SOLVE-II Flight Report: Sunday, 01/12/2003

Paul A. Newman

Flight Type: SAGE III occultation & vortex scan flight

Flight Objectives:

1. SAGE III occultation at 11:07 UT, 65ºN 0º W
   - Arrive at occultation point prior to sunrise to sample ozone and PSC distributions
   - Sun runs at 4 zenith angles
2. Scan for PSCs from center of cold pool to north of cold pool
3. Observation of ozone and temperature distributions in the core of the vortex.
4. Near-pass of Ny Ålesund, Spitzbergen

Flight Plan:

07:13 – Takeoff
09:58 – Begin first sun run
14:09 – North of Spitzbergen
16:35 – Landing

Forecast Meteorology:

A tropospheric ridge just west of the British Isles is starting to break down, producing a strong west northwesterly flow across its top north of Scotland from 700 mb upward. At 12Z on January 12, we expect two jet streams with winds exceeding 70 knots from the WNW at FL350, one striking the Norwegian coast at about 69°N, and the other directly ESE of Iceland. If this forecast holds, there will be a relatively calm region of sub 30 kts winds near the SAGE occultation point.

Associated with the aforementioned ridge is a generally high tropopause -- as high as FL390 near the SAGE occultation point. Given the strong jets, however, gradients in tropopause height are significant, and there is a dry stratospheric intrusion parallel to the flow forecast to be just south of the occultation point. At this intrusion, the tropopause is below 35,000 feet. Another important feature of the ridge is the upper tropospheric moisture field. The baroclinic wave, which generated it several days ago, has brought a large body of moist air northwards, penetrating to 75°N in the mid-Atlantic region. This moisture, coupled with the strong dynamics associated with the jets, implies a real possibility of jet stream cirrus at 35,000 feet. Comparison with satellite imagery for January 11, which has somewhat higher relative humidities and a higher tropopause but weaker dynamics, indicates the presence of scattered, but not thick, cirrus.

As the aircraft travels north northeastward toward Spitzbergen, it will cross the northern jet stream, and the winds will weaken. The tropopause is low in this region, so cloudiness is unlikely at the expected flight levels of 350 to 390.

In the stratosphere, the forecast is for the occultation point to be in the center of the cold pool at 50 mb. Notably, two days after this flight the forecast is for the cold pool to shrink significantly as the stratospheric vortex becomes more symmetric.

Flight Meteorology:

Flight Report:

Takeoff was at 7:20UT. This put us about 7 minutes behind schedule. At first, we were in cloud during takeoff, but we cleared it about 34 kft, and were just above thick cirrus on the track towards waypoint 2 (69°03'N, 13°05'E).

As we cleared the coast, DIAL began to pick up its first PSC - type Ib. Temperatures were approximately 190K in this layer as reported by preliminary AROTAL observations. The layer was approximately 1.5-3 km thick. The swollen sulfate layer at 16 km was also evident. This PSC developed into multiple layers near 69°49'N, 7°E.

A real sharp transition of ozone at the tropopause as we went upward. Values jumped to about 180 ppbv, but fell off later to about 75 ppbv as we continued westward. Winds were about 70-75 kts WNW with temperatures at about -65°C.

As we crossed the prime meridian, the PSCs continued to exist as multiple layers. One at 19 km, and a second at 20 km. No depolarization, so Type Ib particles. Arotal and MTP reported temperatures of ~ 185 to 190K at the level of the PSCs.

Towards the western end of our track, we began to run into a lot of cirrus at 35 kft. We requested a change in altitude to 37 kft to get clear of this stuff. PSCs were evident continuously from the Norwegian coastline to this western waypoint.

Because we had gotten off a few minutes late, we made an early turn at 09:18Z to head back towards the sun run. We climbed to 38 kft prior to the sun run, but the sun was so low on the horizon, and the clouds were so high (just slightly below 38 kft), that the solar instruments were unable to lock onto the sun. Nevertheless, the sunrise was beautiful. Extensive layers of cirrus on the horizon, and extensive and thick PSCs were evident above the aircraft. The sun was finally evident at about 10:09Z with a solar zenith of 92.2°. Both DIAS and GAMS/LAABS were able to lock onto the sun at the end of this first sun run. AATS-14 had problems during this first sun run.

Figure 1. Sunrise observed from the NASA DC-8 on January 12, 2003 over the North Atlantic. The thin line that stretches across the image is a cirrus cloud. Thicker clouds below this cirrus layer were obscuring the sun. The white clouds above the thin line cirrus layer are polar stratospheric clouds (PSCs).

As we turned left (southward) off of the sun run at waypoint 6, we could see our own contrail to the north. Shortly afterward, DIAPER reported that we hit our own exhaust. The wind was 54 kts at about WNW, bringing our contrail down onto our track. FastOz and DAACOM/DLH showed variations of ozone, CO, and H2O that indicated that we were right at the tropopause, consistent with MTP.

Started the second sun run at 10:34Z, with a zenith angle of about 91.3°. Again on this eastern side of the track, cirrus and clouds obscured the sun. As we proceeded along the track, the obscuring cirrus fell off and DIAS locked on during the entire sun run, GAMS locked on early, and at the end saw O4, H2O, O3, while LAABS acquired good A-band spectra. The sun run ended at 10:50 at a zenith angle of 90.7°. We again hit a plume after completing this 2nd sun run while we were on the southern side of our racetrack at around 11Z.

Figure 2. The Gas and Aerosol Measurement Sensor and the Langley Airborne A-Band Spectrometer (GAMS/LAABS) is an instrument that looks directly at the sun and is used to measure O_3, H_2O, O_2, O_4, and aerosols. Here we see Ernest Burcher swapping filters on the instrument during the 2nd sun run of the flight of January 12, 2003.

Started sun run #3 at 11:11. The zenith angle was 90.4° at the start of the run. Just prior to turning onto this run, we ascended to 39 kft. Ozone almost doubled to about 220 ppbv during this ascent and temperatures fell to about -71°C. The obscuring cirrus was completely gone at this altitude. Both DIAS and GAMS/LAABS immediately locked onto the sun at the start of the run. During the run PSCs were evident on the southern

horizon as well as from both lidars. The sun run ended at 11:26Z with a zenith angle of 89.9°. GAMS had a perfect run with no sign of the etaloning that had been seen on the test flight, probably as a result of the use of new filters. DIAS locked on at the start and had a good run, but didn't get many UV photons because of the zenith angle. LAABS got good spectra and solar images. AATS-14 continued to have problems with the communications to their sun tracker.

Just prior to our turn for the 4th sun run, AATS-14 began to track the sun. DIAPER also reported another hit of our wake at about this same time. The final sun run began at 11:46Z with a zenith angle of 89.8°. AATS-14, DIAS, and GAMS/LAABS all began to track the sun at the start of this run. The run ended at 12:02Z at a zenith angle of 89.4°. DIAS tracked through the whole sun run. AATS-14 tracked the entire 4th sun run, and continued to track during the leg north. GAMS was a little late tracking (~1 minute), but got good data. LAABS also got a good run.

Started northward towards Spitzbergen a few minutes ahead of schedule. Winds began to pick up as we proceeded northward. AATS-14 lost sun tracking at about 12:15Z, and the PSC layer above us disappeared at about the same time at about 69°40'N. FastOz ozone values increased as we moved northward to about 280 ppbv, while water decreased to less than 5 ppmv. DIAL saw a large increase of ozone below the aircraft at altitudes from 7-10 km as we passed across the jet.

The temperatures above the aircraft were 185K at about 72°, and a faint type 1a PSC was observed. As we continued northward the temperatures increased. By 75°N, the min temperature at 21 km had increased to about 192K.

North of Spitzbergen, the in-situ ozone values were as high as 600 ppbv, and H2O was near 3.5 ppmv, while CO was below 20 ppbv. The DIAL nadir ozone showed high values all of the way down to about 5-6 km***, a very low tropopause.*** Again, no PSCs were observed in this air.

As we turned southward at waypoint 16 (NE of Spitzbergen) DAACOM/DLH noted some very strong fluctuations of CO, CH4, N2O, H2O, and O3. These variations appeared to be a result of a gravity wave off of Spitzbergen. On the return leg to Kiruna, ozone remained high, while water was quite low. Just before descent we saw a PSC at about 20 km.

Landed at 16:29Z.

Pilots: Bill Brocket, Craig Bomben
Navigator: Russ Pedula
Mission managers: Chris Miller & Bob Curry
Mission scientist on board: Paul A. Newman.

Status Report: Instrument – PI

DIAPER (in situ aerosols) – Anderson
Nice flight. A lot of cirrus and multiple samples of our own jet exhaust.

SP2
Didn't fly today. Instrument problems.

FastOz – Avery
Good flight. A couple of really nice cross-sections across the jet.

DIAL (Lidar ozone and aerosol above and below the AC) – Browell
Excellent flight. A lot of PSCs.

DACOM/DLH (in situ trace gases and open path water vapor) – Diskin
Really good flight. Everything worked.

PANTHER (in situ PAN and other trace gases) – Elkins
Really good flight. Got data the whole flight.

MTP (microwave temperature profiler) – Mahoney
Really good flight.

AROTAL (Lidar ozone, aerosols and temperature above the AC) - McGee/Hostetler
GSFC- Good flight. Good ozone, temperature, and PSC data.
LaRC – Good flight, some interference.

GAMS/LAABS (solar occultation ozone, aerosols and oxygen A band) – Pitts
Really good data. Etalon problem has been eliminated by using new filters.

DIAS (Direct beam solar irradiance) – Shetter
Instrument work fine. Got data on all 4 sun runs.

FCAS/NMAS (in situ aerosols) – Reeves
On auto.

AATS-14 (sun photometer) – Russell
Had some tracking problems, but got it going for sun run #4.

Differential GPS – Muellerschoen
Pretty good flight.

ICATS

Plots (flight plan, solar zenith angles, Rel. humidity):

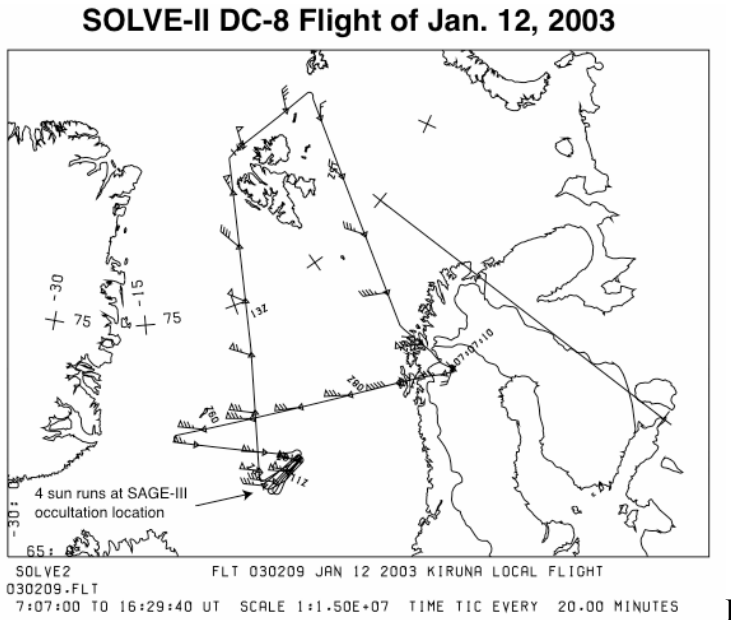

Figure 3. Flight path of the DC-8 for the SOLVE-II mission of January 12, 2003.

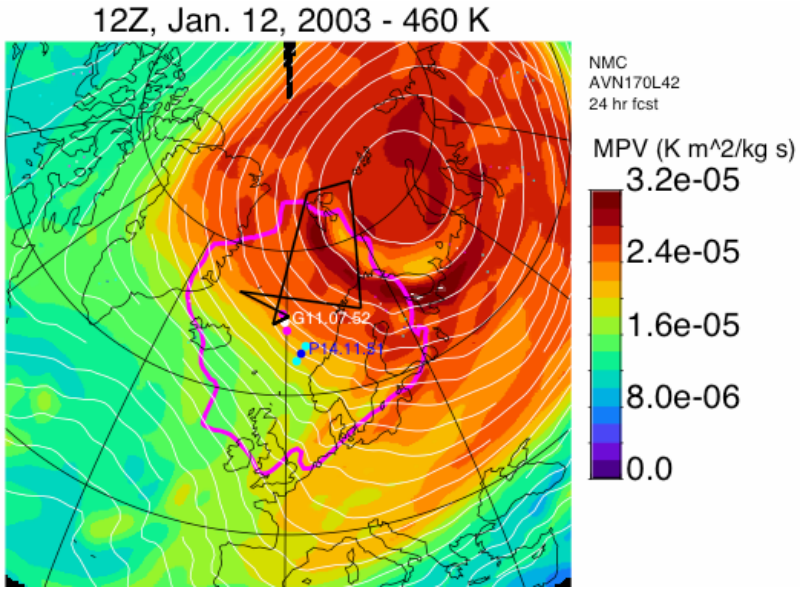

Figure 4. January 12, 2003 DC-8 flight plan (black) superimposed on a 12Z map of modified potential vorticity (color image) for the 460K isentropic surface. The thick magenta line shows the 195K temperature contour. The white point indicates the SAGE III occultation point (occurring at 11:08Z) and the dark blue point is POAM occultation point (occurring at 14:11Z). The white lines are Montgomery stream function lines (winds blow parallel of these line).

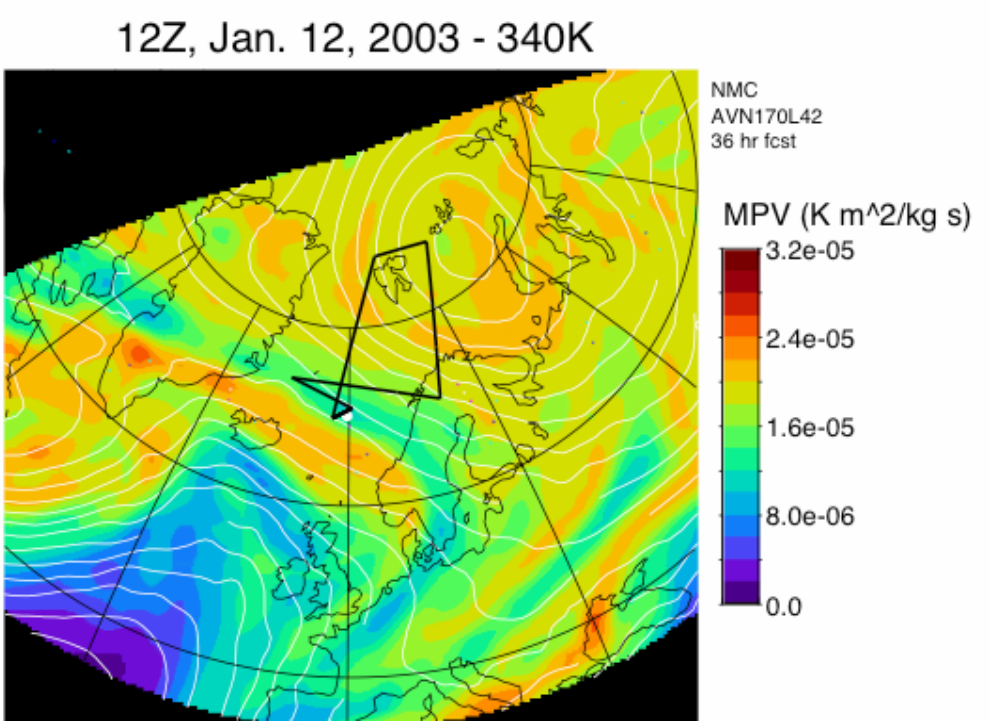

Figure 5. As in the previous figure, but for the 340K isentropic surface (approximately the DC-8 flight altitude).

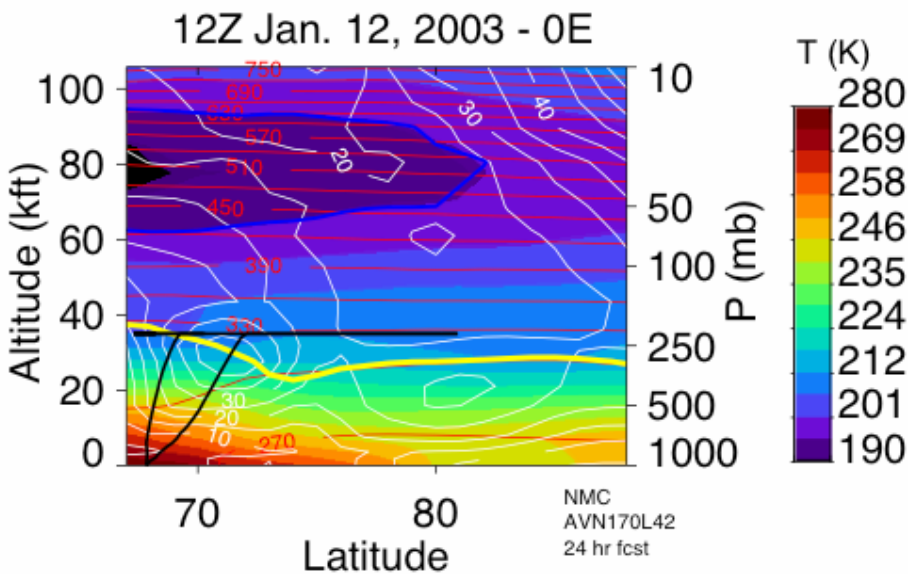

Figure 6. Temperature and wind cross section at the prime meridian (0°E). Potential temperature surfaces are shown in red, white lines indicate wind speed (m/s, the yellow line shows the tropopause, and the thick blue line is the 195K contour.

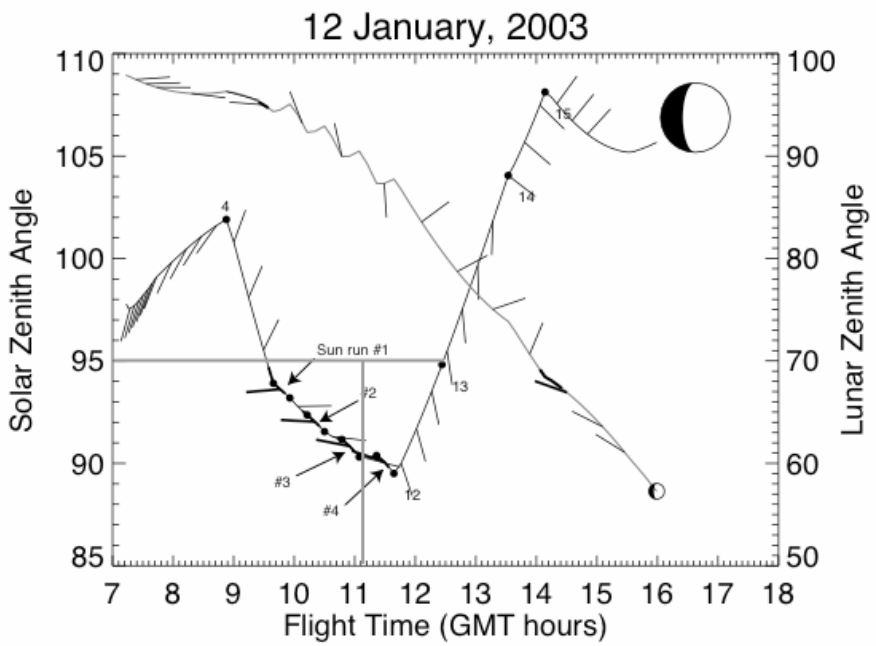

Figure 7. Solar and lunar zenith angles for the flight path shown in the previous figures. The 4 sun runs are indicated by the arrows.