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Aircraft observations of East-Asian cyclone induced uplift and long-range transport of polluted boundary layer air to the lowermost stratosphere

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We report on the airborne detection of a large-scale stratified pollution layer in the lowermost stratosphere which contained increased concentrations of sulfur dioxide, reactive nitrogen, water vapour and sulfate aerosols. The measurements were performed over Central Europe with a chemical ionization mass spectrometer and a high spectral resolution Lidar on board the new German research aircraft HALO. Transport model simulations indicate the East-Asian planetary boundary layer (PBL) as the source region of this layer. The PBL air was uplifted by an East Asian warm conveyor belt (WCB) and thereafter experienced mostly horizontal transport and dispersion covering significant part of the northern hemisphere. The pollution layer extent up to 2 km above the thermal tropopause and appears to be trapped in the upper part of the tropopause inversion layer (TIL). Accompanying chemistry and aerosol model simulations indicate efficient SO_2 conversion to sulfuric acid during the horizontal transport in the TIL, accelerated by increased OH resulting from the increased water vapour. Low temperature and increased water vapour led to efficient binary H2SO4/H_2O nucleation. The uplifted anthropogenic nitrogen oxides experienced OH and particle mediated conversion to HNO_3. The layer of sulfate particles formed in the upper part of the TIL was observed in the Lidar backscatter signal. Since mid-latitude East Asia is a region with very large SO_2 emissions and a very high frequency of WCBs, SO_2 uplift into the lowermost stratosphere from this region may occur frequently, eventually leading very often to corresponding pollution layers in the northern-hemisphere TIL.