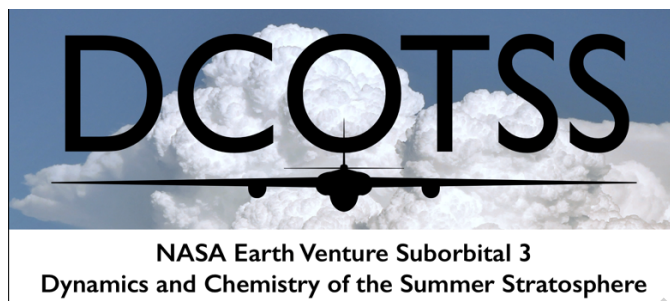


# DCOTSS ER-2 Mission Scientist Flight Summary Report



**Flight identifier:** RF20

**Science goals:** sample 1-day old plume from deep convection that occurred over southern Missouri, Arkansas, and Louisiana

**Start of flight (UTC):** 2022-06-27 18:53Z

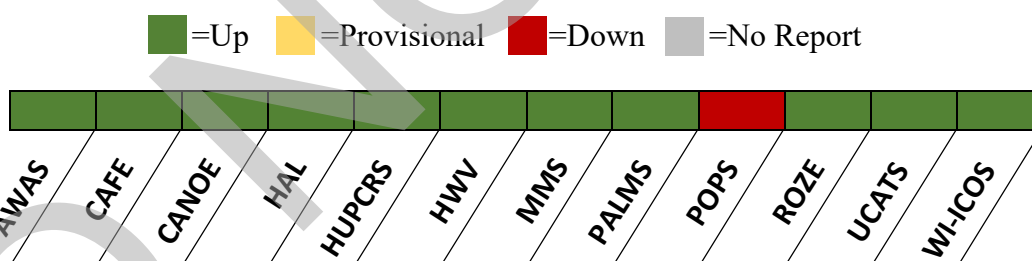
**End of flight (UTC):** 2022-06-28 00:48Z

**ER-2 Pilot:** Greg “Coach” Nelson

**Mission Scientist:** Anita Rapp

Version	Report date and time (UTC)	Author
1	2022-06-29 2200Z	Rapp, Anita
2	2022-07-06 1700Z	Keutsch, Frank, and Bowman, Kenneth

## Instrument Performance:



**Aircraft Performance:** Good; INS problem continues

## Science Objectives:

The primary objective of RF20 was to sample an ~1-day old convective plume from storms that developed along a frontal boundary in the isoprene rich source region in southern Missouri, Arkansas, and Louisiana. Figure 1 shows the (left) tropopause-relative echo top altitude, with an inset zoomed in on the deepest storms >2 km above the tropopause at 20:30 UTC. The overshoot history in the right panel of Figure 1 shows storms began overshooting on 27 June 2022 in southern Missouri and continued through Arkansas and Louisiana as the front pushed south.

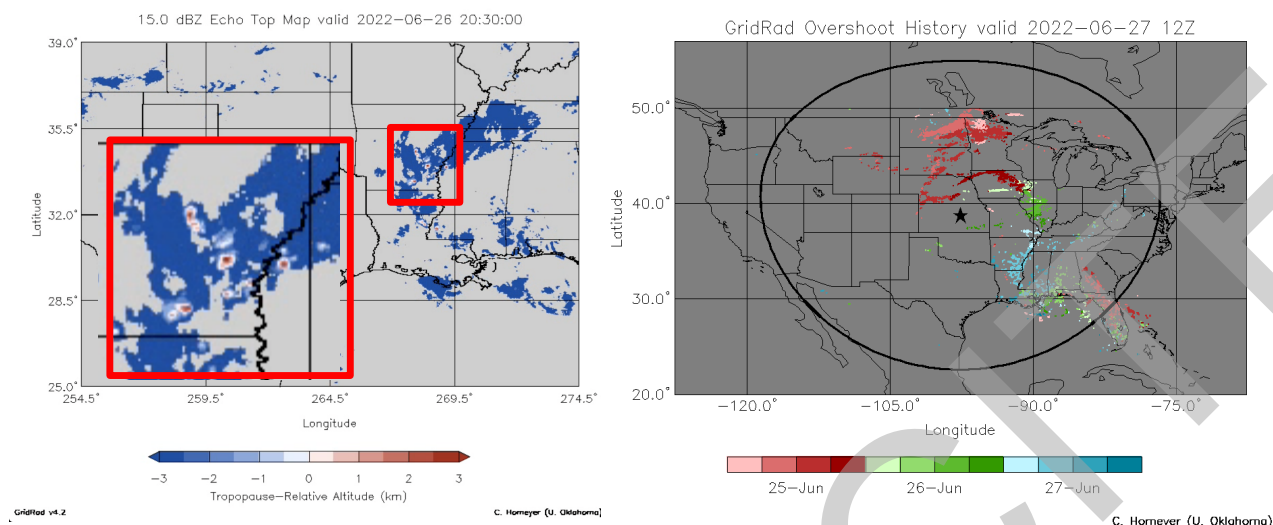


Figure 1. (left) GridRad tropopause-relative 15 dBZ echo top altitude on 26 June 2022, and (right) GridRad overshoot history at 12 UTC on 27 June 2022.

The center of the anticyclone was located over southern California (Figure 2), so the overshoot material was slowly carried slightly westward over Texas. GridRad trajectory forecasts (right panel Fig. 2) showed dense plumes extending from the tropopause up to nearly 60 kft, with the location of the dense material over northeast Texas in the 52-58 kft range. The flight plan shown in the left panel of Figure 3 targeted the densest plumes between 49-59 kft. After departure from Salina, the planned flight ascends to 60 kft, then descends to 49 kft at P1 and begins a series of level legs between P1 and P2 that step up to 59 kft in 2kft intervals. After sampling for 15 minutes at 59 kft, we planned to descend to 46 kft through the plume material. Upon reaching 46 kft and turning to Salina, the plan includes a 10-minute level leg in the troposphere. The aircraft then ascends to 60 kft, followed by a descent to 49 kft for an MMS maneuver and final descent into Salina. The planned takeoff time for the 6-hour flight was 1900 UTC.

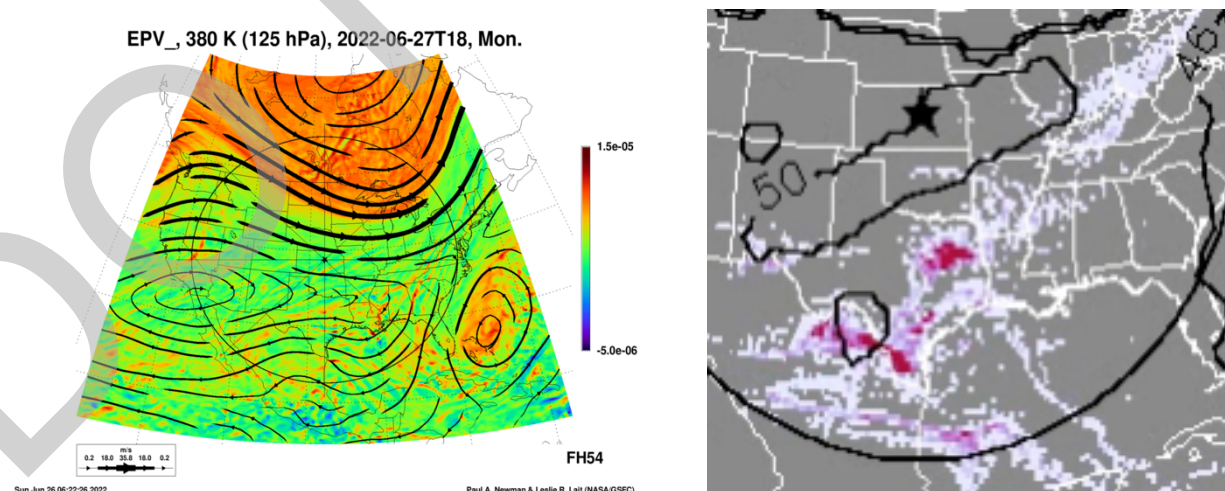


Figure 2. GEOS-5 potential vorticity at 380 K with streamlines overlaid in black, and (right) GridRad 54-58 kft plume density forecast for 18 UTC on 27 June 2022.

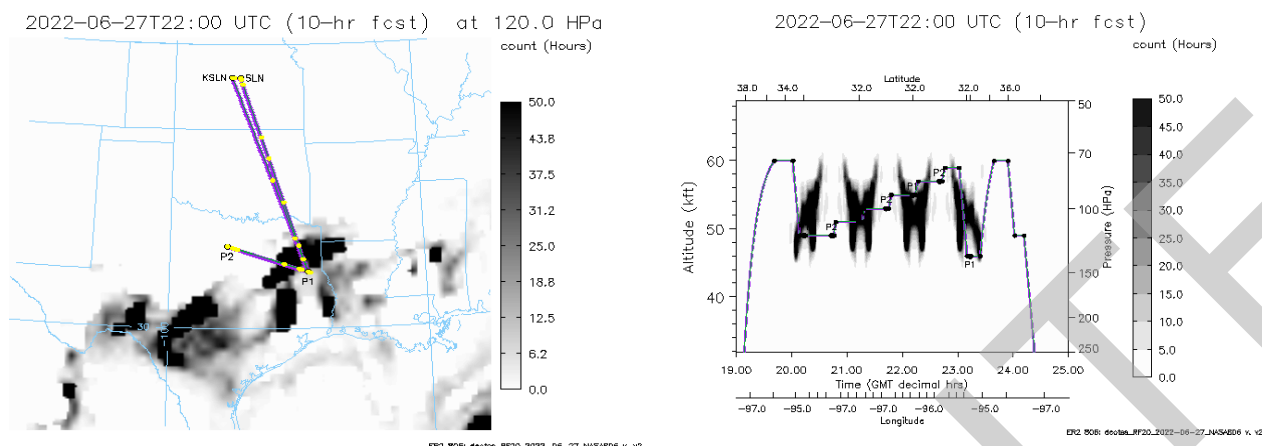


Figure 3. (left) Flight plan map and (right) flight vertical profile overlaid on GridRad overshoot density forecast for 22 UTC on 27 June 2022.

### Flight Summary:

The ER-2 departed Salina at 1853 UTC and the actual flight (top left in Figure 4) very closely followed the planned flight. The actual flight path is shown in the left panel of Figure 4, with measured altitude, temperature, and potential temperature timeseries from MMS for RF20 shown in the right panel of Figure 4. An overview of the aircraft pressure altitude, water vapor mixing ratio from HHH, and O<sub>3</sub> from UCATS timeseries is shown in the left panel of Figure 5, with CH<sub>2</sub>O from CAFE and NO<sub>2</sub> from CANOE in the right panel.

On the first descent from 60 to 49 kft, we descended into the plume on approach to P1. Background water vapor mixing ratio from HHH was about 4.5ppmv as we began the descent at 60 kft and increased to 10 ppmv around 56 kft. H<sub>2</sub>O mixing ratio increased to 12 ppmv at 50 kft approaching P1 at temperatures around 200 K.

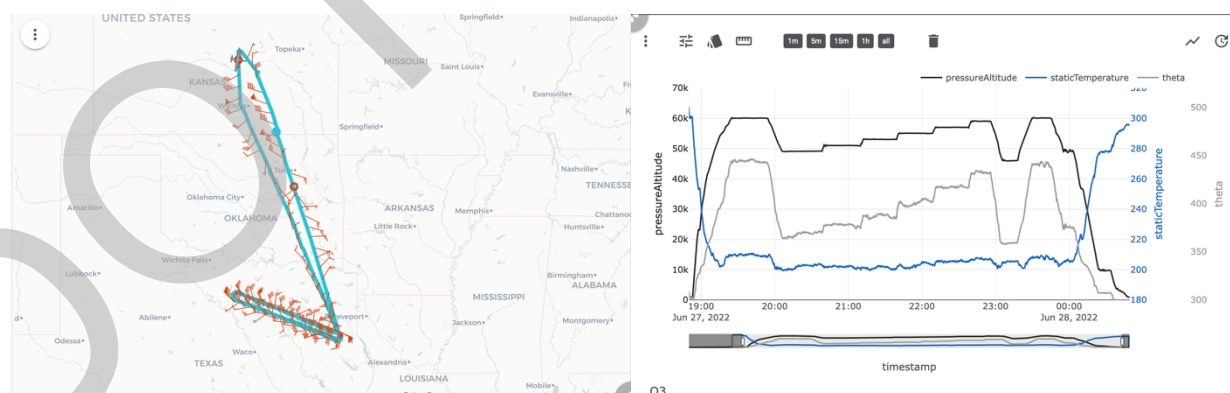


Figure 4. (Left) Actual flight track and (right) time series of pressure altitude (kft, black), MMS temperature (K, blue), and MMS theta (K, gray) during RF20.

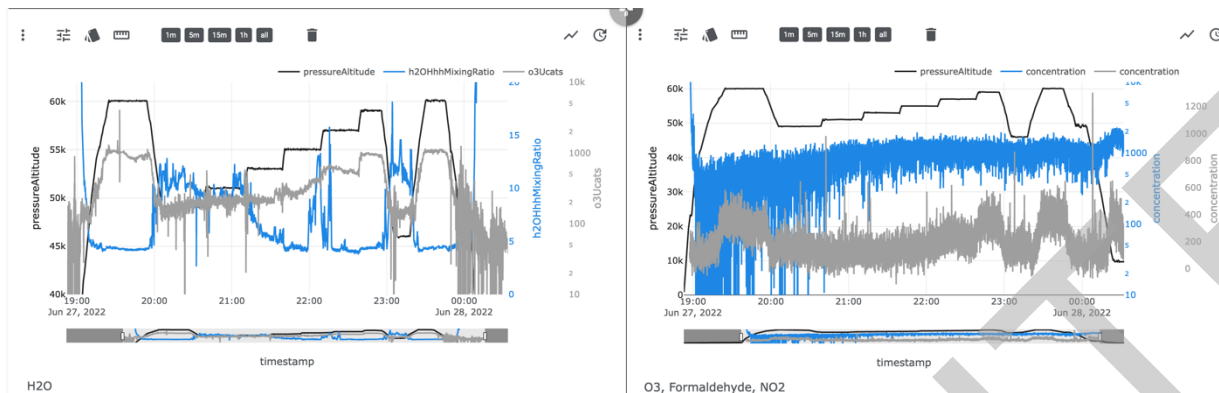


Figure 5. (Right) Timeseries of pressure altitude (kft, black), HHH water vapor mixing ratio (ppmv, blue), and (left) pressure altitude (kft, black),  $\text{CH}_2\text{O}$  from CAFE (pptv, blue), and  $\text{NO}_2$  from CANOE (pptv, gray) during RF20.

On each leg between P1 and P2 we intercepted elevated water vapor in the region of the densest plume material as we approached P1. Several of the storms on the previous day produced relatively deep overshoots, which is consistent with the sampling of multiple water vapor increases that we observed as we traversed between P1 and P2. Assuming that the air sampled near P2 is a good representation of the background, on the two lowest legs, water vapor in the plumes was elevated  $\sim 25$ -50% above background levels. However, while we expected to sample primarily in background air as we approached P2, there is some evidence especially at the lower altitudes ( $< 53$  kft) of occasional small water vapor enhancements that are also likely associated with storms from the previous day. These are evident in the top left panel of Figure 6 between 2132-2140 UTC.

From 53-57 kft, much larger increases above the background levels were observed (top right and bottom panels Figure 6) in the region of the dense plume near P1, with the largest increase in  $\text{H}_2\text{O}$  of  $> 15$  ppmv (relative to 4.5 ppmv background) observed at 57 kft. Near the end of the 59 kft leg as we approached the plume, there was a broad region of very slight elevation in  $\text{H}_2\text{O}$  suggesting we had reached near the top of the plume, which is consistent with the plume density forecast in Figure 2.

At the end of the 59 kft leg, we then profiled through the dense plume down to 46 kft toward P1, turned toward Salina and sampled tropospheric air for 10 minutes, then ascended back to 60 kft through less dense plume material. Large  $\text{H}_2\text{O}$  enhancements were observed between 54-56 kft and again at the tropopause level around 48 kft on both the descending and ascending profiles (bottom right in Figure 5).

One item of note for RF20 was that many of the enhanced water vapor plumes showed corresponding increases of ozone. Several of these positive  $\text{H}_2\text{O}$ - $\text{O}_3$  correlations are evident in both the small plumes observed near P2 in the top left panel of Figure 6 and the larger, denser plume near P1 in top right and bottom left panels of Figure 6.

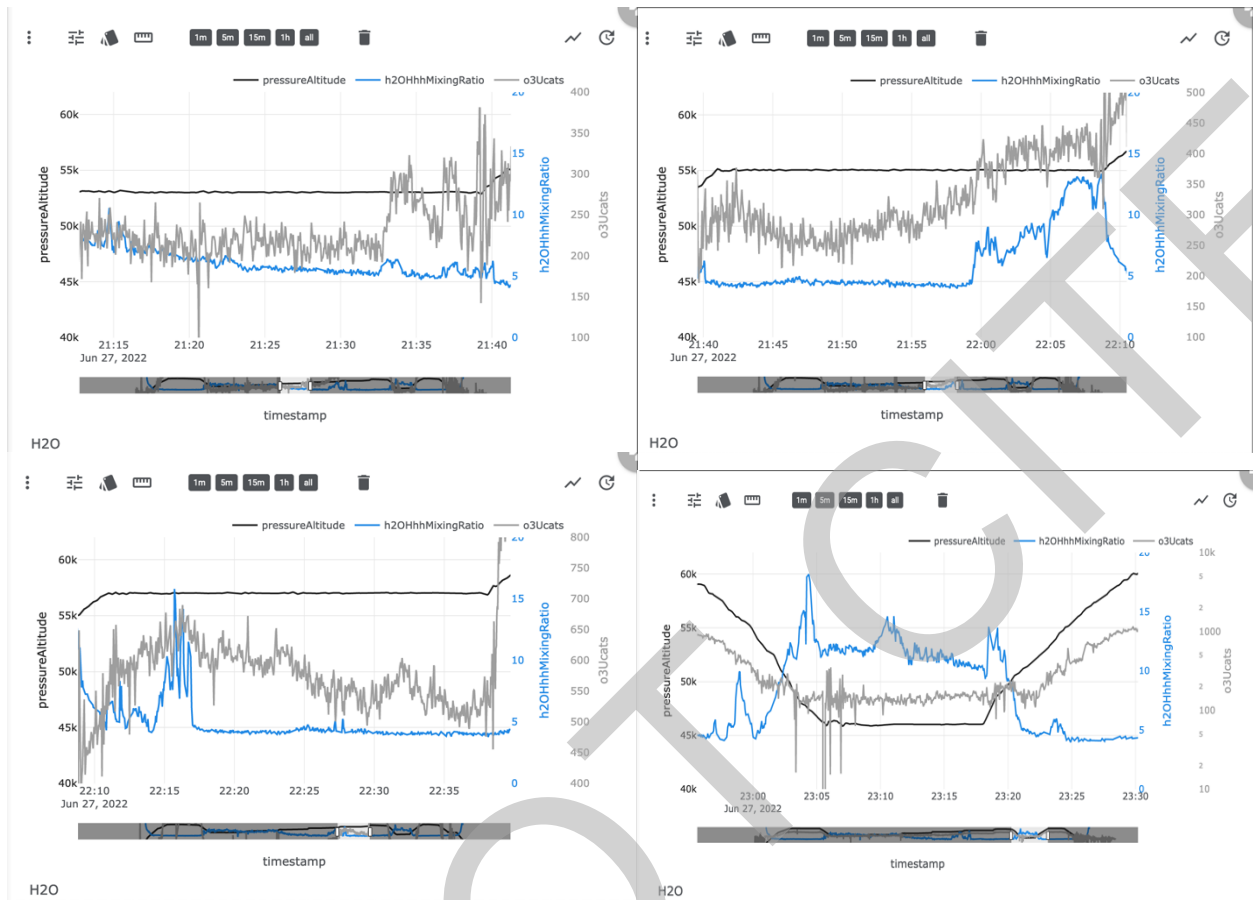


Figure 6. Pressure altitude (kft, black), HHH water vapor mixing ratio (ppmv, blue) and UCATS  $O_3$  (ppbv, gray) at (top left) 53kft, (top right) 55kft, (bottom left) 57kft, and (bottom right) profiles.