CHAPTER 1 INTRODUCTION

1.1 Rationale / Problem Statement

One possible cause of tropical cyclone genesis is a collision of wind streams that results in radial and tangential components of a vortex. Over the Gulf of Thailand strong northeast monsoon wind sometimes collides with the prevailing easterly or southerly winds. With appropriate wind speeds and directions, a vortex could be generated and acts as an inertial disturbance for tropical cyclone formation. If the size of the initial disturbance is large enough, it could be intensified into tropical storm or typhoon. If the storm is formed in the Gulf of Thailand it can move into the country and causes a great damage (Figure 1.1). To alleviate from the disasters associated with tropical cyclones, the first step that has to be done is to predict when and where a vortex will be generated. In this research, a mathematical model for vortex formation based on collision of two fluid jets is developed.

1.2 Tropical Cyclone

A tropical cyclone originates over a tropical ocean and is driven principally by heat transfer from the ocean. Tropical cyclones are categorized according to their maximum wind speed. Tropical cyclones with maximum winds of 17 m/s or less are known as tropical depressions. When their wind speeds are in the range of 18 to 32 m/s they are called tropical storms. Whereas tropical cyclones with maximum winds of 33 m/s or greater are called hurricanes in the western North Atlantic and eastern North Pacific regions, typhoons in the western North Pacific, and severe tropical cyclones elsewhere (Ahrens, 2005).

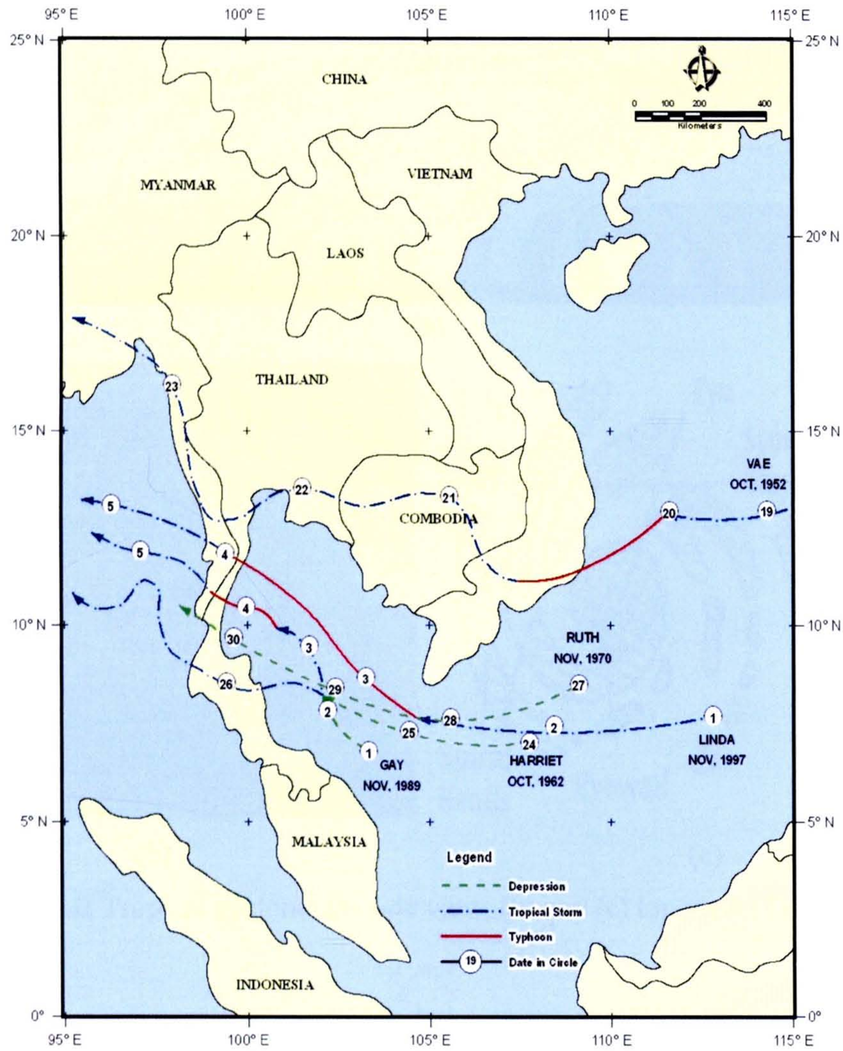
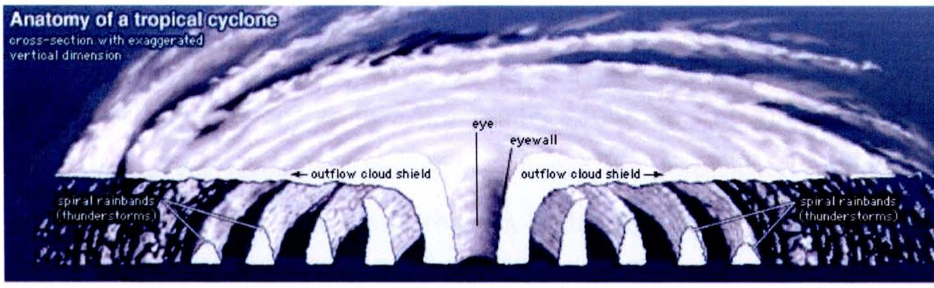
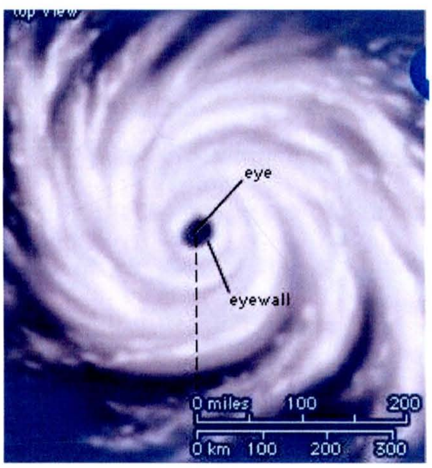


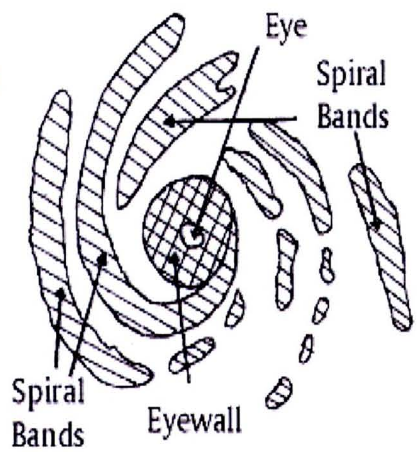
Figure 1.1 Tracks of five most disastrous tropical cyclones over Thailand (Vongvisessomjai, 2009).

The tropical cyclone structure consists of the center (or eye) with calm wind and clear sky, maximum wind speed and convective clouds around the eye called eyewall, spiraling winds converging towards the center (Figure1.2). Wind in a tropical cyclone can be separated into tangential wind and radial wind as shown in Figure 1.3.



(a)





(b) (c)

Figure 1.2 Tropical cyclone; (a) side view, (b) and (c) top view (Tai, 2009).

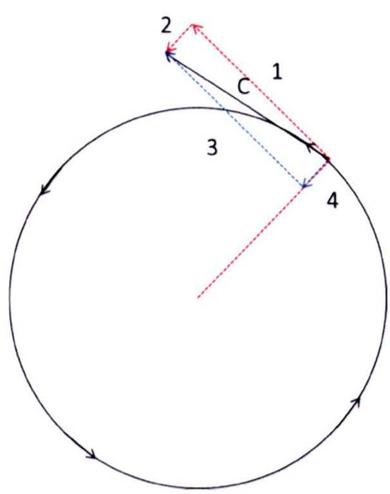


Figure 1.3 Tangential and radial wind components of a tropical cyclone. C is tropical cyclone wind, 1 and 3 are tangential wind components and 2 and 4 are radial wind components.

1.3 Literature Review

Chang et al. (1979) analyze data from a pre-Winter Monsoon Experiment (WMONEX) pilot study to examine the possible interactions between the northeasterly cold surges off the Asia continent and the convective disturbances in the near equatorial region. Based on surface and 850 hPa wind and temperature analyses, satellite data, and synoptic weather charts of the Hong Kong Royal observatory (during 3-12 December 1974), a sequence of synoptic events associated with two cold air surges and near-equatorial disturbances over the WMONEX area of South China Sea and its vicinity during December 1974 is discussed. The results are the varying degree of air-sea interactions between cold-air originating from the Southeastern China coast. This allows a near-equatorial disturbance to be intensified at an early state of the surge by enhanced low-level convergence and organized deep cumulus convection.

Meng et al. (1995) analyze a model for simulation of the wind field in a moving typhoon boundary layer. This model has an upper invisicid layer of cyclostrophic balance and lower friction layer controlled. Perturbation analyzes are performed to obtain the tangential and radial boundary layer velocity in the friction region. Wind speeds and directions agree with 100m tower observation at Nagasaki, Japan during three typhoons in 1991 (Caitlin, Kinna and Mireille). An appropriate ratio between the surface to gradient wind speeds and the related inflow angle determines the formation of the storm.

Gray (1998) shows that the genesis of tropical cyclones only occurs in environments characterized by small vertical shear of the horizontal wind. He establishes a set of conditions that are apparently necessary (though by no means sufficient) for genesis; the coriolis parameter, low-level relative vorticity, inverse of tropospheric vertical wind shear, ocean thermal energy and temperature more than 26°C at depth 60 m, difference in equivalent potential temperature between the surface and 500 hPa and relative humidity in the mid-troposphere.

Letch Ford et al. (2001) study observations of high-resolution wind speed data from two United States of America Atlantic Coast hurricanes to compare several models for evaluating the effect a terrain change on the mean and gusty wind speeds at 10 m height. The results indicate that these models tend to overestimate the increase in speed at 10m height.

Chow et al. (2002) develop a theory based on the shallow water equation to explain the genesis of moving spiral banded structures in tropical cyclones. According to this theory, fluctuation of the vorticity distribution in a compact vortical region can act as a source to generate gravity waves. These gravity waves produce the spiral banded structure.

Majumdar (2003) develops a mathematical model of a disturbance created by winds coming from different directions and colliding to give rise to a vortex. Under favorable conditions, this vortex may lead to the development of a cyclonic storm (cyclogenesis).

Chambers et al. (2006) use a mesoscale model simulation to investigate the formation and intensification of the near-equatorial typhoon Vamei formed in the South China Sea in December 2001. The model simulation shows that a convectively driven vortex may be developed at near equatorial latitudes for a short period.

Juneng et al. (2001) use the Pennsylvania State University/National Center for Atmospheric Research mesoscale model (PSU/NCAR) to simulate tropical cyclone Vamei (2001). The model simulated track of the cyclone is compared to be best track provide by the Joint Typhoon Warning Center. Analysis of the model output indicates the important of the latent heat flux in the genesis and intensification.

Stern et al. (2009) show that the outward slope of the radius of maximum winds (RMW) is a function of the size of the RMW and the intensity of the storm. They find that the RMW becomes increasingly vertical with increasing intensity and decreasing radius. The RMW is a surface of constant absolute angular momentum. The outward slope of the RMW is shown to increase with radius. A relationship is found among the slope of the RMW, intensity and angular momentum surface.

Wei et al. (2011) study the formation of spiral pattern by determine appropriate center point and the equation. Satellite images have been used to verify the spiral pattern.

From various anticles mentioned above, there is no research that develops a model for study the formation of tropical cyclone in the Gulf of Thailand. Thus, it would be a great benefit for Thailand if a simple mathematical model of tropical cyclone formation could be developed.

1.4 Objective

To develop a mathematical model of tropical cyclone formation in the Gulf of Thailand based on a collision of two wind streams.