
Gamma Remote Sensing AG

ANNUAL REPORT 2021

RESEARCH AND DEVELOPMENT

ESA – ESA SnowLabNG (2020-2021)

GAMMA supports WSL-Birmensdorf in the operation and data quality assessment of the WBScat (1-40 GHz Wide-band Scatterometer) during campaigns at Laret-Davos, Switzerland (winter 2019/2020) and Sodankyla, Finland (foreseen in winter 2020/2021 but delayed due to COVID-19 restrictions in Finland).

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. Furthermore, within Option 6 of the precursor project ESA CCI Glaciers, GAMMA is contributing to an Ice Marginal Lake Inventory of Greenland.

ESA – Glacier Science Alps (2021-2023)

The main objectives of the AlpGlacier project (coordinated by University of Zürich, Switzerland) are to provide enhanced observation capacity for glaciers in the Alps regarding surface flow velocity, snow cover, glacier lake size and slope movements around glaciers. GAMMA contributes to this project with its SAR competence.

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 engineering, 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 GmbH, 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 at 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 and the system implementation of the AVHRR Snow Cover Fraction processor.

ESA –SMOS Expert Support Laboratory for Level 2 - Soil Moisture (2020-2024)

The tasks of the SMOS ESL for soil moisture include the development, implementation and assessment of SMOS soil moisture and additional land-surface retrieval algorithms. GAMMA contributed new algorithm ideas relevant for applications to the Cryosphere 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 (2017-2021)

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 2 x 3 wide-band horn antennas was chosen. WBScat can be used in support of tower-based measurements of snow, crops and soil.

ESA – Scientific Campaign Data Analysis for an Alpine Snow Regime (SCANSAS, 2020-2022)

The aim of this activity is to perform an in-depth analysis of the ESA SnowLab and ESA SnowLabNG active and passive microwave data acquired within the two projects as well as the available meteorological data, snow physical data, and ground data. The resulting knowledge gain supports the definition of future microwave mission concepts dedicated to remote snow observations in terms of required data accuracy, optimal combination of frequencies, and observation geometry.

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.

ESA Forest Carbon Monitoring (2021-2023)

The aim of this project under the lead of VTT is to develop a robust, reliable, and transparent approach for the monitoring of forest carbon. In the proposed approach optical and SAR EO data play a central role. In the context of the EU Green Deal an increasing demand for related services is expected. GAMMA contributes to the SAR data based elements.

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 landslide 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.

Global Temporal Coherence Maps using Spaceborne SAR Data (2020-2021)

In a NASA/JPL-funded project, GAMMA Remote Sensing AG and Earth Big Data LLC have produced a global data set of Sentinel-1 coherence as well as backscatter. The data set, produced from 205000 Sentinel-1 Interferometric Wide Swath mode SLCs acquired between December 2019 and November 2020, comprises seasonal mosaics of the interferometric repeat pass coherence at repeat intervals of 6 to 48 days as well as backscatter at a spatial resolution of 3 arcseconds. The data can now be downloaded free of charge via the AWS Registry of Open Data (link can be found under <https://www.gamma-rs.ch/news>).

EO SERVICES, CONSULTING AND TRAINING

Deformation Maps, DEMs , Landcover/Landuse and Change/Hazard Products

A variety of products were generated in 2021 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 2021 we also continued providing services using the GAMMA Portable Radar Interferometer (GPRI) and the GAMMA L-band SAR.

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. L-band SAR) with the acquisition and processing of the data. Furthermore, user specific adaptations of GAMMA microwave instruments were developed and implemented.

Training courses

In 2021 the in-situ training courses for SAR, SAR interferometry, and Interferometric Point Target Analysis (IPTA) could again not take place because of COVID-19. Instead we conducted two training courses online. To support new software users we provided documented demo examples and supported the users over the internet. Courses will again be scheduled for 2022 (for information see our homepage <http://www.gamma-rs.ch>) and will hopefully take place. We trained users in the operation of GAMMA Instruments (GPRI, GAMMA L-band SAR) and the related data processing.

GAMMA SOFTWARE

In 2021 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). Furthermore, a time domain back projection processor (TDBP) is available to process SAR data acquired on non-uniform tracks such as GAMMA's car-borne L-band SAR measurements.

License sale activities were continued with new licenses sold in Europe, Asia, and North 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, PAZ, Gaofen-3, ICEYE, NOVASAR, ASNARO2, RCM, SAOCOM, Capella). The software also supports processing of data acquired with the GAMMA GPRI and L-band SAR instruments.

Further information related to the GAMMA Software is available online:

General information:

www.gamma-rs.ch/software

www.gamma-rs.ch/uploads/media/GAMMA_Software_information.pdf

Technical reports, conference and journal papers:

www.gamma-rs.ch/uploads/media/GAMMA_Software_references.pdf
Release notes / upgrade information:
www.gamma-rs.ch/uploads/media/GAMMA_Software_upgrade_information.pdf

GAMMA INSTRUMENT DEVELOPMENT

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

Under ESA contracts GAMMA developed the VNA based, polarimetric, 1-40 GHz Wide-Band Scatterometer (WBScat) and the X- to Ku-band scatterometer (SNOWSCAT). ESA provides now these instruments to scientists for their field measurements.

GAMMA Portable Radar Interferometer (GPRI)

There was again a significant interest in the GAMMA Portable Radar Interferometer (GPRI). More than 30 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. Our 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) which has been successfully tested for repeat-pass DInSAR-based mobile mapping of surface displacements with car-mounted and UAV-mounted system configurations, as well as a rail-mounted configuration. In 2019/2020, first GAMMA L-band SAR instruments were sold.

VARIA

We are happy to announce that Nina Jones and Silvan Leinss started to work for GAMMA. Andrea Manconi left GAMMA and now works at WSL-SLF. We wish him all the best for his new position.

In 2021 our work was again affected by the COVID-19 pandemic. Especially travelling to customers, attending conferences, and holding training courses was significantly reduced. Some of us worked and are still working primarily from home – a related robust solution was already in place before the pandemic. But overall we are in a good position, the staff is motivated, business and finances are solid.

GAMMA employees are members of national (SIP, SED, SGPF, CHGEOL, FAN) and international (IEEE, RSPSoc, AGU, EARSEL, EGU) 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:

- Balenzano, A., ... Wegmüller, U., Cartus, O., et al., Sentinel-1 soil moisture at 1 km resolution: a validation study. *Remote Sensing of Environment* **263**, 112554 (2021). doi: 10.1016/j.rse.2021.112554.
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- Caduff, R., Strozzi, T., Hählen, N. & Häberle, J. Accelerating Landslide Hazard at Kandersteg, Swiss Alps; combining 28 Years of Satellite InSAR and Single Campaign Terrestrial Radar Data. in *Understanding and Reducing Landslide Disaster Risk* (ed. Vilímek, et al.) 267–273 (Springer International Publishing, 2021). doi:10.1007/978-3-030-60319-9_29.
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- Huang, Y., Ciais, P., Santoro, M., Makowski, D., Chave, J., Schepaschenko, D., Abramoff, R. Z., Goll, D. S., Yang, H., Chen, Y., Wei, W. & Piao, S. A global map of root biomass across the worldforests. *Earth System Science Data* **13**, 4263–4274 (2021). doi: 10.5194/essd-13-4263-2021.
- Izumi, Y., Frey, O., Baffelli, S., Hajnsek, I. & Sato, M. Efficient Approach for Atmospheric Phase Screen Mitigation in Time Series of Terrestrial Radar Interferometry Data Applied to Measure Glacier Velocity. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* **14**, 7734–7750 (2021). doi: 10.1109/JSTARS.2021.3099873.
- Jones, N., Manconi, A. & Strom, A. Active landslides in the Rogun Catchment, Tajikistan, and their river damming hazard potential. *Landslides* **18**, 3599–3613 (2021). doi: 10.1007/s10346-021-01706-5.
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- Werner, C., Frey, O., Naderpour, R., Wiesmann, A., Süß, M. & Wegmüller, U. Aperture Synthesis and Calibration of the WBSCAT Ground-Based Scatterometer. in *Proc. IEEE Int. Geosci. Remote Sens. Symp.* 1947–1950 (IEEE, 2021). doi:10.1109/IGARSS47720.2021.9554592.