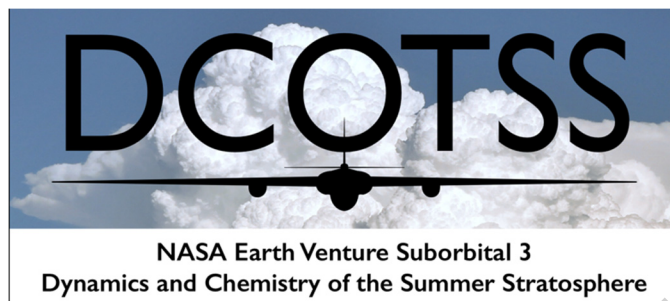


DCOTSS ER-2 Mission Scientist Flight Summary Report



Flight identifier: *RF22*

Science goals: *Sunrise flight to examine stratospheric photochemistry*

Start of flight (UTC): 2022-07-08 9:31Z

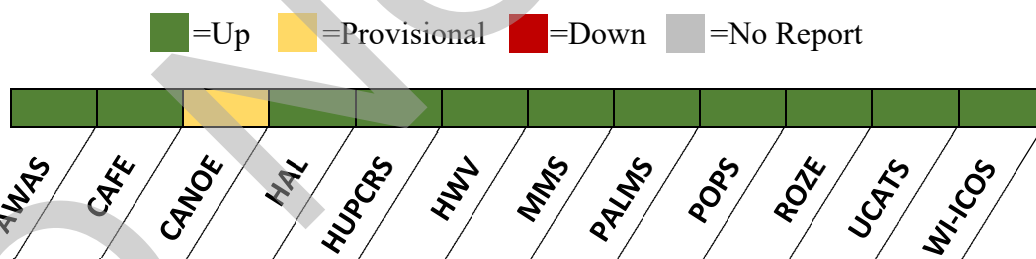
End of flight (UTC): 2022-07-08 17:43Z

ER-2 Pilot: Tim Williams

Mission Scientist: David M. Wilmouth

Version	Report date and time (UTC)	Author
1	2022-07-22 21:00Z	David Wilmouth
2	2022-07-23 11:45Z	Rei Ueyama, Frank Keutsch, Ken Bowman

Instrument Performance:



Aircraft Performance: Good

Science Objectives:

DCOTSS research flight #22 was designed with the principal scientific objective of examining photochemistry in the stratosphere as the sun rises. To observe the largest possible gradients in the inorganic halogen and nitrogen species, and for the best possible signal:noise ratio of the measurements, the goal was to sample in the highest ozone air possible. An equally important consideration was to target air of relatively constant ozone along the primary sampling track to ideally facilitate an experiment in which only the changing solar zenith angle would drive observed changes in measured concentrations.

Flight Summary:

A number of sampling strategies for the sunrise flight were considered, with the one ultimately chosen being the flight plan with the highest and most stable forecasted ozone, as shown in Figures 1 and 2. The primary sampling for the flight took place over the Pacific Ocean off the coast of Washington and Oregon. A North-South racetrack sampling pattern was utilized as the solar zenith angle (SZA) transitioned from complete darkness to daylight with the rising sun.

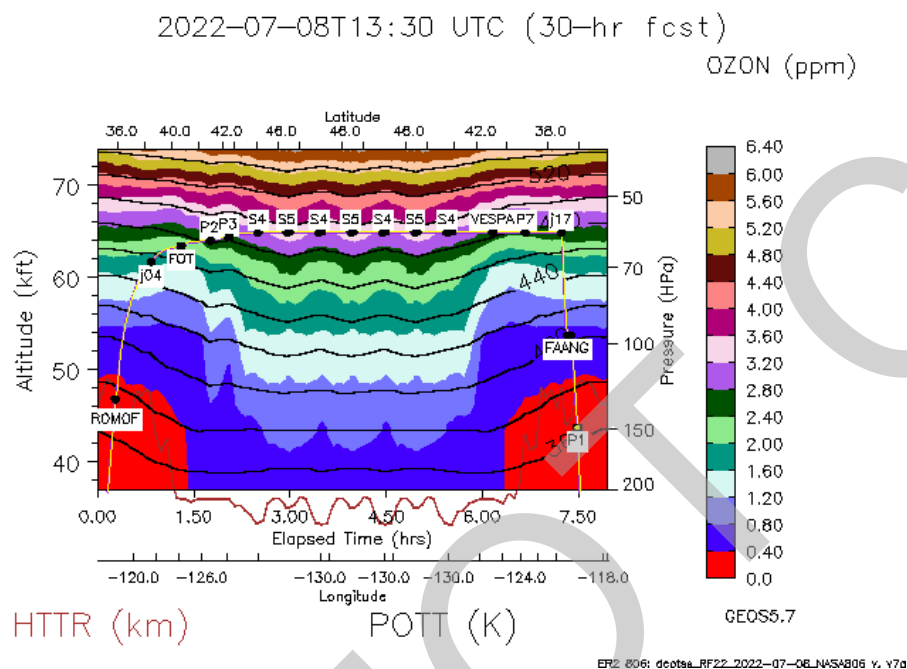


Figure 1. Forecast ozone as a curtain plot, with the flight track overlaid. Ozone mixing ratios of 3.2-3.6 ppm were forecast along the primary sampling track between S4 and S5.

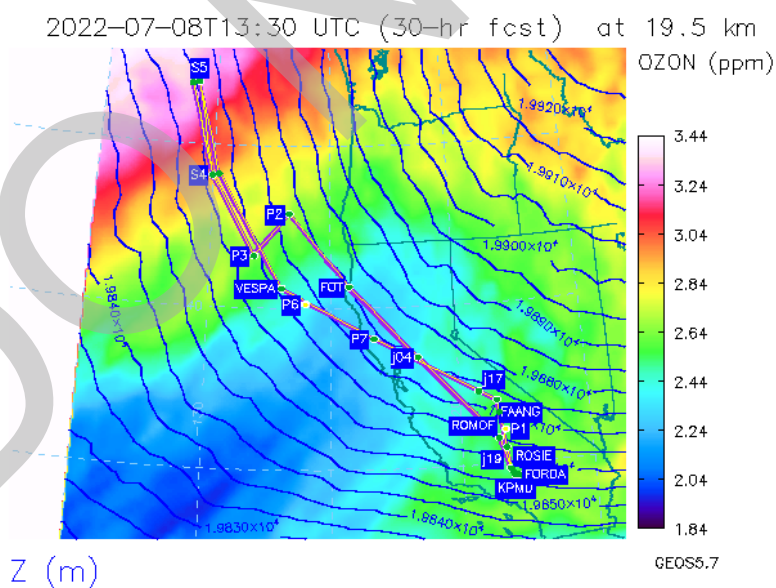


Figure 2. Map of flight track with forecast ozone at 19.5 km (~64 kft) overlaid. Note the alignment of the racetrack between S4 and S5 with the geopotential height contours.

The ER-2 took off from KPDM at 9:31 UTC (2:31 AM PDT) and did an initial climb over Edwards range. After exiting the range, the ER-2 cruise climbed to waypoint P2 and P3 (P2 was in place to allow time adjustment for reaching S4 on time in case of delayed takeoff or strong headwind). From P3, the plane continued to climb to S4 with the objective of reaching maximum possible altitude. At S4, FL643 (19.5 km) was reached, and this altitude was maintained for the duration of the racetrack sampling between S4 and S5. The pilot flew six total level legs at FL643 between S4 and S5 (three roundtrips of approximately one hour each) as the solar zenith angle transitioned from approximately 100 to 72 degrees. The aircraft then exited the racetrack from S4, flew 10 additional minutes at FL643 reaching an SZA of 70 degrees, then cruise climbed to max altitude for approximately 1.5 hr on the return leg. The aircraft descended over Edwards range and landed at KPDM at 17:43 UTC (10:43 AM PDT) for an 8.2-hour duration flight. A map of RF22 is shown in Figure 3.

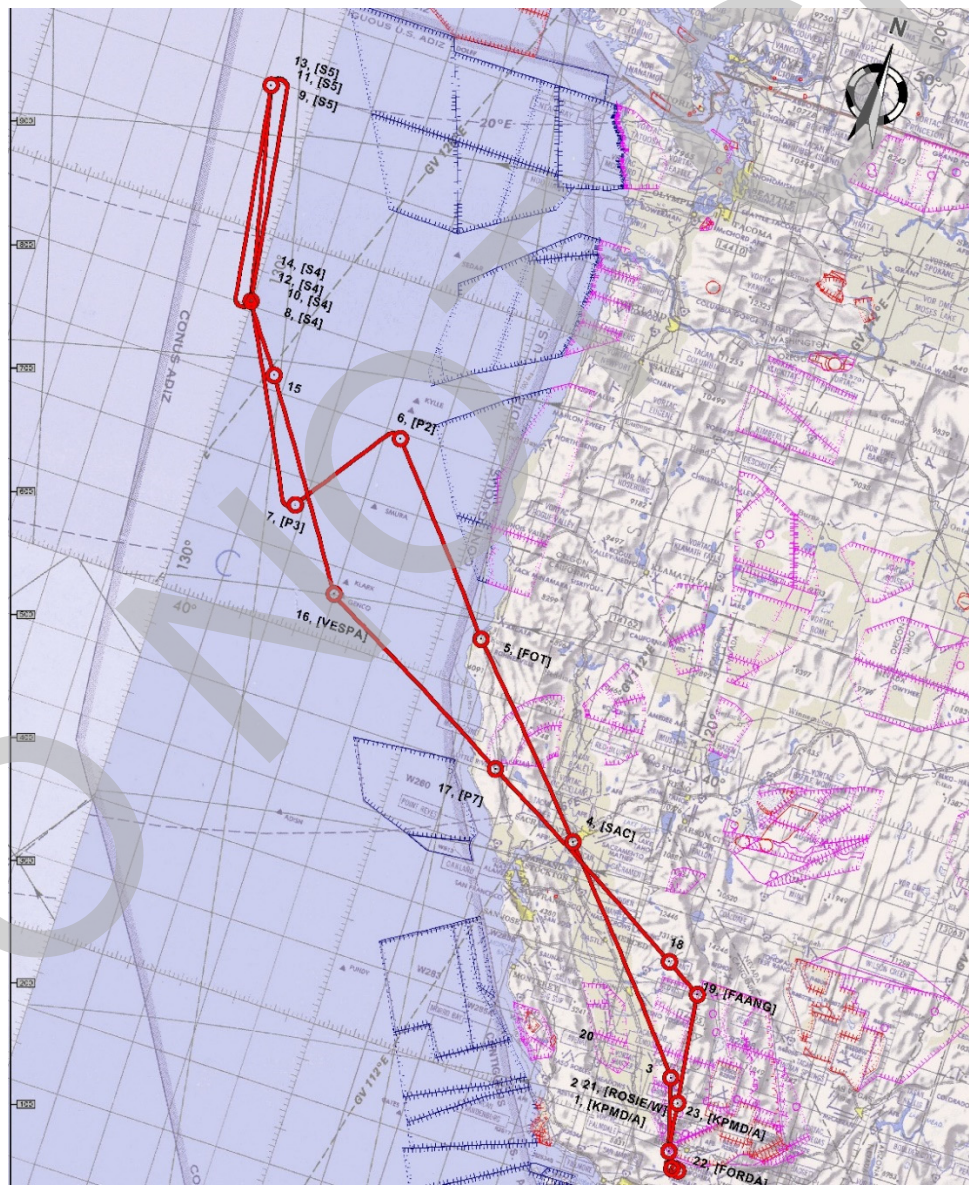


Figure 3. Map of RF22.

The observed ozone mixing ratios during the racetrack sunrise sampling between S4 and S5 were significantly lower than forecast, just under 2 ppm based on the UCATS real-time data rather than the forecasted >3 ppm. A significant positive, however, was that ozone mixing ratios were very stable during the racetrack and unexpectedly continued to be relatively stable well beyond the racetrack. As the ER-2 headed south from S4 and cruise climbed enroute to KPDM, UCATS ozone mixing ratios increased by only approximately 10% for an additional 1.5 hr beyond S4. This effectively enabled extending the SZA experiment an additional 1.5 hr as well. The predicted solar zenith angles for the flight, which were close to the observations, are shown in Figure 4. The observed SZA range covered from the first S4 point to the end of the level leg beyond the last S4 point was 100 – 70 degrees. Accounting for the additional sampling during the cruise climb to maximum altitude when ozone mixing ratios only modestly increased, the SZA sampling range covered during the RF22 sunrise flight was 100 – 45 degrees. The stability of the ozone mixing ratios and the large range of solar zenith angles covered were a significant success for RF22.

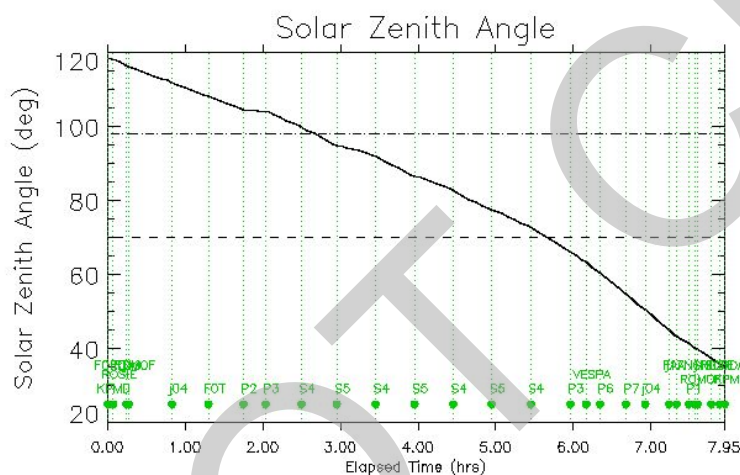


Figure 4. Solar zenith angles along the flight track for the RF22 sunrise flight.

The real-time data showed substantial decreases in NO_2 and increases in ClO with decreasing SZA during the sunrise flight. While not an official data product for DCOTSS, the HAL instrument also measured BrO on the flight, which should allow for valuable photochemistry analyses of inorganic bromine in the stratosphere as well.

Finally, it is worth noting that the sunrise flight presented an opportunity for some of the most spectacular pilot photos from the cockpit of the entire DCOTSS mission, as shown in Figure 5.

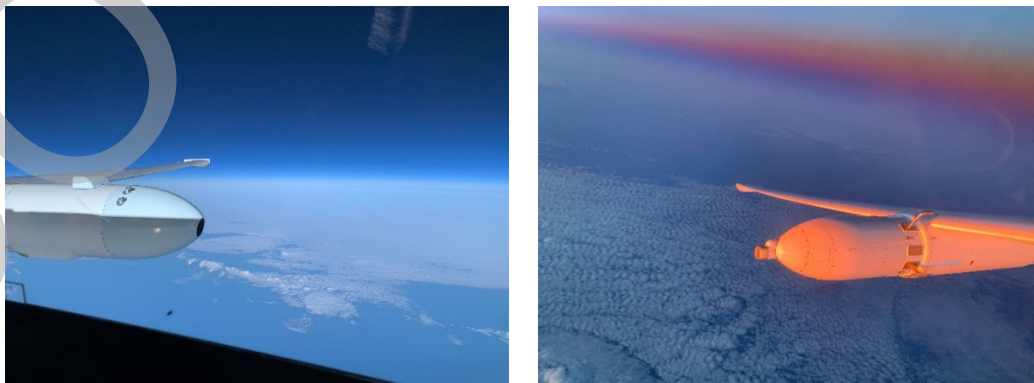


Figure 5. Photos from the ER-2 cockpit during RF22 sunrise showing the left superpod (left) and right spearpod (right).