Sea Level Rise - Project 4

Vanessa Vandenberghe
Wadia Ferjani
Marceau Michel
Mathieu Pierronne

Summary

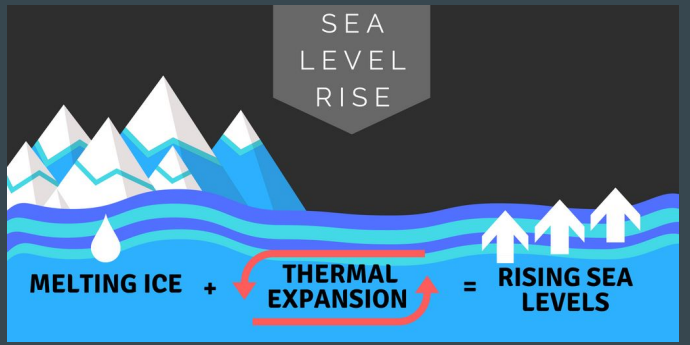
I/ Presentation of the Data

II/ Local study of the Sea level Rise

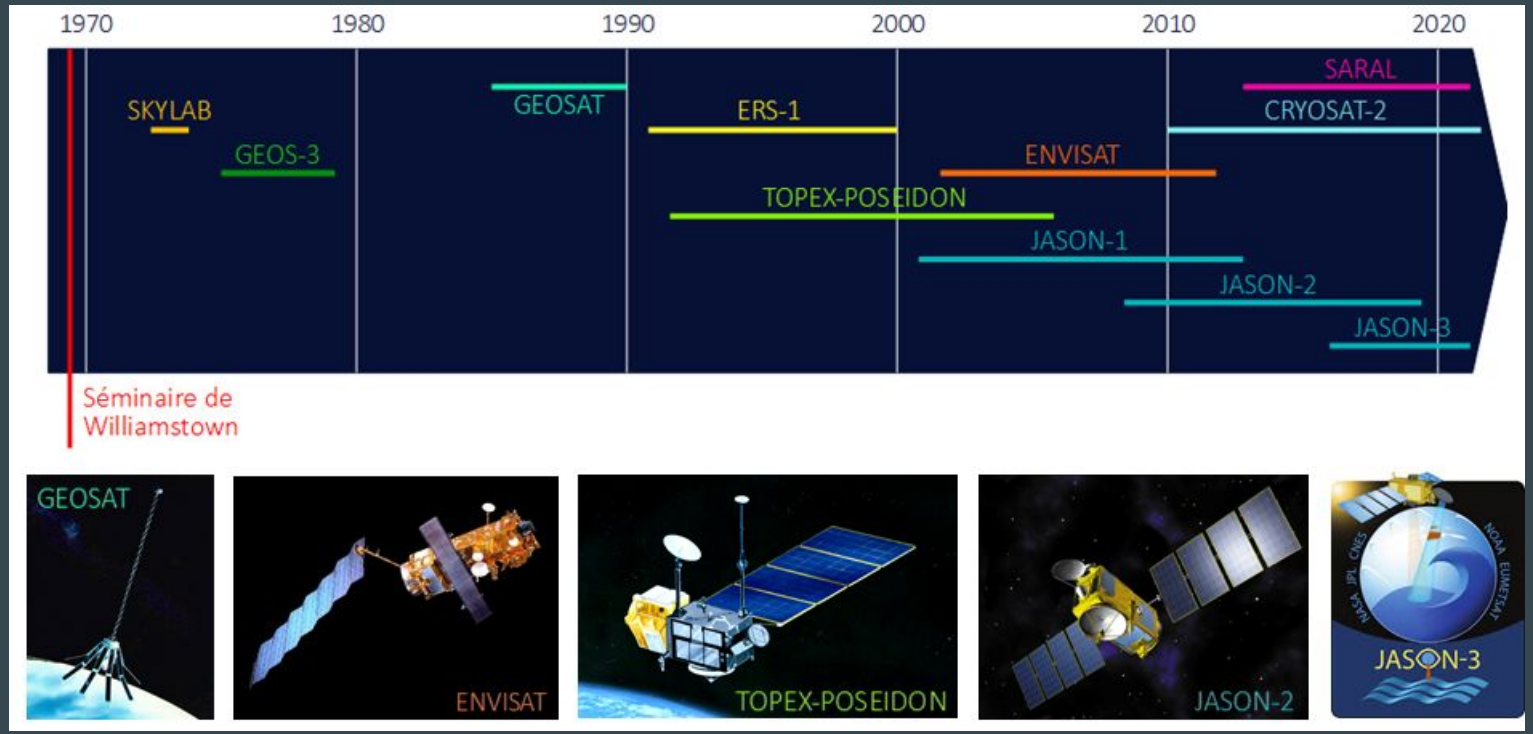
III/ Time series Analysis of mean SSH

IV/ Prediction of the sea level rise by 2100

V/ Comparison with NOAA predictions

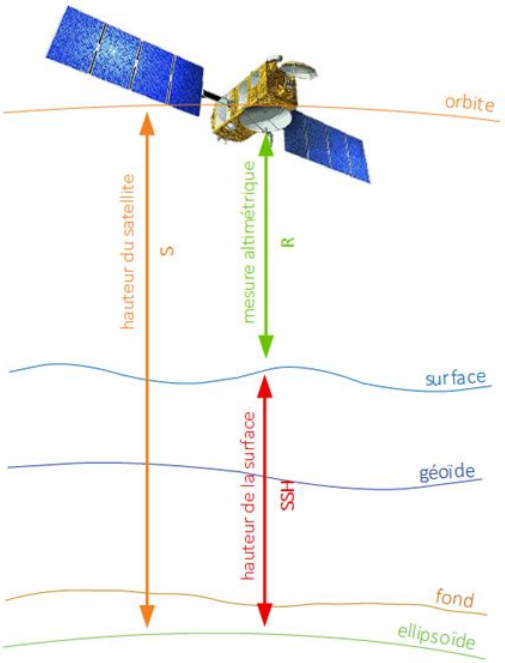


I/ Presentation of the Data: Missions

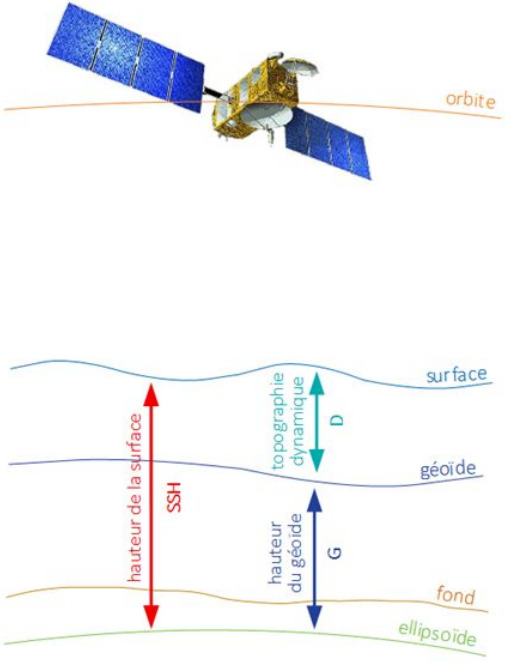


I/ Presentation of the Data: Principe of the Measurement

Measurement of the altimeter distance **R** to determine the surface height:
Sea Surface Height from satellite height **S**



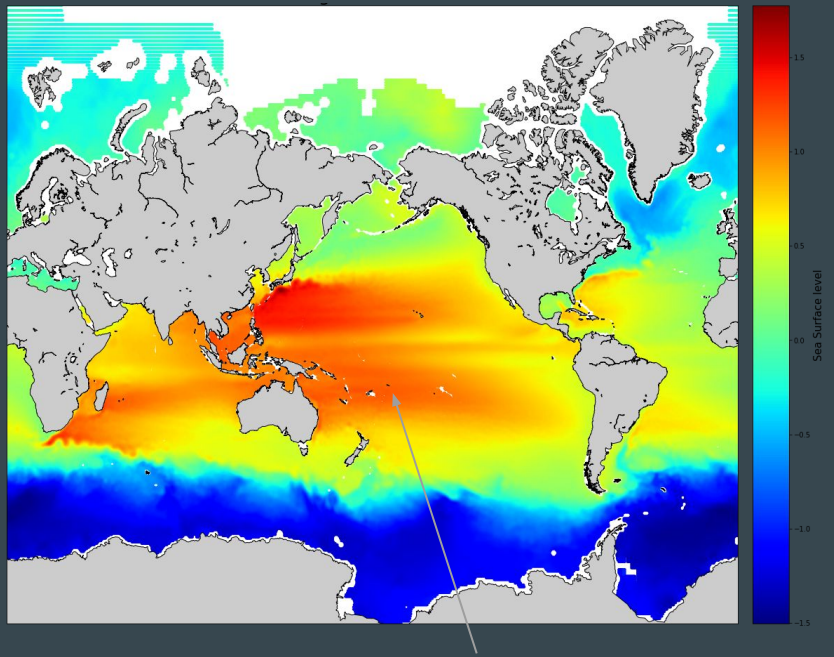
The **SSH** surface height is the combination of the geoid height G and the dynamic topography **D**.



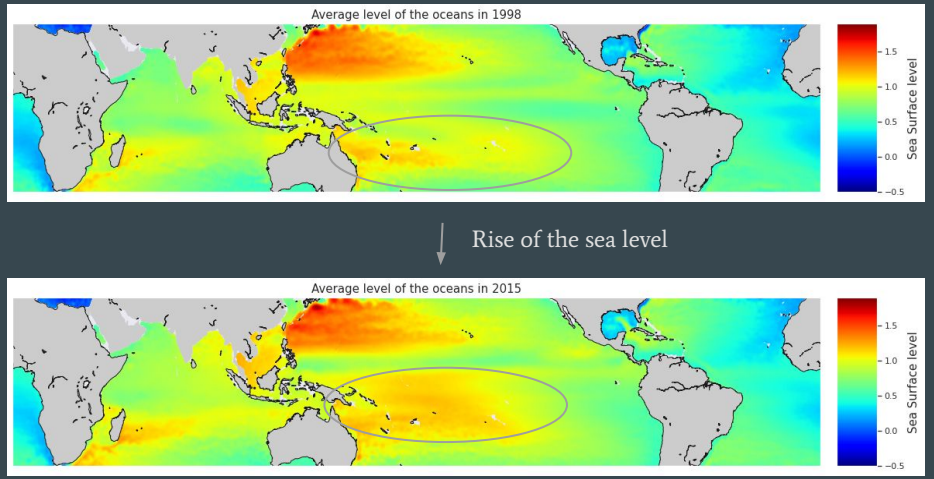
II/ Local Study of the sea level rise

1) Global overview

Sea level average between 1998 and 2005



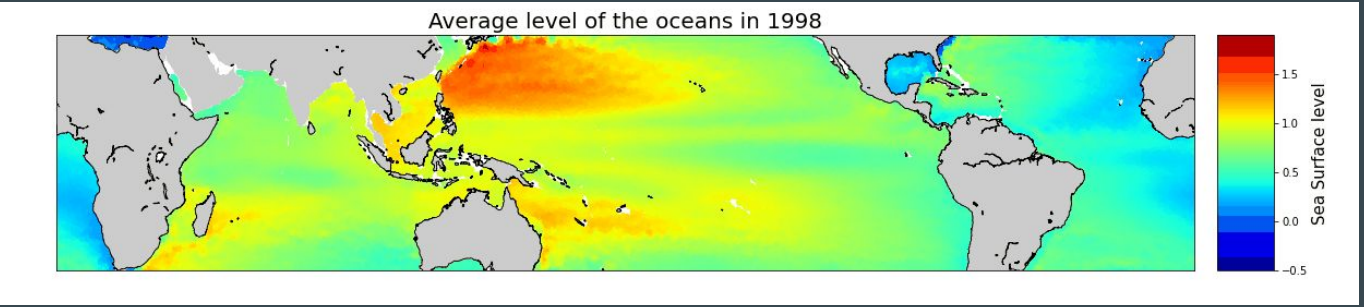
Difference of the sea level between 1998 and 2015

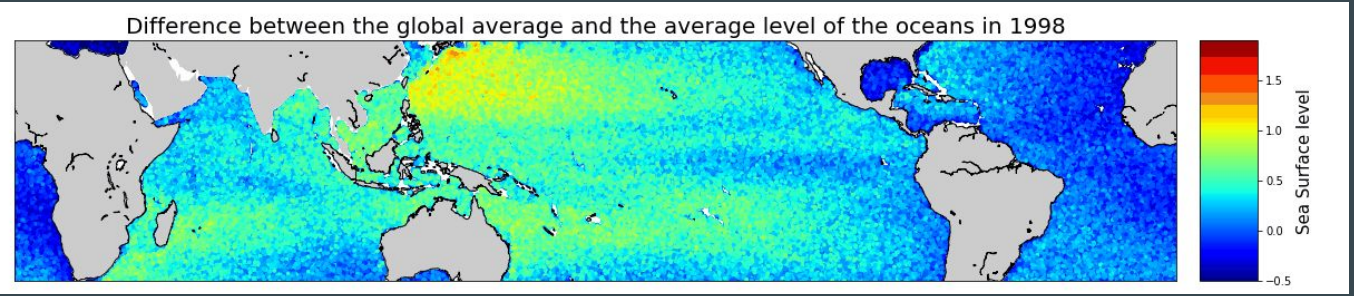


The sun's rays arrive perpendicular to the level of the equator : the solar energy is then more concentrated, the water is hotter, expands and the sea level is higher there

II/ Local Study of the sea level rise

2) Evolution of the Sea Level

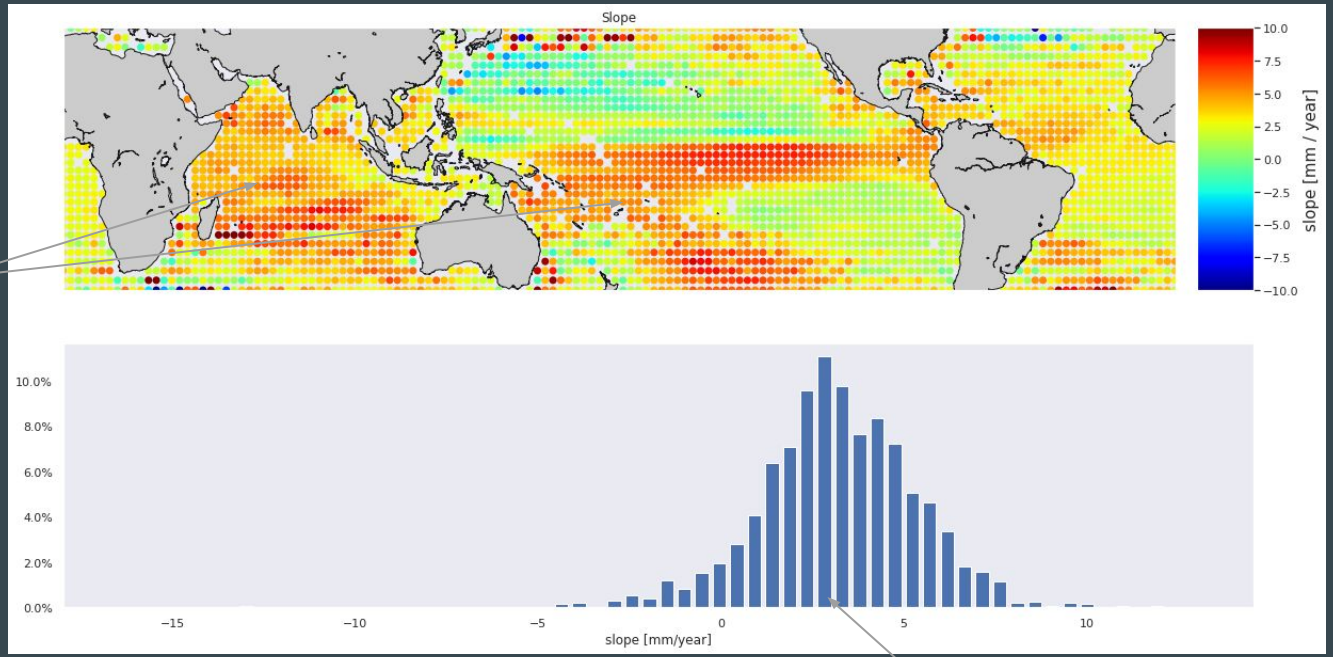




II/ Local Study of the sea level rise

3) Local Regression

Two parts of the globe with the highest rise in sea levels

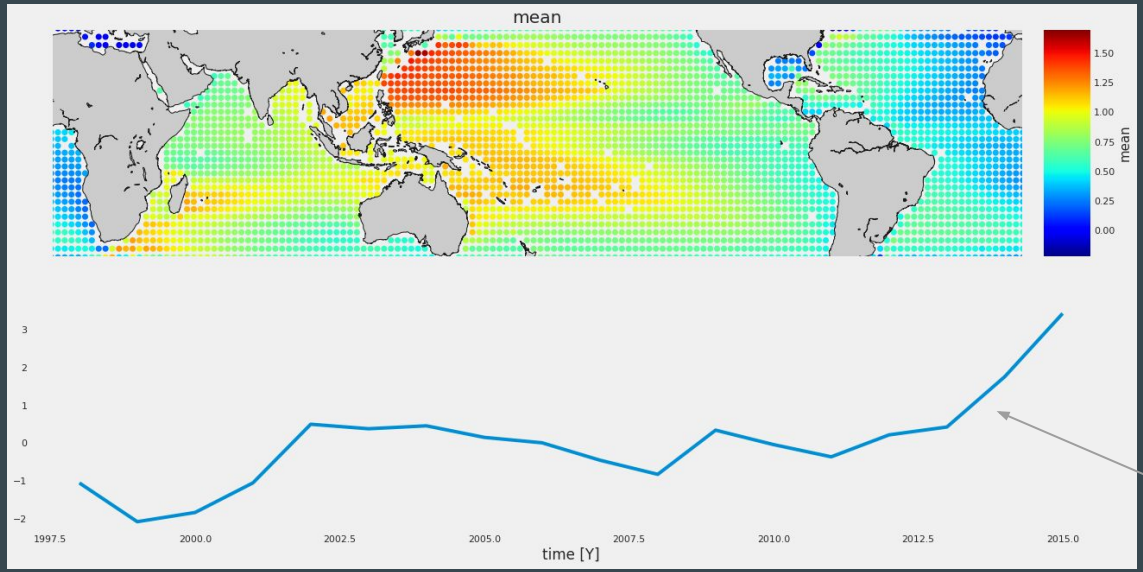


Average slope of 3 mm/year

II/ Local Study of the sea level rise

4) Principal Component Analysis

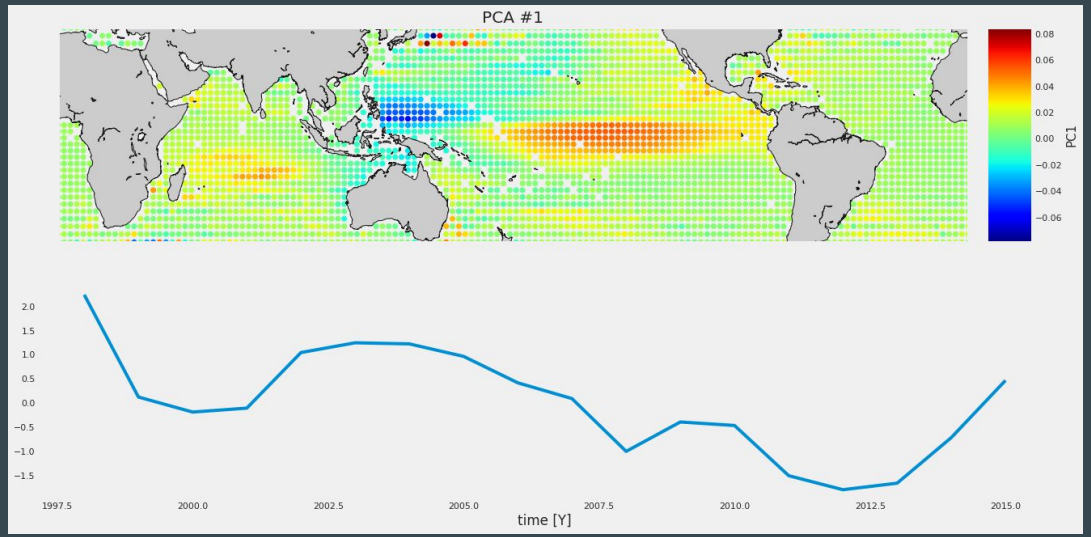
$$SSH(t) \approx \sum_{i=1}^{k} \alpha_i(t) EOF_i$$



Increase in the average of the sea surface height

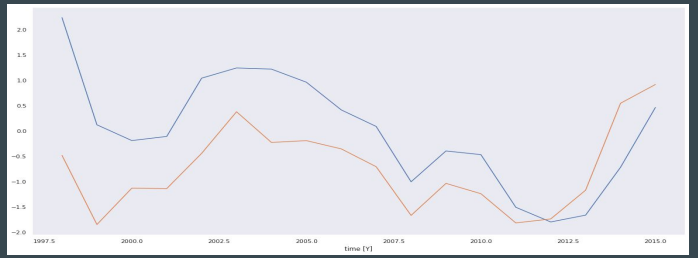
II/ Local Study of the sea level rise

5) Pacific Decadal Oscillation (PDO)



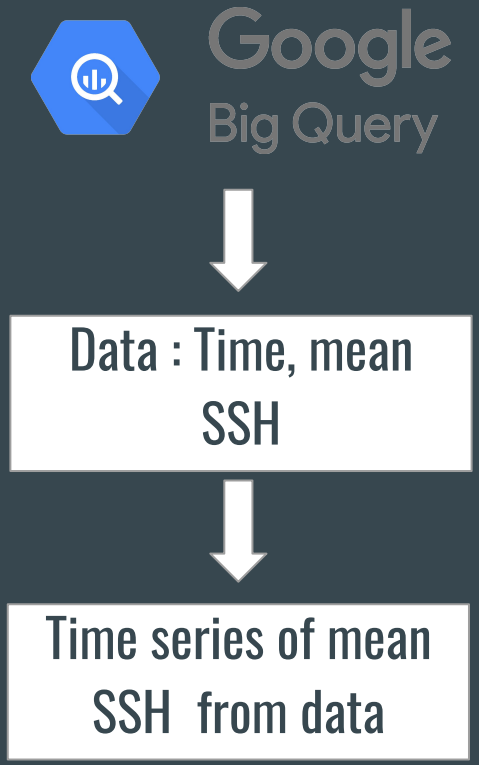
First PC and temporal variations

The Pacific Decadal Oscillation (PDO) is a robust, recurring pattern of ocean-atmosphere climate variability centered over the mid-latitude Pacific basin.



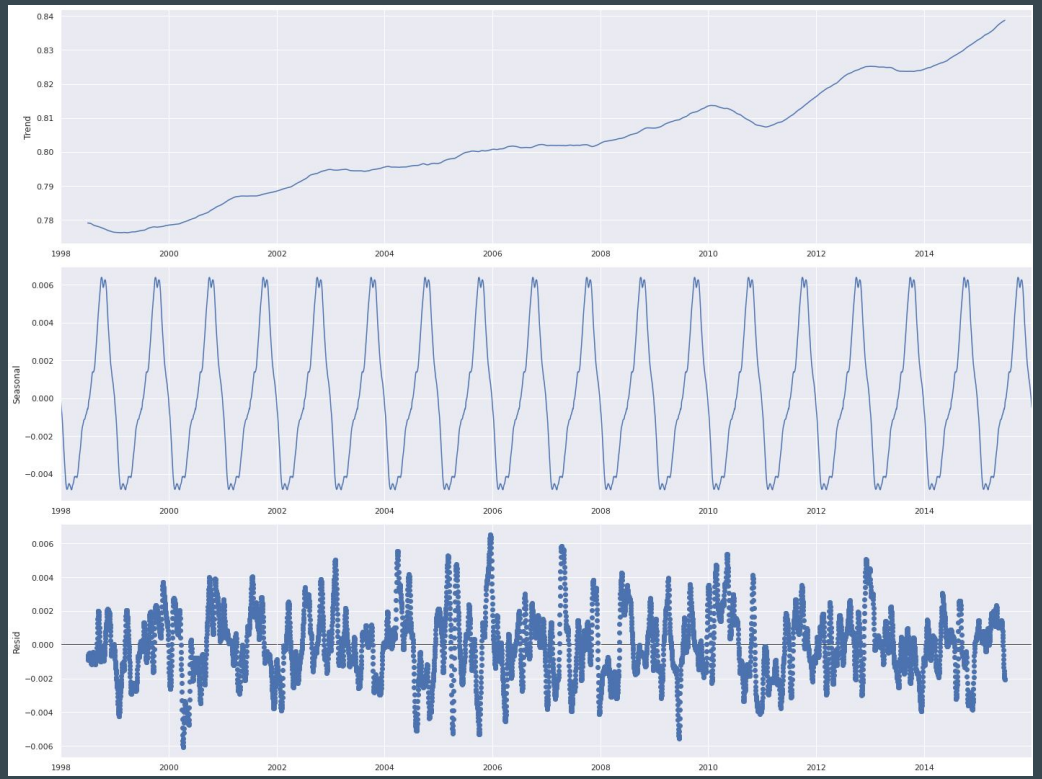
$\alpha(t)$ & PDO (NOAA)

III/ Time series analysis of mean SSH



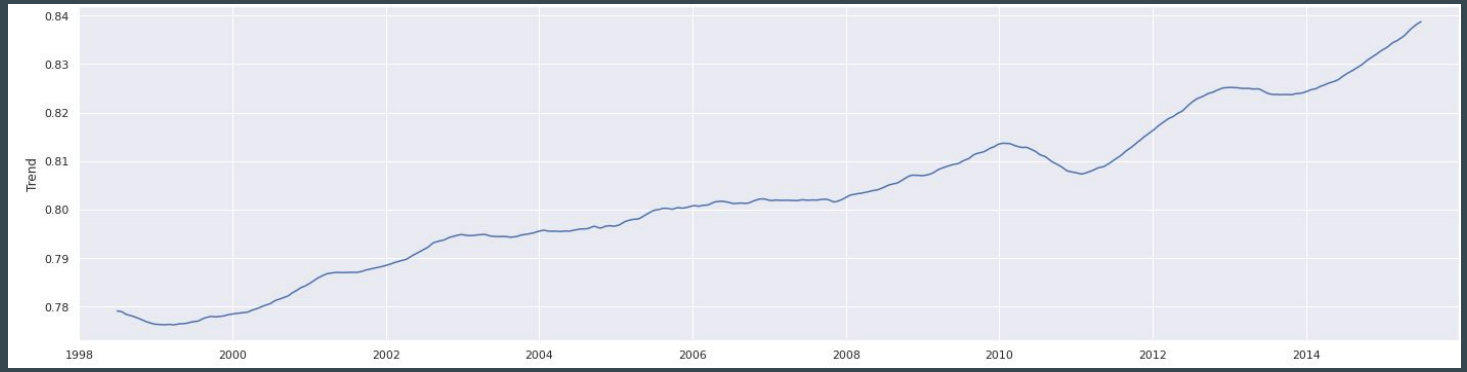
III/ Time series analysis of mean SSH

- Time series decomposition :
  - Trend
  - Seasonality
  - Residuals



III/ Time series analysis of mean SSH

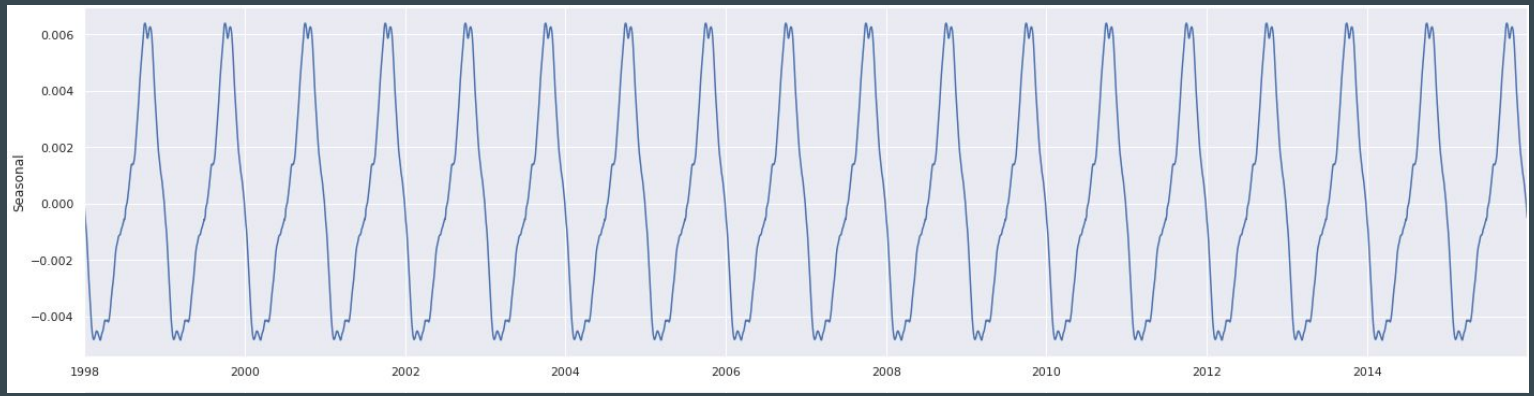
- Time series decomposition :
  1. Trend



- An overall upward trend
- Instability between 2010 and 2015
- During this period the trend sometimes take the shape of a curved line with ups and downs

III/ Time series analysis of mean SSH

- Time series decomposition :
  2. Seasonality

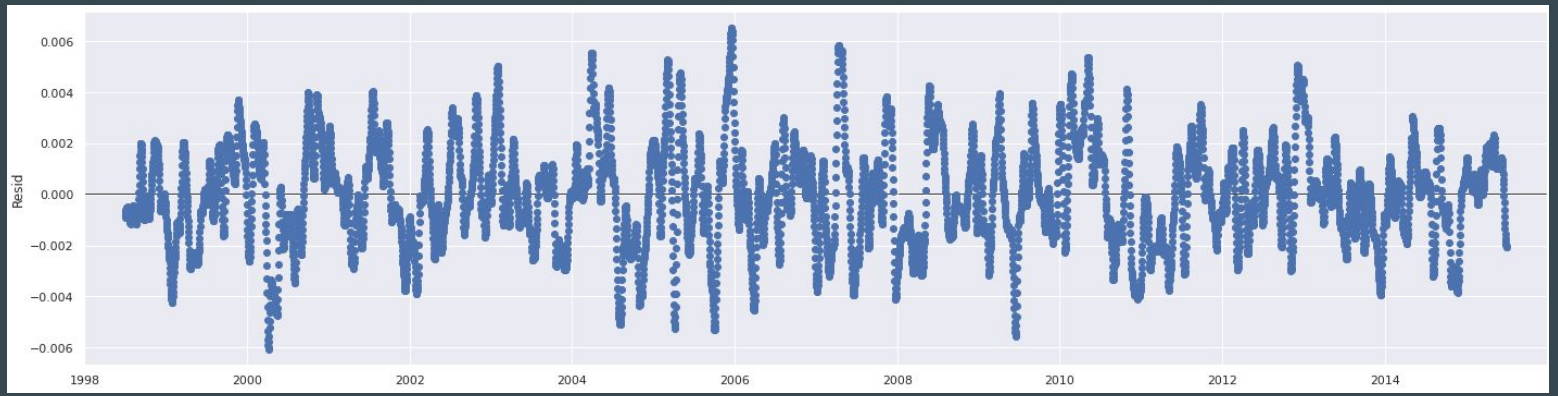


- We have a yearly seasonality

III/ Time series analysis of mean SSH

- Time series decomposition :

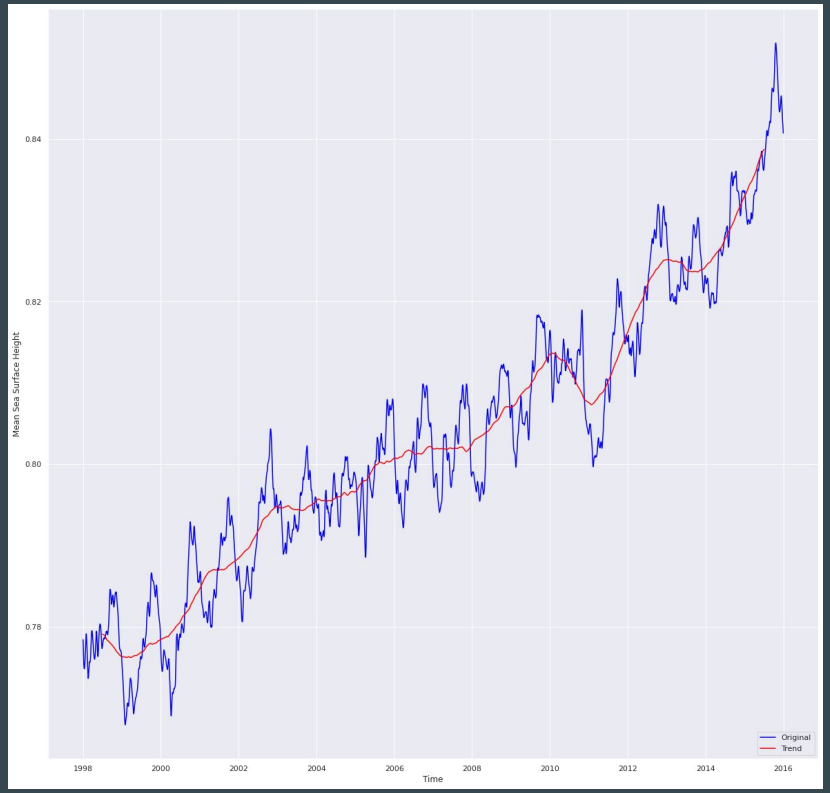
  3. Residuals



- We have random residuals that can be sometimes significant

III/ Time series analysis of mean SSH

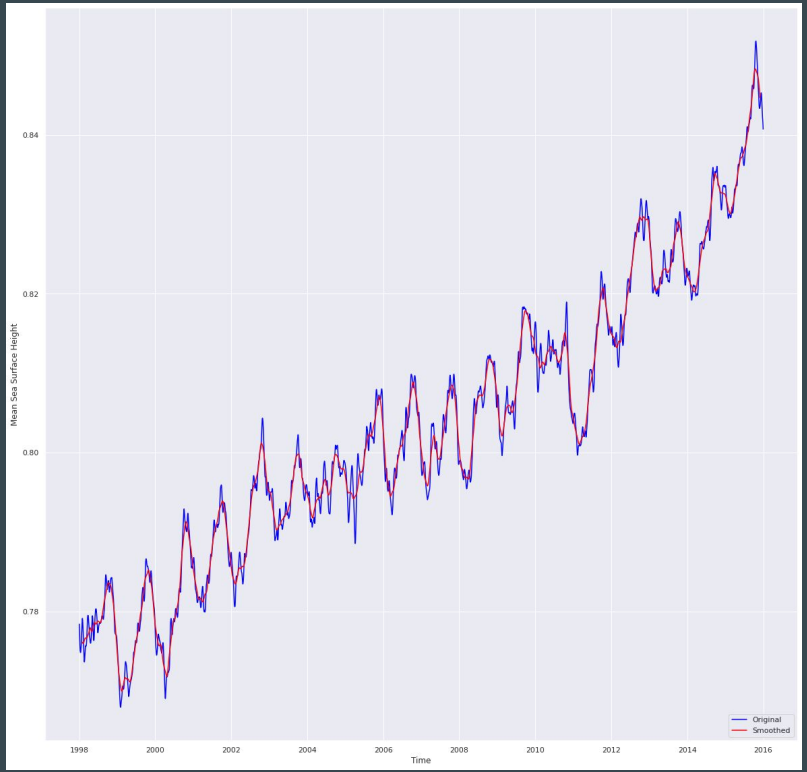
- Original Data vs Trend Data



- The trend shows the overall movement in the Mean SSH series

III/ Time series analysis of mean SSH

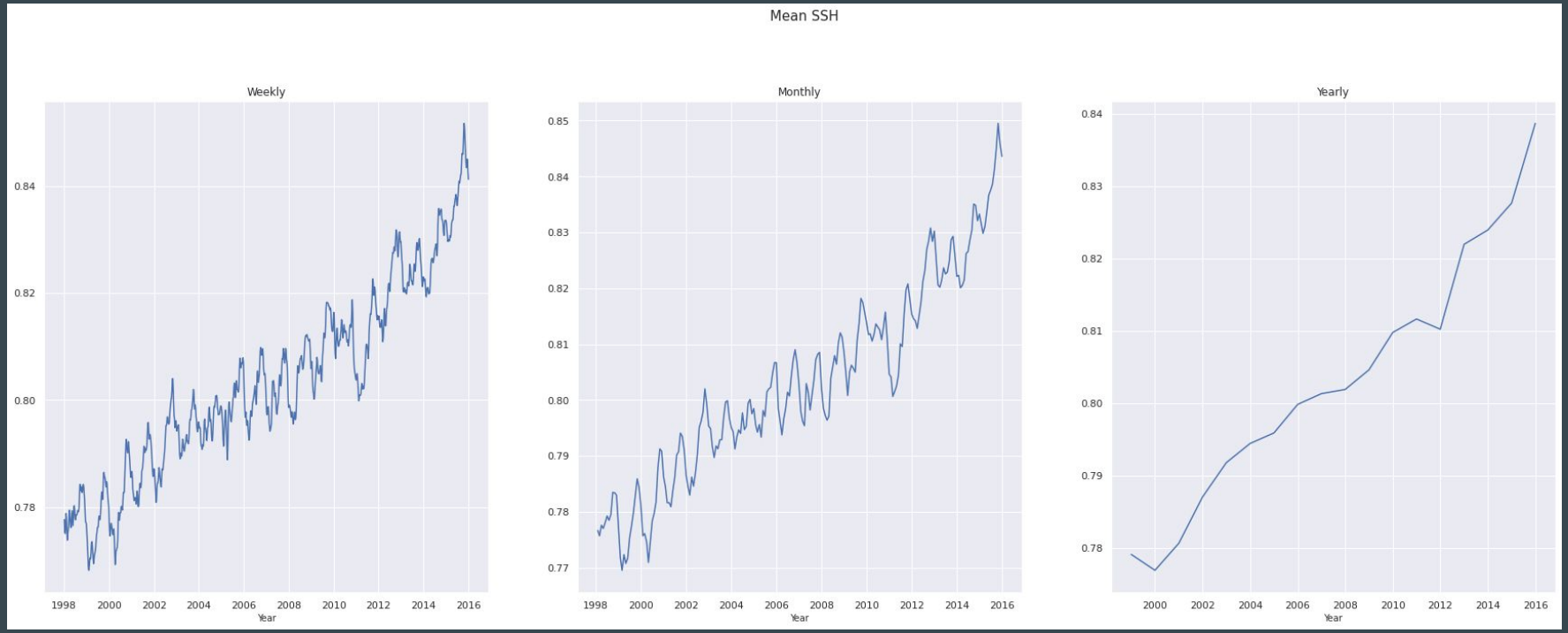
- Original Data vs Rolling mean



- The rolling mean plot take the form of the original data and it remove the outliers

III/ Time series analysis of mean SSH

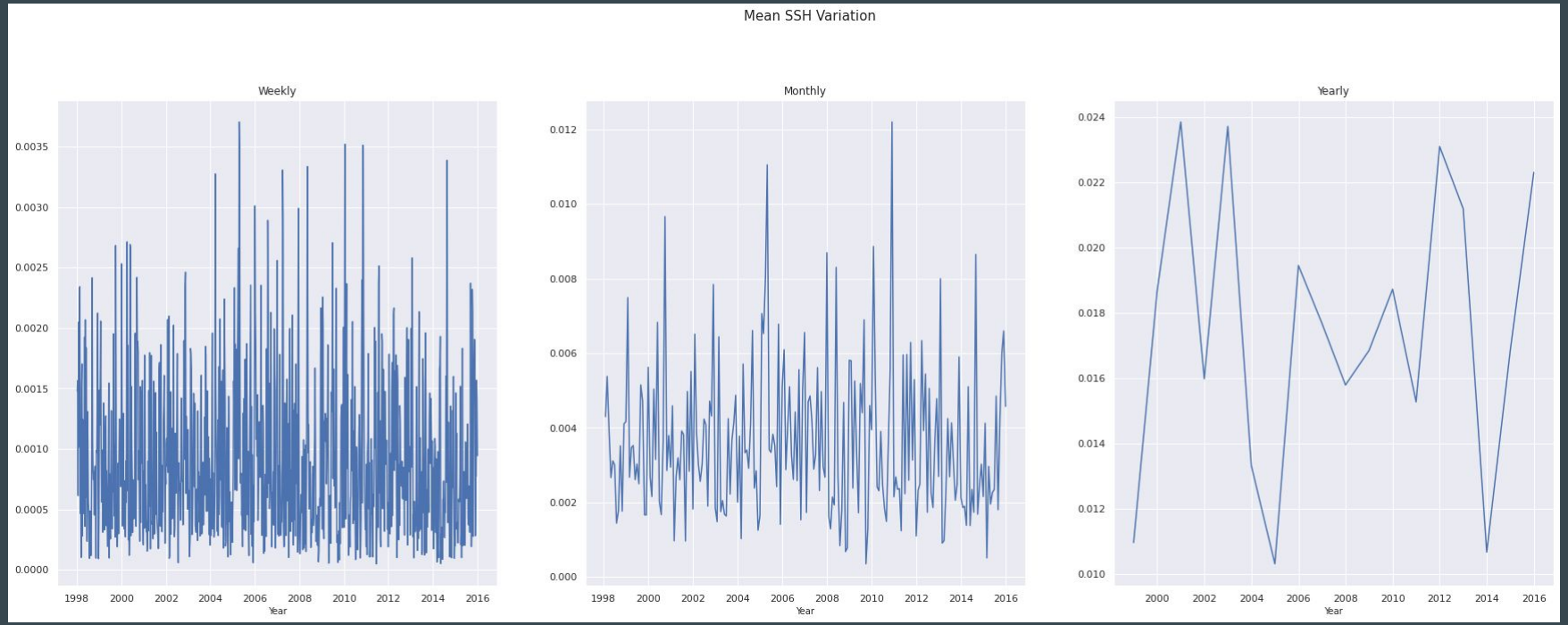
- Mean SSH by Week, Month and Year



- The mean SSH by week, month and year are basically following the trend of the time series
- With the monthly mean SSH plot we can better observe the seasonality

III/ Time series analysis of mean SSH

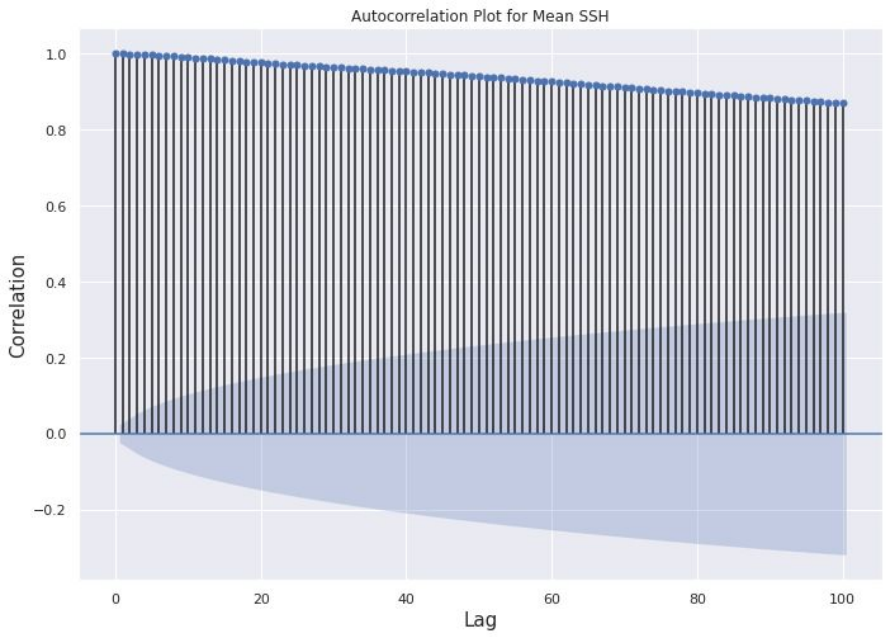
- Mean SSH Variation by Week, Month and Year

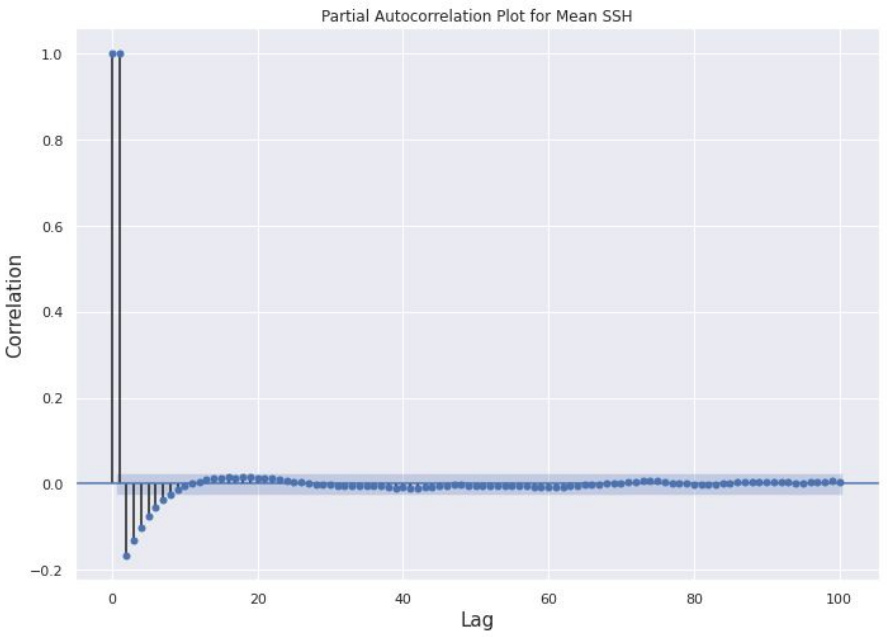


- The variations are random
- Significant values of variations appear in the yearly variation

III/ Time series analysis of mean SSH

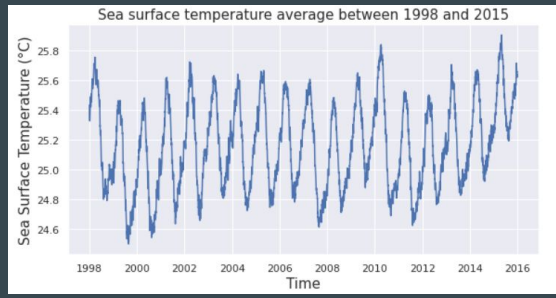
- Autocorrelation and Partial Autocorrelation



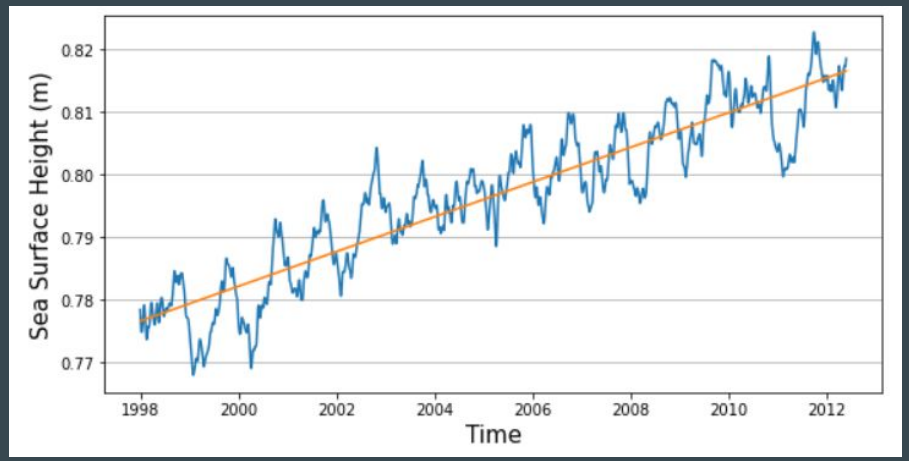


- Autocorrelation : The lags are close to 1 => they are statistically significant
- Partial autocorrelation : partial autocorrelation after first 2 lags is very low.

IV/ Prediction of the sea level rise by 2100



1) Linear regression : at + b



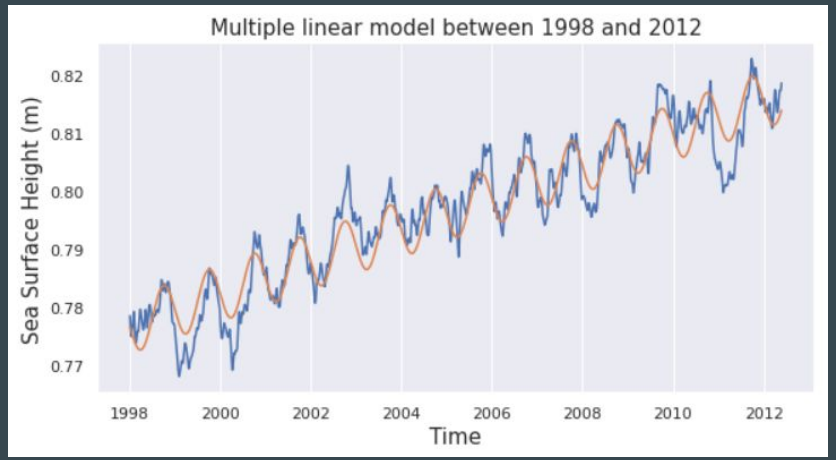
Visualisation of the model

Prediction

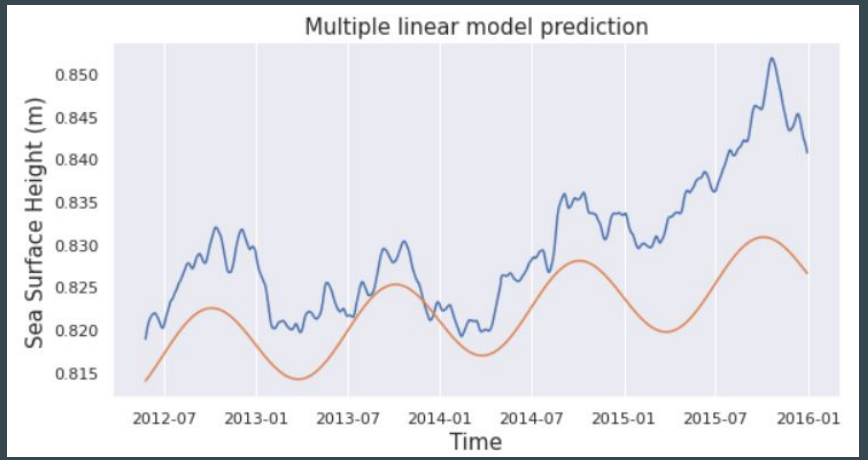
MSE = 9.68e-05

IV/ Prediction of the sea level rise by 2100

2) Multiple linear regression : at + bcos(2pi*omega*t) + csin(2pi*omega*t) + d



Visualisation of the model

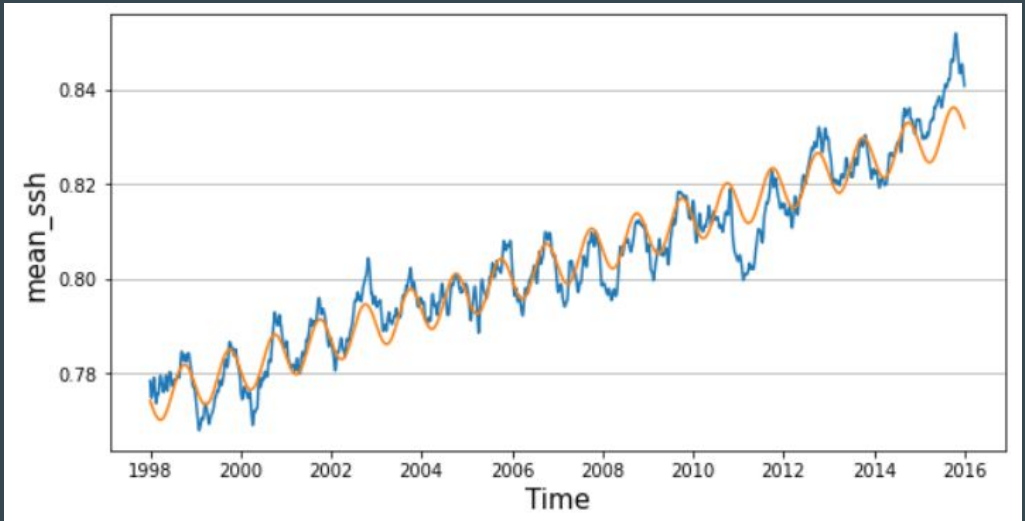


Prediction

MSE = 7.75e-05

IV/ Prediction of the sea level rise by 2100

2) Multiple linear regression : at + bcos(2pi*omega*t) + csin(2pi*omega*t) + d



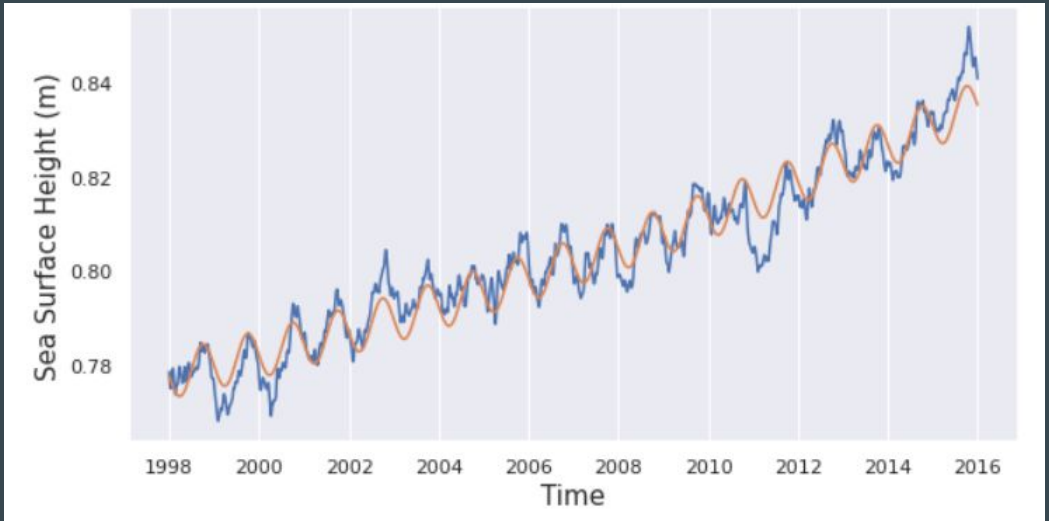
Visualisation of the model

predicted value for 2100 : 1,10 m

r2 score : 94%

IV/ Prediction of the sea level rise by 2100

3) Multiple linear regression : at + bcos(2pi*omega*t) + csin(2pi*omega*t) + dt*t + e



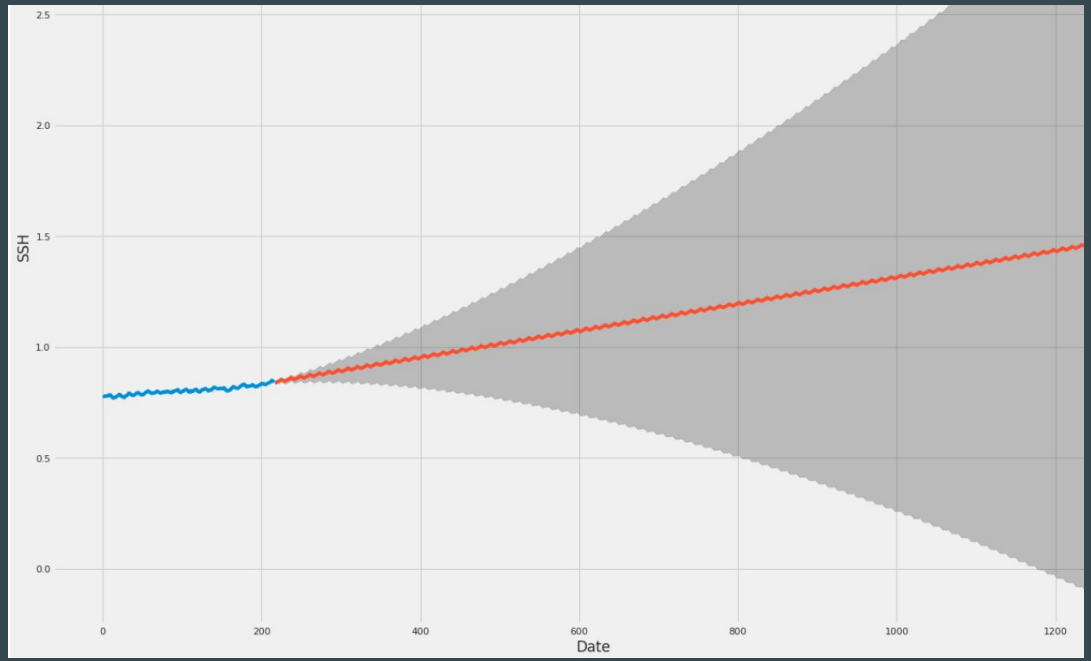
Visualisation of the model

predicted value for 2100 : 1,64 m

r2 score : 95%

IV/ Prediction of the sea level rise by 2100

4) **A**utoreg**R**essive **I**ntegrated **M**oving **A**verage



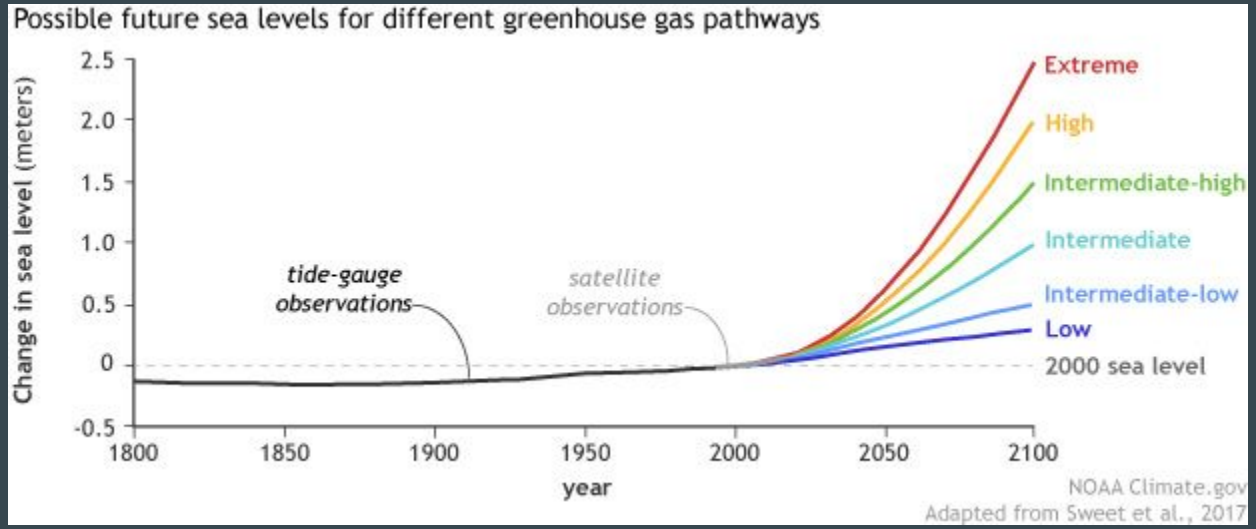
p is the auto-regressive part of the model. It allows us to incorporate the effect of past values into our model.

d is the integrated part of the model. This includes terms in the model that incorporate the amount of differencing to apply to the time series.

q is the moving average part of the model. This allows us to set the error of our model as a linear combination of the error values observed at previous time points in the past.

predicted value for 2100 : 1,46 m

V/ Comparison with NOAA predictions



The prediction for the mean sea level rise (ARIMA) in 2100 compared to the mean sea level in 2000 is **68 cm**.

Thank you for your attention !