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Supplementary material

Trend analysis of fire season length and extreme fire weather in North America between 1979 and 2015

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Trend analysis

Mann–Kendall test

The Mann–Kendall test is a rank based nonparametric estimator of trend (Mann 1945; Kendall 1975). The test is based on the value of the Mann–Kendall Statistic S, which for a time series x_i is defined as:

$$S = \sum_{i}^{n-1} \sum_{j=i+1}^{n} \operatorname{sign}\left(x_j - x_i\right)$$

Positive (negative) values of S indicate a positive (negative) monotonic trend. For identically, independently distributed (i.i.d.) data, the mean $E(S) = 0$ and the variance is:

$$\operatorname{Var}\left(S\right) = \frac{n\left(n-1\right)\left(2n+5\right) - \sum_{i=1}^{n} t_i\left(i\right)\left(i-1\right)\left(2i+5\right)}{18}$$

where t_i is the number of ties of extent i. Moreover, normality of S is approximately valid for $n > 8$. Local significance at level α is then established if the corresponding $Z(S)$ statistic is outside the confidence intervals $Z_{-\alpha/2}$, $Z_{\alpha/2}$ of the null distribution, where:

$$Z\left(S\right) = \begin{cases} \dfrac{S-1}{\sqrt{\operatorname{Var}\left(S\right)}}, \text{ if } S > 0 \\ \dfrac{S+1}{\sqrt{\operatorname{Var}\left(S\right)}}, \text{ if } S > 0 \\ 0, \text{ if } S = 0 \end{cases}$$

Theil–Sen slope estimator

Although the Mann–Kendall statistic indicates the presence of a monotonic trend in time series data, it is often supplemented by the non-parametric Theil–Sen slope estimator (Sen 1968), which gives the corresponding median linear trend. It is defined as:

$$\tau = \operatorname{Median}\left(\frac{x_j - x_i}{j - i}\right)$$

where $j > i$.

Regional Mann–Kendall statistic

The regional Mann–Kendall statistic (Douglas *et al*. 2000; Renard *et al*. 2008) is defined as:

$$S_R = \frac{1}{m}\sum_{k=1}^{m} S_k$$

where S_k is the Mann–Kendall statistic at site k. This statistic determines the presence of monotonic trend at a regional scale. Statistical significance of the regional trend can be determined using the null hypothesis variance given by Douglas *et al*. (2000):

$$\mathrm{Var}\left(S_R\right)=\frac{1}{m^2}\left[\sum_{k=1}^{m}\mathrm{Var}\left(S_k\right)+2\sum_{k=1}^{m-1}\sum_{l=1}^{m-k}\mathrm{Cov}\left(S_k,S_{k+l}\right)\right]$$

where the covariance in the second term accounts for spatial correlation. Here we construct the regional statistic from 3 × 3 (i.e. m = 9) blocks of the gridded NARR data. This value of m is a compromise between improved representation of spatial correlation and the reduction in statistical power that accompanies an increase in m.

Full year fire season

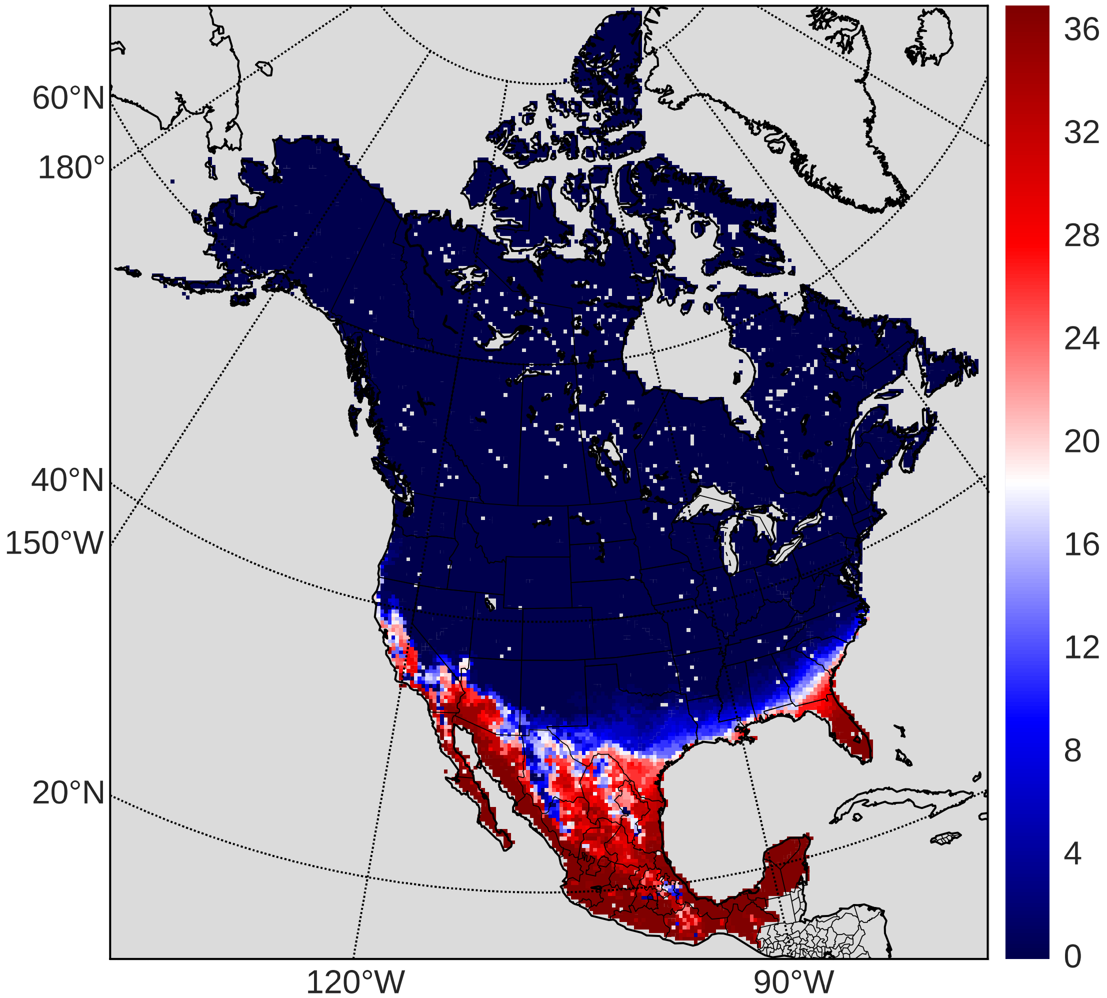

Fig. S1. Number of years with full year fire season at each grid point over period 1979–2015 (37 years).

Trends in input (explanatory) variables

Here we show trend analysis for the annual mean of 1200 hours LST temperature for North America from 1979 to 2015.

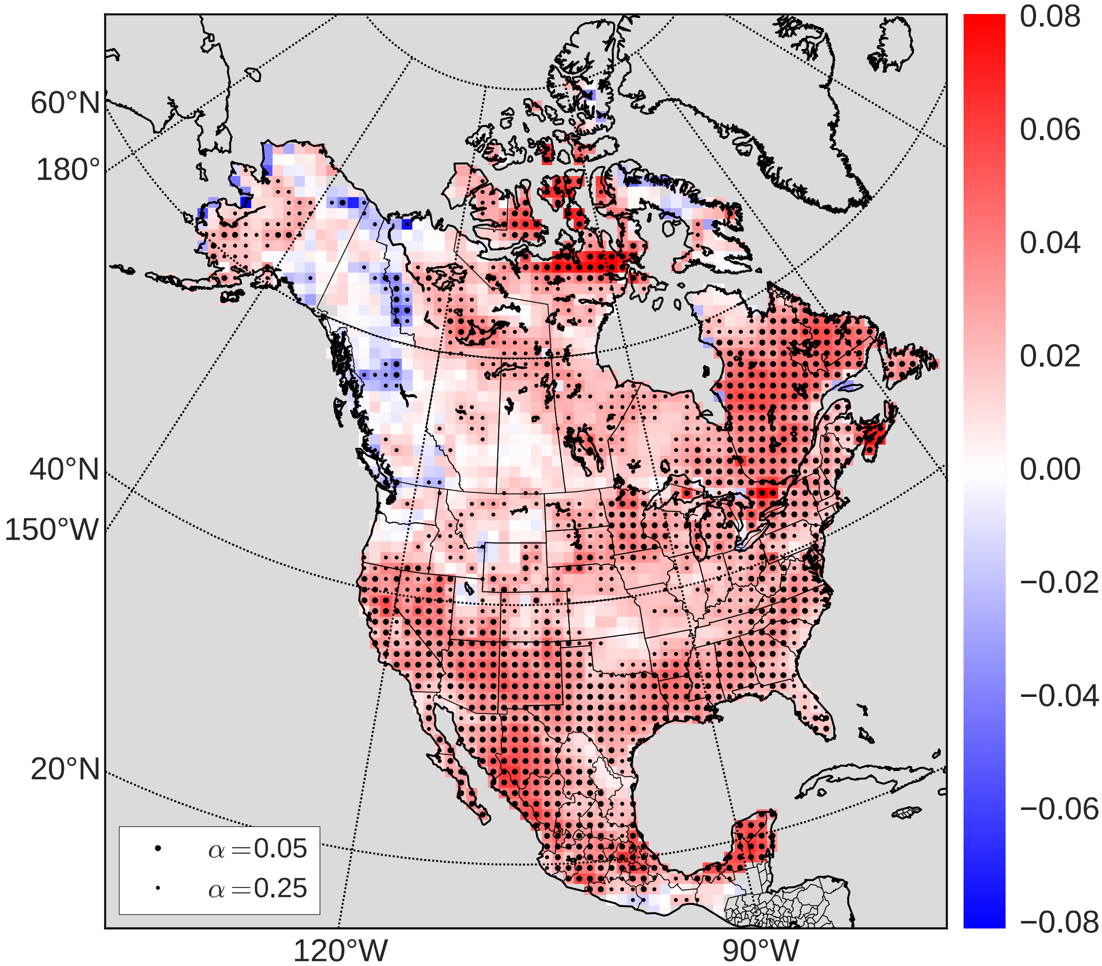

Fig. S2. Theil–Sen slope estimator (year^{-1}) over North America (1979–2015) for annual mean of 1200 hours LST temperature during fire season, aggregated in 3 × 3 blocks; also indicated by dots of different sizes are which trends are field significant with global significance levels of α = 0.05, 0.25, found using the false discovery rate. See text for more details.

Trends in input (explanatory) variables

Here we show trend analysis for the annual mean of 1200 hours LST input variables to the FWI system for Canada from 1979 to 2002.

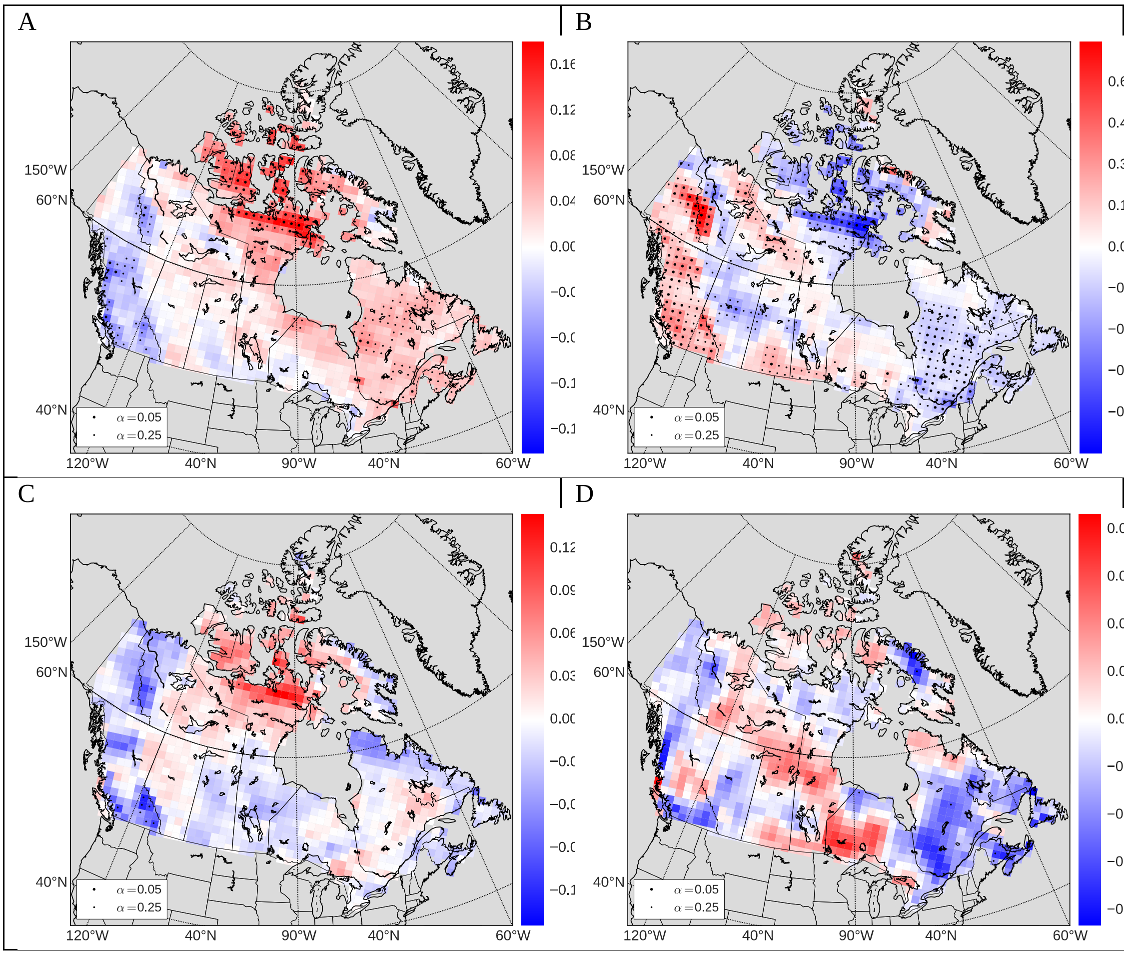

Fig. S3. Theil–Sen slope estimator (year^{-1}) for (*a*) temperature, (*b*) relative humidity, (*c*) wind speed and (*d*) Precipitation over Canada (1979–2002), aggregated in 3 × 3 blocks; also indicated by dots of different sizes are which trends are field significant with global significance levels of α = 0.05, 0.25, found using the false discovery rate. See text for more details.

Here we show trend analysis for annual mean of 1200 hours LST input variables to the FWI system for the contiguous United States (CONUS) from 1979 to 2015.

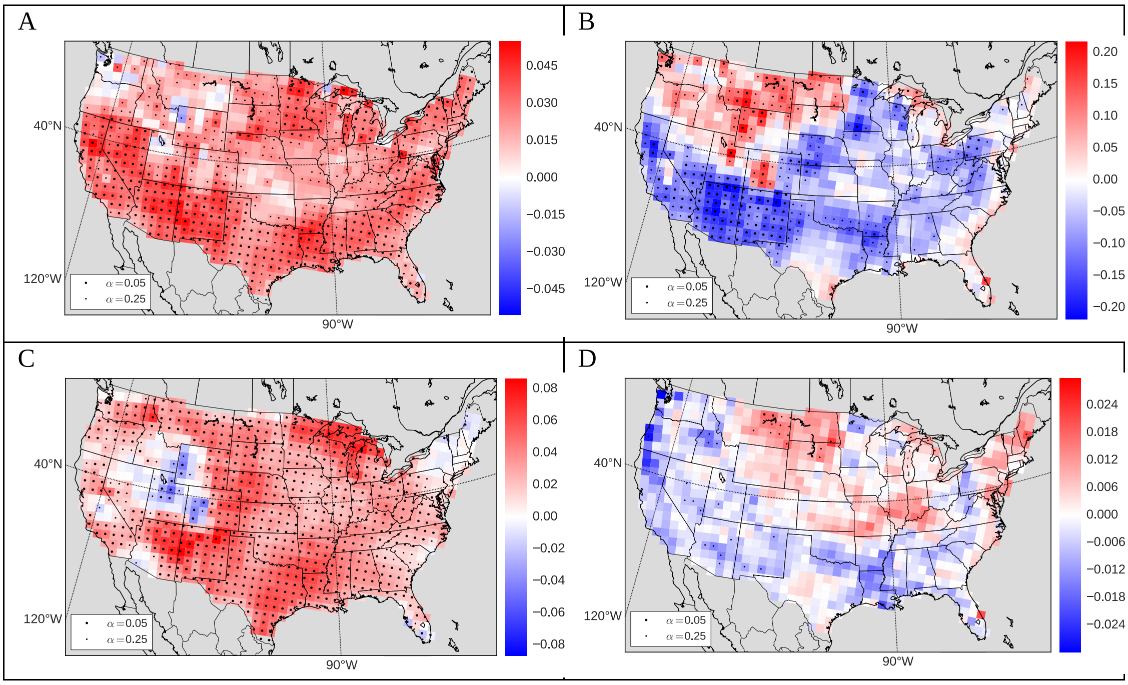

Fig. S4. Theil–Sen slope estimator (year^{-1}) for (*a*) temperature, (*b*) relative humidity, (*c*) wind speed and (*d*) Precipitation over the contiguous United States (CONUS) (1979–2015), aggregated in 3 × 3 blocks; also indicated by dots of different sizes are which trends are field significant with global significance levels of α = 0.05, 0.25, found using the false discovery rate. See text for more details.

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