Air mass origins influencing TTL chemical composition over West Africa during 2006 summer monsoon

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Trace gas and aerosol data collected in the tropical tropopause layer (TTL) between 12–18.5 km by the M55 Geophysica aircraft as part of the SCOUT-AMMA campaign over West Africa during the summer monsoon in August 2006 have been analysed in terms of their air mass origins. Analysis of domain filling back trajectories arriving over West Africa, and in the specific region of the flights, showed that the M55 flights were generally representative of air masses arriving over West Africa during the first 2 weeks of August, 2006. Air originating from the mid-latitude lower stratosphere was under-sampled (in the mid-upper TTL) whilst air masses uplifted from central Africa (into the lower TTL) were over-sampled in the latter part of the campaign. Signatures of recent (previous 10 days) origins were superimposed on the large-scale westward flow over West Africa. In the lower TTL, air masses were impacted by recent local deep convection over Africa at the level of main convective outflow (350 K, 200 hPa) and on certain days up to 370 K (100 hPa). Estimates of the fraction of air masses influenced by local convection vary from 10 to 50% depending on the method applied and from day to day during the campaign. The analysis shows that flights on 7, 8 and 11 August were more influenced by local convection than on 4 and 13 August allowing separation of trace gas and aerosol measurements into "convective" and "non-convective" flights. Strong signatures, particularly in species with short lifetimes (relative to CO2) like CO, NO and fine-mode aerosols were seen during flights most influenced by convection up to 350–365 K. Observed profiles were also constantly perturbed by uplift (as high as 39%) of air masses from the mid to lower troposphere over Asia, India, and oceanic regions resulting in import of clean oceanic (e.g. O3-poor) or polluted air masses from Asia (high O3, CO, CO2) into West Africa. Thus, recent uplift of CO2 over Asia may contribute to the observed positive CO2 gradients in the TTL over West Africa. This suggests a more significant fraction of younger air masses in the TTL and needs to taken into consideration in derivations of mean age of air. Transport of air masses from the mid-latitude lower stratosphere had an impact from the mid-TTL upwards (20–40% above 370 K) during the campaign period importing air masses with high O3 and NOy. Ozone profiles show a less pronounced lower TTL minimum than observed previously by regular ozonesondes at other tropical locations. Concentrations are less than 100 ppbv in the lower TTL and vertical gradients less steep than in the upper TTL. The air mass origin analysis and simulations of in-situ net photochemical O3 production, initialised with observations, suggest that the lower TTL is significantly impacted by uplift of O3 precursors (over Africa and Asia) leading to positive production rates (up to 2 ppbv per day) in the lower and mid TTL even at moderate NOx levels. Photochemical O3 production increases with higher NOx and H2O in air masses with O3 less than 150 ppbv.

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