Name of research institute or organization:

University of Zurich, Department of Geography, Remote Sensing Laboratories (RSL)

Title of project:

Swiss Alpine Airborne SAR-Experiment (SASARE)

Project leader and team

Oliver Stebler, PhD candidate; Arnold Barmettler, PhD candidate; Lukas Divis, MSc candidate; Erich Meier, Dr.; Prof. Dr. D. Nüesch

Project description:

Glacier signals are key elements for early detection (and warning) of climatic change and therefore worldwide glacier monitoring already has a long tradition. Measuring glacier parameters remotely by means of SAR (synthetic aperture radar) goes back to the Seasat satellite (L-band) in 1978 and the launch of ERS-1 (European Remote Sensing Satellite, C-band) in 1991.

SAR interferometry (InSAR) and SAR polarimetry (PolSAR) are two well-known techniques in the field of active microwave remote sensing using airborne and space-borne platforms. Recently, the combination of InSAR and PolSAR has revealed a new methodology called Pol-InSAR. InSAR measures the spatial distribution, Pol-SAR the orientation of scattering elements on surfaces or within volumes. In combination with low system frequencies (e. g. L- [1.3GHz] – or more distinctively – P-band [350MHz]) Pol-InSAR therefore enables for the analysis of complex scattering mechanisms within volume scatterers. So far, the technique has been successfully applied to the analysis of scattering mechanisms within vegetation volumes. In the frame of the SASARE project (Swiss Alpine Airborne SAR Experiment) this technique was flown on an airborne SAR platform for the first time over an alpine glacier to characterise and to analyse firn, snow and ice surfaces using the aforementioned Pol-InSAR measuring technique.

The multi-baseline and multi-temporal SAR flights were carried out in September and October 2003 in the area of the Aletsch glacier using the E-SAR (Experimental SAR) operated by the DLR (German Aerospace Center) and have been accompanied by several extensive ground truth campaigns (Fig. 1). Corner reflectors of various types were mounted in different sub test sites on the glacier (Jungfraufirn, Konkordiaplatz, Fieschersattel) for calibration and validation purposes of the SAR measurements. In order to perform a rigorous geometric calibration of the acquired data sets and – additionally – to account for displacement errors due to glacier movement the positions of the corner reflectors had been determined by means of differential GPS measurements using the AGNES station Jungfraujoch (swisstopo) as reference station.

Furthermore, the October 2003 campaign was designed as a joint venture experiment and therefore also included measurements of the Swedish CARABAS UWB (Coherent All Radio Band Sensing, ultra wide-band) sensor operating in the VHF frequency range. While using different SAR imaging techniques, both sensors make use of microwave frequencies between 20MHz and 9.6GHz and therefore provide a unique data set to study fundamental scattering mechanisms of microwaves interacting with firn, snow and ice surfaces (or volumes?) as a function of different system parame-

ters. The interferometric acquisition mode of E-SAR will enable to perform change detection, to produce digital elevation models of the test site as a function of frequency and polarisation, and to measure surface displacement and/or deformation using differential InSAR. Parallel to both SAR campaigns in September and October, aerial photographs have been taken to support the subsequent SAR image analyses.

Figure 1: Corner reflectors (first row: L-band trihedrals, second row: P-band cubes, third row: VHF trihedral)

It is the very first time that such a SAR experiment as SASARE has been flown in a high alpine environment. It is one aim of this project to evaluate multi-dimensional SAR backscattering measurements of the involved surface types (e. g. firn, snow, ice, moraines, bare rocks, detritus…). Comparing our multi-temporal differential GPS measurements to the Swiss Digital Elevation Model 25 (DHM25) revealed approximately 30-34m vertical ice ablation in the area of Konkordiaplatz since 1986 (11-13m during the last ten years). For the Jungfraufirn (horizontal) ice surface flow velocities were consistently in the order of 0.2-0.25m per day. Therefore, the differential analysis of the interferometric data takes will explicitly focus on the reconstruction of the ice dynamics expanding the GPS point measurements to (remotely sensed) distributed measurements.

Due to the initial stage of the SASARE project and the ongoing analyses of all the data sets, only very preliminary results can be shown within this Activity Report. Fig. 2 shows two hh-polarised multi-look SAR amplitude images (15.09.03) at L- and P-band covering the Jungfraujoch, the Jungfraufirn, and the Konkordiaplatz. Fig. 3 demonstrates the polarimetric Pauli decomposition (15.09.03) representing basic physical scattering mechanisms (surface, double-bounce, and volume scattering) of the imaged area. Both figures represent typical surface conditions at the end of the ablation period in late summer 2003.

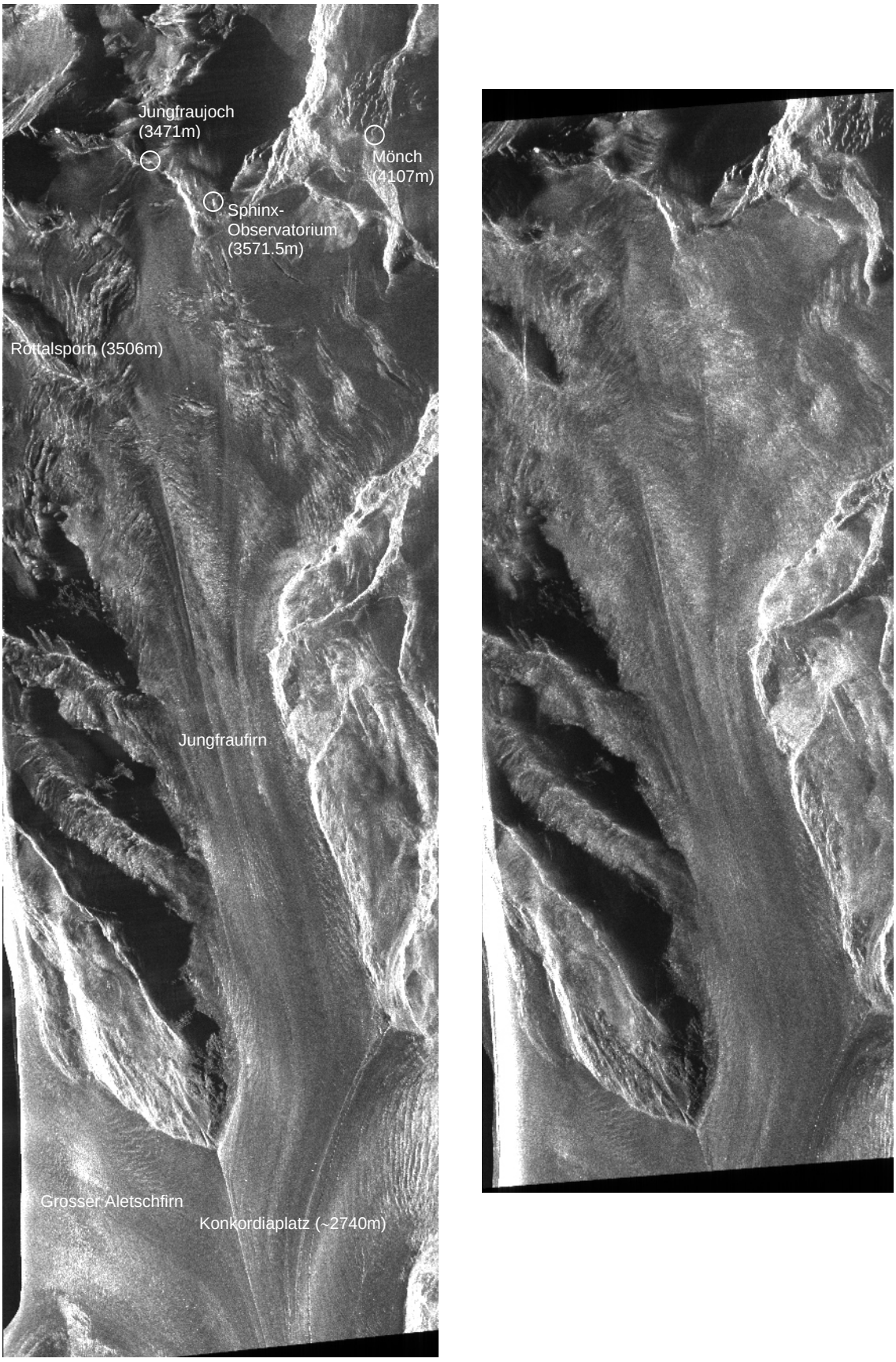

Figure 2: hh-polarised multi-look SAR amplitude images at L- (1.3GHz, left) and P-band (350MHz, right) (E-SAR system, 15.09.03, slant range geometry).

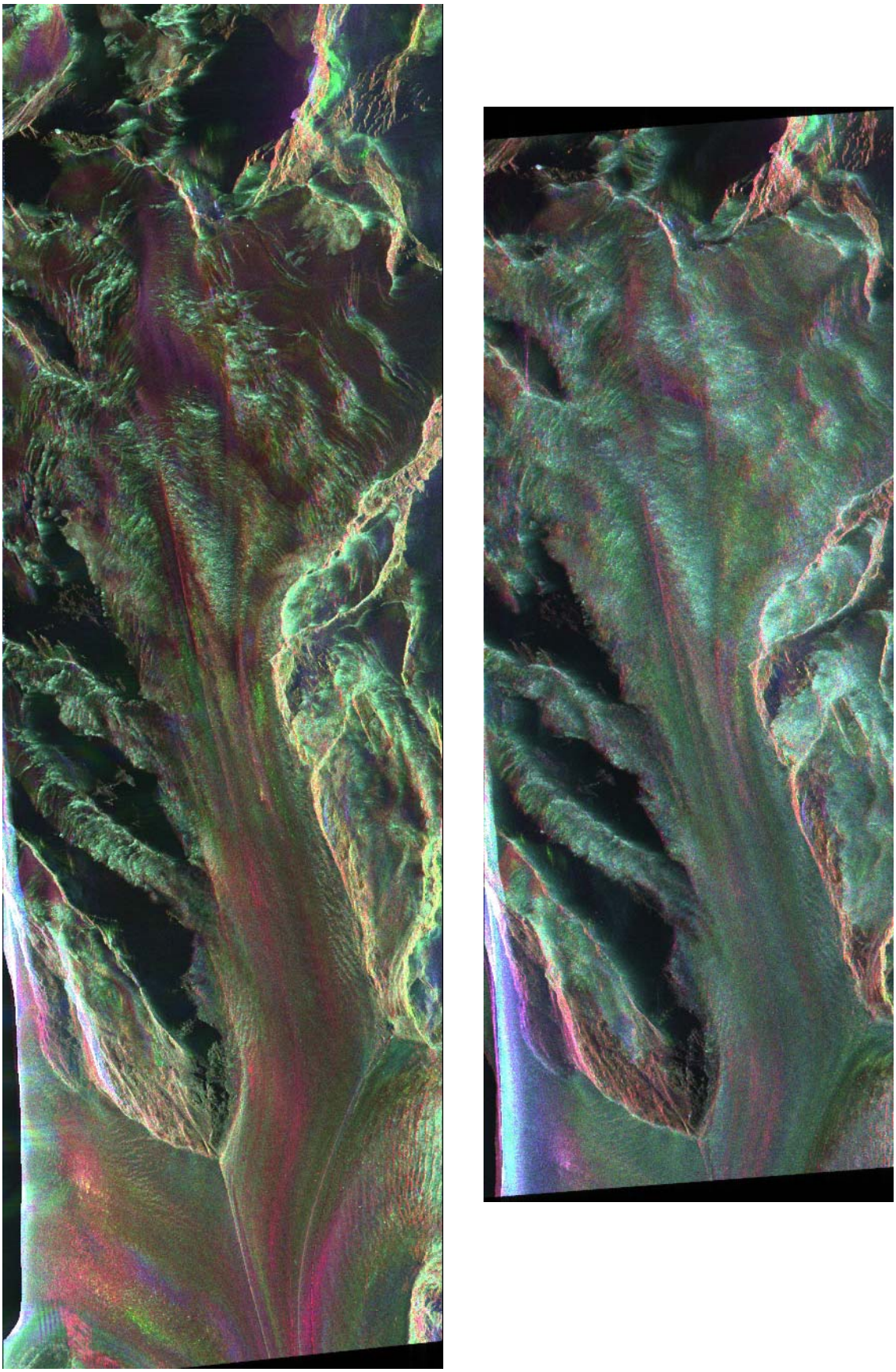

Figure 3: Amplitude images of the coherent polarimetric Pauli decomposition at L- (1.3GHz, left) and P-band (350MHz, right) (E-SAR system, 15.09.03). Red: isotropic 'odd'-bounce scattering (trihedral, surface scattering), blue: isotropic 'even'-bounce scattering (dihedral, double-bounce scattering), green: tilted isotropic 'even'-bounce scattering (volume scattering).

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Key words:

Synthetic aperture radar (SAR), SAR interferometry (InSAR), SAR polarimetry (PolSAR), polarimetric SAR interferometry (Pol-InSAR), single-/multi-baseline Pol-InSAR (SBPI/MBPI)

Internet data bases:

http://www.geo.unizh.ch/rsl/research/SARLab/
http://www.dlr.de/hr/Institut/Abteilungen/SAR_Technologie

Collaborating partners/networks:

German Aerospace Center (DLR Oberpfaffenhofen, Institut für Hochfrequenztechnik und Radarsysteme), Swedish Defence Research Agency (FOI)

Address:

University of Zürich
Department of Geography
Remote Sensing Laboratories (RSL)
Winterthurerstrasse 190
CH-8057 Zürich

Contacts

Oliver Stebler
Tel.: +41 1 635 51 03
Fax: +41 1 635 68 42
e-mail: stebler@geo.unizh.ch
URL: http://www.geo.unizh.ch/rsl/research/SARLab/