Automated monitoring of large forest fires using near-real time satellite data - Experience from India

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Forests and Forestry in India

• 76.74 million hectares of forest area (23.34% of land area)
• 1.3 billion people; 27% rely partly or wholly on forests for livelihood
• Rich diversity- Alpine to mangroves; rain forests to desert scrub
• More than 200 forest types
• Conservation oriented forestry
• Lesser Government control and larger devolution of rights to individuals and local community
• Forestry contributes around 1% to GDP
Forest Fire scenario in India

• Man made, recurrent annual phenomenon closely linked with traditional, subsistence economic practices like shifting cultivation, non wood forest produce harvest etc
• Fewer large fires due to dense population, forest fragmentation and recurrent annual burning
• Forest fires numbers, density and in some regions severity is closely linked to drought conditions
• Increasing number of larger and more serious forest fires closely linked to changing climate
• High reliance on local communities for fire control; use of traditional fire fighting practices
Forest Fire scenario in India

Number of fires and Fire Radiant Power (FRP) Trends in Western Himalayan states (2003-2016)

Number of fires and Fire Radiant Power (FRP) Trends in North Eastern States (2003-2016)
Near Real Time Monitoring of Forest Fires

State Forest Department

Suppression and Mitigation of Forest Fires

Email alerts To States Nodal Officers

SMS alerts to Subscribers

24 X 7 Automated Processing and State wise Dissemination of Fire Alerts using PYTHON script

17/04/2019 23:09:40
Satellite Passing Over INDIA

17/04/2019 23:26:07
E-Mail Received from NRSC as Fire Spot Point Shapefile

17/04/2019 23:27:53
Published FSI Van Agni Geo-portal

17/04/2019 23:28:07
SMS alerts to Subscriber

17/04/2019 23:27:49
Sent Email Alerts to states nodal officers as KML & CSV format

17/04/2019 23:27:06
Prepare Final Forest Fire Dataset with Coordinate Information & Forest Administrative Information

Point Shapefile Converted to Pixelated Shapefile

Filter Pixelated Shapefile Using RFA Boundary & Forest Cover Map

Filter Pixelated Shapefile Using Mining Area Boundary, Industrial Area Boundary etc.

Add Forest Administrative Information

48TH TEMPLE

Thermal Anomaly Detected by Satellite

Data Transmitted to Earth Station

MODIS & SNPP-VIIRS SENSORS

Ground Station (NRSC)

Centre for Forest Fire Studies (FSI)

FSI Van Agni Geo-portal

Link: http://117.239.135.44:90/fsi_fire/fire.html
Large Fire Monitoring System
(Transition from Fire Pixel to Fire Event)

• Automated identification of large fire events based on proximity of fire alerts (pixels) in a given satellite pass (SNPP-VIIRS)
• Automated tracking across satellite passes within the estimated fire boundary till the event is alive
• World’s first satellite alert based large forest fire monitoring system
• First National large fire database of the country
AUTOMATIC SELF DETECTION & GROWTH MONITORING MODEL FOR LARGE FOREST FIRE USING PYTHON SCRIPT

SNPP-VIIRS Fire Point received by email from NRSC

Point data convert to 375m x 375m Pixelated Polygons Data

Filtered the Forest Fire Polygons using FSI forest cover or RFA provided by SFDs

After complete inactivity of 3 days

Large Forest Fire Database

Select Fire Polygons with in 500m of Previous Active Fire & Append under the same Large Forest Fire

National Large Forest Fire Database

Checking for Potential Fire Polygons Which is in Continuation with Previous Active Fire

Create Unique Large Forest Fire Name Based on Range or District Name

Criteria of Changes SNPP-VIIRS >=3 Pixels

Remaining Fire Polygons Analyzed for Detection of New Active large forest fire

Create Dataset of Active Large Forest Fire Layer of the Current Pass of Satellite in Continuation with its Fire extensions from the Previous Passes

Convert Large Forest Fire Database for Geo-Portal Compatibility

Convert to State wise Large Forest Fire KMZ

Convert to State wise Large Forest Fire CSV

Convert to CSV for SMS Compatibility

Automated Update in the Fire Geo-Portal for Interactive Viewing & automated map generation

Disseminate Large Forest Fires KMZ to the Registered Users

Disseminate Large Forest Fires KMZ to the Registered State Nodal Officers with administrative info as a CSV file by Email

Disseminate to the Registered Users by SMS for Active Large Fires in their Subscribed Areas
Firetracker™ software

• First Detection- thresholds- evaluation
• Subsequent detections
  - Estimated max Fire Boundary EFB (500m) around LFF detection-
  EFB automatically grows with additional detections @500m
  - All activity within EFB attributed to the same LFF
  - When two LFF boundary collides? Multiple starts of a fire complex..
• Wait period of three days since last detection in the latest EFB to account for fire recurring within the same area again
• Archived after expiry of 3 day wait period
Software and tools used

Python 2.7 on Arc GIS software 10.3.4
• Clump detection- Buffer tool, select by attributes for 3 pixel clumps
• Buffer creation and continuous updation- Buffer tool
• Large fire nomenclature and append pixels
• Extract details such as First detection, latest detection, active pixels, total pixels of the Large Fire
• Overlaid with admin area data and is appended to it
• SMS generation based on user admin area preference

Python libraries used
arcpy, OS, time, shutil, csv, numpy, glob, email, mimetypes, traceback, sys, smtplib, re, arcpy.mapping, email, dbfpy, datetime, etc.
Case Studies

- *Firetracker™* capabilities (Size and rate of spread)
  - Large slow moving fires
  - Large fast spreading grassland fires
  - Smaller slow moving and fast moving fires
- First detection thresholds (3 pixels Vs 5 pixels)
- Advantages and Disadvantages
Large & Slow
(Bandipur forest fire complex – Karnataka & TamilNadu)
23rd to 26th Feb, 2019

<table>
<thead>
<tr>
<th>Date &amp; Time of Pass</th>
<th>No of SNPP-VIIRS Pixels detected by Large Forest Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>23rd Feb 13:15</td>
<td>19</td>
</tr>
<tr>
<td>24th Feb 1:46</td>
<td>38</td>
</tr>
<tr>
<td>24th Feb 12:57</td>
<td>31</td>
</tr>
<tr>
<td>24th Feb 14:37</td>
<td>42</td>
</tr>
<tr>
<td>25th Feb 1:28</td>
<td>47</td>
</tr>
<tr>
<td>25th Feb 14:18</td>
<td>39</td>
</tr>
<tr>
<td>26th Feb 1:10</td>
<td>1</td>
</tr>
<tr>
<td>26th Feb 13:59</td>
<td>15</td>
</tr>
</tbody>
</table>

Total: 232

SNPP VIIRS Pass wise Fire Progression at Bandipur Tiger Reserve

Legend:
- STATE boundary
- BANDIPUR district
- DATE & TIME OF SATELITE PASS:
  - 2019-02-23 13:15:30
  - 2019-02-24 01:46:43
  - 2019-02-25 14:31:43
  - 2019-02-25 21:28:00
  - 2019-02-26 01:10:18
  - 2019-02-26 13:59:52

TAMIL NADU
KARNATAKA
Large & Fast
(Kesli-2 forest fire – Madhya Pradesh) 2\textsuperscript{nd} April, 2019- 0153 hrs

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<th>No of SNPP-VIIRS Pixels detected by Large Forest Fire</th>
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<tr>
<td>2\textsuperscript{nd} April 2019 01:53</td>
<td>3</td>
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Estimated fire affected area 8.36 sq kms

Sentinel 2 MSI Satellite DoP 2nd Apr 2019
Small & Fast
(Abdullahganj-1 forest fire – Uttar Pradesh) 2nd May 2019 0230hrs

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<tr>
<td>2nd May 2019 02:30</td>
<td>3</td>
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Area affected 1.189 sq kms

**Small & Slow**
(Asaralli forest fire – Maharashtra) 20$^{\text{th}}$ and 22$^{\text{nd}}$ March, 2016

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<th>No of SNPP-VIIRS Pixels detected by Large Forest Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>20$^{\text{th}}$ March, 2016</td>
<td>3</td>
</tr>
<tr>
<td>21$^{\text{st}}$ March, 2016</td>
<td>9</td>
</tr>
<tr>
<td>22$^{\text{nd}}$ March, 2016</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

Fire affected Area- 471 ha
Medium Term Trends in LFF (2016 to 2018) using VNP14IMGTDL_NRT

<table>
<thead>
<tr>
<th>Year</th>
<th>NRT Fire Alert pixel count</th>
<th>LFF Pixel Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>245783</td>
<td>134081</td>
<td>54.6</td>
</tr>
<tr>
<td>2018</td>
<td>258480</td>
<td>151967</td>
<td>58.8</td>
</tr>
</tbody>
</table>

Year wise LFF (comparison of 3 pixel Vs 5pixel thresholds)

- 2016: Total LFF (5 pixel) = 20,0000
- 2017: Total LFF (5 pixel) = 17,0000
- 2018: Total LFF (5 pixel) = 20,0000

- 2016: Total LFF (3 pixel) = 15,0000
- 2017: Total LFF (3 pixel) = 16,0000
- 2018: Total LFF (3 pixel) = 20,0000

Graph showing comparison of total LFF pixel counts for 3 pixel and 5 pixel thresholds from 2016 to 2018.
LFF density in Regions (2016 to 2018)

Number of LFF per Million ha of forest area

- Total
- Western
- Southern
- Northern
- Central India
- North-eastern
- Western Himalayas

LFF events per million ha of forest area across years (India)

- 2016
- 2017
- 2018
Comparison of Duration of Burn in 3 & 5 pixel thresholds

Estimated Burn Duration of LFF

No. of Days of burning

- 2016 - 3 pixel
- 2016 - 5 pixel
- 2017 - 3 pixel
- 2017 - 5 pixel
- 2018 - 3 pixel
- 2018 - 5 pixel

Number of Events
LFF monitoring in 2019 (January- June 2019)

• 12480 candidate LFF events monitored; 7523 were only single detections;
• 2333 events with more than 2 day duration
• 361 more than 5 day duration
• 47 events more than 10 duration

Major Lessons
- Alerts too frequent- Are we raising too many large fire alarms?
- Subsequent detection could added as a criteria for LFF in 2020
LFF NRT dissemination
## LFF NRT dissemination

### Large Fire Events - 14-01-2019

<table>
<thead>
<tr>
<th>#</th>
<th>Fire Name</th>
<th>Division / District</th>
<th>Active Pixels</th>
<th>Total Pixels</th>
<th>First Detection</th>
<th>KMZ Link</th>
<th>MAP Link</th>
<th>Fire Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Y.PALEM -1</td>
<td>ANDHRA PRADESH</td>
<td>6</td>
<td>6</td>
<td>14-01-2019 14:06</td>
<td>Download</td>
<td>View</td>
<td>Active</td>
</tr>
</tbody>
</table>

State: ANDHRA PRADESH  
District: PRakasham  
Circle: TIRUPATTUR CIRCLE  
Division: MARKAPUR DIVISION  
Range: DORNAL RANGE  
Block: KHNITILA BLOCK  
Beat: CHINNARUTLA BEAT

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![Map of Large Forest Fire Events](image)
LFF NRT dissemination

Fire Name: Y.PALEM - 1 View on Map

First detected at 14-01-2019 14:06:16 hrs., 5 of 5 pixels are active.

State: ANDHRA PRADESH
District: PRAKASAM
Circle: FDPT SRISAILAM CIRCLE
Division: MARKAPUR DIVISION
Range: DORNAL RANGE
Block: CHINTALA BLOCK
Beat: CHINANARUTLA BEAT
Advantages

• Enables Fire managers to monitor large forest fire events and provide special emphasis in fire control of these events

• Provides disaster escalation support in order to bring in timely additional support from other agencies such as District Administration, SDMA, NDMA, Armed forces etc

• Supports rehabilitation of fire affected areas

• Enables building up of a National Large Forest Fire Database for planning especially in development of State Crisis Management Plans, Working Plans
Replicability and Adaptability

• Low cost solution for NRT of Large Fire events
• Transparency in Data
• Based on Open source technology
• Forest Survey of India is open to collaboration
• Versatile scalable Platform – It can include data from new sensors in future
• Easy to integrate with communication technologies
• Provides crucial data for medium to long term scientific analysis
THANKS FOR THE OPPORTUNITY!

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