

Convective Injection Observed in the Lower Stratosphere during DC3

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Results

- Convectively injected water vapor observed 1-2 km above the lapse-rate tropopause on 2 flights
 - 19-20 May: GV
 - 30-31 May: GV & DC-8
- H₂O concentrations 50-200 ppmv above stratospheric background levels
- Both cases show large-scale double tropopause from poleward Rossby wave breaking
 - May provide additional instability above the tropopause that facilitates deep injection

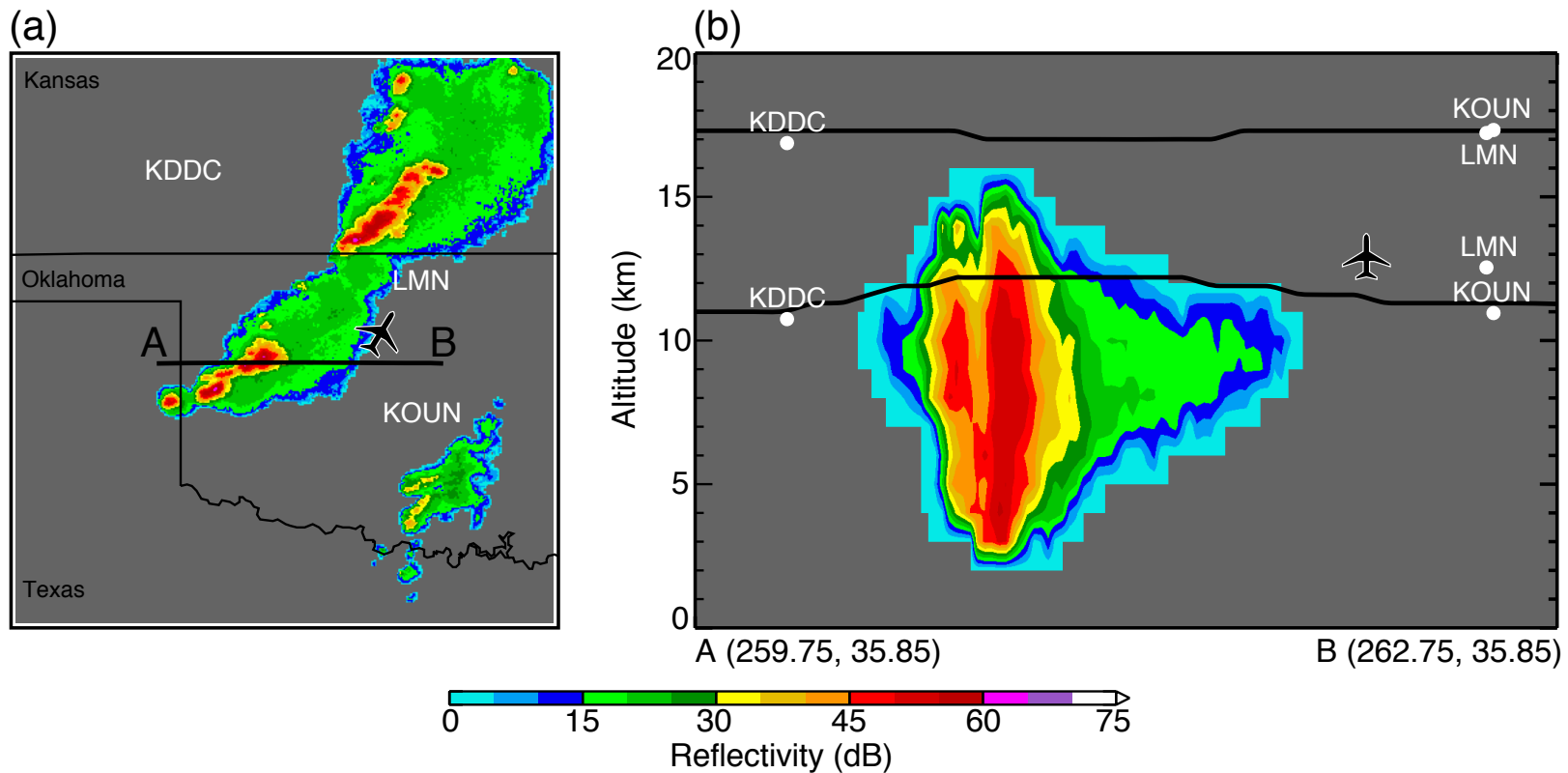


Figure 1. For 20 May 2012 at 00:10 UTC: (a) column-maximum radar reflectivity and (b) vertical cross-section along the line A-B in Figure 1a. The aircraft symbol in each panel shows the corresponding location of the GV. Tropopause altitudes from nearby radiosonde locations are shown as white dots in Figure 1b and labeled with white text in both panels.

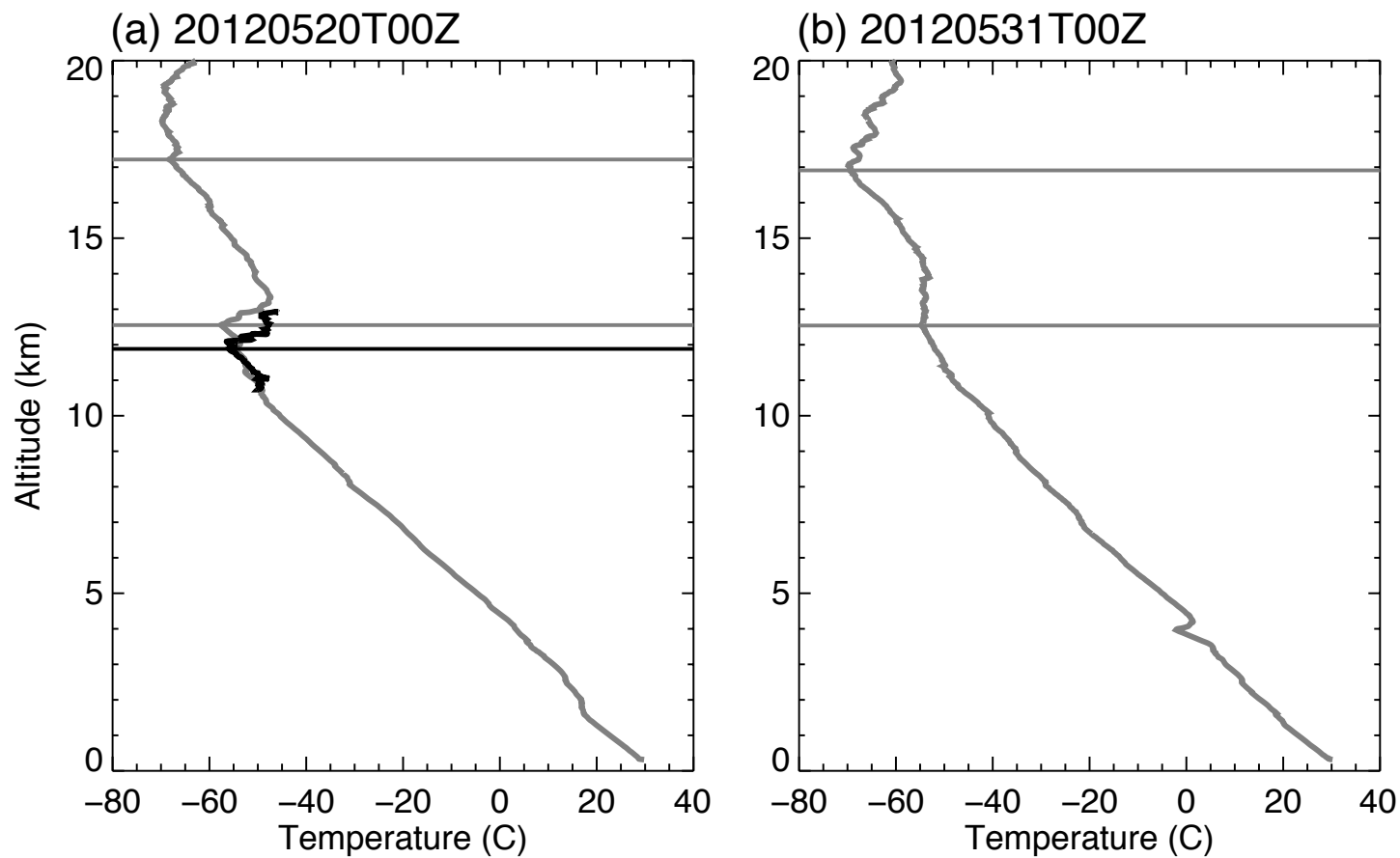


Figure 2. Radiosonde temperature profiles from the DOE-ARM site in Lamont, Oklahoma for (a) 20 May 2012 at 00 UTC and (b) 31 May 2012 at 00 UTC. The gray horizontal lines in each profile illustrate the radiosonde lapse-rate tropopause altitudes from application of the WMO definition. The black profile and horizontal line in Figure 2a shows observations from the NSF-NCAR Gulfstream V (GV) aircraft through the anvil of the storm shown in Figure 1.

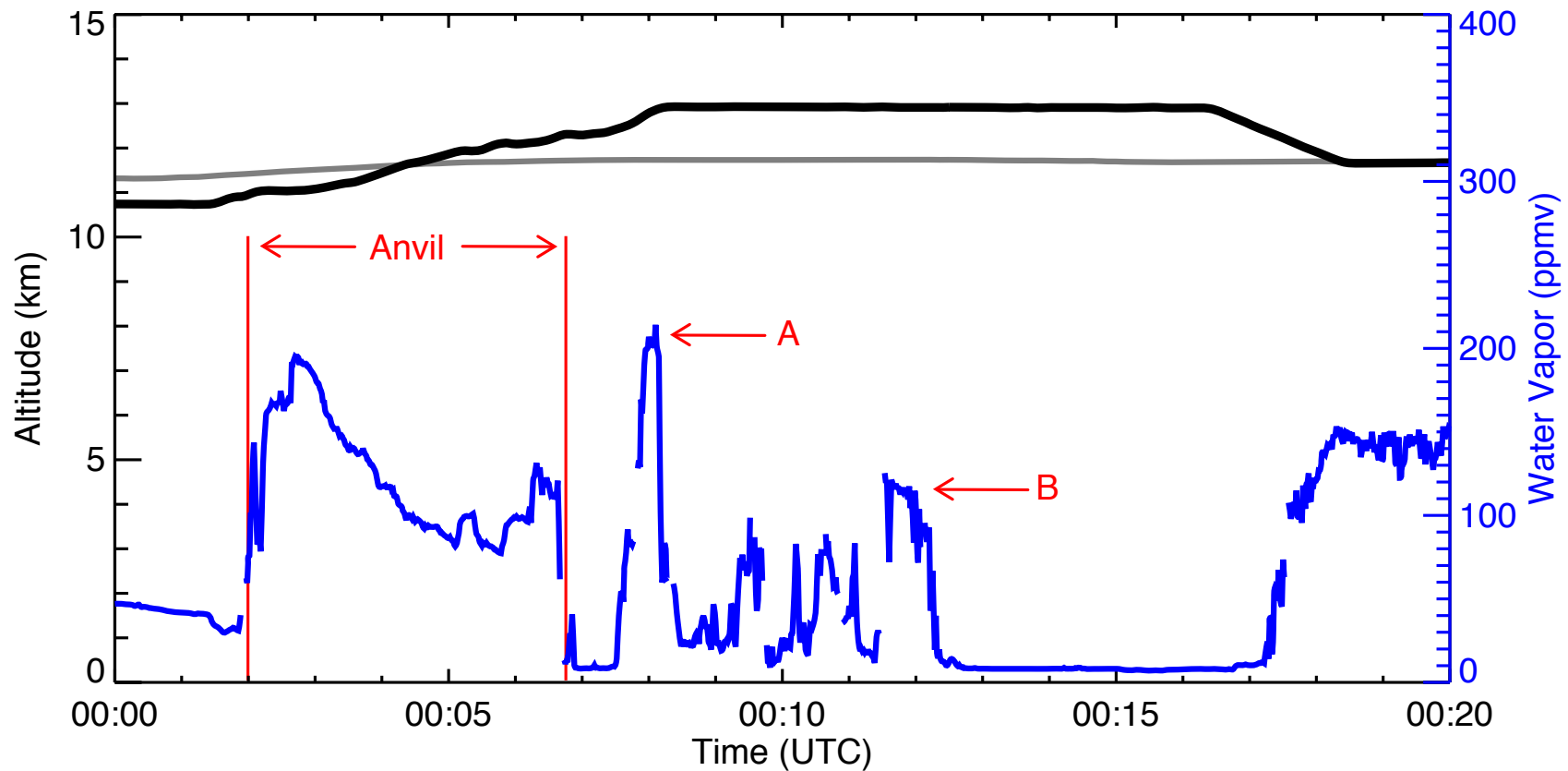


Figure 3. For the 19-20 May 2012 GV flight: aircraft altitude (black), water vapor (blue), and GFS analysis tropopause height (gray) as a function of time since 20 May 2012 at 00 UTC. The water vapor peaks labeled ‘A’ and ‘B’ coincide with clouds sampled above the tropopause.



Figure 4. Visible imagery from left, forward, and right-facing cameras aboard the GV aircraft during the 19-20 May 2012 flight taken about 20 seconds prior to observations of water vapor peaks labeled (a) ‘A’ and (b) ‘B’ in Figure 3.

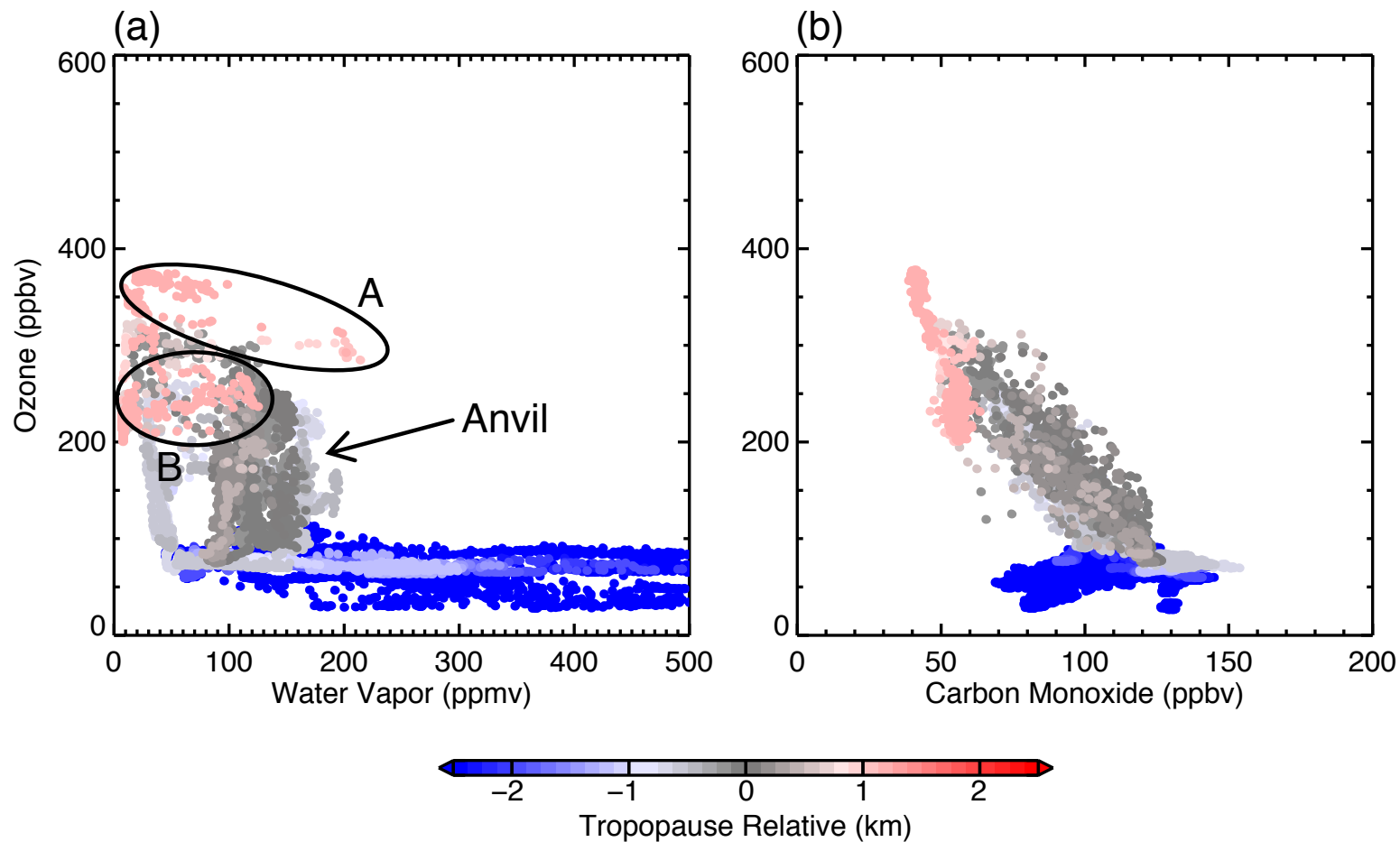


Figure 5. For the 19-20 May 2012 GV flight: scatterplots of (a) ozone and water vapor, and (b) ozone and carbon monoxide. Each point is colored by altitude relative to the GFS analysis lapse-rate tropopause. The ellipses labeled ‘A’ and ‘B’ in Figure 5a correspond to the water vapor peaks labeled in Figure 3.

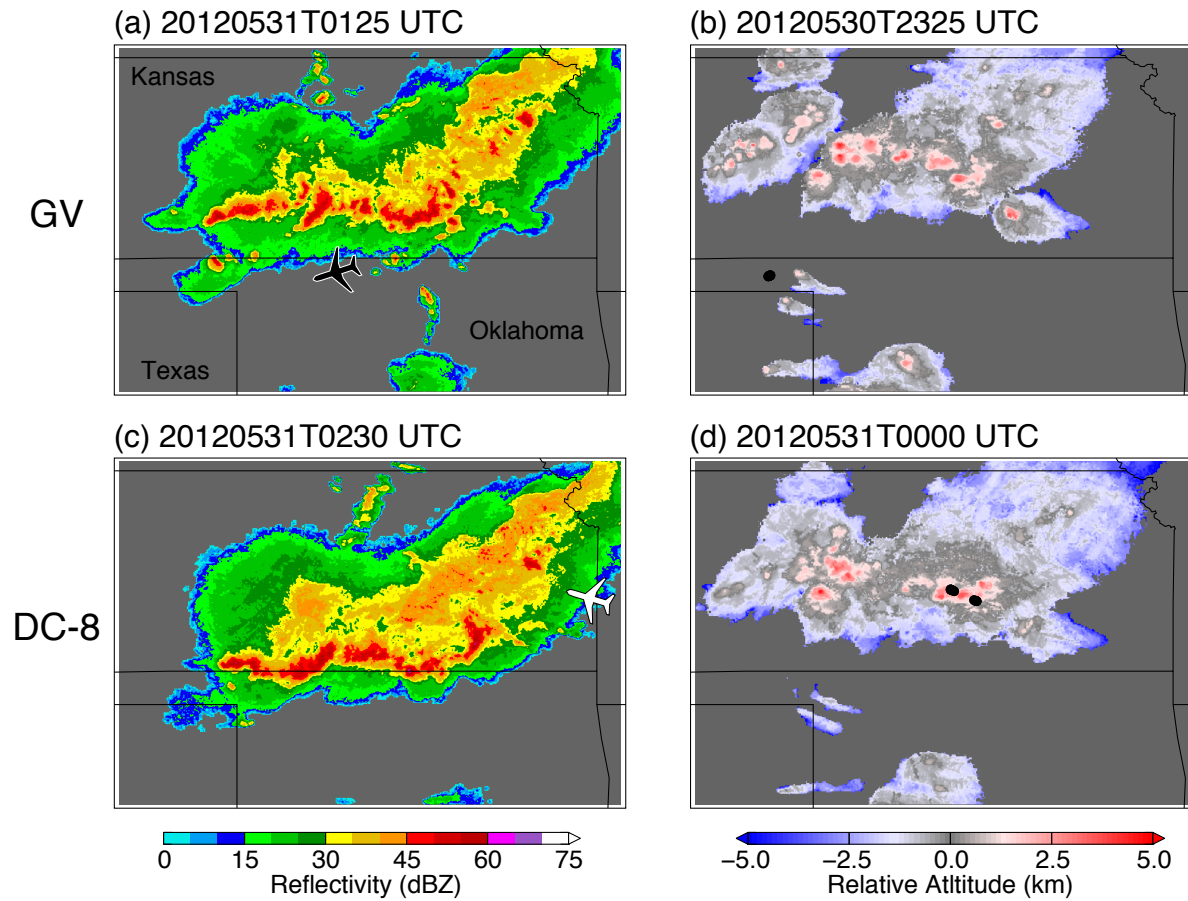


Figure 6. Column-maximum radar reflectivity (left) and relative altitudes of the 10 dB radar reflectivity surface to the tropopause (right) for the 30-31 May 2012 (a) & (b) GV flight and (c) & (d) DC-8 flight. The panels are valid on (a) 31 May 2012 at 01:25 UTC, (b) 30 May 2012 at 23:25 UTC, (c) 31 May 2012 at 02:30 UTC, and (d) 31 May 2012 at 00:00 UTC. The aircraft symbols in panels (a) and (c) show the locations of the planes at the time of the radar images. Particle locations of backward trajectories initialized at the locations of high water vapor observations are shown as black dots in panels (b) and (d).

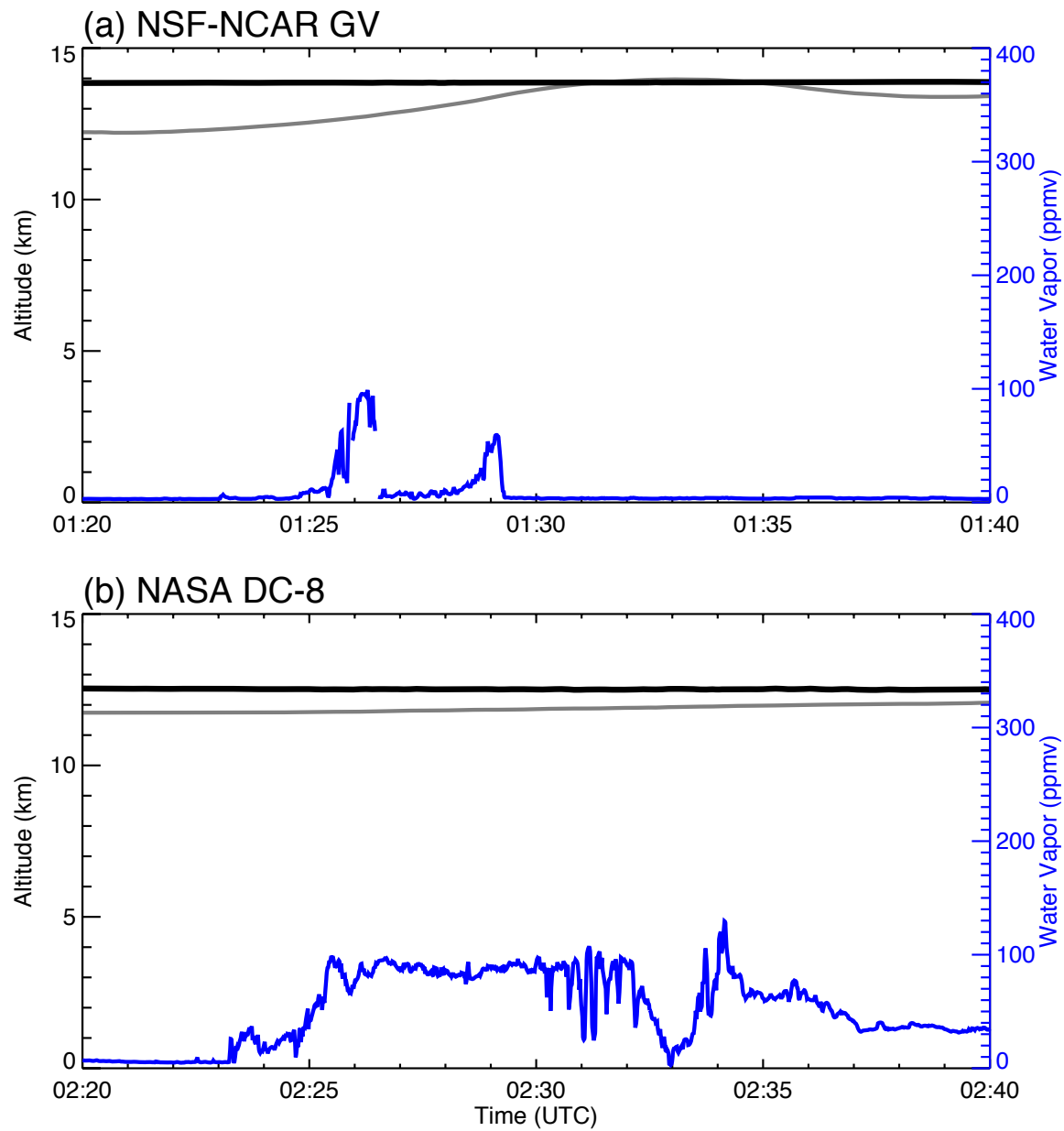


Figure 7. As in Figure 3, but for the 30-31 May 2012 (a) GV flight and (b) DC-8 flight. Times are in UTC and valid for 31 May 2012.

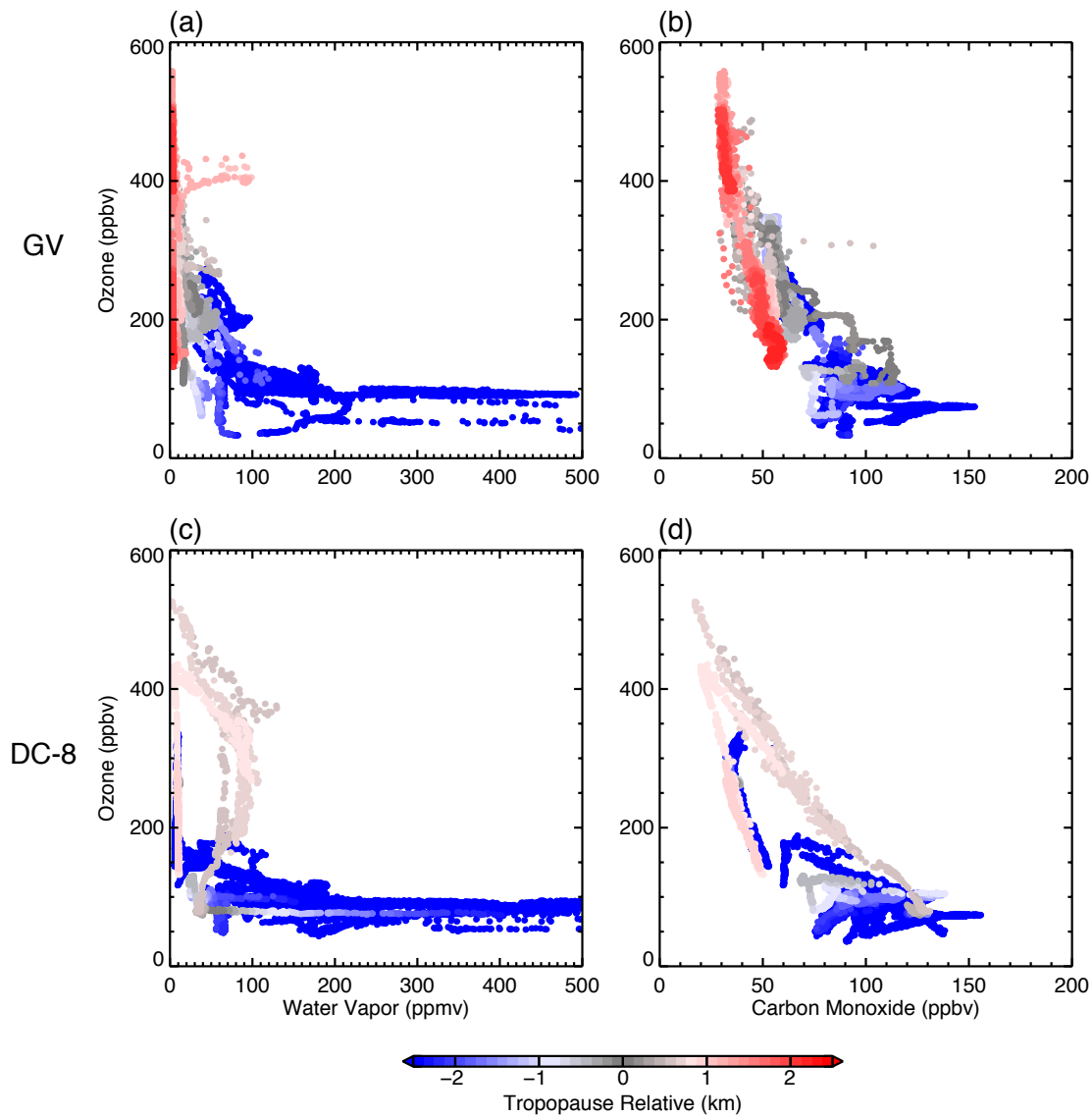


Figure 8. Scatterplots of ozone and water vapor (left) and ozone and carbon monoxide (right) for the 30-31 May 2012 (a) & (b) GV flight and (c) & (d) DC-8 flight. Each point is colored by altitude relative to the GFS analysis lapse-rate tropopause.