SOLVE-II Flight Report: Thursday, 02/06/2003

Mark R. Schoeberl

Flight Type: Transit to Dryden from Kiruna

Flight Objectives:

1. Transit Flight
2. Cross vortex scan

Flight Plan (UT):

7:00 Takeoff
16:53 Land

Flight Plan Discussion

Although this is the transit flight, we will be crossing from the center of the cold pool to the vortex edge and then across northern Canada. PSC models suggest we might see some Type I on our exit from the region. Some cirrus is predicted as we cross to Greenland. Because the plane is so heavy, we may not be able to overfly the cirrus decks as we approach Greenland. Gravity-wave models show little activity.

Flight Report:

Takeoff at 6:57 UT, ozone ~20 ppbv, CO 234 ppbv, and H_2O 250 ppmv at surface. 20 kft. Surface temperature –31˚C. Nice inversion layer near the ground – at 1000 ft, temperatures were 10˚ warmer. At 25 kft, ozone was 110, CO 100, and H_2O 15.

As we move off the coast of Norway, DIAL reports no PSC activity, although some has been predicted at the 400-K level. This level may have been renitrified by falling and evaporating PSCs. MTP recorded a very high troposphere (~11+ km).

At 30 kft, ozone was 124, CO 90.0, and H_2O 20.5. AROTAL showed temperatures at 189 to 190 K at 17 km. AROTAL showed a faint aerosol layer at 17 to 18 km – not a PSC layer – which disappeared as we headed northwest. Leveled off at 35 kft, ozone was 62, CO 119, and H_2O 7.5. We were not in the lower stratosphere.

Optically thin cirrus at 11 km and below the aircraft (DIAL) as we approached WP5. We were flying at the 310K surface. DIAPER showed some cirrus particles in their instrument. At 7:43 UT (71˚N, 11˚ E), thin aerosol layers reappeared at 17 km and 20 km. The cirrus decks thickened slightly; DIAPER showed more particles. AROTAL shows ozone at 1.4 to 1.5 ppmv at 20 km. DIAL zenith aerosol measurement was degraded by the cirrus. AROTAL showed temperature slowly rising to 191-192K (nearly

isothermal from 15 to 19km – with the minimum at 19 km). In situ ozone declined slowly and H_2O increased, tropopause near 12 km (aircraft near 10 km).

As we approached the Greenland coast, the ozone above the aircraft slowly increased to 1.6 ppmv between 16 and 20 km. Temperatures at this time were about 193K, 14 to 22 km. The tropopause began to drop approaching the coast of Greenland. At 9:03 UT, ozone was 53, CO 131, and H_2O 10. Winds increased to 95 kts at 227˚. We began to cross the jet. In situ ozone showed considerable structure with water and CO anti-correlations. The aircraft experienced some chop. Ozone above the aircraft began to increase, with contours bending downward as we began to cross the vortex boundary. At 9:16 UT, we ascended to 36 kft. Ozone was 155, CO 81, and H_2O 18. The cirrus was still present. Temperatures in the lower stratosphere warmed up rapidly as we crossed the jet. Within a few tens of km, we went from 194 K to 202 K (16 to 22 km). Ozone contours descended rapidly. At 9:22 UT, we cleared the cirrus decks and winds decreased to 75 knots from 204.

We crossed into the lower stratosphere over Greenland. Ozone was 323, CO 38, and H_2O 4.7. There was a lot of structure in in situ ozone and other tracers. We definitely exited the vortex by WP5 (mid Greenland); ozone contours rapidly sloped downward (ozone increased at all levels from 30 to 12 km. AROTAL began to detect the high-altitude aerosol layers that we have been seeing outside the vortex since early in the mission. As we moved off Greenland, the aerosol layers at 30 km increased in thickness. AROTAL detected variable ozone and temperature structure in the lower stratosphere. The flight track brackets several SAGE II and POAM occultation points that should help us verify these observations.

As we moved toward lower latitudes (11:08 UT), ozone continued to rise and showed wave-like structure. Ozone was 570, CO 23, and H_2O 3.5

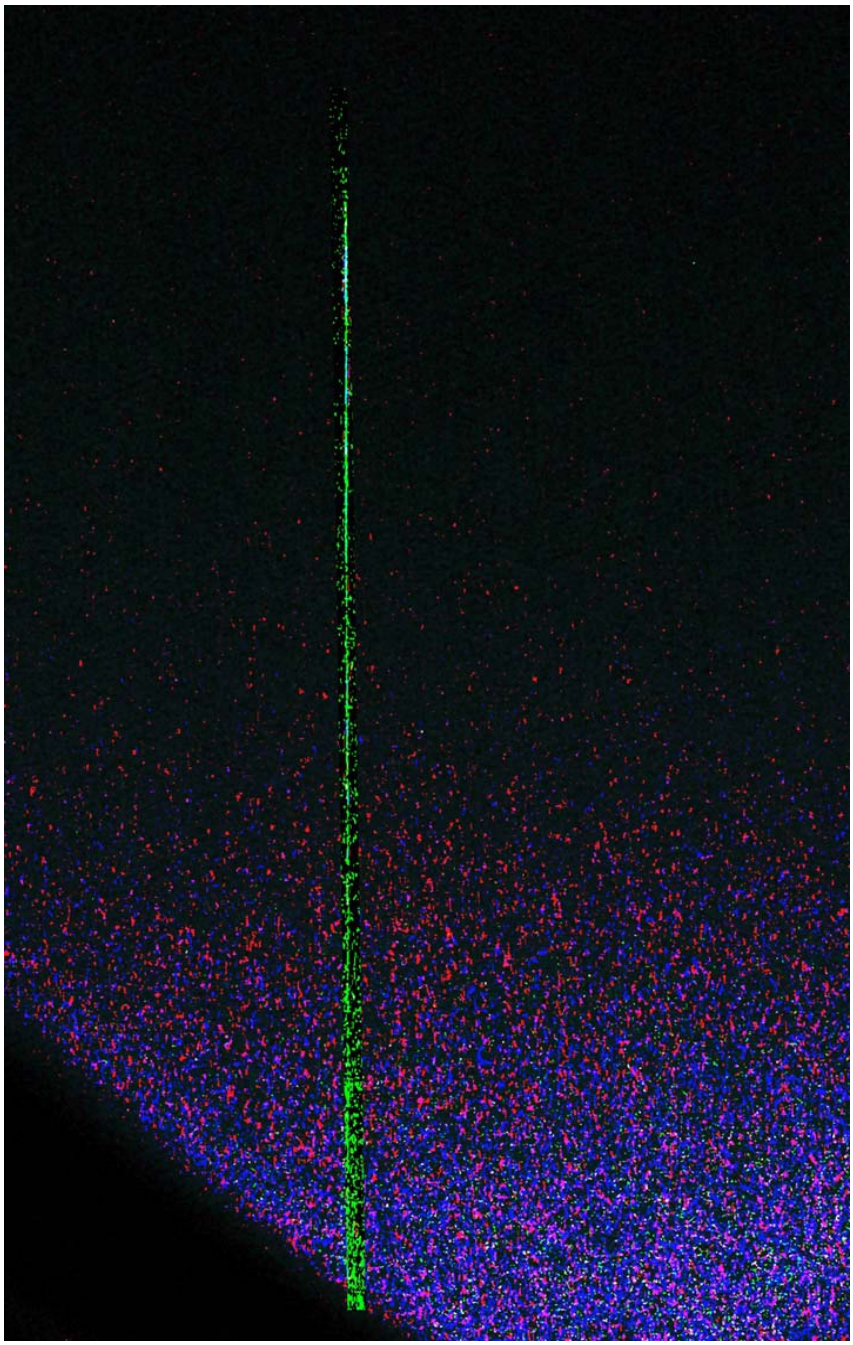

Figure 1a. Photo of the lidar beam from the pilot zenith window looking backward over the DC-8. This is a composite of two photos. The green, red and blue speckles are due to camera noise under low light conditions.

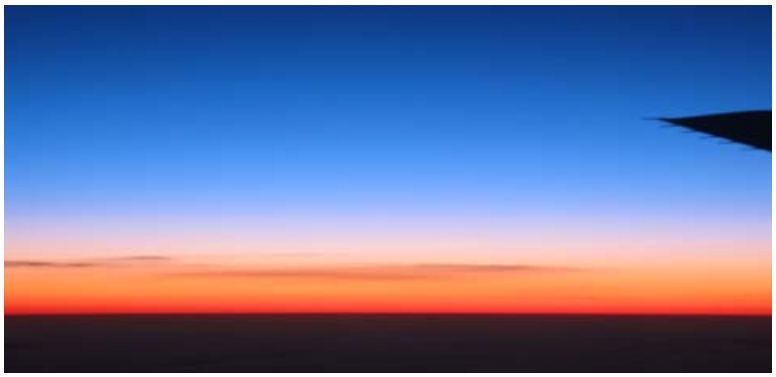

Figure 1b. Sunrise over Canada. Aerosol layers, probably volcanic in origin, above the aircraft are clearly visible and were detected by the DIAL and AROTAL lidars.

Figure 2. Composite photo of the aircraft stationed in Arena Arctica during SOLVE2/VINTERSOL-EUPLEX campaigns . Starting from the left, the picture shows the Geophysica (M55), the DLR Falcon (behind the Geophysica), and the NASA DC-8. EUPLEX lab spaces are behind the Geophysica and the Falcon; the SOLVE2 lab spaces are along the opposite side of the hangar (to the right of the DC-8 as you face the aircraft). SOLVE2 project support teams used the two 'huts' in the foreground. The red hangar doors (shown in this picture in pink) are behind the DC-8. This composite was assembled from four separate pictures taken on 5 February 2003.

AROTAL noted that temperatures at 73˚N were almost isothermal from 15 to 50 km, with wave-like features. DIAL and AROTAL also noted a low ozone feature at 14 km which was tilted downward along the flight path. High aerosols accompanied this tropospheric intrusion into the lower stratosphere.

Near 69˚, in situ ozone rose to 885 ppb – the highest we have seen on this mission. We also saw a strong decrease to ~300 ppb and then an increase back up to 700 ppb. This decrease zone was about 140-km wide. The high ozone values are likely due to the ageostrophic circulation around the jet axis that pulls air down from the stratosphere on the cyclonic side. DIAL and AROTEL showed sloping structures in ozone just above the aircraft. One of the intrusions from the stratosphere can probably be traced to the in situ ozone value. The potential temperature was 353 K. AROTAL and DIAL showed an aerosol layer. The variations in in situ ozone continued as we approached the jet over Northern Canada. At 12:12 UT, we ascended to 38 kft. AROTAL ceased operations for

20 minutes due to overheated chillers in the cargo pit. In situ ozone decreased as we crossed the jet. At 12:30 UT (65˚N, 39˚W), ozone was 441, CO 30, H_2O 3.4, and PT 356.

The tropopause started to rise as we crossed the jet (80 kts). At 61˚S, we were outside the jet. MTP showed a strongly defined tropopause, and the tropopause altitude approached the aircraft altitude. Ozone continued to slowly increase above 20 km. In situ ozone was 214, CO 52, and H_2O 10. In situ ozone continued to fall to 166 (CO 70 and H_2O 13.6) at 59˚S.

At 13:39 UT, we ascended to 41 kft. About 55˚N, we descended out of the stratosphere to 37 kft over Canada as requested by air traffic control. Ozone fell to below 100 ppmv. As we approached the Canadian border, we ascended to 41 kft. We entered the stratosphere at 52˚N. Ozone was 237, CO 38, and H_2O 4.

AROTAL shows an aerosol layer topping out at 13 to 26 km near the Canadian border. Ozone was 423, CO 31, and H_2O 3.2. As we crossed the Canadian border, ozone rose rapidly. Ozone was 770, CO 16, and H_2O 3.1. Ozone rose to 926 and CO dropped to 13. We saw ozone levels as high as **950 to 1000** ppbv during this leg (41 kft). We appeared to be in a long stratospheric intrusion associated with a frontal boundary that extends from Canada to California (see Fig. 6). Solar instruments began to take data after the sun rose; these were the highest zenith angles they had seen during the whole deployment. Aerosol layers were clearly visible in the sunrise (see Figure 1b).

After 45˚N, ozone began to slowly decline. We requested a rapid descent over Edwards so that AATS could look at the change in column data roughly over the same location. At 40˚N, ozone was 721, CO 21, and H_2O 3.1. This flight had some of the lowest water vapor and highest ozone readings we have ever recorded in the lower stratosphere. We landed at 16:51:49 UT. The DC-8 crew immediately unloaded the aircraft to prepare for the "Cold Lands" mission using the AirSAR.

Pilots: Dick Ewers & Ed Lewis
Navigator: Kevin Hall
Mission Managers: Chris Miller & Tom Mace
Mission Scientist onboard: Mark Schoeberl

Status Report: Instrument – PI

DIAPER (in situ aerosols) – Anderson
Good flight. Everything worked. Lots of nice aerosol data – lots of cirrus data.

SP2 – Baumgardner
Excellent flight. Cirrus layer was interesting.

FastOz – Avery

Instrument had a good flight.

DACOM/DLH (in situ trace gases and open path water vapor) – Diskin
Lots of good data. Good flight.

PANTHER (in situ PAN and other trace gases) – Elkins
Good flight.

MTP (microwave temperature profiler) – Mahoney
Great flight – saw the highest and lowest tropopause of the whole deployment.

AATS-14 (sun photometer) – Russell
Tracked sun after it rose.

GAMS/LAABS (solar occultation ozone, aerosols, and oxygen A band) – Pitts
In and out of our tracking range. No data.

DIAL (lidar ozone and aerosol above and below the aircraft) – Browell
Worked well. Saw stratospheric intrusions.

AROTAL (lidar ozone, aerosols and temperature above the aircraft) - McGee/Hostetler
GSFC – Good flight, lots of interesting temperature structure over Greenland. Took ozone data up to 73˚ zenith angle.

LaRC – Great flight until end – had a disc crash.

ICATS – Good Flight. No problems.

DIAS (direct-beam solar irradiance) – Shetter
Good flight – an hour of data.

FCAS/NMASS (in situ aerosols) – Reeves
Good flight.

Differential GPS – Muellerschoen
Worked fine, just a few dropouts.

Plots (flight plan, solar zenith angles, relative humidity):

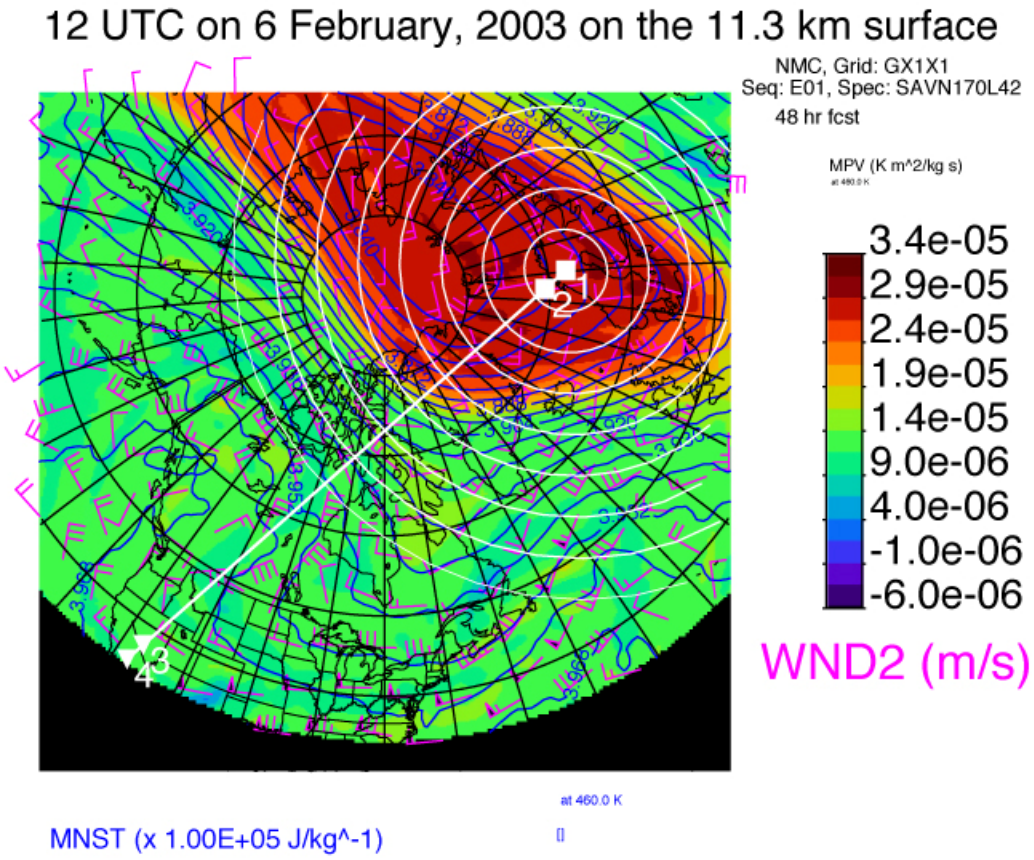

Figure 3. 6 February 2003 DC-8 flight plan (white) superimposed on a 12-Z map of modified potential vorticity (color image) for the 460-K isentropic surface. The blue lines show Montgomery stream function. The blue wind barbs show the wind at 460 K.

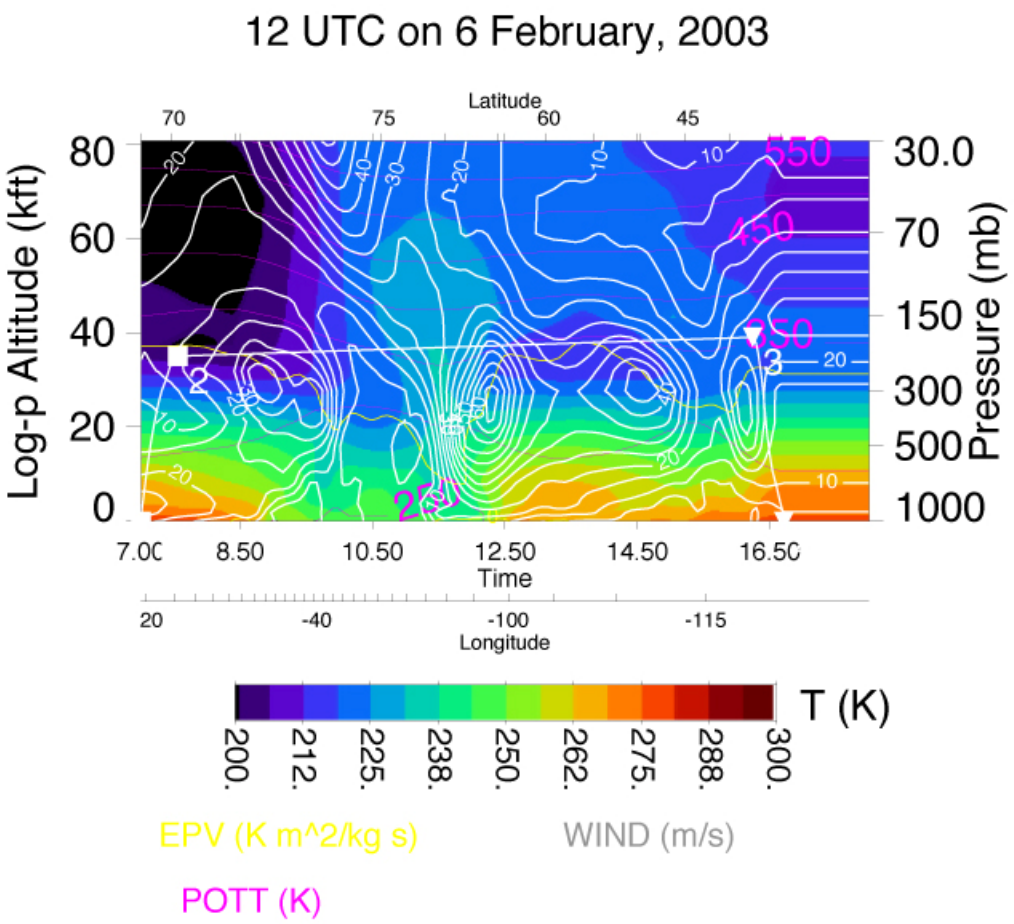

Figure 4. Curtain plot following the flight of 6 February 2003. The colors indicate temperature values (see scale at the bottom of the figure and contours). White contours are wind speed in m/s. Purple contours are potential temperature.

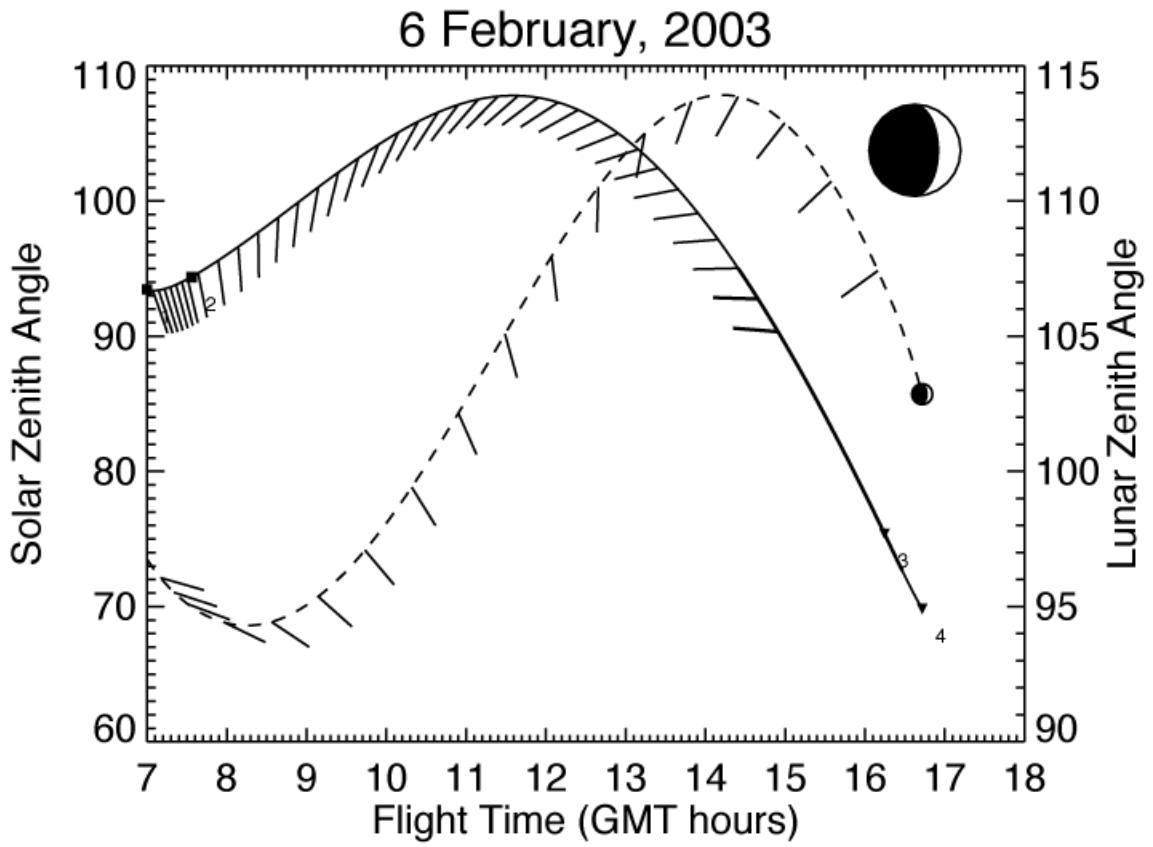

Figure 5. Solar and lunar zenith angles for the flight path shown in the previous figures.

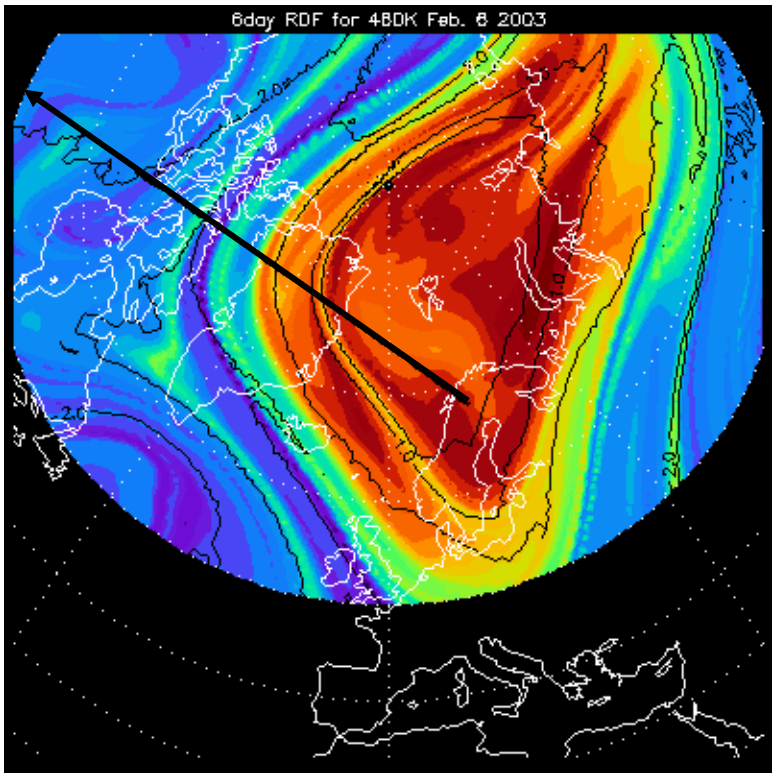

Figure 6. Six-day RDF of the vortex using Data Assimilation Office data. Black arrow indicates the flight track. Colors indicate high PV values (red) to low (blue).

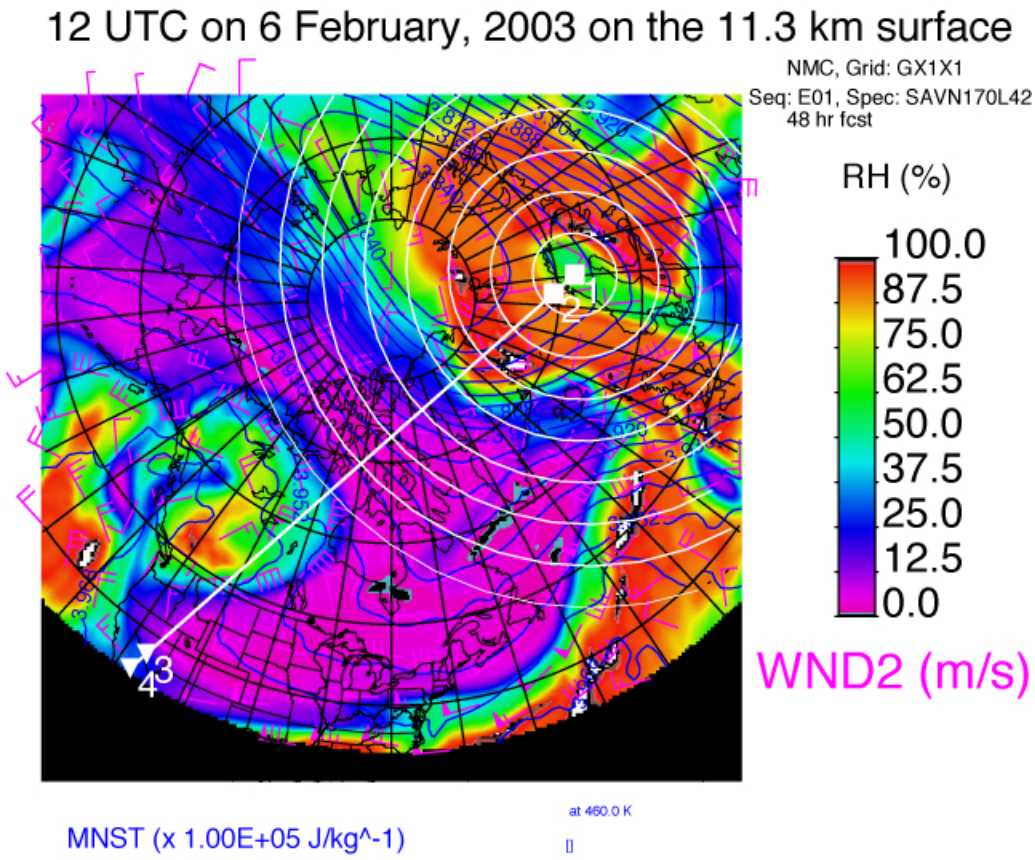

Figure 7. Relative humidity plots for flight level 37 kft. The orange areas show high relative humidity. Flight track is in white. Barbs are flight-level winds in m/s.