CHAPTER 1 INTRODUCTION

1.1 Rational/Problem

Monsoon is a wind system with seasonal variation of wind direction. Monsoon is the major source of rainfall for Thailand, especially summer monsoon. Thus, monsoon variation is critical for well being of the people in the country. It is found that time series of wind speeds and wind direction show characteristic of fractal, that is self-similar properties and fractional dimension. Fractal dimension is dimension which is non-integer. As one of the important aspects of monsoon is wind (Chang et al., 2012), fractal dimension can be applied to analyse characteristics of Southeast Asian monsoon.

In this thesis, fractal dimension of wind in time series data of Southeast Asian summer monsoon over Thailand is investigated.

1.2 Monsoon

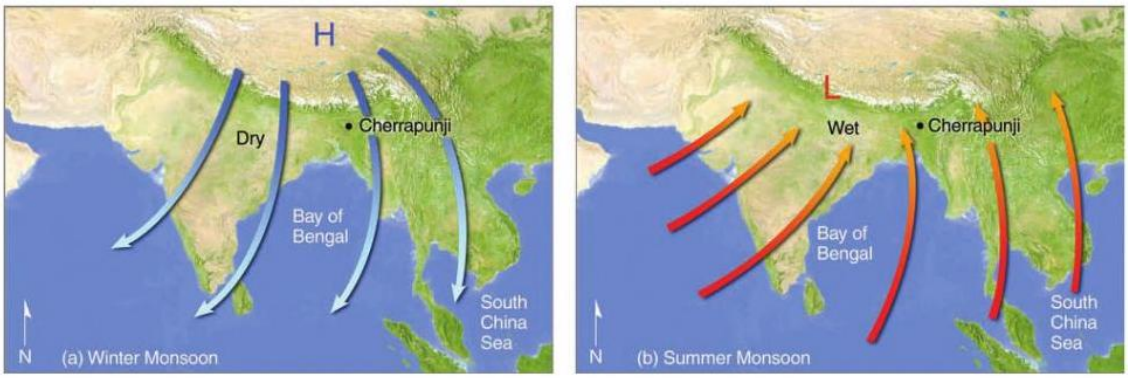
The origin of the word monsoon from the Arabic is mausim, which means seasons. Monsoon is the part of circulation wind that occurs seasonally. A seasonal monsoon wind has certain direction and regularity. The main cause of monsoon is the difference in temperature between continent and ocean (Donald, 2012). The Asian monsoon consists of summer monsoon and winter monsoon. There are opposite in wind direction.

1.2.1 Winter Monsoon

Winter monsoon or northeast monsoon occurs between mid-Octobers to mid-February, the temperature of the continent is lower than the temperature of the ocean, the wind flows from the continent to the ocean (Figure 1.1a). The cool air form Siberian flows southward across eastern China and South China Sea into Southeast Asia (Donald, 2012).

1.2.2 Summer Monsoon

Summer monsoon or southwest monsoon occurs between mid-May to mid-October, the temperature of the continent is higher than the temperature of the ocean, the wind flows from the ocean to the continent (Figure 1.1b). The heated air form The Bay of Bengal and South China Sea flows northward across Southeast Asia (Donald, 2012).



(a) (b)

Figure 1.1 Changing annual surface wind-flow patterns associated with the winter and summer Asian monsoons (Donald, 2012).

1.3 Fractal

The origin of the word fractal from the Latin is fractus, which means break or crack. Most objects in nature have geometric shape that has irregular pattern and fragment. A main characteristic of fractal is self-similar. Thus, fractal is a geometric shape that has self-similar properties and fractional dimension (Breslin, 1999).

1.3.1 Self-Similar

A self-similar object is exactly or approximately similar to a part of itself. When zoom in (Figure 1.2), the shape of small parts will have the same shape as the larger parts. Self-similarity is a typical property of fractals. Self-similar objects can be found in nature such as coastlines, cauliflowers, snowflakes and ferns.

An example for fractal structure is von Koch curve (Falconer, 2003). Let E_0 be a line segment of unit length (Figure 1.3). The set E_1 consists of four segments, each segment is one over three of E_0, obtained by removing the middle third of E_0 and replacing it by other two sides of the equilateral triangle based on the removed segment. Construct E_2 by applying the same procedure to each of the segment in E_1, and so on. Thus E_k comes from replacing the middle third of each straight line segment of $E_{k\text{-}1}$ by other two sides of an equilateral triangle. When k is large, the curves $E_{k\text{-}1}$ and E_k differ only in fine detail and as k tends to infinity, the sequence of polygonal curves E_k approaches a limiting curve F, called the von Koch curve.

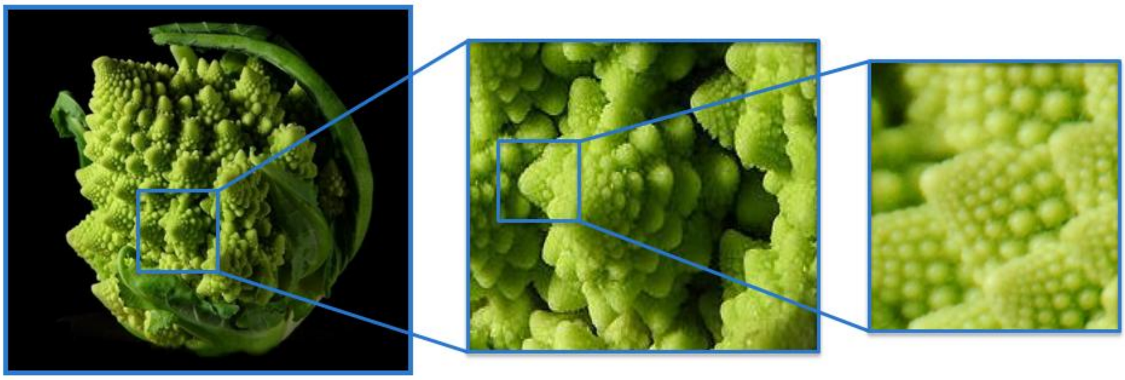


Figure 1.2 A cauliflower is an example of natural fractal (Wikipedia, 2013).

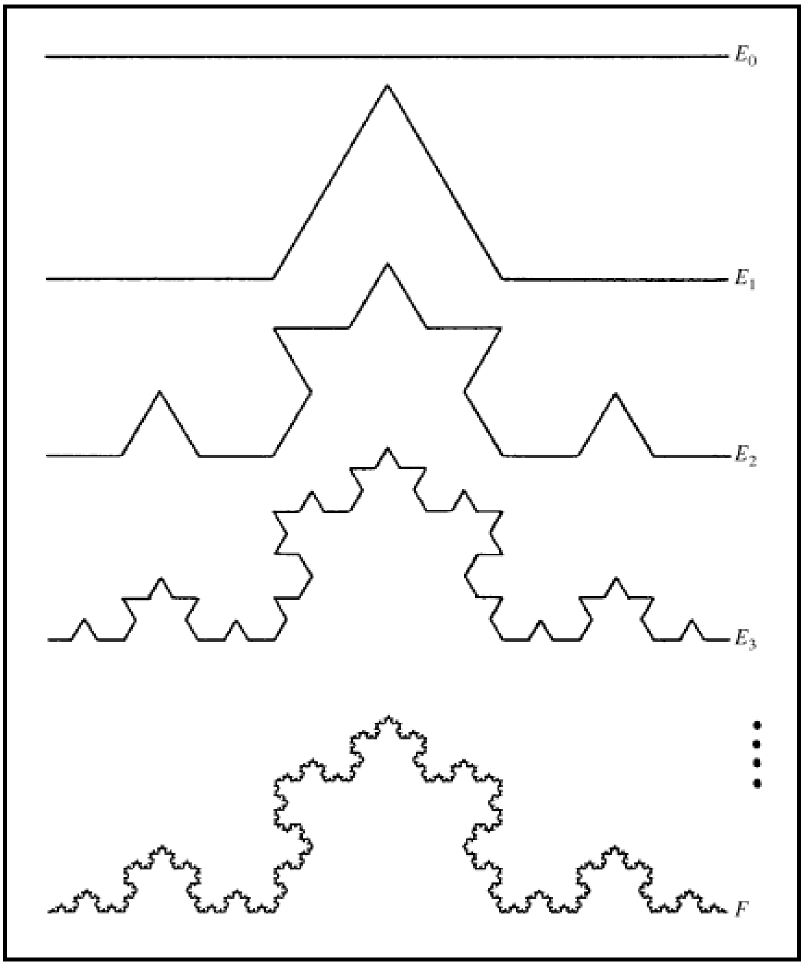


Figure 1.3 Construction of the von Koch curve *F* (Falconer, 2003).

1.3.2 Fractal Dimension

Two examples of fractal object are cauliflower (Figure1.2) and Koch curve (Figure 1.3). Ordinary measurements of the curves, surfaces, and volumes of these objects are very complex. The regular dimension of a geometric object is defined by the number of coordinates required to locate a point in space. For line, square and cube, the dimensions are one, two and three, respectively. For the case of fractal object, regular dimension is not applicable because of complexity of the shape. Thus, fractal dimension which is a non-integer value is used (Peitgen, 2004).

In general, the dimension of fractal object can not be found directly but has to be estimated. There are many researches that propose methods to estimate the fractal dimension of fractal object such as box-counting method, rescale range analysis, Higuchi method, horizontal structuring element method, etc. Estimation of fractal is presented in the next section.

1.4 Literature Review

Dubuc et al. (1989) present the variation method for one dimension. This method is much more efficient than other methods. They show how to generalize the variation method to higher dimensions. The result is a reliable and efficient algorithm for estimating the fractal dimension of surfaces.

Breslin and Belward (1999) present a comparison of 3 methods for calculating the fractal dimension of rainfall time series data. The 3 methods are box-counting, rescaled range analysis and variation methods. The results show that the variation method is more efficient than other methods. They use variation method for finding the fractal dimension of rainfall time series data in Queensland. Dimension of the time series data between 1 and 1.5 indicates persistence, while dimension between 1.5 and 2 indicates anti-persistence.

Rangarajan and Sant (2004) use fractal dimensional analysis to investigate and analyze time series data of three major dynamic components of climate which are temperature, pressure and precipitation. They find an interesting effect that precipitation during the south-west monsoon is affected by temperature and pressure variability during the preceding winter and also find that for most stations it is the unpredictability in pressure which leads to the unpredictability in rainfall.

Brewer and Girolamo (2006) present a comparison of four algorithms to estimate fractal dimension for 1-D fractal curve. The results show that the variation method performs better than other methods. Then they apply this method for cloud studies.

Berizzi et al. (2006) apply the variation method to estimate fractal dimension of sea synthetic aperture radar (SAR) images. They extend the variation method to apply in two dimensions and also propose a corresponding numerical formulation.

Nimkerdphol and Nakagawa (2008) calculate the fractal dimension of the three dimensions time series data of swimming trajectories of goldfish by the Higuchi method and the scaling properties of variance. They found that the scaling properties of variance method performs slightly faster than the Higuchi method.

Suleymanov et al. (2009) calculate the fractal dimension of time series in oil and gas production by the Suggested method. This method possesses high accuracy and rapidity, moreover, it is quite a simple method for calculation of fractal dimension.

Raghavendra and Dutt (2010) develop a method to compute fractal dimension of discrete time signals, by develop a modified box-counting method. The estimation accuracy of the method is compared with that of the Katz, Sevcik, and Higuchi methods. It is found that the Higuchi method requires much less computation time.

Chang et al. (2012) apply the concept of fractal dimension to investigate wind speed characteristics. Wind data are observed from three wind farms in Taiwan with different climatic conditions, from 2006 to 2008. They calculate the fractal dimension of wind speed time series by a modified box-counting method. The results show that the wind speeds are characterized by medium to high values of fractal dimension between 1.61 and 1.66.

In this study, the variation method is improved and then used to investigate fractal dimension of time series of summer monsoon wind over Thailand.

1.5 Objective

To investigate fractal dimension of time series of summer monsoon wind over Thailand using a modified variation method.