การเปลี่ยนแปลงมรสุมและพายุหมุนเขตร้อนในช่วงปี 2524-2556
ในพื้นที่ชายฝั่งอ่าวไทยตอนบน

นางสาวเบญจวรรณ เจ้ยทองศรี

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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MONSOON AND TROPICAL CYCLONE CHANGES DURING 1981-2013 IN COASTAL AREA THE UPPER GULF OF THAILAND

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A Thesis Submitted in Partial Fulfillment of the Requirements
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เบญจวรรณ เจ้ยทองศรี : การเปลี่ยนแปลงมรสุมและพายุหมุนเขตร้อนในช่วงปี 2524-2556ในพื้นที่ชายฝั่งอ่าวไทยตอนบน (MONSOON AND TROPICAL CYCLONE CHANGES DURING 1981-2013 IN COASTAL AREA THE UPPER GULF OF THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ศ. ธนวัฒน์ จารุพงษ์สกุล, 96 หน้า.

ตัวแปรทางอุตุนิยมวิทยาที่มีผลกระทบต่อการเปลี่ยนแปลงชายฝั่งทะเลในพื้นที่อ่าวไทยตอนบนโดยในการศึกษาครั้งนี้จะเห็นปัจจัยที่มีผลการการกัดเซาะชายฝั่งโดยลมมรสุมตะวันออกเฉียงเหนือและลมมรสุมตะวันตกเฉียงใต้ซึ่งมีบทบาทสำคัญในการควบคุมสภาพภูมิอากาศในพื้นที่การไหลเวียนของระบบมรสุมมีความสัมพันธ์ต่อการเปลี่ยนแปลงลม ฝน และการไหลเวียนของกระแสน้ำในอ่าวไทย

วัตถุประสงค์ของการวิจัยเพื่อศึกษาแนวโน้มการเปลี่ยนแปลงของมรสุมและพายุหมุนเขตร้อน ในช่วงปี 2524-2556 ในพื้นที่ชายฝั่งอ่าวไทยตอนบน และผลของความสัมพันธ์ระหว่างการเปลี่ยนแปลงมรสุมและพายุหมุนเขตร้อนที่ส่งผลต่อการกัดเซาะชายฝั่ง โดยใช้ข้อมูลย้อนหลัง 30 ปี ของกรมอุตุนิยมวิทยา 6 สถานี รอบๆพื้นที่ศึกษา ศึกษาโดยการประมวลด้านสถิติ และพล๊อตกราฟดูการเปลี่ยนแปลงและเปรียบเทียบกับภาพถ่ายดาวเทียมการกัดเซาะชายฝั่ง

ผลการศึกษาการเปลี่ยนแปลงของมรุสม พบว่าทิศทางลมในช่วงมรสุมตะวันออกเฉียงเหนือซึ่งมีลมเปลี่ยนทิศทางจากทิศตะวันออกเฉียงเหนือเป็นทิศตะวันออกมากขึ้นถึงแม้ว่าลมมรสุมตะวันตกเฉียงใต้จะมีการเปลี่ยนแปลงไม่เด่นชัดแต่เนื่องจากช่วงที่การเปลี่ยนแปลงทิศทางลมในช่วงมรสุมตะวันออกเฉียงเหนือสอดคล้องกับการกัดเซาะชายฝั่งในพื้นที่มากขึ้นด้วย และจากการรวบรวมข้อมูลพายุหมุนเขตร้อนในอดีตโอกาสที่จะมีพายุไต้ฝุ่นที่เคลื่อนตัวผ่านพื้นที่ศึกษามีไม่มากนัก ดังนั้นการกัดเซาะเนื่องจากพายุมีน้อยตามไปด้วย จากผลถ่ายดาวเทียมแสดงให้เห็นการเปลี่ยนแปลงแนวชายฝั่งเพิ่มขึ้นและเมื่อเปรียบเทียบกับข้อมูลแนวกัดเซาะชายฝั่ง เรียงตามลำดับจังหวัดที่แนวกัดเซาะชายฝั่งที่รุนแรงที่สุดไปน้อยที่สุด คือ จังหวัดเพชรบุรี 49.75 กิโลเมตร จังหวัดสมุทรปราการ 34.69 กิโลเมตร และจังหวัดสมุทรสงคราม 33.45 กิโลเมตร ดังนั้นจากการศึกษาครั้งนี้ทำให้ทราบว่าช่วงมรสุมตะวันออกเฉียงเหนือทำให้เกิดการพัดพาตะกอนออกจากแนวชายฝั่งและภาพถ่ายดาวเทียมของพายุหมุนเขตร้อน Yvette 2004 ส่งผลต่อการเกิดการกัดเซาะชายฝั่งในพื้นที่อ่าวไทยตอนบนด้วยเช่นกัน

ภาควิชา ธรณีวิทยา	ลายมือชื่อนิสิต ....
สาขาวิชา โลกศาสตร์	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
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BENJAWAN JEITONGSRI: MONSOON AND TROPICAL CYCLONE CHANGES DURING 1981-2013 IN COASTAL AREA THE UPPER GULF OF THAILAND. ADVISOR: PROF. THANAWAT JARUPONGSAKUL, 96 pp.

This study of meteorological variables those affected coastal area changes on the upper Gulf of Thailand, revealed that factors affected coastal erosion by north-eastern and south-western monsoons, which had important role for weather condition control in monsoon system blowing areas, related to changes of winds, rain and ocean currents in the Gulf of Thailand.

The objectives of this research were studies of changing trend of monsoons and tropical cyclones during 1981-2013 in coastal area on the upper Gulf of Thailand and effects of relationship between changes of monsoons and tropical cyclones, which affected to coastal erosion on the upper part of the Gulf of Thailand. By using historical data from six stations of meteorology department around studied area and statistical processing with graphical plotting of changes compared to aerial satellite images of coastal erosion.

The study of changing trend of monsoons from the six stations showed obvious change at Phetchaburi station. Wind blowing directions during having north eastern monsoon changed from south eastern direction and south-western monsoon changed to south-eastern and southern directions and during having north eastern monsoon conformed to increasing coastal erosion areas. Aerial satellite images showed increasing coastal change when compared to coastal erosion data from department of Marine and Coastal Resources 49.75 kilometers in Phetchaburi province, 34.69 kilometers in Samut Prakan province and 33.45 kilometers in Samut Songkhram province. For changing trend of tropical cyclones, there was no change in moving direction of the cyclones. There were low opportunities for typhoons to pass through studied area so that there was low coastal erosion from typhoons. During study tropical storm, named “Yvette 2004” affected coastal erosion in the studied area, which could be obviously seen on aerial satellite images

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Field of Study:	Earth Sciences	Advisor's Signature	....
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CHAPTER I INTRODUCTION

1.1 Reason and cause of Coastal Erosion in Gulf of Thailand

There are coast zone linked among 5 provinces together as The upper gulf of Thailand that including Samut Songkhram, Samut Sakhon, Bangkok, Samut Prakan, and Chacherngsoa. There is 4 rivers flow in to the gulf of Thailand; Mekong river, Tha Chin River, Chao Phraya River, and Bang Pakong River. The area is comprised of clay sediments estuary which thick of the clay layer is around 19-21 meter, cover with plentiful mangrove forest, which have a large area as a top list in the country, throughout the coast for 100 kilometers. Therefore the coast area has been affecting a Coastal Erosion continuously and been reducing a space of area for many meters a year. Some area has been reducing for 10-20 meters a years. For sample of critical areas are comprised of a coast length 4.7 kilometers of Bangkhunthian district, Bangkok that has been eroded almost a thousand Rai, as critical as Klongdan, Bangbor district, Samut Prakan in the same time.

Coastal Erosion problem in Thailand currently trend to be increased and became an important problem with provinces which connected to coast area. It will be affected to changing of coastal in Gulf of Thailand, especially losing coast area dramatically, also surely affected to a great number of people who live in the area [1] Cause of Coastal Erosion in Gulf of Thailand.**[1]**

Coastal Erosion is a natural approach of coastal area changing, that a coast been eroded by wave or wind transfer sediments from an area to defame on another. The areas that have less sediments come to replace the old one, is a coastal erosion area.

There are 2 main reasons divided as following;

1. Coastal area changing by natural approach such as erosion of waves and winds, storm, flood, or activity of livings in the area, so wave become an important factor for a changing of sediments and coastal sands

1.1 Strom and monsoonal winds. Northeast monsoon and southwest monsoon are influence to annual natural coastal changing such as quantity of sands in east coast usually been reduced during the northeast monsoon come but increased during the southwest monsoon come. However, in case a great storm buffet into gulf of Thailand is also affect to changing of seacoast too.

1.2 Water stream and tidal processes are affected to moving of sediments and sand mass in the coast area, that is a significant factor of erosion and rising of a land in some area.

1.3 A different coastal characteristic is related to quantity of erosion each area. A bay area will be less eroded than an open-sea for example; a lower gulf of Thailand will be affected dramatically when any storm had risen in South China Sea because waves affected coastline directly as it is an open-sea, and a less steep area will be less eroded than a great steep area.

2. Coastal changing by human activity is a significant factor of the changing of coastline. As human is more emphasizing to develop and improve economic and society by using natural resources in production process, but less caring to preserve and rehabilitate. As a result, important natural resources has been destroyed and degenerated every moment. Activities that increase critical of coastal erosion are including [29]

2.1 Mega project development in coastal area such as building a deep water port, coast road, and land reclaimed for any building construction in the industrial estate to support economic development of the country.

2.2 Development of marine tourism and seacoast, which focus on using benefit of lands to support tourism activity for example building a hotel, resident, transportation that trespass into Barrier Coasts berm, a fortress to protect natural coastline from erosion.

2.3 Building dam or reservoir. These infrastructures are affecting to reduce compiling of sediments from rivers. Once sediments of the area could not be replaced by a new one, but flowed to another area by water stream, coastal area would be eroded continuously as same as Bangkhunthian seacoast for instant.

2.4 A trespassing of mangrove forest area for developing an Aquaculture Area. Mangrove forest is important for many aspects, one is to conduct and precipitate mud to rising soils on coastline and to be a fortress protecting coastline from destroying by waves and winds

2.5 Pumping underground water is affecting to subsidence of land and increasing critical of coastal erosion such as coastal erosion in upper gulf of Thailand because of pumping underground water over limit of the area Bangkok, and Samut Prakan

2.6 Earth climate changing is affecting to Coastal Ecosystems and coral. Inclement weather, especially sea-level rise, affects to seacoast of the whole country and possibly raises coastal erosion at the same time.[1]

A relationship of studying natural changing in the past is still support to understand and predict any change in the future because current status we have found today are all the results from any activities in the past, we would never understand changing of status we are facing of if we are lacking of knowledge of revolution in the past. Some changes in the past could not be seen in the present, but might be come to be seen in the future.

1.2 Objectives of the research

1. To study trends of monsoon's change in the upper gulf of Thailand during 1981 – 2013
2. To study trends of tropical cyclone 's change in the upper gulf of Thailand during 1981 – 2013 and to find relationship between tropical storm and intensity of winds in the upper gulf of Thailand.

1.3 Scope of the research

1. Area of the study is 5 provinces in upper gulf of Thailand including Samut Songkhram, Samut Sakhon, Bangkok, Samut Prakan, and Chacherngsoa. There are 6 Meteorological stations as following; 1. Pilot station, Samut Prakan 2. KlongToey Meteorological station, Bangkok 3. Bangna Meteorological station, Bangkok 4. Kosichang

Meteorological station, Chonburi 5. Pattaya Meteorological station, Chonburi 6. Phetchaburi Meteorological station

2. Study change of monsoon by data from Meteorological Department forwarded back for 32 years, during 1981 – 2013 to study intensity of winds

3. Study change of tropical cyclones flew through the gulf of Thailand for 32 years, during 1981 – 2013, in upper gulf of Thailand that how many of them which had affected to coastal erosion in the area at the mentioned duration

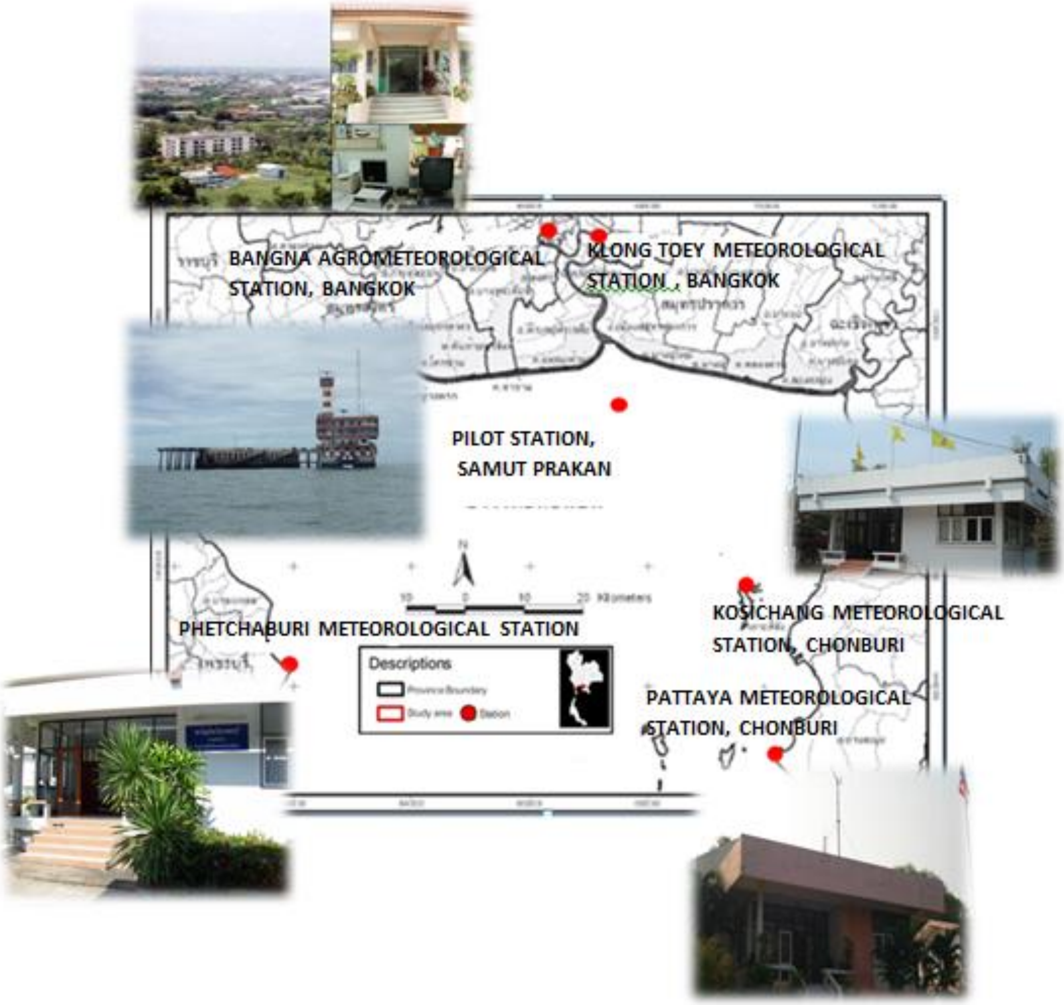


Figure 1 The study area in the upper gulf of Thailand

1.4 Definitions used in research

Monsoon is a circulation part of winds according to the season comprise of seasonal winds that have actual direction regularly. Monsoon is from “mausim” in Aruba, means seasons. The main reason is from differentiation between ground temperature and water temperature. In winter ground temperature is colder than water temperature in ocean, so air above water surface have higher temperature and float up to higher, then air above continents which colder float to replace the space accordingly. Therefore, it caused the wind floating out of continents. In summer, ground temperature is hotter than water temperature in ocean that caused the winds floating into an opposite direction. The strongest monsoon is including the southeast monsoon and the northeast monsoon.

Southeast monsoon The southeast monsoon floating cover Thailand during the mid of May to the mid of October, which is rise from high pressure area in south hemisphere in India ocean, float out of the center as southeast monsoon and turn out to be southwest monsoon when float pass an equator. This monsoon bring moist air mass from India Ocean into Thailand, that affect to be cloudy and rain over the2 country, especially seacoast area and the mountain which facing the wind would have more rain than the others .[2]

Northeast monsoon after end of influence from the southeast monsoon, the northeast monsoon will be covered over the country around the mid of October to the mid of February. This monsoon is rise from high pressure area in north hemisphere, among Mongolia and China, so it bring mass of dry and cold air cover Thailand that make brighten sky, cold weather and dry generally, especially in the north and northeast, while the south is rain especially the southeast. As these monsoons bring mist from gulf of Thailand cover over the country, beginning and ending of both monsoons could be changed from usual in each year. [2]

Tropical cyclone Tropical cyclone have variety of name depends on source location such as a cyclones in Bengal and India Ocean are called CYCLONE, while tropical cyclones in north Atlantic, Caribbean, Mexico Bay, and western of Mexico are called HURRICANE, tropical cyclones in the west of north Pacific Ocean, south Pacific Ocean and South China sea are called TYPHOON. Most of tropical cyclones that have influence to weather of Thailand are raised in the west of Pacific Ocean and South China Sea. There are violence criteria of the storm according to an international agreement divided by using the wind speed near Eye (the center of the storm) of the storm as following

1. Depressions, wind speed not over 33 knots (61 km/ hr.)
2. Tropical cyclone, wind speed 34 -63 knots (62 -117 km/ hr.)
3. Typhoon, wind speed over 64 knots (>118 km/ hr.)

Thailand is located between 2 sources origin of tropical cyclone including Pacific Ocean and South China Sea on the east, Bengal and Andaman Sea on the west. The storms possibly move from Pacific Ocean and South China Sea into Thailand more on the east than on the west. [2]

1.5 Expected Results/ Benefit

1. To know changed of storms and tropical cyclone in upper gulf of Thailand for 30 years

2. to know the relation result between changing of storms and tropical cyclone that have effect to coastal erosion in upper gulf of Thailand during year 1981 – 2013, and find out the relation between tropical cyclone and intensity of coasts wind in upper gulf of Thailand

CHAPTER II LITERATURE REVIEWS

2.1 Geography in Coast of the Upper Gulf of Thailand

The upper Gulf of Thailand (UGOT) is the area from HuaHin district of PrachuapKhiri- Khan Province to Sattahip District of Chonburi province. This area is similar to kokai shape in Thai alphabet. The length of shoreline is about 300 meters. In this study, the areas cover only the head of koh kai from Laem Phak Bia of Phetchaburi province to Pattaya District of Chonburi province. The length of shoreline is about 267 kilometers. [3]

The coastal area of the northern GOT is a support of Nam Tha and sediments since there are four major rivers, i.e., Mae Klong, Tha Chin, Chao Phraya, and Bang Pakong. It caused a coastal area of Samut Sakhon, Bangkok, Samut Prakan and Chachoengsao is a mud flat and slope below. While the west coast of the GOT from Pak BIA to a border of Phetchaburi is the mud flat by deposition of sediments of two rivers, Phetchaburi River and Bangtabun River [30]. For the coastal area of Chonburi in eastern of the GOT, most of the areas are beaches which comprise of a head land and many small islands as the wind waves. The steep sea in the GOT is gradually increased from the north to the south while the east coast is steeper than the west coast. An average depth of upper Gulf of Thailand is about 15 meters comparing with the average depth of about 45 meters of the Gulf of Thailand. The center of gulf has the deepest area of 70-85 meters [4]

2.2 Climate

Thailand is located in the tropical area that is under the influence of two monsoon winds, i.e., northeast monsoon and southwest monsoon. The northeast monsoon starts in October to January which brings the cold weather in Thailand

while the southwest monsoon usually starts from May to September which prevails and abundant rain occurs over the country. For the transitional period of the northeast and southwest monsoons, the weather is quite variable with uncertain direction and dry weather over the country. Moreover, Thailand receives the effect of tropical cyclones, move from Pacific Ocean and the South China Sea in November [5]

The climates of the coastal GOT are as following;

1. An average temperature in the UGOT is about 27.6 to 28.4°C.

2. An average relative humidity is about 73-76%. The highest relative humidity is in September and the lowest relative humidity is in January.

3. The number of clouds is average of 5.7 to 7.6 parts. Cloud cover is normally the most in while December is the month of less cloud cover.

4. The average of the year will have a better visibility. The visible in the far distance is about 9-11 kilometers. Month June and July are the best in clearly seen.

5. The west coast of the GOT during the northeast monsoon, at Phetchaburi, wind is blowing toward the northeast with an average wind speed of 1.0 to 1.8 knots. While during the southwest monsoon, the wind blows to the south and the southwest with an average speed of 1.8 to 3.2 knots.

The north coast of the GOT during the northeast monsoon, winds are blowing toward the northeast with an average speed of 1.9 to 2.4 knots. For the southwest monsoon wind blows to the southwest with the average speed of 3.4 to 3.5 knots. The east coast of the GOT during northeast monsoon in Chonburi, wind is blowing to the east with the average speed of 2.2 to 3.6 knots. For the southwest monsoon, the wind will blow to the southwest with the average speed of 4.1 to 6.0 knots. [2]

6. During the 1953-2013, tropical cyclones had an effect on the GOT at 189 times which most of movement of the Pacific Ocean and the South China Sea. The Tropical Depression usually moves in September until September to November. Tropical storm and typhoon will move in October and November. [5]

2.3 Oceanography

Most of Thailand coast has a sandy beach and gentle slope. For the river mouth and the nearby coast was a beach mud. A shallow area of river mouth is called "sand bar" where the deposition of sediments from the water above.

2.3.1 Wind Wave and Wave of Sea

The wind is important which cause the waves of the sea. Thailand has been influenced by the northeast monsoon and the southwest monsoon, resulting in the wind wave change according to monsoons. The data from the survey of oceanography in the Gulf of Thailand in 1993-1997 by the Hydrographic Department of the Navy [6]summarized the characteristics of waves and winds in the Gulf of Thailand as are following.

Northeast monsoon starts with covering the bottom of the Gulf of Thailand and then moves to the south. In this direction of the wind will blow between 10-350 degrees (relative to true north) with a speed winds ranging from 2-35 knots. The direction of the movement is the same way as wind and wave height which is about 0.1-0.5 meters in 1-5 seconds. The west coast is slightly higher than other areas.

The southwest monsoon will begin covering the lower GOT and over the bottom of the bay. In this direction of the winds and waves in the UGOT spread throughout which blow between 10-320 degrees with wind speed between 1-25 knots and the waves are moving in the same direction as the wind direction with the wave height of 0.1-1 meters and periodic waves of the 2-5 second.

The transitional period of monsoons from the northeast monsoon to the southwest monsoon is generally mild. The winds of the south and southwest monsoon will replace the northeast monsoon. The wind direction of UGOT blows in 130-220 degrees with wind speed between 6-27 knots. While the wave moves in the direction of 120-210 degree with the wave height of 0.1-0.5 meters and periodic waves of 2-4 seconds. Moreover, the west coast is slightly higher than other areas.

2.3.2 Longshore Sediment Transport [6]

A net of longshore sediment transport in the west coast of the Gulf of Thailand is approximately 20,044 cm^3 per year with the movement in the direction to the north. The sediment transport is most moving during the transitional period of monsoons which is about 39,232 cm^3 per year.

The north coast of the GOT, the net of longshore sediment transport is about 78,757 cm^3 per year with the movement in the direction to the north. The sediment transport is most moving during the transitional period of monsoons which is about 76,681cm^3 per year.

A net of longshore sediment transport in the east coast of the GOT is approximately 134,955 cm^3 per year with the movement in the direction to the north. The sediment transport is most moving during the transitional period of monsoons which is about 134,955 cm^3 per year.[4]

2.4 The Current Circulation in Gulf of Thailand

The current circulation in the GOT is a tidal current. For high tide, water flows are in the north direction while water flows are in the south direction when low tide. The circulation strength will change according to the tidal period; which means the circulation of in the UGOT is controlled by the influence of the tidal and the wind. During the northeast monsoon, clockwise circulation existed in the GOT. During the southwest monsoon, the current circulation travels counterclockwise along the Gulf. The influence of the monsoon causes a mass of the upper sea with flowing inside. The transplantation into the open sea area could happen only in deep of Gulf mouth. The region influences the current circulation, leading to a higher content of oxygen. The direction of the current circulation produces a nutrient content in the UGOT. Furthermore, an addition of suspensions into the ocean causes the changing of transparency as well [6]

The model of circulation patterns in the GOT can be divided into two parts. Each part mentions the circulation patterns in each monsoon, which comprised of the northeast monsoon, and during the monsoon transitions from the northeast to southwest monsoon and southwest monsoon, and during the monsoon transitions from the southwest to northeast monsoon. [1]

2.4.1 Northeast Monsoon (November to February).

Studied the circulation pattern in the UGOT by using a circulation model with monthly wind data over an average year during the years 1980 to 2000, including the study of [6]. The circulation model in the UGOT used the *monthly average wind data from* ECMWF (European Center of Medium Range Weather Forecast) in years 1990 to 1998. Water levels on the east coast (Sattahip) and the west coast (HuaHin) were computed using a harmonic analysis technique. The results demonstrated that the amount of water flowing into the harbor was slowly and strong water mass, resulting in weak upwelling by [6]. For the circulation patterns in the UGOT, the direction of circulation turned to the left of the west and flowed out to the west of the gulf, as shown in **Figure 2.** The results agree well with by [7] on studying simulated circulation patterns by using tidal data from SEAWATCH Program me. They reported that the circulation patterns in the UGOT flowed to the west of the gulf. The results were consistency with Somchai's research. He studied the circulation patterns which caused by monthly average wind. A mathematical model illustrated that during the northeast monsoon, the current flowed to the lower of the eastern side of the gulf. Furthermore, the UGOT turned to the left side of the gulf and flowed out to the west side of the gulf.[7]

2.4.2 Southwest Monsoon (May to September)

have been used the monthly average wind data from *ECMWF* (European Center of Medium Range Weather Forecast) in the years 1990 to 1998. Water levels on the east coast (Sattahip) and the west coast (HuaHin) were computed using a harmonic analysis technique. It can be found that the mass flow of water may be separated into two parts by [8]. First, the water mass flowed along the west coast of the upper gulf and flowed in a clockwise direction, and diverted to the right of the gulf and then exited the gulf along the east coast. Second, the bottom of the upper gulf, water flowed to the central part of the upper gulf and exited the gulf along the east coast. Divergence of flowing between the upper and lower of the gulf can be induced upwelling in the central gulf, as shown **in Figure 2** The mass flow of water in the clockwise pattern is an influence of the southwest monsoon, which pushed water up to the top and then turned to the right according to [8]

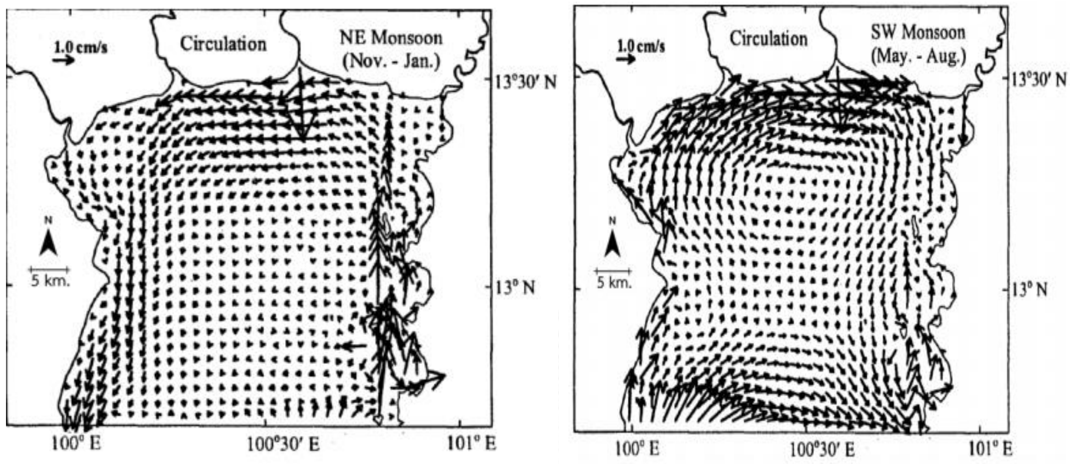


Figure 2 Studied the circulation patterns in the GOT by using an *average wind data* [9]

(a) Tides in the Gulf of Thailand on the use of wind data from ECMWF (northeast- monsoon)

(b) Tides in the Gulf of Thailand on the use of wind data from ECMWF ((Southwest Monsoon)

[10]

Years, including a tidal in open boundary region as major inputs of the circulation model. In term of a season, the circulation flowed into the southern of the gulf and was not unclear as the northeast monsoon. The central area of the gulf, the direction of current flowed into the eastern of the gulf which is obviously in March by **[11]Figure 3**. During April, the water tended to flow slowly with unclear patterns. These results were in agreement with the study of He has been studied on the circulation patterns by three dimensions (3D) simulations (Seawatch 3D) using wind data from oceanography in the Gulf of Thailand as inputs. The wind data were interpolated every grid size of 0.1x0.1 degrees. The results of the tidal from open boundary reported that the circulation patterns during April flowed into the southern of the gulf and the patterns were not clear as the northeast monsoon. [12]

have been investigated the circulation patterns the of in the GOT by using two dimensions (2D) simulations using ADI finite difference technique with an average eight years of wind data, including the tidal information of open boundary as a major inputs. The tidal data was a driving force of the circulation in the gulf by the monthly of flow of water, which is based on the season. During the northeast monsoon, the water flow was very slowly in November, including the direction of the current was not clearly appeared. On the other hand, the south of the gulf can be seen that the current tends to leave the gulf of Thailand. In month December, January and February demonstrated that the current entered the gulf from the south, and diverted to the right and left the gulf through the east by [11].The results were well agreed with [3] which studied the circulation patterns by 3D simulations (Seawatch 3D) using wind data from oceanography in the Gulf of Thailand as inputs. The wind data were interpolated every grid size of 0.1x0.1 degrees. The results of the tidal from open boundary showed that the current entered the gulf from the south and made a counterclockwise circulation, which was agreed with results. [3]

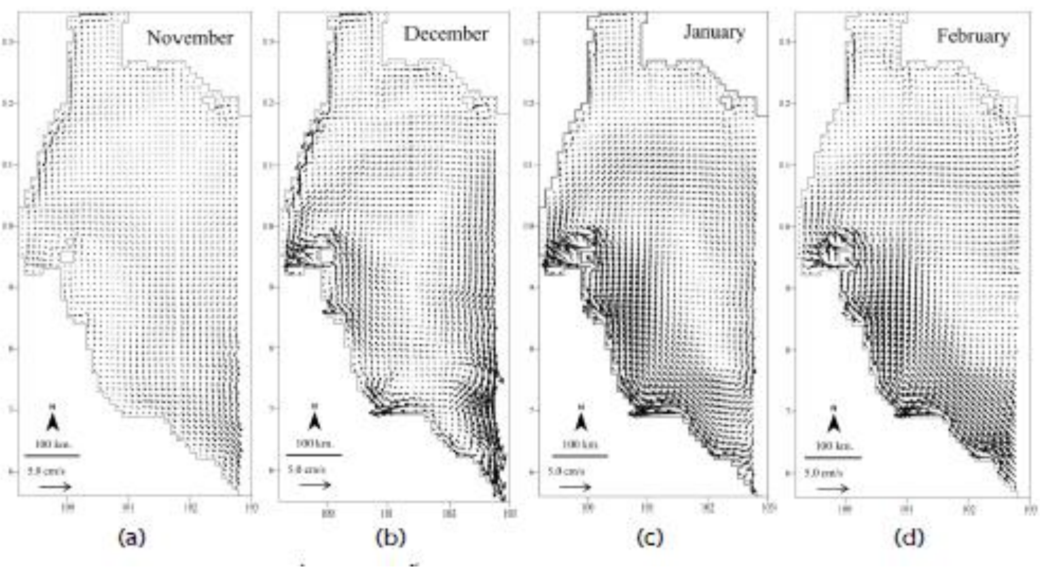


Figure 3 A circulation patterns in the Gulf of Thailand (Northeast Monsoon) [11]

For the UGOT during May and June, the current made the counterclockwise circulation, respectively). During July and August, the current flowed into two patterns which were both clockwise and counterclockwise. For the month of

September, the current flowed slowly and looped along the gulf of Thailand in the counterclockwise.

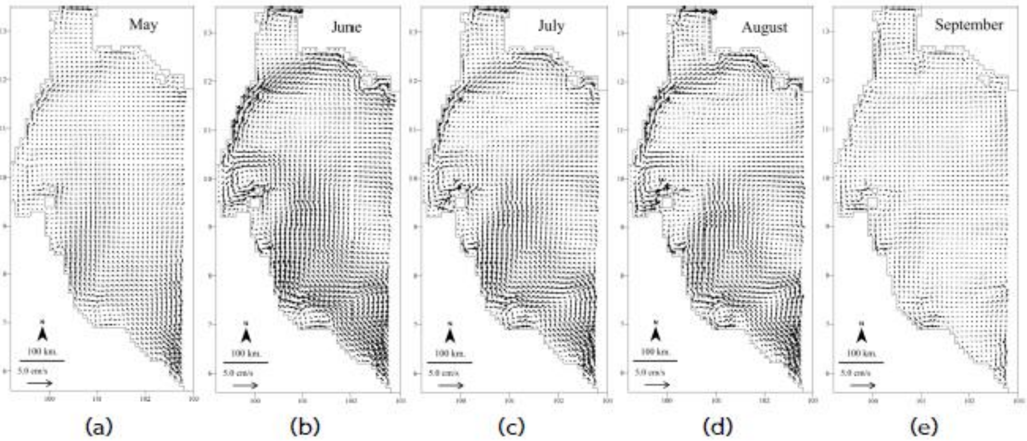


Figure 4 A circulation patterns in the Gulf of Thailand (Southwest Monsoon) [11]]

(see Figure e) have been studied the circulation patterns by 3D simulations (Seawatch 3D) using wind data from oceanography in the GOT as inputs and interpolate the wind data were every grid size of 0.1x0.1 degrees. The results of the tidal from open boundary showed that the current entered the gulf from the west, diverted to the right and left the gulf through the east [3]. The results agreed with the study of [13] demonstrated that the current during the southwest monsoon made the counterclockwise circulation.

Investigated an ocean circulation in the GOT using the circulation pattern models. Inputs to the model were wind data, sea surface temperature, and salinity data. The model predicted that during the northeast monsoon period, January, the high pressure brings strong wind. In month January, the current entered the gulf from the southern, and flowed to the upper gulf and turned to the right side of the gulf. The current of central gulf separated into two parts: the east and west of the gulf. The current speed of southern part of the Gulf of Thailand near Songkhla, Pattani, and Narathiwat provinces was about 0.30 m s^{-1}. The average current speed of the Gulf was 0.05 m s^{-1}. There is no average direction reported clearly in this study. [14]

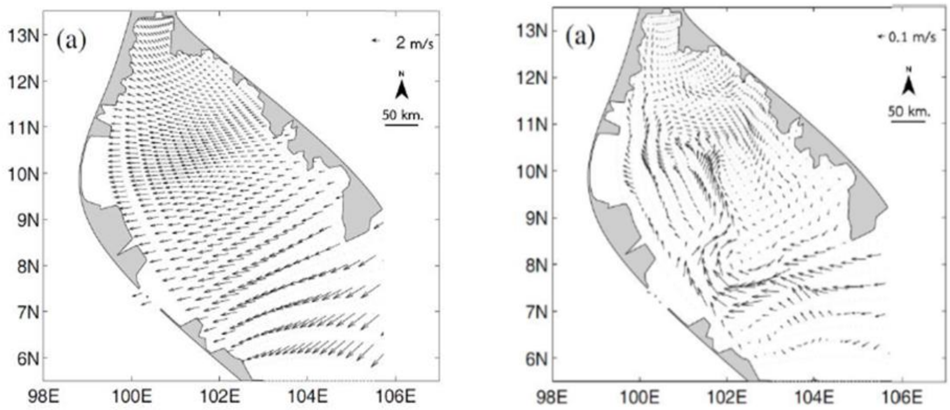


Figure 5 Wind direction and circulation during the northeast monsoon (January) [14]

found that the current at surface (0-10 meters), at level (10-40 meters) and at a deep-water >40 meters, the circulation were similar. The current flowed along the west coast to the north and flowed out of the gulf on the right side at Ca Mau peninsular. The current speed was less than 0.1 m s^{-1}. [3]

Investigated the circulation patterns using Princeton Ocean Model. The data for the model were wind speed and wind direction data from NAVY Global Atmospheric Prediction System (NOGAPAPS). Inputs to the model were sea surface temperature and salinity data of the GOT from oceanographic buoys survey data. The study reported that during the month of April, the GOT has been the influence of the southeast winds, which are in line with the GOT, resulting in similar in the circulation patterns during El Nino years and La Nina years. The current diverted to the right of the GOT. For moderate years, the direction of the current was similar to the current during El Nino and La Nina years. The net current speed of moderate years is faster than the El Nino and the La Nina years. [15]

have found that during the southwest monsoon (July). The wind forcing was quite strong the current flowed from the GOT on the west side and the turned to the right and then flowed out of the southeast coast of the GOT. For the central GOT, it can be found that the circulation pattern is generally clockwise with the current speed of 0.27 m s^{-1}. The average current speed at this level for the whole gulf is about 0.05 m s^{-1}. However, the current direction average is not mentioned clearly. When there was no wind data as inputs, the water would not make the clockwise circulation. The circulation patterns were not obvious, the inflow and outflow of water mass have an uncertain patterns and the current speed flowed slowly. While wind data is taken into account as inputs, the current speed is 0.14 m s^{-1} at 6.5°N to 6.5°N latitude and 102°E to 104°E longitude. The average current of the GOT is 0.02 m s^{-1}, but the current direction average is not mentioned clearly.[16]

have found that water flow during the southwest monsoon was up to 0.40 m s^{-1}. At surface current (0-10 meter), the direction of flow along the west coast of the GOT and the direction of water flow diverted to the right and ran off the southeast coast of the gulf. At a mid-depth of 10-40 meters, the circulation pattern flowed into the east coast of the gulf. At deep-water >40 meters, the speed of the water flow is smooth and no flow. [3]

Investigated the circulation patterns which were derived from Princeton Ocean Model. The data for the model were wind speed data and wind direction data from NAVY Global Atmospheric Prediction System (NOGAPAPS). Inputs to the model were sea surface temperature and salinity data. The results revealed that the circulation during October of El Nino years, La Nina years and moderate years were similar; in other words current flowed out of the gulf via the southeast side and then the currents turned to the tip of Ca Mau peninsular. For the top of GOT, some part of circulation flowed to accumulate during the El Nino, La Nina and moderate year. The net current speed of moderate years is less than the El Nino and the La Nina years. [17]

2.5 Monsoon

The term “monsoon” has its origin from “Mausim” in Arabic, which means seasonal wind. Monsoon wind is a large wind system which blows covertly the vast region and it influence the climate of that area. The circulation in this system depend on the cooling of land during the winter season and heat up quickly during the summer, resulting in changing of an atmospheric pressure over a wide area. The transitional period between summer and winter cause the circulation of the airflow in a reverse direction each season. A large area in Asia is key factors that cause variations in temperature when changing the season, i.e., the temperature dropped to −78°C during the winter season in some areas of Siberia while the monsoon happened explicitly during the summer season. The large region where to connect with ocean, the monsoon often depicted in the many parts of Asia such as South Asia, Southeast Asia, East Asia, North of Indian Ocean and the western of the Northern Pacific Ocean. The influence of the monsoon is reduced in the areas that far away from the tropics. During summer season, the monsoon circulation at low atmosphere over the continent is a cyclonic, while during winter it is anticyclonic . [2]

2.5.1 Monsoon Onset

2.5.1.1 Northeast Monsoon

Typically northeast monsoon onset is considered that there is no climate of the tropics or an air from the equator of the Indochinese peninsula. For Thailand, the northeast monsoon starts when the winds cover the surface up to a level of about 10,000 feet. Regarding the research of Booz Allen, it was found that the northeast monsoon began in South East Asia during the October 23 to November 29, but the average date on November .[13]

Northeast monsoon causes by semi-permanent high pressure in Siberia with the force that produces the anticyclonic circulation to the northeast wind which brings the cool and dry air over major parts of Thailand—clear skies, drop in temperature, very little rainfall. Except in the Southern part of Thailand, this monsoon causes mild weather and abundant rain along the eastern coast of the part.

During the winter season, the northeast monsoon blows cover Indochina and has more power than cover India, resulting in cold air over the outside of the tropical. This wind is cool and dry below Tropic of cancer (23 ½ °N), except the coastal of Vietnam, where the air mass that moved through the South China Sea, which brings a stream of warm air. During the northeast monsoon, the cold front cause by a cold air mass and warm moist air. Sometimes they move down to southern of Indochina, resulting in the weather of middle latitudes. This usually occurs in the Gulf of Tonkin— there is a rainfall in the winter season, the sky was covered with clouds and dust is called Cracking. Sometimes they move at the latitude of 10^{o}N that may cause depression or low disturbance [2] as shown in Figure 6

2.5.1.2 Southwest Monsoon

Before the beginning of the southwest monsoon, approximately 5-30^{o}N latitude receive more energy from the sun. Especially, the surface of the oceans will absorb the energy from the sun and spread out over a larger area. Heat has spread to higher latitudes by water flows in the ocean that are a reason of the temperature of the surface water does not increase too much, on the other hand, on the ground; the heat is absorbed and retained more quickly. Therefore, the ground has the high temperature and spread up the heat into the atmosphere. Moreover, the high pressure covers over the oceans for a long time, there will increase a capacity and cover some part of the ground, leading to raising temperatures. During the summer, the ground temperature is increasing rapidly, resulting in a low pressure due to thermal low or heat low. It gradually spreads over the area near the equator which leads the monsoon troughs extends over the large area and tend to far from the equator. Trade winds in the southern hemisphere move through the equator. The wind speed starts to drop. There is the wind moves from the original position due to cyclonic circulation and Coriolis force which results in the changing of the southeast trade winds to the west wind [2] as shown in Figure 7

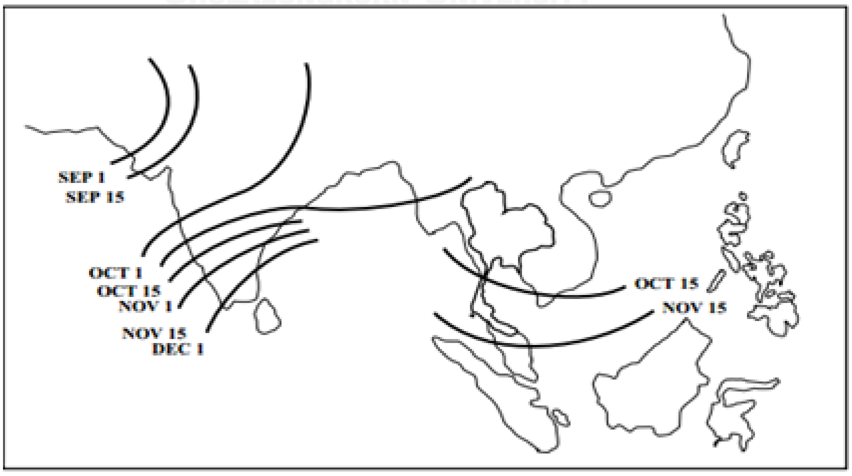


Figure 6 Average date of the start of the north-east monsoon over indo-china and Malaysia [[2]

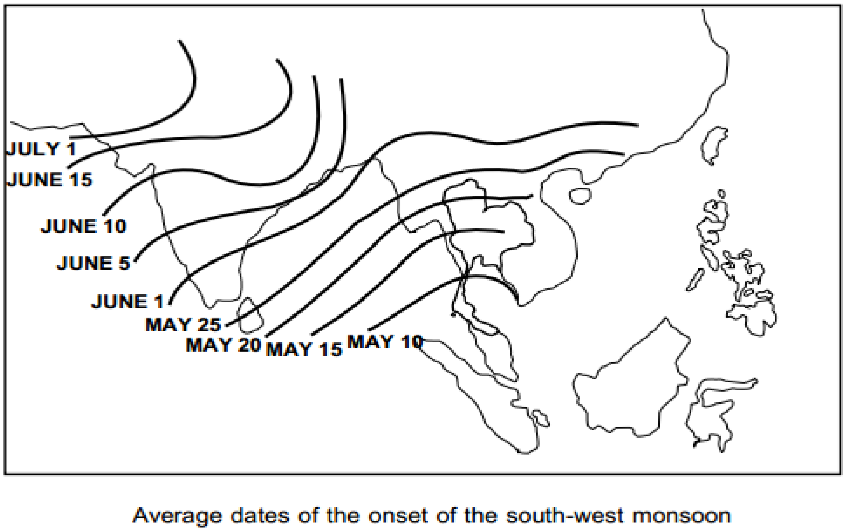


Figure 7 Average date of the onset of the south-west monsoon [2]

2.5.2 Wind Direction Monsoon in Thailand wind shear turbulence

2.5.2.1 Northeast Monsoon Season (Winter Monsoon)

Winter monsoon can be seen clearly on late November. Northeast wind blows to the latitude of 5°S. The South China Sea has an inversion temperature at a low level. While Siberia high and Turkestan high which locate at the east side of the Caspian start and surge the cool air into the northwest of India. Tropical cyclone at Arab Sea and the Bay of Bengal is rare events due to the wind shear turbulence in horizontal and cold air which covers these areas, but in the western of Pacific Ocean, there is still the tropical cyclone, as shown in Figure 8

2.5.2.2 Southwest Monsoon Season (July-August)

During the middle of the summer monsoon, the wind of the west has a strong power and low pressure because the heat covers over African and Arabia, as well as the foothills of the Himalayas range. A front line is along the east into Southeast Asia and the western of Pacific Ocean near an island of Guam. This period of time, the monsoon trough could move into height of the southwest monsoon and typhoon often occurs in particular when the low pressure covers over the western Pacific Ocean, Philippine Sea and the South China Sea

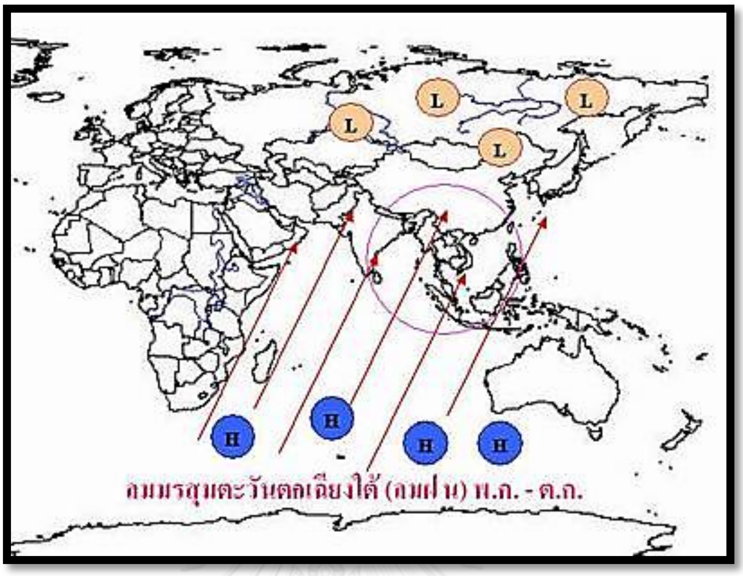


Figure 8 Wind directions in southwest monsoon season [15]

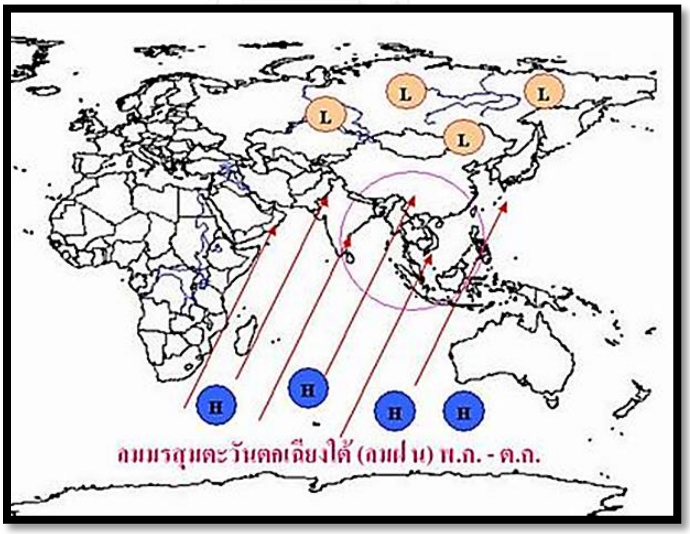


Figure 9 Wind directions in southwest monsoon season [15]

2.6 Tropical Cyclones

A tropical cyclone is a storm that typically forms over the surface of the water in the tropics. The circulation of the wind blows toward the center and a diameter ranging from 100 miles up. When the storm has intensified to 64 knots, are known to vary according to the source, but the formation characteristics are identical. [2]

2.6.1 Classification of Tropical Cyclones

A tropical cyclone can be divided into four stages are as following;

1. A tropical disturbance is an area where the weather is going to be disturbed. Convective activities may have a line pressure as a closed loop or none and have cyclonic circulation, which can see on a wind map a little bit.

2. A tropical depression is a closed loop of a line pressure more than one cycle. The circulation is the cyclonic pattern. The maximum sustained winds are equal or less than 33 knots.

3. A tropical storm is a closed loop system that has cyclonic circulation. The maximum sustained winds are ranging from 34 knots to 63 knots.

4. A hurricane or typhoon increase the number of a closed loop pressure as more and more closely together. Cyclonic circulation is a severe wind speeds equal to or greater than 64 knots or more, but if the typhoon with wind speeds equal to or greater than 130 knots which is called Supper typhoon.

2.6.2 Cycle of Tropical Cyclone

Tropical cyclones have an average lifetime of six days from the time of occurring until the dissolution or moving to obstructions such as mountains, or the earth or changing the direction to the high latitudes. Some of the cyclones, the lifetime is about 2-3 hours and very few of cyclone can up to two weeks. The cycle of tropical cyclone may be divided into four stages as follows:

1. Formative stage: The tropical cyclone will occur need to form of the pressure system such as the monsoon, east wave, low pressure, wind shear turbulence etc. Sometimes, it takes a very long time to be deteriorating. In this stage,

the maximum sustained winds are less than 64 knots and the air pressure is reduced to 1000 hPa.

2. Immature stage: It is not certain that the intensity will reach the typhoon stage. Sometimes it can be dissolved in the formative stage within 24 hours. In the case of a severe typhoon, the speed can up to 64 knots, the pressure drops from 1000 hPa. At this stage, a growth increase and changes happen in various events such as the tropical cyclone has an eye of the storm, the cloud rotates toward the center and the pressure gradient force increase.

3. Mature stage: After pressure, wind speed and intensity of typhoon at highest level are: the pressure at the center of the storm does not reduce and the wind speed around the center does not increase. The rotation will spread out to the periphery, which may take a week. The rotation of winds in immature stage is limited, which has a radius of approximately 20-30 miles. The radius may extend up to 200 miles when reaching this stage. The weather on the right-hand side of the movement is worse than on the left-hand side of the movement. The size of the storm is usually unpredictable, i.e., the typhoons with the central pressure less than 950 hPa and the radius of some storm are only 100-200 km.

4. Decaying stage: Tropical cyclone will decay when moving into an area that colder or surfaces with obstructions which cause a loss of heat and humidity, resulting in decreasing of storm intensity and the wind speed less than 64 knots. The region of the eye of the storm will cover with a cloud or a cold air mass from the cold polar air and then eventually disintegrate. If the tropical cyclone moves to the north or 39 degrees of the northeast in the high latitudes reach a temperate zone, resulting in reducing the storm intensity and changing to an extra tropical cyclone. [2]

2.6.3 The Formation of a Tropical Cyclone

The tropical cyclone formation can be concluded are as following;

1. Basic requirements: Latent heat and sensible heat is produced from the tropical oceans with surface water over 26°C and a mid-depth around 60-70 meters which may cause the lifting of the air stream.

2. Coriolis force: It must be large enough to be induced to rotate of its center. Low pressure will increase between latitude 5°N and 5°S. The tropical cyclone has a less chance of occurring. For an average tropical cyclone formation, it is about 15 degrees latitude and about 65 percent of the global, which form between latitudes 10 and 20 degrees, according to the results of Gray's study.

3. Pre-existing low level disturbance: An air is disturbed at the low level which is induced to be the vortices such as monsoon cyclone, easterly wave, equatorial wave and low pressure.

4. Weak vertical wind shear: Wind speed will not increases with a height, leading to a flow of air around its core of the storm system. In addition, strong vertical wind shear leads to spread out of the heat and there is no energy accumulates.

5. High humidity in the atmosphere: There is a high humidity in the atmosphere, in particular, in the middle troposphere to flow into the entrainment of moist air.

6. Upper level divergence: It causes an air stream flowing into the low level convergence, resulting in reducing of a pressure at the surface. [2]

2.7 The movement of a Tropical Cyclone in Thailand

The movement of a tropical cyclone is typically approximated about 10-12 knots. The movement direction of the cyclone in the Northern Hemisphere moves toward the west or northwest until latitude 25 to 30°N where the tropical cyclone is gradually changed the direction of moving into the north and then turn along the east. Meanwhile, the movement speed is increased.

A tropical cyclone is a type of natural disasters. Thailand has been affected abundant rain over the country and strong winds. Each part of the country can affect by the movement of a tropical cyclone in different time as shown in Figure

During June to September, a tropical cyclone moves over upper Thailand and then moves to the lower Thailand—that is central to the south of the country. The damage caused by rainfall volume, resulting in flooding which includes the strong winds while moving through the rising waves. It depends on the severity of the storm while moving through at which intensity level. Thailand will be influenced by the movement of tropical cyclones from May to December. It moves northeasterly direction and lie over the southern parts at the end of the year. Common paths of storm movement in each month move through different parts of the country by the tropical cyclone. During October to December, the tropical cyclones usually have the brunt of the storm at the level of the tropical storm or typhoon because the position of the tropical cyclone movement moves through the GOT which retains the intensity of the storm. Furthermore, high pressure can reduce the intensity of the tropical cyclone.

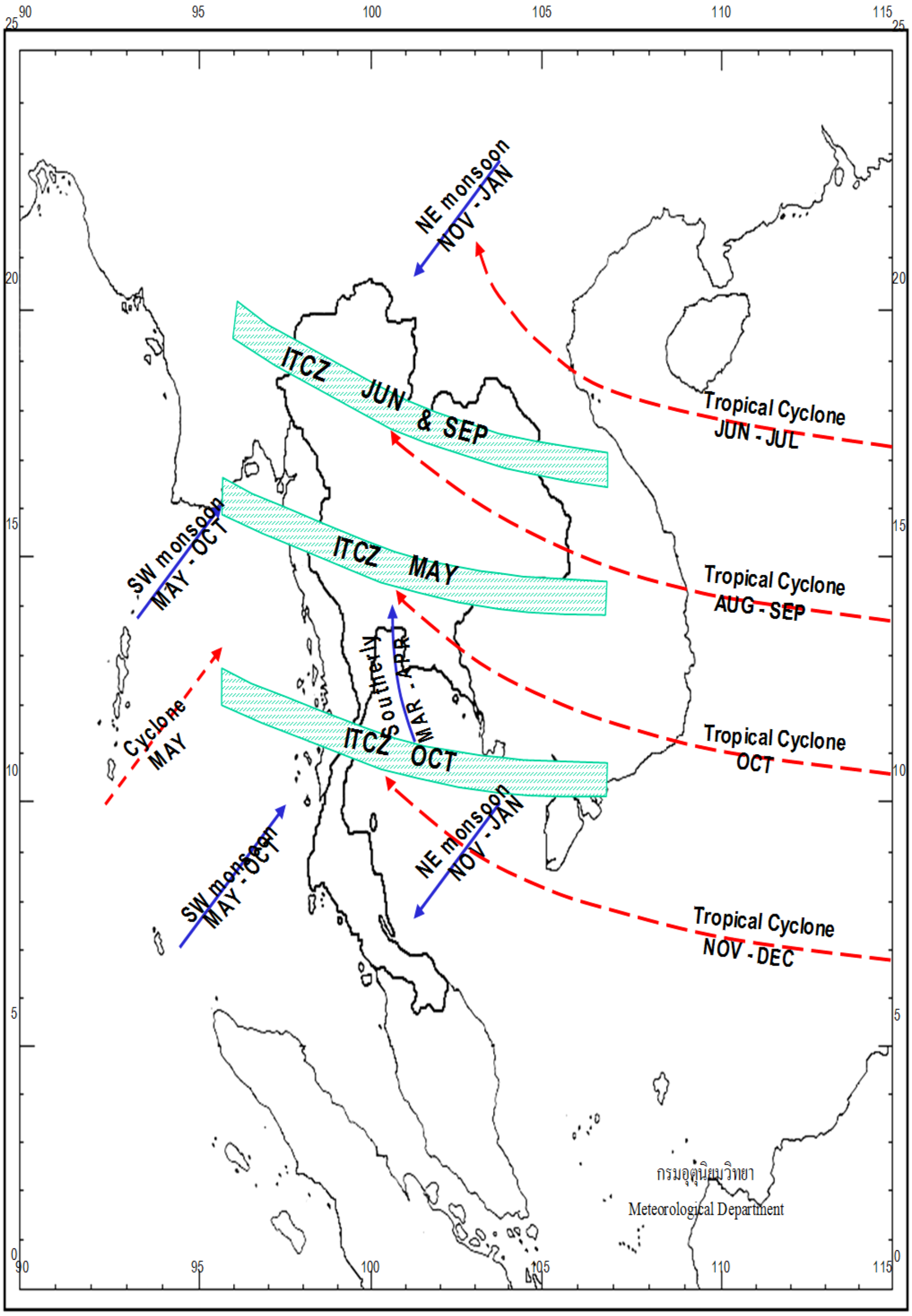


Figure 10 the Monsoon period and cyclone paths in the Thailand[15]

2.8 Literature Reviews

have been studied the seasonal variations in the surface water currents in the GOT by using temperature and salinity data derived from the world ocean database, the monthly dynamic heights anomaly from TOPEX/Poseidon and the ERS-2 altimetry data, during 1995-2001. The mean geostrophic current showed a strong southwestward flow of the South China Sea water along the gulf entrance and counterclockwise eddies in the inner gulf and the western side of the gulf. Seasonal geostrophic currents showed a basin-wide counterclockwise circulation during the southwest monsoon and a clockwise circulation during the northeast monsoon. [18]

Investigated the effects of ENSO phenomena on meteorological and oceanographic parameters in the GOT. The study was performed using the ENSO with monthly air temperature, rainfall from meteorological station, month sea surface and sea surface salinity which recorded by oceanographic buoys during 1997-2003. Moreover, the circulation patterns in the gulf were simulated by Princeton Ocean Model according to the wind model from Navy Operational Global Atmospheric Prediction System (NOGAPS). Using the sea surface temperature and sea surface salinity were as inputs. The circulation patterns were well agree with the data which monitored by buoys about 60-70%. During the southwest monsoon, water flowed out of the gulf via the western side, the counterclockwise eddy exited at the tip of Ca Mau peninsula. While the northeast monsoon, the current turned form the eastern of the gulf and flowed along western coast of the gulf. [19]

Investigated the coastal erosion from Landsat 5 TM and SPOT satellite at Terkos Lake in Turkey. According to meteorological and oceanographic in long term, the analysis of images and overlays at the same place in different time can be seen that the changing of shoreline due to the coastal erosion. The overlays need to define the coordinate system with accuracy and correlation with other information. [19]

Have found that the storm resulted in the coastal erosion, i.e., by the hurricane in 2004 at Volusia city, Florida. The data of Landsat 5 were used to analyze the changing in coastal erosion. The results showed that Charley, Frances, lvan and

Jeanne hurricanes caused in changing of Florida coast, comparing with the coast after being influenced by a tropical cyclone. [20]

Studied the waves of Na Thon beach from two departments, i.e., meteorological stations of KohSamui, and oceanographic buoys of Nakhon Si Thammarad . The wind data were analyzed for the height and the wave period using JONSWAP Spectrums with Fetch Length. From wave statistics, 80% of waves, the height are less than 0.5 meters. Percent of the crossing wave to the north is up to 11.92%. Most of the large waves will pass to the north because the coast was influenced by the southwest monsoon over the northeast monsoon.

Has been hired as a consultant to solve the problem of coastal erosion in the UGOT using Geographic Information System (GIS) and software for analyzing satellite that used to convert the topographic data from 1967 to 1973 and data from satellite images (coastal erosion data from 1993 to 1995). The data were collected to put in the same position in the calculation of the coastal change. The results found that the waves are key factors causing coastal erosion in the UGOT. The changing of a long-term depends on an imbalance of the rate of erosion and deposition of sediment. In each year, land subsidence can be noticed due to these problems. In addition, sediment transports, energy in transportation and logistics are also a factor of coastal erosion. [19]

Investigated the circulation of water in the UGOT. According to a characteristic of seasonal variation in salinity distribution, it can be seen that the direction of air flow due to shear stress at the sea surface that is affected by the sea water with the wind at the same time. The influence on air flow was affected in shallow water more than in deep water because it has more wind power capacity to be obtained. Thus, the wind flowed from the south and west, affecting current flows in clockwise. However studied the circulation of water from the movement. The Monitor of the circulation of water from the movement of oil spills. He found that the air flow from the ocean surface and in the UGOT due to slope current, the counterclockwise current while the wind blows from the southwest. Therefore, both of these studies can be concluded in the different direction. [21]

CHAPTER III RESEARCH METHODOLOGY

Regarding to idea, theory, and related research review to determine study procedure, in this chapter, presents detail of the research method and resource to create understanding about collecting data, analysis, and evaluate all data.

3.1 Research Method

1) Review and analyze idea, theory, and related research.

2) Collect wind direction, wind speed, and tropical cyclone data from Meteorological Department back during year 1981-2013.

3) Study Procedure

3.2 Study and analyze data (surface wind)

by using wind direction and wind speed data which collected 3 hours 4 times; 7 a.m. from Meteorological Department, 6 weather stations around the gulf of Thailand which are 1. Phetchaburi Meteorological station 2. Pilot station, Samut Prakan Province 3. Bangna Meteorological station, Bangkok 4. KlongToey Meteorological station, Bangkok Province 5. Kosichang Meteorological station, Chonburi Province 6. Pattaya Meteorological station, Chonburi Province

3.2.1 Pre-test: use the most changed period to analyze monsoon starting with testing daily, monthly, yearly data, and period of Northeast monsoon and Southwest monsoon by Microsoft Excel and plotting graph to compare monsoon changes tendency during year 1981-2013 from 6 stations to get the best data.

3.2.2 Study and analyze data (surface wind) using wind direction and wind speed data at 7 a.m. which changed obviously to analyze monsoon changes both 2 periods: Northeast monsoon and Southwest monsoon. Analyze wind direction and wind speed data repeatedly all 32 years from 6 stations around the gulf of Thailand which are 1. Phetchaburi Meteorological station 2. Pilot station, Samut Prakan Province 3. Bangna Meteorological Station, Bangkok Province 4. KlongToey Meteorological station, Bangkok 5. Kosichang Meteorological station, Chonburi Province 6. Pattaya Meteorological station, Chonburi Province

3.3 Study and analyze wind data (upper wind at 850 hpa height)

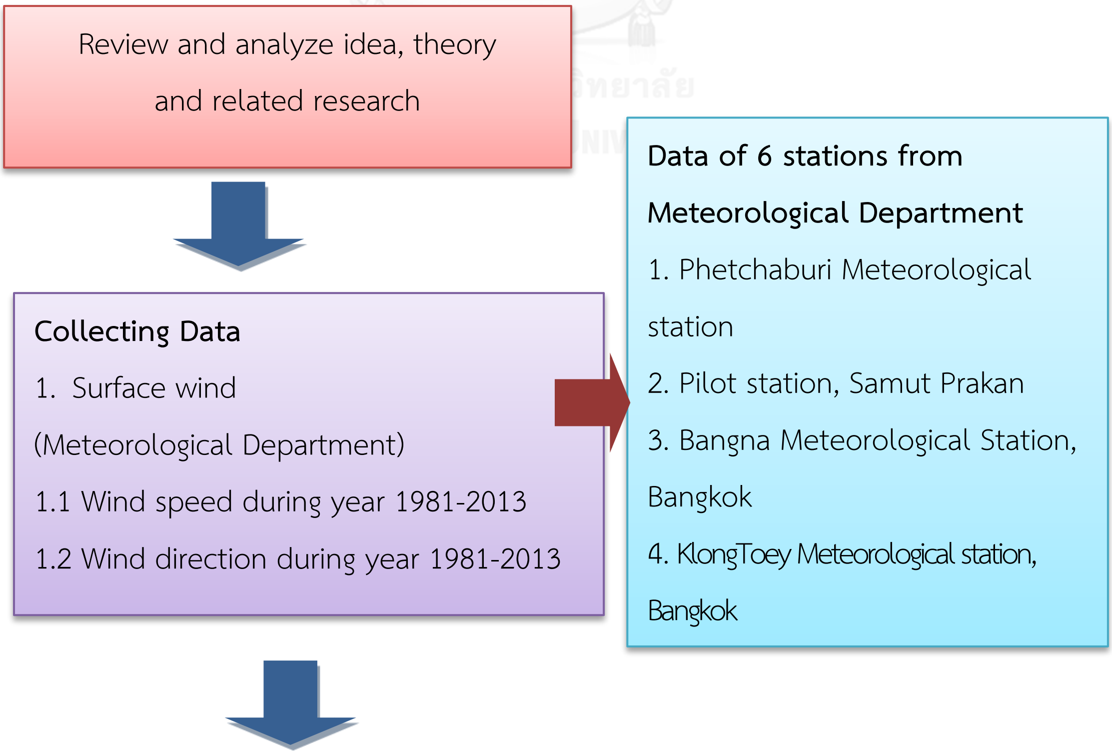
By using wind direction and wind speed data collected for 3 hours from Meteorological Department, 3 stations which is 1.Chiang Mai Weather Station 2. Bangna Weather Station, Bangkok 3. Songkhla Weather Station to test monsoon changes of upper wind data to compare with surface wind.

3.4 Compare El Niño and La Niña data during year 1981-2013

With wind direction to find weather atmosphere changes of each station.

3.5 Analyze tropical cyclone route which passed upper gulf of Thailand during year 1981-2013

To find time of arriving at study areas and compare with satellite pictures and erosion data at that time to find effect to erosion at upper gulf of Thailand coast. That is one factor of natural process of coastal



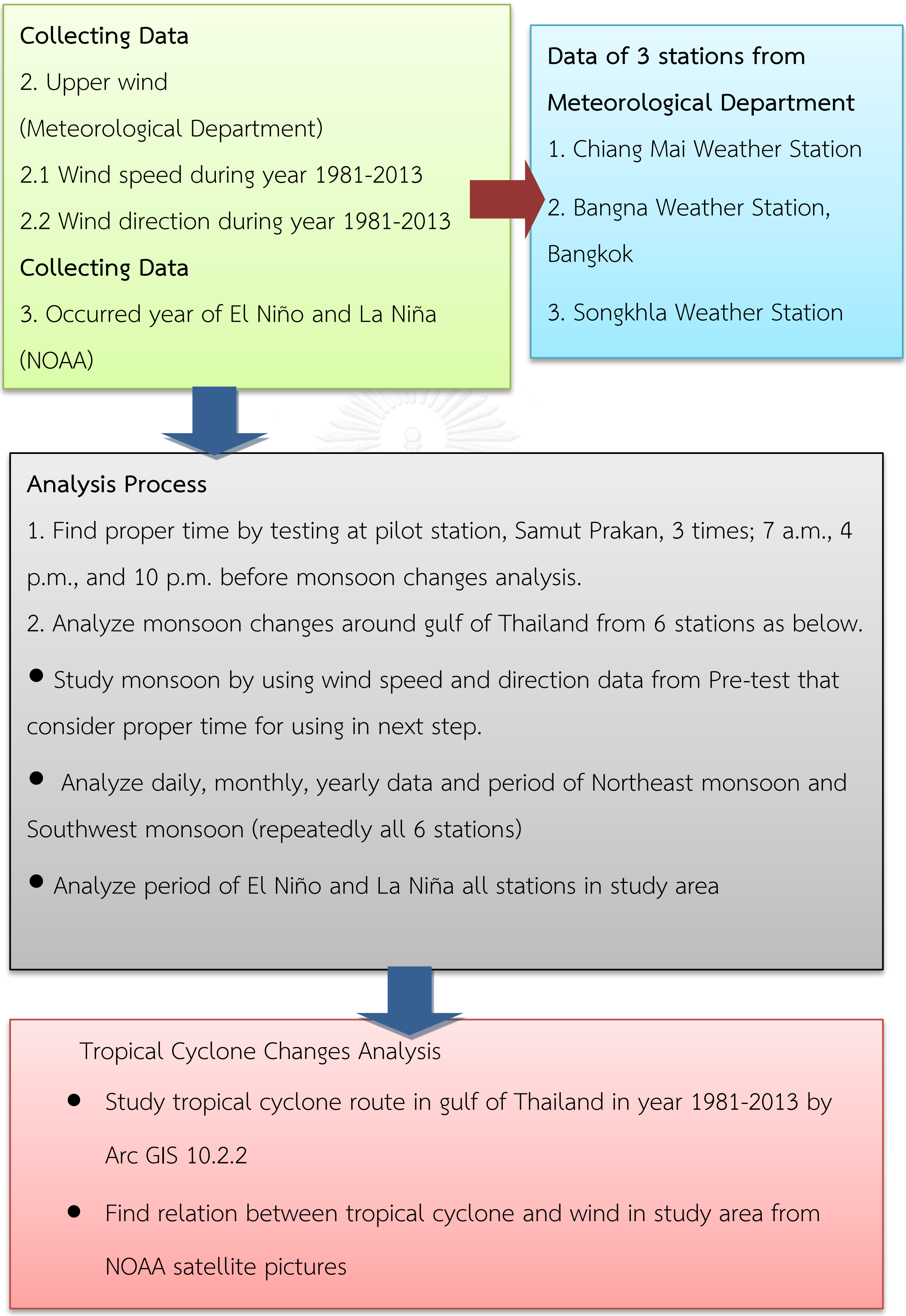


Figure 11 illustrates the methodology used and outputs in this study

CHAPTER IV RESULTS AND DISCUSSIONS

The meteorological study on the changing characteristic of wind direction and wind speed has the data which collected from the Meteorological Department every 3 hours daily. Therefore, before the study on monsoon was conducted, we had examined the optimal period so that the results will be more accurate and distinct. Therefore,

4.1 Analyze the changes of monsoon in the shore area of the upper Gulf of Thailand

4.1.1 Study by examination on the changes of wind speed at navigating station, Samut Prakan Province in order to examine the period with obvious changes. The collected data consists of 4 periods; 7.00 hr., 13.00 hr., 19.00 hr. and all day period. The study of navigating station, Samut Prakan Province (1) at 7.00 hr., in the year 1981-2013 revealed the changes of wind direction of 8-14 knot. In 2006, the wind direction changes at 25-27 knot, which shown the wind directions in the past 32 years has changed as shown in figure 4.1(2). The study also revealed that between the years 1981-2011, at 13.00 hr., the wind direction was at 7-12 knot and in the year 2013, the wind speed was at 17 knot with the insignificant change at 13.00 hr. as shown in figure 4.2(3). The wind speed, between the years 1982-2013, at 19 hr., was at 20-22 knot while the wind speed between the years 1982-2012 was at 8-18 knot with the insignificant change in figure 4.3(4). The average data from all day period of each month between the years 1981-2012 revealed the wind speed at 8-15 knot while the wind speed in 2013 was insignificantly increased at 18 knot in as shown in figure 4.4.

Therefore, according to the data of wind speed collected from the Meteorological Department that can be applied to analyze the changes of monsoon, the examination on 4 periods revealed that the data collected of wind speed at 7.00 hr., every 3 hours, is the most obvious. As the data collected from other periods are not quite obvious, therefore, the data collected at 7.00 hr. is the optimal period to continue the analysis.

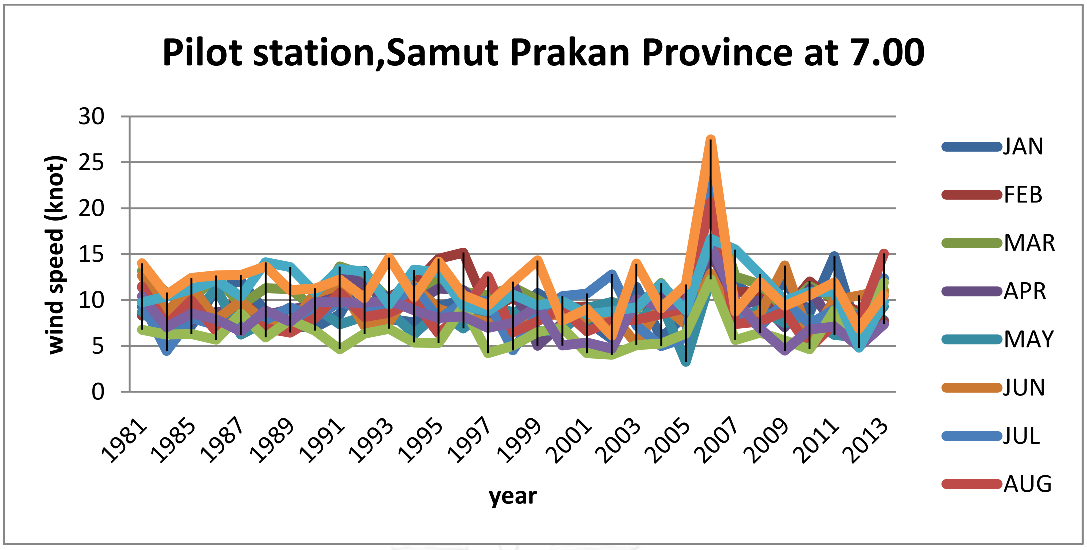


Figure 12 Examine at Pilot station, Samut Prakan Province at 7.00 hr.

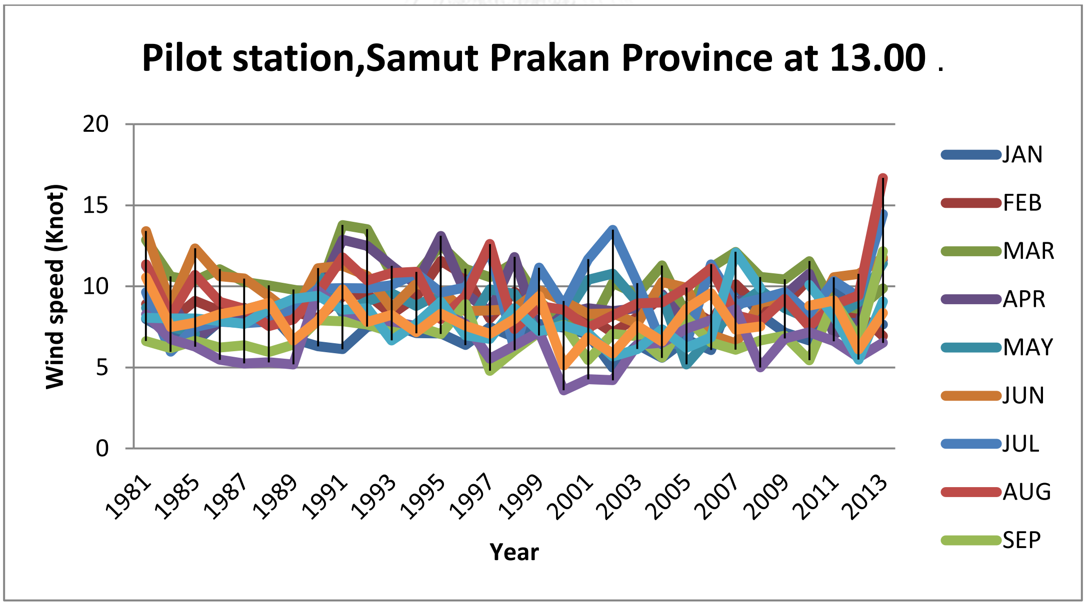


Figure 13 Examine at Pilot station, Samut Prakan Province at 13.00 hr.

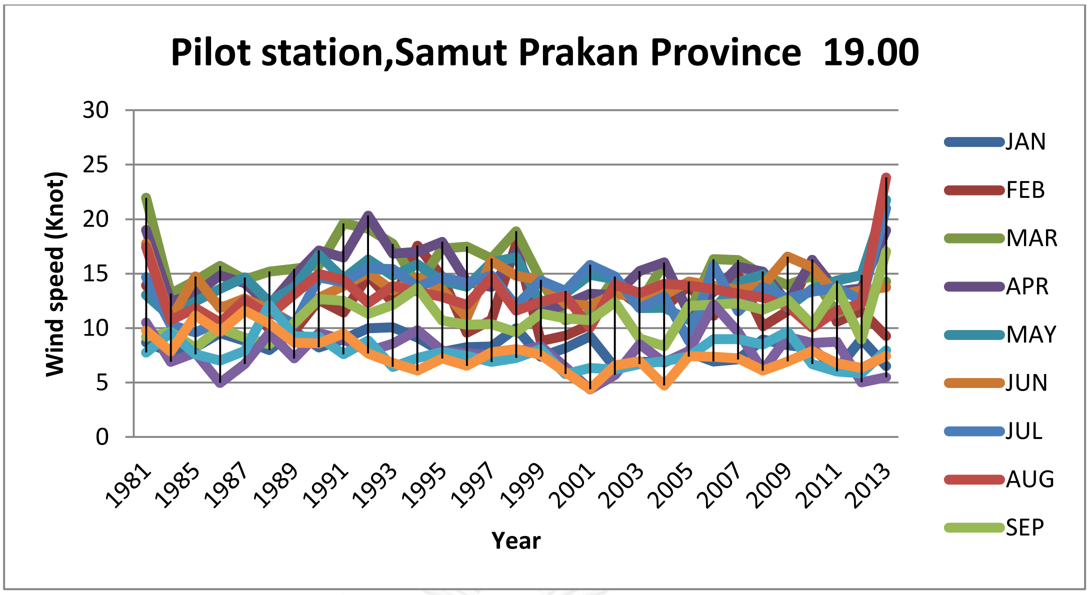


Figure 14 Examine at Pilot station, Samut Prakan Province at 19.00 hr.

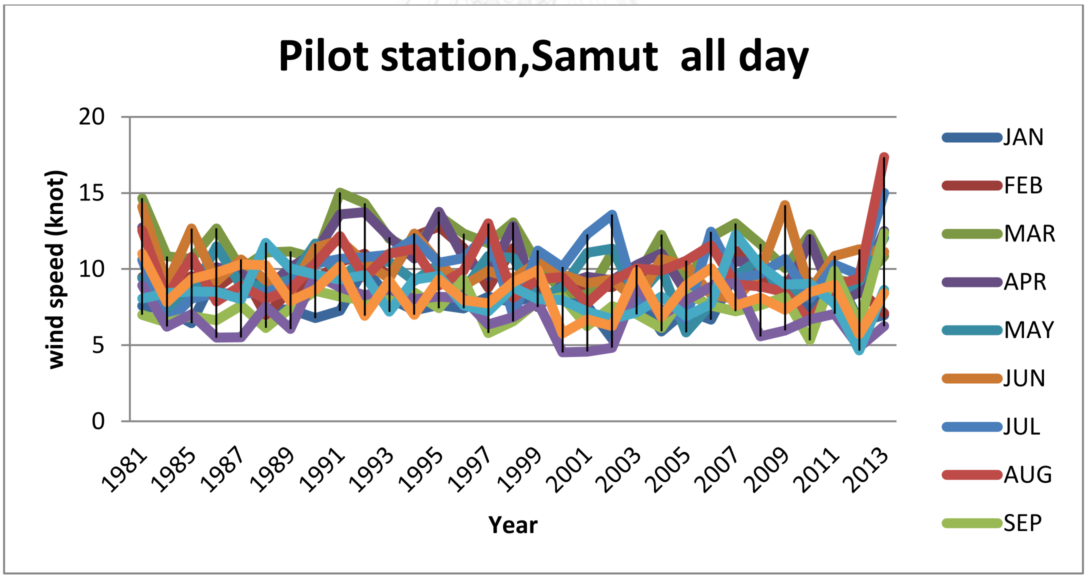


Figure 15 Examine at Pilot station, Samut Prakan Province at all day period.

4.1.2 Data analysis on monsoon of 6 stations around the upper Gulf of Thailand (Surface wind)

Thailand locates under the influence of 2 types of monsoon consisting of the Southwest monsoon and the Northeast monsoon. The Southwest monsoon blows and overspreads Thailand between the middle of May to the middle of October, while the Northeast monsoon overspreads approximately in the middle of October to the middle of February. The results of the study on 6 stations around the Gulf of Thailand are as follows;

1. Phetchaburi Meteorological Station

The data analysis shown that, in the first 18 years of data analysis (A.D. 1981-1999), the Northeast monsoon has not changed its direction (50-60 degrees) with the major wind speed of 2-3 knot, while the Southwest monsoon is in the area of the Northeast monsoon (60-70 degrees) with the wind speed of approximately 1-2 knot. It is obviously seen that the wind in the last 13 years (A.D. 2000-2013) has changed its direction from northeast to southeast (120-170 degrees) with the wind speed of 5 knot, while the Southeast monsoon has changed its direction to southeast and south (120-180 degrees) with the wind speed of 3-7 knot, as show in Figure 12 and Table 4.1

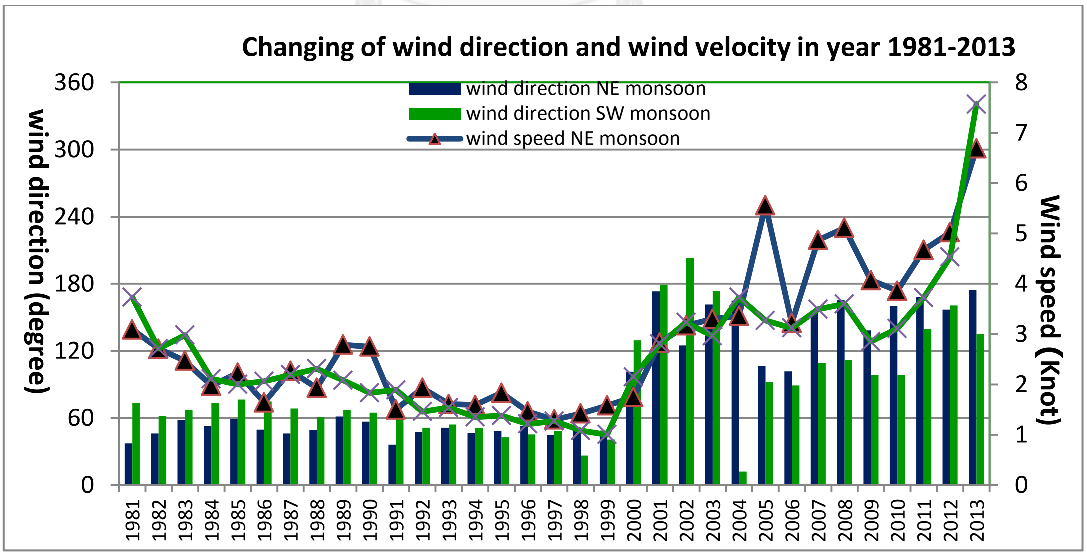


Figure 16 The comparative graph between the wind speed and direction of the Northeast and Southwest monsoon (A.D 1981-2013) at Phetchaburi Meteorological Station

duration	Northeast monsoon		Southwest monsoon	
	Wind direction	Wind speed	Wind direction	Wind speed
1981-1999	NE (50-60)	2-3 knot	NE (60-70)	1-2 knot
2000-2013	ESE,S (110-170)	5 knot	ESE,S (110-180)	3-7 knot
conclude	Changed Wind direction	increase	Changed Wind direction	increase

Table 1 Summary on the changes of wind direction and wind speed of Phetchaburi Meteorological Station

2. Pilot station, Samut Prakan

The data analysis shown that, in the first 16 years of data analysis (A.D. 1981-1997), the Northeast monsoon has changed its direction to southeast (120-150 degrees) with the wind speed of 8-10 knot, while the Southwest monsoon directs to the south with the wind speed of 9-10 knot. The wind in the last 16 years (A.D. 1998-2013) shown that, the Northeast monsoon directs to southeast (110-120 degrees) with the wind speed of 7-9 knot, while the Southeast monsoon directs to south (170-180 degrees) with the wind speed of 10-14 knot, as show in Figure13 and Table 6.2

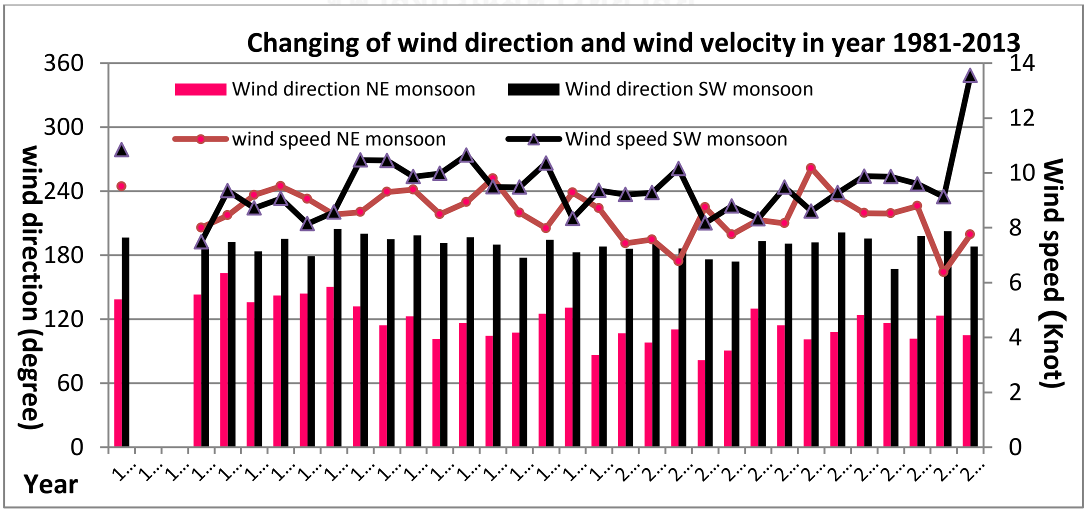


Figure 17 The comparative graph between the wind speed and direction of the Northeast and Southwest monsoon (AD 1981-2013) at Samut Prakan Meteorological Station

duration	Northeast monsoon		Southwest monsoon	
	Wind direction	Wind speed	Wind direction	Wind speed
1981-1997	ESE,S(120-150)	8-10 knot	S,SSW(180-200)	9-10 knot
1998-2013	ESE(110-120)	7-9 knot	S (170-180)	10-14 knot
conclude	little change	little decrease	little change	little increase

Table 2 Summary on the changes of wind direction and wind speed of Pilot station, Samut Prakan Province

3. Bangna Meteorological Station, Bangkok

The data analysis shown that, in the first 16 years of data analysis (A.D. 1981-1997), the Northeast monsoon has not changed its direction (60-80 degrees) with the wind speed of 6-8 knot, while the Southwest monsoon directs to the southeast (120-180 degrees) with the wind speed of 3-4 knot. The wind in the last 16 years (A.D. 1998-2013) shown that, the Northeast monsoon directs to southeast (110-120 degrees) with the wind speed of 7-9 knot, while the Southeast monsoon directs to southeast (110-140 degrees) with the wind speed of 2-3 knot, as show in Figure 14 and Table 4.3

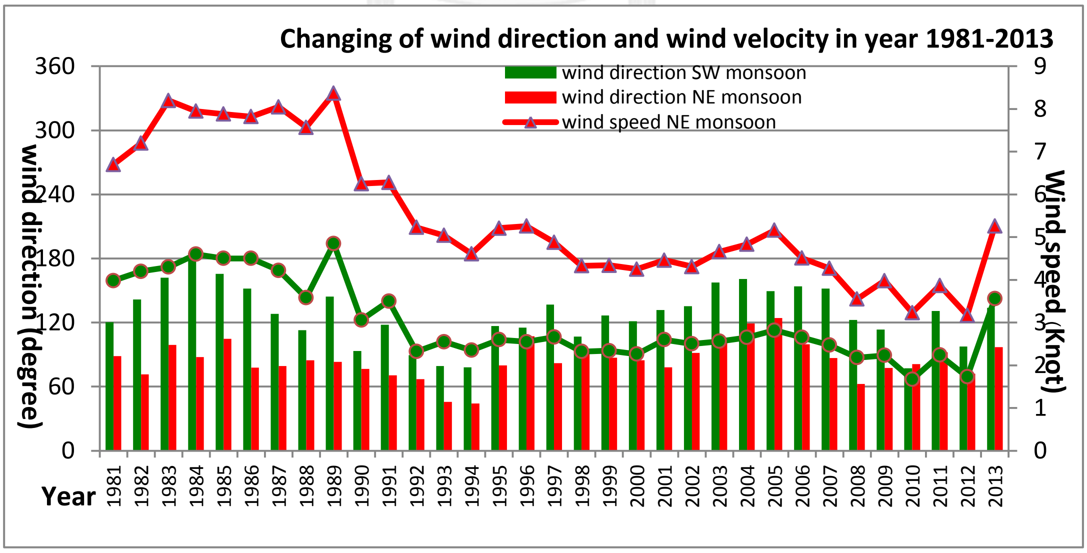


Figure 18 The comparative graph between the wind speed and direction of the Northeast and Southwest monsoon (A.D 1981-2013) at Bangna Meteorological Station, Bangkok Province

duration	Northeast monsoon		Southwest monsoon	
	Wind direction	Wind speed	Wind direction	Wind speed
1981-1997	NE (60-80)	6-8 knot	ESE (120-180)	3-4 knot
1998-2013	E,ESE (80-120)	4-5 knot	ESE,SE (110-140)	2-3 knot
conclude	little change	decrease	not change	Decrease

Table 3 Summary on the changes of wind direction and wind speed of Bangna meteorological station, Bangkok Province

4. Klong Toey Meteorological Station, Bangkok

The data analysis shown that, in the first 9 years of data analysis (A.D. 1994-2003), the Northeast monsoon has not changed its direction (60-100 degrees) with the wind speed of 3-4 knot, while the Southwest monsoon directs to the south (170-180 degrees) with the wind speed of 3-4 knot. The wind in the last 9 years (A.D. 2004-2013) shown that, the Northeast monsoon directs to southeast (110-120 degrees) with the wind speed of 4-5 knot, while the Southeast monsoon directs to south (180 degrees) with the wind speed of 4 knot, as show **Figure 15**

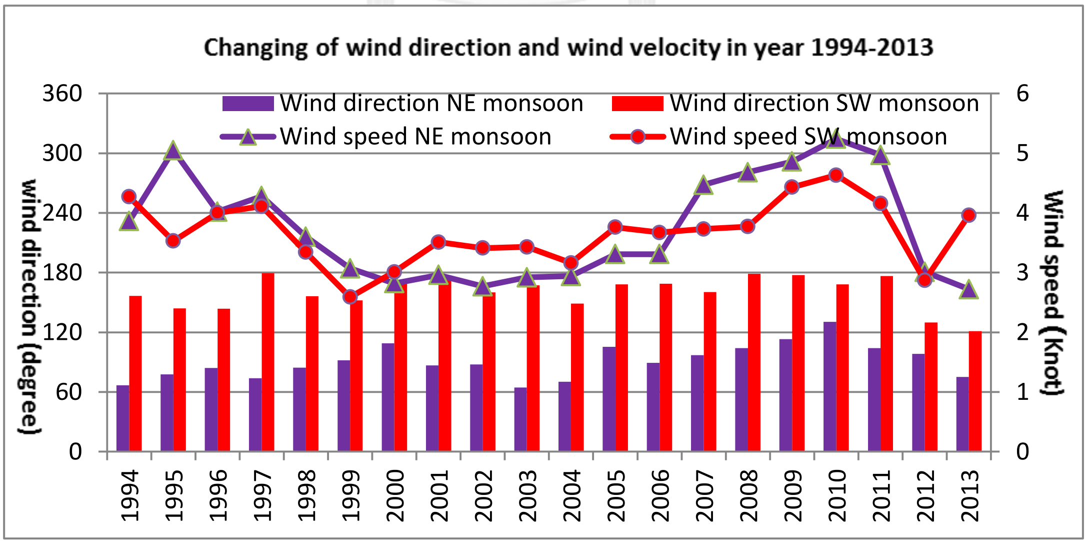


Figure 19 The comparative graph between the wind speed and direction of the Northeast and Southwest monsoon (A.D 1994-2013) at Klong Toey Meteorological Station, Bangkok Province

duration	Northeast monsoon		Southwest monsoon	
	Wind direction	Wind speed	Wind direction	Wind speed
1994-2003	NE (60-100)	3-4 knot	S (170-180)	3-4 knot
2004-2013	ESE (110-120)	4-5 knot	S(180)	4 knot
conclude	Changed	stable	Not changed	Stable

Table 4 Summary on the changes of wind direction and wind speed of Klong Toey Meteorological Station, Bangkok Province

5. Kosichang Meteorological Station, Chonburi Province

The data analysis shown that, in the first 16 years of data analysis (A.D. 1981-1997), the Northeast monsoon has not changed its direction (80 degrees) with the wind speed of 8-11 knot, while the Southwest monsoon directs to the south (120-170 degrees) with the wind speed of 4-5 knot. The wind in the last 16 years (A.D. 1998-2013) shown that, the Northeast monsoon directs to the east (50-100 degrees) with the wind speed of 4 knot, while the Southeast monsoon directs to the south (120-160 degrees) with the wind speed of 6-8 knot, as show in Figure 16 and Table 4.5

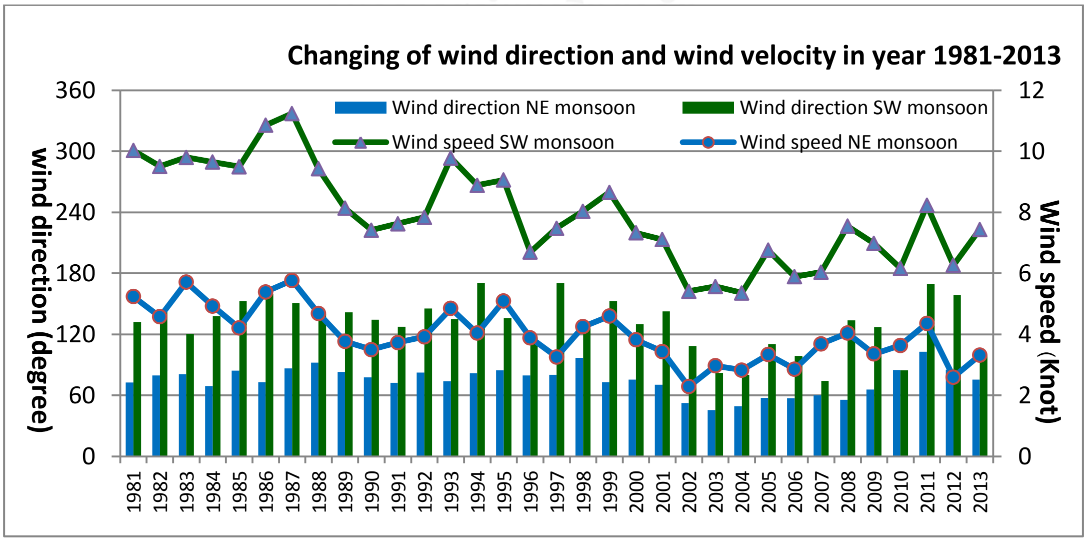


Figure 20 The comparative graph between the wind speed and direction of the Northeast and Southwest monsoon (A.D 1981-2013) at KoSichang Meteorological Station, Chonburi Province

duration	Northeast monsoon		Southwest monsoon	
	Wind direction	Wind speed	Wind direction	Wind speed
1981-1997	NE(80)	8-11 knot	ESE,S(120-170)	4-5 knot
1998-2013	NE,E(50-100)	4 knot	ESE,SSE(120-160)	6-8 knot
conclude	Changed	decrease	Not Changed	little increase

Table 5 Summary on the changes of wind direction and wind speed of Kosichang Meteorological Station, Chonburi Province

6. Pattaya Meteorological Station, Chonburi Province

The data analysis shown that, in the first 16 years of data analysis (A.D. 1981-1997), the Northeast monsoon has not changed its direction (80 degrees) with the wind speed of 8-11 knot, while the Southwest monsoon directs to the south (120-170 degrees) with the wind speed of 4-5 knot. The wind in the last 16 years (A.D. 1998-2013) shown that, the Northeast monsoon directs to the east (50-100 degrees) with the wind speed of 4 knot, while the Southeast monsoon directs to the south (120-160 degrees) with the wind speed of 6-7 knot, as show in Figure 17 and Table 4.6

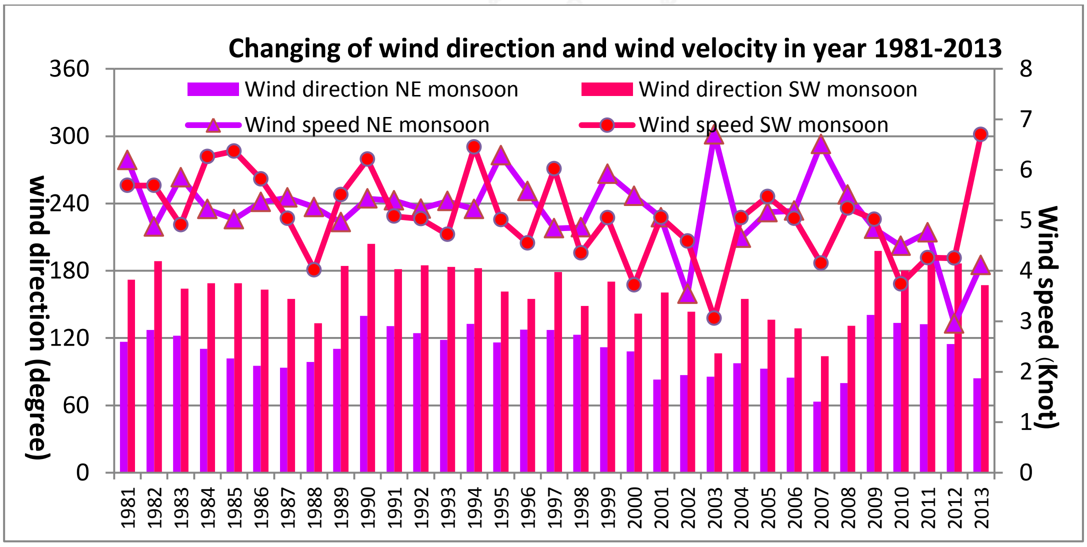


Figure 21 The comparative graph between the wind speed and direction of the Northeast and Southwest monsoon (A.D 1981-2013) at Pattaya Meteorological Station, Chonburi Province

duration	Northeast monsoon		Southwest monsoon	
	Wind direction	Wind speed	Wind direction	Wind speed
1981-1997	ESE (100-120)	5-6 knot	SSE,S(160-180)	5-6 knot
1998-2013	E,ESE (80-120)	5-6 knot	ESE,S (120-180)	6-7 knot
conclude	Not changed	stable	Not changed	stable

Table 6 Summary on the changes of wind direction and wind speed of Pattaya Meteorological Station, Chonburi Province

4.1.3 Analysis on monsoon's data of 3 stations (upper wind at 850 pha)

The study of 3 stations at 850 pha is to compare the characteristic of wind direction and wind speed of monsoon and observe the changes comparing to the surface wind. The study of 3 stations consists of 1. Chiangmai Station 2. Bangna Station, Bangkok 3. Songkhla Station has shown the results that the upper wind changed its direction and speed but not as obvious as the surface wind due to the differences of the level of the wind that has more direct effect to the wind. The surface wind has more effect to the shore as it is nearby the shore. Therefore, there are no changes of monsoon in the study area from the study on the height at 850 pha as in the figure.

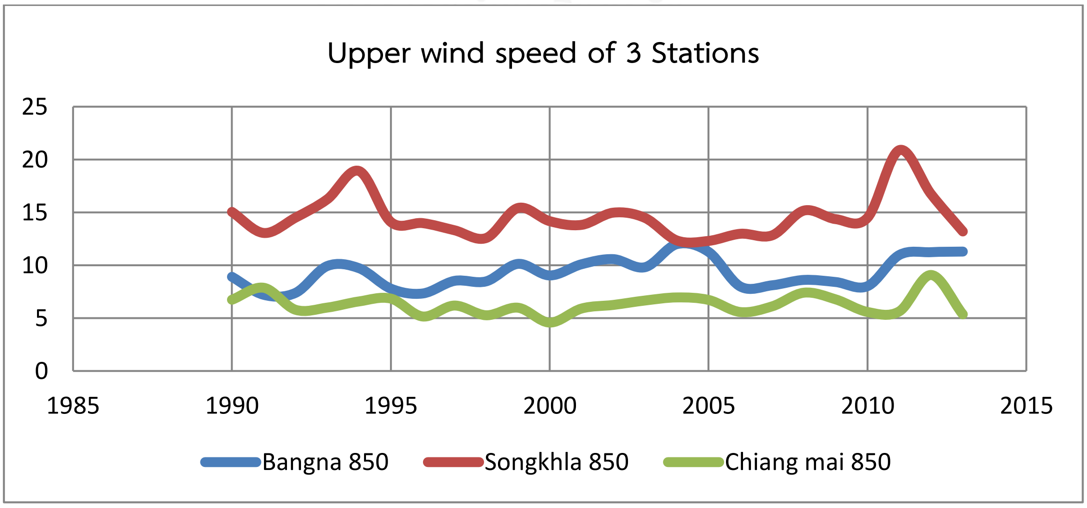


Figure 22 wind speed of 3 stations

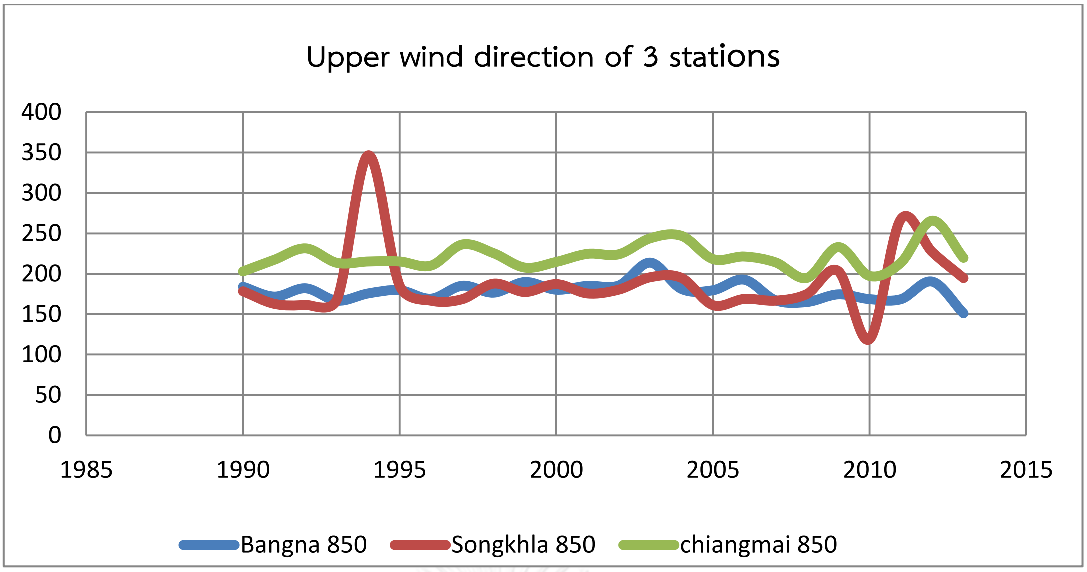


Figure 23 wind direction of 3 stations

4.2 Analysis on Tropical Cyclone which moves into Thailand during the year 1981-2013

The Tropical Cyclone has different names depends on the sources e.g. the storm generating in Bay of Bengal and Indian Ocean called Cyclone, the storm generating in the North Atlantic Ocean, Caribbean Sea, the Gulf of Mexico and the western side of Mexico called Hurricane, the storm generating in the Western of Pacific Ocean, Pacific Ocean and South China Sea called Typhoon. The Tropical Cyclone that has influence to the climate of Thailand, mostly generates in the Northern part of Pacific Ocean and the South China Sea, categorizes by the agreement between countries and subjects as follows;

- Depression: wind speed not over 33 knot (61 km. /hr.)
- Tropical Storm: wind speed 34-63 knot (62-117 km. /hr.)
- Typhoon: wind speed more than 64 knot (118 km. /hr.)

Thailand is located between the sources of Tropical Cyclone, Pacific Ocean and South China Sea on the eastern and Bay of Bengal and Andaman Sea on the western. The storm has the possibility to change it direction from Pacific Ocean and South China Sea into the eastern of Thailand rather than western. In general, the storm passes to Thailand approximately 3-4 storms per year. The northern and north eastern part of Thailand is the area that the storms pass the most. During January to March, the beginning of the year is the period that Thailand has no effect from storm, while the first storm will pass to the south of Thailand in April.

Two periods of monsoon changes at Phetchaburi Weather Station are clearer than other 6 stations around Upper Gulf of Thailand. When compare coastal erosion analysis data in Phetchaburi and examine coastal changes process in each season by calculate area changes ratio during year 2001-2011 from seasons i.e. Southwest monsoon and Northeast monsoon, coastal analysis result by DSAS in each monsoon season is that there are same coastal changes in study area. That is because it takes more than 5 months for coastal changing obviously (differ in each monsoon of studying pictures). We understand current situation of coast in Phetchaburi, Upper Gulf of Thailand coast from Bang Ta Boon district that most of coast are mud flat along with mangrove forest from pictures from THEOS satellite (MS).

Changes of coastal line from coastal changes analysis (DSAS) in the past compare with current coastal line in program GIS shows coastal changes in Phetchaburi as in figure which is consistent with coastal changes in Gulf of Thailand during year 2002 – 2011 (Department of Mineral Resources). We found coastal change occurred from erosion and accumulation in same area with this study result but there is more erosion

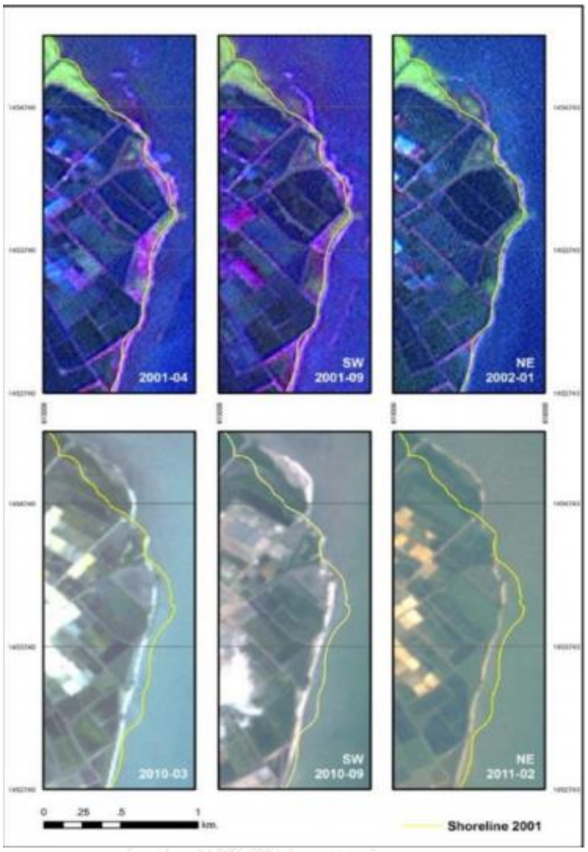


Figure 24 Beach line in Pak TA Lay district[22]

Effect of Southwest monsoon; width of beach in the end of Southwest monsoon season which is wider than beach in early of season shows that Southwest monsoon affects to accumulation of coastal sediment and movement direction of sediment from south to north supported by sediment from canal and causes sand bar outside of the coast. It can be seen from increasing of sand sediment at estuary. Effect of Northeast monsoon; width of beach in the end of Northeast monsoon season which is smaller than beach in the end of Southwest monsoon season shows that Northeast monsoon affects to blowing of sand sediment from coast.

Regarding to study from satellite and survey in study area, found that coast in Phetchaburi was eroded around 11,638 m. Severe eroded coast is erosion ratio more than 4 m. per year. Different monsoon season does not affect to change of sand sediment in beach line of lower study area. We found increasing of sand sediment in period of Southwest monsoon (May-September) and decreasing in period of

Northeast monsoon (October-February).Upper of study area is mud beach. Different monsoon does not affect to coastal changes but affects to changes of sand sediment at beach line in lower study area obviously. We found increasing of sand sediment at beach in period of Southwest monsoon (May-September) and decreasing in period of Northeast monsoon (October-February), and also increasing of sand sediment at beach in estuary along the coast.

Table 7 The Tropical cyclones that passed through Thailand during 1981-2013

D/M/Y	Type and Name	intial	Attacked area	affect
26-27 June 1983	Tropical Storm SARA (8312)	South China Sea	Nakonpanom	F
10 October 1983	Tropical Storm KIM (8315)	South China Sea	Nan	F
18 November 1980	Depression	Pacific Ocean	Trad	-
26-27 June 1983	Tropical Storm SARA (8301)	South China Sea	Nakonpanom	F
18 October 1983	Tropical Storm KIM (8315)	South China Sea	Srakaw	F
8 November 1983	Depression	Gulf of Thailand	Nakonsritamm-erat	L
12 October 1985	Depression	South China Sea	Trad	F
15 October 1985	Typhoon CECIL (8821)	North Pacific Ocean	Nakonpanom	F
4-6 May 1988	Depression	Andaman Sea	-	M

Table 7 Cont'd

D/M/Y	Type and Name	intial	Attacked area	affect
16-18 September 1988	Depression	Upper Andaman Sea	-	F
27-29 September 1988	Depression	South China Sea	-	M
15-17 October 1988	Depression	South China Sea	Ubonratchatani	M
21-29 October 1988	Typhoon RUBY	Pacific Ocean	-	M
4 November 1989	Typhoon GAY**	Gulf of Thailand	Chumpon	W
4 October 1990	Tropical Storm IRA (9022)	Lower part of South China Sea	Ubonratchatani	F
19 October 1990	Tropical Storm LOLA (9024)	Middle part of South China Sea	Prachinburi	F
21-29 October 1988	Typhoon RUBY	Pacific Ocean	-	M
27 October 1991	Depression	End Malay Peninsula	Prachaup khiri Khan	M
30 October 1992	Typhoon ANGELA (9224)	South China Sea	Trad	W
15 -16 November 1992	Tropical Storm FOREST (9312)	West MindaNoa Island	Nakonsritammarat	W

Table 7 Cont'd

D/M/Y	Type and Name	intial	Attacked area	affect
29-30 August 1993	Tropical Storm WINONA (9312)	South China Sea	Nakonpanom	M
27 October 1991	Depression	End Malay Peninsula	Prachaup khiri Khan	M
30 October 1992	Typhoon ANGELA (9224)	South China Sea	Trad	W
28-29 November 1993	Depression	South China Sea	Nakonsritammar at	W
15-16 December 1993	Typhoon MANNY (9505)	Northwest Pacfic Ocean	Songkhla	W
9-10 August 1995	Tropical Storm HELEN (9505)	Pacific Ocean	-	F
17-19 August 1995	Tropical Storm IRVING (9509)	Middle part of South China Sea	-	F
29-31 August 1995	Tropical Storm LOIS (9509)	Upper part of South China Sea	Nan	F
10-11 September 1995	Depression	Middle part of South China Sea	-	F
29-30 September 1995	Depression	Middle part of South China Sea	-	F

Table 7 Cont'd

D/M/Y	Type and Name	intial	Attacked area	affect
27 October 1995	Tropical Storm YVETTE (9519)	Pacific Ocean	-	F
30 November 1996	Depression	End of Malay Peninsula	Prachup Khiri Khan	M
3 November 1996	Depression	South China Ocean	Ubonratchatani	M
18 November 1996	Tropical Storm ERNIE (9625)	Pacific Ocean	Chumpon	M
4 November 1997	Typhoon Linda (9728)*	Lower part of South China Sea	Prachap Khiri Khan	W
17 November 1998	Tropical Storm CHIP (9813)	the Bay of Bengal	Prachap Khiri Khan,Chumpon	W
12 December 1998	Tropical Storm GIL (9817)	the Bay of Bengal	Nakonsritammarat	M
25 October 1999	Depression	South China		
4 December 1999	Depression	South China Ocean	Nakonsritammarat	M
23 August 2000	Tropical Storm KAEMI (0011)	Lower part of South China Sea	Mukdakhan	W

Table 7 Cont'd

D/M/Y	Type and Name	intial	Attacked area	affect
11 September 2000	Tropical Storm WUKONG (0016)	Lower part of South China Sea	Nongkay	W
3 November 2000	Depression	South China Ocean	Nakonsritammarat	F
10 August 2001	Tropical Storm USAGI (0110)	Lower part of South China Sea	Nongkay	W
23 July 2003	Typhoon KONI (0308)	South China Sea	Chiang Rai	M
24 October 2003	Depression	South China Ocean	Prachap Khiri Khan	M
13 June 2004	Typhoon CHANTHU (0405)	Lower part of South China Sea	Ubonratchatani	F
25 November 2004	Typhoon MUIFA	Gulf of Thailand	Suratthani	F
13 September 2005	Depression	South China Ocean	Ubonratchatani	W
28 September 2005	Typhoon DEMREY (0518)	Upper part of South China Sea	Nan	M
2 October 2006	Typhoon XANGSANE (0615)	Lower part of South China Sea	Ubonratchatani	F
6 December 2006	Typhoon DURIAN (0621)	Gulf of Thailand	Chumpon	F

Table 7 Cont'd

D/M/Y	Type and Name	intial	Attacked area	affect
1 May 2007	Depression	Pacific Ocean	Chumpon	F
8 August 2007	Depression	Lower part of		
4 October 2007	Typhoon LEKIMA (0714)	Lower part of South China Sea	Nongkhai	W
30 October 2008	Tropical Storm MEKKHALA (0816)	Lower part of South China Sea	Nongkhai	M
30 October 2009	Typhoon KETSANA (0916)	Lower part of South China Sea	Nongkhai	M
1 November 2010	Depression	South China Ocean	Songkhla	W
31 July 2011	Tropical Storm Nock-TEN (1108)	Lower part of South China Sea	Nan	F
7 October 2012	Tropical Storm GAEMI (1220)	South China Ocean	Sa kaeo	M
1 November 2010	Depression	South China Ocean	Songkhla	W
19 September 2013	Depression	South China Ocean	Ubonratchatani	M
1 October 2013	Typhoon WUTIP (1321)*	South China Ocean	Nakorn Panom	W

The Tropical Cyclone is one of the natural disasters that Thailand will be affected due to the heavy rain and the storm. Each part of Thailand will be affected by the Tropical Cyclone that passes through Thailand in different area as shown in the picture. The Tropical Cyclone will pass to the upper part of Thailand during June to September and pass to the lower part afterwards. Such situation can cause the flood as well as the higher level of the wave. However, the level of the damages depends on the strength of the storm that time. Thailand is influenced by the Tropical Cyclone during May to December with the storm direction in the north eastern part to the southern part as shown in **the Figure 20**.

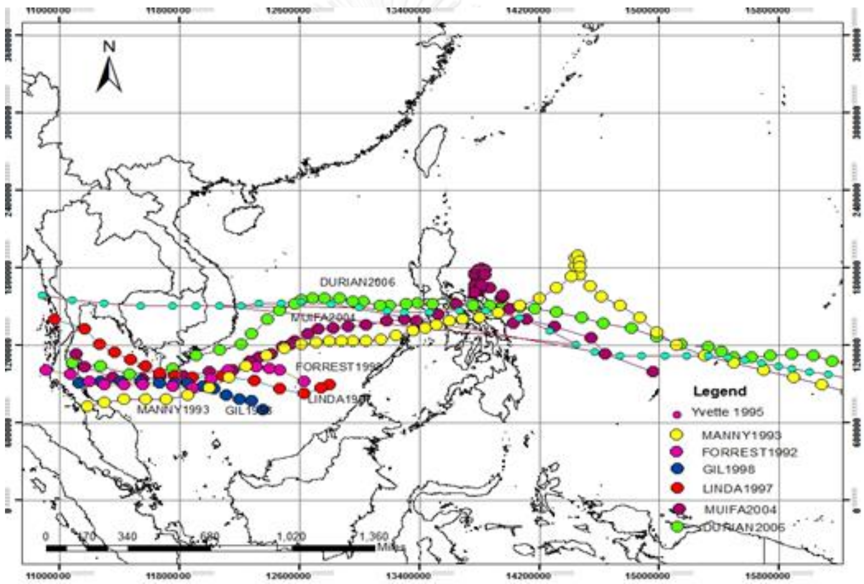


Figure 25 The Tropical Cyclone that passed through the study area consists of 6 storms

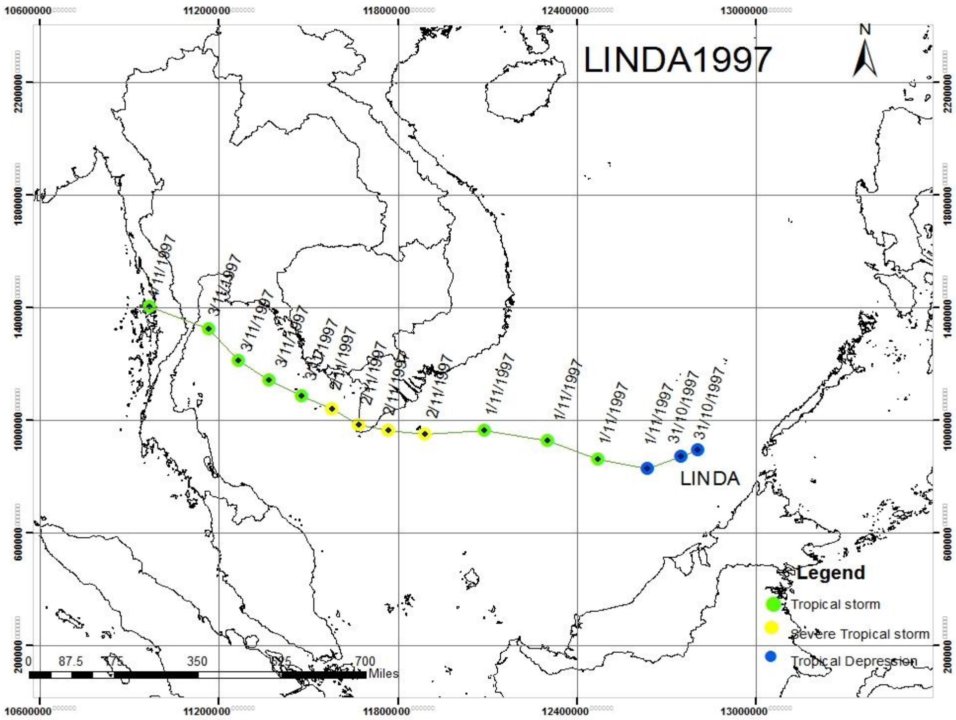


Figure 26 The Typhoon Linda passed through Thailand

1. Typhoon Linda (30W)

The tropical disturbance that would become Typhoon Linda (30W) formed within an area of convection east of the Philippine Islands near 10 N 130 E on 26 October 1997. Typhoon Linda (30W) crossed the Gulf of Thailand on 4 November 1997. Linda reached typhoon intensity shortly after entering the Gulf of Thailand. The cyclone turned northwestward following steering from the subtropical Ridge [2]Consequently the storm surge that was seen along the shoreline north of the standing point was due to the strong onshore wind, piling up the water mass [23] Figure 26

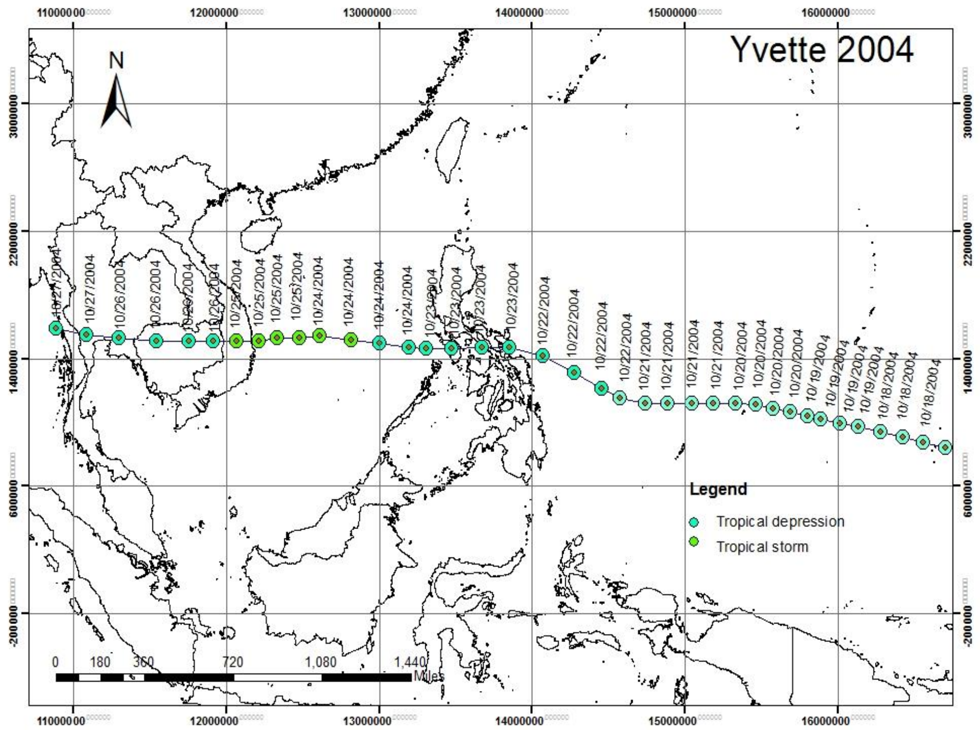


Figure 27 The Typhoon Yvette passed through Thailand

2. Yvette Storm 2004

The Yvette Storm centered in Pacific Ocean from Depression, passed through the Philippines on 13 October 2004. A disturbance became the Tropical Cyclone passed through Myanmar on 25 October 2004 and turn back to be Depression, passed through the eastern part of Thailand. Chonburi Province received the major impacts which lead to severe flood on 26-27 October 2004 with the devastating damages.

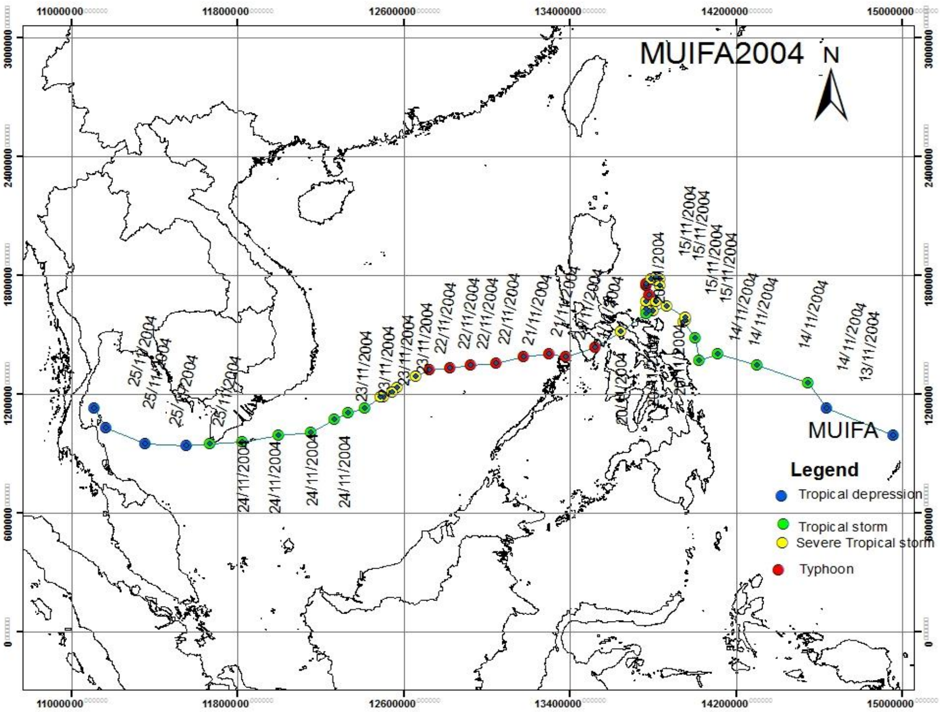


Figure 28 The Typhoon Muifa passed through Thailand

3. Typhoon Muifa

The Typhoon Muifa passed through Thailand with the devastating impact in 2004, as it passed into the Gulf of Thailand and became the Depression at 12.00 hr. on 25th. The Typhoon Muifa passed in to the Gulf to Thailand on 25 November at 22.30 hr. and moved its direction to the western at the wind speed of 15 km. per hour and moved to the north-western with the wind speed of 15 k. per hour afterwards. At last, the Typhoon Muifa reduced its intensity to low pressure area and decomposed in Prachuap Khiri Khan Province

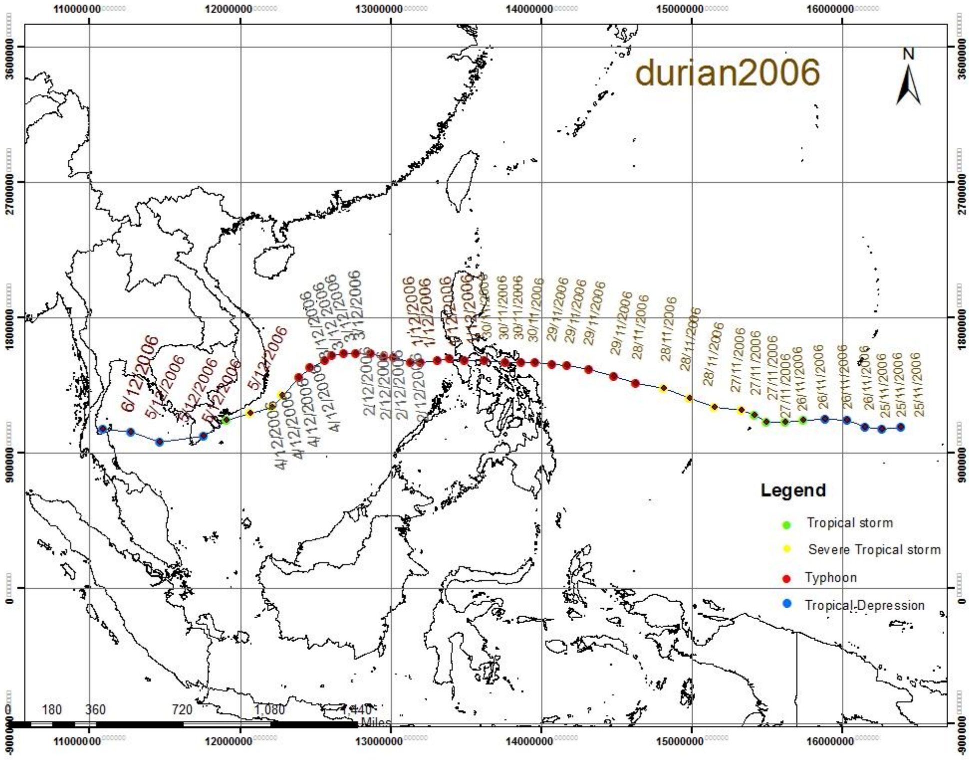


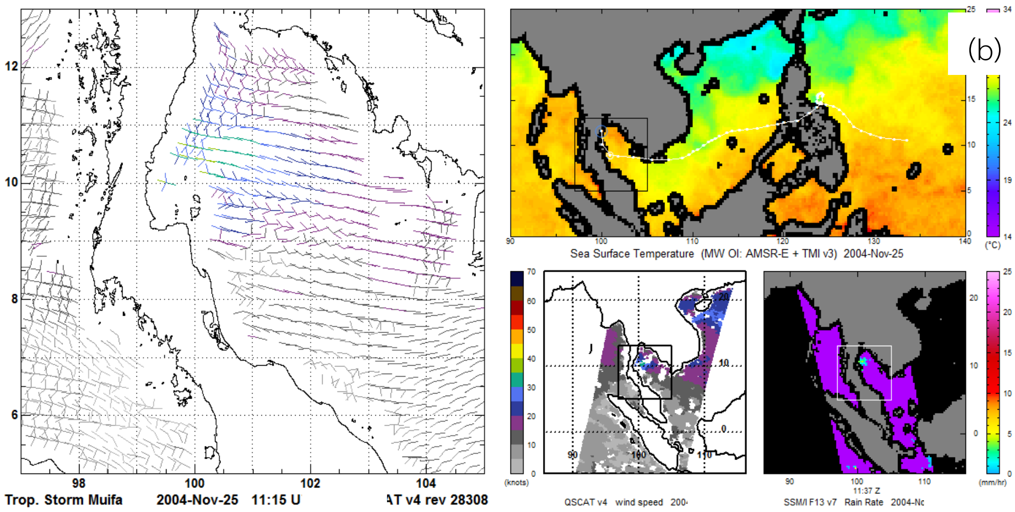
Figure 29 The Typhoon Durian passed through Thailand

4. Typhoon Durian

Typhoon Durian is a very intense storm that caused a lot of damaged in Philippines. It caused massive loss of life when mudslides from the Mayon Volcano buried many villages. The Joint Typhoon Warning Centre mentioned that this typhoon would move from west to northwest before gradually deteriorating and becoming a very dangerous tropical storm on November 27th. The storm moved to Philippines after November 28th, JMA and JTWC announced the storm a typhoon as it moved on to the Philippines on November 29th. On December 4, JMA had downgraded it to an intense tropical storm. The storm later moved along the southwestern coast of Vietnam and hit the province of Ben Jae on December 5th before weakening rapidly. Thus JMA downgraded it to a tropical storm. The final reported from JMA and JTWC mentioned that Durian storm would enter the Gulf of Thailand and weakening to a tropical depression storm. It had swept across the southern part of Thailand and moved forwards to the Bengal Bay.

4.3 Search for the relations between the Tropical Cyclone and the wind strength of the wind in the upper part of the Gulf of Thailand

1. Typhoon Muifa passed through the upper Gulf of Thailand in 2004. Typhoon Muifa moved its direction close to Prachuap Khiri Khan Province with the different speed of surrounding wind as shown in figure 25 According to the study area, the wind is from the upper part of the Gulf of Thailand (The study area)



(a) (c) (d)

Figure 30 The analysis on the wind surrounded Typhoon Muifa by satellite[24]

(a) The characteristic of the wind surrounded the Typhoon Muifa

(b) The wind direction and the sea level temperature

(c) The data of wind speed

(d) The scale of raining in the area2. Typhoon Durian (Reming)

The Typhoon Durian passed through the upper part of the Gulf of Thailand as the Tropical Storm in December 2006. The storm moved to the western part of the Gulf of Thailand on 5 December 2006 at 22.42 UTC. It was obviously seen that the spinning of the wind surrounded the storm due to the movement of the storm lead to the wind speed and direction as shown in **figure 26**

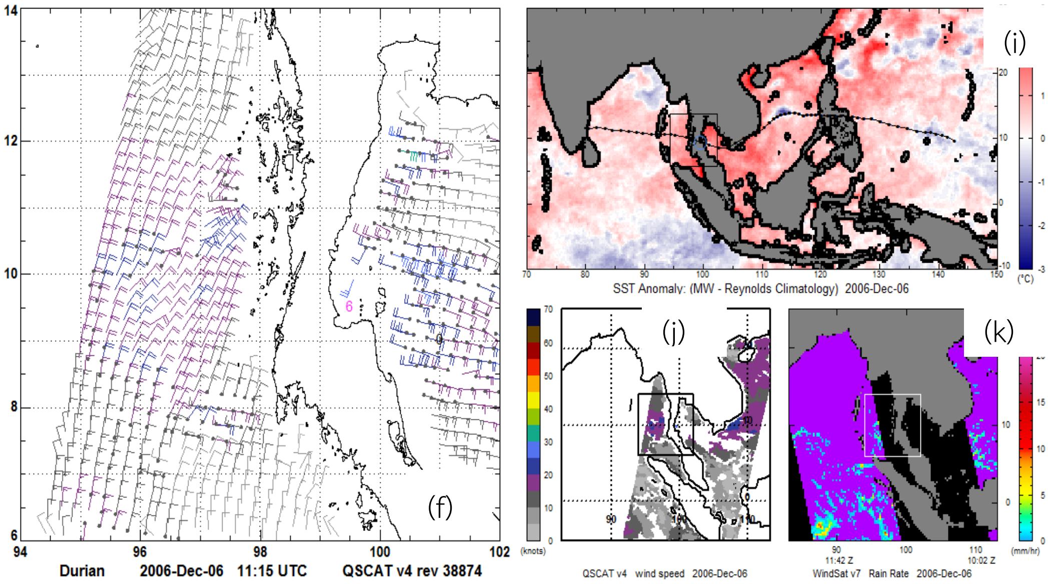


Figure 31 the analysis on the wind surrounded Typhoon Durian by satellite[24]

(F) The characteristic of the wind surrounded the Typhoon Muifa

(i) The wind direction and the sea level temperature

(j) The data of wind speed

(k) The scale of raining in the area

According to the movement and the wind surrounded the Depression, the wind that blow into the center of the Tropical Cyclone in the upper part of the Gulf of Thailand, is the wind direction that moves to the shore which is similar to the example in the figure 26 This is to say, the mentioned period can cause the strong wind and wave which lead to the coastal erosion.

CHAPTER V CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

1. Study trends of monsoon's change in the upper gulf of Thailand during 1981 – 2013

According to study of changes of monsoon and tropical cyclone during 1981 – 2013 in Upper Gulf of Thailand, found data as below

Regarding to wind speed and wind direction analysis in monsoon period from 6 stations around study area found that there are changes in each station as following. 1. Phetchaburi Meteorological station wind changes direction in period of Northeast monsoon, wind changes direction to southeast, and changes to southeast and south with increased speed in period of Southwest monsoon. 2. Pilot station, Samut Prakan Province in period of Northeast monsoon wind direction changes to southeast with stable speed and changes to south in period of Southwest monsoon. 3. Bangna Meteorological station, Bangkok province in period of Northeast monsoon wind direction changes to southeast and changes to southeast with decreased speed in period of Southwest monsoon. 4 KlongToey Meteorological station, Bangkok Province - in period of Northeast monsoon wind direction changes to southeast and changes to south with stable speed in period of Southwest monsoon. **Figure 27**

Obviously, Phetchaburi Weather Station, study result during 1981-1999, in period of Northeast monsoon and Southwest monsoon wind direction goes to northeast and during 2000-2013 wind direction changes to southeast and south. In figure 27, when most changes occurred, they might be many factors that affect to wind direction change. studied coastal erosion in Phetchaburi and examine about coastal changes process in 2 seasons i.e. Northeast monsoon and Southwest monsoon. From satellite view, Upper Gulf of Thailand, Phetchaburi, there are changes of basic meteorology variable which affect to coastal changes clearly. They are wind direction changes in period of Northeast monsoon which wind direction changed from southeast to east more than in the past. Even though, Southwest monsoon and wind in seasons changing period changed unobvious, wind direction also strengthen deflation from coast.

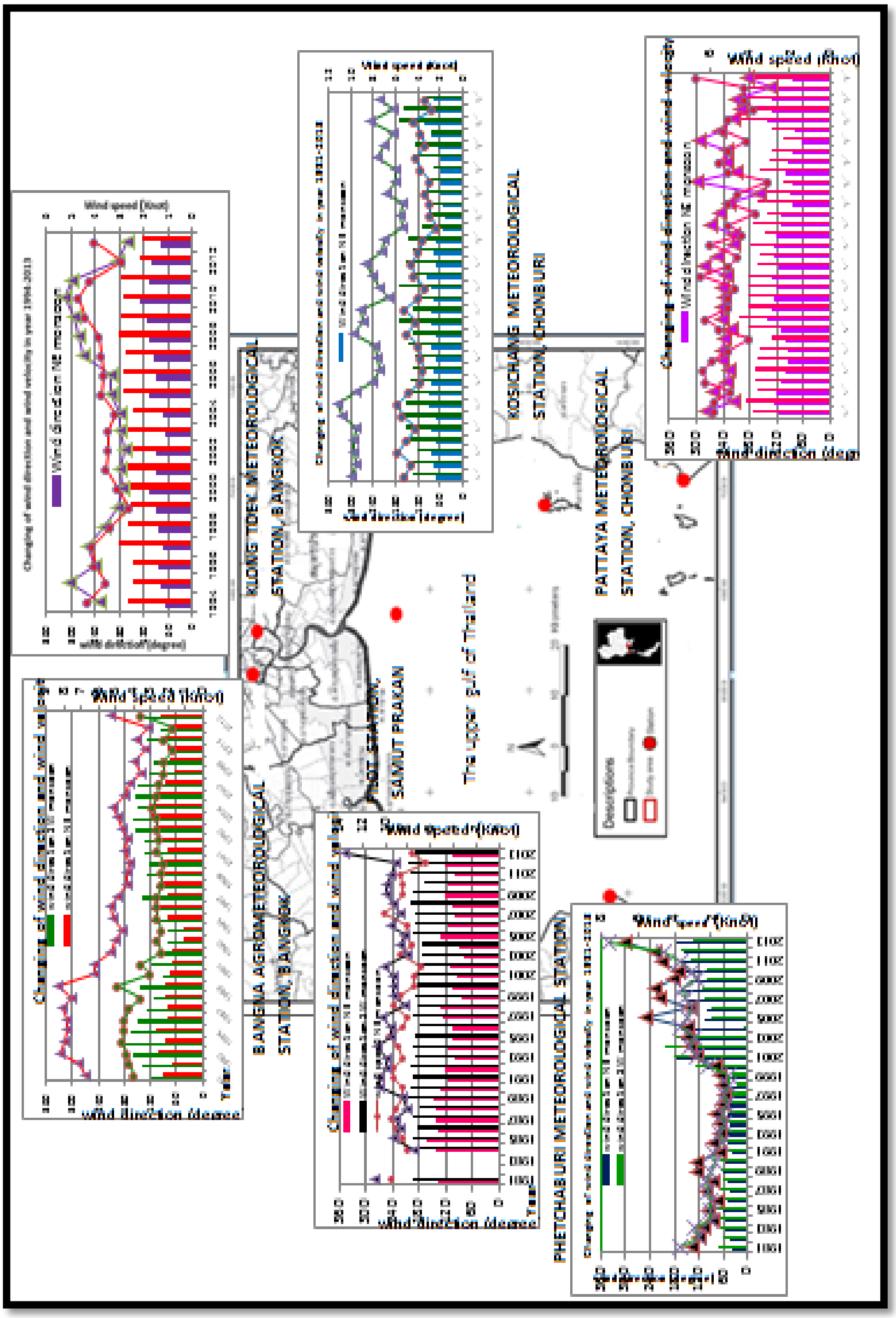


Figure 32 The trends of monsoon's change in the upper gulf of Thailand on the six station

5.2. Study of trends of tropical cyclone changes in upper Gulf of Thailand

Due to sea temperature in Gulf of Thailand can affect to causing of tropical cyclone, if there are other factors which support to causing of tropical cyclone, storm could occurred. Regarding to collecting data previously, there is a little chance for severe level tropical cyclone changing to Typhoon and move pass study area or closing area. As a result of that, chance of erosion occurred from severe level storm is little too. However, it is possible for Depression 1-2 times per year which causes rage and brings sediment out from coast. This is normal movement of tropical cyclone.

Even though there is less chance of study area to affected from tropical cyclone than upper south area, it is affected from rage that have effect on sediment and wind direction that bring large amount of sediment out from coast while tropical cyclone occurring in upper Gulf of Thailand

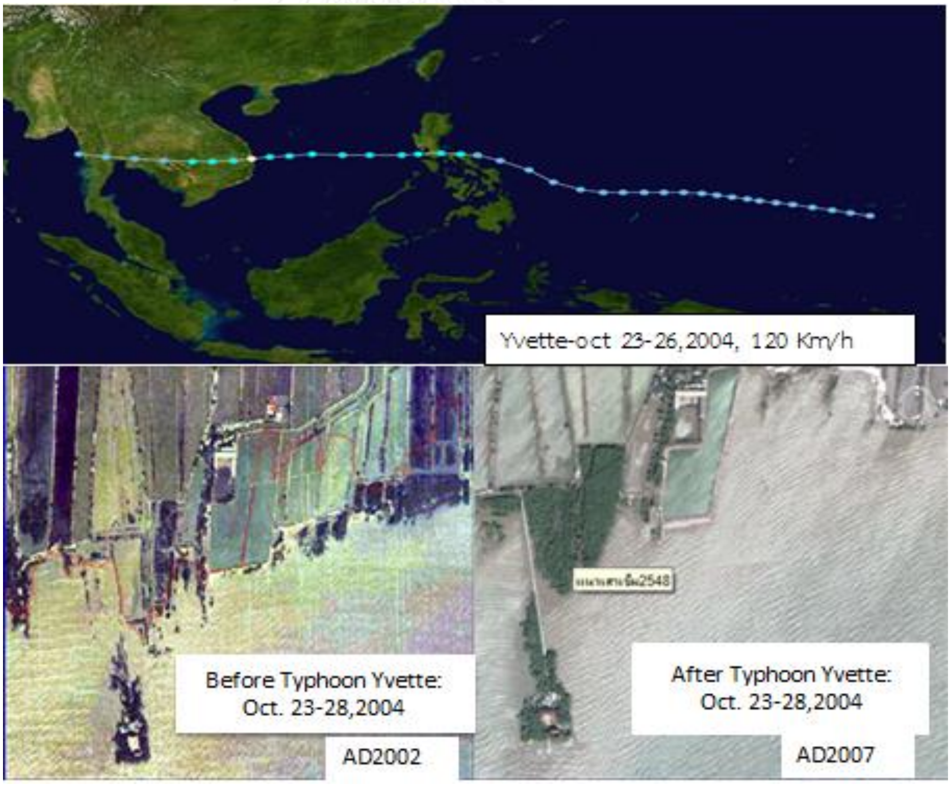


Figure 33 Pictures from satellite before and after Viet storm year 2004 move to upper Gulf of Thailand

Province	Area boundary	Quantity of eroded area	Coast length	Eroded beach line (k.m.)

	data				(k.m.)			
	City	District	City	District		Fair	Worst	Total
1.Chachoengsao	11	50	1	3	16.28	2.04	5.85	7.89
2 . Samut Prakan	6	50	3	6	50.21	3.22	31.47	34.69
3.Bangkok	50	154	1	1	5.81	-	5.71	5.71
4 . Samut Sakorn	3	40	1	8	42.78	19.69	13.76	33.45
5.Samut Songkhram	3	36	1	4	25.50	2.96	-	2.96
6.Phetchburi	8	93	4	13	91.73	39.35	10.39	49.75

Table 8 Coast erosion separated by coastal province in Thailand [4]

Erosion tendency at upper Gulf of Thailand is increasing and may erode into the land which is far from coast around 2 k.m. in next 30 years. Cause of severe erosion in this area is changes of wind wave and storm [4]

Risky area for severe erosion: Bangkok, Samut Prakan and Chachoengsao upper Gulf of Thailand. We found that coastal area of Samut Prakan, Bangkok, Samut Sakorn, and Samut Songkhram are sensitive area and have the worst erosion such as Khun Samut Jean coastal area, Laem Fa Pah district, Samut Je Di, Samut Prakarn; there is erosion distance 12.5 kilometers with erosion ratio over 25 meters per year. In many previous years, they have faced with erosion problem continually that caused people migration. In the past, there were 200 families but now are only 105 families. The evidence which shows that area was a community is electricity in the sea. Bang Khun Tien, Bangkok suffered with severe erosion with erosion ratio around 20-25 meters per year for 28 years with distance more than 800 meters. Area which used to be Bang Khun Tien community became sea now. We can see from Bangkok's landmark which now located in the sea as in above table [4]

One cause of erosion in upper Gulf of Thailand is monsoon and tropical cyclone which occurred naturally. We can see that the most risky areas are Phetchaburi, Samut Prakarn and Samut Sakorn. This information can be used for disaster warning.

5.3 RECOMMENDATIONS

1. Regarding to 3 hours studying of wind direction and wind speed all 6 stations, some weather station is on land such as Bangna, Bangkok, Klong Toey, wind direction is unclear due to buildings. Some station is in the sea, changes are unclear due to wind from all directions. For station where located at coastal area far from sea around 1 k.m., wind direction changes and speed result is clearer than other areas such as Phetchburi and Pattaya Weather Station etc.
2. Meteorological data in this study can be furthered in study of coastal erosion. This data is about upper Gulf of Thailand which is area that affected from more coastal erosion every year. This data can be used to refer about meteorology of monsoon direction changes and tropical cyclone in upper Gulf of Thailand.
3. Engineering This data can be reference for building dam or dam wall about proper wind direction and proper period.
4. Information We can collect wind direction changing time data from satellite pictures and compare with other stations. We can understand coastal changes from satellite pictures which are advantages for further coastal erosion study in the future.
5. Variability of weather causes heavy rain and delayed rain more than in the past. It affects storms to change direction and occurs more often which cause more severe and higher wave in Gulf of Thailand.

REFERENCES

1. Department of marine and coastal resources, *The master plan project and the seperation pad was the problem of coastal erosion on the Gulf of Thailand, the second progress report, proposed by the Research Institute and consultancy, Thammasat University, 3-1 to 3-21.* 2008, .
2. Meteorological Department, *http://www.tmd.go.th/info/info.php?FileID=58.* 2015, .
3. Aschariyaphota, N., et al., *Simulation of Seasonal Circula-tions and Thermohaline Variabilities in the Gulf of Thailand, J. Adv. Atmos. Sci. 25: 489-506.* 2008, .
4. Department of Marine and Coastal resources, *Marine Fisheries Research and Development upper Gulf of Thailand. Samut Prakan.* 2013, .
5. Department of marine and coastal resources, *The master plan project and the seperation pad was the problem of coastal erosion on the Gulf of Thailand, the second progress report, proposed by the Research Institute and consultancy, Thammasat University, 3-1 to 3-21.* 2551, .
6. Israporn Ittaro, *The Hydrographic Department of the Navy.* 2011.
7. Buranapratheprat, A., et al., *Influence of local wind field on seasonal circulations in the upper Gulf of Thailand, J. Coast. Mar. Sci. 30(1): 19-26.* 2006,.
8. Buranapratheprat and Banpapong et al. , *Buranapratheprat, A. and Bunpapong, M., 1998, A two dimensional hydrodynamic model for the Gulf of Thailand, pp. 469- 478, Proceedings of the IOC/WESTPAC Fourth International Scientific Symposium,.* 1998,.
9. Oapsornsuda siripong, *Characteristics of the temperature and the Salisbury hotel in the Gulf of Thailand and the mass sea of China. In the four seasons from the direct measurements, water quality, research, conferences and resources. July 3-life: 1-24.* 2527, .

10. Ekman, V.W., *On the influence of the earth, s rotation on ocean current.Arch.Math.Asteon.* 1905,.

11. Chu, P.C., et al., *Dynamics mechanisms for the South China Sea seasonal circulation and thermohaline variabilities, J. Phys. Oceanogr. 19: 1730-1752.* 1999,.

12. Sitsaraporn titarow, *Climate change, coastal Bang, Master of Engineering Thesis, Department of Water Resources Engineering. Graduate Studies, Chulalongkorn University, 215 pages Jarupongsakul,T., The impact of Coastal erosion on Bangkok-area of Gulf Thailand. 2010.* 2544, .

13. Snidvongs, A. and P. Sojisuporn, *Numerical Simulations of the net current in the Gulf of Thailand under different monsoon regimes, Proc. 1st Tech. Seminar on Marine Fishery Resources Survey in the South China Sea Area I: Gulf of Thailand and East Coast of Peninsular Malaysia, 22-24 November 1997, Bangkok, S1/OG5:54-72.*

. 1997,.

14. Parin lotpitayakon, *thesis, Shreveport la area the glacier and partially wit pramote Sochi suphon, the study of water flow circulation patterns in the Gulf of Thailand. In the NBA, chain condition Re: Science and technology 19 (4): 1-13.* 2011,.

15. El-Reay et al., *the dependence of hurricane intensity on climate. Nature,326,483-485.* 1999,.

16. Sojisuporn, P., A. Morimoto, and T. Yanagi, *Seasonal variation of sea surface current in The Gulf of Thailand. Coastal Marine Science, 34, 1: 000-000, 2010.* 2010.

17. Lopittayakorn et al., *Biological and chemical consequences of the 1997–1998 El Niño in central California waters.* 2012,.

18. al., D.e., *Tropical Cyclone intensity Analysis and Forecasting from Satellite imagery Mon. Weather Rev.,103,420.* 2005,.

19. Payom Rattanamanee · and Payom Rattanamanee., *Remove suggestion. Conference: National Conference on Mapping and Geo-informatics* 2005,.

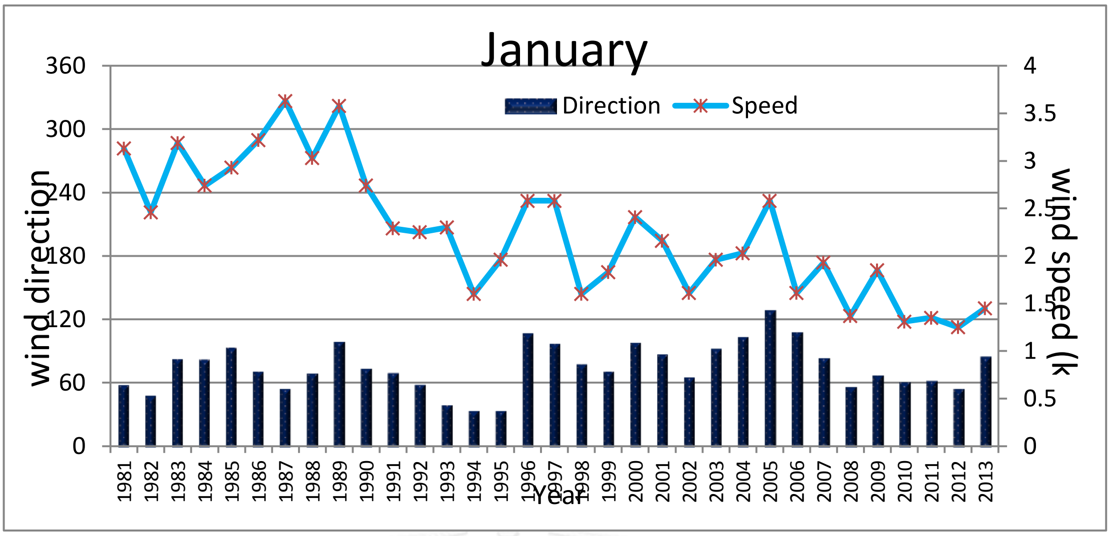
20. Resources, D.o.M.a.C., The oceanography of the Gulf of Thailand. , *Available from:http://marinegiscenter.dmcr.go.th/km/oceanography-of-the-gulf-of-thailand/?lang=en#.VO8zodKUc9I Vongisessomjai et al., 1976. Current and inferred movement of particulate matter in the Upper Gulf of Thailand.Journal of Science, Thailand Volume 2 (1976).* 2013;.
21. NEDECO., *A study on the siltation of the Bangkok Port Channel. The Hague, Holland.* 1965.
22. Oraon Sarajit and Kanjana Nakapakorn, *Geo-information Application for Coastal Erosion situation,Phetchaburi Province.* 2014,.
23. Kanbua, *Forecasting Tropical Cyclone Movement by Statistical and Dynamical Techniques".* 2005,.
24. cyclone/cyclone.html?year=2004&storm=Muifa), w.s.c.

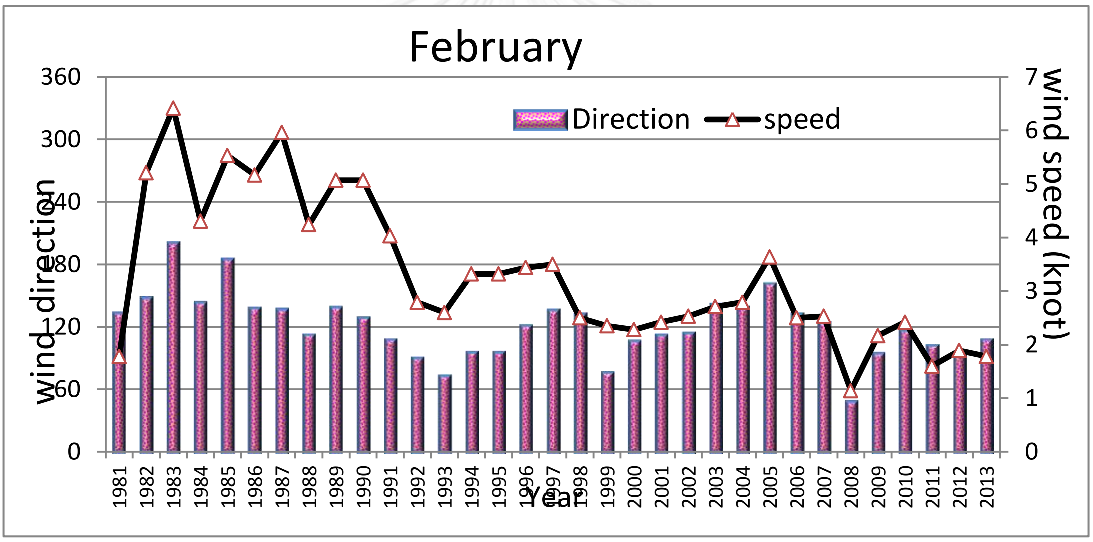
Appendix A

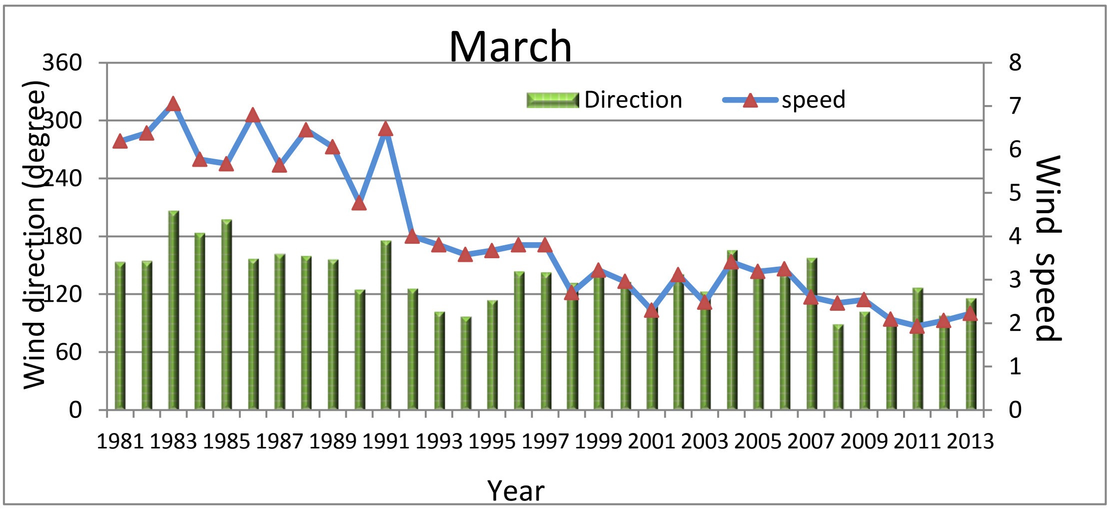
Results of Monthly analysis on monsoon of 6 station (surface wind)

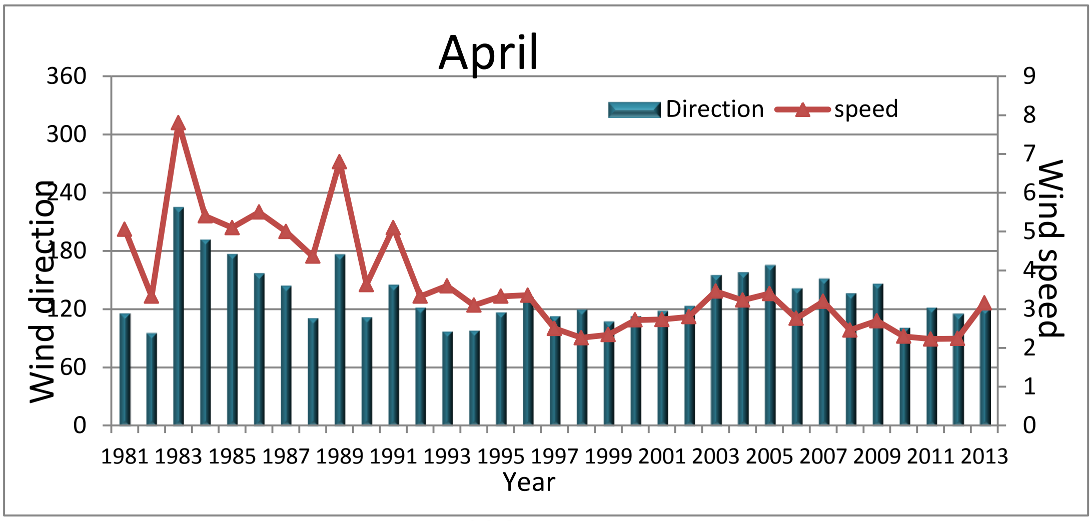
around the upper Gulf of Thai

1. Bangna Meteorological station, Bangkok








April
Direction
speed
Wind direction
Wind speed
360
300
240
180
120
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2
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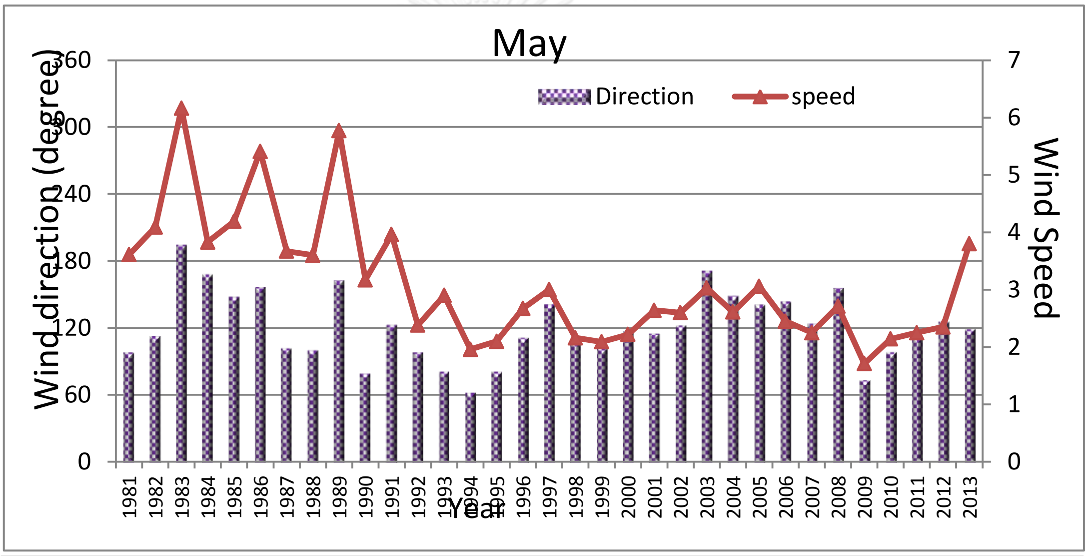
0
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013
Year


May
Direction
speed
Wind direction (degree)
Wind Speed
360
300
240
180
120
60
0
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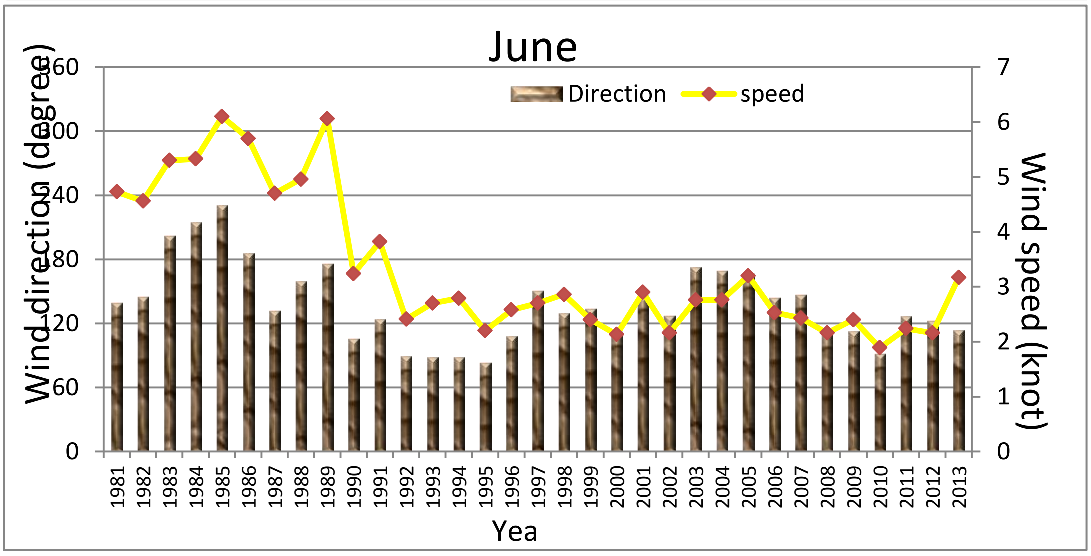
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year


June
Direction
speed
Wind direction (degree)
Wind speed (knot)
360
300
240
180
120
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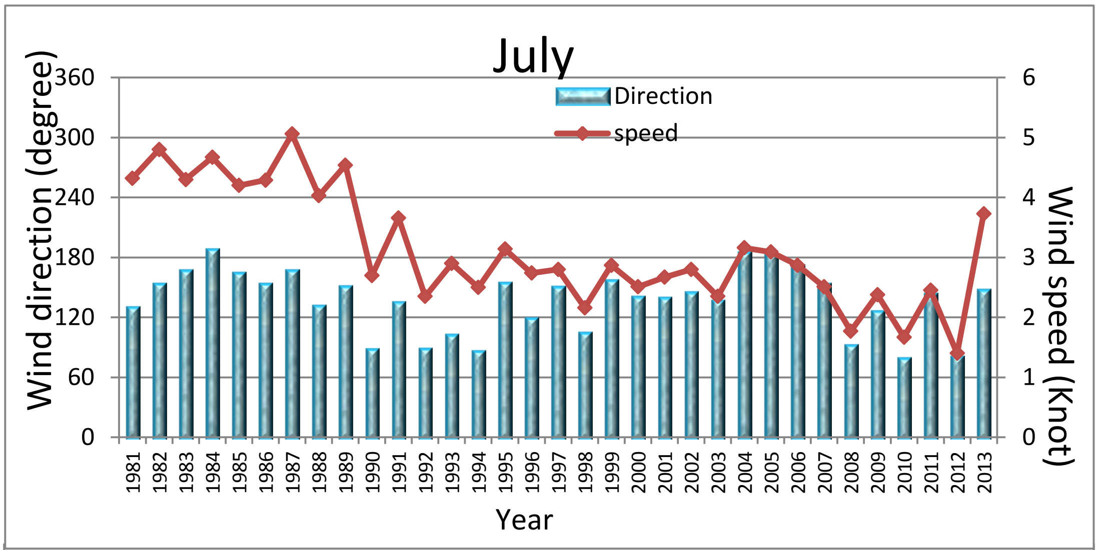
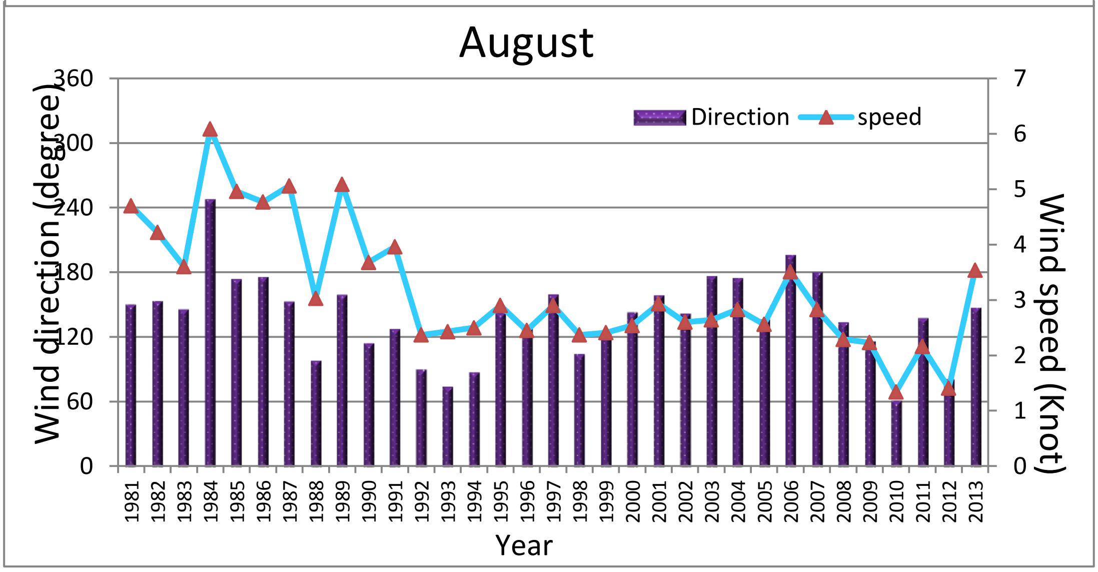
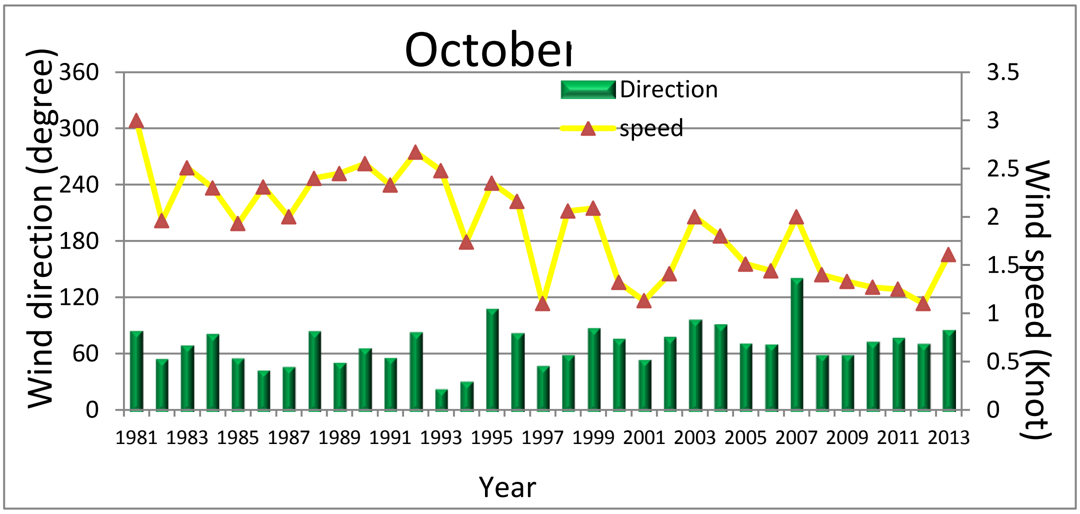


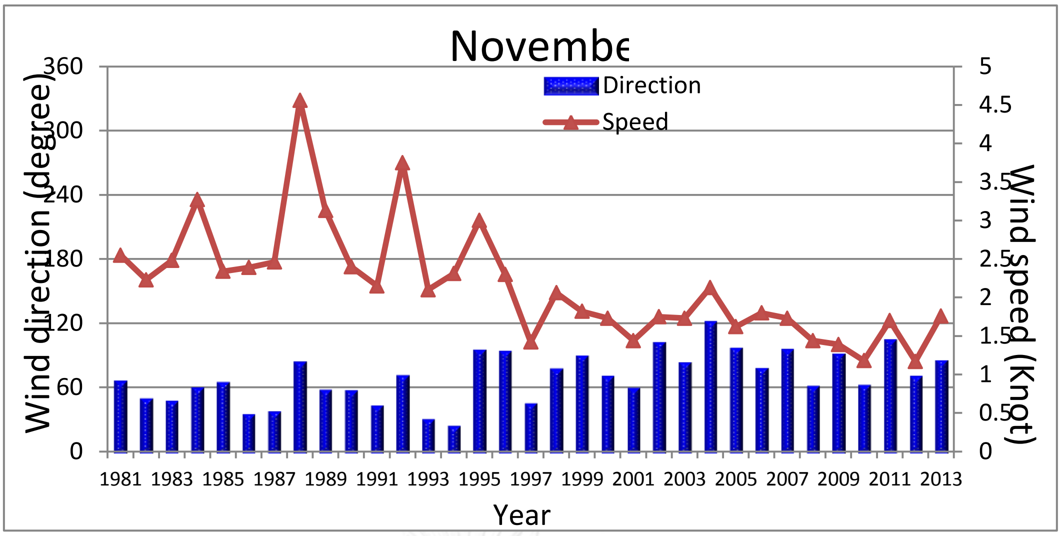
July
Direction
speed
Wind direction (degree)
Wind speed (Knot)
Year



August
Direction
speed
Wind direction (degree)
Wind speed (Knot)
Year



October
Direction
speed
Wind direction (degree)
Wind speed (Knot)
Year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Direction
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Wind direction (degree)
Wind speed (Knot)
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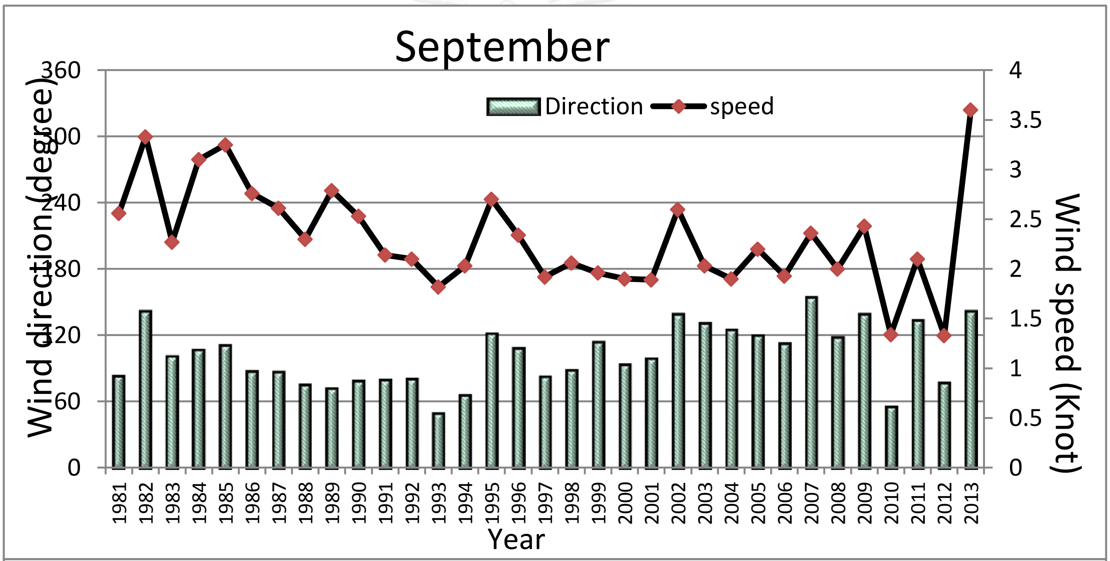
September
Direction
speed
Wind direction (degree)
Wind speed (Knot)
Year
0
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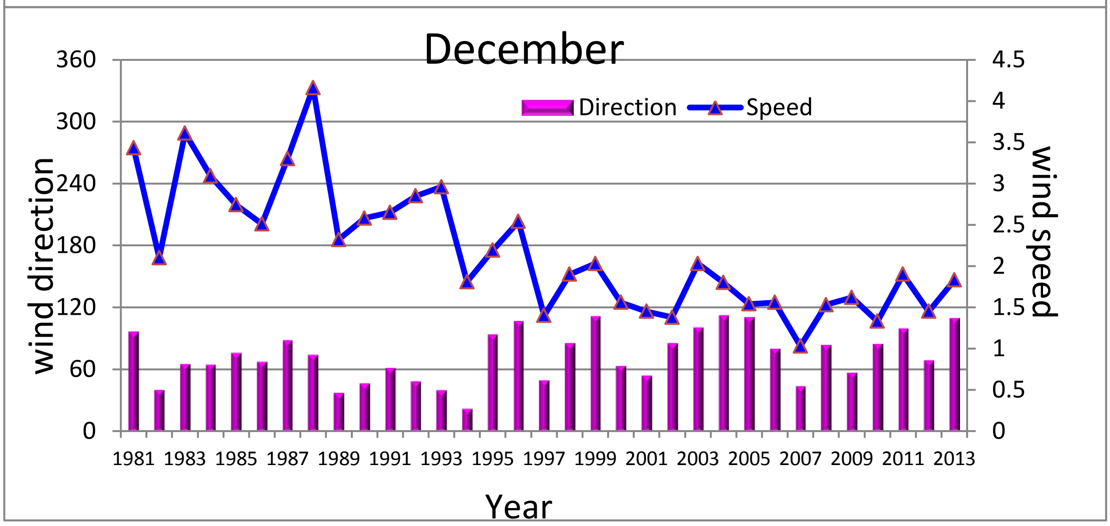
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


December
Direction
Speed
wind direction
wind speed
Year
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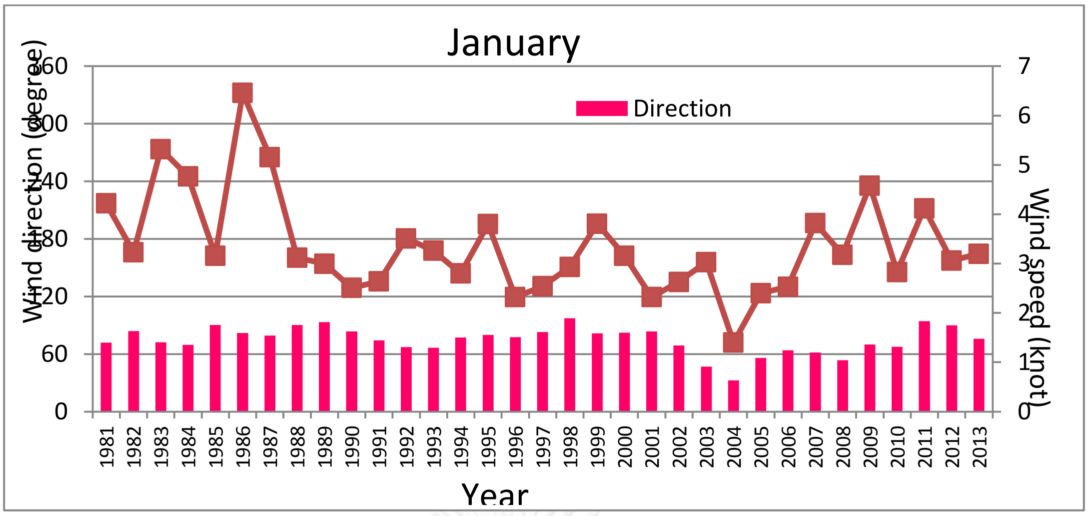
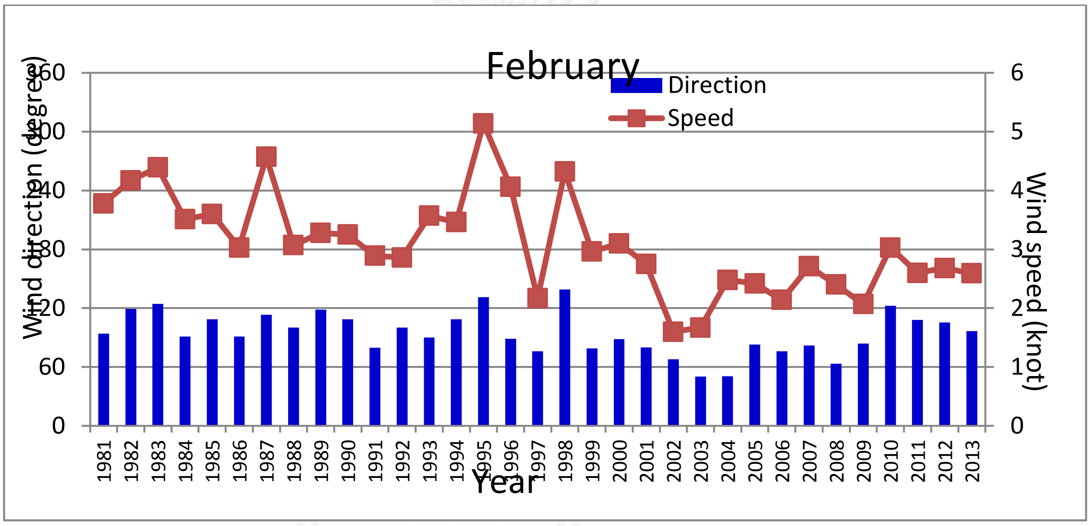
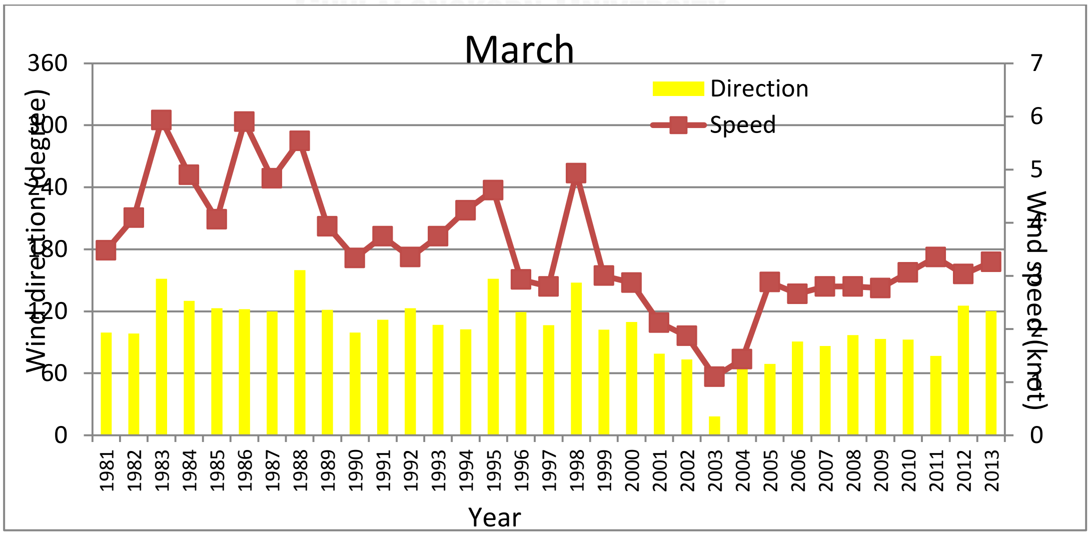
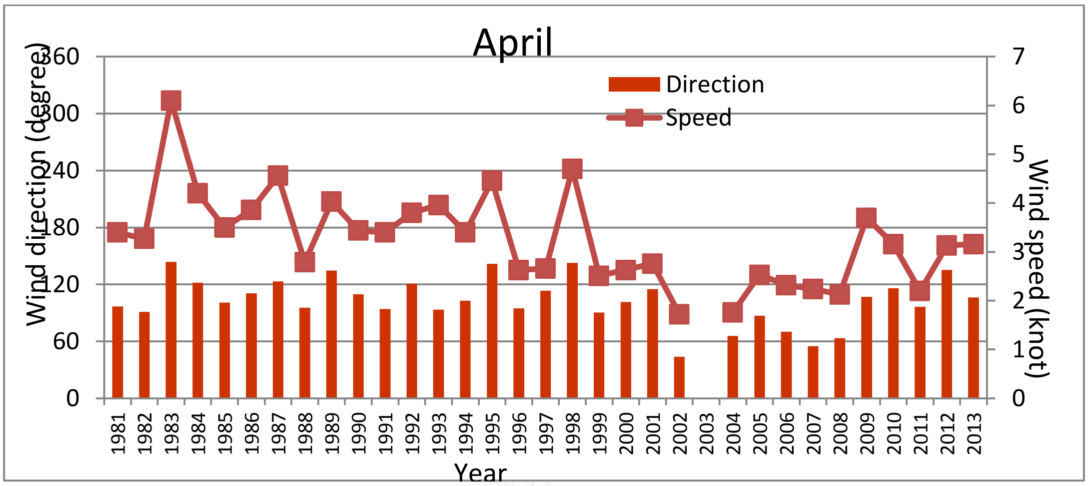
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013

2. Kosichang Meteorological station, Chonburi








April
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
0
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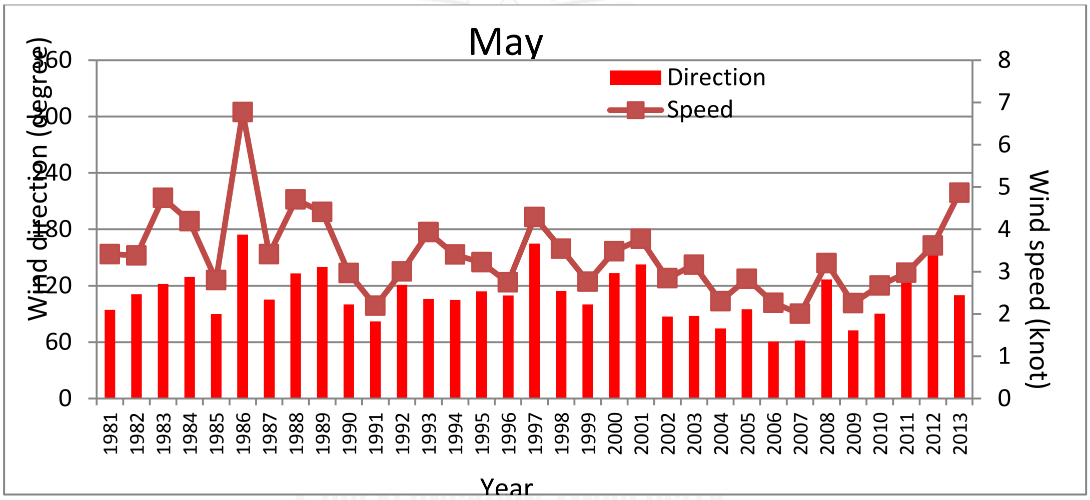
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


May
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
0
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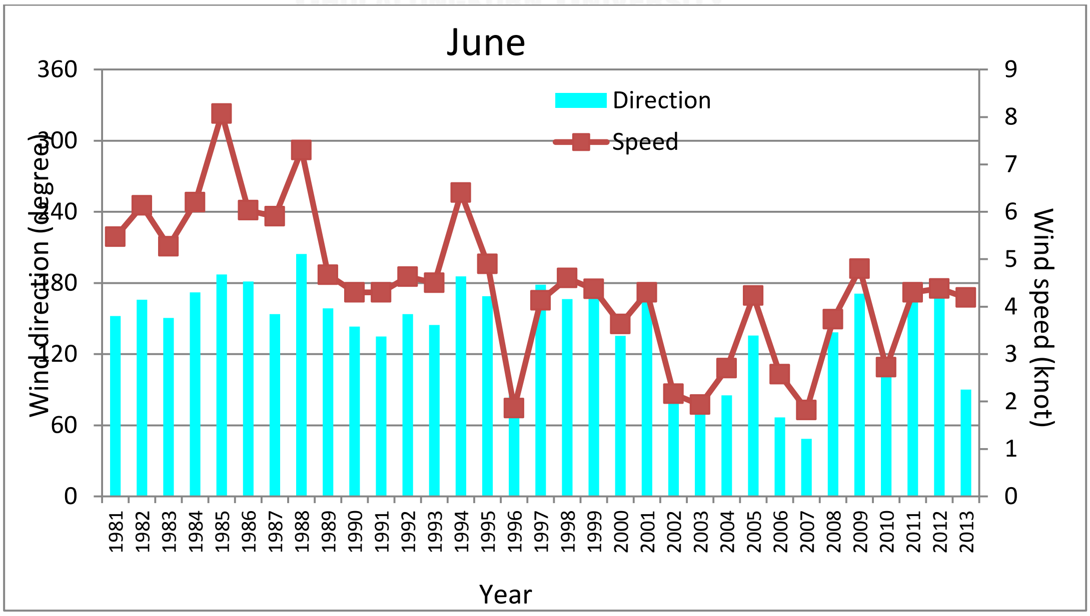
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


June
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
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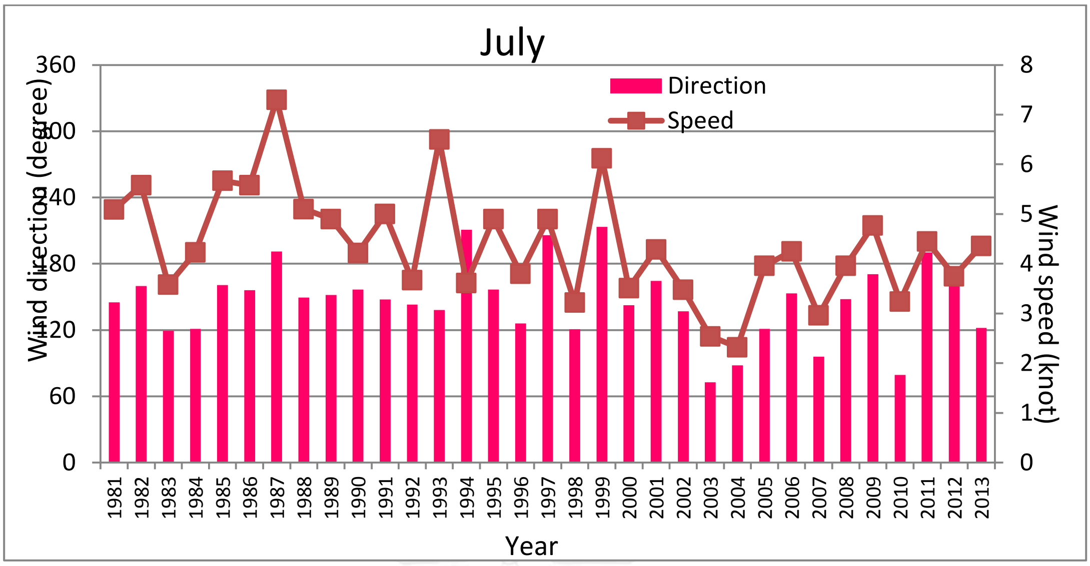
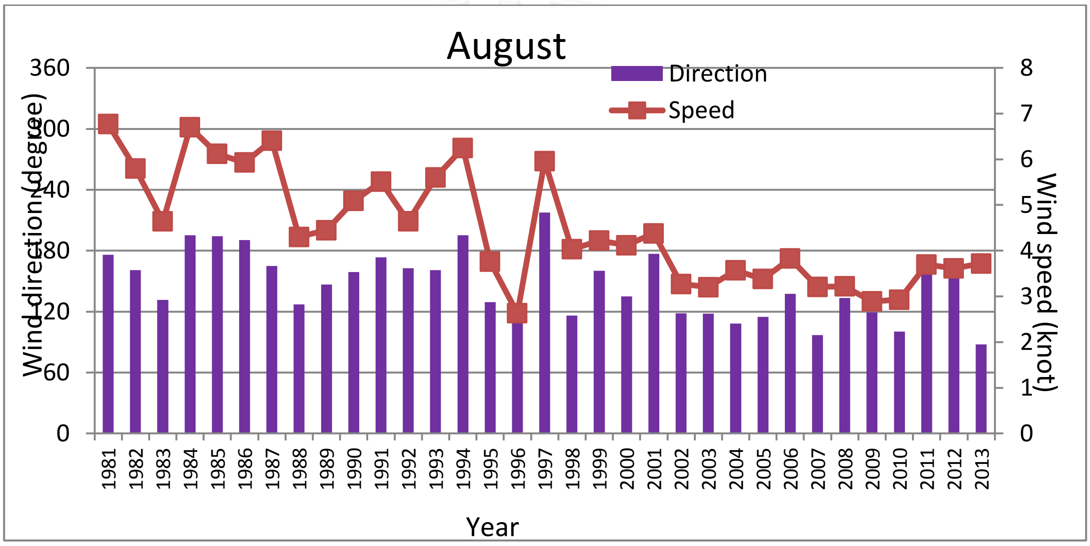
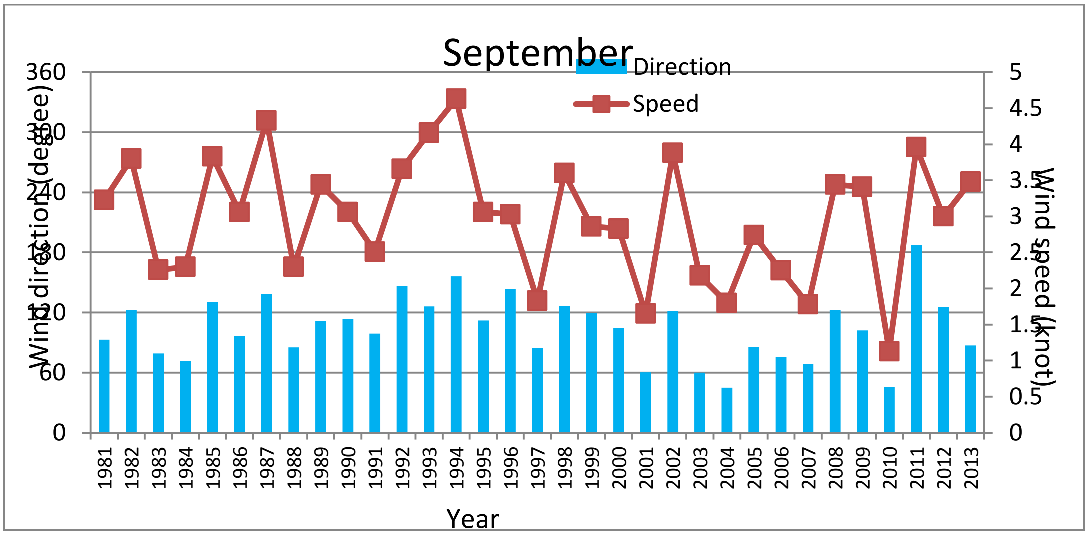
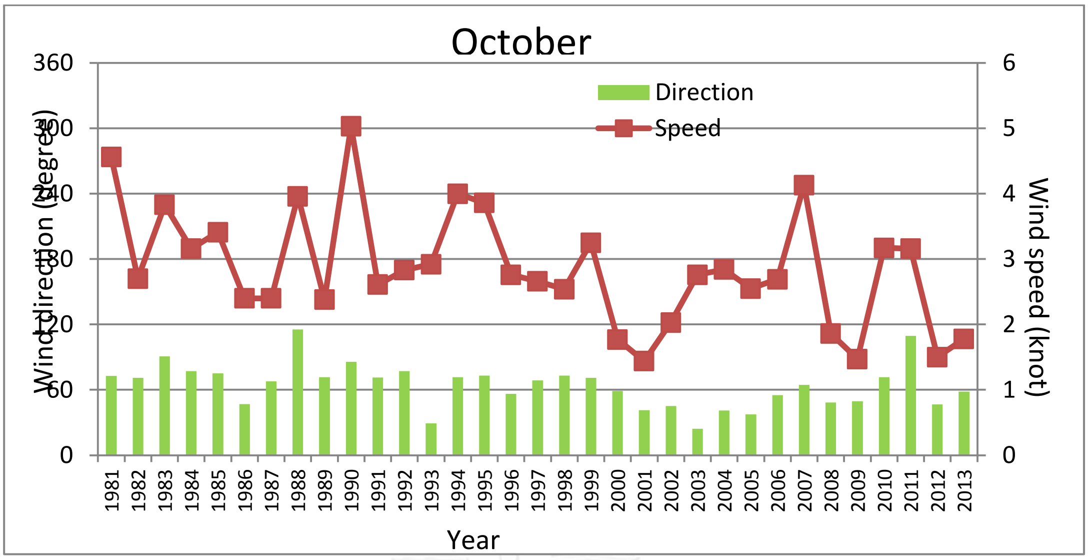
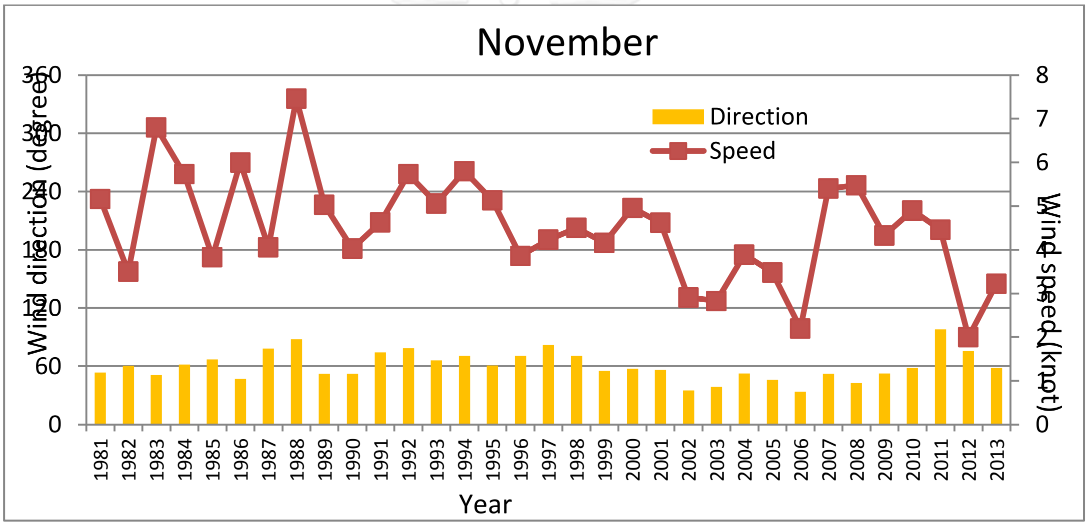
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

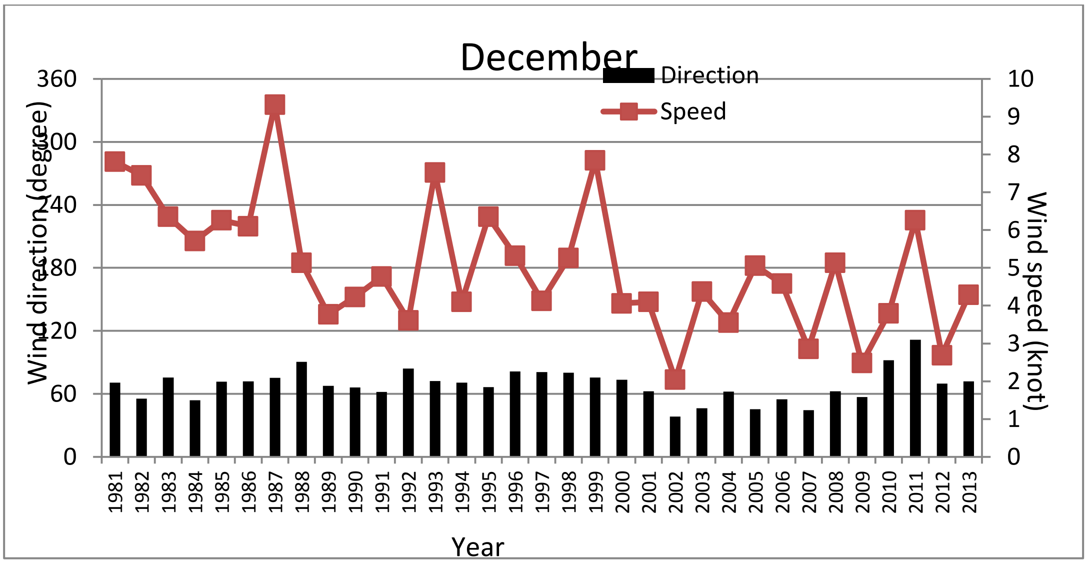

July
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year


August
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year

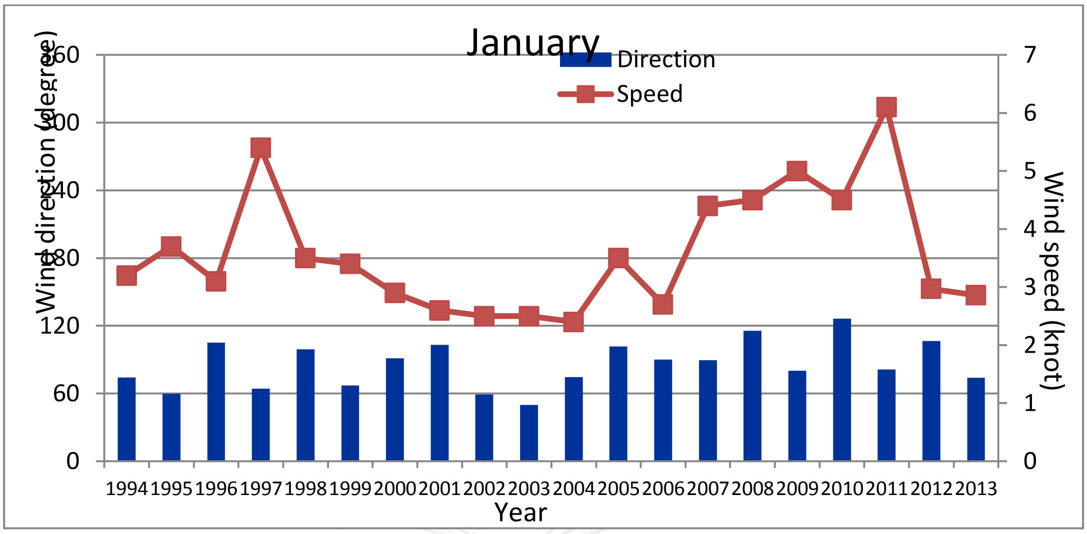

September
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year

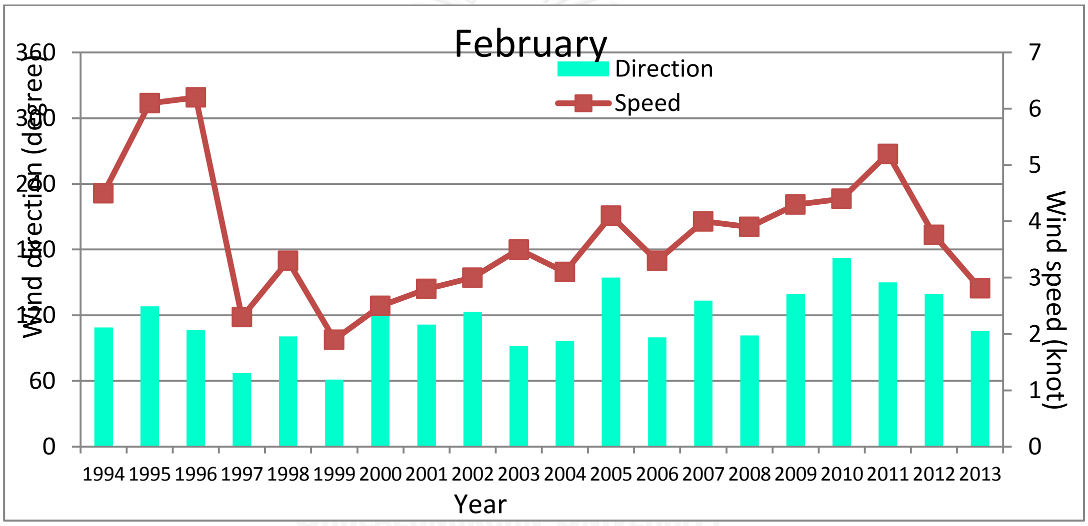

October
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year

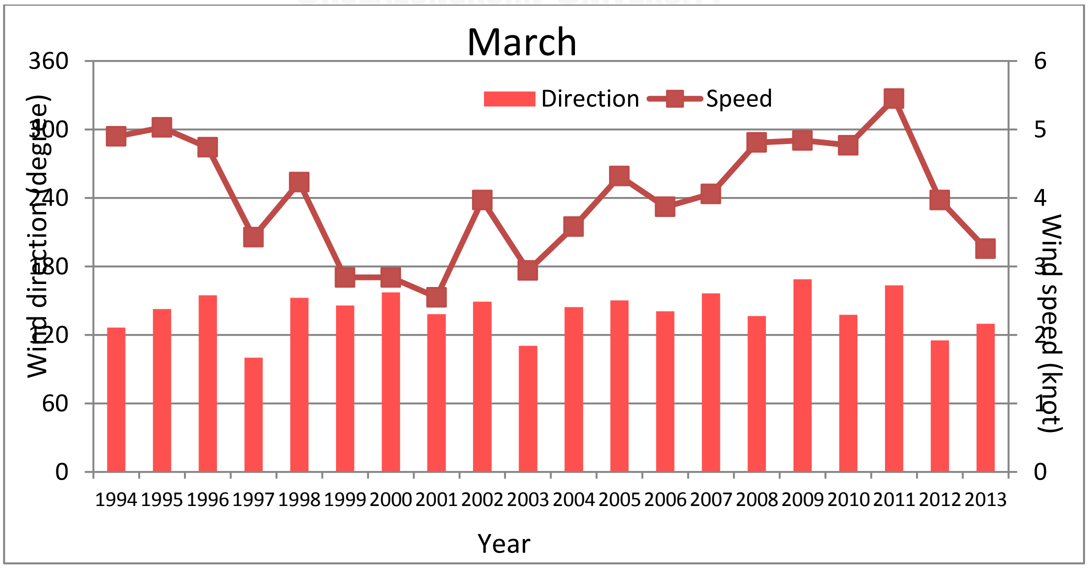

November
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year

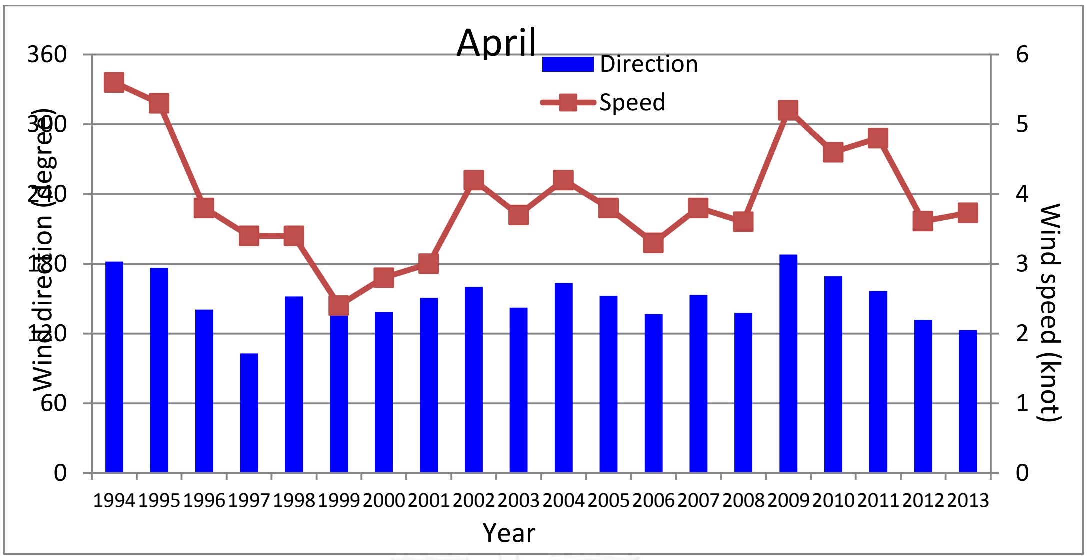

December
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year

3. KlongToey Meteorological station, Bangkok








April
Direction
Speed
Wind direction (degree)
Wind speed (knot)
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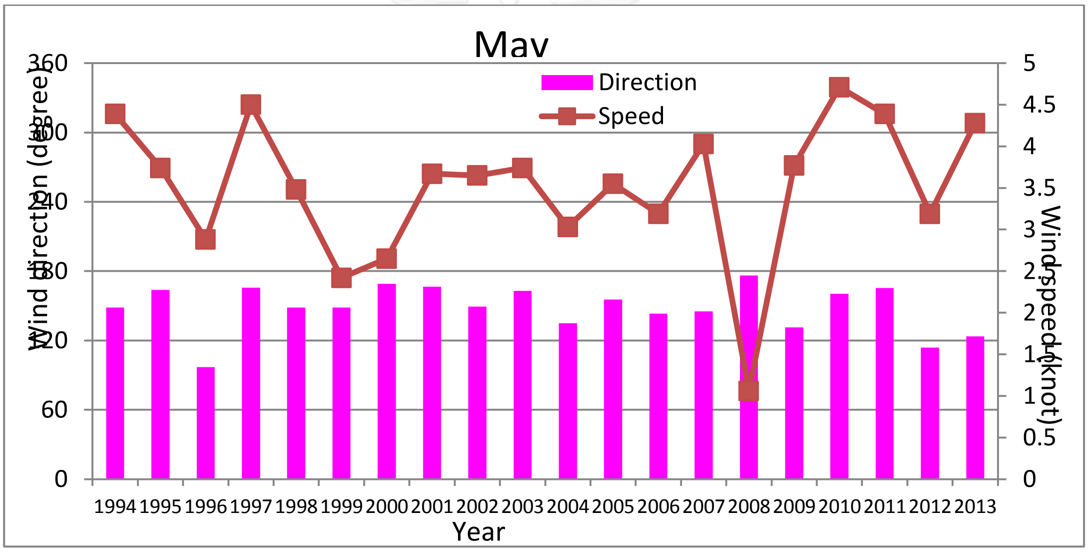
May
Direction
Speed
Wind direction (degree)
Wind speed (knot)
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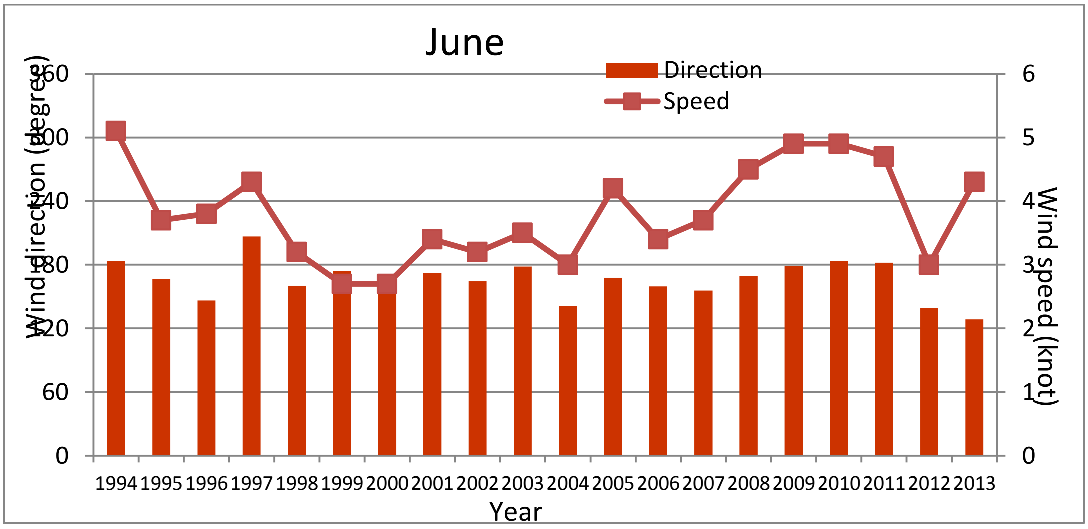
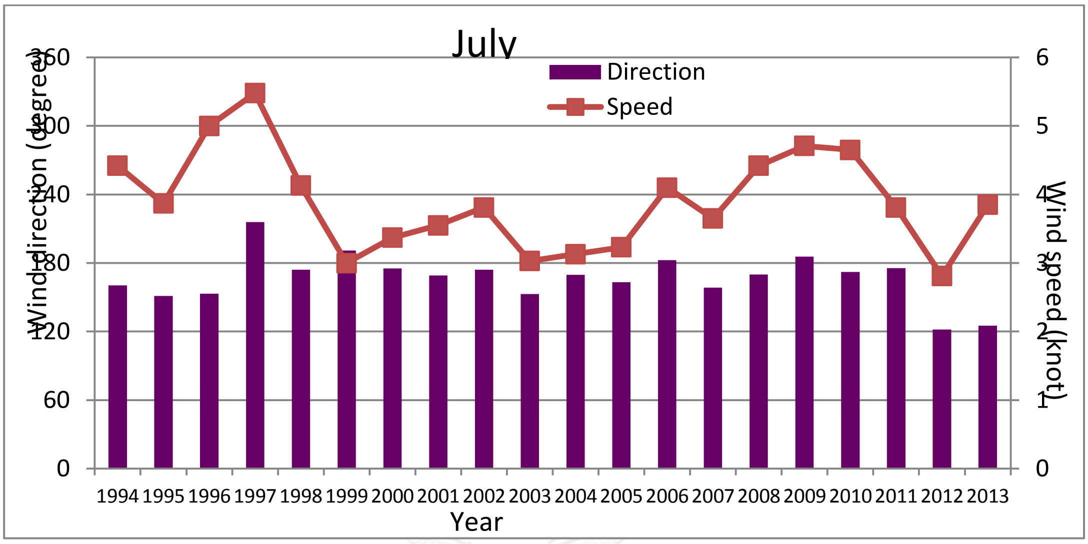
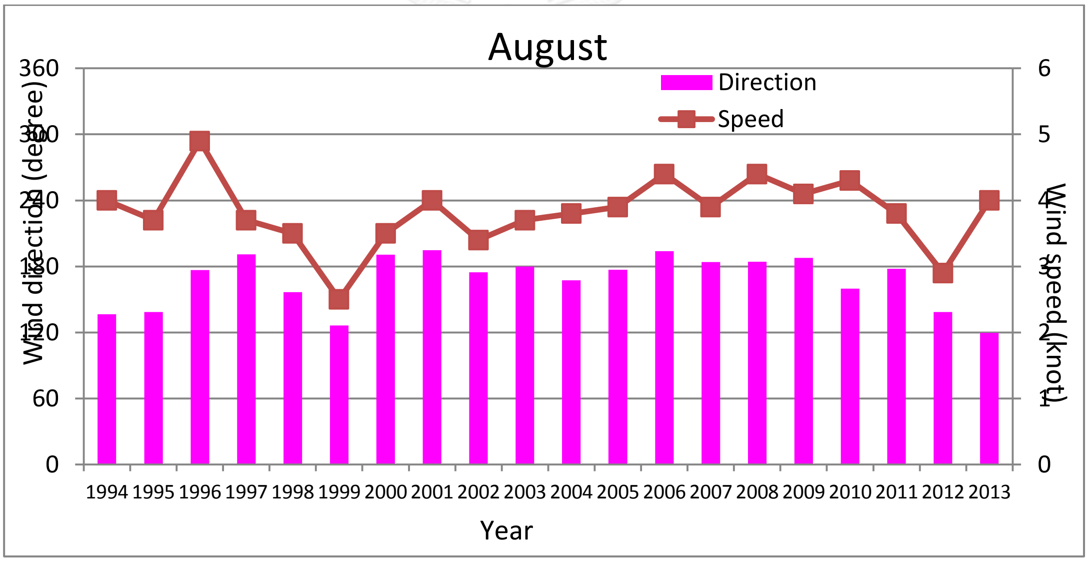
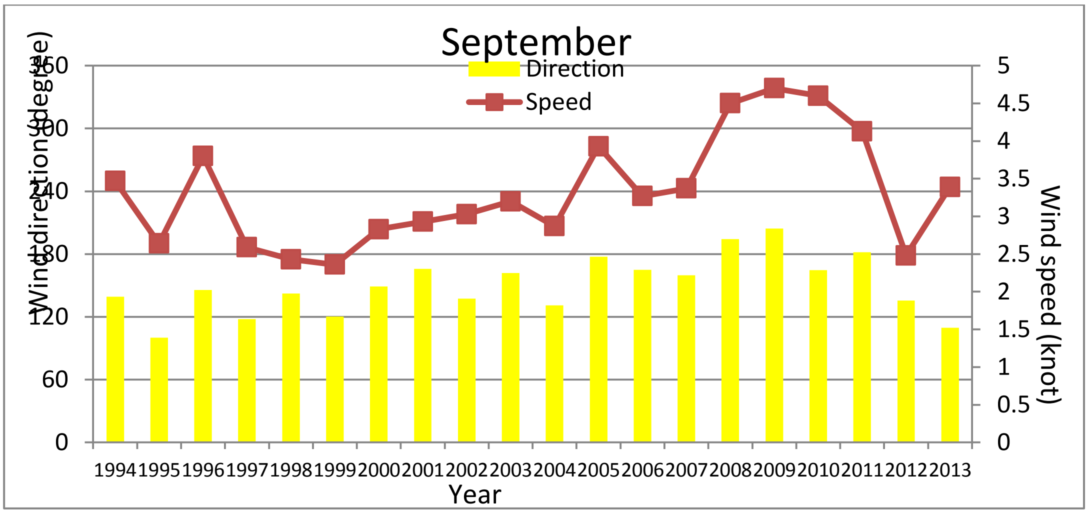
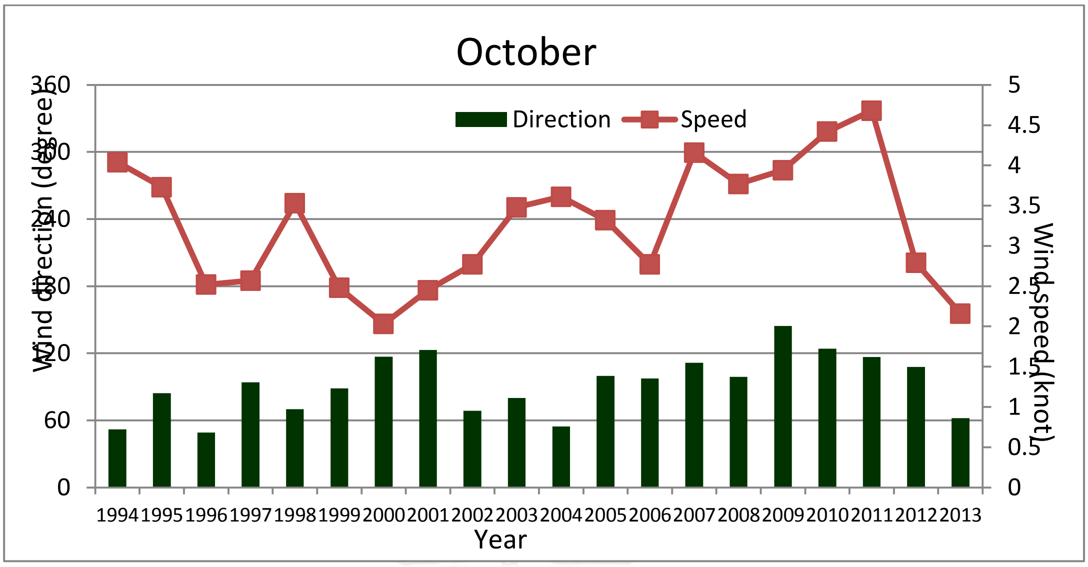
1.5
1
0.5
0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

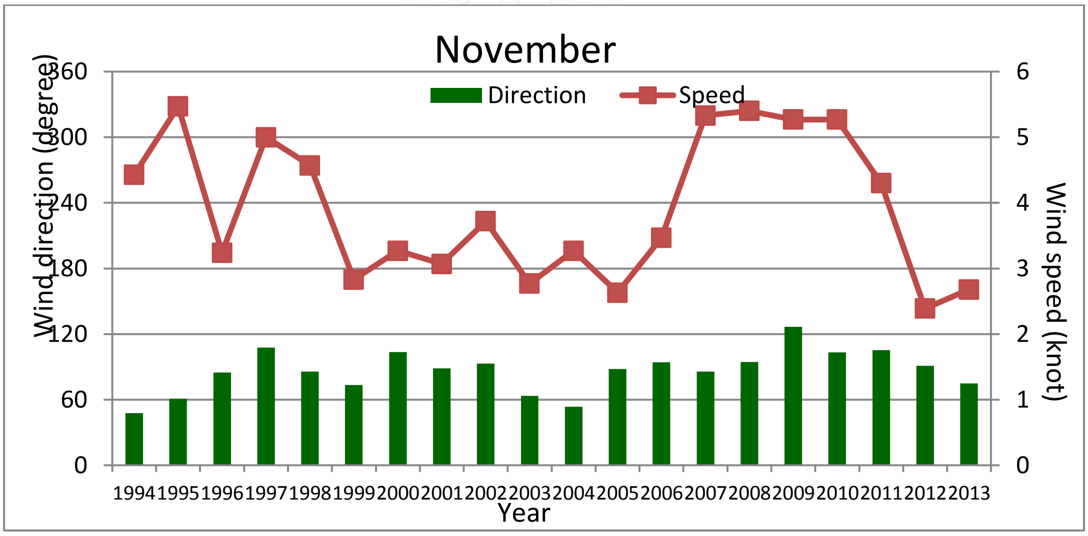

June
Direction
Speed
Wind direction (degree)
Wind speed (knot)
360
300
240
180
120
60
0
6
5
4
3
2
1
0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

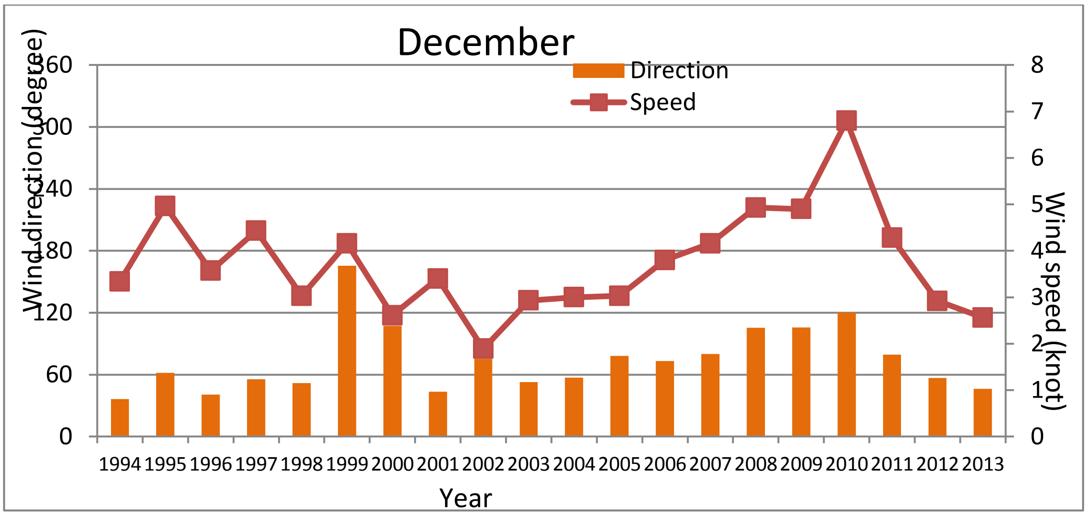

July
Direction
Speed
Wind direction (degree)
Wind speed (knot)
360
300
240
180
120
60
0
6
5
4
3
2
1
0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year


August
Direction
Speed
Wind direction (degree)
Wind speed (knot)
360
300
240
180
120
60
0
6
5
4
3
2
1
0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

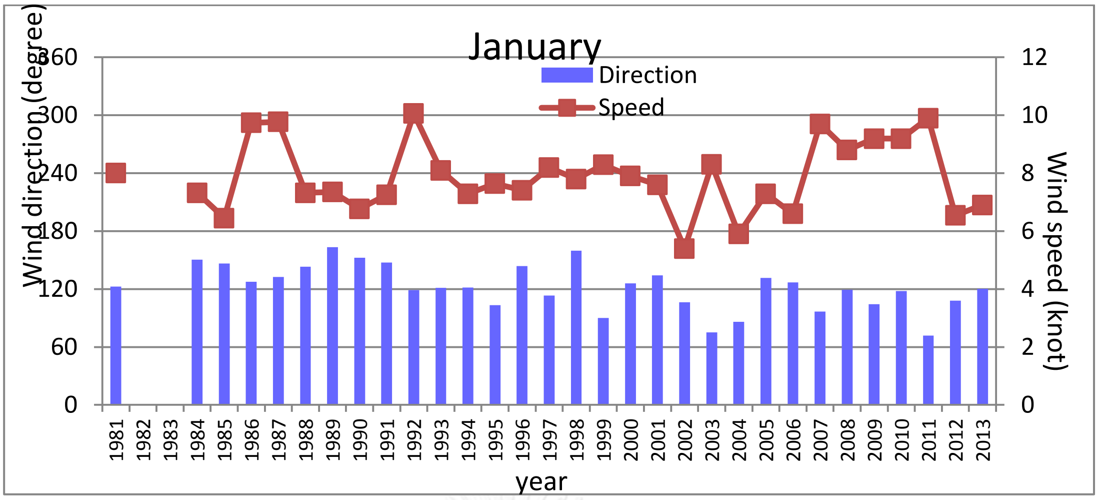

September
Direction
Speed
Wind direction (degree)
Wind speed (knot)
360
300
240
180
120
60
0
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

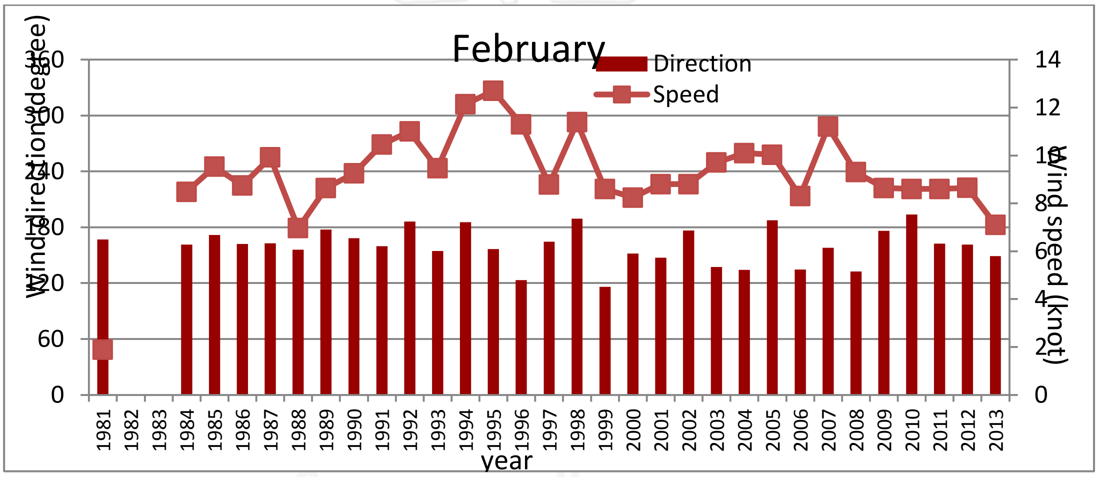

October
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
0
60
120
180
240
300
360
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

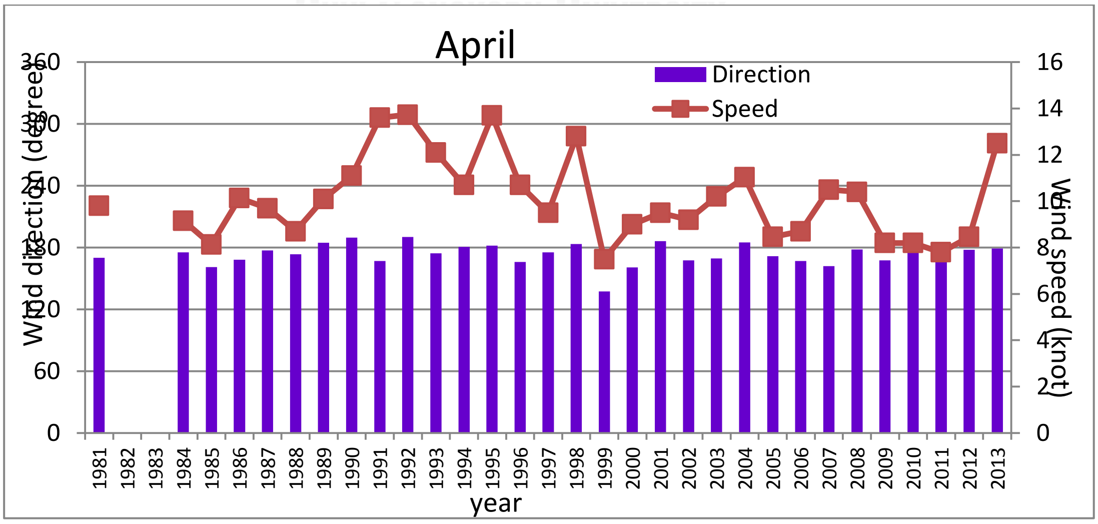

November
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
0
60
120
180
240
300
360
0
1
2
3
4
5
6
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

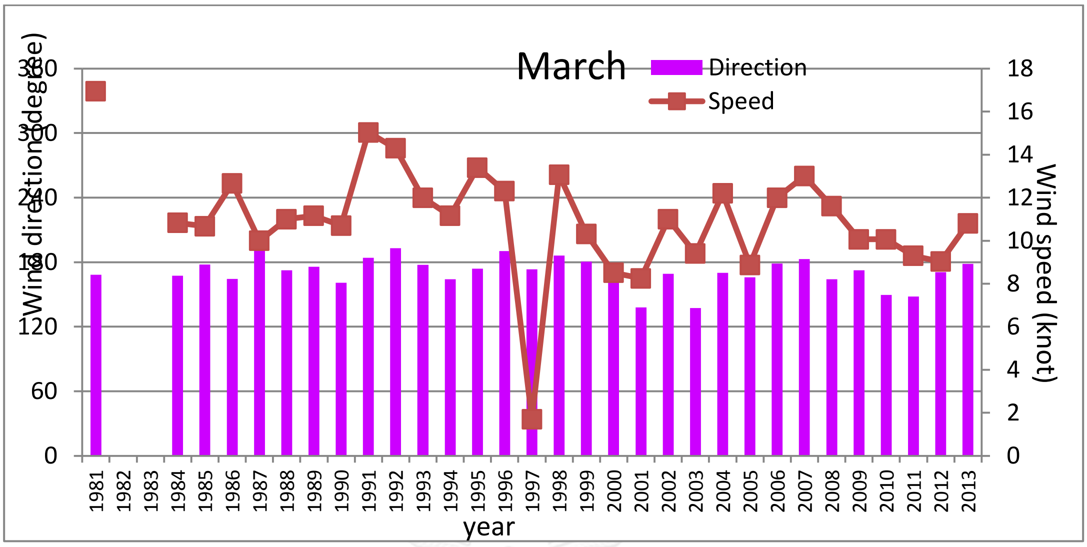

December
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
0
60
120
180
240
300
360
0
1
2
3
4
5
6
7
8
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

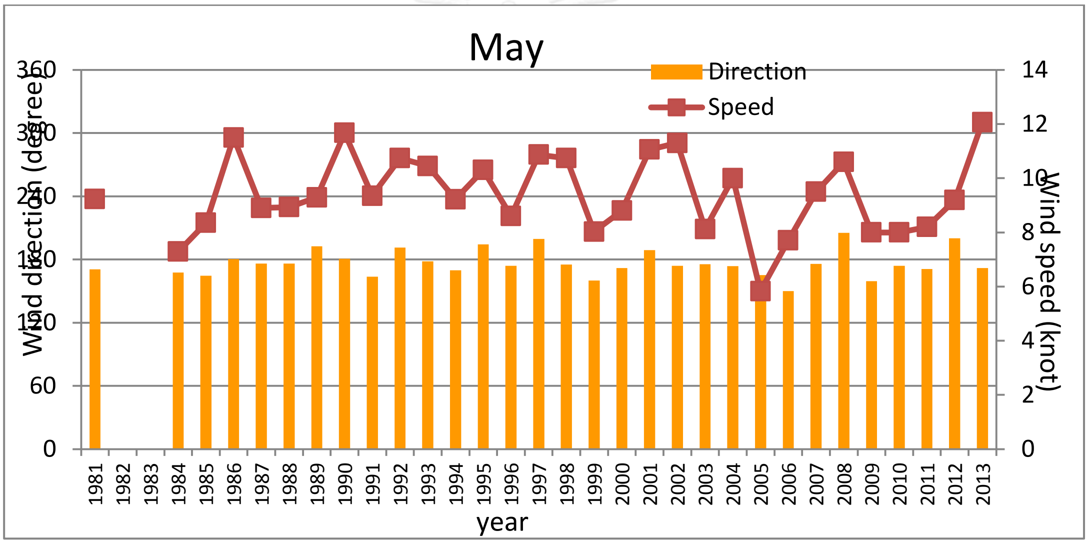
4. Pilot station, Samut Prakan

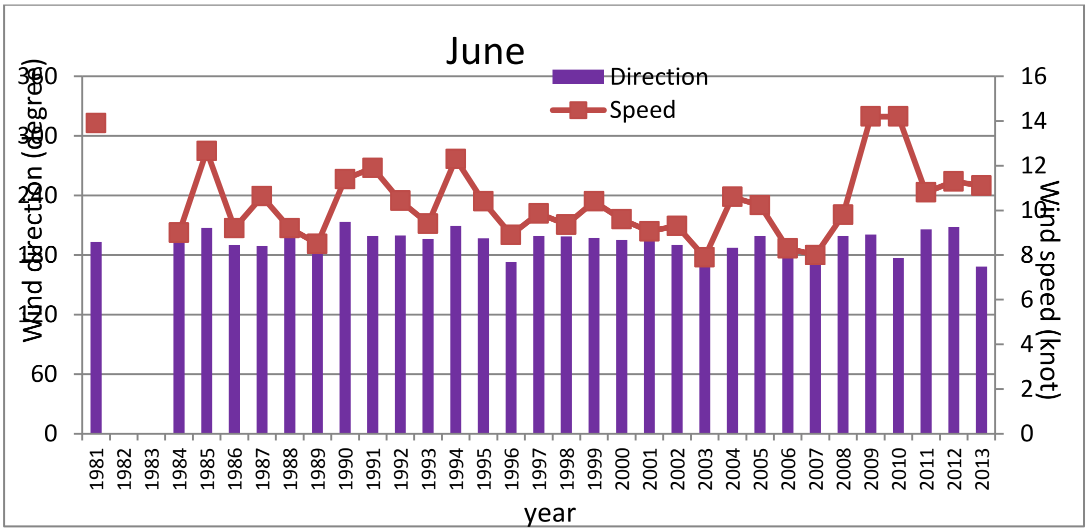


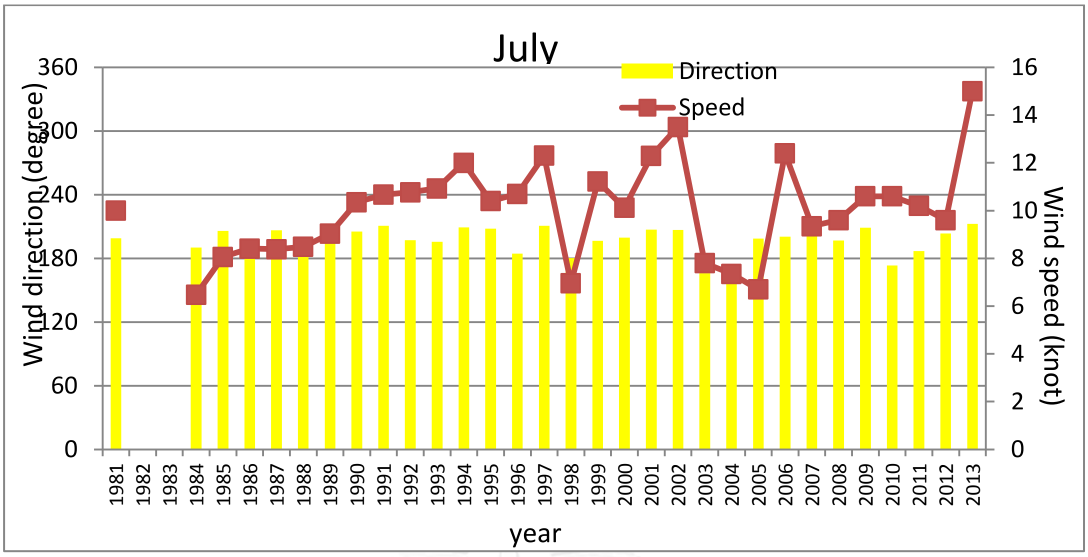


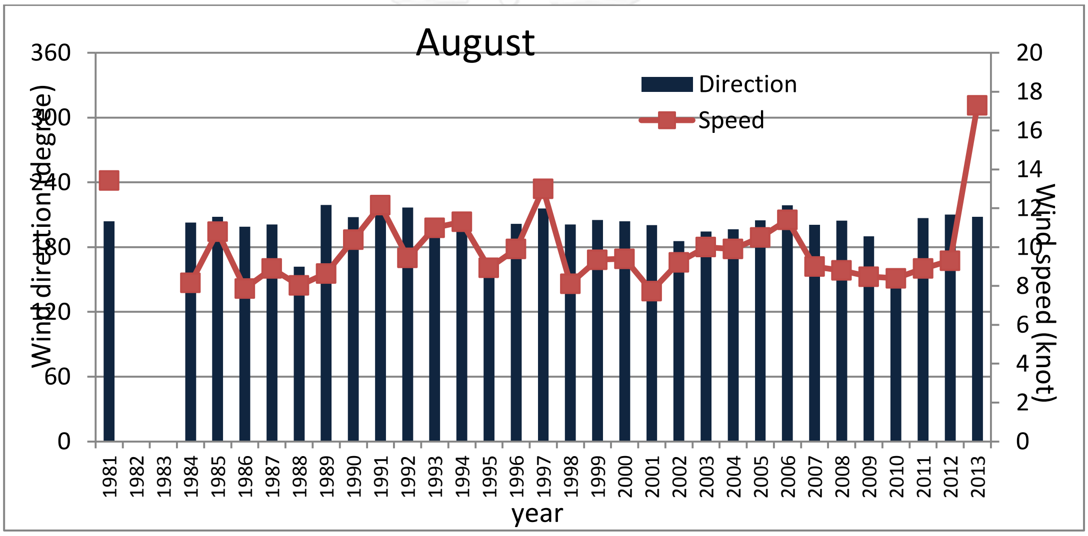


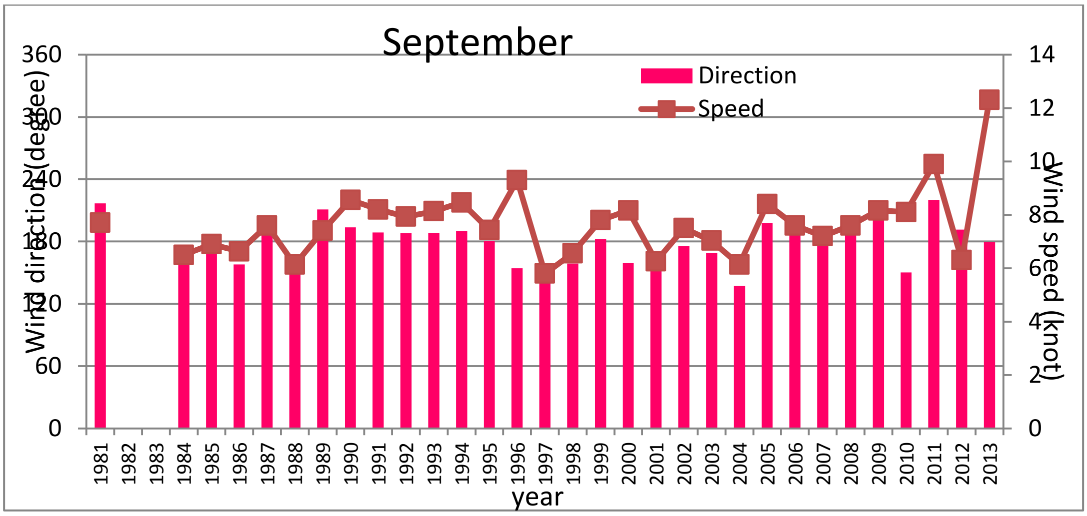

March
Direction
Speed
Wind direction (degree)
Wind speed (knot)
year
0
60
120
180
240
300
360
0
2
4
6
8
10
12
14
16
18
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


May
Direction
Speed
Wind direction (degree)
Wind speed (knot)
year
0
60
120
180
240
300
360
0
2
4
6
8
10
12
14
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

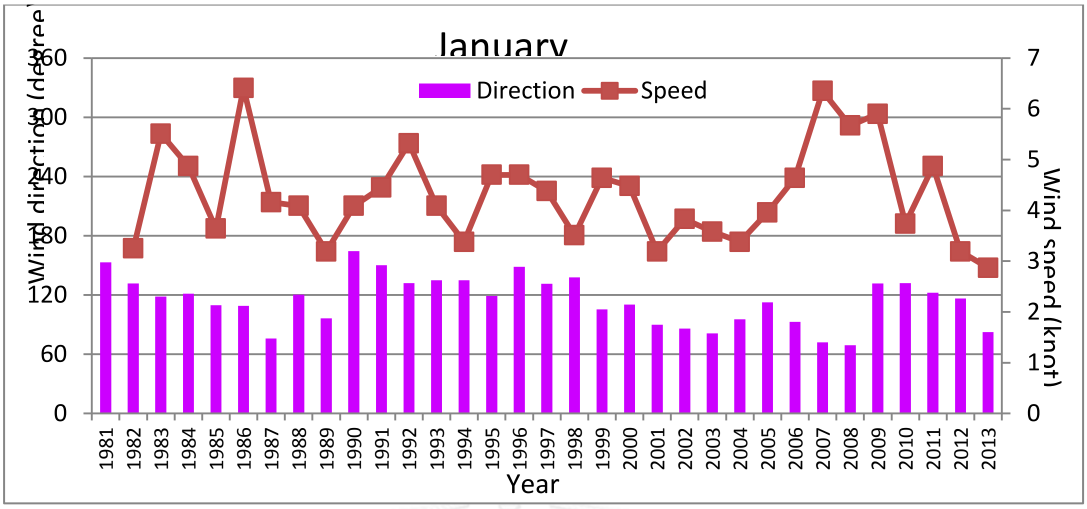

June
Direction
Speed
Wind direction (degree)
Wind speed (knot)
year
0
60
120
180
240
300
360
0
2
4
6
8
10
12
14
16
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

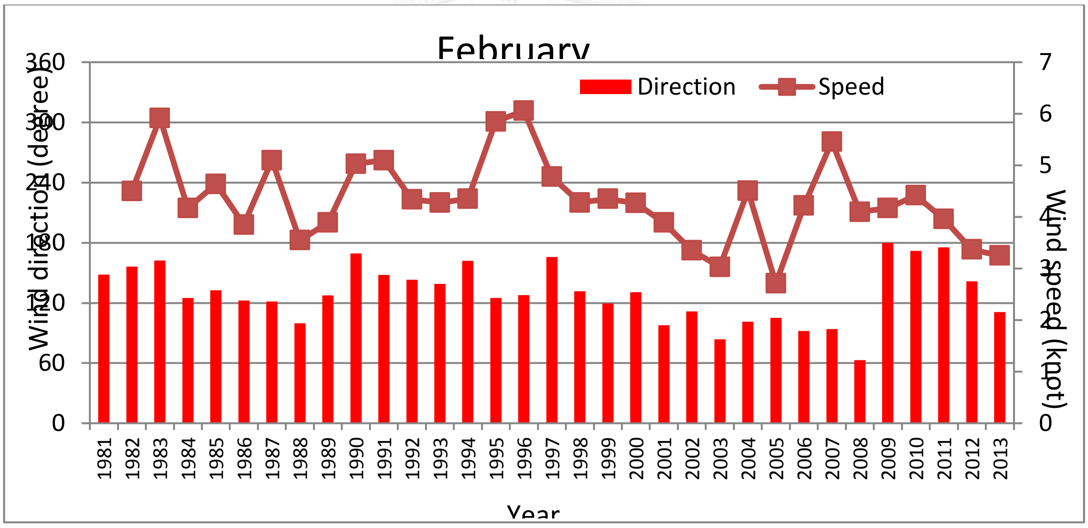

July
Direction
Speed
Wind direction (degree)
Wind speed (knot)
year

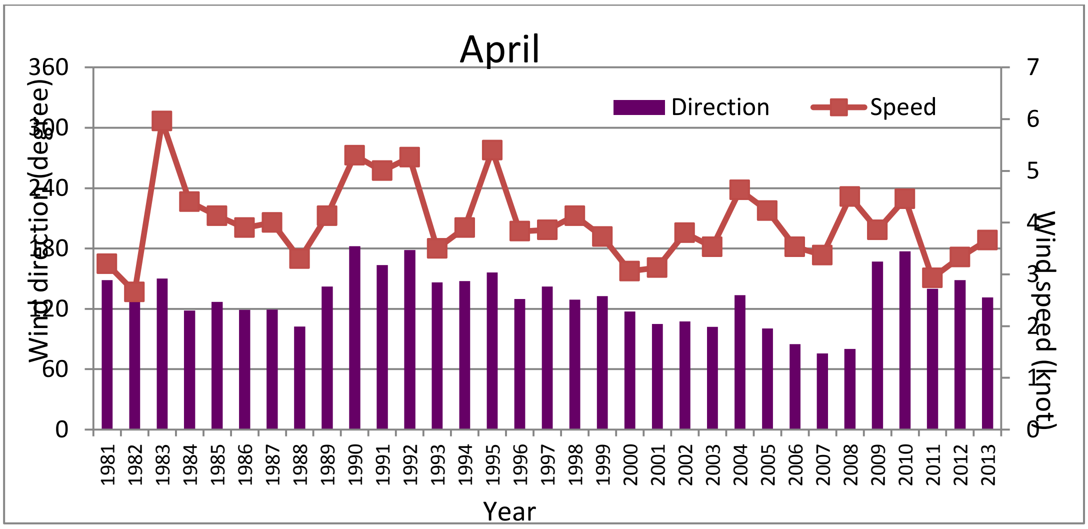

August
Direction
Speed
Wind direction (degree)
Wind speed (knot)
year

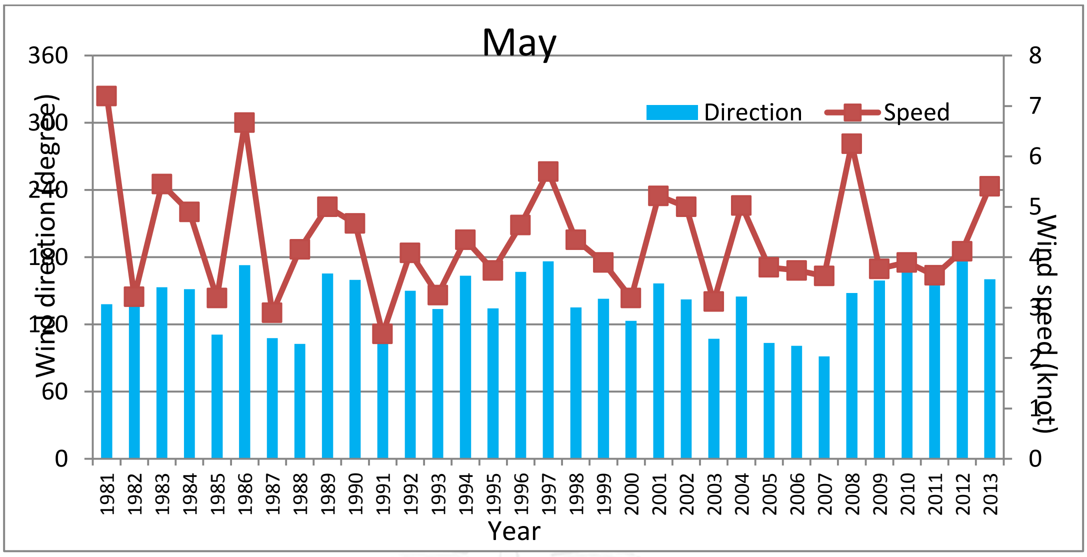

September
Direction
Speed
Wind direction (degee)
Wind speed (knot)
year

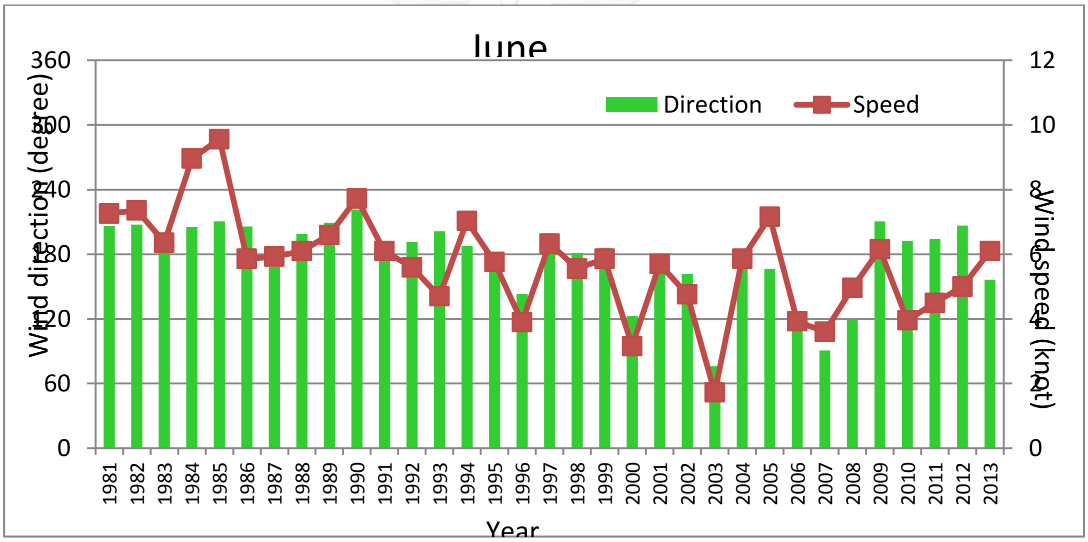
5. Pattaya Meteorological station, Chonburi

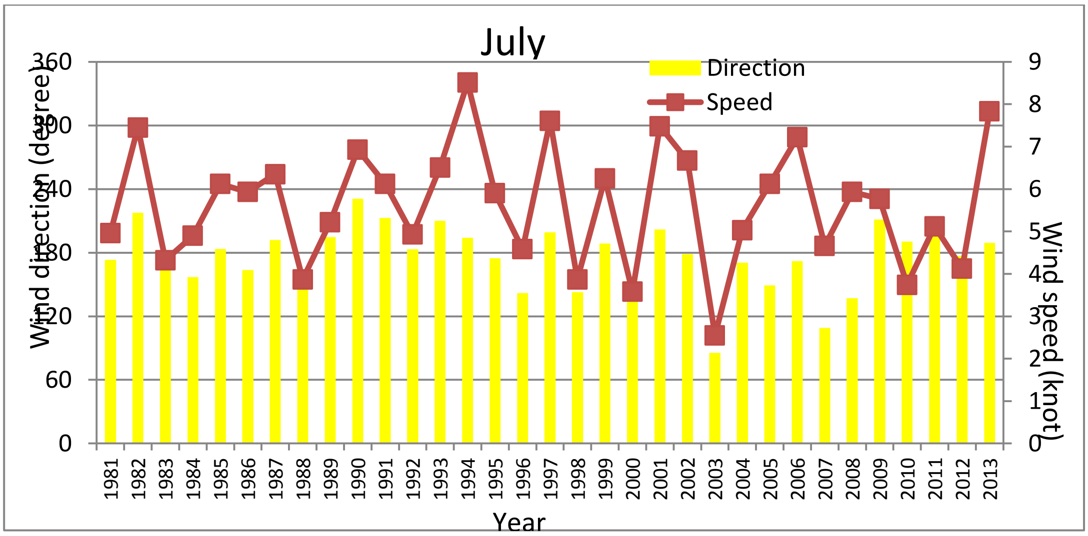


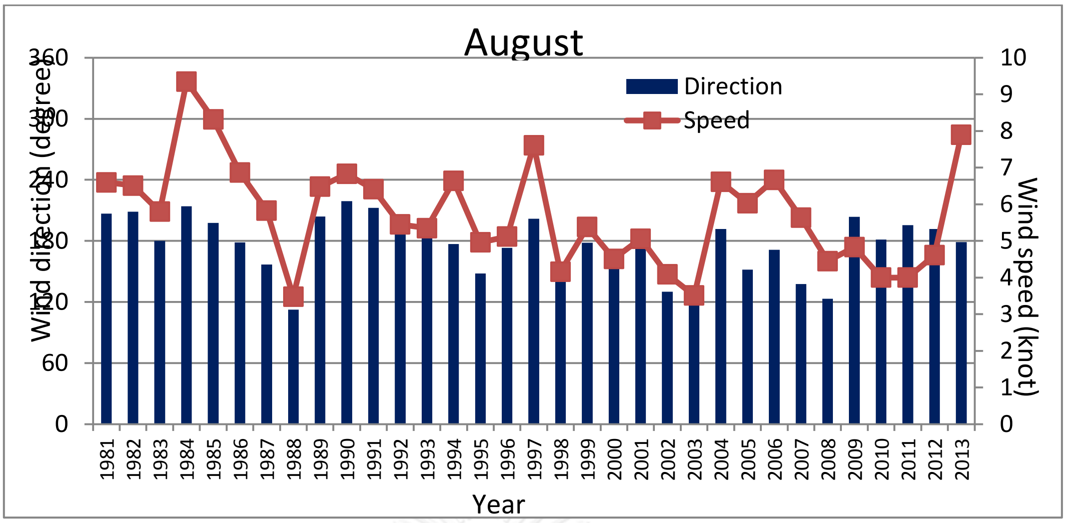




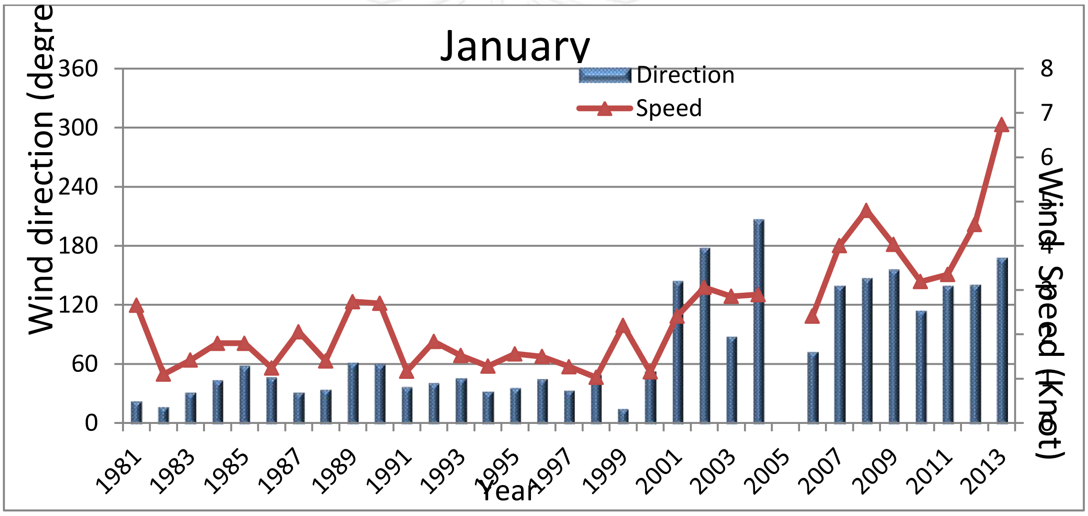

May
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
360
300
240
180
120
60
0
8
7
6
5
4
3
2
1
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

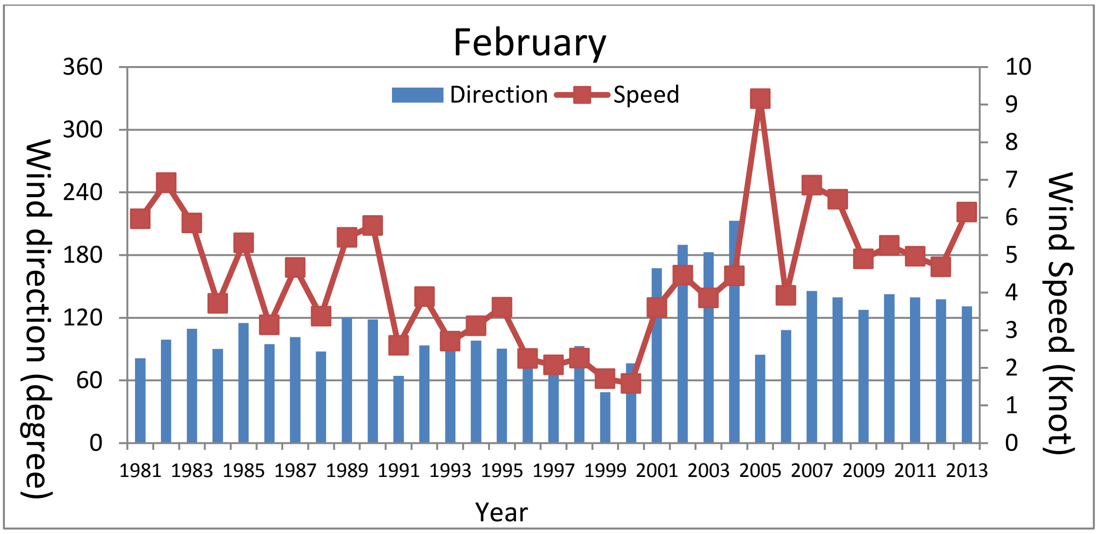

June
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
360
300
240
180
120
60
0
12
10
8
6
4
2
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

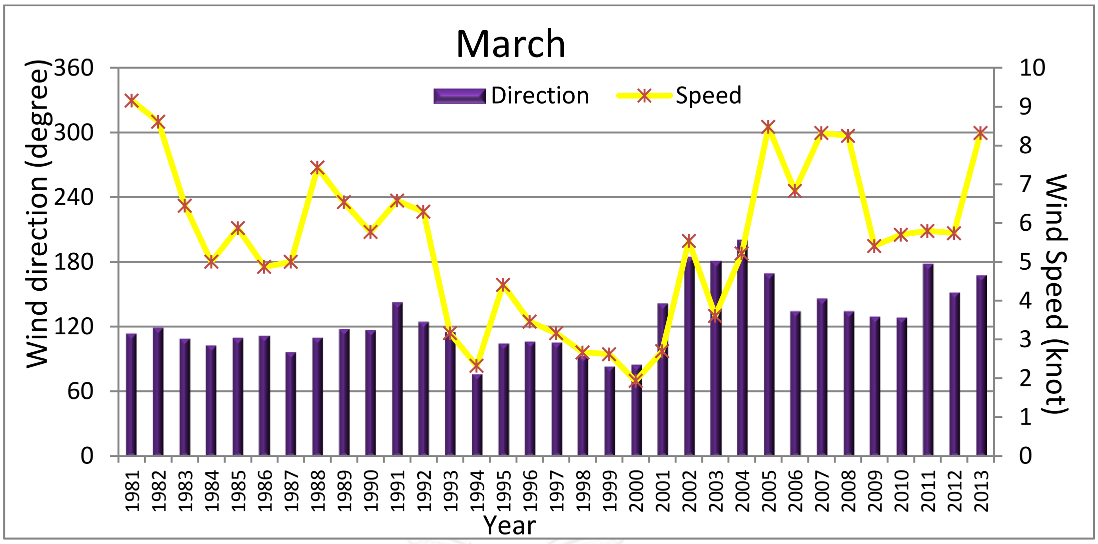

July
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
360
300
240
180
120
60
0
9
8
7
6
5
4
3
2
1
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

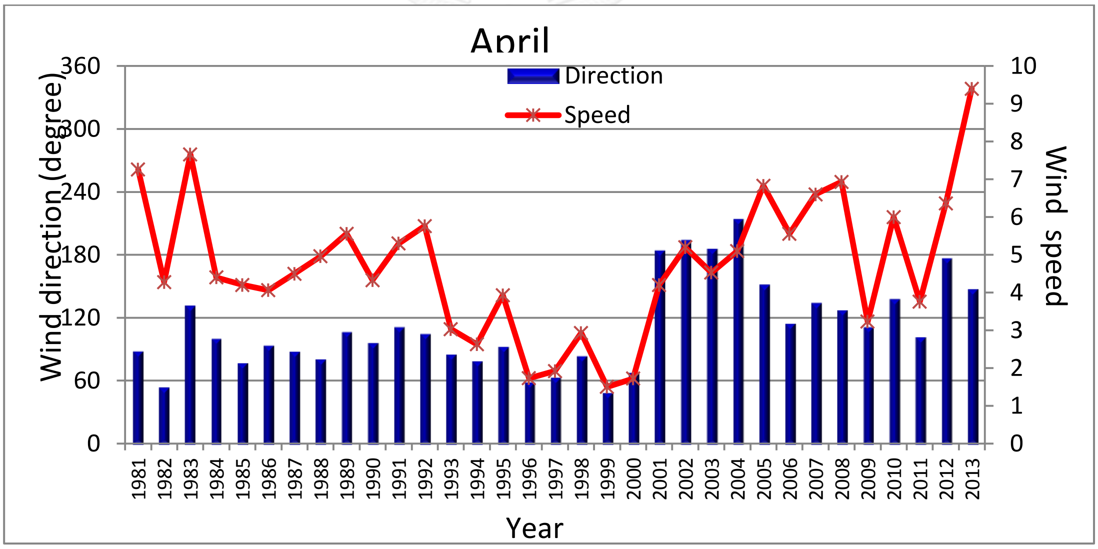


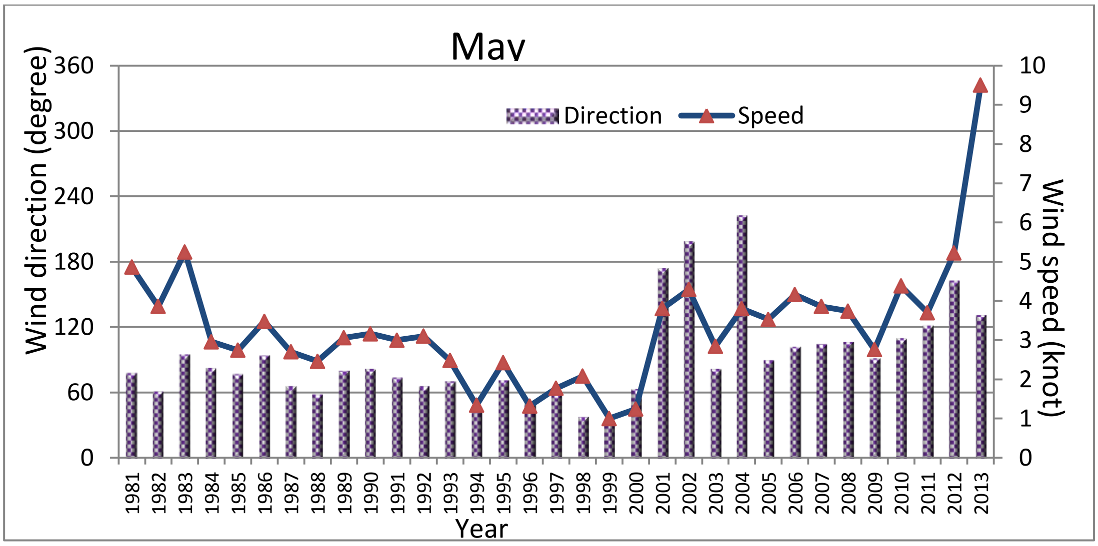
.6. Phetchaburi Meteorological station

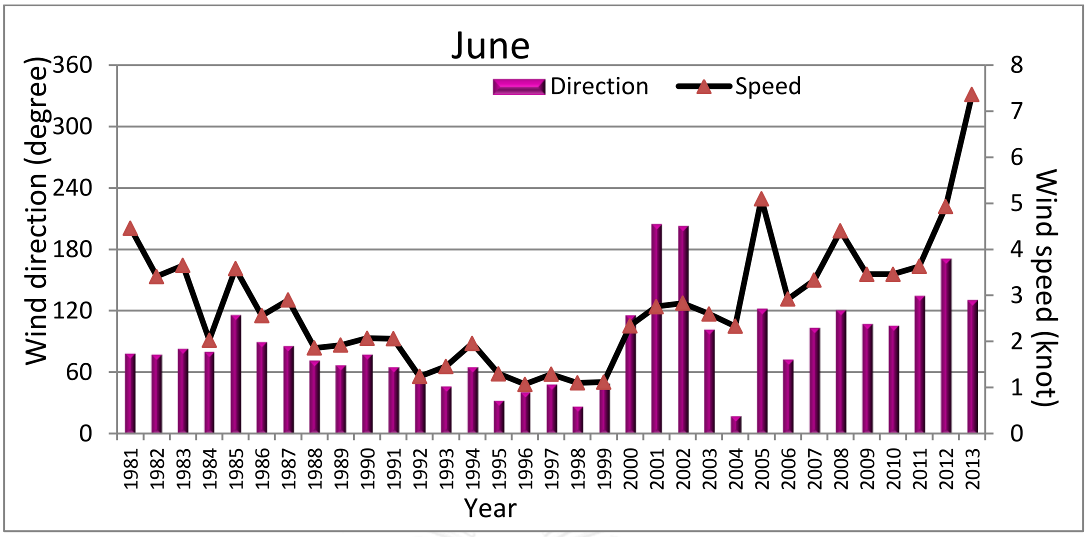


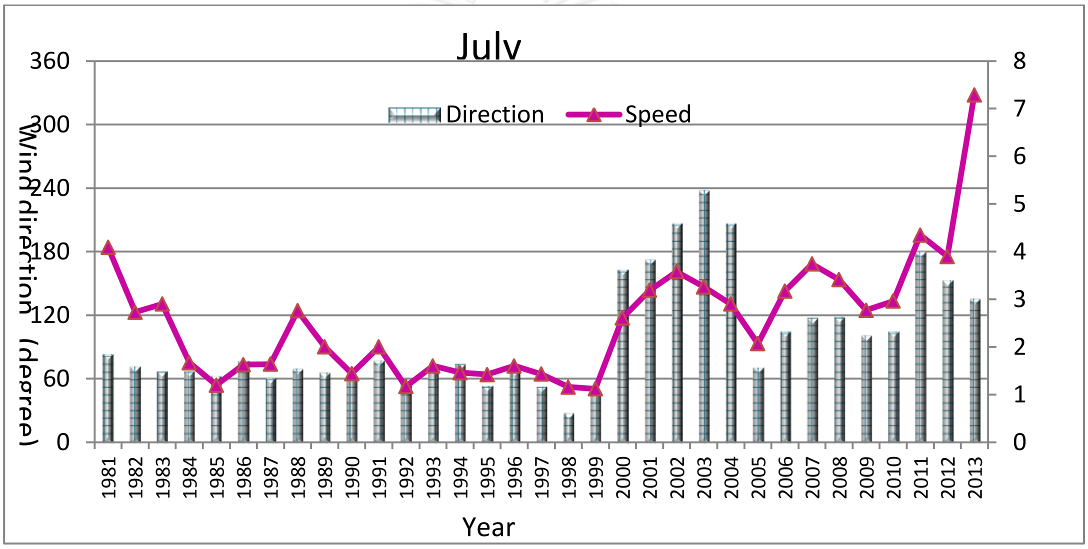


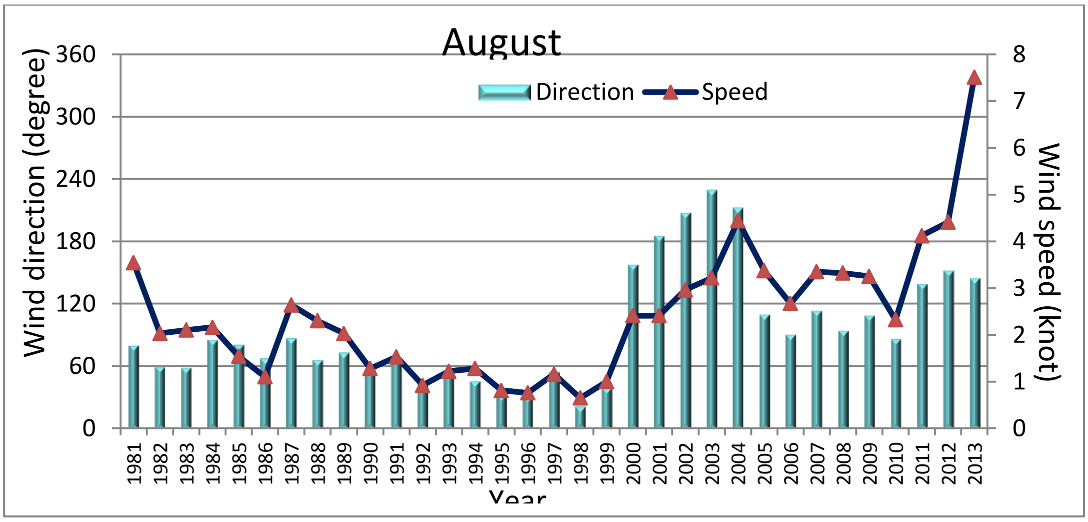

March
Direction
Speed
Wind direction (degree)
0
60
120
180
240
300
360
Wind Speed (knot)
0
1
2
3
4
5
6
7
8
9
10
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

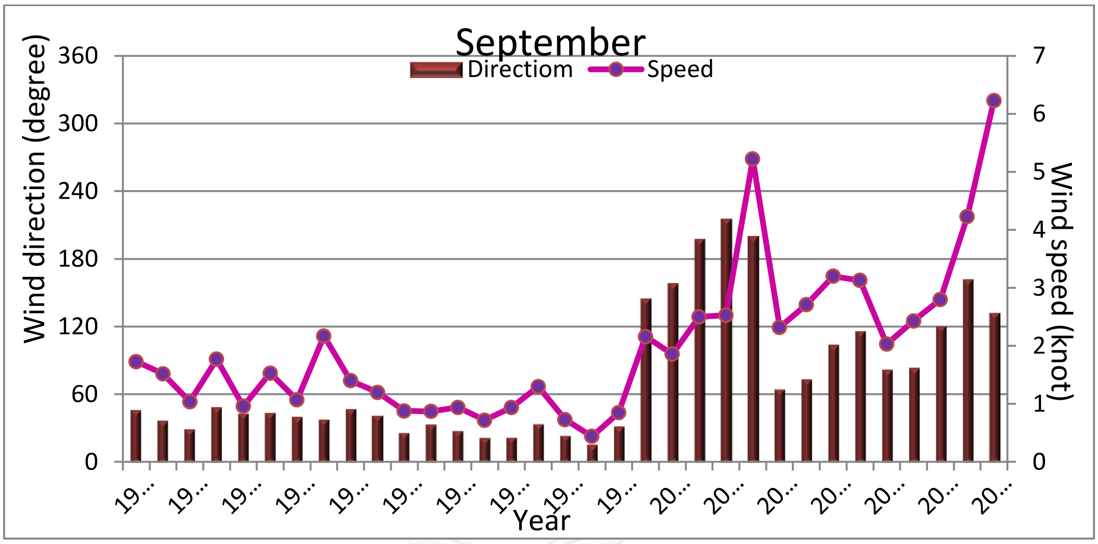

April
Direction
Speed
Wind direction (degree)
0
60
120
180
240
300
360
Wind speed
0
1
2
3
4
5
6
7
8
9
10
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

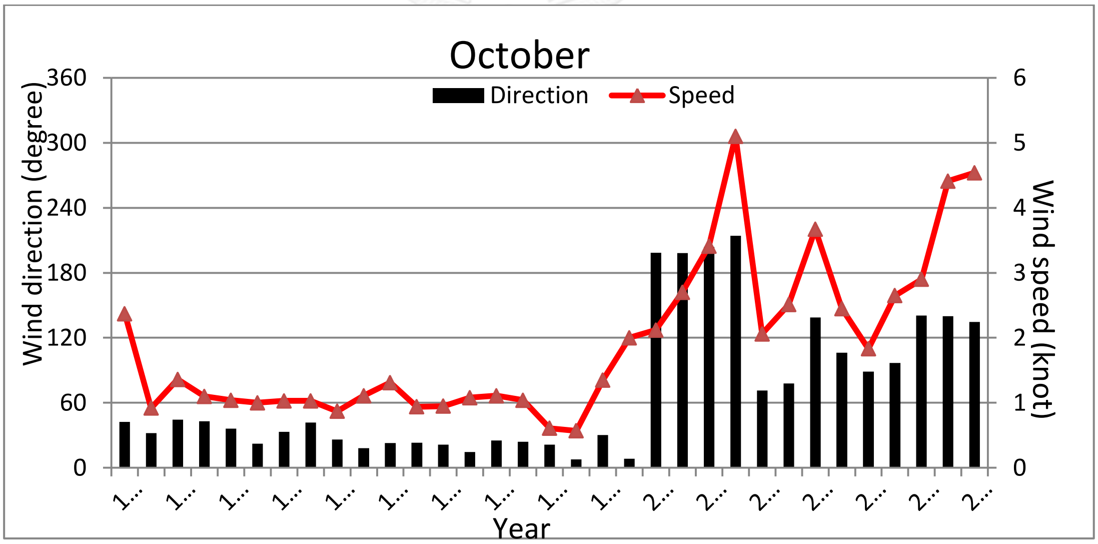

May
Direction
Speed
Wind direction (degree)
0
60
120
180
240
300
360
Wind speed (knot)
0
1
2
3
4
5
6
7
8
9
10
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year

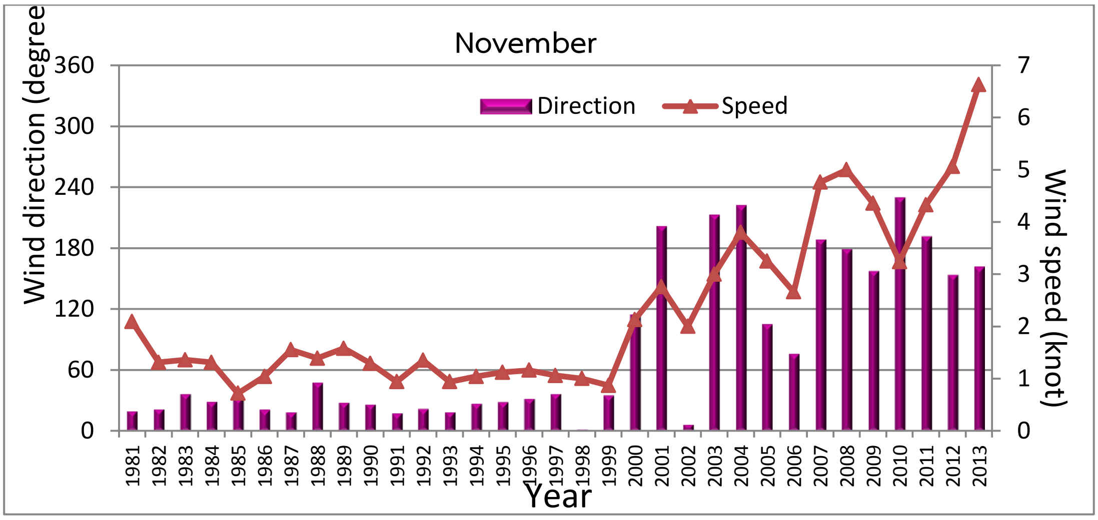

June
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
360
300
240
180
120
60
0
8
7
6
5
4
3
2
1
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

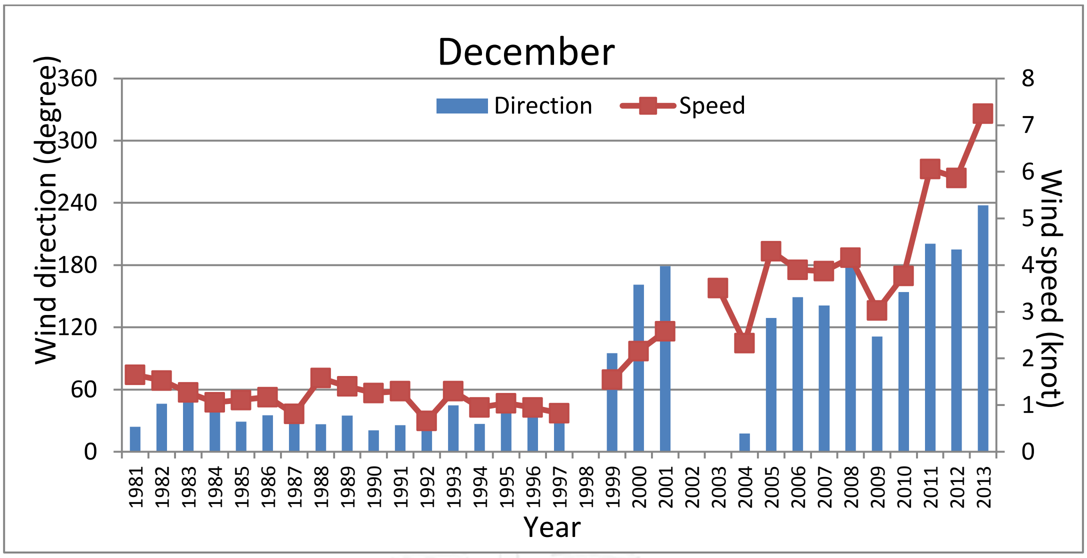

Direction
Speed
Year
360
300
240
180
120
60
0
8
7
6
5
4
3
2
1
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


August
Direction
Speed
Wind direction (degree)
Wind speed (knot)
360
300
240
180
120
60
0
8
7
6
5
4
3
2
1
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


September
Directiom
Speed
Wind direction (degree)
Wind speed (knot)
Year
360
300
240
180
120
60
0
7
6
5
4
3
2
1
0
19…
20…


October
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
360
300
240
180
120
60
0
6
5
4
3
2
1
0
1…
2…

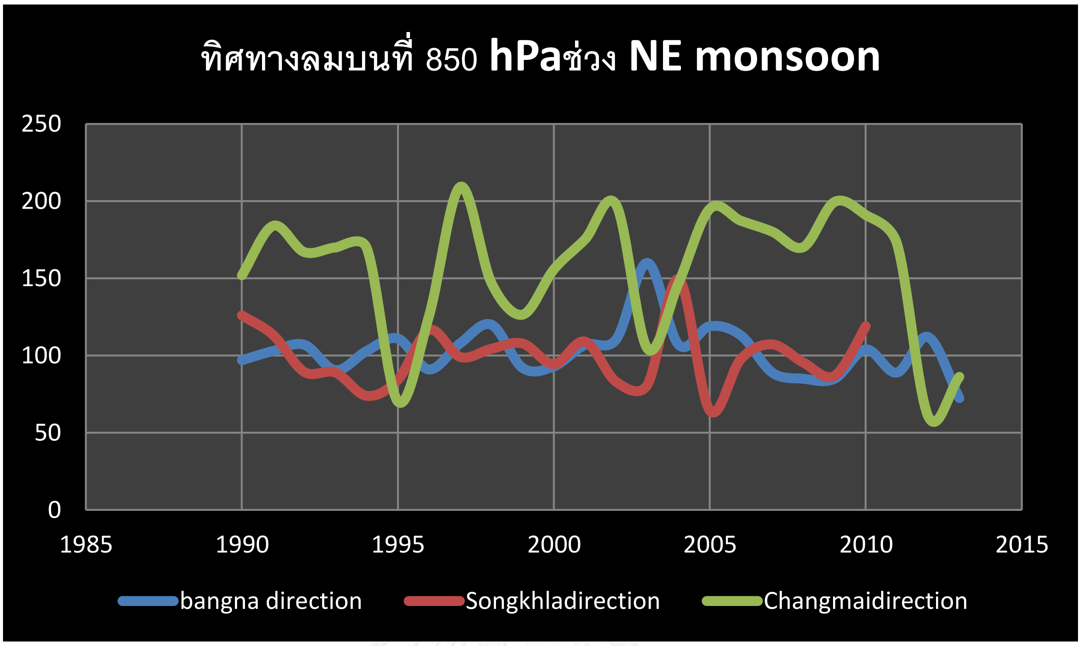

November
Direction
Speed
Wind direction (degree
Wind speed (knot)
Year
360
300
240
180
120
60
0
7
6
5
4
3
2
1
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


December
Direction
Speed
Wind direction (degree)
Wind speed (knot)
Year
0
60
120
180
240
300
360
0
1
2
3
4
5
6
7
8
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

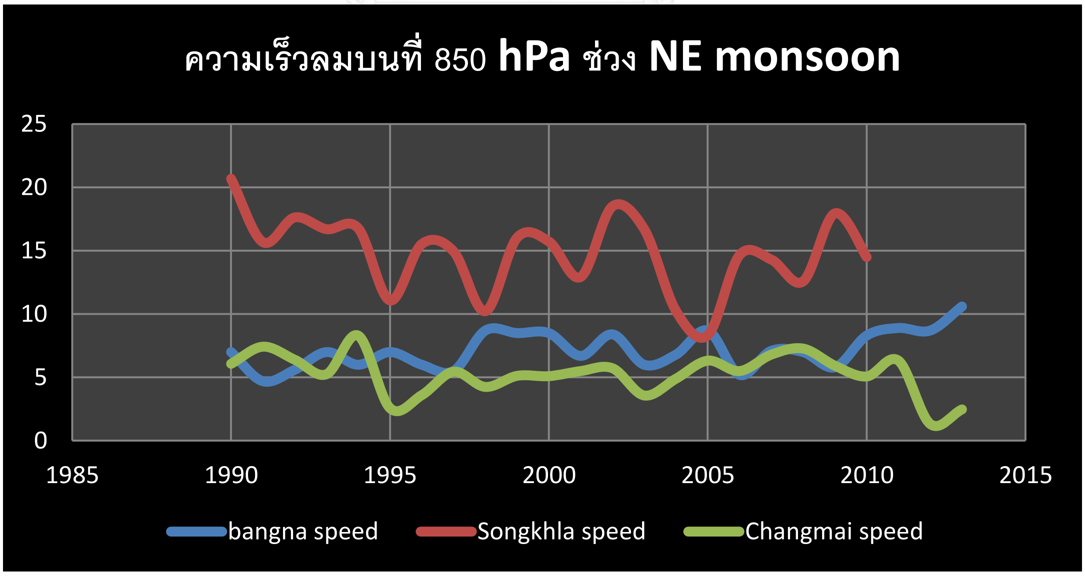
Appendix B

Results of Monthly analysis on monsoon of 3 station (upper wind)

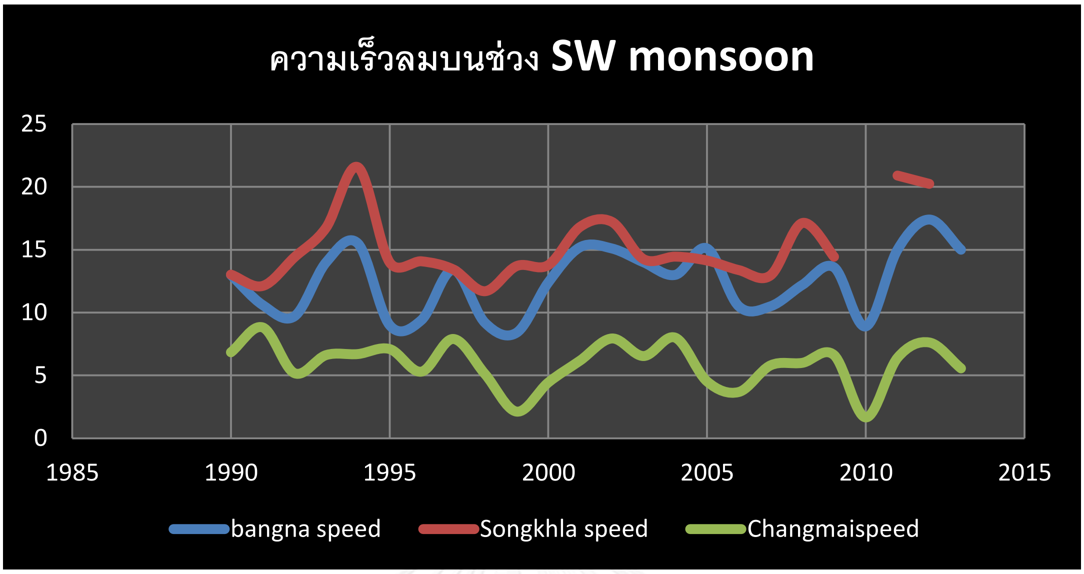
around the upper Gulf of Thailand

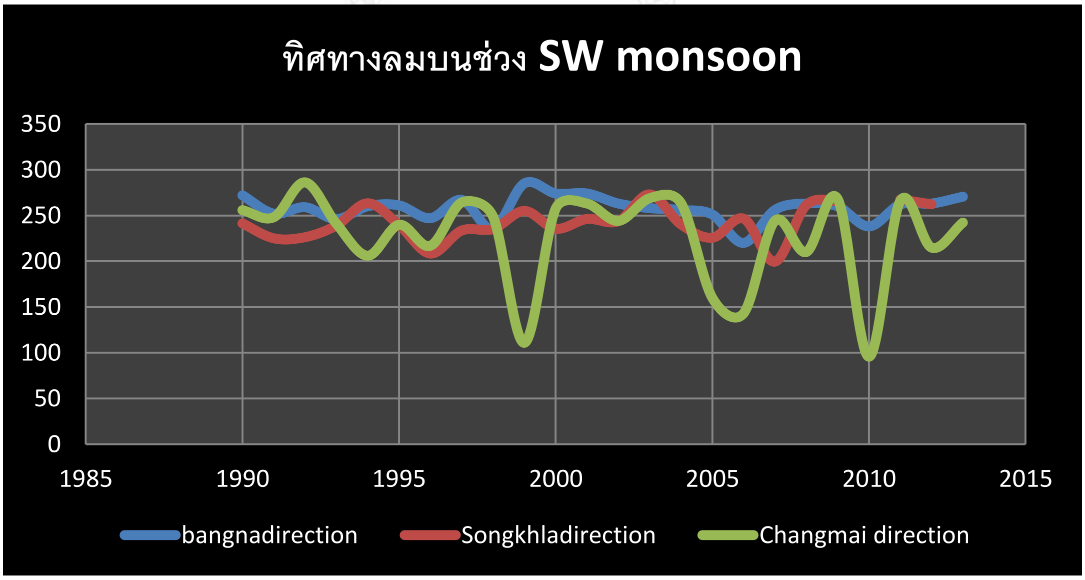


ทิศทางลมบนที่ 850 hPaช่วง NE monsoon
250
200
150
100
50
0
1985
1990
1995
2000
2005
2010
2015
bangna direction
Songkhladirection
Changmaidirection



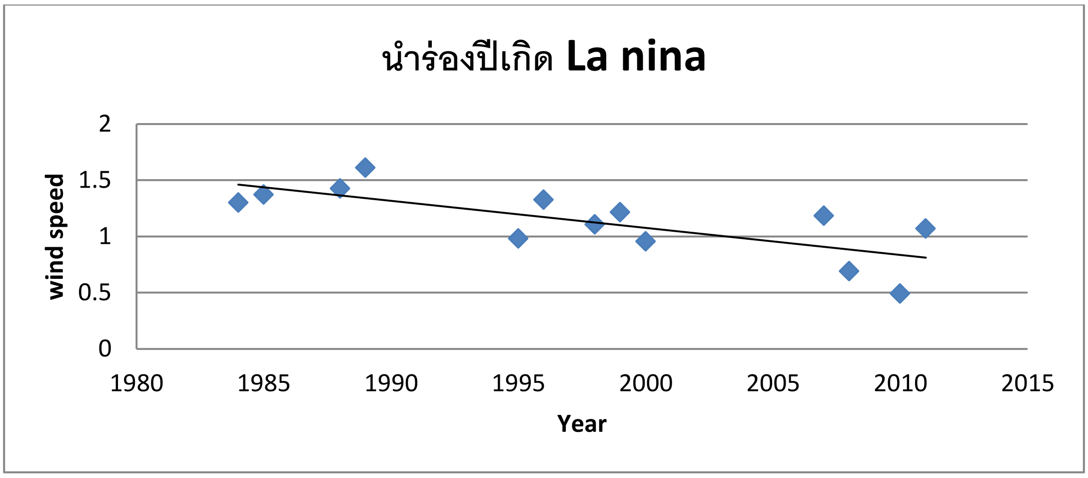
ความเร็วลมบนที่ 850 hPa ช่วง NE monsoon
25
20
15
10
5
0
1985
1990
1995
2000
2005
2010
2015
bangna speed
Songkhla speed
Changmai speed

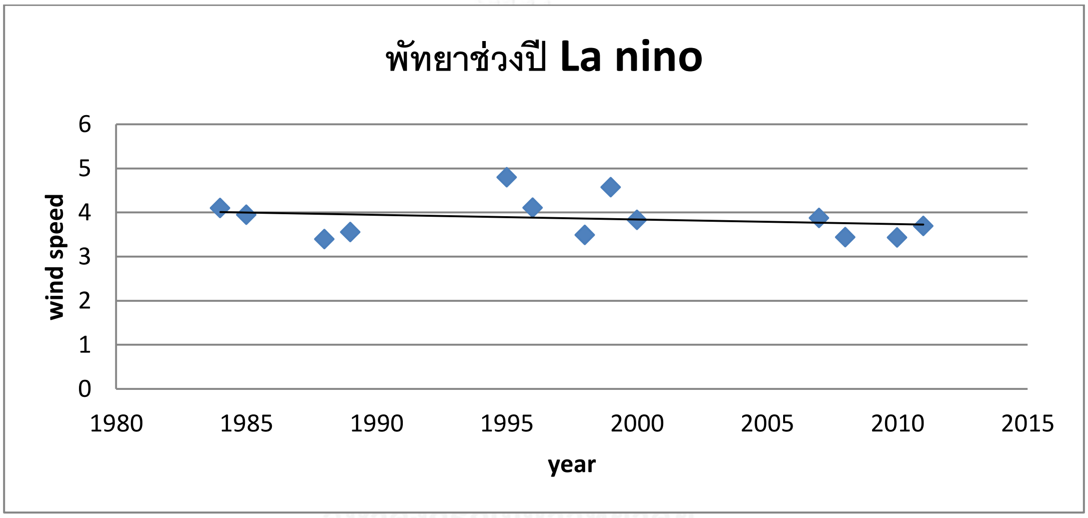

ความเร็วลมบนช่วง SW monsoon
25
20
15
10
5
0
1985
1990
1995
2000
2005
2010
2015
bangna speed
Songkhla speed
Changmaispeed

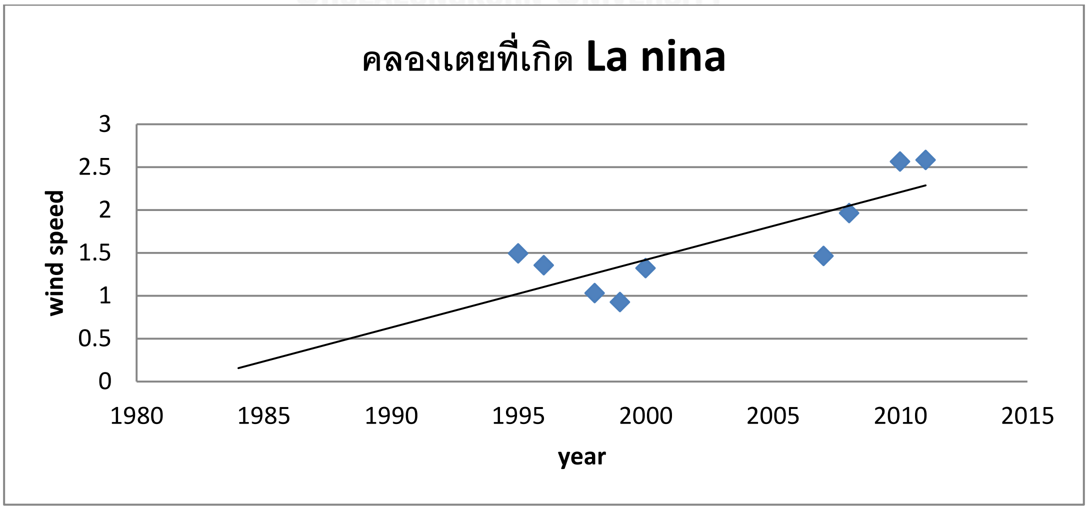

ทิศทางลมบนช่วง SW monsoon
350
300
250
200
150
100
50
0
1985
1990
1995
2000
2005
2010
2015
bangnadirection
Songkhladirection
Changmai direction

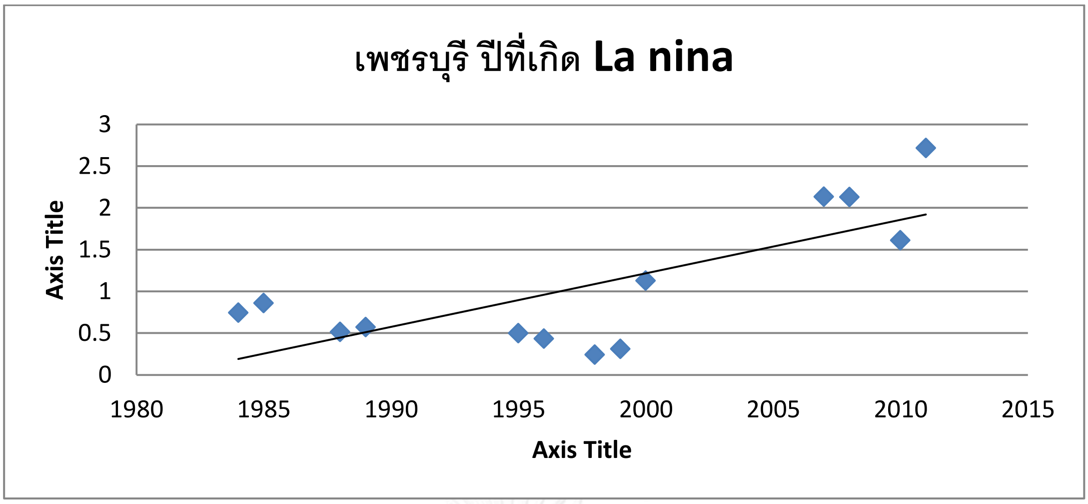
Appendix C

El Niño, La Niña, and Normal year in 1981-20

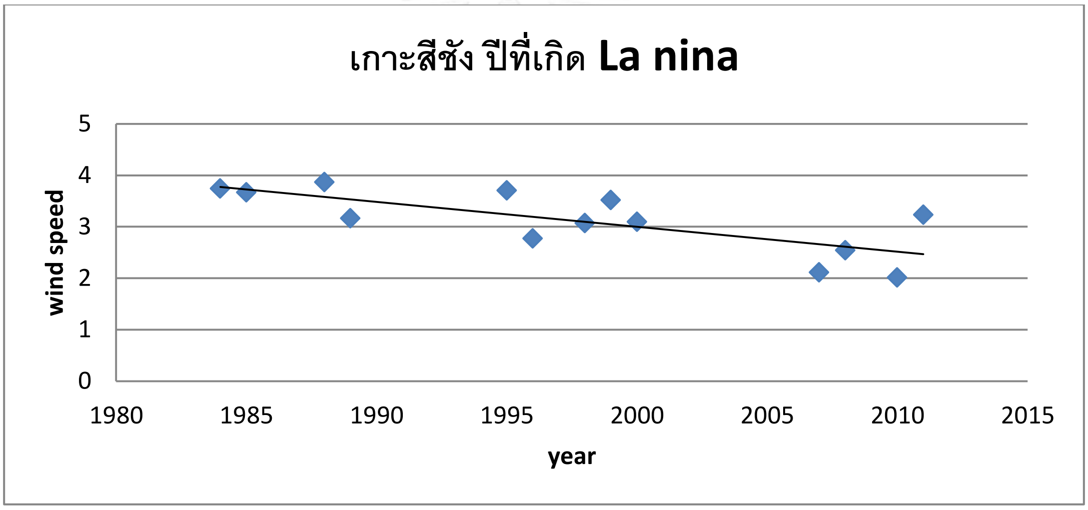

นำร่องปีเกิด La nina
wind speed
2
1.5
1
0.5
0
1980
1985
1990
1995
2000
2005
2010
2015
Year


พัทยาช่วงปี La nino
wind speed
6
5
4
3
2
1
0
1980
1985
1990
1995
2000
2005
2010
2015
year

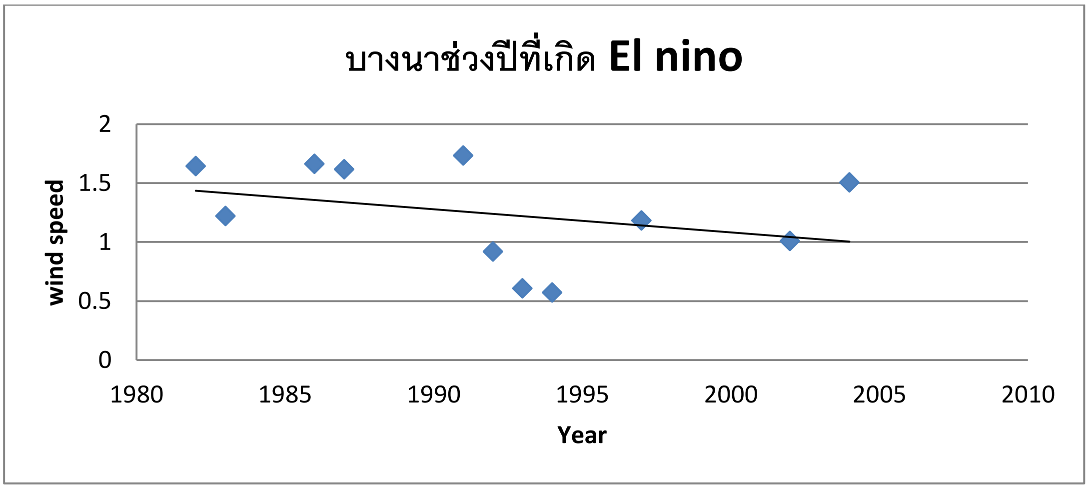

คลองเตยที่เกิด La nina
wind speed
3
2.5
2
1.5
1
0.5
0
1980
1985
1990
1995
2000
2005
2010
2015
year



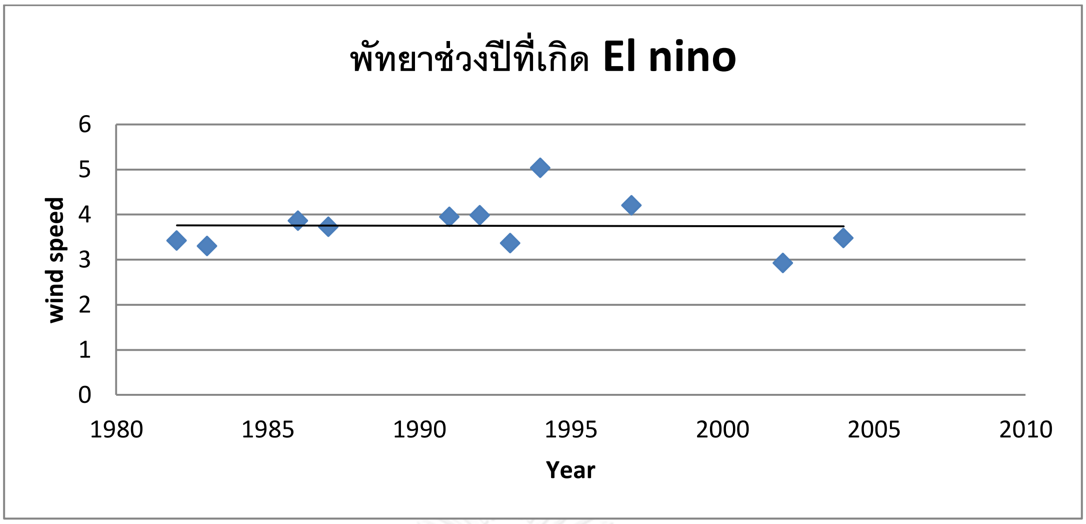
เพชรบุรี ปีที่เกิด La nina
Axis Title
3
2.5
2
1.5
1
0.5
0
1980
1985
1990
1995
2000
2005
2010
2015
Axis Title

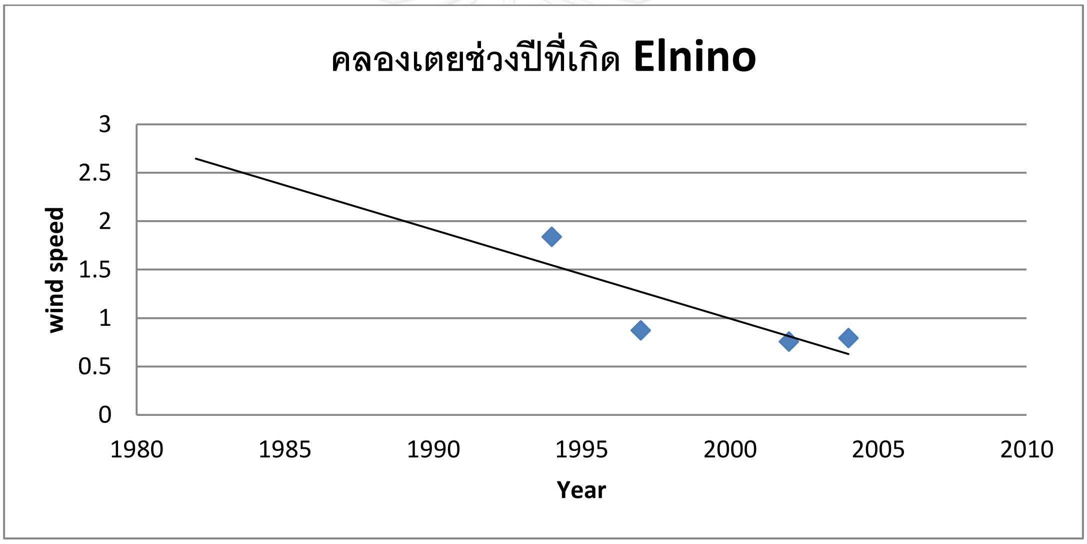


เกาะสีชัง ปีที่เกิด La nina
wind speed
5
4
3
2
1
0
1980
1985
1990
1995
2000
2005
2010
2015
year



บางนาช่วงปีที่เกิด El nino
wind speed
2
1.5
1
0.5
0
1980
1985
1990
1995
2000
2005
2010
Year


พัทยาช่วงปีที่เกิด El nino
wind speed
Year
6
5
4
3
2
1
0
1980
1985
1990
1995
2000
2005
2010


คลองเตยช่วงปีที่เกิด Elnino
wind speed
Year
3
2.5
2
1.5
1
0.5
0
1980
1985
1990
1995
2000
2005
2010

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