K&C product report some insights

Integration of ecosystem dynamics knowledge to the Alos PALSAR data processing for Flooding and Vegetation mapping

Marcela Quinones
Martin Vissers
Dirk Hoekman

Claudia Huertas
Ana Maria Pacheco

Project objectives

- SarVision created two demonstration products for the Colombian Environmental Institutes IDEAM and Humboldt, to support the project of the Colombian Climate Adaptation Fund, to create information on the distribution of the wetland ecosystems.
  - Structural Vegetation Map, 50 m resolution based on FBD Alos PALSAR for the Colombian Continental territory
  - Flood frequency Map: based on the analysis of a time series of 28 mosaics of Alos PALSAR WB data .
- Validation of the Maps was completed by an independent Parthner, TH Amazon Conservation Team (ACT, Colombia).
- We present some insights resulting from the validation process.

.

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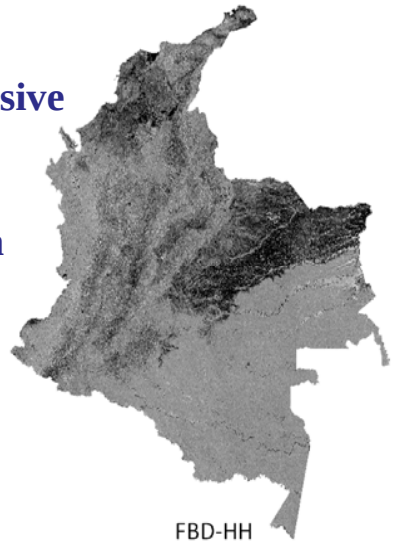
Structural Vegetation Map created only with Alos PALSAR

system	year	RSP109	RSP108	RSP107	RSP106	RSP105	RSP104	RSP103	RSP102	RSP101	RSP100	RSP099	RSP098	RSP097	RSP096	RSP095	RSP094	RSP093	RSP092	RSP091	RSP090	RSP089	RSP088	RSP087	RSP086
FBD HH	2007	20070724	20070822	20070805	20070903	20070817	20070731	20070829	20070812	20070726	20070824	20070807	20070905	20070819	20070802	20070831	20070814	20070728	20070826	20070809	20070723	20070821	20070804	20070902	20070816
FBD HV	2007	20070724	20070822	20070805	20070903	20070817	20070731	20070829	20070812	20070726	20070824	20070807	20070905	20070819	20070802	20070831	20070814	20070728	20070826	20070809	20070723	20070821	20070804	20070902	20070816
FBD HH	2008	20080610	20080824	20080807	20080905	20080819	20080802	20080831	20080814	20080728	20080826	20080809	20080907	20080821	20080804	20080902	20080816	20080614	20080828	20080811	20080725	20080823	20080806	20080904	20080818
FBD HV	2008	20080610	20080824	20080807	20080905	20080819	20080802	20080831	20080814	20080728	20080826	20080809	20080907	20080821	20080804	20080902	20080816	20080614	20080828	20080811	20080725	20080823	20080806	20080904	20080818
FBD HH	2009	20090913	20090827	20090810	20090908	20090822	20090805	20090903	20090817	20090731	20090829	20090812	20090910	20090824	20090807	20090905	20090819	20090802	20090831	20090629	20090912	20090826	20090809	20090723	20090821
FBD HV	2009	20090913	20090827	20090810	20090908	20090822	20090805	20090903	20090817	20090731	20090829	20090812	20090910	20090824	20090807	20090905	20090819	20090802	20090831	20090629	20090912	20090826	20090809	20090723	20090821
FBD HH	2010	20100916	20100715	20100813	20100911	20100825	20100808	20100906	20100820	20100803	20100901	20100815	20100729	20100827	20100810	20100908	20100822	20100805	20100903	20100817	20100915	20100829	20100812	20100910	20100824
FBD HV	2010	20100916	20100715	20100813	20100911	20100825	20100808	20100906	20100820	20100803	20100901	20100815	20100729	20100827	20100810	20100908	20100822	20100805	20100903	20100817	20100915	20100829	20100812	20100910	20100824

Approach:

- **Processing of 193 strips of Alos FBD_HV-HH and FBS-HH, 50m**
- **Combined use of FBD (wet season) and FBS (dry season**
- **Combination of Supervised and unsupervised classification and extensive field data and exiting maps**
- **Legend development process using the LCCS vegetation classification system (FAO)**
- **Validation following methodology of Oloffson et al 2014**



FBD-HH

FBD-HV

•Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E., & Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42-57. http://doi.org/10.1016/j.rse.2014.02.015

•Olofsson, P., Foody, G. M., Stehman, S. V., & Woodcock, C. E. (2013). Making better use of accuracy data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation. Remote Sensing of Environment, 129, 122-131. http://doi.org/10.1016/j.rse.2012.10.031

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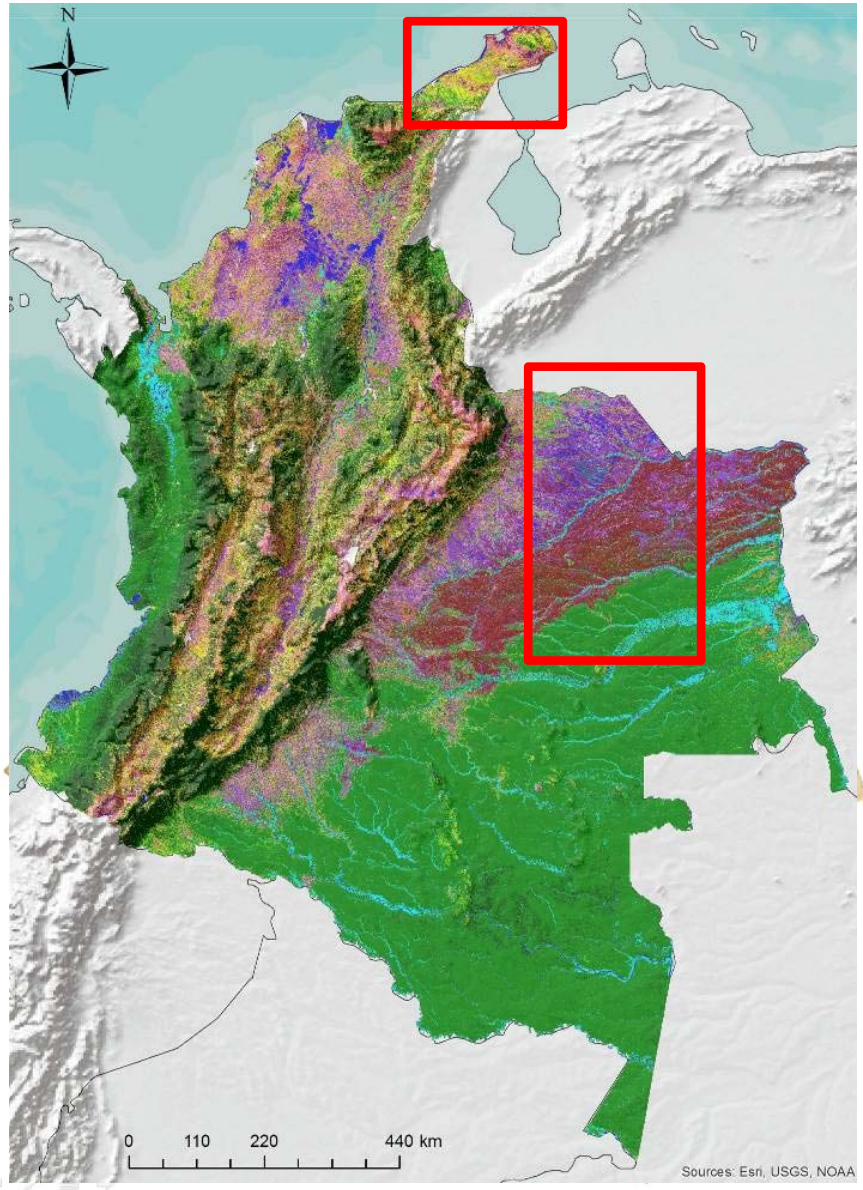
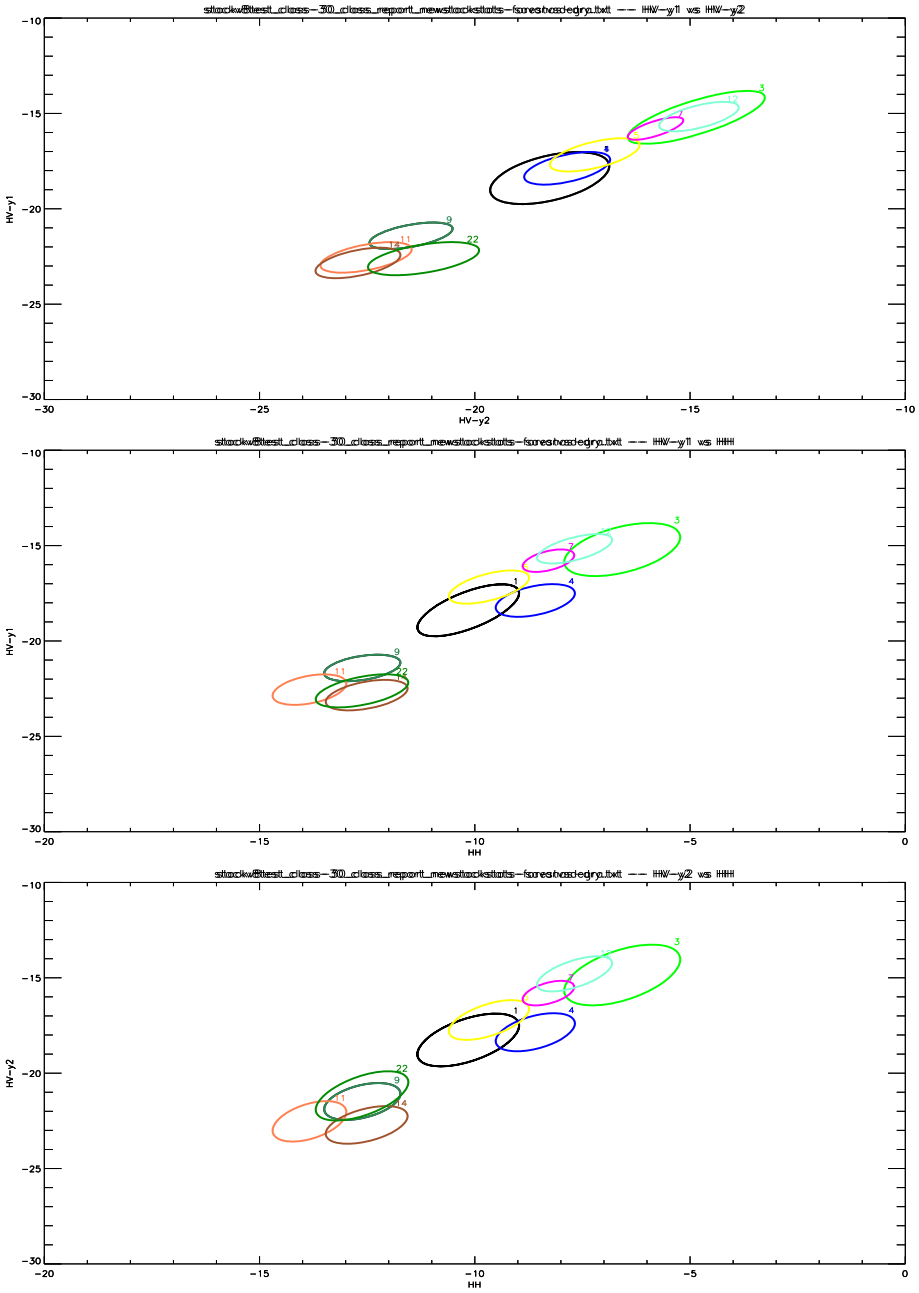
Final result





Código	Cobertura
1	Bosque
2	Bosque
3	Arboladas
4	Agua
5	Bosque
6	Vegetación secundaria
7	Arbustales densos
8	Arbustales
9	Arbustales abiertos
10	Herbazales
11	Sabanas
12	Sabanas Húmedas
14	Áreas construidas
15	Bosque Mangle 1
16	Arboladas Mangle 2
17	Vegetación secundaria Mangle 3

Ecuación 1. Formula de muestreo aleatorio estratificado

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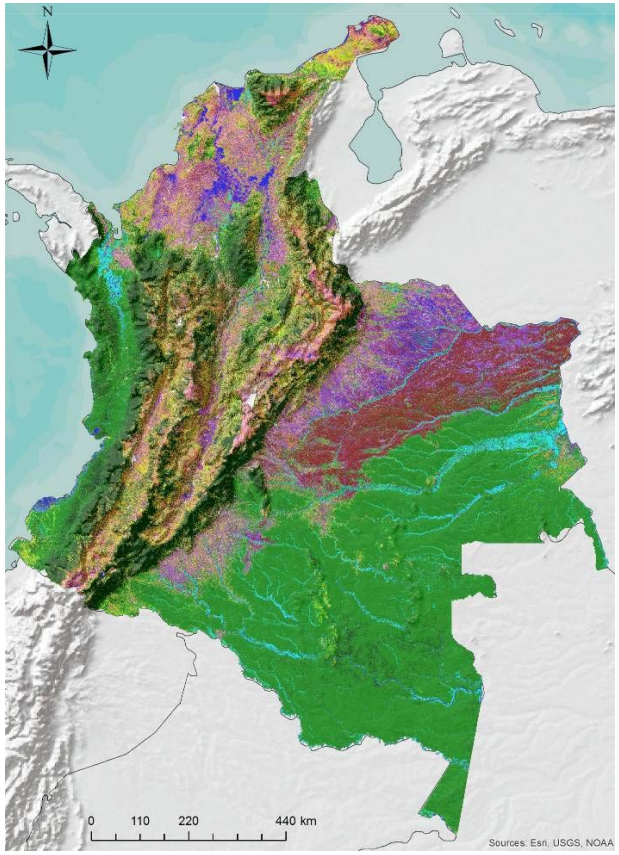
Validation: Methods



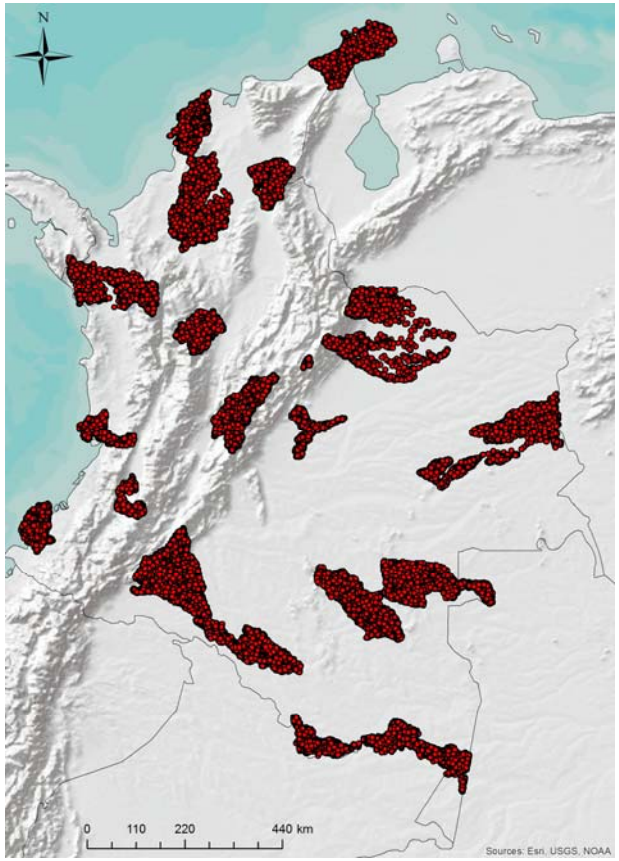


Tabla 1 Distribución del tamaño de la muestra (pixeles) por clase en cada una de las ventanas para el Mapa de Vegetación.

Ventana	Clases												
	1	2	3	6	7	8	10	11	12	15	16	17	Total
Apaporis	3792	15	34	2				1	3				3847
Atrato	1373	1613	213	140	89	63	52	40	3				3586
Bajo Vaupés	4109	118	126	7	18	1	13	2	4				4398
Banadia Cravo Norte	280	245	318	93	279	67	353	237	23				1895
Bogotá Sumapaz	22	491	214	285	284	226	494	271	96				2383
Calima San Juan	656	326	38	15	7	8	8	4	4				1066
Caquetá	3514	1435	577	362	244	129	520	984	63				7828
Cauca		227	79	137	105	76	63	38	11				736
Cienaga de la virgen	99	139	150	309	266	151	385	219	55	2	6	3	1784
Guajira	130	141	369	791	383	274	336	46	99				2569
La Mojana	165	69	250	309	546	241	1130	1156	504				4370
Mataven	3830	34	189	90	119	10	71	34	57				4434
Meta	136	12	44	22	71	19	86	177	273				840
Patía	679	77	164	32	8	1	2		9	165	76	44	1258
Paz de Ariporo	133	324	116	86	159	45	170	196	115				1344
Putumayo Bajo	4167	63	37		1		1		4				4273
Rio Nare	13	1061	104	263	255	207	94	16	4				2017
Tota			2		15	2	11	15	2				47
Zapatosa	84	180	227	195	249	78	245	273	98				1629
Total general	23182	6570	3251	3138	3098	1598	4034	3709	1427	167	82	47	50304

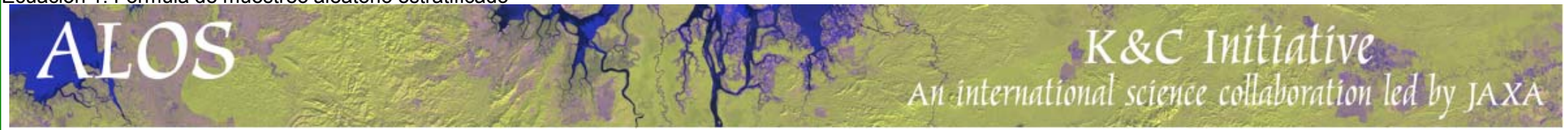
50304

Dónde:
N: Es el número total de unidades del área de muestreo.
S(ô): Es el error estándar de la precisión global estimada que se quiere lograr. En otras palabras el error global permitido en la validación. Este nivel de confiabilidad que se quiere precisar generalmente varía entre el 90 y el 99% por lo que el error permitido iría entre el 0.09 y 0.01.
Wi: Es la proporción de área de cada una de las clases a validar.
Si: Es la desviación estándar de cada estrato o clase generada a partir de la fórmula Si=√Ui(1-Ui) donde Ui es la proporción de precisión hipotética de cada clase. En otras palabras este es un dato deprecisión hipotético que asume el intérprete al revisar visualmente la clasifica

Tabla 3 Distribución del tamaño de la muestra (pixeles) por clase en cada una de las ventanas para el Mapa de Vegetación.

$$n = \frac{(\sum W_i S_i)^2}{\left[S(\hat{O})\right]^2 + (1/N)\sum W_i S_i^2} \approx \left(\frac{\sum W_i S_i}{S(\hat{O})}\right)^2$$

Ecuación 1. Formula de muestreo aleatorio estratificado



Validacion

Código	Cobertura
1	Bosque
2	Bosque
3	Arboladas
4	Agua
5	Bosque
6	Vegetación secundaria
7	Arbustales densos
8	Arbustales
9	Arbustales abiertos
10	Herbazales
11	Sabanas
12	Sabanas Húmedas
14	Áreas construidas
15	Bosque Mangle 1
16	Arboladas Mangle 2
17	Vegetación secundaria Mangle 3

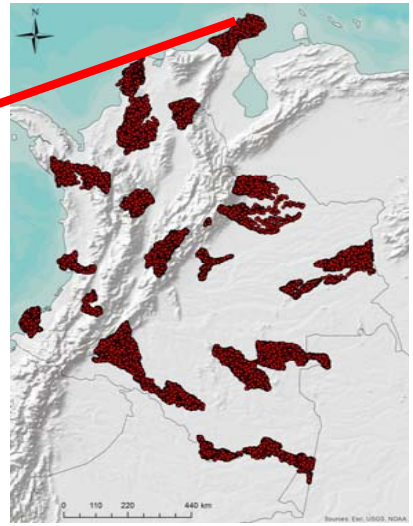
MATRIZ DE ERROR		Referencia												Comisión		Fiabilidad
		1 - Bosque	2 - Bosque	3 - Arboladas	6 - Vegetació	7 - Arbustale	8 - Arbustale	10 - Pastizale	11 - Sabanas	12 - Sabanas	15 - Bosque	16 - Arbolad	17 - Vegetac			
Mapa	1 - Bosque	22094	1	19	304	104	359	128		168	1			1084	4.68	95.32
	2 - Bosque		5216	30	169	124	874	122		34	1			1354	20.61	79.39
	3 - Arboladas	79	3	2481	2	311	128	231		14	1			769	23.66	76.34
	6 - Vegetación s	22	14	8	2200	204	316	369		5				938	29.89	70.11
	7 - Arbustales d	9		27	20	2792		220		30				306	9.88	90.12
	8 - Arbustales	56	10	4			1471	57						127	7.95	92.05
	10 - Pastizales	6	1	7	6	108		3898		8				136	3.37	96.63
	11 - Sabanas	8		2	6	48	51	33	3453	108				256	6.90	93.10
	12 - Sabanas hú	24	1	1	8	9	18	18	96	1250	1		1	177	12.40	87.60
	15 - Bosque Ma	65		2	3		2				95			72	43.11	56.89
	16 - Arboladas M	12		1			1					68		14	17.07	82.93
	17 - Vegetación	12		1	2								32	15	31.91	68.09
Total Omisión		293	30	102	520	908	1749	1178	96	367	4	0	1			
	error de omision	1.31	0.57	3.95	19.12	24.54	54.32	23.21	2.70	22.70	4.04	0.00	3.03			
Precisión		98.7	99.4	96.1	80.9	75.5	45.7	76.8	97.3	77.3	96.0	100.0	97.0	89.6		
		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0			

Ventana	Fase I (Ambiente húmedo)			Fase II (Ambiente seco)			Total		
	Bien	Mal	Precisión	Bien	Mal	Precisión	Bien	Mal	Precisión
Apaporis	401	11	97,3%	3824	23	99,4%	4225	34	99,2%
Atrato	797	25	97,0%	3297	289	91,9%	4094	314	92,9%
Bajo Vaupés	418	7	98,4%	4195	201	95,4%	4613	208	95,7%
Banadia Cravo Norte	348	47	88,1%	1739	156	91,8%	2087	203	91,1%
Bogotá - Sumapaz	433	70	86,1%	2069	314	86,8%	2502	384	86,7%
Calima San Juan	610	30	95,3%	1018	48	95,5%	1628	78	95,4%
Caquetá	407	12	97,1%	7298	529	93,2%	7705	541	93,4%
Cauca	377	42	90,0%	551	185	74,9%	928	227	80,3%
Ciénaga de la Virgen	736	75	90,8%	1519	265	85,1%	2255	340	86,9%
Guajira	736	104	87,6%	1158	1411	45,1%	1894	1515	55,6%
La Mojana	720	74	90,7%	3926	444	89,8%	4646	518	90,0%
Mataven	633	25	96,2%	3969	463	89,6%	4602	488	90,4%
Meta	558	74	88,3%	793	47	94,4%	1351	121	91,8%
Patía	381	23	94,3%	1112	145	88,5%	1493	168	89,9%
Paz de Ariporo	530	53	90,9%	1242	102	92,4%	1772	155	92,0%
Putumayo Bajo	401	13	96,9%	4208	65	98,5%	4609	78	98,3%
Rio Nare	755	81	90,3%	1679	338	83,2%	2434	419	85,3%
Tota	348	47	88,1%	43	4	91,5%	391	51	88,5%
Zapatosa	710	86	89,2%	1410	219	86,6%	2120	305	87,4%
Promedio			**92,2%**			**88,1%**			**89,0%**

45.2%

Overall classification accuracy 89.6 %

- How is the error distributed within the validation windows??
- Which is the class with more classification errors?
- Is it consistent for all the validation windows?



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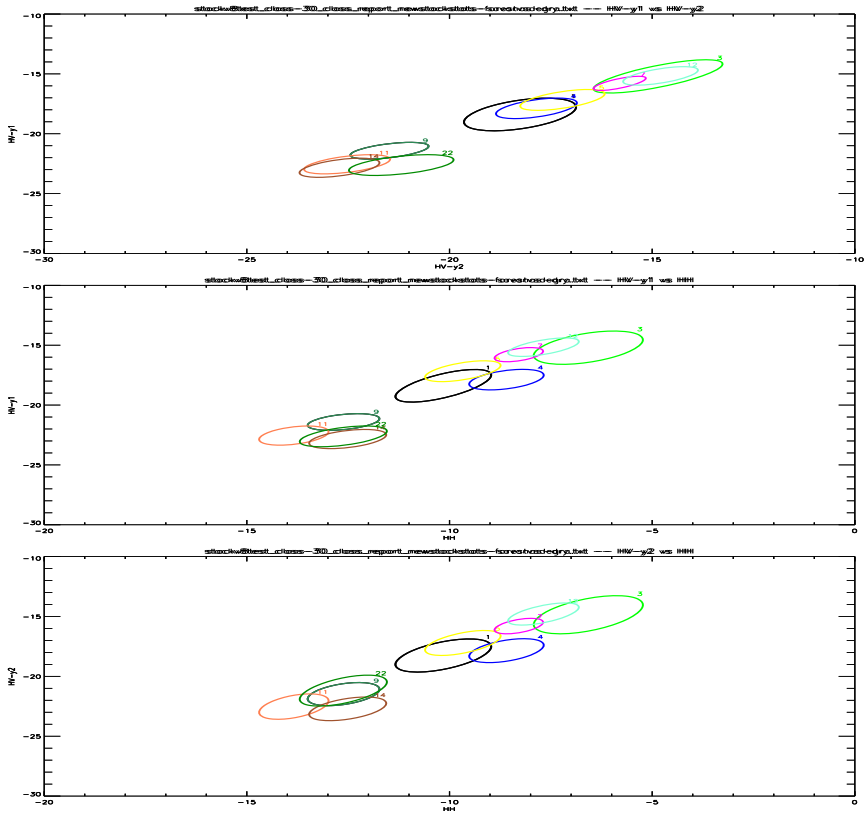
MATRIZ DE ERROR		Referencia												Comisión	Fiabilidad
		1 - Bosque	2 - Bosque	3 - Arboladas	6 - Vegetació	7 - Arbustales den	8 - Arbustales	10 - Pastizales	11 - Sabanas	12 - Sabanas	15 - Bosque M	16 - Arboladas	17 - Vegetaci		
Mapa	1 - Bosque	39		7		55	26	3						91	42.31
	2 - Bosque		23			50	51	17						118	35.46
	3 - Arboladas			71		296	2							298	80.22
	6 - Vegetación secundaria				48	103	297	343						743	13.02
	7 - Arbustales densos					381		2						2	99.48
	8 - Arbustales						269	5						5	0.00
	10 - Pastizales					20		316						20	5.95
	11 - Sabanas						11	24	11					35	0.00
	12 - Sabanas	1				2	8		88					99	2.02
	15 - Bosque Mangle													0	
	16 - Arboladas Mangle													0	
	17 - Vegetación secundaria Mangle													0	
Total Omisión		1	0	7	0	526	395	394	88	0	0	0	0	1158	0.00
Precisión		0.98	1.00	0.91	1.00	0.42	0.41	0.45	0.11					0.45	

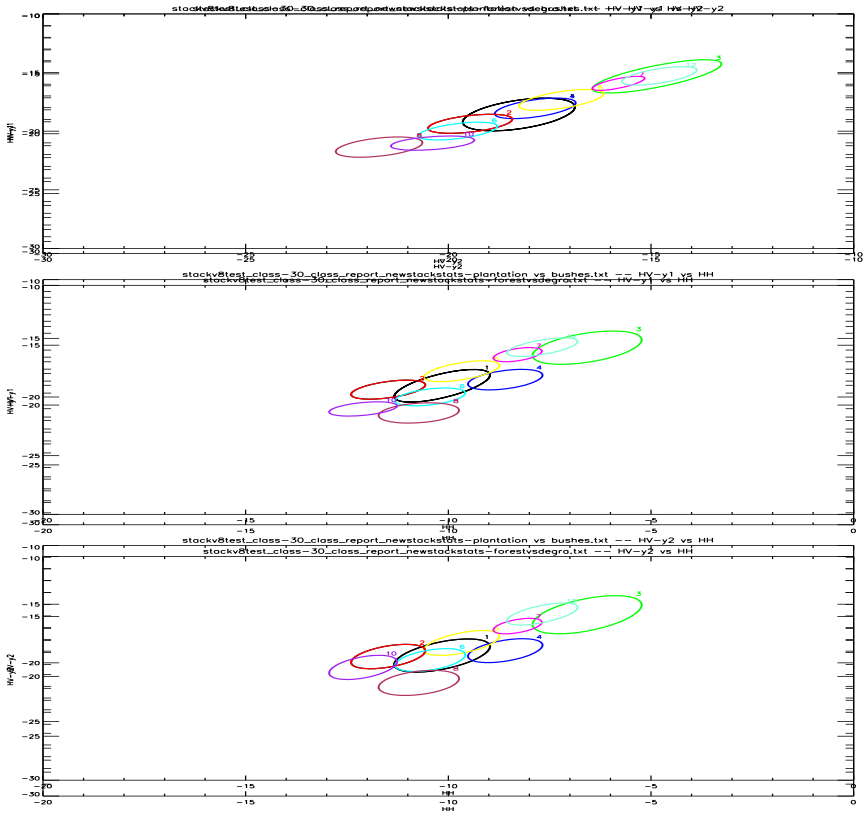
The roughness of the terrain might be responsible for the increase in the level of the backscatter

Signature analysis: feature space HV-HV and HV-HH

From the rest of the country: wet ecosystems and wet vegetation types



From Guajira: Very dry ecosystem and xerofitic vegetation



A shift of the shrubs towards the woodland and forest classes: as shown in the confusion matrix

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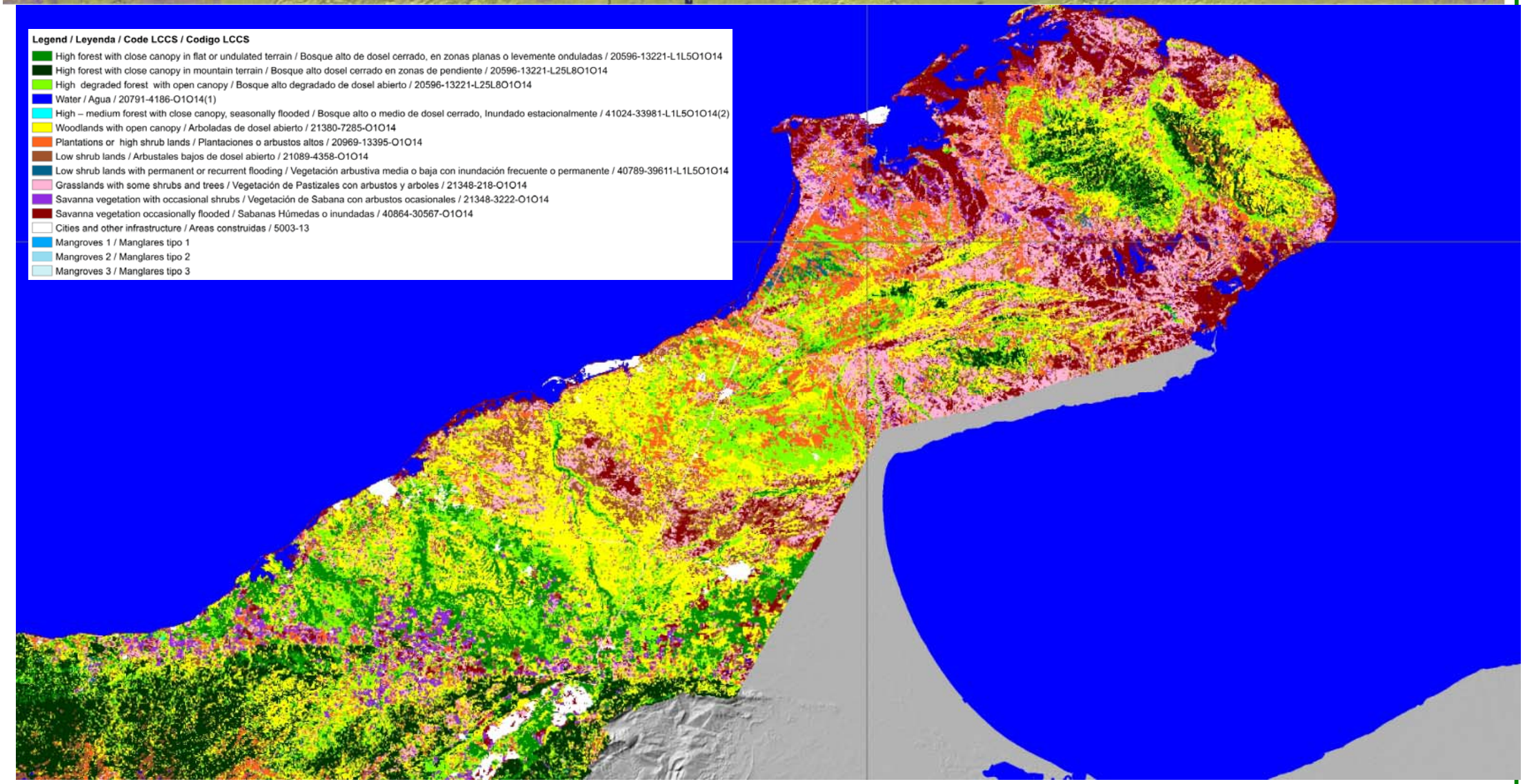


Dry ecosystem in La Guajira: misclassifications are mainly on the misclassification of shrubs as woodlands

Ecuación 1. Formula de muestreo aleatorio estratificado

Validation: Window in the dry ecosystem GUAJIRA presented most of the error

MATRIZ DE ERROR		Referencia												Comisión	Fiabilidad
		1 - Bosque	2 - Bosque	3 - Arboladas	6 - Vegetacio	7 - Arbustale	8 - Arbustale	10 - Pastizale	11 - Sabanas	12 - Sabanas	15 - Bosque I	16 - Arbolada	17 - Vegetaci		
Mapa	1 - Bosque	22055	1	12	304	49	333	125		168	1			993	95.69
	2 - Bosque		5193	30	169	74	823	105		34	1			1236	80.77
	3 - Arboladas	79	3	2410	2	15	126	231		14	1			471	83.65
	6 - Vegetacio	22	14	8	2152	101	19	26		5				195	91.69
	7 - Arbustale	9		27	20	2411		218		30				304	88.80
	8 - Arbustale	56	10	4			1202	52						122	90.79
	10 - Pastizale	6	1	7	6	88		3582		8				116	96.86
	11 - Sabanas	8		2	6	48	40	9	3442	108				221	93.97
	12 - Sabanas	23	1	1	8	7	10	18	8	1250	1		1	78	94.13
	15 - Bosque I	65		2	3		2				95			72	56.89
	16 - Arbolada	12		1			1					68		14	82.93
	17 - Vegetaci	12		1	2								32	15	68.09
Total Omisión		292	30	95	520	382	1354	784	8	367	4	0	1	3837	
Precisión		98.69	99.43	96.21	80.54	86.32	47.03	82.04	99.77	77.30	95.96	100.00	96.97	91.96	

Overall classification accuracy 92.0 % When Guajira is excluded

Conclusions and recommendation:

•LCCS legend describes very well what the radar can see. Since it integrates the information of the vegetation and the wetness condition conditions of the terrain

•Wide area mapping should follow an stratification procedure if ecosystems in an extended area have different metereological conditions. i.e. dry vs wet. If ecosystem maps are not available analysis of available meteorological data should be used for stratification . Good study signatures conditions.!!vegetation information (Xerofitic) .

•Intensive validation procedures are necessary to unravel misclassification of the radar images and to understand the underlying scattering mechanisms involved

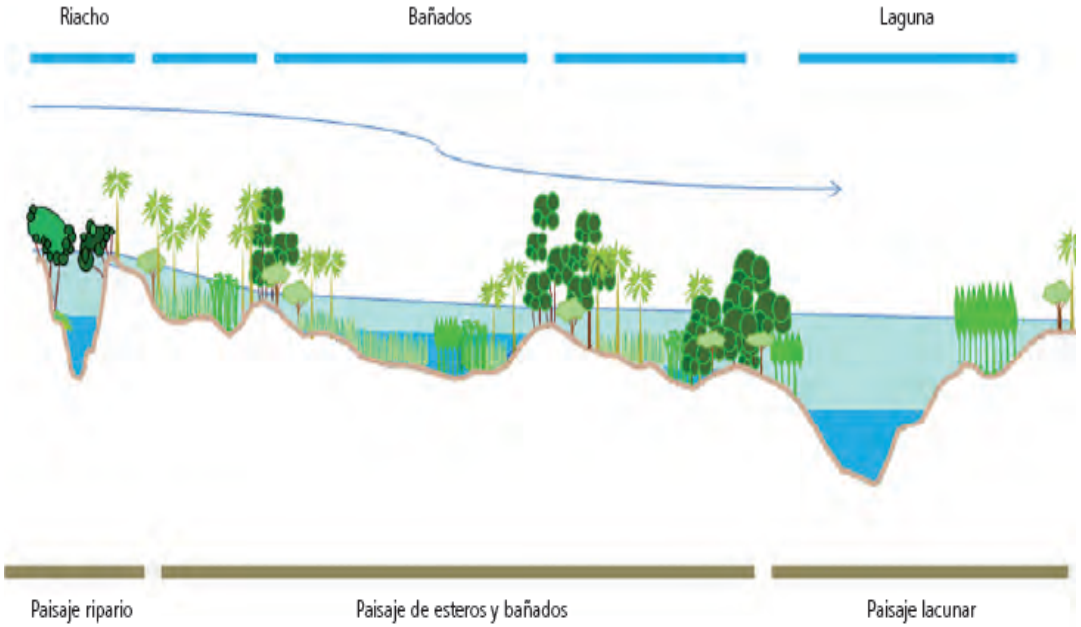
•Understanding of the terrain roughness is necessary to comprehend the scattering mechanisms in areas with low vegetation

•Understanding of the functioning of the ecosystems is necessary or the proper interpretation of the radar signals.
•Proper combinations of polarizations and seasons is necessary in any wide area mapping effort.

Frequency flooding Map

Approach:

- **Map of flooding over the Colombian continental territory**
- **Time series of WB Alos PALSAR / 2007-2011**
- **Processing of 457 strips-29 complete mosaics**
- **Supervised classification using a density slice**
- **Two main classes: Flooded under canopy**
  Open flooding
- **Use of a wetland definition based on RAMSAR**



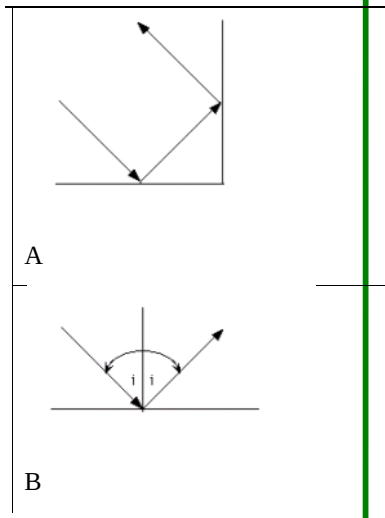
Wetland definition:

Geomorphology : **canal-concave areas- plains,- mountains-slopes**

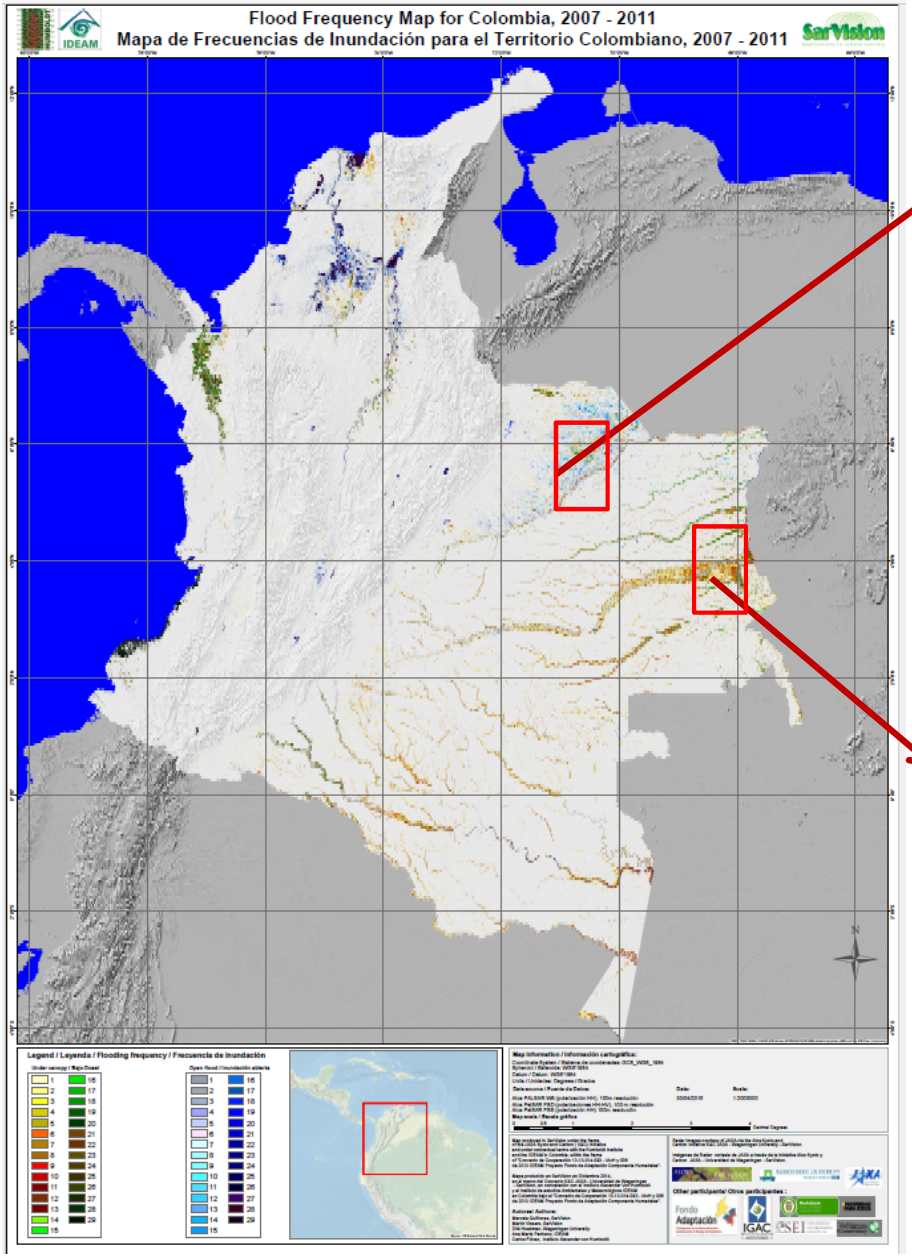
Hydro-soils

Flooding regime**: occasionally- seasonally- permanently**

Vegetation structure: **grasslands-bushland-woodland-Forest**



•*Cowardin, L. M., V. Carter, F. C. Golet and E. T. LaRoe (1979), Classification of wetlands and deepwater habitats of the United* States, U.S., Department of the Interior, Fish and Wildlife Service, Washington, D.C.
•Semeniuk, C. A. and V. Semeniuk (1995), "A geomorphic approach to global wetland classification", Vegetatio, no. 118, pp. 103–124.
•Secretaría de la Convención de Ramsar (2004), Manuales Ramsar para el uso racional de los humedales, Secretaría de la Convención de Ramsar, Gland (Suiza)

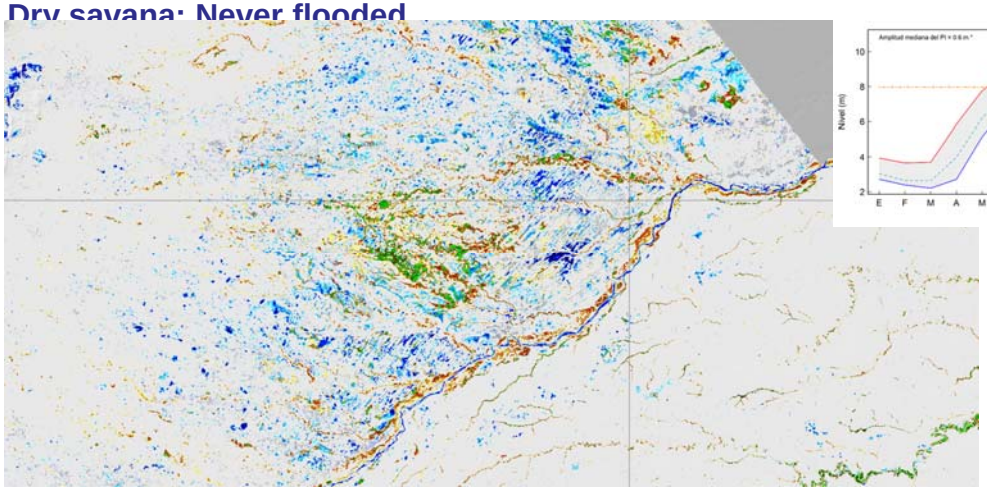


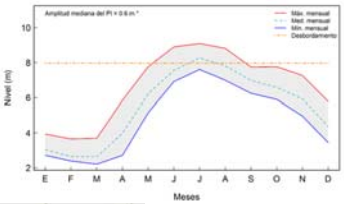
Final Map: Two classes of frequencies

Open Water: Orinoco basin

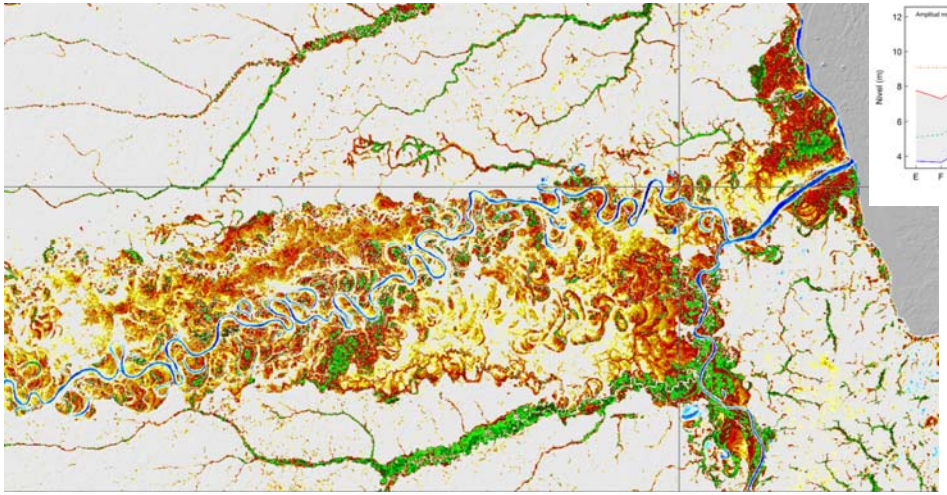
Wet savannas from the Orinoco basin complex ecosystems very difficult to Map.

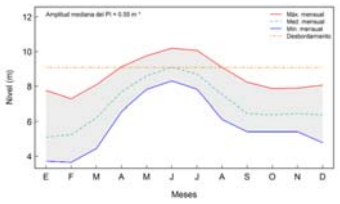
Dry savana: Never flooded



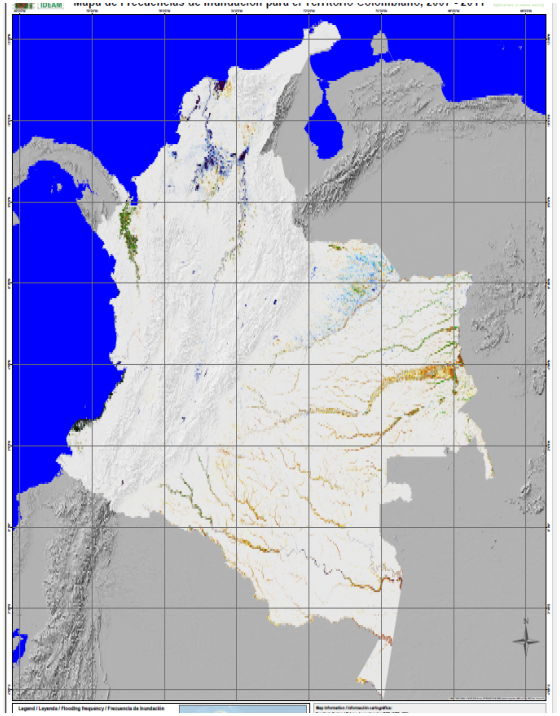


Flood under the canopy: Guaviare River: flooding dynamics never been mapped before)

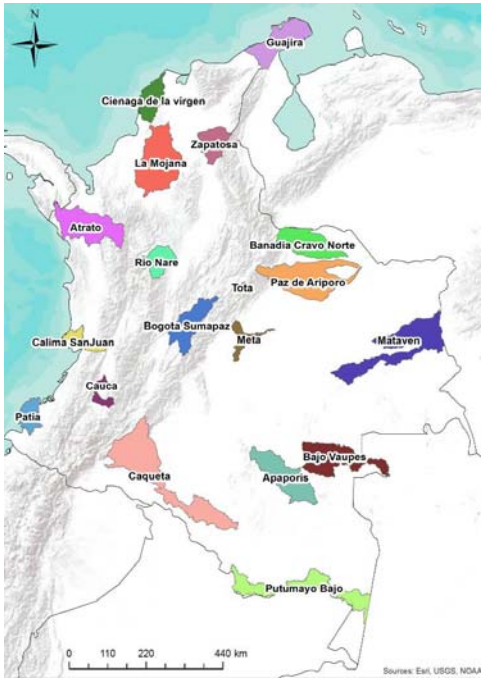




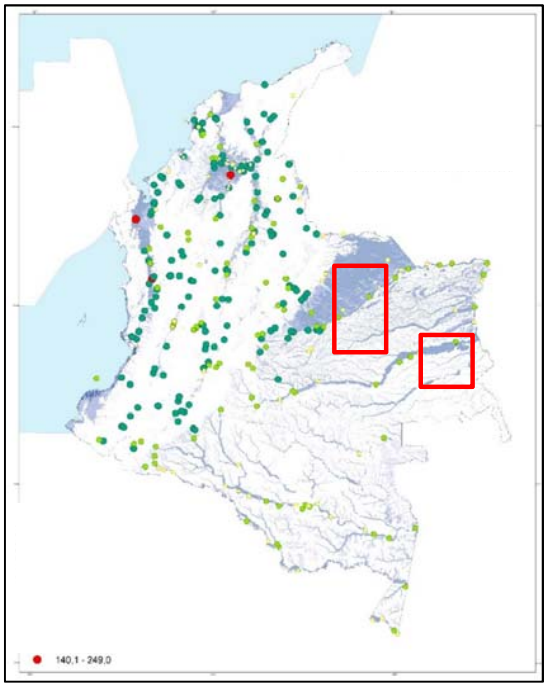
Validation: Intensive validation: use of different available information



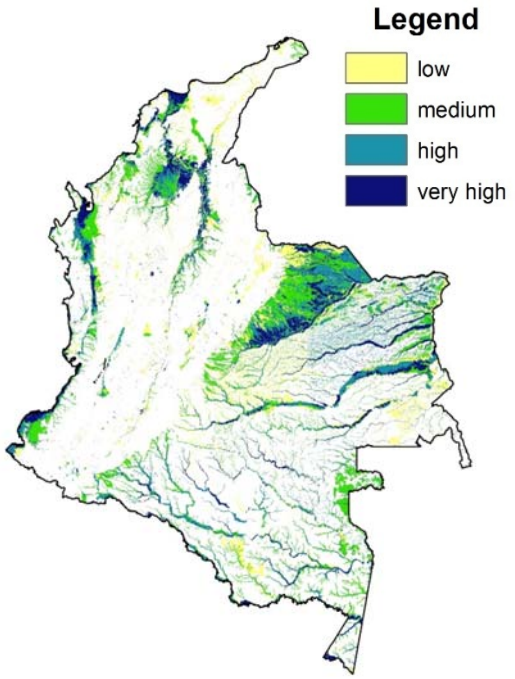
Final Map



19 windows and 9773 points



Information from 357 hydrological stations
We analyzed : levels and water flow from 1974 – 2012 (40 years)



Use of a wetland probability map created with available GIS layers: geomorphology, soils, vegetation coverage. Based on landsat

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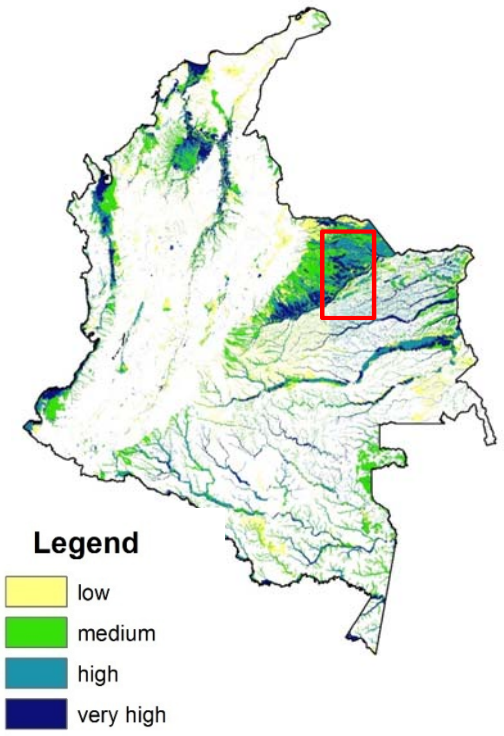
MATRIZ DE ERROR		referencia			Total comisión	Fiabilidad
		Inundación a cielo abierto	Inundación bajo dosel	No inundado		
Mapa	Inundación a cielo abierto	1176	42	606	648	64.47
	Inundación bajo dosel	151	1095	474	625	63.66
	No inundado	71	161	5997	232	96.28
					8268	
Total Omisión		222.00	203.00	1080.00		84.60
Precisión		84.12	84.36	84.74		

- Non flooded areas were classified as flooded
- Most of the Errors of the classification were coming from the validation windows this two areas (Paz de Ariporo)



Savanna Vegetation_ mainly gramineas with low biomass level, mostly subject to changes in biomass levels due to seasonality but occuring on different types of terrain

- Wet savanna: occurring in concave terrain with hidro-morfphic soils, with various types of vegetation, Seasonally flooded

- High savanna o Altillanura: occurring in a high area, with concaves landscapes. Is never flooded except on the concave areas of the riparian forest. Some areas could be temporary saturated. But water running is ver

High land savanna

- Terrain with convex landscapes
- Basin vegetation cover are gramineas
- Phenology and land use patterns have strong effect on and biomass accumulations
- Burning is a common practice after a long dry period
- Most of the biomass accumulates in the wet period
- Monomodal in the rain patterns. Wet period in May-June-july
- Long dry Dec-March

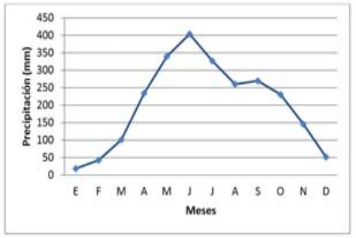
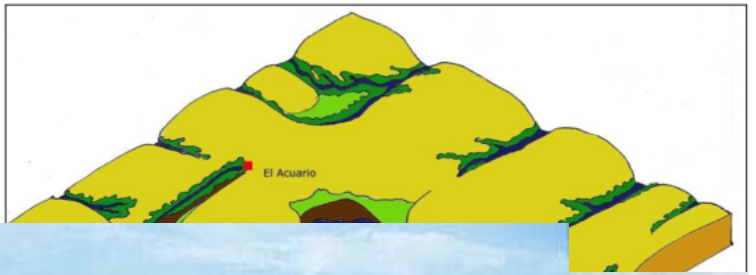
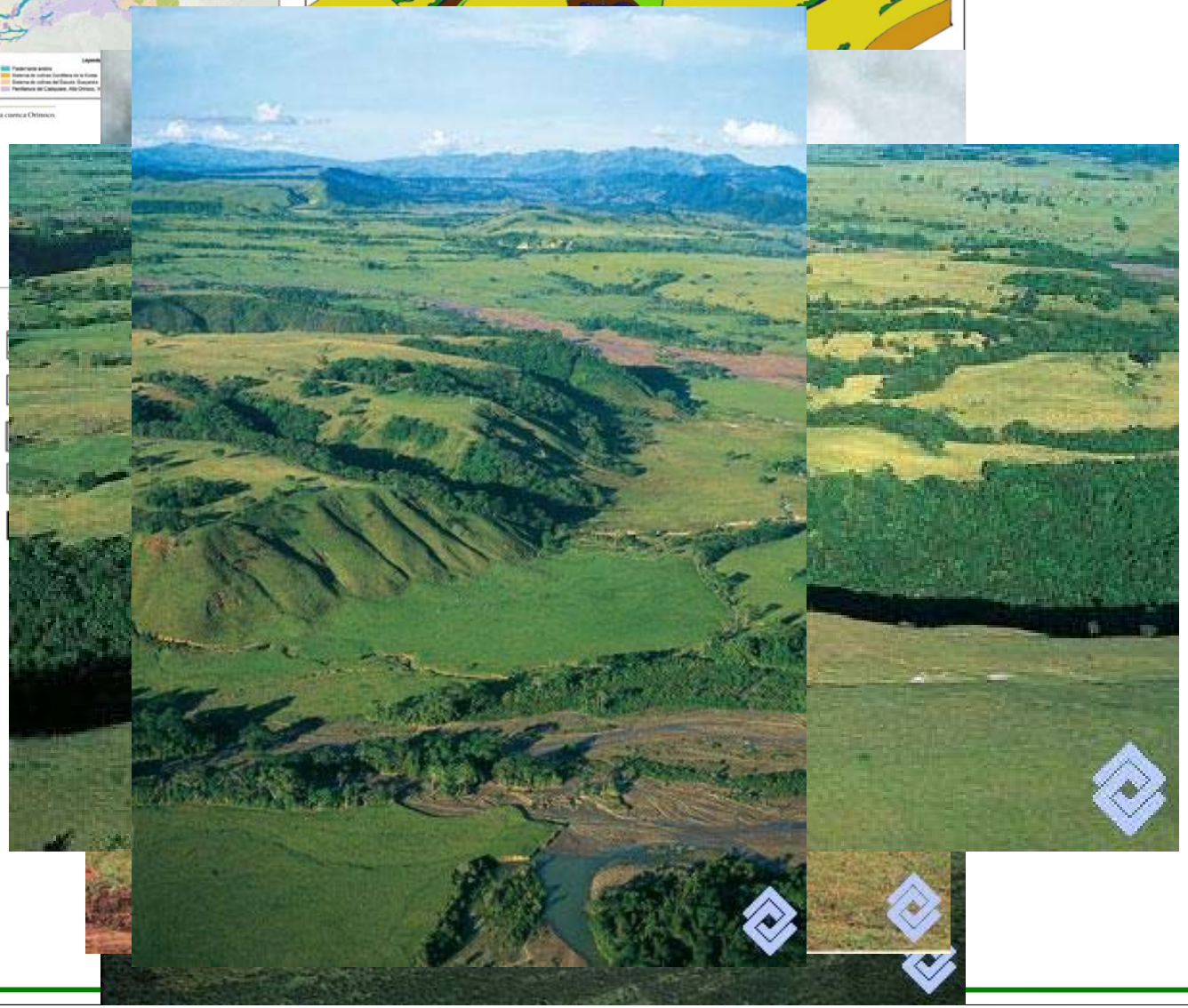


Figura 2. Precipitación media mensual multianual de Carimagua entre los años 1972 y 2010





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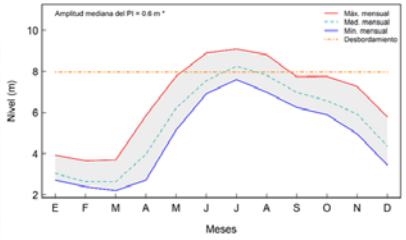
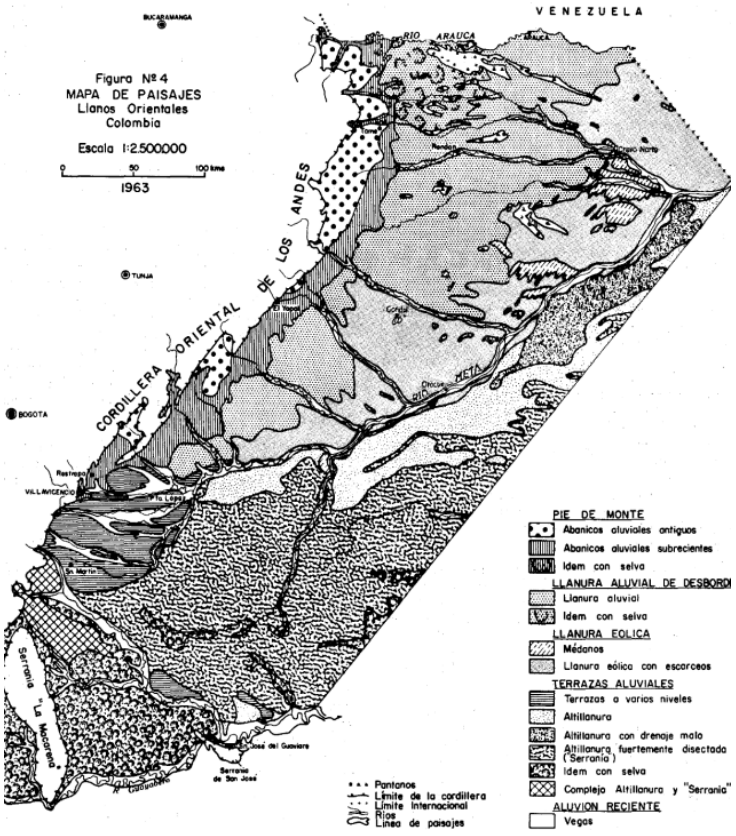




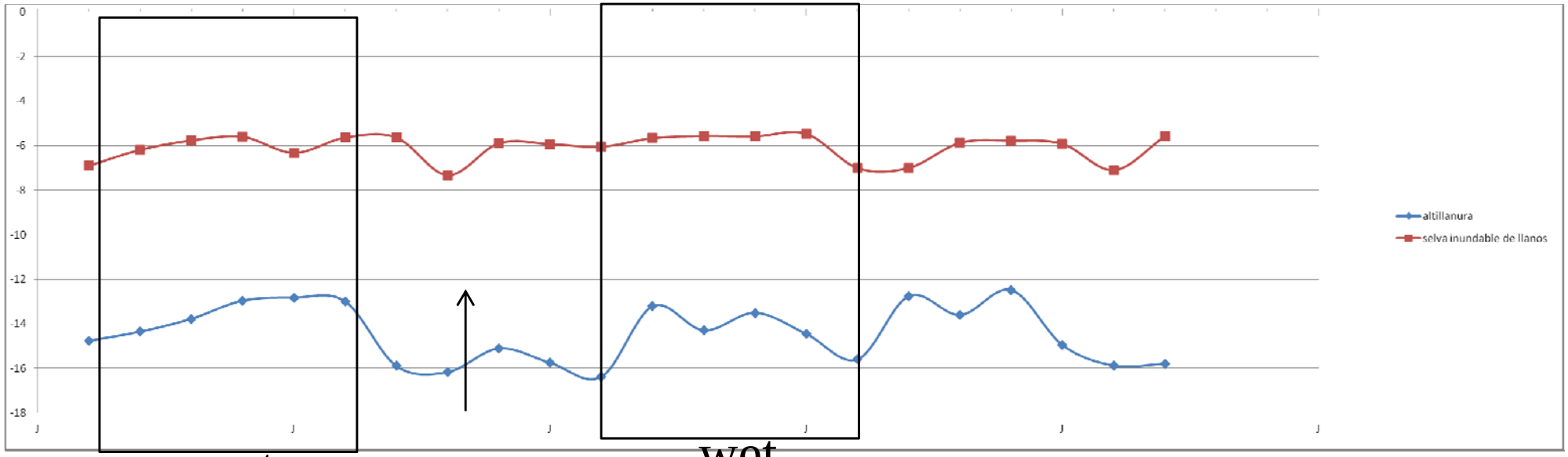
Wet savannas

- Located in concave landscapes
- Main vegetation Gramineas
- Alta estacionalidad en las lluvias
- Very strong dry period where vegetation almost disappear
- High diversity of wetland ecosystems
- Complexity on the flooding regimes define the biomass accumulation patterns :

- ✓Dry savana
- ✓Wet hiperstational savana
- ✓Esteros
- ✓Cananguchales
- ✓Riverine flooded systems
- ✓Riparian Gallery forest
- ✓etc

High land savanna ecosystem types Signature analysis

The window of 2007 to 2011 has special meteorological conditions since the occurrence of el Niño-La Niña there is a shift on the dry and wet season

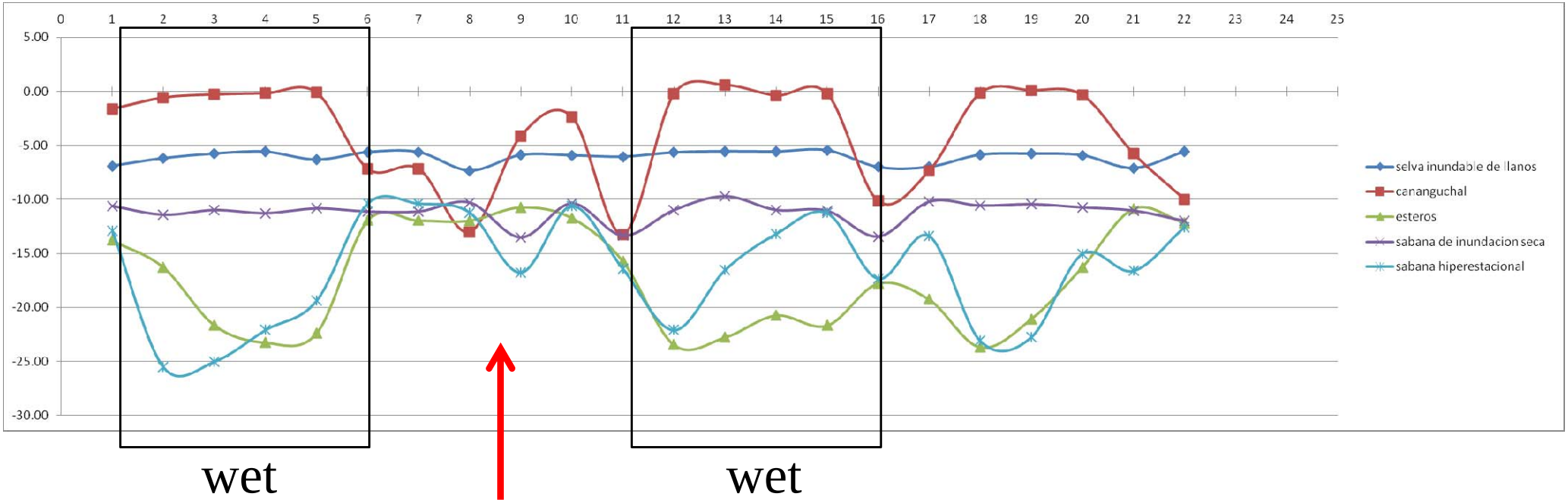


Lower backscatter in dry period that is when it can be misclassified as water

increase in 2 dB due to biomass increase. The selection of the right time for the mapping is crucial. Use of time series is necessary to understand the temporal change of the signatures

Present the classifications before and after the correction with the vegetation map

Wet savannas Signature analysis 2007-2011

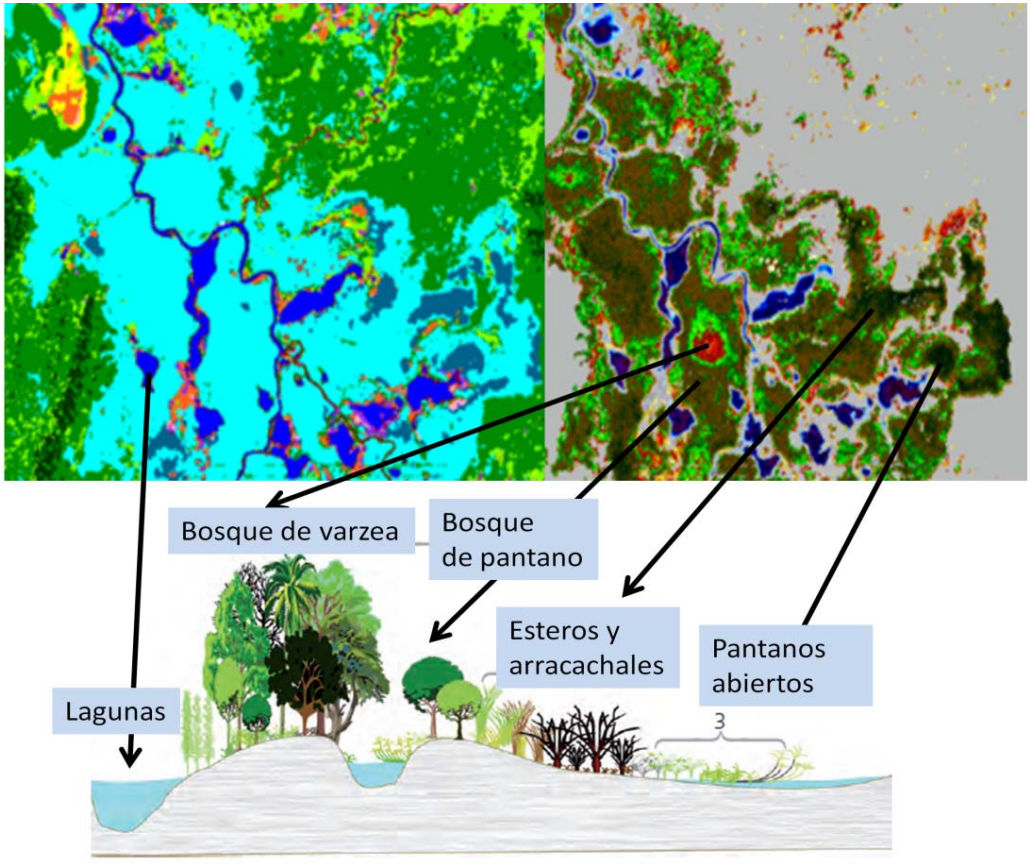


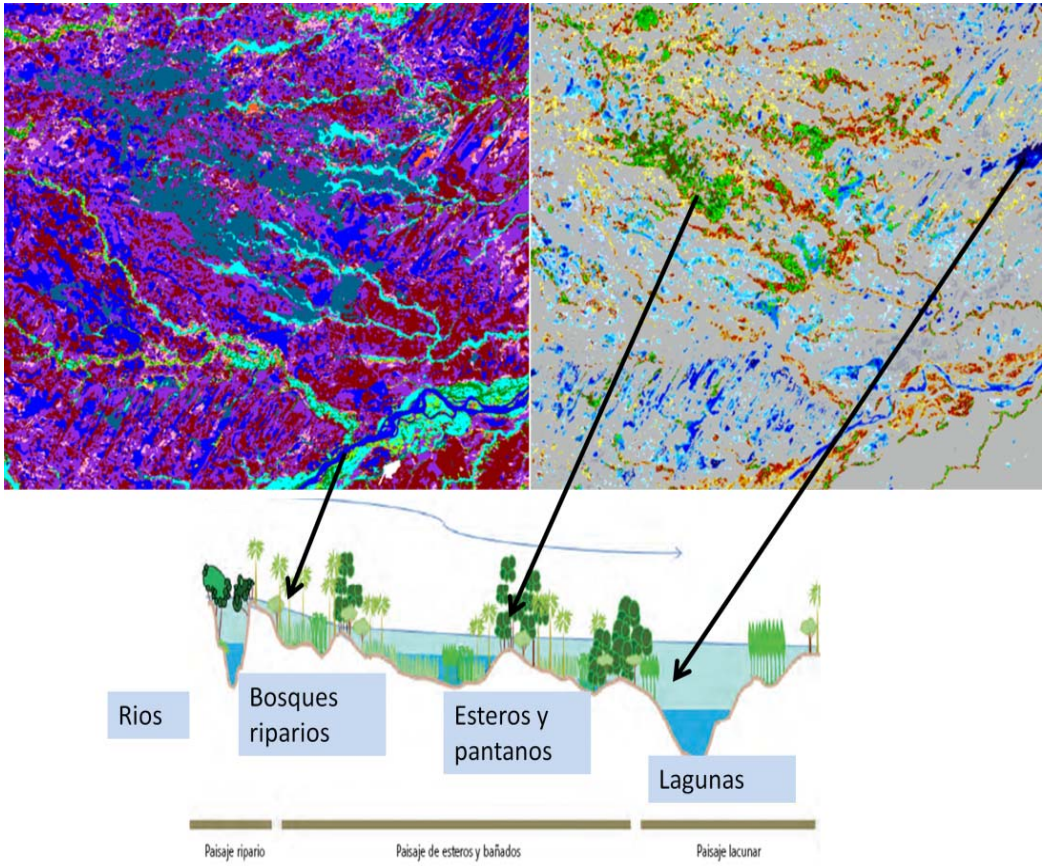
Using only one or two dates is not enough for the detection of the wetlands
A time series is necessary in integration with the proper meteorological data

Present the classifications before and after the correction with the vegetation map

Use of C band to resolve some of the problems in the wet savannas
preferably use of time series of C and L band data to resolve th phrenology issues.

Wetland type mapping required an ecosystemic approach combination of the vegetation map and the flooding frequency map and geomorphology is necessary.





In forested lands and in savannas both the flooding frequency and the vegetation type are essential

Conclusions:

•Use of time series is necessary to understand dynamics of wet ecosystems

•For low biomass wet ecosystems the use of time series of C band will help resolve the complexity of the flooding

•To Map the vast extend of forest under the canopy, dense time series are necessary since there is periodicity at regional level that can not necessary can be capture in one year. Many cycles are supra annual reflecting climate conditions like El Niño - La Niña that produce exceptional flooding events

•The use of an ecosystem approach implies the use of vegetation structures and geomorphologic information to integrate into the analysis of the Alos Images.

• Phenological changes in the vegetation have strong effects on the signature of the Alos images. Interpretation and classification should consider this effects.

•In the Mapping of the Wet savannas the refinement of the spatial resolution helps to decrees the error

•P band will be necessary to resolve and detected the undetected flooded forest but so far is better than ever under representation of the flooded under the canopy

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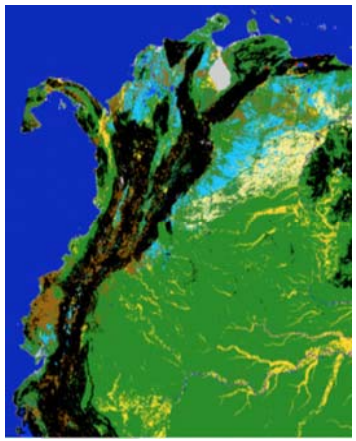

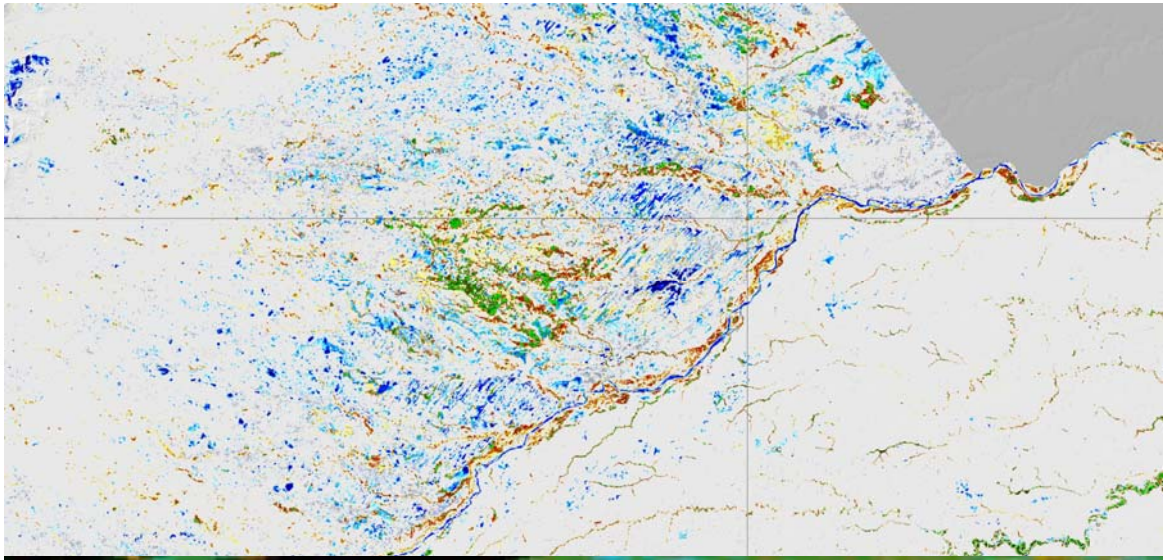

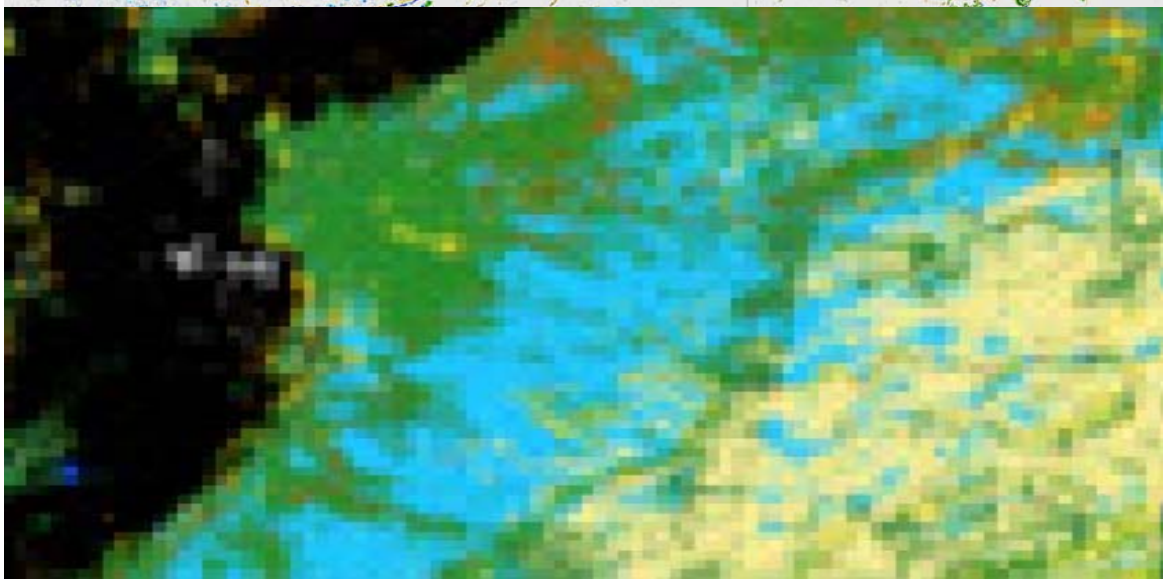

"The Alos PalSAR is able to give a new dimension for the wetlands management in Colombia due to identifications of the flooded under the canopy which changes the management strategies that until now have been focus in the water mirrors"
Humboldt Institute

Actual Work

- Collaborations with the ACT (Amazon Conservation Team) to Work in the Colombian Amazon for monitoring of deforestation at long term
- Support indigenous communities in the governance of their territories by providing updated information on deforestation or degradation occuring in their territories
- Actual Work use of Alos PALSAR-JAXA mosaics at 25m resolution.
  - Baseline mapping: Integrates SRTM-Alos FBD and WB time series
  - Time series analysis for deforestation and degradation detection
- Integration with Sentinel data
- Submitted a proposal for the JAXA to support this initiative

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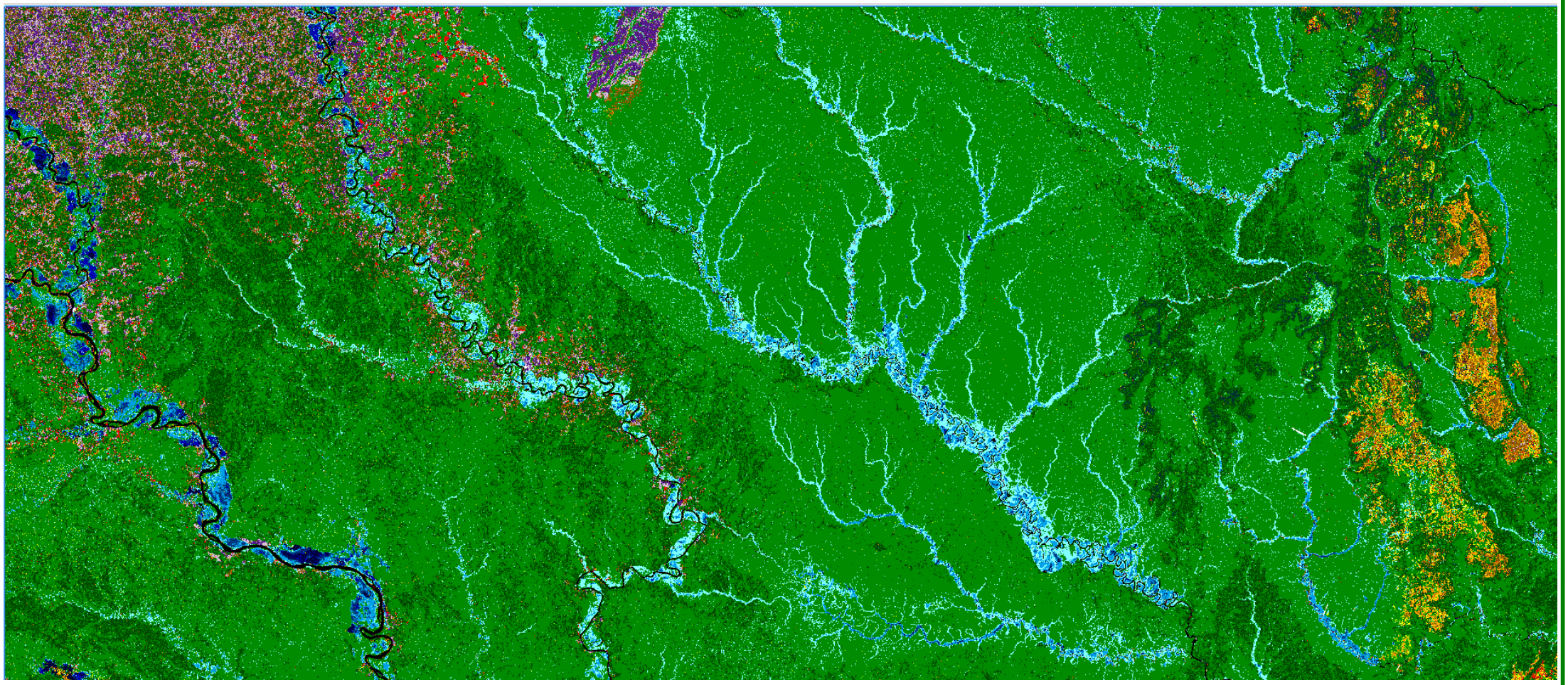

This kind of products integrates geo-morfological data derived from SRTM, Vegetation information and flooding information can be used as a baseline to monitoring and can be linked to Biodiversity studies

Thanks

Acknowledgements:

JAXA and K&C

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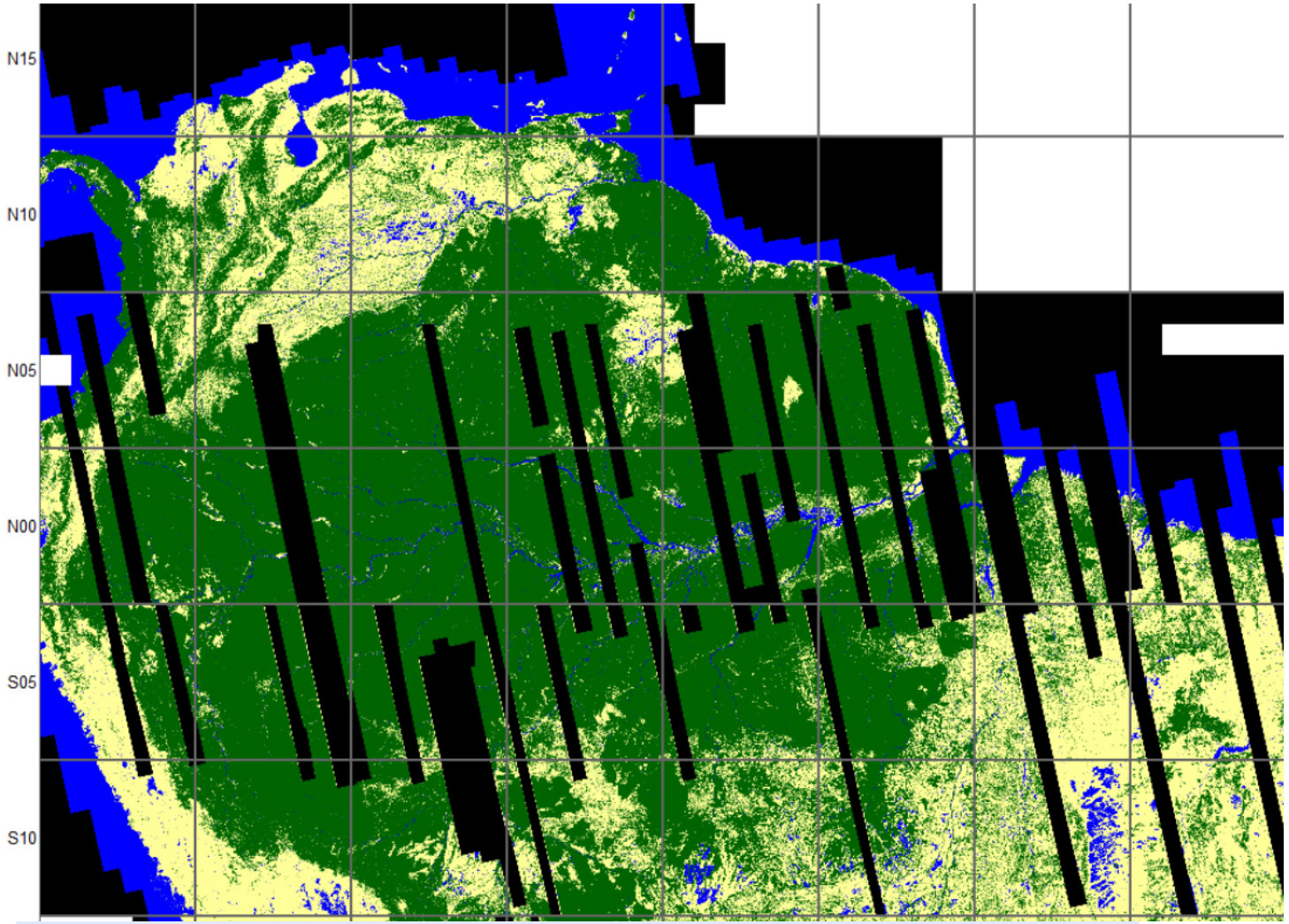
Fondo Adaptación
Trabajamos en la Reconstrucción Gestionando el Riesgo de Desastres

MinAmbiente
Ministerio de Ambiente y Desarrollo Sostenible

PROSPERIDAD PARA TODOS

IDEAM



Palsar 2 Mosaic: Important gaps specially on areas of interest