

# The Empirical Mode Decomposition Method

## Research Objectives

The main objective of the proposed Mini-Project is to better understand the empirical mode decomposition (EMD) method by applying it to toy models and natural data. Dr Nick Watkins would be the supervisor with input from Drs. Mervyn Freeman and Christian Franzke.

## Why is EMD interesting?

The EMD method [Huang et al, 1998] is a way to investigate complex natural time series. It differs from the more familiar Fourier methods, for example, in that it attempts to allow the modes that it identifies to be determined by the data itself. It is becoming increasingly used in a wide variety of applications, including climate time series [Franzke, 2009].

As with any other such method, one has to “calibrate” it using well-understood time series. This is even more crucial when a method is defined via an algorithm rather than mathematics. The process has started using testbeds such as AR(1) [Franzke, op. cit.] and fractional Gaussian noise. In this mini-project we would like to go further and find out how EMD behaves when confronted with “hybrid” natural data. By “hybrid” we mean natural data which contains both phenomena with characteristic time scales, like the magnetospheric substorm [e.g. Freeman and Watkins, 2002], and a multiscale component which may in some cases be fractal (or multifractal). The mini-project would involve both theoretical work and computer modelling and data analysis.

## Background to be assimilated

Literature on EMD and very simple time series models.

## Suggested Literature:

- N.E. Huang, Z. Shen, S.R. Long, M.L. Wu, H.H. Shih, Q. Zheng, N.C. Yen, C.C. Tung and H.H. Liu, “The empirical mode decomposition and Hilbert spectrum for nonlinear and nonstationary time series analysis,” *Proc. Roy. Soc. London A*, **454**, 903–995, 1998.
- M. P. Freeman and N. W. Watkins, “The heavens in a pile of sand”, *Science*, **298**, 979-980, 2002.
- C. Franzke, “Multi-Scale Analysis of Teleconnection Indices: Climate Noise and Nonlinear Trend Analysis”, *Nonlinear Proc. Geophys.*, **16**, 65-76, 2009.

## Techniques Required

Basic knowledge of applied mathematical methods and time series analysis from your Complexity MSc. courses. Simple programming skills (e.g. Matlab, R).

## Prospective Deliverables

- Testing of existing MATLAB code for EMD on simple toy models.
- Analysis of a geophysical time series available to the British Antarctic Survey using EMD. One possibility is the AE auroral electrojet index used in ionospheric physics (e.g. [Freeman and Watkins, op. cit.])

## Relation to end/downstream users

The Natural Complexity Programme at the British Antarctic Survey is working on many closely-related topics in natural data sets drawn from the magnetosphere, atmosphere, biosphere and cryosphere.

## Prospects for this mini-project leading into a PhD project

This is one of the areas the BAS supervisor Dr. Nick Watkins is considering for a possible PhD topic.