A six-year record of size distribution and chemical composition of Arctic aerosol. Main results and future bi-polar perspetives

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The Arctic regions are among the areas most sensitive to present climate changes; through connections involving ocean, atmosphere, biosphere, lithosphere and cryosphere, they respond to, amplify, and drive changes elsewhere in the Earth system, so that understanding their role the climate-environmental feedback processes is essential to set reliable predictive climate models. In particular, the atmospheric aerosol strongly interacts with the climate forcings through scattering and absorption of the solar irradiation and as sources of cloud condensation nuclei. Although these processes are well known, the quantitative and qualitative (the sign of the climate forcing) of the aerosols in the Polar Regions is affected by a large uncertainty, yet. The main uncertainties include the relative cloud/snow surface albedo and the scarce spatial coverage of size distribution and chemical composition of aerosol at high latitudes. To improve our knowledge on the size distribution, the atmospheric load and the chemical composition of the Arctic aerosol, continuous measurements and sampling campaigns are ongoing since 2010 in two Arctic sites: Thule (North Greenland) and Ny Alesund (Svalbard Island, Norway). At Thule, 24-h samples are all-year-round collected at daily or every other day resolution. Contemporaneously, "summer" (March to September) aerosol was annually sampled at Ny Alesund. In the latter site, aerosol was collected by several systems (PM10 samplers, multi-stage impactors (4- and 12-stage Dekati samplers) and on different substrates (Teflon filters, quartz filters, polycarbonate and Teflon membranes). Besides, shorter measurement and sampling campaigns were carried out by using a tethered balloon, up to about 1.000 m altitude, to study the effect of the PBL dynamics on the aerosol atmospheric load and chemical composition. Filter chemical analysis includes: ions composition (inorganic anions and cations and selected organic anions, including light carboxylic acids and MSA), elemental composition (by PIXE analysis), main and trace metals (including Rare Earth Elements - REEs, by ICP-HR-MS), Pb isotopic ratios (by ICP-QMS) and Elemental/Organic Carbon fractions (EC/OC, by Sunset thermo-optical analysis). Besides, continuous measurements of particle size-distribution (TSI-SMPS and TSI-APS; 6 nm – 20um; 10 min resolution), Black Carbon (by Particle Soot Absorption Photometry – PSAP) and natural radioactivity (Rn progeny, by FAI PBL Monitor) were carried out during the sampling periods at Ny Alesund. Here we report the most relevant results up to now obtained and the future perspective both concerning Arctic and Antarctic aerosol, in the framework of three PNRA (Progetto Nazionale di Ricerche in Antartide) projects recently approved and funded. In particular, the use of specific chemical markers (such as nss-sulfate for anthropic Arctic Haze, REEs elements for dust, MSA for biogenic emissions, selected heavy metals for local and long-range anthropic sources) allowed studying the changes in sources intensity and atmospheric transport efficiency for aerosol reaching the Arctic regions. Sulfate source apportionment was performed to evaluate the contribution of sea spray, continental dust, biogenic emissions and anthropic activities to the sulfate global budget. MSA was used to understand the complex interactions among sea ice dynamics, chlorophyll blooms and marine primary productivity. Lead isotopic composition and REEs composition were used in identifying the continental source of dust and anthropic pollutants. Finally, a relationship between marine biogenic emissions and nucleation events was found by particle size distribution in the nanometric mode.