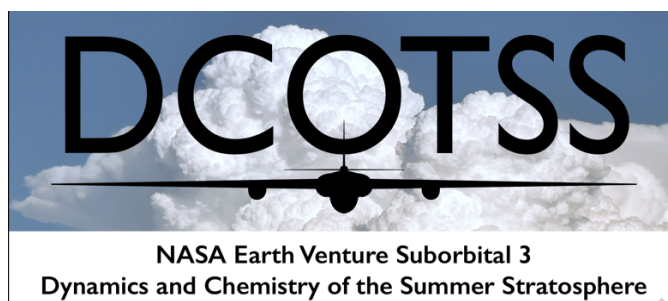


DCOTSS ER-2 Mission Scientist Flight Summary Report



Flight identifier: RF19

Science goals: Sampling of active convection over Nebraska and/or South Dakota; Intensively sample ~18-hr old very deep overshoot material over Kansas.

Start of flight (UTC): 2022-06-24 17:51Z

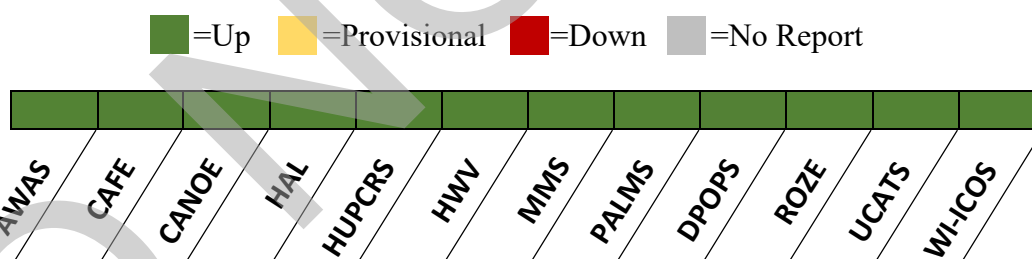
End of flight (UTC): 2022-06-25 01:20Z

ER-2 Pilot: Dean “Gucci” Neeley

Mission Scientist: Cameron Homeyer

Version	Report date and time (UTC)	Author
1	2022-06-29 17:45Z	Homeyer, Cameron
2	2022-07-01 15:30Z	Keutsch, Frank

Instrument Performance:



Aircraft Performance: Good, though navigation system issues continue

Science Objectives:

The primary target of this mission was active convection. Model consensus for widespread tropopause-overshooting convection in the Dakotas provided an ideal opportunity to plan for an active convection flight. Convection was forecast to initiate early somewhere in central South Dakota or north-central Nebraska (near 3 PM local) and persist into the early evening hours (Figure 1). This convection was forecast to be both slow moving and well-isolated from more expansive development of tropopause-overshooting storms to the north and west in the evening, providing a safer evolving target for active convection sampling. Sampling of fresh overshoot

material from these storms was planned via racetrack in south-central South Dakota, spanning level legs from 47 to 51 kft, every 1 kft and complemented by deep profiles in the near-storm environment and in the outflow. The waypoints of the racetrack were expected to change during flight after the real locations of overshooting convection were known.

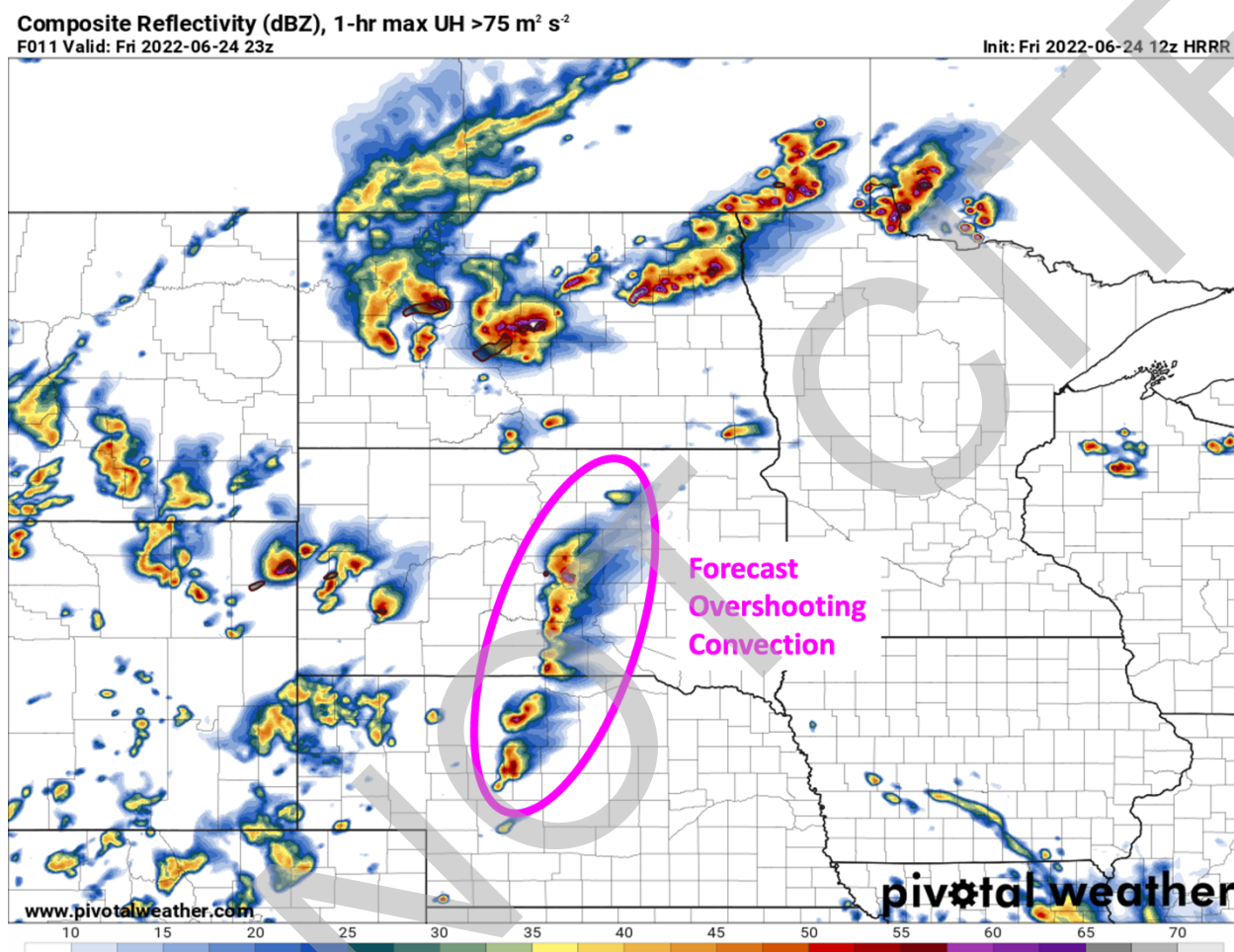


Figure 1: Forecast column-maximum radar reflectivity by the 24 June 2022 12Z HRRR simulation, valid 23 UTC on 24 June 2022. The targeted storms for active convection are enclosed by the magenta ellipse.

In addition to active convection sampling, a deep, discrete supercell storm in north-central Kansas* occurred on the evening of 23 June 2022 and reached altitudes up to 20 km for several hours based on radar observations (Figure 2). This storm dissipated as it neared Salina and had been associated with six tornado reports and numerous 1–1.5-in. severe hail reports and severe wind reports. The exceptional depth of this storm provided a near-range opportunity to target deep overshoot material in the stratosphere while we waited for the northern overshooting convection to materialize for active sampling. The recent stratospheric outflow from the Kansas supercell was the secondary target of the mission, for which we planned a racetrack pattern over northern Kansas spanning altitudes of 59–62 kft, with steps every 1 kft.

*GOES-16 1-min satellite animation of the Kansas supercell lifecycle:

https://rammb.cira.colostate.edu/ramsdisk/online/images/loop_of_the_day/goes-16/20220624000000/video/20220623000000_kssupercell.GIF

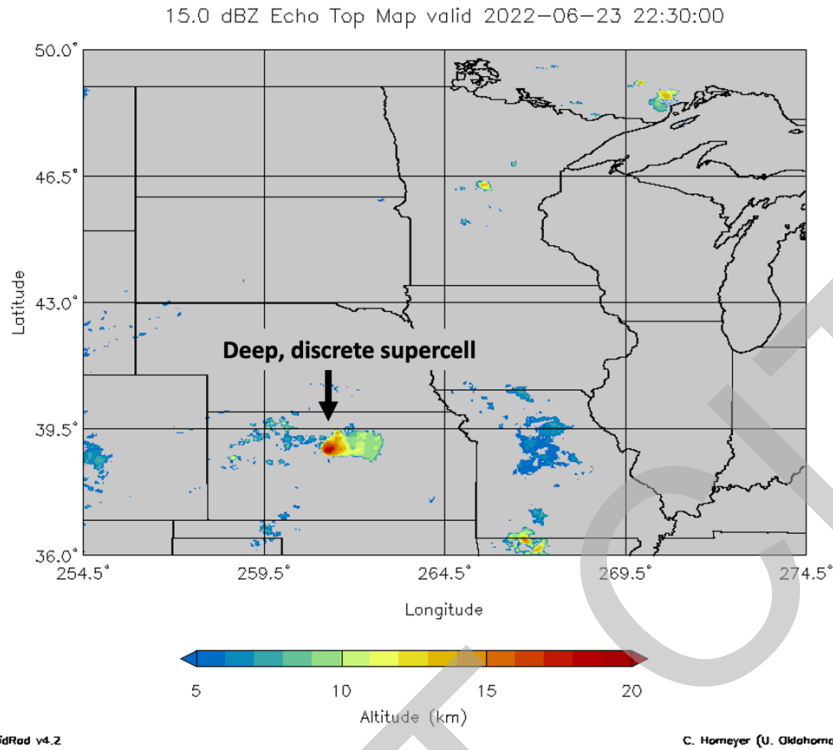


Figure 2: Observed 15-dBZ echo top heights from near-real-time GridRad products during the lifetime of the Kansas supercell, valid 22:30 UTC on 23 June 2022.

Finally, a maximum altitude climb for chemistry and stratospheric background was planned near the end of the mission on return to Salina. A map and vertical section of the flight plan superimposed on GridRad-initialized overshoot trajectory particle density are given in Figures 3 and 4, respectively.

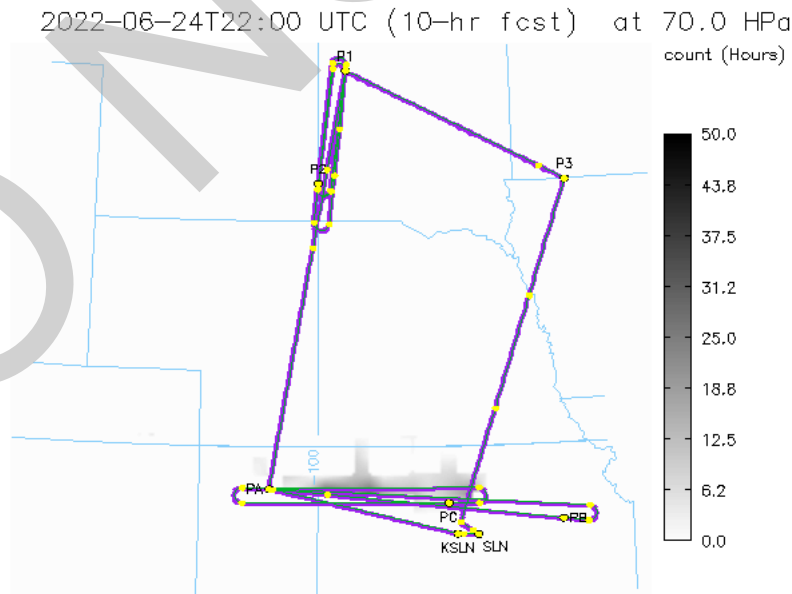


Figure 3: Map of RF19 flight plan superimposed on GridRad-initialized overshoot trajectory particle density at 70 hPa (~60 kft pressure altitude), valid near the mid-time of the Kansas supercell plume sampling.

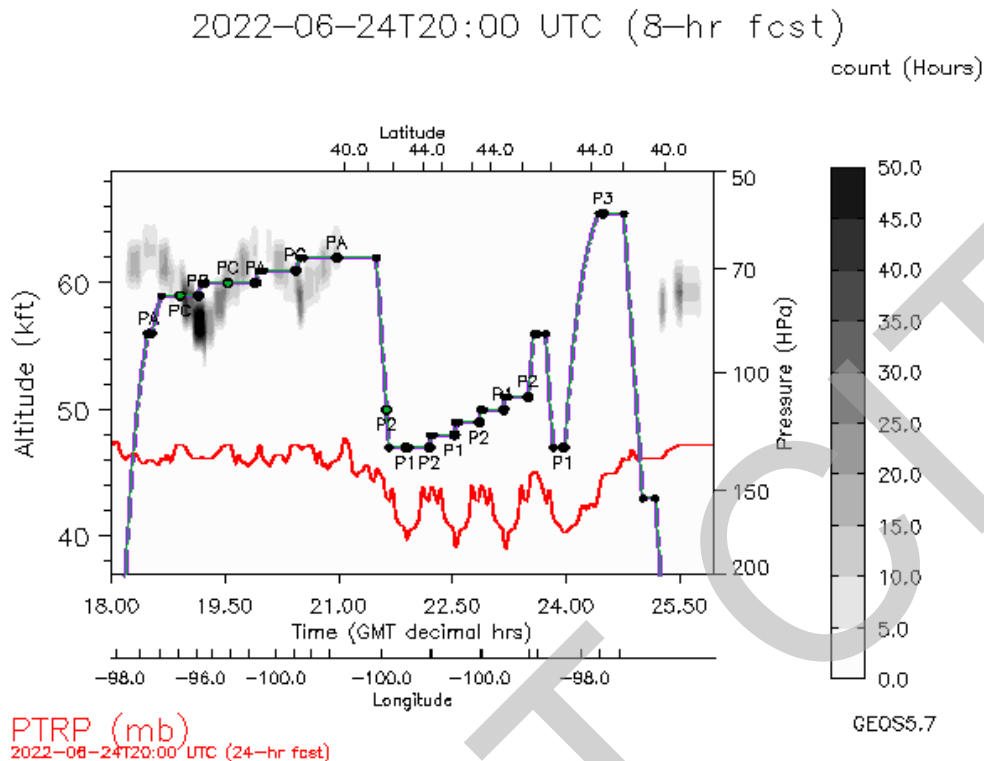


Figure 4: Curtain of forecast GridRad-initialized overshoot trajectory particle density along the flight path. The red line is the GEOS-5 tropopause height.

Flight Summary:

The ER-2 departed Salina as planned, flew to the northwest, and ascended to 59 kft to begin the racetrack pattern over Kansas. Shortly after beginning this racetrack, the aircraft began to experience problems with the navigation system as in previous flights. Despite this issue, the mission was able to continue. The only departure from the planned racetrack over Kansas was a brief accidental climb to 62 kft at the start of the 61 kft leg, which was corrected for the remainder of the flight segment. After completing the planned racetrack over Kansas, the ER-2 transited to sample ongoing convection that had developed as expected over central South Dakota, albeit slightly east of the forecast location (waypoints of the planned racetrack were adjusted accordingly). Due to the navigation issue, the pilot elected to descend slowly in the racetrack pattern near the convection for safety. As such, the racetrack was completed in level legs every 2 kft from 60 to 52 kft, with the last level leg completed at 51 kft and slightly closer to the convective cores than the prior legs. Following the final level leg of the racetrack pattern, the deep profile through the outflow of the active convection was completed as planned. The ER-2 then finished the remaining maximum altitude climb as planned at the end of the flight. The flight plan and completed flight track superimposed on GridRad-initialized overshoot trajectory altitudes from MTS are shown in Figure 5.

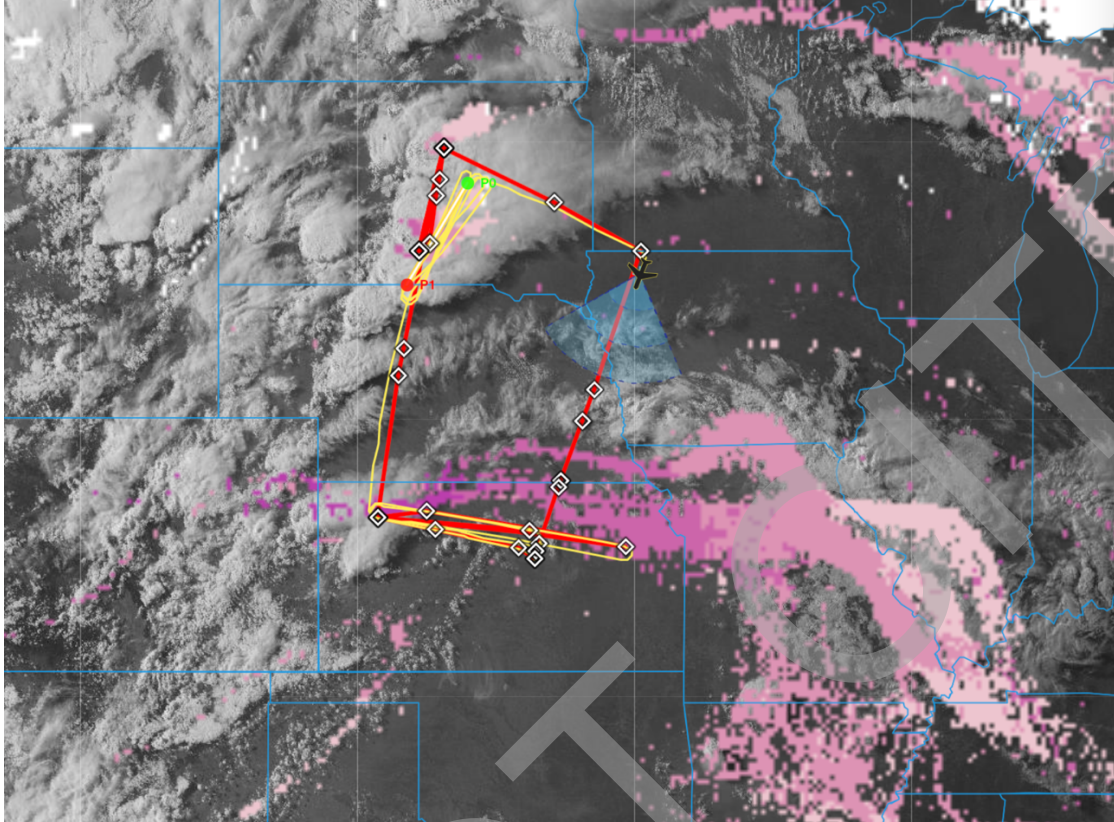


Figure 5: Map of the planned (red) and completed (yellow) flight track, superimposed on visible satellite imagery (black and white image) and GridRad-initialized overshoot trajectory altitudes (pink colors) near the end of the flight (from MTS).

Figure 6 shows select timeseries observations from MTS during the flight. An unexpected water vapor enhancement was observed in the tropopause transition layer near ~53 kft on the initial ascent out of Salina. Enhancements in water vapor coincident with the Kansas supercell overshoot material along the completed racetrack were not apparent until the 61 and 62 kft legs. Namely, the first notable enhancements were observed during ~3 minutes of the 61 kft level leg, beginning near 19:53 UTC. Water vapor increased to as high as ~1.3 ppmv above a background of ~4.5 ppmv. Increases in particle number/concentration were also noted by members of the DPOPS and PALMS teams immediately preceding the water vapor enhancements. The second notable enhancement of water vapor from the Kansas supercell was observed at 62 kft (starting at ~20:26 UTC), with water enhancements of up to ~1.5 ppmv above background for approximately 4 minutes.

Signatures of overshoot sampling (i.e., enhanced water vapor) during the active convection racetrack were not abundantly clear until the end of the 54 kft leg and profile to 52 kft. The pilot reported experiencing light-to-moderate turbulence at and below 54 kft during this racetrack. While the water vapor enhancements at 54 and 52 kft were marginal, two pronounced plumes from the ongoing convection were observed during the final level leg at 51 kft, with enhancements up to ~40 ppmv. A similarly large enhancement was found after the 51 kft leg when the deep profile in the active convection outflow was completed from 56 to 46 kft. Water vapor enhancements spanned altitudes near and below 53 kft and the pilot noted that the ER-2 never entered visible cloud during this time period.

After completing the active convection sampling, the maximum altitude climb during the remainder of the flight reached ~67.5 kft. During descent from maximum altitude to 43 kft for MMS maneuver, water vapor enhancements up to ~3 ppmv above background and nearly coincident with Kansas supercell overshoot material (northernmost plume in Figure 5) were sampled from ~00:17 to ~00:19 UTC in the lowest ~2 km of the stratosphere (at ~58 to ~52 kft pressure altitude and ~425 to ~380 K potential temperature).

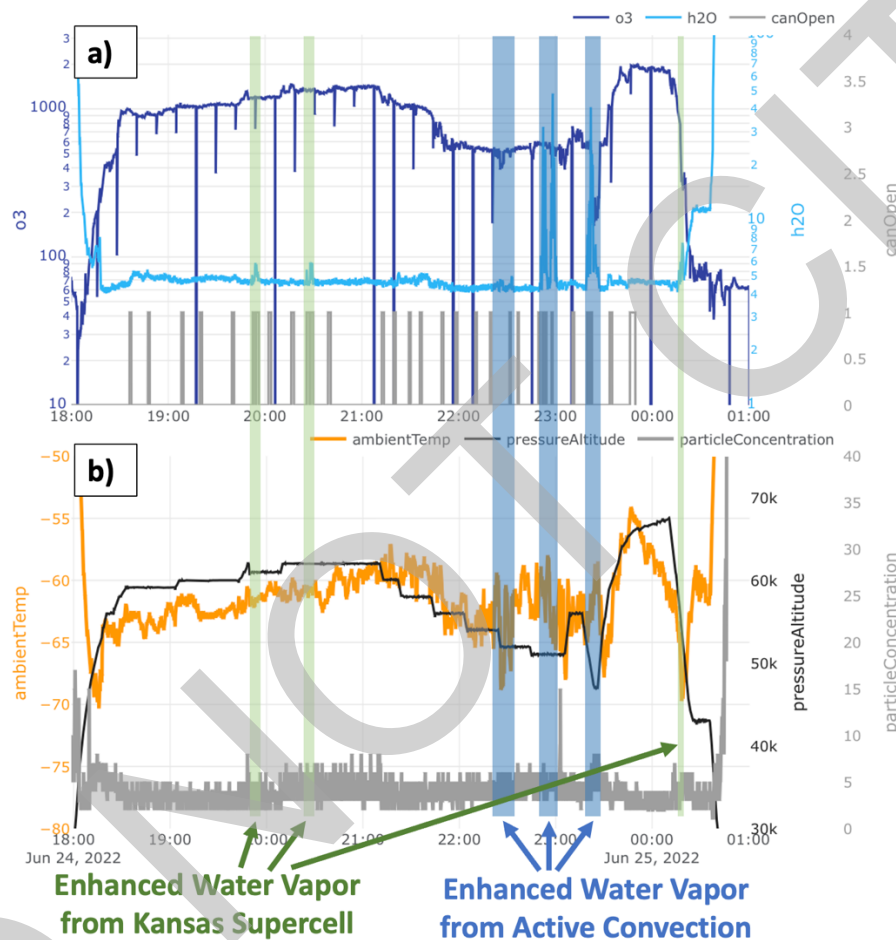


Figure 6: Timeseries of (a) ROZE ozone (dark blue), HWV water vapor (light blue), and AWAS open can times (gray), and (b) pressure altitude (black), ambient temperature (orange), and DPOPS particle concentration (gray) from MTS during the flight. Time periods during the horizontal legs where enhanced water vapor from the Kansas supercell was observed are indicated by green vertical color-fill and times where the active convection was observed by the blue vertical color-fill.