Monthly Technical Report

PROJECT TITLE	Development and Evaluation of an Interactive Sub-Grid Cloud Framework for the CAMx Photochemical Model	**PROJECT #**	14-025
PROJECT PARTICIPANTS	Ramboll Environ Texas A&M University (TAMU)	**DATE SUBMITTED**	7/8/15
REPORTING PERIOD	**From:** 6/1/2015 **To:** 6/30/2015	**REPORT #**	13

A Financial Status Report (FSR) and Invoice will be submitted separately from each of the Project Participants reflecting charges for this Reporting Period. I understand that the FSR and Invoice are due to the AQRP by the 15^{th} of the month following the reporting period shown above.

Detailed Accomplishments by Task

This project was initiated on May 21, 2014. The University of Texas granted a one-month no-cost extension to July 31, 2015. This report documents progress during the month of June 2015.

<u>Task 1: Preparation and Software Design</u>

This task was completed in August.

<u>Tasks 2 and 3: Implementation of a Sub-Grid Convective Model in CAMx</u>

These tasks were completed in October.

<u>Task 4: Model Evaluation</u>

In June, Ramboll Environ and TAMU graphically evaluated results from WRF and CAMx modeling of two periods:

1. May 6, 2008 during START08 using WRF v3.6.1 (with the Alapaty-modified Kain-Fritsch [KF] cumulus scheme) and CAMx with and without the new convection model;
2. September 4, 2013 during DISCOVER-AQ using WRF v3.7 (with multi-scale KF [MSKF] cumulus scheme) and CAMx with and without the new convection model.

Results are summarized below.

Task 5: Reporting

Ramboll Environ and TAMU developed a draft project final report and delivered to the University of Texas on May 18. During June, the team continued to augment the draft report with new modeling results and analyses.

Ramboll Environ prepared for and attended the AQRP Workshop at UT during June 17-18.

Preliminary Analysis

The team evaluated CAMx results for September 4, 2013, which was a day of local convective activity along the Gulf Coast and extending into west Texas. Comparisons to satellite and measured precipitation patterns indicated that WRF-simulated convective activity with MSKF was well characterized on this day. Figure 1 shows flight paths for 8 aircraft spirals on this day. Figure 2 shows profiles of simulated ozone, total NOy (NOx plus oxidized forms) and CO paired with measured data for each spiral, as well as the average among all spirals.

Ozone tended to be over predicted along the coastline (Galveston), while slightly under predicted inland. Convection only marginally impacted boundary layer ozone, but resulted in larger effects aloft that tended to smooth the ozone toward a more uniform profile. Unfortunately these effects occur well above the aircraft profiles so verification was not possible aloft. Both NOy and CO tended to be over predicted in the boundary layer in the non-convective case, but convection improved the agreement with observed profiles by mixing these precursors aloft. Agreement for NOy with convection was particularly good in most cases.

The team also evaluated CAMx results for May 6, 2008, when convective activity moved through northern Texas and Oklahoma. Comparisons to measured precipitation patterns indicated that WRF-simulated convective activity with the Alapaty-modified KF was adequately characterized on this day. Figure 3 shows flight paths with two descent/ascent segments on this day. Figure 4 shows profiles of simulated ozone, total NOy and CO paired with measured data for each descent or ascent, as well as the average among all profiles.

The ozone profile throughout the troposphere was much better simulated in the START08 case than in the DISCOVER-AQ case. CAMx convection made imperceptible impacts on ozone and CO, possibly because of the misplacement and improper intensity/coverage of WRF convection. However, like DISCOVER-AQ, the NOy and CO profiles for START08 tended to be over predicted. Convection had more of an impact on NOy, which tended to improve NOy over predictions throughout the profile. It is apparent from these results that convection on previous days had impacted the vertical distribution and regional transport of aged, less-reactive NOy components (PAN, HNO_3, etc.) as opposed having much of an impact on directly emitted NOx or CO. The fact that these accents and descents occurred in mostly rural areas with little fresh precursor emissions supports this hypothesis of larger impacts to secondary products on a regional basis and little impact to ozone or CO profiles that are dominated by North American background contributions (i.e., via boundary conditions).

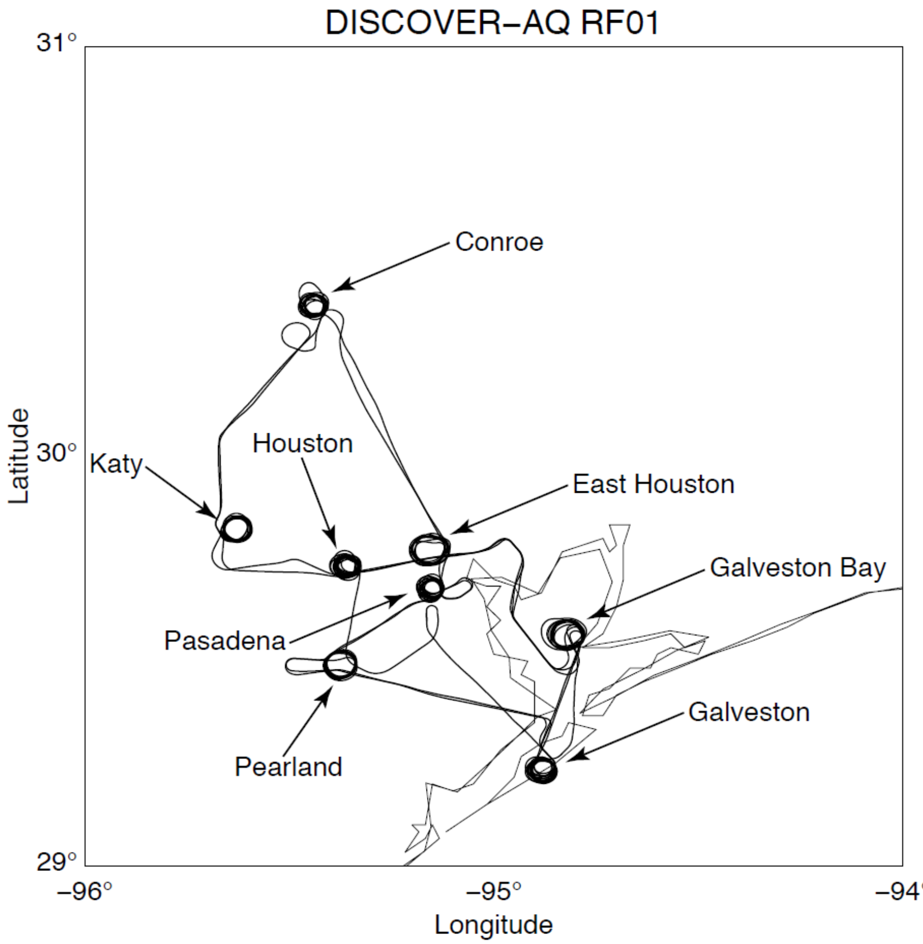

Figure 1. Aircraft flight path on September 4, 2013 indicating location of 8 vertical spirals from which measured profiles were derived.

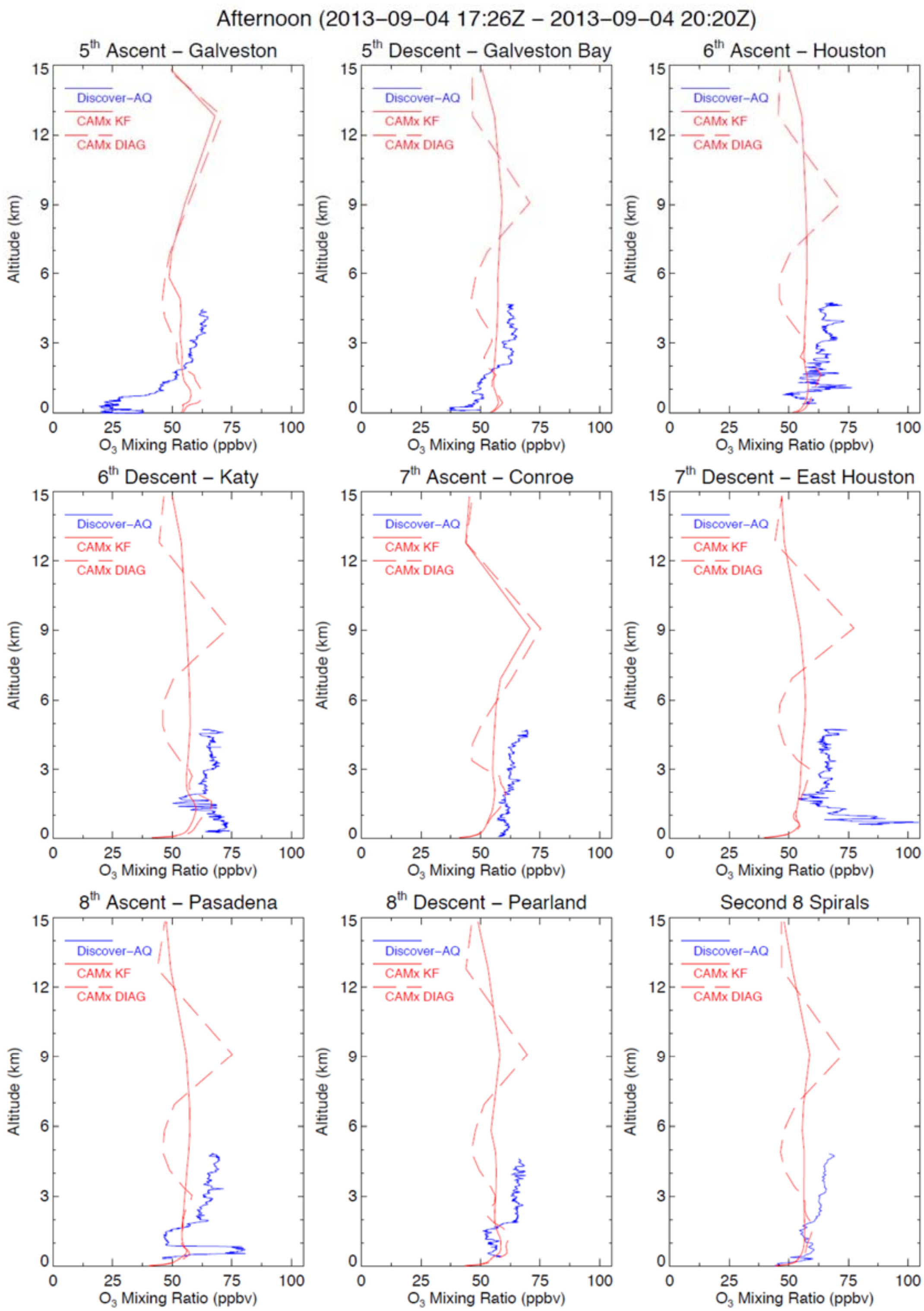

Figure 2a. Aircraft-measured (blue) and CAMx-simulated profiles of ozone with convection (solid red) and without convection (dashed red) on the afternoon of September 4, 2013.

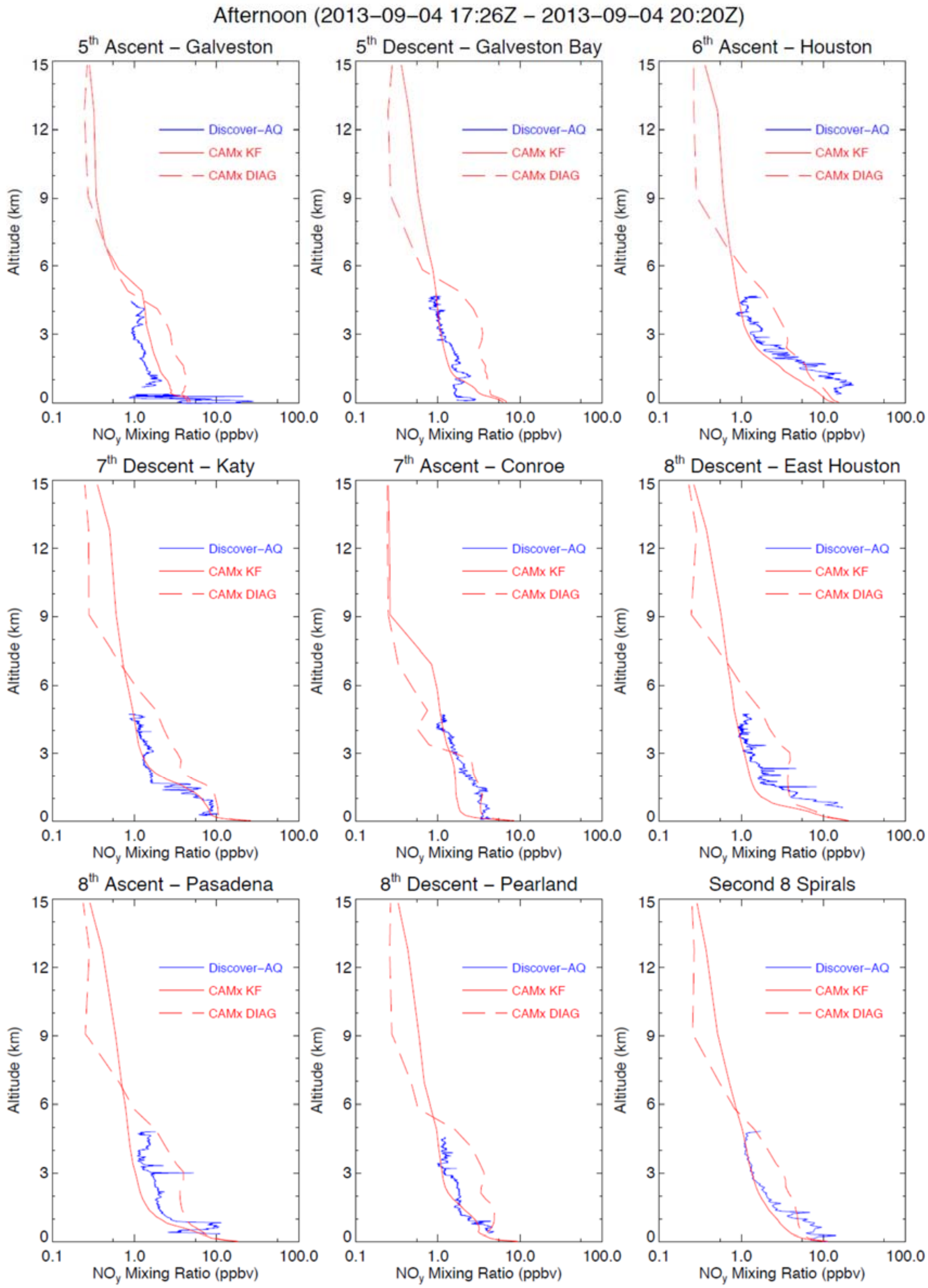

Figure 2b. As in Figure 2a, but for NOy.

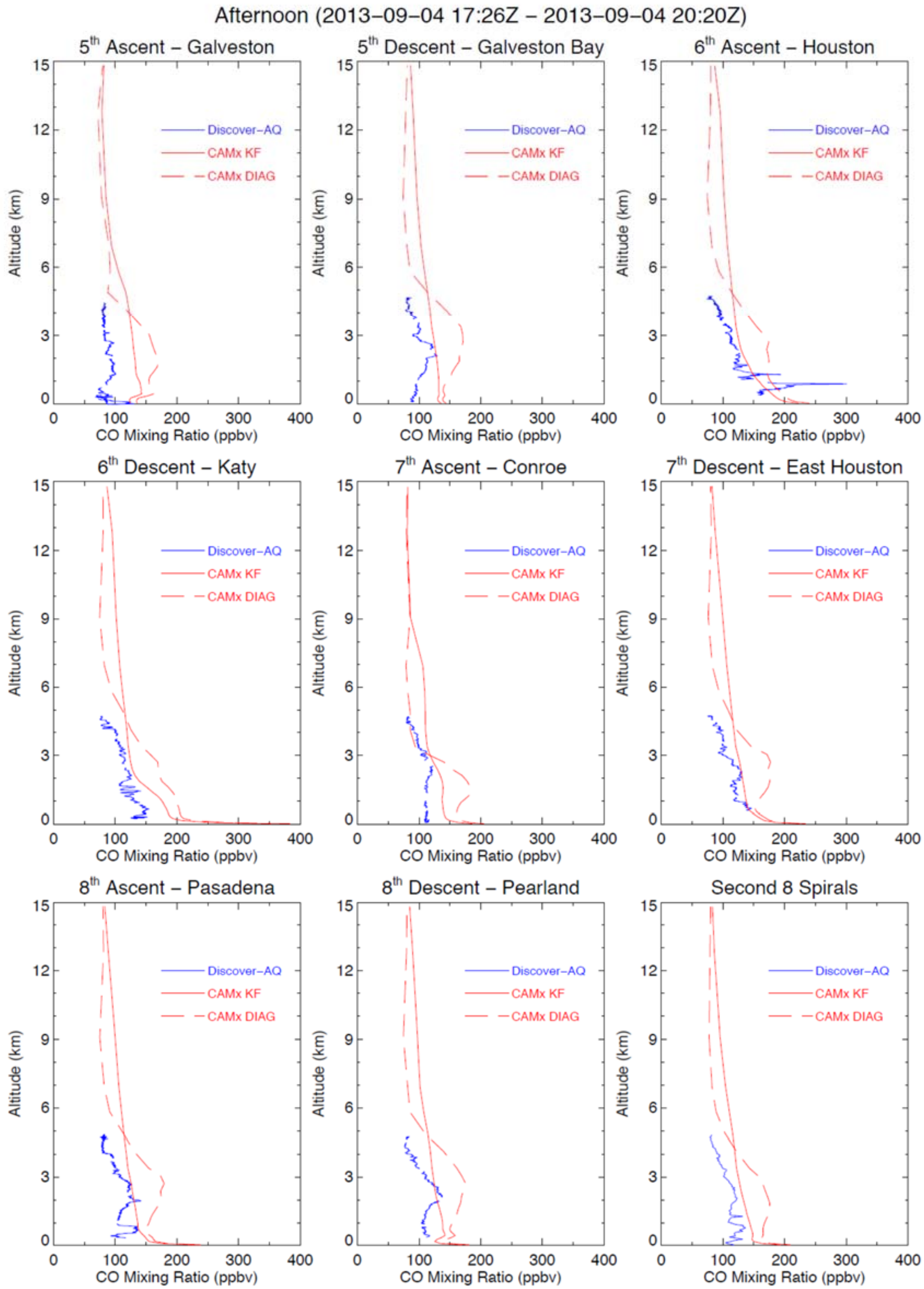

Figure 2c. As in Figure 2a, but for CO.

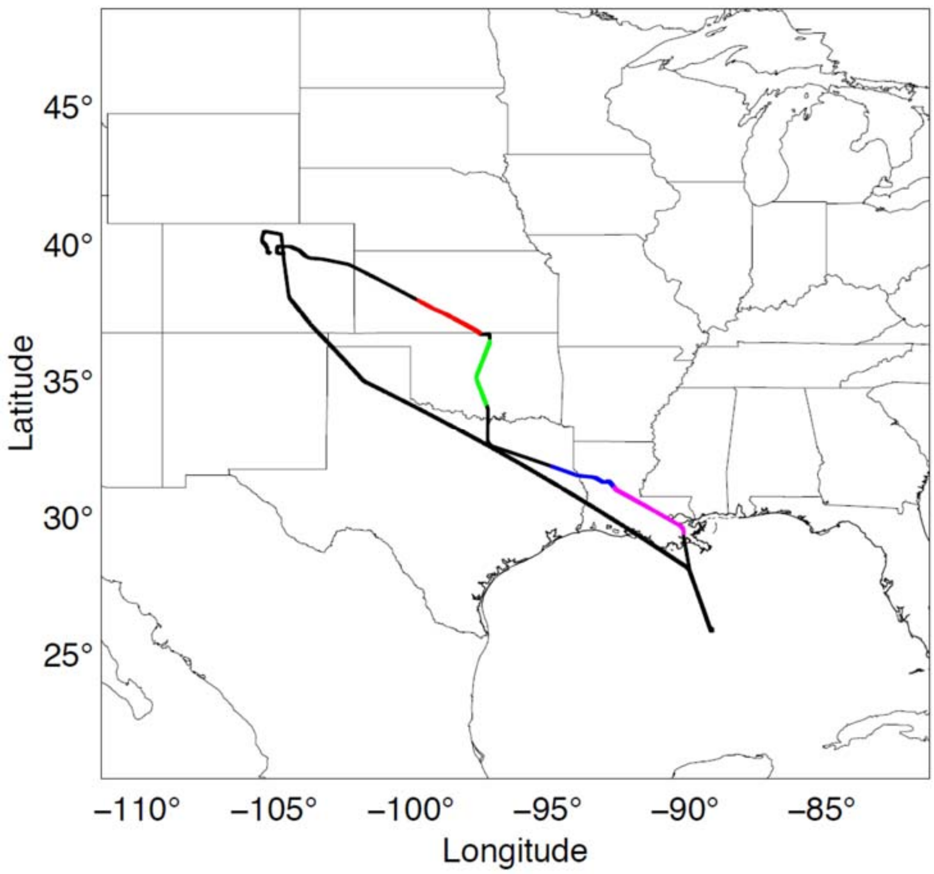

Figure 3. Aircraft flight path on May 6, 2008 indicating location of 4 descent or ascent segments (colored) from which measured profiles were derived.

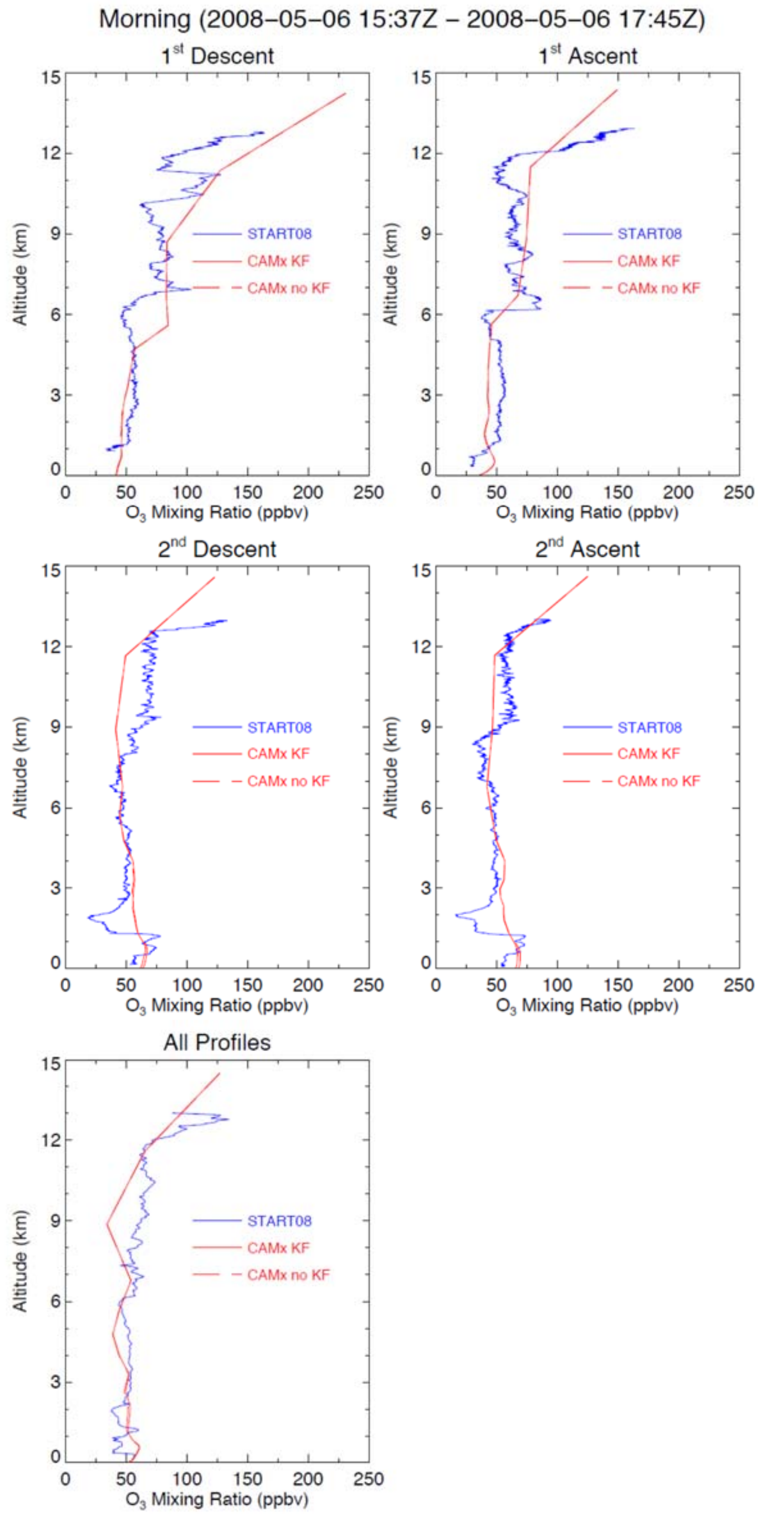

Figure 4a. Aircraft-measured (blue) and CAMx-simulated profiles of ozone with convection (solid red) and without convection (dashed red) on the morning of May 6, 2008.

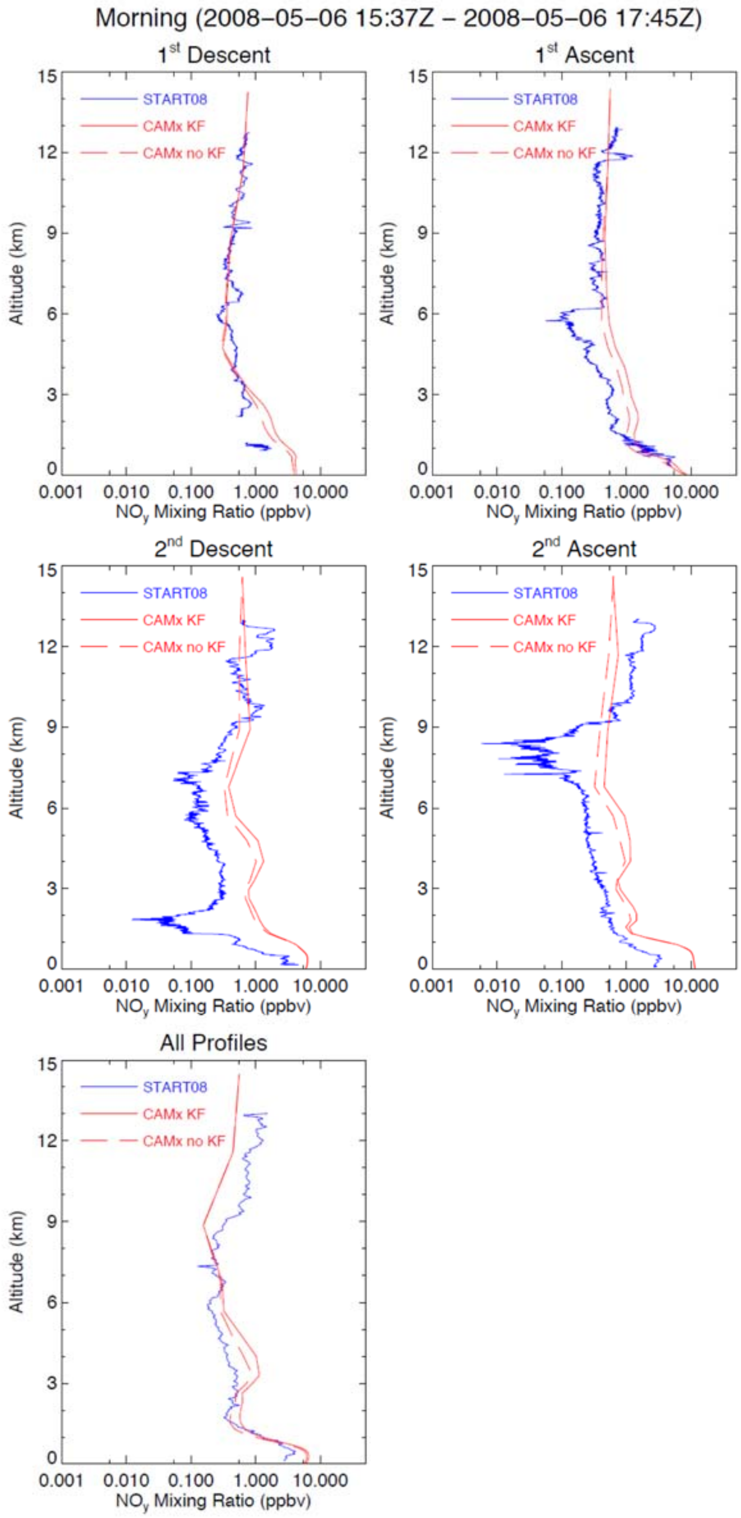

Figure 4b. As in Figure 4a, but for NOy.

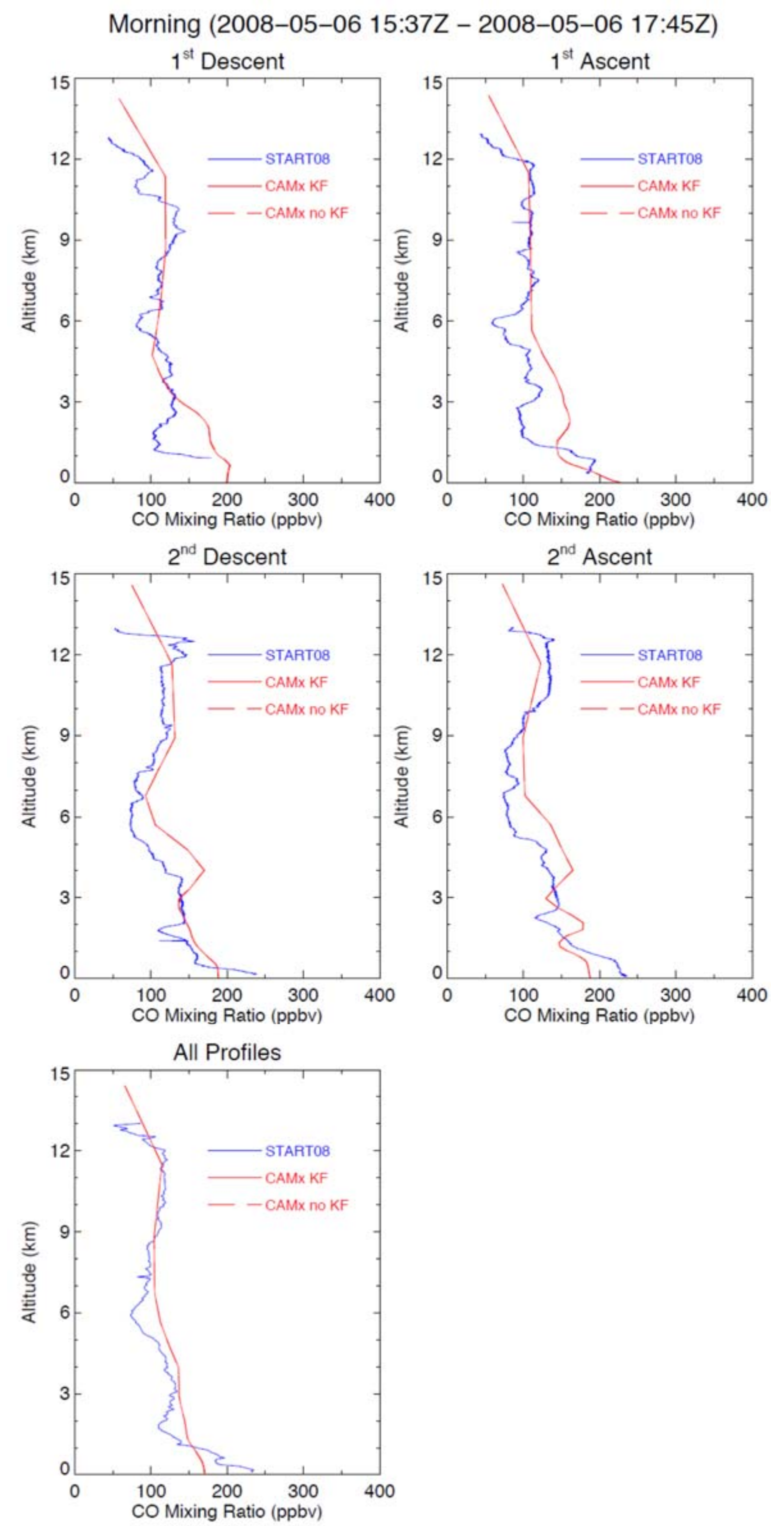

Figure 4c. As in Figure 4a, but for CO.

We have confirmed that the convective mixing parameterization produces substantial changes in constituent mixing ratio in areas of model-simulated convection. The lack of difference at aircraft-sampled locations in May 2008 is a consequence of insufficient model-simulated convection rather than any deficiency in the convective mixing parameterization.

The focus of the project will now shift to examining the behavior of the convective mixing parameterization in locations of model-simulated convection during the two cases. The consequences of convective mixing on the horizontal and vertical distribution of key constituents will be documented.

Data Collected

No additional data were collected by the project team.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

None this period.

Goals and Anticipated Issues for the Succeeding Reporting Period

The team will complete evaluations of model results for the two test periods. A final report will be completed and submitted to UT by July 31.

Detailed Analysis of the Progress of the Task Order to Date

Progress on Task 1 (software design) was completed in August. Task 2 (implementation of a sub-grid convective model in CAMx) and Task 3 (implementation of chemistry and wet deposition) was completed in October. Task 4 (model evaluation) began in February as a result of delays related to our inability to solve technical issues with EPA's latest "multi-scale" version of the WRF Kain-Fritsch scheme. Tasks 4 and 5 are expected to be completed by July 31.

The project remains on budget. Project completion and delivery of the final AQRP-reviewed report is scheduled for July 31, 2015.

Submitted to AQRP by: _Chris Emery____

Principal Investigator: __Chris Emery____