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Key Points:

- The fire season over eastern Siberia has extended dramatically into October, lengthening by approximately 1 month over 2002–2023
- The extension is driven by the accumulated August–September drought rather than contemporaneous October meteorology
- Arctic sea ice loss and North Atlantic cooling favor high-pressure anomalies that promote precipitation deficits over eastern Siberia

Supporting Information:

Supporting Information may be found in the online version of this article.

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Extended Fire Season Over Eastern Siberia Driven by Accumulated August–September Drought

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Abstract Siberian wildfires, a major disturbance to ecosystems and carbon cycles, have intensified in recent decades, yet long-term changes in fire seasonality remain unclear. Here, using a refined fire-season framework, we identify a pronounced shift in fire season characteristics over eastern Siberia during 2002–2023, marked by substantial lengthening of the fire season and increasingly clustered occurrence of large fires. The fire season extends primarily through delayed termination of 1.48 days/yr into late autumn, associated with the growing persistence of extremely large September fires and more wildfire ignitions in October. We further find that enhanced fire-weather conditions are the main driver, arising from accumulated drought associated with precipitation deficits in the preceding August–September period. These deficits coincide with persistent high-pressure anomalies linked to declining Arctic sea ice and subpolar North Atlantic cooling, underscoring the importance of understanding mechanisms and improving early warning of antecedent hydroclimate in shaping high-latitude fire-season dynamics.

Plain Language Summary Wildfires in Siberia have become more intense in recent decades, but it has been unclear whether the timing of the fire season has also changed. By developing a fire-season framework, we examined how wildfire activity has evolved across eastern Siberia and find that the fire season has become noticeably longer, mainly because it is ending later in the year. On average, the end date of the fire season has shifted by about 1.48 days/yr toward late autumn. This delay is linked to large fires that start in September and continue burning into October, as well as an increasing number of new fires ignited during October. The longer season is mainly driven by more favorable fire-weather conditions caused by accumulated drought that develops earlier in late summer. In particular, reduced rainfall in August and September leads to drought that persists into autumn, making vegetation easier to burn. These enhanced drought conditions are linked to large-scale climate patterns, including the long-term decline of Arctic sea ice and subpolar North Atlantic cooling, highlighting the importance of monitoring preceding drought as an early-warning indicator of late-season fire risk.

1. Introduction

Siberian wildfires, predominantly burning boreal forests and carbon-rich organic soils, constitute one of the most consequential components of Pan-Arctic fire activity (Descals et al., 2022; McCarty et al., 2020; Rein & Huang, 2021). Fires in this region typically occur from spring to autumn as surface temperatures rise and snow retreats (Kharuk et al., 2022; Talucci et al., 2022), exerting disproportionate influence on the terrestrial carbon budget and atmospheric composition through direct combustion and post-fire ecosystem impacts (McCarty et al., 2021; Popovicheva et al., 2022; Yang and Gao, 2026; Zheng et al., 2023; Zhu et al., 2024). Understanding the characteristics and long-term evolution of Siberian wildfire activity is therefore critical for assessing climate–wildfire interactions at high latitudes as well as its global impacts.

Over recent decades, Siberian wildfire regimes have undergone pronounced long-term shifts in fire severity, frequency, and spatial distribution (Bondur et al., 2020; Jones et al., 2022; Tomshin & Solovyev, 2022). In contrast to decreased burned areas in much of western Siberia (Zhu et al., 2021), both burned area and fire-related carbon emissions have increased substantially across eastern Siberia, accompanied by an expansion of fire activity toward higher latitudes, rendering it among the most severely affected regions in the Northern Hemisphere (Huang et al., 2024; Zeng et al., 2025; Zheng et al., 2021). These changes in fire activities over eastern Siberia have been attributed to a range of climatic factors, including Arctic warming (Zhong et al., 2024), sea ice loss

(Luo et al., 2024), and decadal North Atlantic sea surface temperature variability (Zeng et al., 2025), acting through elevated temperatures, reduced precipitation, and soil moisture depletion (Hegedűs et al., 2024; McCarty et al., 2021).

Most of these long-term changes, however, have been identified using fire metrics such as burned area, fire emissions, or fire radiative power aggregated over predefined periods (e.g., annual totals or summer seasons) (Ponomarev et al., 2021; Voronova et al., 2020; Yang et al., 2023). While these metrics effectively characterize changes in the overall magnitude of fire activity, studies based on such aggregated metrics provide limited insight into long-term changes in fire season characteristics. Beyond the fire magnitude, fire regimes are also characterized by the timing of fire season onset and termination, the duration of the fire season, and the internal temporal structure of fire activity (Bowman et al., 2009; Chuvieco et al., 2008; Wotton & Flannigan, 1993), which together describe the fire season envelope. Notably, fire seasonality plays a critical role in regulating carbon emissions and shaping ecosystem resilience (Knapp et al., 2009; Miller et al., 2020). Growing evidence indicates long-term shifts in fire seasonality across fire-prone regions, such as earlier fire onset associated with earlier snowmelt in the western United States (Madakumbura et al., 2025; Westerling et al., 2006), increased fire season length over the subtropical grasslands and savannas (Jolly et al., 2015), and projected lengthening of potential fire seasons across boreal and temperate regions under future climate warming (Flannigan et al., 2013; Senande-Rivera et al., 2022; Yue et al., 2013). Such changes are closely linked to increased opportunities for prolonged burning and elevated fire risk. Despite this, systematic investigations of how fire season characteristics have evolved in Siberia, and the factors controlling these changes, remain limited.

Existing fire-season definitions typically rely on either fire weather exceeding prescribed thresholds (Jolly et al., 2015; Senande-Rivera et al., 2022) or on relative or cumulative metrics of fire occurrence, such as periods contributing fixed percentages of annual burned area or emissions (Archibald et al., 2013; Fan et al., 2023; Silva et al., 2023). Although useful for characterizing climatological fire seasonality, these approaches use thresholds that are defined relative to the total burned area (or emissions) in each individual year and therefore vary with annual fire magnitude. This dependence makes fair comparisons of fire seasonality across years difficult, particularly in regions with strong interannual variability and pronounced long-term trends, such as eastern Siberia. Here, we first combine satellite-derived burned area with individual fire tracking to characterize long-term changes in fire season timing, duration, and internal structure over eastern Siberia during 2002–2023. Using a refined fire-season framework, we investigate recent changes in fire seasonality in eastern Siberia and further examine the associated meteorological controls and large-scale climate drivers to provide new perspectives on the evolution of high-latitude fire regimes.

2. Data and Methods

Daily high-resolution (1 km) burned area from the Fire Inventory from NCAR (FINN v1.5) (Wiedinmyer et al., 2011) were used to characterize regional fire activity over eastern Siberia (54–66°N, 104–136°E, see Figure S1 in Supporting Information S1 or Figure 4 for the study domain). FINN was selected because its daily temporal resolution is essential to quantify fire season characteristics, including season onset, termination, duration, and the temporal evolution of fire activity. Previous evaluation over Siberia has demonstrated that FINN reproduces the interannual variability and long-term trends of wildfire activity consistently with independent fire products (Huang et al., 2024). Following Dennison et al. (2014), in which the fire season onset is determined by the 10th percentile of large fires occurrence dates, we define an analogous regional large fire day (LFD) as a day when the daily sum of burned area exceeds the 50th percentile of all non-zero daily burned area values across the full study period. For each year, days exceeding this threshold are classified as LFDs. The start and end of the fire season are then defined as the mean dates of the first and last 10th percentiles of LFD occurrence, respectively. Based on the identified fire-season boundaries, we further quantify fire-season characteristics, including fire-season length (difference between end and onset dates), number of active fire days (number of LFDs within the fire season), and fire continuity (ratio of active fire days to fire-season length). These metrics, together describe the internal temporal structure of the fire activity. The robustness of this framework is evaluated against two commonly used definitions based on relative (80%) and cumulative (10%–90%) contributions (Archibald et al., 2013; Silva et al., 2023). The first defines the fire season as the set of days (ranked by descending order) accounting for 80% of the annual burned area, while the second defines the start and end of fire season as days when cumulative burned area reaches 10% and 90% of the annual total, respectively. Additionally, we use individual-fire information from

an extended data set of the Global Fire Atlas (Abatzoglou et al., 2025; Kelley et al., 2025), which builds upon the original data set (Andela et al., 2019) to provide fire start and end times, expansion rates, and related attributes.

The Fire Weather Index (FWI), a widely used indicator of fire danger integrating the effects of temperature, relative humidity, wind speed, and precipitation (Wagner, 1987), is used to assess meteorological controls on long-term fire-season changes. It has been demonstrated to show good correlations with Siberian wildfires (Jones et al., 2022). The Canadian FWI system consists of three fuel moisture codes (fine fuel moisture code (FFMC), duff moisture code (DMC), and drought code (DC)) and three fire behavior indices (initial spread index (ISI), buildup index (BUI), and FWI). FFMC represents moisture conditions in surface fine fuels and responds rapidly to contemporaneous meteorological variability. DMC and DC characterize moisture conditions in progressively deeper organic fuel layers and therefore retain the influence of meteorological conditions over sub-seasonal to seasonal timescales. ISI is derived primarily from FFMC and wind speed, whereas BUI combines DMC and DC and therefore inherits their longer temporal memory. Based on these differing response times, we classify FFMC and ISI as fast-responding components, and DMC, DC, and BUI as slow-responding components.

For our primary analyses, we use ERA5-derived daily FWI components from the Copernicus Climate Data Store at 0.25° horizontal resolution (Vitolo et al., 2020). To isolate the contribution of individual meteorological variables, we reconstructed FWI following the standard Canadian FWI algorithm using daily ERA5 reanalysis (Hersbach et al., 2020). The reconstructed FWI reproduces both the interannual variability and long-term trend of the ERA5-derived FWI product with high fidelity ($r = 0.98$, Figure S2 in Supporting Information S1). We then performed sensitivity experiments by replacing one meteorological variable at a time with its daily climatological mean while keeping all other variables unchanged. The difference in the reconstructed FWI trend relative to the control reconstruction quantifies the contribution of that variable to the observed long-term trend in FWI. Finally, to examine the underlying mechanisms, we analyzed monthly mean geopotential height and vertical velocity from ERA5 reanalysis, root-zone soil moisture from C3S soil moisture data set (Pasik et al., 2023), along with monthly mean Extended Reconstructed Sea Surface Temperature version 5 (ERSSTv5) at 2° resolution (Huang et al., 2017) and Met Office Hadley Center's sea-ice concentration data at 1° resolution (Rayner et al., 2003). The wave activity flux analysis formulated by Takaya and Nakamura (2001) was used to diagnose the dynamical pathways linking large-scale climate drivers to circulation anomalies over eastern Siberia. All data sets were analyzed at their native spatial resolutions.

3. Results

3.1. Extending Fire Season Over Eastern Siberia

Fire activity in eastern Siberia is primarily concentrated between spring and autumn, as documented in previous studies (Talucci et al., 2022); however, the fire season has lengthened markedly over the past two decades (Figure 1). Most notably, the end of the fire season has shifted from summer into late autumn, with increasing occurrences of LFDs in late September and even October. Over the past two decades, LFD frequency in these two months has increased by 0.6 days yr^{-1} and 0.2 days yr^{-1} , respectively, corresponding to an increase in burned area equivalent to 8.7% yr^{-1} of the 2002–2023 mean September–October burned area. With a prolonging rate of 1.48 days/yr, the fire season termination has shifted later, lengthening the fire season by approximately 1 month. A later termination together with a slightly earlier onset jointly result in a significant increase in total fire season length at a rate of 1.91 days/yr. These findings demonstrate that even in the high-latitude fire regime of eastern Siberia, where cold autumn conditions have traditionally been expected to sharply suppress fire activity, the distinction between fire-active warm summers and quiescent cold autumns is now gradually vanishing. Within the identified fire season envelope, we further examine changes in the internal structure of fire activity. The number of active fire days increases significantly, at a rate exceeding that of fire season length itself. Fire continuity ratio also shows a significant upward trend (Figure 1f), implying that large fires are now occurring in closer succession with shorter intervening gaps. In addition, the within-season variance of daily burned area also increases significantly (Figure 1g), indicating increasingly uneven fire activity within individual fire seasons. Such shifting patterns are further supported by recent findings that Siberian wildfires are becoming more clustered and intensified (Tomshin & Solovyev, 2022).

Individual fire tracking provides further insight into the fire behaviors mainly responsible for the extended fire season. Here we distinguish between fires that originate before October and persist into October (multi-day fires) and fires that originate in October, which include both single-day fires (with coincident start and end dates) and

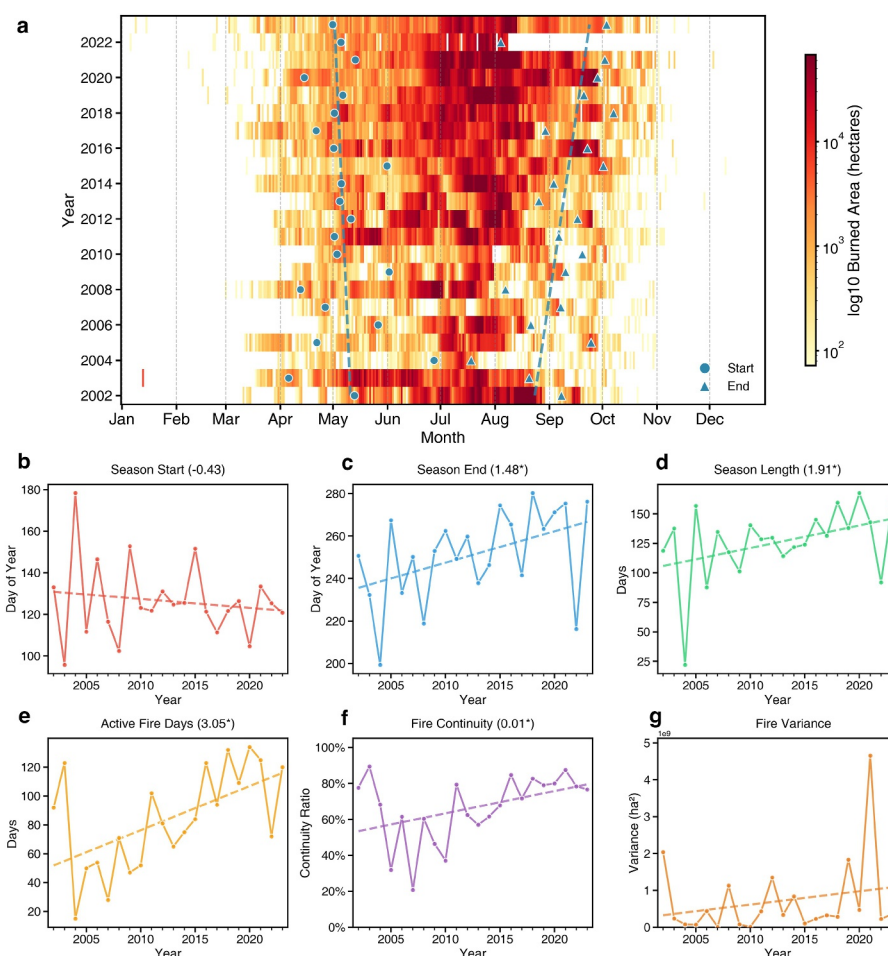


Figure 1. Long-term changes in fire season characteristics over eastern Siberia. (a) Heatmap illustrating the daily evolution of regionally summed burned area during 2002–2023. Blue markers denote fire season start and end days defined using the refined framework, with dashed lines showing linear trends. (b–g) Interannual variation of fire season characteristics: (b) start day, (c) end day, (d) season length, (e) number of active fire days (large fire days occurring within the fire season), (f) fire continuity (ratio of active fire days to fire season length), and (g) within-season variance of daily burned area. Numbers indicate linear trend magnitudes (per year), with asterisks denoting statistical significance at the 90% confidence level.

multi-day fires (Figure 2). Due to the cold temperatures in October, fires starting in this month are generally much shorter-lived and less severe than those in September and rarely persist into the following month. The intensification of October fire activity could be attributed to two distinct pathways. On one hand, extremely large fires originating in September now burn persistently into October (Figure 2a). The number of September fires extending into October has risen from an average of 3 per year during 2002–2012 to 8 per year during 2013–2023 (Figure S3 in Supporting Information S1). On the other, October-origin fires have also intensified over the study period. This intensification is reflected in the growing burned area of October-origin multi-day fires and, more prominently, in the increasing occurrence of October-origin single-day fires across the region (Figure 2b). The occurrence of single-day fires in October has increased dramatically by a factor of 2.8 (Figure S3 in Supporting Information S1), from an average of 7.7 fires per year in 2002–2012 to 21.8 fires per year in 2013–2023. In particular, in 2016, 2020, and 2021, numerous days saw more than 15 single-day fires burning concurrently, and in 2016 alone, more than 60 single-day fires occurred in October. Together, these evolving fire behaviors suggest that conditions in October are becoming increasingly favorable for both sustaining large fires carried over from September and initiating new fires, ultimately delaying the end of the fire season.

The extending fire season is clearly captured by this refined identification framework, but becomes less apparent or even absent with traditional metrics, such as the 80% contribution or 10%–90% cumulative methods (Figures

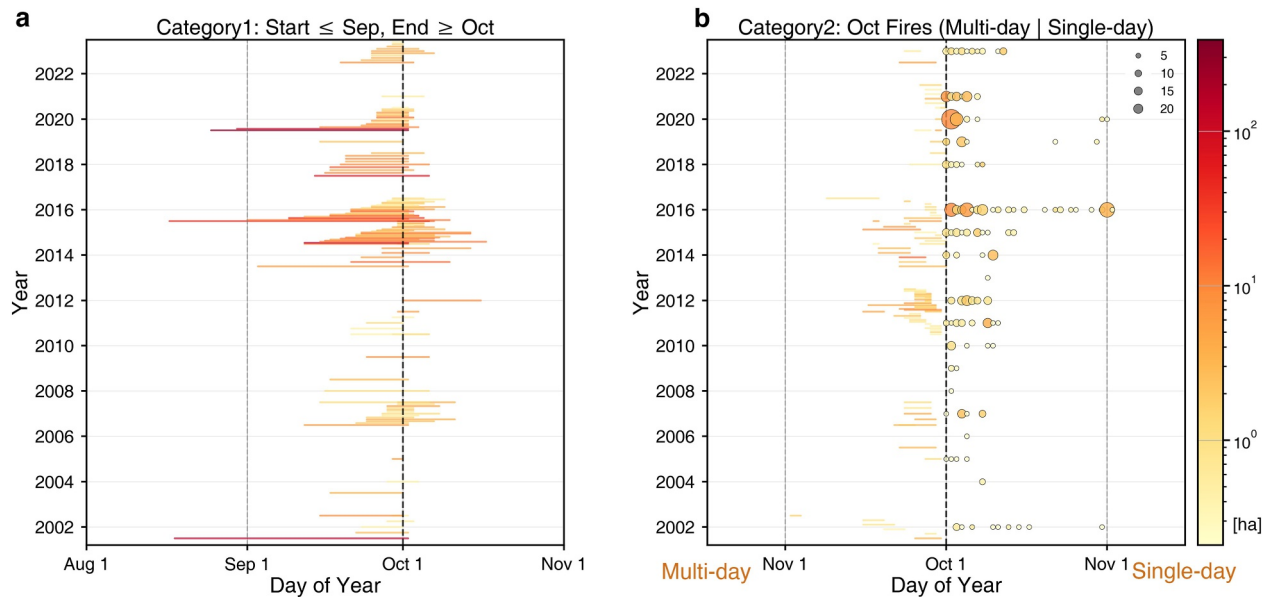


Figure 2. Drivers of the intensified October fire activity. Temporal evolution of fires contributing to the October burned area. (a) Evolution of fires starting before October that persist into October. Each horizontal bar represents an individual fire, spanning from ignition date (left edge) to termination date (right edge), with color indicating total burned areas. (b) Evolution of October-origin fires, separated into multi-day fires (left) and single-day fires (right). For multi-day fires, each bar represents an individual fire with color indicating burned area. For single-day fires, circle size indicates the number of fires occurring on that date, and color indicates total burned area across all fires on that date.

S4–S6 in Supporting Information S1). A key limitation of these two previously-applied approaches is that their relative thresholds vary with annual fire totals. Years with higher annual burned area require substantially higher daily burned area for a day to be classified as part of the fire season than years with lower burned area (Figure S7 in Supporting Information S1). As a result, the fire season definition changes with annual fire magnitude, hindering consistent comparisons of fire season characteristics across years. Relative to the fire season identified using our fixed 50th-percentile threshold, the 80% method excludes a substantial number of LFDs in high-activity years (Figure S6a in Supporting Information S1). For example, more than 80 days exceeding our threshold are excluded in years 2018–2021, compared to very few in low-activity years such as 2004 and 2007. This yields an implausibly short mean season length (41.5 days in Figure S5 in Supporting Information S1) also noted in previous studies (Fan et al., 2023). The 10%–90% cumulative method better captures season length (67.7 days), yet its year-varying thresholds induce a simultaneous shift in both the start and end dates across years, masking the trend in fire season length (Figure S4 in Supporting Information S1). Together, these traditional metrics, while effective at characterizing climatological fire-season features, are less suited to capturing the gradual shifts in fire seasonality emerging in eastern Siberia.

3.2. Mechanisms Underlying the Fire Season Extension

The observed changes in fire behavior could arise from changes in fire ignition, fuel availability, or meteorological conditions. Here, the absence of significant trends in convective available potential energy (CAPE) and late-summer leaf area index (Figures S8 and S9 in Supporting Information S1) suggests that changes in ignition and fuel availability are unlikely to explain the observed fire season extension. Instead, the fire season end day is closely related to fire-weather conditions in October, supported by a strong positive correlation with FWI ($r = 0.5$ and 0.6 for detrended and original data, respectively). It is estimated that October-mean FWI in eastern Siberia has increased by $3.1\%/yr$ over the past two decades (Figure 3a). A 31-day sliding window analysis reveals a close correspondence between FWI trends and trends in LFD frequency, with the largest fractional increases in October (Figure S10 in Supporting Information S1), indicating that changes in fire weather conditions, rather than ignition availability, are the dominant contributor to recent extension of the fire season.

Further analysis of individual FWI components reveals a clear contrast between fast- and slow-responding components (Figures 3a–3f). Fast-responding components (FFMC and ISI), which primarily reflect

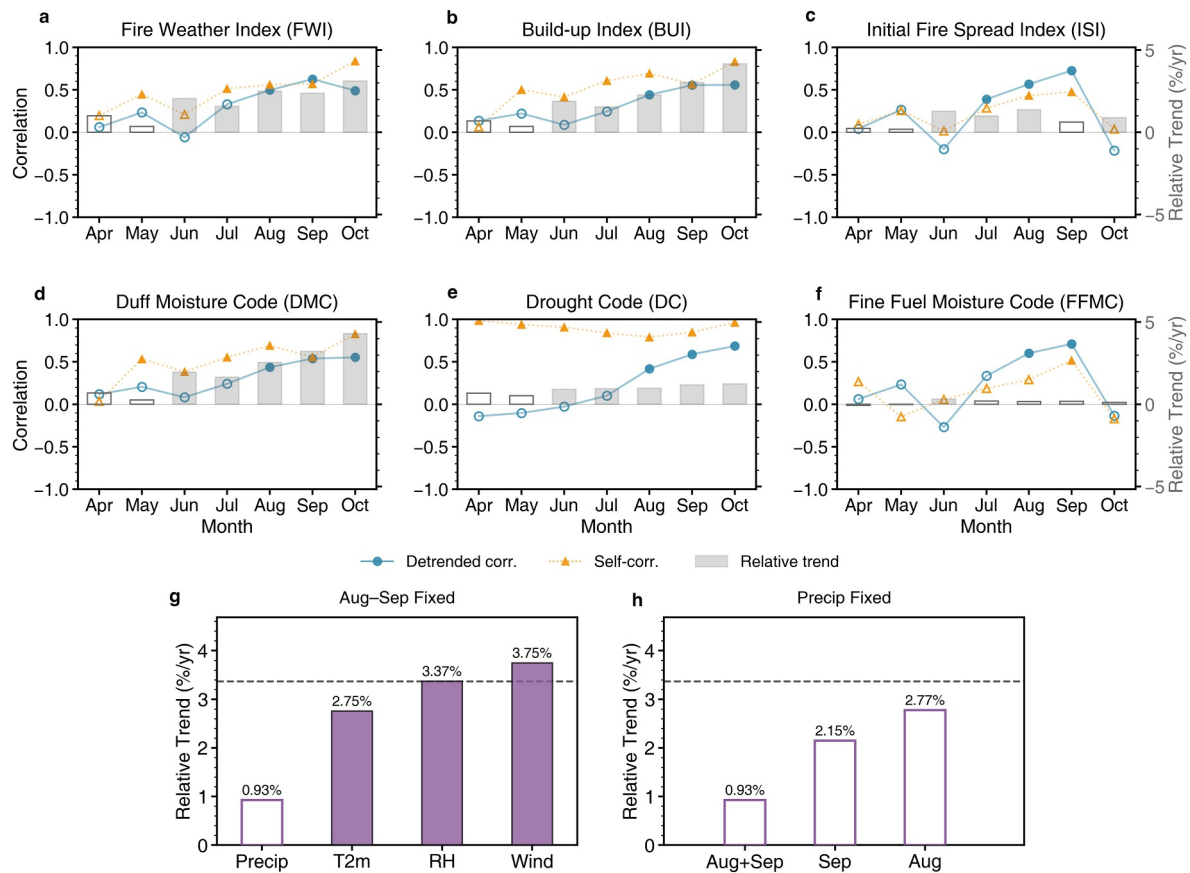


Figure 3. Control of fire season termination by accumulated drought. (a–f) Month-to-month evolution of correlations and trends for six FWI system components. Blue circles show detrended correlations between fire season end day and monthly mean FWI component values; orange triangles show lagged self-correlations of each component with the preceding month; Bars show relative trends of FWI components obtained by dividing the absolute trend with the corresponding multi-year mean. (g–h) Sensitivity experiments isolating meteorological drivers. (g) Reconstructed FWI trends when individual variables (precipitation, temperature, relative humidity, wind) are fixed to daily climatological means during August–September. (h) Reconstructed FWI trends when precipitation alone is fixed during August–September combined, September only, and August only. Dashed lines indicate the baseline trend computed from original meteorological inputs. Filled markers and bars indicate statistical significance at the 90% confidence level in all panels.

contemporaneous meteorological conditions, show weak correlations with the fire season end day. In contrast, slow-responding components (DMC, DC, and BUI), which represent accumulated drying of deeper fuel layers, exhibit strong positive correlations. This sensitivity to deep fuel dryness is consistent with extensive organic soil combustions and sustaining large, long-duration fires over eastern Siberia, in contrast to fires in regions dominated by surface fuel combustion (Rein, 2013).

Compared with the fast-responding components, the slow-responding components retain the influence of antecedent meteorological conditions, as indicated by their pronounced month-to-month lagged autocorrelation. For example, October DC is highly correlated with September DC ($r = 0.96$), which in turn correlates strongly with August DC ($r = 0.82$). Consistently, October FWI also shows strong coherence with September FWI ($r = 0.81$) and weaker but significant coherence with August FWI ($r = 0.49$), indicating that October fire weather retains a strong memory of antecedent hydroclimatic conditions. Furthermore, during 2002–2023, the slow-responding components (DMC, DC, and BUI) and the overall FWI exhibit significant increasing trends throughout August–October, whereas the fast-responding components (ISI and FFMFC) show no consistent trends. This contrast indicates increasingly drier deep fuel conditions that favor the persistence of late-season fires. Consistent with these changes, root-zone soil moisture exhibits significant declining trends across multiple depth layers during August–October (Figure S11 in Supporting Information S1). Together, these findings suggest that October fire weather, and consequently the timing of fire season termination, is more strongly associated with accumulated multi-month drought than with contemporaneous October meteorological conditions.

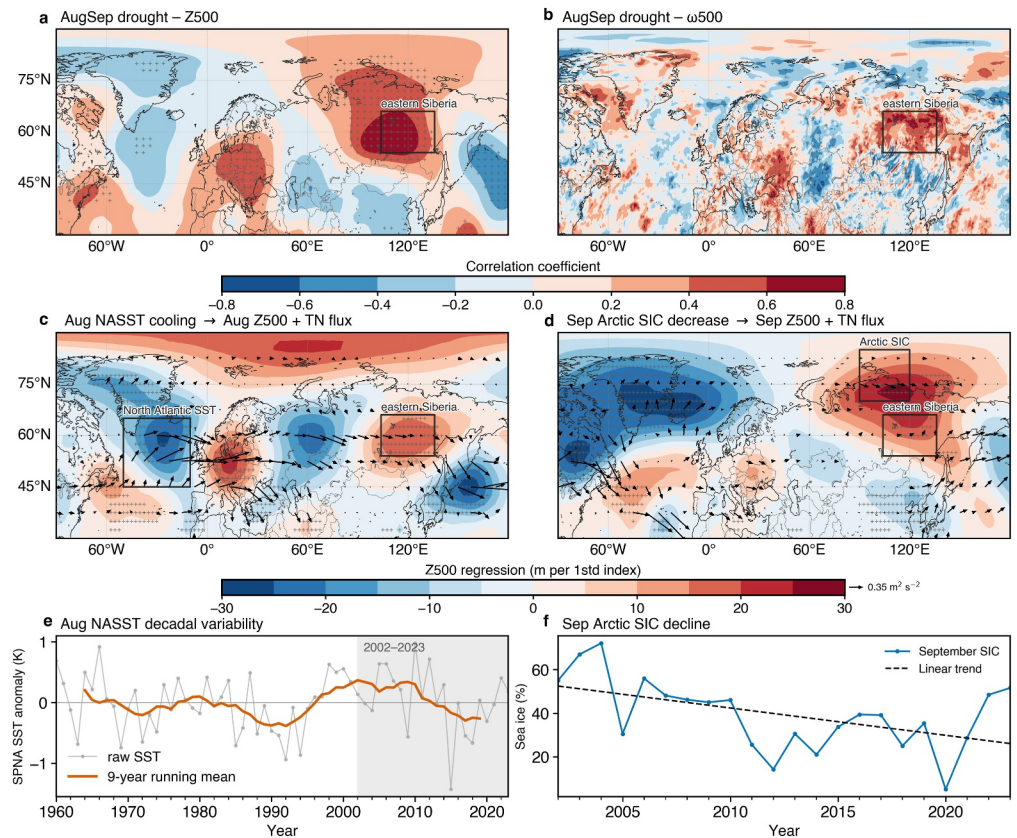


Figure 4. Linkage of August–September precipitation deficits over eastern Siberia to large-scale climate drivers. (a–b) Spatial correlations of detrended August–September mean precipitation averaged over eastern Siberia with 500 hPa (a) geopotential height (Z500) and (b) vertical velocity ($\omega 500$). Signs of correlations are reversed to indicate anomalies associated with precipitation deficits. (c–d) Regression of 500 hPa geopotential height anomalies (shading; m) and wave activity flux (vectors; $\text{m}^2 \text{s}^{-2}$) onto the detrended and standardized regional mean (c) August subpolar North Atlantic SST (NASST) and (d) September Arctic sea ice concentration (SIC). Signs of regressions are reversed to indicate anomalies linked to North Atlantic SST cooling and Arctic sea ice loss. Stippling in (a–d) indicates statistical significance at the 90% confidence level. (e–f) Long-term evolution of the regional mean August subpolar North Atlantic SST (with the global-mean warming signal removed) and September Arctic sea ice concentration averaged over the regions indicated in (c–d).

Given the strong coherence between September and October FWI identified above, September–October FWI are thus combined in subsequent analysis (results hold when analyzed separately). We therefore next examine which meteorological variables are associated with September–October FWI and the timing of fire season termination. Detrended correlations of both the September–October mean FWI and fire season end day with monthly meteorological variables show highly consistent patterns (Figure S12 in Supporting Information S1), indicating that they are governed by similar meteorological controls. Neither FWI nor fire season end day correlates strongly with October meteorological conditions. Instead, both show strong negative correlations with August and September precipitation. Weaker but significant correlations are also found with August relative humidity, September temperature, and wind speed.

While these correlations identify candidate meteorological drivers of the increasing FWI, they do not quantify their relative contributions. We therefore compare the control reconstruction with a series of sensitivity experiments (Figures 3g and 3h). Sensitivity experiments (Figure 3g) show that fixing August–September precipitation to its climatology renders the long-term FWI trend statistically insignificant, whereas fixing relative humidity, wind speed, or temperature has little influence. Additional experiments fixing precipitation separately for August and September (Figure 3h) further show that increasing precipitation deficits during both months contribute to the increase in September–October FWI, demonstrating their joint role in driving the extension of the fire season.

3.3. Links Between Fire Season Extension and Large-Scale Climate Drivers

It is now clear that the fire season extension into October is predominantly driven by August–September precipitation deficits over eastern Siberia. We therefore further investigate the large-scale climate processes underlying these precipitation deficits by first identifying the associated circulation patterns and then examining their remote drivers. Correlations of regional mean August–September precipitation with 500 hPa geopotential height and vertical velocity reveal that precipitation deficits are associated with anomalous anticyclonic circulation and subsidence over eastern Siberia (Figures 4a and 4b). Multiple large-scale drivers have been proposed to generate persistent high-pressure anomalies over Siberia, including Arctic sea ice loss, North Atlantic sea surface temperature (SST) variability, and atmospheric blocking events, reflecting the influence of both anthropogenic forcing and internal climate variability (Luo et al., 2024; Mokhov et al., 2020; Zeng et al., 2025).

Consistent with these previous studies, both regional mean August–September precipitation and the associated 500 hPa geopotential height anomaly over eastern Siberia are found to exhibit significant correlations with subpolar North Atlantic SST cooling and Arctic sea ice loss (Figure S13 in Supporting Information S1). Specifically, positive correlations between precipitation and subpolar North Atlantic SST and Arctic sea ice concentration, together with negative correlations between geopotential height and these two variables, suggest that North Atlantic SST cooling and Arctic sea ice loss are associated with enhanced anticyclonic circulation and reduced precipitation over eastern Siberia. These relationships, however, display pronounced sub-seasonal differences (Figure S14–16 in Supporting Information S1). During August, the eastern Siberian anticyclonic circulation anomaly is more closely associated with subpolar North Atlantic SST cooling (Figure S14 in Supporting Information S1), which excites an eastward-propagating Rossby wave train across high-latitude Eurasia and induces an anomalous high over eastern Siberia (Figure 4c). During September, Arctic sea ice loss exhibits a stronger relationship with the anticyclonic circulation over eastern Siberia (Figure S15 in Supporting Information S1), displaying a broad positive geopotential height anomaly extending from the Arctic toward eastern Siberia (Figure 4d). These complementary influences of large-scale climate drivers help sustain August–September precipitation deficits by favoring anomalous anticyclonic circulation.

Additionally, idealized CESM2 SST and sea ice perturbation experiments reproduce similar circulation and precipitation responses (see Text S1 and Figures S17–18 in Supporting Information S1). When August subpolar North Atlantic SST cooling or September Arctic sea ice loss is imposed, respectively, anomalous anticyclonic circulation and reduced precipitation responses emerge over eastern Siberia, providing independent support for the proposed dynamical linkages. Having identified the relationships of North Atlantic SST and Arctic sea ice changes with eastern Siberian precipitation deficits, we further examine the long-term evolution of these climate drivers. The subpolar North Atlantic exhibits decadal cooling during the study period, while Arctic sea ice shows a continued decline (Figures 4e and 4f). Such long-term changes would favor anticyclonic circulation anomalies and thereby contribute to the increasing August–September precipitation deficits in eastern Siberia. Future efforts to quantify the respective contributions of these two remote forcings remain essential for improving predictive understanding of fire season extension.

4. Conclusions and Discussion

Fires are evolving with growing complexity across their seasonal cycle. Based on a refined fire-season framework, we investigated long-term changes in fire-season characteristics, including timing, duration, and internal temporal structure over eastern Siberia during 2002–2023. The fire season termination has delayed at 1.48 days/yr, prolonging the season by approximately one month into late autumn. This extension is attributable to increasingly favorable October fire-weather conditions, driving both persistence of large September fires and intensification of new October fire activity. Together, these changes signal a progressive erosion of the traditional distinction between fire-active summers and quiescent cold autumns in this high-latitude fire regime.

Counterintuitively, the enhanced October fire weather conditions are not determined by contemporaneous meteorological conditions, but by accumulated drought driven by precipitation deficits in the preceding months of August and September. These earlier precipitation deficits are in turn associated with persistent high-pressure anomalies linked to declining Arctic sea ice and decadal subpolar North Atlantic cooling. While previous studies have primarily focused on the concurrent influence of these large-scale forcings on fire activity, our results further reveal that they also influence the timing of fire season termination through their effects on antecedent drought conditions. Moreover, the complementary influences of these climate forcings exhibit distinct sub-

seasonal characteristics. These findings underscore the importance of monitoring antecedent drought and relevant large-scale forcings as an early indicator of late-season fire risk, with direct implications for fire management and forecasting. Notably, fire also interacts with climate through complex feedback pathways (Huang et al., 2023; Liu et al., 2024; Xue et al., 2025), including emissions, aerosol-radiation effects, and post-fire ecosystem changes, and how these processes further modulate fire season dynamics at high latitudes remains an important direction for future research.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Availability Statement

All the data used in this study are archived in publicly accessible databases. The FWI data can be found at <https://doi.org/10.24381/cds.0e89c522> (Copernicus Climate Change Service and Climate Data Store, 2019). The FINN emissions data is openly accessible at <https://www.acom.ucar.edu/Data/fire> (Wiedinmyer et al., 2011). Individual fire information data can be obtained from <https://zenodo.org/records/11400062> (Andela & Jones, 2024). The ERA5 reanalysis data can be found at <https://cds.climate.copernicus.eu/datasets> (Copernicus Climate Change Service and Climate Data Store, 2024). ERSSTv5 can be found from <https://psl.noaa.gov/data/gridded/data.noaa.ersst.v5.html> (Huang et al., 2017), and sea ice data is available at <https://www.metoffice.gov.uk/hadobs/hadisst/data/download.html> (Rayner et al., 2003). The C3S moisutre data set can be found at <https://cds.climate.copernicus.eu/datasets/satellite-soil-moisture?tab=download> (Copernicus Climate Change Service and Climate Data Store, 2018).

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