The Pol-InSAR Course

…an (experimental) **SAR training course**

Course No 9: 28th of April 2025 – 25th of July 2025

Prepared by DLR-HR's Pol-InSAR Team

German Aerospace Center (DLR), Microwaves & Radar Institute (HR), Pol-InSAR Research Group

Course Organisation: ESA, DLR, EEBIOMASS

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Motivation

A rapidly growing (scientific and commercial) community with limited or no SAR background uses (or intends to use) multi-parameter SAR data:

> … a new generation of multi-parameter SAR missions with open data policy is already operational in orbit or about to be launched;
>
> … synergies between SAR and optical RS data (or products) developed in recent years confront the "optical community" with the use of multi-parameter SAR data.

The interpretation of SAR data is (compared to optical data) less intuitive, while the available literature is often “too mathematical", aiming at a more engineering oriented audience, or oversimplified.

Understanding the information content of SAR data and the basic SAR processing principles/algorithms is neither as difficult nor as complex as it might appear. Anyone willing to invest a reasonable amount of time can achieve both.

The Pol-InSAR course is an online hands-on course that aims to develop the understanding on the information content of multi-parameter SAR data and to eliminate the respect for SAR data processing in an interactive way, without assuming any prior / background knowledge.

The course is run on ESA's Multi-Mission Algorithm and Analysis Platform (ESA-MAAP), so there are no hardware or software requirements for participants.

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Course Outline: 5 SAR (2D and 3D) Techniques in 11 Units

Synthetic Aperture Radar - SAR

1. **Focusing in Range:** Spatial resolution in Range, Matched filter, 1D and 2D focusing, …
2. **Focusing in Azimuth:** Spatial resolution in Azimuth, Synthetic aperture, 1D and 2D focusing, …

SAR Interferometry - InSAR

1. **Interferogram formation:** Image co-registration, flat earth removal, geometric interpretation, …
2. **Differential Interferometry:** D-InSAR principles, LOS deformation, propagation effects, …
3. **Interferometric coherence:** InSAR decorrelation, volume decorrelation, forest height inversion, …

SAR Polarimety - PolSAR

1. **Scattering matrix:** Polarimetric SAR, physical interpretation of scattering mechanisms, ...
2. **Covariance matrix:** Distributed scatterers, depolarization, polarimetric eigen-decomposition, …

Polarimetric SAR Interferometry – Pol-InSAR

1. **The Pol-InSAR space:** Pol-InSAR observation space, interpretation and representation, …
2. **Model based Pol-InSAR inversion:** forest height inversion, dual-pol implementation, …

SAR Tomography - TomoSAR

1. **3D Focusing:** Vertical aperture formation, 3D resolution, 3D focusing, …
2. **3D Refelectivity:** Reconstrucion algorithms, polarimetric extension, interpretation, …

Each Unit = A Week with 3 Sessions !

Mon	**Theoretical Background (~60min) + Break + Introduction of Exercise(s) (~60min)**
Tue	
Wed	**Check Point: Discussion of problems & results, questions & answers (~60min)**
Thu	
Fri	**Closing Session: Discussion of results, questions & answers (~90 + min)**
Sat	
Sun	► Zoom Link: https://zoom.us/j/98253602750?pwd=U0xBOXUrSFY2NHZ6bzBuU3oyWWUxdz09 ► The sessions are recorded and the recording is distributed after each session.

Important Note: The consent to audio and video recording of the sessions and thre distribution of the recordings is mandatory.

Proposed Course Timeline

Synthetic Aperture Radar - SAR

1. Focusing in Range	Week 18	28.04 - 02.05.25
2. Focusing in Azimuth	Week 19	05.05 - 09.05

SAR Interferometry - InSAR

1. Interferogram formation	Week 20	12.05 - 16.05
2. Differential Interferometry	Week 21	19.05 - 23.05
3. Interferometric coherence	Week 22	26.05 - 30.05

SAR Polarimety - PolSAR

1. Scattering matrix	Week 23	02.06 - 06.06
2. Covariance matrix	Week 24	09.06 - 13.06

Polarimetric SAR Interferometry – Pol-InSAR

1. The Pol-InSAR space	Week 27	30.06 - 04.07
2. Model based Pol-InSAR inversion	Week 28	07.07 - 11.07

SAR Tomography - TomoSAR

1. 3D Focusing	Week 29	14.07 - 18.07
2. 3D Refelectivity	Week 30	21.07 - 25.07

Proposed Course Timeline

Synthetic Aperture Radar - SAR

1. Focusing in Range
2. Focusing in Azimuth

SAR Interferometry - InSAR

1. Interferogram formation
2. Differential Interferometry
3. Interferometric coherence

SAR Polarimety - PolSAR

1. Scattering matrix
2. Covariance matrix

Polarimetric SAR Interferometry - Pol-InSAR

1. The Pol-InSAR space
2. Model based Pol-InSAR inversion

SAR Tomography - TomoSAR

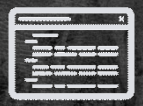
1. 3D Focusing
2. 3D Refelectivity

ESA‘s Mission Algorithm and Analysis Plattform (ESA-MAAP)

The course is hosted by ESA‘s Mission Algorithm and Analysis Plattform (ESA-MAAP) that is a virtual open and collaborative environment that:

Enables researchers to easily discover, process, visualize and analyze large volumes of data.

Provides tools and infrastructures to bring data into the same coordinate reference frame to enable comparison, analysis and evaluation.



Provides a version-controlled science algorithm development environment that supports tools, co-located data, and processing resources.

Addresses intellectual property and sharing issues related to collaborative algorithm development and sharing of data and algorithms.

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Overview of Resources on the ESA-MAAP

Main user interface: JupyterLab

Main programming language: Python

Additional support for: R and Julia

Main packages: NumPy, SciPy, GDAL, Scikit-Learn, Dask, Xarray

Available resources per user:

RAM: 10GB

Storage: 30 GB

There are no hardware or software requirements for participants !!!

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