Exploring the ionic composition of the Asian Tropopause Aerosol Layer using medium duration balloon flights

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Satellite observations have revealed an enhanced aerosol layer near the tropopause over Asia during the summer monsoon, called the Asian Tropopause Aerosol Layer (ATAL). The chemical composition of the ATAL is investigated here using offline ionic analysis of aerosols collected with a balloon-borne impactor near the tropopause region over India onboard extended duration balloon flights in the summer of 2017 and winter 2018. We found NO$_3^-$ and NO$_2^-$ dominant among other ions with values ranging between 87-343 ng/m$^3$ during the summer campaign. In contrast, SO$_4^{2-}$ levels were found above detection limit (>10 ng/m$^3$) only in winter. In addition, we determined the origin of the air masses sampled during the flights through back trajectory analysis combined with convection. The results obtained therein were put into a context of large-scale transport and aerosol distribution with GEOS-Chem chemical transport model simulations. The first flight of summer 2017 sampled air mass within the Asian monsoon anticyclone (AMA), associated with smaller particle size found on stage 2 (particle size cut off > 0.15 microns) of the impactor, while the second flight sampled air mass at the edge of the AMA associated with larger particle size on stage 1 (particle size cut off between 2 and 0.5 microns). The sampled air masses in winter 2018 were affected by smoke from the Pacific Northwest fire event in Canada, which occurred 7 months prior to our campaign. Concentrations of SO$_4^{2-}$, NH$_4^+$, and Ca$^{2+}$ were enhanced. Overall, our results suggest that nitrogen-containing particles represent a large fraction of aerosols populating the ATAL in agreement with aircraft measurements during the StratoClim campaign. Furthermore, GEOS-chem model simulations suggest that lightning NOx emissions had a minimal impact on the production of nitrate aerosols sampled during the two flights.