Escola Politécnica
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Mestrado em Engenharia de Transportes – Informações Espaciais

Behavior Modelling of Multi-Annual GPS Stations Using Time Series Analysis

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CAPES

SUMMARY

1. INTRODUCTION
2. TIME SERIES ANALYSIS
   - Parametric method
   - Non-parametric methods
3. RESULTS
4. DYNAMIC MODELLING
5. CONCLUSION

INTRODUCTION

- What is deformation?
- What is modelling?
- Modelling methods in Geodesy
  - Congruence
  - Kinematic
  - Dynamic

TIME SERIES ANALYSIS

TIME SERIES ANALYSIS

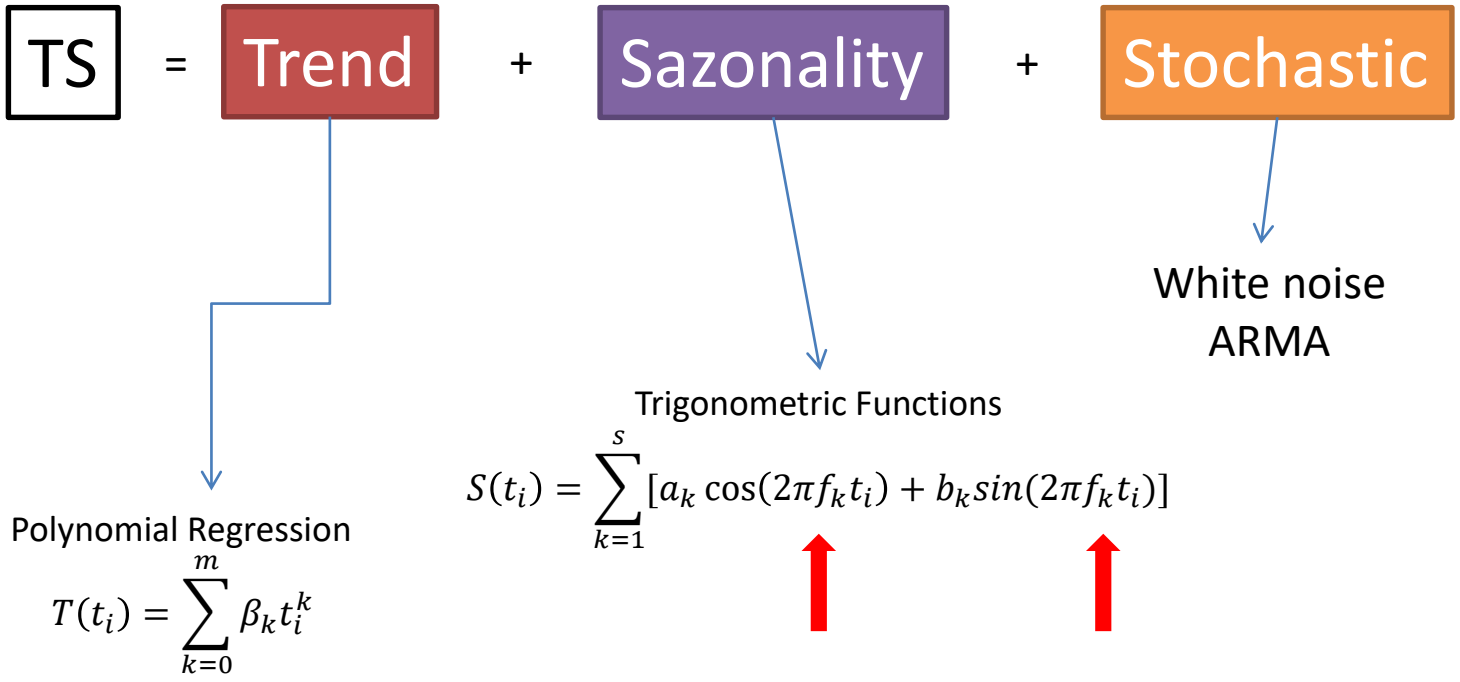
- Time series analysis?
  - According to Morettin and Toloi (2018)....

Time-Domain

Spectral-Domain

Parametric Method

- Aims to define certain components that, in general, compose a Time Series (TS)



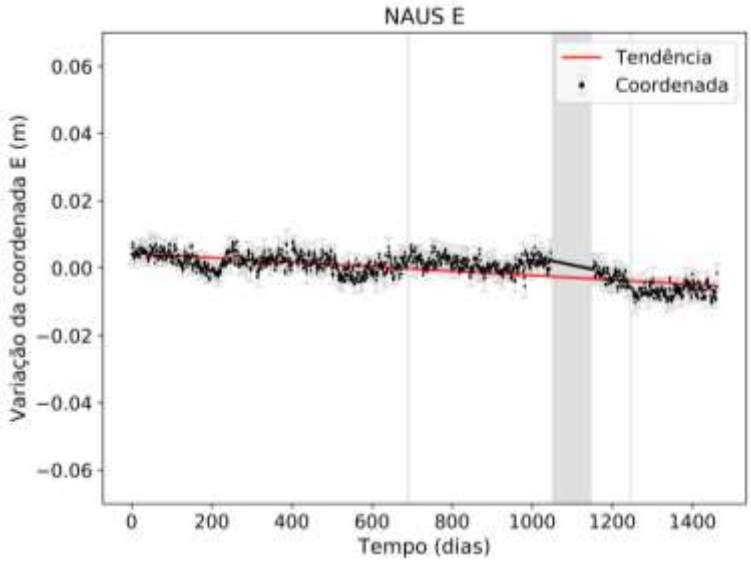
Non-parametric Methods

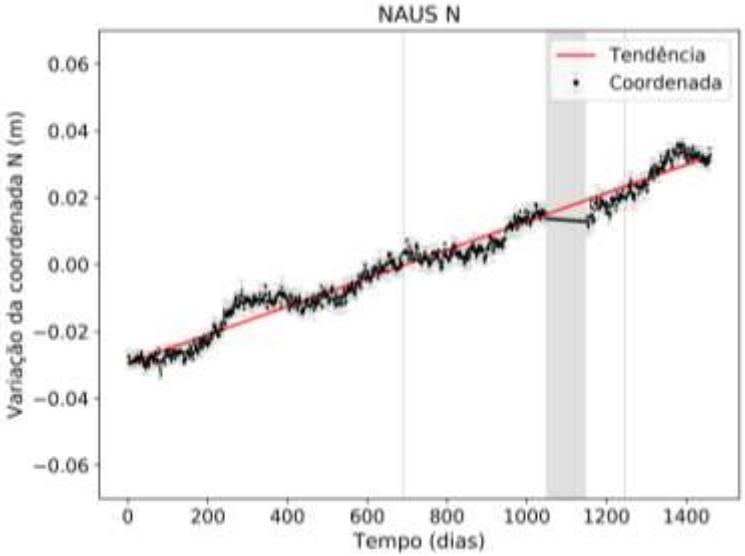
- Concerns to the spectral-domain, also called frequency-domain.
- The analysis can be:

1. Univariate
   - Autocorrelation (ACF) and Partial-Autocorrelation (PACF);
   - Fast Fourier Transform;
   - Periodograms; etc....
2. Bivariate
   - Cross-correlation;
   - Cross-spectral correlation; etc...

SOME RESULTS....

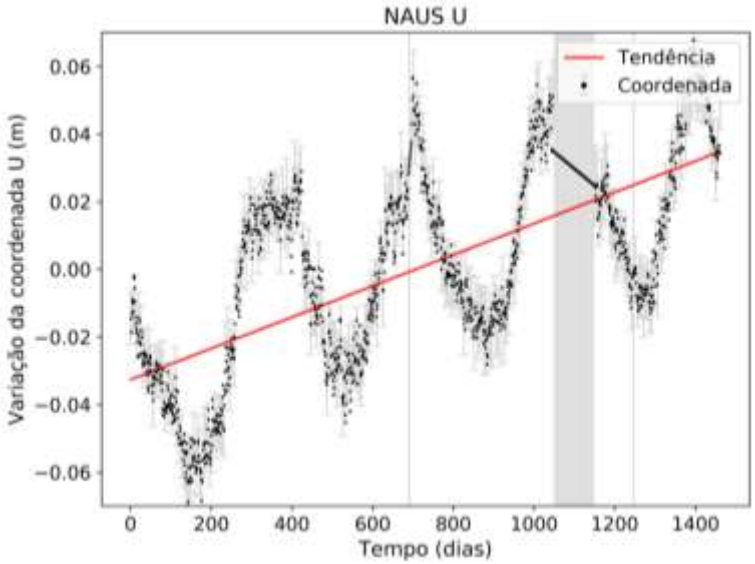
Trend





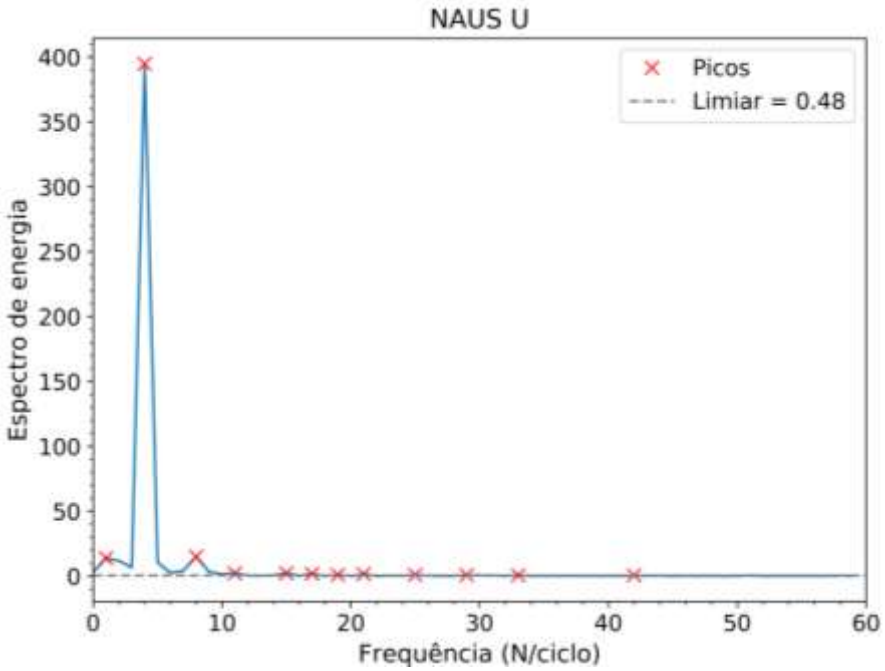
- Binomial Model:

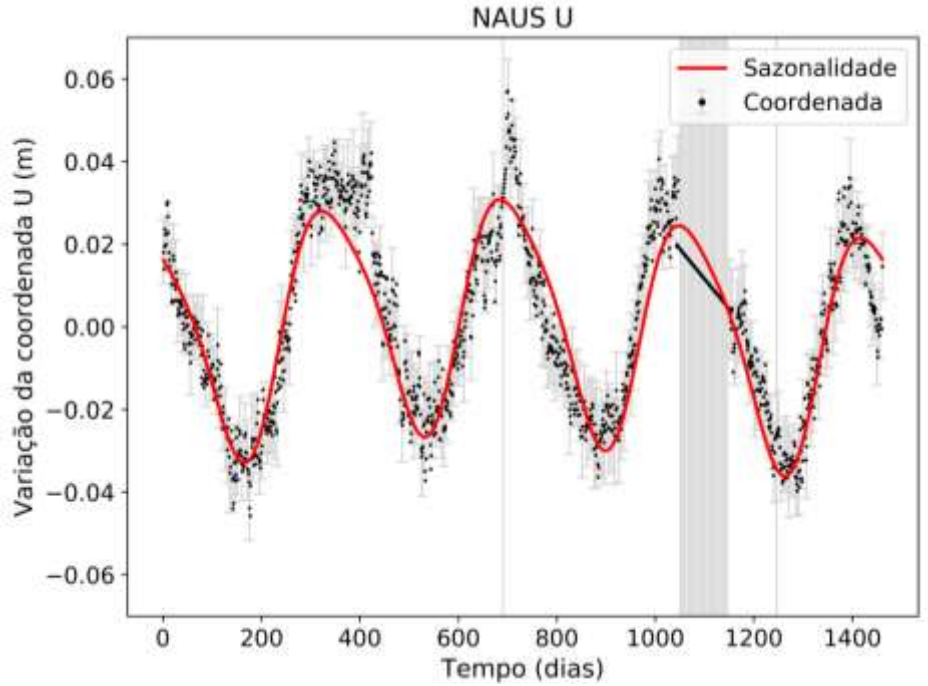
$$TS_f(t_i) = \beta_0 + \beta_1 t_i$$



Sazonality

The main frequencies in a time series can be identified with PERIODOGRAMS.

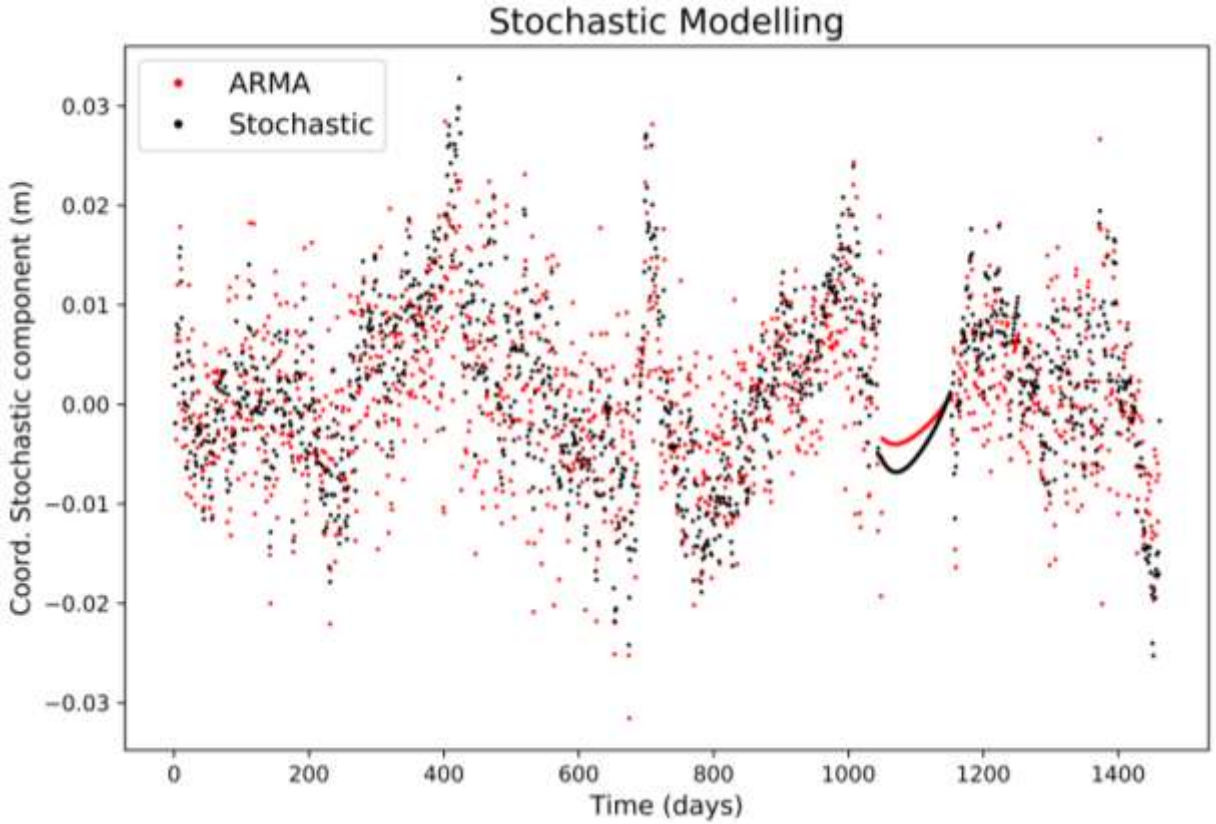




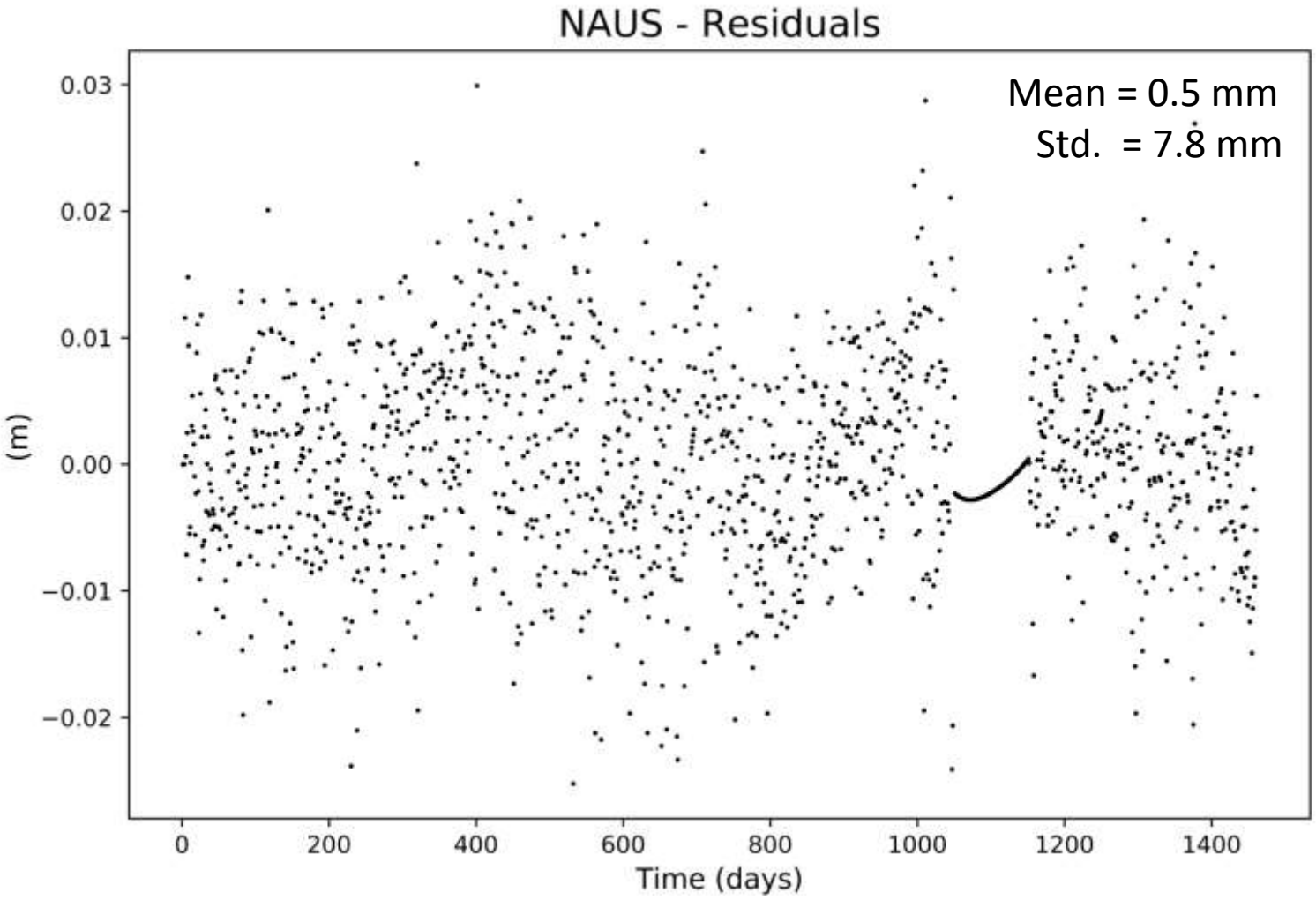
Period (days)		
1461,00	365,25	182,63

Stochastic

- ARMA (q,p) – Best fit -> ARMA (1, 3)



Result - Residuals



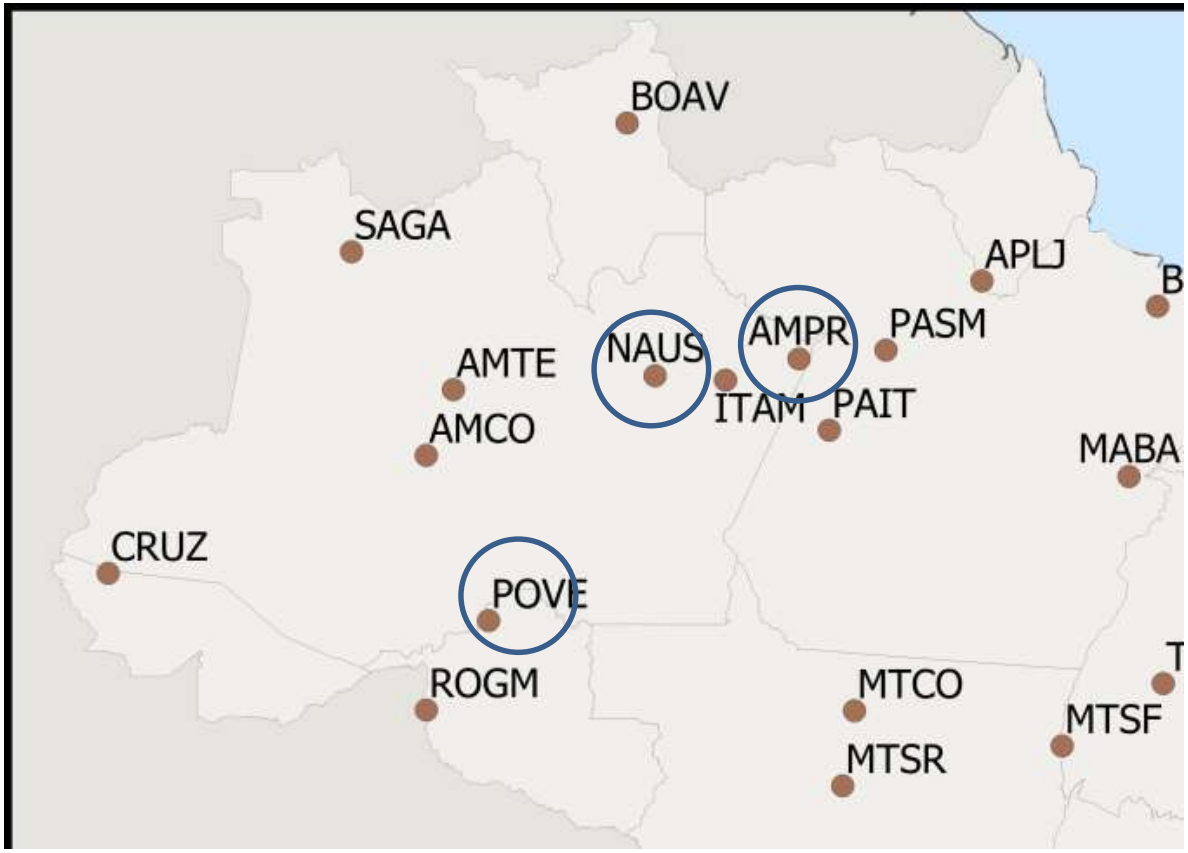
DYNAMIC MODELLING

Dynamic Modelling

- According to Welch and Heunecke (2001), the definition of a model for a transfer function is feaseble if the **input** (y_k) and the **output** (x_k) quantities are measured. And they pose one way to model the system using ARMA (q, p):
- x_k - Altimetric coordinate
- y_k - River level

- $$x_k = \underbrace{a_1 x_{k-1} + a_2 x_{k-2} + \cdots + a_q x_{k-q}}_{\text{Autoregressive}} + \underbrace{b_0 y_k + b_1 y_{k-1} + \cdots + b_p y_{b-p}}_{\text{Moving Average}}$$

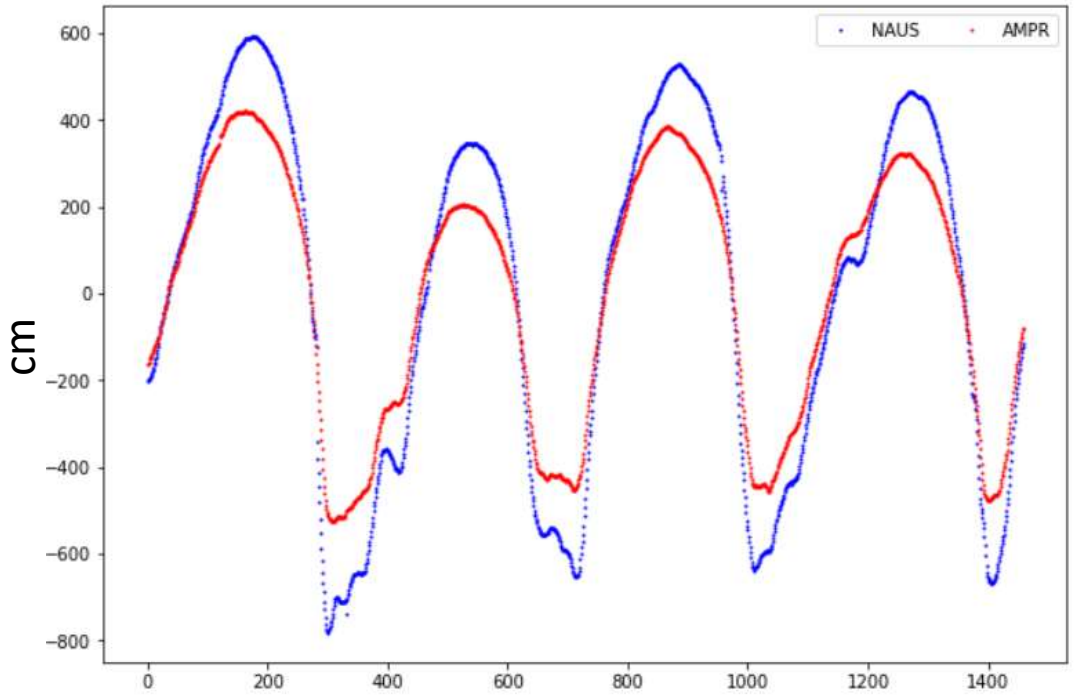
Dynamic Modelling



Dynamic Modelling

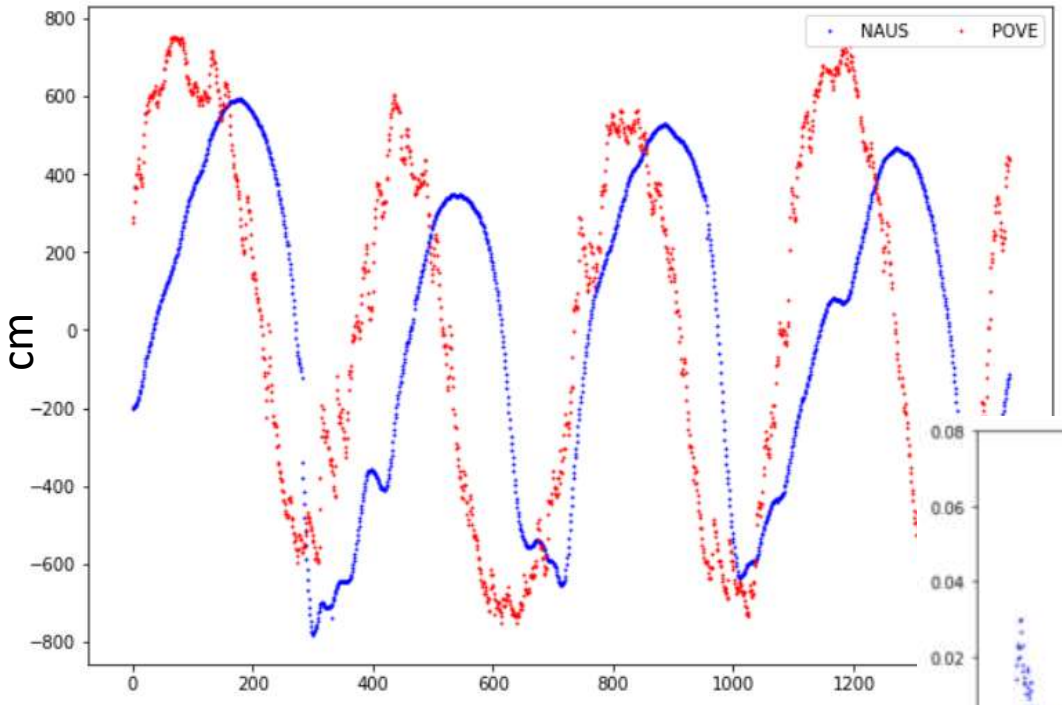
- In order to validate the hypothesis that the river level has influence in the station coordinates, several time series cross-correlation were calculated between:

ALTIMETRY and/or **RIVER LEVELS**



Lag = 1 day

Dynamic Modelling

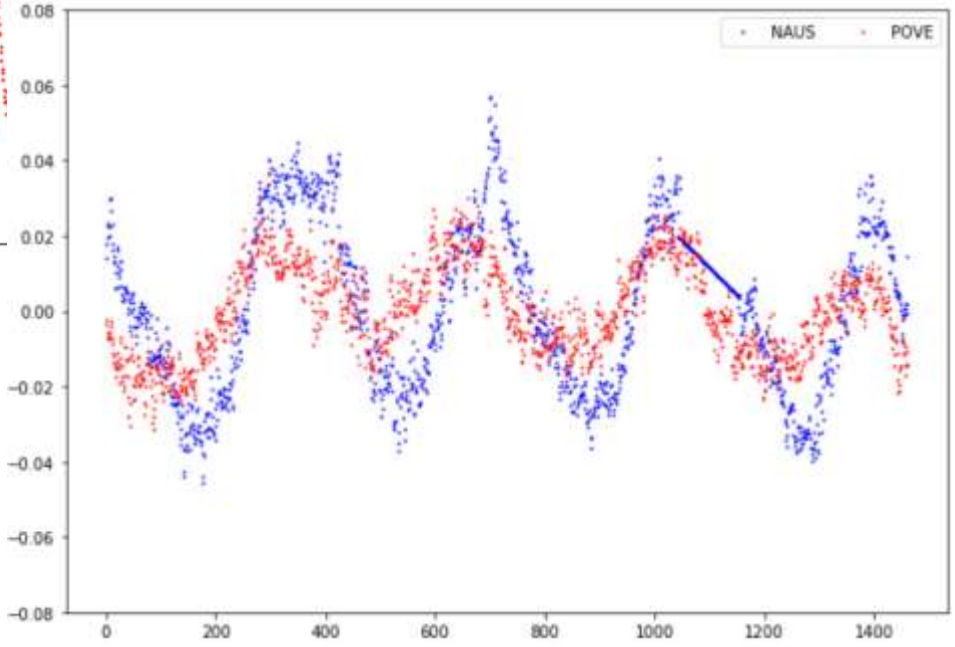


RIVER LEVEL

Lag = 65 days

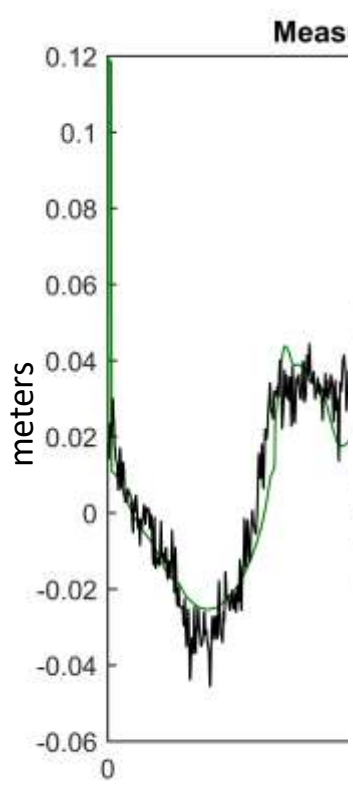
STATIONS

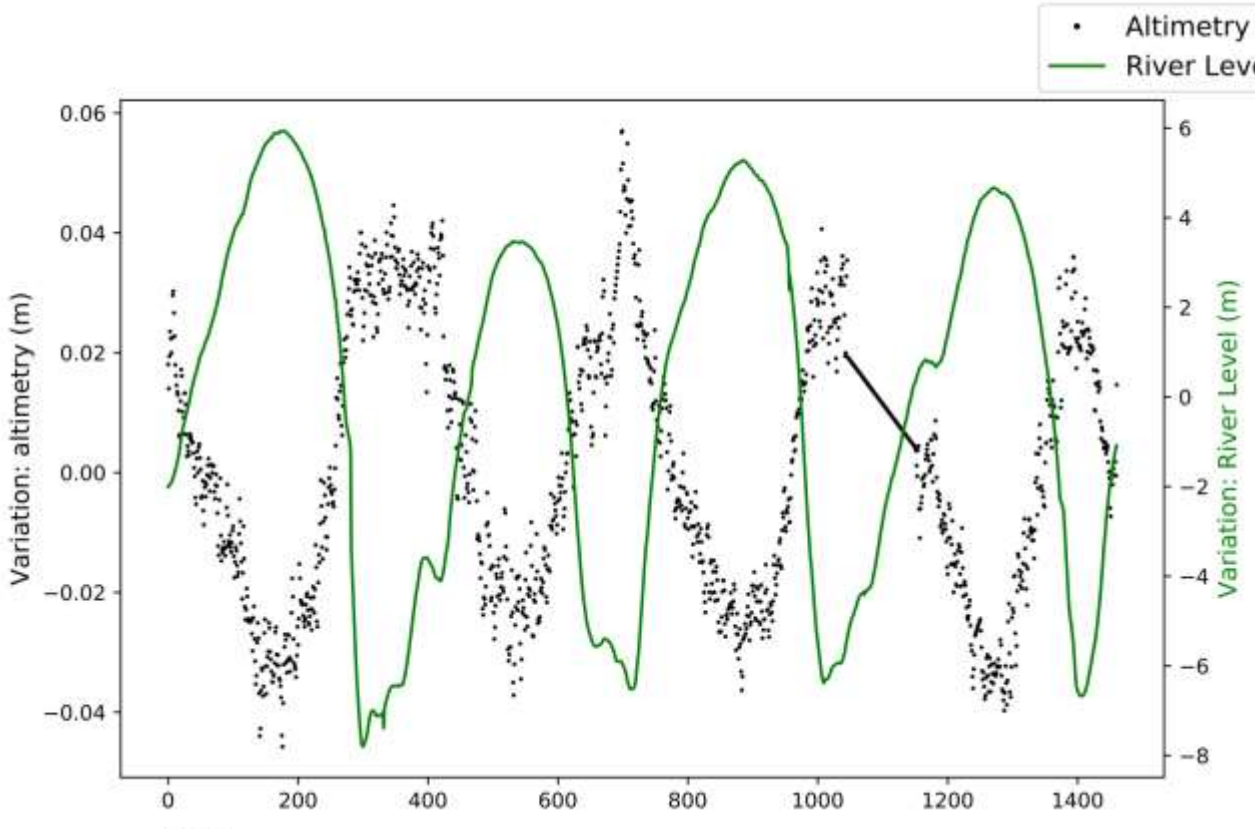
Lag = 40 days

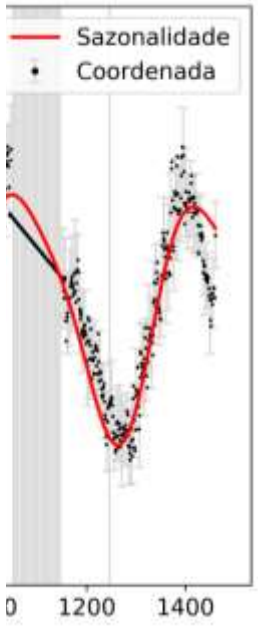


Dynamic Modelling

- ARMA (p,q) – Best fit -> ARMA (2, 1) with lag = 6







CONCLUSION

- By this work, it cannot be said that the river levels in Amazonian region strictely affect station coordinates;
- Nevertheless, the **RIVER x STATION** system has some similarities and river data will be used in the modelling process.
- The portryed methods of analysis showed to be robust for the porpuses of this work;
- The main problem to be attacked is the existence of gaps in the time series. Which may lead to a bad estimation of parameters.

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