

# WB57F AEROSOL MISSION; REPORT

## Summary

The WB57F Aerosol Mission was primarily designed to answer the chemist's first question: *what is it made of?* This was addressed mainly by the Particle Analysis by Laser Mass Spectrometry (PALMS) instrument, which showed that although sulfate was the most abundant anion, it rarely occurred in pure form as sulfuric acid. Organics were common; about a third of the individual particle mass spectra contained mercury, iodine and organics. Meteoritic material was also evident in the stratosphere, with soot being detected both beneath and above the tropical tropopause in a region of recent ITCZ activity. There is great chemical richness in the data, with 35 elements detected to date in the stratospheric aerosol. Statistics are expected to be good, with the number of particles detected on a typical 6.3 hour flight being 7 000 to 11 000.

There were seven flights of 6+ hour duration from Houston (30°N, 95°W), four south and three north, during April and May 1998. There are long legs, some along the tropopause, at altitudes ranging from 13.5 to 19 km at latitudes from 9°N to 47°N. The three northbound flights all encountered high PV air, particularly that in April, and there are also lengthy sections of flight track in the upper tropical troposphere. Cyclonic circulation associated with the Arctic vortex persisted at 70 mb until early June, with frequent peel-off.

It is expected that there will be a rich scientific return from the FCAS II, CNC, MASP, NMASS and ERAST particle sizing instruments; in addition there are measurements of water, ozone, methane, chlorine monoxide and nitrous oxide. The data from the Microwave Temperature Profiler look exceptionally informative about the dynamics on certain flights.

WAM took place from Houston (29.7°N, 95°W) during April and May of 1998, using the NASA/USAF aircraft #928. The payload and flights follow.

## Payload

### *Nose*

**PALMS:** Particle Analysis by Laser Mass Spectrometry. PI: D M Murphy, NOAA/AL

**PTW:** Pressure, Temperature & Winds. PI: T L Thompson, NOAA-AL

### *Pallet #1*

**CNC:** Condensation Nucleus Counter. PI: J C Wilson, University of Denver

**FCAS II:** Focussed Cavity Aerosol Spectrometer. PI: J C Wilson, University of Denver

**ERAST:** Extended Range Aerosol Sizing Technique. PI: C A Brock, University of Denver

**NMASS:** Nuclei Mode Aerosol Sizing Spectrometer. PI: C A Brock, University of Denver

*Pallet # 2*

**Ozone 1:** Dual beam ozone photometer. PI: M H Proffitt, CIRES/NOAA-AL

**Ozone 2:** Dual beam ozone photometer. PI: W T Rawlins, PSI

**Methane:** Near infrared diode laser spectrometer. PI: E C Richard, CIRES/NOAA-AL

*Pallet # 3*

**CIO:** Chlorine monoxide by Cl resonance fluorescence. PI: D W Toohey, UCI

*Pallet # 4*

**N<sub>2</sub>O & CO:** PI's: M T Coffey and W G Mankin, NCAR

*Right Spear Pod*

**Lyman-alpha Water:** PI: K Kelly, NOAA-AL

**MASP:** Multi-angle Aerosol Spectrometer Probe: PI's: D Baumgardner & B W Gandrud, NCAR

**MTP:** Microwave Temperature Profiler: PI: M J Mahoney, JPL/Caltech

*Right Underwing Hatch*

**TDL Water:** Near infrared diode laser water vapor: PI: R D May, JPL/Caltech

### **Catalogue of Flights from Ellington Field (29.7N,95W)**

**19980409** 6 hr cold soak: @ 50 000 ft to (17N,86W): return @ 60 000 ft.  $T_{\min} = -83^{\circ}\text{C}$ .

**19980411** 6+ hr great circle to (46.5N,108W) @ 59000 ft: 2 descents, return along tropopause, 39 000 ft to 53 000 ft: very large Arctic vortex filament.

**19980501** 6+ hr great circle to (12.5N,95W) @ 47 000 ft: return along tropopause. Recent ITCZ activity at south end, cirrus, carbon aerosol.

**19980504** 6+ hr great circle to (9.5N,95W) @ 54 000 ft: return @ 61 000 ft. Aerosol/cirrus event.

**19980506** 6+ hr great circle to (45N,88W) out along tropopause: return @ 61 000 ft. High PV air.

**19980507** 6+ hr great circle to (35N,73W) @ 45 000 ft: return @ 61 000 ft. High PV air, flt along subtropical jetstream between tropical and midlatitude tropopauses.

**19980511** 6+ hr great circle to (10.5N, 95W) @ 50 000 ft: return @ 61 000 ft. One hour of 157 nm laser on PALMS.

Most of the instruments worked most of the time. The flights sampled upper tropospheric air from 29°N to 9°N, with legs also at the tropical tropopause and in the lower stratosphere to 62 000 ft. Flights were made along the midlatitude tropopause, and at altitudes to 62 000 ft; the tropopause was followed to within 100 m using MTP displays in the cockpit.

PALMS took 7 000 to 11 000 individual aerosol particle mass spectra on each of the first six flights, using 193 nm laser radiation. On the seventh flight there is about one hour of data with 157 nm laser light. There is great chemical richness in the aerosol mass spectra; only preliminary qualitative first impressions can be conveyed here. Sulfate is the most abundant anion, but pure sulfuric acid aerosol particles are rare. Organics are common, and can be distinguished from black carbon aerosol ("soot"). About one third of all particles in the upper tropical troposphere contained mercury, iodine and organics, with the first two always appearing together; these particles were also present in the lower stratosphere. Meteoritic particles are frequent, with Fe, Al, K, Mg, Ca in ratios and with PV and altitude behavior consistent with a source at altitudes above the aeroplane, actually mesospheric in all likelihood, followed by vortex descent. There are species adsorbed on to the soot particles. There was clear evidence of soot from the Mexican forest fires both in the tropical upper troposphere and lower stratosphere, and in the cirrus veil from the recently active ITCZ. A total of 35 elements have been detected in the stratospheric aerosol; one particle had 20 elements, but such chemical diversity is the exception rather than the rule.

The MASP, CNC, FCAS II, NMASS and ERAST data should provide an unprecedented degree of particle sizing information; correlation between these data and the PALMS spectra should be very informative.

Simultaneous measurement of ozone, water and methane along the tropopause is expected to provide new insights into troposphere-stratosphere exchange, both in the tropics and at midlatitudes. During the two flights made by the JPL water instrument, the comparison with the Lyman-alpha revealed that while both generally tracked the same features, there was an offset of significant magnitude.

The Arctic vortex filament was large enough to generate its own dynamical features, and showed unique signatures in the MTP data. The MTP also resolved the tropical tropopause very well, and enabled the "tropopause following" flights, usually to within 100 m altitude.

The ozone mixing ratios were extremely variable in the midlatitudes, as suggested by the PV maps and the longevity of the Arctic vortex below 50 mb. Maximum mixing ratios were 2 ppmv at about 430 K potential temperature. In the tropics, it was often the case that the ozone was in the 100-200 ppbv in the upper troposphere.

The abundance of the ClO was generally low; the maximum values in first look preliminary data were about 50 pptv near midday in high PV air, but close to zero near the tropopause.

Methane values ranged from vortex edge values of about 1 ppmv at potential temperatures of about 430 K to values somewhat under 2 ppmv in the troposphere; these values are preliminary pending further development of the retrieval software.