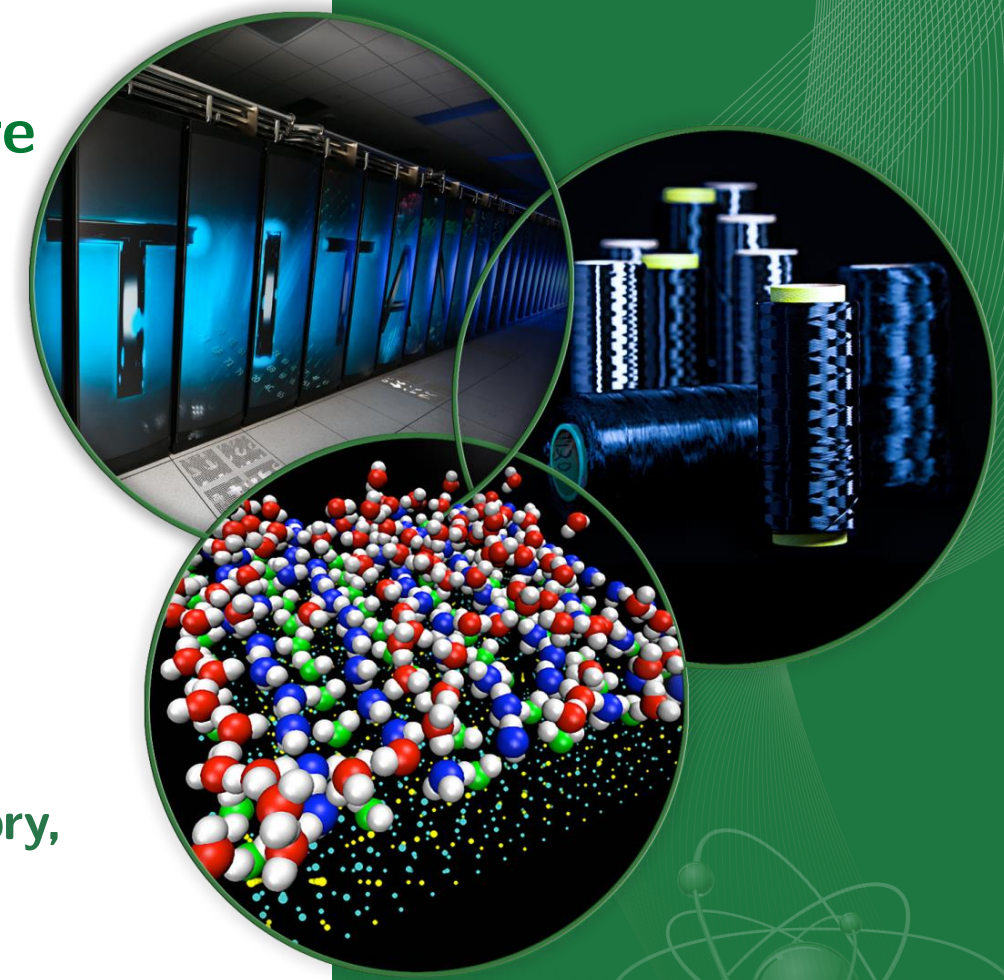
Data Mining Historical MODIS Hotspots Archive to Characterize Global Fire Regimes



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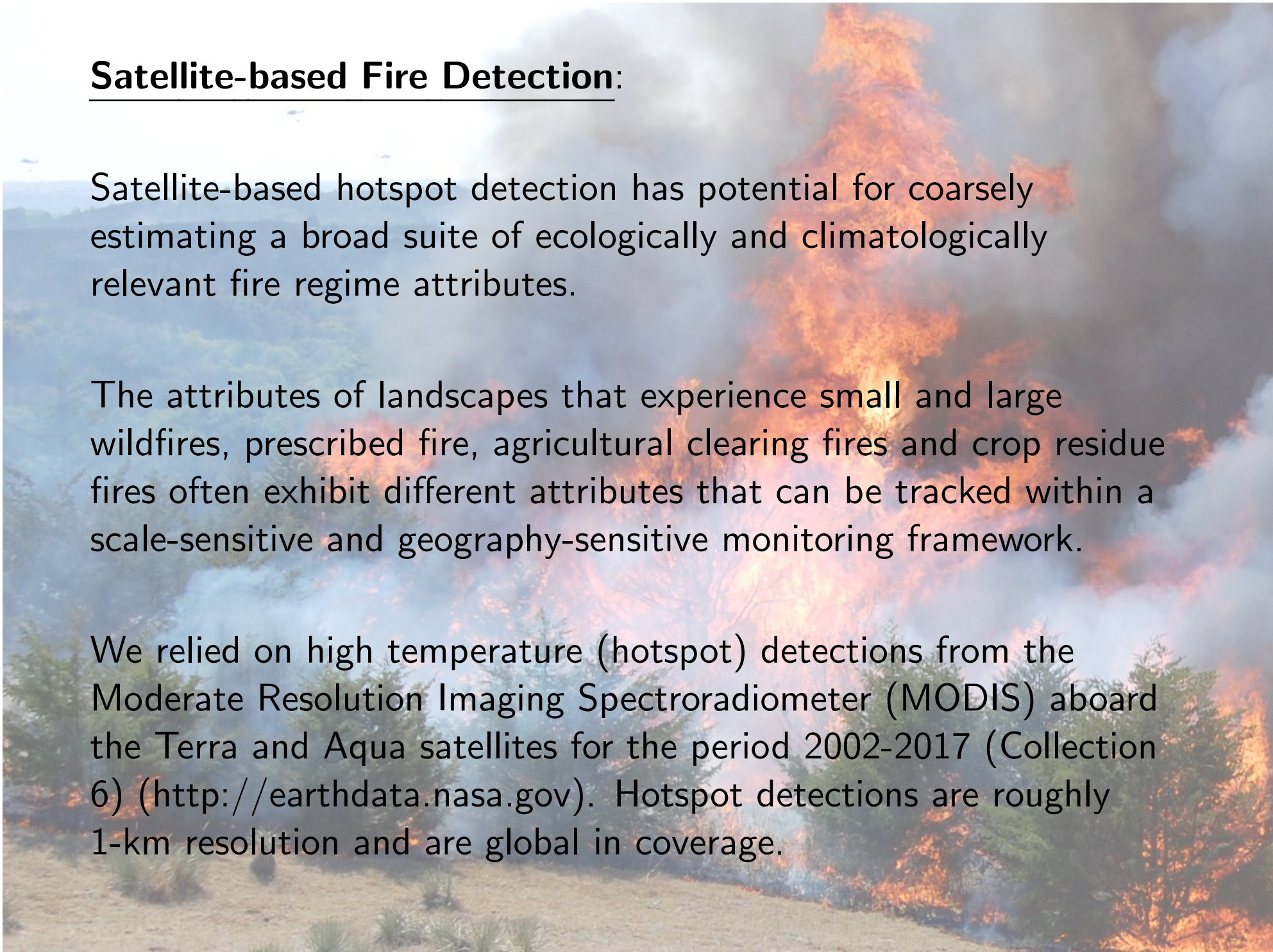
Fire Regimes: Fire regime represents a combination of fire characteristics describing the repeated pattern of fire at a location in space.
Fire regimes are dynamic processes that are sensitive indicators of climate and land use change. Despite their importance for monitoring Earths systems, key fire regime attributes are often only vaguely understood in many places, and systematic tracking of fire regimes at broad scales has proved difficult

Understanding of Fire Regimes is important:

- to quantify the emissions from fires
- plan fire suppression and control
- to understand (and predict) how patterns of fire might change in response to environmental and human drivers

Challenges related to the fire regime concept

- Historical regimes varied with climate, fuels and ignitions, so historical data provide perspective and context
- We need characterizations of and monitoring systems for modern fire regimes that reflect changing stressors, values and tradeoffs, not just conditions relative to historical wildland baselines
- Fire and its tradeoffs involve more than wildland fire, so we need a modern fire regime concept that is inclusive, especially at regional to global scales
  - Wild Wildland Fire, Controlled Burns for Grazing, Wildland Rx Fire, Crop Residue Fires, Urban Fires
- Fire regimes are defined by distributions, not an event
- Fire regimes are both era-specific and area-specific

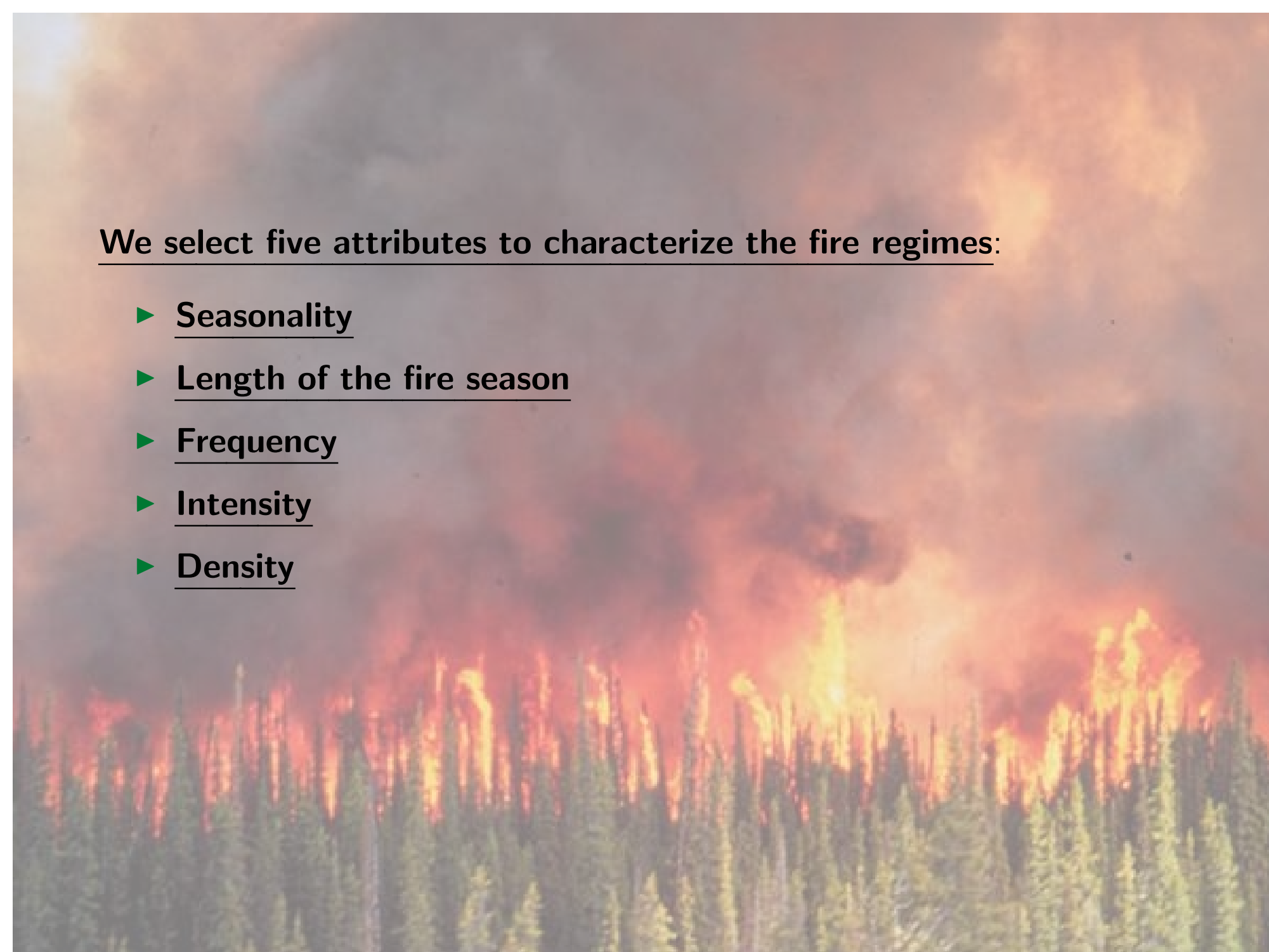


Satellite-based Fire Detection:

Satellite-based hotspot detection has potential for coarsely estimating a broad suite of ecologically and climatologically relevant fire regime attributes.

The attributes of landscapes that experience small and large wildfires, prescribed fire, agricultural clearing fires and crop residue fires often exhibit different attributes that can be tracked within a scale-sensitive and geography-sensitive monitoring framework.

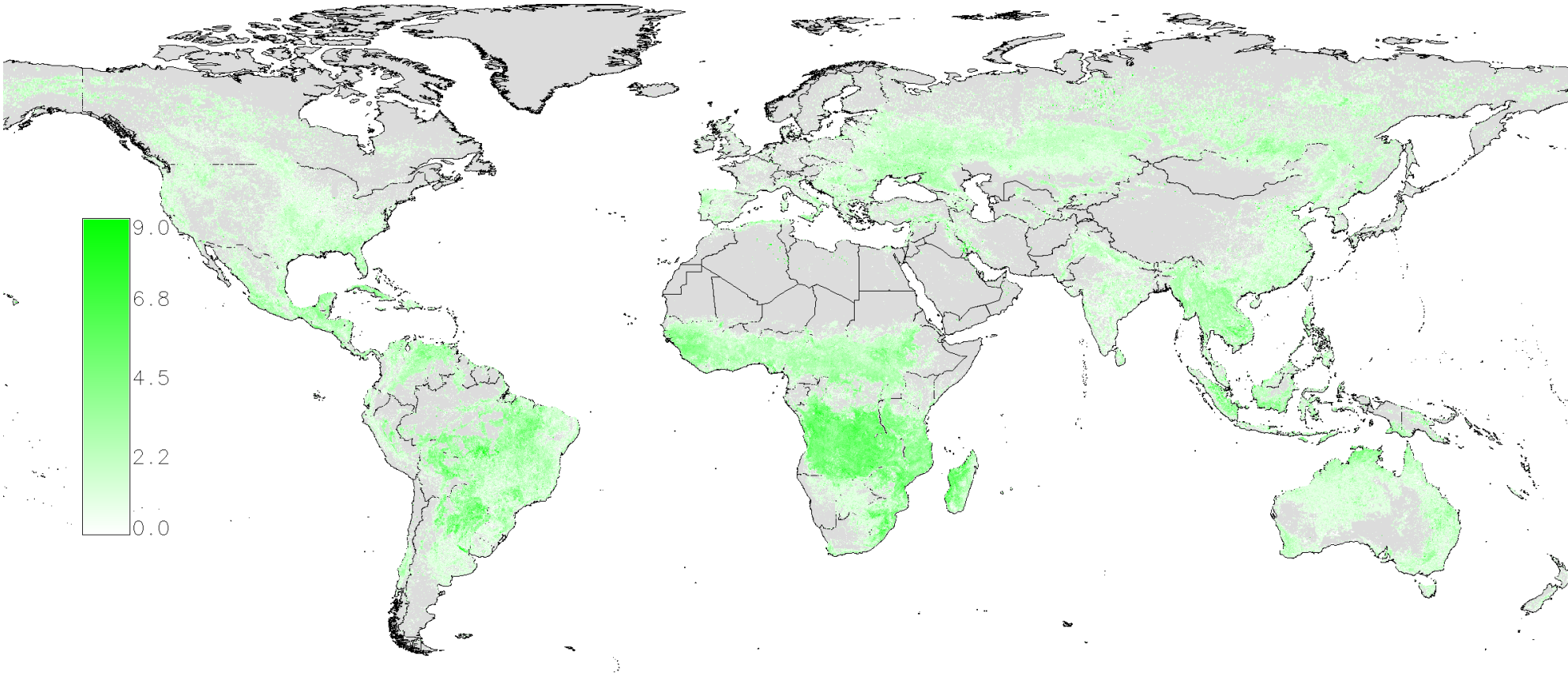
We relied on high temperature (hotspot) detections from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the Terra and Aqua satellites for the period 2002-2017 (Collection 6) (http://earthdata.nasa.gov). Hotspot detections are roughly 1-km resolution and are global in coverage.



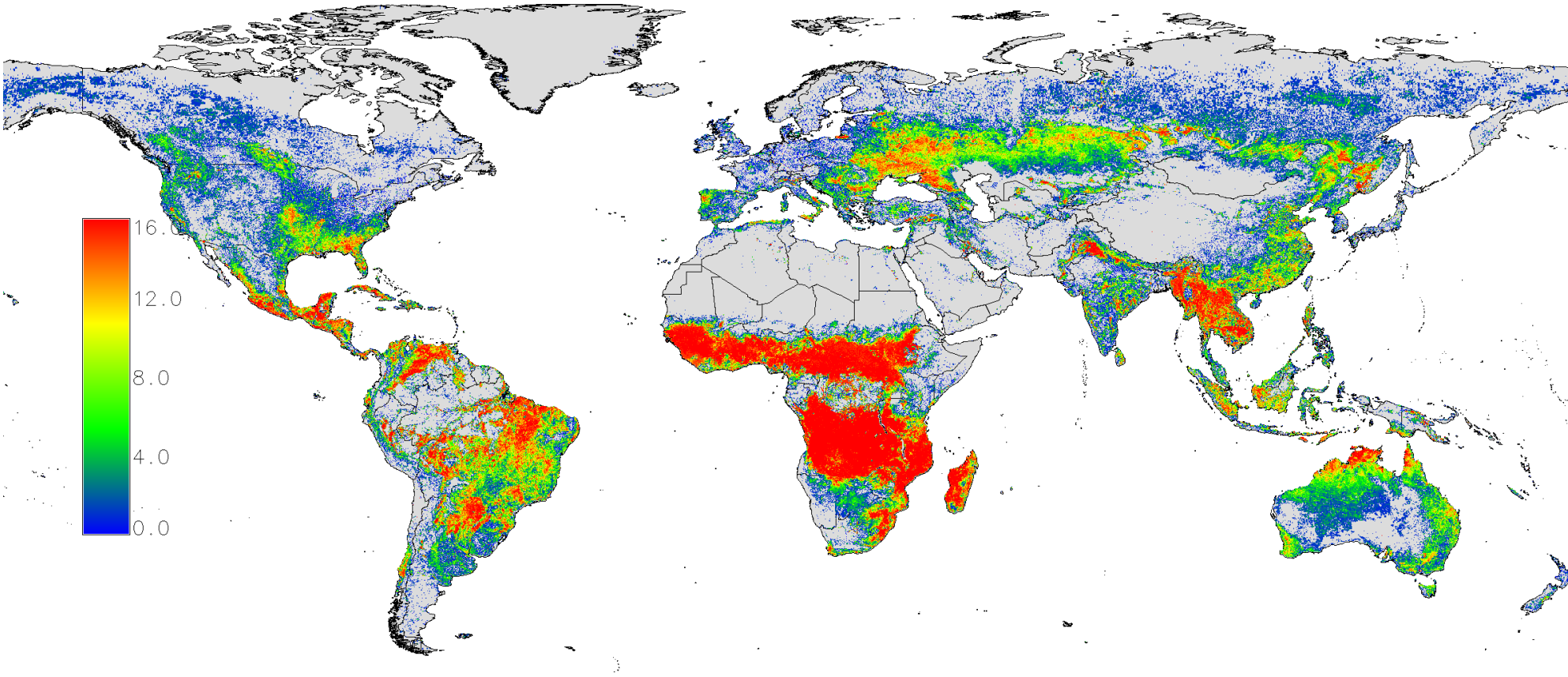
We select five attributes to characterize the fire regimes:

- Seasonality
- Length of the fire season
- Frequency
- Intensity
- Density

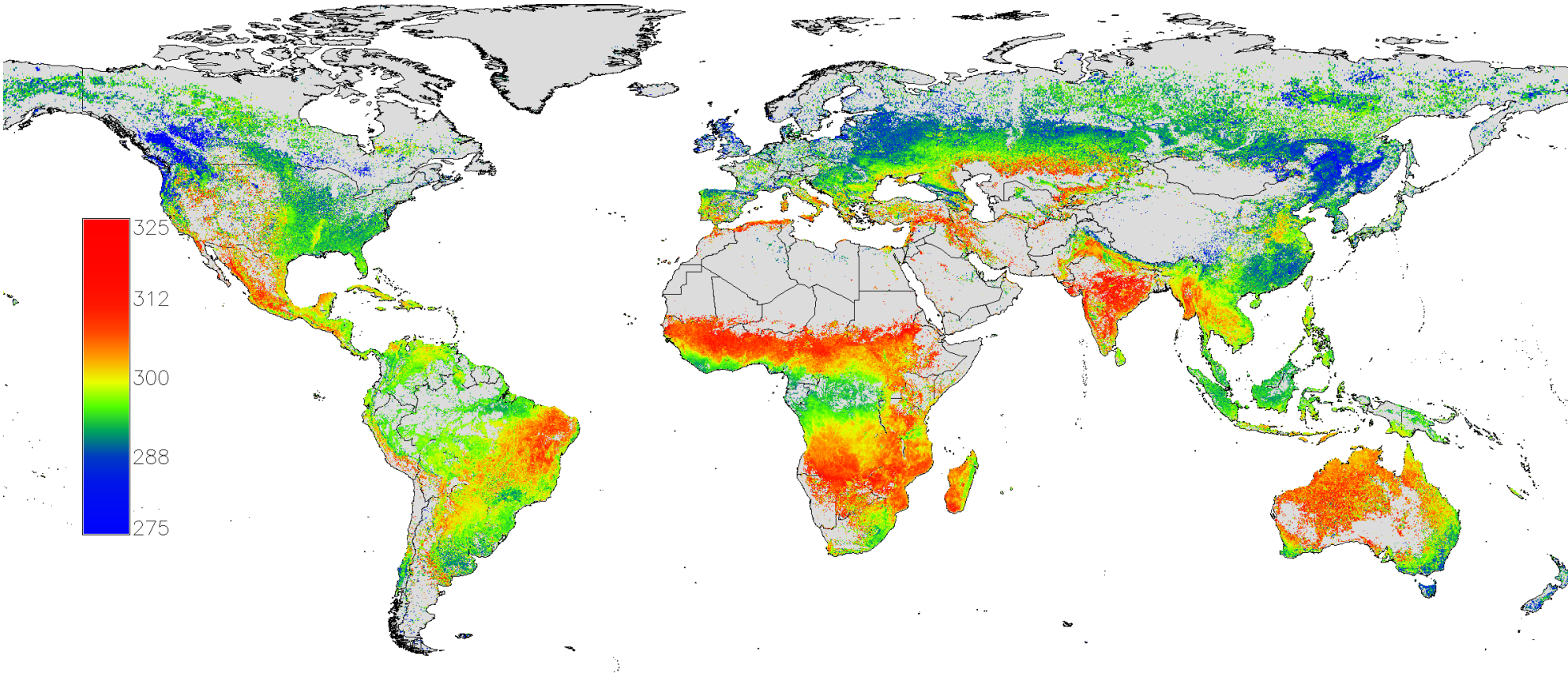
- **Seasonality** was quantified by grouping the day of year into biweeks and selecting the top six (i.e., 3 months of biweeks).
- Cross-year seasonal continuity was retained through use of a sine-cosine transformation.
- A calendar transformation was applied to sync the seasons across northern and southern hemisphere, to allow for development of global regimes.



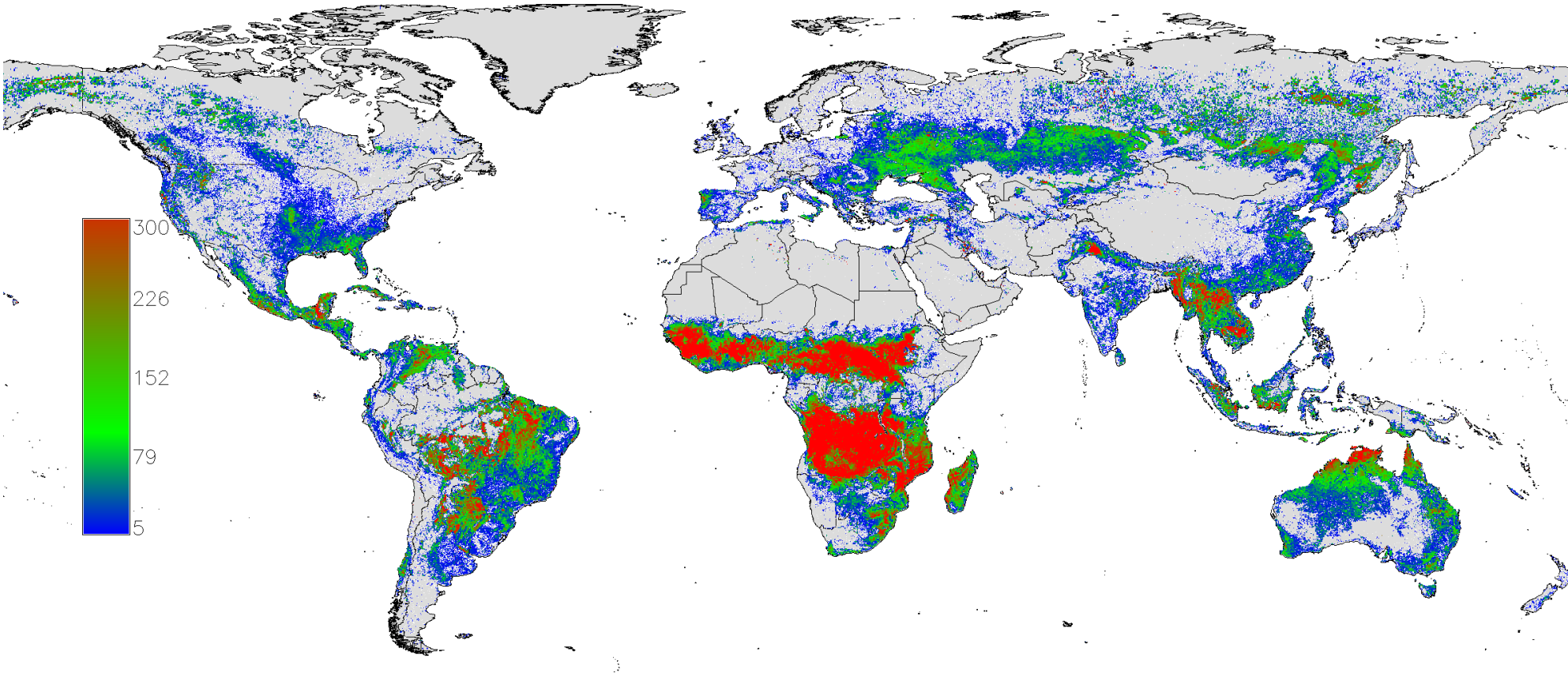
- **Fire season length** was captured by identifying maximum continuous run of biweeks (and months) with atleast two hotspots, and maximum continuous run of biweeks (and months) without any fires.



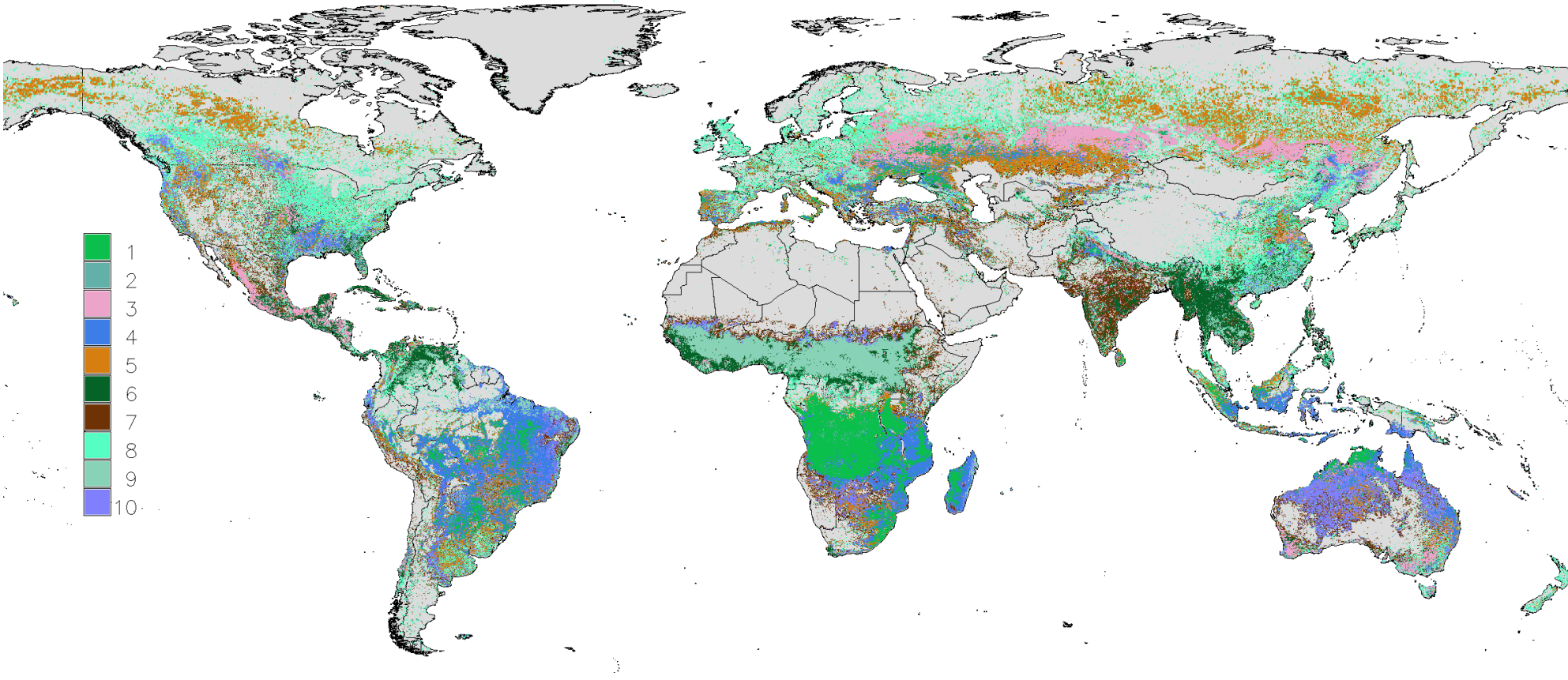
- **Frequency** was captured by 3 measures: the total number of years with > 2 hotspots, the number of continuous years with fire (runs) and continuous years without fire (non-runs)



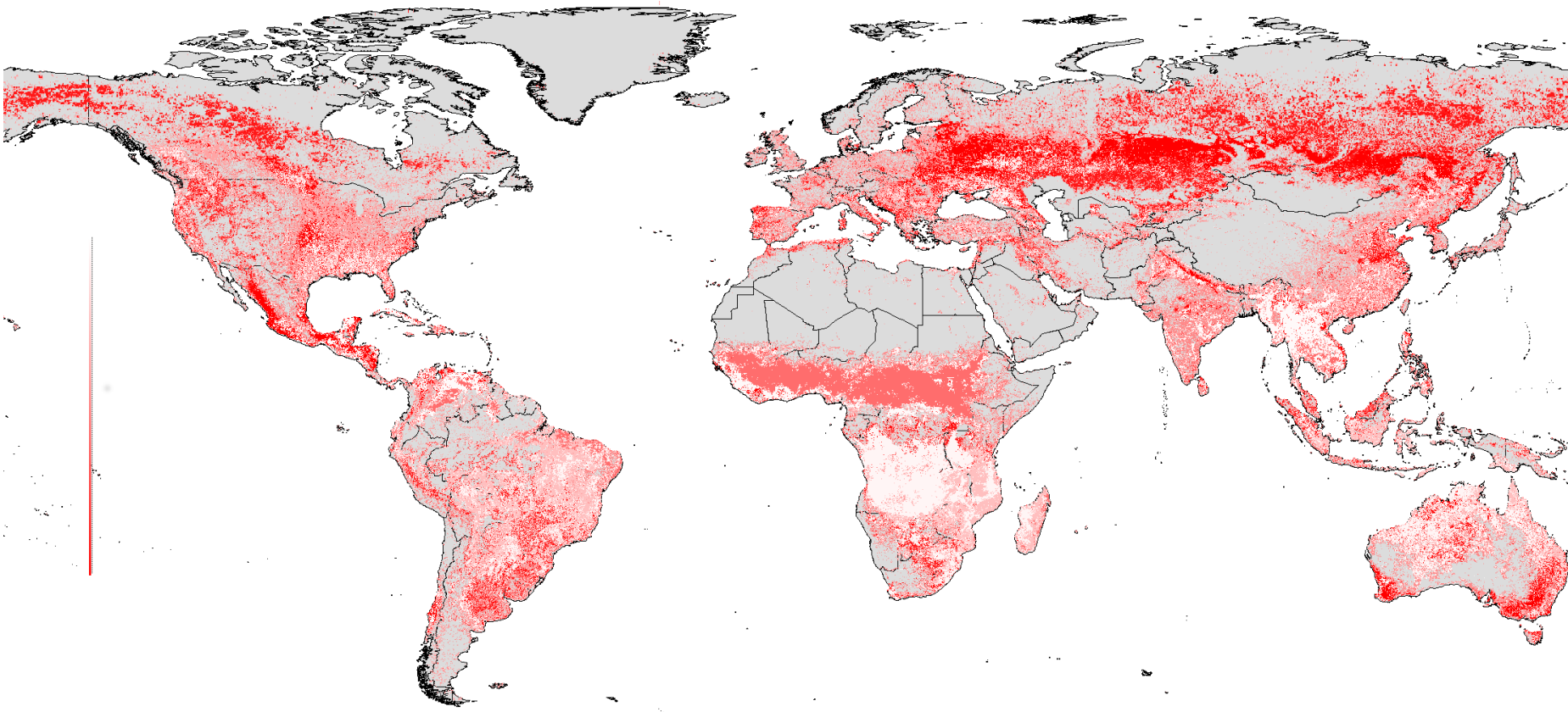
- **Intensity** was captured by calculating the mean, maximum and minimum hotspot brightness temperature



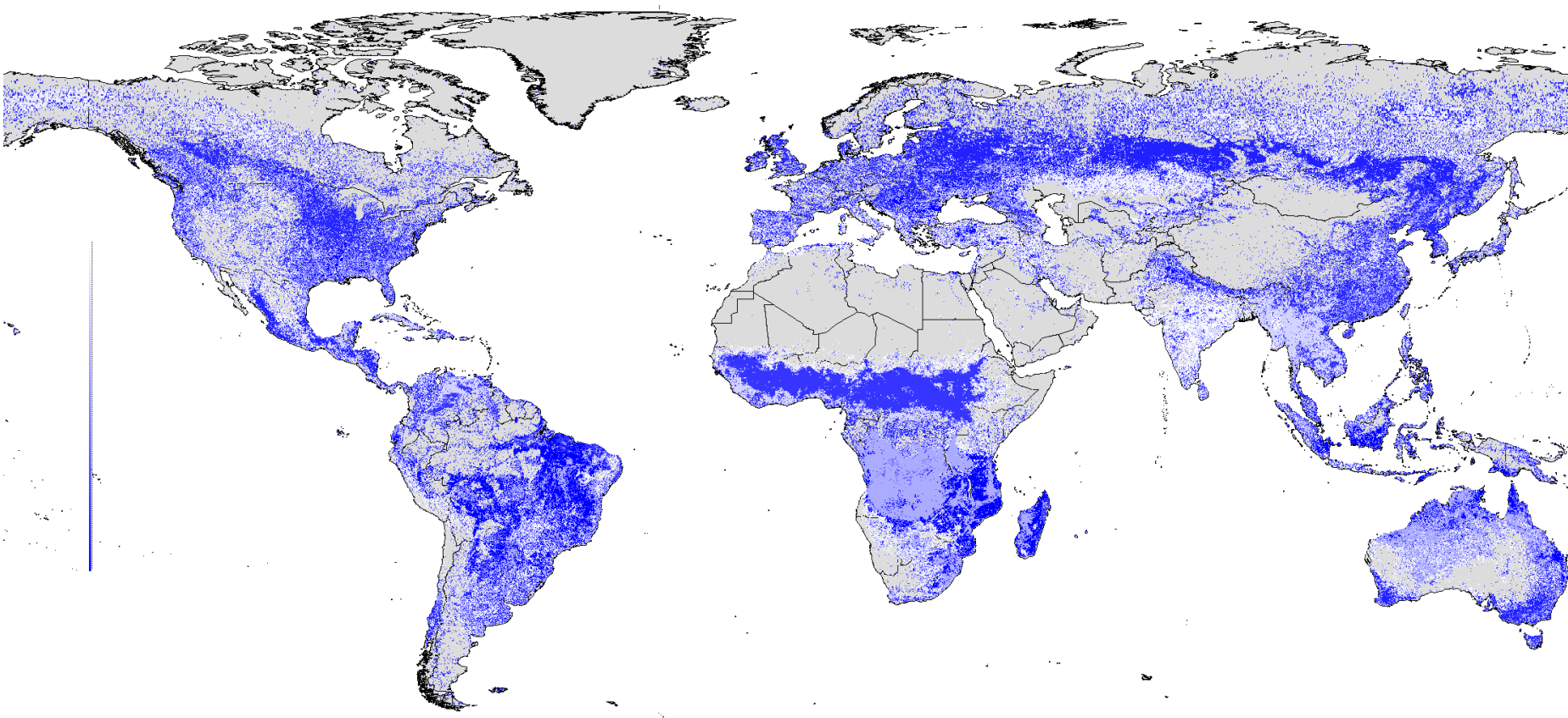
- **Density** was calculated as the total hotspots over the entire period. It is a broad and inclusive measure of the general importance of fire within a grid cell.



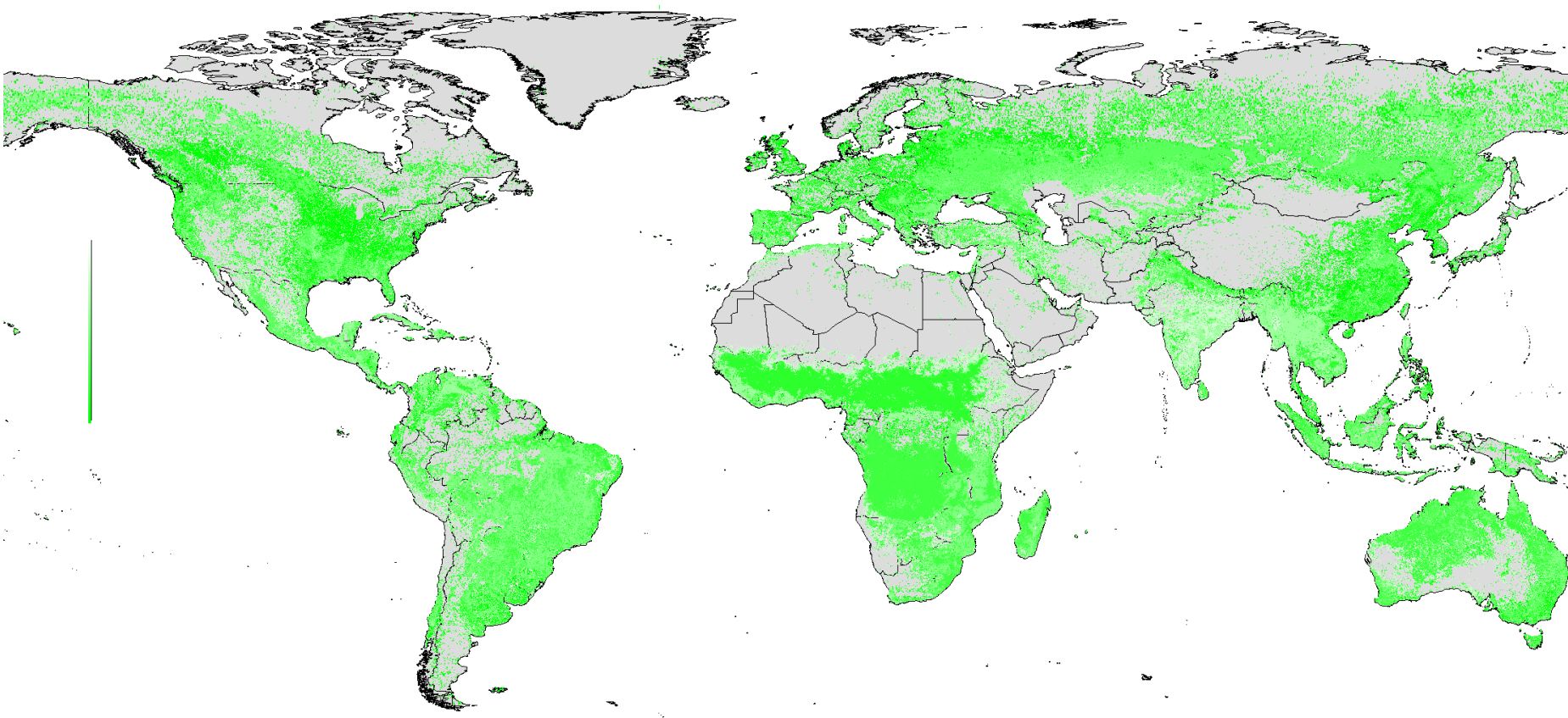
MODIS Hotspots-based Global Fire Regimes: Seamless global classification of showing regions with similar fire behaviors. Strong latitudinal patterns across hemispheres.



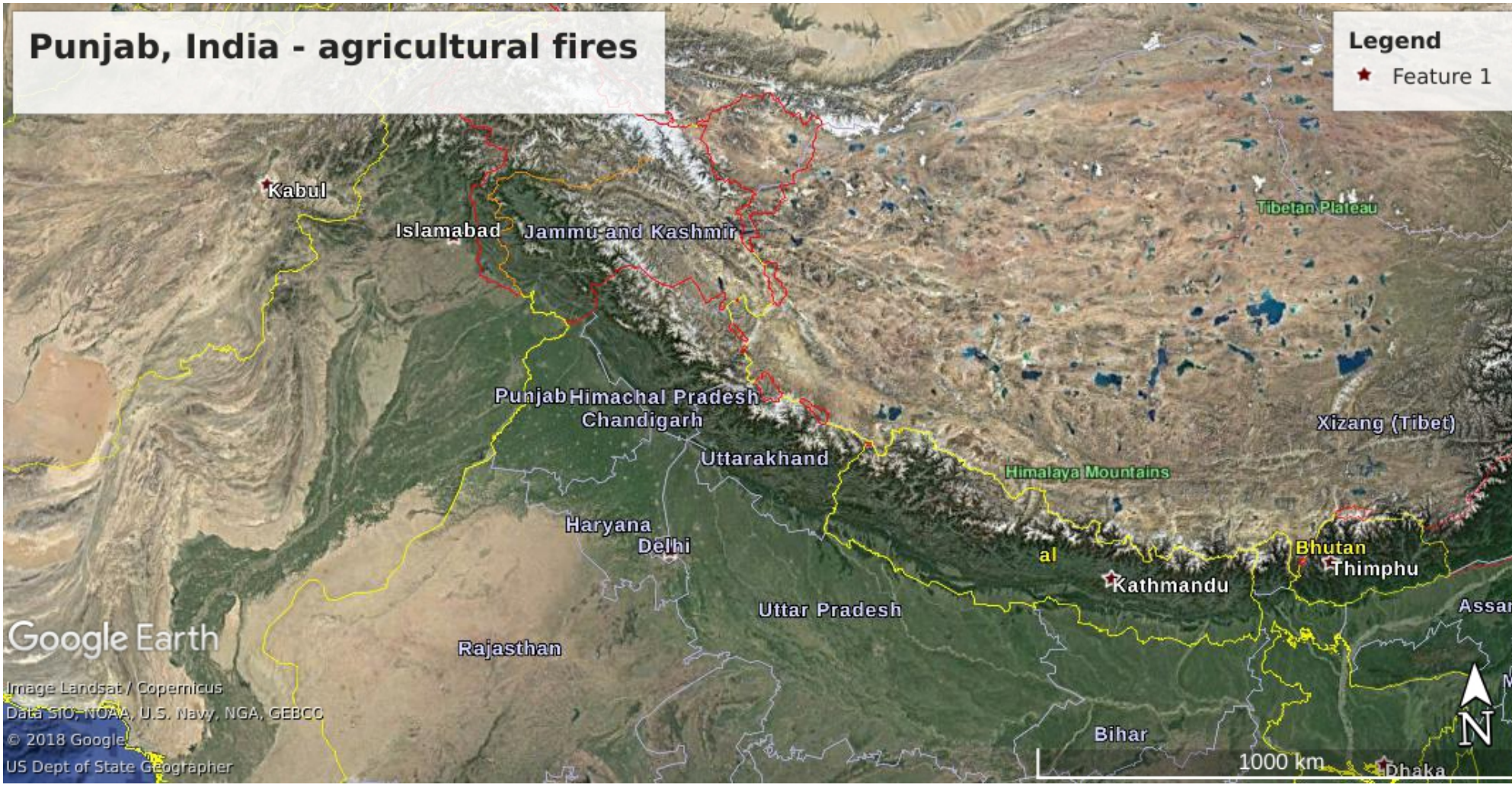
First component: Explained by fire intensity/severity.



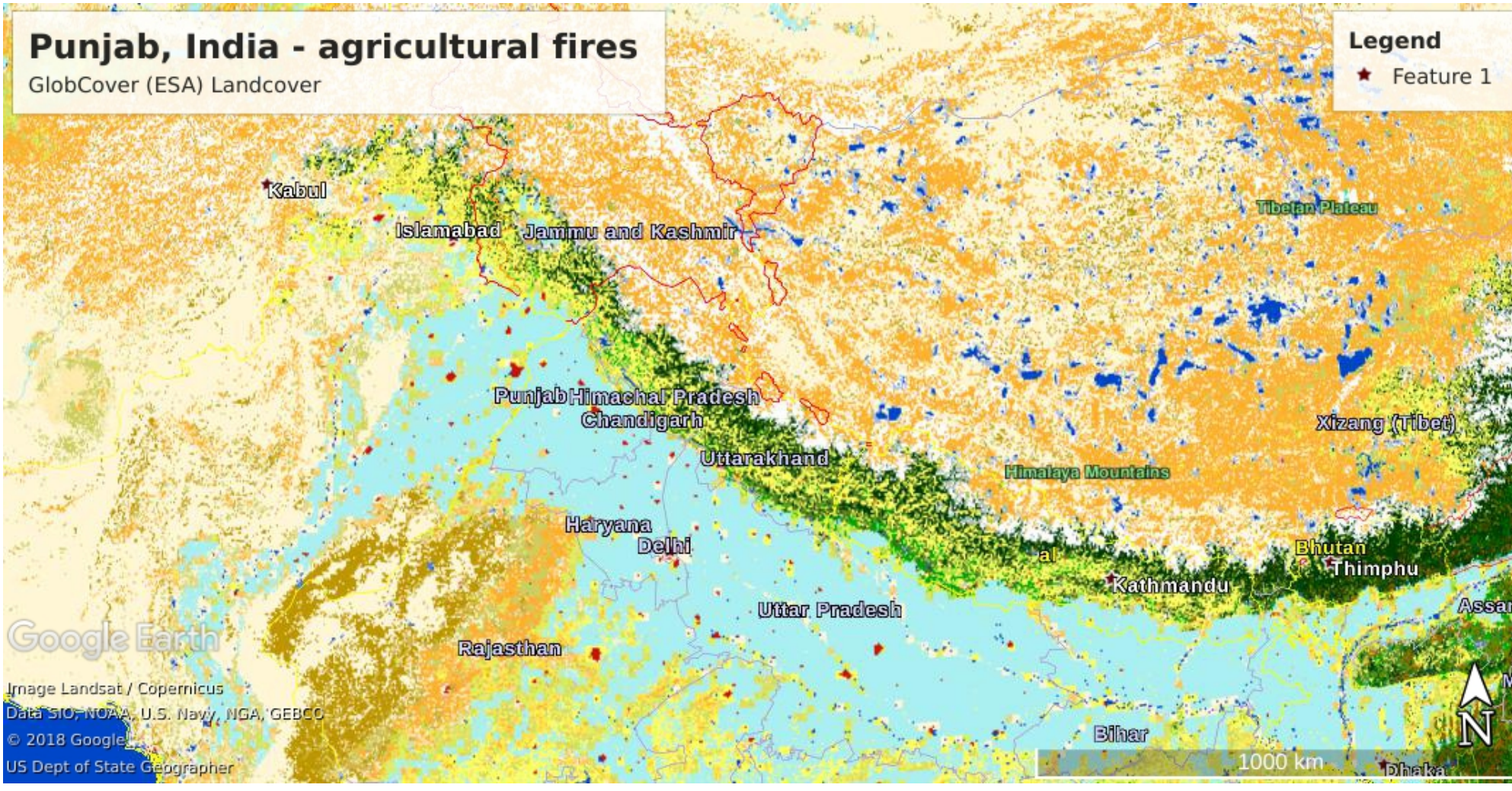
Second component: Explained by fire frequency and return intervals.



Third component: Explained by fire seasonality and season length.



Agricultural (residue) fires in Punjab, India are dominated by the frequency and seasonality.



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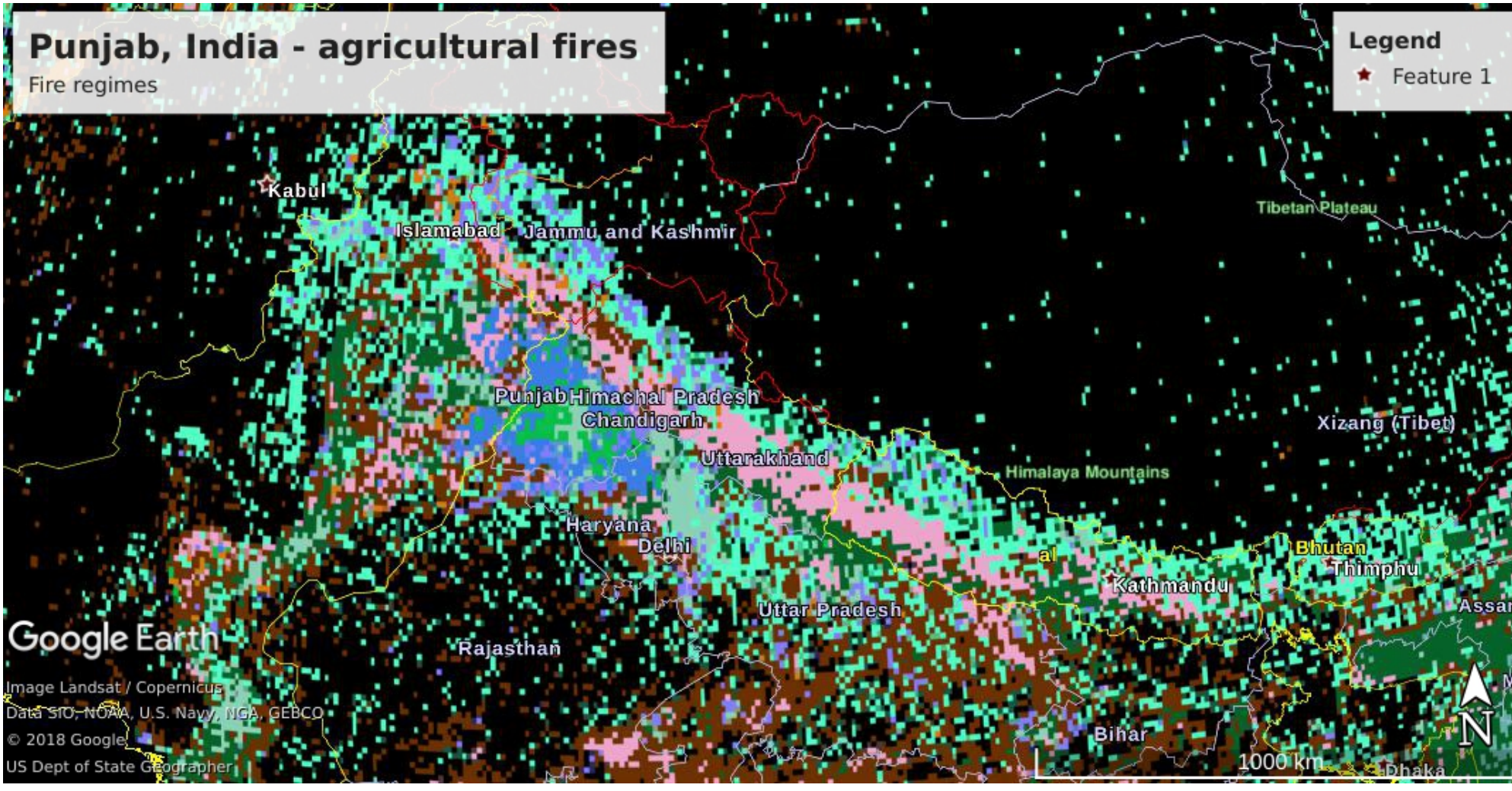
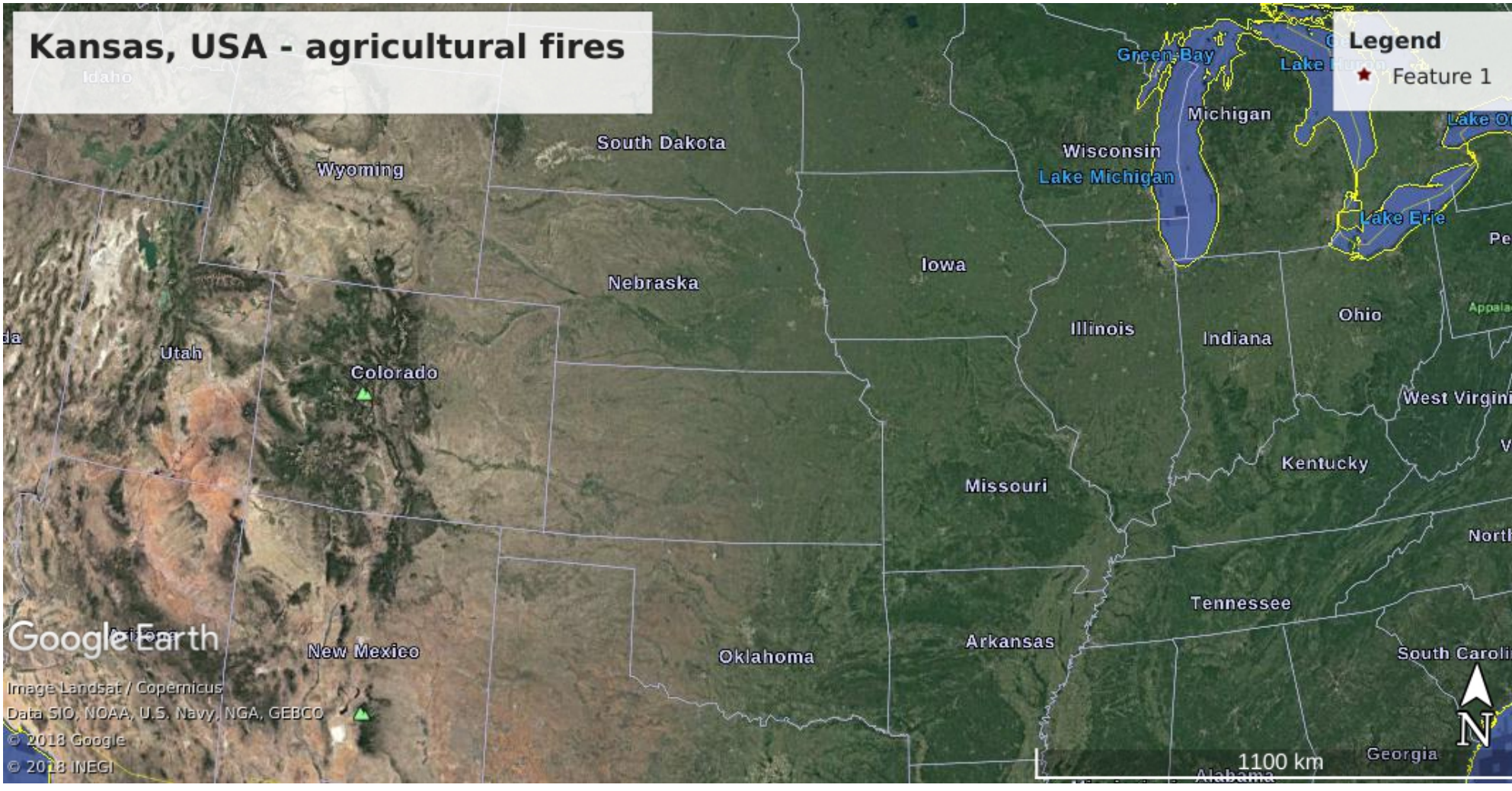
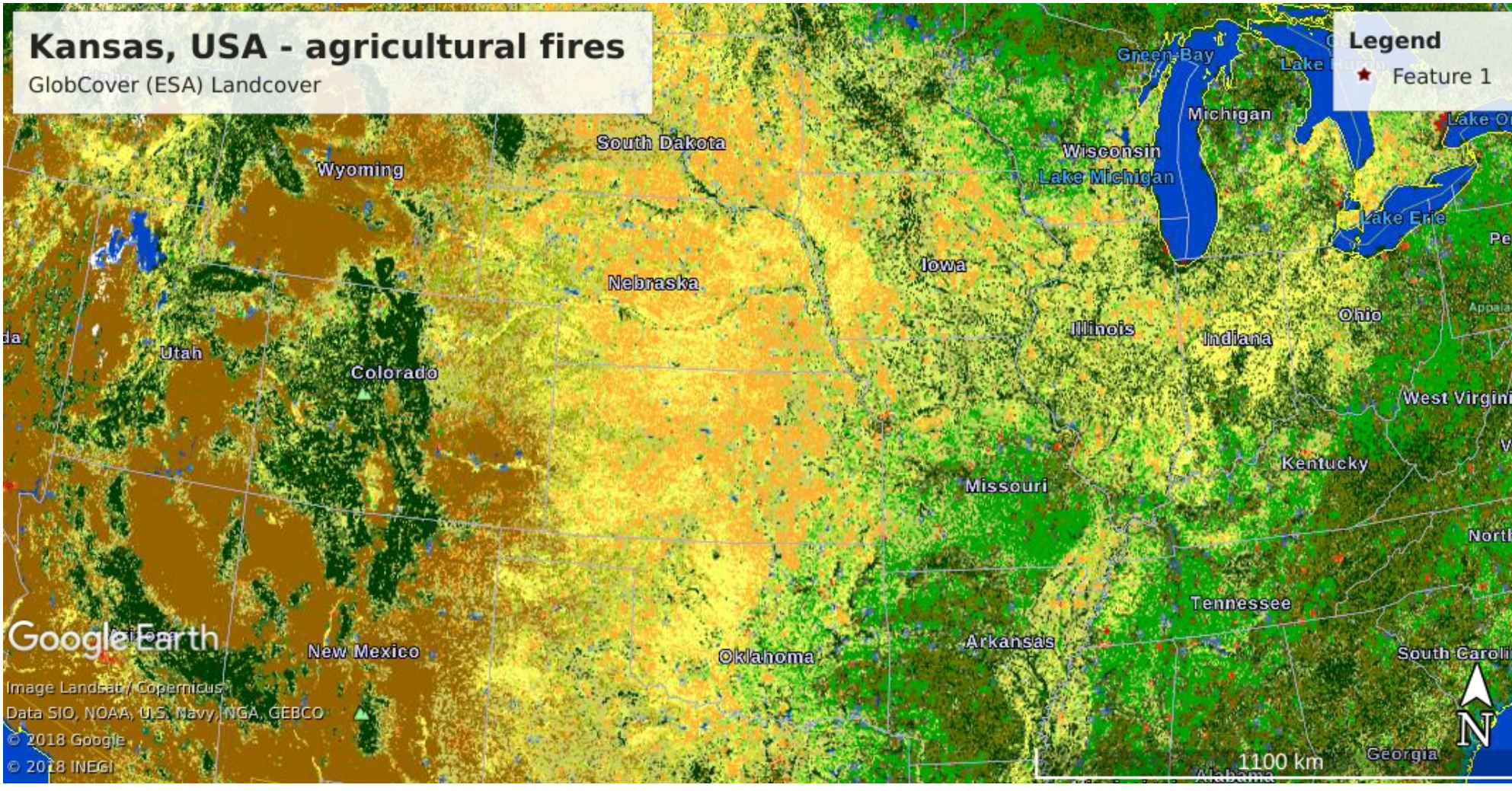


Agricultural (residue) fires in Punjab, India are dominated by the frequency and seasonality.
Regime 1 & 5: Burns almost every year at the end of the two growing seasons (spring, summer)



Agricultural (residue) fires in Kansas, USA.



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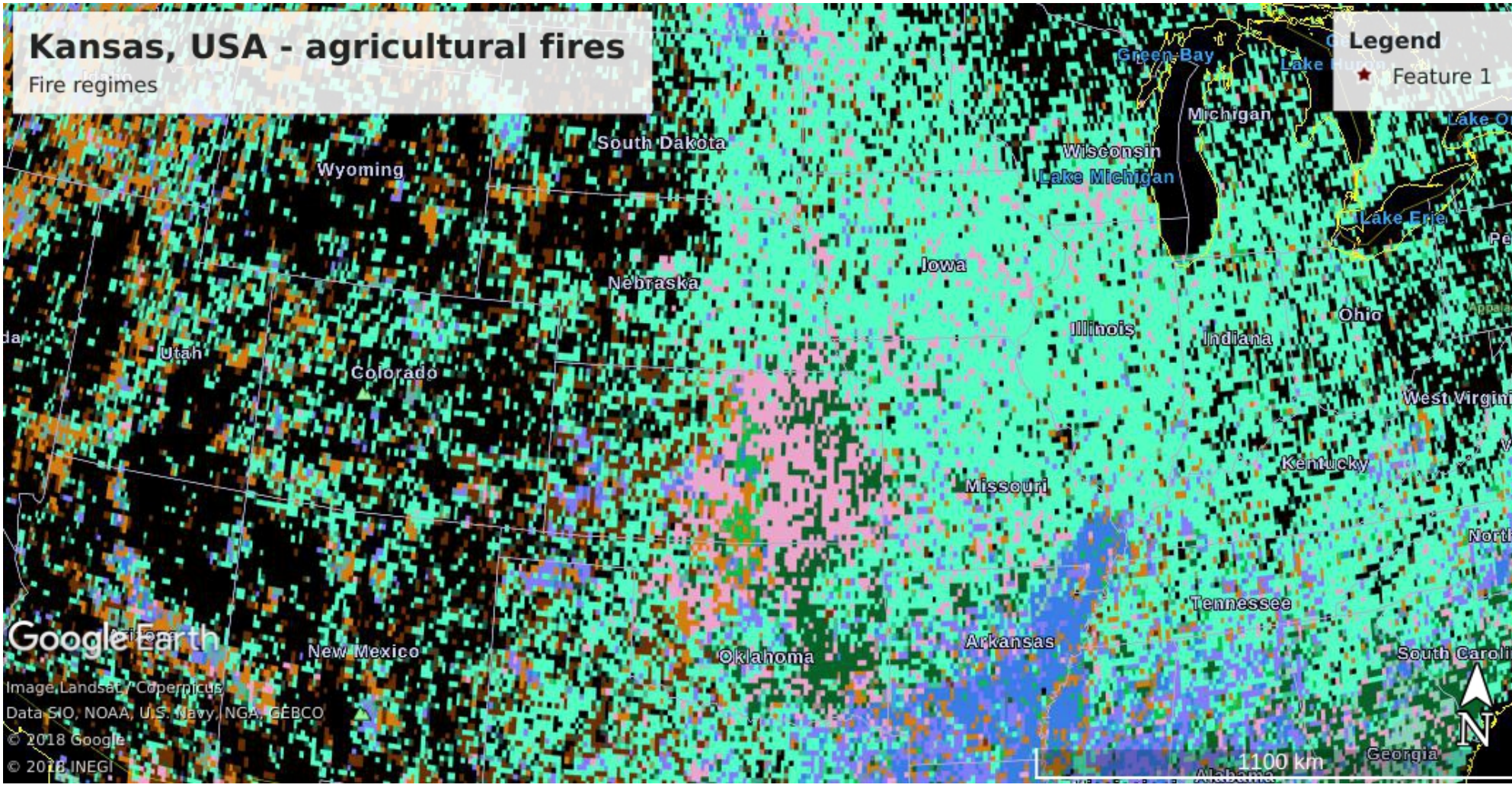

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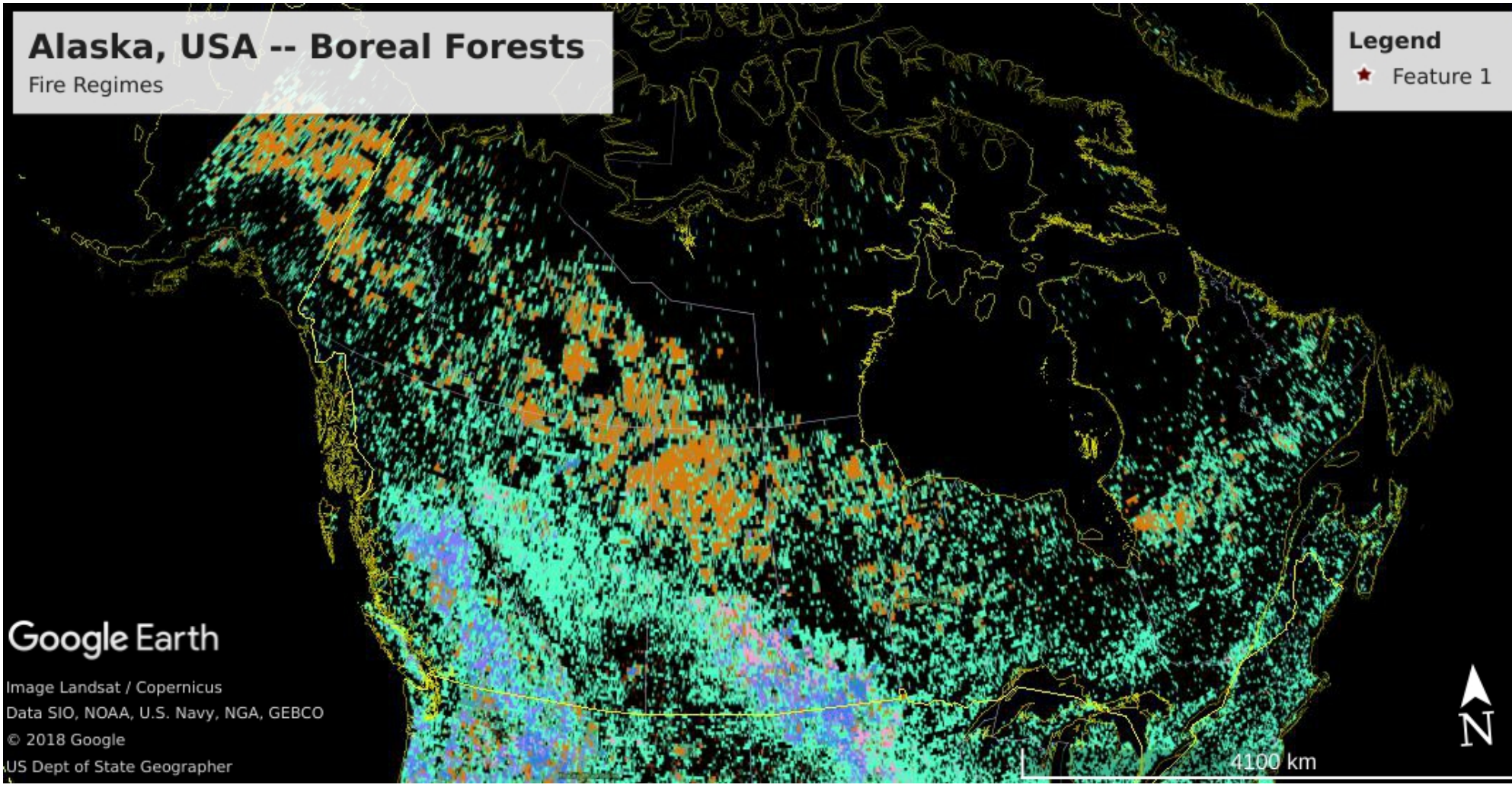
Fire regimes in boreal forests are seasonal and intense.



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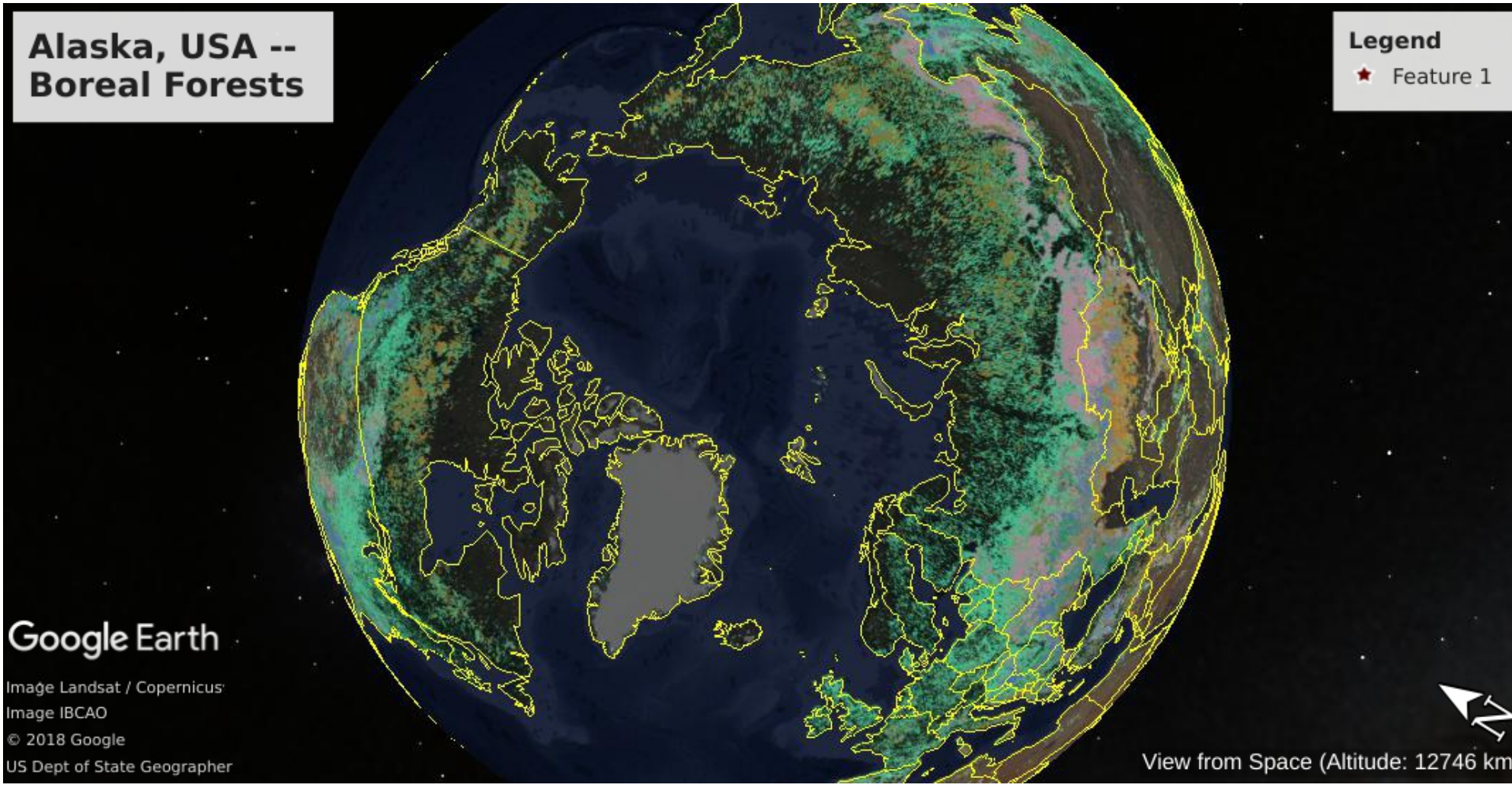
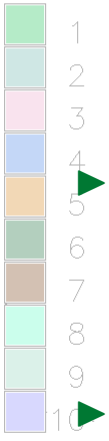


Fire regimes in boreal forests are seasonal and intense. They also show consistency across the northern high latitudes.

Seasonality and fire frequency drives the fire regimes in the Western US.



Summary:

- Continuous patterns of fire regimes across continents related to latitudinal climate that influence vegetation, fuels, land use and natural/anthropogenic fires.
- Able to differentiate (as well as identify similarity) between agricultural fires (ex. Punjab region of India, Kansas and US Midwest, the lower Mississippi Valley) across cropland types.
- Vast portions Earth have no classified fire regime due to the limited fuels (desert or polar conditions), no historical burns, or limitation of MODIS in cloud prone areas.
- Approach has potential as global monitoring tools by combining historical expectations and continuous montoring for fires globally, and quantify the shifts under changing environmental conditons.

Acknowledgments

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