Supplement

Table S1. Model performance at grid level for the selected years (excluding the misclassified grids).

Year/Fire season	**Including misclassified grids**			**Excluding misclassified grids**		
	R^2	RMSE (km^2)	MAE (km^2)	R^2	RMSE (km^2)	MAE (km^2)
2011 (combine winter-spring and summer)	0.30	11.04	3.38	0.42	21.06	5.25
2014 (winter-spring)	0.30	5.19	1.05	0.51	5.87	0.77
2008 (summer)	0.42	1.58	0.38	0.66	1.75	0.43

Table S2. Studies using statistical methods to estimate burned area

Region	period	Method	Spatial domain	Spatial scale (estimated; km^2)	Temporal scale	R^2	Reference
Canada	1959-1997	MLR	Ecoregions	466x466~1123x 1123	Monthly	36-64%	Flannigan et al. (2005)
Portugal	1980-2004	MLR	Portuguese districts	50x50~100x100	Monthly	43-80%	Carvalho et al. (2010)
Alaska and Canada	1960-2002	MARS	Alaska and western Canada	100x100~235x2 35	Annually	82%	Balshi et al. (2009)
EU-Mediterranean		MLR	European Mediterranean basin	1400x1400	Monthly	87%	Camia and Amatulli (2009)[*]
Western US	1916-2003	MLR [1]	Ecoregions	600x600~1000x 1000	Annually	25-57%	Listtell et al. (2009)
Western US	1980-2004	MLR	Ecoregions	600x600~1000x 1000	Annually	37-57%	Spracklen et al. (2009)
Western US	1972-1988; 1989-2005	MLR, RF [2]	NUTS3[4]	600x600~1000x 1000	Annually	73%; 83%	Westerling et al. (2011)
EU-Mediterranean	1985-2004	MLR	Countries	300x300~1000x 1000	Monthly	39-69%	Amatulli et al. (2013)
EU-Mediterranean	1985-2004	RF	Countries		Monthly	33-72%	Amatulli et al. (2013)
EU-Mediterranean	1985-2004	MARS [3]	Countries		Monthly	43-77%	Amatulli et al. (2013)
Spain	1990-2008	MARS	Phytoclimatic zones	25x25~100x100	Monthly	1-37%	Bedia et al. (2013)
Western US	1916-2004	MLR	Ecoregions	600x600~1000x 1000	Annually	25-60%	Yue et al. (2013)
Western US	1916-2004	Parameterization	Ecoregions		Annually	1-69%	Yue et al. (2013)
North-eastern Spain	1983-2012	MLR	Catalonia	300x300	Annually	33%	Marcos et al. (2015)
Iberian Peninsula	1981-2005	MLR	Pyro-regions	200x200~700x7 00	Monthly	52-72%	Sousa et al. (2015)
EU-Mediterranean	1985-2011	MLR	EUMED [5]	2000x2000	Annually	60%	Urbieta et al. (2015)
Pacific western coast of USA	1985-2011	MLR	Oregon and California	1000x1000	Annually	37%	Urbieta et al. (2015)
British Columbia, Canada	1961-2010	MLR	Southern Cordillera	1400x1400	Annually	55%	Kirchmeier-Young et al. (2018)
Catalonia, Iberian Peninsula	1982-2015	MLR	Fire regime zones	80x80~150x150	Annually	57-91%	Duane et al. (2019)
South-Central US	2002-2015	Integration of RF, logistic regression, and QRF	Eastern Texas, Oklahoma, Louisiana, and Arkansas	700x700	Monthly	50% (winter-spring); 79% (summer)	This study

[1] MLR: Multiple Linear Regression; [2] RF: Random forest; [3] MARS: Multivariate adaptive regression Splines; [4] NUTS3: Nomenclature of Territorial Units at the third level [5] EUMED: burned area summation over Portugal, Spain, South France, Italy and Greece

*: focus on only large fires

Table S3. The mean scaled absolute percentage of each effects for the two fire seasons calculated by decompose analysis at large-scale domain

	Weather effect	Fuel effect	Climate effect	Fix effect	Interaction effect
Spring-winter	12.57	21.39	33.23	22.93	10.87
Summer	16.26	17.29	35.79	21.8	8.87

Table S4. The mean variable importance metrics (%IncMSE) of each effect for the two fire seasons calculated based on grid burned area prediction

	Weather effect	Fuel effect	Climate effect	Fix effect
Spring-winter	8.20	9.04	12.09	6.56
Summer	9.12	4.85	19.18	4.59

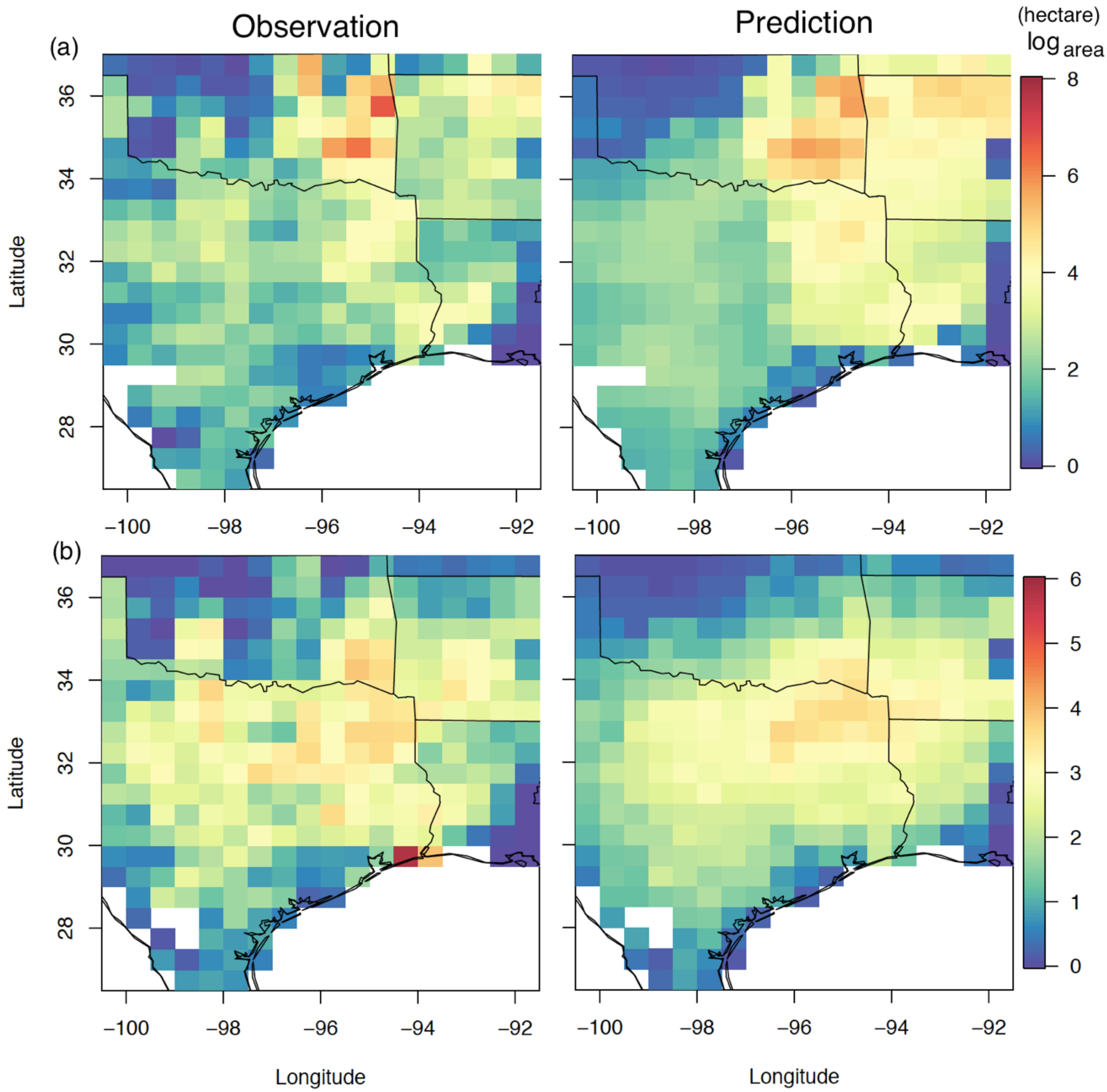

Figure S1. Map of monthly mean observed and predicted burned area averaged from 2002 to 2015 for the (a) winter-spring and (b) summer fire season.

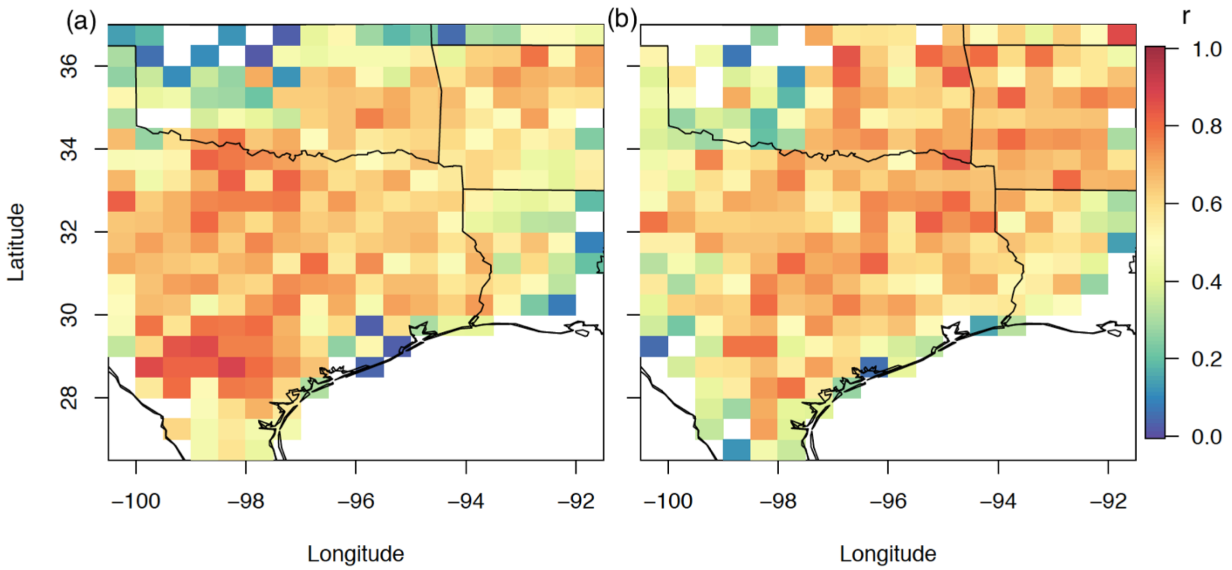

Figure S2. Maps of temporal correlation between observed and predicted burned area for each grid for the (a) winter-spring fire season (b) summer fire season.

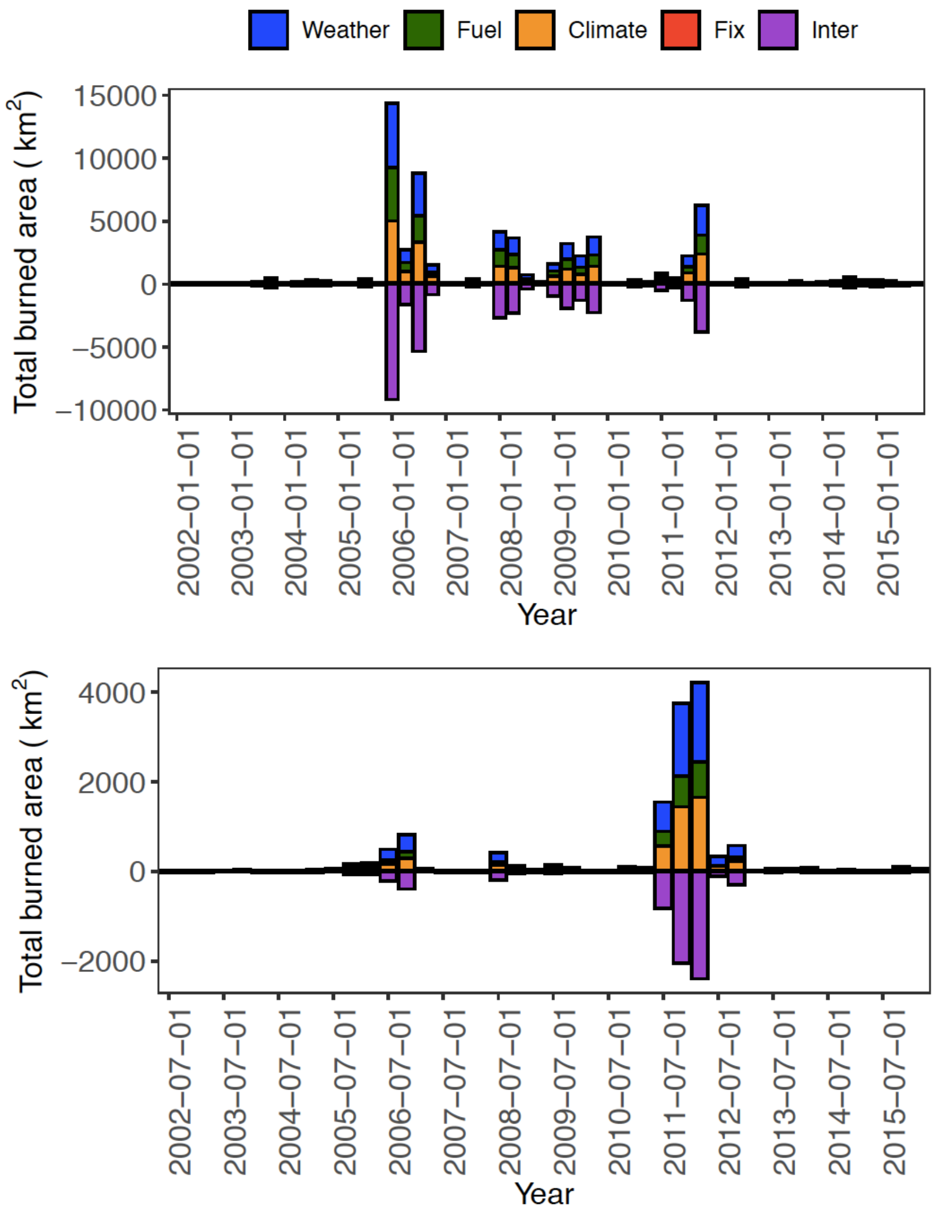

Figure S3. Timeseries of burned area contributed by different environmental controls for the winter-spring (top) and summer fire season (bottom). Color of blue, green, yellow, red, and purple indicate effect of weather, fuel, climate, fix, and interaction.

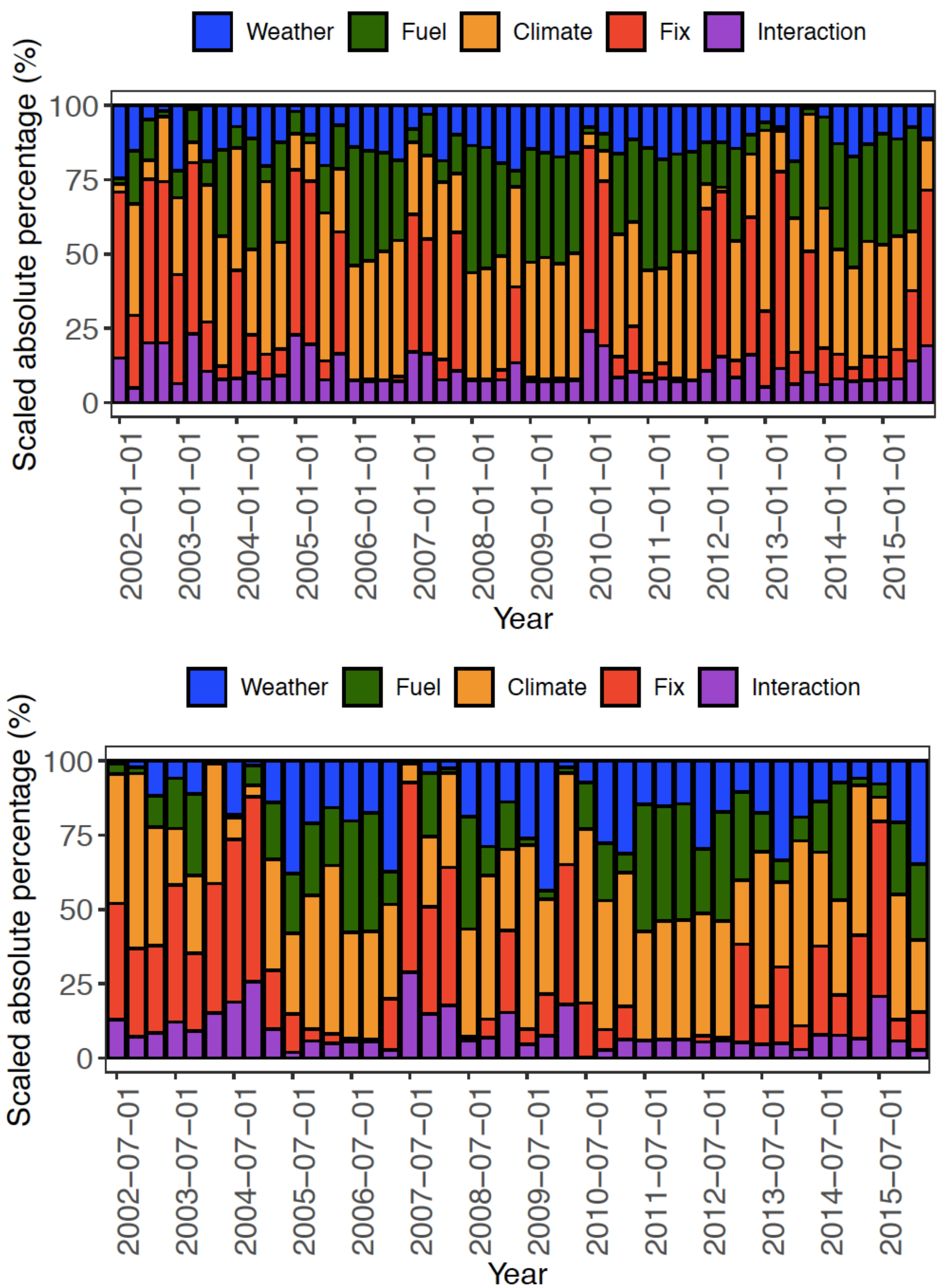

Figure S4. Timeseries of the scaled absolute percentage for the (a) winter-spring fire season and (b) summer fire season. Color of blue, green, yellow, red, and purple indicate effect of weather, fuel, climate, fix, and interaction.

Calculation of correlation coefficient (r)

We also calculated two types of correlation coefficient (r) to evaluate model performance: spatial r and temporal r. For the spatial r, for each month, we calculated the correlation coefficient of the prediction and observation for all the grids over the whole domain. As for the temporal r, for each grid, we calculated the correlation coefficient for the timeseries of observed and predicted burned area. At the end, we obtain a map showing the temporal R, demonstrated in Figure S2.