Origin and properties of the Asian Tropopause Aerosol Layer – a conundrum resolved by in-situ particle mass spectrometry

Abstract

The Asian Tropopause Aerosol Layer (ATAL) is an aerosol layer that develops every year during the Asian monsoon in an altitude band between ≈14 and 18 km. Since its discovery in the late 2000s by CALIPSO satellite observations one of the longstanding unresolved issues is the ATAL chemical composition. During the 2017 EU StratoClim project in-situ experiments were performed on board the M-55 "Geophysica" aircraft based in Kathmandu, Nepal. The novel ERICA aerosol particle mass spectrometer was deployed for automated composition measurements up to 20 km altitude inside the Anticyclone over Nepal, India, Bangladesh and the Bay of Bengal. ERICA combines the techniques of the laser desorption single particle mass spectrometry with the thermal desorption method (TDI, as in the AMS from Aerodyne Inc.) for quantitative bulk information in one instrument, which covers a particle size range from 110 nm to 3.5 µm. Concurrent measurements with optical and condensation particle counters from the eight conducted research flights exhibit significant enhancements of the number densities for particles with diameters from 10 nm to 3 µm in the ATAL altitude range. The ERICA measurements between approximately 13 and 18 km show that the particles in the ATAL mostly consist of ammonium nitrate and organics. The single particle analyses also demonstrate that a significant particle fraction here results from the conversion of inorganic and organic gas-phase precursors, rather than from the uplift of primary particles from below. In this presentation an overview of the measurements within the Asian Monsoon Anticyclone and the ATAL is presented with emphasis on the aerosol microphysical properties, and details of the results concerning particle chemical composition are provided. Based on this, the processes leading to the ATAL formation involving aerosol and cloud microphysics and aerosol chemistry are briefly summarized. Finally, first results are presented from: (1.) the 2022 ACCLIP campaign, where our ERICA instrument was operated on the NCAR/UCAR HIAPER aircraft in South Korea, and (2.) from the 2023 PHILEAS campaign where ERICA was flown on the German HALO based in Anchorage, Alaska.

References:

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