Composition and transport in the Asian summer monsoon anticyclone: A case study based on in-situ observations during ESMVal and EMAC simulations

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We present in-situ measurements of the trace gas composition of the upper tropospheric Asian summer monsoon anticyclone (ASMA) performed with the HALO research aircraft in the frame of the Earth System Model Validation (ESMVal) campaign. Air masses with enhanced O3 mixing ratios were encountered after entering the ASMA at its southern edge at about 150 hPa on 18 September 2012. This is in contrast to the presumption that the anticyclone's interior is dominated by recently uplifted air with low O3 during the summer monsoon season. Enhanced CO and HCl were also found in the ASMA, tracers for boundary layer pollution and tropopause layer or stratospheric air, respectively. In addition, reactive nitrogen was enhanced in the ASMA. Along the HALO flight track across the ASMA boundary, strong gradients of these tracers separate anticyclonic from outside air.

HYSPLIT trajectory calculations show that HALO sampled three times a filament of ASMA air, which included air masses uplifted from the lower or mid troposphere north of the Bay of Bengal. The trace gas gradients between UT and uplifted air masses were preserved during transport within a belt of streamlines fringing the central part of the anticyclone, but are smaller than the gradients across the ASMA boundary. Our data represent the first in-situ observations across the southern and downstream the eastern ASMA flank, respectively. Back-trajectories starting at the flight track furthermore indicate that HALO transected the ASMA where it was just splitting into a Tibetan and an Iranian part.

A simulation with the EMAC model is found to reproduce the observations reasonably well. It shows that O3-rich air is entrained by the outer streamlines of the anticyclone at its eastern flank. Back-trajectories and increased HCl mixing ratios indicate that the entrained air originates in the stratospherically influenced tropopause layer. Photochemical ageing of air masses in the ASMA additionally increases O3 in originally O3-poor, but CO-rich air. The combination of entrainment from the tropopause region, photochemistry and dynamical instabilities can explain the in-situ observations, and might have a greater impact on the highly variable trace gas composition of the anticyclone than previously thought [1].

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References

[1] Gottschaldt, K.-D., Schlager, H., Baumann, R., Bozem, H., Eyring, V., Hoor, P., Jöckel, P., Jurkat, T., Voigt, C., Zahn, A., and Ziereis, H.: Trace gas composition in the Asian summer monsoon anticyclone: A case study based on aircraft observations and model simulations, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-997, in review, 2016.