

# 6th ADVANCED TRAINING COURSE ON RADAR POLARIMETRY 10-14 MAY 2021 ONLINE

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Francesco Sarti,

→ THE EUROPEAN SPACE AGENCY



→ THE EUROPEAN SPACE AGENCY

Welcome to the 6th edition of this course!

Linked to the 2021 PolinSAR Workshop <a href="http://polinsar-biomass2021.esa.int/">http://polinsar-biomass2021.esa.int/</a>

PULINSAR 2021								
10 <sup>th</sup> International Workshop on Science and Applications of SAR Polarimetry and Polarimetric Interferometry								
DAY 1   Monday 26		DAY 2   Tuesday 27		DAY 3   Wednesday 28	DAY 4   Thursday 29		DAY 5   Friday 30	
Opening Session SAR Missions I	9:00-10:40	Methods and theoretical modelling	9:00-10:40	Applications to Agriculture	Tomography	9:00-10:40	Forest and Biomass I	
Coffee Break	10:40-11:10	Coffee Break	10:40-11:10	Coffee Break	Coffee Break	10:40-11:10	Coffee Break	
SAR Mission II	11:10-13:00	SAR Polarimetry and PolInSAR	11:10-13:00	Land	Cryosphere	11:10-13:00 12:50–13:10	Forest and Biomass II Polinsar Wrap-up and Recommendations	
Lunch	13:00-14:00	Lunch	13:00-14:00	Lunch	Lunch	13:10-14:00	Lunch	
BIOMASS Mission	14:00-14:45	PolInSAR tools for MAAP - discussion & recommendations from users (Technical Session via Webex)	14:00-15:00	Science recommendations for tuture polarimetric SAR Missions (Technical Session via Webex)		14:00-15:00		
Coffee Break	15:00-15:30	Coffee Break	15:00-15:30	Coffee Break	Coffee Break	15:00-15:30	Coffee Break	
e-poster session	16:00-18:00		16:00-18:00		Second Biomass Retrieval Inter- comparison exercise - BRIX-2	16:00-18:00	Second Biomass Retrieval Inter- comparison exercise - BRIX-2	



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#### POLINSAR 2021 10<sup>th</sup> International Workshop on Science and Applications of SAR Polarimetry and Polarimetric Interferometry DAY 3 | Wednesday 28 DAY 4 Thursday 29 DAY 1 Monday 26 DAY 2 | Tuesday 27 DAY 5 | Friday 30 **Opening Session** Methods and theoretical modelling 9:00-10:40 Forest and Biomass I 9:00-10:40 Applications to Agriculture Tomography 9:00-10:40 SAR Missions I **Coffee Break Coffee Break Coffee Break** 10:40-11:10 10:40-11:10 Coffee Break 10:40-11:10 **Coffee Break** Forest and Biomass II 11:10-13:00 SAR Mission II SAR Polarimetry and PolInSAR 11:10-13:00 11:10-13:00 Land Cryosphere Polinsar Wrap-up and 12:50-13:10 Recommendations Lunch 13:00-14:00 Lunch 13:00-14:00 Lunch 13:10-14:00 Lunch Lunch

BIOMASS Mission	14:00-14:45	Pollr recor All presentations/videos of the wor	kshop can	14:00-15:00	
Coffee Break	15:00-15:30	be accessed via Brella (as explained later)		15:00-15:30	Coffee Break
e-poster session	16:00-18:00	16:00-18:00	Second Biomass Retrieval Inter- comparison exercise - BRIX-2	16:00-18:00	Second Biomass Retrieval Inter- comparison exercise - BRIX-2
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# POlinSAR 2021 Workshop

in 2019 !!!)

350 participants from 41

countries (compared to 150



European Space Agency



POLinSAR 2021, the 10th International Workshop on Science and Applications of SAR Polarimetry and Polarimetric Interferometry and **BIOMASS** preparation

12 different sessions, plus 2 technical discussion sessions (open discussion to collect users recommendations) A total number of 64 presentations

Algeria ustralia Austria Begium Bulgaria Canada China Penmark Egypt I Guinea Finland France iermany Greece ing Kong India Idonesia Iran Iran Iran Iran Revico Morocco herlands Pakistan

350 Participants from 41 different Countries



### 1994:

major milestone in the field of spaceborne SAR observations: **Two NASA Space Shuttle flights** with **SIR-C X-SAR** 

- Fully polarimetric spaceborne SAR
- Multi-frequency C & L (quad-pol), X (single-pol)

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SIR-C/X-SAR false <u>color composite</u> (not a polarimetric decomposition) of Central Africa, obtained on 3/10/1994 (image credit: NASA)



A fantastic "appetizer" for radar polarimetry .... Unfortunately, NOT a satellite mission



#### First ESA SAR missions:

ERS-1 / SAR first ESA SAR Mission, ERS-2 / SAR ENVISAT / ASAR 1991, C-band, single pol (VV)1995, C-band, single pol (VV)2002, C-band, alt. pol. HH/VV, HH/HV, VV/VH







**2003:** <u>first ESA POLINSAR workshop</u> ... recommendations to fly <u>ESA full-pol radar missions</u>

- Many airborne polarimetric radar campaigns followed
- Polarimetric radar TPM data (e.g. ALOS PalSAR....) accessible via ESA
- Copernicus SENTINEL-1 A&B / SAR (2014 & 2016), C-band, dual-pol HH+HV, VV+VH





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How to access ESA EO data: <u>http://www.esa.int/Applications/Observing\_the\_Earth/How\_to\_access\_data</u>

#### TPM data:

https://earth.esa.int/web/guest/pi-community/apply-for-data/3rd-party https://earth.esa.int/eogateway/

<u>Global ALOS-PALSAR quad-pol data are available in the AIST website</u>: <u>https://gsrt.airc.aist.go.jp/landbrowser/index.html</u>

If you select PALSAR in the sensor button of the opening page (right hand side), you will see the scattering decomposition power (G4U or 6SD) image on the Google map. There are descriptions on the upper menu bar for your information. When you see "save" in the menu, you can download the data (L1.1=SLC, L2.1, L1.1PD=Scattering Power Decomposition image, or L.2.1PD=orthorectified PD image) The ALOS-PALSAR quad pol data sets can be used for research purpose only. At last, you can download data from all ALOS PALSAR quad pol data (250,000 scenes during 2006-2011) plus other data sets. We thank JAXA and AIST to achieve this collaboration project. Hopefully also



### The FUTURE of ESA SAR missions is full-pol:

- Future Earth Explorer: Preparation for **Biomass P-band (2023)** https://www.esa.int/Applications/Observing\_the\_Earth/Biomass
- first P-band SAR mission in space, quad-pol, will deliver crucial information about the state of our forests and how they are changing. Interferometry and tomography capability

3-d revisit, **5 years** life-time design



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### The FUTURE of ESA SAR missions is full-pol:

Future Copernicus: Rose-L Sentinel Expansion mission (2028)

#### full-pol SAR in L-band

It will deliver operationally continuous information, on a free and open basis, on

forests, vegetation, crops, land cover surface displacements and geohazards surface soil moisture conditions sea and land ice....

The goal of Copernicus/Sentinel Expansion missions is to complement the current capabilities of the Sentinels and address gaps in Copernicus user needs. THE EUROPEAN SPACE AGENCY



#### The FUTURE of ESA SAR missions is full-pol:

- Sentinel-1 NG
- C-band, full-pol capability high resolution and wide swath



## PolSAR PAST .....

- ALOS-1: Japan Aerospace Exploration Agency JAXA, L-band, quadpol.
- ✓ RADARSAT-2: Canadian Space Agency & MDA, Cband, quad-pol
- ✓ COSMO-SkYMed: Italian Space Agency ASI, X-band, alternating dual-pol.
- A-SAR: ESA, C-band, alternating dual-pol,
   free access
- ✓ RISAT-1: Indian
  Space Research
  Organisation ISRO,
  C-band, compact-pol

**UNIVERSITY** of

## CURRENT ...

- ✓ ALOS-2: Japan Aerospace Exploration Agency JAXA, Lband, quad-pol, it may offer more free data in the future
- ✓ SAOCOM: Argentinian Space Centre CONAE, L-band, quad-pol.
- ✓ RADARSAT Constellation Mission (RCM): Canadian Space Agency CSA & MDA, C-band, compact-pol.
- ✓ COSMO-SkyMed Second Generation: Italian Space Agency ASI, X-band, quad-pol.
- ✓ GAOFEN-3: China National Space Administration CNSA, C-band, quad-pol
- ✓ TanDEM-X: German Aerospace Agency DLR, X-band, dual-pol (quad-pol experimental)
- ✓ Sentinel-1: ESA, C-band, dual-pol, free access
- ✓ NOVASAR-S: Surrey Satellite Technology and EADS Astrium UK, S-band, alternating triple-pol
  - **PAX**: Spanish Ministry of Defense & Hisdesat, X-band, dual-pol

## and FUTURE missions

- ALOS-4: Japan Aerospace Exploration Agency JAXA, L-band, quad-pol, it could have a free access policy
- NISAR: NASA & ISRO, L-band and Sband, quad-pol in some areas, free access
- BIOMASS: ESA, P-band, quad-pol,
  free access
- Sentinel-1 next generation: ESA, Cband, quad-pol, free access
- ROSE-L: ESA, L-band, quad-pol, free access
- ✓ TanDEM-L: German Aerospace Agency DLR, L-band, quad-pol. Still under discussion
- ✓ Passive receivers: Several space agencies are evaluating the possibility to send passive receivers to accompany current and future SAR missions. Still nothing decided so far, but the future looks bright for this technology!

#### Courtesy of Armando Marino, Univ of STIRLING





# PolSARpro v6.0 (Biomass Edition) Toolbox

- May 2021: release of PolSARpro v6.0.3 (by Uni Rennes for ESA since 2003)
- Polarimetric SAR Toolbox for Polarimetric SAR data analysis and end-to-end processing for the scientific exploitation of fully and partially polarimetric data
- Ingesting data from most polarimetric spaceborne SAR missions (ALOS, CSK, RCM, TSX, SAOCOM, ... and soon BIOMASS, NISAR ... Rose-L...)





#### ESA/NASA MAAP: Multi-Mission Algorithm and Analysis Platform

Virtual open and collaborative environment that leverages cloud technologies to facilitate open data use across aggregated data sets. It will bring together data, algorithms, and computing capabilities in a common cloud environment, to improve our understanding of global terrestrial carbon dynamics.

<u>Purpose</u>: supporting users to share, analyse and process data from field, airborne, and satellite measurements related to ESA and NASA missions.

Data from AfriSAR (preparatory campaign for BIOMASS) and GEDI (Lidar on ISS since 2018) are used as the initial test set for MAAP. Both planned for 2023, NASA/ISRO's NISAR (L-band SAR studying ecosystem disturbances) and ESA's BIOMASS will generate <u>huge</u> data volumes



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#### **Objectives and Content**

- Explain theoretical principles and processing algorithms
- Show use in various applications
- Introduce available tools
- Inform about state of the art in Radar Polarimetry, Polarimetric SAR Interferometry (POLinSAR) and SAR Tomography (TomoSAR)
- Prepare for the scientific exploitation of available polarimetric data (eg. ALOS-2, Sentinel-1, SAOCOM, RCM, NISAR ....)
- Introduce the future ESA polarimetric mission BIOMASS
- Hands-on processing exercises (mainly PolSARpro, installed on Virtual Machines - accessible for one more week after the course; plus MAAP); focus on full-pol (ALOS-1&2, RADARSAT-2, TerraSAR-X) and dual-pol Sentinel-1 spaceborne products, plus airborne campaign data

8.00 8.20	Monday 10/05/2021	Tuesday 11/05/2021	Wednesday 12/05/2021	Thursday 13/05/2021	Friday 14/05/2021		
8:30 - 9:00	Welcome from ESA Francesco Sarti (ESA/ESRIN, Italy)		<b>PolSAR theory (continuation)</b> Eric Pottier (Univ. of Rennes 1, France )	<b>Pol-InSAR Theory</b> Irena Hajnsek ( <i>ETH Zurich, Switzerland</i> )	Pol-TomoSAR Theory Laurent Ferro-Famil ( <i>Univ. of Rennes 1, France</i> ) Stefano Tebaldini ( <i>POLIMI, Italy</i> )		
9:00 - 9:30	BIOMASS Clément Albinet ( <i>ESA/ESRIN, Italy</i> )	Eric Pottier					
9:30 - 10:15	SAR Basics Thuy Le Toan ( <i>CESBIO, France</i> )	(Univ. of Kennes 1, France )					
10:15 - 10:45	Coffee Break						
10:45 - 12:00	(continuation)	(continuation)	<b>PolSAR Application Theory</b> Armando Marino ( <i>Univ. of Stirling, UK</i> )	(continuation)	(continuation)		
12:00 - 13:30	Lunch Break						
13:30 - 15:00	MAAP Introduction & Practical Clément Albinet Stefanie Lumnitz (ESA/ESRIN, Italy)	<b>PolSAR practical 1 (PolSARpro)</b> Eric Pottier Laurent Ferro-Famil ( <i>Univ. of Rennes 1, France</i> )	<b>PolSAR Application Practical</b> Armando Marino ( <i>Univ. of Stirling, UK</i> )	<b>Pol-InSAR Practical 1 (PolSARpro)</b> Irena Hajnsek ( <i>ETH Zurich, Switzerland</i> )	(continuation)		
15:00 - 15:30	Coffee Break						
15:30 - 17:00	MAAP Application Marco Lavalle Unmesh Khati (NASA-JPL, USA)	PolSAR practical 2 (PolSARpro) Eric Pottier Laurent Ferro-Famil (Univ. of Rennes 1, France)	<b>S1 for Agriculture (SNAP)</b> Amalia Castro Gómez and Magdalena Fitrzyk ( <i>RSAC c/o ESA/ESRIN,Italy</i> ) Jolanda Patruno ( <i>RHEA Group, Italy</i> )	<b>Pol-InSAR Practical 2 (PolSARpro)</b> Irena Hajnsek ( <i>ETH Zurich, Switzerland</i> )	Pol-TomoSAR Practical (PolSARpro) Laurent Ferro-Famil (Univ. of Rennes 1, France) Stefano Tebaldini (POLIMI, Italy)		
17:00 - 17:30			Eric Pottier (Univ. of Rennes 1, France)		Closing ceremony Feedback and presentation of certificates		
	Mission presentation						

Theory Practical



EO Science opportunities and recent results on: <a href="https://eo4society.esa.int/communities/scientists/">https://eo4society.esa.int/communities/scientists/</a>

Follow our present and future training opportunities in Earth Observation on: <u>https://eo4society.esa.int/training-education/</u> Including other training courses and MOOCs



#### Re-run of "Echoes in Space – Introduction to Radar Remote Sensing"

ESA has opened a re-run of the successful Massive Open Online Course 'Echoes in Space – An Introduction to Radar Remote Sensing'. The re-run is currently accessible free of charge on the eLearning platform EO College (https://eo-college.org), as from 16th September 2019 for a period of 12 months.

Registration is possible anytime during the duration of the course. Students can follow the five consecutive weeks of lessons at their own pace, and will receive a certificate of completion.

'Echoes in Space' is suitable for anybody interested in getting an introduction to Radar images or looking to deepen into the topic. It covers the history and basics of Radar technology and Radar Remote Sensing from space, and gives a unique hands-on experience in diverse application scenarios.





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#### Scientists: advanced training

by THEME (ocean, land, atmosphere, cryosphere), by TECHNIQUE and MULTI-THEMATIC SUMMER SCHOOLS



See you all in **2023** at the next ESA PolinSAR workshop (hopefully in presence, in ESRIN, Frascati, Italy) where you are invited to present your work and your results in SAR Polarimetry !!!!



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