Recent Changes to the Hazard Mapping System

Mark Ruminski and Shobha Kondragunta
National Oceanic and Atmospheric Administration/National Environmental Satellite and Information Service
5200 Auth Rd. Rm 401, Camp Springs MD 20746
mark.ruminski@noaa.gov

Roland Draxler
National Oceanic and Atmospheric Administration/Air Resources Laboratory
R/ARL - SSMC3 - Rm 3350, 1315 East West Highway
Silver Spring, MD 20910
Roland.draxler@noaa.gov

Jian Zeng
Earth Research Technology Inc.
5200 Auth Rd. Rm 712, Camp Springs MD 20746
jian.zeng@noaa.gov

ABSTRACT

The Hazard Mapping System (HMS) was developed in 2001 by the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite and Data Information Service (NESDIS) as an interactive tool to identify fires and the smoke emissions they produce over North America in an operational environment. The system utilizes 2 geostationary and 5 polar orbiting environmental satellites. Automated fire detection algorithms are employed for each of the sensors. Analysts apply quality control procedures for the automated fire detections by eliminating those that are deemed to be false and adding hotspots that the algorithms have not detected via a thorough examination of the satellite imagery.

Areas of smoke are outlined by the analyst using animated visible channel imagery. A quantitative assessment of the smoke concentration is not performed at this time. However, integration of automated aerosol and smoke products into the HMS, such as the GOES Aerosol and Smoke Product (GASP) and the MODIS aerosol product in early 2006 and the aerosol product from the Ozone Monitoring Instrument (OMI) later in 2006 are expected to aid in providing smoke concentrations and identifying areas of smoke.

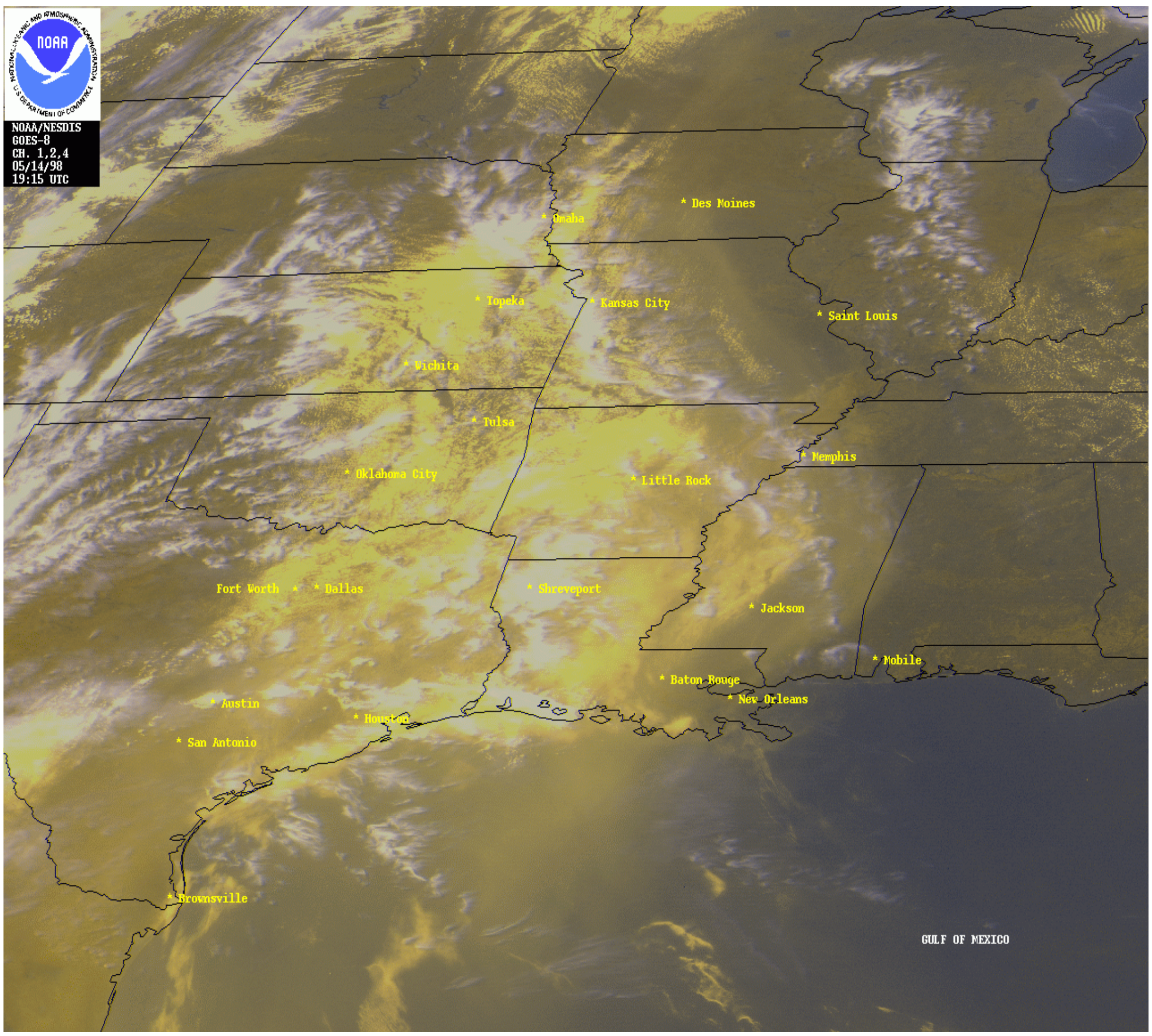
HMS analysts denote fires that are producing smoke emissions. These fire locations are used as input to the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model. In 2005 the model was upgraded to adjust emission rates based on the Blue Skies framework as opposed to using a constant emission rate. Future improvements include specification of fire duration and start/end time of emissions. It is expected that these enhancements will increase the accuracy of the total amount of emissions and their dispersion.

INTRODUCTION

The operational fire and smoke program at NOAA/NESDIS was initiated in the Spring of 1998 during the massive transport of smoke from Central America across Texas, the Southeast and as far north as the Mid-Atlantic States. Figure 1 provides an example of the smoke extent. This occurred as the burn season was at its height and an amplified weather pattern enabled the transport of the smoke northward. It created a health hazard across large areas of Texas and reduced visibility at the surface and aloft. The initial analyses (pre HMS) were quite rudimentary and only regionally based (covering a couple of states), with the region being analyzed changing as conditions warranted. While the analyses primarily supported National Weather Service (NWS) needs, their applicability to wildfire and air quality managers allowed for the development of the HMS.

The HMS was developed to provide coverage for all of North America. It incorporates multiple environmental satellites (NOAA and NASA) by remapping the data from each of the sensors to a

Figure 1. GOES-East visible image from May 14, 1998 showing extensive smoke area extending from the Gulf of Mexico into the western Gulf states and further north.



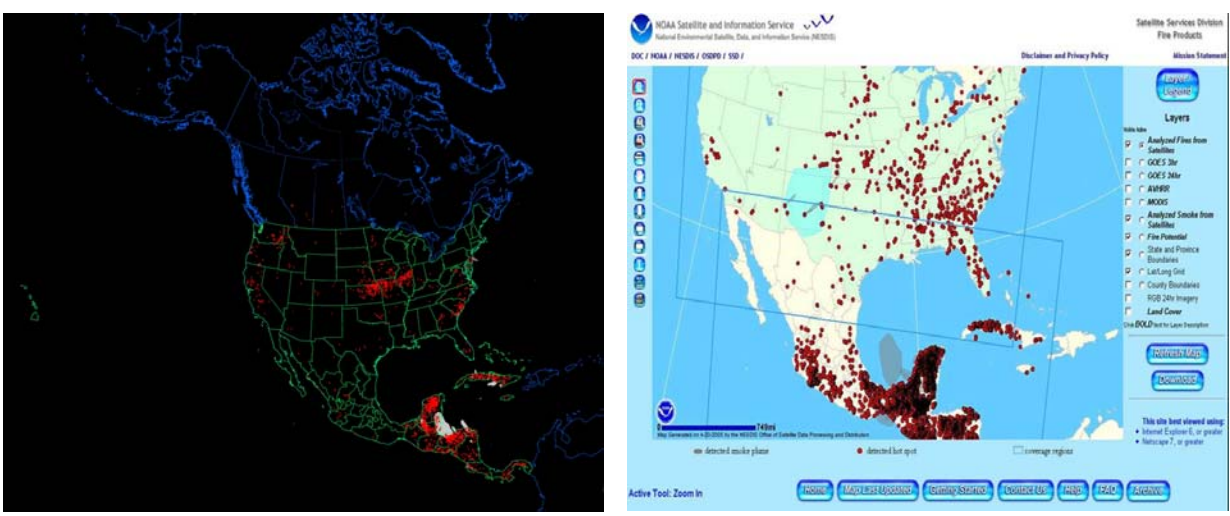
common projection to allow for easy comparison between the different data sources. Currently the HMS analysis domain is adjusted seasonally, covering the coterminous US - including adjacent areas of Mexico and Canada - and Hawaii from October through March, expanding northward to include Alaska and Canada from Spring into early Fall and including Central America in the Spring during each region's respective prime wildfire and burning season. Any of the regions can be analyzed during off-peak periods as conditions warrant. The HMS integrates satellite based (NOAA and NASA) automatically derived fire points with the satellite imagery and allows for an analyst based quality control procedure.

An increasing emphasis of the HMS has been the depiction of areas of smoke and specification of the fires that are producing significant emissions. The smoke outlines are produced manually, primarily utilizing animated visible band satellite imagery. A quantitative estimate of the smoke concentration is not provided at this time. The locations of fires that are producing smoke emissions that can be detected in the satellite imagery are specified and incorporated into the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model, developed by NOAA's Air Resources Laboratory. The HYSPLIT is run once per day and provides a forecast of smoke emissions and dispersion through 48 hours.

There are several limitations to the current procedures for detection and depiction of smoke emissions using satellite data. Since visible band imagery is employed for smoke detection it is useless at night. The presence of clouds may hinder or completely eliminate the capability to detect smoke. During large fire outbreaks when the smoke becomes lofted and can remain suspended for many days it can mix with anthropogenic sources such that only a best subjective estimate of a smoke demarcation is possible. As noted earlier there is no quantitative estimate of the smoke concentration associated with the graphic depiction. Additional satellite data and algorithms are expected to alleviate some of these limitations and will be discussed in more detail.

The fire and smoke analyses are made available to users in several standard formats (Figure 2 shows jpeg and GIS) via the Internet at http://gp16.ssd.nesdis.noaa.gov/FIRE/fire.html. Fire detections from the automated algorithms are placed on the site as they become available. The quality controlled product is updated on an irregular basis. The products are also archived by the National Geophysical Data Center (NGDC) at http://map.ngdc.noaa.gov/website/firedetects/viewer.htm. A text product has also been implemented recently and will be discussed later.

Figure 2. Graphic depictions of fire and smoke analysis in jpeg (left) and GIS (right) format.



An important feature of the air quality aspect of the HMS is the analysis over Central America which can be the source of huge palls of smoke in the US. The US State Department, through the Partners of the Americas, American Fellows Program has funded scientists from Mexico and Guatemala to assist in the fire and smoke analysis over Central America in 2004 and 2005. The success of this effort has resulted in additional funding for the implementation of the HMS technology in Mexico in 2006. While the analysis will be conducted in Mexico the products will be transferred to NOAA and merged with the analysis over the US and Canada to create a comprehensive product covering all of North and Central America.

DATA

The HMS incorporates imagery from seven NOAA and NASA satellites that are currently in orbit to allow for continuous monitoring. Geostationary data are obtained from GOES-10 and GOES-12 and offer high temporal resolution (data refresh of 15 minutes) but with a nominal spatial resolution at satellite subpoint of 4 km for the 3.9µm band which is employed for hotspot detection. Visible band data, used for smoke detection, is available at 1 km resolution. Polar orbiting data are currently provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on both the NASA Terra and Aqua spacecraft as well as the Advanced Very High Resolution Radiometer (AVHRR) on NOAA-15/17/18. The polar data provide a higher nominal resolution of 1 km for the 3.9µm band but at lower temporal refresh rates. Low and mid latitude locations are scanned twice per day by each of the polar orbiting satellites while higher latitudes receive more frequent coverage (up to 6 orbits per day in Alaska and northern Canada). The MODIS Terra and NOAA-17 spacecraft have similar equator crossing times near 1030 AM/PM local standard time (however, the NOAA-17 3.9µm band does not operate during daylight) while MODIS Aqua and NOAA-18 have similar crossing times near 130 AM/PM local standard time. NOAA-15 provides coverage near 600 AM/PM local standard time. This data integration allows for the strengths of each of the instruments to overcome their individual limitations.

FIRE DETECTION ALGORITHMS

Separate automated algorithms are utilized for each of the satellite platforms. While it is beyond the scope of this paper to provide detailed descriptions of each of the algorithms, in summary, each of the algorithms utilizes multi-spectral imagery, applies a form of temperature threshold and evaluates each potential hotspot contextually. The algorithm for MODIS was developed by the MODIS fire and thermal anomalies team at the University of Maryland and NASA[1,2]. The algorithm for GOES (the WildFire-Automated Biomass Burning Algorithm, WF-ABBA) is described by Prins and Menzel[3] while the AVHRR algorithm (Fire Identification, Mapping and Monitoring Algorithm, FIMMA) is based on the scheme described in Li et al.[4], developed by Dr. Ivan Csiszar and subsequently updated for use with NOAA-15/17/18. The WF-ABBA and FIMMA routines are run in the 24x7 operational environment of the Satellite Analysis Branch (SAB) of NESDIS while the MODIS algorithm runs at NASA GSFC under the auspices of NESDIS' MODIS Near Real Time Processing System.

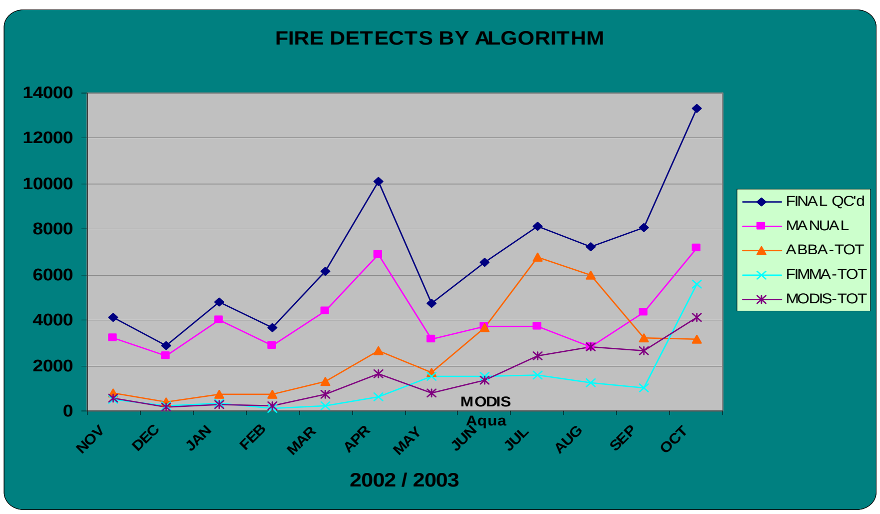
ANALYSIS PROCEDURE

As the satellite imagery and automated hotspot detections become available they are displayed in the HMS. The analysts evaluate each of the automated hotspots for validity based on the underlying satellite data, several ancillary data layers and their experience. Some of the data layers used to aid in the decision making process include land use, power plant locations and stable lights from the Defense Meteorological Satellite Program Operational Linescan System. Those hotspots that are deemed to be false detections are deleted. There are a number of causes for the false detections, including alternate heat sources (other than fires), such as power plants or factories, urban heat islands, high reflectivity from surface features and clouds, etc.

During the quality control process, in addition to deleting automatically detected hotspots interpreted to be false alarms the fire analyst also has the capability to add hotspots that the automated algorithm has not detected. There are a variety of reasons that the algorithms may miss a fire – including a sensed temperature in the 4μm channel below a threshold, ΔT between the 4μm and 11μm channels too small, cloud contamination, etc. This can be caused by a fire that is too small relative to the satellite ground footprint (the nominal sensor resolution at nadir becomes much coarser as the view angle approaches the limb), a fire that is masked by a canopy of vegetation and therefore diminishes the outgoing radiation to space, viewing geometry (the fire may be burning on a slope that is facing away from the radiometer), etc. Often there is enough of a signal, or confirmation from another satellite image, for the analyst to feel confident to add a hotspot to the analysis. Occasionally a smoke plume is the only indication of a fire with no corresponding hotspot detected.

The number of fires undetected by algorithms and added by analysts can be substantial. Figure 3 depicts the monthly number of retained automated fire detects for a 12 month period for each algorithm and for the manually added points. The manually added points represent over 50% of the annual total of quality controlled points[5] and include additions from all of the sensors. Prior to June 2003 MODIS detections were from the Terra spacecraft only (morning overpass).

Figure 3. Monthly statistics from 11/02 to 10/03 showing number of automated fire detects by sensor and manual additions.



Detections from Aqua were added in June 2003 (Aqua has an afternoon overpass about 2 hours after Terra). The final number of detects that passed the quality control procedure include the retained automated detects as well as the manually added points. The line representing the total number of quality controlled points is not merely the sum of the other lines since an individual fire may be detected by multiple algorithms.

The numbers for the automated detections do not represent the number of fires in the final product that each of the individual algorithms actually detected. This is due in part to the navigational discrepancies between the various satellites and even from image to image for the same satellite platform. Due to these navigational errors a single fire may be represented by multiple automated hotspots clustered around the actual fire location. The analysts attempt to cull the number of hotspots by making a determination of the most accurate location based on available land and coastline features. Due to the higher spatial resolution of the polar orbiting MODIS and NOAA spacecraft it is often the GOES WF-ABBA hotspots that are deleted in this manner. Additionally, when computing the statistics only fire points that are unique within .1 degree latitude are counted. In this way, a single fire that is detected multiple times during the course of the day by the WF-ABBA algorithm is only counted a single time. Given these considerations the graph therefore represents an approximation and should be used as such. But even with these considerations the number of manually added fires is considerable.

It should be noted that no distinction is made by the analyst between wildfires, agricultural or prescribed (sometimes referred to as "controlled") burns. This may be inferred by the location of the fire in conjunction with land use datasets but should be done with caution.

Visible imagery, as seen in Figure 4, is used for the smoke analysis with infrared occasionally employed to screen out clouds that can mimic smoke characteristics. At this time there is no automated algorithm used for the smoke depiction – all of the smoke outline areas are manually derived, as depicted in Figure 5. However, access to an automated product from GOES in the HMS has recently been implemented and will be discussed later. GOES data is the primary vehicle used due to its rapid refresh rate. Times near sunrise/sunset provide the best opportunity for smoke detection owing to the favorable low angle of solar incidence.

Analysts denote which fires are producing smoke for inclusion in the HYSPLIT model which produces smoke trajectories for the ensuing 48 hours. Input to the HYSPLIT is based on interrogation of visible imagery from GOES as well as 3.9µm from all of the satellites. If polar imagery from MODIS or NOAA spacecraft is available for a particular emitting fire, the fire is not near the limb of the image swath, the fire is not covered by clouds and the depiction is representative of the fire it is preferred over GOES due to the higher nominal spatial resolution. Figure 6 illustrates this for simultaneous GOES and MODIS images. Both images show bright hotspots for a fire in the Texas panhandle on 11 April 2006. Digital readouts of the images reveal 5 fire pixels for the GOES image and 20 for MODIS. However, since the objective is to provide the most up to date information a polar satellite depiction of a fire would not be considered representative if, for example, a MODIS image from 1830Z captured the fire in question but subsequent GOES imagery indicated a marked increase in the size and intensity of the fire and a corresponding increase in the amount of smoke emissions

The quality controlled analyses are updated frequently (hourly or more often) through the peak burn times in the afternoon and evening. The final, quality controlled product for the day is the result of an iterative process and generally not completed until the following day between 0900 and 1200 UTC. Each of the updates and the final product are made available on the internet (http://www.ssd.noaa.gov/PS/FIRE/) in several standard formats for users to access, including text, graphic and Geographic Information Service (GIS) compatible shape files, and through a GIS viewer. The final product is also archived at the National Geophysical Data Center (NGDC). The quality controlled product is also made available on the Geospatial Multi-Agency Coordination (GeoMAC) web site (http://geomac.usgs.gov) which was developed by the US Geological Survey (USGS) as an online resource for fire managers.

Figure 4. Visible GOES-West image from 26 October 2003 showing multiple smoke plumes from fires near San Diego and Los Angeles drifting out over the Pacific ocean.

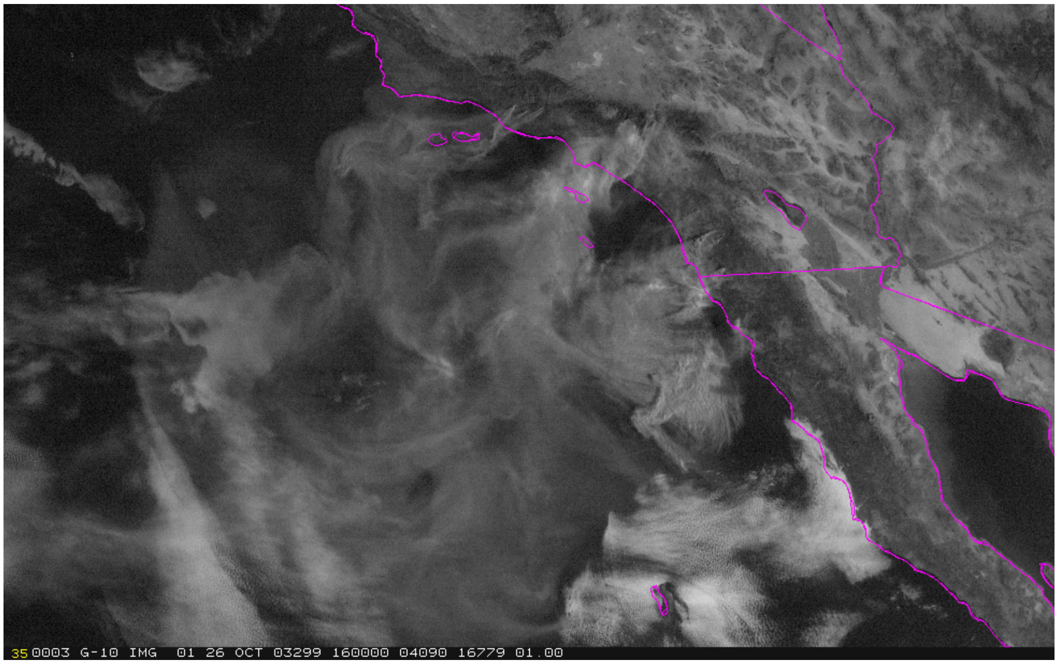


Figure 5. GIS display from 26 October 2003 showing manual smoke (gray shaded areas) depiction.

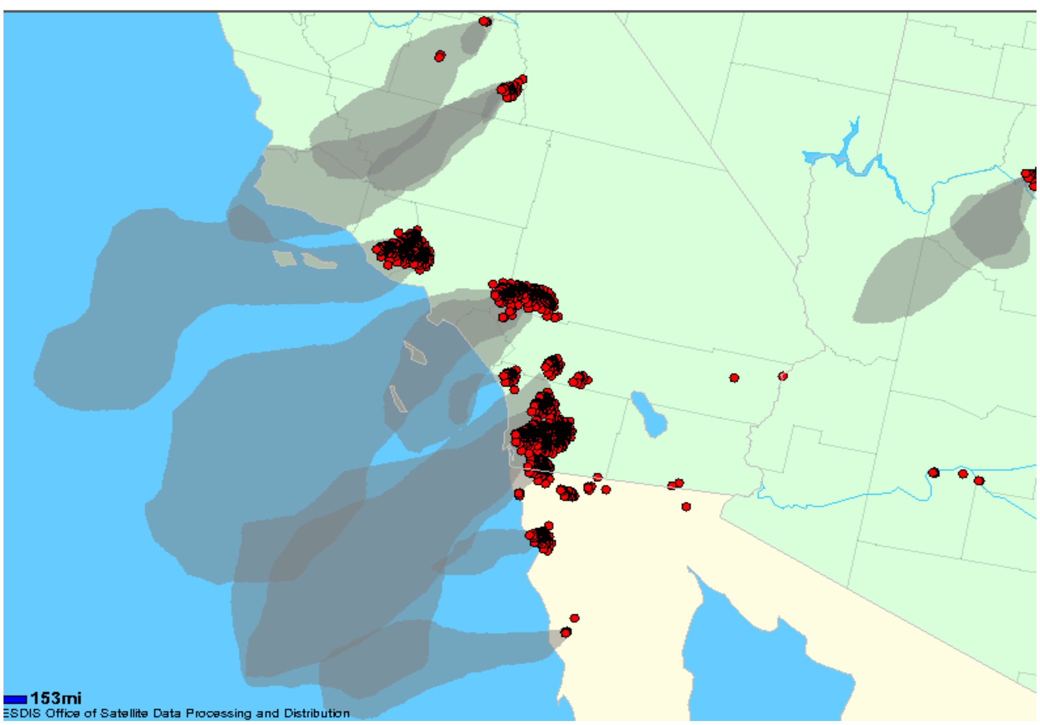


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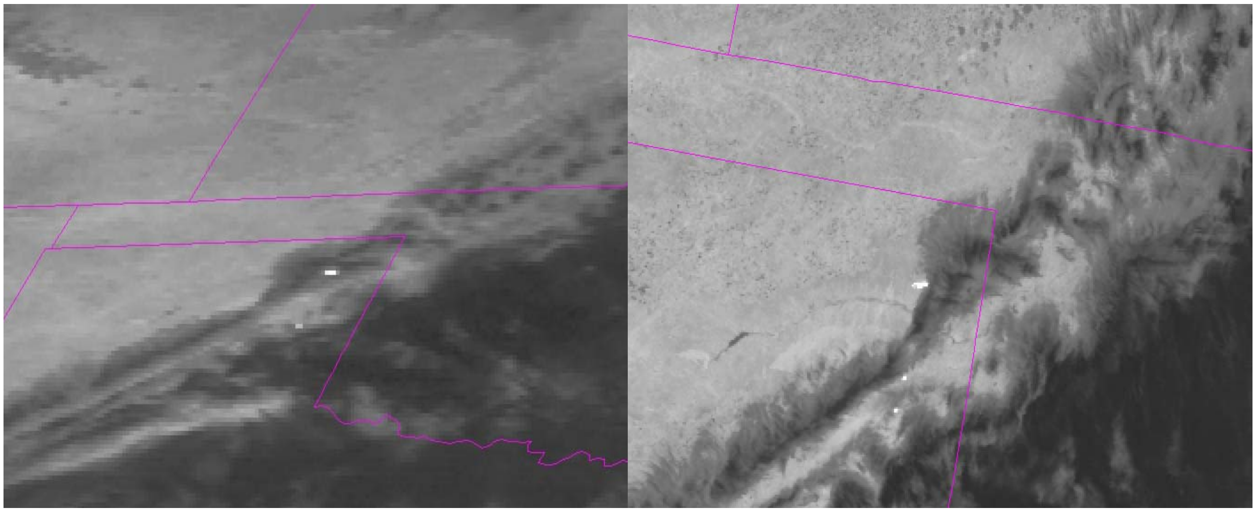
Figure 6. GOES-East (left) and Aqua MODIS images for 2000 UTC 11 April 2006. Bright spots in the northeast Texas panhandle represent fires in that area.



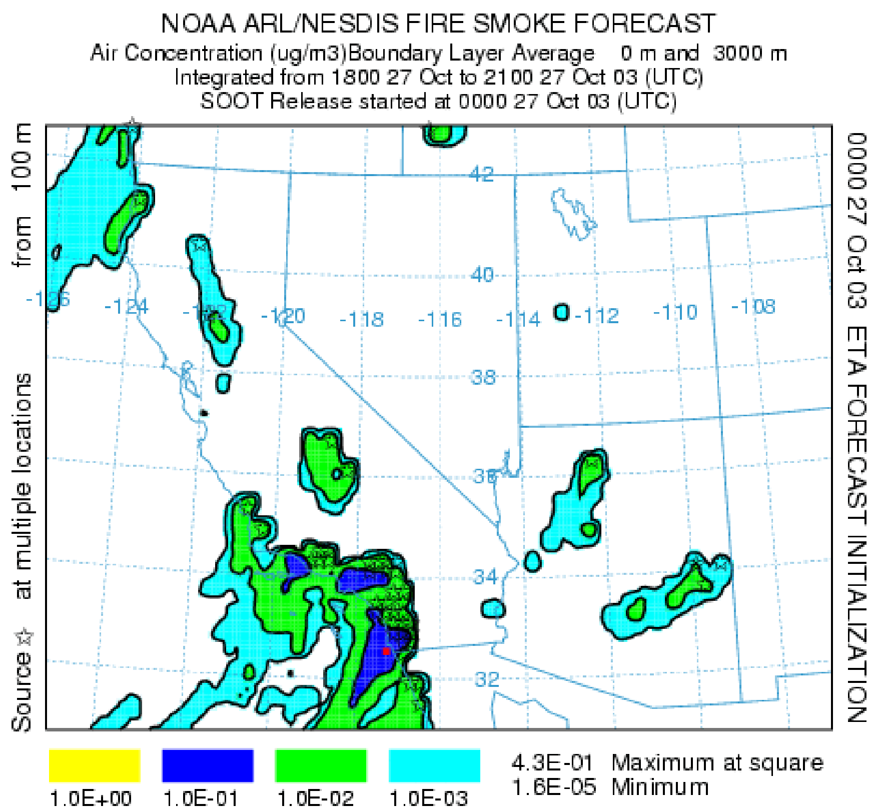
HYSPLIT TRANSPORT AND DISPERSION MODEL

HYSPLIT[6,7] is designed to support a wide range of simulations related to the transport, dispersion, and deposition of pollutants, including ash from volcanic eruptions, smoke from wildfires and emissions of anthropogenic pollutants. It was developed and is maintained by NOAA's ARL and run daily in experimental mode by the NWS' National Centers for Environmental Prediction (NCEP).

As noted above smoke producing fire points are identified by the analyst and used as input to HYSPLIT. Smoke emissions for a fire are determined by, among other factors, the number of points that the analyst adds for a particular fire. Likewise, the number of points for a selected fire is proportional to the number of identified hotspots. A preprocessor reads the fire position data file representing individual pixel hotspots that correspond to visible smoke and aggregates the locations on a 12 km resolution grid. Each fire location is assumed to represent one sq km and 10% of the area is assumed to be burning. The emission rate is obtained via the Blue Skies Framework (http://marlin.airfire.org/BSUG_v1_1_020206.pdf). The rate depends on the burn area (as estimated by the number of points added by the analyst), vegetation and fuels involved in the fire, fuel moisture content and fuel consumption. The total grid cell emission rate and area burning is computed from the sum of the number of fire locations within the aggregation grid cell. The HYSPLIT model is run once per day at 06Z and results are posted on the internet at www.arl.noaa.gov/smoke/forecast.html. Figure 7 provides an example of the output.

The dispersion model creates output maps of soot air concentration. Each day's fire locations are tabulated and two dispersion simulations are produced. A 24 h analysis simulation is run for the previous day using that day's fire locations. The smoke particle positions at the end of the day are used

Figure 7. HYSPLIT output valid for 1800-2100 UTC 27 October 2003, approximately 24 hours after Figures 4 and 5. Blue Skies emission rates were not used at this time.



to initialize the 48 h dispersion forecast simulation. The following day, the same initialization file is used to start the analysis simulation, prior to running the forecast.

The aggregated emission file is saved each day and the next day is loaded by the preprocessor in addition to the new fire location file. New fire emission points supersede previous day's points at the same grid cell, therefore emissions are assumed to be the ones valid for that day. However, if a grid cell has no new emissions, but had substantial emissions the previous day, the previous day's emissions are assumed to decay at a rate of 75% per day until the emission cell has less than 1 pixel burning. At that point the cell emission is set to zero. Particle age is limited to 72 hours after release, although with the large fires observed in Alaska and Canada during 2004 and 2005 much longer durations of elevated smoke were observed allowing for very long range transport.

The North American Model (NAM – formerly known as the ETA) is used as meteorological input for the HYSPLIT. The output grids are created for the NWS air quality model and have a 12 km resolution on sigma levels with a 1 hour interval. Dry and wet deposition is turned off but this can easily be adjusted.

RECENT AND PLANNED CHANGES

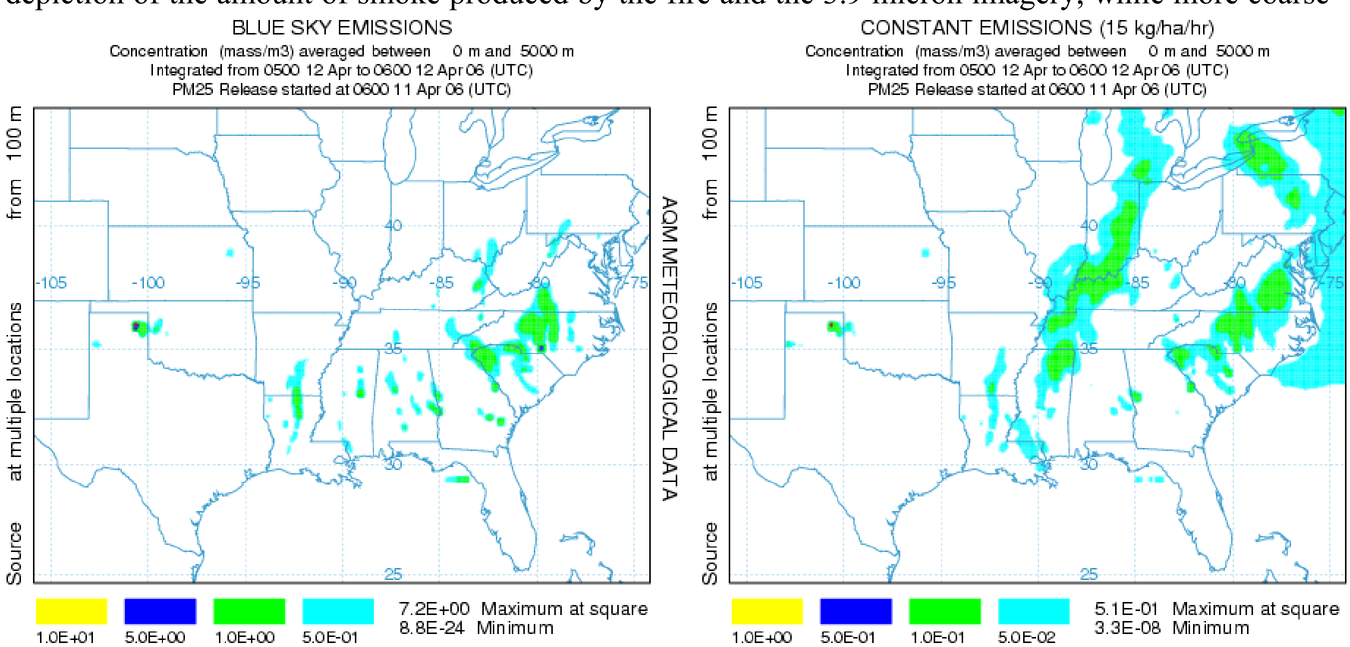
Blue Skies Emission Rates

In the past year the method used to estimate the emission rate used by HYSPLIT has been changed. Previously, the emission rate of carbon soot was assumed to be a constant (5 kg/ha/hr initially and 15 kg/ha/hr subsequnetly) for each fire point entered by the analyst. The only way to adjust the rate for a fire was for the analyst to indicate more fire points which would increase the emissions accordingly (i.e., a fire with 5 fire points would produce 5 times the rate of emissions as a fire that had 1 fire point). While this was a rudimentary estimate it was the most expedient at the time of implementation. It was known that the amount of particulate emission associated with biomass burning depends upon many factors: biomass type, moisture content, wildfire or slash and burn agricultural clearing and that emissions can change depending on whether there are flames or just smoldering. The HMS did not incorporate any of these factors. Levine[8] estimated total particulate matter emissions from biomass burning in the tropics to be 36-154x109 kg/yr. Another estimate, from Crutzen and Andrea[9], determined emission rates of aerosol measured at around 12g aerosol /kg C fuel for a tropical forest. Using these ranges, the normalized emissions are estimated to be from 5 kg/hr/Ha to 50 kg/hr/Ha. The value used for routine operational HYSPLIT calculations was at the low end of the range.

In April 2005 HYSPLIT was adjusted to use a variable emission rate which is determined by the Blue Skies Framework indicated earlier. HMS analysts currently provide the estimate of burn area required as input to Blue Skies. This is accomplished by indicating the number of hotspots on a 1x1 km grid associated with a fire. Polar orbiting satellites employed by the HMS have a nominal 1 km resolution and they are used for estimating the burn area if they are representative of the fire. However they may not be representative of a fire, as noted previously. If polar imagery is not used the burn area is estimated utilizing GOES visible and 3.9 micron imagery. The visible imagery provides a visual

Figure 8. HYSPLIT output valid for 0500-0600 UTC 12 April 2006. See text for important details regarding concentration values.

depiction of the amount of smoke produced by the fire and the 3.9 micron imagery, while more coarse



than polar imagery, provides some estimate as to the burn area, especially for longer duration fires that can be seen to grow in size as estimated by the number of hotspot pixels. Analysts experience is also utilized. Figure 8 depicts HYSPLIT output that compares the new Blue Skies emission rates with the previous constant (15 kg/ha/hr) rate. The graph depicting constant emissions (on the right) has been scaled by a factor of 10 compared to the Blue Sky emissions. If not for this increase the graph would be blank owing to the higher emission rates estimated by the Blue Sky framework. Therefore, areas that appear to be similar, such as the Texas panhandle and western South Carolina, actually represent 10 times the smoke concentration with Blue Sky than with the constant emission.

Fire Duration

HYSPLIT allows for modifying many input parameters in order to tailor the output for specific situations; however it is invoked by the HMS with the assumption that the fire will burn and produce emissions for at least 24 hours. While this may be a reasonable assumption for large wildfires it is not accurate for most of the agricultural and control burns and many of the small wildfires. This was done for simplicity and the belief that large wildfires were the ones of most interest. However, with increasing interest in the large number of smaller fires seen almost daily and the cumulative effect they have on air quality, a more realistic treatment of the fire duration is warranted.

Owing to the frequent refresh rate of GOES imagery (every 30 minutes) each location in the US is sampled at least 55 times per day (MODIS, GOES and AVHRR) and up to 100+ times in areas of optimal satellite overlap (areas covered by both GOES EAST and GOES WEST). However, for smoke detection purposes this number is reduced since smoke is only detected in visible imagery (i.e., only during daylight hours). Utilizing the frequent image updates smoke emission duration will be incorporated into the HMS in late Spring or early Summer of 2006. This will be based on visual observation of smoke plume initiation and cessation by the analyst. A subjective determination of whether a given fire is a wildfire or agriculture/prescribed burn will be made based on location and behavior. A wildfire will be assumed to burn, emit and decay as in the current version of HYSPLIT (for at least 24 hours). However, for fires deemed to be agricultural/prescribed burns the emissions will be limited to the start/end times specified by the analyst. This is expected to improve the accuracy of both the total amount of emissions for a fire and their dispersion. The dispersion accuracy can be improved through a more accurate representation of the time of emission due to wind shifts and vertical temperature/wind profile changes during the course of the day as depicted by the NAM.

An internal study was performed to determine whether the start/end time of emissions could be determined automatically using the WF-ABBA detections used by the HMS. However, the results were not favorable. The study was conducted over 8 days in January and February 2006. Of the 95 smoke plumes that were detected in GOES imagery 46 did not have a corresponding WF-ABBA detection. For those that were detected by WF-ABBA the average emission duration utilizing WF-ABBA was 1.4 hours while the average duration using manual inspection was 3.1 hours. There are several factors that should be noted: most of these fires are assumed to have been agricultural/prescribed; most (55) of the fires were still emitting smoke at sunset, precluding an accurate emission termination; since the study period occurred in the cold season it is possible that the number of WF-ABBA fire detections would be greater in the warm season.

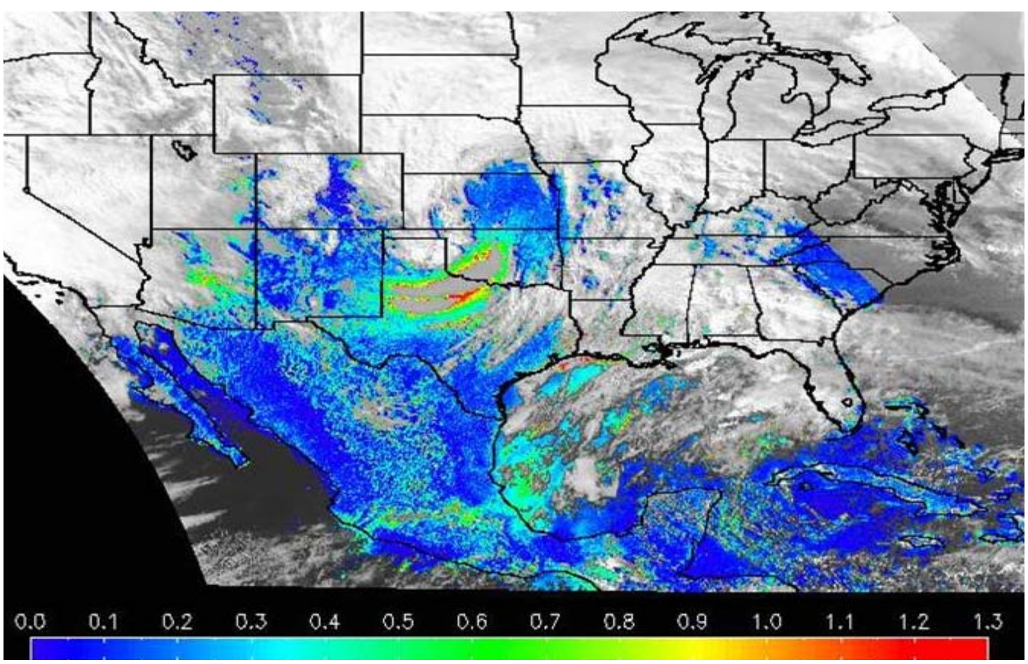
Smoke Concentration Estimates

The HMS was initially designed to only provide outlines of smoke extent. These outlines are manually drawn mainly using GOES visible band imagery. However, contours of a quantitative estimate of the smoke would be more useful to the air quality community. Toward that end estimates of smoke concentration will be included with the analysis beginning in late spring or early summer 2006.

The GOES Aerosol and Smoke Product (GASP), described by Knapp et al.,[10] and depicted in Figure 9, will be utilized as a tool by the analysts to draw the contours and can be viewed at www.ssd.noaa.gov/PS/FIRE/GASP/gasp.html. The output from GASP is Aerosol Optical Depth (AOD). Since the HMS analysis is for smoke, the GOES AOD, which is derived using a continental aerosol model, is scaled for a smoke aerosol model. The AODs are then converted to smoke concentrations assuming a mass extinction coefficient of 7.9 +/- 4.5 m2/g with the smoke confined to the lowest 5 km. The conversion from an AOD to a smoke concentration will easily facilitate validation with the output from HYSPLIT, which is smoke concentration.

The GASP AOD has 2 desirable properties for use with the HMS – it is derived routinely (every half hour over sunlit portions of the GOES domain) and provides an objective, quantitative estimate of smoke concentration. However, there are some deficiencies. As with other satellite based estimates of aerosol content using visible channels GASP performs better over darker surface backgrounds (ocean and moist continental areas) as opposed to over semi-arid regions (such as portions of the western and central US). While GASP employs GOES visible band imagery it only uses 4 km resolution compared to the 1 km imagery used in the HMS. Thus some of the smaller smoke plumes are either not depicted or may have smoke concentration values that are diminished due to averaging with adjoining non-smoke pixels. There is also no distinction made between smoke, dust or other aerosols. It will remain the responsibility of the analyst to segregate the smoke from other types of aerosol. However, it is expected that inclusion of GASP in the HMS will allow for an improved and more useful smoke product.

Figure 9. GASP image depicting aerosol optical depth for late afternoon 1 January 2006. The high values seen across north Texas and western Oklahoma are a combination of smoke and blowing dust.



Smoke Text Product

A smoke text product was initiated in July 2005. The product provides a brief text description of the areal extent, subjective determination of smoke density and direction of movement for fire generated smoke plumes detected in satellite imagery. This was an attempt to provide some information on the amount of smoke being generated by different fires in the absence of smoke concentration or optical depths with the graphic product. This also provided a mechanism to identify long lived smoke events that travel far from their source regions. Some of the initiative for providing a text product was the result of inquiries received by the SAB about the composition and origin of large areas of smoke seen in satellite imagery over different parts of the US. In addition to areas of smoke, blowing dust episodes are also discussed in the text message. The message is available on the internet at http://www.ssd.noaa.gov/PS/FIRE/smoke.html and is updated twice per day – usually around 1700 UTC and again at about 0200 UTC.

Future Plans

Single channel visible imagery used for smoke depiction has its limits. One of the deficiencies is the inability to readily distinguish between different types of aerosols (smoke, blowing dust, sulfates, etc). It becomes increasingly difficult to distinguish smoke from other constituents for long lived smoke events that are carried far from their source region. Another drawback is the challenge posed when clouds are present. Using visible band imagery it can difficult to impossible to identify smoke. The recent availability of the Ozone Monitoring Instrument (OMI) on NASA's Aura spacecraft will help address these deficiencies by utilizing its hyperspectral imaging capability in the visible and ultraviolet wavelengths and applying specialized retrieval techniques. Additionally, OMI can provide better measurements over bright land surfaces than can GASP. Aerosol products from OMI are expected to be incorporated into the HMS for evaluation later in 2006.

A validation of the HMS fire product has not been performed to date. We are planning to perform at least a preliminary validation during summer 2006. Validation of the smoke products, analyzed and forecast, is just beginning and work will continue in conjunction with the NWS as part of their larger air quality forecast initiative.

A longer term goal is to achieve more robust, automated data fusion. Currently, the various satellite sources are incorporated into the HMS to be viewed by the analyst in a common projection for ease of manual comparison. However, better utilization can be achieved by automating a process to use all of the data sources in combination with the quality controlled fire locations to obtain improved estimates of fire and smoke emission duration and attach confidence levels to all analyzed fires (only automatically derived MODIS points currently have assigned confidence factors).

CONCLUSIONS

The HMS has evolved since it's inception in 2001. It's most recent and planned enhancements are focused on improving the detection, depiction and forecasting of the smoke generated from wildfires, and agricultural/prescribed burns. One of the advantages of the system is that the detection and specification of smoke areas and smoke producing fires is performed in near real-time using constantly updating environmental satellite data and covers all of North America.

Recent changes include the use of the more sophisticated Blue Skies emission rate estimates as opposed to a uniform emission rate that was previously used. A quantitative specification of smoke concentration will soon be provided with the analysis based on the objective, automated, hourly GASP product. A smoke emission duration will also be included as input to the HYSPLIT model. These changes are expected to result in a better initial depiction of the smoke state and subsequent forecast to be used as a tool for air quality managers. Validation work will be conducted with the results used to feed back into the system and make future improvements.

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KEYWORDS

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