WORLD METEOROLOGICAL ORGANIZATION
GLOBAL ATMOSPHERE WATCH

No. 131

WMO Workshop on Regional Transboundary Smoke and Haze in Southeast Asia (Singapore, 2-5 June 1998)

Volume 1

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WMO TD - No. 948

TABLE OF CONTENTS

Executive Summary

The World Meteorological Organization (WMO) organized a regional workshop on transboundary smoke and haze in Southeast Asia as part of its continuing response to forest fire episodes which caused widespread air pollution and environmental problems throughout the region. The workshop was held in Singapore from 2 to 5 June 1998, hosted by the Meteorological Service of Singapore and co-sponsored by the Asian Development Bank. Representatives from the National Meteorological and Hydrological Services (NMHSs), the ASEAN Specialized Meteorological Center (ASMC), Regional Specialized Meteorological Centers (RSMCs), and other agencies and organizations that are involved with fire-related activities, as well as invited experts, were in attendance.

The meeting focused on the 1997/98 smoke and haze episodes which interfered with civil aviation operations, maritime shipping, agricultural production, and the tourist industry. They also affected the health of populations in the region. The workshop was designed to foster regional and international cooperation through the review of what has been learned during the latest fire season, and to plan and coordinate implementation activities aimed at improving the NMHS's ability to manage transboundary smoke and haze episodes. This included discussions of regional plans such as the WMO Programme to Address ASEAN Regional Transboundary Smoke (PARTS) and the Regional Haze Action Plan (RHAP).

The workshop concentrated on operational aspects with emphasis on:

- The assessment of the current measurement systems and possible improvements to enhance regional capability in support of health and environmental assessments of smoke and haze effects;

- The regional capabilities to provide meteorological support during episodes of severe smoke, including the improvement of daily smoke trajectory and dispersion forecasts from the Atmospheric Transport Models (ATMs);

- The role of remote sensing in detecting and tracking fires, plumes, and aerosols and other emitted pollutants;

- Improvements in information exchange and coordination of activities among national authorities, NMHSs and international and regional agencies concerned with smoke and haze and other transboundary pollution events.

One major lesson learned from the Southeast Asian fire episodes is that smoke and haze do not recognize national boundaries. The fires last year were exacerbated by the El Niño related drought in the region which provided favourable conditions for large scale fires. It was also evident that the Meteorological Services played a critical role in the response to the smoke and haze problems. They contributed in valuable ways through:

(i) Daily meteorological monitoring and forecasting.
(ii) Specialized activities, that included hot spot identification using satellite imageries, haze trajectory modelling, compiling monthly and seasonal climate prediction information, and enhanced air quality monitoring activities.
(iii) The prompt dissemination of haze and smoke information to governmental agencies and the general public.

The fires of 1997/98 were looked at in comparison with earlier events. Records show that there have been at least nine widespread smoke and haze episodes in the region since the 1970s, occurring most frequently during El Niño periods. It is very likely that widespread smoke and haze episodes will occur again, especially as present plans call for continued large scale land conversion. Thus there is a pressing need for developing and implementing haze-related action plans.

The role of the Meteorological Services during the fire episodes is crucial. It is therefore important to strengthen their capacities for providing the timely warnings and forecasts needed to anticipate risks of future widespread smoke and haze episodes, and assist decision makers in managing these episodes. Towards this end, the following recommendations were developed at the workshop.

RECOMMENDATIONS

The workshop formulated recommendations on modelling (A), remote sensing (B), measurements and monitoring (C) and information exchange (D).

A. Modelling. Enhance the regional capabilities to provide meteorological support in the form of improved predictions of ENSO/climate variability, daily smoke trajectories and dispersion forecasts by the use of Atmospheric Transport Models (ATMs), through:

(a-1). Improvement of regional climate prediction capabilities to interpret global forecasts.

(a-2). Development of flexible, situation-dependent programmes which allow for the provision of enhanced meteorological measurements (expanded frequency and spatial coverage) during periods of severe smoke and haze, and expanded use of satellite-derived meteorological products as input to models.

(a-3). Installation of trajectory/dispersion modelling capabilities at local meteorological services and utilization of local area modelling (LAM) capabilities in the region.

(a-4). Improvement of model performance through case studies and by conducting dry run exercises and possible tracer experiments.

B. Remote sensing. Improve the ability to characterize fire activity and track the movement of smoke and haze by strengthening present remote sensing capabilities by:

(b-1). Improvement of the operational aspects through provisions for back-up hot spot analysis capabilities, harmonization of fire counts by use of a single detection algorithm, through real time transmission of high resolution data on fires derived from satellites, and efforts to verify fire counts and bum-area information through ground-truthing activities.

(b-2). Expanded efforts to estimate aerosol and trace gas emissions from fires by combining fire counts with burn-area, along with a better characterization of sources in the diverse eco- and land-use systems.

(b-3). Promotion of the development of the next generation of satellites. This includes the need for a new NOAA channel-3 detector optimized for fire studies, dedicated fire satellites to monitor fires more precisely, and the use of space-borne radar for burned area and vegetation dryness assessment, and of lidar systems to measure the vertical distribution of trace gases and aerosols.

C. Measurements and monitoring. Strengthen regional monitoring efforts to assess the effects of smoke and haze on human health, to evaluate ecosystem impacts, to help validate atmospheric transport models, and characterize emission sources, by:

(c-1). Enhancement of existing monitoring networks to measure smoke and haze related quantities including aerosol mass (PM2.5, PM10), visibility, optical depth, and meteorological parameters. Two levels of observing stations are envisaged, a base level comprising fewer measurement parameters but with a high level of consistency across the network, and a second level with a more comprehensive measurement suite. At selected sites, targeted chemical quantities including aldehydes and other trace pollutants (CO, O_3, NO_x, VOCs, CO_2, SO_2), aerosol composition, and UV radiation are to be measured.

(c-2). Establishment of additional, including population-based, monitoring stations in areas not presently covered by existing networks (e.g., Kalimantan).

(c-3). Promotion of the scientific exchange of the validated measurement data, and the harmonization of the regional air pollution indices (API) used in regional smoke and haze alerts.

(c-4). Formulation of uniform protocols for sampling, including temporal resolution and reporting procedures. Expanding efforts directed at improvement of QA/QC, building upon the WMO/GAW programme components.

D. Information exchange. Improve the management of smoke and haze (and other transboundary) pollution events through efforts directed at enhanced information exchange and coordination, including:

(d-1). Enhancement of the current system for dissemination of data products and other relevant information, through the use of the GTS for meteorological data and gridded model outputs, and the Intranet and/or Internet systems for non-standard products.

(d-2). Increase the exchange of relevant information including meteorological data (especially rainfall), air quality data (including air pollution indices), and trajectory and plume forecasts. A critical element is the harmonization of data and output products to support effective real-time decision making.

(d-3). Coordination of emergency response responsibilities and activities between national Meteorological Services in the region, with the primary responsibility for the provision of information and forecasts to reside with the ASMC, but with the option of seeking further input from other RSMCs, and with provisions for bilateral arrangements.

(d-4). Improvements in existing mechanisms to regularly review the operational coordination between the NMHSs and activities related to the Regional Haze Action Plan, and to recommend changes and/or improvements to the plans.

(d-5). Development of linkages between the Meteorological Services and other national, regional and international organizations and scientific programmes with common interests, such as (IGBP/IGAC).

It was recognized that large-scale forest fires and the associated socio-economic and health-related problems occur frequently in other parts of the world as well, notably in South and Central America and Africa. It was recommended, therefore, that the deliberations of this workshop be reviewed by the organizations concerned in those regions. It was further strongly urged to organize as soon as possible an expert-level meeting to address the current situation in South and Central America.

The workshop concluded with a plenary session which was joined by a delegation from the Biregional Workshop on Health Impacts of Haze-Related Air Pollution, organized by the WHO Regional Office for the Western Pacific, held in Kuala Lumpur, Malaysia, during 1-4 June 1998. The objectives of that meeting were to: Review haze-related air pollution problems and research findings; Identify further research needs to support haze-related decision-making; and Develop health protection measures/strategies. That workshop concluded that the haze episodes constituted a substantial health risk to the public as evidenced by the widespread exceedances of health-related air quality standards and guidelines for particulate matter (PM10 and PM2.5), increased frequency of respiratory-related hospital visits in the most heavily impacted regions; increased frequency of attacks among asthmatic children; and reported persistent decreases in lung function among school children. The risk of long term health effects from these events is much more difficult to discern.

The representatives at the WMO workshop recognized that the set of recommendations developed by the WHO and WMO workshops are complementary, and strongly encouraged closer cooperative activities between the meteorological and health related aspects of transboundary pollution.

1. OVERVIEW OF THE MEETING

The Workshop on Regional Transboundary Smoke & Haze in South-East Asia was organized by the World Meteorological Organization (WMO) as part of its continuing response to forest fire episodes which caused widespread air pollution and environmental problems throughout the region. The workshop held in Singapore from 2 to 5 June 1998, and hosted by the Meteorological Service of Singapore and co-sponsored by the Asian Development Bank, brought together more than 50 participants from thirteen countries (Figure 1), including: the WMO Secretary General, the directors/heads of the National Meteorological and Hydrometeorological Services (NMHSs) in Brunei, Indonesia, Papua New Guinea, Malaysia, and Singapore and their representatives; representatives from NHMSs of the Philippines, Brazil, the United States, Denmark, and Australia; the director and section heads from the ASEAN Specialized Meteorological Center (ASMC); scientists from the Regional Specialized Meteorological Centers (RSMCs) in Australia, Japan and the United States; the WMO Secretariat; other UN agencies including WHO, UNEP, UNDP; the ASEAN Secretariat; other organizations that are helping countries to address the smoke and haze and related transboundary pollution issues, including the Canadian High Commission, Japan International Cooperative Agency (JICA); and invited experts from universities, NASA, the Max Planck Institute for Chemistry, and the Center for Disease Control and Prevention. The meeting programme is in Annex A. The list of participants is presented in Annex B. A list of the papers are given in Annex C. A list of acronyms and abbreviations is found in Annex D.

The workshop focused on the 1997 smoke and haze episode which interfered with civil aviation operations, maritime shipping, agricultural production, and the tourist industry. It also affected the health of populations in the region. The workshop was designed to further foster regional and international cooperation through the review of what was learned during the 1997 fire season, and to plan and coordinate implementation activities aimed at improving the NMHS's ability to manage transboundary smoke and haze episodes. This included discussions of regional plans such as the WMO Programme to Address ASEAN Regional Transboundary Smoke (PARTS) and the Regional Haze Action Plan (RHAP).

Coincident with this workshop, a Regional Meeting on the Health Impacts of the Fires, sponsored by WHO and held in Kuala Lumpar took place. Representatives from the WMO workshop attended the opening day of the WHO meeting, and representatives from the WHO workshop attended the closing session of the WMO meeting. This provided the opportunity to share workshop recommendations and to discuss possibilities of closer collaborative activities. A proceedings containing the papers presented and/or submitted to the workshop is contained in Volume 2 of this report.

1.1 Opening Ceremony

1.1.1 Welcoming Address

Mr. Woon Shih Lai, Director of the Meteorological Service of Singapore (MSS) and host of the meeting gave the Welcoming Address. He observed that in recent years, climate change has been one of the major concerns among the general public, scientists as well as the politicians. He mentioned that although the recent smoke and haze incidents have received global attention, the region has in fact been affected by the recurrence of such events for years. Since the 1994 episode, 4 years ago, the NMHSs within the region have agreed on a joint surveillance procedure to watch for large-scale land and forest fires. The arrangement was to provide a better support to the environmental agencies in the region with a view to reduce the transboundary pollution incidents. Such collaboration has been further strengthened last year and again early this year.

Figure 1: Group photo of workshop participants.

Mr Woon Shih Lai commended WMO for taking the initiative to organize this important workshop. He closed by stating that with contributions of all these distinguished participants, that there will be a very fruitful exchange of ideas and the region should emerge better prepared to help prevent or reduce future haze incidents. The full text of this address can be found in Volume 2 to this report.

1.1.2 Keynote Address

Professor G.O.P. Obasi, Secretary-General of WMO delivered the Keynote address. He expressed his appreciation and gratitude to the Government of Singapore for hosting this very timely workshop and thanked Mr. Woon Shih Lai, Director of the Meteorological Service and Permanent Representative of Singapore with WMO, for the excellent arrangements made to ensure the success of this workshop. He stated that WMO is very pleased that the Singapore Meteorological Service and the Asian Development Bank have co-sponsored the workshop. The workshop offers an excellent forum for scientists from the National Meteorological Services and other organizations in the region and around the world to freely exchange ideas on what needs to be done at national, regional and international levels to ensure preparedness, early warnings and minimization of the hazards of a future forest fire.

Professor Obasi stated that he looked forward to receiving the priority action items and proposals for their implementation, and assured the attendees that WMO will do what it can, and where necessary in close cooperation with partners, to implement the proposed actions. Prof. Obasi's full address can be found in Volume 2 to this report.

1.1.3 Opening Address

Dr. John Chen, Minister of the State for Communications, Singapore, presented the Opening Address. He emphasized that an important lesson from the recent smoke and haze episodes was that weather and climate do not recognize national boundaries. The region must therefore be better prepared in the future to handle similar situations. In line with that, the ASEAN member countries have agreed to implement a Regional Haze Action Plan to address the problem of forest fires and the resulting transboundary smoke and haze pollution. He stated that Singapore is committed to play an active role in this Action Plan, in particular to engage in monitoring and surveillance functions such as to collect, analyze and disseminate information.

Given the potential of recurrence and the seriousness of the problem, Dr Chen was encouraged to see that WMO has been proactive in organizing this forum so that experts from within and outside the region can contribute and help the region to be better prepared in handling transboundary smoke haze problems. He closed by stating that Singapore was pleased to work with WMO to host this workshop and wished everyone success in the deliberations. Dr. Chen's complete address can be found in Volume 2 to this report.

1.2 WMO Overview

Ms. Liisa Jalkanen, WMO Secretariat reviewed the meeting agenda (Annex A) and Dr. John Miller and Mr. Dieter Schiessel, also representing WMO presented overviews of WMO activities and general guidance on the purpose and goals of the meeting.

Dr. John Miller, Chief of the Environment Division, Atmospheric Research and Environment Programme Department (AREP) began by giving an overview of the Global Atmosphere Watch (GAW) programme. Within the United Nations system the World Meteorological Organization has a continuing responsibility for providing authoritative scientific information and advice on the state and behaviour of the earth's atmosphere and climate using a number of its operational observation networks, one of which is GAW. The GAW system is designed to co-ordinate two related atmospheric chemistry environmental problems: 1) To understand the relationship between changing atmospheric composition and changes of global and regional climate 2) To describe the regional and long-range atmospheric transport and deposition of natural and man-made substances. The goal of GAW is to ensure long-term measurements and related assessments.

The GAW consists of a Global network of currently 22 stations in pristine areas, which measure key variables and serve as standards for other stations in their region. In addition, a Regional network of about 300 stations making atmospheric chemistry measurements are located closer to the source areas. The national meteorological and hydrological services (NMHSs) and other national institutes are responsible for the sampling in the GAW programme. In substantial efforts to broaden the GAW network coverage, six new Global stations have been recently established in collaboration with the United Nations Development Programme (UNDP) and supported through the Global Environment Facility (GEF). One of these stations, Bukit Koto Tabang, Indonesia, provided valuable information during the 1997 smoke and haze episode.

The complete measurement programme for Global stations includes greenhouse gases (CO_2, CFCs, CH_4, N_2O, tropospheric O_3), ozone (surface, total column, vertical profile), solar radiation including ultraviolet UV, reactive gas species (SO_2, NO_x, CO, VOCs), chemical composition of precipitation, chemical and physical properties of atmospheric particles (including optical depth), radionuclides and meteorological parameters. To ensure the required quality of data a number of measurement manuals have been and are being prepared and a data quality assurance/quality control (QA/QC) plan for GAW has been recently developed.

To collect, process, analyse and distribute data obtained from the GAW stations, WMO has established World Data Centres: for ozone and UV radiation (Canada), surface ozone (Norway), greenhouse and other trace gases (Japan), precipitation chemistry (USA), solar radiation (Russia) and on aerosols (EU, Italy). The GAW data are available directly from the Centres upon request to all organizations, scientific institutions and individual scientists.

Scientific Advisory Groups (SAG) have been formed to give scientific guidance for the different components of GAW to complete the range of specifications and tools for observation and management, including quality assurance. The activities of the SAG on UV Radiation, SAG on Ozone and the Aerosol SAG are most closely tied in with the smoke and haze episodes. For instance, according to present knowledge the most hazardous emissions from fires on human health are aerosols. The Aerosol SAG has identified stations that have the potential to monitor biomass burning.

For many of WMO Member countries, a major environmental problem is urban/regional air quality. This is particularly true in developing countries where there has been an explosive growth of urban pollution which, in addition to the direct impact on the local environment, affects the surrounding regions. It is clear that urban activities, when taken collectively, have a profound impact on the environment at all scales, including global. It is also in urban/regional areas, where people have suffered from the transport of smoke and haze on various scales.

Many of the WMO Members need to develop skills and expertise required to manage their environment and natural resources in a sustainable manner. To assist, the GAW has introduced education and training activities which are centered around atmospheric chemistry. Participating with WMO are a number of non-governmental, international research, multinational and governmental organizations. The transfer of expert knowledge and technology, a vital aspect of GAW, is accomplished through academic capacity building for developing countries especially by encouraging twinning or long-term partnership. Training is also accomplished through workshops and special tutorial events.

All of the above GAW activities are directly relevant to monitoring the chemical emissions from smoke and haze episodes. The AREP department of WMO has played a very active role in the fires issue in Southeast Asia. An overview of national and regional capabilities to detect, monitor and track smoke and haze, and modelling and satellite capabilities was obtained during the visit in 1996 of Dr. Bolhofer and Prof. Carmichael, who are present at this meeting. This resulted in the Programme to Address ASEAN Regional Transboundary Smoke (PARTS) proposal. During the 1997 fires episode, there was an expert visit from the Secretariat to the region. As a result of these activities and requests from the WMO Members in the region, this workshop has been organized.

Mr. Schiessl, Director, Basic Systems, reviewed the WMO co-ordinated emergency response activities related to large-scale fires and presented specific meeting objectives in this regard. He stated that the current WMO emergency response activities were originally implemented under WMO's World Weather Watch Programme to provide meteorological support in case of nuclear accidents. During the forest fire episodes WMO co-ordinated several emergency response activities.

1. WMO supports, under the technical responsibility of its Commission for Basic Systems and as part of the World Weather Watch Programme, the Emergency Response Activity programme. This programme has developed and implemented global and regional arrangements for the generation and dissemination, under emergency conditions, of atmospheric transport model forecast products.

2. These arrangements were originally developed in co-ordination with the IAEA to provide meteorological information for use by national meteorological services in case of nuclear incidents. WMO has designated eight Regional Specialized Meteorological Centres (Beijing, Bracknell (UK), Melbourne, Montreal, Obninsk (Russian Federation), Tokyo, Toulouse, Washington D.C.) which have implemented contingency plans for the provision of products on request to associated national meteorological services and relevant international organizations. The arrangements and the product quality and suitability are verified annually in internationally co-ordinated exercises. In addition to these RSMCs, several other meteorological centres in WMO Member countries have also, partially under national requirements, developed an equivalent emergency response and forecast capability.

3. During the SE-Asian fire episode, and resulting from bilateral collaboration with the SE-Asian countries concerned, the RSMCs Melbourne, Toulouse and Washington and the ASMC Singapore (ASMC Singapore is a centre with geographical specialization designated under the WWW Programme of WMO), used their expertise and experience acquired through their involvement in the WMO Emergency Response Activity programme to apply their transport models for forecasting smoke/haze dispersion. The products were made available on their Internet Web servers. The information also included processed satellite images to help identify the hot spots and the smoke/haze distribution.

4. However, this specific forecast methodology was not set up for use in the situation of wide-spread fires, and the actual forecast accuracy was difficult to assess since the actual fire sources and their emissions rates were not adequately and timely known to the RSMCs involved.

5. Experts conclude therefore, that efforts are needed to modify the atmospheric transport models, and to better adjust the content and format of the output products to the needs of the users. It is also to be expected that a requirement will emerge for additional observational data that will be needed to drive the models. This will likely include meteorological surface and upper-air measurements, data derived from satellite remote sensing information and source data on the fires (hot spots). These aspects need to be addressed by experts in order to define the corresponding requirements and to develop the associated operational arrangements for generation and exchange of the additional data.

6. The mechanisms for requesting meteorological support and the means to access the information provided, also need improvement. The latter can be achieved through the clear definition and co-ordinated implementation of efficient emergency response procedures which build on, or include, the pertinent activities and experiences stemming from the last fire episodes both in SE-Asia and in the Amazon area.

7. With respect to the use of the atmospheric transport models, WMO held, inter alia, an expert meeting in April 1998, which addressed this issue with emphasis on chemical incidents. Certain results of that meeting, mainly related to additional observational data, may be relevant.

8. In addition to the above, WMO has implemented an arrangement for providing to UNEP/OCHA an agreed set of meteorological information needed for its aid and rescue operations. As the first responsibility for the provision of such information rests with the country concerned, WMO and UNEP/OCHA have set up a list of national contact points to which OCHA would direct its request for information. A backup arrangement has been developed in the case that a country is unable to satisfy the request. To this end, about 30 NMHS of WMO can be approached according to an established list specifying the geographical responsibility of each RSMC.

Mr Schiessl then presented to the participants specific aspects that should be studied in order to modify and improve the existing WMO emergency response activities with a view to implementing arrangements and procedures that are tailored to meet the specific requirements of the region in emergency situations related to transboundary smoke and haze. These included: (1) Review and consolidate the requirements for the provision of meteorological support, specifically Atmospheric Transport Model (ATM) output and evaluation of satellite data; (2) Develop the requirements for more R&D work, e.g., on the ATM, and assess the possibilities (who, what, when, resources); (3) Study the need for (additional) observational data, including meteorological data (surface, upper-air, other types), environmental data (e.g., air chemistry and satellite data); information on hot spots, types of fires, etc., and develop recommendations on how to generate/obtain such data; (4) Assess the requirements for tele-communication services for the exchange/dissemination of data, products and other relevant information, and develop corresponding recommendations on how to meet them; (5) Propose mechanisms for the coordination and request of emergency response support; and (6) Propose operational arrangements to be followed for the generation and dissemination of data, products and services during an emergency situation.

1.3 Overview of Fire and Smoke Episodes in Southeast Asia.

Dr. Johann Goldammer of the Fire Ecology and Biomass Burning Research Group, Max Planck Institute for Chemistry, Germany, summarized the basics of fire ecology, fire occurrence, and fire-generated smoke and haze in Southeast Asia. He also provided background information regarding international activities and projects related to fire research and management in the region. He emphasized that fire has been present in SE Asia biota since the Pleistocene, and that long-term climate variability (glacial vs. non-glacial) and short-term climate oscillations caused by El Niño-Southern Oscillation (ENSO) events have repeatedly created conditions that are conducive to widespread fires. He emphasized that fire occurs every year, but dry conditions are conducive to rapid spreading, resulting in large-scale fire episodes. The linkages between drought and large-scale fires in the region go back to narratives in 1890, and include 80,000 ha of rain forest and peat in Sabah during the drought of 1914-15, and again in 1958. The more recent record clearly shows the connection between ENSO and fire (cf, Figure 2). Large areas were burned during extended dry periods of 1982-83, 1987, 1991 and in 1994. Furthermore, while wildfires largely dominated in the past, more recent occurrences have resulted from forest and land-use clearing for agriculture and forestry. He stressed that burning the landscape whether for refuse removal or clearing, has been a land-use practice in the region for thousands of years. Drought conditions often present an opportunity to accomplish land clearing objectives which may not be possible during non ENSO conditions.

The synopsis of the 1997 fire was provided by an article, "The Assessment of 1997 Land and Forest Fires in Indonesia" by Michael Brady, in Initial Attack, the magazine for wildfire management, spring, 1998 and in the International Forest Fire News, No. 18, Jan. 1998. Based on daily hot-spot analysis, fires in 1997 began to increase in May, and reached a maximum in September (see Figure 3). Comparison of the satellite images with land-use and concession boundaries showed that most hot spots were found in tree crop plantations, followed by industrial forest plantations, with a small percentage associated with transmigration settlements and areas known to contain shifting cultivation. The dry season in 1997 extended past the normal end of September, and the dryer fuels resulted in an increase in the intensity of the fires, and faster spreading rates. The drought also allowed peatlands and standing forests to dry sufficiently to burn.

Dr. Goldammer emphasized that the fires in SE Asia were caused by humans, and occurred as a result of traditional and commercially-based burning, exacerbated by the severe and prolonged drought. Therefore while these fires are manageable and preventable, they will continue to occur until better land-use policies, which include sustainability of converted land-use, and alternatives to slash and burn and large-scale clear-cuts and burn practices, are developed and implemented. He then presented an overview of the various activities that in the region directed towards the development of policies and strategies for land-use and fire management. These are summarized in Table 1.

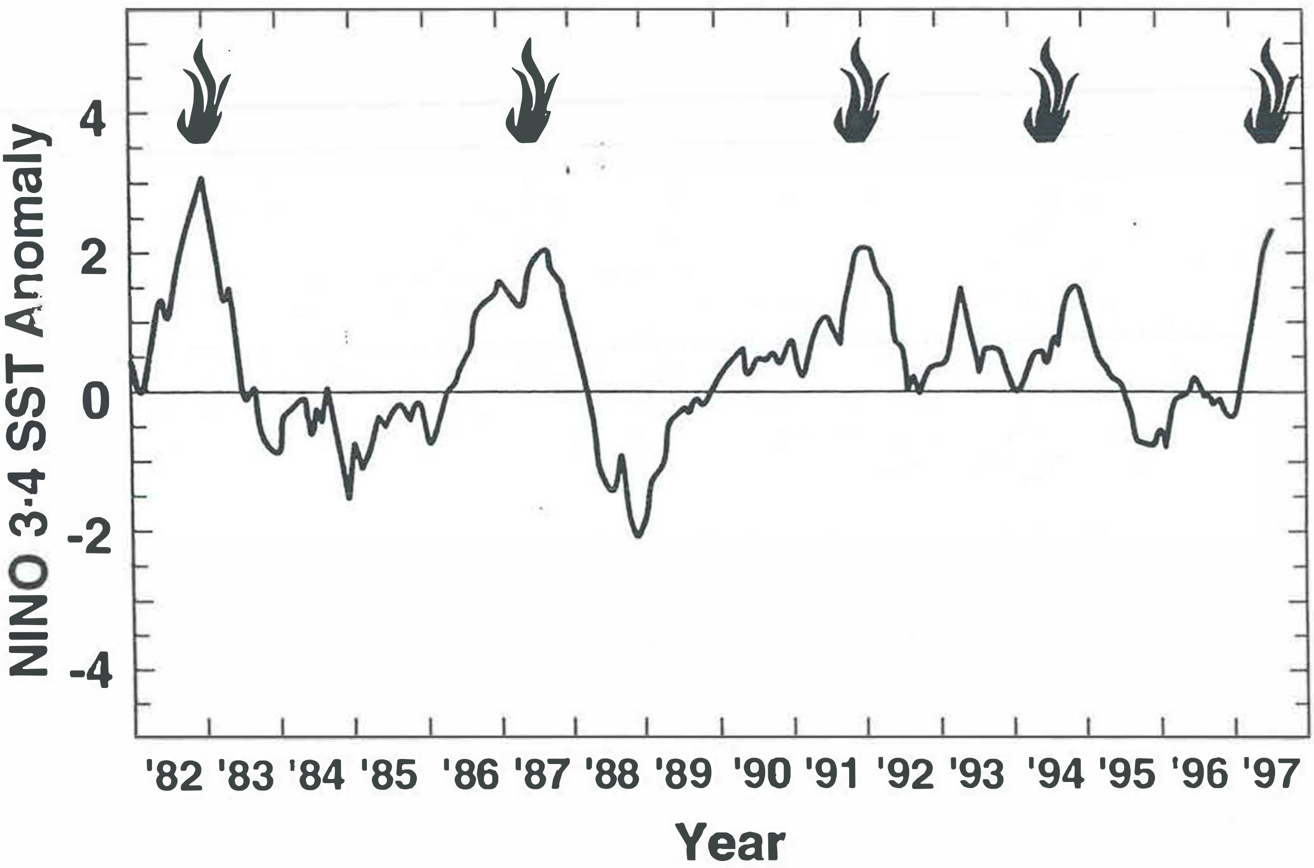


Figure 2: Relation between El Nino and burning. From J. Goldammer

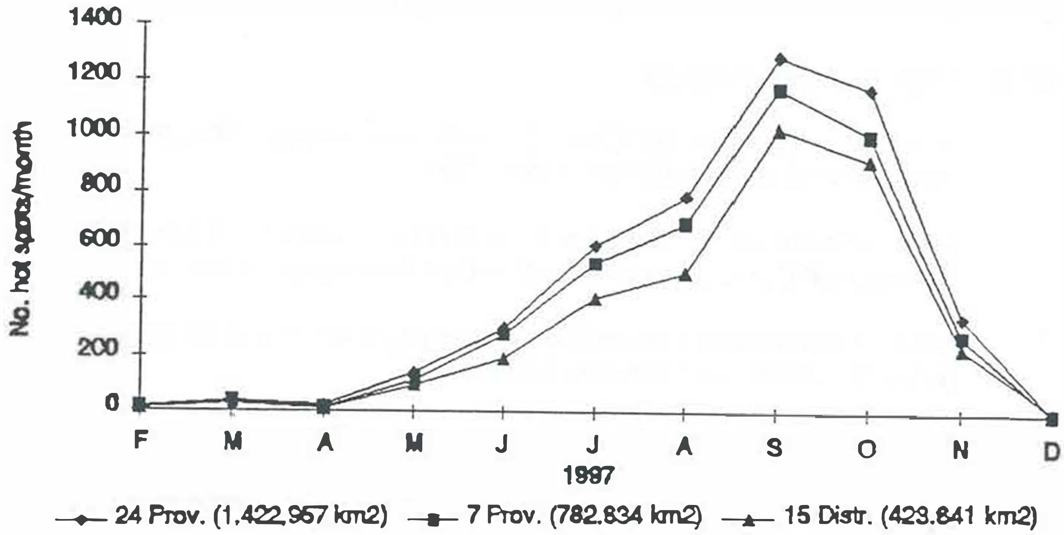


Figure 3: Pattern of hot spot occurrences in 24 Provinces and cities in western Indonesia during 1997. About 82% of the total recorded hot spots were located in seven Provinces. Moreover, about 72% were located in 15 Districts occupying an area of 423,641 km^2, or less than 30% of the total land monitored in western Indonesia.

TABLE 1

National and International Initiatives

Consequence of the 1991 Smog Episode in SE Asia:	
October 1991:	Call of the Government of Indonesia for international cooperation to support national fire management capabilities/institution building
February 1992:	Preparatory workshop in Ciloto, Java: Preparation of an international round table
June 1992:	International round table, Bandung, Java, Indonesia.
Implementation of the Bandung Strategy	
1994	A bilateral German (GTZ/KfW)-Indonesian project "Integrated Forest Fire Management" is operational (1994 - 2000)
1995+	Establishment of a "National Coordination Team on Land and Forest Fire Management" (c/o Environmental Impact Management Agency BAPEDAL)
	Japan International Cooperation Agency (JICA): Fire management projects in Sumatra (Jambi) and West Kalimantan
	European Union (EU): Forest Fire Prevention Project in Sumatra (Palembang)
	UK Overseas Development Administration (ODA): Fire Warning Project in Central Kalimantan
	Food and Agricultural Organization of the United Nations (FAO): Ministry of Forestry (Central Level)
	United States Department of Agriculture (USDA) and US AID: Fire Management Training (inter-project)
1997/98	Was there any impact of the Bandung Strategy in mitigating the effects of the fire and smoke episode?
1998+	Renewal of the Bandung Strategy as a part of a revised land-use and forest protection policy of Indonesia
History of International Cooperation in Fire and Smoke Management:	
1992:	Regional workshop on "Transboundary Haze Pollution", Balikpapan, Indonesia
1995:	Regional workshop on "Transboundary Haze Pollution", Kuala Lumpur, Malaysia

Table 1 -- continued

1996:	ASEAN Fire Forum at AIFM Conference on "Transboundary Pollution and the Sustainability of Tropical Forests", Kuala Lumpur, Malaysia
1997:	Bilateral Memorandum of Understanding between Malaysia and Indonesia to jointly tackle the haze problem and manage any other disasters (12 December 1997) Regional Haze Action Plan finalized by the ASOEN Task Force on Haze (20 December 1997)
1998:	Development of a "Fire Danger Rating System for Indonesia" (joint effort between the Canadian International Development Agency [CIDA], the Canadian Forest Service and ASEAN). (In preparation)
*	Asian Development Bank (ADB) Regional Technical Assistance (RETA) to assist ASEAN in strengthening cooperation among fire- and smoke-affected ASEAN countries (ADB grant).
*	UNEP Meeting "Coordination of UN Response to Indonesian Fires", 20-21 April 1998, Geneva
*	Establishment of SE Asian Fire Monitoring Center, sponsored by IDNDR and UN-FAO/ECE/ILO Team of Specialists on Forest Fire (Germany) as a core component of the Global Fire Monitoring Center. (see:<http:/www-uni-freiburg.de./fireglobe>)

<u>Science and Technology Programmes</u>

*	WMO-PARTS (Programme to Address ASEAN Regional Transboundary Smoke)
*	Integrated SARCS/IGBP/IHDP/WCRP Study "Human Driving Forces of Environmental Change in Southeast Asia and the Implications for Sustainable Development"
*	Upcoming National and International Research Programmes to be Conducted in the Frame of the "Indonesian Research Institute for Climate, Environment and Society" (INRICES) and the IGBP/IGAC "South East Asian Fire Experiment" (SEAFIRE)
*	Technology development , e.g. Fire / Disaster Satellite BIRD and FOCUS sensor on the International Space Station.

<u>Support by Science and Technology Planning</u>

*	Planning Meeting "Human Driving Forces of Environmental Change in Southeast Asia and the Implications for Sustainable Development", Bangkok, May 1996

Table 1 -- continued

*	International Conference on "Science and Technology for the Assessment of Global Environmental Change and its Impacts on the Indonesian Maritime Continent", Jakarta, 10-12 November 1997, which lead to the Foundation of the "Indonesian Research Institute for Climate, Environment and Society" (INRICES)
*	Synthesis Workshop on "Greenhouse Gas Emission, Aerosols and Land Use and Cover Change in Southeast Asia", Chungli, Taiwan, R.o.C., November 1997
*	Coordinated UN Response to Fires in South East Asia, UNEP, Geneva, 20-21 April 1998
*	Workshop on "Land/Forest Fires and Smoke Haze", The National University of Singapore, Singapore, 30 April-2 May 1998
*	Asia-Pacific Regional Workshop on Transboundary Pollution, Germany-Singapore Environmental Technology Agency, Singapore, 27-28 May 1998
*	WMO Workshop "Regional Transboundary Smoke and Haze in South-East Asia", Singapore, 2-5 June 1998
*	WHO Workshop "Guidelines for Forest Fire Emergencies", Lima, Peru, 5-9 October 1998
*	Second International Conference on "Science and Technology for the Assessment of Global Environmental Change and its Impacts on the Indonesian Maritime Continent", Jakarta, (scheduled for 1999)

He closed by discussing the need for further research directed towards understanding the role of fires on the biogeochemical cycles in Southeast Asia. Fires have been studied extensively using large-scale field studies in South America and Africa, but little work has been done in the SE Asia context. He described the IGAC project, South East Asian Fire Experiment (SEAFIRE), which is still in the planning stage and focuses on the interactions between fire, biogenic and industrial emissions, and the atmosphere. The merits and needs for such scientific research activities were discussed. Further details are presented in his paper in Volume 2 of this report.

2. REVIEW OF ACTIVITIES RELATED TO THE 1997 EPISODES

2.1 Country-Level Activities

2.1.1 Indonesia

Dr. Sri Diharto, Director General, of the Meteorological and Geophysical Agency of Indonesia (MGA) discussed the role of his agency in the 1997 smoke and haze event. He stated that the NMHS played a key role, and it is expected that they will continue to do so in the future. He emphasized that the role of the meteorological services is not solely during the episodes themselves, but rather should be viewed in three stages: i.e., the before, during and after stages. The before stage is concerned with early warning. His agency issues seasonal climate forecasts, and in March 1997 they released to the public an early warning of El Niño conditions, and the anticipated outcome of the potential for drought conditions throughout the country. In anticipation of a heavy fire season they set-up a coordinating team which provided daily service to the public in the form of meteorological, air quality and haze information. During the fire period they issued meteorological and climate analysis and predictions to the mass media, national and sub-national crises teams, and to the policy makers. They also coordinated their efforts with evacuation and emergency response efforts. In their smoke and haze forecast activities they relied heavily on the trajectory analysis capabilities at the RSMCs, including Australia and the USA, and the ECMWF meteorological forecasts. This information was useful and gave valuable guidance during the haze periods. This model-based information was augmented with climatological data and current meteorological and environmental data, to provide locally enhanced short-term forecasts.

He also presented a summary of Indonesia-wide actions for coping with large scale smoke and haze. The government set up the National Coordination Team for Land and Forest Management in 1995, comprised of concerned agencies, and designed to be the crises center to combat fires and haze. They also set up renewing legislation concerned with Forest Fire Management as part of a plan to minimize smoke hazards including increased efforts to prosecute those burning illegally, and action-plans to combat fires.

Dr Sri Diharto pointed out that the control and prevention of fires over large areas due to the dry environment condition might be improved through the better design of activities before the onset of the dry season. These steps should involve actions for observation of the weather and climate system including the detecting of the solar activity, analyses and processing of the current data, and the release of information as part of an early warning of the environment. This sounds relatively simple, but in reality it is a difficult task requiring data collection from several sources, the human resources capable for analyses and processing data, and modeling tools for analyses. Experience in 1997 showed that even though the information on early warnings has been disseminated through the public news paper, it didn't work properly. It is important to coordinate and communicate with those concerned with land clearing, forestry management and others especially over natural conservation or mountainous area.

Dr. Paulos Winarso of MGA elaborated on the role of the Indonesian NMHS in providing meteorological support. MGA for the last 7 years has played the major role in the management of information system on the impact of El Niño in terms of the meteorological information. Users both from the governmental and non governmental sectors have increased as El Niño's links to environmental problems such as transboundary air pollution problems over Indonesia and adjoining area have been established. The MGA was designated as the lead agency in the information system of meteorological condition, and several public media companies have requested to include their prediction in their publications. In addition MGA regularly supports agricultural activities especially for food security management of the country and public information. The agricultural sector considers the information system of weather and climate to be an important aspect for better planning of the agricultural activities and the better management of national food security.

He noted the value of sharing supporting information from several countries in advancing the regional experiences and in increasing the quality of the information. As the agency with the task to manage the operational meteorology in Indonesia, several efforts have been made to improve services through technical assistance from advance meteorological services from abroad, the participation in the workshop/seminar/training of the personnel and inviting experts in meteorological fields for promoting research and development activities. The participation in the natural disaster management for the primary source disaster from the activities of meteorological and geophysical fields is an important role in the natural disaster prevention over Indonesia. In relation with the El Niño impact, the leading agency for analyses and prediction of the meteorological parameters for the fires occurrences over Indonesia has been realized with the application of the information to drive the National Coordination Team for Controlling and Preventing Land and Forest. This task began in 1995 and has been enlarged to include ASEAN-wide activities.

He also stated that through the technical assistance of the WMO they have conducted activities aimed at improving the agrometeorological services (1975-1985), and several experts were invited to promote the research and development in meteorology including experts to improve the long-range forecast with incorporation of the El Niño activities. Results of these research activities have added to MGA's capabilities in designing scenarios of the onset of El Niño with the use of the local data. The investigations of the fires in 1991, 1994 and 1997 have helped define a close relation with the El Niño. Application of this experience has encouraged MGA to issue early warnings of El Niño episodes.

Dr Winarso closed by stating that the support from other research institutes inside the country namely LAPAN, BPPT and the leading universities, will further improve the management information system in relation to El Niño episodes in the future. The close relationships with international operational and research institutes is also important, and MGA works closely with WMO and the Bureau of Meteorology Australia and ASEAN Specialized Meteorology in Singapore. Through these cooperative efforts the management of these events will be enhanced.

Mr. Hery Harjanto, MGA, discussed the role that the institute played in monitoring smoke and haze. The GAW background station established in 1996, at Bukit Koto Tabang, West Sumatra, measures gaseous, aerosol and rainwater chemistry, along with a suit of meteorological variables. A selection of the measured quantities are shown in Figure 4. This station provides valuable information and an established, well equipped measurement site, for characterizing the chemical nature of the smoke and haze. In addition MGA operates 27 climate stations throughout the country which measure precipitation chemistry and aerosol using Hi-Vol samplers. Further details regarding Indonesia's efforts are presented in Volume 2 to this report.

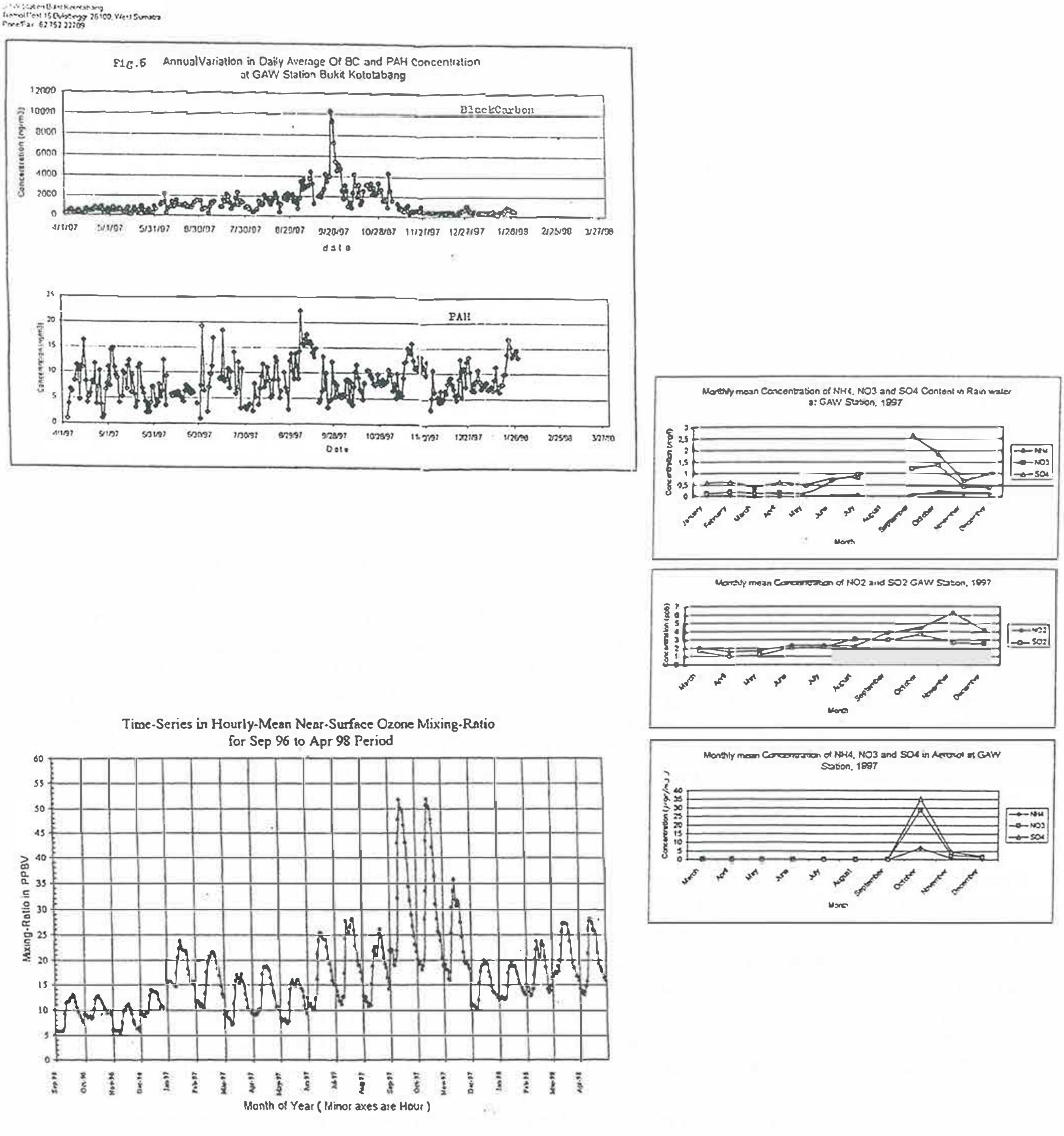


Figure 4: Selected monitoring results at the GAW background station at Bukit Koto Tabang, West Sumatra. Ozone plots shows the average diurnal variation for each month

2.1.2 Malaysia

Dr. Lim Joo Tick, Director General, Malaysian Meteorological Service (MMS), reviewed his countries activities related to the recent fires. He emphasized that the haze episode of 1997 which affected Indonesia, Malaysia, Singapore and Brunei was the most severe in history, causing the Air Pollutant Index (API) to reach unprecedented levels. Many states in Malaysia, particularly Sabah in East Malaysia, recorded rainfall very much below normal during the period from August 1997 till April 1998. The prolonged dry weather resulted in outbreaks of local fires in parts of the country which had never previously experienced such fires. In March 1998, the Malaysian Cabinet ordered immediate action to check the escalating recurrence of haze episodes, reiterating that the cause of the haze was not only forest fires in Indonesia, but also domestic sources of open burning in Peninsular and East Malaysia. Fires in drought stricken districts of Miri and Limbang in Sarawak and Sipitang in Sabah in March and April caused API readings to exceed the extremely hazardous threshold of API 500. Peninsular Malaysia was not spared during the recent dry season with peat fires reported near Pekan in Pahang, Sepang in Selangor, Gunung Ledang range along the Malacca-Johore border and Kerteh-Paka border near Cukai in Trengganu. More recently, fires raging for several weeks in several remote mountains in the Kinabatangan district of Sabah were only recently brought under control.

Dr Lim Joo Tick noted that there has been growing concern in Malaysia regarding the likelihood of a recurrence of haze during the coming Southwest Monsoon. This has reinforced the commitment of the Malaysian Government to seek a regional solution to the issue of transboundary haze and at the national level, to improve the local air quality through strengthening existing policies and to introduce new regulations to ensure better planning and management of the environment. A National Committee on Haze chaired by the Honorable Minister of Science, Technology and Environment with representation from relevant ministries/departments/agencies has been established to formulate strategies and coordinate local efforts to monitor, control and mitigate haze in Malaysia. A set of operational procedures has been established for the early mobilization of resources for combating haze resulting from open burning and forest fires.

Dr Lim Joo Tick summarized Malaysia's extensive actions related to smoke and haze. For example, the Malaysian Cabinet decided in October 1997 that the Ministry of Science, Technology and Environment should coordinate all offers of bilateral and multilateral international assistance. Activities deemed significant from the Malaysian Government perspective, with particular emphasis on a comprehensive and integrated study, should focus on the following areas: (i) Constituents of Haze -- Identifying the particulate matter and the chemical composition of the haze, especially from the burning of tropical species of wood, and comparing the results with other relevant studies in Malaysia and elsewhere. It would also be advantageous to ascertain what proportion of the PM10 contributing to the haze was comprised of PM2.5; (ii) Sources of the Haze -- Including determining local sources contributing to the haze, as well as the factors influencing external and domestic sources of the haze; (iii) Health Effects of the Haze -- Including a comprehensive epidemiological study on the short-term and long-term effects of the haze on human health; (iv) Other Impacts of the Haze -- including impacts on agriculture, including crop yields, tourism, and socioeconomic; and (v) Management of Air Quality -- Including reviewing existing air quality standards, improving the existing air quality monitoring network, refining the API and the Visibility Index, pursuing the development of suitable air quality modeling and computer simulation systems; and (vi) Early Warning and Disaster Preparedness -- Including formulating appropriate national-level and regional-level early warning haze alert systems, designing effective national contingency measures and disaster preparedness mechanisms, and reviewing and improving existing haze-related early warning and disaster preparedness systems.

Dr Lim Joo Tick also reviewed regional-level activities. To address the pressing need for regional cooperation in addressing the transboundary haze problem, a Regional Haze Action Plan which identifies strategies and action programmes to fight land and forest fires in the region has been accepted by ASEAN members. Indonesia is coordinating the Fire Fighting Capability component, Malaysia the Preventive Measures component while Singapore has agreed to coordinate the Regional Monitoring Mechanisms component of the Action Plan. Since last year, the ASOEN Haze Technical Task Force (AHTTF) has met regularly to review the current situation and action programmes relating to preventive measures, fire-fighting capability and monitoring efforts initiated under the ASEAN Regional Haze Action Plan. These meetings are normally followed by an ASEAN Environment Ministerial Meeting on Haze.

Following a Memorandum of Understanding (MoU) signed between Indonesia and Malaysia to handle disaster related issues, a Joint Action Committee was formed in December 1997. With the formation of this committee, Malaysia and Indonesia will be able to implement measures stipulated under the MoU to collectively tackle haze problems arising from land and forest fires. The MoU also provides for both countries to exchange information on technical and scientific knowledge and training in disaster management. In a worst case scenario of a recurrence of fires this year, under the MoU Malaysia can deploy fire fighters, including personnel from the army and Fire Services Department, to Indonesia to assist in fire fighting efforts.

The ASEAN Ministers on Environment during their meeting on haze in Brunei decided to set up the Sub-Regional Fire-Fighting Arrangements (SRFA) for Kalimantan and Sumatra/Riau to contain fires in East Kalimantan and prevent fires in Sumatra and Riau. With the arrival of the Southwest Monsoon, the establishment of the SRFA is now top priority to Malaysia. In order to implement the fire-fighting measures, there are plans to set up a contact point within ASEAN to receive and mobilize assistance from the region and the international community for fire-fighting efforts.

Ms. Leong further reviewed MMS activities with emphasis on measurements. MMS operates a network comprising 32 primary climatological stations and 23 air pollution monitoring stations. As a member of the National Haze Committee, the department plays an important role during haze episodes providing valuable meteorological and air quality information, as well as daily updates on "hot spots" and smoke haze detected using the NOAA and GMS meteorological satellites, in support of national efforts to monitor, control and mitigate the impact of haze. MMS has also been involved in various collaborative studies with local and international scientists, making use of the vast amount of data collected during past haze episodes. This includes: (i) a Malaysia-Denmark Study To Determine The Origin, Formation And Composition Of Aerosol Haze in Malaysia; (ii) a Malaysia-Germany Study on the Effects of Southeast Asian Forest Fire on Atmospheric Environment and Regional Climate; (iii) a Malaysia-Japan Study on Increase of Tropospheric Ozone Due to Forest Fires in Tropical Southeast Asia; (iv) a Malaysia-Australia Study on Acid Deposition and Haze in the Klang Valley; (v) Malaysia-Swiss Study to Compare Aerosol Concentration Measurements With Model Results; and (vi) a Malaysia-USA Study of Solar UV-B Changes in Malaysia and Brazil During the Burning Season. Planned activities include: (a) A two year study funded by AUSAID involving CSIRO, MMS and the Department of Environment (DoE), Malaysia to determine the haze aerosol scattering coefficient and chemical composition of aerosol haze ; and (b) Haze Forecasting for Malaysia project under the DANCED programme between the Danish Meteorological Institute (DMI) and MMS.

Ms Leong also discussed the use of air pollution indices. In 1989, the DoE formulated a set of air quality guidelines, termed Recommended Malaysian Air Quality Guidelines (RMG) for air pollutants, defining the concentration limits of selected air pollutants which might adversely affect the health and welfare of the general public. Based on the RMG, the DoE subsequently developed its first air quality index system known as the Malaysian Air Quality Index (MAQI) in 1993. The index system plays an important role in informing both decision-makers and the general public the status of ambient air quality. When the MAQI was initially adopted nationwide during the 1994 haze episode, there was some confusion with regard to reporting on the levels of the concerned pollutants, primarily stemming from differences in the index systems adopted among the neighboring countries. The DoE eventually revised its index system in 1996, and the Air Pollutant Index (API) was adopted, with the API system of Malaysia following closely the Pollutant Standard Index (PSI) system of the United States.

She closed by reiterating that by recognizing the urgent need for regional cooperation to combat transboundary haze, countries in the region, through the various ASEAN committees, have identified appropriate activities at the national and regional levels aimed at continuing and improving the progress made in smoke and haze cooperation and early detection. In order to carry out their role to advise, alert and generally manage regional pollution events, NMHSs need to work in close consultation with each other, establish an efficient mechanism for rapid exchange of data, and its personnel be given appropriate training to upgrade their skills and knowledge.

Ms Leong also stated that in view of the importance to strengthen regional monitoring mechanism, ASEAN countries support the move to further streamline and strengthen the role of the ASEAN Specialized Meteorological Center (ASMC) to enable it to serve as a regional information centre for collecting, analyzing and disseminating meteorological data and satellite information necessary to detect and monitor land/forest fires and occurrence of smoke haze in the region. The ASMC needs to be well equipped with the necessary tools and support infrastructure to ensure timely generation and effective distribution of its products. In this respect, the World Meteorological Organization (WMO) can play an important role in coordinating efforts and actions to meet the needs of the NHMSs and the ASMC particularly in the area of technology transfer.

Dr Tong, Alam Sekitar Malaysia Sdn. Bhd. (ASMA), also presented information on their monitoring network. ASMA is a company which has been awarded a twenty year privatization concession to install, operate and maintain a network of 50 Continuous Air Quality Monitoring (CAQM) stations and 10 Continuous Water Quality Monitoring (CWQM) stations throughout Malaysia for the Department of Environment (DoE). The company also manages the Environmental Data Center (EDC) that provides environmental data to the DoE and other interested parties. In mid-1997, about 30 air quality stations were in operation. Further details are presented in Volume 2 to this report.

2.1.3 Singapore

Mr. Wong Teo Suan reviewed the various activities of the Meteorological Service Singapore (MSS). He stated that during the 1997 smoke haze episode, the MSS was inundated daily with inquiries from members of the public and the mass media. Many organizations, both local as well as overseas, ranging from those in the tourist trade, government ministries, foreign embassies, and businesses have also consulted the Meteorological Service on various haze-related issues. The questions posed included the causes of the smoke haze, what the authorities are doing about the haze, when will the haze clear and what precautions should be taken to cope with the haze. There was thus tremendous pressure on the department which arose from the inquiries made by the public and organizations and their expectation that it was within the department's capacity to do something about this environmental catastrophe. While the haze problem cannot be solved by the Meteorological Service alone, the provision of information and services in support of daily activities and general welfare of the population is seen as a basic community right and is one of the primary roles of a national meteorological service.

The various roles of MSS in support of smoke haze mitigation activities were summarized in terms of: a) Monitoring of the forest fires and smoke haze in the region, including the regional weather conditions; b) Preparation and dissemination of smoke haze information; c) Participation in the activities of the local Haze Task Force; and d) Media management.

The monitoring of forest fires and smoke haze was routinely carried out using: a) processed AVHRR data received from the US NOAA-12 and -14 polar orbiting weather satellites; b) Japanese GMS-V weather satellite; and c) Surface and upper air station weather reports. The processed satellite images were very useful in identifying the smoke areas and hot spots, which are the most probable areas of forest fires. Hourly GMS-V data also proved to be very useful in monitoring the diurnal behavior of the forest fire activity and the weather conditions in the region. Weather reports from synoptic stations in the region and the low level wind observations were used to monitor reduction in meteorological visibility which gave an indication of the thickness of the smoke haze. In Singapore the monitoring of the ambient air quality was carried out by the Ministry of the Environment (ENV). Three-hour average Pollution Standards Index readings were made available by ENV to the department every hour. In monitoring the regional fires and smoke haze, the department worked very closely with ENV. Whenever significant areas of smoke haze or hot spots and reduction of meteorological visibility in Singapore or in the region were detected, a smoke haze alert was issued to the Ministry of Environment for follow-up action.

In the 1997 smoke haze episode, the Singapore Meteorological Service played a very active role in the provision of forest fires and smoke haze information. Members of the media and the public were kept fully updated on the latest situation. The various information provided included: (i) latest satellite images showing the hot spots and smoke areas; (ii) regional haze map depicting low level winds, locations of hot spots and areas affected by moderate to thick smoke haze; (iii) air quality (3-hour averaged PSI values) updated hourly ; (iv) haze trajectory forecasts and visibility in selected towns or cities in the region; and (v) daily haze situation report and short to medium range forecasts. The information was provided through the press, radio and television, telephone hotlines operated by the department and ministries of the Environment and Health. The internet and the email were found to be very effective means of information dissemination and these were extensively used during the episode.

TABLE 2

Summary of Various Locations Where Smoke Haze Information were Provided

Location	Types of Information
Meteorological Service Internet website http://www.gov.sg/metsin	• latest satellite images showing the hot spots and smoke areas • regional haze map depicting low level winds, locations of hot spots and areas affected by moderate to thick smoke haze • air quality (3-hour averaged PSI values) updated hourly • haze trajectory forecasts • visibility of selected towns or cities in the region • daily haze situation report and short-range forecasts
Meteorological Service - Weather Information Dissemination System (access to recorded voice 542 7788, access to facsimile information: 542 7789)	Voice Information: Latest PSI index including a health advisory Fax information Facsimile: To obtain the latest regional Haze Map
Ministry of Environment's Internet Website http://www.gov.sg/env/haze.html	Latest PSI values List of FAQs on the smoke haze
Ministry of Environment's Call Center at 1800-7319222	PSI readings and health advisories
TV and RADIO PRESS Media	PSI posted on all channels including INTV Regular report by radio Under weather column in daily newspapers

Access rates for haze information provided through the department's automatic telephone answering system went up by 94% in September 1997 at the height of the smoke haze episode, while there was a four-fold increase in the number of accesses to the department's web site.

The haze episode in 1994 prompted the formation of the Inter-Ministry Haze Task Force, comprising senior officers from various government ministries and statutory boards to deal with local problems and issues associated with the haze. Chaired by ENV, the Haze Task Force prepared a Plan for Action to deal with the haze situation. Each individual ministry or agency was tasked with the development of its own specific Haze Action Plan for implementation in accordance with the phase of development of the smoke haze, as determined by the PSI levels. The MSS's mission during a smoke haze episode is to contribute to the mitigation of the impacts of smoke haze in Singapore through the provision of timely alerts and information on the locations and likely spread of forest fires and smoke haze in the region. When a smoke haze episode is declared by the Ministry of Environment in consultation with the MSS, the department convenes a Haze Committee to coordinate the implementation of its standard operational procedures (SOP). The latter will be implemented in phases in accordance with the severity of the smoke haze based on the PSI levels. Essentially, the role of the Meteorological Service under the local Haze Action Plan is to provide assessments of the likely development of the smoke haze at each phase to enable the various agencies to implement their respective action plans. MSS's Haze Action Plan also provide detailed procedures on activation of key personnel to provide advice to the Haze Task Force when a smoke haze emergency is being declared.

One important activity of the local Haze Task Force was to provide regular briefing on the smoke haze situation and other issues to the media, diplomatic corps and local chambers of commerce. The purpose of the briefing was to keep the various sectors updated of the latest smoke haze situation, to clarify issues and address concerns and to explain action plans such as the use of air cleaners and masks. Regular briefing sessions provided an opportunity to keep the public informed of the actions that would be taken by the various authorities to mitigate the impacts of the smoke haze at various stages. The message to be conveyed was that the authorities had a plan of action in place and were ready to implement these plans to help the public cope with the smoke haze problem and that the authorities would do what they could to alleviate the problems posed by the regional smoke haze.

Mr Wong Teo Suan mentioned that one of the most difficult issues that surfaced during the 1997 smoke haze episode was the handling of the media. The department was faced daily with a barrage of media inquiries for smoke haze information, assessments and forecasts of the smoke haze. The reporters were quick to pick up and report on anything that was said that could make the headlines. Some media have a tendency to cause the smoke haze to be blown out of proportion. Thus, statements had to be crafted very carefully to avoid being misinterpreted and at the same time ensuring that the information provided were accurate and consistent. Unnecessary panic or alarm to the public were to be avoided.

Mr Wong Teo Suan closed by stating that several lessons were learned during this period:

a) In coping with such high and sudden demand for information, the use of the Internet, email and automated telephone voice response systems were found to be very useful in disseminating the smoke haze information and in alleviating the pressure faced by the staff. By posting the latest information on the website, members of the public including the press media were able to obtain all the information that they needed. The various communication means proved to be very effective in easing the burden of having to handle the constant barrage of inquiries.

b) The problem posed by the foreign press media in over-playing the smoke haze issue was quite beyond the department's control. However, to counteract the negative impact created by the media, national meteorological services need to be proactive in providing accurate assessments and up-to-date assessments of the haze situation to correct any misconceptions that media reports have brought about. For instance, an intimate knowledge of the local weather gave us the confidence to remain consistent throughout in our assessment on the clearance of the regional smoke haze despite many press reports of the possibility of the smoke haze persisting much longer into 1997/98. Reassuring the public that the smoke haze was not a permanent phenomenon and was likely to go away once the prevailing winds change in direction in November was also useful. This was partly to counteract the picture painted by some overseas media of the whole region, including Singapore as being a disaster area with highly hazardous levels of smoke.

c) For effective media management to be possible, there must be greater capability to predict smoke haze in order to become an authoritative source for smoke haze predictions. Improved capability would result in being able to provide better support to business and leisure activities and also serve to enhance the status of weather services.

2.1.4 Brunei

Ms. Asraya A. Rahman, representing the head of the Brunei Meteorological Service (BMS) reviewed BMS's activities related to the recent smoke and haze events. She stated that the first reports occurred as early as mid-May 1997. The rainfall of almost double the mean for May helped to disperse the haze. However, by mid-July, the presence of tropical cyclones over the South China Sea and to the east and north-east of the Philippines aided the establishment of the southwesterly flow over the country. With it came the smoke-haze from the burning forest of South Kalimantan. Between mid-July to early August tropical cyclones Rosie, Scot and Tina were to some extent influencing the local weather. Although the rain in June was slightly below the mean, the above normal rainfall in July raised little concern about the imported haze. The visibility remained in the 10 to 6 km range until the 3rd and 4th week of August when the persisting southwesterly wind brought in more smoke-haze into the country to cause the visibility to further deteriorate to just between 1-4 km. But a break in the southwesterly in the first two weeks of September improved the visibility to almost normal. The following week saw the return of the southwesterlies and the visibility during this period hovered at or below 4 km. The strengthening of the southwesterly, from the 19th of September caused the visibility to decrease to 2 km. By the 20th the visibility dipped to a first ever low (due to smoke haze) of 700m. Visibility of 600m persisted throughout the end of the 3rd week. Slight improvement in the 4th week brought some relief and the rain which started at the end of September further improved the visibility which returned to normal by 1 October. Apart from the August rainfall which totaled less than half of the month's mean, the rainfall for September and October remained above normal. Despite being aware of the El Niño phenomenon, the abundant November rainfall made the meteorologists at BMS hesitant in issuing a warning of probable drought which normally occurs with active El Niño. The dryness in December, total rainfall for the month was less than a third of the mean, and the failure of the Northeast Monsoon to bring the expected heavy rain (December being the wettest month for the country) put the BMS meteorologists on alert and intensive monitoring (within their limited capability) of the situation began. Warnings of probable severe drought affecting the country were issued to the Water Department and the State Fire Department at the beginning of 1998.

Routine monitoring of visibility was increased from the end of July when the country was affected by thicker than normal haze (the smoke in this episode was not immediately apparent at first). BMS was lucky in this case as the smoke borne by the southwesterly wind affected a few other meteorological stations; Kuching, Bintulu, Miri (the nearest to Brunei Darussalam) in the neighboring state of Sarawak, Malaysia, before reaching the capital Bandar Seri Begawan (BSB). BSB is practically in-line with these towns and at the other end of the line is Kota Kinabalu (KK), the capital of Sabah, Malaysia.

At the height of the haze affecting the country, the BMS Meteorological Data Acquisition System (METDAS) was out of operation, adding to the already existing problems of manpower and demands from all sides to know what was happening. The most commonly asked questions were: will it get worse or better?, when will it be over? Heavily dependent on the information provided by other meteorological services in the region, the meteorologists at BMS continuously searched the Web for more information and updates on the event. The availability of NOAA satellite imageries for Forest Fires Monitoring on the ASEAN Specialized Meteorological Center (ASMC)/ Meteorological Service Singapore (MSS) home page helped BMS to cater for the numerous and endless briefings. The schematic diagram added on to this at a slightly later date further eased the problem of locating the suspected fires and areas affected by the haze.

Further information on the internet were sought from other regional meteorological services such as the Bureau of Meteorology Australia, Climate Prediction Center of the National Center for Environmental Programme (NCEP) and WMO to assist BMS to get out of the dilemma of the forever asked medium to long term predictions. At times the BMS is not even fully capable of the daily routine tasks it needs to perform due to unavailability of data, equipment and information or, as quite often is the case, the unserviceability of equipment.

At the beginning of this first episode there was no equipment for monitoring the air quality available in the country. BMS had just succeeded (after several attempts) in getting approval to buy a high volume sampler and was waiting for delivery. The Ministry of Health took it into their responsibility to acquire several instruments (PM 10) to be immediately delivered and installed. With the assistance of an Australian expert, the instrument gave its first reading on the 25th of September 1997 after the peak of the haze situation. Thus the actual quality of the air during the worst condition can only be guessed at, or at best use the visibility available and make comparisons with the Air Pollution Index (API) of the neighboring state of Sarawak.

The Ministry of Health decided to adopt the American version of quantifying the air quality and thus used the Pollutant Standard Index (PSI) as the indicators. The 25th of September gave the average 24 -hr PSI of about 65 which falls under the moderate category, from then on further improvement of the air quality continued and remained good to the end of the year.

The next wave of smoke and haze was reported on the 24th of January 1998, after a prolonged dry spell beginning December 1997. By early February very poor visibility was observed in the early morning due to smoke with fog but improved later in the day. Visibility as low as 300 m was observed. However, improvements with visibility reaching 8 km was reported in the later part of first week of February, but at the end of the second week, persistent cold air in the lower atmosphere forced the haze to remain close to the surface before midday and fog occurred almost every morning. Visibility of just 50 m (due to smog) on early 14 February forced the aerodrome to be closed the first time followed by a few more times later on. This was the beginning of a period of low visibility, usually the worst time was observed in the early morning. The easterly and northeasterly wind flow brought further smoke into the country from neighboring Limbang and Lawas, Sarawak together with that from East Kalimantan. This caused the situation to become worse with the already bad smoke from local source. Improvement in the visibility came towards the end of February but it did not last. Raging fires all around, on top of the local source, did not give reason for hope for an end to the smoke. Any hope of an end to the dry spell was dashed when as early April came there was nearly zero rainfall at BMS main station in the capital. The worsening smoke haze in March escalated in severity by April and peaked around the second week of April. By this time thick smoke and the smell of burnt wood not only filled the air but started to penetrate into buildings. However the first significant rain at the end of the third week of April (23.9 mm on 20 April 1998) managed to raise the water level in the Benutan Dam Reservoir by about 19mm. By May the smoke haze was almost never experienced again. Apart from a short period of slight smoke-haze around mid-May due to a break in rain activities, the country was smoke haze free from the 18th of May and by end of the month the whole island was free from detectable fires.

Unlike the earlier episode, monitoring the smoke in this occurrence was not easy. There were no stations to monitor. During this time, the monitoring was heavily dependent on the Fire Monitoring products from ASMC/MSS and information from Brunei State Fire. The severity of the event and with no places outside the country to make comparisons with, the public became more demanding thus the monitoring was further enhanced in the region. By this time all available information via the internet or any other sources were searched and utilized. The air quality during this time gave reasons to worry. More than half of the period during this event recorded PSI beyond the maximum limit of 500. To see a reading in the moderate category was a relief.

Ms Asraya A. Rahman reviewed that the most immediate concern at the time when Brunei was first blanketed by thick smoke was how to keep the public well informed and not to cause any undue panic. Newspapers and radio and television broadcasts kept highlighting the severity of the haze situations in neighboring states and, when Kuching declared a state of emergency the lack of monitoring equipment added to the fear that Brunei's air quality was at a similar level. The fact that different indices were used for Brunei and Malaysia did not convince the public that the country's equipment was working and giving the correct values. To add further to the confusion, the equipment (all five of them) are not located at meteorological stations where the visibility is observed. Information passed by our national airlines (Royal Brunei Airlines) pilots gave indication that the haze was patchy in nature and during the first episode extended to a height of about 3000 m, unlike during the second episode when it stayed close to the ground and did not reach as high as in the previous event. Thus low PSI reading and the perceived (by the public) low visibility was not acceptable and unbelievable. Countless explanations to the public by BMS on the discrepancy between readings and visibility and the difference between API and PSI by the Ministry of Health and Environmental Unit left some none the wiser.

Questions were raised about the safety of the public in general, in particular the school children. Unlike government office buildings, schools are not fully air-conditioned except for some rooms which are usually not classrooms. Although the children were given face masks, the effectiveness of the mask was soon very much in question. As a result the schools were closed down during the peak for about two weeks substituting for the scheduled May break. Before and after that schools started later than normal and the hourly PSI was used as a reference for schools to close.

The aviation sector did not escape the problems either. As instructed by the aviation authority, the airport was instructed to be closed when the observed visibility is < 300 m. During the early part of the second episode this closure was almost daily. Obviously this caused considerable concerns among the airline operators. Discussions and re-assessment between the two parties were carried out to come to an acceptable plan of actions with regard to the aviation sector in handling the smoke-haze situation, without jeopardizing the maximum safety aspects of aviation.

Medical issues were the main problems that resulted from these two episodes. At the height of the second episode, problems of open burning and deliberately starting a fire had forced the authority to quickly activate an already existing emergency act for open burning. The maximum penalty is B$100,000 fine or an unlimited amount when it poses threat to life and environment and a 5 year prison term.

In response to these concerns a National Committee headed by the Executive Committee and followed by A Technical Committee were formed. A Sub-committee was also formed in the latter episode to handle the local fires. This is comprised of the Fire Department, Armed Forces, the Police Force and Environmental Unit of Ministry of Development. To avoid misleading and confusing information being passed to the public, an Information Operation Center (IOC) was established and operations started on 26 September 1997. It is located at the Police Operations Center in its Headquarters. Staff from the relevant departments (which the questions were always directed to) manned the IOC. The operational hours vary from 0800-1800 to 24 hours depending on the haze situation. The main function of the IOC is to provide information and answers to the inquiring public.

Ms Asraya A. Rahman closed by stressing that the two episodes were a test of their preparedness in time of real emergency. The current break in the smoke-haze situation now should be wisely used to overcome the shortcomings and problems that resulted from the handling of the situation. On behalf of BMS she expressed a deep appreciation to ASMC/MSS, WMO, BoM Australia, NCEP, ECMWF and all the other NMHSs in the region for their endless assistance and cooperation.

2.1.5 Philippines

Mr. Landrico U. Dalida, Jr. of PAGASA reviewed activities in the Philippines. He mentioned that southern and western regions were affected by smoke and haze (which they call smaze). In response to the smoke and haze events, PAGASA mobilized selected field observing stations to make special hourly observations of weather and visibility. These parameters were used as indicators of smoke and its dispersion. Airport stations were also instructed to insure continued availability of hourly aeromet observations and to make special observations for every change in runway visibility. PAGASA, in cooperation with local and regional authorities, released smaze information and warnings to the Chair of the Task Force Haze and to the media. They also utilized smoke trajectory forecasts produced at the RSMC, Melbourne, and transmitted via the internet. This information proved very useful in their issuance of special advisories and contingency measures to minimize health risks.

2.1.6 Papua New Guinea

Mr. Samuel Maiha of the National Weather Service summarized that the 1997 El Niño episode and its associated effects which included high smoke and haze pollution had unprecedented economic, environmental and social impacts on Papua New Guinea. He stressed that there is an urgent need to initiate and enhance the capacity and capability of the country to respond, advise and issue warnings of similar episodes, including the long range transport of anthropogenic pollutants. While there presently is little infrastructure to monitor smoke and haze in Papua New Guinea, there are discussions taking place between the Department of Environment and UNDP to establish some surface monitoring capabilities. He expressed the opinion that the first step should be a detailed investigation of the 1997/98 episode, as an important initial step towards actually monitoring future events, and stated the need for much needed assistance from their region to help them in these studies. He described the national meteorological network which consists of thirteen official synoptic observation stations and an additional twenty-two minor synoptic stations. Other agencies such as the Department of Agriculture and Livestock, Forestry and the PNG Oil Palm Research Association operate sixteen climatological stations using instruments provided by the meteorological service. Mr Maiha presented results on smoke and haze during 1997 based on observations taken at the meteorological stations on a three hourly basis (typical stations are operated on 12 to 24 hour basis). At all stations studied, the occurrence of smoke and haze in 1997/98 was significantly higher than the non-El Niño years. He closed by stating that PNG has an extensive meteorological network that can provide valuable information on regional climate and smoke and haze. They welcome opportunities to improve their data archive capabilities and to perform aerosol and chemical measurements.

2.2 Regional Specialized Meteorological Centres (RSMC) Activities

2.2.1 RSMC-Washington

Dr. Roland Draxler, of the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL), described the efforts taken at the RSMC-Washington. ARL provides the research support for the development of operational pollutant transport and dispersion models for Washington's Regional Specialized Meteorological Centre (RSMC), and they were requested by the U.S. State Department and Army Health Service to provide some forecast guidance regarding the transport and dispersal of smoke from the Southeast Asian fires. The identical model that is used for the Washington RSMC's radiological predictions was configured for smoke forecasts by assuming continuous point source particulate emissions from each of the major burn areas, different particle sizes, and multiple emission points. The dispersion model was run twice a day on ARL's workstation using the Aviation Model (AVN) global forecast fields produced by NOAA's National Centers for Environmental Prediction (NCEP). The dispersion model results were posted on ARL's web site. This system is also employed for the smoke from the recent fires in Mexico and Central America.

The operations aspects consisted of utilizing satellite images from the Total Ozone Mapping Spectrometer (TOMS) to identify major fire regions. A limited number of significant locations (9) were identified and configured as continuous point sources for the dispersion model simulation. The TOMS images were examined about once-a-week to identify new or extinguished fire regions to update the configuration. The same mass of pollutant particles was released continuously from each fire emission point and the total particulate emissions over all sources were equal to typical forest fire values for the total area being burned and consultation with the Australian Bureau of Meteorology. With each computational cycle the dispersion model forecast was initialized by starting the calculation two days prior to the current forecast to create an initial smoke plume which is then tracked and dispersed for an additional 72 h according to the meteorological fields from NCEP's AVN model. Calculated concentrations were output on a 25 km horizontal resolution grid as 6 hourly averages ($\mu g/m^3$).

He pointed out though that there remain substantial technical limitations to producing a smoke forecast product, and felt that the main purpose should be to provide broad guidance regarding the potential flow and dispersal of smoke rather than the prediction of particulate concentration at a specific location and time. Some of the obvious model limitations include the poor specification of all the fire sources and their relative magnitude, the accuracy of the wind field predictions from our global model, the dispersion model's parameterization of mixing (horizontal and convective) in a region for which it has never been tested, and computational limitations that restricted the smoke initialization to only two days prior to the forecast. The computational platform was not a dedicated workstation and there were many other jobs competing for CPU time. Staff limitations only permitted time to review satellite images and update the model's input configuration about once-a-week.

In addition to the technical aspects of producing a smoke forecast, there was some reluctance on their part to produce such a product due to the many complexities involved in the computation and the corresponding danger that the product would not be realistic, resulting in diminished credibility of other modeling activities. This suggested that some access restriction would be prudent. However, because they were dealing with so many uncertainties in many of the underlying scientific assumptions and with lack of direct knowledge of local conditions, it was decided that an open web page would provide the greatest opportunity of feedback from interested parties and hence the greatest potential for product improvement. This decision, in part, was due to lack of staff time that could be devoted toward research and product development. Further details can be found on the web (www.arl.noaa.gov/ss/models/gethysplit.html), and in Volume 2 to this report.

Dr Draxler also emphasized that the NOAA smoke dispersion forecast product has not been customized nor extensively verified. Most dispersion model parameterizations have been developed from experiments conducted in mid-latitudes and in the absence of contributions from deep convection. There is an immediate requirement that any dispersion model should have the capability to be initialized from satellite or ground-based smoke observations. This would require additional research to determine how data from different measurement systems can be integrated for a dispersion model initialization. This is a problem that transcends the smoke issue and is just as applicable for routine air quality predictions or radiological plume forecasts. What is needed is an improved forecast product, capable of predicting with high skill score the exposure of people and environments at sensitive locations distant from the sources. To this end, several improvements are necessary, and research should be conducted in all such areas:

Locations of fires. Satellite information from U.S. satellites are being coordinated by multi-agency activities. Dr Draxler saw no need to improve on this activity. There was, however, a need to integrate the products of this work with the transport and dispersion models.

Source term intensity. To accurately model the regional impact, detailed areal and vertically-integrated source term information is required. The best approach would be to measure optical depth in areas near the sources, rather than determining emission rates from each single fire. To this end, how optical depth sensors can be used to provide information for assimilation into the existing models needs testing. A small array of sensors ($6,000 US each) should be distributed on a test basis. ARL already has trial devices operational in several locations. Although these devices can be solar powered, access to reliable power and telephone system is highly desirable.

Source term characterization. Information on particle size, gaseous composition of the plume, and chemical composition of the particles would all be important. This requires some relatively intensive work, for which research groups in affected regions should be equipped. From the ARL perspective, all that is needed is an effect infrastructure that will direct the relevant information back to those developing and improving the predictive models.

Research infrastructure. New measurement and modeling programmes cannot be effective unless there is scientific coordination between diverse groups. All of the model development work needs to build upon the best tools available, and interact with on-site regional activities that are designed to provide response services. There needs to be feedback from people observing conditions in affected areas and the people who are actively working on developing and improving the models. Once again, this requires (a) deployment of sensors capable of detecting what the models predict -- e.g. surface-level concentrations and column optical depth, and (b) effective feedback and interaction between those collecting the data and the modelers.

2.2.2 RSMC-Melbourne

Dr. Paul Stewart from the National Meteorological Operations Center (NMOC) in Melbourne, reviewed their capabilities to provide advice in the form of a basic set of products on the transport of pollutants resulting from nuclear disasters, volcanic ash or smoke episodes. Necessary requirements of the system are its maintenance in a state of readiness for the ad-hoc requests and the ability to keep the product generation time required to a minimum. He mentioned that their involvement with the 1997 fires began towards the end of September 1997, when RSMC Melbourne was requested by the Bureau's International and Public Affairs Section to run forward trajectories for a number of locations associated with the fires which were burning in Southeast Asia and to make the products available to the Indonesian Meteorological and Geophysical Agency. Displays of the trajectories were produced in the NMOC, in Melbourne, and were made available, through the Bureau of Meteorology's external web server, to the Indonesian Registered User and later, to a wider group, through a specially set up EER Registered User. Starting points for the trajectories were redefined, and added to, over the next few weeks as the need arose. In addition, the Bureau's Darwin Regional Office requested some additional products in view of the effect of smoke haze on Darwin at one stage.

The basic system used is comprised of a Global Assimilation and Prognosis (GASP) system in which are embedded two Limited Area Prediction Systems - one for the so-called Australian region (LAPS) and another for a Tropical domain (TLAPS). The Australian region LAPS also has a further system embedded in it, viz. MESO_LAPS, which is run over two smaller domains for South East and South West Australia. A number of dependent systems, e.g. analog-statistical tropical cyclone model (TOPEND), model output statistics (MOS) and seastate (WAM), are driven by the core NWP systems. Numerous other systems provide the necessary environment for the successful and productive running of the system, from the collection of observational data on a global and local scale (and the associated decoding and ingestion into the Real Time Data Base) to the display, dissemination, archiving and verification of the NWP output. In addition, special analyses are run for the sea surface, and sub-sea surface, temperature and for rainfall. The Hybrid Single-Particle Lagrangian Integrated Trajectories (HY-SPLIT) system, developed by Roland Draxler at the NOAA Air Resources Laboratory (Draxler 1992, 1994), was modified to run on a Mercator grid using meteorological input from NMOC Melboume's Global Assimilation and Prediction (GASP) scheme. This modification to handle the Mercator grid resulted from the initial development work which was done with the intention of connecting HY-SPLIT to NMOC Melbourne's older Tropical Analysis and Prediction Scheme, which ran on a Mercator grid over a limited domain. The HY-SPLIT system can be run in a purely trajectory, or advective, mode producing either forward or backward trajectory plots at specified levels. Alternatively, it can be run in a dispersion mode producing exposure (or concentration) and surface deposition charts integrated over various time periods and layers. The nature of the source can be defined according to its strength, height and size, and the duration of emission.

Dr Stewart presented typical products. Figure 5 shows examples of the trajectories produced. A large and small domain version were calculated for each location. There is some qualitative agreement with the smoke plume depicted in the satellite picture in Figure 6. Smaller (Figure 5) domain versions of the trajectories were both written to the Bureau's external web server (http://www.bom.gov.au) and were accessible via the web page.

The ability to run the system for a number of locations provides more useful guidance products. Forward trajectories (Figure 7) and average concentrations (Figure 8) for 5 locations highlight the improvements to the system. It is also noted that similar products to those shown in Figures 7 and 8 are now being produced off the South East MESO_LAPS system in the provision of guidance for back-burning in South Eastern Australia.

The current EER system, in RSMC Melbourne, is in the process of being upgraded to incorporate HYSPLIT Version 4, developed by R. Draxler. The new features of HYSPLIT4 include: an upgrade to the advection algorithms; the inclusion of temporal interpolation; the definition of a puff with either a Gaussian or Top-Hat horizontal distribution; the addition of a 3-D particle dispersion routine that enables computation of air concentrations from the dispersal of an initial fixed number of particles; the revision of the equations used to compute the strength of the vertical mixing; and the incorporation of a non-constant rate of horizontal dispersion which is dependent on the deformation of the wind field. Also, from the operational point of view, HYSPLIT4 can now be run off GASP, LAPS, MESO_LAPS and TLAPS. Finally, it is supposed to be an integrated system where it will use the best winds available - depending on the location of the source. So, for example, for a source over Melbourne, it would start off with SE MESO_LAPS winds and if the trajectory or plume went outside the SE domain, and, depending on where it was, winds from LAPS, SW MESO_LAPS, etc. may then be used. The ability to run the system for a number of locations provides more useful guidance products. Forward trajectories (Figure 7) and average concentrations (Figure 8) for 5 locations highlight the improvements to the system. It is also noted that similar products to those shown in Figures 7 and 8 are now being produced off the South East MESO_LAPS system in the provision of guidance for back-burning in South Eastern Australia.

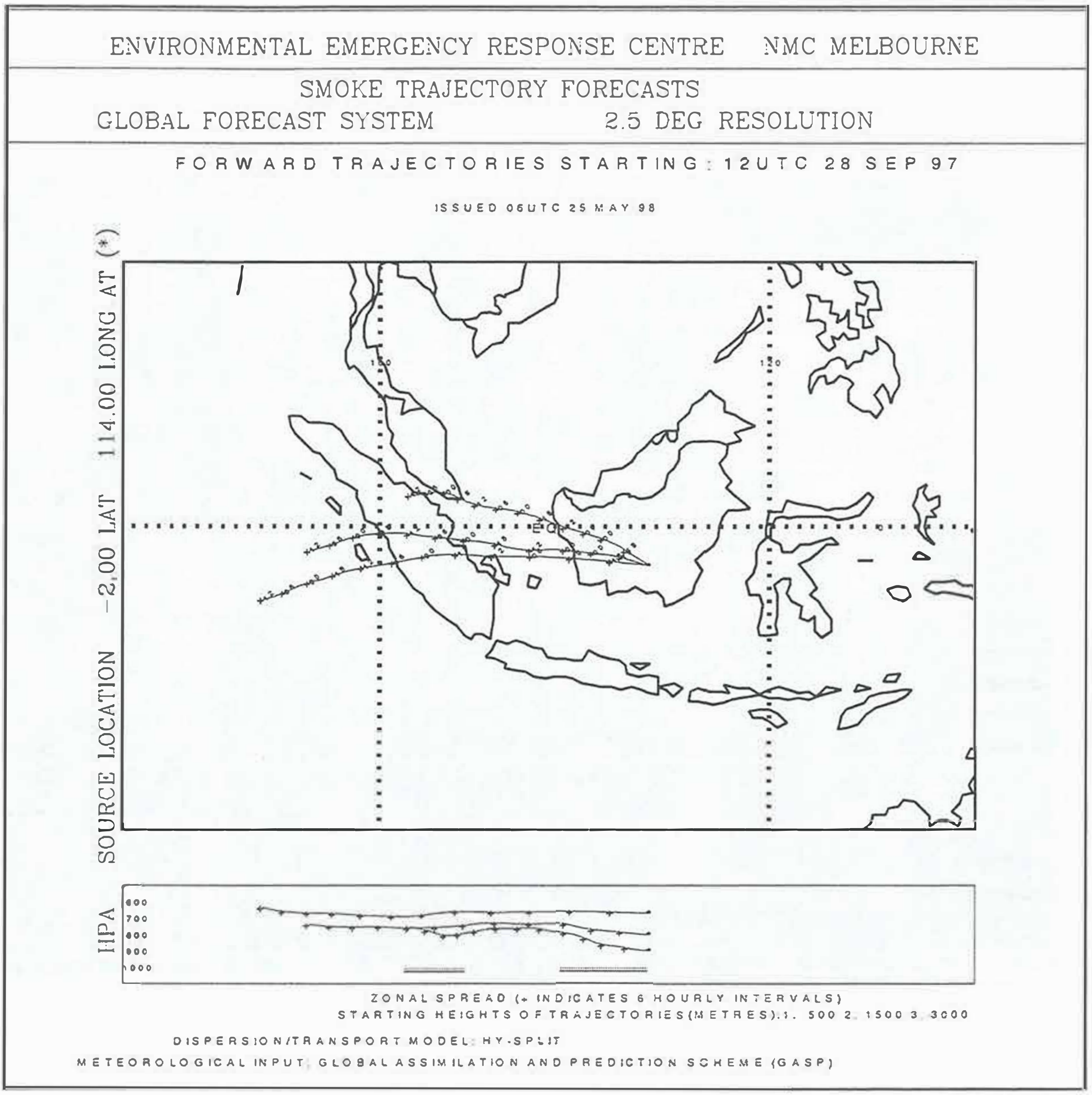


Figure 5: 72-hour forecast forward trajectory chart, displayed on smaller domain.

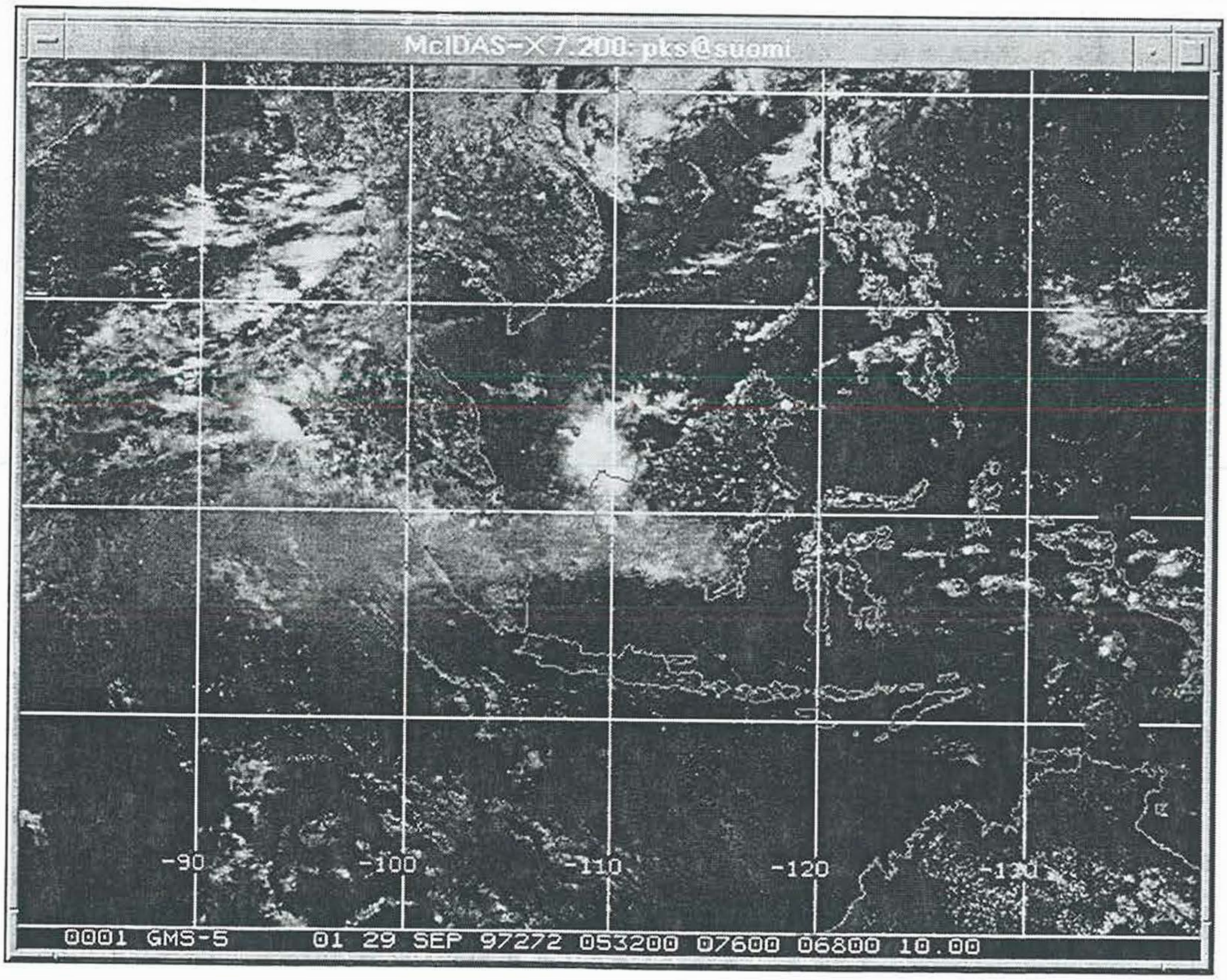


Figure 6: GMS VIS image for 0530 UTC 29 September showing extent of smoke plume.

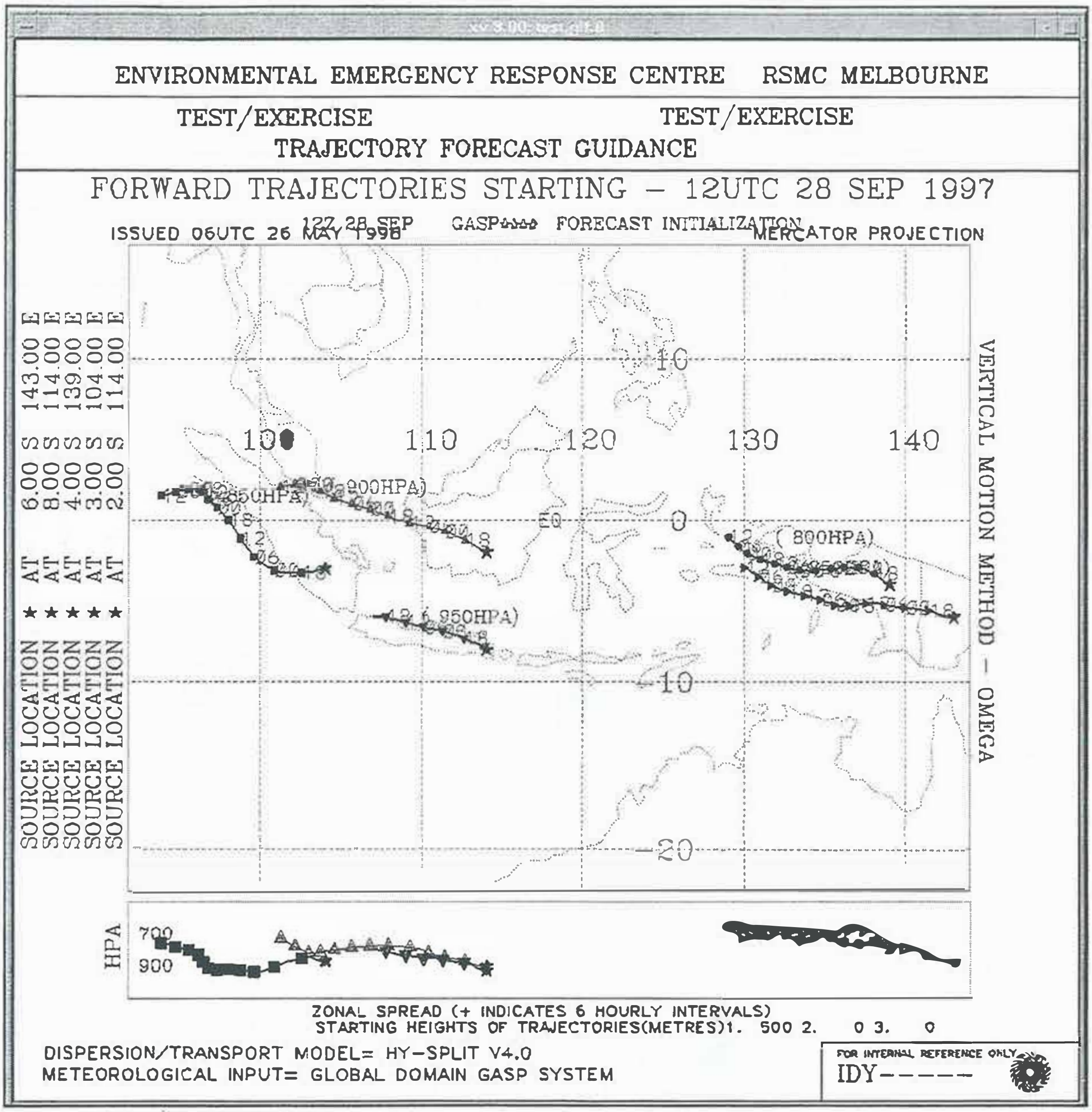


Figure 7: 72-hour forward trajectories starting at 5 locations using HYSPLIT4.

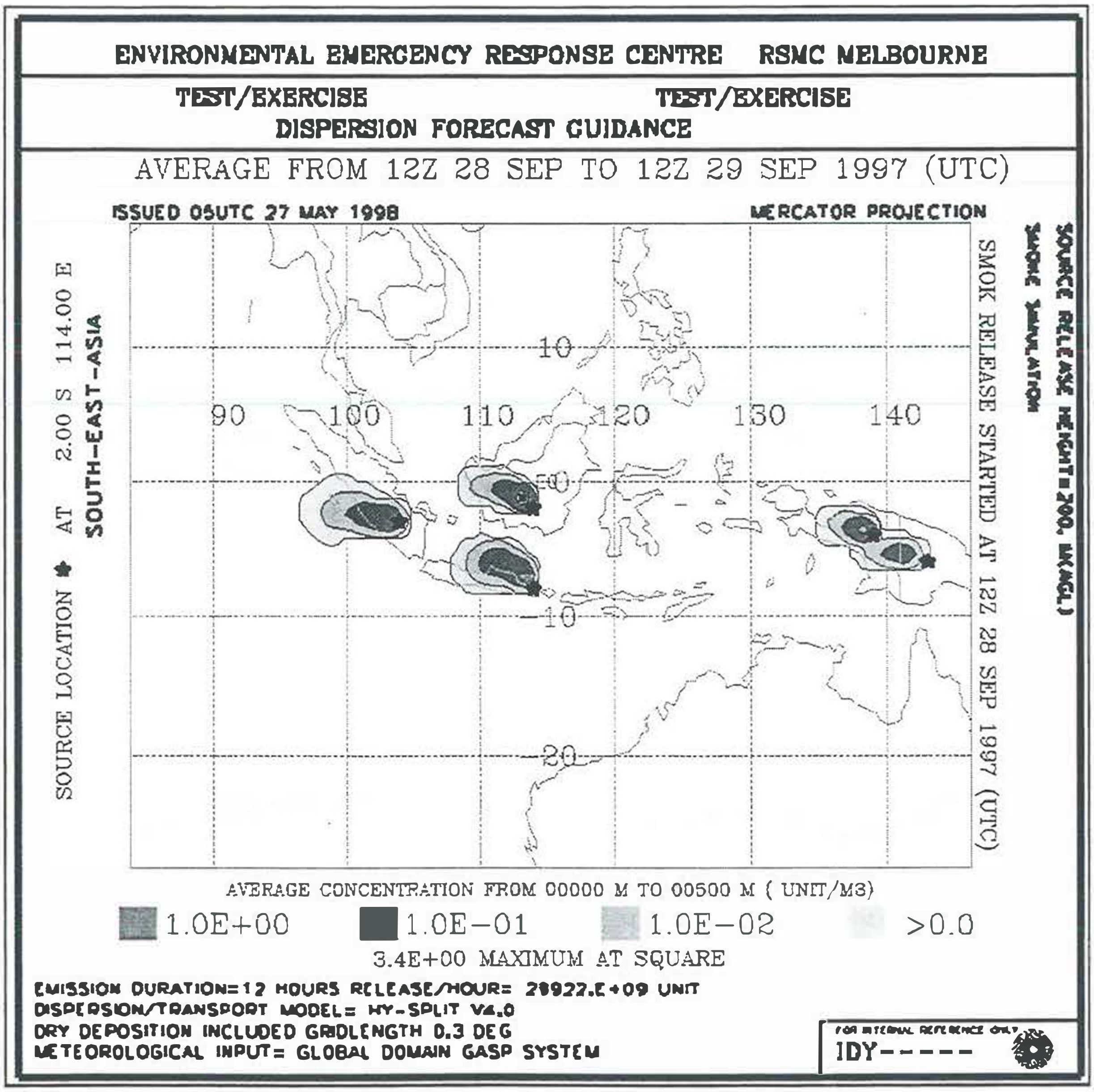


Figure 8: 24-hour average concentrations from 5 sources using HYSPLIT4.

2.2.3 *RSMC-Tokyo*

Mr. Katayama from the Japan Meteorological Agency (JMA) stated that JMA established the services of RSMC Tokyo for the environmental emergency response in RA-II on July 1997. RSMC Tokyo provides products from the JMA tracer transport model and other information to the RA-II Member states for environmental emergencies related to nuclear facility accidents and radiological emergencies. RSMC Tokyo ran the JMA tracer transport model for the forest fires in Southeast Asia. One of the problems was that the model was not able to deal with multiple hotspots. Another problem was that reliable information about the locations of hotspots was not available at JMA. RSMC Tokyo is trying to upgrade the tracer transport model that can deal with a widespread source or several hotspots and to provide useful information on the smoke and haze. RSMC Tokyo is also searching for a reliable information source about the locations and other characteristics of hotspots. They are now in the process of improving the JMA tracer transport model and its products after the Conjoint WMO/CTBTO Expert Meeting on Meteorological Data, Products and Services, and on WMO/IAEA Environmental Emergency Response held on December 1997. Based on a comparison with products from other RSMCs on the global EER exercise which was held on 24 July 1997 and discussion at the WMO/CTBTO expert meeting, the following improvements were made: (1) introduction of horizontal diffusion (2) change in the physics of vertical diffusion and (3) change in the graphical plots.

3 REVIEW OF CAUSALITIES AND IMPACTS

3.1 El Niño

Dr. Wasyl Drosdowsky from the Bureau of Meteorology Research Center Melbourne, Australia reviewed the role of El Niño in the 1997/98 smoke and haze events. He began by discussing the evolution of the 1997/98 event. The medium term history of ENSO over the period 1982 -1998 is shown in Figure 9. During this period there have been four El Niño events, (1982/3, 1986/7, 1991/2 and 1994/5) prior to the current event, but only two La Niña events, (1988/9 and the weak 1996/7 event).

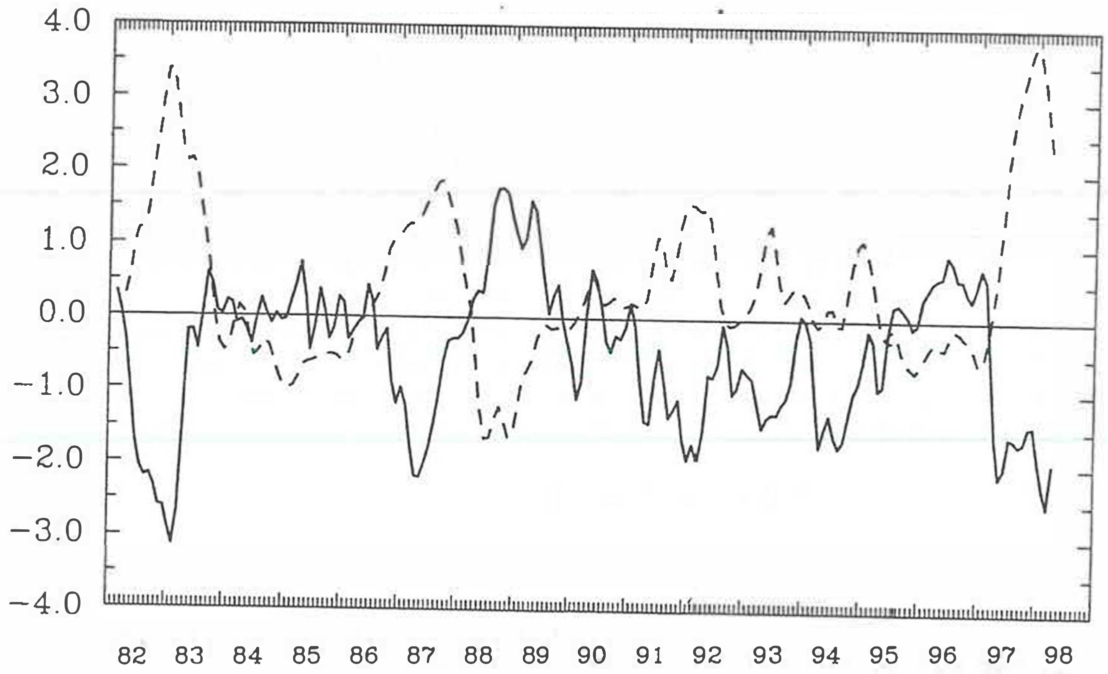


Figure 9: Southern Oscillation Index (SOI, solid curve) and Nino3 Index (dashed curve) for period 1982-1998. Monthly values have been smoothed with a three point 1-2-1 weighted filter.

The evolution of the 1997/98 event is shown in Figure 10. From mid 1996 the equatorial Pacific was in a weak La Niña state with easterly zonal wind anomalies, cool SSTs and a shallow thermocline in the western Pacific. By the end of the (southern) summer of 1996/97 this weak La Niña event was in decline, with equatorial eastern Pacific SSTa of about -1.0C and weakly positive SOI values (+0.7 in Dec-Jan-Feb 97). The southern hemisphere summer monsoon was above average in strength, with above average rainfall over most of northern Australia. The monsoon was dominated by strong, intraseasonal oscillations with periodicity of about 50-60 days, with peak activity in January and March. Each of these events were associated with westerly wind bursts across Indonesia and into the west Pacific warm pool and generated equatorial Kelvin waves which propagated on the oceanic thermocline across the Pacific. The first, generated in mid-January reached the South American coast in February-March, leading to warming of 1-2° C in Nino1 and Nino2 indices. The second strong westerly wind event occurred in early March, reaching South America in April-May. Both these events are clearly seen in the zonal wind anomalies (Fig 10), and the depth of the 20°C isotherm (Fig 10). By May 1997 warm SST anomalies stretched across the entire Pacific, with largest anomalies at the depth of the thermocline exceeding +6.0°C from 180E to 120W. As this warm water upheld during the winter and spring (the equatorial easterlies weakened but remained easterly) the equatorial SST warmed up to 4°C above normal. This evolution was similar to, but much more rapid than, the 'classic' El Niño composite of Rasmussen and Carpenter (1982), as shown by the 1972/73 El Niño. Its subsequent development has been more similar to the strong 1982/83 event, with warm SST anomalies and extreme negative SOI values persisting well into 1998.

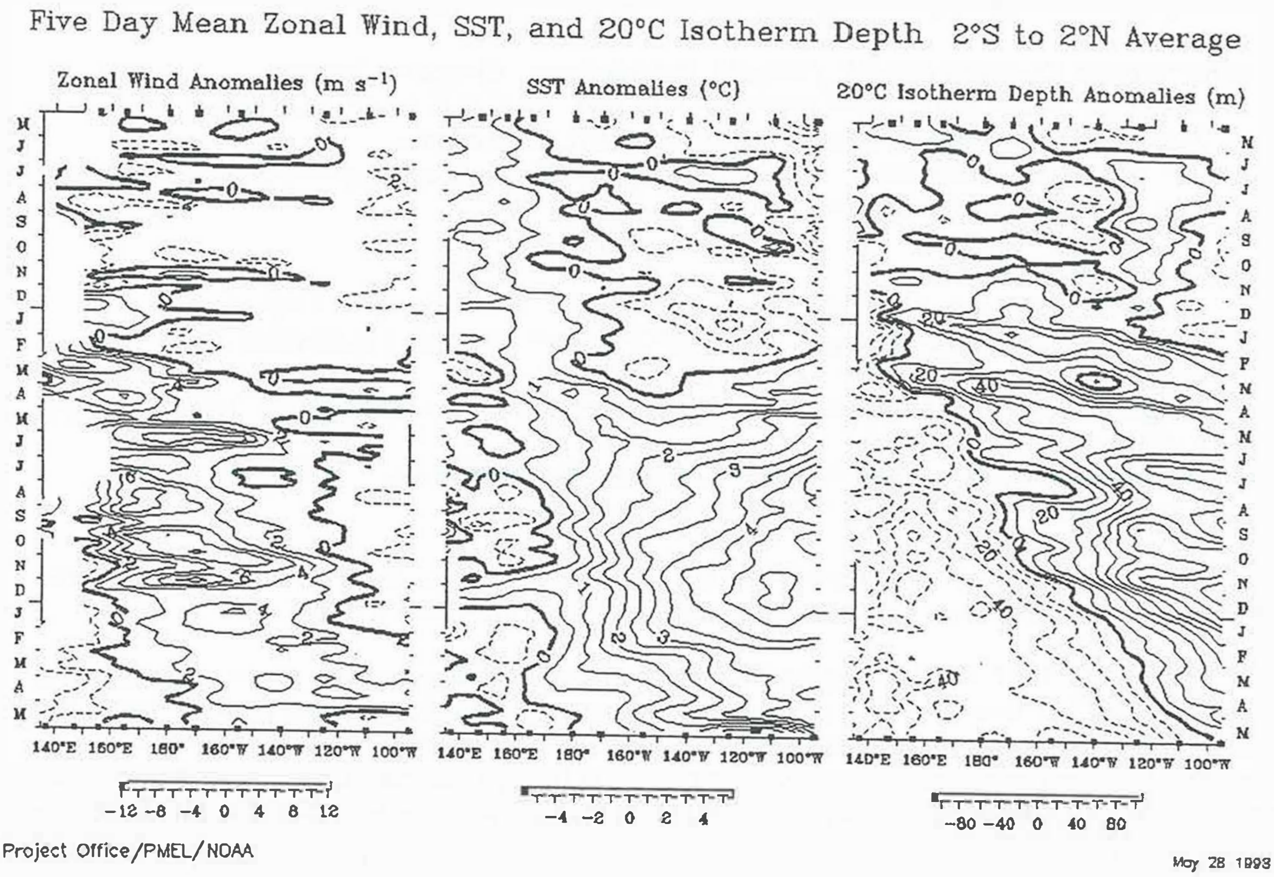


Figure 10: Hovmoller (time-longitude) plots of equatorial (2N to 2S). (a) Zonal wind anomaly; (b) Sea surface temperature anomaly; and (c) Depth of 20°C isotherm anomaly.

Dr Drosdowsky observed that the impact of the 1997/98 event on rainfall has largely conformed to the expected pattern documented by Ropelewski and Halpert (1987), except for two major regions. The Indian summer monsoon of 1997 was near normal, while parts of northern Australia had well above normal summer monsoon rainfall (highest on record at Darwin) during the 1997/98 summer monsoon. Elsewhere in the western Pacific region, particularly over Indonesia and New Guinea many regions recorded rainfall in the lowest ten percent of records for the spring/summer period.

He pointed out that a major difference between this and previous events has been the number and variety of forecasts issued by various research institutes or weather services around the world. Many of these are available in the Experimental Long Lead Forecast Bulletin produced up till December 1997 by NCEP, and now by COLA. The ENSO predictions described below, and available in this bulletin can be grouped into three categories:

(A) Full General Circulation Coupled Models

National Centers for Environmental Prediction (NCEP) (Ji, Kumar and Leetma)
European Center for Medium-range Weather Forecasts (ECMWF)
Scripps Institution of Oceanography/Max Planck Institut fur meteorologie (SIO/MPI) (Barnett et al).
Center for Ocean-Land-Atmosphere Studies (COLA) (Kirtman et al)

(B) Intermediate Coupled Models (Simple Atmosphere - Complex Ocean)

Lamont-Doherty Earth Observatory (LDEO and LDEO2) (Cane and Zebiak)
Bureau of Meteorology Research Center (BMRC) (Kleeman)
Jet Propulsion Laboratory, California Institute of Technology/University of California, Los Angeles (UCLA) (Syu and Neelin)

(C) Statistical Models

Linear Inverse Model, Climate Diagnostics Center (LIM-CDC) (Penland et al)
Canonical Correlation Analysis (CCA-NCEP) (Barnston and Ropelewski)
Neural Network Model (NN) (Tang, Hsieh and Tangang)
Singular Spectrum Analysis - Maximum Entropy Method (SSA-MEM) (Keppenne and Ghil)
Constructed Analogues (CA-NCEP, van den Dool (Nino 3.4))
Consolidated Forecast (CF-NCEP, Barnston et al)

Summaries of forecasts issued in the Experimental Long Lead Forecast Bulletin prior to the event in December 1996 and March 1997 are given in Tables 3 to 5.

Since late 1997 the development of the current El Niño event has been very similar to the strong 1982/83 event. Although the SOI returned to positive values in April 1983, the equatorial SST anomalies associated with this event weakened only gradually during 1983. In contrast, this event may decay far more rapidly, as is being predicted by many of the forecast models (Table 5) and supported by observations of rapid subsurface cooling across the entire Pacific during the past six months.

TABLE 3
Forecasts from December 1996

MODEL	MAM 97	JJA 97	SON 97	DJF 97/98
NCEP CGCM	Warm +0.5	Warm +1.0		
ECMWF	Warm +0.5			
SIO / MPI		Neutral	Warm +1.0	Warm +1.2
COLA	Neutral	Warm +1.0		
LDEO	Cold -1.0	Cold -0.5	Neutral	Neutral
LDEO2	Cold -1.0	Cold -1.0	Cold -1.3	
BMRC	Warm <+0.5	Warm +0.7	Warm +0.5	Warm +0.3
UCLA				
Oxford	Cold -1.0	Cold -0.5		
LIM - CDC	Cold -0.5	Neutral	Neutral	
CCA - NCEP	Warm +0.5	Warm +1.2	Warm +1.5	
NN	Cold -1.0	Cold -0.5		
SSA - MEM	Neutral <+0.5	Neutral <+0.5	Neutral	
CA - NCEP	Neutral +0.2	Neutral +0.4	Warm +0.6	Warm +0.9
CF - NCEP	Neutral	Neutral	Neutral	Warm +0.7
OBSERVED	Warm +1.0	Very Warm +2.5	Very Warm +3.0	Very Warm +3.0

TABLE 4
Forecasts from March 1997

MODEL	JJA 97	SON 97	DJF 97/98	MAM 98
NCEP CGCM	Warm +1.0	Warm +1.3		
ECMWF	Warm +1.5			
SIO / MPI	Warm +0.5	Warm +1.0	Warm +1.2	Warm +1.2
COLA	Warm +0.6	Warm +0.8	Warm +0.7	Warm +0.5
LDEO	Cold -0.5	Cold -0.5	Neutral	Warm +0.4
LDEO2	Cold -1.0	Cold -1.3	Cold -1.0	
BMRC	Warm +0.6	Warm +0.5	Warm +0.3	Neutral
UCLA				
Oxford	Cold -0.5	Cold -0.3		
LIM - CDC	Neutral	Neutral +0.2	Neutral +0.2	
CCA - NCEP	Warm +0.6	Warm +1.0	Warm +1.3	Warm +1.6
NN	Cold -0.5	Cold -0.3		
SSA - MEM	Neutral	Neutral	Neutral	Neutral
CA - NCEP	Neutral +0.3	Warm +0.6	Warm +0.8	Warm +0.7
CF - NCEP	Neutral +0.3	Neutral	Cold -0.6	Warm +0.8
OBSERVED	Very Warm +2.5	Very Warm +3.0	Very Warm +3.0	Very Warm +2.5

TABLE 5
Forecasts from March 1998

MODEL	JJA 98	SON 98	DJF 98/99	MAM 99
NCEP CGCM	Warm +0.8	Warm +0.7		
ECMWF	Cold -1.5			
SIO / MPI				
COLA	Cold -0.5	Cold -0.8	Cold -1.2	Cold -1.3
LDEO	Neutral	Cold -0.5	Cold -0.5	Cold -0.5
LDEO3	V. Warm +2.0	Warm +1.0	Cold -1.0	Cold -0.5
BMRC	Warm +1.4	Warm +0.7	Cold -1.0	Cold -1.5
UCLA	V. Warm +2.0	V. Warm +2.0		
Oxford				
LIM - CDC	Cold -0.6	Cold -0.7	Cold -0.5	Cold -0.4
CCA - NCEP	Cold -0.4	Cold -1.2	Cold -1.3	Cold -1.6
NN	Neutral	Cold -0.5	Cold -1.0	
SSA - MEM	V. Warm +2.0	Warm +1.5	Warm +1.0	
CA - NCEP	Cold -0.6	Cold -1.0	Cold -1.2	Cold -0.3
CF - NCEP	Warm +0.7	Warm +0.5	Cold -0.6	Cold -1.8
OBSERVED				

3.2 Health Effects

Dr. D. Schwela (WHO) discussed the public health and environmental impacts of smoke and haze. He emphasized that forest fires are common throughout the world. Prescribed forest fires are laid in North America with the goal to reduce dead wooden material the ignition of which could lead to uncontrollable fires. In Europe, wildfires occur in periods of drought naturally under certain conditions, in operations of agricultural fires coming out of control, or due to inattentive throwing away of burning cigarettes or matches. In developing countries and countries in transition slash and bum techniques are used to clear the land for purposes of agriculture and commercial plantations. During periods of extreme drought as a consequence of the El Niño phenomenon such fires can get out of control and non intended burning of large areas occur such as in Brazil and Indonesia. Satellite images show the large extension and number of such wildfires with remarkable resolution (up to less than 250 meters).

The smoke produced by forest fires contain several hundred components, and every condition of burning vegetation produces a unique pattern. The compounds most likely to be involved in acute/chronic toxicity include particulates, formaldehyde, other aldehydes such as acrolein, and polycyclic aromatic hydrocarbons. Other compounds such as the "classical" compounds of urban pollution (carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone) appear to play a minor role. Suspended particulate matter in smoke from forest fires is mostly in the size range below 2.5 µm. Information on concentrations of particulates is available in urban areas for total suspended particulate matter (TSP, SPM) and partially PM-10. The annual mean of PM-10 in polluted urban areas appears to lie between 50 and 200 $\mu g/m^3$, the 24-hour means are below 500 $\mu g/m^3$. In indoor environments with wood burning for the purpose of heating and cooking 24-hour mean PM-10 values range mostly between 500 and

5000 μg/m^3 (as inferred from SPM measurements with a PM-10/SPM conversion factor of 0.5). Polycyclic aromatic hydrocarbons (PAHs) with the prominent representative of Benzo-a-pyrene assume annual mean concentrations between 5 and 10 ng/m^3 in urban areas and between 0.4 and 14 μg/m^3 in indoor areas with cooking and heating with wood on open stoves. Carbon dioxide which is emitted from forest fires in great quantities does not produce direct health effects, however, in the long run it can produce health-related impacts due to global warming (impact on biological agents related to vector-borne diseases, extreme weather events, sea level rise, tropospherical ozone depletion).

Suspended particulate matter in the range below 10 μm can increase the number of and exacerbate respiratory diseases, increase daily hospital admissions and daily mortality due to respiratory and cardiovascular diseases. Moreover, indirect effects of smoke can occur such as reduction in photosynthesis and diminution of UV-B radiation, the latter which can result in increases of airborne infectious pathogens with corresponding increase of infectious and mosquito-transmitted diseases and enhancement of survival of pathogenic microorganisms in water (increase in diarrhea's, dysentery, schistosomiasis, onchocerciasis, and others). Aldehydes can produce irritative and sensory effects; in addition formaldehyde can lead to effects on the central nervous system. Carbon monoxide, through reduced oxygenation, can increase incidence and prevalence of cardiovascular diseases (CVD), myocardial infarction, and increase mortality due to CVD.

Information on observed health effects is available for wildland fire fighters, for indoor exposures of children and adults (mostly women), for exposures of humans to ambient wood smoke originating from indoor wood burning, and exposure of the general public to forest fires. Observed effects in these different exposed groups include decreased lung function; increase in respiratory symptoms; increase of acute respiratory infections in children which are a likely cause of infant mortality; increased incidence and prevalence of chronic bronchitis, asthma and chronic obstructive pulmonary diseases; increased prevalence or worsening of airways obstructive symptoms; increase in outpatient visits, hospital admissions and daily mortality. Findings, however, are not consistent for all countries in which forest fires were burning. Available evidence on lung cancer due to smoke from forest fires does not indicate an increased risk; but this long-term effect is very difficult to access due to the long time during which cancer develops.

WHO's Air Quality Guidelines for Europe of 1987 have been revised and updated and made globally applicable in a recent meeting. Tables of the new guidelines and figures for the guidelines for suspended particulate matter are given. A new situation has occurred for respirable particulate matter as no guideline values were derived due to apparent lack of a threshold for the onset of effects. Rather, percent-change-concentration relationships (essentially linear) or risk-concentration relationships are given for respirable particulate matter.

WHO has developed a model for estimating in a first approach the effects of air pollutants on human health using demographic data, the incidence and prevalence of mortality and morbidity, air pollutant concentrations, the number of people at risk, the increase of mortality and morbidity per unit increase of pollutant, the time people spent in various environments, and the presence of sensitive subjects. With this model premature deaths and incidence of morbidity can be estimated in a first approach.

Dr Schwela concluded by commenting that the preliminary findings presented at the WHO Bi-regional Workshop on Health Impacts of Haze-related Air Pollution, held in Kuala Lumpur, 1-4 June, 1998, appear to indicate some more or less significant effects of the 1997 haze event on human health of people living in the Southeast Asian region. As some of these findings are not too consistent which each other and with the known bulk of scientific material on the health impacts of respirable particulate matter, a careful scientific analysis of the findings is necessary before any final statement can be made.

A bibliography of publications of health effects of smoke from wood burning, forest fires and exposure to respirable particulate matter is provided in Volume 2 to this report.

3.3 Field Programmes

Dr. John Gras, CSIRO-Australia, reported on a major field programme executed during the 1997 fire episode. He noted that biomass burning is recognized as a significant source of aerosol over many regions of the globe and has been the subject of a number of major regional field studies, particularly in Africa and South America. However, for some areas of the globe, where there are frequent and at times extensive fires, such as Southeast Asia and tropical Australia, the properties of the aerosol produced by biomass burning have not been equally well characterized, and indeed, there is little detailed information. Accurate prediction of climate impacts, either regional or global, requires such knowledge. He presented data on smoke aerosol obtained from the fifth Pacific Atmospheric Chemistry Experiment, PACE-5, an aircraft-based experiment jointly conducted by the Japanese Meteorological Research Institute, CSIRO Atmospheric Research, Australia, and the Indonesian Meteorological and Geophysical Agency, in tropical northern Australia and Indonesia in October 1997. Its major objective was to study aerosol and gas emissions from savanna fires in northern Australia, but due to the extent of forest fires in Indonesia in late 1997, the field experiment was extended to include some observations in Kalimantan on the island of Borneo. This report presented in Volume 2 gives a general overview of the experiment including a brief summary of a number of the observations for which analyses have been completed.

3.4 Emissions from Fires

Dr. Joel S. Levine from NASA Langley Research Center, USA, discussed the role of fire in releasing trace gases and particulates into the atmosphere, and presented estimates of such emissions for the SE Asia fires in 1997/98. He emphasized that biomass burning, the burning of living and dead vegetation for land-clearing and land-use change, has been identified as a significant source of gases and particulates to the regional and global atmosphere. The bulk of the world's biomass burning occurs in the tropics--in the tropical forests of South America and Southeast Asia and in the savannas of Africa and South America. The majority of biomass burning (as much as 90%) is believed to be human-initiated, with natural fires triggered by atmospheric lightning only accounting for about 10% of all fires. The major gases produced during the biomass burning process include carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), oxides of nitrogen (NO_x = nitric oxide (NO) + nitrogen dioxide (NO_2)), and ammonia (NH_3). Carbon dioxide and methane are greenhouse gases, which trap Earth-emitted infrared radiation and lead to global warming. Carbon monoxide, methane, and the oxides of nitrogen lead to the photochemical production of ozone (O_3) in the troposphere. In the troposphere, ozone is an irritant and harmful pollutant, and in some cases, is toxic to living systems. Nitric oxide leads to the chemical production of nitric acid (HNO_3) in the troposphere. Nitric acid is the fastest growing component of acidic precipitation. Ammonia is the only basic gaseous species that neutralizes the acidic nature of the troposphere. Particulates, small (usually about 10 micrometers or smaller) solid particles, such as smoke or soot particles, are also produced during the burning process and released into the atmosphere. These solid particulates absorb and scatter incoming sunlight and hence impact the local, regional, and global climate. In addition, these particulates (specifically particulates 2.5 micrometers or smaller) can lead to various human respiratory and general health problems when inhaled. The gases and particulates produced during biomass burning lead to the formation of "smog."

The calculation of gaseous and particulate emissions requires quantitative information about the gaseous and particulate emissions produced and released into the atmosphere. The calculation of these emissions is complicated by the nature of the SEA fires, which involved a combination of the burning of tropical forests and peat bogs. Peat is partially decomposed organic matter formed in the acid waters of bogs. Indonesia and Malaysia have more than 20 million hectares of peat or 60% of all tropical peatlands. Dr. Levine and colleagues have calculated the gaseous and particulate emissions based on detailed fire maps developed by the U.S.D.A. Forest Service that show active fires and area burned for three Indonesia islands--Kalimantan, Sumatra, and Java- all areas of extensive and widespread fires, for the period of September 1997 to March 1998. The total area burned on the three islands was found to be 25,632 km^2. An analysis of SPOT images by the Center for Remote Imaging, Sensing and Processing (CRISP), National University of Singapore, for Kalimantan and Sumatra for the period September 1997 to March 1998 yielded a total bum area of 45,600 km^2. Since the SPOT analysis was based on almost complete coverage of the fire area, this estimate was used in estimating emissions. The emission calculation values are presented as a range of values depending on the assumed area extent of peat fires, which is not known. The lower estimate assumes that all the burning was solely due to forest fires (no peat fires), while the upper estimate assumes that peat fires covered 30% of the burned area. The carbon dioxide emissions range from 85 million tons to 316 million tons; the carbon monoxide emissions range from 7 to 52 million tons; the methane emissions vary from 0.3 to 1.8 million tons; the nitrogen oxide emissions range from 0.2 to 9 million tons; the ammonia emissions range from 0.1 to 4 million tons; and the total particulate matter emissions range from 4 to 26 million tons. It is important to point out that these emissions, which represent large emissions of gases and particulates into the atmosphere, only represent lower limit values since the calculations are only based on burning in Kalimantan, Sumatra, and Java. The calculations do not include any emissions from the widespread and extensive burning in Sulawesi, Irian Jaya, Sumbawa, Komodo, Flores, Sumba, Timor, and Wetar in Indonesia or Malaysia and Brunei, since these regions were not included in the fire maps used in this study. The emissions of CO_2, CO, CH_4, NO_x, and particulates from Kalimantan, Sumatra, and Java, are comparable to or exceed the emissions from the Kuwait oil fires of 1991. Further details are presented in Volume 2.

4 ASEAN-WIDE AND INTERNATIONAL PROGRAMMES

4.1 Role of ASMC

Mr. Woon Shih Lai, presented an overview of the role of the ASMC in the RHAP. ASMC works directly with the NMHSs in the region to provide regional products for use in fire, smoke and haze actions. The interactions and resources and facilities of the ASMC are presented in Figure 11. The ASMC plays a critical role in the implementation of the RHAP, working closely with the focus areas and the countries with primary responsibility: preventive measures (Malaysia); regional Monitoring Mechanisms (Singapore), and Fire Fighting Capability (Indonesia). The primary role of the ASMC is in the area of early warning and monitoring of land and forest fires, and to serve as a regional information centre for compiling, analyzing and disseminating information derived from satellite imagery and meteorological data used to support the detection, monitoring and occurrence of fires and smoke and haze. One of the primary mechanism for the exchange of data is through the ASMC Intranet which is presented in Figure 12.

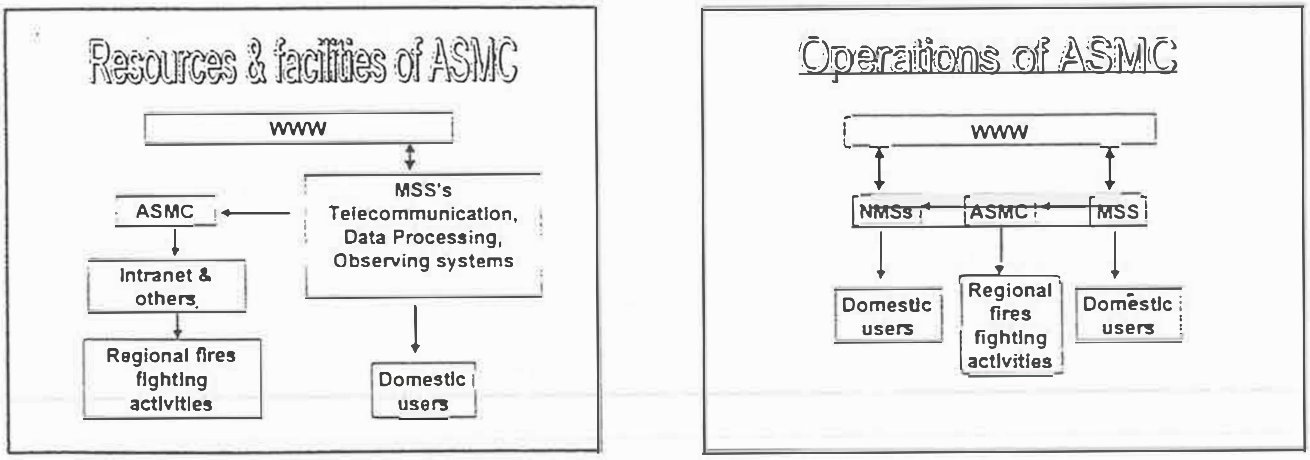


Figure 11: Schematic of operations and facilities at the ASMC.

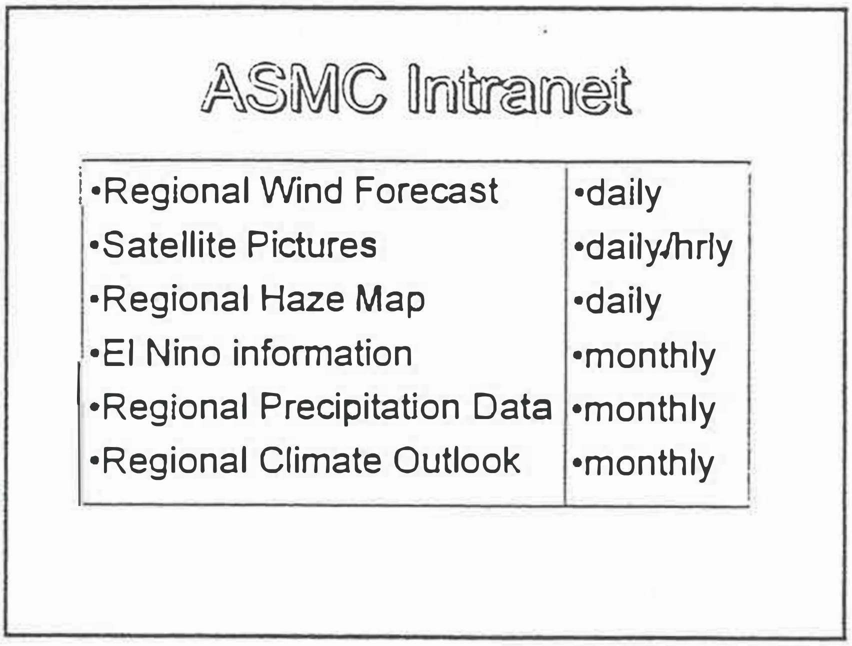


Figure 12: ASMC intranet products.

4.2 Programme to Address ASEAN Regional Transboundary Smoke (PARTS)

Dr. William Bolhofer of the National Weather Service, USA, provided a synopsis of the PARTS project. The PARTS project is in response to the needs and assistance requested by the ASEAN Committee on Science and Technology's Sub-Committee on Meteorology and Geophysics on behalf of the ASEAN countries. At the 18th meeting of the ASEAN Sub-Committee on Meteorology and Geophysics (ASCMG), Bangkok, 21-27 July 1995, there was an agreement to initiate a project on Transboundary Air Pollution. The ASCMG Chairman officially requested the WMO to provide assistance in the formulation of a project proposal and to contact potential donor agencies for funding support and technical assistance. The focus on smoke and haze is due to the fact that the ASEAN countries experience periods of severe regional smoke and haze associated with biomass burning and local pollution emissions. During 1982 and 1994 the ASEAN region experienced severe smoke and haze episodes which interfered with civil aviation, airport operations and maritime shipping. The health of downwind populations was also compromised. So extreme was the 1994 haze episode that an ASEAN Ministerial-Level Meeting on the Management of Transboundary Pollution was convened in Kuala Lumpur, Malaysia, 14-17 June 1995, to develop a regional co-operation plan on transboundary pollution.

In response to the ASCMG request, a World Meteorological Organization (WMO) sectoral site survey mission was conducted in the seven ASEAN countries during August 1996 to review and evaluate National Meteorological and Hydrometeorological Services (NMHSs) capability to detect, monitor and predict the long-range transport of atmosphere pollution. The purpose of each country visit was to obtain an overview of national capability as well as regional linkages to detect, monitor and track smoke and haze associated with biomass burning. The team reviewed satellite imagery capabilities to detect fires and smoke, available meteorological numerical forecast products, and dispersion modeling capability. The team also examined national atmosphere pollution monitoring networks that routinely observe species associated with fossil fuel burning, transportation and industrial processes. These networks, operated by natural resource or environment ministries, fulfill both national and international purposes.

As a result of this study a project proposal was developed consisting of three critical components focused on continuing the progress made at the regional and national levels in smoke and haze co-operation and early detection, and on furthering regional co-ordination. Specific activities to be addressed in this project are: 1. Improve the regional capabilities in satellite usage through technology transfer and training. 2. Enhance the regional capabilities in modeling the long range transport of smoke, haze and other pollutants (LRTAP) through technology transfer and training and 3. Design and implement a monitoring strategy for regional smoke, haze and transboundary pollution.

This project has subsequently been endorsed by various ASEAN committees, and has been adopted as a complementary element of the Regional haze Action Plan. Funding for elements of PARTS have been obtained through US Department of State (DoS) and through UNEP. Further details are presented in Volume 2 to this report.

4.3 Asian Development Bank

Mr. Erik Scarsborough discussed the Asian Development Bank's activities related to the Regional Technical Assistance (TA) Strengthening ASEAN's Capacity to Prevent and Mitigate Transboundary Atmospheric Pollution. This initiative is aimed at assisting the ASEAN region in its efforts to deal with smoke and haze. ASEAN Environment Ministers had in June 1995 agreed on an ASEAN Cooperation Plan on Transboundary Pollution. The Cooperation Plan contains broad policies and strategies to deal with transboundary pollution. In light of the latest haze experience, the ASEAN Environment Ministers have agreed on this Regional Haze Action Plan (see Volume 2), which sets out cooperative measures needed amongst ASEAN Member countries to address the problem of smoke haze in the region arising from land and forest fires. He reviewed the objectives and scope of this project. These consist of: (A) Operationalize and implement RHAP and NHAP's; (B) Improve information management and dissemination in ASEAN Secretariat; (C) Strengthen the capacity of the ASEAN Specialized Meteorological Center (ASMC) to serve as a regional hydrometeorological information centre, in collaboration with national counterpart agencies; (D) Catalyze mechanisms for international cooperation and collaboration in fire prevention and mitigation; and (E) Undertake socioeconomic and scientific studies with a regional focus.

They have identified prevention, mitigation and monitoring as critical aspects to operationalizing the RHAP. Prevention of forest fires and consequent haze comprises: i) forecasting climatological conditions likely to result in fire-and-haze episodes; ii) mapping of areas subject to heightened risk of forest fires, including how these at-risk areas expand or shrink in response to changes in climatological conditions; iii) management and dissemination of information relating to present or likely fire-and-haze episodes, including present or likely geographical areas affected by haze resulting from forest fire episodes, and the human health impacts (or likely impacts) or existing or forecasted haze presence or movement; iv) reviewing the existing policy framework at the national level with a view to determining how the set of economic incentives that policy framework provides is likely to shape the use of fire as a tool or weapon; v) bringing about appropriate policy changes to ensure that the set of economic incentives provided by the policy framework at the national level is consistent with national level policy as it pertains to the use of open burning; vi) providing market-based and other economic incentives for promoting the adoption of new products and technologies that use biomass, logging and land-clearing residues as productive inputs; vii) formulation, operationalization and implementation of National Haze Action Plans (NHAPS) that both serve as the foundation for operationalizing the RHAP, and to increase the degree of readiness to meet forest fire emergencies at the national level; viii) harmonizing and integrating the NHAPs at the ASEAN level to ensure their collective consistency and effectiveness in responding in concert to a regional forest fire event; ix) developing and implementing institutional arrangements for linking national fire fighting capabilities in any combination within ASEAN (e.g., Subregional Fire Fighting Arrangements, or other mechanisms for coordinating multiple national firefighting capabilities); and x) formulating, ratifying and implementing an ASEAN-wide Forest Fire Readiness Protocol that formalizes linkages among national-level fire fighting capabilities by putting into place institutional arrangements that facilitate their rapid deployment

Mitigation of land and forest fires and consequent haze is composed of: i) formalizing arrangements for improved training and retraining of forest firefighters at the national and regional level in a manner that ensures that personnel trained are adequately equipped to cope with future forest fire events on a scale that is likely to occur; ii) inventorying existing fire fighting capability at the national level, including all aspects of fire fighting equipment and personnel, with a view to determining the maximum scale of a forest fire event that the existing fire fighting capability is equipped to handle; iii) strengthening fire fighting capability at the national level to a point at which each ASEAN Member country's fire fighting capacity is sufficient to cope with forest fire events likely to occur on an annual basis; and iv) ensuring the continued readiness of fire fighting capability at the national level by means of regular maintenance of equipment and upgrading of skills among fire fighting personnel.

Monitoring for prevention and mitigation of forest fires and consequent haze includes: i) detecting wildfires; ii) predicting and tracking their movements and the movement of the resulting haze; iii) forecasting the degree to which wildfires are likely to generate haze, as well as the type or composition of emissions likely to be generated; iv) determining the likely health impacts resulting from typical or particular haze episodes; v) determining the areas historically affected by forest-fire-and-haze episodes in the region, or those likely to be affected by particular episode; and vi) assessing the impact of past forest fire episodes, including the extent of area burnt the composition of flora and fauna destroyed, and the socioeconomic cost of particular forest fire episodes at the local, national, regional and global levels.

Mr Scarsborough also reviewed the short term (3 month) and medium term (12 month) mileposts for the project.

A. Short-term Measures to be Completed Within 3 Months of Commencement

a. Compile and analyze ongoing national and regional fire and haze prevention programmes with a view to sharing relevant experience, improving coordination, and avoiding duplication of effort. Based on the findings, make recommendations how national and regional fire and haze prevention measures can be improved in the short and medium term.

b. Inventory existing fire management and suppression capabilities in the affected ASEAN countries, and develop technical assistance programmes and partnerships within and beyond the region to strengthen these capabilities. (Several international and bilateral organizations had expressed interest during the 1997 fire and haze episode to offer assistance in this area.)

c Strengthen the capacity of the ASEAN Secretariat, ASOEN, the working group on transboundary pollution, and the Task Force, in the effective delivery of their functions in fire and haze prevention and mitigation.

d. Improve information's management and dissemination in the ASEAN Secretariat related to fire and haze prevention and mitigation, including the sharing of knowledge and experience, dissemination, coordination, and monitoring of national, regional and international initiatives with institution concerned in the region. This includes the establishment and maintenance of an intranet between institution concerned in the region, and a public information service through the ASEAN world-wide-web home page.

e. Compile initial results of ongoing studies on the impact of transboundary atmospheric haze pollution on affected ASEAN countries, collect additional information where sectors concerned, as well as social (including health related) and environmental impacts. Detailed assessment would be carried out over the medium term (see below, item B [b]).

f. Compile and analyze existing policies and legislation in countries concerned regarding sustainable land use practices with and without the use of fire for land clearing, and recommend changes as appropriate.

g. Compile experience within and beyond the region with fire prevention and control, including land-clearing fires and wild fires, mitigation strategies, etc., and document relevant lessons learned.

h. Based on the outcome of the above (items a-g), provide assistance to the Task Force in finalizing Action Plan, identifying the institutions responsible for various implementation actions, including institutionalized monitoring and review of policies, strategies, legislation, guidelines, early warning pertaining to fire-danger and potential pollution hazard, personnel mobilization for prevention of spread of fires, and other aspects of the Action Plan and providing regular updates to members concerned on the progress of actions taken or pending and need for follow-up actions.

B. Medium-term Measures to be Completed Within 12 Months of Commencement (These measures, which would be initiated on currently with the short-term measures).

a. Strengthen the capacity of the ASEAN specialized Meteorological Center (ASMC) in Singapore, to compile and analyze available ground, atmospheric and remotely sensed data on land and forest fires, haze, related climate and weather patterns, and other relevant environmental parameters in collaboration with national meteorological agencies, and to disseminate the information including early detection and warning through established institutional arrangements with national agencies concerned. The collaboration with national agencies is particularly necessary to compile data from a larger geographical area.

b. Compile available information within and beyond the region regarding the use and marketing of biomass and logging residue products, such as briquettes, mulch, and compost. This includes a study of market-based incentives to promote such products and thereby stimulate mechanical land clearing methods.

c. Taking due account of various national and regional initiatives, evaluate the existing and proposed systems pertaining to fire danger rating, and fire detection and monitoring: based on these initiatives and the information thus generated, promote the development of land and forest fire hazard maps, and standardized national and regional fire danger rating and fire detection and monitoring systems.

d. Develop regional training programme, exchange visits, secondments, partnerships, joint training exercises, in fire management, remote sensing of fires and haze, the application of geographic information systems, and other priority subjects.

e. Compile the results of ongoing studies on the impact of transboundary atmospheric haze pollution on affected ASEAN countries, collect additional information where required, and compile a comprehensive impact assessment covering all economics sectors concerned, as well as social and environmental impacts. The assessment would include the results from national impact assessment in Indonesia financed under the complementary advisory A. It would compare the impact of the 197 fires and haze with that of previous episodes, and would provide scenarios of possible future impact according to the level of concerned preventive action taken by affected ASEAN countries.

f. Develop technical assistance programmes and partnerships to undertake scientific studies to improve the monitoring and prediction of transboundary atmospheric pollution, including analysis of the chemistry of emissions, climate and meteorological patterns affecting pollution formation and dispersal. Such programmes would likely involve ASMC, national institutions in ASEAN countries, and partner institutions within and beyond the region, including the World Meteorological Organization and interested bilateral organizations. This would be based on an inventory and analysis of ongoing and planned scientific studies to improve the knowledge of haze formation and distribution. One such study could gather information on the chemistry of emission of land-use fires, to support the haze transport modeling being undertaken by ASMC.

g. Based on the outcome of the above (items a-f), and in support of and complementary to the earlier developed Action Plan, develop a comprehensive time-bound plan for prevention, monitoring, mitigation and institutional strengthening, identifying required investments, both at the national and at the regional level.

4.4 UNEP

Mr. Peter Usher presented UNEP's programme to address the forest and bush fires in SE Asia. He stated that UNEP was pleased that the international community has been swift to recognize the dangers for what they are and are prepared to collectively address them, particularly in the use of remotely sensed data by satellites for the detection of forest fires and the associated smoke/haze envelopes. He also indicated that UNEP was committed to close collaboration with ASEAN, WMO, US-NOAA and the Asian Development Bank (ADB), to support the regional haze action plan and the associated national initiatives on early warning of forest fire. The specific area of cooperation for UNEP will be to assist the development and improvement of the fire early warning component of the action plan within the UNEP/GEF project Emergency Response to Combat Forest Fires in Southeast Asia.

He described UNEP's project to facilitate the development of an early warning component of the UNEP GEF emergency project to add value to and complement PARTS. Also, UNEP, working together with UNDP, will assist in the development of regional protocols and agreements, using its considerable expertise and long experience in international environmental law which can be harnessed for regional needs.

The proposed cooperation will:

- First, assist ASEAN Member countries in dealing with forest fires to control regional transboundary smoke and haze;
- Secondly, provide experience with, and permit evaluation, of models and mechanisms to be applied elsewhere; and
- Thirdly, promote better linkages and cooperation with national and regional institutions and UN agencies and donors in dealing with transboundary events influencing pollution and global warming issues.

Mr Usher reported that GEF has approved a medium-sized UNEP proposed project - 'Emergency Response to Combat Forest Fires in Indonesia to prevent Haze in Southeast Asia' to be implemented in Indonesia, Malaysia, Singapore and Thailand and the Philippines. These funds are additional to the resources earmarked by the United States and the Asian Development Bank Ltd and others to assist Indonesia and its affected neighboring countries to cope with the environmental disaster.

Planned activities include coordination of all existing efforts to ensure the best use of available resources for fighting and preventing the forest fires in Indonesia and will involve a consultation mechanism among all concerned parties - governments; United Nations and other international agencies, donors and non-governmental organizations, It will require expert group and donor meetings to develop a strategy to combat the fires, and make recommendations to donors. The principal part of the project will be the establishment of an early warning system for fires which will include an aerial surveillance regime for Sumatra under the Sub-Regional Fire Fighting Arrangement and improvement of communication systems.

A significant amount of the GEF grant, about one-third, will be used for training and capacity building to ensure effective implementation of the strategy. There will also be a public awareness programme of seminars, experience-sharing workshops and media coverage to sensitize the public to the full implications of the catastrophe and also to ensure that lessons learned from the experience are available to other countries and continents confronted with similar environmental threats.

The project has developed as a consequence of earlier activities involving UNEP including:

- The OCHA Mission to Indonesia during March-April 1998. The Mission recommended immediate international assistance to contain the fires. It noted the lack of specialized fire-fighting organizational infrastructure, equipment and expertise requiring targeted international arrangements for mobilizing for emergency response, prevention and preparedness. Expert workshop on fire fighting (20 April 1998) facilitated by the UN Office in Geneva.

- Meeting on Medium and Long-term programmes for responding to the Indonesian Fire Emergencies (21 April 1998).

- Donors meeting on the Indonesian fires.

- Expert Working Group on Short Term Costed Action Plan on fire fighting in Indonesia.

- ASEAN Inception Workshop on Strengthening ASEAN capacity to mitigate transboundary haze pollution (May 1998).

He also offered his observations on UNEP/WMO potential collaboration to address the forest fire problem in Southeast Asia.

- The PARTS project originally provided for a satellite remote sensing component. This was to improve the ASEAN region's capability to fully use satellite resources for the early detection of forest fires and related smoke/haze envelopes. While PARTS was funded by US-AID, the satellite early warning component was not.

- The UNEP GEF project has, as a major element - (i) the establishment of an early fire warning system and (ii) associated training and capacity building to implement the strategy.

- It was thought that the two UNEP GEF project elements could add value to the PARTS project, achieve the early warning system objective and meet future needs of the region while addressing the wider issues of smoke and haze contributions to atmospheric and climate issues.

He also commented on UNEP/WMO collaboration including such activities as:

1. Sponsoring an expert workshop to:

   - define the exact nature of the early warning component;
   - formulate the sub-project to implement it and;
   - define its interaction with the PARTS project and programme.

2. Implementing the sub-project in collaboration with WMO, the ASEAN Regional Haze Project and the ASEAN Specialized Meteorological Center (ASMC) in Singapore.

3. UNEP would like to build additional linkages into the sub-project to -

   - allow technical backstopping by the UNEP GRID centers at Sioux Falls, USA, and Bangkok, Thailand, and associated national ministries of the environment in participating ASEAN countries, and;
   - make allowance for an evaluation of the early warning system component in due course with a view to its portability to other regions and countries.

4.5 UNDP

Mr. Neil Buhne presented information on UNDP's activities. The primary roles of UNDP are: (i) emergency response and co-ordination, as the UN Resident Co-ordinator; (ii) prevention and mitigation of the development and environment impacts; and (iii) liaison with UN medical director on the impact on the health of UN and UN agency staff members. During the 1997/98 fires their activities included:

- In Indonesia, the mobilization of people and resources to help fight forest fires, and to alleviate the consequences on people and the environment including field observation teams, and special work in a national park.

- United Nations Disaster Assessment and Co-ordination Team supported Indonesian efforts at co-ordination.

- In Malaysia UNDP supported the Ministry of Environment in 1997 and 1998 in keeping the international community informed of the actions needed and in mobilizing assistance.

- Offered assistance and support to national programmes for environmental emergency preparedness planning.

Mr Buhne discussed various initiatives focused on issues related to development and environment impacts. These included at the global level a number of initiatives related to sustainable forest management, and the links between poverty and the environment. At the regional level, UNDP works through its programme of assistance to the ASEAN Secretariat, through the GEF, and its regional programme. UNEP is working at the country level as illustrated in Indonesia through capacity building in forest fire fighting, and sustainable resource development projects, and in Malaysia through a GEF project under development on peat swamp forest conservation. In addition UNEP is supporting the Special Study Team on transboundary air pollution, specifically its constituents, the health effects, economic effects, management of air quality, and early warning and disaster preparedness of the haze.

He outlined the possible future roles for UNDP and for the UN system in regards to smoke and haze issues in Southeast Asia. These include efforts to support Government in the implementation of the ASEAN haze action plan, in close partnership with other multilateral organizations and countries. This includes working to modify land management practices and developing alternatives to the conditions that create large-scale fires. Efforts directed towards building capacities to warn of conditions which will lead to fires and for early response. He closed by stressing that the issue is more than fires... it is an economic and development issue.

4.6 Danish-Malaysia Bilateral

Mr. Leif Laursen, Danish Meteorological Institute, presented information on the Danish-Malaysian Environmental Agreement to increase the Malaysian capability in haze forecasting by applying Danish meteorological expertise and technology in the Southeast Asia region. The overall objective of the project will be to provide Malaysian authorities with improved planning tools for initiation of measures in order to prevent or mitigate the environmental and human health problems from the haze, and to secure tools for assessments of the consequences of reduced visibility on air traffic and traffic in general during haze episodes.

The project proposal is in five phases: (I) Inception task including the preparation of a more detailed Project Implementation Plan (PIP), and establishment of a steering committee for the project; (II) Adaptation of haze forecasting system and preliminary semi-operational runs at DMI; (III) Validation of haze analysis and forecasting model system on historical data; (IV) Implementation of the haze analysis and forecasting model system at MMS; and (V) Project conclusion.

The main output of the project will be the implementation at MMS of the Numerical Weather Prediction Model DMI-HIRLAM and DMI's dispersion models DERMA and possibly also DACFOS. The project will also focus on the training of key personnel at MMS, and improved methods for localization and estimating the strength of emissions utilizing this information in a real-time forecasting system. Also analysis of the severe haze episode in 1997 will be made, and the project will study methods to improve the models treatment of the tropical convection models, which is a major problem in all weather prediction and dispersion models.

5. WORKING GROUPS REPORTS

Working groups were formed to facilitate more focused discussions and to develop specific recommendations related to improving regional capabilities to manage episodes of large-scale smoke and haze. Four groups were formed: Monitoring & Measurements; Modeling; Remote Sensing; and Information Exchange & Coordination. The reports of the Working groups are presented below.

5.1 Working Group on Modelling

Members:

Paulus Winarso, Meteorological & Geophysical Agency of Indonesia, Chair
Roland Draxler, RSMC Washington, Rapporteur
Paul Stewart, RSMC Melbourne
Keiichi Katayama, RSMC Tokyo
Leif Laursen, Danish Meteorological Institute
Lam Keng Gaik, Singapore Meteorological Service
Asraya A. Rahman, Brunei Meteorological Service
Landrico U. Dalida Jr., Pagasa Weather Bureau, Philippines

Objective: To assess current transport modeling efforts and identify improvements to enhance regional capabilities to forecast smoke and haze, and other transboundary atmospheric pollution events, in support of emergency response activities.

5.1.1 Synopsis of Discussions

The meteorological requirements to support the forecasting of smoke and haze are divided into long-, medium-, and short-terms. Long-term forecasts are associated with improved predictions of ENSO and climate variability, while medium-term requirements are associated with monthly and quarterly. Short-term forecasting was linked to daily smoke trajectory and dispersion forecasts from the Atmospheric Transport Models (ATMs) and the corresponding Numerical Weather Prediction (NWP) models that provide the input data for the ATMs.

Participants felt that the current climate prediction products provided by the Australian Bureau of Meteorology (BoM), NOAA's National Centers for Environmental Prediction (NCEP), and the European Centre for Medium Range Weather Forecasting (ECMWF), should continue to be improved. However, during smoke emergencies there was a need for more frequent updates than the normal monthly issue interval. It was pointed out that the centres actually run their Global Climate Models (GCM) more frequently, but issue the products less frequently to build more of an ensemble estimate. Due to the global nature of the climate prediction models, there was no desire to run the GCMs at local meteorological centres, however there was a suggestion that there is a potential to develop customized local climate products, similar in nature to the common Model Output Statistics (MOS) used for local weather prediction.

The requirements for short-term forecasts of smoke were primarily linked with the accuracy of the meteorological prediction that drives the ATM rather than the parameterizations of the ATM. It was pointed out that all the current ATM predictions are driven by data from the global models and that these models would have trouble reproducing the flows associated with mesoscale features, such as the seabreeze and terrain. These discrepancies were confirmed from satellite observations of smoke and some of the regional meteorological services used their local knowledge of such flows to customize smoke forecasts. The proposed solution was for the regional meteorological centres to run their own higher resolution Local Area Models (LAM). Currently a LAM is run only at the ASMC. Local meteorological services expressed an interest to run their own LAMs in the future, but right now they felt that it would be most practical for them to run only the ATM in their region and obtain the LAM data from the ASMC.

5.1.2 Identification of the Need for Additional Observational Data

It was noted that in many of the fire affected regions there is a lack of meteorological observations, such that there is insufficient spatial density. Increasing the number of reporting stations that are incorporated into the NWP model initialization has the potential for improving the resulting short-term forecasts. The lack of meteorological observations was attributed to the remote nature of many of the regions and to recent financial constraints causing a reduction in the number of upper air observations. Longer-term climate predictions are influenced by SST. It was noted that satellite SST measurements can be disrupted by volcanic eruptions, which are frequent in this region, and other observational methods should be enhanced. Improved predictions from LAM require higher resolution data on land-use and soil moisture. Regional centres were encouraged to develop these data sets.

5.1.3 *Needs and Actions to Improve Model Performance*

As noted previously, additional and more frequent meteorological data has the potential to improve NWP model performance through the specification of better initial conditions. These data are also needed to evaluate the model performance – it is necessary to determine if model changes actually lead to improved performance. Other issues relate to how well the NWP models simulate the tropical boundary layer and its diurnal cycle. This is directly related to the development of convection and the parameterization of vertical mixing in these conditions. It was suggested that there be a review of past meteorological experiments conducted in the tropics, and that these experiments be evaluated for their potential to improve NWP and ATM parameterizations.

Several participants noted that the fire's smoke altered the radiation balance. This in turn affected the development of the boundary layer, precipitation, and evolution of wind fields. It was proposed that over the longer-term research should be conducted to integrate a Chemical Transport Model (CTM) within the NWP model and thereby directly link the smoke with the meteorological forecast. This would perhaps be most effectively implemented within the LAM.

It was also noted that there is a lack of experimental data to verify the dispersion aspects of the ATMs. Two approaches were suggested. One would be to review the SPOT and GMS images for distinct fire/smoke events and compile the corresponding data for analysis. The smoke images could then be used to compare measured (from satellite) and model dispersion estimates. The second approach would be to conduct a planned tracer release, such as has been done previously in North America and Europe (ETEX – European Tracer Experiment).

5.1.4 *Identification of Data Exchange Methods*

All participants liked the concept of using Internet for product distribution and exchange due to its lower cost over Intranet. However, all agreed that access to the Internet products needs to be restricted so that the NMS maintains its responsibility to be the prime provider of products to its own country. Some additional products were identified that could be useful: Drought Index, Fire Risk Index, Inversion Layer Forecasts, and perhaps in the future forecasts of visibility and API.

NMSs expressed a strong desire for continued training on product interpretation through lectures and documentation. In-country end-user's should be trained by their respective NMS. Longer term training needs were identified related to NMS developing the capability to run LAMs. Research and Development is considered to be an integral component of training and existing R&D activities at the ASMC should be strengthened.

5.1.5 *Recommendations*

Short-term recommendations

- Option to obtain more frequent climate forecasts
- Install trajectory/dispersion modeling capabilities at local meteorological services
- Low-level wind forecast products should be provided in addition to trajectories
- Provide resources for additional upper-air and surface observations
- Compile SPOT/GMS images for dispersion parameterizations
- Provide ATM product interpretation training

Long-term recommendations

- Develop MOS type climate products in cooperation with ASMC
- Provide training and infrastructure for NMS to run their own LAM
- Establish additional direct SST measurements as backup to satellite observations
- Create high resolution land-use and soil moisture data sets for LAM
- Review past tropical meteorological experiments for relevance to smoke transport
- Integrate CTM with NWP to properly model the radiation balance
- Evaluate the usefulness (and cost) for a tropical dispersion experiment
- Increase R&D efforts at the ASMC

5.2 Working Group on Information Exchange and Coordination

Members:

Woon Shi Lai, Meteorological Service, Singapore, Chair
Wasyl Drosdowsky, Bureau of Meteorology Research Center, Australia, Rapporteur
Dieter Schiessl, World Meteorological Organization
Erik Scarsborough, ASEAN, Secretariat

Objective: To identify improvements in the exchange of information and coordination of activities among national authorities, Meteorological Services (including RSMCs and ASMC) and others in relation to the management of smoke and haze (and other transboundary) pollution events.

5.2.1 Synopsis of Discussions

The Regional Haze Action Plan (RHAP) is being continuously implemented. At present the data management functions of the environmental monitoring aspects of the RHAP are in place through the ASEAN Specialized Meteorology Center (ASMC) intranet. A long discussion was held on the question of who would request, and who would provide, support for emergency response. The RHAP stipulates that requests come from the national Environment Ministers. The group suggested/agreed that primary responsibility for the provision of information and forecasts (including the running of Atmospheric Transport Models (ATMs)) should rest with ASMC, but with the option of seeking further input from other RSMCs with ATMs. Individual members could also enter into bilateral arrangements with other institutes with ATM capabilities, eg. the Malaysian–Danish project. Some concern was expressed at the free availability of ATM forecasts on the Internet/Web.

The current arrangements for data and product exchange, using the WMO GTS network for routine meteorological observations and gridded forecast products and the Internet/Web for non–standard products, were regarded as satisfactory, but the GTS needs to be enhanced. Some concerns were raised regarding the cost of maintaining the ASMC Intranet service, and the difficulty in updating Internet information located on the general government Internet server.

There was some discussion on the desirability and/or feasibility of completely standardizing the ATM output, as has been done for the nuclear emergency response. It was agreed that some standardization of pollution indices was desirable and should be encouraged. The exchange of routine meteorological data, especially daily rainfall data could be improved, preferably through the GTS.

The provision of climate forecasts was an area of concern. There is little climate prediction capability in the region, but many freely available climate prediction products are available on the Web for regional interpretation. Regional climate prediction capabilities need to be enhanced.

The need for a routine mechanism (other than special meetings such as this) to review the operational co-ordination between the NMHSs concerned with RHAP was discussed. Suggested possible venues were the ASEAN Sub-committee on Meteorology or the regular WMO Region V Working Groups. The need for some form of post-event evaluation was discussed, but some concern expressed not to create a too rigid or costly validation procedure.

5.2.2 Recommendations

1. Maintain and enhance the current system for dissemination of data, products and other relevant information.

   (a) GTS for routine meteorological data and gridded model output.

   (b) Web technology for non-standard.

2. Develop regional Atmospheric Transport Modeling (ATM) capability, while retaining option to request additional input from other RSMCs with ATM expertise, and develop bilateral arrangements (e.g., Malaysia-Denmark).

3. Develop standardized pollution indices for monitoring and standardized ATM outputs.

4. Enhance current arrangements for exchange of meteorological data, especially daily rainfall.

5. Develop regional climate prediction capabilities to (a) interpret, and (b) locally enhance predictions from global climate forecast models.

6. Coordinate/review meteorological arrangements in routine regional meetings (e.g., ASEAN Sub-committee on Meteorology and Geophysics), and WMO Region V meetings.

7. Evaluate all aspects of smoke/haze events as part of the RHAP monitoring process, and recommend changes and/or improvements.

5.3 Working Group on Remote Sensing

Members:

Lim Joo Tick, Chair, Malaysian Meteorological Service
Joel S. Levine, NASA Langley Research Center, USA, Rapporteur
Divino Figueiro, National Meteorological Institute, Brazil
Johann G. Goldammer, Max Planck Institute for Chemistry, Germany
Leong Kwai Yin, Ministry of the Environment, Singapore
John Low, Meteorological Service of Singapore
Sim Choon Siong, Meteorological Service of Singapore
Peter Usher, United Nations Environment Programme, Nairobi
Liisa Jalkanen, WMO, Geneva

Objective: To assess current national and regional remote sensing capabilities to detect fire activity, smoke and haze envelopes, and estimate emissions in support of smoke and haze response and management activities and identify needs to enhance regional capabilities.

5.3.1 Synopsis of Discussions:

The group focused discussion on specific tasks. Each task is presented and followed by a summary of deliberations.

<u>Current national and regional remote sensing capabilities to detect fire activity, smoke and haze envelopes.</u>

Most countries in Southeast Asia have the capability to receive fire activity, smoke and haze data from the following satellite systems: NOAA/AVHRR, GMS-5 and TOMS (aerosol indices available on the Internet). CRISP receives SPOT images and makes them available to neighboring countries.

<u>Future fire satellite systems planned or under development include :</u>

MODIS (on NASA's EOS/AM-1 spacecraft to be launched in 1999), BIRD (German fire satellite to be launched in 1999), FOCUS (German fire instrument to fly on the International Space Station), FUEGO (ESA's 9 satellite constellation to monitor fires in the Mediterranean area), FireSat (NASA Langley Research Center's fire satellite in Phase A study) and Micro-MAPS, (a space instrument to monitor carbon monoxide (CO) from fires).

Some deficiencies of existing satellite capabilities:

Poor repeat coverage of fire locations (cannot be used in operational fire fighting).

NOAA/AVHRR infrared channel for fire detection (channel 3) saturates at low temperatures (50°C). Hence, it is difficult to accurately determine fire locations from other hot surface areas.

SPOT images too expensive for routine fire fighting and fire assessment needs.

<u>Identification of measurement needs to provide ground-truthing of remote sensed information.</u>

Area burned.

Geographical location of fires (geo-location).

Identification of nature of locations experiencing burning, i.e. forests, grasslands, agricultural areas, peat fires, etc.

Vegetation and land-use maps to accurately assess the regions experiencing fires.

<u>Exchange of Data</u>

Existing agreements of data exchange adequate for most operational needs.

Expanded data exchange needed for case studies and research activities.

Wider distribution of fire data to public via television, newspapers, etc

Bangkok and Sioux Falls Global Resource Information Database (GRID) nodes available to countries in Southeast Asia.

5.3.2 Recommendations

1. NOAA channel 3 should be optimized for fire monitoring.

2. Adopt uniform algorithm for detection of active fires.

3. Back-up systems are needed for monitoring fires, i.e. receive fire data from other receiving stations to ensure continuity of fire data.

4. Ground-truthing of fire data from satellites.

5. Real-time transmission of NOAA fire data to users on ground.

6. Begin planning and developing the next generation of dedicated fire monitoring satellite. These satellites should have better spatial and temporal resolution than existing satellites. These advances will permit more accurate and precise measurements of fires.

7. Countries in Southeast Asia should use the Bangkok and Sioux Falls GRID node for the preparation of targeted information products.

8. Better characterization is needed of the fire temperature and resulting gaseous and particulate emissions from diverse ecosystem (i.e. forests, grasslands, agricultural areas, peat fires, etc) and land-use systems.

9. Promote use of aircraft including remotely piloted aircraft to monitor active fires and fire scars.

10. Promote research to use space-borne radar to determine area burned and vegetation dryness.

11. Promote research to use active remote sensing (laser and radar systems) from space and ground based systems to measure the vertical distribution of gases and aerosols produced during fires.

5.3.3 Operational Satellite Fire Monitoring Systems

The following summary gives the current operational satellite systems used in fire monitoring. The application of these systems to monitoring active fires, smoke clouds and/or burned areas is described in the attached recent fire references. These references describe the instrumentation and capabilities of the instrumentation in fire monitoring.

1. NOAA (National Oceanic and Atmospheric Administration)/AVHRR (Advanced Very High Resolution Radiometer): Global 1-km imaging systems. Monitors active fires and burned area.

Some recent fire references

Cahoon, D. R., Jr.; Levine, J. S.; Cofer, W. R. III; Miller, I. E.; Minnis, P.; Tennille, G.M.; Yip, T. W.; Stocks, B. J.; and Heck, P. W.: The Great Chinese Fire of 1987: A View from Space. Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications (J. S. Levine, Editor), The MIT Press, Cambridge, MA., 1991, pp. 61-66.

Cahoon, D. R., Jr.; Stocks, B. J.; Levine, J. S.; Cofer, W. R. III; and Chung, C. C.; Evaluation of a Technique for Satellite-Derived Area Estimation of Forest Fire. Journal of Geophysical Research, Vol. 97, No. D4, pp. 3805-3814, March 20, 1992.

Cahoon, D. R., Jr.; Stocks, B. J.; Levine, J. S.; Cofer III, W. R.; and Pierson, J. M.: Satellite Analysis of the Severe 1987 Forest Fires in Northern China and Southeastern Siberia. Journal of Geophysical Research, Vol. 99, 1994, pp. 18,627-18,638.

Cahoon, D. R. Jr.; Stocks, B. J.; Levine, J. S.; Cofer, W. R. III; and Barber, J. A.: Monitoring the 1992 Forest Fires in the Boreal Ecosystem Using NOAA AVHRR Satellite Imagery. Biomass Burning and Global Change, Volume 1 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp.795-801.

French, H. F. N., E. S. Kasischke, R. D. Johnson, L. L. Bourgeau-Chavez, A. L. Frick, and S. Ustin: Estimating Fire-Related Carbon Flux in Alaskan Boreal Forests Using Multisensor Remote-Sensing Data. Biomass Burning and Global Change, Volume 2 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp. 808-826.

Justice, C. O., J. D. Kendall, P. R. Dowty, and R. J. Scholes: Satellite Remote Sensing of Fires During the SAFARI Campaign Using NOAA Advanced Very High Resolution Radiometer Data. Journal of Geophysical Research, Vol. 101, 1996, pp. 23,851-23,863.

Stocks, B. J., D. R. Cahoon, W. R. Cofer, and J. S. Levine: Monitoring Large-Scale Forest-Fire Behavior in Northeastern Siberia Using NOAA-AVHRR Satellite Imagery. Biomass Burning and Global Change, Volume 2 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp. 802-807.

2. DMSP (Defense Meteorological Satellite Programme)/OLS (Operational Linescan System): Global night-time low light sensor. Monitors active fires.

Some recent fire references

Cahoon, D. R.; Stocks, B. J.; Levine, J. S.; Cofer, W. R. III; and O'Neill, K. P.: The Seasonal Distribution of African Savanna Fires. Nature, Vol. 359, October 29, 1992, pp. 812-815.

Elvidge, C. D., H. W. Kroehl, E. A. Kiln, K. E. Baugh, E. R. Davis, and W. M. Hao: Algorithm for the Retrieval of Fire Pixels from DMSP Operational Linescan System Data. Biomass Burning and Global Change, Volume 1 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp. 73-85.

Kiln, E. A.: Forest Fire Detection from DMSP Operational Linescan (OLS) Imagery. Biomass Burning and Global Change, Volume 1 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp. 86-91.

3. GOES (Geostationary Operational Environmental Satellite)Imager: Continental high temporal frequency, coarse spatial resolution geostationary imaging. Monitor active fires and smoke.

Some recent fire references

Menzel, W.P., and E.M. Prins: Monitoring Biomass Burning with the New Generation of Geostationary Satellites. Biomass Burning and Global Change, Volume 1 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp. 56-64.

Prins, E. M., and W. P. Menzel: Investigation of Biomass Burning and Aerosol Loading and Transport Utilizing Geostationary Satellite Data. Biomass Burning and Global Change, Volume 1 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp. 65-72.

4. ERS (European Remote Sensing Satellite)/ATSR (Along-Track Scanning Radiometer) (European Space Agency): Global 1-km imaging. Monitors active fires and burned areas.

5. ERS (European Remote Sensing Satellite/JERS (Japanese Earth Resources Satellite) SAR (Synthetic Aperture Radar) (European Space Agency/NASDA (National Space Development Agency of Japan): Global microwave high resolution system. Monitors burned area.

Some recent fire references

French, H. F. N., E. S. Kasischke, R. D. Johnson, L. L. Bourgeau-Chavez, A. L. Frick, and S. Ustin: Estimating Fire-Related Carbon Flux in Alaskan Boreal Forests Using Multisensor Remote-Sensing Data. Biomass Burning and Global Change, Volume 2 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp. 808-826.

Kasischke, E. S., L. L. Bourgeau-Chavez, and N. H. F. French: Observations of the Variation in ERS-1 SAR Image Intensity Associated with Forest Fires in Alaska. IEEE Transactions Geosciences Remote Sensing, 32, 1994, pp. 206-210.

Kasischke, E.S., L. Morrissey, J. B. Way, N. H. F. French, L. L. Bourgeau-Chavez, E. Rignot, J. A. Stearn, G. P. Livington: Monitoring Seasonal Variations in Boreal Ecosystems Using Multispectral Spaceborne Data. Canadian Journal of Remote Sensing, 21, 1995, pp. 96-109.

6. LANDSAT (Land Satellite) TM (Thematic Mapper)/MSS (Multispectral Scanner System): Local, high spatial frequency, low temporal frequency. Monitors burned area.

Some recent fire references

Pereira, A. C., A. W. Setzer, and J. R. dos Santos: Fire Estimates in Savannas of Central Brazil with Thermal AVHRR/NOAA Calibrated by TM/LANDSAT. Proceedings of the 24th International Symposium on Remote Sensing of the Environment, Rio de Janeiro, 1991, pp. 825-834.

7. ***SPOT (Systeme Pour l'Observation de la Terre (CNES) (Centre National d'Etudes Spatiales): Local, high spatial frequency, low temporal frequency. Monitors burned area.***

Some recent fire references

French, H. F. N., E. S. Kasischke, R. D. Johnson, L. L. Bourgeau-Chavez, A. L. Frick, and S. Ustin: Estimating Fire-Related Carbon Flux in Alaskan Boreal Forests Using Multisensor Remote-Sensing Data. Biomass Burning and Global Change, Volume 2 (J. S. Levine, Editor). The MIT Press, Inc., Cambridge, MA, 1996, pp. 808-826.

5.4 Working Group on Monitoring and Measurements

Members:

Leong Chow Peng, Malaysia Meteorological Service, Co-Chair
Hery Harjanto, Indonesia Meteorological and Geophysical Agency, Co-Chair
John Gras, CSIRO Atmospheric Research Australia, Rapporteur
Greg Carmichael, University of Iowa
Lim Cheng Choon, Ministry of Environment, Singapore
Tan Yong Piu, Singapore Meteorological Service
Samuel Maiha, Meteorological Service, Papua New Guinea
Gode Gravenhorst, University of Gottingen, Germany
Tong Soo Loong, ASMA, Malaysia
Dietrich Schwela, WHO
John Miller, WMO, Geneva

Objective: To assess current national/regional monitoring systems and identify improvements to enhance regional capabilities to support transboundary smoke and haze studies/assessments.

The group first reviewed its objective and refined the issues to be addressed into four broad tasks, namely: (1) a compilation of a list of the existing haze monitoring facilities in the region with an assessment of the capabilities of the various stations in the existing network to address the issues of transboundary haze measurement (to be defined in later items); (2) the definition of specific, focused objectives for the monitoring network; (3) the proposal of a list of measurements required to address the specific objectives in task 2; and (4) other issues relating to monitoring protocols, reporting (including indices), quality control etc.

Task 1. It was not possible for the group to make a complete compilation of the existing stations because of the absence of representatives from some countries and agencies in the region. The initial compilation is listed below, table 6, with the indicated stations marked in Figure 13.

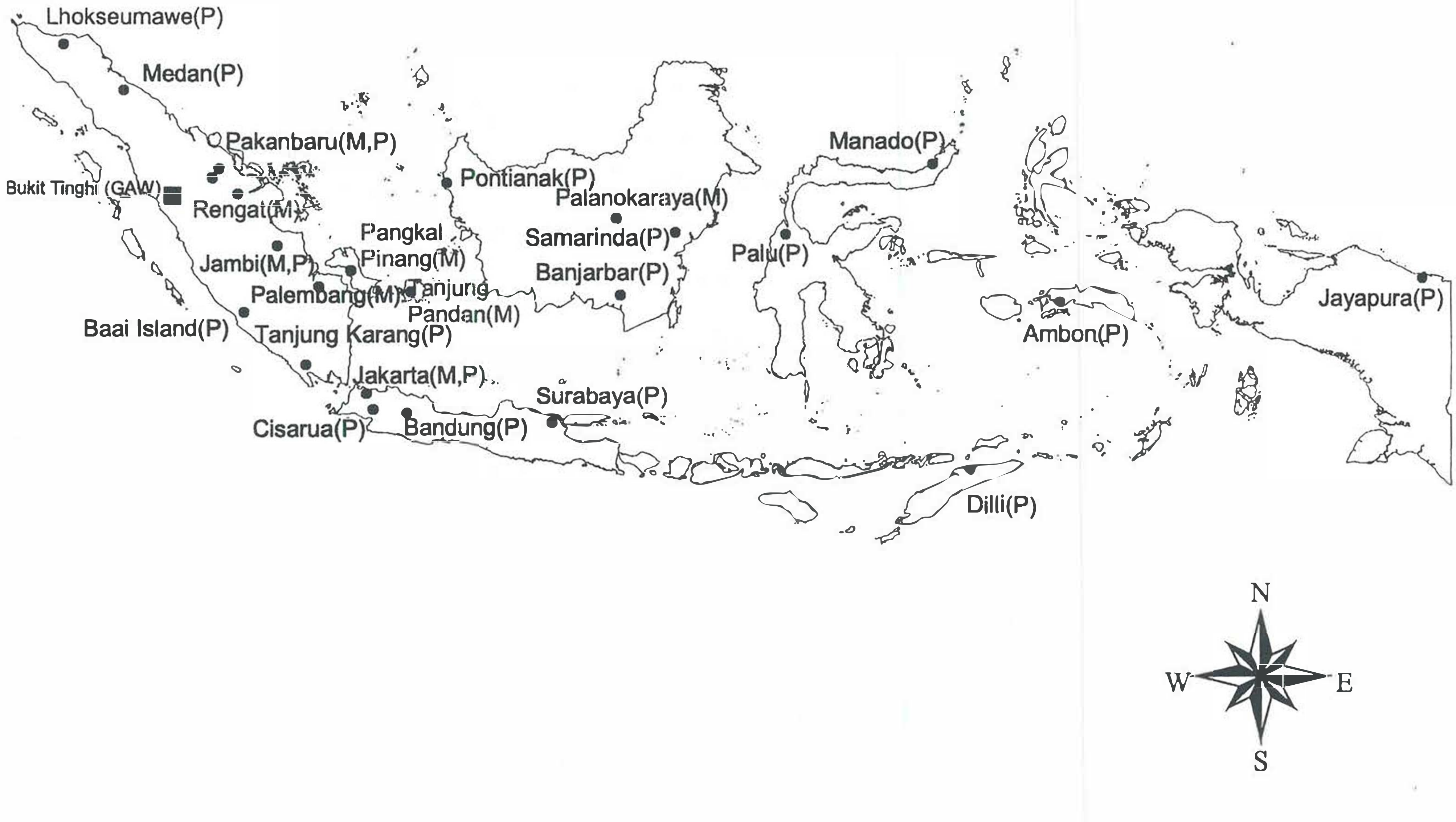
TABLE 6
List of Stations in the Region

INDONESIA	
BMG	1 GAW global station – (black carbon, fine aerosol chemistry, integrated PAH, surface ozone, whr parameters) 27 climate stations (some with TSP Hi Vol., 1 day/week, rain chem. HH to provide information)
BAPEDAL	plans for 1 site per province (27), urban locations Continuous measurements at EMC Serpong, and central city (various species)
LAPAN	? sites (ozone sondes, rain chemistry, IAEC aerosol filters (SFU), total ozone (Brewer) at Bandung and Watukosek, LIDAR at Bandung (coop. programme with Japan)
KPPL	5 continuous stations, 9 manual
Public Health Dept.	short term measurements
Transport Dept.	
Private companies	plantations and mining companies etc, some are known to have programmes.
PNG	no Air Quality stations 12 climate stations [whr and visibility (manual obs.)]
SINGAPORE	1 climate station [2 ozone sondes per month, daily total ozone (Dobson)] 15 Air Quality stations [continuous PM2.5 TEOM at 2 sites, cont. PM10 TEOM at 8 sites, SO_2 and NO_x at all sites, O_3 and CO at 7 sites, NMHC at 4 sites, visibility (manual obs.) at 15 sites]
BRUNEI	3 climate stations (one 24 hour operation) 6 Air Quality stations [continuous PM10 TEOM at 6 sites]
MALAYSIA	30 Air Quality stations ASMA [significant no. with UV-B] 33 climate stations 1 regional GAW station (Cameron Highlands) [surface O_3] PM10/TSP at 23 sites operating daily during haze events (normally 6 day cycle) Petalung Jaya – [total O_3 (Brewer) also UV-B, O_3 sondes 2 per month, SO_2, acid deposition (aerosol, gas, precip.), aerosol chemistry (2 year programme)] Penang – SO_2 Auto network (continuous PM10 TEOM at 6 sites)
PHILIPPINES	54 climate stations [visibility (manual obs.)] Air Quality stations run by Dept. of Environment and Natural Resources. 1 per province?, [TSP, CO, CO_2]
AUSTRALIA	Darwin climate station [visibility manual obs., total O_3] Charles Point [aerosol chemistry, surface ozone, other sp.]

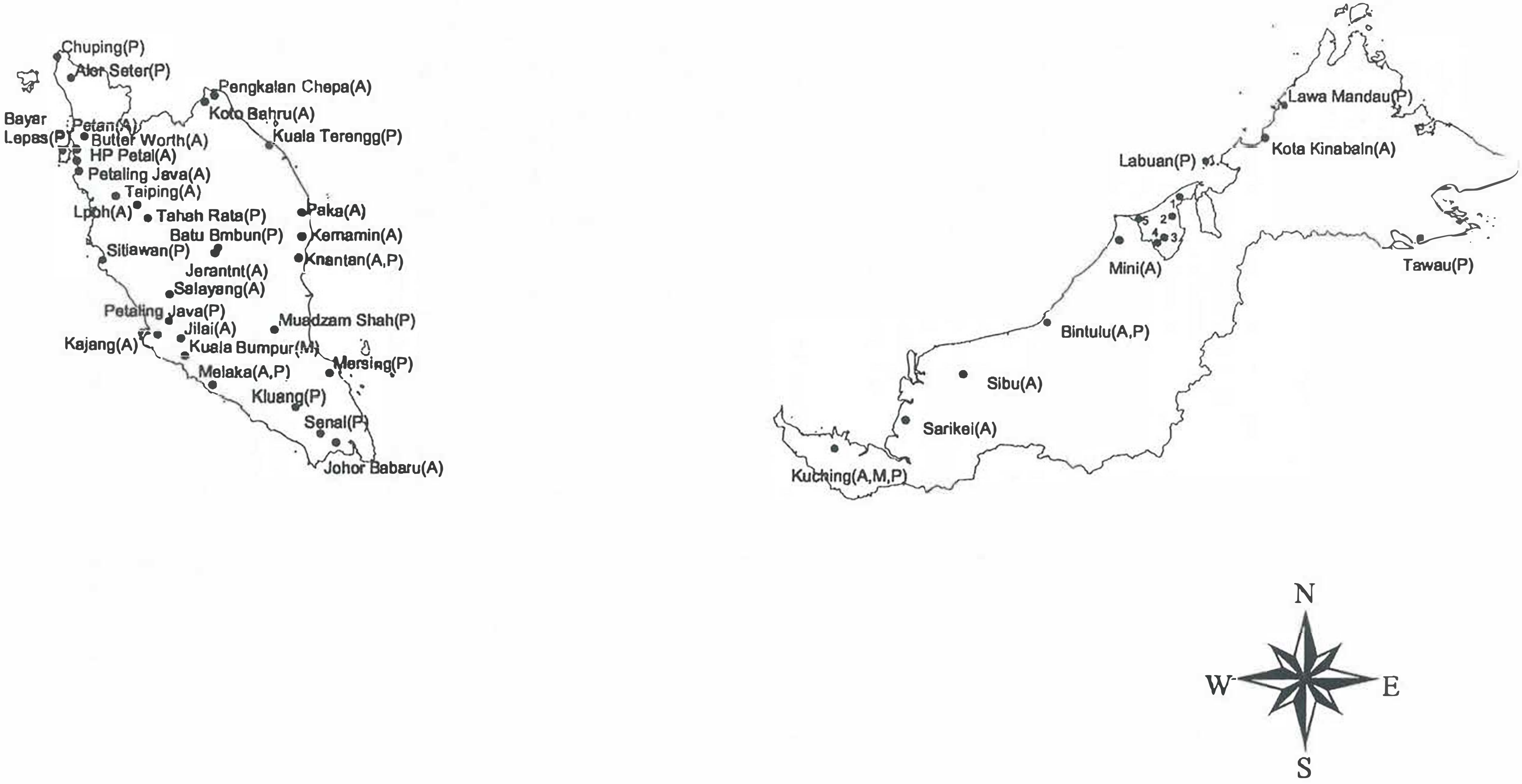
Regional Map of Aerosol & Air Quality Monitoring Sites Singapore

Figure 13: Identified monitoring sites for aerosols and/or trace gases in SE Asia. On the map of Malaysia, "A" refers to ASMA stations.

Regional Map of Aerosol & Air Quality Monitoring Sites Indonesia



Regional Map of Aerosol & Air Quality Monitoring Sites Malaysia & Brunei



Task 2. The group considered it necessary to define the reasons why a monitoring programme is required. Highest priority should be given to measurements that determine the exposure of the population to hazardous materials, directly affecting health (for example fine particle mass) and/or safety (for example the effects of reduced visibility creating hazards to travel by land, sea or air). Other reasons included provision of data for validating models that are used to predict population exposure (for example dispersion and chemical transport models) and for validating remotely sensed properties (for example aerosol and gas loadings). The full list is given in recommendation 1.

Task 3. Measurements required to satisfy these objectives are listed in the recommendations as item 2 with suggested priorities and an indication of the objectives met by the measurement. The major recommendation from the group is that the existing monitoring network requires strengthening. This was based on an assessment that the existing infrastructure does not adequately meet the needs of a measurement programme as listed in Task 2 (above) and in the recommendation 1. (One very specific example is the lack of PM10 or PM2.5 measurements over wide areas of the region from the 1997-1998 disaster for possible health impact assessments). Networks, where they exist vary greatly in sophistication and there is a need to ensure consistent development of methodology and instrumentation. It may be worthwhile considering two levels of observing station, a base level comprising fewer measurements but with a high level of consistency across the network and a second level with a more comprehensive measurement suite. Areas with minimal representation (in terms of monitoring stations), based either on population density, "validation" or other requirements need to be identified once the register of existing stations and their capabilities has been completed. These locations should be given a high priority in establishing new observing stations.

Task 4. A need was identified for unifying methodologies for sampling, including the temporal resolution of measurements. As well, mechanisms for timely reporting of data need to be established, particularly during events (recommendation 3). One further and critical augmentation of the existing network is the introduction of common QA/QC procedures (recommendation 5). This would best be implemented through a regional QA/QC centre, possibly with guidance from, and in association with, WMO GAW which has well developed protocols.

Finally the use of "indices" for reporting haze data was seriously questioned by several of the committee citing confusion created by previous use of different indices in different jurisdictions and difficulties making independent estimates of likely impacts from indices that arbitrarily combine different measurement parameters. Where the use of indices appears warranted, for example for public information (although this was also seriously questioned), they should be harmonized across the region. For all scientific presentations and the exchange of data between jurisdictions the majority opinion was for the exchange of validated data, eg. PM10 mass loading or O_3 concentration etc.

5.4.1 Recommendations

1. *The network of monitoring stations in the region should be expanded to address several specific issues. These issues are :*

    A. Health impacts
    B. Environmental impacts (local, regional, global)
    C. Validation of dispersion models
    D. Validation of chemical transport models
    E. Validation of remote sensed aerosol properties

F. Visibility (transport safety, amenity)
G. Source characterization
H. Compliance with regulations and agreements

2. *Proposed measurements (to address specific issues A-H, see 5.4.1.1)*

i) First priority

Aerosol mass loading (PM2.5, PM10)	all
Visibility (light scattering coefficients, Extinction coefficients)	E, F
Meteorological parameters	all
Optical depth	B,D,E

ii) Second priority

Aldehydes	A
Aerosol chemical composition	A, B, D, G

iii) Third priority

UV	A
CO, CO_2, Ozone, NO_x, SO_2, VOCs	A, B, D

3. *Enhancement of the existing monitoring network.*

i) Upgrading of facilities at selected sites to include the above measurements
ii) Establishment of additional air quality stations at areas that are not well represented
iii) Formulation of uniform protocols for sampling including temporal resolution

4. *Use of Indices*

i) Where indices are used for public information, these should be harmonized across the region
ii) In all scientific exchanges and reporting, the validated measured data should be reported

5. *QA/QC*

i) A coordinated approach to perform QA/QC on all of the network measurements
ii) A centralized facility for QA/QC

6. WORKSHOP RECOMMENDATIONS

Each working group reported on their efforts. The recommendations from the working group were then discussed and combined into a set of overall recommendations which were discussed and adopted in the final plenary session.

A. Modelling. Enhance the regional capabilities to provide meteorological support in the form of improved predictions of ENSO/climate variability, daily smoke trajectories and dispersion forecasts by the use of Atmospheric Transport Models (ATMs), through:

(a-1). Improvement of regional climate prediction capabilities to interpret global forecasts.

(a-2). Development of flexible, situation-dependent programmes which allow for the provision of enhanced meteorological measurements (expanded frequency and spatial coverage) during periods of severe smoke and haze, and expanded use of satellite-derived meteorological products as input to models.

(a-3). Installation of trajectory/dispersion modelling capabilities at local meteorological services and utilization of local area modelling (LAM) capabilities in the region.

(a-4). Improvement of model performance through case studies and by conducting dry run exercises and possible tracer experiments.

B. Remote sensing. Improve the ability to characterize fire activity and track the movement of smoke and haze by strengthening present remote sensing capabilities by:

(b-1). Improvement of the operational aspects through provisions for back-up hot spot analysis capabilities, harmonization of fire counts by use of a single detection algorithm, through real time transmission of high resolution data on fires derived from satellites, and efforts to verify fire counts and bum-area information through ground-truthing activities.

(b-2). Expanded efforts to estimate aerosol and trace gas emissions from fires by combining fire counts with bum-area, along with a better characterization of sources in the diverse eco- and land-use systems.

(b-3). Promotion of the development of the next generation of satellites. This includes the need for a new NOAA channel-3 detector optimized for fire studies, dedicated fire satellites to monitor fires more precisely, and the use of space-bome radar for bumed area and vegetation dryness assessment, and of lidar systems to measure the vertical distribution of trace gases and aerosols.

C. Measurements and monitoring. Strengthen regional monitoring efforts to assess the effects of smoke and haze on human health, to evaluate ecosystem impacts, to help validate atmospheric transport models, and characterize emission sources, by:

(c-1). Enhancement of existing monitoring networks to measure smoke and haze related quantities including aerosol mass (PM2.5, PM10), visibility, optical depth, and meteorological parameters. Two levels of observing stations are envisaged, a base level comprising fewer measurement parameters but with a high level of consistency across the network, and a second level with a more comprehensive measurement suite. At selected sites, targeted chemical quantities including aldehydes and other trace pollutants (CO, O_3, NO_x, VOCs, CO_2, SO_2), aerosol composition, and UV radiation are to be measured.

(c-2). Establishment of additional, including population-based, monitoring stations in areas not presently covered by existing networks (e.g., Kalimantan).

(c-3). Promotion of the scientific exchange of the validated measurement data, and the harmonization of the regional air pollution indices (API) used in regional smoke and haze alerts.

(c-4). Formulation of uniform protocols for sampling, including temporal resolution and reporting procedures. Expanding efforts directed at improvement of QA/QC, building upon the WMO/GAW programme components.

D. Information exchange. Improve the management of smoke and haze (and other transboundary) pollution events through efforts directed at enhanced information exchange and coordination, including:

(d-1). Enhancement of the current system for dissemination of data products and other relevant information, through the use of the GTS for meteorological data and gridded model outputs, and the Intranet and/or Internet systems for non-standard products.

(d-2). Increase the exchange of relevant information including meteorological data (especially rainfall), air quality data (including air pollution indices), and trajectory and plume forecasts. A critical element is the harmonization of data and output products to support effective real-time decision making.

(d-3). Coordination of emergency response responsibilities and activities between national Meteorological Services in the region, with the primary responsibility for the provision of information and forecasts to reside with the ASMC, but with the option of seeking further input from other RSMCs, and with provisions for bilateral arrangements.

(d-4). Improvements in existing mechanisms to regularly review the operational coordination between the NMHSs and activities related to the Regional Haze Action Plan, and to recommend changes and/or improvements to the plans.

(d-5). Development of linkages between the Meteorological Services and other national, regional and international organizations and scientific programmes with common interests, such as (IGBP/IGAC).

The Workshop further recognized that large-scale forest fires and the associated socio-economic and health-related problems occur frequently in other parts of the world, notably in South and Central America and Africa. It was recommended therefore that the deliberations and recommendations of this workshop be reviewed and evaluated by the organizations and agencies (including NMHSs) concerned in those regions. It was further recommended to organize as soon as possible an expert-level meeting to address the current situation in South and Central America, and the existing and/or required coordination/collaboration mechanisms.

6.1 WHO Workshop Briefing and Discussion

At the plenary session on the final day, the Workshop was joined by a delegation from the Bi-Regional Workshop of Haze-Related Air Pollution, organized by WHO Regional Offices for South-East Asia and the Western Pacific, held in Kuala Lumpur during 1-4 June 1998. Mr. Steve Tamplin and Dr. H. Ogawa presented the major findings and recommendations from the WHO meeting. The objectives of that meeting were to: Review haze-related air pollution problems and research findings; Identify further research needs to support haze-related decision-making; and Develop health reduction measures/strategies. That workshop concluded that the haze episodes constituted a substantial health risk to the public as evidenced by the widespread exceedances of health-related air quality standards and guidelines for particulate matter (PM10 & PM2.5) increased frequency of respiratory-related hospital visits in the most heavily impacted regions; increased frequency of attacks among asthmatic children; and reported persistent decreases in lung function among school children. The long term health risks from these events is much more difficult to discern.

One recommendation from the WHO workshop that resonated with those developed in this workshop is related to the need for additional air quality monitoring in the region. The WHO workshop stressed that from a health perspective information on the nature and extent of human exposure to environmental pollutants is essential. Standard monitoring protocols are needed, and data analysis and presentation formats need to be harmonized and easily understood to be useful in health studies. The lack of consistency between the air pollution indices used in the region impedes intercountry comparability. From the measurement perspective priority needs to be given to measurements of PM10 and 2.5, and the reporting of actual concentrations. The WHO workshop also concluded that more attention should be directed to filling in gaps in the measurement networks in the region, with emphasis on population-based locations to facilitate the health impact studies. Measurements are also needed to estimate apportionment of sources of particulate air pollution exposure, especially the relative contributions of biomass and motor vehicle-related urban pollution mixture sources. Further details regarding the WHO report can be found in Volume 2.

The representatives at the Workshop recognized that the set of recommendations developed by the WHO and WMO workshops are complimentary and strongly encouraged closer cooperative activities between the meteorological and health related aspects of transboundary pollution. The representatives pledged to continue to work towards closer collaborations.

7. CLOSE OF THE MEETING

On behalf of WMO, Mr Dieter Schiessl expressed his appreciation to Mr Woon Shih Lai for his gracious hosting of and wonderful hospitality during the workshop. Mr Schiessl thanked the staff of the Meteorological Service of Singapore for the excellent organization and assistance before and during the workshop. He also thanked the participants for their enthusiastic participation and contribution. Mr Woon Shih Lai then declared the workshop closed.

WMO Workshop on Regional Transboundary Smoke and Haze in South East Asia
2-5 June 1998, Singapore

WORKSHOP PROGRAMME

Tuesday, 2 June, start at 08.45

08.45 Participants to be seated

09.00 Arrival of Dr. John Chen, Minister of State for Communications, Singapore

09.00 Welcome Address:
Mr. Woon Shih Lai, Director, Meteorological Service Singapore

09.10 Keynote Address:
Prof. G.O.P. Obasi, Secretary-General, World Meteorological Organization

09.20 Opening Address:
Dr. John Chen, Minister of State for Communications, Singapore

09.30 Group Photograph of all participants

09.45 Tea/Coffee

10.15 Press Conference

Morning session
Chairman: Dr Sri Diharto

10.45 Review of agenda, administrative matters, introductions
Ms Liisa Jalkanen

11.00 Overview of WMO activities and Meeting Objectives
Dr. John Miller, AREP
Mr. Dieter Schiessl, WWW

11.40 Overview of the Fire and Smoke Episodes in South-East Asia between 1982 and 1998:
Dr. Johann G. Goldammer

Review of activities, especially the fires of 1997

12.00 Review of country-level activities related to regional smoke and haze

Indonesia: Dr. Sri Diharto
Malaysia: Dr. Lim Joo Tick

Lunch 13.00 - 14.15 *Hosted by Mr. Woon Shih Lai, Director Meteorological Service Singapore at Ballroom A, Merchant Court Hotel*

Afternoon session
Chairman: Dr. Lim Joo Tick

Brunei: Ms. Asraya Abd Rahman
Papua New Guinea: Mr. Samuel Maiha
Philippines: Mr. Landrico U. Dalida
Singapore: Mr. Wong Teo Suan

15.15 Review of international activities during the 1997 fires:

RSMCs
Melbourne: Dr. Paul Stewart
Tokyo: Mr. Keiichi Katayama
Washington: Dr. Roland Draxler

Tea/coffee break 16.30 -17.00

NOAA: Dr. William Bolhofer
ASMC: Mr. Woon Shih Lai
UNEP: Mr. Peter Usher
WHO: Dr. Dieter Schwela

18.45 Workshop participants meet in Merchant Court Hotel lobby for:
Dinner hosted by Mr Tan Gee Paw, Permanent Secretary (Environment), Singapore (Hotel New Otani)

Wednesday, 3 June

Morning session
Chairman: Dr William Bolhofer

9.00 Review of causalities and impacts
Role of El Niño: Mr. Wasyl Drosdowsky
Environment and Health Effects: Dr. Dieter Schwela

10.00 Operational aspects
Hot spot detection at ASMC: Mr.Woon Shih Lai
The Brazilian experience in Hot Spot and Smoke Detection: Mr. Divino Figueiredo
Emission estimates: Dr. Joel Levine
Contribution: Dr. Johann Goldammer

Tea/coffee break 11.15 - 11.35

11.35 Atmospheric pollutant measurements:
Dr. John Gras
Ms. Leong Chow Peng
Mr. Hery Harjanto
Dr. Soon Loong Tong

12.30 Forecasting
Dr. P.A. Winarso
Prof. Greg Carmichael

Lunch 13.00 - 14.00 *Hosted by Mr. Woon Shih Lai, Director Meteorological Service Singapore at the Ellenborough Market Cafe, Merchant Court Hotel*

Afternoon session
Chairman: Dr. John Gras

14.00 ASEAN-wide and international programmes, initiatives and activities.

WMO-PARTS: Dr. William Bolhofer
Asian Development Bank: Dr. Erik Scarsborough
Malaysian-Danish Initiative: Towards a new haze forecasting system: Dr Leif Laursen

15.00 Overview of action items, objectives and assignments for break out session
Prof. Greg Carmichael

Tea/coffee break 15.15 - 15.30

15.30 Writing of reviews on the previous items

Thursday, 4 June

Planned and future activities
Chairman: Prof. Greg Carmichael

9.00 Overview of action items, objectives and group assignments:
Prof. Greg Carmichael

9.15-12.00 Work in groups:

Monitoring and Measurements
Chairs: Ms Leong and Mr. Harjanto
Rapporteur: Dr. John Gras
Transport Modelling
Chair: Dr. Winarso
Rapporteur: Dr. Draxler

Remote Sensing
Chair: Dr. Lim
Rapporteur: Dr. Levine
Information exchange and Coordination
Chair: Mr. Woon
Rapporteur: Mr. Drosdowsky

12.00 Reports from groups

Lunch 13.00 - 14.00 *Hosted by Mr. Woon Shih Lai, Director Meteorological Service Singapore at the Ellenborough Market Cafe, Merchant Court Hotel*

Writing of recommendations by group rapporteurs

Tea/coffee break 15.00 - 15.30

15.30 Discussion of recommendations and action items, implementation plan

17.00 Writing of draft document

Friday, 5 June

Chairman: Mr. Woon Shih Lai

9.00 Overview of WHO Biregional Workshop on Health Impacts of Haze-related Air Pollution, 1-4 June, Kuala Lumpur, Malaysia
WHO, Dr. Steve Tamplin
Contributions: Dr Hisashi Ogawa and Prof Tord Hjellstrom

10.15 UNDP Activities: Mr. Neil Buhne

Tea/coffee break 10.30 -11.00

11.00 Review of draft document and recommendations: Prof. Greg Carmichael

12.00 Close of meeting

Lunch 12.00 - 13.00 *Hosted by Mr. Woon Shih Lai, Director Meteorological Service Singapore at Ballroom A, Merchant Court Hotel*

13.00 Closing Press Conference

Afternoon

14.00 Visit to the Meteorological Service of Singapore

WMO Workshop on Regional Transboundary Smoke and Haze in South East Asia
2 – 5 June 1998, Singapore

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Papers Presented or Submitted at the Meeting

Full Papers can be found in Volume 2, where available

Opening Ceremony Speakers:

1. "Welcoming Address", Mr Woon Shi Lai, Director, Meteorological Service, Singapore

2. "Keynote Address", Professor G.O.P. Obasi, Secretary-General, World Meteorological Organization, Geneva

3. "Opening Address", Dr. John Chen, Minister of State for Communications, Singapore

Overview of Fire and Smoke Episodes in South East Asia

4. "Environmental Problems Arising from Land Use, Climate Variability, Fire and Smog in Indonesia: Development of Policies and Strategies for Land Use and Fire Management", by Johann G. Goldammer, ECE/FAO Team of Specialists on Forest Fire, Fire Ecology and Biomass Burning Research Group, Max Planck Institute for Chemistry, Freiburg, Germany

Country-Level Activities

5. "Role of the Meteorological Condition Favorable in the Development Fires and Transboundary Air Pollution Smoke/Haze Over Indonesia and Adjoining Area", R. Sri Diharto, Director General, Meteorological and Geophysical Agency, Indonesia

6. "Aspect of the Meteorological Services in the Management and Control of Fires and Transboundary Smoke/haze over Indonesia and Adjoining Area" Paulus Agus Winarso, Meteorological and Geophysical Agency, Indonesia

7. "Policy Aspects of Regional Transboundary Smoke and Haze: Malaysia", Lim Joo Tick, Director General, and Leong Chow Peng, Malaysian Meteorological Service, Petaling Jaya, Malaysia

8. "Measurement and Modeling of Regional Transboundary Smoke and Haze: Malaysia"

9. "Review of Country-Level Activities Related to 1997 Regional Smoke Haze - Country - Singapore", Wong Teo Suan, Meteorological Service Singapore

10. "The Smoke-Haze 1997/98 - The Brunei Experience", Asraya Abdul Rahman, Brunei Meteorological Service, Brunei Darussalam

11. "Review of Country-Level Activities Related to Regional Smoke and Haze (Philippines)", Landrico U. Dalida Jr, PAGASA, Philippines

12. "National Haze Action Plan (Philippines)"

13. "Review of In-Country Activities Related to Regional Smoke and Haze in Papua New Guinea" Samuel Maiha, Papua New Guinea National Weather Service

Regional Specialized Meteorological Services (RSMC) Activities

14. "Regional Trans-boundary Smoke and Haze in South-East Asia", Roland R. Draxler and Bruce B. Hicks, NOAA/RSMC Washington, NOAA Air Resources Laboratory

15. "South East Asian Smoke and Haze Situation 1997 - RSMC Melbourne's Perspective", P.K. Stewart, National Meteorological Operations Centre, Melbourne, Australia

16. "International Activities of RSMC Tokyo", Keiichi Katayama, Numerical Prediction Division, Japan Meteorological Agency

Review of Causalities and Impacts

17. "An Overview of the 1997/98 El Niño Event", Wasyl Drosdowsky, Bureau of Meteorology Research Centre, Melbourne, Australia

18. "Bibliography: Literature Related to Health Effects of Smoke from Wood Burning and Forest Fires"

19. "Airborne Measurements of Smoke in Indonesia and Northern Australia - October 1997", J.L. Gras, J.B. Jensen, S. Lee, C. Tivendale, B. Petraitis and B.F. Ryan, CSIRO Atmospheric Research, Aspendale, Australia; Y. Makino, Y. Tsutsumi, M. Ikegami, Y. Zaizen, K. Okada, M. Matsuada, and Y. Sawa, Meteorological Research Institute,Tsukuba, Ibaraki, Japan; S. Diharto and H. Harjanto, Meteorological and Geophysical Agency, Jakarta, Indonesia.

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Abbreviations and Acronyms

ACSD	ASEAN Committee on Social Development
ADB	Asian Development Bank
ADTA	Advisory Technical Assistance
AEFN	Forestry and Natural Resources East
AMMH	ASEAN Ministerial Meeting on Haze
ASEAN	Association of Southeast Asian Nations
ASMC	ASEAN Specialized Meteorological Centre
ASOD	ASEAN Senior Officials on Drugs
ASOEN	ASEAN Senior Officials on Environment
ASOEN HTTF	ASOEN Haze Technical Task Force
AUSAid	Australian Agency for International Development
AWFN	Forestry and Natural Resources Division West
BAKORNAS	*Badan Koordinasi Nasional* [Government of Indonesia National Disaster coordinating Agency]
BAPEDAL	*Badan Pengendalian Dampak Lingkungan* [Government of Indonesia Environmental Impact Management Agency]
BAPEDALDA	*Badan Pengendalian Dampak Lingkungan Daerah* [Provincial Environmental Impact Management Agency (Government of Indonesia)]
BAPPENAS	*Badan Perencanaan Pembangunan Nasional* [Government of Indonesia National Planning Agency]
BMG	*Badan Meteorologi dan Geofisika* [Government of Indonesia Meteorological and Geophysical Agency]
CGIF	Consultative Group on Indonesian Forestry
CIDA	Canadian International Development Agency
CIFOR	Center for Integrated Forestry Research
COCI	ASEAN Committee on Culture and Information
COCS	Consulting Services Division
COST	ASEAN Committee on Science and Technology
EC	European Commission
ENRICES	Indonesian Research Institute on Climate, Environment, and Society
ENSO	El Niño-Southern Oscillation climatological event
ENVD	Environment Division
EU	European Union
FCB	Functional Cooperation Bureau
GIS	Geographic Information System
GTZ	*Gesellschaft fuer Technische Zusammenarbeit* [German Government Agency for Technical Cooperation]
ICRAF	International Center for Research in Agroforestry
IUCN	International Union for the Conservation of Nature
JICA	Japan International Cooperation Agency
LAPAN	National Institute for Aeronautics and Space of Indonesia
LCB	Local Competitive Bidding
MBIs	Market-Based Instruments
NGO	Non-Governmental Organization
NHAP	National Haze Action Plan
OEOC	Office of the Chief, Office of Environment and Social Development
PARTS	Program to Address ASEAN Regional Transboundary Smoke

PE2	Programs Department East 2
PMU	RETA Project Management Unit
RETA	Regional Technical Assistance
RHAP	Regional Haze Action Plan
SEAFIRE	South East Asian Fire Experiment
SMS	Singapore Meteorological Services
TA	Technical Assistance
TOR	Terms of Reference
UNDP	United Nations Development Program
UNEP	United Nationals Environment Program
USAID	United States Agency for International Development
WB	World Bank
WMO	World Meteorological Organization

In this Report, "$" refers to US dollars

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