



# ***The ESA SAR missions and their Exploitation for Science and Applications Development***



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*ESA-ESRIN Frascati Italy*



# ***ERS Missions***





## ERS mission overview

- 15 years of ERS-1/2 data in the archive
- (suitable for applications requiring long term series products)
- ERS-2 achieved 11 years in orbit in April 2006
- (was designed for 3 years nominal lifetime)
- Some problems with the platform
- (gyroscope in 2001, tape recorder in 2003)
- but all instruments still functioning well
  - engineering solutions have been developed:
    - new 'gyro-less' working mode
    - set up of a station network for Low Bit Rate data recovery
- Operations funding until 2008



## ERS-2 satellite and payload status

<i>Mission elements</i>	<i>Expected evolution</i>	<i>Comments</i>
<b>Service Module</b>	Good	<b>Relaxed attitude control</b> +/- 2deg, all other sub-systems with full redundancy. SPOT-1 platform flown for 17 years before de-orbiting.
<b>Propulsion and Hydrazine</b>	Excellent	1/3 of hydrazine has been consumed within 11 years
<b>Payload Equipment Bay</b>	Fair	<b>Tape Recorders Failed</b> , Realtime mission only with some 40% global coverage. Transmission Tube redundancy available.
<b>SAR Image Mode</b>	Excellent	
<b>SAR Wave Mode</b>	Excellent	
<b>Scatterometer</b>	Fair	Sub System on redundant side
<b>RA &amp; MWR</b>	Excellent	
<b>ATSR</b>	Good	Scan Mirror problem has been overcome by patches on ground
<b>GOME</b>	Good	Calibration lamp problem overcome by using sun measurements
<b>PRARE</b>	Excellent	Reduced surface transponders covering North & South Poles and Europe only; no redundancy



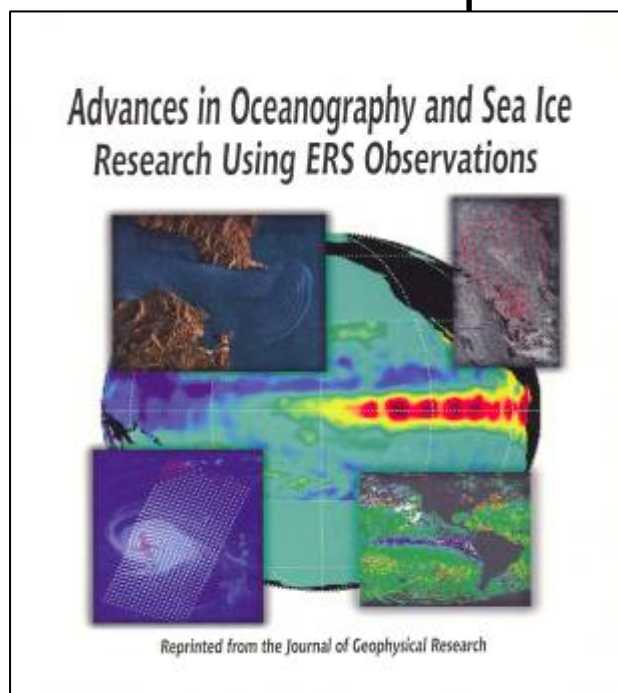


# ***ERS AMI SAR exploitation***

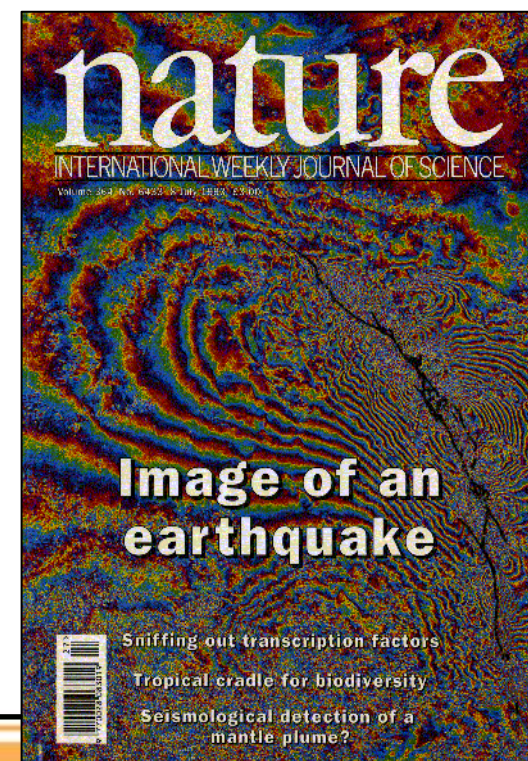
## ERS Achievements - Science



ERS and Volcanic activities



Oceanography and sea Ice

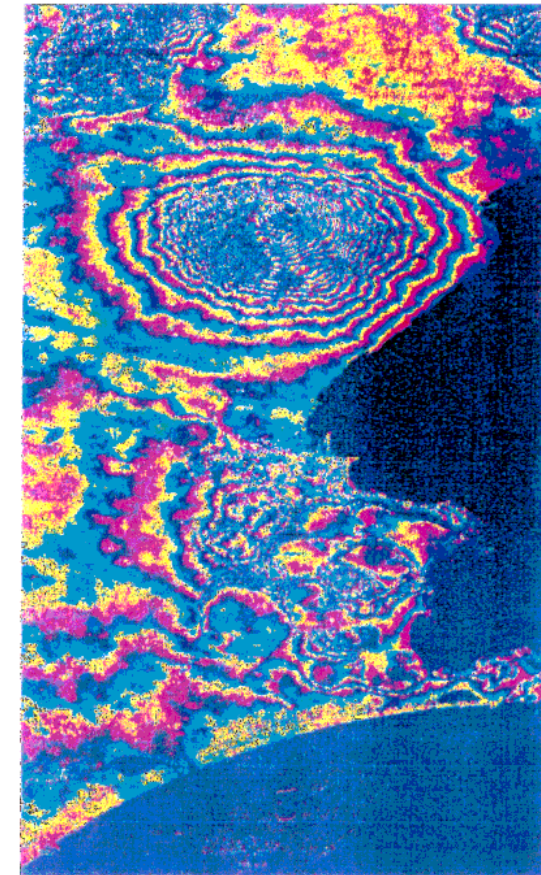


ERS and SAR Interferometry



## FRINGE-1992

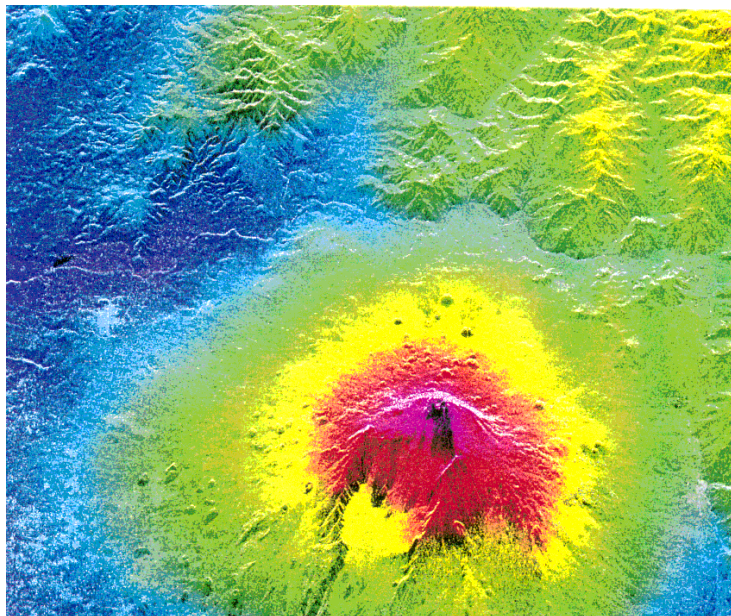
- Originally not anticipated in the ERS-1 specifications  
INTERFEROMETRY was pro-actively supported by ESA
- ERS-1 INSAR activity is co-ordinated within the framework of a mission-dedicated Working Group, called FRINGE,
- set up by ESA/ESRIN at the beginning of 1992 and currently comprising about 200 groups world-wide:
  - Scientific exchange
  - Access to test data
  - Development of first tools





## ERS-1/ERS-2 Tandem 1995

- The successful launch of ERS-2 in 1995 opened the opportunity to fly both ERS-1 and ERS-2 in tandem as a single Interferometer.
- The ERS Tandem mission began in September 95 and will last for a period of 9 months in a configuration such that there a 1-day interval between ERS-1 & ERS-2 observing the same area of ground.
- “Fringe members reported high values of interferogram quality”

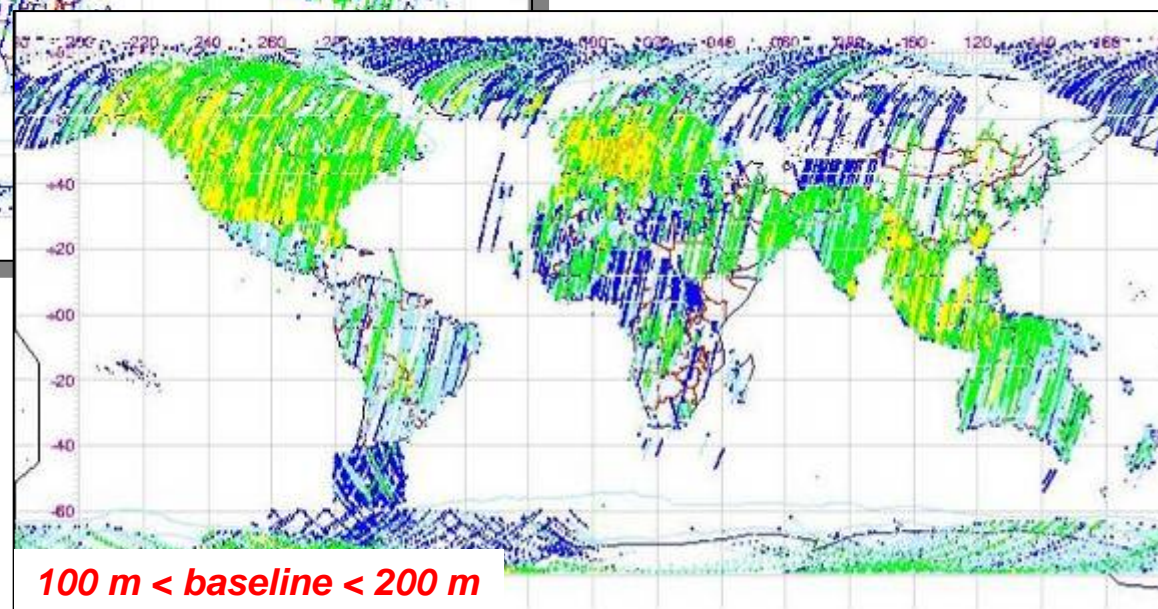
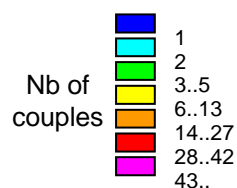
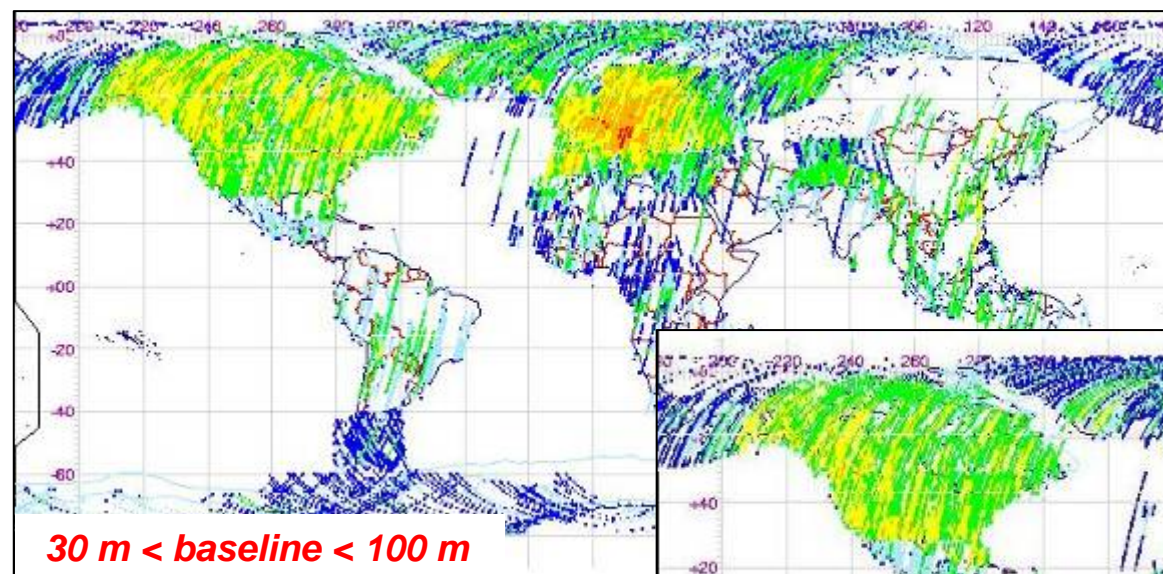


ERS-1/ERS-2 phase interferogramme for the region of Etna in Sicily produced by the group of Ph. Hartl at the Insitiute for Navigational Studies (INS)



## Data catalogues

### ERS SAR data: Tandem ERS-1/ERS-2



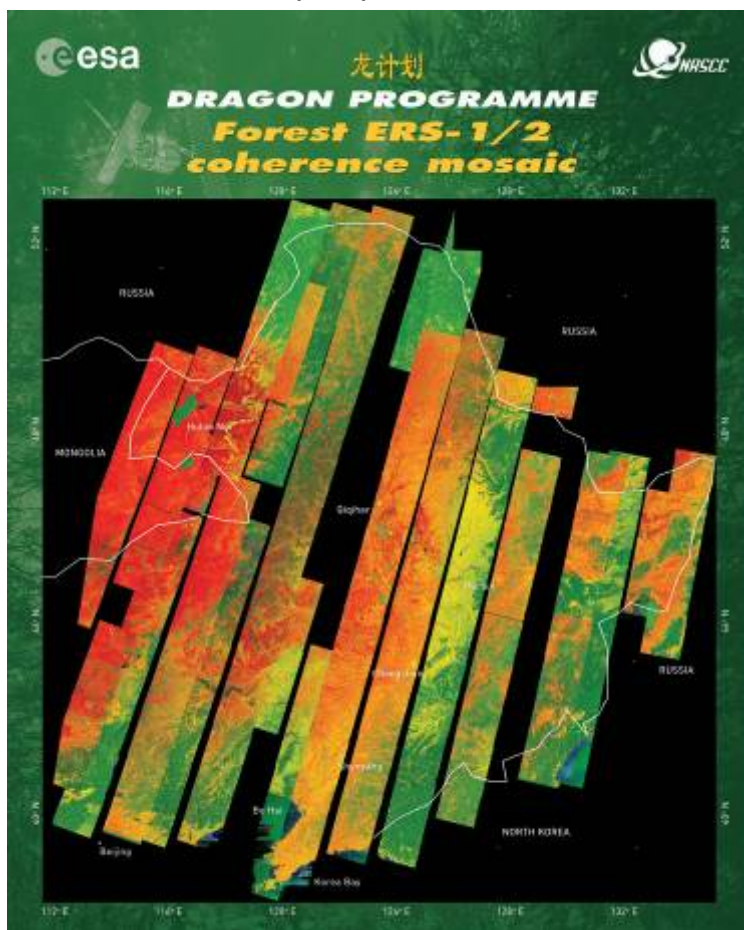
*ERS SAR tandem :  
a unique dataset!*

**73% of the tandem data meet the optimal baseline requirements for DEM generation of 50 to 300 m**

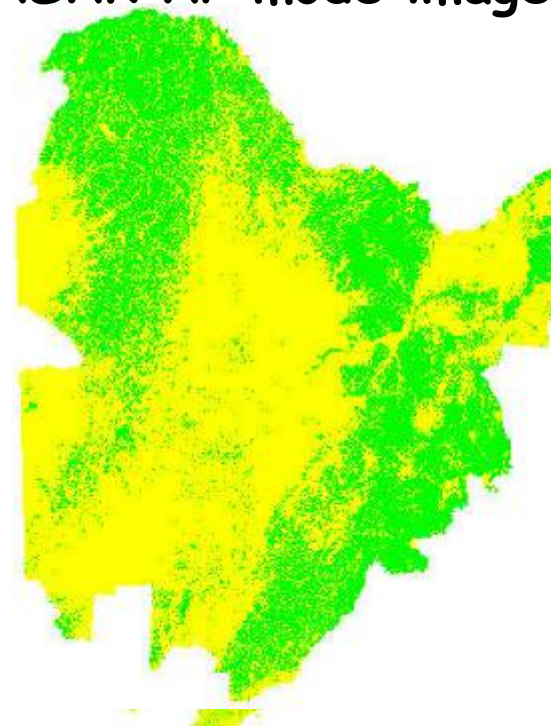
## ERS & ENVISAT exploitation

### Forest Mapping in NE China Using ERS InSAR and ASAR AP data

ERS SAR Tandem mission '95/'96

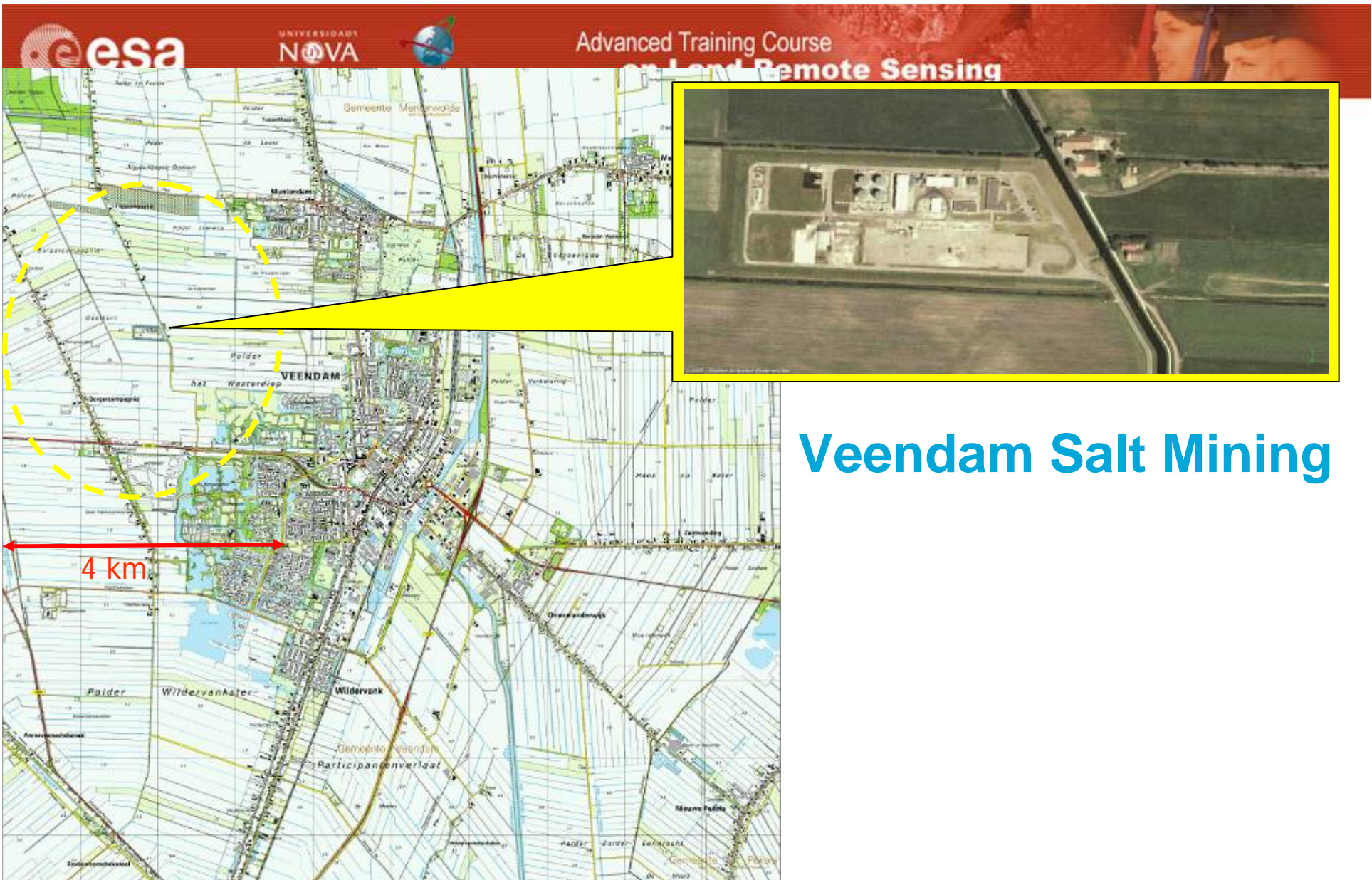


ASAR AP mode imagery 2005/06



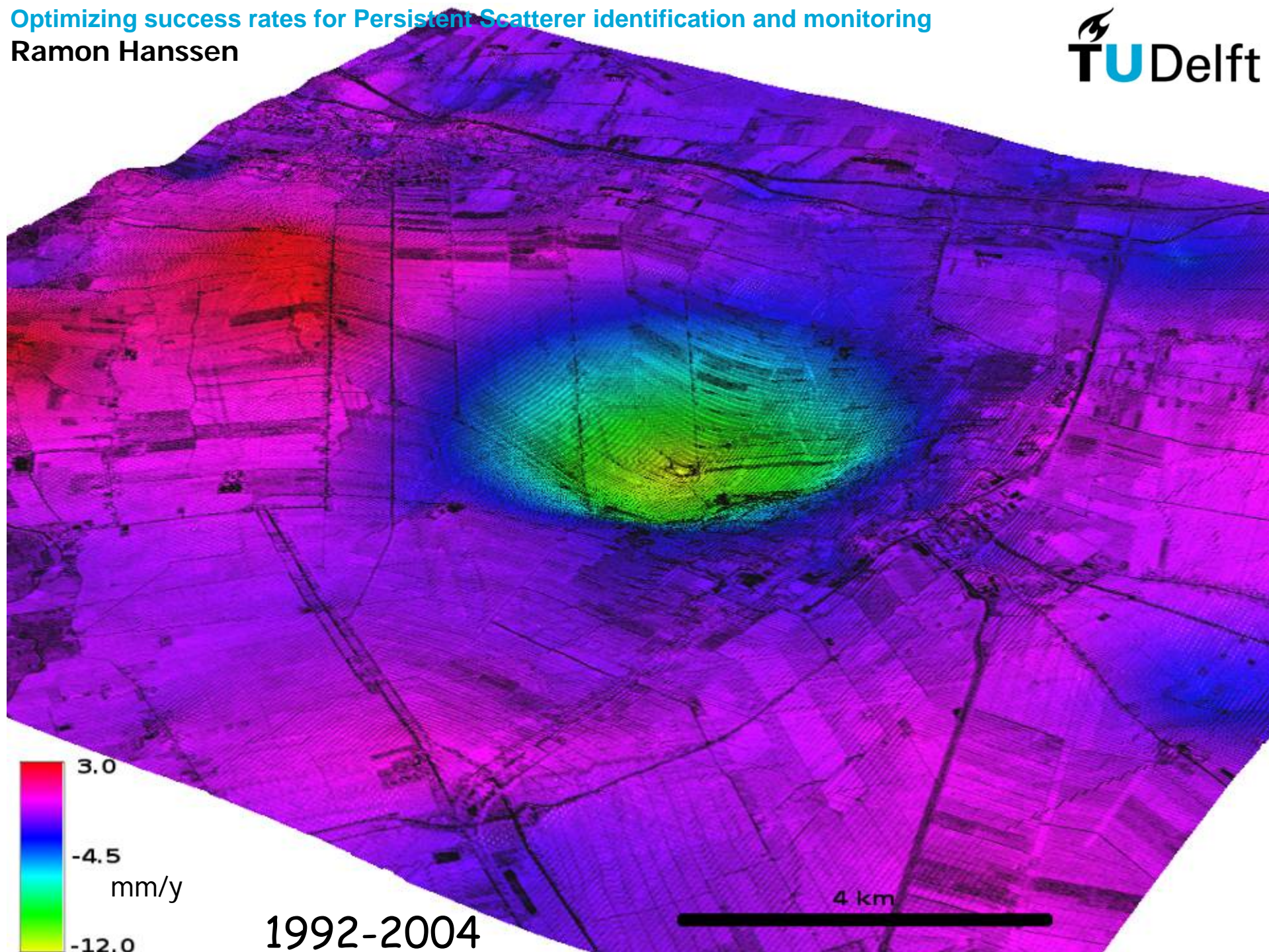
ASAR classification result





Optimizing success rates for Persistent Scatterer identification and monitoring  
Ramon Hanssen and Astrid Humme  
Envisat Symposium, 23-27 April 2007, Montreux, Switzerland





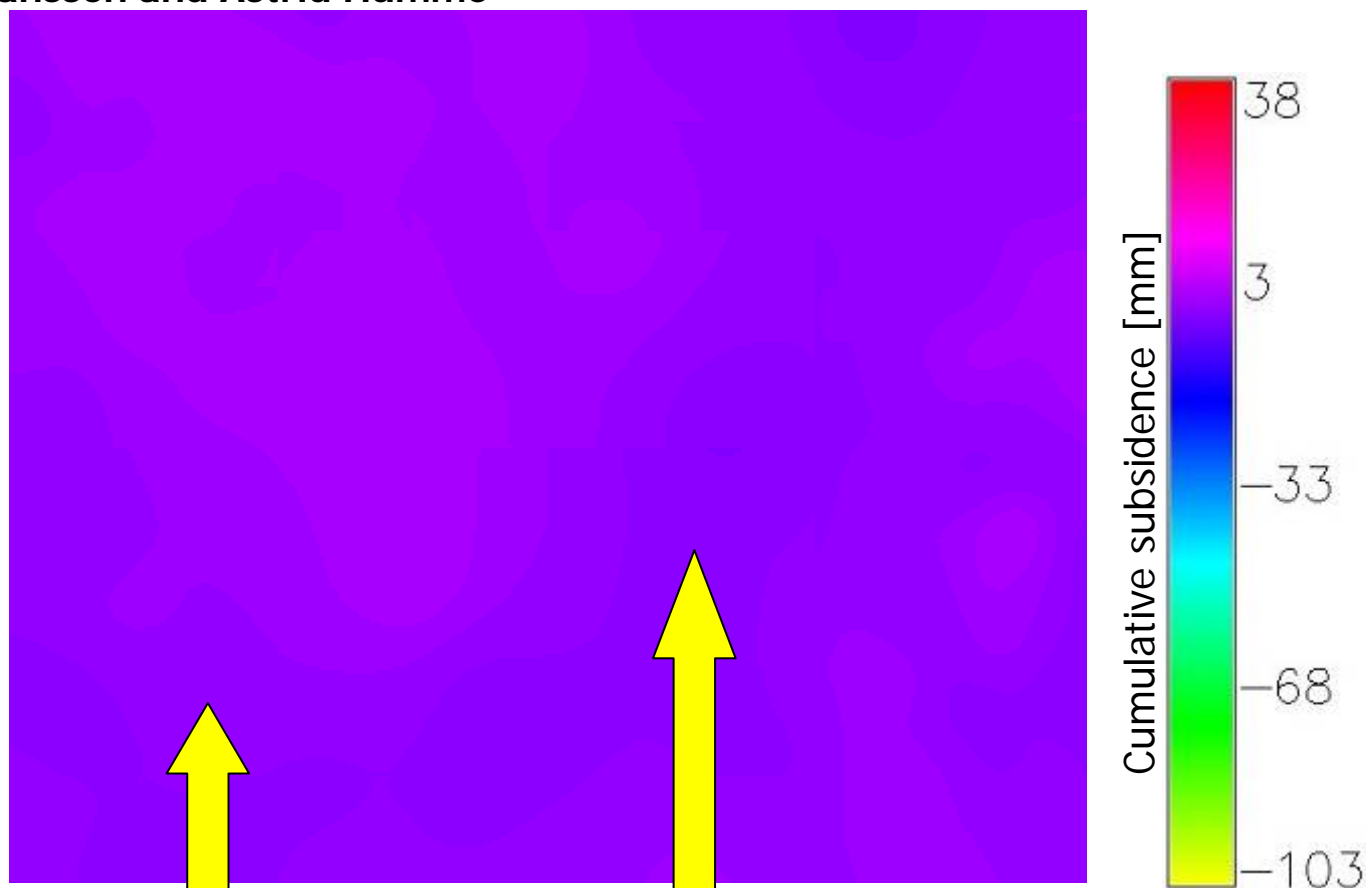




# First (rough) animation deformation May 1992- Dec 2003

Optimizing success rates for Persistent Scatterer identification and monitoring

Ramon Hanssen and Astrid Humme





# ***ENVISAT Mission***

## ENVISAT mission

- ❑ Largest European satellite & largest worldwide EO satellite:
  - unique combination of 10 instruments addressing land, ocean, ice and atmosphere studies,
  - instruments working nominally, except MIPAS instrument
- ❑ Satellite OK with long-term operations capabilities:
  - 65 % of fuel available (about 5 years)
- ❑ 78 different types of data products
  - but many more geophysical parameters
- ❑ 250 Gigabytes of data products generated per day
- ❑ Nominal lifetime (5 years) ends in March 2007
  - but operations funding until end 2010





## ENVISAT satellite and payload status

Mission elements	Expected evolution	Comments
<b>Service Module</b>	Excellent	
<b>Propulsion and Hydrazine</b>	Fair	Main limiting factor of the mission
<b>Payload Equipment Bay</b>	Excellent	
<b>ASAR</b>	Fair	Sub-system on redundant side
<b>MERIS</b>	Excellent	
<b>AATSR</b>	Excellent	
<b>RA-2</b>	Fair	Recent anomaly with altimetric range measurement On ground correction tables
<b>MWR</b>	Good	
<b>DORIS</b>	Fair	Instrument on redundant side
<b>SCIAMACHY</b>	Excellent	
<b>MIPAS</b>	Bad	Progressive mechanical degradation in non redundant part. Used on campaign basis.
<b>GOMOS</b>	Fair	Instrument on redundant side. New operations scenario is satisfactory.



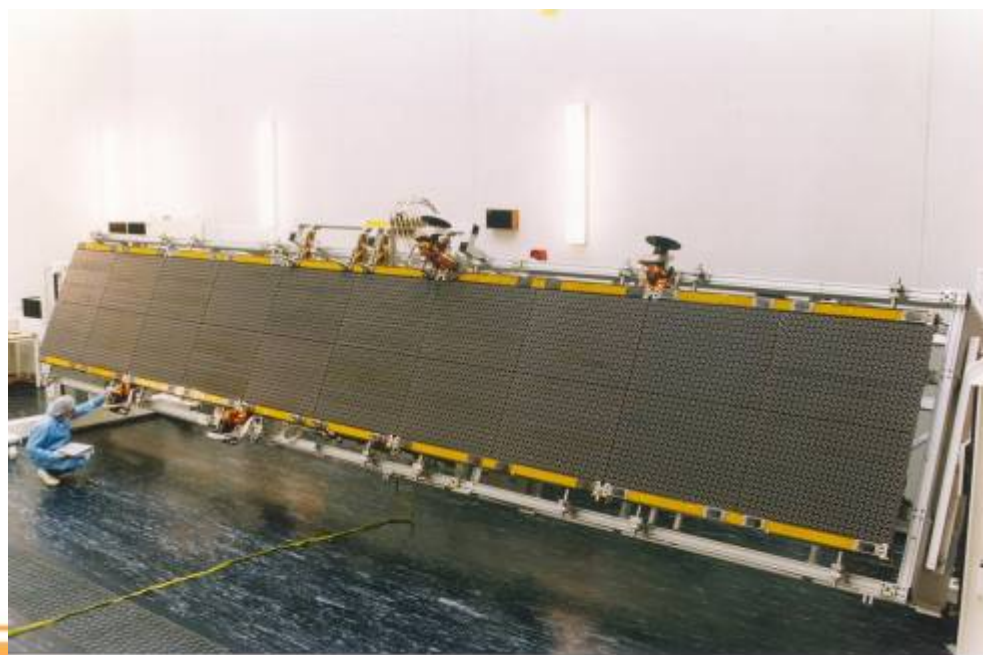
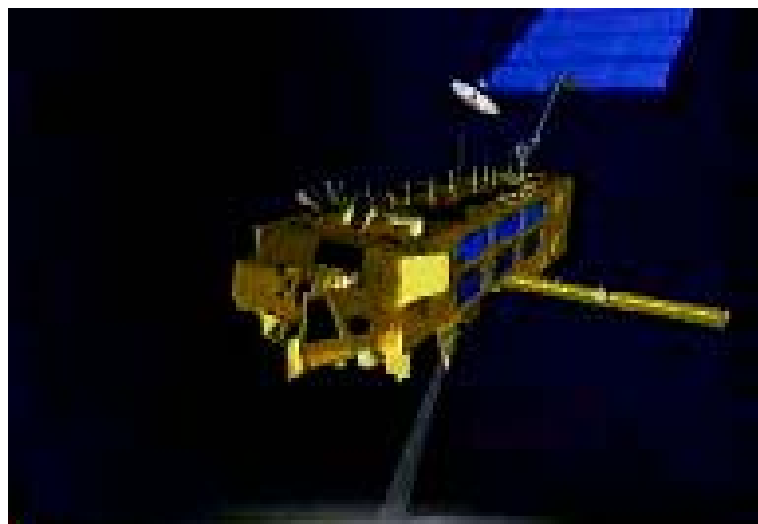
# ***ENVISAT ASAR***

## ***instrument performance***



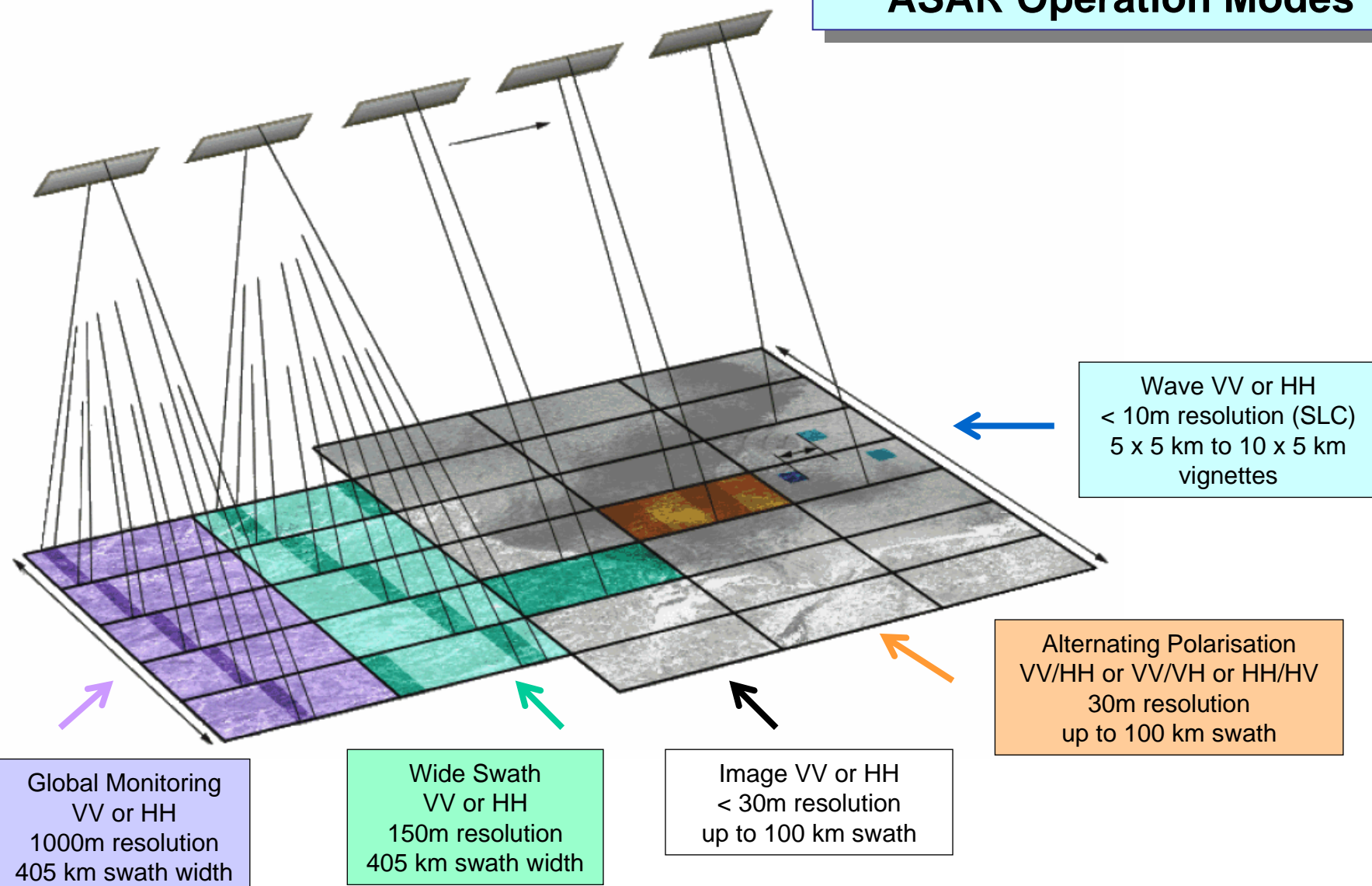
## The instrument ASAR

# ASAR: Advanced Synthetic Aperture Radar



- Selectable incidence
- Selectable polarisation
- Wide Swath 400km (3 day repeat coverage)
- Global mode at 1km resolution

## ASAR Operation Modes



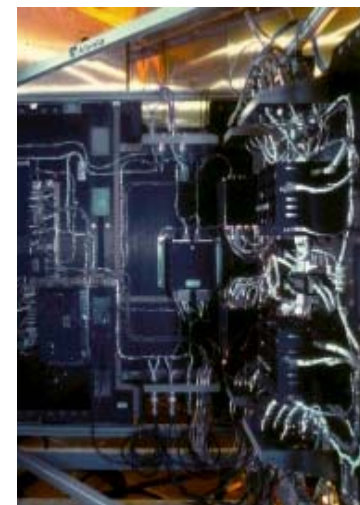
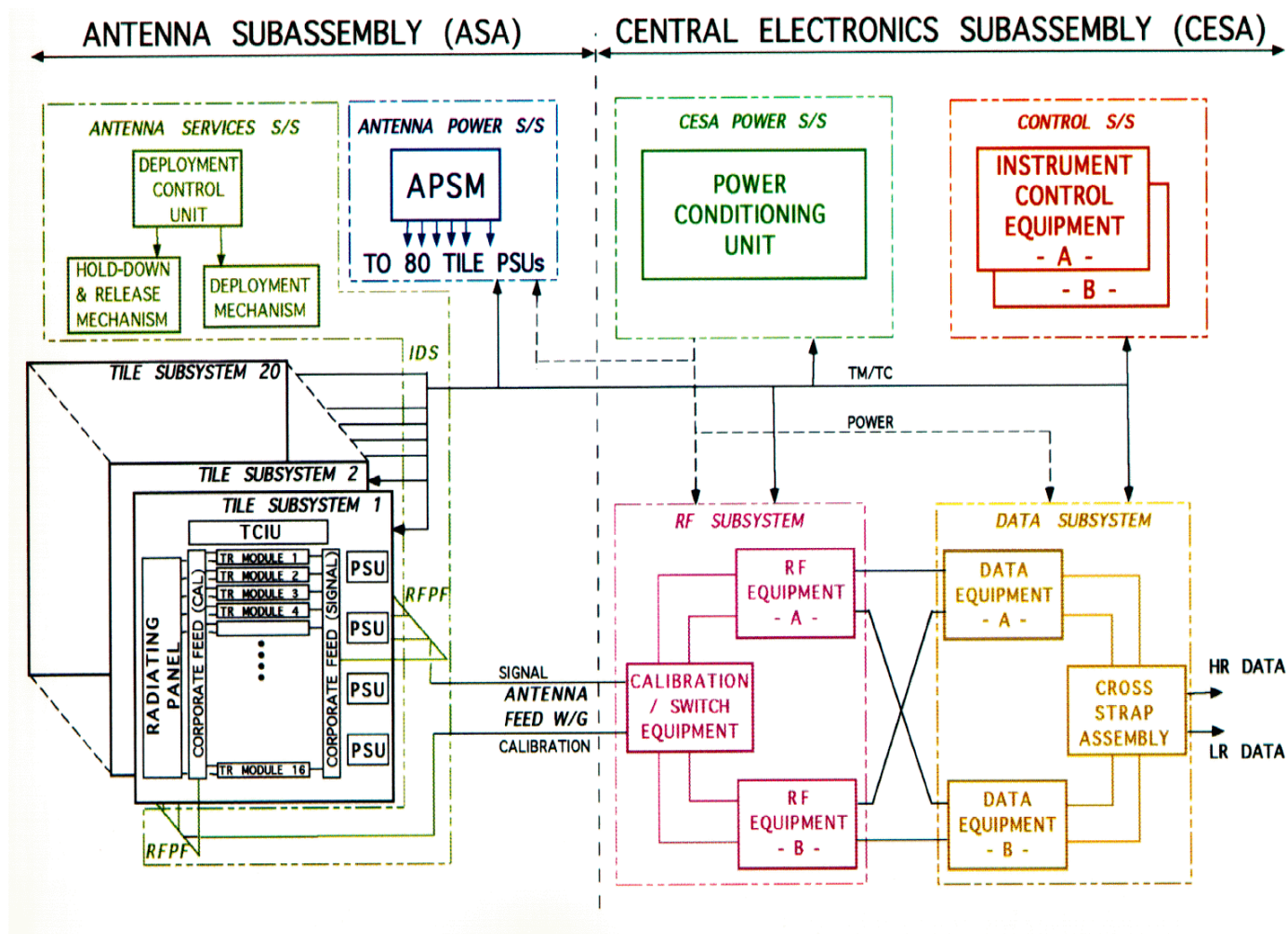


## ASAR INSTRUMENT MAIN FEATURES

- ASAR can be operated in **HH** or **VV** in all modes but
- Alternating Polarisation Mode where it operates in **HH/VV** or **HH/HV** or **VV/VH**
- ASAR can select the swath position in IM, AP and WV (**7 swaths** available)
- ASAR has a **SCANSAR 5 beams** modes of operation: WS and GM
- **Frequency stability and datation have been improved**
- to support interferometric applications @ 5.331 GHz
- **ASAR includes an active array antenna**
- **composed of 320 T/R**
- modules with a dedicated
- calibration path to each T/R
- module
- **ASAR includes a Digital Chirp Generator**
- **ASAR includes a Flexible Block Adaptive Quantizer:**
- large dynamic range of inputs signal (8 bit ADC) and compression 8/4, 8/3, 8/2
- **ASAR includes a Temperature compensation scheme**

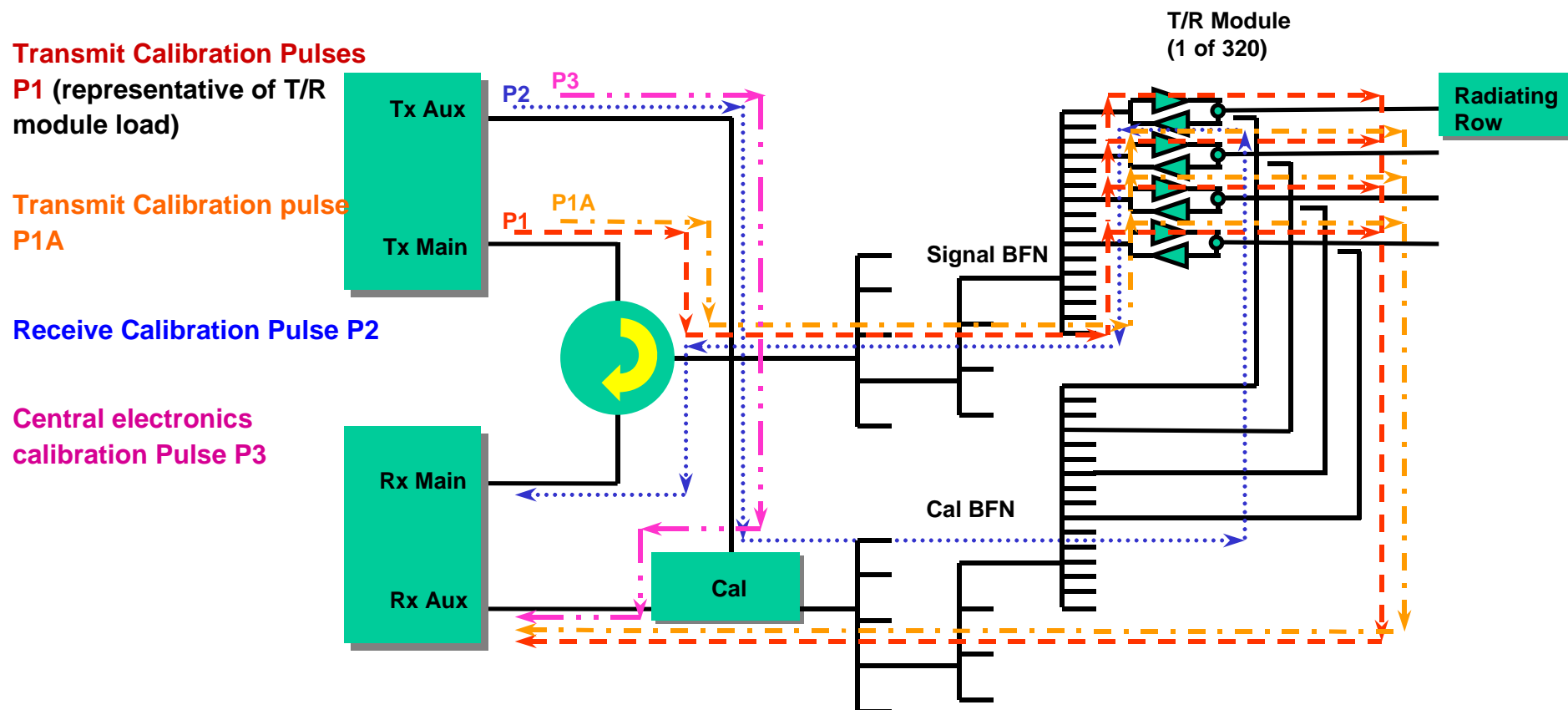


## ASAR INSTRUMENT OVERVIEW



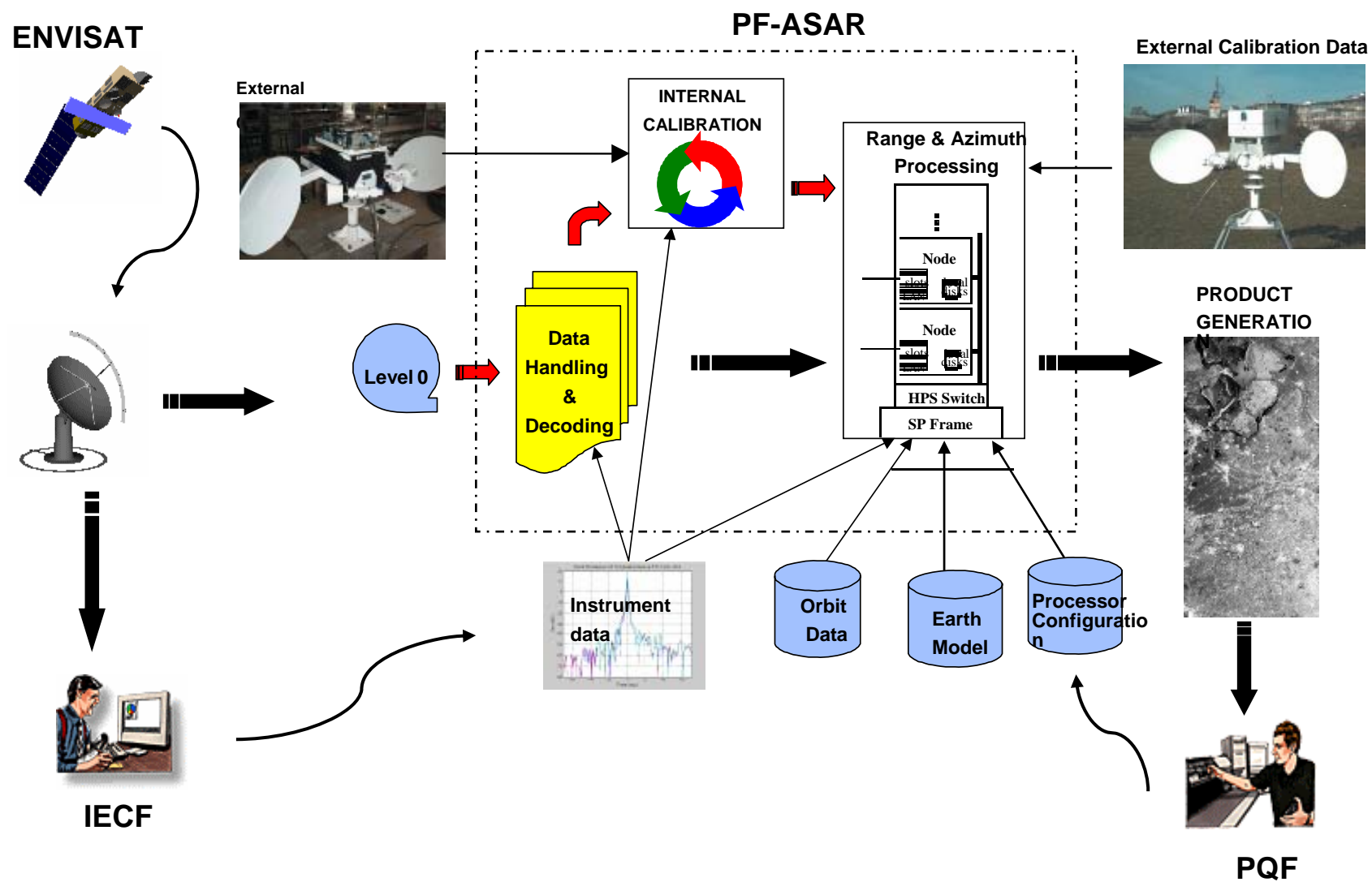
## ASAR INSTRUMENT Internal Calibration

Calibration Pulses Diagram





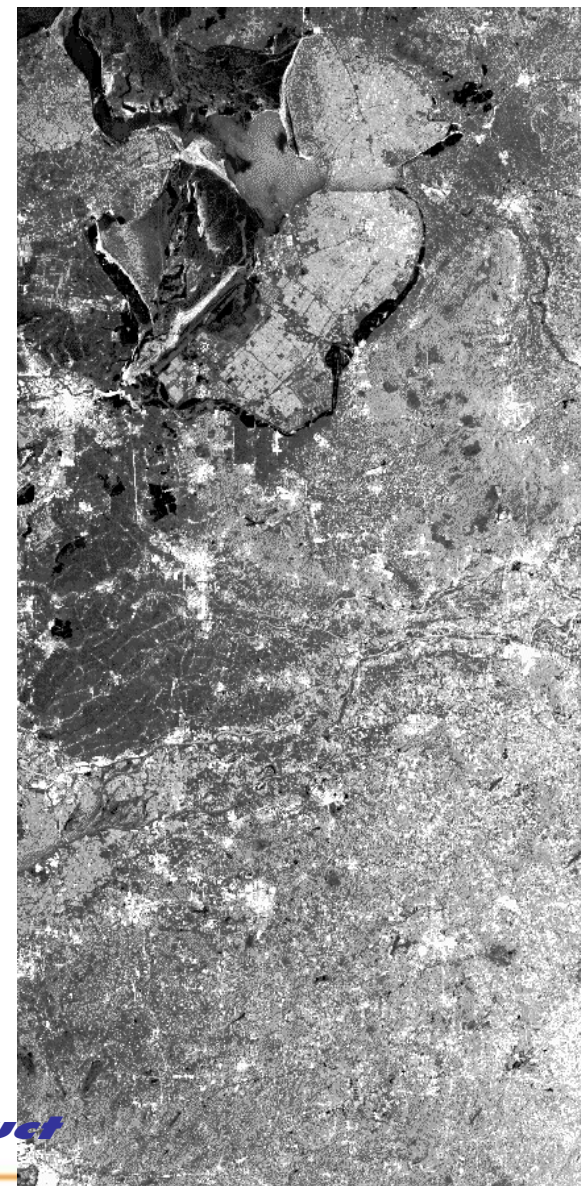
## ASAR PROCESSOR Functional Bloc Diagram



### 3- ASAR PROCESSOR IMAGE QUALITY

	<i>Parameter</i>	<i>Specification</i>
ALL P R O D U C T S	<b>Range and Azimuth broadening</b>	< 10% of theoretical value IRF
	<b>PSLR degradation</b>	< 2 dB
	<b>ISLR degradation</b>	< 2 dB
	<b>Radiometric Error</b>	< 0.1 dB (single beam) < 0.2 dB (scanSAR)
	<b>Absolute location accuracy</b>	<2 pixel
	<b>Geometric distortion</b>	<0.5 pixel
S L C	<b>Phase Preserving Test</b>	
	• <b>Standard deviation</b>	<5 degrees
	• <b>Phase mean</b>	<0.1 degrees
	• <b>No discontinuity</b>	
	<b>Point Target Phase Error</b>	< 0.1 degrees

*Example IMM Product*





## 2- ASAR Processor algorithms

<b>PRODUCTS</b>	<b>Az. Coverage (Km)</b>	<b>Algorithm</b>
<b>IM SLC</b>	100	Range Doppler
<b>AP SLC</b>	100	Modified Range Doppler
<b>AP PRI</b>	100	Specan
<b>IM PRI</b>	100	Range Doppler
<b>IM Medium Res.</b>	100	Specan
<b>AP Medium Res.</b>	100	Specan
<b>WS Medium Res.</b>	400	Specan
<b>GM Image</b>	40.000	Specan
<b>WVI (imagette)</b>	5 x 5	Range Doppler
<b>WVS</b>	5 x 5	Cross Spectra
<b>WWV</b>	5 x 5	Wave Spectra inversion





# Product quality & calibration performance

**“Review of ASAR Instrument Performance and Product Quality”**, Envisat symposium Montreux April 2007

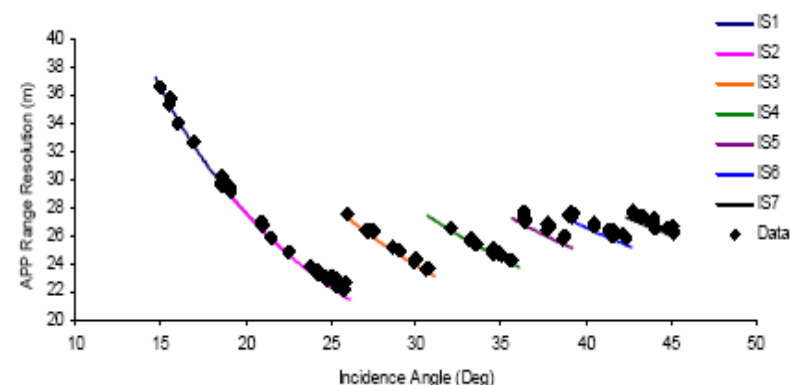
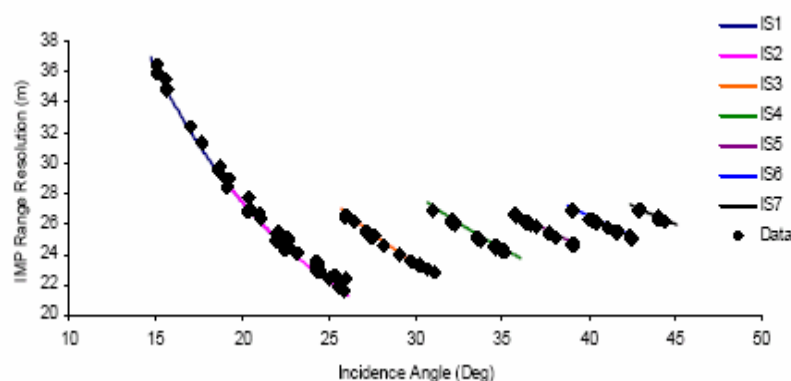
By B. Rosich, ESA-ESRIN et al



## Product Quality – IRF Parameters

- Product quality is routinely monitored, mainly using data over the calibration sites (transponders, ground stations, Amazon rain forest).
- Results are stored and used for calibration and long term performance monitoring.

Product type	Az. Resolution [m]	Range resolution [m]	ISLR [dB]	PSLR [dB]	SSLR [dB]
IMP	22.13±0.49	rg-variant	-13.43±0.57	-16.67±0.98	-22.74±1.76
IMG	22.35±0.45	21.8-35.4	-13.52±0.56	-16.83±1.00	-23.32±1.55
IMS	4.76±0.04	9.44±0.05	-14.47±0.28	-19.19±0.52	-28.47±0.62
IMM	146.87±3.34	rg-variant	-7.01±4.5	-15.52±3.42	-14.65±4.82
APP	27.62±0.82	rg-variant	-12.85±0.47	-19.13±1.02	-26.99±1.64
APG	27.72±0.86	23-35.4	-12.87±0.49	-19.20±1.00	-27.65±1.34
APS	4.38±1.88	8.40±0.07	4.04±2.53	-1.87±1.41	-16.67±4.23
APM	145.03±2.86	rg-variant	-8.29±5.13	-15.39±3.43	-16.57±5.94
WSM	107.24±2.26	rg-variant	-9.06±3.92	-18.83±1.27	-17.35±5.69





## Product calibration

In order to acquire sufficient data for calibration purposes while minimising conflicts with user requests, three of the four ASAR transponders have been successfully redeployed from The Netherlands to Kalimantan (Indonesia), Resolute (Canada) and Ottawa (Canada) since mid 2006.

*See details about the re-deployment activity in a later presentation by C. Goetz.*

- The increase of the number of calibration measurements has made possible to refine the absolute product calibration constants, particularly for AP cross-pol products.

Product Type	Relative Radar Cross Section (RelRCS) [dB]							
	All swaths (bias±stdev)	IS1	IS2	IS3	IS4	IS5	IS6	IS7
IMP	-0.05±0.42	-0.01	-0.08	-0.02	-0.04	-0.01	-0.05	-0.1
IMG	-0.01±0.43	-0.04	-0.11	-0.04	-0.05	0.24	0.04	0.1
IMS	0.00±0.42	-0.02	-0.02	-0.09	0	0.02	0.03	0.1
IMM	0.04±0.95							
APP	-0.06±0.39	-0.28	-0.22	-0.07	0.03	-0.01	0.01	-0.03
APG	-0.04±0.47	-0.3	-0.31	-0.03	-0.06	-0.02	0.22	0.09
APS	-0.06±0.53	-0.1	-0.4	-0.01	-0.25	-0.06	0.17	0.16
APM	-0.06±0.98							
WSM	0.45±1.26							

Product Type	Mean Relative RCS [dB]			
	VV	HH	VH	HV
IMP	-0.03	-0.1		
APP	0.08	-0.04	-0.1	-0.07



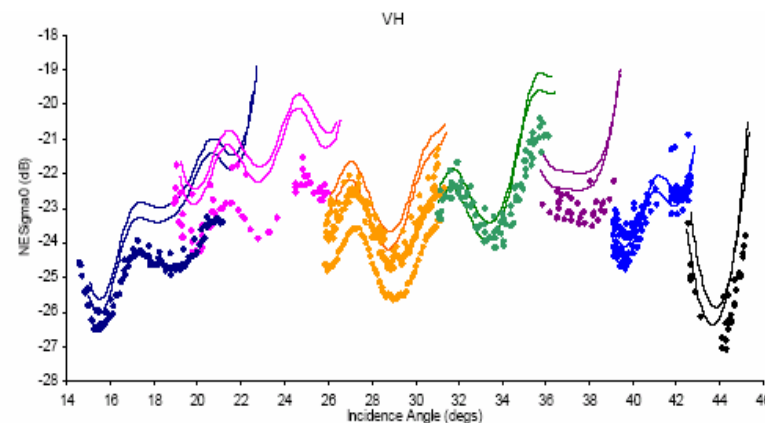
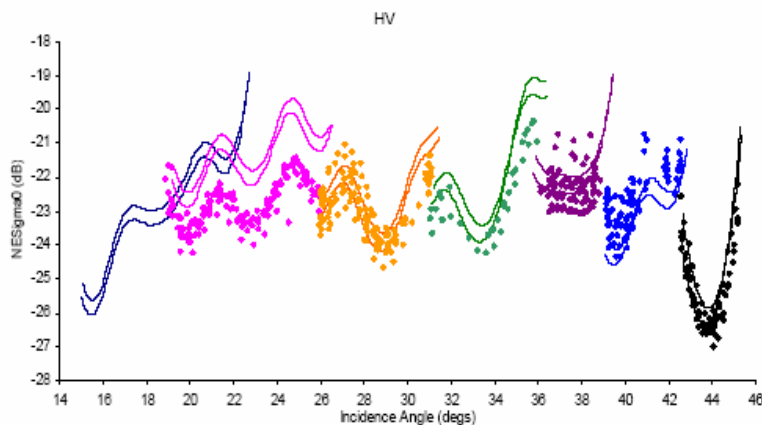


## Product Quality – ENL & NESO

- As part of the routine product quality, some key parameters are monitored, particularly the radiometric resolution and NESO.

	ENL	Rad. Res [[dB]
IMP/IMG Products	3.95	1.77
IMS Products	0.96	3.05
APS Products	0.93	3.09

	APP/APG Products						
	IS1	IS2	IS3	IS4	IS5	IS6	IS7
ENL	1.76	1.73	2.25	2.66	3.3	3.78	3.73
Rad. Res [[dB]	2.44	2.45	2.22	2.08	1.91	1.8	1.81



- Routine ASAR product quality results are published monthly on line at:  
[http://earth.esa.int/pcs/envisat/asar/public\\_reports/](http://earth.esa.int/pcs/envisat/asar/public_reports/)





# ***ENVISAT ASAR SAR exploitation***

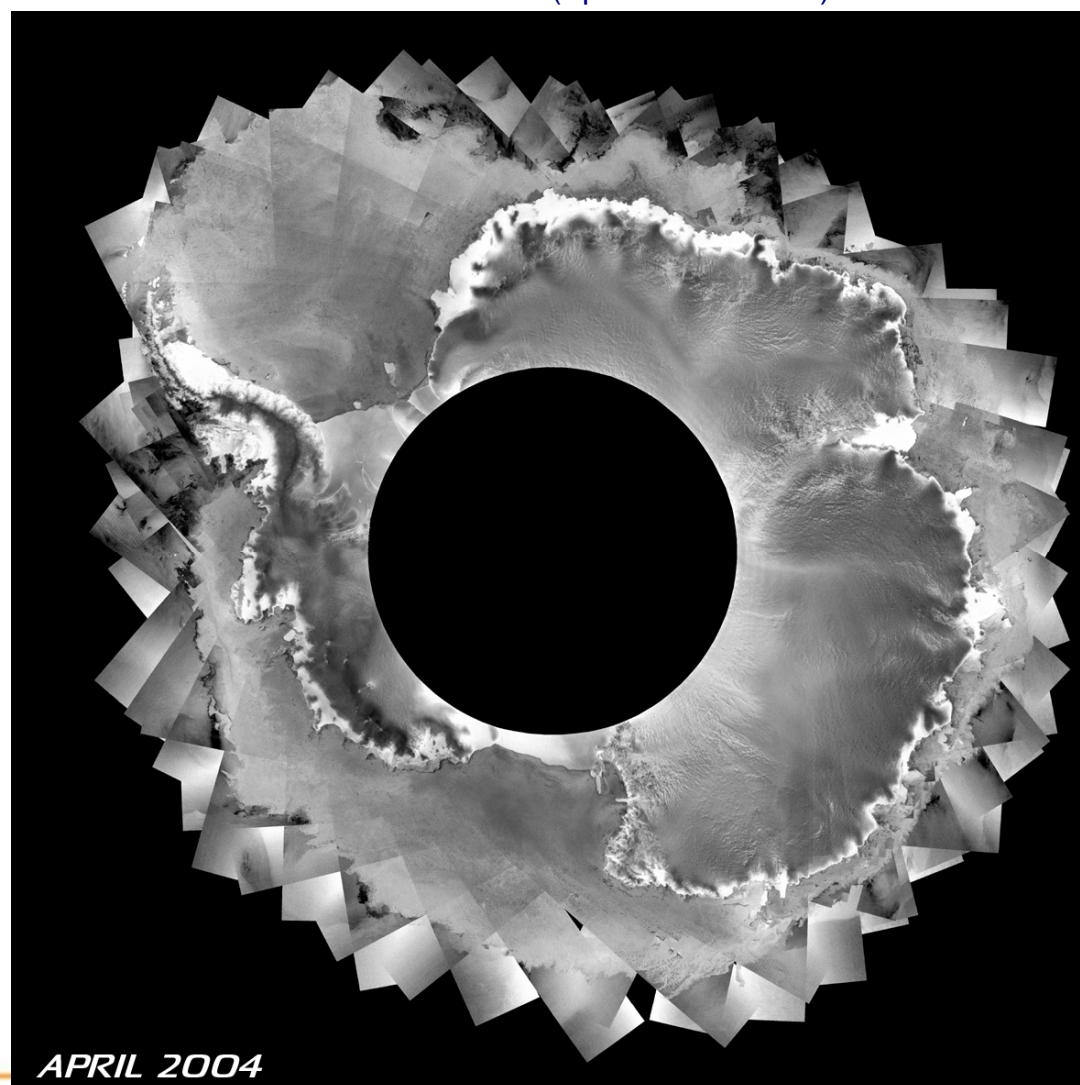
## Envisat monitors Ice-Sea Ice in Antarctica

LARSEN B collapse observed  
in 2002 by ERS /Envisat



Courtesy of H.Rott, Univ Innsbruck, AU

Envisat Radar monitoring Antarctica Ice  
and Sea-Ice extent (April-to June 2004)



(A)SAR instrument series

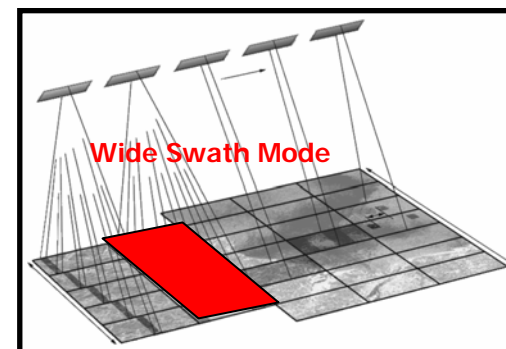
Yves-Louis Desnos



## ENVISAT Imaging Radar



Prestige tanker oil spill - Galicia



4 September 2007

D2L2

(A)SAR instrument series



17 November 2002

© ESA 2002

50 km

Yves-Louis Desnos

52

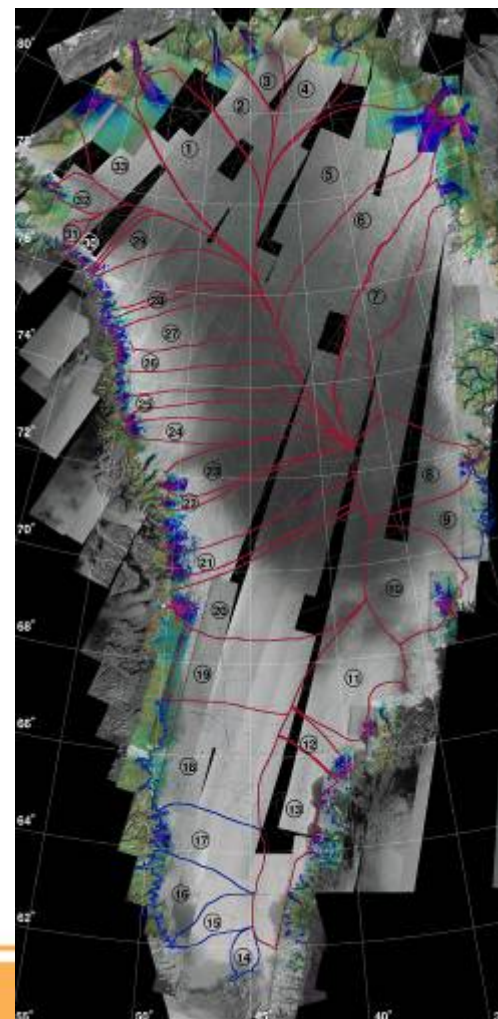
## FRINGE 2005

### Greenland Ice Sheet velocity structure

- “Study of glacier velocity over the Greenland ice sheet has shown significant acceleration of outlet glaciers during the last few years, doubling Greenland’s contribution to sea level rise between 1995 and 2005” – Eric Rignot, JPL
- Contribution to sea level rise is 0.65 mm/yr in 2005.



Rignot, E and Kanagaratnam, P (2006)  
**Changes in the Velocity Structure of the Greenland Ice Sheet**, *Science* vol. 311 no. 5763, pp. 986-990

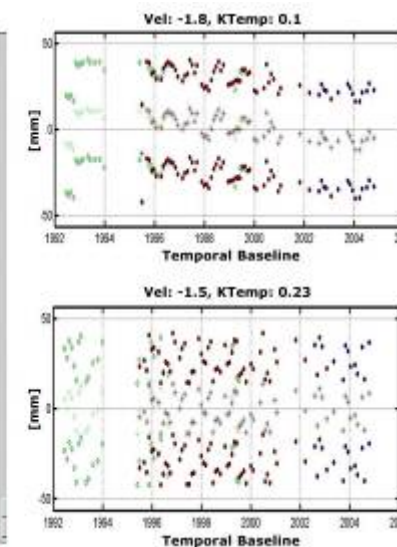
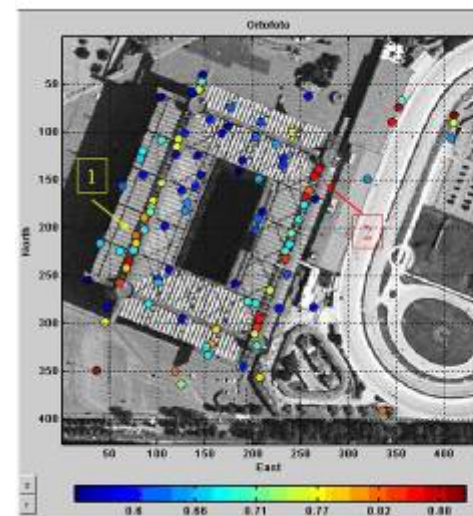
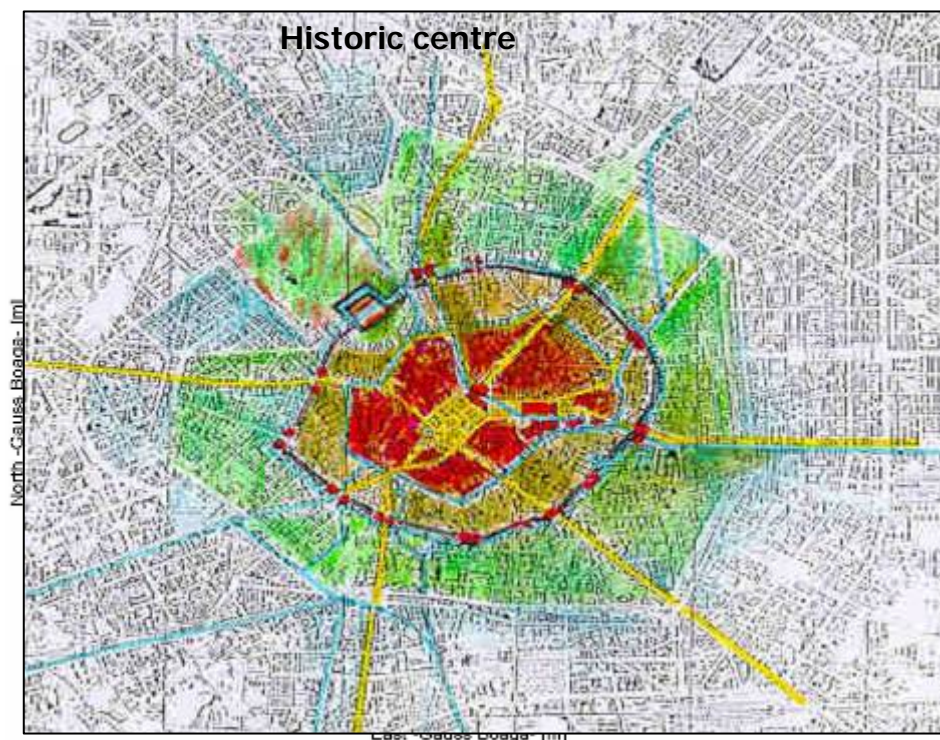




## FRINGE 2005

### PS analysis of Milan

- “PSI extends a collection of 2D SAR images to 4 dimensions, allowing accurate 3D positioning of individual scatterers and assessing their motion, e.g. subsidence.”
- Fabio Rocca/Daniel Perissin



PS on the San Siro stadium  
show variable thermal dilation

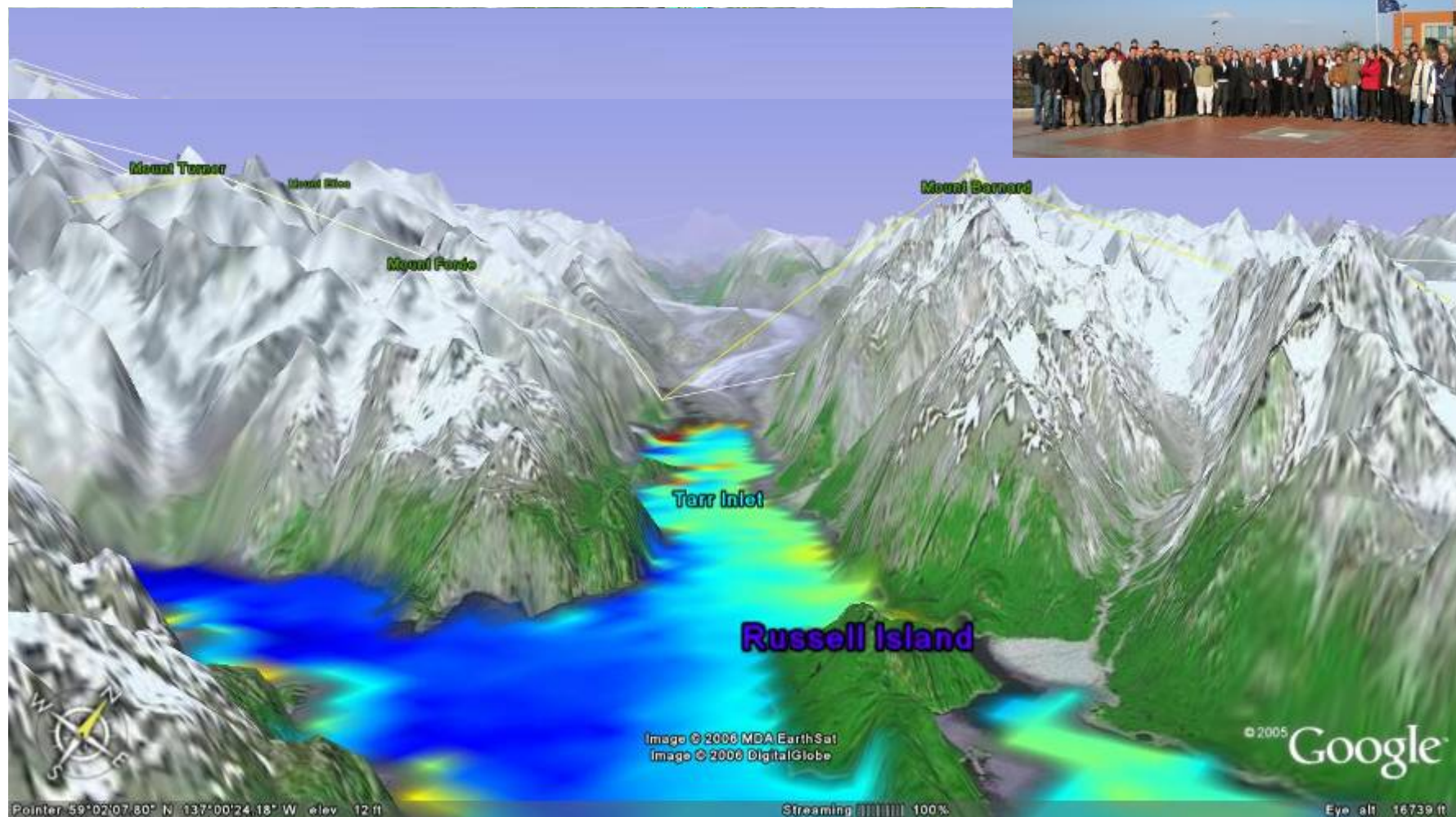
DTM of Milan derived  
from PS measured  
only at ground-level





## SEASAR 2006

### Alaska SAR Demonstration

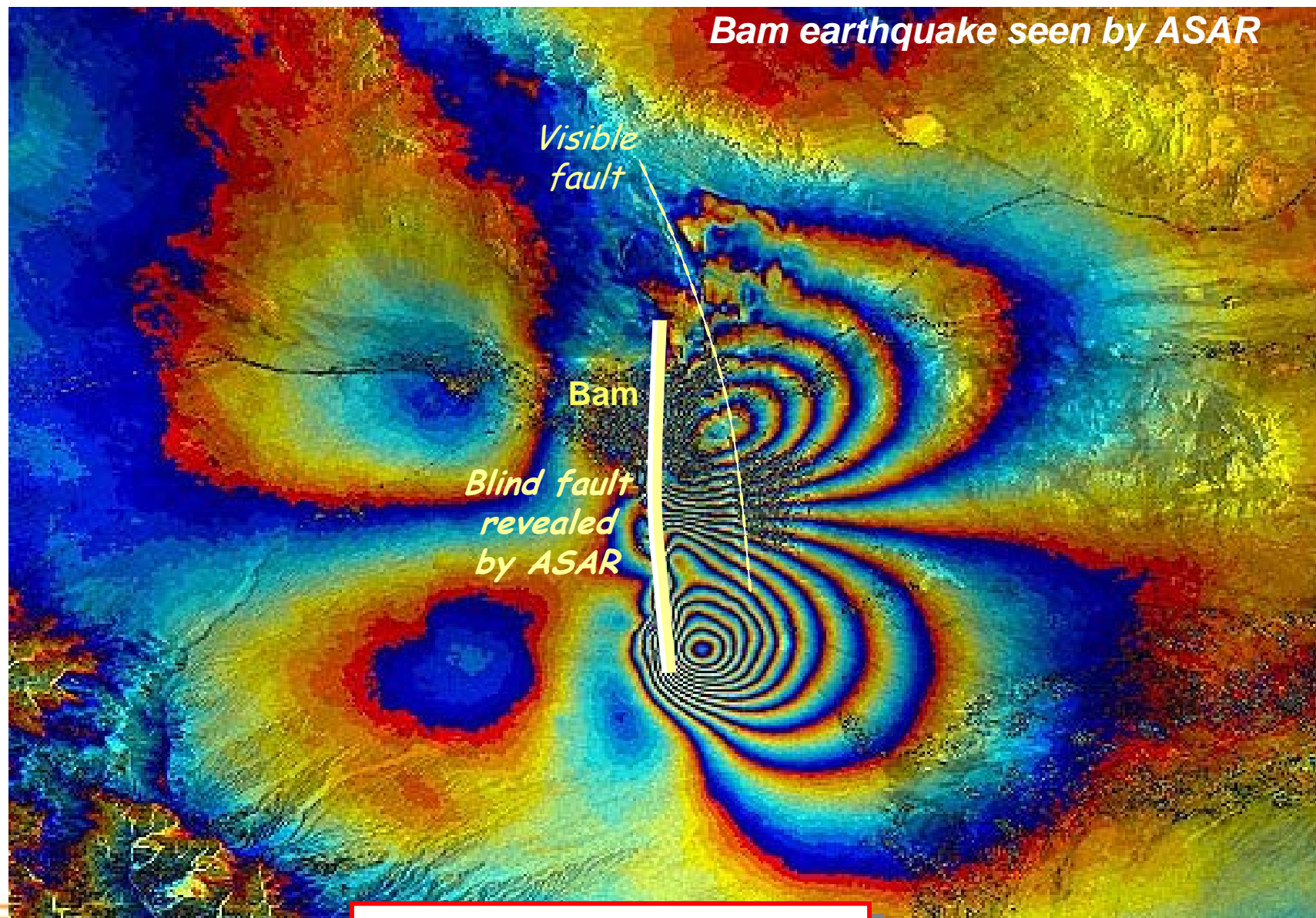


ENVISAT ASAR Wide Swath Mode, 02 Dec 2005 06:43 UT  
William PICHEL et al. (ENVISAT-AO Project 431)



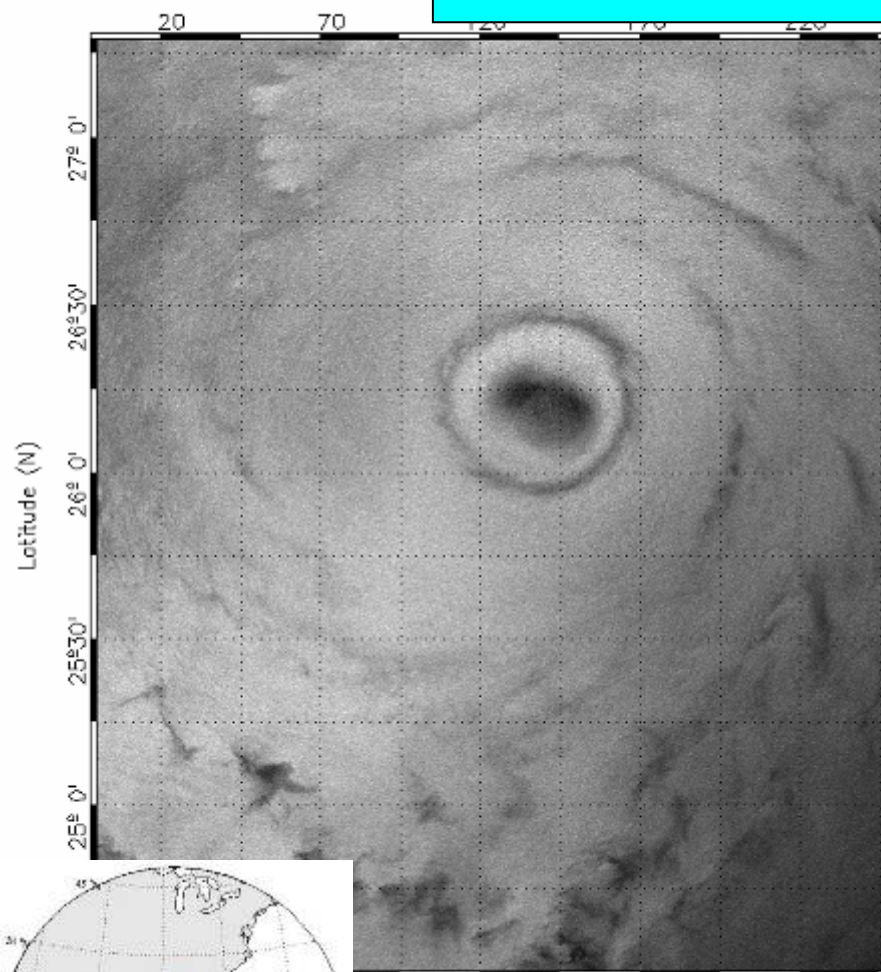
## Envisat identifies blind Tectonic Faults

*Bam earthquake seen by ASAR*

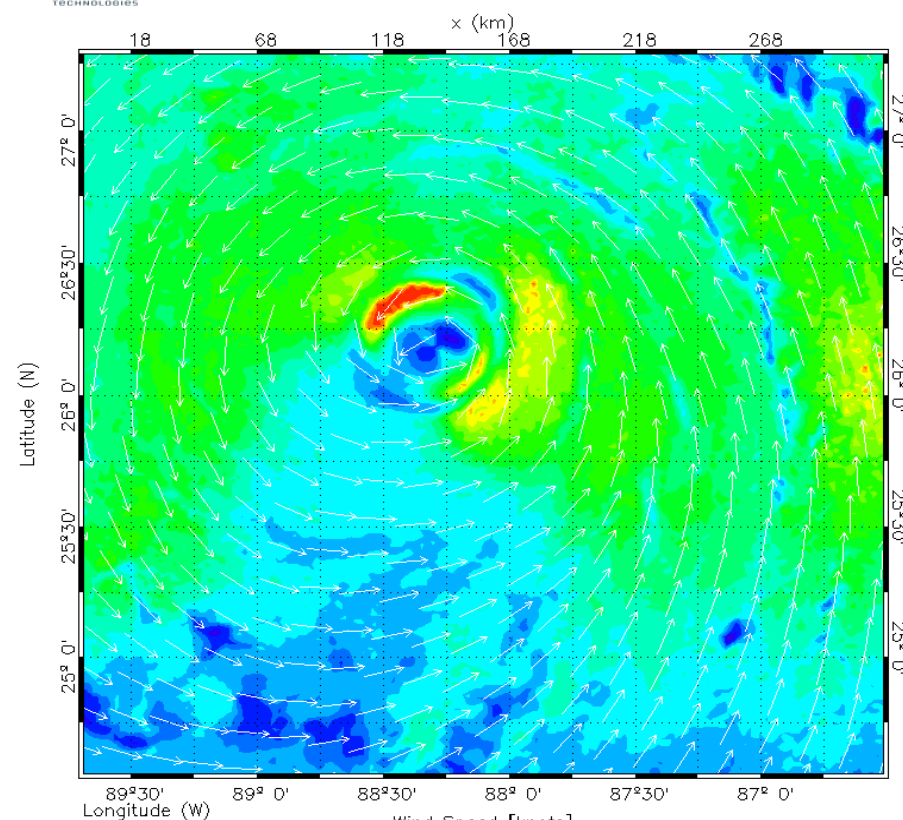




# EYE OF KATRINA - ASAR 28.08.05



28-AUG-2005 15:52:06.773885



COURTESY BOOST

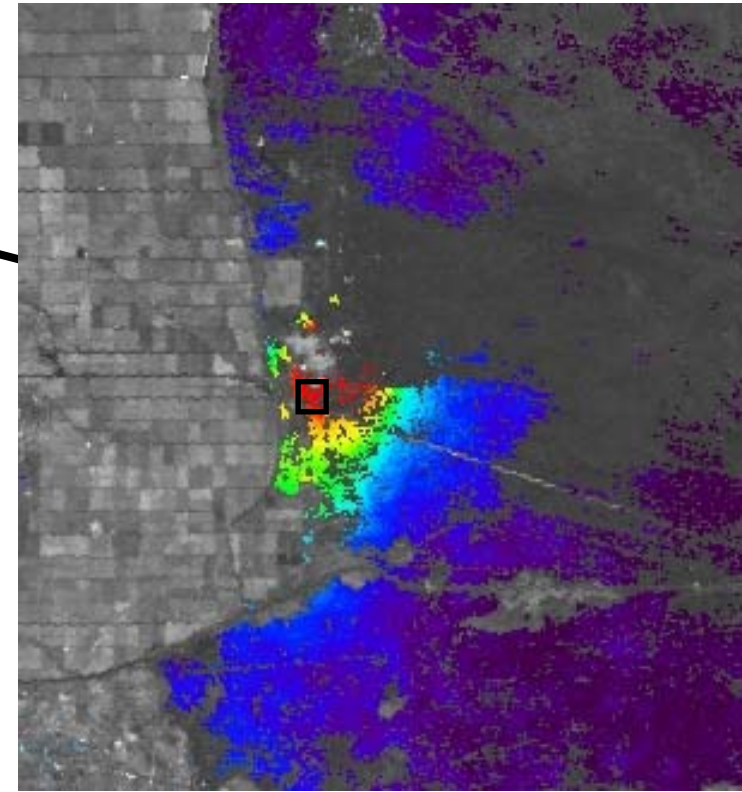
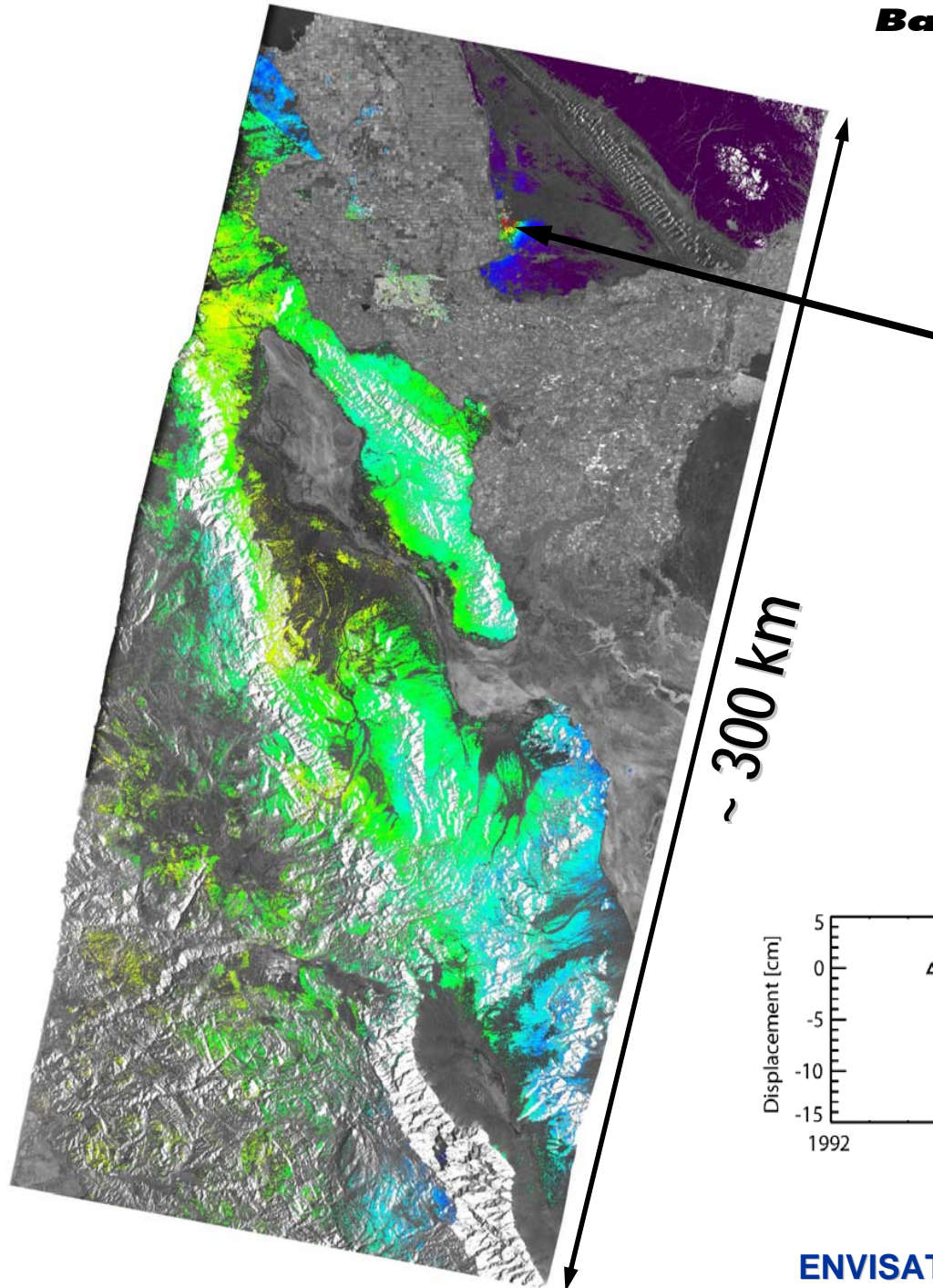


## Baja California area (Mexico)

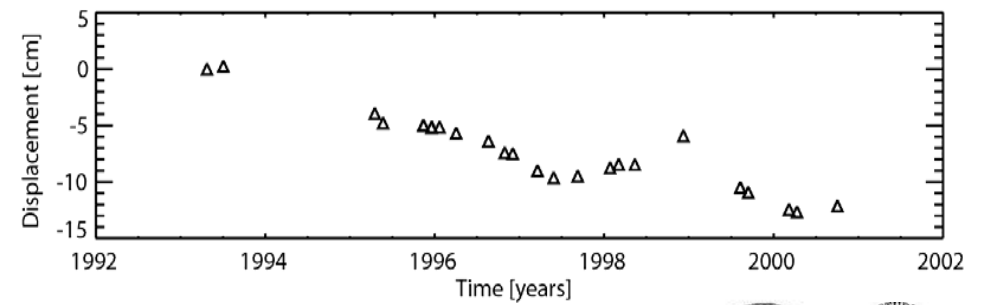
Mean velocity (mm/yr)

> 10

< -10



Cerro Prieto Geothermal Area



ENVISAT Symposium 2007



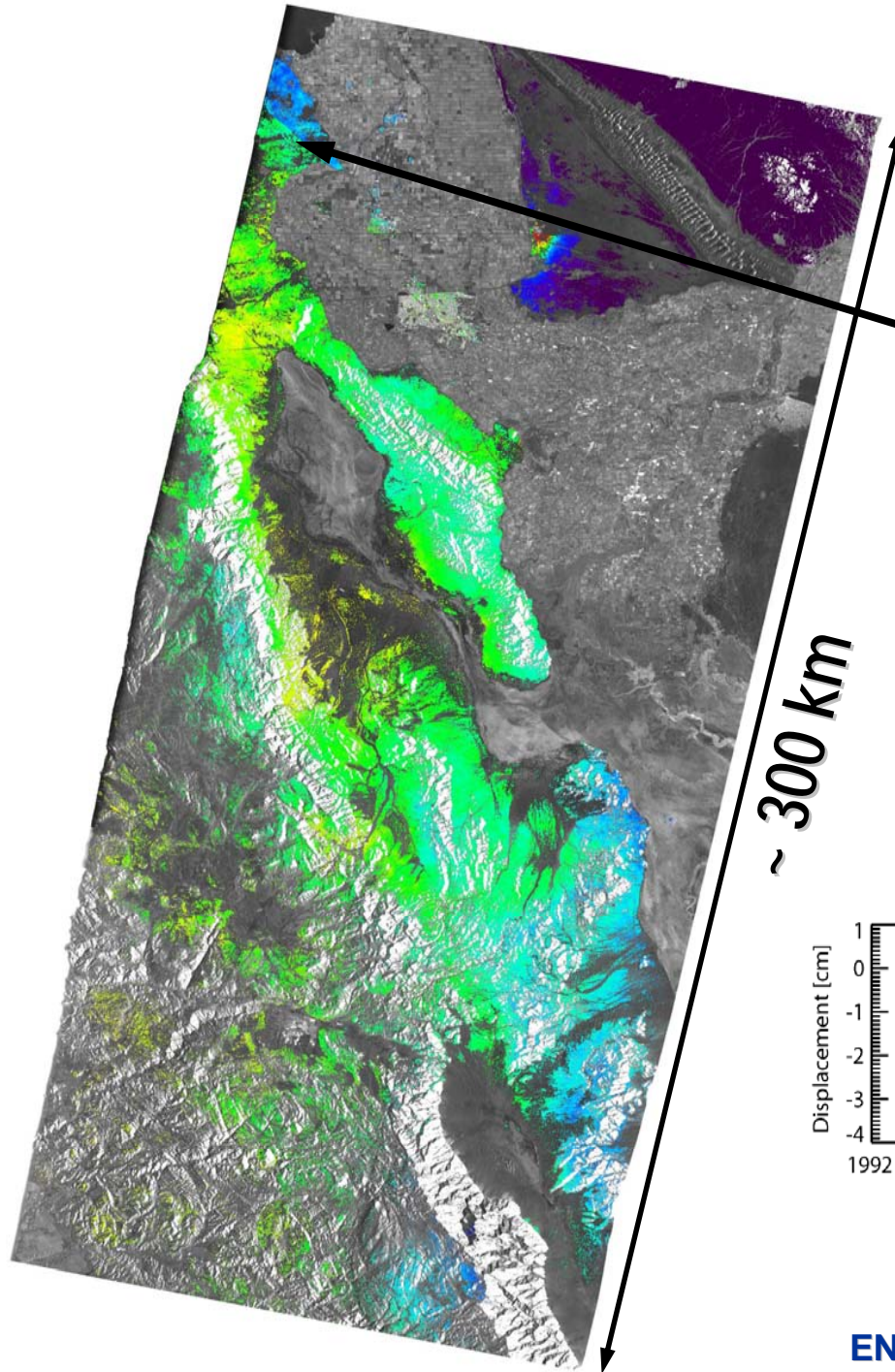


## Baja California area (Mexico)

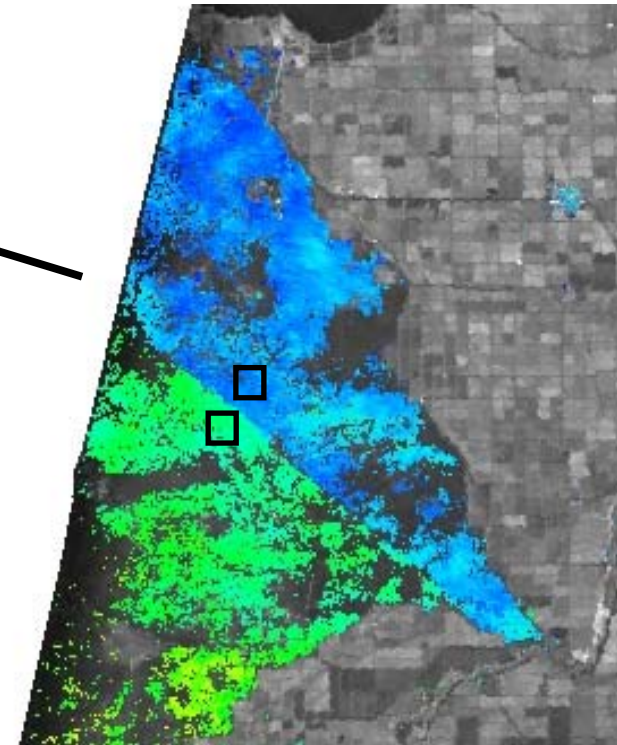
Mean velocity (mm/yr)

> 10

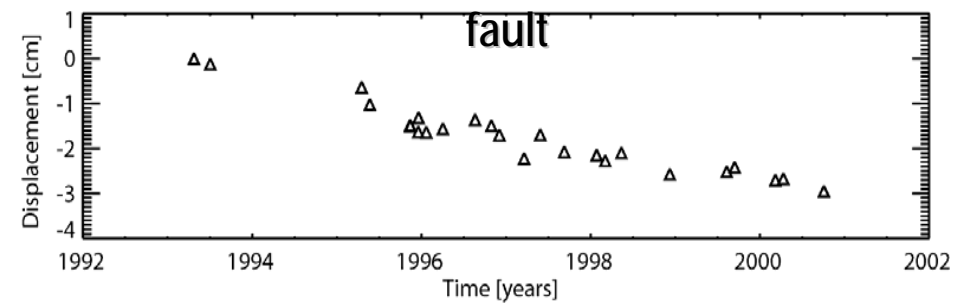
< -10



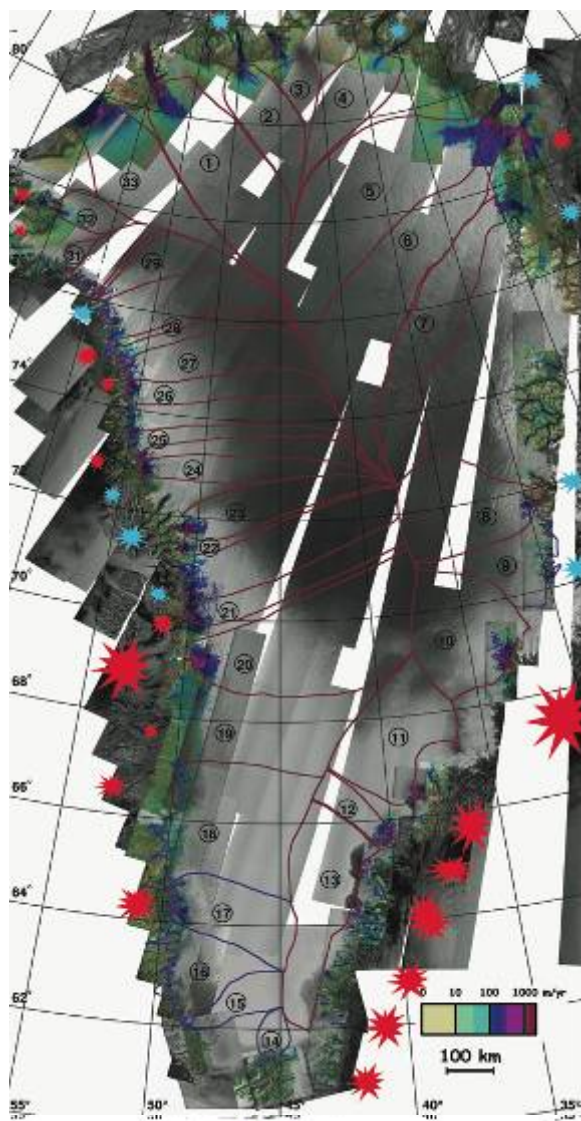
~ 300 km



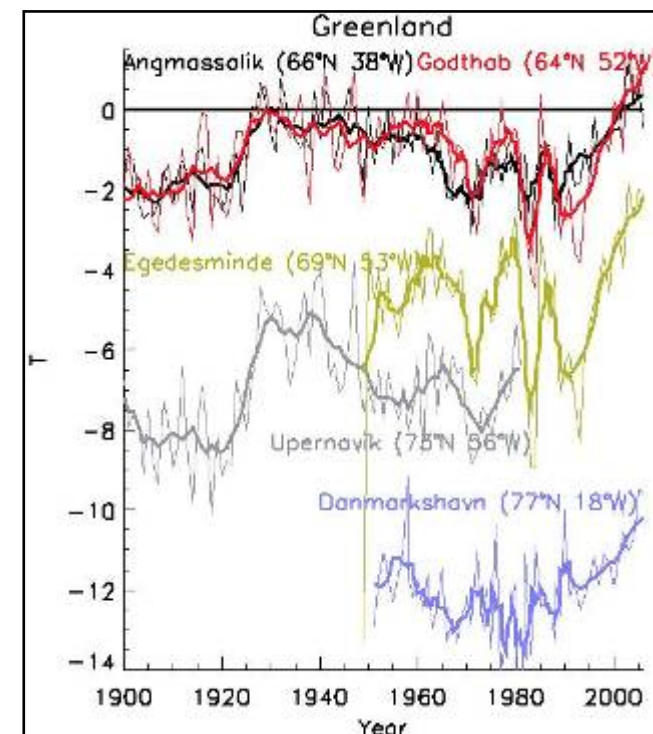
Relative motion across the Cerro Prieto fault



# Greenland mass balance 1996-2005



- Mass deficit:
- $83 \pm 30$  Gt/yr in 1996
- $205 \pm 37$  Gt/yr in 2005
- 2/3rd of loss due to dynamic thinning.



“Greenland’s contribution to sea level rise has been doubling between 1995 and 2005” – Eric Rignot, JPL

Changes in the Velocity Structure of the Greenland Ice Sheet, Science vol. 311 no. 5763, pp. 986-990  
Courtesy of Rignot & Kanagaratnam,



## Antarctic ice velocity: ERS-1/2 (1996), RSAT-1 (2000)

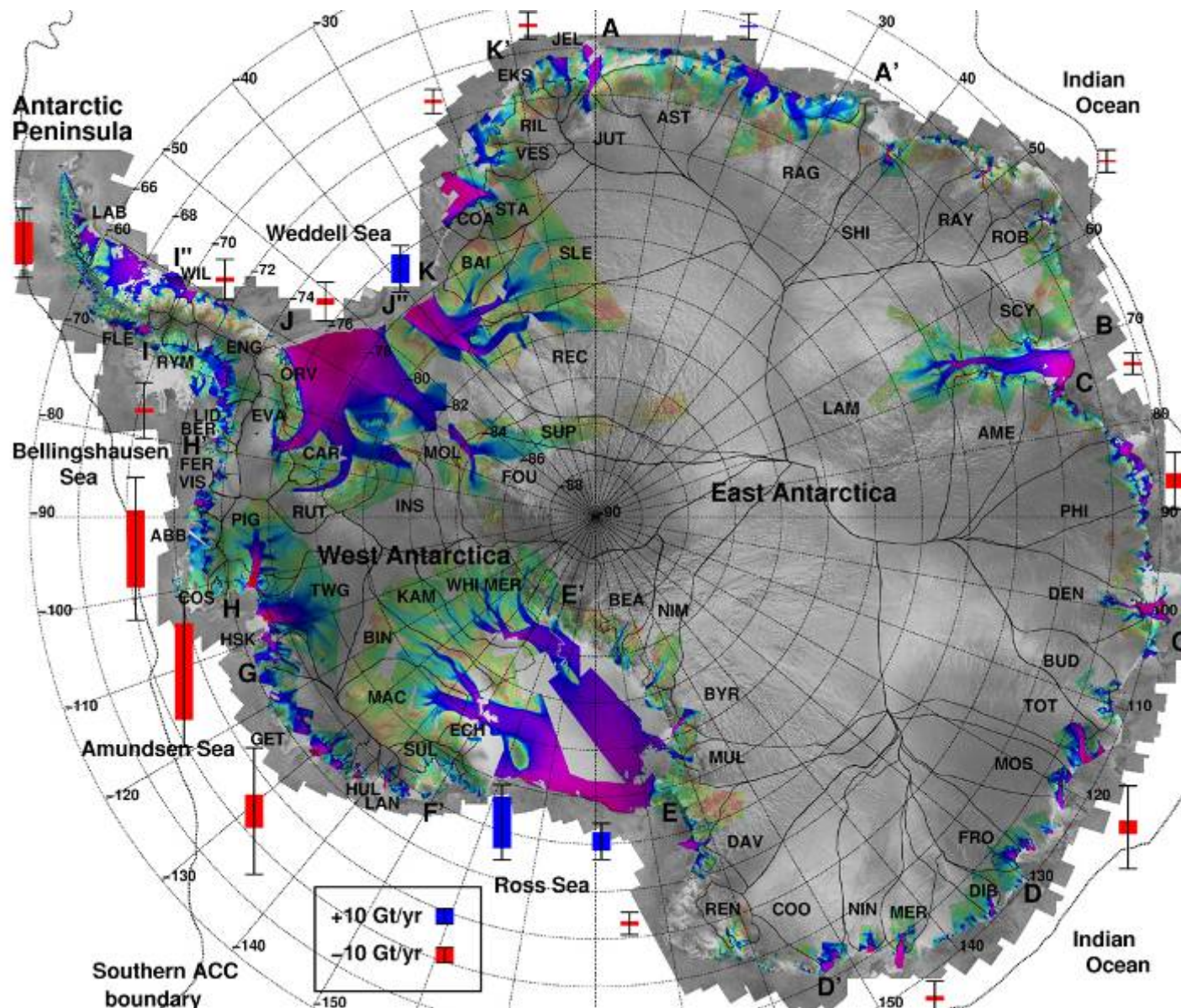
Mass deficit of  
 $140 \pm 50$  Gt/yr,

Mostly  
West Antarctica Ice  
Shelf & Antarctic  
Peninsula.

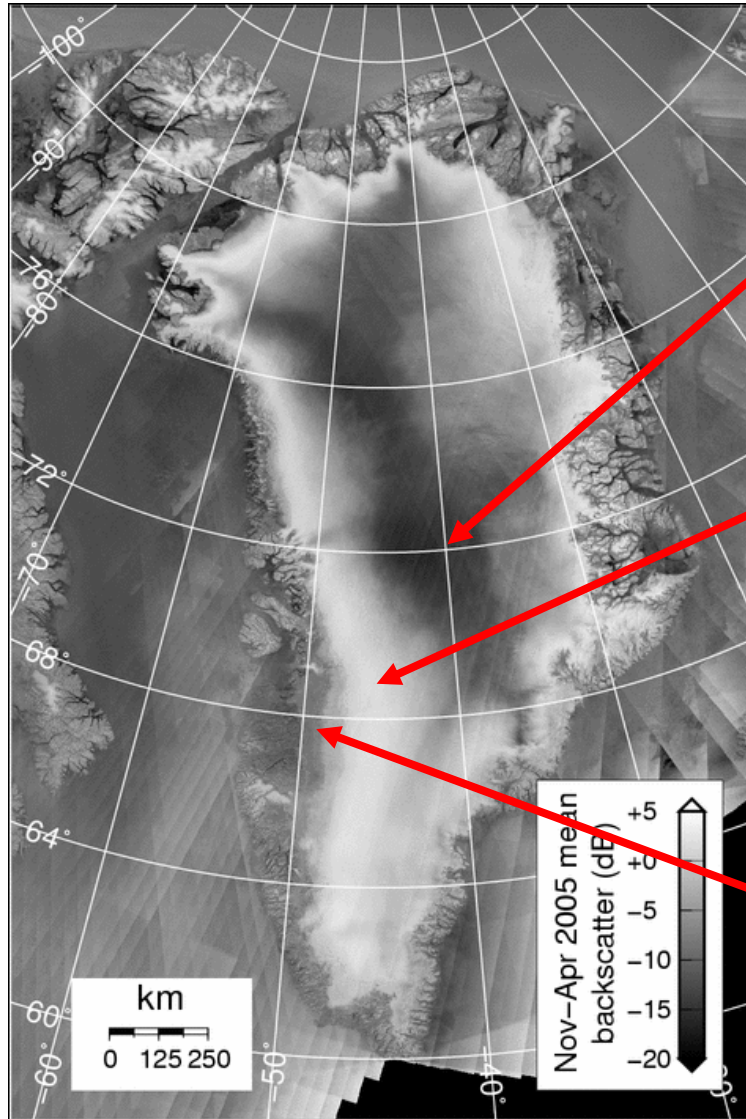
Entire Admundsen  
Sea/Bellingshausen  
Seas sector  
thinning  
dynamically.

East Aantact. Ice Shelf ~ balance

Rignot et al.,  
Subm. 2007



# Greenland with ASAR GM mode



## Dry snow zone

Deep penetration and few scatterers

- *Consistently low backscatter*

## Percolation zone

Ice lenses within snow-pack

- *High backscatter when frozen*

Water absorbs microwave energy

- *Step reduction when melting*

## Bare ice (variable extent)

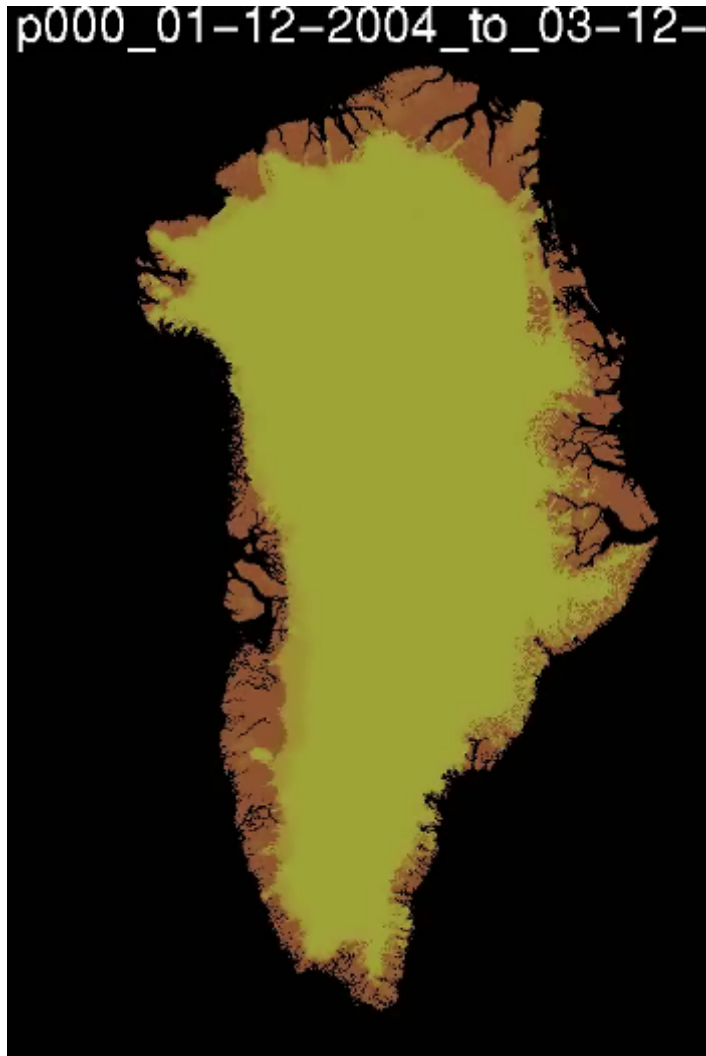
High texture and surface scatter

- *Consistent medium backscatter*





# Melt extent in Greenland



no melt  
melt  
bare ice  
no ice

- Freeze/Melt transition is dramatic
- validation with Greenland climate network
- Envisat ASAR GMM unique tool to monitor ice-sheet/ice-shelf melt extent
  - 1 km spatial resolution
  - Adequate temporal resolution (subject to BRM)
- Improved observations:
  - Melt pattern (ice shelves)
  - Small ice caps
  - Individual Greenland catchments



# ENVISAT for monitoring dikes in the Netherlands

## History: Zeeland, 31 Jan 1953

- Evacuation of 72000 people
- Thousands of buildings destroyed



On the potential of PS-InSAR for monitoring dikes in the Netherlands

*Courtesy of Ramon Hansen Delft Institute of Earth Observation and Space Systems*



# Can we monitor this from space?



17000 km of water barriers:

- 3565 km primary water barriers (big rivers, sea, IJsselmeer, Markermeer),
- >14000 km regional water barriers



Overflowing



Sliding inner slope



Overtopping



Plastic horizontal sliding



Piping



Nipping ice

On the potential of PS-InSAR for monitoring dikes in the Netherlands

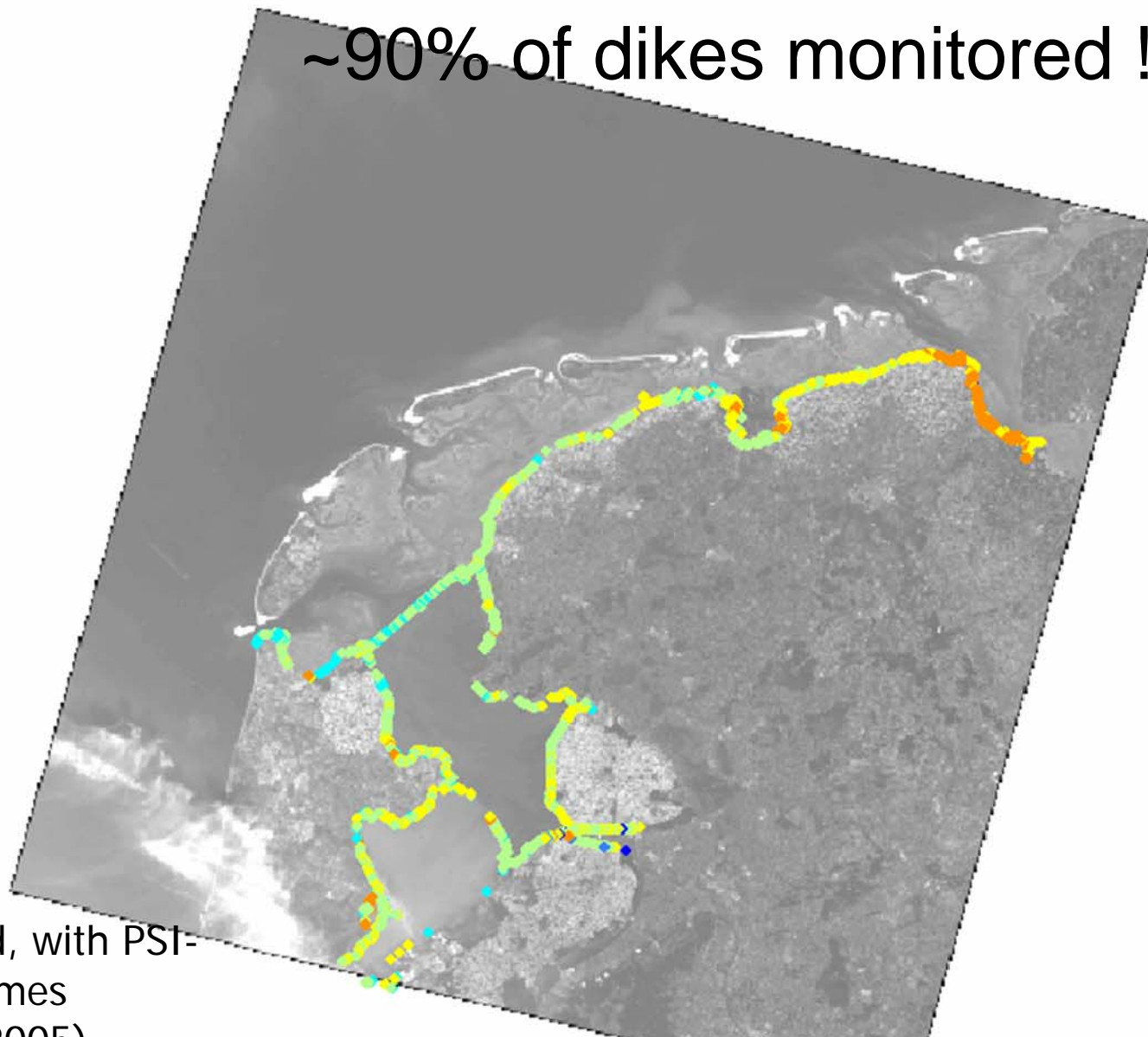
Courtesy R. Hansen Delft Institute of Earth Observation and Space Systems



~90% of dikes monitored !!

*Deformation  
mm/year*

- -10.0 – -6.5
- -6.5 – -4.0
- -4.0 – -1.3
- -1.3 – 1.3
- 1.3 – 4.0
- 4.0 – 7.0
- 7.0 – 10.0



Landsat background, with PSI-  
dike results of 9 frames  
superposed (1992-2005)

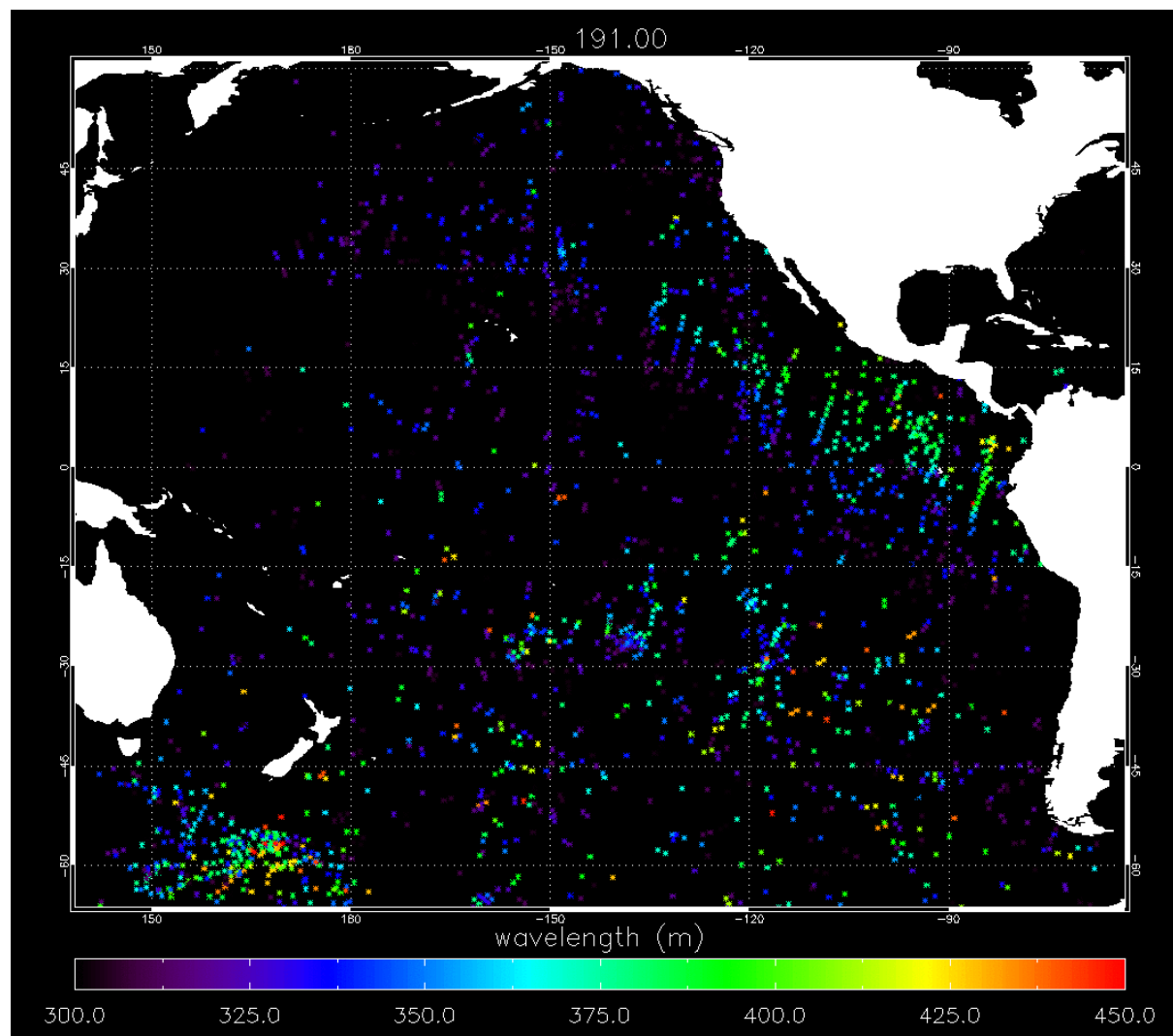
On the potential of PS-InSAR for monitoring dikes in the Netherlands

*Courtesy of Ramon Hansen Delft Institute of Earth Observation and Space Systems*





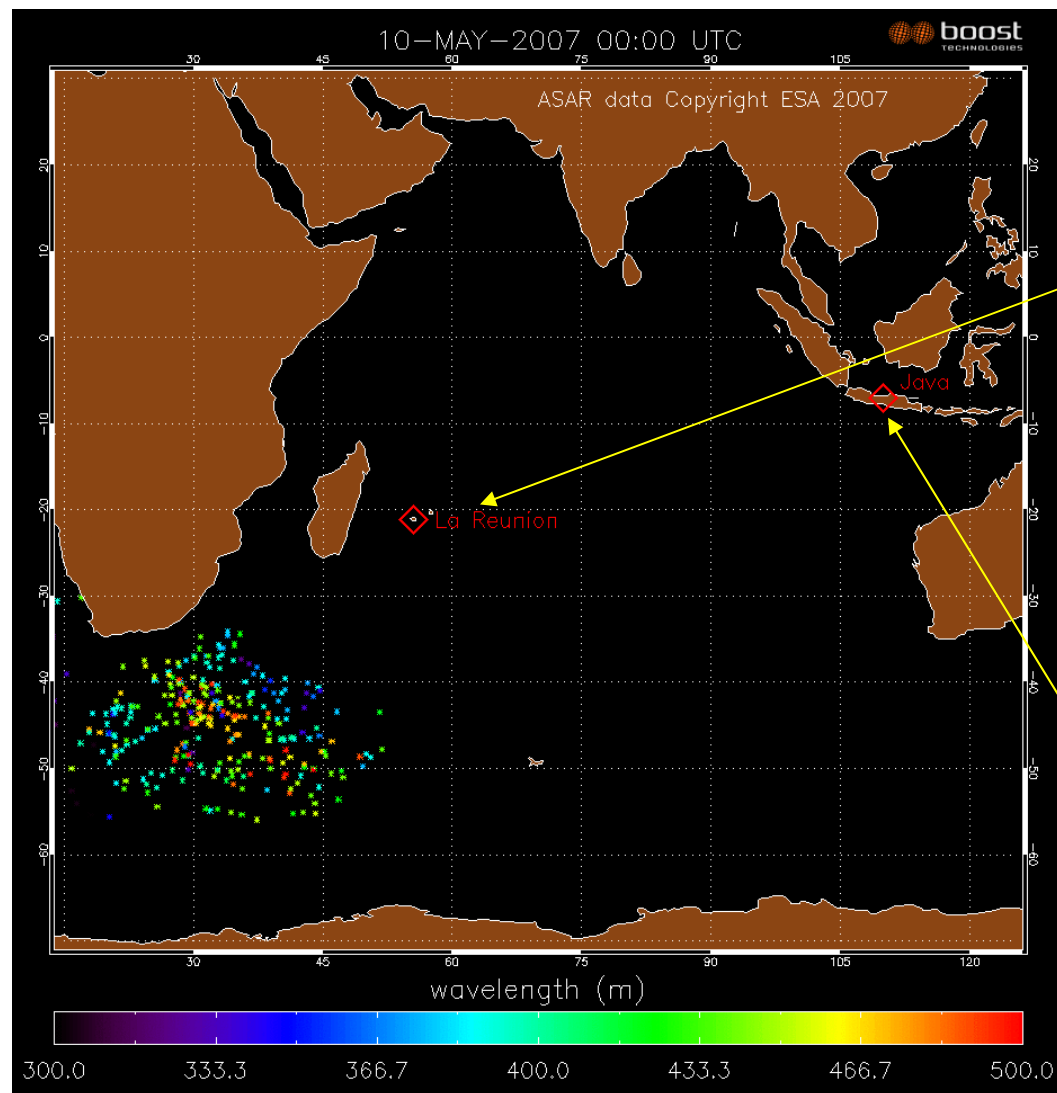
ASAR Wave Mode tracks long swell propagating across the pacific during 12 days



- 6 hour time step
- Wavelength from 300 to 450m
- Wave period from 13 to 17 seconds
- Time period from 8 to 20 July 2004



## Headline news: ASAR Wave Mode tracking the long swell that hit La Reunion and Indonesia



A first giant wave of 11meter hit La Reunion island on 12th May



•A subsequent Giant wave of 7 meter hit Indenosia on 17th and 18th May



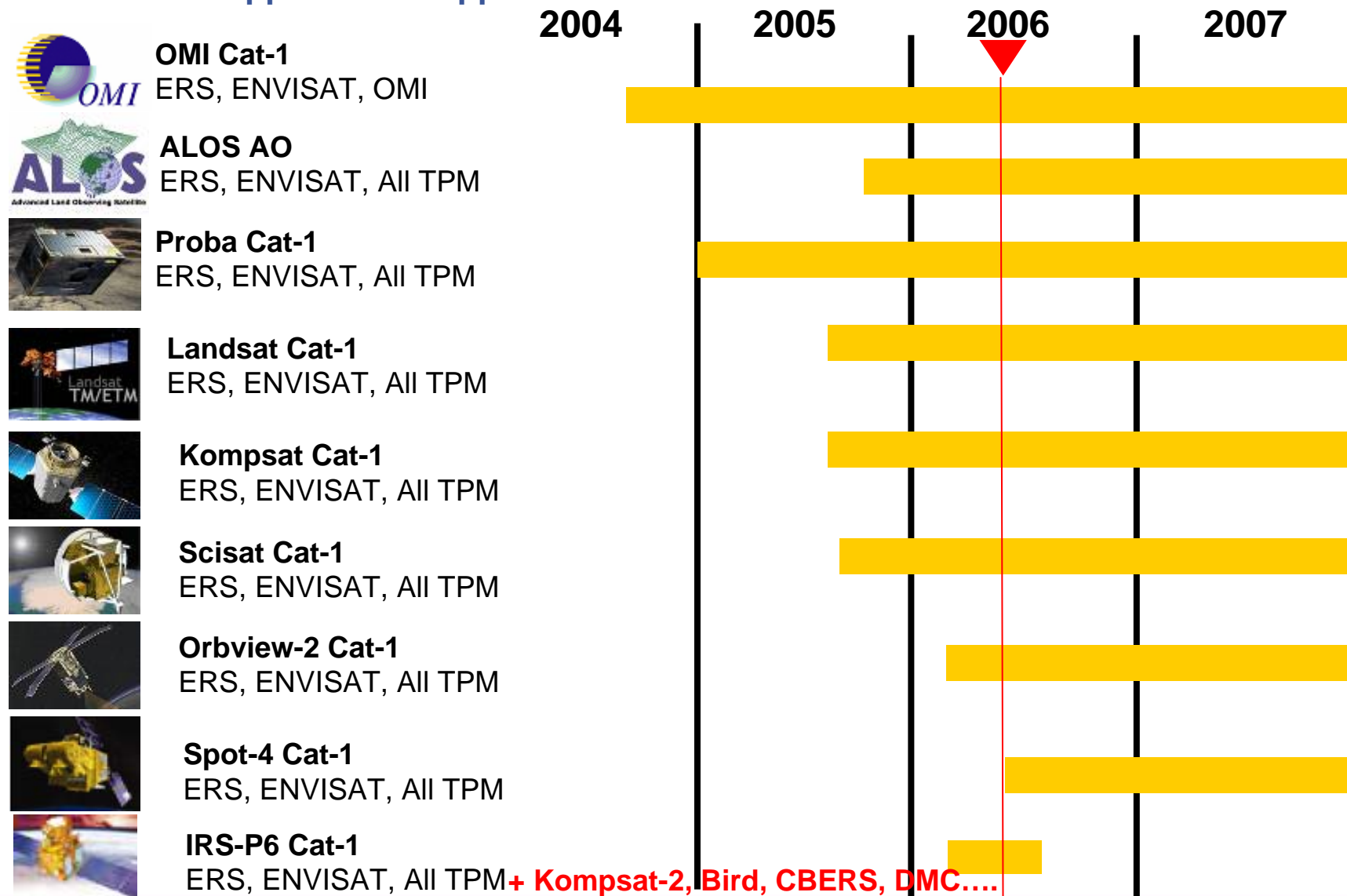


# ***Third Party Missions***



## Research and Applications Opportunities

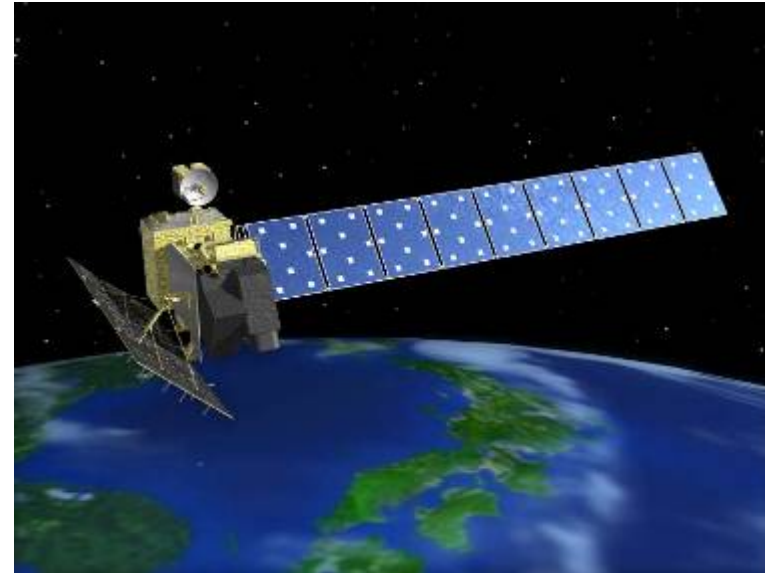
## ESA selected Third Party Missions



## The ALOS Mission

### Mission Objectives

- Develop digital elevation models (DEMs)
- Perform regional observation for *sustainable development*
- Conduct disaster monitoring around the world
- Survey natural resources
- Develop sensor and satellite technology



### Launch

- ALOS launch 24th Jan 2006 successfully by an H-IIA rocket
- **First data:** 14th Feb (PRISM), 15th (PALSAR), 17th (AVNIR-2)
- **First complete downlink with data at Kiruna 28th April**

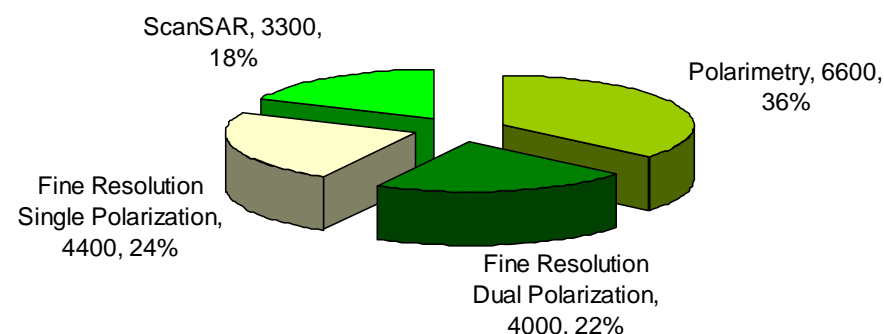
### PALSAR

*Phased Array type L-band Synthetic Aperture Radar.* an active microwave sensor which enables all-weather, 24-hours observations. The sensor has a steerable beam in elevation and the ScanSAR mode. PALSAR has also fully polarimetric capabilities

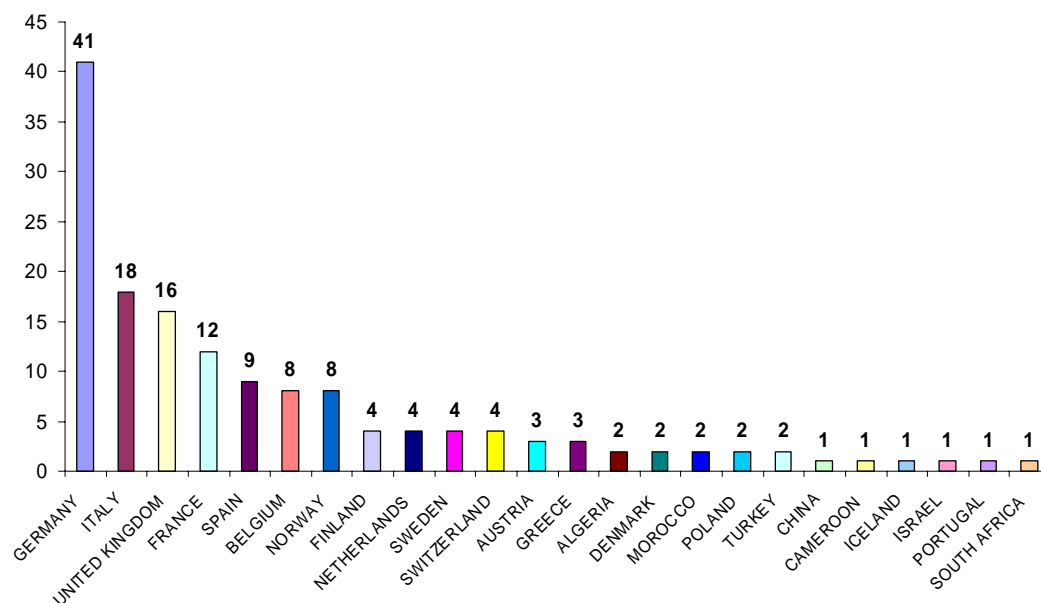
## The ALOS AO

### Schedule

- Opened on September 20, 2005
- Closed January 2006
- PB-EO approval May 2006
- Notification of evaluation results to the PIs: June 2006
- Start of ALOS data delivery: January 2007



### Requested PALSAR Products



...139 proposals by scientists from ESA Member States



<http://eopi.esa.int/ADEN>

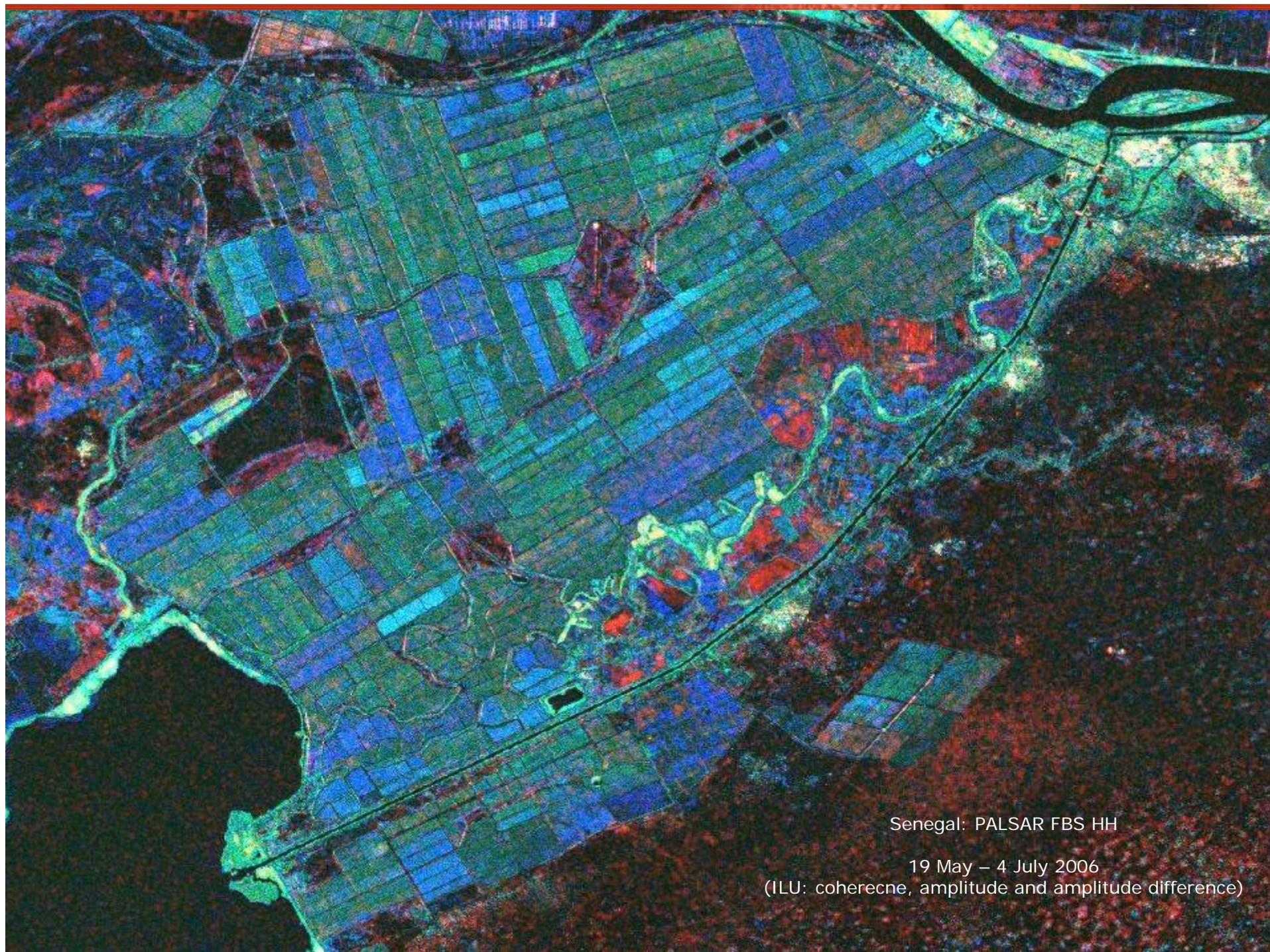




***Celebrating the first anniversary of ALOS in orbit***

PALSAR Polarimetric Image of Hamburg, GERMANY - Produced on 24<sup>th</sup> January 2007 - Red: VV, Green: VH, Blue: HH





Senegal: PALSAR FBS HH

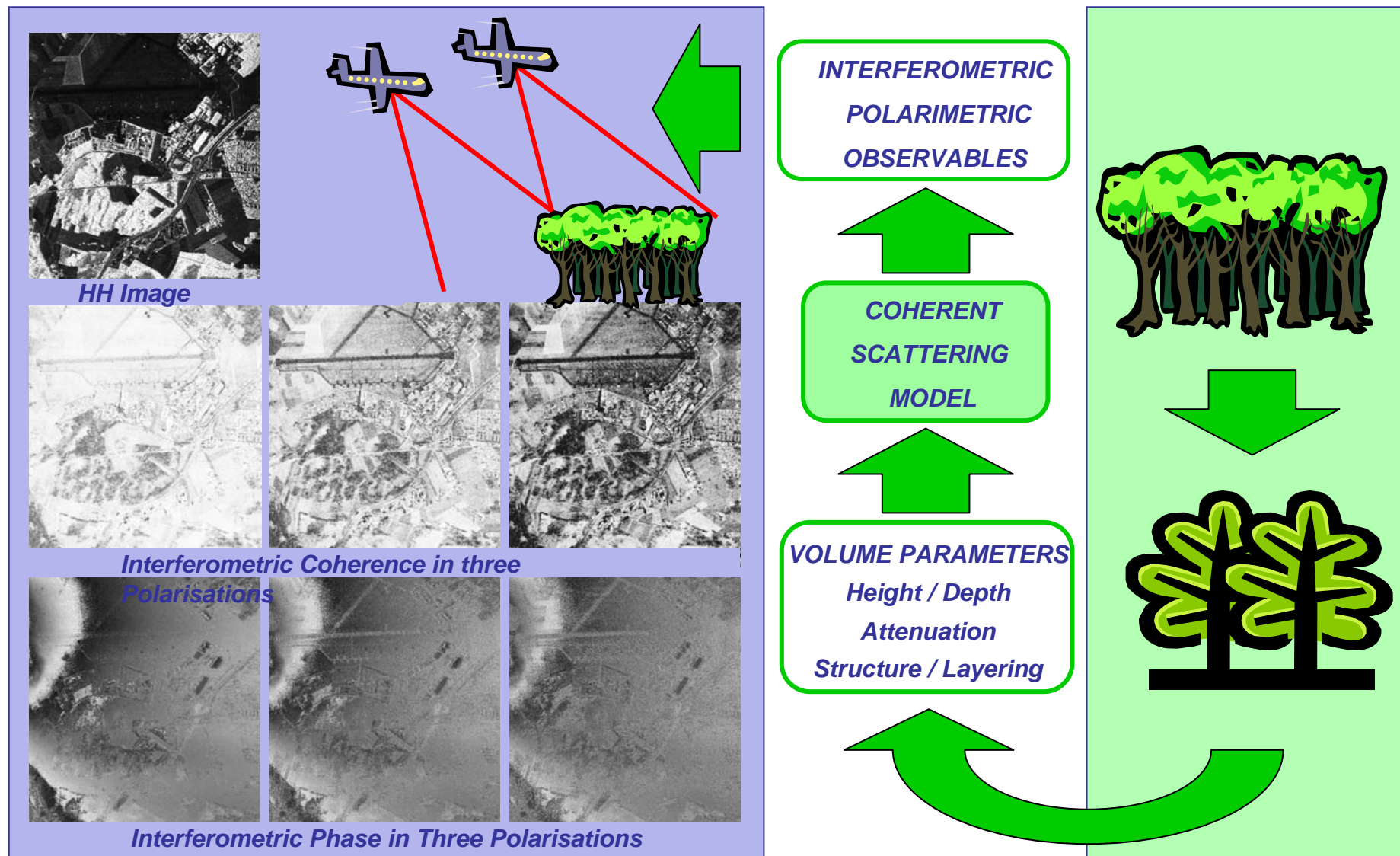
19 May – 4 July 2006  
(ILU: coherence, amplitude and amplitude difference)



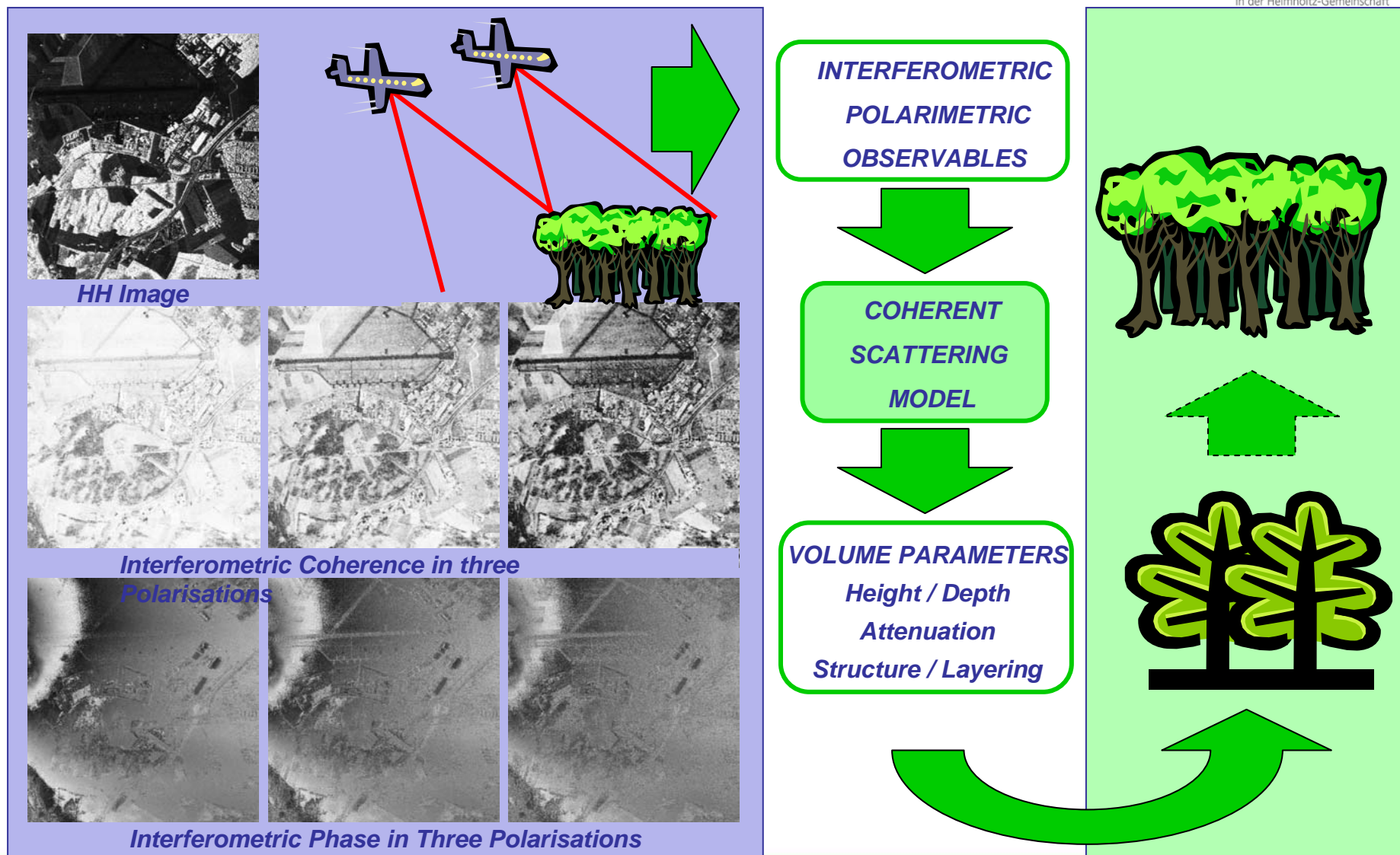




## Parameter Estimation by means of Pol-InSAR: Step 1 - Modeling



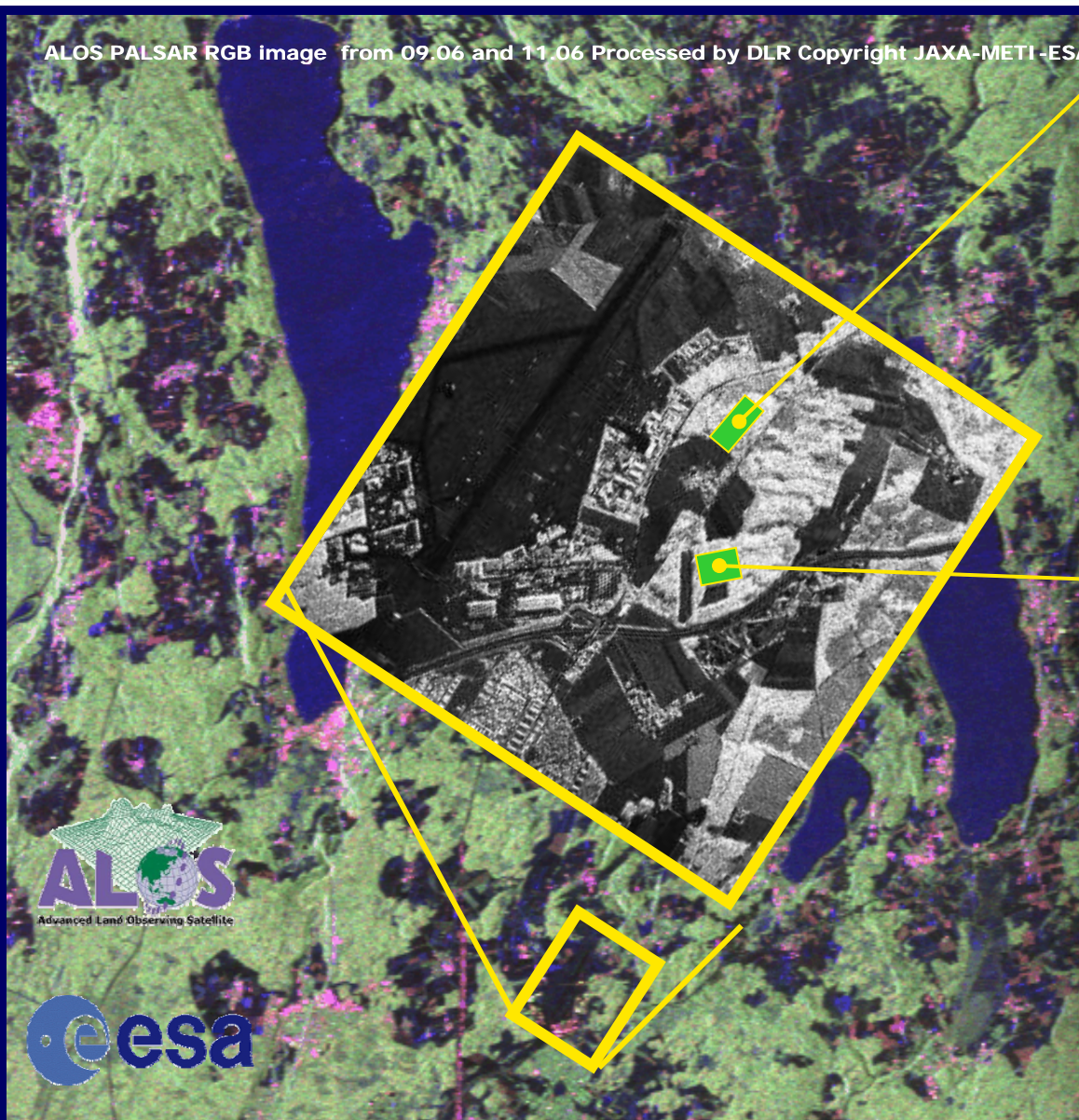
## Parameter Estimation by means of Pol-InSAR: Step 2 - Inversion





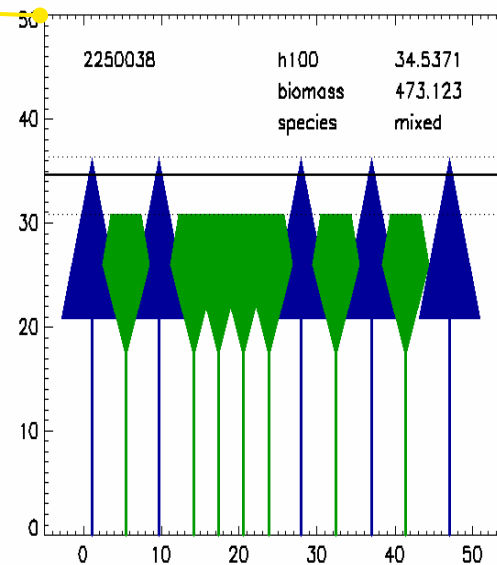
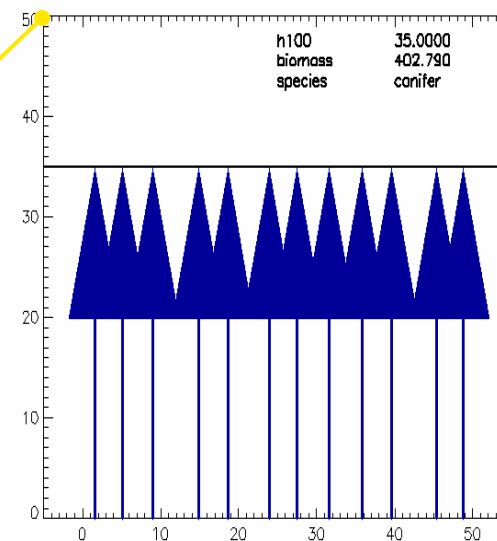


ALOS PALSAR RGB image from 09.06 and 11.06 Processed by DLR Copyright JAXA-METI-ESA



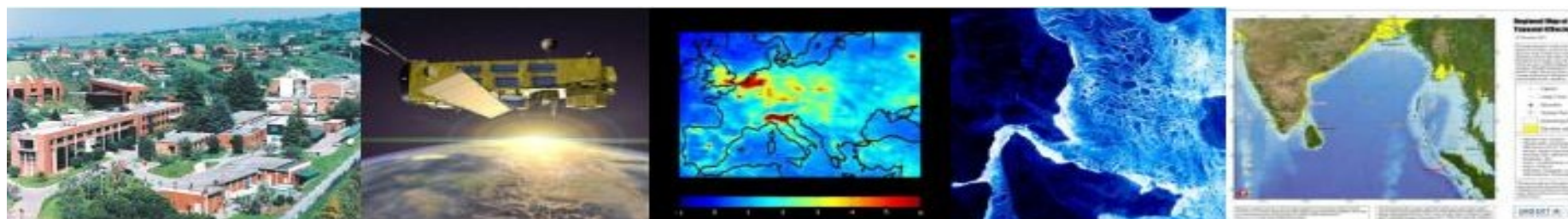
ALOS  
Advanced Land Observing Satellite

esa





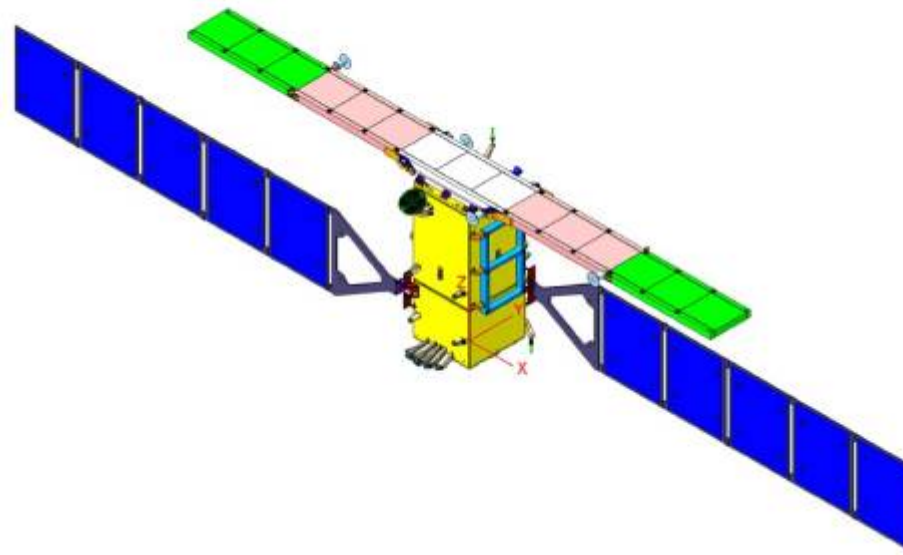
# ***Sentinel-1***







# *Sentinel-1*



- European Radar Observatory: C-band Synthetic Aperture Radar
- Main operational mode: SAR imaging (Interferometric Wide Swath)
- Prime task: Continuity of operational SAR applications including interferometry



## ***Sentinel-1 Services (1)***

<b>GMES Consolidated Service</b>	<b>Sentinel-1 Contribution</b>
<b>Polar Environment Services</b>	<ul style="list-style-type: none"> <li>•Glacier and Snow Monitoring</li> <li>•Iceberg Monitoring</li> <li>•Sea Ice Monitoring</li> <li>•Oil Discharge Monitoring</li> <li>•Near Shore Ice Complex</li> <li>•Land Monitoring</li> <li>•Lake Ice Monitoring</li> <li>•River Ice Monitoring</li> </ul>
<b>Marine &amp; Coastal Environment</b>	<ul style="list-style-type: none"> <li>•Sea surface winds, currents &amp; waves</li> <li>•Oil spill information services (surveillance, drift forecasting)</li> <li>•Ship detection services for fisheries and security</li> </ul>
<b>Land Information Services</b>	<ul style="list-style-type: none"> <li>•Basic Land Cover</li> <li>•Soil Sealing Map</li> </ul>
<b>Forest Monitoring Services</b>	<ul style="list-style-type: none"> <li>•Green house gas reporting</li> <li>•Sub-National Forest Information Updates</li> <li>•Mapping and Monitoring of Disturbances (Clearing, Fires)</li> <li>•Land Cover &amp; Forest Indicators</li> </ul>

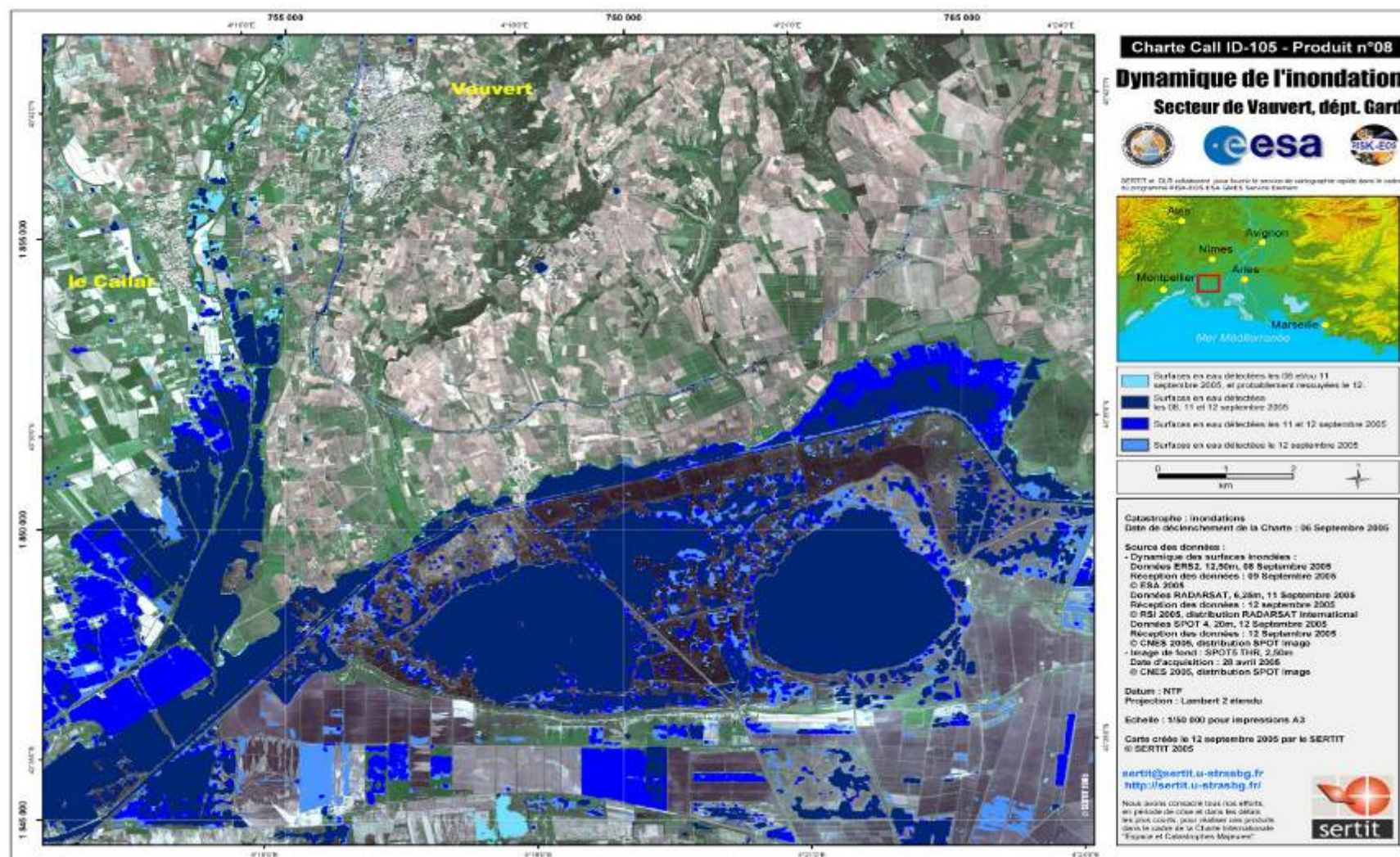




## ***Sentinel-1 Services (2)***

<b>GMES Consolidated Service</b>	<b>Sentinel-1 Contribution</b>
<b>Geo-hazard Risk Management</b>	<ul style="list-style-type: none"> <li>•Historical measurements of ground motion: subsidence risk</li> <li>•Subsidence and landslide monitoring (tunnelling project, water table change)</li> <li>•Geological engineering</li> </ul>
<b>Flood and Fire Risk Operational Information Services</b>	<ul style="list-style-type: none"> <li>•Flash flood early warning</li> <li>•Floods rapid mapping</li> <li>•Flood risk analysis</li> </ul>
<b>Food Security Information</b>	<ul style="list-style-type: none"> <li>•Mapping ploughing time and acreage</li> <li>•Mapping planting time and acreage</li> <li>•Mapping cultivated area at harvest/during growing period</li> </ul>
<b>Humanitarian Aid</b>	<ul style="list-style-type: none"> <li>•Rapid mapping for out-of-area crises operation</li> <li>•Cartography for development and reconstruction planning</li> </ul>

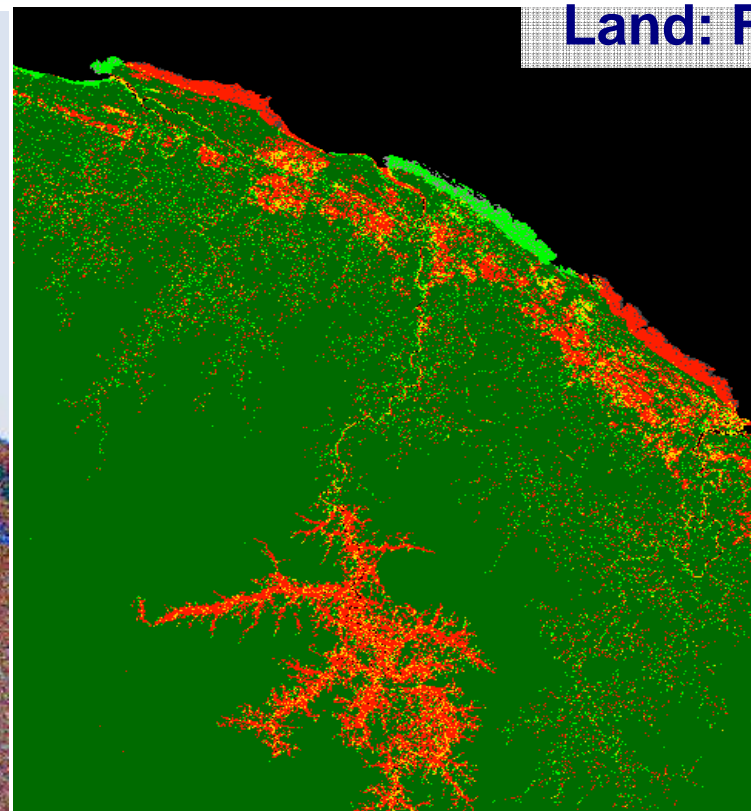
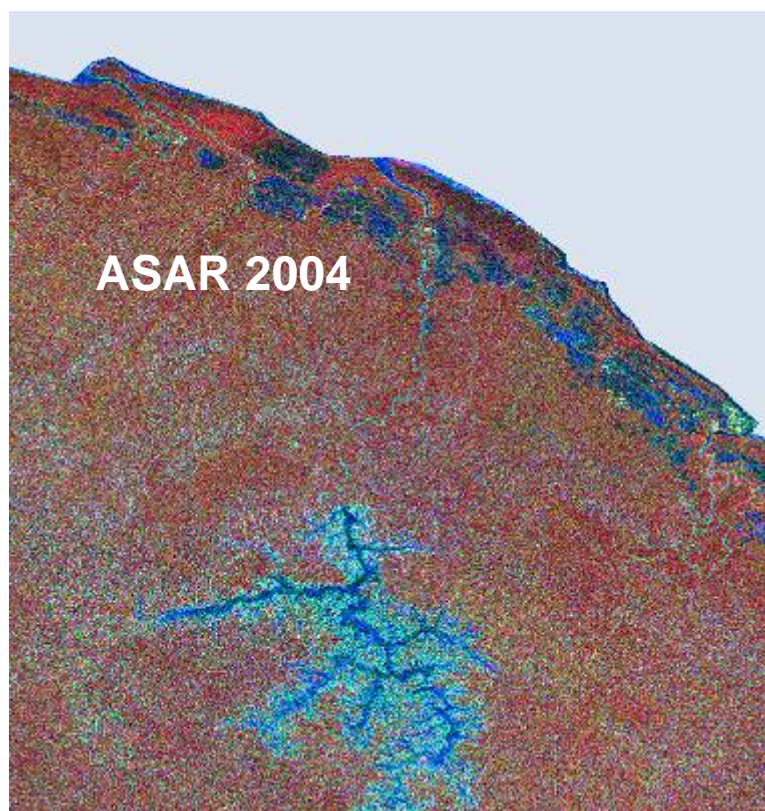
## Emergency: Flood service France 2005



### Flood Dynamics: 06-12 Sept



## Land: Forest service



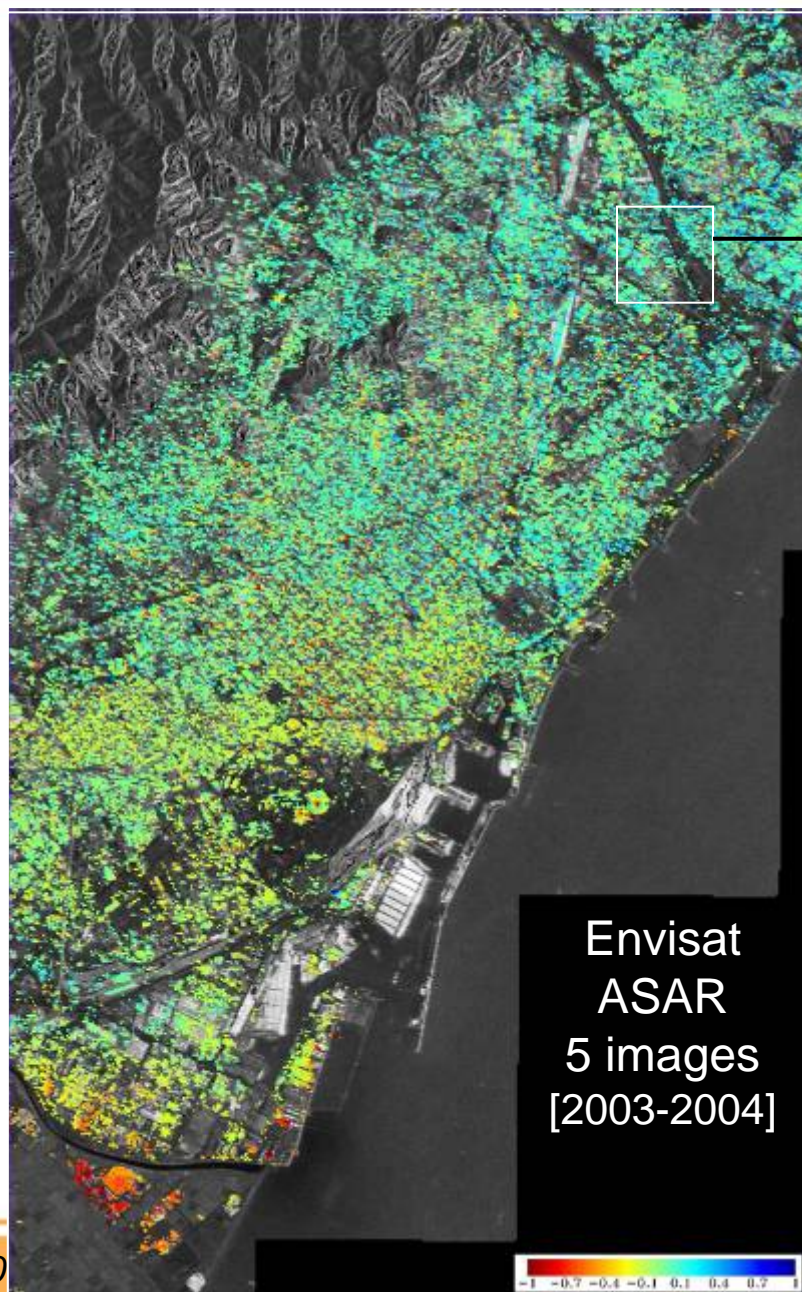
Entire French Guiana (9 million ha)  
mapped for Ministry of Agriculture (F)

Support to national greenhouse gas  
reporting under the Kyoto Protocol



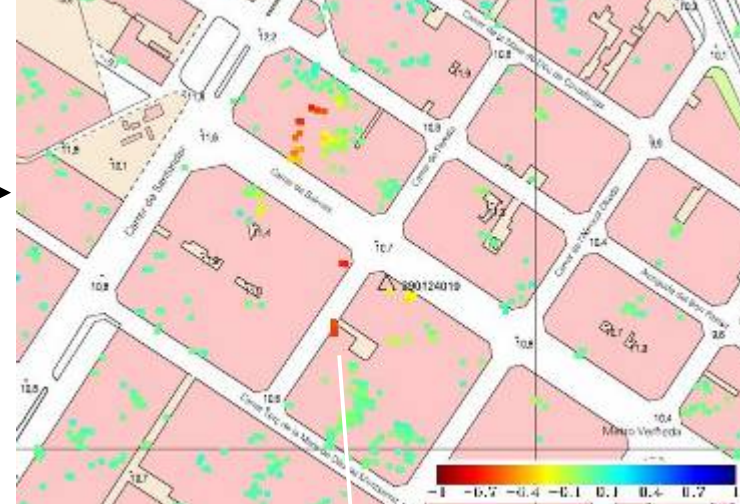
**Subsidence  
in  
Barcelona  
(Spain)**

**Stable  
points  
network  
technique**



Envisat  
ASAR  
5 images  
[2003-2004]

**Geo Hazard Information service**





## Marine: Sea Ice service



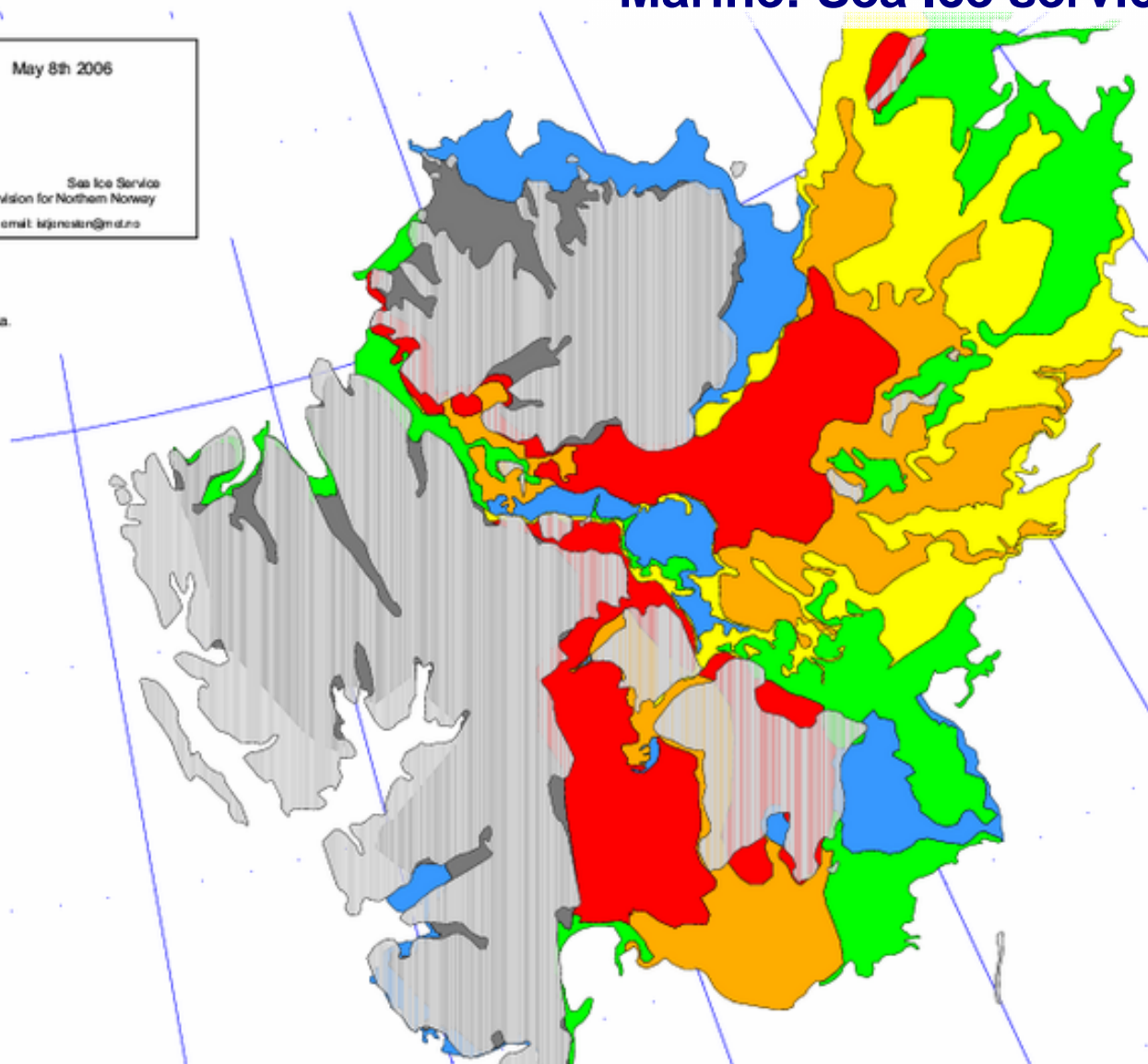
Map Projection: Stereographic Conformal

Data Source:

- 150 m resolution Radarsat/Envisat SAR satellite data.
- 500 m resolution Aqua/Terra MODIS satellite data.
- 1.5 km resolution NOAA/AVHRR satellite data.

Ice Categories:

- Fast ice
- Very Close Drift ice: 9/10 - 10/10
- Close Drift ice: 7/10 - 9/10
- Open Drift ice: 4/10 - 7/10
- Very Open Drift ice: 1/10 - 4/10
- Open Water: 0/10 - 1/10





## Sentinel 1 MRD : Service Network Feedback

GSE Services	Sensors						Operations		
	SAR Band	Polarisation	Radiometry	Resolution	Swath Width	Revisit Cycle	Geo Accuracy	Data Delivery T	Data Order T
<b>Iceberg Monitoring Service</b>	Compliant	Compliant	Partially Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
<b>River Ice Monitoring</b>	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
<b>Floe Edge Service</b>	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
<b>Glacier Monitoring</b>	Compliant	Compliant	Compliant	Compliant	Compliant	Partially Compliant	Compliant	Compliant	Compliant
<b>Snow Monitoring</b>	Compliant	Compliant	Compliant	Compliant	Compliant	Partially Compliant	Compliant	Partially Compliant	Partially Compliant
<b>High resolution ice charts</b>	Compliant	Partially Compliant	Compliant	Partially Compliant	Non-Compliant	Partially Compliant	Compliant	Non-Compliant	Non-Compliant
<b>Ice Forecasting (Baltic Sea)</b>	Compliant	Compliant	Compliant	Partially Compliant	Partially Compliant	Partially Compliant	Compliant	Non-Compliant	Partially Compliant
<b>High-Resolution Ice Thickness Charts (Baltic Sea)</b>	Compliant	Partially Compliant	Compliant	Partially Compliant	Compliant	Partially Compliant	Compliant	Non-Compliant	Partially Compliant
<b>Oil Pollution Alert</b>	Compliant	Compliant	Compliant	Compliant	Partially Compliant	Compliant	Compliant	Non-Compliant	Compliant
<b>Geo-hazard Land Motion Monitoring</b>	Partially Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Partially Compliant	Partially Compliant	Partially Compliant
<b>Flood Monitoring</b>	Compliant	Compliant	Compliant	Compliant	Partially Compliant	Partially Compliant	Missing in MRD	Partially Compliant	Partially Compliant
<b>Flood Risk Analysis</b>	Compliant	Partially Compliant	Compliant	Partially Compliant	Compliant	Partially Compliant	Missing in MRD	Compliant	Compliant
<b>Rapid Mapping</b>	Compliant	Compliant	Compliant	Non-Compliant	Compliant	Partially Compliant	Non-Compliant	Partially Compliant	Partially Compliant
<b>Food Security Crop Mapping</b>	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant	Compliant
<b>National UNFCCC &amp; LULUCF Kyoto Protocol Rep</b>	Partially Compliant	Partially Compliant	Partially Compliant	Partially Compliant	Compliant	Partially Compliant	Compliant	Compliant	Compliant
<b>Environmental Monitoring</b>	Partially Compliant	Partially Compliant	Partially Compliant	Partially Compliant	Compliant	Partially Compliant	Compliant	Compliant	Compliant
<b>Forest Disturbances Detection and Monitoring</b>	Partially Compliant	Partially Compliant	Compliant	Compliant	Compliant	Partially Compliant	Compliant	Compliant	Compliant

Compliant

Partially Compliant

Non-Compliant

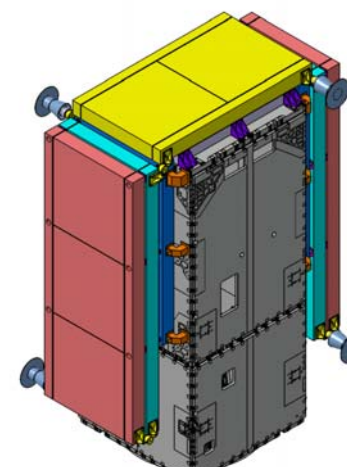
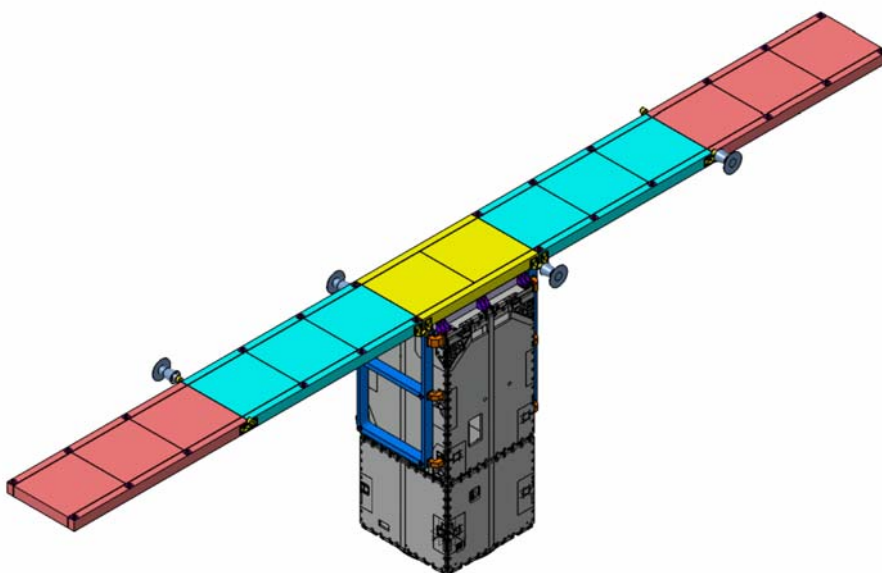
Missing in MRD





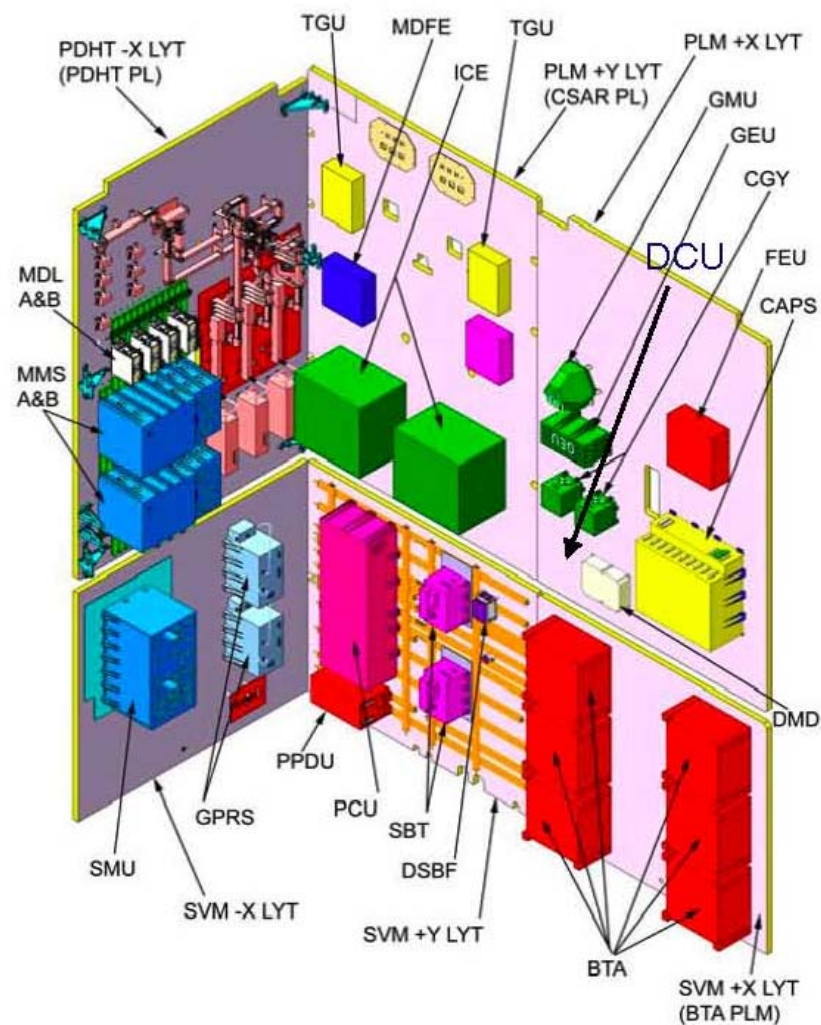
## ***Sentinel-1 Antenna Configuration***

SAR antenna and Solar Array in flight configuration and stowed



***Present Status: start  
Phase B2***

## ***SAR Internal Units Accommodation***



***Present  
Status:  
start  
Phase B2***





## Spacecraft Budgets

- **Mass** 2.1 ton
- **Power** 6 kW
- **Antenna size** 10 x 1.4 m
- **Fuel** > 10 years
- **Downlink rate** ~ 500 Mbps (X band)
- **Center frequency** same as Radarsat 2
- **S-1 revisit period:** 12 days
- **Phase A/B1 activities** completed
- **System Requirement Review** completed
- **Launch date** June 2011

## S1 Payload

Orbit: 12 d (06:00 LTDN)	ASAR : 35 d (10:00 LTDN)
<u>Stripmap Mode (SM)</u>	
Swath: 80 km	comparable to ASAR
Resolution: 5x5 m (1L)	better than ASAR capability
<u>Extra-wide Swath Mode (EW)</u>	
Swath: 400 km	same as ASAR
Resolution: 25x100 m (3L)	better than ASAR capability
<u>Wave (WV)</u>	
Swath: 20x20 km	better than ASAR
Resolution: 20x5 m	better than ASAR
<u>Interferometric Wideswath Mode (IW)</u>	NEW MODE (BASELINE)
Swath: 240 km	
Resolution: cell area	comparable to ERS
Sensitivity, Ambiguity, Radiometric performance	comparable to ASAR
No separate AP mode but dual-pol capability in all modes without performance reduction	





# ***Earth Explorers Candidates***

**Two “SAR missions” in the Six new Earth Explorer  
Candidate missions selected for further assessment study**

**“Report for Assessment” to be finalized spring 2008**

# BIOMASS

Malcolm Davidson BIOMASS Mission Scientist and the BIOMASS MAG(\*)

(\*) Thuy Le Toan, Shaun Quegan, Heiko Baltzer, Philippe Paillou, Konstantin Papathanassiou, Fabio Rocca, Lars Ulander, Stephen Plummer



## ***Mission objectives***

- Better **understanding and quantification** of **land contribution to global carbon cycle** through
  - Gridded high-resolution global estimates of **above ground biomass**
  - Monitoring and quantification of **forest disturbance** and **recovery**
  - Monitoring and quantification of **wetland areas and forest inundation**
- Additional objectives related to opportunity for spaceborne P-Band SAR images
  - Mapping subsurface structures, polar regions,
  - Mapping subsurface geomorphology in arid zones



## Mission requirements



Information Product	Mission Requirements	
Forest Biomass (above ground)	<ul style="list-style-type: none"> <li>• 20% accuracy</li> <li>• 100-300m resolution/16 looks</li> <li>• 2 biomass maps/year</li> <li>• Polarimetric Interferometric mode</li> <li>• Global coverage of forests</li> </ul>	
Forest Disturbance	<ul style="list-style-type: none"> <li>• Maps of disturbed area with 10% classification accuracy</li> <li>• 100m resolution/16 looks</li> <li>• 1-2 forest disturbance maps every 2months</li> <li>• Global coverage</li> </ul>	
Forest Regrowth	<ul style="list-style-type: none"> <li>• Biomass information 20% accuracy</li> <li>• Biomass rate of change – 20% accuracy</li> <li>• 100-200m resolution/16 looks</li> <li>• 2 revisits/year</li> <li>• Global coverage with focus on tropical forests</li> </ul>	
Forest seasonal floods	<ul style="list-style-type: none"> <li>• Inundation area information – 10% classification accuracy</li> <li>• 100m resolution/16 looks</li> <li>• 1 revisit/month during flood season</li> <li>• tropical forests (main target) + boreal wetlands (secondary target) for methane emission</li> </ul>	



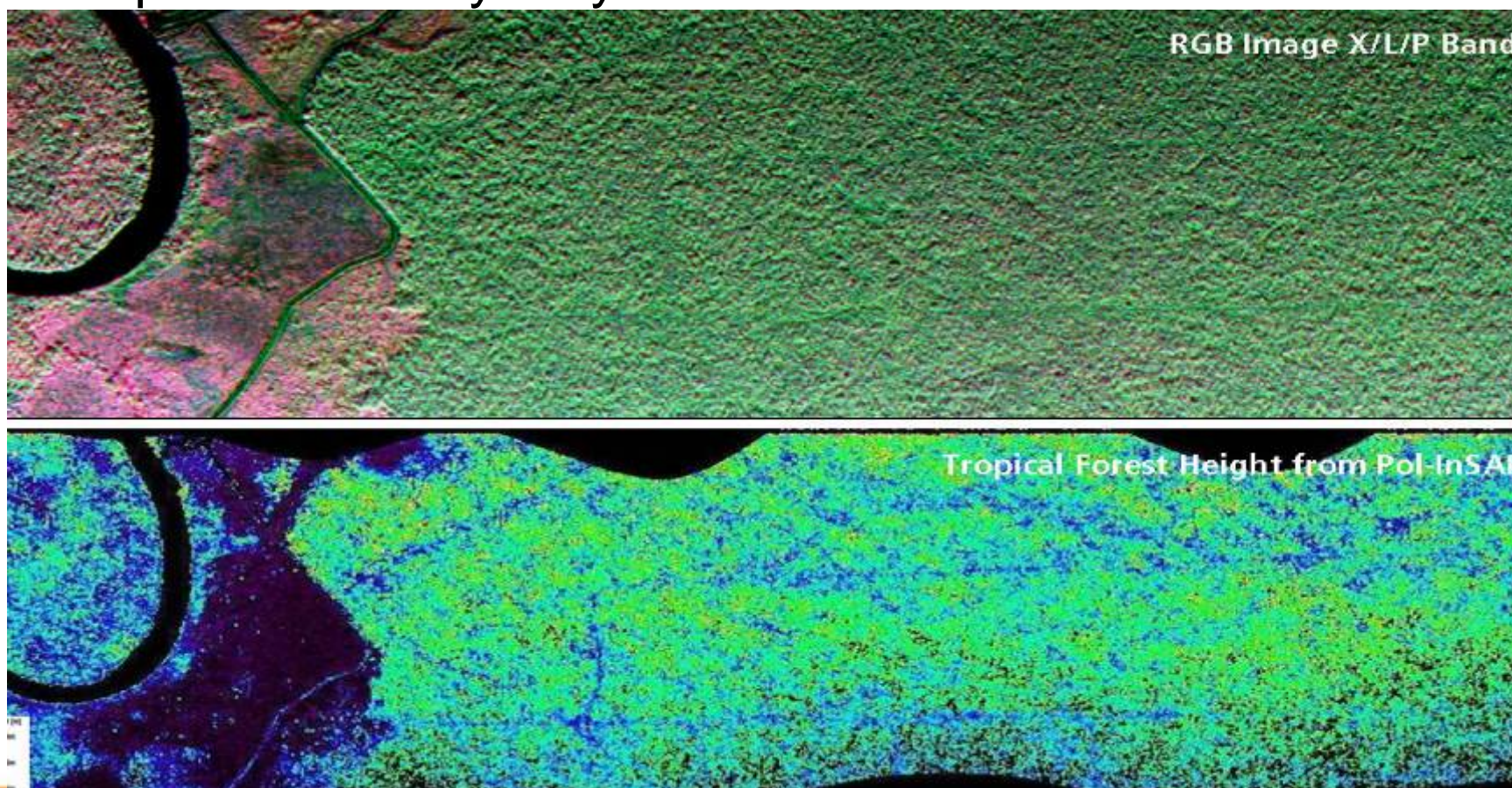
## ***Mission Concept***

- Phase 0 Industrial activity initiated to define P-Band SAR payload and mission platform

Instrument Type	P-band Synthetic Aperture Radar (SAR)
Centre Frequency	435 MHz (P-Band)
Bandwidth	$\leq 6$ MHz (ITU allocation)
Polarisation	Full polarimetry and/or dual polarization (HH, HV)
Data acquisition	Single pass/repeat pass polarimetric interferometry
Spatial Resolution	$\leq 50$ m x 50 m ( $\geq 4$ looks)
Swath width	$\geq 100$ km
Noise Equivalent $\sigma_0$	$\leq -25$ dB (T), $-30$ dB (G)
Radiometric Resolution	$\leq 1$ dB
Radiometric Stability	$\leq 0.5$ dB over 1 orbit

## ***Advanced techniques***

- Biomass retrieval based on advanced techniques (e.g. PolInSAR forest height, classification) expected to improve intensity-only retrievals

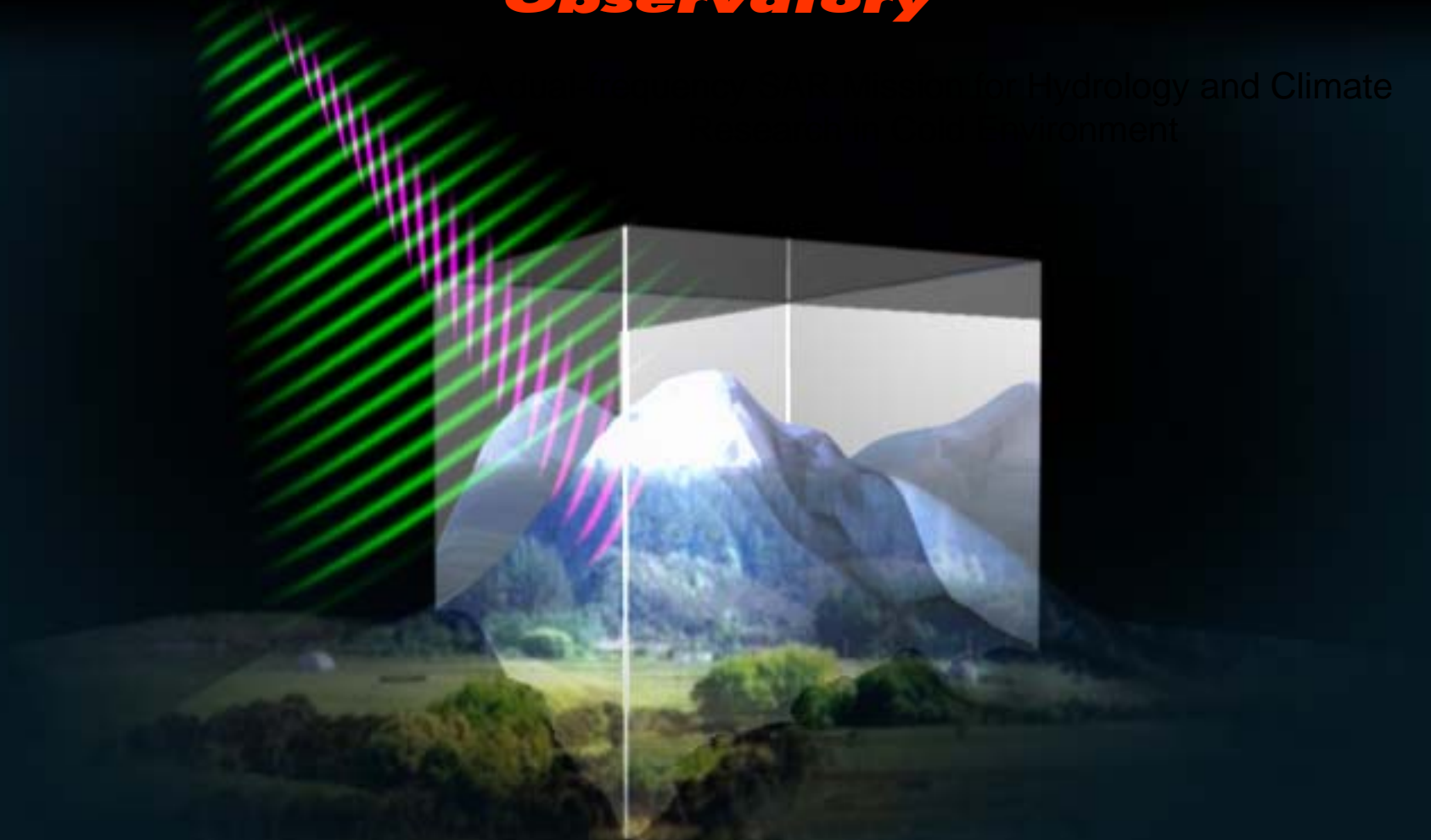




# **Cold Regions Hydrology High resolution Observatory**



CoRe-H2O is a Mission for Hydrology and Climate  
in the Cold Environment



Helge Rebhan, Mission Scientist

Members of CoRe-H2O MAG Helmut Rott, Austria

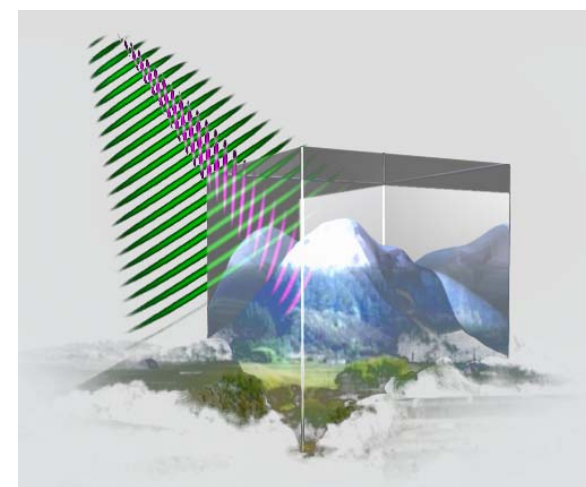
Richard Essery, UK      Christian Haas, Germany

Claude Duguay, Canada, Giovanni Macelloni, Italy, Eirik

Malnes, Sweden, Jouni Pulliainen, Finland

# The importance of Snow and Glaciers observations

- Global climate system
  - Improved understanding and modelling of snow cover.
- Hydrological processes
  - In high and mid latitudes snow cover is a key parameter of the water and energy cycle of land surfaces
- Glacier mass balance and runoff modelling
  - Snow extent and mass are key input parameters .
- Water management and flood control:
  - improve flood forecasting and water resources management.





## Key Observation Requirements



Variable	Spatial scale [m]		Repeat interval	Accuracy (RMS)
	-Threshold -Goal			-Threshold -Goal
	Global	Regional		

### 1. Primary Parameters

#### *Snow*

Snow extent	700	200	3-15 d	4% of hydrological unit (HU)
	500	100		2% of hydrological unit (HU)
Water equivalent	500	200	15 d	20% for WE < 20 cm
	300	100		10% for WE < 20 cm

### 2.) Secondary Parameters

#### *Snow*

Extent of melting snow	500	100	3 d	2% of HU
Snow depth	500	200	3-15 d	10% at HU

#### *Glaciers*

Facies type	200	100	15 d	2% of glacier area
Winter snow accumulation	500	200	15 d	10% of maximum
Terminus position, lakes	N/A	50	15 d	50 m

#### *Freshwater Ice*

Ice area	N/A	50	3 d	5% of overall sea ice area
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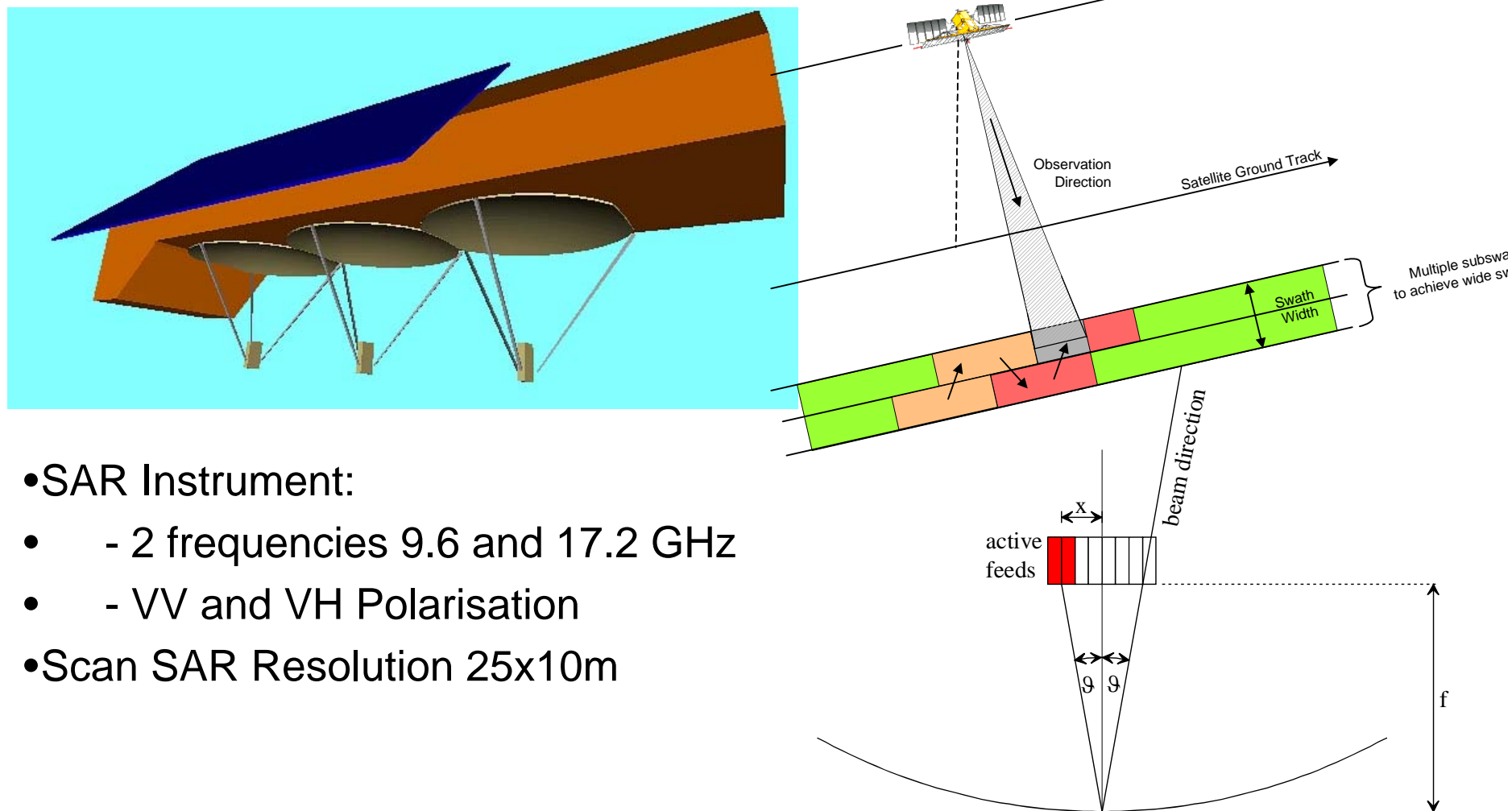
#### *Sea Ice*

Snow Depth	N/A	200	3 -15d	ca. 10 cm
Ice Type	N/A	100	3 d	5% classification error
Ice Motion	N/A	1000	3 d	ca. 200m/day
Ice Melt	N/A	100	3 d	5% of overall sea ice area

#### *Surface Water*

Extent of open water areas	100	50	3-15 d	0.02 km <sup>2</sup> capability
----------------------------	-----	----	--------	---------------------------------

## Potential SAR Satellite Configuration



- SAR Instrument:
  - - 2 frequencies 9.6 and 17.2 GHz
  - - VV and VH Polarisation
- Scan SAR Resolution 25x10m



## ***In-situ Campaigns ESA***



- Ku-band measurement campaign in Austria Jan-Mar 07:
  - first experimental field measurements with existing Ku/X-band radar system
  - Contractor: ENVEO, Austria Univ of Cranfield, UK





***THANK YOU***