Product Delivery Report for K&C Phase 3

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sarmap

Science Team meeting #21 – Phase 3 Result Presentations
Kyoto Research Park, Kyoto, Japan, December 3-4, 2014

Project objectives

The objective is to demonstrate, at country-level, the multi-purpose use of ALOS PALSAR-1 data, particularly of multi-year ALOS PALSAR-1 Intensity data and their synergetic use with other spaceborne SAR data, conditio sine qua non for the provision of accurate and complementary products.

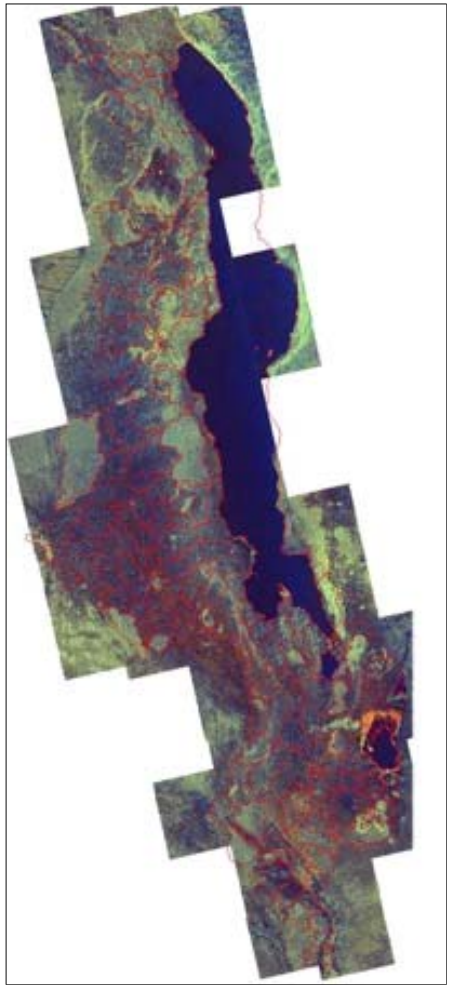
In this framework, following products are targeted:

- Forest map
- Seasonal cultivated area
- Land cover map
- Digital Elevation Model
- Forest height

Malawi

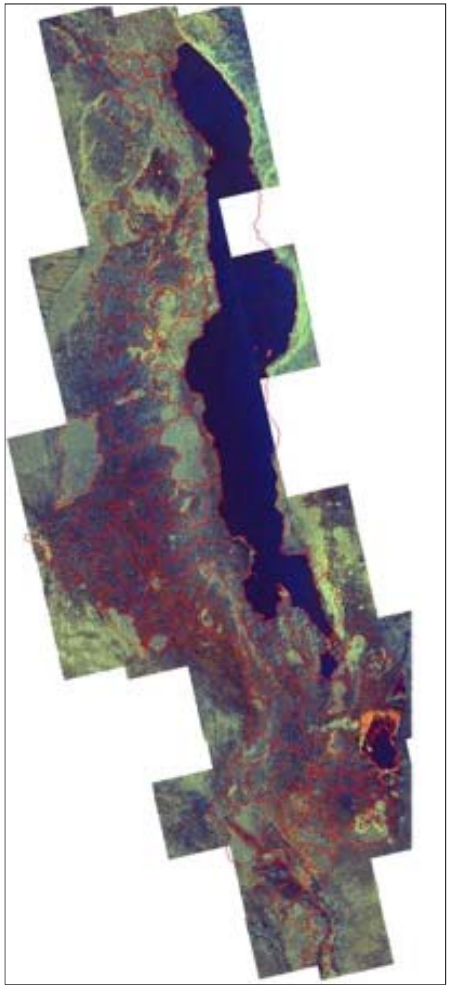
Forest and Seasonal cultivated area

Malawi, Forest map

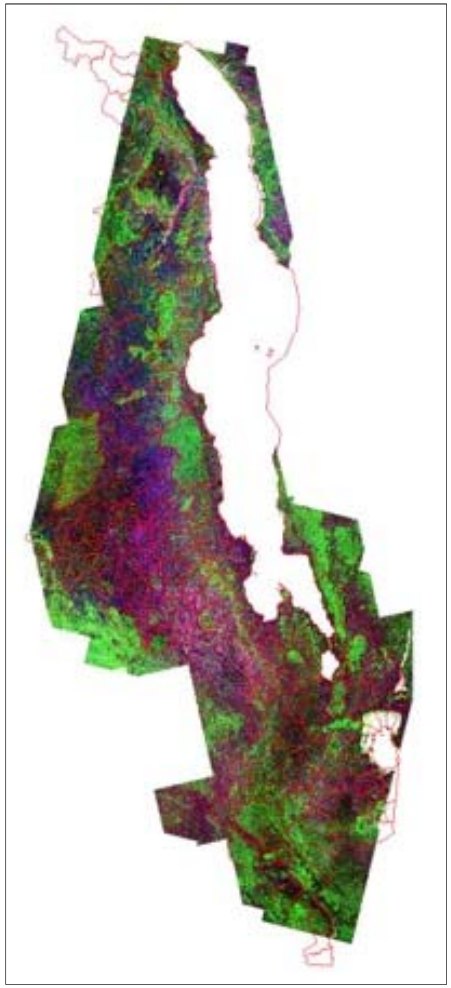


Multi-year PALSAR-1 HH-HV
during dry season

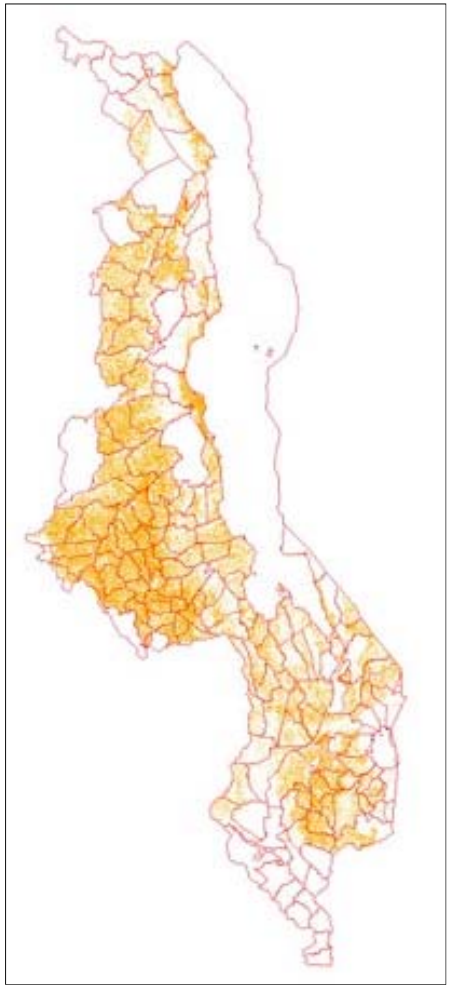
Cultivated Area – PALSAR-1 HH-HV + ASAR HH-HV



Multi-year PALSAR-1 HH-HV
during dry season

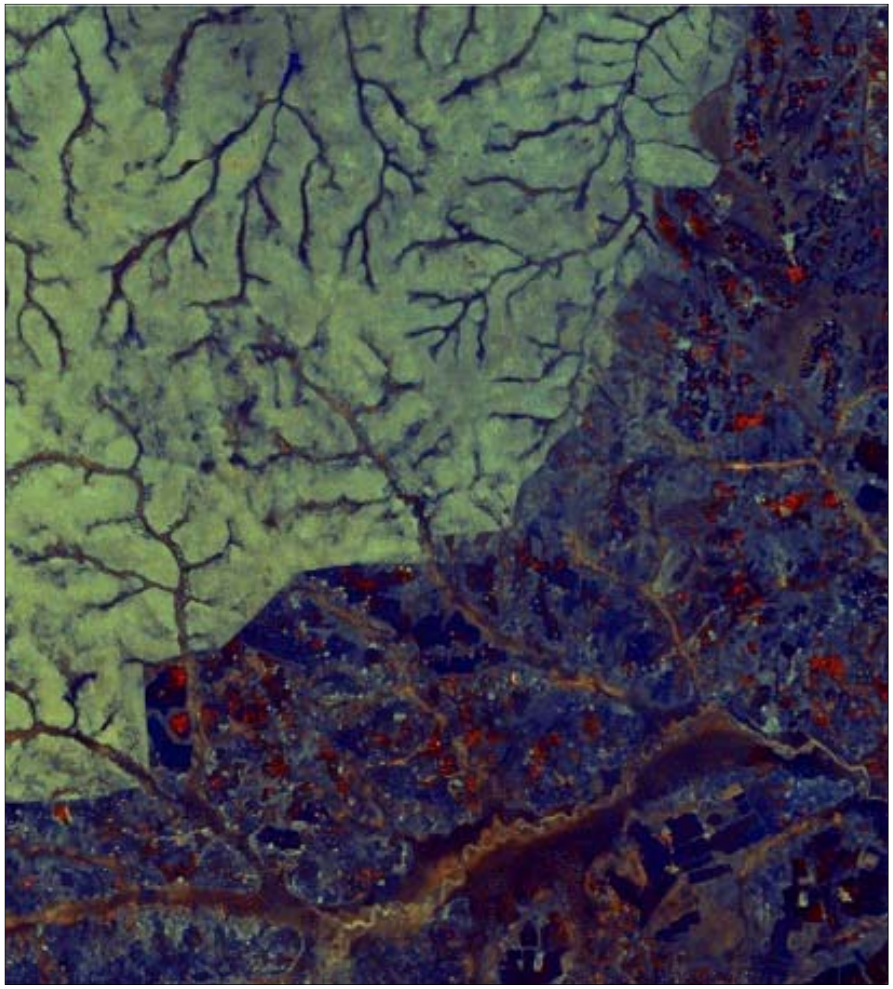


ASAR HH PALSAR HV ASAR HH
ASAR data acquired during wet (crop)season



Cultivated Area (15m)

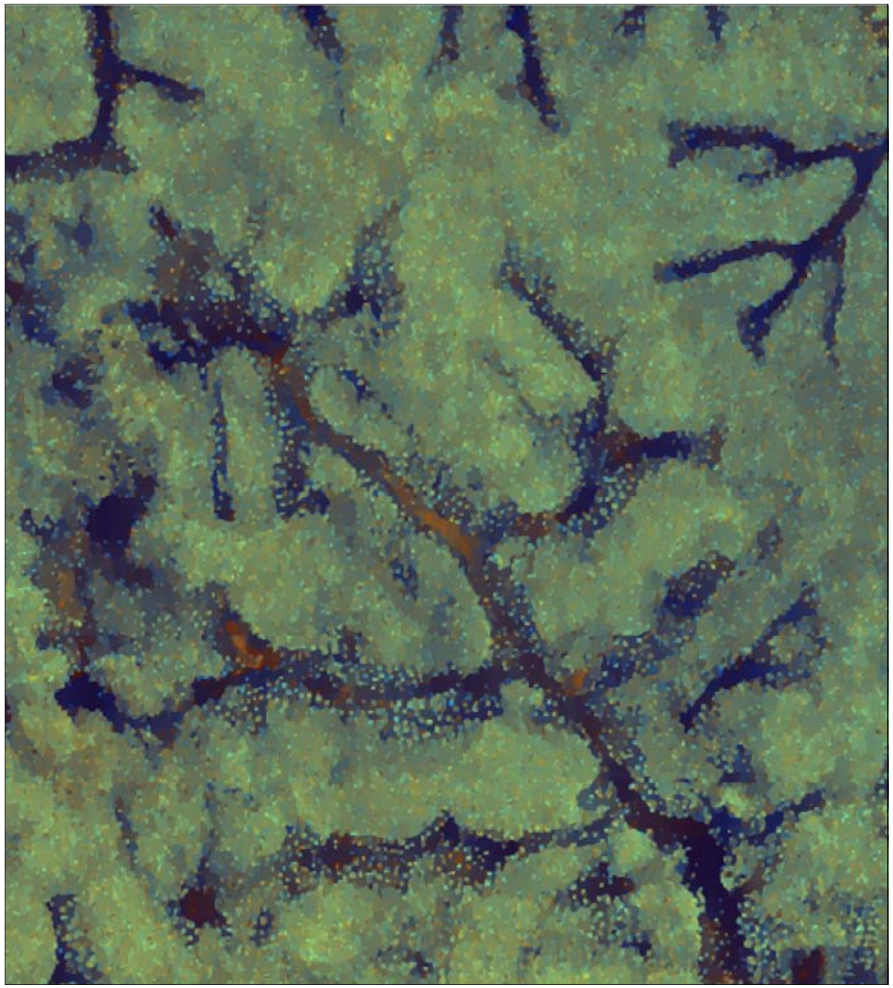
Forest map product – L-band Intensity vs. X-band 1 day InSAR



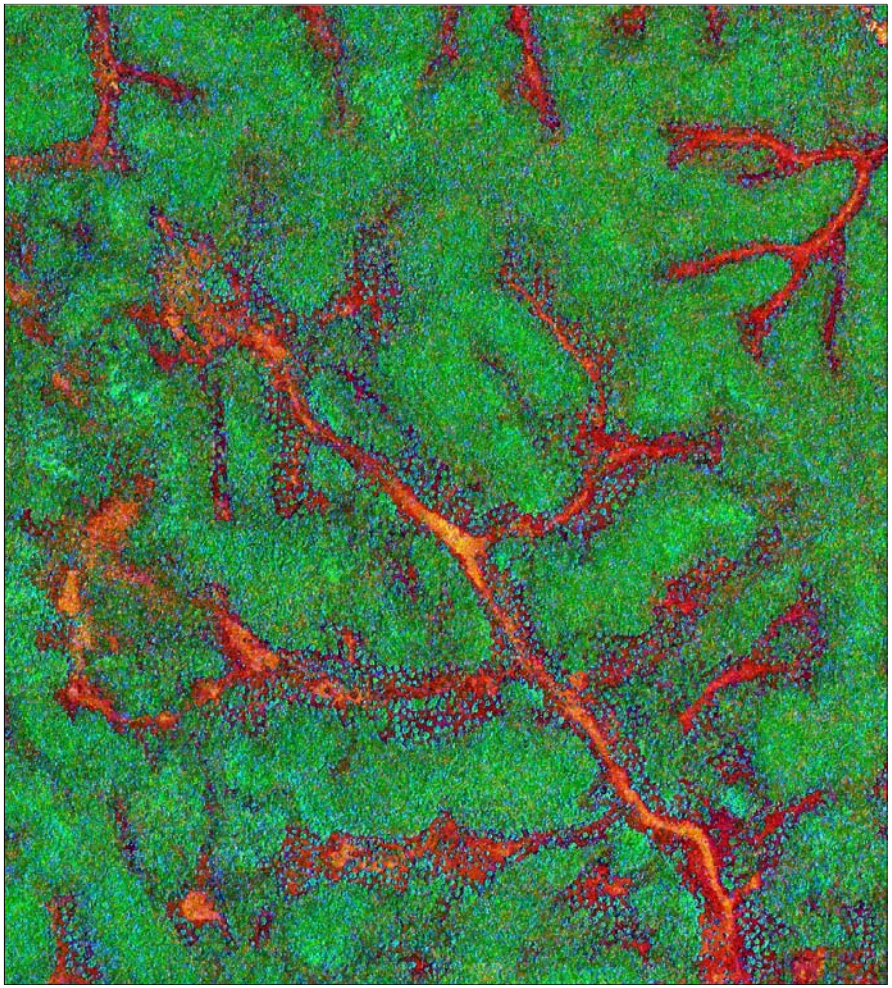
Multi-year PALSAR-1 HH-HV (15m) during dry season

1 day InSAR CSK StripMap (3m) during dry season

Forest map product – L-band Intensity vs. X-band 1 day InSAR



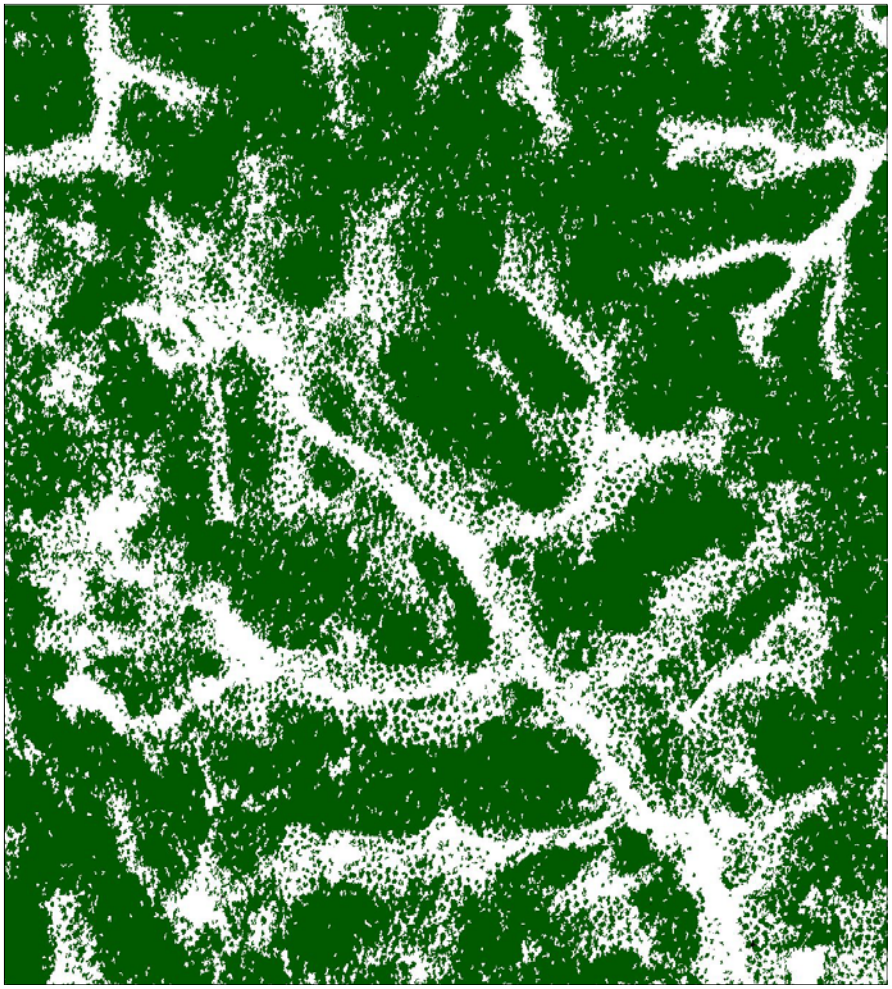
Multi-year PALSAR-1 HH-HV (15m) during dry season



1 day InSAR CSK StripMap (3m) during dry season

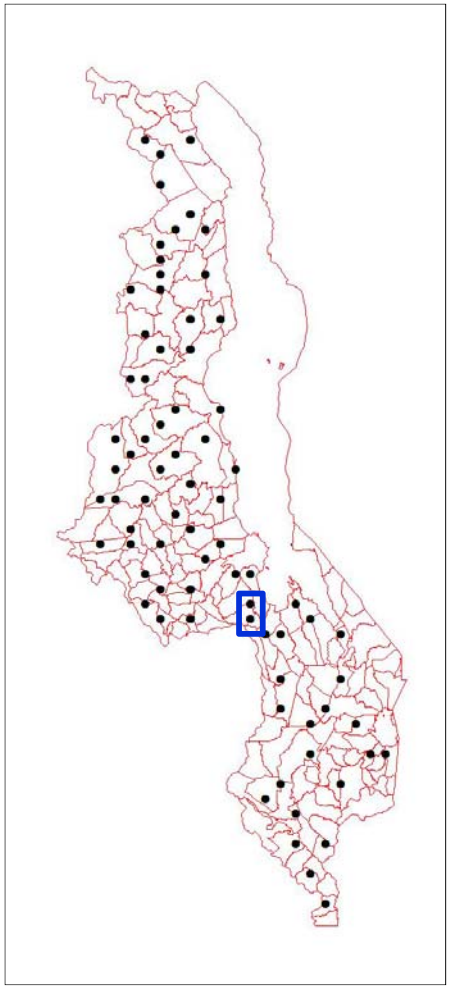
Forest map product – L-band Intensity vs. X-band 1 day InSAR

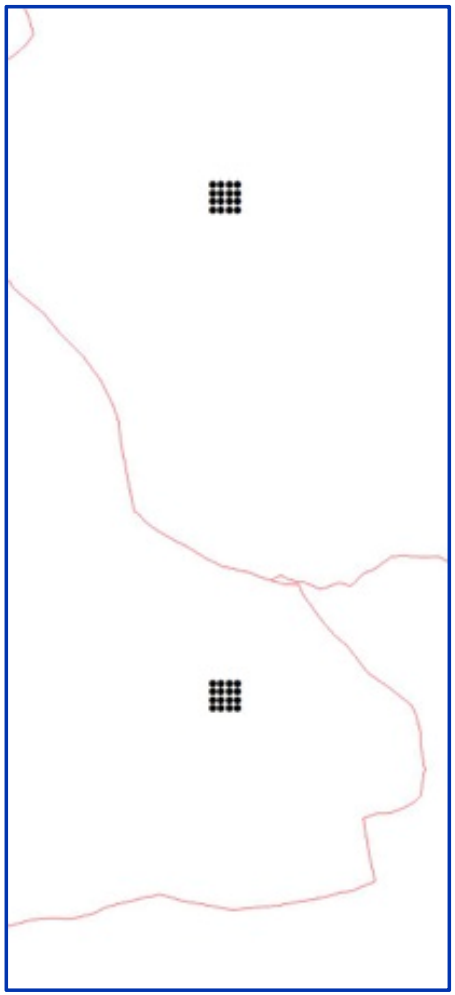
Multi-year PALSAR-1 HH-HV (15m) during dry season



1 day InSAR CSK StripMap (3m) during dry season

Validation approach





Total number of points 868

- Area: 100,000 sqkm
- Distance between clusters: 15km
- Number of points per cluster: 16
- Distance between points within a cluster: 250m
- Collected information

Validation

	forest	sparse veg	other	**Total**	Omission error (%)
Urban	10	0	10	20	50
Sugarcane	19	3	7	29	76
Crop	42	0	347	389	11
Forest	365	0	37	402	9
Other	1	0	27	28	4
Total	437	3	428	868	**K-coeff 0.75**
Commission error (%)	16	0	9	**overall accuracy 87%**	

PALSAR-1 HH-HV

	forest	sparse veg	other	**Total**	Omission error (%)
Urban	10	0	10	20	50
Sugarcane	10	3	16	29	45
Crop	12	0	377	389	3
Forest	357	0	45	402	11
Other	1	0	27	28	4
Total	390	3	475	868	**K-coeff 0.82**
Commission error (%)	8	0	9	**overall accuracy 91%**	

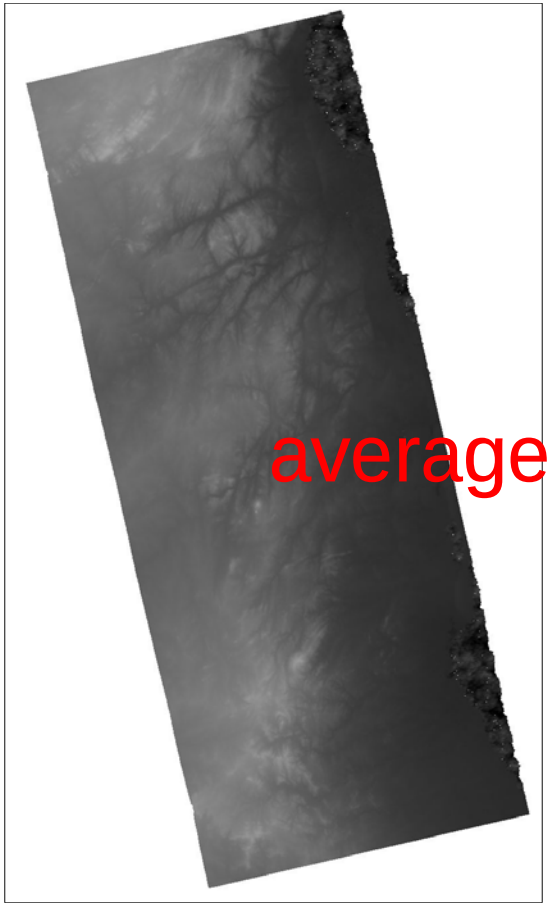
PALSAR-1 HH-HV
Crop Map (ASAR HH-HV)

	forest	sparse veg	other	**Total**	Omission error (%)
Urban	2	0	18	20	10
Sugarcane	10	3	16	29	45
Crop	12	0	377	389	3
Forest	357	0	45	402	11
Other	1	0	27	28	4
Total	382	3	483	868	**K-coeff 0.84**
Commission error (%)	7	0	9	**overall accuracy 92%**	

PALSAR-1 HH-HV
Crop Map (ASAR HH-HV)
ASAR HH-HV

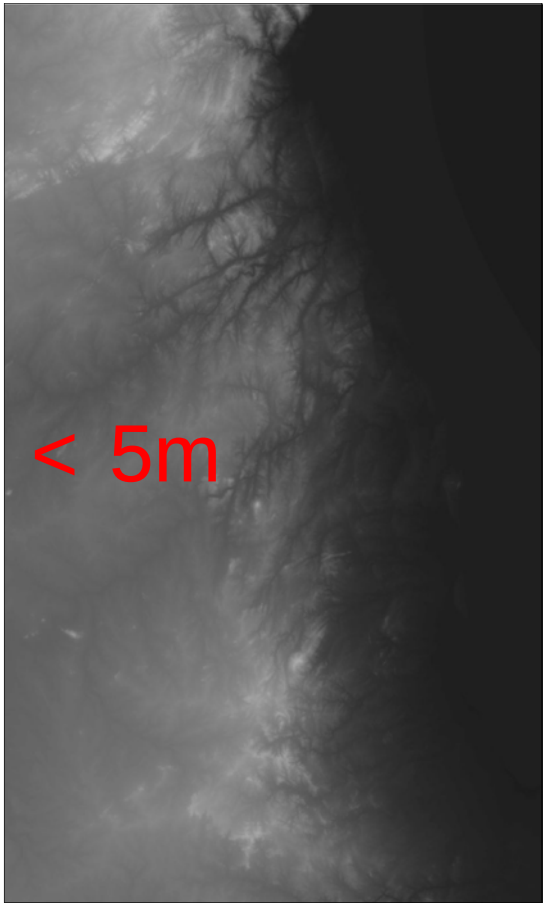
Digital Elevation Model

PALSAR-1 HH coherence
during dry season



PALSAR-1 HH InSAR DEM

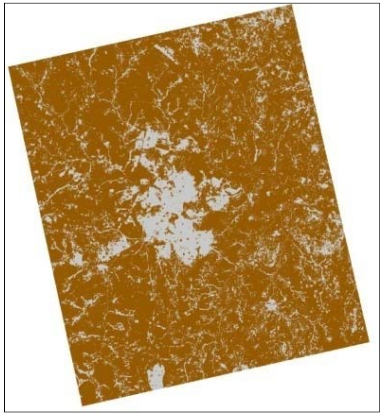
average $\Delta h < 5m$



SRTM

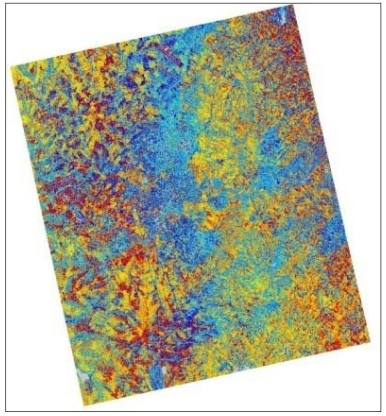
Cultivated Area product – PALSAR-1 HH-HV + CSK 1 day InSAR + ASAR HH-HV

Multi-year PALSAR-1 data in dry season



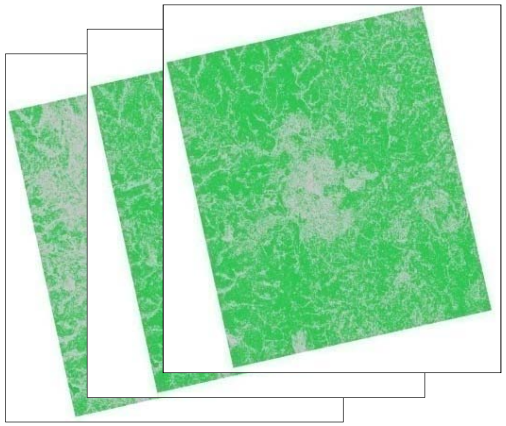
Potential crop extent (15m)

1-day InSAR CSK at SoS

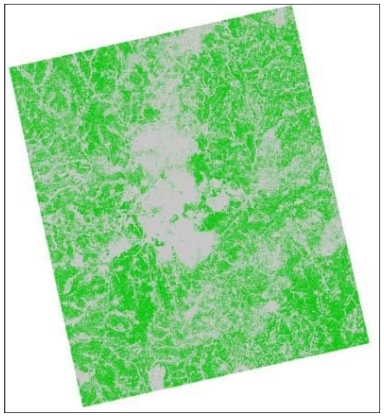


Potential crop area at SoS (3m)

Intra-annual ASAR AP data after SoS



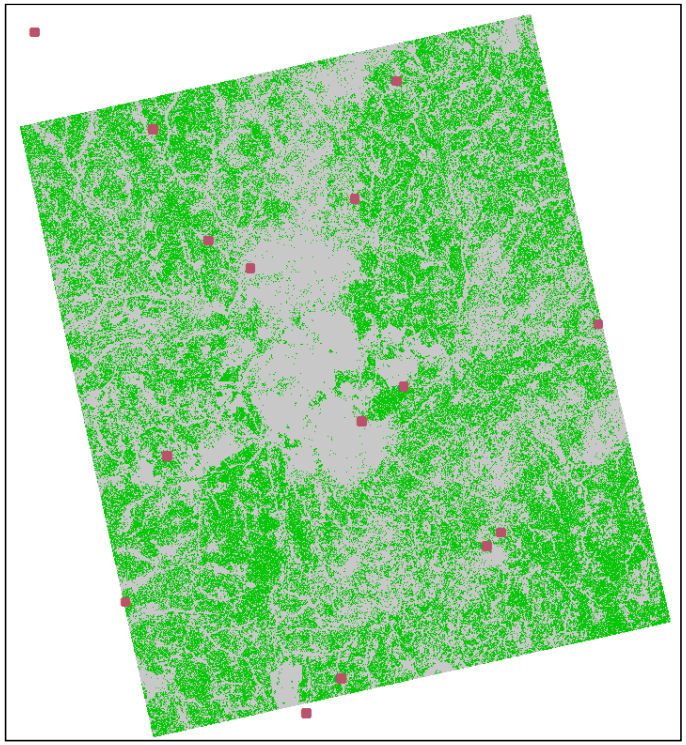
Crop growth extent (15m)



Cultivated Area (15m)

sarmap
your information gateway

Cultivated Area product – Validation



	Other	Crop	**Total**	Omission error (%)
Other - A	32	0	32	0
Crop - B1-6	8	94	102	8
Other - B7	4	0	4	0
Other - C	0	0	0	0
Other - D	4	0	4	0
Other - E	0	0	0	0
Other - F	15	1	16	6
Other - G	0	0	0	0
Other - H	13	0	13	0
Total	76	95	171	**K-coeff 0.9**
Commission error (%)	11	1	**Overall accuracy 95%**	

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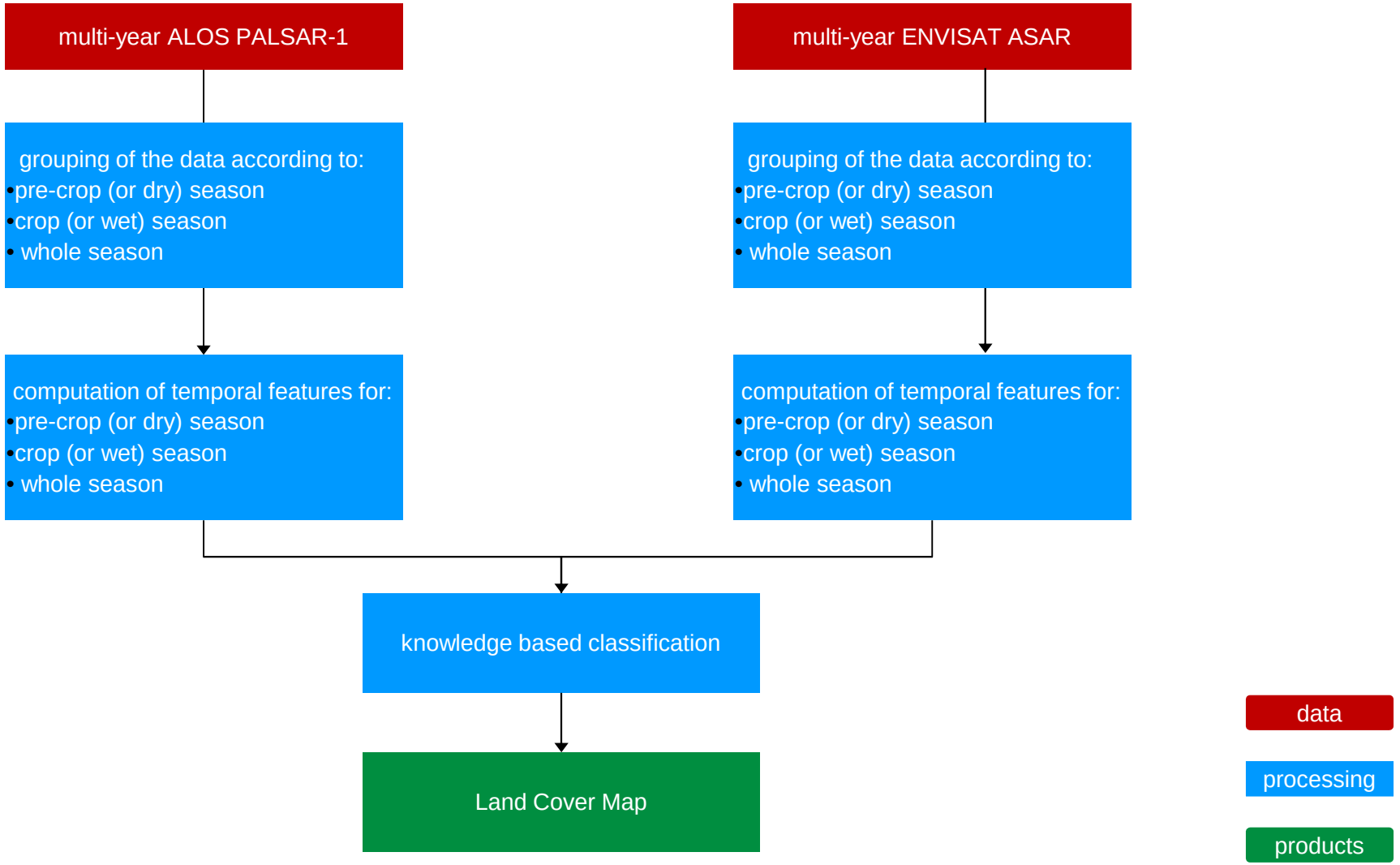
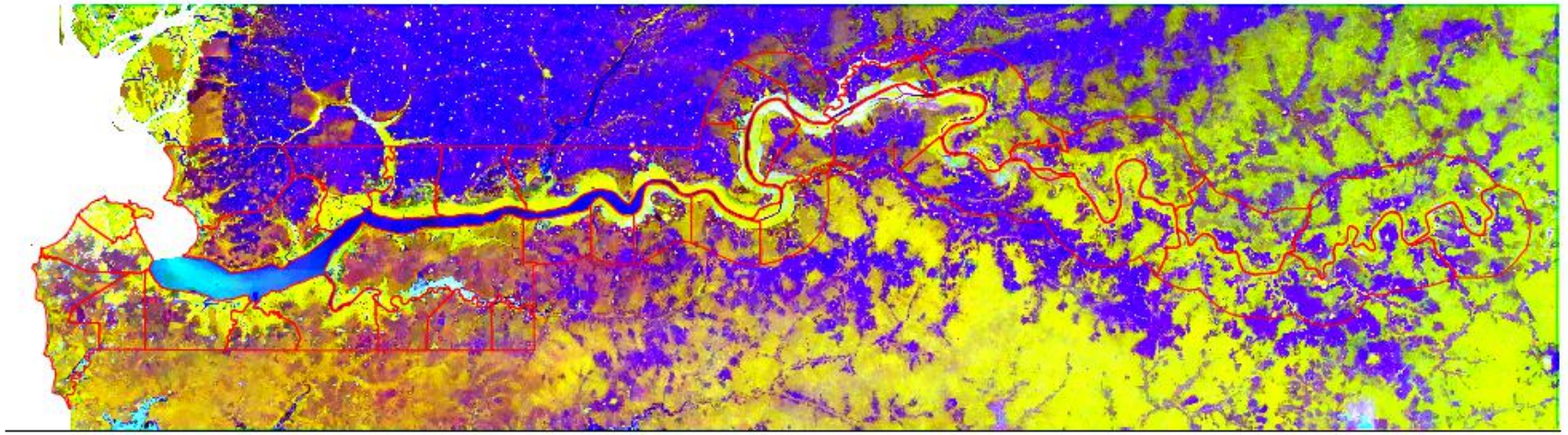
The Gambia

Land Cover Map

Multi-year, multi-sensor Approach



Multi-year, multi-sensor mosaic at 1 hectare

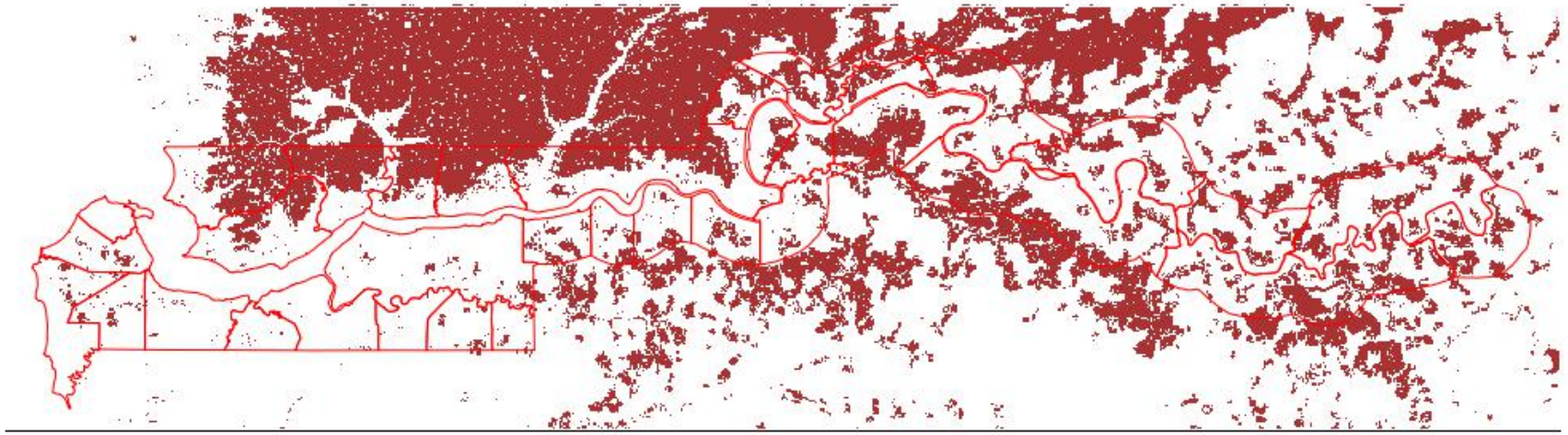


ALOS PALSAR-1 ScanSAR HH pre-crop

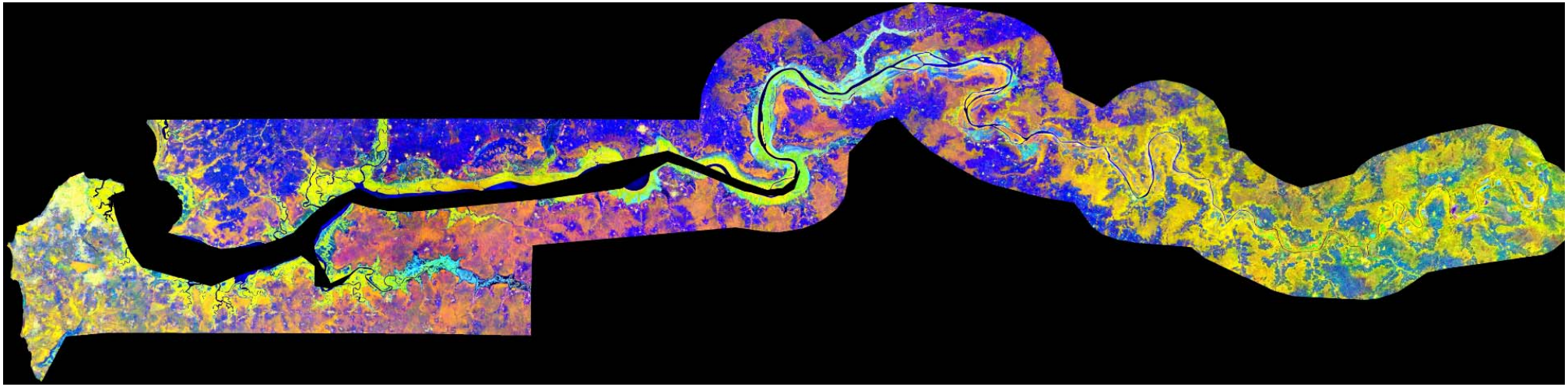
ENVISAT ASAR Wide Swath HH pre-crop

ENVISAT ASAR Wide Swath HH span

Agricultural Extent at 1 hectare



Multi-year, multi-sensor mosaic at 15 meter

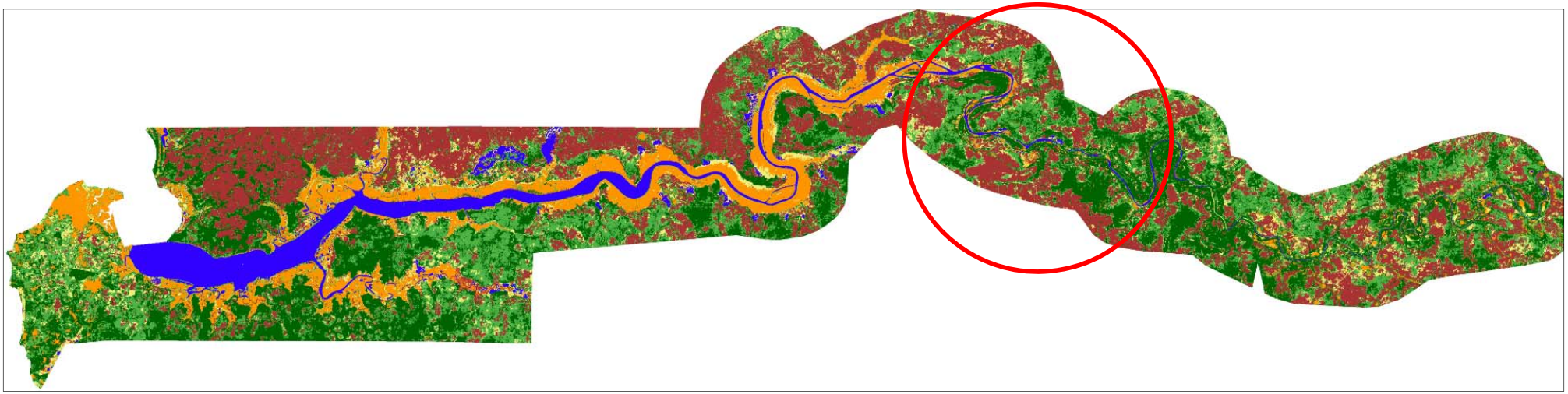


ALOS PALSAR-1 mean HV pre-crop season

ENVISAT ASAR mean HH pre-crop season

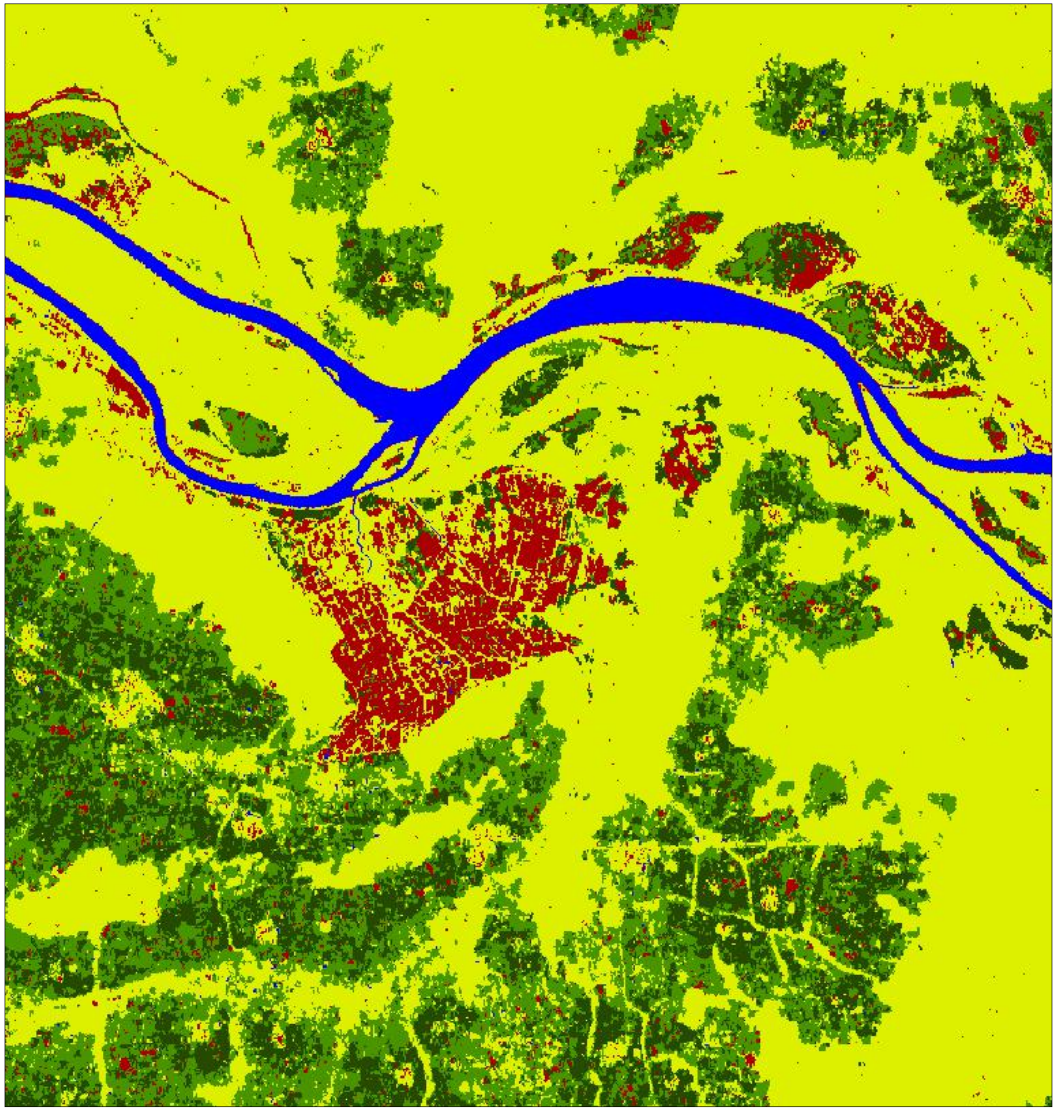
ENVISAT ASAR HH difference crop and pre-crop season

Land Cover Map at 15 meter



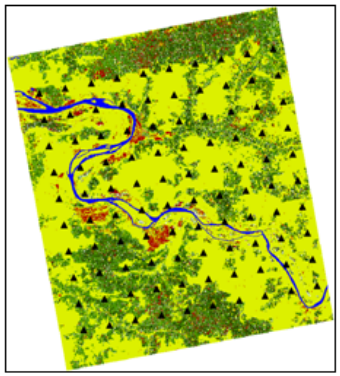
Agricultural area
Mangrove - Sandbanks
Water
Bare soil-weak vegetation (low biomass)
Medium vegetation (medium biomass)
Strong vegetation (high biomass)

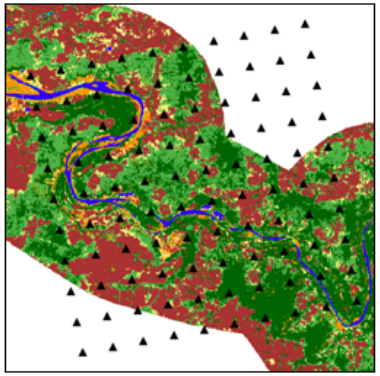
Cultivated Area at 3 meter (Cosmo-SkyMed StripMap)

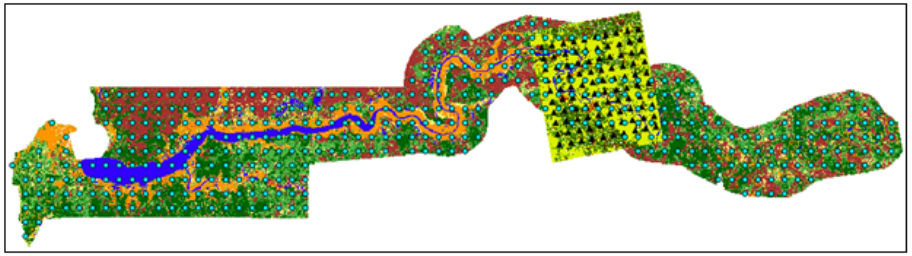


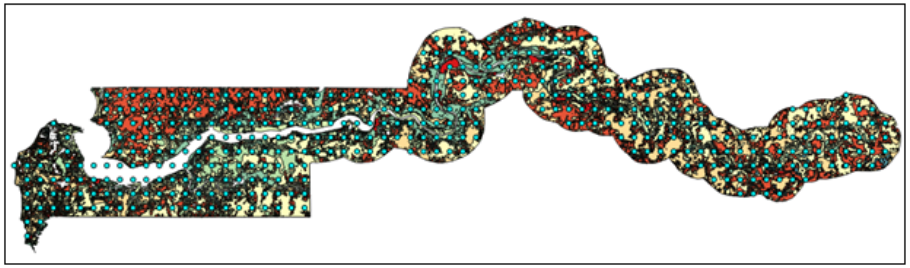
Rice
Crop 1
Crop 2
Water
Forest

Validation









		Map		
		crop	non-crop	accuracy
Survey	crop	17	6	73.9%
	non-crop	5	54	91.5%
	reliability	77.3%	90.0%	87.0%

seasonal LCM 2013

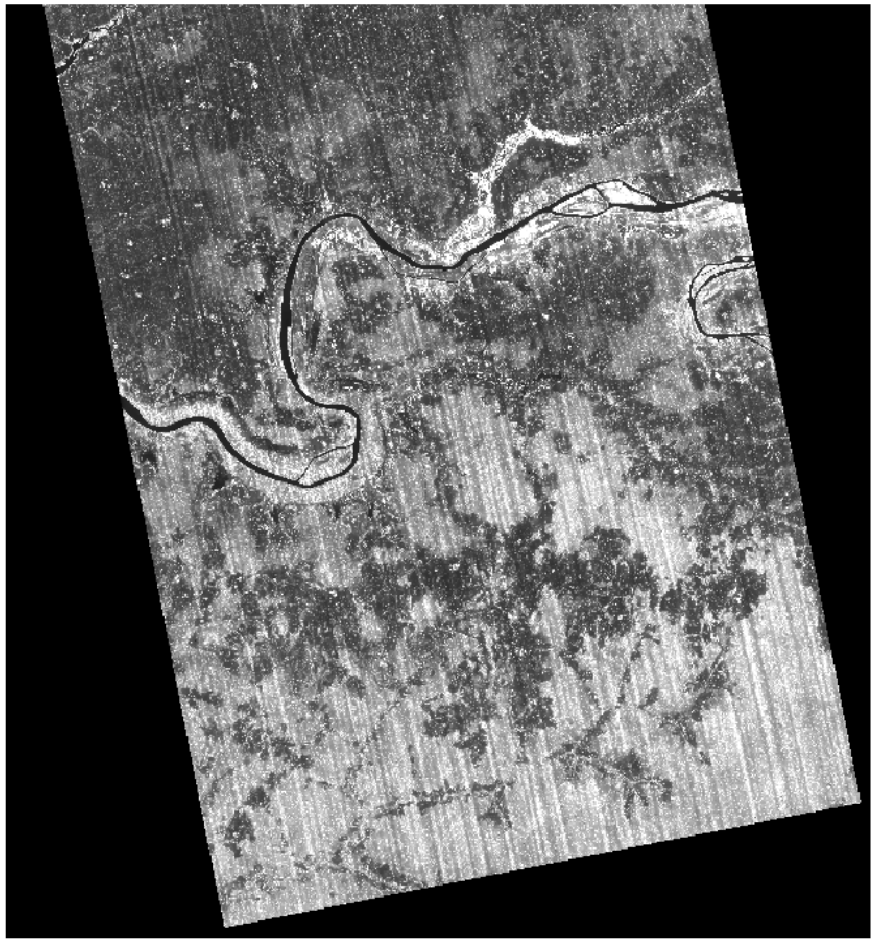
		Map		
		crop	non-crop	accuracy
Survey	crop	18	5	78.3%
	non-crop	8	54	87.1%
	reliability	69.2%	91.5%	85.0%

national baseline
LCM 15m over same
area as LCM2013

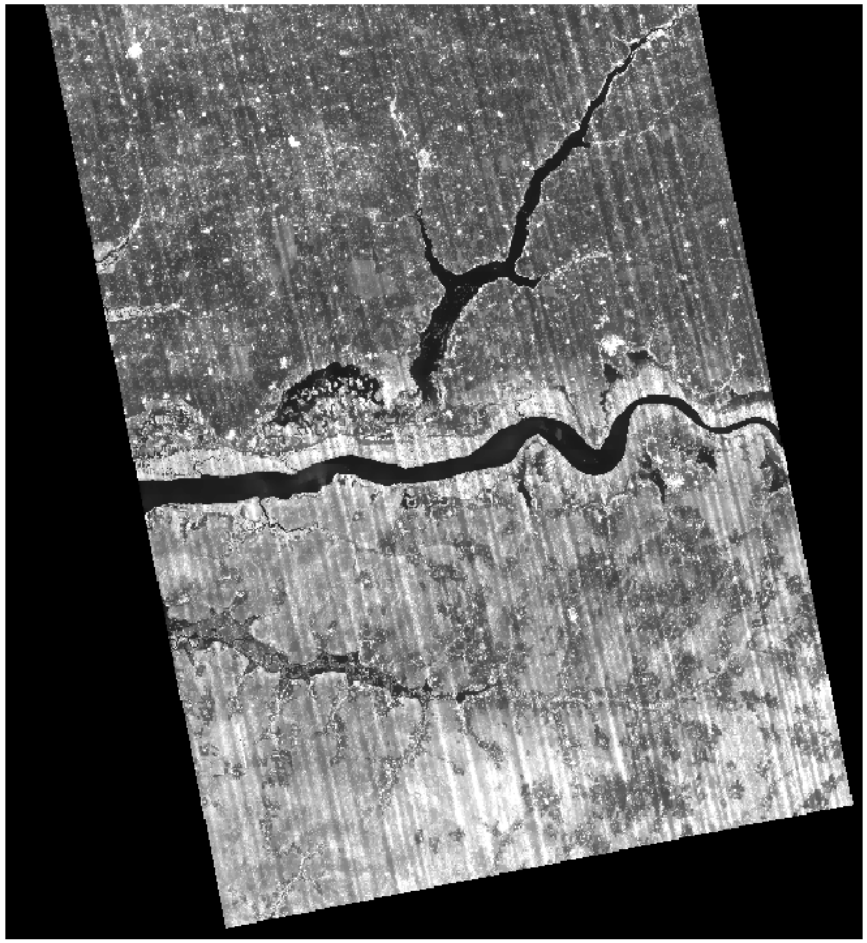
		Map		
		crop	non-crop	accuracy
Survey	crop	85	29	74.6%
	non-crop	29	277	90.5%
	reliability	74.6%	90.5%	86.2%

national baseline
LCM 15m

Ionospheric Effects at L-band 1/3



Fine Beam Single



Fine Beam Dual (HH)

Ionospheric Effects at L-band 3/3

Year / Month	2007		2008		2009		2010		2011		Total		
	n	not OK	n	not OK	n	not OK	n	not OK	n	not OK	n	not OK	%
Jan	6	2	8	0	6	2	6	4	6	6	32	14	43.75
Feb	6	2	6	2	6	0	6	2	4	2	28	8	28.57
Mar	2	2	6	6	4	2	6	2	4	0	22	12	54.55
Apr	0	0	6	2	0	0	6	0	0	0	12	2	16.67
May	0	0	6	2	0	0	8	0	0	0	14	2	14.29
Jun	2	0	10	0	4	0	8	0	0	0	24	0	0.00
Jul	10	0	6	0	8	0	6	0	0	0	30	0	0.00
Aug	8	0	6	0	8	0	8	2	0	0	30	2	6.67
Sep	6	0	6	4	8	4	6	4	0	0	26	12	46.15
Oct	8	6	4	2	8	4	6	4	0	0	26	16	61.54
Nov	2	0	0	0	0	0	4	4	0	0	6	4	66.67
Dec	2	0	2	0	4	0	8	2	0	0	16	2	12.50
Total	52	12	66	18	56	12	78	24	14	8	266	74	27.82
not ok (%)	23.08		27.27		21.43		30.77		57.14 *				

* mission until April 2011

Conclusions – Malawi and The Gambia

- The use of multi-year ALOS PALSAR-1 intensity data provide a high data quality (in terms geometry and radiometry) if compared to single-date intensity or interferometric SAR data.

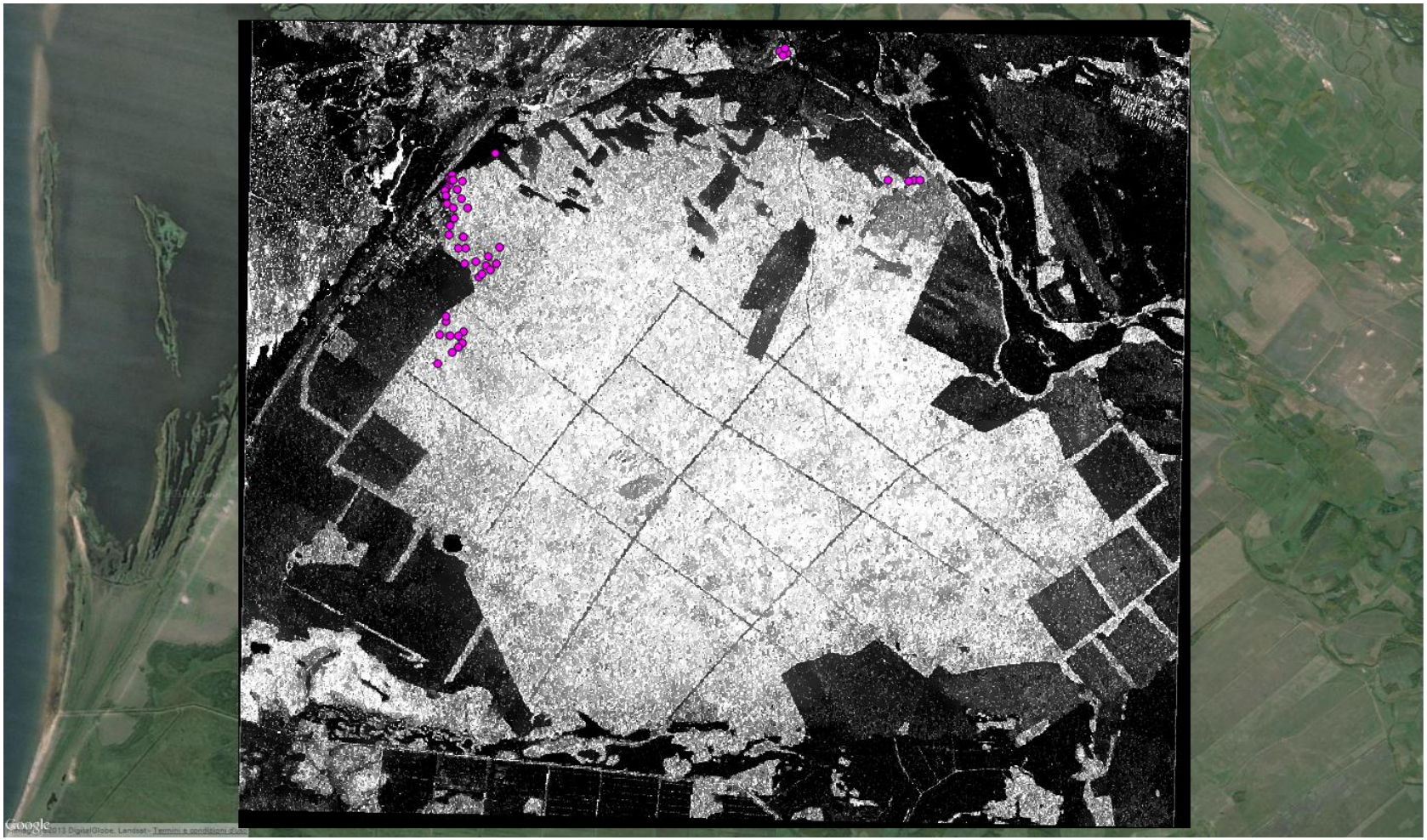
- Understanding of environmental conditions and crop practices is essential for the provision of useful remote sensing products.

- Multi-year ALOS PALSAR-1 intensity data are doubtless valuable for forest and environmental applications. However:
- depending on the geographical area, environmental conditions, and period of the year, data must be selected, processed, and used accordingly;
- SAR data synergy is conditio sine qua non to enhance the product quality.

Boreal forest

Forest height

TSX-Tandem σ^o



TSX-Tandem – InSAR data characteristics

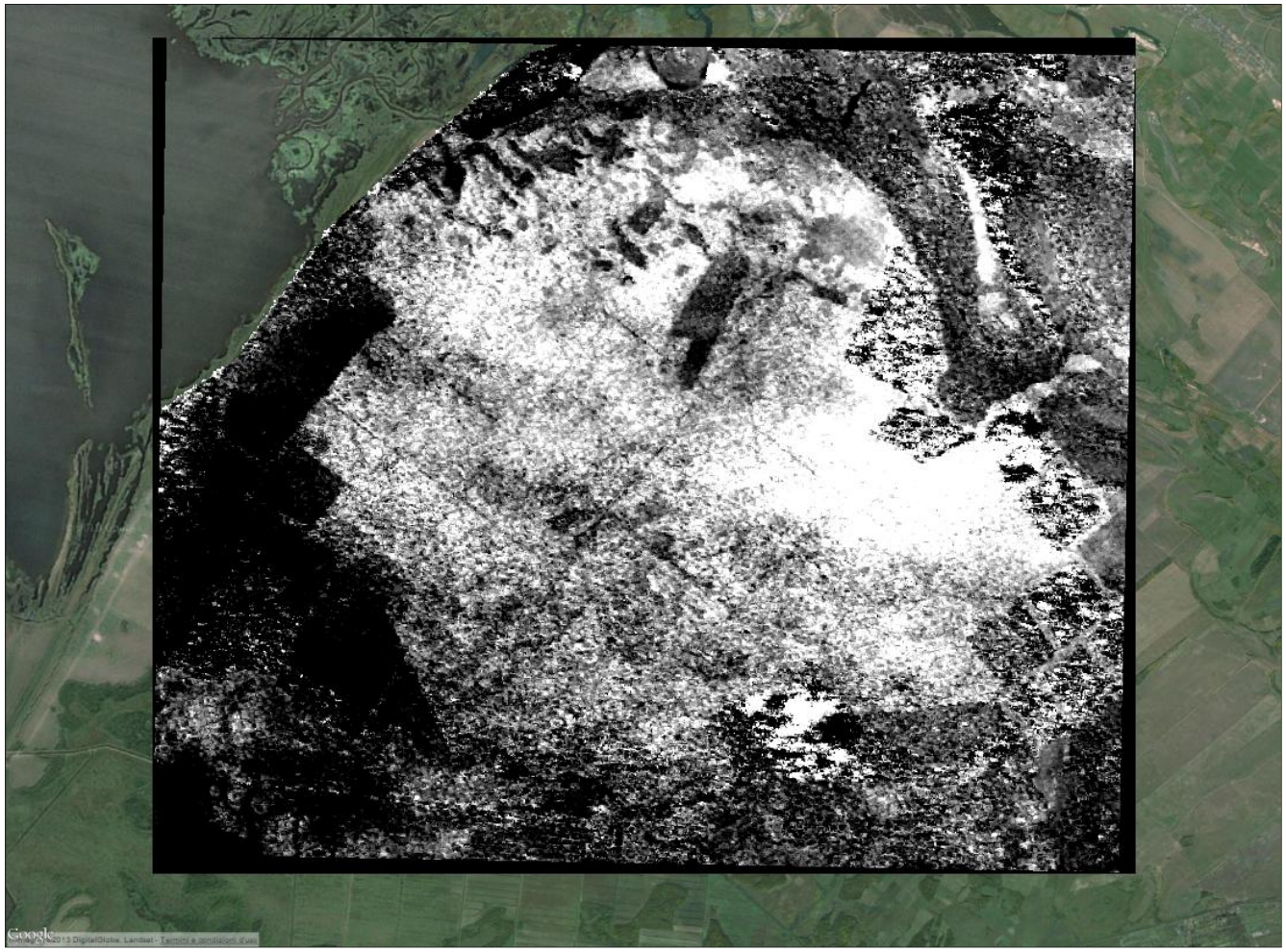
• Spatial resolution	5 m
• 2π phase ambiguity	125 m
• Average coherence forest	> 0.9
• Theoretical height std dev at 1 look	6.7 m
• Theoretical height std dev after processing	4 m
• Acquisition time	February 2012

TSX-Tandem – Estimated forest height, February 2012

ALOS PALSAR-1 FBS – InSAR data characteristics

• Spatial resolution	10 m
• 2π phase ambiguity	25 m
• Average coherence forest	> 0.7
• Theoretical height std dev at 1 look	4 m
• Theoretical height std dev after processing	2.5 m
• Acquisition time	August-October 2006

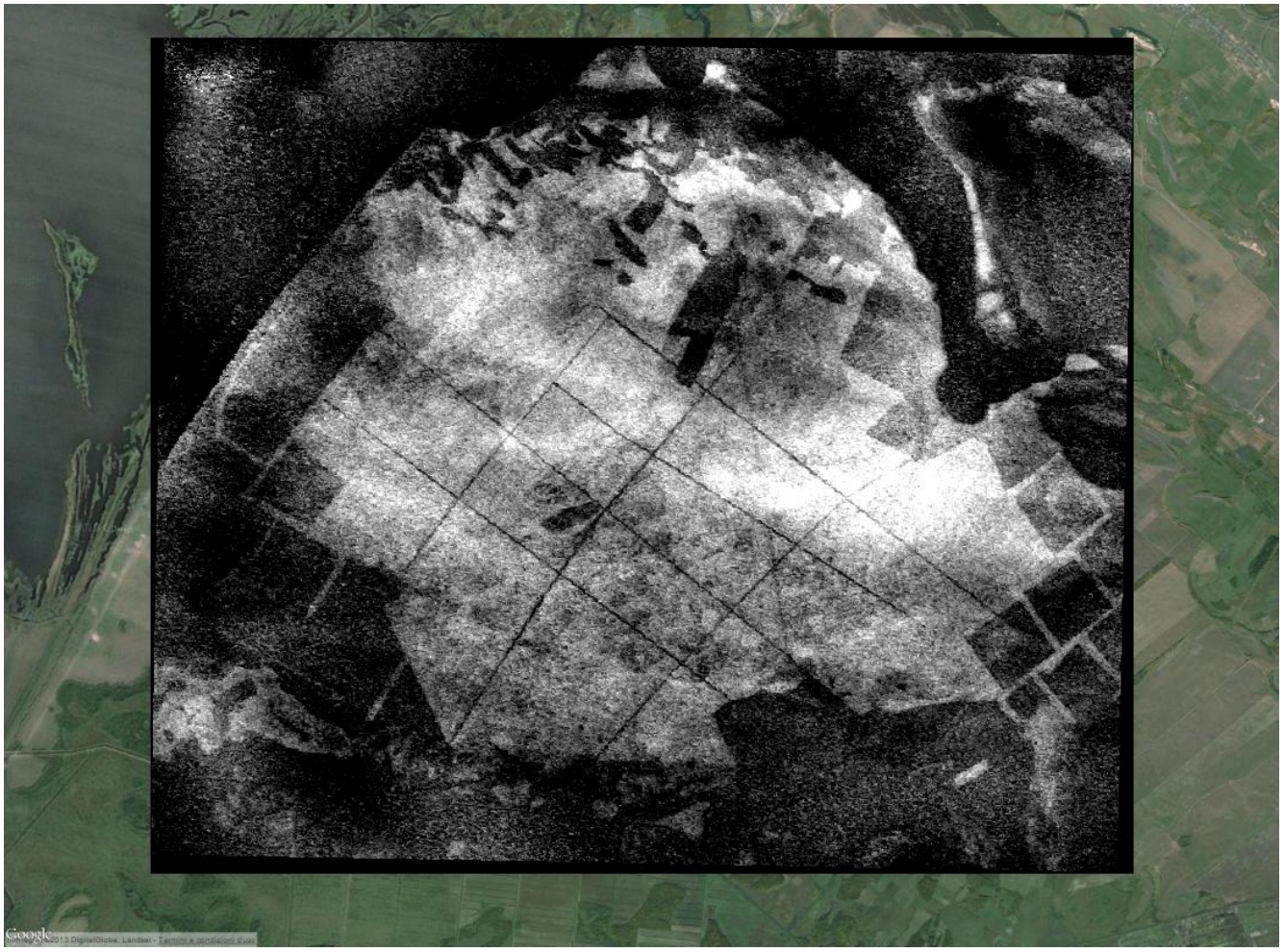
ALOS PALSAR-1 FBS – Estimated forest height, Aug-Oct 2006



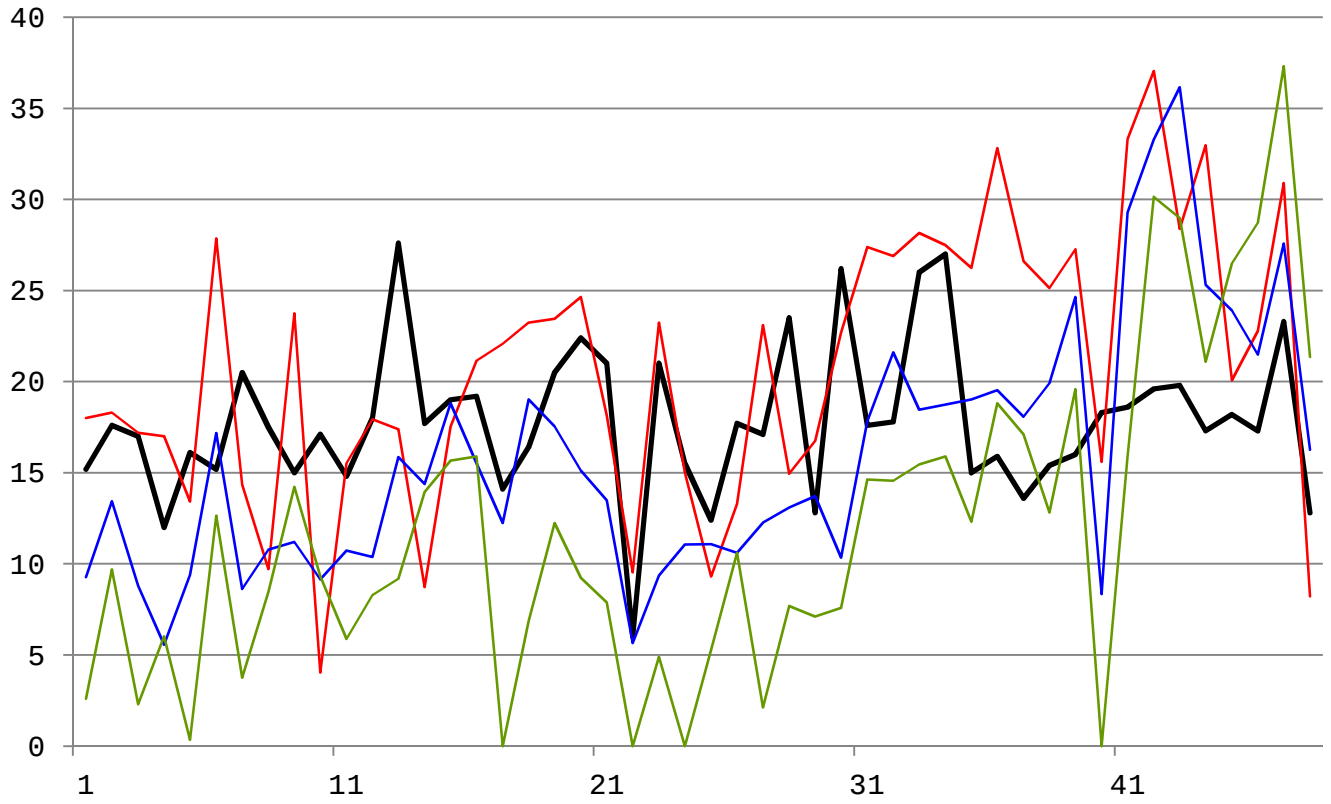
TSX-Tandem – InSAR data characteristics

• Spatial resolution	5 m
• 2π phase ambiguity	285 m
• Average coherence forest	> 0.85
• Theoretical height std dev at 1 look	15 m
• Theoretical height std dev after processing	12 m
• Acquisition time	May 2012

TSX-Tandem – Estimated forest height, May 2012



Estimated forest height – Comparison



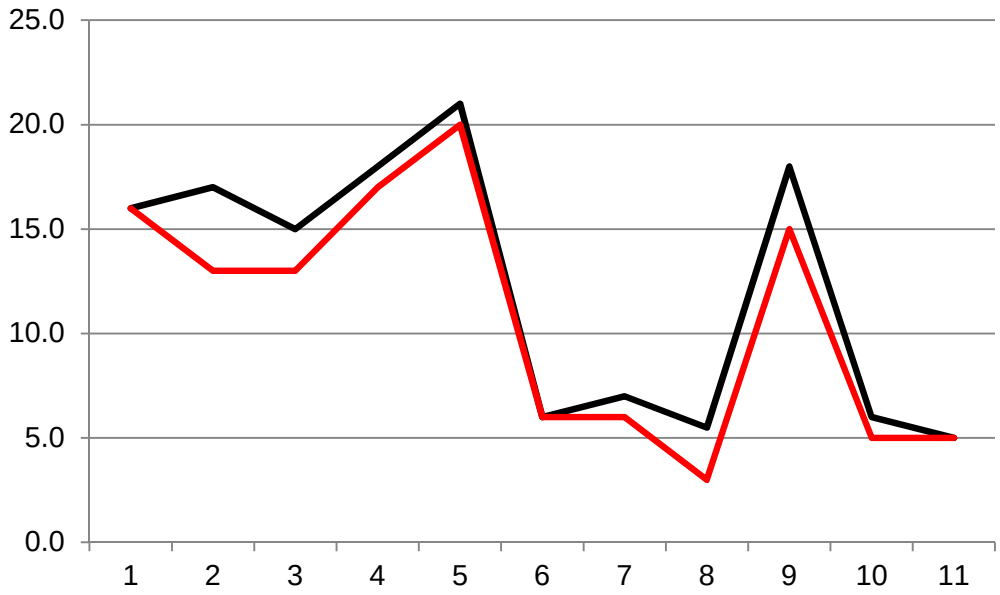
in situ TSX May 12 TSX February 12 PALSAR-1 Aug-Oct

TSX-Tandem – InSAR data characteristics

• Spatial resolution	5 m
• 2π phase ambiguity	26 m
• Average coherence forest	> 0.85
• Theoretical height std dev at 1 look	2 m
• Theoretical height std dev after processing	> 1 m
• Acquisition time	May 2013

TSX-Tandem – Estimated forest height, May 2013

Estimated forest height – Comparison



in situ TSX May 2013

Conclusions – Forest height estimation - preliminary considerations

- Baseline and particularly acquisition date (winter acquisitions) play a key role, especially if the forest consists of deciduous and coniferous trees.

- A final consideration is on the accuracy of the terrestrial measurements: these are still unknown. It is, however, well known that:
  - In forestry, in particular in dense close canopy, the GPS X-Y location is typically inaccurate (several tens of meters): this depends upon the foliage coverage, device, amount of available GPS, atmosphere, and processing software. All this information is not available. Moreover, human errors may occur as shown in the next slide (note that this location is where the inferred TSX height is higher than the GCP one!).
  - In (simple) dense close canopy in deciduous forest conditions (as in this case), terrestrial forest height estimations are typically overestimated by 10 to 20%.

Acknowledgments

- The **Japanese Aerospace Exploration Agency** is acknowledged for the provision of ALOS PALSAR-1 data.

- The **European Space Agency** is acknowledged for the provision of ENVISAT ASAR data and to financially support the work performed in The Gambia.

- The **Italian Space Agency** is acknowledged for the provision of Cosmo-SkyMed data.

- The **German Space Agency** is acknowledged for the provision of TanDEM-X Tandem data.

Deliverables

Published papers and reports

F. Holecz, M. Barbieri, F. Collivignarelli, L. Gatti, A. Nelson, T.D. Setiyono, M. Boschetti, G. Manfron, P. Brivio, E. Quilang, M. Obico, V.Q. Minh, D. P. Kieu, Q. N. Huu, T. Veasna, A. Intrman, P. Wahyunto, and S. Pazhanivelan, An operational remote sensing based service for rice production estimation at national scale, ESA Living Planet Symposium, Edinburgh, 2013.

F. Holecz, F. Collivignarelli, and M. Barbieri, Estimation of cultivated area in small plot agriculture in Africa for food security purposes, ESA Living Planet Symposium, Edinburgh, 2013.

D. K. Atwood, H. Andersen, B. Matthiss, and F. Holecz, Impact of topographic correction on estimation of aboveground boreal biomass using multi-temporal, L-Band backscatter, IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing, 2014.

F. Holecz, M. Barbieri, F. Collivignarelli, and L. Gatti, Synergetic use of multi-annual and seasonal multi-frequency spaceborne SAR data for land cover mapping at national scale and preliminary assessment of dual-frequency InSAR based forest height estimation, JAXA Kyoto and Carbon Initiative, Tokyo, 2014.

F. Holecz, P. Pasquali, N. Milisavljevic, and D. Closson, Land applications of radar remote sensing, INTECH, ISBN 978-953-51 1589-2, 2014.

Deliverables

Data sets and Thematic products

All products have been delivered