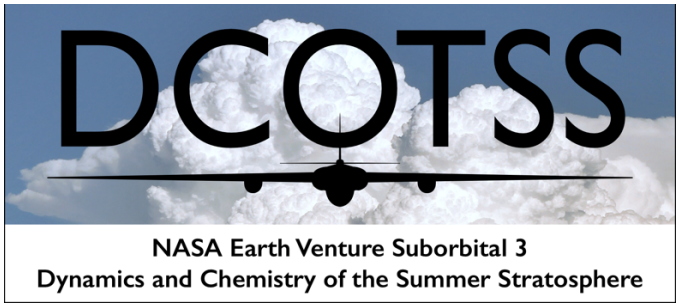
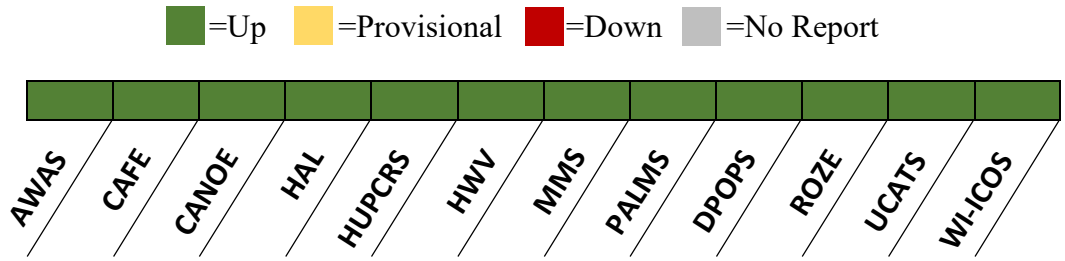
DCOTSS ER-2 Mission Scientist Flight Summary Report



Flight identifier: *RF05*
Science goals: *Recent (0-1 day old) convective plume sampling*
Start of flight (UTC): 2021-07-29 10:47Z
End of flight (UTC): 2021-07-29 18:25Z
ER-2 Pilot: Greg "Coach" Nelson
Mission Scientist: Rei Ueyama

Version	Report date and time (UTC)	Author
1	2021-07-30 19:00Z	Ueyama, Rei
2	2021-07-31 09:00Z	Keutsch, Frank

Instrument Performance:



Aircraft Performance: Good

Science Objectives:

The primary objective of DCOTSS research flight #5 (RF05) was to sample the outflow plume from recent (0-1 day) overshooting convection over Minnesota and Wisconsin. Strong overshooting convection over Minnesota started on 28 July and continued through the morning of RF05 (Fig. 1). During this time period, echo tops reached as high as ~60-64 kft, a few km above the tropopause. The convective system continued to move southeast on the morning of the flight (Fig. 2). A vertical sheet of overshooting material was expected to be over Indiana and Iowa, which was also projected to move southeastward. The challenge of RF05 was to sample

these fresh outflow plumes at a safe distance away from the active storms. The secondary objective was to sample the background stratospheric air for comparison with convective plume measurements.

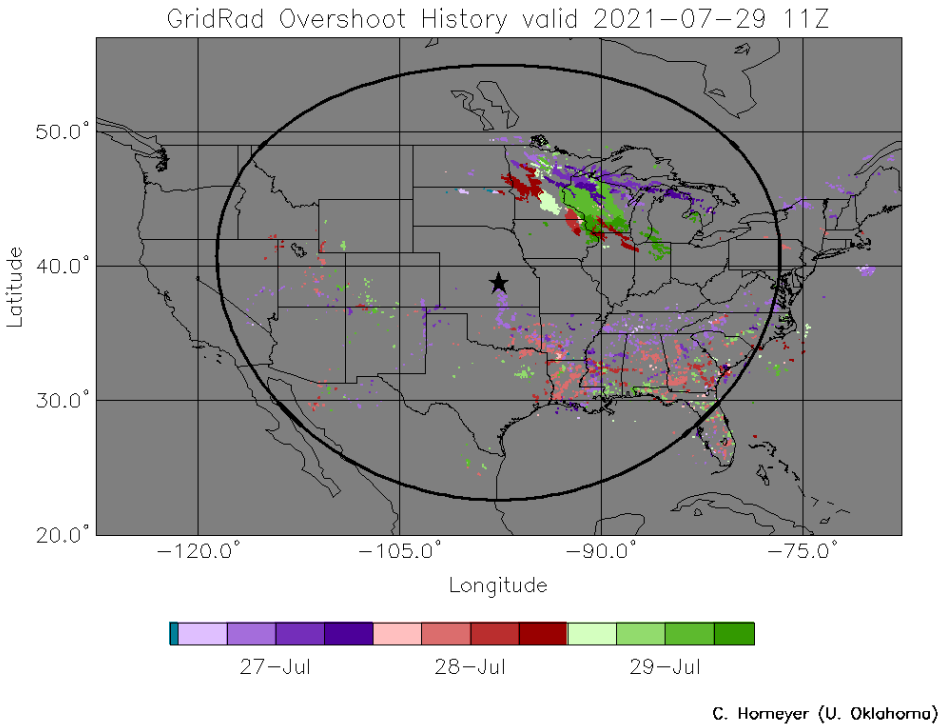


Figure 1: History of overshooting convection valid at takeoff on 29 July 11Z. Since 27 July, overshooting convection occurred over a broad region encompassing Minnesota and Wisconsin.

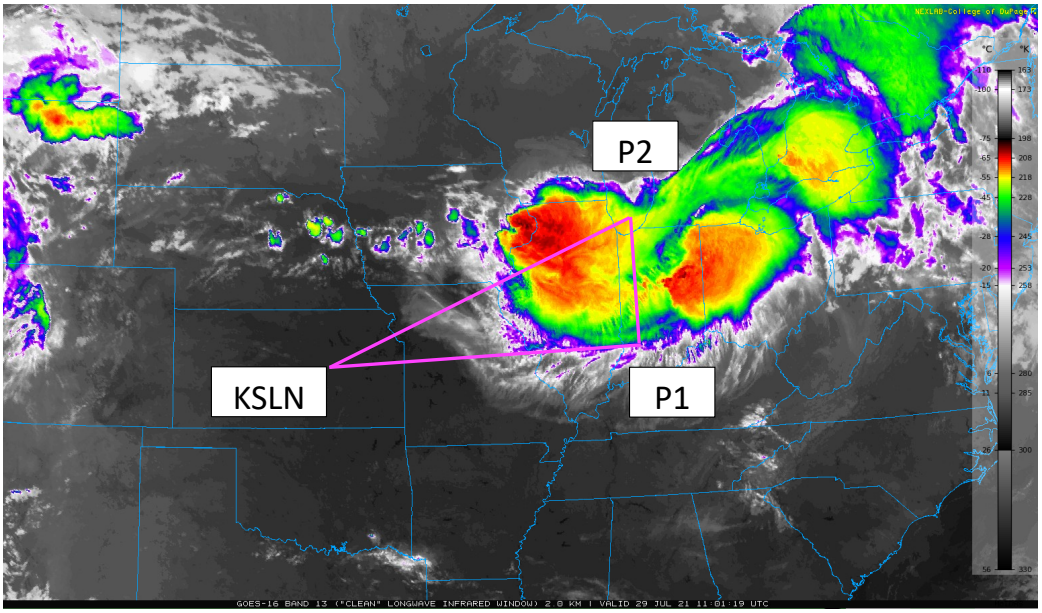


Figure 2: RF05 planned flight track overlaid on the GOES-16 infrared imagery on 29 July at 11Z (takeoff). Note the widespread anvil from overshooting cloud tops over northern Illinois. The ER-2 was expected to overfly the cloud tops at a safe distance.

Flight Summary:

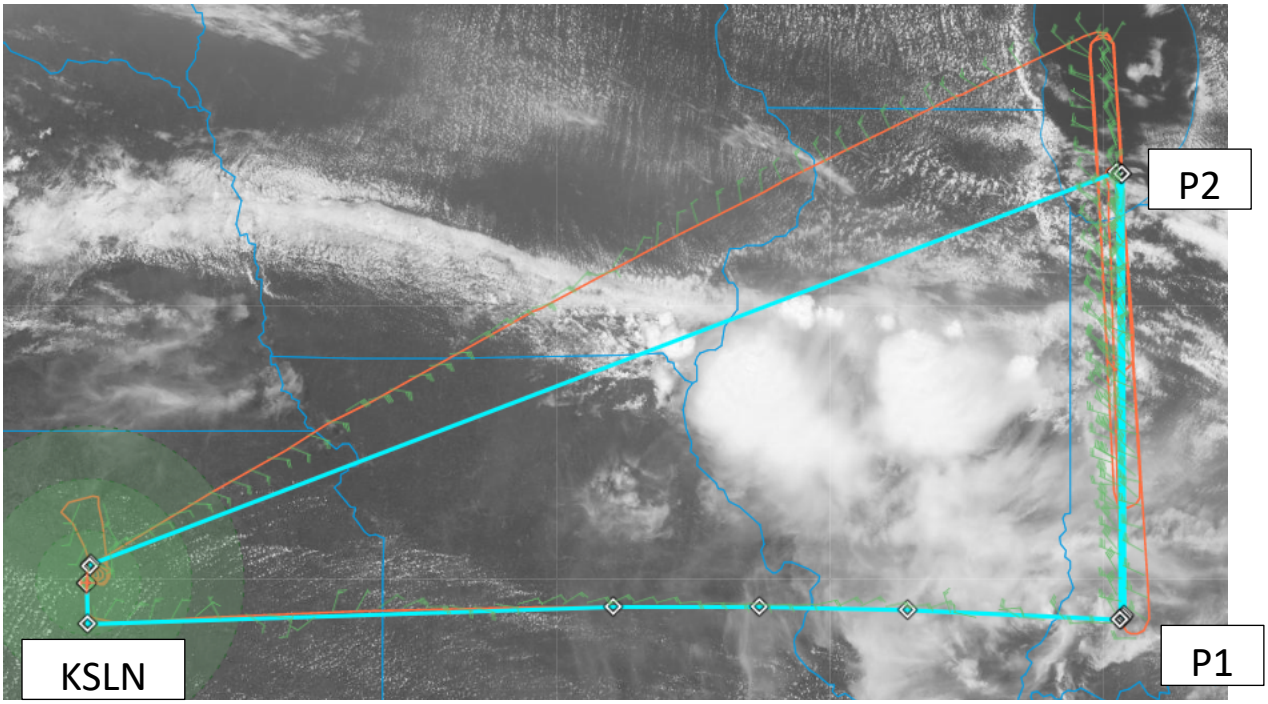


Figure 3: Map of RF05 on MTS overlaid on GOES visible satellite imagery at 1840Z (after landing) on 29 July 2021. Cyan line is the planned flight track. The actual ER-2 ground track is shown in orange.

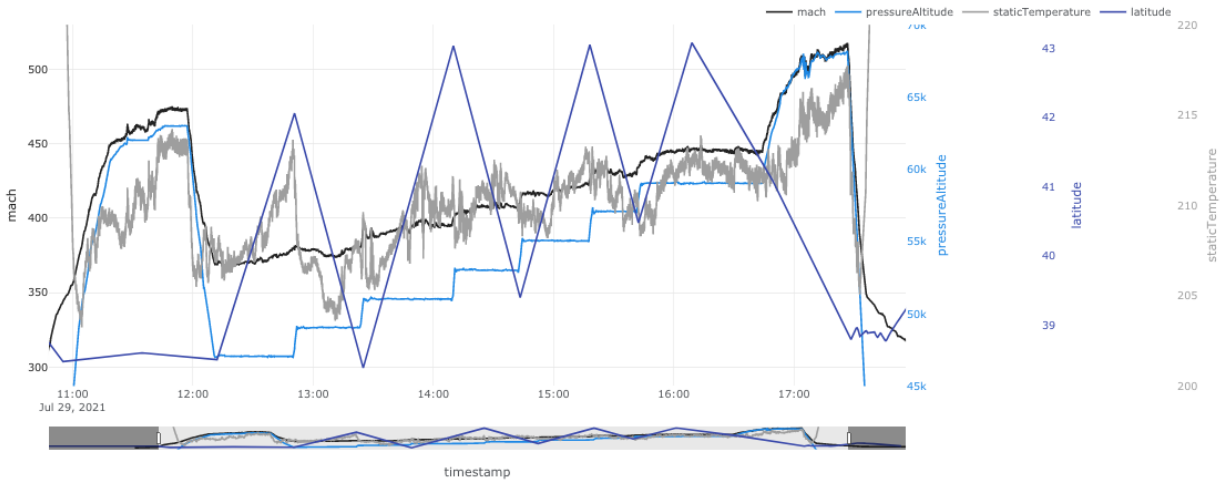


Figure 4: Time series of the IWG1 pressure altitude (ft; light blue) and latitude (°N; dark blue), along with MMS potential temperature (K; incorrectly labeled as "mach" in the MTS; black) and static temperature (K).

The ER-2 ground track and vertical profiling are shown in Figures 3 and 4, respectively. The aircraft took off at 10:47Z (05:47 CDT) towards waypoint P1and ascended to 62 kft. After a 10 min level leg at 62 kft, the aircraft ascended again to 63 kft, followed by another 10 min level leg. The aircraft then descended to 47 kft on the way to waypoint P1. The objective of this initial high-altitude leg was to obtain measurements of the chlorine chemistry during sunrise (HAL and CANOE instruments).

Between P1 and P2, the aircraft performed a series of stacked legs at 47, 49, 51, 53, 55, 57 and 59 kft (Fig. 5). We expected the outflow plumes to be tilted zonally and meridionally, with lower altitude material to the southeast and higher altitude material to the northwest. The location and altitude of the stacked legs were initially chosen to encompass the broad region and layer of the forecasted plumes as well as the stratospheric background air.

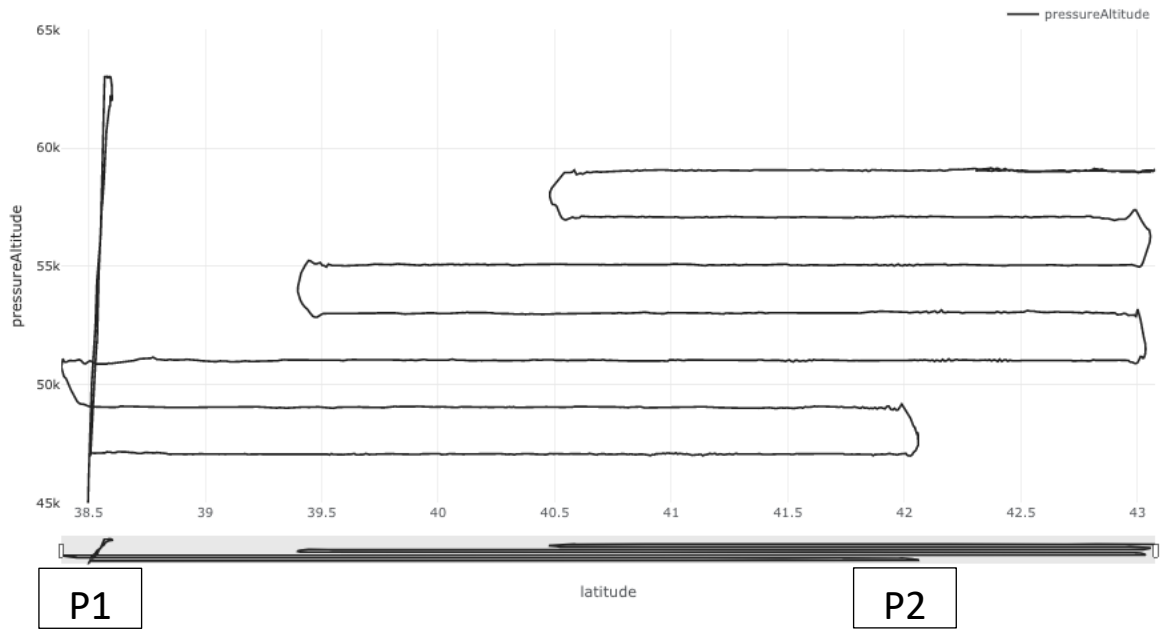


Figure 5. Latitudinal cross-section of the flight track during the north-south oriented stacked legs.

As we started flying through the convective plumes (most evident in real-time water vapor measurements) and determined their latitudinal ranges at 47 and 49 kft, we requested changes to the lengths of the subsequent higher-altitude level legs to maximize our sampling. On the northbound leg from P1 to P2 at 51 kft, we requested to extend P2 northward by 1 degree. Subsequent level legs at 53, 55, 57 kft were shifted northward by 1 degree on both ends (waypoints P1 and P2). On the southbound leg from P2 to P1 at 57 kft, we requested to shorten the leg by moving P1 northward by an additional degree. While flying at 47 kft, the pilot estimated the main cirrus cloud deck to be about 2-3 kft below the aircraft (i.e., 44-45 kft). A very thin layer of high-altitude cirrus was also spotted in images from the forward-looking camera (Fig. 6).

Figure 6: A thin layer of high-altitude cirrus is captured by the forward-facing camera on the ER-2 at 13:06Z on 29 July.

At the northernmost waypoint, the aircraft turned to KSLN and flew straight and level for 33 min. The straight-and-level leg at 59 kft was requested in real time after we identified additional forecasted plume material at high altitudes over northern Illinois and southeast Iowa. The aircraft then cruise climbed to max altitude (68 kft) all the way to KSLN. A pitch and yaw MMS maneuver was performed at max altitude along the flight track towards KSLN. The ER-2 landed at KSLN at 13:25Z via a spiral descent to coincide with a frostpoint hygrometer balloon that was launched at KSLN at approximately 15:20 UT (10:20 CDT).

Real-time in situ measurements indicated that we had flown through convective outflow plumes multiple times during the stacked-leg maneuvers between 47 and 57 kft (Fig. 7).

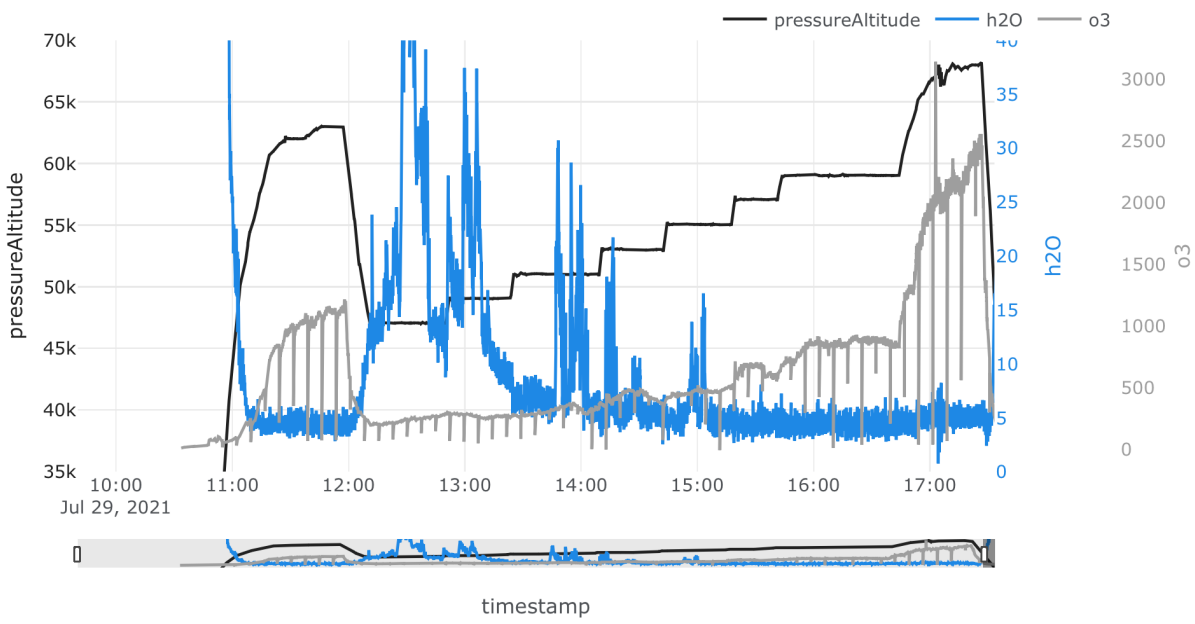


Figure 7: Measurements of H2O from the Harvard WV instrument and O3 from the ROZE instrument collected on RF05. Also plotted are IWG1 pressure altitudes indicating that the convective plume signatures were detected during the stacked-leg maneuvers below ~57 kft.