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An examination of the impact of air from China on summertime air quality in Japan before, during, and after the Beijing Olympics

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An examination of the impact of air from China on summertime air quality in Japan before, during, and after the Beijing Olympics


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Abstract

During July – September 2008 pollution controls in China associated with the Beijing Olympics led to emissions reductions of up to 43%, as observed by NASA satellite instruments. Pollution from China has an impact on air quality throughout East Asia. In this poster, we examine the impact of China’s pollution on Japan through the use of Aura satellite data (2005 – 2009), ozonesonde data (2008), and data from air quality surface monitors (2000 – 2008). We also examine the year-to-year variability in meteorological flow regimes through inversions of model simulations of transport to Japan from the areas around Beijing and Shanghai, and around Seoul, South Korea in order to apportion remote sources of pollution.

6 August 2008 Pollution Event

Figure 1. Sapporo skies were noticeably hazier on 6 Aug. Both photos were taken at ~2 pm local time. The arrows mark the same geographic point. Surface monitors in Beijing recorded high levels of pollution 3 – 8 Aug. Models suggest pollution from near Beijing to Hokkaido around 6 Aug (see Fig. 5 below).

Figure 2. 30-minute average data at Hokkaido Univ. show elevated O3 at the top of the mixed layer. Air in this layer is also hazy, suggesting origins near the surface.

Figure 3. Data from the 6 Aug. ozonesonde launched at Hokkaido Univ. shows elevated O3 at the top of the mixed layer. A special Aura OMI high-resolution retrieval shows O3 near Hokkaido on 6 Aug. The kriging weighted mean O3 from all OMI pixels inside the analysis region was 17.8 ± 2.5 ppb, similar to the Aug. 6 computer animation.

Figure 4. Trap. NO2 column on 6 Aug. in typical. Beijing is marked by the site: (40°-1°, 116°-16°). We analyzed 1-3 > 10 molecules cm-2. Courtesy: E. Celarier (NASA-GSFC).

Figure 5. NASA GFSC Trajectory Model (Schwantes & Spinning, 1995) indicates the source is Beijing, Hong Kong, and Shanghai.

Figure 6. July mean boundary layer SO2 (SUV) from the Aura OMI instrument shows 2008 values relatively lower than 2005 – 2007 values. Data due to enhanced restrictions imposed by China around Beijing for the 2008 Olympics Games.

Figure 7. Running 7-day average column SO2 (DU) for the 1 July – 31 October periods 2005 – 2009 from the Aura OMI instrument shows 2008 values ~12% lower than 2005 – 2007 values. Decreases were also observed for column NO2 (~43%) and CO (~12%). See Witte et al. (2009) for details.

Figure 8. Mean O3 profiles from Sapporo soundings. The black & gray lines (thick = mean, thin = 1σ) are from the Stratospheric Chemistry (CAS) ozonesondes (1980s) launched during Aug. 2008 & 2009 at Hokkaido, Sapporo, and JMA. The orange line is the 2 July 2006 Sapporo data. Error bars are 1σ. Trends are α = 0.05 and trend periods 2005 – 2007 data: 7 – 10 km = (1.44 ± 0.36) and (1.80 ± 0.41) ppb/yr; 2 – 5 km = (0.707 ± 0.087) and (0.630 ± 0.041) ppb/yr. The differences may be in part due to the pollution controls in China during the 2008 Beijing Olympics.

Figure 9. O3 profile trends in 1 km bins as derived from the data plotted in Fig. 8, including (black) and masking (gray) the 44% data, and excluding (white) data of different origin. Trend errors are for α = 0.14.

Figure 10. The dual instrument payload was launched on 18 flights from Hokkaido Univ. in Aug. and Sept. 2008. From set to rift are the RS90 (top), the standard O3-BrO 22 ozonesonde, and a second ozonesonde with NO2 filter (the white tube). When SO2 is present, the standard, unfiltered ozonesonde effectively measures NO2(NO2). By choosing the filtered (right) and unfiltered (left) ozonesonde measurements we can produce SO2 data. Lab tests indicate the filers do not destroy O3, while they are 85 – 100% effective at destroying SO2.

Figure 11. Special Aura OMI high-resolution retrieval shows O3 near Hokkaido on 18 Aug 2008. The OMI overpass at 16:30 local time on 18 Aug 2008 captured a thin ozone (O3) feature at ~7.5 km while a low O3 sounder shows O3 decreases, similar to the ascending profile. The model scenario is air masses from a high source O3 region. Our hypothesis is that strong convection aloft aligned a thin high with SO2, and O3 from near the surface on 16 - 17 Aug. At ~7.5 km, where it was transported rapidly to Hokkaido and observed.

Figure 12. Number of days each August with >100 KTM parcels from Beijing, Shanghai, and Seoul (see above). Data from 2008 shows less than average Asian influence in Hokkaido but was a more typical influence in Kyushu.

Figure 13. A Google Map shows the regions in which the KTM data were collected beginning July 2008. Balloons show the corners of the analysis regions and circles show the centers of the analysis regions. While the poster focuses on Hokkaido and Kyushu, future work will perform similar analyses on other regions within Japan.

Figure 14. The advection of air from 3 source regions spanning the Hokkaido region ≤ 5 km during 2008 is visualized with the KTM (see Fig. 5). The model suggests 6 – 7 and 11 – 12 August as days with influence from Beijing, while 2 – 3, 11 – 14 August are days with influence from Seoul. Shanghai air masses rarely reached Hokkaido during August 2008.

Figure 15. Sapporo Station, Shinsho, and Hokkaido Univ. show ≤ 7 ppm average O3 data for 2008. A residual is computed by subtracting the monthly data from daily averages at each site. A strong peak occurs around 5 – 7 Aug, but not around 11 – 12 Aug. Mean Beijing air quality for 4 – 5 Aug is 80 ± 20 ppb while for 11 – 13 Aug is 44 ± 10 ppb, which only differs from Seoul pollution data from http://www.nies.go.jp/.

Figure 16. Number of days each August with >100 KTM parcels below 2.5 km above Hokkaido (left) and Kyushu (right) originating around Beijing, Shanghai, and Seoul. Data from 2008 shows less than average Asian influence in Hokkaido but was a more typical influence in Kyushu.

Figure 17. August 2008 – 2009 monthly mean surface O3 in Hokkaido (left) and Kyushu (right) (data from stations near gmi versus the number of days with >100 KTM parcels from Beijing, Shanghai, and Seoul below 2.5 km). Each station has varying times of arrival from Beijing with significant influence.

Conclusions and Future Work

- Surface O3 in Hokkaido on 6 Aug. 2008 was enhanced by the arrival of air from China.
- Data from OMI on NASA’s Aura satellite suggest decreases in pollution during the Beijing 2008 Olympics period as compared to 2005 – 2007 data (SO2 ~13%, NO2 ~43%).
- Sapporo ozonesonde data show statistically significant positive trends 2 – 10 km. Trends are higher in 2 – 7 km and 7 – 10 km when 2008 data are excluded, suggesting O3 pollution controls in China may have been effective. Further investigation is needed.
- The 18 Aug. 2009 sondes found a peak of high O3 and high SO2 ~7.3 km that may have been lofted from the surface by strong convection near Beijing 24 – 48 hours earlier. This mechanism may be related to the trends aloft in the Sapporo sondes.
- Higher summertime surface O3 in Hokkaido and Kyushu is linked to air transported from the continent. Arrival of air from Beijing significantly influences surface O3 at both locations, while air from Seoul more strongly influences Kyushu.