Workshop Report:

ENSO and Extreme Events in Southeast Asia

23–26 October 1995
Ho Chi Minh City, Vietnam

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Photo on front: Rice irrigation north of Haiphong, Vietnam (Photo by M.H. Glantz, 1991)

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The Environmental and Societal Impacts Group (ESIG), with the support of the United Nations Environment Programme (UNEP), convened a workshop on the use of El Niño information in climate-related disaster mitigation in Southeast Asia. The workshop was held in the conference facility of the Rex Hotel in Ho Chi Minh City, Vietnam [henceforth HCMC] from 23-26 October 1995. It was the third of four workshops on “usable science.”

The overriding objective of the meeting was to bring the potential usefulness of El Niño information to the attention of people involved in the management of education and training courses for mid-level decisionmakers concerned with environmental issues. We believed that if one could convince those who direct education and training programs of the value to society and to policymakers of El Niño information (including, but not limited to, El Niño forecasts), then their institutes would seriously consider making El Niño research and impacts a part of their training activities. In addition to improving the transfer of knowledge from the scientific community to users in political settings and to the public, a second objective was to call attention to the need for input from the user community to those involved in El Niño-related research. Thus, the meeting focused on the two-way relationship of science and society that is implicit in the notion of “usable science”.

Participants were drawn from several countries, several academic disciplines including both physical and social sciences, and from different organizations, representing various perspectives and levels of awareness of the El Niño phenomenon and its impacts on ecosystems and on society. Countries represented included Australia, China, Cuba (host of the subsequent usable science meeting for the Greater Caribbean Region and Central America), Japan, Laos, New Zealand, the Philippines, Thailand, the United States, and Vietnam.

Participants were selected based on their potential contribution to the discussions at the workshop as identified in the agenda. Each participant was asked to prepare a brief discussion paper describing the activities of their institute and its potential interest in El Niño and his/her research interest in the El Niño phenomenon. Because participants were drawn from different areas of activity, most participants had not met other participants before this workshop. An informal reception was held at the Rex Hotel on Sunday evening preceding the workshop so that participants could gain some idea of the expertise and interests of others attending the meeting.
Some scientists use El Niño and ENSO interchangeably. Others use the phrase "warm event" to describe a warming of the surface waters in the central and eastern equatorial Pacific, and "cold event" to denote the opposite phase of the Southern Oscillation. The glossary which follows is provided to help the reader sort out these concepts. In this report, we have chosen to use El Niño and ENSO in reference to the larger basin-wide phenomenon.

El Niño is a term originally used to describe the appearance of warm (surface) water from time to time in the eastern equatorial Pacific region along the coasts of Peru and Ecuador. It was once suggested that minor El Niño events occurred about every two to three years and major ones about every eight to 11 years. Today, scientists note that El Niño has a return period of four to five years. When an El Niño event occurs, it often lasts from 12 to 18 months.

La Niña refers to the appearance of colder-than-average sea surface temperatures (SSTs) in the central or eastern equatorial Pacific region (the opposite to conditions during El Niño). Many scientists do not like the use of the term and prefer to call it a cold event (described below).

A warm event refers to the anomalous warming of SSTs in the central and eastern equatorial Pacific. This term is being used to avoid confusion over the use of other terms like ENSO and El Niño. A warming in the regions mentioned is accompanied by a relative cooling in the western equatorial Pacific.

A cold event is one where the SSTs become anomalously colder compared to the long-term average for the central and eastern equatorial region. (It is the opposite of a warm event in that region.) It has been referred to in the past as anti-El Niño and, more recently, as La Niña. La Niña, however, unlike the restrictive view of El Niño, is applied to Pacific basinwide phenomena.

The Southern Oscillation is a see-saw of atmospheric mass (pressure) between the Pacific and Indo-Australian areas. For example, when the pressure is low in the South Pacific high pressure cell and high over Indonesia and Australia, the Pacific trade winds weaken, upwelling of cool water on the Pacific equator and along the Peruvian coast weakens or stops, and SSTs increase in these areas where the upwelling weakens.

The Southern Oscillation Index (SOI) has been developed to monitor the Southern Oscillation using the difference between sea level pressures at Darwin, Australia, and Tahiti, although other stations have sometimes been used. Large negative values of the SOI indicate a warm event, and large positive values indicate a cold event (also referred to as La Niña). It is important to note that there is not a one-to-one correspondence between the occurrence of Southern Oscillation events and El Niño events, using the spatially restrictive original definition of El Niño.
ENSO is the term currently used by scientists to describe the full range of the Southern Oscillation that includes both SST increases (a warming) as well as SST decreases (a cooling) when compared to a long-term average. It has sometimes been used by scientists to relate only to the broader view of El Niño or the warm events, the warming of SSTs in the central and eastern equatorial Pacific. The acronym, ENSO, is composed of El Niño-Southern Oscillation, where El Niño is the oceanic component and the Southern Oscillation is the atmospheric component of the phenomenon. The broader definition of El Niño has sometimes been used interchangeably with ENSO, because ENSO is less well known in the popular electronic and printed media.

Teleconnections can be defined as atmospheric interactions between widely separated regions. They have been identified through statistical correlations (in space and time). Some of these correlations have been used to generate hypotheses about geophysical processes related to teleconnections. Most countries in the world are, or should be, interested in this aspect of the Southern Oscillation.

Monday, 23 October

Formal opening of the Workshop

Michael Glantz (NCAR/ESIG), workshop organizer, opened the meeting and introduced the workshop host, HCMC University Rector, Dr. Nguyen Ngoc Giao who welcomed the participants to Vietnam. He invited the participants to visit the university, one of the largest in Vietnam. His remarks were then followed by remarks from Peter E.O. Usher, chief of UNEP's Atmospheric Unit, headquartered in Nairobi, Kenya. Usher welcomed the participants to this, the third, Usable Science workshop focused on the use of El Niño information in decisionmaking. The other usable science workshops are: (1) *El Niño-Southern Oscillation, Food Security and Famine Early Warning Systems* [sponsored by the US Agency for International Development and UNEP, Budapest, Hungary; November 1992], (2) *North American Applications: The Uses and Misuses of El Niño Information* [sponsored by NOAA/OGP; Boulder, Colorado; November 1994], and (4) *ENSO and Extreme Events in the Greater Caribbean Region*. Reports of these workshops are available through ESIG.

UNEP was the first international organization to take interest in and foster discussion on the social and economic aspects of the El Niño phenomenon. The first UNEP-supported effort on El Niño was organized in 1985 by ESIG in Lugano, Switzerland where a working group on the social-economic aspects of El Niño was formed. This was done in the same year that the World Climate Research Program launched its 10-year long Tropical Ocean-Global Atmosphere (TOGA) program. UNEP's El Niño Working Group has since been associated with the production of several reports and workshops focused on the societal aspects of El Niño (e.g., Teleconnections, Fisheries, Climate Change). He noted that today there is a growing interest in El Niño and its impacts on food production, water resources and energy, among other concerns e.g., (fisheries, health, extreme events), although it has not yet received
prominent attention in the Intergovernmental Panel on Climate Change (IPCC) assessments of climate change.

Usher informed the participants of the current status of the IPCC assessment process and of the changes underway in UNEP which could provide different funding opportunities than had been available in past years to those interested in climate-related issues.

**Purpose of the Workshop**

Glantz then addressed the participants about the goals of the workshop and the way in which the discussions would be carried out. Some of the participants were asked to lead the discussion of a session specifically relevant to his/her interest and expertise. He/she was asked to make a brief presentation in order to stimulate discussion, much of which was transcribed at that time by D. Jan Stewart (ESIG).

Glantz noted that the challenge to those in the workshop familiar with and involved in El Niño research and application activities was to attempt to convince those less familiar with El Niño and its potential impacts on environment and society that by including such information in their education and training activities they could enhance the effectiveness of their disaster-related decisionmaking processes. In other words, we had hoped to convince participants that, if properly structured and communicated, scientific research output related to El Niño is usable by decisionmakers at all levels of social and political organization. The role of those less familiar with El Niño was in part to provide specific guidance as to the needs for such El Niño-related information in Southeast Asia and to inform the representatives of the scientific community how such information could be made usable by making them aware of their specific decisionmaking needs.

**Utility of the notion of Usable Science**

Discussion on the issue of “usable science” was opened by Glantz who noted that in the United States and elsewhere the funding of scientific research was undergoing a level of scrutiny that perhaps had not been seen since the beginning of the Cold War in the late 1940s. This level of scrutiny was fostered by several factors including, but not necessarily limited to, the demise of Soviet communism and the abrupt end to the Cold War and to the budgetary difficulties faced by many nations around the globe, especially the industrialized ones.

The US Congress, for example, has challenged the US scientific establishment by reducing its federal budget share and by questioning the efficacy of some of the research activities that had been supported in past years by government funds. The Congress has traditionally divided research into basic, applied and what one congresswoman termed “curiosity-driven” research, without providing specific definitions of these categories. However, in recent years
the Congress has asked for evidence of the value of the science that it supports. The implication was that the scientific community should be producing information that is of clearly identifiable use by American society, and it should be doing so in the near term. Such an emphasis put pressure on those doing basic research and on those whose research may have perceived, rightly or wrongly, by some in Congress to have been curiosity-driven (by implication, most likely interesting but useless, at least in the short term). Some in Congress apparently want to see results in the near term of their support for science; perhaps they want to see those results while they are still holding political office?

Glantz posed three basic questions directly related to the issue of usability of scientific research: (1) usable by whom? (2) usable by when? (3) who decides what is usable?

(1) Usable by whom?

With regard to the first question, it is important to remember that people have different interests. What is usable to one may not be considered usable by another. Scientific information is often surrounded by uncertainty: some might believe that scientific uncertainty renders it useless, while others might find it useful even though uncertain. Scientific information, whether basic, applied or "curiosity-driven" will likely find users somewhere in society who will find ways to benefit from its application. There are many more potential users of scientific research output than actual ones. A goal, then, must be to expand the size of the community of the latter by convincing potential users of the value of El Niño-related scientific information to those activities in which they have interests. Thus, "usable by whom" is a question that should be raised early on in any discussion of what scientific information should be considered societally useful.

(2) Usable by when?

"Usable by when" raises another sore point. As noted earlier, elected officials often want to see rewards of their political support for scientific research, preferably during their tenure in office (2 years, 4 years and 6 years at the federal level in the case of the US). Some basic research may have a relatively long lead time for achieving societal utility (e.g., application) of its findings. So, in recent debates there has been a call for shifting funding from basic to applied research activities. However, basic research is a mainstay of scientific and engineering activities. This suggests that the "by when" criterion should not be a determining factor in whether to provide support for all of scientific research. Once such information is produced, however, there are people in society who will seek ways to take advantage of its use.

Science is a seasoning process; often during research on a particular issue, other topics for research are uncovered that were seemingly unrelated. Research takes time and policymakers must come to realize that not all research supported from their treasuries will yield -- on
demand -- answers to their questions. For their part, however, scientists must realize that policymakers often tend to think of science in terms of projects and programs with a beginning and an identifiable end. Project proposals are, therefore, more appealing to them. Innovative ways are needed to make the two-way connection between scientific research and societal needs, if policies for research are to be true to the nature of research and engender realistic expectations about what science can and cannot do.

(3) Who decides?

A third question centers on who decides what scientific research output should be considered as usable science? Should political organizations -- like a legislature -- be the ones to determine if scientific research is usable? If left to such a political organism, scientific research activities might begin to vary sharply from one set of leadership or election to the next, as different political parties and different political philosophies increase or reduce their funding of science programs according to their "interests of the day." Ultimately, it is society that decides if scientific research output is usable.

Often, to make science usable will require the assistance of those who can translate scientific research into information that is meaningful to decisionmakers. In sum, usable science refers to a process, both in scientific research and in the application of that research. While many researchable questions remain unanswered, it is clear that both science and society can benefit from a closer connection between research and societal needs.

A workshop participant proposed that a fourth question about usability should be raised --- "Where will the information be used?". While politicians evaluate the worthiness of research, they may have a narrow view of where that research could or should be used. For example, is it to be considered usable only at the policymaking level? Scientific information supports various decisionmaking activities (e.g., applications) and not just policymaking. In this regards it is important to identify users of research outside government bodies and even across national boundaries. Where such research output is to be used also draws attention to another key issue: much research support comes from the industrialized countries. Yet, there are important, unresolved scientific issues in the Third World. Support for research on those issues would require support from the more affluent states, even if those programs are not of direct interest to their decisionmakers.

It was also noted that many governments say that the science coming from the IPCC reports is all (or more than) the science that they need for their decisions related to climate change. However, the IPCC science reports are assessments of existing scientific activities undertaken within nations and regions and sectors within nations. Clearly, future IPCC reports would be of little value and probably of poorer quality, if national research efforts were to be curtailed.

A distinction was drawn between the small community of policymakers and the much larger community of public and private decisionmakers within a given society. It was suggested
that either policymakers must be directly convinced of the utility of research or
decisionmakers throughout society must be convinced of its value and they, in turn, convince
c Policymakers. The point is that somehow an explicit connection must be made between the
results of research and the needs of decisionmakers.

It was noted that an improved two-way understanding between policymakers and scientists
was needed so that each becomes sensitized to the needs and limitations of the other. This
would help to avoid the development of unrealistic expectations about what each community
might be able to deliver to the other.

The development of trust in the generation, production, and dissemination of scientific
information is an important and necessary goal. For example, the ozone hole discovery
convinced many policymakers that ozone depletion was a real problem. It was a spectacular
discovery. A similar climate-change-related surprise may not be in the offing for the global
warming issue. Policymakers or, more broadly, decisionmakers tend to accept information
from people that they trust. Thus, there is a need for a neutral translator of scientific research
output. As suggested by Neville Nicholls, translators could help to convert potentially usable
scientific information into information that is actually used in decisionmaking processes.

Concern was raised about how to institutionalize that trust. Each election or change of
government brings a new set of policymakers who have to be educated about how science
works and what the best interactions between scientists and the policymakers that fund them
might be. New Zealand’s situation was put forth as an example of an attempt to separate
politics from scientific research and an attempt to make much of the scientific research
undertaken in New Zealand pay for itself, if not turn a profit. In this case, some areas of
research succeeded, but many lost support because they could not show immediate benefits.

A general discussion focused on identifying the climate-related hazards in Southeast Asia.
The list included the following: typhoons, tsunamis, drought, floods, heat waves, mudslides,
landslides, erosion, frosts, freezes, pestilence and epidemics, saltwater intrusions, salinization,
fires, forest fires, snow, visibility reduction, air quality episodes, dust storms, cyclones,
tornadic activity, and algae blooms. Earthquakes and volcanic eruptions were mentioned, but
it was observed that El Niño-tectonic links were at this point tenuous at best. No mention
was made of El Niño as a cause of regional hazards, even though there already exist some
studies linking these hazards to El Niño events: frosts in New Guinea, fires in Kalimantan,
and drought and bushfires in Australia. Droughts, floods, cyclones, and fires were identified
as high-priority concerns.

What is El Niño (atmospheric and oceanic components)?

Neville Nicholls gave a presentation focusing on the atmospheric aspects of the El Niño-
Southern Oscillation (ENSO) and Mark Cane made a presentation on the oceanic aspects of
the phenomenon. These presentations were designed to assure that all participants had a basic working knowledge of the El Niño process.

Nicholls presented a brief overview of the history of interest in the Southern Oscillation, defined by the sea level pressure differences between two locations across the Pacific basin. Today, those locations are Tahiti and Darwin, Australia. An index, the Southern Oscillation Index or SOI, is based on changes in these pressures (Tahiti minus Darwin). It is used to help in the forecasting of El Niño events. It is taken very seriously, especially in Australia, where it is used in various economic sectors to forecast, for example, rangeland conditions, crop yields, precipitation patterns, potential health effects, and so forth.

**El Niño** \(\text{el niño} \text{ noun [spanish]}\): The Christ Child 2: the name given by Peruvian sailors to a seasonal, warm southward-moving current along the Peruvian coast \(<\text{la corriente del niño}>\): name given to the occasional return of unusually warm water in the normally cold water [upwelling] region along the Peruvian coast, disrupting local fish and bird populations 4: name given to a Pacific basin-wide increase in both sea surface temperatures in the central and/or eastern equatorial Pacific Ocean and in sea level atmospheric pressure in the western Pacific (Southern Oscillation) 5: used interchangeably with ENSO (El Niño-Southern Oscillation) which describes the basin-wide changes in air-sea interaction in the equatorial Pacific region 6: ENSO warm event *synonym* warm event *antonym* SEE La Niña \(\text{La Niña} \text{ noun [spanish]}\): the young girl; cold event; ENSO cold event; *non-El Niño* year; anti-El Niño or anti-ENSO (pejorative); El Viejo \(\text{el vya hoh} \text{ noun [spanish]}\): the old man

M. H. Glantz

![Graph](image)

Monthly means of the Southern Oscillation Index, taken from 1970-90 data. El Niño and La Niña years are identified with horizontal bars. (Nicholls, 1993.)
Interest in the Southern Oscillation began at least as early as the 1870s, as a result of concern about the consequences of a major famine on the Indian subcontinent. Millions of people perished as a result of drought-related food shortages, and British government representatives in India sought to improve their understanding of the physical mechanisms involved in order to avoid the recurrence of such severe famine-like conditions. It was suggested at the time that droughts in Australia seemed to be linked in occurrence to droughts in India, and the search began. In the early decades of the twentieth century, Sir Gilbert Walker, using statistical measures, investigated possible correlations between precipitation and rainfall in different parts of the globe to identify possible precursors that "foreshadowed" droughts. He is credited with having named the Southern Oscillation, popularly described as a seesaw-like oscillation of pressure across the equatorial Pacific basin.

Much of Walker's work was challenged by his colleagues and was followed up only by a few researchers until the middle of the 20th century, as noted in Walker's obituary in the late 1950s. However, Nicholls underscored the fact that much of what we do today with regard to the Southern Oscillation (research and application) and with regard to teleconnections (apparent statistical or physical linkages between remote climate anomalies around the globe) is to refine the work that Walker had started since the turn of this century. Nicholls noted that there is considerable skill in using such El Niño-related information to identify teleconnections for many parts of the tropical world, especially in the equatorial Pacific, because of the proximity of the tropics to the ocean basin in which El Niño events occur.

In the mid-1960s meteorologist Jacob Bjerknes linked changes in sea surface temperatures in the eastern equatorial Pacific (along the Peruvian and Ecuadorian coasts) to the Southern Oscillation, providing a physical explanation for that linkage. In other words it was the interactions between the atmosphere and the ocean, and neither of these media acting alone, that produced the phenomenon known as El Niño. Researchers came up with various plausible hypotheses about how the El Niño-Southern Oscillation and its teleconnection mechanisms worked.

Cane then described the interactions between the ocean and the atmosphere in the equatorial Pacific, discussing the role of wind intensity and direction, the shift in the location of the warmpool (the large area of warm water in the western equatorial Pacific with which heavy convective activity is associated, a change in sea level (declining in the west and rising in the east during El Niño). He underscored the fact that the ENSO phenomenon is a cycle that oscillates from warm events (often called El Niño) to cold events (sometimes referred to as La Niña) and that there is predictive value in information about the entire cycle. An El Niño warm event is a recurrent phenomenon with an average return period of 4-5 years.

The 1982-83 El Niño event took much (but not all) of the scientific community by surprise. It was labeled as the biggest event in a hundred years and served to catalyze political interest in an improved understanding of the causes of the phenomenon. A consequence was the undertaking of a decade-long research and field program in 1985 to focus on the interactions between the tropical ocean and the global atmosphere (TOGA).
In the mid-1980s Cane and Zebiak produced a model that successfully forecast the onset of the 1986-87 El Niño event. Referring back to his 1986 forecast, Cane noted that there was considerable opposition from his fellow scientists to the issuing of such a public forecast, given the state of scientific knowledge at the time and the high level of uncertainty surrounding the El Niño phenomenon. Cane and Zebiak felt strongly that their model, based on wind-related sea surface temperature changes in a region of the equatorial Pacific known as Niño3 (see map below), provided a reliable basis on which to make their forecast to the public. A few years later several research groups began to issue their own projections about the possibility of the onset of El Niño.

The early 1990s witnessed the unusual behavior of the El Niño that began in 1991 and continued into January 1995. Some have argued that it was one long El Niño event ending in early 1995, while others have argued that it was a series of three shorter events. The forecasting of these events proved to be of mixed success, with no one having forecast the total year-to-year sequence of sea level pressure and sea surface temperature changes in the equatorial Pacific between 1991 and 1995.

Map depicting four regions (referred to as Niño1, Niño2, etc.) in the equatorial Pacific Ocean identified as important locations for monitoring the wind and sea surface temperature changes associated with the El Niño process.

Cane then presented the results of a study he had undertaken with Roger Buckland (an economist with the Southern African Development Community (SADC) in Harare, Zimbabwe) on the correlations between maize yields in Zimbabwe (southern Africa) and El Niño events. They argued that there was a strong correlation between the two suggesting that El Niño forecast information many months in advance of the onset of an event could be used in decision-making about regional agricultural production activities.
In the discussion following these presentations:

- Mention was made about the speculation of possible linkages between volcanic eruptions and their effects on the impacts or causes of El Niño events. While eruptions have had a notable effect on global average temperatures, it is not at all certain what, if any, their effects might have been on the El Niño phenomenon itself. As important, how might the impacts of volcanic activity compound the impacts on ecosystems and society of an El Niño event?

- It was pointed out that in the Zimbabwe situation noted earlier a forecast of an El Niño had been available as early as March 1991 but that awareness of the event or its possible linkages to climate anomalies in southern Africa was at a low level. The severe food shortages that occurred at the end of that year and the beginning of 1992 might have been mitigated had El Niño’s linkages to the region been better understood at the time. Today, southern African decisionmakers and especially those concerned with food security issues are much more cognizant of El Niño and its possible implications in food productions activities in the region.

- It was noted that there was relatively good success in Australia with regard to forecasts based on changes in the SOI. Long-term and reliable data bases exist for undertaking research on El Niño in Australia, India and Indonesia. Elsewhere in the region, however, data is not of as long a term, but is still potentially useful by researchers. It was also suggested that the SOI and sea surface temperatures in the Niño3 region were very useful sources of information for initial predictions of possible impacts to society.

- Possible strong linkages were suggested to exist (given preliminary information) between Mekong River flow and the occurrence of El Niño events. Apparently, to date little work has been done on this linkage and it was proposed as a fruitful area for research and forecast application.

- The Queensland (Australia)-developed computer program “Australian Rainman” was mentioned as a possible model that could be developed for other regions in Southeast Asia. The computer program allows a decisionmaker (e.g., a farmer, a grazier, a government agency, a business) to “examine the historical rainfall records, forecast the chances for seasonal rainfall and to identify climatic risks and opportunities”.

- Questions were raised about the possible reasons behind the unusual behavior of El Niño in the first half of the 1990s. It was suggested that the background climate of the region had slowly changed since the early 1970s (slightly warmer sea surface temperatures). It was noted that the 30-year period from the 1970s to the present and the period of the first half of the 1990s were unusual when compare to the past 100 years of record.
What are teleconnections and what do they do globally?

Discussion then focused on the impact of El Niño on regional climate-related anomalies around the globe. These are referred to as teleconnections and can be identified by statistical measures, by geophysical mechanisms and by “wishful thinking” or perceived (anecdotal) correlations. As noted earlier, Sir Gilbert Walker was instrumental in identifying linkages between climate anomalies and changes in sea level pressure in the tropical Pacific and Indian oceans.

Today, scientists have documented the existence of El Niño teleconnections with drought in northeast Brazil (among other locations), and with floods in southern Brazil and coastal Peru and Ecuador. It was noted that in Australia, by monitoring the Southern Oscillation Index and sea surface temperatures from early July on, one can get a good idea about whether there might occur an El Niño or La Niña and what the rainfall conditions might be for the following six months. In the Australian case, it is clear that El Niño-Southern Oscillation can have significant impacts on human and ecological communities and on biological productivity.

Interest in El Niño’s teleconnections has generated much worldwide interest in the El Niño phenomenon. In the middle of the last century interest in El Niño centered on its impacts on sea birds and, therefore, on guano production (sea bird excrement) as guano was a highly valued fertilizer for domestic use and for export. In the 1960s concern shifted to the potentially devastating impacts of El Niño on Peru’s anchovy population, the source of a highly valued export commodity — fishmeal. It was only within the last fifteen years or so that global interest in El Niño shifted away from happenings along the coast of western South America toward its effects on global climate, especially in the tropics.

There are increasing numbers of case studies of the linkages between El Niño and teleconnected impacts. For example, correlations have been documented between El Niño and fires in the southern US, disease outbreaks in Latin and North America, grain production in Canada’s prairie provinces, electric power consumption and production in the Pacific Northwest and northeastern North America and reduced tropical storm frequency in the Atlantic. El Niño information can also be used by those who deal with the production and marketing of food and other commodities. As more information and understanding of El Niño are gained, more sectors of society will likely rely on information provided by El Niño teleconnections to prepare for, mitigate or adapt to El Niño-related impacts.

It was noted by some participants that the interest in and awareness of El Niño and its teleconnections is growing and that such information is becoming increasingly available to the public through the popular media. Experts have noted that they are receiving far fewer calls from decisionmakers in industry requesting basic information about El Niño than had been the case in the recent past.
It was also noted that ENSO information has been available for a long time in Peru and in Australia. But the mere availability of information does not mean that it is being used. Even though there have been more than 100 years of scientific papers and articles about how El Niño affects Peruvian ecosystems and society (with anecdotal and proxy information going back several centuries), it was only after the 1982-83 event that Peruvian political leaders and other high-level decisionmakers in that country began to take El Niño events more seriously in planning various aspects of their economic activities (agricultural as well as marine).

The following map, compiled in 1992 by Chester Ropelewski (Climate Prediction Center of the US National Weather Service), suggests some of the stronger and more reliable correlations in temperature and precipitation. Of course, the association of climate anomalies linked to El Niño events is not a perfect one; not every El Niño produces the same impacts in the same location or with the same level of severity. Nevertheless, armed with a reliable El Niño forecast and statistical (probabalistic) information about teleconnections, decisionmakers can use such input to hedge their decisionmaking in attempts to lower certain risks associated with their decisions.

![Map of typical rainfall and temperature patterns associated with El Niño-Southern Oscillation conditions for the Northern Hemisphere winter season.](image)

**Tuesday, 24 October**

*What do teleconnections do regionally? How reliable are they?*

One can look at teleconnections from the perspective of a "believer" or from the perspective of a "doubter". How one views alleged El Niño teleconnections often has to do with a personal view of the level of reliability of the proposed teleconnection. Few such linkages with an ENSO event occur on a one-to-one basis; every El Niño event will not be
accompanied, for example, by a severe drought in the same location in Indonesia. Nevertheless, there is useful information in teleconnections which decisionmakers can incorporate in their decisionmaking processes (e.g., early warning of possible regional climate-related anomalies). Cane suggested that one should focus on the Northern Hemisphere summer that precedes the peak of an El Niño. For example, El Niño peaked at the end of 1991, and one could count the droughts that occurred in Southeast Asia then (in the Southern Hemisphere summer) as having been linked to the occurrence of El Niño, in other words, in Southeast Asia it is the rains in the summer before ENSO peaks that we should expect to be affected. For the Southern Hemisphere summer one can figure out what is going on with regard to the ENSO cycle by monitoring observations of sea surface temperature changes in the central and eastern equatorial Pacific. Australians are focused more heavily on changes in the Southern Oscillation Index in order to provide seasonal rainfall forecasts for different parts of their country.

Teleconnection maps have been constructed by physical scientists (e.g., Rasmusson, Ropelewski and Halpert, Kiladis and Diaz) and by social scientists (e.g., ESIG/NCAR’s climate impacts maps). The former are based on physical mechanisms within and between the ocean and atmosphere, on observations and on statistical assessments, while the latter are based on the observed societal impacts of climate anomalies around the globe as reported in the printed media (see maps in Appendix I).

El Niño’s regional teleconnections include, but are not limited to, droughts in northern and eastern Australia, Indonesia, the Philippines, and Thailand. El Niño has also been associated with frost in the New Guinea Highlands, an increased risk of brushfires in various parts of Indonesia and Australia, an equatorward shift in the cyclone track, and changes in the possibility for landfall of typhoons in Indochina.

Discussion focused on the apparent strong connections between streamflow in the Mekong River basin and ENSO events. It was suggested that research was lacking on assessing the reliability or strength of this connection. Apparently, almost no research had been done on this particular teleconnection.

Wang Shao-wu noted that he had divided the region into three parts, based on the changes in strength of teleconnections within the region. The first group has a high correlation between local climate and ENSO events (he placed Australia and Indonesia, among other places, in this cluster). The second and third clusters of locales exhibit increasingly lower correlations. He found all three sets of correlations to have a high level of statistical significance.

Wang commented on the issue of time series: he suggested that one needs 500 years or more for general climate studies, although 100 years of data is sufficient to encompass both warm and cold events. Relying on only 30 years of data, however, he cautioned can yield misleading results because the global climate is constantly varying; he noted that one must pay close attention to the influence of climatic change on the development of ENSO events. One must be careful with shorter time series as the correlations may appear to be higher than
is actually the case in the long term. For some countries such as Thailand, however, 30 years of data are all that is available.

El Niño events are not the only factors that are to be considered in forecasting regional and local climatic processes. Regional factors can mitigate or amplify the influence of an ENSO on local conditions. Thus, there are few, if any, one-to-one teleconnected relationships with ENSO. A teleconnection may be strong in general terms, but less confidence should be placed in it for any given event because of the local or regional climatic influences at the time of ENSO’s occurrence.

Uncertainty is not necessarily a major problem for many decisionmakers. They are already making many decisions on a daily basis with less than perfect information. They are used to hedging their bets, so to speak, in the absence of full knowledge. The level on which decisionmakers rely on the use of ENSO-related teleconnections forecasts will depend on whether the decisionmaker is a risk-taker or is risk-averse. Nevertheless, there are interesting linkages that suggest a possible value to ENSO forecasts. Dengue fever is an example of an interesting linkage. The following chart provided by Dr. Tran Viet Lien records the number of dengue fever victims in Vietnam as compared with the monthly value of the Southern Oscillation Index.

![Diagram showing relationship between ENSO index, Dengue fever, and Southern Oscillation Index.]

Relationship of Dengue Fever in Vietnam and the Southern Oscillation Index (Lien and Ninh, 1996)

As the chart suggests, there appears to be a rather close relationship between the two phenomena (with a correlation coefficient of 0.65). If the relationship proves reliable, then with an advanced warning of an ENSO event, it may be possible to create a dengue fever
early warning system to aid decisionmaking. If ENSO events were to increase in intensity or frequency, there would probably be a higher incidence of dengue fever in the country, a true disaster for human health.

What do we expect from an early warning system?

Discussion then shifted to early warning systems in general. The question was asked --how early is early? The response to this question is clearly a function of the purpose of the warning. Different uses by different decisionmakers will require different lead times so that they can act appropriately on that information. A warning can be too early. For example, there are regions that are known to be drought prone. This information is useful for long-term planning but not tailored for responses to specific drought episodes. Thus, an important characteristic for an effective early warning systems is that "timely" information reaches the appropriate decisionmakers with enough lead time to act on it.

It was suggested that there are in fact two levels of early warning; one for generating awareness and another for taking action. To know that an El Niño event is likely to occur at some time in the future provides decisionmakers with the kind of warning that raises awareness that climate-related problems could ensue. The second level of warning is that specific El Niño-associated anomalies are likely to occur (e.g., droughts, floods, fires). An analogy to smoking cigarettes was proposed. Smokers know in general that cigarette smoking is hazardous to their health (e.g., early warning as awareness). Nevertheless, they continue to smoke on the assumption that it will not be the next cigarette that will bring on a life-threatening illness (e.g., such a warning about the next cigarette would be a warning for action). Thus, early warning must be tailored to the specific needs of each decisionmaker or set of decisionmakers.

The monitoring and analysis of physical and societal factors are important aspects of providing early warning, whether for potential food shortages or for potential consequences of extreme meteorological events such as droughts, floods, fires, or the outbreak of climate-related diseases. Another important aspect is that to be effective the warning must be given to the right decisionmakers in a form that they can understand. Many people who receive climate-related information do not necessarily know how best to use it. Early warnings must be issued to the "right" people (e.g., the right users) and communicated appropriately. It is also important to identify those users and to make sure that they not only understand the early warning information but know how to use it. Not everyone requires the same information about an impending anomaly. Thus, it is crucial to identify the appropriate targets of the early warning. This has been referred to elsewhere as the "retailing" of early warning information as opposed to "wholesaling" it. The latter refers to creating awareness among potential users that such information in a general sense has a value to their activities. The former takes the process of awareness a step further, showing specific users the ways in which such early warning information might best be used to add value to their decisions.
Attention was then directed to the term "system". To forecasters, it may be enough from their perspective to issue a forecast (e.g., an early warning product) to national or regional meteorological services. Or they may view the information that goes into their projections as making up the forecast system. However, a broader view of an early warning system (based on climate-related forecasts) was discussed. This meant that the response mechanisms to both the forecast and the impacts of the climate-related anomalies must also be viewed as an integral part of the system.

Methods for disseminating the forecast were also discussed; the printed media, TV, radio. Problems as well as benefits were identified for each of these. It was suggested that there should be at least two sorts of warnings, one for the government and another for the public. Early warnings of possible climate-related anomalies, such as droughts or floods, can cause "panic" as well as inappropriate responses among those users who do not understand full well that early warning are probability statements carrying with them a chance of being incorrect.

The popular media presents additional problems for early warnings. They tend to get more attention but they are subject to misinterpretation from (a) those reporting it in the media and from (b) the public receiving the early warning. While successful early warning can reap great praise from the public, a failed early warning (e.g., the event did not occur) leads to a long-term loss of credibility of those providing the early warning (e.g., forecast) as well as an erosion of credibility in their scientific research.

The importance of generating a regional awareness of El Niño events and the potential use and value of the use of information (not just forecasts) about them was then discussed. There are clear linkages between El Niño events and regional climate anomalies. As part of developing an El Niño early warning system or including early warning information in existing disaster early warning systems, educational and training activities related to El Niño would be very beneficial to decisionmakers in the region. Such decisionmakers include, but are not limited to, those concerned with food production, water resources management, disaster management, energy production, and public safety. Those who manage training centers and institutes for government decisionmakers should incorporate El Niño in their curriculum. Concern about EL Niño events and their possible teleconnections and impacts are much too important to society to be left to the scientific community alone.

While discussion centered on El Niño as a natural phenomenon associated with disasters or unexpected, anomalous behavior of the atmosphere and the oceans, attention was also brought to the positive side of the ENSO cycle, the cold events, sometimes referred to as La Niña events. Information and forecasts of these events can also be used to enhance resource-related decisionmaking, enabling society to take additional advantage of positive impacts of favorable anomalies as well. With appropriate lead time, farmers in Southeast Asia might, for example, be able to produce an additional rice crop. In Australia information about the good years could enable farmers to enhance crop production and rangeland management, especially in regions where the farmer might on average expect three good years in ten. Those three years of favorable production will have to carry the farmer through the seven less favorable
years. Thus, it is in the farmer’s interest to maximize production in the good years and minimize losses in the bad years. Early information could contribute to this end.

El Niño information should not be marketed to potential users as the “be-all, end-all” of information needs for their particular activities. It is but another piece of potentially valuable information, albeit an important piece, but it will likely be considered in context with other information at the disposal of decisionmakers. Judiciously used, it can contribute to improved responses by society to a range of climate-related impacts.

**Are there existing early warning indicators of societal vulnerability?**

It is important to undertake assessments of society in order to identify those populations, groups, and locales at risk to climate-related environmental changes. Many of these areas and people are at risk to variations in climate -- floods, droughts, bush fires, frosts, diseases -- whether or not those variations are related to El Niño events. People are encouraged, coerced, or forced by economic, geographic, social, and by demographic pressures (or by government decree) to occupy vulnerable areas such as flood plains or areas at higher risk of drought. Poor people have less robust coping mechanisms, limited access to the policymaking process, and are therefore more susceptible to the adverse impacts of climate-related anomalies. People who are dependent on producing one crop are also highly vulnerable. Those with little political representation may not necessarily be more vulnerable to an extreme event, but they are less likely to get assistance when a climate-related disaster strikes.

With regard to vulnerability, Gao Pronove suggested looking at five key factors: people, species, habitats, infrastructure, and institutions. Geographical Information Systems (GIS) have been and can be used to identify risks to such key items. Regions affected by teleconnections related to the ENSO cycle can also be identified and incorporated into GIS. A survey of where GIS has been used to identify vulnerable areas and people throughout Southeast Asia should be undertaken. Citing the United States as an example, Margaret Davidson noted that there was growing interest in some sectors (e.g., the insurance industry) to establish a vulnerability index using GIS. This information could assist industries to better understand where they are vulnerable and to adjust their activities accordingly.

The United Nations Institute for Training and Research (UNITAR) has been coordinating a project called CC:TRAIN. The objective of CC:TRAIN is to develop modules for policymakers at several levels of government to identify societal vulnerabilities to climate-change-related environmental changes. Once known, they can be assessed and, if deemed necessary, be prepared for and actions taken to mitigate their impacts. In fact, vulnerability assessments linked to climate change scenarios can provide useful information on existing vulnerabilities within a region, nation, or society. It was proposed that a case assessment focused on ENSO impacts on the Mekong River basin could be beneficial for national and
regional governments and policymakers responsible for the management of the water resources of the Mekong River system.

In many cases, governments know where the vulnerable areas are within their borders and they know who the vulnerable populations are as well. Information on those areas and peoples must be made public and communicated to appropriate users, so that they might be given a better chance to receive support in dealing with the factors that have made them vulnerable.

John Hay proposed the need to compile a set of case studies of the successful use of information in response to climate-related disasters (especially El Niño-related climate anomalies) in various parts of the globe. These could be used to inform those responsible for future management of natural resources and the environment of possible ways such information might be used. Each time there is a success story, it is important to note the person or organization that was key to that success. With regard to generating awareness about the use of El Niño related information to reduce societal vulnerability or to increase societal resilience, it seems that there needs to be a champion, so to speak, to carry the message to those responsible for protecting the vulnerable areas and people. People are aware, in general, of their local climate-related and other hazards, although they may not be aware at all of the linkages of those hazards to the ENSO cycle of warm and cold events occurring in the central and eastern equatorial Pacific Ocean.

Nicholls relayed some examples about the use of El Niño related information (e.g., the SOI) in Australia. While the climate anomaly extremes cannot be prevented, societies can use El Niño related information to reduce the vulnerabilities they face. Murray Valley fever outbreaks have been linked to years absent of El Niño events. Whereas the government used to spray against it every year, now it does so in selected years when the SOI is positive (i.e., during a cold event). Nicholls noted that this accidental discovery brought about discussion and collaboration between physical and medical scientists in his country.

A special issue of *Disasters* journal in the mid-1980s was mentioned as having supplied a set of cases of the impacts on human health of the major 1982-83 El Niño event.

Glantz raised the notion of “risk maker.” Researchers know about risk takers and about those who are risk averse. There is yet another category: that of the risk maker, one who makes risks for others but who is not directly taking that risk. Their decisions about economic development or about disaster responses can elevate the level of risk for those already living in vulnerable areas.

The participants concluded that examples of El Niño information use can be incorporated into education and training programs for decisionmakers to highlight the potential value of knowledge of El Niño in reducing societal vulnerability.
Are there regional disaster preparedness plans?

There is no disaster preparedness plan for Southeast Asia, in large measure because of the great diversity of disasters and societal situations within particular countries in the region. There are national contingency plans for responding to disasters and managing the risks and consequences of disasters. How effective they are is another issue worthy of assessment. Less planning is done at the district level. There is also a capacity for donor (i.e., humanitarian) countries and non-governmental organizations (NGOs) to respond to disasters in the region. Their responses depend in large measure on competing demands for their time, attention and resources in other disaster situations around the globe.

John Barrett discussed the activities of the Asian Disaster Preparedness Center (ADPC) in Southeast Asia; its function is to assist governments and organizations (e.g., the Red Cross, fire services, police) to train the trainers to go into communities to take on their own responsibilities in terms of responding to the impacts of disasters. He noted that within countries there are overlapping jurisdictions and responsibilities for any particular aspect of a disaster. This strongly suggests the need for better coordination and shared responsibilities. There are examples of laws to reduce disaster risks being on the “books,” but in many instances they are not enforced (e.g., building codes). Another problem with disaster preparedness plans relates to the fact that such plans have very limited shelf lives and need to be updated relatively frequently to keep up with demographic changes, changing environmental conditions and technological advances. This means that there will have to be constant training and retraining of personnel.

The ADPC proposed to include ENSO cycle information in its training programs. This would not only generate awareness of the regional impacts of the phenomenon but would provide decisionmakers with usable scientific information for consideration in their decisionmaking processes.

There could be regional plans for those climate-related problems that are transboundary ones. The Mekong River system provides a good focus for Laos, Cambodia, Vietnam, Thailand, etc., for regional disaster planning related to floods and droughts and the quasiperiodic impacts of El Niño and La Niña events. Regional coordination already exists through the WMO with regard to forecasting typhoons in the region, and typhoon numbers and locations are affected by the ENSO cycle. Perhaps this typhoon warning community could share its insights on how best to deal with transboundary El Niño-related climate anomalies.

Participants noted that Thailand is in the process of developing a national disaster plan. As of now there are at least three groups in Thailand that deal with disasters (beyond flood control). Water supply itself falls under the jurisdiction to some extent of more than 30 authorities in Bangkok. To prepare communities at the local level, there must be a national commitment to mitigate the impacts of El Niño related climate impacts, and not just to respond to their effects. This would put authorities in a proactive as opposed to a reactive
mode. With regard to El Niño information (including forecasts), such information should be disseminated at the local as well as the national level.

Wednesday, 25 October

Regional teleconnections for Southeast Asia

Nicholls suggested that El Niño events do not develop randomly. Their evolution can be divided into the following components: year 0 (onset), year -1 (year before the onset) and year +1 (year after El Niño). He noted that the regional data base had improved since the late 1980s. He also noted that the SOI is closely related to the sea surface temperatures (SST) in the Niño3 region; when the SOI is negative, the likelihood of drought in Australia is increased. For example, Nicholls noted that in Australia there had never been a wet year that was also an El Niño year. La Nina years are the wet years.

Nicholls pointed out how unusual the 1991-95 period had been with regard to ENSO. He noted that the nature of ENSO had changed and suggested that we must consider climate change and climate variability together as they are difficult to separate from each other. In addition, the eruption of Mt. Pinatubo confounded the identification of consequences of the El Niño event(s) in this period making analysis of the period more difficult. Using teleconnection maps for the region produced by Kiladis and Diaz, Nicholls strongly suggested that ENSO information must be tailored to regional, national and local needs as well as to the specific needs of different economic sectors.

Discussion of the 1991-1995 situation in the equatorial Pacific highlighted the different conditions that existed in the eastern and in the western Pacific regions. He noted that there were three distinct El Niño events in the central Pacific [in the Niño3 region] (1991, 1993, 1994-95) and that these took place on top of a background warming of the sea surface in the Pacific Ocean.

Cane noted that the skill in forecasting El Niño in the 1980s was much higher than it had been in the 1970s. He suggested that part of the reason is that there were better data available to analyze and in part the climate variations of the 1980s were just larger and more predictable. The 1990s have proven more difficult to predict than the 1980s, despite the availability of more and better data. Cane suggested that we are making even better forecasts in 1995 than had been done for the 1970s and 1980s.

Glantz proposed the need to construct detailed regional climate impacts maps for the major El Niño events in the past few decades by using newspapers and other government reports for specific countries in Southeast Asia. These would be similar to the ESIG/NCAR impacts maps but would focus only on Southeast Asia (see Appendix I). By relying on news reports, the maps would be based on identifying climate-related impacts (e.g., droughts, floods, disease outbreaks) that societies felt strongly enough about to report to the media. These are
not meteorological maps reporting on rainfall shortages or surpluses. Climate impacts maps, from a societal perspective, give meaning to the way shortages or surpluses had affected human activities. John Bennett pointed out that the ADPC has ten years of clippings on file from regional media sources, which could be used in the development of such maps for the Southeast Asian region.

What are global warming scenarios for Southeast Asia?

As for climate change scenarios (e.g., global warming) and vulnerability assessments for the region, several country studies have been completed by the Asian Development Bank, as well as by other organizations. However, it is important to note that the scenarios are highly speculative. While GCMs provided some evidence in support of the view that the global atmosphere is warming as a result of human activities (e.g., the burning of fossil fuels and tropical deforestation), the GCMs that provide such scenarios are poor, for a variety of technical reasons, at providing insights into what might happen at the regional level. This shortcoming of the GCMs and of climate change speculation is recognized by all. Perhaps a useful way to address the regional consequences of climate change would be to focus on societal responses to known regional extreme meteorological events. Such events are of major concern to governments and their citizens. How well societies cope with them under today’s conditions of climate variability could provide insights of how well they might cope with the yet-unknown regional impacts of any changes in global climate several decades into the future.

What is the potential climate change impact on ENSO?

There is speculation about how climate change might affect the various general characteristics (its intensity, its frequency, its teleconnections) of what we have come to view in recent decades as “normal” El Niño. There is no reliable or credible information as yet on how climate change will affect the ENSO cycle of warm and cold events. For example, an Australian report on climate change (CSIRO, 1992) and its possible impacts on ENSO noted the following:

The findings of historical, contemporary, paleo-environmental, and GCM studies are such that any assessment of the behavior of the ENSO phenomenon under enhanced greenhouse conditions must still remain very speculative. Several possibilities exist, namely: ENSO behavior may not change; ENSO variations may change in frequency or amplitude; or ENSO may tend to move predominantly into a mode more like either present ENSO or anti-ENSO event conditions. These alternatives do not neatly fit into “low, medium, or high impact” categories, although all these possibilities could be explored in sensitivity studies in combination with each of the other scenarios. As a consequence, we
are recommending that for this study the ENSO cycle should be assumed to continue unchanged under enhanced greenhouse conditions.

If within-country groups want to assess the implications of a change in ENSO, perhaps the most plausible scenario is that suggested by the results of the Meehl et al. study [1993]. This is that by 2070 the rainfall increase associated with the local wet phase of the ENSO cycle, relative to the dry phase, might increase by some 25%. In other words, the impact of a possible increase in the amplitude of the ENSO cycle might be considered, while keeping the frequency constant. During ENSO or anti-ENSO events, the wet areas may get wetter and dry areas drier. As stated above, thus must be regarded as highly speculative at present. No significant change should be expected by 2010 (p. 24).

Other modeling activities are being designed to address the problem of regional-scale resolution (e.g., limited area models, mesoscale models, nested models).

As one participant suggested, from societal and environmental points of view, the year-to-year variations in the ENSO cycle have impacts that are more intense than a climate change resulting from the greenhouse effect. Thus, El Niño must be considered to be at least as important a research focus as that into human-induced climate change.

It was suggested that a compilation of the various climate change scenarios for Southeast Asia, including southern China, be collected and compared for any potentially reliable insights about how climate change might affect the region. (Again, see Appendix I.)

Education, training, and El Niño

The UNEP World Climate Impacts and Response Strategies Program (part of the World Climate Program) has been instrumental in focusing attention on the societal aspects of El Niño events since the mid-1980s. It was alone in that support, creating an international, multidisciplinary Working Group on the Societal Impacts of ENSO. The working group has produced a number of workshops (and workshop reports) and other publications designed to generate awareness among the physical and social sciences about the importance to society of the ENSO cycle. These publications also demonstrate, where possible, the value of the use of scientific information about El Niño and its teleconnections. The Working Group has produced edited books on Climate and Fisheries, on Teleconnections, and on Climate Change and ENSO. UNEP has also fully or partially supported a series of NCAR/ESIG Usable Science workshops, of which this is the third.

There is considerable growing interest in El Niño in selected countries around the globe. Southern African countries have recently discovered the importance of the phenomenon to their food security planning. Ethiopia is another African country exhibiting early interest in the phenomenon (in the mid-1980s) as a result of recurrent famines. The Brazilian northeast has established in the State of Ceará a climate forecast center in which El Niño is a central
focus. Uruguay, Cuba, Costa Rica, Peru, Ecuador, Chile, Colombia, Venezuela and Mexico among others in the western hemisphere believe that El Niño information can improve their climate-related decisions.

In Southeast Asia Thailand, Vietnam, the Philippines, Australia and Indonesia have been for some years interested in the ENSO cycle and an improved understanding of how it affects their climate. There is considerable value yet to be uncovered from the findings of El Niño researchers. Nevertheless, there is a need for the education and training of decisionmakers in the region about El Niño. The region is implicated in each El Niño event and improved awareness and understanding of the phenomenon could be of great value to the sectors that choose to use it. Hay noted that education and training were different activities requiring different approaches. For example, he suggested that education should be focused on giving people the ability to share the existing knowledge base and enhance their capacity to respond. The development of a training module for CC:TRAIN focused on El Niño was considered useful for both education and training activities.

Thursday, 26 October

Country and institutional experiences of weather and climate-related hazards and responses to them

This session was comprised of comments by participants about their institutions or activities and how they might relate to the ENSO phenomenon. Glantz started the discussion by noting that the interest expressed in improving an understanding of El Niño among decisionmakers in the region was extremely favorable and high. He noted that, throughout the workshop, several participants expressed their desire to incorporate El Niño information into their education and training activities in the near future. The following are summaries of participant presentations about their home organizations.

The Southeast Asian Ministers of Education Organization (SEAMEO) is the parent organization of SEARCA (SEAMEO Regional Center for Graduate Study and Research in Agriculture), which was established in 1965. SEARCA is one of nine regional centers. It focuses on resource management, sustainable agriculture, and rural development. Its program is a blend of theory and practice. Information on ENSO-related climate anomalies (and on long-term climate change) would be useful in these training courses.

Cane provided information on the International Research Institute (IRI) as a proposed structure to allow forecasts and monitoring information related to interannual climate variability to be used by decisionmakers at various levels and in various economic sectors of society. Such information could help society to better adjust to the impacts of interannual climate variability. The function of the IRI will not be just to improve forecasts but to make sure that they are translated into a usable form for different regions around the globe. Pilot application (of the global forecasts) centers at the regional level will be set up; one has
already been operating in Brazil. There are also training courses for the production, translation and use of forecasts of interannual variability already being held composed of people from regions known to be affected by ENSO events. Such courses are not only for meteorologists but for agronomists and water resource managers. Economists and social scientists will also become involved in the IRI.

The participant from Cuba, the site of the Usable Science 4 workshop, noted that his government’s decisionmakers were already convinced by their meteorologists of the value of ENSO research applications for agricultural, fisheries and public safety activities.

The New Zealand participant considered interannual variability an appropriate “notion” for raising awareness among engineers about environmental matters. Using examples from El Niño research and application meets that objective. He also noted that the Network for Environmental Training at Tertiary level in Asia and the Pacific (NETTLAP) was focused on environmental training at the tertiary level to enhance the environmental expertise of educators and through them potential resources managers in Asia and the Pacific who are seeking to achieve sustainable development in the region. NETTLAP has focal points in 35 countries and has more than 200 institutional members and more than 2000 individual members. ENSO information and its potential utility can be disseminated through this network. He also proposed that a list of methods be identified for using ENSO information in education and training courses; suggestions included teleconnections maps, overheads, impacts photos, case studies of ENSO related impacts and societal and ecological responses, casenario studies, videos (e.g., Australia’s “Farming a Sunburnt Country”), disaster planning exercises, ENSO model development, ENSO simulation software (some of which already exists), and so forth. The methods used would be matched to the information needs target audience.

The UNITAR participant provided an overview of the activities and approaches to training decisionmakers on climate change and societal vulnerability issues. CC:Train is considering the possibility of developing an ENSO module for its education and training package for decisionmakers having to deal with climate change related issues.

The representative of START (a global change SysTem for Analysis, Research and Training)/SARCS (Southeast Asia Regional Committee for START) commented on the need for ENSO related proposals for research in the southeast Asia region. ENSO information could be used to identify ways to better manage coastal and other natural resources affected by interannual climate variability.

The ADPC representative expressed great interest in including courses on El Niño and its impacts and the use of El Niño information in disaster prevention, mitigation and adaptation. He noted several areas in the region where ENSO-related information might be of value to decisionmakers who have to deal with climate related problems (droughts, floods, fires, etc). He also noted that ADPC’s facilities were excellent for regional education and training activities.
The new director of a national (US) coastal services center provided examples of how the new center would operate and how it would develop tools for integrated coastal management. Its program would be multidisciplinary, bringing together the physical and social scientists to resolve problems of common concern. The center would also conduct training courses and would assist various levels of government (local, state, national) in addressing their concerns about coastal zone issues.

THE USAID/OFDA has developed a strong interest in ENSO. Its managers believe that reliable information about the ENSO cycle of warm and cold events can help that organization to better understand how to minimize the impacts of ENSO-related climate anomalies in Southeast Asia, in Africa and in Latin America. OFDA representatives work with local officials and institutes to build capacity to cope with disasters, including those related to climate. It was noted that it would also be helpful in their effort to transfer physical science information in an understandable form to social organizations.

The participant from the Mekong Committee noted the importance of ENSO research and application to the management of water resources in the Mekong River basin. He noted that ENSO-related information would be useful for a variety of activities: hydropower, flood control, drought, settlement planning and for public safety in general.

The Vietnamese participants pointed to their several research efforts related to El Niño. Their researchers and some government officials believe that ENSO forecast can be useful for decisionmakers. A Vietnamese participant drew attention to the possible linkage between dengue fever outbreaks and ENSO-related regional climate anomalies affecting his country. He noted that Vietnamese researchers have a duty to study ENSO.

**Educating the public (including the media)**

Glantz raised the issue of whether the media should be given special consideration with regard to education and training about ENSO. The media are users of ENSO information including forecasts and they are also educators of the public (including policy and other decisionmakers). They tend to talk about El Niño, when an event has been forecast or an event is underway. And, then, they focus on the teleconnected disasters (severe and numerous droughts, floods, fires, disrupted marine and terrestrial ecosystems). Once the event has passed, the media put El Niño stories back into the file cabinets to await the next El Niño (for the most part, they do not write about La Niña).

Can the media be better educated by researchers on the ENSO warm and cold event cycle, so that they can better appreciate how events in the Southeast Asian region can affect either positively or negatively human activities of concern to their readers (e.g., agriculture, fisheries, landuse planning). Nicholls noted that in Australia, school children have been exposed to El Niño in their text books and seem to know about the phenomenon. US
textbooks for young people do not provide much information about the phenomenon, perhaps because the linkage to North American weather is less certain and less well known.

One participant suggested putting together a press kit for educating the media about ENSO. Another suggested that there are many opportunities to educate the media but that researchers have not as yet been very adept at using them. Compiling such readable, accessible baseline information could help to reduce the apparent confusion about what El Niño is, what it does and why societies worldwide should care about it.

*Where should we go from here?*

Glantz concluded the meeting thanking the Vietnamese hosts (especially the University of Ho Chi Minh City), thanking the UNEP for its continued support for Usable Science workshops, and thanking the participants for their active participation in and contributions to the workshop. Most participants did not know each other, having been drawn from different fields of endeavor. The mix of expertise was ideal, and several of those in positions of training and educating decisionmakers noted how valuable the discussions were in creating awareness of the importance of physical and social science research on the ENSO phenomenon. Several noted their intent to incorporate El Niño information into their programs. In that regard the workshop was considered a major success, carrying El Niño research into education and training programs.

The following action-oriented suggestions were drawn from the background papers prepared by the participants for the workshop and from the informal presentations and discussions that took place throughout the workshop. They are not presented in any order of priority.

*Action-Oriented Suggestions*

*Teleconnections*

- Identify regional teleconnections with ENSO.
- Identify regional, national, and local climate-related impacts associated with the ENSO cycle of warm and cold events.
- Enhance research activities in order to improve statistical reliability of teleconnections in the region.
- There is a need for improved regional monitoring of ENSO events and their suggested teleconnections.
• There is a need to build regional capacities to monitor and assess ENSO teleconnections in Southeast Asia.

• Identify possible correlations between droughts and floods in the Mekong River basin and ENSO events.

*Societal Impacts*

• It is important to focus on the interactions between climate-related processes in the region and human activities.

• Document exact influences of ENSO in Southeast Asia on agriculture, energy, fisheries, health.

• Identify and assess the regional impacts of past ENSO events.

• Produce detailed climate impacts maps for the region.

• When undertaking ENSO impact assessments in Southeast Asia, include southern China in those regional assessments.

• Focus on a single country in order to demonstrate the existence of ENSO teleconnections, impacts, and the possible uses of ENSO information.

• There is a need to emphasize societal aspects of vulnerability to extreme events.

*Uses*

• Identify uses for ENSO information.

• Use ENSO climatology in the region for long-term planning and sustainable development.

• Compile case studies of successful uses of ENSO information.

• Agricultural activities could benefit from reliable ENSO-related forecasts.

• Use the vulnerability assessments prepared for climate change studies as baseline information for ENSO impact studies.

• Weigh the relative value of ENSO information, including forecasts, as compared to other pieces of information that a decisionmaker considers.
Education

- To the extent that ENSO information can provide early warning of impending climate-related problems, ENSO information should be incorporated in training and public education activities.

- Compile as educational and training material existing regional climate experiences with ENSO teleconnections.

- A mechanism needs to be developed that enables the open exchange of ENSO-related information within the region.

- There is a need for a regional bibliography of research activities and publications for Southeast Asia.

- Assess media reporting of ENSO and ENSO-related regional impacts.

In sum, regional research on ENSO-related processes and their impacts on managed and unmanaged ecosystems and on society would serve to sharpen as well as strengthen global research on ENSO. The Southeast Asian region is in the so-called "field of action" of ENSO and ENSO-related impacts on biogeochemical processes and human activities. Many of the ENSO-related research questions would clearly benefit from broader participation of researchers and decisionmakers from within Southeast Asia.
References

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Biographical Information on Participants to the Workshop

John W. Barrett is the Director of the Asian Disaster Preparedness Center (ADPC). The ADPC assists countries in Asia and the Pacific regions to develop their policies and capabilities related to disaster management. The parent institute of the ADPC is the Asian Institute of Technology, an autonomous international postgraduate technological institute, located near Bangkok, Thailand. Dr. Barrett has held this post for the last two years, and has been interested in the role that El Niño information could play in the development of disaster education, training, and research.

Jariya Boonjawat is an Associate Professor in the Department of Biochemistry at Chulalongkorn University, Bangkok, and also the Interim Technical Director of the Southeast Asian START Regional Centre. She became involved in atmospheric chemistry in 1990 by collaborating with Professor Hiroki Haraguchi at Nagoya University in the study of kinetic behaviors of methane and carbon dioxide in the atmosphere of urban ecosystems in Bangkok. Since 1993 she has been in the National IGBP Committee of Thailand. Her interest in El Niño information began in 1995, as the coordinator of the inventory of existing databases related to global change research for the Southeast Asian region. If climate variability can be predicted in advance, these types of information should be clearly understood not only by scientists but also by policymakers within the region to deal with the impact of droughts and floods in a more economical way. She believes that atmospheric research, especially forecasting, is a very usable science for all societies and needs global collaboration.

Thomas O. Brennan is the Senior Regional Advisor the US Office of Foreign Disaster Assistance (OFDA) based in Manila. In this capacity, he assesses humanitarian needs due to natural and man-made disasters throughout Asia and the Pacific, and both recommends and manages US Government assistance to disaster victims. Between disasters, he also works with Asian governments, institutions, and nongovernmental organizations on disaster prevention, mitigation, and preparedness programs and strategies. Before joining OFDA in 1991, Brennan had spent more than 25 years in Asia and Africa working for a variety of agencies, including the US State Department's Bureau for Refugee Programs, the US Committee for Refugees, UNHCR, the World Bank, and the US Agency for International Development, mainly on issues relating to population displacement. He also served as a Peace Corps volunteer in Malaysia in the mid-1960s.

Mark A. Cane is a Doherty Senior Scientist at the Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York. He was educated in the New York City public schools and at Harvard College, and received a Ph.D. in Meteorology from Massachusetts Institute of Technology. He has written widely on tropical oceanography and ocean-atmosphere interaction, and has served on numerous international and national committees. With Lamont colleague Dr. Stephen Zebiak, he devised the first model able to simulate El Niño and the Southern Oscillation (ENSO), a pattern of interannual climate variability
centered in the tropical Pacific, but with global consequences. In 1992, Dr. Cane was awarded the Sverdrup Gold Medal by the American Meteorological Society.

**Margaret A. Davidson** has recently become the Executive director of the National Coastal Services Center, affiliated with the National Oceanic and Atmospheric Administration (NOAA). She previously was the Executive Director of the South Carolina Sea Grant Consortium. Her background includes a Masters from the University of Rhode Island and a J.D. from Louisiana State University. She describes herself as a science manager and educator; she is generally interested in the interrelationship between natural processes and societal concerns. Both her public presentations and her publications tend to focus on coastal change and the implications of those changes.

**Maxx Dilley** is a Visiting Scientist with the University of Wisconsin Disaster Management Center. Dr. Dilley works at the US Agency for International Development’s Office of Foreign Disaster Assistance (OFDA) in Washington, DC. Current responsibilities include famine mitigation, disaster early warning, vulnerability assessment, and Geographic Information Systems. He holds a Bachelor of Arts degree from the University of Delaware and both Master of Science and Doctoral degrees for the Pennsylvania State University, all in Geography. He was an American Association for the Advancement of Science Fellow at OFDA for two years prior to accepting his present position in 1994. Dr. Dilley’s publications are primarily in the areas of climatology and agriculture.

**Nguyen Ngoc Giao** is a Senior Science and Rector of the University of Ho Chi Minh City, Vietnam, and Director of the Center for Natural Resources and Environmental Studies. He received a Ph.D. in Theoretical Physics in 1972 from Moscow State University, Russia. He is interested in theoretical aspects of environment-related topics such as atmospheric phenomena, population, chaos theory, the interaction between human activities and the environment, and policies for environmental preservation in developing countries.

**Michael H. Glantz** is a Senior Scientist and the Director of the Environmental and Societal Impacts Group, a program at the National Center for Atmospheric Research. He received a Ph.D. in Political Science in 1970 from the University of Pennsylvania. He is interested in how climate affects society and how society affects climate, especially how the interaction between climate anomalies and human activities can affect the quality of life. He is the author of numerous articles and has edited several books on issues related to climate, environment, and policy. He recently finished a manuscript on El Niño, to be published by Cambridge University Press in 1996.

**John E. Hay** is Associate Professor of Environmental Science in the School of Environmental and Marine Sciences at the University of Auckland, New Zealand. He received his Ph.D. in Earth Science from the University of London, where he held his first academic appointment. His teaching and research interests are in interdisciplinary environmental science, with emphasis on climate variability and change and on coastal zone management. Most of these activities focus on small island nations in the South Pacific.
ENSO thus plays a key role in his work. Dr. Hay is also coordinator of UNEP’s Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP). As a result, he is very active in training activities related to the environment and sustainable development.

Srikantha Herath is a Visiting Professor at the International Center for Disaster Mitigation Engineering (INCEDE) at the University of Tokyo. He received a Dr.Eng. degree in civil engineering, specializing in hydrology, from the University of Tokyo in 1988. His main interest is in physically-based hydrologic modeling in order to predict hydrological processes, not only due to natural forces, but also to assess the impact of human activities. He has written many articles on hydrological modeling and the effect of urbanization on hydrological processes. At INCEDE he is in charge of flood studies, mainly in the Asian region, where INCEDE is currently conducting several joint research projects. He is also interested in the role of communications in disaster mitigation, especially in networking and the use of the Internet for information dissemination and exchange.

Nguyen Dinh Huyen is the Head of the Department of Biochemistry at the University of Ho Chi Minh City. He received a Ph.D. in Biological Sciences in 1971 from Moscow State University in Russia. He is interested in climate anomalies and how they influence the living world, or the “allergy” of the living world on climate change. He is the author of numerous articles and books related to biochemistry, the environment, and policy.

Thanoungdeth Insisiengmay is a Project Officer in the Hydrology Unit, Secretariat of the Mekong River Commission (MRC) in Bangkok, Thailand. He completed his Bachelor of Hydraulic Engineering at the Technical University of Dresden, Germany, in 1987. He obtained a Master of Engineering Science in Hydrology at the University of Melbourne, Australia, in 1995. He is involved in the operation and maintenance of hydro-meteorological networking, data collection, Mekong river flood forecasting, and groundwater investigation activities. He is now one of the MRC officials implementing the basinwide “Improvement of Hydro-Meteorological Network” project. The result of the project will be very important for water utilization in riparian countries.

Tran Viet Lien is a principal investigator of climatology and Director of the Climate Research Center, Institute of Meteorology and Hydrology in the Vietnam Hydrometeorological Service. He received his Ph.D. in Geography and Geology in 1987 from the Institute of Meteorology and Hydrology. He is interested in applied climate and the impacts of climate and climate change to socio-economic issues. He is the lead author of the IPCC Workshop Group II, Subgroup A. He is also chief of many study groups on statistical and applied climate. He is also the author of numerous articles in climate, biometeorology, agroclimate, climate for energy and forestry, impacts of climate change on human health, energy and transportation, agriculture, and coastal zones. He is now continuing his studies of climate application, climate change impacts, urban climate and the environment.

Lino R. Naranjo (Diaz) is a Senior Researcher for the National Group on Long-Range Prediction at the National Climate Center of Cuba. He graduated in 1973 from the Academy
of Sciences in Cuba with a Masters degree in Meteorology. He received his Ph.D. in Geographical Sciences from the Academy in 1989. Presently Dr. Naranjo is a specialist in statistical models for weather prediction, with a special interest in short-range climate prediction and ENSO events, including ENSO’s impact on weather patterns and the study of intra-seasonal cycles in the atmosphere.

Neville Nicholls is a Senior Principal Research Scientist and leader of the Climate Group at the Bureau of Meteorology Research Centre in Melbourne, Australia. He is interested in the impacts of El Niño-Southern Oscillation on society, the economy, and the environment, and its use in climate prediction. He published his first paper on El Niño in 1973. Dr. Nicholls has a Ph.D. in Meteorology from the University of Melbourne and an MBA from the Royal Melbourne Institute of Technology. He is a Convening Lead Author of the 1995 Report of the Intergovernmental Panel on Climate Change.

Nguyen Huu Ninh is the Chairman of the Centre for Research and Development (CERED), the Global Environment Program at the University of Hanoi, Hanoi, Vietnam. He is presently the Vice-Chair of the Southeast Asian Regional Committee for START (SARCS/SEACOM) for the period 1995-96. He received a B.Sc. and Ph.D. in Biological Science in 1977 and 1986 from Jozsef Attila University in Hungary. He is interested in different areas of global environmental change, especially the assessment of climate-related impacts on ecosystems in Vietnam. Among his numerous publications, he prepared *Vietnam and Global Warming*, with M. Kelly and S. Granich, which was used in UNITAR training courses on global change. Recently, he edited a book with M.H. Glantz and P.E.O. Usher on *The Potential Socio-Economic Effects of Climate Change in Vietnam*, to be published by UNEP in 1996. He has also published several environmental books in Vietnamese.

Alicia P. Occidental is a Training Specialist and presently the Training Officer and Head of the Training Unit, SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA), based at the University of the Philippines, Los Banos College, Laguna, The Philippines. Equipped with extensive and intensive experience in training management, she serves as training manager, facilitator, moderator, and lecturer on community and rural development, data management, project analysis and planning, curriculum design, and effective teaching/learning strategies. She holds a doctorate in community development and B.S. and Masters degrees in education.

Suwanna Panturat is Associate Dean for Research Affairs, Faculty of Science, Srinakharinwirot University in Bangkok, Thailand. She received a Ph.D. in Interdisciplinary Studies in 1987 from the University of Oklahoma. She is interested in the impacts of climate change and variability on agriculture (especially on field crops), society, and environment, as well as the value of a good forecast (both short- and long-term) of climate information on agriculture, society, and the environment. She has recently conducted a study, supported by UNEP, on policy response strategies to mitigate climate change impacts on field crops in Thailand.
Roger A. Pielke, Jr. is a Visiting Scientist at the Environmental and Societal Impacts Group at the National Center for Atmospheric Research. He is interested in how society conducts scientific research and how society uses the information that results from research in various decisionmaking processes of public and private actors and groups. His current research is related to how the United States deals with mesoscale weather events, and particularly the role of weather forecasts for reducing societal vulnerability to extreme events. He received his B.A. in mathematics (1990), M.A. in public policy (1992), and Ph.D. in political science (1994) from the University of Colorado. He has worked at the House Science Committee in Washington, DC, and taught at the University of Colorado and University of Denver.

Gao Pronovoe received a A.B. and L.I.B. from the University of the Philippines and an M.A. in Environmental Policy from Tufts University. He is the Manager of the CC:TRAIN Programme at the UN Institute for Training and Research (UNITAR). CC:TRAIN is a joint program of UNITAR and the Climate Change Secretariat. It is implemented through the UN Development Programme and is funded by the GEF and other donors. Phase 2 of the program involves 18 countries in Africa, Latin America, the Caribbean, and the Pacific.

Nguyen Van Tai is Head of the Geography Department and the Deputy Director of the Center for Natural Resources and Environment Studies (CENRES), both of the University of Ho Chi Minh City. He received a Ph.D. in Geographical Sciences in 1988 from Leningrad University, Russia. He is interested in different fields of study, including environmental economics, environmental management, urban environment, and environmental sustainable development in LDCs. He also is interested in issues of the interaction of climate change and human activities.

Huynh Trung is Senior Scientist and lecturer of Geology at the University of Ho Chi Minh City, and Deputy Director of CENRES. He received a Ph.D. in Geology/Petrography in 1971 from Moscow Institute in Russia. He is interested in how climate affects society and theoretical aspects of the environment as it relates to geology. He is the author of Geological Catastrophes in Vietnam.

Peter E.O. Usher is a graduate of the University of Wales, Swansea. He is a meteorologist and Chief of the Atmosphere Unit of UNEP, headquartered in Nairobi, Kenya. The Atmosphere Unit deals with ozone layer depletion, climate change, and transboundary air pollution. In particular, it implements the World Climate Impact Assessment and Response Strategies Programme (WCIRP) as part of the international World Climate Programme. It also interacts with and supports the Intergovernmental Panel on Climate Change (IPCC) and the UN Framework Convention on Climate Change (UNFCCC). Under the WCIRP, the Atmosphere Unit develops and supports climate-related activities relating to the impacts of ENSO, including the series of “Usable Science” workshops.

Wang Shao-wu is a professor of Meteorology, Department of Geophysics at Peking University in China. He graduated from Peking University in 1954. He is interested in climate change, climate prediction, and modeling. He has devoted much of his research effort
to the reconstruction of paleo-climate and has initiated work on droughts and floods in China during historical periods. In the 1980s he carried out a series of studies on ENSO, including the impact of ENSO on China's climate throughout history. He has also studied the Walker Circulation. More recently he has published several papers on climate prediction and simulation. He has organized a Climate Unit at Peking University and has constructed a general circulation model consisting of five layers. He is the author of more than a hundred papers and several books.

Zong-ci Zhao is a professor and member of the Science and Technology Committee at the National Climate Center, Beijing, China. She graduated from the Department of Geophysical, Peking University, in 1964. She is interested in climate change, the global climate system, climate dynamics, climate impacts, and the effects of human activities on climate. She and her co-authors have published numerous papers in these fields and has co-authored several books, most recently *Climate Change and Sustainable Development in the World’s Semiarid Regions*, to be published by Cambridge University Press in 1996.
Appendix I

- Selected ENSO Impacts Maps for Southeast Asia
- List of Participants
- Agenda of Workshop
El Niño's impact on the weather
(1982 - 1983)

Philippines:
- Drought
- Damages: $450M

Micronesia:
- Drought

Indonesia:
- Drought
- Victims: 340 dead
- Damages: $500M

New Guinea:
- Drought

Australia:
- Drought, fires
- Victims: 71 dead, 8,000 homeless
- Damages: $3B

NOAA
Arrow 1. Indonesia was plagued with severe drought, resulting in reduced agricultural output, especially rice, and in famine, malnutrition, disease, and hundreds of deaths. This drought came at a bad time, as this country had made great strides toward self-sufficiency in food production. In the few years immediately preceding the 1982–83 El Niño, it was emerging as a rice exporter. This drought, however, coupled with worldwide recession, huge foreign debts, and declining oil revenues, has set back Indonesia’s economic development goals for the near term.

Arrow 2. Australia had its worst drought this century. Agricultural and livestock losses, along with widespread brushfires mainly in the southeastern part of the country, resulted in billions of dollars in lost revenues. An Australian journalist wrote that “the drought is not just a rural catastrophe, it is a national disaster.” The drought has been linked to El Niño.

Fig. 3. As in Fig. 2, except for Eurasian sector precipitation. The W represents wetter than normal, and D drier than normal conditions.

SCHEMATIC OF AREAS WITH A CONSISTENT ENSO PRECIPITATION SIGNAL

Fig. 21. Schematic representation of the principal ENSO-related precipitation based on the detailed analysis for the core regions. Regional maps should be consulted for details.

CLIMATE IMPACTS MAP
DROUGHTS

- 1982 Droughts (January - December)
- 1983 Droughts (January - August)
- 1982 - 1983 Droughts
1993 DROUGHTS

Asia
5. Thailand and Philippines - first half of 1993
   a. Drought reduced crops; caused water shortages
   b. Bangkok reservoirs reached record lows

Australia & Oceania
7. Northeastern and eastern Australia - Feb.-April
   a. Southern half of Queensland received little or no rain in February
   b. In first four months of the year, the Cape York Peninsula received 30% to 70% of normal rains while central and northern Queensland received only 10% to 50% of normal

ESIGN/NCAR
1993 SEVERE STORMS

19. India, Nepal, and Bangladesh - June-July
   a. Southwestern monsoon brought excessive rainfall; catastrophic floods in northeastern India
   b. Flooded rivers in Assam swept away homes and bridges
   c. 1,000 Indians and 5,000 Nepalese died
   d. Millions homeless in India and Bangladesh
   e. Kathmandu isolated by flood waters
   f. 1/2 of Bangladesh under water after 5 days of relentless rain
   g. 6 million Bangladeshis homeless or stranded
   h. Worst deluge in 60 years

20. Southern Nepal and Bangladesh - August
   a. Worst floods and landslides in a century; flooding killed 2,000 people by early August; thousands homeless; extensive property damage
   b. Torrential rains stranded 10,000 people in southern Bangladesh

23. Philippines - Oct. 4
   a. Typhoon Pio; 88 people killed

24. Vietnam - Nov. 16
   a. Heavy rains, flooding; 122 people died

26. Philippines and southern Vietnam - early December
   a. Typhoon Lala
   b. 250 dead and 15,000 homeless in Luzon, Philippines
   c. 130 mph winds along southern coast of Vietnam

27. Central Philippines - Dec. 12
   a. Typhoon Manny; winds at 140 mph; 50 deaths

28. Malaysia - Dec. 27
   a. Worst flooding in 13 years in northeastern states forced thousands from homes

Australia & Oceania

29. Fiji, Tuvalu, and the Solomon Islands - Jan. 2-3
   a. Typhoon Nina; over $120 million in damage reported; 40,000 homeless on the Solomon Islands

30. Australia - February
   a. Kimberley region in northwestern Australia hit by worst floods of the century
   b. Roads leading to an aboriginal village destroyed; villagers stranded

31. Vanuatu - March 30
   a. Tropical Cyclone Prema; 7,000 homeless; $60 million in reported damage

32. Australia - October
   a. Worst flooding in Victoria in 20 years
   b. 4,000 homes destroyed; more than 2,000 sheep and cattle killed
1992 DROUGHTS

Asia
7. Philippines - Jan.-May
   a. Drought; $121 million in crops destroyed; persistent power shortages
8. Thailand - Jan.-May
   a. Drought; 12.5 million hectares of farmland destroyed
9. Irian Jaya, Indonesia - February
   a. Lack of crop planting
   b. 132 people died of starvation

Australia & Oceania
12. Australia - February
   a. Monsoon rains through eastern New South Wales and Queensland broke year-long drought
   b. Western part of New South Wales remained dry; parts of Queensland also remained dry, affecting sugarcane crops
13. Eastern Australia - September
   a. Drought; severe food and water shortages; livestock and wildlife threatened
1992 SEVERE STORMS

Asia

2. Vietnam - Jan. 1
   a. High winds devastated coast, killing at least 100 people

5. Papua New Guinea - May
   a. Floods

6. Northern Vietnam - July
   a. Typhoon Chuck; 21 people killed; winds up to 75 mph

9. Philippines (esp. west coast of Luzon) - Aug. 15-Sept. 5
   a. Cyclones Mark, Omar, and Polly
   b. 500 mm of rainfall
   c. Flooding forced thousands of villagers to flee

12. Manila, Philippines - Sept. 17
    a. At least 10 people died in flash floods and mudslides

13. Central Vietnam - October
    a. Typhoon Angela
    b. Flooding; 50 people dead or missing; 28,000 families homeless

14. Java, Indonesia - October
    a. Floods; 77 casualties; 8,000 people evacuated

Australia & Oceania

17. Australia - February
    a. Monsoon-type rains in New South Wales and Queensland; widespread flooding in New South Wales

19. Fiji - December
    a. Cyclone Joni; wind gusts up to 130 mph; widespread flooding in coastal villages
1990 - 1991 DROUGHTS

Asia
   a. Drought; large forest fires in Borneo and Sumatra
   b. Lower production of rice due to drought

Australia & Oceania
8. Australia - April 1991
   a. Drought killed grass; caused bush fires
   b. Sheep farmers faced disastrous year

   a. Severe drought in Queensland, New South Wales, and southwestern Australia; rainfall in northern New South Wales and southern Queensland totaled less than 1/2 inch from late July to late October
   b. Worst harvest in 20 years; reduced by 30%; Australia had to import wheat
1991 SEVERE STORMS

Asia

5. Bangladesh - April 27-29
   a. Tidal wave submerged many offshore isles, killing 140,000 people
   b. 1 million cattle killed; 1.4 million houses destroyed
   c. $1.5 billion in damage; hundreds of miles of roads and boats washed away
   d. 30,000 people on island of Sandwip swept away; 20,000 died

10. Philippines - June 12
    a. Mt. Pinatubo erupted; coincided with typhoon and rainy season
    b. Mudslides and flooding caused deaths of 581 people; 1 million homeless

12. Bangladesh - July 23
    a. Floods; 1.5 million people affected

14. Northern Bangladesh - Sept. 18
    a. Floods; 50,000 people stranded when flood barrier broke; 20 million people affected; 500 miles of roads washed away; $160 million in crop damage

15. Vietnam - Sept. 18
    a. Floods; 21 people killed

16. Northern Luzon, Philippines - Oct. 28
    a. Typhoon Ruth; flash floods; landslides
    b. More than 60 people killed; 21,000 homes destroyed

17. Leyte Island, Philippines - Nov. 4-5
    a. Tropical Storm Helena hit city of Ormoc; 4,990 people killed; 1,380 missing but presumed dead

19. Vietnam - Dec. 28
    a. Severe storm killed 250 people

Australia & Oceania

20. Australia - June
    a. Wettest June on record in Melbourne

21. New Zealand - June
    a. Coldest June since 1976; reports of sheep frozen to the ground

24. Eastern Australia, coastal Queensland - Late December
    a. 50" of rain in 10 days; homes, highways, and railways flooded
    b. 2,000 head of cattle lost
1986 DROUGHTS
March–December

Australia
5. Australia - September
   a. Wheat harvest reduced 7% due to drought

ESIG/NCAR
1986 SEVERE STORMS
March–December

Asia

2. Western Java, Indonesia - March 16
   a. Floods; two people drowned; 38,000 people in 33 villages forced to leave homes
   a. Monsoon flooded 10 towns and cut off rail and road links
10. Malaysia - Nov. 27-Dec. 1
   a. Four people drowned in floods
11. Southern Vietnam - Dec. 7
   a. Floods; three people drowned; several towns inundated with flood waters; two dams burst

Australia & Oceania

12. Fiji - April
    a. Hurricane Martin; severe flooding in capital city of Suva
13. Solomon Islands - May
    a. Cyclone killed 100 people; 100,000 left homeless
    b. Staple crops of sweet potatoes and rice destroyed
    c. Villages in Guadalcanal Plain flattened by floods and mudslides
14. Sydney, Australia - Aug. 7
    a. Floods and heavy rains; 6 people killed
1983 DROUGHTS
January - August

Asia
15. Nepal, ne India, Bangladesh - Jan thru Apr*
16. se Pacific - Jan thru June
   a. Widespread drought
   b. s & c Philippines - Jan thru June*
   c. n & e Philippines - mid-Apr thru June
   [i] Drought in Philippines wntl since 1958
   d. Malaysia - Jan thru Apr*
   [ii] esp. e coast of peninsula (parts of s Thailand also)
   e. c Indonesia: Sulawesi - Jan thru Apr*
   f. c & sw Indonesia: n Sumatra, n Kalimantan - Mar thru mid-Apr*
18. sw Cambodia - Mar thru Apr
19. s Indonesia: Java & Nusa Tengarra - mid June thru Aug

Australia & Oceania
21. se Australia - Jan thru Apr*
   a. Worst drought since 1890s
   b. Thru Apr in interior New South Wales & Queensland
   c. Heatwave, brushfires, & dust storms in Feb
   [i] Melbourne 110° F Feb 8
   [ii] Feb 15-17, brush fires Victoria & S Australia
22. Fiji - Apr thru July
1983 FLOODS/HEAVY RAINS/SEVERE SUMMER STORMS
January - August

Asia
12. n & c Pakistan, s Nepal, Bangladesh, sw India: Punjab, Uttar Pradesh, Bihar & Bengal - Apr 10-10
   a. Series of major storms, heavy rains, flooding
13. Bangladesh - Apr 24-30  a. Severe storms, major flooding
14. se & s coastal Thailand, Kampuchea, s Vietnam - May thru July; in Thailand - thru Aug
17. c Indonesia: Makuku - June 19-24
18. s & c Philippines - July thru Aug
   a. Pap. Typhoon Vera July 14
20. s Bangladesh - Aug 3-5
   a. Torrential rains, flooding

Australia & Oceania
23. New Zealand: South Island, Christchurch region - Jan 19
   a. Severe storms, hail
   b. sw South Island, Milford Sound, wettest Jan on record
24. coastal S Australia - Mar 1-3
25. a Australia: Northern Territory & n Queensland - Mar 1-15
27. c coastal Australia: s Queensland & c New South Wales - mid Apr thru June
28. Kiribati Islands - no dates available
   a. Intense periods of very heavy rains
   b. Including Gilbert Island, Christmas Island & the Line Islands
1982 DROUGHTS
January - December

Asia
17. Malaysia - Jan thru Apr; Selah - thru May
19. SE Thailand - Jan thru Mar
20. Indonesia, Papua New Guinea, Melanesian Islands - Mar thru Dec
   a. Beginning in Indonesian archipelago & n Solawesi, spreading to entire area by July; worst drought in 10 yrs
21. S & c Philippines - Mar thru May; mid Sept thru Dec
22. S Burma - May thru Oct
23. Laos, n Thailand, n & c Vietnam, parts of Kampuchea & s Vietnam - May thru Aug; c Vietnam - thru Dec
27. s Vietnam, c Kampuchea - July thru Aug
28. se & coastal Bangladesh - Aug thru Nov

Australia & Oceania
30. se Australia - Apr thru Dec
31. New Zealand: c coastal South Island, Canterbury Plains - June thru Aug
   a. Dry in New Zealand entire year except s & w South Islands
1982 FLOODS/HEAVY RAINS/SEVERE SUMMER STORMS
January - December

Asia
20. s & e Philippines - Mar 20-29
   a. Typhoons, flooding, high winds, property & crop damage, fatalities
   b. Typhoon Maria; Mindanao; Mar 20
   c. Typhoon Nelson; Visayas - Mar 25-29
22. sw coastal Burma - May 4
   a. Cyclone, crop & property damage, fatalities
26. n & e Philippines; Luzon & central islands - June thru Oct
   a. Severe typhoons; periods of severe flooding, crop & property damage, fatalities
   b. Exp. Typhoon Nancy - Oct 12-16
27. Indonesia: s Sumatra - June 3-5
   a. Heaviest monsoons in 75 yrs, severe flooding, property damage & fatalities
29. Kampuchea, sw Vietnam - June 1-10
   a. Heavy rains, flooding
31. sw & se Thailand - July 1-10, Dec 7-9
38. ne Thailand - Sept
   a. Heavy rains, flooding
   b. Exp. Tropical Storm Hope early Sept
39. n & e Vietnam, ne Laos - Oct 16
   a. Typhoon Nancy; extensive flooding, high winds, property & crop damage, fatalities
41. Indonesia: s Sumatra & Java - Nov thru Dec

Australia & Oceania
42. Tonga Islands - Mar 2
   a. Typhoon Isaac, severe damage
43. e Australia: s coastal Queensland - Sept 20
44. e Australia: coastal New South Wales - Oct 9-11
1973 DROUGHTS
January - August

Asia
16. a. Vietnam: 5 provinces s of Hanoi - Jan thru July
   a. No rain since Nov 1972, crop losses
17. c & ne Thailand - Apr thru May

Australia & Oceania
19. New Zealand & New Caledonia - dates not known
   a. "Extended droughts" during 1973 caused severe damage to
      agriculture & livestock
1973 FLOODS/HEAVY RAINS/SEVERE SUMMER STORMS
January - August

Asia
12. Indonesia: Islands e of Bali - mid Apr thru July
   a. Series of severe storms, floods, property damage, nearly
      2,000 fatalities (esp. fishermen)
13. c & coastal Bangladesh - Apr 12-27; early June
   a. Apr: Faridpur area; 2 weeks of storms, heavy rains, high
      winds, flooding, river flooding, several hundred fatalities,
      crop & property damage
   b. June: coastal areas; torrential rains, heavy monsoons,
      floods, crop damage

Australia & Oceania
19. n Victoria - June thru Aug
   a. Severe flooding, damage to crops
   b. 1973 was quite wet for much of Australia: many inland
      areas of S Australia reported the wettest conditions in liv-
      ing memory; the dry season in the N Territory was
      unusually wet & several locations had 50-60 times their
      normal
20. se Australia: ne New South Wales - July
   a. Widespread & intensely heavy rains, flooding, i.e., Dorrigo
      472 mm in one 24-hr period
1972 DROUGHTS
March - December

Asia
7. Thailand - Apr thru June
   a. Drought during beginning & middle of rainy season, crop & livestock losses
9. ne India, Nepal, Bangladesh - June thru Aug
   a. Failure of summer monsoon
   b. Assam province, India received 855 mm rain in July compared to 2,855 mm average
10. Indonesia: Java, Madura, Bali & se areas - June thru Oct
14. n Vietnam: 5 provinces s of Hanoi - Nov thru Dec

Australia & Oceania
15. s Australia - Mar thru Jan 1973
   a. Severe drought; sw W Australia in 3rd yr of dry weather, winter 1972 rains below average for most areas in s Australia, conditions worsened as drought extended into summer rainfall areas of se. drought ended late Jan 1973 & into Feb with heavy rainfall
   b. Affected areas included: sw W Australia, S Australia, New South Wales, s Queensland, s Northern Territories, Victoria (esp. Victoria)
   c. Heat waves
      [i] May 1972: Sydney & neighboring areas, bushfires in New South Wales & Victoria
      [ii] Dec 1972: sc areas, esp. Victoria, persistent heat heightened effects of drought
16. Papua New Guinea & Melanesian Islands - Apr thru Aug

ESIG/NCAR
1972 FLOODS/HEAVY RAINS/SEVERE SUMMER STORMS
March - December

Asia
14. s Philippines: Mindanao - Mar 19, Dec 5
   a. Two tropical storms: torrential rains, extensive flooding,
      millions of acres of crops destroyed, property damage,
      thousands homeless, fatalities
15. ne India, ne Bangladesh: csp. Sylhet area - June
   a. Series of monsoon floods, over 100,000 acres of crops
      destroyed, many homeless, property damage
19. n Philippines: Luzon - late June thru Aug
   a. Series of typhoons & tropical storms, heavy and incessant
      monsoon rains, flooding, river flooding, over 1,000
      fatalities, extensive property and crop damage
   b. s & c Luzon, Typhoon Ora - June 24-25
   c. Manila & w provinces - late July thru early Aug
   d. Monsoon floods create worst natural disaster in Philip-
      pines history, July 19-20 Manila airport received 763
      mm rain, 1,000 mm received during period July 18-25
   e. Typhoon Betty - Aug 17

Australia & Oceania
23. c Australia: Alice Springs area - Mar
   a. 700% of normal for month, flooding, crop damage
24. Fiji & surrounding islands - Oct 25
   a. Hurricane Bobbe, heavy rain, high winds, "devastating
      floods," property damage
25. e coastal Australia: Queensland & New South Wales -late Oct
   a. Intense rains, flooding, over 300 mm received in 1 24-hr
      period
1958 DROUGHTS
January - August

Asia
10. Philippines† - dates not known

†Event represented on map with a symbol because of significant geographic uncertainty regarding its location
1958 FLOODS/HEAVY RAINS/SEVERE SUMMER STORMS
January - August

Australia & Oceania
21. equatorial Pacific Islands - Sept 1957 thru Feb 1958
   a. Periods of heavy & unusual rains, 5-29% more than normal,
      i.e., Canton Is. Nov thru Mar: 58.2" vs 61.1" average
22. Fiji Islands - Jan 7
   a. Typhoon, damages
23. e coastal Australia: Queensland - Feb 18-19; Apr 3
   a. Feb: Pioneer River floods Mackay area
   b. Apr: typhoon hits Bowen area, heavy damage
24. Australia: N Australia - Mar
1957 DROUGHTS
March - December

Asia
6. Indonesia† - dates not known

Australia & Oceania
8. Australia† - Mar thru Jan 58
   - Reported in Oct that drought could cut wheat production
   - 50%; heat wave late Dec thru early Jan in Sydney area;
   - New South Wales cap. affected; rains broke drought in late
     Jan 1958

†Event represented on the map with a symbol because of significant geographic uncertainty regarding its location
1957 FLOODS/HEAVY RAINS/SEVERE SUMMER STORMS
March - December

Asia
17. Indonesia: Java - Mar 9; July 19; Dec 23
   a. Mar: c Java flooded
   b. July: Tjijjell River floods w Java, thousands homeless, fatalities
   c. Dec: c Java flooded
23. Philippines: Luzon - July 17; Nov 11-13
   a. July: Pangasinan province, w Luzon, Agoo River floods.
      several hundred fatalities, heavy damages
   b. Nov: typhoon, heavy rain, high winds
28. c Vietnam - Oct 26
   a. Typhoon, heavy rains, high winds, fatalities, damages

Australia & Oceania
30. c equatorial Pacific Islands - Sept 1957 thru Feb 1958
   a. Reports of unusual series of heavy rainfa ls (totals 5 to 20
      times normal) disrupting ecology & economies of islands
   b. Canton Is., Nov-Mar, 68.2" vs 6.3" average
31. Guam - Nov 16
   a. Typhoon, heavy damage
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ENSO and Extreme Events in Southeast Asia
23-26 October 1995
Rex Hotel, Ho Chi Minh City, Vietnam

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Agenda
ENSO and Extreme Events in Southeast Asia
23-26 October 1995
Rex Hotel, Ho Chi Minh City, Vietnam

Sunday, 22 October

7:00-9:00p  Reception at hotel

Monday, 23 October

9:00-9:30a  Formal opening of Workshop (Glantz, Usher, Vietnam reps)
9:30-10:00a  Purpose of workshop
10:00-10:30  Round-the-Table introductions
10:30-10:45  Break
10:45-11:30  Utility of the notion of Usable Science
11:30-12:00  Open discussion
12:00-1:30p  Lunch
1:30-2:00    What are the region's climate-related extreme meteorological events or hazards?
2:00-2:30    What is El Nino (atmospheric)？
2:30-3:00    What is El Nino (oceanic)?
3:00-3:30    Break
3:30-4:30    What are teleconnections and what do they do globally?

Tuesday, 24 October

9:00-10:00a  What do teleconnections do regionally? How reliable are they?
10:00-10:30  How reliable are teleconnections for Southeast Asia?
10:30-11:00  Break
11:00-12:30p  What do we mean by and what do we expect from an early warning system?
12:30-2:15  Lunch

2:15-2:45  Are there existing early warning indicators of societal vulnerability?

2:45-3:15  Early warning and intervention: What kind of information is needed to respond to the early warning? How reliable is the information?

3:15-3:45  Break

3:45-4:00  Is there a regional disaster preparedness plan? (Typhoons, etc.)

4:00-5:00  ENSO and health in Vietnam

Wednesday, 25 October

9:00-9:30am  Regional teleconnections for Southeast Asia

9:30-10:00  What are global warming scenarios for Southeast Asia?

10:00-10:30  What is the potential climate change impact on ENSO?

10:30-11:00  Break

11:00-11:30  Education, training, and El Nino

11:30-12:00p  General discussion

12:00-1:30  Lunch

FREE AFTERNOON

Thursday, 26 October

9:00-11:00a  Country and institutional experiences of weather and climate-related hazards and responses to them

11:00-11:30  Break

11:30-12:00  Educating the public (including the media)

12:00-1:00  Where should we go from here?

ADJOURN