Areal and Seasonal Distribution of Fires Detected in the Eastern US with the Hazard Mapping System

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INTRODUCTION

The Satellite Services Division (SSD) of NOAA's National Environmental Satellite and Data Information Service (NESDIS) produces a daily quality controlled fire and smoke analysis for the US utilizing the Hazard Mapping System (HMS). The HMS was developed as a decision support tool which allows for the integration of an array of satellite data from different platforms with the output from the automated fire detection algorithms of the different instruments as well as various ancillary data layers that aid the analysts in their decision making process.

Satellite analysts review fire detects from the automated algorithms and decide to either retain them in the analysis or delete them if they feel they are false detects. Analysts also scan the satellite imagery and add fire points that the automated algorithms have not detected. All smoke is manually added (no automated algorithm is employed). They also denote those fires that are producing smoke that can be seen in satellite imagery as input to a transport and dispersion model.

The analysis is updated on the web site http://www.ssd.noaa.gov/PS/FIRE/hms.html several times during the course of the day as new satellite imagery becomes available and additional fires are detected. The final quality controlled analysis is normally not completed until early the following day.

SATELLITE DATA AND DETECTION ALGORITHMS

The HMS incorporates imagery from seven NOAA and NASA satellites in orbit. Geostationary data are obtained from GOES-10 and GOES-12 and offer high temporal resolution (data refresh of 15 minutes) but at a reduced spatial resolution (4 km for the 3.9µm channel at satellite subpoint). Polar orbiting data are provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on both the Terra and Aqua spacecraft and the Advanced Very High Resolution Radiometer (AVHRR) on NOAA-15, -16, and -17. Polar data provide a higher nominal resolution of 1 km but at lower refresh rates. This data integration allows for the collective strengths of each instrument to overcome their individual limitations. Incorporating this suite of satellites (MODIS, GOES and AVHRR) each location in the eastern US is sampled over 100 times per day.

The MODIS algorithm currently used is described by Giglio et al., 2003. The algorithm for GOES (the WildFire-Automated Biomass Burning Algorithm, WF-ABBA) is described by Prins and Menzel, 1992 while the AVHRR algorithm (Fire Identification, Mapping and Monitoring Algorithm, FIMMA) is based on the scheme described in Li et al. (2000), developed by Dr. Ivan Csiszar and later updated to use with NOAA-15-17. The WF-ABBA and FIMMA routines are run in the 24x7 operational environment of the SSD while the MODIS algorithm runs at NASA GSFC under the auspices of NESDIS' MODIS Near Real Time Processing System.

ANALYSIS METHODOLOGY

Analysts quality control the automated hotspots by comparing their location with known, static heat sources that are deemed to be false alarms (i.e. power plants, industrial facilities, etc.) and deleting those that overlap. They also interrogate the satellite image that the hotspot was detected from and delete those points that are felt to be a false detect due to highly reflective clouds, urban heat islands, physical characteristics of the ground etc. To aid in this process the HMS integrates the imagery with automated hotspot detects from each of the instruments and several ancillary data layers (land use, power plant locations, stable lights from the Defense Meteorological Satellite Program Operational Linescan System, etc).

While scanning the imagery the analysts also add what are felt to be fire points that the automated algorithms have not detected. These points may be added based on a heat signature in 3.9μm infrared (IR) imagery or a smoke plume that has no heat signature in the IR. It should be noted that in the process of adding and deleting fire points no distinction is made between wildfires, agricultural or prescribed (sometimes referred to as "controlled") burns.

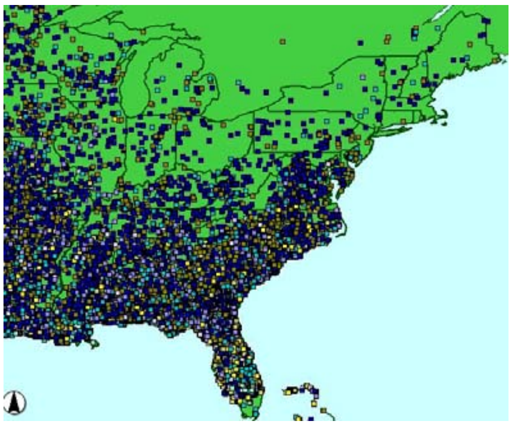

Figure 1 Dec-Jan-Feb fire locations

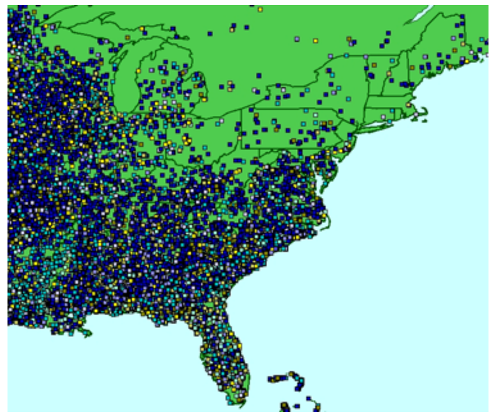

Figure 2 Mar-Apr-May fire locations

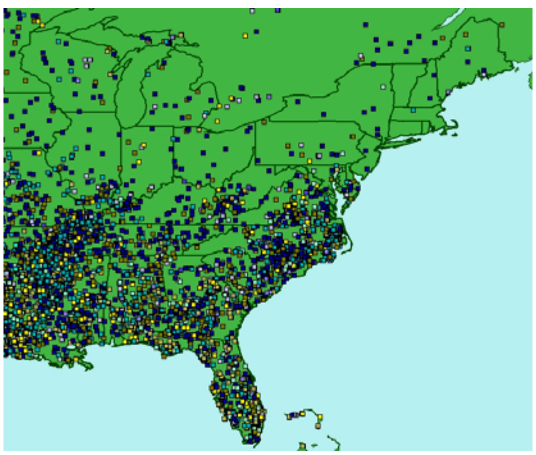

Figure 3 Jun-Jul-Aug fire locations

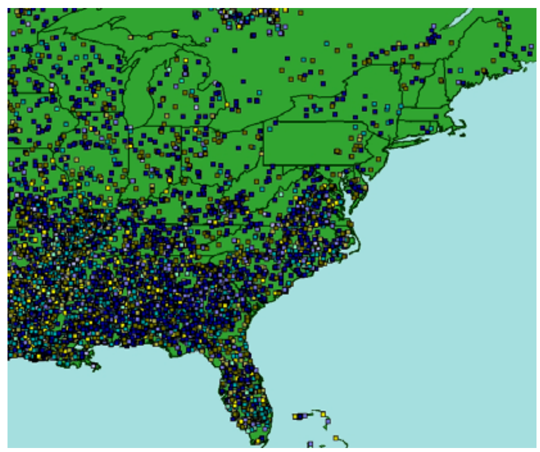

Figure 4 Sep-Oct-Nov fire locations

SPATIAL AND TEMPORAL DISTRIBUTION OF EASTERN FIRES

Daily statistics for the hotspots are collected. These include the location, time of detection and means of detection (either the automated algorithm or whether it was manually added). Each fire location is represented to 3 decimal places, which leads to a bit of an overestimate for the total number of fires due to the navigational discrepancies between satellite platforms as well as frame-to-frame registration with the GOES imagery. Analysts attempt to mitigate this effect by deleting hotspots if they are clustered around a location and they feel that they represent only a single fire. But on days with high fire occurrence this is not always obvious.

The results of 1 year of statistics (April 2004 to April 2005) are summarized in figures 1-6. Figures 1-4 depict the aerial distribution of the three automated detections and analyst detections (the final quality controlled analysis) in each season. Figures 5 and 6 depict the total number of fires detected north and south of 35N as a function of date (fig 5) or season (fig. 6)

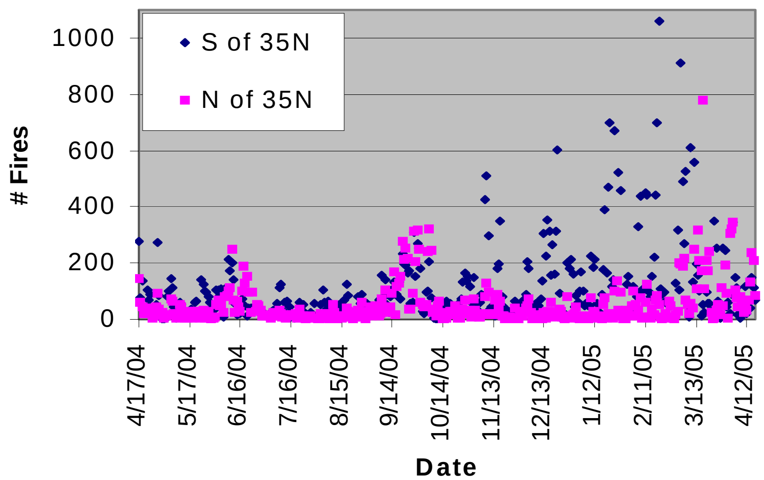

Figure 5 daily number of fires north and south of 35N from April 2004 to April 2005.

Viewing the figures over the eastern US (east of the Mississippi river) a couple of patterns quickly become apparent. First, there is a distinct spatial distribution to the fires, with the majority occurring south of 35N (Mississippi, Alabama, Georgia, South Carolina and a portion of North Carolina). This is true for all seasons (figs. 1-4 and 6) and the vast majority of days throughout the year (fig. 5). While no distinction is made as to the type of fire (wildfire vs agricultural or prescribed) it is felt that due to the duration, location, time of occurrence (time of day and time of year) and prevailing weather conditions that the vast majority of detected fires are agricultural or prescribed burns. A distinct peak of occurrence is observed during the daylight hours (mainly afternoon and evening) with a sharp falloff shortly after sunset. The second observation apparent from the statistics is that the largest number of fires occurs in the winter (Dec-Feb), mainly due to the overwhelming number of fires south of 35N (fig. 6). Conversely, a notable minimum is observed during the summer growing season (Jun-Aug).

While the smoke generated from the individual fires is typically minimal (at least not observed in satellite imagery) there can be significant emissions generated with smoke plumes that extend 100 km or more from the source. Also, the cumulative effect of large numbers of small fires during stagnant weather conditions can also lead to an accumulation of smoke within a regional area. With the dual fire and smoke depictions on the HMS it can be used as a tool by air quality and fire managers to monitor fires and their emissions during the course of the day.

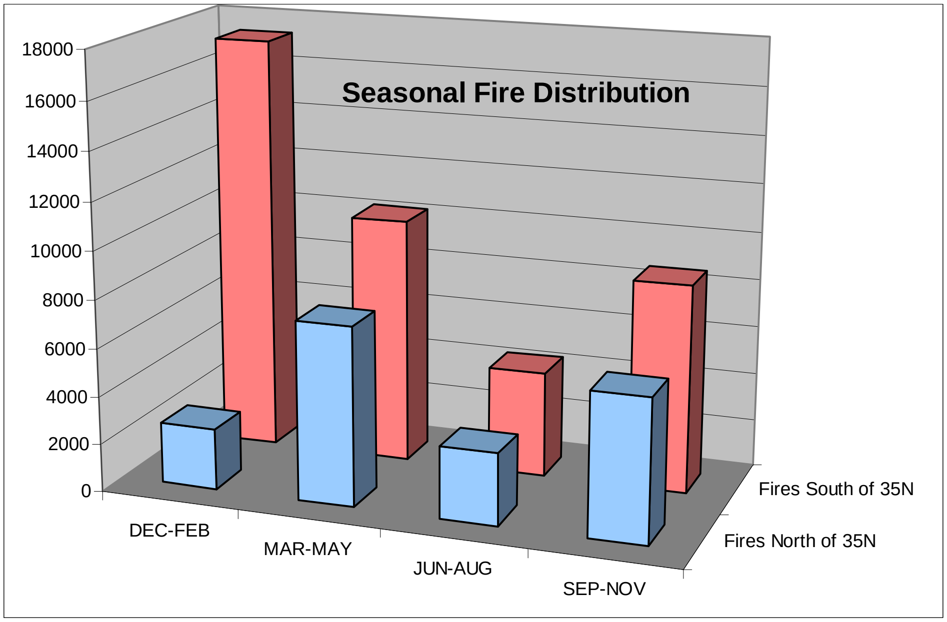

Figure 6 Seasonal distribution of fires east of 93W and sorted north and south of 35N for the period April 2004 to April 2005.

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Biography

Mark Ruminski is the fire team leader for the Satellite Analysis Branch which produces the daily quality controlled fire and smoke product. He has worked with other team members of the Satellite Services Division to establish the Hazard Mapping System which is the main tool used for creating the analysis. He has worked for NOAA for over 20 years with the bulk of that time spent in operational analysis with NESDIS.