Empirical Characterization of Fire Regimes Across the Globe

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Introduction:

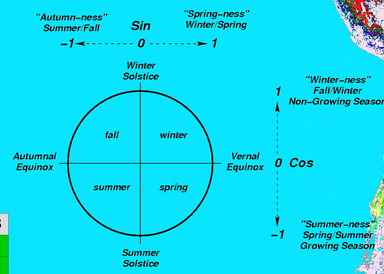
- Occurrence and behavior of fires across the globe is governed by the climate conditions, vegetation, and type and availability of fuel.
- Understanding of seasonality, frequency, intensity and severity of the fires are critical both for land managers to appropriately manage and plan the landscape and to understand the feedbacks to the Earth system.
- Fire Regimes are conceptually useful to land managers and are qualitatively understood, but few quantitative techniques exist for empirically delineating geographic regions whose wildfire spatial and temporal characteristics, re-visitation frequency and intensities are similar.
- Remote sensing data provides an opportunity to produce a quantitative discrimination of different global fire regimes, including tele-connections across hemispheres.

Global date/time transformation:

Southern vs Northern hemispheres experience opposite seasons, yet its desirable e.g. for summer fires to be grouped in same regime regardless of months. We encoded all dates in terms of solstices and equinoxes to be comparable across the globe. This permits common fire regimes to be identified across hemispheres as appropriate.

Characteristics	Factor 1	Factor 2	Factor 3
Biweek 1 Sin	0.023	0.044	**0.815**
Biweek 1 Cos	0.030	**0.829**	0.049
Biweek 2 Sin	-0.002	0.061	**0.792**
Biweek 2 Cos	-0.017	**0.835**	0.061
Biweek 3 Sin	-0.014	0.080	**0.741**
Biweek 3 Cos	-0.042	**0.808**	0.077
Biweek 4 Sin	-0.026	0.117	**0.661**
Biweek41 Cos	-0.053	**0.754**	0.092
Biweek 5 Sin	-0.038	0.137	**0.572**
Biweek 5 Cos	-0.055	**0.690**	0.122
Biweek 6 Sin	-0.048	0.137	**0.466**
Biweek 6 Cos	-0.061	**0.614**	0.154
Fire Season Len.	**0.860**	-0.248	-0.087
No-Fire Season Len.	0.357	0.251	-0.593
Years with Fire	**0.977**	0.047	-0.034
Run of Burns	**0.966**	0.050	-0.025
Run of No Burns	**-0.966**	-0.058	0.034
Mean Temperature	-0.020	0.052	-0.042
Max. Temperature	**0.317**	0.039	-0.263
Min. Temperature	**-0.514**	0.106	-0.077
Num. of hotspots	**0.250**	-0.053	-0.028

Top three factors from Principle Component Analysis represent the dominant end member regimes. All other fire regimes can be made from mixtures of these end members.



Observations:

- Agricultural burning in Punjab and Mississippi valley are purple because farmers burn the fields after harvest of wheat and other grains in Fall.
- Oklahoma, USA is yellow because farmers burn Winter wheat stubble in spring before planting.
  High latitudes are green and dark because of infrequent fires primarily during Winter/Spring season.
- Boreal and sub-boreal evergreen trees and shrubs are blue burning primarily in Fall/Winter season.
- Yellow and purple are associated with dry near-desert Savannah or grasses or agricultural areas
- Light blue/Cyan is mostly within the horse latitudes.
- While consistent with latitude generally, fire regime regions are not entirely predictable or explainable by latitude alone because of other driving factors, like vegetation type.
  Outside tropics, primary colors are dominant due to seasonality being dominant. However, inside the tropics where fires burns all the time, we see mixtures of the three primary colors.
- Same fire regimes are observed to occur in northern and southern hemisphere which is only made possible by global analysis with harmonized seasons.

Methodology:

Data: We used MODIS Hotspots Collection data for the period 2002-2017. All the data were processed on a 10 km x 10 km global grid for analysis.

We computed a range of fire characteristics at each grid cells using all hotspots ever detected by both MODIS sensors.

***Fire Characteristics*:**

- **Seasonality** was quantified by grouping the day of year into biweeks and selecting the top six to minimize zero values resulting from an all-year analysis. Cross-year seasonal continuity was retained through use of a sine-cosine transform.
- **Inter-year fire frequency** was captured by a) the total number of years with >2 hotspots, b) the number of continuous years with fire, and c) continuous years without fire.
- **Intensity** was captured by calculating the minimum, mean, and maximum hotspot temperature.
- **Fire Extent/Density** was provided by the total hotspots over the entire period, linked to the general importance of fire within a grid cell.

50 unique and dominant global fire regime shown as random color map.

Regions of similar colors exhibit similar fire characteristics. Regions around the world show the similarities, and thus provides opportunity to apply and lessons learned in one region to the other parts of the world.

Color key to interpret the map:

- Gray = Not enough fires to have a fire regime; desert, snow, ice, water;
- Red = Frequent fires; long fire season; wet enough to grow fuel but dry enough for frequent burns;
- Blue = Non-growing season (Fall/Winter);
- Green = Winter/Spring fire season;
- Yellow = R + G = Frequent year round fires especially in Winter/Spring;
- Purple = R + B = Frequent year round fires especially in Fall/Winter;
- Light blue = G + B = Winter fire season;
- Darker colors = Aseasonal infrequent fires;
- Lighter colors = Seasonal frequent fires;