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Classifying Drought in Ethiopia Using Machine Learning

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Abstract

This study applies machine learning to the rapidly growing societal problem of drought. Severe drought exists in Ethiopia with crop failures affecting about 90 million people. The Ethiopian famine of 1983–85 caused a loss of ~400,000–1,000,000 lives. The present drought was triggered by low precipitation associated with the current El Niño and long-term warming, enhancing the potential for a catastrophe. In this study, the roles of temperature, precipitation and El Niño are examined to characterize both the current and previous droughts. Variable selection, using genetic algorithms with 10-fold cross-validation, was used to reduce a large number of potential predictors (27) to a manageable set (7). Variables present in ≥ 70% of the folds were retained to classify drought (no drought). Logistic regression and Primal Estimated sub-GrAdient SOlver for SVM (Pegasos) using both hinge and log cost functions, were used to classify drought. Logistic regression (Pegasos) produced correct classifications for 81.14% (83.44%) of the years tested. The variable weights suggest that El Niño plays an important role but, since the region has undergone a steady warming trend of ~1.6°C since the 1950s, the larger weights associated with positive temperature anomalies are critical for correct classification.

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Keywords: Classification, Support Vector Machines, Pegasos, Logistic Regression, Drought, Global Climate Change

1. Introduction

East Africa frequently experiences catastrophic droughts. Currently, severe drought across the Horn of Africa (affecting countries including Ethiopia, Kenya, Somalia, Uganda and Djibouti) has placed over 12 million people in urgent need of assistance. In some areas, the current drought is the worst in over 60 years, as over the past year, the Horn of Africa has experienced two consecutive failed rainy seasons, resulting in one of the driest periods since

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1950/51. Ethiopia, the focus of this study, has a population of about 90 million, of which 10 million are in need, and over 2 million are acutely malnourished because ~80% of the population is reliant on agriculture.

Ethiopia was in drought even before the El Niño phase of El Niño Southern Oscillation (ENSO) hit. Whereas El Niño typically brings more rain to California and the southern United States, it causes drought in other parts of the world, including eastern and southern Africa. Between August and October, 2015 the number of people in need of aid doubled, and numbers have continued to rise sharply, since the drought was exacerbated by El Niño.

The massive Ethiopian famine of 1983–1985, which resulted from a combination of drought and conflict with neighboring countries, 1983–85 left an estimated 400,000–1 million people dead [1], from a population which at that time was much lower, at 40 million, than the present 90 million. The back-to-back recent Ethiopian wet season rainfall failures, which largely are blamed on the current El Niño event, have created a drought, that in some areas of the country, is worse than that of 1983–1985 million.

The main goal of this study is to find a relatively small set of predictors that accurately classify Ethiopian drought years from non-drought years. The target years are the known set of drought years for the period 1953–2013, for which data is available. Although the approach in this study has been applied to both north and central Ethiopia, only the results for northern Ethiopia are described in detail in this study, as the method applied is the same for any climate sub-region of Ethiopia.

2. Data and Methods

2.1. Data

Monthly high resolution gridded rainfall and temperature data for 1953–1993 were obtained from the Climate Research Unit at the University of East Anglia [2]. Station anomalies (from the 1961–1990 means) were interpolated into 0.5° latitude/longitude grid cells covering global land surface. The monthly mean temperature and precipitation totals the cells for the regions 11–13.5°N and 39–41°W were averaged to provide predictor data for the agriculturally important region of northern Ethiopia (Fig. 1).

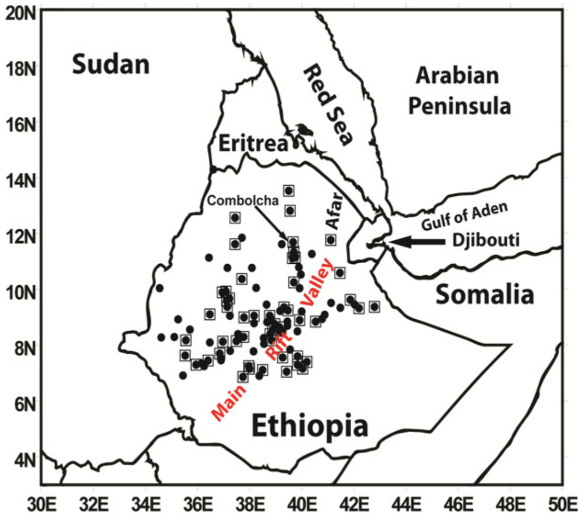

Fig. 1. Map of Ethiopia with location Combolcha centered in northern Ethiopia.

2.2. Methods

El Niño is known to contribute to drought conditions in Ethiopia [3]. This link was extended for various time scales finding numerous SSTA links to Ethiopian precipitations [4]. Hence the Niño3.4 sea surface temperature anomalies (SSTA) and the Trans-Niño Index (TNI) are included, as well as the Atlantic Meridional Oscillation