A case-study using aircraft measurements and NOAA Hysplit trajectory analyses to identify unknown emission sources in Northeast Texas and Louisiana

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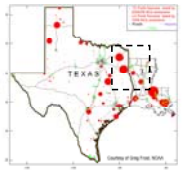
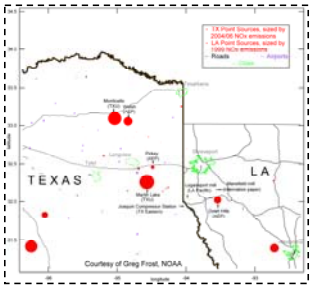
2005 2006 The Texas Air Quality Study II

Abstract

During the 2005 and 2006 monitoring seasons, plumes from unknown emission sources in northeast Texas region were sampled by the Baylor University Piper Aztec aircraft. Some unexpected sources (e.g., forest fires) were identified. However, the most prominent ones, detected in both years on five different occasions, were plumes on the transit leg from Waco, Texas to the Texas-Louisiana border (North of the Toledo Bend Reservoir) and plumes on the flight path along the Texas-Louisiana border. The unidentified plumes on the transit leg were detected on September 2nd, 4th and 5th, 2005. They appeared to be advected from the Mansfield, Louisiana surrounding area. A monitoring mission was dedicated to investigate this matter with one science flight flown from Waco to the Dolet Hills electric generating unit (EGU) near Mansfield, on September 8, 2005. NOAA Hysplit trajectory analyses suggest that the unidentified plume may have been emitted by the Mansfield paper mill on at least this occasion. Additional analyses of these plumes from unidentified point sources will be presented as well as analyses of two 2006 episodes.



Overview of science flights to northeast Texas during 2005 and 2006 that encountered plumes from unidentified sources



Photograph of Mansfield paper mill located 12 miles northeast of Mansfield, LA and 29 miles from TX-LA border

Photograph of Dolet Hills EGU located 8 miles east of Mansfield, LA and 28 miles from TX-LA border

Table 1. Table of dates when aircraft detected plumes from unidentified/unexpected sources.

Year	Date	Type of source/plume	Wind Direction	Location of the unidentified plume/source
2005	August 24	Forest fire 1 Forest fire 2	Variable	Northeast of Martin Lake EGU Northwest of Pirkey EGU
2005	September 2	Forest fire Undetermined	East	North of Longview, Texas Southeast of Longview on the transit leg (Waco to TX-LA border)
2005	September 4	Undetermined	Northeast	South of Carthage, Texas, on the transit leg (Waco to TX-LA border)
2005	September 5	Undetermined	North	West of the Logansport mill and Dolet Hills EGU on the TX-LA border
2005	September 8	Undetermined Mansfield mill	Northeast	South of Carthage, Texas, on the transit leg (Waco to Dolet-Hills) Southeast of Logansport mill(Waco-Dolet Hills)
2006	August 17	Undetermined Undetermined	North	South of Longview, Texas, on the transit leg (Waco to TX-LA border) Southwest of the Logansport mill on the TX-LA border
2006	August 18	Undetermined	South	Southwest of the Logansport mill on the TX-LA border
2006	September 8	Undetermined	South	West of the Logansport mill and Dolet Hills EGU
2006	September 14	Undetermined Undetermined	East	Southwest of the Logansport mill Northwest of the Mansfield mill

September 8, 2005 Case study

On September 8, 2005, Baylor University's Piper Aztec aircraft flew to Louisiana to investigate the Dolet Hills EGU plume and its impact on Northeast Texas. The instrument platform included O_3, SO_2, NO, NO_2,NOy, CO and alkenes. In addition, a 3-wavelength nephelometer was used to measure total particle scattering. Meteorological parameters (air temperature, relative humidity, and wind speed and direction) were also measured.

The synoptic wind flow was from the northwest and wind velocities were approximately 5 meters per second. The flight path of the aircraft is shown on Figure 1-map i with color-coded mixing ratios of SO_2. Maps ii and iv display a section of the transit flight leg from Waco to Dolet Hills. The color grey on the flight path indicates there was an instrument autozero or a standard of additions calibration. The color-coded scales (upper right corners of i., ii., and iv.) were scaled from 0 to 3 ppbv to emphasize SO_2 plumes on the aircraft flight path. Data points equal to or greater than 3 ppbv are displayed as solid red along the flight path. The Dolet Hills plume was advected to the southwest into northeast Texas (map i). Just as with the Sept. 2nd , 4th and 5th 2005 dates, the aircraft flew through a plume from an unidentified source on the transit leg from Waco to TX-LA border. That plume is indicated with a black oval circle labeled "A". A second plume was also detected and is labeled "B".

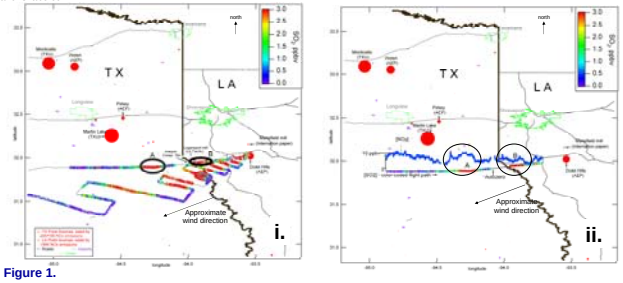


Figure 1.

The map i on the top left illustrates the flight path of the aircraft with color-coded SO_2 mixing ratios. Data points that tend toward red (i.e., downwind of Dolet Hills and areas labeled A and B) are indicative of a plume. In addition, the two unidentified plumes that were detected during the transit leg are depicted by black oval circles on map i. The red solid circles are point sources sized by NOx emissions in tons per day. The Shreveport urban area, Mansfield mill, Logansport mill, and the Joaquin compressor station are also labeled as point sources on map i. The map on the right (ii.) shows one section only of the transit flight leg (Waco to Dolet Hills) and the unidentified plumes labeled as "A" and "B." The blue line trace has been scaled between 0 to 20 ppbv above the flight path as a 3D visualization of the mixing ratio of NOy to show the structure of both plumes (A and B) and a broader plume to the left of A.

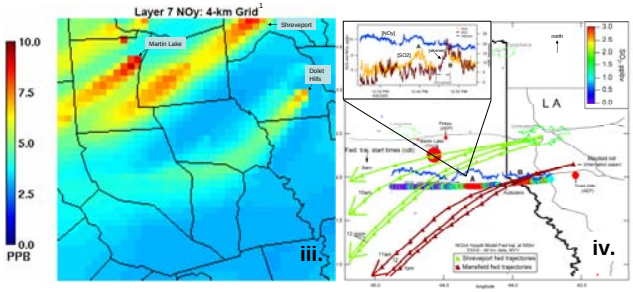


Figure 2.

Two maps are shown (i.e., CAMx model layer 7-iii and Hysplit model trajectories-iv) of models used for two very different applications. The map on the left (iii) is a layer (7) of a CAMx model run with a 4-km nested grid centered over the Tyler-Longview-Marshall area at 581 meters approximately, the altitude the aircraft collected the data. The map shows several plumes (Martin Lake EGU, Dolet Hills EGU and Shreveport, LA urban plume) advected toward the southwest. Map iv on the right shows the SO_2 color-coded flight path and the 3D visualization of the NOy mixing ratio above it. On the upper-left corner, an inset of a SO_2 NOy, and reactive alkenes time-series plot was included to better illustrate plumes A and B. The green and maroon lines that begin in Shreveport, LA and the Mansfield mill, respectively, are forward Hysplit trajectories that begin at the labeled CDT times near the arrows. Since the aircraft detected the plumes between 12:30 and 1:00 pm CDT, trajectories were run between 8 am and 12 pm for Shreveport and 11 am to 1 pm for the Mansfield mill. The forward trajectories (maroon lines) starting at the Mansfield mill pass through plume B, suggesting the emissions are from the Mansfield mill. Conversely, the Shreveport trajectories (green lines) miss plume A. This is within the expected 40 kilometer resolution of the EDAS data used to run the trajectory. The inset graph in map iv reveals a reactive alkene plume merging with the Dolet Hills plume as it is advected to the southwest.

1. Kemball-Cook S., Johnson J., and Yarwood G, 2006. "Modeling Northeast Texas Ozone for Summer 2005". Prepared for East Texas Council of Governments, Kilgore, TX.

Other unexpected/unidentified plumes

There were other instances where the Piper Aztec flew through plumes as in the September 8th case study that merit more study to identify the source(s) of the measured pollutants measured. Figures 3 and 4 below present a general overview of other plumes that were sampled by the Baylor aircraft in 2005 and 2006, respectively.

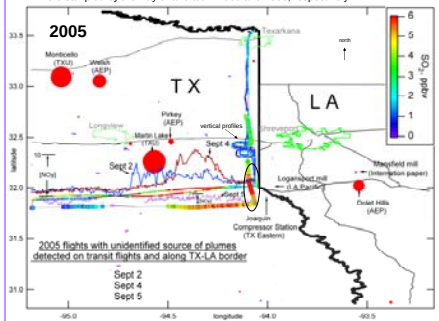
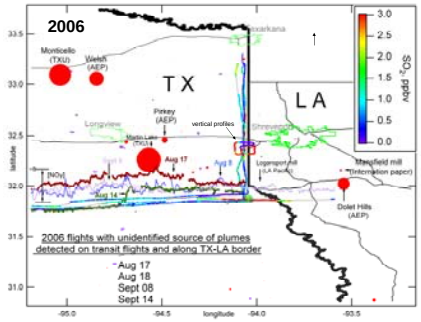


Figure 3.

The map on the left illustrates plumes detected during flights performed in 2005. These unexpected plumes were detected on both the transit leg (east-west) and the flight paths parallel to the TX-LA border (north-south). The line graph traces above the transit legs represent a 3D-visualization of NOy mixing ratios. This effect was not performed due to graph orientation on the north-south leg; therefore, NOy plumes are not illustrated on these legs. For the approximate wind direction refer to Table 1. The color-coded flight paths depict mixing ratios of SO_2 from 0 to 6 ppbv. SO_2 mixing ratios of 6 or greater will show as solid red. The oval black circle indicates a plume west of the Logansport mill. On all three flights, a broad NOy plumes with corresponding SO_2 concentrations were measured on the east-west transit leg (east-west) and an SO_2 plume was measured west of the Logansport mill on the north-south leg.

Figure 4.

The map on the right illustrates additional flights flown in 2006 that detected unexpected plumes on both the transit leg and the flight legs parallel to the TX-LA border. The different color line traces above the flight path represent mixing ratios of NOy on different days and to display a 3D-visualization effect. This effect was not performed on the north-south legs due to graph orientation. The flight path lines depict traces of SO_2 from 0 to 3 ppbv. Mixing ratios of three or greater will show as solid red. Not shown on this graph are NOx plumes on the north-south leg west of the Logansport mill on Aug 17 and Sept 8. In addition, on September 14, an alkene plume was transected south of Panola where the aircraft routinely conducted vertical profiles.



Summary

The analyses conducted on September 8, 2005 seggest that Hysplit trajectories performed within the 40 km resolution limits. Plume B is believed to have been emitted by the Mansfield mill in Louisiana and is supported by the alkene emissions detected. The reactive plume also merged with the Dolet Hills plume. Plume A forward trajectories were inconclusive. The CAMx model presented suggests that it is the Shreveport urban plume advected into the northeast Texas region. Pollutant ratios such as [SO2]/[NOy] and [CO]/[NOx] can help classify the source types (i.e., coal-fired power plants, paper mills, and urban plumes) However, a positive identification of the source can only be done by conducting a science flight that can trace the plumes directly to or from the source.

Acknowledgments

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