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ACID-MODES II (1990): SUMMARY DATA REPORT NOAA KING AIR AIRCRAFT MEASUREMENTS OF SELECTED POLLUTION SPECIES

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ABSTRACT. During April and May 1990 in support of the second intensive of the Acid Model Operational-Diagnostic Evaluation Study (Acid-MODES), cloud water samples were taken and chemical, meteorological, and aerosol measurements were made using the NOAA King Air C-90. Battelle Northwest Laboratory's G-1 was also involved. This report lists the objectives of Acid-MODES II; the instrumentation used and the data obtained with the NOAA King Air; and the data processing, quality and availability of the data from the King Air.

1. INTRODUCTION

The Acid Model Operational-Diagnostic Evaluation Study (Acid-MODES) was initiated to obtain the needed observations for assessment and verification with real-time observations of both the Regional Acid Deposition Model (RADM) and the Acid Deposition and Oxidant Model (ADOM). Two intensives were planned: the first was in August and September 1988, and the second was in April and May 1990. NOAA Technical Memorandum ERL ARL-189 (Gunter and Boatman, 1991) is a summary data report of the first intensive covering the King Air data processing, quality and availability. Battelle Memorial Institute, Columbus, Ohio has published first and second-intensive data reports for its G-1 aircraft (Spicer et al., 1989 and Spicer, et al., 1991).

National Acid Precipitation Assessment Program (NAPAP) funding has been used to develop the RADM. This Eulerian model was designed to utilize meteorological parameters for depiction and prediction of airflow across the United States at varying altitudes as a function of time, and also to simulate chemical parameters for superimposing known chemical processes onto the airflow network. Chang (1985) reported on the first operational model; Chang (1986) discussed preliminary model evaluation studies; and, most recently, Chang et al., (1987) discussed the model's physical concepts and formulation. The ADOM was developed by the Ontario Ministry of the Environment and the Atmospheric Environment Service, Environment Canada, with support from the Federal Republic of Germany's Unweltbundesamt and the Electric Power Research Institute (EPRI). Both models are designed to consider all the atmospheric physical and chemical processes relevant to regional-scale acid deposition.

The aircraft scientific research for Acid-MODES II was directed jointly by NOAA and Battelle Laboratories (both the Columbus, Ohio and Pacific Northwest Laboratories). Three aircraft were involved in the first intensive; only NOAA's King Air and Battelle Northwest Laboratories' G-1 were used in the second intensive.

This report includes the overall objectives of the second Acid-MODES program; instrumentation used and data obtained with the NOAA King Air; and the processing, quality, and availability of data from the King Air. Analysis of the aircraft data will appear in later publications.

2. OBJECTIVES

The general objectives for the second Acid-MODES field intensive remained the same as for the first intensive, with concentration on the vertical exchange of pollutants; the nonlinearity of transformation processes; and the chemical history of polluted air masses.

Flights during the second intensive had either Acid-MODES or cloud-water collection objectives. For the Acid-MODES objectives, the aircraft portion of the intensive focused on characterization of pollutant fields

- by measuring the distribution of trace constituents on a regional scale,
- by studying the influence of frontal passages on the spatial and temporal distribution of primary and secondary pollutants,
- by studying clear-air oxidant formation and chemical balances, and
- by obtaining measurements to determine the influence of nonprecipitating cloud processes.

The pilot cloud-water collection studies from the King Air during the first intensive provided guidance and direction for development of the second-intensive operations; therefore, emphasis for the second intensive was shifted to allow for measurements that would evaluate preconditions for oxidant limitations leading to nonlinearity (both gas and aqueous-phase measurements).

To fulfill the cloud-water collection objectives, the aircraft portion of the intensive focused on measurements for cloudwater composition. Cloudwater samples were analyzed for H_2O_2, dissolved ionic species, Se, and organic acids. It was determined that the measurements could be used to evaluate each step of the chemical chain, including aqueous-phase conversion in storms and clouds.

Historical meteorological analyses indicated that the spring months yielded the highest potential for observing frontal passage comparison, heterogenous chemistry, and oxidant and reactant-limited conditions, as well as frequent scavenging events. Additionally, the potential existed for observing the highest contrast in nonlinearity.

3. DATA COLLECTION

3.1. Field Site

Battelle and NOAA maintained flight operations out of Port Columbus International Airport, Columbus, Ohio, in conjunction with the Operations Center. The Operations Center was responsible for decisions and supervision of all flight activities. Decision to co-locate was based on coordinated flight patterns, aircraft logistics, quality assurance requirements (intercomparison flights), and cost.

3.2. Daily Operations

Preparation time for each flight was approximately 3 hours. This included instrument warm-up time and calibrations of all instruments. Daily meteorological briefings were presented by Battelle personnel, then flight plan decisions were initiated based on the scientific requirements and meteorological conditions.

After each flight, the Principal Investigators and the flight crews met for an informal debriefing of flight and scientific conditions. Post-flight debriefings included in-flight changes, in-flight weather conditions, and instrument problems (if any). Pre-flight, in-flight, and post-flight log notes are presented in the Appendix.

3.3. Flight Plans

A total of 19 flights were made during the second intensive (see Table 1). The King Air and the G-1 had either Acid-MODES objectives (9 flights) or cloud-water collection objectives (8 flights). In addition, one calibration flight for the King Air's instrumentation and one intercomparison flight with the G-1 were accomplished.

Table 1. Flight Listing for Acid-MODES II

DATE	TYPE
900423	Calibration flight
900425	Southeast Zipper
900426	Southeast Zipper
900427	Pre-frontal
900430	Intercomparison
900501	Cloud-water Collection
900502	Cloud-water Collection
900503	Cloud-water Collection
900506	Cloud-water Collection
900507	Southeast Zipper
900508	Northeast Zipper
900509	Pre-frontal
900510	Cloud-water Collection
900511	Post-frontal
900512	Cloud-water Collection
900513	Cloud-water Collection
900514	Northeast Zipper
900517	Cloud-water Collection
900518	Southeast Zipper

3.3.1. Flights Flown to Fulfill Acid-MODES II Objectives:

Nine flights of approximately 4-h duration each were flown to fulfill Acid-MODES II objectives. The flight plans were designed to provide spatial coverage over a broad region containing both source and receptor areas. The King Air (and the G-1) Acid-MODES flight plans consisted of two zipper patterns (northeast and southeast coverage) and pre-frontal and post-frontal traverses.

Both zipper plans called for both aircraft to depart Port Columbus together and do intercomparison flying until the first turning point, at which time each aircraft initiated its specified pattern. Additionally, vertical profiles were to be done by each aircraft at a specific location with respect to each flight pattern (see Figs. 1 and 2).

Southeast Zipper: Four flights started in central Ohio and covered the area as far south as southern South Carolina. The King Air covered the northwestern portion of the pattern with approximately a 650 nautical mile flight track, and the G-1 covered the southwestern portion with approximately a 950 nautical mile flight track. Figure 1 shows the southeast zipper flight track of each aircraft.

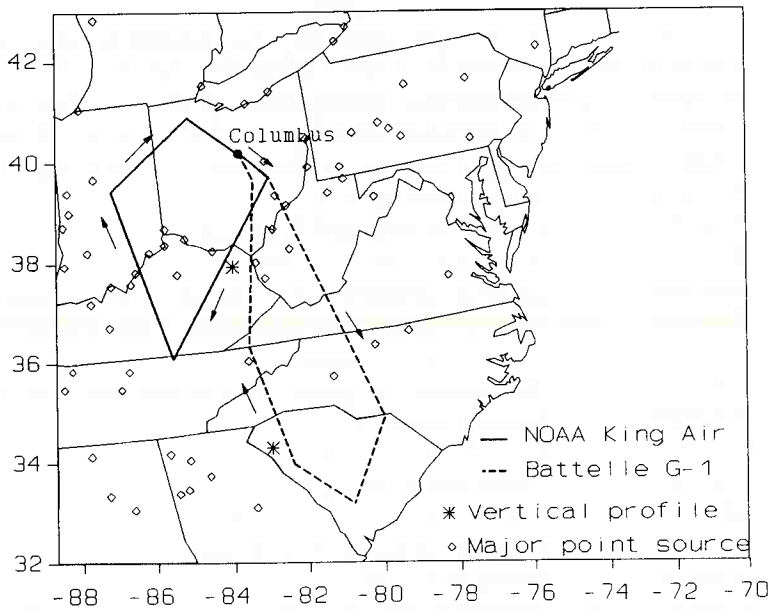

Figure 1. Southeast zipper patterns for the NOAA King Air and the Battelle G-1.

Northeast Zipper: Two flights started in central Ohio and covered the area as far east as eastern Pennsylvania and as far west as eastern Indiana. Figure 2 shows the northeast zipper flight plan for each aircraft.

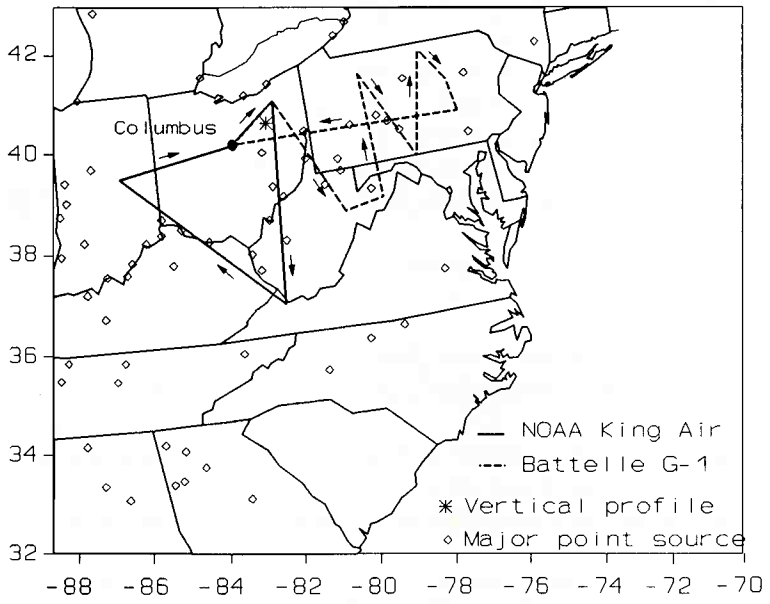

Figure 2. Northeast zipper pattern for the NOAA King Air and the Battelle G-1.

Frontal traverse: Two pre-frontal and one post-frontal flights were flown to investigate the impact of a frontal event on pollutant distribution, scavenging, and buildup. Figure 3 shows a representative frontal flight plan. The actual track depended on the orientation of the front.

3.3.2. Flights Flown to Fulfill Cloud-Water Collection Objectives:

Eight flights of approximately 2-3 h duration each were flown with the objective of collecting cloud-water samples from nonprecipitating, uniform clouds. A modified Mohnen slotted-rod collector was used (Kim and Boatman, 1991). Flight tracks were adjusted in flight to stay in cloud and to sample at different levels. Sampling was done in the Columbus area.

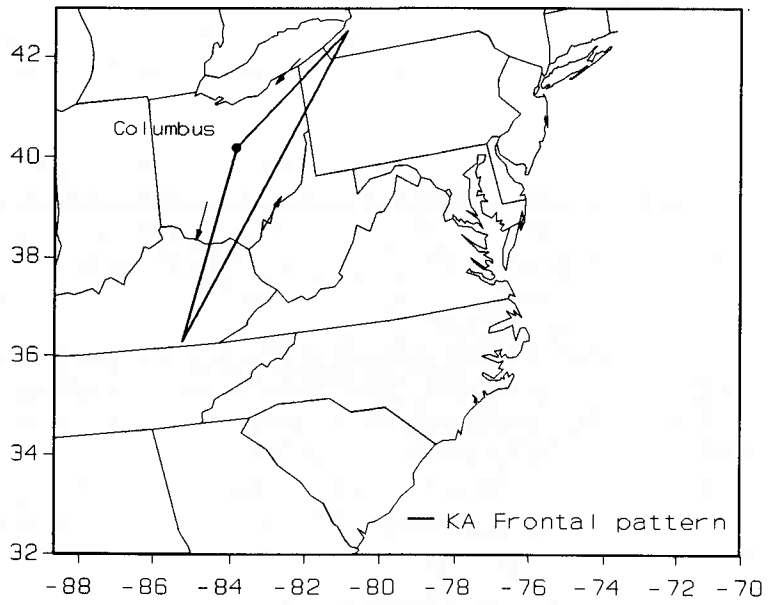

Figure 3. Representative frontal flight pattern for the NOAA King Air.

4. INSTRUMENTATION

The NOAA King Air (Beechcraft C-90) used for the measurements described here is owned and operated by NOAA's Aircraft Operations Center, Miami, Florida. It is equipped to measure aerosols, trace gases, and meteorological parameters (Wellman et al., 1989), and it has a Long Range Navigation (LORAN) system (Advanced Navigation Inc., Model ANI-7000).

The data-acquisition system aboard the aircraft is a Science Engineering Associates (SEA) Model M200, which has the capability of acquiring data from 32, 16-bit, differential-input A/D channels. It is equipped with a LORAN interface card and two one-dimensional (1D) interface cards for recording the Active-Scattering Aerosol Spectrometer Probe (ASASP) and Forward-Scattering Spectrometer Probe (FSSP) size distribution data. Data were sampled every 0.5 s and then recorded to a 40-Megabyte tape using the SEA system tape drive.

Instrumentation aboard the aircraft is a fairly standard package; however, instruments may be added or removed to meet specific research objectives. For Acid-MODES II, 5 A/D channels were used for standard instrumentation, and 14 A/D channels were used for project-specific needs. Additionally, ASASP, FSSP and LORAN data were recorded. The cloud-water collection information is recorded only in the in-flight log. The following is a summary of the data recorded:

A/D Channels (standard instrumentation):	A/D Channels (project-specific instrumentation):
1 Dynamic Pressure	6 SO_2
2 Dew point	7 Ozone
3 Pressure	8 NO/NO_y signal
4 Photometer	9 NO/NO_y mode
5 Temperature	10 H_2O_2 signal
	11 H_2O_2 background
LORAN Data	12 H_2O_2 flow (for signal)
	13 H_2O_2 flow (for background)
Latitude	14 25-mm filter pack flow
Longitude	15 90-mm filter pack flow
Heading	16 pH signal
	17 pH drop count
	18 Liquid water content (LWC) signal
ASASP and FSSP data	19 LWC slave monitor

15 size channels for each probe (16-bit channels)

The pH measurements on Channels 16 and 17 were done with a NOAA-designed instrument that was being flown in an experimental mode and not associated with the Acid-MODES II project; therefore, the data are not reported, nor is the instrument explained.

Following are descriptions of the instrumentation used for Acid-MODES II. Each description (except for the filter pack systems and the cloud-water collector) includes the principle of operation, the algorithm used to convert to engineering units, the specifications (range and accuracy), and the calibration information.

4.1. Dynamic Pressure Transducer

Manufacturer: Tavis

Principle of Operation: This device consists of a pressure-sensing capsule with electronic signal conditioning. The transducer measures the difference between the static pressure port and the pitot tube. Output is in volts, and is converted to millibars by the following:

Dyn Press (mb) = (volts * 51.81) + 11.2.

Specifications: Range: 16.27 to 275.80 mb (0.236 to 4 psid)
Accuracy: 0.73%

Calibration: Calibration in the field is not necessary. An after-project audit and calibration was performed by the manufacturer on 26 October 1990.

4.2. Dew Point Hygrometer

Manufacturer: General Eastern

Principle of Operation: An incoming parcel of air is directed into the dew point hygrometer chamber and is cooled at constant pressure by contact with a thermoelectric cooling module with a mirrored surface. Condensation appears on the surface at a temperature slightly below that of the thermodynamic dew point of the air. The observed dew point will differ from the thermodynamic dew point depending on the nature of the condensing surface, the condensation nuclei, and the sensitivity of the condensate-detecting apparatus. When the dew on the mirrored surface is of a constant thickness, it is in equilibrium with the partial pressure of the water vapor in the air sample. At this point, the temperature of the mirror equals the dew point temperature. The voltage is proportional to the dew point according to the following algorithm:

T_d (°C) = volts * 10.

Specifications: Range: −75° to +50°C
Accuracy: ±0.25°C at +50°C; ±1.0°C at −75°C

Calibration: Calibration was performed on the instrument on 12 February 1990 by the manufacturer. System balance checks were performed during the project to assure correctness of the instrument.

4.3. Static Pressure Transducer

Manufacturer: Rosemount

Principle of Operation: The transducer consists of a precision capacitance pressure-sensing capsule with electronic signal conditioning. It measures the pressure from a static pressure port. Conversion from pounds per square inch absolute (psia) to millibars is through the following algorithm:

Pressure (mb) = [(volts * 3.00122) + 0.00266] * 68.95.

Specifications: Range: 0–15 psia
Accuracy: > ±0.1% Full Scale Pressure (FSP)

Calibration: None required while in the field. An audit of the instrument performance was conducted during the BAO tower flyby 13 October 1988; no adjustment was necessary.

4.4. Solar Radiation Photometer

Manufacturer: LI-COR

Principle of Operation: A silicon photodiode measures solar radiation received from the whole sky (180° field of view). Through use of an amplifier, volts are directly proportional to watts per square meter (W m^{-2}).

Solar insolation (W m^{-2}) = volts * 1000.

Specifications: Range: 0.4–1.2 μm (peak at 0.95 μm)
Accuracy: ±5%

Calibration: No calibration is performed in the field. Calibration was performed by the manufacturer against an Eppley Precision Pyranometer. The calibration was performed under full-sun conditions at midday. Uncertainty of the calibration was ±5%; date of calibration was 25 April 1983.

4.5. Total Temperature Sensor

Manufacturer: Rosemount

Principle of Operation: A sealed platinum resistance sensing element measures total air temperature. For stability and protection, the sealed element is surrounded by a gold-platinum alloy radiation shield, which, in turn, is surrounded by a stainless steel shield. The resistance is measured in volts, which are proportional to total temperature by the following algorithm:

T (°C) = (volts * 20) – 60.

Specifications: Range: +40° to –60°C
Accuracy: ≥ 0.995 (measured temperature to total temperature)
(±0.25°C plus 0.5% of the magnitude of the temperature in degrees Celsius).

Calibration: Intercomparison audits are performed using the BAO 300-m tower and an additional temperature probe. These are performed annually if possible; however, the last calibration that was performed prior to the Acid-MODES II flights was 13 October 1988. A daily check with an on-ground thermometer was performed throughout the project; the readings were consistently within 0.5%.

4.6. SO_2 Analyzer

Manufacturer: Thermo Electron Corporation (TECO)

Principle of Operation: Pulsating ultraviolet (UV) light (190–230 nm) is focused through a narrow-band filter into a fluorescent compartment through which sample air passes. The UV light excites the SO_2 molecules, and they emit decay radiation that passes through another filter onto a photomultiplier tube (PMT). The amount of light energy impinging on the PMT is directly proportional in volts to the amount of SO_2 in the sample:

SO_2 (ppbv) = [volts * 5) – so2zero] * (1013/pmb) * 303/273.16) * 1.086,

where so2zero = zero offset = 0.35 ppb
pmb = recorded pressure (mb).

Specifications: Range: 0–200 ppbv (range selectable)
Accuracy: 0.1 ppbv

Calibration: Zeros and spans, on the low range (0–10 ppbv), were performed daily on the ground prior to flight. Additionally, in-flight zeros/spans were performed.

4.7. Ozone Analyzer

Manufacturer: Thermo Electron Corporation (TECO)

Principle of Operation: Concentration of ozone is directly related to the magnitude of the attenuation of light in the absorption cell, at 254 nm. Dual detectors monitor the changes in light intensity (both zero and sample), and an averaged intensity is calculated by the instrument using the Beer-Lambert Law: $I/I_0 = \exp(-K\ell C)$,

where I = the light intensity of the ambient sample in the absorption cell
I_0 = the light intensity measured with reference in the absorption cell
K = the absorption coefficient, a function of the gas and wavelength; for ozone at 254 nm it is 308 atm^{-1} cm^{-1} at standard conditions (0°C and 760 mm Hg pressure)
ℓ = the length of the absorption cell (in cm)
C = the concentration (in ppm x 10^{-6}).

Each cell measures either I or I_0; when one cell is measuring I the other is measuring I_0, and vice versa. Concentration (in ppbv) is proportional to voltage using the following algorithm:

C (ppbv) = [(volts * 100) * (1013/pmb) * (303/273.16) * 1.0056] + 0.562,

where pmb = recorded pressure (mb).

Specifications: Range: 0–0.5; 0–1 ppm
Accuracy: ±1.0 ppb

Calibration: A calibration was performed on 11 February 1988; an audit was performed using a National Institute of Standards and Technology (NIST) standard on 21 February 1990.

4.8. NO_y Analyzer

Manufacturer: Thermo Environmental Instruments (TEI)

Principle of Operation: This is a modified TEI Model 42 NO–NO_2–NO_x instrument. Ambient air is sampled directly (NO mode) or through the NO_y to NO converter (NO_y mode). The chemiluminescence of NO and O_3 produces an intensity linearly proportional to the concentration of NO. The values (in ppbv) are derived by the following algorithms:

$$NO\ (ppbv) = [(volts * 5) - zero\ offset] * (1013/pmb) * (303/273) * Tfactor * SF,$$

$$NO_y\ (ppbv) = [(volts * 5) - zero\ offset] * (1013/pmb) * (303/273) * Tfactor * 1.03 * SF,$$

where $Tfactor = 85.8961 - (0.40347 * pmb) + (7.125 * 10^{-4} * pmb^2) - (5.563 * 10^{-7} * pmb^3) + (1.625 * 10^{-10} * pmb^4)$,

and where pmb = ambient recorded pressure (mb)
SF = scaling factor = 0.975.

The 1.03 value in the NO_y algorithm is a response difference for the NO_y channel (from the instrument).

Specifications: Range: 0–100 ppbv [range-selectable up to 10 parts per million (ppm)]
Accuracy: 0.1 ppbv

Calibration: Prior to the field intensive, a four-point calibration was completed. In the field, a daily pre-flight and in-flight zero and span were performed.

4.9. H_2O_2 Analyzer

Manufacturer: K & K Inc.

Principle of Operation: The system consists of a dual fluorometric system with a wet chemical flow. In one channel, peroxidase enzyme catalyzes the reaction in which hydroperoxides form the fluorescent dimer of p-hydroxy-phenylacetic acid (POPHA). Both H_2O_2 and organic hydroperoxide are measured; the peroxide concentration is directly proportional to the fluorescence intensity. In the second channel, H_2O_2 is selectively decomposed so that only organic hydroperoxides produce the fluorescence signal. This second channel acts as a back- ground measurement. Output is in volts, and the following converts volts to H_2O_2 parts per billion by volume (ppbv):

$$H_2O_2\ (ppbv) = \{[a_0^{0.023} * \Delta A * SF_A * (1/Gflow_A)] - [\Delta B * SF_B * (1/Gflow_B)]\} \div (a_0^{0.023} - a_0),$$

where a_0 = breakthrough value (catalase efficiency)
ΔA = signal channel voltage minus the zero offset (volts)
ΔB = background channel voltage minus the zero offset (volts)
SF = daily scaling factor (for signal and background, A and B)
$Gflow_A = (volts_{MFCA} * 0.8317) + 0.0379$
$Gflow_B = (volts_{MFCB} * 0.9183) - 0.072$,

and where MFCA and MFCB are mass flow controller values for the signal and background channels, respectively.

Specifications: Range: 0–10 ppbv
Accuracy: 0.1 ppbv

Calibration: There were daily pre-flight and post-flight calibrations using a 1.66 ppbv (1.676×10^{-7} M) and 3.32 ppbv (3.352×10^{-7} M) standard solution. In addition, a daily in-flight calibration was done using the 1.66 ppbv standard solution.

4.10. Filter Pack Systems

4.10.1. One 25-mm-Diameter System

A 25-mm Nuclepore filter pack system was used for all flights to determine aerosol composition. The sample diameter of the filter was reduced to 0.50 cm by means of a Teflon mask. Filter handling and X-ray Fluorescence (XRF) analysis were provided by the University of Colorado. A mass flow meter (Kurz Inc.) monitored the flow which is in liters per minute. An audit of the flow meter was performed on 22 March 1990, prior to the intensive.

4.10.2. Two 90-mm-Diameter Systems

A dual 90-mm filter-pack system was used during the flights, also to determine aerosol composition. When sampling was carried out in cloud, an aerosol separator (Boatman et al., 1989) was in line; for Acid-MODES-objective flights, straight ambient air samples were taken. Filter handling and analysis were provided by New York State Department of Health. Mass flow meters (Kurz Inc.) monitored the flows; output is in liters per minute. The Kurz meter was audited on 21 March 1990, prior to the flights.

4.11. Liquid Water Content Probe

Manufacturer: CSIRO-King

Principle of Operation: This instrument is of a hot-wire-anemometer-type measuring device consisting of the display module, the control circuit module, and the sensor head. When the heated coil of wire is maintained at a constant temperature, any excess power consumed by the wire is proportional to the mass of water impacting on it. The total power to the master coil includes a dry term (the cooling effect of the dry air flowing over the coil) and a wet term (the power need to heat and vaporize the liquid water in the air). Liquid water content (LWC) is calculated by the following series of algorithms:

$P = P_{dry} + P_{wet}$ (total power to the master coil); $P - P_{dry} = P_{wet}$

$P_{wet} = \ell * d\ [L + c(T_{SW} - T_A)] * TAS * LWC$, and

$P_{dry} = [A(T_{SD} - T_A)] * pmb * TAS^x$,

$P = ([A(T_{SD} - T_A)] * pmb * TAS^x) + (\ell * d\ [L + c(T_{SW} - T_A)] * TAS * LWC)$

$P = 10 * V$; $P_{dry} = 10 * V_{dry}$;

$P - P_{dry} = 10(V - V_{dry})$

where V = voltage in cloud
pmb = pressure (mb)
A = 1.962×10^{-5} (empirically determined)
T_{SD} = 190° C (hot wire surface temperature)
T_A = ambient temperature (°C)
TAS = true air speed (m s^{-1})
x = 0.52 (empirically determined)
ℓ = length of the master coil (m)
d = diameter of the master coil (m)
L = latent heat of vaporization (J kg^{-1})
c = specific heat of water (J deg^{-1} kg^{-1})
T_{SW} = 90° C (impacting water evaporation temperature)
LWC = liquid water content, where

$$LWC\ (g\ m^{-3}) = \{10(V - V_{dry})\}/\{\ell * d[L + c(T_{SW} - T_A)] * TAS\}.$$

Specifications: Range: 0–5 g m^{-3} (normal range); 0–1 g m^{-3} (sensitive range)
Accuracy: 0.1 g m^{-3}

Calibration: A wind-tunnel dry-term calibration was performed by the manufacturer in November 1988. During the project, prior to flying in cloud, the dry term was again determined by flying first through clear air.

4.12. Cloud Water Collector

We used a modified Mohnen slotted-rod collector for cloud water sampling (Kim and Boatman, 1991). Samples were collected in clean, deionized water-rinsed bottles that were attached to the base of the collector. The New York State Department of Health analyzed the samples.

4.13. Active-Scattering Aerosol Spectrometer Probe (ASASP)

Manufacturer: Particle Measuring Systems (PMS)

Principle of Operation: A 632.8-nm He-Ne laser is used to size particles in the 0.12–3.12 μm range with 15 size bins by measuring the magnitude of light intensity scattered by individual particles passing through the scattering volume. The probe is a resonant-cavity-type instrument, where the scattering volume is inside the internal cavity of the laser. Particles are detected and sized by the receiving optics which collect scattered light over a solid angle close to 2 steradian. Airflow is directed and constrained to a 150-μm-diameter stream, providing isokinetic flow for sampling.

Specifications: Range: 0.12–3.12 μm (15 bins)
Accuracy: 0.025 μm

Calibrations: No calibration is done onsite. The probe is calibrated by the manufacturer; the last calibration was performed in March 1990, prior to the project. During the project, the instrument was checked periodically with monodisperse latex beads to assure that it was responding correctly.

4.14. Forward-Scattering Spectrometer Probe (FSSP)

Manufacturer: Particle Measuring Systems (PMS)

Principle of Operation: This is a one-dimensional probe that measures a particle's diameter as each particle passes through the sample area. Particles are sized by measuring the amount of light scattered into the collecting optics aperture. There are four overlapping size ranges and each range is divided into 15 size intervals, providing 60 size channels in a 0.5–47 μm range. For Acid-MODES II, the instrument was set either to Range 1, which measures 2–32 μm, or to Range 0, which measures 2–47 μm.

Specifications: Range: 2–32 μm (15 bins); 2–47 μm (15 bins)
Accuracy: ±10% or ±2 μm (whichever is greater)

Calibrations: Performed by the manufacturer; an after-project audit and calibration was done in November 1990. No calibration is necessary while in the field; however, during the project periodic validation checks, using glass beads, were done to assure the instrument was sizing particles correctly.

4.15. Long-Range Navigation (LORAN) System

Manufacturer: Advanced Navigation Inc. (ANI)

Principle of Operation: The LORAN system consists of a pulse-type radio system with ground-based transmitters. A receiver in the aircraft precisely measures signals from each ground station, thereby fixing a line of positions for tracking. Latitude, longitude, and heading are read directly from the LORAN; wind direction and wind speed are calculated using LORAN input. Latitude and longitude are converted to decimal degrees; wind directions are in degrees, and wind speeds are in meters per second.

Specifications: Accuracy: Lat/Long, 0.002 ° (approx 200 m)
Heading, 1.0° (with 1-min averages)
Wind Direction, 1.0° (with 1-min averages)
Wind Speed, 1.0 m s^{-1} (with 1-min averages)

Calibration: None required; however, a check was made of the system over the BAO, and the LORAN accurately received the tower's position.

5. DATA PROCESSING

Data were processed on site for a "first-look" analysis. These data were used to verify instrument performance, and to develop preliminary algorithms to be used in the final processing. A series of steps was involved in developing the final usable data:

- The data were read back to a hard disk on a PC system.

- A program designed specifically for the Acid-MODES II aircraft channel assignments was used to produce a 1-min- and a 10-s-averaged data file.

- The aerosol probe (ASASP and FSSP) data were processed separately, and a 1-min- and a 10-s-averaged file for each probe were produced.

- Some data such as SO_2, O_3, NO/NO_y, H_2O_2, and liquid water content (LWC) needed after-the-fact calibration coefficients applied. These data were initially analyzed for these adjustments, and were then reprocessed with the correction factors.

The final dataset for Acid-MODES II consists of

- 1-min- and 10-s-averaged ASASP (A) and FSSP (F) files (one each per flight), and

- 10-s-averaged chemical, meteorological, and LORAN (C) files (one each per flight). These files have 1-min-averaged data for wind direction and wind speed, since accuracy of these data are not sufficient at averages less than 1 minute.

The C files were further processed: First, an initial quality control program established validity criteria for the data (i.e., assured data were in the correct range and operational). Second, all gas analyzer data were carefully analyzed, and additional validity criteria were established to eliminate suspicious or invalid data. This final analysis also eliminated zero/span periods and ground data.

In the final C files, some data were left in the raw voltage state; however, most were converted (with calibrations) to engineering units. True air speed (TAS), wind speed, wind direction, SO_2 (ppbv), H_2O_2 (ppbv), H_2O_2 ratio, SO_2 (ppbv), NO (ppbv), NO_y (ppbv), and LWC (g m^{-3}) are calculated and added to the processed C files; each C file has 23 columns in it. Table 2 lists the parameters that are in the final averaged C data files.

In the ASASP final processed files, there are 19 columns of data:

Column 1. Beginning time (of the average) in an hhmmss format.

Column 2. Beginning time (of the average) in decimal hours.

Columns 3-17. Bin values (particles cm^{-3} μm^{-1}). The number listed at the top of the columns is the value at the center of the bin (μm). The ASASP has only one range with 15 bins. Table 3 lists the ASASP bin sizes.

Column 18. Average mass (μg m^{-3}). The average concentration (particles cm^{-3} bin^{-1}) is converted to mass based on 2 g cm^{-3} density, then the average mass values are integrated across the bins.

Column 19. Average concentration (particles cm^{-3}). The value in each bin (particles cm^{-3} μm^{-1}) is converted to particles cm^{-3} bin^{-1}, then the average concentration values are integrated across the bins.

Table 2. Processed chemical, meteorological, and LORAN (C) files for Acid–MODES II: April–May 1990, Columbus, Ohio

No.	Parameter	Unit	Accuracy	Response Time	Precision	Comments
1	Begin time	hhmmss	----	----	----	From tape
2	Decimal time	hh.mmss	----	----	----	Computed value
3	Dynamic pressure	mb	0.1 mb	1 s	0.1 mb	Pitot tube and static pressure port
4	Temperature	°C	0.1°C	1 s	0.1°C	Wire
5	Dew point	°C	1.0°C	5 s	0.1°C	Cooled mirror
6	Pressure	mb	0.5 mb	1 s	0.1 mb	Static pressure
7	Solar radiation	W m^{-2}	----	----	----	Short-wave sun photometer
8	SO_2	ppbv	0.1 ppbv	1 min	0.1 ppbv	Pulsed fluorescence/Computed value
9	Ozone	ppbv	1.0 ppbv	1 min	0.1 ppbv	UV photometric detection/ Computed value
10	NO	ppbv	1.0 ppbv	30 s	0.3 ppbv	Chemiluminescence/Computed value
11	NO_y	ppbv	1.0 ppbv	30 s	0.3 ppbv	Chemiluminescence/Computed value
12	H_2O_2	ppbv	0.05 ppbv	2 min	0.04 ppbv	Flow corrected; not time corrected/Computed value
13	H_2O_2 ratio	----	----	----	----	Computed value
14	Filter flow	slpm*	0.1 slpm	1 s	0.1 slpm	25-mm filter pack
15	Filter flow	slpm*	0.1 slpm	1 s	0.1 slpm	90-mm filter pack
16	pH signal	mV	----	----	----	Raw voltages
17	Liq. water content	g m^{-3}	----	----	----	Computed value
18	Latitude	deg-min	200 m	1 s	----	LORAN-C
19	Longitude	deg-min	200 m	1 s	----	LORAN-C
20	Heading	deg	1.0°	1 s	1.0°	Gyrocompass
21	True air speed	m s^{-1}	1.0 m s^{-1}	1 s	0.1 m s^{-1}	Computed value
22	Wind direction	deg	1.0°	2 min	0.1°	Computed value
23	Wind speed	m s^{-1}	1.0 m s^{-1}	2 min	0.1 m s^{-1}	Computed value

*slpm is standard liters per minute.

In the FSSP final processed files there are 22 columns of data:

Column 1. Beginning time (of the average) in an hhmmss format.

Column 2. Beginning time (of the average) in decimal hours.

Columns 3–17. Bin values (particles cm^{-3} μm^{-1}). The number listed at the top of the columns is the value at the center of the bin (μm). When the concentration is greater than 5.0 particles cm^{-3}, the value shifts to liquid water content (g m^{-3}). The FSSP may be set to auto–ranging or to an individual range. During Acid–MODES II, the instrument was either on Range 1 or Range 0. Table 3 lists the FSSP bin sizes.

Column 18. Average mass (μg m^{-3}), based on 2 g cm^{-3} density, except when the value is shifted to liquid water, and then the standard density of water (1 g cm^{-3}) is used. As with the ASASP, the values are integrated across the bins.

Column 19. Average concentration (particles cm^{-3}). Concentration values are converted as with the ASASP: Particles cm^{-3} μm^{-1} to particles cm^{-3} bin^{-1}, then integrated.

Column 20. Range.

Column 21. Pressure in millibars.

Column 22. True air speed (TAS) in meters per second.

ASASP and FSSP data are sized according to the manufacturer's calibration; however, Kim and Boatman (1990a, 1990b,) suggest correcting data with respect to varying relative humidity values (different refractive indices) in order to improve the accuracy in determining the size distribution. Kim and Boatman (1990c) further suggest corrections for the FSSP data for particle trajectory and beam intensity profiles.

Table 3. ASASP and FSSP calibrated bin values

Bin #	Size (μm)	Interval (μm)	Bin #	Size (μm)	Interval (μm)	Size (μm)	Interval (μm)
	ASASP-100X			FSSP			
				Range 1:		Range 0:	
1	0.120-0.145	0.025	1	2.00- 4.00	2.00	2.00- 5.00	3.00
2	0.145-0.195	0.050	2	4.00- 6.00	2.00	5.00- 8.00	3.00
3	0.195-0.270	0.075	3	6.00- 8.00	2.00	8.00-11.00	3.00
4	0.270-0.370	0.100	4	8.00-10.00	2.00	11.00-14.00	3.00
5	0.370-0.495	0.125	5	10.00-12.00	2.00	14.00-17.00	3.00
6	0.495-0.645	0.150	6	12.00-14.00	2.00	17.00-20.00	3.00
7	0.645-0.820	0.175	7	14.00-16.00	2.00	20.00-23.00	3.00
8	0.820-1.020	0.200	8	16.00-18.00	2.00	23.00-26.00	3.00
9	1.020-1.245	0.225	9	18.00-20.00	2.00	26.00-29.00	3.00
10	1.245-1.495	0.250	10	20.00-22.00	2.00	29.00-32.00	3.00
11	1.495-1.770	0.275	11	22.00-24.00	2.00	32.00-35.00	3.00
12	1.770-2.070	0.300	12	24.00-26.00	2.00	35.00-38.00	3.00
13	2.070-2.395	0.325	13	26.00-28.00	2.00	38.00-41.00	3.00
14	2.395-2.745	0.350	14	28.00-30.00	2.00	41.00-44.00	3.00
15	2.745-3.120	0.375	15	30.00-32.00	2.00	44.00-47.00	3.00

6. DATA AVAILABILITY

Processed aircraft data files (Chemical, meteorological and LORAN; ASASP; and FSSP) are available in standard ASCII files on 360-kilobyte or 1.2-megabyte 5.25-inch floppy diskettes, or 760-kilobyte or 1.44-megabyte 3.5-inch floppy diskettes. Copies of all original flight tapes, and all programs, graphs and printouts, are maintained by NOAA/ERL/ARL/Aerosol Research Section, Boulder, CO. Direct all requests for aircraft data to R.L. Gunter or S.W. Wilkison, NOAA/ERL/ARL/ARS, Mail Code R/E/ARx1, 325 Broadway, Boulder, CO 80303; phone numbers, (303) 497-5130 or (303) 497-6500, respectively.

7. ACKNOWLEDGMENTS

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Appendix: Pre-flight, In-flight, Post-flight Log Notes

23 April 1990
Calibration Flight
Flight Crew: Tom Gates and Gregg LaMontagne
Scientific Crew: John Ray and Laureen Gunter

PRE-FLIGHT:

Flight Plan:
2K, 4K, 6K, 8K, 10K
filter pack on ambient up to 10K
10K ↓ filter pack on separator

On ground state parameter check:
Pmb = 990.2, Aircraft Pmb = 991.34
Dry/Wet bulb T = 63.5°F/53.5°F; calculated T_d = 19.5°C

IN-FLIGHT:

[EDT]
GMT 4 hours greater than EDT

≈0830	Start tape
105500	On start-power problem - DAS screen went out-recovered - NO_x did a full restart - SO_2/O_3 OK - H_2O_2 OK - everything seems OK now - FSSP-R1
≈1100	H_2O_2 cal 1
111230	T/O - going to 2500'
111500	@ 2500'
111916	Cal 1 H_2O_2
112130	90mm and HS#1 on - 90mm = 268 lpm; HS = 4.7 lpm
112320	Balance T_d
112546	T_d to sample
1130	ASASP pump on (oops!)
113400	LORAN intermittent (not for very long)
113600	up to 4500'
113818	@ 4500'
1140	TAS_k, WD, WS go to 999's intermittent
114120	90mm 266.68 lpm; HS 5.23 lpm
144814	Cal 1 - H_2O_2
115200	Gregg getting forecast winds aloft - TAS seems OK - heading seems OK - our WD, WS, TAS knots seem incorrect, WS way too high 32 mi SW Parkersburg VOR 3 210/8 6 230/10 9 230/5 Our WD/WS (when on) shows WD=53/WS=152 -- Choppy here
115630	up to 6500'
115840	@6500' - hazy - more calm here - 10+ V on ASASP, 8.5 V on FSSP
120120	Cal 1 H_2O_2 - 90mm = 254.93; 25mm = 5.06
1202	Herman's filter flow seemed too high - twisted "quick connect" a little - flow dropped to 3.65 lpm - twisting a little more gave 3.94 lpm - changes...
120950	25 mm @ 4.01 now (w/o touching)

121508 up to 8500'
121744 @ 8500' – T_d = –43.89°C; T = 10.21°C – WD/WS still going in/out 999's
121906 Cal 1 H_2O_2
122006 7 miles SW York VOR SW bnd heading to Lexington
122112 90mm 240.61; 25mm 3.69
Hazy below – clouds/cloud deck below and all around (horizontal)
122300 our alt in flight shows ≈ 200' – less than altimeter (expected)
122500 T_d now = –23.5 – 98 SW of Columbus now – avoiding clouds – checked heading on pilots LORAN, shows bearing of 17, heading 197 – DAS shows ≈ 230 heading
122840 T_d now back to –42.4
123344 Balance T_d
123540 T_d to sample
123858 Turning and going up to 10500'
124118 @ 10500' – H_2O_2 to Cal 1

NOTE: Forgot to enter flow @ 10500' before changing H_2O_2 flow A 1.17, B 1.17 on machine – .99–1.00 on DAS

124200 90mm off, change to separator
124704 90 FP on separator – flow ≈ 209 lpm – 210; 25mm 3.28 lpm – 3.32
125000 Heading 055, on DAS 50.60 – WS/WD TAS_k still going in/out 999's
125300 Lots of ram-air on aerosol inlet photometer right now is 976 W/m^2 – has been reading high the whole time (800–900), mostly 930's–940's even with clouds above
125700 T_d = –32.38°C; T = 7.05°C – all through flight O_3 on box has been 30's–40's, DAS display shows 1.89–1.90 fairly constantly
130220 turning (about 30 minutes out from CMH)
130456 descend to 4500'
131140 @ 4500' – 90mm = 246.29 → 242 (10 minutes later); 25mm = 4.60 → 4.48 (10 minutes later) – O_3 on display screen = ½V, 2.03 ppb; O_3 on box = 50 ppb
131352 Cal 1 on H_2O_2
131900 Headings now agree
132650 On final – will need power on landing
132900 Shut off 90mm and HS 25mm – will take off on ground, too bumpy to do anything here
133228 Landed – probes off

during flight: Map not displaying – red cross not even showing
TAS m/s = 63.16; TAS knots = .30
Wind speed = 140 knots
Heading agrees with panel ±5°≈ 0830

Flight time:
2 hours 40 minutes

Sub total flight hours:
2 hours 40 minutes

25 April 1990
Data Flight 1 (SE_Zipper)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: John Ray and Laureen Gunter

PRE-FLIGHT:

On ground state parameter check:
Pmb = 993.4, Aircraft Pmb = 991.44
Dry/Wet bulb T = 75°F/63°F; calculated T_d = 12.7°C
T/T_d (AC) = 24.0°C/12.9°C

Flight plan: Stair step profile up to 10000', 1/3 way into 1st leg

IN-FLIGHT:

[EDT]
084500 SEA started - on ground FSSP R-1
102644 Engine start
103400 Taxi out
104050 ASASP on
104656 T/O - going to 4000'
105116 @ 4000'
105900 G-1 just went by - attempting to coordinate now
110030 Alongside G-1 now - G-1 closing
110800 End IC
110930 90mm 1-1 on, flow = 264 lpm; 25mm AM2 on, flow = 4.33 lpm
On line - flew past 1st waypt - correcting to be on flight line
112030 ascending to 6000'

Note: what is horizontal time on strip chart?
how come heading on display doesn't agree with pilot's LORAN? - ±5° most of the time sometimes as much as 10°
Also map on display doesn't agree with waypoints in book. Since turning, the aircraft doesn't follow on display

112314 @ 6000' - very hazy, thin clouds above
113150 ascending to 8000'
113412 @ 8000' - still hazy, thin cirrus above
114240 ascending to 10000'
114530 @ 10000'
114930 90mm 1-1 off, flow = 251.9; 25mm AM2 off, flow = 3.41

Note: 90 mm 1-1 may be in wrong order in bag (after sampling)

115340 90mm 1-2 on, flow = 228.86; 25mm AM3 on, flow = 12+ to 13+ (changing-too high)
115600 25mm AM4 on, flow = 2.85
115700 Descending to 4000' - descending through cloudy area - avoiding clouds
120230 @ 4000' - 90mm flow = 270 lpm; 25mm flow = 6.6 lpm
121514 Turbulent - hard to write anything
122400 Clouds above, haze below

123400 90mm 1-2 off, flow = 278.9
123500 25mm AM3 off, flow = 6.23
123818 90mm 1-B on
124100 Turning to north leg, 36°11 N, 85° W
124300 On line
124416 90mm 1-3 on, flow = 267.6; 25mm AM5 on, flow = 3.5
132430 90mm 1-3 off; 25mm AM5 off
133000 90mm 1-4 on, flow = 267; 25mm AM6 on, flow = 3.56
140014 Turning to CMH - fuel considerations - 46 minutes to Columbus
141230 90mm 1-4 off, flow = 257.7; 25mm AM6 off, flow = 3.18
142840 H_2O_2 signal went to -573 V, bkgd to +58 V - JR checking problem: out of solution (popha) - shutting H_2O_2 off
144038 Beginning descent to CMH
145236 Landed - leaving SEA on - FSSP/ASASP off - T_d off

Flight time:	Sub total flight hours:
4 hours 26 minutes	7 hours 06 minutes

26 April 1990
Data Flight 2 (SE_Zipper)
Flight Crew: Tom Gates and Gregg LaMontagne
Scientific Crew: John Ray and Laureen Gunter

PRE-FLIGHT:

On ground state parameter check:
Pmb = 989.7, Aircraft Pmb = 990.05
Dry/Wet bulb = 68°F, 58.8°F; calculated T_d 11.4°C
T/T_d (AC) = 20.03°C/12.25°C

Note to Stan - need T and T_d on same strip chart display

160 knots sampling speed for this flight

IN-FLIGHT:

[GMT]
≈1215 SEA system started
134700 engine start - FSSP on R-1, A/D
134900 taxi out
135816 ASASP on
135840 T/O going to 4000' rendezvous for IC
140234 @ 4000' - waiting for G-1 (701BN)
141230 G-1 right behind - closing in
141414 G-1 alongside - IC begin
142028 IC over - G-1/KA breaking away
142126 Turning onto first leg
142328 Up to 6500' - TG coordinated level with Battelle
142526 @ 6500' - thin cirrus above, very hazy below

143136 Ascending to 8500'
143336 @ 8500'
143940 ascending to 10500'
144140 @ 10500'
144700 descending to 4000'
145200 @ 4000' - bumpy
145500 90mm 2-1 on, flow = 243.9; 25mm AM7 on, flow = 2.70
152810 Balance T_d
152928 T_d to sample - clouds around, really turbulent
153500 90mm 2-1 off, flow = 262.9; 25mm AM7 off, flow = 3.12
154030 90mm 2-2 on, flow = 205 → 194.3 → 190; 25mm AM8 on, flow = 3.57
154434 Turning onto north leg
154530 John Ray zeroing SO_2, H_2O_2, O_3
155244 SO_2, H_2O_2, O_3, back to sample
160400 Still turbulent - cloud base about 4500'
162030 90mm 2-2 off, flow = 194.26; 25mm AM8 off, flow = 3.44
162200 90mm 2-B on
162500 90mm 2-3, flow = 255; 25mm AM9, flow = 3.45
163000 SO_2 increased coming up over Ohio River - NO_x also - after crossing river values went back down
164800 Clouds all around
165316 Turning to Columbus
173910 Landed - Probes/T_d off, all others on

Flight time:
3 hours 52 minutes

Sub total flight hours:
10 hours 58 minutes

27 April 1990
Data Flight 3 (Pre_Frontal)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Menachem Luria and Laureen Gunter

PRE-FLIGHT:

On ground state parameter check:
Pmb = 987.3, Aircraft Pmb = 987.74 (changed in 1/2 hour)
Dry/Wet bulb = 62°F, 76°F; calculated T_d 11.6
T/T_d (AC) = 25.62°C/11.25°C

Note: Need T/T_d on same strip chart

IN-FLIGHT:

[EDT]
≈0830 SEA started
[GMT]
152530 engine start - FSSP - R-1, A/D
152724 Cal 1 on H_2O_2
153700 ASASP on

153730 T/O
153834 Cal 1 on H_2O_2
155200 @ 13500' - about 1000 ft above clouds - T_d = -40.9°C; T = -.16°C
155730 90mm 3-1 on, flow = 225; 25mm A10 on, flow = 1.75
155950 going up a couple hundred feet to clear clouds
160000 @ 14500'
160900 higher clouds on flight path, circumnavigating
162000 turning onto 2nd leg - no clouds ahead of us - 14500' looks OK
163730 90mm 3-1 off, flow = 203.59
163900 90mm 3-2 on, flow = 164.07

NOTE: AM10 still on - needs longer because of low flow

164348 H_2O_2 zero
165000 Less hazy/cruddy as we head south - no build up of clouds - just barely out of mixed layer
T = 1.11°C; T_d = -17.43°C
170200 Going up a couple hundred feet to see if anything changes, didn't - clearer to NW than the SE - sloping mixed layer
170900 Turning to north
171900 90mm 3-2 off, flow = 164.1; 25mm AM10 off, flow = 1.8
172200 down to 11500' to finish sampling - we're out of oxygen - Chet advised us to try to finish as much as plan as possible
172630 @ 11500' - as we headed north we are still out of the mixed layer!! visually and T/T_d wise - even better than @ 14500' at the south end
172800 90mm 3-3 on, flow = 172.00; 25mm AM16 on, flow = 2.35 (grabbed out of order-sorry)
173220 H_2O_2 to zero
173740 On strip chart T_d was oscillating - not smooth but choppy - could be because we are skimming BL?, sometimes - T/T_d tell us we are out, visually we appear out - lite chop occasionally
175950 T_d to balance - now it is truly oscillating
180210 T_d to sample
180800 90mm 3-3 off, flow = 174.9; 25mm AM16 still on, flow = 2.13
180930 90mm 3-B on
181130 90mm 3-4 on, flow = 214
181300 T_d doesn't look good - too cold?
182230 turning to SE
182700 Still OK (ML) - occasional chop - below us getting cruddier - shaving the top now closer
183516 Going to 11.9 - layer is sloped - we were driving into it
183900 11.9 is just barely keeping us out - choppy ride
184500 90mm 3-4 off, flow = 199.9; 25mm A16 off, flow = 1.97
184536 On descent - H_2O_2 to Cal 1
185600 Landed - probes/T_d off - SEA still on for Cals
220835 SEA off

Filter 3-1 single L_1 (2nd stage)
Filter 3-5 not exposed (used as 'unseen' blank)

Flight time:
3 hours 31 minutes

Sub total flight hours:
14 hours 29 minutes

30 April 1990
Data Flight 4 (Intercomparison)
Flight Crew: Tom Gates and Gregg LaMontagne
Scientific Crew: Dennis Wellman and Laureen Gunter

PRE-FLIGHT:

On ground state parameter check:
Pmb = 983.00, Aircraft Pmb = 984.05
Dry/Wet bulb = 55.0°F/62.0°F; calculated T_d 8.9°C
T/T_d (AC) = 17.14°C/9.74°C

During flight:
1 dynamic zero SO_2 ≈ 10 minutes
2 Cal 1 on H_2O_2; 2 zero's on H_2O_2

IN-FLIGHT:

[GMT]
131900 SEA started for cal's, FSSP on R-1, A/D
142330 engine start
143000 H_2O_2 off scale hi 10 V+
143300 ASASP pump on
143416 T/O
144000 @ 5500' - just out of BL
144230 With G-1 desc to 4500' to get in BL
144400 @ 4500' - on track
144700 90 mm 4-1 on - flow 181.7
25 mm AM12 on - flow 2.5
145200 turning N - IC formation over
145900 zero on H_2O_2
150230 turning to west; T_d to bal oops! turned it off instead - DLW took pix of power plant at NE corner turnpoint
150630 T_d to bal (for real)
150758 T_d to sample
151110 Turning south
151200 SO_2 to dyn zero - thin cirrus above
152200 SO_2 to sample - turning east
152700 90 mm 4-1 off - flow 183.2 -- leaving 25 mm on
152910 desc'ing to 3500'
153000 HS AM12 off - flow 2.5
153100 90 mm 4-2 on - 198.0 flow
25 mm AM13 on - flow 3.5
153200 heading N
154300 turning West
154730 H_2O_2 to zero
155218 turning to S
155800 40°03' 82°26 SO_2 > 64 ppb - offscale on 50 ppb range - didn't change range
160330 turning to east
161000 turning to CMH
161100 90 mm 4-2 off - flow 190.77

25 mm AM13 off - flow 3.27
161316 90 mm 4-B on
161700 HS AM14 BLANK pump off
161802 H_2O_2 CAL 1
162422 landed
162500 probes off; T_d off
162900 power on - SEA still running for cal's

Notes during flight: remember to put bottle back on separator
there is 19" vac on HS's - 13" on 90mm
holds 53.4 steady on H_2O_2 temperature

Flight time:
2 hours 01 minutes

Sub total flight hours:
16 hours 30 minutes

1 May 1990
Data Flight 5 (Cloud Water)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Dennis Wellman and Menachem Luria

PRE-FLIGHT:

On ground state parameter check:
Pmb = 988.3, Aircraft Pmb = 988.01
Dry/Wet bulb = 55.0°F/47.0°F
T/T_d (AC) = 13.3°C/3.49°C

IN-FLIGHT:

[GMT]
124200 SEA started for cal's
142500 engine start - ASASP, FSSP on - VRA,TTD,RO
142800 ASASP pump on
143900 takeoff
H_2O_2 reset Cal 2 run?
144700 Dpt balance OK
144800 Checking LWC looks OK R 0-6
heading ESE toward Zanesville
H_2O_2 flow looks good
in cloud but can see ground below
145500 doesn't look like H_2O_2 changed - H_2O_2 to Cal 2 - just pushed
@ 4000'
145600 out of cloud - null LWC R 0-1
150900 descending to 3000 RAVES intersection - clouds too thin to sample
151400 looks like a plume of some kind here
151515 in some thin cloud - ≈ .-1 gm^{-3} - 30 mi CMH heading W - ANVEL
intersection 165/35 Appleton VOR - some precip from above
151945 H_2O_2 zero
152000 climbing to 5K

152300 H_2O_2 flows: sig 1.156; bkg 1.162 OK! - in precip
152400 climb to 6 - H_2O_2 440, 455
152900 climb to 8K-9K ANVEL W side
153400 rain showers - broke out
153500 will RTB
153502 H_2O_2 to cal 2
153542 LWC off
154400 descending toward CMH
154600 H_2O_2 to cal 1
154800 on final CMH
154930 landed
155125 Quit SEA

Flight time:
1 hours 24 minutes

Sub total flight hours:
17 hours 54 minutes

2 May 1990
Data Flight 6 (Cloud Water)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Dennis Wellman and Laureen Gunter

Prior to the flight, a ground test of the King Air's FSSP was performed:

[GMT]
125234 SEA started
131300 water sprayed thru FSSP - R-0, A/D
131600 more water
132000 vacuum @ 65 V
132320 1-4 μm
132530 3-9 μm
132800 8 μm *new Dukes*! globbed up
132930 25-35 μm
≈1334 stopped SEA
134500 same test being done on G-1's FSSP

PRE-FLIGHT:

On ground state parameter check:
Pmb = 994.5, Aircraft Pmb = 995.29
Dry/Wet bulb = 58.5°F/45.0°F
T/T_d (AC) = 14.86°C/-5.21°C

IN-FLIGHT:

[GMT]
160700 SEA started for cal's - FSSP R-0 A/D to start
180300 engine start - power cart kicked off during engine start
180700 T_d off/on
181600 H_2O_2 Cal 1

181800 ASASP on
181830 T/O
182600 @ 9000 T = 3.5°C, T_d = -41.7°C
182916 flushing 90 mm & 25 mm system
184000 cell - Henderson W to York (developing)
184300 T_d to bal
184422 T_d to sample
184500 pre-cloud check of LWC - all OK
185000 H_2O_2 to zero
185100 zero on SO_2
190100 SO_2 to sample
190510 turning right over Elkins - going to BOIER intersection
190600 ovc 10-12K above us
layer below ≈ 1000' - layers sct to bkn
191130 turning on LWC to see if these intermittent clouds have water
191430 fairly solid clouds now - 38°30' N, 79°40' W
191700 out of cloud now - thin layer below
191800 returning to CMH - need Mohnen collectors
192000 FSSP to INB/DEL Range 0
192550 LWC off
192700 H_2O_2 to cal 1
193000 in precip
193030 indicated airspeed 180 - TAS 101 m/s
193130 heaters on probes
193200 FSSP to ACT/DEL
193500 FSSP to INB/DEL
194200 probe heaters off - back to ACT/DEL
194700 in precip
195900 H_2O_2 to cal 1
202800 landed
203000 ASASP/FSSP off - all else off - getting GPU
205200 QUIT 1st tape - going out again

Notes during flight: reinstall right seat - not in track; fix loose intercom nuts - right side

During second flight - on the H_2O_2 do 2 zeros back to back, then 2 pt cals back to back

Flight time:
2 hours 25 minutes

Sub total flight hours:
20 hours 19 minutes

NOTE: The second cloud water flight on 2 May was canceled.

3 May 1990
Data Flight 7 (Cloud Water)
Flight Crew: Tom Gates and Gregg LaMontagne
Scientific Crew: Dennis Wellman and Laureen Gunter

PRE-FLIGHT:

On ground state parameter check:
Pmb = 996.5, Aircraft Pmb = 997.37
Dry/Wet bulb = 56.0°F/47.0°F
T/T_d (AC) = 11.72°C/0.33°C

During flight instructions: H_2O_2: only zeros, no cals
SO_2/NO same instructions as yesterday

IN-FLIGHT:

[GMT]	
125548	SEA started for cals FSSP R-0, A/D
145330	engine start
150330	ASASP pump on
150530	T/O
151000	King LWC turned on for dry air term
151330	7000 sct w ovc cirrus vis 12 - Finly 55° - winds SE @ 4 30 SE of CMH - occ lite turb @ 6000'
151500	SO_2 to sample @ 8000'
151520	NO to span @ 8000'
151730	in lite rain/cloud
151800	H_2O_2 to zero
152024	NO finish span - put on remote
152500	clouds thinning out - going to try 10K'
152620	up to 10K'
152740	@ 9000 - back in cloud - not real thick - can see to ground - still lite precip
153000	@ 10000' - lite cloud - can see to ground
153352	40°39', 83°59 hdg 290 to Allen City - putting collector out
153630	turning to S, but G-1 reports rain (heavy) @ Rosewood
153750	turning back around to N
153900	collector not getting any water - too dry - leaving collector out
154130	requesting up to 12K' - cloud too thin - see ground
154500	slowing to 140 kts to see if any change
154920	collector out - nothing coming in - some lite ice on it
155000	up to 12K' - hdg to Waterville
155030	collector back out on asc to 12K' - @ 11.5 freezing level
155220	@ 12K' T = -0.59°C; T_d = -5.79°C - can still see ground thru clouds
155300	heaters on probes
155500	H_2O_2 to zero
155530	SO_2 to dyn zero
155930	turning - hdg to CMH
160030	SO_2 to sample
160230	O_3 accidentally turned off - < 1 minute
160300	collector in - nothing

160430 back to 160 kts
160900 thin cirrus deck 7-about 14K' - dry
161144 40°58', 83°27' sun shining thru cloud - can see to ground
161320 desc to 10K'- T = 56°F; T_d = 39°F
162000 request for direct to Rosewood

Note: Weather for various areas - Dayton: 5000' sct, 8000' ovc, T = 52°F, winds 120 @6; Cincinnati: 25000 bkn, 12000 ovc, winds 060 @6; Lunkin (sp?): 3000 bkn, T = 54°F, winds 030 @11; Wright Pat: 4000 sct, lite rain wind 100 @7, T = 54°F

162045 hdg to Rosewood (SW)
162200 probe heaters off T = 4.09°C, T_d = .67°C
162900 H_2O_2 to zero
163000 lite precip - clouds getting a little thicker - can still see thru up and down
163800 FSSP to INH/DEL R-0 thin cloud - lite precip
164300 12 mi from Dayton broke out of cloud
164400 hdg to Wright-Pat (SE)
164900 over Dayton - thin cirrus about - cloud to east
165030 adj dry term on King LWC
165100 turning to CMH
165400 putting collector out
165800 still thin cloud
170030 bottle on for Faust
170240 desc to 7000' - approach CMH
170400 collector in - no water in bottle (off) - clear now (in no cloud)
170800 lite precip
171500 landed
171800 all off - QUIT SEA

Flight time:
2 hours 22 minutes

Sub total flight hours:
22 hours 41 minutes

6 May 1990
Data Flight 8 (Cloud Water)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Dennis Wellman and Laureen Gunter

PRE-FLIGHT:

On ground state parameter check:
Pmb = 984.1, Aircraft Pmb = 985.06
Dry/Wet bulb = 51.0°F/46.0°F
T/T_d (AC) = 10.46°C/10.46°C (couldn't do T_d - saturated)

IN-FLIGHT:

[GMT]

121100 SEA started for cals FSSP A/D R-0
142740 engine start
143400 put NO_x to M5Z
143700 ASASP pump on
143800 T/O
144150 SO_2 to sample/NO_x to sample
144420 adj dry term on King LWC
144700 on King LWC chg R to 0-1, adjusted on the 0-6
144930 flushing 90 mm FP system
145400 G-1 @ 3500', we're @ 5500' - hdg to Henderson - T = 5.26°C
T_d = -6.73°C
145700 H_2O_2 to zero
150500 continuing S to Charleston - hi thin clouds above - thin sct @ Charleston (reported)

Note: dynamic zero has regular tick in it

151300 1500' ovc - lite rain reported @ Huntington
151630 hdg to Huntington
151900 clouds thickening as we go - bkn below
152100 turning to Newcomb VOR
152500 47 DME E of Newcomb VOR - G-1 at 3000' - bkn layer above them; we're @ 6000' bkn below - thicker deck above us ≈ 1000' - lite precip
152800 tops @ 12000' Huntington reports - vis 6 lite rain 1500' ovc
153130 G-1 @ 1000 AGL - in lite rain - we are heading to CMH - G-1 finishing their box
153400 icing on wings
155100 @ 6000 - lite icing - lite precip (lite ice and snow) - lite turb
160336 LWC off
160600 H_2O_2 cal 1
161430 landed
161440 ASASP off
161530 probes off/T_d off

Flight time:
1 hour 47 minutes

Sub total flight hours:
24 hours 28 minutes

7 May 1990
Data Flight 9 (SE_Zipper)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter and Bobbi Watkins

During flight: on stair step profile: NO_x to M1/M2 (3 min each)

PRE-FLIGHT:

On ground state parameter check:
Pmb = 987.8, Aircraft Pmb = 988.94
Dry/Wet bulb = 65.0°F/54.0°F
T/T_d (AC) = 17.43°C/6.88°C

IN-FLIGHT:

[GMT]	
130700	SEA started for cals FSSP R-1 A/D
154330	engine start
155940	ASASP on
160210	@ 4000'
160700	887.6 Pmb (barometer); Aircraft pressure 880.58 just @ base of clouds
161200	G-1 behind us on right - never got alongside
161730	turning onto track
161900	going up to 6500'
162210	@ 6500' - clouds all around - at cloud tops
162230	M1 on NO_x
162530	M2 on NO_x - clouds building
162830	up to 8500'
163050	@ 8500' NO_x to M1
163350	M2 on NO_x
163650	up to 10500'
163850	@ 10500' M1 on NO_x
164150	M2 on NO_x
164230	H_2O_2 to zero
164450	desc to 4000'
165230	@ 4000'
165300	90 mm 8-1 on - 192 lpm; 25 mm AM11 on 6.24 lpm → 5.78
171300	H_2O_2 - 2 pt cal (using Battelle's standards)
171930	turbulent/choppy - hard to write anything - hard for pilots to maintain 160 kts
174000	882.38 Pmb (aircraft) - 890.6 Pmb (barometer)
174100	turning onto N track
174300	90 mm 9-1 off; 25 mm AM11 off

Note: Filter packs: some have 4 stages - some have 5 - used empty pack's ring (on back)

174900	90 mm 9-2 on flow 206.6→202 lpm; 25 mm AM15 on flow 5.95→5.61 lpm
180400	883.6 Pmb (barometer) 880.6 Pmb (aircraft)
181100	T_d to bal
181228	T_d to sample
181300	H_2O_2 to zero
≈1825	pH signal square waves dynamic P really noisy - can't distinguish definite peaks
183400	90 mm 9-2 off flow 193; 25 mm off flow 5.5
183630	90 mm 9-B on (BLANK)
184200	90 MM 9-3 on flows 203→198; 25 mm AM17 on flow 4.39

185340 turning to CMH - fuel considerations
190206 going under cloud deck - right at bases
192020 AC hdg 94; display 89
192700 90 mm 9-3 off flow 198.8; 25 mm AM17 off flow 4.13
193000 H_2O_2 to cal 2 pt (Battelle's standards)
194100 landed - probes/T_d off - leaving gas anal/H_2O_2 on

Note: on unloading filters - blanks back ring had no O-ring; all Li filters had yellow O-ring stain

Flight time:
4 hours 00 minutes

Sub total flight hours:
28 hours 28 minutes

8 May 1990
Data Flight 10 (NE_Zipper)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter and Bobbi Watkins

PRE-FLIGHT:

On ground state parameter check:
Pmb = 988.6, Aircraft Pmb = 989.70
Dry/Wet bulb = 66.0°F/56.0°F
T/T_d (AC) = 18.70°C/9.53°C

Instructions for NO_x instrument: M1 and M2 during comparison time

IN-FLIGHT:

[GMT]
122100 SEA started for cals
143500 stop SEA to change position tables
143614 SEA started again FSSP R-1 A/D
145300 SO_2 to sample
145910 engine start
151040 ASASP on
151120 T/O
151500 @ 4000' NO_x to M1 - just barely in BL (it looks like) - choppy ride
T = 16.5°C, T_d = 6.28°C
151700 G-1 off to right KA 170 kts
151900 NO_x to M2 - LORAN showing 42 hdg, display 37 hdg
152300 NO_x to M1
152700 NO_x to M2
153100 NO_x to remote - done with IC
153200 turning to S track
153330 up to 6500' 1000'/min
hazy on climb - not well-defined BL T/T_d not indicating - still large particles (FSSP)
153630 @ 6500' NO_x to M1

153930 NO_x to M2 – sct clouds above, hazy below – smoother ride – lite turbulence
154230 up to 8500'
154400 @ 7000–7500 at very top of BL (visually and meteorologically)
T = 9.11°C, T_d = -20.5°C – few clouds off to the east above it
154500 NO_x to M1
154800 NO_x to M2
155100 up to 10500'
155330 @ 10500'
155400 NO_x to M1
155600 flush 90 mm system
155700 NO_x to M2
160000 desc to 4000' 1000'/min
160430 @ ≈ 6500 back into BL – choppy/turbulent ride again – can't write well
160730 @ 4000'
160800 90 mm 10–1 on flow 198
25 mm AM18 on flow 3.35
161230 thin cirrus above/sct fair weather CU's also – haze to ground
161500 high SO_2 crossing river
162000 H_2O_2 to 2 pt cal
162140 re-setting H_2O_2 to 1 pt cal (CAL1)
163800 clear above now – still hazy – still quite turbulent
165300 90 mm 10–1 off flow 194.77
leaving 25 mm on as requested (for 2 90 mm's)
165400 turning onto NW leg
165600 90 mm 10–2 on flow 188 – 183 3 min later
25 mm flow 3.63
171000 cirrus above O_3 = 61, SO_2 = .8 V
171100 H_2O_2 to zero
172900 right @ cloud base (≈ 500' above us – if that)
sct cirrus above them
174100 90 mm 10–2 off flow 195
25 mm AM18 off flow 3.8
174320 90 mm 10–B BLANK exposed
174700 90 mm 10–3 on flow 197
25 mm AM19 on flow 4.14
175600 thickening deck above
180630 turning to CMH
181200 SO_2 high in approx location (latitude) as 1st encounter – TG says winds from W/SW at ≈ 10
181500 H_2O_2 to zero
182200 ≈ 39°25' N, 84°24' W, SO_2 4.2 V
183000 H_2O_2 to CAL1
183300 90 mm 10–3 off; 25 mm AM19 off
184950 landed – lousy landing
185100 T_d off – probes off – leaving on for cals
185108 SEA to stop

Flight time:
3 hours 50 minutes

Sub total flight hours:
32 hours 18 minutes

9 May 1990
Data Flight 11 (Pre-frontal)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter and Stan Wilkison

PRE-FLIGHT:

On ground state parameter check:
Pmb = 986.3, Aircraft Pmb = 986.6
Dry/Wet bulb = 66.0°F/56.0°F
T/T_d (AC) = 18.1°C/9.5°C

IN-FLIGHT:

[GMT]
120800 SEA started for cals
134600 SEA 'stop'
134700 SEA started for flight FSSP R-1 A/D
134830 engine start
135522 SO_2 to sample
135600 H_2O_2 to CAL1
135720 T/O
135830 ASASP on
140100 hazy (very)
140300 cloud bases ≈ 6500' - 1st layer ≈ 500' thick
140400 BL top ≈ 8000' - 7500'
140500 flushing 90 mm system
140700 @ 10000'
141000 90 mm 11-1 on flow 179 - was 168 @ 10.5K'
25 mm AM20 on flow 2.4 was 2.1 @ 10.5K'
141200 going to 9500' - we were getting into cloud deck above us - T_d going up - bumpy ride
141400 @ 9500 - much better - T_d OK
141600 turned S - @ 9500'
143900 turning to SW - just before turn, cloud deck above us was lowering
144234 now clear skies above - sun shining even
144300 H_2O_2 to zero
144800 G-1 90 from Livingston @ 4000' - they are in haze
145500 up to 9700 - BL coming up
150000 90 mm 11-1 off flow 181.5
25 mm AM20 off flow 2.5
150100 going up to 10.5 - BL right at
150200 @ 10.5 - clouds about 1000' above us now
150400 90 mm 11-2 on flow 157
25 mm AM21 on flow 2.89
150700 clouds thickening above us - ≈ 1000' above - BL only ≈ 1000-1500' below us
151300 cloud deck above us getting thinner and higher
151646 T_d to bal
151830 T_d to sample
152200 G-1 hdg 011 @ 4000'
152300 clouds thickening below us - building CU's - deck above us thin -

still about 1000′ above
152500 now clouds below us are sct – still building CU's
152800 turning to N a little early – cloud deck above us came down – we're in lite cloud
153000 FSSP counts shot up – moving E to get out of cloud
153700 still hdg E – 42° hdg
154100 going to 9500′ to avoid clouds
154400 hdg more E – haze/cloud ahead – clear layer disappearing on us
154800 skirting clouds – trying to get clear
155100 skirting around big build-up – est. 13K′ top
155400 stopped 90 mm filter pack flow 165 – leaving Herman's on
155540 putting blank on – going to 10500′
155720 at 10500′ – Stan is still awake!
155800 filter pack 90 mm 11–3 on flow 161; AM21 still on – going to 11500′ – cloud deck below has risen
160200 hdg 353 – thin deck above 38°29 N, 84°13′ W – building CU's below – smooth flight now
160700 clearing as we head N – thick cloud deck below, blue skies, thin cirrus above – 11500′
161900 clouds above us getting thicker and lower
162400 now clouds below and above thinning out
162800 going to 11K′ – clouds above us again thickening and lowering
163000 going to 10.5K′ – still clouds
163300 momentary encounter with cloud – small area of deck lowering – clear ahead
163730 T_d to bal
163838 T_d to sample
163900 right at top of mixed layer now
164000 up to 11K′ just to be sure
164530 turning to CMH – going to 11500
164800 90 mm off – 25 mm off – changing 90 mm at 11500
164900 start 90 mm 11–4 – at 11500′
165300 descend to 10500 – tower request
165600 thickening cloud deck above ≈ 500′
165900 going to 10.4K′ – clouds lowering – clouds thickening again below us – CU's building – circumnavigating
170930 90 mm 11.4 off – on approach to CMH – only 18 min exposure
171130 H_2O_2 to CAL1
172050 another jerky landing
172830 SEA to "stop"

Flight time:
3 hours 32 minutes

Sub total flight hours:
35 hours 50 minutes

10 May 1990
Data Flight 12 (Cloud-water)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Dennis Wellman and Laureen Gunter

PRE-FLIGHT:

On ground state parameter check:
Pmb = 973.4, Aircraft Pmb = 974.3
Dry/Wet bulb = 60.0°F/48.5°F; calculated T_d = 2.22°C
T/T_d (AC) = 13.6°C/2.29°C

IN-FLIGHT:

[GMT]	
152600	SEA started for cals FSSP R-0 A/D
170758	engine start
171600	SO_2 to sample
171704	ASASP on
171756	T/O
171930	checking dry term on King LWC
172200	cloud bases 5000-5100
172244	no water in clouds (King)
172400	lite rain lite turbulence
172444	-4°C @ 8000' - icing
172600	going to 6000'
172650	ice on windshield
172830	@ 6000' -0.14°C - in/out of bases - lite water - ice
173200	clouds thinning out - sct to bkn
173320	in cloud again T = -1.8°C; T_d = -4.0°C at 6000' - lite ice
173610	0-1 range King LWC - nulled (dry term)
173824	heaters on probes
173900	in/out clouds T = -1.42°C; T_d = -4.88°C
174200	moderate turbulence 15 miles to Finlay - cold - more cloud - RTB'ing
174400	request 8000' to clear clouds/turbulence
174410	up to 8000'
174600	@ 7500 cloud top
174646	@ 8000' T = -4.03°C; T_d = -10.97°C - nice and smooth
174830	some building CU's - tops @ ≈ 8000-8500'
175556	ice on windshield - in cloud 7500'
180000	@ 5000' - cloud base T = 3.4°C; T_d = -1.38°C
180108	King LWC off
180118	probe heaters off
180940	landed - turning all off
181034	SEA to "stop"

Flight time:
1 hour 02 minutes

Sub total flight hours:
36 hours 52 minutes

11 May 1990
Data Flight 13 (Post-frontal)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter and Bobbi Watkins

PRE-FLIGHT:

On ground state parameter check:
Pmb = 986.6, Aircraft Pmb = 987.77
Dry/Wet bulb = 60.0°F/43.0°F
T/T_d (AC) = 9.44°C/0.63°C

Instructions for instruments in-flight: H_2O_2 - zero; NO_x - dynamic zero at altitude; SO_2 - dynamic zero at altitude

IN-FLIGHT:

[GMT]
SEA started for cals FSSP R-1 A/D
144800 engine start
150000 ASASP on
150200 T/O - to 9500'
150700 5800' top of mixed layer - cloud bases
150900 H_2O_2 to zero
151000 flushing 90 mm FP system
151100 going up to 10.5K' - we're out of the BL for sure but its hazy and this will keep us out as it builds
151300 @ 10.5 T = -0.5°C
151700 90 mm 13-1 on flow 170 lpm; 25 mm AM22 on flow 1.98 lpm turning S on track
152130 clear skies above, hazy to ground - sct clouds below - thin dirty layer to the west a little below us

Note: Dyn Pressure (V) has regular tick in it (as before)

153630 turning to SW
154300 to the SE - thin cloud layers ≈ at out level; to the NW - dark thin layers ≈ a little lower - hard to tell altitude of layers - clear above
154500 H_2O_2 to zero
160700 90 mm 13-1 off flow 177.7 - leaving 25 mm AM22 on
160900 90 mm 13-2 on flow 199 lpm - dirty haze layer becoming more defined - still looks a little below us - thin cirrus above
T = 2.66°C; T_d = -38.94°C
161300 NO_x to M5 zero; SO_2 to dyn zero
161800 NO_x to M6 zero; SO_2 still on dyn zero
161930 becoming hazy(er) - more cloud layers ahead of us - still high thin cirrus above

Note: winds were less down S (on the average of 20 kts) - winds when we leveled out after takeoff were ≈ 40-45 kts

162300 SO_2 to sample; NO_x to sample (remote)
163100 turning to N
163300 really defined dirty purple haze layer to the W – we must be just above it – smooth ride
164900 as we head N dirty haze layer getting less defined and thinner – haze to ground
165400 90 mm 13–2 off flow 199
25 mm AM22 off flow 1.95
165700 90 mm 13–3 on flow 164
25 mm AM23 on flow 2.85
170500 very high thin cirrus above, haze to ground below – T down to .80°C; T_d = –39.80°C – getting colder as we head N
171200 no haze layer detectable (visually now) – coming back into sct clouds below, clear skies above
171530 crossing river – winds ≈ 40 kts again from ≈ 303° – est from LORAN input
173300 H_2O_2 to zero
173400 sct clouds off to the E & W – haze layer appearing again – more haze to ground now – fairly dirty looking – dark – not too much cloud under us
174000 now sct clouds dissipating to W to just a few sct clouds still to the East
174700 90 mm 13–3 off flow 191
leaving AM23 on flow 2.44
174820 09 mm 13.B BLANK exposed
175000 90 mm 13.4 on flow 191 – clouds disappearing off to E – hazy to ground – we are just barely at top of haze layer – some stratification at the top – wind 309/28
175340 T_d to bal
175520 T_d to sample
180100 turning to CMH 40°58'N, 84°27'W
180800 T = –4.20°C; T_d = –25°C (but it's oscillating too much now to give a good reading) – sct clouds also now
182400 90 mm 13–4 off flow 193
25 mm AM23 off flow 2.32 – both changed when TAS changed
182800 cloud top 7700–7600'
182900 bases ≈ 6500
182930 H_2O_2 to CAL1
183420 landed – probes/T_d off – leaving SEA on for cals

Flight time:
3 hours 46 minutes

Sub total flight hours:
40 hours 38 minutes

12 May 1990
Data Flight 14 (Cloud-water)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter and Dennis Wellman

PRE-FLIGHT:

On ground state parameter check:
Pmb = 990.7, Aircraft Pmb = 991.9
Dry/Wet bulb = 53.0°F/45.0°F
T/T_d (AC) = 10.4°C/1.7°C

IN-FLIGHT:

[GMT]
080400 SEA started for cals FSSP R-0 A/D
100000 engine start
101030 SO_2 to sample, NO_x to remote, ASASP on
101130 T/O
101430 King LWC on dry air term 0-1 range
101730 T_d to bal
101840 T_d to sample
101900 @ 8000' - just below cloud
103300 lite precip on windshield
103500 probe into buffer solution - reading 4.16 - should be 4.1
103628 reading 4.11 in buffer solution
104000 in cloud - lite ice/snow on windshield - lite chop (lite to mod)
104400 going down to 7000' - lite ice
104500 @ 7000' - can see to ground
104800 PIREP: from Richmond area - bases @ 9000' - sct layers
105016 lite rain
105120 up to 8000' - back into cloud - G-1 in rain near Columbus - going to Cleveland - 40°08'N, 83°09'W: G-1's position
105430 getting warmer as we go south T = 4.32°C; T_d = 0.19°C
105530 going to 9000'
105622 collector out
105720 @ 9000 T = 3.07°C; T_d = -.67°C - in cloud, lite precip
110114 Bottle # 1 on
110540 up to 10000; - small amt of water in Bottle 1 - lite precip
110640 @ 10K' - 0.1-.05-.01 readings on King LWC

Note: weather reports for Huntington 4000-5000 sct, 7500 ovc, grd T = 50°F; Charleston 9000 vis 1.2; Lexington 9000 1.0 vis T = 54°F on grd, winds 130/8

110900 90 mm 14-1 on flow 167; 25 mm AM24 on flow 2.2
111110 bringing in collector to check for ice - ice on collector - ice on windshield
111230 going to 9000'
111258 heaters on probes
111414 snowing - rain mixed with snow @ 9000'
111702 collector going back out - Bottle # 1 still on - ice melted and ran into it

111800 at bases - can see through to ground
112430 mod-heavy snow - ice
113200 in thin cloud - can see to ground - still lite precip
113630 in turbulence - at cloud bases
113900 now out of cloud
113950 turning E
114050 readjusted King LWC to 0.0 (was reading slightly neg)
114400 H_2O_2 to zero
114550 clouds getting a little thicker - still lite precip
115510 going to 10000'
115646 @ 10000' - snow mixed with rain
115744 putting collector w/pH out
120030 turning N
120400 90 mm 14-1 off flow 163 - 25 mm still on
120800 90 mm 14-2 on flow 179
121040 25 mm flow on AM24 went to 13 lpm+ - appears to be a hole

Note: opened 25 mm AM24 after flight - filter sucked in - couldn't tell if it had water or not - 90 mm's didn't have and they were on the separator also

121206 25 mm AM25 started - circuit breaker popped
121400 AM25 started flow 3.86
121540 going to 9000'
121700 @ 9000' - lite precip - mod thick cloud
123110 pH probe being put in place

Note: pH display different than meter - ? pH count V neg (-2.7)

123900 slowing to 150 kts (indicated)
124700 desc to 8000'
124800 @ 8000' - mod rain - in/out cloud - at bases - can see to ground at times
125800 90 mm 14-2 off flow 195
25 mm AM25 off flow 4.27
≈1259 standard back in pH meter
130200 bringing collectors in
130400 in precip (mod) on approach to CMH
≈1305 probe heaters off
130920 King LWC off
131110 landed
131220 SEA to QUIT - all off

Flight time:
3 hours 12 minutes

Sub total flight hours:
42 hours 50 minutes

13 May 1990
Data Flight 15 (Cloud-water)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter and Dennis Wellman

PRE-FLIGHT:

On ground state parameter check:
Pmb = 979.3, Aircraft Pmb = 980.1
Dry/Wet bulb = 59.0°F/58.0°F
T/T_d (AC) = 14.6°C/11.8°C

IN-FLIGHT:

[GMT]
122000 SEA started for cals
135450 SO_2 back to zero FSSP R-0 A/D
135540 engine start
140500 NO_x and SO_2 to sample
140630 ASASP on
140720 T/O
141000 King LWC on - clear air term
141030 ≈ 3500 cloud bases
141130 putting collector out side port - Bottle # 1 on
141300 tops of clouds 6500' - out of cloud - going back down to 4K'
141600 @ 4000 - lite precip on windshield
141700 90 mm 15-1 on flow 174→170
25 mm AM26 on flow 3.32

Note: pH counter doesn't work - too much air going into it. Bottles don't fit collector!

141800 collector with pH sensor out top port
142100 in mod rain - turning to NE - back to near CMH
142744 Bottle # 2 on - pH collector
143150 in heavy rain - turning to get out
144000 disconnected pH (temp)
144130 reconnecting pH sensor - still in mod precip - still @ 4000'
144800 Bottle # 1 off
144824 Bottle # 3 on - side port
144900 mod rain - hdg NE
145250 15 mi W of Lanka (sp?) intersection - in clear
145600 back in cloud - heavy rain
145800 now in clear air - thin clouds below
150000 90 mm 15-1 off

Note: Orion goes to zero periodically - why? Drill hole in pH sensor block.

150340 in very heavy rain - going to Zanesville
150600 in clear layer now
150720 now back in cloud - in/out
150900 E of Rickenbacker, W of Zanesville - front position reported

151000 again in/out clouds
151200 going to Appleton
151530 back in cloud and mod precip
151700 H_2O_2 to zero
152000 still mod precip
152220 Bottle # 3 off
152300 Bottle # 4 on - side port
152500 in heavy rain - under cloud
152600 25 mm AM26 - filter sucked in
152800 up to 6000'

Notes: When probe was in buffer solution (4.10) was showing 3.84 then jumped to 4.89. Put pH probe in pH sensor waste water - reads 3.54. Temp not reading correctly on Orion - reading temp .9

153000 @ 6000' - mod rain
153100 going to 8000'
153316 @ 8000' - lite to mod rain - cloud not too thick
153500 hdg SW towards CMH
153820 taking probe out of pH block - putting in buffer solution - reading 3.84 - should be 4.10
154130 8 mi NE of CMH - lite precip - in/out of cloud
154340 NE to SW - front line reported in CMH area
154600 thin cloud/blue skies above - we're in clear now
154700 probe in buffer solution was showing 3.84 then jumped to 4.89??
155000 SW of CMH @ 8000' - lite to mod precip
155450 put pH probe in waste water solution from pH - measuring 3.58 - now back in buffer - measures 3.77
155800 probe back in pH block - @ 7000' now - lite precip

Notes: No water being held in probe cell - being blown out. pH reading on Orion goes down when no water is in probe cell. Wire on pH probe pulling probe out of cell.

160300 going to 5000' - got into clear
160700 @ 5000' - in lite rain - in/out still
161040 going to Clyde intersection
161516 Bottle # 2 off
161544 Bottle # 5 on (pH block)
161644 Bottle # 4 off
161800 Bottle # 6 on (side)
162300 going to 5000' - in clear layer now - in/out again - layering all around
162500 @ 5000' - in cloud now - occasionally can see to ground
162730 slowing to 150 IAS
163220 15-B BLANK RUN (90 mm)
163300 side port collector in
163700 top port collector in

Notes: Black, greasy residue on side port collector - top port collector dirty also. Need to figure out support for cone when on separator. (done)

164200 clear air term on King LWC
164230 King LWC off
164600 cloud base 1500–1800′
164700 landed – T_d and probes off – leaving SEA on/H_2O_2 and analyzers on

Flight time:
2 hours 52 minutes

Sub total flight hours:
45 hours 42 minutes

14 May 1990
Data Flight 16 (NE_Zipper)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter and Stan Wilkison

PRE-FLIGHT:

On ground state parameter check:
- Pmb = 993.4, Aircraft Pmb = 994.3
  Dry/Wet bulb = 56.0°F/50.5°F
  T/T_d (AC) = 11.9°C/7.4°C

IN-FLIGHT:

[GMT]
120242 SEA started for cals FSSP R–1 A/D
145350 engine start
151038 ASASP on
151130 T/O
151330 ≈ 3000–3200 top of BL – cloud base
151700 G–1 alongside
153300 turning to S
153434 up to 6500′
153730 @ 6500′ – M1 on NO_x – hazy
154030 M2 on NO_x
154250 flushing 90 mm FP system
154410 up to 8500′
154618 @ 8500′ – M1 on NO_x – in haze or cloud layer – lite chop – clear above
154928 M2 on NO_x
155230 up to 10500′
155500 @ 10500′ NO_x M1
155800 NO_x to M2
155900 coming into cloud layer above us – in cloud/haze layer here too
160100 down to ≈ 3000′ – we′ll see where BL is – G–1 is at 3000′ at last communication – NO_x to remote
160300 layer beginning ≈ 8500–7000′
160900 3700′ top of BL
160930 @ 3000′
161000 90 mm 16–1 on flow 197 lpm
161500 high NO_x – high SO_2 (offscale)
161600 over river – going right by power plant

161900 just barely in BL now - right @ cloud base
162200 going to 2500'
162600 still as we go S the BL is shallow - cloud base only ≈ 200' above us - high cirrus above
163000 getting hazy all around
164500 going up to 3000' - need to clear hills, towers, etc. BL now building
164600 @ 3000' - not as hazy now - cloud base still ≈ 500' above
165100 H_2O_2 to zero
165500 90 mm 16-1 off flow 187
165600 90 mm 16-2 on flow 182.7
165700 up to 3500' - turning NW to clear terrain
170700 sct clouds above - haze SW/NE - thin cirrus up high
170900 coming into more cloud/more haze
171420 down to 3000' - right at bases
171500 @ 3000'
173000 < 200' from cloud base
173500 more cloud overhead - moderate thick layers - one ≈ 200-300' above - high layer - hard to tell - maybe 10K' - 8K'
174100 90 mm 16-2 off flow 200
174320 90 mm 16-B BLANK exposed
174400 90 mm 16-3 on flow 200
174600 Cincinnati reported ceilings @ 2400 - we are coming into lower clouds/hazy conditions
175200 turning to CMH - fuel considerations
175400 down to 2500' - clouds
175506 @ 2500'
180100 H_2O_2 to zero
182500 H_2O_2 to CAL1
182900 90 mm 16-3 off flow 210
183430 landed - not bad
T_d off - probes off
leaving SEA on

Flight time:
3 hours 23 minutes

Sub total flight hours:
49 hours 05 minutes

16 May 1990
ASASP Test (with G-1)

[EDT]
110000 purged each ASASP (G-1's and KA's)
110500 .198 μm started into KA - not enough concentration
110930 .198 μm input to KA - not enough concentration
111200 .198 μm again
111330 out of KA
111400 .198 μm to G-1 (seeing Bin 2 & 3)
111800 out of G-1
112730 .945 μm to G-1
113000 .945 μm to KA (seeing Bin 8)

113545 1.32 μm to KA (seeing Bins 9 & 10)
113700 out of KA
113730 1.32 μm to G-1
113900 out of G-1

Note: G-1 seeing each size correctly

≈1142 ASASP on KA shut off

Notes: 16 May, 1990, Del P grounded at A/D to take out noise in signal. Changed on-ground del p from ≈ -7 to ≈ -12. [This note was added by rlg on May 9, 1991]

On 16 May buffer solution checked - in lab

Filter information as of 5/15/90: Teflon filter # H9JK88007A
Nylasorb Lot # 0032903
Li batch prepared on 5/1/90

Teflon used first were the 1st ones sent (batch # not recorded)
Next: from the 2 batches sent out second - did not record batch # used - the above # is the only pack left

Cloud water flight was scheduled, calibrations started, then flight was canceled.

17 May 1990
Data Flight 17 (Cloud Water)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter and Dennis Wellman

PRE-FLIGHT:

On ground state parameter check:
Pmb = 976.1, Aircraft Pmb = 976.8
Dry/Wet bulb = 64.5°F/61.0°F
T/T_d (AC) = 17.0°C/13.8°C

IN-FLIGHT:

[GMT]
112652 SEA started for cals FSSP R-0 A/D
123100 engine start
123626 H_2O_2 to zero (was going offscale)
124000 ASASP on
124040 SO_2 to sample
124050 NO_x to remote
124100 T/O
124230 cloud base 2000' - thin sct layer
124320 dry term on King LWC 0-1 range

124600 lite rain - right at bases of 2nd layer
124730 moderate rain going up to 7000'
124900 going Zanesville to Belair @ 7000'
124910 collector out side port
125130 Bottle #1 on (off soon - in/out of cloud too much - not good)
lite to moderate rain; lite to moderate turbulence
125330 collector out top port - just popped out of cloud - clear ahead - going down - layer below
≈1255 pH hooked up - not pH count
125520 going to 4000' - have a block from 4-6K'
125640 ATC having us hold at 6K'
125710 T_d to bal
125810 T_d to sample
125830 approved now for block 4-6K' - tops @ 5800'
130100 @ 4000' - not as good as 5000' - going to 5K'
130200 now tops are 4800' - back to 4K'
130428 Bottle (top) # 2
130450 Bottle (side) # 1
130900 having to turn (ATC)
131300 having to turn (ATC)
131400 lite precip on windshield
131600 90 mm 17-1 on flow 156 lpm
132300 Bottle # 1 off (side port)
132330 Bottle # 3 on (side port)

Note: side port - no pH block; top port with pH block not as efficient as side

132800 drier clouds now - not much coming in - clouds thinning
133400 H_2O_2 to zero
133800 in/out thin/thick clouds along this path
133840 Belair to Parkersburg at 4000' [G-1]
134200 pH meter not acting correctly - not cal'd with buffer

Note: pH meter (Orion) jumped up

134616 out of cloud - turning
135100 lite to moderate turbulence
135600 90 mm 17-1 off flow 159
135800 90 mm 17-2 on flow 186
135940 .05-.08 (King) - lite precip - turbulent
140640 Bottle # 3 off (side port)
140700 Bottle # 4 on (side port)

Note: one tube on pH block collector seems plugged

141100 heavy rain - avoiding large cell - turbulent
141630 holes in clouds - occasionally clear down to ground - in/out
141800 29.69 Parkersburg altimeter
141930 S of Newcomerstown at 6000' [G-1]
142250 going to 5000' - in/out - holes all around
143200 @ 5000' back in cloud - lite to moderate rain - turbulent

143700 in good conditions now
143730 Bottle # 3 off (top)
143740 Bottle # 5 on (top)
144000 Bottle # 4 off (side)
144008 Bottle # 6 on (side)
144230 .10 g/m^3 on King - lite precip
145100 90 mm 17-2 off flow 180 lpm
145400 90 mm 17-B BLANK exposed
150000 severe wx warning - heading to CMH

Note: weather at CMH - 2800 bkn, winds 280/26; altimeter 29.79

150100 Bottle # 6 (side) off
150130 Bottle # 5 off (top)
150300 collectors coming in
150400 going up to 12K'
150700 @ 8000' heavy rain
150900 @ 10000' out of clouds - clear above - some tops @ 11500-12000'
151400 coming up on clouds with tops ≈ 15-16K' - we're at 12K'
151800 ASASP - power fluctuation - down to 4 V - back to 8 V
152140 up to 12.2K' momentarily
152300 probe heaters off - LWC heater off - speeding up to ≈ 180 kts
152600 pH meter affected by altitude - @ 12000' [rinsing probe in waste water from clouds - may have touched tip - needs rinsing] - now rinsing in buffer solution
153020 King LWC off
153100 now probe being put in buffer solution - reading 3.84 - should be 4.10 - 12K' - adjusting it to read 4.10 - opened 4/6/90 - % slope = 100% - T = 2.5°C (wrong?) - Orion now displaying 5.17
153420 descending to 8000'
153500 Orion now displaying 4.10 (we're descending now)
154332 Orion now displaying 4.12 - 7500' - T = -1.3°C (?)
154500 cloud tops ≈ 6500'
154700 cloud bases ≈ 4000'
154750 Orion now displaying 5.24 - 4000' - T = -7.3°C
155314 landed
155330 Orion now displaying 4.16 on ground - T = -1.5°C
155430 H_2O_2 to cal 1 - probes off; T_d off; SO_2 to zero; NO_x to zero; O_3 to zero - leaving SEA on for cals
174600 SEA to "stop" - awaiting IC decision or whatever

Flight time:
3 hours 22 minutes

Sub total flight hours:
52 hours 27 minutes

18 May 1990
Data Flight 18 (SE_Zipper)
Flight Crew: Gregg LaMontagne and Tom Gates
Scientific Crew: Laureen Gunter

PRE-FLIGHT:

On ground state parameter check:
Pmb = 985.0, Aircraft Pmb = 985.9
Dry/Wet bulb = 60.0°F/49.0°F
T/T_d (AC) = 14.8°C/2.7°C

Instrument instructions (for in-flight): H_2O_2 - zeros during flight, cal 1 on landing; NO_x - zero in flight (M6); SO_2 - zero in flight and during IC; NO_x - M1/M2 on stair step

IN-FLIGHT:

[GMT]

	SEA started for cals FSSP R-1 A/D
135200	O_3, NO_x, SO_2 starting out in zero
135930	engine start
140500	H_2O_2 to zero - was going offscale high - ? - pushed zero - it started to recover, then shot back offscale high ?
140910	T/O
141300	@ 4000' skimming BL right now
141500	G-1 alongside IC begin
141700	instruments to sample - NO_x to M1
141830	ASASP to on (oops!) - really rough ride!
142300	NO_x to M2
142830	NO_x to M1
143300	zero - passing plume
143330	BL coming up
143900	IC over

Note: pH signal (pH)(on display showing 10.34 - changing a little)

143930	splitting up
144000	climbing to 6500'
144200	instruments to sample - O3, NO_x, SO_2
144300	@ 6500 - NO_x to M1
144600	NO_x to M1
144900	up to 8500' - NO_x to M1
145100	@ 8000' - top of BL down here
154130	@ 8500' - NO_x to M1
145500	NO_x to M2 - coming into dark haze layer
145800	up to 10.5K'
145930	flushing 90 mm FP system
150000	@ 10.5K' - NO_x to M1
150300	NO_x to M2
150430	T_d to bal
150600	down to 4000' - yech! - T_d to sample

150700 NO_x to remote
151000 @ 7K' - BL top
151430 @ 4000'
151500 90 mm 18-1 on flow 196
155700 turning to N
160500 90 mm 18-1 off flow 190
160700 90 mm 18-2 on flow 191 - really turbulent!! - can't do a thing!!
165700 90 mm 18-2 off flow 188
165906 90 mm 18-B BLANK
170200 90 mm 18-3 on flow 185
171430 turning to CMH
172600 H_2O_2 to zero
175000 90 mm 18-3 off flow 188
175130 H_2O_2 to Cal 1
175800 landed - all off
175900 SEA to "quit"

Flight time:
3 hours 59 minutes

Sub total flight hours:
56 hours 26 minutes

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