HAIS Advanced Whole Air Sampler (AWAS)

Final Report
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Introduction

The Advanced Whole Air Sampler (AWAS) was built under contract as part of the HIAPER Airborne Instrument Solicitation (HAIS) activity. The instrument was designed to be able to collect ambient air samples from the Gulfstream V platform for subsequent analysis of trace gas and/or isotopic composition. This report describes the operation of the instrument during its final testing and use during the HEFT and START08 campaigns. Also included here is a CD that contains current LabView software that controls the operation of the AWAS, and example data files that are generated during flight. The detailed description of the instrument and its operation is included in a separate "Guide to Operation".

This report will discuss the use and performance of AWAS during the recent missions and its operating characteristics. Examples of trace gas data collected during the START08 mission will be presented to demonstrate that the instrument meets its design targets and is ready to be delivered for final acceptance by UCAR.

AWAS Mechanical/Electrical Performance

1) Reliability

The AWAS instrument flew successfully on all of the 18 Research and 2 Test Flight missions of START08. For most of the missions, a full set of AWAS canisters were collected (=60 / flight). Over 1000 samples were successfully collected over the course of the mission, with only one recorded failure (due to a loose wire connection on one of the sample valve solenoids). The pneumatic supply cylinder was filled prior to each intensive period (April-May, and June), though we were pleased to see that a single filling at the beginning of START would have lasted for more than 20 research flights. Overall the instrument proved to be very reliable and durable in both mechanical and electrical performance.

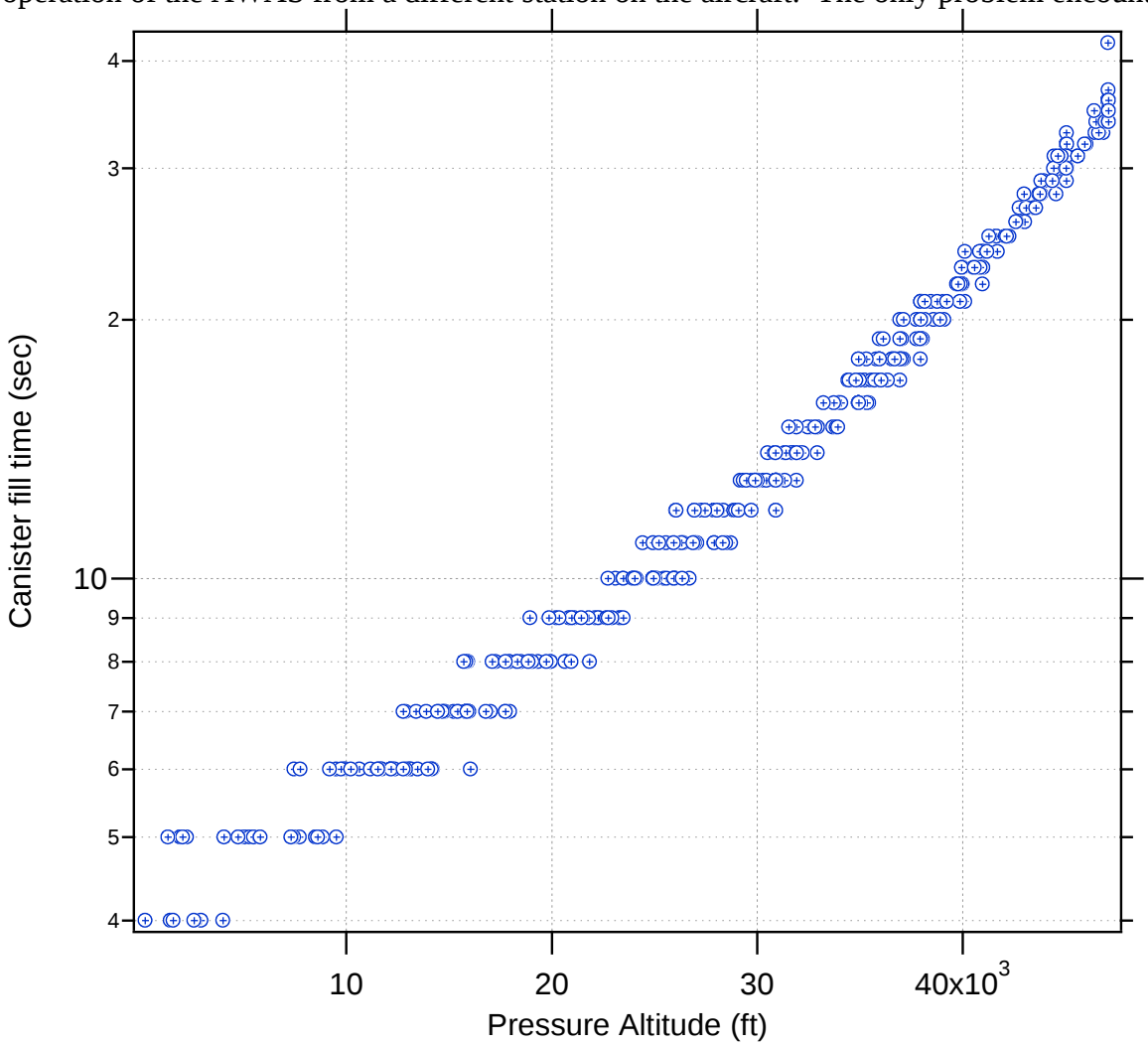
2) Sample integration time

The instrument design targeted a canister fill time (sample integration time) of about 25 seconds. With the inlet used during START and HEFT (1/4" stainless steel in HIMIL), we approached that target. At maximum altitudes, sample integration time was about 35 seconds to fill a sample canister to 50 psia. Shorter sample integration times were achieved at lower altitudes. A plot of the observed fill times versus pressure altitude is shown in Figure 1. If shorter sample integration times are desired, slightly larger tubing in the inlet and/or modifying the inlet to allow ram pressure (e.g. a simple forward-facing tube) should shorten the sampling integration time.

3) Remote control

As proposed, the instrument was able to be controlled from different computers connected to the aircraft network. For many of the flights, the PANTHER/UCATS instrument operator was able to control the sampling instructions for AWAS through the LabView control interface available on one of the data display laptop computers. This control included initiating "on – command" sampling as well as adjustment in sample collection interval to accommodate

changing flight plans and conditions. For other flights, the Mission Scientist controlled the operation of the AWAS from a different station on the aircraft. The only problem encountered



with the remote operation occurred when the aircraft network had problems in assigning the necessary IP address for our instrument.

FIGURE 1. AWAS canister fill time versus altitude observed during START08.

4) Servicing AWAS modules

The AWAS canister modules were relatively easy to install and remove from the aircraft, especially since the AWAS was located near the forward door. Though not necessary, it is much more convenient to have the AWAS mounted near one of the aircraft doors to facilitate loading and unloading of the sample modules. Time to remove sampled canisters with a new set of AWAS modules was about 1.5 hours for one person.

AWAS Trace Gas Sampling

The AWAS instrument is designed to collect trace gases for analysis of chemical and isotopic composition. The ultimate test of the instrument is in the quality of the data collected. At this stage, only chemical composition measurements have been made on the samples collected with the AWAS. The START08 mission covered a wide range of tropospheric and stratospheric conditions, and was thus a very stringent test of the AWAS. Below we present an example of some measurements from the first START08 research flight to illustrate the data obtained from the AWAS samples.

Figure 2. Sample collection along the flight track. The sample start/stop times are indicated by the blue bars.

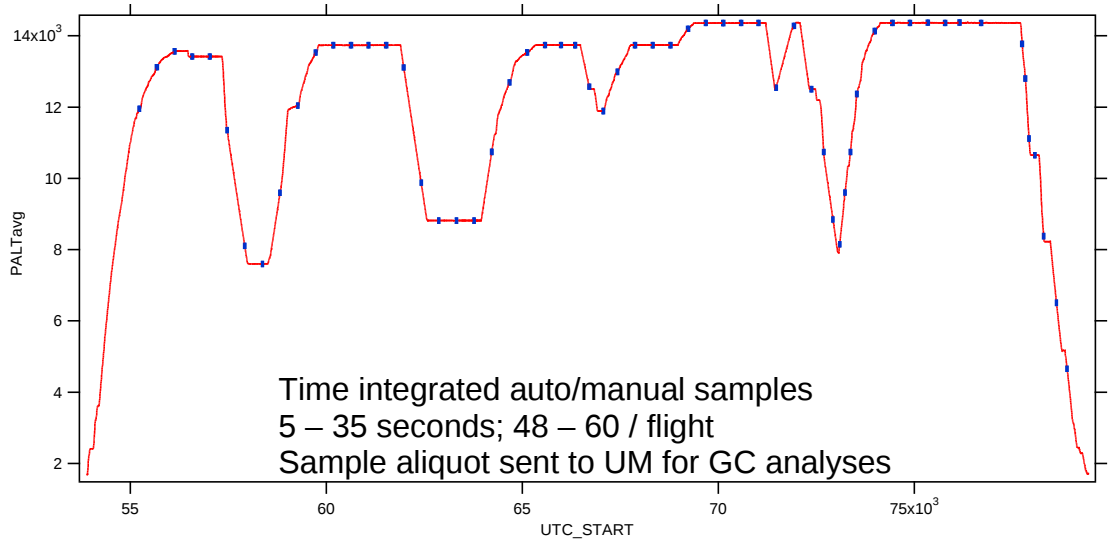


Figure 3. Time series of fast response CO and O3 (top). Time series of ethane and ethyne is able to capture much of the significant variability observed in the fast-time data.

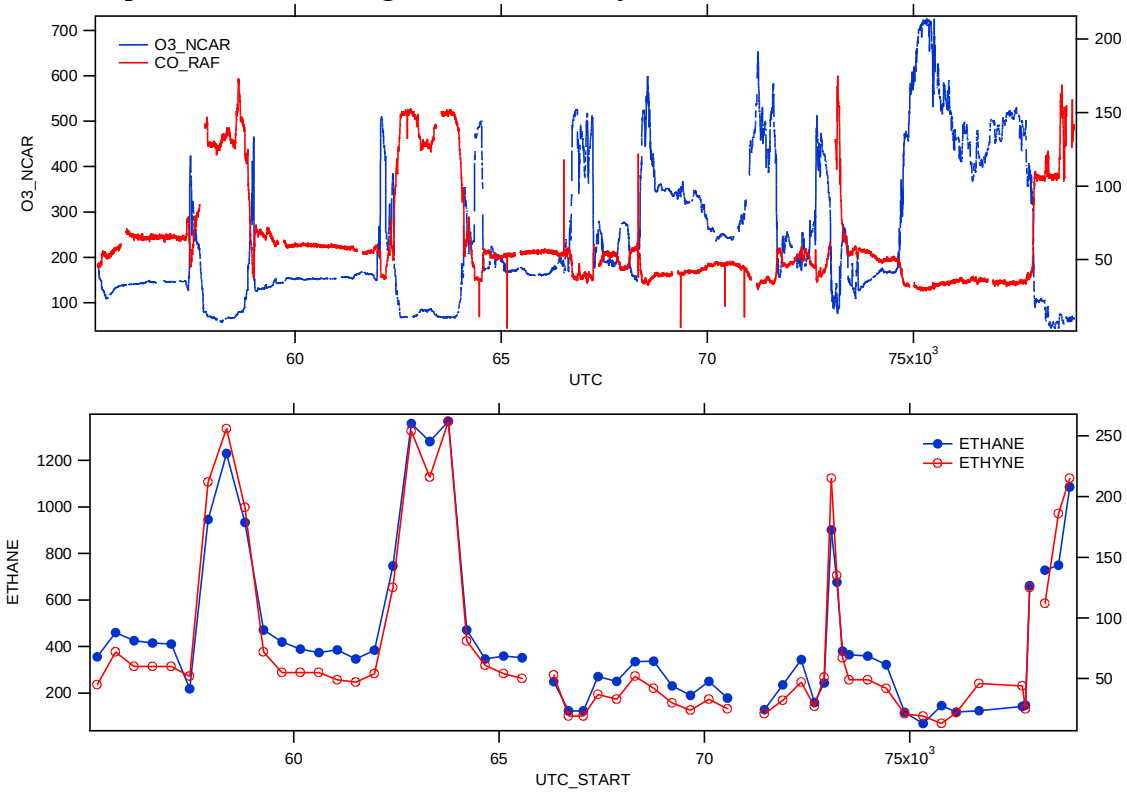


Figure 4.Time variation of selected halocarbons during RF01. Note the good reproducibility even at low mixing ratios.

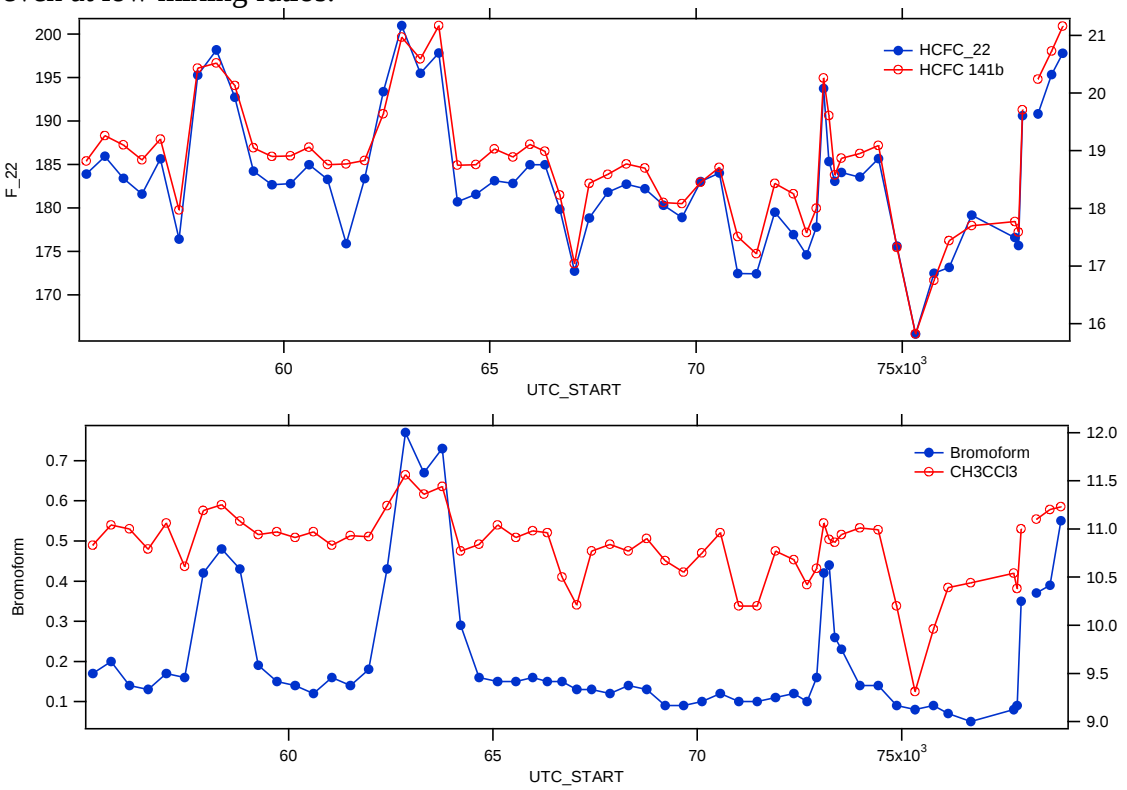
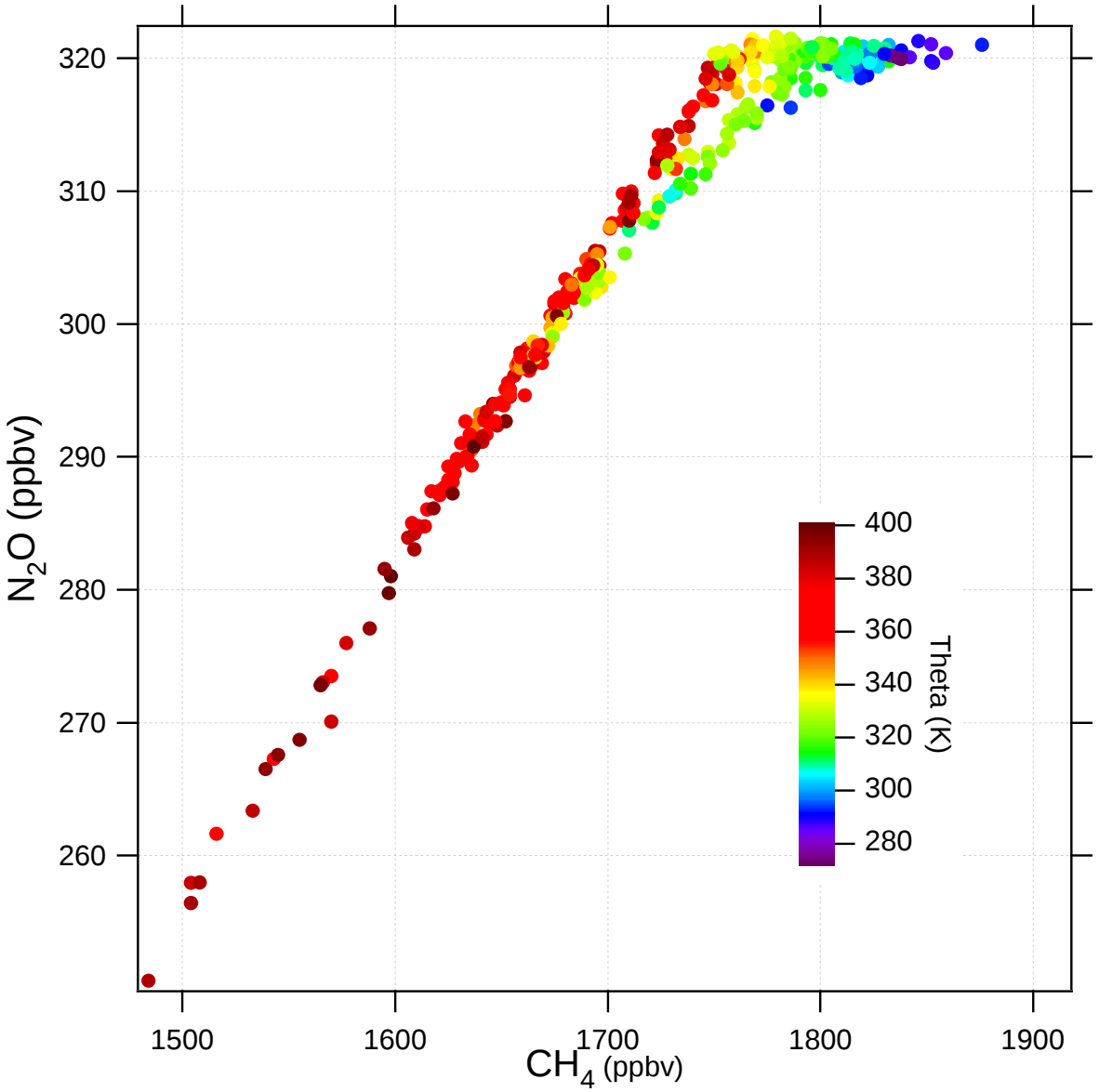


Figure 5. Correlation of methane and nitrous oxide observed during START, an example of high precision chemical data from AWAS.



COMMENTS

Excellent performance of the AWAS for chemical measurements was obtained during START. Each module was used five or six times during the mission, and there is no evidence of any carryover or other problem during the mission.

The problems we did observe were minor and seemed to be transitory. The problems we noted were:

1) Initial contamination. During the first use of the sampler, we noted increased levels of certain chemicals (e.g., n-propyl bromide, toluene, trichloroethylene). It is likely these came from the pump (n-propyl bromide was known to be used by

the pump manufacturer), but other sources such as the inlet and inlet tubing cannot be ruled out.

2) Sample adsorption. Certain compounds are known to be lost to the surface in very dry canisters. To alleviate this problem, we add 5 Torr water vapor to each of the evacuated canisters. Still, it appeared that some of the samples collected lost two of the gases most sensitive to this sort of loss (Carbonyl sulfide and carbon tetrachloride). There is no evidence of continued loss in any individual canister, so it is possible that an individual can did not get sufficient passivation during preparation. This should be monitored further as the sampler gets more use.
3) Stratospheric artifacts. The AWAS suffers some of the same artifact problems for selected trace gases when sampling stratospheric air, esp. high ozone conditions. The artifacts that were observed in START were associated with light alkenes (ethane, propene) and trichloroethylene. Occasional problems were also observed with ethyl chloride. All of these artifacts are in the pptv range of concentration.
4) Sample transfer. Because of the limited number of AWAS modules available, and the mission requirements, we needed to transfer sample air from the AWAS canisters to individual canisters (used in other airborne samplers) so the AWAS modules could be recycled for upcoming flights. This was accomplished (at considerable labor expense) for about 600 of the samples. Approximately 400 samples were analyzed directly from the AWAS modules. We were pleased that the transfer was accomplished with very little effect on the sample, but in some cases the extra transfer step did add measurable background noise, and there is an ever present danger of contamination (which did occur for several compounds during one set of transfers). This transfer procedure should be viewed as an emergency measure in future missions, and other options should be considered to avoid this step. Other measures could be construction of additional AWAS modules or more rapid cycling and analysis of the canisters (perhaps by moving the analytical facility near to the deployment site).

SUMMARY

The Advanced Whole Air Sampler is shown to be a fully functional and certified instrument for use on the GV aircraft. The instrument was proven in actual research flights to be reliable and provide air samples for trace gas measurement. The instrument operates as proposed. Based on the success of these tests, and the success of isotopic measurements with other whole air samplers constructed and used by the UM group, we also expect that isotopic composition measurements (as proposed) from the AWAS will also be reliable. We hope to test this facet of the AWAS instrument in upcoming missions.