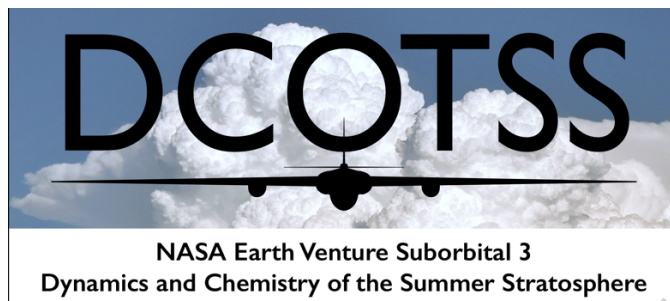


# DCOTSS ER-2 Mission Scientist Flight Summary Report



**Flight identifier:** RF15

**Science goals:** Survey flight to high latitudes and altitudes

**Start of flight (UTC):** 2022-06-05 14:49Z

**End of flight (UTC):** 2022-06-05 22:23Z

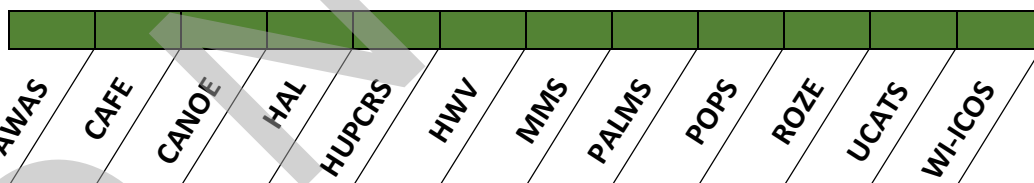
**ER-2 Pilot:** Kurt Stallings

**Mission Scientist:** Paul A. Newman

Version	Report date and time (UTC)	Author
1	2022-06-21 2000Z	Newman, Paul A.
2	2022-06-22 1600Z	Bowman, Kenneth

## Instrument Performance:

■ = Up, ■ = Provisional, ■ = Down, ■ = No Report



**Aircraft Performance:** Good

## Science Objectives:

The flight was designed to provide a broad survey of the free stratosphere ( $>430$  K) and the UTLS region down to the tropopause. The planned flight is shown in Figure 1 as the green line. The flight was developed to follow a “high ozone streamer” curving NW from the Minnesota, North Dakota, South Dakota region into Canada to point P1 on the 470 K map. Three deep vertical profile maneuvers (VPMs) were planned on the return leg down to the tropopause. Takeoff was planned for 1500 UT, with landing at 2301 UT.

2022-06-05 T19:05 UTC

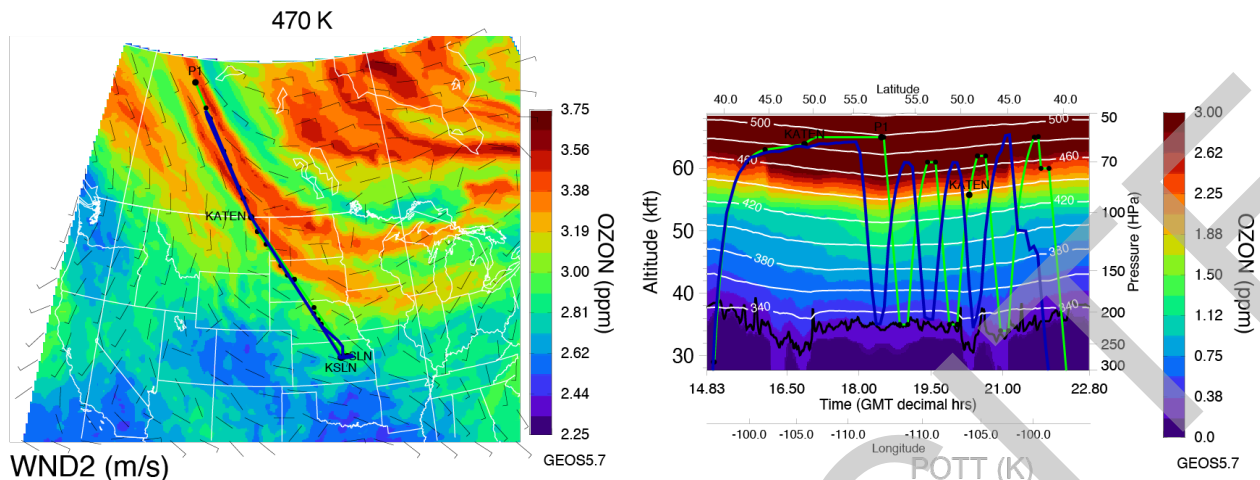


Figure 1. Ozone and winds on the 470 K surface (left) and ozone and potential temperature as a curtain plot following the flight track (right), note the different scales for the plots. The green line shows the planned track, and the blue line shows the track as actually flown. The curtain plot also includes the tropopause (thick black line) as defined by the 3 PVU contour.

### Flight Summary:

The ER-2 departed Salina early at 1449 UT, turned to the KATEN (US-Canadian FIR crossing) waypoint while cruise climbing. After reaching KATEN, the ER-2 made a slight turn towards P1. The restricted zones at Cold Lake in Canadian air space were bypassed. The aircraft reached a max altitude of 64,071 feet ( $\theta = 501$  K) at the northern point ( $55.5^\circ\text{N}$ ,  $111.1^\circ\text{W}$ ).

During the flight, the forecast team was closely watching convective systems that were approaching Salina. These storms were possibly appearing over Salina at around 6 PM CDT (2300 UT). Based upon this forecast, the pilot was asked to turn 20 minutes ( $\sim 130$  nmi.) short of waypoint P1 to save 40 minutes of flight time and be on the ground by 5:20 PM CDT (note that the blue line on Fig. 1 left panel does not extend to point P1). Because of this turn short of P1, the times between VPMs were shortened and the dives occurred earlier than planned (see curtain plot on RHS of Fig. 1). Nevertheless, the three VPMs were successfully completed. The bottom of the 1<sup>st</sup> VPM was an 11-minute segment at FL350, the 2<sup>nd</sup> VPM bottom segment was 11 minutes at FL360, and the 3<sup>rd</sup> VPM bottom segment was split between FL340 and FL360 (ATC adjustment). Prior to descent following the 3<sup>rd</sup> VPM, the ER-2 reached an altitude of 65,543 feet (498 K) at about 21 UTC.

During the flight, the forecast team identified some outflow from storms west of Salina. The ER-2 was redirected to fly to a new waypoint ( $40^\circ\text{N}$ ,  $97^\circ 42'\text{W}$ ) following completion of the 3<sup>rd</sup> VPM. This new waypoint was slightly eastward of the original plan, and was to the ENE of storm outflow. The ER-2 was requested to descend to FL500 at the new waypoint, then fly straight south to  $39^\circ 15'\text{N}$ ,  $97^\circ 42'\text{W}$  at FL500. This north-south segment would have crossed the leading edge of the outflow. Unfortunately, the pilot missed this right turn to the south and overshot to the east of the projected outflow. Following this, the ER-2 descended to FL450 and

executed the MMS box, pitch, roll and yaw maneuvers. After the MMS maneuvers, the ER-2 delayed for ~10 minutes at FL100, prior to landing at 22:23 UT.

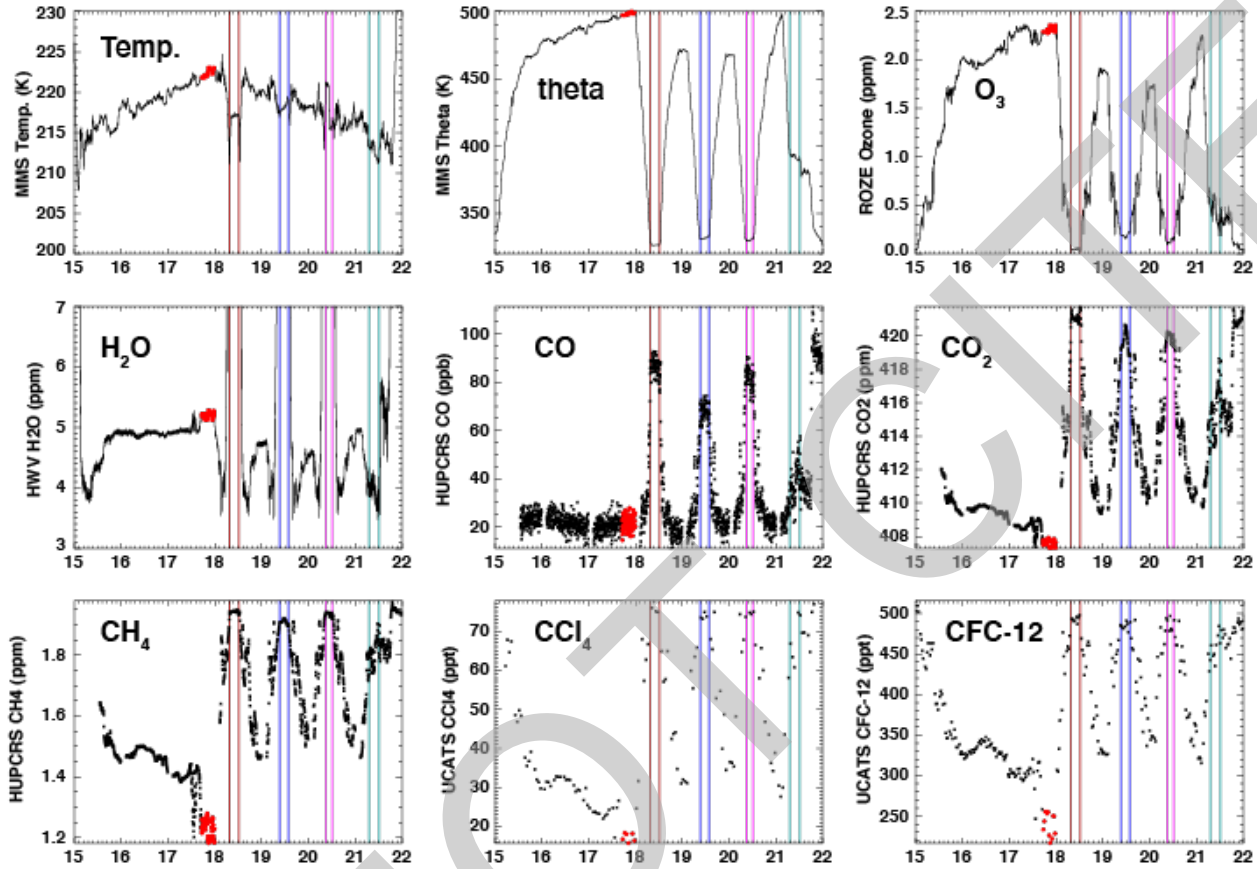


Figure 2. Time series of MMS temperature (K), MMS potential temperature (K), ROZE ozone (ppm), Harvard water vapor (ppm), HUPCRS CO (ppb), HUPCRS CO<sub>2</sub> (ppm), HUPCRS CH<sub>4</sub> (methane, ppm), UCATS CCl<sub>4</sub> (carbon tetrachloride, ppt), and UCATS CCl<sub>2</sub>F<sub>2</sub> (chlorofluorocarbon-12, ppt). The bottoms of the 4 descents are bracketed by the red, blue, magenta, and cyan lines. The red points on each graph denote a time period when HUPCRS CO<sub>2</sub> was less than 408 ppm (implying aged stratospheric air).

During the first half of the track northward, the potential temperature steadily increased to about 501 K at the most northerly point while the temperature increased to values greater than 220 K (temperature at 500K over Salina was about 216 K) and ozone increased to above 2.3 ppm (see Figure 2). This far NW point (red points on all Fig.2 graphs) had the oldest air, characterized by low values of HUPCRS CO<sub>2</sub> and SF<sub>6</sub>, with a preliminary guesstimate of 4-6 year mean age. Harvard water had a value slightly below 5 ppm for most of this northward leg, but jumped a few tenths of a ppm at the far point, consistent with a decrease of methane - oxidation of methane is a water source in the stratosphere. The low values of CCl<sub>4</sub> and CFC-12 (also CFC-11, not shown) are also consistent with older air, and suggest a large reservoir of inorganic chlorine from the degradation of these compounds.

Eight stratospheric vertical profiles were made during this flight, inclusive of the takeoff and landing profiles (see Fig. 2). The lowest altitude holds of the 4 main vertical profiles are

bracketed by red lines (35 kft, 327 K average), blue lines (35.7 kft, 332 K), cyan lines (35.3 kft, 330 K), and green lines (49.7 kft, 392 K). The bottom of the 1<sup>st</sup> profile (red) is below the tropopause (see temperature plot) with an average ozone of 45 ppb and about 71 ppm of water. The 2<sup>nd</sup> and 3<sup>rd</sup> profiles are stratospheric-tropospheric mixes of air – ozone is 190 ppb and 132 ppb ozone respectively, and water is 32 ppm and 49 ppm respectively. The 2<sup>nd</sup> profile is slightly more “stratospheric” than the third profile with higher ozone and lower water concentrations. The final level flight segment (green) at 49.7 kft is predominantly stratospheric air with 4.3 ppm of ozone and 3.9 ppm of water. However, this segment has strong variations in trace gas values over its 12-minute duration.

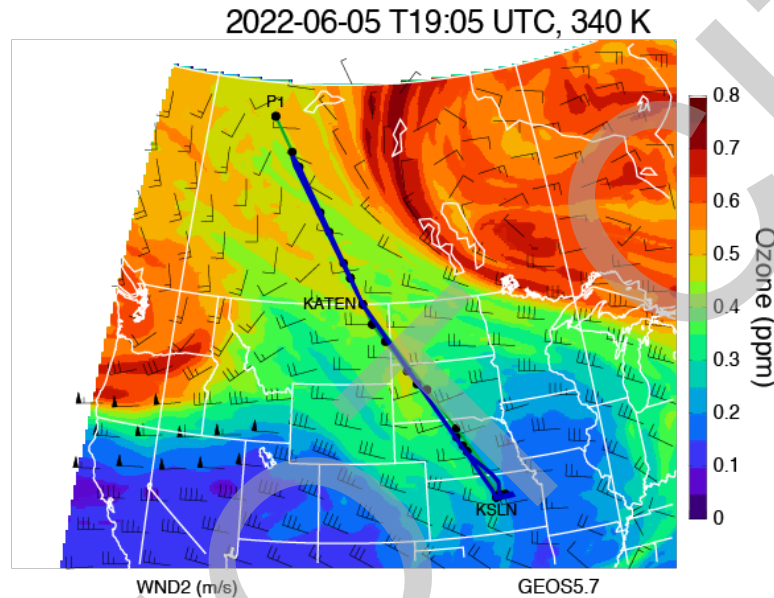


Figure 3. Ozone and winds on the 340 K surface. The green line shows the planned track, and the blue line shows the track as actually flown. Wind barbs are  $\text{ms}^{-1}$ .

Comparisons of ROZE ozone with GEOS-FP ozone analyses at higher theta levels suggest that GEOS-FP ozone has considerably higher values than ROZE. This remains to be investigated. At lower altitudes ( $\sim 340$  K), ozone was lower near Salina than at points to the north, in broad agreement with values shown in Figure 3.