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**Publication Date**

1998-07-02

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**Potential of Long-lead Streamflow and Drought Forecasting in California**

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TECHNICAL COMPLETION REPORT

Project Number UCAL-WRC-W-856

July 2, 1998

University of California Water Resources Center

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UNIVERSITY OF CALIFORNIA  
BERKELEY, CALIFORNIA

The research leading to this report was supported by the University of California Water Resources Center, as part of Water Resources Project UCAL-WRC-W-856.

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## TECHNICAL COMPLETION REPORT

**PROJECT NUMBER:** W-856

**START:** July 1, 1995

**TITLE:** Potential of Long-Lead Streamflow and Drought Forecasting in California.

**INVESTIGATOR:** John A. Dracup, UCLA

**KEY WORDS:** Streamflow (2300), Climate (0395), El Niño/La Nina (0680), Drought (0635), Hydrology (1255).

### PROBLEM AND RESEARCH OBJECTIVES:

The research problem studied here is whether regional streamflows can be identified and potentially predicted based on the impact of El Niño, La Niña and the Southern Oscillation. The research focused on the following question: **Can streamflow and drought in California be predicted by scientifically understanding ENSO and large scale circulation patterns?** ENSO is defined as the El Niño/Southern Oscillation climatic phenomenon. For decades, the prediction of streamflow and drought has intrigued hydrologists; our current research suggests that ENSO strongly affects streamflow and thus could be an important factor in making long range forecasts of streamflow.

Researchers have determined that ENSO events have significant worldwide impacts on such events as precipitation, temperature, floods, droughts and wildfires. ENSO is a warm event in the tropical Pacific Ocean and is considered a significant perturbation of the general atmospheric circulation. El Niño events have been observed and recorded since 1726. They occur approximately once every 4 years; however, the time interval between successive events varies from 2 to 10 years.

The research objective was to identify regions of land that appear to have a coherent and consistent ENSO-related signal. The identification of these regions and the predictions of the onset of an ENSO event could then lead to the prediction of climatic anomalies.

### METHODOLOGY:

This research project was accomplished in four tasks. *Task 1* involved the formation of ENSO composites on the basis of an ENSO lifetime. For this project, a 24-month period was chosen to represent an ENSO lifetime. The 24-month period encompassed the various phases of an ENSO event, with the middle 12 months representing the ENSO year. Data on California streamflow and drought discharges for the period corresponding to the ENSO lifetime dates were obtained, and a 24-month percentile composite, based on ENSO episodes, was established for each individual California station. All data was

put into a composite, and these ENSO composites were tested for their statistical significance by using bootstrap and jackknife analysis.

*Task 2* quantified the ENSO signal using boxplots. After examining the composites produced by Task 1, data that were deemed to be statistically significant at the 95% level were broken into three subsets. Two subsets corresponded to the extreme phases of ENSO that were labeled La Niña and El Niño, and the third subset corresponded to a non-ENSO phase. The 10th, 30th, 50th, 70th, and 90th percentiles were then computed and presented in a boxplot. The shifts in the probability distributions were evaluated, corresponding to the three events.

*Task 3* involved the development of long range prediction models based on fuzzy concepts. One model was fuzzy-rule based; viewed as the prediction of streamflow or drought conditioned upon atmospheric circulation patterns. Another model was fuzzy regression where the regression parameters take the form of fuzzy numbers. These fuzzy numbers reflected the relative degree of membership of a parameter in the general model. The model parameters are chosen to minimize the vagueness, which is used instead of the least squared criterion.

*Task 4* involved applying the model developed in Task 3 to those stations with a strong response to ENSO. Particular emphasis was placed on those stations with long term records (>50 years); thus, adequate verification and calibration of the models was performed.

## **PRINCIPAL FINDINGS AND SIGNIFICANCE:**

Several regions of coherent response to ENSO were identified. The strongest relationship between El Niño and extreme drought years is found in the Pacific Northwest. A strong relationship is also noticed in the southern U.S., where dry conditions occur consistently during La Niña events. The Palmer Drought Severity Index (PDSI) results were compared to similar analyses on 41 years of station temperature, precipitation, and streamflow data. A consistent response is seen in the other hydroclimatic variables, though the greatest response is seen in PDSI data and streamflow data. The major contribution to the understanding of the ENSO-U.S. climate relationship is the evaluation of the general form of drought, and the comparison of these results to the fundamental hydrologic processes of precipitation, temperature, and streamflow.

**M.S. THESIS:** None

## **PH.D. DISSERTATION:**

Piechota, T.C. 1997. Streamflow, Drought, and Regional Hydrologic Variations in the United States: Associations with the El Niño/Southern Oscillation. Ph.D. dissertation, Civil and Environmental Engineering Department, University of California, Los Angeles, California.

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