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Aircraft measurements over Europe of an air pollution plume from Southeast Asia – aerosol and chemical characterization

A. Stohl[1], C. Forster[1,2], H. Huntrieser[2], H. Mannstein[2], W. W. McMillan[3], A. Petzold[2], H. Schlager[2], and B. Weinzierl[2]

[1]Norwegian Institute for Air Research, Kjeller, Norway
[2]Institut für Physik der Atmosphäre, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen, Germany
[3]University of Maryland, Baltimore, USA

Abstract. An air pollution plume from Southern and Eastern Asia, including regions in India and China, was predicted by the FLEXPART particle dispersion model to arrive in the upper troposphere over Europe on 24–25 March 2006. According to the model, the plume was exported from Southeast Asia six days earlier, transported into the upper troposphere by a warm conveyor belt, and travelled to Europe in a fast zonal flow. This is confirmed by the retrievals of carbon monoxide (CO) from AIRS satellite measurements, which are in excellent agreement with the model results over the entire transport history. The research aircraft DLR Falcon was sent into this plume west of Spain on 24 March and over Southern Europe on 25 March. On both days, the pollution plume was found close to the predicted locations and, thus, the measurements taken allowed the first detailed characterization of the aerosol content and chemical composition of an anthropogenic pollution plume after a nearly hemispheric transport event. The mixing ratios of CO, reactive nitrogen (NO_y) and ozone (O_3) measured in the Asian plume were all clearly elevated over a background that was itself likely elevated by Asian emissions: CO by 17–34 ppbv on average (maximum 60 ppbv) and O_3 by 2–9 ppbv (maximum 22 ppbv). Positive correlations existed between these species, and a $\Delta O_3/\Delta CO$ slope of 0.25 shows that ozone was formed in this plume, albeit with moderate efficiency. Nucleation mode and Aitken particles were suppressed in the Asian plume, whereas accumulation mode aerosols were strongly elevated and correlated with CO. The suppression of the nucleation mode was likely due to the large pre-existing aerosol surface of the transported larger particles. Super-micron particles, likely desert dust, were found in part of the Asian pollution plume and also in surrounding cleaner air. The aerosol light absorption coefficient was enhanced in the plume (average values for individual plume encounters 0.25–0.70 Mm^{-1}), as was the fraction of non-volatile Aitken particles. This indicates that black carbon (BC) was an important aerosol component. During the flight on 25 March, which took place on the rear of a trough located over Europe, a mixture of Asian pollution and stratospheric air was found. Asian pollution was mixing into the lower stratosphere, and stratospheric air was mixing into the pollution plume in the troposphere. Turbulence was encountered by the aircraft in the mixing regions, where the thermal stability was low and Richardson

numbers were below 0.2. The result of the mixing can clearly be seen in the trace gas data, which are following mixing lines in correlation plots. This mixing with stratospheric air is likely very typical of Asian air pollution, which is often lifted to the upper troposphere and, thus, transported in the vicinity of stratospheric air.