
Gamma Remote Sensing AG

ANNUAL REPORT 2019

RESEARCH AND DEVELOPMENT

ESA - Snowlab (2016 – 2019)

After a SNOWSCAT (X- to Ku-band scatterometer) / WBScat (1-40 GHz Wide-band Scatterometer) cross-comparison campaign in early winter 2018/19 the measurements were continued, using the WBScat, in combination with the L- and X-band radiometers ELBARA and MORA operated by WSL-Birmensdorf.

ESA – CCI+ - Glaciers (2019-2022)

The main objectives of the CCI+ Glaciers Project (coordinated by University of Zürich, Switzerland) in the frame of the Climate Change Initiative (CCI) are to provide EO based services for glacier monitoring, as developed and demonstrated under the DUE GlobGlacier Project and CCI Glacier. GAMMA's responsibilities are in the glacier flow monitoring and in the service and system engineering.

ESA – CCI+ – Biomass (2018-2021)

The main objectives of the CCI+ Biomass Project (coordinated by Aberystwyth University, UK) in the frame of the Climate Change Initiative (CCI) are to provide EO based services for forest biomass monitoring. GAMMA has the technical lead, with responsibilities in the algorithm development, system implementation and the generation of the global biomass products.

ESA – CCI+ – Permafrost (2018-2021)

The main objectives of the CCI Permafrost Project (coordinated by GAMMA, with T. Strozzi acting as project manager, and B.GEOS, with A. Bartsch acting as science leader) is to deliver a permafrost related climate data record which complies with the requirements of the climate user community. The work builds upon elements developed and demonstrated under the ESA DUE GlobPermafrost project. GAMMA's responsibilities are in the coordination of the work, mountain permafrost thematic products, overall system design engineering and the production of subsidence maps on Arctic permafrost sites.

ESA – CCI+ – Snow (2018-2021)

The main objectives of the CCI Snow Project (coordinated by ENVEO, Austria) in the frame of the Climate Change Initiative (CCI) is to provide essential climate variables for snow based on EO data. GAMMA's responsibilities are in the system design engineering.

ESA - Dragon 4 Cooperation Programme (2016-2019)

The Dragon Programme focuses on exploitation of ESA, Chinese, and third party mission EO data for geo-science and applications development in land, ocean and atmospheric applications in 50 joint Sino-European projects. GAMMA is involved in forest, glacier dynamics and permafrost projects.

ESA - GlobPermafrost (2016-2019)

ESA has launched the GlobPermafrost initiative to develop, validate and implement information products to support the research communities and related international organizations like IPA and CliC in their work on understanding permafrost better by integration of Earth Observation data. In this project coordinated by

Zentralanstalt für Meteorologie und Geodynamik (ZAMG), GAMMA has the lead for the mountain permafrost thematic products and the overall system design engineering and will produce subsidence maps on Arctic permafrost sites.

ESA – Exploitation of S-1 for Surface Soil Moisture Retrieval at High Resolution (2016-2019)

In this project, led by CNR-ISSIA, the objective is to develop and generate surface soil moisture products at 100m spatial scale, based on multi-temporal Sentinel-1 C-band SAR backscatter and L-band radiometry soil moisture products of the ESA SMOS and NASA SMAP missions.

ESA –SMOS Expert Support Laboratory for Level 2 - Soil Moisture (2014-2019)

The tasks of the SMOS ESL for soil moisture include the development, implementation and assessment of SMOS soil moisture retrieval algorithms. GAMMA contributed new algorithm ideas arising from 2-stream radiative transfer modeling that are now being further tested and that may be introduced at a later stage into the operational processor.

ESA – Wide-Band Scatterometer Development (2017-2019)

In this project GAMMA develops and builds the coherent, polarimetric 1 – 40 GHz scatterometer WBScat. A design incorporating a Vector Network Analyzer and a front end with 3 wide-band horn antennas was chosen. During The WBScat can be used in support tower based measurements of snow, crops and soil.

ESA – Biomascats (2018-2019)

The objective of this project under the ESA EO SCIENCE FOR SOCIETY program is the assessment of vegetation carbon dynamics from multi-decadal spaceborne Scatterometer and SAR observations. GAMMA develops and applies the biomass retrieval algorithms, the Max-Planck Institute, Jena incorporates the biomass maps in their climate modeling and provides feedbacks on their usefulness.

KTI/CTI - Development of a car-borne repeat-pass differential interferometric synthetic aperture radar (SAR) system at L-band for ground displacement measurements. (2016-2019)

In this project GAMMA and the Earth Observation & Remote Sensing Group, ETH Zurich (EO-ETHZ) develop and test a car-borne repeat-pass differential interferometric synthetic aperture radar. In 2018 the focus of the work on GAMMA side was on the development of the L-band hardware while EO-ETHZ gained experience with the acquisition and processing of car-borne SAR data using a modified GPRI-II Ku-band system. In addition, the new L-band radar hardware was successfully tested in a series of measurement campaigns. The feasibility of repeat-pass interferometry using the car-borne L-band SAR could be confirmed.

Eurostars RAMON (2019-2022)

The objective of the Eurostars RAMON Project, coordinated by GAMMA with the partners SATIM and ICEYE Polska, are to design, develop and test an innovative radar-based landslides monitoring service to support different phases of the landslide risk management. The service combines existing, established elements as landslide velocity maps derived from stacks of satellite SAR data using Persistent Scatterer Interferometry with completely new near-real-time monitoring elements, as urgently required during crisis situations, made possible using a novel microsatellite constellation and terrestrial radars.

ESA AALM4INFRAM (2019-2020)

In this project EO based services in support as a high-level building and infrastructure stability management aid in permafrost areas are developed and assessed. The project is coordinated by GAMMA who is responsible for the SAR based EO elements. Partners are the Danish Technical University and ASIAQ who contribute geotechnical competence, in-situ information and optical EO components.

ESA Worldcover (2019-2021)

The aim of this project under the lead of VITO is to deliver to the public a land cover map of the entire globe at 10m resolution based on its Sentinel-1 and 2 data. GAMMA contributes the pre-processing of Sentinel-1 SAR data, including quality assessments and support to the thematic classification chains.

EO SERVICES, CONSULTING AND TRAINING**Deformation Maps, DEMs , Landcover/Landuse and Change/Hazard Products**

A variety of products were generated in 2019 for customers in Switzerland, Europe, and North America using data of the ERS, ENVISAT, Radarsat, ALOS-1/2, TerraSAR-X, Cosmo-Skymed, and Sentinel-1 satellites. SAR, InSAR, offset tracking and Persistent Scatterer Interferometry (PSI) were used to generate forest biomass maps, deformation maps, deformation histories, terrain heights, and glacier velocity maps.

For Sentinel-1 near-real-time processing capability is applied for glacier velocity and ground stability mapping.

In 2019 we also continued providing services using the GAMMA Portable Radar Interferometer (GPRI).

Consulting

GAMMA's consulting activity included SAR and interferometric processing related aspects, application development support, and radar system engineering. GAMMA also supported users of GAMMA Instruments (GPRI, ELBARA) with the acquisition and processing of the data. Furthermore, user specific adaptations of GAMMA hardware were developed and implemented.

In the ANCSI Project “EO-ROFORMON Project on Prototyping an Earth-Observation based monitoring and forecasting system for the Romanian forests (2016-2019)”, GAMMA is part of the Scientific Advisory Board.

Training courses

In 2019 we organized again training courses for SAR, SAR interferometry, and Interferometric Point Target Analysis (IPTA). Further courses will follow in spring and fall 2019 (for information see our homepage <http://www.gamma-rs.ch>). We also trained users in the operation of GAMMA Instruments (GPRI, GAMMA L-band SAR) and the related data processing.

GAMMA SOFTWARE

In 2019 GAMMA continued to provide licenses for its user-friendly and high quality software to support the entire processing from SAR raw data to products such as digital elevation models, deformation, and landuse maps. The software consists of the Modular SAR Processor (MSP), Interferometric SAR Processor (ISP), Differential Interferometry and Geocoding (DIFF&GEO), Land Application Tools (LAT), and Interferometric Point Target Analysis (IPTA), complemented by the stand-alone module for Geocoding and image registration (GEO). The use of Sentinel-1A and 1B is well supported. The software was adapted for ICEYE, NOVASAR, ASNARO2, and the Radarsat Constellation Mission (RCM).

License sales activities were continued with new licenses sold in Europe, Asia, Australia and North and South America. User contacts indicate that the advanced algorithms and our competent support are important features of our software. This is also confirmed by an increasing number of running maintenance contracts. Many long-term users updated their license to the current version to be able to process data acquired by the newest SAR satellites (Sentinel-1, ALOS-2, Gaofen-3, ICEYE, NOVASAR, ASNARO2, and the Radarsat Constellation Mission, RCM). On several occasions the software was presented to potential customers.

GAMMA INSTRUMENT DEVELOPMENT

GAMMA WBScat / Terrestrial X- to Ku-band scatterometer (SNOWSCAT)

The development of the VNA based, polarimetric, 1-40 GHz Wide-Band Scatterometer (WBScat) was completed (except for some reports and documentation). After comparative measurements the SNOWSCAT instrument at the WSL-SLF “Davos-Laret Remote Sensing Field Laboratory”, Switzerland was replaced by the WBSCAT instrument (ESA Snowlab project).

GAMMA Portable Radar Interferometer (GPRI)

There was again a significant interest in the GAMMA Portable Radar Interferometer (GPRI). More than 20 instruments are in operation by users in Europe, North America and Asia. The primary application is displacement monitoring over glaciers, rock glaciers, rocks, slopes, and infrastructure. Besides the standard instruments, instruments supporting polarimetric and bistatic measurements were built. Existing customers promote the instrument with their high quality results.

GAMMA L-band radiometer (ELBARA)

There is one more ELBARA L-band radiometer on stock, ready to be sold.

GAMMA L-band SAR

In 2016 GAMMA started the development of an L-band Synthetic Aperture Radar (SAR). In collaboration with the Earth Observation & Remote Sensing Group, ETH Zurich (EO-ETHZ). In 2019 GAMMA L-band SAR measurements were completed using a dedicated 12m long rail, mounted on a car, and mounted on a helicopter type drone of the Aeroscout. Results were good. In particular it was possible to generate high coherence repeat pass interferograms using the drone. The L-band SAR was also shown to interested potential customers and a first sale could be realized.

VARIA

In 2019 Dr. Andrea Manconi started to work at GAMMA. At least initially he works part time at GAMMA and at ETH. He mainly supports us in the application of InSAR and PSI to geohazards.

GAMMA employees are members of national (SIP, SED, SGPF, CHGEOL, FAN) and international (IEEE, RSPSoc, AGU, EARSEL) organizations, acted as peer reviewers (various journals, books), were members of scientific committees, and engaged in University teaching and PhD supervision (FSU Jena, ETH Zürich, SLU Umeå).

PUBLICATIONS

Articles in journals and books:

- Bartsch A., M. Leibman, T. Strozzi, A. Khomutov, B. Widhalm, E., Babkina, D. Mullanurov, K. Ermokhina, C. Kroisleitner and H. Bergstedt, Seasonal Progression of Ground Displacement Identified with Satellite Radar Interferometry and the Impact of Unusually Warm Conditions on Permafrost at the Yamal Peninsula in 2016, *Remote Sensing*, 11(16), 1865, doi:10.3390/rs11161865, 2019.
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- Houtz D., R. Naderpour, M. Schwank, K. Steffen, Snow wetness and density retrieved from L-band satellite radiometer observations over a site in the West Greenland ablation zone, *Remote Sensing of Environment* 235: 111361, 2019.
- Li X., A. Al-Yaari, M. Schwank, L. Fan, F. Frappart, J. Swenson and J.-P. Wigneron, Compared performances of SMOS-IC soil moisture and vegetation optical depth retrievals based on Tau-Omega and Two-Stream microwave emission models, *Remote Sensing of Environment* 236: 111502, 2020.
- Méndez Domínguez E., C. Magnard, E. Meier, D. Small, M. E. Schaepman and D. Henke, "A Back-Projection Tomographic Framework for VHR SAR Image Change Detection," in *IEEE Trans. Geosci. Remote Sens.* vol. 57(7), pp. 4470-4484, July 2019. doi: 10.1109/TGRS.2019.2891308
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- Scapozza C., C. Ambrosi, M. Cannata and T. Strozzi, Glacial lake outburst flood hazard assessment by satellite Earth observation in the Himalayas (Chomolhari area, Bhutan), *Geogr. Helv.*, 74, 125-139, doi: 10.5194/gh-74-125-2019, 2019.
- Siddique M.A., T. Strozzi, I. Hajnsek and O. Frey, A Case Study on the Correction of Atmospheric Phases for SAR Tomography in Mountainous Regions, *IEEE Trans. Geosci. Remote Sens.* vol. 57(1), pp. 416-431, doi: 10.1109/TGRS.2018.2855101, 2019.
- Wilgan K., M. A. Siddique, T. Strozzi, A. Geiger and O. Frey, Comparison of Tropospheric Path Delay Estimates from GNSS and Space-Borne SAR Interferometry in Alpine Conditions, *Remote Sensing*, 11(15), 1789, doi:10.3390/rs11151789, 2019.
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Articles in conference proceedings:

- Coscione R., I. Hajnsek, and O. Frey, "Trajectory Uncertainty in Repeat-Pass SAR Interferometry: A Case Study," *Procs IGARSS 2019, Yokohama, Japan*, 28.7. – 2.8. 2019.
- Frey O., C. L. Werner, and R. Coscione, "Car-borne and UAV-borne mobile mapping of surface displacements with a compact repeat-pass interferometric SAR system at L-band," *Procs IGARSS 2019, Yokohama, Japan*, 28.7. – 2.8. 2019.
- Houtz D., R. Naderpour and M. Schwank, "Retrievals of Snow Properties over Greenland from L-Band Radiometry," *IGARSS 2019 - 2019 IEEE International Geoscience and Remote Sensing Symposium, Yokohama, Japan, 2019*, pp. 3990-3993.
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- Santoro, M., O. Cartus, O., N. Carvalhais, N., M. Thurner, and J. Fransson, "Dynamics of forest biomass pools estimated from spaceborne SAR data," *Geophysical*

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Wiesmann A., R. Caduff, C. L. Werner, O. Frey, M. Schneebeli, and Lö, "ESA Snowlab Project: 4 Years of Wide Band Scatterometer Measurements of Seasonal Snow," Procs IGARSS 2019, Yokohama, Japan, 28.7. – 2.8. 2019.