Data Analysis of FIRMS Dataset

<div align="right">**Date – 27/02/2024**</div>

AIM –

The objective of this analysis is to explore the FIRMS dataset and identify hotspot regions in India. Specifically, we aim to pinpoint areas prone to fires based on the Fire Radiative Power (FRP) values present in the dataset. By analysing the FRP values across different regions, we can identify and map out the areas that experience frequent and intense fire incidents. This analysis will provide valuable insights into understanding the distribution and intensity of fires in India.

Dataset Description –

This study utilizes data from NASA's FIRMS website, obtained through Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) instruments. It provides near real-time monitoring of thermal anomalies and fire locations globally using MODIS data from Aqua and Terra platforms. With a spatial resolution of 1 km at nadir, it aids in identifying hotspot regions prone to fires. This dataset serves as a crucial resource for fire management and research worldwide.

- **Latitude** - Latitude Centre of 1 km fire pixel, not necessarily the actual fire location as multiple fires can be detected within the 1 km pixel.
- **Longitude** - Longitude Centre of 1 km fire pixel, not necessarily the actual fire location as multiple fires can be detected within the 1 km pixel.
- **Brightness -** Brightness temperature of the fire pixel measured in Kelvin.
- **Scan -** Along Scan pixel size Algorithm generates 1 km fire pixels, MODIS pixels enlarge toward the edge of scan. Reflects actual pixel size.
- **Track** - Along Track pixel size Algorithm generates 1 km fire pixels, MODIS pixels enlarge toward the edge of scan. Reflects actual pixel size.
- **Acq_Date** - Acquisition Date of MODIS acquisition.
- **Acq_Time** - Acquisition Time of acquisition/overpass of the satellite (in UTC).
- **Satellite** - A = Aqua and T = Terra.
- **Confidence (0-100%)** - Value based on intermediate algorithm quantities used in detection process, helping users assess hotspot/fire pixel quality. Confidence ranges between 0 and 100%, categorized into low, nominal, or high confidence fire classes.
- **Version (Collection and source)** - Version identifies collection (e.g., MODIS Collection 6.1) and source of data processing (Ultra Real-Time (URT), Real-Time (RT), Near Real-Time (NRT), or Standard Processing). Example: "6.1URT" - Collection 6.1 Ultra Real-Time processing.
- **Bright_T31-** brightness temperature of the fire pixel measured in Kelvin.
- **FRP Fire Radiative Power (MW)**- Depicts pixel-integrated fire radiative power in megawatts (MW).
- **Type** –   0 = presumed vegetation fire

  1 = active volcano,

  2 = other static land source,

  3 = offshore.
- **Day/Night** -   D= Daytime fire,

  N= Night time fire

Data Pre-processing

Data pre-processing was conducted using Python in our study.

1. Latitude and longitude information was utilized to create a new column indicating the respective states so that it becomes easy to map the values.

2. Due to inaccuracies in delineating Indian boundaries, neighbouring countries were erroneously categorized within India in the dataset. To address this issue, Indian states were manually separated using Google Maps and python library to ensuring accurate representation.

   As we can see from the above image, all the states are correctly integrated now.

3. Two new columns, namely year and month, were derived from the Acq_date column to facilitate temporal analysis.

Assumption

**We have established an FRP threshold value of 15 for our analysis.**

This decision was made to streamline the visualization process, as displaying all points regardless of fire occurrence was proving challenging.

**Our assumption is based on the following reasons:**

1. The FRP values in our dataset range from 0 to 6000. Upon examination, we observed that for each year, the minimum FRP value consistently hovers around 15. Additionally, the average FRP value is approximately 21, indicating a significant portion of data exceeding our chosen threshold.

2. We found support for our threshold choice in a research paper where FRP values below 20 were categorized as indicative of fire incidents. This further validates our decision to set the threshold at 15, ensuring that only significant fire events are considered in our analysis.

Analysis

1. **Top 10 states with maximum number of Fire occurrences.**
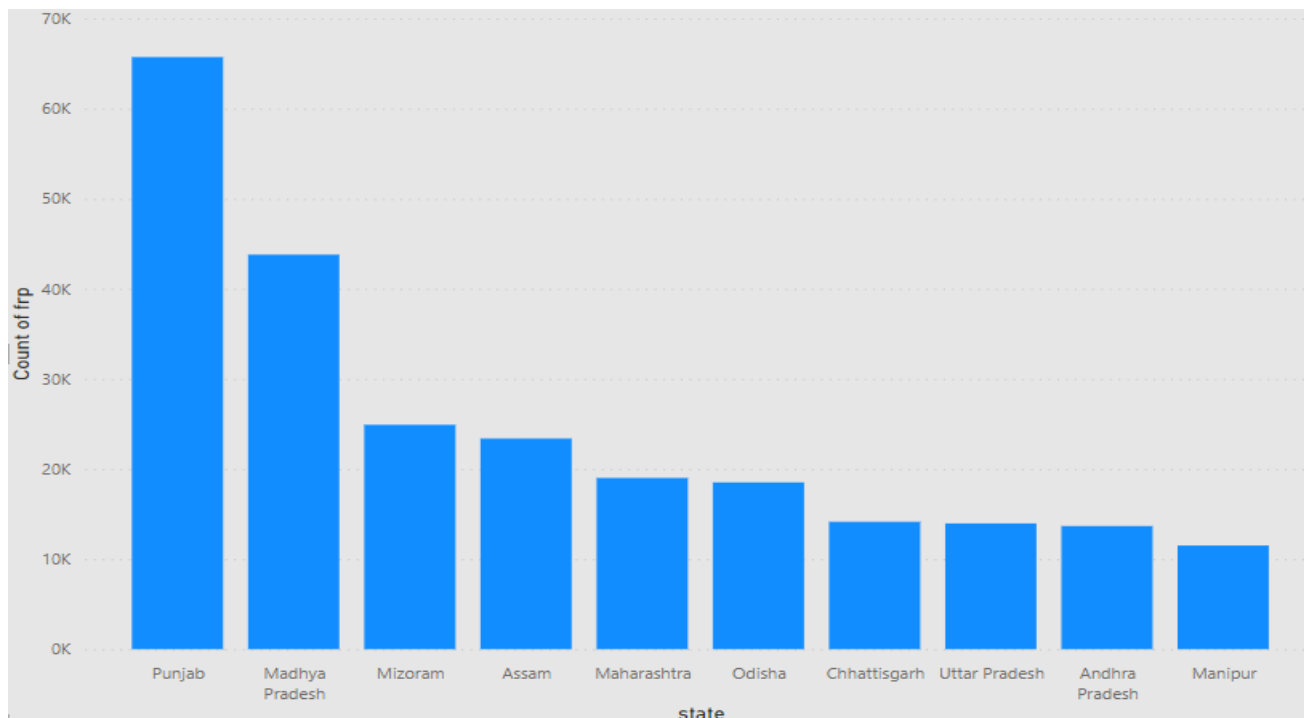
Punjab ranks high on the list, primarily due to stubble burning incidents that occur annually for a duration of two months. It's important to note that stubble burning cannot be categorized as forest fires. As a result, we are filtering out data from specific months to explore subsequent trends and patterns.
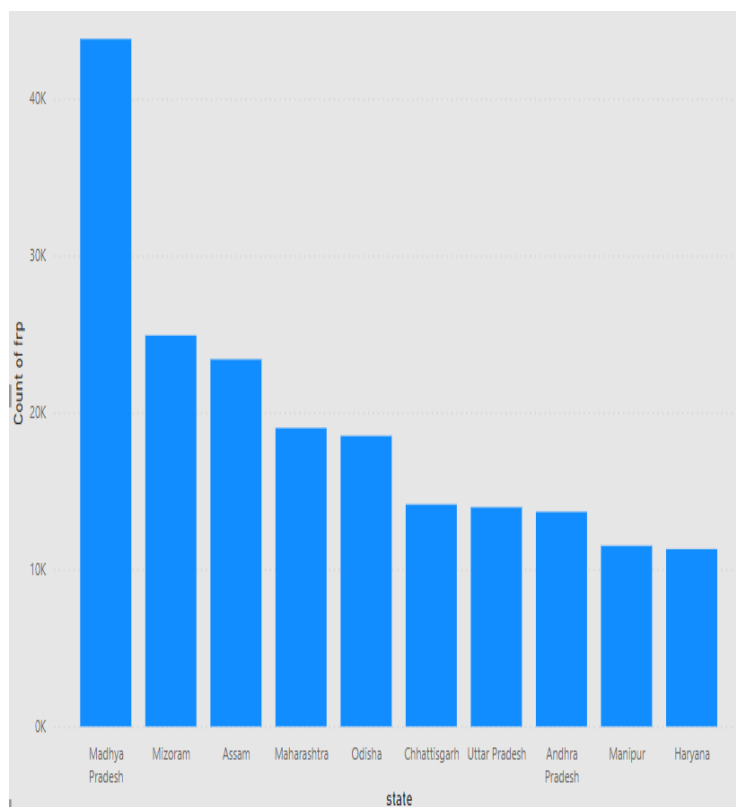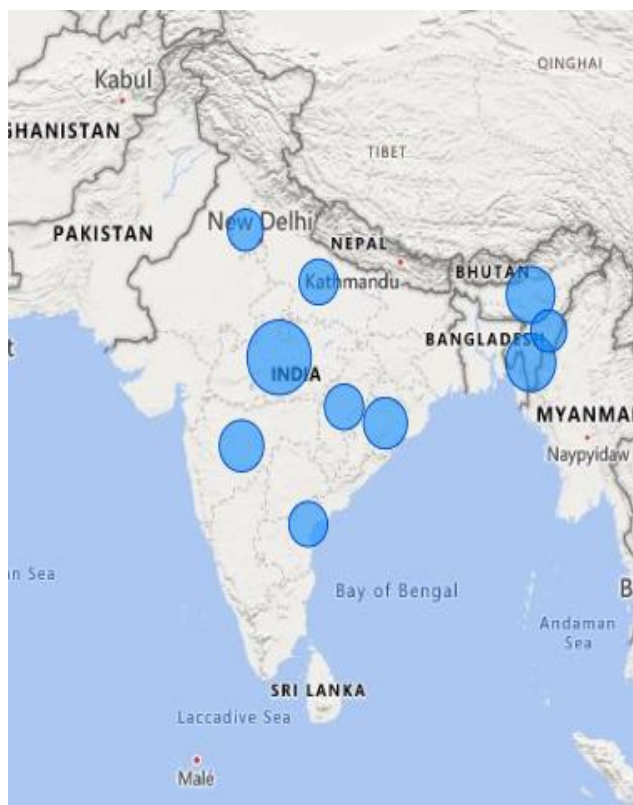
So now, we can conclude that <u>Madhya Pradesh</u> is showing us the maximum occurrences of forest fires.

2. **Bottom 10 States –**
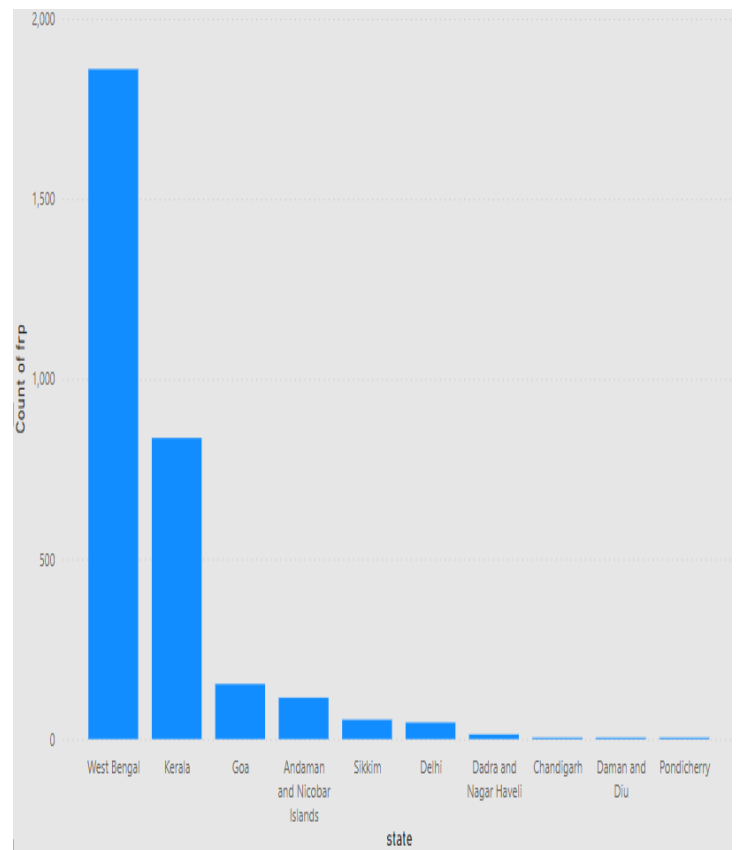
3. Statistical distribution which supports our assumption.

Statistical Description

In [50]: ▶ | 1 merged_df.describe(include='all').T

Out[50]:

	count	unique	top	freq	mean	std	min	25%	50%	75%	max
latitude	830166.0	NaN	NaN	NaN	24.38148	5.009841	8.0987	21.148492	24.2581	29.5506	34.9734
longitude	830166.0	NaN	NaN	NaN	81.224611	6.671297	68.4513	75.7258	79.1165	85.000075	97.3359
brightness	830166.0	NaN	NaN	NaN	324.002588	14.329491	300.0	314.7	322.1	331.2	506.1
scan	830166.0	NaN	NaN	NaN	1.418435	0.635565	1.0	1.0	1.2	1.5	4.82
track	830166.0	NaN	NaN	NaN	1.151539	0.202539	1.0	1.0	1.1	1.2	2.0
acq_date	830166	3619	2021-04-01	3108	NaN	NaN	NaN	NaN	NaN	NaN	NaN
acq_time	830166.0	NaN	NaN	NaN	819.005523	347.337259	321.0	645.0	753.0	821.0	2201.0
satellite	830166	2	Aqua	576150	NaN	NaN	NaN	NaN	NaN	NaN	NaN
instrument	830166	1	MODIS	830166	NaN	NaN	NaN	NaN	NaN	NaN	NaN
confidence	830166.0	NaN	NaN	NaN	64.170609	18.262606	0.0	54.0	66.0	76.0	100.0
version	830166.0	3.0	6.03	757478.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
bright_t31	830166.0	NaN	NaN	NaN	303.390128	8.419127	266.7	298.0	302.3	309.0	400.1
frp	830166.0	NaN	NaN	NaN	27.579234	74.093195	0.0	8.8	13.8	24.7	6961.8
daynight	830166	2	D	742117	NaN	NaN	NaN	NaN	NaN	NaN	NaN
type	757478.0	NaN	NaN	NaN	0.112831	0.462227	0.0	0.0	0.0	0.0	3.0
state	830166	56	Punjab	162191	NaN	NaN	NaN	NaN	NaN	NaN	NaN

4. Analysis of type of fire –

We have 4 types of fire with us –

0 = Presumed vegetation fire,   1 = active volcano,   2 = other static land source,   3 = offshore.

Presumed Vegetation Fire (Type 0): This type refers to fires that are presumed to originate from vegetation, such as forest fires, grassland fires, or wildfires. These fires typically occur on land and are fuelled by combustible vegetation.

Active Volcano (Type 1): This category encompasses fires that originate from active volcanoes. Volcanic eruptions can release molten lava, gases, and ash, which can ignite fires on the volcano's surface or in surrounding areas.

Other Static Land Source (Type 2): This type includes fires that originate from static land sources other than vegetation or volcanoes. It may include fires caused by human activities, industrial processes, or natural phenomena unrelated to vegetation or volcanic activity.

Offshore (Type 3): This category refers to fires that occur offshore, typically in bodies of water such as oceans or seas. These fires may originate from ships, oil rigs, or other marine structures.
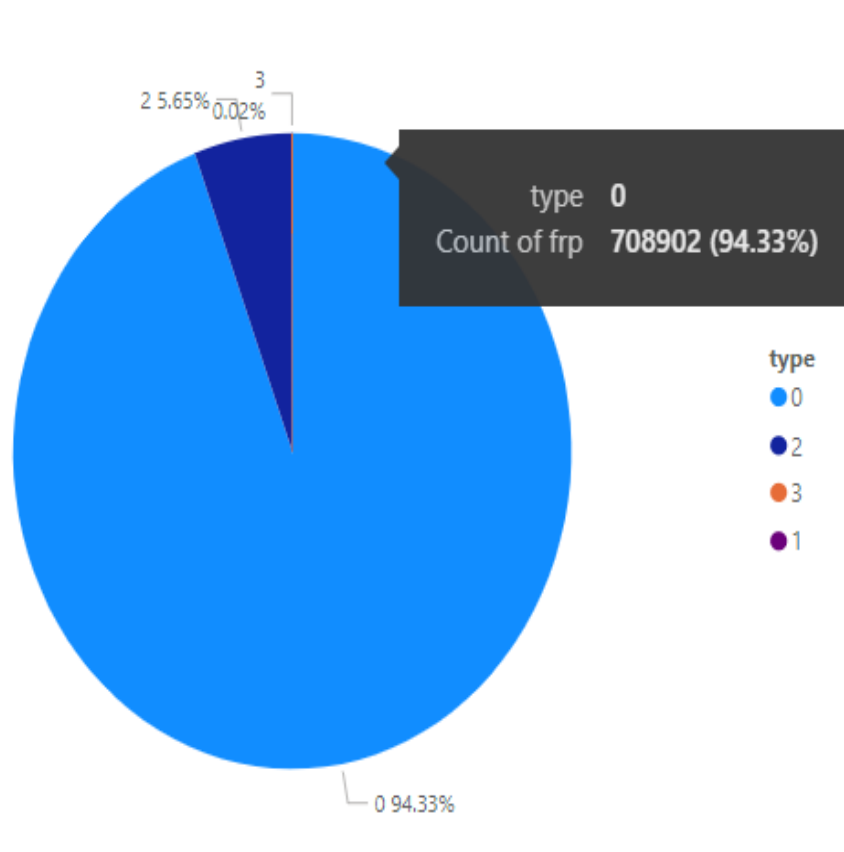
By this chart we can conclude that Presumed forest fire is the leading type of fire.
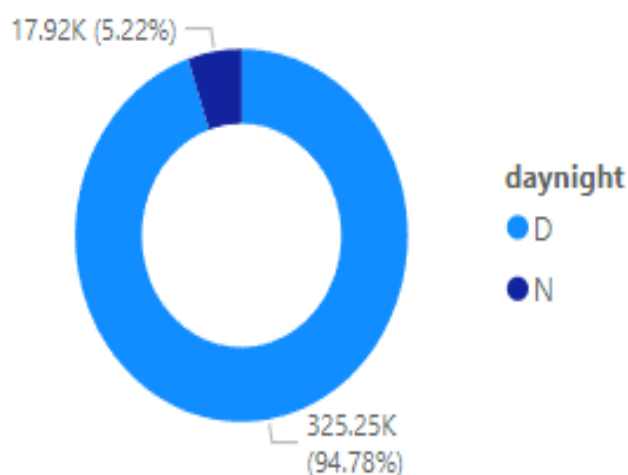
5.   Yearly trend of fires in Madhya Pradesh region.

year	Count of frp
2014	5093
2015	4663
2016	7940
2017	11499
2018	10723
2019	9377
2020	10629
2021	15644
2022	11593
2023	250
Total	**87411**

We can see an increasing trend from the year 2014 to 2022.

6. **Day Night Comparison with FRP readings.**

As we can observe, readings at day time is greater. Initially we were thinking that the FRP reading will be more in night as compared to day time but this chart totally rejects this assumption. So the FRP reading is independent of this factor that is; whether it is day or not, it will not affect the reading.