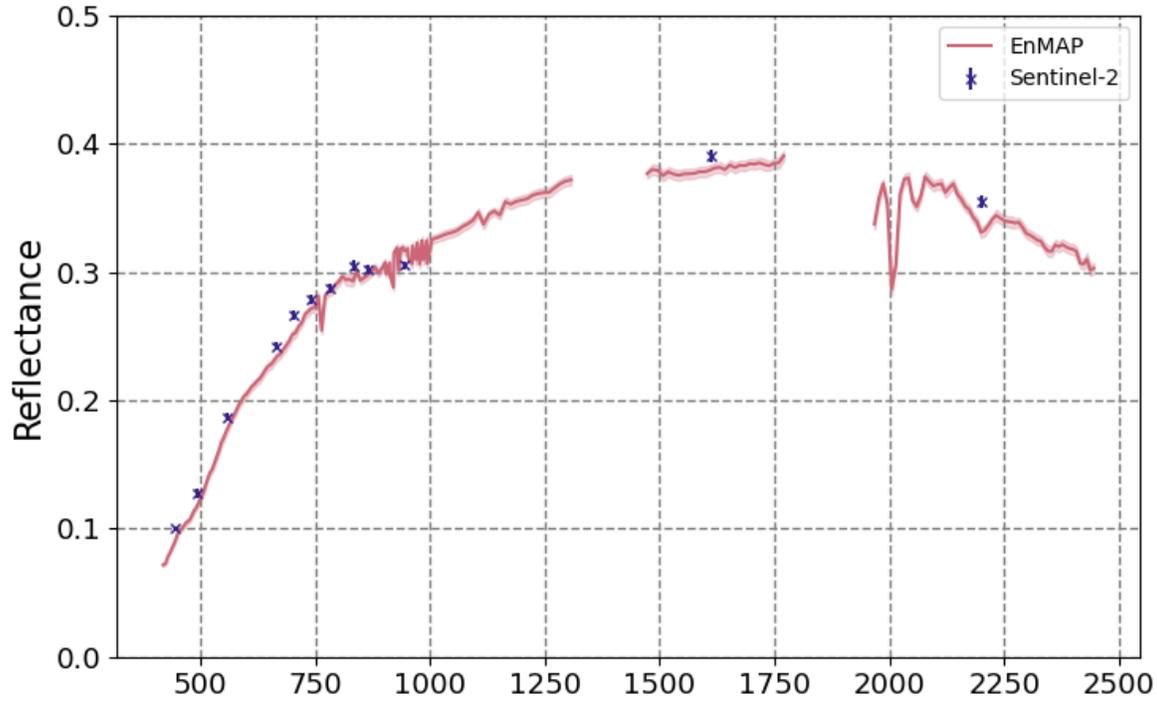




Overpasses: HySpex, EnMAP, Sentinel-2C

In-Situ uncertainty:	8%
HySpex residual:	2%
EnMAP residual:	8%
Sentinel-2C residual:	12%



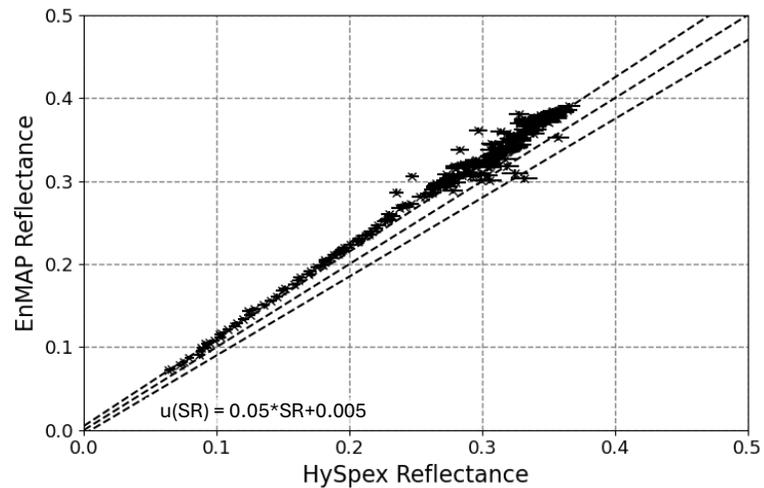
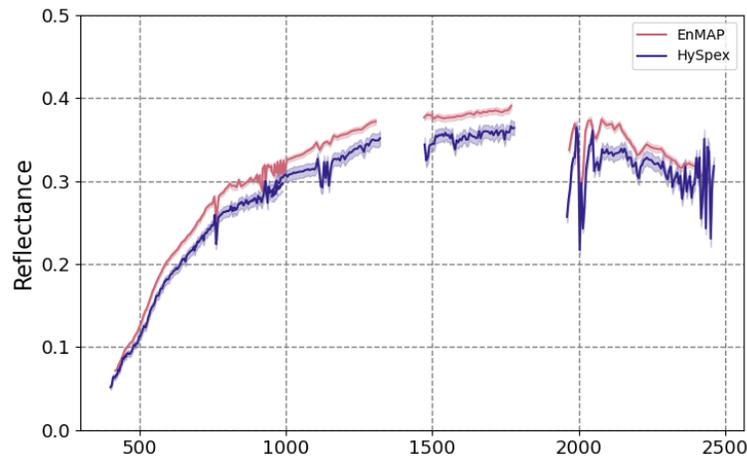


EnMAP – S2C

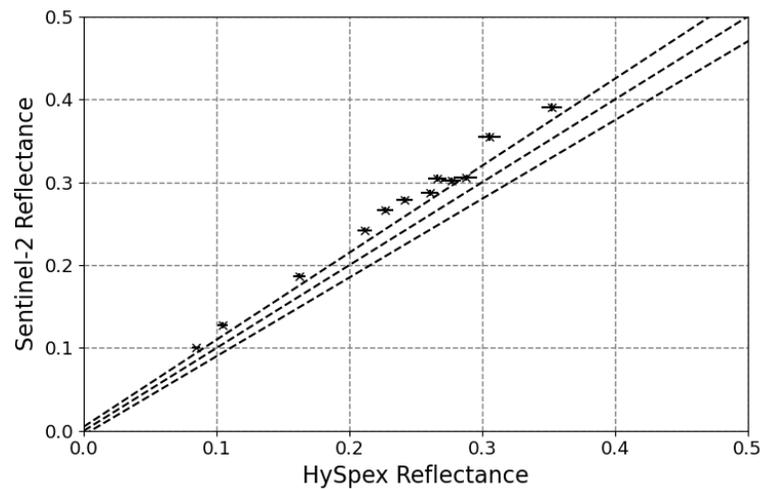
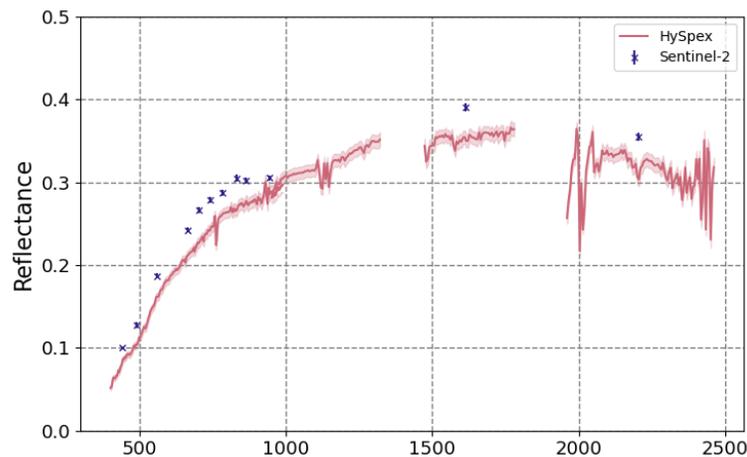
Good agreement, within uncertainty:

$$u(SR) = 0.05 * SR + 0.005$$

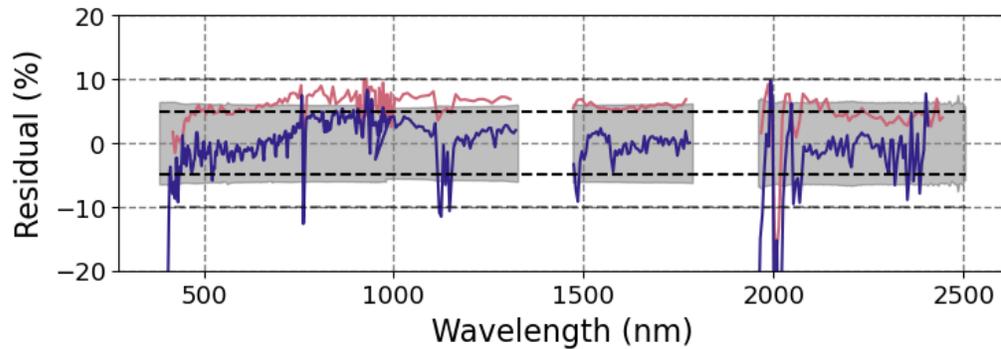
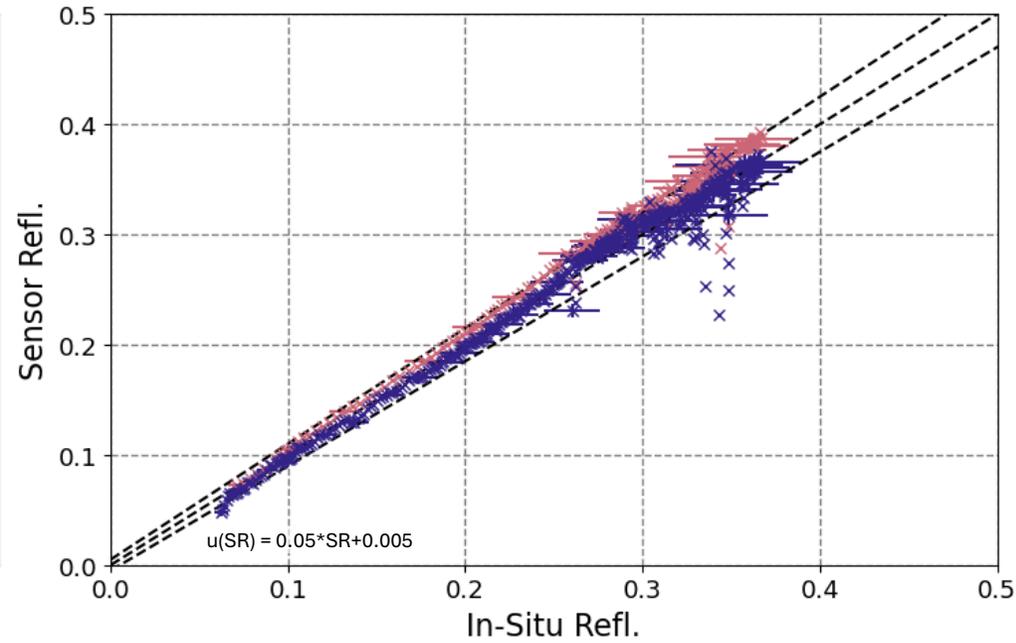
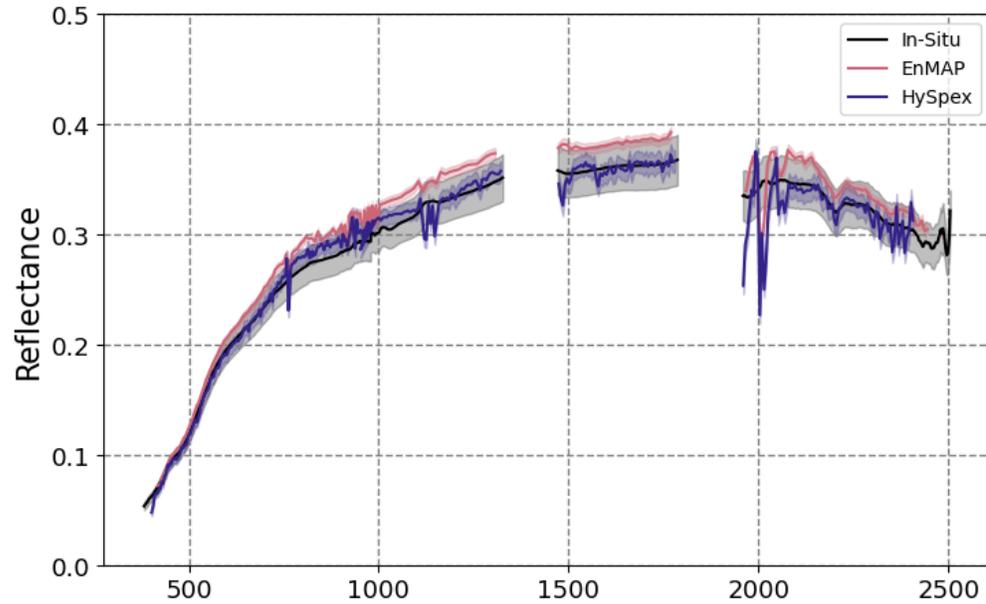
where surface reflectance is SR



EnMAP – HySpex
Outside $u(SR)$
Overall shape in agreement



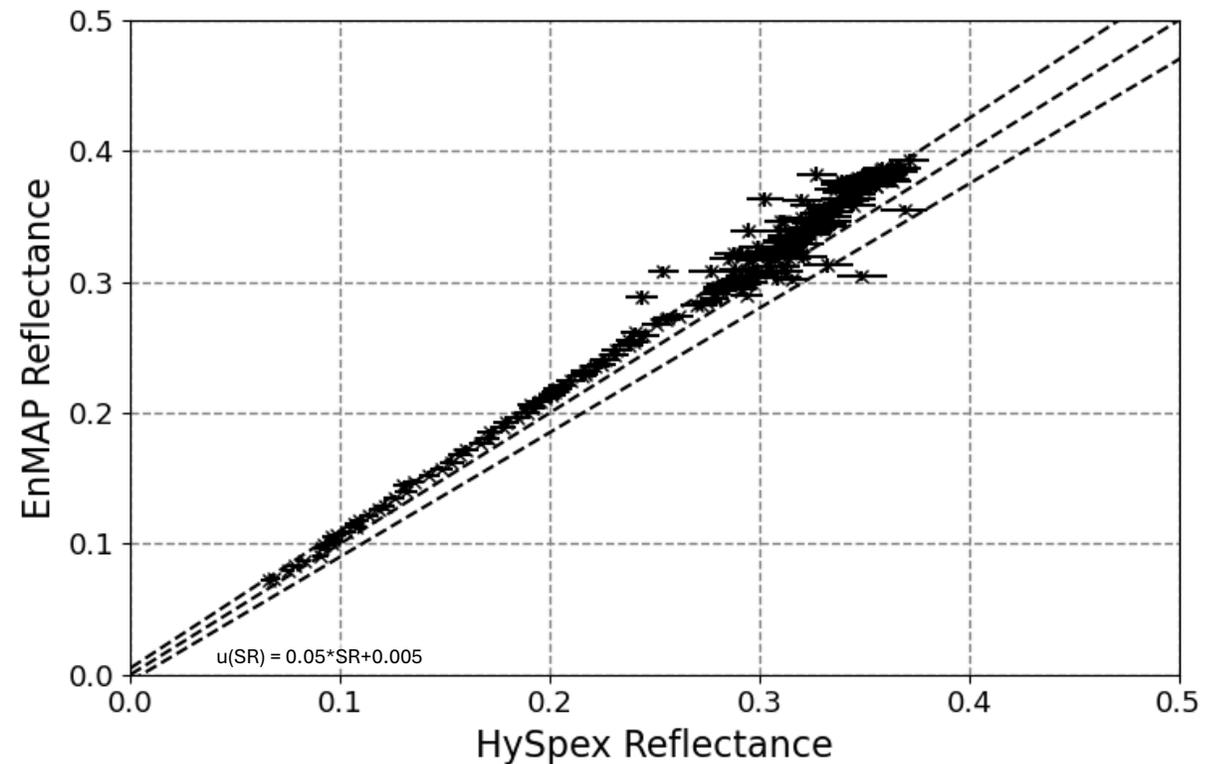
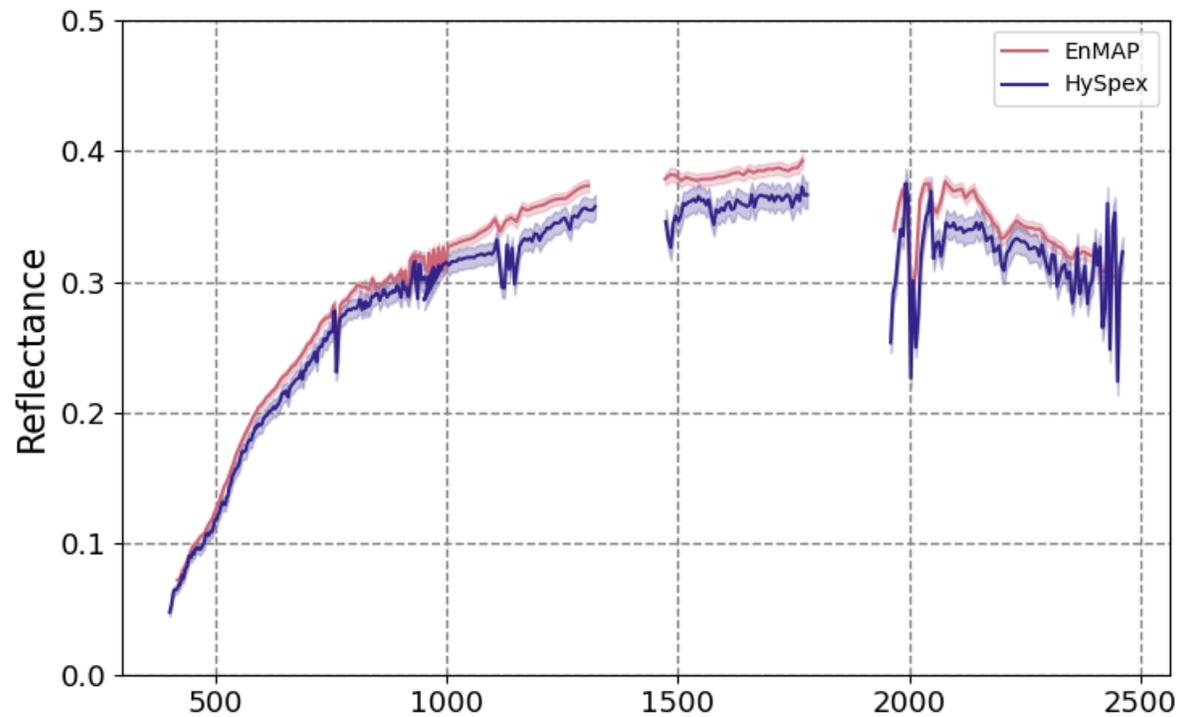
Hyspex – S2C
Outside $u(SR)$



Overpasses: HySpex, EnMAP

In-Situ uncertainty:	6%
HySpex residual:	3%
EnMAP residual:	6%

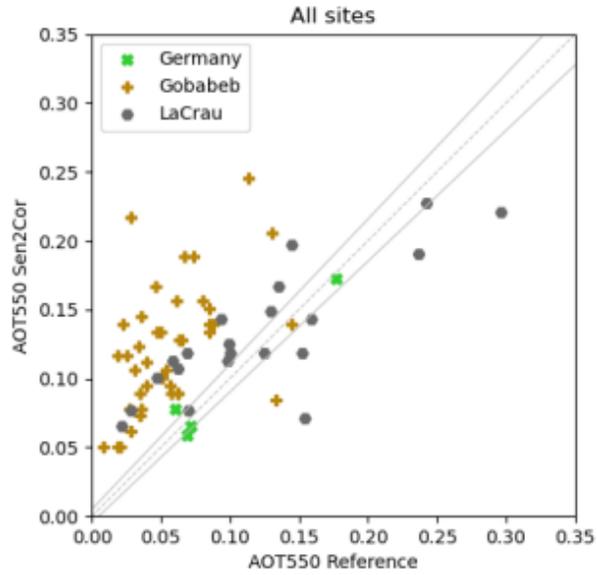




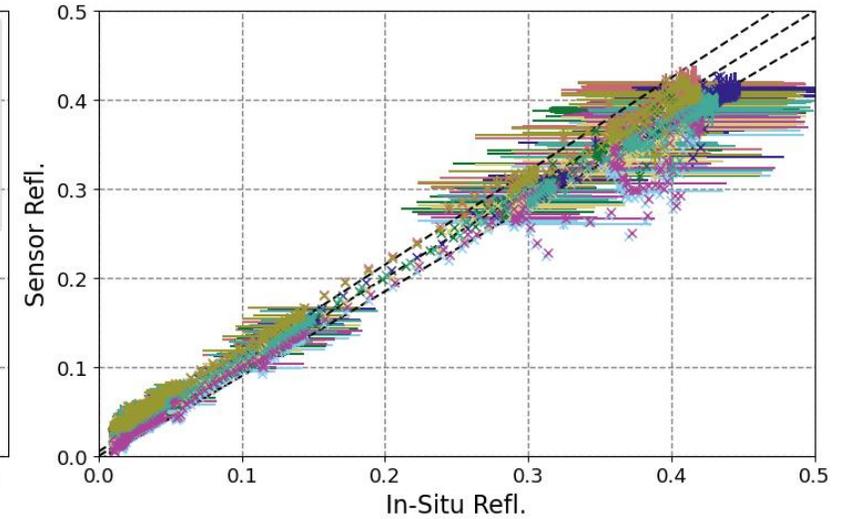
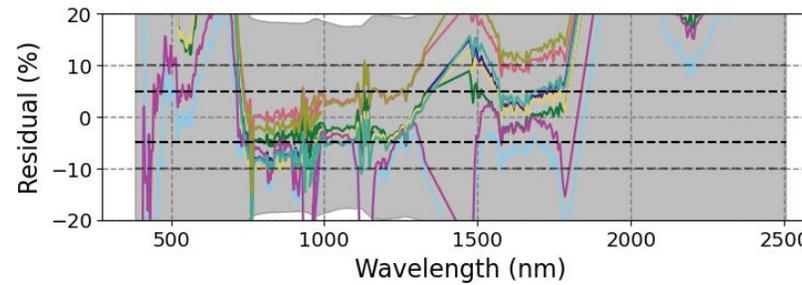
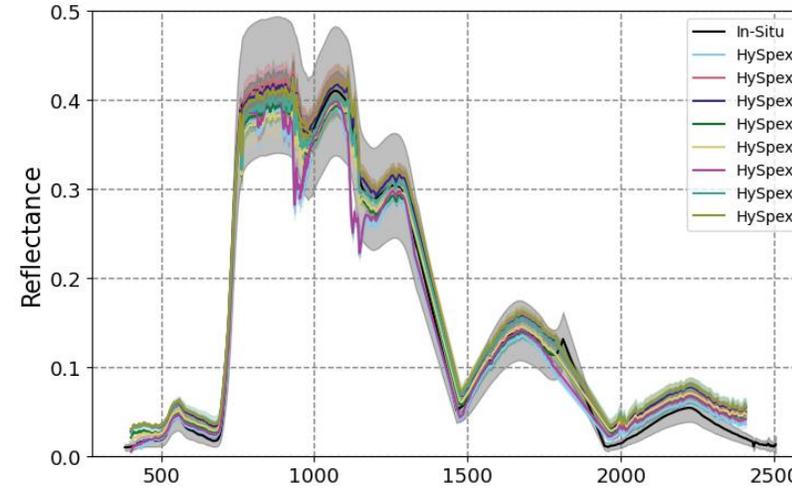
EnMAP – HySpex
Good agreement, within $u(SR)$
Overall shape in agreement

- Sensor validation with in-situ measurements (6-8% uncertainty)
 - HySpex:
 - Good agreement (2-3% residual)
 - EnMAP
 - Reasonable agreement (6-8% residual)
 - Consistently above in-situ measurements
 - Sentinel-2
 - Worse agreement (12% residual) but no spectral convolution applied yet
 - Consistently above in-situ measurements
 - In-situ measurements:
 - Variable inhomogeneity of sites
 - Bare soil targets 6-8% uncertainty
 - Vegetation targets 28-47% uncertainty
 - Harvested field 37% uncertainty
 - 4° optic lens with small measurement area
- > site uncertainty needs careful handling
- > measurement scales need careful handling

AOT-retrieval



Incorporate sun photometer measurements to look at atmospheric properties



BRDF campaign with HySpex



Thank you for listening

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