Observations of NO and NOy in the southernmost CRYSTAL-FACE mission flights

Introduction

Two southern flights of the WB-57 during the CRYSTAL-FACE campaign in Florida in July 2008 (Fig. 1a) are from two distinct sources of NO and NOy in the UT and LS. While the flight tracks and altitudes were very similar between the two flights, air masses sampled were drawn primarily from the North American Continent (0709) and from low-latitude Atlantic sources on 0726. Convective influence from recent storms, cells, and residual outflow regions were measured on both flights. Consistent differences in features between the two flights can be attributed to the marked increase in NOy in the UT compared to more typical LS constituent mixing ratios on 0726.

Flight Comparisons

0709 Flight

The WB-57 flight left four distinct segments based on the NO/NOy correlation shown in Fig. 2a. These are labeled “Inbound,” “Outbound,” “Typical Strat,” “Biomass Burning.” The “Inbound” and “Outbound” events occurred near condensation level, while the “Typical Strat” and “Biomass Burning” outflows were essentially parallel to the aircraft track. NO and NOy mixing ratios on 0709 were similar to those in the 0706 northerly flight, but NOy mixing ratios of 80-100 ppbv were observed on 0709. The large NO mixing ratios are very likely due to lightning activity in the storm (Fig. 5b).

Ascent through 12 km occurred in approximately the same spatial location as the return descent, with NO mixing ratios of 1-50 ppbv and NOy mixing ratios of up to 400 ppbv. The large NO mixing ratios are very likely due to lightning activity in the storm (Fig. 5b). The “Typical Strat” segment was sampled when the aircraft flew over the system to about 17 from the island of Cuba. NO mixing ratios of 2-3 ppbv and NOy mixing ratios of up to 4 ppbv are observed on ascent from and descent into Key West. The “Biomass Burning” segment occurred on the 0726 flight centered at approximately 66000 ft and 15.2 km altitude, with NO mixing ratios of 80-100 ppbv. The large NO mixing ratios are very likely due to lightning activity in the storm (Fig. 5b).

0726 Flight

The correlation between O3 and NOy on 0726 (Fig. 2b) is considerably simpler than the previous flight. There are basically two lobes, one very similar to that of 0709, and typical of the lower tropical lower stratosphere. There is a second “tropospheric” lobe of large NOy at relatively low altitudes, measured from the surface track images. NO mixing ratios over Northern Cuba earlier in the day on 0726 (see Fig. 3a) were much lower, with NO mixing ratios of about 3 ppbv and NOy mixing ratios of about 2 ppbv. NO mixing ratios of 80-100 ppbv are observed on 0726, about 4 hours later, with NO and NOy mixing ratios of about 3 ppbv and NOy mixing ratios of about 2 ppbv.

Ascent through 12 km occurred in approximately the same spatial location as the return descent, with NO mixing ratios of 1-50 ppbv and NOy mixing ratios of up to 400 ppbv. The large NO mixing ratios are very likely due to lightning activity in the storm (Fig. 4b). The “Typical Strat” segment was sampled when the aircraft flew over the system to about 17 km altitude. NO mixing ratios of 2-3 ppbv and NOy mixing ratios of up to 4 ppbv are observed on ascent from and descent into Key West. The “Biomass Burning” segment occurred on the 0726 flight centered at approximately 66000 ft and 15.2 km altitude, with NO mixing ratios of 80-100 ppbv. The large NO mixing ratios are very likely due to lightning activity in the storm (Fig. 5b).

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Conclusion

The two southern flights were similar in flight path, altitude and time of day, but sampled dramatically different sources, almost entirely low-latitude Atlantic on 0709 and almost entirely over eastern North America on 0726. The most remarkable feature of the 0709 flight was the much thicker layer of NO, NOy, and NOy/O3 observed in the UT compared to the LS, and NO/NOy ratios from convection below the tropopause. The remainder of the flight was enroute to or from this convective system, in clear air, termed “Outbound/Inbound” in Fig. 2a. A remarkable feature, termed “Zonal Boundary,” was encountered near 35°N and 95°W (Fig. 2b) with very low NO and NOy mixing ratios. Mixed layer aerosol and residual outflow were observed on ascent from and descent into Key West. The back trajectories shown in Fig. 4a, are for southern low-latitude Atlantic outflow and show no clear source region as indicated by the lack of a clear boundary layer. The back trajectories shown in Fig. 4b, are for northern North American outflow and show a distinct source region associated with the NO and NOy mixing ratios and NOy/O3 ratios.

The two southern flights were similar in flight path, altitude and time of day, but sampled dramatically different sources, almost entirely low-latitude Atlantic on 0709 and almost entirely over eastern North America on 0726. The most remarkable feature was the NO mixing ratios observed in the UT, with NO mixing ratios of 80-100 ppbv and NOy mixing ratios of 150-300 ppbv observed on both flights. The NO mixing ratios are very likely due to lightning activity in the storm (Fig. 5b).

References