

Ice nucleating particles over the Eastern Mediterranean measured at ground and by unmanned aircraft systems

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During the intensive INUIT-BACCHUS-ACTRIS field campaign focusing on aerosols, clouds and ice nucleation in the Eastern Mediterranean in April 2016, we have measured the abundance of ice nucleating particles (INP) in the lower troposphere both with unmanned aircraft systems (UAS) as well as from the ground. Aerosol samples were collected by miniaturized electrostatic precipitators onboard the UAS and were analyzed immediately after collection on site in the ice nucleus counter FRIDGE for INP active at -20°C to -30°C in the deposition/condensation mode (INP_D). Immersion freezing INP (INP_I) were sampled on membrane filters and were analysed in aqueous extracts by the drop freezing method on the cold stage of FRIDGE. Ground samples were collected at the Cyprus Atmospheric Observatory (CAO) in Agia Marina Xyliatou (Latitude; $35^{\circ} 2' 8'' \text{N}$; Longitude: $33^{\circ} 3' 26'' \text{E}$; Altitude: 532 m a.s.l.).

During the one-month campaign, we encountered a series of Saharan dust plumes that traveled at several kilometers altitude. Here we present INP data from 42 individual flights, together with OPC aerosol number concentrations, backscatter and depolarization retrievals from the Polly-XT Raman Lidar, dust concentrations derived by the dust transport model DREAM (Dust Regional Atmospheric Model), and results from scanning electron microscopy. The effect of the dust plumes is reflected by the coincidence of INP with the particulate mass (PM), the Lidar retrievals and the predicted dust mass of the model. This suggests that mineral dust or a constituent related to dust was a major contributor to the ice nucleating properties of the aerosol. Peak concentrations of above $100 \text{ INP} \text{ std.l}^{-1}$ were measured at -30°C . The INP_D concentration in elevated plumes was on average a factor of 10 higher than at ground level. The INP_I concentration at ground also agreed with PM levels and exceeded the ground-based INP_D concentration by more than one order of magnitude. Since desert dust is transported for long distances over wide areas of the globe predominantly at several km altitude, we conclude that INP measurements at ground level may be of limited significance for the situation at the level of cloud formation.

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