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Short contribution – Fuel Management

Climate-induced variations in global severe fire weather conditions

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Abstract

Surface weather conditions are a major drivers of wildland fire size and intensity. Climatic changes over the last four decades are thought to be influencing these burning conditions both regionally and globally but few studies have comprehensively explored how climatic changes may be affecting fire weather severity during the fire season. Here we explore how these climatic changes impact two metrics of wildland fire weather: the weather-mediated length of the fire season and the within-season fire weather severity. We show that these metrics are strong predictors of burned area across the Western US, Western Europe and other fire-adapted global ecosystems. We leverage these two metrics to describe changes in fire season length and severity across the globe in an effort to map areas that are experiencing significant changes in both fire weather season length and fire weather severity. These results will help us better understand how climatic variations are manifesting themselves as tangible changes in observed fire activity and it will improve our understanding of the complex interactions between long-term climatic changes, short-term weather variations and wildland fire-induced carbon cycle feedbacks.

Keywords: climate change, fire danger, fire weather severity, fire weather season length

1. Introduction

Wildland fire activity across the globe is heavily tied to local weather variations and over time, climatic shifts may alter the sizes and types of fires that occur. Climatic changes are occuring across the globe and these changes are lengthening global fire seasons. Regionally, tese longer fire seasons are leading to more area burned and possible higher intensity fires. However, another possibility exists that the within-season fire weather severity is changing

Here we explore how climatic shifts are influencing two aspect of global fire weather conditions: a lengthening of the fire weather season and an increase in the within-season fire weather severity.

2. Methods

2.1. Meteorological data

Three global reanalysis projects provided gridded, sub-daily surface meteorological data from 1979 to 2016. Two data sets at ∼210 km spatial resolution were obtained from NCEP, including the Reanalysis I and the DOE Reanalysis II data sets. Six-hourly data fields for 2 m maximum temperature, minimum temperature, specific humidity, surface pressure, precipitation rate, water equivalent of actual snow depth and 10 m U and V wind components were summarized to daily data. We assumed that diurnal variations in actual vapor pressure are small and thus daily mean actual vapor pressure was calculated from the NCEP data using mean daily specific humidity and surface pressure65, and saturation vapor pressure was calculated from daily maximum and minimum temperature to calculate daily maximum and minimum relative humidity. In addition, we used the ECMWF ERA Interim Reanalysis. This data set is similar to NCEP's but at a higher spatial and temporal resolution (∼78 km resolution). We extracted 3-hourly 2 m air temperature, dewpoint temperature, surface total precipitation, and 10 m U and V wind components using the ECMWF GRIdded Binary Application Programming Interface (GRIB-API) and used them to derive daily maximum and minimum temperature, maximum and minimum relative humidity, maximum wind and total daily precipitation amount and daily precipitation duration. Daily maximum and minimum relative humidity were calculated using mean daily dewpoint temperature and minimum and maximum daily 2 m air temperature, respectively.

2.2. Fire Danger Indices

These data were used to calculate three daily fire danger indices, the US Burning Index, the Canadian Fire Weather Index and the Australian (McArthur) Forest Fire Danger Index, for each of the three ensemble datasets. A fire weather season length and a season fire weather severity metric were calculated for each index / reanalysis dataset combo.

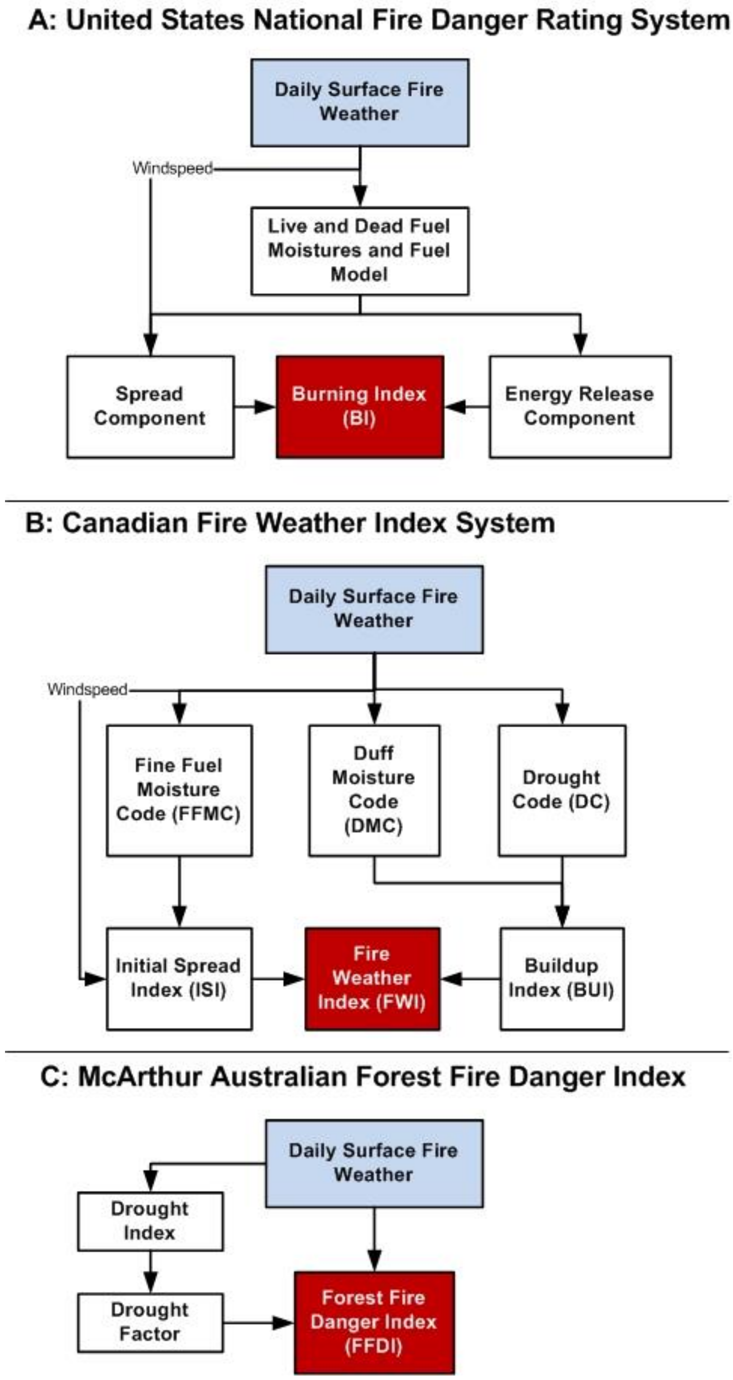

Figure 1 - Simplified diagrams of the three fire danger rating indices used for this study.

3. Results

Consistent with our previous study, we found increases in fire weather season length across nearly 20% of the global vegetated land mass. Further, we found a steady increase in fire weather severity since 2000 in the adsence of any changes in season length suggesting a previous unexplored way that climatic changes may be impacting seasonal burning conditions worldwide. Mean global fire weather season severity increased abruptly after about the year 2000 and have remained high for the last one and a half decades (Figure 2). Further, across much of the Western US, fire seasons are both longer and within-season conditions are becoming more severe, while in Europe, some places are observing more severe within-season burning conditions while the lengths of the seasons are remaining relatively constant. Part of Western South America, Sub-sahelian West Africa and Western India are all observing shorter fire seasons and reduced burning condition severity.

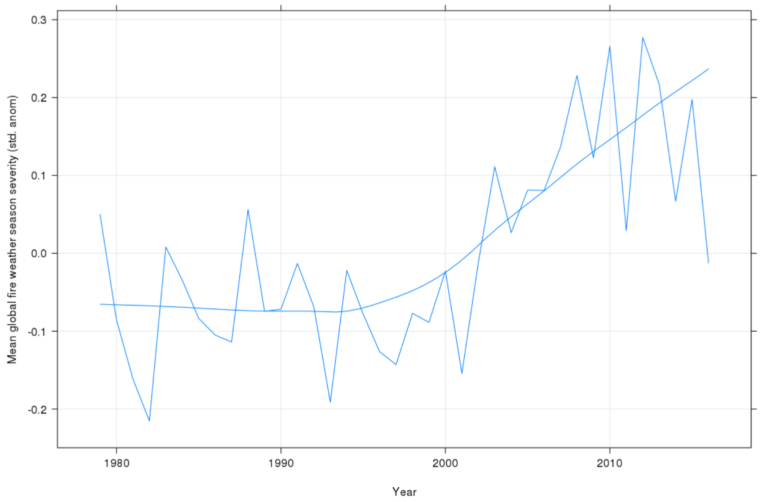

Figure 2 - Mean global fire weather severity from 1979-2016 calculated from an ensemble of fire weather season length metrics and cumulative annual fire weather severity.

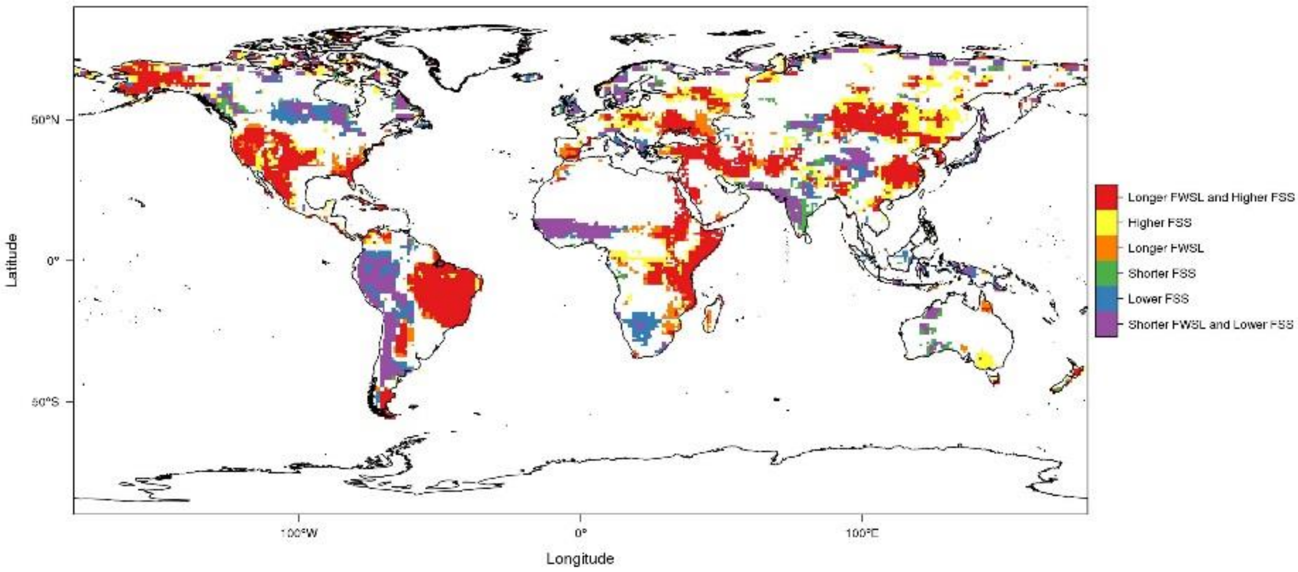

Figure 3 - Global, composite change in Fire Weather Season Length (FWSL) and Fire Season Severity (FSS). Red areas show regions where seasons are lengthening and the within-season conditions becoming more severe, yellow areas show regions where only the sesaonal severity is increasing and the FWSL is not changing. Orange areas show areas where only the FWSL is increasing, green areas show places where the seasons are getting shorter, blue areas are becoming less severe and purple areas are observing shorter seasons and less seasonal weather severity.

4. Discussion

Previous work has shown that fire weather season length is increasing across nearly 20% of the vegetated surface of the Earth. These longers seasons are contributing to more days available to burn each year and these fires come at a high socio-economic cost. Extending from this previous work, we show that regional changes in within-fire season severity are also increasing, suggesting that while fire season lengthening may play a role in increased regional fire activity, more severe fire weather conditions may also be playing an important role in regulating global fire activity. These regional changes in fire season length and severity can have a strong impact on fire activity and can lead to substantial changes in atmospheric carbon feedback.