THE NORTH AMERICAN CLIMATE PATTERNS ASSOCIATED WITH EL NIÑO-SOUTHERN OSCILLATION

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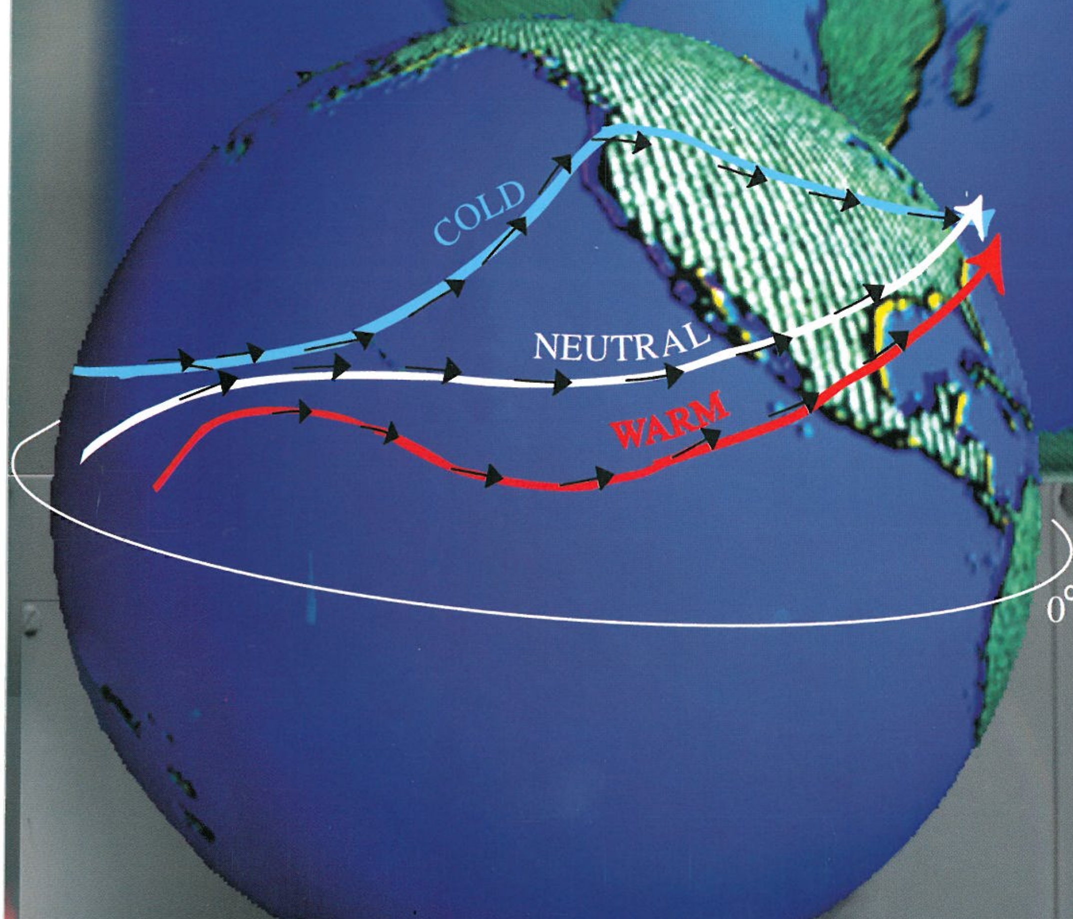

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Cover: On the globe are the artist's renditions of the winter mean jet stream for the cold, neutral, and warm phase of ENSO. Note that the tropical origin for the warm phase is more eastward and the the tropical origin of the cold phase is more westward than for the neutral phase.

FOREWORD

Since the **1982-1983 "Mother of All Los Niños,"** the public and scientists have been fascinated with the apparent climate variations in floods and droughts linked to teleconnections from the equatorial Pacific. By 1987, ocean scientists demonstrated a new technical ability to forecast the sea-surface temperature patterns along the equator in the Pacific Ocean up to a year in advance using wind-driven ocean models. This **technical advancement** encouraged governments to support the development of coupled ocean-atmosphere models. **These models** have the promise of **forecasting** 1-2 seasons in advance the shifts in seasonal physical climate patterns. In order to validate these models, studies are necessary to document the location and intensity of climatic impacts.

In this short report, we present artistic renditions of the changes in precipitation and temperature for each of the four seasons surrounding the mature phase of a warm (El Niño) or a cold (El Viejo) ENSO event. Over 60 million individual climate observations were used to construct this climatology of ENSO impacts over North America.

***The Center for Ocean-Atmospheric Prediction Studies* (COAPS), is the focus of climate variability investigations at The Florida State University.**

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INTRODUCTION

Variations in climate and weather can significantly impact our daily lives in subtle ways. We are irrevocably linked to our ecosystem in events resulting from extremely cold winters, crop failure from drought, or emergency conditions such as flooding, heat waves, or forest fires. These events can cause higher heating bills and accelerating food prices. Many of our valuable resources are wasted due to lack of preparation. Effective planning requires study of regional analysis of climatic variability. The largest are the effects associated with El Niño Southern Oscillation (ENSO).

The phenomenon known as El Niño has been observed as early as the 1600's off the coast of Peru. At varying intervals, anomalously warm waters off the Peruvian coast appeared around Christmas and were dubbed El Niño, for the Christ child. The development of the El Niño phenomenon has its origins in the western tropical Pacific Ocean. Easterly trade winds relax and a westerly wind anomaly develops, exciting eastward propagating Kelvin waves along the equator. These waves suppress the thermocline, deepening the surface mixed layer. As the result, warm sea surface temperature (SST) anomalies develop and spread eastward to the South American coast. Teleconnection link the tropical Pacific and higher latitudes and shift mid-latitude synoptic weather patterns. Today El Niño is known to be the warm extreme of an interannual climate fluctuation called El Niño Southern Oscillation. The cold extreme, (La Niña, El Viejo, cold phase) has consequences of equal or greater importance than the effects of El Niño.

This document provides the physical climatic effects associated with ENSO on North America. Eight cartoons are included which illustrate the anomalous conditions for the fall, winter, spring, and summer seasons following the onset of the warm or cold ENSO phase.

DATA AND METHODOLOGY

Monthly mean temperature and monthly precipitation totals for 788 North American stations were selected from the Global Historical Climatology Network dataset (GHCN)(Vose et al., 1992). Data were subject to quality control and flagged by the GHCN for suspicious, revised, or large data gaps.

The time period is 1947-1986 for Canada, Alaska, and the continental United States, and 1944-1983 for Mexico. For inclusion, each Canadian and US. station must have less than 10% missing monthly climate data. Mexican stations are selected if they have less than 15% missing precipitation and temperature records. The recovery of missing data for Mexican stations is necessary in order to increase the number of stations selected.

The indicator used for classification of the extremes of ENSO events is a Sea Surface Temperature (SST) index defined by the Japan Meteorological Agency (JMA). The JMA index has been used in past studies such as Green(1996) and Sittel (1994). The JMA index is based on monthly mean Sea Surface Temperature anomalies averaged for the area 4°N to 4°S and 150°W to 90°W. The JMA index is readily available for all the years in this study.

The forty years of GHCN temperature and precipitation data are classified into appropriate ENSO categories: cold, neutral or warm phases, using the JMA Index. The ENSO year is defined to start in October-November-December and ends in July-August-September (Table 1), for the three ENSO categories. The effects of ENSO can be observed from mature stage through to dissipation in the following summer. Current research indicates that the previous summer is also important for the cold phase impacts but is not included in this report.

Deviations in temperature and precipitations due to warm and cold phases from the neutral phase values are geographically variable. Animations of these results, plus those from a similar study on the United States (Sittel 1994), have been composed to show a comprehensive view of the deviations associated with the cold and warm phases for the entire North American continent (Green 1996). Artistic renditions or cartoons are made for each season in the warm (cold) phase using the animation stills for precipitation and temperature. In the cartoons, illustration of the cold (warm) phase refers to the deviation of the cold (warm) phase climatology from the neutral phase climatology.

Table 1: ENSO Season

Fall	October/November/December
Winter	December/January/February
Spring	March/April/May
Summer	June/July/August

Table 2: ENSO PHASES

Cold Phase	Neutral Phase	Warm Phase
1945	1944	1951
1946	1950	1957
1947	1952	1963
1948	1953	1965
1949	1958	1969
1954	1959	1972
1955	1960	1976
1956	1961	1982
1964	1962	1986
1967	1966	
1970	1968	
1971	1974	
1973	1977	
1975	1978	
	1979	
	1980	
	1981	
	1983	
	1984	
	1985	

NOTE: A year, such as 1945, indicates a cold phase from October 1945 to September 1946.


WARM EVENT FALL
Dry
WET
Very Wet
WARM
Dry
Very Dry
COLD
Dry
Dry
WET
WET
Dry
Very Wet
WET
COLD
WET
WET
WARM
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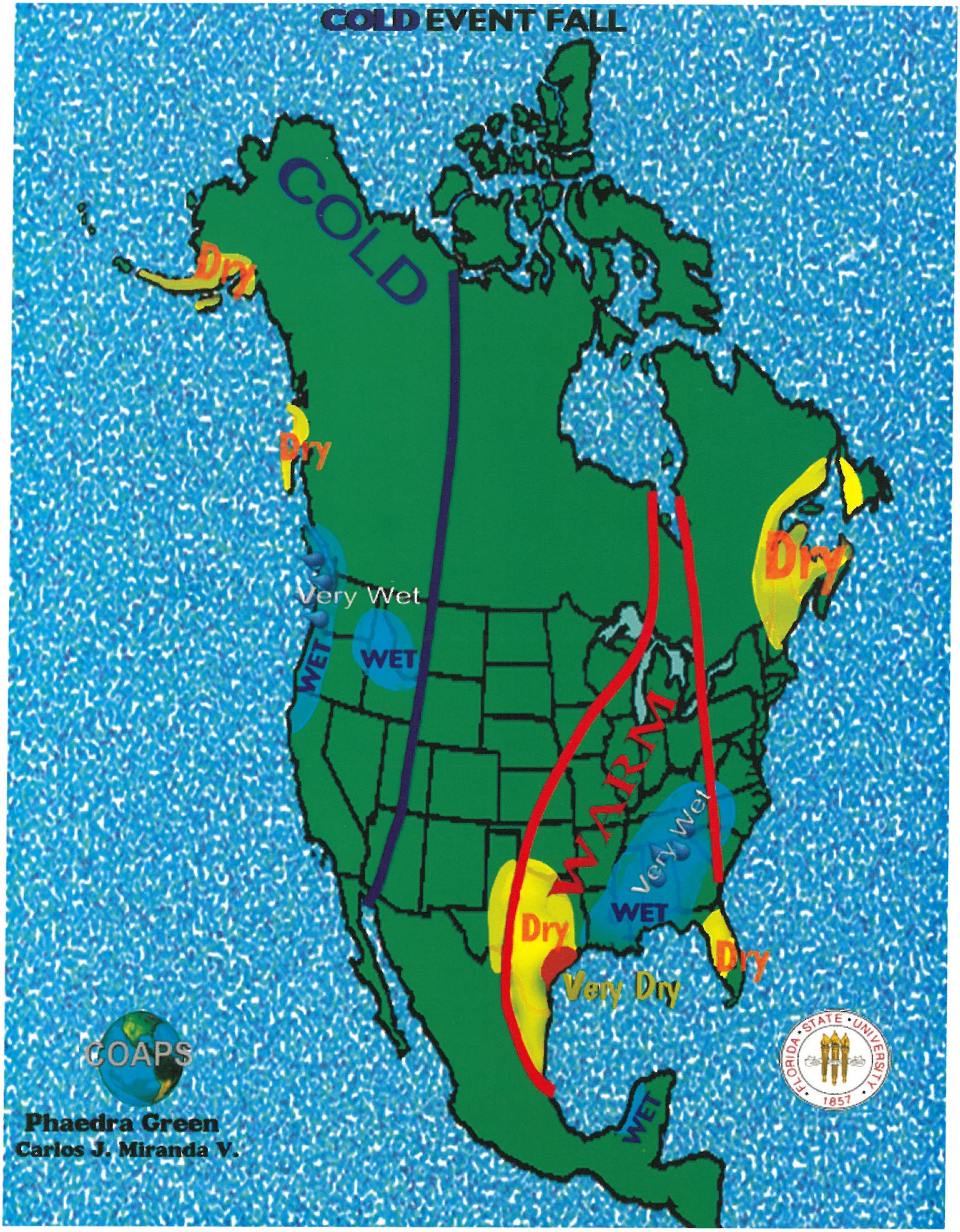
COLD EVENT FALL
COLD
Dry
Dry
Very Wet
WET
WET
WARM
Dry
Very Wet
Very Wet
WET
Dry
Dry
Very Dry
WET
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WARM EVENT WINTER
COLD
WARM
WET
WET
Dry
Very Dry
Dry
WET
Dry
Dry
WET
COLD
Very Wet
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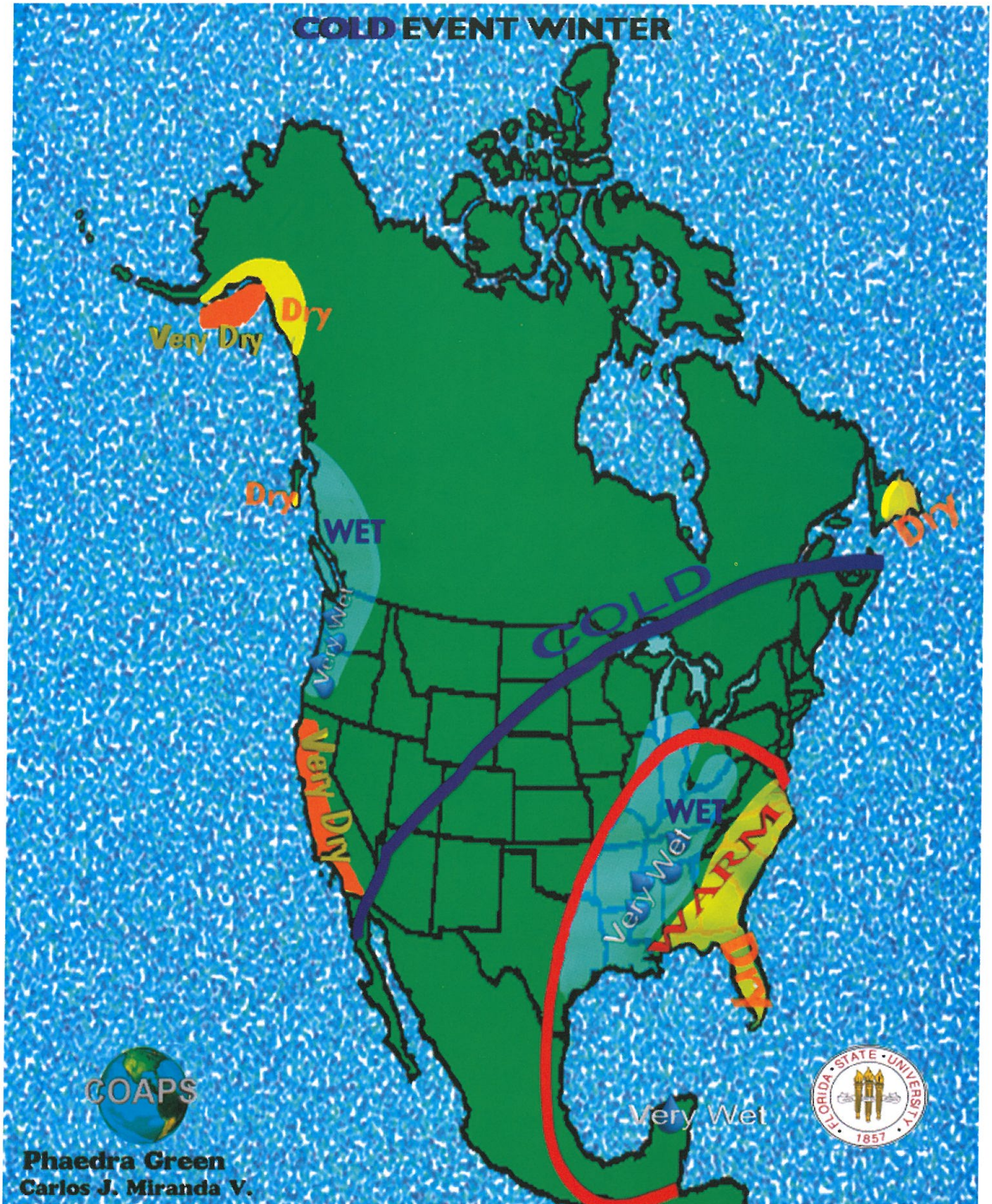
COLD EVENT WINTER
Dry
Very Dry
Dry
WET
Very Wet
Dry
Very Dry
COLD
WET
Very Wet
WARM
Dry
Very Wet
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WARM EVENT SPRING
COLD
WET
COLD
WARM
Very Dry
Dry
Dry
Very Dry
Dry
Very Wet
WET
COLD
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Dry


COLD EVENT SPRING
COLD
Dry
WET
Dry
WET
COLD
WET
Dry
WARM
WARM
WET
Very Wet
Dry
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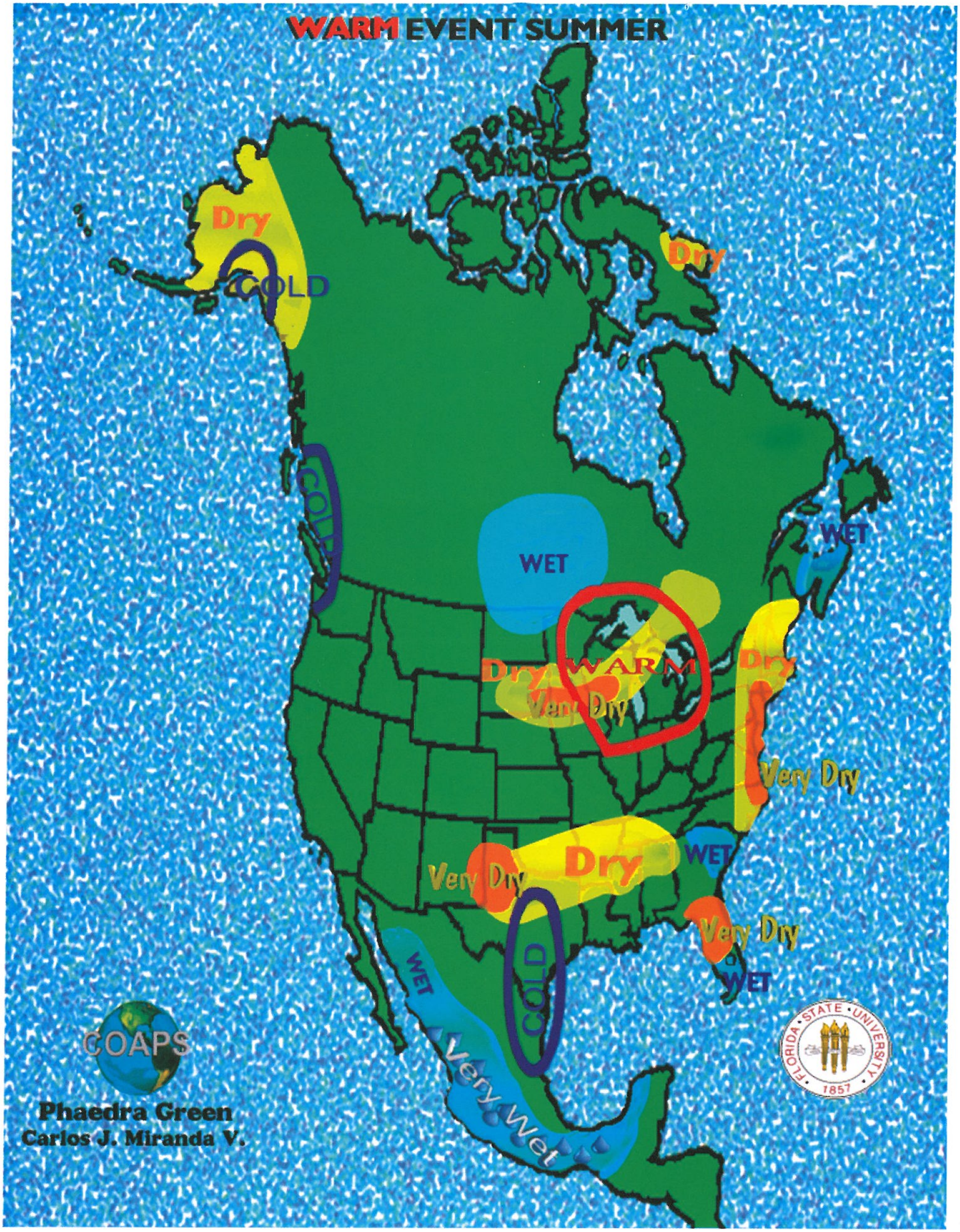
WARM EVENT SUMMER
Dry
COLD
Dry
COLD
WET
WET
Dry
WARM
Very Dry
Dry
Very Dry
WET
Very Dry
Dry
COLD
Very Dry
WET
WET
Very Wet
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COLD EVENT SUMMER

Phaedra Green
Carlos J. Miranda V.

FUTURE APPLICATIONS

Evaluation of climatic variables are needed for the Northern Hemisphere as a whole to discern better the sequence of phases during the ENSO cycles. More study needs to be focused on the higher latitude connections with ENSO. Studies can be undertaken in a variety of fields connected with this investigation. Future work could include relating temperature and precipitation anomalies to crop yields in interior Canada and Mexico. Also, some applications of this investigation could be used in preparation for ENSO related drought and forest fires. On the municipal scale, energy budgets for a city in the upcoming fiscal year could be made more effective with these ENSO effects in mind.

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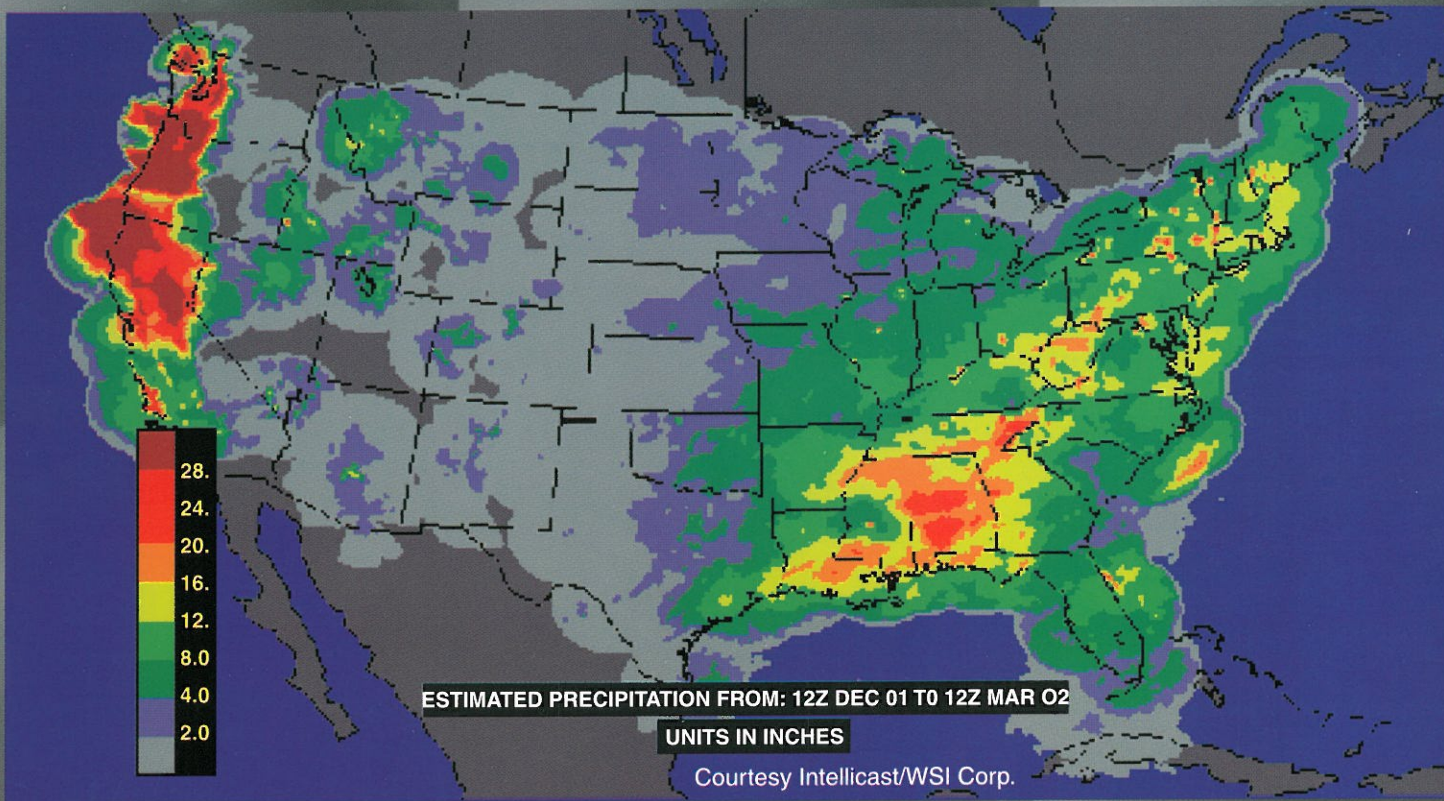
Winter '95-'96 Radar Estimated Precipitation



Winter ENSO Cold Phase Total Precipitation