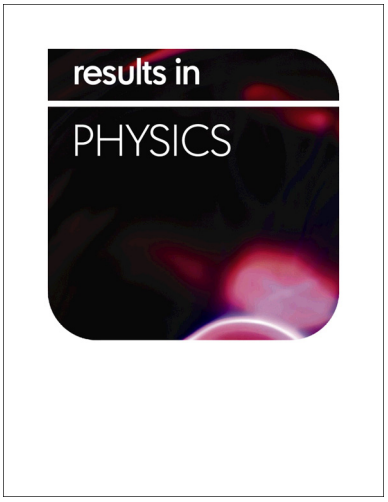

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Jonathan L. Case, Bradley T. Zavodsky

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Evolution of 2016 Drought in the Southeastern United States from a Land Surface Modeling Perspective

Jonathan L. Case (ENSCO, Inc./NASA Short-term Prediction Research and Transition [SPoRT] Center, 320 Sparkman Dr., Room 3000B, Huntsville, AL, 35805) and Bradley T. Zavodsky (NASA MSFC)

Abstract

The Southeastern United States (SEUS) climate region experienced a marked transition from excessively wet conditions early in 2016 to an exceptional drought during the Autumn. The unusually warm and dry conditions led to numerous wildfires, including the devastating Gatlinburg, Tennessee (TN) firestorm on 28-29 November. The evolution of soil wetness anomalies are highlighted through soil moisture percentiles derived from an instance of NASA's Land Information System (LIS). A 33-year soil moisture climatology simulation combined with daily, real-time county-based distributions illustrate how soil moisture began above the 96th percentile early in 2016, and declined to below the 2nd percentile in many locales by late November.

Keywords: drought; Gatlinburg wildfire; NASA; land surface modeling; soil moisture percentiles

Introduction: A combination of three-month mean temperatures of 3–4°C above normal coupled with very little rainfall led to a rapid intensification of drought over the SEUS from September to November 2016. The drought culminated in numerous wildfires during November, including the tragic firestorm in Gatlinburg, TN on 28-29 November, resulting in $500M+ in property damage and the deaths of 14 persons. This micro article documents the rapid intensification of the SEUS Autumn drought by presenting regional and local soil moisture percentiles, which are derived from a high-spatial-resolution, real-time instantiation of the NASA LIS [1], as configured and managed by the NASA Short-term Prediction Research and Transition (SPoRT) Center (hereafter "SPoRT-LIS"; [2], [3]). The objective is to illustrate the evolution of modeled soil moisture leading up to a rapid drought onset and significant wildfire event. By applying a relatively long-term/high-resolution modeled soil moisture database with real-time output, we aim to demonstrate the potential utility of such a tool for enhanced drought and wildfire situational awareness, and form the basis for future probabilistic-based wildfire decision support.

Method and Datasets: The SPoRT-LIS is an observations-driven, real-time simulation of the Unified Noah land surface model [4] over a full Contiguous U.S. (CONUS) domain, providing soil moisture estimates at ~3-km grid resolution over a 2-meter deep soil column. The basis of the SPoRT-LIS is a 33-year soil moisture climatology simulation spanning 1981–2013 and extended to the present time, forced by atmospheric analyses from the operational North American Land Data Assimilation System-Phase 2 [5]. The 33-year climatology comprises daily histograms of 0-2m relative soil moisture (RSM; ratio of volumetric soil moisture between wilting and saturation points for a given soil texture) for every county in the CONUS, resulting in ~10^6 total unique soil moisture distributions. Real-time percentile maps are generated using current soil moisture values at a given model point in relation to the daily county distributions from 1981–2013. Proxy U.S. Drought Monitor (and analog wetness) categories are represented by threshold percentiles used within the drought community (Fig. 1 caption and color bar; described further in [6]).

Results and Discussion: Year 2016 began quite wet in the SEUS due to heavy rainfall and flooding from December 2015. The 0-2m RSM exceeded the 95th percentile across many parts of the SEUS on 1 January 2016, but substantially dried throughout the Spring to below the 20th percentile across northern Alabama (AL), Georgia, and central/eastern TN (not shown). Soil moisture rapidly declined over a large portion of the SEUS during the Autumn (Fig. 1) when a combination of above-average temperatures and little rainfall led to soil moisture falling below the 2nd percentile of the 1981 – 2013 climatology by late November (Fig. 1b). The expanse and intensity of the weekly U.S. Drought Monitor product categories markedly increased from early September (Fig. 2a) to late November (Fig. 2b), showing a strong correspondence to the patterns of SPoRT-LIS soil moisture percentiles in Fig. 1.

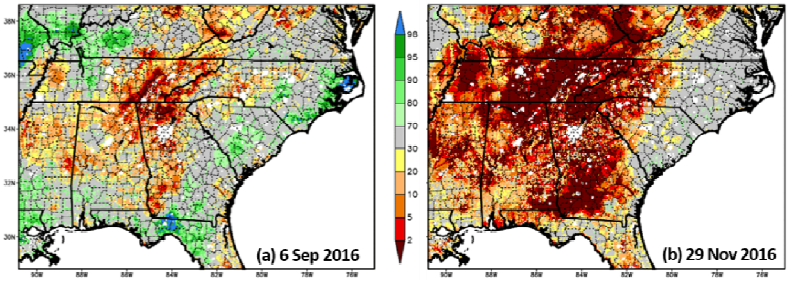

Figure 1. SPoRT-LIS 0-2m RSM percentiles during 2016 valid (a) 6 Sep, and (b) 29 Nov. Following [6], drought categories (see Fig. 2) are given by: D4 (≤2%); D3 (≤5%); D2 (≤10%); D1 (≤20%); D0 (≤30%).