Testimony of Dan Jaffe, Professor, University of Washington, before the US-China Economic and Security Review Commission, Washington D.C.
August 13, 2008.

Thank you for the opportunity to testify before the commission today.

My name is Dan Jaffe, I am a professor of Environmental Science at the University of Washington. I have studied global pollution for more than 20 years. I have reviewed the questions for today's hearing and I hope my testimony will shed some light on these issues.

First point, over the past several decades, China has become a major economic power and at the same time has become one of the largest emitters of air pollutants. For some pollutants China's emissions have now surpassed US emissions. This is certainly true for sulfur dioxide and carbon dioxide. In other cases, such as nitrogen oxides, US emissions are still larger, but Chinese emissions are increasing rapidly. The emissions are largely due to coal combustion, but emissions from motor vehicles and other sources are also increasing rapidly. These large emissions are responsible for poor air quality and significant health impacts within Chinese cities. A recent World Bank report estimated that there are approximately 700,000 premature deaths annually with an economic impact of nearly 4% on GDP in China due to air pollution.[1] And of course we've all heard many reports about the impacts of poor air quality on the Olympics.

Given the continuing rapid economic growth in China, we expect these emissions to continue to increase. Depending on the level of emission controls used and the particular pollutant, emissions will likely increase 50-200% by 2020[2]. But the good news is that China could keep the growth in emissions to modest levels or even see slight decreases for some pollutants, if advanced control technologies are employed. If this is not done, these large emission increases will be a major assault on the global environment.

But it is also important to recognize that China's per capita emissions are still a fraction of what they are in the United States. The average Chinese citizen wants nothing more than what we already have: a high standard of living based on high energy consumption.

My research group at the University of Washington first detected the transport of Asian pollution to the United States in 1997 [3]. Since then we have identified dozens of episodes of such transport and this result has been confirmed by numerous other university and federal scientists. My research group also operates the only continuous mountain top observatory in the western US which routinely detects pollutants originating in Asia[4]. We use a number of tools to identify the source region for these pollutants including surface and aircraft observations to give us a "chemical fingerprint", meteorological data, satellite observations and chemical transport models.

Currently a number of scientific groups are trying to understand the influence Asian emissions have on US air quality. This is a complex issue due to daily, seasonal and annual variations in meteorology and there are large uncertainties.[5] It should be noted that on most days, the contribution to local air quality from Asian sources is relatively small, but on a few days per year the Asian contribution can be a large fraction of the regulatory standard. There are three main pollutants of concern: ozone, particulate matter and mercury. For ozone, a respiratory irritant, the average contribution from Asian emissions to the 8-hour primary standard is in the range of 3-10% for the western U.S. While this contribution is relatively modest, it will certainly increase in the future and, when added to local pollution, it can push some areas over the air quality standard. On a few days, we have seen even higher ozone enhancements due to Asian emissions, up to 37% of the standard.[6] For fine particulate matter, or PM2.5, which has significant respiratory and cardiovascular impacts, the Asian contribution is 2-5% of the annual standard, including dust and industrial pollution, but on a few days per year the impact can be quite large. In the most extreme case, which occurred in April 2001, Asian dust contributed approximately 50% of the particulate matter on a few days and resulted in concentrations that exceeded the daily PM2.5 primary standard at several cities in the western U.S.[7] For mercury, a potent neurotoxin, the best way to understand the Asian contribution is to consider how much mercury deposition occurs, in both wet and dry forms. The Asian industrial contribution is approximately 10-30% of the total deposition across the US, with the highest contributions in Alaska and the western U.S.[8] For all of these estimates, there are large uncertainties.

Finally, we turn to the question of what can the United States do to assist China in its quest to develop more sustainably. For this question there are two parts to my response, one focused on the traditional air pollutants, such as particulate matter, ozone, sulfur dioxide and nitrogen oxides and the second on the greenhouse gases. For the traditional air pollutants, high efficiency control technologies are available. The US can encourage rapid implementation of these technologies by providing technical assistance. This could be a win-win scenario for US industries involved in control technologies. Another approach is to help Chinese policy makers understand the economic benefits of a clean environment. For example the US could support joint research or symposia with China to understand the significant economic and social benefits of clean air. I believe it is also essential that we continue to support US based research on this issue, both as a means to understand the air quality impacts within the US and also as a means of monitoring Chinese compliance with future negotiated agreements[9].

On greenhouse gas emissions we have a very different set of issues. Here, current technologies are not adequate and global leadership on the issue is lacking. China's per capita emissions of carbon dioxide are approximately 1/5th of those in the US, therefore it is not reasonable, for both economic and equity reasons, to expect that China will control its greenhouse gas emissions unilaterally. Given that the US is the largest per capita emitter of greenhouse gasses and the largest global economy, it is paramount that we show leadership on this issue by:

- reducing our reliance on fossil fuels;
- developing alternative energy sources;
- making energy conservation a hallmark of our economy;
- developing carbon sequestration strategies;
- providing assistance to developing nations to implement these strategies; and,

- participating fully in international negotiations on greenhouse gas reductions.

I believe these strategies are not only essential for stabilizing our climate, but will also improve our national economy in the long-run.

This concludes my testimony. Again, I want to thank the commission for allowing me to present my testimony today and I would be happy to answer any questions.

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Technical details/additional information

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[1]World Bank (2007) Cost of Pollution in China, Economic Estimates of Physical Damages. World Bank, Washington, DC.

[2] See for example:

Wang, X., Mauzerall, D. L., Hu, Y., Russell, A. G., Larson, E. D., Woo, J. H., et al. (2005). high-resolution emission inventory for eastern China in 2000 and three scenarios for 2020. Atmos. Environ, 39(32), 5917-5933.

Chen, C. H., Wang, B. Y., Fu, Q. Y., Green, C., & Streets, D. (2006). Reductions in emissions of local air pollutants and co-benefits of Chinese energy policy: a Shanghai case study. . Energy Policy, 34(6), 754-762.

[3] See:

Jaffe, D. A., Anderson, T., Covert, D. S., Kotchenruther, R., Trost, B., Danielson, J., et al. (1999). Transport of Asian Air Pollution to North America. . *Geophys. Res. Lett.*, *26*, 711-714.

[4] Our observatory is located on the summit of Mt. Bachelor in central Oregon. Data from the site are available in realtime at http://research.uwb.edu/jaffegroup. Published results from the Mt. Bachelor Observatory include:

Jaffe, D. A., Prestbo, E., Swartzendruber, P., Weiss-Penzias, P., Kato, N., Takami, A., et al. (2005b). Export of Atmospheric Mercury from Asia. *Atmos. Environ.*, *39*(17), 3029-3038.

Weiss-Penzias, P., Jaffe, D. A., Swartzendruber, P., Dennison, J. B., Chand, D., Hafner, W., et al. (2006). Observations of Asian air pollution in the free troposphere at Mt. Bachelor Observatory in the spring of 2004. *J. Geophys. Res.* , *111*(D 10), D10304.

Swartzendruber, P., Jaffe, D. A., Prestbo, E. M., Weiss-Penzias, P., Selin, N. E., Park, R., et al. (2006). Observations of reactive gaseous mercury in the free troposphere at the Mount Bachelor Observatory. *J. Geophys. Res.*, *111*(D24301).

Weiss-Penzias, P., Jaffe, D. A., Swartzendruber, P., Hafner, W., Chand, D., & Presto, E. (2007). Quantifying atmospheric mercury emissions from biomass burning and East Asian industrial regions based on ratios with carbon monoxide in pollution plumes at the Mount Bachelor Observatory. Atmos. Environ, 41(21), 4366-4376.

[5] See:

Reidmiller, D. R., D. A. Jaffe, D. Chand, S. Strode, P. C. Swartzendruber, G. M. Wolfe and J. A. Thornton: Interannual variability of long-range transport as seen at the Mt. Bachelor Observatory. Submitted to Atmos. Chem. Phys. Discuss., July 2008.

Zhang, L., Jacob, D., Boersma, K. F., Jaffe, D. A., Olson, J. R., Bowman, K. W., et al. (2008). Transpacific transport of ozone pollution and the effect of recent Asian emission increases on air quality in North America: an integrated analysis using satellite, aircraft, ozonesonde, and surface observations. *Atmos. Chem. Phys. Discuss., 8,* 8143-8191.

[6] For ozone, particulate matter and mercury, estimating the contribution to local air quality from distant sources is a complex process. To do this we use computer simulations that model the emissions, the physical-chemical processes and the transport. However before these models can be used, it must be evaluated against actual environmental data. Thus the final result, come from a combination of the model and observations. For ozone, Fiore et al (2002) estimate the ozone contribution from European and Asian emissions to surface air quality in the US using 1995 emissions, however there is good evidence that Chinese emissions have approximately doubled since then (Richter et al., 2005). Fiore et al., (2008) estimate the ozone impact from Asia using 2001 emissions. Zhang et al. (2008) show that the recent increase in Asian emissions (2000-2006) has significantly increased the impact on surface ozone in the US. They calculate that Asian emissions are responsible for an average of 7 ppbv of ozone at the surface in the western U.S. during spring. Weiss et al. (2006) shows that plumes of Asian pollution seen at the summit of Mt. Bachelor (2.7 km asl) can be enhanced by up to 28 ppbv for an 8-hour mean. However it is not clear how these plumes impact surface air quality in urban areas. While none of these analyses give exactly the information we seek, we can use these published studies as a basis to estimate the Asian impact on surface ozone in the US:

Fiore, A.M., F.J. Dentener, O. Wild, C. Cuvelier, M.G. Schultz, P. Hess, C. Textor, M. Schulz, et al., Multi-model Estimates of Intercontinental Source-Receptor Relationships for Ozone Pollution , submitted to J. Geophys. Res., July 21, 2008.

Fiore A. M., D. J. Jacob, I. Bey, R. M. Yantosca, B. D. Field, A. C. Fusco, and J. G. Wilkinson (2002), Background ozone over the United States in summer: Origin, trend, and contribution to pollution episodes, J. Geophys. Res., 107 (D15), 4275, doi:10.1029/2001JD000982.

Richter, A., et al. (2005), Increase in tropospheric nitrogen dioxide over China observed from space, Nature 427, 129-132.

Weiss-Penzias, P., Jaffe, D. A., McClintick, A., Jaeglé, L., & Liang, Q. (2004). Influence of long-range-transported pollution on the annual and diurnal cycles of carbon monoxide and ozone at Cheeka Peak Observatory. *J. Geophys. Res. , 109,* D23S14.

[7] For particulate matter, the analysis of Chin et al (2007) show that dust is the most significant contribution to the fine particulate matter transported from Asia. This is also consistent with the analysis of Heald et al (2007). The modeling of Chin and the analysis

of Fischer et al (2008) suggest that the Asian dust contribution in spring for the western US is ~1-3 ug/m^3. Assuming this only occurs in spring, this is ~2-5% of the annual PM2.5 standard. The analysis of Husar et al., (2001) first documented large episodic transport of Asian dust to the US which occurred in 1998. Jaffe et al. (2003) show that in the most extreme case, which occurred in April 2001, the contribution from Asian dust to the fine particulate mass was up to 50% at several cities in the western US and resulted in concentrations that were greater than the daily PM2.5 primary standard (35 ug/m3).

Husar, R. B., Tratt, D. M., Schichtel, B. A., Falke, S. R., Li, F., Jaffe, D. A., et al. (2001). The Asian Dust Events of April 1998. *JGR-ATM, 106*(D16), 18317-18330.

VanCuren, R., & Cahill, T. (2002). Asian aerosols in North America: Frequency and concentration of fine dust, . *J. Geophys. Res., 107*(D24), 4804.

Jaffe, D. A., Snow, J. A., & Cooper, O. (2003c). The April 2001 Asian dust events: Transport and substantial impact on surface particulate matter concentrations across the United States. *EOS transactions*.

Heald, C. L., Jacob, D. J., Park, R. J., Alexander, B., Fairlie, T. D., Yantosca, R. M., et al. (2006). Transpacific transport of Asian anthropogenic aerosols and its impact on surface air quality in the United States. *J. Geophys. Res., 111*, D14310.

Mian C., Diehl, T., Ginoux, P., & W., M. (2007). Intercontinental transport of pollution and dust aerosols: implications for regional air quality. *Atmos. Chem. Phys., 7*, 5501-5517.

Fischer, E.V., Hsu, N.C., Jaffe, D.A., Jeong, M.-J, and Gong, S.L. A Decade of Dust: Asian Dust and Spring Air Quality in the Western U.S. Submitted to Nature Geosci., June 2008.

Zhao, T. L., Gong, S. L., Zhang, X. Y., & Jaffe, D. A. (2008). Asian dust storm influence on North American ambient PM levels: observational evidence and controlling factors. *Atmos Chem Phys, 8*, 2717-2728.

[8] See:

Jaffe, D. A., & Strode, S. (2008). Fate and Transport of Atmospheric Mercury from Asia. Journal of Environmental Chemistry *Environ. Chem*, *5*(121).

Strode, S., Jaeglé, L., Jaffe, D. A., Swartzendruber, P., Selin, N., Holmes, C., et al. (2008). Trans-Pacific Transport of Mercury. *J.Geophys. Res.*

Travnikov, O. (2005). Contribution of the intercontinental atmospheric transport of mercury pollution in the Northern Hemisphere. *Atmos. Environ, 39*(39), 7541-7548.

Seigneur C., K. Vijayaraghavan, K. Lohman, P. Karamchandani, and C. Scott, (2004), Global Source Attribution for Mercury Deposition in the United States, *Environ. Sci. Technol* . 38, 555-569.

[9] See, for example Jaffe et al., 2005, which shows a method to quantify Asian mercury emissions based on measurements at Mt. Bachelor in central Oregon:

Jaffe D. A., E. Prestbo, P. Swartzendruber, P. Weiss-Penzias, S. Kato, A. Takami, S. Hatakeyama and Y. Kajii.(2005) Export of Atmospheric Mercury from Asia.

Atmos. Environ. 39, 3029-3038.