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Airborne measurements of hygroscopicity and mixing state of aerosols in the planetary boundary layer during the PEGASOS campaigns

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Aerosols interact directly with the incident solar radiation by scattering or absorbing the light. The optical properties of an aerosol particle can strongly be altered at enhanced relative humidity (RH). Depending on the particle's chemical composition, it can experience hygroscopic growth, leading to a change in size and index of refraction compared to the dry particle (Zieger et al., 2011). Besides, aerosols can exist in different mixing states which are usually divided into internal and external mixtures. If all particles of a certain size have the same chemical composition, they are described as internally mixed, whereas if particles of equal size have different chemical composition, they are defined as externally mixed. Depending on the mixture the hygroscopic behavior will change: internally mixed aerosols will grow uniformly with increasing RH, while the different substances in external mixtures will experience different growing behaviors leading to a mode-splitting or broadened size distribution. Laboratory studies are commonly performed at dry conditions but it is known that temperature and RH as well as chemical composition are changing with altitude (Morgan et al., 2010). This further leads to the conclusion that the in-situ measurements of optical properties at different heights are crucial for climate forcing calculations. Within the Pan-European Gas-Aerosols-climate interaction Study (PEGASOS) the white- light humidified optical particle spectrometer (WHOPS) was developed and installed on the Zeppelin to investigate changes of light scattering with regard to water uptake and altitude. This instrument firstly selects a dry monodisperse aerosol by its electrical mobility and then exposes it to a well-defined RH (typically 95%). Alternately, the dry and humidified particles are measured in a white-light optical particle spectrometer (WELAS). In this way it is possible to infer the effective index of refraction of the dry particles, their hygroscopic properties and mixing state. By combining these results with measurements from an aerosol mass spectrometer (AMS) and an aethalometer, insights can be gathered to explain their hygroscopicity. In this work we will present vertical profiles of the hygroscopic growth and mixing state of aerosol particles measured during Zeppelin flights of the PEGASOS campaigns in the Netherlands, Italy and Finland. Results from ground measurements will also be included to compare the aerosol directly at the surface with different heights.

W.T. Morgan et al., Enhancement of the aerosol direct radiative effect by semi-volatile aerosol components: Airborne measurements in North-Western Europe, Atmospheric Chemistry and Physics 10(2010), pp. 8151-8171.

P. Zieger et al., Comparison of ambient aerosol extinction coefficients obtained from in-situ, MAX-DOAS and LIDAR measurements at Cabauw, Atmospheric Chemistry and Physics 11(2011), pp. 2603-2624.