



PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Marianna Franzese

Cycle: XXXIX

Training and Research Activities Report

PhD Year: First

Tutor: Prof. Antonio De Maio

Co-Tutor: Dr. Eng. Claudio De Luca (CNR-IREA)

Date: October 31, 2024

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

1. Information:

- **PhD student:** Marianna Franzese **PhD Cycle:** XXXIX
- **DR number:** 997194
- **Date of birth:** 14/02/1991
- **Master Science degree:** Telecommunication Engineering
- **University:** University of Naples “Federico II”
- **Scholarship type:** CNR Istituto per il Rilevamento Elettromagnetico dell’Ambiente (IREA)
- **Tutor:** Prof. Antonio De Maio
- **Co-tutor:** Dr. Eng. Claudio De Luca (CNR-IREA)

2. Study and training activities:

Activity	Type ¹	Hours	Credits	Dates	Organizer	Certificate ²
Antenna Sparse Arrays	Courses	20	4	28/11/2023 - 15/12/2023	Prof. Stefano Perna. University of Naples Parthenope	Y
Towards Trustworthy Autonomy: How AI Can Help Address Fundamental Learning and Adaptation Challenges	Seminar	1	0.2	29/09/2023	IEEE - AESS (Aerospace and Electronic Systems Society), lecturer G. Inalhan	Y
Remote Sensing for Crustal Deformation Studies	Seminar	1	0.2	05/12/2023	Intelligent Machines and Communication System (IMCS) Group CSIR-Center Scientific Instruments Organisation, lecturers	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

					P.Striano, T.Singh	
Adaptive Radar Detection	Seminar	1	0.2	06/12/2023	IEEE - AESS (Aerospace and Electronic Systems Society), lecturer A.De Maio	Y
Sensor Location Optimization for Effective and Robust Beamforming	Seminar	1	0.2	07/12/2023	IEEE - AESS (Aerospace and Electronic Systems Society), lecturer W.Liu	Y
Filter Design for Radar Tracking of Maneuvering Targets	Seminar	1	0.2	14/12/2023	IEEE - AESS (Aerospace and Electronic Systems Society), lecturer D.Blair	Y
Study of the book: Synthetic Aperture Radar Processing (G. Franceschetti, R. Lanari) Study of the following research papers: • The potential of low-frequency SAR systems for mapping ionospheric TEC distributions (F. Meyer, R. Bamler, N. Jakowski, T. Fritz); • The influence of equatorial scintillation on L-band SAR image quality and phase (F. Meyer, K. Chotoo,	Research		5	01/11/2023 – 31/12/2023		

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

S.D. Chotoo, B.D. Huxtable, C.S. Carrano); • On the detection of Faraday rotation in linearly polarized L-band SAR backscatter signatures (A. Freeman and S.S. Saatchi); • Measurement and mitigation of the ionosphere in L-band Interferometric SAR data (P. Rosen, S. Hensley, C. Chen); • Estimation and compensation of ionospheric delay for SAR interferometry” (R. Brcic, A. Parizzi, M. Eineder, R. Bamler, F. Meyer); • Ionospheric correction of SAR interferograms by multiple-aperture interferometry (H.S. Jung, D.T. Lee, Z. Lu, J.S. Won); • Time series InSAR ionospheric delay estimation, correction, and ground deformation monitoring with reformulation Range Split-Spectrum Interferometry (W. Mao, X.Wang, G.Liu, S. Pirasteh, R. Zhang, H. Lin, Y. Xie, W. Xiang, Z. Ma and P. Ma)						
Game Theory and analysis of competitive dynamics for industrial systems	Courses	16	3	05/02/2024 - 22/02/2024	Prof.ssa Lina Mallozzi. DII	Y
Overview sui sistemi di monitoraggio vulcanico	Seminar	5	1	06/02/2024	Istituto per il	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

e sviluppi futuri relativi al programma ROSE-L					Rilevamento Elettromagnetico dell'Ambiente (CNR-IREA), lecturer R.Lanari	
A Bandwidth Efficient Dual-Function Radar Communication System Based on a MIMO Radar Using OFDM Waveforms	Seminar	1	0.2	07/02/2024	IEEE Signal Processing Society, lecturer Athina P.Petropulu Zhaoyi Xu	Y
Real-time, Robust and Scalable Computational Methods for Extreme 3D Lidar Imaging	Seminar	1	0.2	22/02/2024	IEEE Signal Processing Society, lecturer Abderrahim Halimi, Sandor Plosz, Aurora Maccarone, Stephen McLaughlin, Gerald S. Buller	Y
PANNs: Large-Scale Pretrained Audio Neural Networks for Audio Pattern Recognition	Seminar	1	0.2	29/02/2024	IEEE Signal Processing Society, lecturer Qiugiang Kong	Y
Acceptance of the following abstracts at the General Assembly 2024 of the European Geosciences Union (EGU):	Research		10	01/01/2024 – 29/02/2024		

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

• Detection and mitigation of ionospheric artifacts in the azimuth ground displacements through the SAOCOM-1 L-band SAR data exploitation (M. Franzese, C. De Luca, A. Aubry, M. Bonano, F. Casu, M. Manunta, G. Onorato, Y. Roa, P. Striano, A. De Maio and R. Lanari); • A quantitative assessment of the SAOCOM-1 L-band DInSAR time-series retrieved through the P-SBAS approach in natural and anthropogenic hazard scenarios of the Italian territory (Y. Roa, C. De Luca, M. Bonano, F. Casu, M. Franzese, M. Manunta, G. Onorato, P. Striano, M. Yasir and R. Lanari); • National scale full-resolution P-SBAS processing for the investigation of critical infrastructure deformations related to the built-up environment” (P. Striano, S. Buonanno, F. Casu, C. De Luca, F. Cotugno, M. Franzese, A. Fusco, M. Manunta, G. Onorato, Y. Roa, M. Yasir, G. Zeni, I. Zinno, R. Lanari and M. Bonano); • Detailed Slip Distribution Model of the Turkey-Syria						
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Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

2023 Seismic Event exploiting SAOCOM-1, Sentinel-1 and ALOS-2 Satellite Imagery” (N. Svigkas, P. Striano, S. Atzori, M. Bonano, C. Tolomei, N. Vavlas, A. Kiratzi, F. Casu, C. Bignami, C. De Luca, M. Polcari, M. Franzese, A. Antonioli, M. Manunta, F. Monterroso, Y. Roa and R. Lanari). Submission of the following paper to the European Conference on Synthetic Aperture Radar (EUSAR): • A First Quantitative Assessment of the P-SBAS Approach Capability to Retrieve SAOCOM-1 DInSAR Deformation Time Series over the Italian Territory” (C. De Luca, Y. Roa, M. Bonano, F. Casu, L. Euillades, P. Euillades, M. Franzese, M. Manunta, M. Yasir, G. Onorato, P. Striano, I. Zinno and R. Lanari).						
Synthetic Aperture Radar: An Electromagnetic Perspective	Courses	40	8	31/01/2024 – 23/02/2024	Prof. S. Perna, Prof. M. Migliaccio, Prof. F. Nunziata, Prof. A. Buono, University of Naples Parthenope	Y
Permutation Entropy for Graph Signals:	Seminar	1	0.2	06/03/2024	IEEE Signal	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

Theoretical Framework and Application to Neuroimaging Data					Processing Society, lecturer Javier Escudero	
Joint Waveform and Beamforming Design for RIS-Aided ISAC Systems	Seminar	1	0.2	13/03/2024	IEEE Signal Processing Society, lecturer Rang Liu	Y
NOMA Assisted Far-Field and Near-Field Communications	Seminar	1	0.2	26/03/2024	IEEE Signal Processing Society, lecturer Zhiguo Ding	Y
Federated Learning Using Three-Operator ADMM	Seminar	1	0.2	29/03/2024	IEEE Signal Processing Society, lecturers Shashi Kant, Josè Mairton B. da Silva, Jr.	Y
The P-SBAS DInSAR web tool for Earth surface deformation analysis	Seminar	5	1	18/04/2024	Istituto per il Rilevamento Elettromagnetico dell'Ambiente (CNR-IREA), lecturer C. De Luca	Y
Image-to-Image Translation: Methods and Applications	Seminar	1	0.2	25/04/2024	IEEE Signal Processing Society, lecturers Zhibo	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

					Chen, Jianxin Lin	
Presentation of the work “Detection and mitigation of ionospheric artifacts in the azimuth ground displacements through the SAOCOM-1 L-Band SAR data exploitation” at the General Assembly 2024 of the European Geosciences Union (EGU). Study of the following research papers: • Effects of Plasma Media With Weak Scintillation on the Detection Performance of Spaceborne Radars (A. De Maio, M. Maffei, A. Aubry, A. Farina); • Effects of Ionospheric Scintillation on Differential Demodulation of GPS Data (Roger A. Dana); • The Impact of Strong Scintillation on Space Based Radar Design I: Coherent Detection” (Roger A. Dana, Dennis L. Knepp); • The Impact of Strong Scintillation on Space Based Radar Design II: Noncoherent Detection (Roger A. Dana, Dennis L. Knepp).	Research		5	01/03/2024 – 30/04/2024		
Matrix Analysis for Signal Processing with MATLAB Examples	Courses	16	3	30/04/2024 – 28/05/2024	Dr. Massimo Rosamilia DIETI	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

Deep Learning-based Non-Intrusive Multi-Objective Speech Assessment Model with Cross-Domain Features	Seminar	1	0.2	07/05/2024	IEEE Signal Processing Society, lecturer Ryandhima s E. Zezario	Y
Pol-InSAR Approach for 3D Imaging of Non-Cooperative Targets	Seminar	1	0.2	08/05/2024	IEEE Signal Processing Society, lecturer Ajeet Kumar	Y
5G & Digital Transformation: a view from an unconventional perspective	Seminar	4	0.8	10/05/2024	5G Academy, lecturer Maurizio Irlando	Y
End-to-End Automatic Speech Recognition	Seminar	1	0.2	10/05/2024	IEEE Signal Processing Society, lecturer Junyu Li	Y
Regolazione in tema di intelligenza artificiale alla luce dell'AI ACT	Seminar	5	1	13/05/2024	5G Academy, lecturer Elvira Raviale	Y
Nonnegative Autoencoders with Applications to Music Audio Decomposing	Seminar	1	0.2	14/05/2024	IEEE Signal Processing Society, lecturer Meinard Muller	Y
Exploring the oceans with distributed acoustic sensing: achievements and challenges	Seminar	2	0.4	16/05/2024	IEEE Oceanic Engineering Society, lecturer Lukas Thiem	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

Plug & Play Priors and Multi-agent Consensus Equilibrium for Scientific Applications	Seminar	1	0.2	16/05/2024	IEEE Signal Processing Society, lecturer Suhas Sreehari	Y
EPOS Data Portal Training Event	Seminar	2	0.4	22/05/2024	European Plate Observing System (EPOS), lecturer Jan Michalek	Y
Sustainable IT: strategies and best practices for a green engineering future	Seminar	5	1	27/05/2024	5G Academy, lecturers A. Di Leva, D. Cuomo, B. Ramazzotti, T. Marcozzi	Y
Generative AI for software engineering: strategies, impacts, and practical applications	Seminar	5	1	29/05/2024	5G Academy, lecturers A. Di Leva, C. Cui, G. Favale, A. Zoccoli	Y
Submission of the following abstract at the 6th Alfred Rittmann Conference: "Joint exploitation of multi-frequency and multi-platform DInSAR data to monitor ground displacements in volcanic areas: the Stromboli case study" (C. De Luca, Y. Roa, M. Bonano, N. Casagli, F. Di Traglia, M. Franzese, T. Gracchi, M. Manunta, F. Monterrose, T. Noselini, G. Onorato, P. Striano, M. Yasir, R. Lanari and	Research		2	01/05/2024 – 30/06/2024		

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

F. Casu). Study of the following research papers: • Deformation time series generation in areas characterized by large displacement dynamics: The SAR amplitude pixel-offset SBAS technique” (F. Casu, A. Manconi, A. Pepe, and R. Lanari); • An update on the NASA-ISRO dual-frequency DBF SAR (NISAR) mission (Rosen, Paul, et al.); • Measuring two-dimensional movements using a single InSAR pair (N. B. D. Bechor and H. A. Zebker).						
Innovation and Entrepreneurship	Courses	20	4	12/06/2023 - 26/06/2023	Prof. Pierluigi Rippa DII	Y
15 th International Sumemr School on Radar/SAR, Bonn, Germany	Doctoral School		4	13/07/2023 - 19/07/2023	Organizer: Dr. Matthias Weiß	Y
Submission of the following extended abstract to the IEEE TechDefense 2024: “Addressing ionospheric impairments in the azimuth ground displacements retrieved by using SAOCOM-1 L-band SAR data” (M. Franzese, A. De Maio, R. Lanari, A. Aubry, P. Noli, G. Onorato, Y. Roa, P. Striano and C. De Luca).	Research		2	01/07/2024 – 31/08/2024		

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

Basic Principles of Radar Backscatter	Courses	8	2	24/10/2023	Prof. Dr. Iain Woodhouse EO College	Y
Introduction to Hyperspectral Remote Sensing	Courses	8	2	26/10/2023	A. Brosinsky, S. Förster, C. Wilczok, R.Eckardt, EO College	Y
How to write a scientific paper	Seminar	1	0.2	07/10/2024	Springer Nature, lecturer Ghada Badawy	Y
Research Integrity	Seminar	1	0.2	08/10/2024	Springer Nature, lecturer Davide Migliorini	Y
Submission of the following paper to the IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing: "SAOCOM-1 L-band DInSAR Time Series generation through P-SBAS approach: algorithm extension and products analysis" (C. De Luca, Y. Roa, M. Bonano, F.Casu, P. Euillades, L. Euillades, M. Franzese, M. Manunta, M. Yasir, G. Onorato, P. Striano L. Dini, D. Tapete and R. Lanari). Submission of the following paper to the IEEE TechDefense 2024:	Research		6	01/09/2024 – 31/10/2024		

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

“Addressing ionospheric impairments in the azimuth ground displacements retrieved by using SAOCOM-1 L-band SAR data” (M. Franzese, A. De Maio, R. Lanari, A. Aubry, P. Noli, G. Onorato, Y. Roa, P. Striano and C. De Luca). Study of the following research papers: • Mapping high spatial resolution ionospheric total electron content by integrating Time Series InSAR with International Reference Ionosphere (W. Mao, P. Ma, J. Tang); • Ionospheric Phase Delay Correction for Time Series Multiple-Aperture InSAR Constrained by Polynomial Deformation Model (W. Mao, X. Wang, G. Liu, P. Ma, R. Zhang, Z. Ma, J. Tang and H. Liu); • Time Series InSAR Ionospheric Delay Estimation, Correction, and Ground Deformation Monitoring With Reformulating Range Split-Spectrum Interferometry (W. Mao, X. Wang, G. Liu, S. Pirasteh, R. Zhang, H. Liu, Y. Xie, W. Xiang, Z. Ma and P. Ma).						
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- 1) Courses, Seminar, Doctoral School, Research, Tutorship
- 2) Choose: Y or N

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	4	1	5	0	10
Bimonth 2	3	1.6	10	0	14.6
Bimonth 3	8	2	5	0	15
Bimonth 4	3	5.6	2	0	10.6
Bimonth 5	8	0	2	0	10
Bimonth 6	4	0.4	6	0	10.4
Total	30	10.6	30	0	70.6
Expected	30 – 70	10 - 30	80 - 140	0 – 4.8	

3. Research activity:

Development of Algorithms to Process L-Band SAR Data: Focusing on Ionospheric Impairments Affecting Azimuth Ground Displacements

TOPIC

In recent years, space agencies have significantly invested in the development of L-band satellite Synthetic Aperture Radar (SAR) systems, including sensors like NISAR (NASA-ISRO), PALSAR-3 (JAXA), and ROSE-L (ESA), as well as the already operational PALSAR-2 (JAXA) and SAOCOM-1 (CONAE). These investments highlight the increasing importance of L-band SAR sensors, especially for interferometric applications. In this context, understanding the key challenges and issues associated with L-band SAR data is crucial. One of the most relevant issues is the presence of ionospheric effects, which can determine a noticeable impact on both the phase and amplitude of the acquired data. In particular, ionospheric disturbances in SAR images can cause local subpixel offsets in the azimuth position, thus affecting the SAR image's co-registration procedure and, consequently, the surface displacement measurements. The impact of this misregistration appears like "azimuth streaks" in the displacement maps retrieved with Multi Aperture Interferometry (MAI), and Pixel Offset Tracking (POT) techniques.

This PhD research topic addresses the problem of ionospheric impairments on L-band SAR images and derived products, emphasizing the importance of mitigating these effects to improve the quality of the estimated ground displacement. Specifically, the focus is on ionospheric effects impacting retrieval operations along the azimuth direction, as the methods available in the open literature are highly effective at addressing ionospheric disturbances in the slant range direction.

METHODOLOGY

The main objective of this research is to develop a method capable of detecting and mitigating ionospheric effects that impact the displacement component along the azimuth direction. Specifically, the goal is to isolate the ionospheric impact from the azimuth ground displacements by

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

leveraging its dispersive nature. For this purpose, the MAI technique, based on the spectral diversity (SD) method, is employed. In particular, this technique uses sub-aperture processing in the along azimuth direction to generate forward- and backward-looking interferograms. In the methodology investigated during this year of research activity, the MAI technique is applied by splitting the azimuth spectrum of SAR images more densely, in order to examine the impact of the ionosphere over narrower bands and to analyze its tendency to vary in the angular space. In other words, the MAI technique enables (from the SAR images) the generation of sub-images (characterized by lower resolution) corresponding to different portions of the synthetic aperture, which exhibit a different Doppler history. The objective is to exploit this angular diversity to analyze the behavior of the ionosphere. After dividing the signal spectrum into multiple sub-bands, the MAI technique is applied, focusing on two distinct types of analyses that differ in terms of angular diversity. In the first approach, minimal angular diversity is considered by computing the difference between the interferometric phase obtained from adjacent sub-bands. In the second analysis, the angular diversity is progressively increased by applying the MAI technique between the first sub-band and all the others.

RESULTS

The results obtained through the application of the approaches described above provide evidence of the variation in ionospheric behavior depending on the sub-bands pairing. Specifically, in the analyses conducted using the first approach, the displacement maps derived from the MAI technique reveal azimuth streaks that exhibit variations in amplitude and shifts along the azimuth direction. In contrast, the second approach demonstrates that a gradual increase in the angular diversity of the sub-band pairing leads to a corresponding increase in the amplitude of the azimuth streaks. These results provide evidence of the variation in ionospheric behavior depending on the sub-bands pairing. This variation can be exploited to estimate an empiric law relevant to the ionospheric changes, with the aim of improving the ability to detect and mitigate ionospheric effects in the displacement component, along the azimuth direction.

Future work will also focus on analyzing and studying the ionospheric impact within individual single-look complex (SLC) images. Unlike the previous techniques, this new approach does not rely on a pair of SLC, but instead aims to directly estimate the ionospheric impact on each SLC image Doppler history. Incorporating this additional level of analysis is expected to enhance the ability to detect and mitigate ionospheric effects in azimuth deformation maps.

4. Research products:

- **M. Franzese**, C. De Luca, A. Aubry, M. Bonano, F. Casu, M. Manunta, G. Onorato, Y. Roa, P. Striano, A. De Maio and R. Lanari “Detection and mitigation of ionospheric artifacts in the azimuth ground displacements through the SAOCOM-1 L-band SAR data exploitation,” EGU General Assembly 2024, Vienna, Austria, 14-19 Apr 2024, EGU24-16496. (**speaker**)
- **M. Franzese**, A. De Maio, R. Lanari, A. Aubry, P. Noli, G. Onorato, Y. Roa, P. Striano, and C. De Luca “Addressing ionospheric impairments in the azimuth ground displacements retrieved by

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

using SAOCOM-1 L-band SAR data”, IEEE TechDefense 2024, Napoli, 11-13 Nov. 2024. (speaker)

- Y. Roa, C. De Luca, M. Bonano, F. Casu, **M. Franzese**, M. Manunta, G. Onorato, P. Striano, M. Yasir and R. Lanari “A quantitative assessment of the SAOCOM-1 L-band DInSAR time-series retrieved through the P-SBAS approach in natural and anthropogenic hazard scenarios of the Italian territory” EGU General Assembly 2024, Vienna, Austria, 14-19 Apr 2024, EGU24-16229.
- P. Striano, S. Buonanno, F. Casu, C. De Luca, F. Cotugno, **M. Franzese**, A. Fusco, M. Manunta, G. Onorato, Y. Roa, M. Yasir, G. Zeni, I. Zinno, R. Lanari and M. Bonano “National scale full-resolution P-SBAS processing for the investigation of critical infrastructure deformations related to the built-up environment”, EGU General Assembly 2024, Vienna, Austria, 14-19 Apr 2024, EGU24-21611.
- N. Svigkas, P. Striano, S. Atzori, M. Bonano, C. Tolomei, N. Vavlas, A. Kiratzi, F. Casu, C. Bignami, C. De Luca, M. Polcari, **M. Franzese**, A. Antonioli, M. Manunta, F. Monterroso, Y. Roa and R. Lanari “Detailed Slip Distribution Model of the Turkey-Syria 2023 Seismic Event exploiting SAOCOM-1, Sentinel-1 and ALOS-2 Satellite Imagery”, EGU General Assembly 2024, Vienna, Austria, 14-19 Apr 2024, EGU24-6179.
- C. De Luca, Y. Roa, M. Bonano, F. Casu, L. Euillades, P. Euillades, **M. Franzese**, M. Manunta, M. Yasir, G. Onorato, P. Striano, I. Zinno and R. Lanari “A First Quantitative Assessment of the P-SBAS Approach Capability to Retrieve SAOCOM-1 DInSAR Deformation Time Series over the Italian Territory,” EUSAR 2024; 15th European Conference on Synthetic Aperture Radar, Munich, 23-26 Apr 2024.
- C. De Luca, Y. Roa, M. Bonano, N. Casagli, F. Di Traglia, **M. Franzese**, T. Gracchi, M. Manunta, F. Monterroso, T. Noselini, G. Onorato, P. Striano, M. Yasir, R. Lanari and F. Casu “Joint exploitation of multi-frequency and multi-platform DInSAR data to monitor ground displacements in volcanic areas: the Stromboli case study,” 6th Alfred Rittmann Conference, Catania, Italy, 18-20 Sep 2024.
- C. De Luca, Y. Roa, M. Bonano, F. Casu, P. Euillades, L. Euillades, **M. Franzese**, M. Manunta, M. Yasir, G. Onorato, P. Striano L. Dini, D. Tapete and R. Lanari “SAOCOM-1 L-band DInSAR Time Series generation through P-SBAS approach: algorithm extension and products analysis”, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.

5. Conferences and seminars attended

- European Geosciences Union (EGU) General Assembly 2024, Vienna, Austria, 14-19 Apr 2024. 1 work presented.
- IEEE International workshop on Technologies for Defense and Security 2024, Napoli, 11-13 Nov. 2024. 1 work presented.

6. Activity abroad

None

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Marianna Franzese

7. Activity in partner companies:

No period in the company.

8. Tutorship

None