# Similarities and differences between meandering and anabranching rivers

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**Abstract**

Amazonian rivers are highly interconnected and dynamic systems. Their behavior depends, to a large extent, on their geomorphology, being classified in 1) meandering rivers (MR), characterized by high rates of migration and sinuosity, and 2) anabranching rivers (AR), known for forming several permanent channels and islands. A planimetric characterization of the main rivers of the Peruvian Amazon (Huallaga, Ucayali, Marañon, and Amazonas), spanning from the Andes to the Amazon lowland region, was carried out to understand their physical dynamics. By a multi-temporal analysis from 1987 to 2017 using Landsat images, a segmentation was made for each river based on 1) the characterization of the geological valley, 2) the confluence of important tributaries, 3) changes of the main channel through the years, and 4) planimetric variables such as confinement, bend length, amplitude, sinuosity, and asymmetry. As a result, a total of 160 sections were obtained, in which a new set of 25 metrics was applied, filtered from an initial set of 31 variables and their statistics (i.e. mean, variance, kurtosis, and skewness), calculated through different approaches (i.e. half-meander, full-meander, and full-river). The variables were standardized and principal component analysis (PCA) was performed. The resulting biplot showed a distinction between AR and MR, with a shared area consisting predominantly of Marañon and Huallaga sections. The average value of sinuosity was found more associated with the MR, while higher length and asymmetry variance values were more oriented to the AR. This study also indicated the similarity in the behavior of some river sections of different types, based exclusively on their morphometric characteristics. At the same time, revealed how some sections could not be differentiated from others despite being nominally different. In this scenario, the PCA highlighted the need for a complete set of statistics that can recognize different features of these rivers, capturing greater complexity. Thus, the evaluation and segmentation of these planimetric variables, according to their planform characteristics, allows a better understanding of their dynamics, providing accurate information for coherent decision-making.

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# SIMILARITIES AND DIFFERENCES BETWEEN MEANDERING AND ANABRANCHING RIVERS

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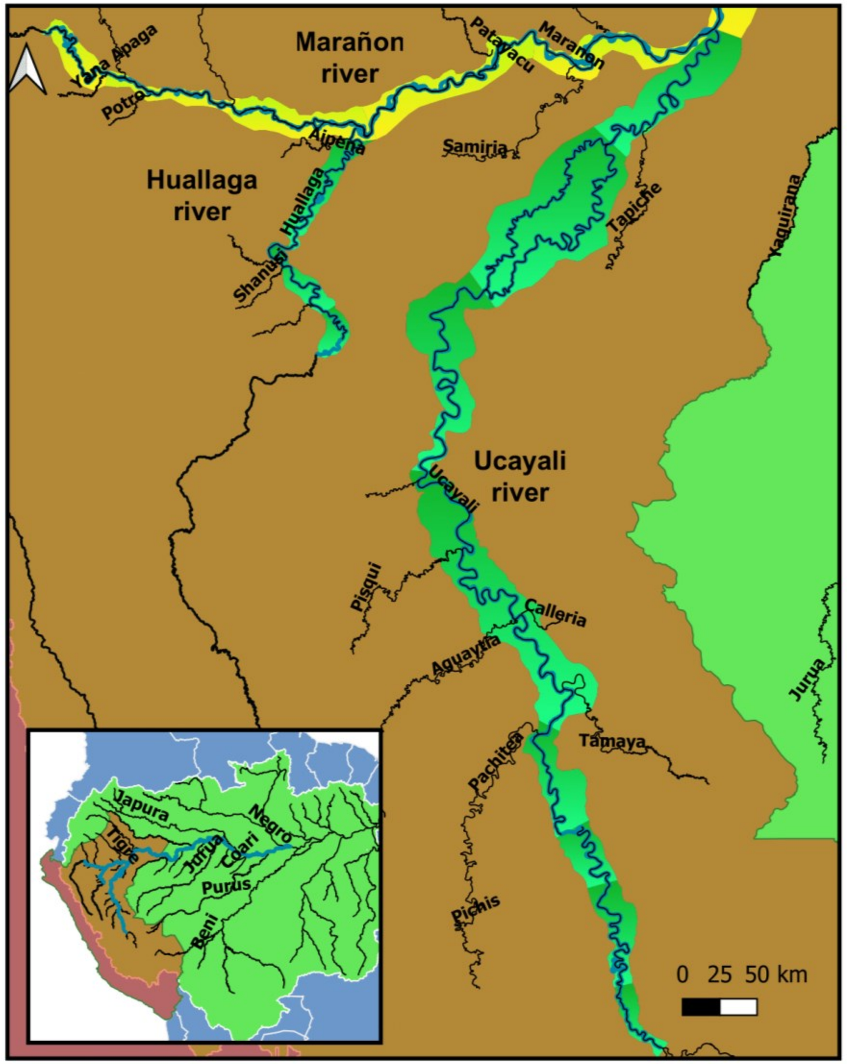
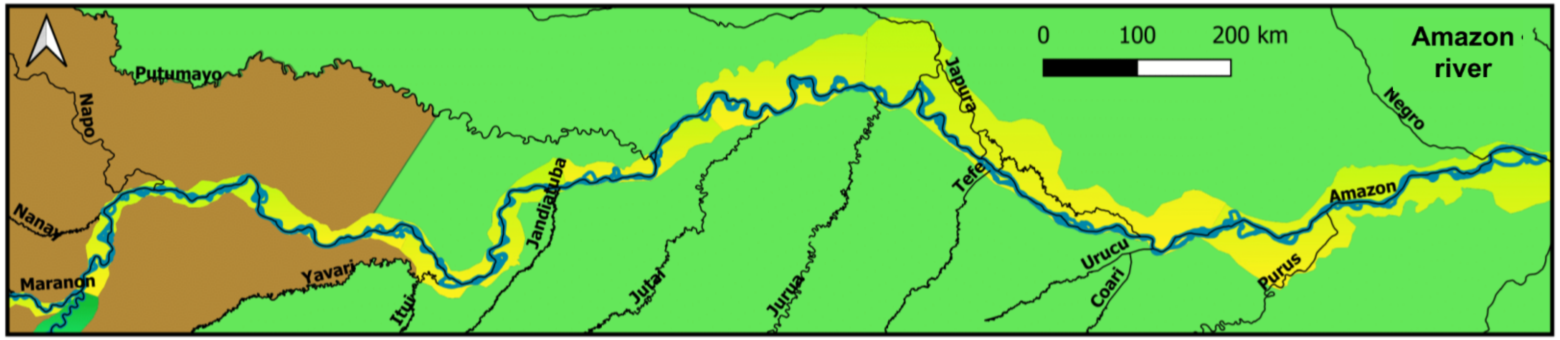
# CONTEXT




Four rivers of the Amazon basin:

- Lower Huallaga river (from "Pongo de Aguirre" to confluence with Marañon river).
- Lower Marañon river (from "Pongo de Manseriche to confluence with Amazon river)
- Ucayali river (from the confluence of Urubamba and Tambo rivers, to the confluence with Amazon river).
- Amazon river (from the confluence of Ucayali and Marañon rivers, to past the confluence with the Negro river).

# HIGHLIGHTS

## Multitemporal analysis

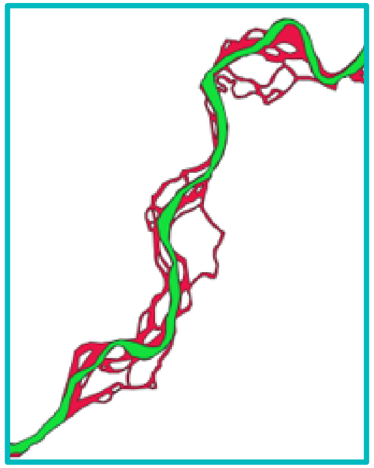
From: 1987 - 1989
To: 2017
Span: 4 (Meandering) and 6 (Anabranching) years

## Valley

Using DEM (30m) to delineate the geological valley.

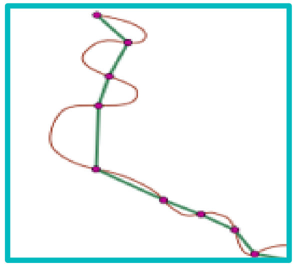
## River images

Images: Using Landsat 5, 7 and 8.
Temporal scale: Dry season (June to August).
Metrics: Mstat, R and QGIS



## Main channel centerline

For Anabranching: Selection of the wider channel.



## Inflection points

Half (two consecutive inflection points) and full meanders (two consecutive half meanders).

## Sections

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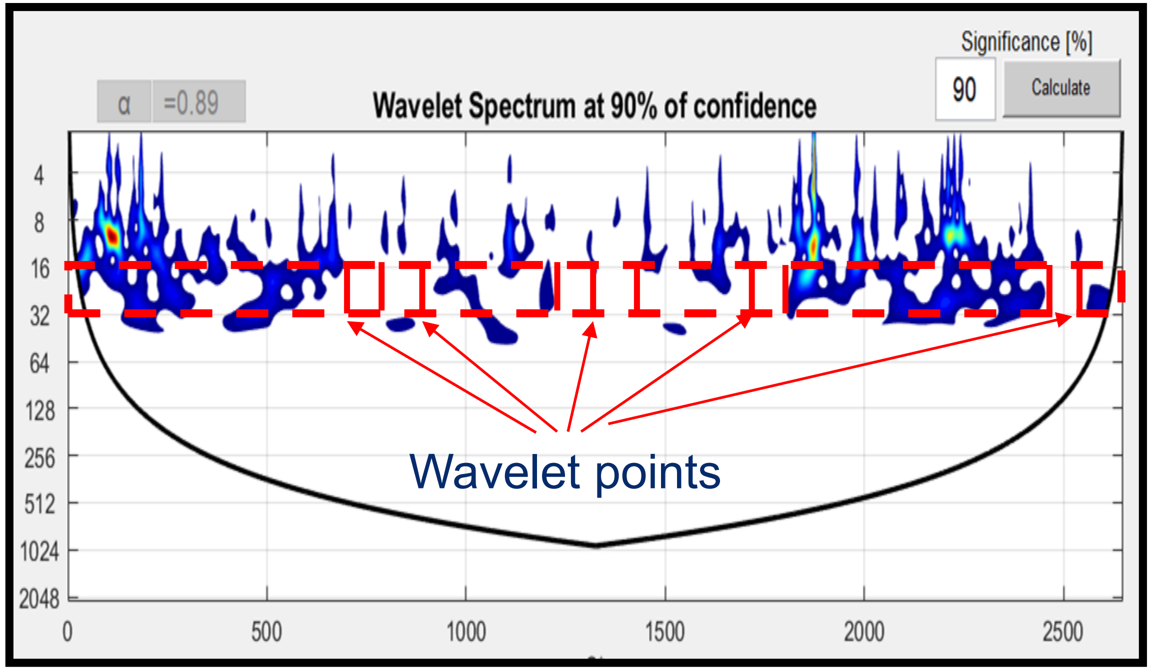
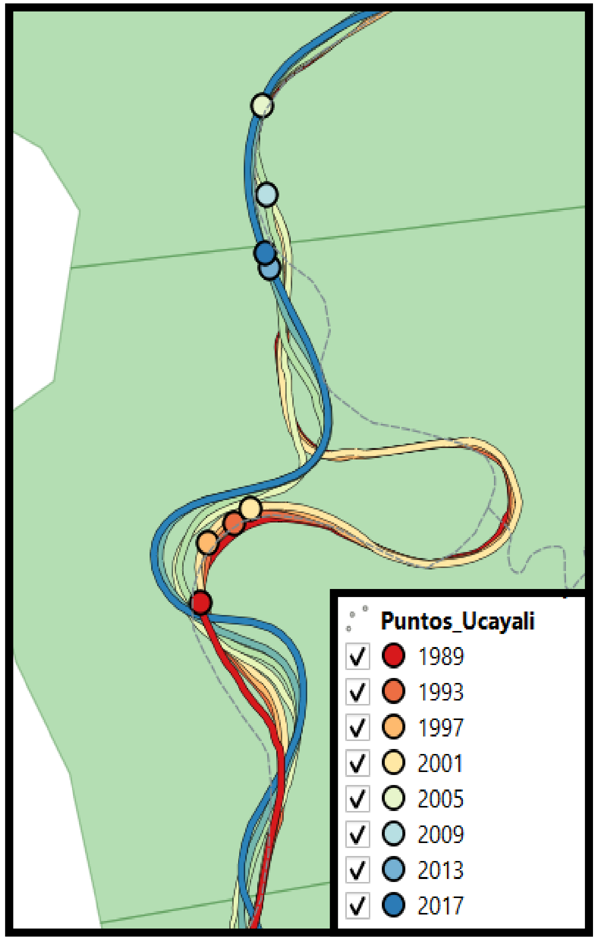
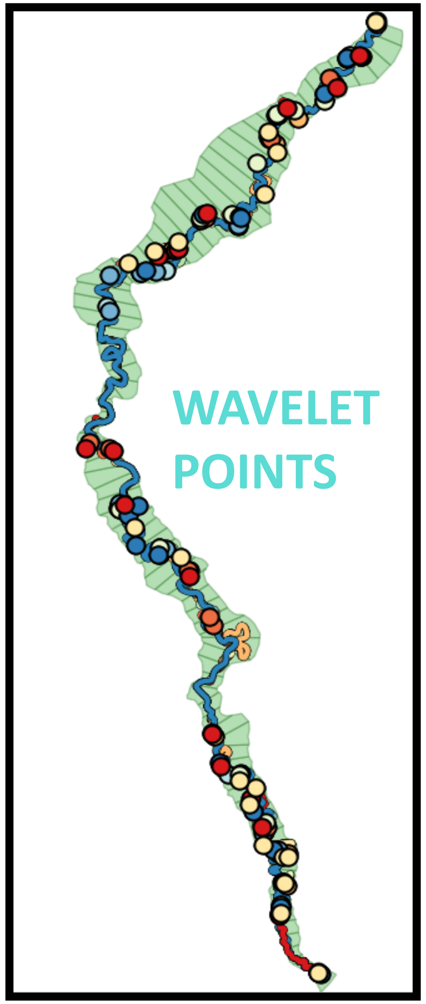
# SECTIONS

- Size of the half meanders (using wavelets) for all years.

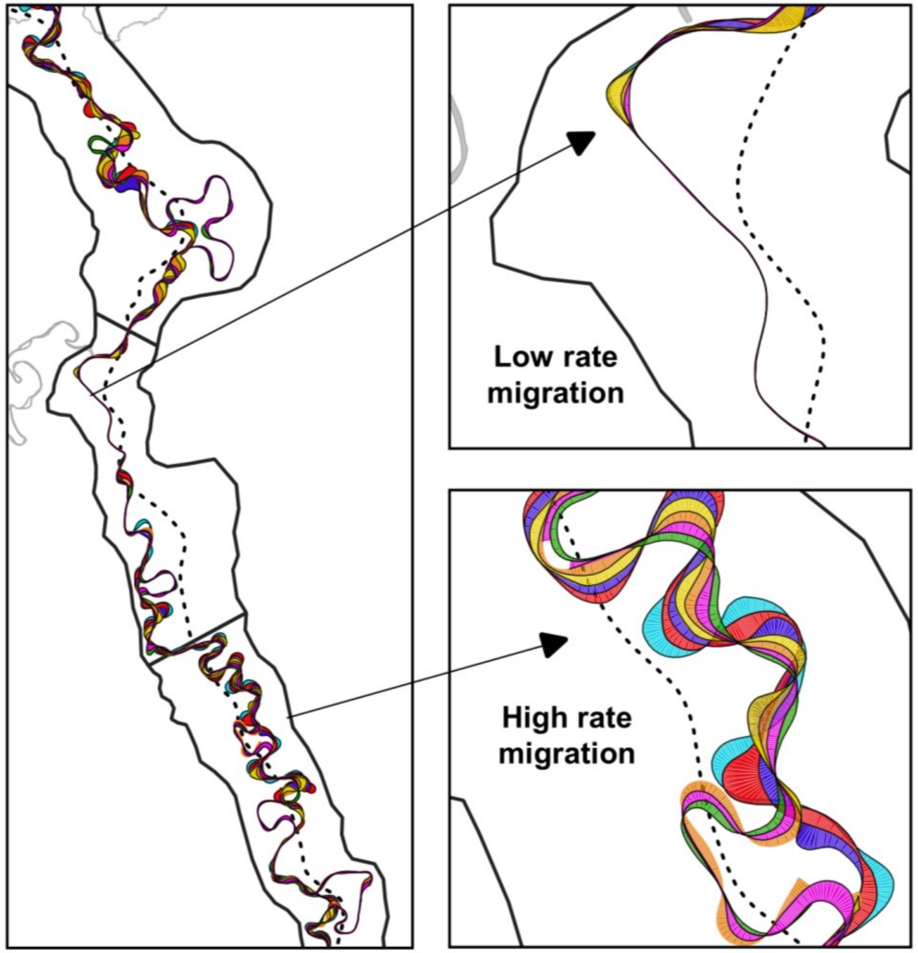


# SECTIONS

- Multitemporal river behavior (migration rates).
- Valley restrictions (confinement or river redirection).
- Tributary rivers.



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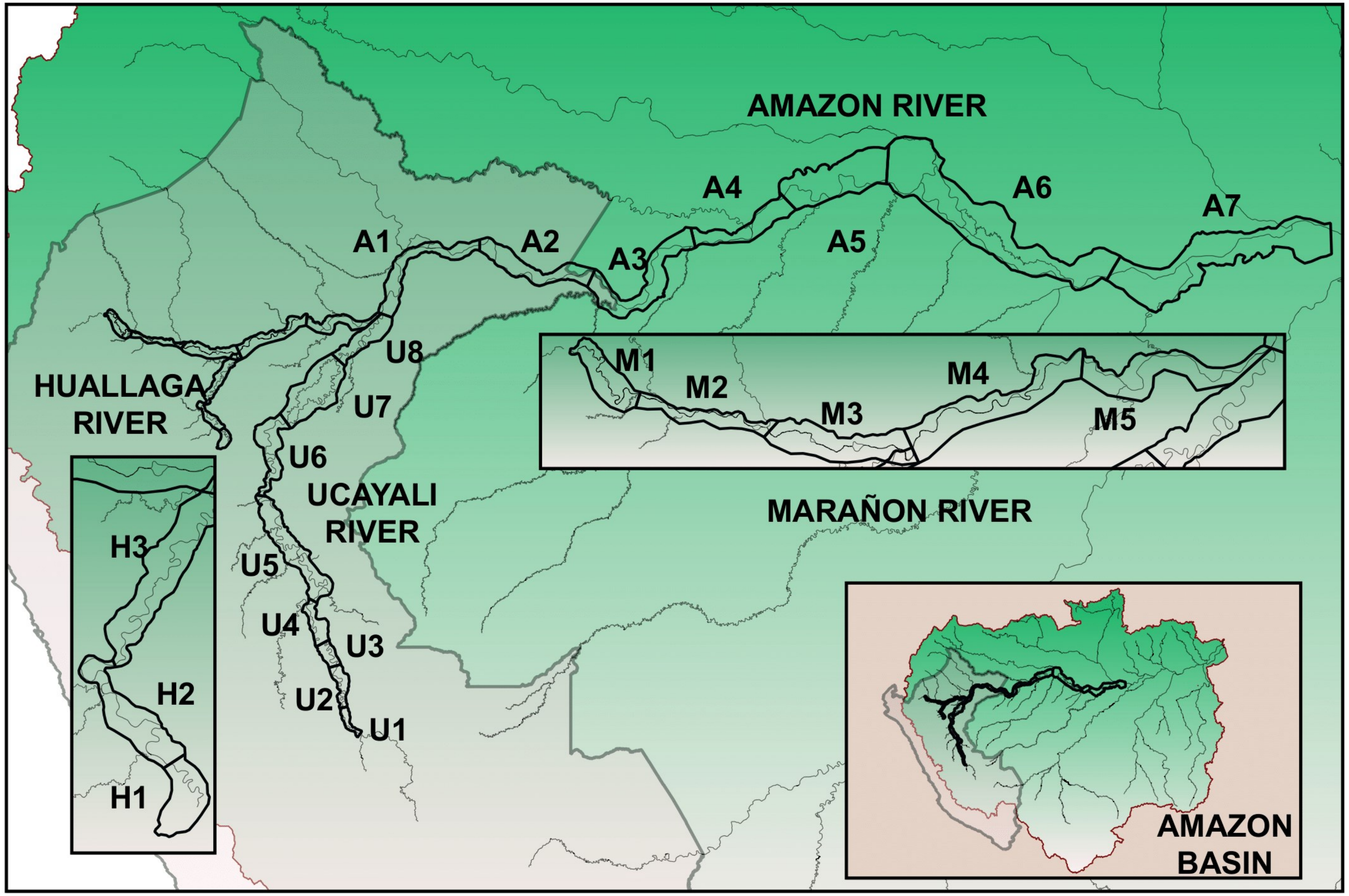


# TOTAL SECTIONS

- Amazon: 7
- Huallaga: 3
- Ucayali: 8
- Marañon: 5

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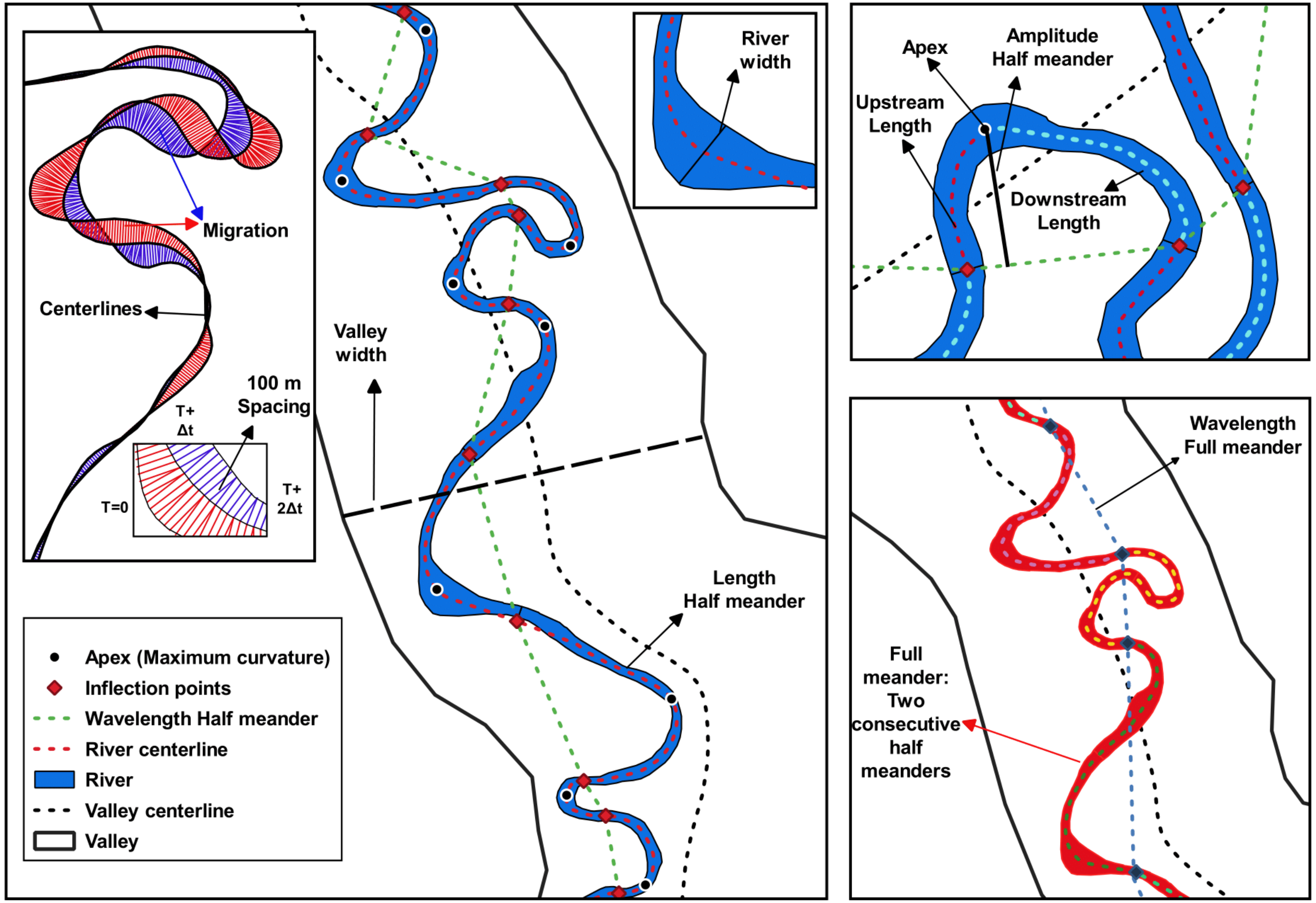
# VARIABLES

- Migration rates
- $\frac{Length}{Width}$
- $\frac{Valley\ width}{Amplitude}$
- Confinement: $\frac{Valley\ width}{River\ width}$
- Sinuosity: $\frac{Length}{Wavelength}$
- Asymmetry: $\frac{Upstream\ -\ Downstream}{Length}$



# VARIABLE STATISTICS

- **Half meander**
  - Length/ Width
  - Valley/ Amplitude
  - Sinuosity
  - Confinement
  - Asymmetry
- **Full meander**
  - Length/ Width
  - Sinuosity
- **Full river**
  - Sinuosity
  - Migration (sum)
  - Migration rate (mean)

| | |
|---|---|
| Mean | Variance |
| Kurtosis | Skewness |

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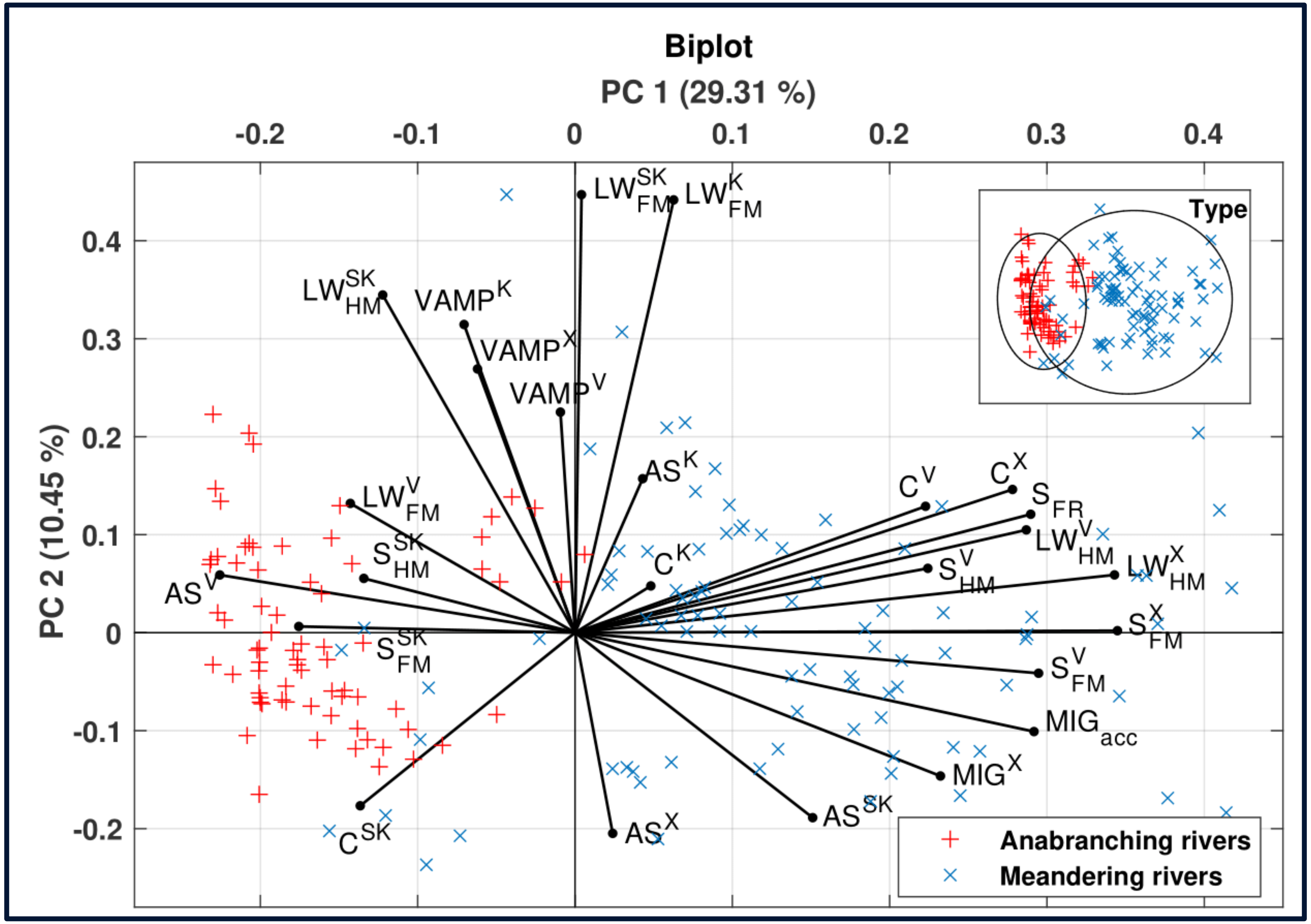
# PCA

## Anabranching

- More variance in Asymmetry.
- Valley/Amplitude variables more associated.




## Meandering

- Lower mean confinement (elevated values).
- Higher Sinuosity.
- Elevated rate of Migration.

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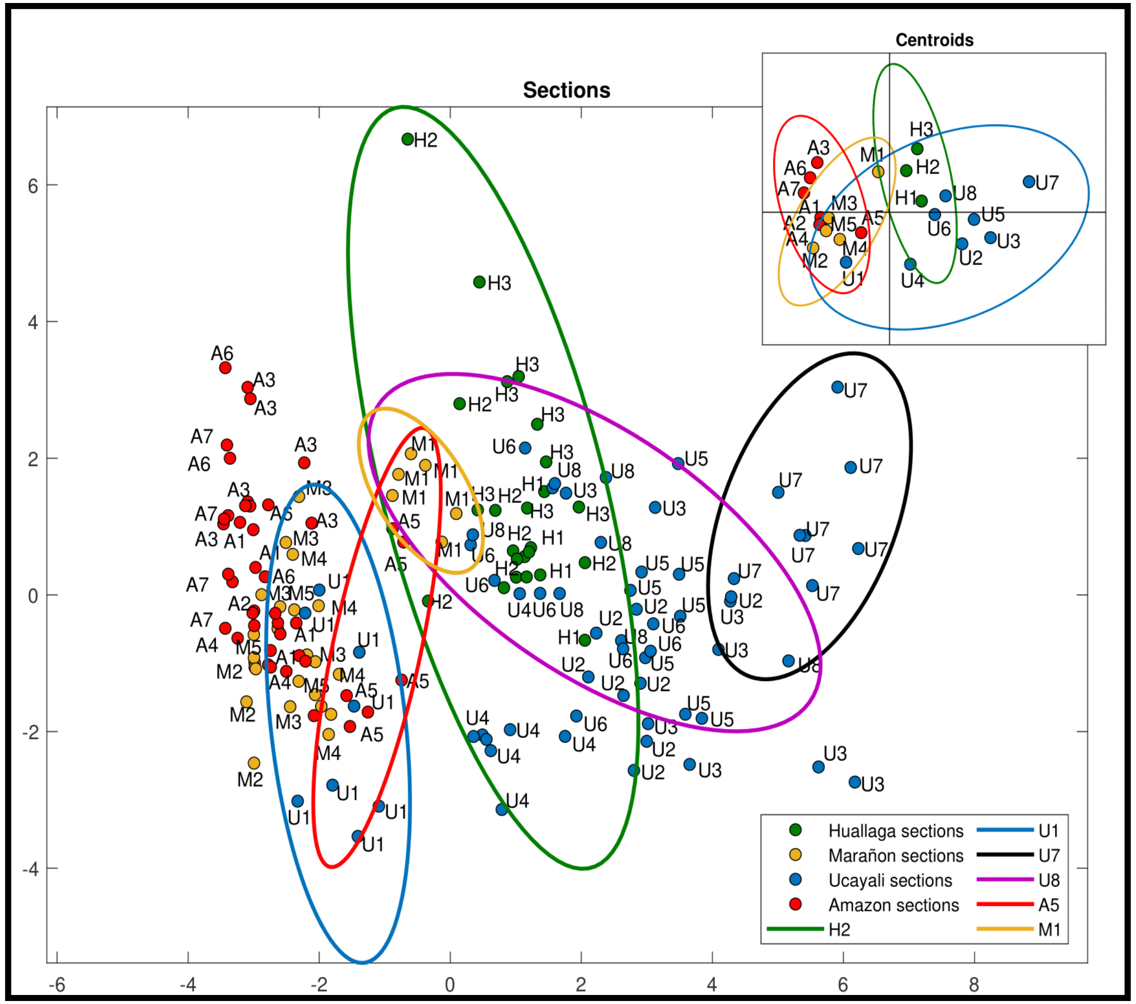


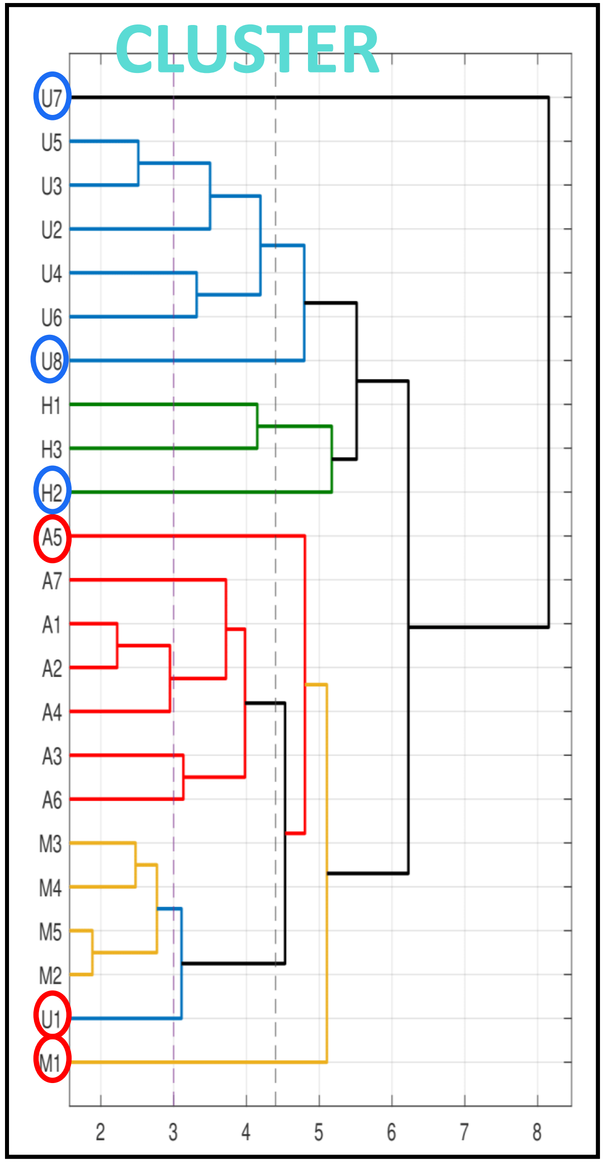


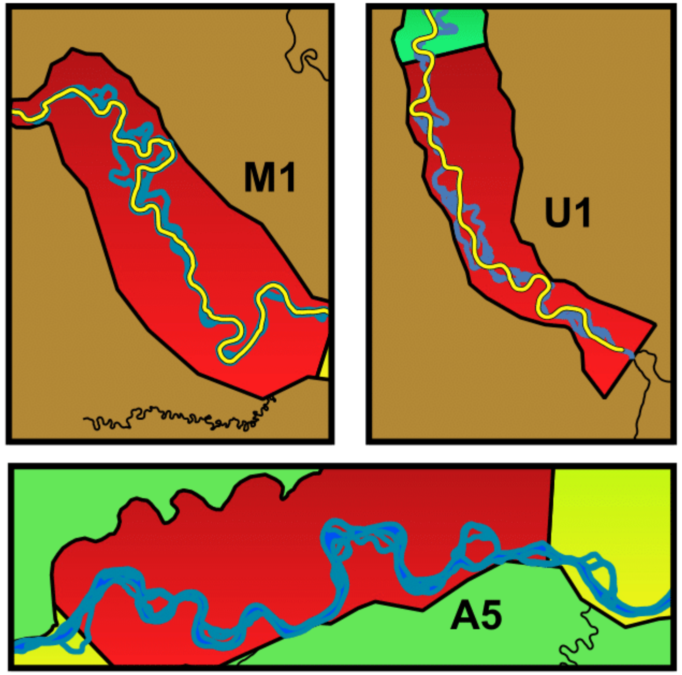


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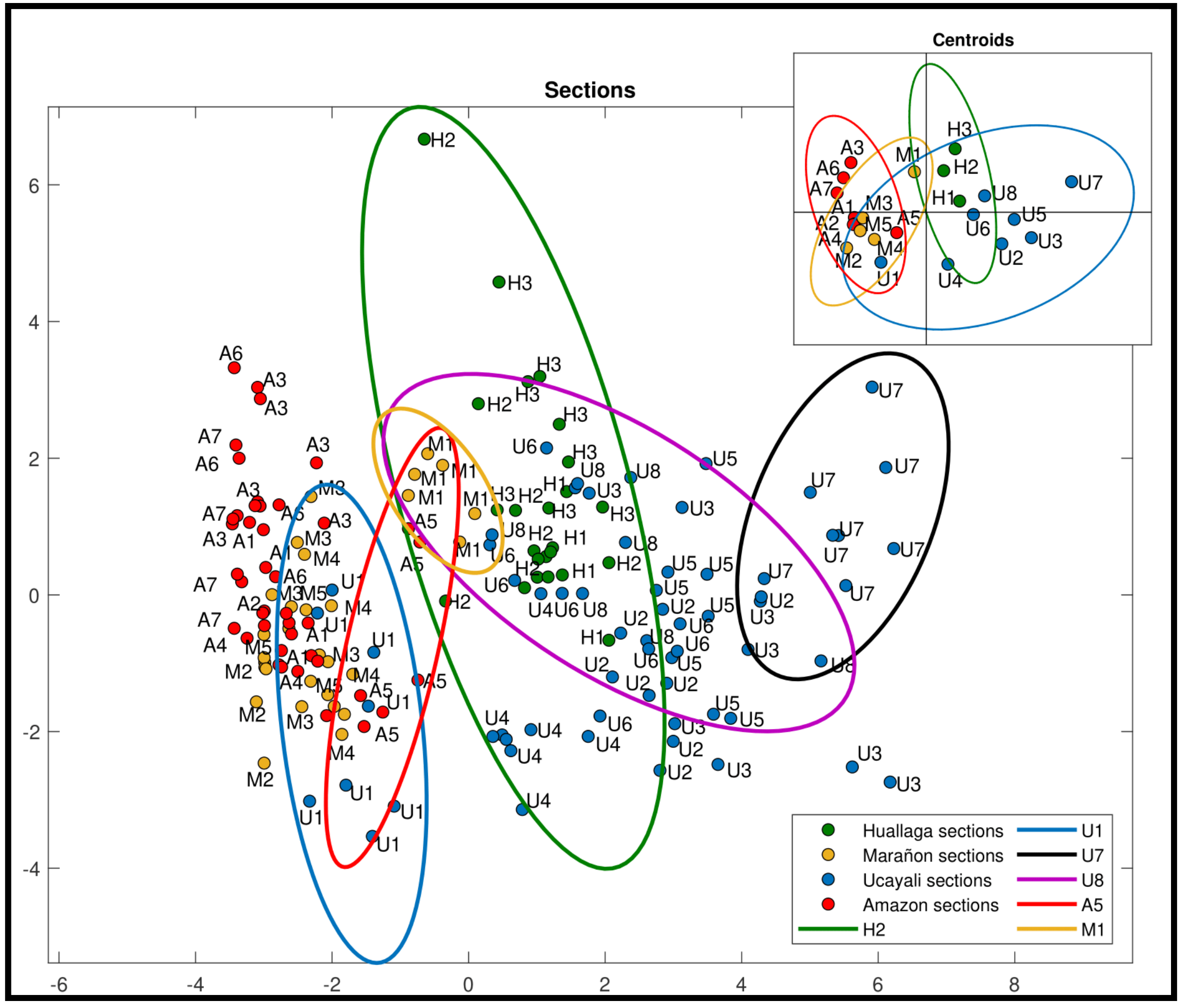
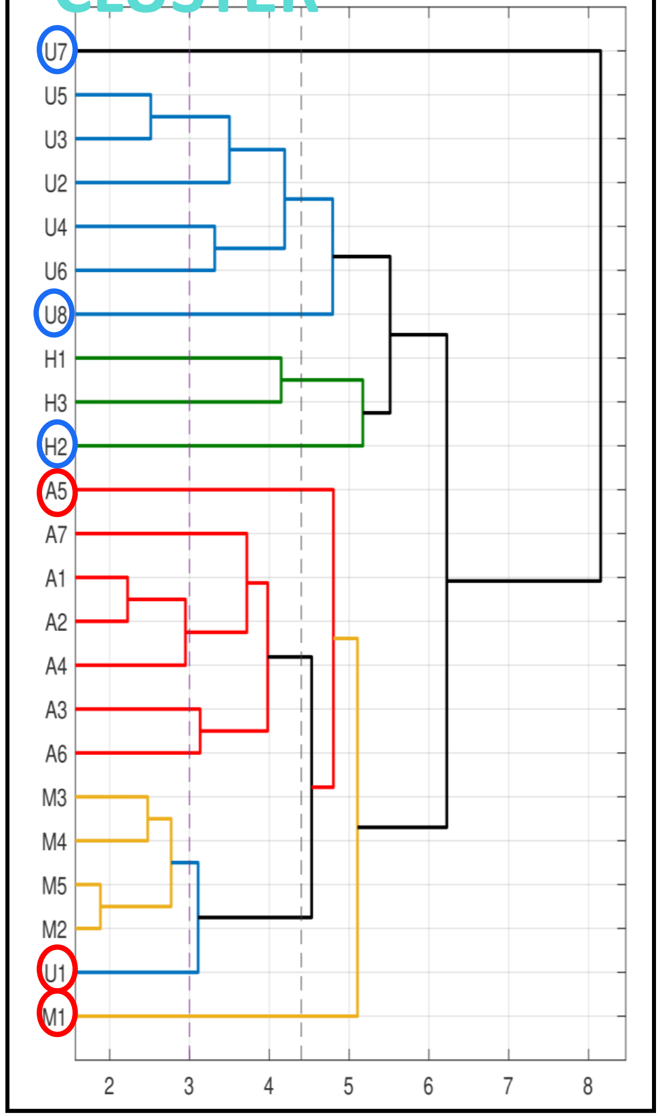
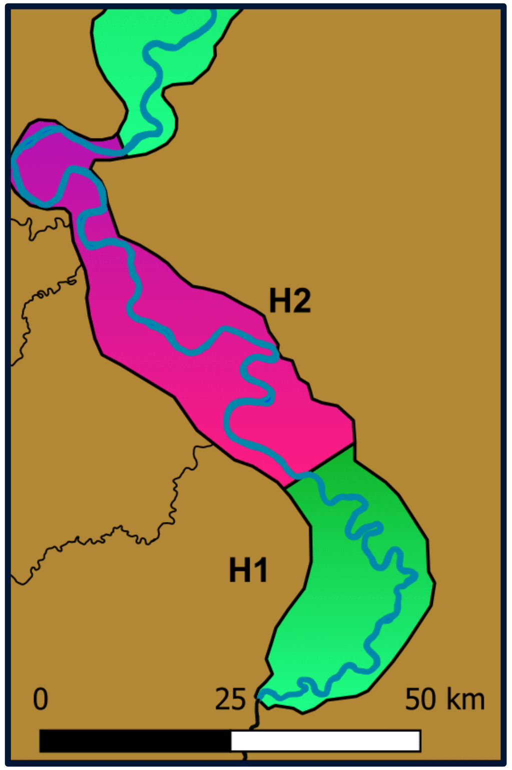
# CLUSTER

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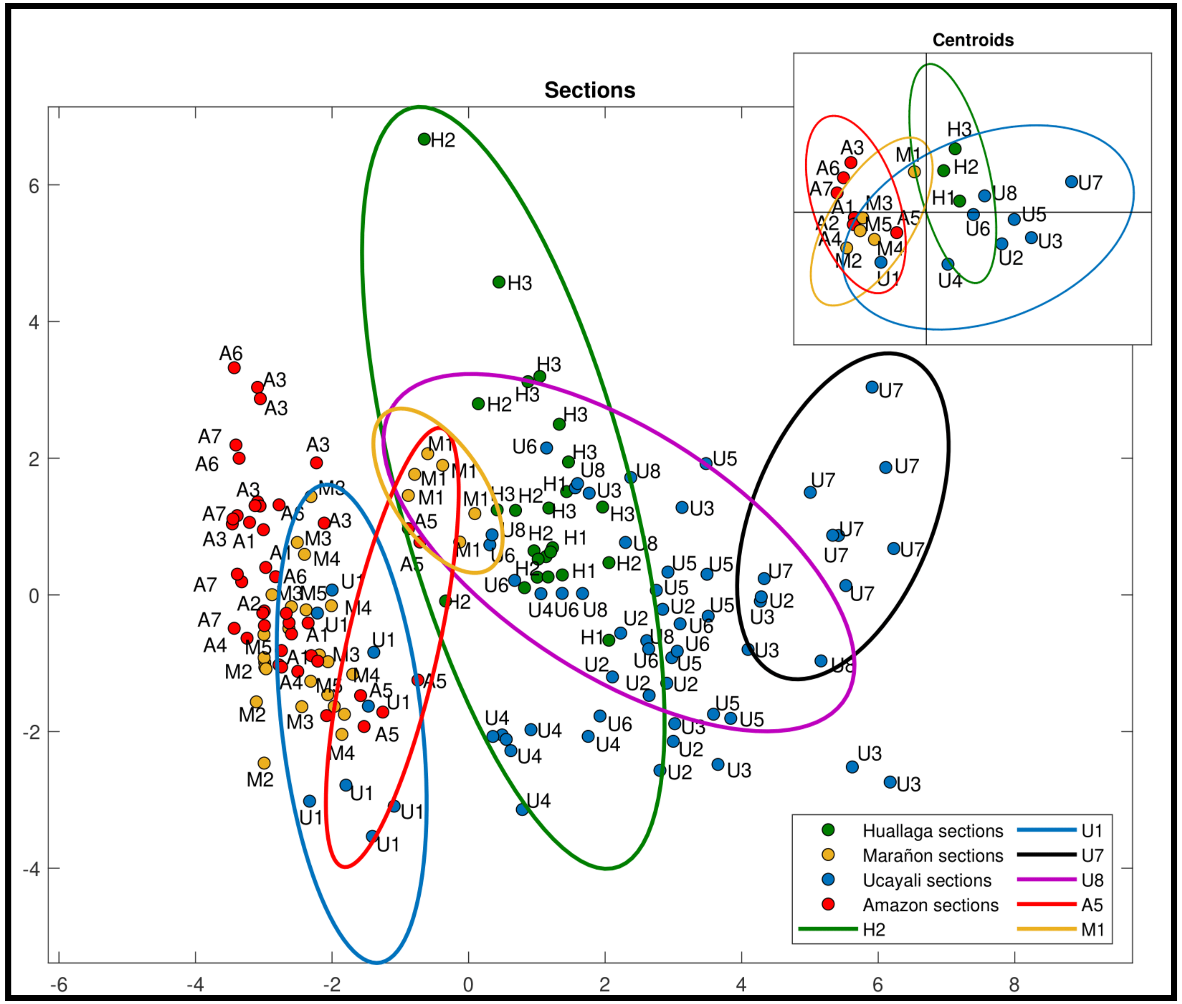
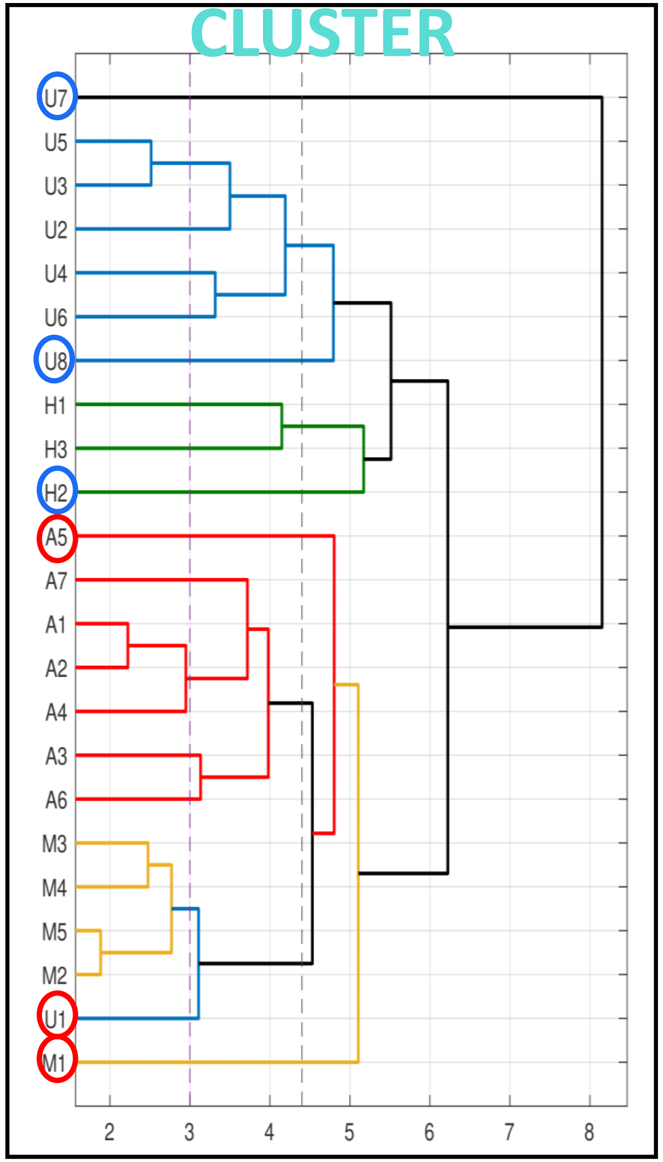

Sections
Centroids
Huallaga sections
Marañon sections
Ucayali sections
Amazon sections
U1
U7
U8
A5
H2
M1
-6
-4
-2
0
2
4
6
8


CLUSTER
U7
U5
U3
U2
U4
U6
U8
H1
H3
H2
A5
A7
A1
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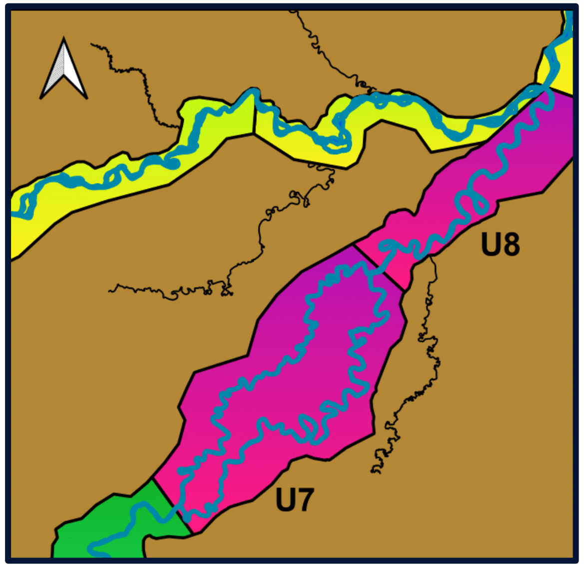
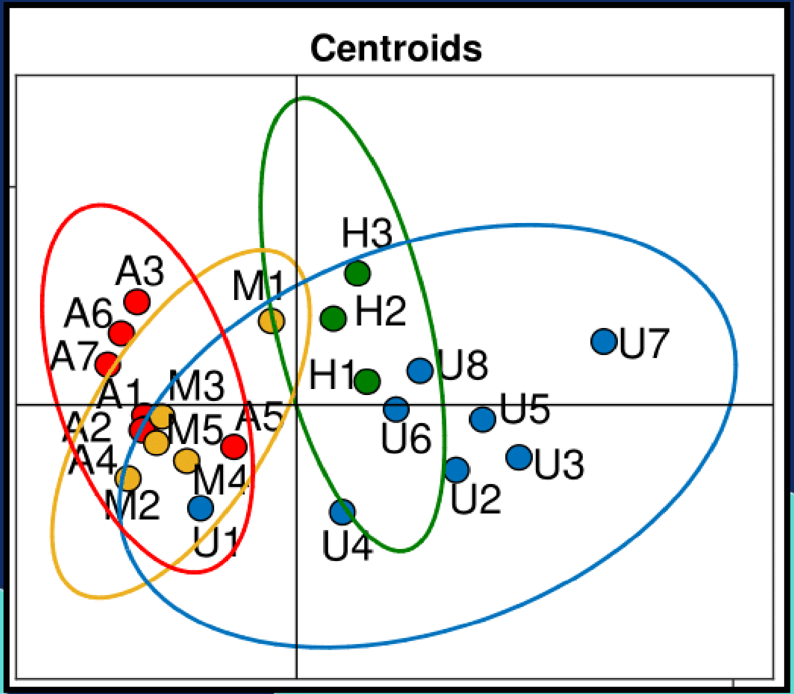

U8
U7

# Summary

- Characterizing some sections as individuals allows us to understand some local processes that may define the structure of the river.
- The multitemporal approach denotes a great importance of analysis in systems that are subject to constant dynamics.
- The PCA highlighted the need for a complete set of statistics that can recognize different features of these rivers, capturing greater complexity.

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**THANK YOU!**

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