1

Introduction

MICHAEL H. GLANTZ
Environmental and Societal Impacts Group
National Center for Atmospheric Research*
Boulder, CO 80307

Teleconnections, the linkages over great distance of seemingly disconnected weather anomalies, have been identified through the appearance of geophysical processes, through statistical correlations (in space and in time) and through recognition that many atmospheric processes are manifested as waves.

The earliest known use of this term was by Ångström (1935), who wrote an article of the teleconnections related to an atmospheric "seesaw" mechanism, since referred to as the North Atlantic Oscillation (van Loon and Rogers, 1978), although the notion of teleconnection had been recognized decades earlier. The term became very popular in articles about the societal and environmental impacts of worldwide weather anomalies that have been associated with the 1972–73 El Niño. An El Niño event can generally be identified with the invasion of warm water from the western equatorial Pacific into the central and/or eastern equatorial Pacific Ocean, in conjunction with a cessation of upwelling of cold water along the equator.

A hundred years ago one of the major concerns about El Niño events was their impacts on Peruvian guano production. Guano, produced by sea birds on the rock islands along the coast of Peru, is a highly valued fertilizer. During El Niño events biological productivity in the upwelling region along the coast of Peru is greatly reduced. As a direct result, there was a sharp increase in mortality within the bird colonies. Birds in search of their staple food, anchoveta, could not find enough to stay alive and perished in the search, only to wash up along the shore by the million. Thus, with an El Niño, Peruvian guano production and guano exports declined. Other local impacts were also noted during El

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

Niño events: heavy rains in normally arid parts of western South America, mudslides, damage to infrastructure, the appearance of fish species more attuned to warmer sea surface temperatures, a dislocation within the artisanal fishing communities with the disappearance of traditionally fished species. In sum, El Niño was in general seen as a local problem with local impacts.

In the 1950s and 1960s, fishmeal, a highly valued and highly sought after animal feed supplement, became an important industry within the Peruvian economy, generating about one-third of its foreign exchange. With the rapid development of this industry, interest in El Niño events became heightened. The major El Niño of 1972–73 and a recruitment failure, together with overfishing, devastated the anchoveta fishery and the Peruvian fishmeal industry, and caused disruptions in the lucrative fishmeal export market. In addition to these local impacts, droughts, floods, and food shortages around the world were also blamed on the 1972–73 El Niño event. Since then the scientific community has deepened its interest in understanding the El Niño phenomenon.

Today, El Niño has been overshadowed by the broader concept of El Niño–Southern Oscillation (ENSO), the linking together of oceanic and atmospheric changes in the Pacific Ocean region. In January 1985, an international scientific research program called TOGA (Tropical Ocean–Global Atmosphere) was established to improve the understanding of the interannual variability in climate that results from the interaction between the tropical ocean and the atmosphere (NAS/NRC, 1983). The Southern Oscillation is basically, as Trenberth notes (Chapter 2) "a see-saw in atmospheric mass involving exchanges of air between eastern and western hemispheres ... with centers of action located over Indonesia and the tropical South Pacific Ocean." ENSO events are now acknowledged to have global implications. The study of the ENSO process has led to the identification of "warm" events and "cold" events. These are often identified by monitoring the Southern Oscillation Index (the difference between sea level pressures at Darwin, Australia and Tahiti), although other indices are sometimes used. High negative values of the SOI indicate a warm event and high positive values indicate a cold event (also referred to as La Niña). However, 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.

Observers have noted that there have been weather anomalies, both within and outside the tropics, that appear to have occurred in association with the warm events. It has been suggested that these anomalies may be correlated, or linked (that is, "teleconnected") to ENSO events. ENSO events have been associated with droughts in Indonesia, India, the Philippines, Australia, Northeast Brazil, Ethiopia, and southern Africa, as well as other regions. They have been also been associated with floods in southern Brazil, Peru, and Ecuador, warm winters in the U.S.S.R., mild winters in eastern Canada, and cool summers in northeast China. ENSO events have been blamed for contributing to the collapse of the Peruvian anchoveta fishery, the rise of the Chilean sardine fishery, and the collapse of the salmon fishery off the coast of the U.S. Pacific Northwest. They have also been blamed for encephalitis outbreaks in the U.S. Northeast, the increase in the incidence of plague in the U.S. Southwest, various disease outbreaks in South America and in Australia, and so forth. This is not to say that each of these claims has strong scientific support. One cannot blame every societal ill on the ENSO phenomenon. Clearly, its impacts in the high latitudes do not occur as reliably as in the tropical Pacific. Some of these "associated" temperature and rainfall anomalies are depicted in Figs. 1.1 and 1.2 (adapted from WMO, 1984).

After the 1982–83 ENSO event, interest in teleconnections associated with ENSO took on heightened levels. This interest broadened in scope to include extratropical teleconnections. It is now widely appreciated that the ENSO phenomenon is a global-scale phenomenon that now holds out to societies in many parts of the world the prospect of the forecasting of its occurrence and concomitant climate anomalies some months in advance.

It does not take much effort to show how information about ENSO can benefit societies in many countries around the world. Some of those countries are only just beginning to realize the importance of this phenomenon to the management of their national, regional and local economies. The highest level of government in Ethiopia, for example, has instructed its national meteorological service to inform it about ENSO events so that it might have some forewarning about the possible development of drought and, therefore, famine conditions.

Even those countries for which it is less clear that their economic activites might be directly affected by ENSO events are showing an

Cambridge University Press
978-0-521-36475-1 - Teleconnections Linking Worldwide Climate Anomalies: Scientific Basis and Societal Impact
Edited by Michael H. Glantz, Richard W. Katz and Neville Nicholls
Excerpt
More information

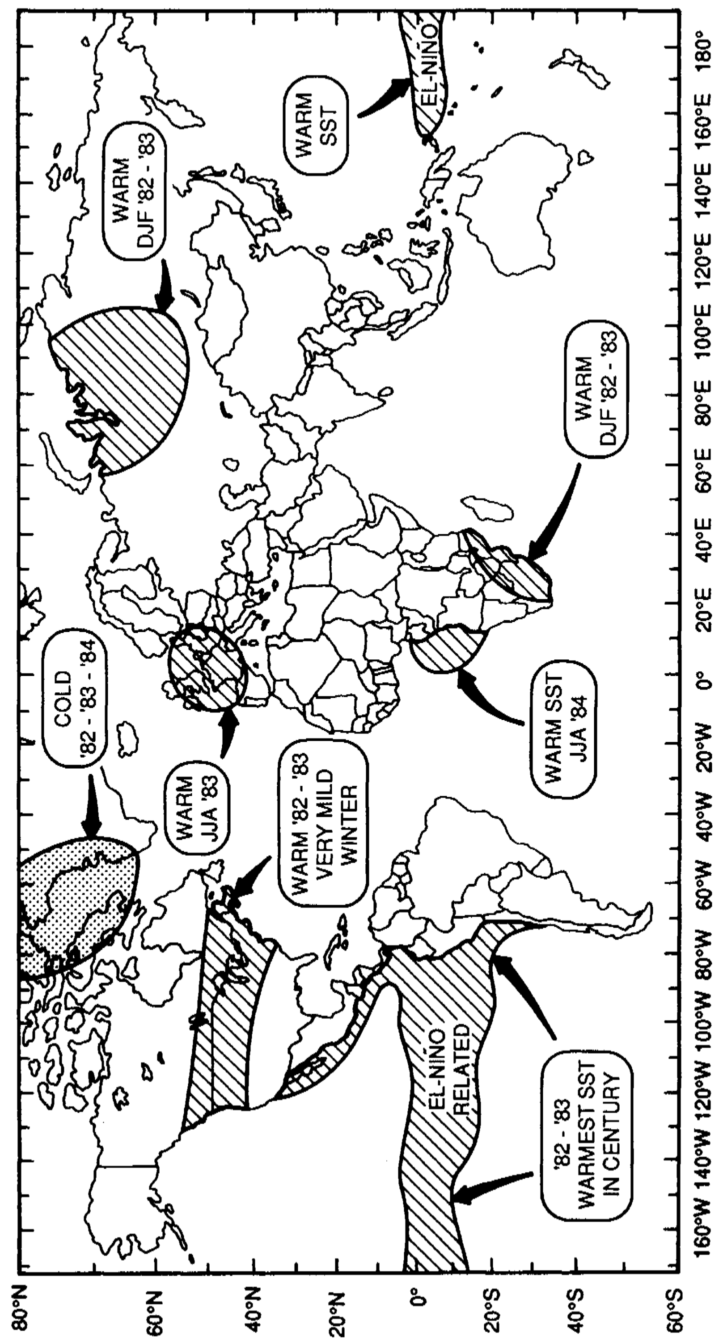

Fig. 1.1 Selected extreme temperature events that persisted for a season or longer in the 1982–84 period.

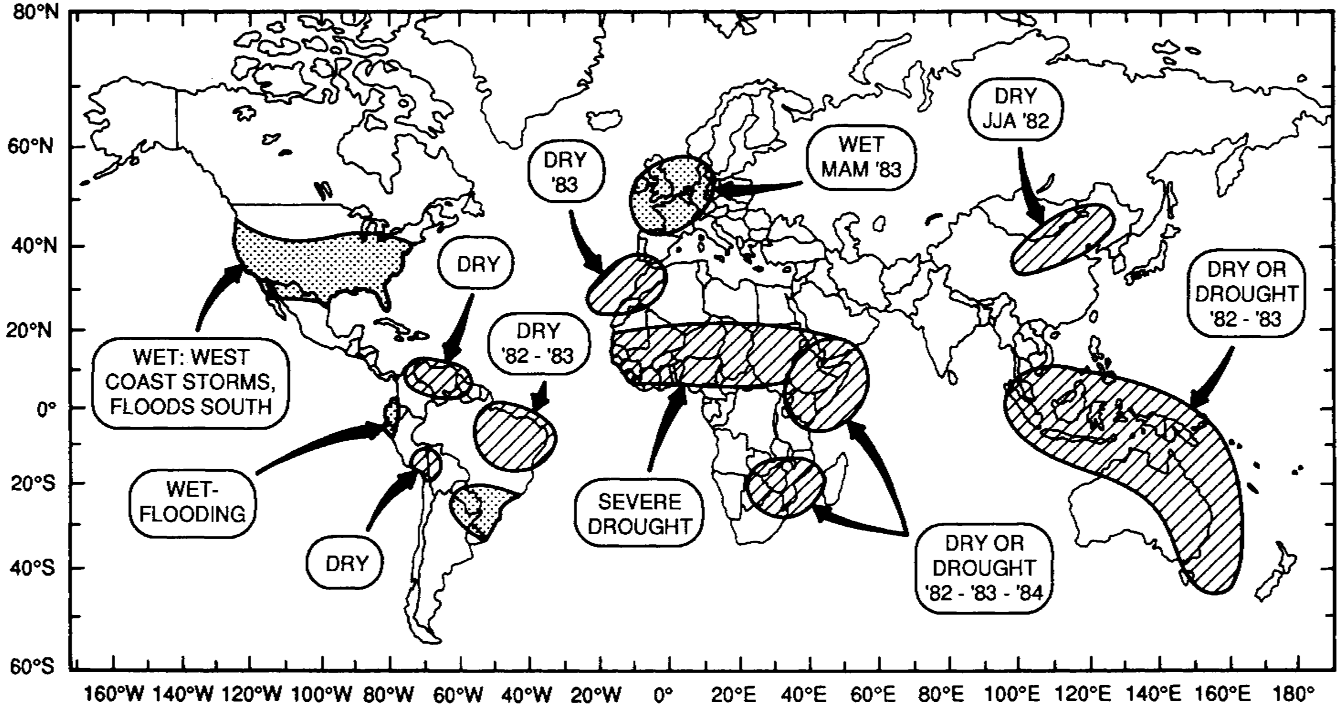

Fig. 1.2 Selected extreme continental precipitation (wet and dry areas) that persisted for a season or longer in the 1982–84 period.

increased interest in the phenomenon. While Kenya, for example, may not be directly affected by ENSO, it does grow crops that compete for sale in the international marketplace. It is, therefore, not so difficult to show why it is in Kenya's interest to know how its competitors in the coffee trade – Brazil, Ethiopia, Southeast Asian countries – have been affected by ENSO.

Of importance to decisionmakers is that an improved understanding of ENSO and related teleconnections can provide a forecast tool that could be used at least to mitigate the impacts on society of teleconnected meteorological events. At best such a forecast tool can aid decisionmakers in coping with food shortages, adverse health effects, and other economic impacts associated with recurrent ENSO events. There is also value in knowing about the contemporaneous occurrence of climate anomalies even if there is no lead time for forecasting.

A great deal of attention in the past few years has focused on the scientific and policy aspects of climate change. Although tens of millions of dollars have gone to groups involved in monitoring or predicting those climate changes that may result from anthropogenic activities, it appears that the global warming issue still remains controversial. While all scientists seem to agree that an increased loading of the atmosphere with radiatively active trace gases is occurring and that these gases are producing a "greenhouse-like effect" in the lower atmosphere, they do not agree on what the greenhouse effect may mean for precipitation in specific regions or for ecosystems and societies around the world. Nor is it yet at all clear how global warming might change the frequency or intensity of ENSO events.

Global climate change will surely be reflected in regional climates. Today there are attempts, using a variety of methods, to ascertain what the impacts of a global climate change will be at the regional and local levels. Many countries are engaged in research to identify how a global warming of a few degrees Celsius might affect their coastal communities, their vulnerability to severe storms, to changes in precipitation, and so forth. Yet, we are still in the process of seeking to understand today's natural climate variability on the inter- as well as intra-annual time scales. We are searching for such information in order to better understand the interactions between atmospheric processes and societies. Thus, in a sense, attention to these climate and global change issues has served to underscore how much more we need to know about our present day global and regional climate regimes. Thus, efforts by physical and social scientists to understand such a global phenomenon as ENSO should be strengthened because ENSO affects so many physical and societal processes and it holds out promise for forecasting climate anomalies on a worldwide basis. The editors and contributors to this volume have, therefore, chosen to focus on the concept of teleconnections.

For the most part the concept of teleconnections relates to climate anomalies around the globe that have been associated with ENSO events in the Indian Ocean–Pacific Ocean field of action. However, because of the recent interest in forecasting droughts in the countries bordering the Atlantic Ocean (especially in Africa), a chapter has been included on possible teleconnections to changes in the difference between sea surface temperatures in the northern and southern Atlantic Oceans. This chapter, in addition to shedding light on this particular teleconnection, serves to remind the readers that other regional teleconnections, not particularly linked to ENSO events, have been suggested to exist.

The contributions in this book have been divided into five parts: Introduction to Teleconnections, Regional Case Studies of Teleconnections: Physical Aspects, A Scientific Basis for Teleconnections, Regional Impacts of Climate Anomalies: Environmental and Societal Aspects, and Implications for ENSO Forecasting.

In the introductory part Trenberth discusses the general characteristics of the ENSO phenomenon providing an outline of "the main physical mechanisms leading to the coupled atmosphere–ocean interannual variability ...." More specifically he examines the mean annual cycle and observed interannual fluctuations involving the sea surface temperatures, atmospheric winds, surface convergence, and links with convection and rainfall, along with how they may contribute to the different character of each El Niño event.

The regional case studies part (physical aspects) contains six case studies from around the globe. Chu's chapter focuses on assessing the level of strength of the linkages between rainfall in various parts of Brazil (the Nordeste, the Amazon Basin and southern Brazil) and ENSO. The teleconnection to the drought-plagued Nordeste, as Chu points out, was noted by Walker in the mid-1920s. Chu also reviews similar linkages (or teleconnections) with circulation anomalies over the Atlantic Ocean and addresses questions relating to the use of diagnostic relationships in long-range forecasting.

Australian social scientists as well as policymakers have become increasingly aware of the impact of ENSO events on their environment and society, especially following the severe 1982–83 event. In his chapter, Allan presents an historical account of scientific interest in teleconnections between ENSO as well as anti-ENSO (i.e., cold) events and climate anomalies in the Australasia region. He describes several of the significant correlation patterns that have been investigated between ENSO and rainfall, wind patterns, mean sea level pressure, sea level, sea surface temperatures, air temperatures and cloudiness. Allan also addresses the prospects for using regional teleconnections in long-range forecasting.

Barnett and colleagues focus their chapter on the connections between Asia snow cover, monsoons and ENSO. As the authors note, the connection between Asia snow cover and the monsoons in Asia was suggested as early as 1884 by Blanford. This chapter discusses using sophisticated numerical models to show "... the hypothesis that snow-induced changes in the monsoon are significant ..." and that "changes in the monsoon can affect the SST in the tropical Pacific and hence induce ENSO events ... ." Note that this is an instance in which the climate anomaly leads ENSO rather than vice versa. They also include a brief section on some of the problems associated with their assessment.

In their chapter, Lau and Sheu assess teleconnections in global rainfall anomalies in order to determine whether major precipitation anomalies in geographically separated regions occur independently (i.e., simultaneously only by chance) or whether "... they are the manifestation of a global scale coherent shift in rainfall patterns that is likely to recur in the future." Such a study, they assert, is important for scientific as well as for societal reasons.

Gray and Sheaffer provide geophysical and statistical evidence for teleconnections between El Niño events and tropical cyclone activity in the Atlantic–Caribbean basin. They conclude that "seasonal Atlantic hurricane activity during El Niño years has been much suppressed in comparison with hurricane activity occurring during non-El Niño years." They provide observational evidence for mechanisms to explain the linkages between El Niño and seasonal hurricane activity in the western parts of the Atlantic Ocean.

Part III addresses the scientific basis for teleconnections. Tribbia's chapter outlines "the current state of the theoretical understanding of the mechanisms underpinning atmospheric teleconnections excited by ENSO." His assessment of the mechanisms that extend local sea surface temperature anomalies from the equatorial Pacific vertically (to the troposphere) and horizontally (to the extra-tropical latitudes) relies on the use of the principles of mechanics and thermodynamics.

In his chapter, Rasmusson relies on observations to address teleconnections related to the ENSO cycle. He "focuses on the general characteristics of teleconnection patterns, both tropical and extra-tropical, during opposite phases of the ENSO cycle." He discusses the potential for forecasting such events and provides notes of hope for forecasters if statistical relationships within a well developed conceptual framework on ENSO events are used with care. In conclusion, he provides a note of caution that "any 'canonical' description of ENSO cycle teleconnection patterns should be viewed in the abstract, much as the mean annual cycle, which is never strictly observed."

Cane makes the case that skillful prediction of ENSO is possible under certain conditions. He provides an assessment of the state of the art of computer-based predictions of El Niño events. In particular, he discusses his model and strongly asserts that to predict El Niño "one must predict both atmosphere and ocean." Cane contends that "the tropical Pacific region remains the locus for all the physics responsible for the existence of the ENSO cycle," while accepting that events elsewhere can influence the development of an El Niño. Cane's modeling activities suggest that El Niño may generally be predictable up to one year in advance.

The chapter by Brown and Katz on past and present statistical approaches to the study of teleconnections suggests that a number of statistical problems remain to be resolved. Some of these problems were identified and partial solutions provided by Sir Gilbert Walker. For example, some statistical characteristics of climatic time series, such as autocorrelation, are not adequately handled, in most teleconnection studies. Moreover, problems of multiplicity that result from computing a large number of correlation coefficients and selecting the largest, may lead one to conclude that a teleconnection exists when in fact it does not. In many current studies these issues are not adequately handled, thereby exaggerating the strength of some teleconnections. Brown and Katz suggest that stronger linkage should be made between physical and statistical studies of teleconnections, and that more sophisticated approaches should be implemented to handle statistical problems such as autocorrelation and multiplicity.

Chapters in Part IV address issues related to the impacts on the environment and society of climate anomalies teleconnected to ENSO events. These chapters supplement the growing list of publications on the impacts of El Niño and ENSO events on ecology, economy, and society (especially health).

Jordán's contribution focuses on one of the centers of action – the eastern equatorial Pacific. His concern relates to changes in biological productivity along the western coast of South America. His assessment of the impacts of El Niño includes not only atmospheric, oceanic and biological factors affecting natural resources on land and in the marine environment, but also societal factors such as levels of fishing activity. The impacts of the 1982–83 El Niño event are highlighted to underscore the multitude of changes that can be associated with El Niño (and more broadly, ENSO) events.

As noted in earlier chapters, much of the present day awareness about and interest in teleconnections began in the last part of the nineteenth century with discussions about the monsoon on the Indian sub-continent. Kiladis and Sinha discuss the scientific basis for the relationship between Indian rainfall and ENSO events. Droughts on the Indian sub-continent have had devastating impacts on people, livestock and the environment and have been an official concern of Indian governments for at least a century. Problems of coping with the failure of the monsoons are discussed. The value for Indian food production of forecasting the failure of the monsoons becomes quite evident.

Marie White and Mary Downton focus their attention on the possible linkages between biological productivity in the Gulf of Mexico and climate variability on a regional scale as well as large-scale atmospheric phenomena, including ENSO events. While there is some statistical evidence in support of the belief that heavy rains in the South-Central U.S. are associated with ENSO events, it is not at all clear what the impacts of those events are on shrimp populations in the Gulf. Other atmospheric phenomena such as the Pacific/North American pattern and the North Atlantic Oscil-