AGRIROSEL AND CARMA 2025

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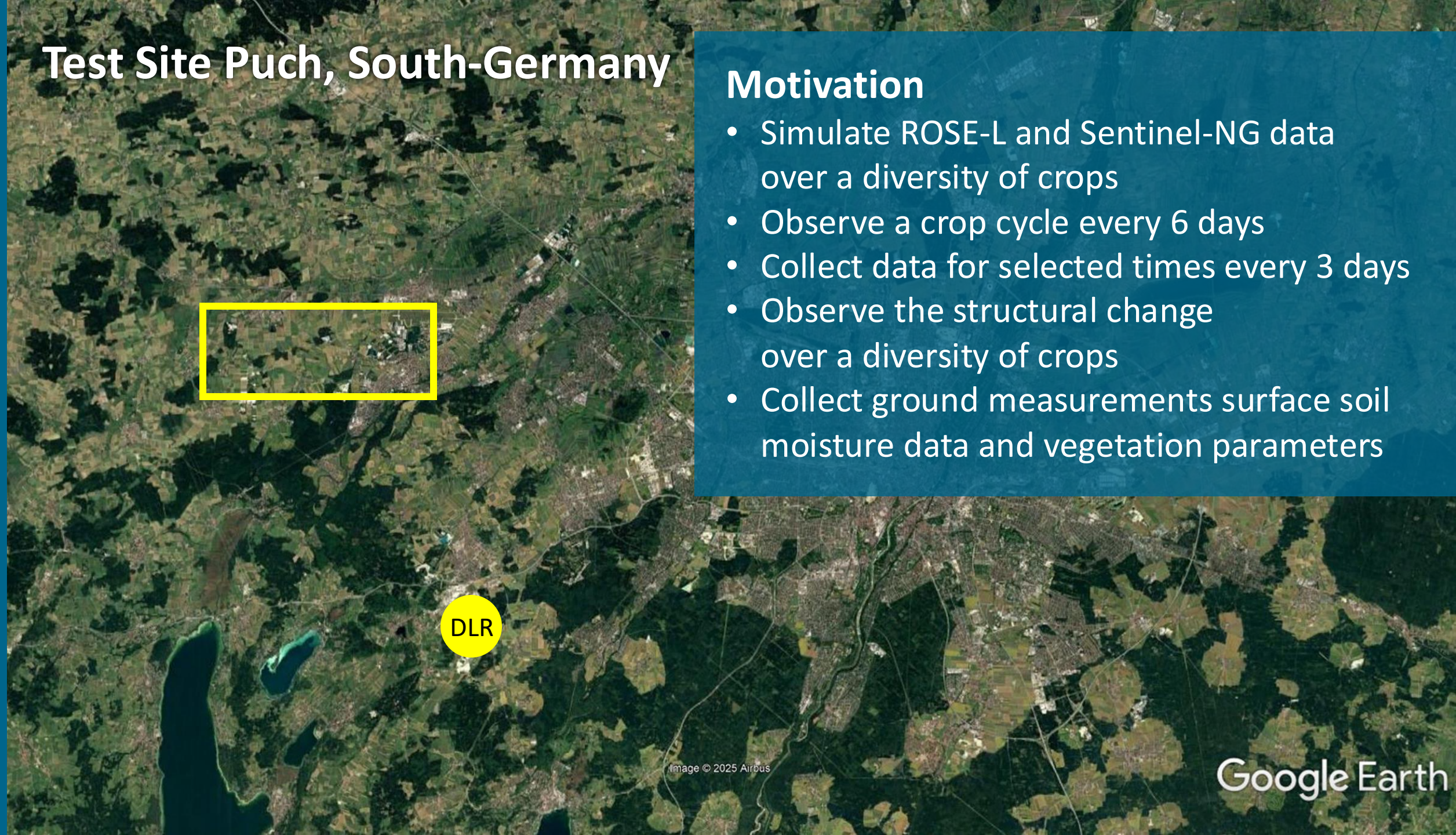
Test Site Puch, South-Germany



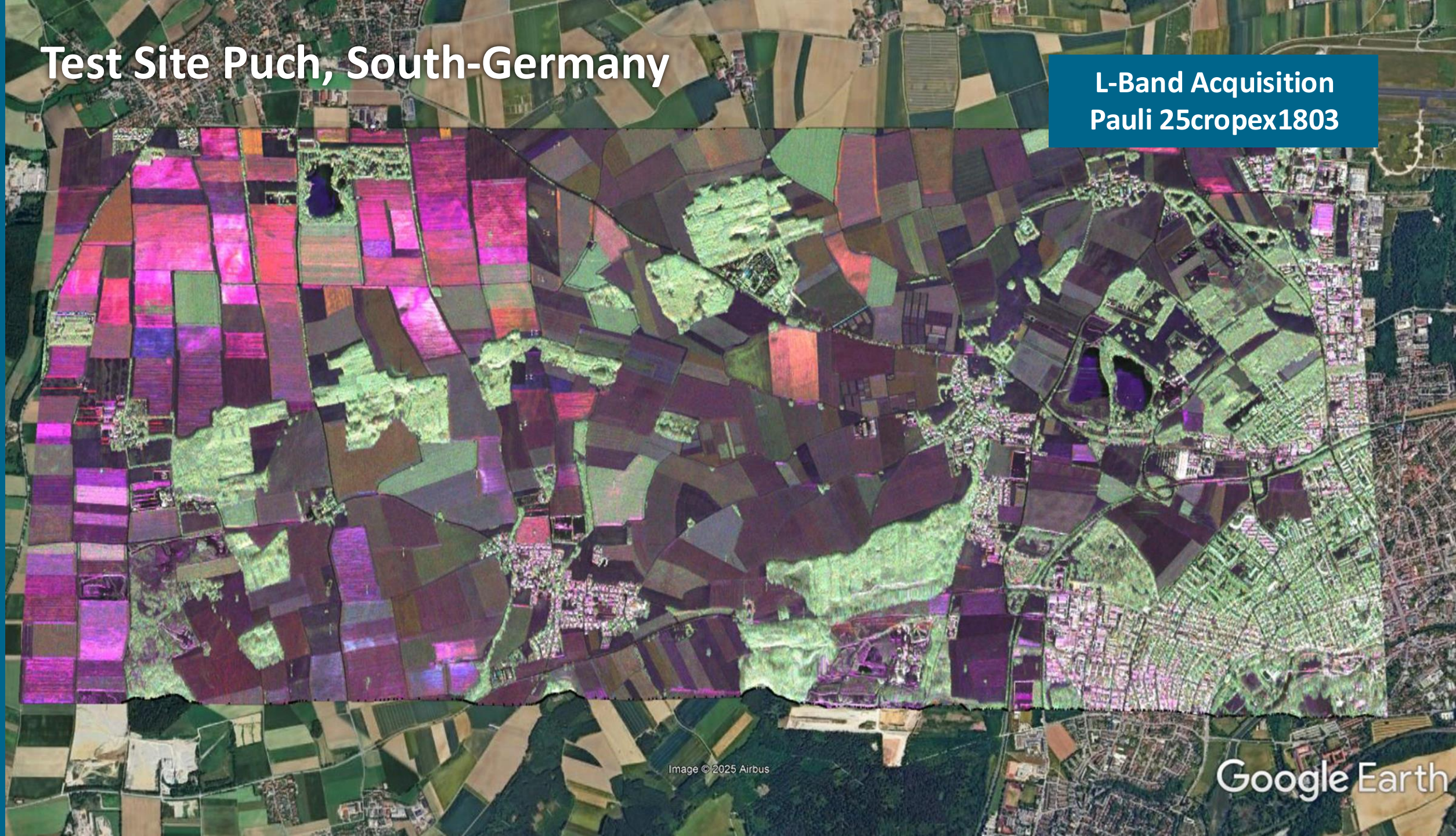
Motivation

- Simulate ROSE-L and Sentinel-NG data over a diversity of crops
- Observe a crop cycle every 6 days
- Collect data for selected times every 3 days
- Observe the structural change over a diversity of crops
- Collect ground measurements surface soil moisture data and vegetation parameters

Test Site Puch, South-Germany

Test Site Puch, South-Germany

L-Band Acquisition
Pauli 25cropex1803



Test Site Puch, South-Germany

L-Band Acquisition
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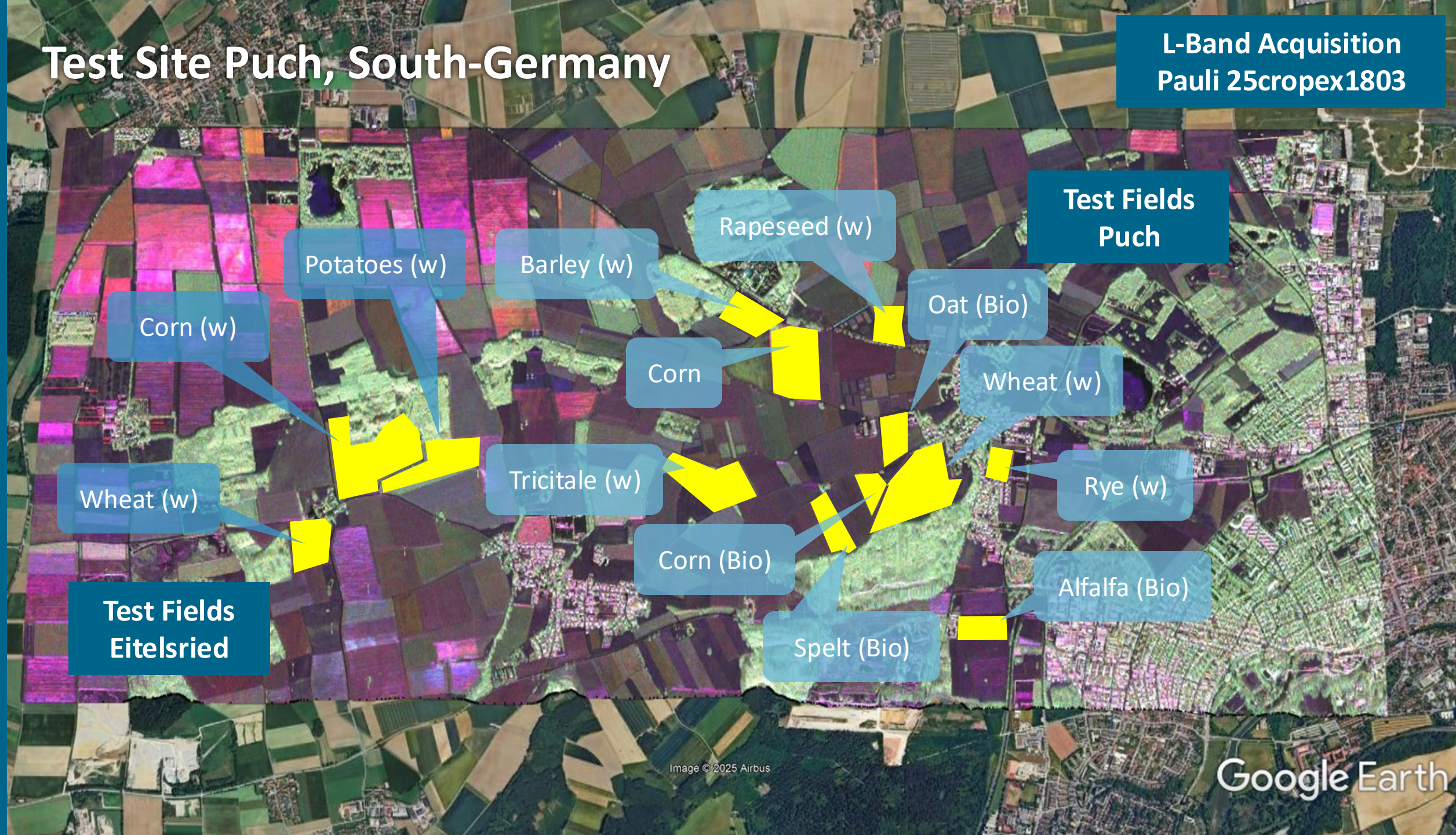

Target Variables

Optical Campaign
Leaf-Area-Index (LAI)
Average Leaf Inclination Angle (ALIA)
Leaf Mass Area (LMA)
Leaf Chlorophyll Content (Cab)
Aboveground dry biomass (leaf)
Aboveground dry biomass (stem)
Aboveground dry biomass (fruit)
Aboveground dry biomass (total)
Canopy Water Content (CWC, leaf)
Canopy Water Content (CWC, stem)
Canopy Water Content (CWC, fruit)
Canopy Water Content (CWC, total aboveground)
Phenology
Average Canopy Height
Spectral signature
Vertical photograph
Canopy Nitrogen Content (CNC, leaf)
Canopy Nitrogen Content (CNC, stem)
Canopy Nitrogen Content (CNC, fruit)
Canopy Carbon Content (CCC, leaf)
Canopy Carbon Content (CCC, stem)
Canopy Carbon Content (CCC, fruit)
(Bot.) Rating
Fractional Cover (fCover)
Soil Organic Carbon Content (SOC)

Radar Campaign
Leaf-Area-Index (LAI)
Aboveground dry biomass (total)
Canopy Water Content (CWC, total aboveground)
Phenology
Average Canopy Height
Vertical photograph
(Bot.) Rating
Soil moisture toplayer
Soil moisture at 10 cm depth
Surface Roughness
Observation of external wetting (intercepted water, dew, rain etc.)
Fractional Cover (fCover)
LiDAR, DSM, DEM

Sampling Strategy

- Vegetation sample points
- Narrow Grid – Soil Moisture

Sampling Protocoll

Measurement report

Campaign name: CARMA

Field -ID : 1 (Wintergerste) Date:

Operating persons:

Weather conditions: Sky cover: / 8 Begin/: End time:

Remarks:

Pictures:
- Row-oriented
- From above (sensor view)
- North to South
- Overview picture

Protokoll geprüft:
Messwerte geprüft:
Digitalisiert:
Digitalisierung geprüft:

ESU: 1.1 Time: Picture number(s): * all pictures taken?

Phenology: LMA bag:

Estimated share of **brown leaf area** per layer: [%] upper layer [%] lower layer

LIDF : tick box below

ALIA (Average leaf inclination angle) Top: Mid: Bottom:

LAI (Leaf Area Index) last value: SEL: (max: 0.3) file name:

Spherical Uniform Erectophile Planophile Plagiophile Extremophile

Crop height [cm]: / / / / /

Leaf Chlorophyll (SPAD): / / / / /

Biomass (0.25 m²): [g] * 3 rows

Row distance [cm]:
Plants p. [m]:
Row incl. angle [°]:

(Bot.) Rating

External wetting
No ☐ | little ☐ | much ☐
Description:

Field-ID: 1

e number(s): * all pictures taken?

LMA bag:

LAI (Leaf Area Index) last value: SEL: (max: 0.3) file name:

Plagiophile Extremophile

Biomass (0.25 m²): [g] * 3 rows

External wetting
No ☐ | little ☐ | much ☐
Description:

e number(s): * all pictures taken?

LMA bag:

LAI (Leaf Area Index) last value: SEL: (max: 0.3) file name:

Spherical Uniform Erectophile Planophile Plagiophile Extremophile

Crop height [cm]: / / / / /

Leaf Chlorophyll (SPAD): / / / / /

Biomass (0.25 m²): [g] * 3 rows

Row distance [cm]:
Plants p. [m]:
Row incl. angle [°]:

(Bot.) Rating

External wetting
No ☐ | little ☐ | much ☐
Description:

Measurement report

Campaign name: CARMA

Field -ID : 1 (Wintergerste) Date:

Operating persons:

Weather conditions: Sky cover: / 8 Begin/: End time:

Soil moisture

ESU	GPS	Time	Value #1	Value #2	Value #3	Value #4	Value #5
1.1							
1.2							
1.3							
1.4							
1.5							
1.6							
1.7							
1.8							
1.9							
1.10							
1.11							
1.12							
1.13							
1.14							
1.15							
1.16							

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LMU Drone & Lab Work

F-SAR Collected Data over 4 Months

April

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

x3

May

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

June

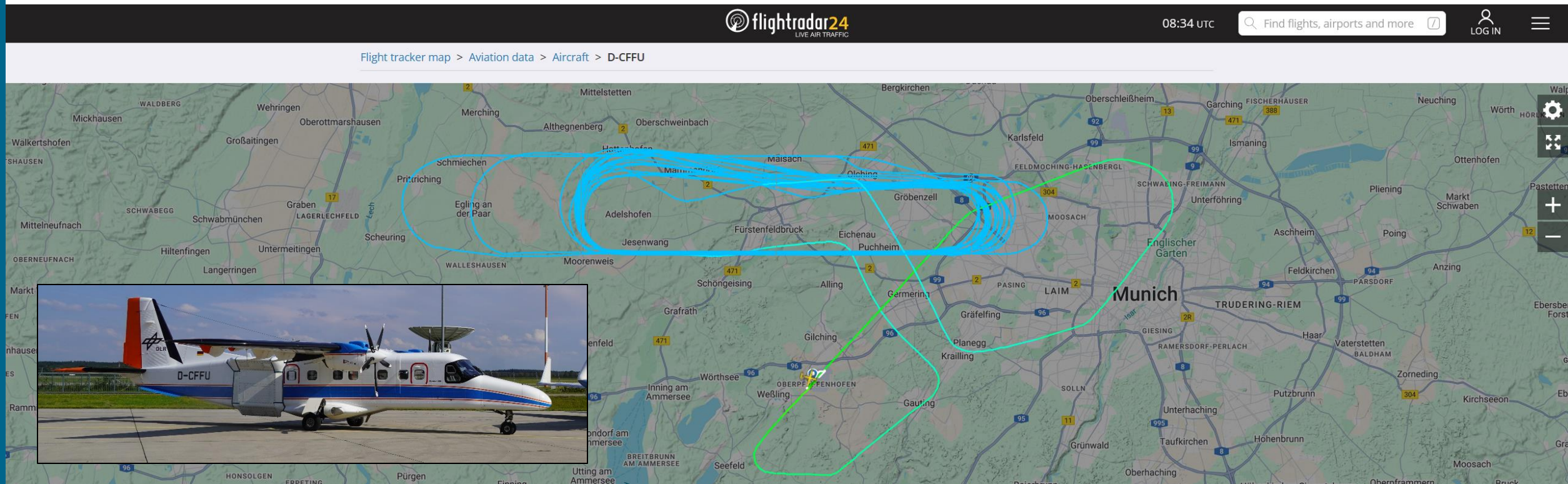
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

x3

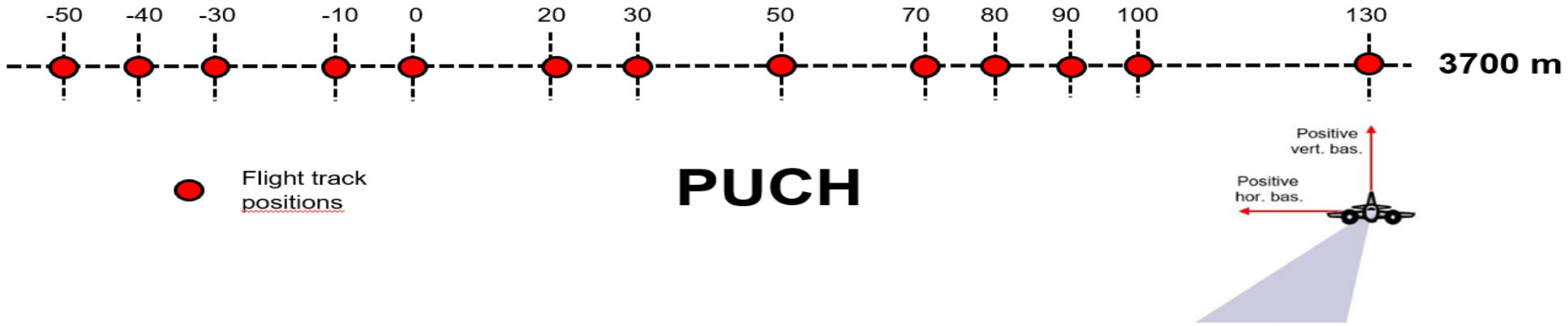
July

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

x2



F-SAR TomoSAR Configuration



Horizontal BL [m]	-50	-40	-30	-10	0	20	30	50	70	80	90	100	130
Vertical BL [m]	0	0	0	0	0	0	0	0	0	0	0	0	0
Freq.	L C	L C	L C	L C	L C	L C	L C	L C	L C	L	L	L	L

		Near	Mid	Far	Baselines
Incidence angle		25°	40°	55°	
L-Band	Height amb.	21.55	45.88	104.29	-50 – 130
	Vert. res.	1.2	2.55	5.79	
C-Band	Height amb.	5.39	11.47	25.07	-50 – 70
	Vert. res.	0.45	0.96	2.17	

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HySpex Collection

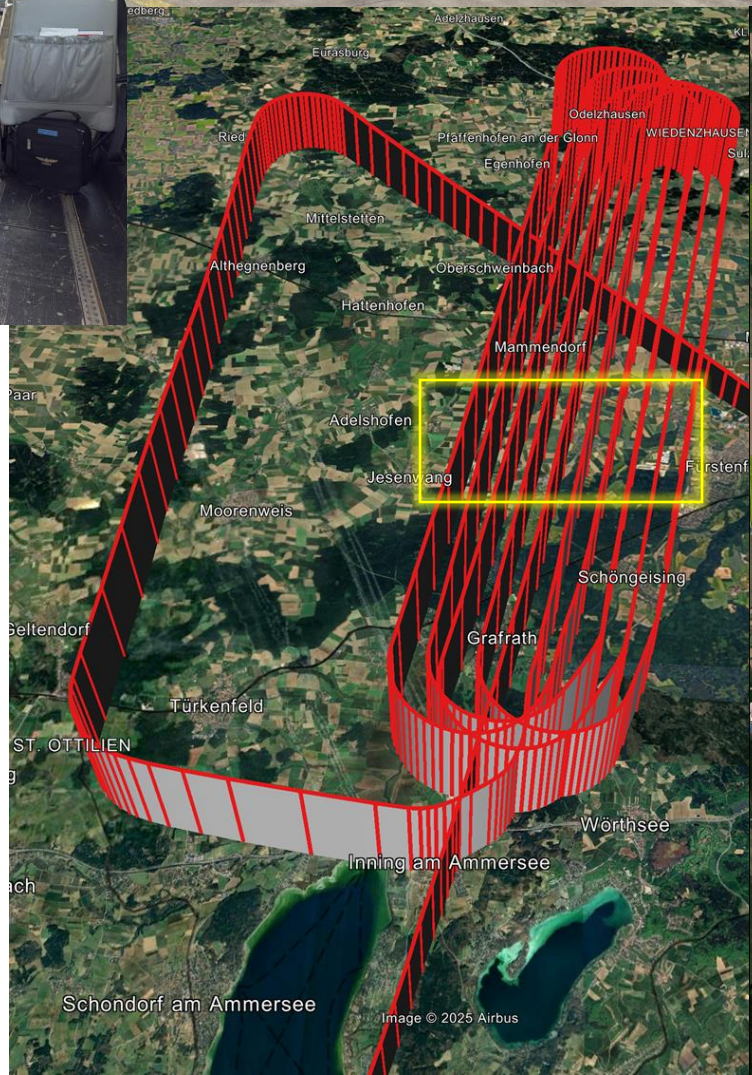
DLR Earth Observation Center

Airborne Imaging Spectrometer:

- 420nm - 2500nm
- 426 bands
- 1.4m Spatial Resolution

Four successful flights:

- 30.04.25
- 12.05.25 → in parallel with PRISMA
- 13.05.25 → related to BRDF effects
- 19.05.25 → in parallel with EnMAP



IMF-ASP:

- SVC → Surface Reflectance Measurement's
- Microtops → AOT, WVP etc.
- 15.000 UAV RGB Images
- Coordination of Hyperspectral Satellite Acquisitions
  - EnMAP (13)
  - DESIS (16)
  - PRISMA (11)

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Optical Sensing and Soil Parameters

Date	Flight altitude	Sensors	Resolutions spatial / spectral	Synergies
19 Jul 2025 CzechGlobe	2200m AGL (Airborne)	HyPlant (FZJ)	DUAL 3.3m / 626 bands, fwhm 2.8 – 11 nm FLUO 3.3m / 1024 bands, fwhm 0.11 nm	EnMap Biomass, LMA and (vegetation variables sampling) 
		TASI	2.6 m / 22 bands	
		LiDAR	>3.6 pts/m^2	
1-3 Oct 2025 GFZ	120m AGL (UAV)	**HySpex Mjolnier** VS-620	~6.5 cm / 200 VNIR (3nm), 300 SWIR (5nm) bands 6 flights 2 crop fields	**DLR EnMAP + ASI PRISMA** No Condordant EnMap (clouds/orbit) ☹ **GFZ** **Field ASD** 1nm 0.4-2.5 µm **Field Agilent** FTIR 4wn^{-1} 3-20 µm **Topsoil sampling** - TC, TOC, and TN determination - pH and electrical conductivity (in H_2O) - Fe (dithionite-extractable) - Particle-size distribution (Laser Diffraction)
3 Oct 2025 CzechGlobe	4100m AGL (Airborne)	**CASI/SASI**	CASI 2 m / 144 bands, fwhm 4.8 mm SASI 5 m / 100 bands, fwhm 10 nm	
		TASI	5.0 m / 22 bands Malfunctioning -> no data ☹	
		LiDAR	>1.0 pts/m^2	

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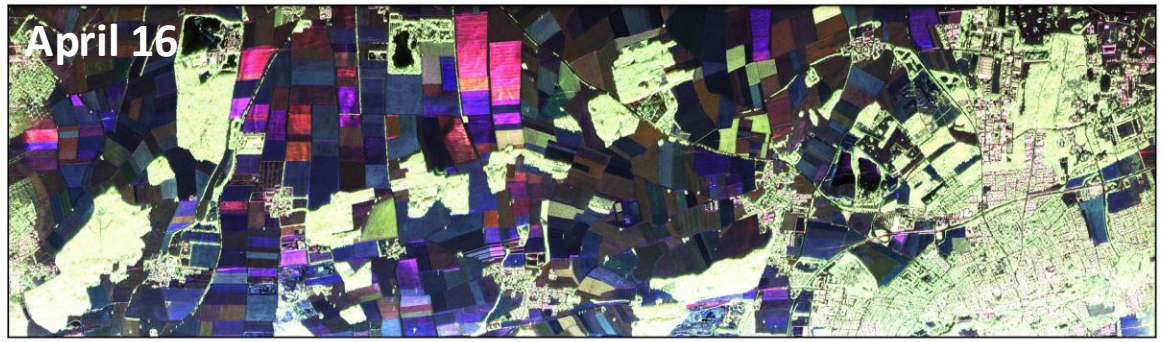
GFZ@ R. Milewski, D. Angelopoulou, A. Abdelbaki, L. Marrone, S. Chabrillat

Eitelsried Fields, April 16

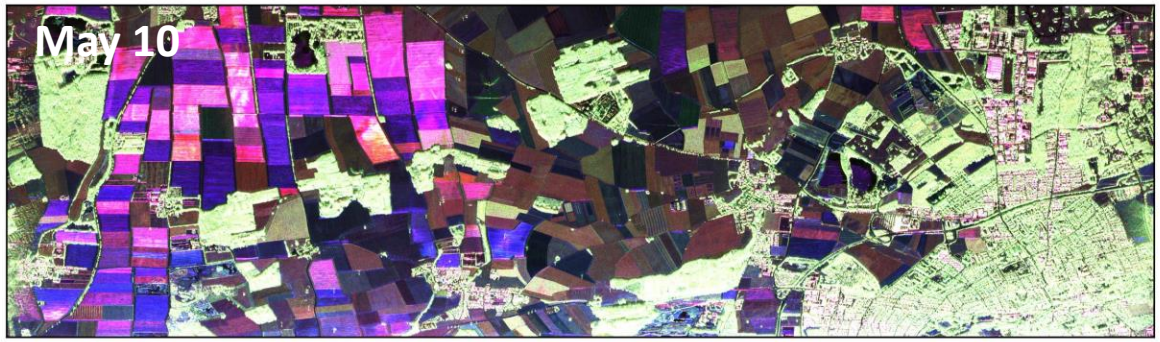
Eitelsried Fields, July 23

Preliminary Data Analysis – Polarimetry L-band

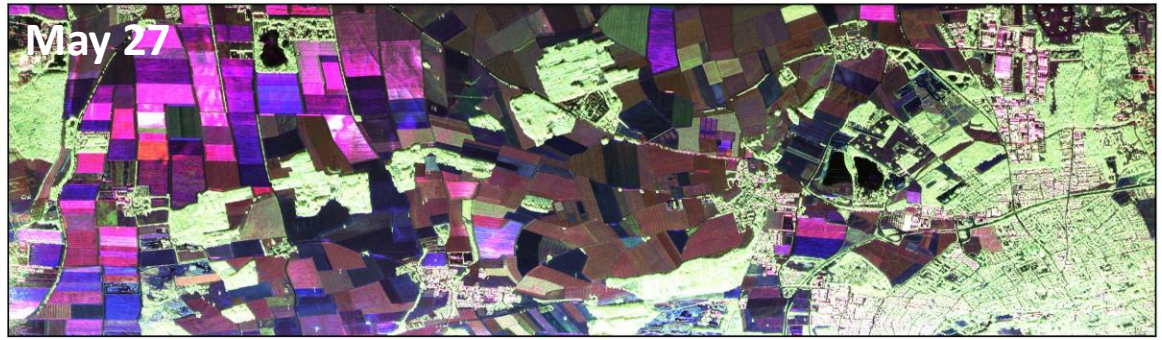
25cropex0103, L, 2025-04-16 08:25 UTC



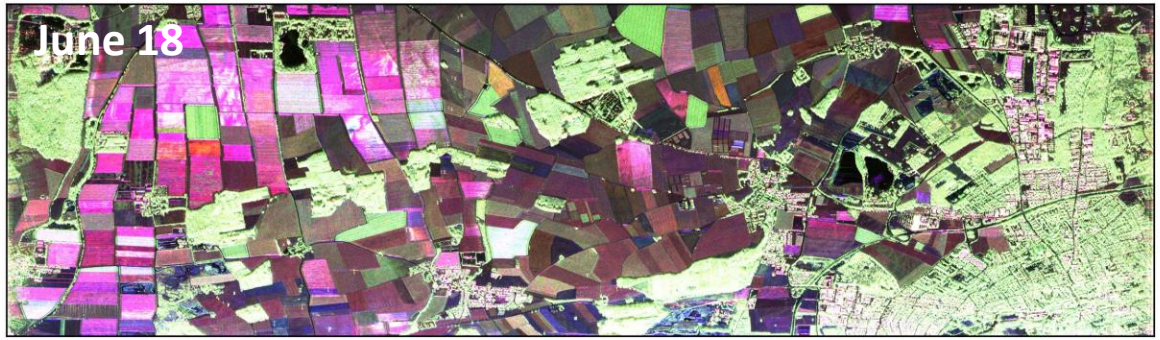
25cropex0712, L, 2025-05-10 09:59 UTC



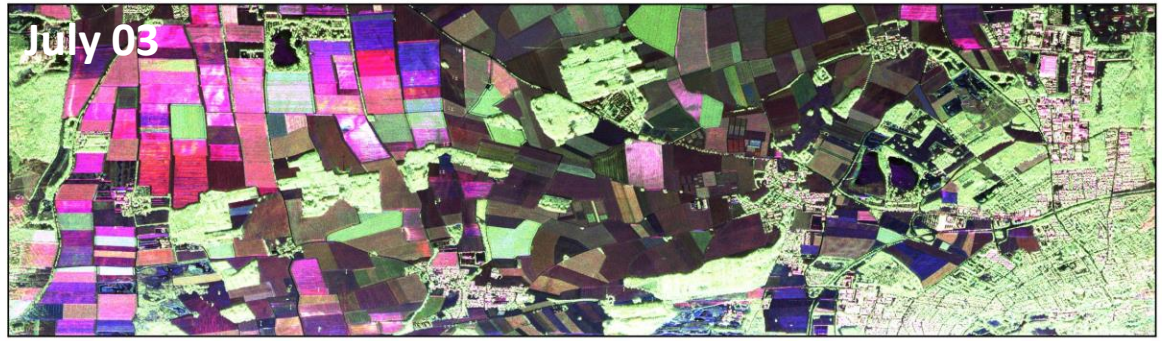
25cropex1011, L, 2025-05-27 14:06 UTC



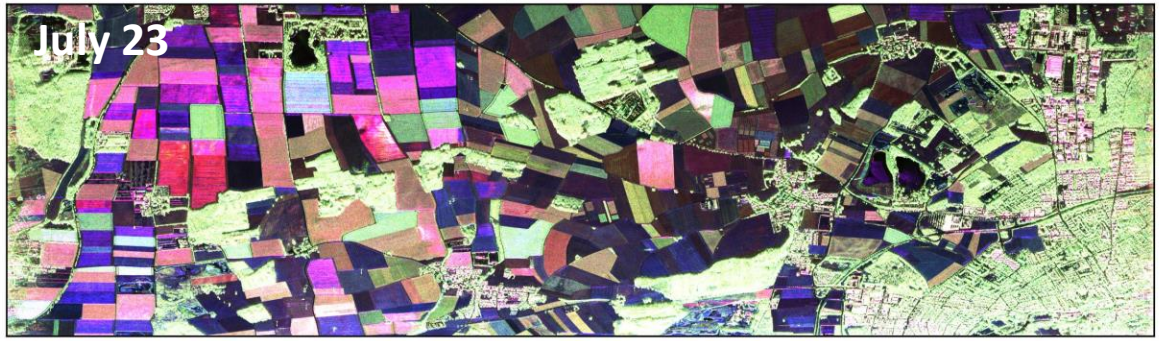
25cropex1603, L, 2025-06-18 07:52 UTC



25cropex1913, L, 2025-07-03 09:25 UTC



25cropex2303, L, 2025-07-23 08:03 UTC



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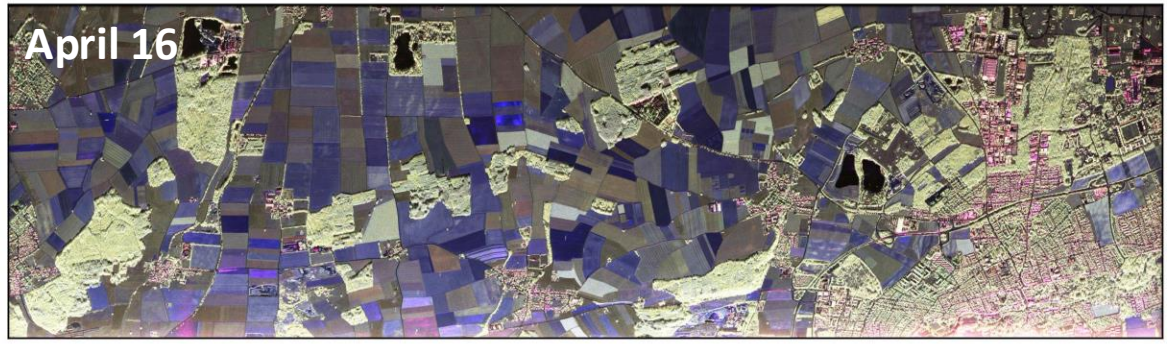
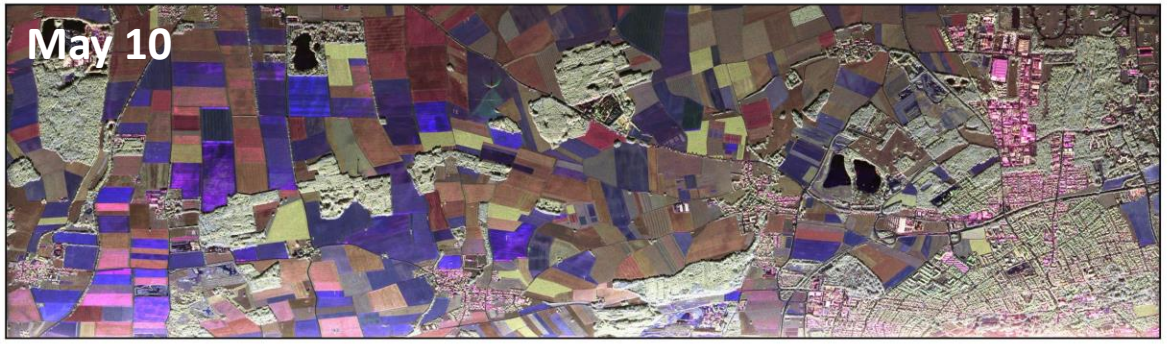
Polarization RGB: HH-VV, HV, HH+VV

Preliminary Data Analysis – Polarimetry C-band

25cropex0103, C, 2025-04-16 08:25 UTC



25cropex0712, C, 2025-05-10 09:59 UTC



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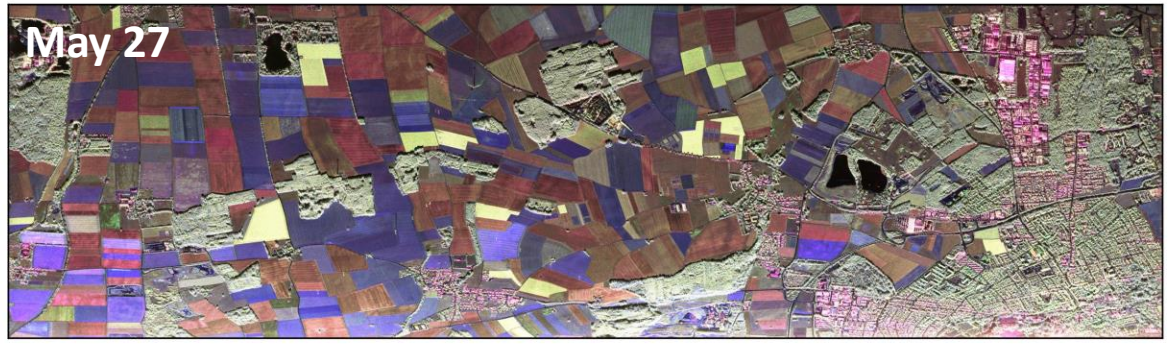

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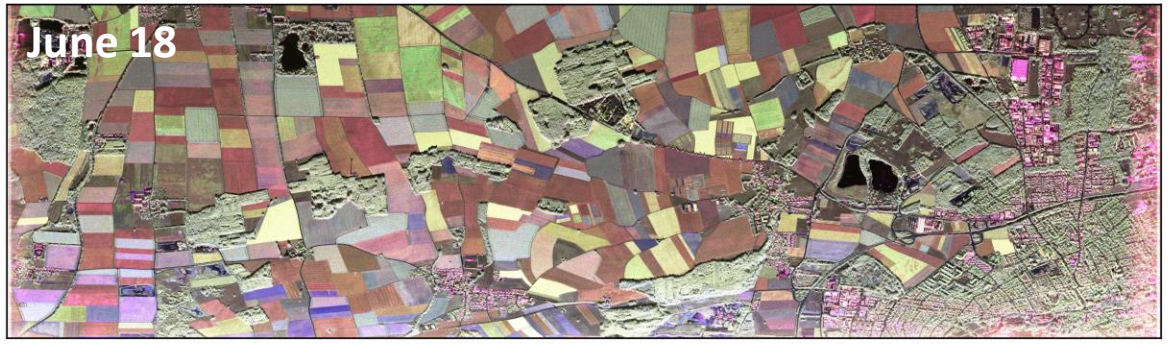
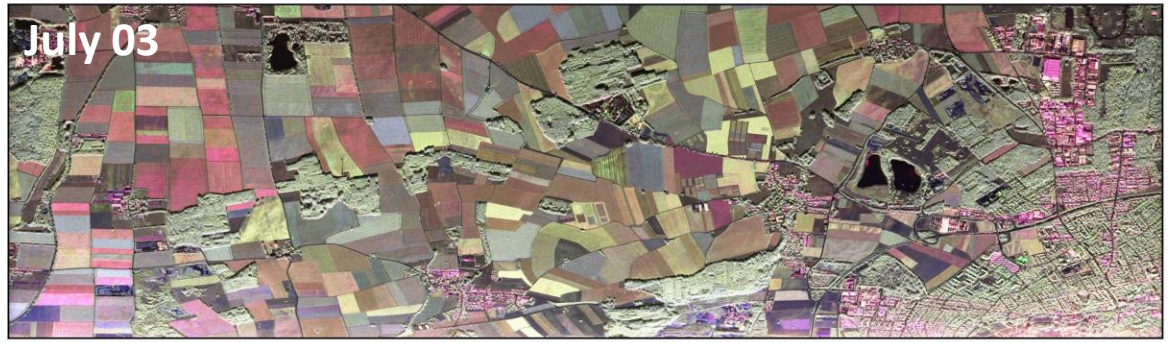
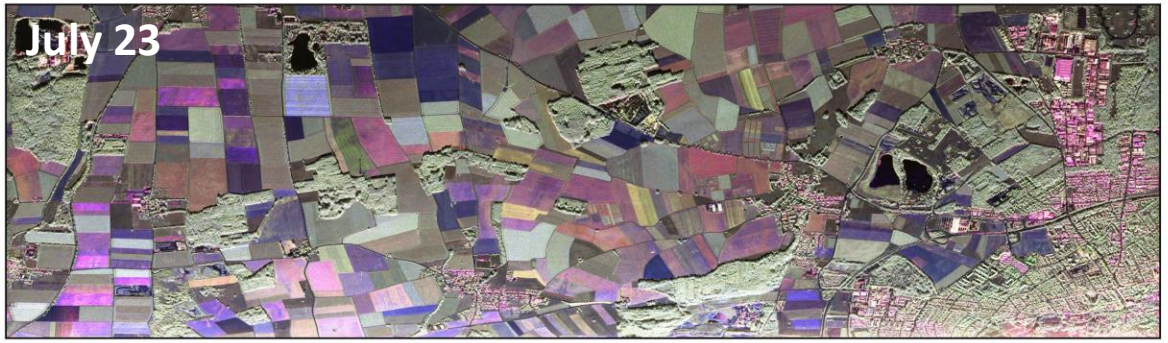


25cropex1913, C, 2025-07-03 09:25 UTC



25cropex2303, C, 2025-07-23 08:03 UTC



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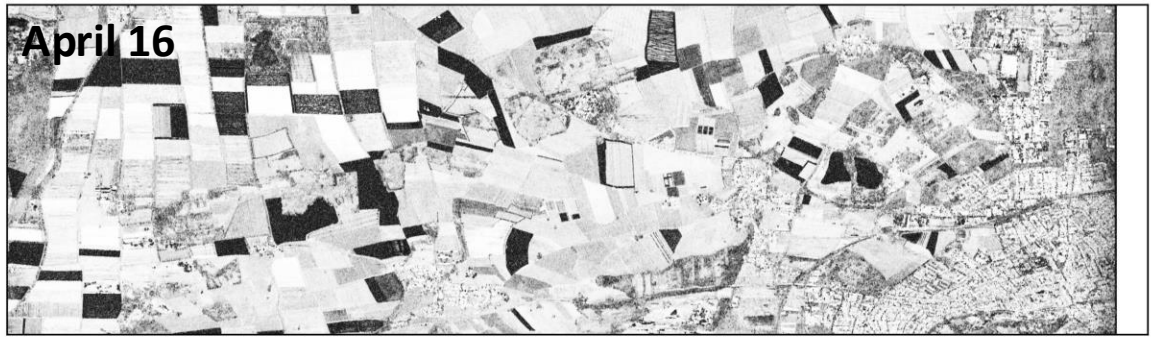
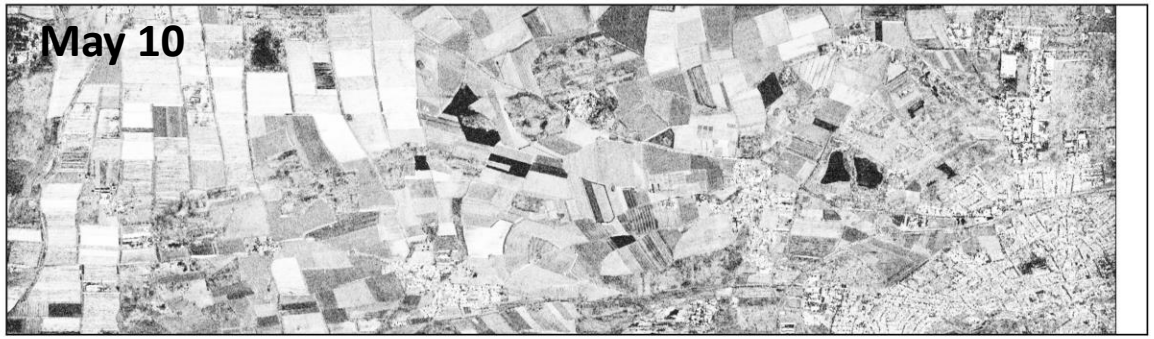
Polarization RGB: HH-VV, HV, HH+VV

Preliminary Data Analysis – Interferometry L-band (D-InSAR)

25cropex0212 - 25cropex0404, L, vv, 2025-04-22 + 6 days

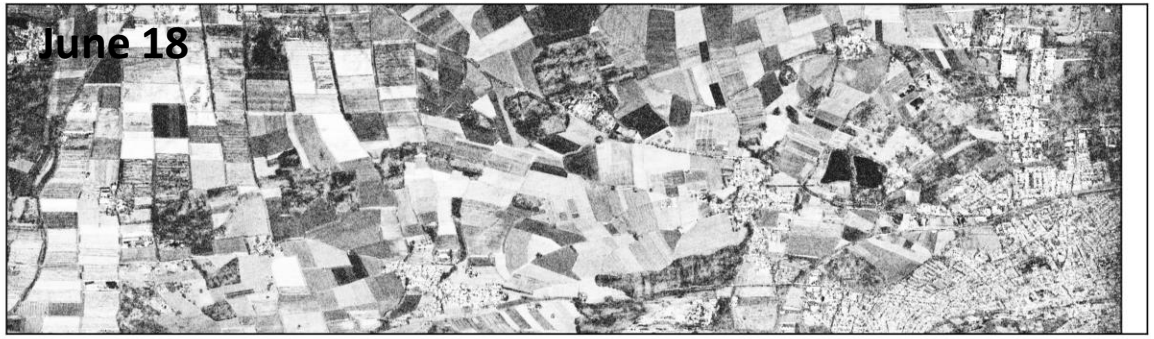


25cropex0905 - 25cropex1011, L, vv, 2025-05-21 + 6 days

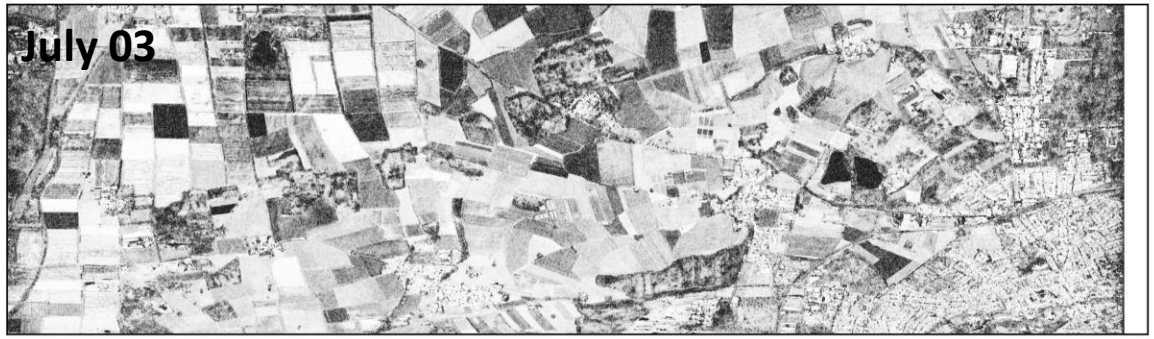


25cropex1211 - 25cropex1419, L, vv, 2025-06-03 + 3 days

25cropex1603 - 25cropex1711, L, vv, 2025-06-18 + 6 days



25cropex1803 - 25cropex1913, L, vv, 2025-06-30 + 3 days



25cropex2203 - 25cropex2303, L, vv, 2025-07-15 + 8 days

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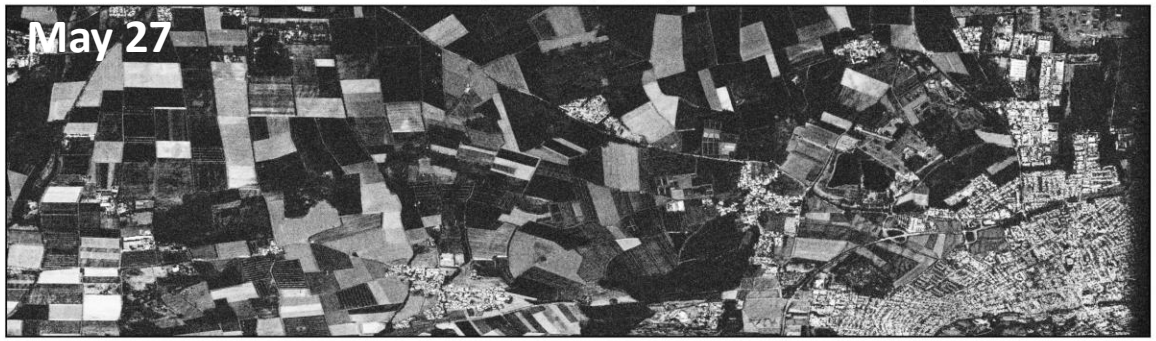
Polarization RGB: HH-VV, HV, HH+VV

Preliminary Data Analysis – Interferometry C-band (D-InSAR)

25cropex0212 - 25cropex0404, C, vv, 2025-04-22 + 6 days

25cropex0905 - 25cropex1011, C, vv, 2025-05-21 + 6 days

25cropex1211 - 25cropex1419, C, vv, 2025-06-03 + 3 days



25cropex1603 - 25cropex1711, C, vv, 2025-06-18 + 6 days

25cropex1803 - 25cropex1913, C, vv, 2025-06-30 + 3 days

25cropex2203 - 25cropex2303, C, vv, 2025-07-15 + 8 days

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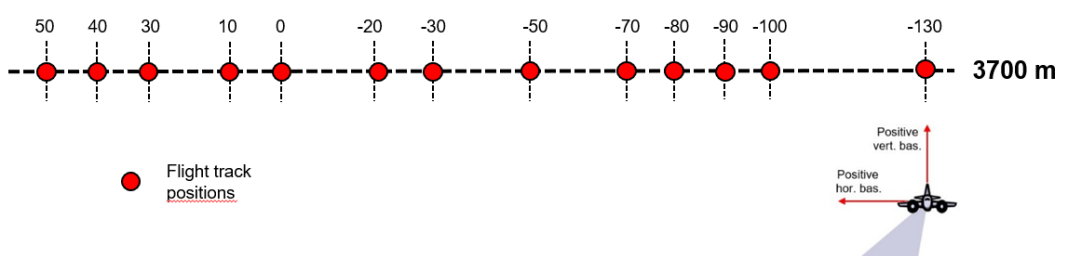
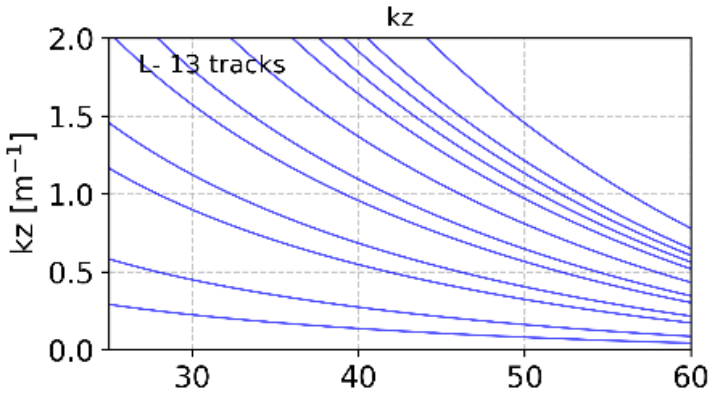
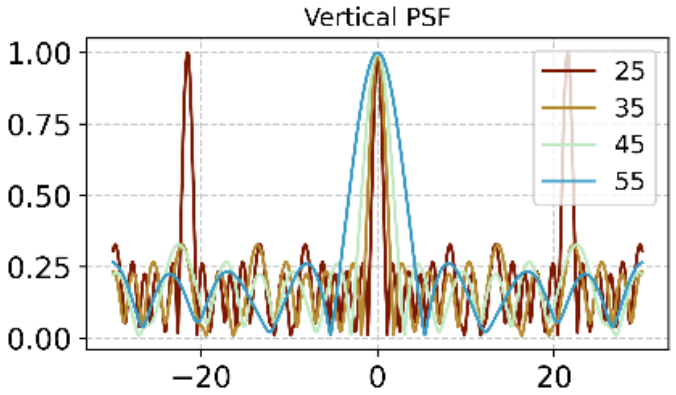
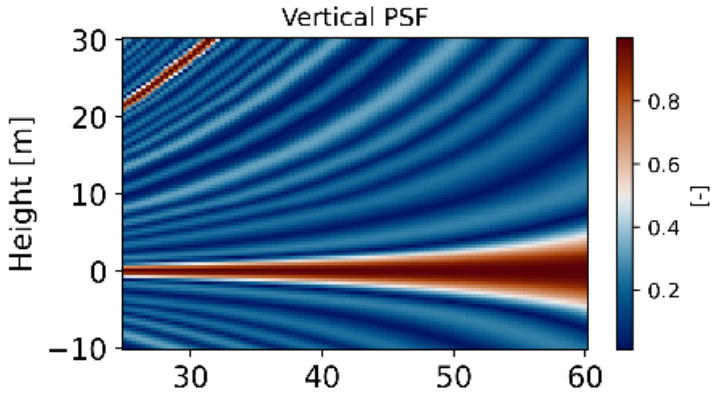
Polarization RGB: HH-VV, HV, HH+VV

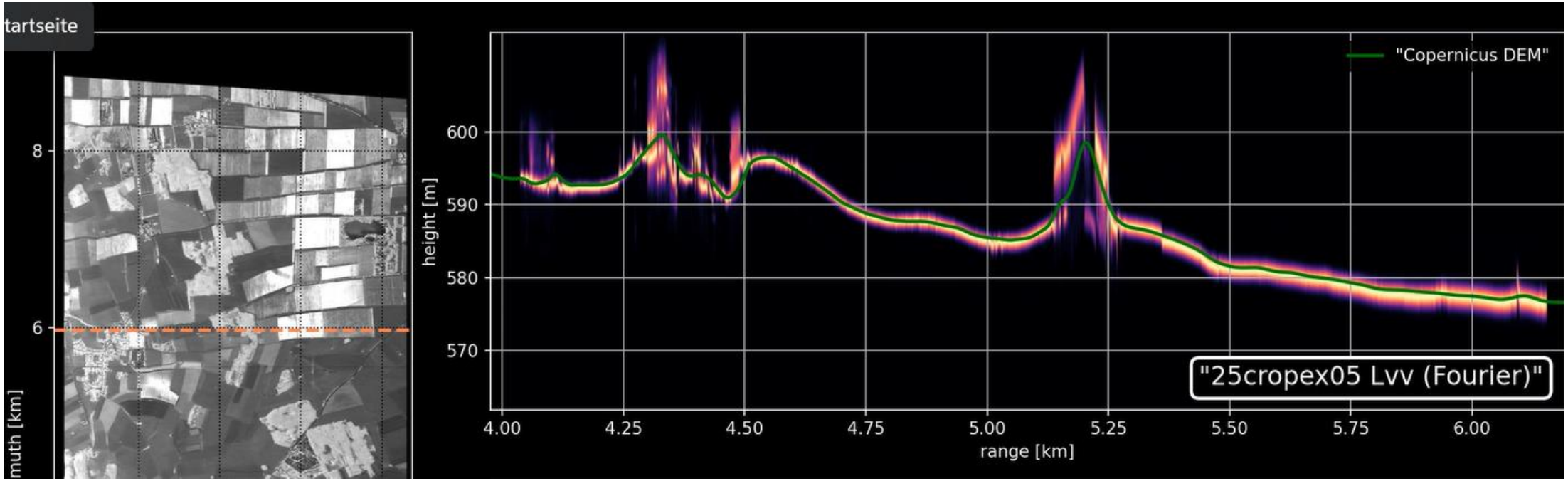
TomoSAR Baselines



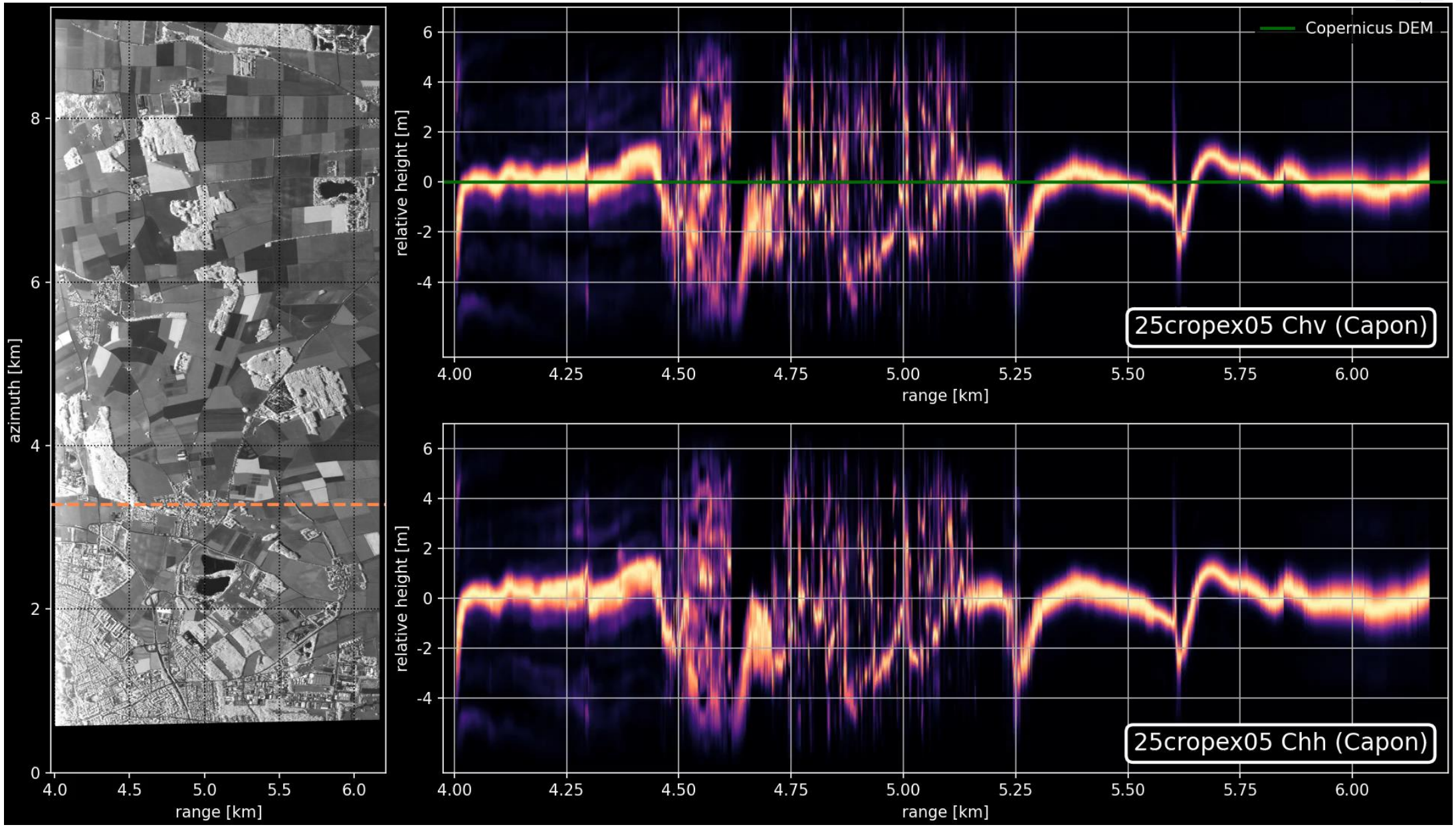






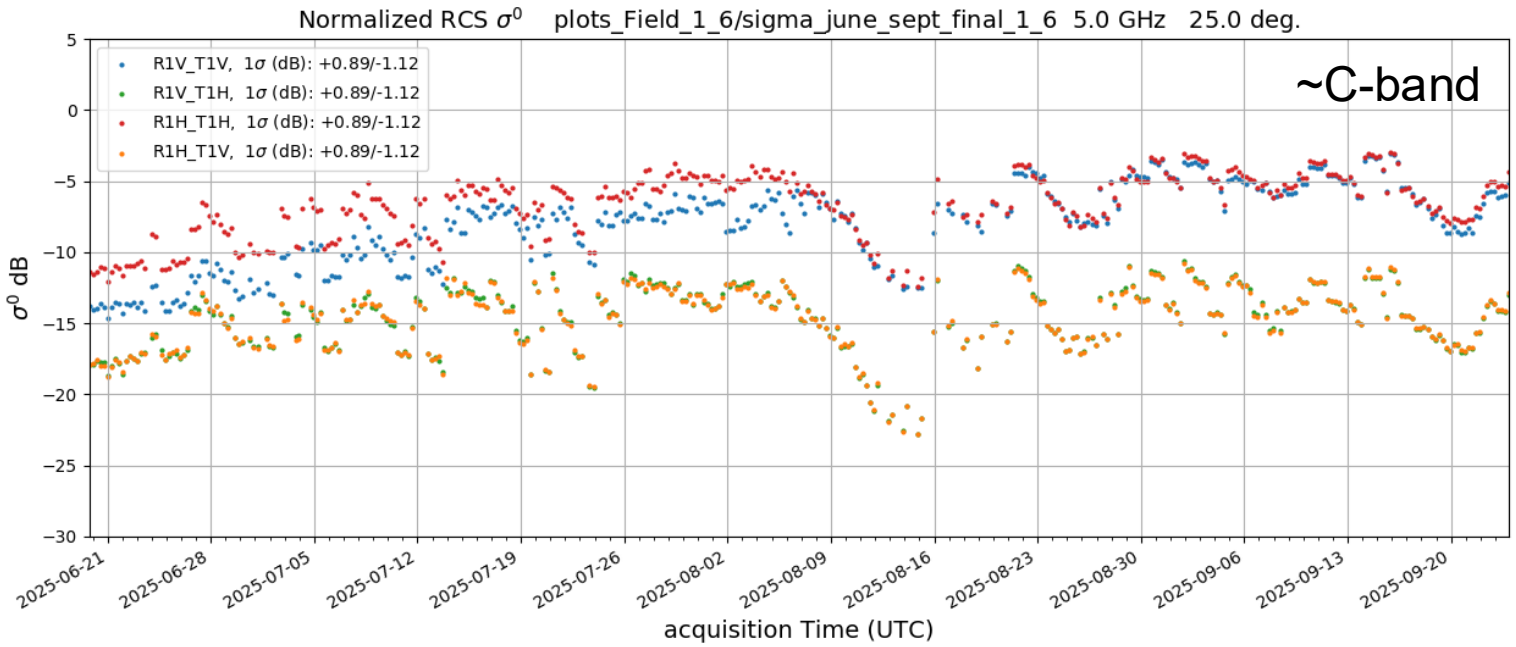


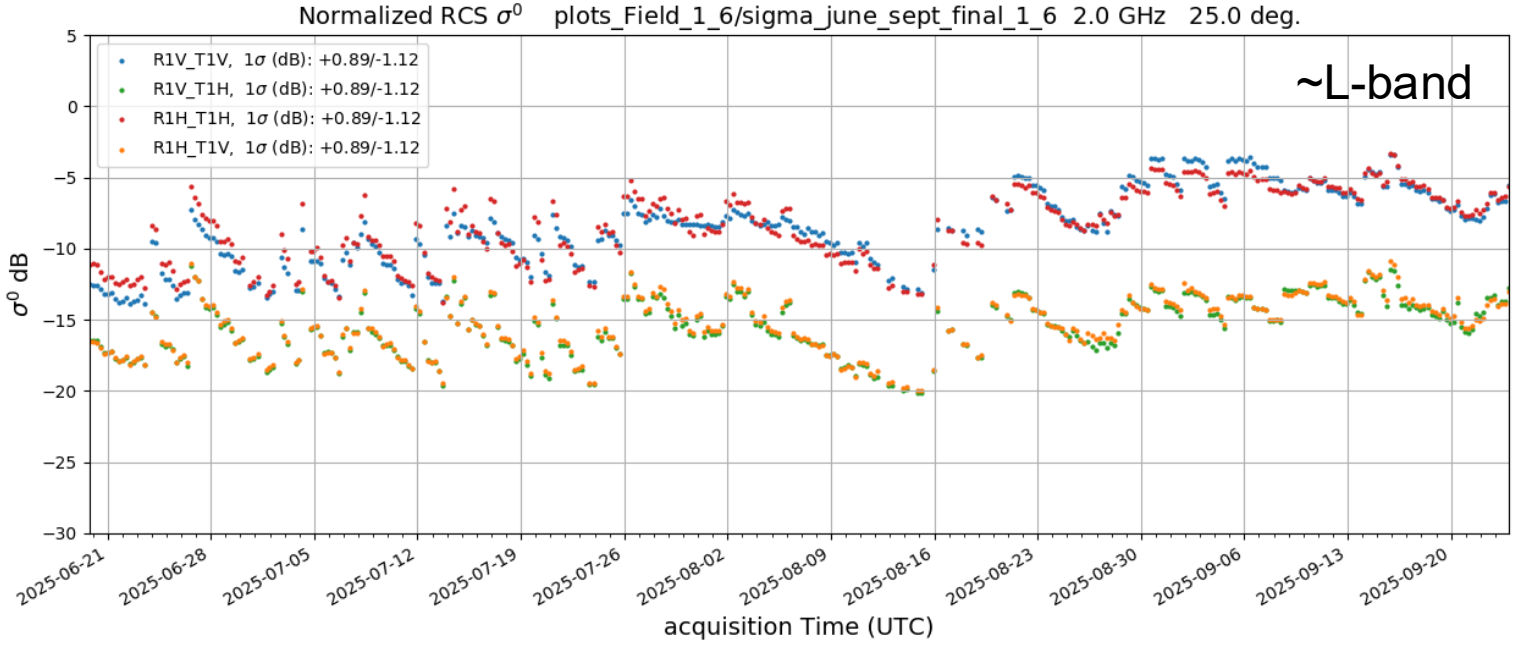
TomoSAR C-band Capon



WBSCAT

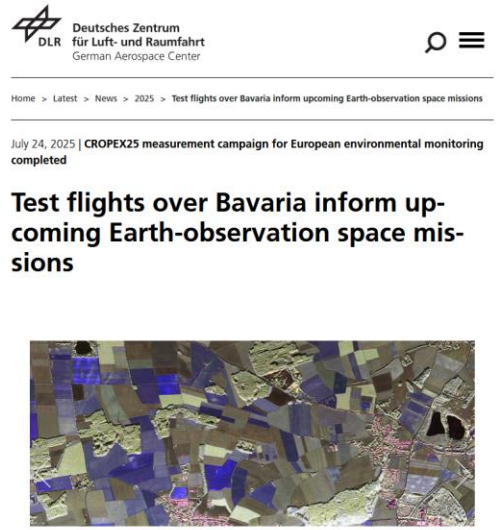
WBSCAT


Normalized RCS σ^0 plots_Field_1_6/sigma_june_sept_final_1_6 5.0 GHz 25.0 deg.
R1V_T1V, 1σ (dB): +0.89/-1.12
R1V_T1H, 1σ (dB): +0.89/-1.12
R1H_T1H, 1σ (dB): +0.89/-1.12
R1H_T1V, 1σ (dB): +0.89/-1.12
~C-band
σ^0 dB
5
0
−5
−10
−15
−20
−25
−30
2025-06-21
2025-06-28
2025-07-05
2025-07-12
2025-07-19
2025-07-26
2025-08-02
2025-08-09
2025-08-16
2025-08-23
2025-08-30
2025-09-06
2025-09-13
2025-09-20
acquisition Time (UTC)


Normalized RCS σ^0 plots_Field_1_6/sigma_june_sept_final_1_6 2.0 GHz 25.0 deg.
R1V_T1V, 1σ (dB): +0.89/-1.12
R1V_T1H, 1σ (dB): +0.89/-1.12
R1H_T1H, 1σ (dB): +0.89/-1.12
R1H_T1V, 1σ (dB): +0.89/-1.12
~L-band
σ^0 dB
5
0
−5
−10
−15
−20
−25
−30
2025-06-21
2025-06-28
2025-07-05
2025-07-12
2025-07-19
2025-07-26
2025-08-02
2025-08-09
2025-08-16
2025-08-23
2025-08-30
2025-09-06
2025-09-13
2025-09-20
acquisition Time (UTC)

Next Steps…

- Data processing still ongoing
  - F-SAR interferometric and tomograhic stack are processed
  - Sentinel-NG and ROSE-L mission simulation completed
- Data analysis:
  - 6 day and 3 day temporal decorelation of L-band and C-band
  - First order soil moisture performance in time and with vegetation
  - Trade-off analysis between dual- and quad-pol acquisitions
  - Analyse phase changes and changes in backscatter over time and relate to soil moisture and vegetation dynamics.
- AI-ready data compilation:
  - F-SAR AGRIROSEL data
  - CARMA data



DLR Publication

ESA Publication

https://www.dlr.de/en/latest/news/2025/test-flights-over-bavaria-inform-upcoming-earth-observation-space-missions
https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Measuring_soil_from_the_sky_for_ROSE-L_and_CHIME

The AGRIROSE-L and CARMA campaign team

Dinner after a day out on the field

DLR team at the field

Target Variables: Radar Campaign

Variable	Method	Physical Unit
Leaf-Area-Index (LAI)	LiCOR LAI-2200C (non-destructive)	$m^2\ m^{-2}$
Aboveground dry biomass (total)	gravimetric (destructive)	$g\ m^{-2}$
Canopy Water Content (CWC, total aboveground)	gravimetric (destructive)	$g\ m^{-2}$ / % / cm EWT
Phenology	Visual interpretation (non-destructive)	BBCH
Average Canopy Height	Folding rule (non-destructive)	cm
Vertical photograph	Panasonic LUMIX (non-destructive)	RGB image
(Bot.) Rating	Visual interpretation (non-destructive)	-
Soil moisture toplayer	UMS InField 7 (non-destructive)	%
Soil moisture at 10 cm depth	UMS InField 7 (non-destructive)	%
Surface Roughness	UAV-Based	-
Observation of external wetting (intercepted water, dew, rain etc.)	Visual interpretation (non-destructive)	no / little / much external wetness
Fractional Cover (fCover)	UAV-Based, provided by Uta Heiden's group at DLR	%
LiDAR, DSM, DEM	UAV-Based, provided by Lukas Lehnerts's group at LMU	m

Target Variables: Optics Campaign

Variable	Method	Physical Unit
Leaf-Area-Index (LAI)	LiCOR LAI-2200C (non-destructive)	$m^2\ m^{-2}$
Average Leaf Inclination Angle (ALIA)	Inclinometer (non-destructive)	°
Leaf Mass Area (LMA)	LiCOR LI-3000c, LI-3050C (destructive)	g cm^{-2} leaf area
Leaf Chlorophyll Content (Cab)	SPAD 502plus (non-destructive)	µg cm^{-2} leaf area
Aboveground dry biomass (leaf)	gravimetric (destructive)	g m^{-2}
Aboveground dry biomass (stem)	gravimetric (destructive)	g m^{-2}
Aboveground dry biomass (fruit)	gravimetric (destructive)	g m^{-2}
Aboveground dry biomass (total)	gravimetric (destructive)	g m^{-2}
Canopy Water Content (CWC, leaf)	gravimetric (destructive)	g m^{-2} / % / cm EWT
Canopy Water Content (CWC, stem)	gravimetric (destructive)	g m^{-2} / % / cm EWT
Canopy Water Content (CWC, fruit)	gravimetric (destructive)	g m^{-2} / % / cm EWT
Canopy Water Content (CWC, total aboveground)	gravimetric (destructive)	g m^{-2} / % / cm EWT
Phenology	Visual interpretation (non-destructive)	BBCH
Average Canopy Height	Folding rule (non-destructive)	cm
Spectral signature	ASD FieldSpecd 3 JR, ASD FieldSpec 4 Standard, SpectralEvolution RS-3500 (non-destructive)	% absolute reflectance
Vertical photograph	Panasonic LUMIX (non-destructive)	RGB image
Canopy Nitrogen Content (CNC, leaf)	Laboratory C/N-Analyzer (destructive)	kg ha^{-1} / %
Canopy Nitrogen Content (CNC, stem)	Laboratory C/N-Analyzer (destructive)	kg ha^{-1} / %
Canopy Nitrogen Content (CNC, fruit)	Laboratory C/N-Analyzer (destructive)	kg ha^{-1} / %
Canopy Carbon Content (CCC, leaf)	Laboratory C/N-Analyzer (destructive)	kg ha^{-1} / %
Canopy Carbon Content (CCC, stem)	Laboratory C/N-Analyzer (destructive)	kg ha^{-1} / %
Canopy Carbon Content (CCC, fruit)	Laboratory C/N-Analyzer (destructive)	kg ha^{-1} / %
(Bot.) Rating	Visual interpretation (non-destructive)	-
Fractional Cover (fCover)	UAV-Based, provided by Uta Heiden's group at DLR	%
Soil Organic Carbon Content (SOC)	Destructive sampling + laboratory analysis, provided by Sabine Chabrillat's group at GFZ	%
HySpex airborne data preprocessing	Provided by Uta Heiden's group at DLR	% reflectance