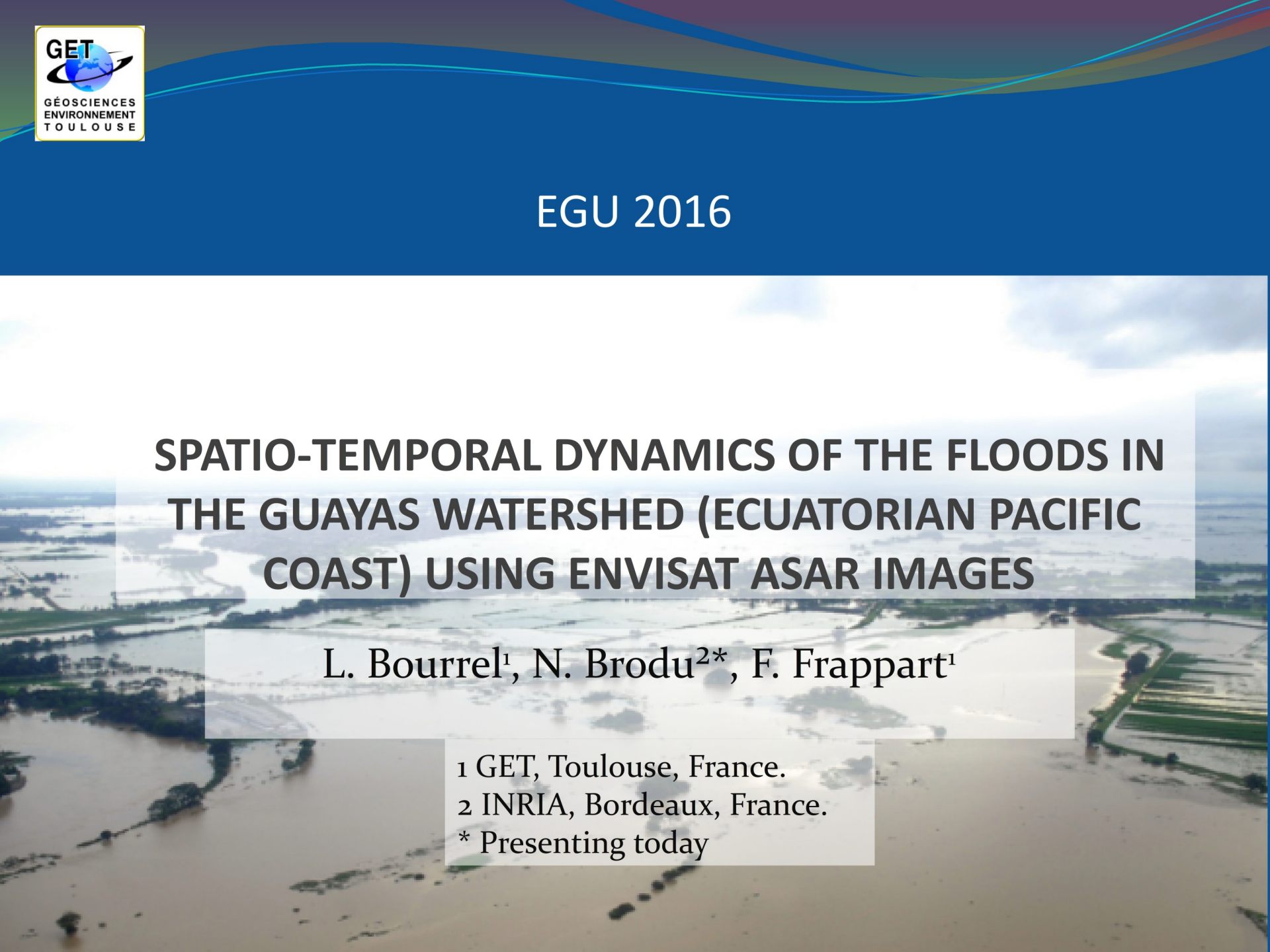


EGU 2016



**SPATIO-TEMPORAL DYNAMICS OF THE FLOODS IN
THE GUAYAS WATERSHED (ECUATORIAN PACIFIC
COAST) USING ENVISAT ASAR IMAGES**

L. Bourrel¹, N. Brodu^{2*}, F. Frappart¹

¹ GET, Toulouse, France.

² INRIA, Bordeaux, France.

* Presenting today

Introduction

Flood on the Pacific Ecuadorian coast:

- Annual phenomena with large interannual variability.
- Larger amplitude during El Niño events.
- Impact on environment, society and economy as it affects $\approx 40\%$ of the population and agriculture (50 % of GDP).

Goals:

- Developing an approach based on the use of SAR images to identify flooded areas.
- Better understanding the spatio-temporal dynamics of the annual floods.
- Study period: 2004 - 2008.

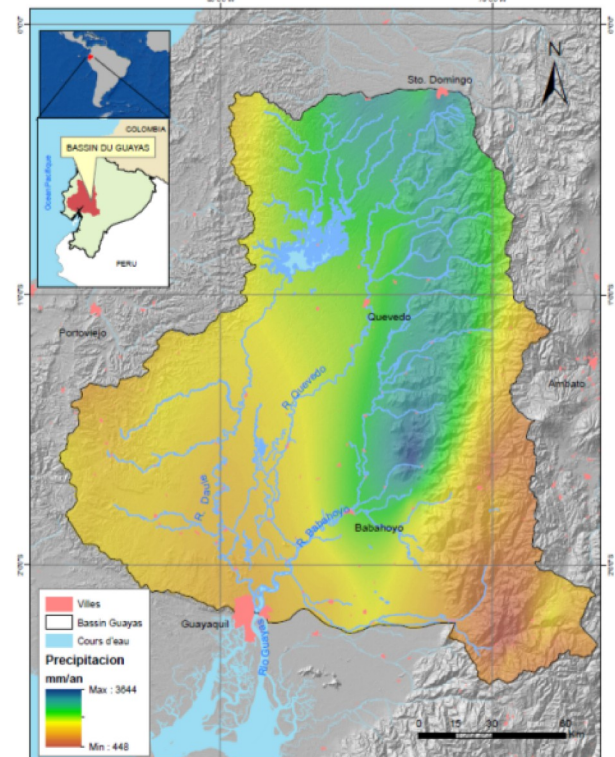
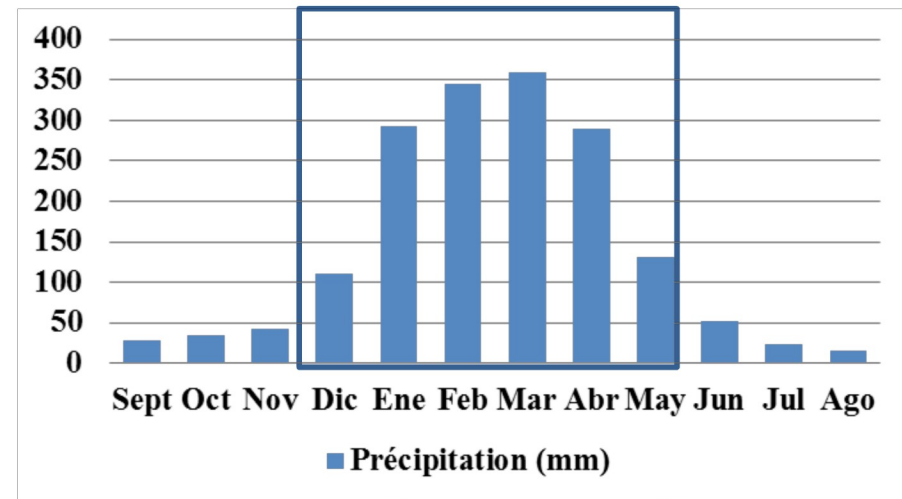


Study area: the Guayas Basin

- Guayas drainage basin (**32,300 km²**).
- The **largest drainage basin** in the Pacific coast of South America

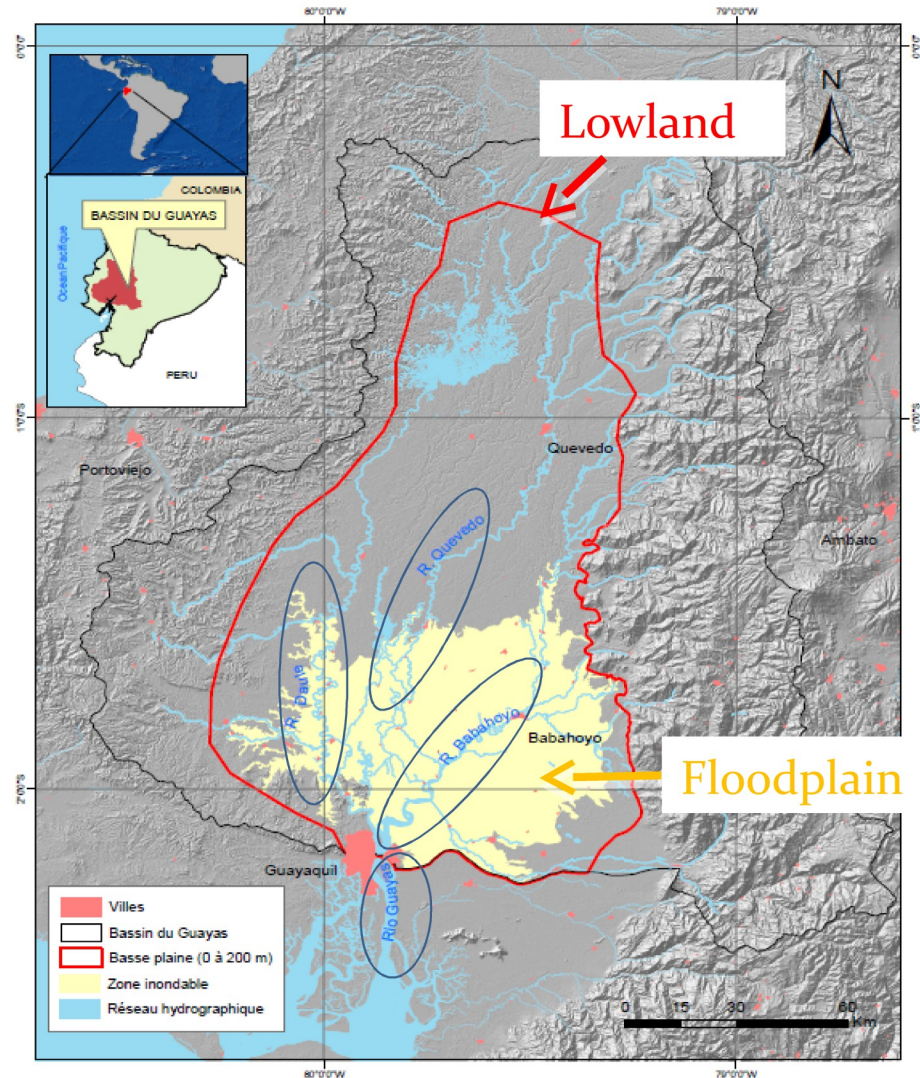
Well marked seasonal cycle : Wet season (December - May) / Dry season (June - November)

The annual average rainfall in the drainage basin is \approx **1850 mm** during the hydrological year (September – August)



Physical characteristics of the Guayas Basin

- Lowland:
Elevation between 0 et 200 m a.s.l.
15,000 km²
- Floodplain:
Represents 30% of the lowland
≈ 5,000 km².
- River network:
Guayas River
Babahoyo, Quevedo and Daule
tributaries



Datasets (2004 – 2008)

- **Radar images**

Radar images are less affected by meteorological and environmental conditions than multispectral ones.

ENVISAT ASAR images:

- ENVISAT = ENVironment SATellite. Launched by the European Space Agency (ESA) in 2002.
- **GM** = Global Mode
 - C Band ($\lambda = 5.6$ cm).
 - Spatial resolution : 1 km
 - 220 images available over the Guayas basin

- **Land cover map:**

MAGAP, Ecuador (2002)

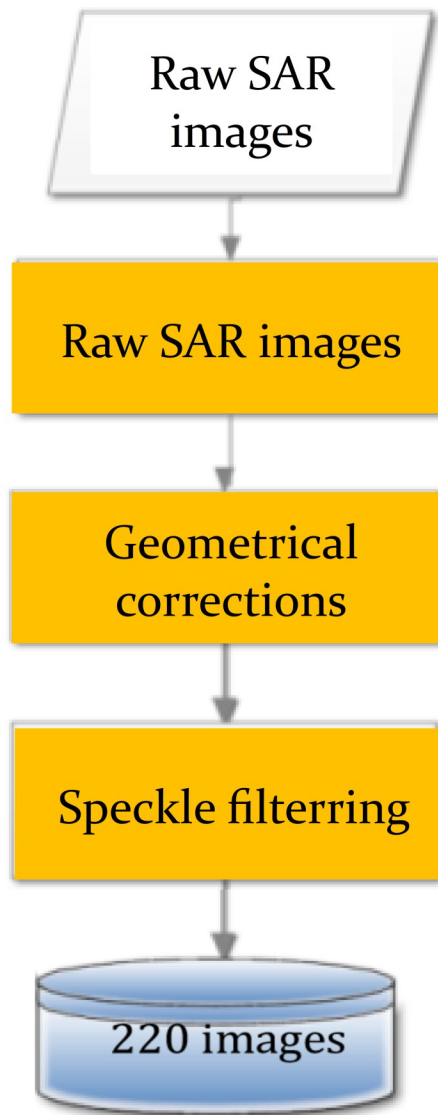
- **Rainfall:**

Monthly data from INAMHI (Ecuador)

Méthod (1/3)

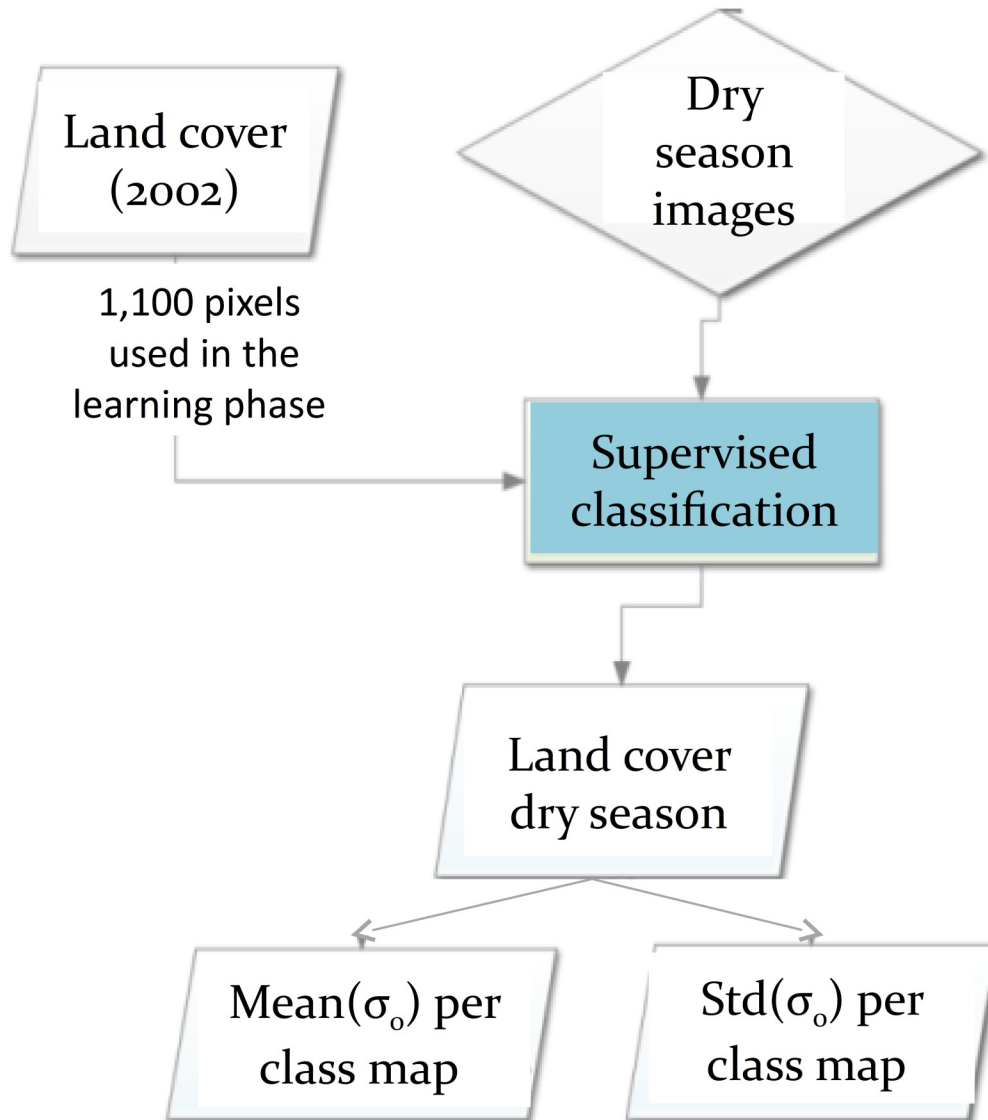
Data preprocessing :
from raw images

Amplitude/power images



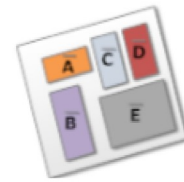
Méthod (2/3)

Supervised classification of SAR images during the dry season using Maximum Likelihood
→ Land cover map of the Guayas floodplain

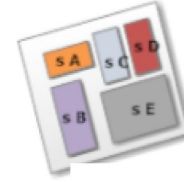


Method (3/3)

Images from the wet season



Mean(σ_o) per class map



Std(σ_o) per class map



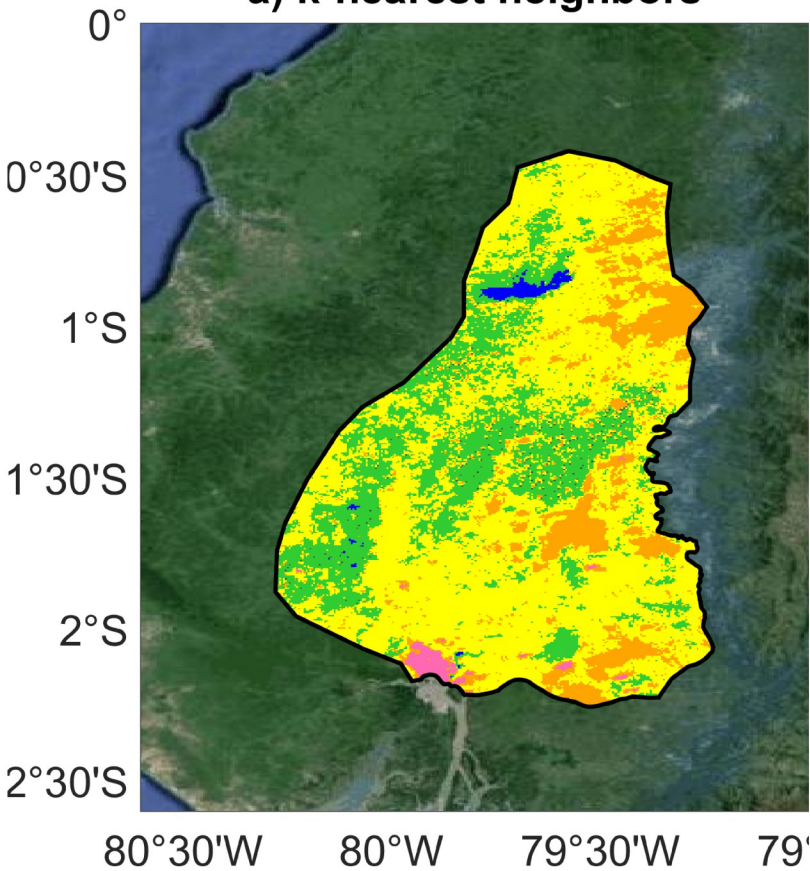
$$\Delta\sigma_o(\lambda, \varphi, t) = \frac{\sigma_o(\lambda, \varphi, t) - \langle \sigma_o(\lambda, \varphi) \rangle_{dry}}{std(\sigma_o(\lambda, \varphi, t))_{dry}}$$



- Identification of flooded areas**
 Analysis of the changes that occurred between the dry and wet seasons to detect the flooded pixels present in the floodplain.
- Computation of the standardized anomalies**
 Negative values represent wetlands and flooded areas.
 Identification of the threshold for floodplains detection.

Image classification during the dry season

a) k-nearest neighbors



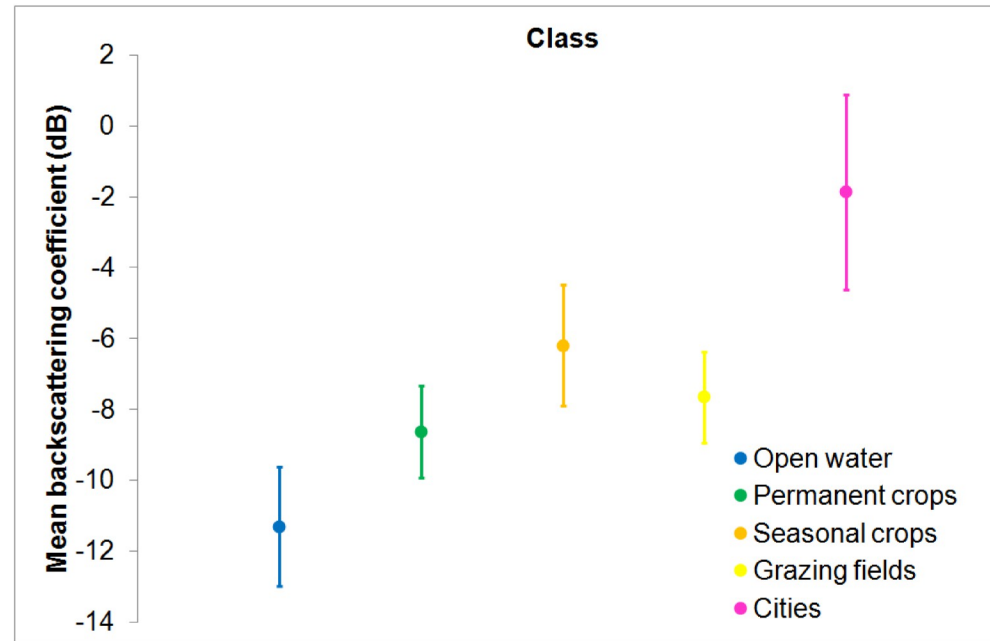
- 16 images were used corresponding to the dry seasons of 2004 – 2008 period
- 5 classes identified:

| | |
|---------|--|
| Class 1 | Open water |
| Class 2 | Mostly tropical arboriculture |
| Class 3 | Mostly seasonal crops |
| Class 4 | Agricultural crops mosaic, mostly pastures |
| Class 5 | Towns |

- **Validation of the results:**
Confusion matrix: Mean accuracy around 93%

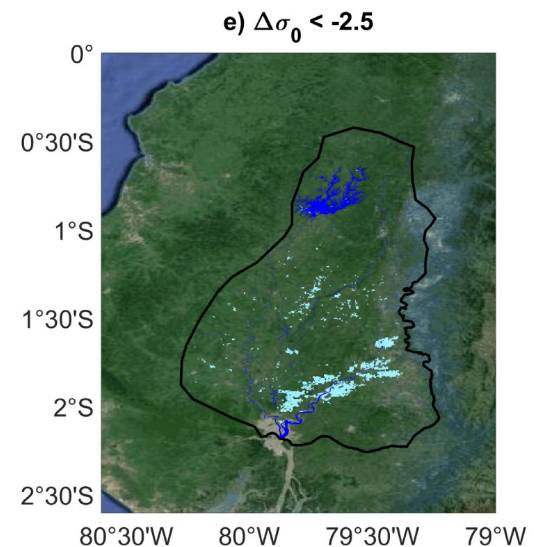
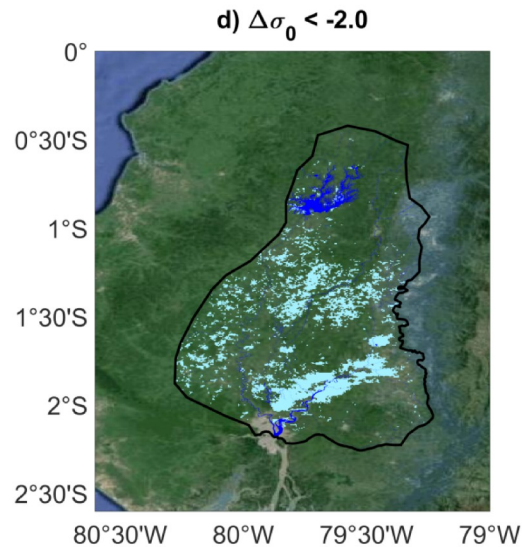
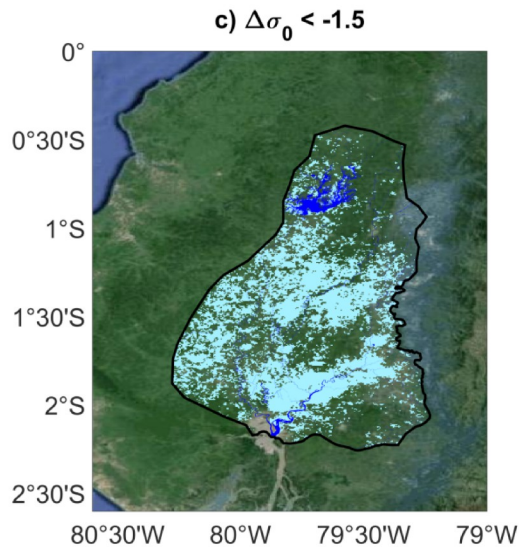
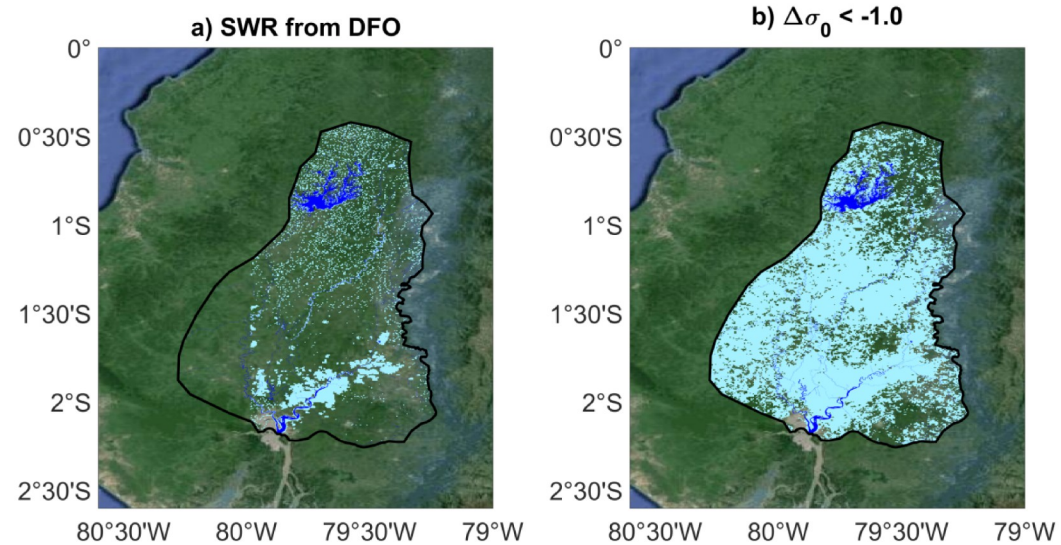
Image classification during the dry season

- Values corresponding to open water are the lowest, and well separated from the other classes.
- Backscattering coefficients from open water and towns are very different from the other classes. The distance separating the vegetation classes are lower.
- Low variability of the backscattering coefficient of each class during the 4 dry seasons.



Identification of flooded areas

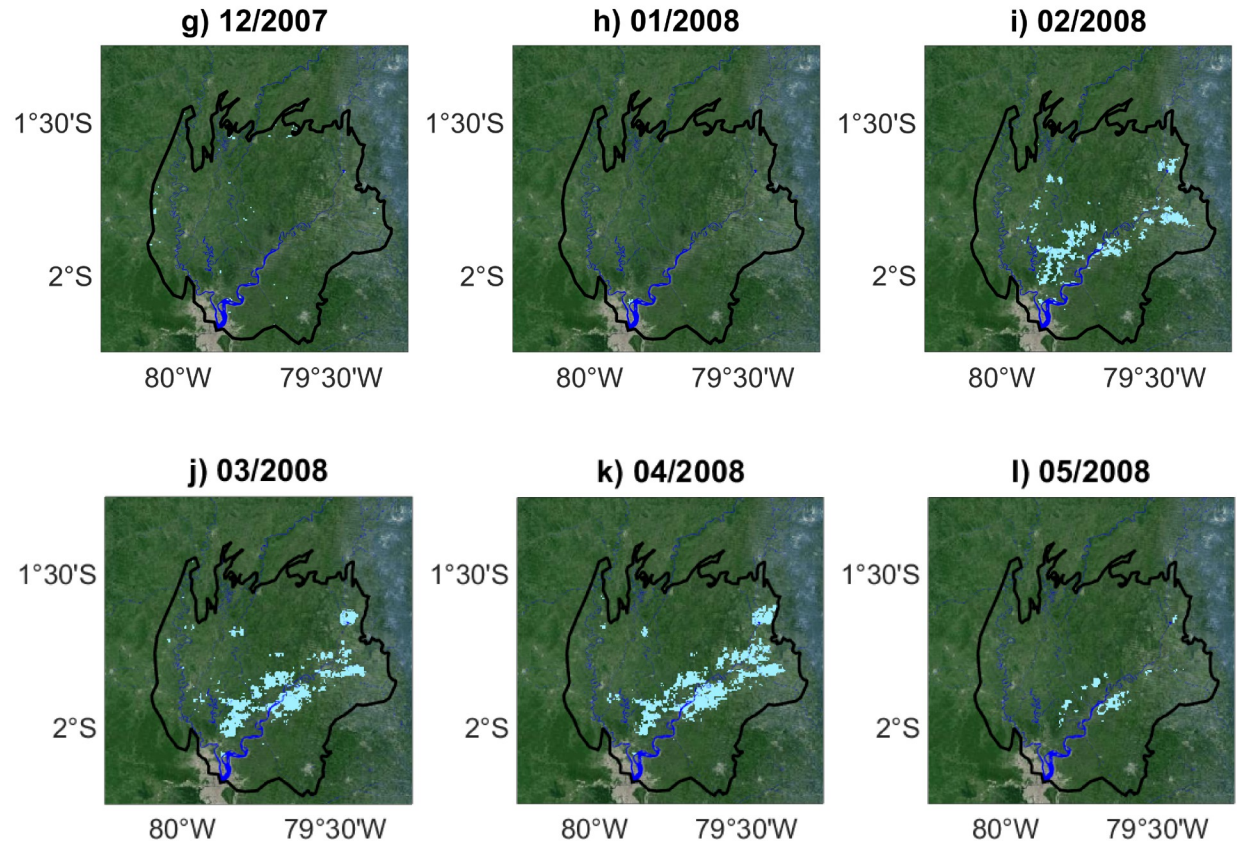
- Computation of backscattering coefficient anomalies acquired during the wet season between 2004 and 2008
- Thresholds on the negative standardized anomalies of backscattering coefficients.



Results and discussion (4/6)

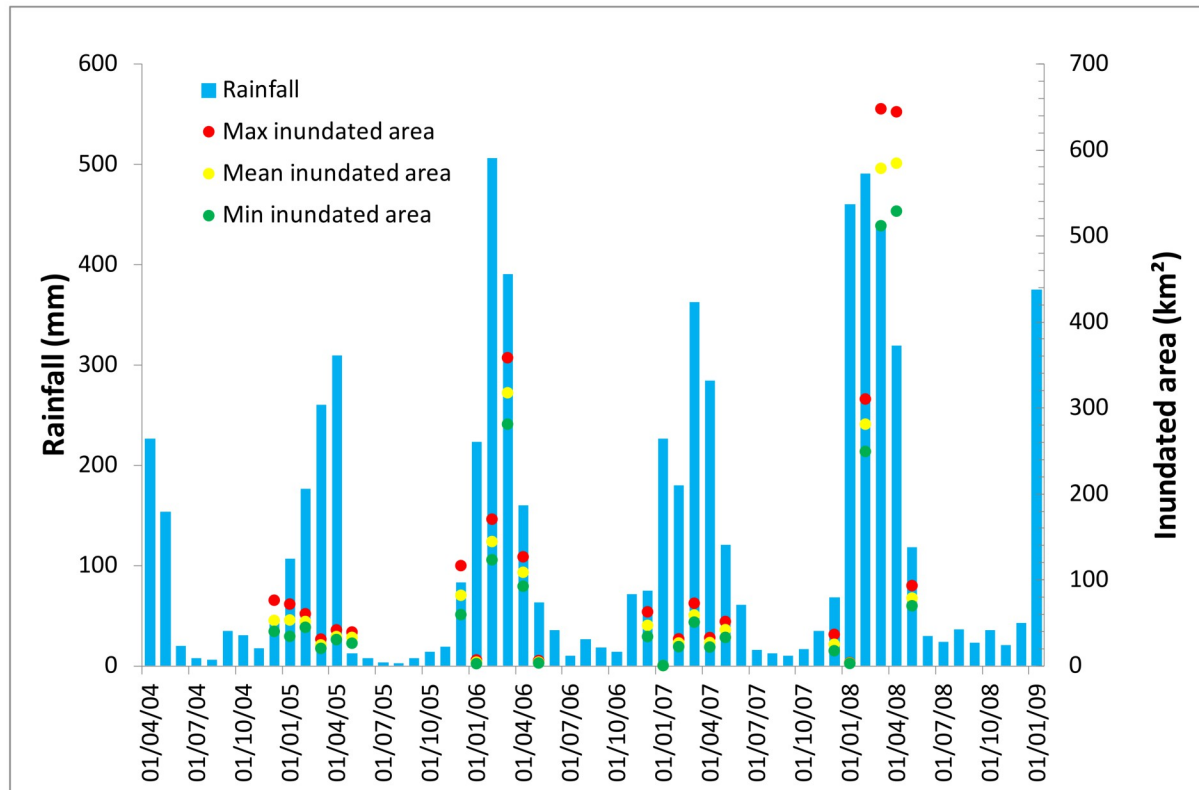
Spatiotemporel monitoring of the floded areas (2005 – 2008)

- Inundations detected from February to May (wet season from December to May)
- Most flooded months: february and March.
- 2006 and 2008 exhibit the largest flooded areas.



Results and discussion (5/6)

Spatiotemporal monitoring of the flooded areas: relationship with the rainfall



Frappart et al., ISPRS J. Photogram. Remote Sens. (submitted)

Cumulated rainfall amount (February to May):

2006: 1 121 mm (normal year) → flooded areas = 13% total

2008: 1 366 mm (wet year: +20%) → flooded areas = 12% total

2005 and 2007: dry years(-33 % et -16 %) → flooded areas = 6% and 4% total

Conclusion and prospects

- **ASAR GM** with its spatial resolution of 1 km allows the monitoring of the **spatio-temporal dynamics of the flood in the Guayas basin**.
- **Images classification** during 4 **dry seasons** gives access to **land cover**. Results are consistent with external data sources.
- **Negative values of standardized anomalies of** backscattering coefficient between the dry and the wet season were used to identify **wetlands and floodplains** (use of a threshold).
- Depending on the years, **wetlands** are located in the lower part of the floodplain of the Guayas drainage basin along the three main tributaries originating from the Andes and the coastal cordillera.
- First step towards a more comprehensive study about the **spatio-temporal variability of the flood (seasonal and interannual)** in the Guayas drainage basin using multi-sensors and multi-resolution SAR images and their relationship with **ENSO**.
- Ongoing work on Sentinel-1: 1 km/pixel → 20m/pixel, higher acquisition rate AND we combine with Sentinel-2 for reference land use maps in the dry season ⇒ Huge amount of data to process

Thank you for your attention

