APPENDIX 1

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The Impact of El Niño and La Niña on Southeast Asia

Fortuna Hotel, Hanoi, Vietnam

21 - 23 February 2000

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APPENDIX 2

WORKSHOP AGENDA

THE IMPACT OF EL NIÑO AND LA NIÑA ON SOUTHEAST ASIA

FORTUNA HOTEL, HANOI, VIETNAM

21 - 23 FEBRUARY 2000

VUSTA/CERED/APN/UEA WORKSHOP
AGENDA

DAY 1, FEBRUARY 21ST 2000

8.15-9.00
Registration

OPEN SESSION: INTRODUCTION AND GLOBAL OVERVIEW

9.00-10.00
Chair: Dr. Nguyen Huu Ninh

* **Opening address**: Professor Academician Vu Tuyen Hoang, Chairman of Vietnam Union of Science and Technology Associations (VUSTA), 10 mins
* **Welcome speech**: Dr. Vu Minh Mao, MP, Vice Chairman, Committee on Science, Technology and Environment, National Assembly of Vietnam, 10 mins
* **Introduction to meeting**: Dr. Nguyen Huu Ninh, CERED/ Dr. Mick Kelly, University of East Anglia, 10 mins
* **APN introduction**: Representative of the Asia-Pacific Network for Global Change Research - Dr. Gerhard Breulmann, 10 mins
* **Global overview of the El Niño Southern Oscillation (ENSO) phenomenon:** Dr.William Kininmonth, Australasian Climate Research, Australia, 25 mins

10.10-10.30
Refreshment break

OPEN SESSION: CLIMATE EFFECTS AND SOCIETAL IMPACTS

10.40-12.30
Chair: Dr. Mick Kelly

* **Significance of El Niño and La Niña for Southeast Asia:** Mr. Sidup Bin HJ Sirabaha, Brunei Meteorological Service, Brunei, 20 mins
* **Natural hazards in Laos**: Mr. Sengdeuane Phomavongsa**,** National Disaster Management Office, Laos, 20 mins
* **Natural hazards in Cambodia**: Mr. Mak Sideth, Ministry of Environment, Cambodia , 20 mins
* **Effect on typhoon occurrence in Vietnam:** Dr. Hoang Minh Hien, Hydro-Meteorological Service, Vietnam, 20 mins
* **Open discussion**

12.30-14.00
Buffet lunch

CLOSED SESSION: IMPACT ASSESSMENT

14.00-16.00
Chair: Dr. Mick Kelly

* **Working group discussion I - Impact assessment**

Refreshments served 16.00

16.30-17.00
Chair: Dr. Nguyen Huu Ninh/Dr. Mick Kelly
- **Summary of working group recommendations and general discussion**

18.00-20.00
Reception for international participants hosted by the Vice-Chairman of the Committee on Science, Technology and Environment of the National Assembly of Vietnam at the Office of the National Assembly of Vietnam.
Followed by dinner at the Hilton Hanoi Opera Hotel.

DAY 2, TUESDAY, FEBRUARY 22ND 2000

OPEN SESSION: SEASONAL CLIMATE FORECASTING

9.00-10.40
Chair Dr. William Kininmonth
- **International forecasts of the ENSO phenomenon**: Dr. Simon Mason, UCSD/IRI, United States, 20 mins
- **Practical aspects of forecasting rainfall in eastern Australia and Southeast Asia using ENSO indicators**: Dr. Roger Stone, Queensland Centre for Climate Applications, Australia, 20 mins
- **Climate forecasting in China:** Prof. Wang Shaowu, Peking University, PR China, 20 mins
- **Climate forecasting in Vietnam:** Dr. Nguyen Van Thang, Climate Research Center, Vietnam, 20 mins
- **Use of seasonal forecasts:** Ms. Louise Bohn, University of East Anglia, UK, 20 mins
- **Open discussion**

10.40-11.00
Refreshment break

OPEN SESSION: RESPONSE STRATEGIES

11.00-12.20
Chair: Prof. Mikiyasu Nakayama
- **Responding to El Niño and La Niña**: Priorities for the region, Dr. Sanny Jegillos, APDMC, Philippines, 20 mins
- **The response to the flooding in Central Vietnam in 1999**: Dr.Tran Thanh Xuan, Institute of Hydro-Meteorology, Vietnam, 20 mins
- **The lessons of Typhoon Linda, Vietnam** – Ms. Duong Lien Chau, Hydro-Meteorological Service, Vietnam, 20 mins
- **The impacts of El Niño and La Niña on Myanmar** – Mr. U Tun Lwin, Department of Meteorology and Hydrology of Myanmar, 20 mins
- **Open discussion**

12.20-14.00
Buffet Lunch

Afternoon free

18.00-20.00
Dinner at the Cha Ca La Vong restaurant

DAY 3, WEDNESDAY, FEBRUARY 23RD 2000

CLOSED SESSION: PROSPECTS FOR PREDICTION

9.00-11.45
Chair: Dr. Mick Kelly
- **Working group discussion II - Prospects for prediction**

Refreshments served 10.30

11.45-12.30
Chair: Dr. Nguyen Huu Ninh/Dr. Mick Kelly
- **Summary of working group recommendations and general discussion**

12.30-14.00
Buffet lunch

CLOSED SESSION: RESPONDING TO EL NIÑO AND LA NIÑA

14.00-15.30
Chair: Dr. Mick Kelly
- **Working group discussion II - Responding to El Niño and La Niña**

15.30-16.00
Refreshment break

OPEN SESSION: CONCLUSIONS AND CLOSE OF MEETING

16.00-17.00
Chair: Dr. Nguyen Huu Ninh/Dr. Mick Kelly
- Summary of working group recommendations and general discussion
- Workshop statement on latest assessment of La Niña breakdown
- Evaluation of workshop outcome
- The next stage of the Indochina Global Change Network
- Close of meeting

18.00-20.00
Dinner at the Lau Tu Xuyen restaurant

Additional presentations
During the course of the working group sessions, short presentations were made by Dr. Ooi See Hai (Malaysian Meteorological Service), Dr. Aida Jose (Climatology and Agrometeorology Branch, Philippines) and Dr. Patipat Patvivatsiri (Meteorological Department, Thailand) on the impact of El Niño and La Niña and associated research in their respective countries. Dr. Nguyen Van Viet (Institute of Meteorology and Hydrology, Vietnam) described the significant impact of El Niño and La Niña on rice production in Vietnam. Dr. Aida Jose discussed work on monitoring and early warning in the Philippines and Dr. Le Van Sanh (Vietnam Committee for the International Hydrological Program) presented an account of the recommendations of the Vietnam Committee for the International Hydrological Program with respect to the El Niño-Southern Oscillation Phenomenon.

APPENDIX 3

THE INDOCHINA GLOBAL CHANGE NETWORK

THE INDOCHINA GLOBAL CHANGE NETWORK

The overall goal of the Indochina Global Change Network is to strengthen the scientific capacity of Cambodia, Laos and Vietnam and hence the ability of these nations to respond to the threat posed by global environmental change and related hazards. Network activities include policy-relevant information provision, training and research on global change issues.

The Network has three main aims:

- to foster and provide support for focused capacity-strengthening projects, directed at specific regional needs;
- to provide training in global change studies through workshops, studentships and fellowships and to promote the development of relevant educational materials for the scientific community, policy makers and the general public; and,
- to foster and, where appropriate, coordinate regional research on global environmental change, providing high-level expertise in support of policy development.

The Network is pledged to interdisciplinary research and, in particular, the fusion of biophysical and socio-economic methods. The Network is also committed to a long-term perspective since the problems of global change have characteristic timescales of decades to centuries. The Network recognizes that an effective precautionary response to long-term environmental change must be based on action to reduce present-day vulnerability and that this is, in many cases, a more immediate development priority. Finally, the Network is dedicated to the ideal of sustainable development, meeting present-day needs while ensuring environmental security across both space and time, through the fostering and coordination of regional activities on global environmental change and related hazards.

Past Network activities have been supported by the Netherlands Foundation for the Advancement of Tropical Research (WOTRO) and the Asia-Pacific Network for Global Change Research. Activities planned for the coming period include training workshops on climate prediction and impact assessment and training, information provision and research on land-cover change, coastal zone management and other issues.

The Indochina Global Change Network is coordinated by Dr. Nguyen Huu Ninh of the Center for Environment Research Education and Development, Hanoi, Vietnam, with technical support from Dr. Mick Kelly and Ms. Sarah Granich.

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Indochina Global Change Network
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APPENDIX 4

SUMMARY PAPERS

CONTENTS

GLOBAL OVERVIEW OF THE EL NIÑO SOUTHERN OSCILLATION PHENOMENON

William Kininmonth
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Over the past two decades the term El Niño has become synonymous with social, economic and environmental crises in many parts of the globe. El Niño events signal major departures from normal seasonal climate patterns, particularly over tropical regions. For some countries an El Niño event is typically associated with abnormal heat and drought, for others it is persisting rain and devastating flooding.

El Niño was originally the name given by local fishermen to the annual appearance of a warm southward flowing current in the surface waters off coastal Ecuador and northern Peru during the Southern Hemisphere summer (December-February). The coastal communities also recognised that in some years the offshore waters were warmer than usual and cold nutrient rich waters failed to return during the following year, giving a poor fish harvest and with disastrous consequences on local food stocks and community welfare. Flood rains that caused loss of life and severe damage often accompanied the periods of abnormally warm coastal waters. Now it is the periods of prolonged abnormal warming that are referred to as El Niño events. However, it was not until the mid-1960s that the El Niño phenomenon was recognised as of more than local significance. New global data sets have established linkages between the El Niño of the eastern equatorial Pacific Ocean and the Southern Oscillation that affects weather patterns across the tropical Pacific Ocean.

The fluctuating characteristics of the ocean and atmospheric circulations across the equatorial Pacific Ocean arise because of the coupling of the ocean and atmosphere through wind stress and from the transfer of heat, moisture (latent energy) and momentum. Positive feedbacks assist in maintaining the Walker Circulation of the atmosphere and surface layer characteristics across the equatorial Pacific Ocean. During an El Niño event, however, warm surface water spreads eastward across the equatorial Pacific Ocean towards South America and upwelling of cold water is reduced. The combined effect of the influx of warm water and the reduction of upwelling is to produce a warmer than normal surface layer over an extensive area of the central and eastern equatorial Pacific Ocean. The reduced equatorial cross-Pacific sea surface temperature gradient weakens both the overlying surface atmospheric pressure gradient and the strength of the surface Trade Winds.

Studies associated with the TOGA project have identified that the positive anomalies of tropical sea surface temperature act as an abnormal source of heat, moisture and momentum to the atmosphere and force the tropical circulation in a direct sense. As an outcome of the improved climate monitoring capability arising from the TOGA project many aspects of the forcing of the atmospheric circulation by the 1997-98 El Niño can be readily identified. Early in the event (June to August) there was enhanced deep atmospheric convection over the central equatorial Pacific Ocean and a reduction in deep atmospheric convection over the western Pacific. As the El Niño event developed (September to November) there was a strengthening of the intensity of abnormal convection over the central equatorial Pacific Ocean. At the same time there was a continuing reduction in the intensity of deep atmospheric convection and cumulative regional rainfall over the western Pacific Ocean. During the mature phase of the El Niño event (December to February) the region of anomalous deep atmospheric convection extended eastward to coastal South America. At this time there was also a reduction in the deep atmospheric convection associated with the intertropical convergence zone (ITCZ) north of the equator across the Pacific Ocean. The islands of the equatorial western Pacific Ocean that generally receive high rainfall were drier than normal and many experienced drought. The generally dry coastal regions of Ecuador and Peru received copious rain that caused much damage. Also, seasonal tropical storms of the western Pacific Ocean tended to form further east than usual over the abnormally warm ocean and made little contribution to the seasonal rainfall of the Philippines.

Empirical teleconnection patterns have been derived that imply physical/dynamical processes account for the simultaneous variation of weather patterns over various parts of the globe in response to distant ocean forcing. During El Niño events the patterns of anomalous deep tropical convection over the central and eastern equatorial Pacific Ocean are able to persist on seasonal timescales and develop large-scale overturning circulations. Strong upper atmosphere divergence over the regions of convection in the tropics and convergence in the subtropics act as a Rossby wave source. (Rossby waves are large scale (planetary) waves in the horizontal flow of the atmosphere that grow in amplitude as a result of the change in relative spinning motion of the earth from lower to higher latitudes.) The February 1998 upper atmosphere (250 hPa – about 10.5 km altitude) geopotential height anomalies had, over the eastern Pacific ocean, similarities to the forcing necessary to generate Rossby waves. A persisting feature over East Asia was the strong anticyclonic circulation over northern China and the cyclonic circulation to its south.

In the comparison of different El Niño events there is a set of broadly repeating patterns of significant anomalies in the occurrence of deep atmospheric convection and these indicate a characteristic response to El Niño forcing in some regions of the globe. In other parts of the globe there are significant responses but the characteristics are not the same for each event.

For development of sectoral response strategies to mitigate the impacts and to take advantage of any favourable opportunities during El Niño events it is essential for each country to have access to global, regional and national climate monitoring products. The Global Climate Observing System (GCOS) based on the World Weather Watch (WWW) is an outcome of international cooperation and already provides an array of products accessible over the Internet. More detailed assessments of the scale and extent of climate anomalies affecting countries will require cooperation at the regional level and this would be assisted by the establishment of regional climate centres. National climate centres are necessary to manage the essential climate data archives and provide a focus to ensure that national needs for climate information and prediction services are met and that essential products are available for other agency and industry needs.

SIGNIFICANCE OF THE EL NIÑO SOUTHERN OSCILLATION FOR SOUTHEAST ASIA

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SUMMARY

The El Niño Southern Oscillation (ENSO) phenomenon is highly significant for the countries of Southeast Asia (SEA). On intraseasonal and interannual time-scales, ENSO forcing has a profound impact on climate and weather in this region. During El Niño and La Niña events the warming and cooling of the tropical Pacific Ocean causes large-scale changes in the atmospheric circulation in the region. One of the contributors to drought conditions in SEA appears to be a major eastward shift of the upper anticyclonic at 200mb whose location is related to a major shift of the east-west Walker Circulation. The velocity potential at the higher level (200mb) is used to diagnose the divergent outflows with respect to monsoonal and ENSO forcing. Through the velocity potential, displacement of convective areas with respect to weakening of the Walker Circulation due to El Niño can easily be determined, and vice-versa during La Niña events.

An El Niño event is associated with droughts in most parts of the region including Indonesia, Brunei, Malaysia, Philippines, Vietnam, Myanmar, Cambodia, Laos, Thailand and Papua New Guinea. La Niña events are more likely to bring excessive monsoon rain and more likely to cause flooding, especially in low lying areas. Climatic anomalies associated with ENSO events are particularly important to Southeast Asia because of the agrarian economies of the region. Agricultural outputs are severely affected if there is a serious deficit in water supply due to major displacement of the monsoon rain. Socio-economic losses to SEA countries attributed to major ENSO events can be enormous, due to prolonged drought, forest fires, environmental damage, wildlife deaths, tourism reduction, increased health hazards, loss of crops and floods.

ENSO-related precipitation is especially well indicated in Indonesia, East Malaysia, Papua New Guinea, Philippines and Brunei. This area is one of the core tropical regions in the world which has strong ENSO related precipitation. Rainfall across Indonesia is strongly modulated by ENSO, with above (below) normal occuring during cold (warm) episodes. This ENSO-related interannual variability is consistent with the suppressed (enhanced) equatorial Walker Circulation, typical of Pacific warm (cold) episodes. During El Niño, some countries experience an increase of surface temperature of around 0.25°C. During La Niña, there is not much cooling over the region except over northern Vietnam and northern Philippines, of around -0.25°C.

The monetary losses attributed to the 1997/98 El Niño for SEA were more than US$1.38 billion. In Malaysia and Singapore, the tourism industry was badly affected by migrant smog haze which incurred losses of around US$360 million. While drought in Vietnam, which lasted about eight months, caused around 4,000 people in the mountains and central Vietnam to be close to starvation. In Papua New Guinea, about 80,000 to 300,000 people were at life threatening risk due to prolonged drought. Conversely, in Burma there was flooding and landslides which caused thousands of people to die. About two million people were affected and 500,000 forced from their homes. The SEA transboundary smoke haze problems are usually exacerbated during warm event years. The seasonal haze causes many parts of the region to be shrouded with a prolonged thick layer of seemingly

threatening smog. The occurrence of haze is not uncommon in Indonesia, Brunei and Philippines, threatening the health of millions of people and closing airports due to poor visibility.

The La Niña impact in the region is manifest in the form of excessive monsoon rainfall. During this period, the ITCZ and ascending Walker Circulation is far more active over the western Pacific, particularly over the maritime countries of SEA. This area experiences an increase of rainfall of up to 150%. Frequent flash floods have been reported in SEA countries related to La Niña events. It has been estimated that La Niña displaced many thousands of people and many casualties have occured within flood prone areas. In terms of general casualties, La Niña is still less documented compared with El Niño.

A regional climate outlook for SEA region is becoming a necessity in order to be able to assess in advance on likely impact of climatic variability. The SEA countries should be given more access to long range seasonal forecast products from the international centers in order to be more prepared in facing impending climatic events such as El Niño or La Niña. The scientific communities in the region would then have a basis to convince or brief the policy makers within their respective countries on likely impact of adverse climatic conditions. At the same time, the region itself should be encouraged to generate it own climate model either using simple coupled ocean-atmosphere models or physically-based statistical models by pooling available resources from ASEAN member countries. Such opportunity has been laid down by the establishment of the ASEAN Specialised Meteorological Center (ASMC) in Singapore. The regional-based product can be more sensitive to regional and national climate variability, spatial and temporal variability, as compared to international centers.

Bilateral and cross regional cooperation on mutual interests in the aspect of climatic variability is crucial because climatic impacts do not recognize national boundaries as has been proven in the recent forest fires in Indonesia during 1997/98 El Niño. Information and data exchange amongst the SEA member countries should be further enhanced. This will help to provide a basic input for the common people to know about climatic events as well as to foster small scale research related to ENSO. A better informed society and high accessibility of seasonal forecast products to users and policy makers could contribute more feedback on the need to establish proper policy and response strategies concerning the adverse impact of climatic events such as ENSO. Rapport among the scientific bodies, mitigation agencies, policy makers and the media could be the key factors in providing an effective and precise information to different levels of users and general public at large.

In order to develop an appropriate response strategy for ENSO impacts on the socio economy of the SEA countries, research on the monsoon interaction with ENSO is particularly important. As such, the deep understanding of the physics of ENSO interaction with the monsoons systems on intraseasonal and interannual time-scale is needed. This can be unveiled through multidisciplinary research involving all aspects of ENSO and monsoon mechanisms. The physical systems of the SEA monsoon, which involve ocean and atmosphere interaction, have yet to be fully understood. The mechanisms through which climate anomalies are connected to impacts on agriculture and water supplies must be better understood.

ENSO's EFFECTS ON ACTIVITY OF TYPHOONS IN WESTERN NORTH PACIFIC, BIEN DONG SEA AND VIETNAM

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The Western North Pacific region is one of the most productive and violent of tropical storm formations in the world accounting for 36% of the global average. The Vietnam and South China coast are exposed to typhoons from two source regions, namely the North Pacific Ocean and the Bien Dong Sea. This study aims to identify whether there is distinct relationship between ENSO and typhoon characteristics in Western North Pacific, Bien Dong Sea and Vietnam. The typhoon track data used in this study is based on the information given by the Typhoon Center of Japan. This database contains details of all recorded tropical cyclones for the western North Pacific for the 48-year period from 1951-1998.

The ENSO events have impacted to the different characteristics in typhoon's activity in the Western North Pacific, Bien Dong Sea and in Vietnam. The appearance of warm and cool sea surface anomalies in large area in central equatorial Pacific have caused the changes in the origin of typhoon formation, frequency, intensity, track and in other characteristics of acted typhoons in these regions.

In the time before most of people are concerned mainly only to the impacts of El Niño events, however the analysis in this study shows that the impacts of La Niña on typhoon's activity are serious too. The impacts of La Niña on typhoons are very different than impacts of El Niño events, even more complicated than El Niño's impacts. The analysis of typhoon's activity in different scenarios (El Niño, La Niña and Non-ENSO) gives us more completed view of ENSO's impacts.

The analysis of ENSO in two different events El Niño and La Niña shows that their effects on typhoons characteristics are very different and reveals more completed view of ENSO impacts. It is necessary to establish separately protection plan of typhoon for different scenarios: El Niño, La Niña and Non-ENSO.

Up to now there are many models for prediction of onset and intensity of ENSO event, so we can build the methods for prediction of ENSO's effects on typhoon's activity many months in advance based on results of prediction for ENSO events.

According the limitations of short record of typhoon data, in this study we have not done more detail analysis of ENSO's effects on the characteristics of typhoons. The ENSO events have different duration, different intensity, so probably their effects on typhoon's activity are different. We can classify the El Niño and La Niña event in more groups, for example based on their intensity or their duration for more detail scenario analysis.

In ENSO year we have to pay attention on formation of typhoons in Bien Dong Sea. In ENSO years the typhoons can be formatted at low latitudes, very near to the coastal zone of Vietnam and after short time of their formation make landfall in Vietnam. Those typhoons often cause the difficulties to the monitoring, prediction and protection process. Almost of those typhoons have had no strong intensity however they often caused heavy damages to Vietnam.

It was very rarely the typhoons to make landfalls in the Nam Bo region, especially the most southern part of Nam Bo, however the landfall in this region typhoons often caused heavy damages. It is important to pay a high attention to the typhoons probably make landfalls in this region.

In different months of the year, for different scenarios, the typhoons have a tendency to make landfall in different latitude regions of Vietnam. The impacts of El Niño are different than impacts of La Niña events. We can build the climatic-analog methods for prediction of ENSO impacts on typhoon's activity in Vietnam based on different effects of El Niño and La Niña events in different months for different regions of Vietnam.

In El Niño years:

> The activity of typhoons has a tendency to shifts eastward. The activity of typhoons in Bien Dong Sea and in Vietnam is weaker than in La Niña years. The number of landfall in Vietnam typhoons in El Niño years is less than in other years, however there exits the probability that in some years there are many typhoons (including unseasoned typhoons) to make landfalls in Vietnam. There were typhoons made landfall in most southern part of Vietnam.
>
> To pay attention about landfall of typhoons in summer months, especially in September the rate of landfall in Vietnam typhoons is very high. In September, almost of landfall in Vietnam typhoons are formatted at the longitudes much closer to Vietnam than average.
>
> The average intensity and the strongest intensity of typhoons in El Niño years are higher than in other years. The typhoon's intensity at the moment of landfall is higher than in other years too.
>
> In El Niño years, the frequency of landfall in all regions of Vietnam typhoons is lower than in other years.
>
> In the late moths of year, the frequency of landfall in Vietnam typhoons is much lower than average value. In October there were little typhoons made landfall in Vietnam however they have made landfall in higher latitudes than usual and caused impacts to Bac Bo region of Vietnam.

In La Niña years:

> The activity of typhoons has a tendency to shifts westward. In La Niña years the annual number of landfall in Vietnam typhoons is higher than in El Niño years. For all scenarios, the activity of typhoon in Bien Dong Sea is most strong in La Niña years.
>
> There exits probability that there are unseasoned typhoons to make landfall in Vietnam, however with lower frequency than in El Niño years. As a whole there were no typhoons made landfall in Vietnam in the first four months of year.
>
> The typhoons are formatted in different regions of Western North Pacific, more difficult for prediction than in other years. In Bien Dong Sea the typhoons can be formatted at lower

latitudes than normal with higher probability to make landfall in Vietnam than in other years.

The intensity and the class of typhoons in La Niña years are quite weaker than in El Niño years.

In La Niña years the frequency of landfall in all regions is higher than in El Niño years. Especially for the southern Trung Bo the frequency of landfall typhoons is near two times higher than in El Niño years.

The activity of typhoons is strongly in the period from September to November; two months later than in El Niño years. The frequency of landfall in Vietnam typhoons is high in October and November. In La Niña scenario the November is the month with highest frequency of landfall in Vietnam typhoons in comparison with all scenarios. In those months Vietnam is under most dangerous threaten of typhoons in comparison with all regions in Western North Pacific. Probably in the short period of time in those months there are many typhoons to make landfall to the same area in southern Trung Bo of Vietnam, causing serious flood for this area. It is important to pay high attention on landfall of typhoons in those months in southern Trung Bo.

Up to now there was still low attention to the impacts of La Niña on the typhoon's activity, however the analysis in this study shows that just impacts of La Niña on activity of landfall in Vietnam typhoons was very serious and more complicated than El Niño's impacts. In La Niña years the number of landfall in Vietnam is higher than in El Niño year. The typhoons have made irregularly landfalls in different regions of Vietnam. As a whole, in La Niña years, the monitoring, prediction and protection of typhoons in Vietnam will be more difficult than in El Niño years.

FACTORS CONTRIBUTING TO CLIMATE CHANGE IN CAMBODIA

Prepared by Long Rithirak, Mak Sideth and Chea Sina

Cambodia's climate is tropical monsoonal with a pronounced wet and dry season. Each season is six months: the wet season starts from May until October and the dry season is from November to April. The temperature is approximately from 20-32^{o}C. The temperature rarely falls below 10^{o}C.

Unfortunately, there is little data in Cambodia that relates specifically to climate change, making this a difficult topic to research. However, there are a number of factors that could contribute to climate change in Cambodia.

Forestry

The forests are a priority resource that supports the livelihood of the Cambodian people and is the main natural resource that can regulate and maintain the quality of the environment in a sustainable way. At the present, almost 40% of the forest (from what was13,2 million ha) has been degraded and cut due to the increase in logging activities, uncontrolled forest fires, increase demand for agriculture land, and the collection of fuelwood for charcoal production and other domestic use. The result from the survey estimated 2 million hectares of forest have been lost (about 100,000 hectares per year (MoE, 1994)). Therefore, the loss of forest in the country can cause a phenomenon disaster.

Flooding

The climate of Cambodia is determined by monsoons that can play a triggering role in the annual flooding of the Mekong-Tonle Sap Basin. A flash flood in central Cambodia, August 1991, caused an estimated US$ 150 million in damage to roads, reservoirs and irrigation structures in the central provinces of Cambodia (Dannis and Woodsworth, 1992).

In July 1994, the floods hit some provinces including Battambang, Kompong Speu, Kompot and Kandal caused around US$ 200 million in damage to roads, reservoirs and irrigation structures. This estimate did not include the environmental and social costs.

Some provinces along the Mekong River and Tonlesap Basin were flooded in 1996. This flood caused a lot of damage to houses, rice and livestock productions. Floods caused, again, damage in some provinces along the river and Tonle Sap Basin during 1997.

Flooding has been caused in Cambodia for a series of reasons including: deforestation, changes in weather patterns, soil erosion and sedimentation in the Tonle Sap Lake.

Changes in weather

Although no one is exactly sure if weather patterns are changing in Cambodia, it has been noticed by many people that the weather is less predictable then it once was. For example, last years (1999) rainy season was initially quite light yet lasted far longer than expected (into late October). This left many people’s rice fields flooded.

Carbon dioxide

From year to year the number of vehicles in Cambodia are increasing. More and more cars are driven on the road, and the number of motorbikes continues to increase.

Another issue is open burning that occurs in Cambodia. People burn their garbage, land is burned for agriculture and people often cook with charcoal.

It is difficult to say if industry is adding to carbon dioxide emissions.

The effects of climate change on Cambodia

There is no concrete data in Cambodia relating to climate change. However, should weather patterns remain unpredictable or should temperature's rise, this will affect Cambodia greatly. It is quite possible that rice production would decrease, and coastal areas could become flooded. This will significantly threaten the coastal population. Already in December of 1999 and January of 2000 coastal communities in Kampot and Koh Kong province were seriously flooded.

EFFECTS OF EL NIÑO AND LA NIÑA ON LAOS

The Laos delegation: Khampao Hompangna, Sengdeuane Phomavongsa,
Sitha Phouvayong and Phetsavang Sounnalath

BACKGROUND

The Lao People's Democratic Republic is landlocked country, situated in the center of the Indo-Chinese peninsula and sharing borders with China, Vietnam, Cambodia, Thailand and Myanmar. The country covers an area of 236,800 km^2, much of which is mountainous, forested and covered by rivers. According to population census conducted in 1995, the population is 4,7 million people, the annual growth rate is 2.6 per cent, the average population density is only 20 persons per km^2, the Lao people are known for their considerable cultural and ethnic diversity, with more than 47 different, distinct ethnic language groups live in Lao PDR. life expectancy is only 51 years. The country, however, suffers from the widespread effects of poverty and natural disasters with an estimated GDP per capital of 333 USD, the Lao PDR. is classified as one of the least developed countries in the world.

I. The Impact of El Niño and La Niña in Laos

1. In the past, El Niño events have occurred several times throughout the twentieth century and they are not well known or familiar in Lao PDR. It is also rare to observe a normal year that means no drought or no flood in recent years. Based on general concepts, El Niño have direct impact on weather conditions in Lao PDR, very dry in 1957-57, extreme low flow in 1965 and large flood in 1966, alternatively drought and flood in 1972-3.

2. Strong ENSO events during 1982-83

Extremely heavy rainfall in Southern province (Pakse, Paksong). Daily rainfall of more than 500 mm were observed on the 25-26 June 1983 during the mature stage of the event. Severe flooding conditions were reported between the lower Sedon and Pakse urban area. However, damages on rice crop were not important because it's happened in the beginning of the transplantation season but delayed the planting period.

3. Drought during El Niño 1987-88

Severe drought occurred in northern region of Lao PDR during the 1987 monsoon while central and southern regions have precipitation above normal. Precipitation observed at Nape station was only 1200 mm (normal annual rainfall 1943. 2 mm) this location is situated in a high forest coverage area 64%. Yet no stress to the forest vegetation could be casually noted in this high coverage (note: based on multivariate ENSO index of the 1986-87 was in the positive phase and the effect was prolonged to the end of 1988).

4. Drought during El Niño 1991-2

In 1991, annual precipitation was above normal and flooding condition was observed in southern province, but in 1992 the weather conditions was completely different, low rainfall and very low river runoff throughout the country some examples are given below:

Rainfall Luangnamtha province was only 500 mm/year compared with normal about 1500 mm/year. The peak flood staged of the Mekong river at Vientiane was only 6.67 m on 7th August 1992 (the lowest of this century was 7.34 in 1906). The annual discharge of the Mekong River in 1992 at Pakse was 74% of the average.

5. Severe flooding episode from 1994-1997

In 1994 annual precipitation in central and southern provinces were above normal in some provinces twice higher than normal as resulted severe flooding conditions in Borikhamxay, Khammuane provinces. In some districts of the northern provinces, landslide condition occurred in several section of the roads was impracticable during August-September.
The 1995 flood was the most severe for Vientiane plain after the historic large flood occurred in August-September 1966.
1996 flood in central and southern provinces affected and damages were important and there were loss of lives. Provinces affected: Borikhaxay, Khammuane, Savanaket, Champasak, Saravanh, Attapei and Sekong. Special phenomenon was observed from unusual flooding condition in Khamkeuth district (more than 470 msl high) from flash flood and from Namcaking River.
1997 flood again in central and southern provinces where Borikhamxay, Khammuane and Champasak were heavily affected in September damages were more severe than 1996 flood for this provinces. For Vientiane plain, flooding downstream of Nam Ngum Dam's powerhouse, houses, public offices, paddy field and orchards by the bank of NamNgum River were flooded.

1997. The recent El Niño 1997-98
Dry condition prevails throughout the country in 1998 as resulted from the late stage of the 1997-98 El Niño. In some areas precipitation was only 50% of normal. an extreme low flow condition occurred in several rivers. Annual discharge of the Mekong River at Pakse was only 72% of the average of 9651.5 m^3 from period of 1961-1998).

Effects of El Niño and La Niña on:

From climate data is concluded the 1997-98 El Niño has serious impacts on weather condition, river runoff (extreme low flow), shortage of water supply especially for rice plantation in the dry season. It is noted that during the 1998 raining season no typhoon or tropical storm hit in Lao PDR and during the dry season 1998-99 severe forest fires reported.
Statistic of impact:

On environment issue: Climate changed and led to a much higher incident of forest fires nationwide
- 1996 50,000 ha
- 1997 40,000 ha

1998 134,995 ha

On Agricultural production: Damages reported from flooding in Vientiane plain, 1995:
- persons affected 153,398;
- households 26,603;
- villages affected 427;
- Land use total flood area 102,912 ha
- rice crop total area 61,142 ha
- flood affected 34,471 ha
- damaged area 30,962c ha and
- other crops 17,167 ha.

II INSTITUTIONAL FRAMEWORK FOR CHALLENGES

a) National Disaster Management Office (NDMO) started in September 1997 and its function and responsibility

- Provide of secretariat and expert services to National Disaster Management Committee.
- Promotion of disaster prevention/mitigation and preparedness within all agencies and levels of government and NGOs as well.
- Providing guidelines, organizing disaster training and awareness, and promoting the preparation of disaster action plan.
- Operating the national Emergency Operations Center at time of Disaster.

b) National Disaster Management Committee (NDMC) has been formulated consisting of key Ministries:

- Ministry of Labor and Social Welfare	Chairman
- Ministry of Agriculture and Forestry	Vice Chairman
- Ministry of Foreign Affairs	Vice Chairman
- Ministry of Defense	
- Ministry of Interior	
- Ministry of Education	
- Ministry of Finance	
- Ministry of Communication, Transportation and Construction	
- Ministry of Industry	
- Ministry of Public Health	
- Ministry of Culture and Information	
- Department of Social Welfare	MLSW
- Lao Red Cross	

with its roles and responsibilities:

- defines priorities and criteria for the allocation of resources
- Implements policies and decisions on an inter-ministries basic
- Co-ordination by all government consisted of representatives of the concerning government ministries and agencies the roles and responsibilities
- Establishes policies, including the national disaster management plan, and provides overall direction for all aspects policies and has overall direction of the activities of the NDMO
- Responsible for major operational decisions during an emergency
- Decides on allocations of relief resources.

c) Counter Measures Taken:

Awareness and preparedness against the impacts of El Niño and La Niña is recently observed in 1997-98 event. This event begins to draw attention from government and general public. At the Seminar on Hydrological work and Pumping irrigation in the Mekong River basin held in Vientiane 23-27 February 1998. The Department of Meteorology and Hydrology has announced the weather conditions during the first 3 months of 1998. The general outlook for the seasonal climate outlook forum conveyed in Bangkok on the 2 February 1998. the general tendency is dry for year 1998 that coincide with a return period of 50 years 1957-58 (extreme dry year). Consequently the Nam Ngum

Dam operation was reduced turbine generating to nearly 50% in order to keep the water level of the reservoir closely the previous year.
In the agricultural sector, especially for farmers, advice or warning were frequently issued to be prepared against shortage of water for paddy rice during the growing season.
Flood control activities have been implementing in the flood prone areas.
Drought measures were taken with providing early warning to farmers and technical assistant, irrigation systems, water shortage with water pumps to dry season cropping.

III. CONCLUSION AND RECOMMENDATIONS

In Lao PDR the El Niño cycle of 4-5 years was frequently observed 1991-92, 1997-98, and affected rainfall distributed, the rivers runoff. However, due to difference occurrences of the phenomenon, the variation in arrival times of the Southwest monsoon, is of major consequence to the agricultural sector of the country. Rice production occupied over 80% of cultivated. For the foreseeable future the agricultural sector remain a key to providing food self-sufficiency at the national level and employment to the majority of the population and to alleviating poverty. In additional the afford can be minimized through the following measures:

- Create and effectively early warning and public awareness to communities of El Niño and La Niña events;
- Project watersheds against environmental degradation;
- Increase the flood control and irrigation systems to minimize flood and drought;
- Design and locate specific water harvesting and management system;
- Adopt after flood rice cropping followed by irrigated dry season rice cropping in flood prone areas.

IV. THE WORKSHOP ON THE IMPACT OF EL NIÑO AND LA NIÑA ON SOUTHEAST ASIA

The Lao delegation underscores the need for:

- Regional co-operation on the impact of El Niño and La Niña preparedness among the "Southeast Asia countries"
- Strengthen regional co-operation Information Systems in order to be well prepared against these phenomenon including Warning Systems
- Wider use of training resources, development of training and public awareness modules
- "Sharing experts": Rosters of Experts and establishment of Expert Groups.

Table 1: Areas affected by forest fires nationwide

Location	1996	1997	1998
Luang Prabang*	-	-	- 3.000 ha
Bokeo*	-	-	4,200 ha along the Lao-Thai border
Oudomxay*	35.000 ha	25.000 ha	20.000 ha
Luang Namtha*	-	-	17 mountains along the Lao-Chinese border
Phongsaly*	-	-	-
Saygnabuly*	15,000 ha slash-and-burn	15,000 ha slash-and-burn	127,360 ha
Viengtiane**			710 ha
Viengtiane Pre-fecture**			1,240 ha
Xieng Khouang**			10.000 ha
Houaphane**			
Saysomboune**			
Bolikhamsay**			
Khammouane**			58 ha
Savannakhet**			600 ha
Salavane**			100 ha
Champasack**			200 ha
Sekong**			67.527 ha
Attapeu**			
TOTAL	50.000 ha	40.000 ha	134,995 ha

Source: * Provincial administration
** Ministry of Agriculture/Forestry, Dept. of Forestry

Table 2: Damage due to natural hazards.

YEAR	TYPE OF DAMAGE	DAMAGE COST (US$)	LOCATION OF DAMAGE
1966	Large flood	13,800,000	Central
1967	Drought	5,200,000	Central and Southern
1968	Flood	2,830,000	Southern
1969	Flood	1,020,000	Central
1970	Flood	30,000	Central
1971	Large flood	3,573,000	Central
1972	Flood and Drought	40,000	
1973	Flood	3,700,000	Central
1974	Flood	180,000	Southern
1975	Drought	not available	
1976	Flash flood	9,000,000	
1977	Severe Drought	15,000,000	
1978	Large flood	5,700,000	
1979	Drought and Flood	3,600,000	
1980	Flood	3,000,000	Central
1981	Flood	682,000	Central
1982	Drought	not available	
1983	Drought	50% below normal production levels	
1984	Flood	3,430,000	
1985	Flash Flood	1,000,000	Oudomsay
1986	Flood and Drought	2,000,000	
1987	Drought	5,000,000	Central and Northern
1988	Drought	Crop losses of 40,000,000 Reduction in Electricity Production (Hydro) 10,500,000	Southern
1989	Drought	20,000,000	Southern
1990	Flood	100,000	Central
1991	Flood and Drought	3,650,000	Central
1992	Flood, Forest Fires, and Drought	302,151,200	Central, Northern
1993	Flood and Drought	21,827,927	Central, Southern
1994	Flood	21,152,400	Central, Southern
1995	Large Flood	35,700,000	Central, Southern
1996	Large Flood; Flash floods and landslides	34,400,000	Central & Southern Northern

THE IMPACTS OF EL NIÑO AND LA NIÑA EVENTS ON THE CLIMATE OF MYANMAR

U Tun Lwin (Department of Meteorology and Hydrology of Myanmar)

The period between May 1997 and June 1998 was a major El Niño event. During this period many countries around the world suffered, to some extent, from climatic calamities in terms of loss of lives, properties and economy. The impact on the climate of Myanmar was evident during 1997 and 1998.

Out of the six major El Niño events, the mean annual temperature for Myanmar showed four events which were above normal. Only a single episode in 1972 showed a below normal mean annual temperature. Therefore, it could be suggested that the mean annual temperatures during El Niño years are generally above the normal.

Studies on the mean annual rainfalls in six episodes of the major El Niño events show that four (five) events have below normal rainfall occurring during the preceding (following) years of the peak El Niño episode. Therefore, from this information, we can see that 70% (80%) of the El Niño events show below normal annual rainfall in Myanmar during the preceding years.

We can confidently say that the relation of monsoon rainfall to El Niño events clearly reveals that the monsoon rainfalls in Myanmar are below normal in most of the El Niño years. This is particularly true in the preceding year of the peak episode. However, even in the following year the possibility of below normal rainfall is still rather high with a statistic of five out of six events.

Studies on the drought index in relation to El Niño events show a good relationship. In most of the El Niño events, four (five) out of the six events show a positive drought index in the preceding (following) years of the episode. Thus, it can be confidently stated that during El Niño years the drought index in rainfall shows positive (dry) values.

Studies on the relationship between the frequency of storms and El Niño events have been controversial for a long time. The present study indicates that the annual storm frequency in preceding years of the peak of El Niño events are below normal. However, during the following years of a peak El Niño event, the annual storm frequency is below normal to normal.

The relationship between early monsoon intensity and El Niño events does not perform very well, although one would expect below-normal intensity, especially during the second (following) year of a peak El Niño period. The present study shows that only 16% (33%) of the events have below-normal intensity in the early monsoon period in preceding (post) years of the peak El Niño events. However, 67% (51%) of El Niño events show normal monsoon intensity in pre- and post peak periods.

The noteworthy fact is that only 16% of the cases in pre- and post years of the peak El Niño events show above normal monsoon intensity in early monsoon periods of the respective years. Therefore, it can be concluded that the monsoon intensity in the pre-monsoon periods of both the preceding and following years of the peak of major El Niño events could be below normal to normal.

To summarize this paper and to conclude, we can see that the impacts of El Niño events on weather parameters such as annual temperature, annual precipitation and the drought index are evident. Moreover, the El Niño event also has an impact, to some extent, on monsoon climatology.

Myanmar benefits from the southwest monsoon and it is an agricultural country so, as almost 90% of the country’s annual rainfall is received from monsoon rains, Myanmar’s economy will be affected.

El Niño events have been more frequent than ever during the 1990s. This definitely calls for a better understanding of this phenomenon. Myanmar is also starting to notice that the reverse of El Niño, La Niña, is having a reverse effect on the climate of Myanmar. For example, the weather in 1998 and the weather in 1999 was very different, with 1998 being an El Niño year and 1999 being a La Niña year. It is obvious that more research and studies are needed in respect to El Niño and La Niña.

INTERNATIONAL FORECASTS OF THE ENSO PHENOMENON

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1. Introduction

In the mid-1960s, observational and diagnostic studies of the ocean and atmosphere began to make it clear that certain behaviors of the coupled system might be predictable on seasonal time-scales, including in particular the El Niño–Southern Oscillation (ENSO) phenomenon (Latif *et al.* 1998; Neelin *et al.* 1998). The aim in this paper are to describe how forecasts of the ENSO phenomenon are made, and how accurate they are.

2. Statistical models

a. Model design

The implicit assumption behind statistical models for predicting the future state of the ENSO phenomenon is that antecedent or expected future values of predictor variables can be used to predict the future evolution of the predictand, based upon historical observations of mathematical relationships between the predictors and predictands. Most of these models involve prediction of a field of tropical Pacific sea-surface temperatures, or a simple area-average of representative regions of the equatorial Pacific, such as the NIÑO3 (5°N-5°S, 150°-90°W) or NIÑO3.4 (5°N-5°S, 170°-120°W) areas. The predicted sea-surface temperature anomalies usually are derived from previously observed sea temperatures, and/or wind stress anomalies over the equatorial Pacific, although relationships with atmospheric anomalies further afield, particularly in the Indian Ocean and over Eurasia, often are considered (Barnett *et al.* 1991). The most frequently used statistical models include:

- regression, involving a linear relationship between a single predictand (such as the NIÑO3 index, and a set of precedent predictands (such as surface wind stress and/or sea-surface temperature anomalies throughout the tropical Pacific);
- canonical correlation analysis, involving linear relationships between a set of predictands (such as tropical Pacific sea-surface temperatures) and a set of precedent predictands;

Although probabilistic methods of statistical prediction have been used in forecasts of precipitation anomalies (Ward and Folland 1991; Mason 1998), there are few examples of their application in forecasting the ENSO phenomenon per se. Many of the statistically based forecasts are published in the *Experimental Long-Lead Forecast Bulletin*, which is available on the worldwide web at http://grads.iges.org/ellfb/.

b. Strengths and weaknesses

Positive attributes of statistical approaches to predicting ENSO (and to predicting climate anomalies) mainly are based on the inherent relative simplicity of such models. In most cases statistical models can be constructed, applied, interpreted and diagnosed, and run with ease. There are, however, a number of negative attributes. Perhaps the most serious problems with statistical forecasting methods result from the fact that such models are not explicitly linked to physical processes. The statistical relationships that are identified do not necessarily indicate causal relationships, and so:

- model skill may be artificial;
- it is difficult to get a true estimate of operational skill (most estimates of the skill of statistical models over-estimate operational skill);
- if background conditions change, the models may no longer give good forecasts;
- different models are required for different seasons and regions.

An additional problem associated with most statistical models, is that the output is in the form of a deterministic prediction, and they thus provide little indication of forecast uncertainty. While confidence intervals are sometimes provided, these are defined in terms of the mean-square error of the model over the training period (Wilks 1995) rather than being direct indications of the inherent uncertainty in the prediction of the current season (Mason 1998).

3. Dynamical models

Dynamical approaches to the prediction of the ENSO phenomenon involve a fundamentally different approach to the problem, and are based upon attempts to model the physical processes responsible for tropical Pacific variability using the first principals of the laws of physics. In many cases the physical processes involved, rather than being explicitly modelled, are parameterized in the form of statistical or mathematical relationships. A hierarchy of dynamical models can be defined based upon increasing levels of complexity.

a. Intermediate models

Intermediate models involve a simple shallow water model, coupled to a simple atmospheric model. Such models do not attempt to include all the physical processes involved in ocean and atmospheric circulation and coupling, but rather focus on attempting to model only those processes that form key components of the ENSO system. In most cases intermediate models are consistent with the delayed-oscillator model of ENSO variability (Neelin *et al.* 1998), which implies that the mechanism for inter-annual variability is associated with the subsurface memory of the equatorial Pacific. External forcing, from the Eurasian land mass for example (Barnett *et al.* 1991), therefore is explicitly excluded.

Probably the best known example of an intermediate model of the ENSO phenomenon is the Cane-Zebiak model (Cane and Zebiak 1985). This model involves a simple atmospheric model in which winds are driven by convective heating, which in turn is parameterized in terms of sea-surface temperatures and surface wind convergence. The ocean component to the model is more complex, and involves ocean waves and currents represented by physical laws that are consistent with the delayed oscillator model. Variability in sea-surface temperatures is modelled as a function of advection, heat fluxes, and thermocline depth. The Cane-Zebiak model is an anomaly model, and so biases in model climatology and errors in the representation of the seasonal cycle can be avoided.

b. Hybrid coupled models

Hybrid coupled models involve a more comprehensive physical ocean model than intermediate models, but have an empirical atmospheric model. Because hybrid coupled models are confined to the tropical Pacific, there is the assumption that ENSO physics is inherently rooted in the tropical ocean-atmosphere system (as is the case for intermediate models). Hybrid coupled model strengths and weaknesses are very similar to those for Intermediate models, and are discussed below.

c. Fully coupled models

Fully coupled models involve a physical ocean model coupled to a physical atmosphere model. The oceanic model may be global, as in the case of ECMWF (Stockdale *et al.* 1998), or confined to the tropical Pacific, as in the case of the NCEP model (Ji *et al.* 1998). Such models are no longer constrained by the assumption that the physics of ENSO variability are confined to the tropical ocean-atmosphere system. The ECMWF forecasts are available from http://www.ecwmf.int/services/seasonal/forecast/.

b. Strengths and weaknesses

Positive attributes of dynamical approaches to predicting ENSO (and to predicting climate anomalies) include:

- less susceptibility to bias in skill estimates because the models are harder to tune, and the parameters generally are constrained by physical laws;
- ability to model the effects of the non-linear behaviour of the ocean-atmosphere system;
- less affected by changes in the background state;
- ability to provide probabilistic forecasts, and therefore to give better estimates of forecast uncertainty (although in practice it is only the fully coupled models that are run operationally in ensemble mode);

Negative attributes of dynamical models are based largely on the inherent relative complexity of such models:

- they are difficult to build, maintain, and operate;
- they are expensive to operate;
- it can be difficult to understand their behaviour;

Although the dynamical models are harder to tune than the statistical models, in general the hindcast skill estimates, at least from the intermediate and hybrid coupled models, are over-estimated because model parameterizations are fine-tuned to optimize model skill.

4. Skill Levels

In practice, the various model types perform approximately equally well. Despite the greater complexity of the dynamical models, although theoretically, the dynamical models hold greater promise for forecast improvement. For all types of models forecast skill is limited by:

- model flaws;
- gaps in the observing system;
- inherent limits to predictability.

However, the skill of the dynamical models additionally is restricted by data assimilation and initialization problems. Improvements in data assimilation in both the Cane-Zebiak model and the NCEP coupled model have resulted in demonstrable improvements in forecast skill. There still is considerable scope for improving model initialization, which should contribute further to increases in skill.

Although there have been claims of high skill in forecasting ENSO events with lead-times of twelve months or more, operational skill estimates, which provide the only truly unbiased indications of forecast skill, suggest that ENSO events can be forecast qualitatively only a few months in advance (Barnston et al. 1999), and usually only after an event has begun. In addition to be a function of the ENSO phase, skill levels have varied inter-decadally, with high skill levels in the 1980s, but relative poor skill in the 1970s and 1990s (Balmaseda *et al.*, 1995; Kirtman and Schopf, 1998). This low-frequency variability in the predictability of ENSO events may be a reflection of changes in the role of the delayed-oscillator mechanism in equatorial Pacific ocean-atmosphere dynamics (Goddard and Graham 1997). Some evidence suggests that there may be seasonal variability in the predictability of the equatorial Pacific, involving a loss of predictability in about March, and is referred to as the "springtime barrier" (Balmaseda *et al.*, 1995; Webster, 1995; Latif *et al.*, 1998). The spring barrier is most well defined during decades of relatively poor predictability, but is not evident all ENSO-prediction models, and so may not be an inherent feature of the ENSO phenomenon (Chen *et al.* 1995).

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PRACTICAL ASPECTS OF FORECASTING RAINFALL IN EASTERN AUSTRALIA AND SOUTH EAST ASIA USING EL NINO/SOUTHERN OSCILLATION (ENSO) INDICATORS

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Introduction

ENSO is often predicted with an aim that this prediction may then be used to estimate rainfall or temperature on a seasonal time scale. However, while ENSO has a strong influence in the tropical genesis regions of the Pacific Ocean, the effects of ENSO in extra-tropical regions is less certain. Thus, in extra-tropical regions an ENSO event should be thought of as 'putting a bias in the system rather than as a certain cause' (Cane, 2000).

Prediction of ENSO impacts is currently made with physical or statistical models or other empirical methods. Fully coupled global General Circulation Models (GCMs) may predict global impacts associated with ENSO along with the prediction of the changes to ENSO itself in the tropical Pacific. Another method is to take a "two-tiered" approach whereby a more simple oceanic GCM predicts tropical Pacific sea-surface temperatures. A global atmospheric GCM then uses the predicted SSTs as boundary conditions to calculate variations in rainfall or temperature or other variables of interest.(Cane, 2000; Barnett *et al*., 1994; Hunt *et al*., 1994). Forecasting ENSO using empirical approaches may also be two-tiered. This may take the form of producing a forecast of rainfall at a location or for a region by combining the prediction of the Southern Oscillation Index (SOI) or of the NINO3 SST anomaly pattern with the historical relationship with rainfall.

However, in this paper I am proposing a more efficient and practical approach is the do the entire prediction at once, using known, observed values of the SOI or SST to predict a future rainfall or temperature. This approach also avoids the problem of compounding errors (a multiplicity of errors associated with the prediction of ENSO in the first place combined with the error in predicting the outcome given that ENSO did in fact occur).

<u>Examples of ENSO-based prediction methods used in Australia.</u>

Two main approaches are employed in Australia to produce seasonal climate forecast output. These are:

- a base 'phase' system that incorporates the SOI as predictor. 5 SOI phases based on a Principal Components and Cluster Analysis of the time series of the SOI have been identified and these are used as predictors (Stone and Auliciems, 1992; Stone *et al*, 1996a; Stone *et al*, 1996b). The prediction of Australian and global rainfall of Stone *et al.* (1996a), based on the phase system uses values of the SOI at 2 different times to predict rainfall a season or more ahead.

- an SST-based system that employs empirical orthogonal functions (EOFs) of Pacific and Indian Ocean SSTs as predictors. These EOFs of SST are matched with principal components of rainfall patterns in Australia using a 1 month and 3 month lag. (Drosdowsky, 1993; Nicholls *et al*, 1998).

The important point is that neither of these approaches is necessarily ‘concerned’ over whether an ‘El Niño’ or La Niña’ is forecast or is even underway. Both of the above methods use lag-relationships between the SOI ‘phase’ or SST EOF and the predictand (e.g. rainfall, temperature, dates of first and last frost). Additionally an SST pattern system that incorporates 9 patterns of SST in the Pacific and Indian Oceans is being developed (Drosdowsky, personal comm.).

The skill of both of the above climate forecast systems has been assessed using cross-validated LEPS Scores (LEPS stands for Linear Error in Probability Space) (Potts, *et al.*, 1996). An interesting issue is that both of these systems seem to have equivalent skill in forecasting rainfall in Australia, although the SST-based system seems to have higher skill over southern Australia than the SOI-based system. Conversely, the SOI-based system appears to have higher skill over northern Australia than the SST-based system, although direct comparison is not as simple as might first seem apparent. We also know that the nature of the climate system does not allow unlimited predictability, so that even a perfect forecasting system would not be able to deliver precise forecasts. Thus to be correct a forecast must be phrased as a probabilistic statement and considerable effort is made in Australia to always refer to climate forecasts in a probabilistic manner (also from Cane, 2000).

A further benefit of employing the above approaches (especially the 9-pattern SST system and the 5-phase SOI phase system) is that each month for the last 100 years can be categorised into which SOI phase or SST pattern it belongs. This result then allows analogue seasons or years to be extracted easily from the data. This result also allows for considerable transportability of the forecast systems across different variables (e.g. frost, number of raindays, streamflow, dam in-fill rates). This approach also allows the connection of the climate forecast system to crop and pasture and other simulation models that require input of analogue seasons for their use.

Indeed, one of the reasons for the modest success of climate forecasting in Australia is that the methods that have been developed have been directly able to produce outputs of key variables in agricultural risk management. These include the probability of pasture growth, probability of attaining certain crop yield values for many crops grown in Australia (e.g. sugar, wheat, sorghum, cotton, peanuts, maize, chickpeas), the value of adding fertilzer inputs to a crop given the likelihood of a certain type of season, the amount of irrigation water that will be available for a coming season, the amount of water likely to flow into a dam, and so on. They also include estimates of disease and waterlogging.

In other words, the more direct approach of doing the entire prediction at once without necessarily forecasting a major El Niño or La Niña has facilitated a particularly practical and useful climate forecasting industry to quickly become established in Australia. .

We have also applied these climate forecasting methods to many other world regions including South-East Asia with interesting results.

Figure 1 shows rainfall probability distributions for Hanoi, Vietnam for the March-May period associated with SOI phases for the immediately preceding January/February. This type of analysis shows that the probability of exceeding 300mm total rain during March/May following a consistently negative SOI phase is 30% while following a ‘rapid rise’ SOI phase the probability of exceeding 300mm is 80%. This analysis simply extracts the rainfall records for Hanoi for the last 70 years and determines the rainfall distributions associated with those seasons following the respective SOI phases.

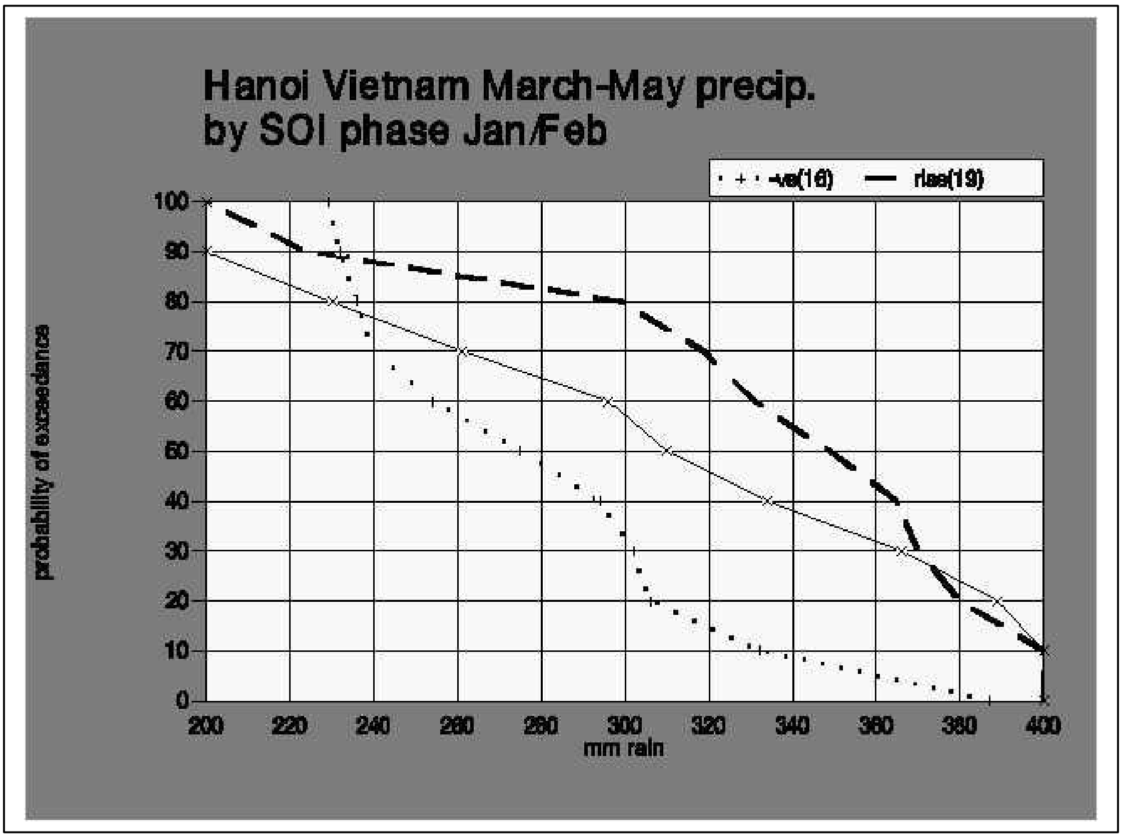

Figure 1. Rainfall probability distributions for Hanoi, Vietnam, for the March-May period associated with two SOI phases (‘consistently negative’ and ‘rapid rise’ SOI phases). It is suggested we are currently (February 2000) in a ‘rapid rise’ SOI phase. Similar analyses have been completed for a number of locations in South-East Asia and will be presented at the Conference.

However, a key point in applying this type of analysis in climate forecasting is that the analogue years or seasons associated with these SST patterns or SOI phases can also be extracted. This enables crop simulation models to use the daily data associated with these analogue seasons to grow crops in the computer. Figure 2 provides an example from Queensland, Australia where this type of method is currently applied successfully to predict not precipitation but crop yield. Figure 2 shows the potential yield for a crop planted on the 1st of June according to the various SOI phases known *before planting.* This analysis clearly shows the potential yield following a ‘consistently negative’ SOI phase is comparatively low (just over 1 tonne/ha) compared, for example, with the potential yield following a ‘rapid rise’ SOI phase where the potential yield is over 3 tonnes/ha (planted on a half-full profile of moisture.

It is suggested, there is some advantage in applying the type of seasonal climate forecasting procedure outlined above over the type that aims for a precise forecast of an El Niño or La Niña. The type of analysis outlined above can also be applied across a large range of requirements ranging from ‘simple’ rainfall analysis to more complex crop yield analysis. The latter type of output is often the type of information the user is actually seeking from climate forecast information. A systems approach to climate forecasting appears to be the most rewarding. This certainly applies from the users point of view where the climate forecast output directly applies to his decision system. This approach also helps when seeking funds from Government. Government may often be more predisposed to granting of funds for this type of climate forecasting research if it can clearly be shown where the payoffs lie in rural or other industries. The type of systems analysis outlined above using direct forecasts of precipitation or such as crop yield has greater capability in defining *value* (as opposed to forecast skill) in climate forecasting (Hammer, *et. al*, 1996).

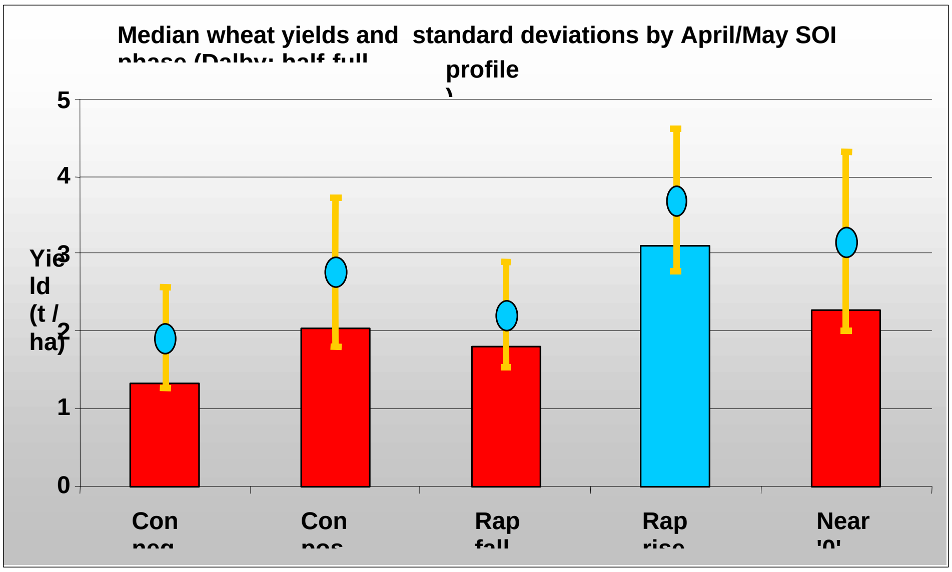

Figure 2. Potential yield values (median at the top of the bar, mean values the circle) for a wheat crop planted at Dalby, Australia on the 1st of June. The respective values are those associated with the data partitioned according the SOI phase known before planting.

Capacity building.

It is suggested there are some major requirements needed in capacity building before an effective systems approach to climate forecasting can be realised. The first is to do the climate research within an overall systems framework so that the end-to-end requirements of the entire climate forecasting-user-output value can be addressed properly. It is not much use if the climate forecasting system is unable to interact with other vital biophysical models that can provide forecasts of crop or pasture growth or to interact with power demand models or dam-in-fill rate models (see Hammer, *et al*, 1996)

A major need in capacity building is to employ appropriate staff with the necessary statistical modelling and analytical skills in climatic analysis. Finally, continued user engagement is required for this systems approach to gain user ownership from the outset of the climate forecasting research and development work.

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OVERVIEW OF CLIMATE FORECASTING IN VIETNAM

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I/ Introduction

Vietnam is located in the area affected by the transverse and lateral components of monsoon system and the Walker circulation and the country is often threatened by storms, flood, inundation and salinity intrusion. So we strongly support the research activities to predict and assess the impacts of ENSO on climate and socio-economic in Vietnam and Southeast Asia, and endorse a vigorous international programme of research to improve understanding and prediction of the climate system and its variability.

Due to the importance of climate variability and climate change to Vietnam, the country pays more attention to serving and monitoring the climate and atmosphere to provide the data for climate research, monitoring and prediction, supports applications of climate information such as seasonal and interannual prediction and has actively responded to the issues of climate change raised by scientific researchers throughout the world.

II/ climate predictability and prediction in vietnam

Upon on the grade of historical climate data, and by using the dynamical and statistical methodologies, there are series of studies had been published and applied to predict climate variations and tendency in Vietnam such as

- The prediction of monthly and winter season average temperature (from December to February);
- Prediction of rainfall in Hanoi;
- Medium-range forecasting (10 days) processes on medium and heavy rainfall in the North of Vietnam;
- Establishing medium- and long- range forecast of winter and summer season temperatures in North regions of Vietnam;
- Predicting onset of the first severe cold of winter season;
- Tendency of summer rainfall;
- Forecasting trends of climatic change in Vietnam;...

But almost studies based on the computation of averages and particularly trends for each data time series and the analysis of correlation coefficients, linear regression, or multi-regression,..., and there is no climate specific prediction model (global or regional) applied in Vietnam.

Due to the insufficiency of the computerizing capacity including computer hardware and software for model operations and shortages of skilled personnel and expertize in development of numerical modeling experimentation, and the Climate Research Center (CRC) has just been established since 1995, so its ability to predict climate on the short and long time scales as well as further changes is still limited. The present research programme prepared by the Climate Research Center (for 1999 - 2002) on establishing technology base for empirical study on climate prediction and issue of climate bulletin (Initial Implementation Plan) in Vietnam had been approved to implement.

III/ climate prediction empirical study

Climate prediction empirical study is an initial implementation plan, continues the development of Climate Prediction Programme (CPP) and provides a necessary step towards its implementation.

The goals of programme are to:

1. foster the production and use of seasonal climate forecast information, thereby reducing societal losses due to climate variability and assisting to achieve sustainable development;
2. modernize the CRC and strengthen its capacity for research and application to provide seasonal climate prediction and climate information.

The overall scientific objectives of the CPP are following:

1. Establishing climate data base (historical and real time data) to serve the climate prediction activities and to issue the Climate Bulletin or Outlook Fora;
2. Experimenting in application of climate forecasts: monthly, seasonal, annual based on empirical or statistical models. Forecast criteria are necessary for empirical methods:
    - Predictors should be physically plausible and based on current scientific understanding;
    - Assessing the skill in real - time is controversial, but some estimate of skill independent of model training is needed;
    - Satellite records are generally considered too short to be used in empirical models;
    - A data set of 30 - 40 years is considered necessary to derive reliable skill estimates; and
    - A number of methods for testing skill levels are available, including cross - validation and retroactive real - time validation.
3. Issuing the Climate Bulletin;
4. Education and training of scientists and decision makers skilled in the use and interpretation of new forecast capabilities and analysis techniques;
5. Considering and examining the regional climate simulations to understand and evaluate the strengths and weaknesses of regional climate models through systematic comparative simulations (Reg CM2, ECMWF Ensemble Simulation CD-ROMs,...).

However, we are waiting for benefits that will come from successful completion of the World Climate Research Programme (WCRP): especially CLIVAR, CLIPS; IRI - NOAA Proposal for Capacity building in Seasonal Climate Prediction for ASEAN: Regional Modeling, Applications studies, Training and others to develop the ability to predict the climate system on "seasonal, interannual, decadal, and centennial time scales", and to "predict the response of the climate system to human influences.

CLIMATE FORECASTING IN CHINA

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Statistics indicated that 70%   80% of the annual loss of natural disaster in China can be attributed to the droughts and floods. The annual loss ranged from 1.0 to 2.0 hundred bullion of Chinese Dollar in 1990’s. Summer rainfall consists of about 60%-70% of annual precipitation in north, and 40%-50% in south China. Therefore, forecast of summer rainfall anomaly pattern has critical in service to the society. Operational forecast on summer drought and flood was firstly issued in 1958 by the Section of Long Range Forecast, Central Meteorological Observatory, National Meteorological Administration, for severe flood along the Changjiang River in 1954 and along the Hui River in 1956 had made significant lose in the economy.

Development of seasonal forecast operations for the last 42 years (1958   1999) has undergone three stages. In the first stage, from late 1950’s to the middle 1960’s, statistical method of Namias (1953) was used in China in preparing prediction of monthly mean 500hPa level height. However, only monthly prediction was made in that time, so it is impassable to issue seasonal forecast by using of this method. Then, a lot of statistical method was applied, for example, regression equation or periodicity analysis.

The Second stage lasted nearly 30 years from middle 1960’s to middle 1990’s. Physical mechanism responsible for the development of summer rainfall anomaly was extensively examined not only in the Meteorological Observatories, but also in the Institutes and Universities. Experiences in operational forecasting indicated that the following factors may used as precursor: ENSO, snow corer over Tibet plateau, SST of kuroshio, solar activity. For example, it has been established that summer rainfall will greater than the normal along the middle reaches of the Changjiang River and south of it when snow fall was greater than the normal over the Tibet plateau and SST in equatorial eastern Pacific was higher than the normal in previous winter. 1997 was a year of El Niño, and snow cover over the Tibet plateau was significantly greater than the normal in the winter of 1997-1998. Then, severe flood along the Changjiang River in summer of 1998 was successfully predicted. Unfortunately, it was only an example in operational prediction service rather than a rule, though of summer rainfall forecast has increased about 10% from 1980’s to 1990’s. Correlation coefficient between observed and predicted rainfall anomalies remained relatively low for the period of 1988-1997(Table 1). 0.1 of averaged correlation coefficient relates to about 55% of accuracy. Only in a few case accuracy can equal or greater than 60%.

It infers that our knowledge is far from complete. Some times, the main reason of development of summer rainfall anomaly was not fairly understood even when the phenomena have been happened. Only half of the variance of seasonal rain fall anomaly can be interpreted by simultaneous seasonal mean 500hPa level heights. Table 2 illustrates clearly the limitation of our understanding on the mechanism of development of summer rainfall anomaly.

Table 1 skill score and anomaly correlation coefficient of summer rainfall forecasts

Summer	SS	ACC
1988	0.24	0.21
1989	0.02	-0.04
1990	0.13	0.13
1991	-0.03	-0.09
1992	0.14	0.10
1993	0.17	0.06
1994	0.32	0.45
1995	0.20	0.20
1996	0.11	0.05
1997	-0.03	-0.08
average	0.13	0.10

Table 2 Interpretation of summer rainfall along the middle and lower reaches of the Changjiang River by the simultaneous circulation factors.

No	Circulation factor	Single correlation Coefficient	Variance Interpreted
1	Subtropical High	0.50	20.0%
2	Trough over east Asia	-0.51	15.3%
3	High over Okhotsk	0.45	9.7%
4	High over Tibet Plateau	-0.19	4.4%
Total	Complex correlation coefficient	0.68	47.0%

Therefore, hope of improvement of seasonal prediction is placed to dynamic model. Atmospheric or Coupled General Circulation Model (AGCM or CGCM) have gradually inter the practice of seasonal prediction. From this started the third stage of seasonal prediction studies.

Probably, scientists of Institute of Atmospheric Physics (IAP) have made the first seasonal rainfall prediction experiment in China in the middle of 1980’s. Successful prediction on the summer rainfall anomaly of 1985 proves the possibility of seasonal prediction by using of AGCM. Later, CGCM had developed in 1988 and used in making summer rainfall prediction. Prediction is usually made in middle of March, it ensures two and a half month lead time. The products of prediction of IAP and other models were used in forecast synthesis in National Climate center (NCC). It shows that including the GCM products into operational prediction has great benefit. At present time prediction products of eight models were joined into operational prediction, which is made by NCC and other institutions, for example IAP.NCC has developed a series of AGCM, CGCM, regional GCM and CGCM used in making ENSO prediction.

THE USE OF SEASONAL FORECASTS

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The climate effects and societal impacts of climate variability such as those resulting from ENSO in this region have already been covered. Seasonal forecasts are one way to decrease our vulnerability to, and help us deal with, climate variability. Increases in the availability and accuracy of seasonal climate forecasts, such as those referred to previously, has resulted in a greater interest in their use and application. ENSO related climate forecasts are intended, and in many cases do, help us to cope with climate variability. Indeed there is no doubt that forecasts have the potential to help combat the effects of climate variability but efficient use is essential.

There are a variety of applications of climate forecast. Some of the initial larger scale uses included the famine early warning system predicting food security status in vulnerable regions with climate forecasts as a major input. Other documented uses include power utilities who use temperature forecasts to predict energy demand and water resource managers who can benefit from rainfall forecasts for a river catchment. The agricultural sector with its vulnerability to climate variability is an area for which forecast use potentially has great implications. Indeed in some regions, especially north America and Australia (Stone this report) the application of climate forecasts to aid in farm management decisions is well documented. This leads to the questions how are, and how could, climate forecasts be used?

Climate forecasts are often used as input into a decision making process. They can be the sole deciding factor but more commonly they are only one input, of many feeding, into the process. Because of the variety of inputs going into decision making and the very specific needs of the users the commonly made assumption that forecasts by default must be useful is not necessarily correct. In the past few decades research has concentrated on the climate science side of forecasting but more recently attention has also turned towards a multidisciplinary approach that addresses the issue of the actual use of the forecast. For example the National Research Council (US) has noted that

“Scientific activities [e.g. forecasts] that are intended to be relevant to practical decision making are more effective and useful when they are designed in a process that integrates the needs and perspectives of those who would use the scientific results…”

Research is necessary therefore not only for improving climate prediction methods but also in ensuring that the intended recipients of this information can actually use it. If we want to determine how forecasts can be effectively used we need to turn to the user.

In terms of agriculture users can range from government ministries down to the individual small scale farmer. A case study can be used to illustrate the complexity of individuals needs and some of the major challenges to forecast use that can arise. Although this study is business and country specific (commercial agriculture in Swaziland) the findings have a much broader implication. The first step in assessing users requirements is to determine how the users operations are affected by climate variability, the sort of climate influenced decisions that the user makes, what climate information is used by the user and the climate information the users requires throughout the agricultural year. This can all be included in seasonal timelines, also known as seasonal calendars. As a tool in the field they provide a simple yet effective means of focusing interviews to gain this information.

So what do these timelines tell us? Well, a three month subsection for example gives us an indication of the climate side of things but it should be noted that as with the rainfall the operations change throughout the year. This can be seen from one 3 month profile to the next. If we compare two businesses for example, forestry and sugar the periods within the year that are busiest vary for each operation. A number of points ca be illustrated through this case study. Namely that the influence of climate varies between users, the users needs are very specific and that these needs vary between users.

After gaining an understanding of the role climate has on a sector – in this case commercial agriculture some of the limitations or constraints to the utilisation of forecasts can be assessed. It is these constraints that complicate forecast use and create a barrier between the forecast and its efficient use. These constraints can be divided into two classes – the human and the physical dimension. The physical dimension relates to the actual forecast, its timing and scale for example whereas the human dimension relates more to economic and social factors that may influence use.

The fieldwork from the case studies mentioned highlighted a number of constraints which can be summarised as a list of questions that the farmer might ask:

- ❑ Is the forecast at the right time to act?
- ❑ Is the Temporal and spatial scale of the forecast sufficient?
- ❑ What is the forecast reliability?
- ❑ What event is being forecast - wet or dry?
- ❑ Is there enough certainty to risk acting on it?
- ❑ Are there other factors more important then the forecast?
- ❑ Where is the forecast available from ?

This is only one level of the agricultural sector. In theory commercial agriculture should have the greatest access to resources and the greatest ability to cope with climate variability. This may be why the constraints listed mainly relate to problems with the forecast. This is not to say that these constraints are not applicable to say a small scale farmer but there may be other constraints that have a greater impact. Thus different sectors experience different constraints.

To enable the full utility value of a forecast to be met we need to consider how to overcome constraints. One of the most commonly cited constraints in this field of research for example is the lack of access to the forecast. Research can therefore be carried out in more detail to determine the access routes a user has to information and how these can be improved. In parts of Africa for example research has shown the most common means of forecast communication is through the radio. Thus resources can be concentrated on developing suitable radio broadcasts.

Is there any actual value in this information? It only has some kind of value if people can change their actions in a beneficial way based on that information. A number of studies have addressed this issue but in most cases, however, it is unlikely that these cover the full utility value. There is no doubt that forecasts can be valuable in some sense to decision makers at any level but there are constraints. To address this issue a thorough understanding of the users needs is necessary as well as the potential role that forecasts may have. The utility of forecasts can be increased if the forecasts and the users needs are brought closer together. This includes identifying :

- ✓ the climate parameters to which a sector or group is highly sensitive,
- ✓ the forecast products available and their limitations,
- ✓ the processes that encourage interaction between forecast producers and users,

- ✓the constraints – both human and physical which limit use,
- ✓a means of narrowing these constraints and maximising the use value.

In conclusion this presentation and those of the previous speaker have shown that there is a need to undertake interdisciplinary projects that integrate both forecasters and users to be able to fully benefit from the application of such information.

TWO BIG FLOODS OCCURRED AT THE END OF 1999 IN CENTRAL VIETNAM

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Within only one month, from the early November to the beginning of December 1999, there were two special floods occurring successively in Central Vietnam. Historical flood appeared in some rivers, they were the biggest ones within recent 70-100 years. This report will describe general characteristics of these two floods.

1. Characteristics of rainfall:

At the beginning of November 1999, due to the influence of cold air combine with strong activities of inter-tropical zone going through South Vietnam from 1st to 4th and tropical depression landed in South part of Central Vietnam on 5th evening, throughout provinces of Central Vietnam and Central Highlands of Vietnam, a heavy rainfall with high intensity occurred in a short time from 1st to 6th of November 1999. Amount of rainfall unequally distributed from day to day, normally 50-100 mm at Thanh Hoa, Nghe An, Ninh Thuan, Binh Thuan, Kontum, Daklak provinces, 150-300 mm at Ha Tinh, Phu Yen, Khanh Hoa, Gia Lai provinces, 300-800 mm at Quang Binh, Binh Dinh, 500-2000 mm at provinces from Quang Tri to Quang Ngai, the center of rainfall is at Thua Thien-Hue province (A Luoi: 2770 mm, Hue: 2288 mm, Phu Oc: 1826 mm, …)

Subsequently, at the beginning of December 1999, with the impacts of cold air and rather strong activities of Eastern wind zone combine with tropical depression moving though the sea of south part of Ca Mau province, from 1st to 7th of December, there was an extreme rainfall widely spreading in coastal provinces of Central Vietnam, focusing on 3rd- 5th of December. Precipitation and rainfall intensity in some places were extremely large.

Total amount of rainfall in days of 1st to 7th ranged from 200 to 2000mm. At region from South Quang Nam to Quang Ngai: greater than 1000mm, at the center of rainfall in upstream Tam Ky river: greater than 2000 mm (Xuan Binh: 2192 mm), Ve river basin (Ba To: 2011 mm). Normally, at Thua Thien Hue, Binh Dinh, Phu Yen, Khanh Hoa provinces, rainfall is about 400-600 mm. Exceptionally, at Hinh river (Phu Yen province): 600 -800 mm, at Quang Tri province: 150-250 mm.

These rainfall had a very large total amount of rainfall, widely affect and the rainfall intensity also was very high. The maximum daily rainfall can attain to 500-1000 mm at some places. Especially, the maximum rainfall in 24 hours duration at Hue station was 1384 mm (7 o'clock on 2nd-7 o'clock 3rd November 1999), at Son Giang station (Quang Ngai province): 1009 mm (13 o'clock on 3rd - 13 o'clock on 4th November 1999, etc…). The maximum values of rainfall in 24 hours duration is the biggest in Viet Nam and rarely recorded in the world (1870 mm at Cilaos, Renim Island, Pacific Ocean on 16th March 1952, and 1166 mm at Baguio, Luzon Island, Philippine on 5th July 1911).

2. Characteristics of flood

These rainfall mentioned above caused two special big floods rivers of Central Vietnam, historical flood occurred in some places. The general characteristic are complex flood (having -5 peaks), large amplitude, flood rising in a short time but falling very slowly. Water level on some rivers were over third alert level from 0.3 to 3 meters, approximately equal or higher than historical flood. The high water level was maintaining in several days in almost rivers.

The flood on early November had many peaks. The largest peak happened on 2nd in Quang Tri, Thua Thien Hue provinces, on 3rd in Quang Ngai, Da Nang province, on 5th and 6th in Quang Ngai, Binh Dinh provinces. The maximum water levels (H_{max}) in almost rivers were greater than the third alert level, even 1.5 to 2m in some places (Huong, Thu Bon, Tra Khuc River). The maximum water levels on rivers of Quang Tri, Thua Thien Hue provinces were higher than H_{max} in 1983 from 0,18 to 1.06 m. Especially, H_{max} at downstream of Huong river (Kim Long station) exceeded 0.46m compared to H_{max} of historical flood in 1953. On Thu Bon, Tra Khuc, Ve river, H_{max} greater than H_{max} in 1998, but lower than H_{max} of historical of flood in 1964. Flood amplitude greatly oscillated from 4-5m to 8-10m. Flood rose in a short time, it can be reached to 1 meter/hour at some places. However, due to rising tide, flood falls down very slowly; water levels which were greater than third alert level maintained 3 days at downstream of Thu Bon river, and 4 days at downstream of Huong river (Table1, Fig1).

The flood occurred at the beginning of December 1999, was also a complex flood, amplitude was large but flood rising intensity was in average range at Tra Khuc river. H_{max} appeared mainly on 4,5th ; but at some places appeared on 3rd . Floods on Tra Khuc, Ve and probably on Tra Bong river were greater than historical flood occurred in 1964. The maximum value of water level exceeded H_{max} of historical flood (in 1964) 0.35 meters in Tra Khuc river (at Tra Khuc hydrological station) and 0,24 meter in Ve river (at Ve hydrological station). Also, because of rising ride, flood falls down very slowly; water levels maintained above third alert level, even 3-4 days at some locations. Moreover, flash flood occurred at the middle and upper part of some river basins.

Table 1 ***Maximum water level of two special big floods occurred at the end of 1999 in some rivers of Central Vietnam***

Station	***River***	*Flood in November*		*Flood in December*	
		H_{max} (cm)	Duration	H_{max} (cm)	Duration
Le Thuy	Kien Giang	315	19h 3-11		
Quang Tri	Thach Han	**729**	**20h 2-11**		
Phu Oc	Bo	**518**	**15h 2-11**	409	2h 4-12
Hue	Huong	**594**	**14h 2-11**	373	23h 3-12
Ai Nghia	Vu Gia	1027	5h 3-11	943	11h 4-12
Cau Lau	Thu Bon	523	13h 3-11	454	15h 4-12
Hoi An	Thu Bon	320	12h 3-11	259	20h 4-12
Tra Khuc	Tra Khuc	777	3h 6-11	**836**	**8h 4-12**
Song Ve	Ve	541	24h 5-11	**599**	**16h 5-12**
An Hoa	An Lao	2388	13h 5-11	2508	10h 3-12
Thach Hoa	Con	836	8h 6-11	855	6h 4-12
Phu Lam	Da Rang	310	5h 6-11	383	15h 3-12

3. **Damage situation**

Two floods mentioned above caused serious damage for people and properties in Coastal Provinces of Central Vietnam, especially in Thua Thien-Hue, Quang Nam, Quang Ngai, Quang Tri, Binh Dinh provinces and Da Nang city. According to preliminary estimation, there were 700 killed and missing people, hundreds of injured. Flood swept away and collapsed 48967 houses, 5914 classrooms, and 50506 boats. There were 28779 hectares rice inundated, a lot of structures, bridges, culverts, roads destroyed. Total economic losses was estimated about 4.7 billion VND. On the other hand, floods caused damage for natural environment, cracked and crumbled mountains, eroded river banks and thousands hectares of cultivation land were filled up with alluvia. Especially, big flood in Huong river made some new estuaries such as river mouth Hoa Duan (width: 600m), strongly affect to ecological environment of Tam Giang lagoon and Cai Hai bay.

These two floods left below bad consequences which will impact for a long time to human's life as well as socio-economical development in provinces of Central Vietnam.

LESSONS FROM SEVERE TROPICAL STORM LINDA

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Formed in a relatively low latitude in the South China Sea at the beginning of November 1997, developed rapidly into a severe tropical storm whose life lasted for only 30 hours from the formation to the landfall, Linda was an unusual event in the historical data set in this region. Landed on Ca Mau province (in the southern Vietnam) on 2 November 1997, Linda was the most disastrous tropical storm in this century in Vietnam. Many years have passed since then, but what Linda brought to us as lessons in the forecasting as well as in the disaster prevention and preparedness activities is still worth to consider.

1. Overview of the tropical cyclones landfall in Vietnam

According to statistic data during the period from 1954 to 1989, 224 tropical cyclones (including tropical depressions) landed on Vietnam which indicated the average number of 6,22 T.C per year (See Table 1).

Table 1: The landfall of tropical cyclones in Vietnam (Period 1954 - 1989).

Year	Number	Year	Number	Year	Number	Year	Number
1954	4	1964	11	1974	8	1984	7
1955	4	1965	8	1975	6	1985	5
1956	6	1966	2	1976	0	1986	5
1957	2	1967	5	1977	3	1987	5
1958	4	1968	7	1978	12	1988	4
1959	4	1969	3	1979	6	1989	12
1960	10	1970	8	1980	9		
1961	7	1971	8	1981	6	Total	224
1962	7	1972	6	1982	5		
1963	6	1973	11	1983	8		

It clearly showed a minimum of zero in 1976 and only 2 T.C in 1957 and 1966. A maximum of 10 dropped in 1960; 11 in 1964 and 1973 and even 12 T.C in 1978 and 1989.

According to Table 2, it can be said that the tropical storm season really began from June to November where an approximately of 1 T.C occurred per month. Although the landfall of T.C was possible for the rest of months (except January), it rarely occurred : once for 30 years in February and March and for 17 to 25 years in April, May or December.

Table 2: Monthly distribution of tropical cyclones landfall
(Period 1954 - 1989)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total year
Total	0	1	1	2	3	24	21	40	48	52	30	2	224
Average	0	0.03	0.03	0.06	0.08	0.67	0.58	1.11	1.33	1.44	0.83	0.06	6.22

2. Some features of 1997's tropical storm season

Tropical storms affected to Vietnam in 1997 relatively late and ended rather earlier than normal. Although the number of T.C affecting to our country was small, but the damages brought by them were very serious.

In overview, there were 28 tropical storms and 1 tropical depression having their activities in the Northwest Pacific in 1997 which was approximately the average number. But in the South China Sea, there were only 5 T.S and 1 T.D which were less than the average number. Unlike other years, all T.C in 1997 were originated in the South China Sea (normally only 50% of the total T.C having their activities in the South China Sea were formed in this region) and there was no typhoon (T.S with maximum sustained wind ≥ 64 Kts) in this year (normally typhoons accounts for 40% of the total T.S number).

3. Severe tropical storm Linda and its forecasting

Being the tropical storm No. 26 in the Northwest Pacific in 1997, Linda developed into a T.C from a tropical depression in the southern part of the South China Sea, just about 50 km south of Truong Sa station (48820) at noon of 1 November 1997. It initially took a westnorthwesterly track at about 27 km/h and intensified gradually. Then it turned slightly to the westsouthwest and reached intensity of minimum pressure of 985 mb and maximum sustained wind of 50 knots (force 10 on the Beaufort scale) on the morning of the next day just about 100 km of Con Dao (48819). Moving westwards, by the noon of the same day, Linda passed very close to this station where maximum sustained winds of 30 m/s (force 11), gust 42 m/s (force 14) and minimum pressure of 989,1 mb were recorded. Six hours later, it made landfall on Ca Mau province (the southern extreme of Vietnam) then continued its way in the Gulf of Thailand.

With the high resolution satellite images received hourly from GMS-5 (Japan) and the warnings received from other foreign forecasting centers, together with synoptic maps and a skillful forecaster team, Linda was watched from very early in her formation stage. Warnings were issued timely 4 times/day by the National Center for Hydrometeorological Forecasting as required by a Decree of the Government.

4. Damages caused by severe tropical storm Linda: See Table 3

Table 3: Damages caused by Linda on Southern provinces
(Up to 15 January 1998 by CCFSC)

Category of damage	Item	Unit	Total
People	**Killed** **Injured** **Missing** **Affected**	**Person**	**778** **1232** **2123** **495,495**
Housing	**Destroyed** **Submerged and damaged**	**House**	**107892** **204564**
School	**Destroyed** **Damaged**	**Room**	**1424** **5727**
Clinic	**Destroyed** **Damaged**	**Room**	**76** **308**
Agriculture	**Rice fields inundated** **Rice fields washed away** **Farmland inundated**	**ha** **ha** **ha**	**323,050** **21,742** **57,751**
Transportation	**Bridges destroyed** **Bridges damaged**	**unit** **unit**	**302** **1846**
Fishery	**Shrimp and fish pond broken** **Fishing ships sunk** **Fishing ships damaged**	**ha** **unit** **unit**	**136,334** **2897** **1856**
Total damage		**million VN dong**	**7179,615**

5. Causes of damages

- Linda was a strong tropical storm rarely found landed in this region in this century.
- It landed in the late afternoon when the tide was strongest (from 3.5 to 4.5 m).
- It landed on a place where the people have little experiences in the disaster prevention and preparedness activities.
- Lack of effective means to communicate to the fishermen in the open sea of the danger of approaching tropical storm.
- Fishermen had no experiences on finding shelters and in anchoring their boats.
- Limited means and experiences in relief and rescue activities.

6. Lessons from Linda

The WMO has recommended all nations that the tropical storm's accurate forecasts would become meaningless if necessary steps for prevention were not taken, and Linda was an example. In the case of Vietnam where the infrastructure is not good enough, the education for the people to have knowledge for their own protection is very importance. It includes the knowledge about natural phenomena, about how to find shelters in case of tropical cyclones especially when found in the open sea, how to help other people in such case ... Providing fishermen with communication means like radio or by other means to help fishermen to receive weather forecasts is also necessary.

Aware of the importance of the disaster prevention and preparedness activities, the Government of Vietnam has carried out a series of activities aimed to the reduction of damages and minimize human life loss such as promoting every form of education on the mass media to raise awareness of the public on natural disaster and measures for reducing damages, establishment of funds for flood and storm control in provinces and cities in Vietnam.

MANAGING RISKS ASSOCIATED WITH ENSO: PRIORITIES FOR THE REGION

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In Asia, natural and human-induced disasters have had a devastating effect on the region's people, environment, and national economies. Global disaster statistics for 1998 are staggering yet, on an average, 60% of all disaster-related economic losses, deaths, injuries and displacement are absorbed by Asia. In Southeast Asia, emerging disaster-related issues are increasingly linked to growing environmental degradation, population growth, poverty and unplanned rapid industrialization. These are compounded by the impact of Asia's economic slowdown and shrinking public budgets resulting to competing investment priorities for these countries.

The dominant disaster management capacities in Southeast Asia have been focused on post-disaster activities particularly emergency response. This can be traced to the association of disasters with sudden, violent and uncontrollable and natural phenomena such as earthquakes, typhoons, and volcanic eruptions. In addition, the front-runners of disaster management (such as the Red Cross and Civil Defense Authorities) emerged largely in response to war and civil conflicts. As a result, disaster management was generally regarded as the responsibility of neutral and/or mandated authorities.

Since then, there has been a significant improvement in the emergency response systems in Southeast Asian countries such as the Philippines; this has resulted in decreasing death and injuries. However, despite such progress, disaster-related economic losses are increasing dramatically while the efficiency of social services continues to decline.

In Southeast Asia, disaster occurrences often uncover and highlight unsustainable relationships between affected communities and their surrounding environment. This dynamic extends far beyond the duration of a specific emergency, affecting the ability of communities to resist and recover from natural and other human-induced disasters.

In this context, research conducted in South America since the 1970s has closely associated the causes of disasters with unsustainable development patterns. Flawed development increases the risk faced by large sectors of the population. The fact that past emergency management practices have not adequately addressed this relationship underlines the need for a new vision of disaster management. This is called disaster risk management.

This strategy focuses on the emergency itself and on actions carried before and after the emergency including emergency preparedness and recovery. Its objectives are to reduce the losses, damage and disruption when disasters occur and to facilitate a quick recovery. This approach assumes that disasters are recurring and inevitable. The concept of emergency management is often repeated in international and national training activities and this constitutes the prevailing thoughts and actions among professionals involved in disaster or humanitarian assistance.

It focuses on the underlying conditions of risk generated by unsustainable development which lead to disaster occurrence. Its objective is to increase capacity to identify, manage and reduce risk and hence the occurrence and magnitude of disasters. It recognizes that people have coping capabilities and expertise and aided with other stakeholders, they are in the best position to anticipate hazards impact and manage risks.

The regional situation with regard to an El Niño event, its associated fire and smoke haze disaster in Indonesia, and the host of emergency response and planning activities this generated in Southeast Asia underlines several significant issues.

First, there is an urgent need to strengthen capabilities at national and regional levels for effective emergency preparedness, prevention, mitigation, response and recovery.

Second, regional cooperation is increasingly viewed by national governments as a key modality for mobilizing assistance in weak areas and for sharing material and technical resources more efficiently. This conclusion was reached by the ASEAN Regional Forum in Wellington, New Zealand, in January 1997, and was further reiterated in Bangkok, Thailand, in February 1998. The regional importance of disaster management is further reflected by its placement on the priority agenda of APEC, as well as ASEAN.

Third, in spite of the great advances made by the International decade for Natural Disaster Reduction, there is a great need for accelerated human resource development, and technical assistance for planning at the national, local and community levels. There is growing demand for general and specialized training in natural and human-induced disaster management. This is accompanied by increasing national investment in a sector previously dominated by the international humanitarian assistance community.

Professional and technical resources for training and technical assistance, on the other hand, remain either scarce or largely uncoordinated. There are pressing needs for a mechanism to advocate, plan for, and engage countries in their own action plans, and for an institutionalized programme which mobilizes the region’s existing professional capabilities.

Finally, the need has been identified for a regional focal point to assist in the facilitation of regional coordination between various regional (and international) organizations and institutions, The primary role for such a facilitator would be in the areas of research and information dissemination among key stakeholders. Regional trends also include increased global and regional competition for a share of available opportunities in the disaster management sector. There are positive trends towards regional and subregional cooperation, as well as new possibilities for strategic alliances and partnerships. These developments, combined with improved access to new markets through information technology, are generating a range of new risk reduction projects, products, and innovative arrangements.

Major technological advances are now opening new frontiers in the area of information applications to training and education. This includes a wide range of new distance learning tools, such as video and teleconferencing and virtual classrooms. The demand for distance education at the tertiary level for disaster management professionals is increasing and is a cost-effective training strategy for the public sectors of countries from Southeast Asia.

Overall, there is recognition among countries in the region that greater effort is needed to improve the coordination and sharing of human, technical and material resources of better risk management of impacts of El Niño and La Niña. Further, it is increasingly recognized that it is unaffordable to duplicate scientific and technical research. In the same way, there are pressing needs for closer cooperation in areas of common interest such as early warning systems, and in exchanging valuable knowledge and information between countries. Disasters are truly cross border issues, and their management is a matter of concern for all countries situated in vulnerable areas and beyond.