J019-P003 Time: May 30 17:00-18:30

Impact of lightning on reactive nitrogen and ozone : Results from BIBLE-C aircraft measurement campaign

Hibiki Ikeda[1], Yutaka Kondo[1], Makoto Koike[2], Kazuyuki Kita[3], Nobuyuki Takegawa[4], BIBLE Science team
KITA Kazuyuki

[1] RCAST, Univ. of Tokyo, [2] EPS, Univ. of Tokyo, [3] RCAST, Univ. Tokyo, [4] STEL

Biomass Burning and Lightning Experiment Phase C (BIBLE-C) was conducted over Australia between Nov. 30 and Dec. 14, 2000, with the aim of estimating the impact of lightning on reactive nitrogen oxides and ozone. During BIBLE-C, atmospheric compositions such as NO, NOy, CO, O3 and HCs were measured, using in-situ instruments and whole air sample apparatus aboard G-II aircraft. The summer in year 2000/2001 in northern Australia was characterized by La Nina condition, resulting in stronger convective activity than average year.

Four intensive survey flights were carried out near Darwin, northern Australia, concentrating in the upper troposphere (UT, defined as above 10 km in this study) in order to capture anvil outflows. Although these four flights, Flight #8, 9, 10, and 13, were carried out in similar region and in downwind of convective activities, NOx mixing ratios observed in the UT showed significant difference for the former two flights and the latter two. For Flight 8 and 9, NOx mixing ratios were overall low, with median value of 26 pptv. On the contrary, large enhancement in NOx mixing ratio was frequently observed during Flight 10 and 13, and the median value of which was 150 pptv. In this study, Flight 8 and 9 were referred to as Low NOx regime (L-NOx) and Flight 10 and 13 as High NOx regime (H-NOx) for convenience.

Ten-day backward trajectories starting along the flight track of G-II aircraft showed H-NOx air masses came from Pacific Ocean east of Australian continent, whereas L-NOx air masses stagnated around Indonesia and north-western Australia. For both air masses, the trajectories moved vertically to large extent, indicating they experienced extensive convective activities. To determine the location of convections that air masses encountered, we analyzed trajectories and cloud top temperature data obtained by Geostationary Meteorological Satellite (GMS). This analysis showed most of the trajectories encountered convections within one day, near Gulf of Carpentaria and the coastal region surrounding it. Lightning activities that coincided with the trajectory-encountered convection were estimated by using Lightning Position and Tracking System (LPATS), a ground-based lightning detection network operated in Australia. The number of lightning flashes showed significant difference, with the values of which for H-NOx data about thirty times higher than those for L-NOx, and some of H-NOx air masses were exposed to a few thousand flashes. These results indicate that H-NOx air masses experienced stronger lightning activity than L-NOx air mass, and that observed high NOx plumes were mostly due to lightning activity.

During Flight 6, which was carried out to survey central Australia, we encountered large-scale lightning plumes with NOx enhancement up to 800 pptv. The high mixing ratios were observed continually over about 800 km in the north-south direction. Trajectories showed these air masses were transported from north along anticlockwise flow, and the GMS analysis indicated the trajectories encountered convection over fairly broad region from northern Australia to New Guinea, about two to four days before the measurement. Similar to the H-NOx cases, the convection was accompanied by strong lightning activities. For this flight, diurnal average O3 production rate (PO3) calculated by a box model showed monotonic increase with NOx with maximum value of about 3 ppbv/day. For this flight, positive correlation between O3 and NOx were also found. Relatively long transport time as well as PO3 of about 3 ppbv/day indicated that the tight positive correlation between O3 and NOx were caused, at least partly, by photochemical O3 production due to NOx originated from lightning. A rough estimate showed that about 5-10 ppbv of O3 was possibly originated from lightning NOx.