การประมาณวันเริ่มต้นฤดู(ฝน)มรสุมตะวันตกเฉียงใต้ของประเทศไทย ด้วยการเสนอเงื่อนไขใหม่

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บัณฑิตวิทยาลัยร่วมด้านพลังงานและสิ่งแวดล้อม
มหาวิทยาลัยเทคโนโลยีพระจอมเกล้าธนบุรี บางมด ทุ่งครุ กรุงเทพฯ 10140

รับเมื่อ 8 กุมภาพันธ์ 2551 ตอบรับเมื่อ 14 มีนาคม 2551

บทคัดย่อ

ได้มีการศึกษาเพื่อเสนอเงื่อนไขใหม่สำหรับกำหนดวันเริ่มต้นฤดูมรสุมตะวันตกเฉียงใต้ในประเทศไทย โดยศึกษาพฤติกรรมของลมที่ระดับ 850, 500 และ 200 hPa ความกดอากาศที่ระดับทะเลปานกลาง ความชื้นสัมพัทธ์ที่ผิวพื้น อุณหภูมิอากาศที่ผิวพื้น และ sensible heat flux ที่ผิวพื้น ซึ่งได้บันทึกไว้ในช่วงเดือนพฤษภาคม ตั้งแต่ปี พ.ศ. 2539 ถึง 2543 จากการจำลองลักษณะอากาศด้วยแบบจำลองทางคณิตศาสตร์ MM5 เวอร์ชั่น 3 ในบริเวณลองจิจูด 40 ถึง 120 องศาตะวันออก ละติจูด 30 องศาใต้ ถึง 40 องศาเหนือ ขนาดของกริด 50 x 50 กม. การจำลองลักษณะอากาศมีระยะเวลา 11 วันโดยมีประมาณการวันเริ่มฤดูฝนอยู่กึ่งกลาง ผลการศึกษาพบว่า อุณหภูมิของอากาศที่ผิวพื้นมีค่าอยู่ที่ 30 - 31℃ ในช่วงก่อนวันเริ่มต้นฤดูฝน และมีค่าอยู่ที่ประมาณ 30℃ ในวันที่ฤดูฝนเริ่มต้นก่อนจะมีค่าลดลง ส่วนความชื้นสัมพัทธ์ของอากาศที่ผิวพื้นพบว่ามีค่าร้อยละ 80 - 85, ร้อยละ 80 - 90 และ ร้อยละ 85 - 95 ในช่วงก่อนวันเริ่มต้นฤดูฝน ในวันที่ฤดูฝนเริ่มต้น และหลังจากนั้น ตามลำดับ สำหรับความกดอากาศที่ระดับทะเลปานกลางจะค่อนข้างคงที่แต่จะลดลงเล็กน้อยในช่วงวันเริ่มต้นฤดูฝน โดยตำแหน่งของความกดอากาศต่ำมีแนวโน้มเคลื่อนที่ไปทางทิศตะวันตก ผลต่างระหว่างความกดอากาศต่ำเหนือประเทศอินเดียกับความกดอากาศสูงบริเวณประเทศอินโดนีเซียมีค่า 10 - 12 hPa ก่อนเพิ่มขึ้นเป็นประมาณ 14 hPa ในวันเริ่มต้นฤดูฝน และลดลงมาอยู่ที่ประมาณ 10 hPa ในระยะต่อมา เมื่อพิจารณา sensible heat flux ที่ผิวพื้นบริเวณประเทศไทย พบว่ามีค่าสูงในช่วงก่อนวันเริ่มต้นฤดูฝนหลังจากนั้นมีค่าคงที่ตั้งแต่วันเริ่มต้นของฤดูฝนเป็นต้นไป ลมที่ระดับ 850 hPa ส่วนใหญ่เป็นลมใต้ในช่วงก่อนวันเริ่มต้นฤดูฝนและมีทิศทางตะวันตกเฉียงใต้มากขึ้นทั้งในช่วงวันเริ่มต้นฤดูฝนและหลังวันเริ่มต้นฤดูฝน ที่ระดับ 500 hPa ทิศทางลมในระดับนี้ชี้ให้เห็น trough พาดผ่านเหนือประเทศอินเดียทางด้านตะวันออกในช่วงก่อนวันเริ่มต้นของฤดูฝน ก่อนที่จะเคลื่อนมาอยู่บริเวณประเทศบังคลาเทศและอ่าวเบงกอลตอนบนในช่วงวันเริ่มต้นฤดูฝนและหลังจากนั้นตามลำดับ ส่วนลมที่ระดับ 200 hPa เป็นลมตะวันออกตลอดทั้งสามช่วง นอกจากนี้การกระจายของความชื้นสัมพัทธ์ในแนวดิ่งแสดงให้เห็นว่ามีการเลื่อนที่ต่ำลงของมวลอากาศที่มีความชื้นสูงในช่วงก่อนวันเริ่มต้นฤดูฝนด้วย

คำสำคัญ : แบบจำลองทางคณิตศาสตร์ MM5 / ศูนย์พยากรณ์อากาศระยะปานกลางแห่งยุโรป / มรสุม / อุณหภูมิ / ความชื้นสัมพัทธ์ / ความกดอากาศ / พลังงานความร้อนที่รู้สึกได้ / ร่องมรสุม

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Proposed New Criteria for Southwest Monsoon Onset Date in Thailand

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Abstract

A study had been conducted in order to achieve a new criteria to identify the southwest monsoon onset in Thailand. The elements used in this study included wind directions at the 850; 500; and 200 hPa levels, mean sea level pressure, relative humidity at the surface level, surface air temperature, and heat flux at the surface level, recorded in May since 1996 until 2000. The Mesoscale Model version 5 (MM5) was used to simulate the above elements. The domain in this study was located within 40°E to 120°E in longitude and 30°S to 40°N in latitude. The grid size was set to be 50 by 50 kilometers. The simulation had been processed for 11 consecutive days, with the assumed first date of the rainy season in the middle. The results revealed that surface air temperature in Thailand had been 30 – 31°C before the beginning of the rainy season. Such value was about 30°C on the onset date and would reduce afterward. For the relative humidity, it was found to be 80 – 85 %, 80 – 90 %, and 85 – 95 % prior to the monsoon onset, on the onset date, and later on, respectively. In case of the mean sea level pressure, it had been rather stable, but slightly dropped on the onset date. The location of a low pressure cells had a tendency to move toward the west. The difference between the low pressure cell above India and the high pressure area above Indonesia had been in the range of 10 – 12 hPa before the onset date. It had increased to be about 14 hPa on the onset date before dropping down to about 10 hPa afterward. When examining sensible heat flux at the surface level in Thailand, it had been in the high level before the monsoon onset and remained constant since the onset date. The majority of the wind field at the 850 hPa level over Thailand had been southerly before the monsoon onset. It later became more southwesterly since the monsoon onset date. The wind field at the 500 hPa level had portrayed a trough over the eastern area of India prior to the monsoon onset before it shifted to be over Bangladesh and the upper part of the Gulf of Bengal on the onset date and later on, respectively. For the wind field at 200 hPa level, it had been easterly since before till after the onset date. In addition, the distribution of relative humidity in the vertical axis represented the downward movement of moist air masses prior to the onset date also.

Keywords : MM5 / ECMWF / Monsoon / Temperature / Relative Humidity / Pressure / Sensible Heat Flux / Trough

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1. Introduction

Thailand is located in the southwestern part of the Indo-China Peninsula. The weather and climate on Thailand are strongly influenced by the monsoon from the India Ocean (Southwest monsoon) and cold air mass from the East-Asia continent. The agriculture and other industries in Thailand are favored by the tropical monsoon climate. Therefore the onset of southwest monsoon is very important for Thailand agriculture.

The onset of the southwest monsoon is preceded by an increase in temperature over almost all the monsoon regions. During the southwest monsoon season, the monthly mean surface air temperatures exceed 33-35 °C in the land areas of northwest India and adjoining areas [1]. The surface air temperatures, particularly the daytime temperatures, drop dramatically with the onset of the southwest monsoon, the monthly mean temperature falling to less than 30 °C [2]. The progressive development of heat lows before and during the monsoon season is considered to be one of the major causative factors of the Indian summer monsoon circulation [3]. Jay and Pamela [4] said the monsoon rain and winds are the end result of heating patterns produced by the sun and the distribution of land and ocean. Near the west coast of India, the winds were west southwesterly to westerly, with speeds of 5-10 m/s, while the mean speed was 5 m/s inland. This pattern persists throughout the active phase of the southwest monsoon [2].The monsoon troughs were investigated at the 500 hPa level. The monsoon troughs were over India during the monsoon onset before moving eastward after the monsoon onset. An important part of the anatomy of the monsoon circulation is the mean trough running from West Pakistan to the north Bay of Bengal. This trough extends from the sea level to 500 hPa, with southward slope [5]. Saman and Kumar [6] examined the circulation and moisture change over India associated with the onset of the southwest monsoon over south Kerala.

2. Material and Methods

2.1 Model Description

The PSU/NCAR mesoscale model [7] is a limited-area, nonhydrostatic or hydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation. It has been developed at Penn State and NCAR as a community mesoscale model and is continuously being improved by contributions from users at several universities and government laboratories.

The Fifth-Generation NCAR/Penn State Mesoscale Model (MM5) is the latest in a series developed from a mesoscale model used by Anthes at Penn State in the early 70's that was later documented by Anthes and Warner (1978). Since that time, it has undergone many changes designed to broaden its usage.

The MM5 model is supported by several auxiliary programs, which are referred to collectively as the MM5 modeling system.

MM5 has been used for a broad spectrum of theoretical and real-time studies, including applications of both predictive simulation and four-dimensional data assimilation to monsoons, hurricanes, and cyclones.

2.2 Study Domain

The study was done for the five years 1996, 1997, 1998, 1999, and 2000. In each case, the five days before the onset date, the onset date, and five days after the onset date were considered.

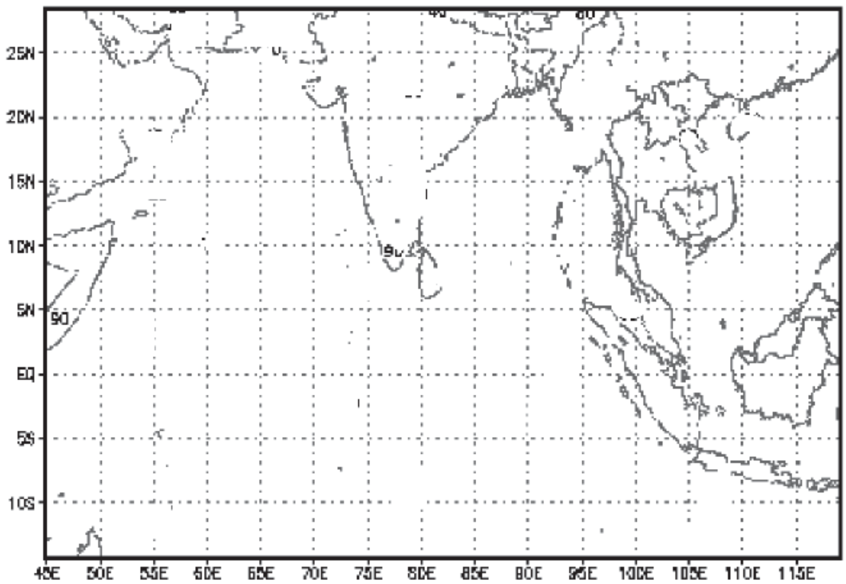


Fig. 1 The study domain (30°S to 40°N and 40°E to120°E).

The model was run with horizontal grid resolutions of 50x50 km and 23 levels in the vertical. The models were started at 00 utc using 12-hr analysis data with resolution of 2.5°x2.5° in the area 40°e to 120°e in longitude and 30°s to 40°n in latitude (Fig. 1).

2.3 Data Collection

The pressure levels data (u & v wind components, geopotential, temperature, and relative humidity, at all levels) and surface data from 1996-2002 were obtained from the European Center for Medium Range Weather Forecasting (ECMWF). The 12-hr (00 and 12 UTC) data with resolution of 2.5° x 2.5° in the area of 40°E to 120°E in longitude and 30°S to 40°N in latitude are selected in this study. The precipitation data are obtained from Thai Meteorological Department (TMD).

2.4 The TMD Official Criteria of Southwest Monsoon Onset Date in Thailand

- There are three consecutive rainy days in a five day period.
- The consecutive rainy days must have not less than 5 mm each day.
- The accumulated rain of the five rainy days must not be less than 25 mm.
- The low level wind direction must change to westerly or southwesterly.
- The upper level wind direction must change to easterly.

Special conditions of rainfall, such as tropical cyclones or the intertopical convergence zone, strongly affect the southwest monsoon onset date estimation. The estimation of southwest monsoon onset dates performed in 1996, 1997, 1998, 1999 and 2000 are shown in Table 1.

Table 1 The estimated southwest monsoon onset date by TMD.

Southwest monsoon onset dates				
1996	**1997**	**1998**	**1999**	**2000**
7th May	18th May	17th May	4th May	15th May

3. Results and discussion

3.1 Input Data and Model Running

All MM5 required data were prepared in 12 hour period data and then input to the model. The model run with 150 second time step, Grell scheme physical method [8]. The study was done for the five years 1996, 1997, 1998, 1999, and 2000. In each case, the five days before the onset date, the onset date, and five days after the onset date were considered. The 2002 data were used to verify the study model. The model was run with horizontal grid resolutions of 50x50 km and 23 levels in the vertical. The models were started at 00 UTC using 12-hr analysis data with resolution of 2.5°x2.5° in the area 40°E to 120°E in longitude and 30°S to 40°N in latitude.

3.2 The model output evaluations

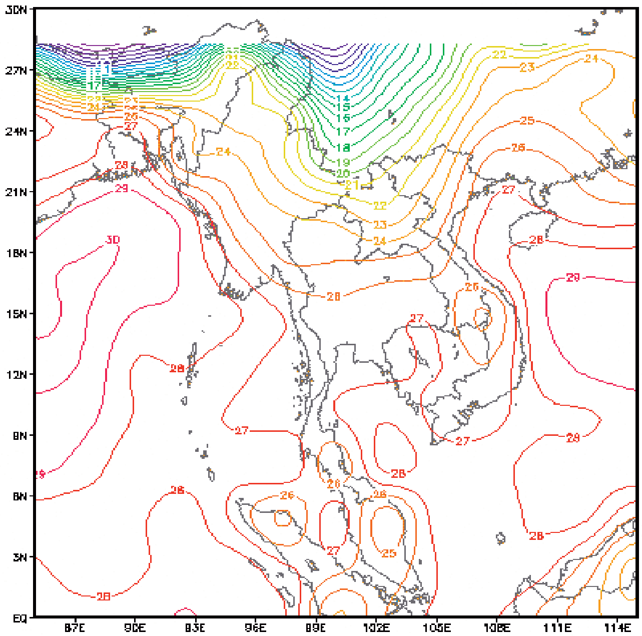
To evaluate the model outputs, the surface air temperature, surface relative humidity and sea level pressure contour patterns from the model were compared with those contour patterns from the observed data. Quantitative comparisons were obtained by calculating various statistical averages and root mean square error analyses.

The world meteorological organization WMO [9] issued standard limits for errors of meteorological parameters as shown in Table 2. The errors of the model forecast parameters are less than the WMO limits for errors. Therefore, the sensible heat flux will be estimated by the models and the results are assumed to be valid.

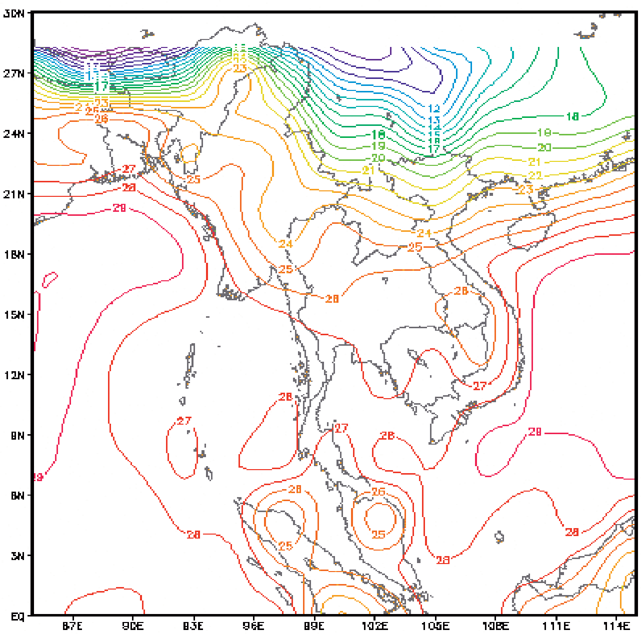
Table 2 Comparison of model RMSE values with WMO Standards.

RMSE of	1996	1997	1998	1999	2000	Limits for errors
Temp (°C)	1.36	0.93	1.49	0.97	1.02	4 °C
PSLV (hPa)	0.43	1.22	1.51	0.43	0.42	2 hPa
RH (%)	1.74	1.52	1.59	1.72	1.69	15%

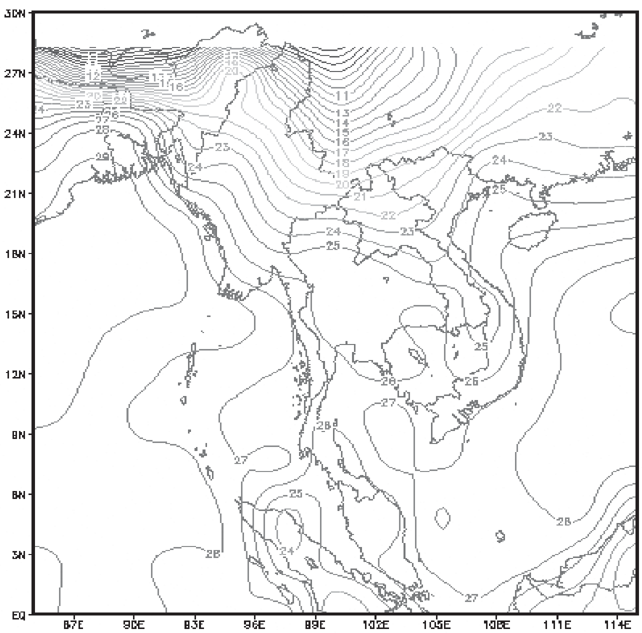
- Surface Air Temperature



2 a)



2 b)



2 c)

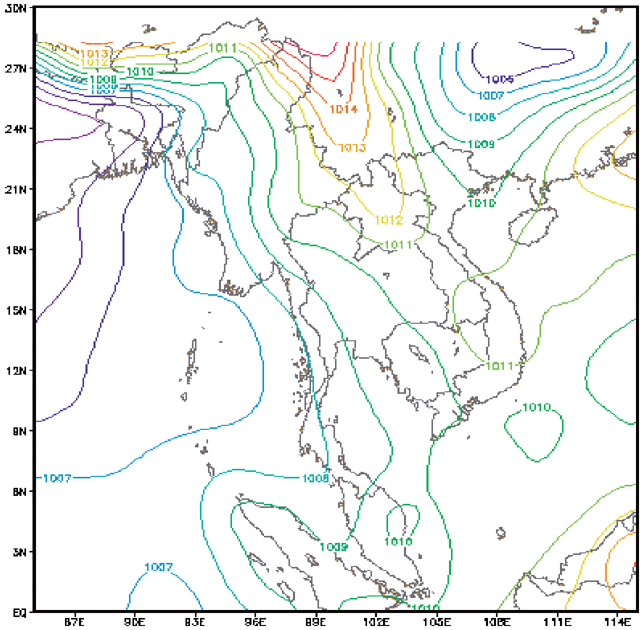
Figs. 2a), 2b), and 2c) show the surface air temperature (℃) at 00 UTC on 13/5/1997, 18/5/1997, and 23/5/1997 respectively.

During the pentad before the southwest monsoon onset, low pressure cells or high temperatures are found over the Bay of Bengal and Thailand. Low pressure cells with temperature 29-30℃ are located over India and the Bay of Bengal (15-20°N, 75-80°E), and about 28-29℃ over Thailand, and 28-29℃ over the South China Sea during the pentad before the monsoon onset (Fig. 2a).

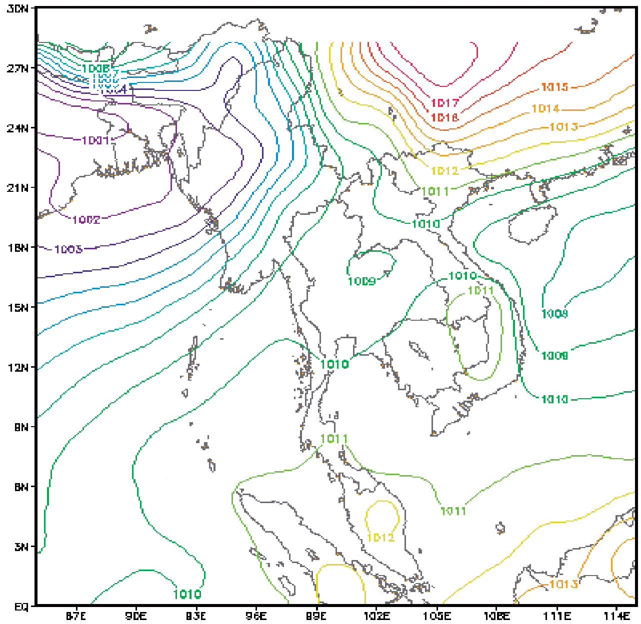
Lows pressure cells with temperature 30-31℃ are located in India and the Bay of Bengal (15-20°N, 75-80°E), 29-30℃ over Thailand, and 29-30℃ over the South China Sea during the onset period. The system of high temperature shifted from northern India to the west coast of Thailand (Fig. 2b).

The air temperature are still high about 28-29℃ over India, the Bay of Bengal, Thailand and the South China Sea. The air temperature over Thailand decreased during the pentad after the monsoon onset. When precipitation and cloud occurs, the heating of the surface decreases because the specific heat of soil increases with the addition moisture and the heat from the sun is used in evaporation (Fig. 2c).

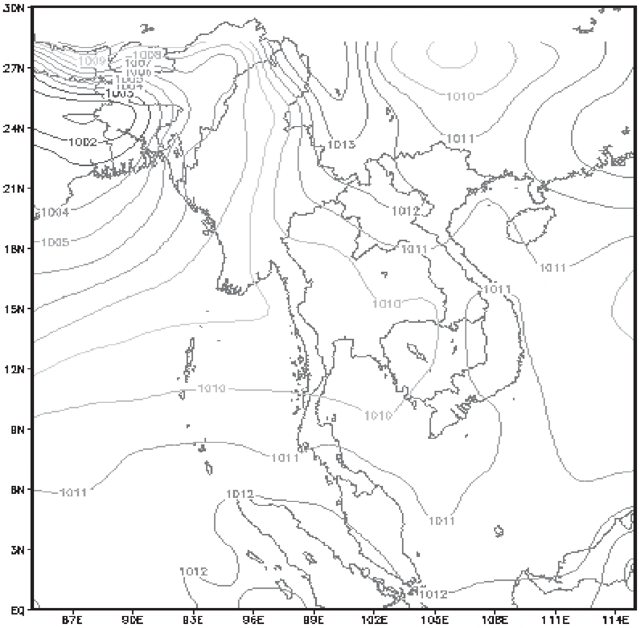
- Sea level pressures



3a)



3b)



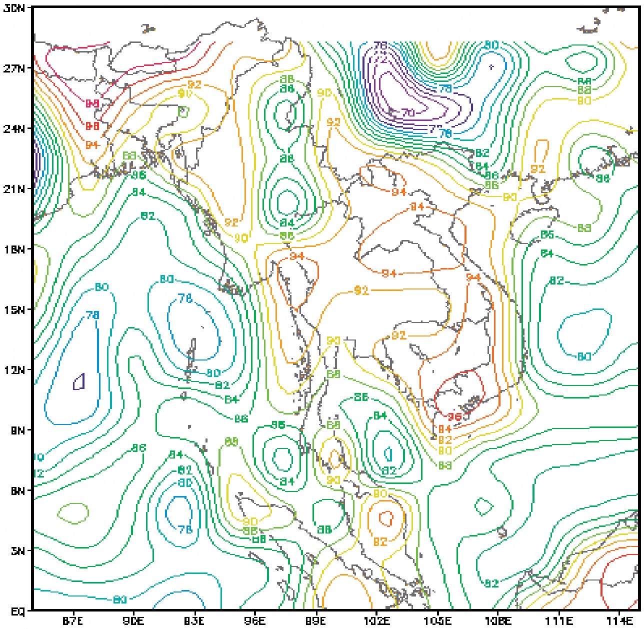
3c)

Figs. 3a), 3b), and 3c) show the sea level pressure (hPa) at 00 UTC on 13/5/1997, 18/5/1997, and 23/5/1997 respectively.

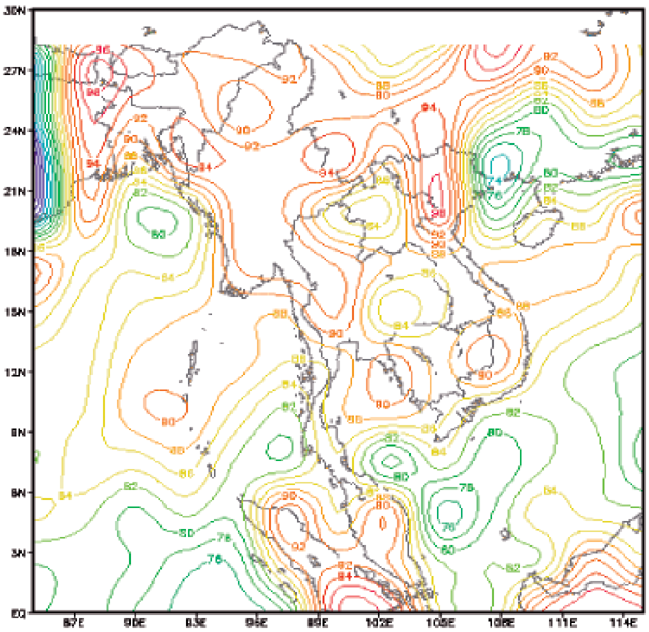
Fig. 3a shows the sea level pressure at 00 UTC on 13/5/1997, it found that the low pressure area with the central pressure 1,002-1,006 hPa and strong gradient to the north is found over northeastern India and western the Bay of Bengal. The sea level pressure over Thailand was 1,007-1,010 hPa, and was 1,009-1,013 hPa over the South China Sea. High pressures are found over northern Myanmar, the South China Sea and Indonesia.

Fig. 3b shows the sea level pressure at 00 UTC on 18/5/1997, it found that heat low pressure areas are found over northeastern India, Bangladesh and the northern Bay of Bengal with central pressure 1,001-1,007 hPa and a steep gradient to the north (25-28 °N and 85-93 °E), 1,008-1,010 hPa over northeastern Thailand, and 1,009-1,011 hPa over south China. The high pressure persisted over northern Myanmar with 1,016 hPa central pressure, and the other high system remained over Indonesia. Fig. 3c shows the sea level pressure at 00 UTC on 23/5/1997, it found that the the low pressure area with pressure 1,001-1,003 hPa is found over northeastern India and western Bay of Bengal. The sea level pressure over Thailand was 1,009-1,011 hPa, and was 1,009-1,013 hPa over the South China Sea. High pressures are found over northern Myanmar, the South China Sea and Indonesia. Low pressure cells occurred over land areas throughout the period before, during and after the monsoon onset. The sea level pressure was lowest over Bangladesh and Thailand.

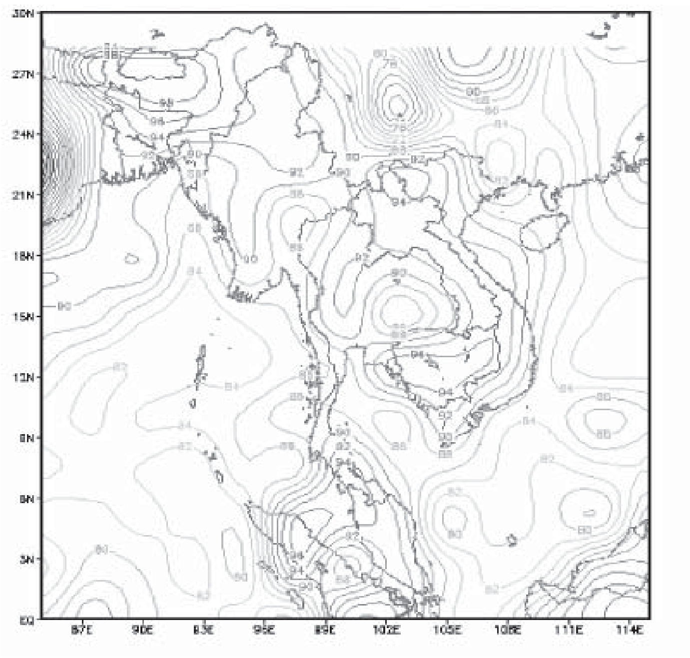
- Surface relative humidity



4a)



4b)



4c)

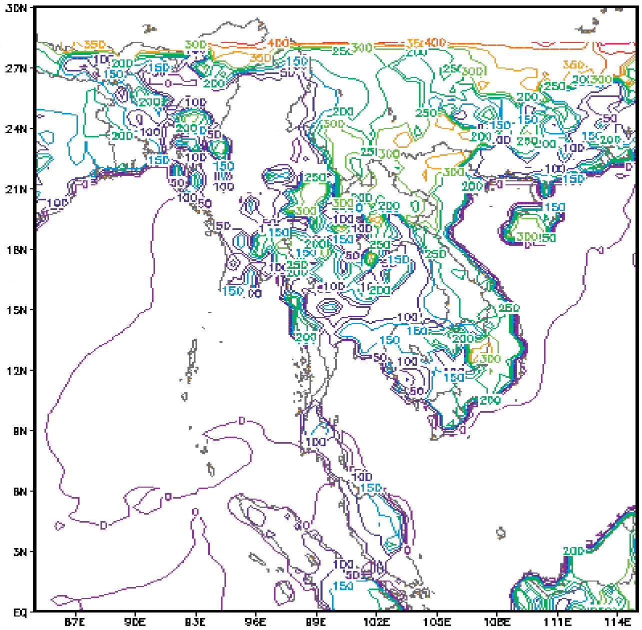
Figs. 4a), 4b), and 4c) show the surface relative humidity (%) at 00 UTC on 13/5/1997, 18/5/1997, and 23/5/1997 respectively.

The surface relative humidity during the pentad before the monsoon onset was rather high: 80-95% over the Bay of Bengal, 75-92% over Thailand, and 80-90% over the South China Sea. Low relative humidities are found over the continent of Bangladesh and India (Fig. 4a).

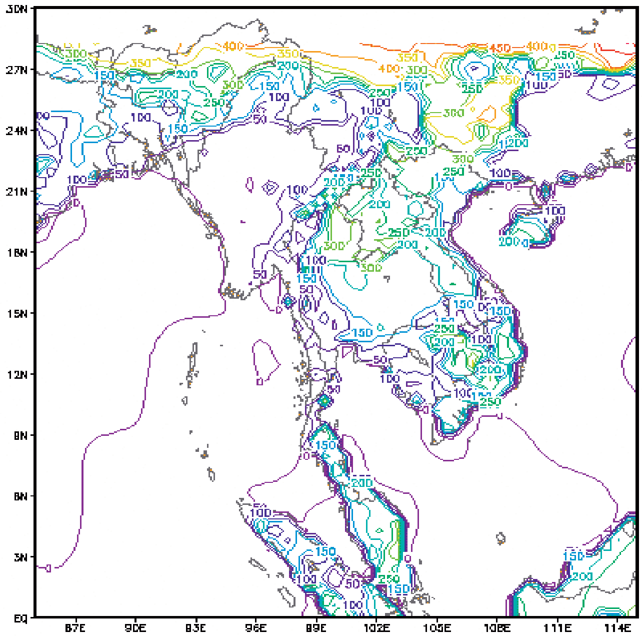
The surface relative humidity during the monsoon onset was 80-95% over the Bay of Bengal, 80-90% over Thailand, and 80-95% over the South China Sea. Low relative humidities are found over the continent of Bangladesh and India (Fig. 4b).

The surface relative humidities during the pentad after the monsoon onset are 85-95% over the Bay of Bengal, 85-92% over Thailand and 80-90% over the South China Sea. Low relative humidities are found over the continent of Bangladesh and India (Fig. 4c).

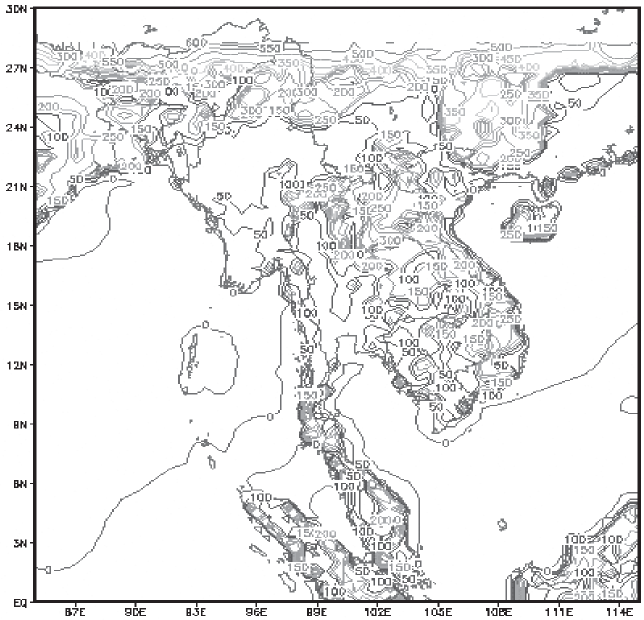
- Surface sensible heat flux



5a)



5b)



5c)

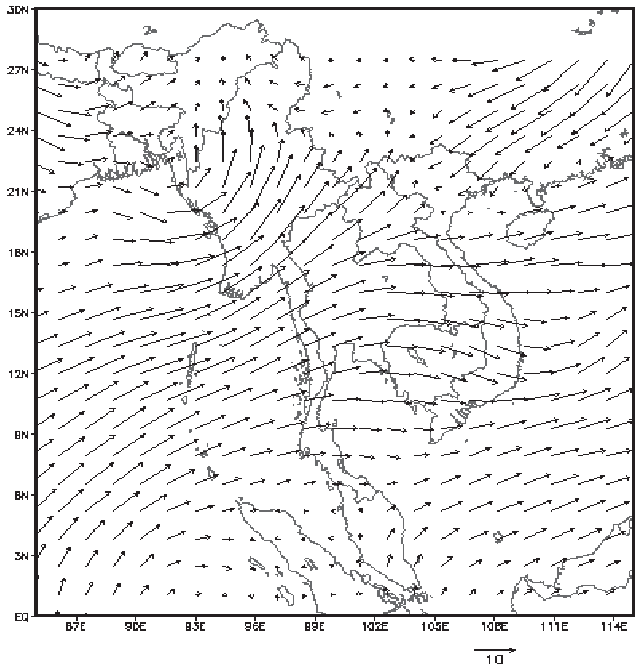
Figs. 5a), 5b), and 5c) show the surface sensible heat flux (W/m^2) at 00 UTC on 13/5/1997, 18/5/1997, and 23/5/1997 respectively.

The surface sensible heat flux at 00 UTC was about 0-50 W/m^2 in both the Bay of Bengal and the South China Sea. The surface sensible heat flux was 100-200 W/m^2 over Thailand. A high surface sensible heat flux more than 400 W/m^2 occurred over South China (Fig. 5a).

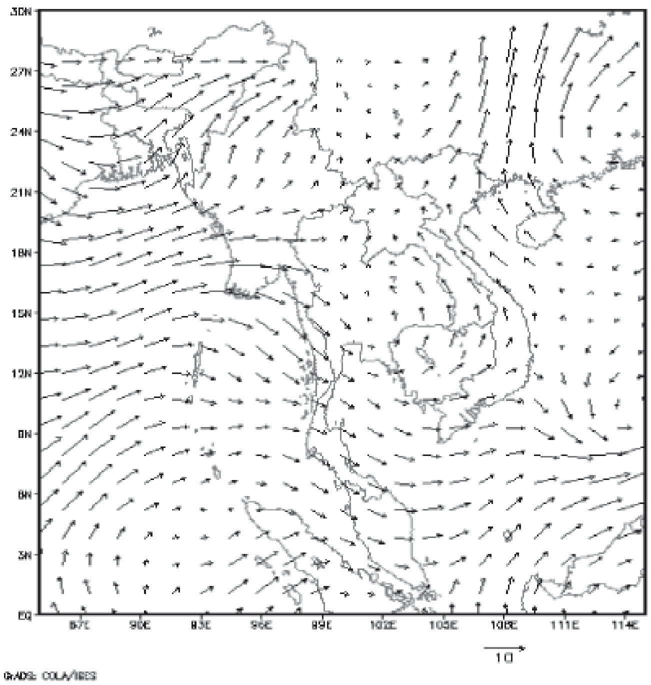
The surface sensible heat flux at 00 UTC was about 0-50 W/m^2 in both the Bay of Bengal and the South China Sea. The surface sensible heat flux was 150-300 W/m^2 over Thailand. A high surface sensible heat flux more than 400 W/m^2 occurred over south China (Fig. 5b).

The surface sensible heat flux at 00 UTC was about 0-50 W/m^2 in both the Bay of Bengal and the South China Sea. The surface sensible heat flux was 100-200 W/m^2 over Thailand. A high surface sensible heat flux more than 400 W/m^2 occurred over the South China (Fig. 5c).

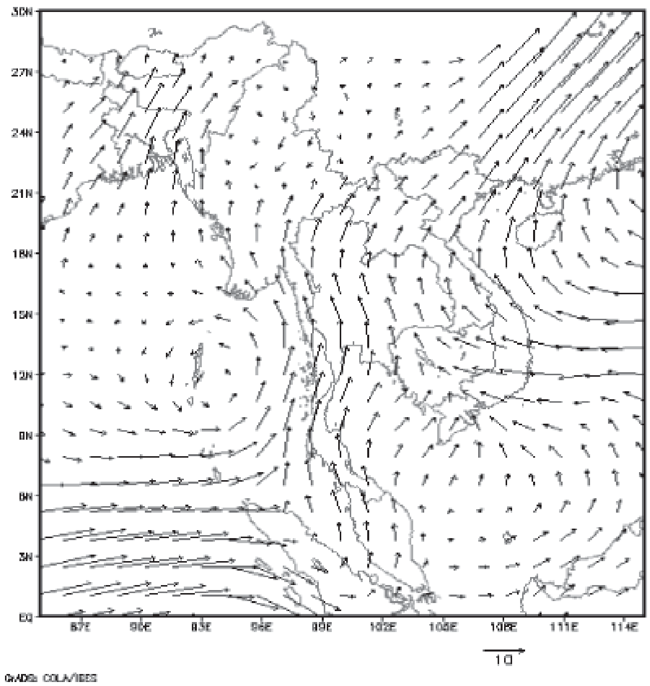
- Wind field at 850 hPa



6a)



6b)



6c)

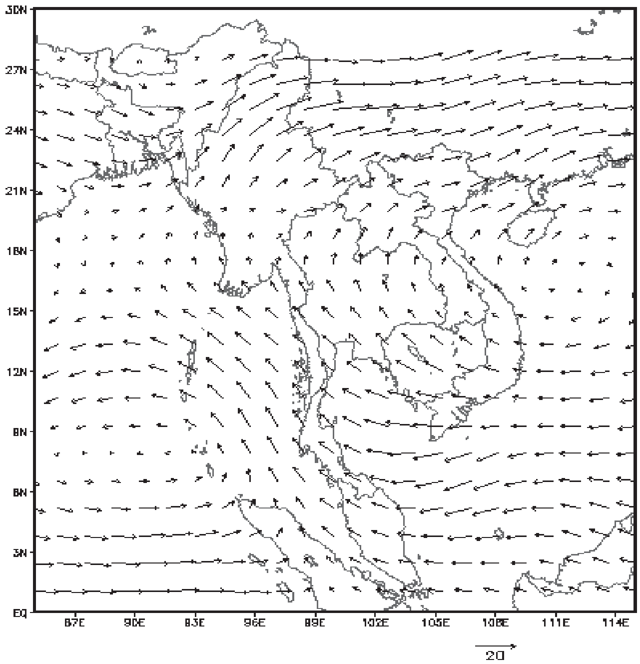
Figs. 6a), 6b), and 6c) show the wind fields at 850 hPa at 00 UTC on 13/5/1997, 18/5/1997, and 23/5/1997 respectively.

The winds over Thailand at 850 hPa at 00 UTC were southerly with speeds of 5-10 m/s (Fig. 6a).

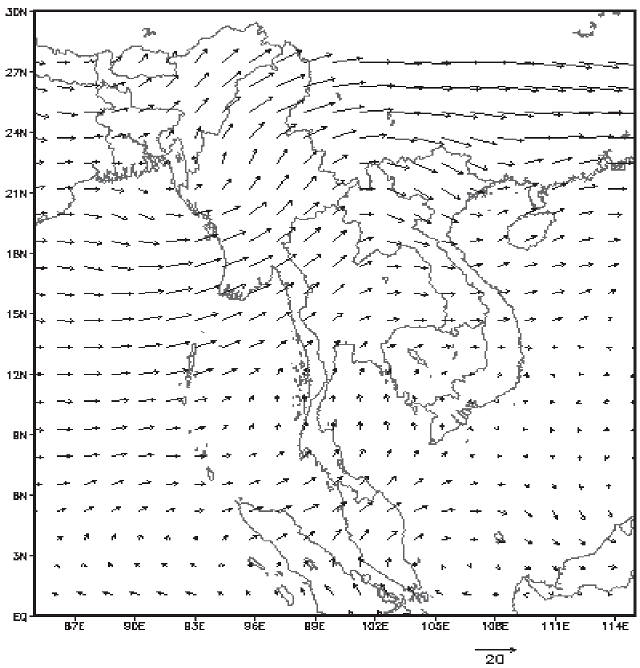
The winds over Thailand at 850 hPa at 00 UTC were southwesterly with speeds of 10-15 m/s (Fig. 6b).

The winds over Thailand at 850 hPa at 00 UTC were northeasterly to southwesterly with speeds of 5-10 m/s (Fig. 6c).

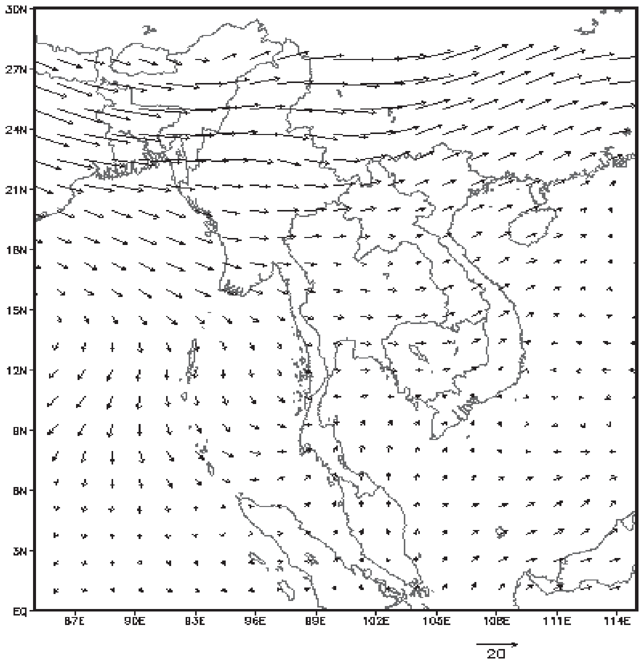
- Wind field at 500 hPa



7a)



7b)



7c)

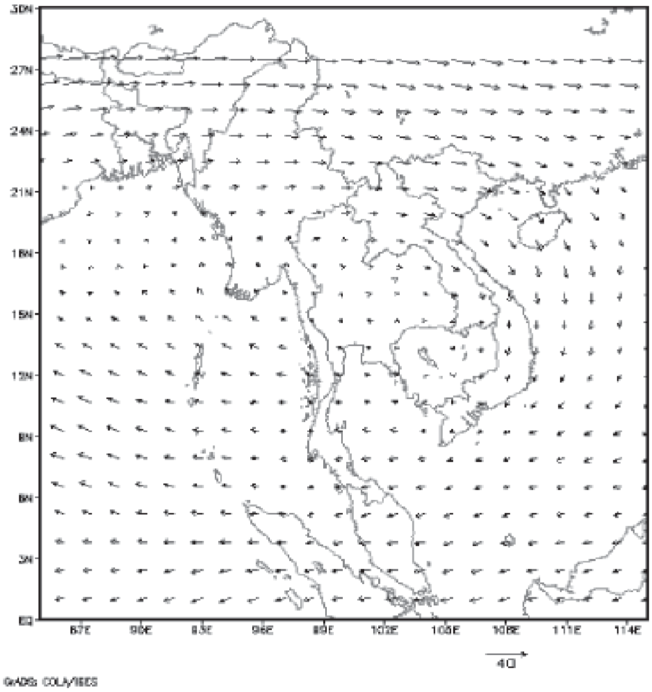
Figs. 7a), 7b), and 7c) show the wind fields at 500 hPa at 00 UTC on 13/5/1997, 18/5/1997, and 23/5/1997 respectively.

Troughs were found over Bangladesh with axes along latitude 15-30 °N and longitude 92-93 °E. Northwesterly winds and wind speeds of 5-10 m/s were found in the areas behind the trough. Southwesterly winds and wind speeds of 10-20 m/s were found in front of the trough (Fig. 7a).

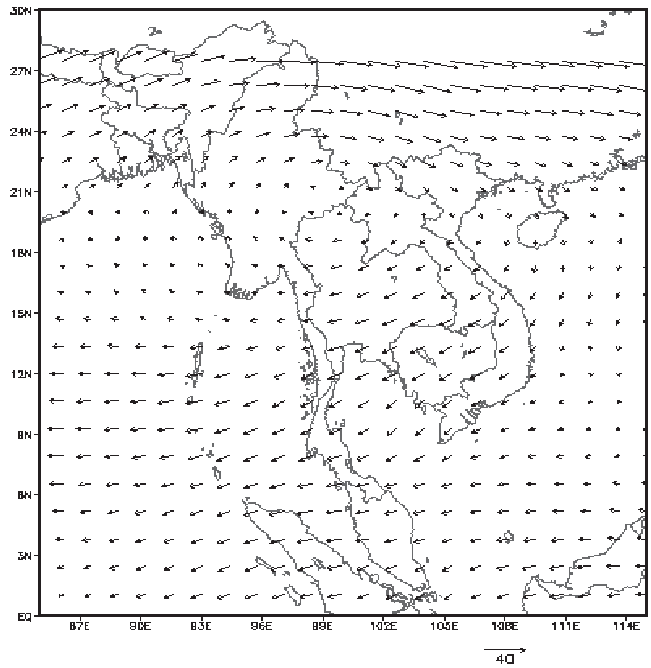
Troughs persisted over Bangladesh with axes at latitude 15-30 °N and longitude 93-94 °E. Northwesterly winds and wind speeds of 5-10 m/s were found in the areas behind the trough. Southwesterly winds and wind speeds of 10-20 m/s were found in front of the trough (Fig. 7b).

Troughs persisted over the Bay of Bengal with axes at latitude 5-30 °N and longitude 95-96 °E. Southeasterly winds and wind speeds of 5-20 m/s were found in the areas behind the trough. Northeasterly winds and wind speeds of 5-30 m/s were found in front of the trough (Fig. 7c).

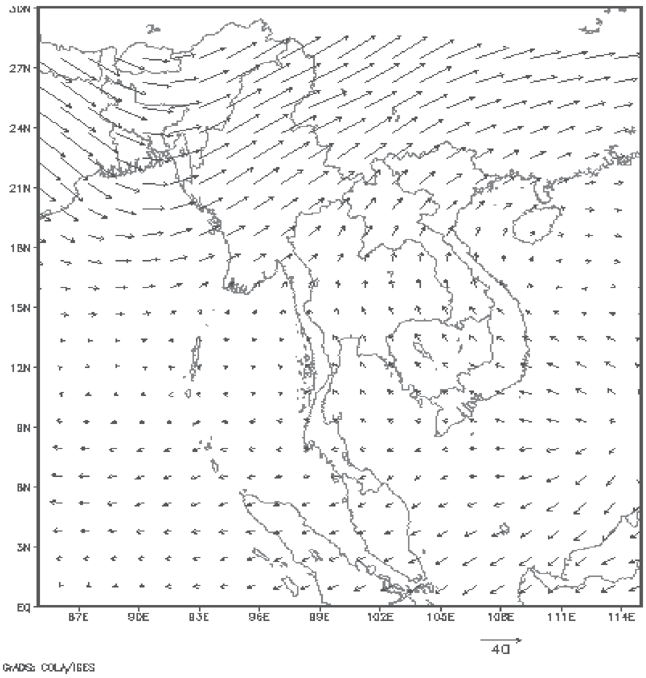
- Wind field at 200 hPa



8a)



8b)



8c)

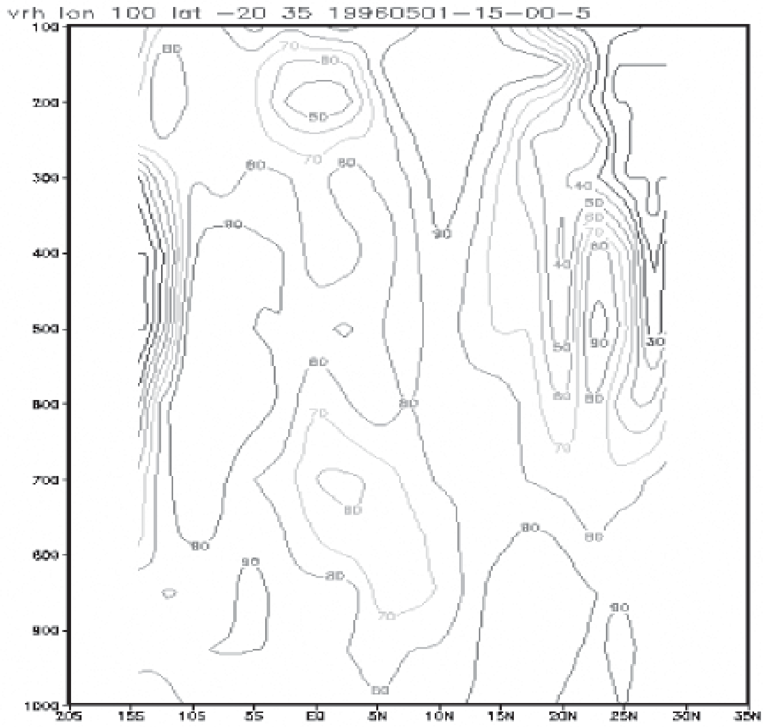
Figs. 8a), 8b), and 8c) show the wind fields at 200 hPa at 00 UTC on 13/5/1997, 18/5/1997, and 23/5/1997 respectively.

The winds at 200 hPa at 00 UTC during the pentad before the monsoon onset were northeasterly to easterly over southern Thailand and westerly over northern Thailand with speeds of 5-10 m/s (Fig. 8a).

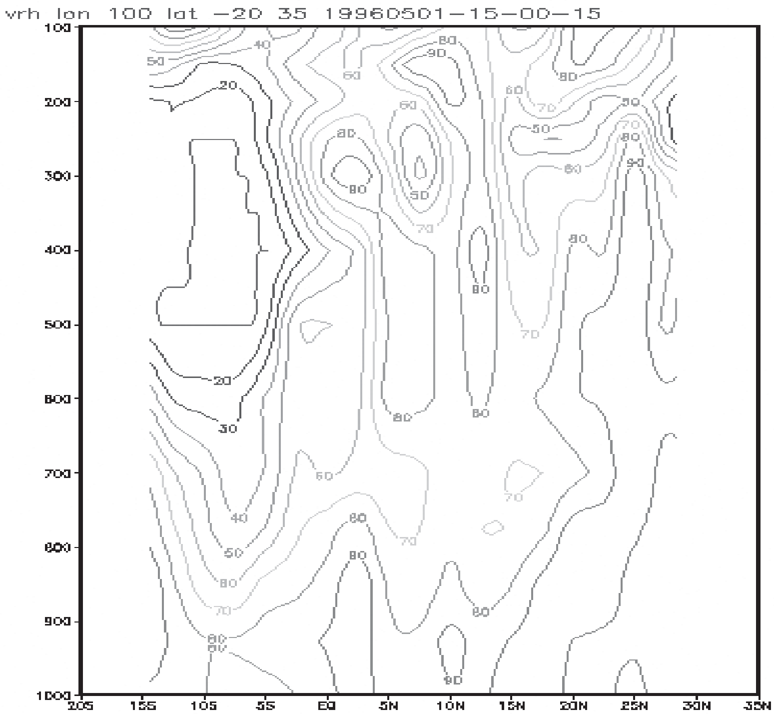
The winds at 200 hPa at 00 UTC during the monsoon onset were northeasterly to easterly over southern Thailand and westerly over northern Thailand with speeds of 5-10 m/s (Fig. 8b).

The winds at 200 hPa at 00 UTC during the pentad after the monsoon onset were northeasterly to easterly over southern Thailand and westerly over northern Thailand with speeds of 10-15 m/s (Fig. 8c).

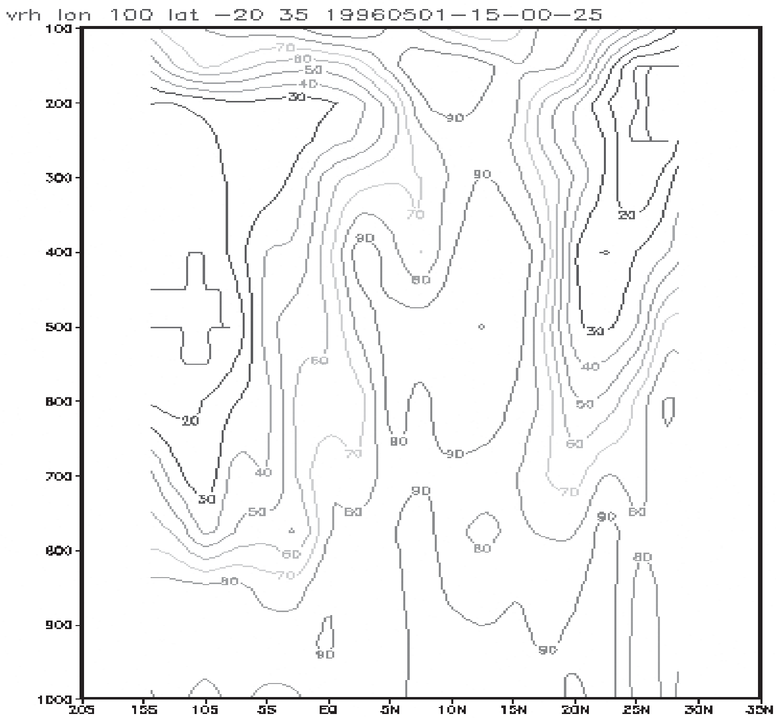
- Vertical Relative Humidity



9a)



9b)



9c)

Figs. 9a), 9b), and 9c) show the vertical relative humidity at 00 UTC on 13/5/1997, 18/5/1997, and 23/5/1997 respectively.

The vertical relative humidity during the pentad before the monsoon onset showed moisture layers around 90% at heights 1,000-700 hPa and 500-100 hPa (Fig. 9a).

The vertical relative humidity during the monsoon onset showed moisture layers around 90% at heights 1,000-900 hPa and 500-100 hPa (Fig. 9b).

The vertical relative humidity during the pentad after the monsoon onset showed moisture layers around 90% at heights 1,000-600 hPa, 700-300 and 200-100 hPa (Fig. 9c).

The lower moisture layers persisted over Thailand and shifted northward during the monsoon onset period, and the upper moisture layers were stationary or shifted down.

4. Conclusion

According to investigation of meteorological parameters, it was found that 3 elements (: surface air temperature, sea surface temperature, and sensible heat flux at the surface level) showed high relationship with the beginning of the rainy season in Thailand. Both surface air temperature and sensible heat flux at the surface level had increased prior to the first day of the rainy season before the values of both parameters declined. In case of sea surface temperature, its value had either increased or remained the same ahead of the first date of the rainy season before it either remained the same or decreased, respectively.

The values of relative humidity at the surface level and the same element in the vertical axis with in the latitude 20 °S – 35 °N and along the longitude 100 °E show moderate relationship with the first date of the rainy season. What could be noticed were the facts that moist air masses had covered Thailand at the lower altitude and tended to move northward on the very first date the rain was observed whereas moist air masses at the higher altitude was in the rather stable condition or tended to move downward on the date the rain took place.

As this study was set to investigate any changes of related elements within 11 days only (5 days before and another 5 days after the first date of the rainy season), no changes of the wind directions at the 850, 500, and 200 hPa levels could be detected although they are regarded as main features of the Southwest Monsoon. The summarizes all the results showed in Table 3.

Table 3 The change of meteorological parameters during the monsoon onset periods.

Parameters	Before the monsoon onset	During the monsoon onset	After the monsoon onset
Surface air temperature °C	28-29	30	<30
Surface relative humidity (%)	80-85	80-90	85-95
Sea level pressure (hPa)	1007-1010	1,008-1,010	1,009-1,011
Sensible heat flux (W/m^2)	100-200	150-300	100-200
Wind field at 850 hPa (m/s)	Southerly, 5-10	Southwesterly, 10-15	Southwesterly, 5-10
Wind field at 500 hPa (m/s)	Northwesterly, 5-10, B Southwesterly, 10-20, F	Northeasterly, 5-10, B Southwesterly, 10-20, F	Northeasterly, 5-10, B Southwesterly, 10-20, F
Wind field at 200 hPa (m/s)	Northeasterly to easterly, 5-20	Northeasterly to easterly, 5-20	Northeasterly to easterly, 5-20
Vertical 90 % relative humidity (hPa)	1,000-700 and 500-100	1,000-900 and 500-100	1,000-600, 700-300, and 200-100

5. Acknowledgments

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