Definition and Classification of Soil Moisture Flash Droughts Over the United States

Mahmoud Osman[1]

[1]Johns Hopkins University

November 24, 2022

Abstract

Flash droughts have recently gained significant attention due to their severe economic and ecological impacts. Despite extensive and growing research on flash drought processes, predictability, and trends, there is still no standard quantitative definition that encompasses all flash drought characteristics and pathways. This has motivated efforts to define, inventory, monitor, and forecast flash drought events. In our recent studies of flash droughts over the United States, we have introduced the Soil Moisture Volatility Index definition (SMVI) to inventory the onset dates and severity of flash across the Contiguous United States (CONUS) for the period 1979-2018. Post to an extended evaluation and comparison to other flash drought definitions and independent vegetation and crop datasets for seminal flash drought events, the SMVI has proved effectiveness in capturing flash drought onset in both humid and semi-arid regions. Using our SMVI inventory of flash droughts, we examine and classify flash droughts events based on multiple land surface and atmospheric conditions that may represent predictable drivers using a K-means-based clustering methodology. We found that there are three distinct classes of flash drought that can be diagnosed in our inventory. The first defined class of events are the "dry and demanding" droughts, showing high anomalies of evaporative demand and low soil moisture levels; The second are "evaporative" events, which develop under conditions of high demand and when elevated evapotranspiration accelerates soil drying, and a third class that we refer to as "stealth" events, which may be challenging to predict based on precursor atmospheric conditions due to the lack of a clear atmospheric signal with the observed modest anomalies. The contrasting meteorological and surface process signatures of the three classes do, however, indicate that events identified as "flash drought" using a reasonable definition, including events that have been widely reported as seminal flash droughts, represent a diversity of onset and intensification processes. Our results suggest that recognizing this diversity is critical to advance our understanding and ability to predict these events.

505-02 - Definition and Classification of Soil Moisture Flash Droughts Over the United States

Friday, 24 June 2022

08:15 - 08:30

PRCC - Room 209

Abstract

Flash droughts have recently gained significant attention due to their severe economic and ecological impacts. Despite extensive and growing research on flash drought processes, predictability, and trends, there is still no standard quantitative definition that encompasses all flash drought characteristics and pathways. This has motivated efforts to define, inventory, monitor, and forecast flash drought events. In our recent studies of flash droughts over the United States, we have introduced the Soil Moisture Volatility Index definition (SMVI) to inventory the onset dates and severity of flash across the Contiguous United States (CONUS) for the period 1979-2018. Post to an extended evaluation and comparison to other flash drought definitions and independent vegetation and crop datasets for seminal flash drought events, the SMVI has proved effectiveness in capturing flash drought onset in both humid and semi-arid regions. Using our SMVI inventory of flash droughts, we examine and classify flash droughts events based on multiple land surface and atmospheric conditions that may represent predictable drivers using a K-means-based clustering methodology. We found that there are three distinct classes of flash drought that can be diagnosed in our inventory. The first defined class of events are the “dry and demanding” droughts, showing high anomalies of evaporative demand and low soil moisture levels; The second are “evaporative” events, which develop under conditions of high demand and when elevated evapotranspiration accelerates soil drying, and a third class that we refer to as “stealth” events, which may be challenging to predict based on precursor atmospheric conditions due to the lack of a clear atmospheric signal with the observed modest anomalies. The contrasting meteorological and surface process signatures of the three classes do, however, indicate that events identified as “flash drought” using a reasonable definition, including events that have been widely reported as seminal flash droughts, represent a diversity of onset and intensification processes. Our results suggest that recognizing this diversity is critical to advance our understanding and ability to predict these events.

Full Abstract

"Flash Drought", a fast forming dry periods that affects our crops and economy. In the past 10 years, researchers have been trying to define it so we can predict it. In our studies of "Flash Droughts" over the United States, we have defined it based on the amount of water in soil. We then created a complete record of all flash droughts since 1979 which we measured its quality by ground reports and satellite images. As we look more into why flash droughts happen, we found that there are three separate types of flash droughts: (1) “Dry and demanding” droughts which we see very little amount of water in the soil and high water loss into the air. (2) "Evaporative" droughts which the air has very strong drying power, and (3) "Stealth" droughts that we could not find a clear action from the air when they happen. These types can be different if a different way is used to define flash droughts, but they show us that not all flash droughts are happening for the same reasons. Our results might help researchers predict flash droughts before happening.

First Author

Mahmoud Osman
Johns Hopkins University

Authors

Ben Zaitchik
Johns Hopkins University

Hamada S Badr
Johns Hopkins University

Jason Otkin

Yafang Zhong

University of Wisconsin-Madison

University of Wisconsin-Madison

David J Lorenz
University of Wisconsin-Madison

Martha Anderson
USDA ARS Hydrology and Remote Sensing Laboratory

Trevor F Keenan
Lawrence Berkeley National Laboratory

David L Miller
University of California Berkeley

Christopher Hain
NASA Marshall Space Flight Center

Thomas Holmes
NASA Goddard Space Flight Center

Scientific Team

PREEVENTS

View Related