Malawi

Multi-purpose use of ALOS PALSAR-1 data

sarmap

and

Forest Research Institute of Malawi (FRIM)

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Objective

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:

- Digital Elevation Model
- Forest map
- Forest biomass map (to be completed)
- Cultivated area map

Data, Processing, Products

Data

•Multi-year ALOS PALSAR-1 Fine Beam Dual SLC data (15m) acquired during the dry season
•Intra-annual ENVISAT ASAR Alternating Polarization SLC data (15m) acquired during the wet (crop) season
•1-day Cosmo-SkyMed StripMap Interferometric SLC data (3m) acquired during the dry season

Intensity processing

1.Strip mosaicing of single frames in slant range geometry (if zero-Doppler) and multi-looking
2.Grouping of the strip mosaics acquired with the same geometry
3.DEM based orbital correction of one reference image for each group, when necessary
4.Co-registration
5.De Grandi time series speckle filtering
6.Terrain geocoding and radiometric calibration
7.Radiometric normalisation
8.Anisotropic Non-Linear Diffusion filtering

InSAR processing

•Interferogram generation, adaptive filtering and coherence estimation
•Interferogram generation, phase unwrapping, phase-to-height conversion

Products

•Digital Elevation Model
•Forest map
•Forest biomass map
•Cultivated area map

Fully automated processing

around 1000 scenes processed

Semi-automated processing

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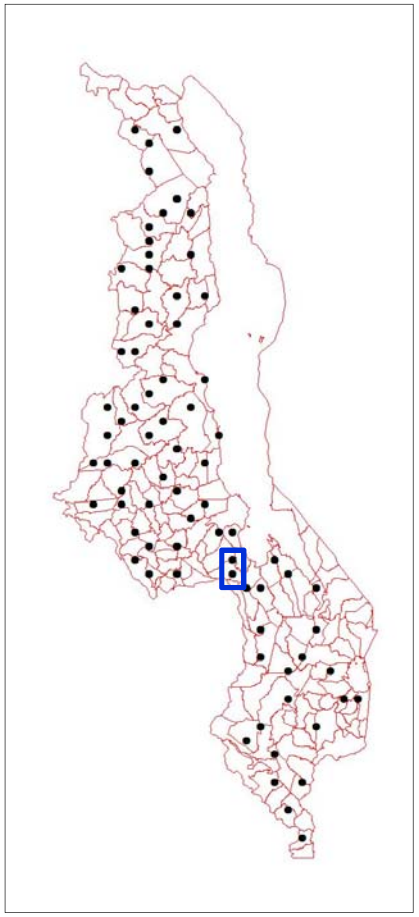
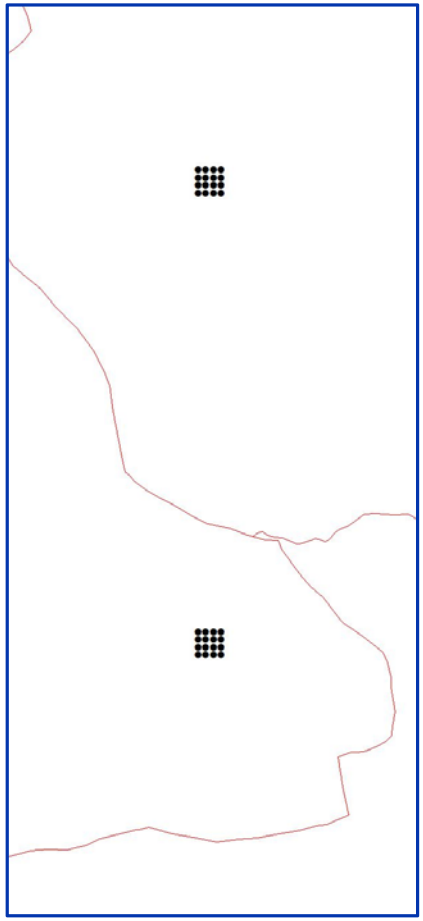
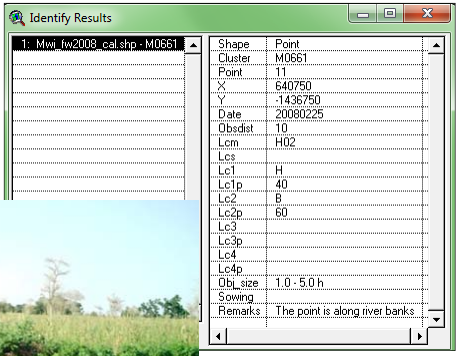
Validation – Approach





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



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Validation – Nomenclature

Level 1		Level 2		Level 3	
A	ARTIFICIAL LAND	A1	BUILT-UP AREAS	A11	Buildings
				A12	Greenhouses
		A2	NON BUILT-UP AREAS	A21	Non built-up area features
				A22	Non built-up linear features
B	ARABLE LAND	B1	CEREALS	B11	Wheat
				B12	Millet
				B13	Maize
				B14	Sorghum
				B15	Rice
				B19	Other cereals
		B2	ROOT CROPS	B21	Potato
				B22	Sweet potato
				B23	Cassava (1)
				B29	Other root crops
		B3	NON PERMANENT INDUSTRIAL CROPS	B31	Soya
				B32	Cotton
				B33	Other fibre and oleaginous crops
				B34	Tobacco
				B35	Sugar cane
				B39	Other non permanent industrial crops
		B4	DRY PULSES, VEGETABLES AND FLOWERS	B41	Ground nuts
				B42	Ground beans
				B42	Pigeon peas
				B43	Cow peas
				B44	Other pulses
				B45	Vegetables
				B46	Floriculture and ornamental plants
		B5	TEMPORARY, ARTIFICIAL PASTURES	B50	Temporary, artificial pastures
		B6	OTHER CROPS	B60	Other crops
		B7	FALLOW LAND	B70	Fallow land
C	PERMANENT CROPS	C0	PERMANENT CROPS:	C01	Fruit trees, berries
				C02	Permanent industrial crops
				C03	Nurseries
D	WOODLAND	D1	FOREST	D11	Brachystegia
				D12	Evergreen forest
				D13	Mixed forest
		D2	OTHER WOODED AREA	D20	Other wooded area
		D3	TIMBER PLANTATIONS	D30	Timber plantations
E	SHRUBLAND	E0	SHRUBLAND	E01	Shrubland with sparse tree cover
				E02	Shrubland without tree cover
F	PERMANENT GRASSLAND	F0	PERMANENT GRASSLAND	F01	Permanent grassland with sparse tree/shrub cover
				F02	Permanent grassland without tree/shrub cover
G	BARE LAND	G0	BARE LAND	G00	Bare land
H	WATER AND WETLAND	H0	WATER AND WETLAND	H01	Inland water bodies
				H02	Inland running water
				H03	Coastal water bodies
				H04	Wetland

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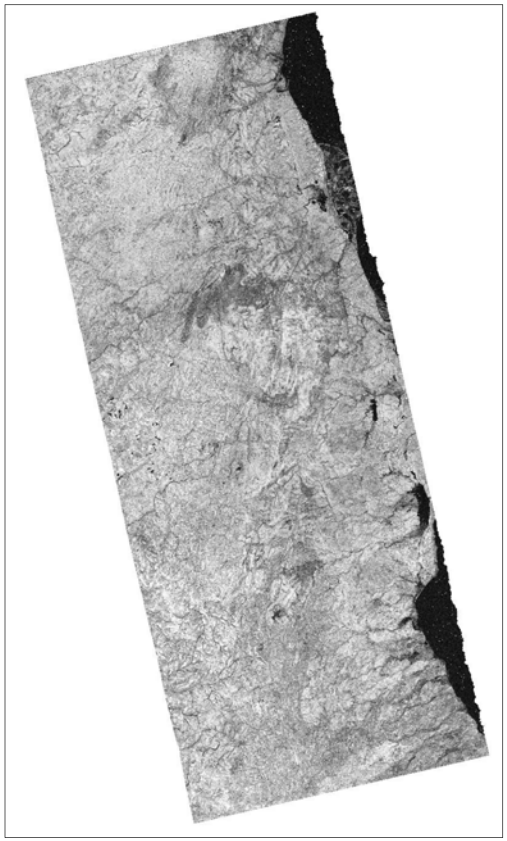
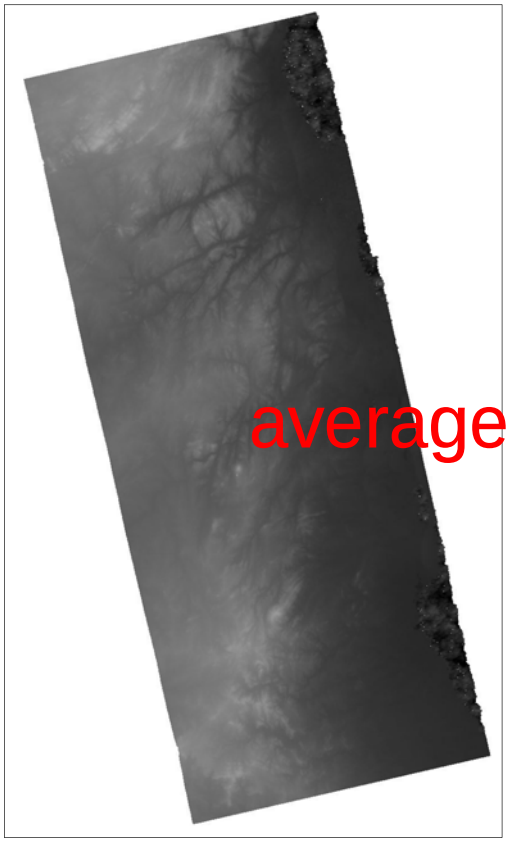
Digital Elevation Model

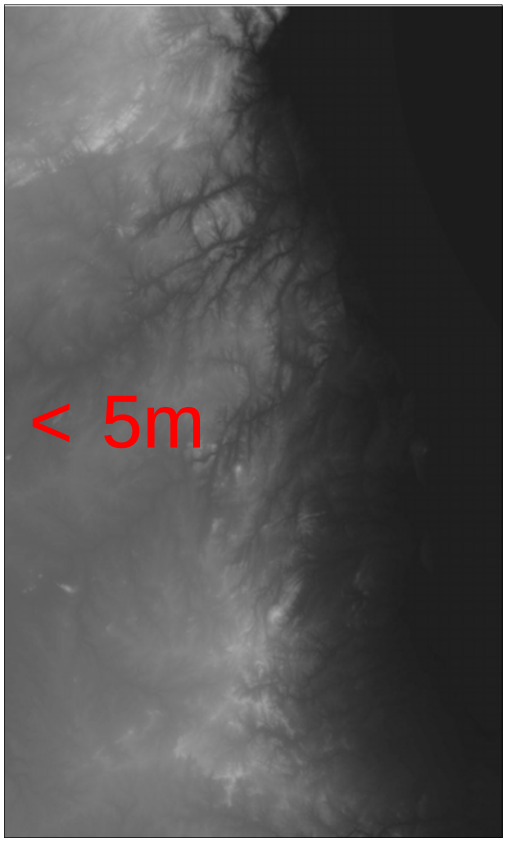


PALSAR-1 HH coherence
during dry season



PALSAR-1 HH InSAR DEM

average $\Delta h < 5m$



SRTM

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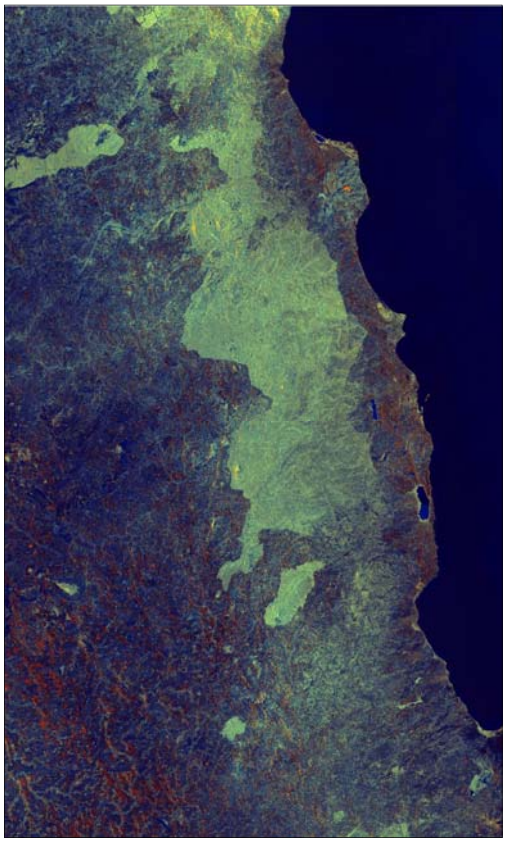
Coherence vs. Intensity

PALSAR-1 HH coherence
during dry season

PALSAR-1 HV coherence
during dry season



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

Not suitable
for thematic purposes

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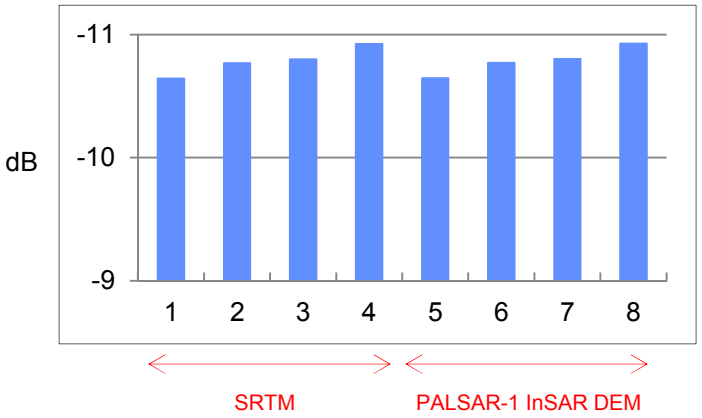
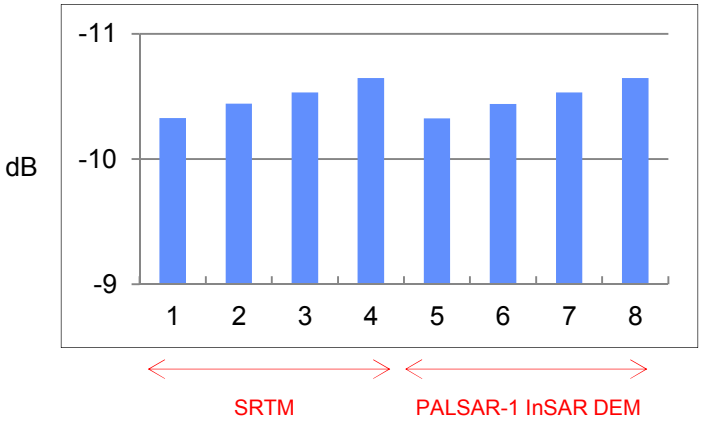
Radiometric Calibration L-HH

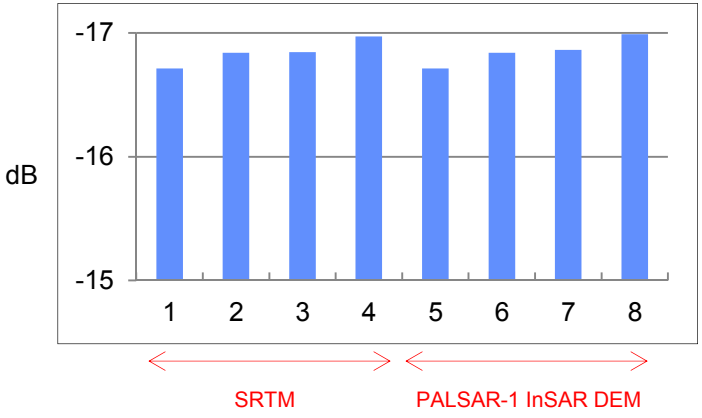
Flat forest – Mean



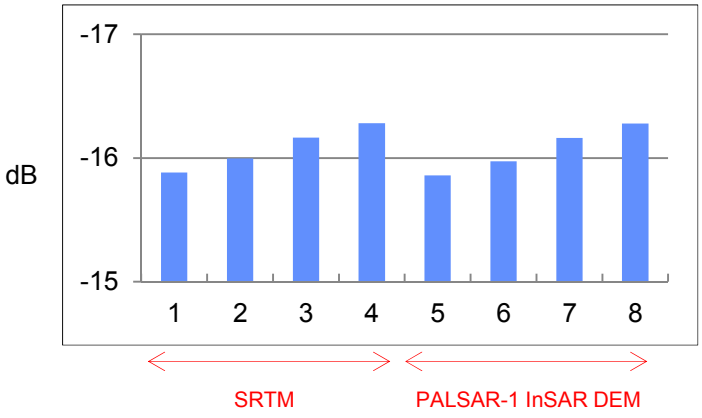
Slope forest – Mean



Flat forest – Stdv



Slope forest – Stdv



1, 5 = σ^o_{lia} 2, 6 = γ^o_{lia} 3, 7 = σ^o_A 4, 8 = γ^o_A

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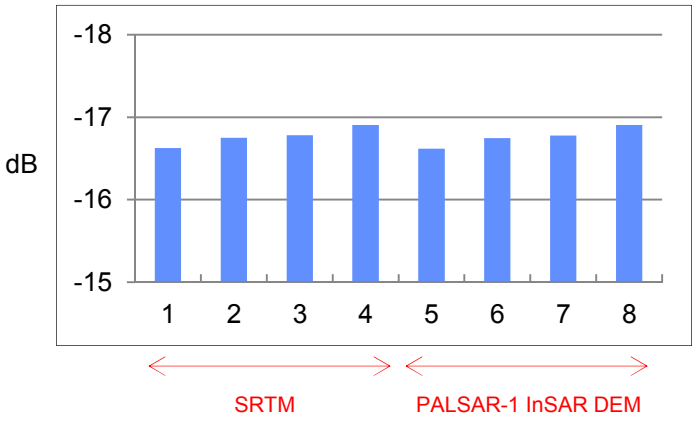
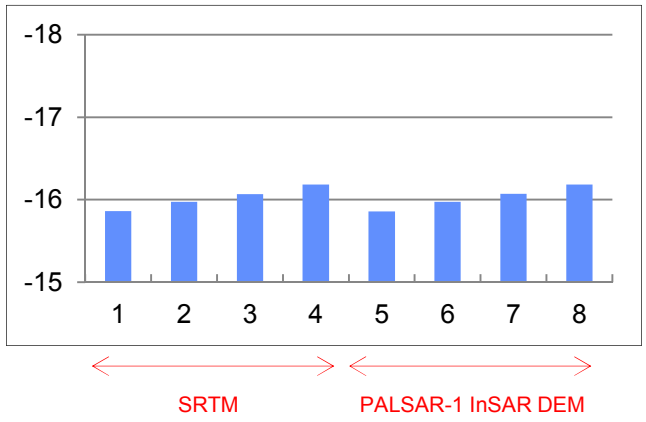
Radiometric Calibration L-HV

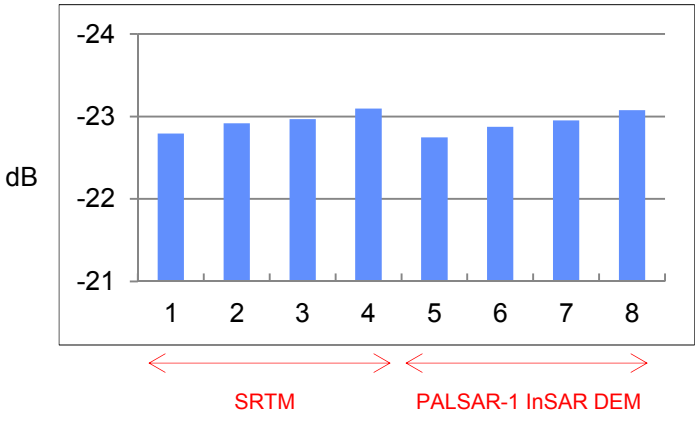
Flat forest – Mean



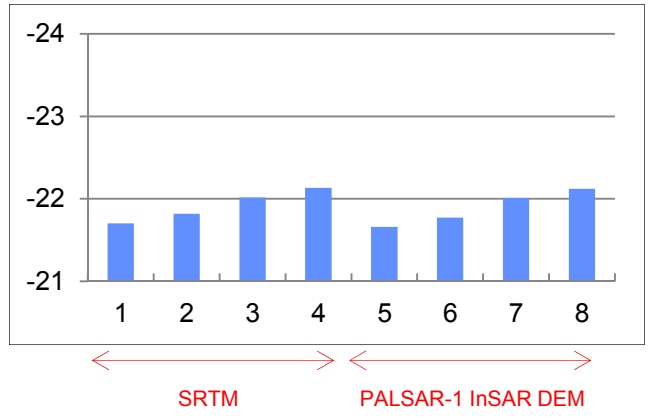
Slope forest – Mean



Flat forest – Stdv



Slope forest – Stdv



1, 5 = σ^o_{lia} 2, 6 = γ^o_{lia} 3, 7 = σ^o_A 4, 8 = γ^o_A

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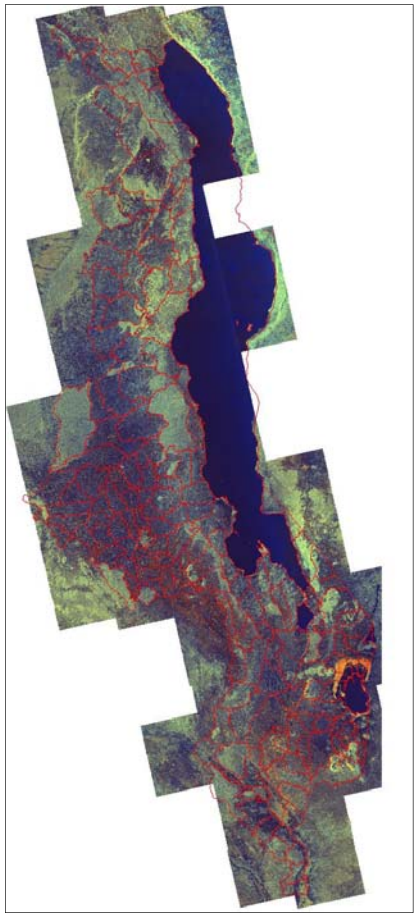
ALOS PALSAR-1 mosaics – Intensity vs. coherence



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

PALSAR-1 HH coherence &
intensity during wet (crop) season

PALSAR-1 HH coherence
during wet (crop) season

Disadvantages:

- **reduced spatial resolution**
- **coherence at 44 days during the wet season is unpredictable**

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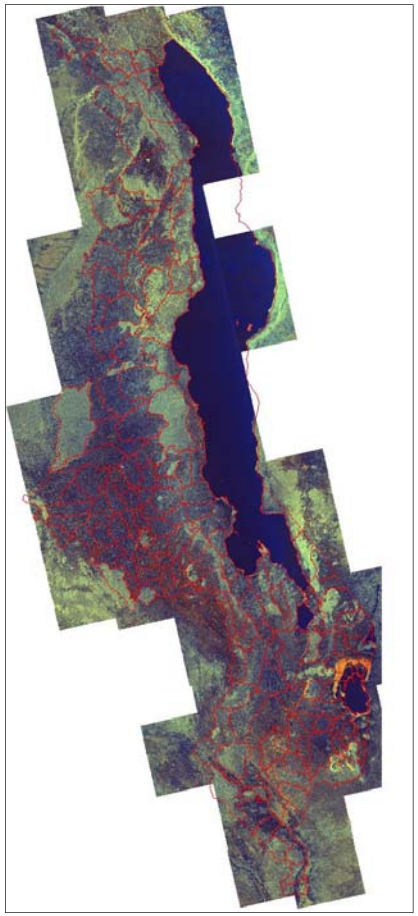
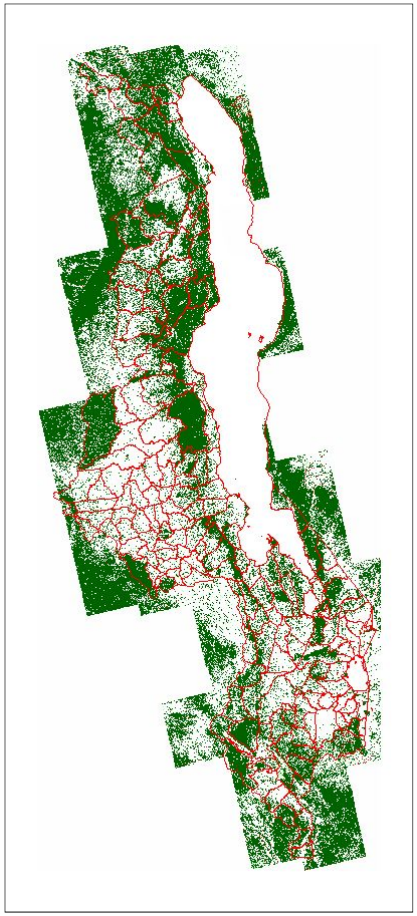
Forest map product



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



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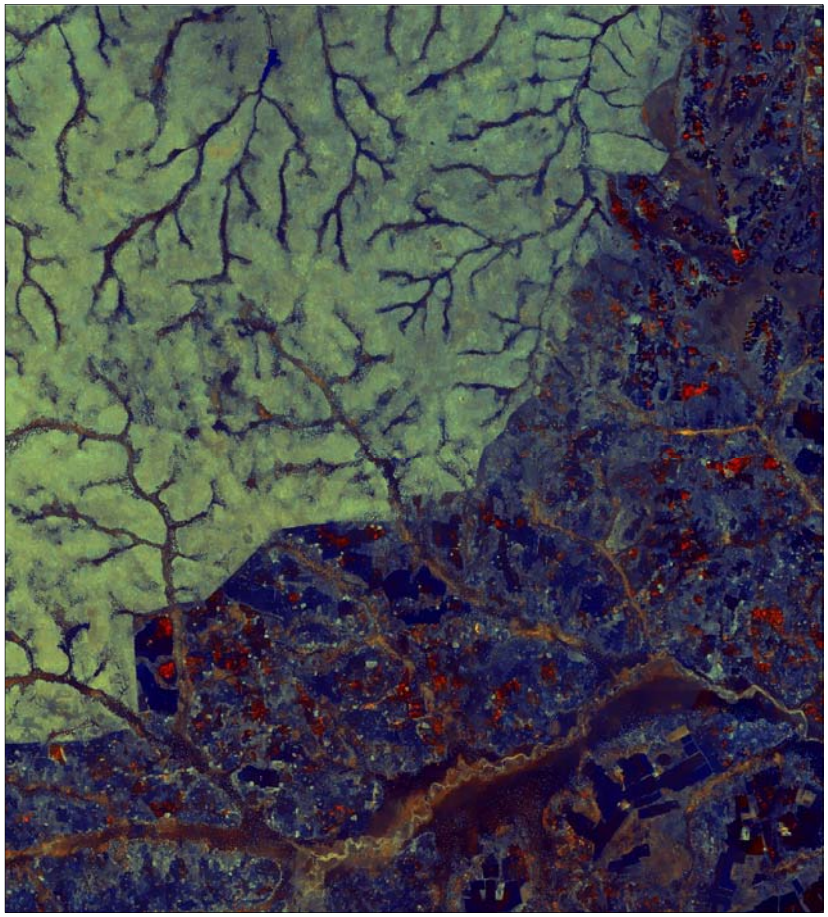
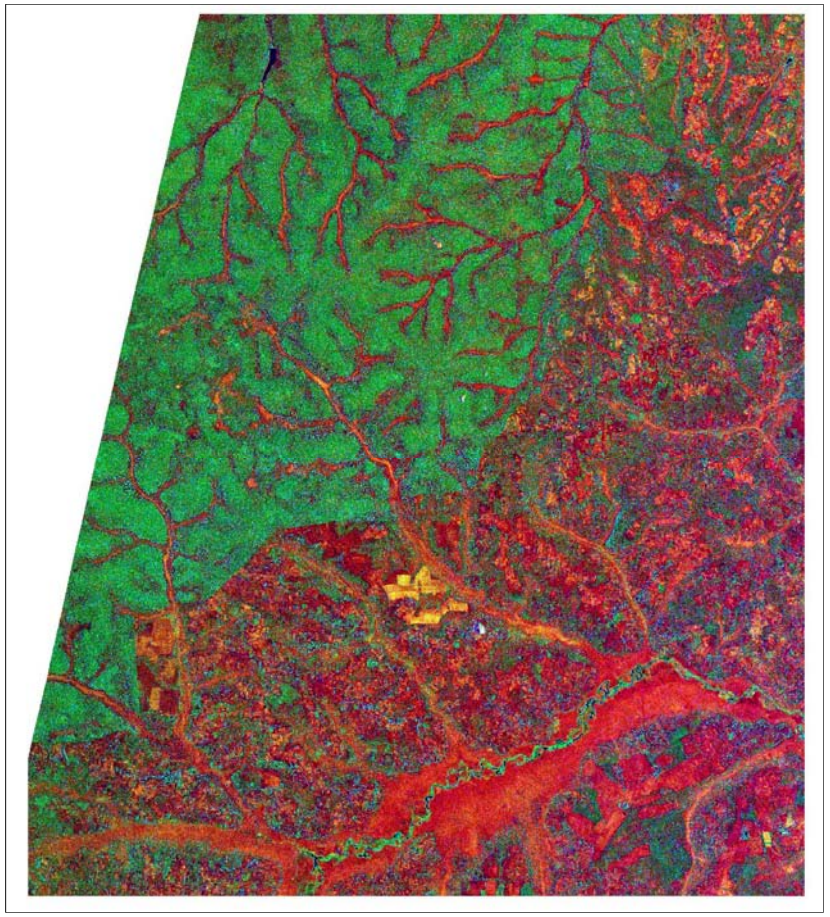
Forest map product – L-band Intensity vs. X-band 1 day InSAR

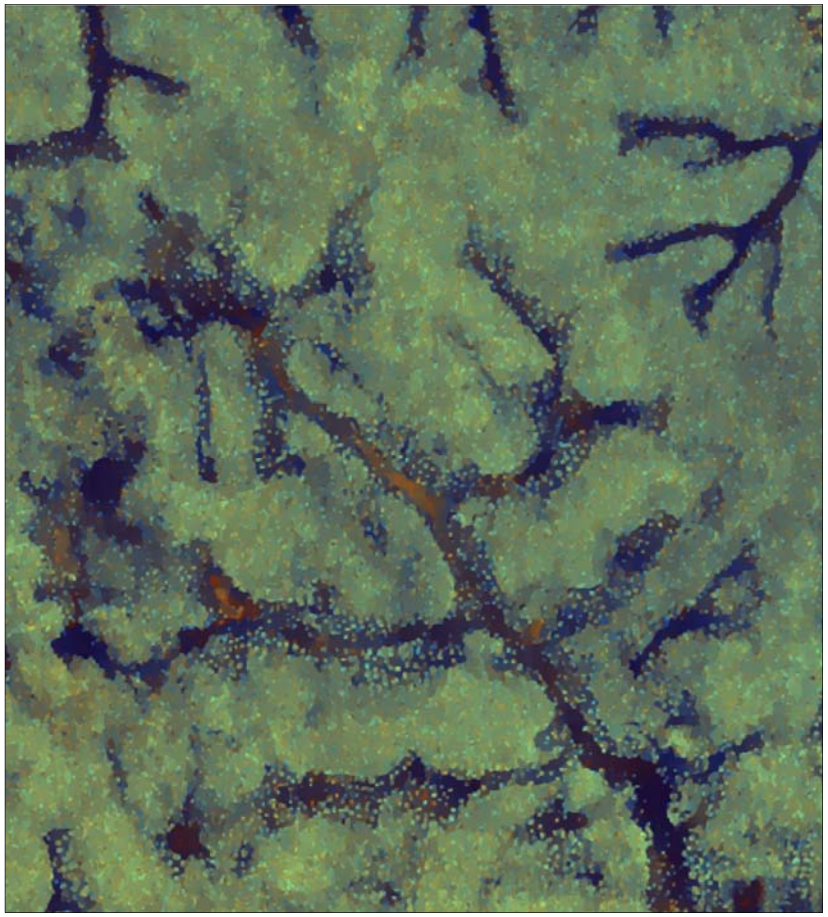


Multi-year PALSAR-1 HH-HV (15m) during dry season

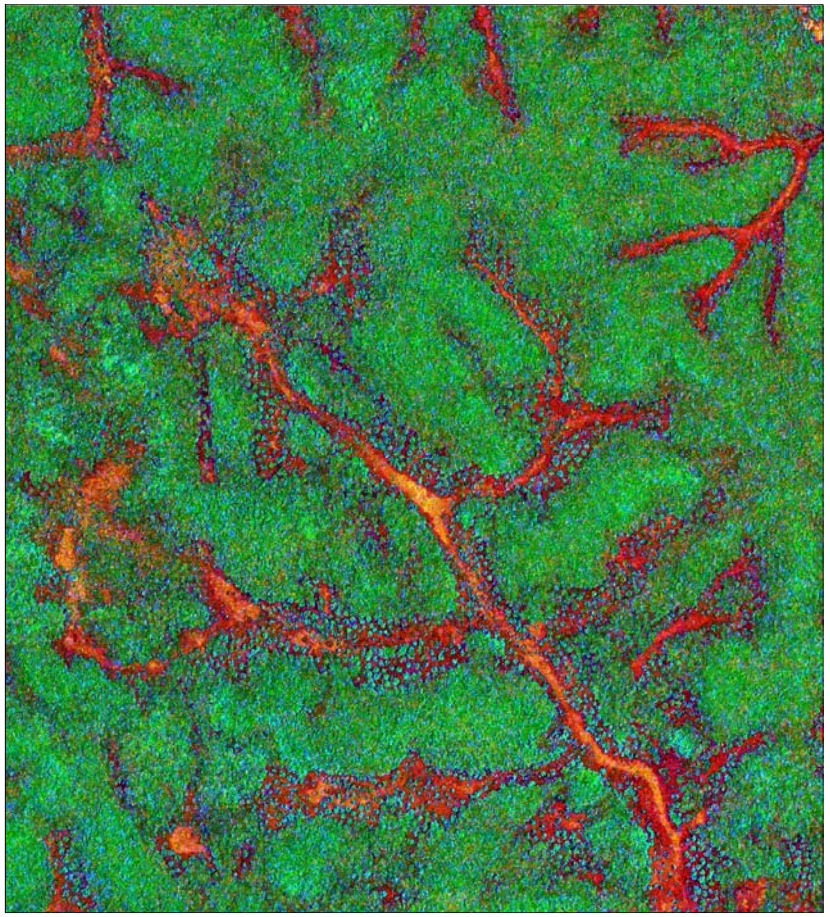


1 day InSAR CSK StripMap (3m) during dry season

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

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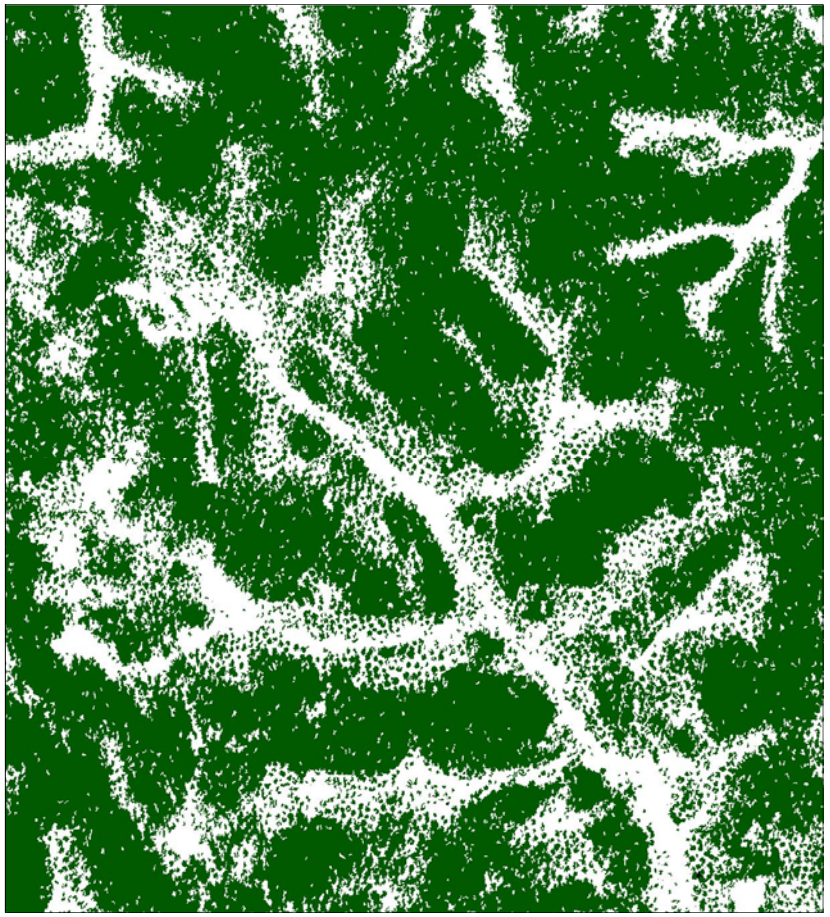
Forest map product – L-band Intensity vs. X-band 1 day InSAR

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



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

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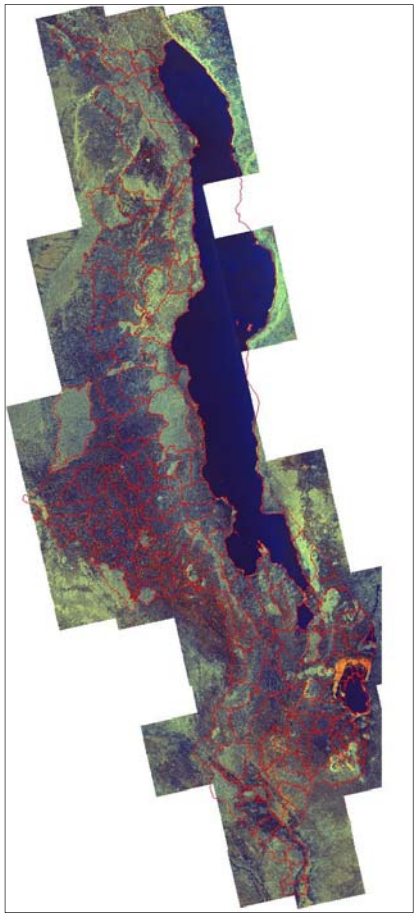
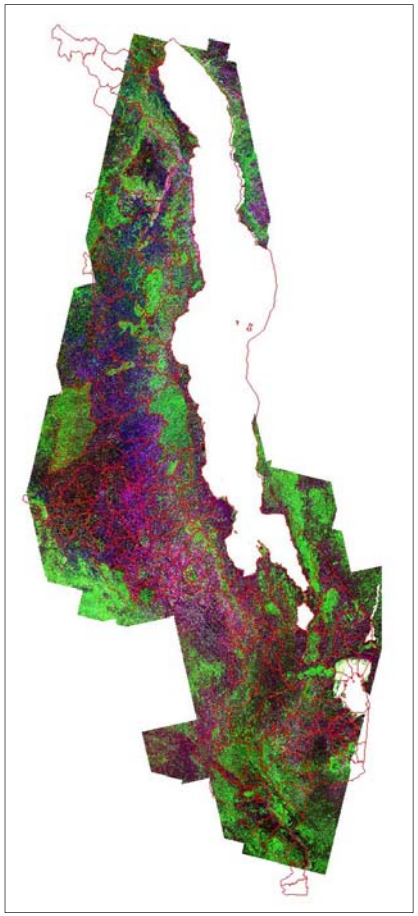
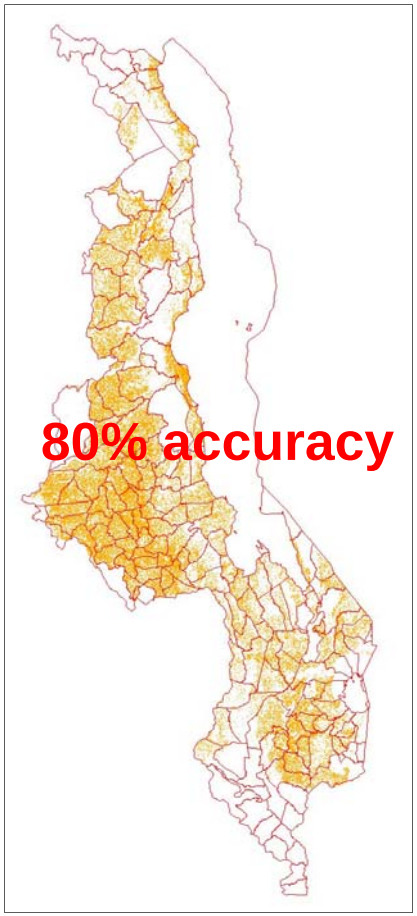
Cultivated Area product – PALSAR-1 HH-HV + ASAR HH-HV



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)

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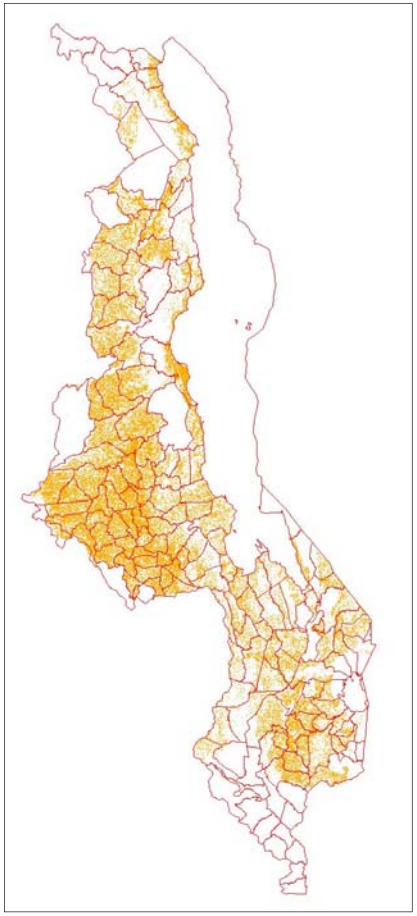
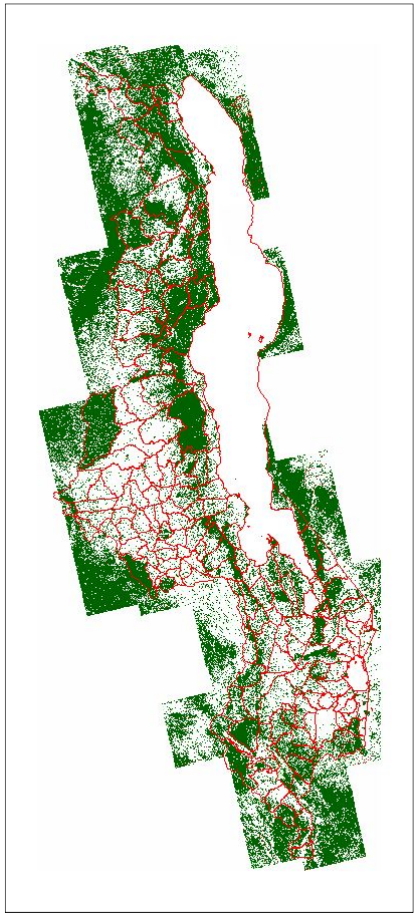
Forest & Cultivated Area product – PALSAR-1 HH-HV + ASAR HH-HV



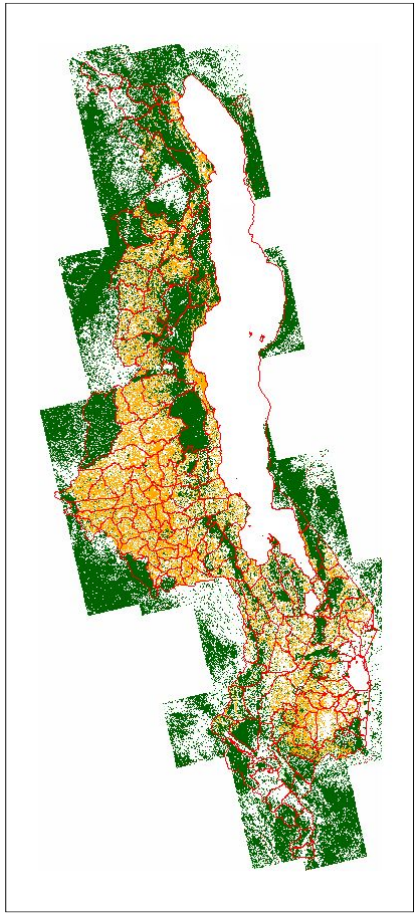
Cultivated Area (15m)

+



Forest Map (15m)

=



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Forest map product – 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

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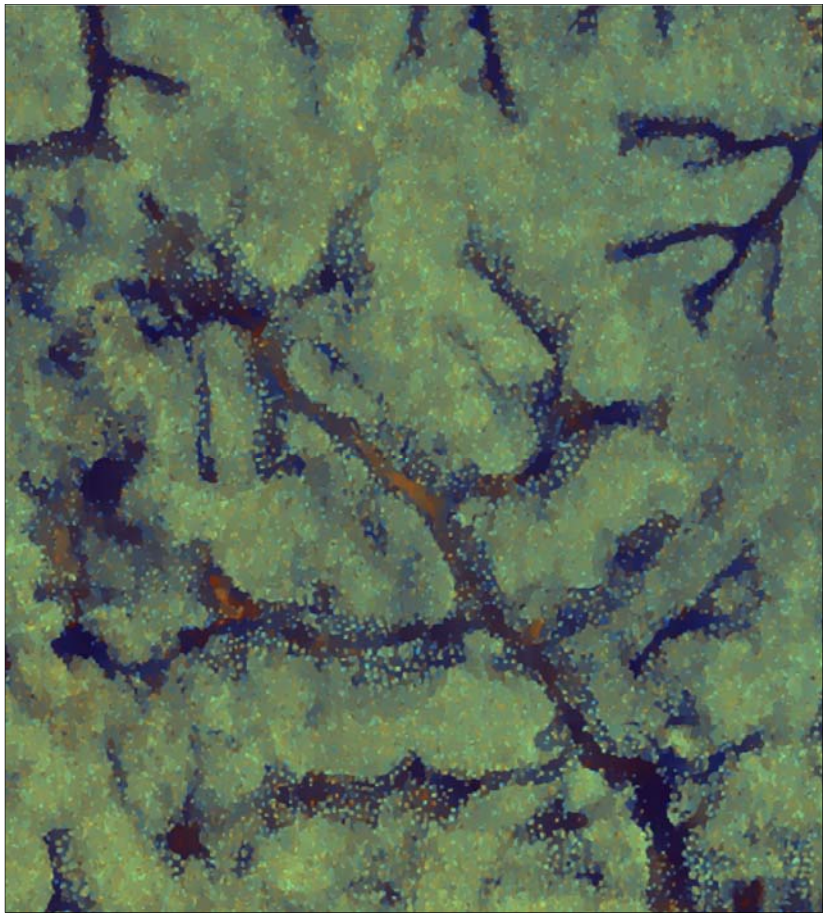
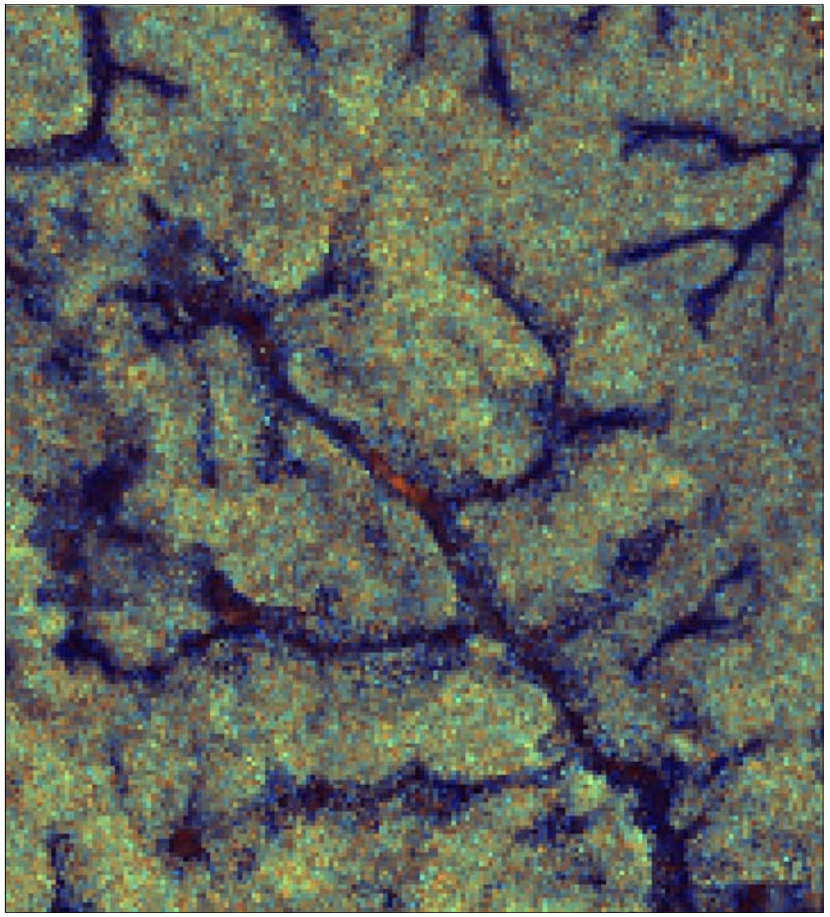
Forest map product – Multi-year full resolution vs. single-date 50m



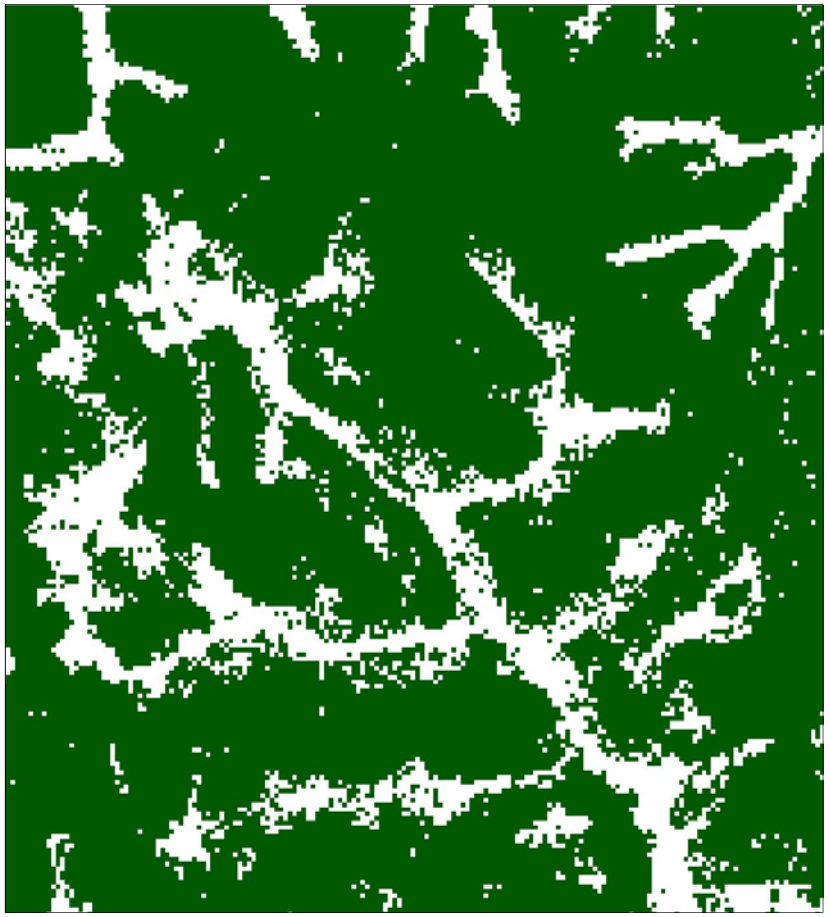
Multi-year PALSAR-1 HH-HV (15m) during dry season



Single-date PALSAR-1 HH-HV (50m)

Forest map product – Multi-year full resolution vs. single-date 50m

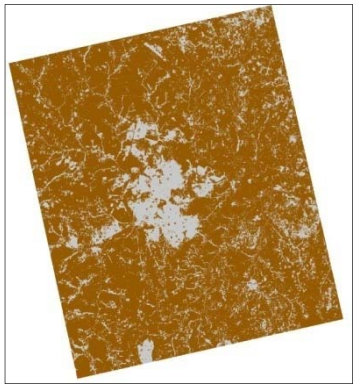
Multi-year PALSAR-1 HH-HV (15m) during dry season



Single-date PALSAR-1 HH-HV (50m)

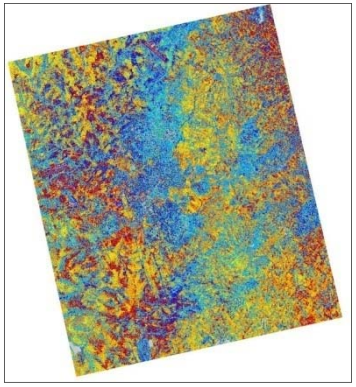
Cultivated Area product – PALSAR-1 HH-HV + CSK 1 day InSAR + ASAR HH-HV

Multi-year PALSAR-1 data in dry season



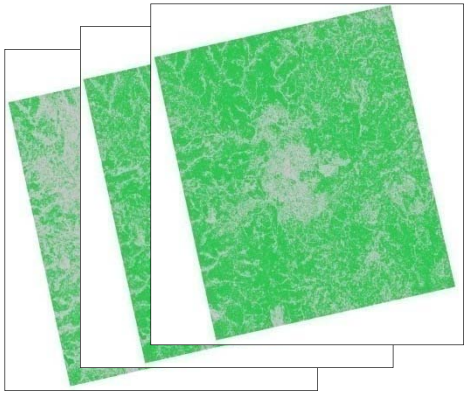
Potential crop extent (15m)

1-day InSAR CSK at SoS

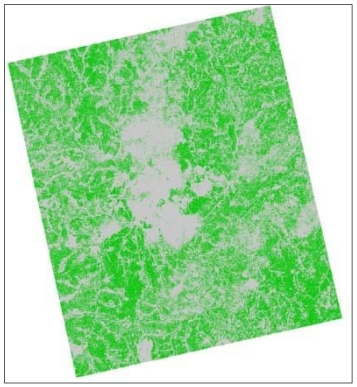


Potential crop area at SoS (3m)

Intra-annual ASAR AP data after SoS



Crop growth extent (15m)



Cultivated Area (15m)

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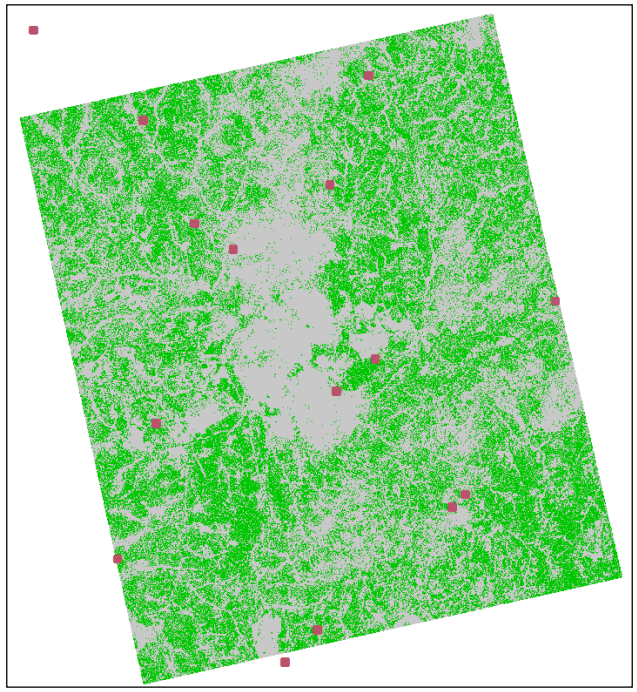
Cultivated Area product – Validation



	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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In situ bio-physical measurements

- Plot sample size is 0.1ha. Center is positioned with GPS.
- Surveyors demarcates the nested concentric circular plots with specified dimensions (0.01 ha for smaller, inner plot and 0.1 ha for larger, outer plot).
- The dimensions of each plot are corrected for slope
- All trees ≥5 cm ≤ 20 cm dbh are enumerated for their species names and measured for their dbh, total height, clear bole length in a smaller plot (0.01 ha-plot).
- All trees above 20 cm dbh were enumerated and measured in a larger, outer plot (0.1 ha-plots).
- Above ground biomass in Kg C = 0.0267*dbh^2.5996

Coordinates	ALTITUDE	SPECIES	DBH	TOTAL HEIGHT	Biomass Kg C	Total/plot	Main forest type
36L0759871/8280	860	Brachystegia manga	2.8	5.6	2.352344132		
		Julbernardia globiflora	3.8	5.4	2.140139484		
		Julbernardia globiflora	3.6	4.8	1.575672597		
		Julbernardia globiflora	4.2	4.9	1.662436215		
		Julbernardia globiflora	2.7	4.5	1.332301486		
		Flacourtia indica	3.3	3.5	0.693219147		
		Brachystegia spiciformis	5.1	4.7	1.49175277		
		Brachystegia spiciformis	5.8	5.7	2.463108462		
		Julbernardia globiflora	5.2	4.3	1.183793248		
		Brachystegia spiciformis	5.4	4.6	1.410641059		
		Brachystegia manga	5	4.8	1.575672597		
		Brachystegia spiciformis	5.7	5.4	2.140139484		
		Julbernardia globiflora	10.7	5.1	1.844636047		
		Swartzia madagascariensis	6.4	4.8	1.575672597		
		Swartzia madagascariensis	6.8	4	0.980903795		
		Swartzia madagascariensis	5.4	4.2	1.113551011		
		Burkea africana	7.6	4.7	1.49175277		
		Julbernardia globiflora	10	4.7	1.49175277		
		Burkea africana	5.2	4.2	1.113551011		
					29.63304068	**29.63304068**	**Miombo**

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Conclusions

- 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.

- 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.

- The products, at country-level, have been generated in an almost automated way. Today information at this level of detail is not available in Malawi.

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

Deliverables

- Digital Elevation Model
- Forest map
- Forest biomass map
- Cultivated area map
- Validation points
- In situ biophysical data

RIICE – www.riice.org
sarmap, IRRI, AllianzRe, Swiss & German Development Cooperation

1. Reduce the vulnerability of 5 million rice farmers in Asia and beyond to flood and drought over the next 5 years.

2. Help Governments and NGOs to better plan for food crises through better crop growth monitoring.

3. Increase efficiency and effectiveness of crop insurance solutions and turn it into a viable business also in emerging markets.

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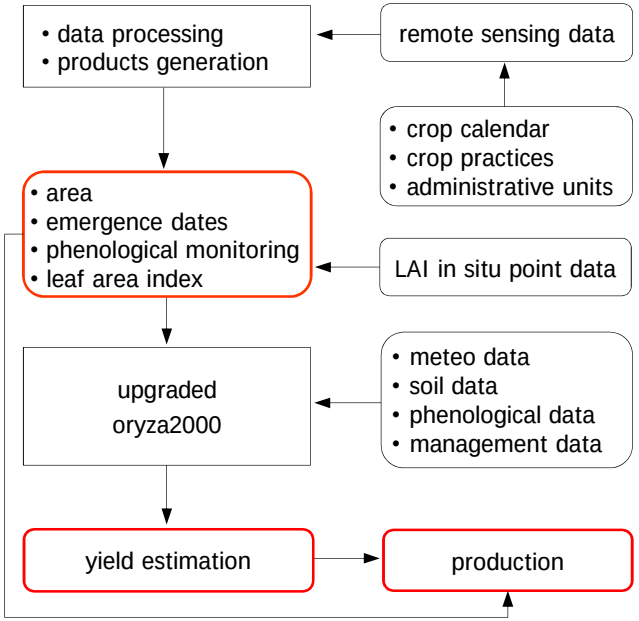
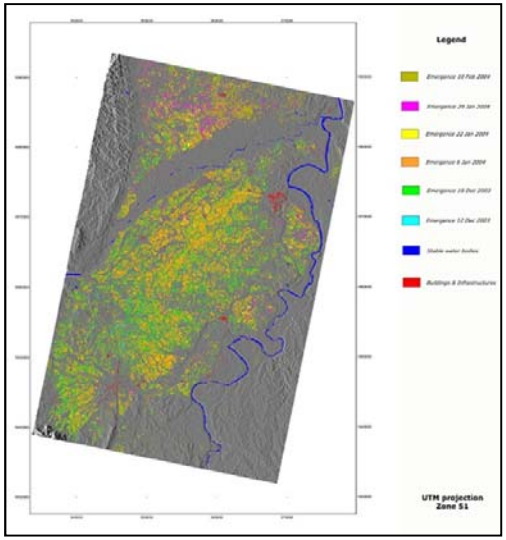
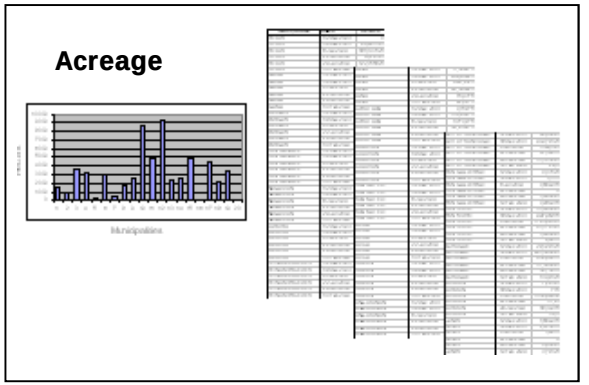
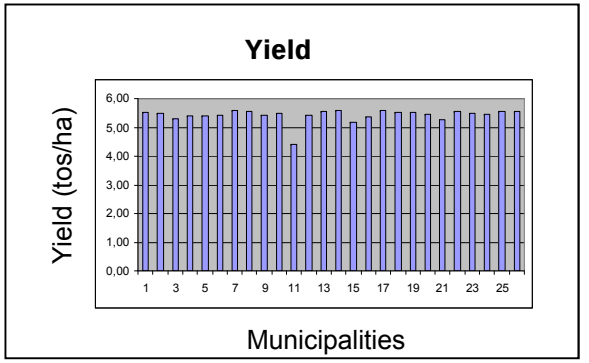
RIICE – Method and Product









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RIICE – Sensors and Modes

ENVISAT ASAR	Wide Swath – HH	C-band	75 m
ENVISAT ASAR	Alternating Polarization – HH+HV	C-band	15 m
ENVISAT ASAR	Image Mode – HH	C-band	15 m
ALOS PALSAR-1	Fine Beam Single – HH	L-band	8 m
ALOS PALSAR-1	Fine Beam Dual – HH+HV	L-band	15 m
COSMO-SkyMed-1/2/3/4	Huge ScanSAR – HH	X-band	15 m
COSMO-SkyMed-1/2/3/4	StripMap – HH	X-band	3 m
RISAT-1	StripMap – HH	C-band	3 m
RISAT-1	Medium ScanSAR – HH	C-band	23.5 m
RISAT-1	Coarse ScanSAR – HH	C-band	55 m
ALOS PALSAR-2	Fine – Single, Dual, Full	L-band	10 m
ALOS PALSAR-2	ScanSAR Wide – Single, Dual	L-band	60 m
Sentinel-1 A/B	IWS – HH+HV	C-band	20 / 5 m

MODIS 8- and 16-days composite		2 bands	250 m
MODIS 8-days composite	7 bands	500 m	
Proba-V	4 bands	300 m	
Sentinel-3	15 bands	250-500 m	

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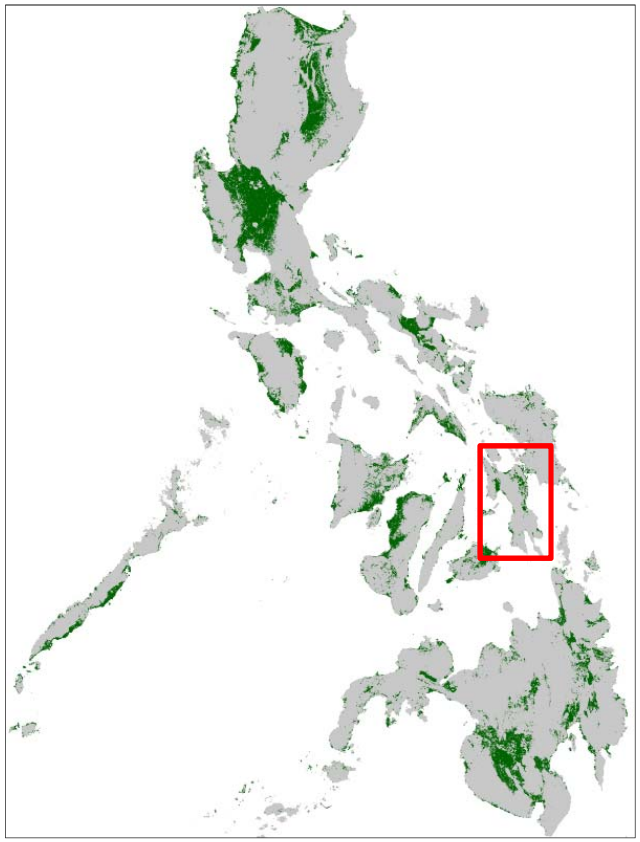
RIICE – Baseline Map (1 ha), Philippines



ENVISAT ASAR Wide Swath

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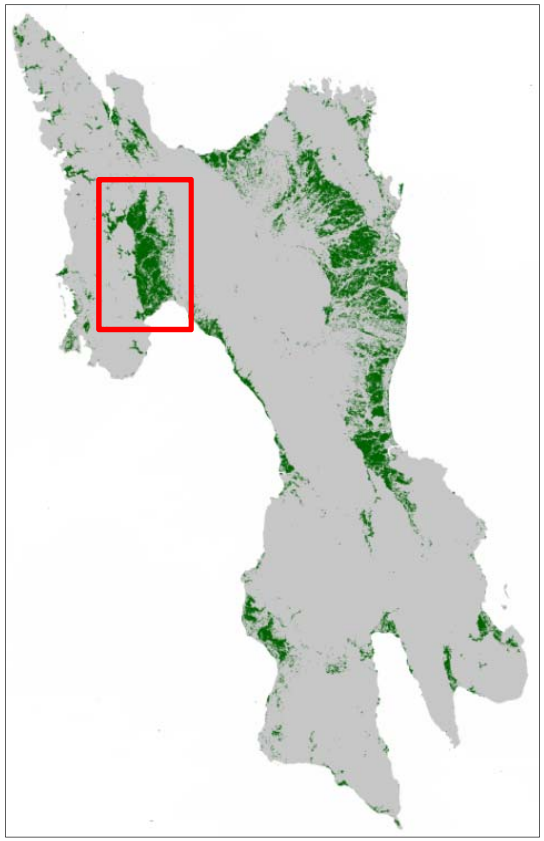
RIICE – Rice Area 2011 (15 m), Leyte – Philippines



ENVISAT ASAR AP
ENVISAT ASAR IM
ALOS PALSAR-1 FBD
ALOS PALSAR-1 FBS

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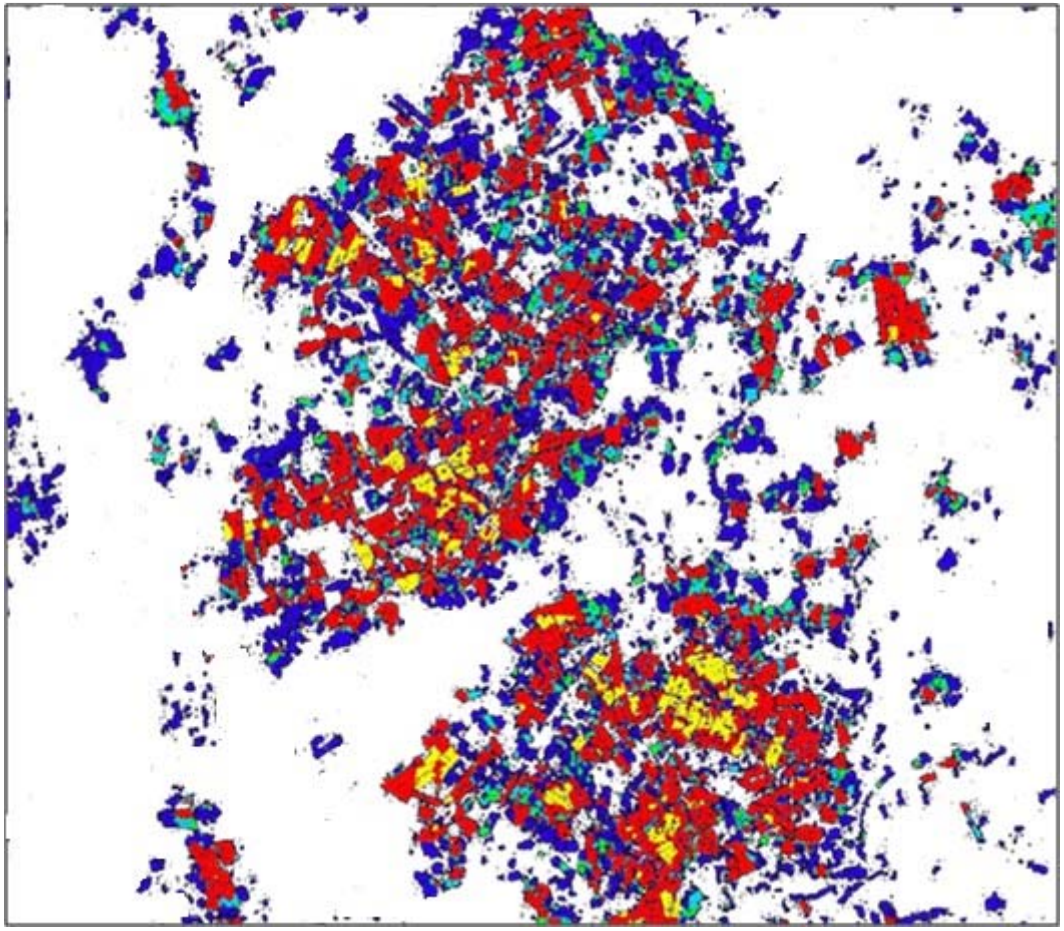
RIICE – Precise Rice Area 2011 (3 m), Leyte – Philippines



Precise Rice Area, 3m on 26 June 2012

The colors represent the different rice phenological development

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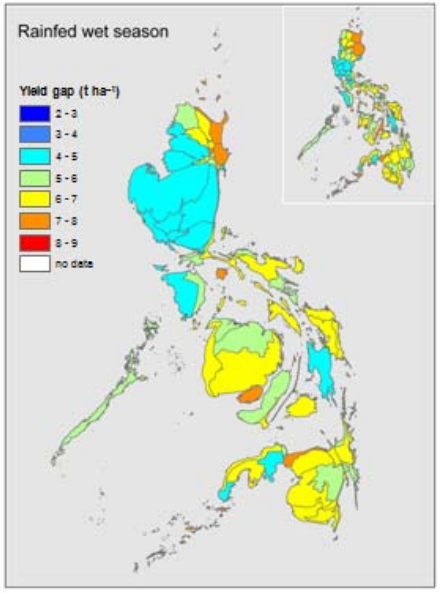
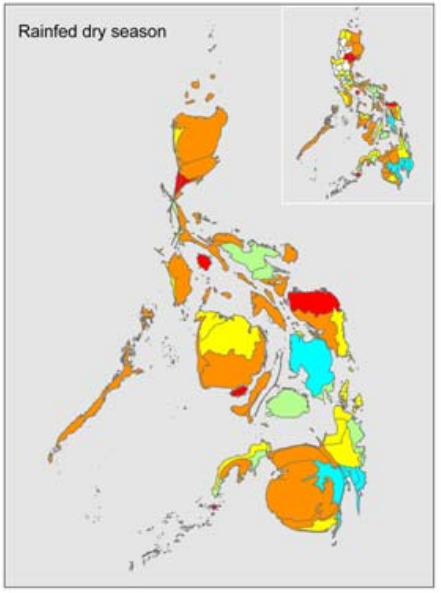
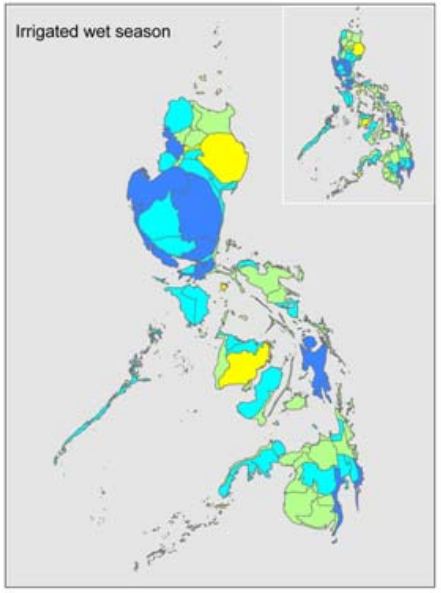
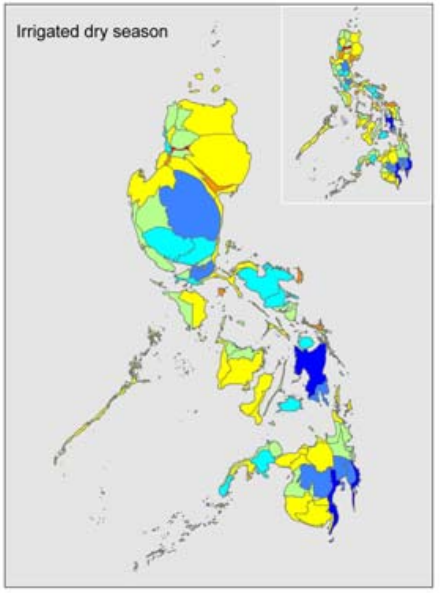
RIICE – Average Yield Gap, Philippines









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