

FINAL REPORT

The Southeast Texas Transport Study

Prepared for the Houston Advanced Research Center

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EXECUTIVE SUMMARY

This project had two objectives. The first was to develop and demonstrate new communication technology and software that would allow aircraft to repeatedly sample air that had been tagged by balloons whose altitude and location could be controlled and monitored by scientists on the ground. The second objective was to demonstrate the practicality of this new technology by releasing these balloons within plumes of pollution coming from the greater Houston area and deploying an instrumented aircraft to measure pollution within the plumes tagged by the balloons.

Three missions, each consisting of an instrumented aircraft that followed balloons launched from just north of Houston, were made between July 21 and 31. The Houston plume was tracked and sampled into north Texas on each mission. Because thunderstorm activity during the first week of the campaign precluded daytime launches, our demonstration study focused on nighttime transport and chemistry of the Houston plume. The aircraft that tracked the balloons made in situ observations of O₃, CO, NO_y, NO, SO₂, volatile organic compounds (VOCs) and aerosol size. Because the balloons were originally launched in the Houston plume, the aircraft measurements in the vicinity of the balloons were clearly associated with Houston emissions. The balloons released on July 23 (Saturday evening) showed the Houston plume to drift just east of Dallas-Ft. Worth before sunrise, with maximum ozone levels aloft of ~80 ppbv. To put this number in perspective, we note that background ozone concentrations are typically of order 40 ppbv. The two balloons released on this night moved along paths that were practically indistinguishable after ~9 hours of flight, implying that the balloons trace a unique trajectory in the nocturnal atmosphere. The two balloons released on July 26 (Tuesday evening) showed the Houston plume to drift northwest of Shreveport, Louisiana, before sunrise, with ozone levels of 70 to 80 ppbv. Again, these numbers represent typical high values made during cross-wind transects of the plume that had been followed by the balloons from the Houston area. Both the balloons released on this mission described paths that were within 5-10 miles of each other after ~10 hours of flight, again implying that the balloons trace a unique trajectory in the atmosphere.

These and other results presented in this report should be considered preliminary because final data checks of quality assurance have not yet been carried out, nor has any analysis beyond the presentation of the observations within this report been done yet. However, although the numbers may change slightly as a result of quality assurance checks, this project has demonstrated that balloons carrying modern communication equipment can be used to unambiguously track emissions and pollutants from major source areas and used to guide aircraft to sample within these plumes. In addition, a number of preliminary conclusions, or “working hypothesis,” can be drawn from these preliminary observations:

It appears that emissions from Houston are high enough and the transport at night fast enough that it is reasonable to consider that these emissions can affect air quality in the Dallas-Ft. Worth area. This hypothesis is based on our (preliminary) results showing ozone levels to be well above background levels at distances downwind from Houston that are comparable to the distance between Houston and Dallas-Ft. Worth. It also seems reasonable to conclude that if high levels of pollutants from Houston can be transported at night to the Dallas-Ft. Worth area then similar exchange processes are occurring not only throughout Texas, but also between Texas and the neighboring states. The ability to forecast such events will be limited until the

confidence in forecast trajectories over these time and distant scales is better understood; a comparison of the observed balloon paths with forecast HySplit trajectories (using the Eta Data Assimilation System) suggest a large element of uncertainty still remains in this fundamental capability. Testing these hypotheses and establishing the confidence limits for trajectories will require additional studies using meso-scale meteorological and chemical modeling systems that can be verified against a wider range of conditions than those encountered during the 2005 field campaign.

We also found evidence of a nocturnal jet forming in areas far removed from the wind profilers that are commonly used to detect jets. The existence of these fast moving layers of air would accelerate the transport of material from one urban area to another. But because meso-scale meteorological models have difficulty simulating these features, it seems reasonable to ask if their role in transport is not yet properly accounted for in studies using these models. Assessing the hypothesis that the role of low-level jets in the transport of pollutants is underestimated can probably best be answered by comparing the results of meteorological forecast and analysis models with our observations. In this context, we bring to the readers attention work underway at Texas A&M University to compare output from MM5 with the observations described in this report.

The work described here sets the stage for future projects that will analyze the nighttime chemistry and transport of pollutants and evaluate their impact on surface concentrations on other areas in east Texas. While this report focused on transport issues using only the preliminary observations contained herein, future analysis should elucidate the role of nighttime chemistry, and, in particular, the role of heterogeneous and VOC chemistry within these plumes. Such studies should compare the airborne observations presented in this report with monitors in the sampling area. We also propose that a more extensive set of balloon/aircraft missions be carried out in future field studies to assess transport not only from Houston, but from other suspected source regions that affect air quality in Dallas-Ft. Worth and surrounding areas. A second campaign of longer duration would provide daytime observations when the atmospheric boundary layer is more active and photochemical processes dominate changes to the emissions.