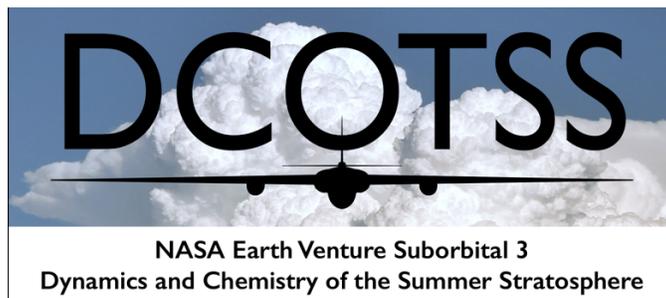


DCOTSS ER-2 Mission Scientist Flight Summary Report



Flight identifier: RF06

Science goals: Intensively sample 1–3-day overshoot material; descent through PyroCb plume

Start of flight (UTC): 2021-08-02 13:54Z

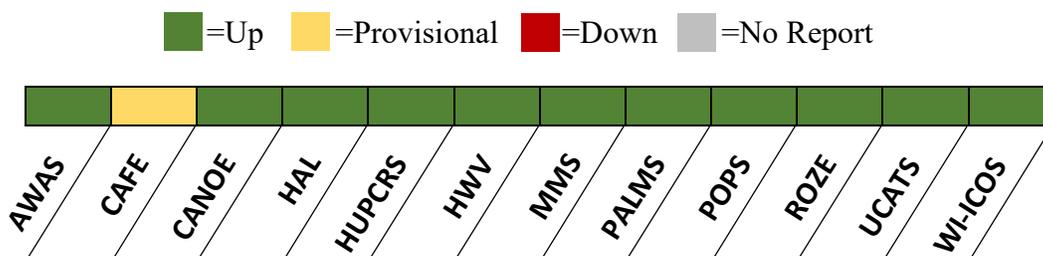
End of flight (UTC): 2021-08-02 20:36Z

ER-2 Pilot: Gary “Thor” Toroni

Mission Scientist: Cameron Homeyer

Version	Report date and time (UTC)	Author
1	2021-08-03 21:30Z	Homeyer, Cameron
2	2021-08-04 15:30Z	Bowman, Ken

Instrument Performance:



Aircraft Performance: Good

Science Objectives:

In the three days leading up to the flight (and to the elation of those in the field), a cold front progressed south through the Great Plains of the US, initiating widespread overshooting convection in the afternoon/evening and along the front each day. Specifically, there was ample overshooting across Nebraska and neighboring states on 30 July, slightly less overshooting along the Oklahoma-Kansas border and extending further east on 31 July, and even less overshooting that was also less confined to the front on 1 August. This overshooting history was consistent in radar and satellite analysis.

The overshoot material was transported south toward a saddle point in the flow and stretched east-west (shearing in altitude). Material from the multiple overshoot regions described above accumulated in a narrow band across the southern U.S., with lower, near tropopause material advected east and higher altitude material advected west. The forecast location of all overshoot material from the preceding 3 days is shown in Figure 1 and the density of overshoot material by altitude layer in Figure 2. The densest regions of overshoot material in the 52-58 kft altitude layer over southeast Texas were the primary target of the mission.

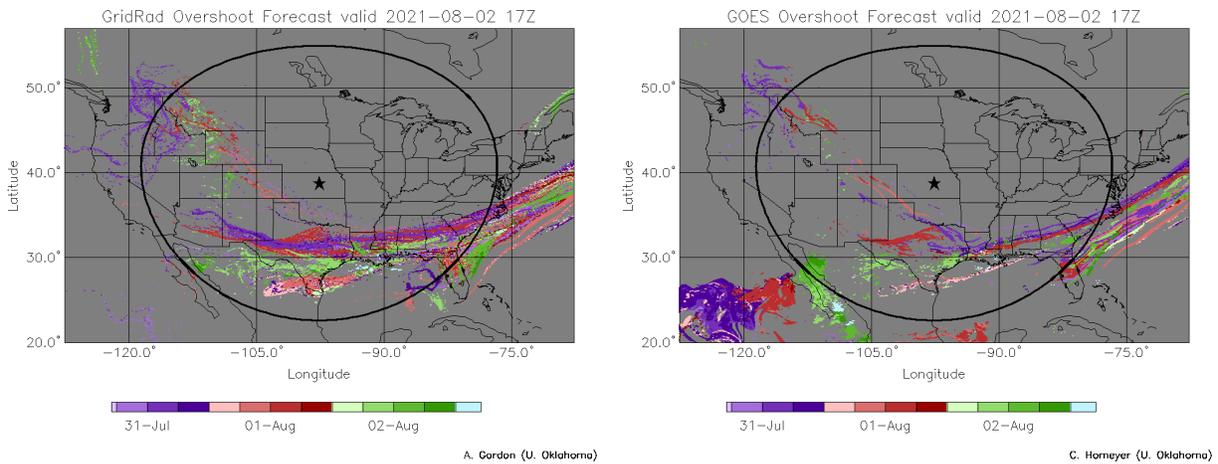


Figure 1: Overshoot material forecast from (left) GridRad and (right) GOES, valid 17 UTC on 2 August 2021.

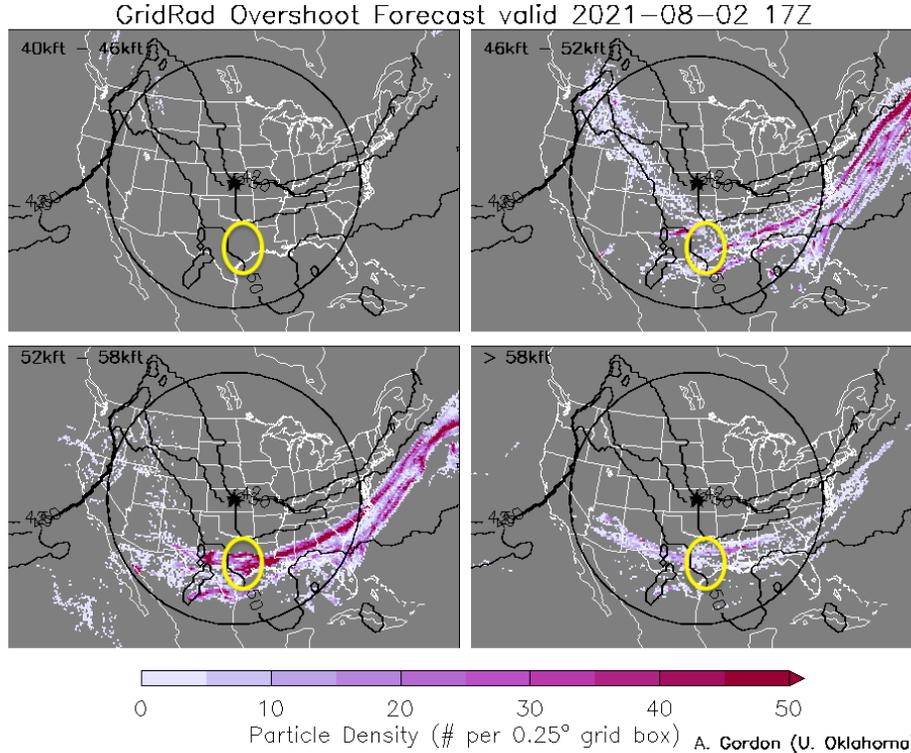


Figure 2: Forecast density of overshoot trajectory particles by altitude layer, valid 17UTC on flight day. The sample region is encircled in yellow.

The secondary target of the flight was a possible near-tropopause PyroCb-lofted smoke plume that originated near the Idaho-Montana border on the evening of 31 July. This plume was targeted on the return to Salina. The plan was to fly to southwest Kansas, then profile through the lower stratosphere near the expected location of the plume (down-up-down while moving northeast) and then descend to land in Salina. Figure 3 shows some point trajectories of material from multiple PyroCb plumes identified in satellite imagery and run by M. Fromm on the morning of the flight. The western-most plume was that targeted on the return to Salina.

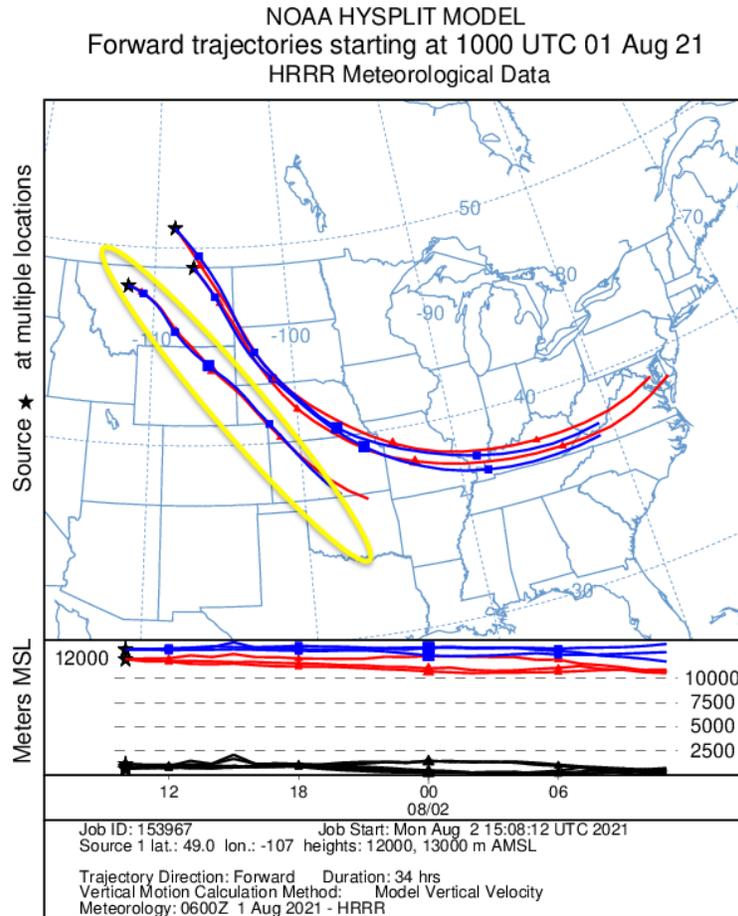


Figure 3: Trajectory calculations for PyroCb-lofted smoke plumes identified by M. Fromm in satellite imagery. The plume encircled in yellow is the secondary target of the mission.

Figures 4 and 5 summarize the flight plan, showing a map of the path overlaid on satellite imagery during the flight (from MTS) and a curtain of the forecast overshoot material along planned flight path, respectively.

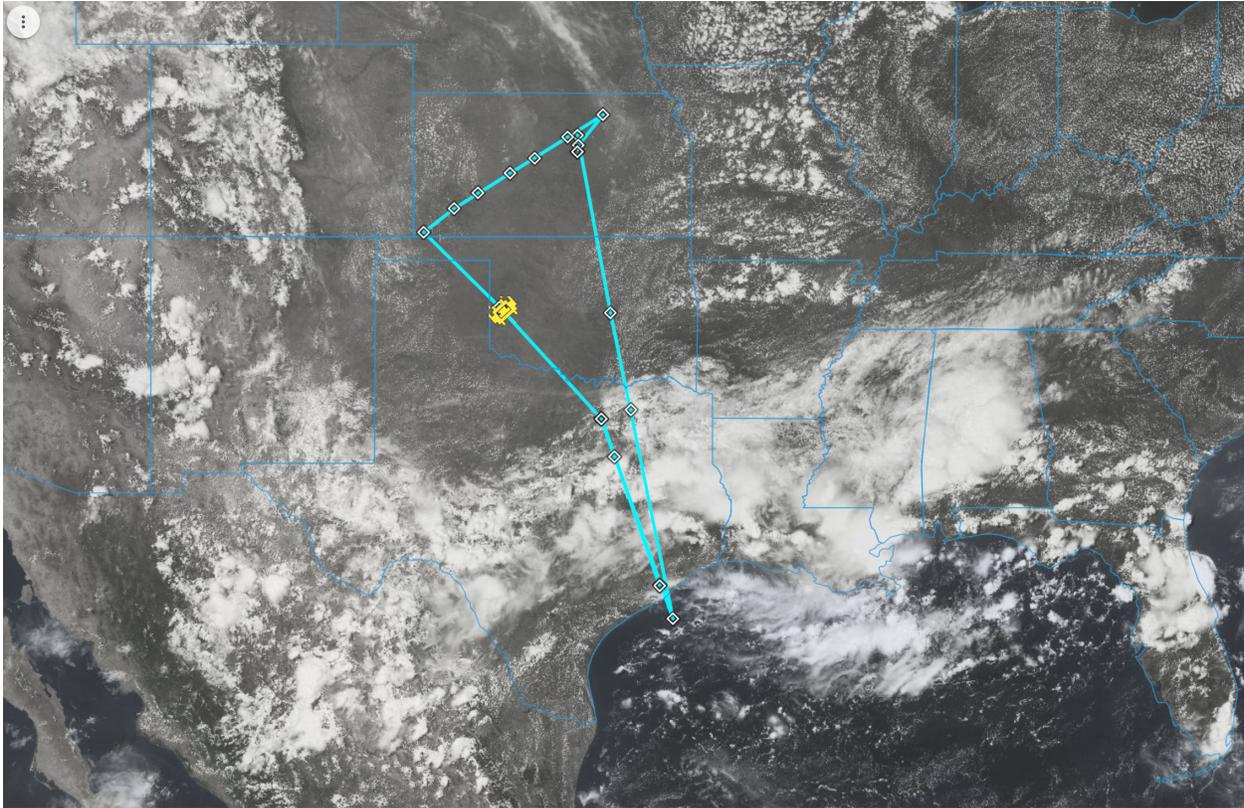


Figure 4: Satellite map valid during RF06 and the flight path superimposed.

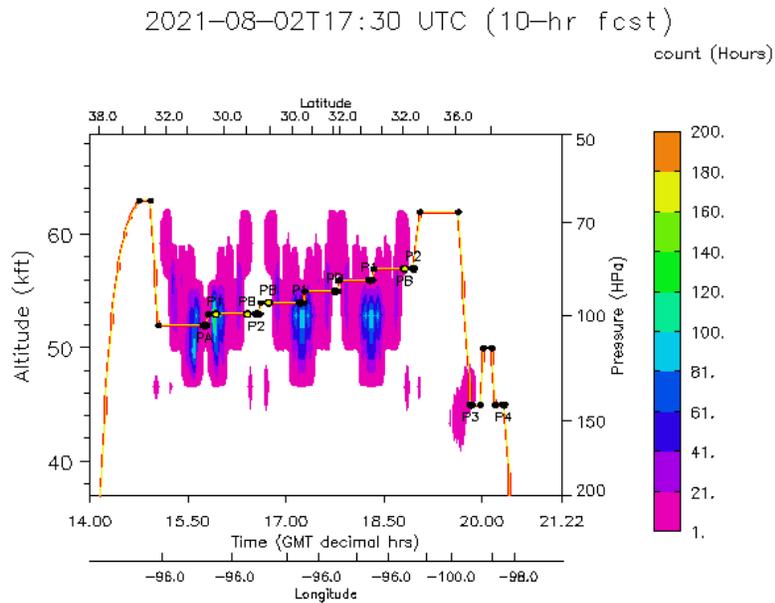


Figure 5: Curtain of the forecast density of GridRad and GOES overshoot trajectory particles with the flight plan superimposed.

Flight Summary:

There was much visible haze over Salina on the morning of the flight due to smoke across the region. The tropopause was low to the north and high to the south, with a gradient over Salina that followed the passage of the cold front two evenings prior. Within the region of the primary target (aged overshoot material) the tropopause was 50-53 kft (based on radiosondes and GFS analysis), while near the return and in the region of the secondary target (PyroCb smoke plume) the tropopause was ~46 kft (based on preliminary aircraft observations in MTS and broad view from GFS analysis). Figure 6 shows the flight path superimposed on a GFS analysis tropopause map during the flight.

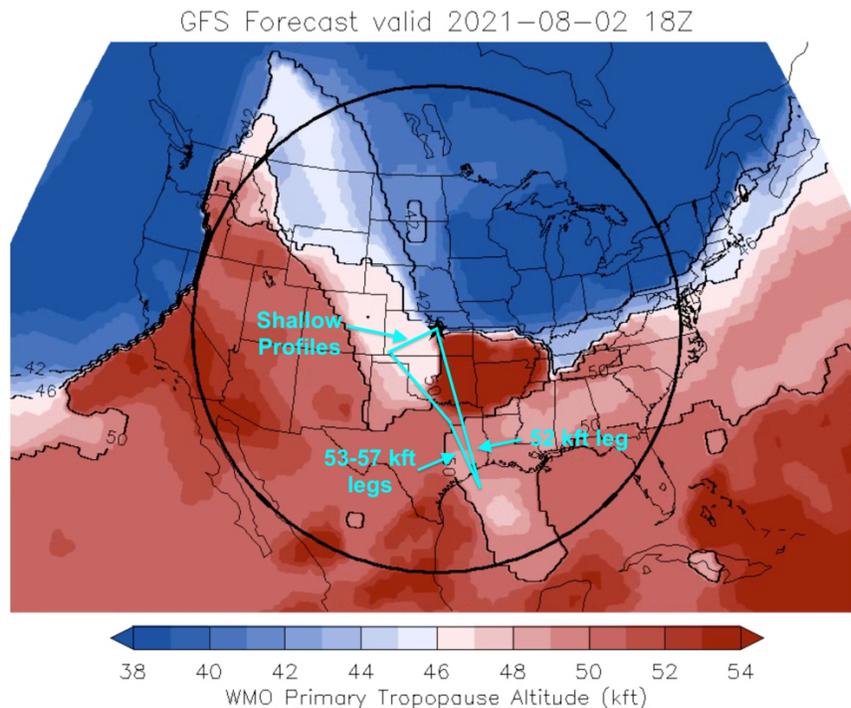


Figure 6: GFS tropopause map valid 18 UTC on 2 August 2021, with annotated flight plan overlaid in cyan.

The sampling strategy for the aged overshoot material was sequential horizontal legs (ER-2 racetrack) every 1 kft, from 52 to 57 kft over Texas. Broad water vapor enhancements were seen in the first 5 legs (52-56 kft), with the largest enhancement (up to ~13 ppmv) measured at 55 kft toward the southern end of the leg. The final pass at 57 kft did not reveal obvious water vapor enhancement. During this flight ozone increases were observed in several of the water vapor plumes. Figure 7 shows several real-time parameters from MTS during this portion of the flight.

During the transits over Texas, multiple weak storms formed and matured in view of the camera and at least two exhibited overshooting and above-anvil cirrus generation, though it is not clear if these were both above-tropopause. The first case was observed during the transit to the gulf coast following takeoff, near 15:36 UTC (Fig. 8). This storm was viewed from the ER-2 looking south. The second, which was verified to be associated with a short-lived tropopause-overshooting storm from radar, was observed during the 56 kft horizontal leg from 17:40-17:50 UTC.

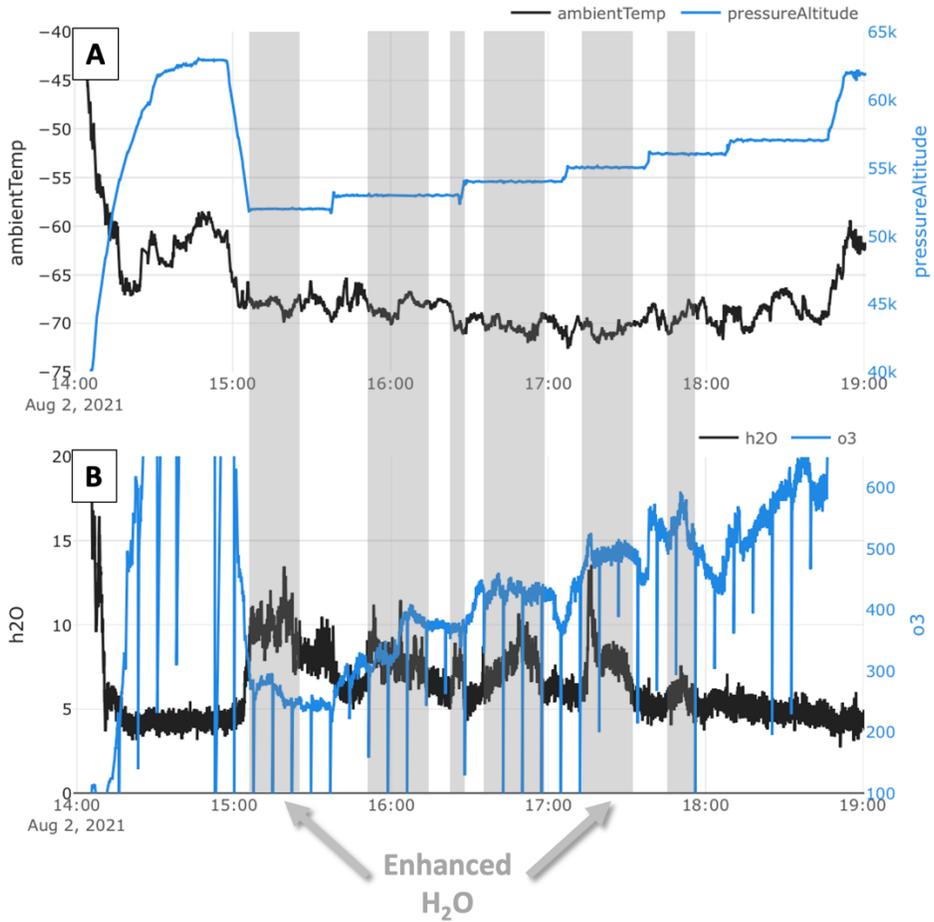


Figure 7: Timeseries of (a) air temperature and altitude and (b) ROZE ozone and LyA water vapor from MTS during the portion of the flight targeting aged overshoot material. Time periods during the 1-kft horizontal legs where evidence of enhanced water vapor (relative to typical background concentrations) was observed are indicated by gray vertical color-fill.



Figure 8: The first storm with above-anvil cirrus observed during the horizontal legs over Texas. This image is valid at approximate 15:36 UTC.

Following the stacked legs in Texas, a max altitude leg to southwest Kansas included a simple MMS maneuver (pitch and yaw), between 19:50 and 20:00 UTC. The ER-2 descended to 45 kft on approach to southwest Kansas, where it turned northeast toward Salina. Suspected sampling of PyroCb-lofted smoke was indicated by increases in aerosol particle count, water vapor, and ozone near the end of the 50 kft leg (19:57-19:59 UTC). Figure 9 shows multiple parameters from MTS during this portion of the flight.

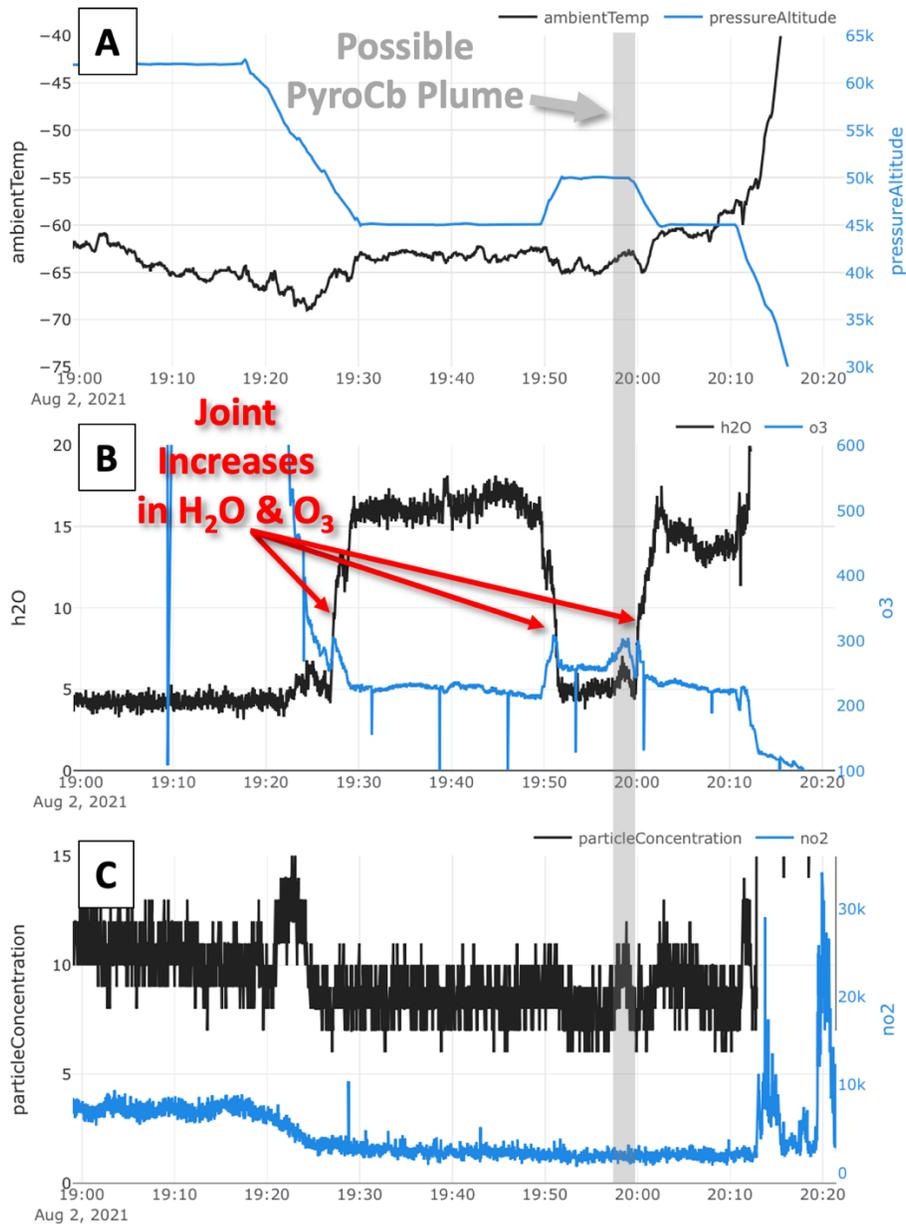


Figure 9: Timeseries of (a) air temperature and altitude, (b) ROZE ozone and LyA water vapor, and (c) DPOPS particle concentration and CANOE NO₂ from MTS during the portion of the flight targeting smoke lofted by a PyroCb over northern Idaho. The suspect PyroCb layer sample is indicated by the gray vertical color-fill and shallow layers of joint increases in water vapor and ozone are indicated by the red labeled arrows.

More substantial smoke plumes were apparent in the troposphere during the final descent and approach to Kansas, with a notable layer in the upper troposphere between 32 and 38.5 kft (evidenced by both enhanced aerosol and NO₂). This dense smoke was also visible in the camera imagery ahead of the ER-2 across the entire horizon during this southwest-to-northeast transit, though it remained below the aircraft during the 45 kft legs that were executed during the PryoCb plume sample. Figure 10 shows two images of the dense upper troposphere smoke layer in the path of the aircraft – one before and one during sampling, and Figure 11 repeats the DPOPS aerosol and CANOE NO₂ panel from Figure 9 with increased range to reveal the tropospheric plumes sampled during final descent.



Figure 10: Images before (left; valid ~19:51 UTC) and during (right; valid ~20:15 UTC) sampling of the upper tropospheric smoke plume).

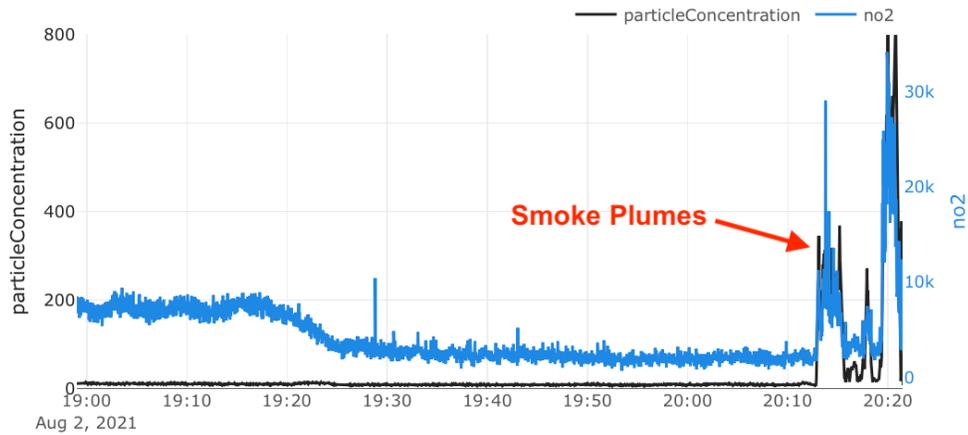


Figure 11: As in Fig. 9c, but with increased range of values. The sampled tropospheric smoke plumes are indicated by the red arrow.