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Vertically resolved aerosol characterization during the GAMARF campaign: aerosol size distribution and radiative properties

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The GAMARF (Ground-based and Airborne Measurements of the Aerosol Radiative Forcing) campaign was carried out during 10 days on April-May 2008 in Lampedusa. The campaign took place in the framework of EUFAR (European Facility for Airborne Research) to study the vertical variation of the aerosol physical and radiative properties and the aerosol radiative effects. Several flights with an instrumented ultra-light aircraft (Enduro-KIT) provide vertical resolved measurements of the aerosol size distribution, upward and downward radiative fluxes in the shortwave and longwave spectral ranges, and meteorological variables such as temperature and relative humidity. Ground based measurement of column integrated aerosol size distribution; aerosol optical depth (AOD) and Angström exponent (AE) were also available. Surface aerosol size distribution, downward fluxes of shortwave and longwave radiation, backscattering and extinction profiles by lidar, and meteorological profiles by balloon soundings were also acquired.

A closure experiment was carried out to study the vertical variation of the aerosol size distribution and radiative properties in different atmospheric situations occurred during the campaign. Three days with a large aerosol load, displaying AOD at 500 nm of about 0.6 and AE of about 0.4 were associated with a dust event. Backtrajectories from HYSPLIT, Dream Model and Lidar measurements confirm that a dust layer was located between 2 and 4 km height, and was travelling over the boundary layer. Two other days displayed relatively clean atmospheric conditions, with mean AOD at 500 nm of 0.2 and AE of 1.0, and a large amount of particles in the lowermost atmosphere.

The aerosol stratification is determined from the vertical variation of the fine and coarse fraction, with diameters smaller and larger than 1 micron respectively, and changes in the backscattering coefficient from the lidar profiles. The days corresponding to the dust event display an increase in the coarse fraction around 2 km height. The dust layer is characterized by a trimodal size distribution with mean radii around 0.06, 0.8, and 6 micron respectively for each mode. Moreover, a large contribution of the coarse mode to the total number of particles is observed. Conversely, the aerosol sited in the first km altitude shows a bimodal size distribution with mode radii of about 0.08 and 0.6 micron, with a large contribution of the fine mode to the total particles number. Aerosol size distributions similar to those obtained in the first 2 km altitude were observed during the clear days, when a limited vertical variation of the fine and coarse contribution was observed.

The Mie theory has been applied to the aerosol size distribution measured for each aerosol layer and an iterative procedure accounting for the vertical variation of the backscattering coefficient from lidar was run to retrieve the refractive index of each layer. Therefore the average spectral aerosol radiative properties (backscattering, scattering, extinction, and absorption coefficients) of each layer are retrieved in the shortwave spectral range using the Mie theory.

The different aerosol properties for the dust event and clear days and its different vertical structure directly influence the vertical distribution of radiative fluxes, possibly also affecting cloud properties and temperature profile.