SOLVE-II Flight Report: Sunday, 01/19/2003

Paul A. Newman

Flight Type: SAGE-III & POAM occultation flight

Flight Objectives:

1. SAGE III occultation at 09:52:10 UT, 69.17ºN 22.15º E
    a. 4 sun runs at similar zenith angles
2. Sun run in mid-latitude air at a zenith angle of 84º.
3. POAM occultation at 13:36:13 UT, 64.92ºN 16.21º E
    a. 2 sun runs at similar zenith angles
4. Scan of ozone, aerosols, and temperatures across vortex boundary.
5. Coordinated flight with Geophysica and Falcon. Coordination at 78º30'N, 30º E at 15:35Z

Flight Plan:

07:22 Takeoff
08:28 SAGE III sun run #1
09:07 SAGE III sun run #2
09:46 SAGE III sun run #3
09:52:10 SAGE-III overpass
10:25 SAGE III sun run #4
11:39 30-minute 84º-sun run
12:42 POAM sun run #1
13:27 POAM sun run #2
13:36:13 POAM overpass
15:34 Rendezvous with Geophysica and Falcon east of Spitzbergen
17:15 Land

Forecast Meteorology:

There is no air remaining at either 50 hPa or 30 hPa that is cold enough to maintain PSCs at equilibrium. In fact, the vortex has split into two separate closed circulations at 480K, one centered over Nova Zemlya and the other over the southeastern corner of Hudson's Bay. The outer edge of the eastern portion is just north of Kiruna.

In the troposphere, the circulation is dominated by a large low-pressure region centered just west of Nova Zemlya. Small waves have circulated around this system, giving periods of snow. In fact, this morning Kiruna is looking at the end of a major snowstorm as one of these waves moves southeastward around this 700-hPa low. Snow is projected to end soon after takeoff, followed by the movement of dry air from the north, ridging at 700 hPa, and descending motion. Thus, clearer skies are expected by landing. The tropopause is below 300 hPa (29000 feet or less) over Kiruna and the SAGE occultation run. In fact, the tropopause is not expected to reach 35000 feet anywhere in the flight

region north of 60 degrees (the southernmost way point of the flight is about 62N). This is due to the position of the tropospheric jet core, which is split at Scandinavian longitudes. Over the Atlantic, the jet is at 40N. It then splits over Europe with a northern portion at 60N and a southern portion well south. Cirrus clouds may top out well below the tropopause, especially north and west of Kiruna, because the middle and upper troposphere is dry.

Flight level flow and temperatures are driven by a broad upper level low-pressure region over Nova Zemlya (right above the 700 hPa low pressure region, resulting in a broad northwesterly flow of about 30 knots at 39000 feet. Temperatures are unremarkable. The tropopause is quite low, which means that the stratospheric middleworld region that the aircraft is flying through will have average to above-average temperatures (on the order of 218K at 39000 feet.

Some mountain wave induced turbulence is expected over northern Scandinavia. This is due to the fairly unidirectional flow from 700 hPa upwards, and the fact that the winds are weakening with altitude at the DC-8 flight levels.

Flight Meteorology:

Flight Report:

It was snowing in Kiruna as we took off. A bit of concern about the friction level on the runway combined with the crosswinds, but the Kiruna airport plow guys had the runway plowed down to concrete. Took off nearly on time at 07:22 UT. Ascended to waypoint 3 off of the Norwegian coast passing the tropopause at about 29 kft (300K). At flight altitude (FL350), ozone was 349 ppbv, H_2O was 4.7 ppmv, and CO was about 18 ppbv. Winds were 36 kts at NW (305º).

The snow created some problems for once we were in the air. Because the airplane was warm as we pulled it out of the hangar, the snow melted on the plane. After takeoff, this water froze. The DIAL shutter almost froze shut, and the AROTAL shutter completely froze shut.

Started our first sun run at 08:31 with a zenith of 92.2º. The sun was not visible at this time. There was a 2-km deep layer of cirrus below us with tops at approximately 29 kft. DIAS started tracking the top of the sun at 8:34, but there was very little sun (data was probably not very good). GAMS began tracking at 08:36 UT. AATS-14 began tracking at 08:38 UT, they also reported that their window was ice free with their field-of-view test. The GAMS solar imager showed the partial disc of the sun increasing as we flew along this track. Fine layer structures in the image indicated thin layers of aerosols or thermal variations between the sun and us. DIAL reported a lot of ozone variability above us on this run. Ended the sun run on time with a zenith angle of 91.3º. The sun was not really available until 08:42 UT.

DIAPER reported a plume hit on the backside of this run.

We started our 2nd sun run at 09:11 with a zenith angle of approximately 90.7º. DIAS reported tracking almost immediately. Both GAMS/LAABS and AATS-14 also reported track near the start of the run. The solar imager shows no structure on this 2nd run, in contrast to the first run. The sun run ended at 09:29 with a zenith angle of 90.1º. AATS-14 reported an optical depth of 0.007 in the visible at 500-520 nm. Good sun run for GAMS/LAABS and DIAS, while AATS-14 locked on late, but still acquired good data. DIAPER reported a plume hit again on the backside of the 2nd sun run.

We descended to 31 kft (309 K) prior to our 3rd sun run. Again, all 3 instruments locked on almost immediately. GAMS/LAABS reported an increase in water, in good agreement with the increase of in situ water to 7.9 ppmv from about 4.4 ppmv. Ozone also decreased to about 179 ppbv. At this time, the AROTAL port was finally opened. The solar imager indicated no clouds obscuring the sun. Ended the sun run at 10:07 with a zenith angle of 89.5º. Another nice run for GAMS/LAABS. DIAS took data through the whole run, and started to see some photons at 325 nm. AATS-14 took data through the whole run.

Figure 1. Steve Davis (the DC-8 crew chief) opens the port for the AROTAL lidar. Tom McGee on the right, and Don Silbert on the left offer their encouragement.

After we turned on the backside of the 3rd run, we began an ascent to 37 kft for the 4th sun run for SAGE-III. At the turn we had 7.6 ppmv of H_2O, 39.1 ppbv of CO, 220 ppbv of ozone, at 310.3K with 30-kt winds at 319º. After ascending to 37 kft, H_2O was 4 ppmv, CO was 17.5, and ozone was 480 ppbv at 340K with 41-kt winds at 302º.

Sun run #4 was started at 10:29 UT with an angle of 89.6º. All 3 solar instruments locked on quickly and began to track the sun. Sun run ended at 10:46 with a zenith angle of 89.4º. AATS-14 and DIAS tracked throughout the sun run. DIAS had signal down to about 320 nm. GAMS/LAABS also had a good sun run.

AATS reports column ozone and water to be increasing as we tracked southward towards our high sun run. In situ H_2O, ozone, and CO did not show much variation from the northern point, but winds steadily increased as we flew southward (52 kts/282º at 65ºN).

At 62º45'N and 17º46'E, we observed a narrow non-depolarizing layer of cloud at 17 km. This cloud was above us during the southern most sun run. MTP reported temperatures near 17 km of about 215 K. This suggests

At the start of the 5th sun run (11:41 UT), the zenith angle was 83º. DIAS and AATS-14 started tracking early. Winds were at about 74 kts at 277º. H_2O was 4.4, CO was 16.7, and ozone was 360. AATS-14 saw an optical depth of 0.007 at 520 nm, consistent with the optical depths measured at the SAGE-III occultation location earlier. DIAL showed cirrus below us at 32.5 kft (30 kft geometric) on this leg. We ended the run at 12:10 UT at a zenith angle of 89.6º. GAMS/LAABS had a good run, but quiet. GAMS showed an optical depth change of only 5% over the course of the run. DIAS got good data over the whole run and got data down to 306 nm. AATS-14 got data over the whole run. Some small ozone changes.

After our sun run, we went up to 39 kft at 12:14Z near 63ºN, 11º30'E. At 37 kft, water 4.5 ppmv, CO=21 ppbv, ozone=339 ppbv, theta=336K, wind=61 kts @ 264º. At 39 kft (12:16), H_2O=3.0, CO=17, ozone=395, 345.6K, -55.9ºC, 59 kts @ 271º. As we progressed to waypoint 17 (6th sun run), the volcanic plume at 17 km died away.

We started our 6th sun run at 12:35Z with a zenith angle of 86.5º. All 3 instruments began tracking shortly after the start of the run. At the start of the run, H_2O 3.9, CO 17, ozone 430, 348K, 59 kts @ 283º, -54ºC. GAMS/LAABS had a good run and saw a spike of ozone that correlated with a spike of the in situ ozone. DIAS took data through the whole sun run, as expected, the UV wavelengths fell off. AATS-14 tracked throughout the sun run.

We started our 7th sun run at 13:20 with a zenith angle of 89.3º. The tracers and potential temperature showed considerable variation was we flew westward. Ozone jumped at one point to 525 ppbv as theta increased to 349K. Ended the sun run at 13:42Z with a zenith angle of 90.7º. GAMS/LAABS had a good sun run. AATS-14 had a good sun run and continued to track well on the northbound leg until the sun fell below the horizon.

Excellent sunset. There appeared to be layering in the sunset. DIAL showed thin aerosol layers above us.

Figure 2. Sunset as we proceeded up the Norwegian coastline. Note the bright layers in the image. Possibly high cirrus.

AROTAL Langley was showing an aerosol layer at about 19 km, AROTAL GSFC showed a temperature of about 207-208K. This aerosol layer was descending downward as we moved northward.

At 14:15Z, we confirmed that the Falcon and Geophysica had taken off on time. Rendezvous was set for 15:35 UT, but we were about 8 minutes ahead of schedule at this point. The rendezvous time was re-set to 15:44 UT.

As we proceeded northward, ozone at 20 km dropped fairly rapidly as we passed about 68ºN. Values near 20 km were slightly larger than 2 ppmv in both DIAL and AROTAL. In situ values showed interesting variability along this track northward. At 72º45'N, ozone jumped to over 600 ppbv. At 73ºN, 20ºE, 41 kft, H_2O=3.5, CO=12.3, ozone=555, theta=351.5, T=-58.2ºC, wind=49 kts @ 301º. MTP put the tropopause down around 30 kft. We also began to see patches of air with values less than 2 ppmv near 20 km.

Problem encountered with the aircraft at about 14:55 UT. We decided to abort our northern rendezvous with the Geophysica and Falcon. We turned southward and descended to 28 kft. At 41 kft just as we started down, water was 3.5 ppmv, CO was not working, ozone was 630, theta was 349, T=-58.3, and wind =36 kts @ 299º. When we leveled off, H_2O was 14, CO was 90.5, ozone was 103, T=-57.8ºC, theta=296.3, wind = 47 kts @ 317º.

Did a spiral descent into Kiruna. Landed at 16:19 UT.

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

Status Report: Instrument – PI

DIAPER (in situ aerosols) – Anderson
Good flight. Ready to fly on Tuesday. 3 plume intercepts and some cirrus.

SP2
Instrument was not operated today.

FastOz – Avery
Worked well today. Saw over 700 ppbv today.

DACOM/DLH (in situ trace gases and open path water vapor) – Diskin
Generally a good flight.

PANTHER (in situ PAN and other trace gases) – Elkins
Best flight so far. Data on both ECD and mass spec.

MTP (microwave temperature profiler) – Mahoney
Excellent flight.

AATS-14 (sun photometer) – Russell
Excellent flight. Got data whenever the sun was there. Did not have ice today.

GAMS/LAABS (solar occultation ozone, aerosols and oxygen A band) – Pitts
Seven good runs. A lot of interesting runs. LAABS had some problem with GUI interface.

DIAL (Lidar ozone and aerosol above and below the AC) – Browell
Another excellent flight. Saw a lot of variability above us. Some good variability of aerosols going into vortex.

AROTAL (Lidar ozone, aerosols and temperature above the AC) - McGee/Hostetler
GSFC – Real good flight once the window got open thanks to Steve Davis. Saw some really warm minimum temperatures today.
LaRC – A good flight.

DIAS (Direct beam solar irradiance) – Shetter
Good flight through all the sun runs.

FCAS/NMAS (in situ aerosols) – Reeves
Automated.

Differential GPS – Muellerschoen
Came up as advertised each time.

ICATS
No problems. Good flight.

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

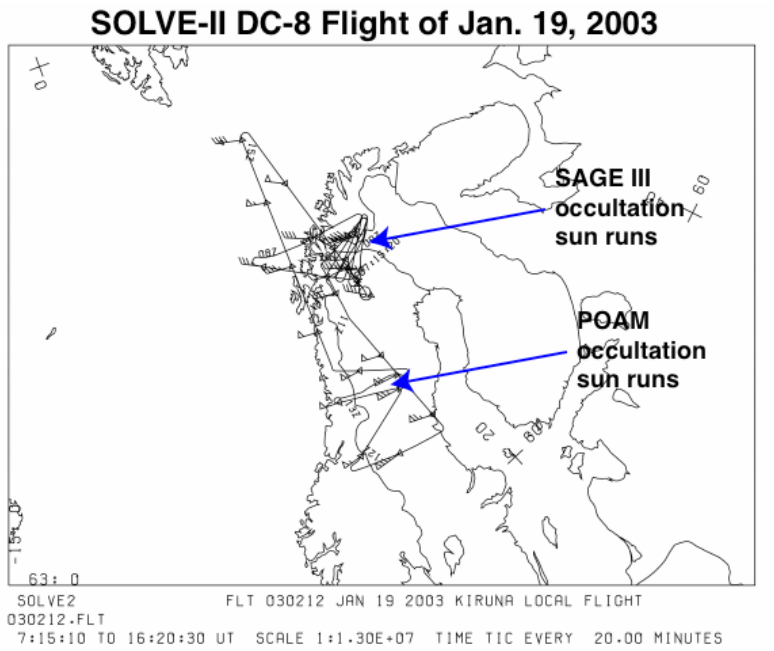

Figure 3. Plot of the actual flight path of the DC-8 for the SOLVE-II flight of January 19, 2003.

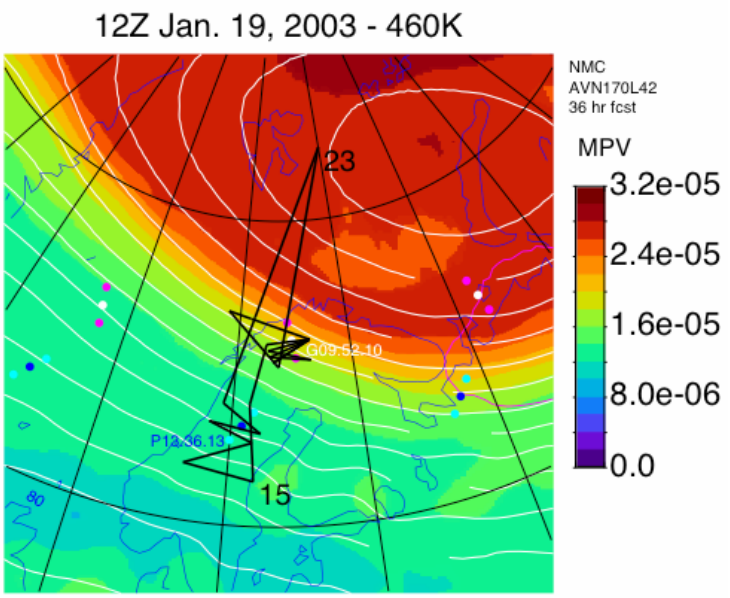

Figure 4. January 19, 2003 DC-8 flight plan (black) superimposed on a 12Z map of modified potential vorticity (color image) for the 460K isentropic surface. The thick magenta line shows the 200 K temperature contour. The white point indicates the SAGE III occultation point (occurring at 09:52Z) and the dark blue point is POAM occultation point (occurring at 13:36Z). The white lines are Montgomery stream function lines (winds blow parallel of these line).

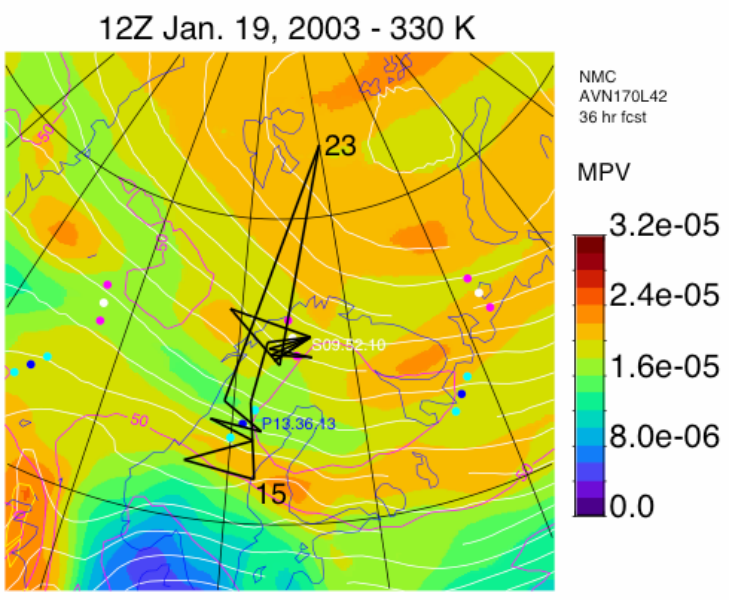

Figure 5. As in the previous figure, but for the 330K isentropic surface (approximately the DC-8 flight altitude).

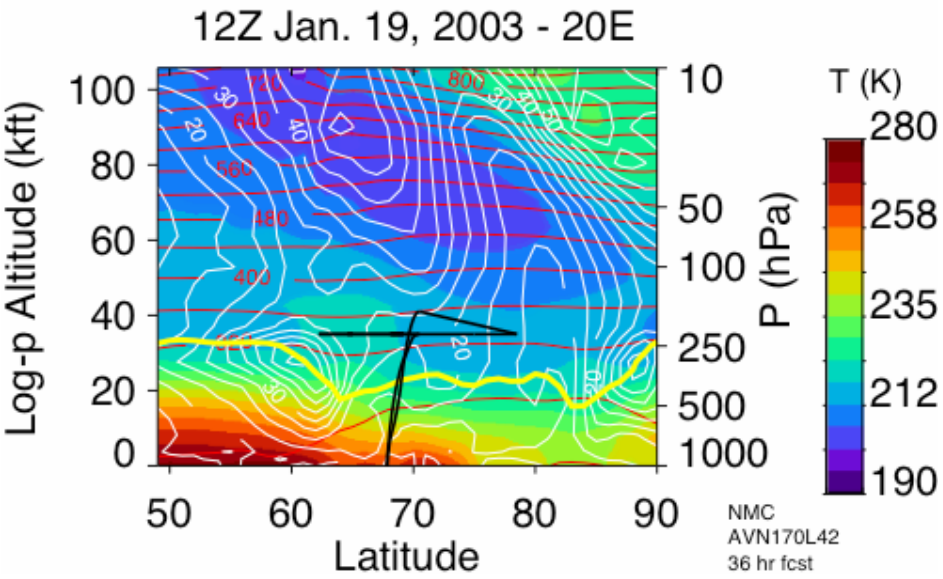

Figure 6. Temperature and wind cross section (20°E). Potential temperature surfaces are shown in red, white lines indicate wind speed (m/s), and the yellow line shows the tropopause.

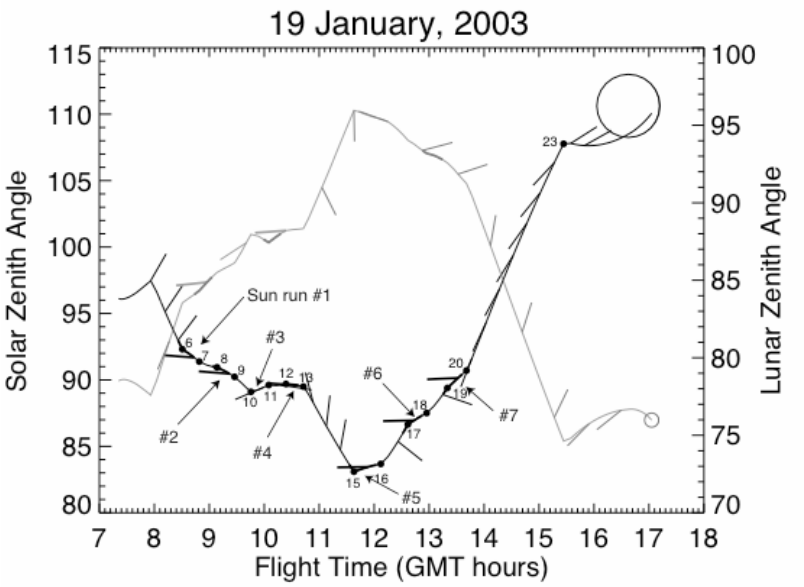

Figure 7. Solar and lunar zenith angles for the flight path shown in the previous figures. The 4 SAGE III sun runs begin at way-points 6, 8, 10, and 12; the 83º solar zenith angle sun run begins at way point 15, and the 2 POAM sun runs begin at way points 17 and 19.