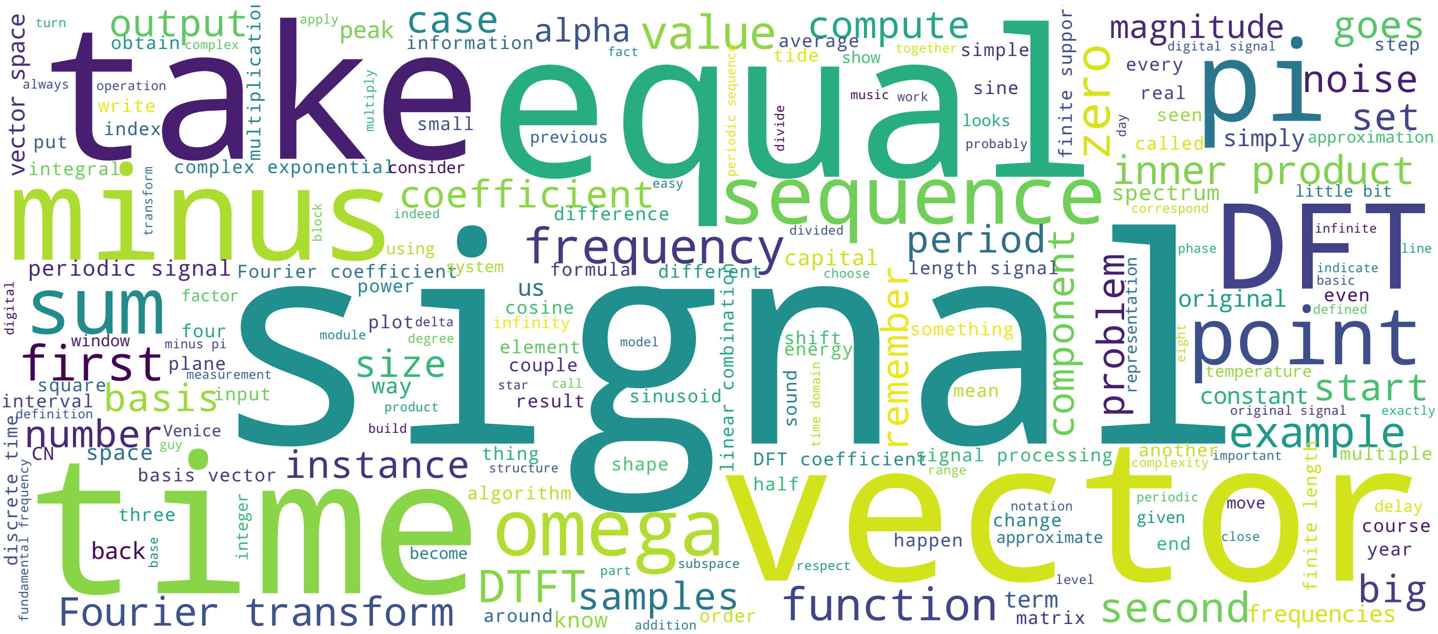
Tides Prediction

- Tides are due mostly to periodical astronomical phenomena (moon, sun, etc...)

- Tides can adversely affect human activity.

- Can we predict tides using our friend Fourier? The first step is to approximate them.



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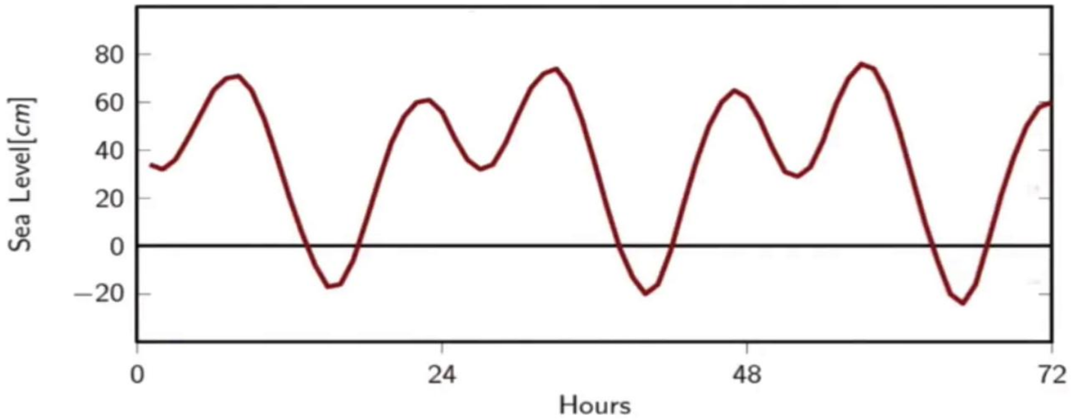
Dataset

- We consider hourly measurements taken in Canal Grande during 2011.
- Example: three days of tides measurements



What is the problem of tide prediction? Well, the tides are phenomenon linked to the movement of the sun, of the moon or the rotation of the earth and so on. All these things are periodic, but they are not all of the same period. We have a phenomenon that is only to first order a simple periodic phenomenon. Now, tides are, of course, important because they can lead to some trouble. Here in Venice is a case in point. Every now and then, the tides plus other natural phenomenon lead to floods in Venice. This is easier for the fun of the tourists or for the annoyance of the people that try to make a living there. Can we try to predict when there will be flooding in Venice? The first step is, as we mentioned, to approximate the tides. Dataset we're going to look at is hourly measurements taken in the Grand Canal during the year 2011. That's very recent data. We can look, for example, here at three days of measurements. That's 72 hours. You can see it's a smooth curve and it has a periodic feel to it, but it's not completely clear what the period is, what the components would be in a Fourier transform. We shall take a Fourier transform of such signal ones and see how to approximate these periodic signal.

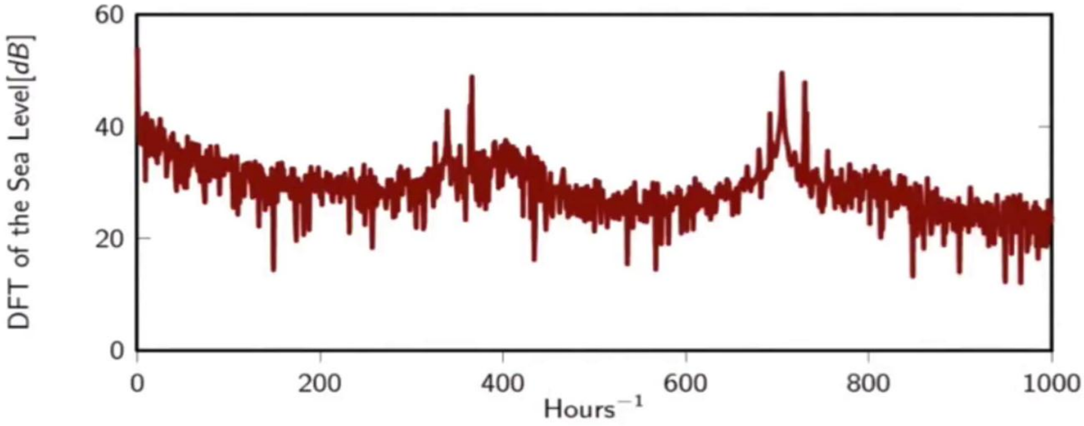
Notes

Summary

0m 01s

Fourier Analysis of the Tides

Look at the Fourier domain of a year of measurements:



If we take one year of measurement, and we take Fourier transform now, the frequencies in one over hours. We can see that there are a few peaks and then there is a lot of noise. The DFT magnitude is plotted on a log scale here. It's very important. You take as the DFT, you take the magnitude of its coefficients and then take the level in dB or in [inaudible 00:01:58] in base 10. Therefore, you can see all the components on a very short scale. You can see there is a peak at zero, then a couple of peaks moving towards 400, a couple of peaks around 700 and a lot of other information that we don't quite understand.

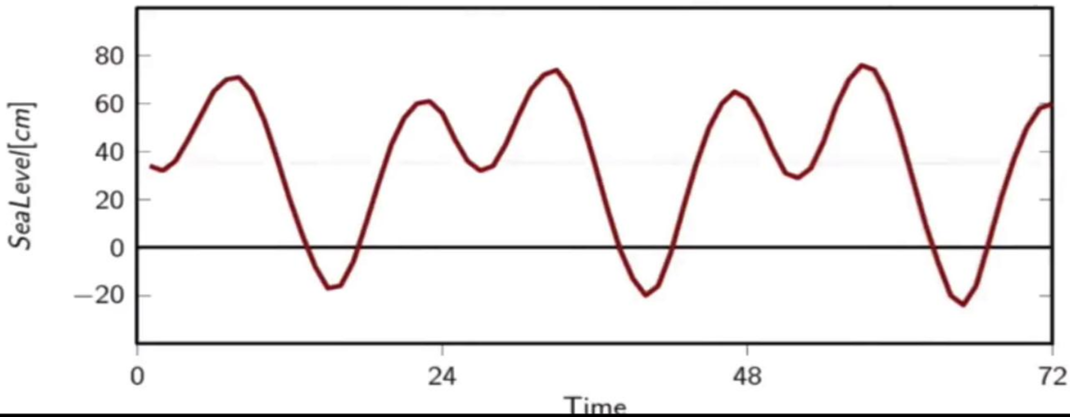
Notes

Summary

1m 31s

Let us approximate tides using few Fourier coefficients

- We consider only $K = 1, 3, 5, 11$ Fourier coefficients
- Darker gray represents approximation with more coefficients.
- The approximations are very precise with a limited number of coefficient.



Let's do now an approximation of this periodic signal and we consider either one Fourier coefficient three, five or 11. That's a very small number with respect to a potential number of Fourier coefficients needed to exactly represent a signal. We're going to start with light grey approximation, which is one coefficient.

Notes

Summary

2m 22s

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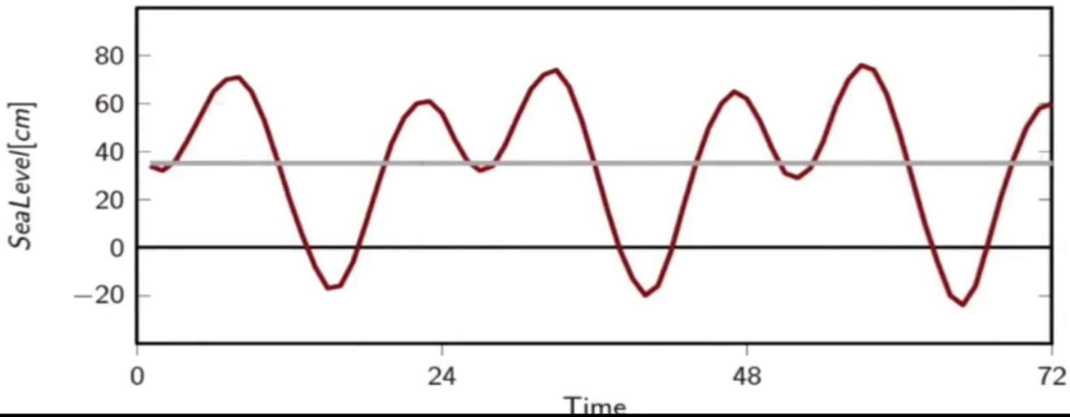
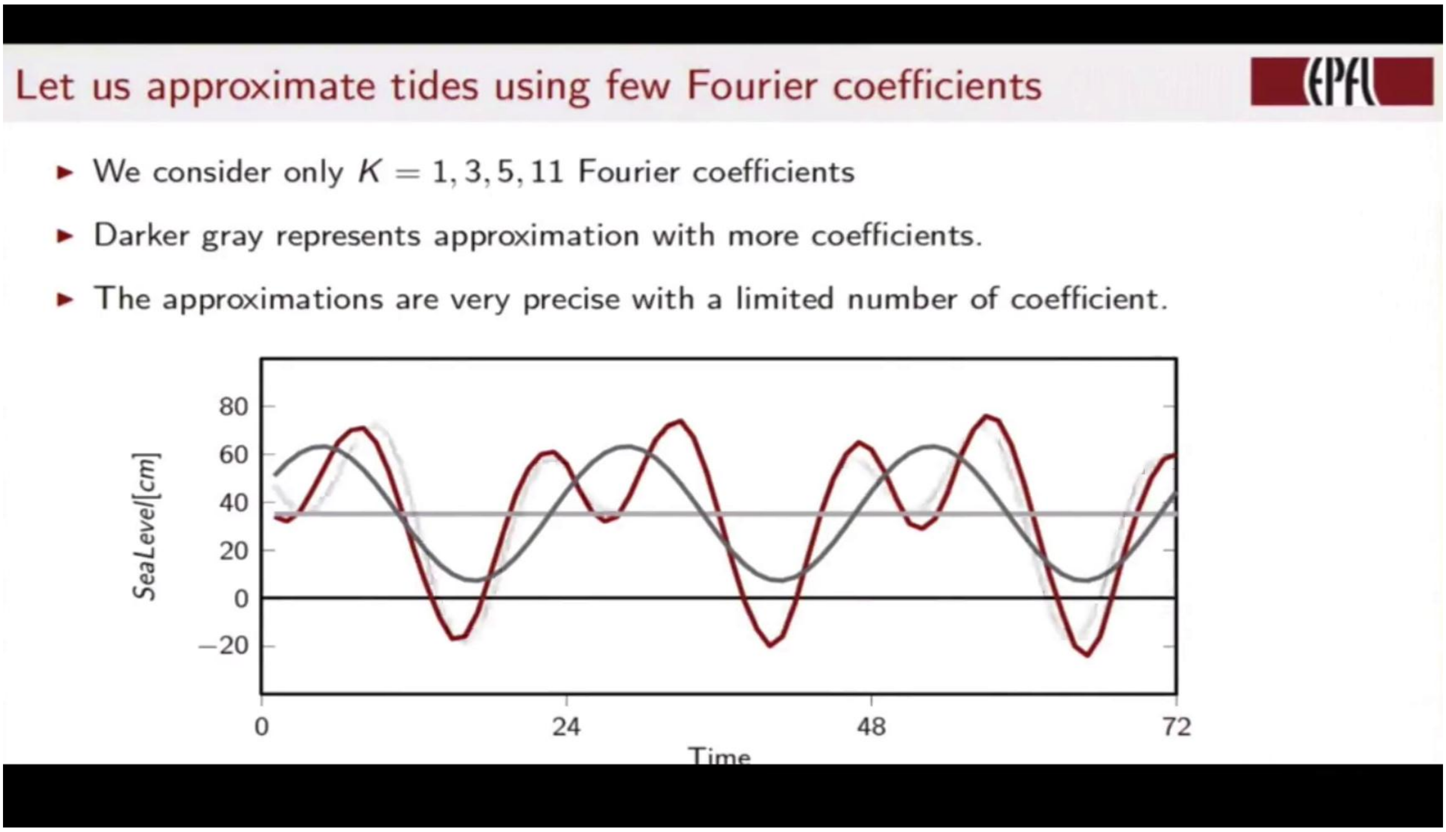


One coefficient is the constant. That's when you simply average out all the signal values and you get this sea level in centimetre approximation in grey, which is a constant, not a very good approximation, just the average.

Notes

Summary

2m 46s



The second one is the constant plus cosine wave. That's three Fourier coefficients plus and minus that frequency. The first fundamental frequency, then we have five Fourier serious coefficients.

Notes

Summary

3m 04s

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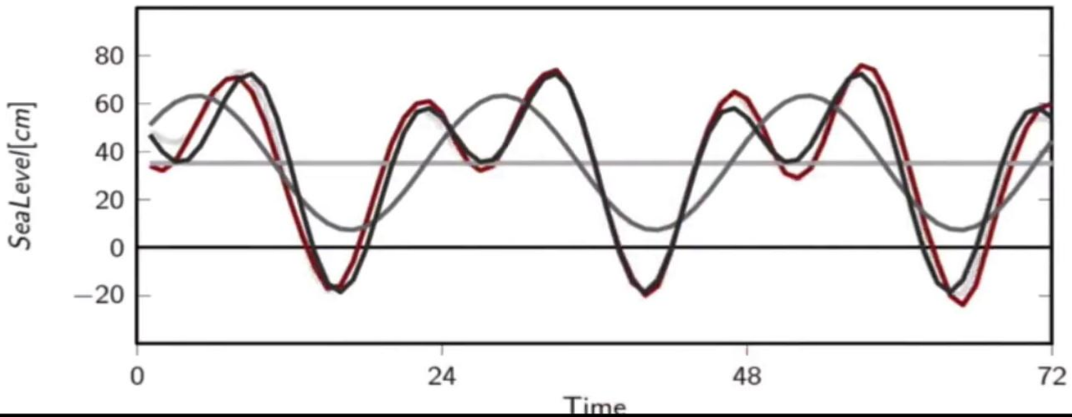

That's a couple of sinus [inaudible 00:03:22]. We have this darker grey value and we see it starts to look like the original signal.

Notes

Summary

3m 21s

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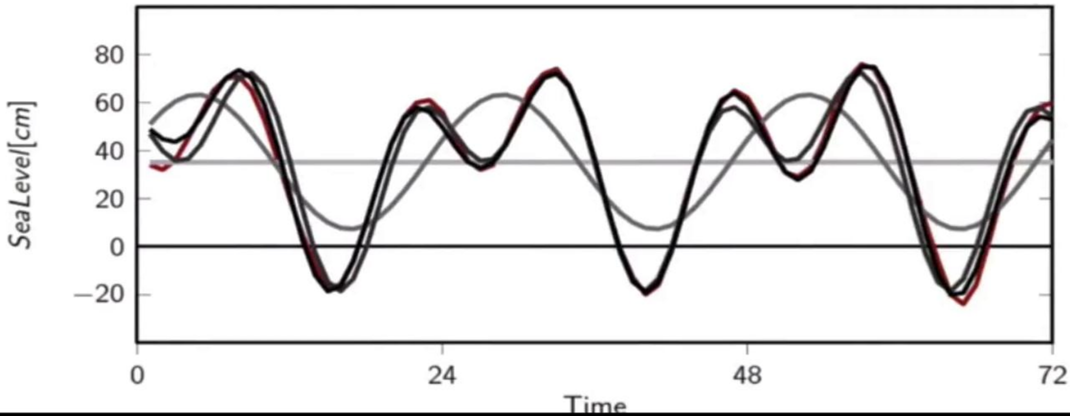

Finally, with 11, only 11 coefficients, we are almost there. The black curve is very close to the original red curve. We get the precise approximation with only a very limited number of coefficients. That is good, because now, if we needed to just look a little bit beyond 72 hours, we probably could have a pretty good prediction based on this model. But we are not going to go into the prediction, this was just a goal of showing approximation, something we had seen previously when we studied Hilbert phases, we had looked at Legendre Polynomial approximations, for example. Here we have Fourier coefficient based approximation of a periodic signal.

Notes

Summary

3m 28s