ATHENA

Remote Sensing Science Center for Cultural Heritage

H2020-TWINN-2015. Grant Agreement no 691936	
Project full title:	Remote Sensing Science Center for Cultural Heritage
Project acronym:	ATHENA
Work Package	WP4
Deliverable	D4.9 Report from short term visits

	H2020-TWINN-2015 **Grant Agreement no 691936** This project is funded under the **EUROPEAN COMMISSION** in the Framework Programme for Research and Innovation (2014-2020).	
Call:	Work programme **H2020** under **"Spreading Excellence and Widening Participation", call: H2020-TWINN-2015: Twinning** (Coordination and Support Action).	
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Work Package (WP):	**WP4**	
Deliverable (D):	**D4.9 (Report from short term visits)**	
Due date of deliverable:	**Nov 2018** **(Month 19 of the project)**	**Version: 1**
Author(s):	**Andreas Christofe, Vasiliki Lysandrou, Athos Agapiou, Argyro Nisantzi, Marios Tzouvaras, Christodoulos Mettas, Evagoras Evagorou, Christiana Papoutsa, Kyriakos Themistocleous, Diofantos G. Hadjimitsis**	
Contributor(s):	**Rosa Lasaponara, Nicola Masini, Thomas Krauss, Gunter Schreier**	
Start date of project:	**1/12/2015**	Duration: **36 months**

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CO	Confidential, only for members of the consortium (including the Agency Services)	□

Document Sign-off				
Nature	**Name**	**Role**	**Partner**	**Date**
DRAFT	Andreas Christofe, Vasiliki Lysandrou, Athos Agapiou, Argyro Nisantzi, Marios Tzouvaras, Christodoulos Mettas, Evagoras Evagorou, Christiana Papoutsa, Kyriakos Themistocleous, Diofantos G. Hadjimitsis	Project leader	CUT	28/09/2018
DRAFT	Gunter Schreier Thomas Krauss Rosa Lasaponara Nicola Masini	Advance Partners	DLR CNR	12/11/2018
APPROVED	Diofantos G. Hadjimitsis	Project coordinator	CUT	28/11/2018

Work Package: 4 – Training and knowledge transfer Deliverable: D4.9 –Report from short term visits				
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Contents

Summary

The present deliverable reports the short-term visits of the CUT personnel to Germany and Italy hosted by DLR and CNR, for training on remote sensing technologies, data and sensors as well as active and passive remote sensing (including geophysics) for archaeology. In collaboration with the project partners, selected members of the ATHENA team from Cyprus visited different facilities and had the opportunity to train, discuss and implement novel remote sensing technologies.

The main goal of these activities was to further build on the synergies of the ATHENA network. With the involvement of high performance partners (CNR and DLR), the network will encourage the development and exchange of knowledge, technology and innovation in the domain of the cultural heritage.

A great effort has been made by all partners to maximize the role and capabilities as well as increase the strategic collaborations in the region of the ATHENA Centre, thereby providing access to their links and making use of the available networks.

1. Introduction

During this task, short term visits took place where CUT personnel visited DLR's facilities to receive training on remote sensing technologies, data and sensors used by DLR and trained under the auspices of CNR in Pompeii and active and passive remote sensing (including geophysics) for archaeology operated by CNR. In detail three short term visits were carried out though the lifetime of the project as follow:

- 09-13 of May 2016 at CNR
- 20-23 of March 2018 at DLR
- 20-21 of November 2018 at DLR

For each of these visits the agenda, the material as well as photographs taken during these visits are provided below in chronological order.

2. 1st Short term visit (CNR)

Selected staff from the ATHENA partners in Cyprus attended the International School "Geophysics and Remote Sensing for Archaeology" which took place in Pompeii, Italy during 9-13 May, 2016. The visit was organized by CNR and consisted of training on data collection, processing and interpreting geophysical techniques (such as GPR, 3D laser scanning, magnetic and ERT) as well as passive and active remote sensing. A short video of the visit and the training can be found at https://youtu.be/l8D00wC_QVQ.

2.1 Agenda

Soprintendenza Speciale Beni Archeologici Pompei Ercolano Stabia

FIRST ANNOUNCEMENT FOR THE

International School "GEOPHYSICS AND REMOTE SENSING FOR ARCHAEOLOGY"

Pompei, 9-13 May 2016

The School aims at giving the opportunity to scholars, PhD students, researchers and specialists in Geophysics, Remote Sensing and Archaeology to deepen their knowledge and expertise with geophysical and remote sensing techniques for archaeology and cultural heritage documentation and management.

The school consists of **lectures** and **practical work** in laboratory and on-field at the prestigious site of Pompei. The course will provide the basics about data collection, processing and interpretation for geophysical techniques (GPR, magnetic, ERT), passive and active remote sensing and low-cost approaches based on the use of UAV.

The school is organized by two Institutes of the Consiglio Nazionale delle Ricerche, i.e., CNR-IBAM and CNR-IREA, and Soprintendenza Speciale Beni Archeologici Pompei, Ercolano e Stabia.

The course will be held from Monday May 9 to Friday May 13, 2016, and will foresee lectures/practical work on morning and afternoon (8 hours) for the first four days and only the morning for the last day.

Preliminary programme

- Sunday, 8/5: Arrival and icebreaking party
- Monday, 9/5: Lectures: Introduction and description of the course; Remote sensing and UAV for archaeology; Magnetic and Electrical Resistivity Tomography for Archaeology
- Tuesday, 10/5: Lectures: Ground Penetrating Radar for archaeology; Non-invasive diagnostics of monuments and artifacts; Integrated approaches and strategies for archaeology and cultural heritage
- Wednesday ,11/5: Data acquisition in a test site at the archaeological area of Pompeii (UAV, magnetic, seismic, ERT and GPR), for both archaeological and conservation purposes
- Thursday, 12/5: Tutorial regarding the processing and integration of the collected data (UAV, magnetic, ERT and GPR)
- Friday, 13/5 (only the morning): Presentation of the data processing results (in charge of the students), Wrap-up and conclusions

Chairs

Francesco Soldovieri IREA-CNR, Nicola Masini IBAM-CNR, Raffaele Persico, IBAM-CNR

Lecturers (to be completed)

- Giovanni Leucci, Nicola Masini and Raffele Persico - CNR-IBAM
- Francesco Soldovieri, Ilaria Catapano - CNR/IREA
- Rosa Lasaponara, Enzo Rizzo - CNR-IMAA

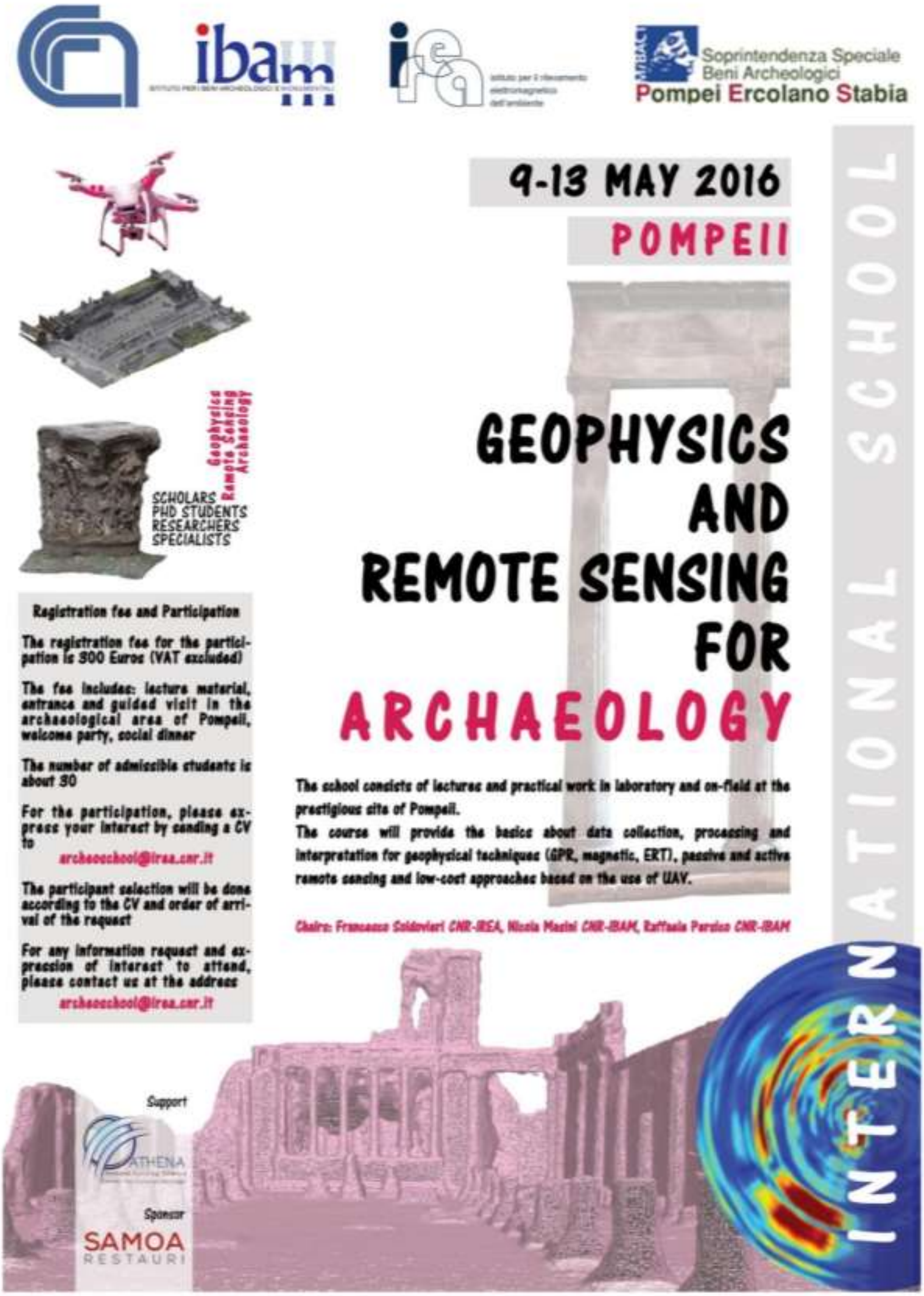
Tutors

- Antonio Pecci, Maria Sileo, Loredana Matera- CNR/IBAM
- Gianluca Gennarelli - CNR/IREA

Venue

The location of the school is the archaeological area of Pompeii, 15 km south of Naples (Italy). Pompeii can be easily reached by car or train. The closest international airport is Naples. The event will take place in the Auditorium inside the archaeological area. The on-field activities will be carried out at one of the areas of the archaeological site of Pompeii.

2.2 Material of the short-term visit to CNR



I International School "GEOPHYSICS AND REMOTE SENSING FOR ARCHAEOLOGY"

Pompeii, 9-13 May 2016

The School aims at giving the opportunity to scholars, PhD students, researchers and specialists in Archaeology, Geophysics, Remote Sensing, Geoscience and Science for Conservation of Cultural Heritage to deepen their knowledge and expertise with geophysical and remote sensing techniques for archaeology and cultural heritage documentation and management.

The school consists of lectures and practical work in laboratory and on-field at the prestigious site of Pompei. The course will provide the basics about data collection, processing and interpretation for geophysical techniques (GPR, magnetic, ERT, seismic), passive and active remote sensing.

The school is organized by two Institutes of the Consiglio Nazionale delle Ricerche, i.e., CNR-IBAM and CNR-IREA, and Soprintendenza Speciale Beni Archeologici Pompeii, Ercolano and Stabia.

The course will be held from Monday May 9 to Friday May 13, 2016, and will foresee lectures/practical work on morning and afternoon (8 hours) for the first four days and only the morning for the last day.

Organization : CNR-Istituto per i Beni Archeologici e Monumentali (IBAM); CNR- Istituto per il Rilevamento Elettromagnetico dell'Ambiente (IREA); Soprintendenza Speciale Beni Archeologici Pompei, Ercolano and Stabia

Support: ATHENA Project (H2010)

Sponsor: Samoa srl

Chairs: Francesco Soldovieri IREA-CNR, Nicola Masini IBAM-CNR, Raffaele Persico, IBAM-CNR

Lecturers: Giovanni Leucci, Nicola Masini and Raffele Persico (CNR-IBAM); Francesco Soldovieri and Ilaria Catapano (CNR/IREA); Rosa Lasaponara and Enzo Rizzo (CNR-IMAA); Bruno De Nigris SS-PES, Athos Agapiou (Cyprus University of Technology)

Tutors: Antonio Pecci, Maria Sileo (CNR/IBAM); Gianluca Gennarelli (CNR/IREA)

Administrative/Economic Organization: Generoso Sole CNR/IREA

Logistics Support and Information: Maria Consiglia Rasulo CNR/IREA

Venue

The location of the school is the archaeological area of Pompeii, 15 km south of Naples (Italy). Pompeii can be easily reached by car or train. The closest international airport is Naples. The event will take place in the Auditorium inside the archaeological area. The on-field activities will be carried out at the archaeological site of Pompeii.

Registration fee and Participation

The registration fee for the participation is 300 Euros (VAT excluded).
The fee includes: lecture material, entrance and guided visit in the archaeological area of Pompeii, welcome party, social dinner.
The number of admissible students is about 30.
For the participation, please express your interest by sending a CV to archeoschool@irea.cnr.it . The participant selection will be done according to the CV and order of arrival of the request.

Payment Method only by Wire Transfer

NAME of BANK: **BANCA NAZIONALE DEL LAVORO (BNL gruppo BNP Paribas)**
ACCOUNT HOLDER: **Consiglio Nazionale delle Ricerche, "Incassi giornalieri da altre dipendenze"**
SWIFT/BIC: **BNLIITRR**
IBAN: **IT57S0100503392000000218155**
REF: **CDR 072, *NAME SURNAME*, Registration for GEOPHYSICS AND REMOTE SENSING FOR ARCHAEOLOGY SCHOOL**

After sending your registration payment by bank wire transfer, scan the bank receipt and attach the PDF file in an email to amministrazione@irea.cnr.it and archeoschool@irea.cnr.it

For any information request and expression of interest to attend, please contact us at the address archeoschool@irea.cnr.it

Programme

Monday, 9 May 2016		
8.30-9.30	*Opening Ceremony*	Chairs, Institute directors and Superintendent
9.30-10	*Introduction to the course*	Chairs (N. Masini, F. Soldovieri, R. Persico)
10:00-11:00	*The role of the sensing technologies in the CH management and protection*	B. De Nigris
11:00-12:30	*Remote sensing for Archaeology and cultural heritage management*	R. Lasaponara
12:30-13:30	*Ground-truth spectroradiometric data for archaeological applications*	A. Agapiou
13:30-14:30	*Lunch break*	
14:30-16	*Magnetic and ERT for preventive archaeology*	E. Rizzo
16-17:30	*Ground Penetrating Radar*	R. Persico

Tuesday, 10 May 2016		
9:00-10:30	*Infrared and high frequency technologies for diagnosis*	I. Catapano
10:30-12:00	*Acoustic and seismic techniques*	G. Leucci
12:00-13:00	*Strategies for non invasive diagnosis of structure and monuments*	F. Soldovieri
13:30-14:30	*Lunch break*	
14:30-16:00	*Integrated approaches and strategies for archaeology and cultural heritage*	N. Masini
16:00-18:00	Visit of the archaeological area of Pompeii and test sites	

Wednesday, 11 May 2016		
9:00-13:00	*Field surveys on monuments Part 1*	All the lecturers and tutors divided in two-three groups
13:00-14:00	*Lunch break*	
14:00-18:00	*Field surveys on monuments Part 2*	All the lecturers and tutors divided in two-three groups

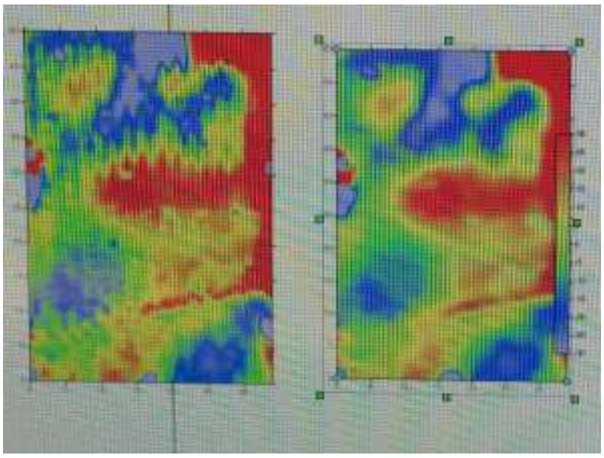
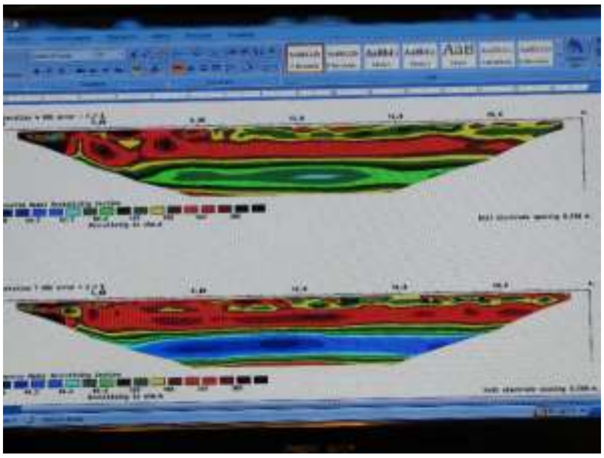
Thursday, 12 May 2016		
9:00-11:00	*Tutorial of data processing for the technologies deployed at field survey*	The lecturers involved in the data processing
11:00-13:00	*Processing of data collected during the field survey*	All lecturers and tutors
13:00-14:00	*Lunch break*	
14:00-18:00	*Processing of data collected during the field survey*	All lecturers and tutors

Friday, 13 May 2016		
9.00-12:00	*Presentation and interpretation of data processing results*	All lecturers and tutors
12:00-13:00	*Conclusion of the course*	Chairs

Presentations from the material can be found in the Annex of the Deliverable. Tutorials related to the application of various remote sensing technologies can be found in Appendix 1:

2.3 Photos during the visit







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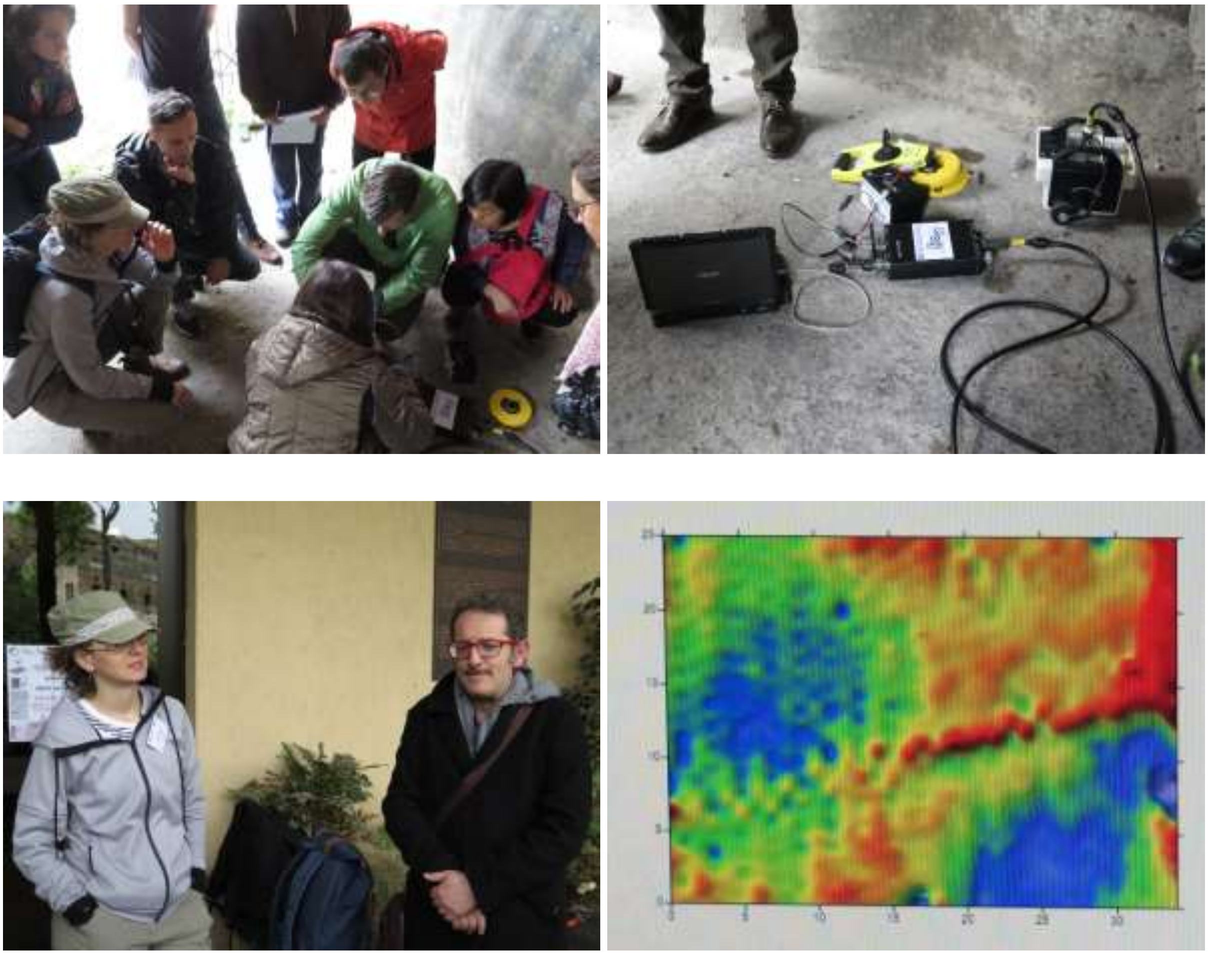
FLIR


GEOMETRICS





Photos taken during the training at the Pompeii archaeological site.

3. 2nd Short term visit (DLR)

Selected staff from the ATHENA partners in Cyprus visited the DLR premises in Oberpfafflenhofen, Germany during 20-23 March, 2018 in order to receive training on airborne imaging, SAR, space borne radar imaging, subsidence mapping and disaster identification.

3.1. Agenda of the 2nd short term visit

Visit CUT at DLR – 20.–23.3.2018

Preliminary program:

20.3. Tue.
- 10:10 Arrival MUC airport
- 12:00 Transfer to city center[1]: Europa Hotel, Dachauer Straße 115, 80335 Munich
- 15:00 Guided tour Old Town Munich (meet at Marienplatz, Mariensäule, 2 hours)
- 19:00 Joint dinner in the old town Munich

21.3. Wed.
- 10:00 Visit Office of historical monuments (Landesamt für Denkmalpflege, tbc)
- 12:00 Lunch
- 14:00 TUM, discussions about cooperation (Prof. Uwe Stilla)
- 15:30 Visit Königsplatz, Glyptothek (Dr. Gebauer, Foyer)
- 16:30 End of visits

22.3. Thu.
- 09:00 Transfer from main station to DLR, Oberpfaffenhofen[2]
- 10:00 Planning project video at DLR-VIS with Nils Sparwasser and Peter Folie
- 11:00 Short presentations:
  - ZKI: center for crisis information, International Charter Space & Disasters (Simon Plank)
  - VABENE, airborne imaging, traffic and security (Veronika Gstaiger)
  - SAR: space borne radar imaging, subsidence mapping (Ramon Brcic)
- 12:00 Lunch
- 13:00 Guided tour to DLR institutes
  - 13:00 Robotics (G135, Foyer Mr. Kondak, flight robotics demo, lab exhibits)
  - 13:45 Galileo control center for the European GNSS (G144, Mr. Güttler)
  - 14:30 GSOC Columbus mission control, exhibitions "ALL.täglich", "Rosetta"
  - 15:00 Flight experiments: Planes, airborne experiments (G160, Foyer)
- 15:30 Excelsior-Projectmeeting (all, Daniele, remote: Egbert Schwarz)
- 16:30 Return to the city center of Munich[2]

23.3. Fri.
- 08:00 Transfer to airport[1]
- 10:20 Departure MUC airport

List of participants (needed for registration DLR-campus, Galileo and GSOC):

Last name	*First name*	*Institution*	*Nationality*
Christofe	Andreas	CUT	CY
Hadjimitsis	Diofantos	CUT	CY
Themistocleous	Kyriacos	CUT	CY
Schreier	Gunter	DLR-DFD	DE
Krauß	Thomas	DLR-IMF	DE

[1] For public transport (S8 airport to/from main station, about 45 minutes) you need the „Airport-City-Day-Ticket Group" which is 24,30 € for one full day (group of up to 5 adults, valid in whole Munich the whole day until 6 am of following day).

[2] For traveling from Munich main station to Neugilching (DLR) take the S8 below Munich main station in direction Weßling or Herrsching (needs about 33 minutes). We will pick you up[3] at the train station in Neugilching and bring you to DLR. You need the MVV XXL-Group-Day-Ticket (it is valid for 5 adults, the whole day of 22.3. until 6 am of the following day in the whole area of Munich city center to DLR, the larger area covering also the airport needs the Airport-City-Day-Ticket, for single traveling there are day-tickets XXL/Airport-City for 8,90 €/13 €).

[3] Support/contact: Thomas Krauß, +49 175 411 5898

3.2. Material of the 2nd short term visit to DLR

3.2.1. Guided tour to the historic centre of Munich






3.2.2. Ludwig-Maximilians-Universität München (LUM) & Bavarian State Dept. of Monuments & Sites (Munich)

On 21 March 2018 Prof. Diofantos G. Hadjimitsis with Dr Kyriacos Themistocleous and Mr Andreas Christofe (ATHENA, Cyprus University of Technology) with Gunter Schreier from DLR had the opportunity to meet with Prof. Jörg W. E. Fabbinder from the Department of Earth and Environmental Sciences which is located at the Ludwig-Maximilians-University in Munich, Germany and the Bavarian State Dept. of Monuments & Sites (Munich). The Archaeological Prospection Group Munich at the Bavarian State Department for Monuments and Sites (BLFD) has been responsible for non-destructive geophysical survey methods for archaeology in Bavaria since 1982. Prof. Fabbinder conducted a presentation and provided short visits to the laboratoriess and premises of the Bavarian State Dept. of Monuments & Sites (Munich), during which he explained the various remote sensing techniques that have been used to manage the Bavarian cultural heritage. Prof. Fabbinder presented the topics of Archaeological Geophysics, Soil Magnetism and Magnetometer Prospection, for possible collaboration through the ATHENA Center in Cyprus.

3.2.3. Leonhard Obermeyer Center / Department of Civil, Geo and Environmental Engineering of the Technical University of Munich

The Leonhard Obermeyer Center focuses on intense cross-disciplinary collaboration between the participating chairs in research and teaching, with particular emphasis on all aspects of model and methods integration from CAD, BIM, GIS as well as on methods for the automated generation and validation of digital models. The members are actively involved in the development of international standards in the fields of BIM (e.g. IFC) and virtual 3D city models (e.g. CityGML, Web 3D Service, IndoorGML) in the buildingSMART Alliance and the Open Geospatial Consortium.

The Center also provides a platform for close collaboration with international stakeholders of the Architecture, Engineering and Construction (AEC) and GIS industry. Prof. Dr.-Ing. Uwe

Stilla presented the structure and activities of the Department of Civil, Geo and Environmental Engineering, which includes the Photogrammetry and Remote Sensing Labs. Additional visits were also made to the BIM, Cartography and Remote sensing labs.

The ATHENA team had the opportunity to visit the Department of Civil, Geo and Environmental Engineering of the Technical University of Munich (TUM), which is responsible for teaching and research in the field of civil and environmental engineering, surveying and geology at the TUM. It includes 40 departments and professorships, 17 study programmes and several research and development institutions such as testing centers, external institutes and laboratories.





3.2.4. DLR, Oberpfaffenhofen

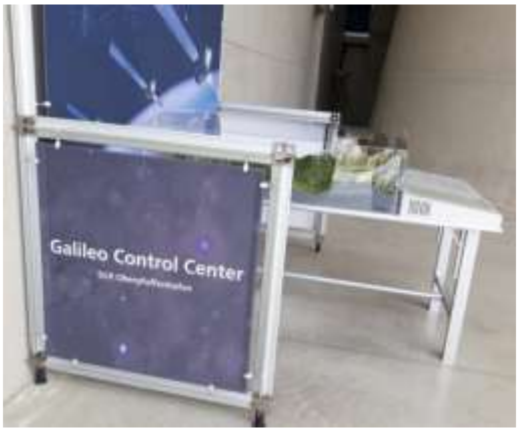
On the 22 March, 2018, the ATHENA team visited the Earth Observation Data Centre Department of DLR in Munich, Germany. The ATHENA team discussed the upcoming video production for the ATHENA deliverable by DLR with Nils Sparwasser and Peter Folie.


In addition, several presentations took place. Simon Plank presented the ZKI center for crisis information, International Charter Space & Disasters, Veronika Gstaiger presented the VABENE, airborne imaging, traffic and security and Ramon Bercic gave a short presentation for SAR: space borne radar imaging as well subsidence mapping.



The DLR team provided the ATHENA team with a tour of the DLR premises and provided a presentation on how DLR operates. During the tour, Mr. Kondak provided an analytical presentation in the Robotics laboratories to the ATHENA team. This was followed by a presentation by the German Space Operations Center [GSOC] which it is responsible for operating spacecraft for more than 35 years and it is playing a key role in countless manned and unmanned missions as the Galileo control center for the European GNSS.


Visit to the Galileo Control Center at DLR



During the visit to DLR , the ATHENA team had an analytical guided tour in the Robotics laboratories by Mr. Kondak.





The tour ended in the GSOC Columbus mission control, exhibitions.


3.2.5 ESA Business Incubation Centre

The ATHENA team had also visited the headquarters in Oberpfaffenhofen and met with Thorsten Rudolph, Stefanie Hermann and Daniela Dobreva-Nielsen. Mr Rudolph, who is the CEO of the Anwendungszentrum GmbH Oberpfaffenhofen, presented the activities of the ESA BIC. The scientific expertise and development network of ESA BIC Bavaria's partners are complementing local start-ups' technical development and promote both the commercialisation and the usage of aerospace technologies in other growth areas.

4. 3rd Short term visit (DLR)

Selected staff from the ATHENA partners in Cyprus visited the DLR premises in Munich and Oberpfafflenhofen, Germany during 20-21 November, 2018 in order to receive training on remote sensing technologies, data and sensors used by DLR.

4.1 Agenda of the 3rd short term visit

tk, 2018-11-08

Visit CUT at DLR – 20.–21.11.2018

Program:

19.11. Mon.		Arrival MUC airport, Transfer to city center[1]
20.11. Tue.	09:00	Transfer Munich to DLR, Oberpfaffenhofen[2]
	10:00	Introduction to DLR sensors (DLR, G122-R0136-Maxwell)
	10:30	FSAR-Applications (Ralf Horn, DLR-HR)
	11:00	Visit of Sensors and laboratories, part 1 - 3K/4K-camera (Dominik Rosenbaum/Veronika Gstaiger)
	12:00	Lunch
	13:00	Visit of Sensors and laboratories, part 2 - HySpex camera (Claas Köhler) - Calibration Home Base (Claas Köhler/Andreas Baumgartner) - UAVs (Stefan Plattner/Jürgen Wörishofer) - Spektroscopy lab (Christian Röske)
	15:00	Visit of EUSI receiving station at DLR (tbc)
	15:30	Questions and Summary (DLR, G122-R0136-Maxwell)
	16:30	Return to the city center of Munich[2]
21.11. Wed.	10:00	Visit of GAF and European Space Imaging (EUSI) in Munich (Arnulfstraße 199, 80634 München) Lunch in between, around 12:00
	15:30	End of program
22.11. Thu.		Transfer to airport[1], Departure MUC airport

List of participants:

Last name	*First name*	*Institution*	*Nationality*
Christofi	Andreas	CUT	CY
Themistocleous	Kyriacos	CUT	CY
Danezis	Christodoulos	CUT	GR
Schreier	Gunter	DLR-DFD	DE
Krauß	Thomas	DLR-IMF	DE

[1] For public transport (S8 airport to/from main station, about 45 minutes) you need the „Airport-City-Day-Ticket Group" which is 24,30 € for one full day (group of up to 5 adults, valid in whole Munich the whole day until 6 am of following day).

[2] For traveling from Munich main station to Neugilching (DLR) take the S8 at 8:25 below Munich main station in direction Weßling or Herrsching (needs about 33 minutes). We will pick you up[3] at the train station in Neugilching at 8:58 and bring you to DLR. You need the MVV XXL-Group-Day-Ticket (it is valid for 5 adults, the whole day until 6 am of the following day in the whole area of Munich city center to DLR – the larger area covering also the airport needs the Airport-City-Day-Ticket, for single traveling there are day-tickets XXL/Airport-City for 8,90 €/13 €).

[3] Support/contact: Thomas Krauß, +49 175 411 5898

4.2 Material of the 3rd short term visit to DLR

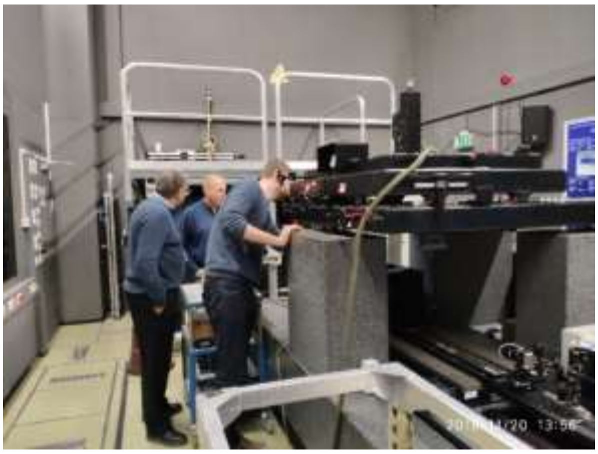
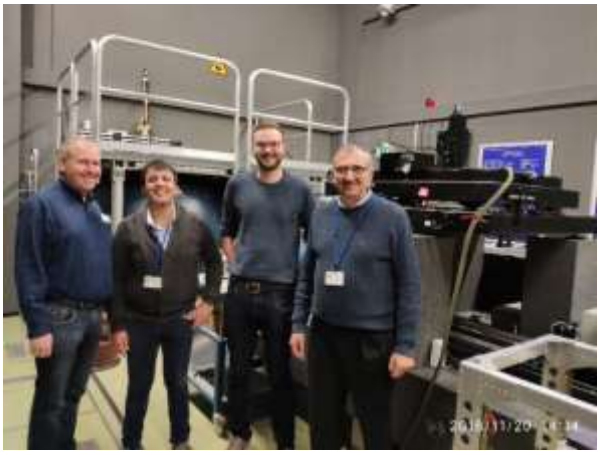
Selected members of the ATHENA team visited DLR premises under the auspices of the ATHENA project. Mr. Andreas Christofe, Dr Kyriacos Themistocleous and Ass. Prof. Chris Danezis visited sensors and laboratories and the European Space Imaging (EUSI) ground station at DLR facilities in Munich, Germany. Dr. Maxwell provided a general Introduction presentation to DLR sensors to the ATHENA team. Following, Dominik Rosenbaum discussed the capabilities of the 3K/4K-camera. The DLR Airborne Remote Sensing team Claas Köhler, Stefan Plattner & Jürgen Wörishofer conducted a presentation to the ATHENA team regarding the HySpex camera and UAVs. As well, Andreas Baumgartner discussed the importance of the Calibration Home Base at DLR facilities. Finally, Christian Röske provided a tour to the ATHENA team to the Spectroscopy lab. The ATHENA team also visited the European Space Imaging (EUSI) receiving station at DLR premises.

Mr Andreas Christofe, Dr Kyriacos Themistocleous and Ass. Prof. Chris Danezis from CUT at DLR premises on the 3rd short staff visit of the ATHENA project.

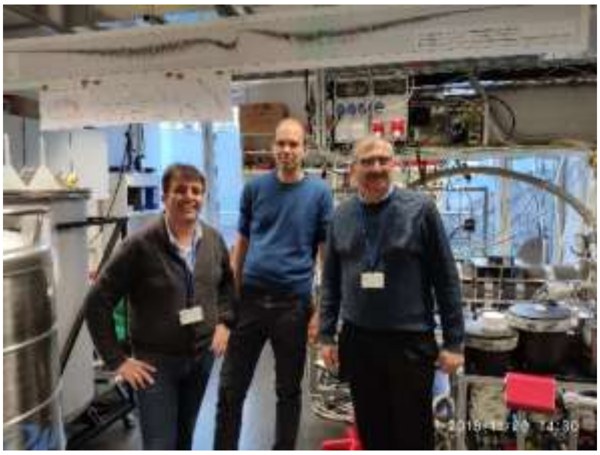
ATHENA team had a general Introduction presentation to DLR sensors by Maxwell

Dominik Rosenbaum present 3K/4K-camera to the ATHENA team

DLR Airborne Remote Sensing team Claas Köhler, Stefan Plattner & Jürgen Wörishofer presented HySpex camera and UAVs.

Andreas Baumgartner explained to the ATHENA team the importance of the Calibration Home Base at DLR facilities.




Christian Röske introduced the ATHENA team to the Spectroscopy lab

ATHENA team at the European Space Imaging (EUSI) receiving station at DLR premises

ATHENA team visited the GAF AG and the European Space Imaging (EUSI) in Munich

On 21 November, 2018, the ATHENA team visited the GAF AG and the European Space Imaging (EUSI) in Munich. Mr Samuel Barisch, the technical manager of Earth Observation & image Processing of GAF AG gave an overall presentation of the company to the ATHENA team. GAF, which is a part of the Telespazio Space Service Grouping, has developed into a European leader with outstanding skills in the geo-information industry.

Mr Samuel Barisch (GAF AG) discussing with Dr Kyriacos Themistocleous and Ass. Prof. Chris Danezis (CUT) at GAF AG premises.

ATHENA team with Mr. Samuel Barisch, the technical manager of Earth Observation & image Processing of GAF AG

Dr Kyriacos Themistocleous at European Space Imaging (EUSI) office in Munich.

ANNEX

Annex 1. Training at Pompeii

GprInterface2D: a friendly interface for GPR data processing

Ilaria Catapano, Gianluca Gennarelli, Francesco Soldovieri
IREA-CNR

International School on Geophysics and Remote Sensing for Archaeology, GRSA, 9-13 May, Pompei (Italy)

Outline

- GPR signal processing chain
- Electromagnetic modeling
- GPR2DInterface
  - General information
  - Raw data pre-processing
  - Data inversion
  - Iterative elaboration
- An example with real data

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GPR signal processing

a possible data processing chain

Phase 1		Phase 2		Phase 3
Pre-Processing (time domain)	→	frequency range selection → DFT	→	Data Inversion (frequency domain)

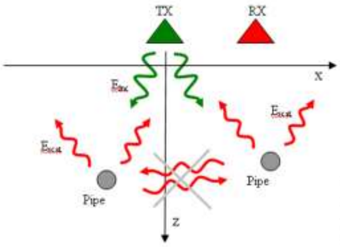
- zero-time setting
- mean value cancellation (back-ground removal)
- time window selection
- amplitude decay compensation (gain)
- estimation of the wave velocity (hyperbola method)

available in commercial codes

Born Approximation based 2D imaging approach

successfully used in on field surveys

Born Approximation model



2D scattering model

$$E_s = k_b^2 \int_D G_e(x_0, \vec{r}') E_{inc}(x_s, \vec{r}') \chi(\vec{r}') d\vec{r}' \in Y$$

Linear integral equation

E_{inc} incident field in the investigation domain D

G_e Green's function of the scenario

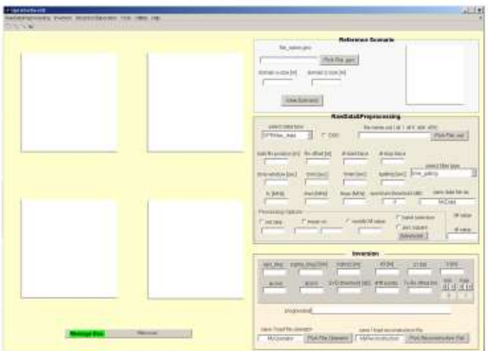
E_s scattered field (data) χ unknown object function (defined over target region)

After discretization, the linear integral equation is transformed into a linear matrix problem:

$$E_s = \underline{\underline{L}}\, E_{inc}$$ $\underline{\underline{L}}$ operator matrix

The linear inverse problem is ill-posed and solved with Truncated Singular Value Decomposition (TSVD) algorithm.

GprInterface2D

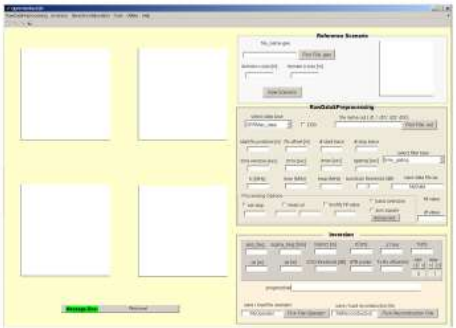


The GUI is organized into three parts, each one corresponding to a phase of GPR data processing:

- Reference scenario (synthetic data generation)
- RawData & PreProcessing
- Inversion

The software allows processing both synthetic data (generated by GprMax2D simulator) and real data (collected by a commercial GPR system).
It allows visualizing raw radargrams, intermediate and final results.

General information



- **Message Box:** it informs about the interface's status (e.g. ready, processing, etc.). It takes two colors: if the interface is ready to perform a new task the color is green, otherwise it is red.
- **Progressbar :** It is active when the user is computing the operator matrix L and provides information about the processing status.
- Pre-precessed data, operator, and tomographic reconstructions are stored in the folder where GprInterface2D is located. Name files can be specified in the corresponding text boxes.

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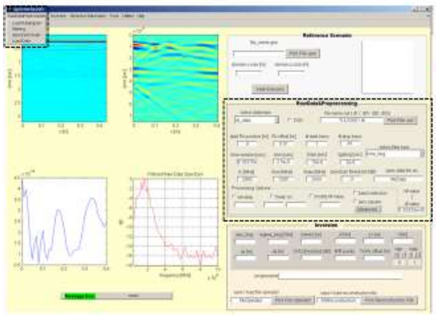
RawData&Preprocessing

This part of the GUI allows to load, filter and transform GPR data in the frequency domain. Different data file formats can be imported.



- **Load Radargram**: imports raw data according to 'select data type' menu (GPRmaxdata, .dt, .dt1, .dzt, .MAT). When load radargram is selected, raw data are automatically displayed as B-SCAN.
- **Filtering**: it filters raw data to increase signal/noise ratio according to 'select filter type' menu (time gating, background removal, time gating + background removal). When filtering option is selected, the pre-processed radargram is visualized.
- **Spectral Domain**: it transforms time domain data into frequency domain. Central frequency must be specified by the user. Frequency band of data can be determined on the basis of a spectrum threshold or defined by the user. When spectral domain option is selected, the interface plots the data in the frequency domain.

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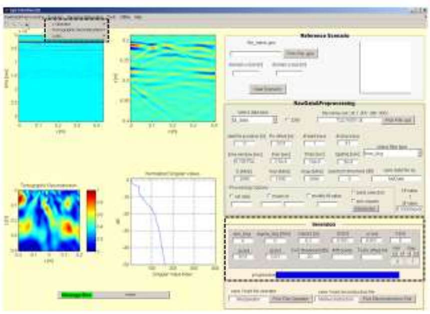
Inversion

This part of the GUI computes the operator matrix L, its SVD, and finally performs the tomographic reconstruction.



- **L-Operator**: this function calculates the operator matrix L relating the frequency domain data to the unknown contrast function and automatically stores it in a file. Singular values of the matrix are shown. Electromagnetic and geometrical parameters of the model have to be specified in the corresponding text boxes by the user.
- **Tomographic Reconstruction**: the reconstruction is computed via TSVD for the input threshold (dB) and its normalized amplitude is plotted and stored in a file.
- **Load...**: this function loads both operator and tomographic reconstruction files that have been previously stored.

The user can model the surveyed scenario as an homogenous medium or an half-space (i.e the air-soil interface can be neglected or not). Use homogenous medium for faster calculation.

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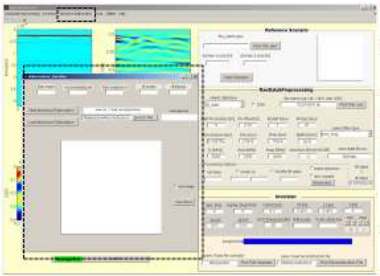
Iterative elaboration

This function enables the processing of several B-Scans related to the same scenario in order to obtain a 3D representation of the subsurface scene. Once processed the first trace, the GUI automatically processes the remaining profiles using the same settings of the first trace.



The acquisitions are named in "a sequential way" according to:

- **files main**: part of the file's name that is constant for all the acquisitions.
- **incremental part**: part of the file's name that is updated to switch to another acquisition.
- **files extension**: file's extension.
- **# traces**: minimum number of measurements for all profiles.
- **# scans**: number of profiles to be elaborated in iterative way.
- **pick ric file**: it picks a file referred to a previous iterative elaboration; the name is set in the 'save as../load reconstructions..' field.
- **axis image**: sets the aspect ratio so that equal tick mark increments are equal in all directions
- **Start Iterative Elaboration**: it runs the iterative elaboration.
- **Load Iterative Elaboration**: it loads a previous elaboration

When an iterative elaboration is performed, the reconstruction file is saved with the name specified in field 'save as../load reconstructions..' field. If this field is empty, the file is automatically named as 'MyIteractiveReconstruction'.

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An example with real GPR data

IREA equipment facilities

K-RIS GPR system manufactured by IDS

- time domain GPR system
- dual-frequency shielded and single fold antennas (working at 200 MHz and 600 MHz)
- single-frequency shielded and single fold antennas (working at 2 GHz)

very low cost test beds

- **measurement grid**
  - 38 profiles (B-scans) spaced 1 cm each other
  - measurement step along each profile equal to 1cm
- **Data collection with the 2 GHz probe**
- **homogeneous hosting medium**
  ε = 2.7 - σ = 0 S/m

C-shaped target made by 3 chipboard parallelepipeds (20 x 5 x 2) cm³

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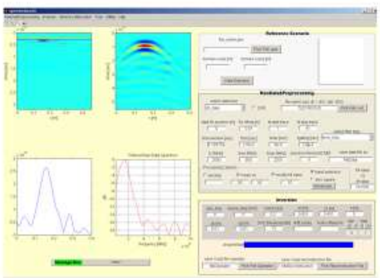
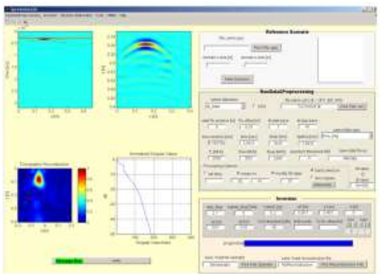
Data processing

The 20th profile is selected and processed.



step 1-2: data filtering + spectrum computation



step 3: inversion

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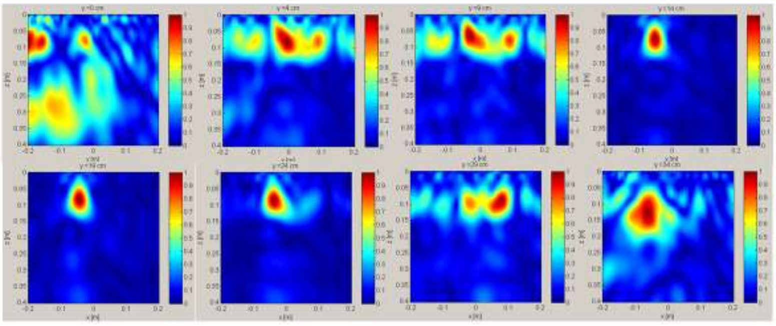
Tomographic reconstructions

Images achieved for some profiles



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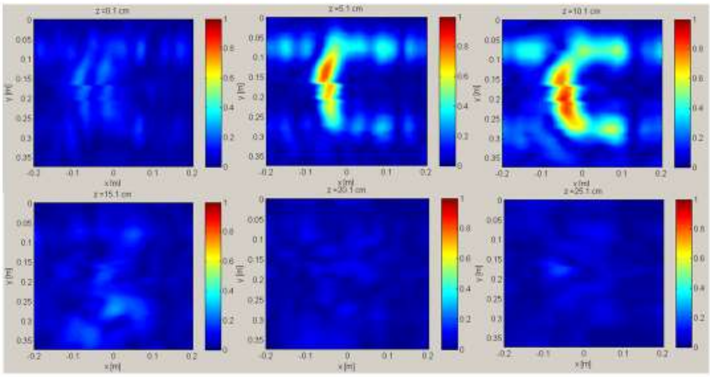
Tomographic reconstructions

Constant depth slices



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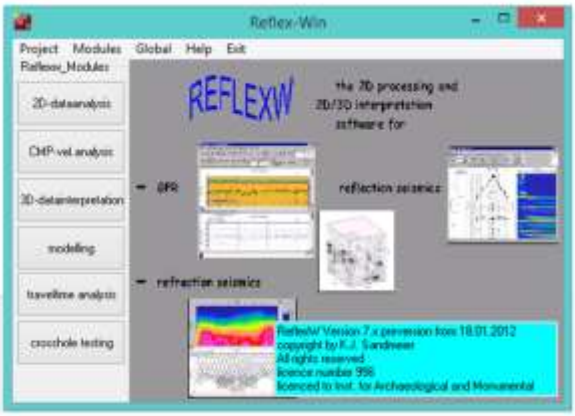
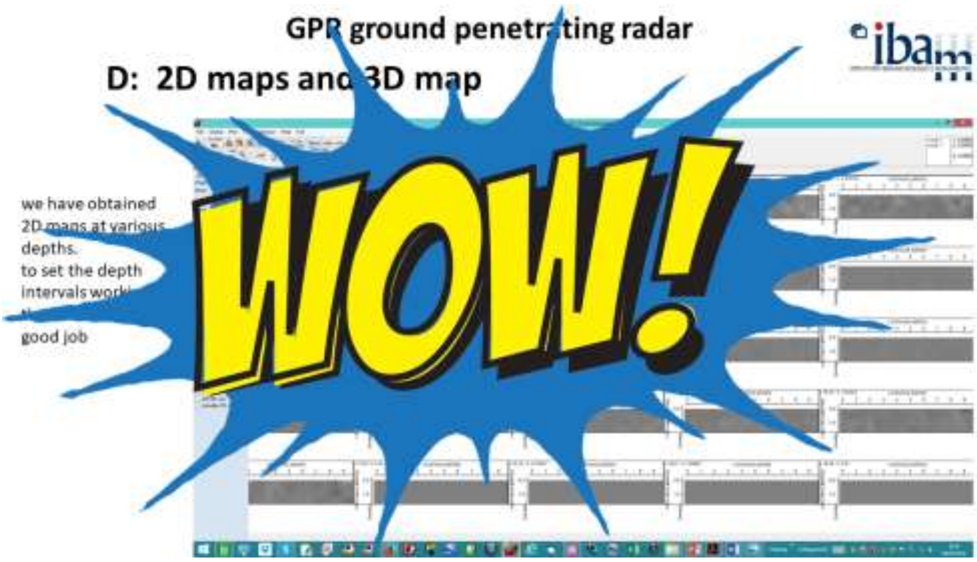
GPR ground penetrating radar

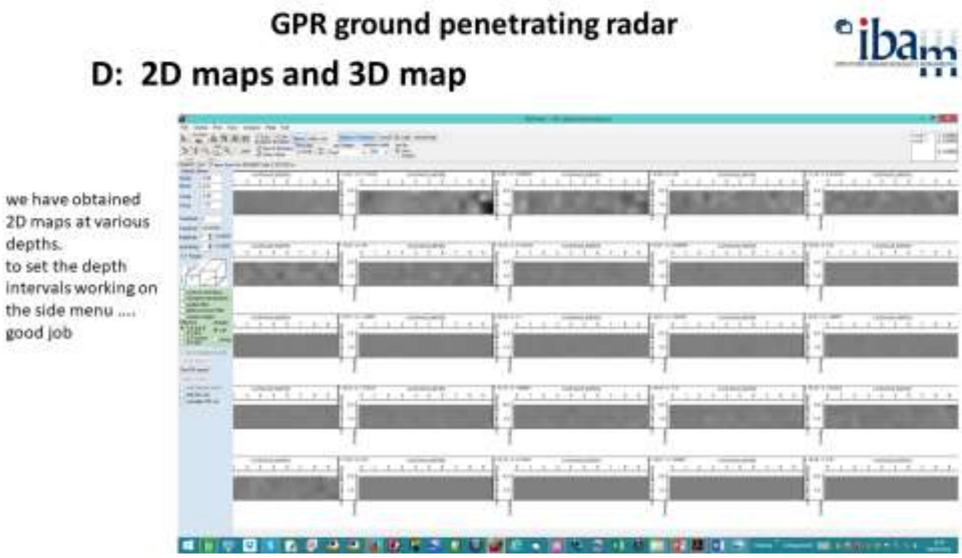
Data processing by software
Four phases

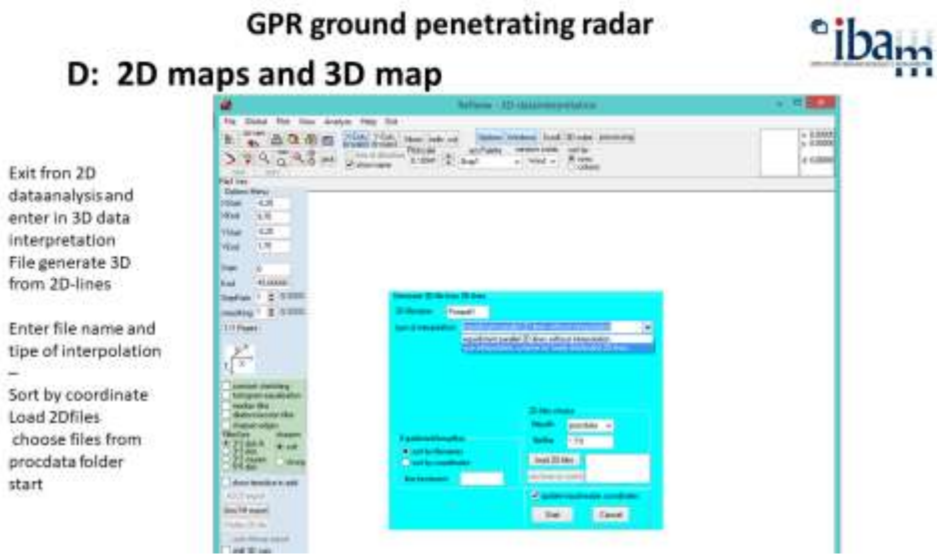
- A: import and straightening of the files
- B: Processing on the profiles
- C: setting the spatial coordinates of each profile
- D: 2D maps and 3D map

.... Here it is presented a base for processing the data obtained from the survey campaigns of archaeological sites and artifacts processing of data must be adapted according to the antennas used, 200MHz 600MHz 900MHz and 2GHz, based on the type of artefact or investigated site




WOW!
we have obtained
depths.
to set the depth
good job

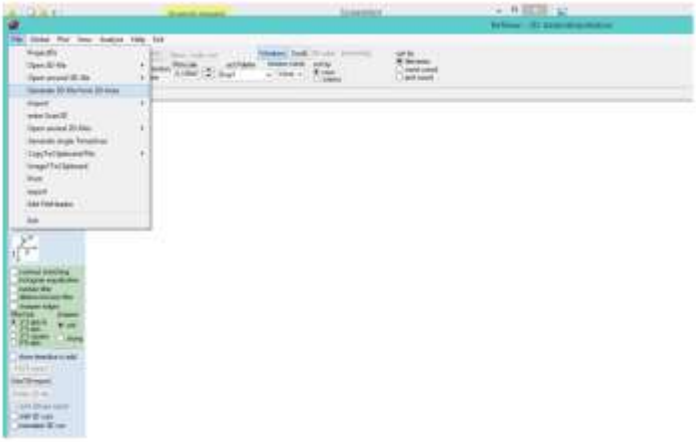

GPR ground penetrating radar
D: 2D maps and 3D map
we have obtained
2D maps at various
depths.
to set the depth
intervals working on
the side menu ....
good job


GPR ground penetrating radar
D: 2D maps and 3D map
Exit fron 2D
dataanalysis and
enter in 3D data
interpretation
File generate 3D
from 2D-lines
Enter file name and
tipe of interpolation
Sort by coordinate
Load 2Dfiles
choose files from
procdata folder
start

GPR ground penetrating radar

D: 2D maps and 3D map

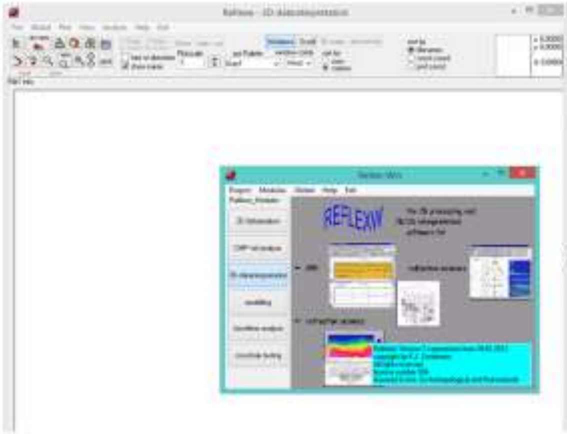
Exit fron 2D dataanalysis and enter in 3D data interpretation
File generate 3D fron 2D-lines



GPR ground penetrating radar

D: 2D maps and 3D map

To Exit fron 2D dataanalysis and to enter in 3D data interpretation



GPR ground penetrating radar

C: setting the spatial coordinates of each profile

Now all file are processed, the next step is to indicate the coordinates x and y according to capture mode in site : File/edit several FileHeaders/...

Open files, select file with the processing label 6 and click on open

Now to insert y coordinate for all profile according to the sampling

Then save the file header changes

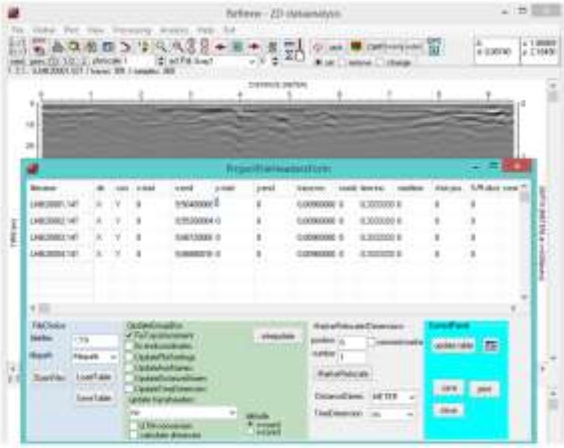
GPR ground penetrating radar

C: setting the spatial coordinates of each profile

Now all file are processed, the next step is to indicate the coordinates x and y according to capture mode in site : File/edit several FileHeaders/...

Open files, select file with the processing label 6 and click on open

Now to insert y coordinate for all profile according to the sampling



GPR ground penetrating radar

C: setting the spatial coordinates of each profile

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Open files, select file with the processing label 6 and click on open

GPR ground penetrating radar

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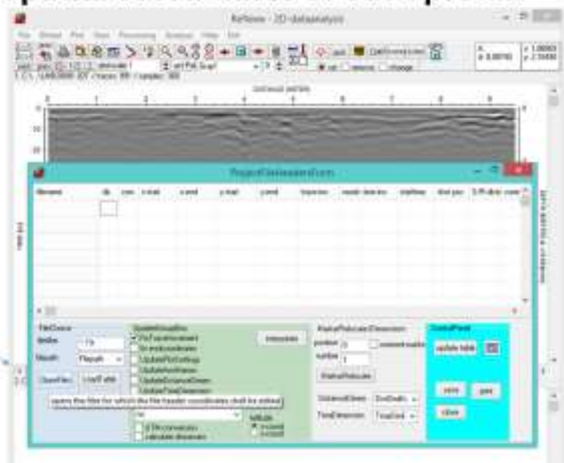
Now all file are processed, the next step is to indicate the coordinates x and y according to capture mode in site : File/edit several FileHeaders/...

Open files



GPR ground penetrating radar

C: setting the spatial coordinates of each profile

Now all file are processed.
the next step is to indicate the coordinates x and y according to capture mode in site :
File/edit several FileHeaders/...

GPR ground penetrating radar

B: Processing on the profiles

Then save the actual sequence processing under the project directory....

Now you need to repeat all the steps for the other profiles of the campaign survey using the processing sequence just saved
Processing /sequence processing
Select the file with .O processing label , take the ygain in the folder and click start

Processing label 6 **6° step**

GPR ground penetrating radar

B: Processing on the profiles

Then save the actual sequence processing under the project directory....

Now you need to repeat all the steps for the other profiles of the campaign survey using the processing sequence just saved
Processing /sequence processing

Processing label 6

6° step

GPR ground penetrating radar

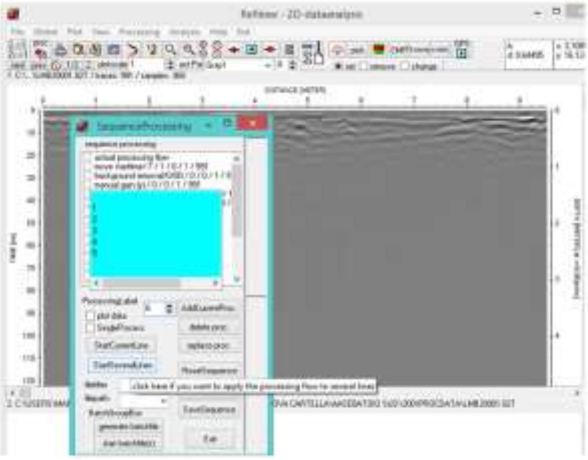
B: Processing on the profiles

Then save the actual sequence processing under the project directory....

Now you need to repeat all the steps for the other profiles of the campaign survey using the processing sequence just saved
Processing /sequence processing

Processing label 6

6° step

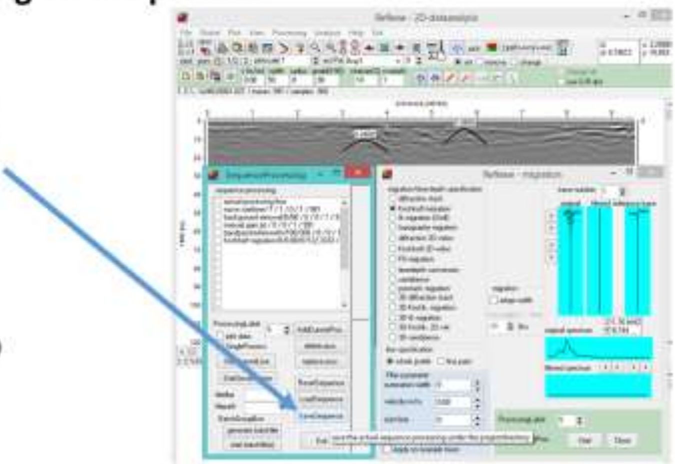


GPR ground penetrating radar

B: Processing on the profiles

Then save the actual sequence processing under the project directory....

6° step



GPR ground penetrating radar

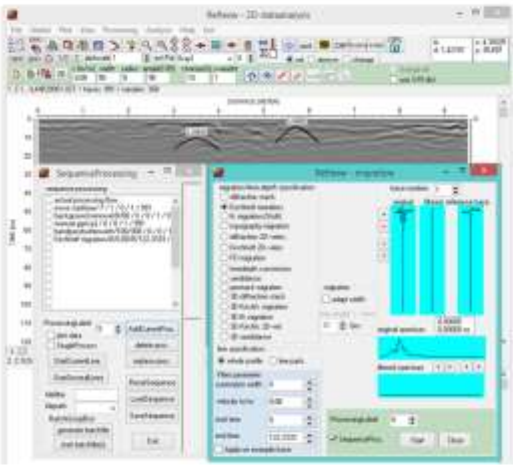
B: Processing on the profiles

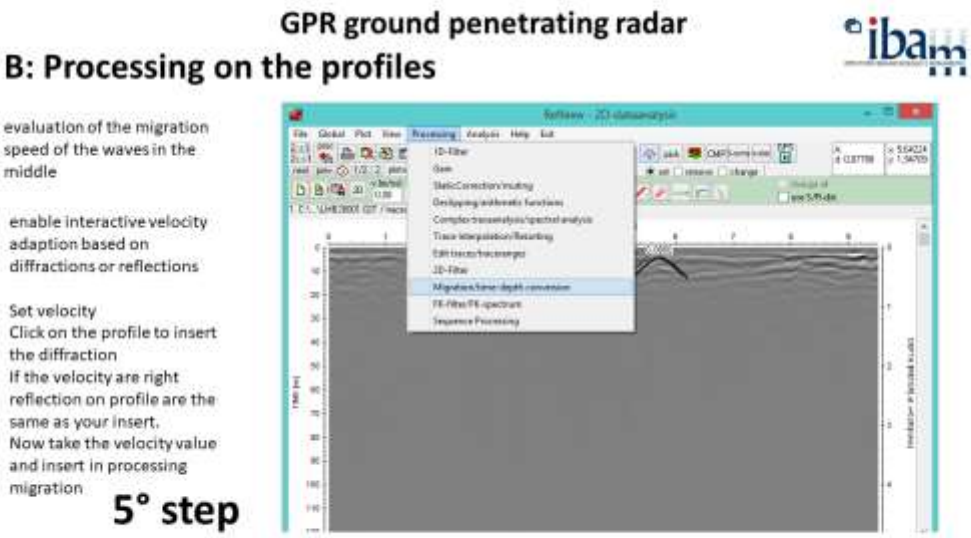
Processing/migration.../Kirchhoff migration

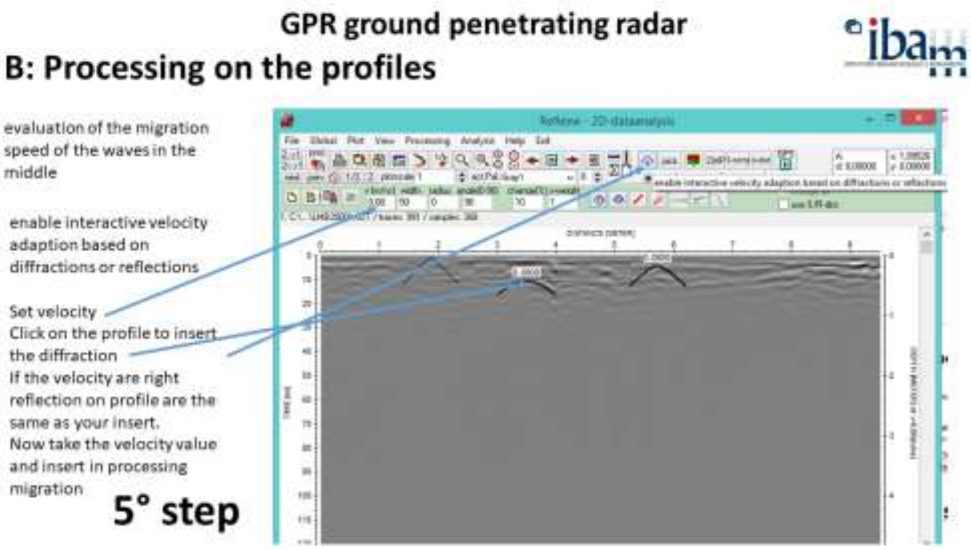
Now take the velocity value and insert in processing migration

Set velocity
Processing label 5

5° step




GPR ground penetrating radar
B: Processing on the profiles
evaluation of the migration speed of the waves in the middle
enable interactive velocity adaption based on diffractions or reflections
Set velocity
Click on the profile to insert the diffraction
If the velocity are right reflection on profile are the same as your insert.
Now take the velocity value and insert in processing migration
5° step


GPR ground penetrating radar
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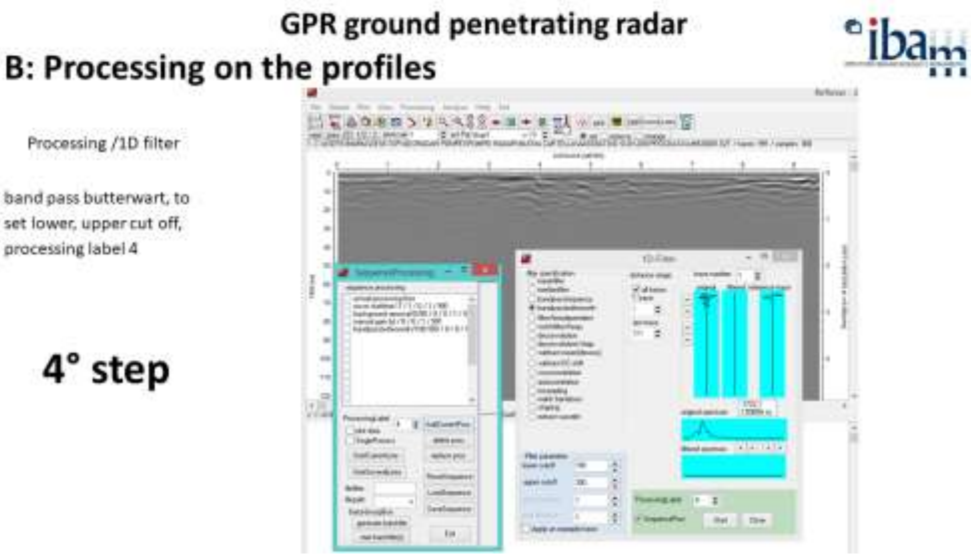

GPR ground penetrating radar
B: Processing on the profiles
Processing /1D filter
band pass butterwart, to set lower, upper cut off, processing label 4
4° step

GPR ground penetrating radar

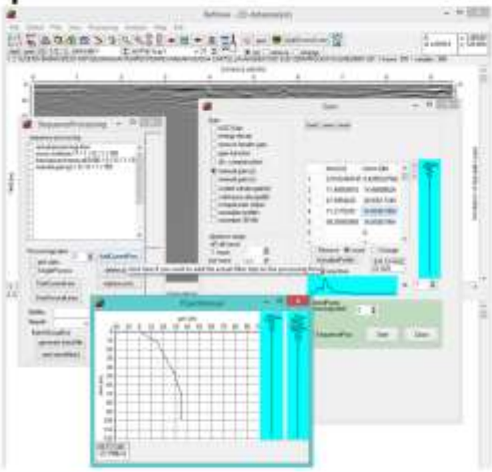
B: Processing on the profiles

Processing /Gain /manual gain y ,

you have to manually set or insert a gain curve already made

Processing label 3

3° step



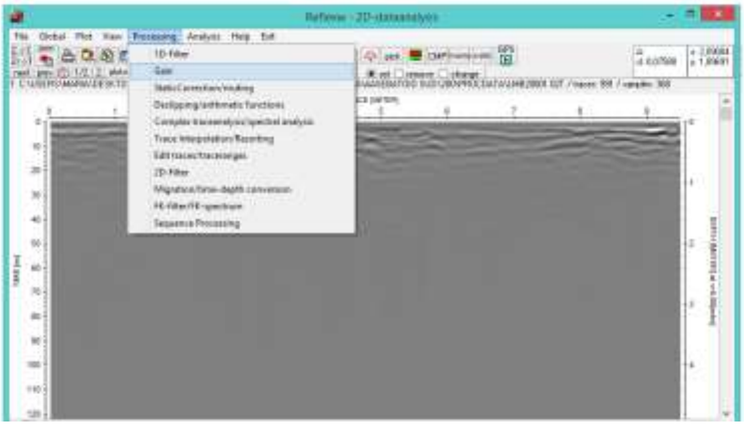
GPR ground penetrating radar

B: Processing on the profiles

Processing /Gain /manual gain y ,

you have to manually set or insert a gain curve already made

3° step

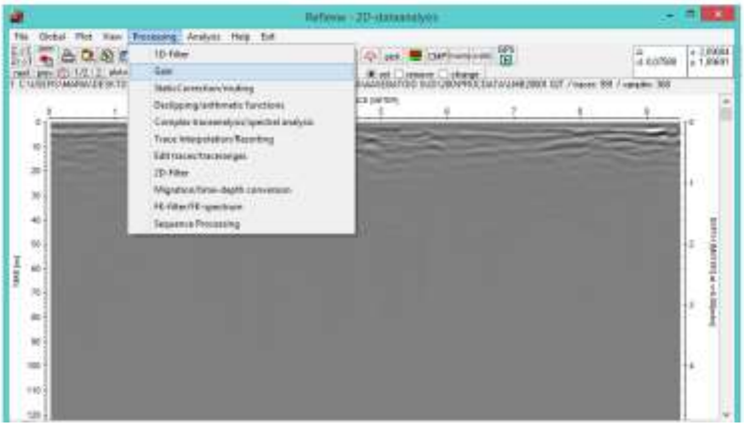


GPR ground penetrating radar

B: Processing on the profiles

Gain manual gain y , tracciare la curva, salvare e fare processing label 3 start

3° step



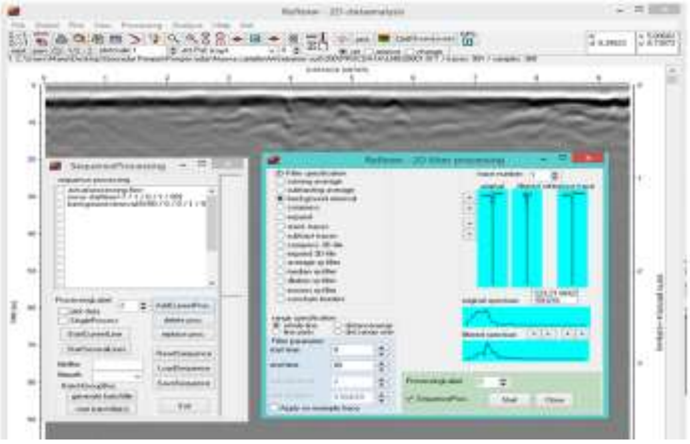
GPR ground penetrating radar

B: Processing on the profiles

2d filter background removal, to set the start time and the end time , then save processing label 2

2° step

Change secondary line on primary line , so the next step will be carried out on profile already cut the time not necessary



GPR ground penetrating radar

B: Processing on the profiles

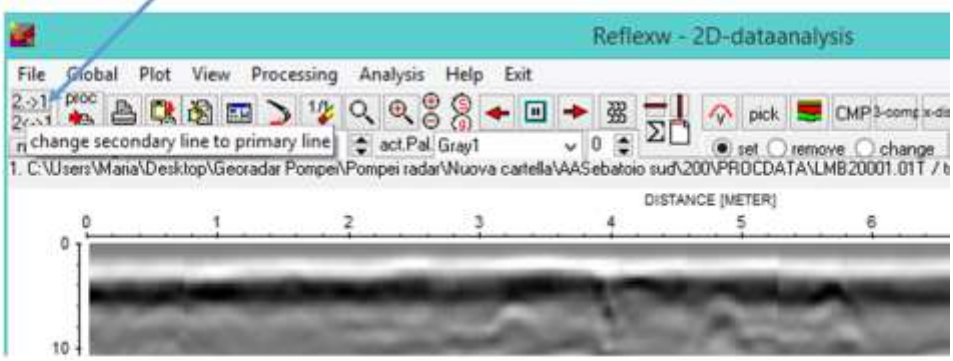
1. 2d filter background removal, to set the start time and the end time , then save processing label 2

2° step

GPR ground penetrating radar

B: Processing on the profiles

Change secondary line on primary line , so the next step will be carried out on profile already cut the time not necessary

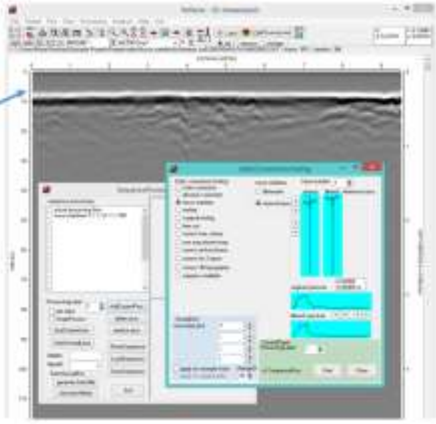


GPR ground penetrating radar

B: Processing on the profiles

Now begins the real processing, in fact all the profiles are straightened or if the profiles are collected in the same direction, then the phase A should not be carried out

zero time, open file in procdata/rowdata folder, evaluating how much to cut in time with the zoom, static correction... move start time to set on manual imput , control panel processing label 1 move time , es - 7,00



B 1° step

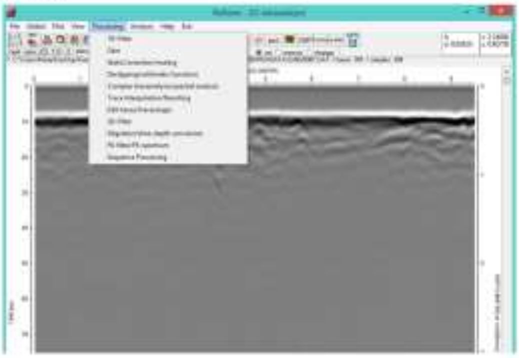
Change secondary line on primary line

GPR ground penetrating radar

B: Processing on the profiles

Now begins the real processing, in fact all the profiles are straightened or if the profiles are collected in the same direction, then the phase A should not be carried out

zero time, open file in procdata/rowdata folder, evaluating how much to cut in time with the zoom , static correction move start time to set on manual imput , control panel processing label 1 move time , es - 7,00

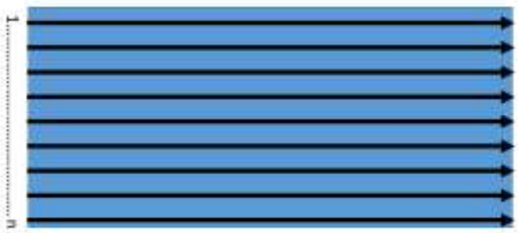


B 1° step

GPR ground penetrating radar

B: Processing on the profiles

if the profiles are collected in the same direction, then the phase A should not be carried out



GPR ground penetrating radar

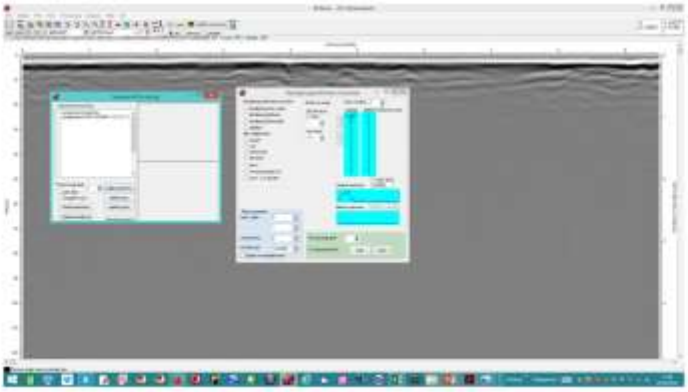
A: import and straightening of the files

To move the other data file not flipped in procdata folder make a moltiplication x1 from

processing/declipping/multiplication/multi value/ 1/ start putting the same processing sequence 1

A 5° step

if the profiles are collected in the same direction, then the phase A should not be carried out

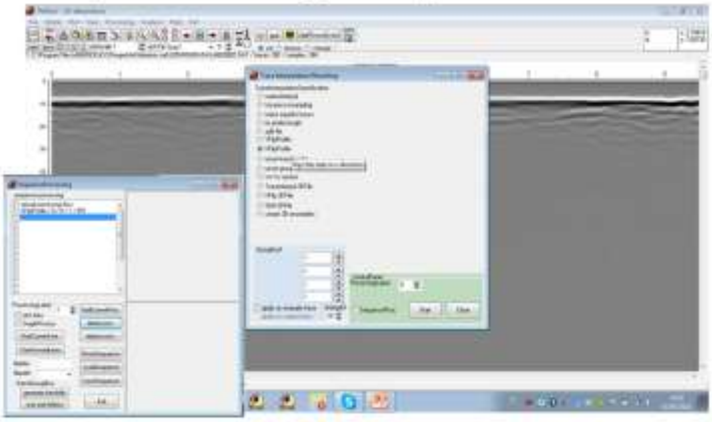


GPR ground penetrating radar

A: import and straightening of the files

To Create a flip sequence and to save as FlipX even or odd number files
Then flip all files even or odd numbers

A 4° step

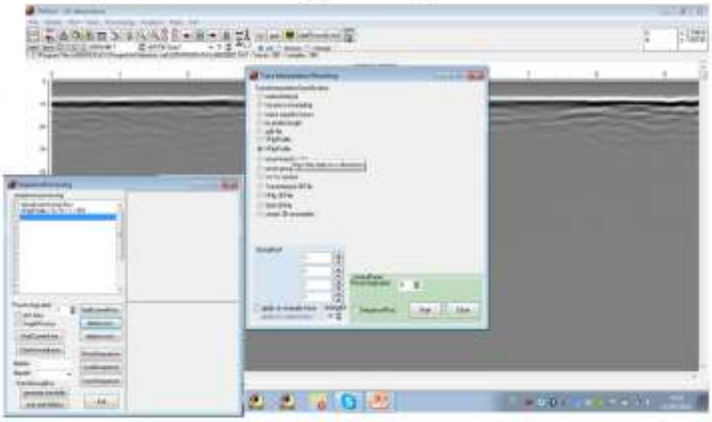


GPR ground penetrating radar

A: import and straightening of the files

Create a flip sequence and save the as FlipX egual or odd number files

A 4° step



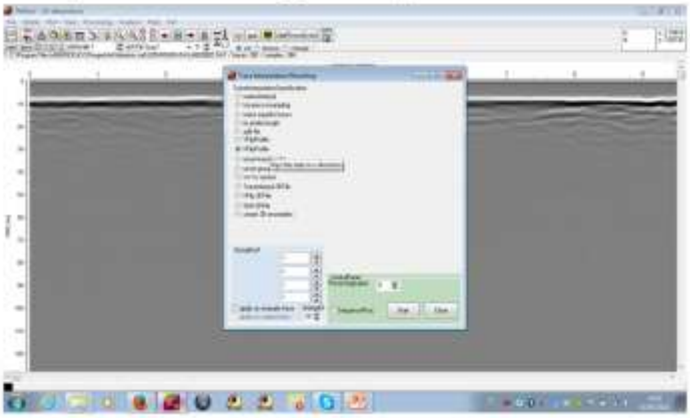
GPR ground penetrating radar

A: import and straightening of the files

if the data were acquired in snake mode **you must to flip them in x direction, only even or odd number files**

The command is on : processing /trace interpolation /resorting/XFlipProfile/start

A 4° step



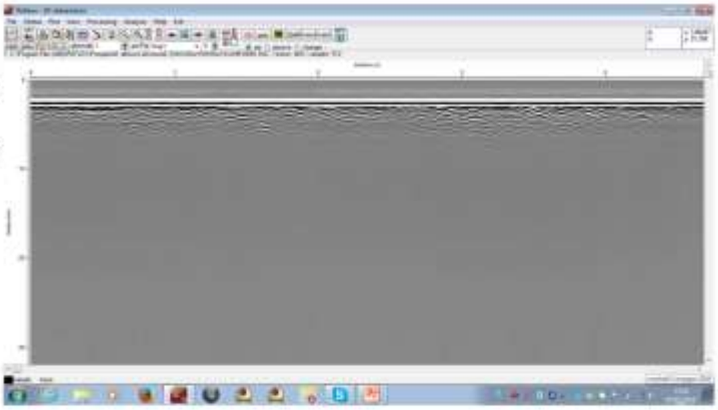
GPR ground penetrating radar

A: import and straightening of the files

Open the first file by raw data folder

Now you can see the raw data file

A 3° step



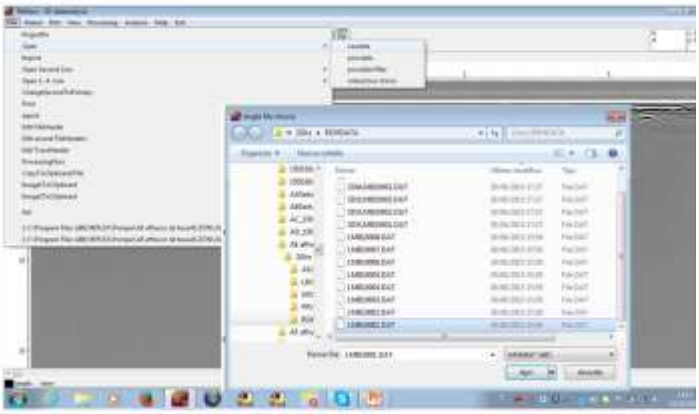
GPR ground penetrating radar

A: import and straightening of the files

Import data file
Select file by folder
choose the import informations

Then Convert to Reflex all the input file

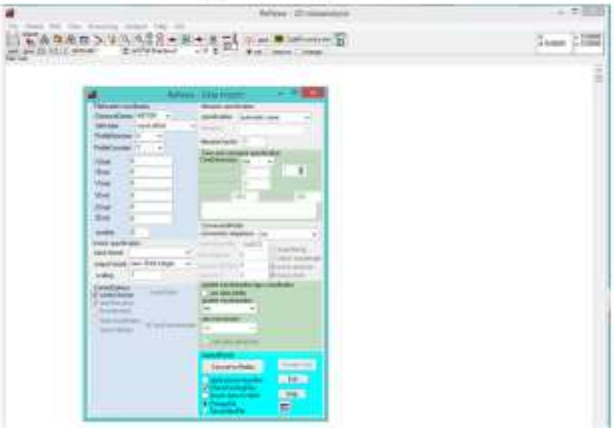
A 2° step



GPR ground penetrating radar

A: import and straightening of the files

Open reflex software
Confirm the project folder
Copy the .dat files in the folder ascii
Import the first file from ascii folder and set parameters of original file
For example, ids format, name, etc.,
Then convert to reflex the file .
Then open the other files and covert all



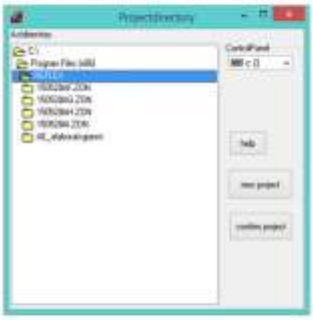
A 2° step

GPR ground penetrating radar

A: import and straightening of the files

if the profiles were collected in snake mode

Create a folder (ASCII)
Insert data file in the new folder
Install the theme folder
Select the folder from software and
Chose the folder , then click on 2D-dataanalysis

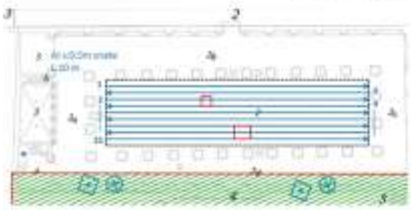


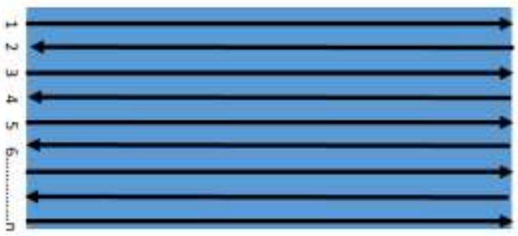
A 1° step

GPR ground penetrating radar

A: import and straightening of the files

if the profiles were collected in snake mode



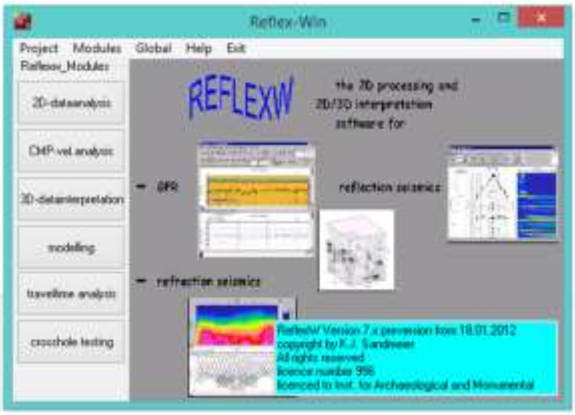


GPR ground penetrating radar

Data processing by software

Four phases

- A: import and straightening of the files
- B: Processing on the profiles
- C: setting the spatial coordinates of each profile
- D: 2D maps and 3D map

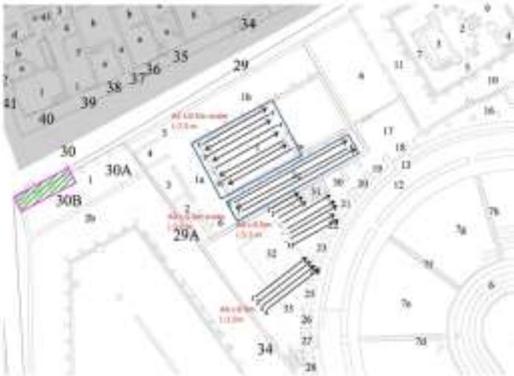


GPR ground penetrating radar

The survey area is located in the Regio VIII, 7 Insula, and ranks near the theater, in the area between the Theater and the Gymnasium Sannitica. The area is characterized by the presence of a tank that has a circular shape with a diameter of about 5:20 m, it reaches a maximum depth of about 3.50 m and is inscribed inside a quadrangular structure of about 6.70 m wide.

The reservoir collects the water source and probably coming from a system of channels not identified. With ground penetrating radar surveys the goal is just to understand where are the pipes, if downstream of the tank or on the south side there are pipes that carry water to the theater. So this is a typical castellum acquae linked with other sites in the upper wells of the city.

Currently this reservoir appears completely filled with water. The current level is just below the threshold level identified at about 00:20 m from the water surface and identified thanks to the presence of 2 channels of 0:08 to 0:10 m diameter which convey the water in the downstream direction during periods of full , avoiding the overflow of the tank.



GPR ground penetrating radar

How to acquire the profiles?
It depends on the object that you want to investigate
Choice of the survey area according to the boundary conditions
Choose the antenna, choosing the sampling step

Acquisition:
Delimitation of the survey area
positioning of the seaming rolls metrics
Choice of sampling direction, one way or snake

Prospecting on frescoed walls

GPR ground penetrating radar

How to acquire the profiles?
It depends on the object that you want to investigate
Choice of the survey area according to the boundary conditions
Choose the antenna, choosing the sampling step

Acquisition:
Delimitation of the survey area
positioning of the seaming rolls metrics
Choice of sampling direction, one way or snake

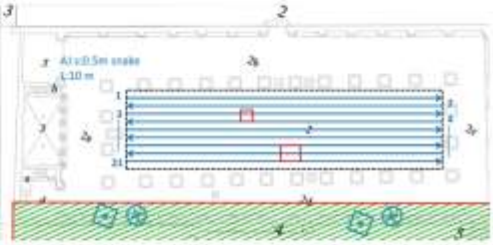
Prospecting on masonry

GPR ground penetrating radar

How to acquire the profiles?
It depends on the object that you want to investigate
Choice of the survey area according to the boundary conditions
Choose the antenna, choosing the sampling step

Acquisition:
Delimitation of the survey area
positioning of the seaming rolls metrics
Choice of sampling direction, one way or snake

Prospecting on archaeological sites



GPR ground penetrating radar

How to acquire the profiles?
It depends on the object that you want to investigate
Choice of the survey area according to the boundary conditions
Choose the antenna, choosing the sampling step

Acquisition:
Delimitation of the survey area
positioning of the seaming rolls metrics
Choice of sampling direction, one way or snake

Prospecting on archaeological sites


GPR ground penetrating radar

Annex 2. Presentation from DLR visit

F-SAR – The DLR Experimental Airborne Synthetic Aperture Radar

Ralf Horn, Marc Jaeger, Martin Keller, Markus Limbach,

Anton Nottensteiner, Matteo Pardini, Andreas Reigber, Rolf Scheiber

German Aerospace Center (DLR e.V.), Microwaves and Radar Institute, Germany

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

Airborne SAR at DLR

Airborne SAR is employed by DLR:

- ✓ to study signal processing problems
- ✓ to experiment with innovative modes
- ✓ to develop and test components and hardware

It is further used:

- ✓ to investigate the information content of the imagery
- ✓ to measure physical parameters of targets and target areas
- ✓ to develop applications

Airborne SAR is especially needed:

- ✓ to support spaceborne SAR missions (TanDEM-L, BIOMASS, Sentinel, others)
  - *Mission definition, Phase A and B studies*
  - *Cross calibration*

F-SAR System Functional Modes

Radar system characteristics

- ✓ Calibrated multi-channel operation
  - *Up to five frequency bands:* *P, L, S, C and X*
  - *Wavelengths:* *69cm, 23cm, 10cm, 5.6cm, 3.1cm*
  - *Single-Pass Interferometry:* *X (XTI / ATI) and S (XTI)*
  - *Repeat-Pass Interferometry:* *P and L*
  - *Polarisations:* *full polarimetric*
  - *Swath width:* *1 to 6 km (varies with altitude over ground)*

- ✓ Modular design
  - *Base module:* *System control and data acquisition*
  - *X-C-S-L-Band:* *Three combined segments*
  - *L-Band:* *Single segment*
  - *L-P-Band:* *Two combined segments*
  - *others (e.g. Ku):* *Single segment, alternatively to L- Band*

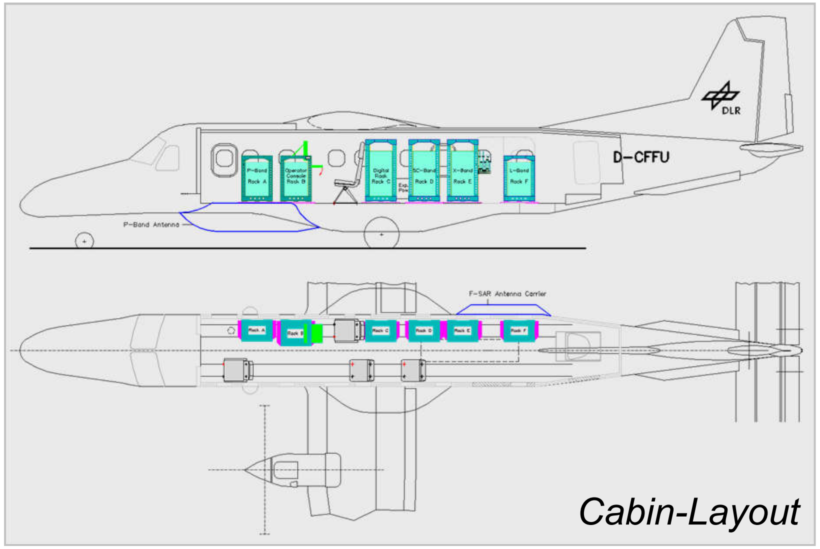
Airborne Platform for F-SAR

DLR DO 228-212

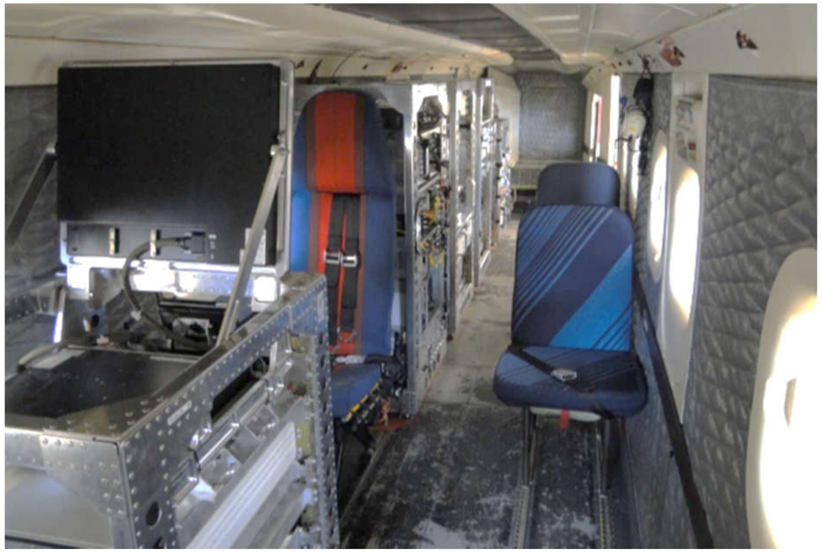
Platform for short range operations!

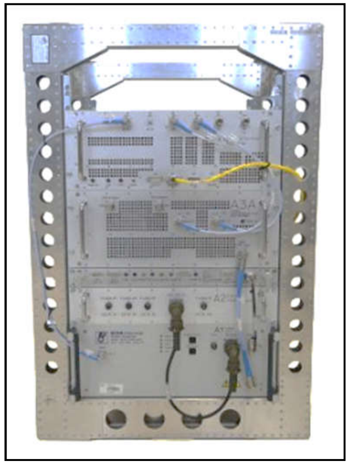
Ceiling:	6.3km (a.s.l.)
Altitude range:	0.6 – 6km
Endurance (rel. payload):	2h – 5h
Swath width:	up to 6 km

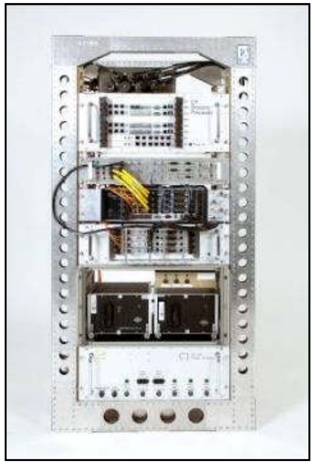
F-SAR System installed on board DO228-212



Cabin-Layout

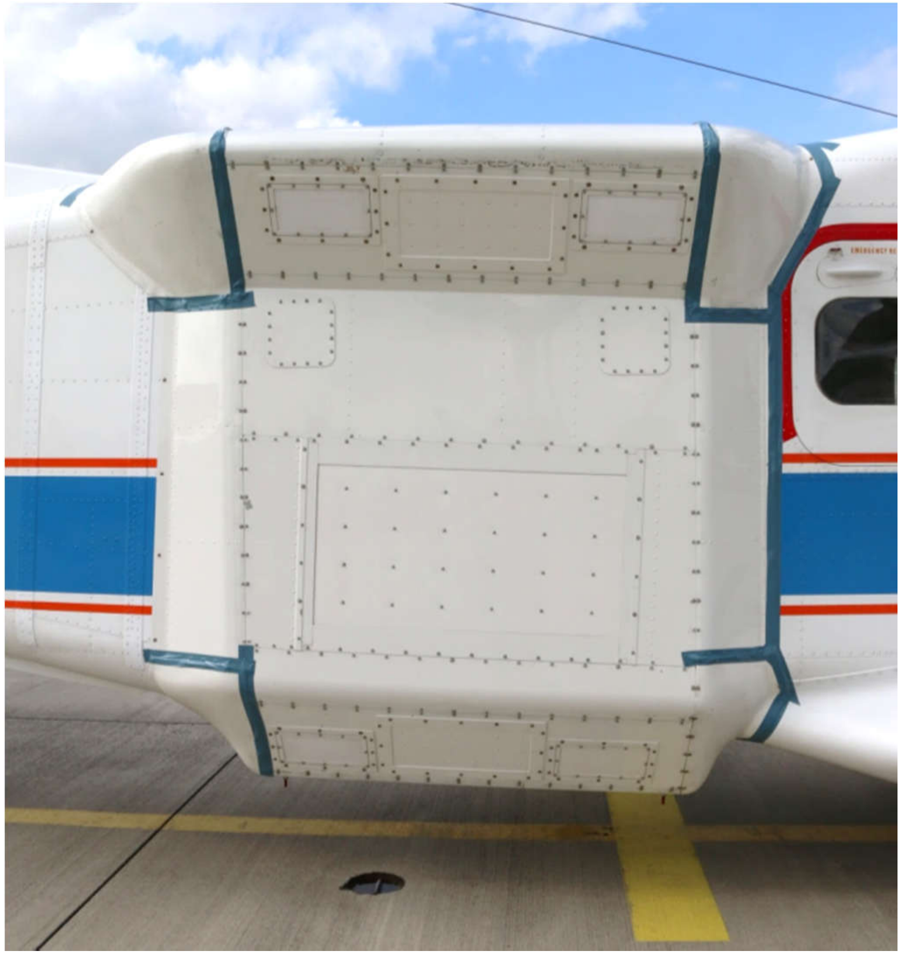






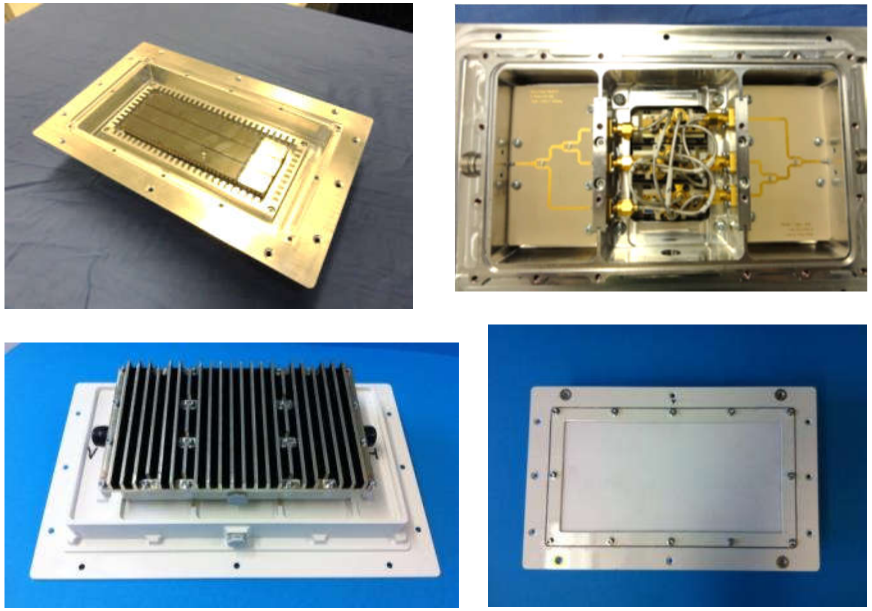

P-band segment | *Base segment* *System control & data acquisition* | *C-S-band segment* | *X-band segment* | *L-band segment*

F-SAR Antennas



F-SAR Antenna Carrier

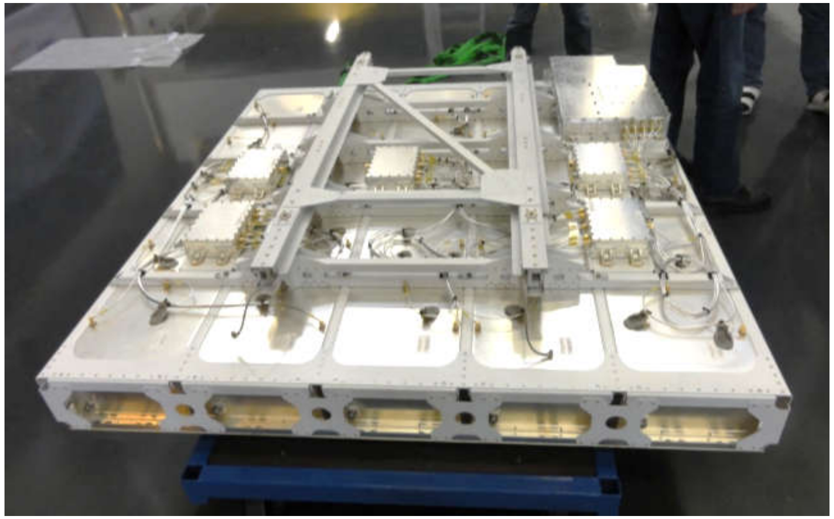
Real model with all antennas mounted!



F-SAR X-band antenna - Flight model

Inside (top) and outside view (bottom)

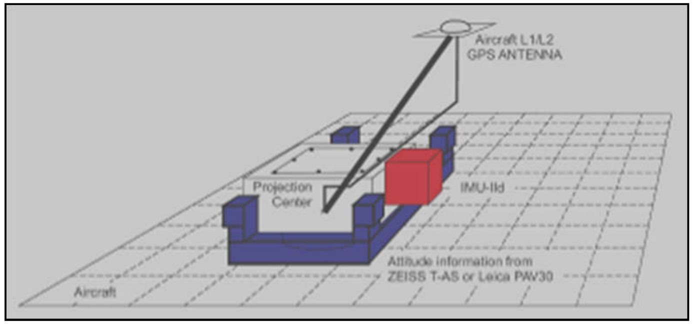
F-SAR Antennas

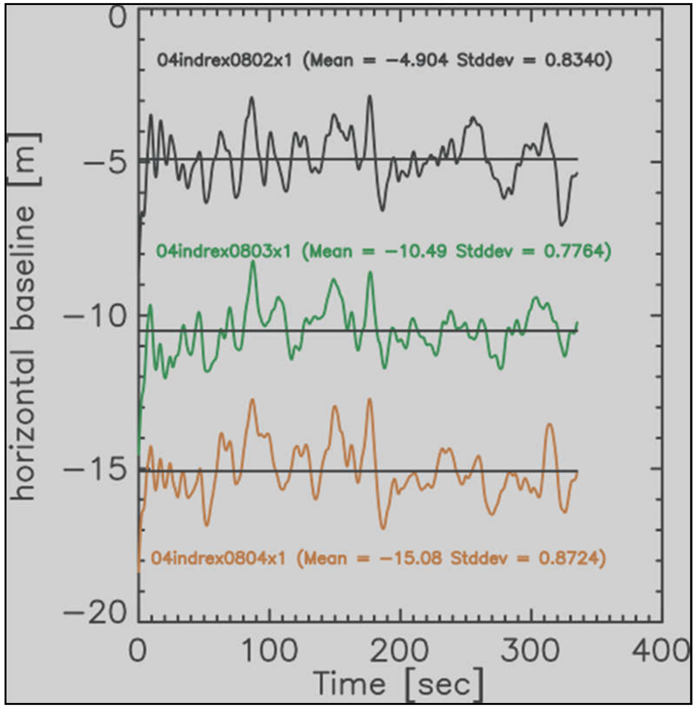


The new P-Band antenna (2015):

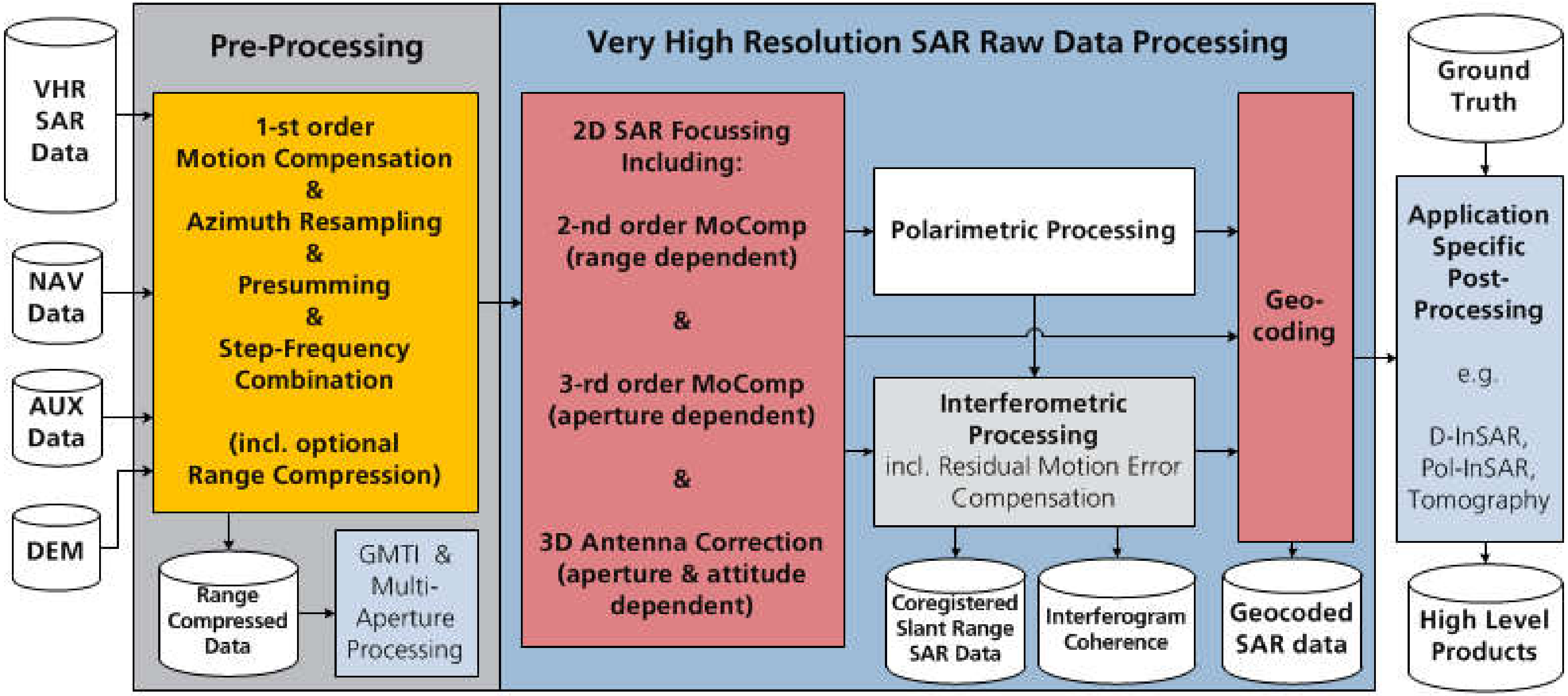
Frequency range:	410 – 460MHz
Dual polarisation!	
Gain:	13dB
Cavity design:	5 x 5 elements

Precision Navigation and Positioning – IGI CCNS4/AeroCtrl





F-SAR processing environment



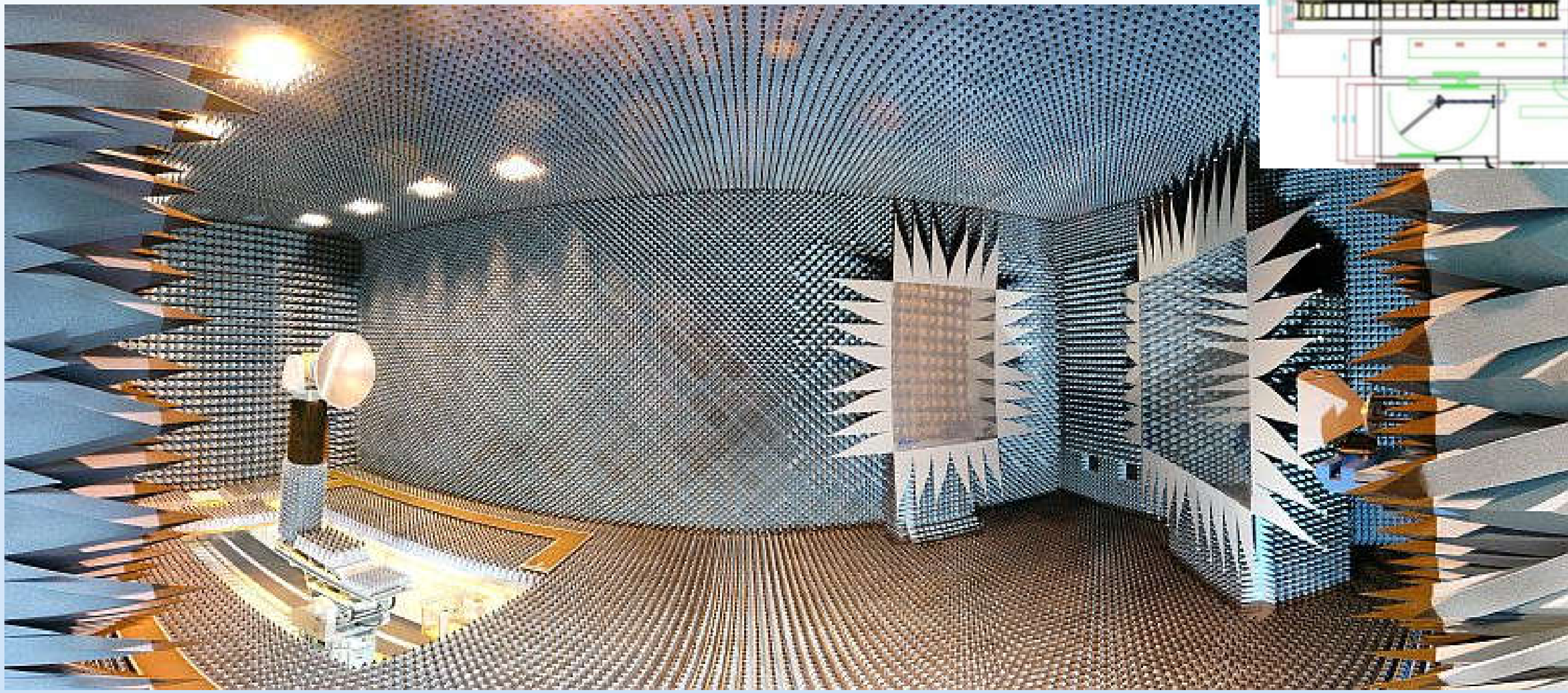
The F-SAR ground segment consists of:

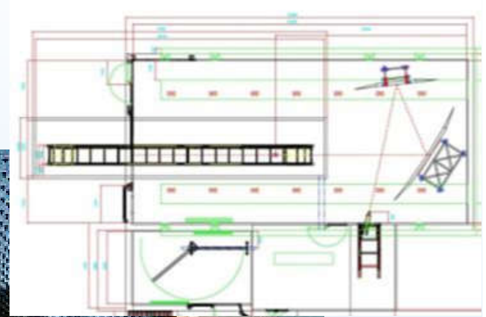
- a data ingestion subsystem
- a processing cluster
- a large storage system
- a connection to the DLR DIMS (data archive).

It is configured to handle large data amounts at high throughput.

Test environment at DLR: CTR – The Compact Test Range

Dual Reflector Compact Test Range





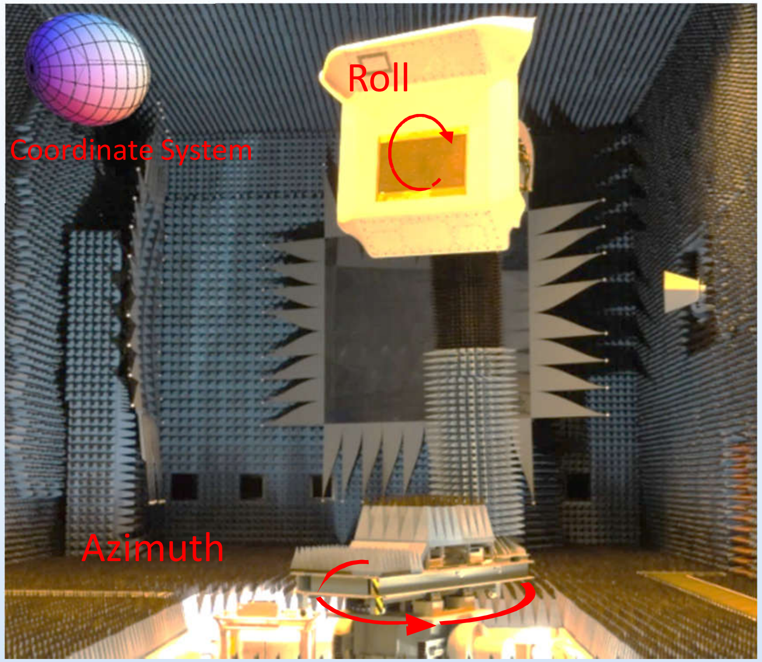
24m x 11.7m x 9.7m shielded anechoic chamber for measuring

Plane wave zone: up to 3.8m

6 axis positioner, handling up to 300 kg

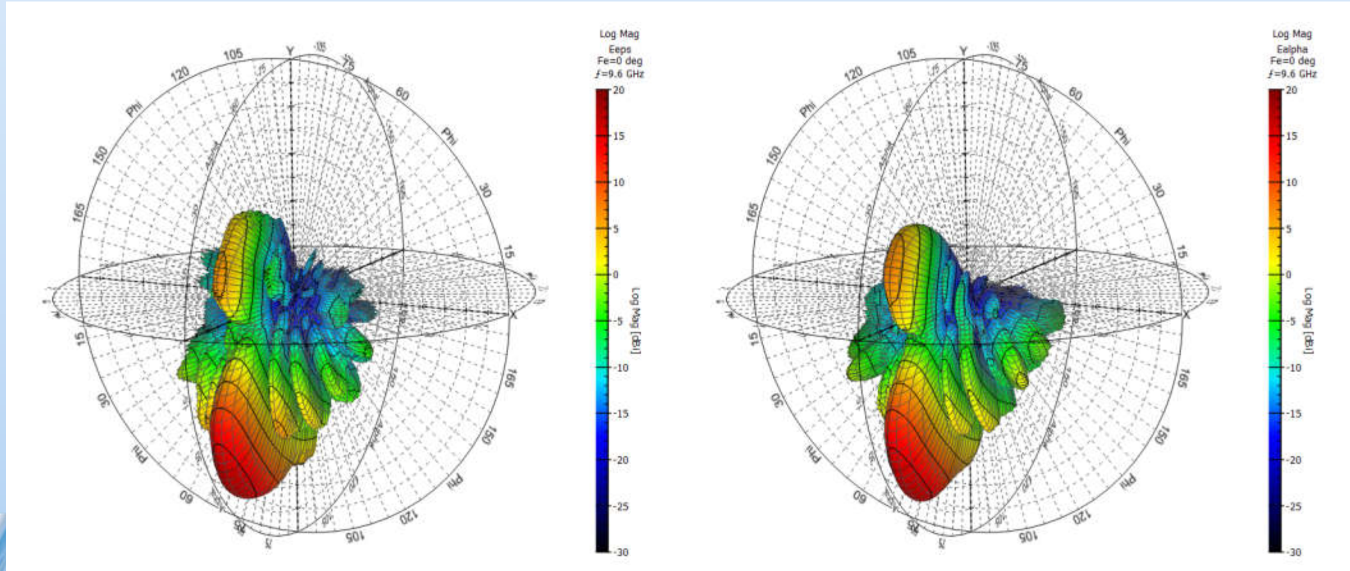
- antenna radiation patterns (200 MHz) 1 GHz – 100 GHz
- Radar Cross Section (RCS) of targets (C-, X-, Ku-, Ka-band, others upon request)

Test objects: DLR airborne SAR L-/S-/C-/X-band antennas



- L-band polarimetric in 4 elevation beams
  acquisition of 4 spheres (11 hours each)
- S-band polarimetric cross-track interferometer
  acquisition of 2 spheres (21 hours each)
- C-band polarimetric
  acquisition of 1 hemisphere (23 hours)
- X-band polarimetric cross- and along-track interferometer
  acquisition of 3 hemispheres (23 hours each)

HH-VV 2D/3D Antenna patterns



Acquisition Geometry:

Roll over Azimuth

Frequency swept over common WG bands

Kaufbeuren, Germany

X-band, 384 MHz bandwidth

Kaufbeuren, Germany

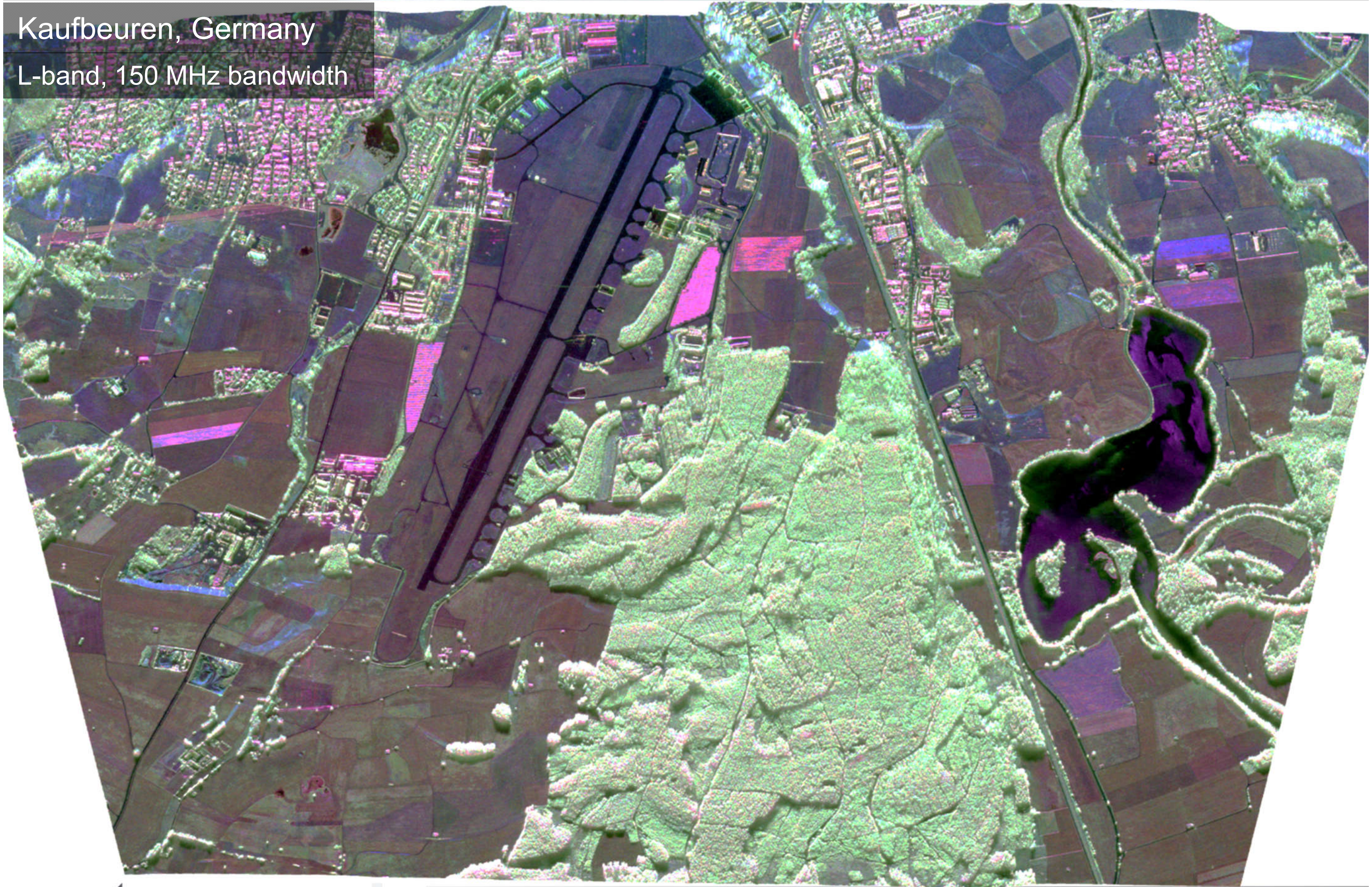
C-band, 384 MHz bandwidth

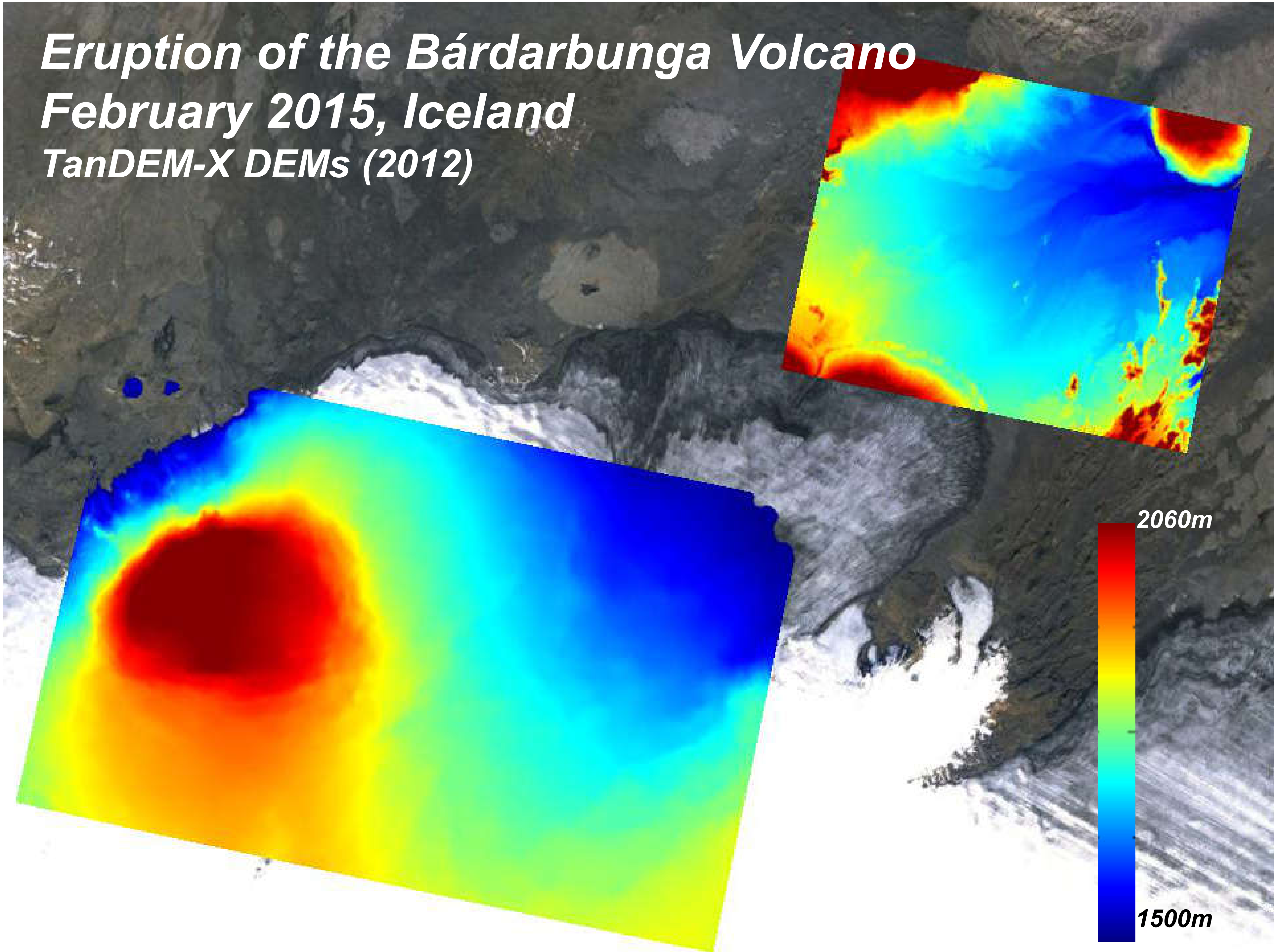
Kaufbeuren, Germany

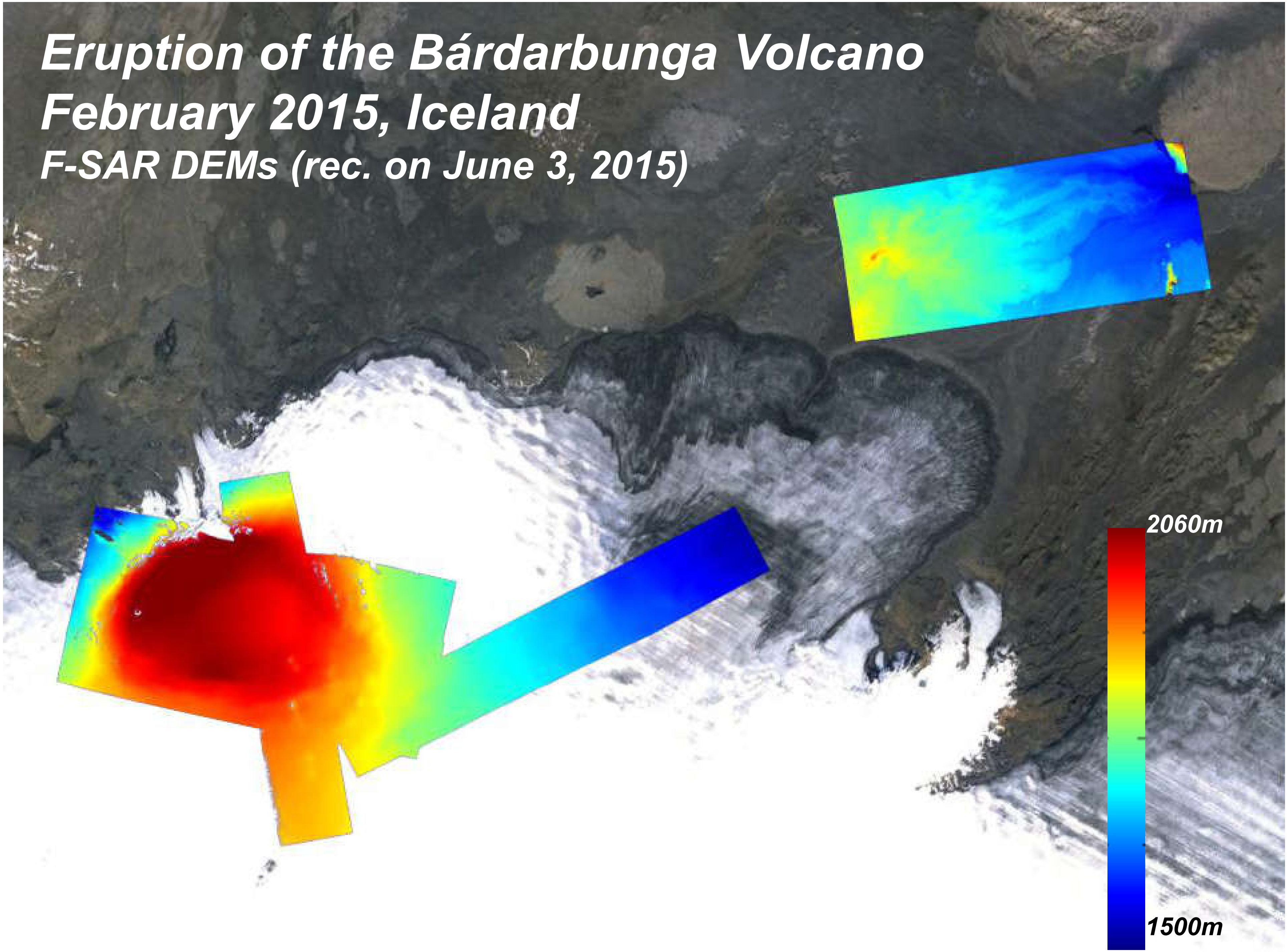
S-band, 300 MHz bandwidth

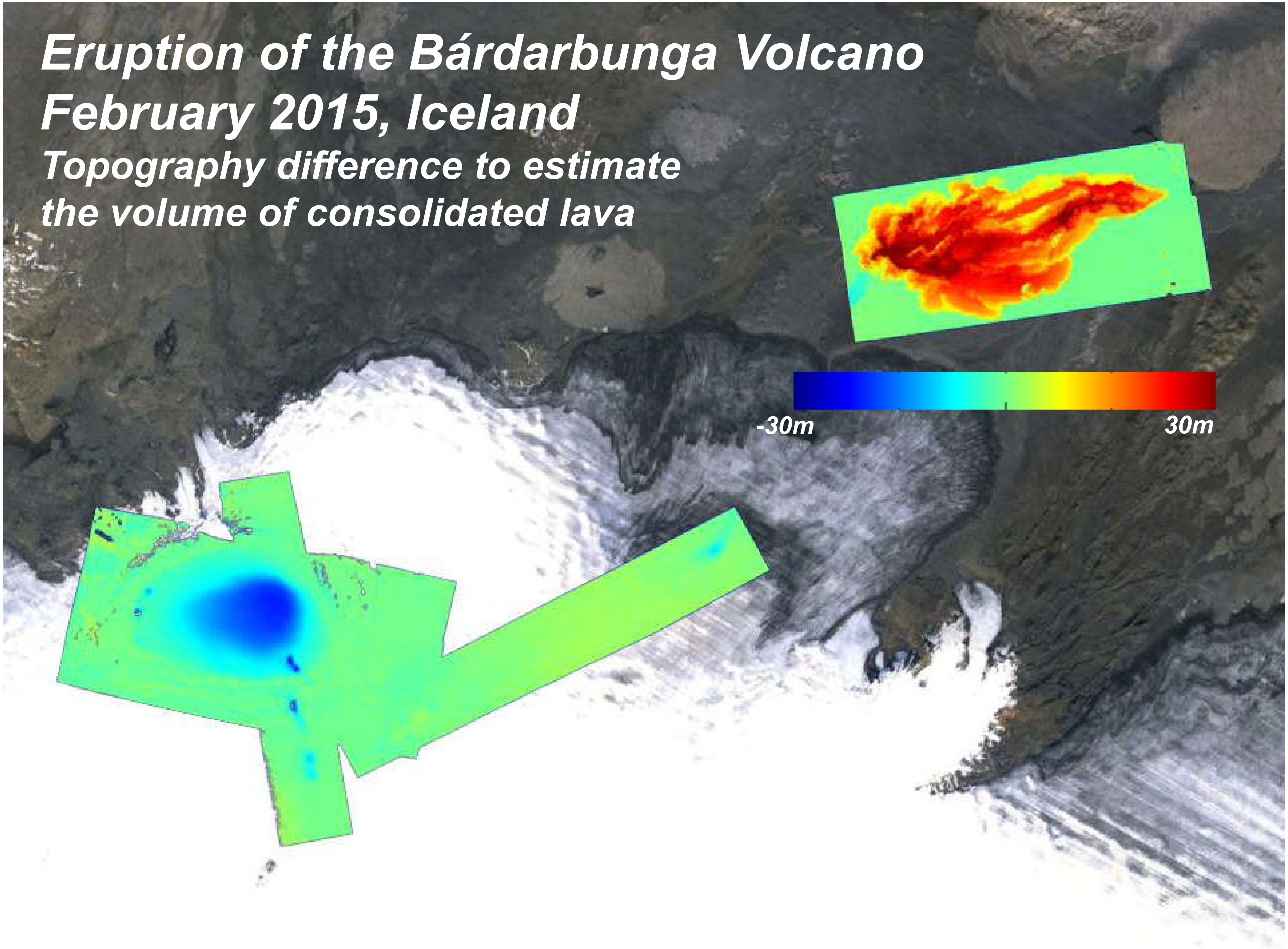
Kaufbeuren, Germany

L-band, 150 MHz bandwidth

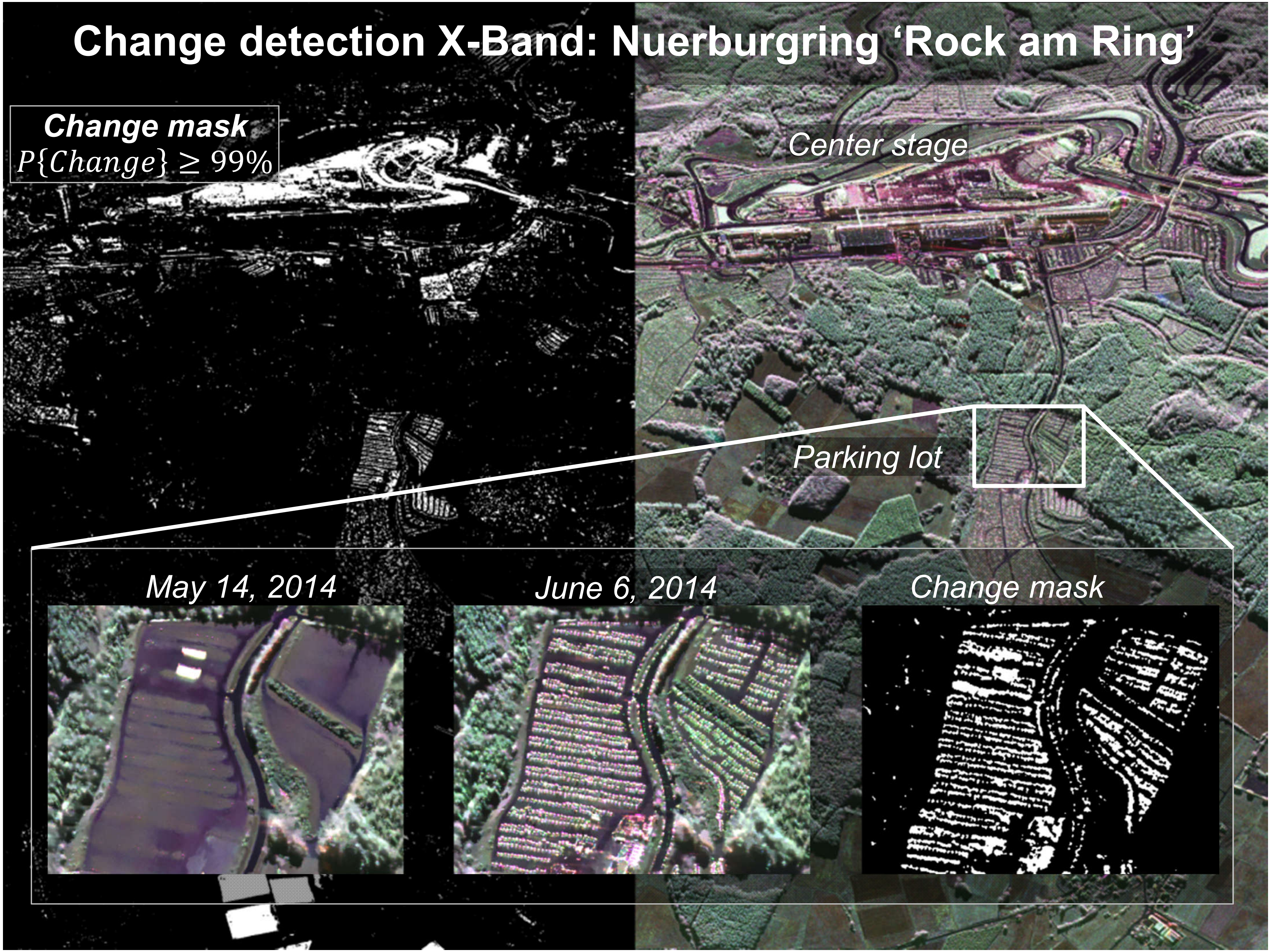



Eruption of the Bárdarbunga Volcano
February 2015, Iceland
TanDEM-X DEMs (2012)
2060m
1500m


Eruption of the Bárdarbunga Volcano
February 2015, Iceland
F-SAR DEMs (rec. on June 3, 2015)
2060m
1500m

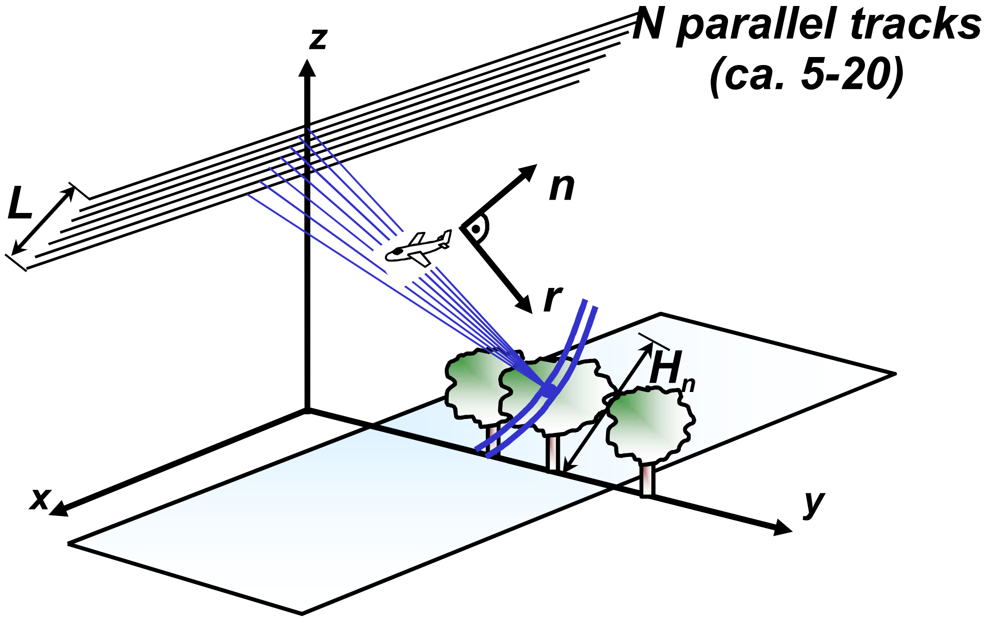


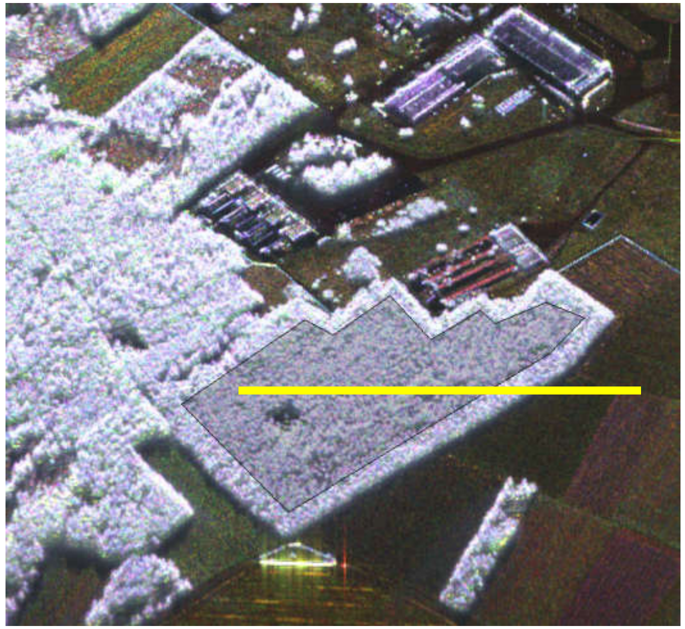
Eruption of the Bárdarbunga Volcano
February 2015, Iceland
Topography difference to estimate
the volume of consolidated lava
-30m
30m

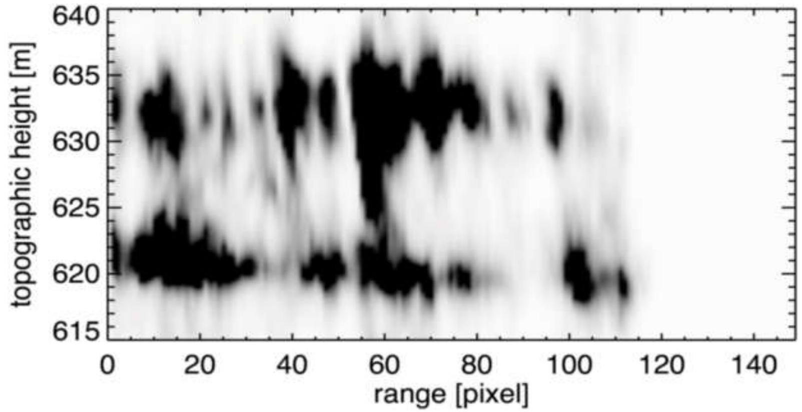

Change detection X-Band: Nuerburgring 'Rock am Ring'
Change mask
$P\{Change\} \geq 99\%$
Center stage
Parking lot
May 14, 2014
June 6, 2014
Change mask

SAR Tomography: 3D Imaging

- ***Innovative 3D-imaging Method***
- ***Potential applications:***
    - *Vegetation structure, biomass estimation*
    - *Urban modelling*
    - *Archaeology*

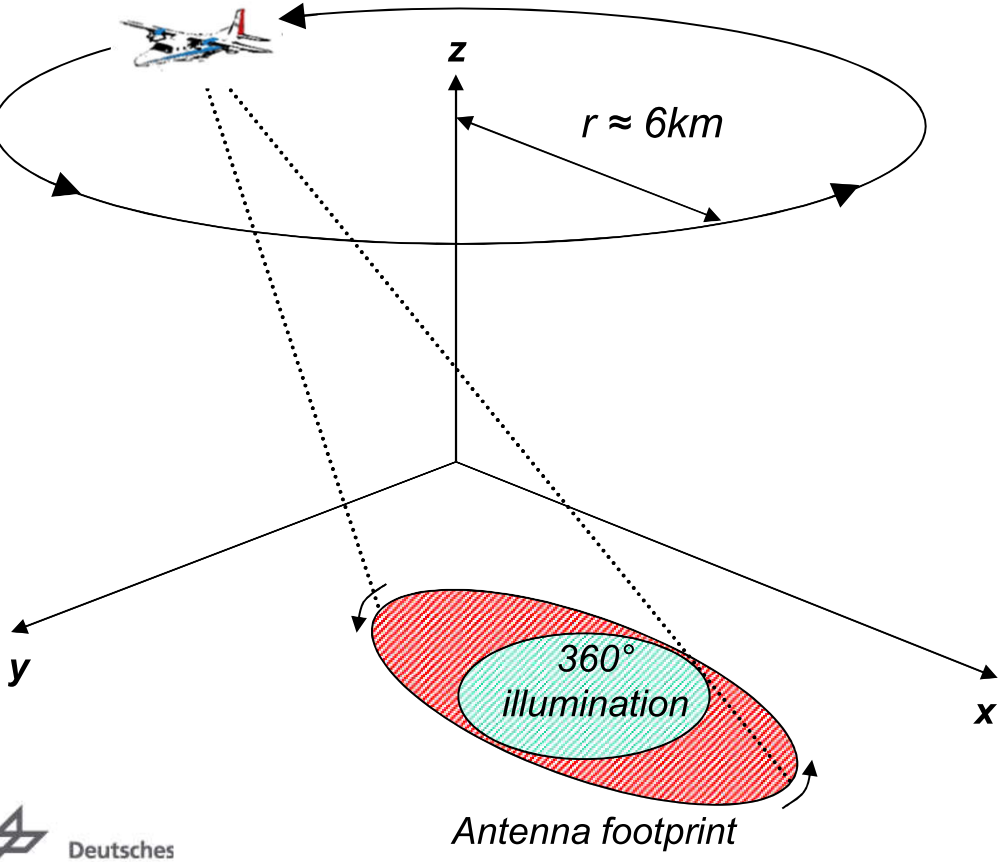






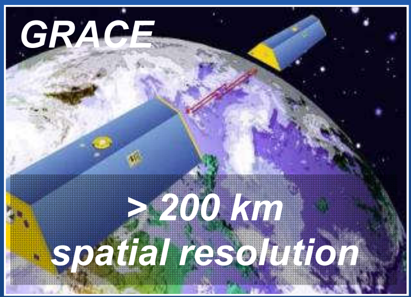
Circular SAR Imaging

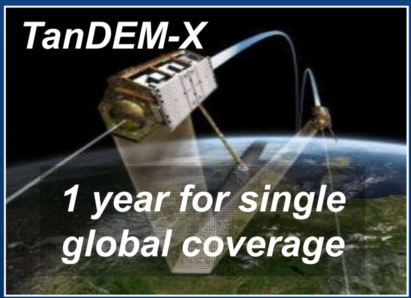
- *Extremely high resolution (up to λ/4, i.e. 6cm in L-band)*
- *Potential for 3D imaging*
- *Possibility of continuous monitoring*

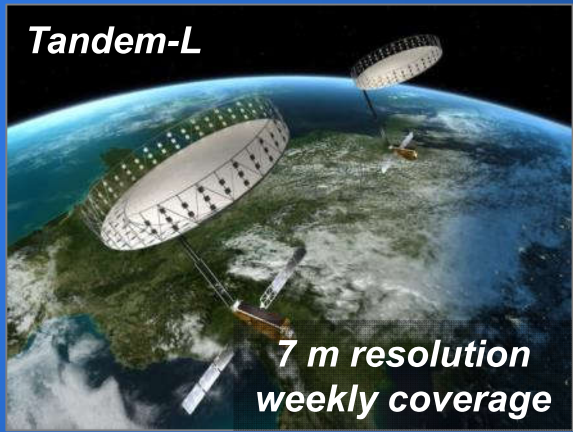


Deutsches
DLR für Luft- u

Cryosphere



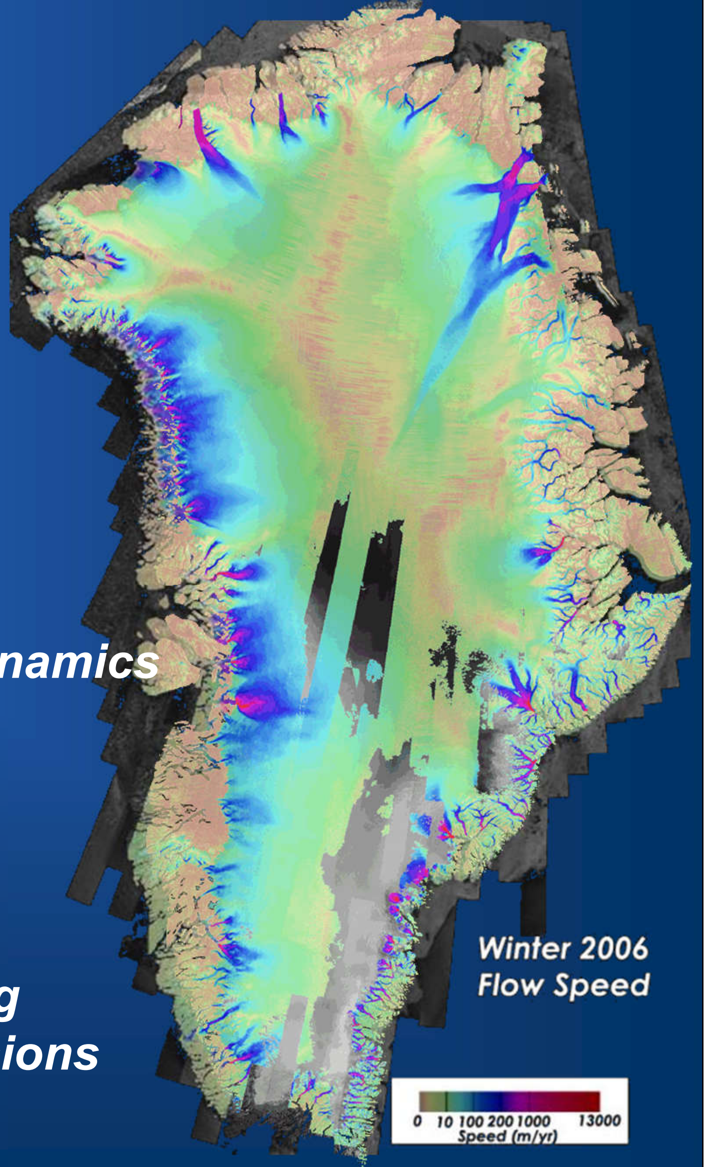




Tandem-L will provide unique information:

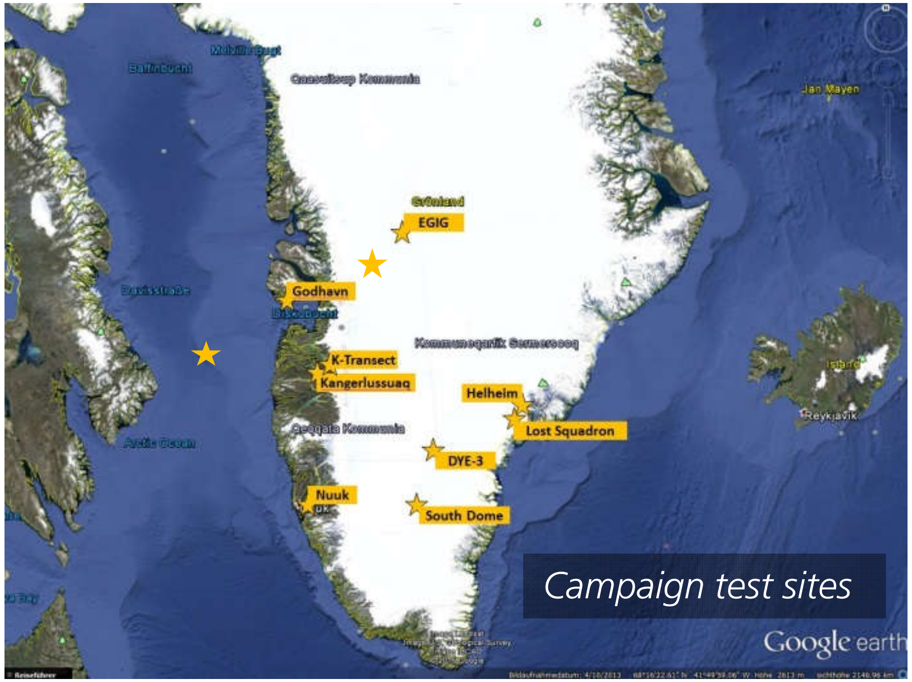
- ***glacier flow in 3-D***
- ***3-D ice structure and its dynamics***
- ***DEMs mit high spatial and temporal resolution***
- ***thaw and freeze cycles***
- ***sea ice classification***

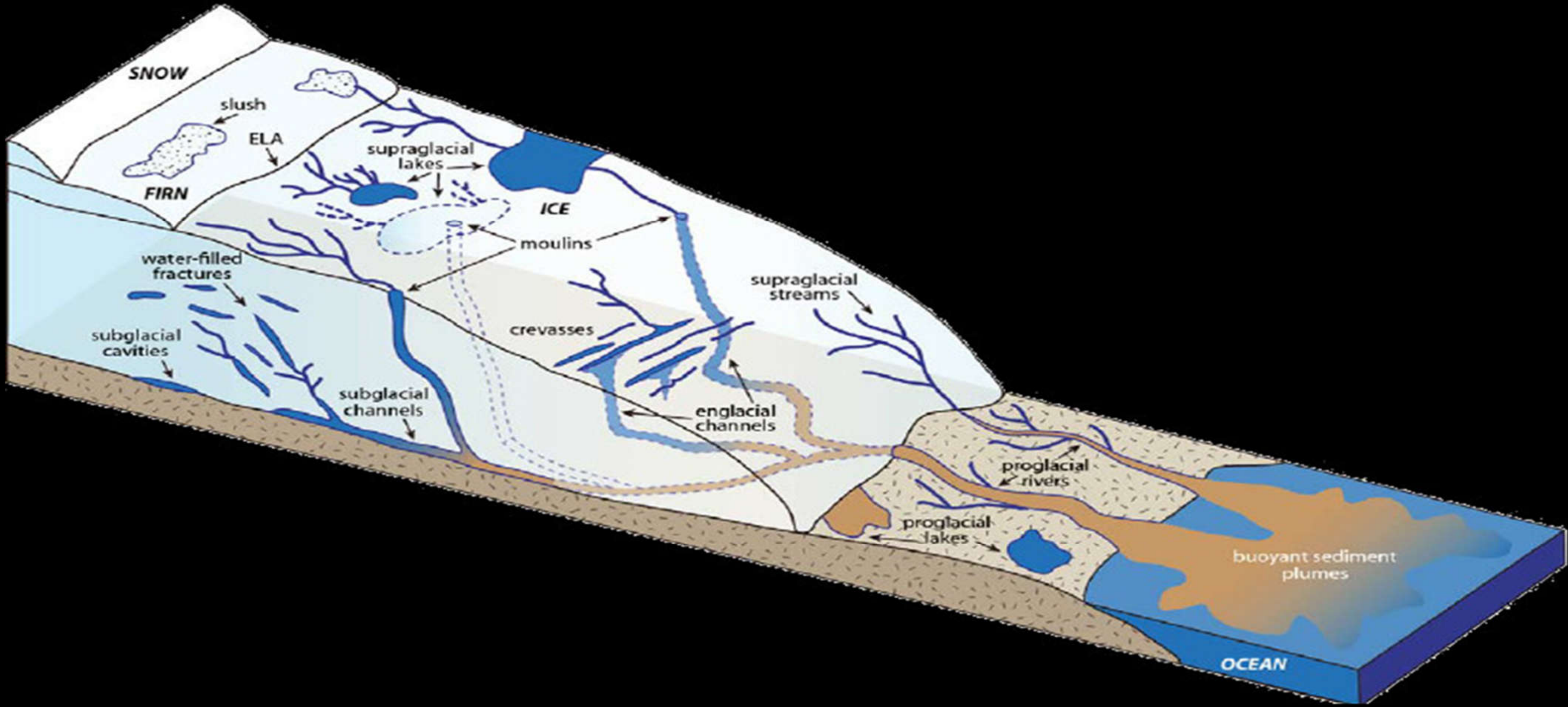
→ ***ideal complement to existing or planned cryosphere missions***



F-SAR Campaign ARCTIC (April - May 2015)

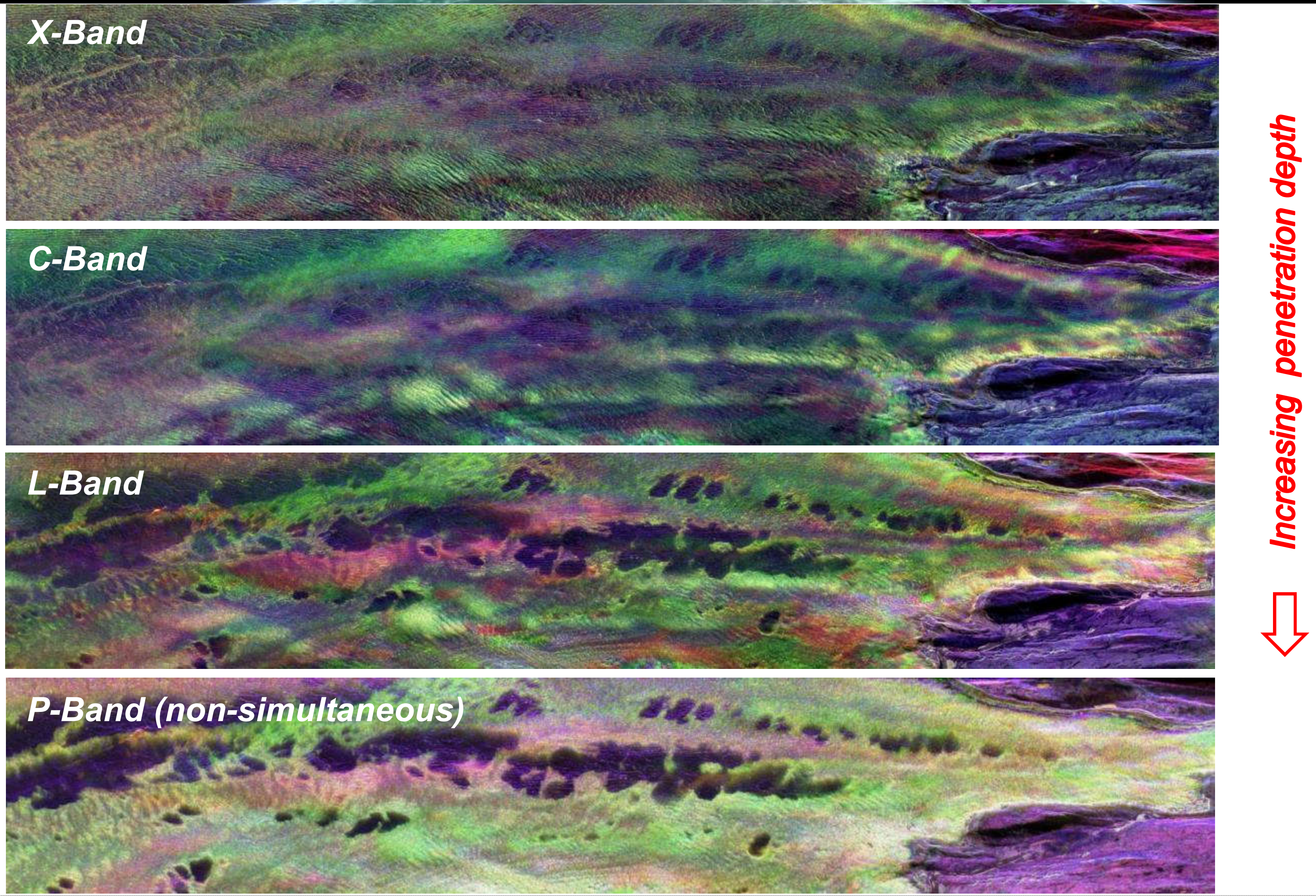
- ***11 test sites*** *in Greenland*
- *Investigation of several new methods to estimate* ***snow and ice parameters***
- *Investigation of the highly variant penetration depths in snow and ice at different wavelengths*
- *Demonstration of multi-spectral SAR imaging*
- *Preparation for Tandem-L*





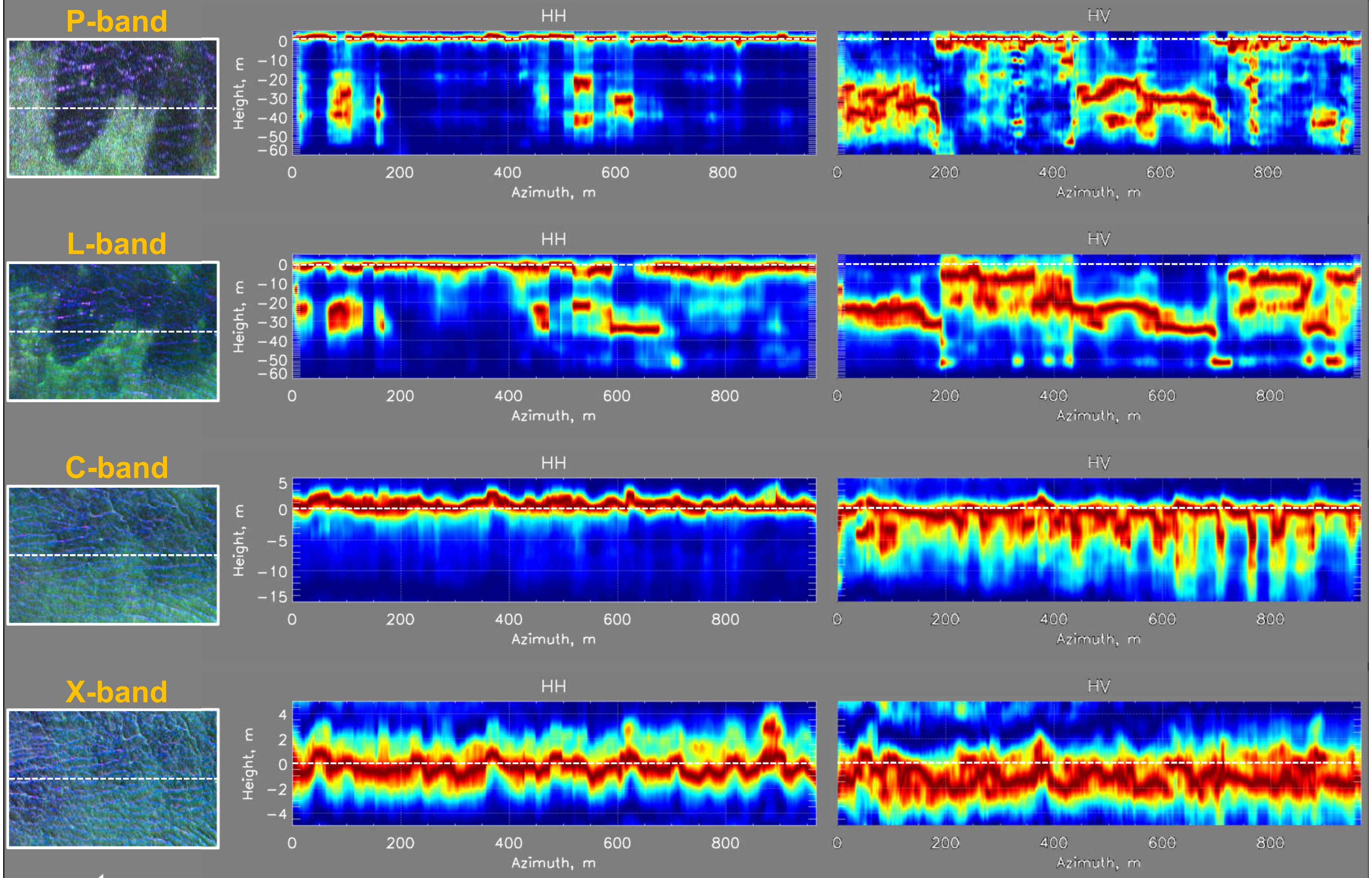
ARCTIC15 - K-Transect - Percolation zone

Schematic drawing



ARCTIC15 - K-Transect - Percolation zone (Russel Glacier)

Fully polarimetric images; Pauli decomposition R,G,B = HH-VV, HV, HH+VV.

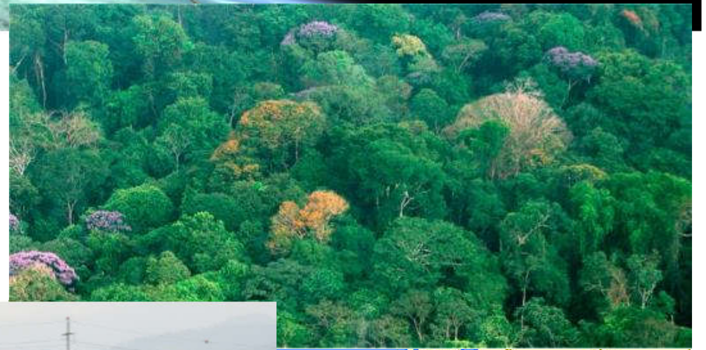


0 Norm. intensity 1

K-Transect: tomograms at multiple frequencies and pol. channels

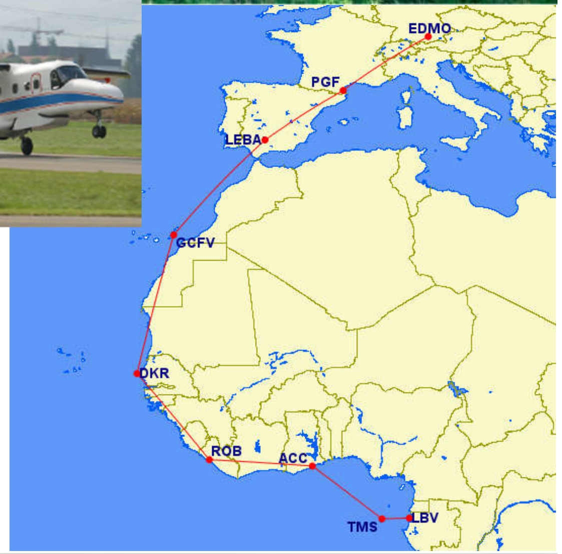
▶ **Capon Profiles** ▶ 20m x 20m multilook cell

AfriSAR Campaign 2016



Facts:

- Preparation for the BIOMASS Satellite SAR mission
- Preparation for Tandem-L
- Development of algorithms for Tandem-L & BIOMASS
- Several test sites in Gabon (tropical forest)
- Cooperation with ESA, ONERA, NASA/JPL, AGEOS
- Extensive ground work



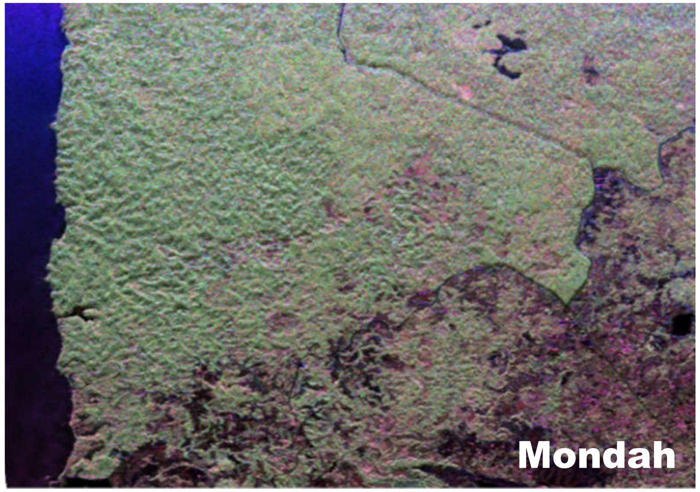
Schedule:

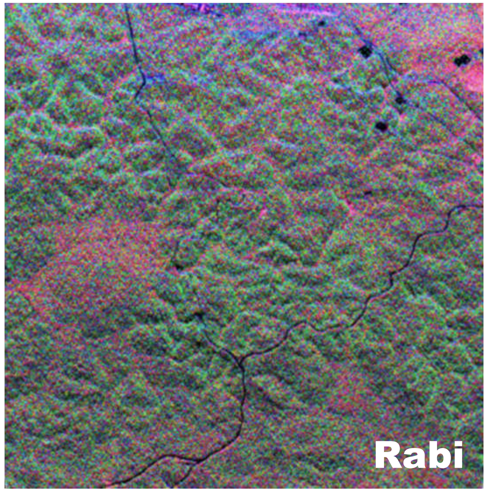
- Dry season: SETHI (ONERA) operates in July 2015
- Wet season: F-SAR (DLR) operates in February 2016
- Overflights by UAVSAR & LVIS (NASA) in Feb 2016

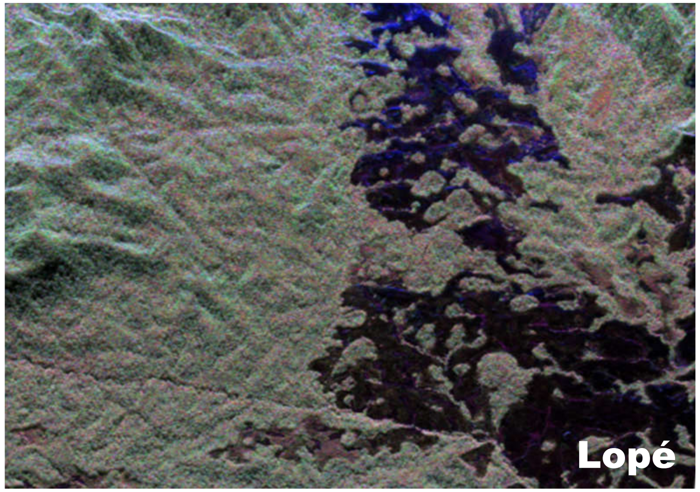
Results:

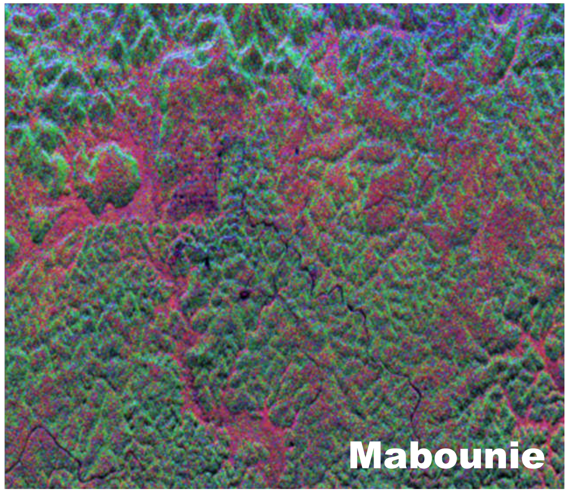
- SAR data sets in L- & P-Band quadpol.
- Backscatter maps, PolInSAR, Tomography
- Estimation of forest structure & tree heights
- Quality assessment of algorithms

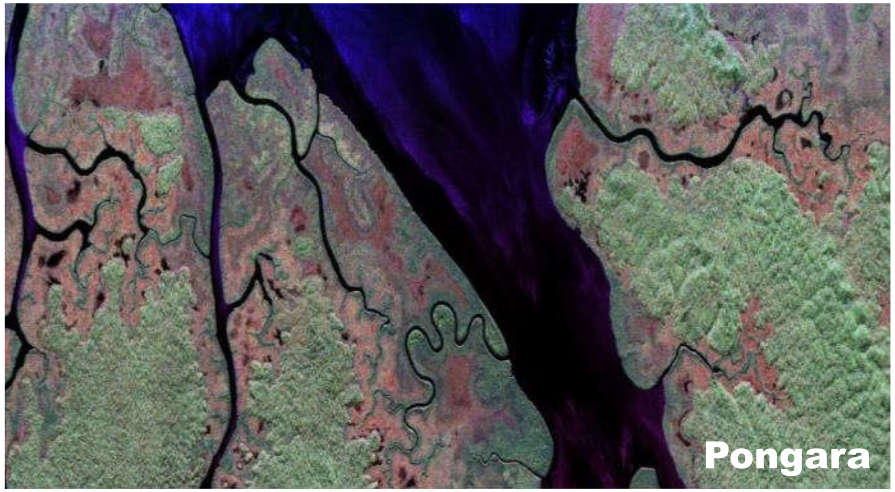
F-SAR Campaign AfriSAR (Gabon, February 2016)











esa
European Space Agency

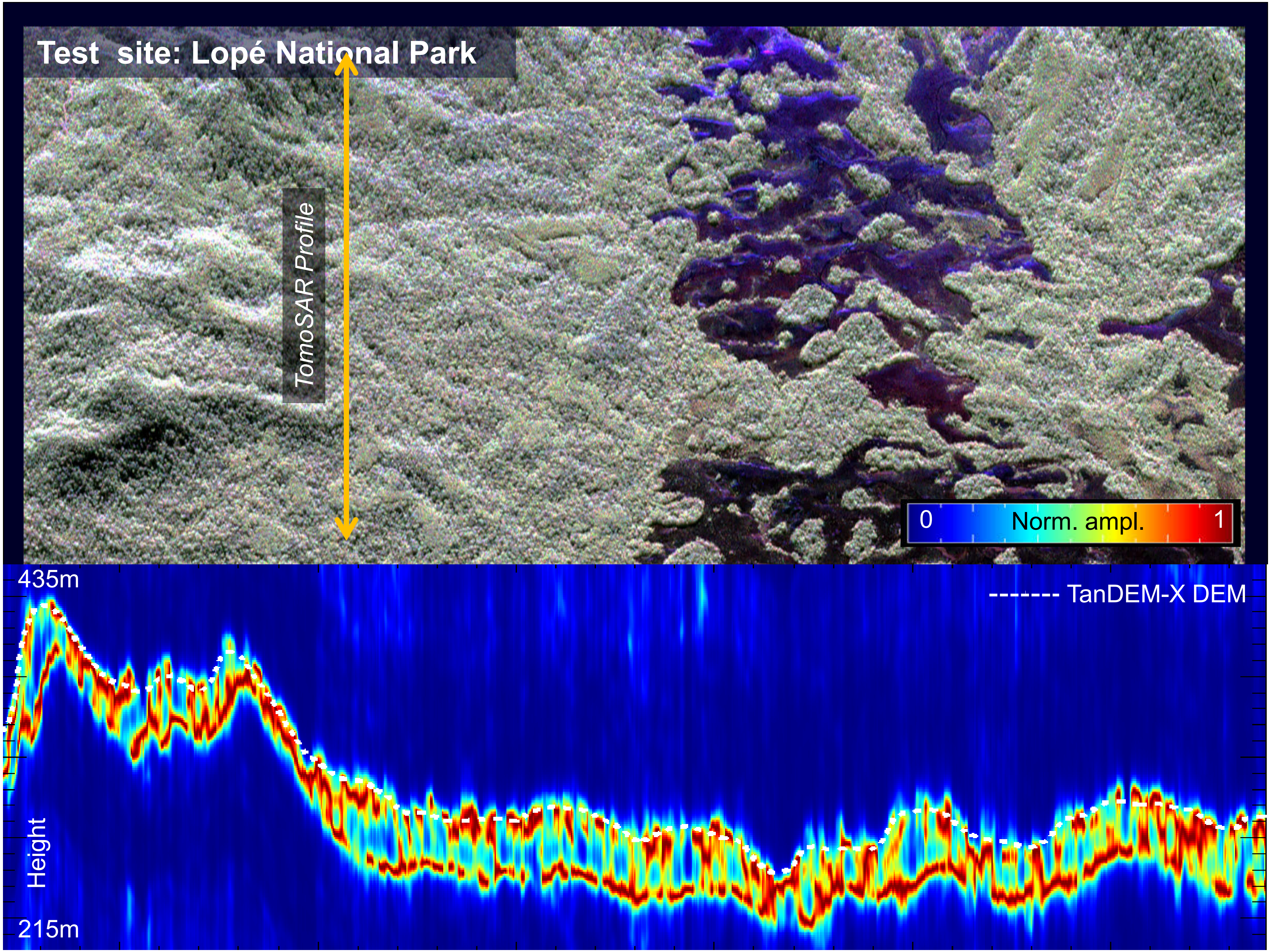
AGEOS

Parcs Gabon

ONERA
THE FRENCH AEROSPACE LAB

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

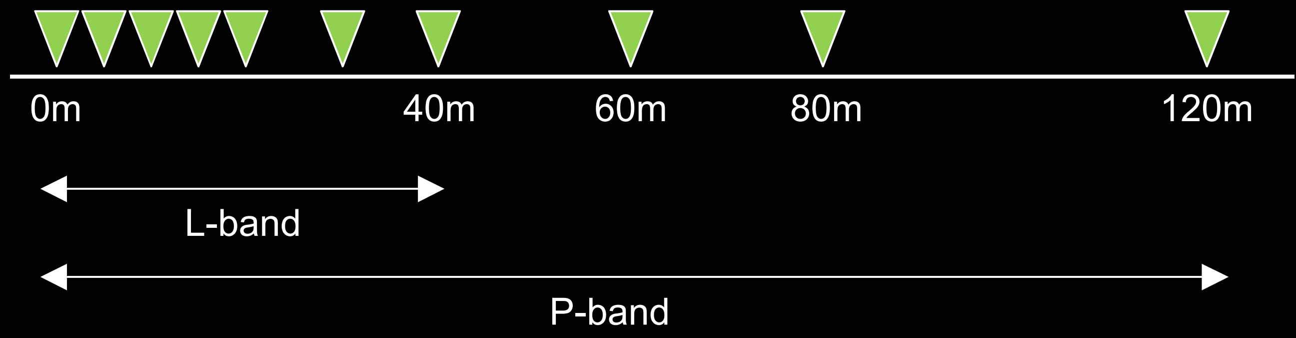
NASA



Test site: Lopé National Park
TomoSAR Profile
0
Norm. ampl.
1
435m
------- TanDEM-X DEM
Height
215m

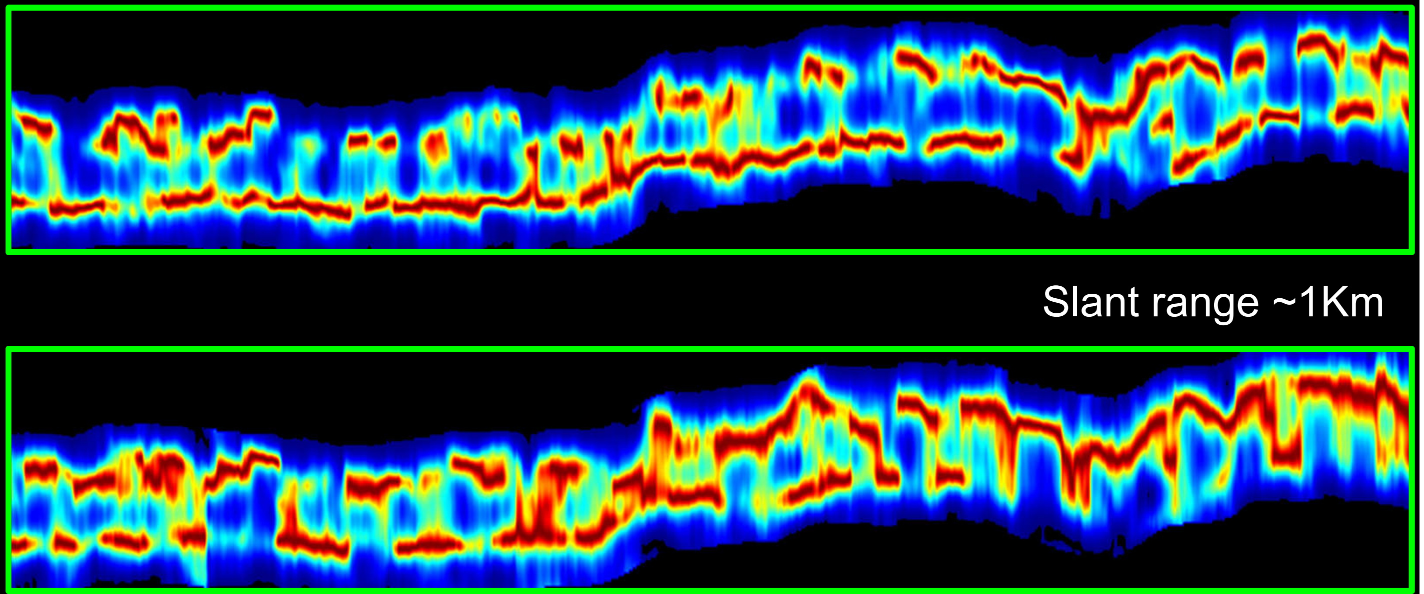
Lopé: Comparison P-band vs L-band of TomoSAR profiles (HH)

F-SAR horizontal baselines :
Baseline aperture needed for 15m TomoSAR vertical resolution :



P-band
Wavelength: ~ 70cm

340m
230m



Slant range ~1Km

L-band
Wavelength: ~23cm

340m
230m

AfriSAR Campaign 2016 - Media Day at LBV Airport