Non-refractory submicron aerosols in the Po Valley: Sources, vertical transport, and chemical composition from measurements at Bologna (54 m a.s.l.) and Mt. Cimone (2167 m a.s.l.) within AirPoDynamic

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Atmospheric submicron aerosols have long been studied due to their impact on climate, ecosystems, and human health. Organic Aerosol (OA), the predominant constituent of PM_1 mass, can be directly emitted (Primary OA, POA) or formed through atmospheric processes (Secondary OA, SOA). Understanding the evolution and oxidation of OA during atmospheric transport is a key research focus.

This study aims to investigate OA ageing along a vertical transport in the Po Valley, from an urban site (Bologna, 54 m a.s.l., BO) to a high-altitude remote station (Monte Cimone, 2167 m a.s.l., CMN), in relation to Planetary Boundary Layer (PBL) dynamics. Measurements were conducted simultaneously at CMN and BO during August–September 2024 using a Time-of-Flight Aerosol Chemical Speciation Monitor (ToF-ACSM) and a Quadrupole-ACSM (Q-ACSM), respectively, within the ITINERIS activity 4.14 and *AirPoDynamic* framework.

The selected period comprises the transition from summer to early autumn evidencing the effect of PBL evolution on the chemical composition of non-refractory PM_1 (NR-PM_1), sulphate, ammonium, nitrate, and organics (OA), at the two sites. NR-PM_1 components at CMN summit show the alternation between the Free Troposphere (FT), characterized by lower concentrations, and PBL-influenced periods, exhibiting a decreasing PM_1 concentration trend over the campaign. Conversely, BO shows a progressive increase in NR-PM_1 concentration as a consequence of the reduction in PBL height resulting from the seasonal decrease in solar radiation. At both sites, OA constitutes the dominant NR-PM_1 fraction. Conversely, sulphate tends to be relatively more abundant at CMN than at BO in the colder periods, while nitrate is the second more important NR-PM1 component at low altitude in autumn.

OA composition was further analysed through source apportionment (SA) techniques (seasonal-PMF by ME-2). Findings indicate that the lower Po Valley is characterized by fresher, local anthropogenic emissions, despite a significant SOA presence. In contrast, aged OA prevails at CMN, although vertical transport from the Po Valley enhances the presence of less oxidized OAs at the summit during warmer days, particularly in the afternoon when aerosol mixing is enhanced.

Keywords: Vertical transport, ACSM, Source Apportionment