CEOS-SAR/CI-Val Workshop 2009
Westin-Hotel, Pasadena, 2009 November 17 - 19

Invited State of the Art Review
Wednesday, 2009 November 18

Recent dramatic advances in developing fully polarimetric space SAR sensors: Why must reduced Compact SAR concepts not be accepted for satellite sensor implementation, and where do we go from here?

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University of Illinois at Chicago, Department of Electrical & Computer Engineering,
Communications, Sensing & Navigation Laboratory
Chicago, IL/USA

OUTLINE

1. **Recent most pertinent POLinSAR Workshops**

   - 1. POLinSAR 2003 January 14 - 16: No space-borne SAR, participants: 80
     http://earth.esa.int/workshops/polinsar2003

   - 2. POLinSAR 2005 January 17 - 21: No space-borne SAR, participants: 120
     http://earth.esa.int/workshops/polinsar2005

   - 3. POLinSAR 2007 January 22 - 26 : ALOS-PALSAR, participants: 160+
     http://earth.esa.int/workshops/polinsar2007

   - 4. POLinSAR 2009 January 26 - 30: 3 space-borne SAR, participants: 180+
     http://earth.esa.int/workshops/polinsar2009

2. **Advent of 3 Fully Polarimetric Space-borne SAR Sensors**

   - ALOS-PALSAR L-Band: January 2006
   - RADARSAT-2 C-Band: December 2007
   - TerraSAR-X X-Band: June 2007

SUMMARY of POLinSAR 2009

POLinSAR 2009: 3 Fully Polarimetric Sensors, ~ 180+ participants
http://earth.esa.int/workshops/polinsar2009

- Summary: **further advancement of POLinSAR with all 3 sensors**

  - New Findings: POLinSAR old & young expert community is growing

  - What was accomplished: Excellent presentations especially by junior experts & advances made on several basic and applied POLinSAR R&D projects

  - What is still required: **More test-site multi-sensor data acquisitions**

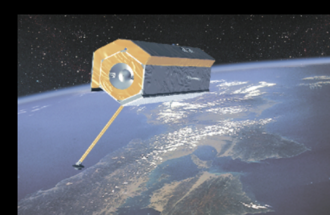

YLD WMB
MR
POLinSAR-2009 Participants: Wednesday, 2009 January 28

Table 1. Comparison of High-Level Parameters

Parameter	PALSAR	RADARSAT-2	TerraSAR-X
Orbit: LEO, circular	Sun-synchronous	Sun-synchronous	Sun-synchronous
Repeat Period (*days*)	46	24	11
Equatorial Crossing time (*hrs*)	22:30 (ascending)	18:00 (ascending)	18.00 (ascending)
Inclination (*degrees*)	98.16	98.6	97.44
Equatorial Altitude (*km*)	692	798	515
Wavelength (*Band*)	23 cm (*L*)	5.6 cm (*C*)	3 cm (*X*)
Fully polarimetric mode	Yes	Yes	Yes

ALOS / PALSAR
Japanese Space Agency (JAXA)
L-Band (quad), 2006

RadarSAT-II
Canadian Space Agency (CSA)
C-Band (quad), 2007



TerraSAR-X
German Aerospace Center (DLR) / Astirum
X-Band (quad), 2007

ALOS is one of the largest Earth observing satellites ever developed, at 3850 kg. It is in a near-exact 45-day repeat sun-synchronous orbit, 690 km altitude above the equator. The active phased array SAR antenna is obliquely Earth-facing, aligned with the spacecraft velocity vector. The solar array is arranged at right angles to the orbit plane, consistent with the near-mid-day orbit phasing. The X-band down-link must be shared with optical instruments, which constrains SAR operation times.

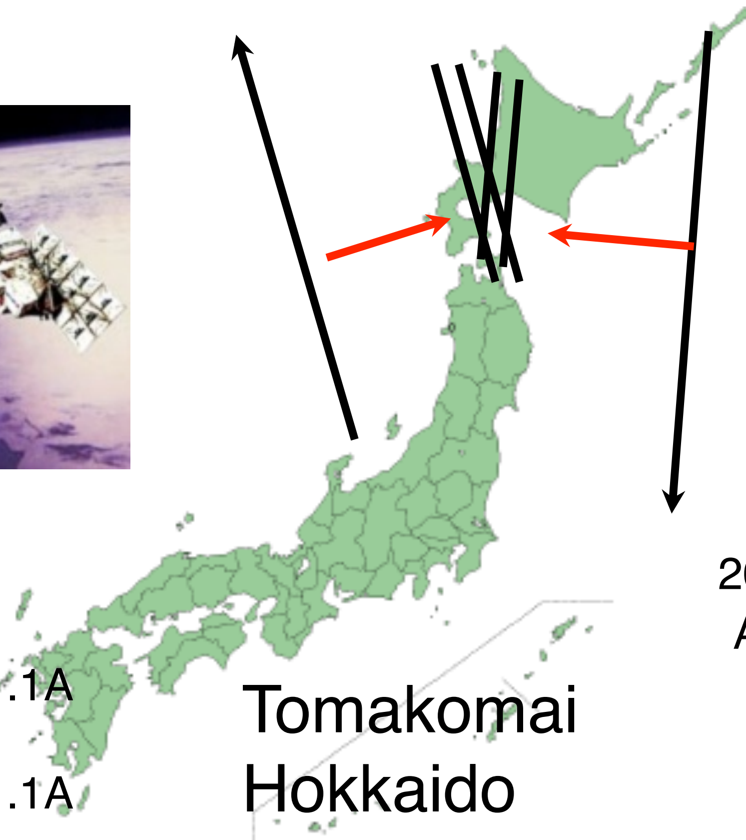
Table 1. Selected PALSAR Mode Parameters

Mode (selected)	Resolution (m)	Swath (km)	Looks	Polarization
Standard, stripmap	20 x 10	70	2	HH or VV
Fine	10	70	1	HH or VV
ScanSAR (5-beam)	~ 100	350	8	HH or VV
Dual polarization	(as above)	(as above)	(as above)	(HH, HV), (VV, VH)
Quad-pol	30 x 10	30	2	Full polarization

ALOS-PALSAR Polarimteric Mode

Ascending

Descending



2006/8/17
ALPSRP029970850-1.1A
2006/10/2
ALPSRP036680850-1.1A

2007/10/10
ALPSRP091090850-1.1A

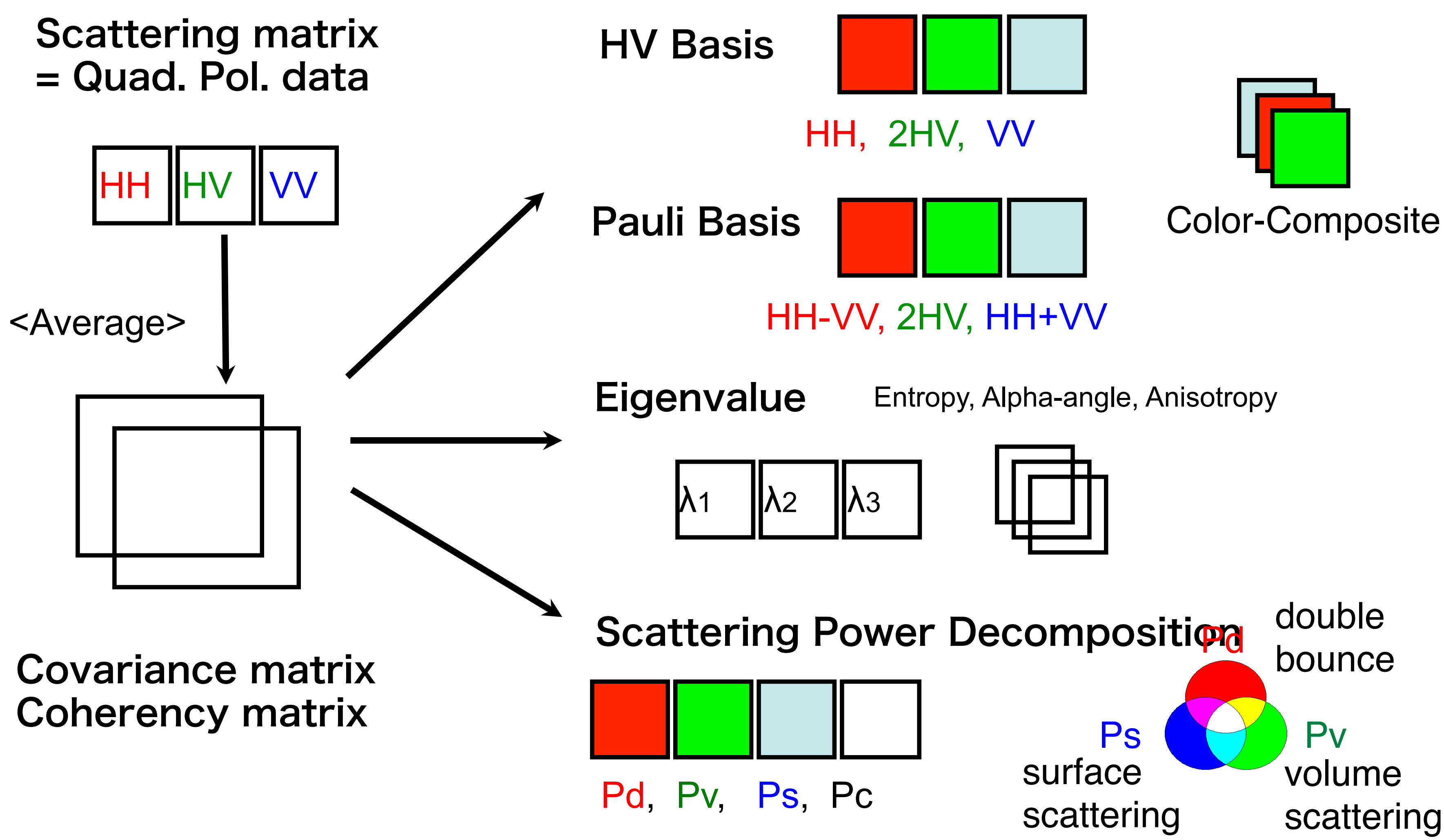
Tomakomai
Hokkaido

2006/8/19
ALPSRP030192750-1.1D

Yoshio Yamaguchi

Niigata University

POLSAR image analysis



Tomakomai Hokkaido

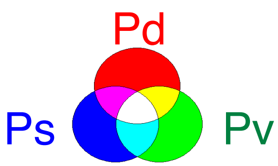
42.17N
143.04E

N

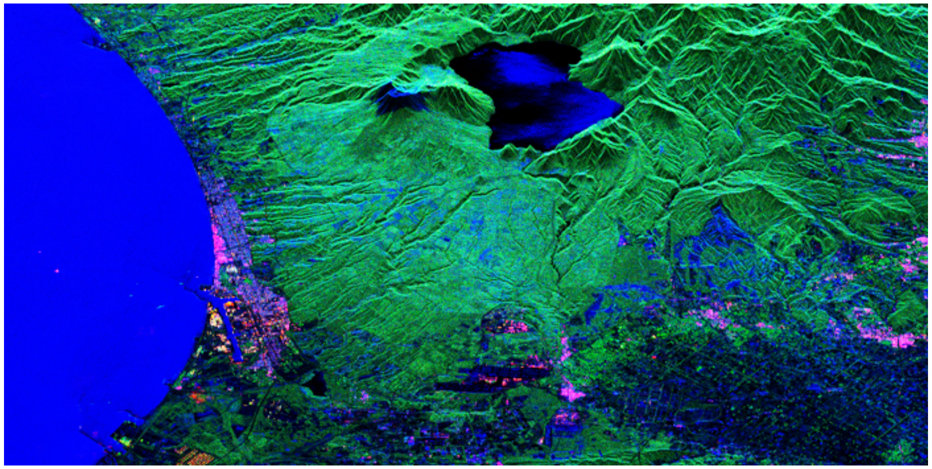
Google earth optical image

ALPSRP029970850-1.1A

2006/8/17



Niigata University

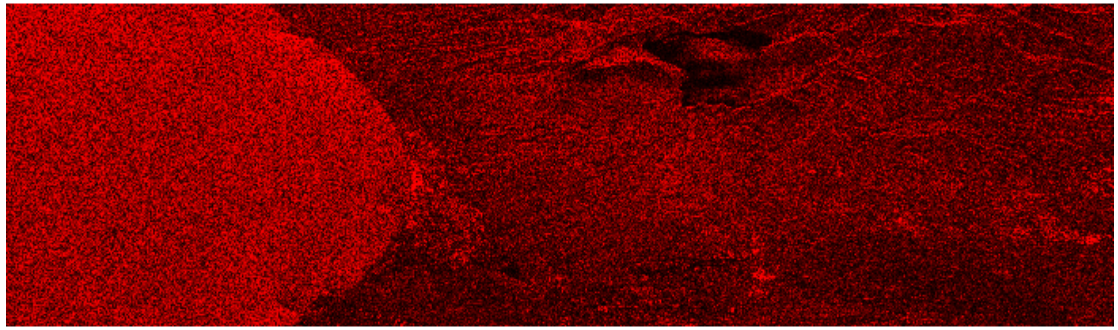


Scattering power decomposition (Ps, Pd, Pv)

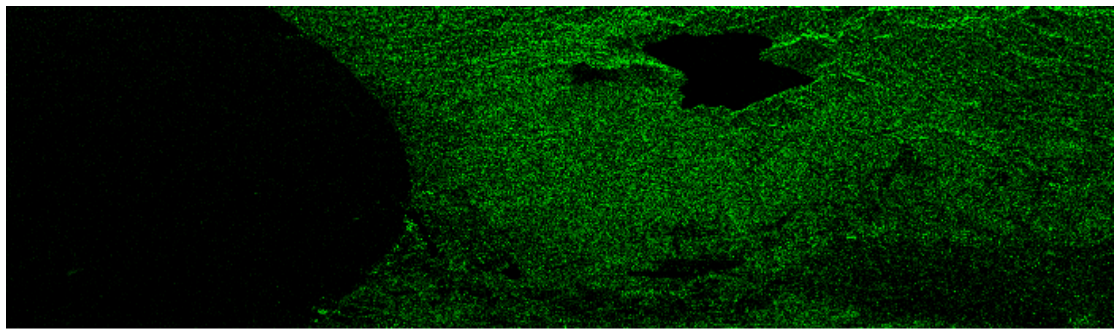
Tomakomai Hokkaido

Coloring by RGB

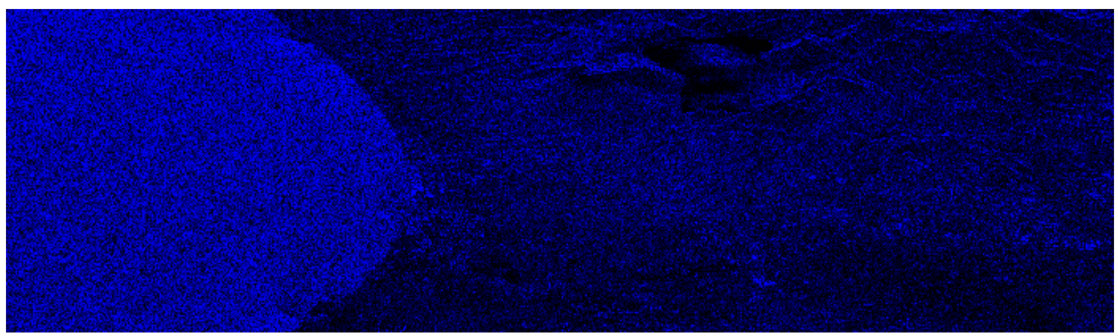
HH



HV=VH



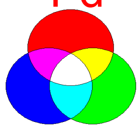
VV



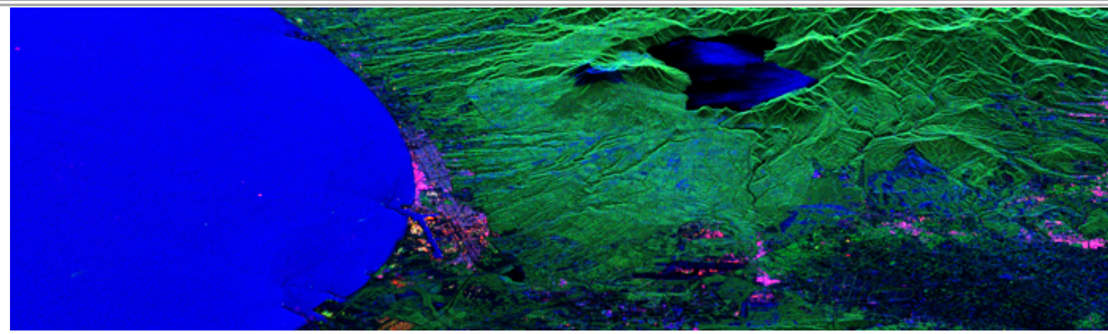
42.17N
143.04E

2006/8/17 ALPSRP029970850

Scattering power decomposition

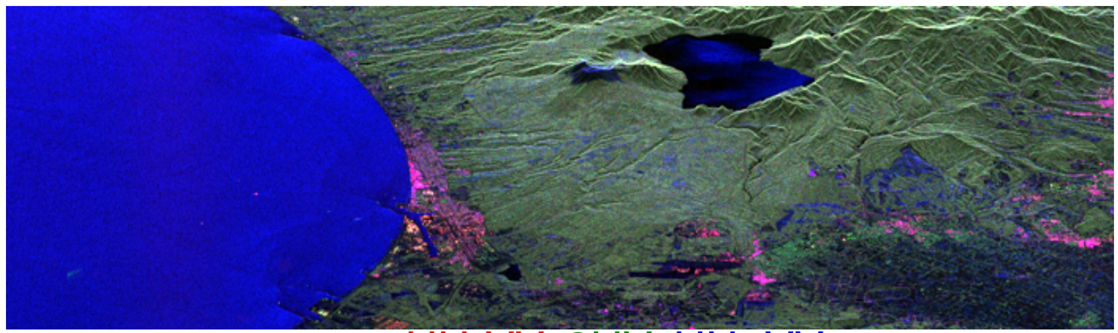


Niigata University



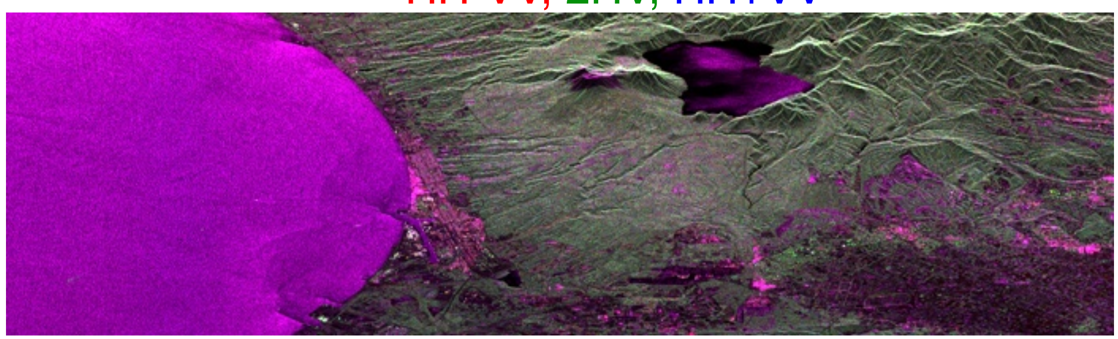
Pd, Pv, Ps

Pauli-basis



HH-VV, 2HV, HH+VV

HV-basis



HH, 2HV, VV

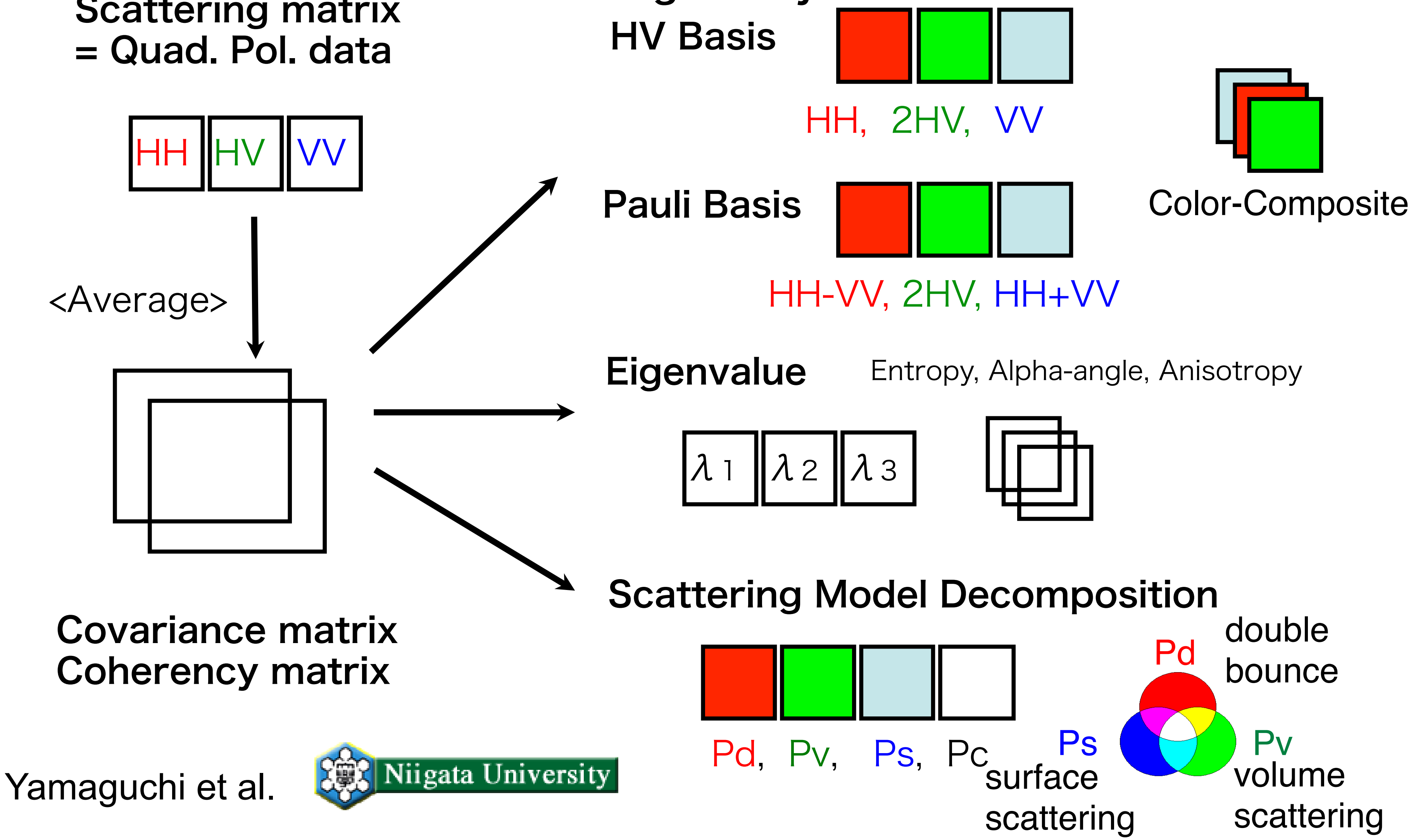
Tomakomai Hokkaido

42.17N 143.04E

2006/8/17

ALPSRP029970850

POLSAR image analysis

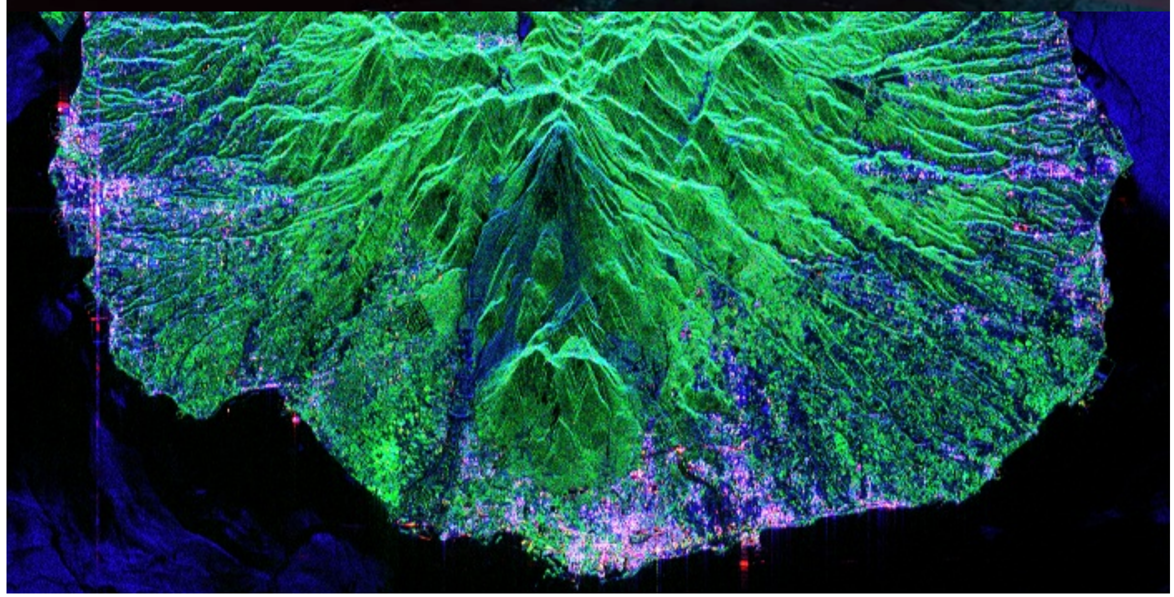


Fugen-dake Unzen

32.825N
130.364E

Google earth optical image

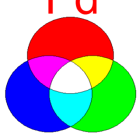
ALOS-PALSAR pol. image



ALPSRP072570650-1.1A
©JAXA, METI

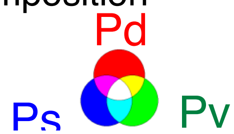
2007/6/5

Pd

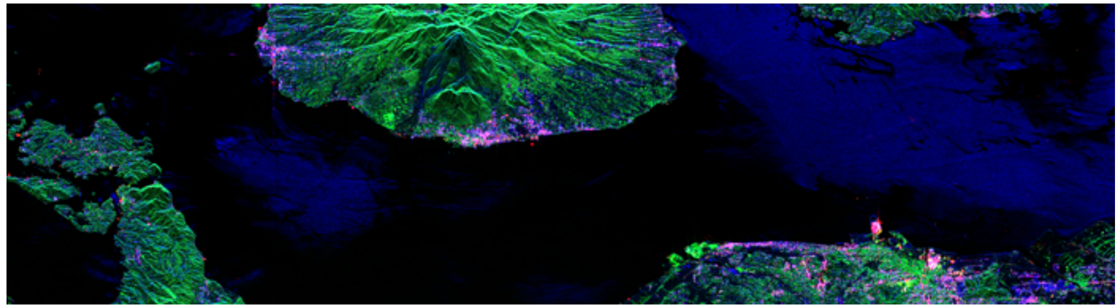
Ps  Pv

Niigata University

Scattering power decomposition

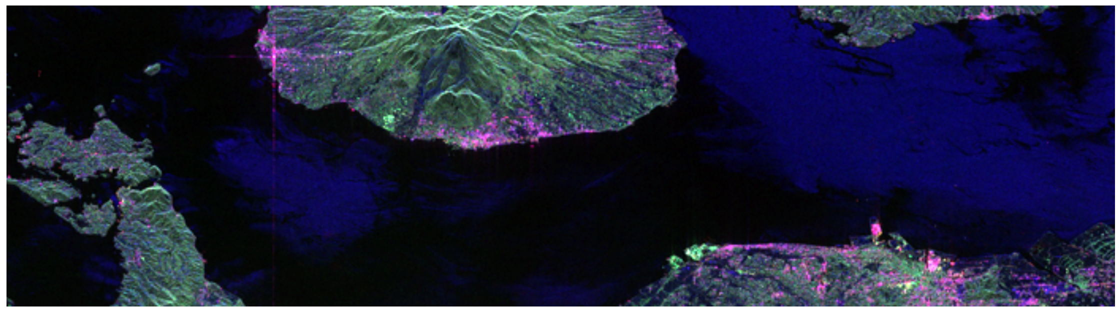


Niigata University



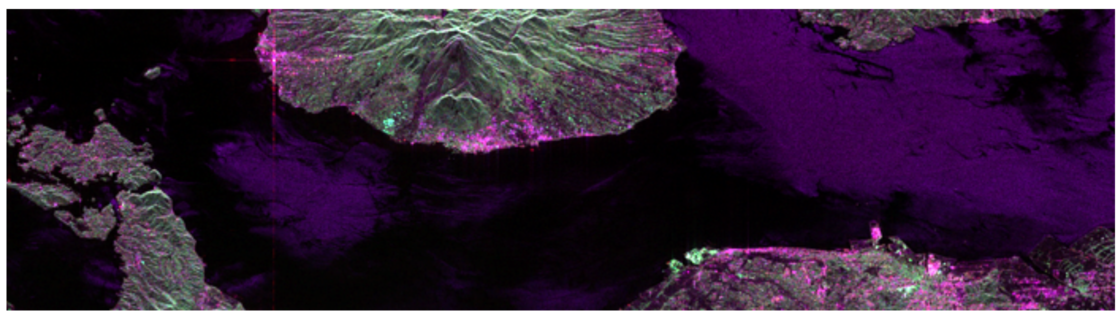
Pd, Pv, Ps

Pauli-basis



HH-VV, 2HV, HH+VV

HV-basis

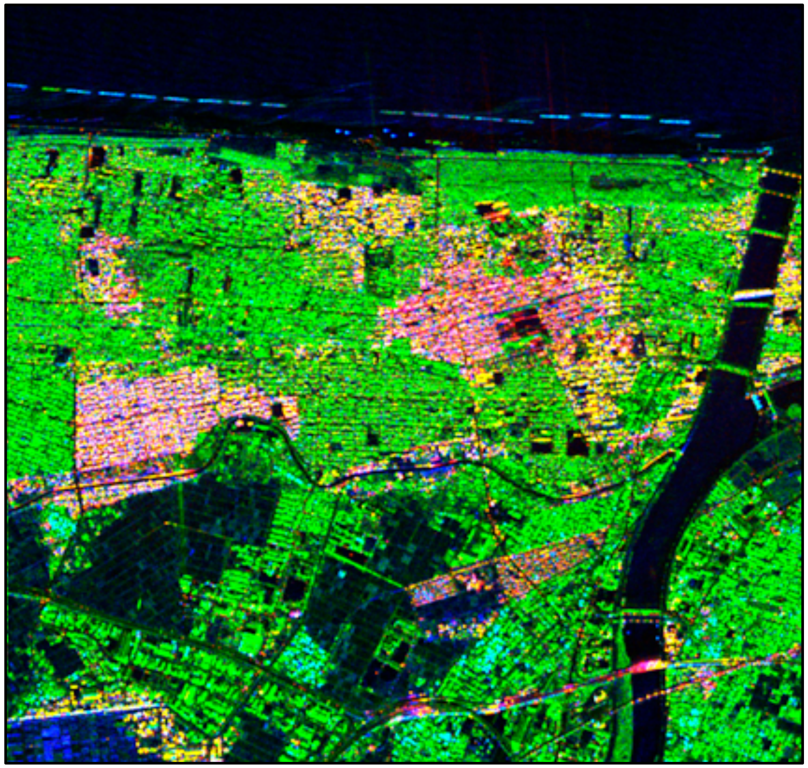


HH, 2HV, VV

Fugen-dake Unzen

32.825N
130.364E

2007/6/5 ALPSRP072570650-1.1A



Four-component decomposition

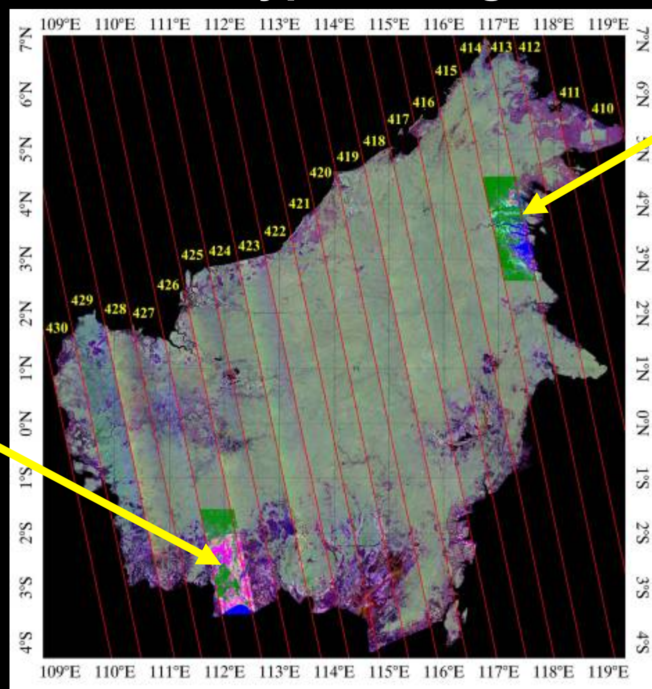
New rotated decomposition

Scattering power decomposition by rotation of coherency matrix for Niigata City area in Niigata Prefecture of Japan

ALOS-PALSAR In Orbit Demonstration Study

Exploration / Validation of the INDREX-II Campaign

Classification of Land Cover Types using PALSAR WB & Dual Pol



414: Mangrove area

426: Oil palm development area

SarVision

WAGENINGEN UNIVERSITY ENVIRONMENTAL SCIENCES

esa

Courtesy Prof. D. Hoekman – POLINSAR09

ALOS-PALSAR In Orbit Demonstration Study

Exploration / Validation of the INDREX-II Campaign

SarVision WAGENINGEN UNIVERSITY ENVIRONMENTAL SCIENCES

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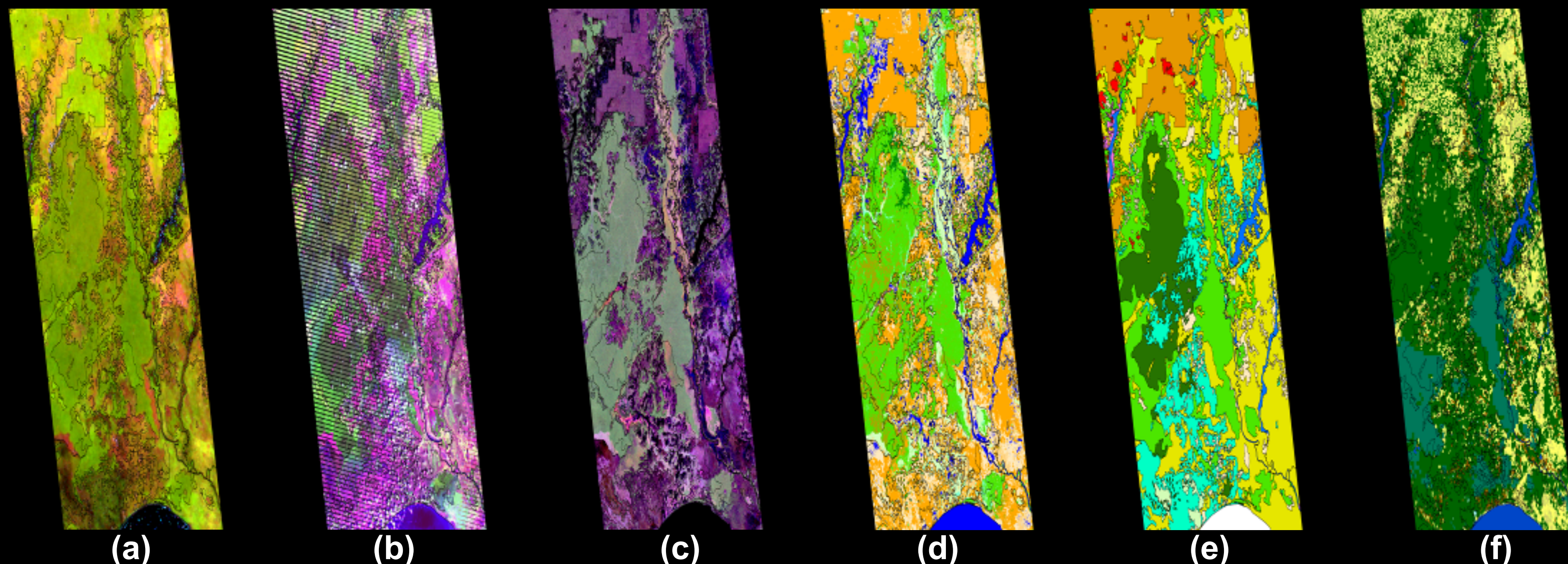

(a) SarVision MODIS 2007 aggregate;
(b) Landsat 2008;
(c) PALSAR FBS-FBD 2007

(d) PALSAR 2007 classification;
(e) Ministry of Forestry 2005 classification based on Landsat;
(f) GlobCover 2005-2006 regional classification

Courtesy Prof. D. Hoekman – POLINSAR09

esa

ALOS-PALSAR In Orbit Demonstration Study

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WAGENINGEN UNIVERSITY
ENVIRONMENTAL SCIENCES

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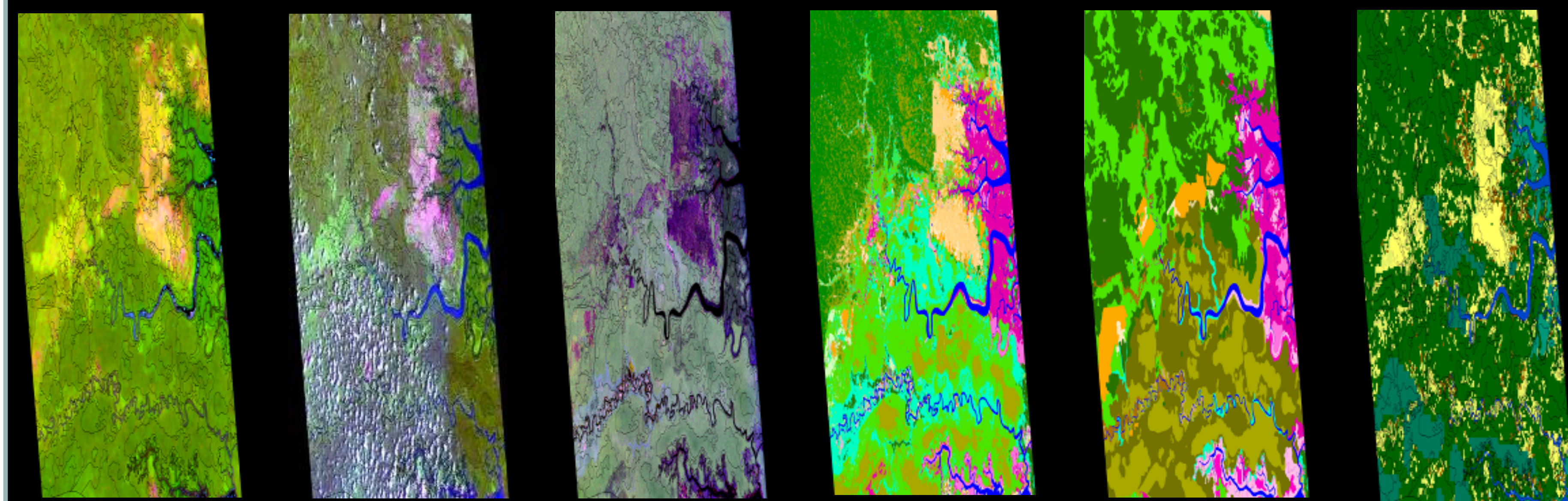
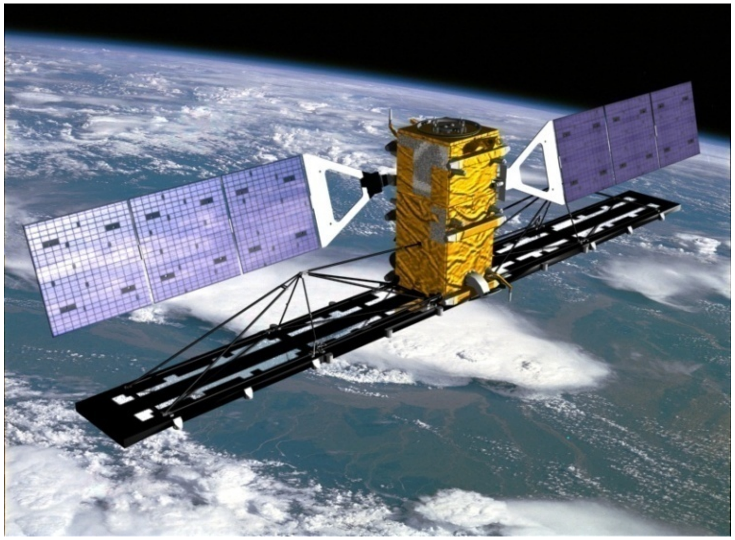


(a) (b) (c) (d) (e) (f)

(a) SarVision MODIS 2007 aggregate;
(b) Landsat 2007;
(c) PALSAR FBS-FBD 2007

(d) PALSAR 2007 classification;
(e) NRM 1997 classification based on Landsat;
(f) GlobCover 2005-2006 regional classification

Courtesy Prof. D. Hoekman – POLINSAR09



The RADARSAT-2 satellite bus is based on the PRIMA architecture developed by Alenia Spazio of Italy. The bus features a primary rectangular structure with the body-mounted SAR antenna on the Earth-facing panel, and two solar panel arrays mounted on single-degree-of-freedom axels. The antenna and solar arrays are parallel to each other, a consequence of the dawn-dusk sun-synchronous orbit. The X-Band down link presents no interference hazard with the C-band SAR. Dawn-dusk operations permit a relatively large 28-minute data acquisition time per orbit.

Table 1. Selected RADARSAT-2 Modes

Mode	Resolution (m)	Swath (km)	Looks	Polarization
Standard, stripmap	25	100	4	HH or VV
Fine	8	50	8	HH or VV
ScanSAR Wide	100	500	8	HH or VV
Dual polarization	(as above)	(as above)	(as above)	(HH, HV), (VV, VH)
Quad-pol (standard)	25 x 8	25	4	Full polarization
Quad-pol (fine)	8	25	1	Full polarization

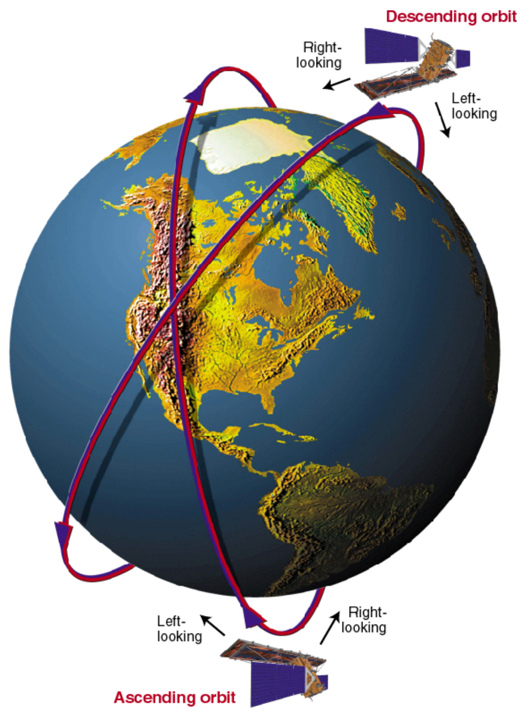
R A D A R S A T - 2

Orbit Parameters

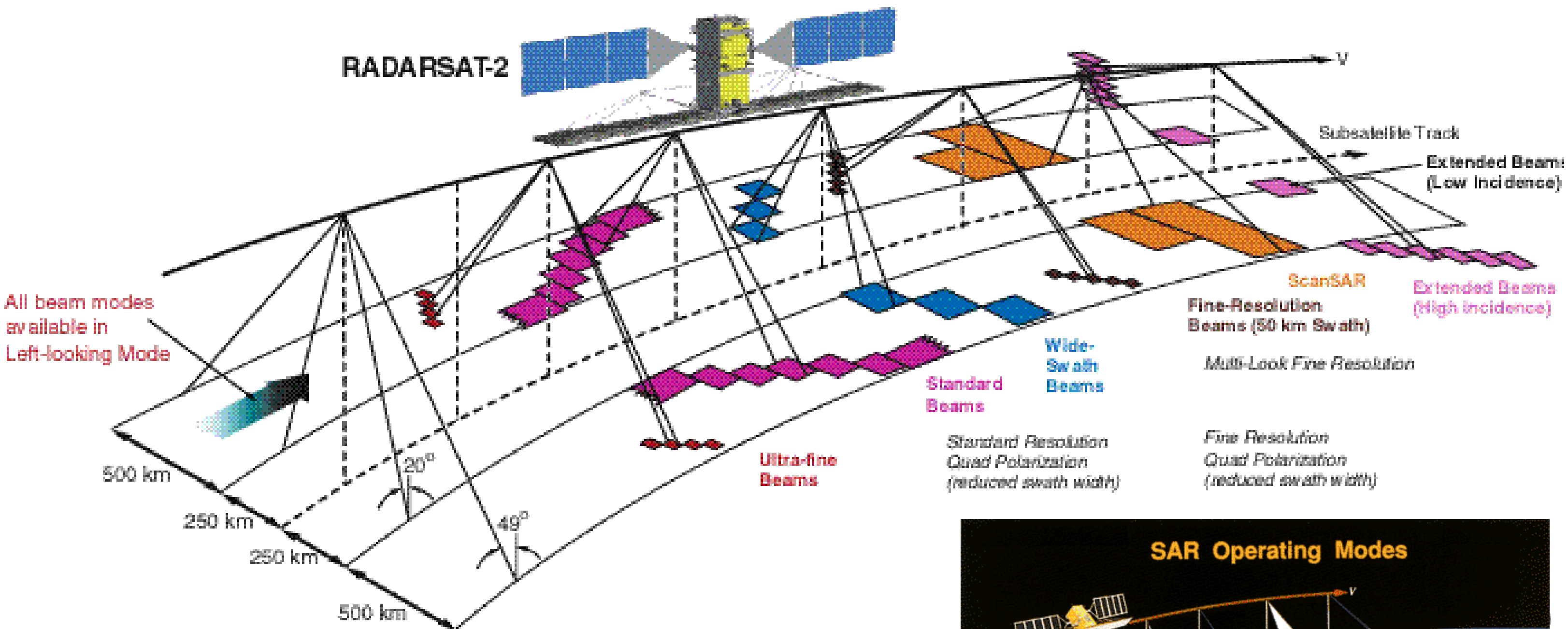
ORBIT CHARACTERISTICS	
Altitude (average)	798 km
Inclination	98.6 degrees
Period	100.7 minutes
Ascending node	18 hrs (± 15 min)
Sun-synchronous	14 orbits per day
Repeat cycle	24 days

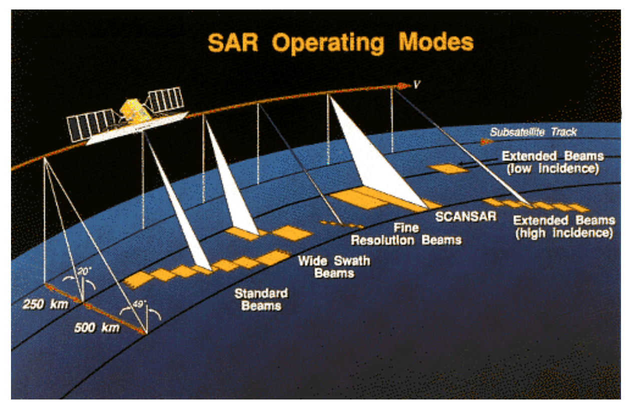
COVERAGE ACCESS USING 500 KM SWATH WIDTH	
North of 70°	Daily
North of 48°	Every 1-2 days
Equator	Every 2-3 days

RADARSAT-2 will operate in an orbit identical as RADARSAT-1 except for an offset in time

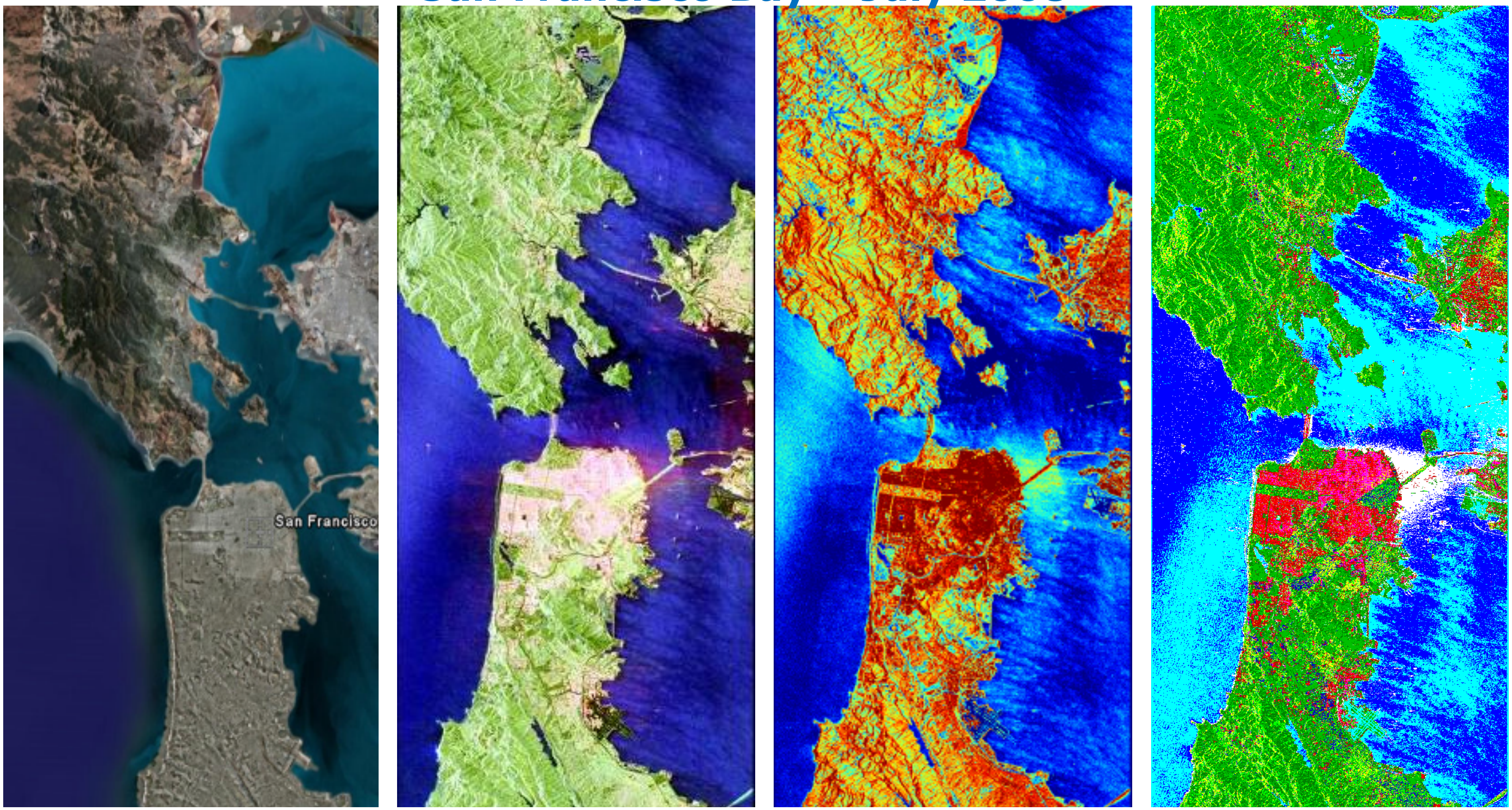


RADARSAT-2 Imaging Modes



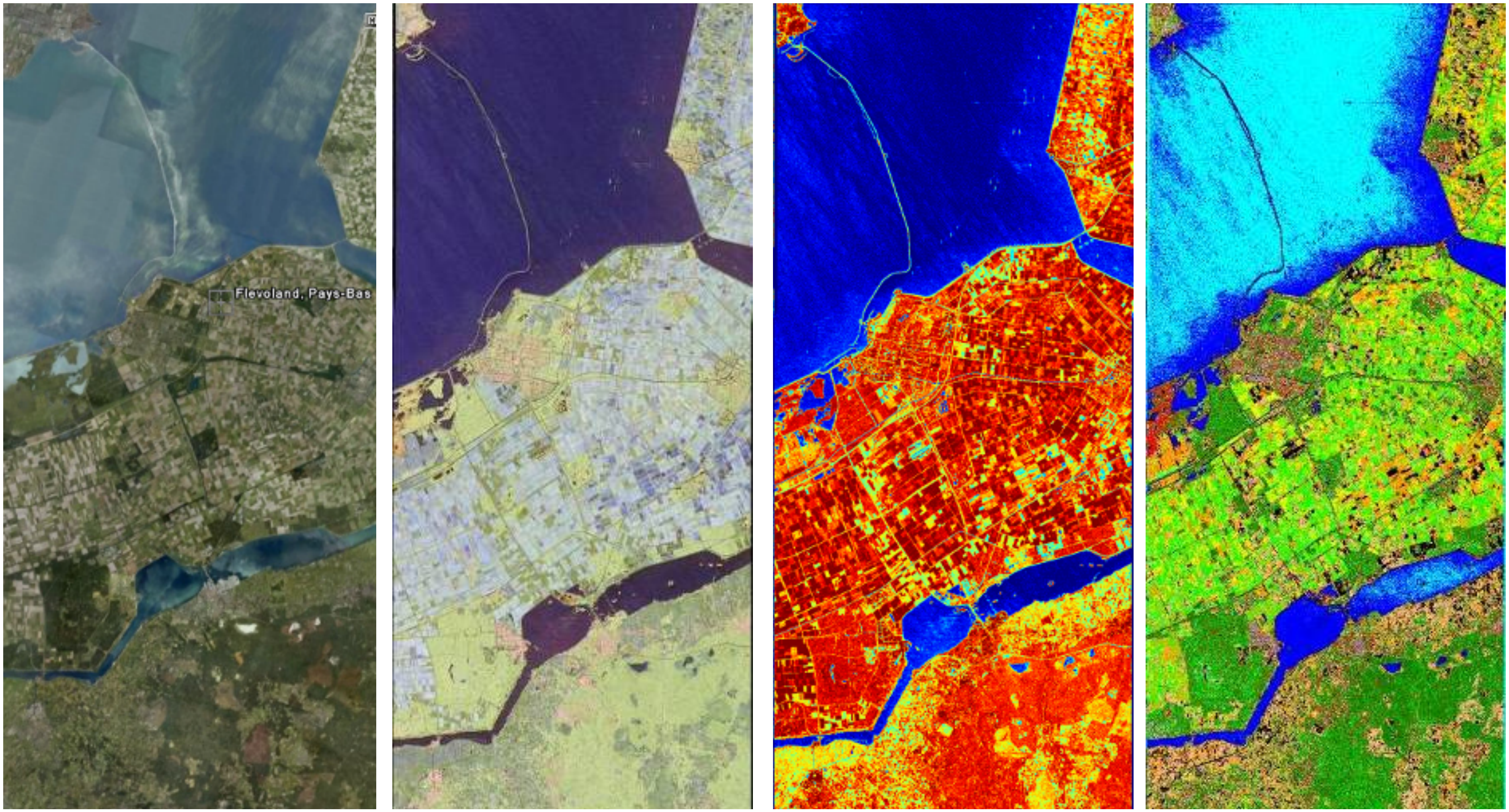


Space-borne RADARSAT2 PolSAR Sensors
San Francisco Bay – July 2008



Space-borne RADARSAT-2 PolSAR Sensors

Flevoland – July 2008



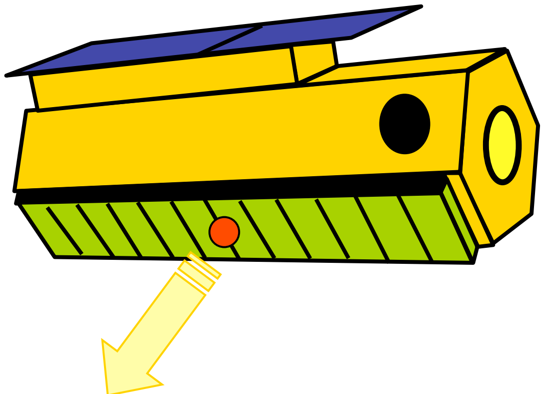
The TerraSAR-X satellite bus claims heritage from the successful Champ and Grace Missions. The spacecraft bus features a primary structure with a hexagonal cross section. The active phased array SAR antenna is attached on the Earth-facing panel in the figure. The solar array is body-mounted, a satisfactory scheme for the sun-synchronous orbit plan. The X-Band down link antenna is mounted on a 3.3 m long deployable boom in order to prevent interference with the X-Band SAR instrument. This concept enables simultaneous data acquisition and data down link.

Table 1. Selected Mode Parameters

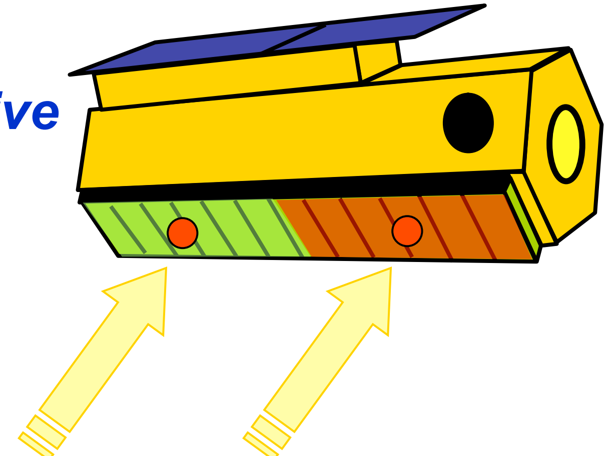
Mode (selected)	Resolution (m)	Swath (km)	Looks	Polarization
Standard, stripmap	3	30	1	HH or VV
High-resolution Spotlight	1	10	1	HH or VV
ScanSAR	16	100	1	HH or VV
Quad-pol (experimental)	3	15	1	Full polarization

Dual Receive Antenna Mode (DRA Mode)

Transmit



Receive



Principle

- **For <u>transmit</u> the full antenna is used**
- **For <u>receive</u> the antenna is ‚electrically' divided into two sections in azimuth direction ➔ two independent receive channels are available**

New Experimental Modes

- **Along-Track Interferometry (ATI)**
  (Moving Target Indication, Widespread Traffic Control, Ocean Current Measurement)
- **Quad polarization**
  (Sea/Ice, Snow Cover, Urban Environment)

Quadpol switching scheme

TX:	V	H	V	H	…
RX_1:	V	V	V	V	…
RX_2:	H	H	H	H	…
CH_1:	VV	HV	VV	HV	…
CH_2:	VH	HH	VH	HH	…

Polarization Modes

Single Polarization

- 1 polarization channel, {HH, VV}
- stripmap, spotlight, ScanSAR

Dual Polarization

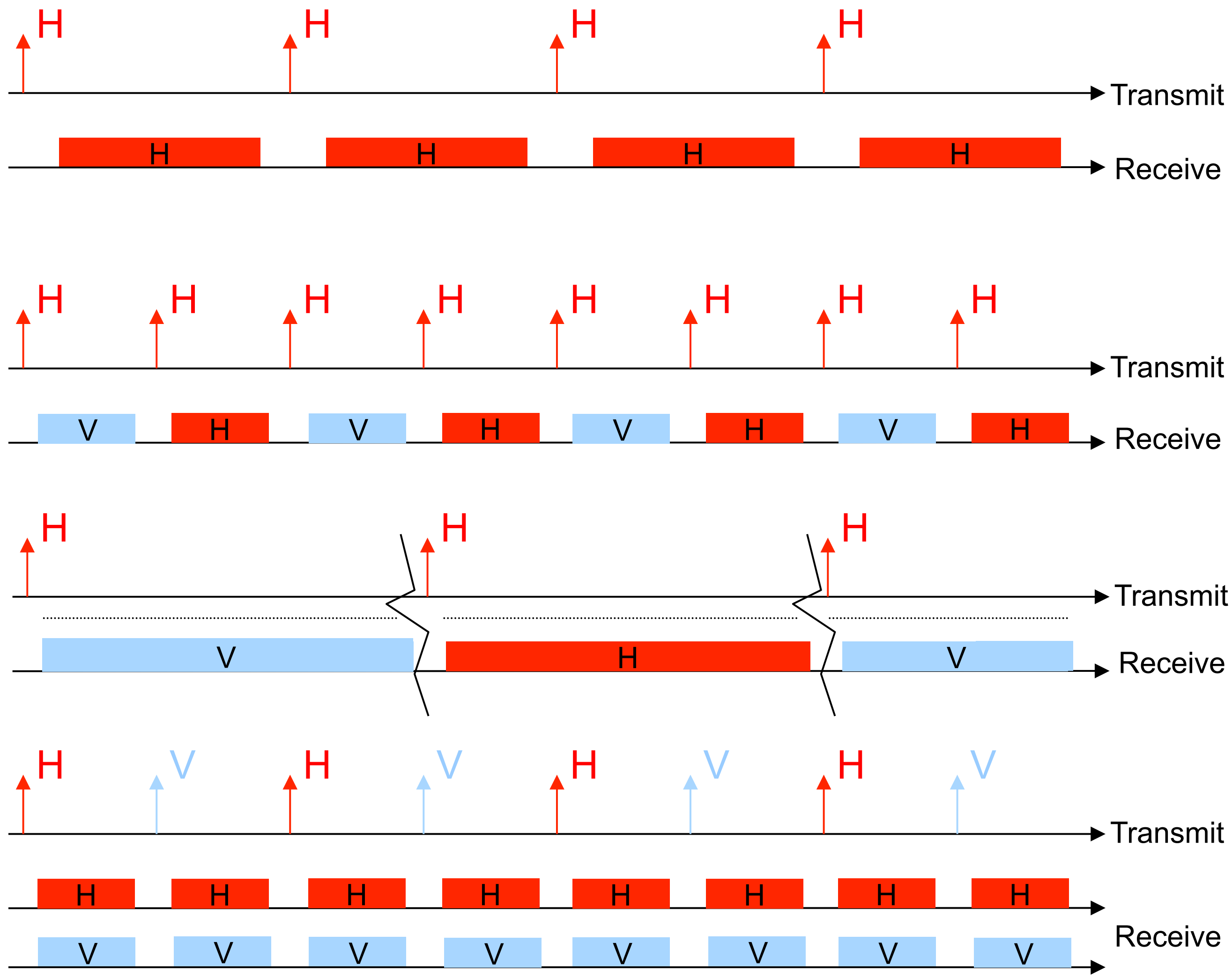
- 2 polarization channels, {HH/VV, HH/HV, VV/VH}
- stripmap, spotlight
- coherent pol. phase
- smaller elevation beam

Twin Polarization

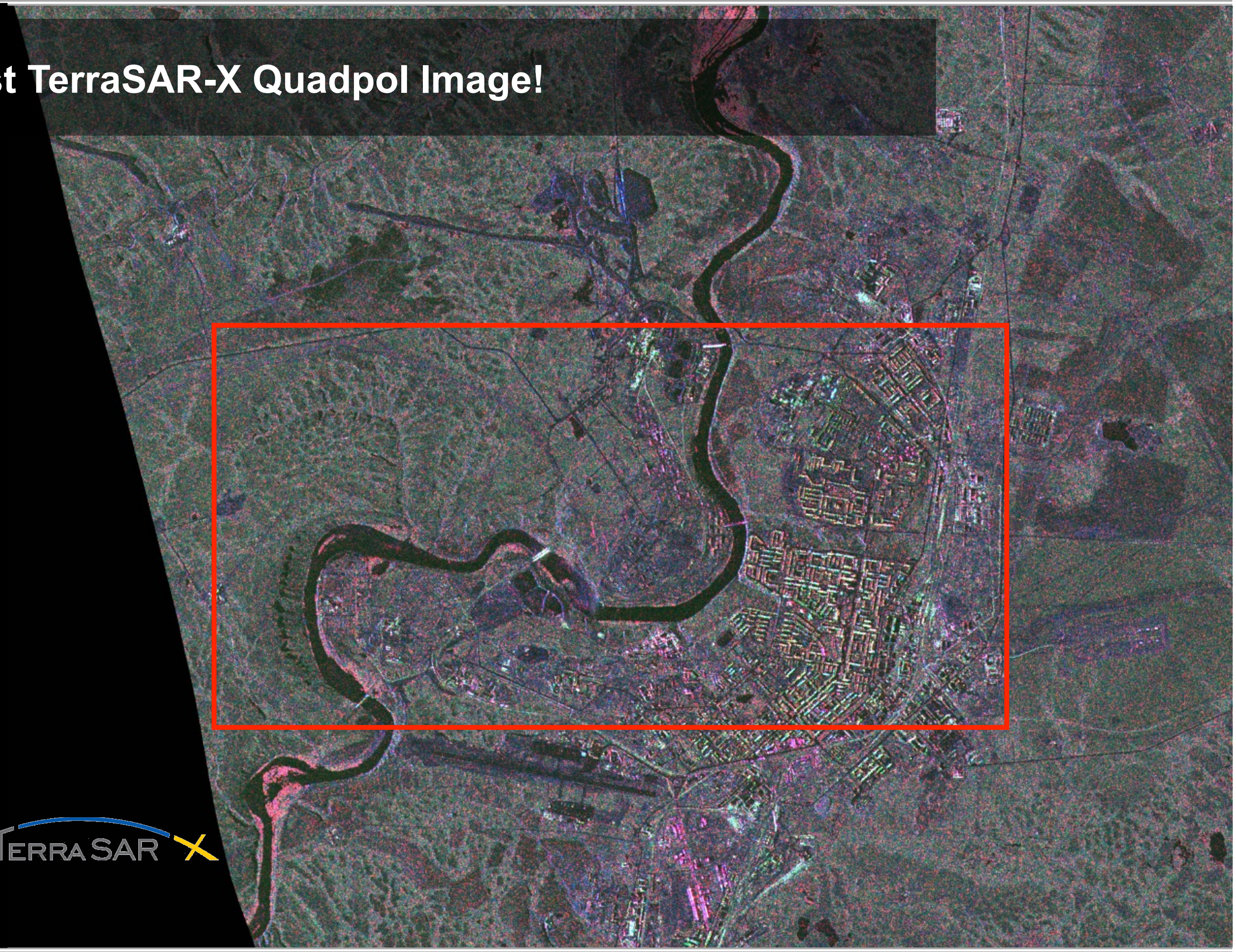
- 2 polarization channels, {HH/VV, HH/HV, VV/HV}
- Stripmap, incoherent pol-phase, full el beam

Quad Polarization

- All 4 pol. channels
- Stripmap
- coherent pol. Phase
- smaller elevation beam
- Experimental product



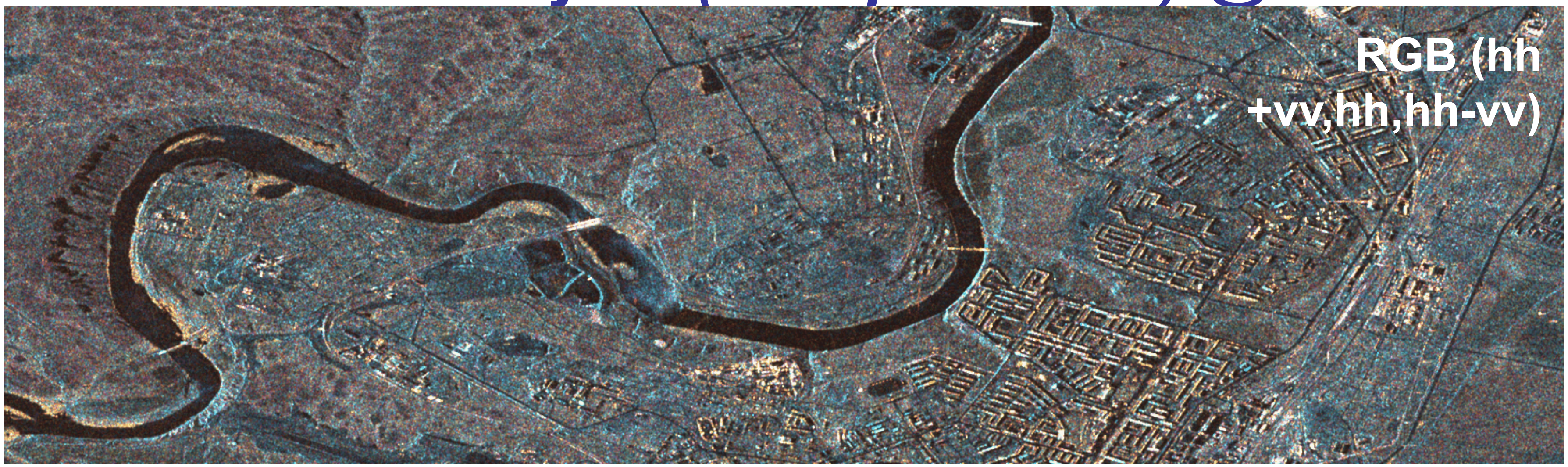
First TerraSAR-X Quadpol Image!

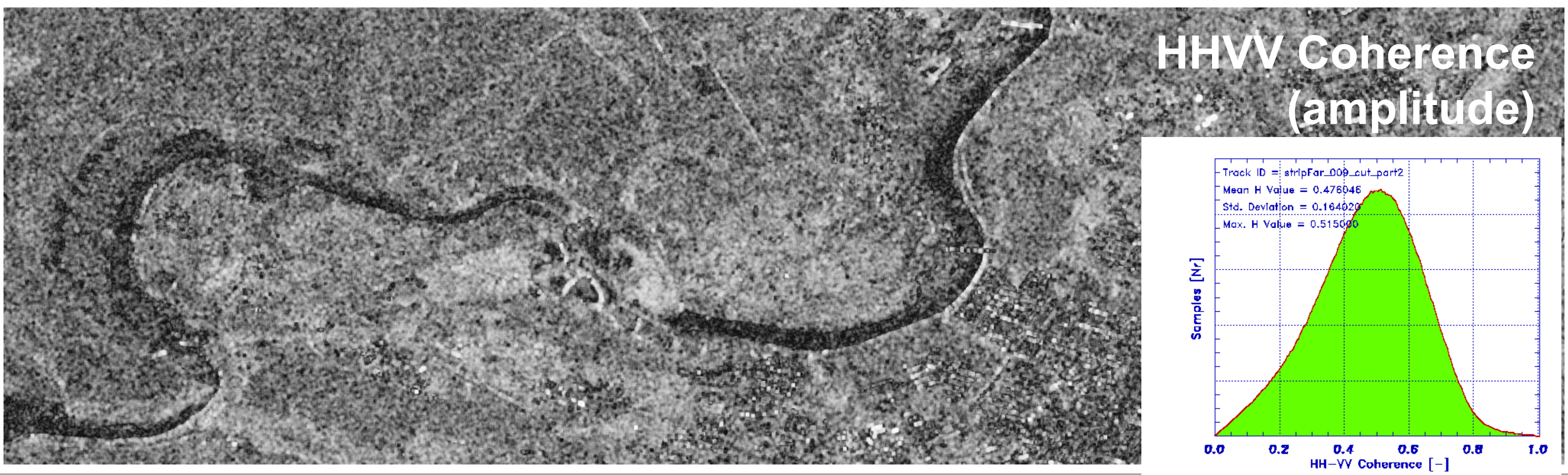


Workuta, Russia
Stripmap
June 23, 2008
red: HH-VV
green: (HV+VH)/2
blue: HH+VV

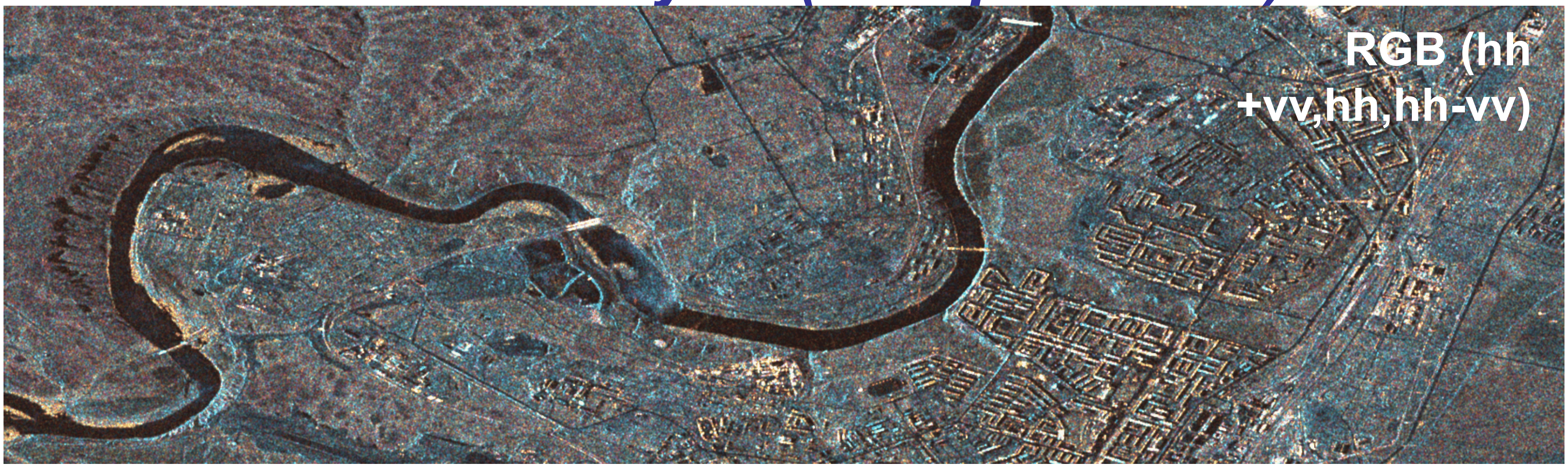
DLR
TERRASAR X

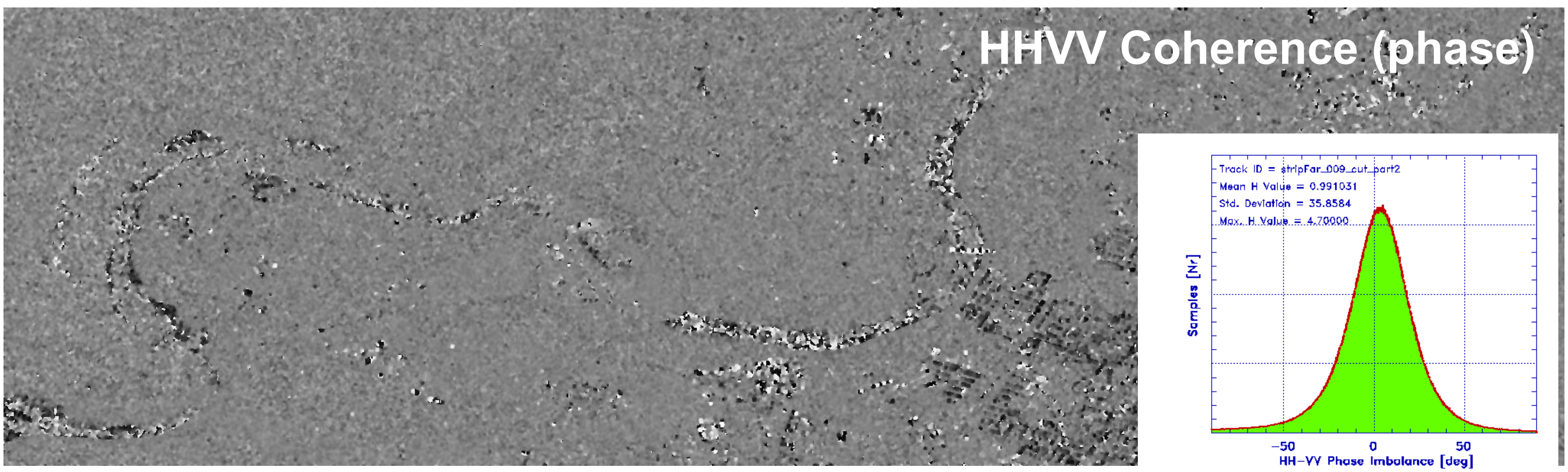
Polarimetric Analysis (dual pol HHVV) @ X-



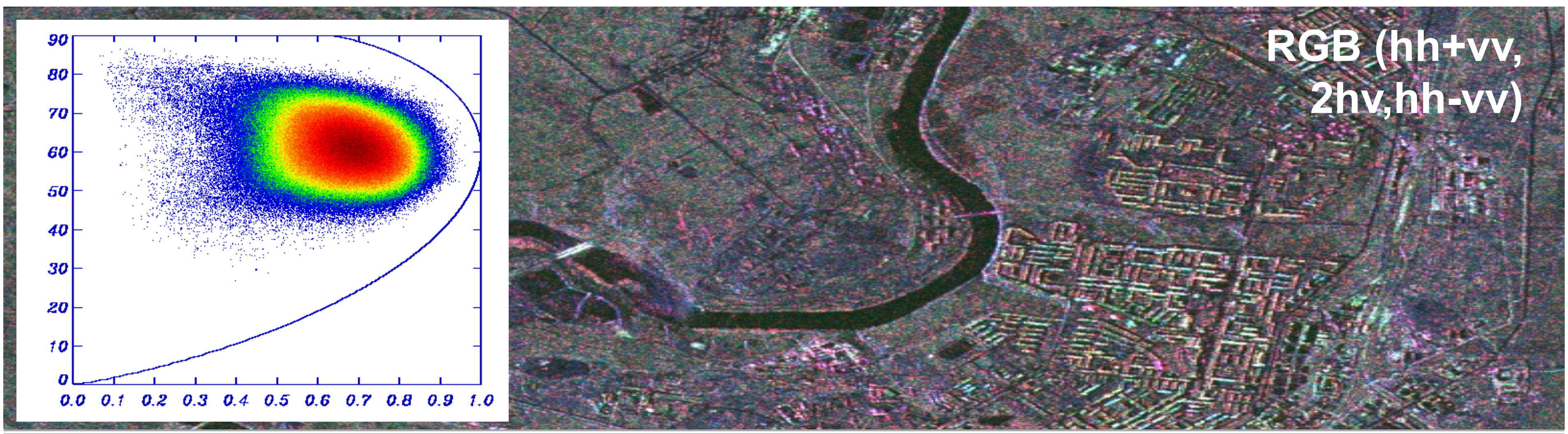


Polarimetric Analysis (dual pol HHVV)

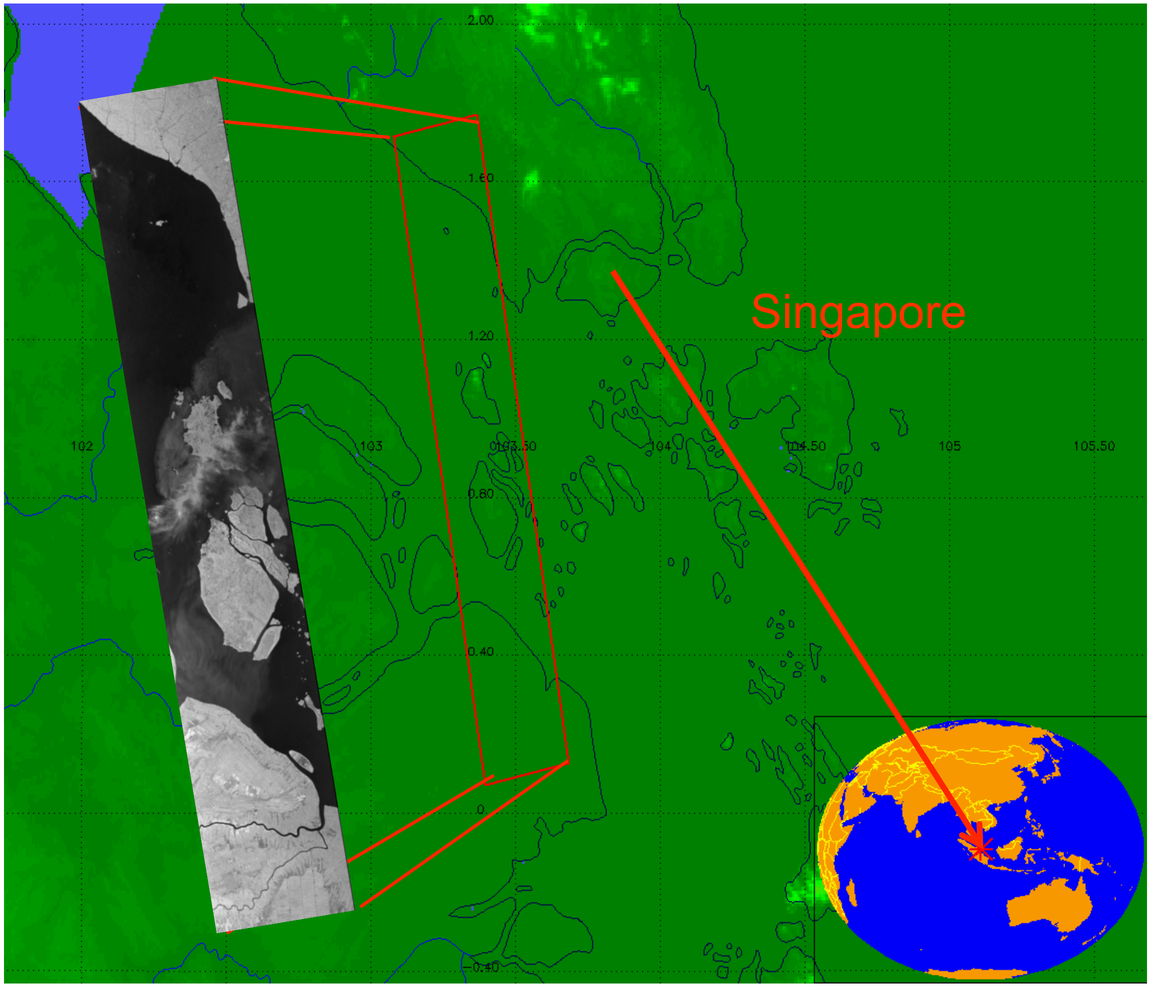




Polarimetric Analysis (dual pol HHVV vs quad pol)



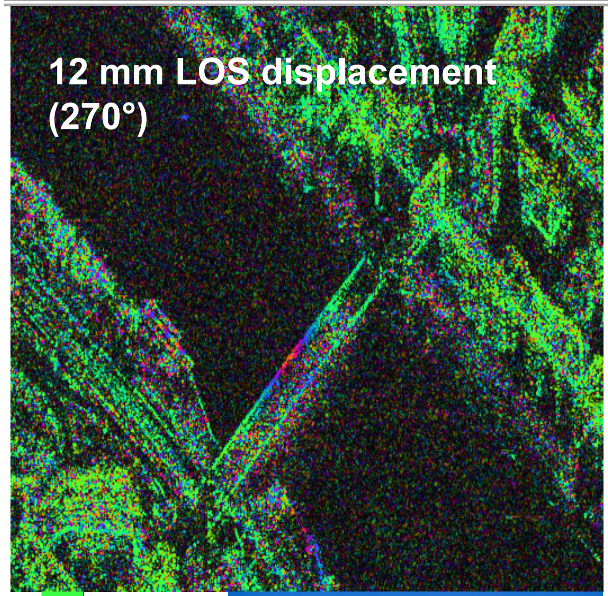
Clouds over Melaka Strait
TerraSAT-X X-Band



A. Danklmayer

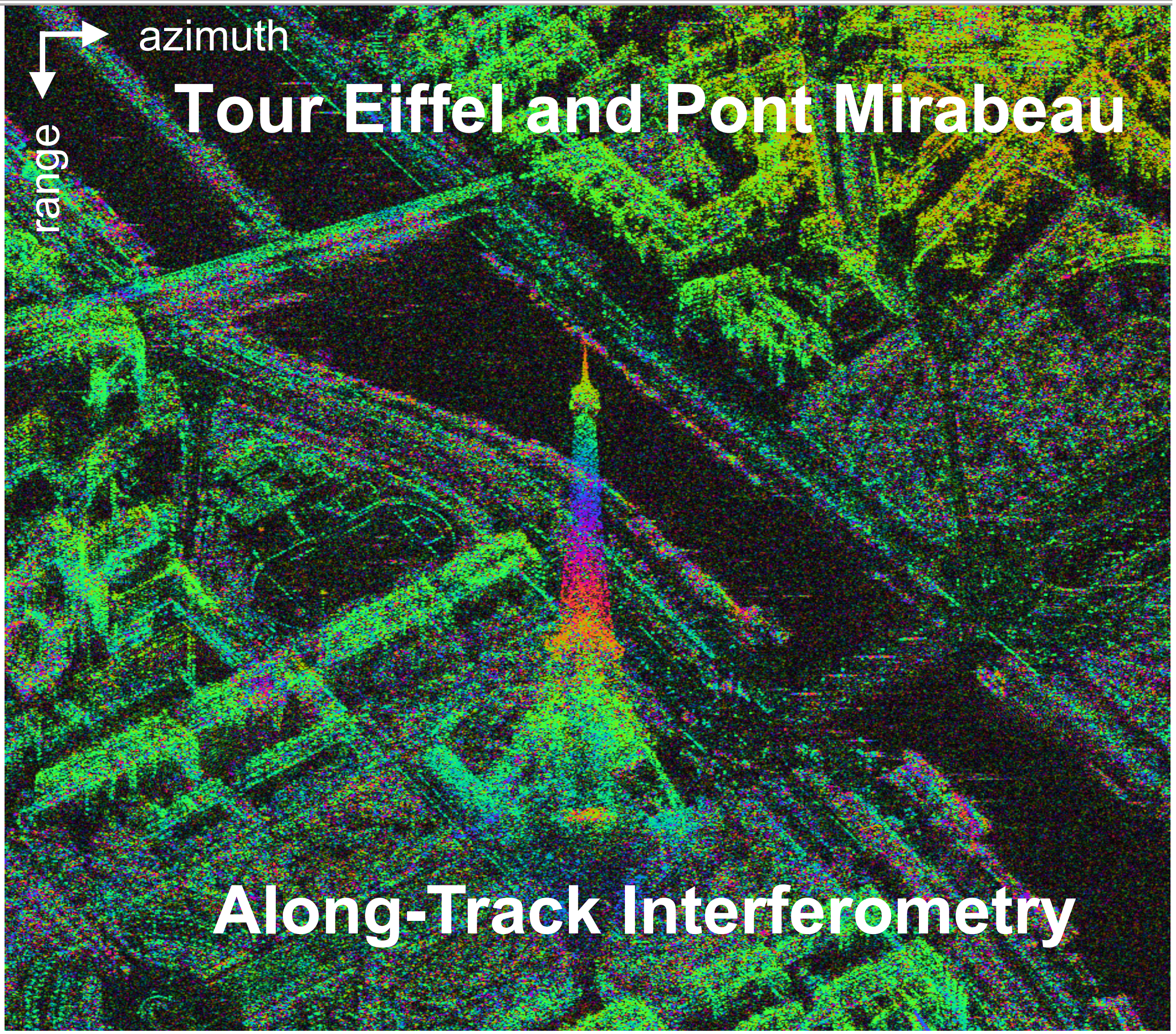
Microwaves and Radar Institute

German Aerospace Center (DLR)


12 mm LOS displacement
(270°)


360°
0°


325 m


azimuth
range
Tour Eiffel and Pont Mirabeau
Along-Track Interferometry

POLARIMETRIC AIRBORNE SAR SENSORS

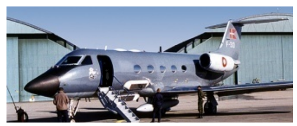
AES1
AeroSensing (D)
GulfStream Commander
X-Band (HH), P-Band (Quad)

AIRSAR
NASA / JPL (USA)
DC8
P, L, C-Band (Quad)

DOSAR
EADS / Dornier GmbH (D)
DO 228 (1989), C160 (1998), G222 (2000)
S, C, X-Band (Quad), Ka-Band (VV)

RENE
UVSQ / CETP (F)
Écureuil AS350
S, X-Band (Quad)

ESAR
DLR (D)
DO 228
P, L, S-Band (Quad)
C, X-Band (Sngl)



EMISAR
DCRS (DK)
G3 Aircraft
L, C-Band (Quad)

MEMPHIS / AER II-PAMIR
FGAN (D)
Transal C160
Ka, W-Band (Quad) / X-Band (Quad)

STORM
UVSQ / CETP (F)
Merlin IV
C-Band (Quad)

PHARUS
TNO - FEL (NL)
CESSNA – Citation II
C-Band (Quad)

PISAR
NASDA / CRL (J)
GulfStream
L, X-Band (Quad)

RAMSES
ONERA (F)
Transal C160
P, L, S, C, X, Ku, Ka, W-Band (Quad)

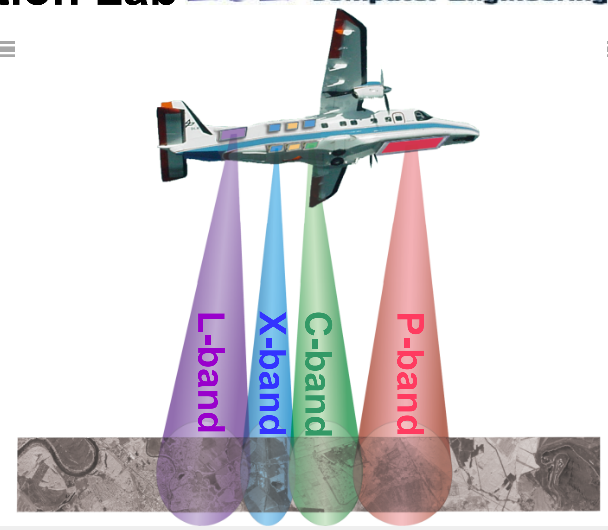
SAR580
CCRS (CA)
Convair CV-580
C, X-Band (Quad)

+ CASSAR (China), MIT/Lincoln Lab (USA), P3-SAR (NADC / ERIM -USA), Military Systems …

E-SAR and F-SAR

- The E-SAR and F-SAR are operated onboard DLR's DO228-212 D-CFFU by the Microwaves and Radar Institute in cooperation with DLR's Flight Facilities based in Oberpfaffenhofen

  The F-SAR is currently in development and is planned to fully replace the E-SAR until middle of 2011



New features:

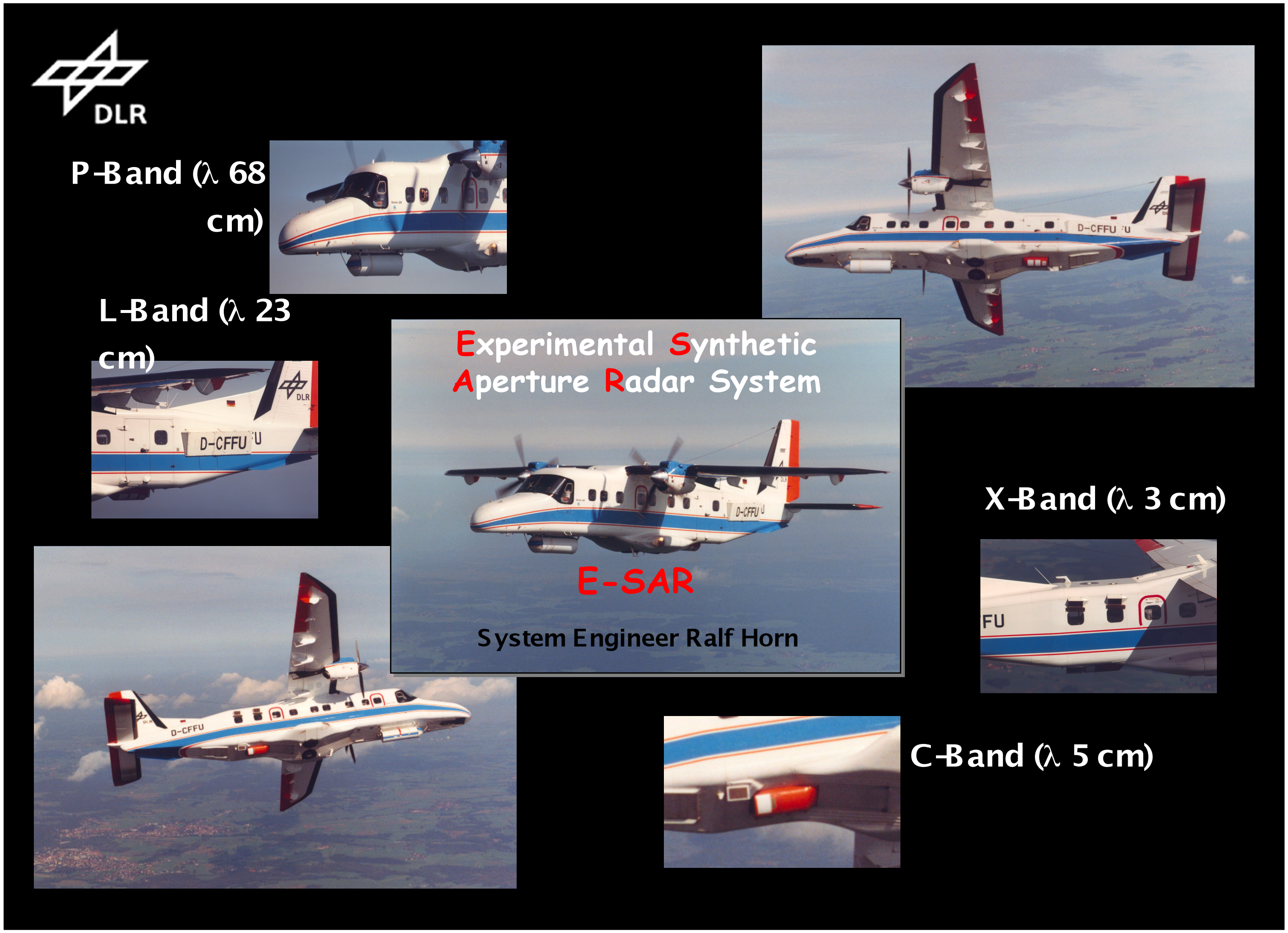
- significantly enhanced resolution and image quality
- simultaneous data recording in up to four frequency bands
- modular design for easy reconfiguration
- single-pass polarimetric interferometry in X- and S-band
- fully polarimetric capability in all frequencies

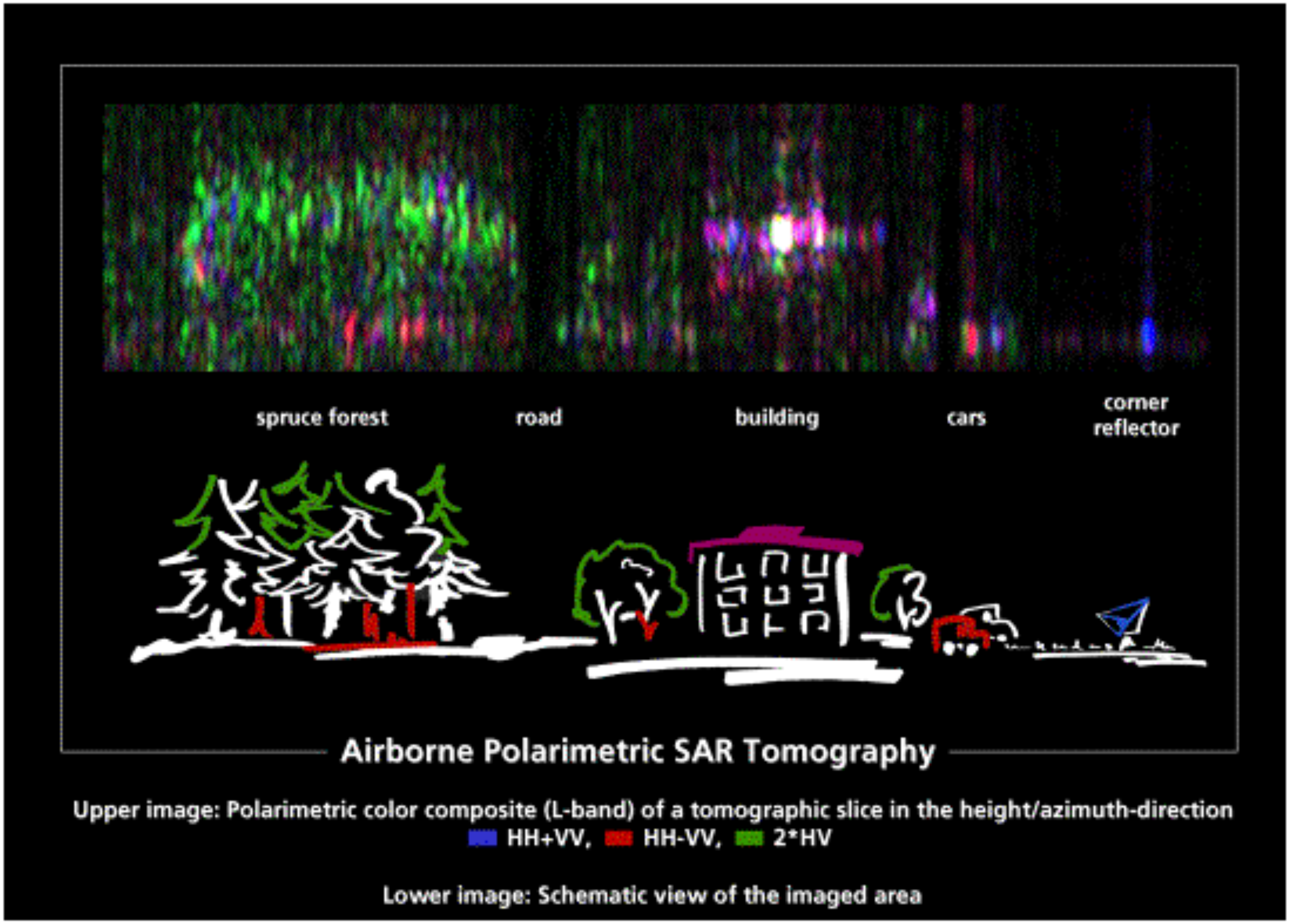
E-SAR technical characteristics

	X	C	L	P
RF [GHz]	9.6	5.3	1.3	0.35
BW [MHz]	50-100 (selectable)			
PRF [kHz]	up to 2			
Rg res. [m]	1.5	1.5	2.0	3.0
Az res. [m]	0.2	0.3	0.4	1.5
Pol/InSAR	-/+	-/-	+/o	+/o
Rg cov [km]	3-5			
Sampling	6-8 Bit complex; 100MHz; max number of samples 4 K per range line; 1 recording channel.			

F-SAR technical characteristics

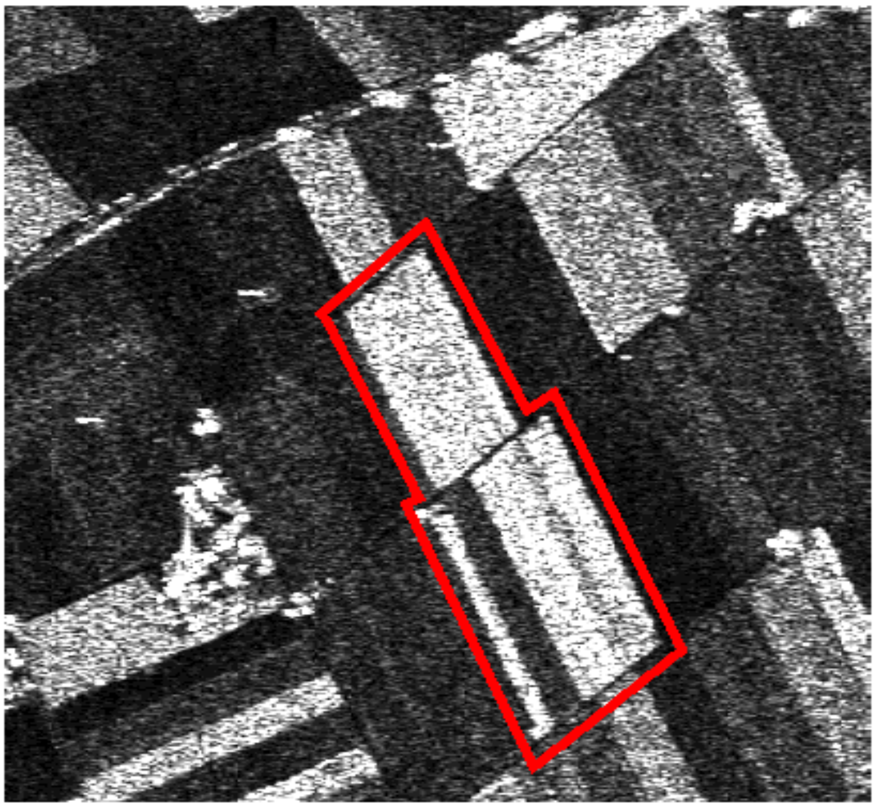
	X	L	P	C	S
RF [GHz]	9.6	5.3	3.2	1.3	0.35
BW [MHz]	800	400	300	150	100
PRF [kHz]	up to 12				
Rg res. [m]	0.3	0.6	0.75	1.5	2.25
Az res. [m]	0.2	0.3	0.35	0.4	1.5
Pol/InSAR	+/+	+/o	+/+	+/o	+/o
Rg cov [km]	12.5		(at max.bandwith)		
Sampling	8 Bit real; 1000MHz; max number of samples 64 K per range line; 4 recording channels.				


DLR
P-Band (λ 68 cm)
L-Band (λ 23 cm)
Experimental Synthetic Aperture Radar System
E-SAR
System Engineer Ralf Horn
X-Band (λ 3 cm)
C-Band (λ 5 cm)
D-CFFU

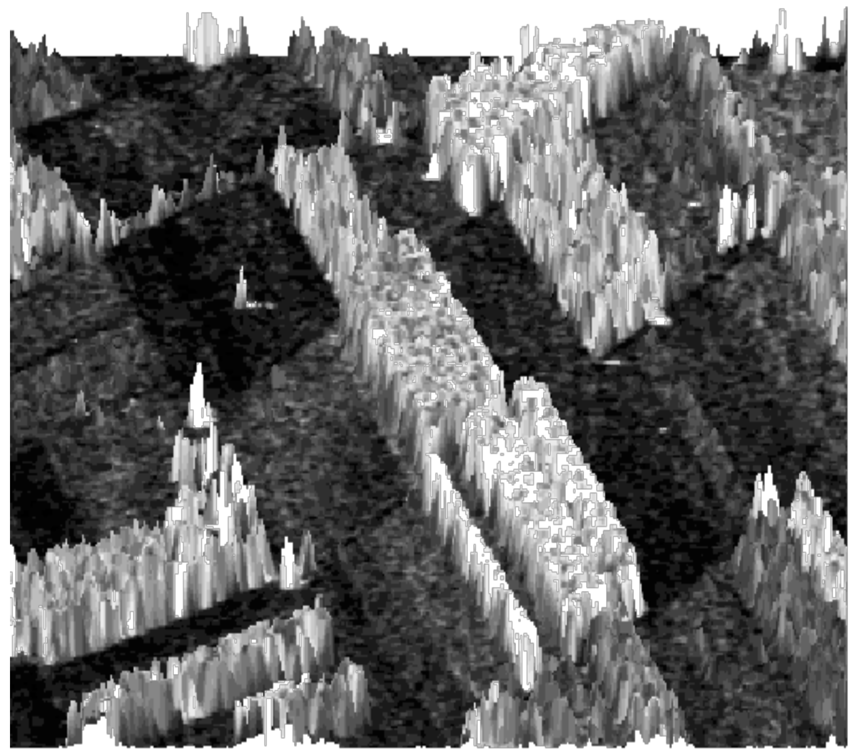

spruce forest
road
building
cars
corner reflector
Airborne Polarimetric SAR Tomography
Upper image: Polarimetric color composite (L-band) of a tomographic slice in the height/azimuth-direction
HH+VV, HH-VV, 2*HV
Lower image: Schematic view of the imaged area

Random-Volume-over-Ground Model Inversion Results

ESAR / Test Site: Kuettighoffen, Switzerland

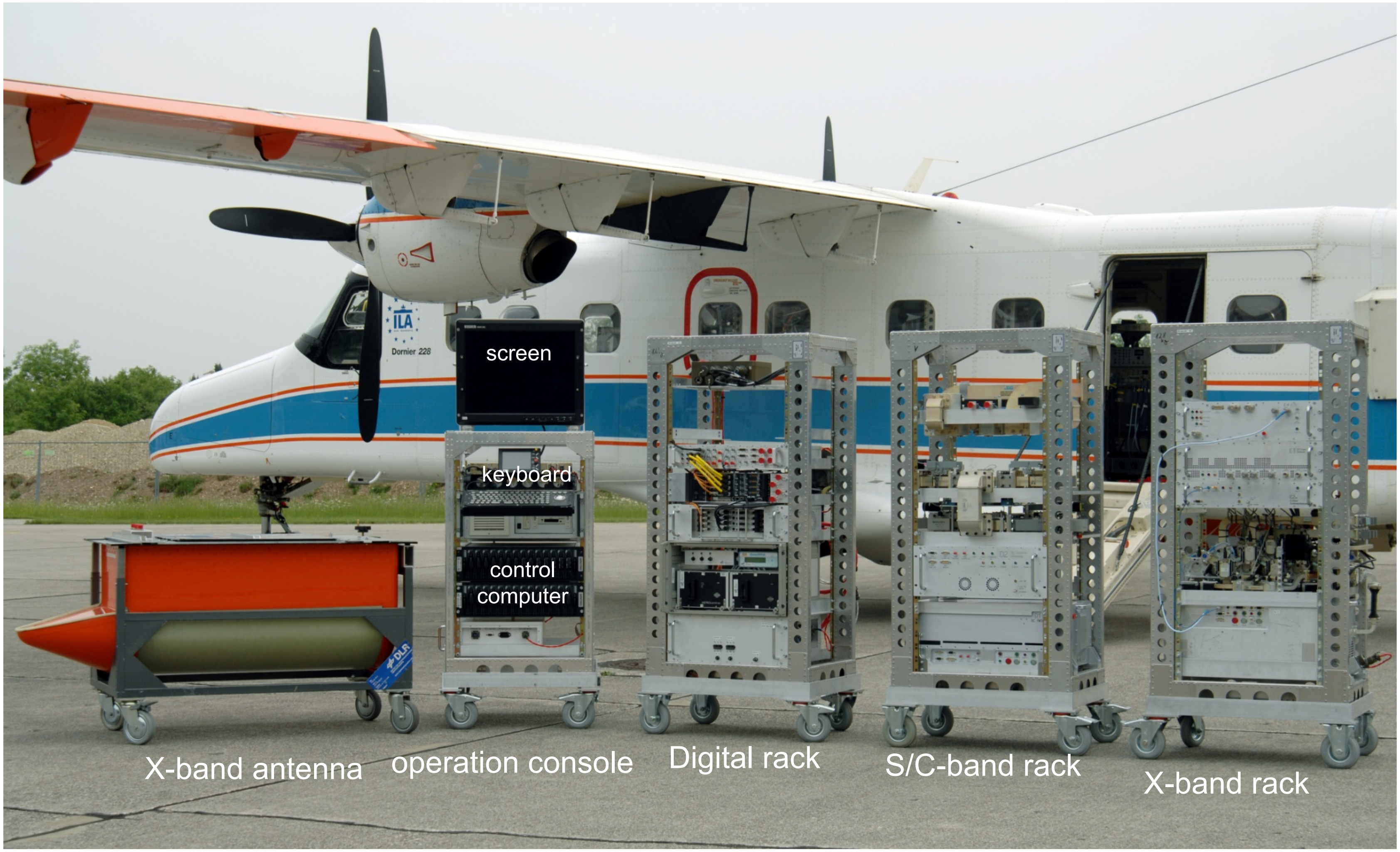


SAR Image L-band



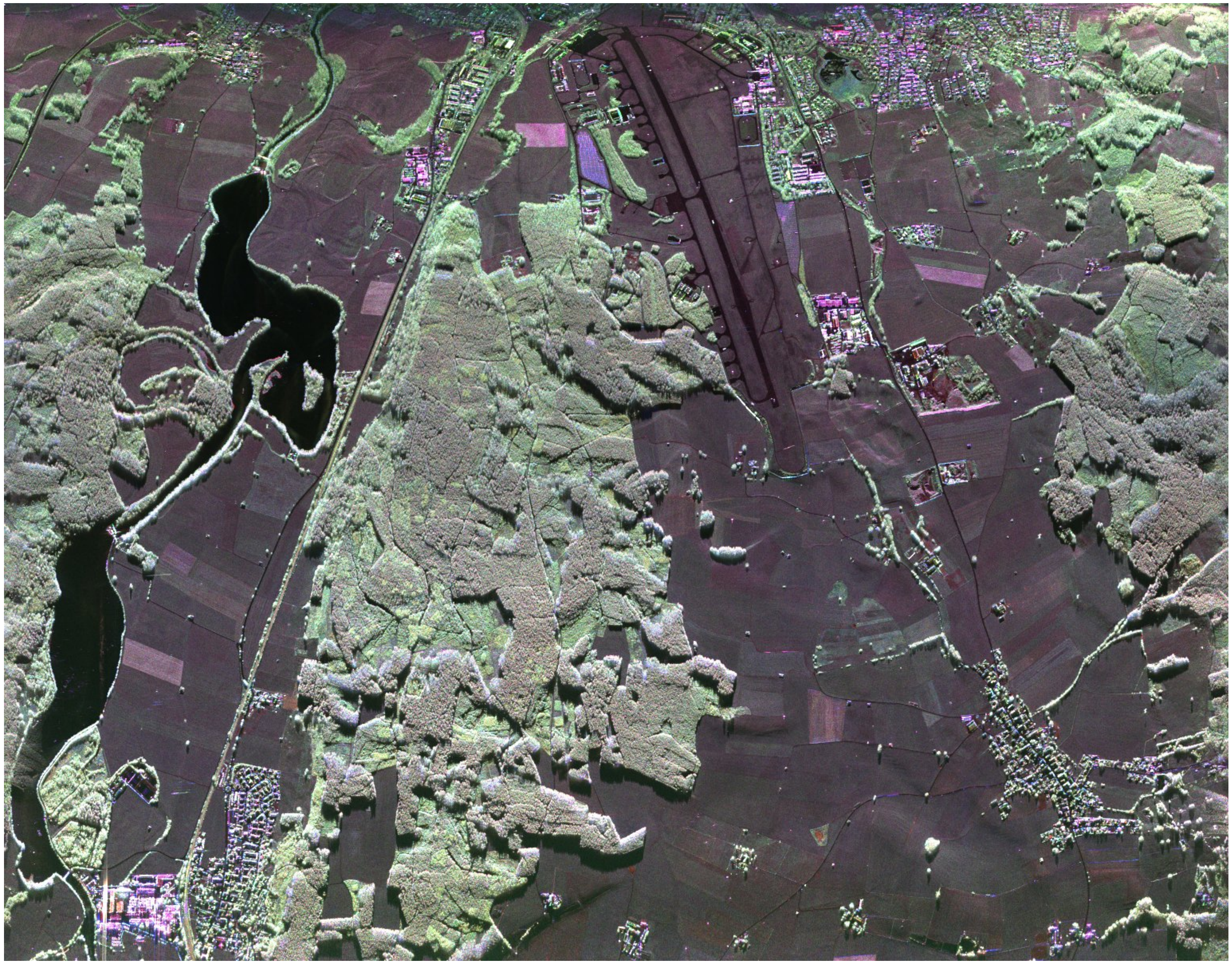
Corn Height Map

DLR-HR’s new SAR sensor



F-SAR X-Band Quad-Pol

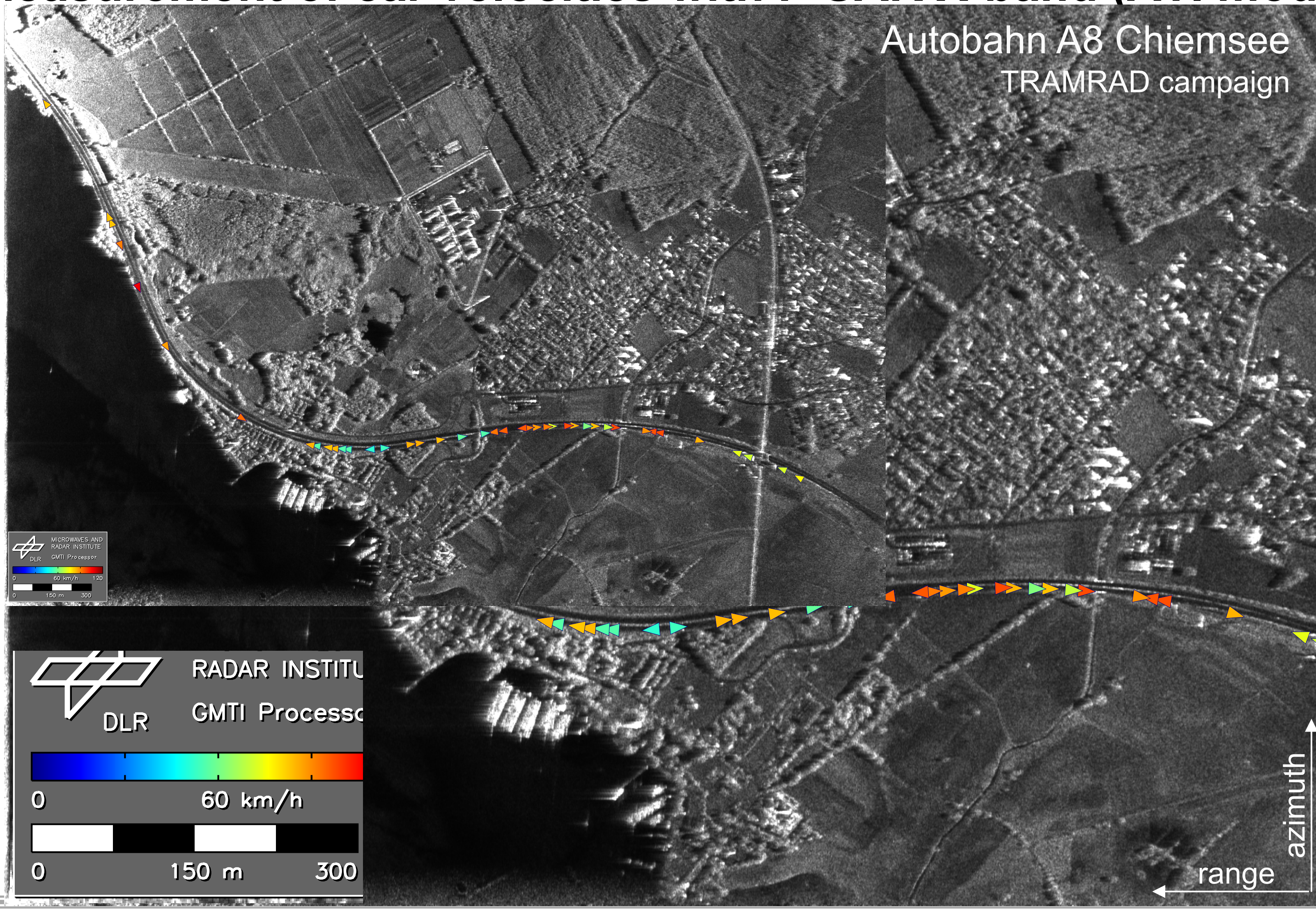
DLR
F-SAR
S-band
Quad-Pol



DLR
F-SAR
S-band
Quad-Pol

Zoom

Measurement of car velocities with F-SAR X-band (ATI mode)

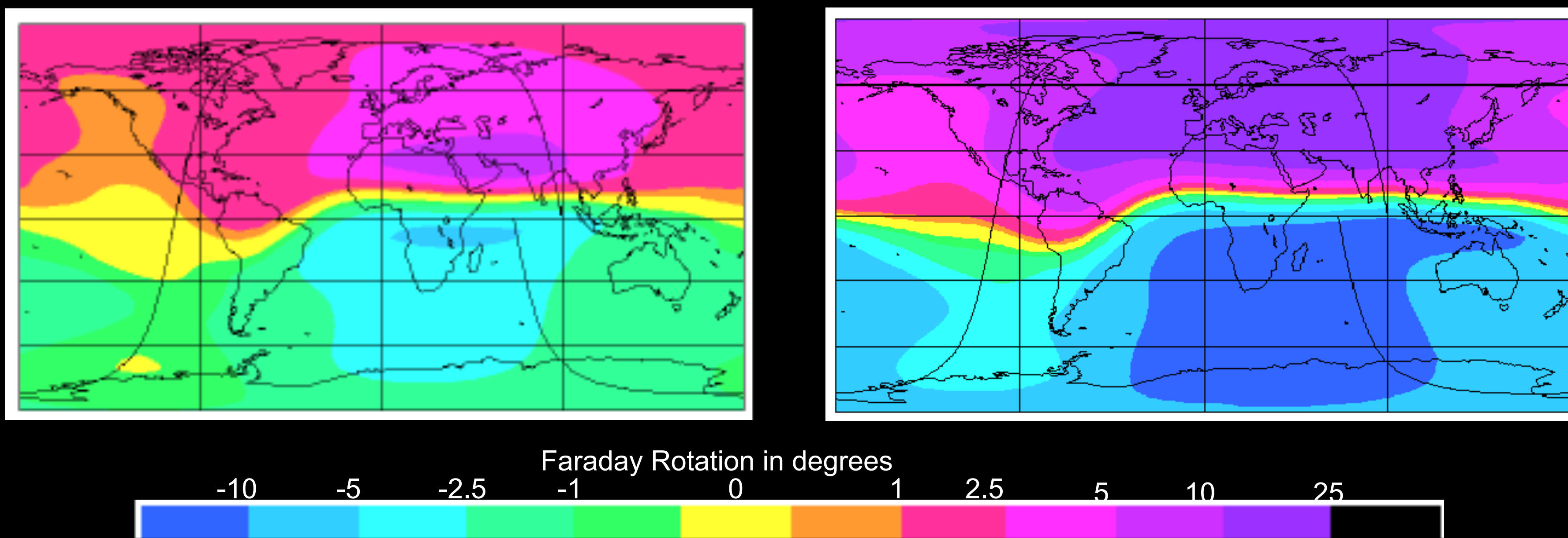


Ionosphere Problem

Model predictions of FR based on TEC, magnetic field

Mean Faraday Rotation at L-Band, April, GMT = 12:00

Moderate Sunspot activity — High Sunspot activity



$$[M_\Omega] = \begin{pmatrix} M_{HH} & M_{HV} \\ M_{VH} & M_{VV} \end{pmatrix} = \begin{pmatrix} \cos\Omega & \sin\Omega \\ -\sin\Omega & \cos\Omega \end{pmatrix} \begin{pmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{pmatrix} \begin{pmatrix} \cos\Omega & \sin\Omega \\ -\sin\Omega & \cos\Omega \end{pmatrix}$$

ONERA JPL Courtesy of Dr. P. Dubois-Fernandez and A. Freeman – POLINSAR09

THE UAVSAR INSTRUMENT: DESCRIPTION AND EXAMPLE DATA SETS

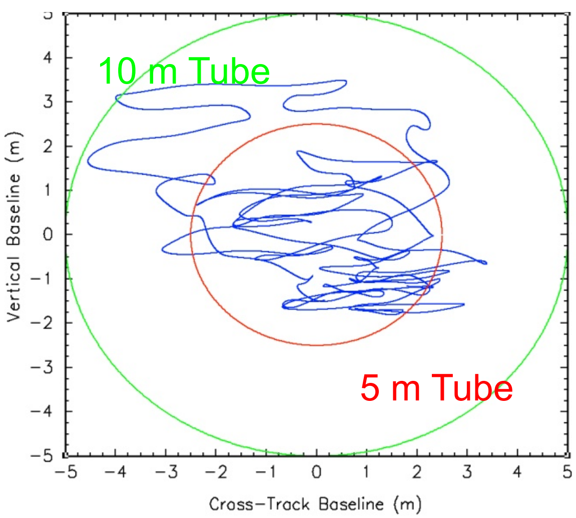
Dr Scott Hensley
PI and Chief Scientist

UAVSAR Overview

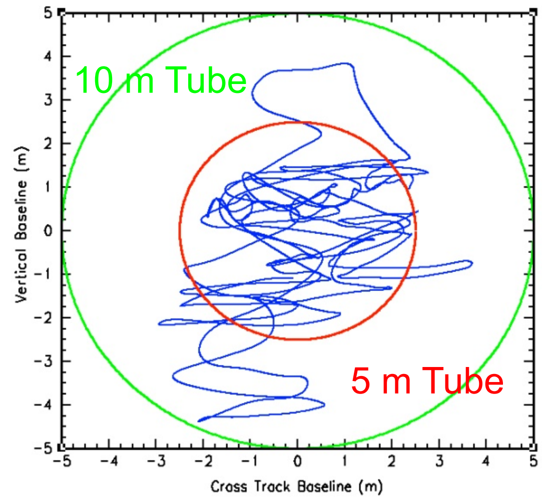
- UAVSAR developed under NASA ESTO funding beginning in 2004.
- UAVSAR is an L-band fully polarimetric SAR employing an electronically scanned antenna that has been designed to support a wide range of science investigations.
  - Science investigations supported by UAVSAR include solid earth, cryospheric studies, vegetation mapping and land use classification, archeological research, soil moisture mapping, geology and cold land processes.
  - To support science applications requiring repeat pass observations such as solid earth and vegetation applications the UAVSAR design incorporates:
    - A precision autopilot developed by NASA Dryden that allows the platform to fly repeat trajectories that are mostly within a 5 m tube.
    - Compensates for attitude angle changes during and between repeat tracks by electronically pointing the antenna based on attitude angle changes measured by the INU.
- UAVSAR is testing new experimental modes, e.g. the multi-squint mode whereby data is collected simultaneously at multiple squint angles to enable vector deformation measurements with a single repeat pass.

Initial Flight Testing of UAVSAR

Mt. St Helens Repeot Poss Boseline
5 m Tube in Red – 10 m Tube in Grreen.

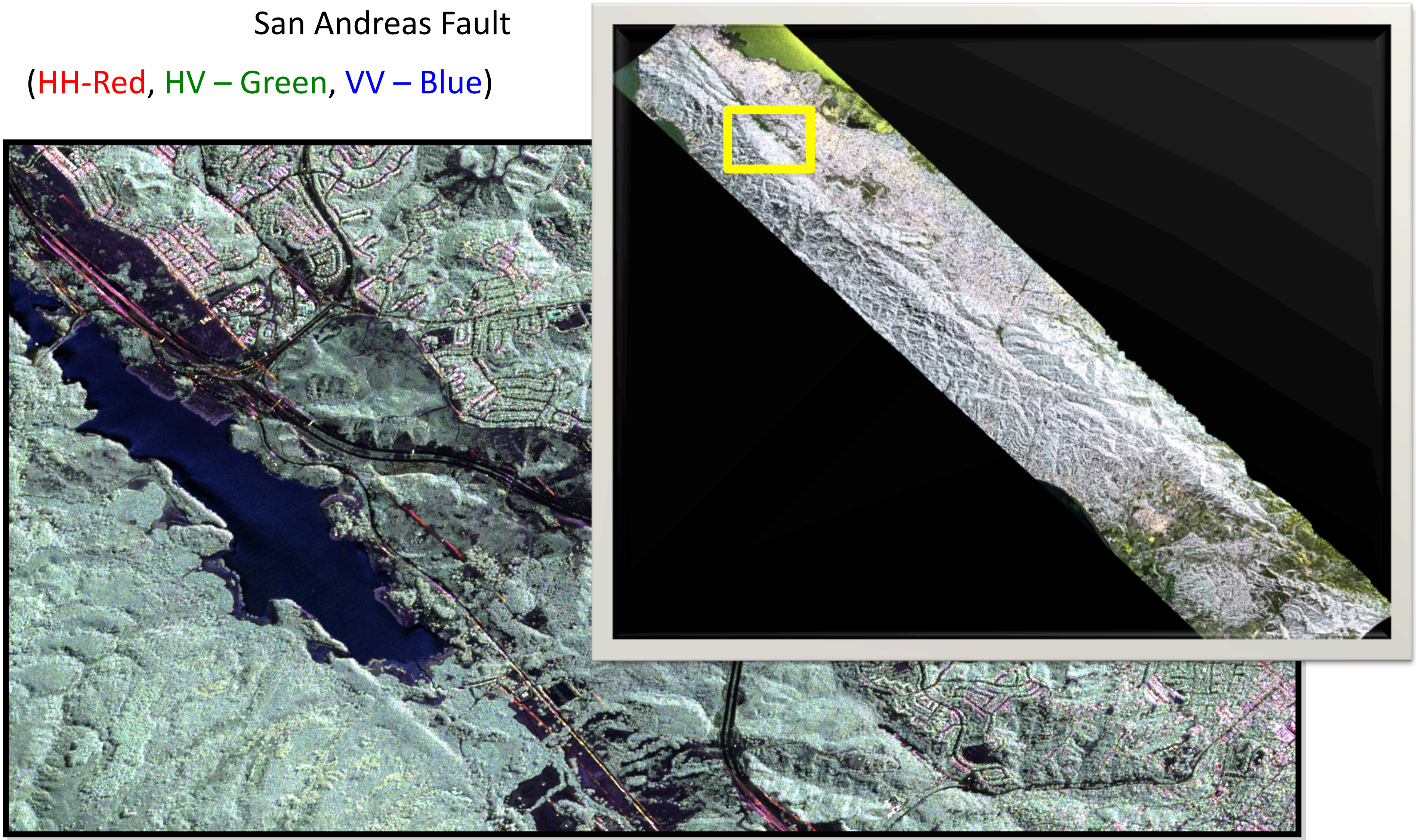


San Andreas Fault Repeat-Pass Baseline
80 km Datatakes on February 12 and 20 of 2008.

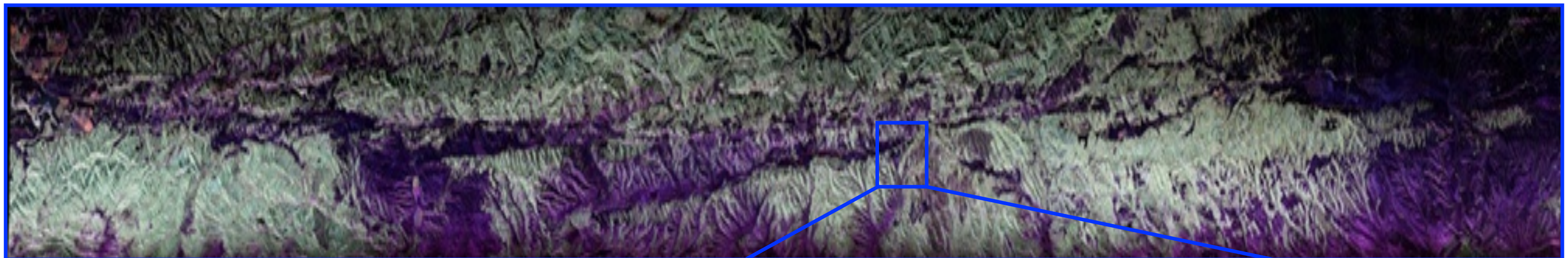


San Andreas Fault

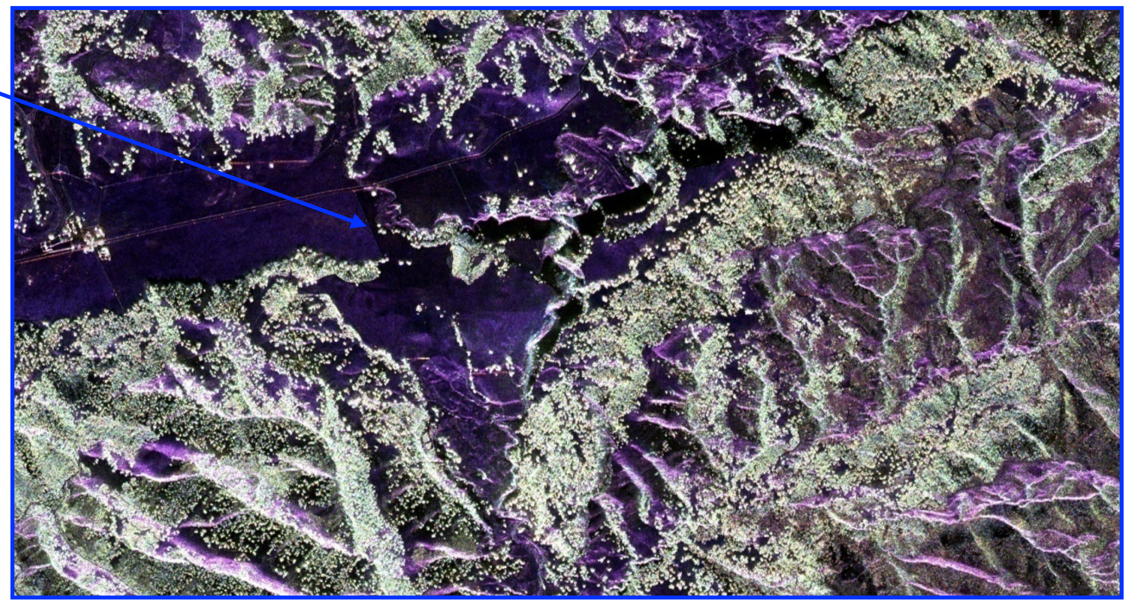
(HH-Red, HV – Green, VV – Blue)



San Andreas Fault Imagery



The same trees in Google Earth image can be seen in UAVSAR L-band image



The different colors in the UAVSAR image generally correspond to different vegetation characteristics on the surface. Compensation for & projection to surface topography not applied.

1 km

LHH=red
LHV=green
LVV=blue

Data collected Feb 12, 2008

2x6 looks (3m resolution)

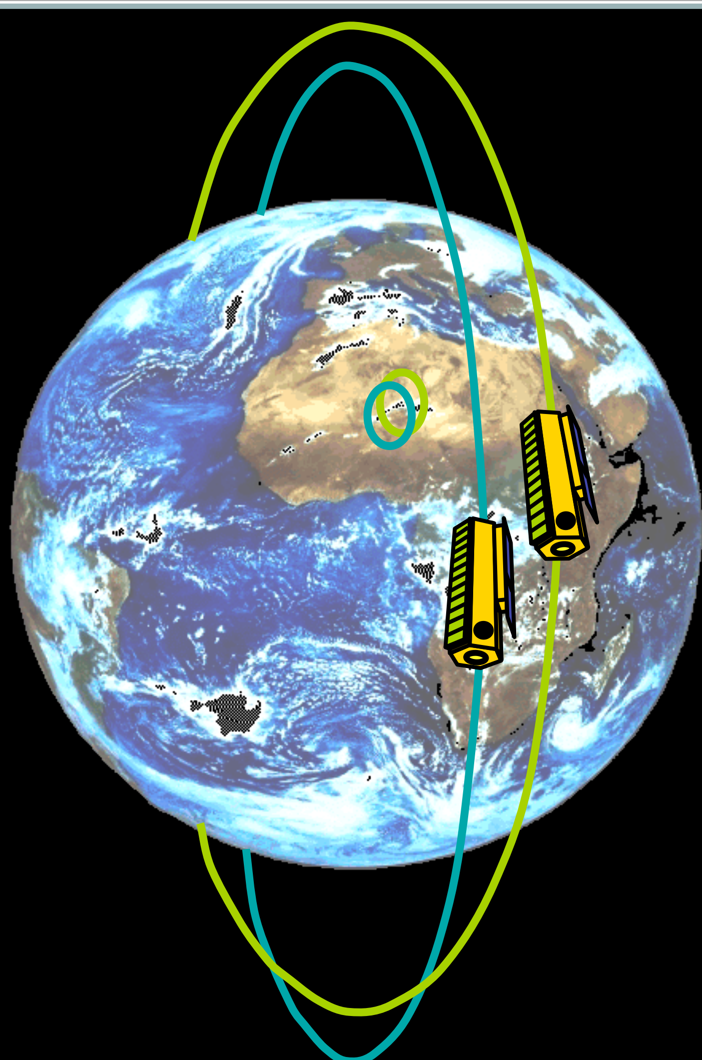
5. Outlook & Future Needs

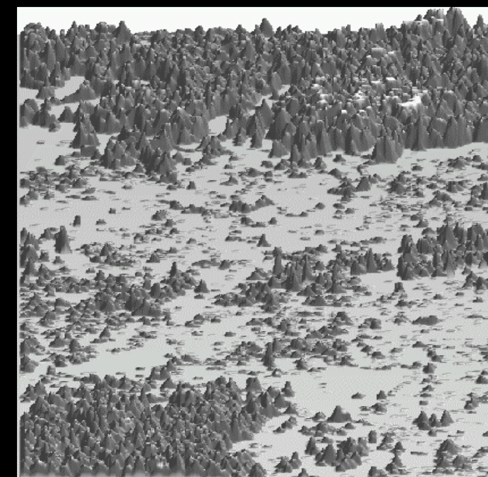
- New Sensors, space-borne: TandemSAR-X, TandemSAR-L (Destiny), . . .
-New Sensors, air-borne: F-SAR (P, L, S, C, X, K, V, W) , …
- New Sensors, ultrahigh air-borne: JPL-UAV (Global Hawks), ...

- Algorithm Developments: Fully Polarimetric RP-POLinSAR assessment

- Applications: Focused increase providing clear-cut successes

6. POLinSAR 2011 Single & Tandem Space-borne POL-SAR Sensors, Increase number of Text books & Training Workshops

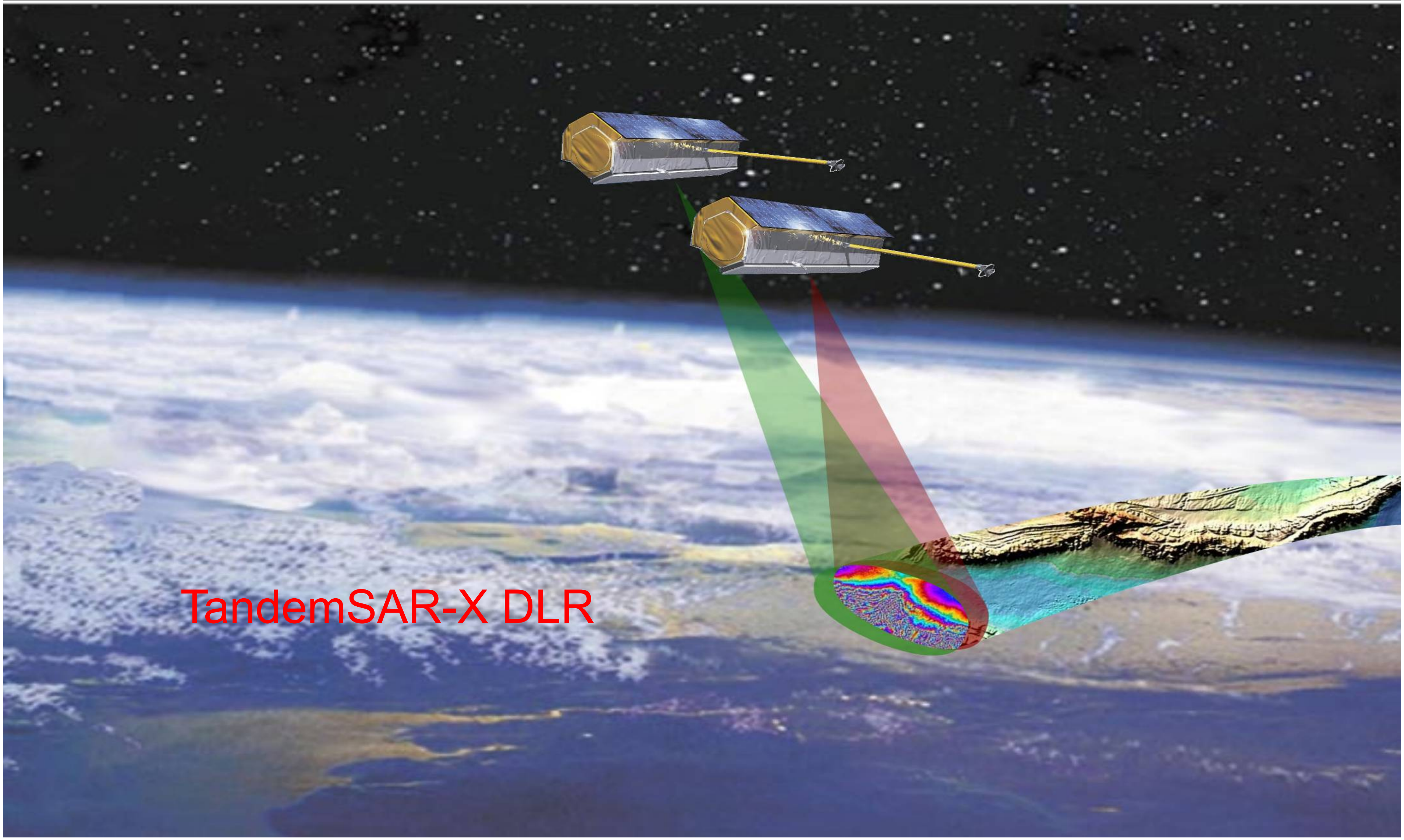


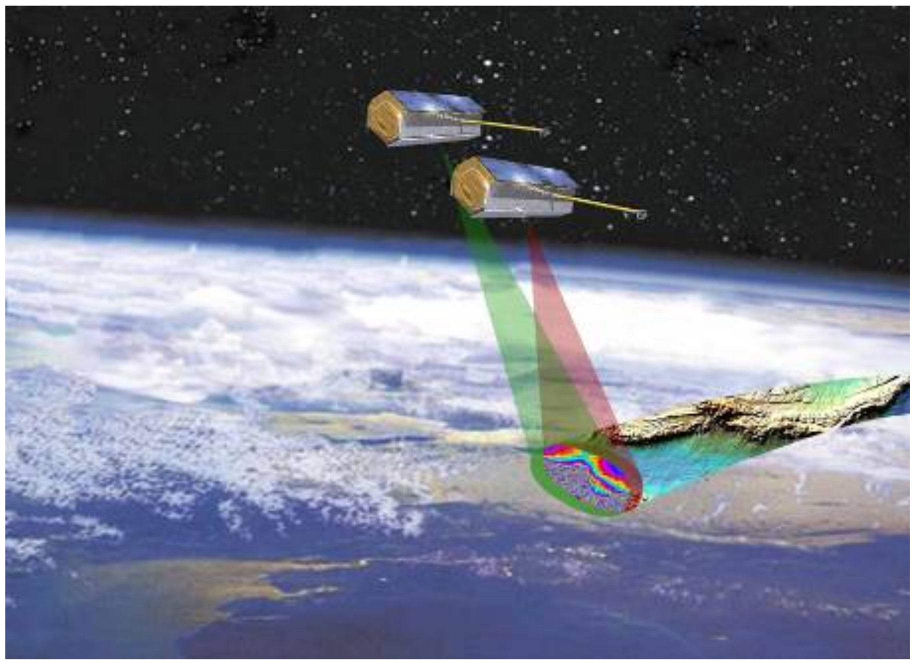


Global Monitoring of Bio-, Geo-, Cryo- and Hydrosphere processes with hith temporal and spatial resolution.

(Prof. A. Moreira – POLINSAR09)

Radar Interferometry

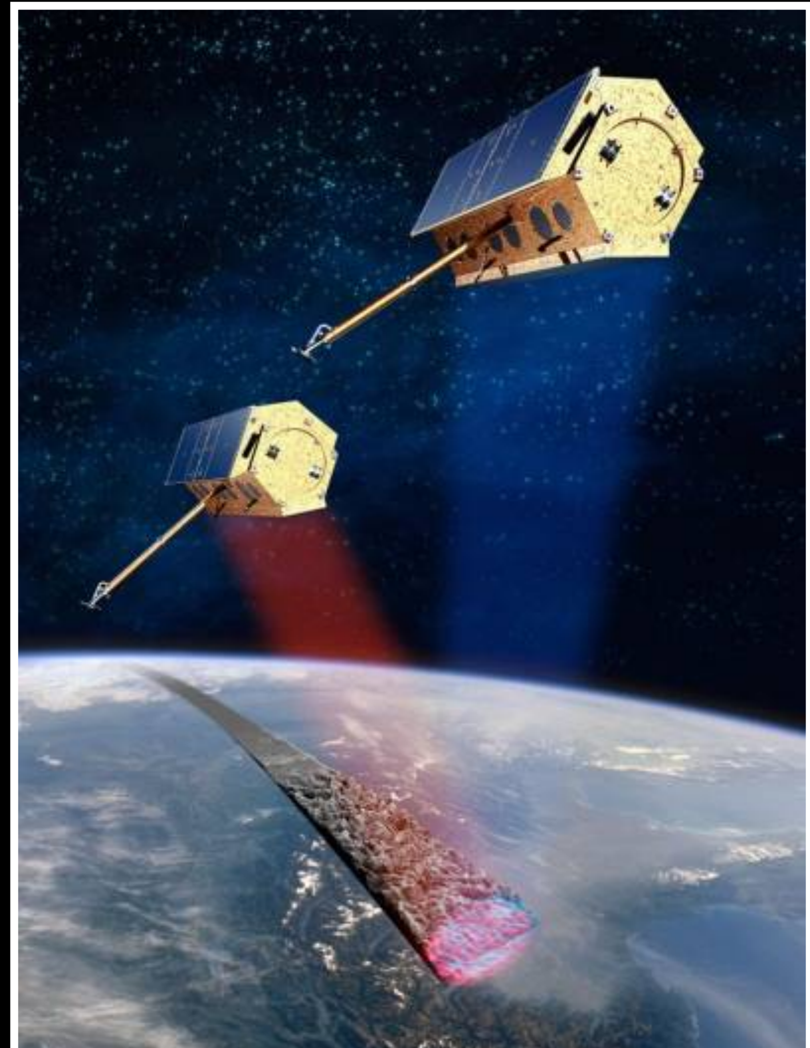

TandemSAR-X DLR



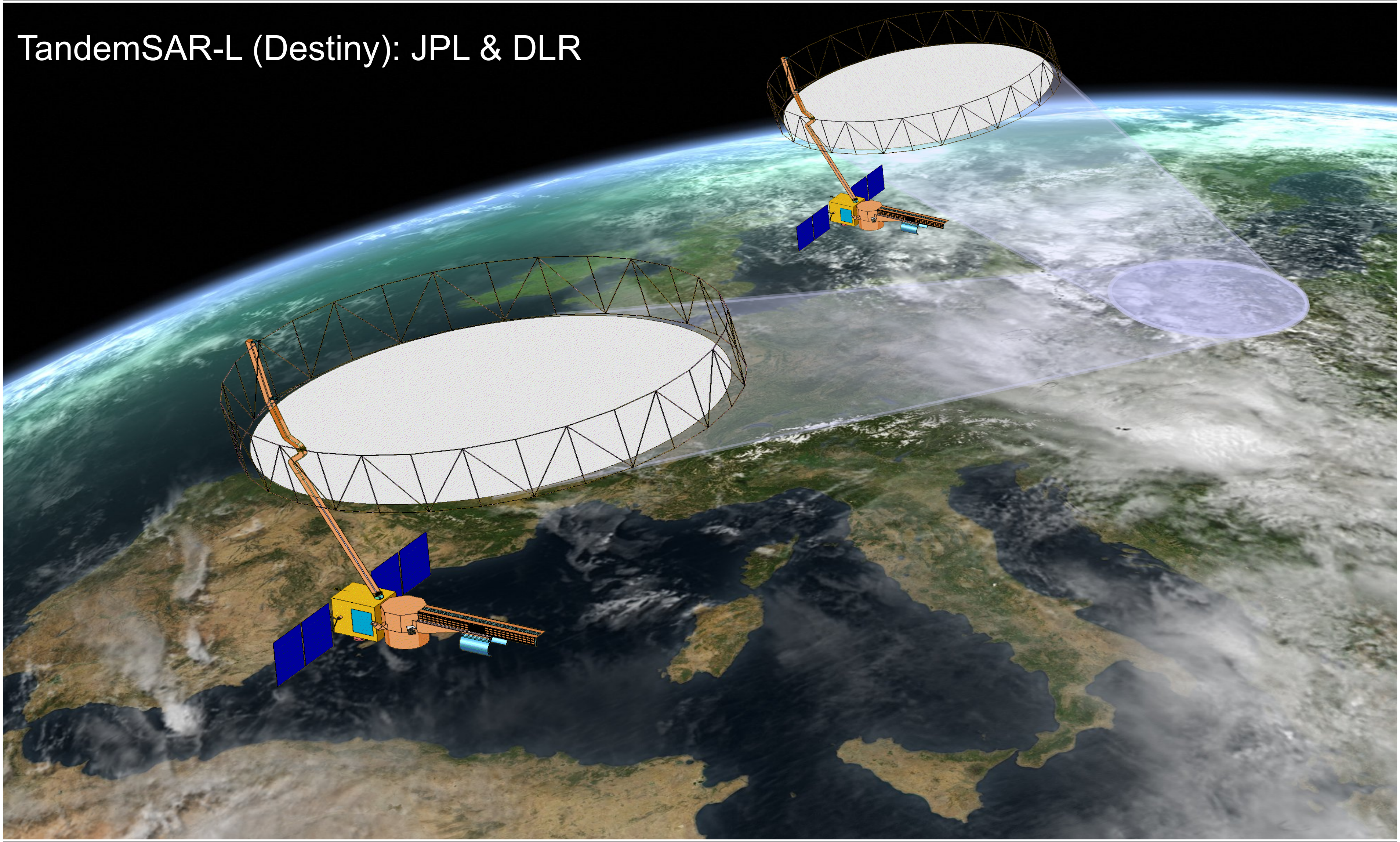
TerraSAR – X (1 & 2)
(2010)

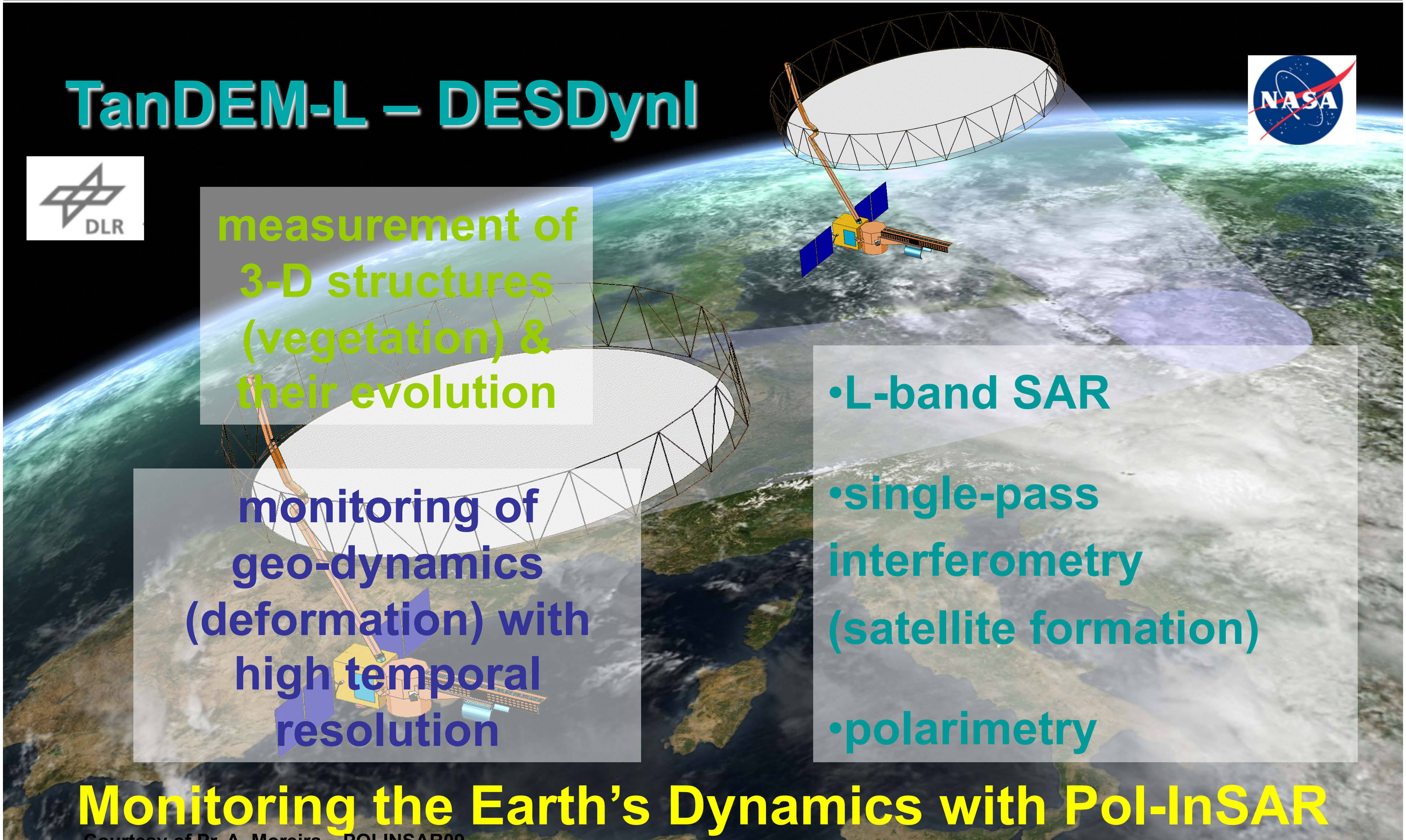
Pol – InSAR Sensors

TanDEM-X



TandemSAR-L (Destiny): JPL & DLR



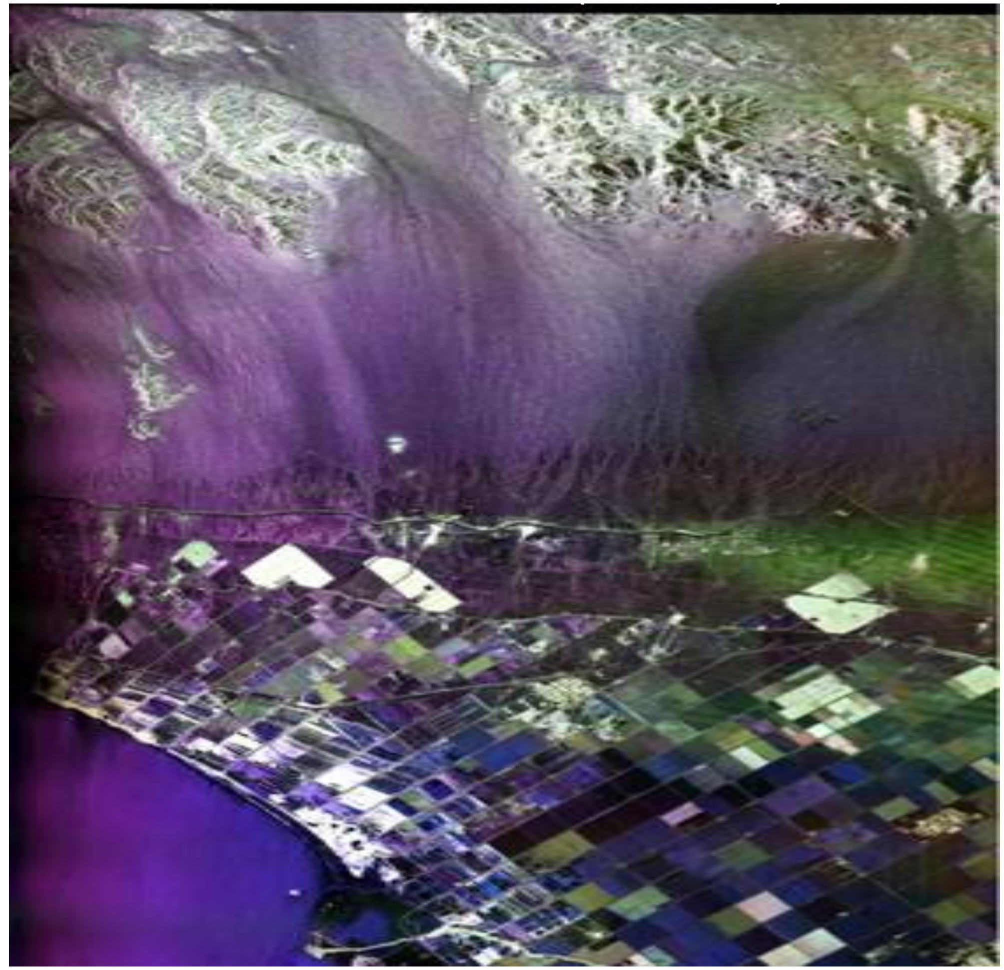

TanDEM-L – DESDynI
DLR
NASA
measurement of 3-D structures (vegetation) & their evolution
monitoring of geo-dynamics (deformation) with high temporal resolution
•L-band SAR
•single-pass interferometry (satellite formation)
•polarimetry
Monitoring the Earth's Dynamics with Pol-InSAR
Courtesy of Pr. A. Moreira – POLINSAR09

Upcoming High-altitude PolSAR Sensors

UAVSAR JPL

Gulf-Stream III

L (Quad - Pol)



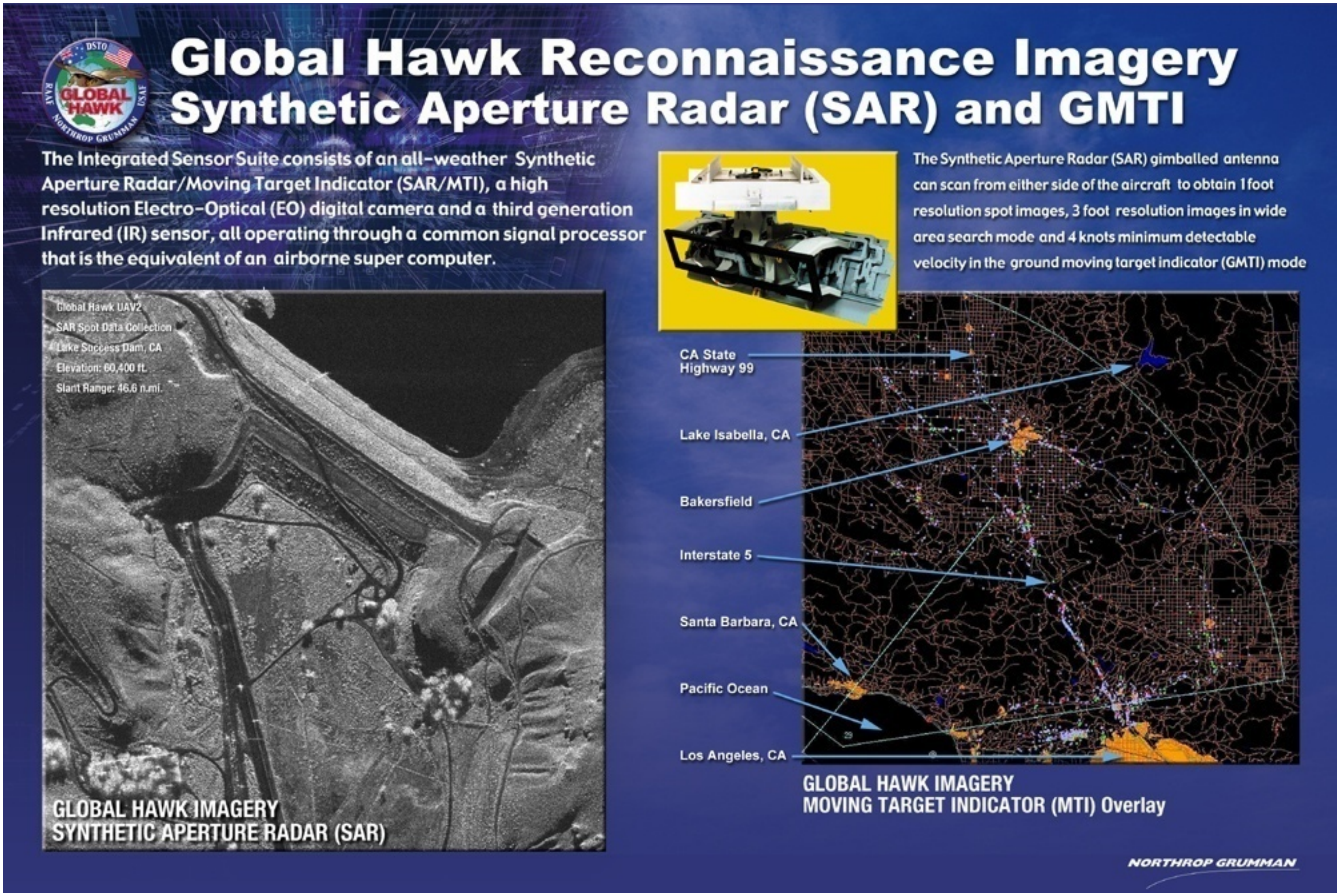
(HH-VV, HV, HH+VV)

UAVSAR Port To Global Hawk

- Measuring millimeter-scale surface deformation at both high temporal and spatial resolution (20 minutes to years at resolutions down to 10 m)
- Full polarimetric imagery enables reflectivity analysis of surface properties supporting
  - Soil moisture and sea surface salinity measurement
  - Biomass measurement and land surface classification
  - Archeological studies
- Global Hawk application with two UAVSAR pods would enable high precision topographic map generation and single pass fully polarimetric interferometry for vegetation structure measurements
- Global Hawk endurance of nearly a day would enable long loiter time over dynamic targets such as volcanoes and earthquake prone regions for pre-event signature studies or post-event scientific and hazard management activities
- Global Hawk range on the order of 8500 nm could enable data collection of distant areas of interest (e.g. Greenland, Aleutians) without complicated campaign deployments
- Global Hawk would be an ideal platform to performing mapping and regional science using the UAVSAR

NASA-JPL UAVSAR on Global Hawk


Global Hawk Reconnaissance Imagery
Electro-Optical (EO) and Infrared (IR)
GLOBAL HAWK
DSTO
RAAF
USAF
NORTHROP GRUMMAN
Global Hawk's onboard, high-resolution sensors can look through adverse weather conditions, day or night, and conduct surveillance over an area the size of Illinois in just 24 hours. The imagery is processed on board and relayed to the user via line-of-sight or satellite communication links.
The Electro Optical (EO) and Infrared (IR) sensors onboard Global Hawk operate through shared reflective optics
Global Hawk UAV2
EO Spot Data Collection Mode
China Lake, CA
Elevation: 56,000 ft.
Slant Range: 13.1 n.mi.
GLOBAL HAWK IMAGERY
ELECTRO-OPTICAL (EO)
Global Hawk UAV2
IR Spot Data Collection Mode
China Lake, CA
Elevation: 61,000 ft.
Slant Range 12.2 n.mi.
GLOBAL HAWK IMAGERY
INFRARED (IR)
NORTHROP GRUMMAN


Global Hawk Reconnaissance Imagery
Synthetic Aperture Radar (SAR) and GMTI
DSTO
GLOBAL HAWK
RAAF
USAF
NORTHROP GRUMMAN
The Integrated Sensor Suite consists of an all-weather Synthetic Aperture Radar/Moving Target Indicator (SAR/MTI), a high resolution Electro-Optical (EO) digital camera and a third generation Infrared (IR) sensor, all operating through a common signal processor that is the equivalent of an airborne super computer.
The Synthetic Aperture Radar (SAR) gimballed antenna can scan from either side of the aircraft to obtain 1 foot resolution spot images, 3 foot resolution images in wide area search mode and 4 knots minimum detectable velocity in the ground moving target indicator (GMTI) mode
Global Hawk UAV2
SAR Spot Data Collection
Lake Success Dam, CA
Elevation: 60,400 ft.
Slant Range: 46.6 n.mi.
GLOBAL HAWK IMAGERY
SYNTHETIC APERTURE RADAR (SAR)
CA State Highway 99
Lake Isabella, CA
Bakersfield
Interstate 5
Santa Barbara, CA
Pacific Ocean
Los Angeles, CA
GLOBAL HAWK IMAGERY
MOVING TARGET INDICATOR (MTI) Overlay
NORTHROP GRUMMAN

7. Recent Textbooks on Radar Polarimetry & Polarimetric Interferometry

Mott, Boerner, Yamaguchi, Souyris, Jin, Jin-Xu, Pottier-Lee, Cloude, Jian Yang,Cumming-Wong

Addendum: Boerner, Literature Assessment

Recent Books on Polarimetric Radar & SAR, Polarimetric Interferometry

Harold MOTT, ***Remote Sensing with Polarimetric Radar,*** Wiley-IEEE Press, 1st ed., January 2007, pp309 , ISBN: 978-0470074763 {also see previous books by late Harold Mott, 1986 & 1992}

Boerner, Wolfgang-Martin, ***Introduction to Synthetic Aperture Radar (SAR) Polarimetry*****,** Wexford Press (reprinted *without permission* from W-M. Boerner (April 2007), Basics of SAR Polarimetry 1, *In Radar Polarimetry and Interferometry (pp. 3.1- 3-40),* Educational Notes RTO-EN-SET-081bis, Paper 3, Neuilly-sur-Seine, France RTO, available from: http://www.rto.nato.int/abstracts.asp

Yamaguchi, Yoshio, ***Radar Polarimetry from Basics to Applications: Radar Remote Sensing using Polarimetric Information (in Japanese),*** IEICE Press, Dec. 2007, (soft cover), ISBN: 978-4-88552-227-7, http://www.ieicepress.com/

Masonnett Didier & Souyris Jean-Claude***, Imaging with Synthetic Aperture Radar*****,** EPFL/ CRC-Press, Engineering Sciences/Electrical Engineering, Taylor & Francis Group, 2008, (hard-cover), ISBN 978-0-8493-8239-4; http://www.crcpress.com

Ya-Qiu JIN & Feng XU, ***Theory and Approach for Polarimetric Scattering and Information Retrieval of SAR Remote Sensing (In Modern Chinese)***, Beijing: Science Press, 2008, (hard cover), ISBN978-7-03-022649-5; http://www.sciencep.com

Lee Jong-Sen & Pottier, Eric, ***Polarimetric Radar Imaging – from basics to applications*****,** CRC Press – Taylor & Francis Group, January 2009, ISBN 978-1-4200-5497-2 (hard-cover), TK6580.L424.2009, 621.3848- -dc22; http://www.crcpress.com {Chinese version to be published by 2009 October}

Cloude, Shane Robert, ***Polarisation: Applications in Remote Sensing,*** Oxford University Press, UK & EU, August 2009, ISBN 978 -0-19-9569731-1 (352p, 260 line-ill: hard-copy), http://www.oup.com.contact/

vanZyl Jakob-Johannes & Kim Yun-Jin, Introduction ***to SAR Polarimetry*** **–** in progress and to be completed by 2009 December: To be published with the JPL Series, John Wiley.

Cumming, I. G. and F. W. Wong, "*Digital Processing of Synthetic Aperture Radar Data".* Artech House, 653-pages, January 2005. (Published in Chinese, October 2007).

ENGINEERING SCIENCES *Electrical Engineering*

IMAGING WITH SYNTHETIC APERTURE RADAR

Didier Massonnet & Jean-Claude Souyris

Synthetic Aperture Radar (SAR) is a field that has been transformed by the recent availability of data from a new generation of space and airborne systems, and the authors take full advantage of this data to offer a synthetic geometrical approach to the description of the SAR technique, one that addresses physicists, radar specialists, as well as experts in image processing.
The book begins with a "theoretical emergency kit" that provides the foundation necessary to understand the math and science behind the SAR technology. It then provides a comprehensive description of the technique itself, stressing the geometrical approach to radar processing, followed by a description of how these principles are applied by considering SAR design from a radiometric perspective. The authors then turn their attention to radar interferometry, explaining the practical aspects behind obtaining interferometric products from radar data, in the context of resolving ambiguity interpretation, the availability of space-borne systems, radar-data archives and software-processing resources. The book closes with a detailed description of radar polarimetry.
Richly illustrated with a careful mathematical development of the basic scientific concepts, the book is intended for both academic use (by professors and students), as well as by professionals working in industry or government laboratories.

DIDIER MASSONNET of the CNES is an IEEE fellow and an AGU member; he's the author of several patents, notably the interferometric cartwheel.

JEAN-CLAUDE SOUYRIS is head of the altimetry and radar department at the CNES. He is an IEEE member, and Associate Editor for Geoscience and Remote Sensing Letters.

2008, 290 pages, Hardcover,
EPFL Press ISBN 2-940222-15-5
(CRC Press ISBN 978-0-8493-8239-4)

EPFL Press — CRC Press Taylor & Francis Group

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Ya-Qiu Jin
This book presents some new progress on the theoretical and numerical approaches for information retrieval of the remote sensing via electromagnetic scattering and emission. It covers the vector radiative transfer theory for inhomogeneous scatter media, polarimetric scattering theory for the synthetic aperture radar (SAR) imagery and some innovative applications, new approach and data validation for current space-borne remote sensing programs, fast computational method and numerical simulation for bistatic scattering of randomly rough surface with a target presence, especially at low grazing angle. Some inverse problems in radiative transfer and inverse scattering are also discussed. Novel electromagnetics of complex media are also presented.
This book is intended as a textbook for graduate students and a reference book for scientists to see the most recent progress in the author's research laboratory.
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Ya-Qiu Jin
Theory and Approach of Information Retrievals from Electromagnetic Scattering and Remote Sensing
Ya-Qiu Jin
Springer


(P-1788.0101)
金亚秋 1970年毕业于北京大学，1978年中国科学院首批公派出国研究生，1982、1983、1985年先后获美国麻省理工学院(MIT)科学硕士、电气工程师、博士学位。曾任职于AER、纽约城市大学、英国York大学、美国NOAA/NESDIS、香港城市大学、日本东北大学。现为复旦大学信息科学与工程学院教授、波散射与遥感信息教育部重点实验室主任。他是国家级有突出贡献的中青年科技专家、上海市劳动模范、国家重点基础研究973项目首席科学家、IEEE Fellow、Electromagnetics Academy Fellow、IEEE Transactions on Geoscience and Remote Sensing副主编。他曾获国家自然科学奖等十多项科技奖励。他的研究领域为自然环境中电磁波散射辐射传输与传播、空间遥感与对地监测信息理论与技术、复杂系统中计算电磁学等。他在国内外发表了540多篇学术论文、11部学术专著与文集。
徐丰 2003年获东南大学工学士学位，2007年获复旦大学博士学位。现为美国NOAA/NESDIS博士后研究员。他曾获东南大学优秀研究生一等奖、复旦大学优秀研究生一等奖、中国电子学会优秀青年学者论文奖、复旦大学研究生创新基金、每年全世界遴选一名的美国SUMMA研究生奖学金、上海市高校科创杯奖等。他的研究领域为星载遥感建模与SAR成像技术等。他在国内外学术刊物上发表了40多篇学术论文。
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金亚秋 徐 丰 著
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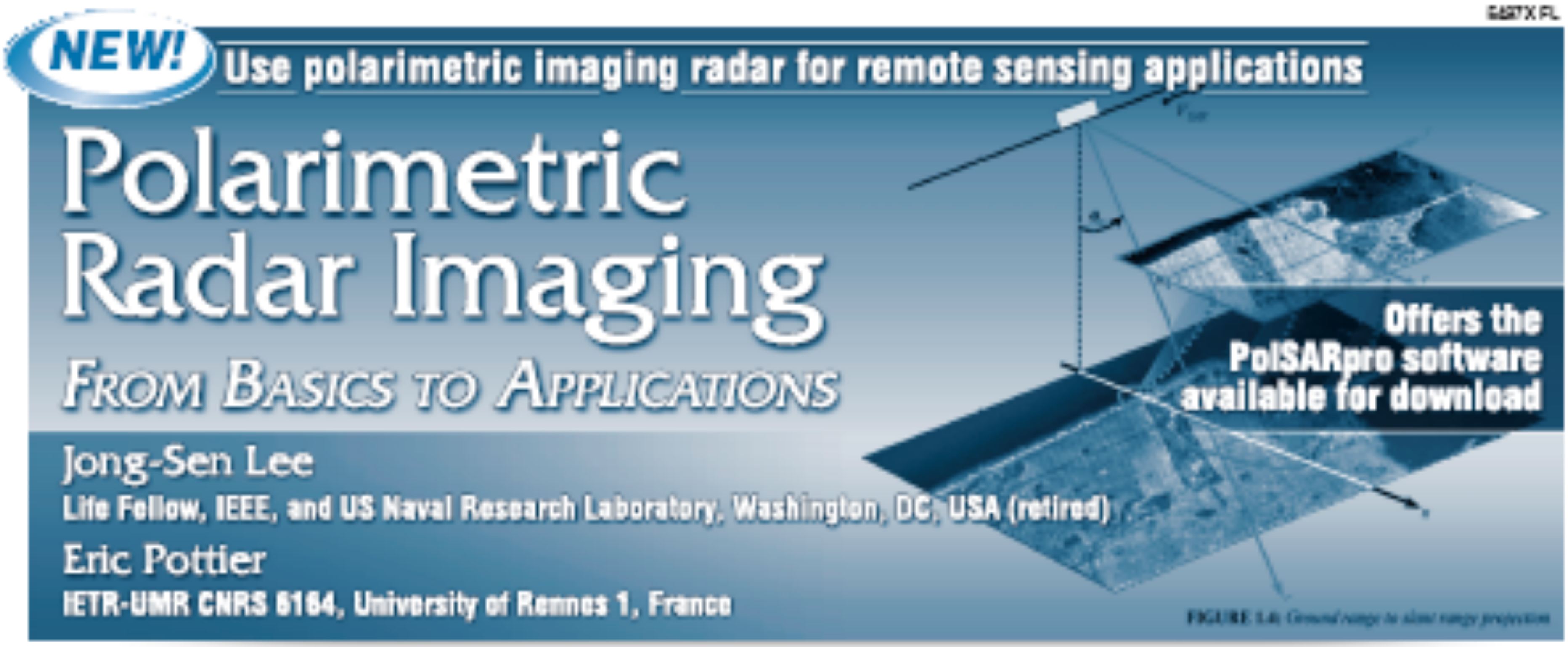
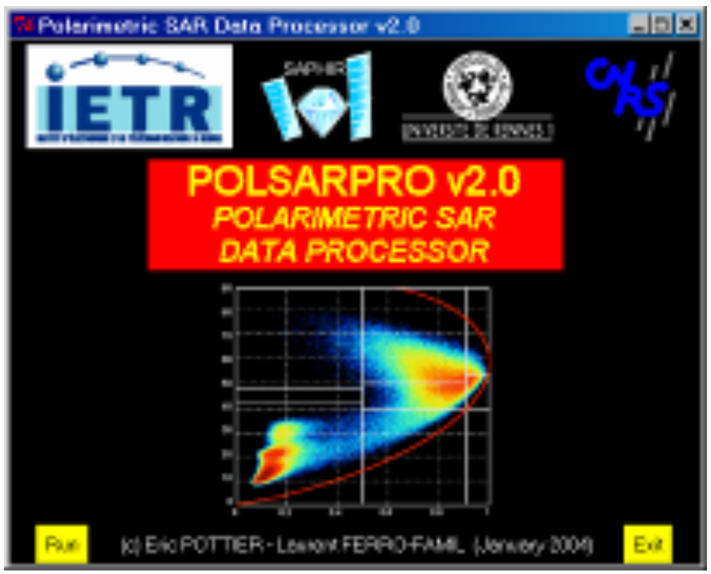
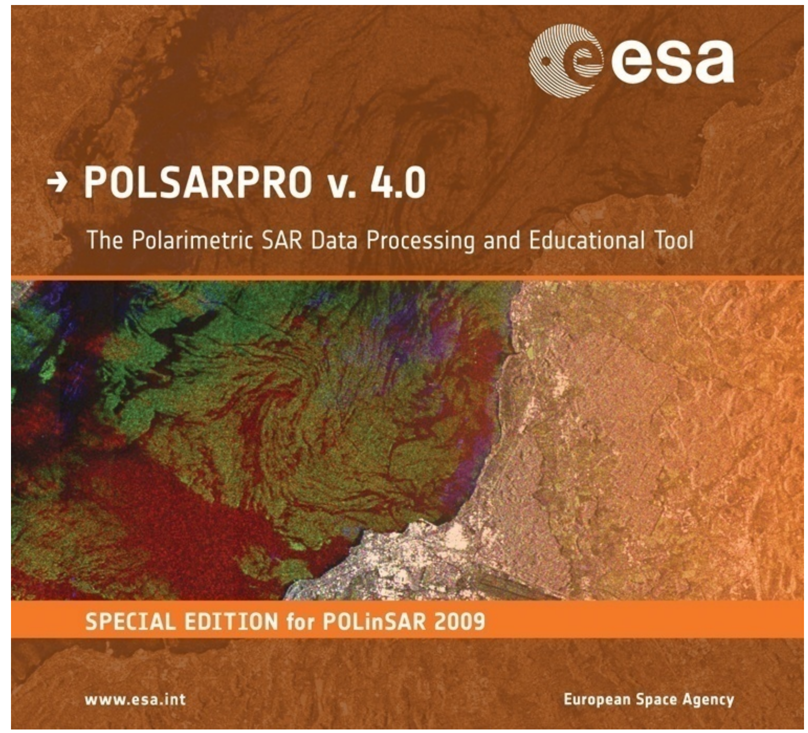

NEW!
Use polarimetric imaging radar for remote sensing applications
Polarimetric Radar Imaging
From Basics to Applications
Jong-Sen Lee
Life Fellow, IEEE, and US Naval Research Laboratory, Washington, DC, USA (retired)
Eric Pottier
IETR-UMR CNRS 6164, University of Rennes 1, France
Offers the PolSARpro software available for download

POLSARPRO

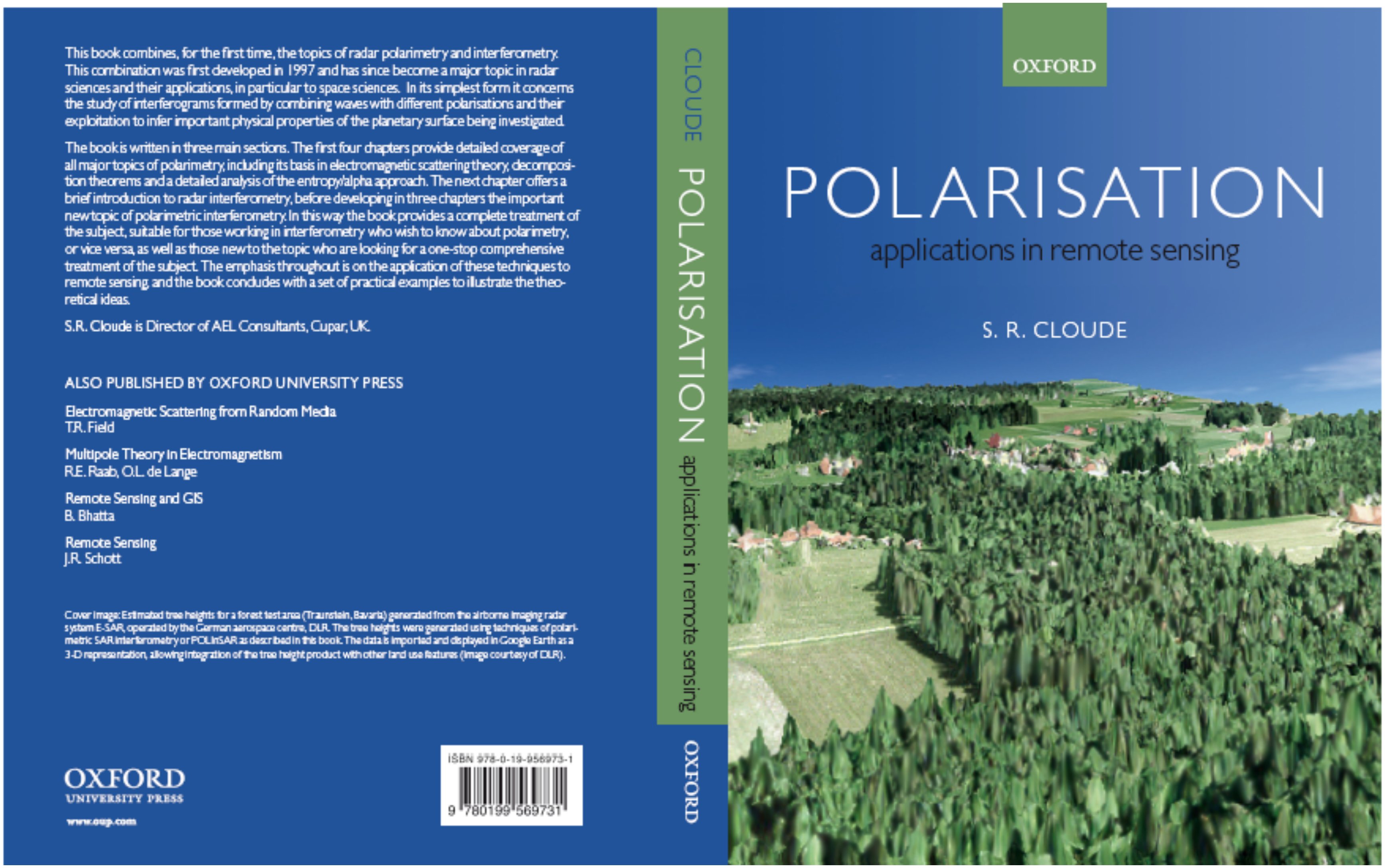
The development of POLSARPRO Software is a direct result of recommendations made during the POLinSAR Workshops held at ESA-ESRIN in January 2003.



2003



New version 4.0 released in occasion of POLinSAR 2009


This book combines, for the first time, the topics of radar polarimetry and interferometry. This combination was first developed in 1997 and has since become a major topic in radar sciences and their applications, in particular to space sciences. In its simplest form it concerns the study of interferograms formed by combining waves with different polarisations and their exploitation to infer important physical properties of the planetary surface being investigated.
The book is written in three main sections. The first four chapters provide detailed coverage of all major topics of polarimetry, including its basis in electromagnetic scattering theory, decomposition theorems and a detailed analysis of the entropy/alpha approach. The next chapter offers a brief introduction to radar interferometry, before developing in three chapters the important new topic of polarimetric interferometry. In this way the book provides a complete treatment of the subject, suitable for those working in interferometry who wish to know about polarimetry, or vice versa, as well as those new to the topic who are looking for a one-stop comprehensive treatment of the subject. The emphasis throughout is on the application of these techniques to remote sensing, and the book concludes with a set of practical examples to illustrate the theoretical ideas.
S.R. Cloude is Director of AEL Consultants, Cupar, UK.
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Cover image: Estimated tree heights for a forest test area (Traunstein, Bavaria) generated from the airborne imaging radar system E-SAR, operated by the German aerospace centre, DLR. The tree heights were generated using techniques of polarimetric SAR interferometry or POLInSAR as described in this book. The data is imported and displayed in Google Earth as a 3-D representation, allowing integration of the tree height product with other land use features (image courtesy of DLR).
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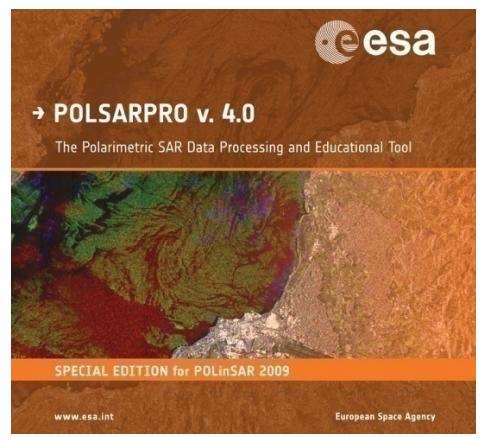

2009 Conferences Pertinent to Radar and SAR Remote Sensing

ICONIC 2009, Taipei, Taiwan, 2009 June 24 – 26
{Int'l. Conference on Electromagnetic Near-Field Characterization and Imaging, Oriental Institute of Technology, Taipei} http://www.oit.edu.tw/iconic2009/

IGARSS 2009, Capetown, South Africa, 2009 July 13 – 17
{Int'l. Symposium on Geosciences & Remote Sensing} http://www.igarss09.org/

ISAP 2009, Bangkok, Thailand, 2009 October 20 – 23
{IEICE, Int'l. Symposium on Antennas & Propagation} http://isap09.org/

APSAR 2009, Xian, PRC China, 2009 October 26 – 28
{CIE, Asia-Pacific Conference on Synthetic Aperture – 2nd symposium in China} http://www.isap2009.org

AEMC 2009 & CODEC 2009, Kolkata, India, 2009 December 14 – 16
{Applied Electromagnetics Conference, and Int'l. Conference on Computers for Communications: both with Institute of Radio Physics and Electronics, University of Calcutta, 92, A. P. C. Road, Kolkata - 700009, India} http://www.irpel.org./codec-09

ICMARS 2009, Jodhpur, Rajasthan, India, 2009 December 19 - 21
{International Conference on Microwaves, Antennas & Remote Sensing, International Centre for Radio Science(ICRS), "OM-NIWAS" A-23, Shastri Nagar
Jodhpur - 342003,Rajasthan,In} http://www.radioscience.org

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The Electromagnetic **Vector-Wave** Spectrum:
A Natural Global Treasure

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