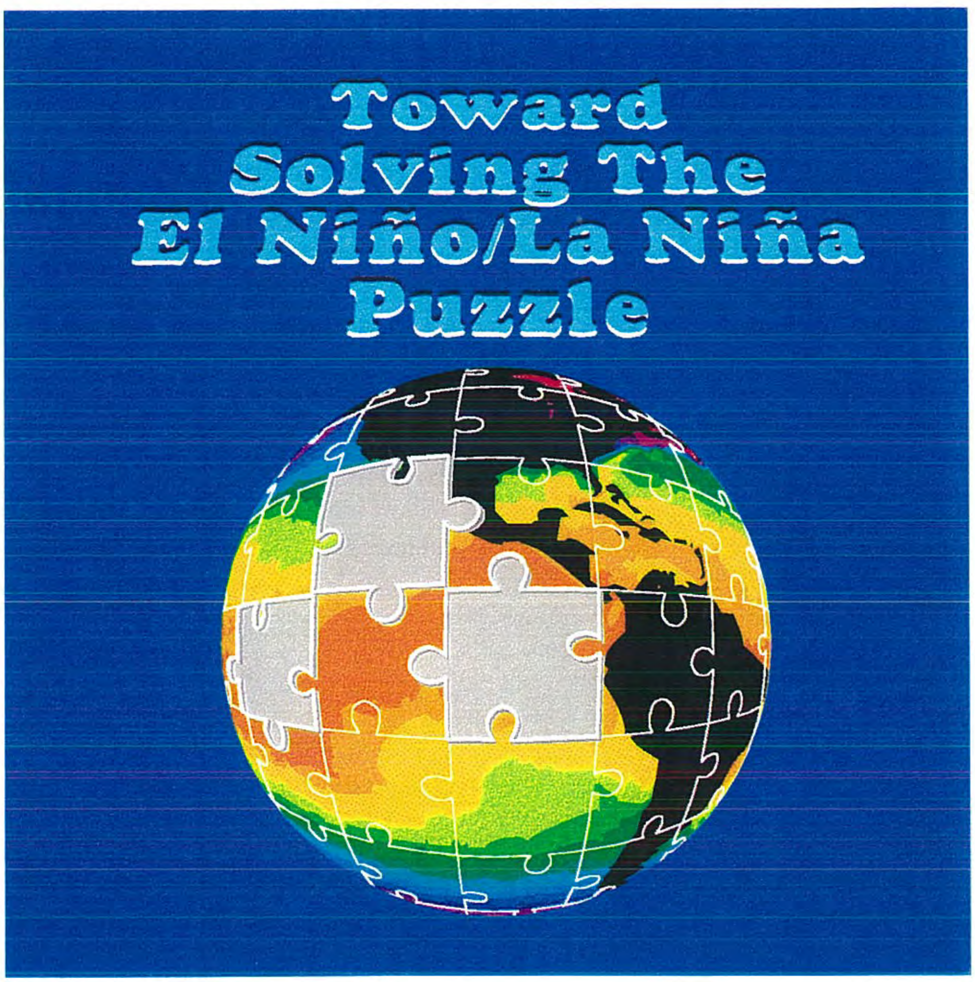
Executive Summary

A La Niña Summit:
A Review of the Causes and Consequences of Cold Events

Workshop Report
Boulder, Colorado
15-17 July 1998

Michael H. Glantz, editor
National Center for Atmospheric Research
Boulder, Colorado, USA



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National Center for Atmospheric Research*
PO Box 3000
Boulder, Colorado 80307-3000 USA

Sponsored by

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United Nations Environment Programme (Nairobi, Kenya)
National Science Foundation (Washington, DC)

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*The National Center for Atmospheric Research is sponsored by the National Science Foundation.

Glantz, M.H., 1998: *A La Nina Summit: A Review of the Causes and Consequences of Cold Events*. Executive Summary of the workshop held 15-17 July 1998 in Boulder, Colorado. Environmental and Societal Impacts Group, NCAR: Boulder, Colorado.

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Executive Summary
La Niña Summit Report

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This is an executive summary of the presentations and deliberations of the participants to the Workshop held in Boulder, Colorado, from 15-17 July 1998 on "A La Niña summit: A review of the causes and consequences of cold events." The workshop was supported by the United Nations University (Tokyo), the National Center for Atmospheric Research (Boulder, Colorado), the United National Environment Programme (Nairobi), and the US National Science Foundation (Washington, DC). The entire workshop was carried on the Internet in audio by the Exploratorium in San Francisco, California (http://www.exploratorium.edu/la_nina).

The purpose for convening such a meeting was to identify what is known, not known and what societies need to know about cold events in order to forecast their onset, growth, and decay several months in advance and to prepare for their societal impacts. (The terms *La Niña* and *cold event* will be used interchangeably in this report).

This executive summary of the Summit is based on a draft of the full report of the workshop. The full report also contains brief discussion papers prepared by several of the participants from a variety of disciplines and countries. Given the growing interest in the output of the La Niña Summit as expressed by individual researchers, commercial organizations, resource managers, the general public and the media as well government agencies, this executive summary has been issued a few weeks in advance of the full report.

The following pages attempt to capture the key aspects of deliberations during each of the workshop sessions: A review of the ENSO process of 1997-98; Problems associated with definitions of La Niña; Consideration of what constitutes 'normal' sea surface temperatures in the tropical Pacific; Teleconnections associated with La Niña; Climate change and the ENSO process; The issue of symmetry between El Niño and La Niña; Symmetry between the societal impacts of El Niño and La Niña; The attribution of societal and environmental impacts to specific La Niña events; A review of media panel discussions; Perspectives on how well the 1997-98 El Niño was forecast; Forecasting the onset of a La Niña in 1998-99; The differences in forecasting El Niño and La Niña; and Monitoring La Niña. Each section provides highlights of a few (but not all) of the key points made during the individual sessions.

Although discussion on each of these topics was centered in a specific workshop session, some of the topics were raised again directly or indirectly in other sessions. Thus, these are cross-cutting, not mutually exclusive topics. For example, the concern about the need for a more precise definition of La Niña was expressed in most sessions. Symmetric impacts as well as teleconnections of El Niño and La Niña were also mentioned in different contexts throughout the workshop. The attribution issue was also revisited several times.

El Niño, La Niña and the climate swings of 1997-98

Michael McPhaden (National Oceanic and Atmospheric Administration/Pacific Marine Environmental Labs) provided an overview of development of the 1997-98 ENSO cycle in the tropical Pacific. He noted that the successes in observing the evolution of the 1997-98 El Niño, and in forecasting its impacts, were in striking contrast to the situation only 15 years ago when the last major El Niño in 1982-83 was not even detected until it was nearly at its peak. These recent successes were in large part the result of (1) the development of an observing system of satellites and ocean measurements, anchored by a buoy network spanning the equatorial Pacific (Figure 1) providing data in real time (within hours of collection); and (2) the development of computer forecast models for predictions.

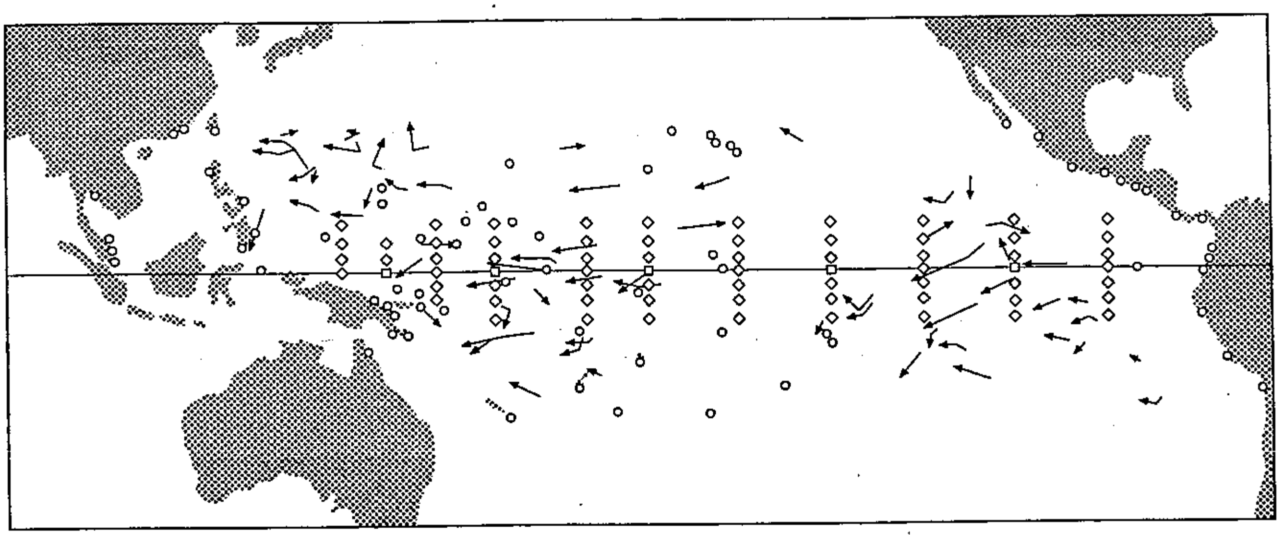


Figure 1. Tropical Atmosphere Ocean (TAO) Array. Courtesy of M. McPhaden, NOAA's Pacific Marine Environmental Labs. Open circles denote automatic tide gauge stations. Squares and diamond indicate locations of moored buoys, and the arrows depict the tracks of drifting buoys.

He reported that the onset of El Niño was heralded by warm sea surface temperature (SST) anomalies (i.e., deviations from normal) erupting in the tropical eastern Pacific during April-June 1997. By July 1997, SST anomalies in this region were the warmest observed in the past hundred years. By the end of the year, SST anomalies exceeded 5 degrees C, and were higher than the anomalies observed at any time during the 1982-83 event (which up to that time had been the strongest of the century).

As the warm SST anomalies began to wane in early 1998, prediction models were largely consistent among themselves in forecasting an end to El Niño, and the development of a La Niña sometime during the second half of 1998.

The surprise to El Niño researchers, though, was how quickly the tropical Pacific switched from warm to cold conditions. McPhaden commented that a temperature drop of 8 degrees C at one buoy location in the central Pacific over a relatively brief 30-day span had not been observed before, making the termination of the El Niño as stunning as was its relatively rapid onset. He suggested that the seeds for El Niño's demise, and for the birth of La Niña, were to be found below the ocean's surface. In late 1997, the buoy array detected a cold mass of water — situated at a depth of 100-150 m west of the Date Line — and documented its expansion eastward along the equator.

McPhaden concluded by noting that during the past two years we have witnessed a spectacular display of climatic variability. The first part of that display, El Niño, is over, and the second, La Niña, is under way. A newly completed observing system, designed specifically for ENSO detection and forecasting, provided essential information at a level of detail never before possible. As a result, our climate crystal ball was sufficiently clear in 1997 to motivate national and local governments to undertake disaster preparedness, mitigation efforts, and other worldwide responses to developing El Niño conditions on an unprecedented scale.

Key Points:

- The successes in observing the evolution of the 1997-98 El Niño, and in forecasting its impacts, were in striking contrast to the situation only 15 years ago when the last El Niño in 1982-83 was not even detected until it was nearly at its peak.
- As the warm SST anomalies began to wane in early 1998, prediction models were largely consistent among themselves in forecasting an end to El Niño, and the development of a La Niña sometime during the second half of 1998.
- The seeds for El Niño's demise and for the birth of La Niña were to be found below the ocean's surface.
- Our climate crystal ball was sufficiently clear in 1997 to motivate governments to undertake disaster preparedness, mitigation efforts, and other worldwide responses to developing El Niño conditions on an unprecedented scale.

Problems associated with definitions of La Niña

James O'Brien (Center for Ocean/Atmosphere Prediction Studies, Florida State University) led discussion on this topic. Cold events in the central and eastern equatorial Pacific have been referred to in many ways by various scientists and media personnel. For the most part, La Niña (or cold event) has been defined in terms of El Niño, that is, with El Niño as its reference point. For example, one can find in the media and in professional journals such statements as the following: El Niño's counterpart, the inverse of El Niño, El Niño's sister, anti-El Niño, the opposite of El Niño, the flip side of El Niño, El Niño's lesser known twin, and non-El Niño.

In a strict sense, La Niña is an extreme cooling of the central and eastern tropical equatorial Pacific over a period of several months. It is not just any drop in temperature below (i.e., cooler than) the long-term average. For some parts of the globe, La Niña is perceived as an extreme case of normal in that nothing unusual is expected to occur with regard to climate anomalies.

Problems in the evaluation and use of La Niña-related information arise because of the lack of consensus on a single, universally accepted description of what constitutes a La Niña event. The lack of a widely accepted definition creates problems for users of ENSO information who seek to identify correlations between La Niña events and, for example, crop yields, fish landings, or rainfall anomalies in a particular location.

Also, the way in which one defines La Niña in quantitative terms determines how many events have occurred. The more strict the definition, the fewer the events and the smaller the sample of La Niña cases to assess for its physical characteristics or for its environmental and societal impacts. Thus, scientists point out that there have been about twice as many El Niño events as La Niña events since the early 1970s.

Key Points:

- Until now, most articles that refer to La Niña put it in the context of the El Niño phenomenon. Thus, the reference point for La Niña (or, cold event) is El Niño, whereas the reference point for El Niño is 'normal' sea surface temperatures (SSTs) in the central Pacific.
- Because of differing definitions of La Niña, the reliability is reduced of the statistical correlations identified between La Niña events and their worldwide teleconnected impacts on environment and society.
- Physical scientists appear to be less concerned about the need for a universally agreed on definition than are various users of La Niña information.

- Some researchers have proposed that the smaller number of La Niña events than El Niño since the early 1970s has been the result of human-induced global warming of the atmosphere.
- Should the definition of what constitutes a La Niña event change over time, in order to take into account decadal scale changes in air-sea interaction and their impacts in the Pacific?

What is 'normal' with respect to sea surface temperatures in the tropical Pacific?

Jospeh Tribbia (Climate and Global Dynamics/NCAR) opened the session, noting that views differ about what constitutes normal sea surface temperatures in the tropical Pacific. Some observers suggest that there are only two states, warm and cold. Others suggest that there are two different states, El Niño (warm) and non-El Niño (i.e., everything else). Still others suggest that there are three states of ocean temperatures in the central Pacific: *extreme* warm, *extreme* cold and *normal*. Each of these states can be quantitatively defined and each can be associated with the occurrence of weather and climate anomalies (i.e., extreme meteorological events) around the globe. The public, fostered by media stories, video clips, and interviews with scientists, tends to believe that the El Niño phenomenon is "the culprit" in bringing about poor climatic conditions and death and destruction in many countries, rich and poor alike.

Only recently, following the 1997-98 El Niño event, now considered to have been one of the two largest in a century, have the media shown any serious interest, though short-lived, in La Niña, in part because of its expected adverse impacts. Adverse impacts include an increase in the number of tropical storms and hurricanes in the tropical Atlantic and in the Gulf of Mexico.

It has been known for some time that extreme meteorological events (e.g., droughts, floods, tropical storms) can be associated with a normal range of SSTs in the tropical Pacific. However, the relatively short time series for global sea surface temperatures makes it difficult to determine what really constitute normal.

Key Points:

- Clearly, a definition is needed of what constitutes normal with respect to SSTs in the central and eastern Pacific in general and what constitutes El Niño and La Niña.

- "Normal" should not be defined simply as "average"; it should also include the extremes. La Niña conditions represent one facet of what might be considered "normal" in terms of expected climate conditions.

- Even under normal conditions, extreme meteorological events such as droughts and floods and climate-related forest fires will occur at various locations around the globe.

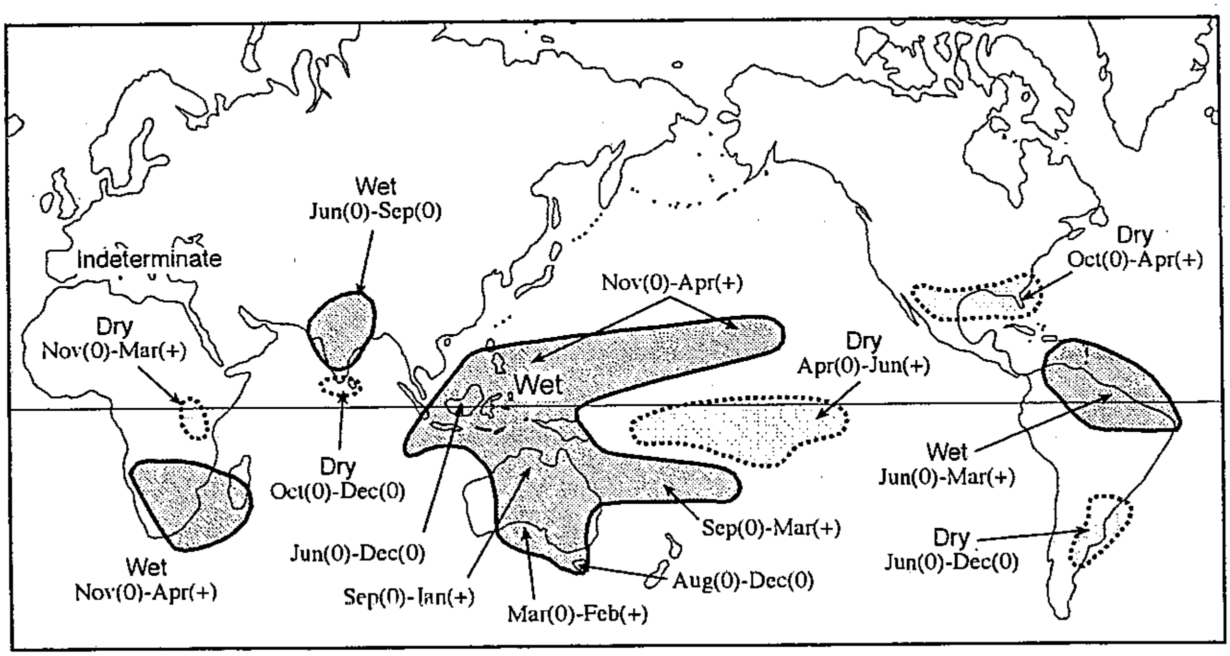
- In general, typical variations around the norm in tropical SST's do not generate normal variations in impacts at distant locations.

Teleconnections associated with La Niña

George Kiladis (Aeronomy Lab, NOAA) opened the workshop session on La Niña teleconnections by defining the term "teleconnections" as the influence of SST variations in the tropical Pacific on regional and local climate regimes around the world. He then provided a brief overview of the causes and effects of teleconnections during La Niña (Figure 2) and their probable physical cause (Figure 3).

Physical scientists are researching how events in the tropical Pacific transmit a signal through the atmosphere to distant places on the globe. Since tropical convection represents the primary "heat engine" for the global atmospheric circulation, changes in the location of this convection alter that circulation, which in turn is manifested as climate anomalies. For example, as convection shifts westward from the tropical Pacific into the Indian Ocean during La Niña, the jet stream over the Pacific is weakened, thereby affecting the downstream wave activity (high and low pressure weather systems) moving into North America.

Several maps were then presented to the participants depicting the global temperature and precipitation composites for both La Niña and El Niño events (for an example, see Figure 3). It was suggested that there was some degree of linearity between El Niño and La Niña impacts over many regions, meaning that cold events in several locations produced the opposite climate anomalies to those occurring during warm events. However, the reliability of the teleconnection signals becomes less as one moves farther away from the tropical



(0) = Year of La Niña Onset
(+) = Year Following La Niña Onset

Figure 2. Potential rainfall impacts from La Niña events (cold episodes). Source: USDA, 1994.

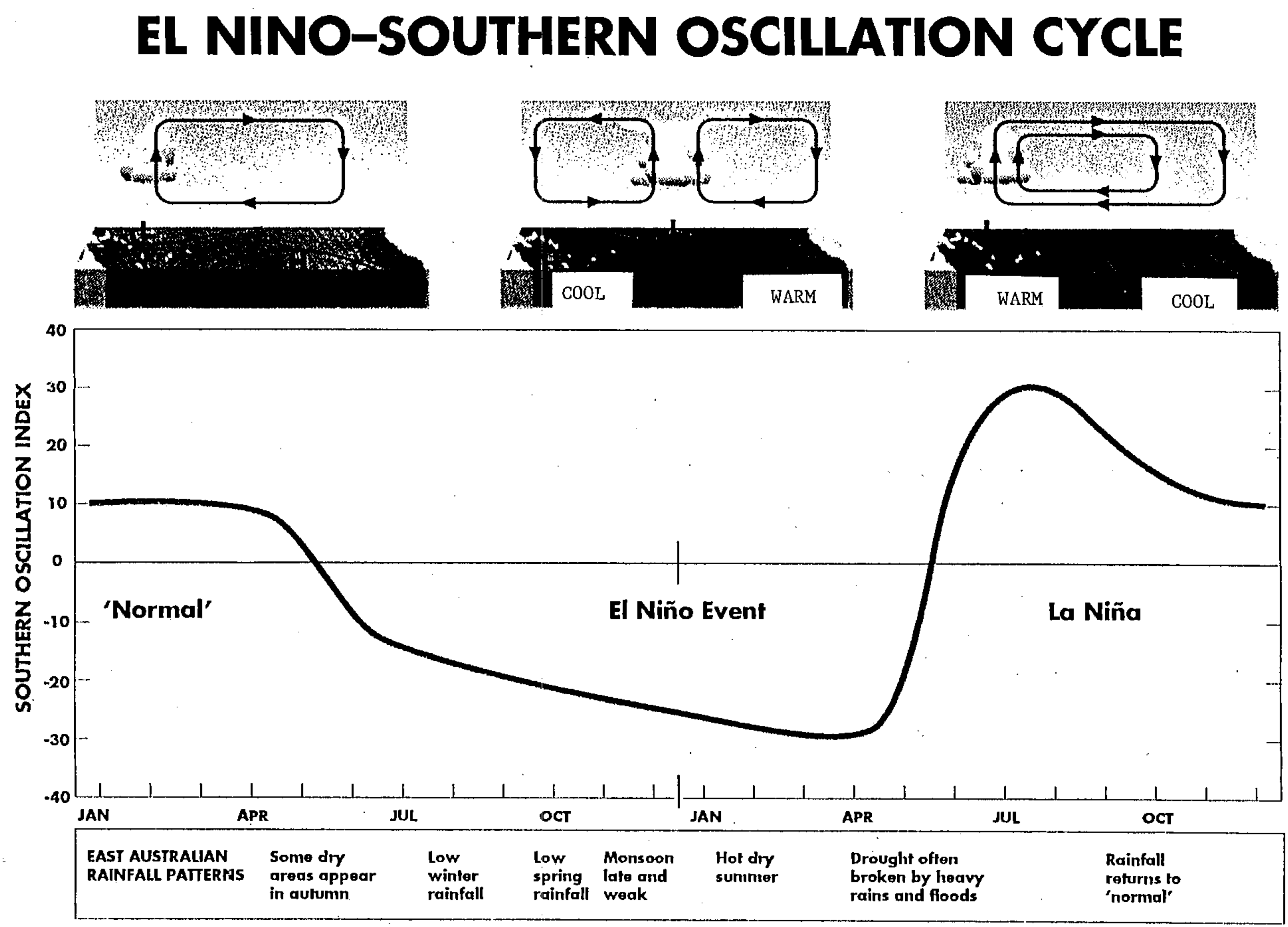


Figure 3. Graphic depicting the ENSO cycle. Taken from http://www.dnr.qld.gov.au/longpdk

Pacific, the "center of action" of ENSO. Thus, even though a given teleconnection might still be defined as statistically significant, and most certainly related to the entire population of warm or cold events, the probability of that signal occurring during any one event may not necessarily be very high because of the large amount of climate "noise" (random fluctuations in the atmosphere) that exists at any given time. This is especially true in the extratropics, where a large degree of internal climate variability is dominant, as opposed to the tropics, where climate variability is determined by SSTs to a much greater degree. In addition, weak and moderate La Niña events might not be strong enough to generate climate anomalies in distant locations.

Kiladis then noted what he considered to be among the robust (reliable) La Niña teleconnections. These included a tendency for wetter-than-normal conditions and a risk for flooding in southern Africa and the monsoon regions of India, Indonesia, and northern Australia, and drier-than-normal conditions, sometimes leading to drought, over eastern Africa, the western equatorial Indian Ocean, southern South America, and the southern Plains and southeastern portions of the United States. In general, tropical sea surface temperatures tend to be below normal, with robust signals appearing even as far away from the tropical Pacific as Africa. The most pronounced extratropical temperature signals during La Niña are seen over North America in winter, where there is a tendency for colder-than-normal conditions over Alaska, western Canada, and the central Plains of midwestern Canada and the northern United States, and warmer-than-normal tendencies over the southeastern United States.

Key Points:

- Even though a given teleconnection might be defined as "statistically significant" and almost certainly related to the entire population of warm or cold events, the probability of that signal occurring during any one La Niña or El Niño event may not be very high because of the random fluctuations in the atmosphere.

- A fruitful area for ENSO research might involve going beyond simply documenting the "expected" anomalies during a particular season due to La Niña and El Niño, and looking at the variability within a season as it relates to tropical SSTs.

- Many of the time series used in teleconnection analyses are of relatively short duration. Therefore, teleconnections identified as being robust during one epoch may fail completely during a later epoch. While some of this might be attributed to the statistical fragility of using short-term samples, there could also be long-term changes in the climate system itself which could alter the response of the atmosphere to sea surface temperature anomalies.

The impacts of La Niña on specific countries and sectors

Several participants were asked to present their thoughts in brief discussion papers that focused on country- and sector-specific information about La Niña, specifically, and the ENSO cycle in general. Many countries have, until now, shown little, if any, interest in cold events. In fact some of these countries have only recently become concerned about El Niño research and about research about the impacts of El Niño on key sectors of their societies. The countries represented in the discussion papers* in the full report are the following:

Cuba (Lino Naranjo Diaz, *La Niña Impacts in Cuba*),
Kenya (Peter Usher, *Kenya and ENSO: An Observation and La Niña Prediction*),
Vietnam (Nguyen Huu Ninh, *Effects of La Niña on Cyclone Tracks in the Western North Pacific*),
Ecuador (Pilar Cornejo-Grunauer, *La Niña Effects in Ecuador*),
Peru (Kenneth Broad, *The La Niña Summit: Lessons for the Societal Application of Climate Information*; and Norma Ordinola, *The Consequences of Cold Events for Peru*),
Uruguay (Walter Baethgen, *El Niña and La Niña Impacts in Southeastern South America*),
Argentina (Guillermo Berri, *Some Effects of La Niña on Summer Rainfall, Water Resources, and Crops in Argentina*),
Australia (Tahl Kestin and Neville Nicholls, *Forecasting with ENSO in Australia: The Problems are Not Over Yet!*),
Panama (Maria Concepcion Donoso, *La Niña and Mesoamerica*),
Ethiopia (Tsegay Wolde-Georgis, *ENSO Cold Event Impacts and Ethiopia*),
United States (Allan Brunner, *Energy, Economics and ENSo in the US*; Nate Mantua, *La Niña Impacts in the Pacific Northwest*; Maurice Roos, *Effects of ENSO on California Precipitation*; and Warren Wooster, *La Niña and El Niño Impacts in the Eastern North Pacific*, among others*),
Canada (Ray Garnett, *La Niña from a Canadian Perspective*; and Amir Shabbar and B. Bonsal, *The Impact of ENSO on the Canadian Climate*),
China (Wang Shao-wu, *La Niña Events and their Impacts on the Climate of China*),
Japan (Mikiyasu Nakayama, *Awareness of ENSO Events in Japan*)
South Korea (Jai-Ho Oh and Yong Hee Lee, *Detection of the ENSO Signal on the Climate of Korea*).

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*These and other papers can be found in the Appendix of the full report of the workshop. A list of these papers is on pages 36-37 of this report.

Climate change and the ENSO process

Kevin Trenberth (Climate and Global Dynamics/NCAR) opened the discussion session on climate change by noting that interest in the relationship between the ENSO process and global warming of the atmosphere has been increasing in recent years. Some studies have suggested that (1) the unusual behavior of the tropical Pacific's sea surface temperatures in the first half of the 1990s (considered by some observers to have been one continuous El Niño from 1991 to 1995) and (2) the apparent climate regime shift after the mid-1970s are the result of influences of human-induced global warming of the atmosphere. Others have challenged that view, arguing that there is not enough evidence as yet to identify with certainty the linkages between these two processes, one natural and one possibly human-induced. Because ENSO is involved with the movement of heat, it is conceptually easy to see how increased heating from the buildup of greenhouse gases can "interfere."

The instrumental observational record is not really long enough to sample all of nature's variety, especially with regard to variations on decadal time scales. One approach to this then is to use proxy data, such as those provided from tree rings, and the annual layers of coral or tropical glaciers. Some reconstructions using these methods show El Niño variations quite nicely. However, their decadal variability is compromised by the impacts of non-climatic effects. Another problem with proxy data is that the actual climate is changing, and so the results do not simply give the variability that occurs in an unchanging climate.

Another approach is to use models. At this point, no global climate model is able to simulate El Niño events as realistically as desired to build confidence in the results. Several models, but not all, suggest increased warming in the eastern Pacific, so the mean climate becomes a bit more El Niño-like. Some models suggest strong El Niño/La Niña swings may occur, but none simulate El Niño with sufficient fidelity to have confidence in their results. The natural variability of the atmosphere must be identified at both the interannual and interdecadal time scales and a more extensive time series of SST changes in the equatorial Pacific must be developed before one can begin to assert with confidence that linkages between these two processes have an acceptable degree of reliability.

Key Points:

- While it is reasonable to assume that global warming would affect the ENSO process, it is not yet known how.

- The paucity of data makes establishing a reliable, long El Niño record difficult. Proxy data are not yet up to the task. An SOI (Southern Oscillation Index) is a good simple (single number) index to monitor the state of the tropical Pacific on time scales beyond interannual. It shows something unusual is happening in the tropical Pacific. Models are not yet adequate to clarify what this unusual happening is or what is causing it to occur.

- Following El Niño's warming peak, the earth's atmosphere temporarily warms up.

Symmetry between El Niño and La Niña events

Martin Hoerling (NOAA-University of Colorado, CIRES Climate Diagnostics Center) noted that the tropical Pacific Ocean undergoes an oscillation, albeit irregular, between warm (El Niño) conditions an cold (La Niña) conditions. This variability occurs relative to a climatological mean, or normal ocean state.

The overall distribution resembles a bell curve, or Gaussian, shape, and the El Niño and La Niña events reside in the less-frequented tails of that curve. But is that distribution a perfect bell shape, or is it somehow skewed? For example, can the sea surface temperatures become anomalously colder by as many degrees as they can become anomalously warm? Furthermore, does the atmosphere, by which we refer to the rainfall, pressure and wind systems, respond symmetrically with respect to El Niño and La Niña? In other words, is the atmospheric response to La Niña merely the mirror image of its response to El Niño? Furthermore, does the atmosphere react twice as strongly, if the ocean temperature anomalies are doubled?

Symmetry of course would greatly simplify the problem of predicting the expected effects of tropical Pacific SST anomalies on climate, but the problem is somewhat more complicated than this simple linear symmetric view of the world.

Hoerling presented an overview of the issue of symmetry between El Niño and La Niña, using as a tool the results from several sophisticated numerical models of the atmosphere and their sensitivity to ENSO extremes.

His purpose was to study the atmosphere's sensitivity in the extreme tails of the ENSO bell-shaped distribution, since the extreme events undoubtedly exert the largest impact, and for which any departures from symmetry would be critical to understand.

Hoerling provided some examples from the observational data alone that, if one were to separate out the events according to their varying intensities, one would find that the weaker events tend to behave in a linear fashion. It is for the larger ENSO events that one tends to see asymmetry or nonlinear behavior in atmospheric and oceanic anomalies. His main point was that in several parts of the globe, including North America and even the tropical Pacific, the wintertime (i.e., December, January and February) climate anomalies associated with the extreme La Niñas were weaker than their El Niño counterparts. Also, the spatial patterns were not mirror images of each other, but instead the centers of maximum anomalies over the Pacific-North American region were shifted several thousand kilometers with respect to one another.

These impressions, drawn from empirical analysis, were substantiated by results based on general circulation model simulations of the atmospheric response to warm and cold tropical Pacific Ocean temperature anomalies. Taken together, the observational and model results cast doubts over the simple notion of symmetry.

He also noted that the climate system was much more deterministic with respect to tropical Pacific rainfall: a single ENSO event produces a reliably detectable signal across the tropical Pacific. Over North America, however, one needs to witness several El Niño or La Niña events in order to get a statistical sampling of the climate signal related to the SST forcing, and to be able to distinguish that from the the range of climate states that occur naturally in the absence of extreme ENSO conditions.

In response to questions raised about the influence of temperature changes in other oceans, it was noted that SST changes in the Indian and Atlantic oceans and convection processes in the maritime region of Indonesia and Malaysia have been less well studied than those in the tropical Pacific.

Key points:

- Evidence was provided that the climate impact of strong El Niño events is not a simple mirror image of the impact of strong cold events.

- The climate response tends to behave symmetrically with respect to the sign of the equatorial Pacific sea surface temperature forcing when that forcing is weak, i.e., that response associated with the most often observed "garden variety" ENSO events.

- The spatial pattern of climate impacts associated with extreme La Niña events is different from the pattern during extreme El Niño events. In particular, the centers of strongest impact over the Pacific-North American region were shifted several thousand kilometers with respect to one another.

- The reliability (and, hence, the predictability) of North American climate impacts during extreme La Niña events is lower than it is for extreme El Niño events.

- The wintertime (December, January, February) climate anomalies associated with extreme La Niña events are weaker than their El Niño counterparts.

Symmetry between the societal impacts of El Niño and La Niña

Michael Glantz (NCAR) opened the discussion on the symmetry of impacts by first drawing attention to the sharp increase in access to the Internet, which has helped to proliferate the number of websites devoted to various scientific and societal aspects of the ENSO cycle. At first, websites focused mainly on El Niño, but interest in La Niña has increased in recent times.

Almost every website refers to the El Niño-La Niña process as one of symmetry in impacts, meaning that it believes that the opposite impacts of about equal strength will accompany either El Niño or La Niña. But a closer look at the local and regional societal and environmental impacts should prompt a call to move away from such a simple view of symmetry in impacts of the ENSO cycle. It is necessary and more useful to talk about societal impacts in terms of tendencies and probabilities of occurrence.

Because people and governments have been blaming El Niño, rightly or wrongly, for many climate-related problems faced by their citizens and economies, a "Buyer Beware" label should accompany the information on (including forecasts of) ENSO extremes provided in some of these sites.

Factors that cast a shadow on the claim of symmetry include, but are not limited to, the following: scientists do not agree on a precise list of La Niña or El Niño years; composite maps are misleading in that they average out the impacts of weak events with the strong ones; a reliance on a previous El Niño event as an analogue to identify or forecast impacts is also misleading because the set of impacts from one event to another will likely differ, depending on the influences of regional and local climate processes around the globe; and the number of observed events is too small as yet for reliable scientific projections.

However, there are some locations around the globe where the societal impacts of El Niño and La Niña appear *in general* to exhibit some "usable" degree of symmetry: for example, Uruguay, Argentina, Brazil, Australia, Indonesia, Papua New Guinea, Peru, Ecuador, Chile, the US Gulf states, Central America, western Canada, and southern Africa.

At present, there are several impacts maps that depict in a general way the impacts of El Niño and La Niña on precipitation and temperature in a number of countries around the globe. Most of these maps, although seemingly different, are graphic variations of those produced in the late 1980s. However, because these maps were produced in the late 1980s, it is time to update as well as to assess them critically. Although they tend to show symmetry of physical and, therefore, societal impacts, the sample size of La Niña events used to prepare the maps is small. Also, these maps are composites of the impacts of a set of events, but such composites mix the impacts of weak and strong events together. Thus, there appears to be symmetry but considerable detail is lost. However, if one were to separate the weak from the strong events, different maps would emerge, as suggested by Kiladis and Hoerling in other sessions of this workshop. While weaker events tend to behave in a similar and symmetric fashion, the stronger ones appear to manifest nonlinear behavior in the ocean or the atmosphere.

Perhaps one can speak of symmetry between the societal and environmental impacts of El Niño and La Niña in much the same way that one refers to the greenhouse analogy when discussing the greenhouse effect with regard to the atmosphere. While the analogy of the atmosphere as a greenhouse has its beneficial uses (e.g., educating the public), it is inaccurate and misleading if carried too far. The same applies to the notion of the symmetry of ENSO impacts on environment and society.

Key Points:

- The notion of symmetry in societal impacts between El Niño and La Niña is useful for educating the public about the ENSO process. However, it does not provide enough information for making specific decisions with regard to impact mitigation for a specific ENSO event.

- While there are locations around the globe that appear to exhibit some degree of symmetric societal impact, there are many other locations where such symmetric impacts should not be expected.

- Composite maps of ENSO impacts provide average information for a relatively small number of La Niña events. Today they are in need of review, amendments and refinement.

- The climate system is more deterministic in the tropical Pacific where a single event can produce a signal across the basin. In North America, however, one needs to observe several El Niño events in order to get a better sampling of what is the range of physical and, therefore, societal impacts that might occur.

The attribution of societal and environmental impacts to specific La Niña and El Niño events

Just about everything that happened between September 1997 and May 1998 that was either unwanted or unexpected was blamed on El Niño, i.e., the devastating ice storm in Quebec and the northeastern US, killer tornadoes in Florida and Alabama, heat wave and drought in Texas, coastal storms in California, and so on. However, just because there are weather and climate extremes that occur while an El Niño or La Niña event is in progress, there may be little reason to link them in terms of cause and effect.

Gerald Meehl (Climate and Global Dynamics Division, NCAR) identified two major issues involved with attribution. The first is to what do we attribute the actual cause of La Niña. This involves mechanisms of ocean-atmosphere coupling, and are captured to various degrees in the coupled climate models used to forecast El Niño or La Niña. This type of attribution was left to other discussion sessions.

Instead, the focus was on a second type of attribution. This concerns the type of climate anomalies or impacts we can attribute to La Niña. Here we separate the manifestations of occurrence of El Niño or La Niña from the climatic impacts of individual events. For the former, a number of studies have documented low-frequency decadal time-scale variability in the tropical Pacific that could affect the manifestation of El Niño and La Niña impacts. Thus, the record-setting El Niño of 1997-98 could be characterized as having a contribution from (1) coupled processes on the interannual time scale; (2) a warm phase in the decadal oscillation, and (3) a longer-term warming trend in the eastern Pacific. These effects, superimposed upon one another, could combine to produce the large El Niño we experienced in 1997-98. Similarly, these factors could affect the manifestations of individual La Niña events. Thus, we could think of attributing El Niño or La Niña occurrences to a combination of processes acting on different time scales.

In the latter category of how we can attribute seasonal mean climate anomalies to individual El Niño or La Niña events, the concept was developed of a seasonal mean anomaly as a collection of meteorological events, or a shift of the probability distribution of certain conditions in a season in a certain region.

It is very important that such attributions to La Niña events be reliable, because actions taken by societies will likely be taken based on the belief that La Niña events tend to spark certain kinds of adverse conditions, such as Midwestern drought conditions in the summer of 1988. If such an attribution proves to have been incorrect, societies will have wasted scarce resources to respond to unlikely adverse events.

While there is a strong, almost irresistible, temptation to attribute every individual meteorological event to La Niña or El Niño, most of these attributions cannot as yet be supported by scientific proof, with some exceptions.

The following graphic (Figure 4) depicts an alleged cause-and-effect chain of events that begins with the increase in sea surface temperatures in the central and eastern equatorial Pacific (in this case, a strong El Niño) and ends with a number of people suffering from carbon monoxide poisoning. While there is some logic to the stream of cause and effect noted below, there is a point at which the logic is carried too far. For example, while it may be feasible to blame El Niño for having contributed to the strength of the ice storm and the ensuing destruction, and to link the sale of gas-fired space heaters to the ice storm, it would be rather a "stretch" to blame El Niño for the placement of leaky space heaters in poorly ventilated areas, thereby increasing the incidence of carbon monoxide poisonings. The bottom line is that we cannot blame everything that happens in an El Niño or La Niña year on that particular event.

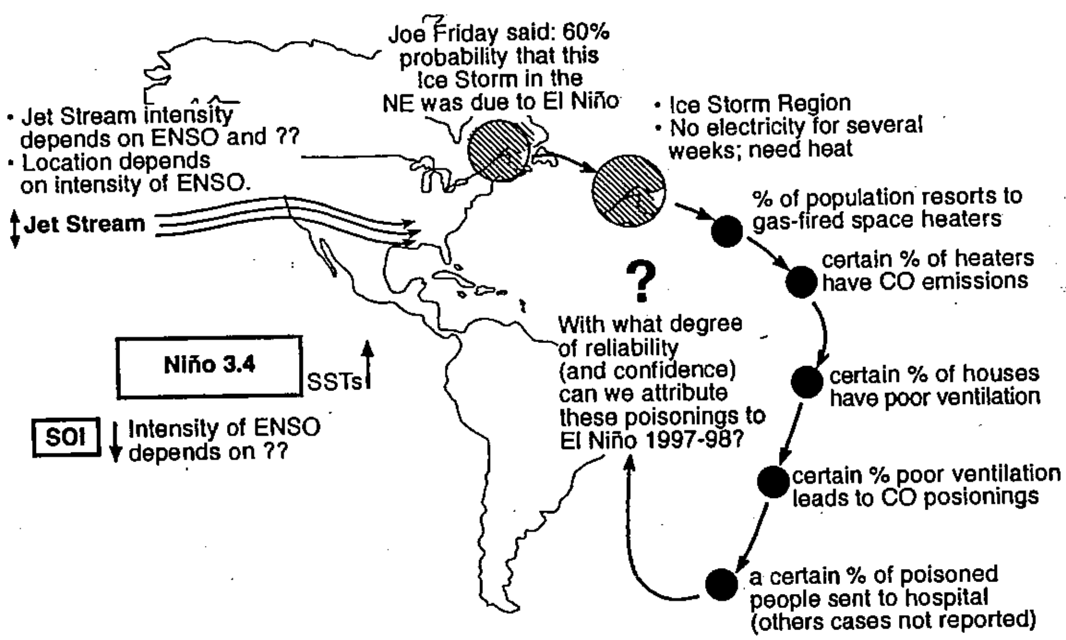


Figure 4. Problem of attribution of impacts to ENSO: January 1998 ice storm example (M. Glantz, NCAR 1998)

As a final comment, it was suggested that the best way to view attribution was to think of the forcing of sea surface temperature changes from the tropical Pacific as having the effect of shifting the statistical probabilities of a set of meteorological events over the course of a season toward wetter or drier, warmer or colder conditions.

Key Points:

- There are two types of attribution: the first is "to what do we attribute the actual cause(s) of La Niña," and the second is "what are the types of climate anomalies or societal impacts we can attribute to La Niña."

- The best way to view attribution is to think of changes in SSTs in the tropical Pacific as having the effect of forcing a shift in probabilities of the sum total of teleconnected meteorological events over the course of a season toward wetter or drier, warmer or colder.

- The 1988 US Midwest drought/La Niña teleconnection is now being challenged, as researchers develop other plausible climate scenarios that could produce a drought of similar magnitude in that region. This is important to note because many people have tended to look at what happened during the strong 1988-89 La Niña as a guide to their responses to the forecast of the possible onset of a moderate to strong La Niña in late 1998 and early 1999.

Media panel review of "Reporting on the 1997-98 El Niño"

The media had a major role in fostering awareness among policy makers and the public of an upcoming El Niño in 1997-98 and its potential for devastating impacts around the globe several months in advance of its onset. As it happened, that event did turn out to be one of the two strongest in the 20th century. Media coverage of El Niño was so intense and often sensationalized that the media were accused of "hyping" El Niño in a negative way by generating "gloom and doom" scenarios, many of which were either premature or eventually proved to be incorrect. One workshop participant suggested that for all practical purposes "El Niño might as well have been the Spanish word for hype". Even some members of the media have begun to assess their performance during the recent El Niño, contending, however, that the constant headline coverage of El Niño was dictated to them by the interests of the public in the topic. The tendency of the press coverage of El Niño, for example, to focus on adversity has been reflected in various newspaper headlines (Figure 5).

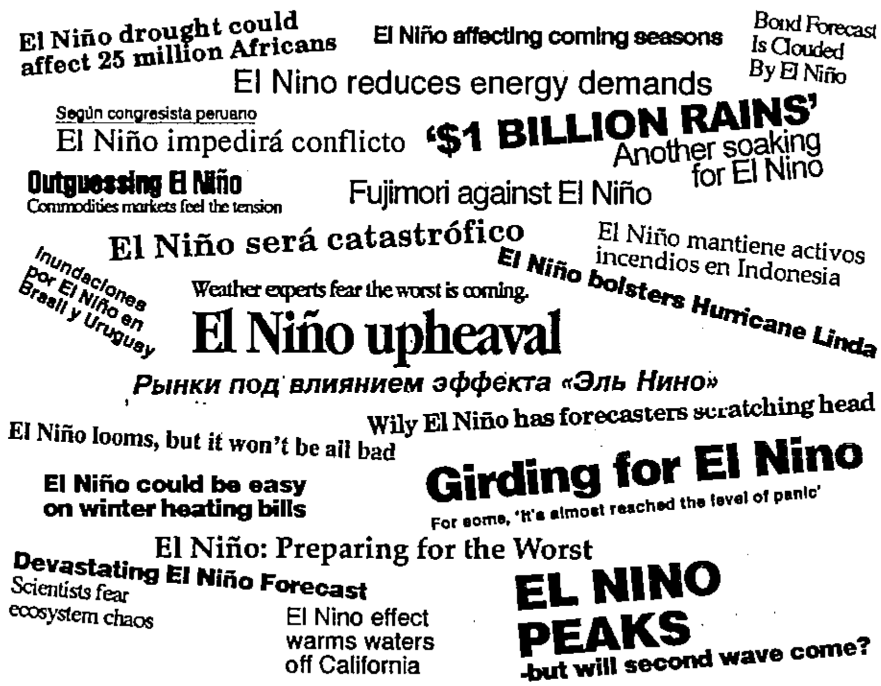


Figure 5. Headlines taken from various newspapers around the world (M. Glantz, NCAR).

Media representatives pointed out that a serious "language" (i.e., communication) problem existed between them and the scientific community. Causes of this problem include, but are not limited to, the following: very few science writers have scientific backgrounds; there is a tendency among scientists and the media to overstate conditions (the media tend to highlight extremes and shifts, while the scientists tend to present their efforts in a more positive light); time constraint is an important factor as it is difficult for the media to maintain interest in long term scientifically based issues; the media have the added difficulty of presenting a range of views thereby having to take note of outlying as well as minority views on scientific issues, even when those views might lack much support. It was proposed that scientists and the media should work closely together, exploring new ways to educate each other more effectively on the ENSO cycle and its impacts on environment and society. There was confusion between forecasting the El Niño phenomenon and forecasting its societal impacts several months following its onset. Successful forecasts of the latter (e.g., societal impacts) do not necessarily stem from forecasts of the former (e.g., the physical event).

It appears that the media's interest in La Niña is following on the coattails of one of the biggest El Niño events in a century. It became clear very quickly that much less is known about La Niña events than El Niño, as it had received much less attention until now from the scientific community than El Niño had. Note that the following media headlines on La Niña (Figure 6) are considerably less sensational than those for El Niño stories (Figure 5).

Figure 6. La Nina headlines taken from the international media (M. Glantz, NCAR).

Key Points:

- The media is not a homogeneous unit that speaks with one voice, nor do they operate by one set of rules or share the same reporting ethics.
- The media is attracted to stories that are unusual or have adverse consequences. They do not necessarily focus on reporting good news or long-term processes. They believe they are responding to the interests of the general public.
- While all agreed that presenting La Niña and El Niño information in probabilistic terms was the correct way to go, several participants felt that the public was not yet capable of understanding or using such information. Others felt that it was time to prepare the public for probabilistic statements.

How well did we forecast the 1997-98 El Niño?

Forecasting El Niño (and La Niña) is still fraught with difficulties, with some researchers suggesting that forecasting the onset of La Niña was a more difficult task than forecasting the onset of El Niño. Anthony Barnston (NOAA's National Center for Environmental Prediction, Climate Prediction Center) began this session noting that, based on an analysis of 15 statistical and dynamical models, most models did forecast some degree of warming of the tropical Pacific sea surface temperatures one to two seasons prior to the onset of the 1997-98 El Niño in the Northern Hemisphere spring of 1997. However, none had detected its strength until the event was already on its way to becoming strong in the early summer of 1997.

The dynamical and statistical models performed with about the same level of success during this episode. He noted that the most comprehensive dynamical models performed better than the simple dynamical ones. Once the El Niño had developed in mid-1997, a larger set of the models was able to forecast its peak in late 1997 and dissipation and reversal to cold conditions in late spring and early summer 1998.

Because ENSO extremes usually begin to develop in the Northern Hemisphere spring or early summer and persist through the following winter, forecasting the *tendencies* of the teleconnected impacts in extra-tropical North America for the winter (when impacts are most pronounced) at lead times of about five months is not difficult. Given the strength of the 1997-98 El Niño and the consequent skill of the 5-month lead forecasts of U.S. impacts in the winter of 1997-98, the success of these forecasts of impact tendencies was noticed to an unprecedented extent by the media and, hence, the general public and policy makers.

Because of the need for forecasts to be expressed verbally and also to be precise enough for meaningful utility and verification, a simple numerically based verbal classification system for describing ENSO-related forecasts was proposed.

Key Points:

- The performance in forecasting the onset of the 1997-98 El Niño was largely mediocre.
- Dynamical models as yet do not outperform the statistical ones, with respect to forecasting El Niño.
- The communication between forecasters and users still leaves something to be desired. It appears that neither really understands how the other thinks and what the other does or does not understand.
- Forecasting the tendencies of teleconnected impacts in North America for the winter season following the peak of an El Niño event at lead times of about five months is not, relatively speaking, difficult.

Forecasting the onset of a La Niña in 1998-99

Nicolas Graham (International Research Institute/Scripps Institute of Oceanography) opened discussion on forecasting La Niña by noting that, as of mid-July 1998, the observed trend in sea surface temperatures in the tropical Pacific in the region referred to as Niño3.4 was from a warm event toward a La Niña. Cold SSTs were beginning to appear in the central Pacific. It was suggested that the relatively rapid decline of El Niño conditions in such a short period of time was more similar to that for the 1972-73 event than for the 1982-83 event.

Several models had projected several months in advance a shift from a warm event in mid-1998 to a cold event by the winter of 1998-99. Although the dynamical and statistical models performed about the same, it was expected that in the future the dynamical models (producing an ensemble of forecasts) would produce more reliable forecasts than the statistical ones.

It was noted that several models have different but consistent biases and that such biases should be taken into account in their forecasts. It is important to know the model biases, so that their forecasts can be judged against them.

The behavior of the tropical Pacific in the first half of the 1990s, when the SSTs in the eastern Pacific (in regions referred to as Niño1 and Niño2) changed from a warm event to normal and back to a warm event a few times, showed that not every El Niño has been followed by a La Niña (Figure 7). Furthermore, one should not expect that the precipitous drop in SSTs in May and June 1998 would necessarily lead to a precipitous onset of a strong La Niña event later in the year.

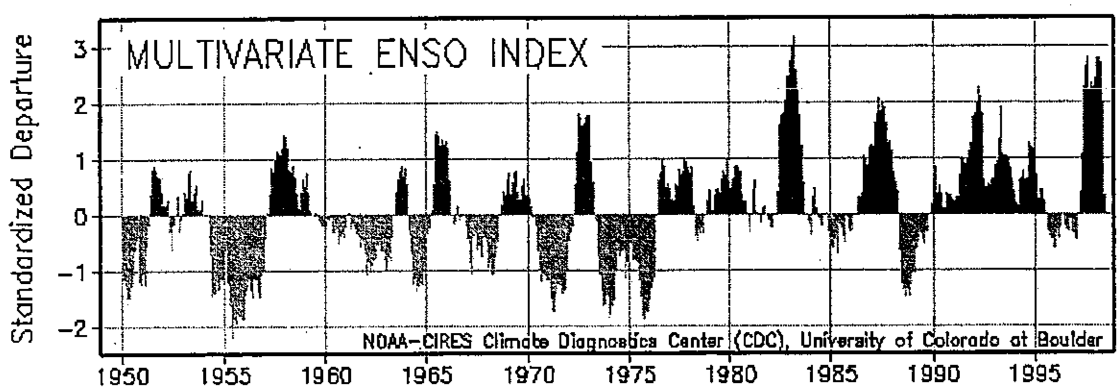


Figure 7. Multivariate ENSO Index (MEI), 1950-1998. MEI measures six variables: sea level pressure, east-west and north-south components of the surface wind, sea surface temperature, surface air temperature, and total amount of cloudiness. (Source: Climate Diagnostics Center, NOAA/CIRES.)

Key Points:

- However they define La Niña, most modelers forecast (as of mid-July 1998) the onset of a La Niña for late 1998 and a strong event during the winter of 1998-99.

- Several models have consistent but different biases, and those biases should be taken into account in their forecasts. It is very important to know the model's bias, so that their forecasts can be judged against that bias.

- Strong cold events do not necessarily follow strong warm events. A rapid decay in an El Niño event does not assure that there would be a rapid development of a La Niña.

The identification of differences in forecasting El Niño and La Niña

Stephen Zebiak (Director of Modeling, International Research Institute/Lamont-Doherty Earth Observatory) opened the session by noting that after 15 years or so of research, we have come to think of ENSO warm and cold events as a process, an oscillation, and not as a sequencing of random events. In the context of an oscillation, the same physics describes the whole state including both extremes. However, the succession of extreme warm and cold states have systematic differences. For example, it is believed that the cold states do not depart from an average condition to the same extent that warm states do. Also, some decades have been inactive and others have been dominated either by cold events (earlier in the century) or by warm events (in recent decades).

The physical differences between the extreme warm and cold events relate to changes in the thermocline depth, the spatial extent of convective activity, and a shift in the zone of convection, among others.

However, even though some of the physics at work in the two extremes are different, the predictability of El Niño and La Niña is not much different. Four key factors were noted as limiting forecast skill: model flaws, flaws in the way that data are used, gaps in the observing system, and the inherent limits of predictability.

It was not clear whether the terms used to describe the varying strengths of El Niño — weak, moderate, strong, very strong, extraordinary — could be used to describe the varying strengths of La Niña events. La Niña events have been fewer, so the number of cases for statistically reliable assessment is small.

Questions about the definition of La Niña once again surfaced. Some argued, as noted earlier, that perhaps there are two states in the tropical Pacific, El Niño and non-El Niño (or normal). Such a distinction would have a major effect on looking for similarities and differences between forecasting La Niña and forecasting El Niño.

Key Points:

- The predictability of La Niña and El Niño are not much different.

- Factors that limit the forecasting skill for cold and warm events include, but are not limited to, the following: model flaws, flaws in the way that data are used, spatial and temporal gaps in the observations and in the observing system, and the inherent limits to predictability of the atmosphere.

- ENSO forecasts issued to the public serve several useful purposes: draw attention to the phenomenon; draw attention to the needs of the ENSO research community: inspire future generations to engage in societally beneficial research on the ENSO 'puzzle'.

Monitoring La Niña

Historically, El Niño researchers have used regions in the tropical Pacific referred to as Niño3 and Niño3.4 to generate indices of SSTs that are convenient for describing the evolution of an El Niño event (Figure 8). The session focused on whether these historical indices were appropriate for describing and understanding the character of La Niña as well. Stated another way, is what we believe to be an appropriate monitoring system for El Niño equally appropriate for monitoring La Niña?

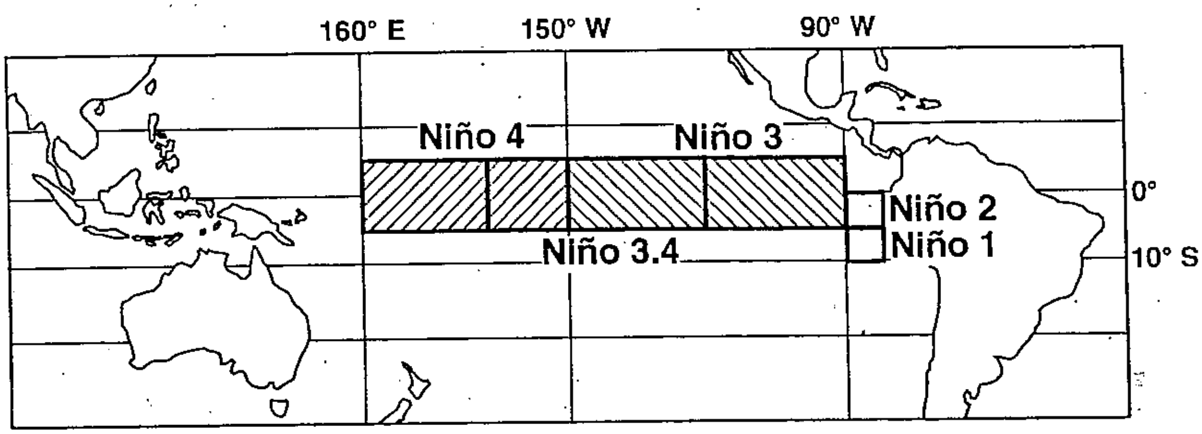


Figure 8. Map depicting five regions in the equatorial Pacific Ocean identified as important locations for monitoring the wind and sea surface temperature changes associated with the El Nino process (Source: M.H. Glantz/NCAR).

Antonio Busalacchi (National Aeronautics and Space Administration's Goddard Space Flight Center) presented the argument that the TOGA TAO array was originally set up as an equatorial waveguide array to monitor the development of El Niño (warm) events. Construction of the system began in 1985 in large part as a response to the 1982-83 event. It was completed by the mid-1990s.

While noting that the development of the 1997-98 El Niño event was captured by the TAO array (8 deg N and S latitudes), it appears that the changes in ocean temperatures below the surface that signaled the trend toward a cold event were taking place outside the 8° N and S latitude band. In fact, the first sign that a change was in the offing was detected by the SeaWiFs satellite instrument and showed up in satellite color images of biological productivity a few degrees north of the Equator in the area of the Galapagos Islands. The return of upwelling in the near equatorial region signaled a shift away from a warm event a couple of months before other indicators captured physical changes in the ocean and atmosphere environments.

Such occurrences underscored the need to expand the TOGA TAO array toward the west and the east (zonally) and poleward (meridionally). Because ENSO's teleconnections are affected by local and regional factors, it was urged that similar monitoring systems be established for the Indian and Atlantic oceans as well. A case was made for the need to monitor salinity changes in the tropical Pacific in order to provide yet another indicator of changes in the ENSO oscillation.

Key Points:

- The appearance of depressed sea level in the western tropical Pacific observed by TOPEX/Poseidon (indicative of a shoaling [less deep] thermocline) signaled the end of the 1997-98 El Niño and the possible onset of a cold event (of uncertain magnitude). The majority of this signal took place outside the TOGA TAO array. This suggests that, in order to improve forecasts related to La Niña events, there needs to be a better synthesis of remotely sensed and in situ observations. Also, the TAO array needs to be expanded in its geographical coverage in the western Pacific in the poleward direction.

- There is a need for improved monitoring of the world's oceans, given the 'unexpected' simultaneous behavior (e.g., warming) of the Pacific, Atlantic and Indian oceans. More specifically, there is a need for improved monitoring of the Indian and Atlantic oceans, as they influence the teleconnections associated with ENSO warm and cold events.

- Monitoring changes in ocean color from space (e.g., phytoplankton blooms) around the Galapagos Islands a couple of months before other key indicators identified changes in oceanic upwelling processes provides hope for earlier detection of changes in El Niño strength and, therefore, in the progression of the ENSO cycle than is currently available.

- Expanding the monitoring system to higher latitudes would improve our understanding of the role of subtropical SSTs in relation to La Niña events.

Working group sessions

The final session of the La Niña Summit involved dividing the participants into two groups. One group was asked to discuss what it is that the user/application/impacts community needs and wants from the ENSO research community. The second group was asked to focus on the needs and wants of the scientific research community.

The following comments compiled by each of the working groups were presented to the full workshop for brief discussion in the time remaining. Thus, it is important to note that the results of these discussions were only expected to be suggestive and did not represent an exhaustive list of needs.

The user/application/impacts community discussions centered on the following suggestions:

- There is a need for an improved public understanding of how La Niña and El Niño events bring about probability shifts in terms of potential impacts in distant locations of extreme climate-related impacts about which societies are likely to be concerned.
- There is a need for agreed-upon definitions of warm and cold events, as well as those of El Niño and La Niña events.
- There is a need worldwide by those carrying out impact assessments for more and better weather data at the local level, as opposed to the more generalized regional level.
- Error bars should accompany El Niño and La Niña forecasts.
- There is an important need to reduce societal constraints, including institutional ones, on society's ability to use ENSO and ENSO-related forecasts.
- Users of ENSO information should be involved early in the ENSO forecast process.

Discussions in the research community group centered on the potential utility of a mutually agreed-upon multivariate index to include factors denoting magnitude as well as threshold criteria, and discrete categories. Suggestions were also raised concerning the possible value of "official" forecast products (this generated a heated discussion within the group as well as within the full workshop; some participants claimed that it would serve to indirectly censor information on El Niño or La Niña not considered to be part of the mainstream perspective). Concern was raised, and steps called for, related to the issue of identifying accountability and credibility of each of the growing number of ENSO and ENSO-related forecasts.

Tuesday, 14 July 1998

Informal Reception at the Golden Buff, 7-9 p.m.

Wednesday, 15 July 1998

Introduction

8:30-9:00a Welcome to meeting. Why this workshop? Why now?

9:00-10:00 What's happening in the tropical Pacific Ocean now.

10:00-10:30 Break

Definition

10:30-11:30 La Niña, cold event, ENSO cold event -- or "What La Niña Is"

11:30-12:00 What constitutes "normal"?

12:00-1:30p Lunch (1:00-1:30, voluntary tour of NCAR)

Teleconnections

1:30-2:00 La Niña's global teleconnections

2:00-3:30 Expected regional teleconnection impacts of La Niña (2:00-2:45, Tropics) (2:45-3:30, Southern Hemisphere)

3:00-3:30 Break

3:30-4:15 Expected regional teleconnection impacts of La Niña (Northern Hemisphere)

Climate Change

4:15-5:00 El Niño, La Niña, "Normal" and climate change

Thursday, 16 July 1998

Symmetry

8:45-9:30 Is there symmetry between El Niño and La Niña phenomena? (The physical side)

9:30-10:15 Is there symmetry between El Niño and La Niña impacts? (The meteorological, societal, and ecological sides)

10:15-10:45 Break

Attribution

10:45-11:30 How can we tell ENSO impacts of La Niña (or El Niño) from other factors' impacts?

Media

11:30-12:15p A Panel: Media coverage of La Niña/El Niño

12:15-1:30 Lunch

Forecasting

1:30-2:15 How well did we forecast this 1997-98 El Niño?

2:15-3:00 How well did we forecast the onset of this La Niña?

3:00-3:30 Break

3:30-4:00 Are the problems of forecasting La Niña the same as those for forecasting El Niño?

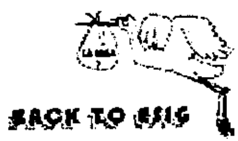
Monitoring

4:00-4:45 Is what is needed for El Niño monitoring sufficient for monitoring La Niña?

Friday, 17 July 1998

Working Groups: Parallel sessions

8:30-10:00	(a) What does society want from the ENSO scientific community? (b) What can the ENSO scientific community provide to society?
9:45-10:45	Recommendations?
10:00-10:30	Break
10:30-11:30	Plenary (for Working Group statements)
11:30-12:00p	Recommendations: Where do we go from here?



A Review of the Causes and Consequences of Cold Events
UNU/NCAR/NSF/UNEP La Niña Workshop

15-17 July 1998
Boulder, CO

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REVIEW OF THE CAUSES AND CONSEQUENCES OF COLD EVENTS:

A La Niña Summit

Individual Papers

Table of Contents

The actual papers will be available on or before October 16, 1998

Those participants who wished to do so were asked to prepare very brief papers that could be used for discussion purposes during the various sessions of the La Niña Summit. They were asked to share their thoughts with the workshop participants on La Niña, El Niño or the ENSO processes.

La Niña Summit | Table of Contents | ESIG | Summary |Executive Summary

Impacts

In the USA:

http://www.wrcc.sage.dri.edu/enso/percentile.html
La Niña's Impact on Precipitation and Streamflow Values in the Western US
http://www.nnic.noaa.gov/products/analysis_monitoring/ensostuff/lanina/index.html
Seasonal Mean Temperatures and Precipitation for the United States during Strong La Niñas
http://www.coaps.fsu.edu/research/matt/maxtdjf.ev.gif
La Niña's Effect on Temperature in the USA (Max. Temps)
http://www.coaps.fsu.edu/research/matt/mintdjf.ev.gif
La Niña's Effect on Temperature in the USA (Min. Temps)
http://www.coaps.fsu.edu/research/matt/predjf.ev.gif
La Niña's Effect on Precipitation in the USA
http://www.coaps.fsu.edu/lib/booklet/Cold_E._Fall.html
La Niña's Impacts on USA (Fall)
http://www.coaps.fsu.edu/lib/booklet/Cold_E._Winter.html
La Niña's Impacts on USA (Winter)
http://www.coaps.fsu.edu/lib/booklet/Cold_E._Spring.html
La Niña's Impacts on USA (Spring)
http://www.coaps.fsu.edu/lib/booklet/Cold_E._Summer.html
La Niña's Impacts on USA (Summer)
http://nic.fb4.noaa.gov/products/analysis_monitoring/lanina/usimp.html
La Niña's Impacts on USA (General)
http://nic.fb4.noaa.gov:80/products/predictions/multi_season/13_seasonal_outlooks/color/legend.gif
Legend for the Following Two Websites
http://nic.fb4.noaa.gov:80/products/predictions/multi_season/13_seasonal_outlooks/color/page3.gif
Temperature Outlooks for the USA (in three month periods from now until the end of 1999)
http://nic.fb4.noaa.gov:80/products/predictions/multi_season/13_seasonal_outlooks/color/page4.gif
Precipitation Outlooks for the USA (in three month periods from now until the end of 1999)

In Other Countries:

http://www.mb.ec.gc.ca/Nino/PNR_charts_English.html
Impacts of La Niña in Western Canada
http://nic.fb4.noaa.gov/products/analysis_monitoring/impacts/enso.html
Global La Niña Impacts
http://naulu.soest.hawaii.edu/subdir/update.dir/update.html
Pacific ENSO Update (reports on the status and effects of La Niña in the Pacific)
http://nic.fb4.noaa.gov:80/products/analysis_monitoring/impacts/cold.gif
La Niña's Global Impacts (Teleconnections)

Data Sources

General Data Sources:

http://www.pmel.noaa.gov/toga-tao/datdis.html
Tropical Atmosphere Ocean (TAO) Array's Data Displays
including Figures in Realtime from TAO (http://www.pmel.noaa.gov/toga-tao/realtime.html)
http://nic.fb4.noaa.gov/data/cddb/

Data and Graphs of Current Monthly Atmospheric and SST Index Values
http://nic.fb4.noaa.gov:80/products/analysis_monitoring/enso_update/index.html
Figures and Graphs of General Data
http://www.bom.gov.au/bmrc/mrlr/nrs/pastanal.htm
Figures of Past and Present Ocean Analyses (BMRC)

Specific Representations:
http://faster.gsfc.nasa.gov/enso97/timeseries/timeseries.html
Graphs of SST and Precipitation anomalies during El Niño and La Niña
http://psbsgi1.nesdis.noaa.gov:8080/PSB/EPS/SST/climo.html
Figure of Global Experimental "Daily" SST Anomaly Charts
http://www.dnr.qld.gov.au/longpdk/lpsoidat.htm
SOI Table and Graphs from 1900 - Present
http://iri.ucsd.edu/hot_eqsst/ninacomp.html
Graph of 1997-98 La Niña Evolution Compared with Previous La Niñas
http://nic.fb4.noaa.gov:80/products/analysis_monitoring/bulletin/ssttime.gif
Graphs of the Symmetry of SSTs (Niño SST Indices)
http://www.cdc.noaa.gov/~map/maproom/text/climate_pages/sst_olr/sst_anim.shtml
Pacific SST Animation (1997-98) from CDC
http://www.pmel.noaa.gov/toga-tao/el-nino/la-nina.html
Comparison of SST for La Niña, Normal and El Niño Conditions (PMEL)

General Websites

http://www.intellicast.com/elnino/
Articles on El Niño and La Niña
http://www.tidepool.org/ElNino.html
Articles on El Niño and La Niña
http://www.ogp.noaa.gov/enso/
El Niño/Southern Oscillation Home Page (NOAA/OGP)
http://www.dnr.qld.gov.au/longpdk/help/soihp.htm
El Niño and the Southern Oscillation (Long Paddock, Australia)
http://naulu.soest.hawaii.edu/
Pacific ENSO Applications Center
http://www.exploratorium.edu/la_nina/index.html
La Niña Summit Info and Real Audio
http://www.pmel.noaa.gov/toga-tao/la-nina-story.html
La Niña Theme Page (NOAA/PMEL/TAO)
http://www.dir.ucar.edu/esig/lanina/
La Niña Summit (NCAR)
http://www.publicaffairs.noaa.gov/lanina.html
La Niña Information (NOAA)
http://iri.ucsd.edu/hot_eqsst/
IRI's La Niña Website
http://www.elnino.noaa.gov/lanina.html
NOAA's La Niña Page

Other

Forecasts:

http://nic.fb4.noaa.gov:8000/research/cmb/climate_ensofcst.html

SST Forecasts

http://www.ecmwf.int/html/seasonal/forecast/index.html

ECMWF's Seasonal Forecast Project

La Niña 1988-89:

http://dao.gsfc.nasa.gov/experiments/assim54A/sample_results/elnino.html

Analysis of La Niña 1988-89

Miscellaneous:

http://nic.fb4.noaa.gov/products/analysis_monitoring/lanina/primer.html

Primer on La Niña