September 1997. Indonesia and Malaysia had to declare a state of national emergency in the same month.

The fundamental cause of the problem is not haze but uncontrolled forest fires due to shortcomings of proper forest management and practice. This phenomenon is still very common in some Southeast Asian countries, including Thailand. To effectively address this issue in the broader context of sound forest management remains difficult. However, there is no other easy way. The 1997 haze confirmed its large-scale and huge impacts on the environment, economy, health, and society, when good forest management failed.

Uncontrolled forest fires from Indonesia under favourable meteorological condition resulted in rapid air quality deterioration over South-East Asia region. The transboundary transport of smoke caused the haze effects not only in Indonesia, but also all over the Malayan peninsula in 1997. The spreading of the smoke to the peninsula, including the southern Thailand, was helped by the prevailing synoptic scale winds, as indicated by the low-level southerly wind circulation. During the days with high PM_{10} in September 1997, wind speeds were very weak and thus helped in accumulating high levels of particles.

The 1997 haze has proved once again that improper land clearing practices, compounded by the El Niño climatic factors, could produce a large-scale air pollution episode. In Thailand, the air pollution episode occurred in two peaks over a rather short period. Fine particulate matter was the main pollutant in this event: other air pollutants generally remained low. The first peak of PM_{10} occurred between 22 and 29 September, with the maximum level recorded during 24 and 25 September, followed by a lower second peak during 6 and 8 October 1997. The highest 24-hour average PM_{10} observed that of the 218 $\mu g/m^3$ on 26 September 1997 in Hatyai. At this level, it was 4-5 times higher than normal air quality in the region.

Compared to forest fires in other continents in the past, the 1997 haze from Indonesia was unique. Because of its wide coverage of densely populated areas in South-East Asia region, almost 100 million populations in five countries were exposed to the smoke. With a large number of population at risk, its impact on health could be readily observed.

Retrospective data showed elevated and widespread short-term respiratory health effects during the same period. In relatively clean areas, an air pollution episode with particulate matter rising abruptly to moderate levels can still have major impacts upon health. At the regional level, a substantial increase in OPD visits and IPD admissions for respiratory illness was observed in southern Thailand. The increases were significant for OPD visits for all respiratory diseases and IPD admissions for almost all categories of respiratory diseases: pneumonia, bronchitis/COPD, and asthma. At the elevated levels of fine particles, the net health impacts from the 1997 haze were estimated as 8 per cent and 7 per cent increases in OPD visits and IPD admissions for respiratory diseases, respectively. At the city level, the health impact estimated from the 1997 haze was 7 per cent increase in OPD visits for respiratory diseases. However, the increases were significant only for OPD visits for all respiratory diseases and IPD admissions for bronchitis/COPD. The significant effect of the haze in terms of daily PM_{10} was that for each 1 $\mu g/m^3$ increase, there was 0.2 deviation from daily average OPD visits for all respiratory diseases and URTI.

The PM_{10} level in this haze episode (200 $\mu g/m^3$, 24-hour average) was about twice that of the national ambient air quality standards of Thailand (120 $\mu g/m^3$). At this low to low-moderate increase, the health effects can be clearly and readily observed in large population at the regional level. However, the effects may be less likely or more difficult to be detected in smaller area, such as Hatyai city. Pooling of data from several cities may be needed in evaluating the health impacts.

The 1997 haze was one of the large-scale forest fires and transboundary air pollution. Activities and mitigation or prevention measures implemented during the haze episode provided valuable experience for Thailand and other ASEAN countries in dealing with widespread forest fires.

The attempt on source control proved difficult, especially in transboundary transport of haze, when the source was in Indonesia but the effects were felt in other countries. National efforts as well as international or regional cooperation and actions were too late and modest compared to the magnitude of the fires. It took almost 6 months before most of the fires subsided at the end of 1997.

Health risk communication and public advice on personal protective measures, within the framework of inter-agency coordination, were applied in most ASEAN countries, including Thailand. These measures covered suggestions for the susceptible population groups (asthmatics and chronic bronchitis, elderly, infants and children, persons with underlying lung or heart disease, and smokers) and general population. The health advisory includes avoiding strenuous activities and smoking, staying indoors, drinking clean water and temporarily refraining from rainwater, seeking medical care when having respiratory and cardiovascular symptoms or attacks, and wearing protective masks outdoors in severe haze. Because of poor visibility during the haze period, emphasis on awareness and prevention of traffic accidents was also included.

Some preventive measures recommended during the haze period may be inadequate or inappropriate, and may not be fully justified based on the best available knowledge (3, 12). There are as yet no clear answers to several prescribed mitigation/protective measures and more research is clearly needed. Who are actually the sensitive population groups? How many are they? Do asthmatics or chronic bronchitis need prophylactic medication before or during the haze event? Are protective masks for the general public really effective? Are there benefits of staying indoors? What is the difference between indoor and outdoor pollution levels? Other appropriate measures such as the use of public shelter or public place during the haze need further investigations.

The question of how we can better prevent and prepare for future haze event has to be answered before future action and recommendations are made. The primary focus should be on prevention. That is the integrative and region-wide approach of medium-, and long-term measures towards the real solution—sound forest management. Measures to control forest fires need to be strengthened, including regulations, incentives and enforcement, and fire control operation. Complementary measures of community participation and public education on the serious health and socio-economic impacts of uncontrolled forest fires, NGOs involvement, and inter-sectoral cooperation are necessary. Regional agreement and cooperation have been initiated in ASEAN countries. It remains to be seen how these concerted efforts will help reduce this problem in the South-East Asia region.

For preparedness, recommendations on immediate haze-related activities in many fronts are urgently needed in order to protect health and quality of life. Rapid detection capability for uncontrolled forest fires using available and advanced monitoring system needs to be established. National environment and health response plans has to be developed. The plan should include establishment of an early warning system based on air quality and meterological data procurement of emergency supplies and equipment, and health surveillance. Close monitoring of the haze situation through data collection is essential to provide feedback on the health advisory issued and the mitigation measures implemented.

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Table 1
Ambient air quality standards for Thailand and the United States ($\mu g/m^3$)

Pollutant	Averaging Time	Thailand	United States
PM_{10}	24-hour average	120	150
	annual average	50	50
Lead	monthly average	1.5	-
	quarterly average	-	1.5
CO	1-hour average	50000	40000
	8-hour average	20000	10000
NO_2	1-hour average	320	-
	annual average	-	100
SO_2	1-hour average	300	365
	annual average	100	80
Ozone	1-hour average	200	235

Table 2
Percent change in mortality and morbidity (daily admissions, daily symptoms) from respiratory and cardiovascular diseases per 30 μg/m³ increase in PM_{10} in Bangkok and some selected cities

(a) Mortality

	General population	Persons with respiratory diseases	Persons with cardiovascular diseases	Elderly
Bangkok, Thailand	3.0	16.4	4.3	3.3
Philadelphia, USA	3.6	10.2	5.2	5.2
Santiago, Chile	3.0	3.9	2.4	2.7

(b) Daily hospital admissions

	All ages		Elderly	
	Respiratory diseases	Cardiovascular diseases	Respiratory diseases	Cardiovascular diseases
Bangkok, Thailand	11.0	5.3	17.6	7.6
Detroit, USA	-	-	4.7	2.1
Toronto, Canada	13.2	1.1	-	1.1

(c) Daily respiratory symptoms

	Adults		Children	
	Upper respiratory symptoms	Lower respiratory symptoms	Upper respiratory symptoms	lower respiratory symptoms
Bangkok, Thailand	26	19	12	13
Los Angeles, USA	NS	23	-	-
Provo, USA	-	-	11	16

NS = not significant

Table 3
Monthly 24-hour average of PM_{10} ($\mu g/m^3$) in Hatyai, 1996 and 1997.

	1996	1997
January	-	43
February	-	43
March	-	45
April	28	45
May	34	34
June	60	60
July	-	32
August	54	-
September	48	69
October	48	38
November	41	31
Dec	32	28
Average	43	43

Table 4
Monthly 24-hour average of other gas pollutants in Hatyai, 1996 and 1997.

Month	CO (ppm)		NO_2 (ppb)		SO_2 (ppb)	
	1996	1997	1996	1997	1996	1997
January	-	0.4	-	5	-	2
February	-	0.4	-	5	-	3
March	-	0.3	-	8	-	2
April	0.5	0.4	6	3	2	2
May	0.5	0.4	5	4	3	2
June	0.7	0.7	7	7	2	1
July	0.6	0.8	10	13	3	4
August	0.4	0.6	9	10	4	4
September	0.3	1	9	11	3	4
October	0.3	1	8	8	2	3
November	0.3	0.5	8	6	4	2
Dec	0.2	0.3	7	5	4	1

Table 5
The 5 leading causes of outpatient (OPD) visits and inpatient (IPD) admissions in southern Thailand, 1996-97

Rank	Diagnosis group	Percent
	OPD visits	
1	Respiratory diseases	30
2	Digestive system diseases	12
3	Eye/Skin diseases	10
4	Infectious diseases	7
5	Musculoskeletal system diseases	6
	Others	35
	IPD admissions	
1	Pregnancy-related conditions	23
2	Respiratory diseases	14
3	Infectious diseases	13
4	Digestive system diseases	8
5	Accidents	6
5	Cardiovascular system diseases	6
	Others	30

Table 6
Changes in respiratory disease morbidity in southern and upper northern Thailand and the net health impacts from the haze, September-October 1997

	South	North	% net haze impacts	P-value [1]
OPD visits				
All respiratory diseases	26	18	8	<0.01*
IPD admissions				
All respiratory diseases	33	26	7	<0.01*
Pneumonia	36	18	18	<0.01*
Bronchitis/COPD	40	28	12	0.01*
Asthma	12	9	3	NS

[1] Chi-square goodness of fit test, using contingency table analysis (2 ×2) for each condition * Significant NS = Not significant

Table 7
Regression analysis of monthly respiratory illness with PM_{10} levels and weather variables in southern Thailand, 1997

	R^2	Coefficient	P-value
OPD visits			
All respiratory diseases	0.32		
PM_{10}		1372	0.21
Relative humidity		2420	0.54
Temperature		-1506	0.33
IPD admissions			
All respiratory diseases	0.53		
PM_{10}		85	0.07
Relative humidity		305	0.08
Temperature		-76	0.90
Pneumonia	0.80		
PM_{10}		28	0.02*
Relative humidity		178	0.002*
Temperature		-96	0.54
Bronchitis/COPD	0.45		
PM_{10}		13	0.04*
Relative humidity		14	0.50
Temperature		7	0.92
Asthma	0.64		
PM_{10}		13	0.006*
Relative humidity		-7	0.60
Temperature		-25	0.64

* Significant

Table 8

Changes in outpatient visits and hospital admissions for respiratory illness and the net health impacts from the 1997 haze, Hatyai, September-October 1997

	% change	% net Haze impacts	P-value [1]
OPD visits			
All respiratory diseases	11	7	<0.01
URTI	19	15	<0.01
Pneumonia/acute bronchitis	-4	-8	<0.01
Bronchitis/COPD	12	9	NS
Asthma	2	-1	NS
Reference	4		-
IPD admissions			
All respiratory diseases	8	1	NS
Pneumonia/acute bronchitis	11	4	NS
Bronchitis/COPD	56	49	0.01
Asthma	-7	-14	NS
Reference	7		

[1] Chi-square goodness of fit test, using contingency table analysis (2 × 2) for each condition

NS = Not significant

Table 9
Regression analysis of daily outpatient visits for respiratory diseases with PM_{10} levels and weather variables in Hatyai city, September-October 1997

OPD visits	R^2	Coefficient	P
All respiratory diseases	0.08		
PM_{10}		0.2	0.05*
Relative humidity		-0.5	0.66
Temperature		3.1	0.70
URTI	0.12		
PM_{10}		0.2	0.02*
Relative humidity		-0.9	0.35
Temperature		0.3	0.96

* Significant

Table 10
Changes in the age distribution among hospital outpatient and inpatients in Hatyai during September-October 1997

	% change	% net haze impacts	P-value [1]
OPD visits			
<5 years of age	11	2	NS
Reference	9		
≥60 years of age	7	-2	NS
Reference	9		
IPD admissions			
<5 years of age	-2	-8	0.05
Reference	6		
≥60 years of age	5	3	NS
Reference	2		

[1] Chi-square goodness of fit test, using contingency table analysis (2 × 2) for each condition
NS = Not significant

Table 11
Changes in hospital mortality in Hatyai during September-October 1997

	% change	% net haze impacts	P-value [1]
All causes	5	5	NS
Deaths from cardiovascular diseases	7	7	NS
Death from respiratory diseases	30	30	NS
Reference	0.1		

[1] Chi-square goodness of fit test, using contingency table analysis (2 × 2) for each condition

NS = Not significant

Figure 1
Map of Southern Thailand

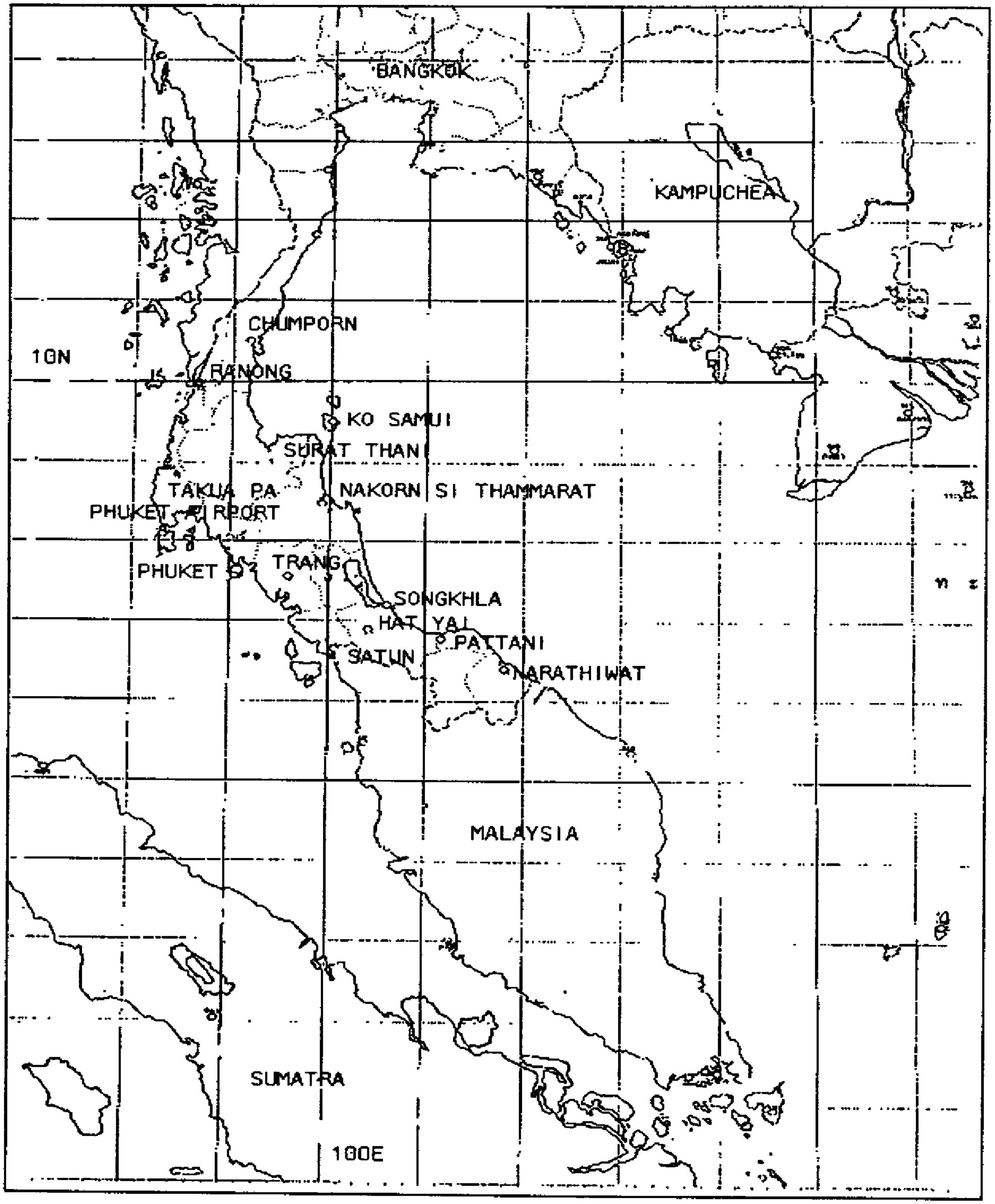

Figure 2
Monthly surface meteorological observations for Hat Yai in 1996 and 1997 compared with the 30-year mean

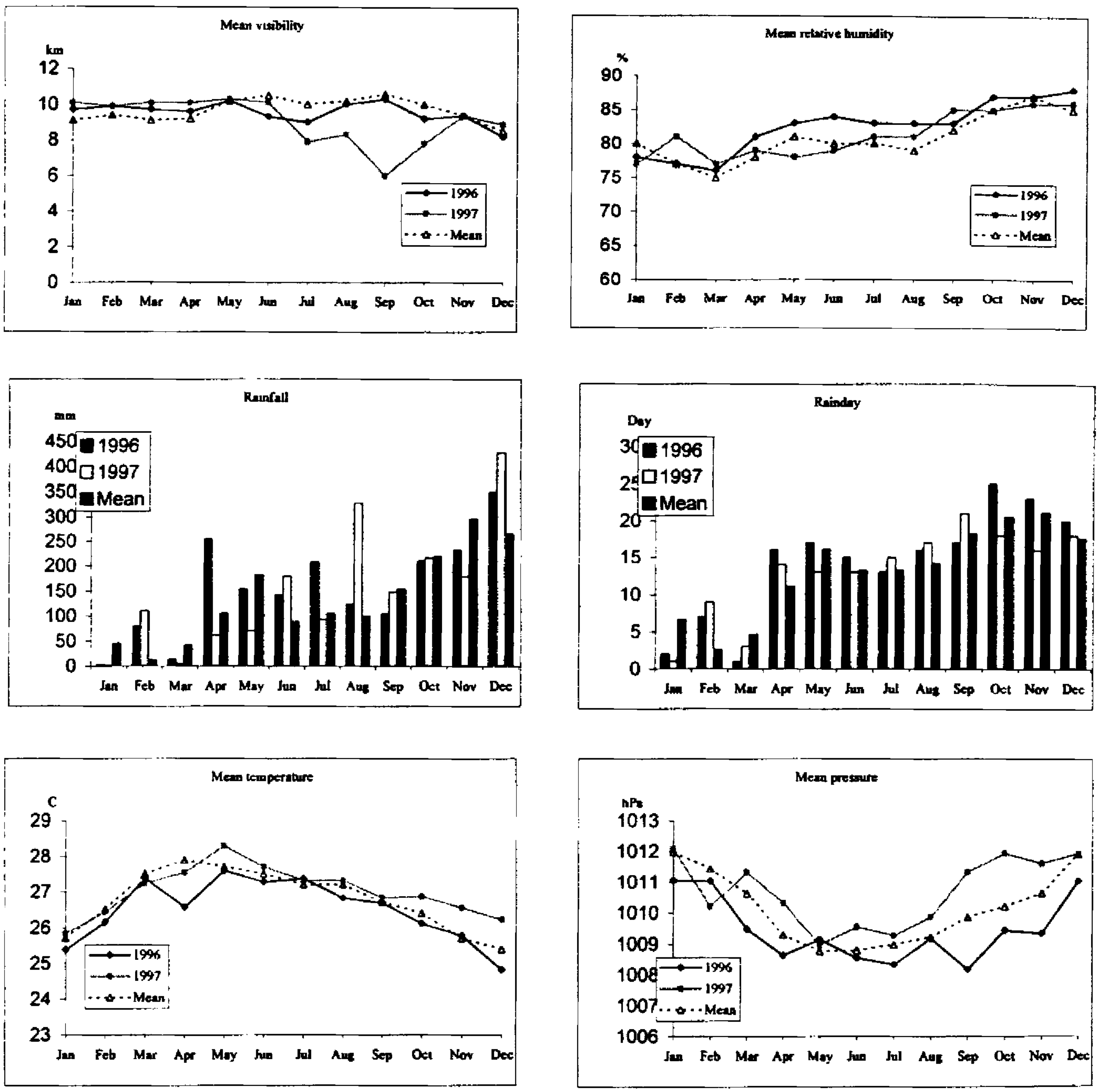

Figure 3
Daily surface meteorological observations for Hat Yai in the months of September and October 1996 and 1997.

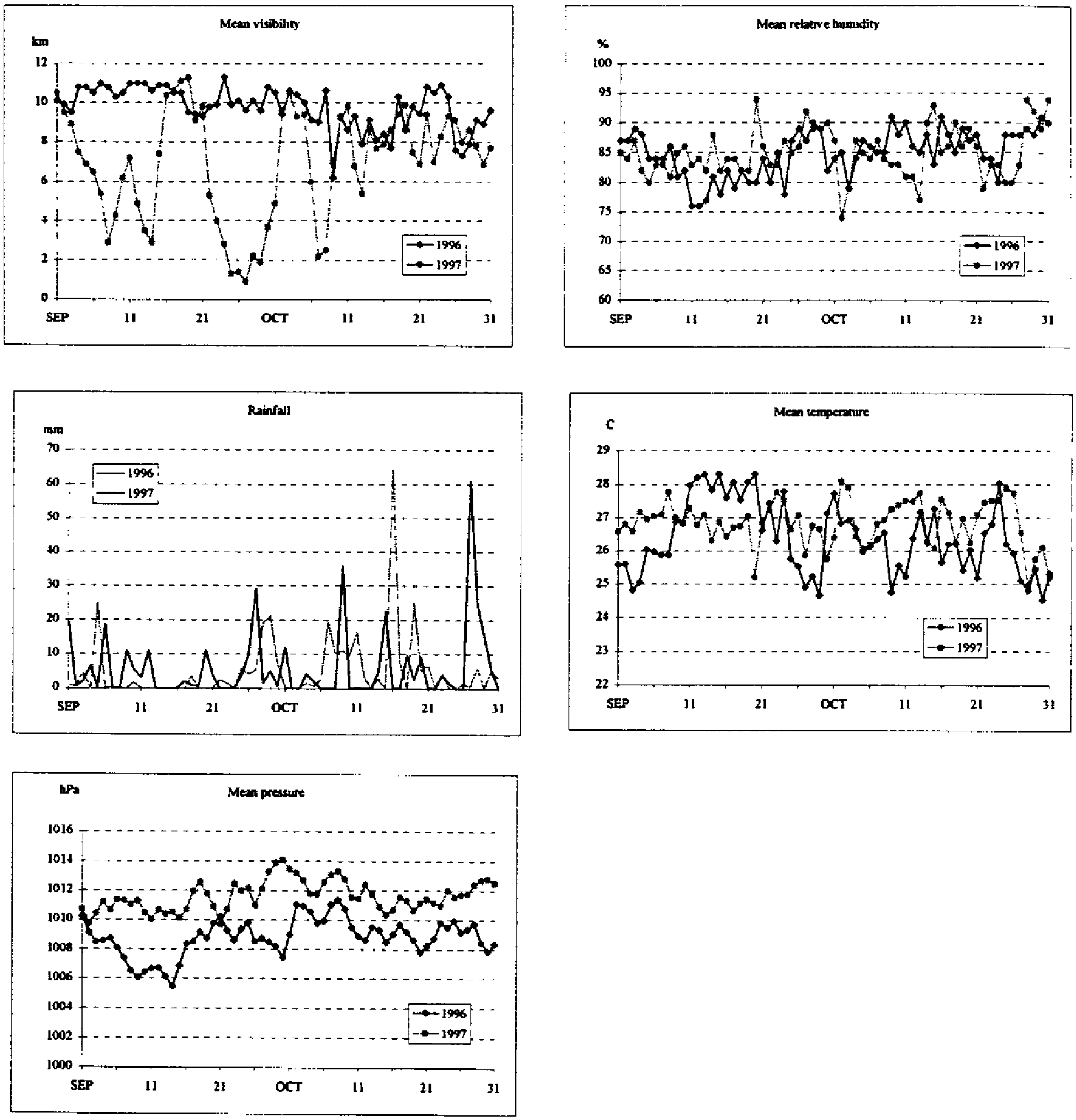

Figure 4
10-day wind rose analysis for Hat Yai, September–October 1997.

HAT YAI

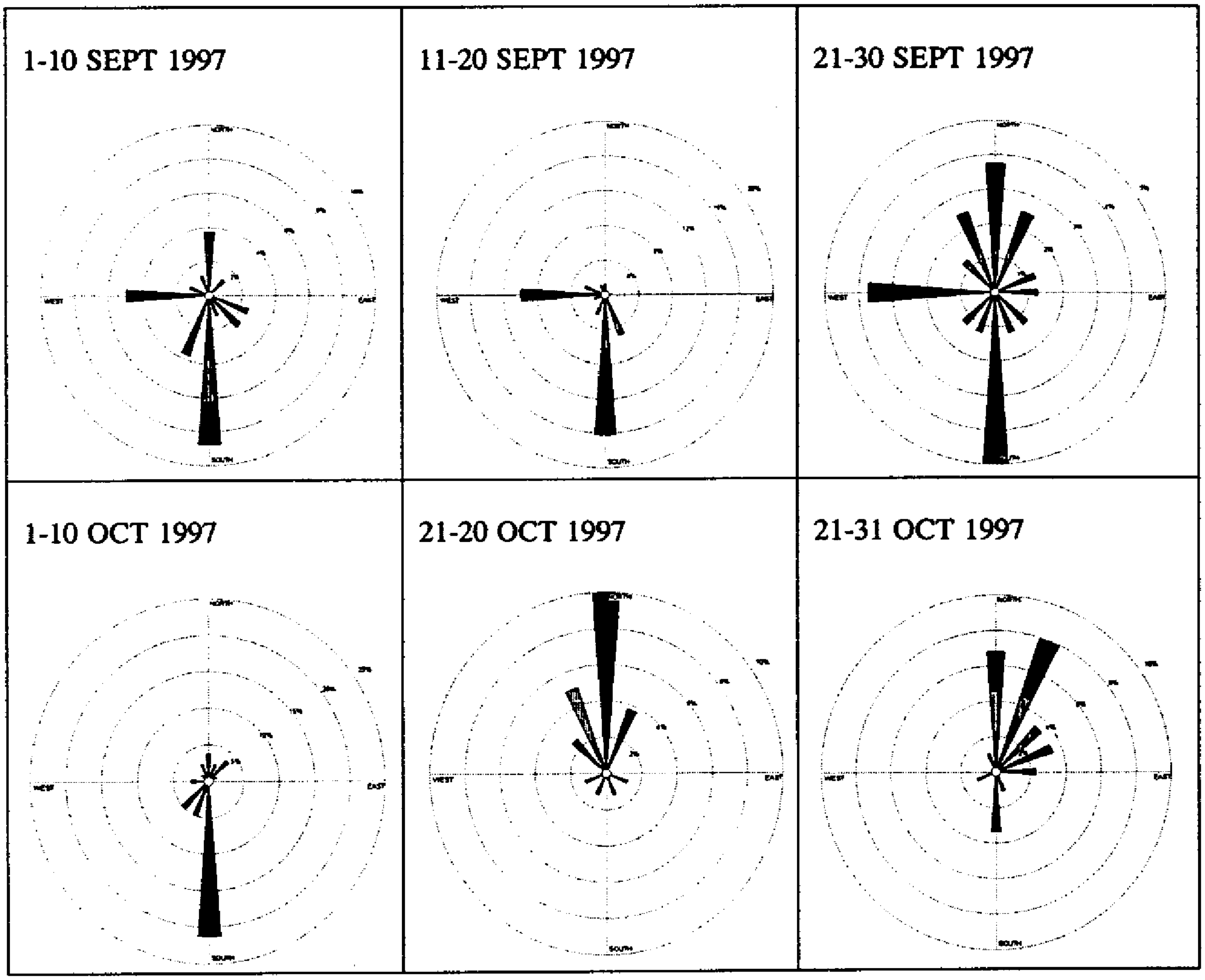

Figure 5
Wind circulation at 600 metres above sea level on 23 September 1997.