# Identification and mapping of Colombia wetlands: An Ecosystem Approach

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20 AÑOS INVESTIGANDO
IDEAM Instituto de Hidrología, Meteorología y Estudios Ambientales
IGAC INSTITUTO GEOGRÁFICO AGUSTÍN CODAZZI
PROSPERIDAD PARA TODOS
MINAMBIENTE
Fondo Adaptación
TODOS POR UN NUEVO PAÍS PAZ EQUIDAD EDUCACIÓN

# With the collaboration of:






# Wetland definition:

According with **RAMSAR** Convention we build a own definition:

**Ecosystem** that appears in a **special landform** that promote the **water accumulati**on (temporary or permanently) and produce particular **soil conditions** and **hydro biological organism**s adapted to this conditions**.**

This definition allows build a legend with:

**Identified wetlands:**

- High certain of the wetland area
- High spatial coincidence within layers (landforms, soils, coverage, radar)
- Validation with optical imagery

**Potential wetlands:**
*Ecosystem that appears under particular climate, landform and soil before had been transformed*

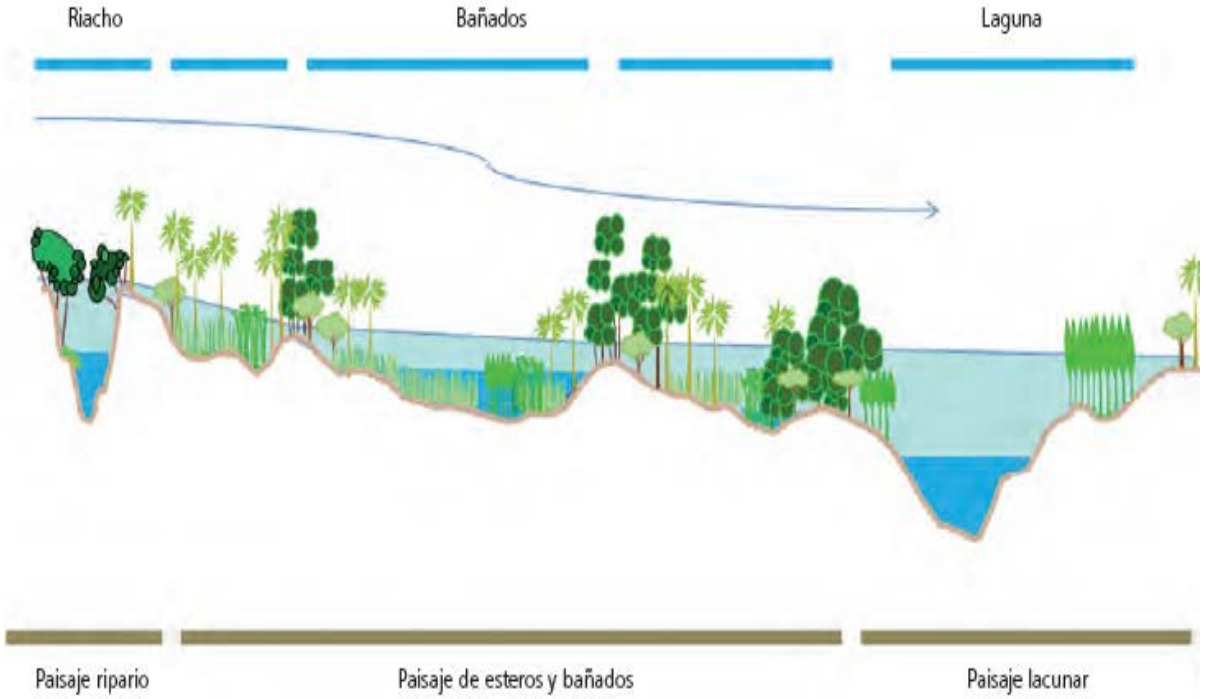
- Include areas associated to flood events in a frame of risk management
- Areas related with transformation processes that now are crops, pastures or city's.

# Ecosystem approach

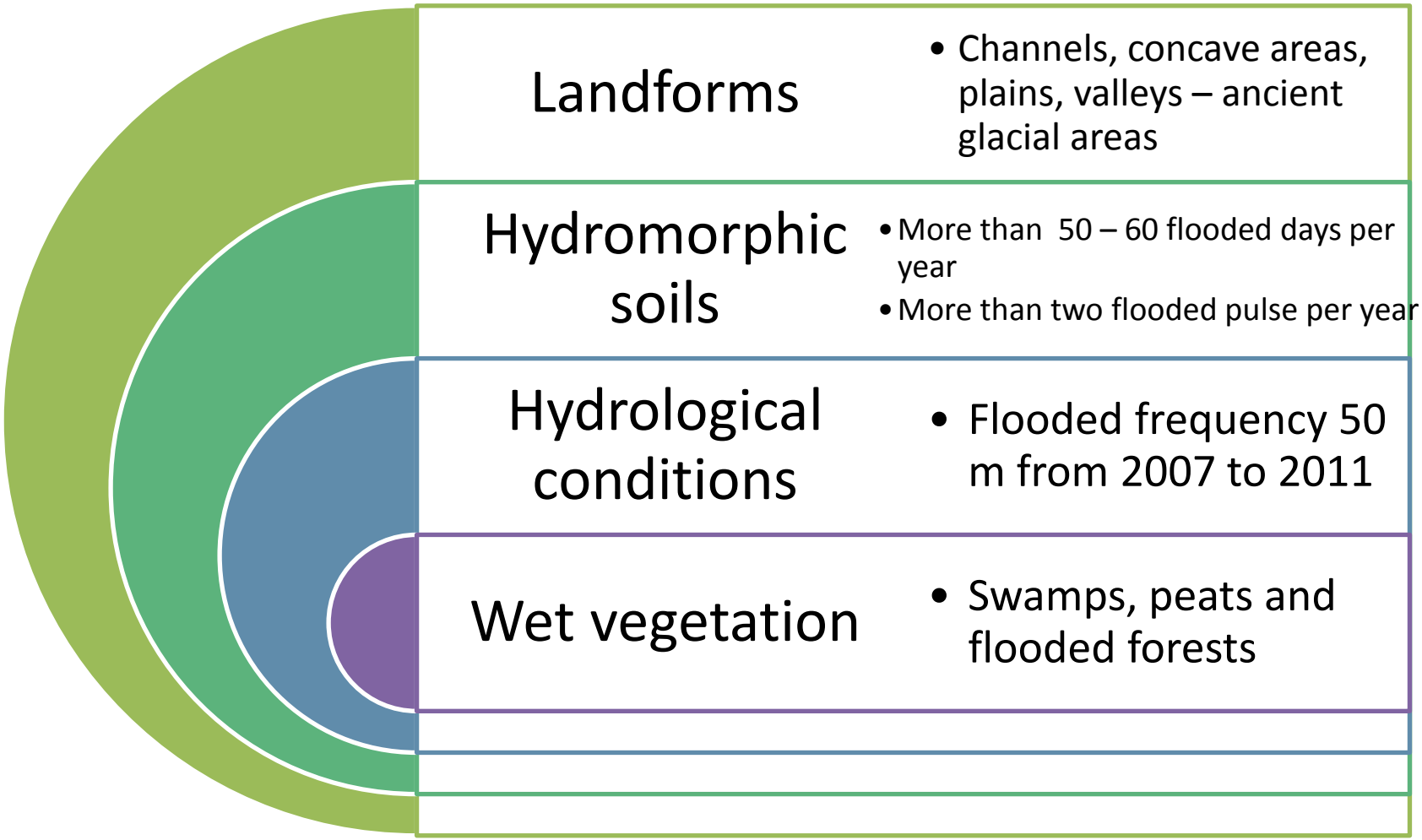
Colombian wetlands has landscapes associated with different elevations (0 – 4000 msnm) and different landforms

**Highlands:** Peats, lagoons and lakes

**Lowlands:**
- Flooded plains and savannas,
- Estuaries,
- swamps, coastal lagoons
- Flooded forests and mangroves



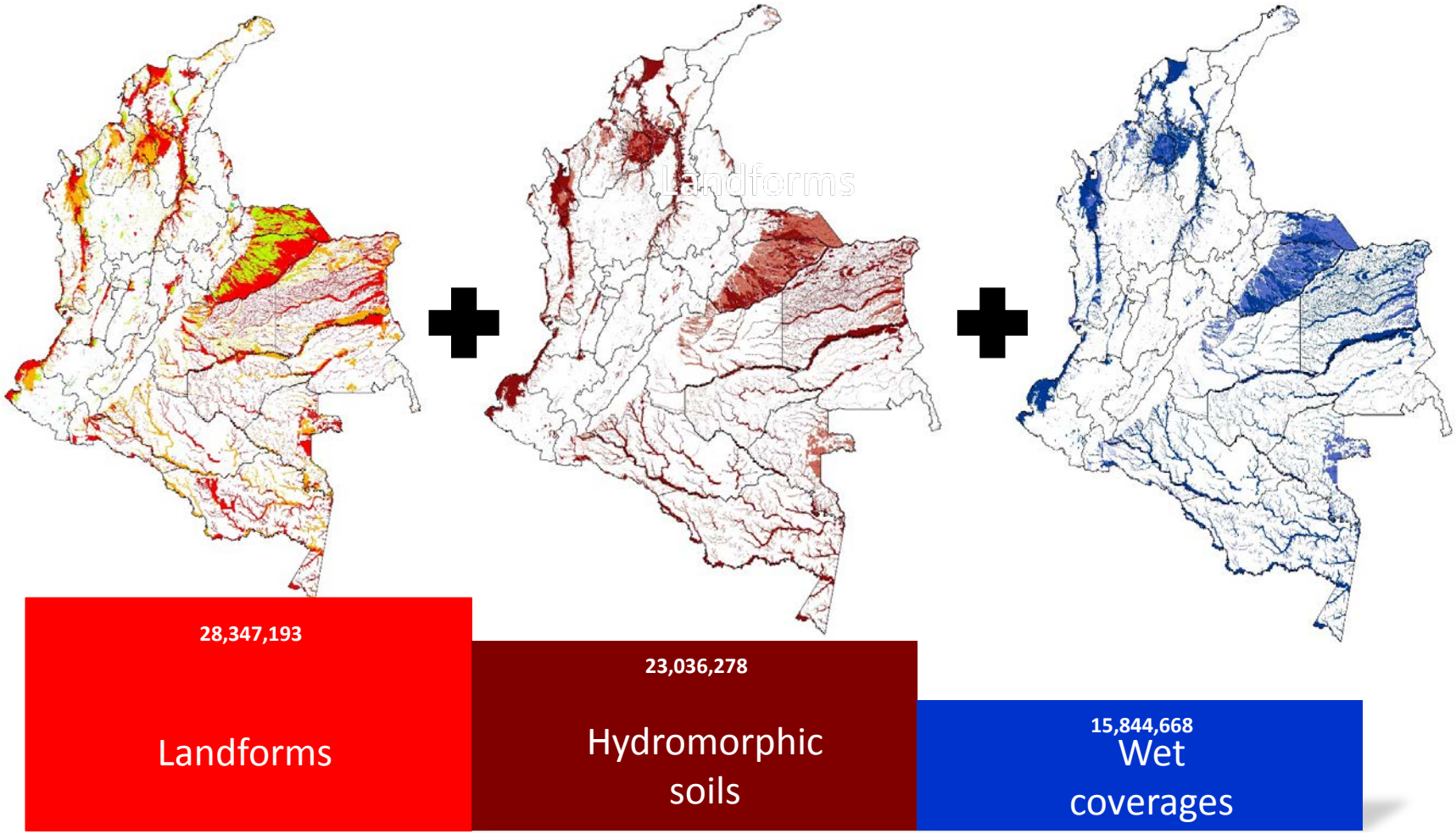

**According to the teoretical frame, the main criteria to the wetland process identification are these:**



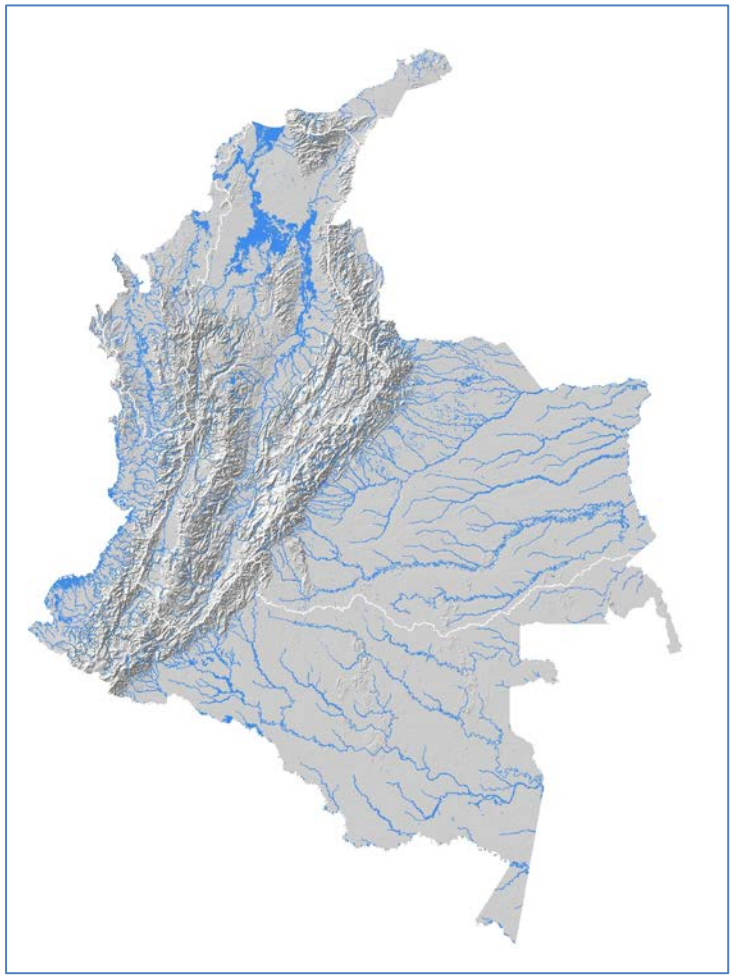

Each variable was editing and integrated in a GIS software at 1:100.000 scale

**Colombia counts with GIS layers as basic spatial information for landforms, solis and coverages :**

**With the team specialist we selected the classes of these layers that are relevant for the wetland identification and we refined this information to a 1:100.000 scale .**

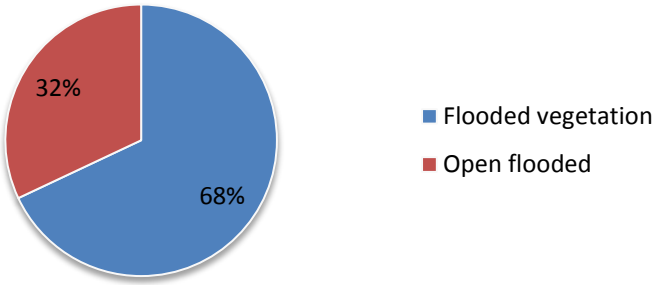


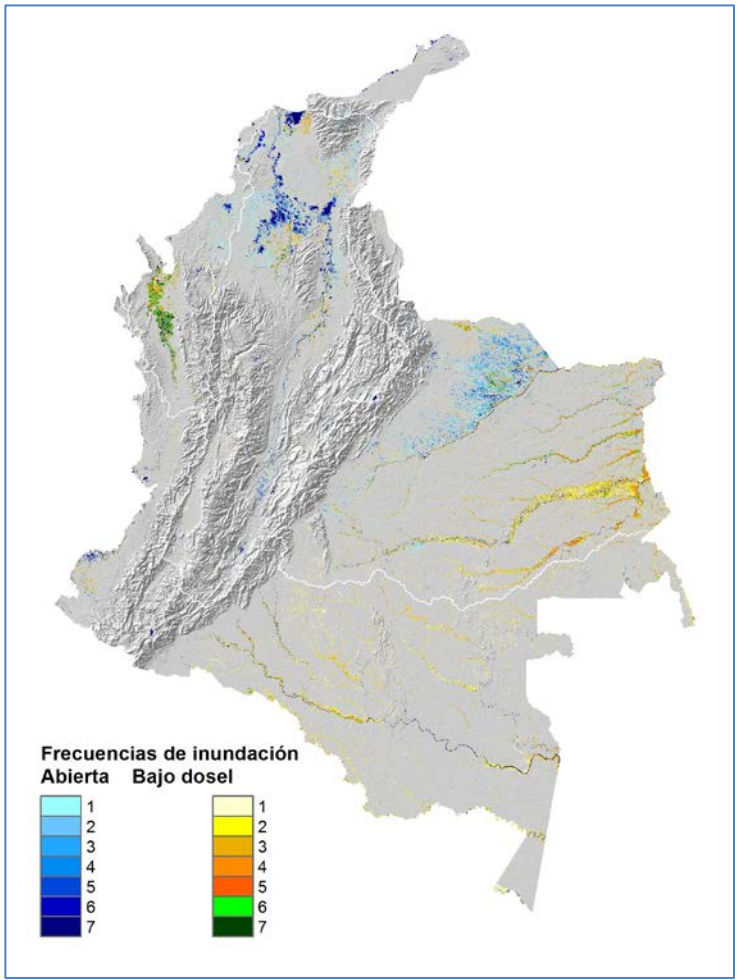
# Hydrological component



**Colombia web drainage**

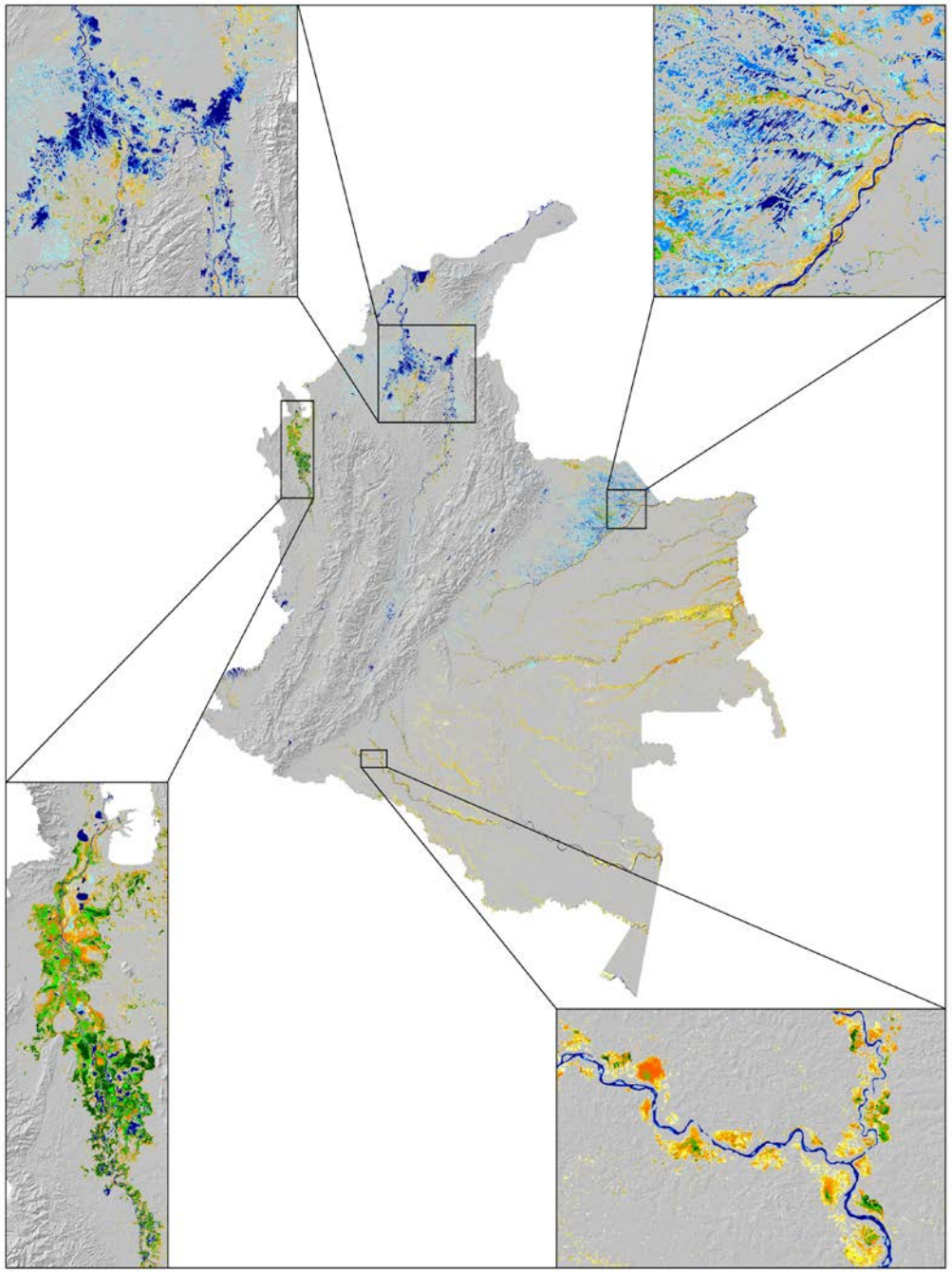
**Radar flooded frecuency**



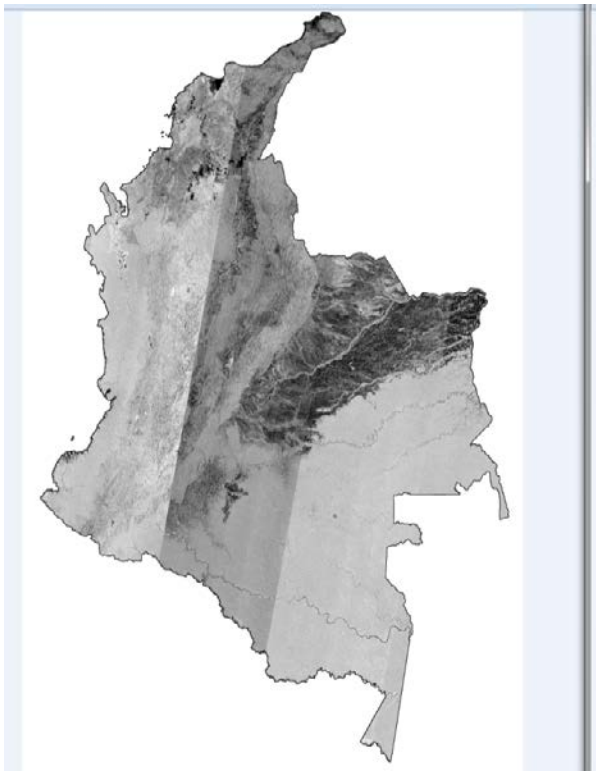



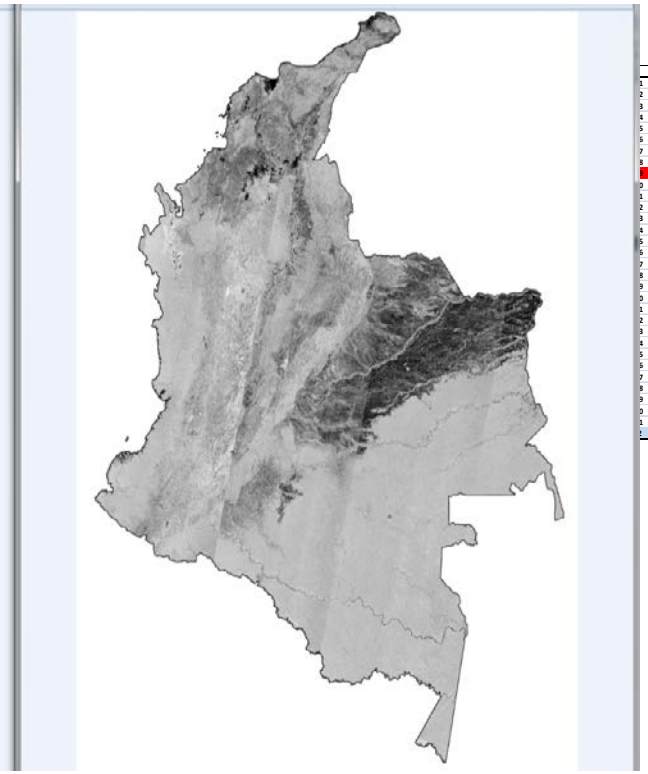
**Flooded frequency 2007 – 2011 (compilation of time series in Map)**

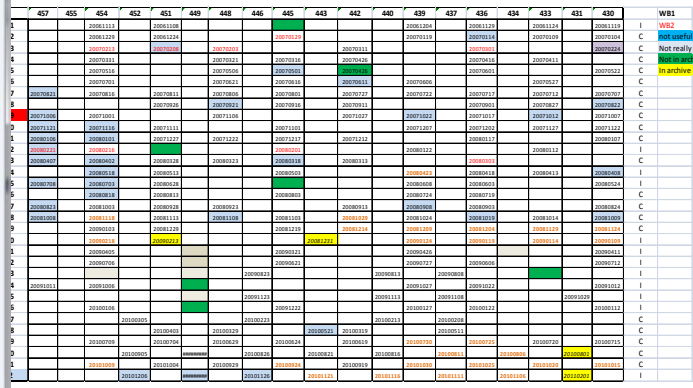
We build 28 national mosaics for 100m y 8 for 50m that classify in open flooded and vegetation flooded



# Results: Flooding Maps Dense Time series





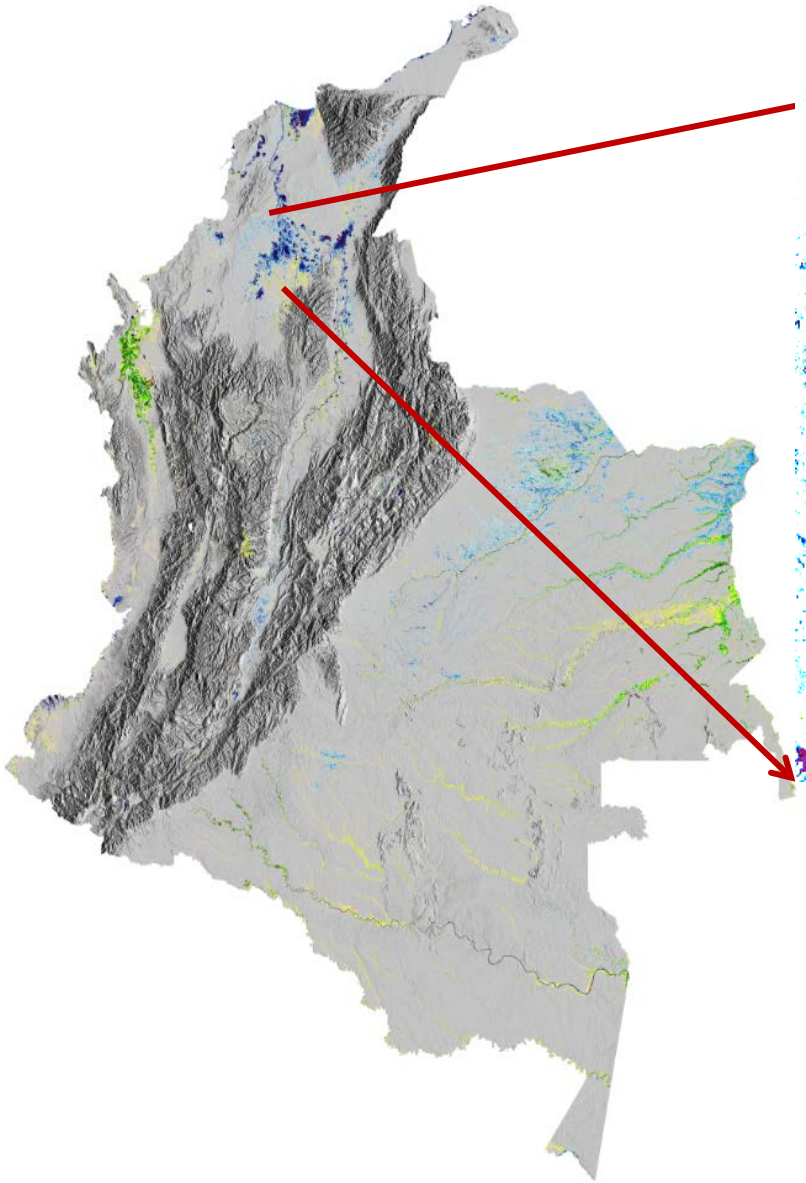


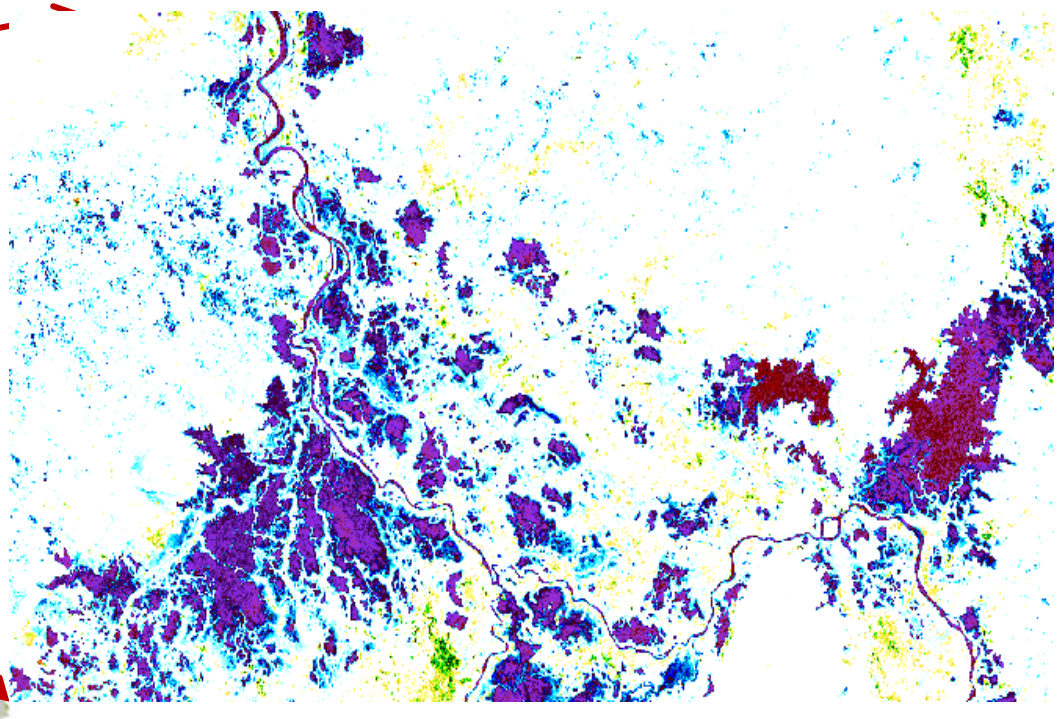
- Data Evaluation
- Data screening
- Orthorectification
- Calibration
- Slope correction

**457 strips - 36 mosaics - 28 complete**

Supervised classification two main classes: open water and flooded under canopy

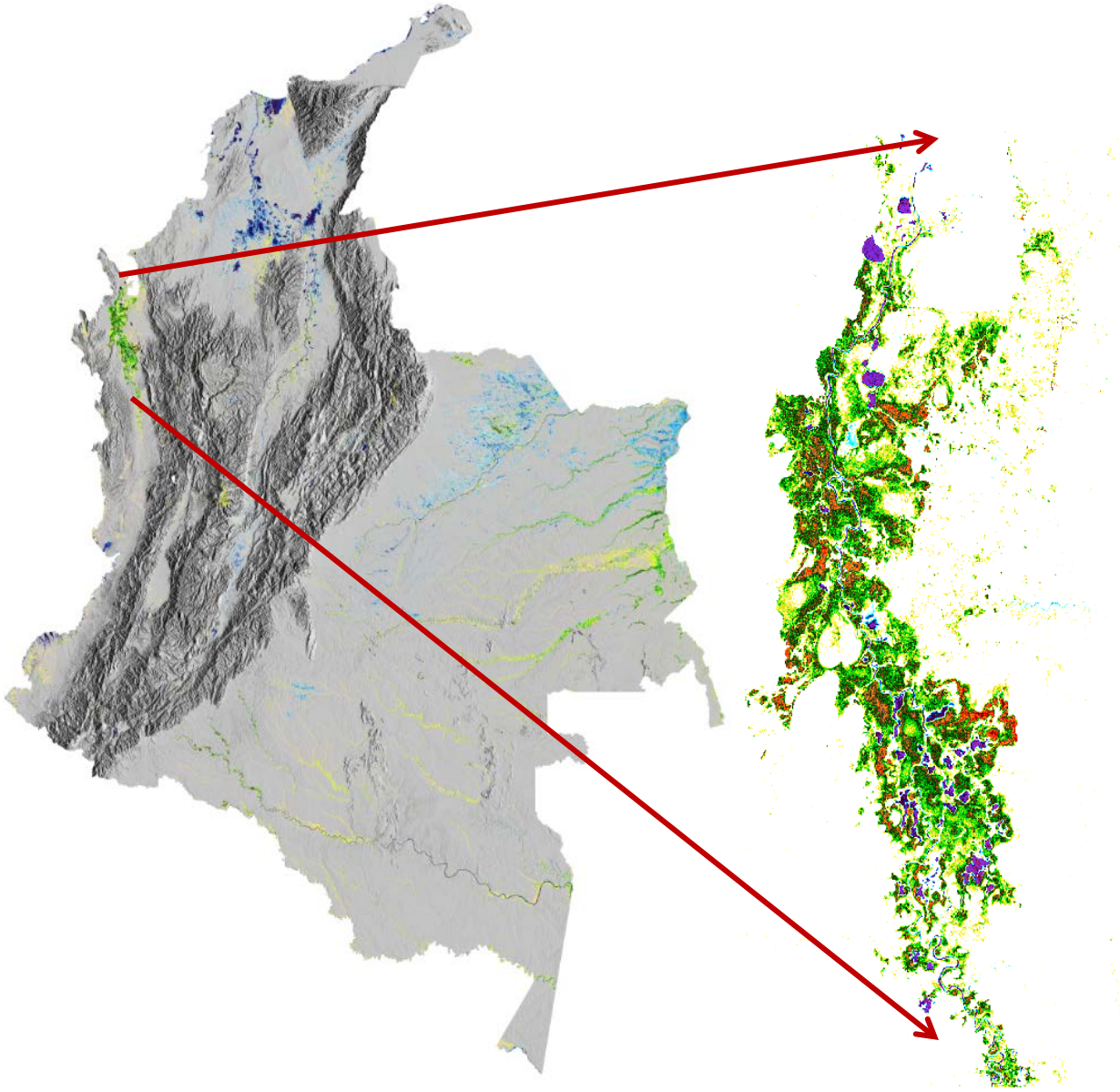
# Open Water: La Mojana : internal delta





Allow the observation of the flooded dynamic within the wetland system

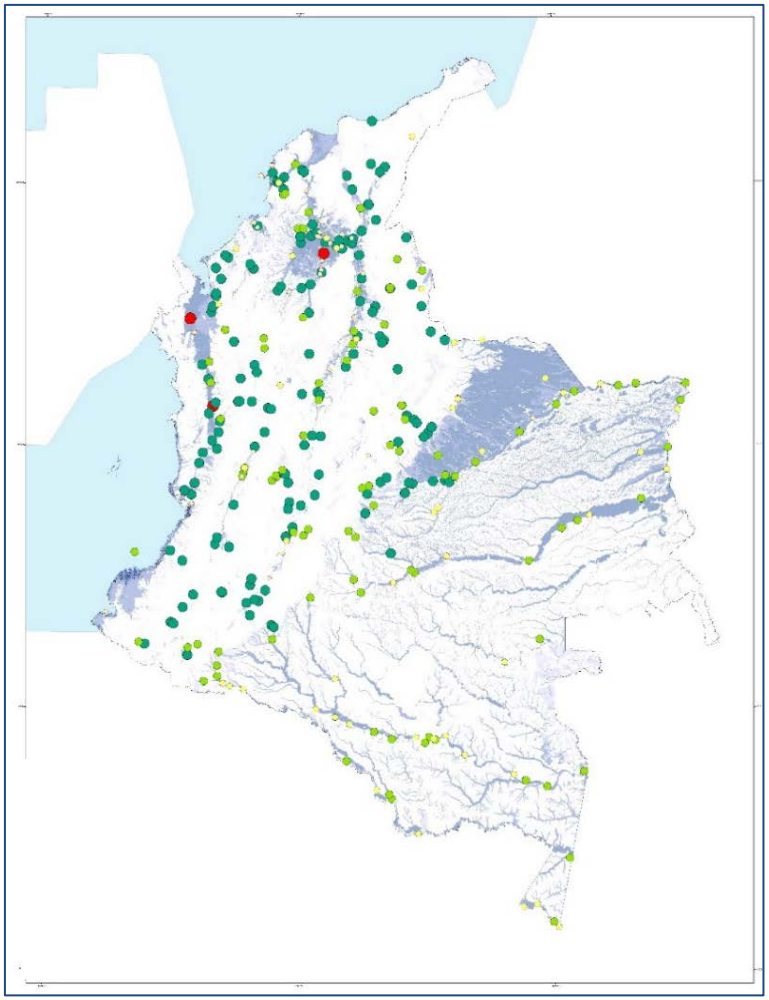
# Flood under the canopy: Atrato – Choco

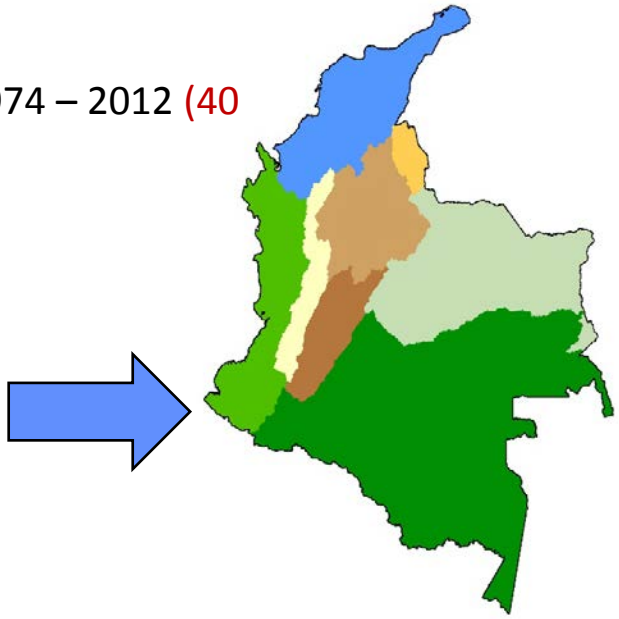


The Alos PalSAR information is able to give a new dimension for the wetlands management in Colombia due to identifications of the flooded under the canopy which changes the management strategies that until now have been focus in the water mirrors

# Hydrological component coming from local measurement

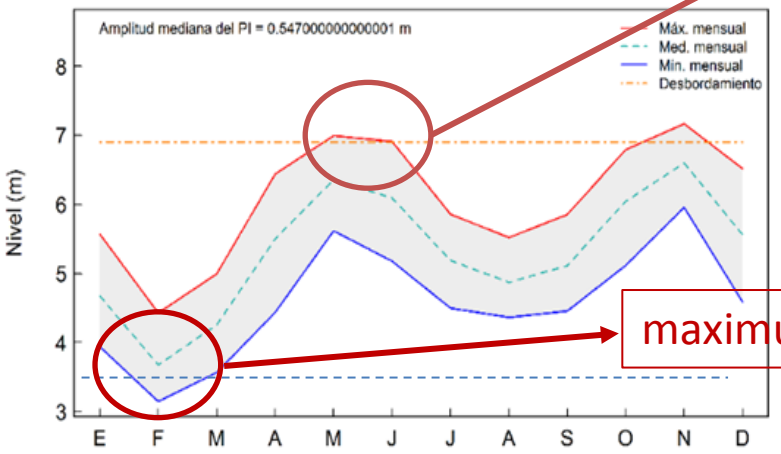
Location of 357 hydrological stations
We analyzed : levels and water flow from 1974 – 2012 (40





From this analysis we identify 8 regions with similar **hydrological regimes or flooded and dry pulses**

maximum flood

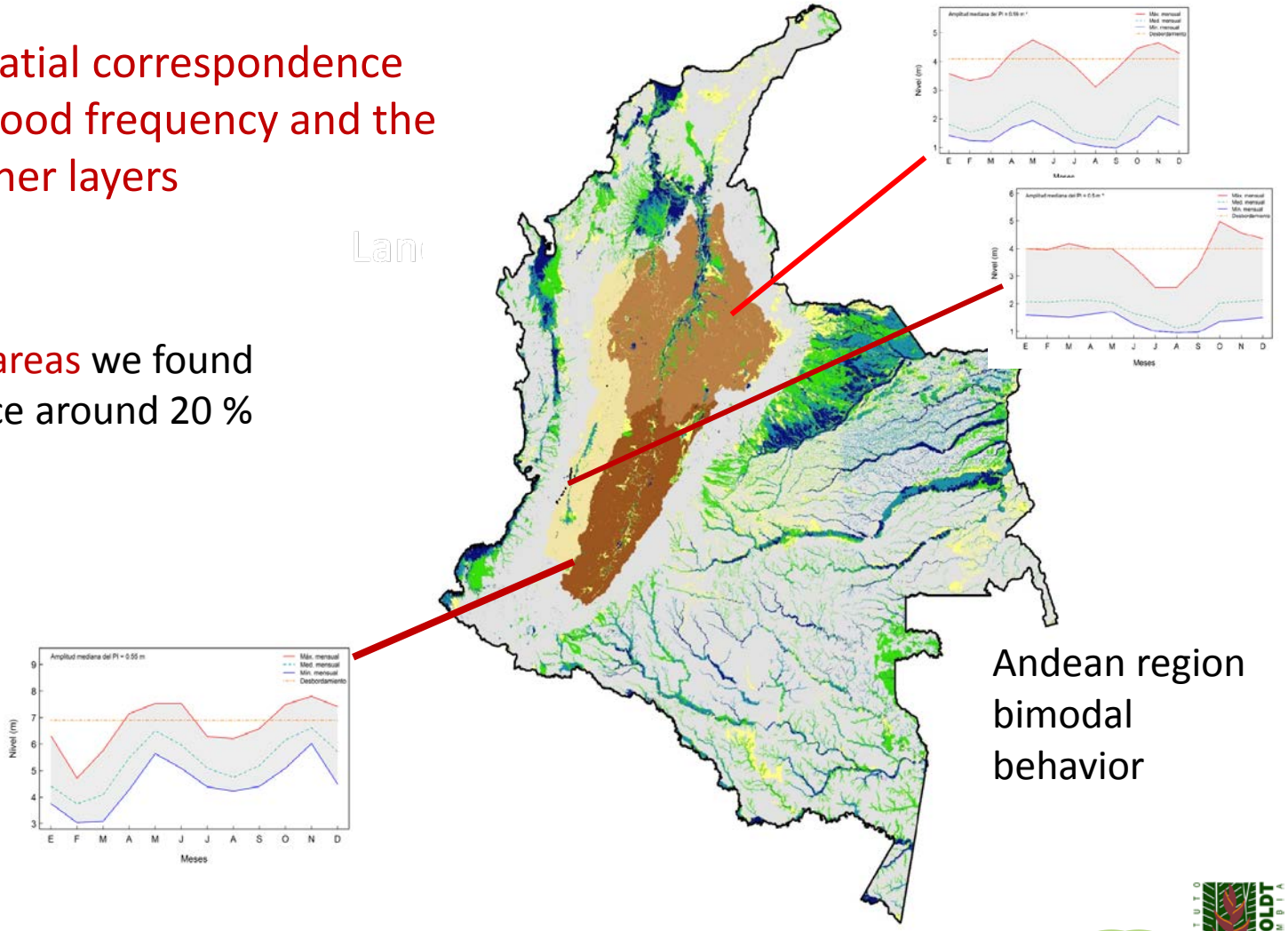



maximum dry

# Hydrological component - Flooded frequency evaluation

We analyze spatial correspondence between Alos Flood frequency and the other layers

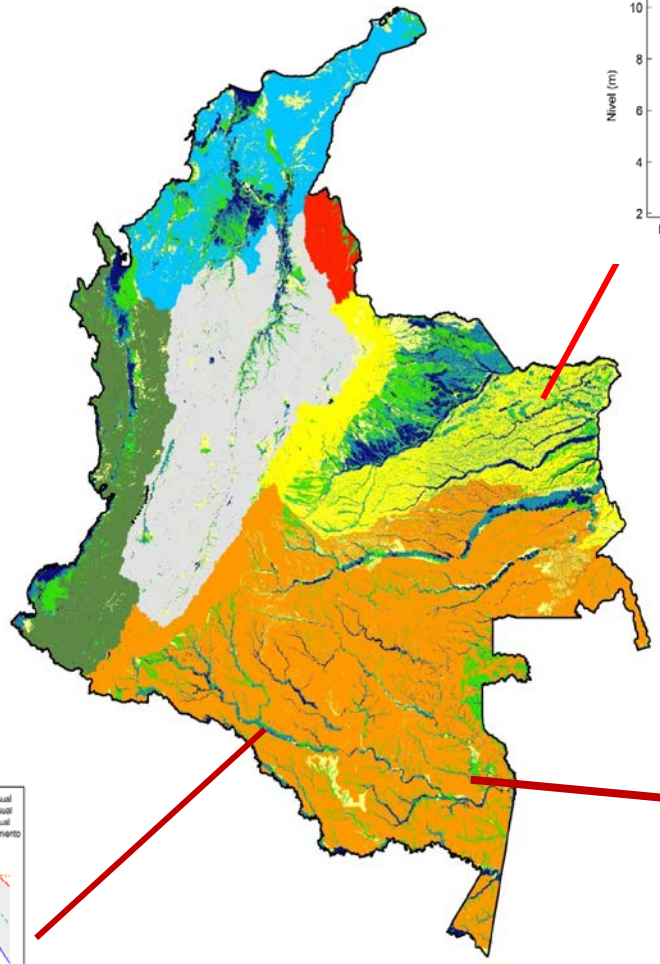
For mountain areas we found correspondence around 20 %

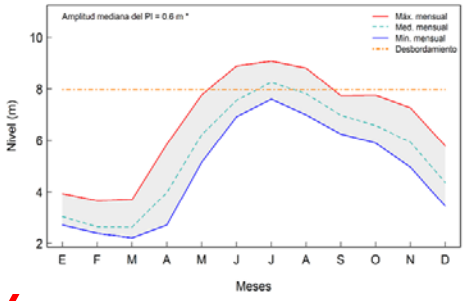



Andean region bimodal behavior

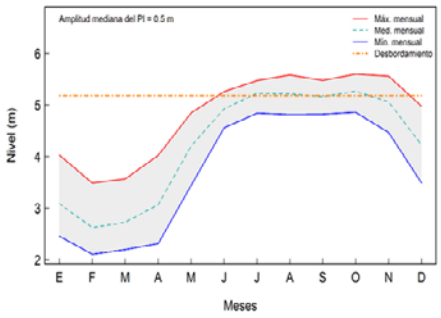
# Hydrological component - Flooded frequency evaluation

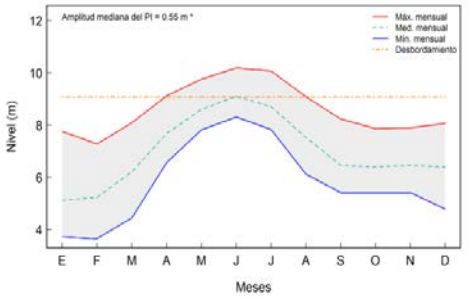
For the Lowlands we found correspondence around 50 %



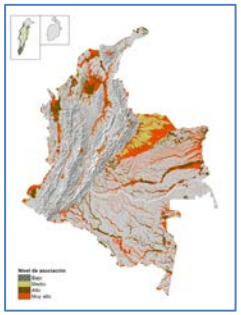



Lowland region uni-modal behavior

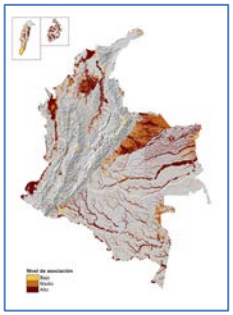


# Wetland map: around 30 % of the country

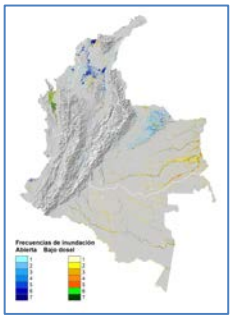


Landforms



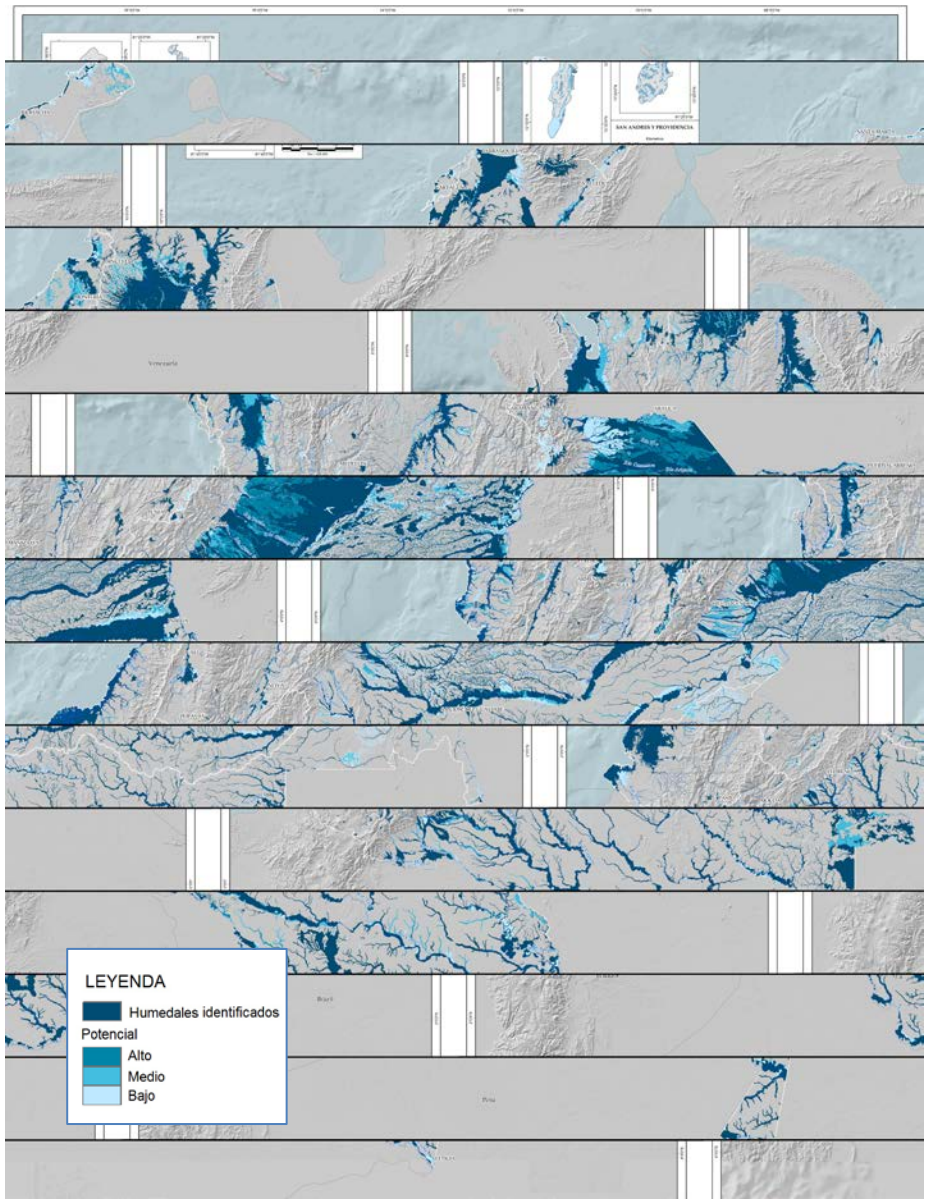
Hydromorfic soils

Web drainage



Flooded frequency

Wet coverages



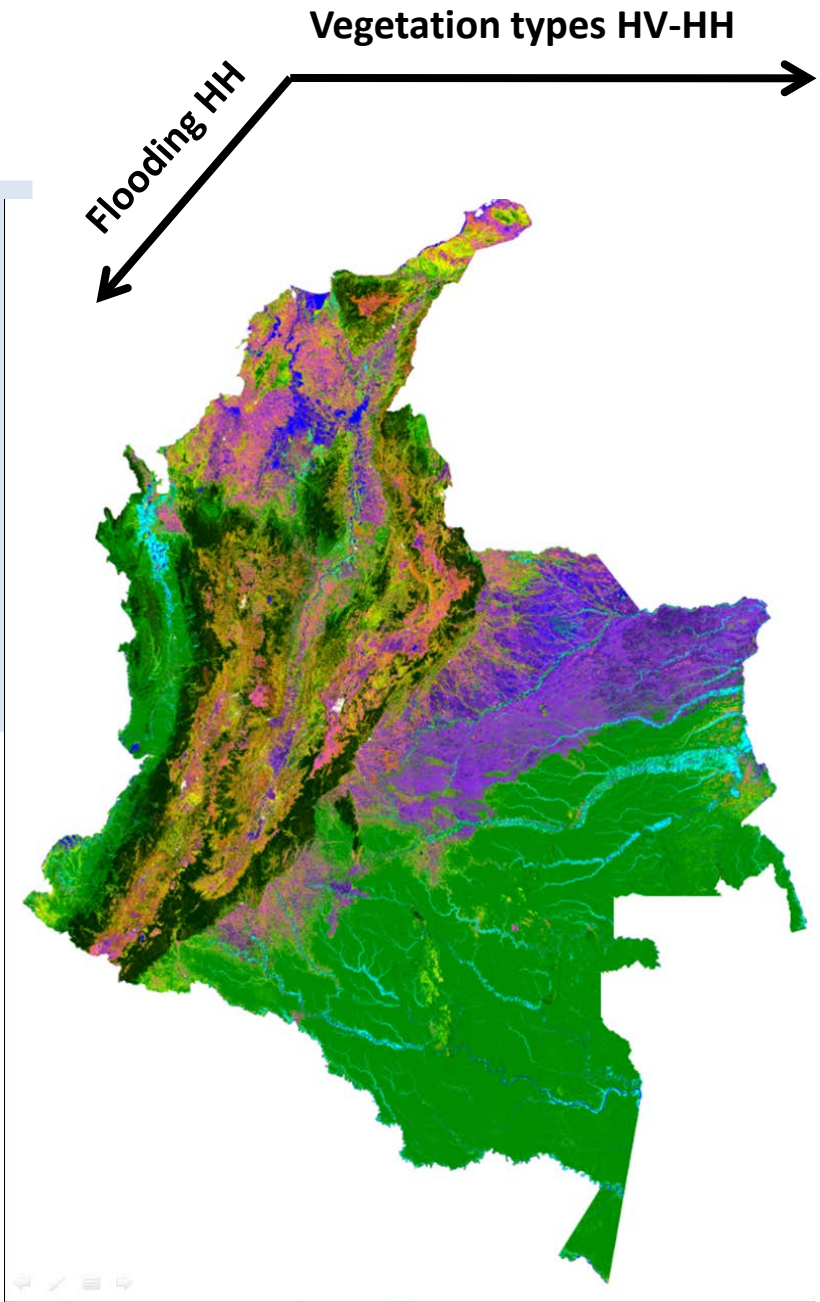
# Vegetation analysis from Alos PalSAR

**Wetland definition using AlosPalSAR**

***Vegetation structural Mapping:*** **Analysis of flooding vegetation types**

- Legend LCCS combination of structure and wetness or Flooding occasionally/ Temporarily/permanently

**Approach:** ***Combination of Supervised and unsupervised classification and field information***



# Results: 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 | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 |

193 strips
FBD_HV/HH
FBS-HH
50 m

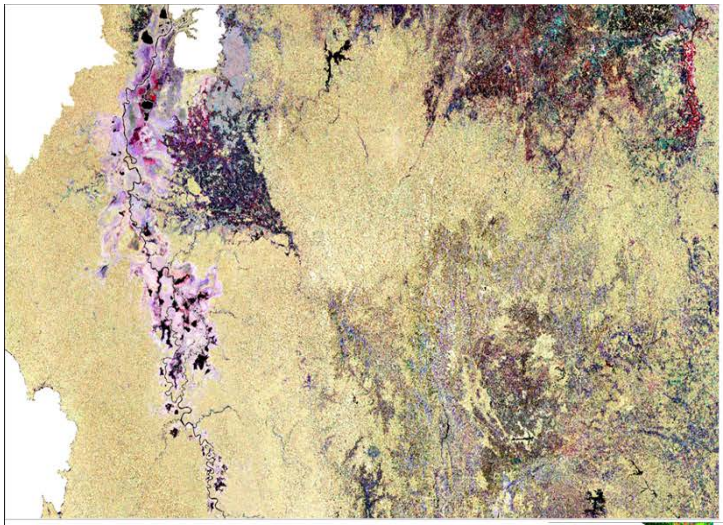



**Approach:** ***Combination of Supervised and unsupervised classification and field information***

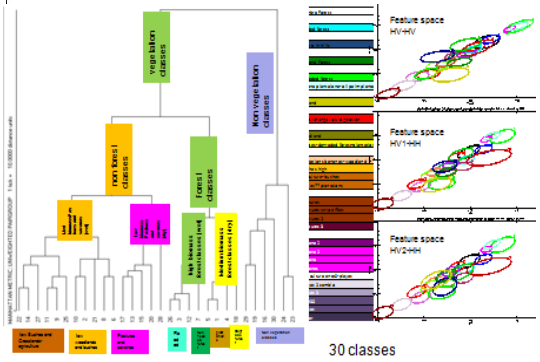
4 mosaics FBD Wet season
2 FBS Dry season

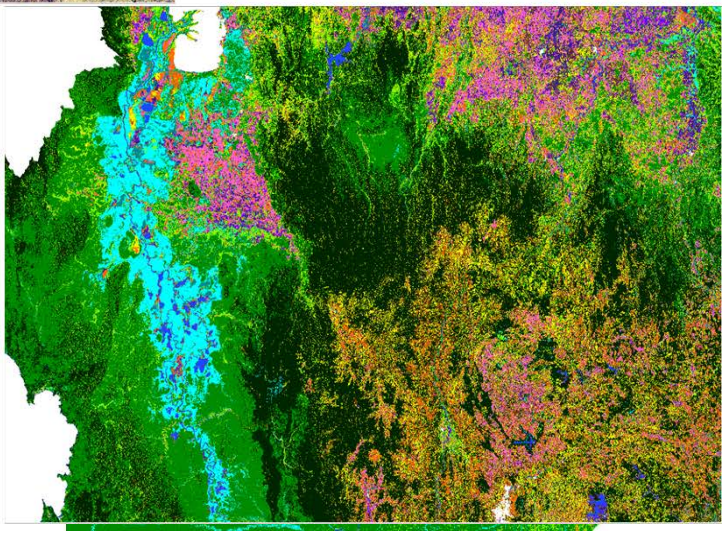
•Olofsson P, G.M. Foody, S.V. Stehman, C.E.Woodcock, C.E.Woodcock, M.A. Wulder. (
Making better use of accuracy data in land change studies: Estimating accuracy and
area and quantifying uncertainty using stratified estimation Remote Sensing of Environment 129 (2013) 122–131

# Results: Structural Vegetation Map created only with Alos PALSAR



Atrato-Choco



| | Cobertura | LCCS Code |
|---|---|---|
| | Bosque | 20596-13221-L1L5O1O14 |
| | Bosque | 20596-13221-L25L8O1O14 |
| | Arboladas | 20791-4186-O1O14(1) |
| | Agua | |
| | Bosque | 41024-33981-L1L5O1O14(2) |
| | Vegetación secundaria | 21380-7285-O1O14 |
| | Arbustales densos | 20969-13395-O1O14 |
| | Arbustales | 21089-4358-O1O14 |
| | Arbustales abiertos | 40789-39611-L1L5O1O14 |
| | Pastizales | 21348-218-O1O14 |
| | Sabanas | 21348-3222-O1O14 |
| | Sabanas Húmedas | 40864-30567-O1O14 |
| | Areas construidas | 5003-13 |

Validation:
92 % accuracy

# Some highlights into the Validation Process

- Validation is performed by IDEAM Institute that didn´t participated in map production
- 19 validation windows  representing the main wetland complexes of the country
- Use of high resolution images, and other radar data available RADARSAT

Preliminary results:

- Good detection for flooded forests and water mirrors
- We have problems with confusion between water and dry shrubs and dry pastures  and bare soils with open areas (reflection of the wave  in this covers)
- City peripheries  appear to be flooded due to double bounce
- Since the diversity of Colombia is very high the Validation process is still I progress.
- Final report will include confusion matrixes

# Validation results overall accuracy!

$$\hat{p}_{\cdot 1} = \sum_{i=1} W_i \frac{n_{i1}}{n_{i\cdot}}$$

$$\hat{A}_1 = A_{tot} \times \hat{p}_{\cdot 1}$$

| MATRIZ DE ERROR | | referencia: Inundación a cielo abierto | referencia: Inundación bajo dosel | referencia: No inundado | Total comisión | Fiabilidad |
|---|---|---|---|---|---|---|
| Mapa | Inundación a cielo abierto | 1704 | 12 | 67 | 1783 | 0.955692653 |
| | Inundación bajo dosel | 2 | 1326 | 455 | 1783 | 0.74 |
| | No inundado | 31 | 288 | 7422 | 7741 | 0.96 |
| Total Omisión | | 1737 | 1626 | 7944 | 11307 | **0.89** |
| Precisión | | 0.98 | 0.82 | 0.93 | **0.91** | 0.924383125 |

Structural Vegetation Map

| MATRIZ DE ERROR | | referencia: Inundación a cielo abierto | referencia: Inundación bajo dosel | referencia: No inundado | Total comisión | Fiabilidad |
|---|---|---|---|---|---|---|
| Mapa | Inundación a cielo abierto | 1487 | 35 | 139 | 1661 | 0.895243829 |
| | Inundación bajo dosel | 166 | 1148 | 355 | 1669 | 0.69 |
| | No inundado | 117 | 167 | 5581 | 5865 | 0.95 |
| Total Omisión | | 1770 | 1350 | 6075 | 9195 | **0.84** |
| Precisión | | 0.84 | 0.85 | 0.92 | **0.87** | 0.893529092 |

Frequency flooding 50m

| MATRIZ DE ERROR | | referencia: Inundación a cielo abierto | referencia: Inundación bajo dosel | referencia: No inundado | Total comisión | Fiabilidad |
|---|---|---|---|---|---|---|
| Mapa | Inundación a cielo abierto | 1176 | 42 | 606 | 1824 | 0.644736842 |
| | Inundación bajo dosel | 151 | 1095 | 474 | 1720 | 0.64 |
| | No inundado | 71 | 161 | 5997 | 6229 | 0.96 |
| Total Omisión | | 1398 | 1298 | 7077 | 9773 | **0.75** |
| Precisión | | 0.84 | 0.84 | 0.85 | **0.84** | 0.846004298 |

Frequency flooding 100m

# Working perspectives

Consolidate a 10 years national flooded and vegetation types base line to: **Use of PalSAR 2 and Sentinel (C band) programs will be essential to complete the baseline**

- Understand the hydrologic dynamics of the Colombia wetlands

- Determine the structure and extension of the wetland vegetation types to provide information to the environmental agencies for restoration and compensation projects (mining and infrastructure)

- Offer information for wetland zoning and management process based in flooded frequencies

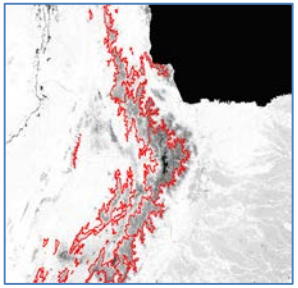
- Use of MODIS information and other optical high resolution for delineation at more detail

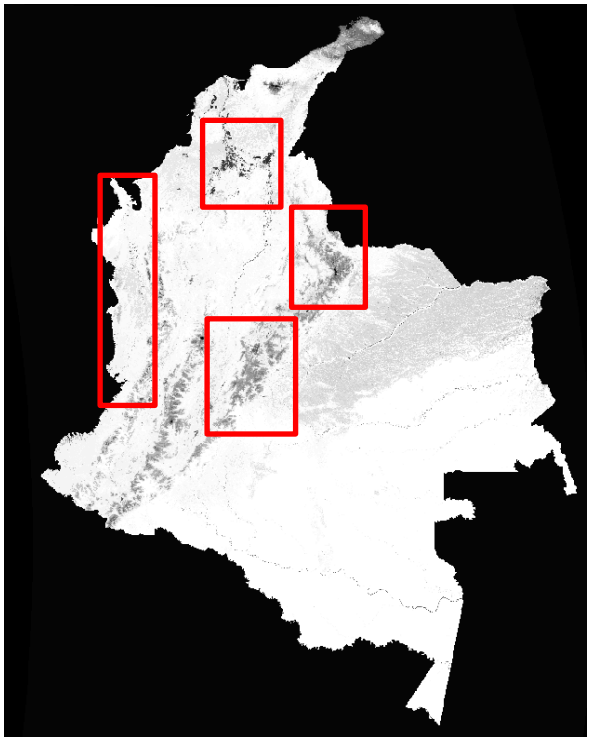
- We already applied to imagery from **Venus – ESA program**

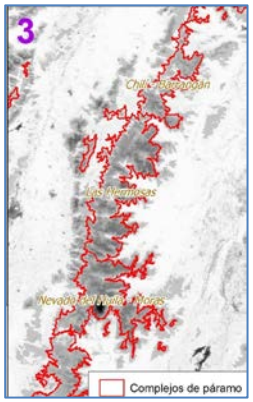
# Combination of optical and radar systems

## MODIS

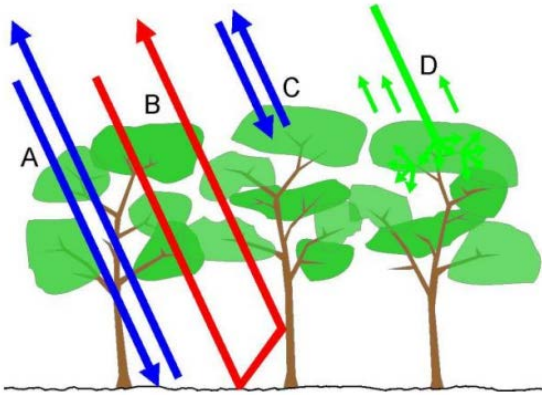




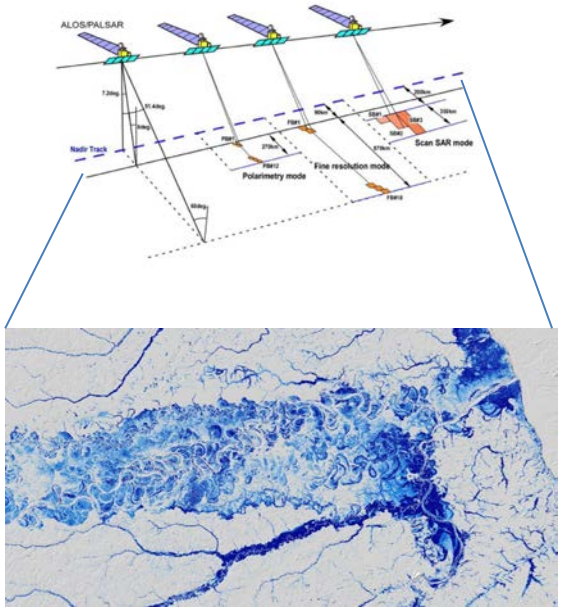





## Radar – double bounce




## Nesting observations



# Conclusions

- Colombia already has the map of wetlands ecosystems for the entire country to conservation and management programs
- Around of 30 % of the country are wetlands
- Radar information is a very useful tool to detect open and under vegetation flooded, but it works better in low land flooded forests than in mountain areas.
- We want to establish a monitoring system based in passive and active imagery

**Acknowledgements:**

**JAXA and K&C**

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**Marcela Quinones & Martin Vissers - SarVision**

Jeronimo Rodriguez, Ursula Jaramillo, Sandra Vilardy, Lina Estupiñan, Cesar Aponte**. Humboldt Institute**

Ana Maria Pacheco & Beatriz Alzate **IDEAM**

Carlos Pedraza: **TNC**

Dalton Valeriano **INPE**








# Thank You !!

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