INDRAPRASTHA INSTITUTE *of*
INFORMATION TECHNOLOGY **DELHI**

## ESC-205 Project Report

# Near - Real Time Forest Fire Detection by Processing Satellite Spectroradiometer Data

# An Analysis of Forest Fires in Gujarat

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# Near - Real Time Forest Fire Detection by Processing Satellite Spectroradiometer Data

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## ABSTRACT

**India has to meet the needs of 1.252 billion people and 500 million cattle from 1% of the world forest resources. The forests of the country are therefore, under tremendous pressure. A major cause of degradation of these forests is forest fires. According to an assessment of the Forest Protection Division of the Ministry of Environment and Forests, Government of India, 3.73 million hectares of forests are affected by fires, annually in India. To reduce impacts of forest fires, an early fire detection is one of essential components in firefighting activity. The detection model is based on processing MODIS high resolution (250 m/pixel) satellite imagery. The satellites chosen are NASA's Earth Observing System's flagship satellite "Terra" and "Aqua" Satellites that together take four global readings in a day, making the algorithm near real time. The freely available modis datasets will be crawled and the appropriate images will downloaded as Shapefiles. These shapefiles will be parsed for active fire pixels, which are plotted on the map using Google Earth. Additional modules are used for providing geographical information about the source of the fire as well as the meteorological conditions like temperature, humidity and wind speed which gauge the severity of danger of the fire. A list of Active Fire Stations, their contact numbers and their locations are maintained which are equipped to handle forest fires. The Haversine distance between these Fire Stations and the threat coordinates are**

**dynamically calculated, so we get the nearest fire station for each fire detected. Gujarat, one of the most forest fire prone states in the country has been analyzed using this application.**

## 1. Introduction

**India has a forest cover of 78.92 million hectare, which is 24.01 percent of the geographical area. Of the total forest cover, 12.06 per cent is very dense forest (more than 70% crown density), 46.35 per cent is moderately dense forest (40% to 70% crown density), and the remaining 41.59 per cent is open forest (10% to 40% crown density). This means only 60% of the forests are well stocked to meet the demands of a 1.252 billion people and 500 million cattle. India is one of the 18 mega diverse countries of the world. It has a huge variety of ecosystems, thus a need for preserving ecological balance while meeting the demands of the population puts a tremendous strain on it's forests.**

| State of the Forest Report Year | Dense (40 % and above crown cover) Forest (in sq. km) | Open (10 to 40 % crown cover) Forest (in sq. km) | Total Forest Cover (in sq. km) |
|---|---|---|---|
| 1991 | 385008 (60.64) | 249930 (39.36) | 634938 |
| 2001 | 395169 (60.43) | 258729 (39.57) | 653898 |
| 2011 | 404207 (58.41) | 287820 (41.59) | 692027 |
| Change from 1991 to 2011 | 19199 | 37890 | 57089 |

*Note:* Figure in parenthesis are the percentage to total forest cover
*Source:* Various issues of State of the Forest Report

**Table: Change in forest cover from 1991-2011**

**With population explosion and urbanization, the forest cover of the country is deteriorating fast, a major cause being forest fires. According to Forest Survey of India Report, about 50 percent of forest areas in the country are fire prone. About 6 percent of the forests are prone to severe fire damage. Such forests have high densities of trees and other woody plants and, consequently, large**

**fuel loadings. When these dense fuels dry out and an ignition source is present, the resulting fires can spread rapidly and quickly become difficult or impossible to suppress. One of the most severe forest fires was witnessed during the summer of 1995 in the hills of Uttar Pradesh and Himachal Pradesh, burning an area of 677,700 hectares. Thus, there is an urgent need for real time detection and rapid response in combating forest fires.**

## 2. Forest Fire Causes and Impact

**With the population increase, the frequency and subsequent damage of the forest fire is increasing, since 95% of the causes of forest fires are caused by human causes deliberately for personal gain, or due to indiligence or by accident as summarized in the table below.**

| Natural | Anthropogenic | |
|---|---|---|
| | **Deliberate causes** | **Accidental causes** |
| 1. Lightning<br>2. Friction of Rolling Stone<br>3. Volcanic Explosion<br>4. Rubbing of Dry Bamboo Clumps | 1. Shifting Cultivation<br>2. To flush growth of *tendu* leaves<br>3. To have good growth of grass and fodder<br>4. To settle score with forest department. or personal rivalry<br>5. To clear path by villagers<br>6. To encroach upon the forest land<br>7. For concealing illicit felling<br>8. Tribal traditions/ customs | 1. Collection of Non Timber Forest Produce<br>2. Burning farm residues<br>3. Driving away wild animals<br>4. Throwing burning *biri*/ cigarettes<br>5. Camp fires by picnickers<br>6. Sparks from vehicle – exhaust<br>7. Sparks from transformers<br>8. Uncontrolled prescribed burning<br>9. Resin tapping<br>10. Making Charcoal in forests<br>11. Extracting wine in forest<br>12. Sparks from cooking near the forest<br>13. Heating coal tar for road construction in forest |

**Causes of Forest Fire in India**

**Forest fire data in India is very inaccurate, making it difficult to arrive at the accurate losses from the forest fires and make mitigation measures. According to the forest survey of India, losses due to forest fires are grossly underestimated as the raw data does not accurately portray the actual ground situation.**

**The various impacts of forest fires in India are:**

1. **Loss of timber resources and quality.**
2. **Upsetting ecological balance**

3. **Degradation of water catchments areas resulting into loss of water**
4. **Death of wildlife and their habitat**
5. **Loss of natural vegetation and reduction of forest cover**
6. **Global Warming and Air pollution, through production of carbon dioxide, carbon monoxide, methane, non-methane hydrocarbons, nitric oxide, methyl chloride and various other gases, and destruction of fauna.**
7. **Changes microclimate of region**
8. **Soil erosion**
9. **Threat to livelihood, property and life of people who settle near forests or who are dependent on forest use.**

**Impact of forest fires can be felt decades after in the form of diseases, insect attacks, change in local weather and degradation.**

## 3. Methodology , Tools and Results

**The app makes use of MODIS (The Moderate Resolution Imaging Spectroradiometer) aboard NASA's Aqua and Terra satellites, which orbit the Earth sending back high resolution images and spectroradiometer readings, which are made publicly available in their website: *https://earthdata.nasa.gov* .**

MODIS channels used in detection algorithm

| Channel number | Central wavelength (μm) | Purpose |
|---|---|---|
| 1 | 0.65 | Sun glint and coastal false alarm rejection; cloud masking. |
| 2 | 0.86 | Bright surface, sun glint, and coastal false alarm rejection; cloud masking. |
| 7 | 2.1 | Sun glint and coastal false alarm rejection. |
| 21 | 4.0 | High-range channel for active fire detection. |
| 22 | 4.0 | Low-range channel for active fire detection. |
| 31 | 11.0 | Active fire detection, cloud masking. |
| 32 | 12.0 | Cloud masking. |

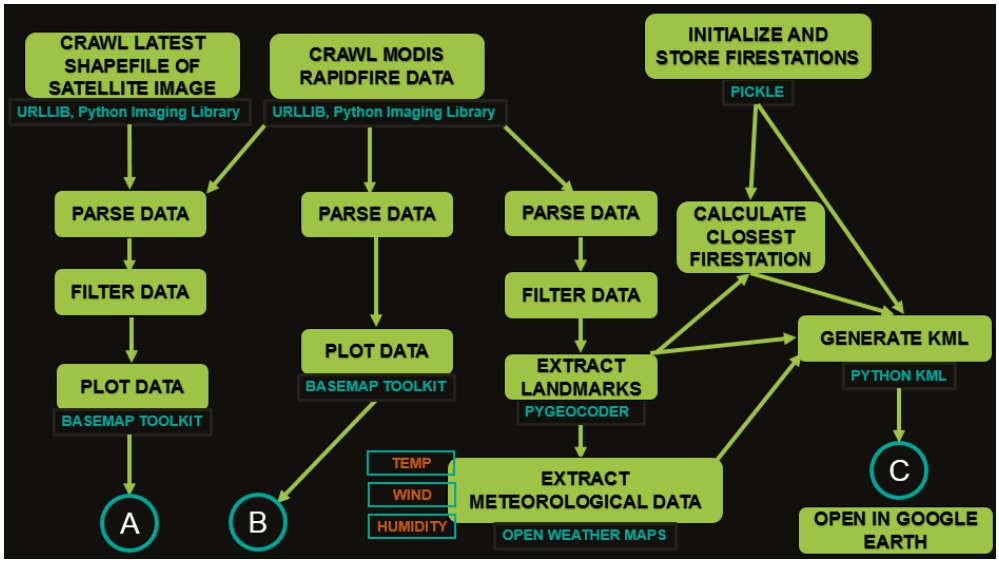
**Factors for calculating fire pixels**

**The app performs these basic functions:**

1. **Crawling latest satellite images and their metadata from NASA**

2. **Crawling FIRMS (Fire Information For Resource Management System) Shapefiles of active fire hotspots**
3. **Parsing these shapefiles and extracting essential parameters**
4. **Plotting the fire hotspots on the map in the basis of fire confidence intervals**

**Using this basic framework, the app runs in three modes, each performing different functions and having various features. The internal working of the application is represented by the flowchart:**




**Application Modes A,B,C and Python modules**

## Mode A: High Resolution Satellite Image Plot

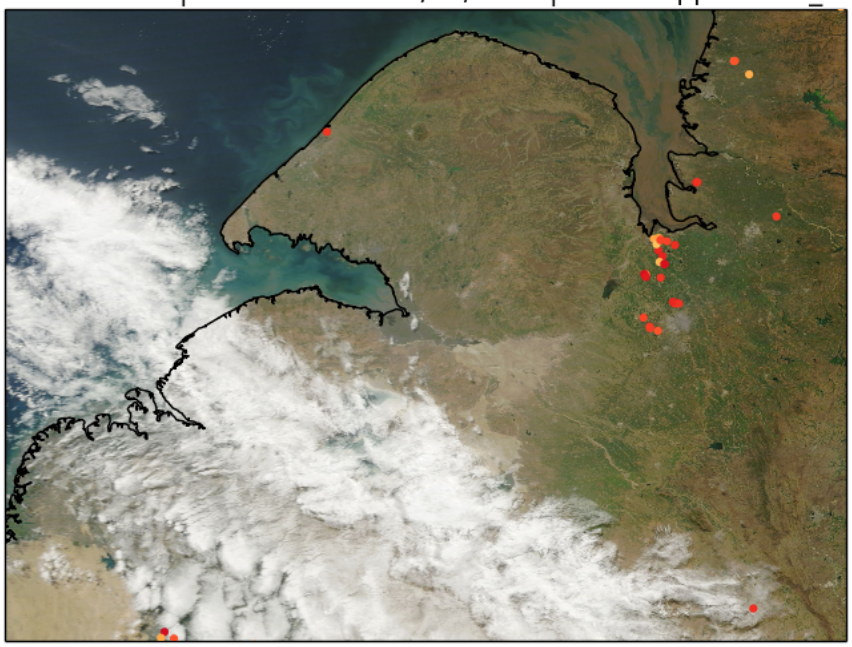
**Plotting forest fires based on confidence interval, on the latest satellite image of Gujarat. This mode takes time, at least 2-3 minutes depending on speed of the connection as the high resolution image is downloaded.**

**Features:**
**High resolution image (250m/pixel)**
**Near Real Time Image**
**Ability to Zoom freely**
**Save Image to Disk**
**Accurate coordinates at each pixel**
**Ability to change duration of detected fires (last 24h, 48h, 7 days)**

**Confidence interval values [0-100] are plotted as yellow to red color scheme**

**Mode A Results:**


The recent fire hotspots for last 7d
Pixel size: 250m | Current Date: 01/12/2014 | Area Mapped: FAS_India2



## Mode B: Global Fire Plot

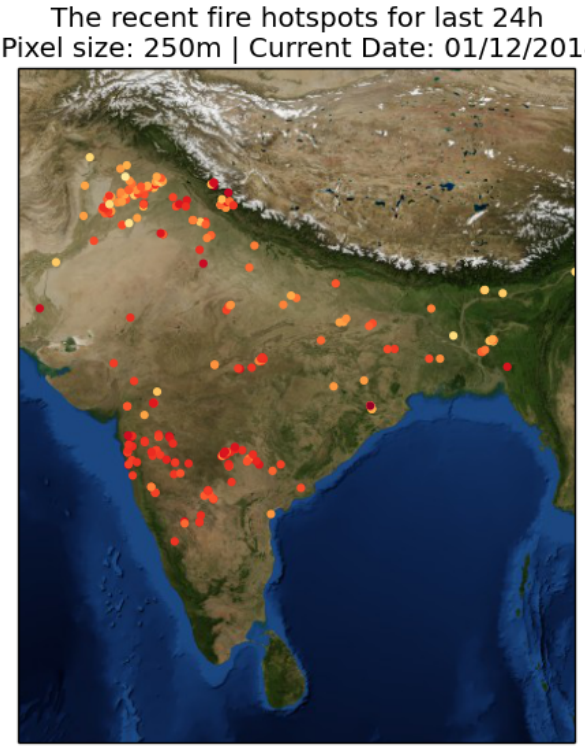
**Plots all the detected fires in the world using NASA's Blue Marble as a base. This is the fastest plot as it does not have to download any satellite image.**

**Features:**

**Global Plot**
**Ability to Zoom freely**
**Accurate coordinates at each pixel**
**Save Image to Disk**
**Ability to change duration of detected fires (last 24h, 48h, 7 days)**

**Confidence interval values [0-100] are plotted as yellow to red color scheme**

**Mode B Results (Zoomed to India):**


**The fires of North India are the leftover fires, which have lasted for more than a month due to burning crop fields in the states of Punjab, Haryana and Uttar Pradesh. This has been the major reason for heavy smog and haze in Delhi, as the wind is blowing pollutants including aerosols and soot into the city from these crop fields. Crop burning is already illegal in most states in India, including Punjab, and violators are supposed to be booked under Section 188 of the Indian Penal Code and the Air pollution (Prevention and Control of Pollution) Act. But this law is ignored, as farmers want to find the easy way out.**

## Mode C: Main Program - Gujarat Analysis

**This is the main program, which demonstrates how this information can be practically applied in real life to detect and fight forest fires. After getting the forest fire coordinates, the program uses pygeocoder module to return a nearby landmark for reference. A list of fire stations equipped to handle forest fires are maintained, along with their phone numbers which are plotted on the map along with the fires. For each fire location, the meteorological data of the current location is accessed using open weather maps module for python. For every fire, the nearest fire station is calculated using the haversine distance function. The fire can be highly dangerous under some conditions, Temperature > 26.6 C, Wind Speed >3 mph, Humidity < 55%. These dangerous fires are plotted in Red on the map.**

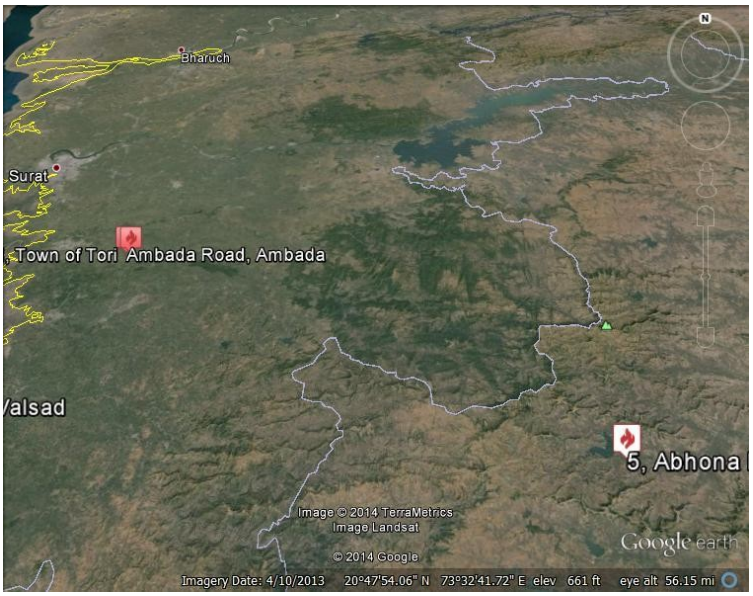
**This method is extremely fast at state level and even at country level, requiring less than 5 seconds to run for Gujarat. But due to the high amount to processing for each fire point, once the number of fires cross 500, it takes significant time. At any point of time, modis detects roughly 10000 fires in the world so plotting global fires will need more processing power and is beyond the scope of a basic computer.**

**Features:**

**Uses Google Earth for a dynamic interface (Dynamically Generates KML File) All the features of Google Earth can be used to navigate.**
**Plots fires in Gujarat.**
**At each fire location, retrieves temperature, humidity and wind speed.**
**Based on these factors, identifies some fires as high risk, which are plotted separately.**
**Fire Stations equipped to handle forest fires are plotted on the map, along with their contact information.**
**Haversine distance is used to calculate the closest fire station for each fire.**

**Mode C Results**


**Fires in Gujarat on 1st December**

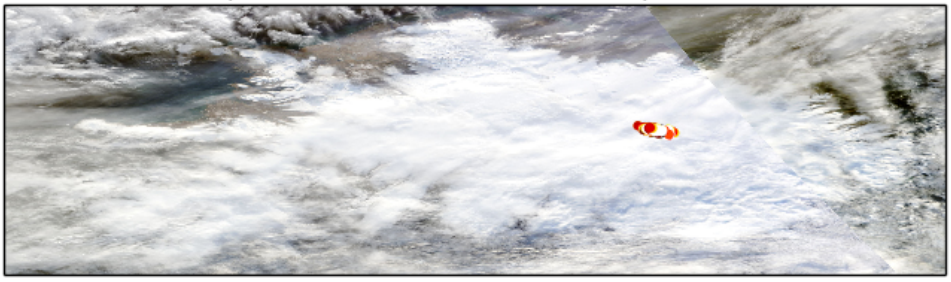



**Highly dangerous fires plotted in red**


**Data generated for each fire**

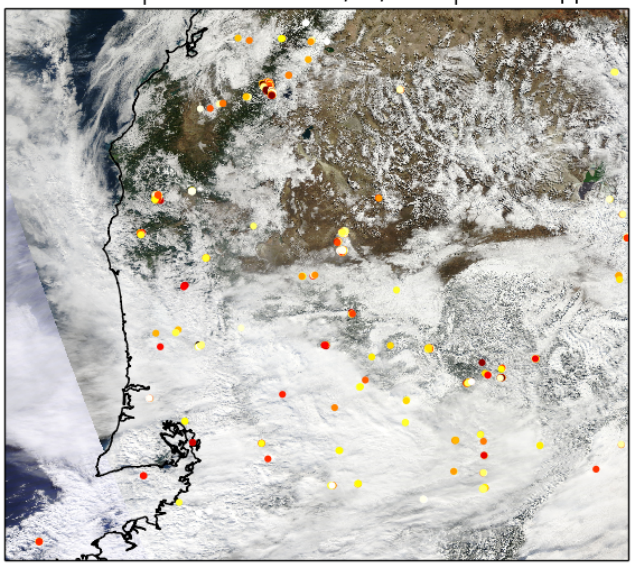
## Some examples of fires detected throughout the world (confirmed with the help of news reports)

The recent fire hotspots for last 7d
Pixel size: 250m | Current Date: 19/09/2014 | Area Mapped: Iceland



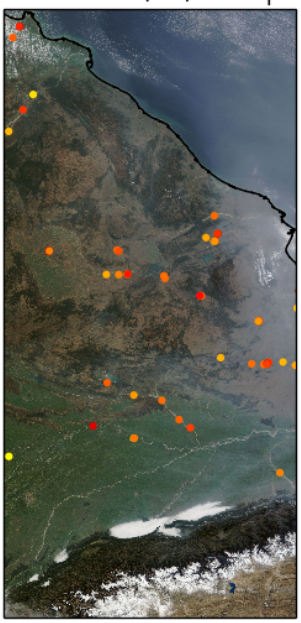
**Bardarbunga Volcano, Iceland**

The recent fire hotspots for last 7d
Pixel size: 250m | Current Date: 19/09/2014 | Area Mapped: USA1



**Fires in Yosemite National Park, USA**

The recent fire hotspots for last 7d
Pixel size: 250m | Current Date: 19/09/2014 | Area Mapped: FAS_India3



**Fires in East India**

## 4. Conclusion and Future Scope

**The application in an early fire detection and alert model for Gujarat which gives fire readings twice a day and runs extremely fast on a basic laptop.**

**The application has two main weaknesses: Unavailability of public fuel moisture map and topographical dataset for India. The datasets of Indian remote sensing satellite which maintains this information is not available publicly. Inclusion of fuel moisture and topological data would have resulted in a higher accuracy of detection of fires and their threat levels.**

**There is also the overall question of the accuracy of Modis Data in Indian forest fire context, which will determine the effectiveness on any tool that uses modis data. Further research needs to be done correlating actual forest fire reports with modis detected fires, finding the accuracies for each kind of forest and whether using different bands (Changing fire pixel detection algorithm) will bring better results for India. Once a suitable model has been established, further research can be done using weather forecasts and historical data and machine learning to predict forest fires before they occur, especially high threat wildfires.**

## 5. References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