Presentations

The three presentations provided here focus on the topic of SAR Polarimetry, increasing in their level of detail. The first presentation, on the basics of SAR Polarimetry, is intended for non-experts or undergraduate students. The second and the third increase in the level of technical details and are considered for advanced students (masters or PhD), remote sensing experts or professionals.

These talks can be tailored, both in content and length, according to the needs of each hosting institution.

From a didactic point of view, all three presentations will establish clearly the *learning objectives* at the beginning of the session and will finish with a list of *take-home messages*.

The presentations can be given in English, Spanish or French.

Presentation 1

Title: "Basics of SAR Polarimetry"

Abstract: Nowadays, many spaceborne Synthetic Aperture Radar (SAR) systems acquiere polarimetric data. These range from systems presenting fully polarimetric acquisition modes, as for instance TerraSAR-X (X-Band), RADARSAT-2 (C-Band), ALOS-2 (L-band), SAOCOM (L-band) or the future missions BIOMASS (P-band) or NISAR (L&S-bands), to systems presenting dual or compact polarimetric modes, as for example Sentinel-1a&b (C-band dual polarimetric) or RCM (C-band).

Respect to single-channel SAR data, Polarimetric SAR (PolSAR) data allows an improved characterization of the targets being observed, especially in terms of their geometry and their water content, hence offering a better physical description.

The objective of this presentation is to introduce, in a didactic and enjoyable way, the concept of polarization and the basics of PolSAR, how to interpret the physical information contained in PolSAR data, the particularities of dual or compact PolSAR data compared to fully polarimetric data and the main applications, all of them with examples based on real PolSAR data from the main spaceborne systems.

Presentation objectives:

- What is polarimetry?
- Conceptual description of wave polarimetry
- Conceptual description of scattering polarimetry
- To know the physical interpretation of PolSAR data
- To know the past, present and future polarimetric spaceborne, airborne and ground-based SAR sensors

- To know the difference and how to interpret dual, compact and fully PolSAR systems
- To know the main applications of PolSAR data

Notes:

- If necessary, this presentation may also include a brief introduction to the principles of Synthetic Aperture Radar

Presentation 2

Title: "SAR Polarimetry: Theory and Applications"

Abstract: Nowadays, several spaceborne Polarimetric Synthetic Aperture Radar (PolSAR) systems are in operation: TerraSAR-X (X-Band), RADARSAT-2 (C-Band), Sentinel-1a&b (C-band dual polarimetric), ALOS-2 (L-band), SAOCOM (L-band), RCM (C-band) and Gaofen-3. Also, future missions as BIOMASS (P-band) or NISAR (L&S-bands) are designed to have polarimetric sensitivity.

The availability of spaceborne PolSAR data provides an unprecedented opportunity for applying advanced PolSAR information processing techniques to the important tasks of environmental monitoring and risks management. PolSAR remote sensing offers an efficient and reliable means of collecting information required to extract quantitative geophysical and biophysical parameters from Earth's surface. This remote sensing technique has found many successful applications in crop monitoring and damage assessment, in forestry clear cut mapping, deforestation and burn mapping, in land surface structure (geology) land cover (biomass) and land use, in hydrology (soil moisture, flood delineation), in sea ice monitoring, in oceans and coastal monitoring (oil spill detection) etc. The scope of different applications is increasing nowadays thanks to the availability of multiemporal and dual polarimetric acquisitions.

PolSAR represents today a very active area of research in radar remote sensing and Earth observation, and for instance polarimetric applications start to be operational in the frame of the Sentinel-1. Consequently, it becomes important to train and to prepare the future generation of researchers to this very important topic.

The aim of this presentation is to provide a substantial and balanced introduction to the theory, scattering concepts, systems and advanced concepts, and applications typical to PolSAR. This presentation on PolSAR touches several subjects: theory, scattering modelling, data representations, target decompositions, speckle filtering, terrain and land-use classification, man-made target analysis, etc. The presentation will be illustrated by images for the different sensors indicated above. The connection to polarimetric SAR interferometry may be also presented.

This lecture is intended to scientists, engineers and students engaged in the fields of Radar Remote Sensing and interested in PolSAR image analysis and applications.

Presentation objectives:

- What is polarimetry?
- Technical description of the concept wave polarimetry and its main descriptors
- Technical description of the concept of scattering polarimetry
- To know the scattering, covariance and coherency matrices
- To know the physical interpretation of PolSAR data
- Description of the concept of deterministic and distributed targets
- Description of speckle noise
- To know the main polarimetric target decomposition theorems for physical information extraction.
- To know the past, present and future polarimetric spaceborne, airborne and ground-based SAR sensors
- To know the difference and how to interpret dual, compact and fully PolSAR systems
- To know the main applications of PolSAR data

Notes:

- If necessary, this presentation may also include a brief introduction to the principles of Synthetic Aperture Radar

Presentation material:

For this presentation, the material to be employed is also included in the nomination. The length of this presentation can be adapted to a lecture between one to two hours.

Presentation 3

Title: "SAR, SAR Polarimetry & Multitemporal SAR Statistical Description"

Abstract: Nowadays, several spaceborne Polarimetric Synthetic Aperture Radar (PolSAR) systems are in operation: TerraSAR-X (X-Band), RADARSAT-2 (C-Band), Sentinel-1a&b (C-band dual polarimetric), ALOS-2 (L-band), SAOCOM (L-band), RCM (C-band) and Gaofen-3. Also, future missions as BIOMASS (P-band) or NISAR (L&S-bands) are designed to have polarimetric sensitivity.

An accurate Polarimetric SAR (PolSAR) data interpretation and understanding, as well as the process of quantitative and qualitative bio- and geophysical information extraction, need, on the one hand, from a physical knowledge of the polarimetric scattering process and, on the other hand, the statistics and the elements of information theory that apply to PolSAR data. After an introduction to the description and the physical interpretation of PolSAR data, this presentation will introduce a detailed description PolSAR and multidimensional SAR data, as well as the description of the relevant elements of information theory for a complete understanding of PolSAR data.

SAR and PolSAR systems are based on the use of coherent microwaves. This coherent nature is at the origin of the Speckle phenomena. Despite being a complete physical phenomena, the complexity of the scattering process in man-made and natural targets

makes necessary to describe PolSAR data statistically, and then, to consider Speckle as a noise component. The first objective of this presentation is to stablish the connection between the physics and the statistics, and then, to introduce the concept of Speckle noise under the Gaussian scattering assumption. Following it, the statistical distributions that characterize SAR, PolSAR and multidimensional SAR data will be presented. At the same time, the state-of-the-art in Speckle noise filtering shall be also presented. Finally, advanced statistical concepts for the description of data texture and highly heterogeneous PolSAR data shall be also considered

Presentation objectives:

- What is polarimetry?
- To know the concept of scattering polarimetry and the PolSAR data descriptors
- To know the physical interpretation of PolSAR data
- Description of the concept of deterministic and distributed targets
- Description of speckle noise and the concept of Gaussian scattering
- To know the statistical description of SAR data
- To know the statistical description of PolSAR data
- Describe the state-of-the-art of Speckle noise filtering
- To know the statistical description of target decomposition theorems
- Description of the concept of data texture
- To know the statistical description of SAR and PolSAR texture data
- Information extraction based on the use of higher order statistical moments and log-cumulants

Biography:

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Dr. Carlos Lopez-Martinez (S'97-M'04-SM'11) received the MSc. degree in electrical engineering and the Ph.D. degree from the Universitat Politècnica de Catalunya, Barcelona, Spain, in 1999 and 2003, respectively.

Dr. Lopez-Martinez is Associate Professor in the area of remote sensing and microwave technology in the Universitat Politècnica de Catalunya, Barcelona, Spain. He has a large professional international experience at DLR (Germany), at the University of Rennes 1 (France), and as a group leader of the Remote Sensing and Natural Resources Modelling team in the Luxembourg Institute of Science and Technology (Luxembourg). His research interests include Synthetic Aperture Radar (SAR) theory, statistics and applications, multidimensional SAR, radar polarimetry, physical parameter inversion, advanced digital signal processing, estimation theory, and harmonic analysis.

Dr. López-Martínez has authored more than 200 articles in journals, books, and conference proceedings, and received the EUSAR 2002 Conference Student Prize Paper Award, co-authored the paper awarded with the EUSAR 2012 Conference First Place Student Paper Award, and received the IEEE-GRSS 2013 GOLD Early Career Award. Dr. López-Martínez has broad academic teaching experience from bachelor, master, and Ph.D. levels to advanced technical tutorials presented at international conferences and space and research institutions worldwide. He is an associate editor of the IEEE-JSTARS journal and the MDPI Remote Sensing, acting also as invited guest editor for several special issues. He has collaborated in the Spanish PAZ and the ESA's SAOCOM-CS missions, in the proposal of the Parsifal mission and he is member of the ESA's Sentinel ROSE-L Mission Advisory Group. He was appointed vice-president of the IEEE-GRSS Spanish chapter, and in 2016 he became its secretary and treasurer. From 2011 Dr. López-Martínez collaborates with the IEEE-GRSS Globalization initiative in Latin America, contributing to the creation of the IEEE-GRSS Chilean chapter and the organization of the 2020 LAGIRSS conference, being appointed as Latin America liaison in 2019. He is also co-chair of the Tutorial Technical Committee of the Indian 2020 InGARSS conference