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# Gamma Remote Sensing AG

## ANNUAL REPORT 2017

### RESEARCH AND DEVELOPMENT

#### **FP7 – APHORISM: Advanced Procedures for Volcanic and Seismic Monitoring (2014-2017)**

In this project coordinated by INGV two new methods to combine different types of Earth Observation satellite data and ground data, one for volcano ash monitoring and one for earthquake damage mapping are developed. GAMMA is mainly involved with the earthquake damage mapping product and provides elements related to the use of SAR data, including the mapping of ground deformation and change detection for damage mapping.

#### **FP7 – SEN3APP (2014-2017)**

In this project coordinated by FMI processing lines and operational services combining Sentinel and in-situ data for the terrestrial cryosphere and boreal forest zone are being developed. GAMMA is mainly involved in the installation of the SAR processor and the use of SAR data from Sentinel-1 for application development.

#### **H2020 - COREGAL (2015-2017)**

In this Project coordinated by DEIMOS, Portugal, the use of GNSS-Reflectometry is investigated to complement biomass estimation from spaceborne EO data at high spatial resolution. GAMMA provides biomass estimates from spaceborne SAR data and expertise on biomass estimation.

#### **ESA - Snowlab (2016 - 2018)**

In 2017 the SNOWSCAT X- to Ku-band scatterometer was operated for snow measurements near Davos, Switzerland where it is operated at the new Snowlab site of WSL-SLF. The objective is to resolve layer structures in the snow pack. Again the Snowscat will also be operated in a tomographic mode.

#### **ESA - CCI – Glaciers 2 (2014-2017)**

The main objectives of the Glaciers-CCI Project 2 (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 - Landcover 2 (2014-2017)**

In this Project coordinated by UCL, Louvain, Belgium, GAMMA provides waterbody information derived from multi-temporal SAR data.

#### **ESA Snow Concepts Study - Scientific Evaluation of Mission (2016 – 2018)**

In this study GAMMA is involved in the development of concepts to monitor snow mass and other cryospheric parameters.

**ESA – Snow Microstructure (2015-2017)**

GAMMA supports this project on “Microstructural origin of electromagnetic signatures in microwave remote sensing of snow”, coordinated by Université Joseph Fourier Grenoble, with its experience in snow scattering and emission.

**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 – GlobBiomass (2014-2017)**

In this project, led by the University of Jena, the main goal is to develop and demonstrate an integrated and validated methodology using EO and in-situ data to improve regional and global biomass estimates. Where possible, very recent and near-future satellite data such as from the Sentinel-fleet will be implemented. GAMMA’s role is to lead the System Development and Prototyping and the Global Biomass Estimation.

**ESA – Information content of multi-spectral SAR data (2015-2017)**

In this project, led by GAMMA, the capability of improving retrievals and classifications using multi-spectral SAR data is investigated. GAMMA is responsible for the forest biomass and the water body phenology themes.

**ESA – Exploitation of S-1 for Surface Soil Moisture Retrieval at High Resolution (2016-2018)**

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 - Alcantara : InSAR and Landslides in Peru (2016-2017)**

In this ESA study to support space R&D cooperation between groups in Europe and those based elsewhere and coordinated by the University of Zürich (Switzerland), GAMMA is evaluating the potential of InSAR for detecting and analyzing different types of high-mountain terrain motions in Peru with a comparison to conventional in-situ methodologies.

**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-flux radiative transfer modeling that are now being further tested and that may be introduced at a later stage into the operational processor.

### **ESA - ELBARA-III in Bubnow, Poland (2015- 2017)**

In this project GAMMA provides an ELBARA-III L-band radiometer to be operated in Bubnow, Poland. The ongoing measurements are supported by GAMMA with training and technical support on the instrument operation and calibration aspects.

### **ESA – Wide-Band Scatterometer Development (2017-2018)**

In this project GAMMA develops and builds a coherent, polarimetric 1 – 40 GHz scatterometer. A design incorporating a Vector Network Analyzer and a front end with 3 wide-band horn antennas is foreseen. The WBScat shall support tower based measurements of snow, crops and soil.

### **JAXA Kyoto & Carbon (K&C) Initiative, 4<sup>th</sup> phase (2014- 2017)**

The objective of the ALOS K&C Initiative is to define, develop and validate thematic products derived primarily from ALOS PALSAR data that can be used to meet the information requirements relating to Conventions, Carbon Cycle Science and Conservation of the environment. GAMMA supported related activities on forest change detection and biomass mapping.

### **KTI/CTI - Development of a car-borne repeat-pass differential interferometric synthetic aperture radar (SAR) system at L-band for ground displacement measurements. (2016-2018)**

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 2017 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.

## **EO SERVICES, CONSULTING AND TRAINING**

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

A variety of products were generated in 2017 for customers in Switzerland, Europe, and North America using data of the ERS, ENVISAT, Radarsat, ALOS-1/2, TerraSAR-X, Cosmo-Skymed, RISAT, 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 was achieved in 2017 and is now applied for glacier velocity and ground stability mapping.

In 2017 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 2017 we organized again training courses for SAR, SAR interferometry, and Interferometric Point Target Analysis (IPTA). Further courses will follow in spring 2018 (for information see our homepage (<http://www.gamma-rs.ch>). On several occasions we also trained users in the operation of GAMMA Instruments (GPRI, ELBARA) and the related data processing.

## **GAMMA SOFTWARE**

In 2017 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. To improve the burst selection procedure we defined an absolute burst number. In 2017 support for TSX ScanSAR interferometry and tools supporting for several sensors cross-mode interferometry were added. Again a significant effort was spent to add and update processing demo examples. Furthermore, processing SAR data of the Chinese Gaofen 3 satellite is now supported.

License sales 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, Gaofen-3). On several occasions the software was presented to potential customers.

## **GAMMA INSTRUMENT DEVELOPMENT**

### **Terrestrial X- to Ku-band scatterometer (SNOWSCAT)**

In 2017 the X- to Ku-band scatterometer SNOWSCAT was measuring at the WSL-SLF Snowlab site near Davos, Switzerland in the frame of the 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)**

GAMMA finished manufacturing a second updated ELBARA L-band radiometer series and delivered most instruments to customers. 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) the SAR will be operated from the roof of a car with the intention to use repeat-pass interferometry to map displacements.

## GAMMA WBScat

In the frame of an ESA project GAMMA started the development of a VNA based, polarimetric, 1-40 GHz Wide-Band Scatterometer (WBScat).

## VARIA

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:

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- Naderpour R., M. Schwank, C. Mätzler, J. Lemmetyinen, and K. Steffen, "Snow Density and Ground Permittivity Retrieved From L-Band Radiometry: A Retrieval

- Sensitivity Analysis“, IEEE JSTARS, Vol. 10, No. 7, pp. 3148-3161, 2017
- Naderpour R., M. Schwank, and C. Mätzler, "Davos-Laret Remote Sensing Field Laboratory: 2016/2017 Winter Season L-Band Measurements Data-Processing and Analysis," Remote Sensing, vol. 9, p. 1185, 2017.
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