Marc Rußwurm

Assistant Professor at Wageningen University, Netherlands

Overview

Contact

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last updated January 1, 2025

Positions - Overview

2023 – today Assistant Professor (Tenure Track) at Wageningen University, Netherlands
2021 – 2023 Postdoc at École Polytechnique Fédérale de Lausanne (EPFL), Switzerland
2018 – 2022 Ph.D. Studies at Technical University of Munich (TUM), Germany
2011 – 2018 Geodesy and Geoinformation Studies at TUM (B.Sc; M.Sc.)

Academic Profiles & Links

Twitter/X twitter.com/MarcCoru
Bluesky @marccoru.bsky.social
Google Scholar scholar.google.com/citations?user=MfGMG9wAAAAJ
Semantic Scholar semanticscholar.org/author/Marc-Rußwurm/35469144
Scival scival.com/overview/summary?uri=Customer/325017/Researcher/16873697

Recent Key Activities and Achievements

outstanding publication The paper Geographic Location Encoding with Spherical Harmonics and Sinusoidal Representation Networks was acknowledged as **spotlight (top 5%)** at the International Conference of Learning Representations 2024 (ICLR)

workshop organization I was the lead-organizer of the second Machine Learning for Remote Sensing (ML4RS) workshop at ICLR 2024 that attracted 72 paper submissions and raised 10k EUR in industry sponsoring that enabled travel support, paper and poster awards at the conference.

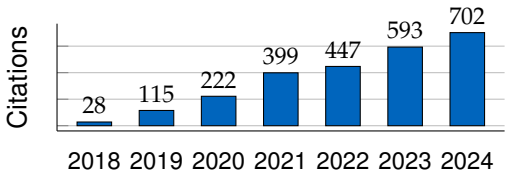
proposal coordination I coordinated a MSCA Doctoral Network (HORIZON-MSCA-2024-DN-01) proposal titled *Marine Litter Network (MLN)* that involves 15 institutions across 13 European countries.

Research Metrics

updated Dec 2024

Google Scholar

	All	Since 2019
Citations	2534	2495
h-index	19	19
i10-index	22	22



updated Dec 2024

Scival - Benchmarking

32 Scholary Output | 1,343 Citation Count | 42.0 Cit. per Output | 12 h-index

Top 5 Research Topics	Output	FWCI	Perc.
Learning Systems; Computer Vision; Image Classification	5	2.39	99.502
Remote Sensing; Time Series; Sentinel-2	5	5.67	99.126
Marine Pollution; Water Pollutant; Environm. Monitoring	3	5.15	99.454
Time Series; Neural Network; Data Mining	2	9.25	97.451
Generative Adv. Networks; Deep Learning; Image Synth.	1	1.47	99.910

FWCI = Field-Weighted Citation Impact; Perc. = World Wide Prominence Percentile

Academic Career

Academic Positions and Education

Sept '23 – today Assistant Professor

Wageningen University

Tenure Track Assistant Professor in Machine Learning and Remote Sensing: Research Interests: Time Series, Domain Shift, Transfer Learning, Crop Type Mapping, Marine Debris Detection

Sept '21 – '23 Postdoctoral Researcher

École polytechnique fédérale de Lausanne

Environmental Computational Science and Earth Observation Laboratory: Research: Machine Learning and Earth Observation; Domain Shift and Transfer Learning. Self-supervised representation learning on globally distributed data.

2018 – Feb 2022 Technical University of Munich

Dr.-Ing. (Ph.D.)

Chair of Remote Sensing Technology:
Thesis: *Data-driven Feature Learning with Discriminative Models for Satellite Time Series* Ph.D. defense (23rd of Februrary 2022)

2015–June 2018 Technical University of Munich

Master of Science

Geodesy and Geoinformation (M.Sc): Machine Learning, Computer Vision, Deep Learning, Earth Observation, Remote Sensing, Photogrammetry.
Thesis: *Multi-temporal Land Cover Classification with Recurrent-Convolutional Neural Networks*
Cooperation: *Bavarian Ministry of Food, Agriculture and Forestry (StMELF).*

2011–2015 Technical University of Munich

Bachelor of Science

Geodesy and Geoinformation (B.Sc): Photogrammetry, Remote Sensing, Surveying, Cartography, Geo-informatics, Gravity Science, GNSS Science, and Land Management.
Thesis: *Tri-ocular Image Rectfification and Photogrammetric Reconstruction*

Research Stays and Academic Visits

Oct 2024 Visiting Scholar Focus Period 2024

Linköping, Sweden

3-week research stay at ELLIT Focus Period 2024 on Machine Learning for Climate Science. Seminar Talk titled Global Geographic Location Encoding with Implicit Neural (Geo)Representations

Jan–Mar '20 Visiting Researcher Palo Alto, USA

Stanford University (Visit)

Lobell Lab and Sustainability and AI Lab
Few-Shot Meta Learning for the Remote Sensing context. Research received *Best Paper Award* at Earthvision 2020 worshop at CVPR

May '19 Short Visit OATML Oxford, UK

Oxford Applied Machine Learning Group (Visit)

Visit (one-week). Participation in ESA project:
Multi-image super-resolution on Satellite Data. Presentation about Machine Learning and Earth Observation.

Oct '18–Feb '19 Visiting Researcher Vannes, France

IRISA Institute (Visit)

Environment Observation with Complex Imagery:
Research stay. Early classifification of time series. Multi-objective optimization (optimize accuracy and earliness).

July–Aug 2018 Participant—Frontier Developments Lab

University of Oxford & European Space Agency

Kellogg College in Oxford, UK & ESRIN Φ-lab, Frascati near Rome, Italy.

Deep multi-resolution satellite data-fusion for disaster relief. The Frontier Developments Lab is an research and commercial accelerator composed of teams with machine learning and Earth observation background.

June 2018 Visiting Researcher

European Space Agency

European Space Research Institute (ESRIN) at Φlab
Presentation of multi-temporal EO research (link). Setup of deep learning infrastructure and framework outlines for the Frontier Developments Lab.

Invited Talks

Invited Talks - in-person

2024 Global Geographic Location Encoding with Implicit Neural (Geo)Representations. ELLIT Focus Period 2024, Linköping, Sweden. 2024-10-15

Global Geographic Location Encoding with Implicit Neural (Geo)Representations, Invited Speaker Research Visit at La Universidad Pública de Navarra, Spain. 2024-05-16.

Machine Learning Models across Geographies. Invited Speaker Geodätisches Kolloquium, Bonn, Germany. 2024-01-11

2023 Early Classification and Transfer Learning Challenges in Large-scale Crop Type Mapping. Time Series & Transfer Learning Workshop, Huawei Paris. Huawei Paris, France. 2023-10-19

Marine debris detection with Sentinel-2 and Deep Segmentation Models. Visit Geoforschungszentrum GFZ Potsdam. 2023-05-17

Learning from Earth Observation Tasks, Wageningen University. 2023-01-13. Interview Talk Assistant Professor

2022 Learning from Earth Observation Tasks. Invited talk LIU Linköping, Sweden. 2022-06-30

Invited Talks - online

2023 Meta-Learning across different geographies. Invited speaker ImageCLEF - GeolifeCLEF. 2023-09-19

2022 Meta-learning data-efficient Machine Learning Models for Diverse Earth Observation Problems. ESA ECMWF Workshop 2022.

2021 Data-Driven Vegetation Modeling and Understanding Representation Shift at Lastig Seminar Deep Learning for Earth Sciences organized by Loic Landrieu, IGN France

Early Classification for Agricultural Monitoring at ANR Seminar organized by Romain Tavenard, Univ Rennes 2

Podcast Inverviews

2024 ”Meta-learning with Meteor” in Satellite Image Deep Learning Podcast by Robin Cole. YouTube

Scientific Leadership Positions

Research Community Engagement

Peer Review

Transactions on Geoscience and Remote Sensing (TGRS); Elsevier Remote Sensing of Environment (RSE); Geoscience and Remote Sensing Letters (GRSL); International Conference on Computer Vision (ICCV); Neural Information Processing Systems (NeurIPS);

Conference Program Committees/Reviewing

EarthVision Workshop at CVPR (since 2021); MAChine Learning for EArth ObservatioN (MACLEAN) workshop at ECML/PKDD (since 2019); Machine Learning for Remote Sensing Workshops at ICLR (2023-2025); ISPRS Geospatial Week (2025); ESA-NASA International Workshop on AI Foundation Model for Earth Observation (2025)

Scientific Working Groups/Committees

International Scociety of Photogrammetry and Remote Sensing (ISPRS) Working Group II/5 Temporal Geospatial Data Understanding (link); International Associateion for Patter Recognition (IAPR) Thematic Committee 7 Remote Sensing & Mapping (link)

Grant/Stipend Reviewing Committees

Deutscher Akademischer Austrausch Dienst (DAAD). IFI Program - Internationale Forschungsaufenthalte für Informatikerinnen & Informatiker (2025-2029); Deutsche Forschungsgemeinschaft (DFG)

PhD Examination Commettees

PhD Proposal Review Enzo Campomanes - ITC Twente (2024); Ph.D. Thesis Ámbar Pérez-García - University of Las Palmas de Gran Canaria (2024); PhD Upgrade Viva Weibin Chen - University College London (2025); PhD Thesis Maria Yli-Heikkilä - University of Helsinki (2025)

Awards

Personal Research Awards

June 2020

Best paper - Earthvision Workshop at Computer Vision and Pattern Recognition Workshop (2020) (link)

Oct. 2017

Best presentation - NVIDIA Deep Learning Workshop at Leibnitz Supercomputing Center (LRZ)

July 2017

Best paper - Earthvision Workshop at Computer Vision and Pattern Recognition Workshop (2017) (link)

Sept. 2016

Best presentation - Polish-National Remote Sensing Conference (link)

Research Award Nomination - Finalist

Oct. 2020

Two Nominations at IGARSS 2020 Best Student Paper Award (final 10 out if 250 submissions) with two papers: (Wang et al., 2020)´ and (Rußwurm et al., 2020)

Nov. 2019

Nomination finalist for the AI-Newcomer award of German Informatics Society (GI) and the Federal Ministry of Education and Research (BMBF) in the category of natural sciences

Teaching

Course Coordination

2025 - ongoing

Deep Learning (GRS-34806). Co-coordination with Prof. Ioannis Athanasiadis. Professors Kootstra, Dick Ridder, Riccardo da Silva Torres involved in lecturing the course.

Lectures (recurring yearly)

2024 - ongoing

WU - Deep Learning (GRS-34806) - Lectures on Regularization in Deep Learning and Computer Vision Segmentation Models

WU - Machine Learning (FTE-35306) - Lecture on Random Forests and Decision Trees

WU - Advanced Earth Observation (GRS-32306) - Lecture on Remote Sensing within Marine Applications

2022-2023 EPFL - Spatial Modeling for Earth Observation (EPFL ENV-408) - Lecture on Linear Regression for Environmental Science

Guest Lectures

2023 Mila/McGill Montréal, Canada. ”Mapping crop type at large scale in Europe”. Guest Lecture COMP767 CS/Mila/McGill by invitation from Prof. Rolnick (2023-02-15)

2022 University of Bonn, Germany. ”Interpretable Machine Learning Examples in Marine Debris Detection and Crop Type Mapping”. Invitation by Prof. Roscher (2022-10-19)

Exercises & Practicals

2024 - ongoing (WU) Exercises on Remote Sensing within Marine Applications (2024)

WU Machine Learning (FTE-35306) - Exercise on Random Forests and Decision Trees

2022-2023 (EPFL) Image processing for Earth observation (EPFL ENV-540) - Exercises on Deep Learning for Remote Sensing (2023)

2018 (TUM) Excercise Image understanding. Introduction to Deep Learning. TU Munich. Master level Geodesy and Geoinformation.

Workshops, Tutorials & Seminar Talks

SSL4EO Summer School Lecture on Deep Location Encoders and self-supervised learning on geographic data(workshop) (video)

IGARSS 2024 Time Series Tutorial: Understanding Dynamics with Advanced Time-Series Processing Techniques with Charlotte Pelletier, Dainius Masiliūnas, and Jan Verbesselt (link)

IGARSS 2023 Time Series lecture in the Tutorial for Machine Learning for Remote Sensing Tutorial with Ribana Roscher, Ronny Hänsch, Claudio Persello

ISPRS Congress 2022 Deep Learning for Satellite Time Series (Tutorial Session with Prof. Charlotte Pelletier)

Universal Teachning Qualification (UTQ) Courses

Jan 2025 UTQ Teaching Course - Wageningen University

Sept 2024 UTQ Supervise Course - Wageningen University

University Teaching Qualification (UTQ) courses in the Netherlands are designed to prepare academic staff for effective teaching at higher education institutions and are part of the tenure track requirements.

Publications

Dissertation

2022 **Rußwurm**, M. (2022). Data-Driven Feature Learning with Discriminative Models for Satellite Time Series (Doctoral dissertation, Technische Universität München). Doctoral Defense on February 23rd 2022.

Book Chapter

2021 **Rußwurm, M.**, & Körner, M. (2021). Recurrent Neural Networks and the Temporal Component, Deep Learning for the Earth Sciences. Editors Gustau Camp-Valls, Xiaoxiang Zhu, Devis Tuia.

Journal Articles

2025 (in review) Kraft, B., Nelson, J. A., Walther, S., Gans, F., Weber, U., Duveiller, G., Reichstein, M., Zhang, W., **Rußwurm, M.**, Tuia, D., Körner, M., Jung, M. On the Added Value of Sequential Deep Learning for Upscaling of Evapotranspiration

2025 (in prep.) van Dalen, J., Asano, Y., **Rußwurm, M.**. SAMSelect: An Automated Spectral Index Search for Marine Debris using Segment-Anything

2024 Roscher, R., Ribana, M., **Rußwurm, M.**, Gevaert, C., Kampffmeyer, M., Dos Santos, J. A., Vakalopoulou, M., Hänsch, R., et al. Better, Not Just More: Data-centric Machine Learning for Earth Observation. IEEE Geoscience and Remote Sensing Magazine (2024).

Gabeff, V., **Rußwurm, M.**, Tuia, D., Mathis, A. WildCLIP: Scene and Animal Attribute Retrieval from Camera Trap Data with Domain-adapted Vision-Language Models. International Journal of Computer Vision

Tollenaar, V., Zekollari, H., Pattyn, F., **Rußwurm, M.**, Kellenberger, B., Lhermitte, S., Izeboud, M., Tuia, D., 2024. Where the White Continent is Blue: Deep Learning Locates Bare Ice in Antarctica. Geophysical Research Letters, 51(3)

Nguyen, T. A., **Rußwurm, M.**, Lenczner, G., Tuia, D. Multi-temporal Forest Monitoring in the Swiss Alps with Knowledge-guided Deep Learning. Remote Sensing of Environment

Pisl, J., **Rußwurm, M.**, Hughes, L., Lenczner, G., See, L., Wegner, J. D., Tuia, D. Mapping Drivers of Tropical Forest Loss with Satellite Image Time Series and Machine Learning. Environmental Research Letters

Rußwurm, M., Wang, S., Kellenberger, B., Roscher, R., Tuia, D. (2024). Meta-learning to address diverse Earth Observation Problems across Resolutions. Nature Communications Earth & Environment

2023 **Rußwurm, M.**, Venkatesa, S. J., Tuia, D. (2023). Large-scale Detection of Marine Debris in Coastal Areas with Sentinel-2. Cell Iscience 26(12).

Rußwurm, M., Courty, N., Emonet, R., Lefèvre, S., Tuia, D., & Tavenard, R. (2023). End-to-end learned Early Classification of Time Series for in-season Crop Type Mapping. ISPRS Journal of Photogrammetry and Remote Sensing, 196, 445-456.

Frank, C., **Rußwurm, M.**, Fluixa-Sanmartin, J., & Tuia, D. (2023). Short-term Runoff Forecasting in an Alpine Catchment with a Long Short-term Memory Neural Network. Frontiers in Water, 5, 1126310.

2020 Körner, M., **Rußwurm, M.** (2020). Self-attention for raw Optical Satellite Time Series Classification. ISPRS Journal of Photogrammetry and Remote Sensing, 169:421 – 435.

Tavenard, R., Faouzi, J., Vandewiele, G., Divo, F., Androz, G., Holtz, C., Payne, M., Yurchak, R., **Rußwurm, M.**, Kolar, K., Woods, E., 2020. Tslearn, a Machine Learning Toolkit for Time Series Data. Journal of Machine Learning Research, 21(118), pp.1-6.

2018 Körner, M., **Rußwurm, M.**. http://www.mdpi.com/2220-9964/7/4/129, ISPRS International Journal of Geo-Information, 2018.

2015 Moore, A., **Rußwurm, M.**. "Visualising the project landscape": A Spatialisation describing Workload Attributes as Terrain, In Environmental Earth Sciences 2015, volume 74, pp. 7159-7172.

Machine Learning Conferences

2025 Klemmer, K., Rolf, E., Robinson, C., Mackey, L., **Rußwurm, M**. SatCLIP: Global, General-Purpose Location Embeddings with Satellite Imagery. To appear In Proceedings of the AAAI Conference on Artificial Intelligence

2024 **Rußwurm, M.**, Klemmer, K., Rolf, E., Zbinden, R., Tuia, D. Geographic Location Encoding with Spherical Harmonics and Sinusoidal Representation

Networks (2024). International Conference on Learning Representations. ICLR Spotlight paper (top 5%)

2022 Drees, L., Weber, I., **Rußwurm, M.**, & Roscher, R. (2022, September). Time Dependent Image Generation of Plants from incomplete Sequences with CNN-Transformer. In DAGM German Conference on Pattern Recognition (pp. 495-510). Cham: Springer International Publishing.

2021 Kondmann, L., Toker, A., **Rußwurm, M.**, et al., (2021). DENETHOR: The DynamicEarthNET dataset for Harmonized, inter-Operable, analysis-Ready, daily crop monitoring from space. In Thirty-fifth Conference on Neural Information Processing Systems Datasets and Benchmarks Track (Round 2).

2019 Bischke, B., Fil, J., Pelich, R., Rudner, T. G. J., **Rußwurm, M.**, Kopačková, V., Biliński, P. Multi^{3}net: Segmenting flooded Buildings via Fusion of Multiresolution, Multisensor, and Multitemporal Satellite Imagery. In Proceedings of the AAAI Conference on Artificial Intelligence (Vol. 33, No. 01, pp. 702-709).

Computer Vision Workshops - peer-reviewed, with proceedings

2023 Gabeff, V. A. G., **Russwurm, M.**, Tuia, D., & Mathis, A. (2023, June). Scene and Animal Attributes Retrieval from Camera Trap Data with Domain-adapted Language-Vision Models. In Computer Vision and Pattern Recognition (CVPR) Workshops.

2020 **Rußwurm, M.**, Wang, S., Körner, M., and Lobell, D. (2020). Meta-learning for Few-shot Land Cover Classification. In 2020 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), pages 788–796. EarthVision 2020 Best Paper Award.

2017 **Rußwurm, M.** & Körner, M. Temporal Vegetation Modelling using Long Short-Term Memory Networks for Crop Identification from Medium-Resolution Multi-Spectral Satellite Images, *In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Workshops* 2017. (best paper award)

Machine Learning Workshops - peer-reviewed, non-archival

2024 Claire, R., Weynants, M., Benson, V., Carvalhais, N., **Rußwurm M.**, and Reichstein, M. Spatially far, Ecologically close: Evaluating Extrapolation on Vegetation Forecasting Models. In 2nd Machine Learning for Remote Sensing Workshop at ICLR 2024.

2023 **Rußwurm, M.**, Gül, D., & Tuia, D. (2023, April). Improved Marine Debris Detection in Satellite Imagery with automatic Refinement of Coarse Hand Annotations. In 1st Machine Learning for Remote Sensing Workshop at ICLR 2023.

2022 **Rußwurm, M.**, & Tuia, D. (2022, November). Instance Norm improves Meta-learning in Class-imbalanced Land Cover Classification. In 36th Conference on Neural Information Processing Systems.

2019 **Rußwurm, M.**, Lefèvre, S., & Körner, M. (2019, June). Breizhcrops: A Satellite Time Series Dataset for Crop Type Identification. In Proceedings of the International Conference on Machine Learning Time Series Workshop.

2019 **Rußwurm, M.**, & Körner, M. (2018). Convolutional LSTMs for cloud-robust Segmentation of Remote Sensing Imagery. NeurIPS 2018 Spatiotemporal Workshop.

2018 Rudner, T. G., **Rußwurm, M.**, Fil, J., Pelich, R., Bischke, B., Kopacková, V., & Bilinski, P. (2018, December). Rapid Computer vision-aided Disaster Response via Fusion of Multiresolution, Multisensor, and Multitemporal Satellite Imagery. In Proceedings of the First Workshop on AI for Social Good. Neural Information Processing Systems (NIPS-2018), Montreal, QC, Canada (pp. 3-8).

Conference Proceedings - Environmental Science

2023 Antropov, O., Molinier, M., Kuzu, R.S., Hughes, L., **Rußwurm, M.**, Tuia, D., Dumitru, C.O., Ge, S., Saha, S. and Zhu, X.X., 2023, July. Semi-Supervised

Deep Learning Representations in Earth Observation Based Forest Management. In IGARSS 2023-2023 IEEE International Geoscience and Remote Sensing Symposium (pp. 650-653). IEEE.

Chevalley, A., Tomoiagă, C., Detyniecki, M., **Rußwurm, M.**, & Tuia, D. (2023, July). Improving Few-Shot Object Detection with Object Part Proposals. In IGARSS 2023-2023 IEEE International Geoscience and Remote Sensing Symposium (pp. 6502-6505). IEEE.

Pisl, J., Hughes, L. H., **Rußwurm, M.**, & Tuia, D. (2023, July). Classification of Tropical Deforestation Drivers with Machine Learning and Satellite Image Time Series. In IGARSS 2023-2023 IEEE International Geoscience and Remote Sensing Symposium (pp. 911-914). IEEE.

Rußwurm, M., Hughes, L. H., Pasquali, G., Dumitru, C. O., & Tuia, D. (2023, July). Detection of Settlements in Tanzania and Mozambique by many regional Few-shot Models. In IGARSS 2023-2023 IEEE International Geoscience and Remote Sensing Symposium (pp. 522-525). IEEE.

2022

Rußwurm, M., Wang, S., & Tuia, D. (2022, July). Humans are poor few-shot Classifiers for Sentinel-2 Land Cover. In IGARSS 2022-2022 IEEE International Geoscience and Remote Sensing Symposium (pp. 4859-4862). IEEE.

2021

Mifdal, J., Carmo R., **Rußwurm M.** (2021). Towards detecting Floating Objects on a global scale with Learned Spatial Features using Sentinel 2. ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., V-3-2021, 285–293, 2021, 169:421 – 435.

Ansari, H., **Rußwurm, M.**, Ali, M., Montazeri, S., Parizzi, A., & Zhu, X. X. (2021, July). InSAR Displacement Time Series Mining: A Machine Learning Approach. In 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS (pp. 3301-3304). IEEE.

Carmo, R., Mifdal, J., & **Rußwurm, M.** (2021, September). Detecting Macro Floating Objects on Coastal Water Bodies using Sentinel-2 Data. In OCEANS 2021: San Diego–Porto (pp. 1-7). IEEE.

2020

Rußwurm, M., Pelletier, C., Zollner, M., Lefèvre, S., and Körner, M. (2020). Breizhcrops: A Time Series Dataset for Crop Type Mapping. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLIII-B2-2020:1545–1551.

Rußwurm, M., Ali, M., Zhu, X. X., Gal, Y., and Körner, M. (2020). Model and Data Uncertainty for Satellite Time Series Forecasting with Deep Recurrent Models. In IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, pages 7025–7028. Nominated best Student Paper IGARSS 2020.

Wang, S., **Rußwurm, M.**, Körner, M., and Lobell, D. (2020). Meta-learning for Few-shot Time Series Classification. In 2020 IEEE International Geoscience and Remote Sensing Symposium, IGARSS 2020. IEEE. Nominated best Student Paper IGARSS 2020.

2019

Coca-Castro, A., **Rußwurm, M.**, Reymondin, L., & Mulligan, M. (2019, July). Sequential Recurrent Encoders for Land Cover Mapping in the Brazilian Amazon using Modis Imagery and Auxiliary Datasets. In IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium (pp. 9843-9846). IEEE.

2017

Rußwurm, M. & Körner, M. Multitemporal Crop Identification from Medium-Resolution Multi-Spectral Satellite Images based on Long Short-Term Memory Neural Networks, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences (ISPRS)*, 2017, volume XLII-1/W1, pp. 551-558.