

Project 1: Toy stochastic climate models

In this project, you will practice with the analysis of observations and with several conceptual stochastic models to explain certain aspects of these data. Make a Python notebook for all computations below.

- (i) Read in the two time series of the corresponding data file for this Project. The data consists of sea surface height (SSH) and sea surface temperature (SST) at the location (153°E, 33°N) in the Pacific Ocean between 1993 – 2018. Plot both the SSH and SST anomalies (w.r.t. to the time mean) and discuss qualitative differences between the time series.
- (ii) Determine the probability density function (PDF) of the time series, calculate the Fourier spectra and determine the power law coefficient of the spectral power decay at high frequency. Do this for both SST and SSH. Remove the seasonal cycle and long-term trend before determining the PDF and Fourier Spectra.
- (iii) Consider the following stochastic differential equation

$$dX_t = \lambda X_t dt + (\mu + \nu X_t) dW_t$$

with X_0 given and real parameters λ , μ and ν . Determine the analytical solution of the stationary Fokker-Planck equation associated with this stochastic differential equation.

- (iv) Provide a method to estimate the parameters λ , μ , in the case where $\nu = 0$ for both SSH and SST and determine their 'best' values. Compare the PDFs for the estimated parameters with the PDF of SSH and SST (as in ii)).
- (v) Provide a method to estimate the parameters λ , μ and ν for the observations for SST and SSH and determine their values. Give a physical argument why these parameters are different for SST and SSH. Compare the PDFs for the estimated parameters with the PDFs of SSH and SST (as in ii)).