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Physical aerosol properties and their relation to air mass origin at Monte Cimone (Italy) during the first MINATROC campaign

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Abstract. Aerosol physical properties were measured at the Monte Cimone Observatory (Italy) from 1 June till 6 July 2000. The measurement site is located in the transition zone between the continental boundary layer and the free troposphere (FT), at the border between the Mediterranean area and Central Europe, and is exposed to a variety of air masses. Sub-µm number size distributions, aerosol hygroscopicity near 90% RH, refractory size distribution at 270°C and equivalent black carbon mass were continuously measured. Number size distributions and hygroscopic properties indicate that the site is exposed to aged continental air masses, however during daytime it is also affected by upslope winds. The mixing of this transported polluted boundary layer air masses with relatively clean FT air leads to frequent nucleation events around local noon.
Night-time size distributions, including fine and coarse fractions for each air mass episode, have been parameterized by a 3-modal lognormal distribution. Number and volume concentrations in the sub-µm modes are strongly affected by the air mass origin, with highest levels in NW-European air masses, versus very clean, free tropospheric air coming from the N-European sector. During a brief but distinct dust episode, the coarse mode is clearly enhanced.

The observed hygroscopic behavior of the aerosol is consistent with the chemical composition described by Putaud et al. (2004), but no closure between known chemical composition and measured hygroscopicity could be made because the hygroscopic properties of the water-soluble organic matter (WSOM) are not known. The data suggest that WSOM is slightly-to-moderately hygroscopic (hygroscopic growth factor GF at 90% relative humidity between 1.05 and 1.51), and that this property may well depend on the air mass origin and history.

External mixing of aerosol particles is observed in all air masses through the occurrence of two hygroscopicity modes (average GF of 1.22 and 1.37, respectively). However, the presence of "less" hygroscopic particles has mostly such a low occurrence rate that the average growth factor distribution for each air mass sector actually appears as a single mode. This is not the case for the dust episode, where the external mixing between less hygroscopic and more hygroscopic particles is very prominent, and indicating clearly the occurrence of a dust accumulation mode, extending down to 50 nm particles, along with an anthropogenic pollution mode.

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The presented physical measurements finally allow us to provide a partitioning of the sub-µm aerosol in four non-overlapping fractions (soluble/volatile, non-soluble/volatile, refractory/non-black carbon, black carbon) which can be associated with separate groups of chemical compounds determined with chemical-analytical techniques (ions, non-water soluble organic matter, dust, elemental carbon). All air masses except the free-tropospheric N-European and Dust episodes show a similar composition within the uncertainty of the data (53%, 37%, 5% and 5% respectively for the four defined fractions). Compared to these sectors, the dust episode shows a clearly enhanced refractory-non-BC fraction (17%), attributed to dust in the accumulation mode, whereas for the very clean N-EUR sector, the total refractory fraction is 25%, of which 13% non-BC and 12% BC.

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