Environmental Research Letters

CrossMark

LETTER

Climate change is increasing the likelihood of extreme autumn wildfire conditions across California

Michael Goss[1,10] (iD), Daniel L Swain[2,3,4] (iD), John T Abatzoglou[5,6] (iD), Ali Sarhadi[1] (iD), Crystal A Kolden[5,7] (iD), A Park Williams [8] (iD) and Noah S Diffenbaugh[1,9] (iD)

1 Department of Earth System Science, Stanford University, Stanford, CA, United States of America
2 Institute of the Environment and Sustainability, University of California, Los Angeles, CA, United States of America
3 The Nature Conservancy of California, San Francisco, CA, United States of America
4 Capacity Center for Climate and Weather Extremes, National Center for Atmospheric Research, Boulder, CO, United States of America
5 Management of Complex Systems Department, University of California, Merced, CA, United States of America
6 Department of Geography, University of Idaho, Moscow, ID, United States of America
7 College of Natural Resources, University of Idaho, Moscow, ID, United States of America
8 Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, United States of America
9 Woods Institute for the Environment, Stanford University, Stanford, CA, United States of America

E-mail: goss@stanford.edu

Abstract

California has experienced devastating autumn wildfires in recent years. These autumn wildfires have coincided with extreme fire weather conditions during periods of strong offshore winds coincident with unusually dry vegetation enabled by anomalously warm conditions and late onset of autumn precipitation. In this study, we quantify observed changes in the occurrence and magnitude of meteorological factors that enable extreme autumn wildfires in California, and use climate model simulations to ascertain whether these changes are attributable to human-caused climate change. We show that state-wide increases in autumn temperature (~1 °C) and decreases in autumn precipitation (~30%) over the past four decades have contributed to increases in aggregate fire weather indices (+20%). As a result, the observed frequency of autumn days with extreme (95th percentile) fire weather—which we show are preferentially associated with extreme autumn wildfires—has more than doubled in California since the early 1980s. We further find an increase in the climate model-estimated probability of these extreme autumn conditions since ~1950, including a long-term trend toward increased same-season co-occurrence of extreme fire weather conditions in northern and southern California. Our climate model analyses suggest that continued climate change will further amplify the number of days with extreme fire weather by the end of this century, though a pathway consistent with the UN Paris commitments would substantially curb that increase. Given the acute societal impacts of extreme autumn wildfires in recent years, our findings have critical relevance for ongoing efforts to manage wildfire risks in California and other regions.

1. Introduction

California has recently endured a multi-year period of unprecedented wildfire activity. The state's single deadliest wildfire, two largest contemporary wildfires, and two most destructive wildfires all occurred during 2017 and 2018 [1]. Over 150 fatalities were directly

attributed to these fires [2]—a total greater than during any California earthquake since San Francisco's 'Great Quake' of 1906 [3]. Over 30 000 structures and >1.2 million ha burned in 2017–2018, including nearly the entire Sierra Nevada foothill town of Paradise (population 27 000). State-level fire suppression expenditures exceeded $1.6 billion in 2017–2018 [1], and estimated economic losses exceeded $40 billion [2]. Wildfire smoke was transported across the state, exposing millions to prolonged periods of degraded

---

10 Author to whom any correspondence should be addressed.