Acreage Estimation using SAR Data

Francesco Holecz

sarmap
your information gateway

Basic Questions

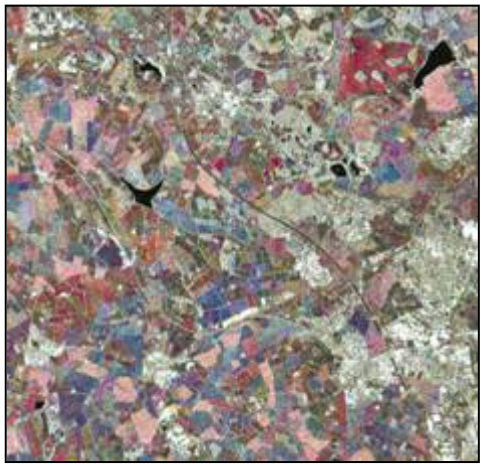
- What is/are the crop calendar(s)?
- What are the land practises?
- What crop type(s) are we looking for?
- What are the End User needs?

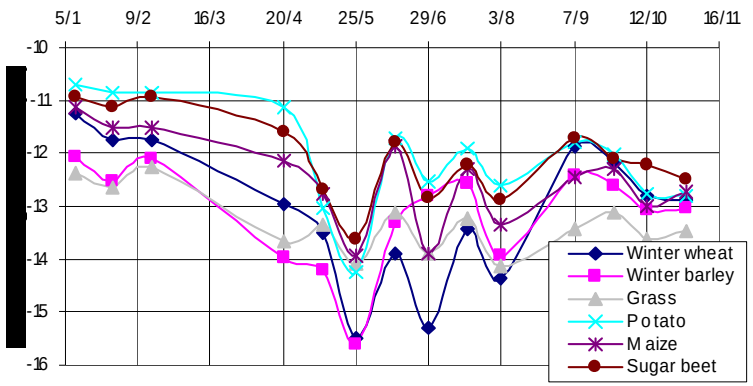
→ Definition of

- Acquisition mode (geometry, frequency, polarisation)
- Acquisition time and interval
- Temporal signature
- Type of product
- Processing chain

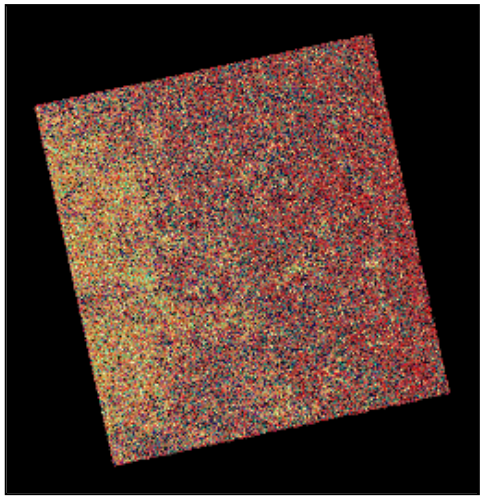
Agriculture and Synthetic Aperture Radar

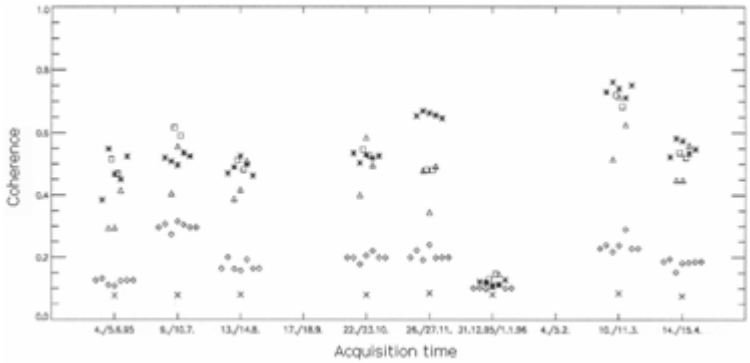
Intensity



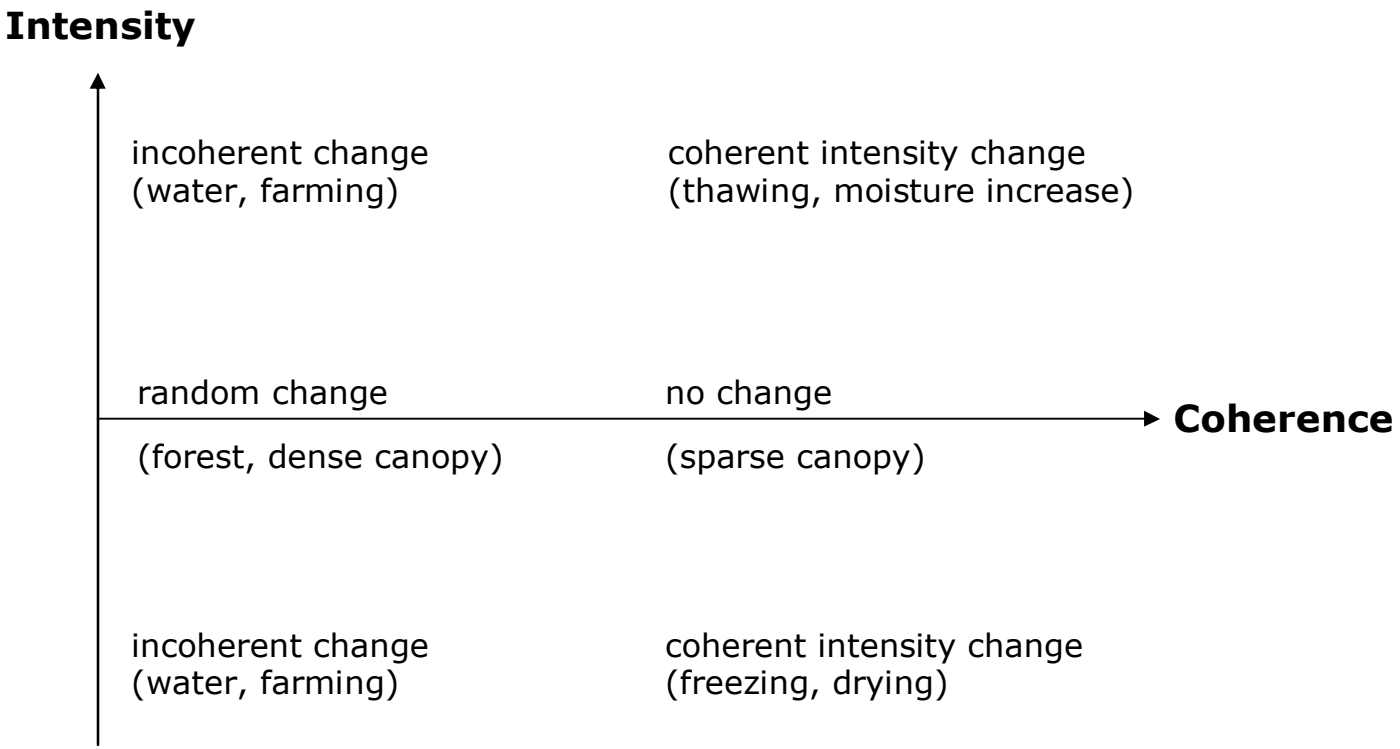


Coherence

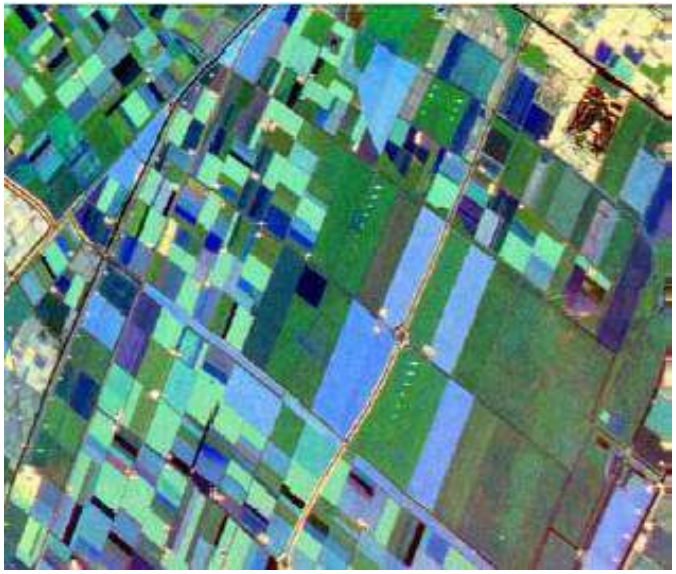


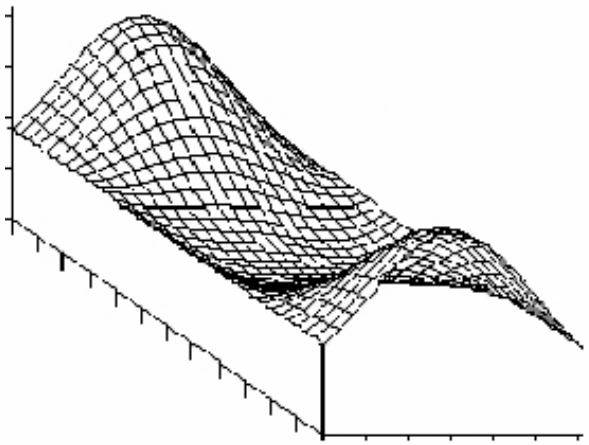


SAR Intensity and Coherence - Information Content



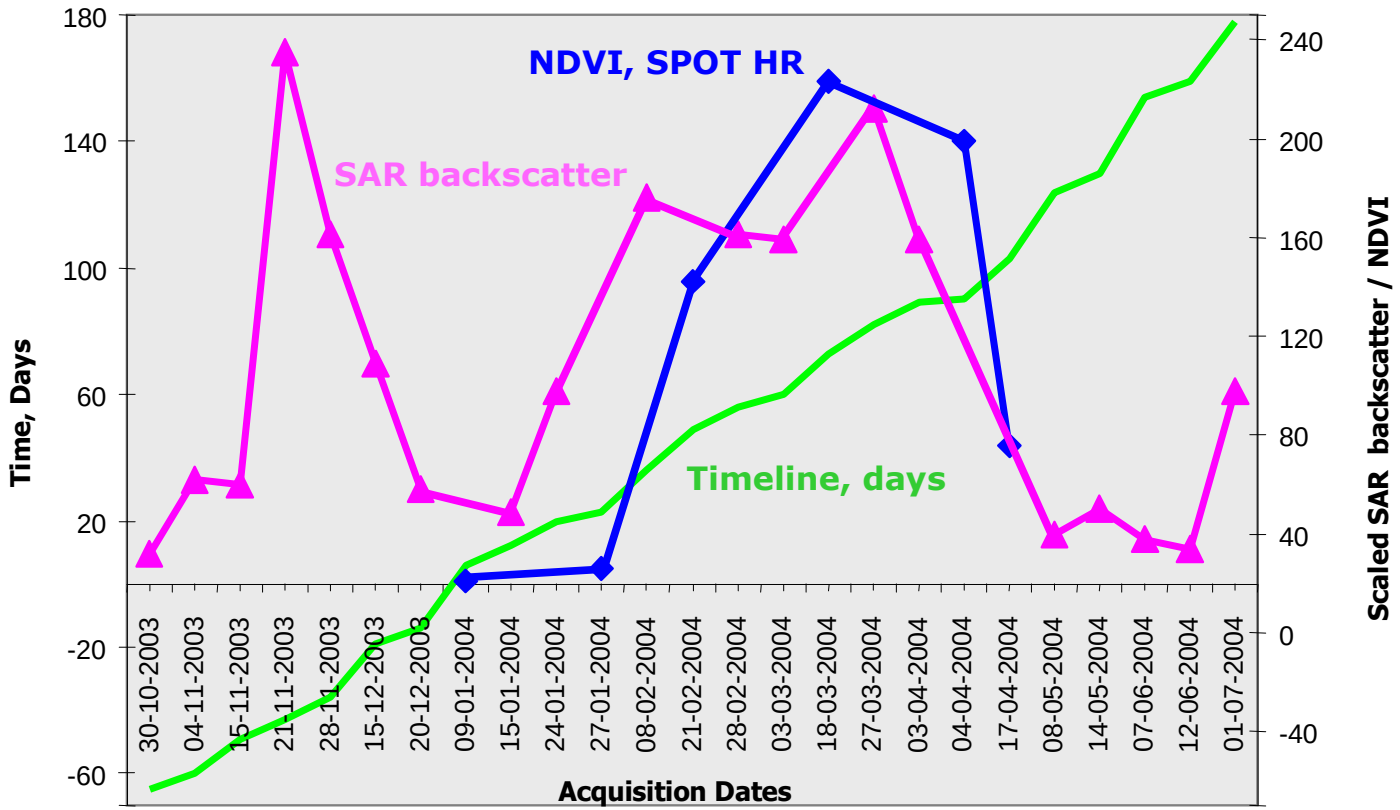
Agriculture and SAR Polarimetry





➔ **It remains a fact that one image is no information!**

SAR (C-band) versus Optical (multi-spectral) Data



SAR backscatter - ENVISAT ASAR AP (HH/HV) and RADARSAT-1 Fine Beam data

SAR (C-band) versus Optical (multi-spectral) Data

SAR enables

- Detect field preparation, e.g. ploughing, irrigation, re-ploughing, terrain flattening
- Detect emergence time
- Monitor crop progression
- Detect plant full maturity
- Detect plant drying
- Detect harvest time
- Detect frost events and heavy damages

Optical enables

- Monitor phenological development and health of crops
- Detect damages (severity and extent) of pest and diseases
- Identify problem areas, e.g. heterogeneities due to fertilisers, watering, etc.
- Identify over-crop production

… However …

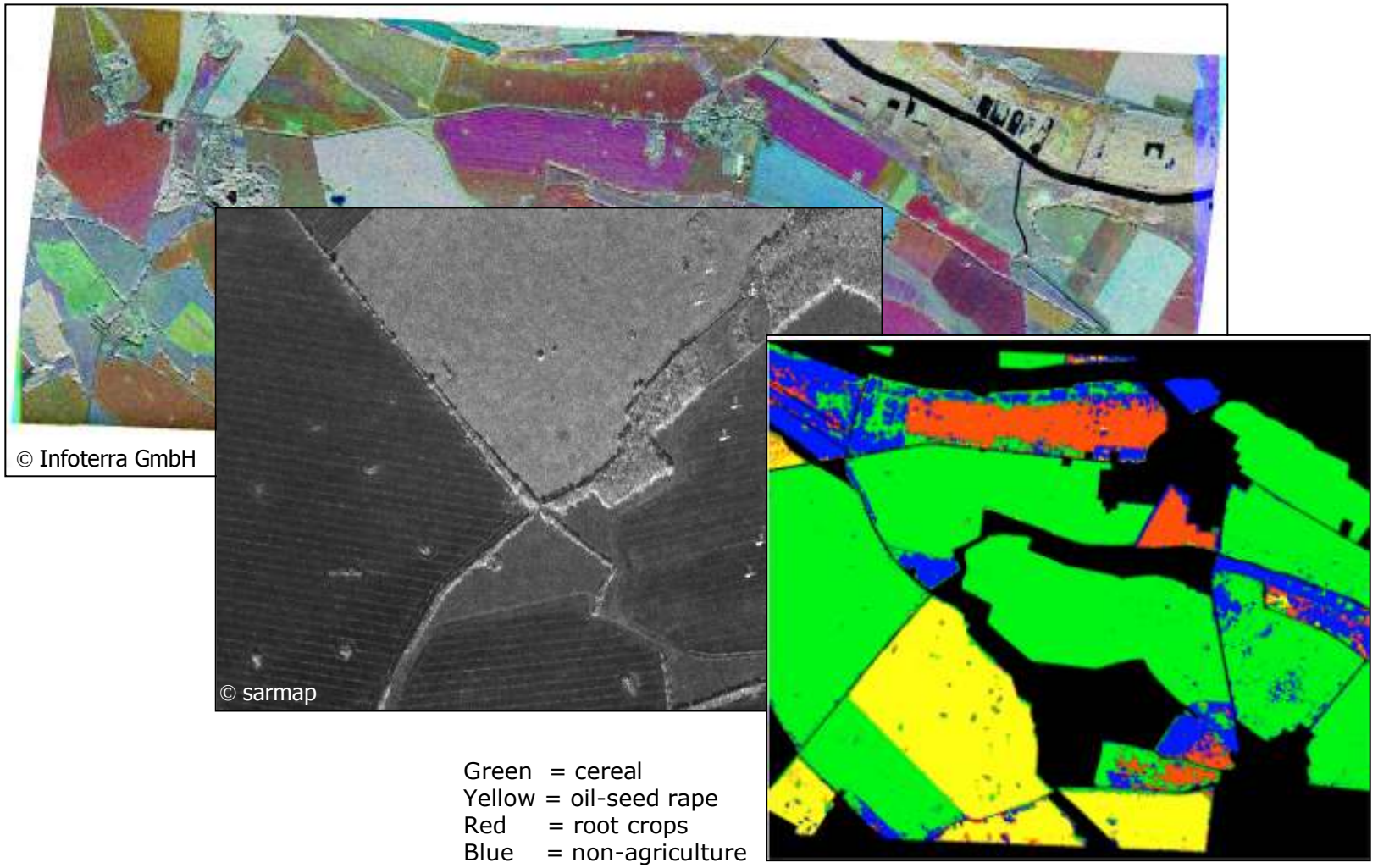
- It is imperative that spaceborne SAR systems provide
  - Adequate spatial resolution
  - Adequate repetition frequency
  - Timing
  - Long term continuity
  - Sensor consistency

- Sporadic images acquired randomly (in spatial and temporal terms) are useless.

What spaceborne SAR systems are/will be available

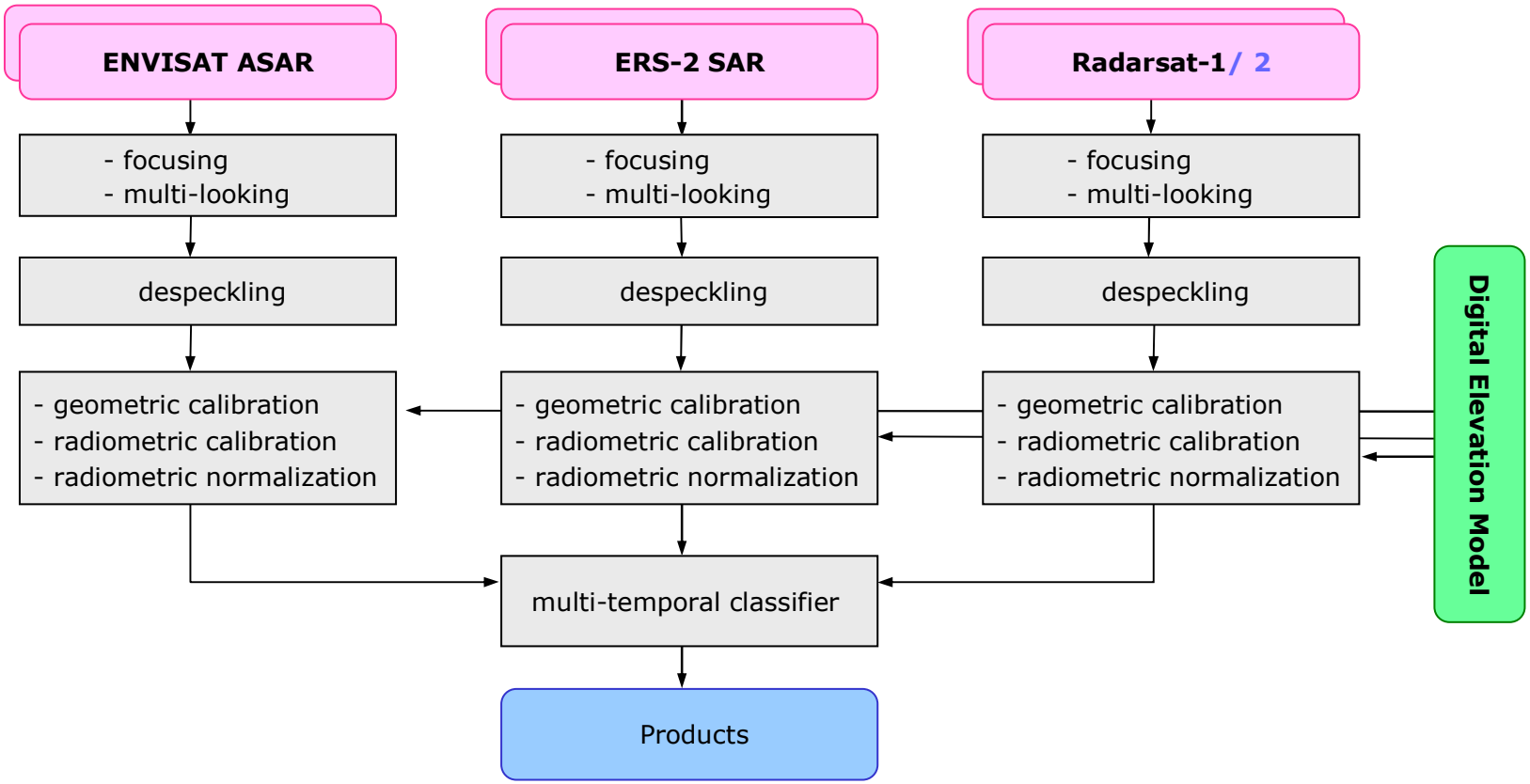
ERS-2 SAR	C	VV	100km	35days	fix
RADARSAT-1	C	HH	50-500km	24days	steerable
ENVISAT ASAR	C	AP	100-400km	35days	steerable
ALOS PALSAR	L	Qpol	20-350km	35days	steerable
RADARSAT-2	C	Qpol	50-500km	24days	steerable
TerraSAR-X-1	X	Dual Pol	15-60km	11days	steerable
SENTINEL-1 ?	C	Dual Pol	240km	14days	steerable

Just a short look on SAR data/products available in 2006



Green = cereal
Yellow = oil-seed rape
Red = root crops
Blue = non-agriculture

SAR Multi-Mission Approach : A Basic Need



Information Extraction - Some Remarks

- **General -** When dealing with multi-temporal SAR data, it becomes obvious that the utilisation of multi-temporal filtering or segmentation, and multi-temporal classification is the optimal solution.

- **Reconstruction Filtering -** SAR specific filtering should not be limited to the first-order statistics.

- **Segmentation -** In general these methods tends to overestimate the segments (i.e. more segments are detected). This problem is essentially related to the characteristics of the system: in fact, the type of information represented in the actual SAR images is more detailed, if compared to the simplified map representation.

- **Classification -** When dealing with multi-temporal SAR data or when combining SAR with optical images, multi-temporal non-parametric context based approaches enables a better description of the irregular and complex distributions in the feature space than joint probabilistic (e.g. parametric) distributions.

Processing chain - SARscape®

- **Basic -** It includes a set of processing steps for the generation of SAR products based on intensity and coherence (interferometric correlation). This module is complemented by a multi-purpose tool, and optical multi-spectral data processing capabilities.

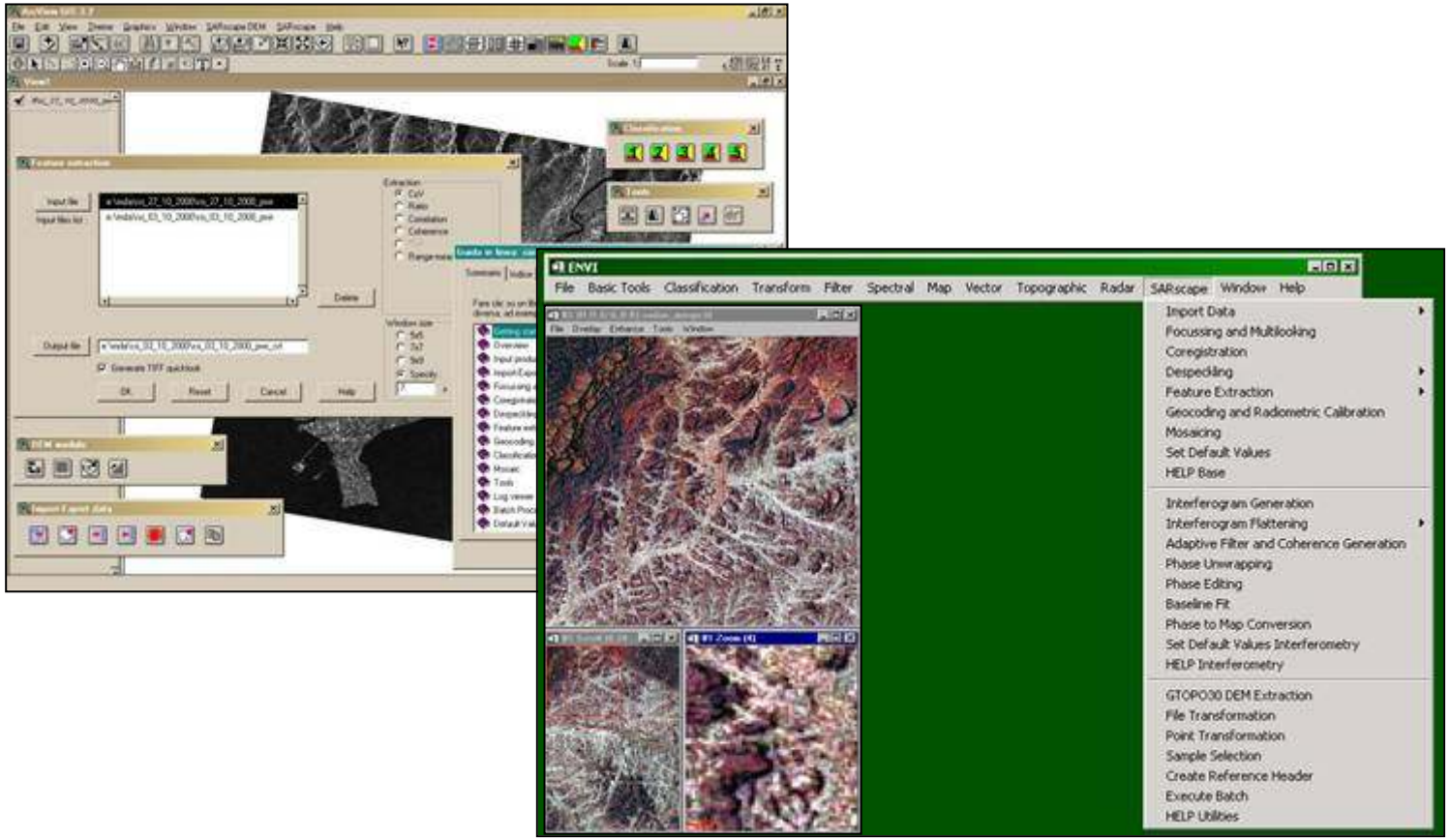
- **ASAR - RADARSAT-1 Focusing -** It supports the focusing of RADARSAT-1 (Fine Beam and Standard Beam), and ENVISAT data (Alternating Polarization, Image, and Wide Swath).

- **Gamma & Gaussian Filter -** It includes a whole family of SAR specific filters. They are particularly efficient to reduce speckle, while preserving the radar reflectivity, the textural properties and the spatial resolution, especially in strongly textured SAR images.

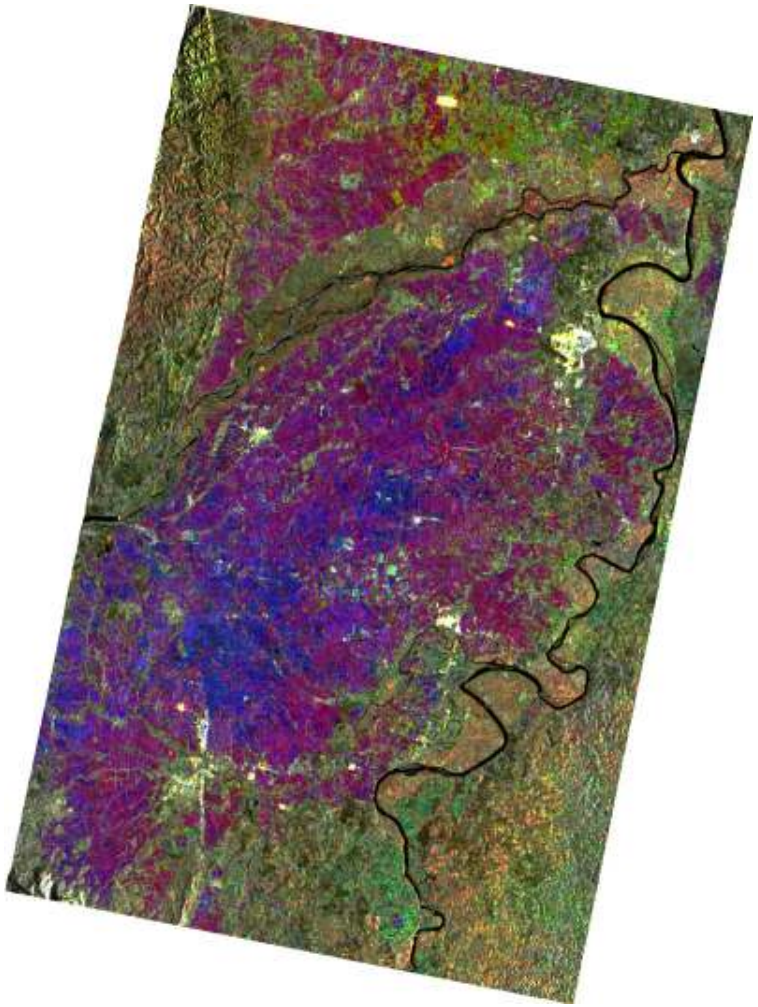
- **Interferometry -** It supports the processing of Interferometric SAR (2-pass interferometry, InSAR) and Differential Interferometric SAR (n-pass interfereometry, DInSAR) data for the generation of Digital Elevation Model, Coherence, and Land Displacement/Deformation maps.

- **ScanSAR Interferometry -** It extends the Interferometry one to the ScanSAR mode, offering the capabilities to generate interferograms over large areas (500 x 500 km). This module combined with the Interferometry one enables also the generation of Digital Elevation Model, Coherence, and Land Displacement/Deformation maps.

SARscape® in Arcview® and ENVI® environment



Philippines - Rice Acreage and Emergence Moments 2003/4



Acquisitions Nueva Ecija

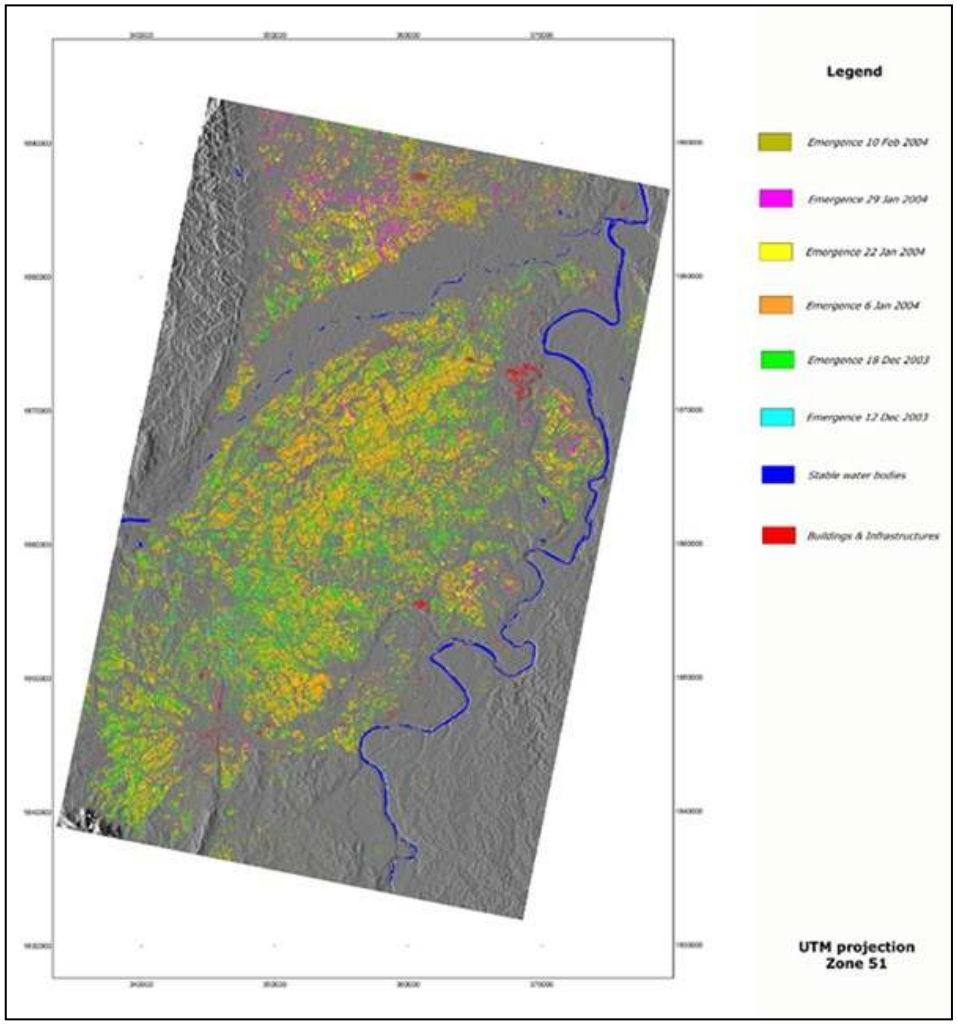
Acquisition Date	Sensor	Product Mode	Status
20/11/2003	ASAR	APS HH/HV	OK
06/12/2003	ASAR	APS HH/HV	OK
10/12/2003	Radarsat	F3N	OK
25/12/2003	ASAR	APS HH/HV	OK
03/01/2004	Radarsat	F3N	OK
10/01/2004	ASAR	APS HH/HV	OK
29/01/2004	ASAR	APS HH/HV	OK
20/02/2004	Radarsat	F3N	OK
04/03/2004	ASAR	APS HH/HV	OK
15/03/2004	Radarsat	F3N	Not OK
08/04/2004	ASAR	APS HH/HV	OK

13 November 2003, ENVISAT ASAR AP, HH

18 December 2003, ENVISAT ASAR AP, HH

06 January 2004, RADARSAT-1 FB, HH

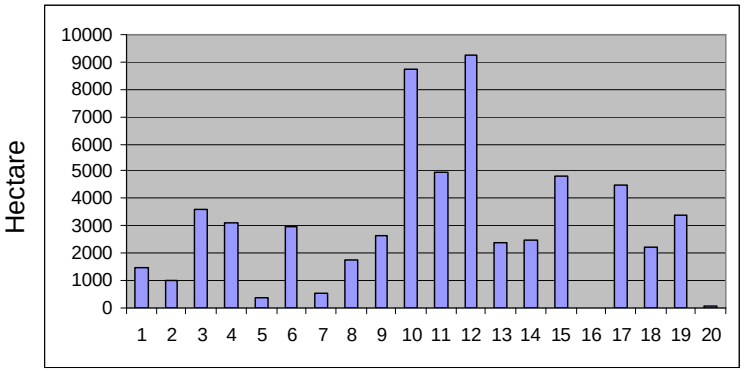
Philippines - Rice Acreage and Emergence Moments 2003/4



Nueva Ecija

Philippines - Rice Acreage and Emergence Moments 2003/4

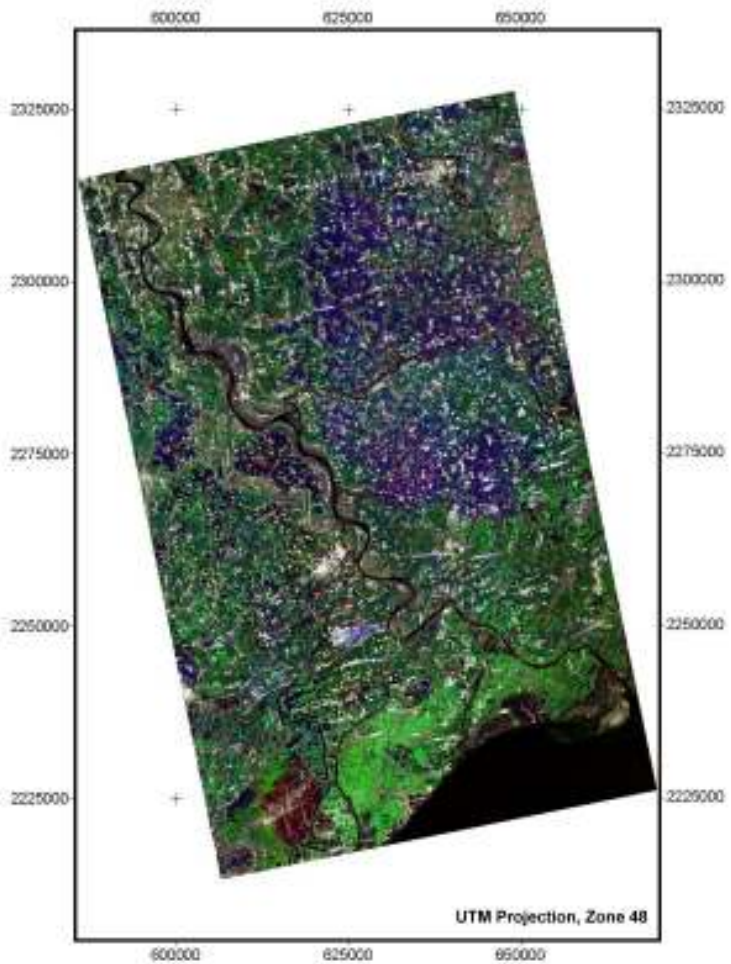
Nueva Ecija - Cumulative Acreage



Municipalities	Dates	Hectars
ROXAS	12 Dec 2003	0
ROXAS	18 Dec 2003	84,953125
ROXAS	6 Jan 2004	181,703125
ROXAS	22 Jan 2004	44,28125
ROXAS	29 Jan 2004	122,015625
ROXAS	10 Feb 2004	
GAMU	12 Dec 2003	
GAMU	18 Dec 2003	
GAMU	6 Jan 2004	
GAMU	22 Jan 2004	
GAMU	29 Jan 2004	
GAMU	10 Feb 2004	
BURGOS	12 Dec 2003	
BURGOS	18 Dec 2003	
BURGOS	6 Jan 2004	
BURGOS	22 Jan 2004	
BURGOS	29 Jan 2004	
BURGOS	10 Feb 2004	
SAN MANUEL	12 Dec 2003	
SAN MANUEL	18 Dec 2003	
SAN MANUEL	6 Jan 2004	
SAN MANUEL	22 Jan 2004	
SAN MANUEL	29 Jan 2004	
SAN MANUEL	10 Feb 2004	
NAGUILIAN	12 Dec 2003	
NAGUILIAN	18 Dec 2003	
NAGUILIAN	6 Jan 2004	
NAGUILIAN	22 Jan 2004	
NAGUILIAN	29 Jan 2004	
NAGUILIAN	10 Feb 2004	
AURORA	12 Dec 2003	
AURORA	18 Dec 2003	
AURORA	6 Jan 2004	
AURORA	22 Jan 2004	
AURORA	29 Jan 2004	
AURORA	10 Feb 2004	
REINA MERCEDES	12 Dec 2003	
REINA MERCEDES	18 Dec 2003	
REINA MERCEDES	6 Jan 2004	
REINA MERCEDES	22 Jan 2004	
REINA MERCEDES	29 Jan 2004	
REINA MERCEDES	10 Feb 2004	
LUNA	12 Dec 2003	5,109375
LUNA	18 Dec 2003	249,90625
LUNA	6 Jan 2004	493,8125
LUNA	22 Jan 2004	66,140625
LUNA	29 Jan 2004	11,4375
LUNA	10 Feb 2004	22,6875
CABATUAN	12 Dec 2003	0,71875
CABATUAN	18 Dec 2003	336,84375
CABATUAN	6 Jan 2004	1070,875
CABATUAN	22 Jan 2004	59,234375
CABATUAN	29 Jan 2004	
CABATUAN	10 Feb 2004	
CAUAYAN	12 Dec 2003	
CAUAYAN	18 Dec 2003	
CAUAYAN	6 Jan 2004	
CAUAYAN	22 Jan 2004	
CAUAYAN	29 Jan 2004	
CAUAYAN	10 Feb 2004	
SAN MATEO	12 Dec 2003	
SAN MATEO	18 Dec 2003	
SAN MATEO	6 Jan 2004	
SAN MATEO	22 Jan 2004	
SAN MATEO	29 Jan 2004	
SAN MATEO	10 Feb 2004	
ALICIA	12 Dec 2003	
ALICIA	18 Dec 2003	
ALICIA	6 Jan 2004	
ALICIA	22 Jan 2004	
ALICIA	29 Jan 2004	
ALICIA	10 Feb 2004	
RAMON	12 Dec 2003	
RAMON	18 Dec 2003	
RAMON	6 Jan 2004	
RAMON	22 Jan 2004	
RAMON	29 Jan 2004	
RAMON	10 Feb 2004	
ANGADANAN	12 Dec 2003	
ANGADANAN	18 Dec 2003	
ANGADANAN	6 Jan 2004	
ANGADANAN	22 Jan 2004	
ANGADANAN	29 Jan 2004	
ANGADANAN	10 Feb 2004	
CITY OF SANTIAGO	12 Dec 2003	43,40625
CITY OF SANTIAGO	18 Dec 2003	909,78125
CITY OF SANTIAGO	6 Jan 2004	1329,125
CITY OF SANTIAGO	22 Jan 2004	42,59375
CITY OF SANTIAGO	29 Jan 2004	33,765625
CITY OF SANTIAGO	10 Feb 2004	29,5
SAN GUILLERMO	12 Dec 2003	0,03125
SAN GUILLERMO	18 Dec 2003	0,375
SAN GUILLERMO	6 Jan 2004	0,609375
SAN GUILLERMO	22 Jan 2004	0
SAN GUILLERMO	29 Jan 2004	1,640625
SAN GUILLERMO	10 Feb 2004	0,984375
SAN ISIDRO	12 Dec 2003	33,640625
SAN ISIDRO	18 Dec 2003	997,96875
SAN ISIDRO	6 Jan 2004	1783,89063
SAN ISIDRO	22 Jan 2004	61,578125
SAN ISIDRO	29 Jan 2004	3,640625
SAN ISIDRO	10 Feb 2004	8,4375
ECHAGUE	12 Dec 2003	28,328125
ECHAGUE	18 Dec 2003	283,390625
ECHAGUE	6 Jan 2004	436,96875
ECHAGUE	22 Jan 2004	37,140625
ECHAGUE	29 Jan 2004	36,71875
ECHAGUE	10 Feb 2004	134,8125
CORDON	12 Dec 2003	7,28125
CORDON	18 Dec 2003	771
CORDON	6 Jan 2004	1150,98438
CORDON	22 Jan 2004	75,25
CORDON	29 Jan 2004	16,34375
CORDON	10 Feb 2004	16,5
JONES	12 Dec 2003	1,609375
JONES	18 Dec 2003	2,421875
JONES	6 Jan 2004	1,9375
JONES	22 Jan 2004	0
JONES	29 Jan 2004	0,90625
JONES	10 Feb 2004	3,78125

Acreage at emergence

Vietnam - Acreage 2004/5



ENVISAT ASAR acquisitions Thai Binh

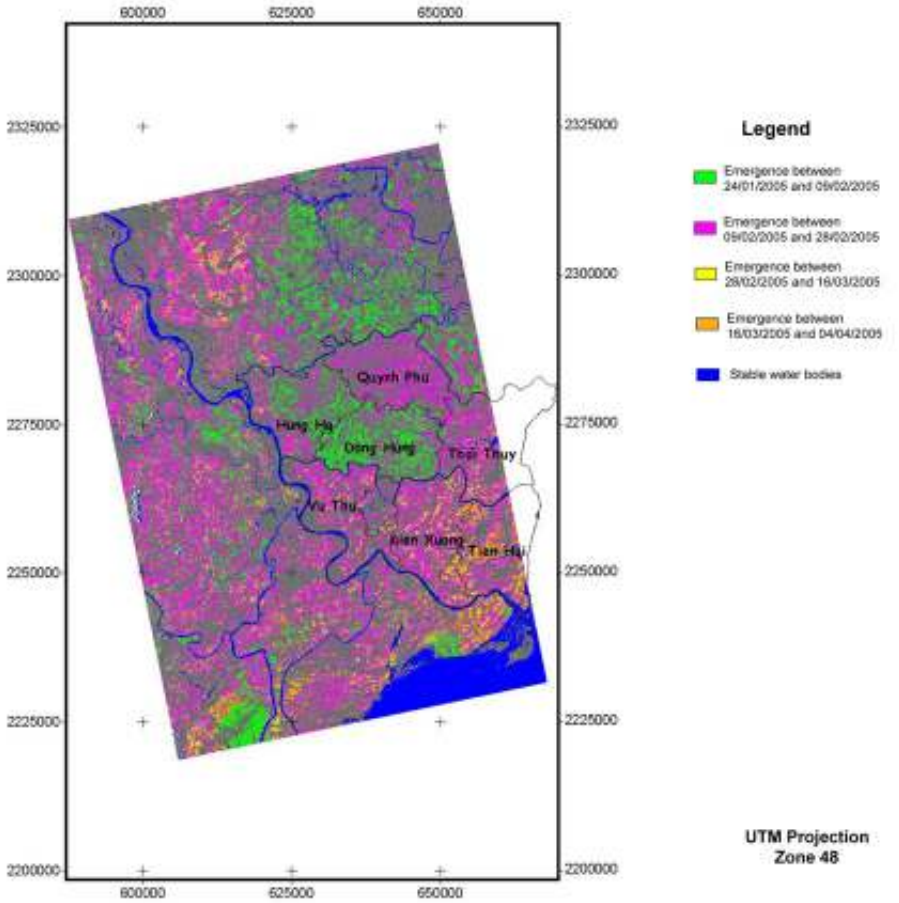
Acquisition Date	Product Mode
15/11/2004	APS - IS5 HH/HV
01/12/2004	APS - IS4 HH/HV
20/12/2004	APS - IS5 HH/HV
05/01/2005	APS - IS4 HH/HV
24/01/2005	APS - IS5 HH/HV
09/02/2005	APS - IS4 HH/HV
28/02/2005	APS - IS5 HH/HV
16/03/2005	APS - IS4 HH/HV
04/04/2005	APS - IS5 HH/HV
20/04/2005	APS - IS4 HH/HV

28 February 2005, ENVISAT ASAR AP, HH

24 February 2005, ENVISAT ASAR AP, HH

04 April 2005, ENVISAT ASAR AP, HH

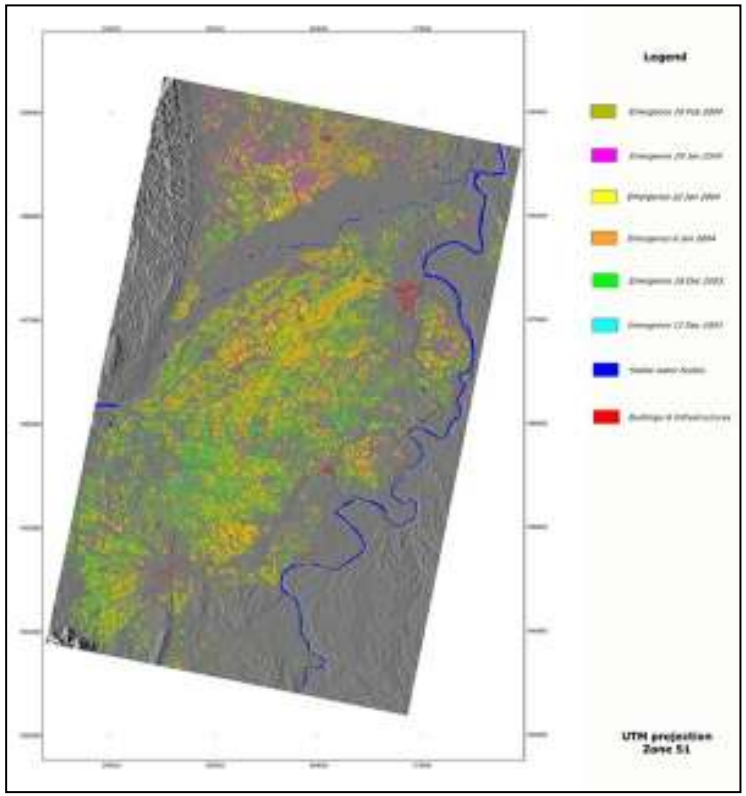
Vietnam - Acreage 2004/5

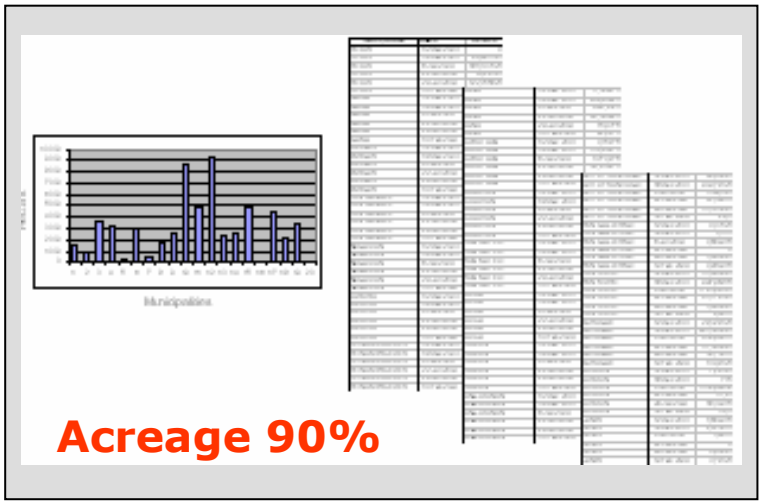


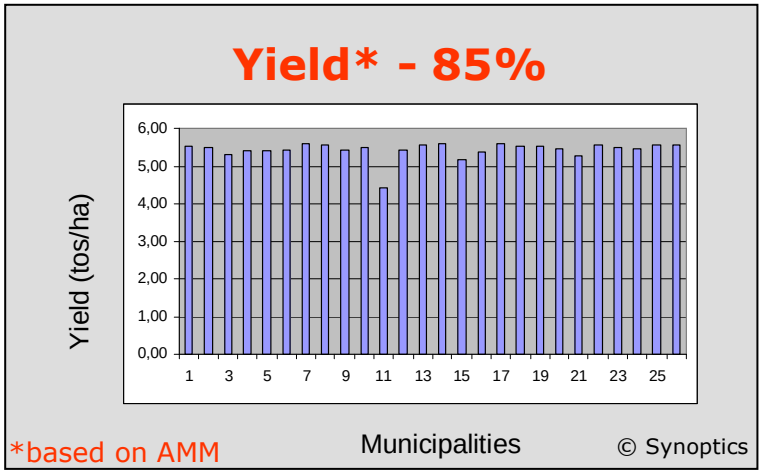
Acreage at emergence

Quynh PhuQuynh Phu	676,98
Hung Ha	2645,1225
Thai Thuy	616,95
Dong Hung	6400,7325
Vu Thu	105,2775
Kien Xuong	112,7475
Thai Binh Town	72,675
Tien Hai	123,7725
Quynh PhuQuynh Phu	6804,585
Hung Ha	3230,955
Thai Thuy	5937,0975
Dong Hung	2599,29
Vu Thu	5174,01
Kien Xuong	7324,4925
Thai Binh Town	743,0175
Tien Hai	4308,93
Quynh PhuQuynh Phu	313,785
Hung Ha	282,015
Thai Thuy	1029,3075
Dong Hung	51,3225
Vu Thu	1275,165
Kien Xuong	2375,82
Thai Binh Town	113,2875
Tien Hai	1650,2625
Quynh PhuQuynh Phu	20,43
Hung Ha	15,03
Thai Thuy	321,525
Dong Hung	11,655
Vu Thu	122,355
Kien Xuong	850,455
Thai Binh Town	27,6525
Tien Hai	1956,645

IRRI/CGIAR & PhilRice - Service Endorsement







South Africa - Crop Monitoring 2003/4

Radarsat-1 acquisitions	Beam mode
04/11/2003	F4F
21/11/2003	F2N
28/11/2003	F4F
15/12/2003	F2N
22/12/2003	F4F
15/01/2004	F4F
08/0	
03/0	
27/0	
20/0	
14/0	
07/0	
01/0	
25/0	
18/0	

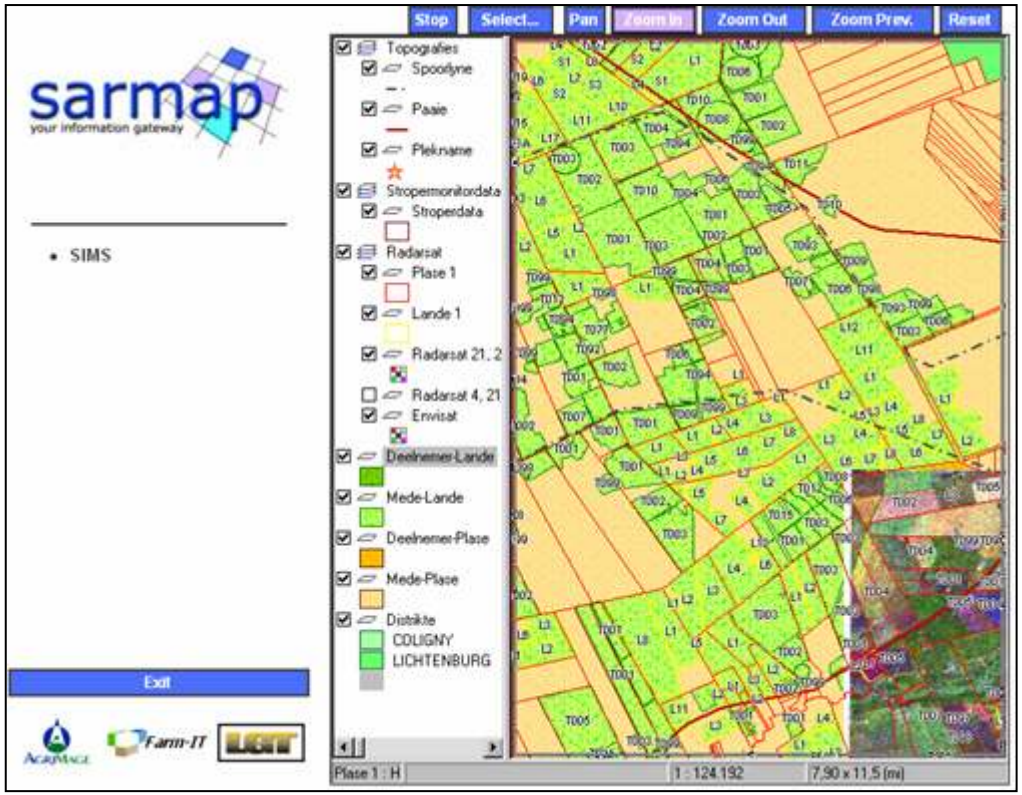
ASAR acquisitions	Beam mode
30/10/2003	IS5 HH/HV
15/11/2003	IS6 HH/HV
04/12/2003	IS5 HH/HV
20/12/2003	IS6 HH/HV
24/01/2004	IS6 HH/HV
28/02/2004	IS6 HH/HV
03/04/2004	IS6 HH/HV
08/05/2004	IS6 HH/HV
12/06/2004	IS6 HH/HV
17/07/2004	IS6 HH/HV
21/08/2004	IS6 HH/HV

Radarsat-1 Fine Beam

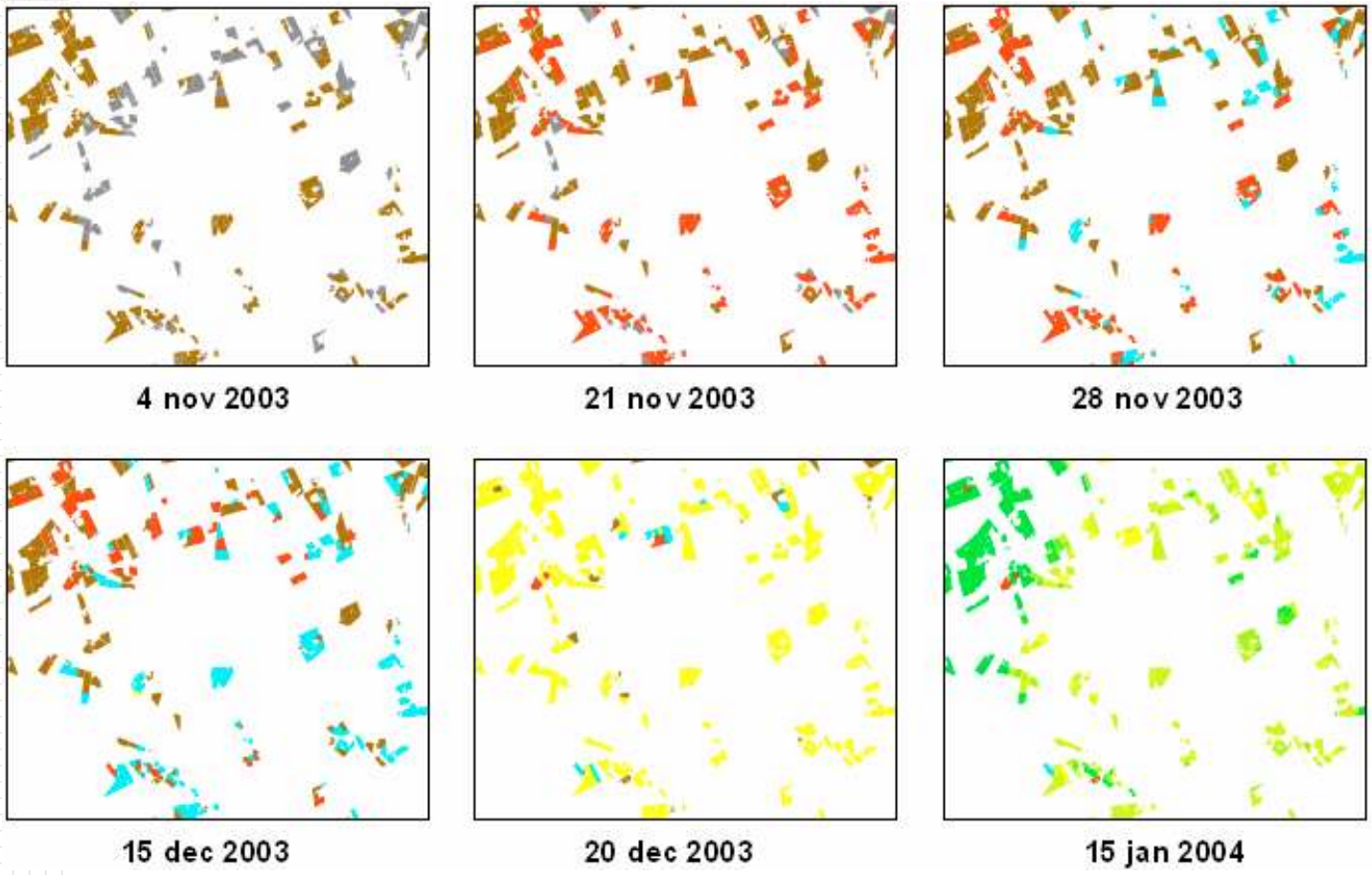
04 Nov 2003
21 Nov 2003
28 Nov 2003

Lichtenburg, South Africa

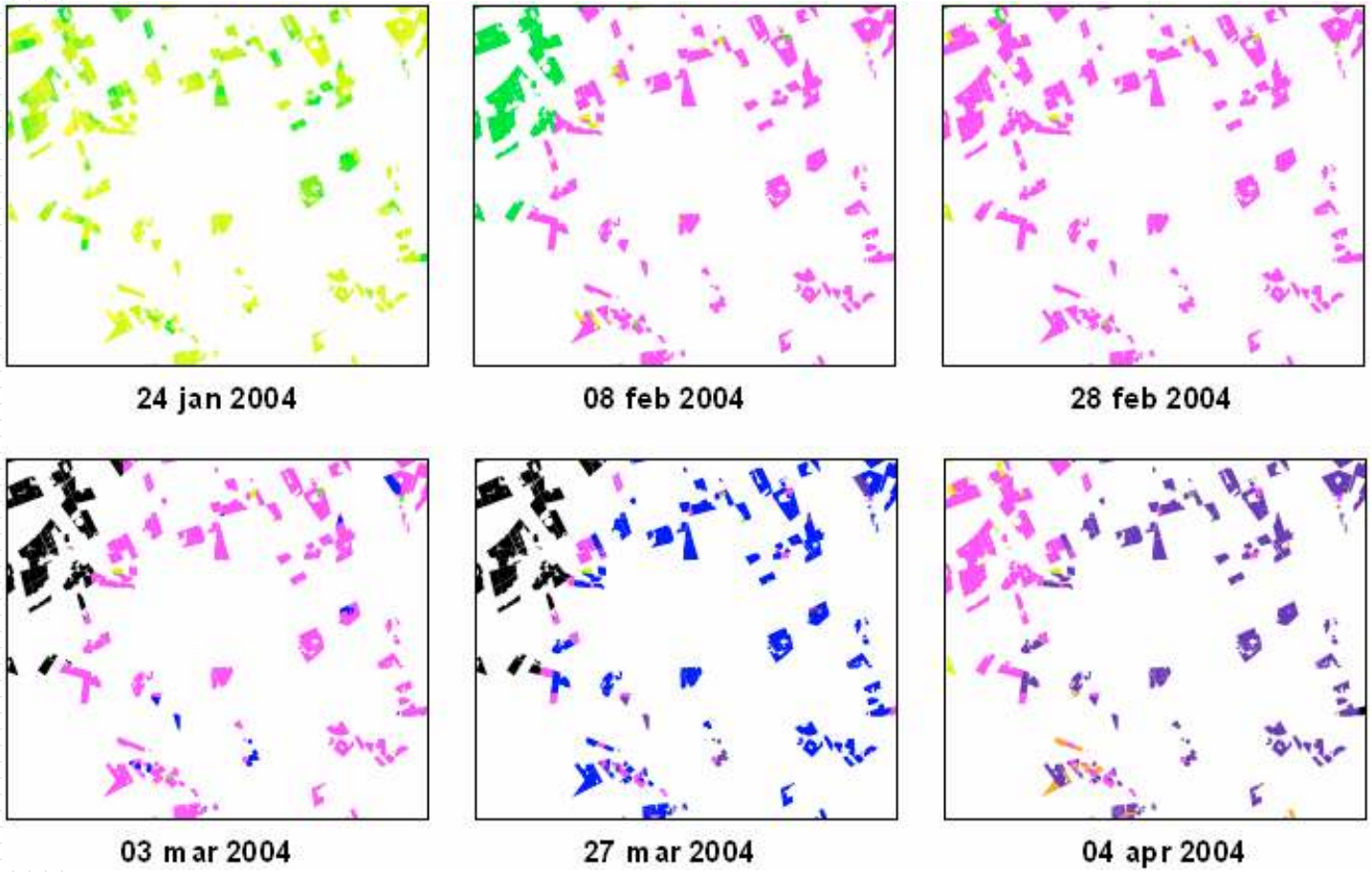
South Africa - Integration of SAR data into User's Environment



South Africa - Crop Monitoring Product

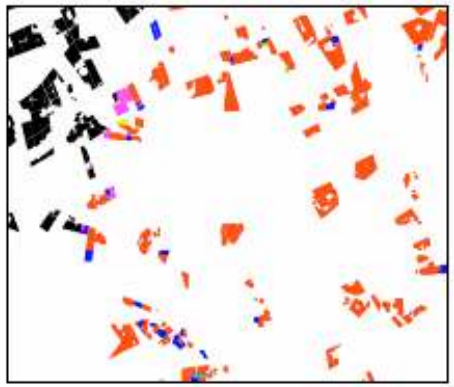


South Africa - Crop Monitoring Product

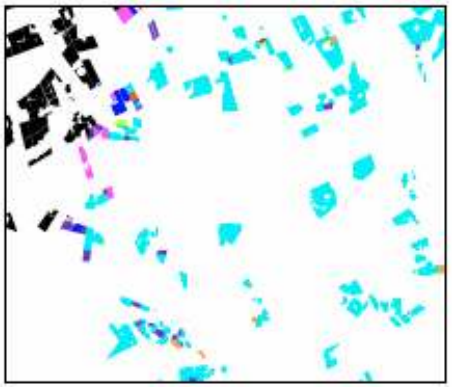


South Africa - Crop Monitoring Product

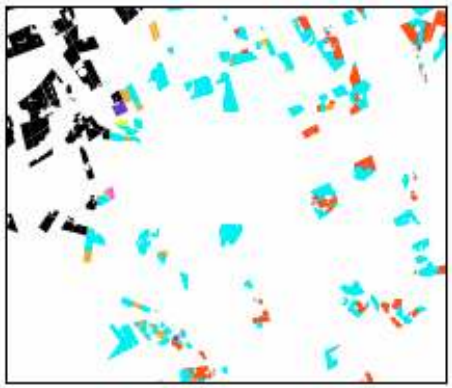
08 may 2004



14 may 2004



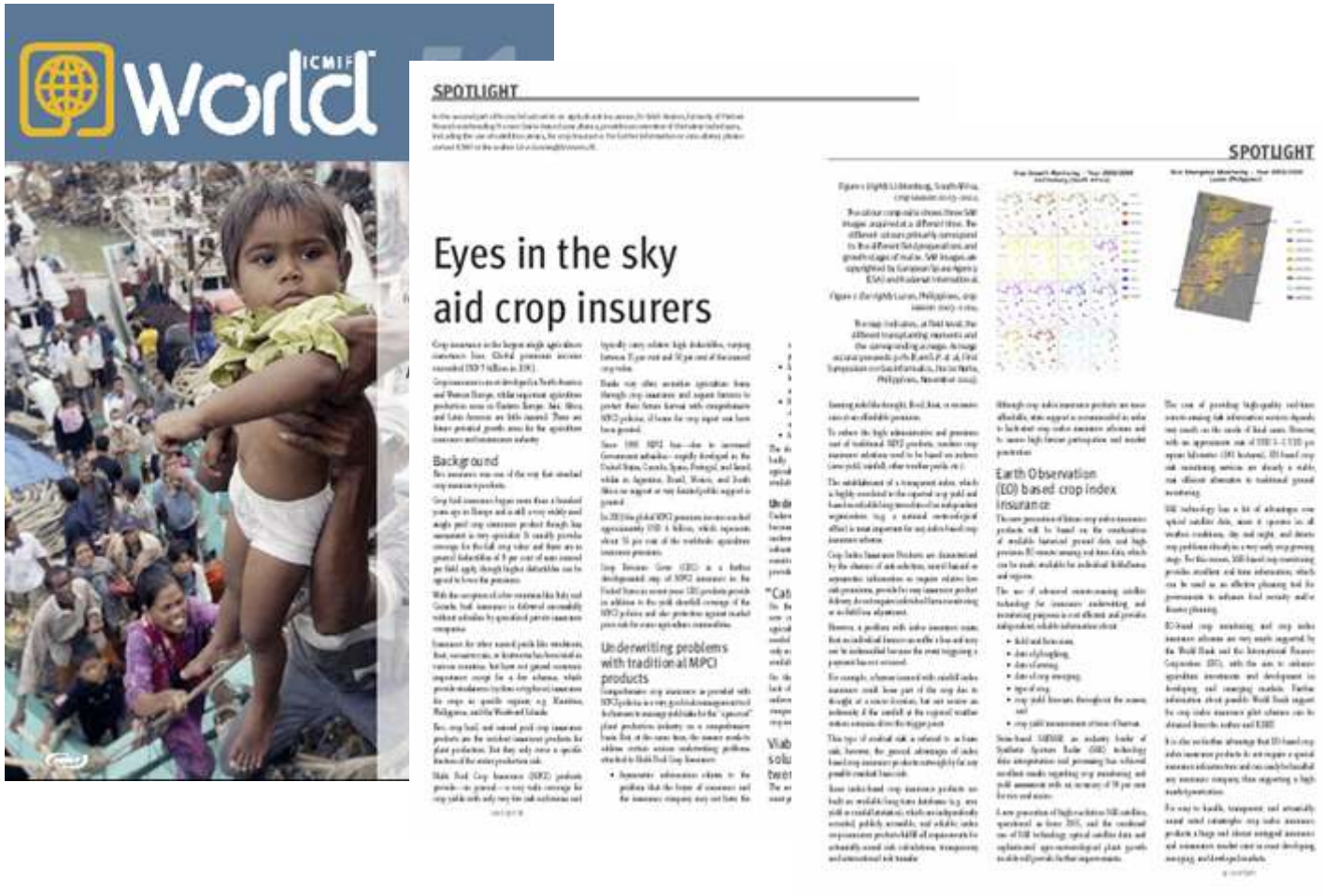
07 jun 2004



12 jun 2004

- No data
- Before ploughing
- After ploughing
- Weeds emergence
- Weeds removal/frost
- Plants just emerged
- Plant growing 1
- Plant growing 2
- Flowering
- Full plant development
- Plant drying
- Full maturiry

International Co-operative and Mutual Insurance Federation



World ICMIF

SPOTLIGHT

Eyes in the sky aid crop insurers

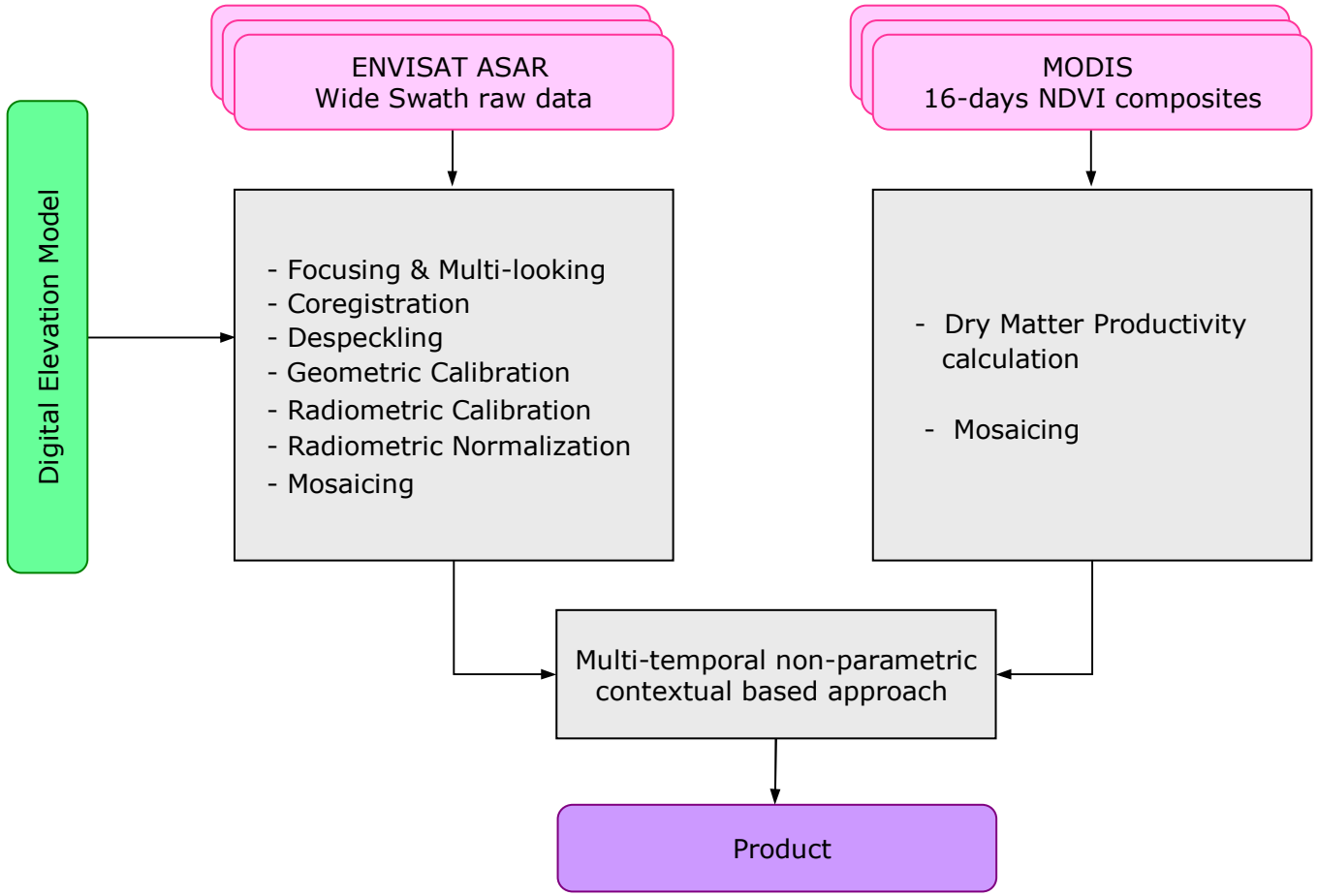
Background

Underwriting problems with traditional MPCI products

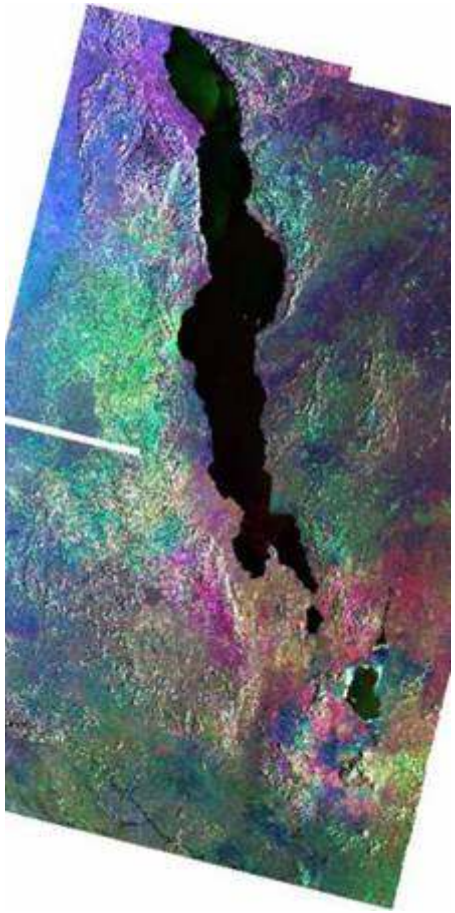
SPOTLIGHT

Earth Observation (EO) based crop index insurance

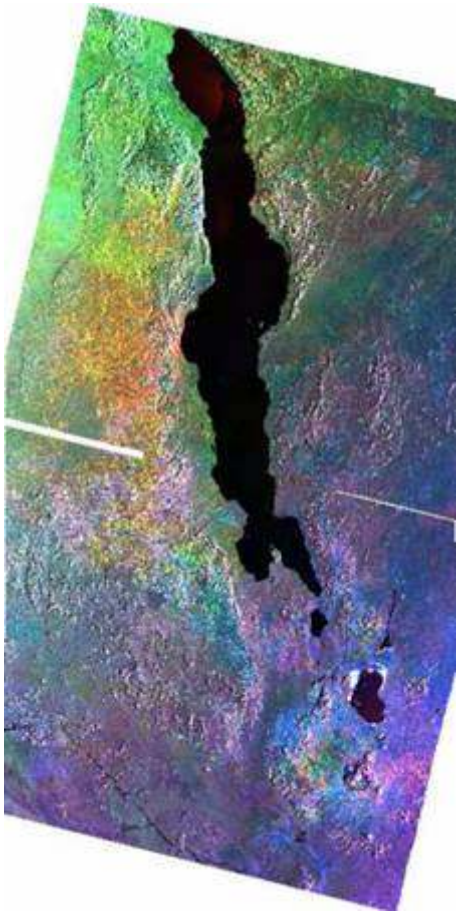
Malawi - Monitoring of Crop Extent and Stages 2004/5 at National Scale



Malawi - Monitoring of Crop Extent and Stages 2004/5



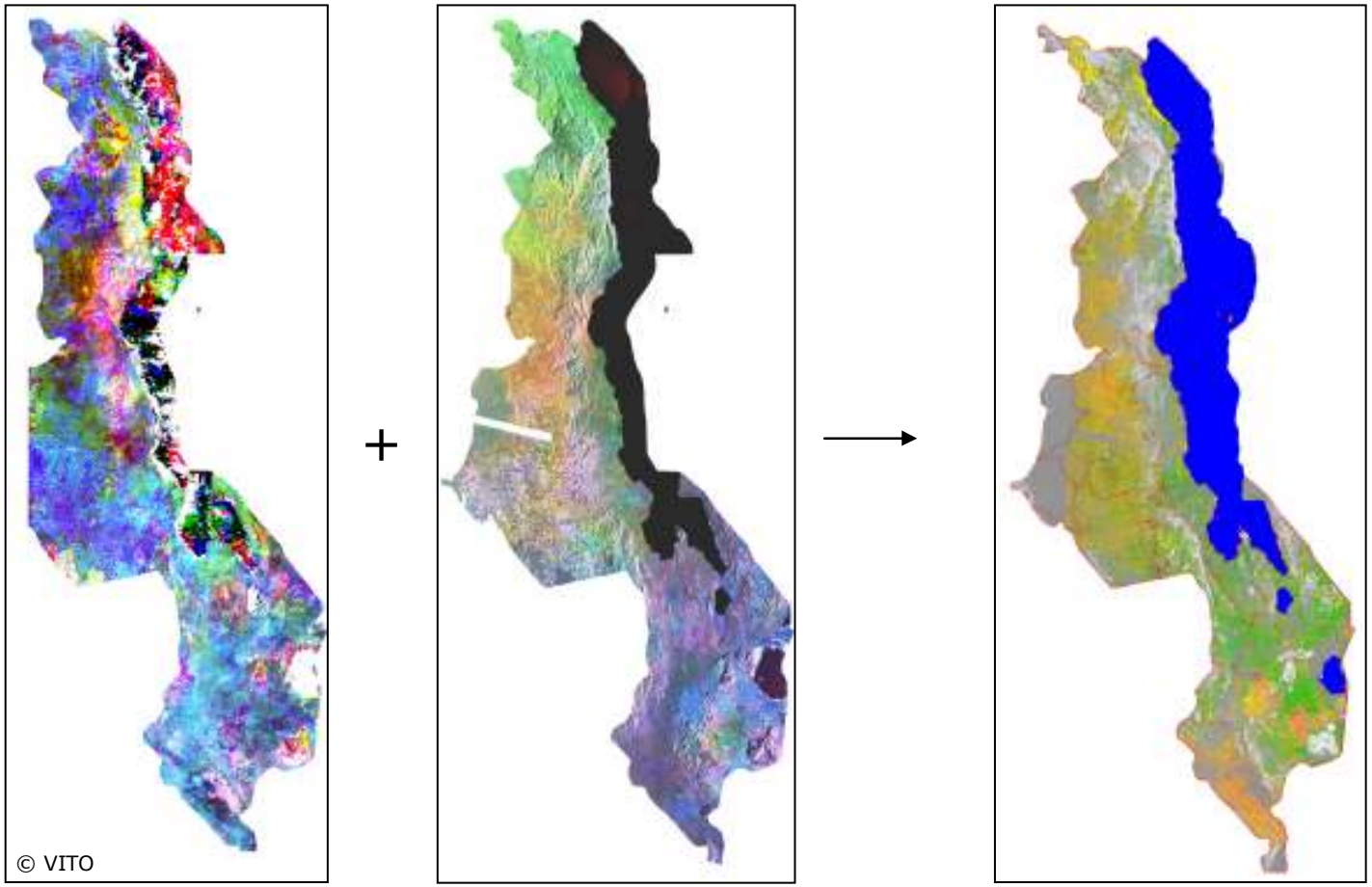
Nov - Dec 2004



Dec 2004 - Jan 2005

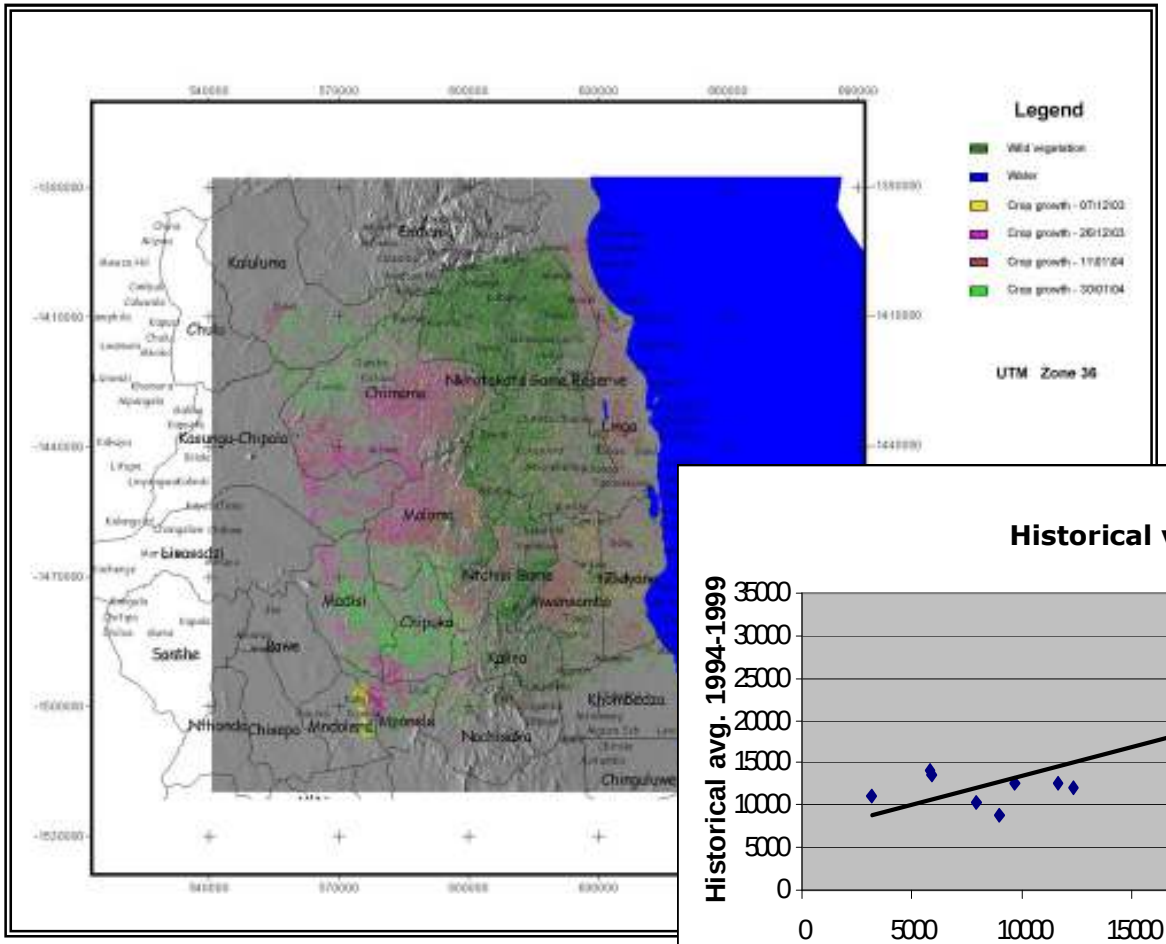
Multi-temporal ENVISAT Wide Swath Mosaic (100m)

Malawi - Monitoring of Crop Extent and Stages 2004/5

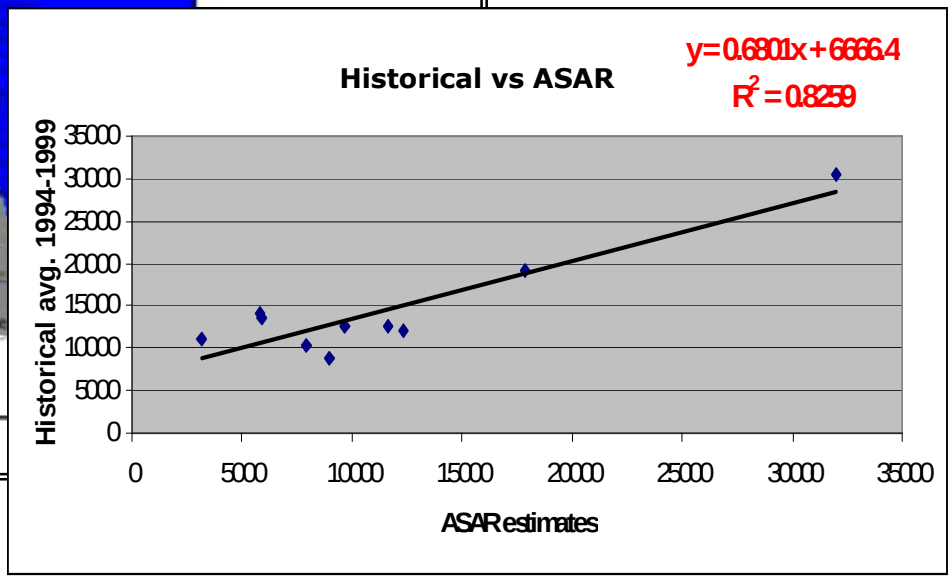


MODIS DMP product ASAR WS product Crop Extent

Malawi - Monitoring of Crop Stages 2003/4



Based on multi-temporal ENVISAT AP data (15m)



Conclusions

- SAR reflectivity plays a relevant role for agricultural (qualitative) applications. **Temporal variations are not casual**.
- The synergy between SAR and optical products is fundamental in order to derive a complete set of information.
- However, only few products based on SAR are currently available, primarily due to the **inappropriate consideration** of multi-temporal multi-mission data (one image is no information, or 35 days cycle do not correspond to field activities) but also due to the **lack of appropriate tools**.
- Besides reflectivity, coherence is also a key component. However, unfortunately SAR data with short-time interval (ERS-Tandem like) are **not available** (except ASAR - ERS-2 …).
- A general product is useless. Think in terms of user requirements, land practises, baseline information in order to develop **tailored-made products**.

Just a last slide … on education …

Around 350 slides on SAR Theory, Application Examples, Exercises, and Questions & Answers

Thank you for your attention