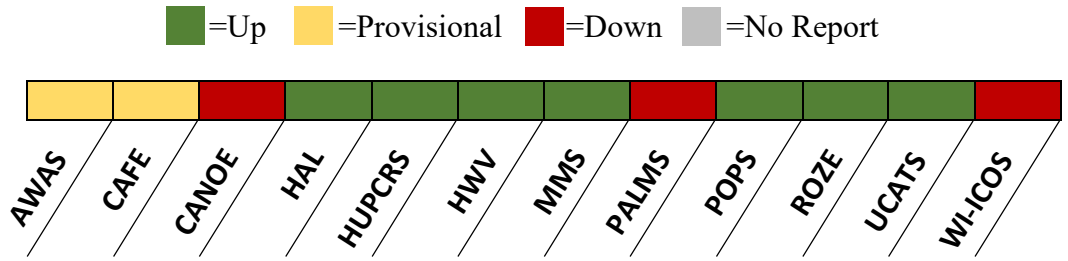
DCOTSS ER-2 Mission Scientist Flight Summary Report

NASA Earth Venture Suborbital 3
Dynamics and Chemistry of the Summer Stratosphere

Flight identifier: *RF01*
Science goals: *NH stratosphere survey and overshooting plume sampling*
Start of flight (UTC): 2021-07-16 14:13Z
End of flight (UTC): 2021-07-16 22:10Z
ER-2 Pilot: Greg "Coach" Nelson
Mission Scientist: Paul A. Newman

Version	Report date and time (UTC)	Author
1	2021-07-17 15:00Z	Newman, Paul
2	2021-07-17 23:00Z	Ueyama, Rei

Instrument Performance (post-flight debrief, 22:40Z):



Aircraft Performance: Good

Science Objectives:

DCOTSS research flight #1 was designed with two principal science objectives. First, it was planned as a survey of the northern hemisphere summer mid-latitudes lowest-most stratosphere (tropopause to 380 K) and the free stratosphere (> 380K). Second, trajectory analyses suggested that some overshoot of convection was possible at two points along the flight track, and the aircraft was vectored to intercept those potential plumes. In addition to these two primary objectives, there was a possibility that we would sample smoke plumes from recent pyroCb activity over Saskatchewan and Manitoba.

Flight Summary:

The ER-2 ground track and vertical profiling are shown in Figures 1 and 2, respectively.

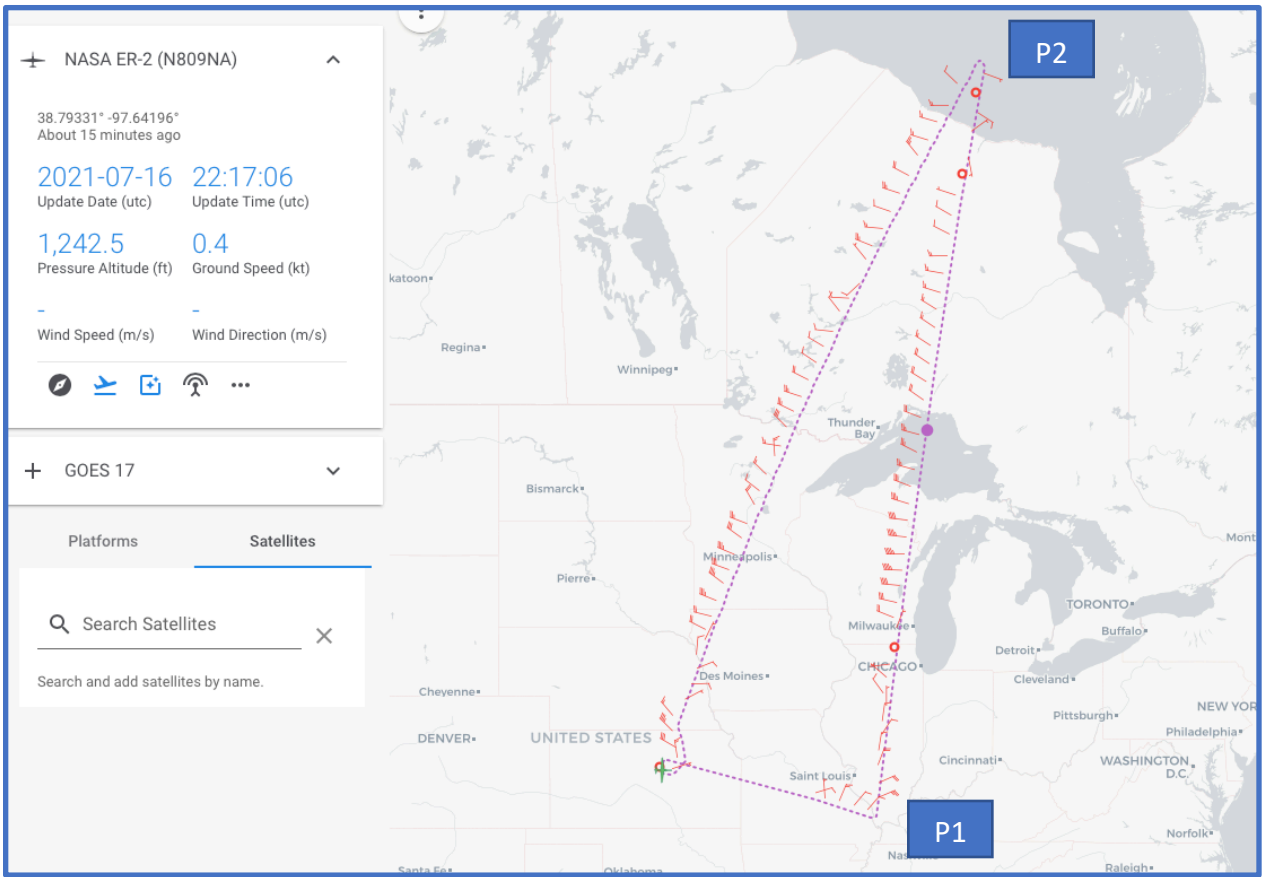


Figure 1. Map of RF01.

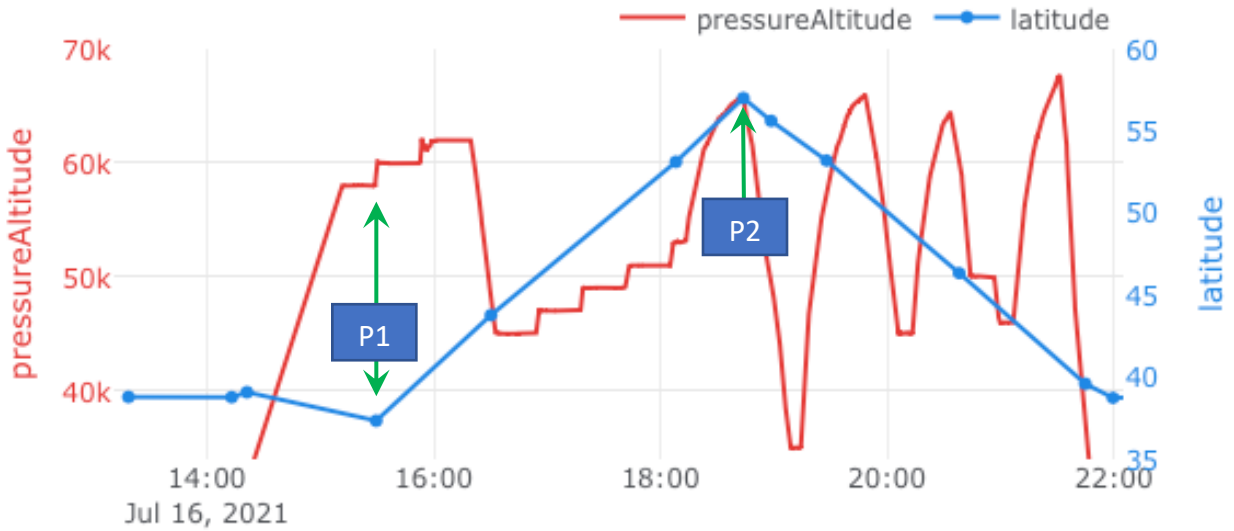


Figure 2. IWG1 altitude v s. time (red, left scale) and latitude vs. time (blue, right scale).

The ER-2 took off at 1413 UT (9:13 AM CDT) and ascended to FL560 where it performed the MMS maneuvers and an MMS box en route to waypoint P1 (see Fig. 1, the flight segment up to about 1515 is not included in Fig. 1). After reaching FL580, the aircraft did a level leg of about 20 minutes duration. The aircraft turned northward at waypoint P1 at 1529 UT and ascended to FL600 for 20 minutes, followed by a 3rd 20 minute leg at FL620. These three legs were optimized to intercept an overshooting plume. Figure 3 shows the cloud image at 1530 UT from the GOES-16 IR channel. The ER-2 pilot indicated that minor chop was encountered during the short period after turning north from P1. It is hypothesized that this light chop was a result of gravity waves spawned by the taller cell (~225 K) located half-way up the track from P1 to Q. IR cloud tops were mostly in the 240-250K range, well below the ER-2 altitudes.

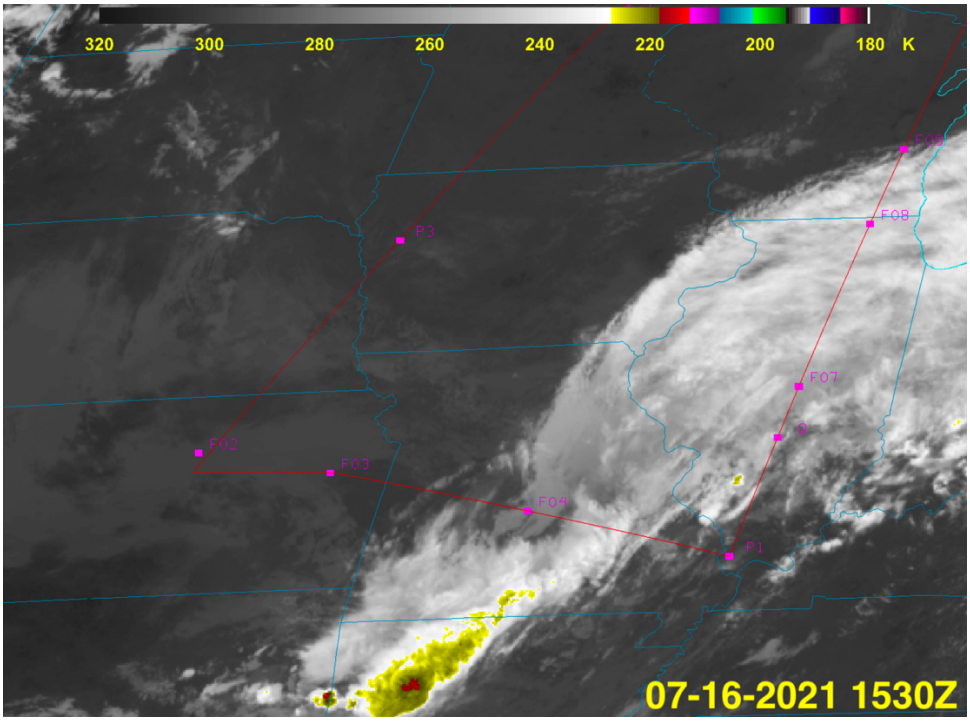


Figure 3. GOES-16 infrared image at 1530 UTC with planned flight track.

At approximately 1615UT, the ER-2 descended to FL450 and then did a series of 20 minute level flight segments, incrementing upward 2000 feet for each segment: FL450, FL470, FL490, FL510, and FL530. The 20-minute segment that was planned at FL530 was cut short to increase the amount of time to reach maximum altitude at the far northern waypoint over Hudson Bay (P2).

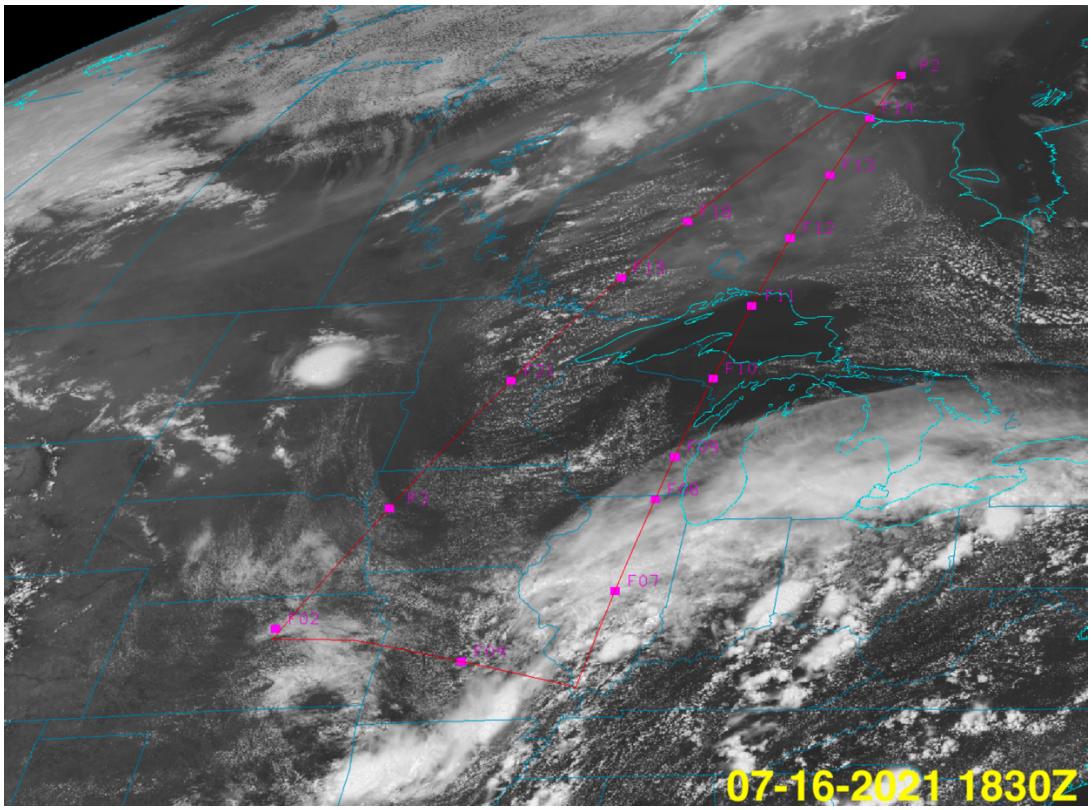


Figure 4. Planned flight track overlaid on GOES-16 VIS at 1830 UTC when aircraft was over Hudson Bay and smoke in vicinity.

At a point just shy of reaching waypoint P2, the ER-2 turned towards Salina and descended to FL350. After reaching FL350, the plane flew straight and level for approximately 5 minutes before ascending to maximum altitude (~65 kft). This was followed by another descent to FL450 (5-minute hold FL450), and another ascent to about 65,000 feet. Over Minnesota, the ER-2 began its final descent to intercept a possible convective overshooting plume in southern Minnesota. Initially, the ER-2 paused at FL500, but the scientists requested an additional descent to FL460. After reaching the Minnesota-Iowa border, the ER-2 ascended to over 67,000 feet

before descending for landing at KSLN.

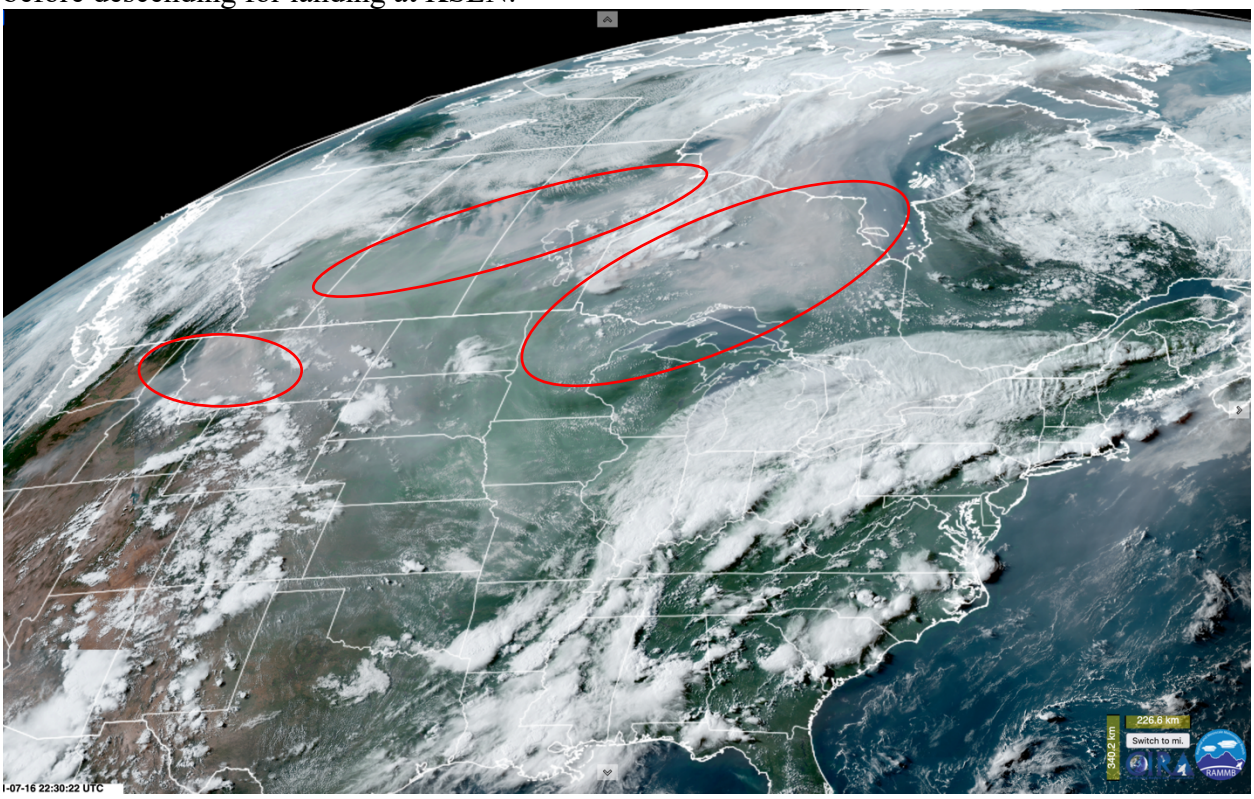


Figure 5. GeoColor image (2230 UT) showing extensive smoke over entire flight domain. Pilot Greg Nelson reported orange cloud over Southern Minnesota on return leg. Red ovals added to highlight prominent smoke.

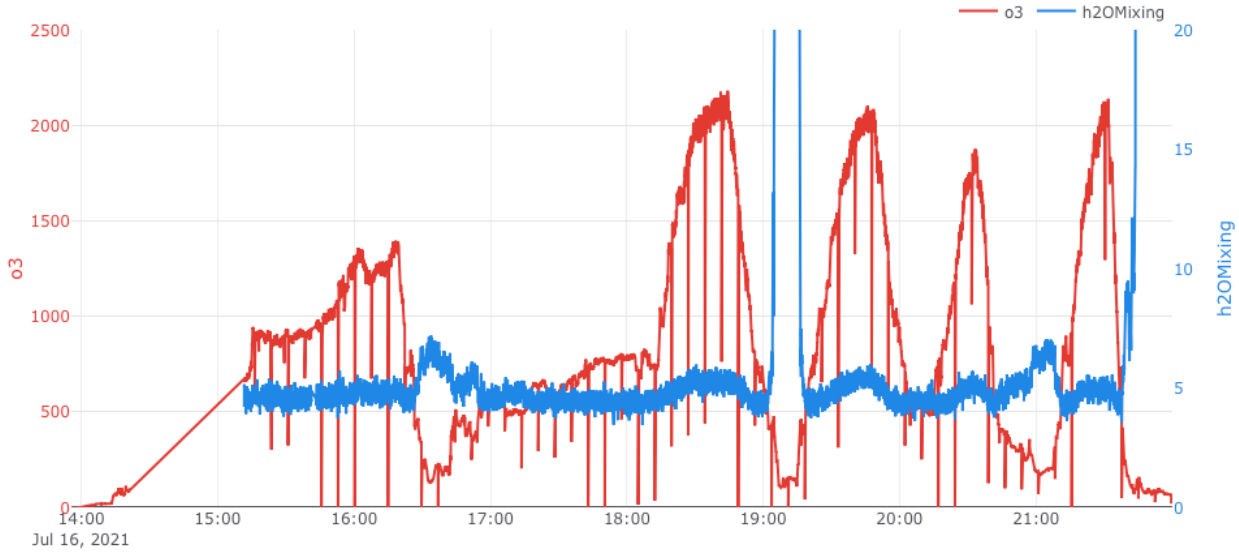


Figure 6. Harvard water vapor (units of ppm, blue) and NASA GSFC ROZE ozone (units of ppb, red)

The flight was broadly dominated by stratospheric air. Ozone concentrations exceeded 200 ppb with water vapor concentrations below 6 ppm over the entire flight with the exception of (a) takeoff and landing, (b) the first descent to FL450, (c) the deep descent down of Hudson Bay to FL350, and (d) the descent over Minnesota to FL500 and then FL460. In descent (b), ozone

decreased to less than 200 ppb and water increased to 7 ppm suggesting a mix of tropospheric and stratospheric air. In descent (c) to FL350, ozone dropped to 150 ppb and water increased to 80-120 ppm indicating heavy tropospheric influence. In descent (d) to FL460, ozone decreased to less than 200 ppb and water increased to 7 ppm suggesting again a mix of tropospheric and stratospheric air.

There was little indication in the real-time data that we had intersected the forecasted convective outflow plumes (Fig. 7). However, preliminary data suggest that convectively-influenced air parcels were sampled during this flight. Whether or not these sampled air parcels correspond to the forecasted convective outflow plumes remains to be seen.

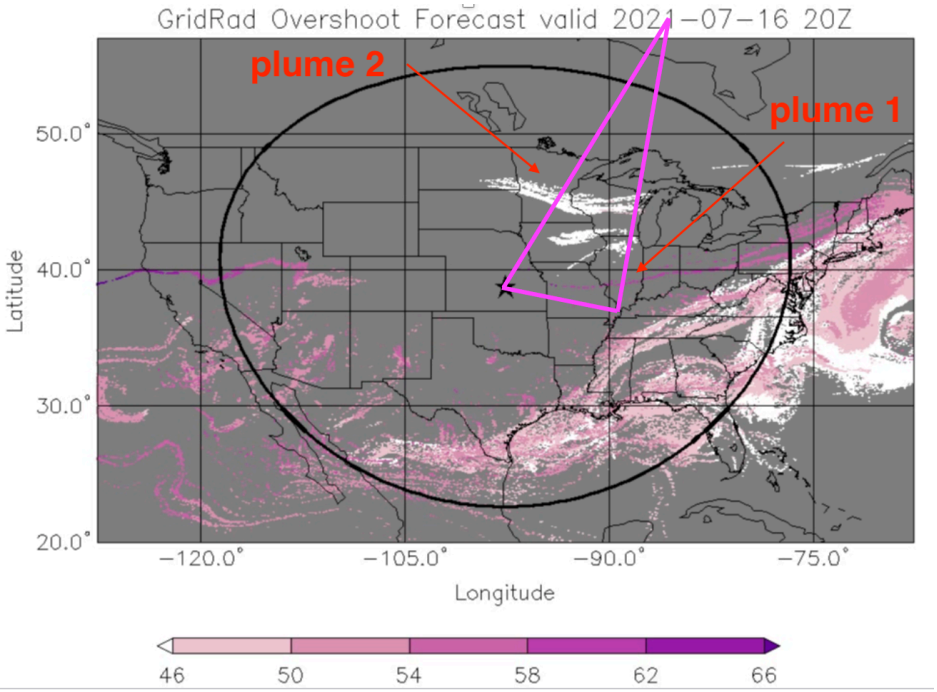


Figure 7. GridRad-based forecast of overshooting convective outflow plumes valid on 16 July 2021 at 20Z (plume altitude (kft) in color). 1-2 day old plume was expected at waypoint Q at ~55-60 kft (plume 1). Recent (<1 day) old plume was expected over the southern half of Minnesota at ~50 kft based on Bowman trajectory model while it was forecasted to be at a lower altitude based on Homeyer trajectory model (plume 2).