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Unique airborne measurements at the tropopause of Fukushima Xe-133, aerosol, and aerosol precursors indicate aerosol formation via homogeneous and cosmic ray induced nucleation

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We report unique airborne measurements, at the tropopause, of the Fukushima radio nuclide Xe-133, aerosol particles (size, shape, number concentration, volatility), aerosol precursor gases (particularly SO_2, HNO_3, H_2O). Our measurements and accompanying model simulations indicate homogeneous and cosmic ray induced aerosol formation at the tropopause. Using an extremely sensitive detection method, we managed to detect Fukushima Xe-133, an ideal transport tracer, at and even above the tropopause. To our knowledge, these airborne Xe-133 measurements are the only of their kind. Our investigations represent a striking example how a pioneering measurement of a Fukshima radio nuclide, employing an extremely sensitive method, can lead to new insights into an important atmospheric process.

After the Fukushima accidential Xe-133 release (mostly during 11-15 March 2011), we have conducted two aircraft missions, which took place over Central Europe, on 23 March and 11 April 2011. In the air masses, encountered by the research aircraft on 23 March, we have detected Fukushima Xe-133 by an extremely sensitive method, at and even above the tropopause. Besides increased concentrations of Xe-133, we have detected also increased concentrations of the gases SO_2, HNO_3, and H_2O. The Xe-133 data and accompanying transport model simulations indicate that a West-Pacific Warm Conveyor Belt (WCB) lifted East-Asian planetary boundary layer air to and even above the tropopause, followed by relatively fast quasi-horizontal advection to Europe. Along with Xe-133, anthropogenic SO_2, NO_x (mostly released from East-Asian ground-level combustion sources), and warer vapour were also lifted by the WCB. After the lift, SO_2 and NO_x experienced efficient solar UV-radiation driven conversion to the important aerosol precursors gases H2SO4 and HNO_3. Our investigations indicate that, increased concentrations of the gases SO_2, HNO_3, and H_2O promoted homogeneous and cosmic ray induced aerosol formation at and even above the tropopause.