THE 1997-1998 EL NIÑO EVENT: A SCIENTIFIC AND TECHNICAL RETROSPECTIVE

A contribution to

The United Nations Task Force on El Niño for implementation of United Nations General Assembly Resolutions 52/200 and 53/185

The Inter-Agency Committee for the Climate Agenda

led by the

World Meteorological Organization

with support from the

Intergovernmental Oceanographic Commission of UNESCO

the

United Nations Environment Programme

and the

International Council for Science

1999

WMO

of UNESCO

UNEP

ICSU

Front cover
The sea surface warms and rises off the South American coast and out into the Pacific Ocean as the El Niño of 1997–1998 spreads its influence across the planet. Sea level anomaly 10 November 1997 as measured by TOPEX/Poseidon (NASA)

WMO-No. 905

ISBN 92-63-10905-2

NOTE

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Meteorological Organization concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Contents

Foreword

This retrospective analysis on the 1997–98 El Niño event has its origins at a major international conference held in Guayaquil, Ecuador from 9 to 13 November 1998. In response to Resolution 52/200 of the United Nations General Assembly, on international cooperation to reduce the effects of the El Niño phenomenon, the United Nations Task Force on El Niño, operating within the framework of the International Decade for Natural Disaster Reduction, convened the First Global Assessment of the 1997–98 El Niño Event. On behalf of the agencies supporting the Climate Agenda, I am pleased to present this important scientific analysis, entitled *The 1997–98 El Niño Event: A Scientific and Technical Retrospective*, which is in itself a further response by the United Nations system to the General Assembly resolution.

There can be no doubt that we have seen enormous strides made in recent years in our understanding of the climate system. Of particular interest here are the complex and interrelated subsystems associated with the El Niño phenomenon and its sibling La Niña. We have also witnessed encouraging progress in making predictions on seasonal timescales that causes us to reflect back to the early, tentative steps of weather forecasting many decades ago. While the current skill in seasonal predictions is limited in terms of its detail and scope, we know that many of our needs for advanced planning do not demand high levels of precision. Information on expected seasonal conditions cast in probabilistic terms, if used wisely, can be of great value to society. This is the challenge of the newly-found predictive skills and the climate science community is keen to ensure that the benefits of its endeavours are put to best use.

There are clear lessons for both the climate science community and the wide range of potential users of seasonal predictions in this most recent El Niño episode — some say the most intense in recorded history and certainly comparable to that which occurred in 1982–83. I trust that this publication will serve as a base of information for further analysis to understand El Niño related phenomena, to mitigate their destructive forces and to take advantage of opportunities that they can also provide.

Special appreciation is extended to Mr W.R. Kininmonth, Australia, for his efforts and dedication in the preparation of this publication.

(G. O. P. Obasi)
Secretary-General

Preface

The First Global Assessment of the 1997–98 El Niño Event (International Seminar on the 1997–98 El Niño Event: Evaluation and Projections) was carried out in Guayaquil, Ecuador, 9–13 November 1998 within the framework of the United Nations General Assembly Resolution 52/200. The meeting was co-sponsored by the Government of Ecuador the United Nations Task Force on El Niño, and the Permanent Commission for the South Pacific. *The 1997–98 El Niño Event A Scientific and Technical Retrospective* is an outcome of the First Global Assessment.

While every effort has been made to be as comprehensive as possible in this analysis of the 1997–98 El Niño event, scientific research on its onset, development and decay continues. Undoubtedly new insights will emerge after this *Retrospective* has been published. Nonetheless it is believed that it will serve as a solid reference point for the socio-economic studies under way on the overall social and economic costs of the event and, more importantly, to determine how best to deal with the next event that history tells us will surely come For example, the United Nations Environment Programme (UNEP), with financial support from the United Nations Fund for International Partnerships and with the collaboration of the US National Center for Atmospheric Research, the World Meteorological Organization (WMO) and the United Nations University, is conducting a series of in-depth studies of how 15 countries reacted to warnings of the event and coped with its evolution and aftermath.

Each of the presenters to the Guayaquil seminar, listed on page 96, has significantly assisted in the drafting of the *Retrospective* and their respective involvement is deeply appreciated. The presenters have recognized expertise in the subject areas and were nominated by international agencies and national governments. In addition, the Scientific Steering Group of Climate Variability and Predictability (CLIVAR), through its co-chair, Dr Kevin Trenberth of the US National Center for Atmospheric Research, submitted a comprehensive report as a contribution to the work of the United Nations Task Force on El Niño. The drafting of the *Retrospective* has only been possible because of scientific assessments and material made available by the contributors, and through discussion and additional material provided following the international seminar.

National Meteorological and Hydrological Services, in response to a request to Members of WMO by the Secretary-General, Prof G.O.P. Obasi, have provided reports on the climate anomalies and impacts experienced by their respective countries. Data and analyses have been provided through contributors to the international seminar, during the drafting of the *Retrospective* or on their Internet sites

Several scientists with extensive research experience in climate and the El Niño/Southern Oscillation (ENSO) phenomenon made time to read the draft manuscript. Their constructive suggestions have added to the final document and are greatly appreciated.

The source of a significant proportion of the material used to illustrate the ENSO phenomenon and the evolution of the 1997–98 El Niño event is the climate monitoring information generated by specialists and organizations and made freely accessible through the Internet. Particular acknowledgement is given to the US National Oceanic and Atmospheric Administration (NOAA) Climate Diagnostics Center, Boulder, Colorado for permission to use the climate analyses from its web site (http://www.cdc.noaa.gov); the US NOAA Pacific Marine Environmental Laboratory, Seattle, Washington for TAO ocean analyses from its web site (http //www.pmel.noaa.gov); and the US National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory for TOPEX/Poseidon (operated jointly with France, *Centre national d'études spatiale*) analyses from the web site (http://topex-www jpl. nasa gov/enso97/el_nino_1997 html).

The relatively brief Introduction and description of the Climate System (Part I) of the *Retrospective* cannot adequately reflect the extensive international research effort and the historical development of understanding about the El Niño phenomenon and the coupled ENSO. The Selected Bibliography reflects the source of material directly used in the *Retrospective* and is expanded as partial acknowledgement of the extensive scientific literature. In this context, English has been the working language of the First Global Assessment and of the *Retrospective*. For this reason, many excellent historical and contemporary studies reported in other languages do not get appropriate recognition in the global assessment, and this is regretted. However, the effort of contributors who have drawn material from non-English speaking sources has partially offset the deficiency and is appreciated.

(Dr Michael J. Coughlan)
Director, WMO World Climate Programme Department

Executive Summary

The intensity and global extent of natural disasters concurrent with the 1997–98 El Niño event highlights that, unless a concerted effort is made to prevent and mitigate the impacts extremes of climate variability will continue as a yoke of natural disasters burdening especially the developing world

The strong 1997–98 El Niño event brought to international attention the global scale of risks posed by extremes of climate, particularly for the developing world. Loss of life, destruction of infrastructure, depletion of food and water reserves, displacement of communities and outbreaks of disease all occurred as manifestations of climate-related natural disasters concurrent with the event. The United Nations (UN) General Assembly took note of the intensity and global extent of natural disasters and requested the Secretary General, as reflected in Resolutions 52/200 and 53/185, to develop a strategy within the framework of the International Decade for Natural Disaster Reduction (IDNDR) to prevent, mitigate and rehabilitate the damage caused by the El Niño phenomenon. An intergovernmental UN Task Force on El Niño was established.

This *Retrospective* reviews existing knowledge and capabilities for monitoring and forecasting El Niño/Southern Oscillation (ENSO) in order to establish a sound basis for new strategies to mitigate the negative impacts and capitalize on potential positive benefits. Although the focus of the *Retrospective* is on the scientific and technical aspects of monitoring and prediction of ENSO, it also identifies productive linkages to multidisciplinary impact assessment studies necessary to support preparedness and management of the economic, environmental, developmental and societal dimensions of natural disaster reduction.

Within the UN Task Force on El Niño, the World Meteorological Organization (WMO) took a lead role to coordinate the gathering of scientific and technical information about the 1997–98 El Niño event and its primary impacts. In particular, during the course of the event WMO prepared a series of publications, called *El Niño Updates*, providing information on the current status; these were issued to national Meteorological and Hydrological Services (NMHSs) and made available to the media and international agencies.

WMO, with the United Nations Environment Programme (UNEP), the Intergovernmental Oceanographic Commission (IOC) of the United Nations Education, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU), working with the IDNDR Secretariat within the framework of the UN Task Force on El Niño, organized the scientific programme for the First Global Assessment of the 1997–98 El Niño Event carried out at Guayaquil, Ecuador, the First Global Assessment (International Seminar on the 1997-98 El Niño Event: Evaluation and Projections) was co-sponsored by the Government of Ecuador, the UN Task Force on El Niño, and the Permanent Commission for the South Pacific.

The term El Niño, although not yet rigorously defined, is associated with a major warming of the surface layers of the central and eastern equatorial Pacific Ocean. An El Niño event occurs when warm water flows eastward from the warm pool of the western tropical Pacific Ocean and there is a reduction in upwelling of cold water in the eastern equatorial Pacific Ocean and along the Pacific coast of the Americas. Once initiated, an El Niño event typically lasts about a year, although climate anomalies in some parts of the globe may persist longer.

During mid-1997, sea surface temperatures across the central and eastern equatorial Pacific Ocean became significantly warmer than normal and a major El Niño event developed. Deep tropical atmospheric convection shifted eastward from the region of Asia and the western Pacific Ocean and, as a consequence, unusually heavy rainfall occurred over many parts of the normally dry Pacific coastal regions of South

America. As the deep tropical atmospheric convection shifted eastward subsiding dry air and reduced rainfall became the prevailing conditions over the western Pacific Ocean and parts of South East Asia. The El Niño event ended in mid-May 1998 when sea surface temperatures rapidly returned to normal (and then somewhat cooler than normal)

The dramatic changes in atmospheric circulation across the Pacific Ocean associated with El Niño are one extreme of what is referred to as the Southern Oscillation, and the overall coupled ocean-atmosphere processes are referred to as El Niño/Southern Oscillation, or ENSO. The other extreme of the Southern Oscillation is associated with colder than normal waters over the eastern equatorial Pacific Ocean and a piling up of warm waters in the west, referred to as a La Niña event. These extremes are often referred to as the warm phase and cold phase of ENSO, indicating that they appear to be part of a single phenomenon

The eastward movement of deep atmospheric tropical convection during 1997–98 also triggered a shift in seasonal patterns of weather systems over many subtropical and mid-latitude parts of the globe. The abnormal location of Pacific Ocean convection changed the source of tropical heating of the atmosphere and, through dynamic processes in the atmosphere (called "teleconnections"), affected the locations and mobility of subtropical and mid-latitude cyclones and anticyclones. Some regions received more seasonal storms and rainfall than normal while other regions received less than normal seasonal rainfall, with attendant increased potential for drought.

The shifting of seasonal weather patterns that was triggered by the 1997–98 El Niño event produced climate extremes over many parts of the globe, often with major socio-economic impacts.

- More than 24 000 lives were lost because of high winds, floods or storm tides that occurred during intense storms.
- More than 110 million people were affected and more than six million people were displaced as community infrastructures, including housing, food storage transport and communications, were lost during storms
- The direct value of losses exceeded US $34 billion.
- Waterlogging of fields as a result of recurring periods of rain reduced agricultural production in many parts.
- In other regions, the absence of the usual seasonal storms and rains led to prolonged dry spells, loss of crops and reduction in water supplies.
- Outbreaks and spread of wildfires were also more frequent during extended dry periods.
- Increased incidence of disease was an outcome of prolonged disruption to weather and rainfall patterns over many months that resulted in contamination of water supplies or a more favourable environment for disease-carrying insect vectors.

As an outcome of several decades of climate research and observing system development there is now an extensive body of knowledge about the climate system and a capacity to monitor in real-time aspects of its variability. The ability to watch the 1997–98 El Niño develop was made possible by the systems that had been established over the previous decade There is also a developing capability to predict climate anomalies up to several seasons in advance over some parts of the globe, for some seasons of the year.

Science and technology provide tools that are essential to build better community preparedness against the hazards of climate extremes and provide early warning of events. For example, historical climate data, and understanding of the processes of the climate system, provide the basis for assessment of climate risk and vulnerability to natural disasters. Monitoring and prediction of the climate system provide early warning for implementation of rapid response in the event of climate extremes, including those associated with El Niño.

The 1997–98 El Niño event clearly demonstrated useful and developing capabilities in the areas of climate monitoring and prediction, but the gaps in knowledge of the climate system, the gaps in monitoring coverage, and the early stage of development of climate forecasting models indicate the potential for significant improvement

The global climate changes through a combination of natural and anthropogenic influences. Some of these changes appear through shifts in patterns of weather and regional climate, and especially in changing

The inseparability of El Niño from broader issues of climate variability and change underscores the importance of a concerted effort on the part of governments and non-governmental organizations to continue research into climate variability to improve forecast skill and to develop appropriate policies for mitigating the impacts of climate extremes.

The mitigation of the negative impacts of the El Niño phenomenon and other extremes of climate variability will require ongoing international support for the Climate Agenda, with special emphasis on technology transfer, capacity building and meeting the needs of developing countries

patterns of risk associated with extreme events, such as El Niño

The Climate Agenda

The Climate Agenda is the existing organizational framework for coordinating international climate activities and for developing regional and global climate infrastructures. The Climate Agenda provides the scientific and technical capability necessary to support a global, multidisciplinary approach to mitigating the negative impacts of climate extremes and for the promotion of sustainable development.

Co-sponsors of the Climate Agenda are relevant agencies of the United Nations led by WMO, and non-governmental bodies led by the ICSU The four pillars of the Climate Agenda for addressing global climate issues are.

- Dedicated observations of the climate system,
- New frontiers for climate science and prediction;
- Studies of climate impact assessments and response strategies to reduce vulnerability; and
- Climate services for sustainable development.

Observations

International commitment to the development and operation of Global Climate Observing System is critical.

Human impact on the climate system particularly on the pattern of weather and climate extremes, is a fundamental issue to be resolved through the CLIVAR research project

Information about the climate of a locality is fundamental to understanding and developing preparedness against the hazards associated with climate extremes Local climate records, in computer-compatible format, are the means for identifying and assessing the potential dangers of local climate extremes It is for this reason that WMO, supported by the donations of Member countries to the Voluntary Cooperation Programme, is assisting developing countries to preserve early manuscript climate records through the Data Rescue (DARE) project. WMO is also assisting the national Meteorological and Hydrological Services of developing countries to establish computer-based climate archives using a standardized data management package The CLICOM (Climate Computing) project has been the means through which many developing countries have made the necessary transition towards modern computer-based climate information services. Accessible climate information allows community involvement at all levels in disaster preparedness and promotes good design and an appropriate pattern of development

An essential prerequisite to building preparedness for climate risk is a national commitment to the development of publicly accessible national climate archives.

Despite recent advances in global climate monitoring there are still serious data gaps. WMO, the IOC of UNESCO, UNEP and ICSU are cooperating in planning for a Global Climate Observing System (GCOS) to provide comprehensive meteorological, oceanographic and related environmental data necessary for detecting climate change, for climate research, climate forecasting and operational services. GCOS includes new observing instruments and systems that have been proven through research, such as the Tropical Atmosphere Ocean (TAO) array of moored buoys across the equatorial Pacific Ocean and the altimeter of the TOPEX/Poseidon satellite. GCOS will build upon the long established World Weather Watch system of WMO

Research

Many benefits from developments in climate monitoring and prediction were demonstrated during the 1997–98 El Niño event but there are still many unknowns about the phenomenon and the associated teleconnections that affect global weather patterns The Climate Variability and Predictability (CLIVAR) project has been established within the framework of the World Climate Research Programme Amongst its aim is the extension of the capability for climate prediction to larger geographic regions and longer timescales for the ultimate benefit of the world's communities

Vulnerability and disaster preparedness

Data on the full extent of climate anomalies during the 1997–98 El Niño event are not available in many parts of the globe For many countries it is only possible to provide general estimates of the type and extent of impacts from weather and climate extremes, including loss of life, destruction and damage to housing and infrastructure, and the extent of disease during the aftermath. Communities and economies were affected differently and UNEP is taking the lead, within the framework of the Climate Agenda, for coordinating and arranging support for impact assessment studies. An initial study of the impacts of the 1997–98 El Niño event, supported through the United Nations Fund for International Partnerships and with a duration of 19 months, will cover impacts in 15 countries.

The UN Task Force on El Niño was created within the framework of the International Decade for Natural Disaster Reduction (IDNDR) and demonstrated the immense value of multidisciplinary approaches in the global disaster reduction effort. The successor arrangements to IDNDR will require continuation of an inter-agency mechanism for concerted action on El Niño.

To be fully effective, impact assessment studies at the national and regional levels should be multidisciplinary and policies for the mitigation of the impacts of climate extremes should be integrated into sustainable development strategies. Multidisciplinary risk assessment provides the basis for an effective preparedness and early warning system for the mitigation of natural disasters associated with climate extremes, such as El Niño events.

Services

WMO has initiated the Climate Information and Prediction Services (CLIPS) project to assist national Meteorological and Hydrological Services in delivering an enhanced range of operational climate services, including prediction on seasonal to interannual timescales. CLIPS will strengthen the interface between national providers and sectoral users so that climate services are delivered in a framework that assists the various decision-making processes.

The development of regional climate centres, within the CLIPS framework, will establish a focus for cooperation in data management, monitoring and prediction, and will assist technology transfer and capacity building.

Effective climate information and prediction services require an appropriate framework where users recognize what is possible to predict, where the providers recognize what is essential to be predicted, and where the scientific information flow is in a form that can be readily assimilated in decision-making

National climate programmes

Climate-related natural disasters, such as those linked to El Niño, are a major consideration by governments in the overall scope of community protection and well-being. The management of climate risk is multidimensional and involves agencies with economic, environmental, social and developmental objectives. Many governments have established a formal national climate programme as a framework for coordination and to ensure that, through the national Meteorological and Hydrological Service, firstly, the appropriate scientific and technical infrastructures are adequately supported, and secondly, to ensure that information and prediction services are accessible to policy and decision makers for planning, early warning and better management across a range of sectors, including natural disaster reduction.