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

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* 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 ≈ 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 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 ≈ 1850 mm during the hydrological year (September – August)
Physical characteristics of the Guayas Basin

- Lowland:
  Elevation between 0 et 200 m a.s.l.
  \(15,000\) km\(^2\)

- Floodplain:
  Represents 30% of the lowland
  \(\approx 5,000\) km\(^2\).

- 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)
Data preprocessing:
from raw images

Amplitude/power images

Raw SAR images

Geometrical corrections

Speckle filtering

220 images
Supervised classification of SAR images during the dry season using Maximum Likelihood

→ **Land cover map of the Guayas floodplain**

- **Land cover (2002)**
  - 1,100 pixels used in the learning phase

- **Dry season images**

- **Supervised classification**

- **Land cover dry season**

- **Mean($\sigma_o$) per class map**

- **Std($\sigma_o$) per class map**
Method (3/3)

- **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.
Results and discussion (1/6)

Image classification during the dry season

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

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Open water</td>
</tr>
<tr>
<td>Class 2</td>
<td>Mostly tropical arboriculture</td>
</tr>
<tr>
<td>Class 3</td>
<td>Mostly seasonal crops</td>
</tr>
<tr>
<td>Class 4</td>
<td>Agricultural crops mosaic, mostly pastures</td>
</tr>
<tr>
<td>Class 5</td>
<td>Towns</td>
</tr>
</tbody>
</table>

- **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)

Spatiotemporal monitoring of the flooded 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.

Spatiotemporal monitoring of the flooded areas: relationship with the rainfall

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